Section 3

ENGINE

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Engine

Introduction

The Cabriolet and Scirocco engines are all four-cylinder, front-mounted and water-cooled. The cast iron cylinder block supports the crankshaft in five main bearings. The overhead camshaft running in the cylinder head is driven from the crankshaft by a reinforced toothed belt. Displacement is 1781 cc (109 cu. in.), commonly referred to as 1.8 liters. Horsepower is 94 (SAE net). The Scirocco 16V engine is also 1.8 liters, but its cross-flow cylinder head design and dual overhead camshafts with four valves per cylinder (two intake and two exhaust) raises rated horsepower to 123 (SAE net).

The engine is transverse-mounted and inclined toward the rear of the car—a design that permits a lower hood line and improves weight distribution. The engine and transaxle are supported as a single unit by a combination of bonded rubber mounts that isolate the drivetrain and help reduce the transmission of noise and vibration to the rest of the car.

The engine's transverse placement takes up less overall space than other designs and makes possible a roomier passenger compartment. It also concentrates drivetrain weight over the front driving wheels where it helps improve traction under slippery conditions. Despite a slight forward weight bias when the car is empty, total vehicle weight is distributed about equally on the front and rear wheels when the car is loaded. Near-equal weight distribution increases stability and assures precise handling.

The information in this section of the manual is intended both as a guide to Cabriolet and Scirocco owners and as a reference for professional mechanics. Some of the procedures and repairs described require special equipment and some prior knowledge of general engine repair and assembly practices. If you lack the skills, tools, or a suitable workplace for servicing or repairing the engine, we suggest you leave these repairs to an authorized Volkswagen dealer or other qualified automotive repair shop. We especially urge you to consult your authorized Volkswagen dealer before beginning any repairs on a car that may be covered wholly or in part by any of the extensive warranties issued by Volkswagen United States, Inc.

1. GENERAL DESCRIPTION

The in-line four-cylinder overhead cam engine is water-cooled and transmits power through a piston-driven crankshaft. The cylinder block is made of cast iron with integral cylinders completely exposed on all sides to the coolant that circulates through the water jacket. A separate cast aluminum alloy cylinder head contains the belt-driven camshaft and the entire valve train. A cutaway view of the engine appears in Fig. 1-1.

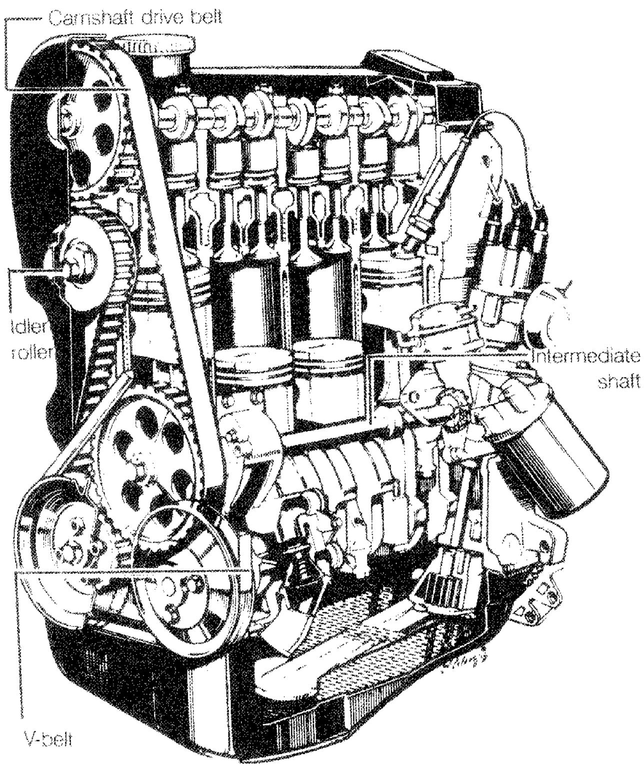


Fig. 1-1. Cutaway view of engine.

1.1 Engine Components

Crankshaft and Bearings

The fully counterweighted crankshaft rotates in five replaceable split-shell main bearings. A 6-piece center main bearing (upper shell, lower shell, and four thrust bearings) controls crankshaft end thrust. Flexible lip seals, pressed into light alloy seal carriers, are used at both ends of the crankshaft to prevent oil leakage.

Connecting Rods and Pistons

The connecting rods are steel forgings. Replaceable split-shell bearings are used at the crankshaft end and lead-bronze coated steel bushings at the piston pin end. The pistons are of the three-ring type with two upper compression rings and a lower one-piece oil scraper ring. Full-floating piston pins are retained at each end by circlips.

Cylinder Head

The cylinder head is an aluminum alloy casting. The overhead camshaft bearing surfaces and the bores for the cam followers (valve lifters) are machined directly into the cylinder head casting. The valve guides are press-fit and replaceable.

Valve Train

The single overhead camshaft is driven from the crankshaft by a toothed, steel-reinforced belt. The cam lobes and bucket-style cam followers directly actuate the intake and the exhaust valves. Valve clearance is adjusted by fitting the cam followers with shims of different sizes. Starting with the 1988 model year, 8-valve engines have hydraulic cam followers. These use engine oil pressure to maintain correct valve clearances. Intake and exhaust valves are equipped with dual valve springs and both upper and lower spring seats.

Intermediate Shaft

The intermediate shaft, turning in the cylinder block, is located above and parallel to the crankshaft. It is driven at half crankshaft speed by the camshaft drive belt, and in turn drives the oil pump and the ignition distributor shaft.

Lubrication System

A gear-type oil pump driven by the intermediate shaft draws oil through a strainer in the bottom of the oil pan and forces it through a spin-on replaceable filter and into the engine's oil passages. A pressure relief valve limits the pressure in the system, and a filter bypass valve assures lubrication even if the filter is plugged. An oil cooler is attached to the filter housing. Engine coolant circulates through the oil cooler to help moderate oil temperature. In addition to a warning system for low oil pressure, a more sensitive dynamic oil pressure warning system operates at elevated engine rpm.

1.2 16-valve Engine

The 16-valve engine is a highly developed version of the basic 1.8 liter engine, sharing most of its major design features. There are several differences, in the cylinder head as well as other related systems, which distinguish the 16-valve version.

Cylinder Block

The cylinder block used for the 16-valve engine has several modifications to help make it more suitable to the higher power output, primarily in the lubrication system. The passageways connecting the crankcase and the upper cylinder head are larger, to allow better ventilation and oil return, and an additional oil passage in the block supplies oil to a series of spray nozzles, one below each cylinder. At oil pressure above 3.5 bar (50 psi), the nozzles open and small streams of oil are sprayed at the underside of each piston to provide additional cooling. The cylinder block casting is also modified to accept a larger crankcase breather.

Pistons

The 16-valve engine, because of its different cylinder head design and valve arrangement, uses a different piston than the other 1.8 liter engines to achieve the necessary combination of compression ratio and valve clearance.

Cylinder Head

The cylinder head is, of course, the 16-valve engine's major departure from Volkswagen's other 1.8 liter engines. Its cross-flow design features four valves per cylinder, versus the usual two, operated by two overhead camshafts. The result is more efficient air flow into and out of the combustion chambers, and an engine with greater efficiency and power over a wide rpm range.

The cylinder head is an aluminum alloy casting with sintered steel valve seats. The press-fit valve guides are replaceable, while the bearing surfaces for the dual camshafts and the bores for the cam followers are machined directly into the cylinder head casting. Fig. 1-2 shows the 16-valve cylinder head and its four-valve combustion chambers.

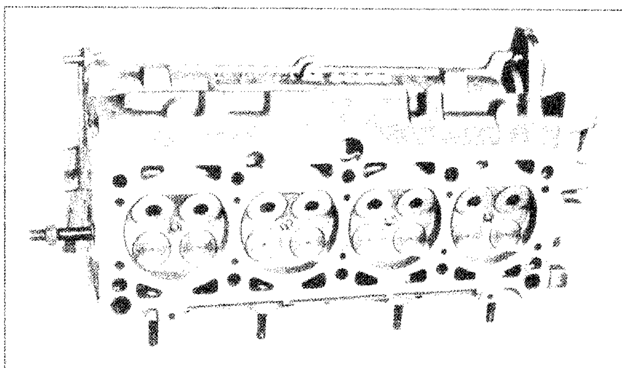


Fig. 1-2. 16-valve cylinder head showing orientation of intake valves (top) and exhaust valves (bottom).

Valve Train

The camshafts are driven by the crankshaft via a single toothed, steel-reinforced belt. The belt drives a single sprocket attached to the exhaust camshaft. The exhaust camshaft in turn drives the intake camshaft through a roller chain and sprockets at the other end of the cylinder head. The drive belt and sprockets, although similar to those of the other 1.8 liter engines, are modified to handle the extra loads of the 16-valve valve train. Fig. 1-3 shows the orientation of the camshafts and drive mechanisms in the assembled cylinder head. The cam lobes operate the intake and exhaust valves directly through hydraulic cam followers which use engine oil, supplied under pressure by the lubrication system, to maintain correct valve clearances. A spray-jet assembly, similar to that used to cool the pistons, is used in the cylinder head to prevent oil from draining out of the supply gallery for the cam followers. Sodium-filled exhaust valves aid heat transfer and reduce valve seat temperature. Dual valve springs and both upper and lower spring seats are used on the intake and exhaust valves.

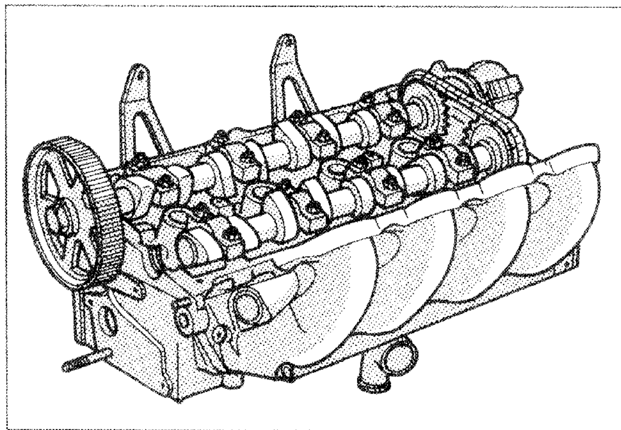


Fig. 1-3. 16-valve cylinder head and valve train.

Intermediate Shaft

The ignition distributor on the 16-valve engine is driven directly by the exhaust camshaft. The intermediate shaft, which drives only the oil pump, is driven at 60% of crankshaft speed by the camshaft drive belt.

1.3 Engine Identification Codes and Specifications

Different versions of the basic four-cylinder engine are used in the cars covered by this manual. Volkswagen uses a unique engine code to identify each version and to distinguish between their different parts and specifications. The engine code is the single most important piece of information for you to know about your engine. Throughout this manual, where different procedures or specifications may apply, the engine codes are used to identify the correct information for each engine.

Finding Engine Codes

The engine code can be viewed in the engine compartment. The code, JH for example, appears at the beginning of the engine number. The number is stamped on a flat area of the top of the engine block, just below the lower edge of the cylinder head, between cylinders No. 3 and No. 4. The engine number stamp is shown in Fig. 1-4. **Table a** lists Cabriolet and Scirocco engine codes, application information, and major engine specifications.

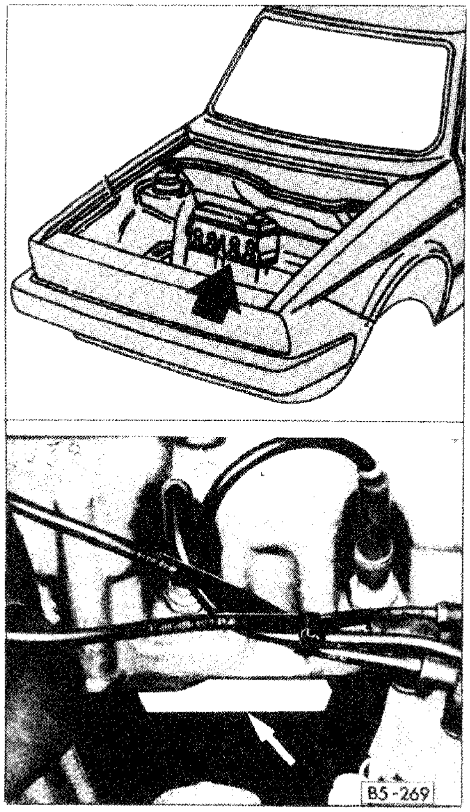


Fig. 1-4. Engine code and production number stamped on cylinder block between cylinders three and four.

Table a. Engine Codes and Specifications

Engine code	JH	2H	PL
Number of cylinders		4	
Bore – mm (in.)		81.0 (3.19)	
Stroke – mm (in.)		86.4 (3.40)	
Displacement – cc (cu. in.)		1781 (109)	
Compression ratio	8.5:1	10:1	10:1
Horsepower – SAE net @ rpm	94 @ 5500	94 @ 5400	123 @ 5800
Torque – lbs-ft @ rpm	102 @ 3000	100 @ 3000	120 @ 4250
Fuel injection / Engine management	CIS	Digifant	CIS-E
Application notes	–	from 1990	Scirocco 16V

2. MAINTENANCE

Volkswagen specifies the maintenance steps below, to be carried out at specific time and mileage intervals. A number in bold type indicates that the procedure is in this section, under that numbered heading. See **LUBRICATION AND MAINTENANCE** for other listed items, and for the prescribed intervals.

1. Checking engine oil level
2. Changing engine oil and oil filter
3. Replacing spark plugs
4. Checking engine compression pressure. **3.2**
5. Adjusting valve clearance (with mechanical cam followers, 1985-1987 8-valve engine only). **4.4**
6. Replacing cylinder head cover gasket (only with valve adjustment listed above). **4.1**

3. TROUBLESHOOTING

The principles of internal combustion can be very complex, but the basic engine functions are pretty simple. The potential for problems is limited.

Wear is the main cause of any problem in an engine that sees normal use and receives proper maintenance. Wear affects the ability of the pistons, piston rings and valves to seal the combustion chambers—to create and maintain compression. Wear increases clearances between moving parts. Finally, wear affects the components that keep the crankshaft and pistons, valve train and ignition properly timed.

This troubleshooting section deals with the basic engine functions. To investigate an engine oil pressure warning, or to troubleshoot the lubrication system, see **7. Lubrication System** in this section. To troubleshoot other, more general problems with engine cooling or the way the engine starts or runs, see **COOLING SYSTEM**, **FUEL SYSTEM** and **IGNITION**.

3.1 Basic Troubleshooting Principles

To isolate and identify engine problems, always begin with careful observation of the symptoms. Some important things to look for are:

How quickly did the problem develop? Problems that occur suddenly are probably caused by a failure that can be corrected by some sort of repair. A problem that has developed gradually, especially after years and many tens of thousands of miles, is more likely brought on by wear. It may mean that more comprehensive overhaul work is required.

Does the symptom change with engine speed? If so, the problem is most likely an engine problem. Noises which repeatedly occur only in a certain rpm range suggest a vibration problem. Noises or other symptoms that vary with the speed of the car are more likely caused by problems somewhere else in the drivetrain or running gear.

Is the symptom load dependent? Forces at work inside a running engine vary as the demand for power varies. Symptoms which are more severe during hard acceleration indicate certain kinds of problems. Symptoms which are more apparent at no load or high vacuum (example: coasting at high rpm) point to other problems. Note that higher engine loads also affect the fuel and ignition systems, which may be responsible for high-load performance problems.

Is the symptom temperature dependent? Does it only occur when the engine is cold? Does it change as the engine warms up? How? Metal parts expand and contract with changes in temperature. Clearances change. Oil viscosity and cooling system pressure change. In troubleshooting symptoms which change as the engine gets warm, look for an engine characteristic that changes with temperature.

The paragraphs which follow describe particular types of problems and some of the basic troubleshooting principles associated with them. **Table b** lists symptoms of problems commonly associated with engine trouble, their probable causes, and suggested corrective actions. The numbers in bold type in the corrective action column refer to numbered headings in this section where the suggested repairs are described.

Noise

In order to run reliably and smoothly under harsh conditions, the internal engine parts are manufactured to precise dimensions, assembled with precision clearances between moving parts, and lubricated by a pressurized oiling system.

Most unidentified engine noises result from clearances which have become too large due to worn or failed parts, lack of adequate lubrication, or both. The importance of lubrication cannot be over-emphasized. For best results, troubleshooting engine noises should only be done when the oil and filter have been recently changed and the oil level is correct.

High-pitched metallic tapping noises are caused by relatively small, lightweight parts and are most likely an indication of excessive clearances in the valve train. Valve train noise accompanied by burning oil (blue-gray smoke in the exhaust), particularly at startup or when decelerating from high rpm, is an indication of worn valve guides which can only be remedied by overhaul or replacement of the cylinder head. In a high-mileage engine, a light metallic rattle or chatter under acceleration, accompanied by increased oil consumption and smoking, may indicate severely worn or broken piston rings. Since this diagnosis means overhaul or replacement of the engine, the problem should be further investigated with a compression or cylinder leakage test. See **3.2 Diagnostic Testing**.

Deep, metallic knocking sounds are caused by excessive clearances between heavier components. Closer analysis of the noise will often help identify the problem. Piston slap, caused by excessive piston skirt to cylinder wall clearance, is worse when the engine is cold and may be accompanied by increased oil consumption and reduced compression due to accelerated piston ring wear. A double knock, most pronounced at idle or low load, is due to excessive clearance at the piston pin and upper connecting rod bushing.

Crankshaft bearing problems produce a deep, hollow knock that is worst when the engine is warm. A noise that is very pronounced under load, perhaps louder during the transition from acceleration to coasting, is most likely caused by a damaged connecting rod bearing. Crankshaft main bearings produce a lower, dull knock. An intermittent knock, indicating excessive crankshaft end play, may be most apparent when depressing or releasing the clutch. These problems seldom occur as isolated failures. They are almost always an indication of the overall engine condition which can only be properly corrected by complete engine overhaul or replacement.

Rumbling or groaning from the engine compartment may not indicate engine problems at all, but rather a worn bearing or bushing in an engine-driven accessory. They include the coolant pump, alternator, and may include a power steering pump and air conditioning compressor. The air conditioning compressor is equipped with an electrically-switched clutch-type pulley, so a bad compressor will only be noisy when the air conditioning is on. To check other accessories, run the engine briefly with the drive belt disconnected and see if the noise has stopped. Once the drive belt is removed, turning the pulley and shaft by hand may also reveal a bad bearing or bushing. A properly functioning accessory should turn smoothly.

Fluid Leaks

Fluid leaking from and around the engine is most likely either oil, coolant, or brake fluid. Look for wet spots on the engine to help pinpoint the source. It may be helpful to start by cleaning the suspected area.

The most likely sources of engine oil leaks are the oil filter gasket, the crankcase oil seals, the cylinder head cover gaskets, or the oil pan gaskets. See **6. Cylinder Block and Pistons** for more information on the gaskets and seals.

The power steering system is another possible source of oil leaks near the engine. For repairs to the power steering system, see **SUSPENSION AND STEERING**.

Coolant is a mixture of water and anti-freeze, yellow-green in color or perhaps brown if the cooling system is corroded. A pressure test of the cooling system is the best way to discover and pinpoint leaks. See **COOLING SYSTEM**.

Brake fluid is clear, perhaps slightly purple, and a little slippery. Look for wet spots around the master cylinder or brake lines. Especially check the flexible hoses near the wheels. See **BRAKES** for repair information.

Smoking

Smoke which is visible under the hood will be either blue-gray smoke from burning oil, or white steam from the cooling system. Both symptoms indicate a leak. See **Fluid Leaks** above.

Smoke in the exhaust indicates something getting into the combustion chamber and being burned which does not belong there. The color of the smoke identifies the contaminant.

Blue-gray smoke is from oil. Oil smoke, probably accompanied by increased oil consumption and oil residue on spark plugs, indicates that engine oil is getting past piston rings, valve guides, the cylinder head gasket, or some combination of the three. Use a compression test for diagnosis. See **3.2 Diagnostic Testing**. Compression pressures in an older engine which are even, but below specifications, point to piston ring and cylinder wall wear and the need for engine overhaul or replacement. If the smoking is most obvious under high engine vacuum, such as while coasting at high rpm, and compression pressures are within specifications, leaking valve guide oil seals or valve guides are a probable cause. See **4. Cylinder Head** for repair information.

Oil smoke or steam appearing suddenly in the exhaust, along with low compression pressure in one cylinder or two adjoining cylinders, is very probably due to a failed cylinder head gasket. Look also for coolant loss, oil in the radiator, or water in the oil (which turns the oil an opaque, creamy brown). See **4.8 Removing and Installing Cylinder Head** for repair procedures.

Black smoke is caused by the engine getting too much fuel. See **FUEL SYSTEM** for more troubleshooting information.

Excessive Oil Consumption

Some oil consumption is normal and indicates healthy flow and distribution of the vital lubricant in the engine. This is why oil level must be checked, and occasionally corrected, between oil changes. Aside from leaks, increased oil consumption will usually be accompanied by some smoking, however slight, and the causes of excessive oil consumption are the same as those for oil smoke in the exhaust. As with smoking symptoms, gradual increases are caused by worn piston rings and/or valve guides. Sudden high oil consumption suggests broken rings or a failed cylinder head gasket. See **Smoking** above for more troubleshooting information.

Poor Fuel Consumption and Low Power

Poor fuel consumption and low power can, of course, suggest problems with the fuel or ignition systems, particularly on a low-mileage engine. On an engine with high mileage, suffering the effects of wear, low compression may be the cause.

Normal wear of the valves, piston rings, and cylinder walls decreases their ability to seal. The intake and compression of the air/fuel mixture becomes less efficient, and the engine has to work harder, using more fuel, to produce the same amount of power. Engine condition can be evaluated with a compression test. See **3.2 Diagnostic Testing**.

Engine Not Running

An engine problem which affects timing may prevent the engine from starting or running. The camshaft drive belt and sprockets are responsible for timing the actions of the valves and the ignition system relative to the pistons and crankshaft. A worn belt and sprockets may jump teeth, throwing off all the engine's timing functions, and still appear to be perfectly normal. To check camshaft and ignition timing, see **4.2 Camshaft Drive Belt** and **IGNITION**. Other troubleshooting information for an engine which fails to start can be found in **ELECTRICAL SYSTEM**, **FUEL SYSTEM**, and **IGNITION**.

Table b. Engine Troubleshooting

Symptom	Probable cause	Corrective action
1. Pinging or rattling noise under load, uphill or accelerating, especially from low speeds. Indicates detonation or pre-ignition	**a.** Ignition timing too far advanced **b.** Fuel does not meet manufacturer's octane requirements **c.** Overheating **d.** Spark plugs damaged or wrong heat range **e.** Air/fuel mixture too lean	**a.** Correct ignition timing. See **IGNITION** **b.** Switch to higher octane fuel. See **FUEL SYSTEM** for fuel octane requirements **c.** See **COOLING SYSTEM** **d.** Replace spark plugs. See **IGNITION** **e.** See **FUEL SYSTEM**
2. Screeching or squealing noise under load. Goes away when coasting. Indicates slipping V-belt	**a.** Loose, worn, or damaged V-belt(s) **b.** Excessive belt loads due to failed engine-driven component	**a.** Inspect, replace, or tighten belt(s). See **LUBRICATION AND MAINTENANCE** **b.** Locate and replace failed component. **3.2**

continued on next page

Table b. Engine Troubleshooting (continued)

Symptom	Probable cause	Corrective action
3. Growling or rumbling, varies with engine rpm. Bad bearing or bushing in an engine-driven accessory	a. Coolant pump b. Alternator c. Power steering pump d. Camshaft drive belt tensioner bearing e. Air conditioning compressor	a. See **COOLING SYSTEM** b. See **ELECTRICAL SYSTEM** c. See **SUSPENSION AND STEERING** d. Replace belt tensioner. **4.2** e. Replace compressor
4. Light metallic tapping noise, varies directly with engine speed. Oil pressure warning light **not** illuminated	a. Low oil pressure and defective warning light circuit b. Valve lash out of adjustment (1985–1987, engine code JH) c. Defective cam follower(s)	a. Check oil pressure and/or warning system. **7.** b. Adjust valve lash. **4.4** c. Check cam followers and replace as required. **4.6**
5. Light metallic knock, varies directly with engine speed. Oil pressure warning light blinking or fully illuminated (may be most noticeable after hard stops or during hard cornering) indicates lack of sufficient oil supply	a. Low oil level b. Restricted (dirty) oil filter c. Insufficient oil pressure	a. Check and correct oil level. See **LUBRICATION AND MAINTENANCE** b. Change engine oil and filter. See **LUBRICATION AND MAINTENANCE** c. Check oil pressure. **7.**
6. Blue-gray exhaust smoke, oily spark plugs. Indicates oil burning in combustion chamber	a. Leaking valve stem oil seals b. Worn valve guides c. Worn or broken pistons or piston rings	a. Replace valve stem oil seals. **4.7** b. Overhaul or replace cylinder head. **4.** c. Overhaul or replace engine
7. Blue-gray smoke and/or white steam in exhaust	a. Failed cylinder head gasket (probably accompanied by low compression readings). See **3.2** b. Warped or cracked cylinder head (probably accompanied by low compression readings). See **3.2** c. Cracked cylinder block	a. Replace cylinder head gasket. **4.8** b. Resurface or replace cylinder head gasket. **4.8** c. Replace engine or short block. **5.**
8. Black exhaust smoke	a. Rich air/fuel mixture	a. See **FUEL SYSTEM**
9. Engine runs badly, pops and backfires	a. Spark plug wires installed incorrectly b. Incorrect valve timing	a. Install wires correctly. See **IGNITION** b. Check camshaft drive belt and camshaft timing. **4.2**
10. Engine will not start or run. Starter operates, engine turns over at normal speed	a. Failed ignition system b. Broken camshaft drive belt c. Incorrect camshaft timing due to jumped belt or incorrect assembly	a. See **IGNITION** b. Check cam sprocket rotation as engine turns over. Install camshaft drive belt as necessary. **4.2** c. Check camshaft timing. Replace belt and sprockets as necessary. Adjust belt tension. **4.2**

3.2 Diagnostic Testing

The tests that follow can be used to help isolate engine problems, to better understand a problem before starting expensive repairs, or just to periodically check engine condition.

Compression Test

A test of compression pressures in the individual cylinders will tell a lot about the condition of the engine without the need for taking for taking it apart. The test is relatively simple and requires a compression tester, a spark plug wrench, a screwdriver, and a jumper wire to disable the ignition system.

The battery and starter must be capable of turning the engine at normal cranking speed to achieve meaningful results. The area around the spark plugs should be clean, to avoid getting debris inside the engine when they are removed. Because engine temperature may affect compression, the most accurate results are obtained when the engine is at normal operating temperature.

To test compression:

1. With the ignition off, disconnect the coil wire from the center of the distributor cap (terminal 4) and connect it to ground on the engine block using a jumper wire. This is to disable the secondary circuit of the ignition system.
2. Disconnect one end of the duct between the air flow sensor and the throttle body to disable the fuel injection system.
3. Remove the spark plug wires from the spark plugs. Use care to pull on both the wire and the boot at the same time to avoid damage to the connectors. Label the wires so that they can be reattached to the correct spark plugs.
4. Remove the spark plugs and set them aside, in order corresponding to the cylinders from which they were removed.
5. Thread the compression tester into the first cylinder's spark plug hole, just tight enough to seal around the spark plug hole. Use care not to damage the seal on the gauge line.
6. With the transmission in neutral and the throttle held wide open, crank the engine with the starter. The gauge reading should increase with each engine revolution. Continue cranking until the gauge reading stops increasing (about 4 to 5 revolutions). Record the highest value indicated by the gauge.
7. Release the pressure, either with the gauge valve or by slowly removing the gauge, allowing the pressure to bleed off while threading it out of the spark plug hole.
8. Repeat the test for each of the other cylinders. Record the data and compare with **table c**.

Table c. Compression Pressure Specifications

	Engine code	
Compression pressure – psi (bar)	**JH**	**2H, PL**
new engines	131–174 (9.0–12.0)	145–189 (10.0–13.0)
wear limit	109 (7.5)	109 (7.5)
maximum difference between cylinders	44 (3.0)	44 (3.0)

9. Reinstall the spark plugs and the spark plug wires in their original locations. Reinstall the air duct. Reconnect the coil wire.

Low compression is evidence of poorly sealed combustion chambers. The characteristics of the test results help isolate the cause or causes. Generally, compression pressures which are relatively even but below acceptable specifications indicate worn piston rings and/or cylinder walls. Low but erratic values tend to indicate valve leakage. Dramatic differences, such as acceptable values in some cylinders and very low values in one or two cylinders are the sign of a localized failure, probably of a head gasket. There are two more tests which can further isolate the problem.

Wet Compression Test

To analyze poor compression and further identify the source of the leakage, repeat the compression test, this time with about a tablespoon of oil squirted into each cylinder. The oil will temporarily help seal between the piston rings and the cylinder wall, practically eliminating leakage past the rings for a short time. If this test yields higher compression readings than the "dry" compression test, the difference can be attributed to leakage between the piston rings and cylinder walls, due either to wear or to broken piston rings. Little or no change in compression readings indicates other leakage, probably from the valves or a failed cylinder head gasket.

Leak-down Test

The most conclusive diagnosis of low compression symptoms requires a leak-down test. Using a special tester and a supply of compressed air, each cylinder is pressurized. The rate at which the air leaks out of the cylinder, as well as the sound of the air escaping, can more accurately pinpoint the magnitude and source of the leakage. Any engine compression diagnosis which will require major disassembly should first be confirmed by the more accurate leak-down test. Because the test requires special equipment and experience, it may be desirable to have it performed by a Volkswagen dealer or other qualified repair shop.

4. CYLINDER HEAD

The cylinder head can be removed from the engine for repairs without first removing the engine from the car, and many cylinder head repairs can be accomplished without removing the cylinder head from the engine. The cylinder head cover gasket, the camshaft(s), the camshaft drive belt, the camshaft oil seal, the valve guide oil seals, and the cam followers are all accessible with the cylinder head installed.

Reconditioning the cylinder head is not overly complicated, but requires time and an extensive tool selection. If good machine shop services are not available in your area, or time is a factor, installation of a remanufactured cylinder head is an alternative. Remanufactured cylinder heads are available from an authorized Volkswagen dealer.

4.1 Cylinder Head Cover and Gasket

Gaskets that have been compressed will never seal as well if used a second time. They should be replaced any time the cover is removed. Any sign of oil leakage around or below the cover is also cause to replace the gaskets. The 8-valve engines use a two-piece gasket set. Notice that the half-round plug at the back of the head is also an important seal. The two-piece gasket set for 16-valve engines has built-in plugs.

To remove and install cylinder head cover and gaskets (8-valve engines):

1. Remove the eight 10 mm nuts and the reinforcing strips.
2. Remove the socket-head flanged nut from the camshaft drive belt upper cover.
3. Lift off the cylinder head cover and its gasket. Raise the camshaft drive belt upper cover slightly for clearance. If the gasket is stuck to the cylinder head, use a gasket removing tool to separate the gasket from the head. Remove the sealing plug from the rear of the cylinder head and remove the semi-circular gasket piece from inside the front of the cover.

> *CAUTION —*
> *Remove all of the old gasket. Work carefully if the gasket is stuck. Damage to either surface will cause leaks. Only use a gasket remover tool designed for the purpose.*

4. Installation is the reverse of removal. Make sure the tabs on the semi-circular piece correctly mate the slots on the gasket to ensure a good seal. Torque the eight nuts and the socket head flanged nut to 10 Nm (87 in. lb.).

To remove and install cylinder head cover and gasket (16-valve engines):

1. Remove the spark plug wire connectors. Remove the intake air boot from the throttle housing and remove the small rubber hose between the intake air boot and the idle air valve.
2. Disconnect the electrical connector for the charcoal canister control valve, and the large vacuum hose from the back of the upper intake manifold.
3. Remove the support bolt from the back of the upper intake manifold, then remove the five nuts and washers that join the upper intake manifold to the lower intake manifold.
4. Rotate the upper manifold up and away from the engine. Remove and label electrical connections or vacuum hoses as required. Then secure the manifold out of the way.
5. Remove the two inner bolts and the six outer bolts from the cover, and lift the cover from the cylinder head. If necessary, use a soft hammer to loosen the cover. Remove the center gasket from the cylinder head or the cover.

> *CAUTION —*
> *Remove all of the old gasket. Work carefully if the gasket is stuck. Damage to either surface will cause leaks. Only use a gasket remover tool designed for the purpose.*

6. Installation is the reverse of removal. Torque the eight cover bolts to 10 Nm (87 in. lb.). Torque the five manifold nuts and the manifold support bolt to 20 Nm (15 ft. lb.). Torque the support bolt last.

4.2 Camshaft Drive Belt

The camshaft drive belt and its related parts are shown in Fig. 4-1. The belt is installed for the life of the engine. However, to guard against unexpected failure the publisher recommends periodic inspection of the belt, as well as the additional precaution of belt replacement at 60,000 to 75,000 miles (96,000 to 120,000 km) or every 4 to 5 years.

Removal of the belt is the best way to perform a thorough inspection. For PL (16-valve) engines, a special wrench is required to adjust the camshaft drive belt tensioner. On all engines, the drive belt can be replaced without removing the drive belt sprockets.

Whenever the drive belt is installed, the camshaft and intermediate shaft timing must be adjusted.

To remove and inspect camshaft drive belt:

1. Remove the nut and the socket-head shouldered nut securing the upper camshaft drive belt cover, and remove the cover.
2. Loosen the coolant pump pulley bolts, and remove the V-belts as described in **LUBRICATION AND MAINTENANCE**. Remove the coolant pump pulley.
3. Using a socket wrench on the crankshaft vibration damper bolt, rotate the engine by hand to set the No. 1 piston at Top Dead Center (TDC), and remove the vibration damper from the crankshaft.

> *CAUTION —*
> *Rotating the crankshaft or the camshaft with the drive belt removed may cause interference which can damage pistons and valves.*

4. Remove the nuts and bolt that hold the lower camshaft drive belt cover to the coolant pump and to the front of the engine, and remove the lower cover.

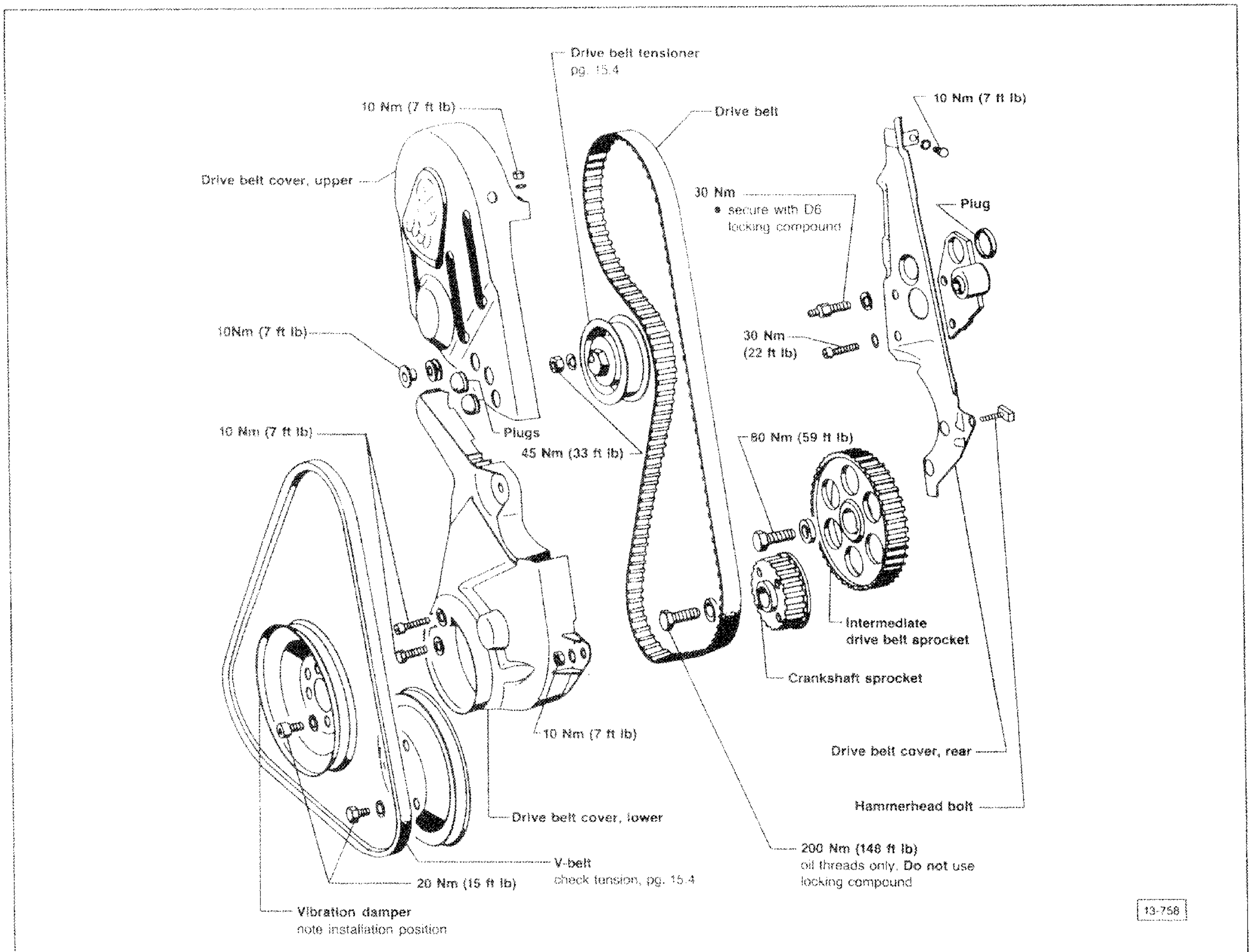


Fig. 4-1. Camshaft drive belt and cover.

5. Loosen the camshaft drive belt tensioner locknut to relieve belt tension. Then remove the drive belt by working it off the sprockets.

6. Inspect the tensioner bearing and the belt. Spin the bearing to check that it runs smoothly. Inspect the drive belt for visible damage such as exposed threads and missing teeth. Damaged components should be replaced.

NOTE —
Failure of the sealed tensioner bearing is a possibility. On a high-mileage engine, consider replacing the tensioner when replacing the belt.

To install and adjust camshaft drive belt:

1. Use a socket on the center bolt to rotate the camshaft sprocket by hand until the timing marks are aligned. The camshaft timing marks for PL (16-valve) engines are shown in Fig. 4-2. The camshaft timing marks for the 8-valve engines are shown in Fig. 4-3.

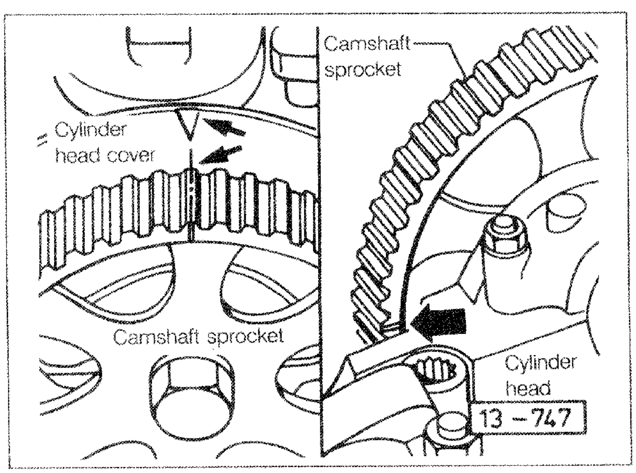


Fig. 4-2. Camshaft timing marks on PL (16-valve) engine with cylinder head cover on (left) and off (right).

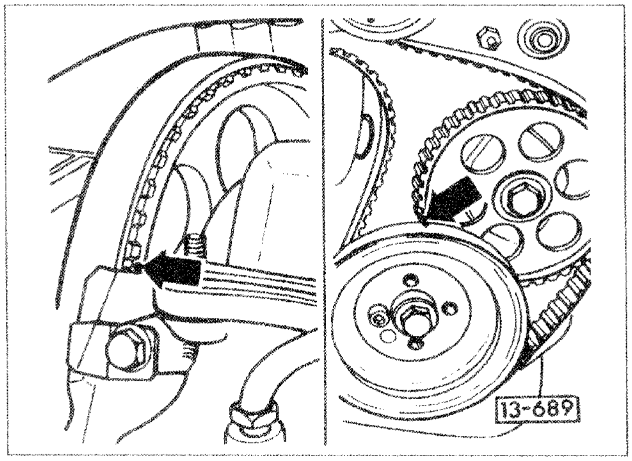


Fig. 4-3. Drive belt timing marks (arrows) for camshaft and intermediate shaft on 8-valve engines.

2. Loosely install the camshaft drive belt over the crankshaft and intermediate shaft sprockets. Then temporarily install the crankshaft vibration damper onto the crankshaft.

3. Rotate the crankshaft and the intermediate shaft by hand until the timing marks line up. The crankshaft and the intermediate shaft timing marks for 8-valve engines are shown above in Fig. 4-3. The crankshaft timing marks for PL (16-valve) engines are shown in Fig. 4-4.

NOTE —
On 8-valve engines only, the intermediate shaft timing is included because it drives the ignition distributor and determines basic ignition timing.

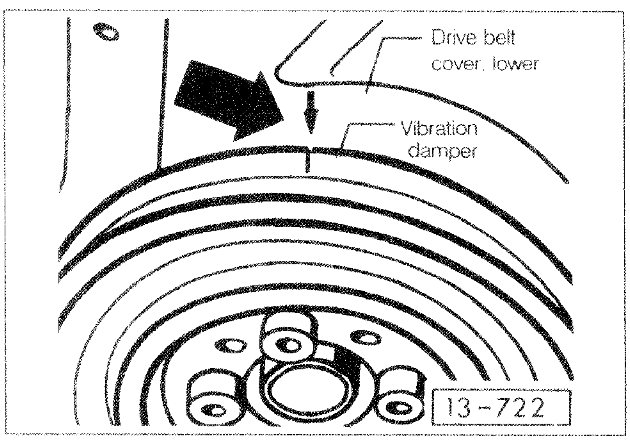


Fig. 4-4. Crankshaft timing marks on vibration damper and lower drive belt cover on PL (16-valve) engine.

4. Install the camshaft drive belt. Start on the crankshaft and intermediate shaft sprockets. Install the belt so that it is as tight as possible between the crankshaft and the intermediate shaft sprockets, and between the intermediate shaft and the camshaft sprockets.

5. Adjust belt tension by turning the tensioner clockwise. The direction is important to avoid contact with the belt cover. Lock the tensioner in position with the locknut. Check the tension by twisting the belt, as shown in Fig. 4-5. On 8-valve engines, you should be able to twist the belt no more than 90°. On PL (16-valve) engines, you should be able to twist the belt no more than 45°.

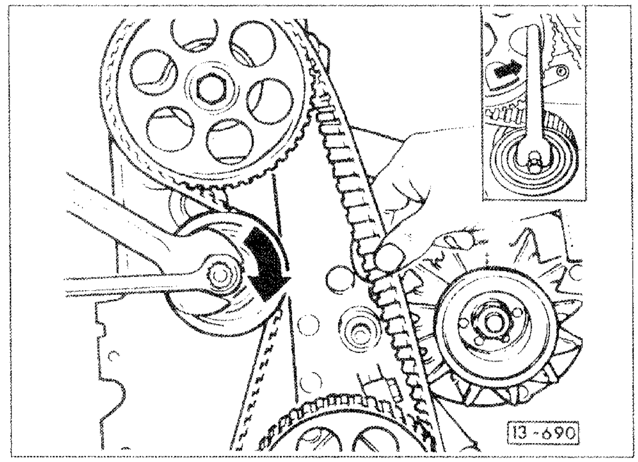


Fig. 4-5. Camshaft drive belt tension being adjusted. Check tension halfway between the camshaft and the intermediate shaft sprockets. For later style tensioner use spanner (inset) to engage holes in tensioner.

NOTE —
Only the later-style tensioner is available as a replacement part.

6. Torque the tensioner locknut to 45 Nm (33 ft. lb.). Turn the crankshaft two full revolutions and recheck the tension and the timing marks.

NOTE —
Slight movement of the sprockets and marks is to be expected as belt tension is adjusted. Small movement is OK. Keep in mind that the smallest possible increment of adjustment is one whole tooth of the belt or sprocket.

7. The remaining installation is the reverse of removal. Remove the vibration damper to install the lower drive belt cover. On PL (16-valve) engines, torque the upper belt cover bolt to 6 Nm (53 in. lb.). Torque 8-valve belt cover nuts and bolts to 10 Nm (87 in. lb.). Torque the coolant pump pulley bolts and the crankshaft vibration damper bolts to 20 Nm (15 ft. lb.). Install the V-belts as described in **LUBRICATION AND MAINTENANCE**.

4.3 Camshaft Oil Seal

To save disassembly, the camshaft oil seal can be removed using a seal extractor such as Volkswagen special tool no. 2085, shown in Fig. 4-6. The procedure that follows involves more disassembly and does not require special tools.

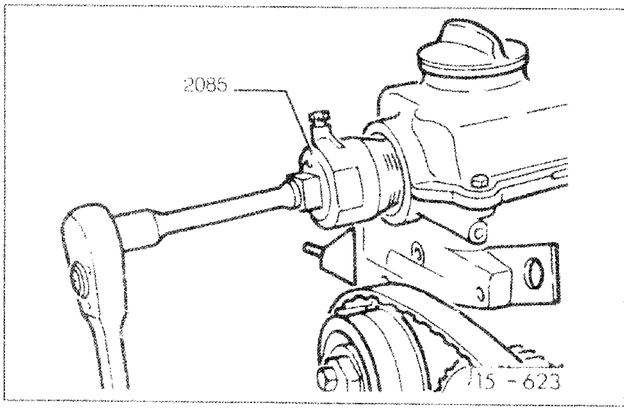


Fig. 4-6. Oil seal extractor being used to remove camshaft oil seal.

To replace camshaft oil seal:

1. Remove the camshaft drive belt as described in **4.2 Camshaft Drive Belt**.

2. Remove the cylinder head cover as described in **4.1 Cylinder Head Cover and Gasket**.

3. Remove the camshaft sprocket. Loosen the center sprocket bolt $^1/_2$ turn and, using a soft-faced hammer, tap the sprocket loose. On 8-valve engines, take care also to remove the woodruff key from the shaft.

4. On PL (16-valve) engines only, remove the ignition distributor from the cylinder head, as described in **IGNITION**.

5. Loosen the camshaft bearing caps in exact order as described in **4.5 Removing and Installing Camshaft**, so that the camshaft is loose and free to move slightly.

CAUTION —

Failure to loosen and tighten the bearing caps in the order prescribed may damage the bearing caps or warp the camshaft.

6. Lift slightly on the sprocket end of the camshaft and remove the oil seal. A small screwdriver may help to pry it loose. On PL (16-valve) engines, use care not to disturb the camshaft drive chain at the other end of the cylinder head.

7. Tighten the camshaft bearing caps in exact order as described in **4.5 Removing and Installing Camshaft**.

8. Install the cylinder head cover, with a new gasket, as described in **4.1 Cylinder Head Cover and Gasket**. On PL (16-valve) engines, first check to see that the markings on the camshaft chain sprockets are correctly aligned. See **4.5 Removing and Installing Camshaft**.

9. Lightly oil the seal lip and camshaft's sealing surface. Fit the seal into position, and carefully drive it into place until it is flush with the front of the cylinder head. Use care not to distort the seal as it is installed. For best results, use a seal driver such as Volkswagen special tool no. 10-203, shown in Fig. 4-7.

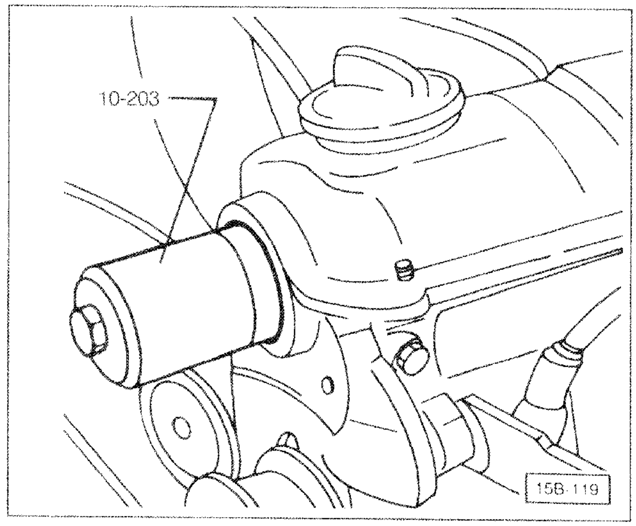


Fig. 4-7. Camshaft oil seal being installed.

10. Reinstall the camshaft drive belt sprocket. On 8-valve engines, the woodruff key should be a tight fit. If not, replace it. Torque the sprocket bolt to 80 Nm (59 ft. lb.). On PL (16-valve) engines, the curved side of the integral key faces the engine. Torque the sprocket bolt to 65 Nm (48 ft. lb.) on PL (16-valve) engines.

11. Reinstall the camshaft drive belt as described in **4.2 Camshaft Drive Belt**.

4.4 Valve Adjustment

(8-valve engine code JH, 1985-1987 only)

1985, 1986 and 1987 8-valve JH engines have mechanical cam followers (valve lifters) that require periodic valve lash or valve clearance adjustment. The 16-valve engines and the later 8-valve engines do not. For more information on those engines see **4.6 Hydraulic Cam Followers**.

The **LUBRICATION AND MAINTENANCE** section specifies particular valve adjustment intervals. Valve clearance should also be rechecked 1000 miles (1500 km) after any repairs to the cylinder head.

Valve clearance is determined by the thickness of an adjusting disc on the top of each cam follower. Clearance is adjusted by replacing the disc with one of a different thickness. Fig. 4-8 shows a typical cam lobe, cam follower and adjusting disc.

The discs are available in a range of thickness from 3.30 to 4.25 mm (0.130 to 0.167 in.) in increments of 0.05 mm (about 0.002 in.). **Table d** lists thicknesses and part numbers of the available adjusting discs. The thickness of each disc is etched on its underside. The procedure which follows requires two Volkswagen special tools. These are no. 2078, used to compress the valve spring, and no. 10-208, used to replace the adjusting disc.

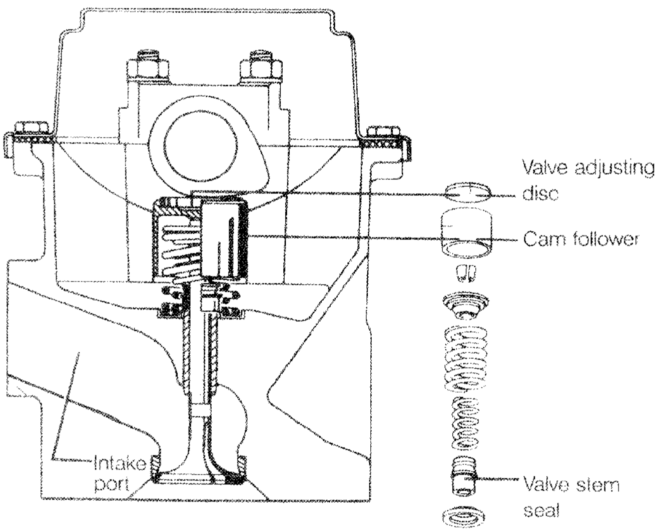


Fig. 4-8. Cross-section of cylinder head showing cam lobe and cam follower. Adjusting disc fits in recess in follower.

Table d. Valve Adjusting Discs

Thickness mm (in.)	Part No.
3.30 (.1299)	.056 109 561
3.35 (.1319)	.056 109 562
3.40 (.1339)	.056 109 563
3.45 (.1358)	.056 109 564
3.50 (.1378)	.056 109 565
3.55 (.1398)	.056 109 566*
3.60 (.1417)	.056 109 567*
3.65 (.1437)	.056 109 568*
3.70 (.1457)	.056 109 569*
3.75 (.1476)	.056 109 570*
3.80 (.1496)	.056 109 571*
3.85 (.1516)	.056 109 572
3.90 (.1535)	.056 109 573
3.95 (.1555)	.056 109 574
4.00 (.1575)	.056 109 575
4.05 (.1594)	.056 109 576
4.10 (.1614)	.056 109 577
4.15 (.1634)	.056 109 578
4.20 (.1654)	.056 109 579
4.25 (.1673)	.056 109 580
* **most commonly used adjusting discs**	

Valve clearance should be measured with the engine warm. Coolant temperature should be at least 35°C (95°F) or the engine should be at least warm to the touch. The clearance changes with engine temperature, so more precise adjustment is possible when the engine is warm. Because it may be necessary to adjust the valves when the engine is cold, such as after cylinder head repairs, specifications for both hot and cold engines are given.

To adjust valve clearance:

1. Remove the cylinder head cover, as described in **4.1 Cylinder Head Cover and Gasket**.

2. Using a socket wrench on the crankshaft vibration damper bolt, hand-turn the crankshaft clockwise until both the No. 1 cylinder's cam lobes are pointing approximately upward (valves fully closed).

NOTE —

No. 1 cylinder is the one closest to the camshaft drive belt.

3. Measure the valve clearances. Insert feeler gauges between the cam lobe and the adjusting disc on the top of the cam follower, as shown in Fig. 4-9. Compare the measured clearance values with the specifications given in **Table e**.

Table e. Valve Clearance Specifications (1985–1987, engine code JH)

engine warm	
intake	0.20–0.30 mm (.008–.012 in.)
exhaust	0.40–0.50 mm (.016–.020 in.)
engine cold	
intake	0.15–0.25 mm (.006–.010 in.)
exhaust	0.35–0.45 mm (.014–.018 in.)

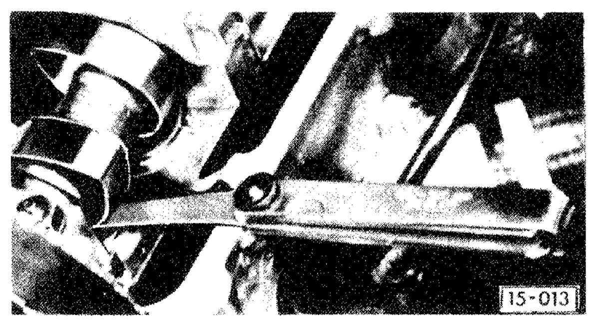


Fig. 4-9. Valve clearance being measured. Both valves are closed. Both cam lobes are pointing up, away from cam followers. Feeler gauge is inserted between cam lobe and adjusting disc on top of cam follower.

4. If valve clearance is not within the specifications, replace the adjusting disc. Depress the cam follower and lift out the disc as shown in Fig. 4-10.

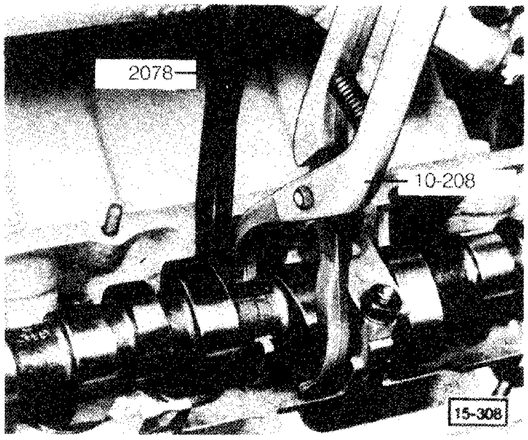


Fig. 4-10. Adjusting disc being removed from cylinder head. Volkswagen tool no. 2078 is used to depress cam followers. Tool no. 10-208 is used to remove adjusting disc.

NOTE —
To calculate the correct adjusting disc thickness, first determine the thickness of the old disc. Read the thickness in millimeters that is etched on its underside, or measure it with a micrometer. The change in thickness required is the same as the difference between the measured clearance and the specification given in **table e** above. A thicker disc will reduce valve clearance. A thinner disc will increase valve clearance.

5. Install the correct adjusting disc. Lightly oil the contact surfaces. Depress the cam follower and install the disc the same way it was removed, as shown in Fig. 4-10, above. The etched disc thickness numbers should face down.

6. Using a socket wrench, rotate the crankshaft clockwise by hand for two complete turns, to ensure that the adjusting disc is properly seated, and recheck the clearance.

7. Rotate the crankshaft by hand clockwise 180° (1/2 turn) and repeat the procedure on the valves for the No. 3 cylinder. Turn another 180° to adjust the No. 4 cylinder, and another 180° to adjust the No. 2 cylinder.

8. Install the cylinder head cover with new gaskets, as described in **4.1 Cylinder Head Cover and Gasket**.

4.5 Removing and Installing Camshaft

The camshaft can be removed without removing the cylinder head. Removing the camshaft allows access to the cam followers, the valve springs, and the valve stem oil seals. When removed, the camshaft should be checked for wear and other visible damage as described in **4.9 Disassembly, Assembly, and Reconditioning**.

To remove and install camshaft (8-valve engines):

1. Turn the engine over by hand until the No. 1 cylinder is at Top Dead Center (TDC), and remove the camshaft drive belt from the camshaft sprocket as described in **4.2 Camshaft Drive Belt**.

2. Remove the cylinder head cover and gasket as described in **4.1 Cylinder Head Cover and Gasket**.

3. Loosen the nuts on each of the bearing caps, a little at a time so that valve spring tension is relieved evenly. Then, remove the bearing caps.

4. To install, place the bearing caps in position as shown in Fig. 4-11. Install the washers and nuts, gradually tightening all the nuts until the camshaft is drawn down fully and evenly into the bearing saddles. Torque all the nuts to 20 Nm (15 ft. lb.).

CAUTION —
To avoid uneven and accelerated wear, the bearing caps must be reinstalled in their exact original positions. Although each bearing cap is numbered, the numbers are not always marked in the same place on the cap.

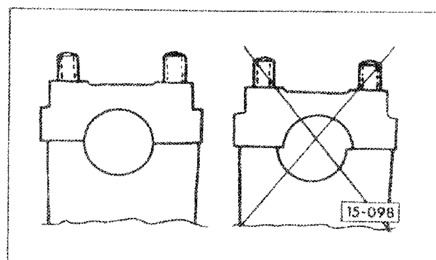


Fig. 4-11. Cross-section of camshaft bearing, showing cap installed correctly (left) and incorrectly (right).

5. Reinstall the camshaft drive belt as described in **4.2 Camshaft Drive Belt**. Reinstall the cylinder head cover with a new gasket, as described in **4.1 Cylinder Head Cover and Gasket**.

To remove and install camshafts (16-valve engines):

1. Turn the engine over by hand until the No. 1 cylinder is at Top Dead Center (TDC), and remove the camshaft drive belt from the camshaft sprocket as described in **4.2 Camshaft Drive Belt**.

2. Remove the cylinder head cover and gasket as described in **4.1 Cylinder Head Cover and Gasket**.

3. Remove the ignition distributor from the rear of the cylinder head as described in **IGNITION**.

4. Remove bearing caps 1, 3, 5 and 7, as illustrated in Fig. 4-12. Also remove the three end caps at this time.

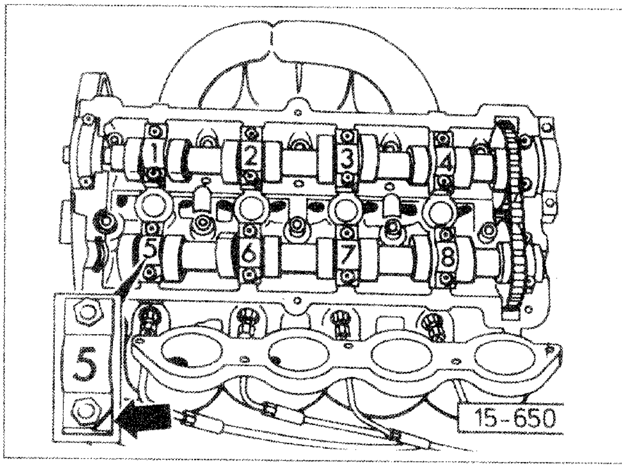


Fig. 4-12. Identification of 16-valve engine camshaft bearing caps. Notice also three camshaft bearing end caps (not numbered). Inset shows proper installation (beveled corners face intake side).

5. Gradually and evenly loosen each of the eight nuts from bearing caps 2, 4, 6 and 8, a little at a time so that valve spring tension and cam chain tension are relieved evenly.

CAUTION —
Removal of camshaft bearing caps by any other method may damage the camshafts, the camshaft chain, or the bearing caps.

6. Installation is the reverse of removal. Install the camshafts and the drive chain so that the markings on the chain sprockets face each other and align with the top of the cylinder head, as shown in Fig. 4-13.

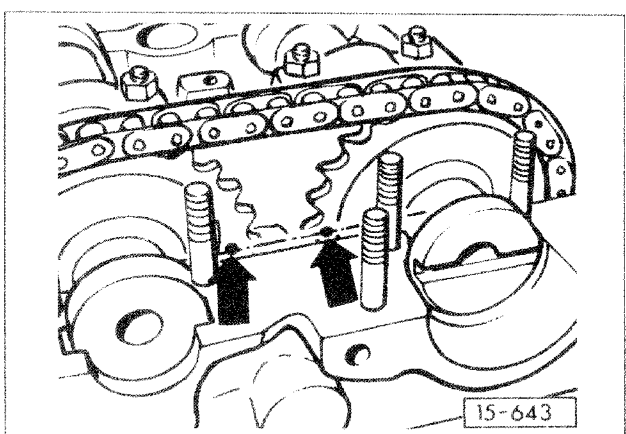


Fig. 4-13. Camshaft drive chain sprockets correctly aligned in 16-valve cylinder head.

7. Torque the bearing cap nuts to 15 Nm (11 ft. lb.). Reinstall the cylinder head cover with a new gasket, as described in **4.1 Cylinder Head Cover and Gasket**.

8. Install the camshaft drive belt and adjust the camshaft timing as described in **4.2 Camshaft Drive Belt**.

9. Install the ignition distributor and adjust ignition timing as described in **IGNITION**.

4.6 Hydraulic Cam Followers

Hydraulic cam followers (valve lifters) maintain proper valve clearance and do not require adjustment. They are installed on 8-valve engines starting with 1988 models, and on all PL (16-valve) engines. The cylinder head cover label shown in Fig. 4-14 indicates an engine equipped with hydraulic cam followers.

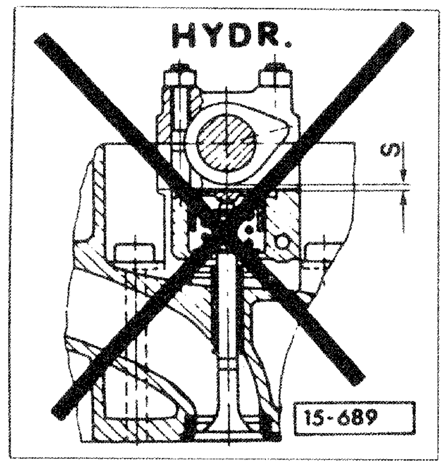


Fig. 4-14. Label on cylinder head cover identifies engines with hydraulic cam followers that maintain proper valve clearance and do not require adjustment.

Hydraulic cam followers are pumped up by engine oil pressure. They expand as necessary to close the gap between the valve stem and the camshaft lobe. Oil pressure inside keeps the follower at the proper height. Excess oil pressure is allowed to bleed off through a small orifice.

Some valve noise at start-up is normal, especially when the engine has not run for some time and the hydraulic cam followers have bled down from lack of oil pressure. Allow a minute or so with the engine running for the lubrication system to properly pump up the cam followers. Before checking noisy cam followers, make sure that the engine oil level is adequate.

CAUTION —
After installing new cam followers, the engine should not be started for at least 30 minutes. New cam followers are at full height and must be allowed to bleed down to their proper height. Failure to do this may cause valve or piston damage.

Checking Hydraulic Cam Followers

Cam followers should only be checked when the engine is fully warm. Run the engine, preferably drive the car, for 20 to 30 minutes. Shut the engine off and proceed immediately while the engine is still warm.

To check the hydraulic cam followers, remove the cylinder head cover as described in **4.1 Cylinder Head Cover and Gasket**. Turn the engine by hand until both the camshaft lobes of one cylinder are pointing approximately up. Using a non-metal object such as wood or plastic, lightly apply pressure to the top of the cam follower, as shown in Fig. 4-15.

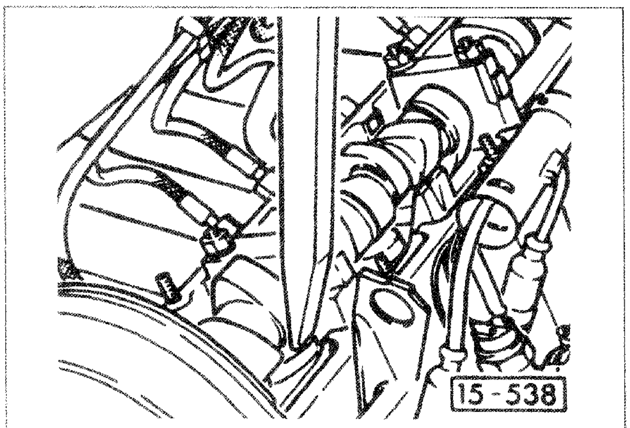


Fig. 4-15. Hydraulic cam follower being checked with a non-metal object.

If the follower can be pushed down more than 0.1 mm (.004 in.) with hand pressure, it is faulty and should be replaced. Repeat the test for the other cylinders. Replace a faulty cam follower by removing the camshaft, as described in **4.5 Removing and Installing Camshaft**, and pulling the follower from the cylinder head. Hydraulic cam followers are non-adjustable and non-repairable, and are replaced only as complete assemblies.

> NOTE —
> Place removed hydraulic cam followers on a clean surface with the camshaft contact surface facing down, to prevent bleed down, and cover them.

4.7 Valve Stem Oil Seals

The sign of faulty valve stem oil seals are excessive oil consumption and blue-gray oil smoke from the exhaust after starting and during sudden deceleration. For more information on excessive oil consumption and smoking, see **3. Troubleshooting**.

Replacement of the valve stem oil seals requires that the camshaft(s), the cam followers, and the valve springs be removed. Valve springs can be removed while the cylinder head is installed with the use of compressed air to hold the valves closed, or with the cylinder head removed. Either method requires the use of a valve spring compressor. An additional special tool is highly recommended for installation of the new seals. If the special tools are not available, an alternative is to remove and partially dismantle the cylinder head, following the procedures in this section, and have the valve spring and valve stem oil seal work performed by an authorized Volkswagen dealer or other qualified repair shop.

To replace valve stem oil seals:

1. If working with the cylinder head installed, remove the cylinder head cover, as described in **4.1 Cylinder Head Cover and Gasket**. Otherwise, remove the cylinder head as described below in **4.8 Removing and Installing Cylinder Head**.
2. Remove the camshaft, as described in **4.5 Removing and Installing Camshaft**, and remove the cam followers. Keep all parts so that they can be reinstalled in their original locations.
3. Remove the valve springs as shown in Fig. 4-16. The valve spring compressors shown are Volkswagen special tools, designed specifically for use on Volkswagen engines.

> NOTE —
> To support the valves with compressed air and remove the valve springs with the cylinder head installed, install an air hose adapter in the spark plug hole. Position the piston for the cylinder being worked on at top dead center (TDC). Apply a constant air pressure of at least 6.0 bar (87 psi).

4. Remove the valve stem oil seals. Volkswagen recommends the use of a slide hammer, special tool no. 3047A, to remove the seals without damage to the valve stems.
5. Install each new valve stem oil seal by temporarily fitting the protective plastic cap over the valve stem end, and then hand-pressing the seal onto the valve stem as shown in Fig. 4-17. Remove the protective cap for use on the next valve.

> NOTE —
> The protective cap protects the seal from being damaged by the keeper grooves in the valve stem. In the absence of a protective cap, temporarily wrap the valve stem with plastic tape.

> NOTE —
> The use of an inexpensive hand-held tool will guard against damaging the new seals on installation. Such a tool is Volkswagen special tool no. US5042 (order no. TU5 042 000 15 ZEL).

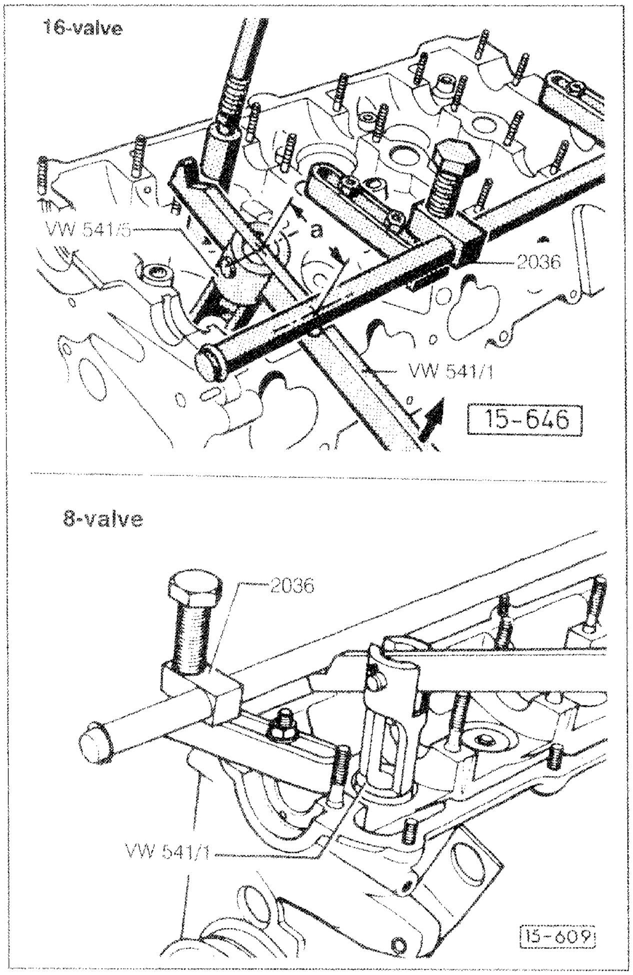


Fig. 4-16. Valve spring compressor being used to remove valve springs from 16-valve engine (top view) and 8-valve engine (bottom view). Numbers identify Volkswagen special tools. For 16-valve engines, notch the handle of special tool VW 541/1 as shown to keep it from slipping. Dimension **a** to notch is 50 mm ($^{31}/_{32}$ in.).

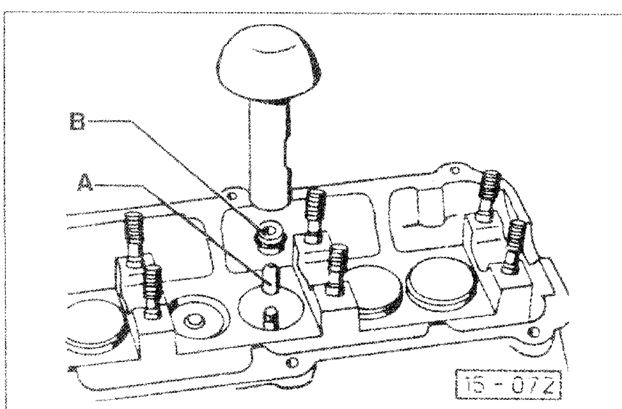


Fig. 4-17. Protective cap **A**, new valve stem oil seal **B**, and installing tool.

6. Reinstall the valve springs. The closely spaced coils of the outer valve springs face down, toward the lower spring seats.

7. Repeat the procedure for each pair of valves. Assembly is the reverse of disassembly. See **4.5 Removing and Installing Camshaft**, **4.8 Removing and Installing Cylinder Head**, and **4.1 Cylinder Head Cover and Gasket**. Torque spark plugs to 20 Nm (15 ft. lb.).

4.8 Removing and Installing Cylinder Head

The cylinder head can be removed without removing the engine from the vehicle, and without removing the camshaft(s).

If a failed head gasket or warped head is suspected, a compression test, as described in **3.2 Diagnostic Testing**, may aid diagnosis and should be performed before the cylinder head is removed. A failed head gasket may be caused by a warped cylinder head. When replacing a failed head gasket, always check the cylinder head for straightness. Specifications for maximum permissible warpage can be found in **4.9 Disassembly, Assembly, and Reconditioning**.

To remove cylinder head:

1. Disconnect the battery negative (–) terminal from the battery. Disconnect the ground strap from the cylinder head or intake manifold.

2. Disconnect the intake air duct from the throttle body on the intake manifold.

3. Drain the coolant as described in **COOLING SYSTEM**.

4. Remove the camshaft drive belt as described in **4.2 Camshaft Drive Belt**.

5. Pull out the fuel injectors and remove the cold start valve from the intake manifold, leaving the fuel lines attached. Cover the injectors and the cold start valve to keep them clean, and plug the openings. Disconnect the throttle cable and throttle switches from the throttle body. Disconnect and label the hoses and wires connected to the throttle body and the intake manifold. For more information on fuel injection components, see **FUEL SYSTEM**.

6. Disconnect the exhaust pipe from the exhaust manifold, as described in **EXHAUST SYSTEM AND EMISSION CONTROLS**.

7. Loosen the alternator mounting bolts and remove the upper alternator mounting bracket.

8. Disconnect the coolant hoses from the outlet on the front of the cylinder head and from the heater outlet on the left (driver's side) end of the cylinder head. Disconnect the wires from the temperature and oil pressure sending units, and label them.

9. Disconnect the spark plug connectors from the spark plugs. On PL (16-valve) engines, also disconnect the high voltage lead from the coil, and then remove the distributor as described in **IGNITION**.

10. Remove the cylinder head cover, and, on PL (16-valve engines), the upper intake manifold, as described in **4.1 Cylinder Head Cover and Gasket**.

11. Gradually and evenly loosen the cylinder head bolts, beginning with the outer bolts and working toward the center, and remove the cylinder head. If the head is stuck, use a soft-faced mallet, or pry gently with a wooden stick to loosen it.

To install cylinder head:

1. Clean the cylinder head and the gasket surface of the cylinder block. Clean the threads of the head bolts and bolt holes with thread chasers, and remove all foreign matter from the holes. Avoid letting debris into the cylinders or oil passages in the cylinder block.

> *CAUTION —*
> *Do not use a metal scraper or wire brush to clean the aluminum cylinder head. These may damage the cylinder head. Instead, use a solvent to soften carbon deposits and old sealing materials. If necessary, use a wooden or plastic scraper.*

2. Check the gasket surfaces of the cylinder head and the cylinder block for warpage. See **4.9 Disassembly, Assembly, and Reconditioning**.

3. Place a new cylinder head gasket on the surface of the cylinder block. The word "OBEN", found imprinted on the gasket near the part number, should face up.

> *CAUTION —*
> *Cylinder head gaskets will give a reliable seal only once. Always use a new gasket that has not previously been compressed by tightening the cylinder head bolts.*

4. Place the cylinder head in position on the cylinder block. Loosely install all the head bolts, with the special wa ers, then thread them in until they are finger-tight.

> NOTE —
> To be sure of proper alignment of the installed cylinder head, place two 200 mm long, 9 mm diameter (8 in. x 3/8 in.) wooden dowels into two of the outermost head bolt holes to hold the gasket and serve as guides as the cylinder head is installed. Thread in several bolts, then remove the dowels and install the remaining bolts.

5. Torque the bolts to 40 Nm (30 ft. lb.), in the sequence shown in Fig. 4-18. Repeat the sequence, torquing the bolts to 60 Nm (43 ft. lb.). Repeat the sequence a third time, tightening each bolt an additional 1/2 turn. Alternatively, this last step may be done as two 1/4 turns.

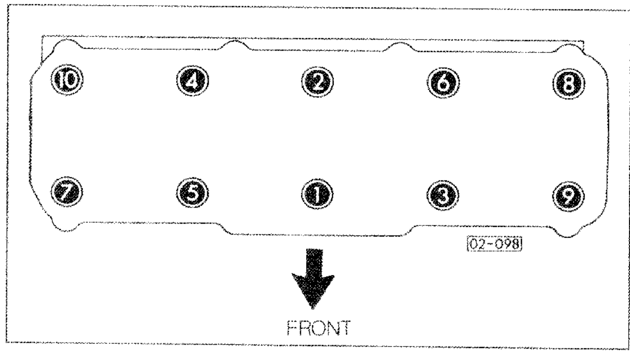


Fig. 4-18. Cylinder head bolt tightening sequence. 8-valve engine shown. 16-valve sequence is the same.

6. Installation of the remaining parts is the reverse of removal. See **4.2 Camshaft Drive Belt**, **4.1 Cylinder Head Cover and Gasket**, **FUEL SYSTEM**, and **EXHAUST SYSTEM AND EMISSION CONTROLS**. For installation of the ignition distributor on PL (16-valve) engines, see **IGNITION**.

7. Refill the cooling system as described in **COOLING SYSTEM**.

4.9 Disassembly, Assembly, and Reconditioning

Disassembly, assembly, and reconditioning procedures for the cylinder heads used on the 1.8 liter Volkswagen engines covered in this manual are similar to those for most other modern 4-cylinder, water-cooled engines. For anyone with the proper tools and equipment and basic experience in cylinder head reconditioning, this section provides the specifications and special reconditioning information necessary to repair these Volkswagen engines.

Those who are without the necessary tools, or unfamiliar with reconditioning procedures, will still find this information to be important to the qualified machinist who does the work. If machine shop services are not readily available, one alternative is to install a Volkswagen remanufactured cylinder head, available from an authorized Volkswagen dealer parts department.

> *CAUTION —*
> *Volkswagen advises that engine coolant must not be reused when replacing the cylinder head, the cylinder head gasket or the engine.*

Cylinder Head Assembly

(8-valve engines)

Fig. 4-19 shows the 8-valve cylinder head and valve train detail. Later engines with hydraulic cam followers are similar.

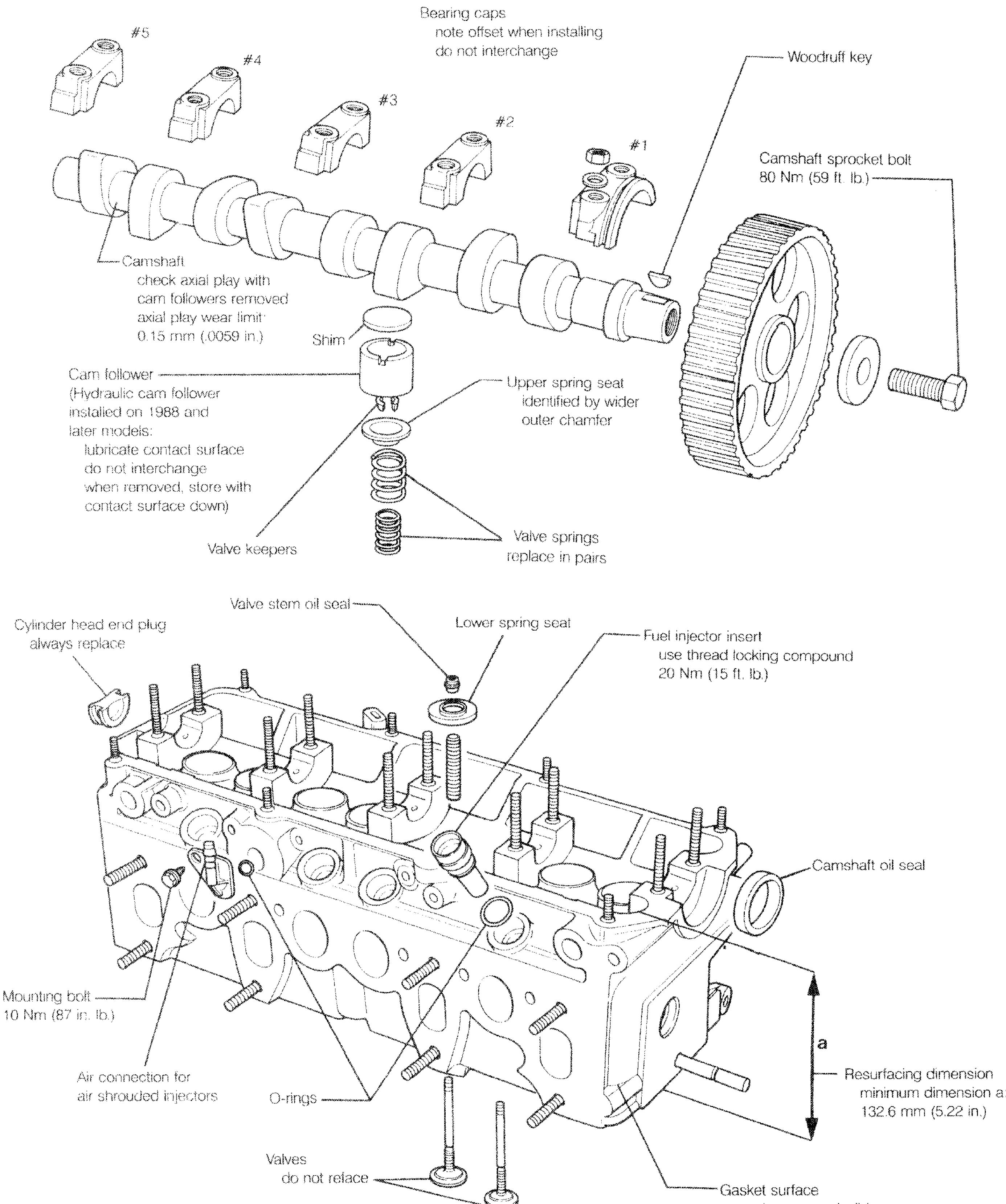


Fig. 4-19. Exploded view of 8-valve cylinder head. Look for small, fine cracks between valve seats and spark plug threads. Heads with cracks can be reused provided cracks are not more than 0.5 mm (0.02 in.) wide, and do not extend into more than the first few spark plug threads.

Cylinder Head Assembly
(16-valve engine, code PL)

Fig. 4-20 shows the cylinder head and valve train assembly used on PL (16-valve) engines.

Camshaft and Cam Followers

To measure camshaft axial play, relieve the tension on the cam lobes by first removing the cam followers. Store hydraulic cam followers with the camshaft contact surface face down. Lubricate the cam follower's contact surfaces before installing.

Do not interchange camshaft bearing caps or cam followers. Note the bearing cap offset when installing. On PL (16-valve) engines, the beveled corners on the bearing caps face the intake side of the cylinder head. On PL (16-valve) engines, align the camshaft chain sprockets as shown in Fig. 4-21.

> *CAUTION* —
> *After installing new hydraulic cam followers, the engine should not be started for at least 30 minutes. New cam followers are at full height and must be allowed to bleed down to their proper height. Failure to do this may cause valve or piston damage.*

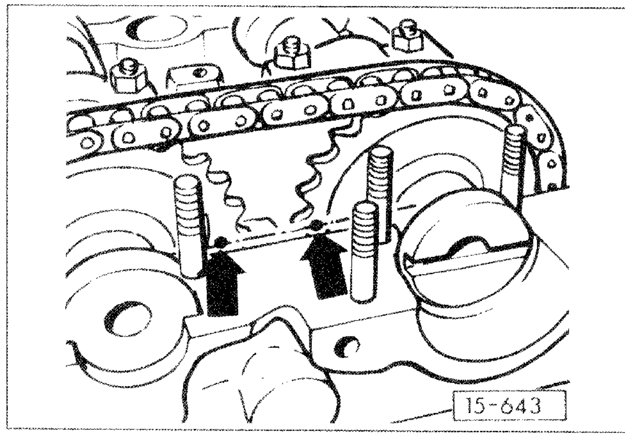


Fig. 4-21. Camshaft chain sprocket timing marks on PL (16-valve) engine. Marks should align with each other and cylinder head top surface.

Valves and Valve Springs

All engine valves should be hand-lapped only. Valve specifications are listed in **table f**.

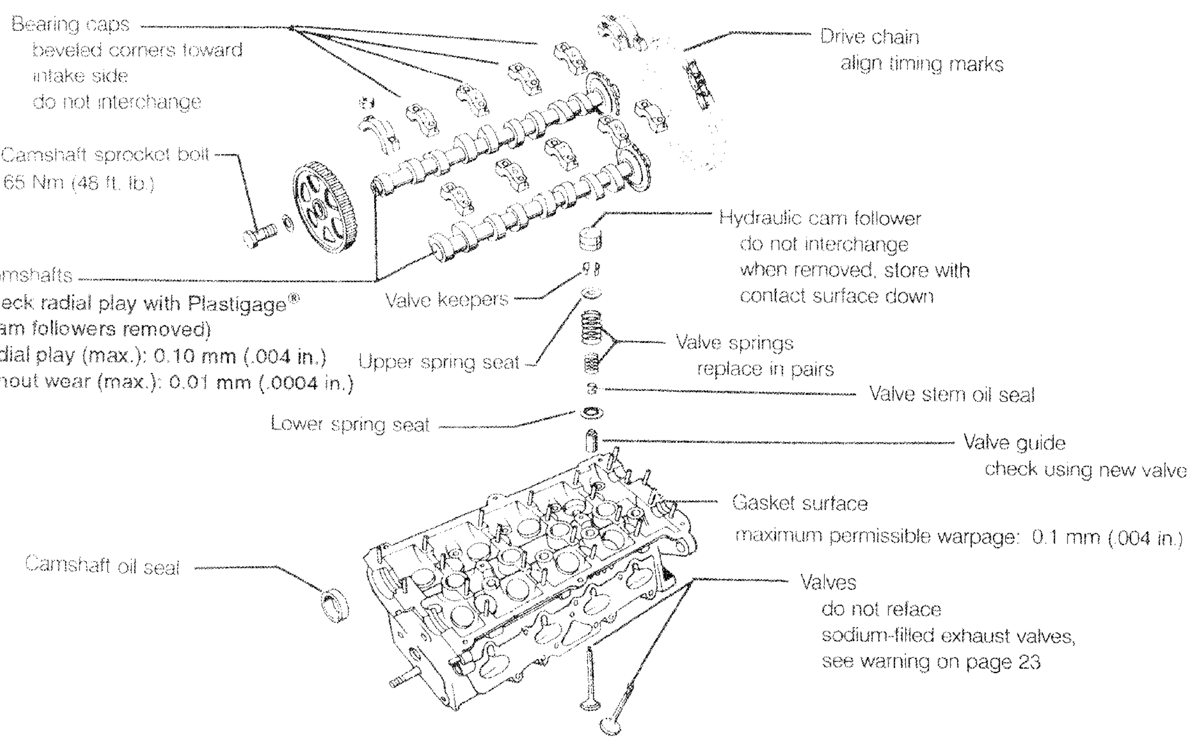
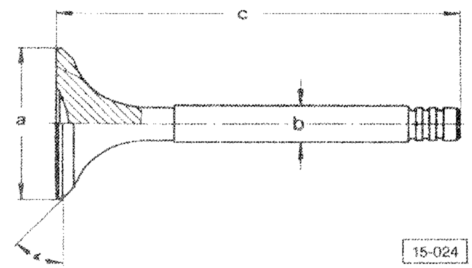


Fig. 4-20. Exploded view of 16-valve cylinder head. Cylinder heads with small, fine cracks between valve seats and plug threads are usable provided the cracks are not more than 0.5 mm (.02 in.) wide and do not extend into more than the first few spark plug threads.

> *CAUTION* —
> *16-valve cylinder heads must not be resurfaced.*

Table f. Valve Specifications



Engine code	JH (1985-1987)	JH (from 1988)	2H (from 1990)	PL (16-valve)
Cam followers	mechanical	hydraulic		
Head diameter (a)				
intake	40.0 mm (1.58 in.)			32.0 mm (1.34 in.)
exhaust	33.0 mm (1.30 in.)			28.0 mm (1.10 in.)
Stem diameter (b)				
intake	7.97 mm (0.314 in.)			6.97 mm (0.274 in.)
exhaust	7.95 mm (0.313 in.)			6.94 mm (0.273 in.)
Length (c)				
intake	98.7 mm (3.89 in.)	91.0 mm (3.58 in.)		95.5 mm (3.76 in.)
exhaust	98.5 mm (3.88 in.)	90.8 mm (3.56 in.)		98.2 mm (3.87 in.)
Valve face angle (d)				
intake	45°			
exhaust	45°			

Exhaust valves used in PL (16-valve) engines are sodium-filled. Disposal of used valves is dangerous and requires special care to avoid personal injury.

WARNING —

Dispose of 16-valve engine sodium-filled exhaust valves properly. By hand, cut off the valve stem near the head of each valve. Use only a hack saw. Do not use a power saw. Do not let water contact the valve while cutting. Throw the valve parts (no more than 10 valves at a time) into a bucket of water and stand clear. Discard the valves when the reaction has ceased.

Valve Guides

Special tools and a press are required to replace valve guides. Check valve guide wear with a new valve, as shown in Fig. 4-22. Inspect the valve seats to ensure that the cylinder head can be reconditioned before installing new valve guides.

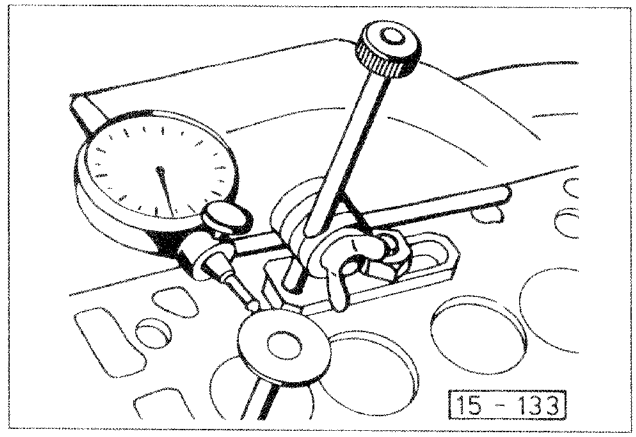


Fig. 4-22. Valve guide wear being checked with a new valve. Insert valve until stem end is flush with end of guide. Maximum play for all intake valves is 1.0 mm (.039 in.). Maximum play for exhaust valves is 1.3 mm (.051 in.).

Valve guides are pressed out from the combustion chamber side of the cylinder head. Lubricate new valve guides with oil and press them in from the camshaft side. For 8-valve engines, remove and install the valve guides using a drift, Volkswagen special tool 10-206 (order no. T10 206 000 15 ZEL).

On PL (16-valve) engines, remove and install guides with Volkswagen special tool no. 3121 (order no. T03 121 000 15 ZEL), and ream guides with Volkswagen special tool no. 3120 (order no. T03 120 000 15 ZEL). To remove and install intake valve guides, support the cylinder head at an angle as shown in Fig. 4-23, using Volkswagen special tool no. 3123 (order no. T03 123 000 15 ZEL).

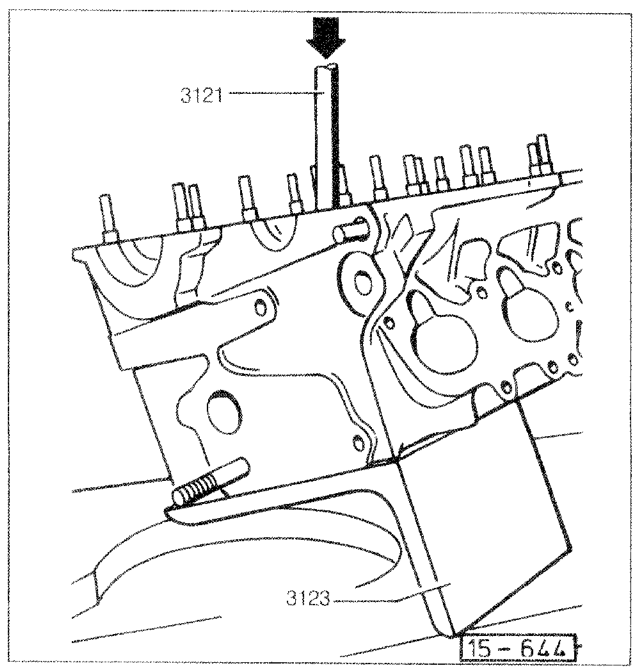


Fig. 4-23. Angle plate (Volkswagen special tool no. 3123) used to support 16-valve cylinder head when removing and installing intake valve guides.

Valve Seats

When resurfacing valve seats on engines with hydraulic cam followers, there is a limit to the amount of material which can be removed. If too much material is removed, the final assembly will leave too little space for the hydraulic cam follower to function correctly. The maximum refacing dimension, the maximum amount of material that can be removed from the valve seat, is calculated from the measurement shown in Fig. 4-24.

Measure dimension **a**, and subtract the minimum dimension, as given in **Table g**. The difference is the maximum amount of material that can be removed from the valve seat.

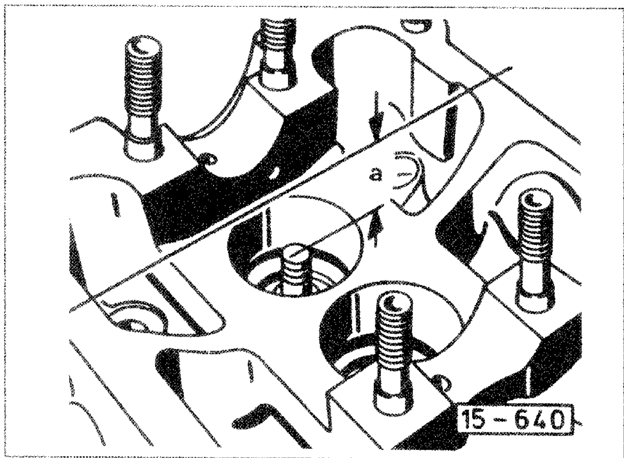


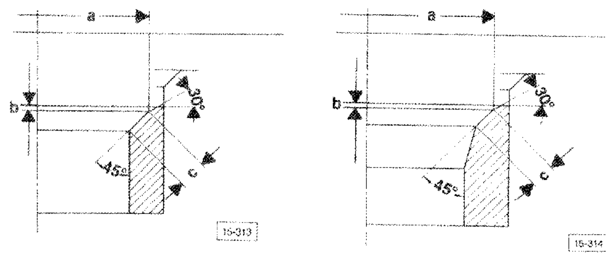
Fig. 4-24. Top view of cylinder head. Dimension **a**, distance between top of valve stem and upper surface of cylinder head, is used to calculate maximum refacing dimension.

Table g. Minimum Dimensions for Calculating Valve Seat Refacing Dimensions

Engine Code	Intake	Exhaust
JH , 2H (8-valve)	33.8 mm (1.331 in.)	34.8 mm (1.370 in.)
PL (16-valve)	34.4 mm (1.354 in.)	34.7 mm (1.366 in.)

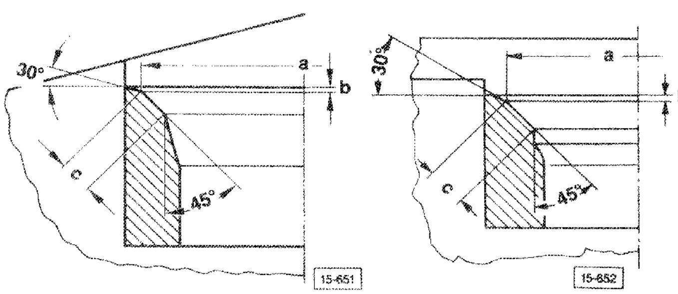
Valve seat dimensions are listed in the tables that follow. **Table h** lists dimensions for 8-valve engines. **Table i** lists dimensions for 16-valve engines.

Table h. Valve Seat Dimensions (8-valve engines)



Engine Code	JH (all years)
diameter **a**	
intake	39.2 mm (1.543 in.)
exhaust	32.4 mm (1.276 in.)
Maximum permissible refacing depth **b**	calculate See Fig. 4-24, **Table g.**
Seat width **c**	
intake	approx. 2.0 mm (.080 in.)
exhaust	approx. 2.4 mm (.094 in.)
Valve seat angle	45°
Upper correction angle	30°

Table i. Valve Seat Dimensions (16-valve engines)



Engine Code	PL
diameter **a**	
intake	31.2 mm (1.228 in.)
exhaust	27.6 mm (1.087 in.)
Maximum permissible refacing depth **b**	calculate See Fig. 4-24, **Table g**
Seat width **c**	
intake	1.5 to 1.8 mm (.06 to .07 in.)
exhaust	approx. 1.8 mm (.07 in.)
Valve seat angle	45°
Upper correction angle	30°
Lower correction angle	75°

5. REMOVING AND INSTALLING ENGINE AND TRANSAXLE

The engine and transaxle are removed as a unit, and separated from each other for additional work once they are removed. The assembly is lifted out from the top, but it is not necessary to remove the hood, unless it will interfere with the type of lifting equipment being used.

Removing

On air-conditioned cars, the air conditioning compressor and condenser are removed and set aside without disconnecting the refrigerant lines. On cars with power steering, remove the power steering pump and fluid reservoir. Set them aside without disconnecting the power steering fluid lines.

To remove:

1. Disconnect the negative (–) battery terminal, and then the positive (+) terminal. Remove the battery.
2. Loosen the fuel filler cap in order to relieve fuel tank pressure.
3. Remove the rubber duct that connects the throttle valve assembly to the fuel injection system's mixture control unit.
4. Drain the cooling system as described in **COOLING SYSTEM**, and remove the coolant hoses connected to the engine.

    CAUTION —
    Volkswagen advises that engine coolant must not be reused when replacing the cylinder head, the cylinder head gasket or the engine.

5. Disconnect the electrical connectors for the radiator cooling fan and the radiator thermoswitch, then remove the radiator and fan assembly as described in **COOLING SYSTEM**.
6. Remove the wiring from the alternator, and then remove the alternator. See **ELECTRICAL SYSTEM**.
7. At the front of the engine, disconnect wiring from the oil pressure switch, the coolant thermoswitch and, on engines with CIS fuel injection, the control pressure regulator. Remove the intake air preheat pipe.
8. On cars with air conditioning, remove the compressor drive belt. Without disconnecting any refrigerant lines, remove the air conditioning compressor from the engine. Set it aside on the fender, using care to avoid kinking the refrigerant lines. Tie the compressor down to hold it.
9. At the left side of the engine, disconnect the coolant temperature sensor wires, the heater hoses, and the starter wiring harness. Disconnect the vacuum hoses, the center coil wire, and the Hall sender connection on the distributor.
10. Detach the fuel lines from the control pressure regulator and the cold start valve. Disconnect the wiring from the cold start valve, the auxiliary air regulator, and the full-load enrichment switch. Disconnect the vacuum hoses for the brake vacuum servo and the vacuum amplifier. Remove the PCV hose.

    WARNING —
    Fuel will be expelled. Do not smoke or work near heaters or other fire hazards. Have a fire extinguisher handy.

11. On PL (16-valve) engines, remove the upper intake manifold, as described in **4.1 Cylinder Head Cover and Gasket**, and disconnect the oxygen sensor connector behind the cylinder head. Remove all engine ground connections.
12. Remove the four fuel injectors.
13. Remove the speedometer drive cable from the transaxle housing.
14. On models with manual transmission, detach the clutch cable and shift linkage as described in **MANUAL TRANSMISSION AND CLUTCH**. Remove the accelerator cable from the engine as described in **FUEL SYSTEM**.
15. On models with automatic transmissions, place the selector lever in the "Park" position. Remove the accelerator cable and the selector lever cable as shown in **AUTOMATIC TRANSMISSION**.
16. Disconnect all remaining electrical connections to the engine and transaxle, including the wires for the starter solenoid and the back-up light switch. Remove the horn.
17. Detach the exhaust front pipe from the exhaust manifold. See **EXHAUST AND EMISSION CONTROLS** if necessary.
18. Working under the car, remove the drive axles as described in **SUSPENSION AND STEERING**, and then reinstall the ball joints into the wheel bearing housings so that the car can be lowered onto its wheels.
19. On cars with manual transmission, remove the starter as described in **ELECTRICAL SYSTEM**.
20. Remove the engine/transaxle front mounting.
21. Prepare to lift the engine by connecting the Volkswagen engine sling or its equivalent to the lifting points shown in Fig. 5-1 (for 8-valve engines) or Fig. 5-2 (for 16-valve engines).
22. Raise the hoist slightly, so that the weight of the engine and transaxle assembly is supported by it.
23. Remove the rear transaxle mount as shown in Fig. 5-3.

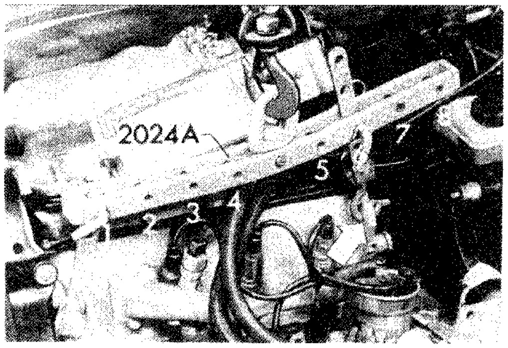


Fig. 5-1. Engine sling (Volkswagen special tool no. 2024A) correctly attached for lifting 8-valve engines with proper weight distribution. Note specific connecting points. Always secure connecting pins and hooks with cotter pins as shown.

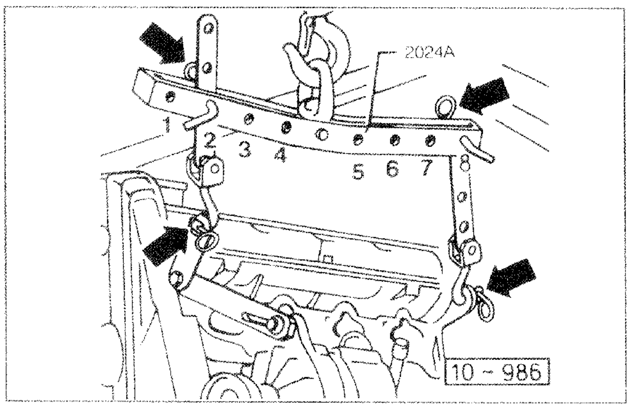


Fig. 5-2. Engine sling (Volkswagen special tool no. 2024A) correctly attached for lifting 16-valve engines with proper weight distribution. Note specific connecting points. Always secure connecting pins and hooks with cotter pins as shown.

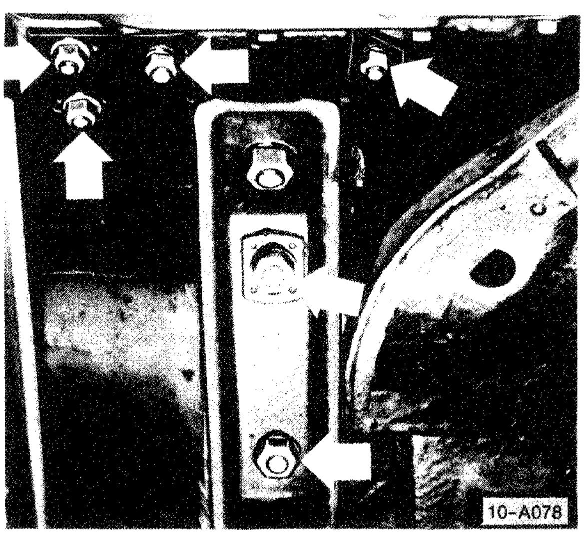


Fig. 5-3. Nuts (arrows) to be removed to remove rear transaxle mount.

24. Remove the bolt that holds the bonded rubber part of the right transaxle mounting to the brackets on the body. Similarly remove the bolt for the right mounting.

25. Raise and remove the engine and transaxle assembly from the car. Proceed slowly. Check frequently to make sure no hoses or wires are interfering with engine removal. If the car has been raised on jack stands, check often see that it remains stable and adequately supported.

Separating Engine and Transaxle

Both the engine and the transaxle should be supported. On cars with automatic transmission, remove the three bolts holding the torque converter to the drive plate. These bolts are near the outside diameter of the torque converter, and are accessible from the bottom as shown in Fig. 5-4.

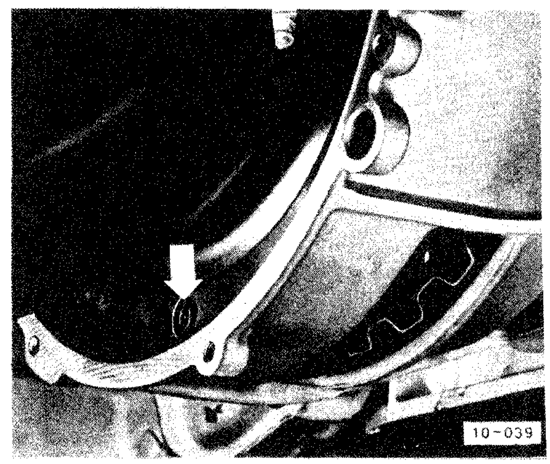


Fig. 5-4. One of three bolts (arrow) that hold torque converter to drive plate. Use crankshaft pulley bolt to turn engine for access to bolts.

On all models, remove the cover plate shown in Fig. 5-5, and remove the bolts which hold the transaxle to the engine. Separate the engine and transaxle using care not to place any strain on the transmission mainshaft.

CAUTION —
On models with automatic transmission, be sure that the drive plate separates cleanly from the torque converter without pulling the torque converter off its support. As soon as the engine and transaxle are separated, install a bar across the open bellhousing to keep the torque converter from falling.

CAUTION —
On models with manual transmission, at no time should the weight of either the engine or the transaxle be supported by the transmission mainshaft. If it is, the clutch, the clutch pushrod, or the mainshaft may be damaged.

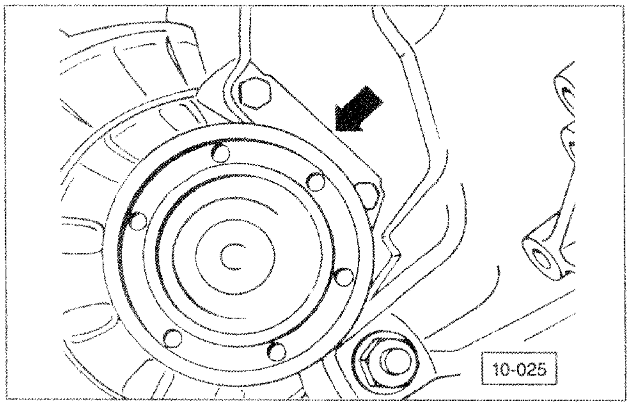


Fig. 5-5. Cover plate (arrow) to be removed when separating engine and transaxle.

Installing

Engine and transaxle installation is the reverse of removal. On models with automatic transmission, make certain during reassembly that the torque converter has not slipped from its support. See Fig. 5-6.

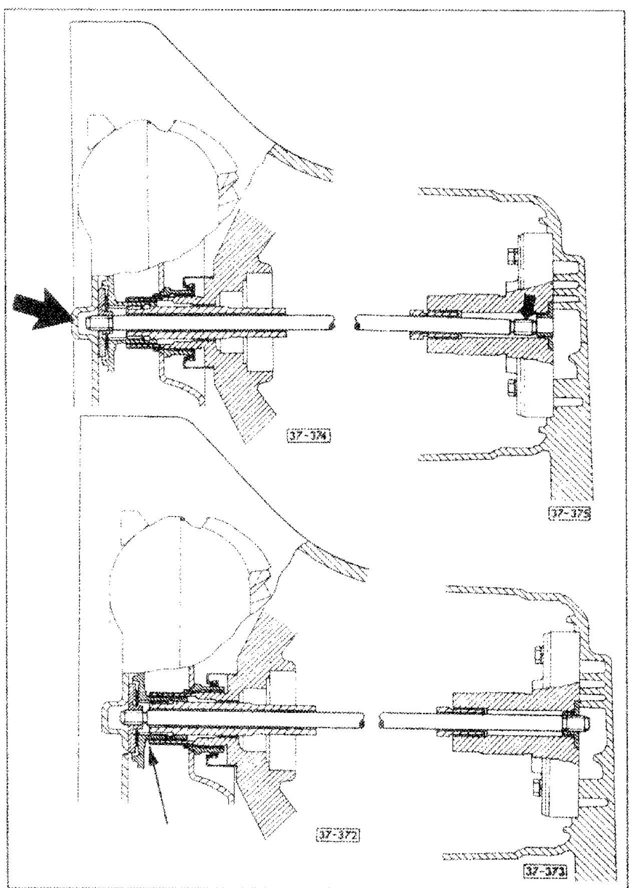


Fig. 5-6. Torque converter positions. Top: converter slipped off support; pilot projects at left arrow, pump driveshaft may be disengaged, as at right arrow. Bottom: converter correctly positioned on support (arrow).

The engine-to-transaxle bolts are two sizes, 10 mm and 12 mm. Torque the larger (12 mm) bolts to 75 Nm (55 ft. lb.) and the smaller (10 mm) bolts to 45 Nm (33 ft. lb.). On models with automatic transmission, torque the bolts holding the engine drive plate to the torque converter to 30 Nm (22 ft. lb.). Torque the starter mounting bolts to 45 Nm (33 ft. lb.), and the cover plate mounting bolts to 15 Nm (11 ft. lb.).

With the engine and transaxle in position, install the left transaxle mount first. Roughly align the engine/transaxle assembly, then install the remaining mounts. Do not fully torque the mounting bolts. Torque the horn mounting bolts to 18 Nm (13 ft. lb.).

On cars with air conditioning, adjust the tension of the compressor drive belt as described in **LUBRICATION AND MAINTENANCE**.

Following installation of the remaining engine and transaxle parts and fluids, the assembly should be aligned in its mounts as described in **Aligning Engine and Transaxle Assembly**.

Aligning Engine and Transaxle Assembly

It is normally necessary to align the engine and transaxle mounts only after the assembly has been installed, or after the mounts have been loosened as part of another repair. However, a misaligned engine/transaxle can be one of the causes of excessive engine vibration, indicated by buzzing noises in the passenger compartment.

To align:

1. Loosen the mounting bolts and nuts as indicated in Fig. 5-7.

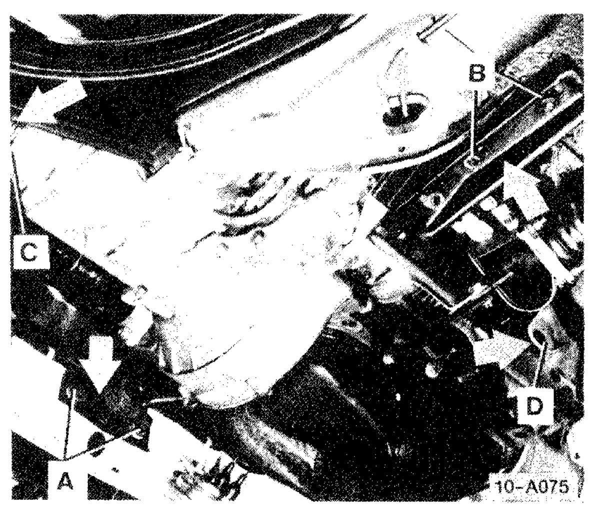


Fig. 5-7. Bolts and nuts to be loosened when aligning engine and transaxle. Loosen front mount bolts at **A**, rear mount nuts at **B**, left mount center bolt at **C**, and right mount center bolt at **D**.

2. With the car sitting on the ground, move the engine and transaxle assembly until the rear transaxle mount is straight as shown in Fig. 5-8, and the left and right engine and transaxle mounts are centered as shown in Fig. 5-9. Then torque the rear mount nuts and the left and right center bolts to 35 Nm (26 ft. lb.). Recheck the mounts to make sure that there is no twisting or strain.

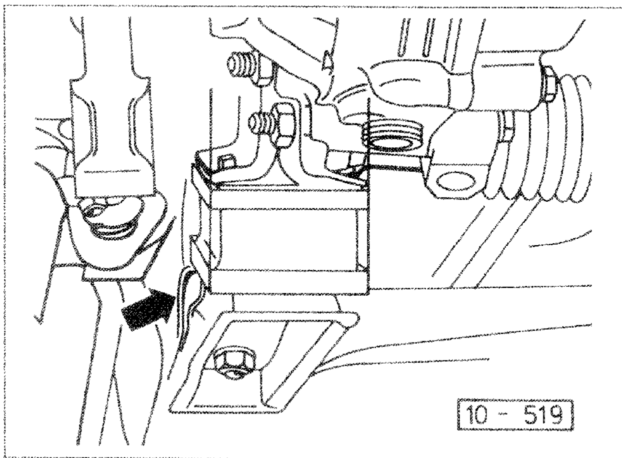


Fig. 5-8. Rear transaxle mount correctly aligned (lines).

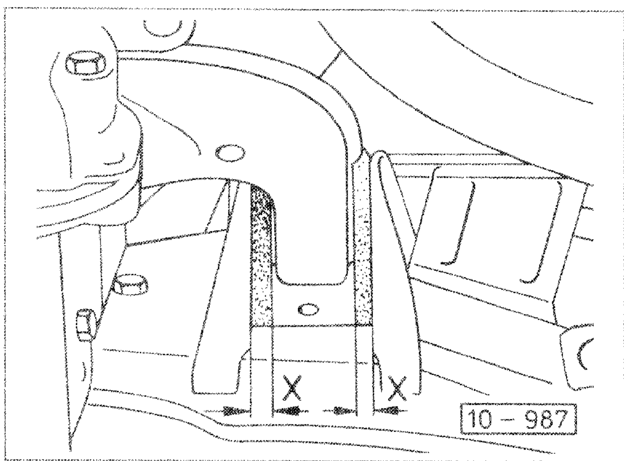


Fig. 5-9. Correct alignment (lines) of left and right engine and transaxle mounts.

3. Move the front mount on the body until the rubber core is centered in the mount as shown in Fig. 5-10, then torque the nuts. For 8-valve engines, torque the mount nuts to 52 Nm (38 ft. lb.). For 16-valve engines, torque the nuts to 40 Nm (30 ft. lb.).

> NOTE —
> After the alignment, check gearshift function and exhaust system alignment. If necessary, adjust the shift mechanism as described in either **MANUAL TRANSMISSION AND CLUTCH** or **AUTOMATIC TRANSMISSION**, and align the exhaust system as described in **EXHAUST AND EMISSION CONTROLS**.

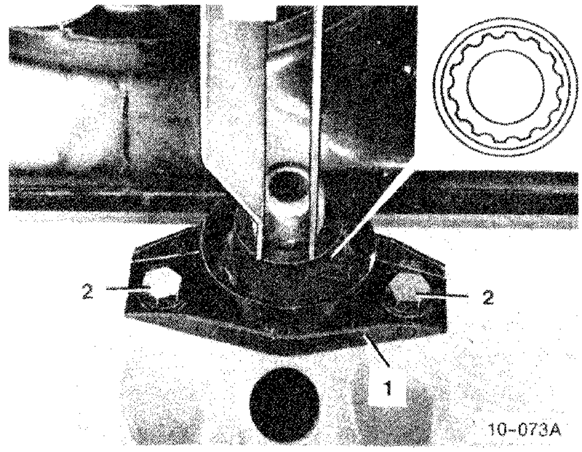


Fig. 5-10. Front engine mount being aligned. Move housing (**1**) on bolts (**2**) until rubber core is centered (inset).

6. CYLINDER BLOCK AND PISTONS

The cylinder block and pistons are normally affected only by wear due to high mileage. Low compression and noise caused by worn clearances between parts are signs of wear. For more information, see **3. Troubleshooting**.

> *CAUTION —*
> *Replacement blocks may not include the oil pump shaft/distributor drive bushing. Assembly without the bushing will result in little or no oil pressure.*

6.1 Cylinder Block Oil Seals

The front crankshaft and intermediate shaft oil seals can be replaced with the engine installed. Replacing of the rear crankshaft oil seal requires separating the engine and transaxle.

Replacing Front Crankshaft Oil Seal

Remove the drive belt as described in **4.2 Camshaft Drive Belt**. Then remove the belt sprocket from the crankshaft. To remove the seals, Volkswagen special tools shown in Fig. 6-1 are recommended. Alternatively, remove the seal carrier from the cylinder block and the oil pan. Always use care to prevent marring the sealing surfaces. Be careful during reassembly to seat the seal properly. Use a new gasket.

Lubricate the new seal with clean engine oil. Press it all the way into the carrier, being careful not to distort the seal. The sealing lip faces inward. For best results, use a seal driver such as the one shown in Fig. 6-2. Lubricate the threads of the crankshaft sprocket bolt with engine oil.

Tightening torques:
- seal carrier (small M6 bolt) 10 Nm (87 in. lb.)
- seal carrier (all other bolts) 20 Nm (15 ft. lb.)

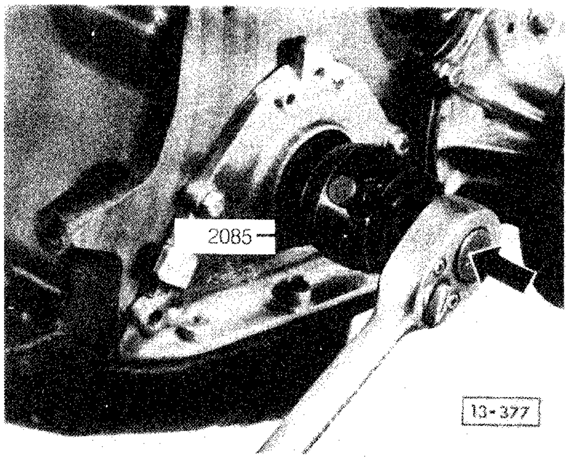


Fig. 6-1. Crankshaft front oil seal being removed using Volkswagen special tool no. 2085. Rotate tool clockwise to remove seal.

Tightening torques:

• hex bolt (with washer)	150 Nm (111 ft. lb.)
• 12-point bolt (without washer)	90 Nm (66 ft. lb.) plus $^1/_2$ turn (180°)

NOTE —
Only 12-point bolts are supplied as replacement parts. Install without washer. Always replace.

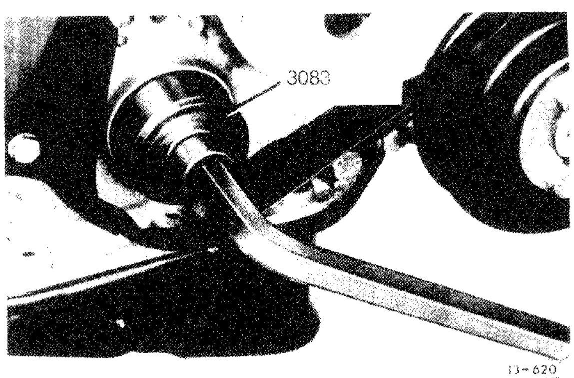


Fig. 6-2. Front crankshaft oil seal being installed, using Volkswagen special tool no. 3083.

Replacing Intermediate Shaft Oil Seal

Remove the camshaft drive belt, as described in **4.2 Camshaft Drive Belt**. Loosen the intermediate shaft sprocket bolt and, using a soft faced hammer, tap the sprocket loose. Remove the bolt and the sprocket. Remove the two bolts holding the oil seal carrier to the cylinder block and pull out the seal carrier. Pry or hand-press the seal out of the carrier.

Reinstall the seal carrier with a new O-ring. Torque the bolts to 25 Nm (18 ft. lb.). To install the seal, lightly oil the seal and shaft's sealing surface. Fit the seal into position, and carefully drive it into place. Use care not to distort the seal as it is installed. For best results, use a seal driver such as Volkswagen special tool no. 10-203.

6.2 Disassembly, Assembly, and Reconditioning

Disassembly, assembly, and reconditioning procedures for the 1.8 liter Volkswagen engines covered in this manual are similar to those for most other modern 4-cylinder, water-cooled engines. For anyone with the proper tools and equipment and basic experience in engine reconditioning, this section provides the specifications and special reconditioning information necessary to repair these Volkswagen engines.

Those who are without the necessary tools, or unfamiliar with reconditioning procedures, will still find this information to be important to the qualified mechanic who does the work. If machine shop services are not readily available, one alternative is to install a Volkswagen remanufactured engine or short block, available from an authorized Volkswagen dealer parts department.

To minimize wear during engine start-up, clean engine oil should be used to lubricate all friction surfaces during engine assembly.

Pistons and Connecting Rods

Pistons, piston pins, piston rings, connecting rods, and bearings, if they are to be reused, should never be interchanged. Mark the cylinder numbers on connecting rods and connecting rod caps before removal. Mark the piston tops as shown in Fig. 6-3. (avoid scratching the piston). The components of one piston and connecting rod assembly are shown in Fig. 6-4.

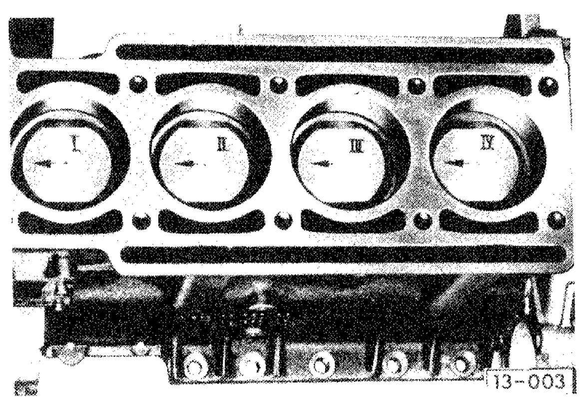


Fig. 6-3. Cylinder numbers and arrows marked on piston crowns. Used pistons should always be installed in their original orientation.

The piston pin should fit such that, with the piston heated to approximately 60°C (140°F) in an oil bath, a light push will move the pin. Replace the piston and the pin if the fit is excessively loose. Connecting rods should always be replaced in complete sets.

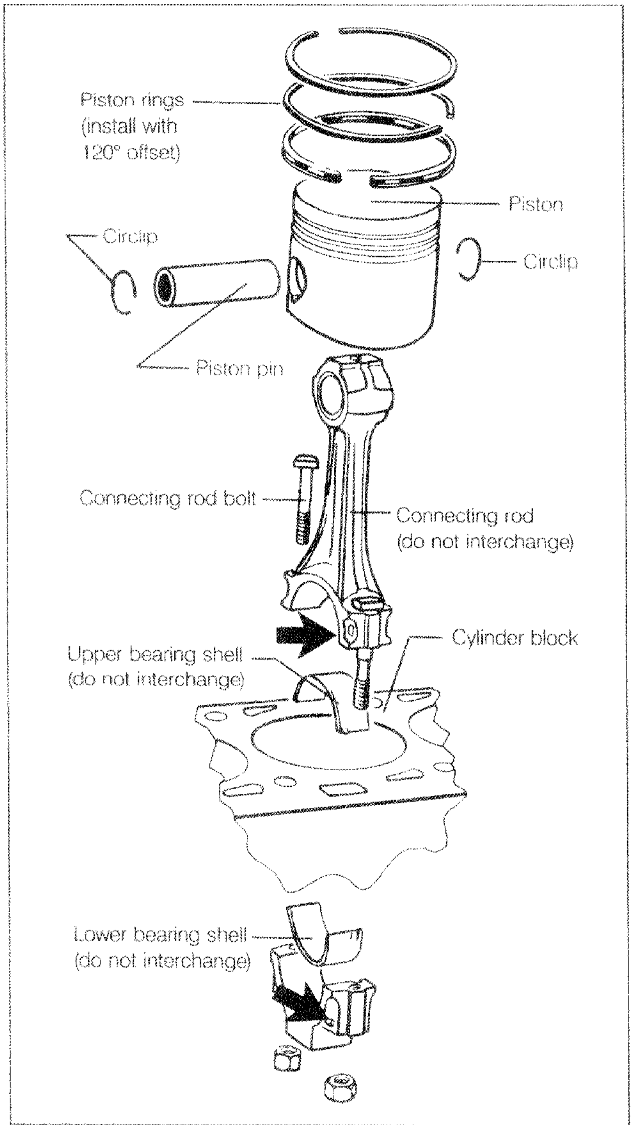


Fig. 6-4. Components of piston and connecting rod assembly. Connecting rod markings (arrows) face camshaft drive belt.

Measure the cylinder bores at approximately the top, the middle, and the bottom of piston travel, and at right angles (90°), as shown in Fig. 6-5. The top and bottom measurements should be made approximately 10 mm (⅜ in.) from the ends of the cylinder. Nominal piston and cylinder bore diameter specifications are given in **Table j**.

NOTE —
Nominal piston diameters are marked on the piston crowns.

Maximum out-of-round variation in any one cylinder is 0.04 mm (.0016 in.). Minor irregularities may be corrected by honing. If the diameter of any one cylinder exceeds the nominal dimension by more than 0.08 mm (.003 in.), all four cylinders should be rebored and honed to accept new oversized pistons. Visually inspect the bores for scoring and other imperfections which will also prevent good piston ring to cylinder wall sealing. When fitting pistons, the piston-to-cylinder clearance should be 0.03 mm (.0012 in.). Maximum piston-to-cylinder clearance is 0.07 mm (.0028 in.).

CAUTION —
Mounting the bare cylinder block to an engine stand will distort its shape and cause inaccurate cylinder bore measurements.

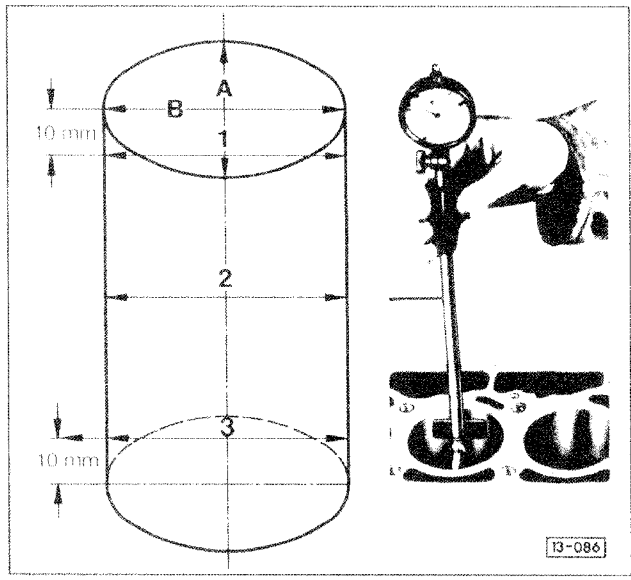


Fig. 6-5. Cylinder bore measuring points. Top **1** and bottom **3** measurements should be made at least 10 mm (3/8 in.) from ends of cylinder, first in direction **A** and then in direction **B**.

Table j. Cylinder and Piston Diameter Specifications

Engine Code	Repair Stage	Piston Diameter	Cylinder Bore
JH, 2H	Basic Dimension (standard)	80.98 mm (3.1882 in)	81.01 mm (3.1894 in.)
	1st oversize	81.23 mm (3.1980 in.)	81.26 mm (3.1992 in.)
	2nd oversize	81.48 mm (3.2079 in.)	81.51 mm (3.2091 in.)
PL	Basic Dimension	80.98 mm (3.1882 in.)	81.01 mm (3.1894 in.)

NOTE —
At the time of printing, only standard size pistons are available for PL (16-valve) engines. Check with an authorized Volkswagen dealer parts department for the latest information on parts availability.

Measure connecting rod bearing clearances using Plastigage®. Inspect the connecting rods for any bending, distortion, or other visible damage. Connecting rod specifications are listed in **Table k**.

Table k. Connecting Rod Specifications

Radial Clearance Wear Limit	0.12 mm (.0047 in.)
Side Clearance Wear Limit	0.37 mm (.0145 in.)
Checking Torque	30 Nm (22 ft. lb.)
Assembly Torque	30 Nm (22 ft. lb.) + ¼ turn (90°)

NOTE —
When checking radial clearance, lubricate the contact surface of the nut before tightening.

If connecting rod radial clearance is excessive, the crankshaft connecting rod journals should be checked as described in **Crankshaft and Intermediate Shaft**. If the crankshaft journal diameters are within specifications, recheck radial clearance using new bearing shells.

When installing each connecting rod to the crankshaft, the two bearing shells' retaining tabs should be on the same side of the journal, and the marks on the connecting rods, shown earlier in Fig. 6-4, should face the drivebelt side of the engine.

Piston Rings

Piston ring end gaps are checked with the piston rings inserted approximately 15mm (5/8 in.) from the top of the cylinder. The piston ring gap specifications are listed in **Table l**.

Table l. Piston Ring End Gap

	Gap	Wear Limit
Compression Rings	0.30 to 0.45 mm (.012 to .018 in.)	1.0 mm (.039)
Oil Scraper Rings (bottom ring)	0.25 to 0.45 mm (.010 to .018 in.)	1.0 mm (.039)

Piston ring side clearance is checked using feeler gauges. Measure each ring in its original groove. Piston ring side clearance specifications are listed in **Table m**.

Table m. Piston Ring Side Clearance

Ring	Clearance (new parts)	Wear Limit
all	0.02–0.05 mm (.0008–.0019 in.)	0.15 mm (.0059 in.)

Install the piston rings with the gaps offset from each other by 120°, as illustrated earlier in Fig. 6-4.

Crankshaft and Intermediate Shaft

Fig. 6-6 shows the assembly of the crankshaft and the intermediate shaft in the cylinder block. To remove the crankshaft, both crankshaft oil seal carriers must be removed from the ends of the cylinder block. Crankshaft main bearing caps must not be interchanged. Crankshaft main bearing shells, if they are to be reused, should only be installed in their original positions. On 8-valve engines, the ignition distributor must be removed before removing the intermediate shaft.

NOTE —
On models with automatic transmission, mark the position of the driveplate on the crankshaft before removing the driveplate.

NOTE —
Replacement No. 3 main bearing shells are one-piece with integral thrust washers.

Crankshaft journal specifications are listed in **Table n**. Tightening torques are listed in **Table o**. Crankshaft and intermediate shaft clearance specifications are listed in **Table p**. Crankshaft bearings are available in three undersizes to fit reconditioned crankshafts. If a crankshaft must be replaced, a Volkswagen remanufactured crankshaft is available from an authorized Volkswagen dealer.

Table n. Crankshaft Journal Diameter

	Main Bearing Journal Diameter	Connecting Rod Journal Diameter
Basic Dimension	53.958–53.978 mm (2.1243–2.1251 in.)	47.758–47.778 (1.8802–1.8810 in.)
1st Undersize (0.25 mm)	53.708–53.728 mm (2.1145–2.1153 in.)	47.508–47.528 mm (1.8704–1.8712 in.)
2nd Undersize (0.50 mm)	53.458–53.478 mm (2.1046–2.1054 in.)	47.258–47.278 mm (1.8606–1.8613 in.)
3rd Undersize (0.75 mm)	53.208–53.228 mm (2.0948–2.0956 in.)	47.008–47.028 mm (1.8507–1.8515 in.)

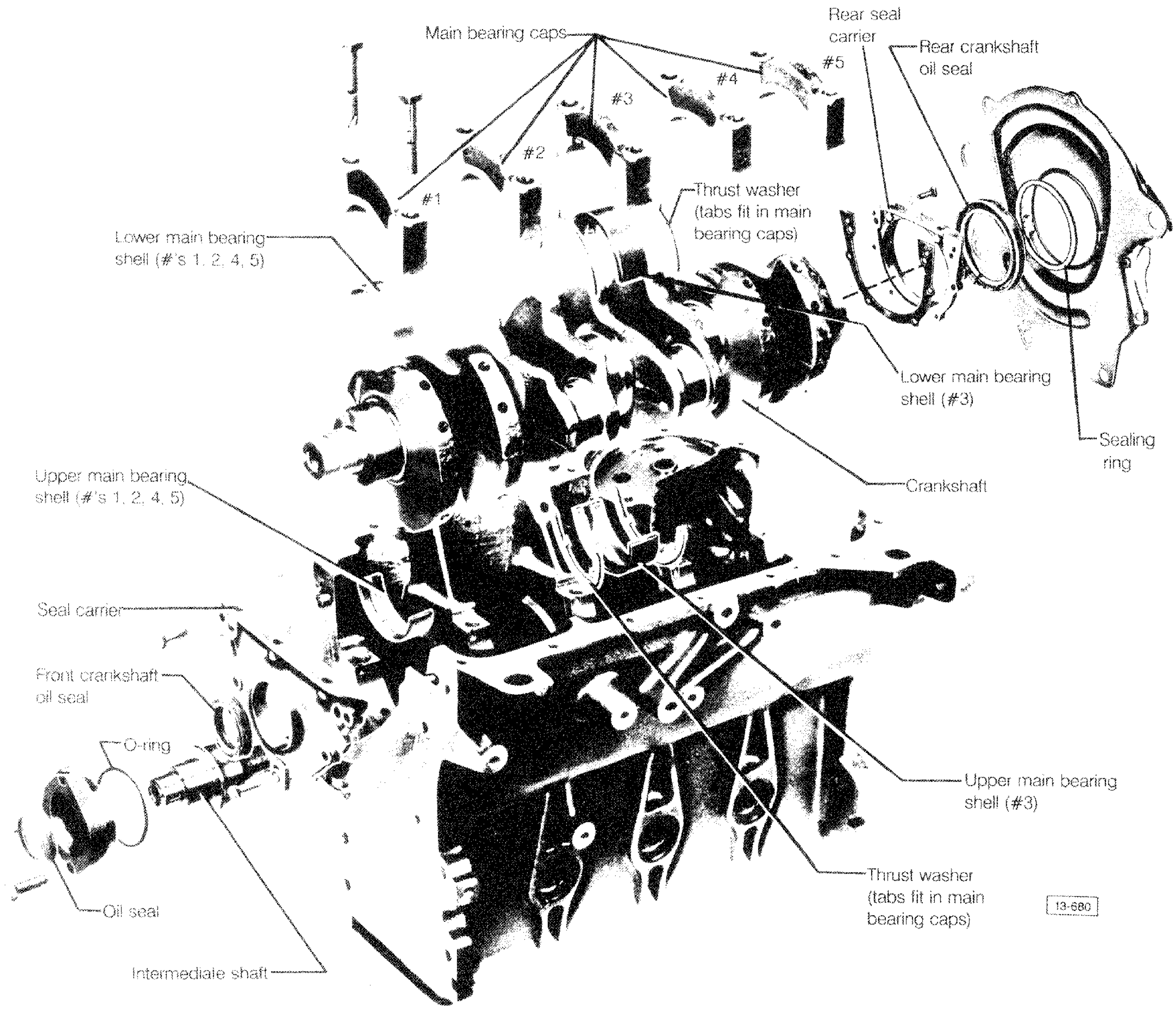


Fig. 6-6. Exploded view of cylinder block, crankshaft, intermediate shaft, and related parts.

Table o. Crankshaft and Cylinder Block Tightening Torques

Crankshaft Oil Seal Carrier Bolts	
M6	10 Nm (87 in. lb.)
M8	20 Nm (15 ft. lb.)
Intermediate Shaft Oil Seal Carrier Bolts	25 Nm (18 ft. lb.)
Main Bearing Cap Nuts	65 Nm (48 ft. lb.)
Oil Pan Bolts	20 Nm (15 ft. lb.)

Table p. Crankshaft and Intermediate Shaft Clearance

	New parts	Wear limit
Crankshaft main bearings		
radial clearance	0.03–0.08 mm (.0012–.0031 in.)	0.17 mm (.0067 in.)
axial (thrust) clearance	0.07–0.17 mm (.0028–.0067 in.)	0.25 mm (.0098 in.)
Connecting rod bearings		
radial clearance	—	0.12 mm (.0047 in.)
axial (side) clearance	—	0.37 mm (.0146 in.)
Intermediate shaft		
axial clearance	—	0.25 mm (.0098 in.)

Flywheel or Drive Plate

Fig. 6-7 and Fig. 6-8 show the tightening sequence and a holding fixture, Volkswagen special tool VW 558. Torque the bolts, with locking compound, to 30 Nm (22 ft. lb.) plus $\frac{1}{4}$ turn (90°).

> *CAUTION —*
> *Always replace flywheel or drive plate mounting bolts with new bolts for final installation.*

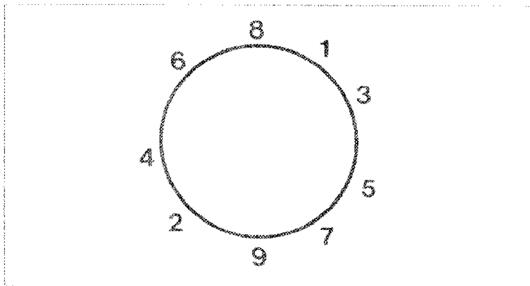


Fig. 6-7. Flywheel or drive plate bolt torque sequence. Loosen and remove in reverse order.

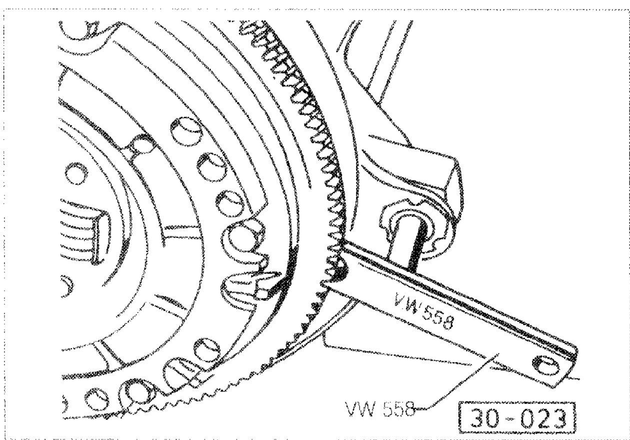


Fig. 6-8. Flywheel secured with holding fixture VW 558.

Replacement flywheels may not have an ignition timing mark. Make a timing mark 12 mm (0.47 in.) arc length to the left of the Top Dead Center (0) mark, as shown in Fig. 6-9.

On automatic transmission cars, mark the drive plate during disassembly and reinstall it with the same orientation. See Fig. 6-10. When replacing the drive plate, first install it with old bolts and a 1 mm shim and check drive plate to cylinder block clearance as shown in Fig. 6-11. Install 4 mm and/or 1 mm shims to achieve a dimension of 31.3 ± 0.7 mm (1.23 ± 0.028 in.). With the correct shims, install the drive plate with new bolts. Use one shim between the drive plate and the bolts. Torque as described above. Torque the torque converter bolts, with D6 locking compound or equivalent, to 35 Nm (26 ft. lb.).

> NOTE —
> A modified drive plate, installed in production as of VIN _15MK_005500 (1989), is the only one available as a replacement. It requires a different combination of shims than the earlier drive plate.

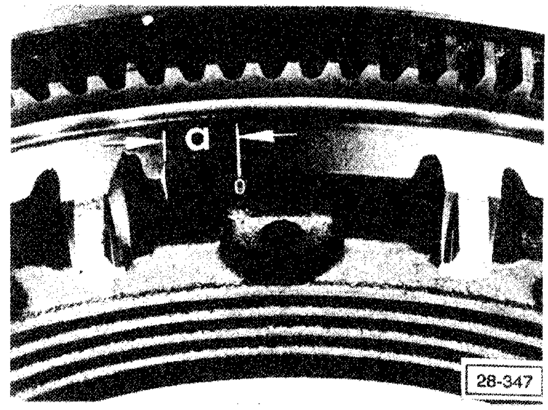


Fig. 6-9. Location on replacement flywheel to make new ignition timing mark. Dimension **a** is arc length from Top Dead Center (0) mark.

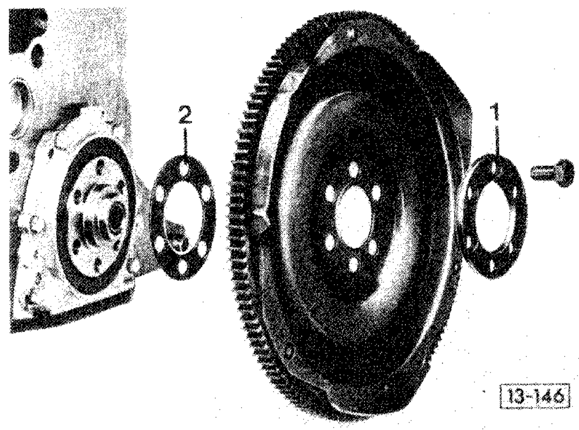


Fig. 6-10. Drive plate assembly. Use only one shim **1**. Combine shims **2** (1 mm and/or 4 mm) to achieve correct cylinder block clearance dimension.

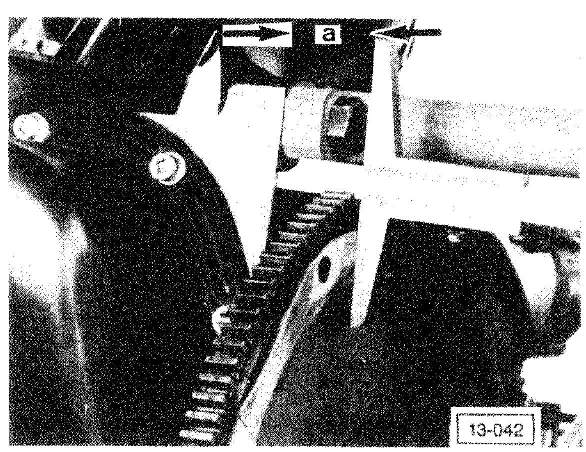


Fig. 6-11. Drive plate to cylinder block clearance being measured. Dimension **a** should be 31.3 ± 0.7 mm (1.23 ± 0.028 in.). Adjust distance by adding or removing shims behind drive plate.

7. LUBRICATION SYSTEM

The primary function of the lubrication system is to lubricate the internal moving parts of the engine. The circulation of oil also aids engine cooling. Proper lubrication relies on a constant supply of oil, fed to the moving parts under pressure. Pressure is supplied by a gear-type oil pump located inside the oil pan. Engine oil returns to the oil pan where it is stored for pickup by the pump. It is cleaned by circulating through a replaceable filter. Fig. 7-1 is a schematic view of the lubrication system showing the paths of pressurized oil supply to the engine bearings.

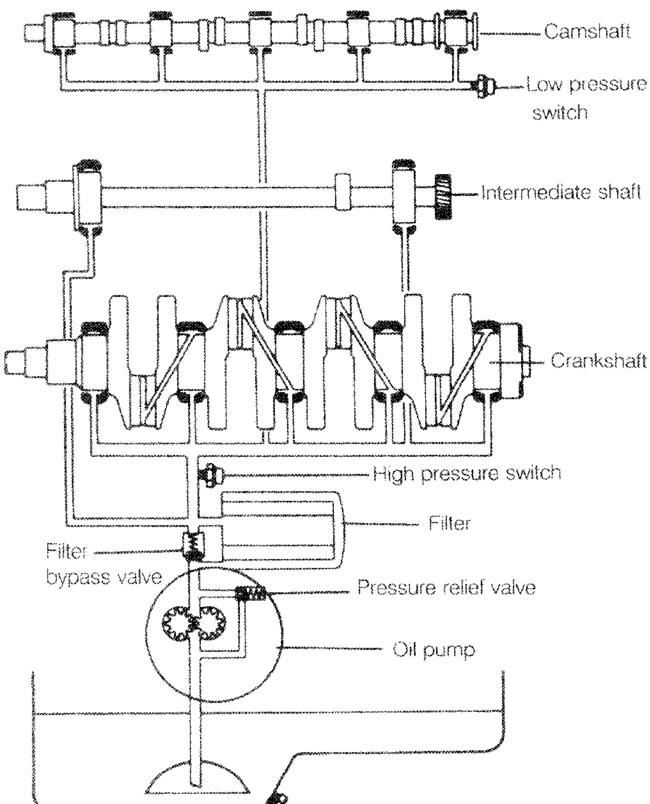


Fig. 7-1. Schematic view of lubrication system. Pressure relief is part of pump. On 16-valve engines, both pressure switches are on oil filter flange.

This section covers inspection, repair and assembly of the lubrication system. Oil and filter change and engine oil specifications are covered in **LUBRICATION AND MAINTENANCE**.

To prevent serious engine damage, a dynamic oil pressure warning system warns the driver of insufficient oil pressure. Other safety features include a filter by-pass, to guard against bursting the filter due to over-pressure, and an oil pump pressure relief valve to prevent excessive system pressure.

On cars equipped with the multi-function indicators, an oil temperature sensor, located on the oil filter flange, monitors the oil temperature. On PL (16-valve) engines the sensor is located on the end of the cylinder head.

Lubrication system problems are caused by an inability to create or sustain adequate oil pressure. In rare cases, indications of trouble may be false alarms caused by faults in the oil pressure warning system.

CAUTION —
Always assume that a warning is valid. Take proper precautions to avoid engine damage until adequate oil supply and proper oil pressure can be verified.

NOTE —
To prevent oil being drawn into the air filter through the crankcase breather on 16-valve engines, replace the oil pump splash shield with a baffle, Volkswagen part no. 027 103 623.

Proper lubrication is essential to long engine life. Change the engine oil and oil filter regularly, at least as often as specified by Volkswagen's scheduled maintenance intervals, and periodically check engine oil level between oil changes. See **LUBRICATION AND MAINTENANCE**.

7.1 Dynamic Oil Pressure Warning System

The dynamic oil pressure warning system includes pressure switches, the electronic control unit, the warning indicator and a warning buzzer. A 0.3 bar pressure switch provides warning when the oil pressure falls to near zero at any time. The other (1.8 bar) switch provides earlier warning, at higher rpm, whenever oil pressure falls too low.

The pressure switches are located on the oil filter flange (0.3 bar) and on the end of the cylinder head (1.8 bar). On 16-valve engines, both switches are on the oil filter flange. The electronic control unit is behind the instrument cluster.

CAUTION —
*If the warning indicator stays on after the engine is started, or flashes on while driving, always assume that the warning is valid. Check oil level and test oil pressure before testing the warning system. See **8. Engine Technical Data**.*

Checking Low Oil Pressure Warning System

With the ignition off, the 0.3 bar switch is closed (completing the circuit to ground). When the ignition is switched on, the indicator will flash. When the engine is started and oil pressure rises, it opens the switch (opening the ground circuit), and the indicator goes out. With too little oil pressure or a stuck switch, the indicator will continue to flash. For switch opening and closing pressures see **Testing Oil Pressure Switches**.

To quick-check the 0.3 bar switch, simulate a closed switch. Remove the blue/black wire and connect it to ground. With the ignition on, the indicator should flash. If not, the problem is in the circuit or the indicator. If the indicator flashes only when tested in this way, replace the switch.

If the indicator flashes with the engine running, and the oil pressure tests OK, remove the blue/black wire from the switch with the engine running. The indicator should go out. If not, the circuit is shorted to ground between the wire and indicator. If the indicator does go out, the switch is stuck closed and should be replaced.

Checking Dynamic Oil Pressure Warning System
(high rpm)

The 1.8 bar pressure switch is normally open (no circuit to ground). When the engine is running above 2000 rpm (ignition distributor input to control unit), oil pressure closes the switch (completing the circuit to ground). If oil pressure is insufficient to close the pressure switch, or the switch is stuck open, the indicator will flash and the buzzer will sound. The pressure switch opens and closes at specific pressures. See **Testing Oil Pressure Switches**.

To quick-check the pressure switch, raise the engine speed above 2000 rpm and disconnect the yellow wire from the switch. The indicator should flash and the buzzer should sound. If the wire is connected to ground, the warning should stop. Disconnect the wire from ground and connect it to the switch. If the indicator does not go out, replace the switch.

Testing Oil Pressure Switches

The oil pressure at which the pressure switches react can be tested by temporarily installing an oil pressure gauge in parallel with the switch with a T-fitting and monitoring switch performance with a multimeter or test light, as shown in Fig. 7-2. See **8. Engine Technical Data**.

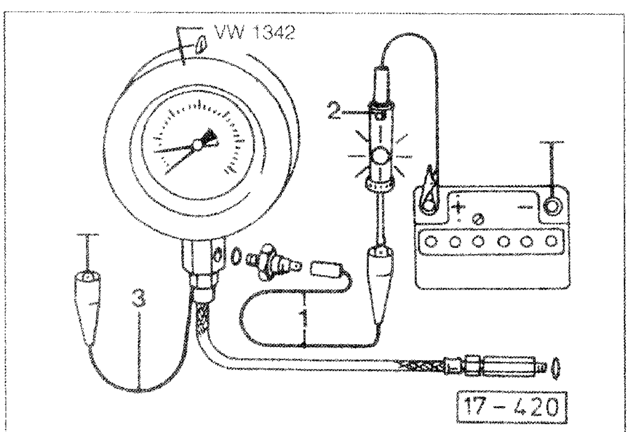


Fig. 7-2. Pressure gauge and test light being used to test oil pressure switches.

7.2 Oil Pump

The oil pump is located inside the engine oil pan, and draws engine oil through a pickup tube from near the bottom of the pan. The pump can be removed for inspection of its internal clearances (a potential source of low oil pressure problems) by removing the oil pan.

There is normally no need to remove and inspect the oil pump unless oil pressure is inadequate. Check the oil pressure by installing a pressure gauge in place of one of the oil pressure switches and run the engine. Engine oil pressure at normal operating temperature should be at least 2.0 bar (29 psi) at 2000 rpm.

To inspect the oil pump, drain the oil and remove the oil pan. Remove the pump and disassemble it. See Fig. 7-3.

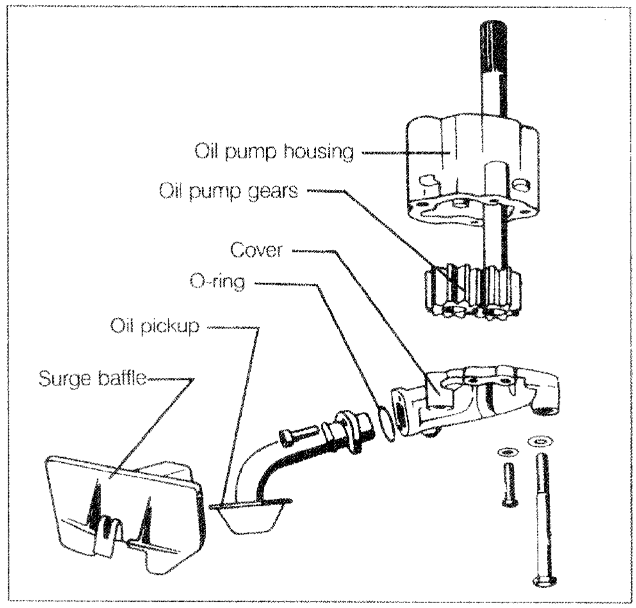


Fig. 7-3. Exploded view of oil pump. Note long mounting bolts and short cover bolts.

With the oil pump removed and disassembled, use feeler gauges to check the clearances. Backlash, shown being measured in Fig. 7-4, should be between 0.05 and 0.20 mm (.002 and .008 in.). If not, replace the gears or the pump. Oil pump gear axial play, shown being measured with a straight-edge in Fig. 7-5, should not exceed 0.15 mm (.006 in.). If it does, replace the pump.

If the oil pickup has been removed from the pump cover, replace the O-ring when installing the pickup. Torque the pickup bolts and cover bolts to 10 Nm (87 in. lb.). Torque the oil pump mounting bolts to 20 Nm (15 ft. lb.).

Replace the oil pan gaskets and install the oil pan. Torque the oil pan bolts to 20 Nm (15 ft. lb.) and the drain plug to 30 Nm (22 ft. lb.). Add engine oil, as described in **LUBRICATION AND MAINTENANCE**.

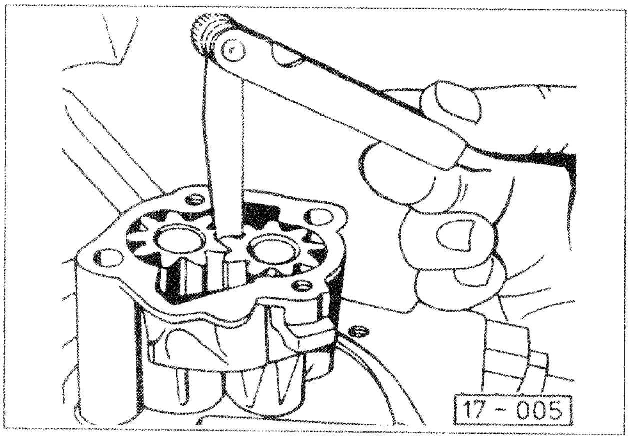


Fig. 7-4. Oil pump gear backlash being measured using feeler gauge.

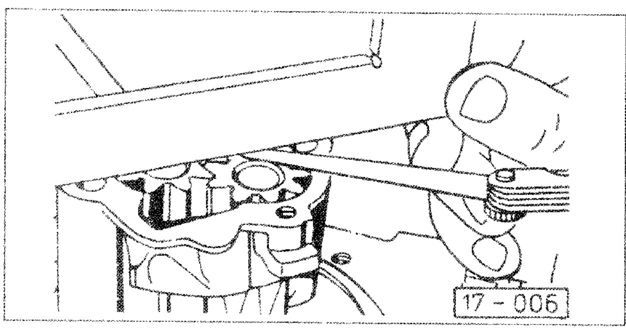


Fig. 7-5. Oil pump gear axial play being measured using straight-edge and feeler gauge.

Oil Spray Nozzles

PL (16-valve) engines are equipped with oil spray nozzles which, above a certain oil pressure threshold, spray oil from the main oil galley against the bottoms of the pistons for added cooling.

Install these nozzles with sealing paste, Volkswagen part no. AMV 188 100 02, and torque the bolts to 10 Nm (87 in. lb.).

NOTE —
Part numbers are subject to change. Always rely on an authorized Volkswagen dealer parts department for the latest information.

7.3 Oil Cooler

The oil cooler is an oil-to-coolant heat exchanger. Engine oil flows through one part of the cooler and gives up heat to the engine coolant flowing through the other part of the cooler. The cooler is a potential source of leakage between the lubrication system and the cooling system, and should be considered whenever such leakage is suspected.

Fig. 7-6 is an exploded view of the oil cooler, the oil filter, and the mounting parts. Remove the oil cooler only if it needs to be cleaned, inspected, or replaced. On installation, use sealing paste, Volkswagen part no. AMV 188 100 02, on the sealing surfaces and check to see that there is adequate space for the coolant hose connections. Torque the oil cooler mounting nut to 25 Nm (18 ft. lb.).

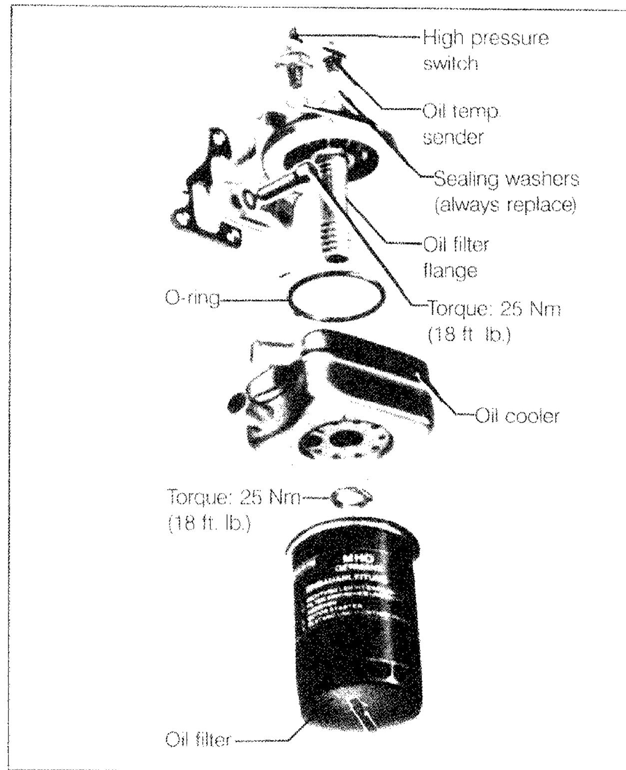


Fig. 7-6. Exploded view of oil cooler and related parts. 8-valve engine components shown. Specifications also apply to similar parts for 16-valve engines.

CAUTION —
If metal shavings are found in the engine oil as a result of engine damage, all engine oil passages must be thoroughly cleaned. The engine oil cooler should be replaced.

8. ENGINE TECHNICAL DATA

I. Tightening Torques

Air connection to cylinder head for 8-valve engines (bolt)	10 Nm (87 in. lb.)
Alternator adjusting bracket to engine (bolt)	20Nm (15 ft. lb.)
Alternator to adjusting bracket of vehicle (bolt)	35 Nm (26 ft. lb.)
Alternator to lower mounting of vehicle (bolt)	35 Nm (26 ft. lb.)
Camshaft bearing caps to cylinder head (nut)	
8-valve engines	20 Nm (15 ft. lb.)
16-valve engines	15 Nm (11 ft. lb.)
Camshaft drive belt sprocket to camshaft or intermediate shaft (bolt)	
8-valve engines	80 Nm (59 ft. lb.)
16-valve engines	65 Nm (48 ft. lb.)
Camshaft drive belt tensioner locknut	45 Nm (33 ft. lb.)
Clutch pressure plate or automatic transmission drive plate to crankshaft	30 Nm (22 ft. lb.) plus 1/4 turn (90°)
Connecting rod cap to connecting rod	30 Nm (22 ft. lb.) plus 1/4 turn (90°)
Cover plate to transaxle	15 Nm (11 ft. lb.)
Crankshaft oil seal carrier to cylinder block	
M 6 bolt	10 Nm (87 in. lb.)
M 8 bolt	20 Nm (15 ft. lb.)
Crankshaft timing belt sprocket to crankshaft	
Hex bolt (with washer)	150 Nm (111 ft. lb.)
12-point bolt (without washer)	90 Nm (66 ft. lb.) plus 1/4 turn (90°)
Cylinder head cover to cylinder head (nut)	10 Nm (87 in. lb.)
Cylinder head to engine block (engine cold)	60 Nm (43 ft. lb.) plus 1/2 turn (180°)
Drive belt rear cover to stud in cylinder head (socket-head bolt)	30 Nm (22 ft.lb.)
Drive belt upper and lower front cover to rear cover (bolt and nut)	
except front bolt on 16-valve engines	10 Nm (87 in. lb.)
front bolt on 16-valve engines	6 Nm (53 in. lb.)
Drive shaft to transaxle drive flange	
8-valve engines	42 Nm (30 ft. lb.)
16-valve engines	45 Nm (33 ft. lb.)
Engine to transaxle bellhousing	
M10	45 Nm (33 ft. lb.)
M12	75 Nm (55 ft. lb.)
Engine front mount to body (bolt)	52 Nm (38 ft. lb.)
Engine right and left mounting to rubber (through bolt)	35 Nm (26 ft. lb.)
Engine/transaxle rear mount to engine (nut)	35 Nm (26 ft. lb.)
Engine/transaxle mount to body 16-valve engines	40 Nm (30 ft. lb.)
Fuel injector insert to cylinder head (with thread locking compound)	20 Nm (15 ft. lb.)
Flywheel to clutch pressure plate	20 Nm (15 ft. lb.)
Intermediate shaft oil seal carrier to cylinder block	25 Nm (18 ft. lb.)
Manifolds to cylinder head	25 Nm (18 ft. lb.)
Main bearing caps to cylinder block	65 Nm (48 ft. lb.)
Oil cooler to oil filter flange (nut)	25 Nm (18 ft. lb.)
Oil filter mounting flange to engine cylinder block (socket-head bolt)	25 Nm (18 ft. lb.)
Oil pickup to oil pump housing cover (bolt)	10 Nm (87 in. lb.)
Oil pressure switches	25 Nm (18 ft. lb.)

I. Tightening Torques (continued)

Oil pan to cylinder block	20 Nm (15 ft. lb.)
Oil drain plug in oil pan	30 Nm (22 ft. lb.)
Oil pump to cylinder block (M8 bolt)	20 Nm (15 ft. lb.)
Oil pump cover bolt	10 Nm (87 in. lb.)
Power steering pump to mount (bolt)	20 Nm (15 ft. lb.)
Spark plug	20 Nm (15 ft. lb.)
Starter to bellhousing (manual transmission)	46 Nm (34 ft. lb.)
Torque converter to drive plate (with D6 locking compound)	35 Nm (26 ft. lb.)
Upper intake manifold to lower intake manifold (16-valve engines)	20 Nm (15 ft. lb.)
Upper intake manifold to support bracket (16-valve engines)	20 Nm (15 ft. lb.)
V-belt pulleys to coolant pump or crankshaft sprocket	20 Nm (15 ft. lb.)

II. Crankshaft, Intermediate Shaft and Crankshaft Bearing Specifications

Main bearing journal diameter	
basic dimension	53.958–53.978 mm (2.1243–2.1251 in.)
1st undersize (0.25 mm)	53.708–53.728 mm (2.1145–2.1153 in.)
2nd undersize (0.50 mm)	53.458–53.478 mm (2.1046–2.1054 in.)
3rd undersize (0.75 mm)	53.208–53.228 mm (2.0948–2.0956 in.)
Main bearing radial clearance (with Plastigage®)	
new parts	0.03–0.08 mm (.0012–.0031 in.)
wear limit	0.17 mm (.0067 in)
Crankshaft axial play (side clearance)	
new parts	0.07–0.17 mm (.0028–.0067 in.)
wear limit	0.25 mm (.0098 in.)
Crankshaft connecting rod journals diameter	
basic dimension	47.758–47.778 mm (1.8802–1.8810 in.)
1st undersize (0.25 mm)	47.508–47.528 mm (1.8704–1.8712 in.)
2nd undersize (0.50 mm)	47.258–47.278 mm (1.8606–1.8613 in.)
3rd undersize (0.75 mm)	47.008–47.028 mm (1.8507–1.8515 in.)
Connecting rod bearing radial clearance (with Plastigage®) wear limit	0.12 mm (.0047 in.)
Connecting rod bearing axial clearance (side clearance) wear limit	0.37 mm (.0146 in.)
Intermediate shaft axial clearance (side clearance)	0.25 mm (.0098 in.)

III. Piston, Piston Ring and Cylinder Bore Specifications

Cylinder bore diameter
- 8-valve engines
  - basic dimension . . . . .81.01 mm (3.189 in.)
  - 1st oversize (0.25 mm) . . . . .81.26 mm (3.199 in.)
  - 2nd oversize (0.50 mm) . . . . 81.51 mm (3.209 in.)
  - out-of-round (max.) . . . . .0.04 mm (.0016 in.)
  - maximum deviation from nominal size . . 0.08 mm (.003 in.)
- 16-valve engines
  - basic dimension . . . . .81.01 mm (3.189 in.)
  - out-of-round (max.) . . . . .0.04 mm (.0016 in.)
  - maximum deviation from nominal size . .0.08 mm (.0031 in.)

Piston diameter
- 8-valve engines
  - basic dimension . . . . .80.98 mm (3.188 in.)
  - 1st oversize (0.25 mm) . . . . .81.23 mm (3.198 in.)
  - 2nd oversize (0.50 mm) . . . . .81.48 mm (3.208 in.)
- 16-valve engines
  - basic dimension . . . . .80.98 mm (3.188 in.)

Piston-to-cylinder clearance
- with new parts . . . . .0.03 mm (.0012 in.)
- wear limit . . . . .0.07 mm (.0028 in.)

Piston rings clearance (ring to ring land) . . . . .0.02–0.05 mm (.0008–.0019 in.)

Piston ring end gap (measured with ring only in cylinder)
- compression ring . . . . .0.30–0.45 mm (.012–.018 in.)
- compression ring wear limit . . . . .1.0 mm (.039 in.)
- oil scraper ring . . . . .0.25–0.45 mm (.010–.018 in.)
- oil scraper ring wear limit . . . . .1.00 mm (.039 in.)

IV. Camshaft, Valve and Cylinder Head Specifications

Camshaft
- axial play, maximum . . . . .0.15 mm (.0059 in.)
- runout, maximum permissible . . . . .0.01 mm (.0004 in.)
- radial clearance (with Plastigage®)
  - wear limit . . . . .0.1 mm (.004 in.)

Cylinder head
- warpage, maximum . . . . .0.1 mm (.004 in.)
- thickness, minimum
  - 8-valve engines . . . . .132.6 mm (5.220 in.)
  - 16-valve engines (do not resurface) . . .118.1 mm (4.650 in.)

Cylinder block
- deck warpage, maximum . . . . .0.1 mm (.004 in.)

Valve seat dimensions
- seat angle . . . . 45°
- upper correction angle . . . . 30°
- lower correction angle (16-valve engines)
  - intake . . . . 75°
- seat width, intake
  - 8-valve engines .2.00 mm (.079 in.)
  - 16-valve engines . . . . .1.5-1.8 mm (.059 -.071 in.)
- seat width, exhaust
  - 8-valve engines . . . . .2.4 mm (.094 in.)
  - 16-valve engines . . . . approx. 1.8 mm (.071 in.)
- outside seat diameter of 45° face, intake
  - 8-valve engines . . . . .39.2 mm (1.543 in.)
  - 16-valve engines . . . . .31.2 mm (1.228 in.)
- outside diameter of 45° face, exhaust
  - 8-valve engines . . . . .32.4 mm (1.276 in.)
  - 16-valve engines . . . . .27.6 mm (1.087 in.)

IV. Camshaft, Valve and Cylinder Head Specifications (continued)

Valve guide wear, maximum (measure with new valve)
- intake . . . . 1.0 mm (.039 in.)
- exhaust . . . . 1.3 mm (.059 in.)

Intake valve dimensions
- stem diameter
  - 8-valve engines . . . . 7.97 mm (.314 in.)
  - 16-valve engines . . . . 6.97 mm (.274 in.)
- length
  - 8-valve engines
    - w/mechanical cam followers . . . . . . 98.70 mm (3.886 in.)
    - w/hydraulic cam followers . . . . 91.00 mm (3.583 in.)
  - 16-valve engines . . . . 95.50 mm (3.760 in.)
- head diameter
  - 8-valve engines . . . . 40.00 mm (1.575 in.)
  - 16-valve enginess . . . . 32.00 mm (1.259 in.)

Exhaust valve dimensions
- stem diameter
  - 8-valve engines . . . . 7.95 mm (.313 in.)
  - 16-valve engines . . . . 6.94 mm (.273 in.)
- length
  - 8-valve engines
    - w/mechanical cam followers . . . . . . 98.50 mm (3.878 in.)
    - w/hydraulic cam followers . . . . 90.80 mm (3.575 in.)
  - 16-valve engines . . . . 98.20 mm (3.846 in.)
- head diameter
  - 8-valve engines . . . . 33.00 mm (1.299 in.)
  - 16-valve engines . . . . 28.00 mm (1.102 in.)

Valve clearance
- 1985-1987 8-valve (JH) w/adjustable cam followers only
- engine cold
  - intake . . . . 0.15–0.25 mm (.006–.010 in.)
  - exhaust . . . . 0.35–0.45 mm (.014–.018 in.)
- engine hot (minimum coolant temperature 95°F (35°C))
  - intake . . . . 0.20–0.30 mm (.008–.012 in.)
  - exhaust . . . . 0.40–0.50 mm (.016–.020 in.)

V. Lubrication System Specifications

Oil pump gears
- backlash . . . . 0.05–0.20 mm (.002–.008 in.)
- axial play, wear limit. . . . . 0.15 mm (.006 in.)

Oil pressure, minimum at 2000 rpm
- (with SAE 10W oil at 140°F (68°C)) . . . . 2.0 bar (28 psi)

Oil pressure warning system
- low pressure switch
- (nominal 0.3 bar, normally closed)
  - opens . . . . 0.15–0.45 bar (2.2–6.5 psi)
- dynamic pressure switch
- (nominal 1.8 bar, normally open)
  - closes . . . . 1.6–2.0 bar (23–29 psi)