

117 Camshaft Timing Chain

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GENERAL

This repair group covers timing chain repair information for the 4- and 6-cylinder engines.

4-cylinder engines use one double-row chain to drive the dual overhead camshafts. See Fig. 1.

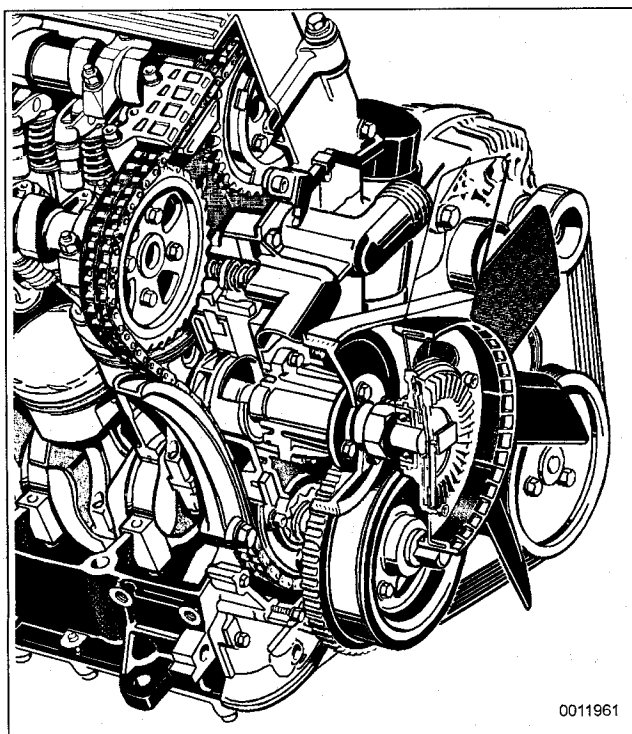


Fig. 1. M44 engine valvetrain chain drive. M42 engine is similar.

6-cylinder engines use two chains to drive the camshafts. A primary chain is driven off the crankshaft and drives the primary sprocket on the exhaust camshaft. The secondary chain drives the intake camshaft. Each chain is tensioned by a hydraulic tensioner. See Fig. 2.

The timing chains are lubricated by engine oil and do not require maintenance. A worn timing chain and sprockets can lead to noisy operation and erratic valve timing. A faulty tensioner can also cause timing chain noises.

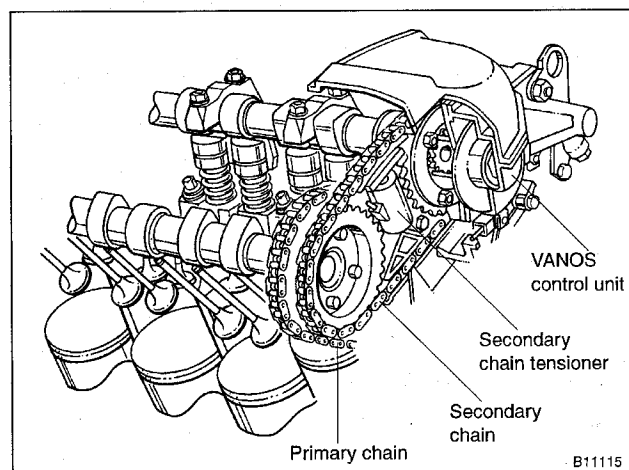


Fig. 2. Cutaway view of camshaft timing chains on 1993 and later 6-cylinder engine with VANOS.

NOTE —

See 100 Engine—General for engine code and application information.

GENERAL

CAMSHAFT TIMING CHAIN, 4-CYLINDER

Special BMW service tools are needed for timing chain removal and installation procedures. The special tools assure proper timing of the valvetrain. Precise marks to set the timing on the camshafts are not provided for reassembly. Read the procedures through before beginning the job.

CAUTION —

If the camshafts are not properly timed, the pistons can contact the valves.

Camshaft timing chain, removing (4-cylinder engines)

1. Disconnect negative (–) cable from battery.

CAUTION —

Prior to disconnecting the battery, read the battery disconnection cautions given at the front of this manual on page viii.

2. Drain engine coolant. Drain engine block by removing block drain. Remove radiator cooling fan shroud and cooling fan. See **170 Radiator and Cooling System..**

WARNING —

Allow the engine to cool before opening or draining the cooling system.

CAUTION —

On cars with viscous-type fan clutch, fan has left hand threads.

NOTE —

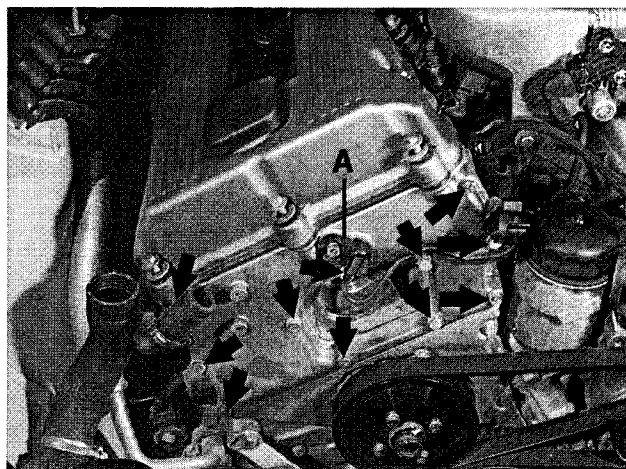
The block drain plug is located on the exhaust side of the engine, below cylinder no. 4.

3. Remove cylinder head cover. See **113 Cylinder Head Removal and Installation.**

NOTE —

Make note of the arrangement of the rubber insulators when removing the cylinder head cover mounting bolts.

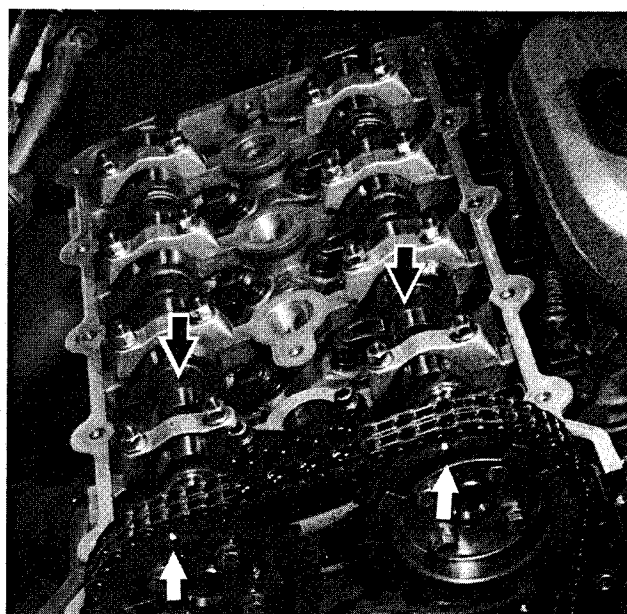
4. Loosen spark plugs. See **120 Ignition System.**
5. Disconnect coolant hoses from thermostat housing on front of cylinder head. Unbolt thermostat housing from cylinder head.
6. Remove cylinder identification sensor from upper timing chain cover. Remove upper timing chain cover. See Fig. 3.



0011996

Fig. 3. Upper timing chain cover mounting bolts (arrows). Thermostat housing shown removed. Cylinder identification sensor (A) also shown.

7. Set engine to approximate TDC by rotating in normal operating direction until camshaft lobes at cylinder no. 1 are facing up and toward each other. See Fig. 4.



0011998

Fig. 4. Engine set to approximate TDC. Cylinder no. 1 camshaft lobes face in and sprocket arrows point up (arrows).

8. Remove air conditioning drive belt. Loosen and push aside air conditioning compressor. Remove air conditioning compressor mounting bracket. See **640 Heating and Air Conditioning.**
9. Remove engine drive belts and coolant pump pulley. See **020 Maintenance Program.**
10. Secure crankshaft vibration damper to prevent crankshaft from turning. Using a socket, loosen vibration damper hub center bolt.

CAMSHAFT TIMING CHAIN, 4-CYLINDER

NOTE —

The vibration damper center bolt is very tight. A heavy duty holding device, such as BMW special tool no. 11 2 150, should be used to hold the vibration damper hub stationary while the bolt is loosened.

11. Using loosened bolt at vibration damper, turn crankshaft to TDC and lock in position by inserting BMW special tool no. 11 2 300 through transmission bellhousing. See Fig. 5.

NOTE —

- If necessary, remove plug from locating bore in lower edge of bell housing.
- Confirm that locking tool has been correctly installed by trying to rotate the crankshaft.

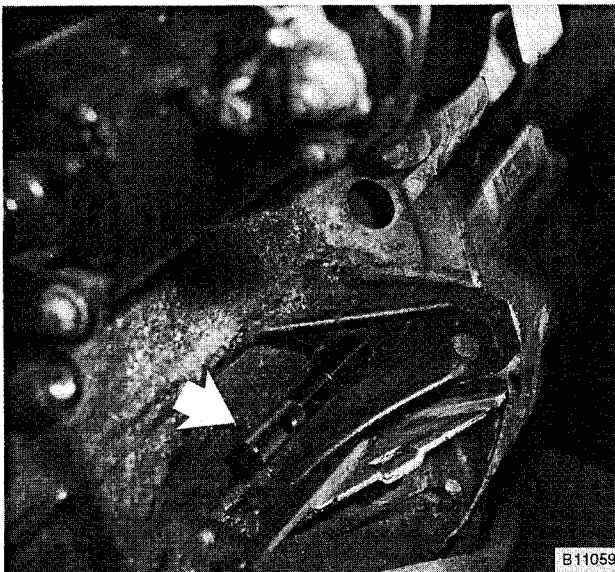


Fig. 5. BMW special tool no. 11 2 300 installed through bellhousing and into flywheel to lock crankshaft at TDC (arrow).

12. Lock camshafts at TDC by mounting BMW special tool no. 11 3 240 over square ends of camshafts. See Fig. 6.
- Check that tool is squarely seated on cylinder head gasket surface. If necessary, rotate camshafts slightly using an open-end wrench at hex on camshafts.

CAUTION —

The camshafts must be locked in the TDC position using the special service tool before removing the timing chain. The tool holds the camshafts parallel to each other and perpendicular to the valve cover gasket surface.

13. Remove lower timing chain cover mounting bolts and carefully lift cover off. Clean sealing surfaces and gasket grooves. See Fig. 7.
14. Remove hydraulic chain tensioner from right side of cylinder head. See Fig. 8.

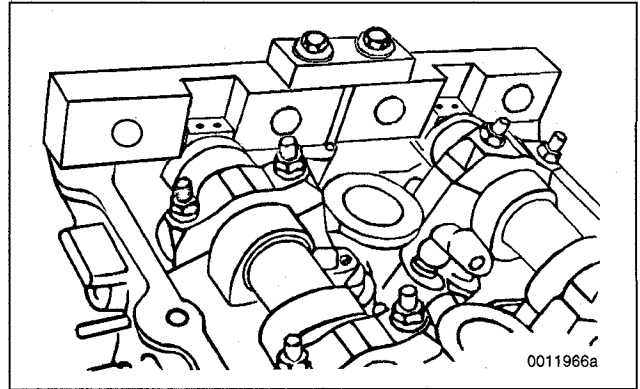


Fig. 6. BMW special tool no. 11 3 240 installed on rear of camshafts to position camshafts at TDC. (M44 camshafts shown. Other engines are similar.)

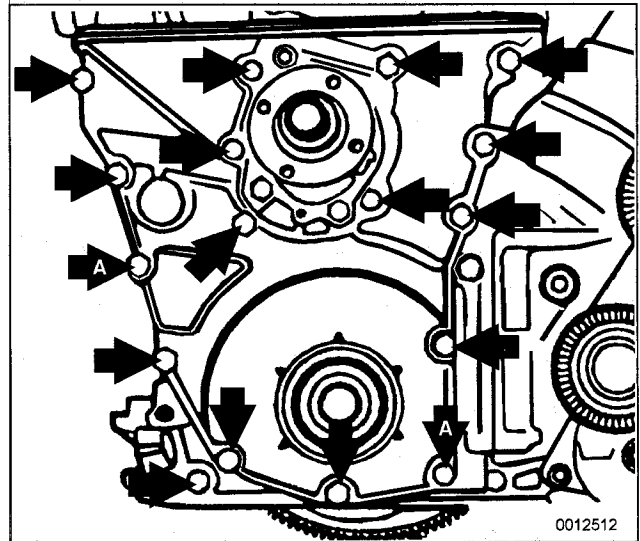


Fig. 7. Lower timing chain cover mounting bolts (arrows). Bolts A are installed through hollow locating dowels.

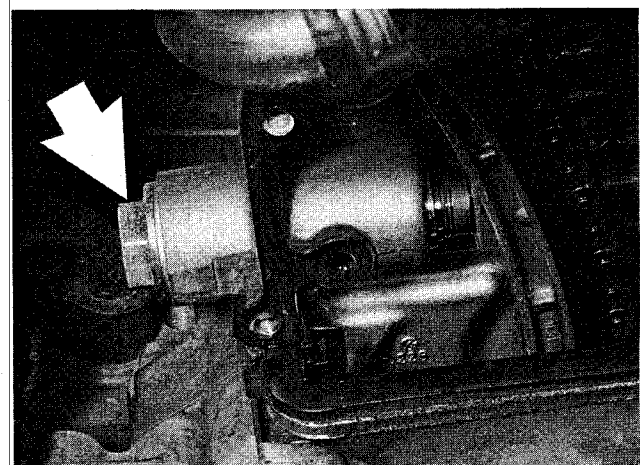


Fig. 8. Hydraulic chain tensioner plug (arrow).

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15. Remove mounting bolts from left and right camshaft sprockets.
16. On M42 engines, remove upper bolt on right side chain guide and unbolt lower timing chain guide below crankshaft.
17. Remove camshaft sprockets from camshafts together with chain and crankshaft sprocket. Note Woodruff key when removing crankshaft sprocket.

CAUTION —

The crankshaft must not be allowed to rotate when the timing chain is removed. The pistons can contact the valves.

Camshaft timing chain, installing (4-cylinder engines)

Inspect all sprockets for wear or damage. Inspect the chain guide and tensioner rails for grooves caused by chain contact. Replace any part that is worn. If any of the sprockets are worn, the chain and sprockets are replaced as an assembly.

The procedure outlined below assumes that the camshafts and the crankshaft are locked in the TDC installation position with special tools (shown earlier in Fig. 5 and Fig. 6).

1. Install timing chain to crankshaft sprocket, then slide sprocket on crankshaft while aligning woodruff key.
2. Place camshaft sprockets on chain, then place sprockets on camshafts so that arrows on sprockets point up and elongated holes in sprockets are centered to tapped holes in camshafts. See Fig. 9.

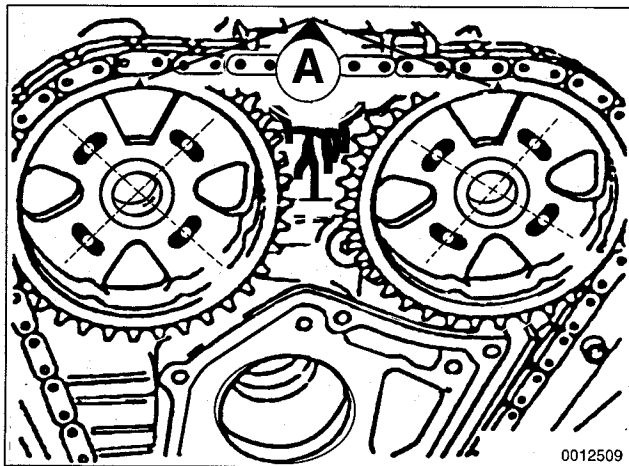


Fig. 9. Camshaft sprockets correctly installed with arrows pointing up and bores centered to tapped holes (M44 engine).

3. On M44 engine: Place cylinder position sensor plate on intake camshaft sprocket so that arrow on sensor plate points up.

4. Install and hand-tighten sprocket mounting bolts.
5. On M42 engine: Install lower chain guide.
6. On M44 engine: Remove allen-head retaining screw at left chain-guide. Turn slotted-head of adjusting sleeve so that sleeve contacts cylinder head. Then install and tighten allen-head screw fully. See Fig. 10.

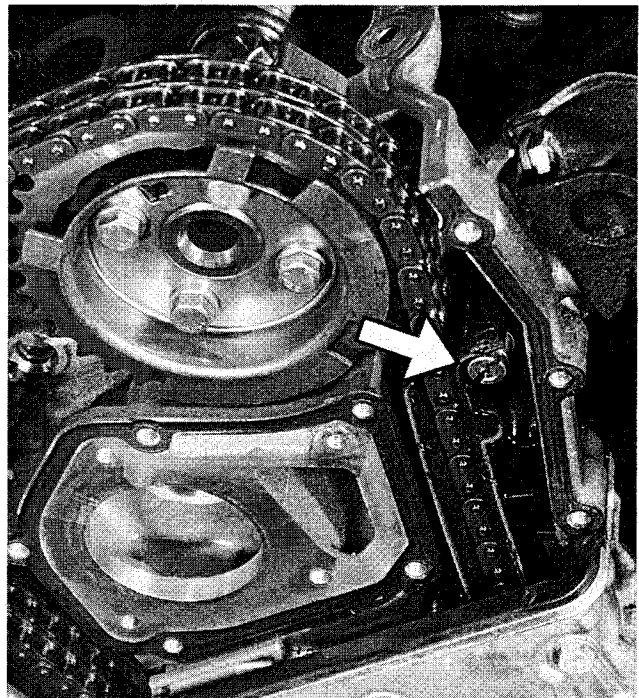


Fig. 10. Left upper chain guide adjusting sleeve (arrow). Note camshaft position

CAUTION —

Different hydraulic chain tensioners were used during manufacture, depending on engine type. See Fig. 11. Note that the late style tensioner can be retrofitted to the earlier engine, so be sure to identify the version of tensioner installed as installation instructions vary between the two.

7. On M42 engine: Disassemble chain tensioner by striking outer sleeve against a solid object. This will release snap ring and tensioner will separate. See Fig. 12.
8. On M42 engine: Clamp chain tensioner piston in vice (soft jaws). Slowly compress piston, making sure detent ring fits into taper of outer sleeve. If necessary, press ends of detent ring together. Slowly continue pressing tensioner together until snap ring audibly clicks into outer sleeve. Measure overall length of tensioner to confirm correct assembly: 68.5 mm (2.7 in.).

NOTE —

The late-style tensioner on the M44 engine can be retrofitted to the M42 engine.

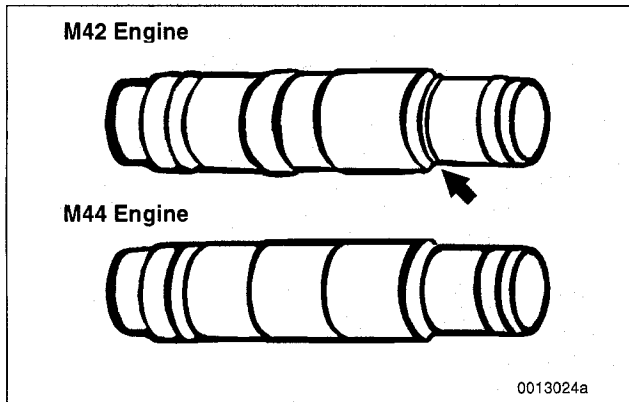


Fig. 11. Two versions of hydraulic chain tensioners. Original chain tensioner on M42 engine (**top**) can be disassembled. Chain tensioner on M44 engine (**bottom**) cannot be disassembled. Note differences in outer sleeve. Also, the M42 tensioner detent ring groove is visible when tensioner is extended (**arrow**).

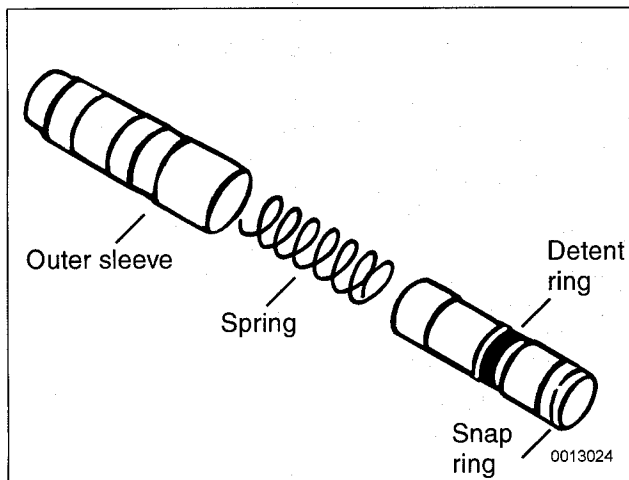


Fig. 12. Disassembled early-style chain tensioner used on M42 engine.

9. On M44 engines: Clamp tensioner piston in vice (soft jaws) and squeeze oil from it. Slowly compress piston only up to end circlip. Repeat procedure twice to ensure all oil is expelled. See Fig. 13.

10. Install hydraulic chain tensioner to cylinder head. Use a new sealing washer on tensioner plug when installing.

Tightening Torque

- Chain tensioner to cylinder head 40 Nm (30 ft-lb)

11. On M42 engines: Release early-style chain tensioner by pressing chain guide against tensioner until it unlocks and expands out.

12. Check that chain is now free of slack. Tighten down sprocket mounting bolts.

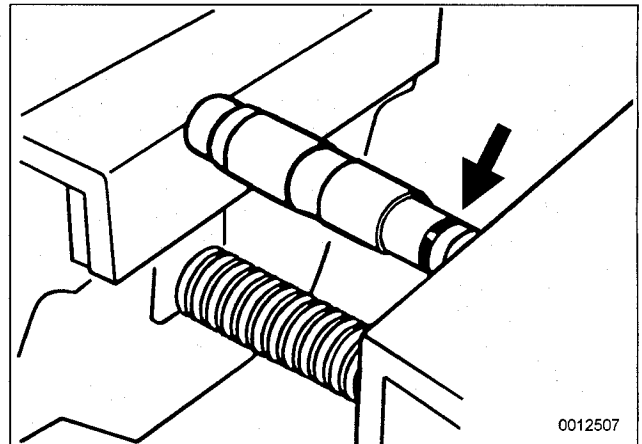


Fig. 13. When reinstalling chain tensioner, oil in tensioner piston must first be expelled by compressing piston in vise. When compressing piston, only compress up to end circlip (**arrow**).

Tightening Torque

- Chain sprocket to camshaft flange (M6) 10 Nm (89 in-lb)

13. Remove crankshaft locking tool from bellhousing and camshaft locking tool from rear of cylinder head.

14. Install lower timing chain cover:

- Install new crankshaft oil seal in cover.
- Use new gaskets when installing cover.
- Thoroughly clean profile gasket groove and all gasket sealing surfaces on lower chain cover.
- Apply a small bead of silicon sealer (3-Bond 1209® or equivalent) to joint corners where chain cover meets head and block. See Fig. 14.
- Tap cover into position to engage locating dowels.
- Tighten cover mounting bolts alternately and in stages.

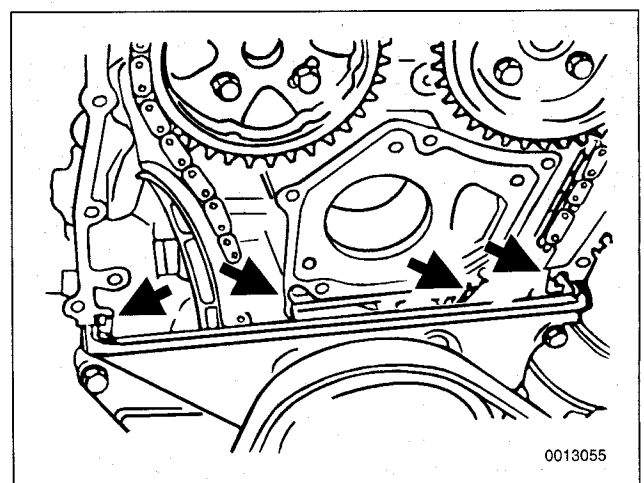


Fig. 14. Apply sealer (3-Bond 1209® or equivalent) to joint corners where chain cover meets head and block (**arrows**).

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15. Install upper timing chain cover:

- Thoroughly clean profile gasket groove and all sealing surfaces.
- Apply a small bead of silicon sealer (3-Bond 1209® or equivalent) to upper and lower joint corners where chain cover meets cylinder head.
- Install new profile gasket to groove in lower chain cover.
- Protect top of profile gasket using thin sheet metal (BMW special tool no. 11 2 330 or equivalent). See Fig. 15.
- Attach new gaskets to cover with light dabs of gasket sealant, hold gaskets in place using cover mounting screws.
- Place upper timing cover into position. Snug down all screws, without tightening. Carefully slide out sheet metal.
- Temporarily install cylinder head cover without gasket. Install and tighten at least two cylinder head cover mounting bolts to seat upper timing chain cover.
- Tighten all upper timing cover screws.
- Remove valve cover.

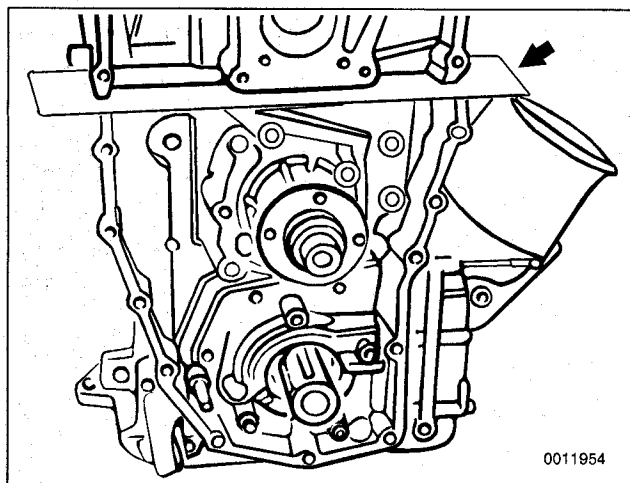


Fig. 15. When installing upper timing chain cover, use thin sheet metal (arrow) to protect profile gasket when installing upper cover.

Tightening Torque

- Upper timing chain cover to engine block or cylinder head (M6 screws) 10 Nm (89 in-lb)

16. Install vibration damper while aligning woodruff key. Hold crankshaft stationary and tighten mounting bolt.

Tightening Torques

- Pulley to vibration damper 22 Nm (17 ft-lb)
- Vibration damper to crankshaft
M16 stretch bolt (always replace) . . 330 Nm (244 ft-lb)

17. Remove crankshaft locking tool from transmission bell-housing and camshaft locking tool from rear of cylinder head.

18. Turn engine over by hand in direction of rotation at least two full rotations. Reinstall camshaft and crankshaft locking tools to check engine timing. Repeat cam timing procedure if tools do not fit easily into position. Remove locking tools.

19. Install cylinder head cover as described in 113 Cylinder Head Removal and Installation.

NOTE —

On M44 engines, note oil supply O-ring and replace if necessary.

Tightening Torque

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

20. Installation of remaining parts is reverse of removal. When installing thermostat, make sure arrow or vent hole faces up. Refill cooling system as described in 170 Radiator and Cooling System.

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)

CAMSHAFT TIMING CHAINS, 6-CYLINDER

Camshaft timing chain removal on 6-cylinder engines requires that you remove the engine oil pan by raising the engine and/or lowering the front suspension crossmember.

Special BMW service tools are needed for timing chain removal and installation procedures. The special tools assure proper timing of the valvetrain. Precise marks to set the timing on the camshafts are not provided for reassembly. Read the procedures through before beginning the job.

CAUTION —

If the camshafts are not properly timed, the pistons can contact the valves.

Camshaft timing chains, removing (6-cylinder engines)

1. Disconnect negative (-) cable from battery.

CAUTION —

Disconnecting the battery may erase fault code(s) stored in control module memory. Check for fault codes using special BMW diagnostic equipment.

2. Drain engine coolant. Drain engine block by removing block drain. Remove radiator cooling fan shroud and cooling fan. See **170 Radiator and Cooling System..**

WARNING —

Allow the engine to cool before opening or draining the system.

CAUTION —

Radiator fan has left hand threads.

NOTE —

The block drain plug is located on the exhaust side of the engine, below cylinder no. 4.

3. Drain engine oil and remove oil pan. See **119 Lubrication System.**
4. Remove alternator cooling duct.
5. Remove two large coolant hoses from thermostat housing. Remove engine lifting bracket and thermostat housing from front of cylinder head.
6. Loosen bolts for coolant pump pulley. Then remove drive belts for alternator and A/C compressor. See **020 Maintenance Program.** Remove coolant pump pulley.
7. Remove drive belt tensioner from front of engine. See Fig. 16.

NOTE —

On M50 engines with a two-roller drive belt tensioner, remove the upper roller to access the tensioner mounting bolts.

8. Remove engine speed sensor from lower timing chain cover, if applicable. See Fig. 17.
9. Remove cylinder head cover. See **113 Cylinder Head Removal and Installation.**

NOTE —

Make note of the arrangement of the rubber insulators when removing the cylinder head cover mounting bolts.

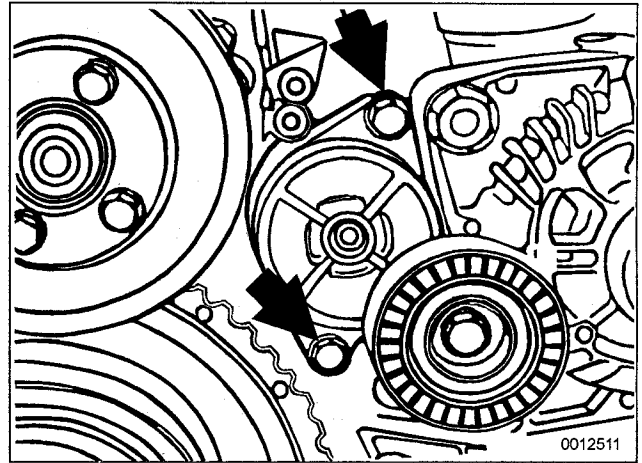
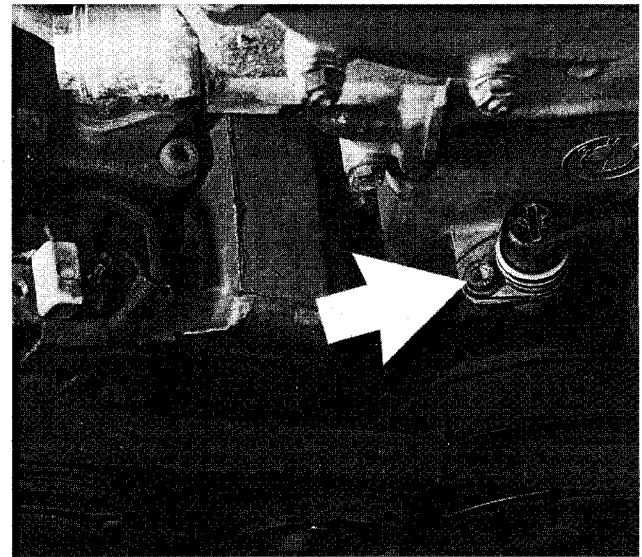


Fig. 16. Drive belt tensioner mounting bolts (arrows).



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Fig. 17. 1992-1995 M50 engine speed sensor on timing cover (arrow).

10. Unclip and remove baffle cover from above intake camshaft. See Fig. 18.
11. On 1992 engines: Remove upper timing chain cover from front of cylinder head. See Fig. 19.
12. Loosen spark plugs. See **120 Ignition System.**
13. Set engine to approximate TDC by rotating in normal operating direction until camshaft lobes at cylinder no. 1 are facing each other. See Fig. 20.
14. Set engine to TDC by aligning "0/T" mark (0°TDC) on front vibration damper with cast boss on lower timing chain cover. See Fig. 21.
15. Remove vibration damper mounting bolts and remove vibration damper and pulley. See Fig. 22.

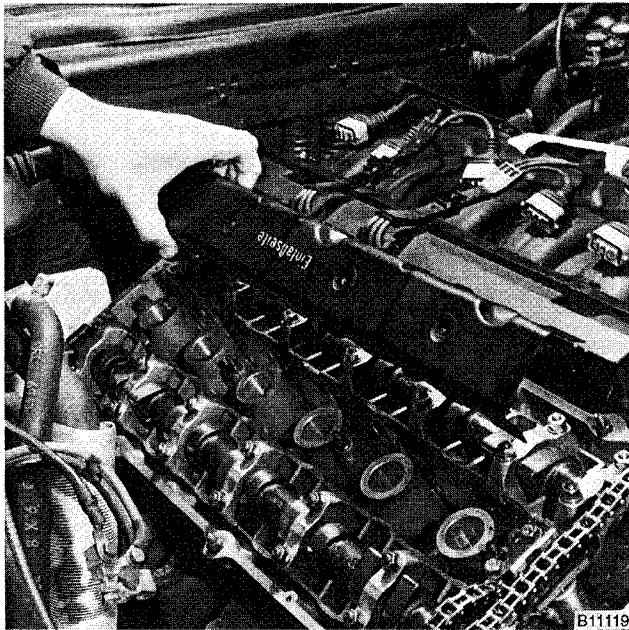


Fig. 18. Oil baffle cover being removed.

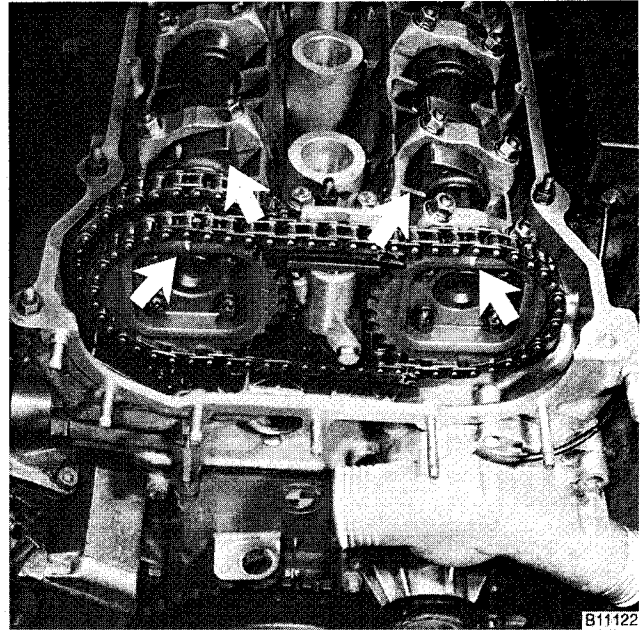


Fig. 20. Engine set to approximate TDC. Camshaft lobes face in and arrows on sprockets point up (**arrows**).

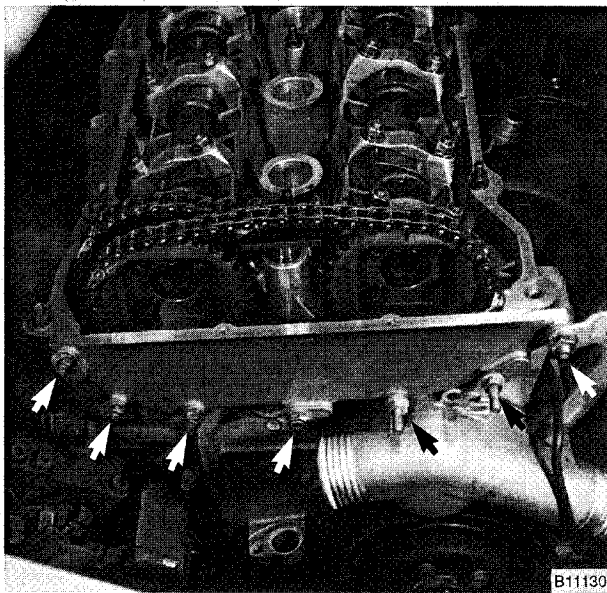


Fig. 19. Upper timing chain cover mounting nuts (**arrows**) on pre-VANOS engines.

16. Secure crankshaft hub to prevent crankshaft from turning. Using a socket, loosen but do not remove crankshaft hub center bolt.

NOTE —

The crankshaft hub center bolt is tightened to a torque of 410 Nm (300 ft-lb). A heavy duty holding device, such as BMW special tool no. 11 2 150, should be used to hold the crankshaft hub stationary while the bolt is loosened. Use a heavy duty 3/4-inch drive socket and breaker bar to break the bolt free.

CAMSHAFT TIMING CHAINS, 6-CYLINDER

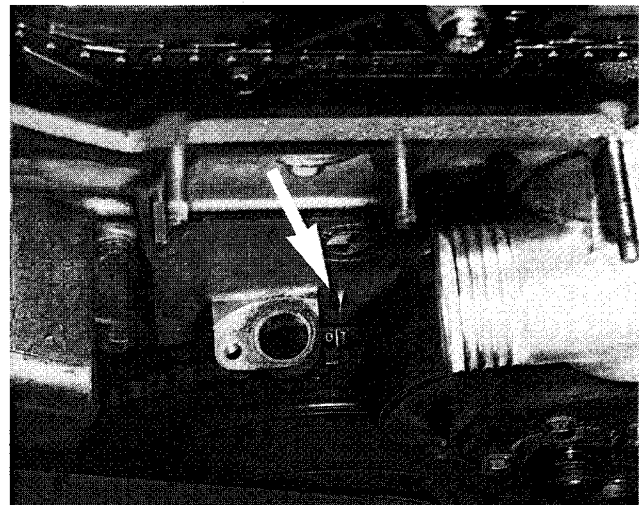


Fig. 21. O/T (0°TDC) mark on vibration damper aligned with boss on timing chain cover (**arrow**).

17. Lock crankshaft in TDC position by inserting BMW special tool no. 11 2 300 through transmission bellhousing and into hole in flywheel or drive plate. See Fig. 23.

NOTE —

Confirm that the locking tool has been correctly installed by trying to rotate the crankshaft.

18. Remove crankshaft hub bolt and washer. Remove hub from crankshaft.
19. Remove cylinder head cover mounting studs at rear of head. Lock camshafts at TDC using BMW special tool no. 11 3 240 at ends of camshafts. See Fig. 24..

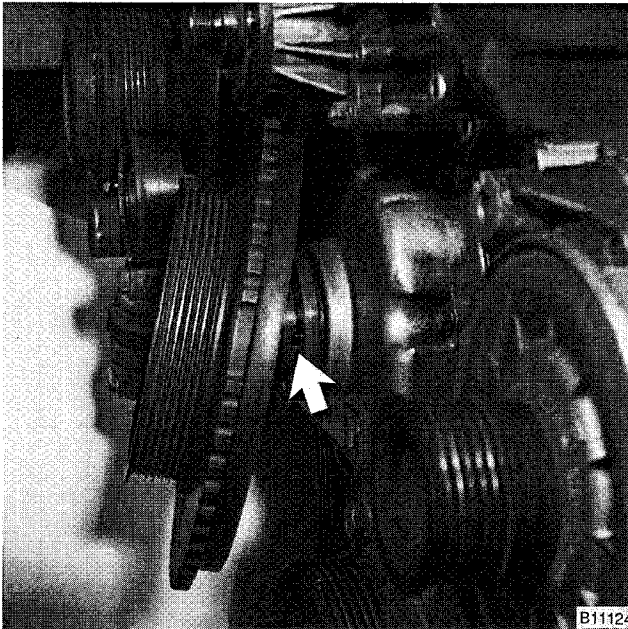


Fig. 22. Vibration damper with drive belt pulley being removed. Note hub locating dowel (arrow).

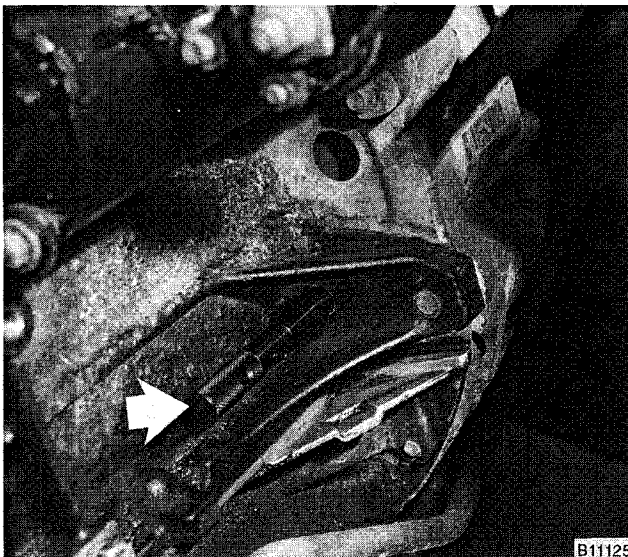


Fig. 23. BMW special tool no. 11 2 300 installed through bellhousing and into flywheel.

20. Remove primary chain tensioner plug and primary chain tensioner. See Fig. 25.

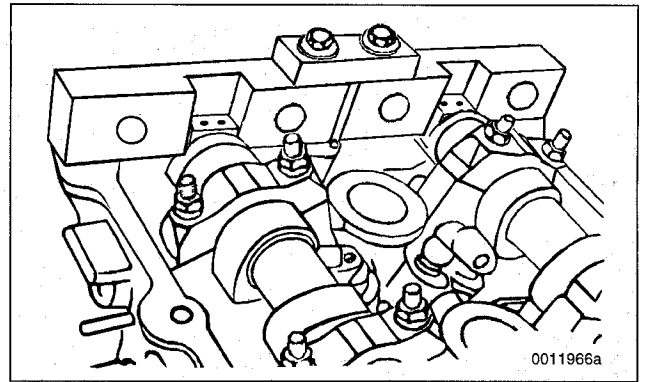


Fig. 24. BMW special tool no. 11 3 240 installed on rear of camshafts to position camshafts at TDC. (M44 camshafts shown. Other engines are similar.)

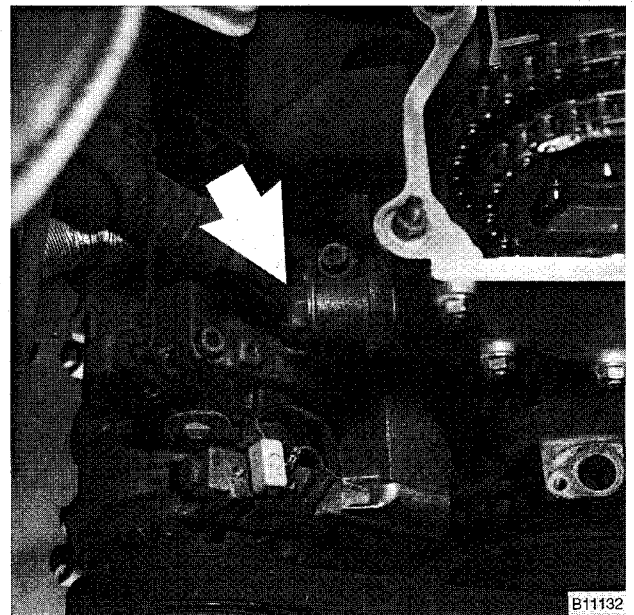


Fig. 25. Primary chain tensioner plug (arrow).

CAUTION —

- Check that tool is squarely seated on cylinder head gasket surface. If necessary, rotate camshafts slightly using a 24 mm wrench
- On pre-VANOS engines (engines built up to 8-92), the camshaft locking tool may not fit correctly when the crankshaft is set to TDC. Do not assume the valve train is out of time. On some engines, valve overlap may have been reduced as a dealer service campaign to correct for an uneven idle. Check the timing by placing a 3mm drill bit under the left and right outside edges while pressing down on the center of the tool (tool center bolts loosened). If the tool now fits, the campaign has been done on the engine.

117-10 CAMSHAFT TIMING CHAIN

21. On 1993 and later engines: Remove access plugs from VANOS control unit in front of exhaust camshaft sprocket. Remove 4 bolts from exhaust camshaft sprocket (use Torx E10 socket). See Fig. 26.

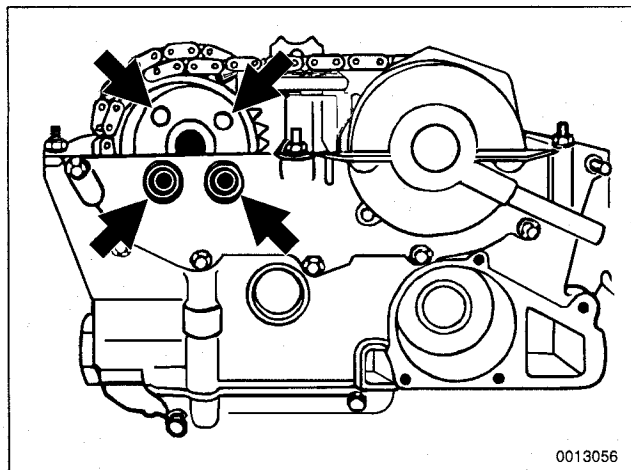


Fig. 26. Exhaust camshaft mounting bolts (arrows).

22. Depress secondary timing chain tensioner and lock down by inserting stiff wire into the openings in rear of tensioner. See Fig. 27.

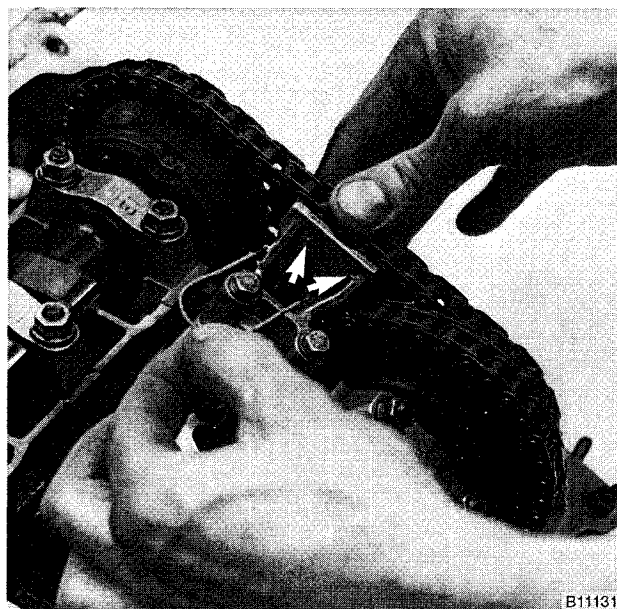


Fig. 27. Secondary timing chain tensioner being locked down on M50 engine. Press tensioner down and insert locking wire through holes (arrows). Tensioner on M52/S52 US engines vary slightly.

23. Remove secondary chain tensioner and lift out primary chain guide.

24. On 1993 and later engines:

- Remove VANOS control unit as described later in this repair group.
- Remove intake camshaft sprocket mounting nuts.
- Remove intake and exhaust sprockets together with secondary chain. Note location of thrust washers and spring plate (where applicable) on intake sprocket.

NOTE —

Hold the camshaft stationary (at hex on camshaft) when loosening or tightening sprocket mounting bolts.

CAUTION —

The crankshaft must not be allowed to rotate once the timing chain is removed. The pistons can contact the valves.

25. On 1992 engines:

- Remove from intake and exhaust sprocket mounting bolts.
- Remove sprockets together with secondary chain.

26. Remove bolts holding lower timing chain cover to cylinder head (use Torx E8 socket). See Fig. 28.

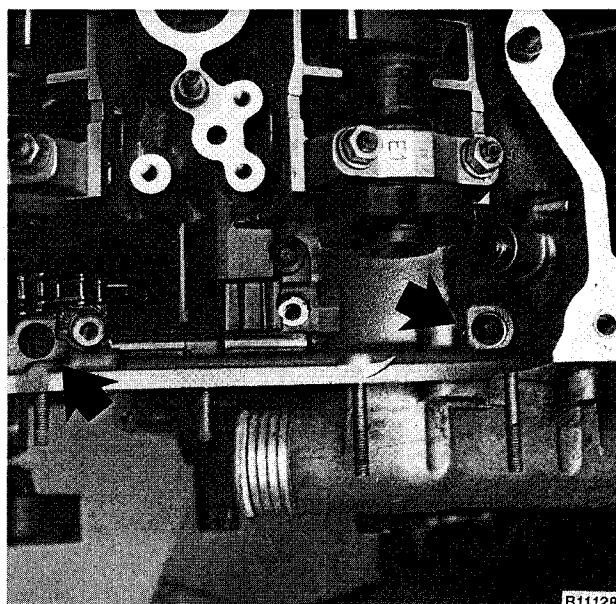


Fig. 28. Cylinder head-to-timing chain cover mounting bolts (arrows).

27. Using a drift, drive two locating dowels in left and right sides of lower timing chain cover toward rear of car. Remove cover mounting bolts and carefully lift cover off. See Fig. 29.

CAUTION —

Use care when removing the cover from the cylinder head gasket. If the cover is stuck, use a sharp knife to separate it from the head gasket.

CAMSHAFT TIMING CHAINS, 6-CYLINDER

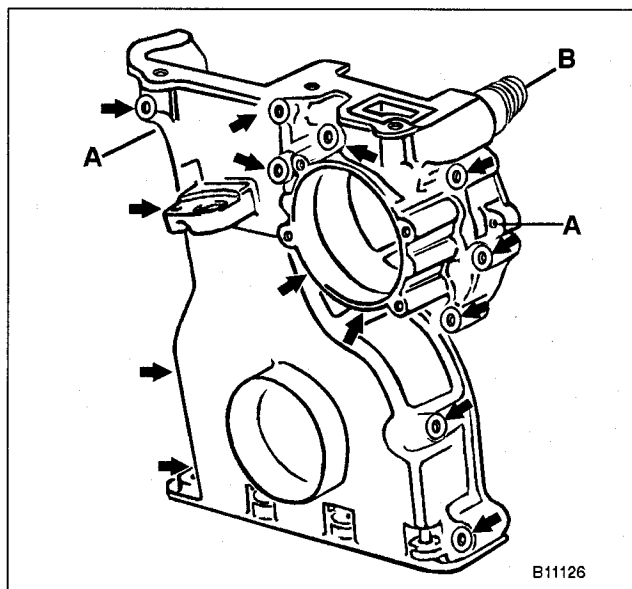


Fig. 29. Lower timing chain cover mounting bolts (arrows) and dowel locations (A). Coolant hose fitting B is replaced by coolant pipe pressure fitting in later models.

NOTE —

- The timing chain cover can be removed with the coolant pump installed.
- Use care when removing the chain cover from the coolant pipe or hose at the rear of the cover.

28. Remove remaining Torx bolt from timing chain guide. See Fig. 30.

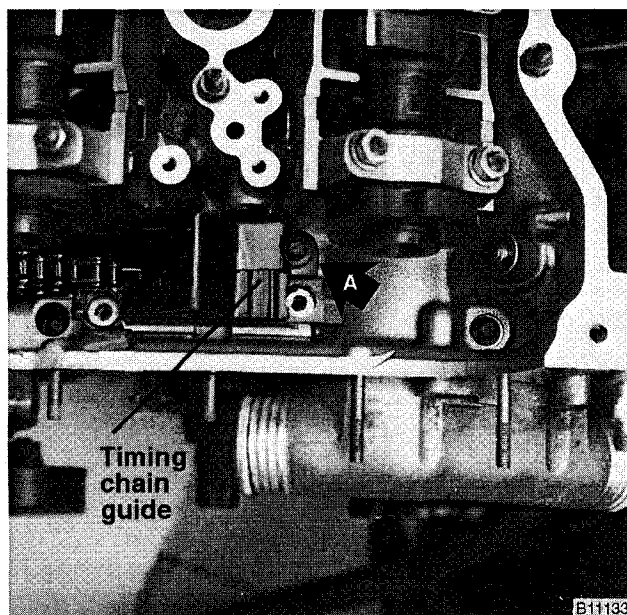


Fig. 30. Timing chain guide mounting bolt (A).

29. Lift primary chain sprocket off exhaust camshaft and remove chain.

NOTE —

- If any of the sprockets are being replaced due to wear, the chain should also be replaced.
- If the crankshaft sprocket requires replacement, the oil pump drive sprocket and chain must be removed as described under 119 Lubrication System.

Camshaft timing chains, installing (6-cylinder engines)

Inspect timing chain sprockets. Sprockets that have worn or missing teeth should be replaced. Inspect guide rail and tensioner rail for deep grooves caused by chain contact. Replace any part that is worn.

The procedure outlined below assumes that the camshafts and the crankshaft are locked in the TDC installation position with special tools (shown earlier in Fig. 23 and Fig. 24).

NOTE —

On pre-VANOS engines (engines built up to 8-92), the camshaft locking tool (Fig. 24) should be raised up on either side by 3mm (use feeler gauge or drill bits). Be sure the clamping bolts on tool are loose and the center of the tool is contacting the cylinder head surface. This service campaign helps improve idle characteristics by reducing valve overlap.

1. Install primary timing chain to crankshaft sprocket and tie it up through cylinder head opening.
2. Using new gaskets and coolant pipe O-ring, install lower timing chain cover:
 - Drive timing cover dowels in until they just protrude slightly from sealing surface.
 - Apply a small bead of silicon sealer (3-Bond 1209® or equivalent) to corners of cylinder head where timing cover meets cylinder head and engine block.
 - Tap cover into position to engage dowels.
 - Install mounting bolts hand tight, including two outer Torx bolts from above.
 - Drive dowels in flush to front of cover.
 - Tighten cover mounting bolts alternately and in stages.

Tightening Torque

- Lower timing cover to cylinder block

M7	15 Nm (11 ft-lb)
M8	20 Nm (15 ft-lb)

3. Install oil pan using a new gasket. See 119 Lubrication System.

4. Mount primary timing chain sprocket to primary chain so that arrow on sprocket faces up. Mount sprocket to camshaft so that tapped holes in camshaft are on left side of elongated holes in sprocket. See Fig. 31.

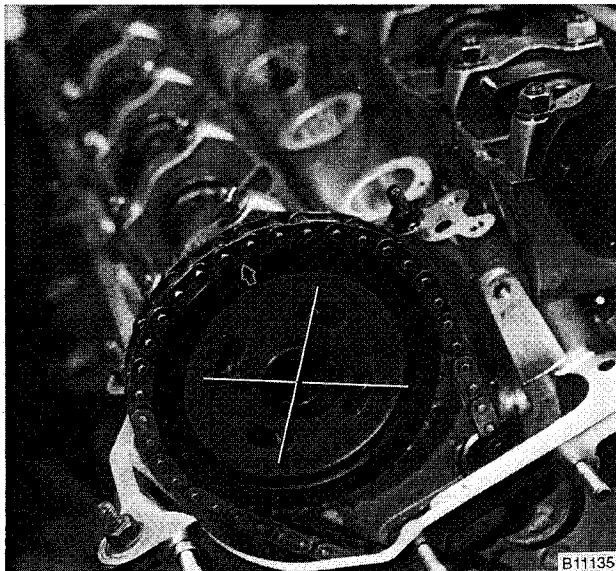


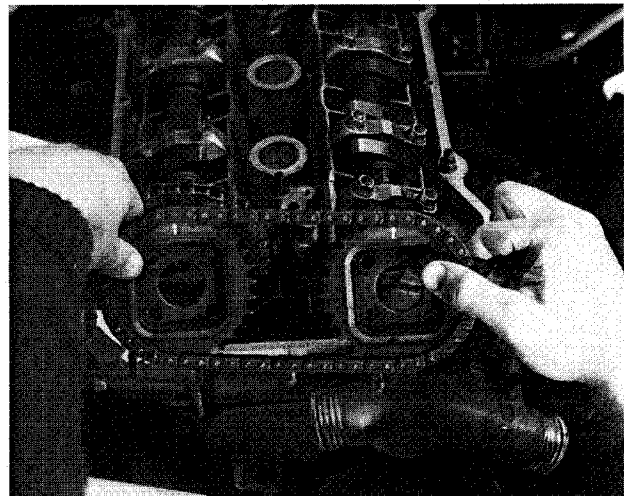
Fig. 31. Primary timing chain sprocket correctly aligned to exhaust camshaft. Elongated sprocket holes should be aligned to left side of threaded camshaft holes.

5. On 1993 and later engines: Install BMW special tool no. 11 3 390 into primary timing chain tensioner sleeve. Thread tool in finger tight until slack is removed from chain.
 - Check that elongated holes in primary sprocket are centered to bolt holes in camshaft and chain is free of slack.

NOTE —

BMW special tool no. 11 3 390 is a dummy primary chain tensioner and simulates the function of the hydraulic tensioner.

6. Install primary timing chain guide and secondary chain tensioner. Tighten mounting bolts. (Tensioner remains locked down for now.)
7. Install cylinder identification trigger plate to front of intake camshaft. On 1993 and later engines, install thrust washer to front of intake camshaft.
8. Install secondary chain sprockets and chain as an assembly so that arrows on sprockets are pointing up. Center mounting holes in sprockets to bolt holes in camshafts. See Fig. 32.
9. On 1993 and later engines: Install thrust washers and spring plate (where applicable) to intake cam sprocket.



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Fig. 32. Secondary chain sprockets being installed. Attach sprockets with arrows pointing up and elongated holes centered to threaded holes in shaft flange.

NOTE —

On engines built beginning from March 1995, the VANOS intake cam sprocket assembly was updated to include a spring plate and two thrust washers. See Fig. 33.

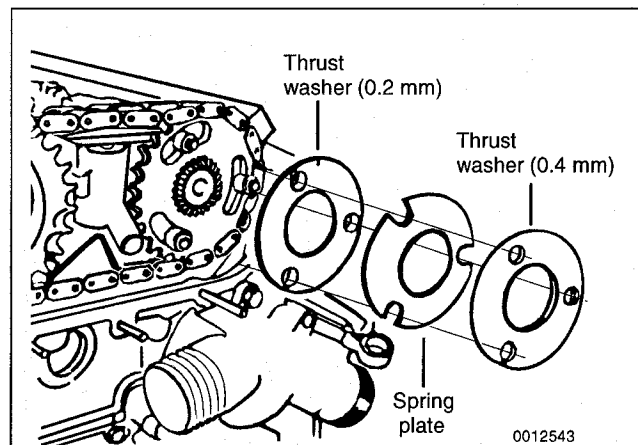


Fig. 33. VANOS spring plate and thrust washers on engines built 3/95 and later.

10. On 1993 and later cars, tighten nuts at intake camshaft sprocket.

Tightening Torque (1996 and later)

- Intake camshaft sprocket nut to stud (M6) 10 ± 1 Nm (89 ± 9 in-lb)

11. On 1992 engines: Install primary chain tensioner so that cutout in tensioner piston engages chain rail. See Fig. 34. Check that chain is free of slack.

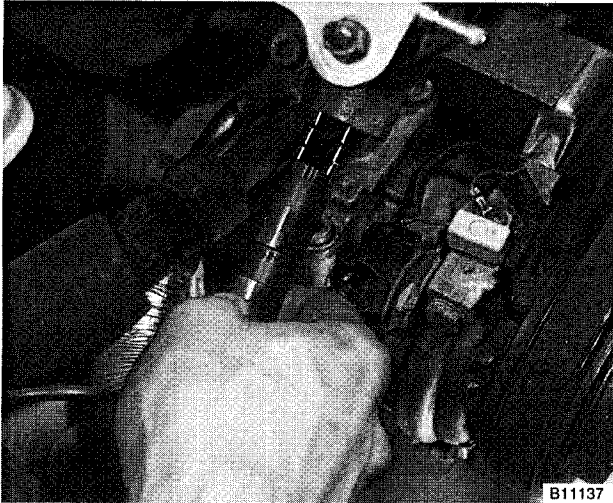


Fig. 34. Primary timing chain tensioner being installed. Piston cutout must be in position shown to engage chain rail.

12. On 1993 and later engines: Install VANOS control unit as described later in this repair group.
13. Unlock and release secondary chain tensioner.
14. On 1992 engines: Tighten intake and exhaust timing chain sprocket bolts alternately in two stages, working at intake side first.

Tightening Torques

- Secondary timing chain sprockets to camshafts (M7 Torx bolts)

Stage 1.....	5 Nm (44 in-lb)
Stage 2.....	22 Nm (17 ft-lb)

15. On 1992 engines: Install upper timing chain cover to cylinder head using a new gasket. Apply a small amount of liquid gasket sealer (3-Bond 1209® or equivalent) around cover alignment dowels.
16. On 1993 and later engines: Preload primary chain by tightening BMW special tool no. 11 3 390 (dummy chain tensioner) to 1.3 Nm (11 in-lb). Then tighten exhaust camshaft sprocket bolts alternately in two stages.

Tightening Torques (1993 and later engines)

- Exhaust camshaft sprockets to camshafts (M7 Torx bolts)

Stage 1.....	5 Nm (44 in-lb)
Stage 2.....	22 Nm (17 ft-lb)

17. Remove flywheel locking tool from transmission bell-housing. Remove camshaft locking tool from rear of cylinder head.

18. Install crankshaft hub and washer while aligning woodruff key. Hold hub stationary and tighten mounting bolt. Install vibration damper and pulley, making sure that locating pin in hub engages hole in vibration damper.

NOTE —

When installing crankshaft hub mounting bolt, the stepped (shouldered) side of the washer should face the hub.

Tightening Torques

- Crankshaft hub to crankshaft (stretch bolt—always replace)..... 410 ± 20 Nm (300 ± 15 ft-lb)
- Vibration damper and pulley to crankshaft hub (M8)..... 22 Nm (17 ft-lb)

19. Turn engine over by hand in direction of rotation at least two full rotations. Reinstall camshaft and crankshaft locking tools to check engine timing. Remove locking tools if no faults are found.

NOTE —

On pre-VANOS engines, be sure to install the 3mm drill bits on left and right sides of tool.

20. On 1993 and later engines: Remove BMW special tool 11 3 390 (dummy tensioner). Install primary chain tensioner so that cutout in tensioner piston engages the chain rail. See Fig. 34. Install and tighten access plugs in VANOS control unit.

Tightening Torques

- Access plugs to VANOS control unit..... 50 Nm (37 ft-lb)
- Primary timing chain tensioner to tensioner sleeve

M50/S50US engine.....	50 Nm (37 ft-lb)
M52/S52US engine.....	40 Nm (30 ft-lb)

21. Install cylinder head cover mounting studs. Install oil baffle cover. Install cylinder head cover.

Tightening Torque

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

22. Installation of remaining parts is reverse of removal, noting the following:

- When installing thermostat, make sure arrow or vent hole faces up, if applicable.
- Refill cooling system as described in **170 Radiator and Cooling System**.
- Install oil pan as described in **119 Lubrication System**.
- Fill engine with oil and install a new oil filter as described in **020 Maintenance Program**.
- Install ground wires at cylinder head cover mounting studs and at front of cylinder head and thermostat housing, where applicable.

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)
- Upper timing chain cover to cylinder head
 - M6 nut 10 Nm (89 in-lb)
 - M8 bolt 22 Nm (17 ft-lb)
- VANOS control unit to cylinder head
 - M6 nut 10 Nm (89 in-lb)
 - M8 bolt 22 Nm (17 ft-lb)
- VANOS oil supply pipe to VANOS control unit
 - banjo bolt 32 Nm (24 ft-lb)

VANOS (VARIABLE VALVE TIMING)

1993 and later 6-cylinder engines are equipped with a variable valve timing system called VANOS. This system is controlled by the engine management system and dynamically adjusts intake camshaft timing based on engine load, engine speed and engine temperature.

The main components of the VANOS system are the control unit with piston housing and integral spool valve, and the modified intake camshaft. See Fig. 35.

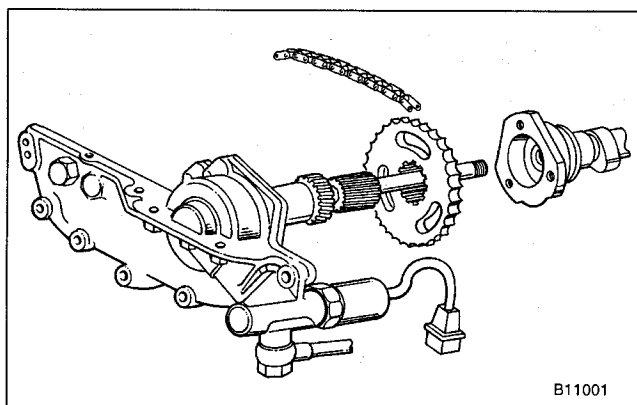


Fig. 35. VANOS control unit with modified intake camshaft.

VANOS (VARIABLE VALVE TIMING)

When the engine is running, the piston housing is supplied with pressurized engine oil. At idle, the solenoid is in the off position (de-energized) and valve timing is maintained in the normal position. When the solenoid is energized, the gear cup piston moves forward to advance the camshaft by a maximum of 12.5°.

WARNING —

Special BMW service tools are required to check and repair the VANOS system. Read the procedures through before beginning the job.

VANOS system operation, testing

There are 3 special tools required to check VANOS operation; an electrical test lead (BMW special tool no. 12 6 410), an air line fitting (BMW special tool no. 11 3 450), and a crankshaft TDC locking tool (BMW special tool no. 11 2 300).

The test lead is used to power the solenoid, simulating the ground signal from the DME control unit. The air line fitting takes the place of the oil supply line fitting to simulate oil pressure. The locking tool positions and locks the crankshaft at TDC, cylinder no.1.

1. Remove alternator cooling air duct.
2. Disconnect crankcase ventilation hose fitting from cylinder head cover.
3. Remove top plastic engine covers. Disconnect ignition coil harness connectors from coils. Remove ignition coils.
4. Remove cylinder head cover mounting bolts and remove cylinder head cover. Unclip and remove oil baffle cover from above intake camshaft. See **113 Cylinder Head Removal and Installation**.

NOTE —

Note the arrangement of the cylinder head cover bolt insulators and gaskets during removal.

5. Set engine to approximate TDC by rotating in normal operating direction until camshaft lobes at cylinder no. 1 are facing each other. See Fig. 20.
6. Set engine to TDC by aligning "0/T" mark (0°TDC) on front vibration damper with cast boss on lower timing chain cover. See Fig. 21.
7. Lock crankshaft in position by inserting BMW special tool no. 11 2 300 through transmission bellhousing and into hole in flywheel or drive plate. See Fig. 36.

NOTE —

Confirm that the locking tool has been correctly installed by trying to rotate the crankshaft.



Fig. 36. BMW special tool no. 11 2 300 installed through bellhousing and into flywheel.

8. Remove oil line fitting from VANOS control unit.

NOTE —

Wrap the VANOS oil line fitting with a shop to absorb leaking oil.

9. Using hollow bolt and seals from oil supply line, install BMW special tool no. 11 3 450 (air line fitting) and connect a supply of compressed air (30-115 psi) to VANOS oil fitting.

10. Measure and record distance between trigger plate edge and side of secondary timing chain tensioner. See Fig. 37.

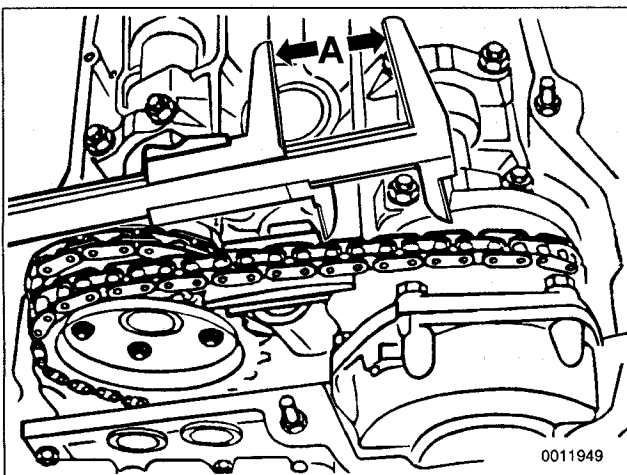


Fig. 37. VANOS reference measurement (dimension A) between trigger plate (sender gear) and side of secondary chain tensioner.

11. Disconnect harness connector from VANOS solenoid. Connect BMW special tool no. 12 6 410 (electrical test lead) to VANOS solenoid connector.

- Connect positive (+) test lead to positive (+) terminal of battery. Connect negative (-) test lead to chassis ground. solenoid should audibly click and intake camshaft should advance.

CAUTION —

• Be sure to connect the test harness polarity correctly. If the polarity is reversed, the internal diode in the VANOS solenoid will be destroyed. Although the solenoid will still function with a faulty diode, a fault code may be set in the ECM memory.

• To confirm voltage polarity, turn the ignition on and check for positive (+) battery voltage at the terminal corresponding to the red/white wire in the main harness connector. Check that the positive terminal (+) in the main connector corresponds to the same terminal in the solenoid connector that is being connected to the battery.

12. With solenoid actuated, measure and record new distance between trigger plate edge and side of secondary timing chain tensioner, as shown in Fig. 37.

13. Difference between first measurement (step 10) and second measurement (step 12) should be at least 8.5 mm (0.3346 in.). If any faults are found, solenoid may be faulty, or hydraulic control unit may be faulty or incorrectly installed.

14. Check VANOS solenoid by removing it from control unit. Check that solenoid plunger and control unit plunger move freely. Install solenoid using tightening torque given below.

NOTE —

• The solenoid is available as a replacement part. If the control unit plunger is sticking, the complete control unit will have to be replaced.

• If the VANOS system does not advance correctly and no other faults can be found, it is possible that the VANOS control unit may have been installed incorrectly—especially if the camshaft sprockets have previously been removed for other repairs. Check the installation by removing and reinstalling the control unit as described later.

VANOS (VARIABLE VALVE TIMING)

15. Remove crankshaft locking tool. Remove special test equipment. Install oil supply line using new seals and reconnect solenoid connector. Remainder of installation is reverse of removal.

Tightening Torque

- Cylinder head cover to cylinder head. 10 Nm (89 in-lb)
- VANOS oil supply line to VANOS control unit (banjo bolt) 32 Nm (24 ft-lb)
- VANOS solenoid to VANOS control unit 30 Nm (22 ft-lb)

VANOS control unit, removing

Special BMW service tools are required to remove and install the VANOS control unit. Read the procedure through before starting the job.

1. Remove radiator cooling fan shroud and cooling fan. See **170 Radiator and Cooling System**.

CAUTION —

Radiator fan has left hand threads.

2. Remove top plastic engine covers. Disconnect ignition coil harness connectors from coils. Remove ignition coils. Remove cylinder head cover. Unclip and remove oil baffle cover from above intake camshaft. See **113 Cylinder Head Removal and Installation**.

NOTE —

Make note of the mounting bolt insulator arrangement during removal of the cylinder head cover.

3. Set engine to TDC by rotating engine in normal operating direction until camshaft lobes at cylinder no. 1 are facing each other and "0/T" mark (0°TDC) on vibration damper lines up with cast boss on lower timing chain cover. See Fig. 38.
4. Lock crankshaft at TDC by inserting BMW special tool no. 11 2 300 through transmission bellhousing and into flywheel or drive plate. Refer to Fig. 36 given earlier.

NOTE —

Confirm that the locking tool has been correctly installed by trying to rotate the crankshaft.

5. Remove three cylinder head cover mounting studs from rear of head. Lock camshafts at TDC by mounting BMW special tool no. 11 3 240 at ends of camshafts. Check that tool is squarely seated on cylinder head gasket surface. If necessary, rotate camshafts slightly using a 24 mm wrench. Refer to Fig. 24 given earlier.

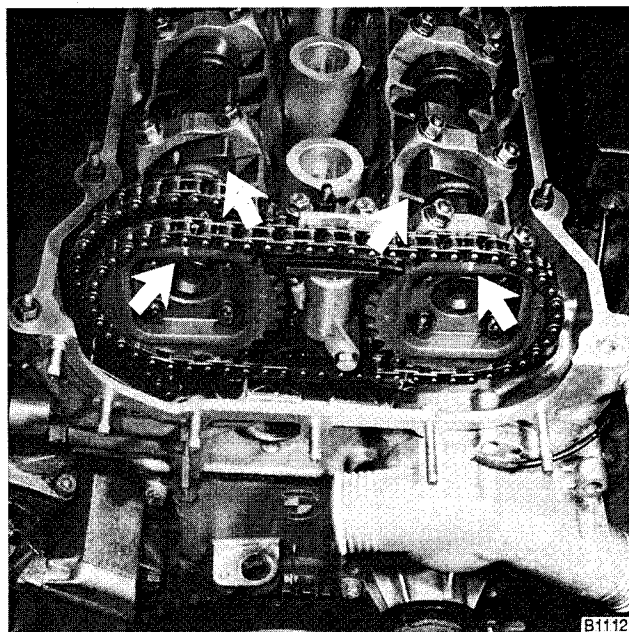


Fig. 38. Camshafts positioned at TDC—Cyl. No. 1 cam lobes face in Note 0/T mark (0°TDC) on vibration damper aligned with boss on front cover.

CAUTION —

The camshafts must be locked in the TDC position using the special service tool or an equivalent before removing the timing chain. The arrows on the sprockets should not be used to accurately set the engine to TDC. The special tool holds the camshafts parallel to each other and perpendicular to the valve cover gasket surface.

6. Disconnect harness connector and oil line fitting from bottom of VANOS control unit.

NOTE —

Wrap the VANOS oil line fitting with a shop rag to absorb leaking oil.

7. Remove two access plugs from VANOS control unit in front of exhaust camshaft sprocket. Loosen 4 exhaust camshaft sprocket mounting bolts but do not remove (Torx E10 socket).

NOTE —

Removal of the access plugs allows the lower exhaust camshaft sprocket mounting bolts to be accessed.

8. Depress secondary timing chain tensioner and lock it in down position by inserting a stiff wire into rear of tensioner. See Fig. 27.
9. Remove VANOS control unit mounting nuts and bolt at front of cylinder head.

10. On cars built up to 3/95: Slide control unit off front of cylinder head, hand turning the exhaust sprocket clockwise (as viewed from front) as the unit is removed.
11. On cars built 3/95 and later: Use a spanner tool to rotate exhaust sprocket until stop on intake sprocket is contacted. See Fig. 39. Then slide control unit off front of cylinder head.

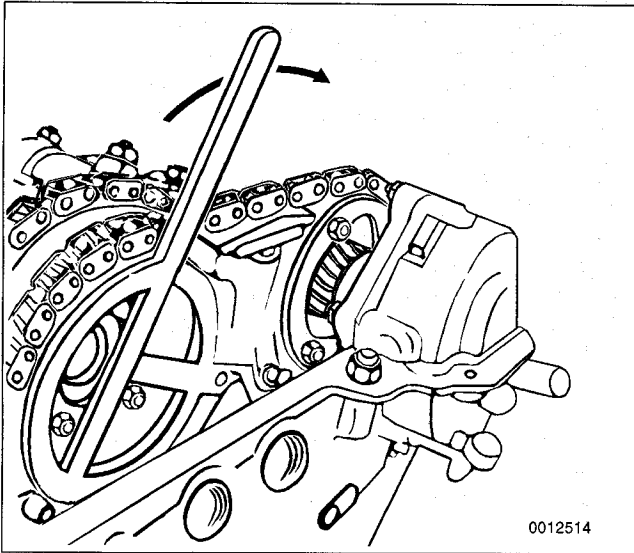


Fig. 39. On VANOS control unit with spring plate (cars built 3/95 and later), rotate exhaust camshaft sprocket clockwise until intake camshaft contacts stop. BMW special tool 11 5 490 shown.

VANOS control unit, installing

CAUTION —

Incorrect installation of the VANOS control may result in damage to the engine valvetrain.

1. Lock camshafts and crankshaft in TDC position with BMW special tools as described above in removal procedure.

CAUTION —

The camshafts and crankshaft must be locked in the TDC position using BMW special tools no. 11 2 300 and 11 3 240. If the camshafts and crankshaft are not at TDC, the valves can contact the pistons when the engine is turned over.

NOTE —

Be sure the secondary timing chain tensioner is locked down and the exhaust camshaft mounting bolts are loose before proceeding.

2. Remove primary timing chain tensioner from side of cylinder head. See Fig. 40.

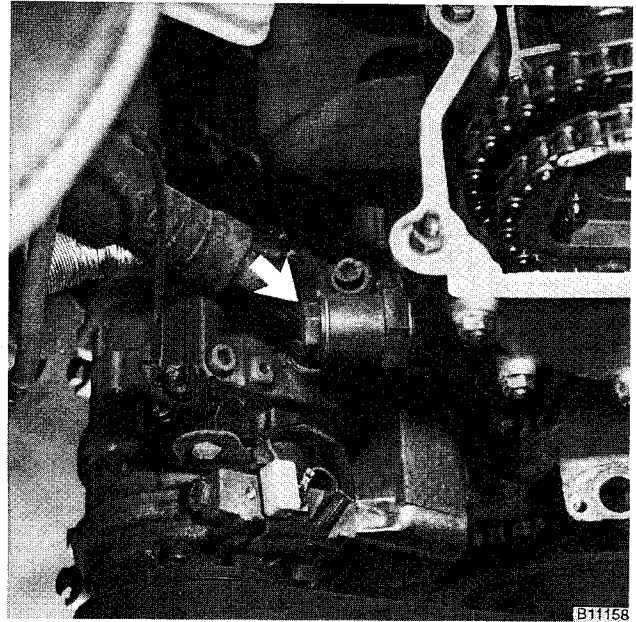


Fig. 40. Primary timing chain tensioner (arrow). Remove tensioner slowly to relieve spring tension beneath end plug.

3. Install BMW special tool no. 11 3 390 into primary timing chain tensioner sleeve. Thread tool in finger tight to remove chain slack.

NOTE —

BMW special tool no. 11 3 390 is a dummy chain tensioner and simulates the function of the tensioner.

4. Hand turn secondary sprockets clockwise (as viewed from front of engine) until sprockets contact stops.
5. Apply a small amount of liquid gasket sealer (3-Bond 1209® or equivalent) to VANOS housing alignment dowels on front of cylinder head. Install a new gasket.
6. Push VANOS piston gear cup into VANOS housing until it bottoms out in housing. Position VANOS control unit into place, but do not engage splines on gear cup.
7. On cars built up to 3/95:
 - Hand turn exhaust sprocket counterclockwise (as viewed from front of engine) **only enough** to mesh gear cup splines with camshaft gear.
 - Slowly push VANOS control unit in until fully seated, guiding chains in counterclockwise direction.

CAUTION —

It is critical that the exhaust camshaft sprocket be turned only the minimum amount necessary to engage the gear cup. If this procedure is done incorrectly, the VANOS system may not function throughout its full range.

NOTE —

As the control unit is installed, the secondary sprockets will rotate in the counterclockwise direction. It may be necessary to guide sprockets counterclockwise as the control unit is installed.

8. On cars built from 3/95: Use a spanner tool (See Fig. 39.), turn exhaust sprocket counterclockwise (as viewed from front of engine) **only enough** to mesh gear cup splines with camshaft gear. Slowly push VANOS control unit towards camshaft until it is fully seated, guiding chains in counterclockwise direction.

CAUTION —

Ensure that the first available tooth engages.

9. Install and tighten control unit nuts and bolt.
10. Connect harness connector to VANOS solenoid. Using new seals, install oil line fitting.

Tightening Torques

- VANOS control unit to cylinder head
 - M6 nut 10 Nm (89 in-lb)
 - M8 bolt 22 Nm (17 ft-lb)
- VANOS oil supply line to control unit . 32 Nm (24 ft-lb)

11. Slowly unlock and release secondary chain tensioner.
12. Preload primary chain by tightening BMW special tool no. 11 2 240 (dummy chain tensioner) to 1.3 Nm (11 in-lb). Then tighten exhaust camshaft sprocket mounting bolts alternately in two stages.

Tightening Torque

- Secondary timing chain sprockets to camshafts (Torx bolts)
 - Stage 1 5 Nm (44 in-lb)
 - Stage 2 22 Nm (17 ft-lb)

13. Remove flywheel locking tool from transmission bell-housing. Remove camshaft locking tool from rear of cylinder head.
14. Turn engine over by hand at least two full crankshaft rotations. Reinstall camshaft locking tool and flywheel locking tool to make sure all adjustments are correct. If settings are correct, remove locking tools.
15. Remove BMW special tool 11 2 420 (dummy chain tensioner) from side of cylinder head. Install primary chain tensioner so that cutout in tensioner piston engages chain rail. See Fig. 34. Using new seals, install and tighten access plugs in VANOS control unit.

Tightening Torque

- Access plugs to VANOS control unit. 50 Nm (37 ft-lb)
- Primary timing chain tensioner plug to tensioner sleeve
 - M50/S50US engine 50 Nm (37 ft-lb)
 - M52/S52US engine 40 Nm (30 ft-lb)

16. Install oil baffle cover above intake camshaft. Install three cylinder head cover mounting studs to rear of head. Install cylinder head cover.

Tightening Torque

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

17. Installation of remaining parts is reverse of removal.

NOTE —

Be sure to install the ground wires at the cylinder head cover mounting studs and at the front of the cylinder head, if applicable.



VANOS (VARIABLE VALVE TIMING)