

General

This group covers E46 cylinder head removal and installation as well as cylinder head/valve diagnosis procedures.

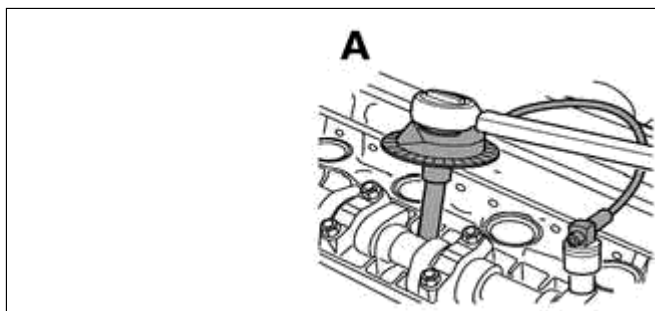
The information given in this repair group assumes that the engine is installed in the engine bay. In order to remove the cylinder head from the engine block, the VANOS control unit and the camshafts must be removed from the cylinder head. For cylinder head and valvetrain reconditioning information, see ⇒ [116 Cylinder Head and Valvetrain](#).

Note:

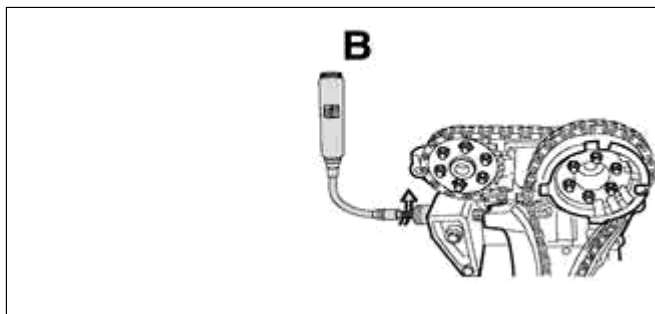
If a head gasket problem is suspected, a compression test or leak-down test will usually detect the fault. See ⇒ [Diagnostic Testing](#) later in this group.

Special tools

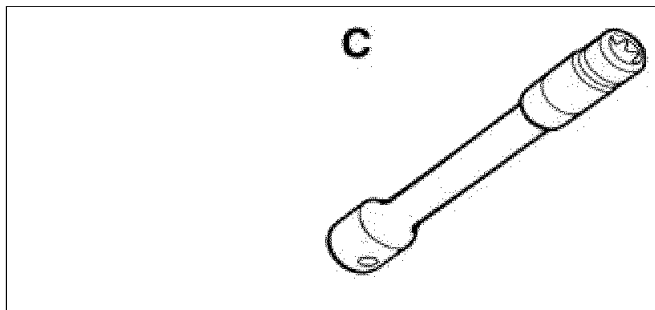
Special BMW service tools are required to properly remove and install the cylinder head on engines covered by this manual. The special tools are used to time the valvetrain to the crankshaft, to remove the VANOS control unit, the camshafts and the Torx (E12) head bolts. Read the entire procedure through before beginning the job.



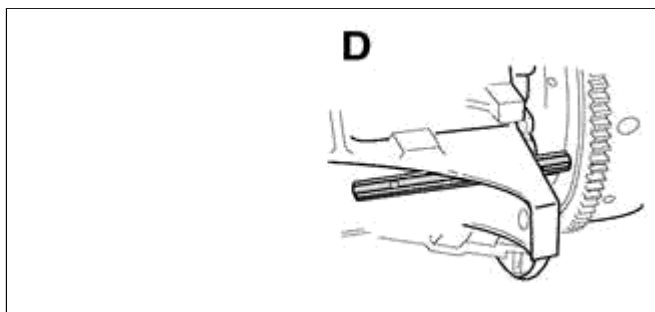
- ✦ Rotary angle dial gauge BMW special tool 00 9 120



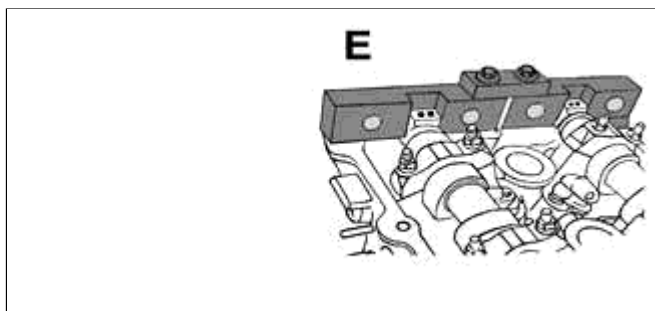
- ✦ Torque wrench w/ flex extension BMW special tool 00 9 250



- ✦ E-12 Torx socket BMW special tool 11 2 250



- ✦ Crankshaft locking tool BMW special tool 11 2 300



- ✦ Camshaft locking tool BMW special tool 11 3 240



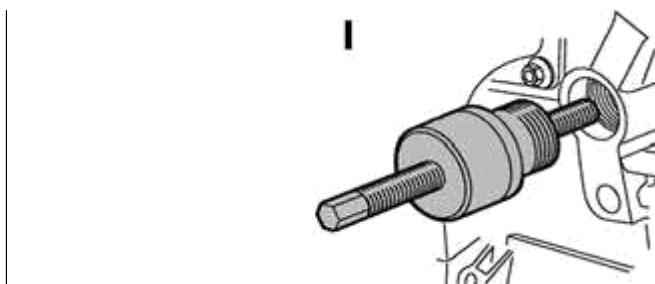
- ✦ Camshaft locking tool bracket BMW special tool 11 3 244



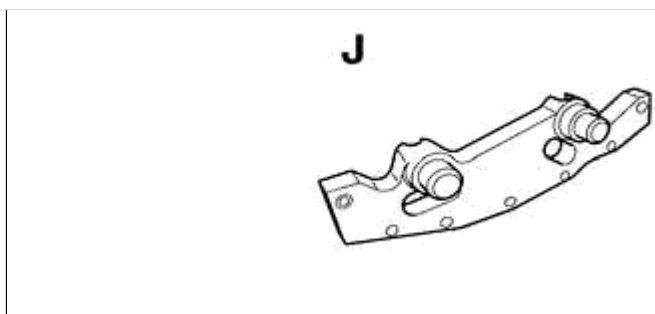
- ✦ Lifter retaining suction cup BMW special tool 11 3 250



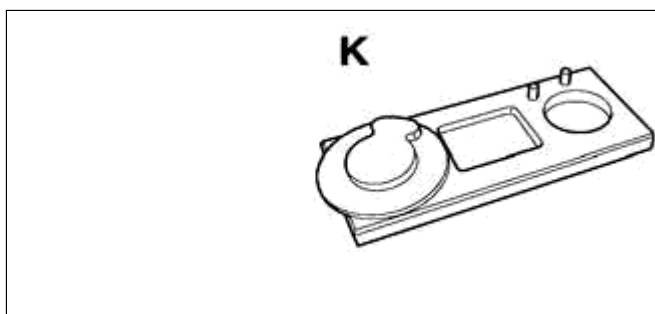
- Camshaft bearing cap removal tool
BMW special tool 11 3 260 /11 3 270



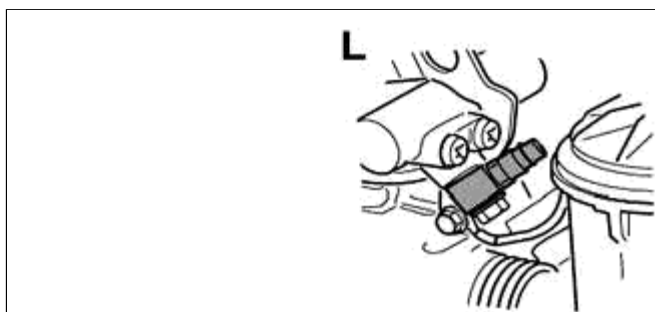
- Timing chain tensioner tool BMW
special tool 11 4 220



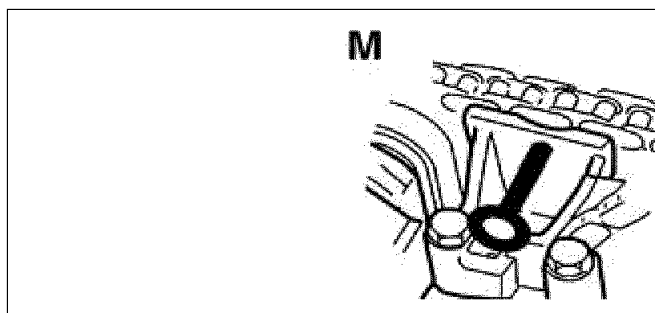
- VANOS adjustment plate BMW special
tool 11 6 150



- Secondary sprocket setup tool BMW
special tool 11 6 180



- Air line adapter BMW special tool 11 3
450



- Secondary chain tensioner lock pin
BMW special tool 11 3 292

Cylinder Head Removal

WARNING!

Due to risk of personal injury, be sure the engine is cold before beginning the removal procedure.

Cylinder head removal and installation is a complicated repair procedure. VANOS control unit, timing chain, and camshaft removal and installation all require special tools. Read the entire procedure before beginning the repair.

CAUTION!

Cover all painted surfaces before beginning the removal procedure. As an aid to installation, label all components, wires, and hoses before removing them. Do not reuse gaskets, O-rings or seals during reassembly.

To assist the technician in this repair, the procedure has been organized into discrete jobs. Please be advised that these individual jobs must be accomplished in the order in which they appear.

- ⇒ [Intake manifold, removing](#)
- ⇒ [Cylinder head cover, removing](#)
- ⇒ [VANOS control unit, removing](#)
- ⇒ [Camshafts and valvetrain, removing](#)
- ⇒ [Cylinder head assembly, removing](#)

Intake manifold, removing

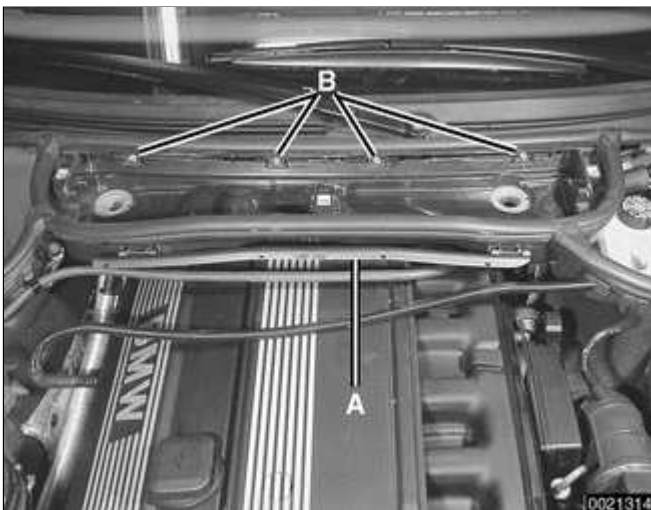
- Disconnect negative (-) battery cable in trunk.

CAUTION!

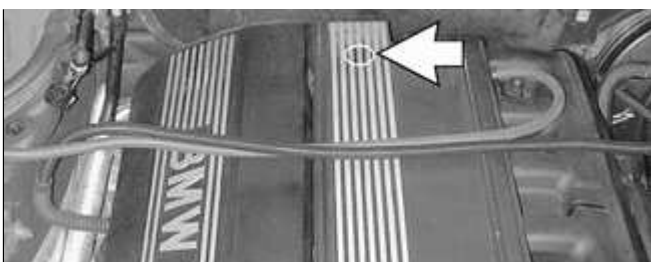
- ♦ **Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.**
- ♦ **Disconnecting the battery may erase fault code(s) stored in control module memory. Check for fault codes using special BMW diagnostic equipment.**



- Remove microfilter for interior ventilation.



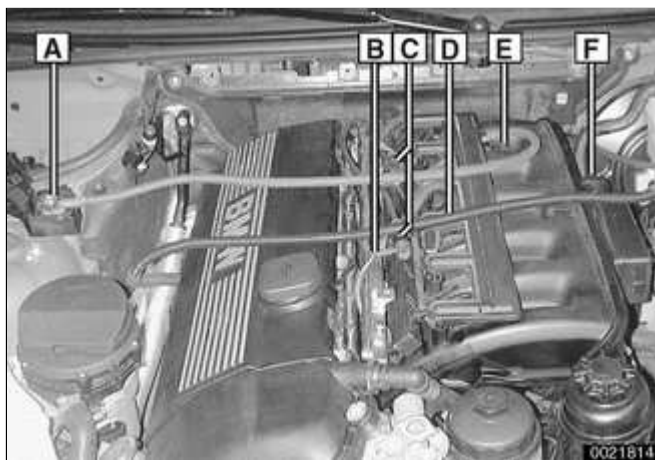
- Remove housing for interior ventilation microfilter.
 - ♦ Open wiring harness loom cover (A) and remove wires.
 - ♦ Unfasten screws (B) and remove lower microfilter housing.



- Remove intake manifold cover:
 - ♦ Remove plastic trim covers (arrows).

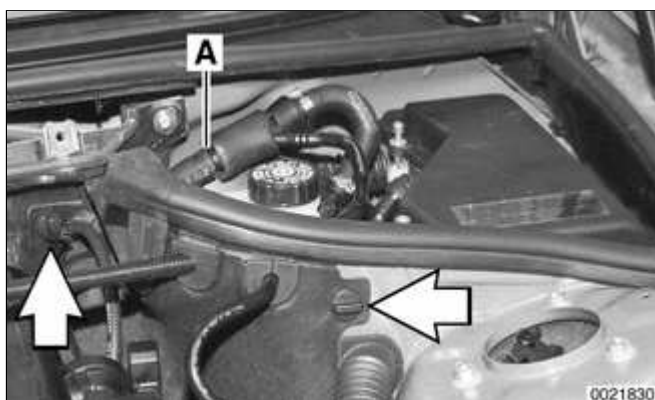


- ◆ Remove cover hold down bolts from intake cover and lift off cover.



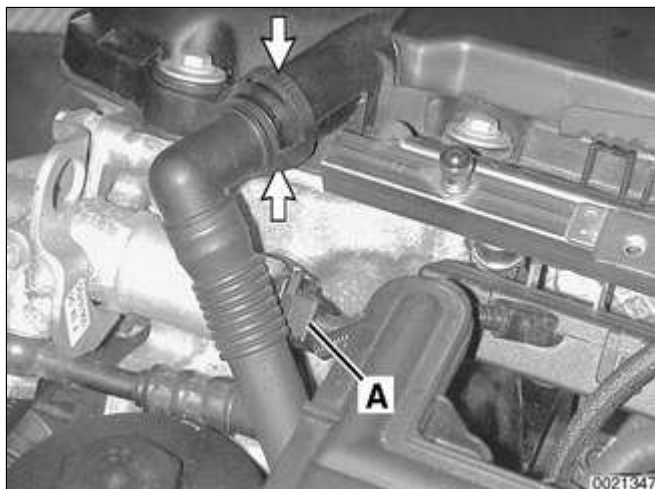
- ✦ Working above engine, disconnect the following:

- ◆ **A** Positive engine lead at B+ terminal
- ◆ **B** Manifold vacuum line
- ◆ **C** Oxygen sensor connectors (label connectors before disconnecting)
- ◆ **D** Electrical harness connector for intake air temperature sensor
- ◆ **E** Positive lead hold-down bracket
- ◆ **F** Intake manifold resonance valve electrical connector



- ✦ Working at left rear of engine compartment:

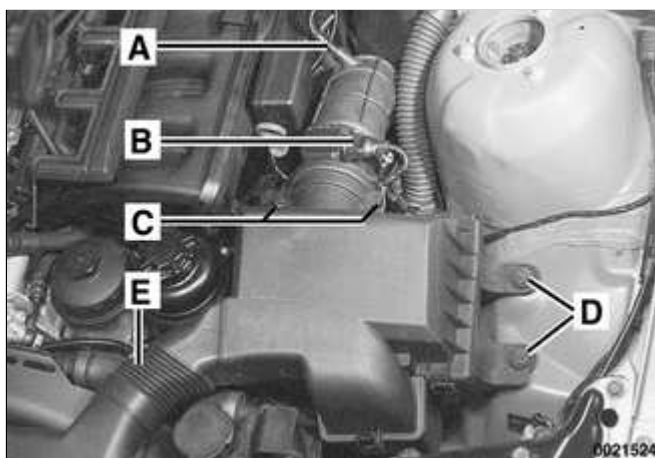
- ◆ Peel rubber edge seal off top of panel.
- ◆ Separate brake booster vacuum hose at intake jet pump (**A**). Plug hose ends.
- ◆ Twist plastic panel retainers (**arrows**) 90° and pull out to remove.
- ◆ Disengage panel from hoses and wiring harnesses and remove from engine compartment.



- ✦ Disconnect engine vent hose from cylinder head cover by squeezing sides of spring clip (**arrows**). Disconnect VANOS solenoid electrical harness connector (**A**).



- ✦ Disconnect fuel injector electrical connectors from injectors:
 - ◆ Use small screwdriver to pry one corner of wire lock clip on fuel injector 1 connector.
 - ◆ Repeat for all injectors.
 - ◆ Lift off connector loom and lay aside.

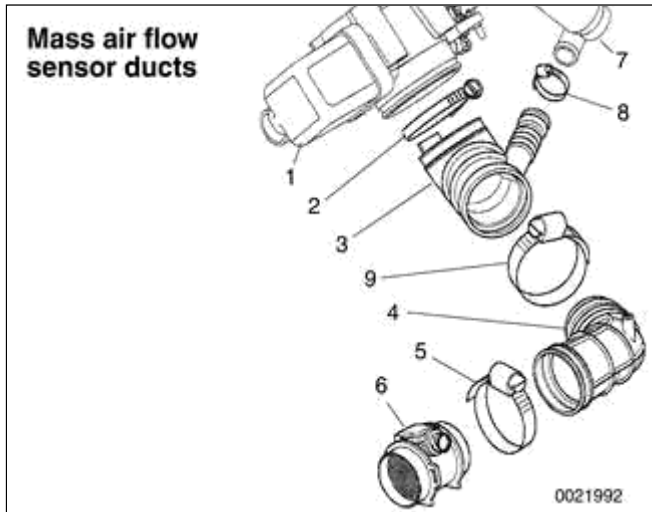


- ✦ Remove complete air filter housing:
 - ◆ Disconnect vacuum line at intake boot (**A**).
 - ◆ Disconnect electrical harness connector on mass air flow sensor (**B**).
 - ◆ Release mass air flow sensor clips (**C**).
 - ◆ Remove filter housing mounting screws (**D**).
 - ◆ Disconnect air duct connection (**E**) and lift complete air filter housing out of engine compartment,

pulling it forward away from mass air flow sensor.

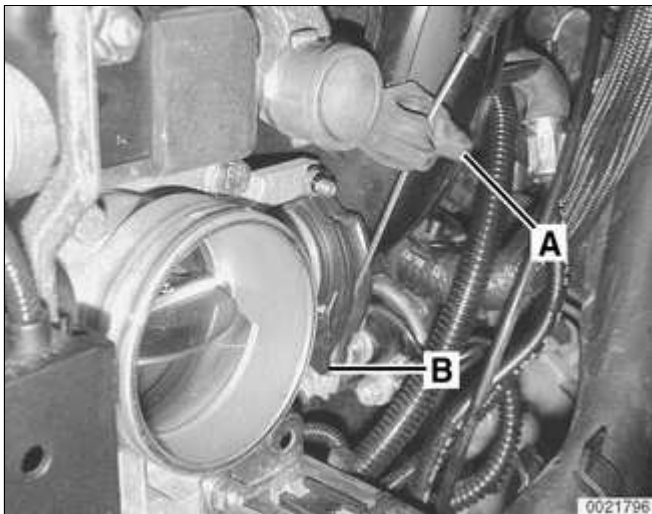
Note:

In this step, mass air flow sensor remains attached to rubber air duct.



- ✦ Loosen clamps **2** and **8** and remove mass air flow sensor and air duct.

- 1 - Throttle assembly
- 2 - Hose clamp 77 - 84 mm
- 3 - Y-duct
- 4 - Air duct
- 5 - Hose clamp 83 - 90 mm
- 6 - Mass air flow sensor
- 7 - Idle control valve
- 8 - Hose clamp 28 - 33 mm
- 9 - Hose clamp 77 - 84 mm



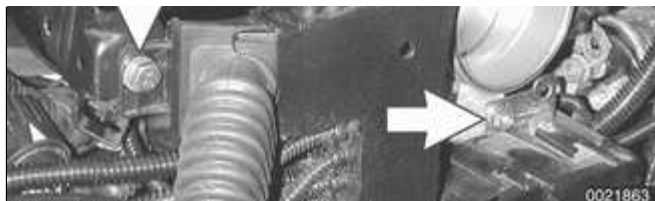
- ✦ Where applicable: Pull throttle cable upwards out of rubber retainer (**A**) and unhook ball end of cable (**B**) from throttle actuator.

Note:

Models with M54 engines do not use a throttle cable.



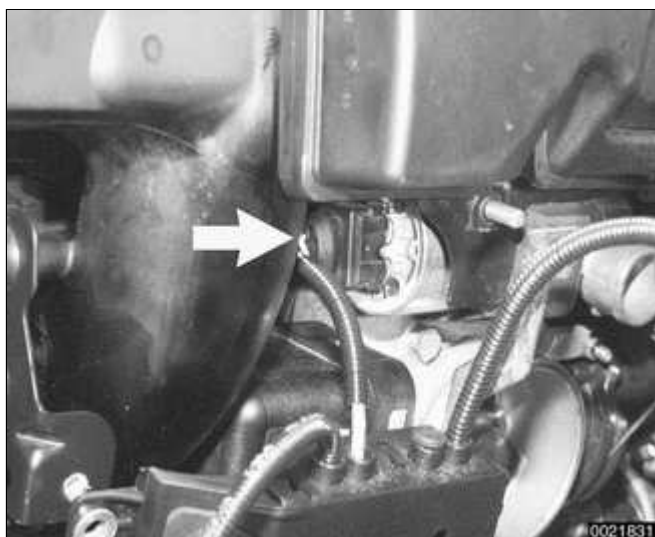
- ✦ Remove nuts and bolt (**arrows**) retaining wiring harness conduit to throttle body.



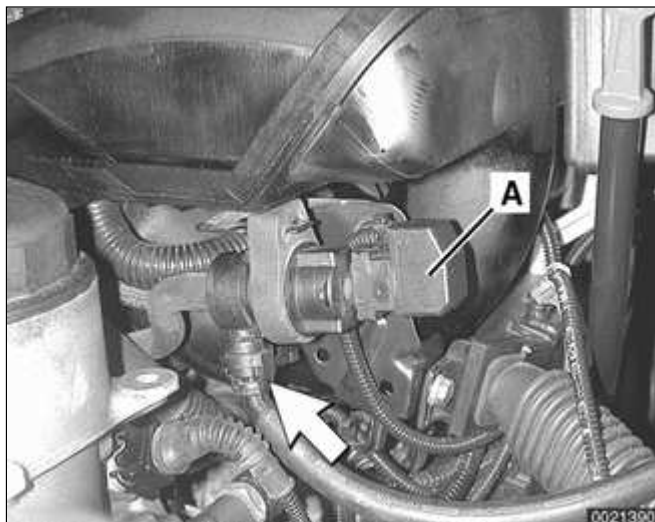
- ✦ Working at throttle housing:
 - ◆ Turn harness plug (**arrow**) counterclockwise and remove.

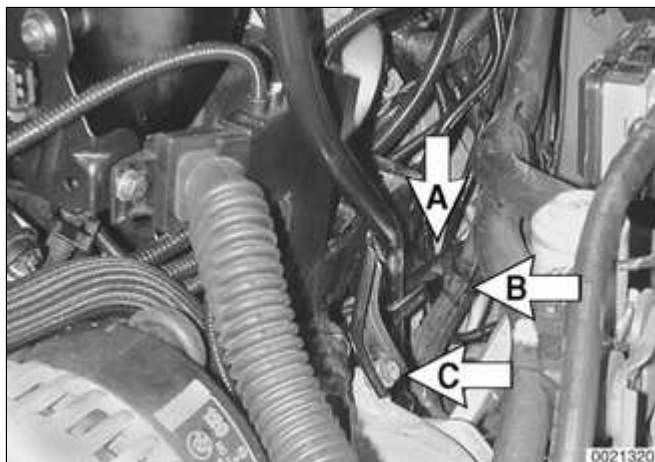


- ✦ Disconnect electrical harness connector at idle speed control valve (**arrow**) directly above throttle housing.



- ✦ Working under front corner of intake manifold, disconnect electrical harness connector at fuel tank venting valve (**A**). Disconnect vent hose at quick disconnect fitting (**arrow**).





Remove dipstick guide tube:

- ◆ Disconnect wiring harness brackets from tube (A).
- ◆ Disconnect fuel lines from retaining clips (B).
- ◆ Remove lower dip stick guide tube mounting bolt (C). Pull out guide tube.



Remove schræder valve cap (**arrow**). Using a tire chuck, blow fuel back through feed line using a brief burst of compressed air (maximum of 3 bar or 43.5 psi).

WARNING!

- ◆ **Fuel in fuel line is under pressure (approx. 3 - 5 bar or 45 -75 psi) and may be expelled under pressure. Do not smoke or work near heaters or other fire hazards. Keep a fire extinguisher handy. Before disconnecting fuel hoses, wrap a cloth around fuel hoses to absorb any leaking fuel. Catch and dispose of escaped fuel. Plug all open fuel lines.**
- ◆ **Always unscrew fuel tank cap to release pressure in the tank before working on the tank or lines.**
- Raise car and support in a safe manner.

WARNING!

Make sure the car is stable and well supported at all times. Use a

professional automotive lift or jack stands designed for the purpose. A floor jack is not adequate support.

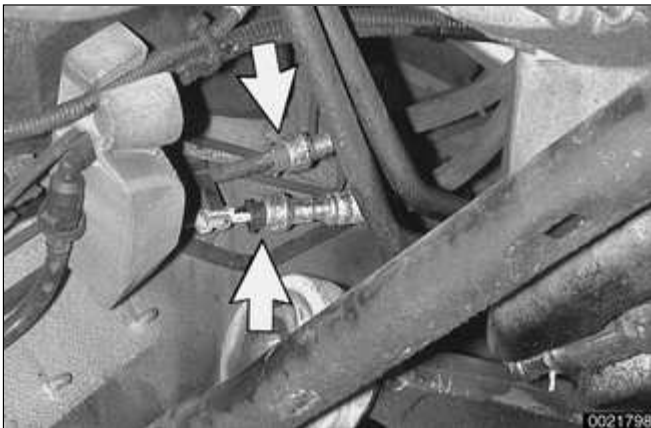
- Remove protective engine splash guard from beneath engine compartment.



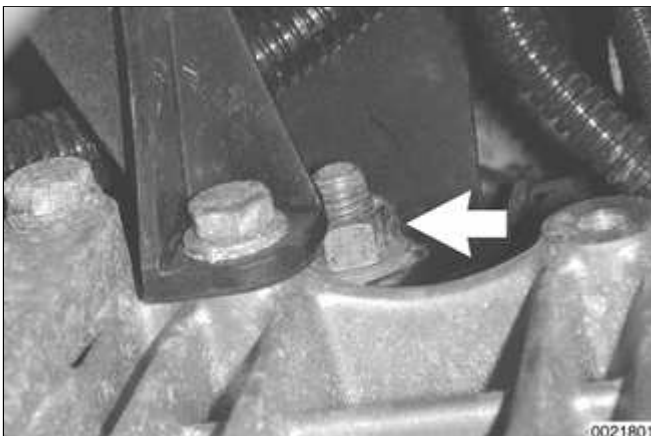
- Working beneath car (on left side under driver seat), remove fuel filter cover and clamp off fuel hose(s) (**arrows**).

Note:

M54 engines equipped with a non-return fuel rail use only a single supply line.



- Disconnect fuel hose(s) from fuel line(s) (**arrows**) using special fuel line removal tool 16 1 050 or equivalent. Plug open fuel line(s) with BMW special tools 13 5 281/13 5 282.



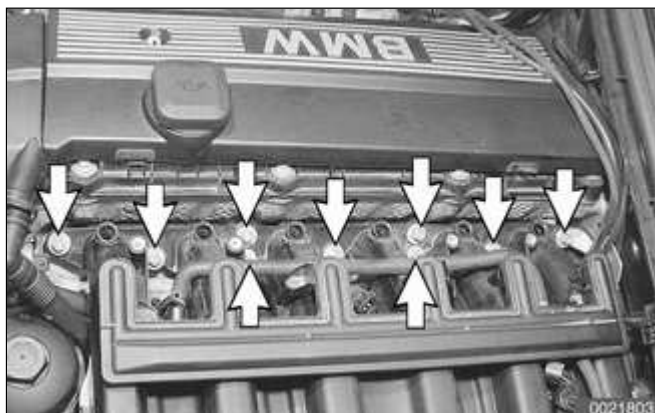
- Working underneath car, remove lower intake manifold support mounting bolt (**arrow**), located adjacent to left (driver's side) engine mount.



- Remove fuel rail mounting bolts (**arrows**).
- ♦ Carefully pry fuel rail off manifold.



- ◆ Separate fuel line support bracket at rear of intake manifold.
- ◆ Thread fuel line(s) out of rear of engine compartment while lifting fuel rail out.



- ✦ Remove intake manifold mounting nuts (**arrows**).



- ✦ Lift up manifold enough to disconnect positive cables from starter motor terminal (**arrow**).
- ◆ Remove intake manifold from cylinder head while carefully checking for any remaining electrical connections or hoses.

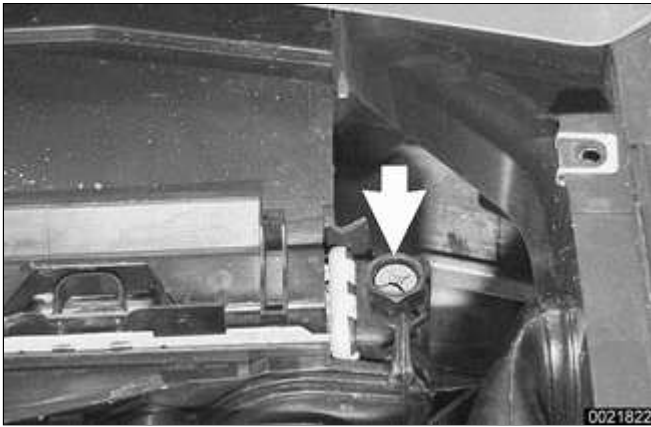
CAUTION!

Stuff clean lint free rags into open intake ports to prevent any foreign matter from falling into the ports.



- ✦ Drain engine coolant from engine block:
 - ◆ Remove expansion tank cap on radiator.
 - ◆ Place 3-gallon pail beneath engine to capture coolant.
 - ◆ Remove coolant drain plug located on exhaust side of cylinder

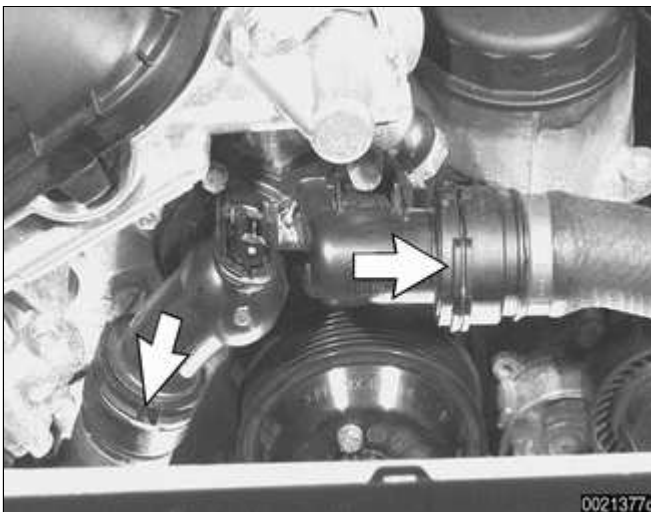
2 of engine block (**arrow**).



- ✦ Drain radiator into a 3-gallon pail by removing plastic drain plug at lower left end of radiator (**arrow**).

WARNING!

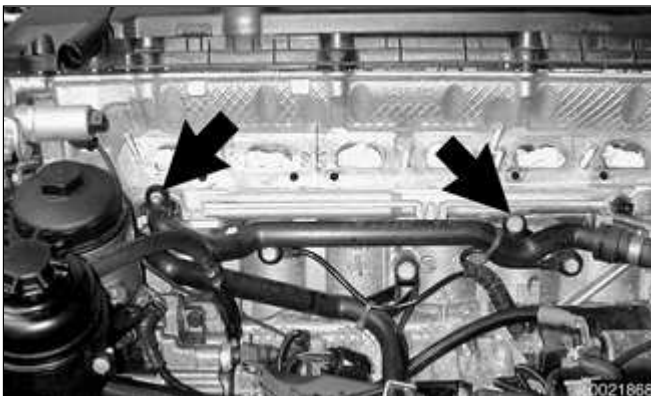
Use caution when draining and disposing of engine coolant. Coolant is poisonous and lethal to humans and pets. Pets are attracted to coolant because of its sweet smell and taste. Consult a veterinarian if coolant is ingested by an animal. Dispose of drained coolant according to local, state, and federal laws.



- ✦ Remove hoses from thermostat housing by releasing locks (**arrows**).
 - Disconnect electrical harness at thermostat housing.
 - Remove radiator cooling fan and shroud as described in ⇒ [170 Radiator and Cooling System](#)

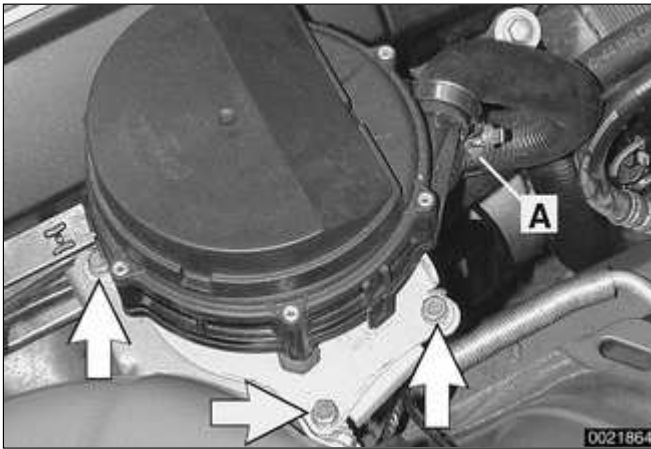
CAUTION!

On cars with viscous clutch cooling fan, radiator fan mounting nut (32 mm) has left-hand threads.



- ✦ Remove fasteners (**arrows**) from heater bypass tube and set tube to side leaving heater hose connected.
 - Unbolt power steering fluid reservoir and pull aside without disconnecting hoses. Tie to fender with cord or stiff wire.
 - Remove windshield and headlight washer reservoir:

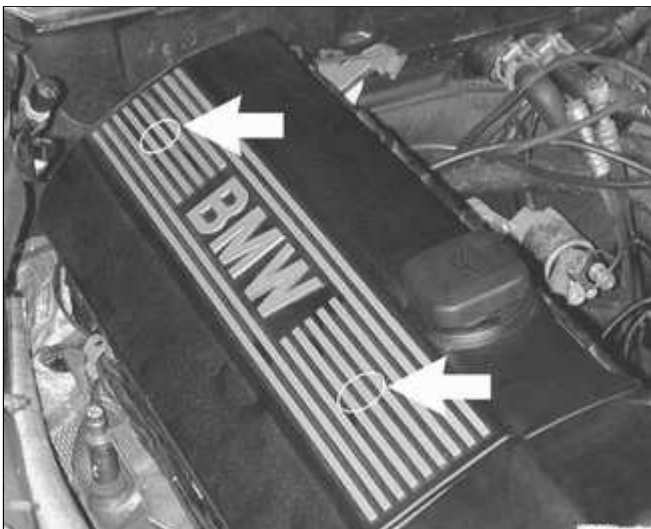
- ◆ Remove bolt on top of reservoir.
- ◆ Lift tank and disconnect electrical connections to pump and to washer fluid level sensor.
- ◆ Disconnect hoses to windshield washer and headlight washer. Tilt reservoir to prevent fluid from leaking out.

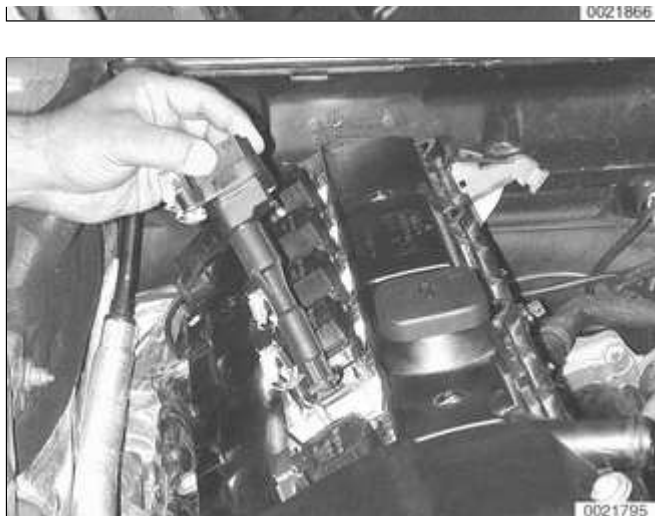


- ✦ Remove secondary air pump:
 - ◆ Disconnect hose at one-way valve (**A**).
 - ◆ Remove bolts at support bracket on strut tower (**arrows**).
 - ◆ Lift up pump and disconnect electrical harness from bottom of pump. Remove pump.
 - ◆ Unbolt and remove pump bracket from strut tower.

Cylinder head cover, removing

- ✦ Remove cylinder head top cover:
 - ◆ Remove plastic trim covers (**arrows**).
 - ◆ Remove cover hold down nuts and lift off cover.





- Remove ignition coils.
 - ◆ Disconnect ignition coil harness connectors.
 - ◆ Remove coil mounting fasteners.
 - ◆ Remove coils.
 - ◆ Remove ground straps.
 - ◆ Set coil harness to left side of engine compartment.
- Remove cylinder head cover mounting fasteners and remove cylinder head cover.

Note:

The cylinder head cover mounting bolt insulators and gaskets should be reinstalled in their original locations. The three grounds mount to the first, second and fourth central studs. Make note of their arrangement during removal.

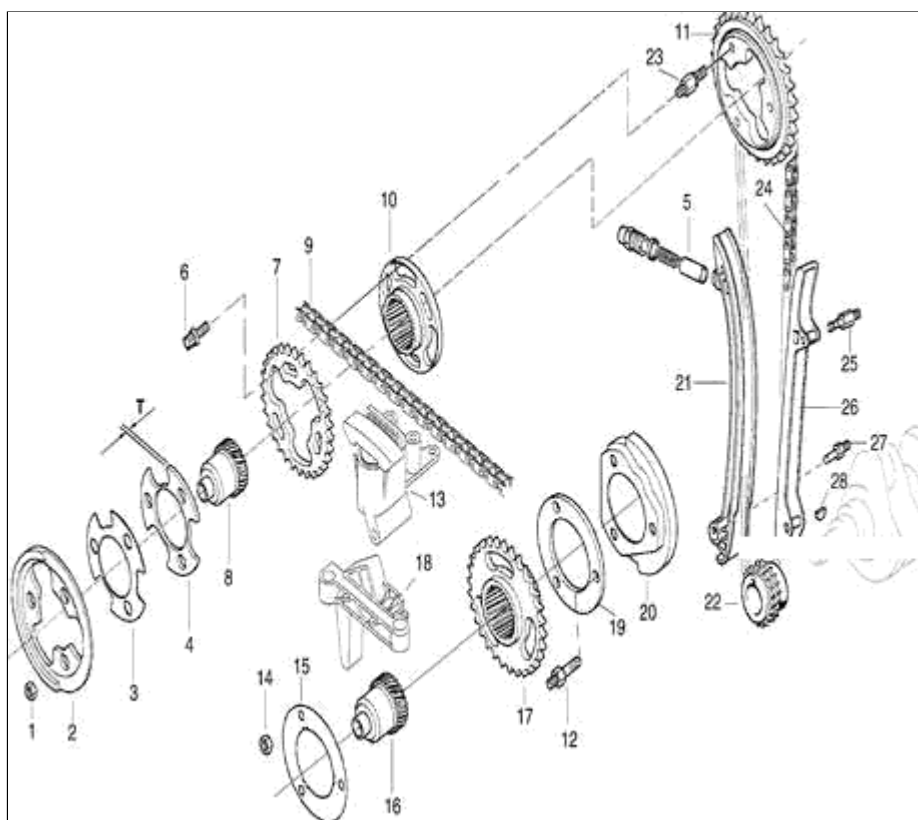
- Remove spark plugs.

CAUTION!

Stuff clean lint free rags into open intake ports to prevent any foreign matter from falling into the ports.



- Remove oil baffle cover from above intake camshaft.



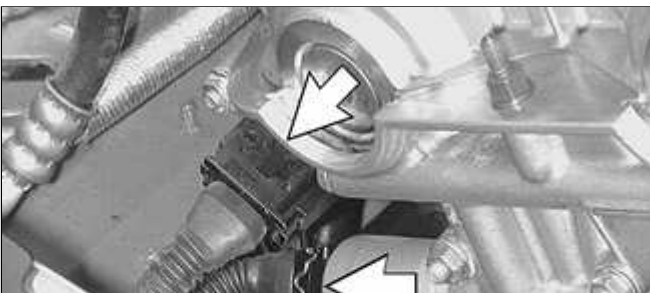
Double VANOS components (M52 TU, M54 engine)

- 1 - Impulse wheel mounting nut
- 2 - Exhaust camshaft impulse wheel
- 3 - Spring plate
- 4 - Thrust spacer (T = 3.5 mm)
- 5 - Splined shaft
- 6 - Torx screw
- 7 - Exhaust secondary sprocket
- 8 - Secondary timing chain
- 9 - Splined sleeve
- 10 - Primary sprocket
- 11 - Threaded locating stud
- 12 - Secondary chain tensioner
- 13 - Secondary chain lower guide

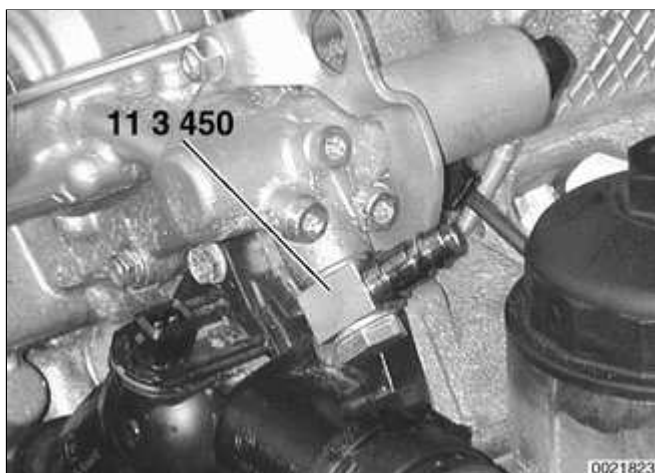
- 14 - Sprocket mounting nut
- 15 - Spring plate
- 16 - Splined shaft
- 17 - Intake camshaft sprocket
- 18 - Locating stud
- 19 - Thrust spacer
- 20 - Intake camshaft impulse wheel
- 21 - Chain tensioner rail
- 22 - Crankshaft sprocket
- 23 - Primary chain tensioner
- 24 - Primary chain
- 25 - Locating stud
- 26 - Guide rail
- 27 - Locating stud
- 28 - Woodruff key

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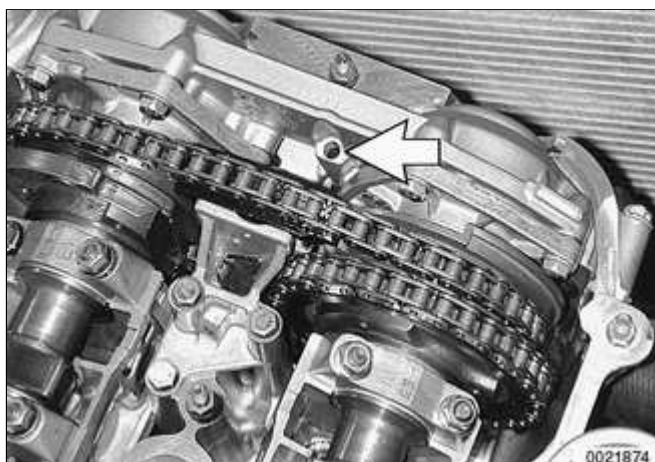
VANOS control unit, removing



- ◀ Disconnect electrical connections at exhaust camshaft position sensor and exhaust camshaft VANOS control valve (**arrows**).

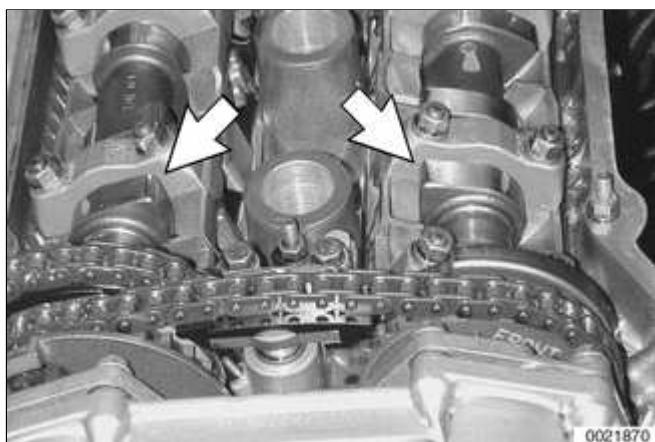


- Remove banjo bolt from VANOS unit oil pressure line. Use banjo bolt to attach BMW special tool 11 3 450 (compressed air fitting) to VANOS control unit.



- Cover oil hole (**arrow**) in VANOS unit with shop towel to capture oil which will spray when compressed air is applied.

- Connect compressed air line to air fitting. Apply air pressure set to 2 - 8 bar (30 - 110 psi).

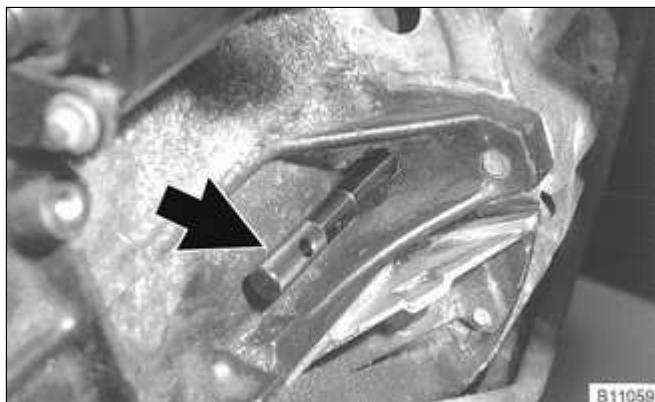


- With compressed air line connected, rotate engine in direction of rotation (clockwise) until cylinder 1 intake and exhaust camshaft lobes face each other (**arrows**) in the top dead center (TDC) position for cylinder 1.

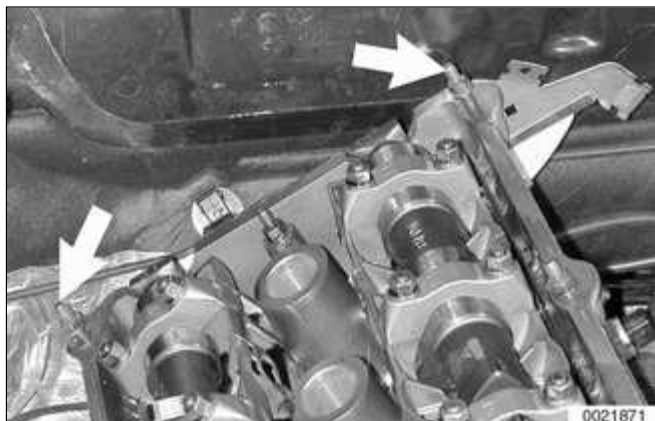
- Rotate engine at least twice, leaving the cylinder 1 intake and exhaust camshaft lobes facing each other, as shown.

CAUTION!

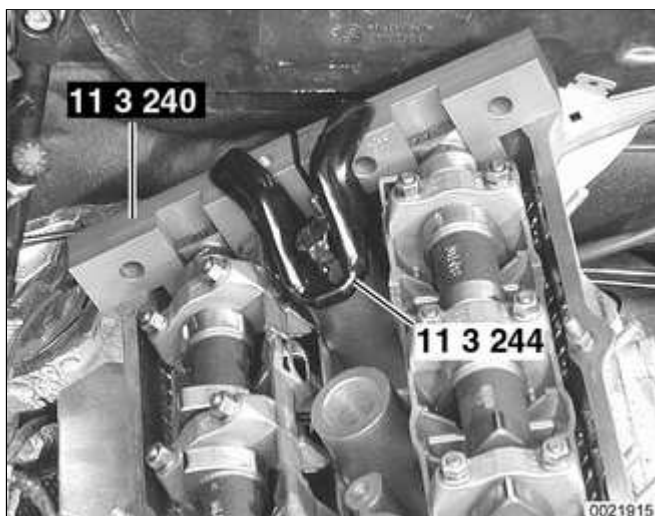
Do not rotate engine counterclockwise to reach the top dead center position. Instead, complete another two complete rotations.



- Remove sealing plug from special tool bore on lower left side of engine block near flywheel. Secure crankshaft in TDC position with BMW special tool 11 2 300 (**arrow**).



- Unscrew and remove two cylinder head cover studs (**arrows**) at rear of cylinder head.

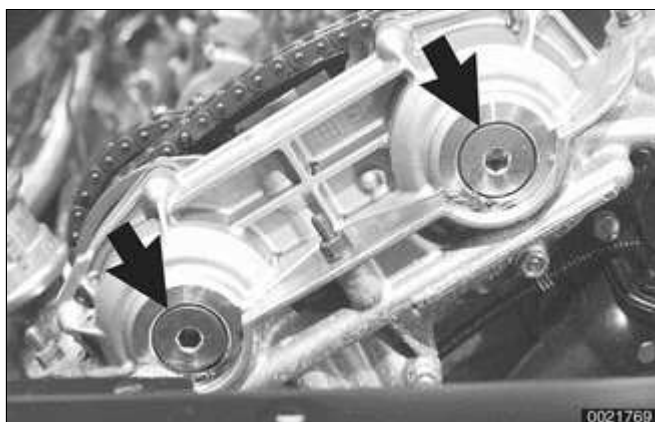


- Secure camshafts in TDC position using BMW special tools 11 3 240 and 11 3 244.

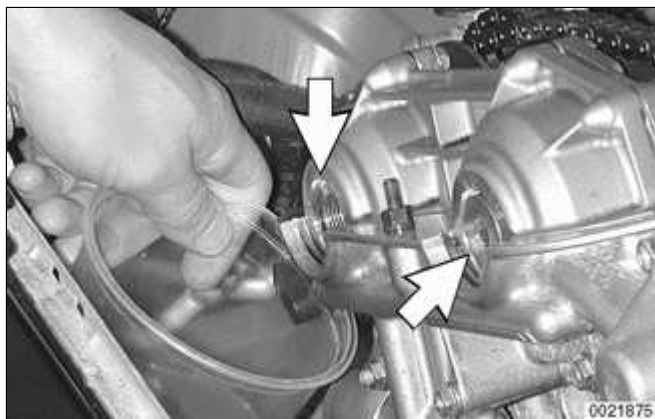
- Disconnect compressed air line, leaving compressed air fitting attached to VANOS unit.

CAUTION!

Oil will drain from pressure line. Have a drain container and rags ready. Do not allow oil to run onto drive belts.



- Unscrew sealing plugs (**arrows**) from VANOS unit.



- ⚡ Oil will drain from plugs (**arrows**) when removed. Have a container and rags ready. Do not allow oil to run onto drive belts.



- ⚡ Pull sealing caps straight out of VANOS unit with BMW special tool 11 6 170, or with short nose pliers.

Note:

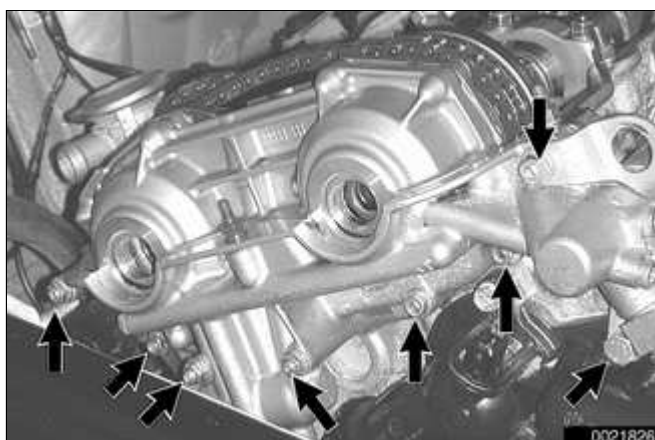
Additional oil may drain from VANOS unit.



- ⚡ Remove set screws (left-hand thread) on ends of intake and exhaust camshafts.

CAUTION!

Set screws have left hand threads. Remove in clockwise motion.



- ⚡ Remove VANOS unit:
 - ◆ Remove engine support eye fasteners from side of VANOS unit.
 - ◆ Remove VANOS mounting nuts (**arrows**) from cylinder head and pull VANOS unit and metal gasket off.

CAUTION!

Do not crank the engine with VANOS unit removed. The splined shaft on the intake camshaft might slip out of the VANOS spline teeth, causing the intake cam to no longer be positively connected to the timing chain, allowing for possible piston/valve interference.

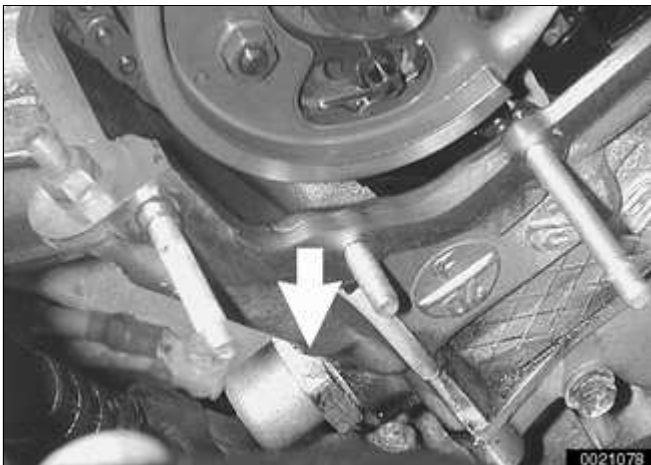
Note:

The VANOS unit will contain a small quantity of oil. Place shop towels to catch oil as unit is removed or tilted.

CAUTION!

If the VANOS adjustment unit is replaced, or if operations are completed that may change the timing of the camshafts, the camshaft timing must be checked as described later in this chapter.

Camshafts and valvetrain, removing



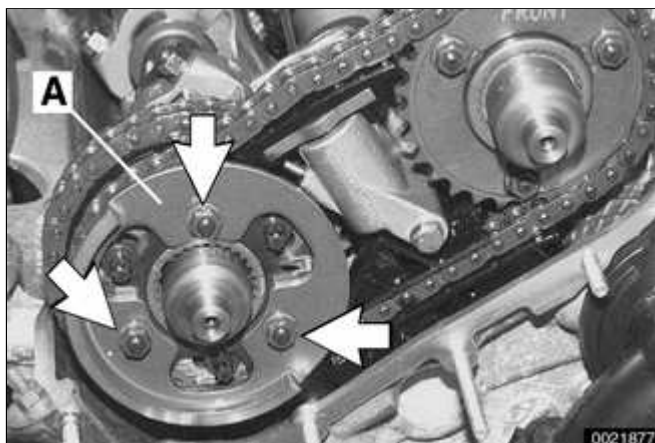
- Remove primary camshaft chain tensioner cylinder (**arrow**).

CAUTION!

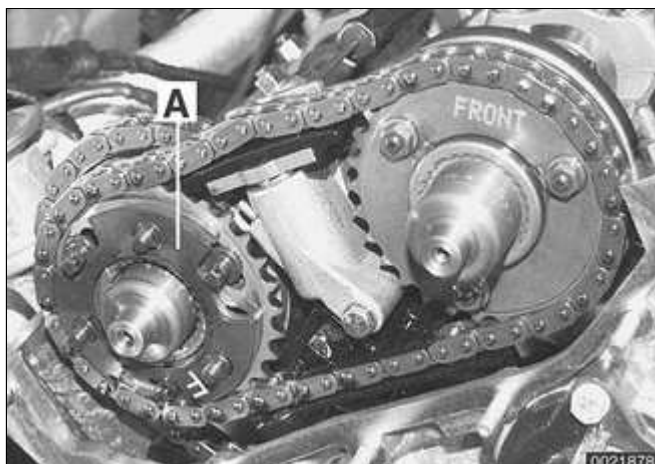
Primary camshaft chain tensioning piston is under spring pressure.



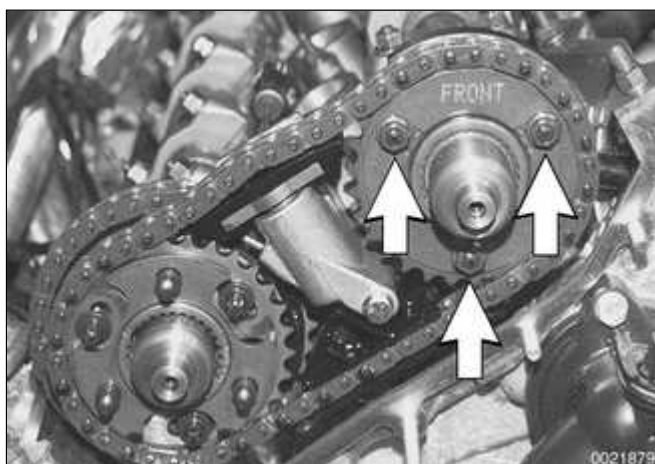
- Press down on secondary chain tensioner and lock into place using BMW special tool 11 3 292 or a similar size pin.



- Remove exhaust camshaft impulse wheel mounting nuts (**arrows**). Remove impulse wheel (**A**).



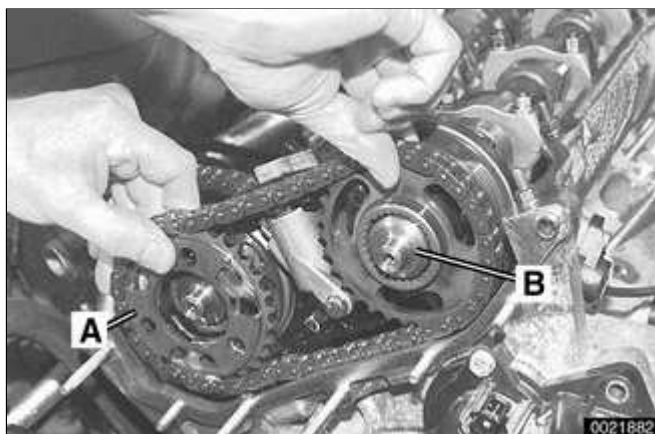
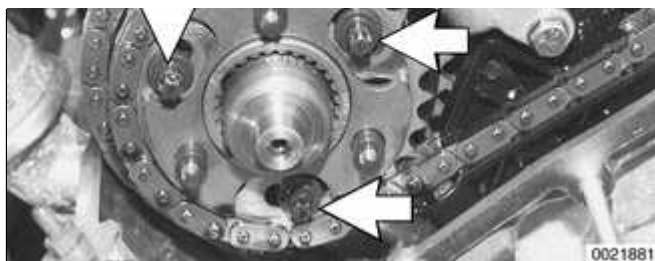
- Remove spring plate (**A**).



- Remove intake camshaft sprocket mounting nuts (**arrows**) and remove spring plate (labelled **FRONT**).



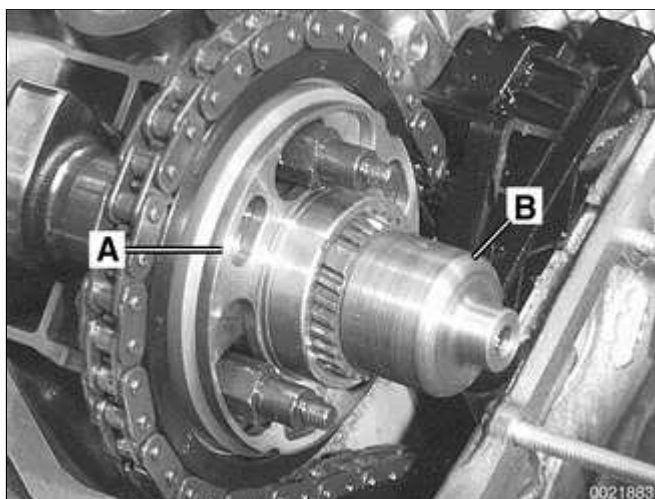
- Remove torx screws from exhaust camshaft sprocket (**arrows**).



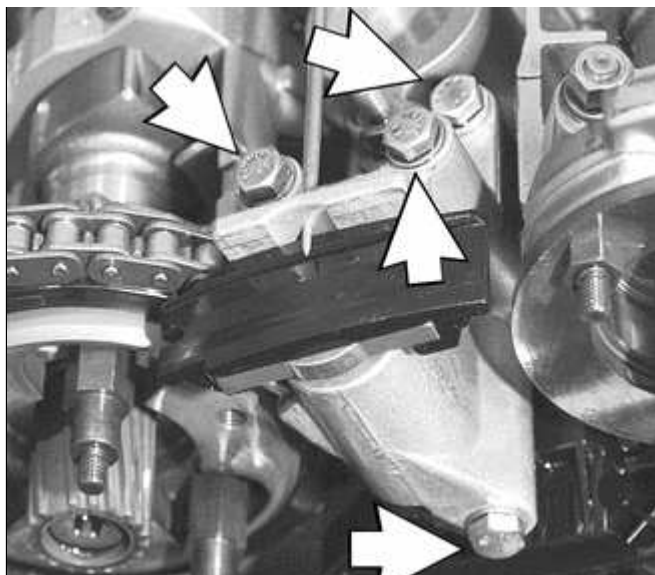
- Lift off exhaust and intake sprockets together with secondary chain, thrust spacer (A) from exhaust camshaft, and splined shaft (B) from intake camshaft.

CAUTION!

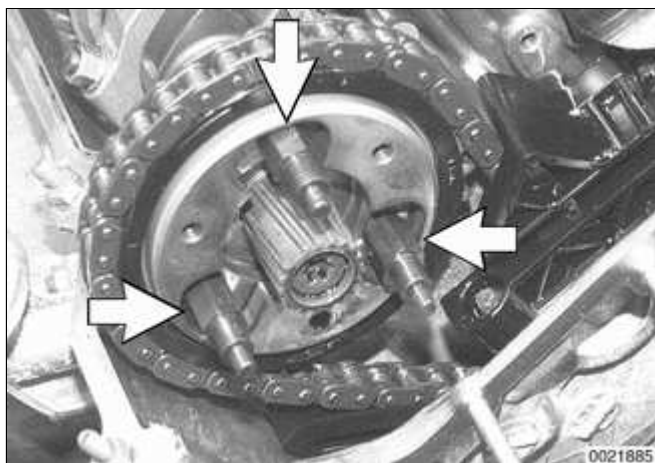
Splined shafts share the same part number for both intake and exhaust camshafts. Remove and mark used splined shafts in order and reinstall in original locations.



- Remove exhaust camshaft splined sleeve (A) and shaft (B).



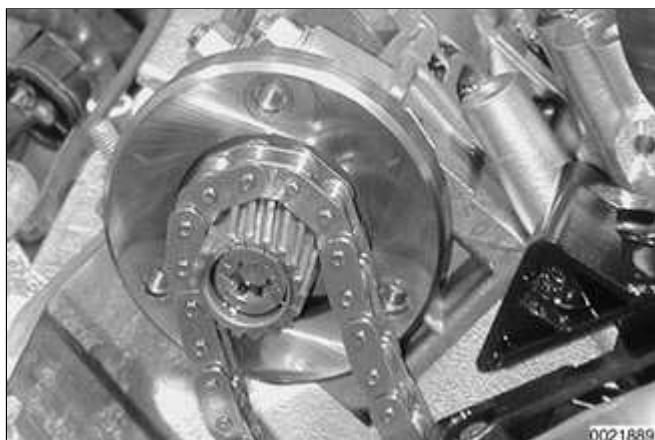
- Remove secondary chain tensioner mounting bolts (arrows). Remove tensioner from between camshafts while keeping retaining pin in place.



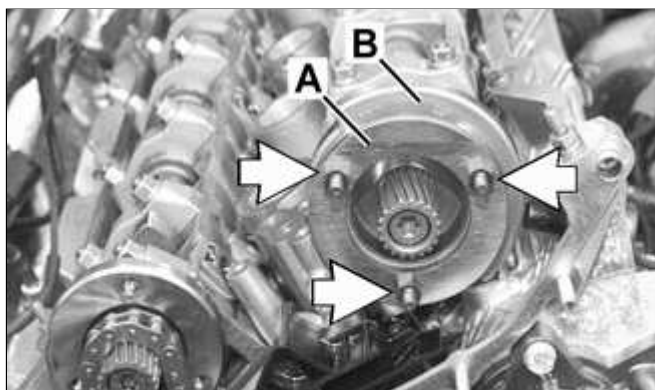
- Remove primary chain sprocket mounting studs (**arrows**) on exhaust camshaft.



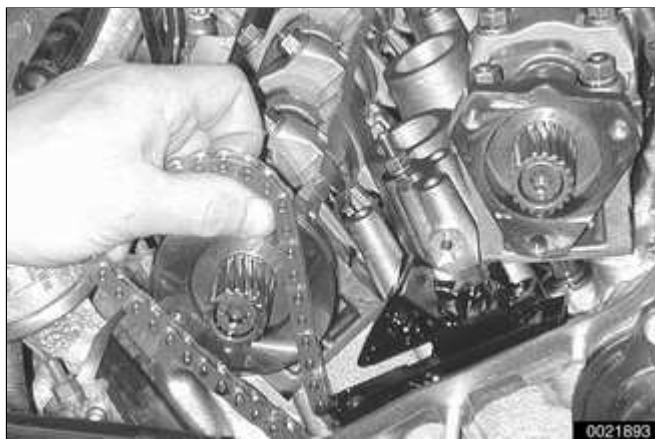
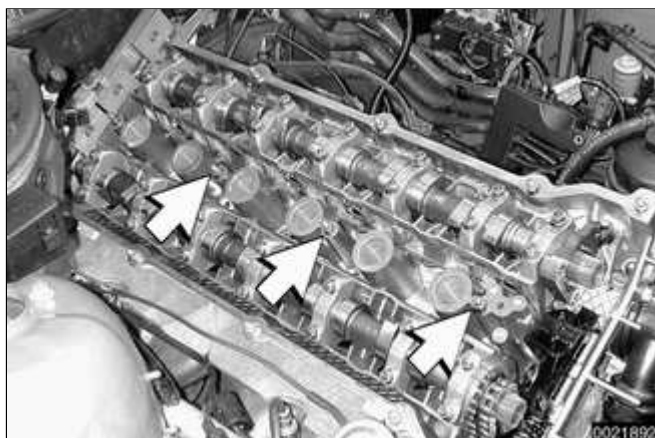
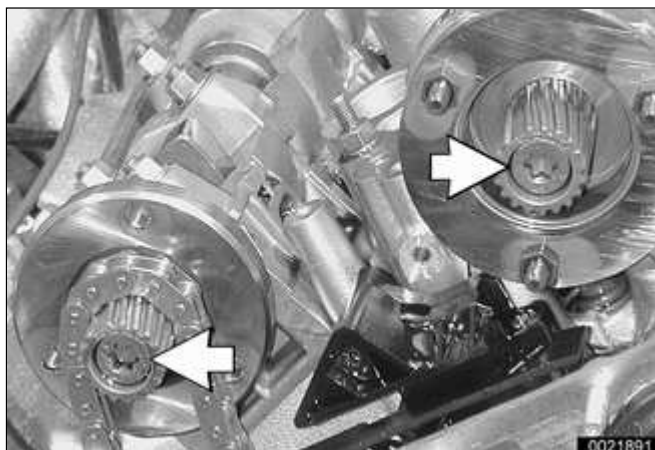
- Lift primary chain sprocket off exhaust camshaft. Remove sprocket from chain.



- Place timing chain on end of exhaust camshaft.



- Remove locating studs (**arrows**) from intake camshaft. Lift off intake camshaft thrust spacer (**A**) and impulse wheel (**B**).



- ⚠ Do not remove end spline retaining screws from camshafts (**arrows**).

- ⚠ Remove cylinder head cover mounting studs (**arrows**) from center of cylinder head.

- Remove flywheel locking tool from transmission bellhousing so that crankshaft is no longer secured.

- ⚠ Lift primary chain and hold under tension, then rotate engine against direction of rotation (counterclockwise) approximately 30°.

CAUTION!

To prevent damaging valves while working on camshafts, no pistons should be in the TDC position.

- Remove BMW special tools 11 3 240 and 11 3 244 from rear of cylinder head.

- ⚠ Remove retaining nuts (**arrows**) and bearing cap 1 of intake camshaft.

CAUTION!

Intake camshaft bearing cap 1 is



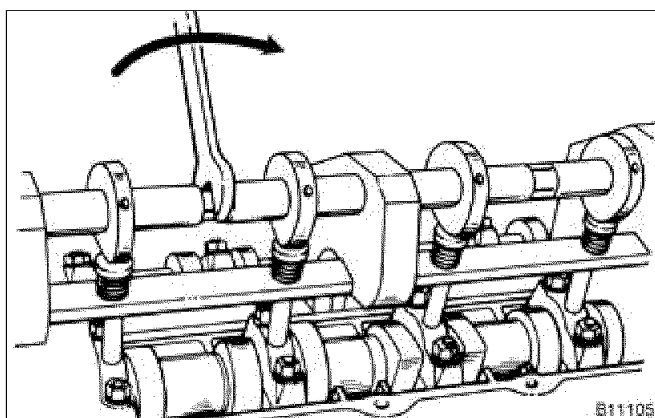
centered with adapter sleeves. To avoid camshaft damage, it must be removed before any other caps.



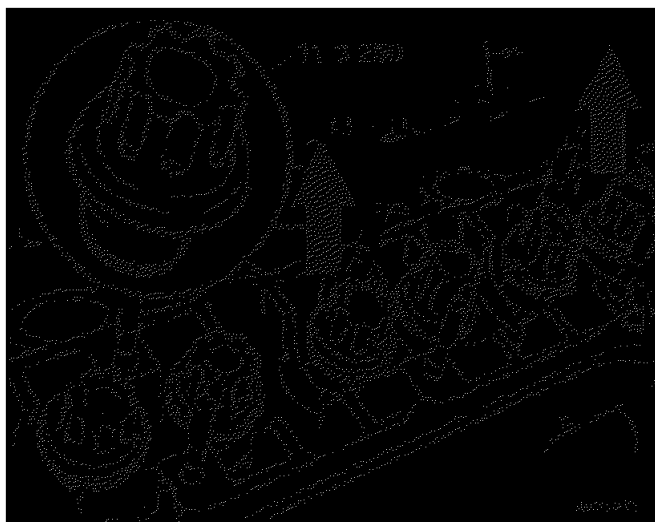
- ◀ Fit BMW special tools 11 3 260 (A) and 11 3 270 (B) to cylinder head and screw long bolts (arrows) into spark plug threads. Tensioners will align with the bearing caps on the intake camshaft.

CAUTION!

Do not over torque bolts into spark plug holes.



- ◀ Turn eccentric shaft of special tool to pretension intake camshaft bearing caps. Remove nuts on remaining bearing caps.
 - Release tension on eccentric shaft and remove BMW special tools 11 3 260 and 11 3 270. Remove bearing caps and set aside in order. Remove camshaft and store safely.
 - Repeat procedure for exhaust camshaft.



- ◀ Secure hydraulic lifters in lifter bores using BMW special tool 11 3 250, or remove lifters using a magnetic pick-up tool. With lifters secure or removed, lift out camshaft bearing carriers from cylinder head.

CAUTION!

- ♦ **Do not let the hydraulic lifters fall out as the camshaft carrier is removed.**

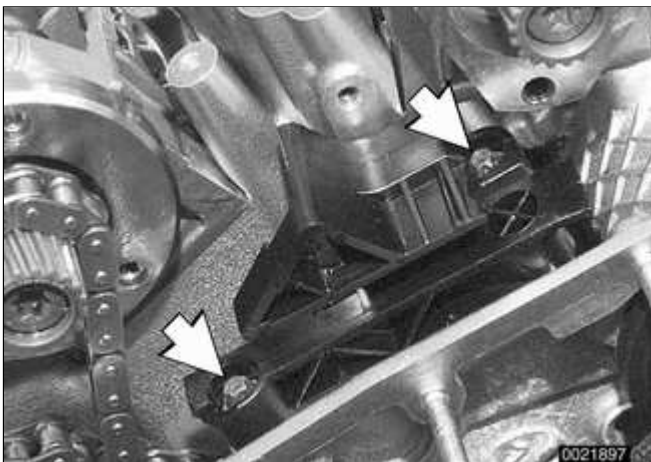
- ♦ *Hydraulic lifters should be stored in an upright position.*
- ♦ *Used hydraulic lifters must be replaced into original lifter bores.*

Cylinder head assembly, removing

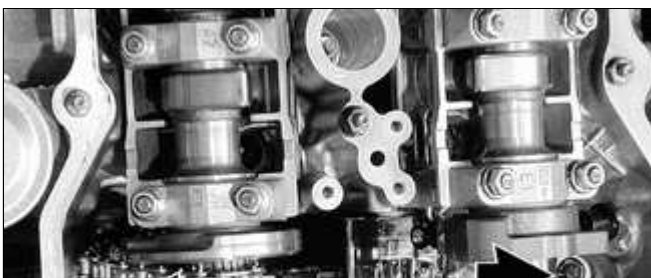
- Remove exhaust manifolds. See 180 Exhaust System.



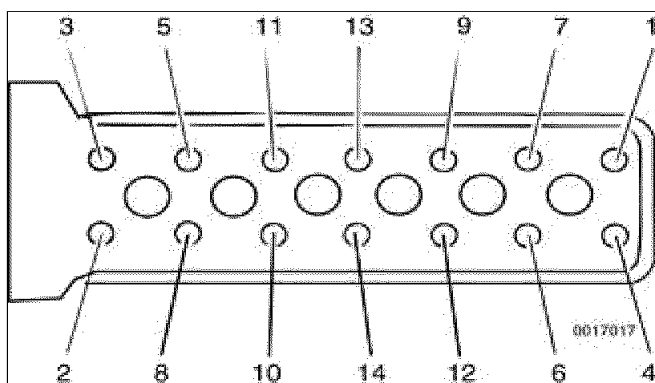
- ◀ Remove intake camshaft position sensor (**arrow**) from side of cylinder head.



- ◀ Remove secondary chain lower guide bolts (**arrows**). Remove chain guide. The bolt on the intake camshaft side is a long bolt that extends into the lower timing chain cover.



- ◀ Remove screws (**arrows**) holding lower timing chain cover to cylinder head. (Photo shows camshafts in place).



- ⚡ Using BMW special tool 11 2 250 or equivalent, loosen cylinder head bolts in several stages in sequence shown. Discard head bolts.

Note:

BMW special tool 11 2 250 is a thin-walled Torx E12 socket with an extended reach. The cylinder head bolts are recessed into the head below the camshaft towers with little working space.

- Lift off cylinder head. Refer to ⇒ [116 Cylinder Head and Valvetrain](#) to evaluate the head.

Cylinder Head Installation

Clean cylinder head and gasket surfaces of cylinder block and all timing chain covers.

Remove foreign matter and liquid from bolt holes.

CAUTION!

Do not use a metal scraper or wire brush to clean the aluminum cylinder head or pistons. If necessary, use a hard wooden or plastic scraper. Also available are abrasive discs to be used in conjunction with an electric drill. Be sure to use the correct disc for the type of metal being cleaned.

Evaluate cylinder head as shown in ⇒ [116 Cylinder Head and Valvetrain](#).

Note:

- ◆ *If the cylinder head has been machined, a special 0.3 mm (0.011 in.) thicker gasket should be installed. The thicker gasket is available from an authorized BMW dealer.*
- ◆ *Cylinder head and valve specifications are covered in ⇒ [116 Cylinder Head and Valvetrain](#).*

Lubricate camshafts, camshaft carriers, bearing caps, hydraulic lifters, friction washers, splined shafts and spline hubs with assembly lubricant before installation.

To assist the technician in cylinder head installation, the procedure has been organized as separate

operations. Please be advised that these individual jobs must be accomplished in the order in which they appear.

⇒ [Cylinder head assembly, installing](#)

⇒ [Camshafts and valvetrain, installing](#)

⇒ [VANOS control unit, installing](#)

⇒ [Cylinder head cover, manifolds, cooling system, installing](#)

Cylinder head assembly, installing



✦ Check that two cylinder head locating aligning sleeves (**arrows**) are correctly positioned in block and are not damaged.

- Apply permanently elastic sealing compound 3 Bond® 1209 to joints with timing belt cover.
- Place new cylinder head gasket on cylinder block.

Note:

The word OBEN, printed on the gasket, should face up. The cylinder head gasket will fit correctly in only one orientation.

- Set cylinder head in position, guiding primary chain through cylinder head opening.

CAUTION!

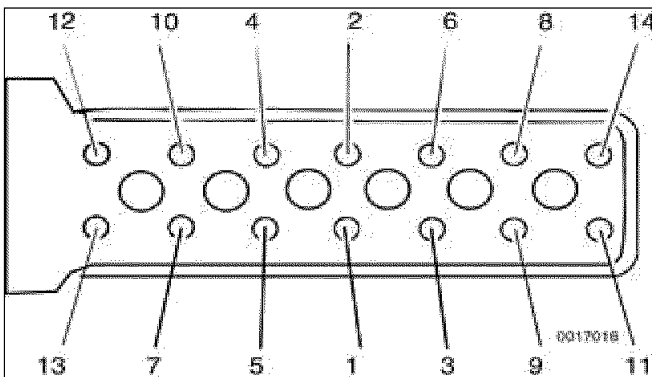
Make sure the crankshaft, which had been rotated approximately 30° opposite the direction of engine rotation from TDC, is still in that

position before lowering the cylinder head into position. All pistons must be out of TDC position to prevent valve/piston interference when the camshafts are installed.

- Lightly lubricate new cylinder head bolts. Install bolts and washers finger tight. Install cylinder head-to-lower timing chain cover bolts finger tight.

Note:

- ◆ Cylinder head bolts should not be reused. They are stretch-type bolts and must always be replaced whenever loosened.
- ◆ Check that all washers for the head bolts are in place before installing the bolts. Some of the washers may be staked to the cylinder head.



Tighten cylinder head bolts in correct sequence (1-14).

CAUTION!

The bolts should be tightened in three stages as listed below. The final stages require the use of a BMW special tool 11 2 110 or a suitable protractor to tighten the bolts to a specified torque angle.

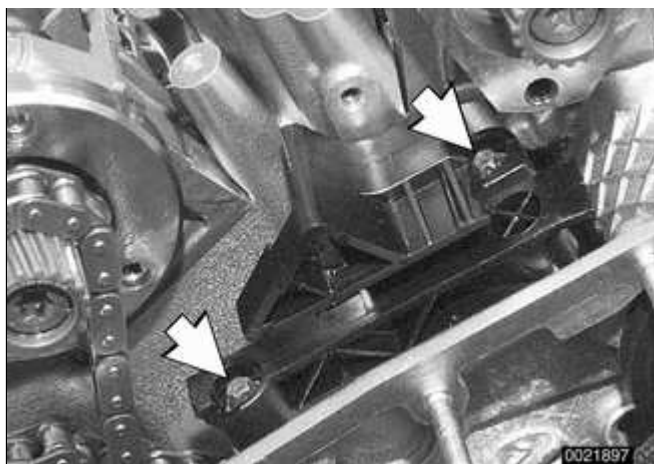
- Secure cylinder head bolts by torquing an additional 90° each for Stage 2 and 3.

Tightening torques	
Cylinder head to engine block (Torx E12 M10 bolts)	
Stage 1	40 Nm (30 ft-lb)



- Install intake camshaft position sensor (**arrow**).

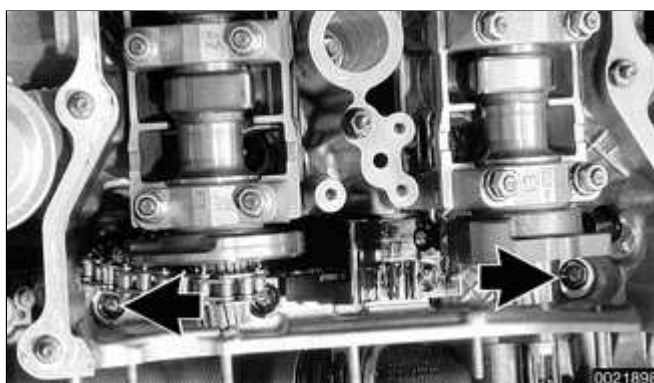
- Install exhaust manifolds. See 180 Exhaust System.



- Install lower secondary chain guide. Tighten Torx bolts (**arrows**) to specifications. The bolt on the intake camshaft side is long and extends into the engine block.

Tightening torque	
Secondary chain guide to cylinder head	10 Nm (89 in-lb)

Secondary chain guide to cylinder head	10 Nm (89 in-lb)
--	------------------



- Install and tighten cylinder head-to-lower timing chain cover bolts (**arrows**). (Photo shows camshafts in place)

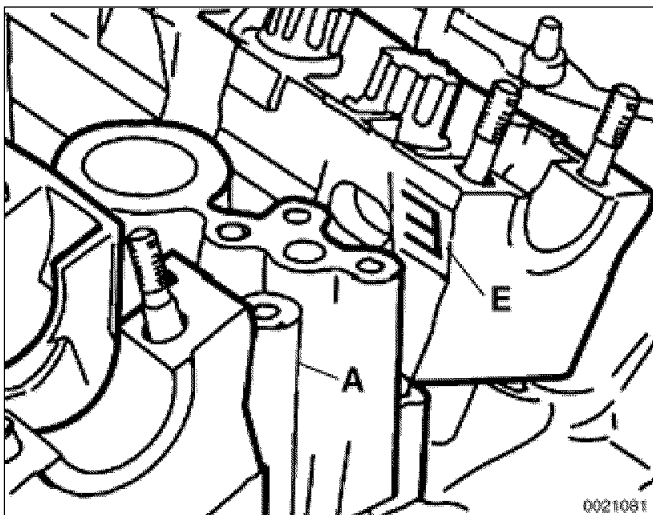
Camshafts and valvetrain, installing

CAUTION!

A minimum waiting time is required for the hydraulic lifters to "bleed down" after installing the camshafts into the cylinder head, but before synchronizing the crankshaft and valve train timing. When the camshafts are removed, the hydraulic lifters can expand. This expansion can cause increased valve lift when the camshafts are bolted down, possibly resulting in piston interference.



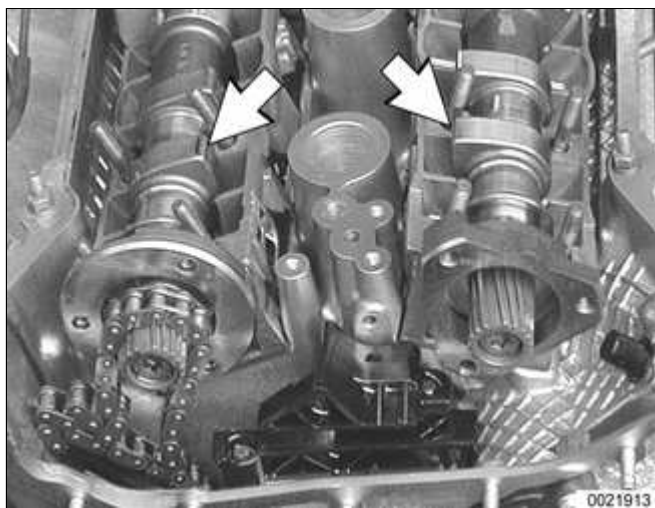
- Before installing camshaft carriers, examine bearing points (**arrows**) on hydraulic lifter bores for signs of wear.



- Install camshaft carriers with hydraulic lifters into cylinder head. Note marks on carriers: (**E**) for intake side and (**A**) for exhaust side.



- Center camshaft carrier on pins (**arrows**) at bearing positions 2 and 7.
 - Lift timing chain and place exhaust camshaft onto exhaust camshaft carrier. Place intake camshaft on intake camshaft carrier.



- Rotate camshafts so that intake and exhaust lobes for cylinder 1 face each other (**arrows**).

CAUTION!

Be sure that crankshaft is still positioned at least 30° back from TDC.

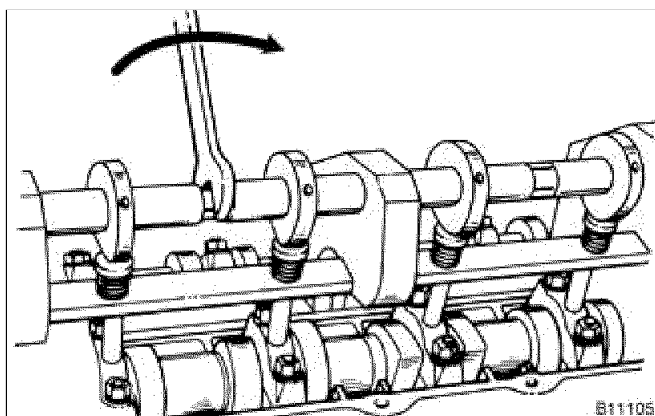
- Place bearing caps on cams, but do not install retaining nuts.



- Fit BMW special tools 11 3 260 (**A**) and 11 3 270 (**B**) to cylinder head over intake camshaft and screw long bolts (**arrows**) into spark plug threads.

CAUTION!

Do not overtighten bolts into spark plug holes.



- Turn eccentric shaft of special tool to pretension bearing caps. Install and torque nuts on intake camshaft bearing caps.

Tightening torque

Camshaft bearing cap to cylinder head (M7)	14 Nm (10 ft-lb)
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- Release tension on eccentric shaft and remove BMW special tool 11 3 260/270.

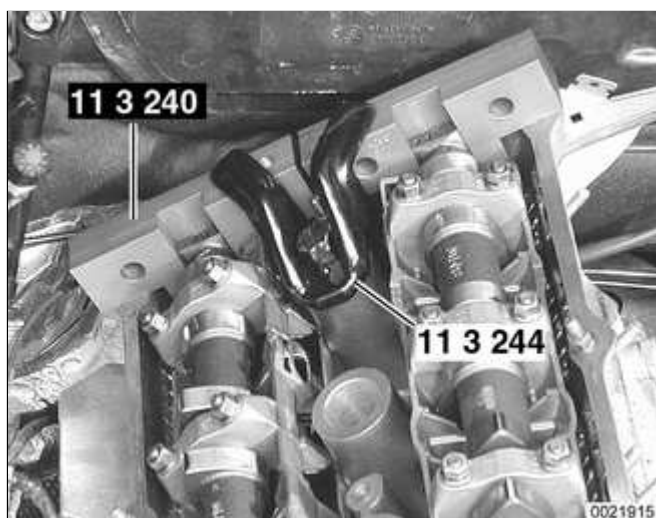
- Repeat procedure for exhaust camshaft.

Note:

Before the next step, observe waiting time for lifter bleed down before continuing with camshaft installation.

Crankshaft / valve timing waiting times

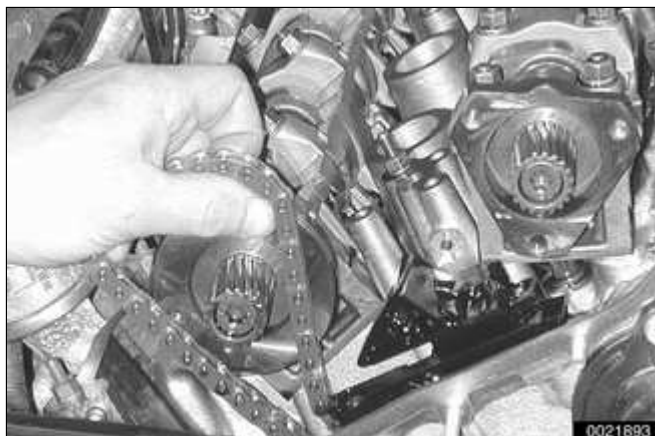
68°F (20°C) and higher	4 minutes
50 - 68°F (10 - 20°C)	11 minutes
32 - 50°F (0 - 10°C)	30 minutes



- Secure camshafts in TDC position using BMW special tools 11 3 240 and 11 3 244.



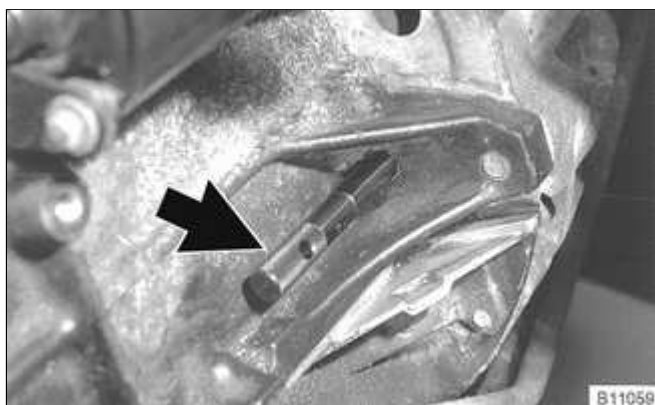
- If necessary, turn camshaft so that special tools are squarely seated on cylinder head.



- ✦ Lift timing chain and hold under tension.



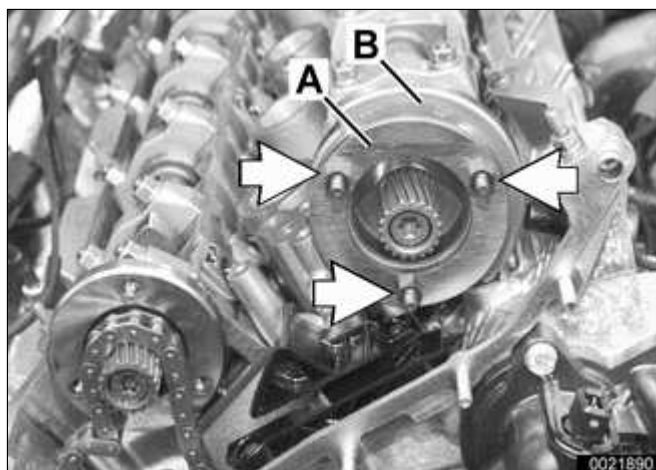
- ✦ While maintaining tension on timing chain, rotate crankshaft from 30° before TDC in direction of rotation up to cylinder 1 TDC position (**01T** on front pulley lined up with pointer on lower timing chain cover).



- ✦ Secure crankshaft in TDC position with BMW special tool 11 2 300 (**arrow**).



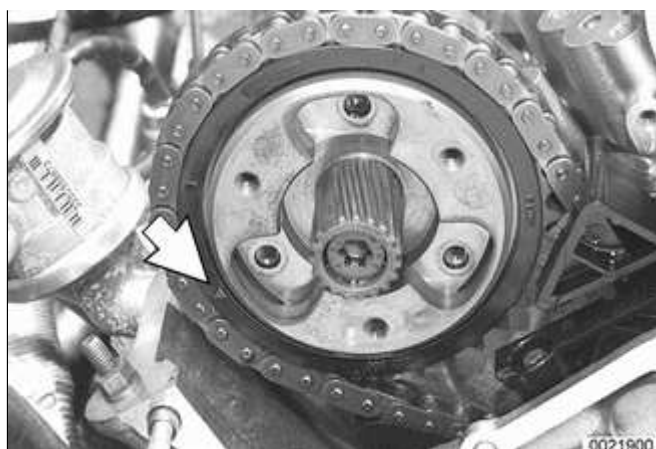
- ✦ Slide impulse wheel on intake camshaft, aligning boss with raised portion on camshaft (**arrow**).



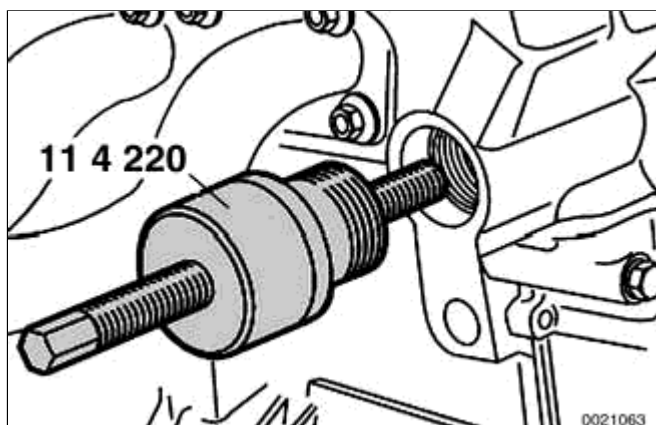
- Fit thrust spacer to intake camshaft and tighten down with threaded locating studs (place longer threaded portion of studs into camshaft).

Tightening torque

Impulse wheel studs to intake camshaft (M7)	20 Nm (15 ft-lb)
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- Fit top sprocket to primary timing chain and install on exhaust camshaft so that pointer on sprocket (**arrow**) lines up with cylinder head sealing surface.

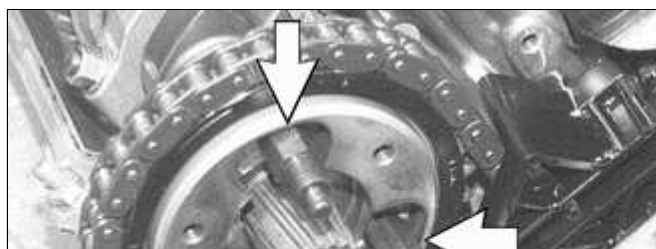


- Insert BMW special tool 11 4 220 into timing chain tensioning piston bore and bring adjustment screw into contact with tensioning rail, but do not pretension timing chain.

Note:

BMW special tool 11 4 220 is a dummy primary chain tensioner and simulates the function of the tensioner.

- Recheck that arrow on top primary sprocket is aligned with upper edge of cylinder head. Reposition sprocket if necessary.



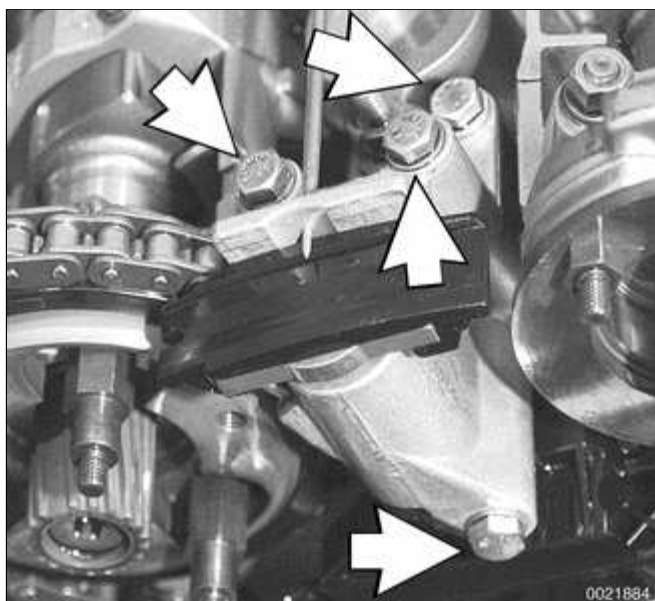
- Insert and tighten down threaded locating studs (**arrows**) in end of exhaust camshaft.

Tightening torques

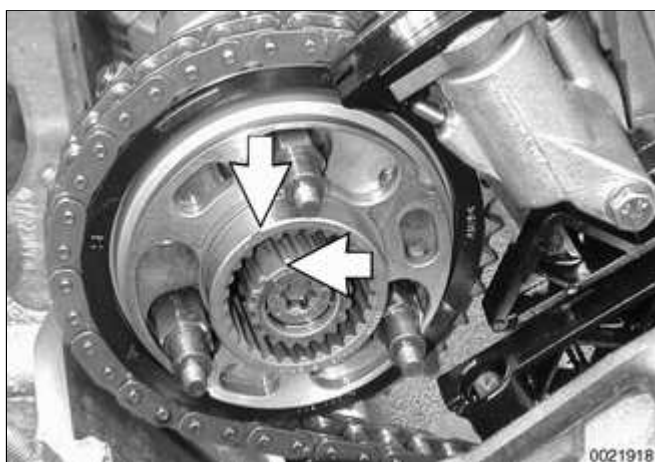


Tightening torques

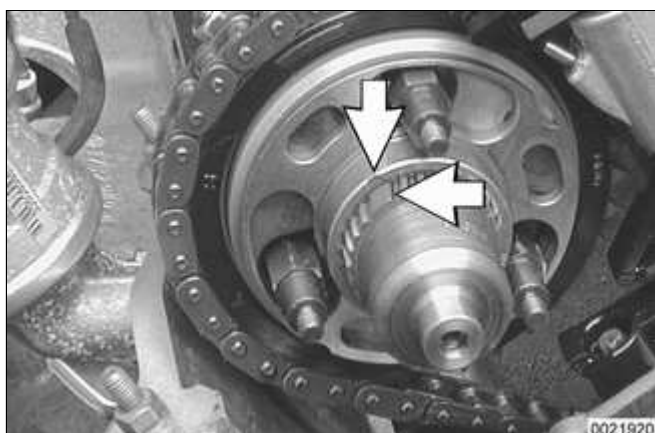
Exhaust camshaft locating stud	20 Nm (15 ft-lb)
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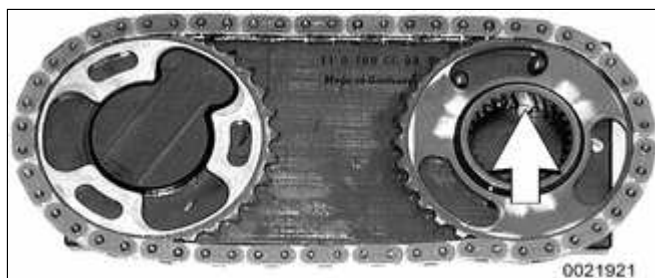
- Install secondary chain tensioner on cylinder head (**arrows**). Keep tensioner compressed using BMW special tool 11 3 292 or suitable pin.



- Fit exhaust camshaft splined sleeve. Confirm that gap in sleeve splines aligns with corresponding gap in camshaft splines (**arrows**).



- Slide splined shaft onto exhaust camshaft. Be sure that locating tooth of shaft (**arrow**) fits into spline gaps of camshaft and splined sleeve.
- Slide splined shaft in further until three small slots on splined sleeve are centered on three threaded holes in primary chain sprocket.



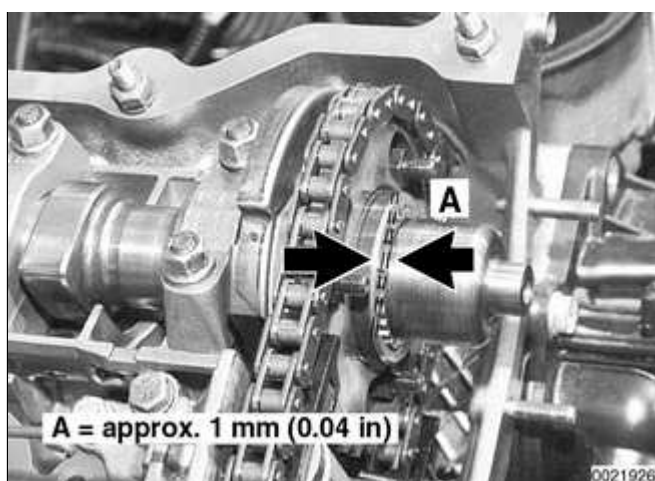
- Place intake and exhaust sprockets in BMW special tool 11 6 180. Position spline gap on intake sprocket (**arrow**) as shown and place secondary chain on sprockets.



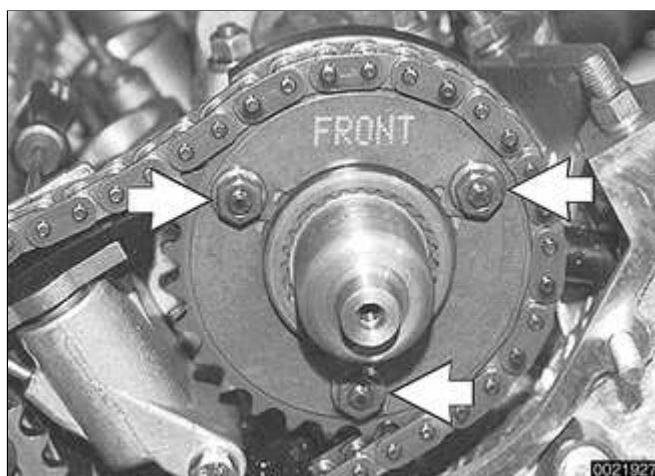
- Remove chain and sprockets from tool and slide sprockets on camshafts. Confirm that gap in intake sprocket splines lines up with corresponding gap in camshaft splines (**arrow**).

CAUTION!

Do not alter position of sprockets with respect to chain when removing from special tool 11 6 180.



- Slide splined shaft onto intake camshaft until approx. 1 mm (0.04 in.) of splines (**arrows**) are visible. Confirm that locating tooth of shaft fits into spline gaps on camshaft and sprocket.



- Install intake camshaft spring plate so that **FRONT** mark is visible. Install mounting nuts (**arrows**) finger tight.

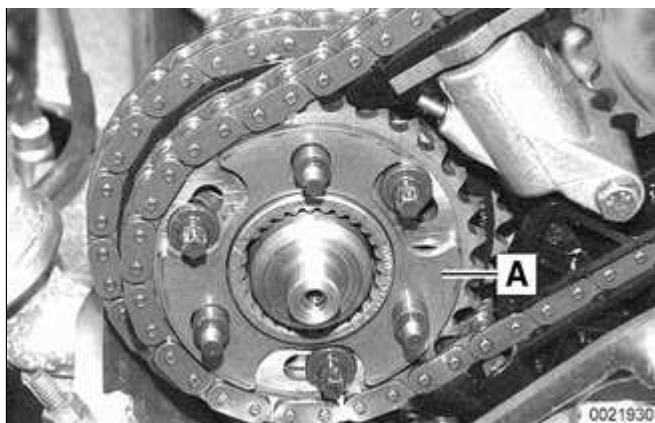


- Insert sprocket mounting bolts (**arrows**) on exhaust side camshaft

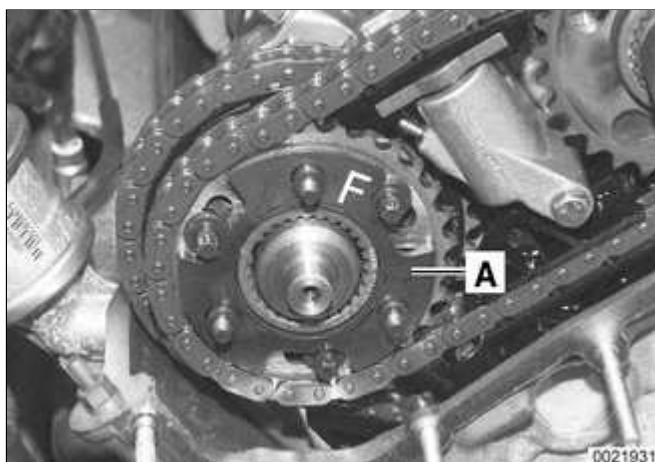


assembly.

- ◆ Initially tighten to approx. 5 Nm (44 in-lb) and then back off by half a turn.



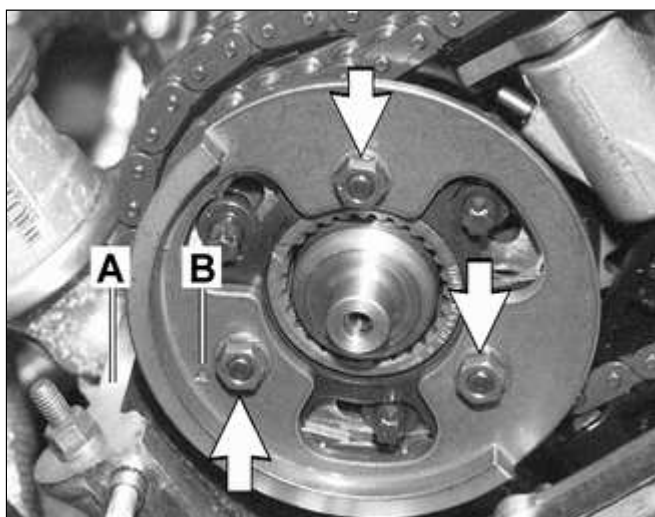
- ✦ Fit thrust spacer (A) on exhaust camshaft.



- ✦ Install spring plate (A) to exhaust camshaft. Make sure that F mark is visible.

Note:

If F mark is no longer visible, install spring plate so that convex side points forward (toward front of car).



- ✦ Install exhaust camshaft impulse wheel, aligning pointer (B) with top edge of cylinder head (A). Install mounting nuts (arrows) finger tight.



- ✦ Pull out exhaust camshaft splined shaft to stop.

- Press down on secondary chain tensioner and remove tensioner lock-down tool.



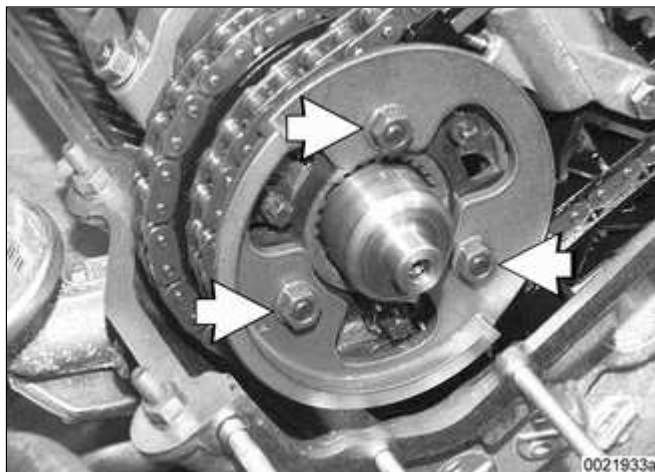
- ✦ Preload primary chain:

- ◆ Tighten adjusting screw on BMW special tool 11 4 220 to specified torque.

Tightening torque	
Primary chain tensioner preload	0.7 Nm (6 in-lb)



- ✦ Preload exhaust camshaft spring plate by pressing on impulse wheel while tightening mounting nuts (**arrows**) finger tight.



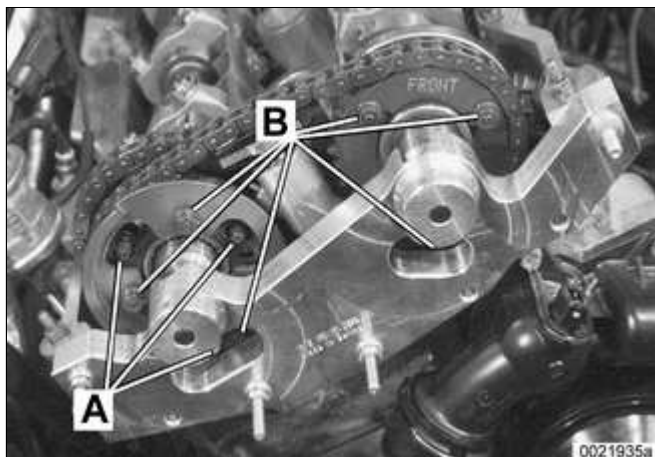
- ✦ Install BMW special tool 11 6 150 (VANOS setup bracket) to front of cylinder head timing case. Install nuts (**arrows**) finger tight, then tighten down uniformly until special tool is in full contact with cylinder head.



CAUTION!



Make sure all gasket material is removed from face of cylinder head. Clean sealing face and keep free of oil. If any foreign material is present on the sealing surface, the camshaft timing will be incorrect.



Secure camshaft sprockets and impulse wheels:

- ◆ Tighten mounting screws (**A**) on exhaust camshaft impulse wheel to approx. 5 Nm (44 in-lb).
- ◆ Tighten mounting nuts (**B**) on exhaust and intake sprocket assemblies to approx. 5 Nm (44 in-lb).
- ◆ Torque down mounting screws (**A**) and nuts (**B**) to final specifications.

Tightening torques

Sprocket assembly to camshaft

initial torque	5 Nm (44 in-lb)
----------------	-----------------

Sprocket assembly wheel to camshaft

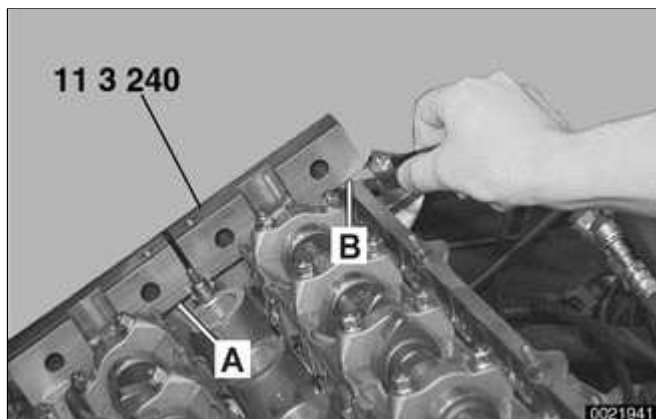
M7 Torx screws (A)	20 Nm (15 ft-lb)
-----------------------------	------------------

M6 mounting nut (B)	10 Nm (8 ft-lb)
------------------------------	-----------------

- Remove flywheel locking tool from transmission bellhousing so that crankshaft is no longer secured.
- Remove camshaft locking tools from cylinder head.



Turn engine over twice in direction of rotation until cylinder 1 intake and exhaust camshaft lobes (**arrows**) face



each other.

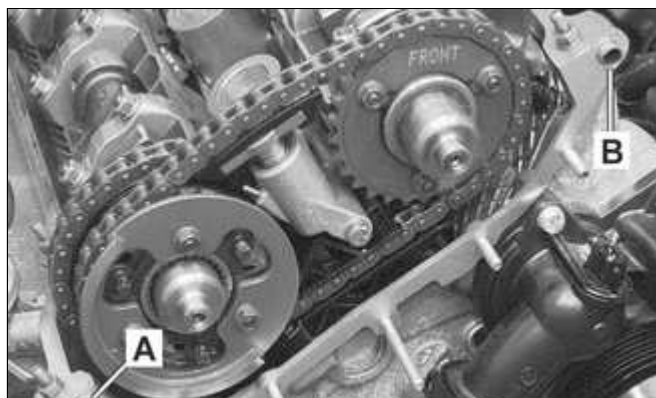
- Secure crankshaft in TDC position with BMW special tool 11 2 300.

- Place BMW special tool 11 3 240 over camshafts and measure clearances.

Note:

- ◆ *If the exhaust side of the tool (A) is not flush with the head, camshaft timing is incorrect. Reset camshaft timing as described in ⇒ [117 Camshaft Timing Chains](#).*
- ◆ *Due to flexible sprocket design, VANOS unit tolerances and play in the VANOS splines, when the camshaft timing is set correctly, the intake side of special tool 11 3 240 (B) may be up to 1 mm (0.04 in) above the surface of the cylinder head. This is normal. Reassemble engine. Otherwise, reset camshaft timing as described in ⇒ [117 Camshaft Timing Chains](#)*
- Remove BMW special tool 11 6 150 from front of cylinder head.

VANOS control unit, installing



- Clean contact edges of cylinder head face and VANOS unit and apply a thin coat of sealing compound 3-Bond®1209 or equivalent to surfaces.

CAUTION!

- ◆ **Make sure all gasket material is**



removed from face of cylinder head. Clean sealing face and keep free of oil. If any foreign material is present on the sealing surface, the camshaft timing will be incorrect.

- ♦ **Check locating dowel (A) and dowel sleeve (B) at top of cylinder head for damage or incorrect installation.**

- Replace steel gasket.
- Install VANOS unit to front of cylinder head.

Note:

If Double VANOS control unit is being replaced, be sure to check and adjust camshaft timing as described in ⇒ [117 Camshaft Timing Chains](#).

- Reinstall engine support hook.

Tightening torque	
VANOS unit to cylinder head	
M6 nut	10 Nm (89int-lb)
M7 nut	14 Nm (10 ft-lb)

- Reconnect electrical harness connectors to camshaft position sensors and VANOS solenoid valves.



- ✦ Insert and tighten down VANOS hydraulic piston set screws (**arrows**) in splined shafts on intake and exhaust camshafts.

CAUTION!



**Set screws have left hand thread.
Tighten counterclockwise.**

Tightening torque

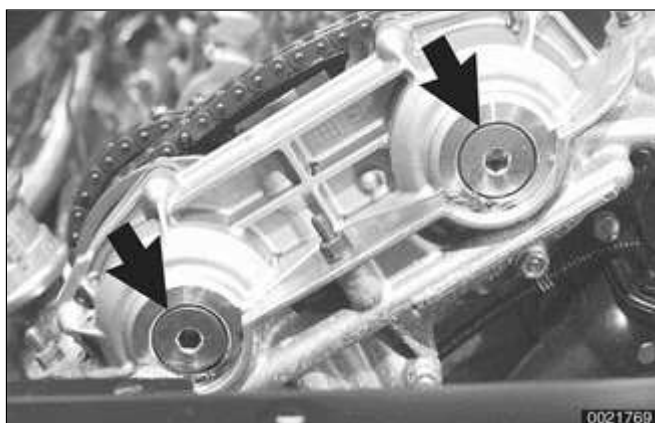
Hydraulic piston to splined shaft

M6 set screw

10 Nm (89 in-lb)



- Replace sealing caps inside VANOS unit with BMW special tool 11 6 170, or short flat nosed pliers.

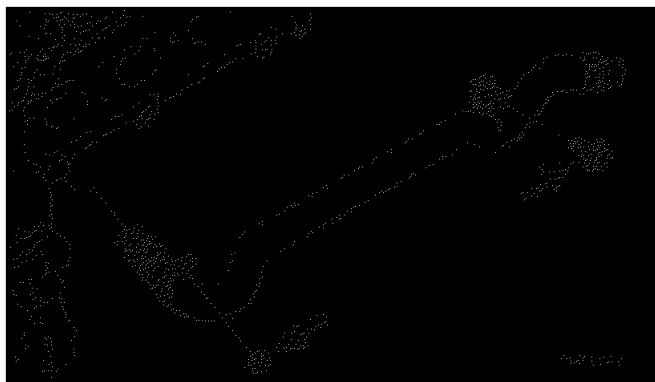


- Insert and secure VANOS sealing plugs (**arrows**) with new sealing O-rings.

Tightening torque

Sealing plug to
VANOS unit

50 Nm (37 ft-lb)



- Install coolant pipe fasteners at base of cylinder head and tighten fasteners (**arrows**).

Note:

Use new sealing O-ring on coolant pipe.

- Install VANOS oil line banjo bolt with new seals. Attach oil line to VANOS unit.

Tightening torque

Tightening torque

Oil line to VANOS unit (banjo bolt)	32 Nm (24 ft-lb)
-------------------------------------	------------------

- Remove BMW special tool 11 4 220 and reinstall chain tensioner cylinder.

Tightening torque

Primary chain tensioner cylinder to cylinder head	70 Nm (52 ft-lb)
---	------------------

- Remove flywheel locking tool from transmission bellhousing. Replace special tool bore sealing plug.
- Remove camshaft locking tools from cylinder head.

Cylinder head cover, manifolds, cooling system, installing

- ▲ Install intake camshaft cover and cylinder head cover.
 - ◆ Check for correct seating of half-moon seals (A) in back of cylinder head cover.
 - ◆ Use a small amount of 3-Bond®1209 or equivalent sealant at corners (B) of half-moon cutouts.
 - ◆ Seat gasket and seal corners in front of cylinder head at VANOS unit.

Tightening torque	
Cylinder head cover to cylinder head (M6)	10 Nm (89 in-lb)

Cylinder head cover to cylinder head (M6)	10 Nm (89 in-lb)
---	------------------

- Install exhaust manifolds using new gaskets and nuts. Coat manifold studs with copper paste prior to installing nuts.

Tightening torque	
Exhaust manifold to cylinder head (M7)	20 Nm (15 ft-lb)

Exhaust manifold to cylinder head (M7)	20 Nm (15 ft-lb)
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- Install electrical harness connectors for oil pressure sender and coolant temperature sensor before installing intake manifold.



- ◀ Intake manifold Installation is reverse of removal.

- 1 - Manifold mounting nuts -tighten to 15 Nm (11 ft-lb)
- 2 - Fuel pipe bracket
- 3 - Fuel pipe bracket
- 4 - Vacuum pump bracket
- 5 - Manifold mounting bracket
- 6 - Tank venting valve bracket
- 7 - Mounting bracket to manifold bolt (M6) -tighten to 10 Nm (7 ft-lb)
- 8 - Mounting bracket to cylinder block nut (M10) -tighten to 47 Nm (33 ft-lb)

- ◆ Use new fuel injector seals.

- ◆ Carefully check intake manifold gasket and replace if necessary.
- ◆ Inspect O-ring seal between mass air flow sensor and air filter housing. To facilitate reassembly, coat seal with acid-free grease.

CAUTION!

When reattaching throttle assembly harness connector, connector is fully tightened when arrows on connector and plug line up.

Tightening torques	
Intake manifold to cylinder head	
M7	15 Nm (11 ft-lb)
M8	22 Nm (16 ft-lb)
Mounting bracket to cylinder block (M10)	47 Nm (33 ft-lb)
Mounting bracket to intake manifold (M6)	10 Nm (7 ft-lb)

- Installation of remaining parts is reverse of removal, noting the following:
- ◆ Refill cooling system as described in ⇒ [170 Radiator and Cooling System](#).
- ◆ Change engine oil and filter as described in ⇒ [020 Maintenance](#).
- ◆ If necessary, adjust accelerator cable.

- ◆ Reconnect battery.

CAUTION!

To prevent damaging engine electronic systems, install all ground wires previously removed, including the ground wires for the ignition coils.

Tightening torques	
Coolant drain plug to cylinder block	25 Nm (18 ft-lb)
Radiator cooling fan to coolant pump	40 Nm (30 ft-lb)
Radiator drain screw to radiator	2.5 Nm (22 in-lb)
Spark plug to cylinder head	25 Nm (18 ft-lb)

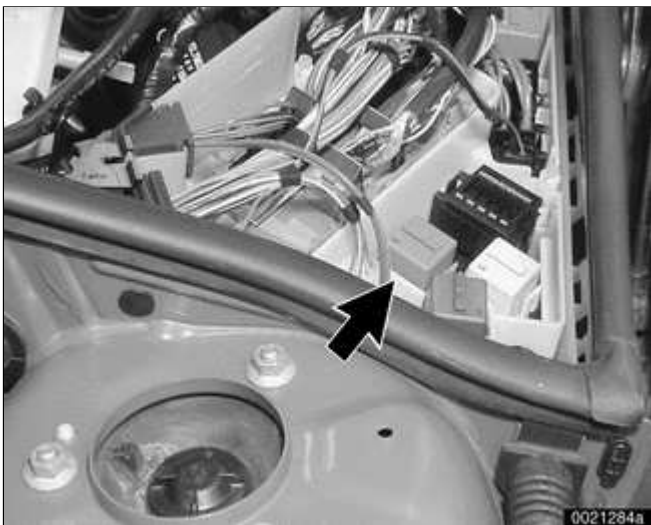
Diagnostic Testing

Cylinder compression, checking

A compression gauge is needed to make a compression test. For accurate test, the battery and starter must be capable of cranking the engine at least 300 rpm, and the engine should be at normal operating temperature.

Note:

Performing a compression test may cause a fault to set in the ECM and may illuminate the engine service light. The light can only be turned out using either BMW special service scan tools or an equivalent aftermarket scan tool. Disconnecting the battery will not erase the fault memory nor turn out the light.

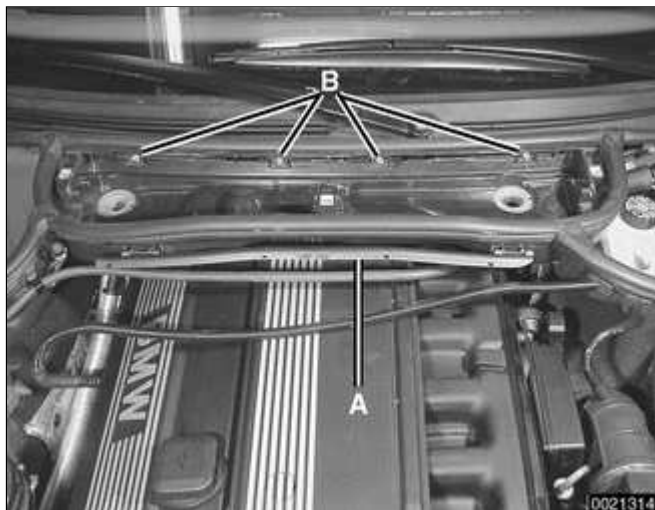


- ✦ Disable ignition system by removing DME main relay (**arrow**) from the electronics box (E-box) in left rear of engine compartment

WARNING!

- ✦ **The ignition system produces high voltages that can be fatal. Avoid contact with exposed terminals and use extreme caution when working on a car with the ignition switched on or the engine running.**
- ✦ **Do not touch or disconnect ignition components while the engine is running or being cranked by the starter.**

CAUTION!



Failure to remove the DME main relay or attempting to disable the ignition system by other methods may result in damage to the engine control module (ECM).

➤ Remove housing for interior ventilation microfilter.

- ◆ Remove upper cover and microfilter.
- ◆ Open wiring harness loom cover (A) and remove wires.
- ◆ Unfasten screws (B) and remove lower microfilter housing.
- Remove oil filler cap.
- Remove engine cover over ignition coils. Replace oil filler cap.



➤ Remove ignition coils.

- ◆ Pull up on spring clips to disconnect ignition coil harness connectors.
- ◆ Remove coil grounding straps.
- ◆ Remove coils.
- ◆ Remove spark plugs.

Note:

Check the spark plugs for oil deposits that may indicate poor cylinder sealing, then set them aside in order. Used spark plugs should be reinstalled in the same cylinder from which they were



removed.

- ✦ Install compression gauge in first cylinder's spark plug hole, tight enough to form a good seal.
- With parking brake set, transmission in PARK or NEUTRAL, and accelerator pedal pressed to floor, crank engine with starter. Record highest value indicated by gauge.

Note:

- ◆ *The compression gauge reading should increase with each compression stroke and reach near its maximum reading in about 4-6 strokes.*
- ◆ *All cylinders should reach maximum compression in the same number of strokes. If a cylinder needs significantly more strokes to reach maximum compression, there is a problem.*
- Release pressure at compression gauge valve, then remove gauge from spark plug hole. Repeat test for each cylinder and compare results with values given below.

Compression pressures	
Minimum	10 - 11 bar (142 - 156 psi)
Maximum difference between cylinders	0.5 bar (7 psi)

- Compression readings may be interpreted as follows:

- ◆ Low compression indicates a poorly sealed combustion chamber.
- ◆ Relatively even pressures that are below specification normally indicate worn piston rings and/or cylinder walls.
- ◆ Erratic values tend to indicate valve leakage.
- ◆ Dramatic differences between cylinders are often the sign of a failed head gasket, burned valve, or broken piston ring.
- Reinstall spark plugs and ignition coils.

Note:

Used spark plugs should be reinstalled in the same cylinder from which they were removed.

- Remainder of installation is reverse of removal. Be sure to reinstall all wires disconnected during test, especially ground wires at coils and cylinder head cover (where applicable).

Tightening torque	
Spark plug to cylinder head	25 Nm (18 ft-lb)

Wet compression test

To further help analyze the source of poor compression, a wet compression test is the next step:

- Repeat compression test, this time with about a teaspoon of oil squirted into each cylinder. (The oil will temporarily help seal between piston rings and cylinder wall, practically eliminating leakage past rings for a short time.)
- If this test yields higher compression reading than "dry" compression test, there is probably leakage between piston rings and cylinder walls, due either to wear or to broken piston rings.
- Little or no change in compression reading indicates other leakage, probably from valves.

Cylinder leak-down test

The most conclusive diagnosis of low compression symptoms requires a cylinder leak-down test. Using a special tester and compressed air, each cylinder, in turn, is pressurized. The rate at which the air leaks out of the cylinder, as well as where the air leaks out, can accurately pinpoint the magnitude and location of the leakage.

Before attempting any repair that requires major engine disassembly, use a leak-down test to confirm low compression.