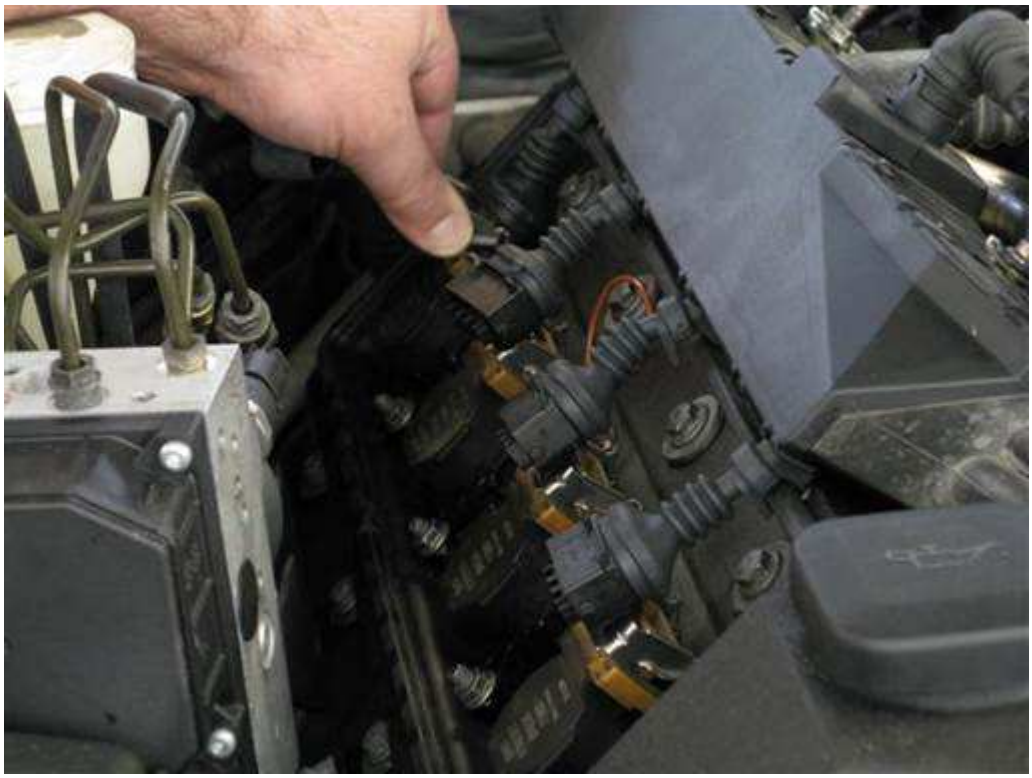
Removal of valve covers

Disconnect battery negative cable.
Open rear trunk lid. Open right fender cabin door (at trunk orientation).
Loosen battery negative cable mounting nut (10 mm socket 3/8” / 3/8" ratchet & extension).
Remove negative cable clamp from battery negative post and set to side.

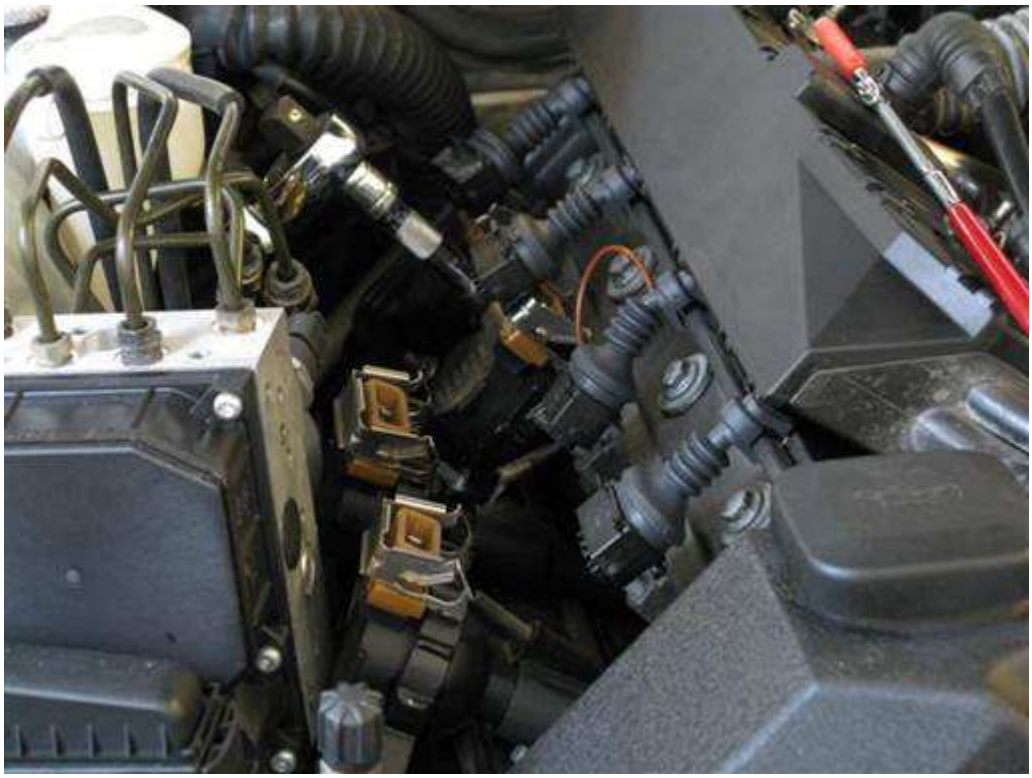
Caution: Do not fully close trunk lid. It cannot be opened using electronic latch. If trunk lid closed, key is needed to mechanically open trunk lid.

Note: Battery negative cable removal is necessary for removal of battery positive cable at engine bank 2 valve cover in subsequent step.

Remove bank 1 & 2 top cover. For each cover perform following.
Pry off and remove 2 center caps (flathead).
Remove 2 cover mounting bolts (10mm socket 3/8” / 3/8” ratchet & extension, magnet pickup).
Note: Bolt shaft can remain in cover.
Remove engine cover.



Disconnect bank 1 & 2 ignition coils electrical cable connectors. For each set of coils perform following.
For each coil, pull up on coil connector metal lock and pull off cable electrical connector.



Remove bank 1 & 2 ignition coils. For each set of coils perform following.
Remove 2 mounting nuts at each coil (10mm socket 3/8” / 3/8” ratchet & extension, magnet pickup).
Remove from coil studs, ground wires at coils 2 & 7 and ground straps at coils 3 & 6.
Pull up and remove all coils.

Note: Maintain coil/cylinder association for reinstallation. This is not necessary, but is good practice.

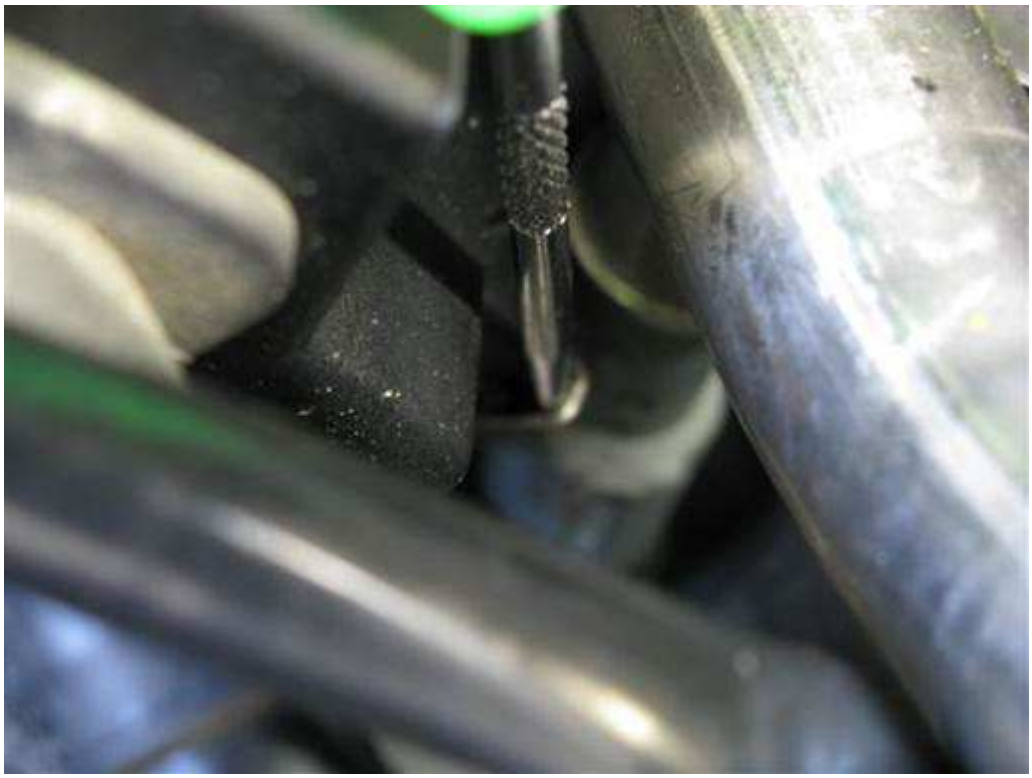
Disconnect bank 1 & 2 O2 sensor cable connector. For each O2 sensor perform following.
Pull off O2 sensor electrical cable connector from top center of electrical housing (black box).

Disconnect bank 1 & 2 camshaft position sensor cable connector. For each camshaft position sensor perform following.
Press in wire clip and pull off connector from top front of electrical housing (black box).

Disconnect secondary air control solenoid electrical connector at top left center of intake manifold. Press in connector wire clip and pull off connector.

Remove bank 1 & 2 electrical housing mounting nuts. For each electrical housing perform following.
Remove mounting nut from top front and rear electrical housing studs (10mm deep socket 3/8” / 3/8” ratchet & extension, magnet pickup).

Remove secondary air solenoid mounting bracket from bank 1 electrical housing front stud.
Remove vacuum accumulator mounting bracket from bank 2 electrical housing front stud.



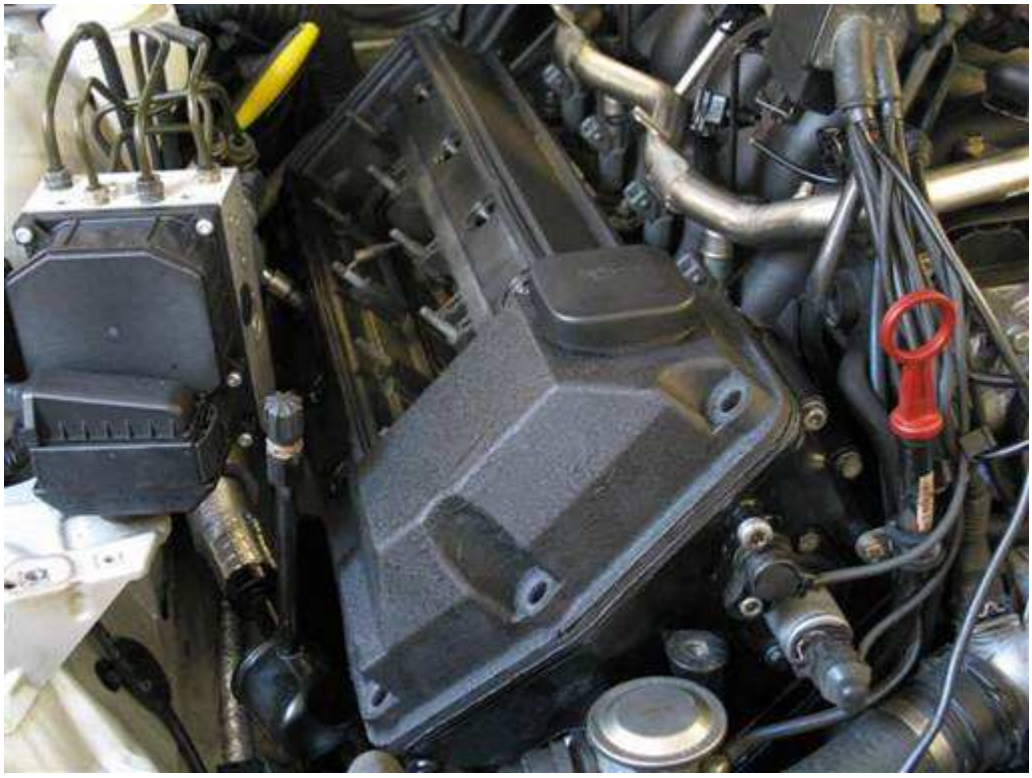
Remove bank 1 & 2 fuel injector electrical connectors. For each set of fuel injectors perform following.
From front to rear injector consecutively pry out injector connector wire clip (strait pick) and pull up on electrical housing to dislodge connector.

Pull up on bank 1 & 2 electrical housings and tie together to keep up and off valve covers (bungee cord).

Caution: Battery negative cable must first be disconnected from battery in trunk. This was first step in procedure.

Remove battery positive cable mounting nut at bank 2 valve cover cable box (19mm socket 1/2" / 1/2" ratchet).

Remove battery positive cable from cable box and valve cover and set to side (see second picture below).



Remove bank 1 & 2 valve cover mounting bolts. For each valve cover perform following.

Remove 11 valve cover mounting bolts w/ washers & grommets, 3 at front and 4 at each side (10mm socket 3/8” / 3/8” ratchet & extension and 10mm

socket 1/4” / 1/4” long-arm ratchet, flathead).
Loosen bolts evenly in multiple passes.
Note: Front 3 bolts are different from 8 side bolts.

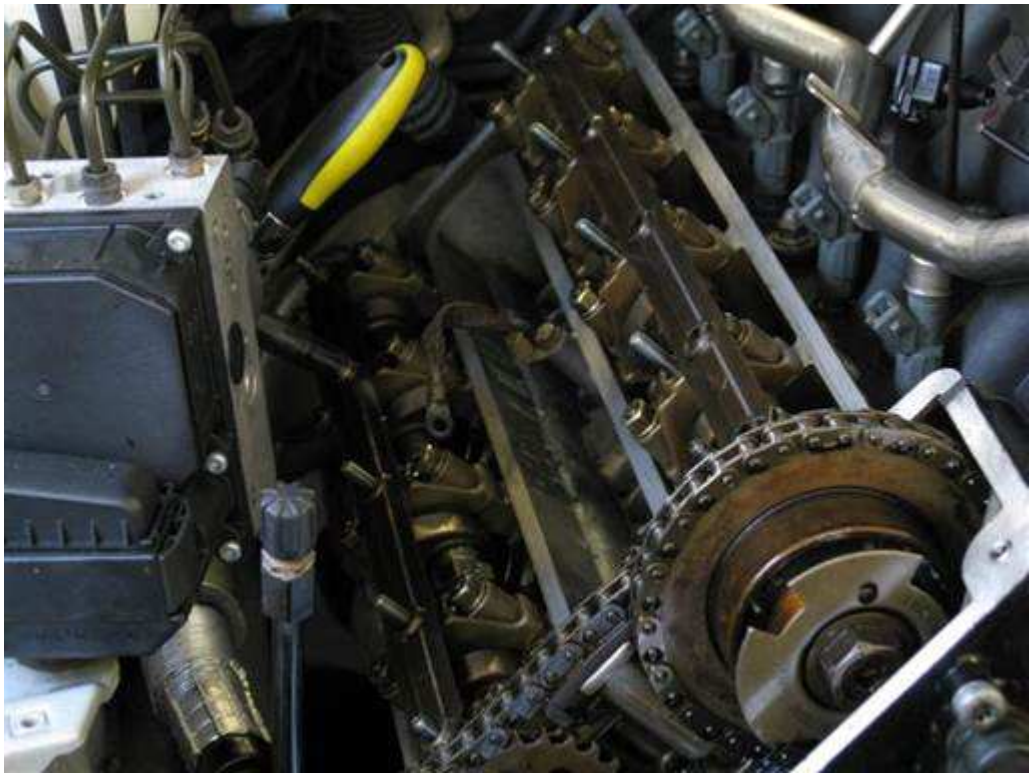
Remove bank 1 & 2 valve cover. For each valve cover perform following.
Insert blade (putty-knife) between valve cover gasket and engine head at all front end accessible locations to break gasket bond.

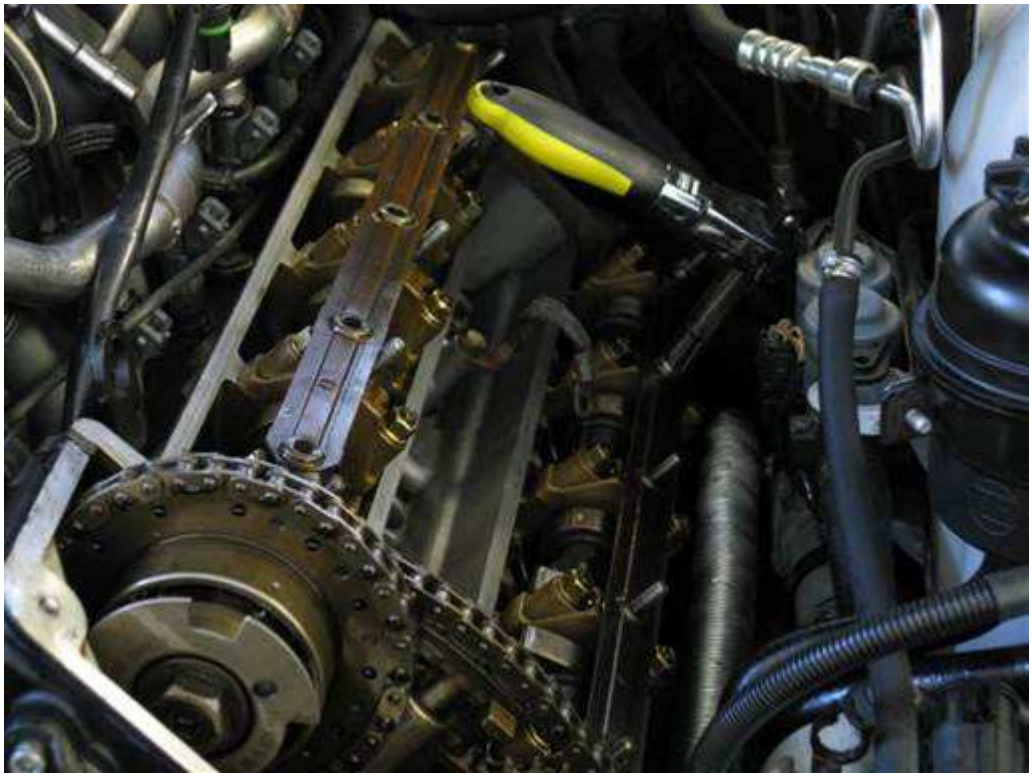
Pull up and remove valve cover. If resistant, insert blade (putty-knife) between valve cover gasket and engine head at sticking locations.
Note: If valve cover cannot be removed, double check valve cover 11 mounting bolts have been removed. If valve cover is stuck, pull up on free front end of cover to break gasket bond on remainder of valve cover.

Maintain valve cover perimeter gasket with cover.
Valve cover perimeter gasket will stick at rear half-moons due to gasket sealant. Pull up on gasket to release.

Remove valve cover sparkplug well gasket from engine head.
Note: Sparkplug well gasket could have maintained with valve cover.

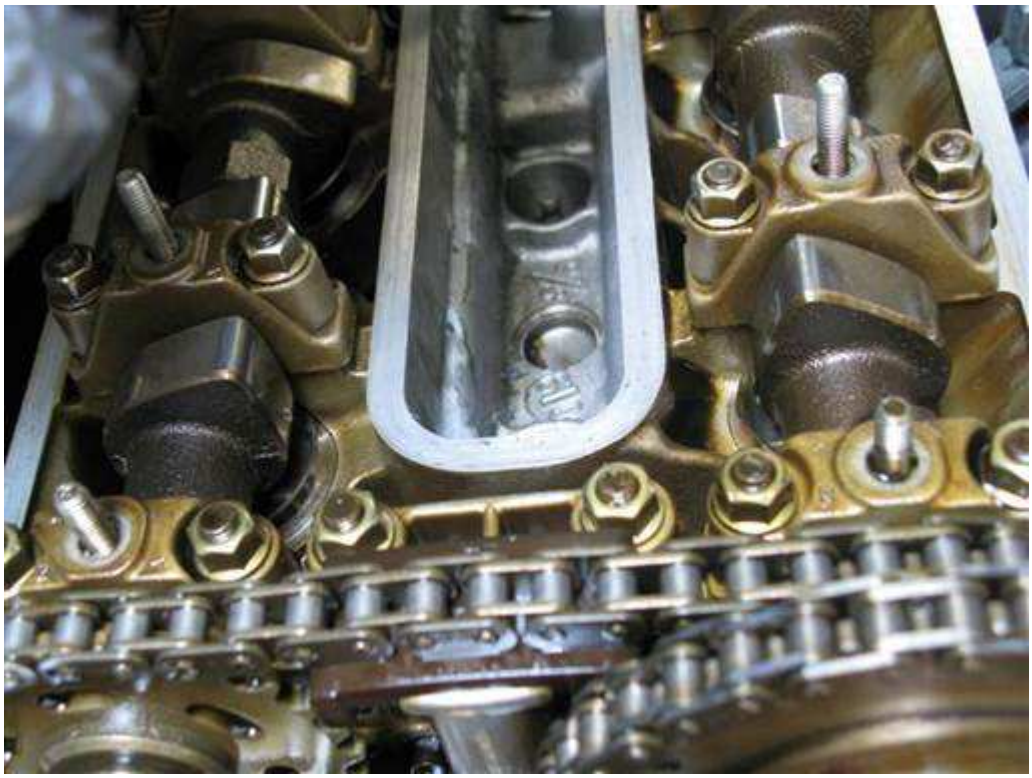
Note: If gasket is stuck to engine head, attempt inserting blade between gasket and head from an edge (putty-knife). This facilitates gasket removal without breaking plasticized brittle gaskets into pieces.





Remove bank 1 & 2 camshaft oil rails. For each set of oil rails perform following.
Remove intake and exhaust oil rail 5 mounting nuts (10mm deep socket 3/8” / 3/8” ratchet, 10mm ratcheting wrench, magnet pickup).
Remove oil rails.
Note: Oil rails are symmetrical front to rear and top to bottom. Thus maintaining oil rail orientation is not necessary.

Locking crankshaft



If manual transmission, place transmission in neutral.
Turn crankshaft pulley clockwise until cylinder 1 (bank 1) intake and exhaust cams point to each other at ~45 degree angle (27mm socket 1/2" / 1/2" long-arm ratchet & short extension).
Note: Turning crankshaft counter clockwise is acceptable.

Note: Intake camshaft will be rotated further clockwise due to vanos advancement. Thus reference exhaust cam for 45 degree positioning.

Inspect TDC (top dead center) timing marks on engine timing cover and crankshaft harmonic balancer at ~11 o'clock position (mirror).
Adjust crankshaft pulley to align TDC timing marks (27mm socket 1/2" / 1/2" long-arm ratchet & short extension).
Note: Angle of view changes alignment position. A tilted view to ~11 o'clock position provides correct alignment view.
Note: Picture is not of M62TU engine, but M62TU marks will be very similar.

Raise front of car and place on jack stands (follow appropriate procedure; chock both sides of both rear wheels).

Remove large engine compartment shield underneath front of car.
Turn 3 mounting bolts at each side 1/2 turn to release lock (Philips).

Locate crankshaft lock hole and inspection hole at bottom rear of engine.

Pull off inspection hole cap if present.
Insert crankshaft lock pin into crankshaft lock hole. Pin will not likely fully insert.

Inspect position of lock pin and flywheel / drive plate lock hole through inspection hole (mirror & flashlight).
Adjust crankshaft rotation position to perfectly align lock pin and lock hole (27mm socket 1/2” / 1/2” long-arm ratchet & short extension).
Fully insert lock pin.

Draining coolant

Drain coolant from engine block.
Remove engine left side (front orientation) coolant drain bolt (13mm socket 3/8” / 3/8” ratchet).
Note: Drain bolt located on engine block between cyl 2 & 3.
Catch draining coolant in receptacle (coolant receptacle).

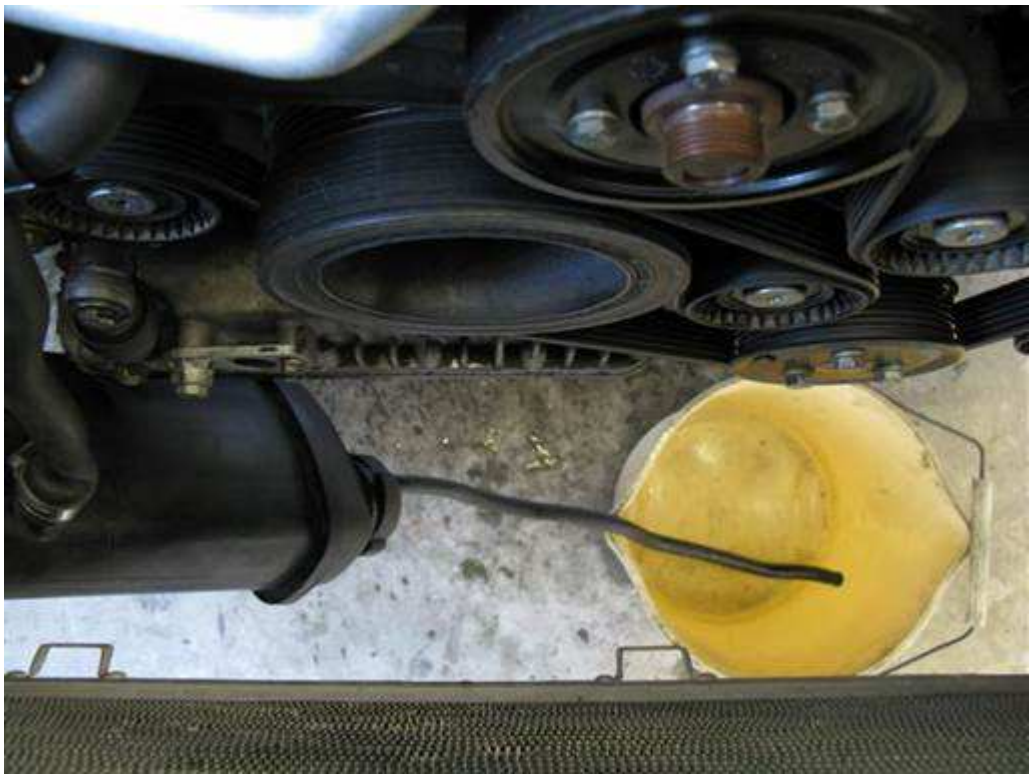
Remove and discard bolt crush washer.
Note: If washer not on bolt it is likely at hole or fallen in coolant receptacle.

Note: It is not necessary to drain coolant from engine right side. This does not affect repair and there is very little coolant to drain and thus is of no significance.

If radiator drain plug is present at radiator bottom right, drain radiator coolant form drain hole.
Turn radiator drain plug 1/4 turn and pull off from radiator.
Catch draining coolant in receptacle (coolant receptacle).

If radiator drain plug is not present at radiator bottom right, drain radiator coolant form radiator lower hose connector.

Remove radiator lower hose from radiator.
Remove temperature sensor cable connector. Press in connector locking wire clip and pull off connector.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off radiator.



Rotate and lower coolant expansion tank down and let hang from hose.
Place expansion tank overflow hose in receptacle to catch draining coolant.
Remove expansion tank cap to drain coolant form expansion tank. Catch coolant in receptacle.
Reinstall expansion tank cap once expansion tank is emptied.

Install engine left side coolant drain bolt.
Install new crush washer on drain bolt.
Install drain bolt (13mm socket 3/8” / 3/8” ratchet).
Fully tighten, 25 Nm (18.5 ft-lb) (by feel) (13mm socket 3/8” / 3/8” ratchet).

Install radiator drain plug.
Insert drain plug into radiator drain hole and turn 1/4 turn (pliers).

Bring up expansion tank and overflow hose and lay expansion tank lower hose on AC compressor pulley.
Maintain expansion tank overflow hose high to prevent loss of coolant.

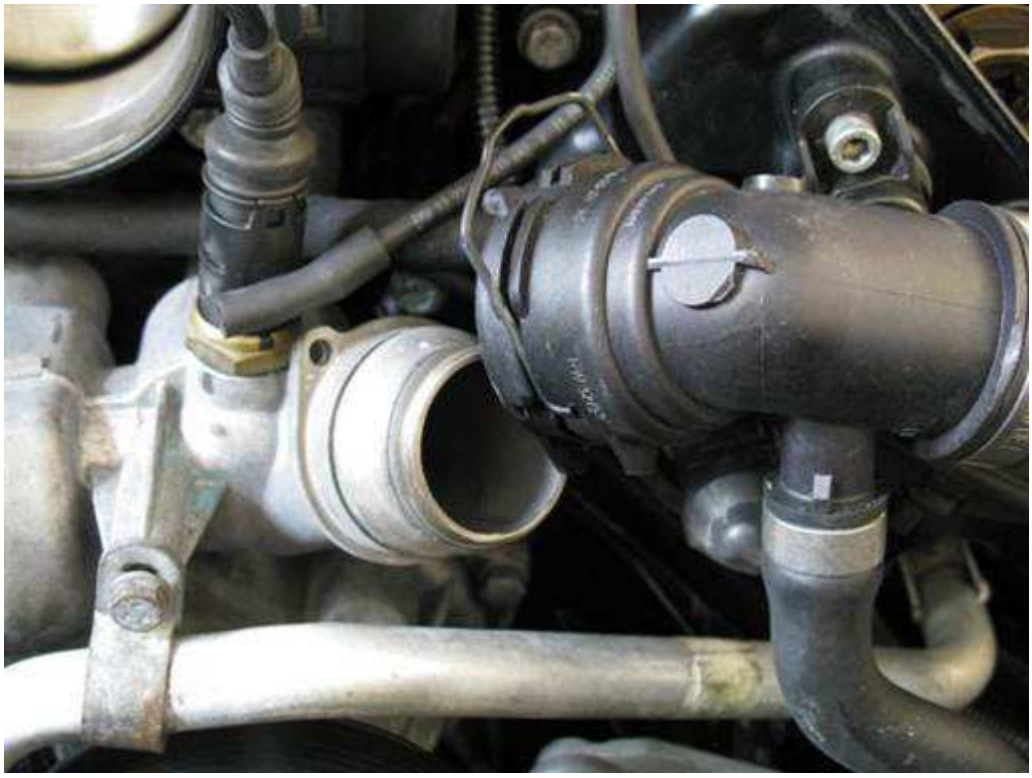
Install large engine compartment shield underneath front of car.
Insert shield front inside front bumper.

Align and insert side bolts into bolt holes.
Turn 3 mounting bolts at each side 1/2 turn clockwise to install (Philips).

Lower car from jack stands (follow appropriate procedure).

Removal of engine front components

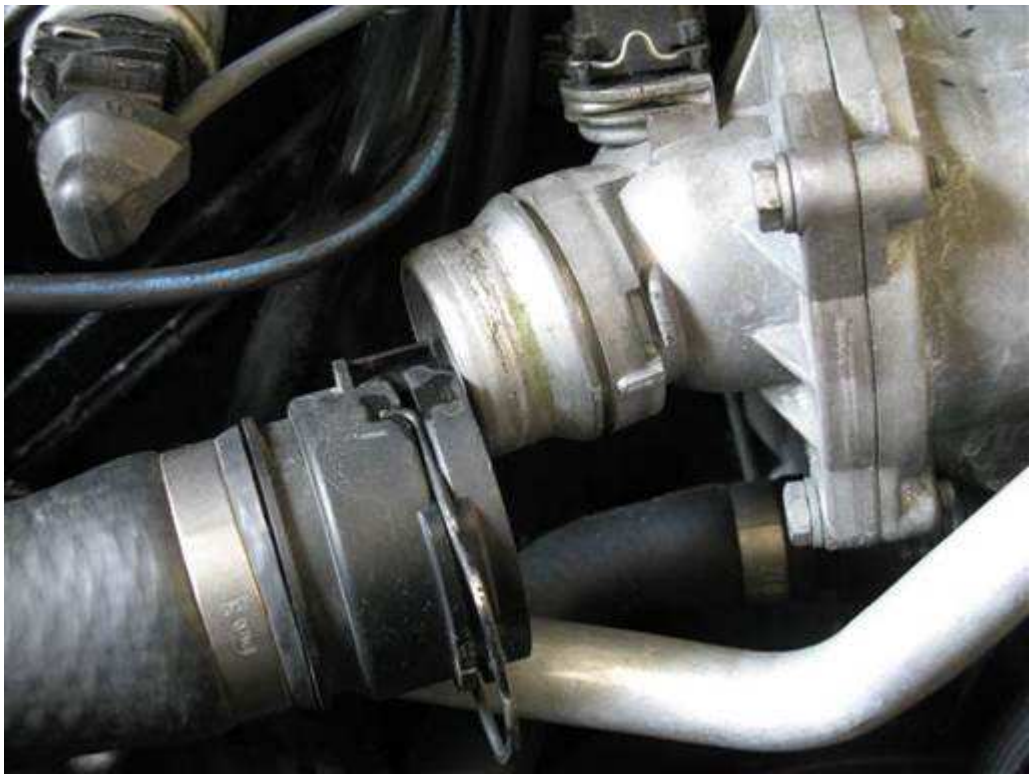
Remove radiator upper hose from radiator.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off radiator.



Remove radiator upper hose from thermostat.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off thermostat.

Remove radiator upper hose from alternator.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off alternator.

Remove radiator upper hose from engine compartment.



Remove radiator lower hose from thermostat.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off thermostat.

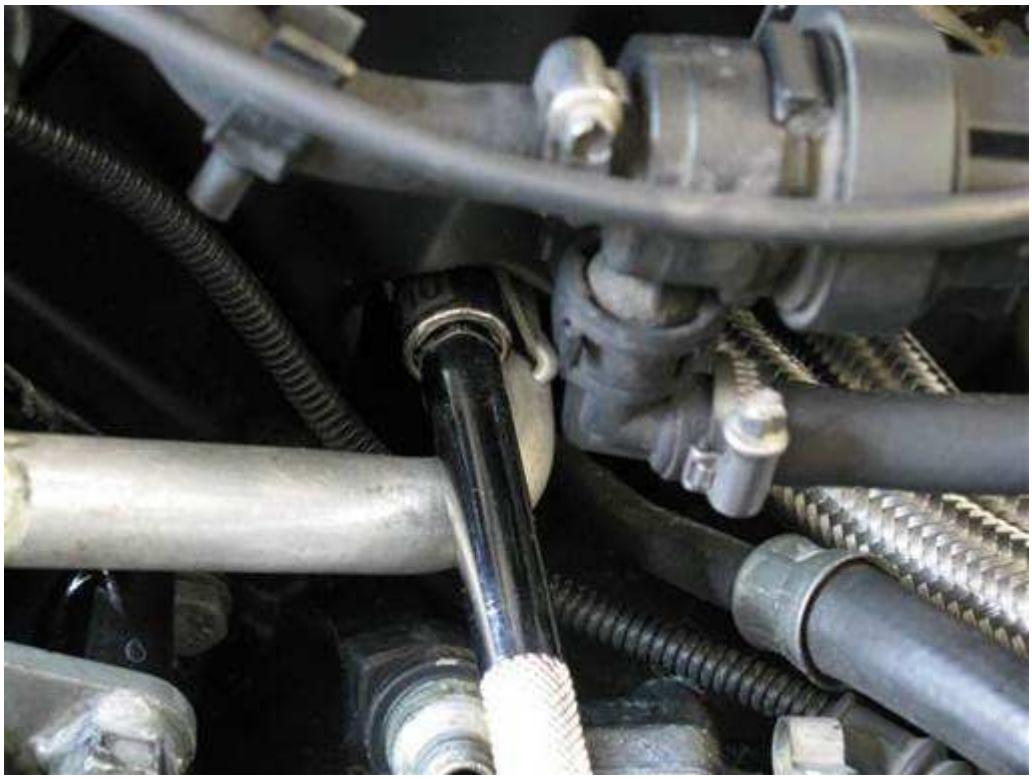
If not previously performed, remove radiator lower hose from radiator.

Remove temperature sensor cable connector. Press in connector locking wire clip and pull off connector.
Pull out hose locking wire clip (small flathead).
Wiggle and pull hose connector off radiator.

Remove radiator lower hose from engine compartment.

Remove secondary air blower hose and secondary air vacuum control hose from secondary air exhaust valve.
Press in blower hose circular locking clip at top and bottom and pull off hose.
Pull off vacuum hose.
Place blower hose to side.

Remove secondary air pipe left end mounting bolt (10mm socket 3/8” / 3/8” ratchet & medium extension).
Note: Reposition expansion tank as necessary.

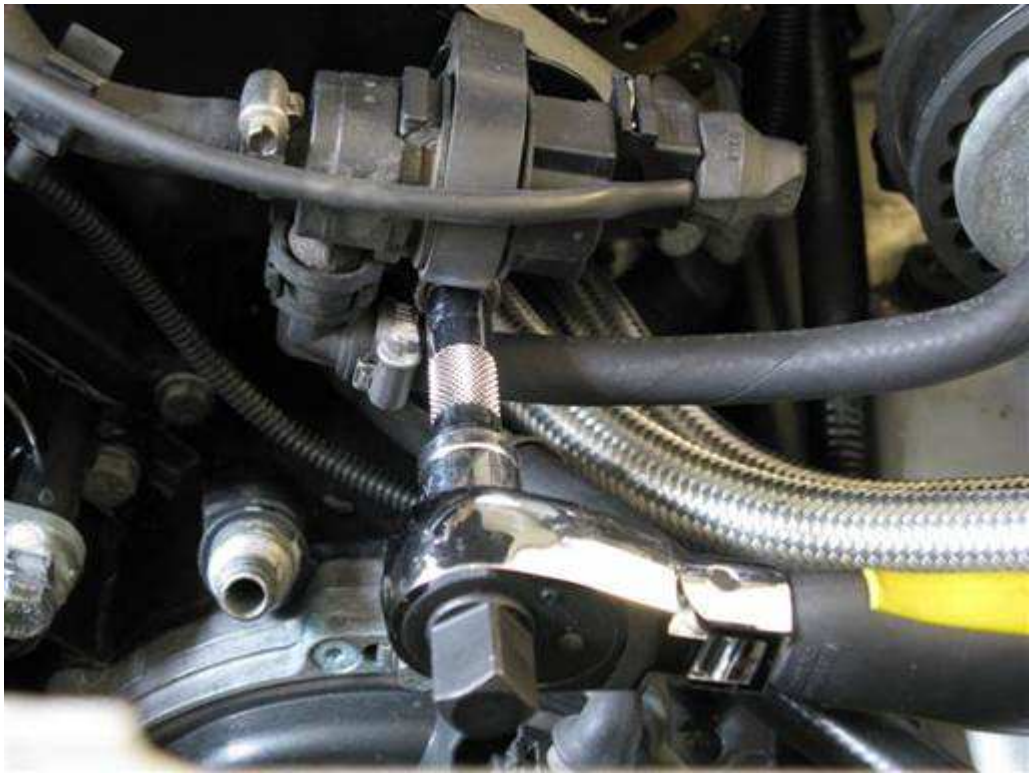


Remove secondary air pipe right end mounting bolt (10mm socket 3/8” / 3/8” ratchet & medium extension).

Remove secondary air pipe center mounting bolt (T30 torx bit socket 1/4” / 1/4” ratchet & extension).

Pull secondary air pipe right and left ends out of engine and remove pipe from engine compartment.

5 series



Remove fuel purge valve bracket mounting bolt (10mm socket 3/8” / 3/8” ratchet & extension).
Allow purge valve to lower and suspend from hoses.

7 series

Remove hose/cable bracket mounting bolt just to left of bank 2 solenoid (10mm socket 3/8” / 3/8” ratchet & extension).

Remove hose bracket mounting bolt at middle bank 2 upper timing cover (10mm socket 3/8” / 3/8” ratchet & extension).


Remove hose bracket mounting bolt at oil filter housing (10mm socket 3/8” / 3/8” ratchet & extension).

Move fuel purge hose and alternator electrical cable down and away from bank 2 upper timing cover.

Remove oil dip stick pipe clamp mounting bolt (10mm socket 3/8” / 3/8” ratchet & extension).

Removal of crankshaft chain tensioner

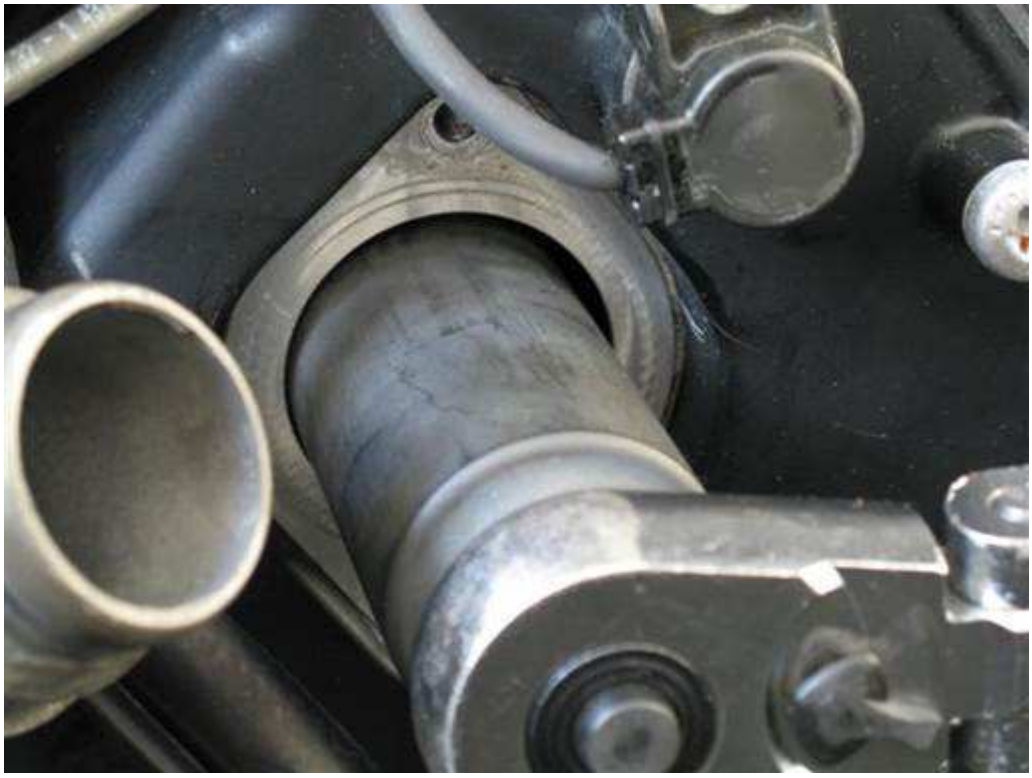
Remove crankshaft chain tensioner from engine lower left side (19mm deep socket 3/8” / 3/8” long-arm ratchet).
Place towel under tensioner to catch draining oil (towels).
Discard tensioner crush washer.

Removal of vanos solenoids

Remove bank 1 & 2 vanos solenoid electrical cable connector. For each solenoid perform following.
Press in electrical cable connector wire clip and pull off connector.

Remove bank 1 & 2 vanos solenoid gasket mounting bolts. For each solenoid perform following.
Remove gasket top and bottom mounting bolt (10mm socket 3/8” / 3/8” ratchet & extension).

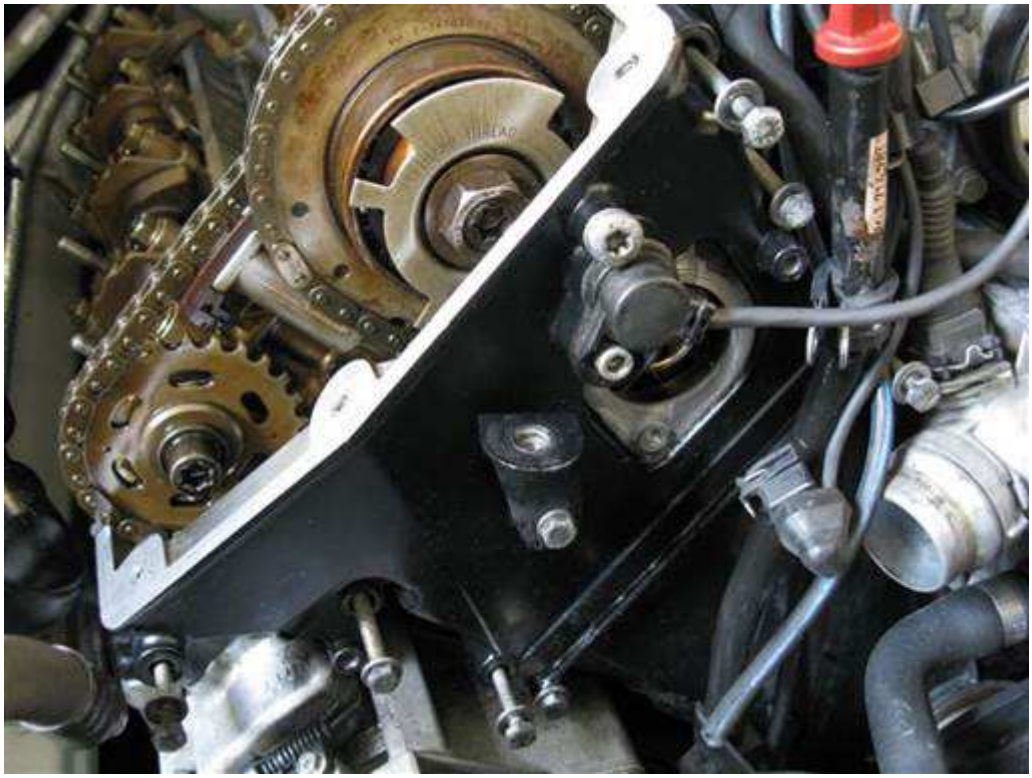
Remove bank 1 & 2 vanos solenoid gasket. For each solenoid perform following.
Pry gasket at top sides to initially move gasket and break gasket seize (flathead).
Remove gasket by pulling out alternatingly at gasket top and bottom from bolt mount hole (90 degree pick tool).

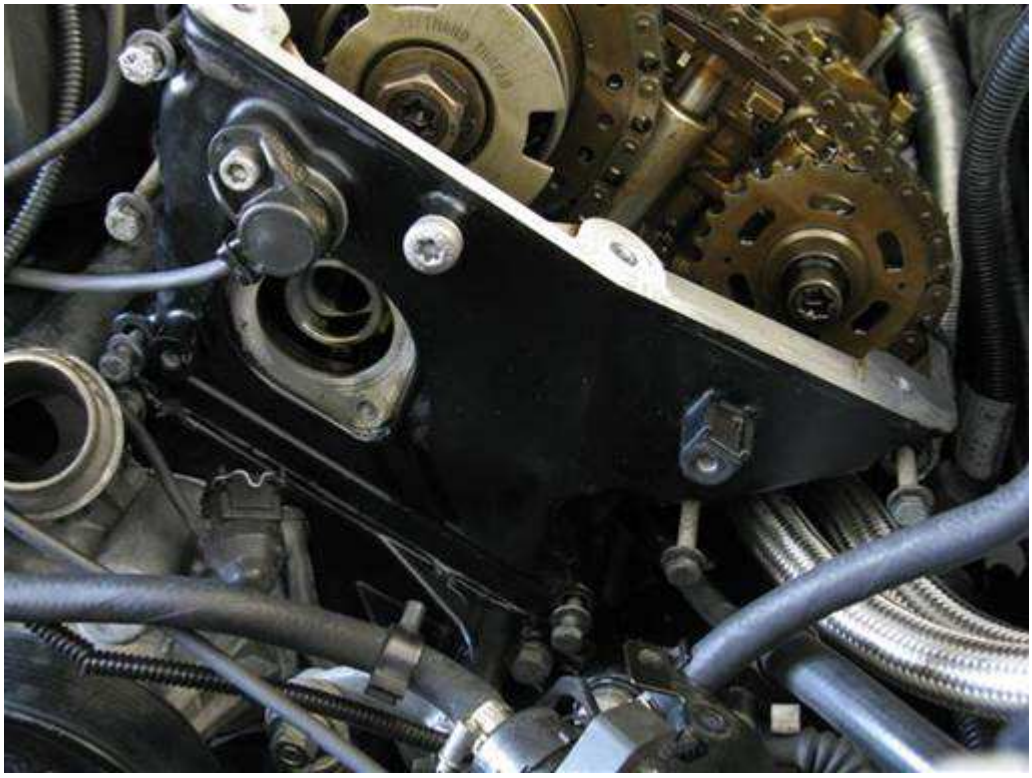


Loosen bank 1 & 2 vanos solenoid. For each solenoid perform following.
Loosen (break seize) solenoid (32mm special deep socket 1/2” / 1/2” long-arm ratchet).
Note: Do not remove solenoid.

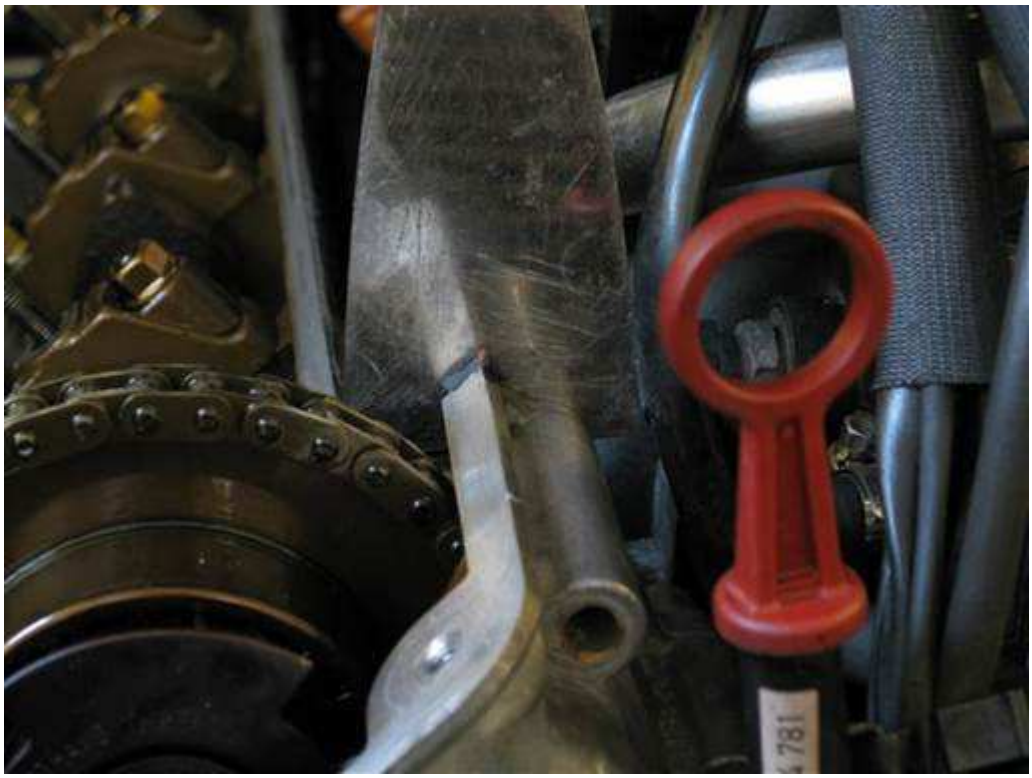
Remove bank 1 & 2 vanos solenoid. For each solenoid perform following. Place towel under solenoid to catch draining oil and unscrew and pull out solenoid (hands, towels).

Removal of upper timing covers



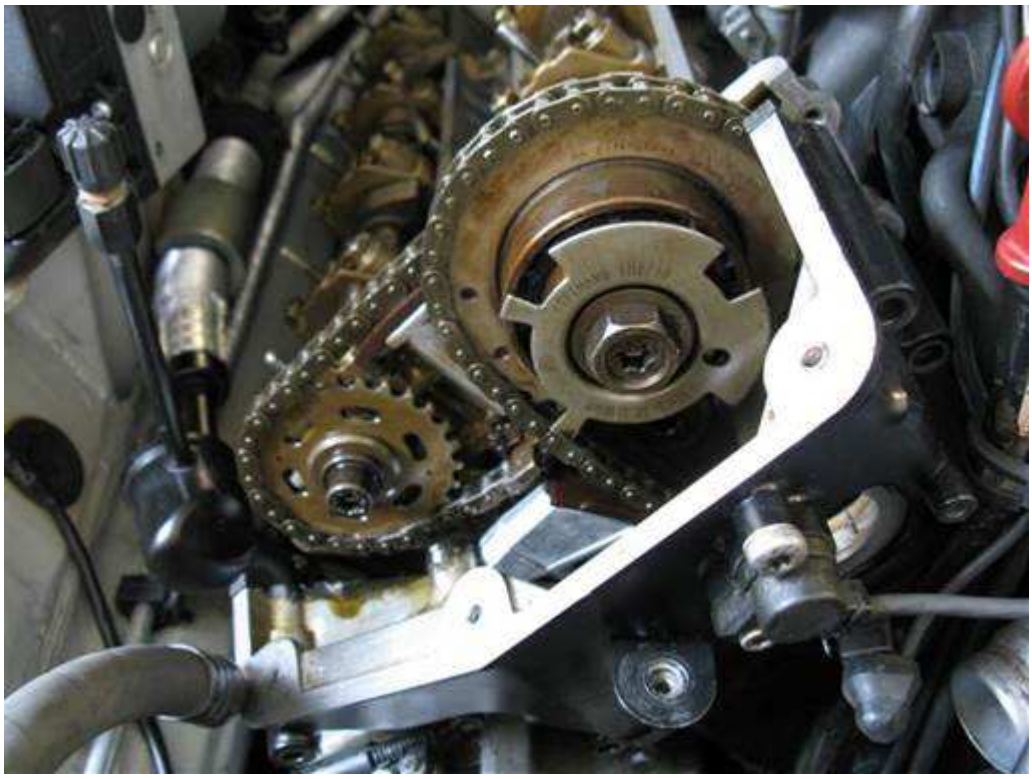


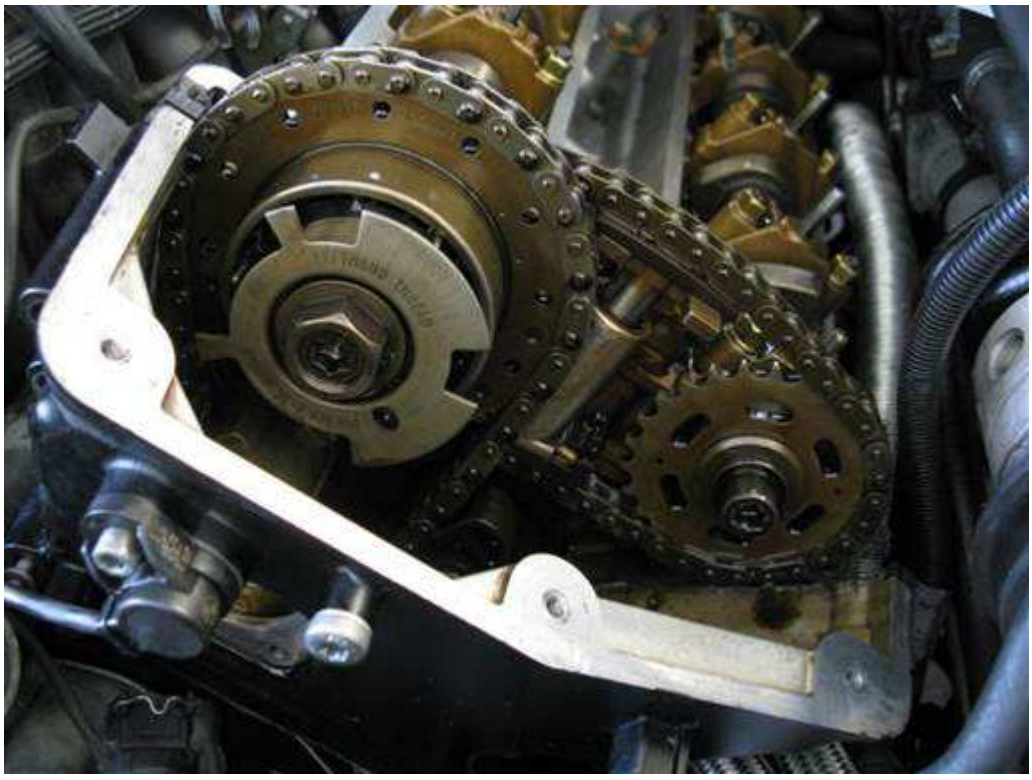
Remove bank 1 & 2 upper timing cover mounting bolts. For each timing cover perform following.
Remove cover 3 left and 3 right mounting bolts (10mm socket 3/8” / 3/8” ratchet & extension).
Bank 2 lower left mounting bolt requires a low profile tool for access (10mm ratcheting wrench).
Loosen bolts evenly in multiple passes.
Note: Bank 2 lower left mounting bolt cannot be removed due to access restriction and needs to be removed with cover.



Break bond of bank 1 & 2 upper timing cover gasket. For each timing cover perform following.
Insert blade (putty-knife) between timing cover gasket and engine head at cover top corner to break gasket bond.
Pull forward on timing cover while inserting blade to facilitate further insertion on blade.

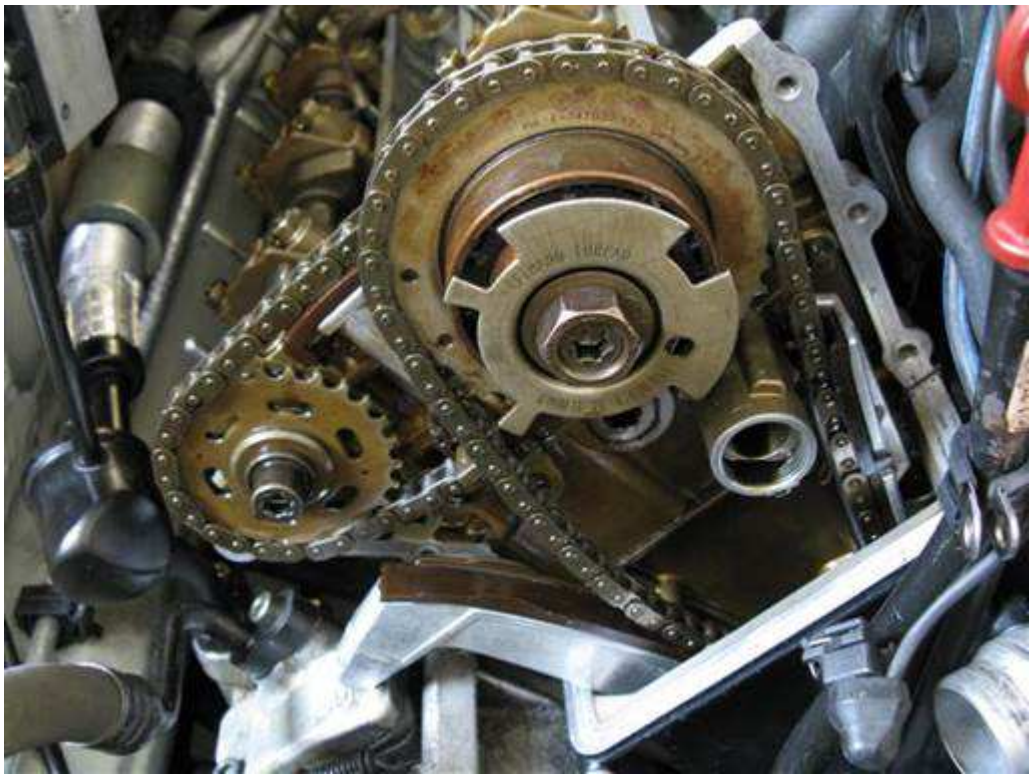
Pull forward on timing cover to break all cover gasket bond.
Note: If timing cover cannot be moved, double check cover 6 mounting bolts have been removed.





Remove bank 1 & 2 upper timing cover. For each timing cover perform following.
Pull forward and up on timing cover to remove. Remove gasket with cover.

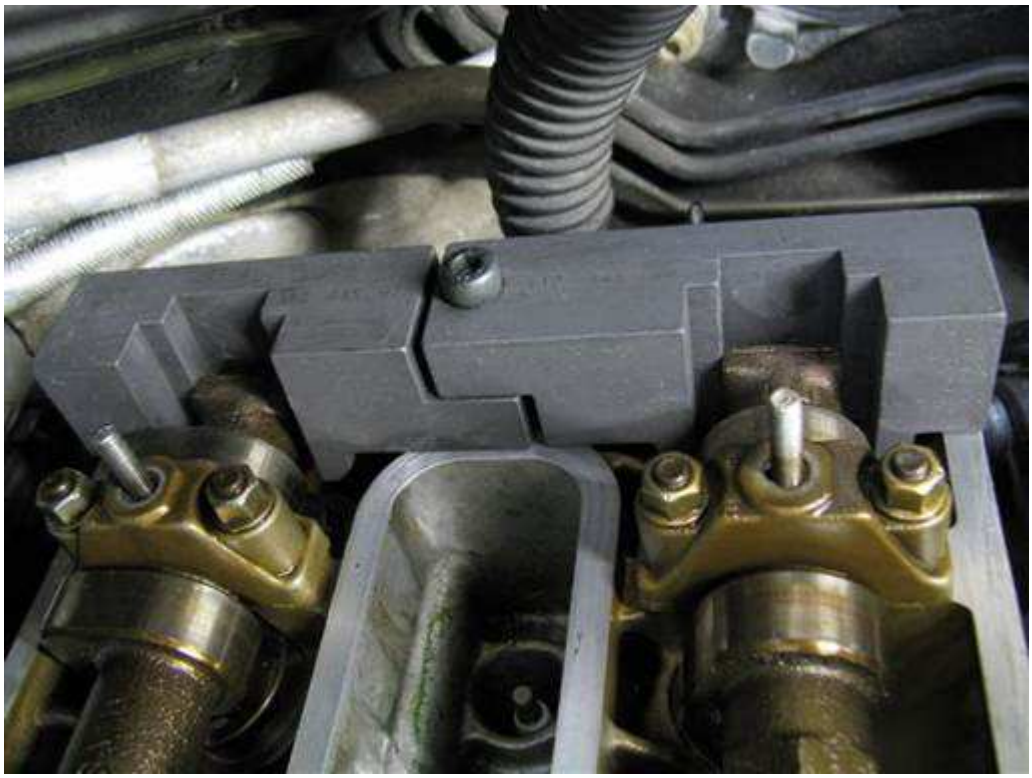
Note: Sealant bond at top and bottom rear of cover will be broken.
Note: Camshaft position sensor remains mounted on timing cover and is removed with cover.



Bank 1 & 2 with removed upper timing covers.

<u>Locking of camshafts</u>


27



Install bank 1 & 2 camshaft locking blocks. For each camshaft set perform following.

Note: If locking blocks are marked in German, E is intake and A is exhaust.

Place locking block set on intake and exhaust camshaft rear square ends.

Adjust each camshaft position as needed to align for locking block insertion (27mm open wrench).

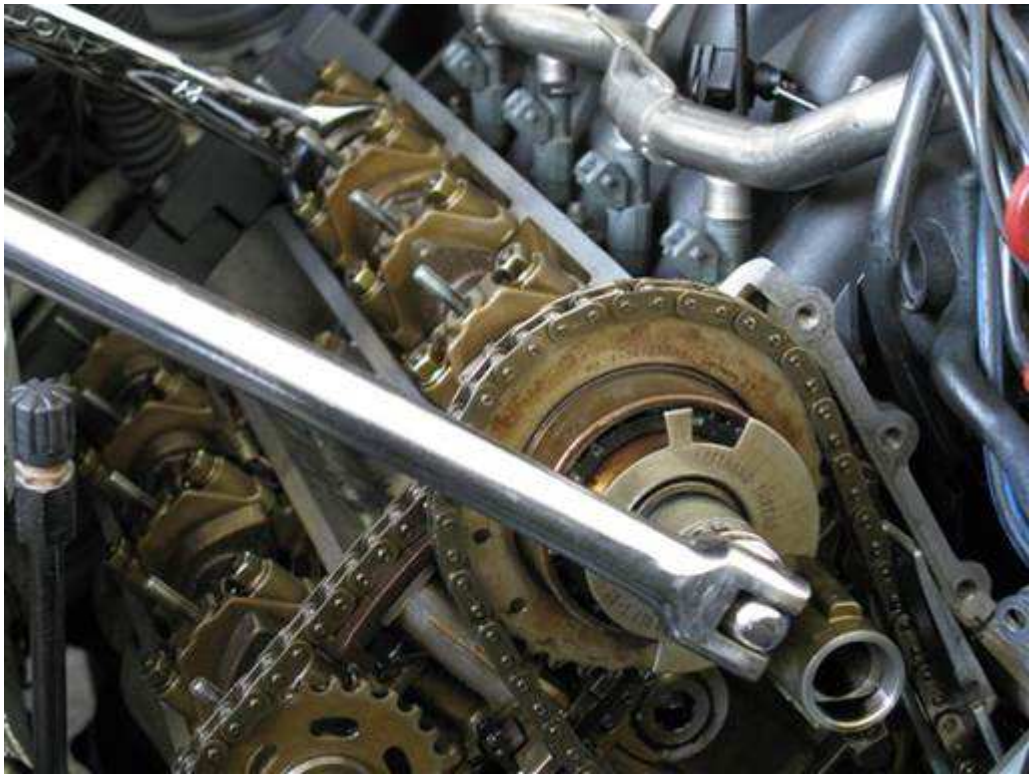
Note: Each camshaft incorporates a hex to facilitate camshaft rotation. Loosen and retighten locking blocks matting bolt as needed to facilitate block mounting (6mm hex bit socket 3/8” / 3/8” ratchet).
Note: Bank 1 intake camshaft will need to be rotated counter clockwise opposing a valve spring to properly position for locking block. This is due to valve spring load and vanos timing advance.

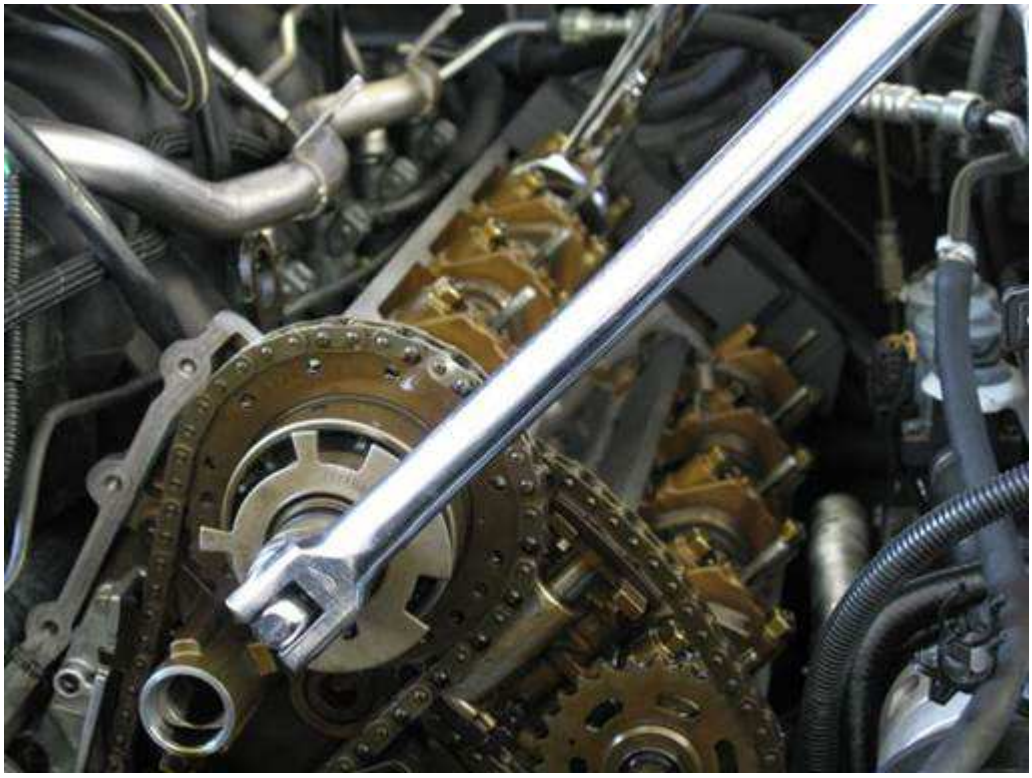
Rock each camshaft slightly back and forth while pressing down and forward on locking block to fully seat and align block on head surface.

Verify camshaft rear squares inserted into locking blocks rear narrow slot.
Note: Camshafts ends extend to rear of camshaft rear squares. Thus camshaft rear squares will not fully seat to rear of blocks’ rear slot.

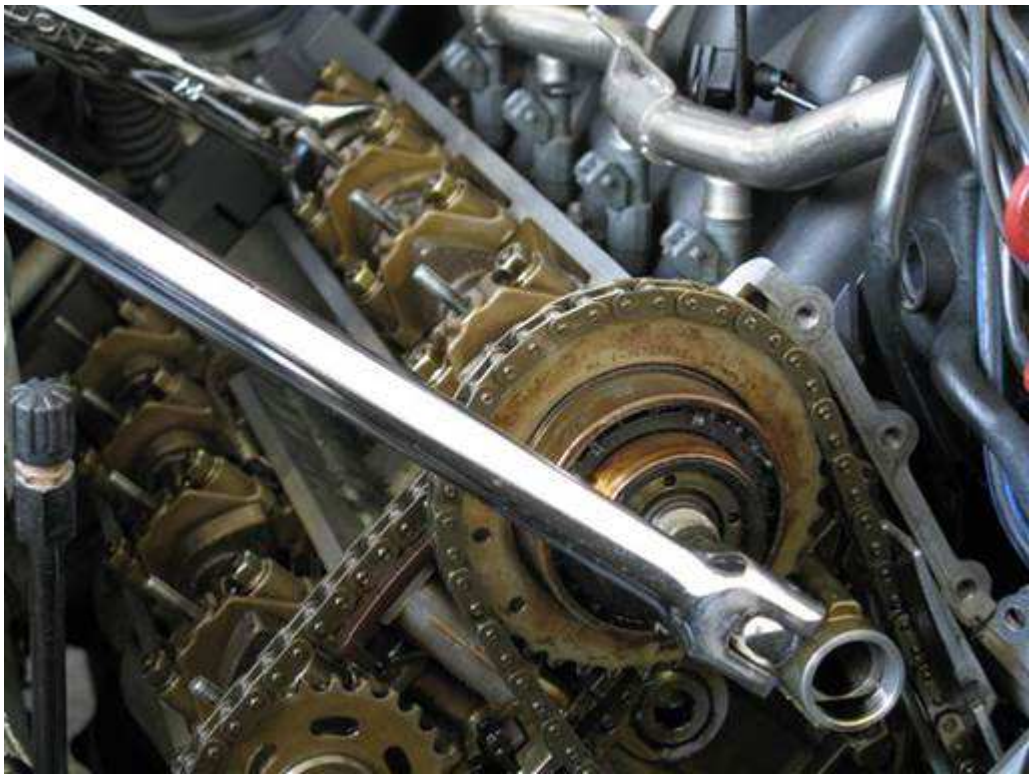
Removal of vanos units

During following component removal, maintain component to engine head association. This is not necessary but is good practice.



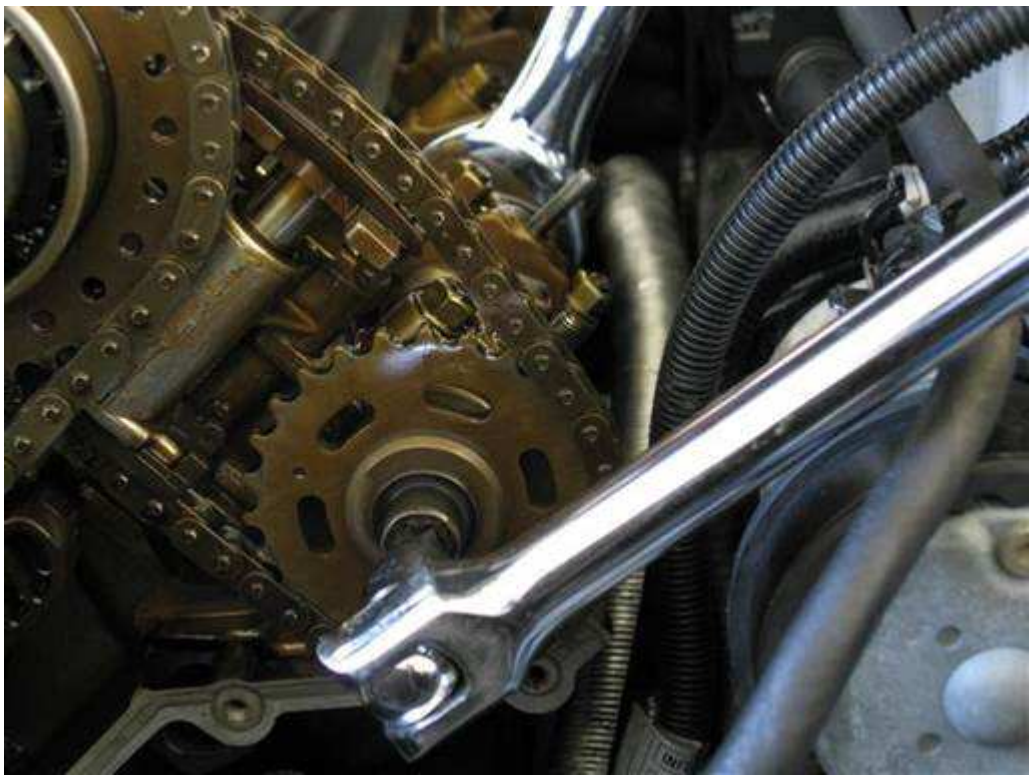


Remove bank 1 & 2 intake camshaft timing wheel. For each timing wheel perform following.
Counter hold intake camshaft and loosen timing wheel mounting nut; left hand thread (24mm socket 1/2" / 1/2" breaker bar, 27mm open wrench).
Note: Nut is left hand thread, thus unscrew by turning breaker bar from left to right (clockwise) (car front orientation).
Note: Intake camshaft is counter held by locking block. But do not rely on this alone as camshaft can be damaged. Further counter hold camshaft at camshaft hex (27mm open wrench).
Remove timing wheel and mounting nut.



Loosen bank 1 & 2 vanos mounting bolt. For each vanos perform following.
Counter hold intake camshaft and loosen vanos mounting bolt; left hand thread (T55 torx bit socket 3/8" / 3/8" breaker bar, 27mm open wrench).
Note: Bolt is left hand thread, thus unscrew by turning breaker bar from left to right (clockwise) (car front orientation).
Note: Intake camshaft is counter held by locking block. But do not rely on

this alone as camshaft can be damaged. Further counter hold camshaft at camshaft hex (27mm open wrench).
Note: Verify tool inserts fully into vanos bolt head (T55 torx bit 3/8”).
Do not remove vanos mounting bolt at this time.



Loosen bank 1 & 2 exhaust sprocket mounting bolt. For each exhaust sprocket perform following.

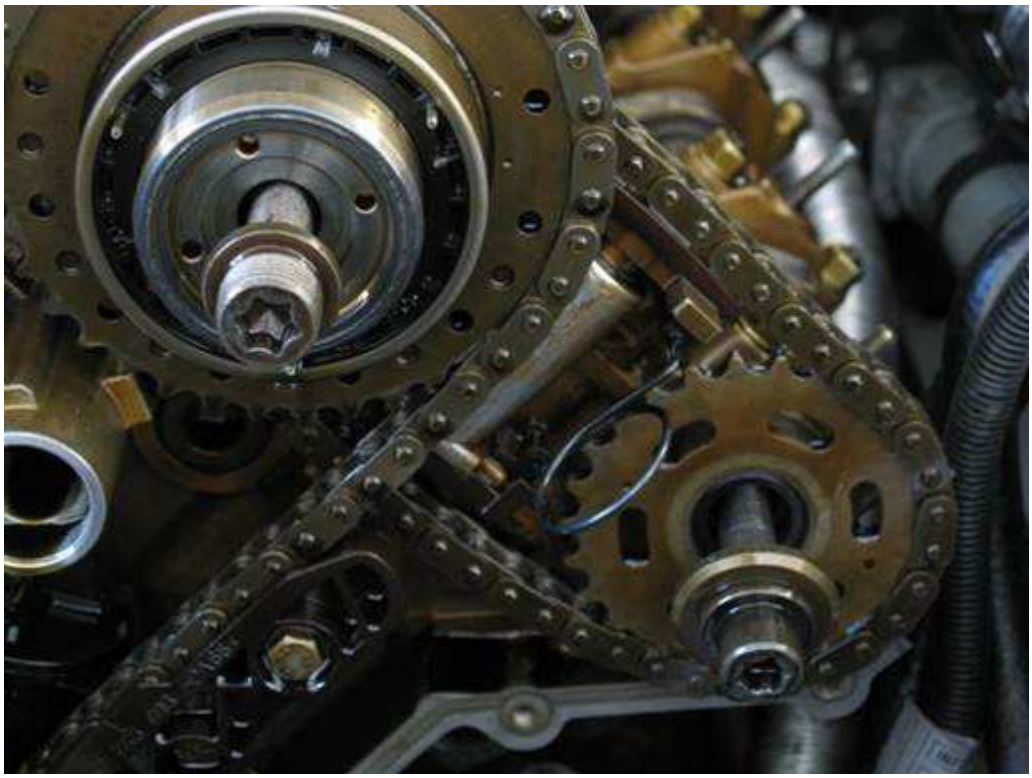
Counter hold exhaust camshaft and loosen exhaust sprocket mounting bolt; left hand thread (T55 torx bit socket 3/8" / 3/8" breaker bar, 27mm open wrench).
Note: Bolt is left hand thread, thus unscrew by turning breaker bar from left to right (clockwise) (car front orientation).
Note: Exhaust camshaft is counter held by locking block. But do not rely on this alone as camshaft can be damaged. Further counter hold camshaft at camshaft hex (27mm open wrench).
Note: Verify tool inserts fully into sprocket bolt head (T55 torx bit 3/8”).
Do not remove exhaust sprocket mounting bolt at this time.

Lock bank 1 & 2 camshaft chain tensioner. For each camshaft chain tensioner perform following.

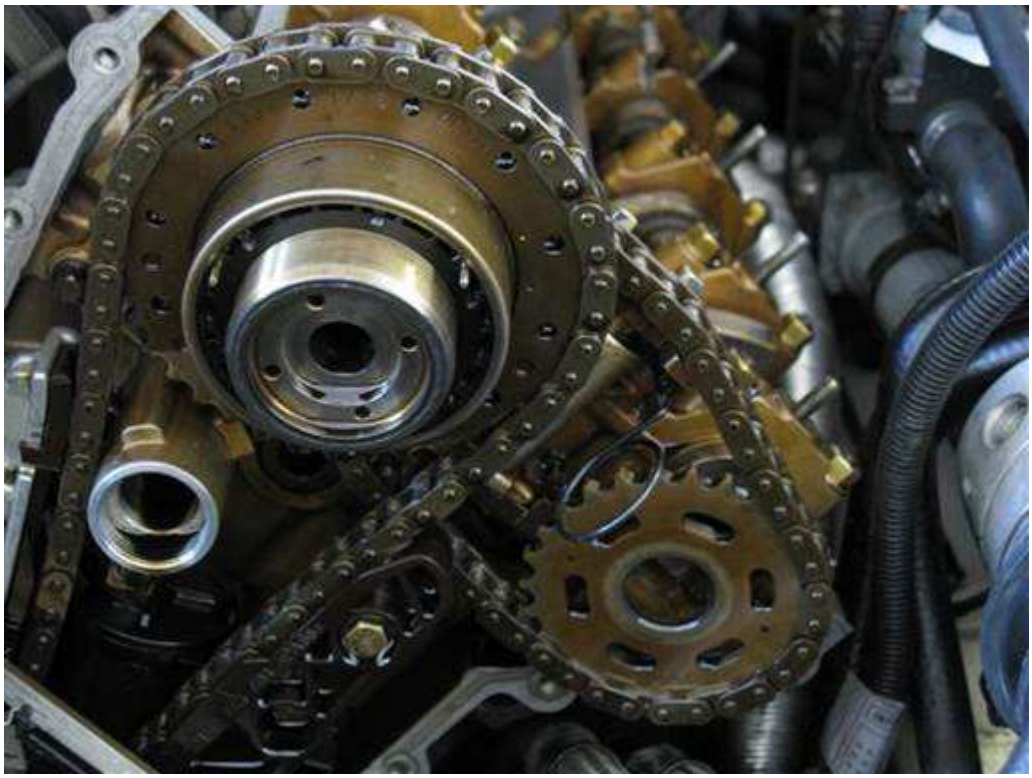
Compress chain tensioner and fully insert locking clip into locking holes.

Note: Bank 1 chain tensioner is compressed from below tensioner and bank 2 chain tensioner is compressed from above tensioner.

Note: If locking clip not fully inserting, remove clip and press in locking clip pins to make parallel, then reattempt insertion.

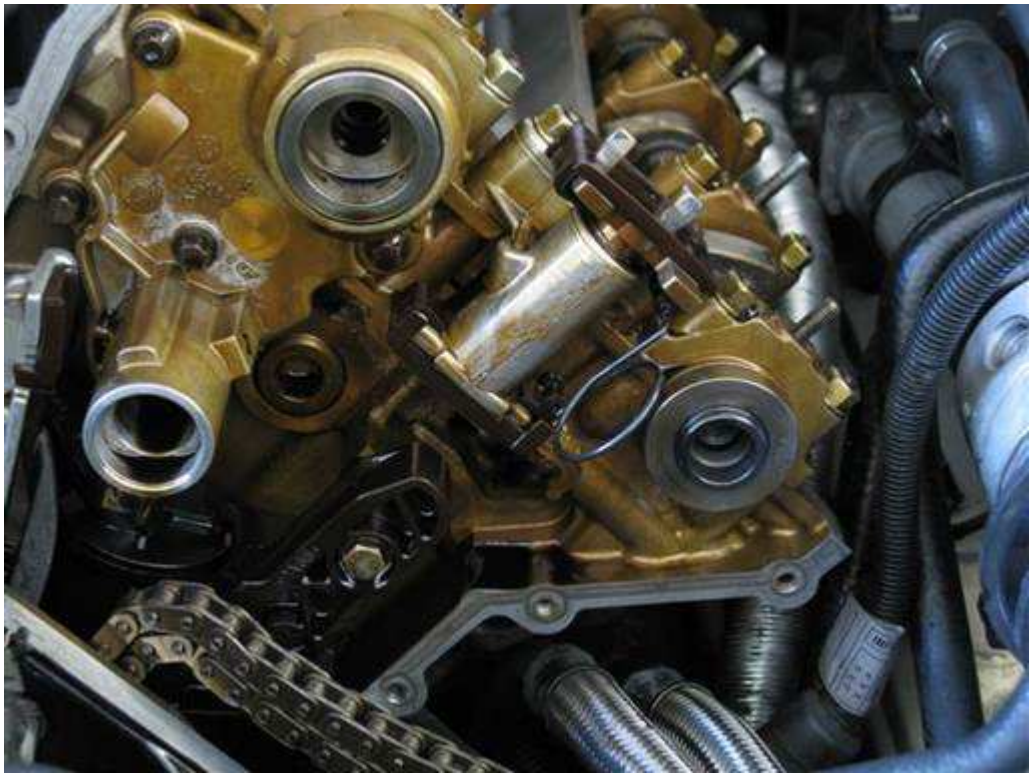


Remove bank 1 & 2 vanos and exhaust sprocket mounting bolts. For each vanos and exhaust sprocket perform following.
Unscrew and remove vanos and exhaust sprocket mounting bolts; left hand thread (hand).
Do not remove vanos and exhaust sprocket at this time.



Remove bank 1 & 2 exhaust sprocket and camshaft chain. For each exhaust sprocket and camshaft chain perform following.
Pull vanos and exhaust sprocket forward and off camshafts.
Move exhaust sprocket closer to vanos to loosen camshaft chain and remove chain from vanos rear sprocket.

Reinstall vanos onto intake camshaft.
Remove exhaust sprocket and camshaft timing chain.



Remove bank 1 & 2 vanos. For each vanos perform following.
Pull vanos forward and off intake camshaft.
Remove crankshaft chain from vanos sprocket. Remove vanos.
Maneuver crankshaft chain past distribution piece and lay down to side of

engine.

Caution: Do not remove vanos center shaft from vanos body. Shaft is balanced to vanos body and must be marked before removal.

Cover up bank 1 & 2 crankshaft chain access slot. For each chain slot perform following.

Lay towel over chain slot (towels).
Note: Towel will prevent components from dropping in chain slot during following repair steps.

Removal of vanos components

Remove bank 1 & 2 vanos oil distribution piece mounting bolts. For each

vanos oil distribution piece perform following.
Loosen then remove distribution piece 5 mounting bolts (E-10 torx socket 3/8” / 3/8” ratchet & extension).
Note: Lower mounting bolt, just below solenoid hole, is longer and has washer.

Remove bank 1 & 2 vanos oil distribution piece. For each vanos oil

distribution piece perform following.
Pull oil distribution piece from engine head.
If distribution piece resistant, pry distribution piece off head while hitting distribution piece cylinder (wide flathead, hard hammer).
Note: Distribution piece can be stuck on camshaft due to camshaft seal ring scoring on distribution piece cylinder. This can be seen once distribution piece is removed.

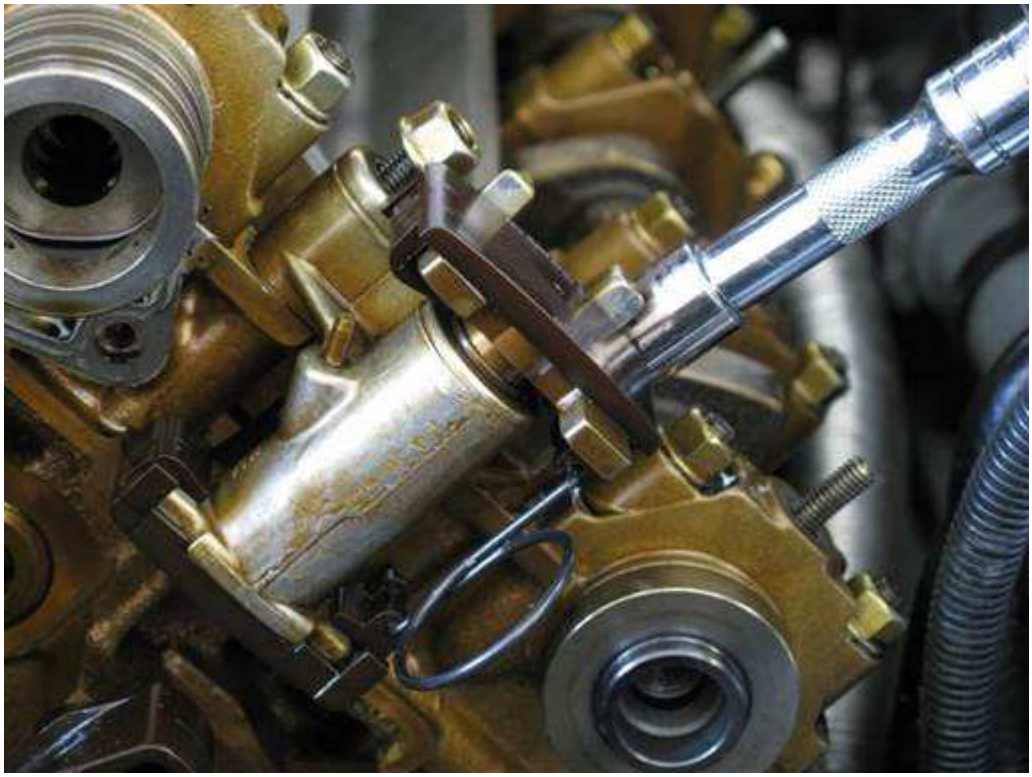
Remove bank 1 & 2 vanos oil distribution piece gasket. For each vanos oil distribution piece gasket perform following.
Pull off and remove oil distribution piece gasket.
Discard distribution piece gasket.

Remove bank 1 & 2 intake camshaft seal rings. For each intake camshaft perform following.
Pry off and remove 3 seal rings from camshaft from front to rear order.
Perform following for each seal ring.
Rotate seal ring to position locking ends at top of camshaft.
Push in and up on seal ring from sides to push up seal ring ends out of camshaft seal grove.
Press down one seal ring end and pull up other seal ring end and disconnect end locking hooks.
Pry apart seal ring ends and pull seal ring off camshaft moving each side forward in alternating increments.
Remove and discard seal ring.

Remove bank 1 & 2 vanos solenoid oil check valve. For each check valve perform following.
Screw removal tool into check valve (10mm thread diameter bolt).
Note: Check valve thread pitch is 1.0, but more standard 10mm 1.25 pitch bolt will thread some into check valve. This is sufficient to mount and remove check valve.

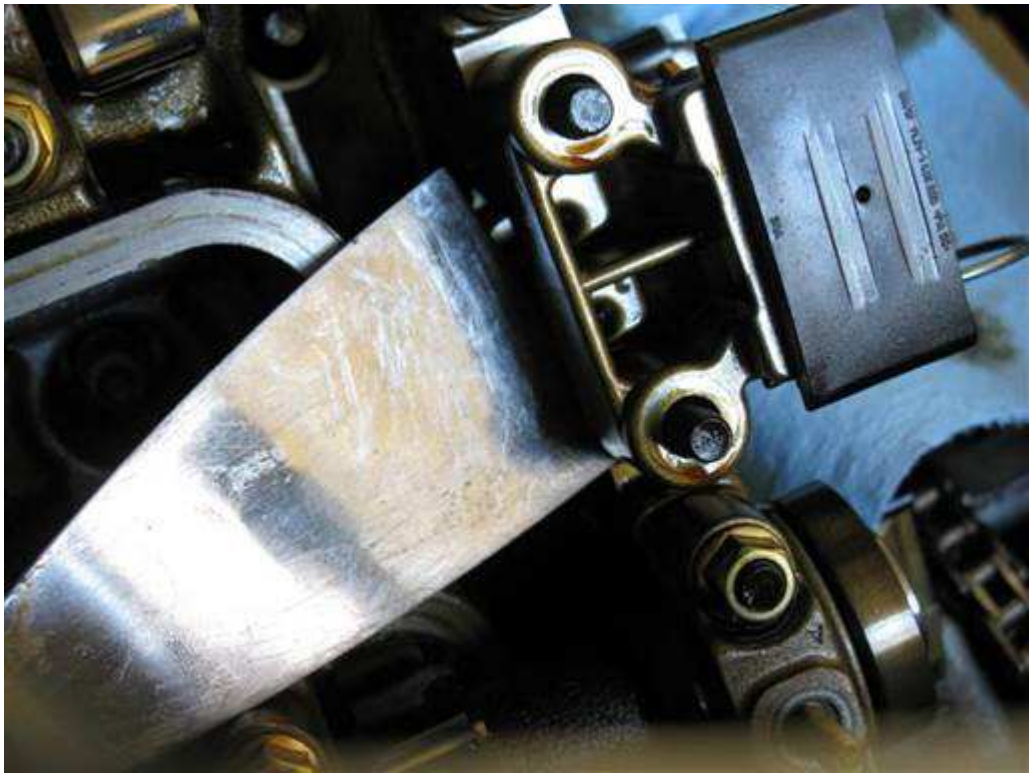
Pull off check valve from head (10mm thread diameter bolt).
Note: Check valve is mounted in head by check valve O-ring.
Unscrew installation tool from check valve and discard check valve.

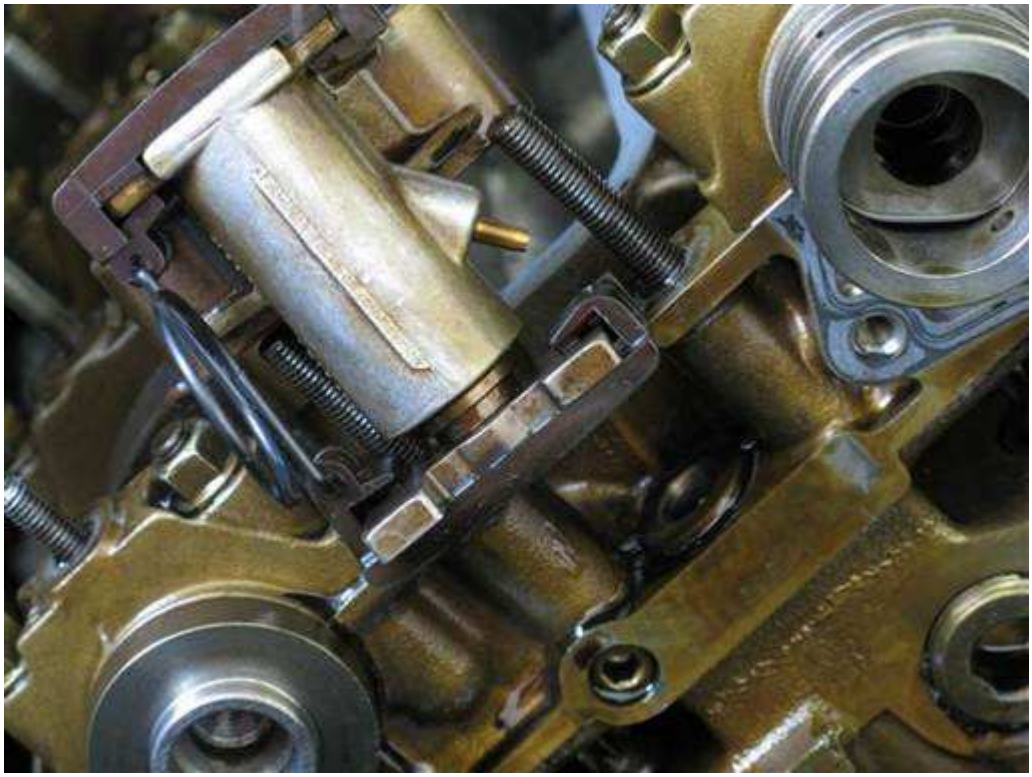
Removal of camshaft chain tensioners



Remove bank 1 & 2 camshaft chain tensioner mounting nuts. For each chain

tensioner perform following.
Remove 2 top mounting nuts (11mm socket 3/8” / 3/8” ratchet & extension).





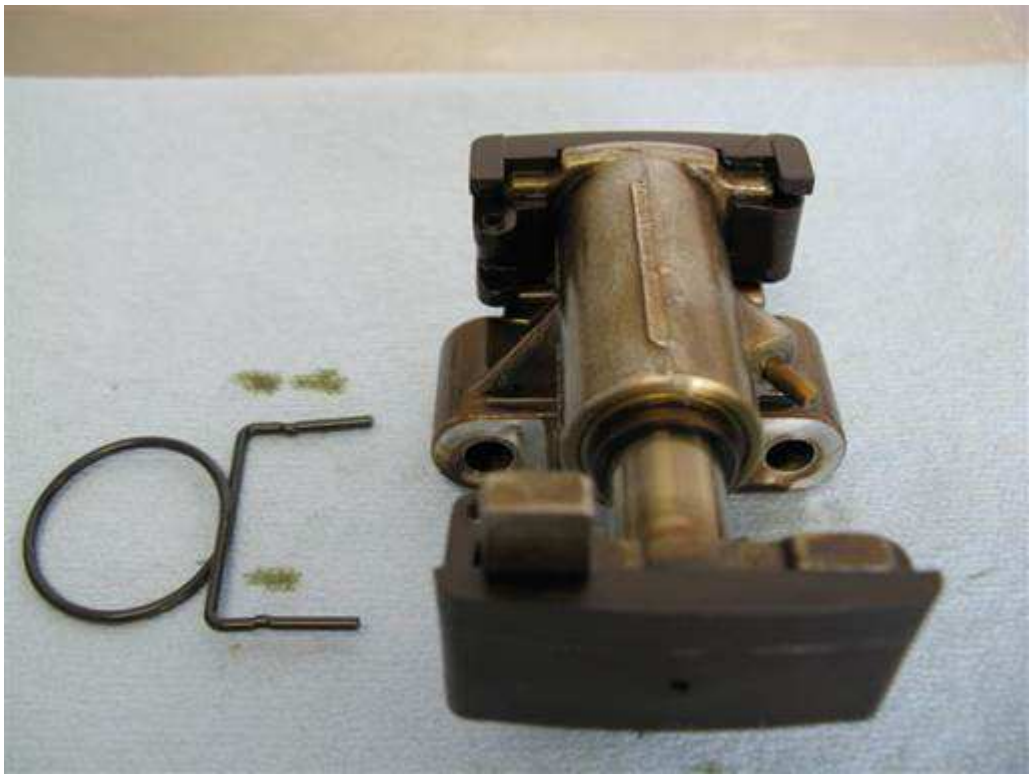
Remove bank 1 & 2 camshaft chain tensioner. For each chain tensioner perform following.
Pull up chain tensioner and insert pry tool under tensioner edge (putty knife).
Prey up on tensioner to release tensioner mount (putty knife).
Note: Tensioner mounted to engine head by O-ring.

Pull up and remove chain tensioner.

Rebuilding of camshaft tensioners

Perform following for each camshaft chain tensioner.

Following rebuild is of bank 2 camshaft chain tensioner. Bank 1 chain tensioner rebuild is very similar.



Compress chain tensioner and pull out locking clip.

Pull off chain tensioner guide from tensioner base.

Slide new chain tensioner guide on tensioner base. Press guide on until it locks into place.

Remove chain tensioner piston from tensioner.
If necessary, pull hard to remove piston.

If chain guide difficult to remove, pry open guide bracket tabs (flathead).

Pull off chain tensioner guide from tensioner piston.

Slide new chain tensioner guide on tensioner piston. Press guide on until it locks into place.

Insert chain tensioner piston in tensioner.

Remove old O-ring from tensioner.
Cut cross section of O-ring in groove (razor knife).
Note: Rocking of blade while pressing helps create cutting motion.

Install new O-ring on tensioner.
Place O-ring in groove on one end and stretch and drop O-ring opposite end in groove.
Lightly lubricate O-ring to ease tensioner installation (assembly oil).

Compress chain tensioner and fully insert locking clip into locking holes.

Note: If locking clip not fully inserting, remove clip and press in locking clip pins to make parallel, then reattempt insertion.

Replacement of vanos seals

Perform following for each vanos.

Marking of vanos shaft to vanos body

Vanos center shaft is balanced to vanos body. Thus vanos shaft must be marked to vanos body before removal to facilitate reinsertion in same position.

Clean vanos surfaces (brake cleaner & towels).
Note: Hold in vanos center shaft while cleaning to prevent from falling out of vanos.

Rotate vanos center shaft fully clockwise to insert internal piston in vanos body.
Note: Vanos piston has to be in a fixed position that can be replicated for shaft reinsertion.

Mark vanos shaft and body to document rotational orientation of shaft to vanos body (magic marker).

Note: It is helpful for reference to place marks along one of shaft top holes (picture).
Note: Do not use vanos plastic housing or plastic housing pins for reference as these can move.

Lift up and remove vanos center shaft from vanos body.
Shaft will need to rotate slightly clockwise to facilitate removal.

Note vanos piston is fully inserted in vanos. This was performed above by rotating vanos shaft clockwise.

Removal of vanos seals

Following vanos seals removal and installation is best performed at table while sitting.

If large washer is on vanos shaft, pry washer and remove from shaft (combination pick).
If large washer in vanos piston center skip next step.

If washer was on shaft and removed, press washer into vanos piston center (fingers).

Pull up vanos piston by prying at washer inside bottom (combination pick). Vanos can also be turned upside down and jerked to move piston out of vanos (hands).

During following seals removal, hold piston in top most position by holding up at center washer (finger).

Note: Piston outer helical (slanted) gears end half way down piston and piston diameter decreases at piston lower half. This decreased diameter facilitates space needed to access vanos seals in upper plastic housing. Thus pulling piston up allows positioning piston smaller diameter at plastic housing seals cavity and allowing for seals access and removal.

Pry vanos seal Teflon ring from vanos plastic housing seal cavity (combination pick).
Note: If O-ring is also engaged, release and attempt prying less of seal to only engage Teflon ring.
Pull Teflon ring out and past piston and plastic housing (combination pick).
Fully remove Teflon ring from vanos (combination pick, then fingers).

Pry vanos seal O-ring from vanos plastic housing seal cavity (combination pick).
Pull O-ring out and past piston and plastic housing (combination pick).
Note: This will take some force.
Fully remove O-ring from vanos (combination pick, then fingers).

Removed vanos seals.
Note Teflon ring thin cross section.
Note O-ring flat side and flat inner diameter.

Installation of vanos seals

During following seals installation, hold piston in top most position by holding up at center washer (finger).

Note: Piston outer helical (slanted) gears end half way down piston and piston diameter decreases at piston lower half. This decreased diameter facilitates space needed to insert new vanos seals into upper plastic housing. Thus pulling piston up allows positioning piston smaller diameter at plastic housing seal cavity and allowing for access to seal cavity and seals installation.

In following step seal O-ring will be inserted into plastic housing seal cavity.
Above two pictures show empty seal cavity and then seal O-ring installed in seal cavity.

Note: Above pictures are taken with vanos piston removed to allow for direct view. This cannot be performed without cutting vanos open.

Place vanos seal O-ring around vanos piston. Insert O-ring into vanos.
Press down on O-ring incrementally along its circumference to press O-ring past piston helical gears and into vanos (90 degree pick) (picture).
Note: O-ring will drop below plastic housing seal cavity.
Continue Inserting O-ring until it has been inserted ~3/4 along piston circumference (picture).

Pull inserted O-ring up (combination pick) and press exposed O-ring into vanos to insert inserted O-ring into plastic housing seal cavity.
tart O-ring insertion into seal cavity at center point of inserted O-ring.
Insert all inserted O-ring into seal cavity.

Insert exposed O-ring into vanos starting from one side (90 degree pick) while pressing on exposed O-ring to assure inserted O-ring enters seal cavity.

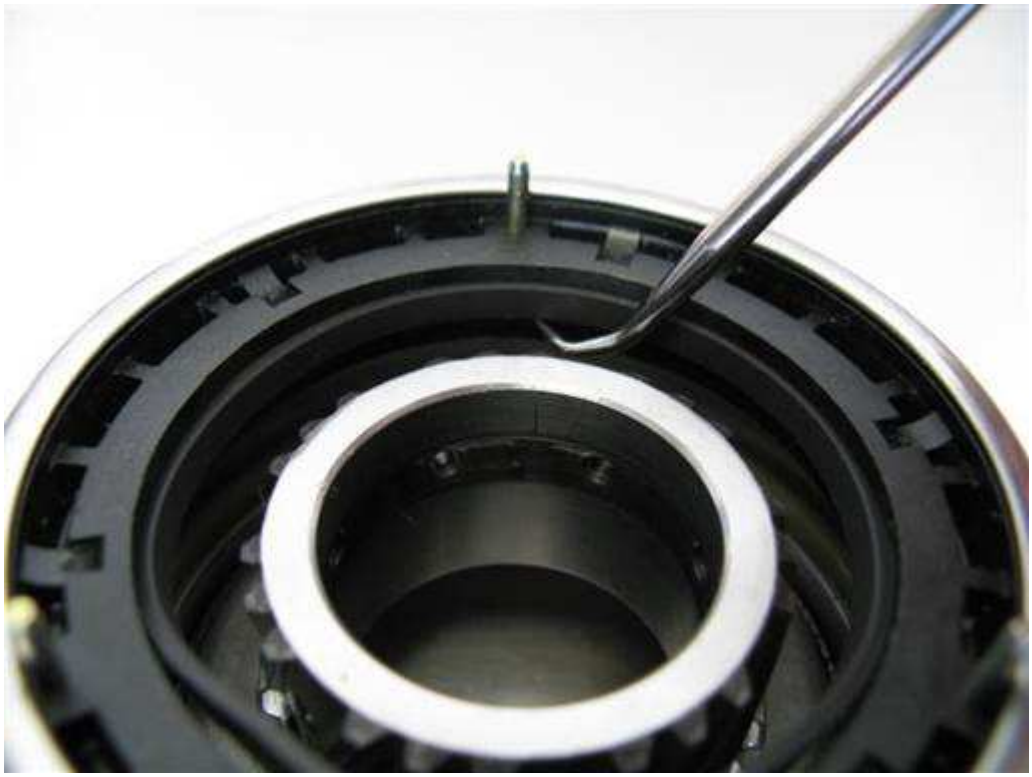
Insert last section of exposed O-ring into vanos and it will enter into seal cavity (90 degree pick).

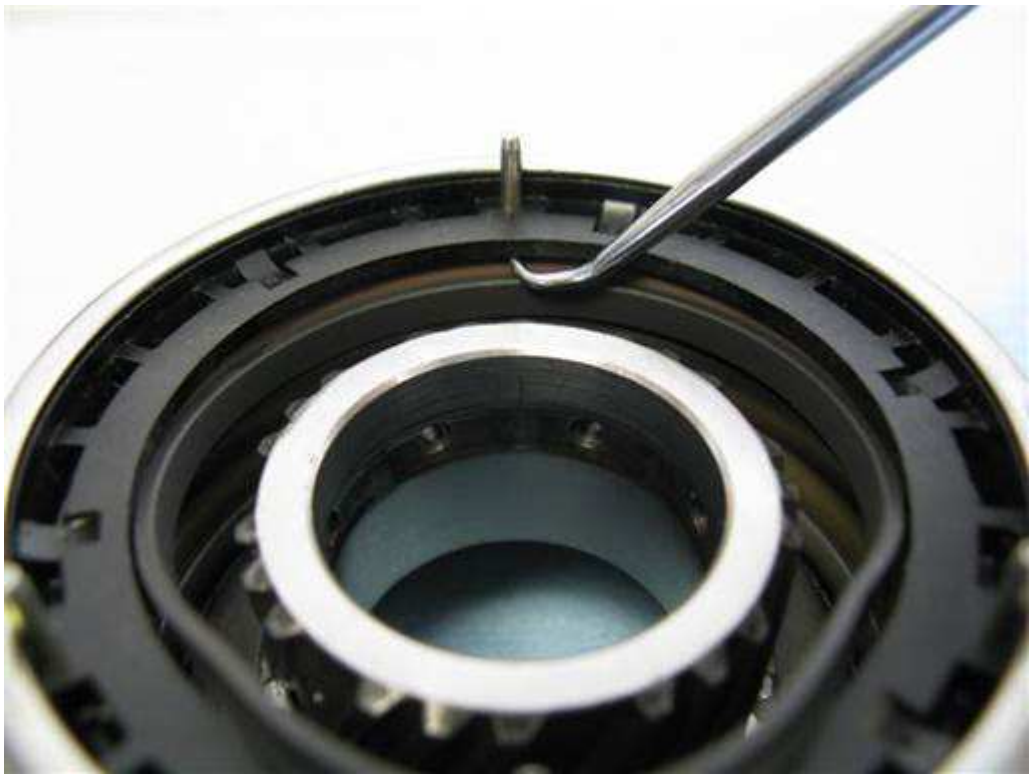
Check no O-ring part is seen along piston and thus all O-ring is in seal cavity.

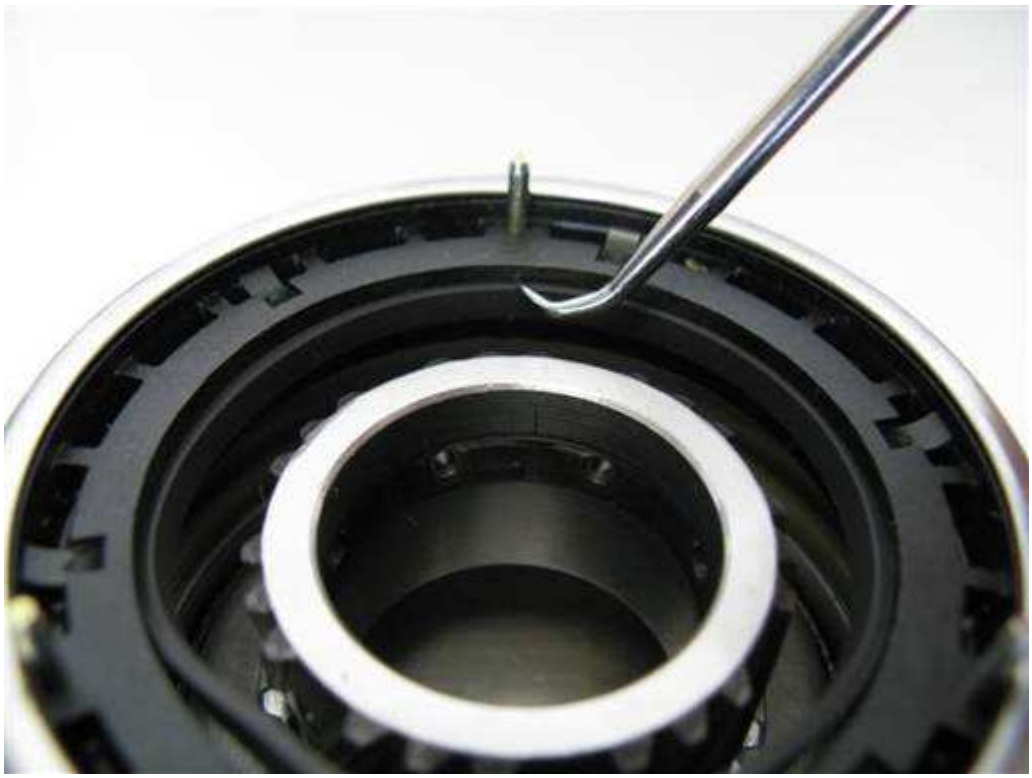
If seal Teflon ring in cold environment, < 70F (21C), soak Teflon ring in

warm water for 2+ minutes.
Remove and dry Teflon ring just before installation.

Place vanos seal Teflon ring around vanos piston.
Insert Teflon ring into vanos at one end.







In following step seal Teflon ring will be inserted into plastic housing seal cavity.
Above pictures show two techniques needed to assure correct insertion.
While inserting Teflon ring into vanos, pull up on inserted section at center point and insert into seal cavity and seat over O-ring (combination pick).
Note: Teflon ring will need to be bent some at transition point from exposed

to inserted section to accomplish insertion into seal cavity.
Teflon ring insertion and seating over O-ring in seal cavity can be verified by checking for space between Teflon ring top and seal cavity top. (combination pick) (pictures). There should be no space between Teflon ring top and seal cavity top.
Note: Second picture above shows Teflon ring not seated correctly over O-ring and space found between Teflon ring top and seal cavity top. Last picture above shows Teflon ring seated correctly over O-ring and no space found between Teflon ring top and seal cavity top.

Note: Above pictures are taken with vanos piston removed to allow for direct view. This cannot be performed without cutting vanos open.

While inserting Teflon ring into vanos, pull up on inserted section at center point and insert into seal cavity and seat over O-ring (combination pick).
Note: Teflon ring will need to be bent some at transition point from exposed to inserted section to accomplish insertion into seal cavity.
Verify Teflon ring insertion and seating in seal cavity by checking for space between Teflon ring top and seal cavity top (combination pick). There should be no space between Teflon ring top and seal cavity top.
Repeat Teflon ring insertion as needed to assure Teflon ring insertion and seating in seal cavity.
Caution: Correct Teflon ring insertion and seating in seal cavity is critical to success of Teflon ring installation. If this step is performed incorrectly Teflon ring can be damaged in next step.

Insert all inserted Teflon ring into seal cavity while pressing incrementally on exposed Teflon ring.
Press in exposed Teflon ring until it notably bends at sides. This Teflon ring deformation is needed to keep Teflon ring from popping back out of vanos.
Verify Teflon ring insertion and seating in seal cavity by checking for space between Teflon ring top and seal cavity top (combination pick). There should be no space between Teflon ring top and seal cavity top.

Press in and down on exposed Teflon ring at different locations (90 degree pick) to insert exposed Teflon ring to inside of plastic housing (picture). Teflon ring will deform in process and multiple waves will develop in Teflon ring shape.

Note: If exposed Teflon ring cannot be easily inserted to inside of plastic

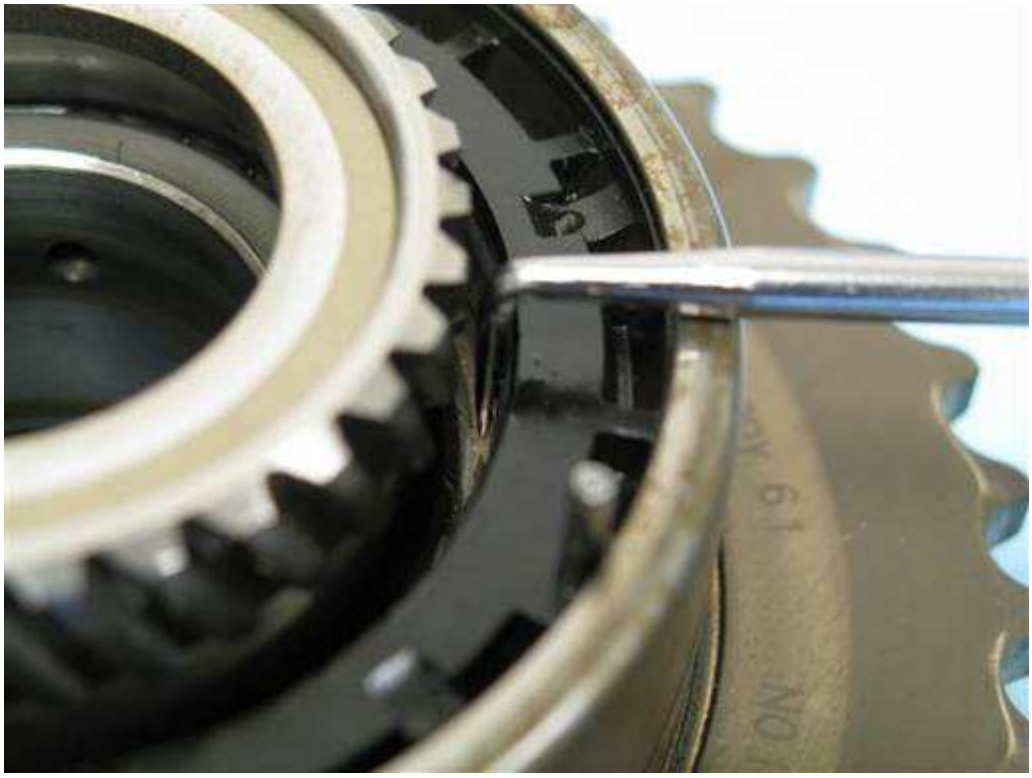
housing, then inserted Teflon ring is not inserted and seated in seal cavity and procedure should be repeated.

If Teflon ring is damaged due to wrong insertion, it can be mostly rectified by mounting it on vanos shaft sealing surface at cup rim (picture).
Heating Teflon ring (heat gun or hair dryer) and pressing in (90 degree pick) at center of damaged Teflon ring can further rectify damage.
Note: Damaged sides of Teflon ring are of no significance to Teflon ring function.

Press exposed Teflon ring in and down (90 degree pick). This allows Teflon ring bottom edge to go past O-ring and for Teflon ring to seat on O-ring in seal cavity.
Perform Teflon ring insertion from sides of unseated Teflon ring. This allows a progression of Teflon ring seating on O-ring in seal cavity.
Last section of exposed Teflon ring will insert in one piece.

Last Inserted section of Teflon ring will have waves and wrinkled form.

Press protruding Teflon ring waves into seal cavity to stretch Teflon ring and return to original shape (90 degree pick).
Preform pressing at multiple locations multiple times.
Once Teflon ring waves dampen, begin to smooth Teflon ring by pressing along wrinkled section from end to end (90 degree pick).
Continue to press along Teflon ring wrinkled section until much of wrinkles are smoothed. Moderate force is needed at end of smoothing process for effective results.
Note: It is not necessary to fully smooth Teflon ring surface. This will occur once Teflon ring is exposed to engine temperature and vanos is exercised.



Check that all Teflon ring is inserted in seal cavity (90 degree pick).

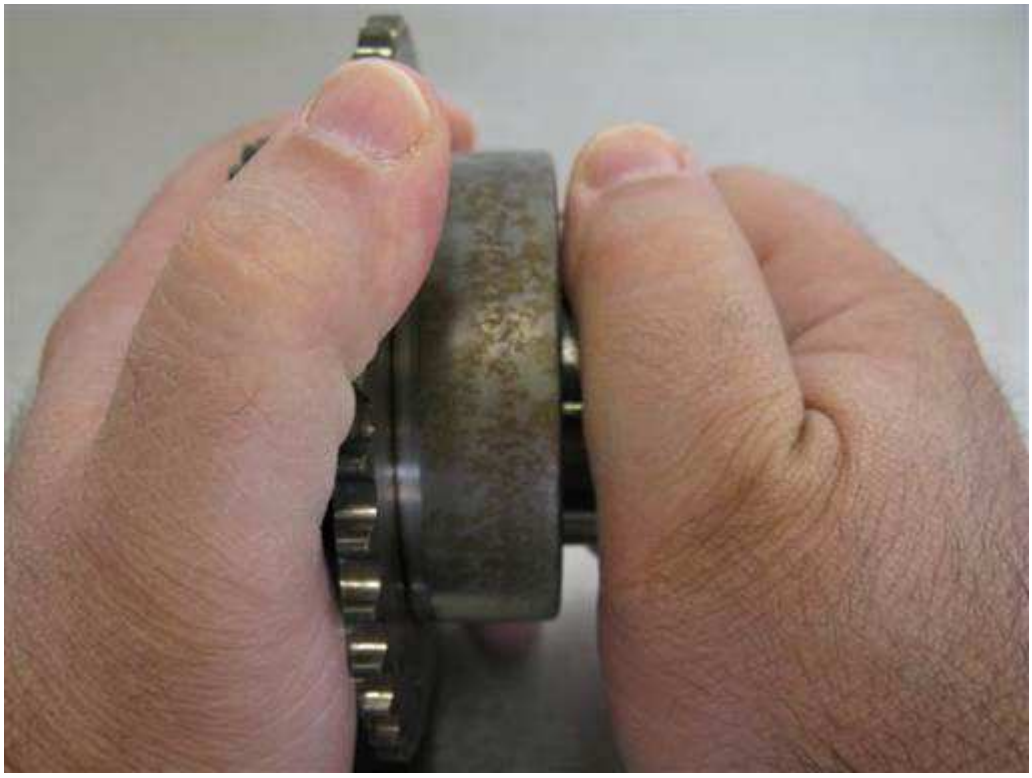
Press vanos piston fully into vanos.
Apply lubricant generously along top of Teflon ring (assembly oil).

Insert vanos shaft into vanos.
Adjust shaft as needed to facilitate helical gear matting.
Insert shaft until resistance is met (picture).

Turn vanos upside down on table.

Press strait down on vanos body to fully insert vanos shaft into vanos (hands/arms). Resistance will be encountered.
If shaft is resistant to insertion, remove shaft and repeat Teflon ring smoothing and oiling, then reattempt shaft insertion.

Turn vanos right side up.
Note full insertion of vanos shaft into vanos (picture).



Rotate vanos shaft in vanos to check normal movement of vanos.
Shaft will be difficult to rotate. This will ease as Teflon ring polishes and O-ring compresses during normal operation.

Remove vanos shaft from vanos by pressing out from rear of vanos.
Check Teflon ring is in seal cavity (90 degree pick).

Pressing of vanos lip

During following procedure vanos lip will be pressed down onto vanos plastic housing to fully seat plastic housing bottom onto vanos wall shelf below plastic housing. Seating of plastic housing creates functional oil seal between plastic housing and shelf. This seal circumvents function of plastic housing failing outer O-ring and thus need to replace it, which is not practical.

Press vanos piston fully into vanos.
Vanos center washer can be present or removed from vanos during following procedure. If present, washer should be fully pressed onto vanos and should not protrude past piston.

If present, clean oil sludge from vanos plastic housing (brake cleaner & towels).

As needed clean press tool and remove previous alignment marks from press bolt and press washer (brake cleaner & towels).

Press down plastic housing into vanos at multiple locations (medium flathead).
Plastic housing will seat on vanos wall shelf below housing and ~.9mm space will be present between vanos lip and plastic housing (picture).

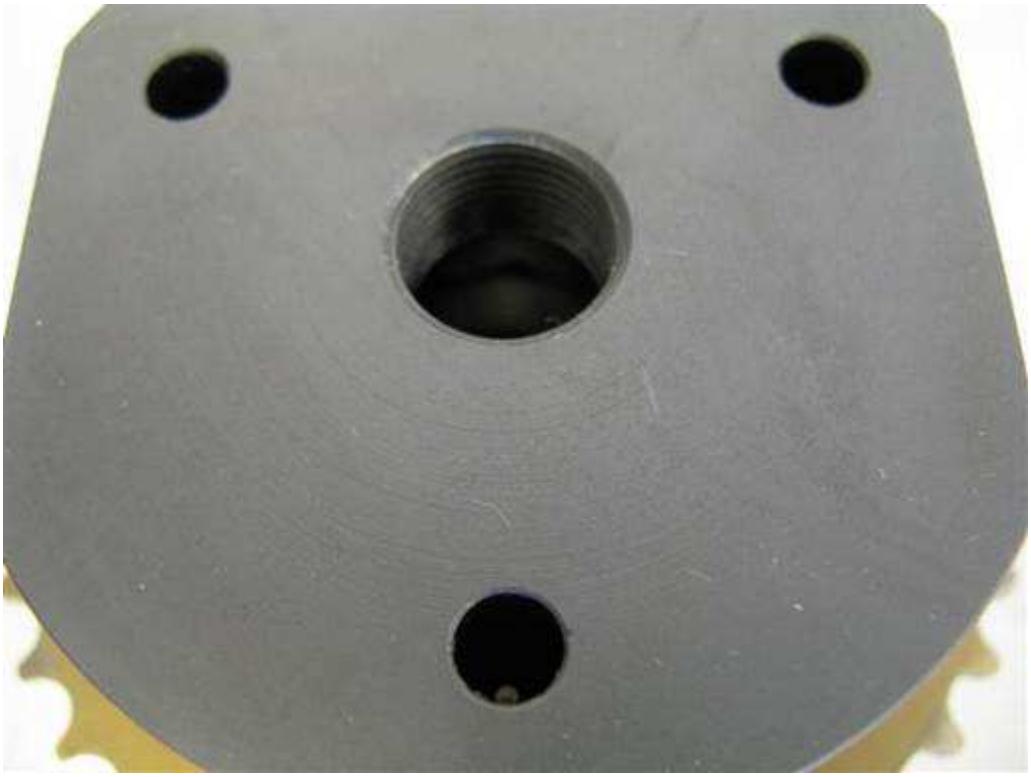
In following steps press tool press cap will be pressed onto vanos lip to press lip down onto plastic housing. It is useful to understand press cap

inner side design which facilitates this press function.
A press cap wall functions to support vanos wall top to keep it from collapsing to outside when lip is pressed. A wall initial 2mm barrel chamfer allows initial alignment and seating of press cap on vanos.
Indentation of press cap along perimeter allows space for vanos wall to insert into indentation and not be pressed. Only inner edge of vanos lip is pressed. This allows best leverage and thus easiest press.
Three holes in press cap allow vanos test pins to insert into holes and avoid being pressed down. Holes outer edge aligns with pins outer edge. Holes cannot be aligned further out as press shelf at pins would be removed.
An inner indentation prevents press cap from pressing against vanos center piston.

Bend vanos three test pins to vanos inboard side by ~2mm at pin top to allow pin insertion into press cap holes and prevent being pressed down. Rest tool (press bolt head) on vanos lip and press against pin to bend.

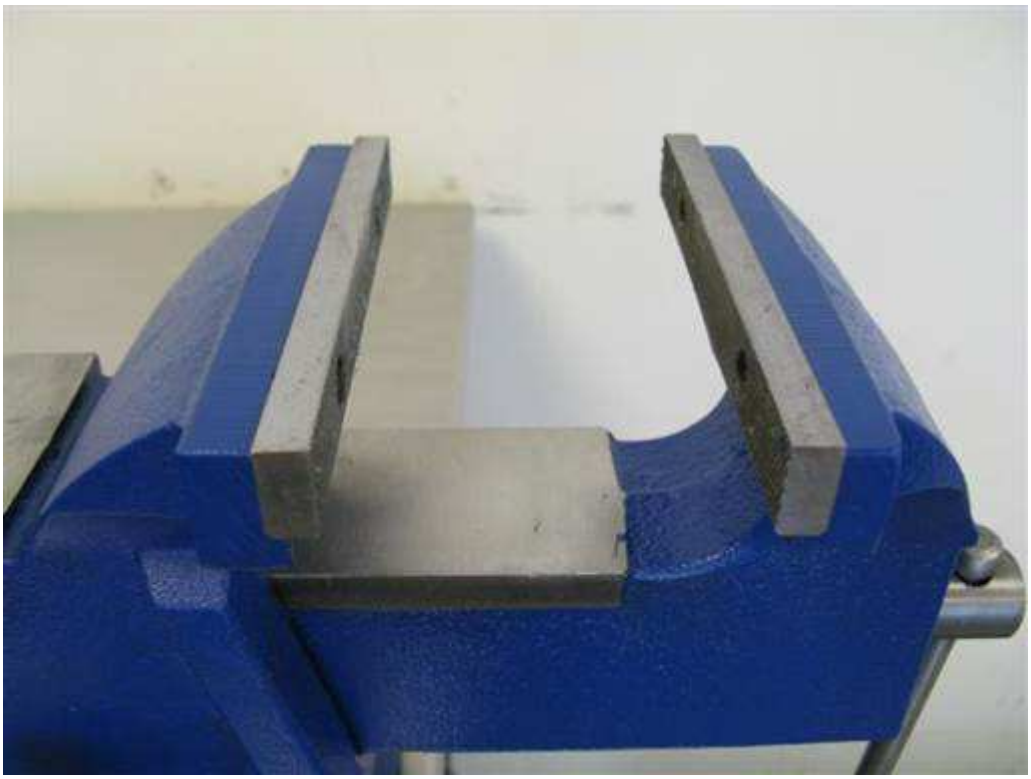
Place vanos with a test pin directly facing you.
Orient press cap with flats to side and pin hole without flat facing you.

Place press cap on top of vanos with a pin hole directly aligned with test pin and remainder of press cap aligned with vanos.



With press cap aligned with test pin and vanos, install press cap onto vanos. Check and align press cap on vanos so three test pins are inserted and roughly centered in pin holes.

Press press cap down onto vanos wall. Tilt press cap as needed to align and insert.
Full insertion and alignment is not necessary.



Open vise wide enough to insert vanos press cap.

Install press cap and vanos upside down into vise.
Rest press cap flat on vise fixed jaw top and press cap against jaw.
Close vise to allow moving jaw to insert under press cap flat and lay press cap flat on top of jaw.

Center press cap in vise jaws and strongly tighten vise.

Insert press washer into vanos rear hole and rest on vanos.

Apply grease to press bolt lower 2/3 threads and head flange bottom (graphite grease).
Note: Applying grease to bolt is critical for proper function and longevity of press tool.

Insert press bolt into press washer center hole.

Press down and tighten press bolt to insert into press cap center threaded hole (27mm socket 1/2” / 1/2” ratchet).
Fully tighten bolt (27mm socket 1/2” / 1/2” ratchet).
Note: Bolt can be difficult to thread as press cap can be misaligned. As bolt fully tightens press cap will fully insert onto vanos and become aligned.

Mark press washer and vanos to document rotational position of press washer on vanos (magic marker).
Marking will be used to reinstall press washer on vanos at same position if second, further press, is necessary.

Mark press cap and vanos to document rotational position of press cap on vanos (magic marker).

Marking will be used to reinstall press cap on vanos at same position if second, further press, is necessary.

Tighten press bolt to 136 Nm (100 ft-lb) (27mm socket 1/2” / 1/2” torque wrench).
Note: Counter hold vanos at socket (hand).
Caution: As bolt tightens turn bolt slowly to avoid overshooting torque value.
If vise begins to swivel, loosen vise swivel and allow vise to rotate to swivel end position.

Clean grease from press bolt base and press washer (brake cleaner & towels).
Mark press bolt and press washer at a press bolt hex edge (magic marker).
Note: Be sure to mark bolt head top as side mark can be scraped.

Tighten press bolt a further full turn (27mm socket 1/2” / 1/2” breaker bar).
Note: Counter hold vanos at socket (hand).

If vise begins to swivel, loosen vise swivel and allow vise to rotate to swivel end position.
Stop bolt tightening when bolt and washer alignment marks align again.
Precise alignment is not necessary and slight under and over turning is acceptable.
Note: Great force is needed to accomplish press, thus minimum 24” breaker bar is needed.

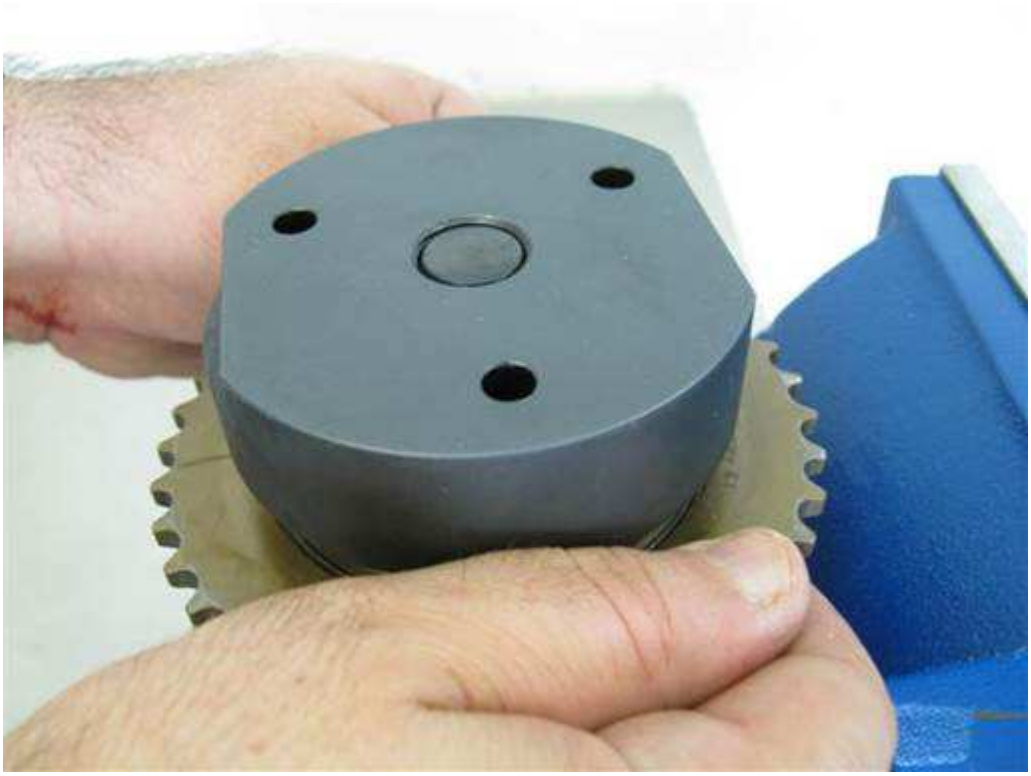
Warning: Once press begins it must be completed. Otherwise if tool is removed it will be difficult to assess how much further press is needed.

Loosen press bolt (27mm socket 1/2” / 1/2” breaker bar).
Note: Counter hold vanos at socket (hand).
If vise begins to swivel, loosen vise swivel and allow vise to rotate to swivel end position.

Unthread press bolt and remove press bolt and press washer from vanos (hand).
Note: If press washer difficult to remove, go to next step of removing vanos from vise and hit washer through press cap hole to dislodge (3/8” medium extension).

Loosen vise and remove vanos and press cap from vise.

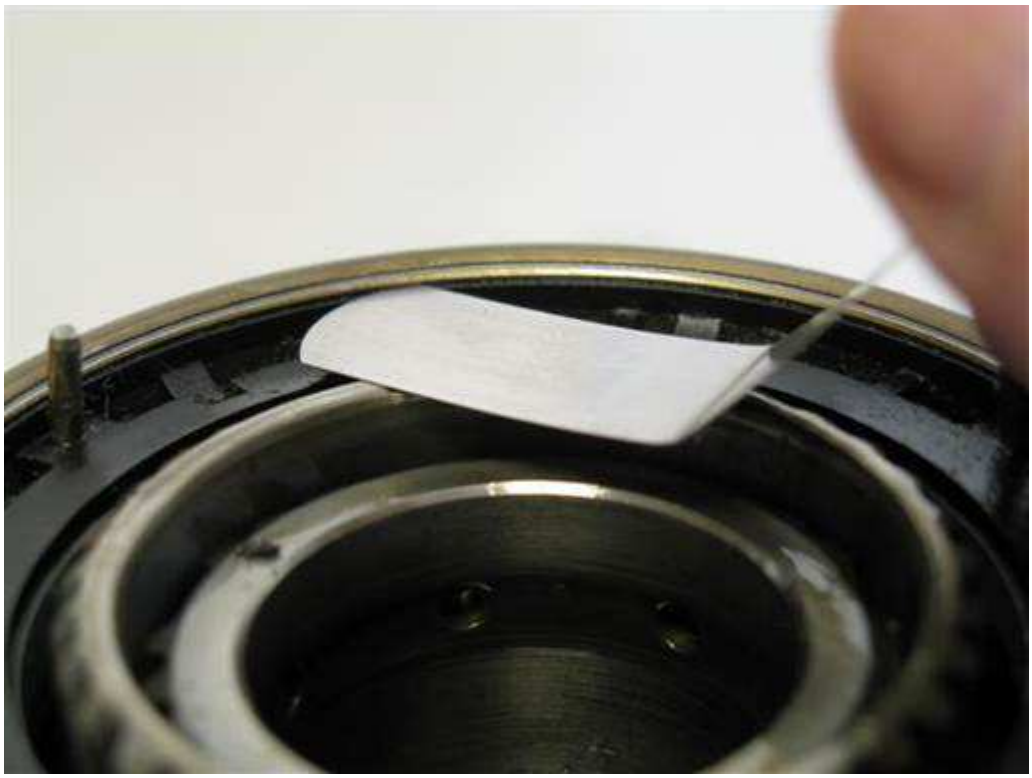
Thread press bolt into press cap form vanos rear (hand).



With vanos right side up, hold vanos from large sprocket at each side and repeatedly hit press bolt head onto vise anvil until press cap removes from vanos.
Note: Strong hitting will be needed to remove press cap from vanos.

Unthread press bolt from press cap and remove press bolt and press cap from vanos.

Inspect vanos lip in reference to vanos plastic housing. Vanos lip should be pressed against vanos plastic housing.



Insert thinnest available feeler gauge to assess any remaining gap between vanos lip and plastic housing. There should be none.

Turn vanos to its side and attempt to rotate plastic housing from test pin (hand & pliers). There should be no movement.

Second vanos press

If gap is found between vanos lip and plastic housing, or if plastic housing rotates, a second further press is necessary.
Reinstall press tool on vanos as before but use marks to align press cap and press washer to vanos at same rotational position as before.
Tighten press bolt until bolt and press washer marks align, then further tighten bolt by ~10mm (1/3”). This should fully press vanos lip.
Remove press tool as before and check vanos lip and plastic housing rotation as before.

Clean press tool and remove alignment marks (brake cleaner & towels).

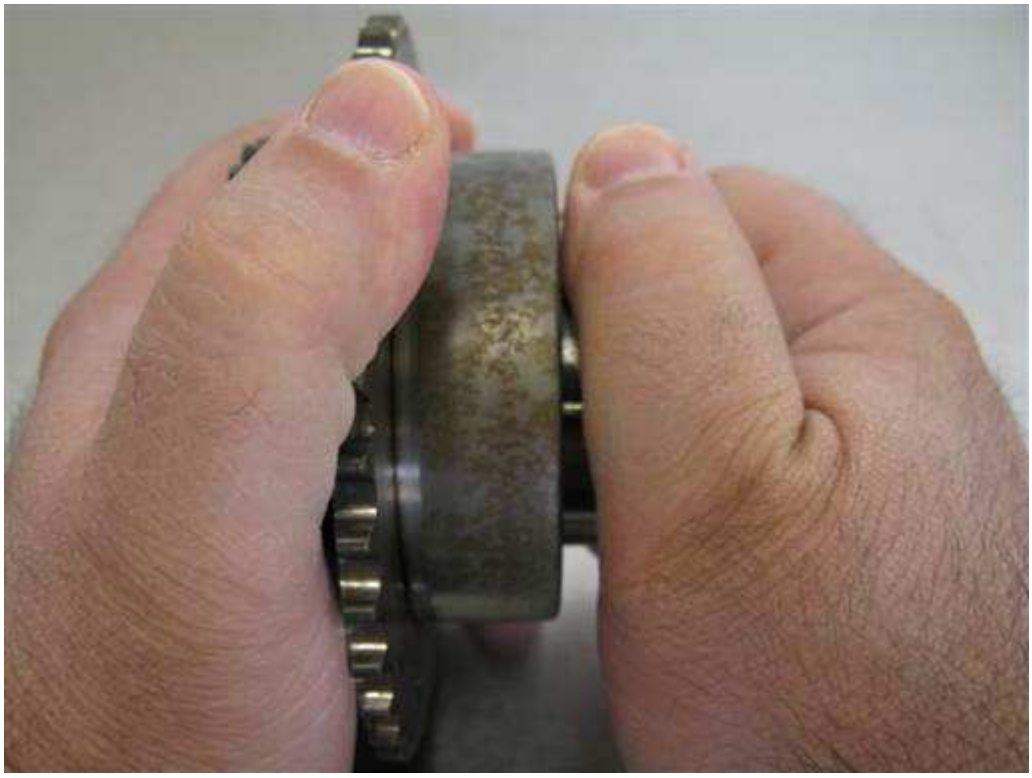
Alignment of vanos shaft to vanos body

Remove vanos shaft from vanos body.
Press vanos piston fully into vanos.
If not already present, install washer in vanos piston center.

Insert vanos shaft in vanos body and orient alignment mark on shaft to left of vanos body alignment mark.

Insert vanos shaft fully into vanos body.
Turn over vanos and press on table as before to ease installation.

Vanos shaft alignment mark should roughly align with vanos body alignment mark. If marks do not align, remove vanos shaft and reattempt alignment and insertion.



Rotate vanos shaft in vanos to check normal movement of vanos.
Shaft will be difficult to rotate. This will ease as Teflon ring polishes and O-ring compresses during normal operation.

Cleaning of parts

Note: When cleaning parts, spray cleaning compound on towel then wipe component with towel. Components can also be placed in a small container and sprayed with cleaning compound then individually wiped with towel.

Remove and discard valve cover bolt grommets. Cut off valve cover front 3 bolt grommets (diagonal cutters).

Clean all mounting bolts, nuts, washers (brake cleaner & towels).

Clean heads matting surfaces; sparkplug well, valve cover perimeter, camshaft bearing cap studs, timing cover perimeter, tensioner mount and studs, distribution piece (brake cleaner & towels).

Clean tensioners mating surfaces (brake cleaner & towels).

Clean coils ground straps and coil harness ground wire ends (brake cleaner & towels).
Clean coils mounting hole surfaces.

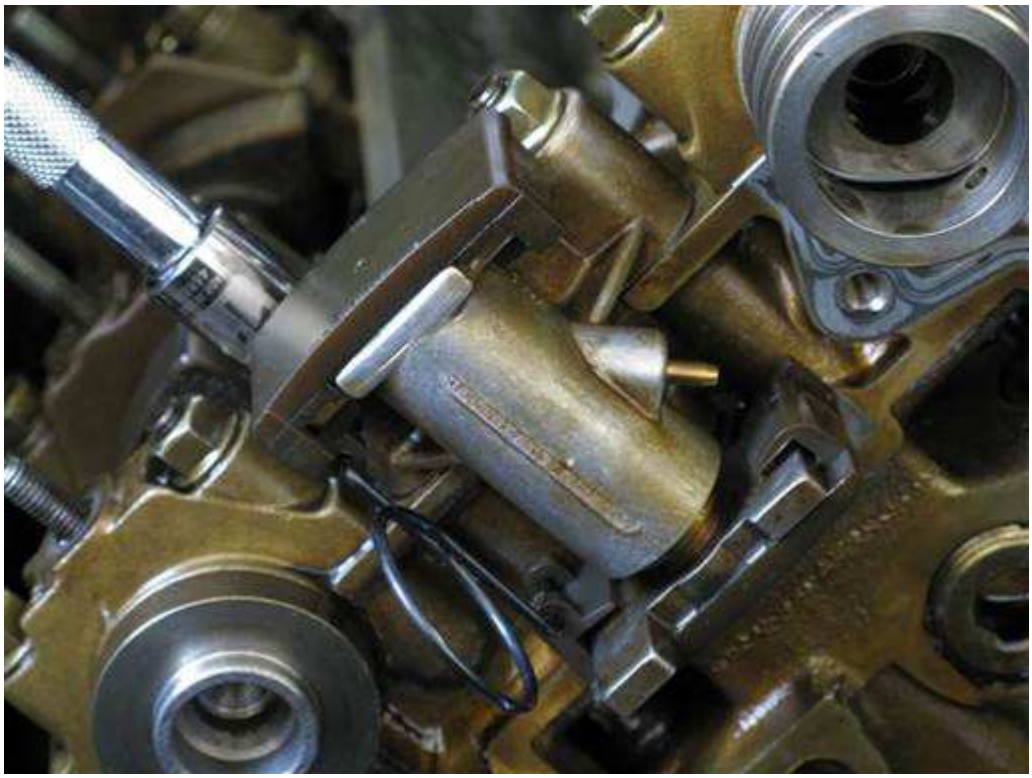
Clean battery positive cable mounting end and mounting post on bank 2

valve cover (brake cleaner & towels).

Remove valve cover gaskets and top cover gaskets from valve covers.
Clean valve cover mating surfaces; inner gasket grooves, bolt access holes, coil mounting studs, better positive cable mounting stud (brake cleaner & towels).

Remove upper timing cover gaskets from upper timing covers.
Clean timing cover mating surfaces; inner gasket grooves, bolt access holes (brake cleaner & towels).

Installation of camshaft chain tensioners



Install bank 1 & 2 camshaft chain tensioner. For each chain tensioner perform following.
Insert chain tensioner onto mounting studs and press down on tensioner to fully seat.
Install 2 mounting nuts (11mm socket 3/8” / 3/8” ratchet & extension).
Fully tighten, 14 Nm (10.5 ft-lb) (11mm socket 3/8” / 3/8” torque wrench & extension).
Tighten nuts evenly in multiple passes. Verify one pass with both nuts fully tightened.

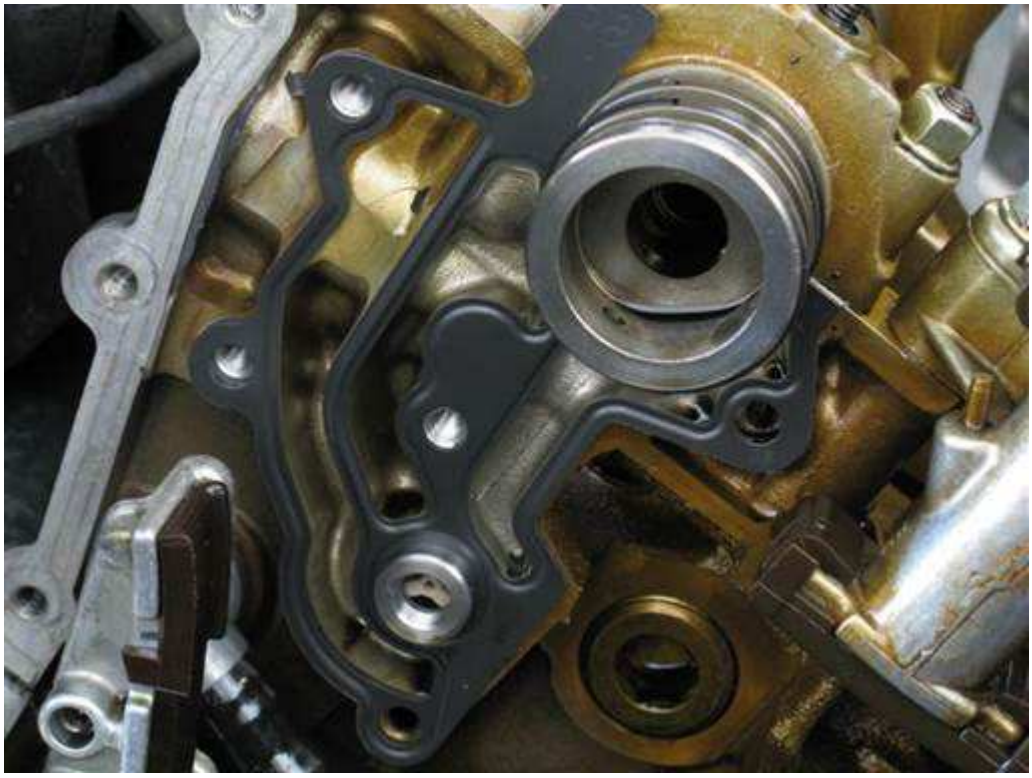
Installation of vanos components

Install bank 1 & 2 vanos solenoid oil check valve. For each head perform following.
Screw installation tool in new check valve (10mm thread diameter bolt).
Note: Check valve thread pitch is 1.0, but more standard 10mm 1.25 pitch bolt will partially thread into check valve. This is sufficient to mount and install check valve.

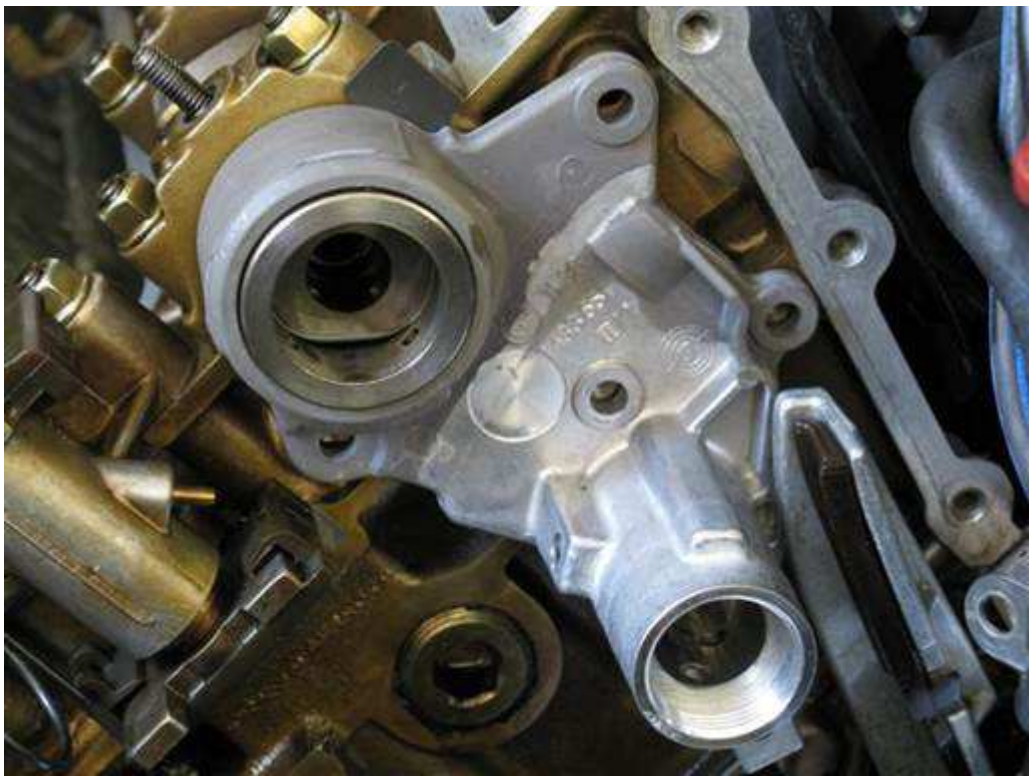
Fully press check valve into head at bottom of distribution piece gasket outline (10mm thread diameter bolt).
Note: Check valve is mounted in head by check valve O-ring.
Unscrew installation tool from check valve.

Install bank 1 & 2 intake camshaft seal rings. For each intake camshaft perform following.

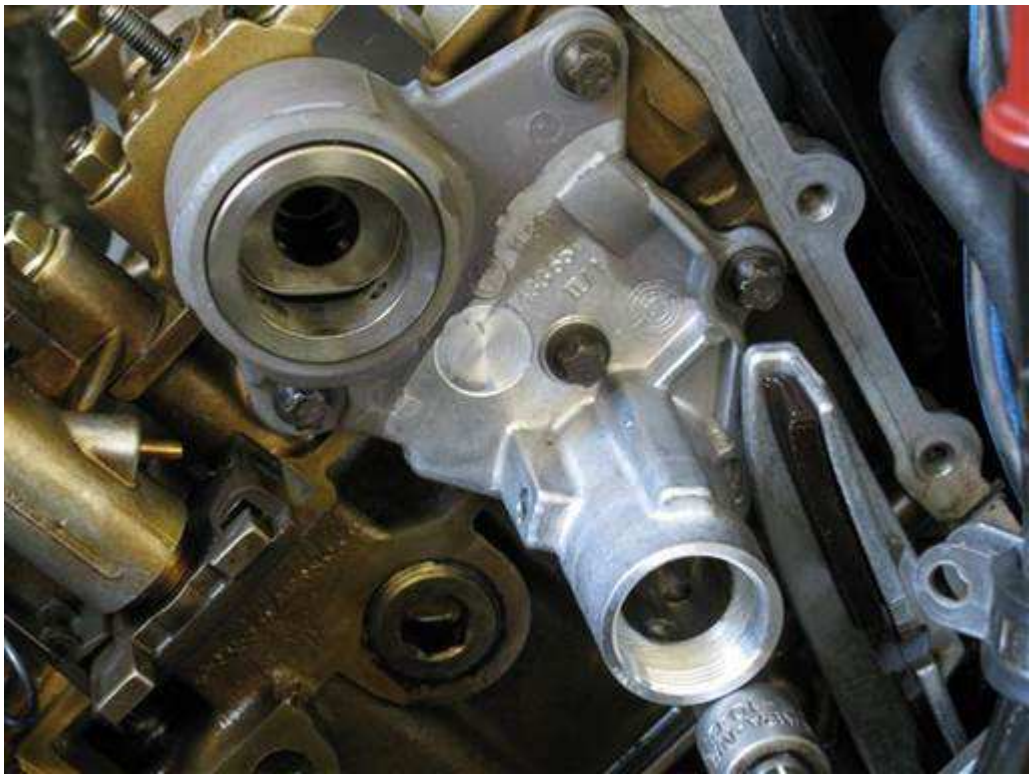
Install 3 seal rings on camshaft from rear to front order. Perform following for each seal ring.
Pry apart new seal ring ends and push seal ring on camshaft moving each side in alternating increments until seal ring is positioned in seal groove.
Push in and up on seal ring from sides to push up seal ring ends out of camshaft seal grove. Press one seal ring end down and under other seal ring end and engage seal ring end hooks.
Rotate seal ring to position locking ends at top of camshaft and press down into seal groove. Note: This is to prevent seal ring ends from protruding from seal groove and be disconnected when installing oil distribution piece.
Lightly lubricate seal rings to ease distribution piece installation (assembly oil).

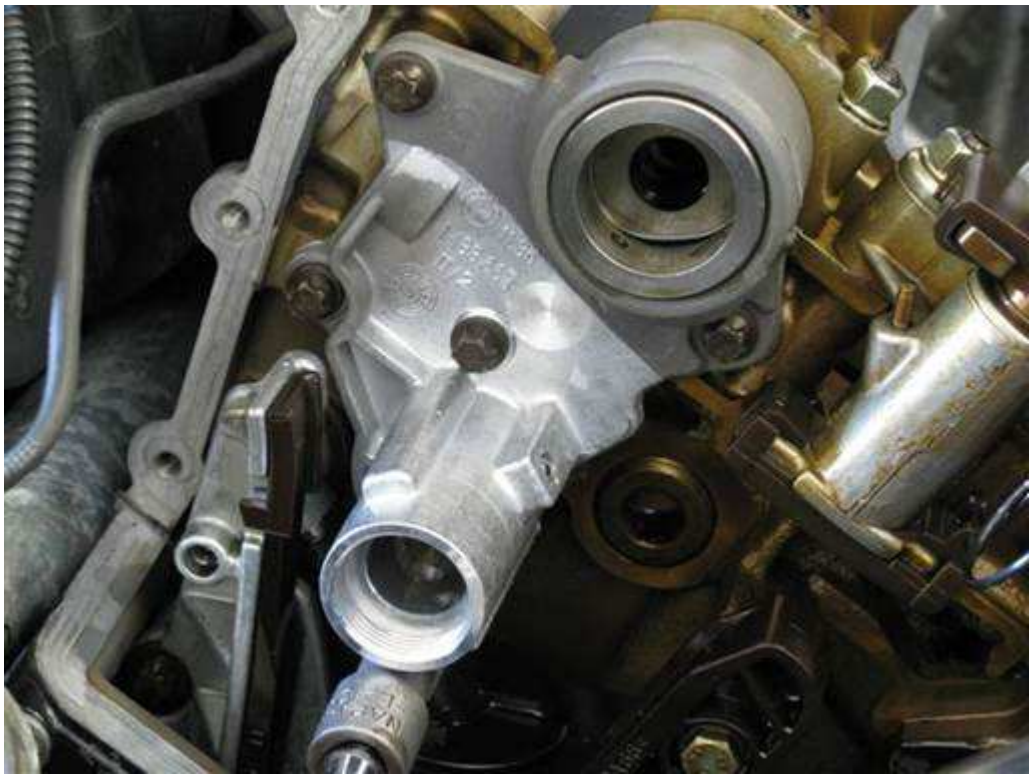


Install bank 1 & 2 vanos oil distribution piece gasket. For each distribution piece gasket perform following.
Press new gasket top against head and up into camshaft housing groove.
Insert gasket onto vanos check valve and press onto head to fully install.
Note: gasket top tab printed number faces front (pictures).
Verify gasket bolt holes fully align with head bolt holes.



Install bank 1 & 2 vanos oil distribution piece. For each vanos oil distribution piece perform following.
Lightly lubricate distribution piece cylinder to ease installation.
Press oil distribution piece onto camshaft and engine head.
Alternatingly tilt in top and bottom of distribution piece to insert over camshaft seals. Rotate distribution piece to avoid obstacles.
Fully press distribution piece against engine head.
Rotate distribution piece to align bolt holes with engine head bolt holes.



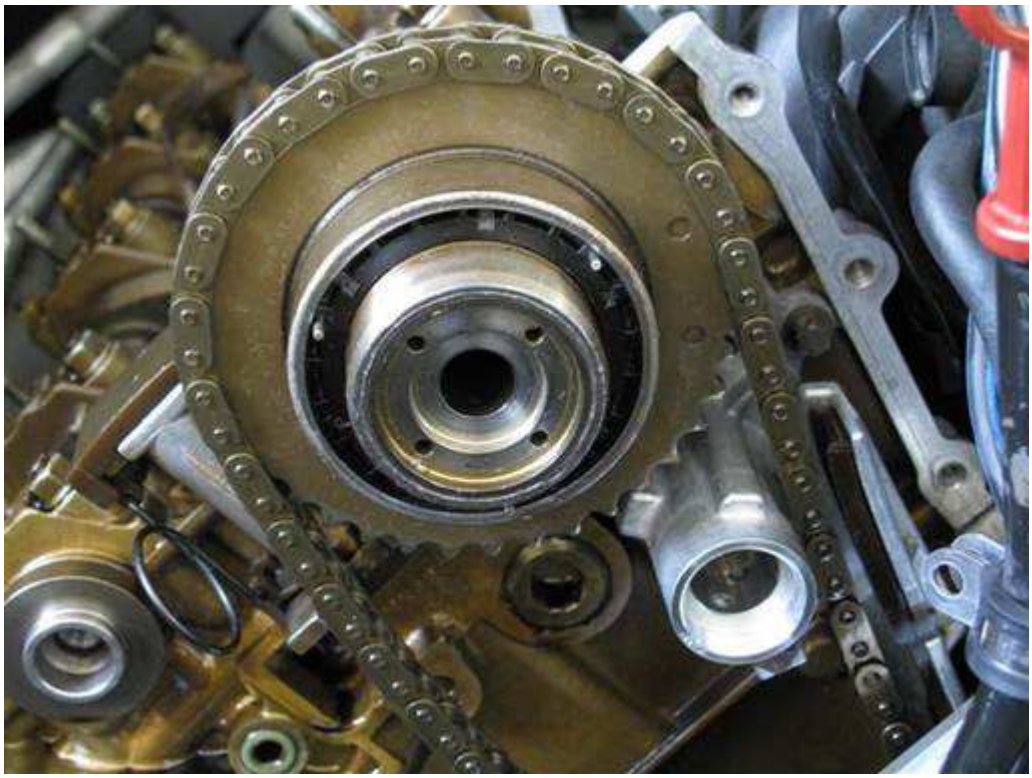


Install bank 1 & 2 vanos oil distribution piece mounting bolts. For each vanos oil distribution piece perform following.
Install distribution piece 5 mounting bolts (E-10 torx socket 3/8” / 3/8” ratchet & extension).
Note: Lower mounting bolt, just below solenoid hole, is longer and has washer.

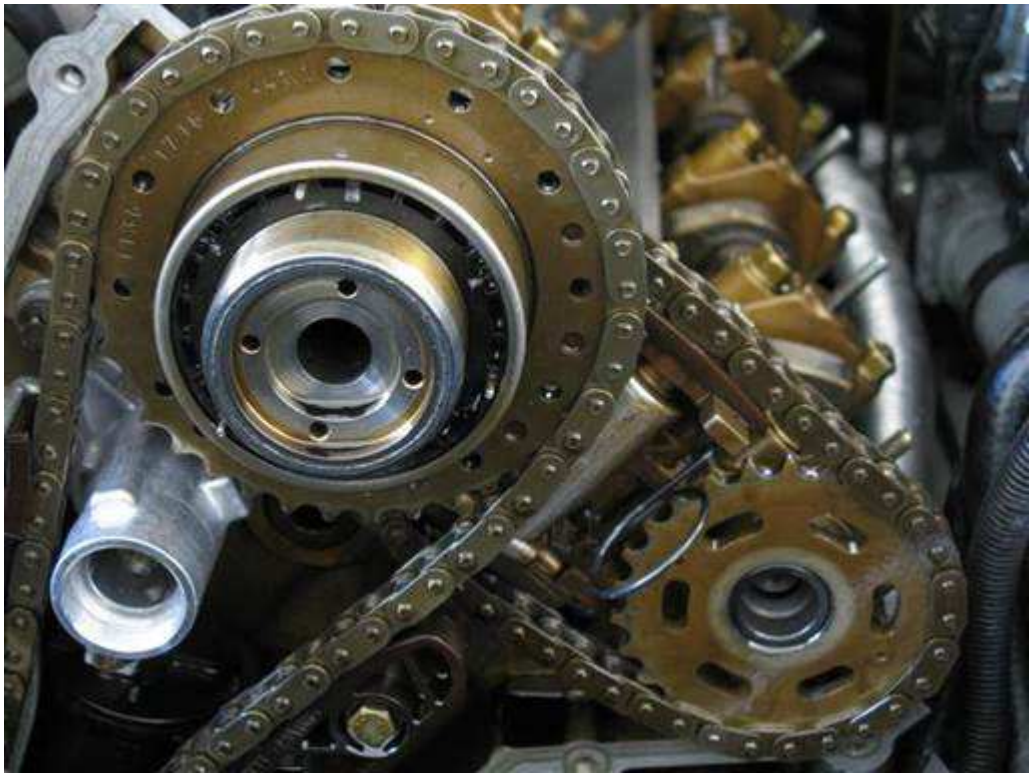
Fully tighten, 10 Nm (7.5 ft-lb) (E-10 torx socket 3/8” / 3/8” torque wrench & extension).
Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully tightened.
Note: Gasket will compress as bolts are tightened.

Remove towels from chain slot at bank 1 & 2.

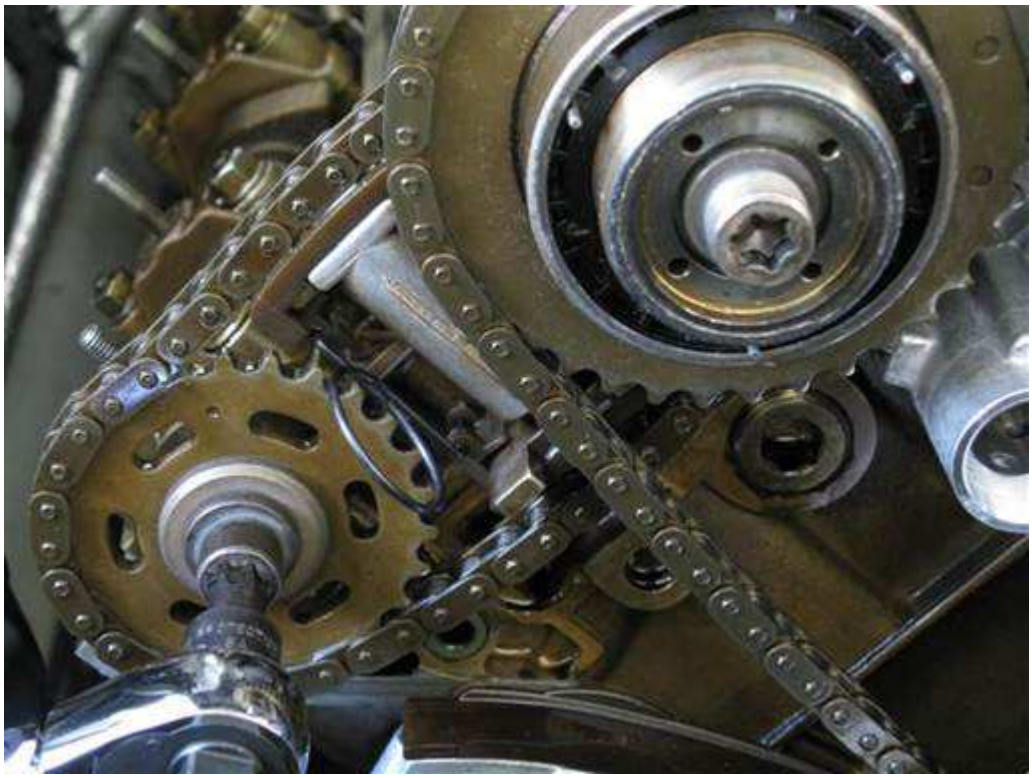
Installation of vanos units and exhaust sprockets

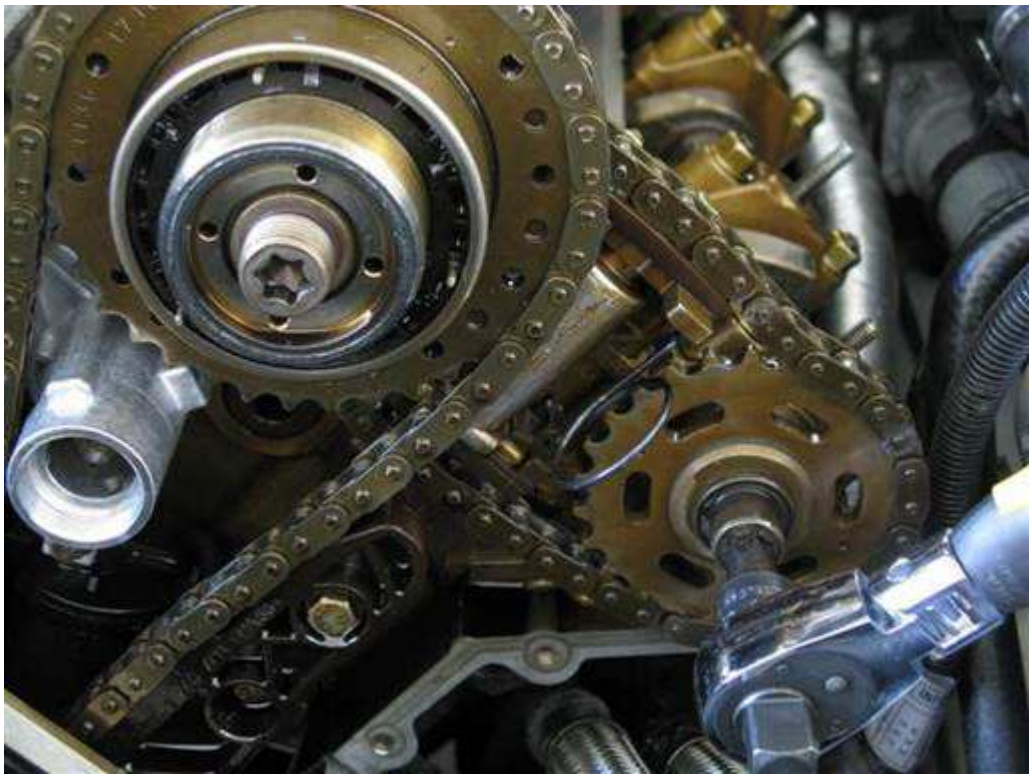


Install bank 1 & 2 vanos. For each vanos perform following.
Bring up crankshaft chain and maneuver past distribution piece.
Install crankshaft chain onto vanos front sprocket.
Mount vanos onto intake camshaft.
Note: There is no relative orientation of vanos and crankshaft chain.



Install bank 1 & 2 exhaust sprocket and camshaft chain. For each exhaust sprocket and camshaft chain perform following.
Mount camshaft chain onto exhaust sprocket.
Note: Exhaust sprocket rear has larger diameter oil mark circle than front.
Pull vanos forward and off intake camshaft.
Install camshaft chain onto vanos rear sprocket.
Mount vanos and exhaust sprocket onto intake and exhaust camshafts.
Note: There is no relative orientation of vanos, exhaust sprocket, and camshaft chain.

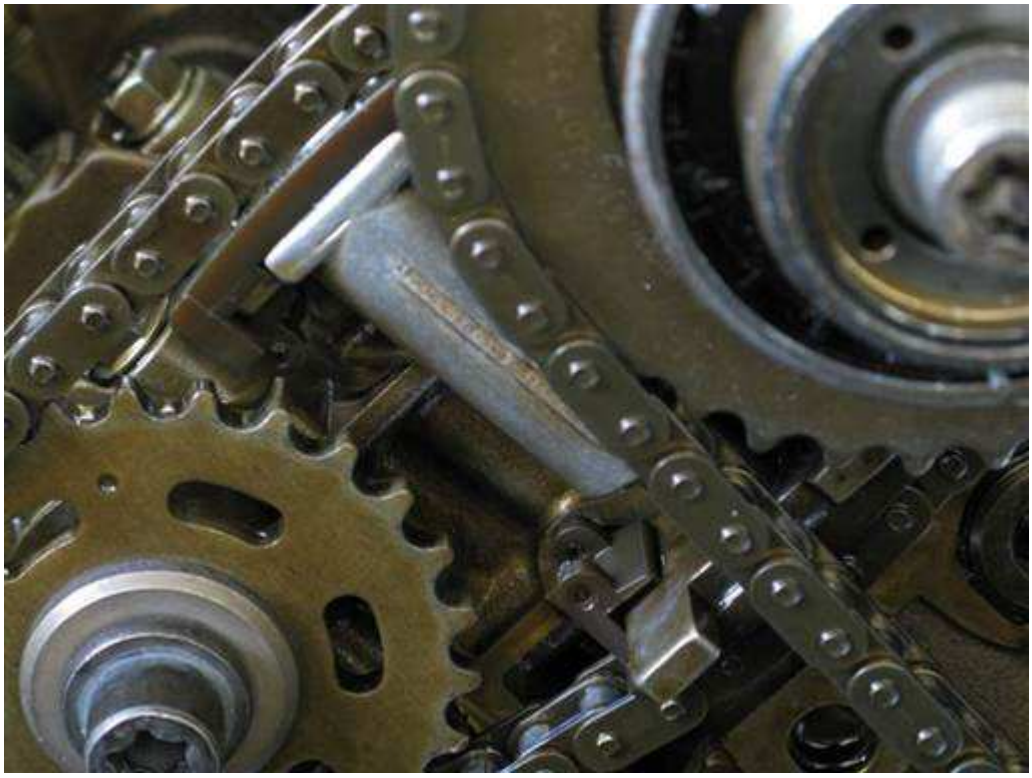




Install bank 1 & 2 vanos and exhaust sprocket mounting bolts. For each vanos and exhaust sprocket perform following.
Install vanos and exhaust sprocket mounting bolts; left hand thread (hand).
Tighten then slightly loosen (1/8 turn) both bolts; left hand thread (T55 torx bit socket 3/8" / 3/8" ratchet).
Note: Tightening bolts seats vanos and exhaust sprocket.

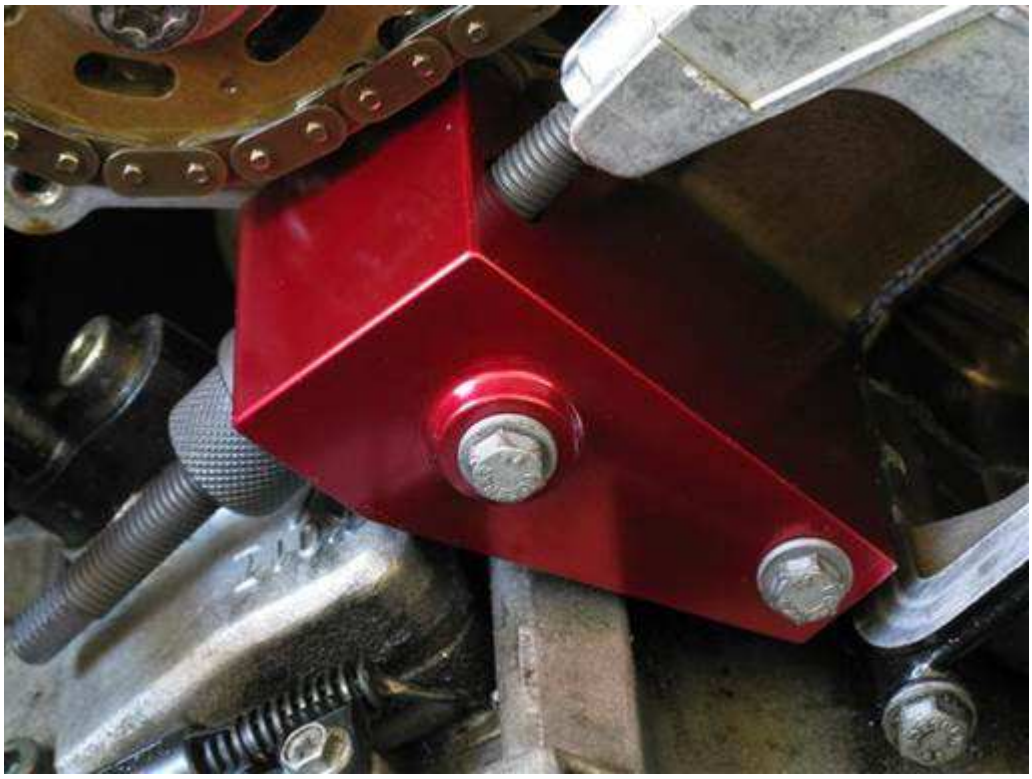
Note: Loosening bolts allows free rotation of vanos and exhaust sprocket which is needed for timing setup.

Setting of engine timing

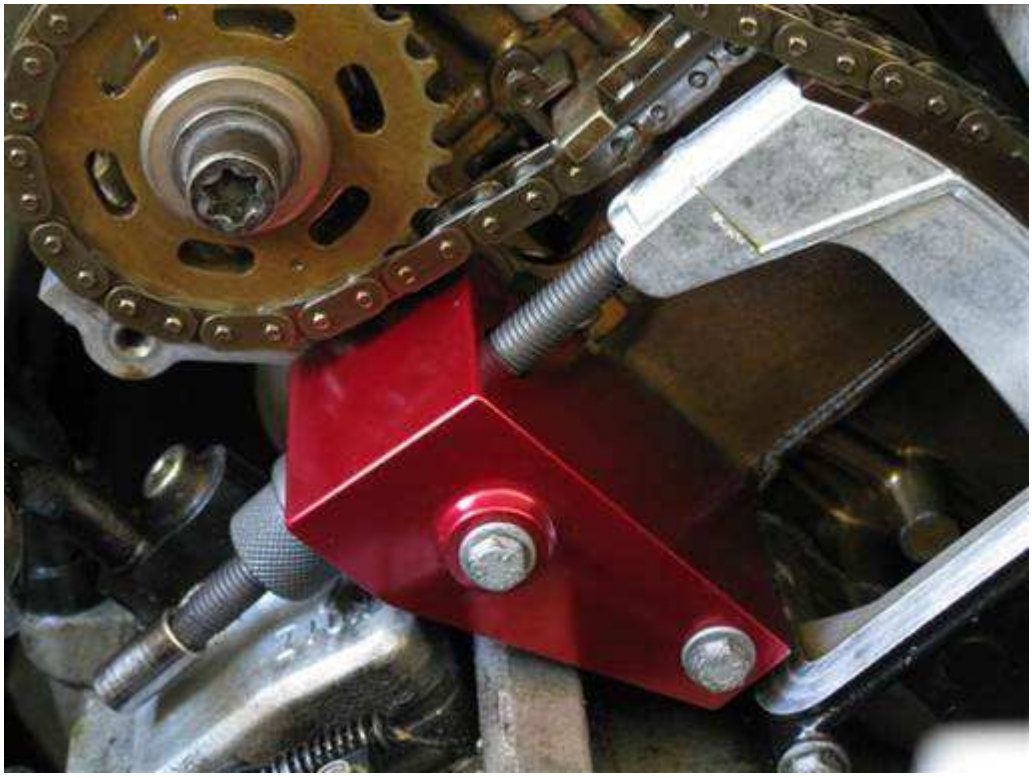


Unlock bank 1 & 2 camshaft chain tensioner. For each camshaft chain tensioner perform following.

Compress chain tensioner and pull out locking clip from locking holes.
Note: Bank 1 chain tensioner is compressed from below tensioner and bank 2 chain tensioner is compressed from above tensioner.



Install crankshaft chain tensioning tool.
Thread tool spindle nut fully into tool block.
Position tool block on bank 1 head below exhaust sprocket (picture).
Mount tool block with upper timing cover long bolt at top and short bolt at bottom. Align block with head to facilitate bolt insertion.
Lightly tighten bolts (10mm socket 3/8” / 3/8” extension).



Tighten tensioner tool spindle to press against chain rail guide and tension crankshaft chain (8mm socket 1/4" / fingers).
Align tool spindle and rail guide as needed.
Verify crankshaft chain is positioned on chain rail guides at bank 1 & 2.
Tighten until difficult to further tighten (8mm socket 1/4" / fingers). Do not over tighten.
Note: Amount of chain tightening and spindle protrusion from tool block will depend on chain age and stretch. Chain in picture is old and stretched.

Verify crankshaft chain is tight at all segments.
If chain is loose at a segment this is likely due to a tightly mounted vanos or exhaust sprocket. Slightly loosen vanos or exhaust sprocket mounting bolt to allow rotation and release of chain bind.
Further tension chain as needed.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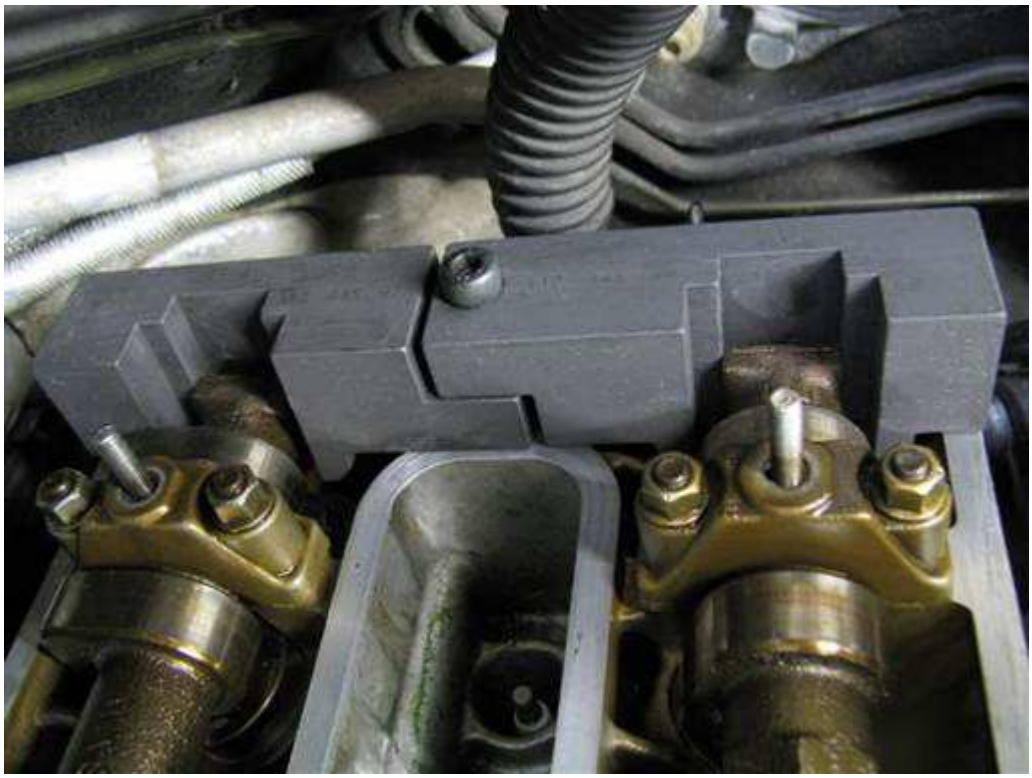
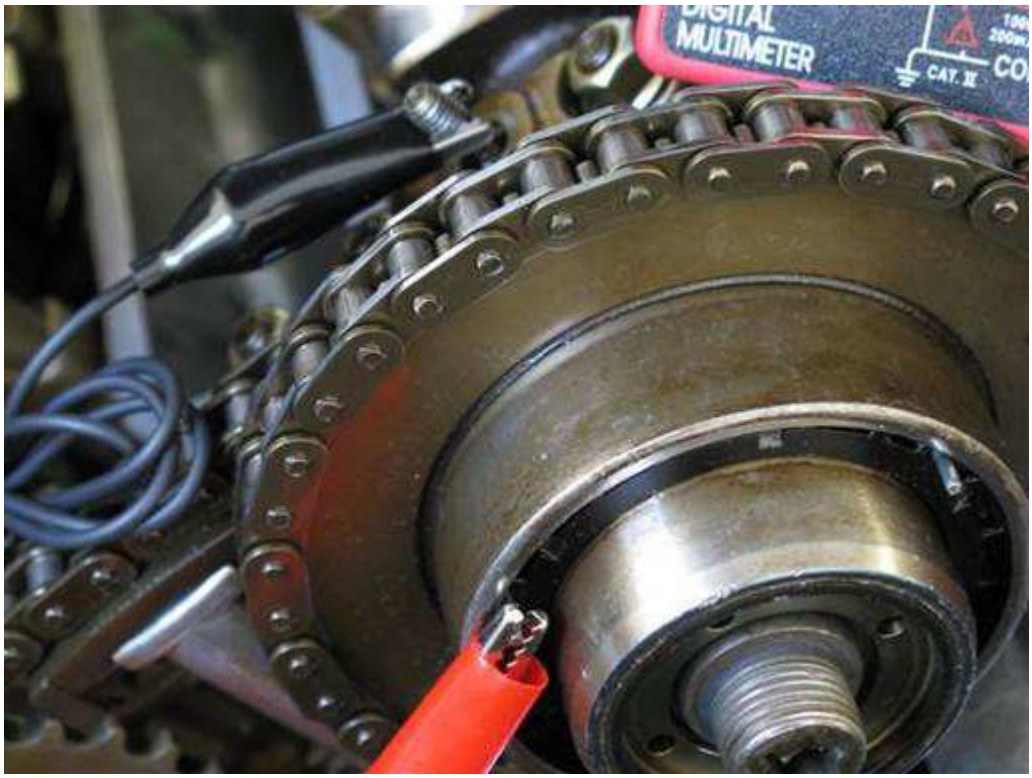


Check and realign camshafts and camshaft locking blocks as necessary.
Rock each camshaft slightly back and forth while pressing down and forward on locking block to fully seat and align block on head surface (27mm open wrench).
Loosen and retighten locking blocks matting bolt as needed to facilitate block mounting (6mm hex bit socket 3/8” / 3/8” ratchet).


DIGITAL
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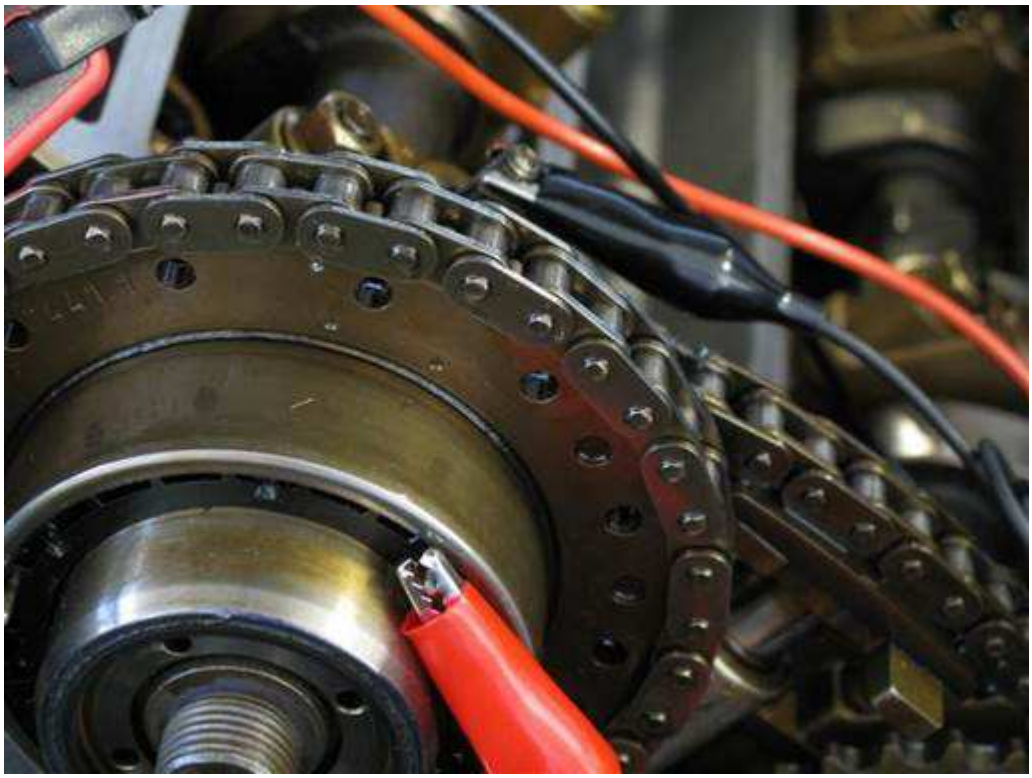
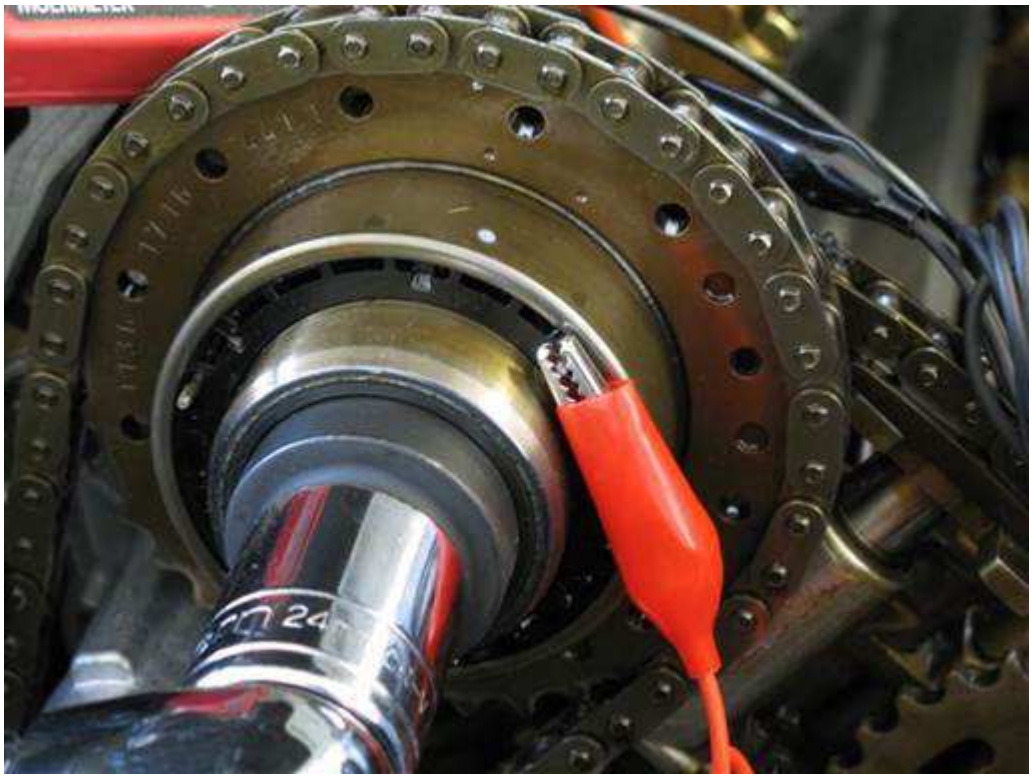
CAT. II



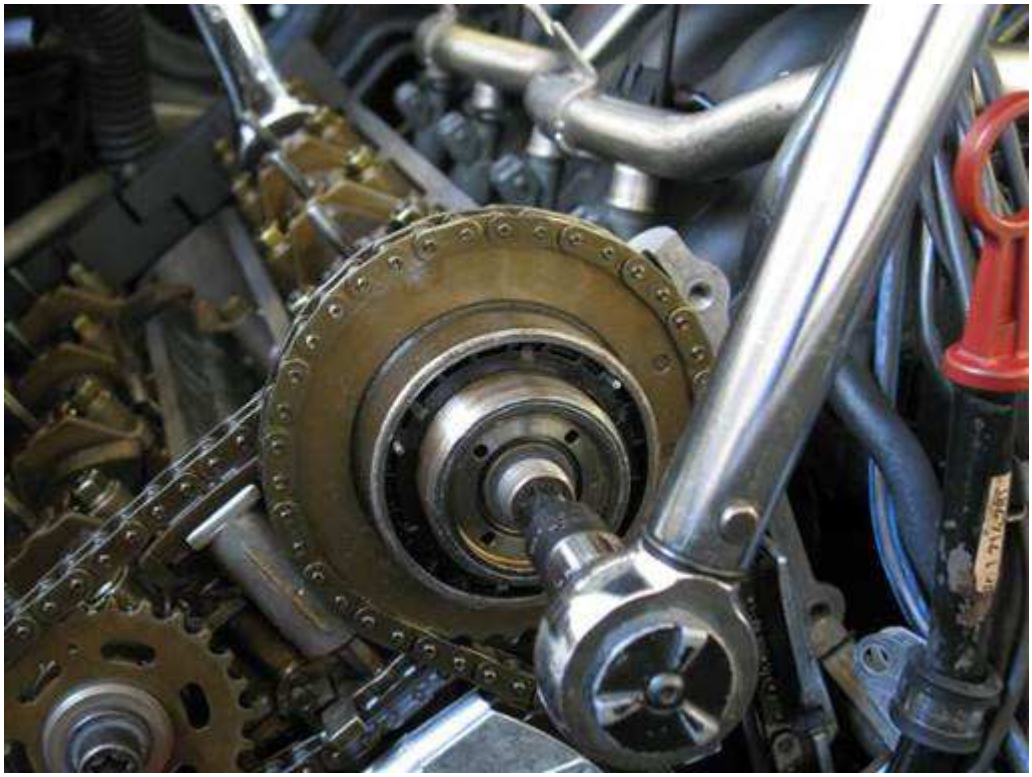


Fully retard bank 1 & 2 vanos timing. For each vanos perform following.
Connect ohm meter positive lead to one of vanos test pins and negative lead to intake camshaft first bearing cap stud (digital multimeter & alligator clip wires).
Turn on ohm meter (digital multimeter on ohm setting).
Install vanos turning tool onto vanos center shaft. Insert tool pins into vanos

shaft pin holes.
Turn vanos shaft counter clockwise until end adjustment position (vanos turning tool & 24mm socket 1/2" / 1/2" ratchet).
Caution: Do not place notable pressure on vanos turning tool as pins will break.
Ohm meter will display 0 ohm when vanos at fully retarded position.
Note: Vanos internal piston will connect with vanos test pins when fully retarded and cause a short reading (0 ohm).
Note: When ratchet pressure is released ohm reading can change to open circuit (infinite ohm). This is normal.
Note: In many cases a short will not be achieved and a 0 ohm reading will not occur. This is normal.
Remove ohm meter and wires.

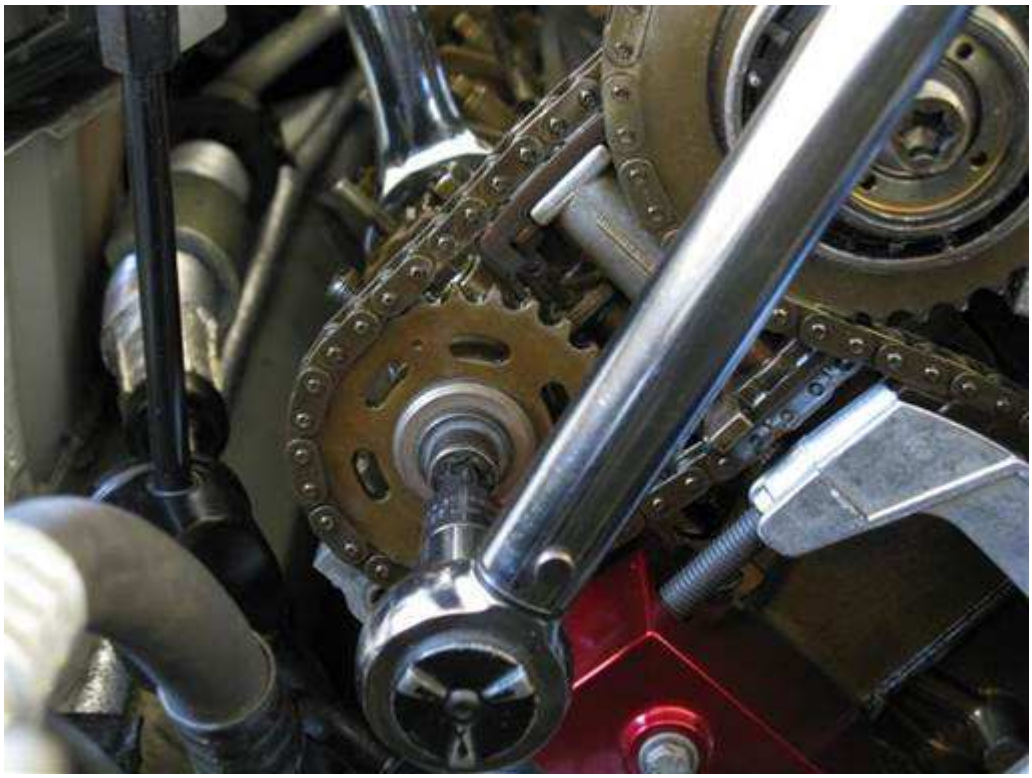
Locking of engine timing

Perform following two steps in two passes. First pass lightly tighten vanos and exhaust sprocket mounting bolts to fix timing. Second pass fully tighten vanos and exhaust sprocket mounting bolts.
Note: Mounting bolt tightening torque values are high and set timing can be disturbed in tightening process. Two pass tightening allows fixing set timing at first pass then fully tightening at second when timing can’t be disturbed.



Tighten bank 1 & 2 vanos mounting bolt. For each vanos perform following. Tighten bank 2 then bank 1. Note: This assures any chain looseness it drawn to chain tensioner.
Counter hold intake camshaft and fully tighten vanos mounting bolt, first pass 20 Nm (15 ft-lb), second pass 110 Nm (81 ft-lb); left hand thread(T55 torx bit socket 3/8" w/ 1/2” to 3/8” socket adapter / 1/2" torque wrench, 27mm open wrench).
Note: Verify tool inserts fully into vanos bolt head (T55 torx bit 3/8”).
Note: Intake camshaft is counter held by locking block. But do not rely on this alone as camshaft can be damaged. Further counter hold camshaft at camshaft hex.

Check and realign camshafts and camshaft locking blocks as necessary.



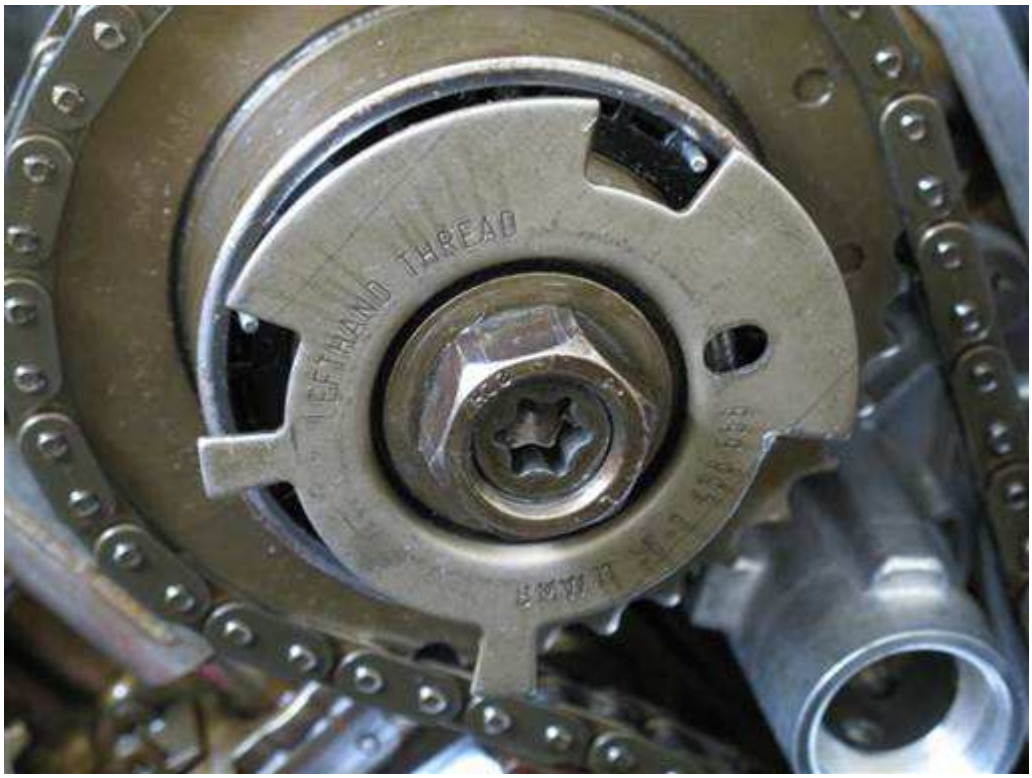
Tighten bank 1 & 2 exhaust sprocket mounting bolt. For each exhaust sprocket perform following.

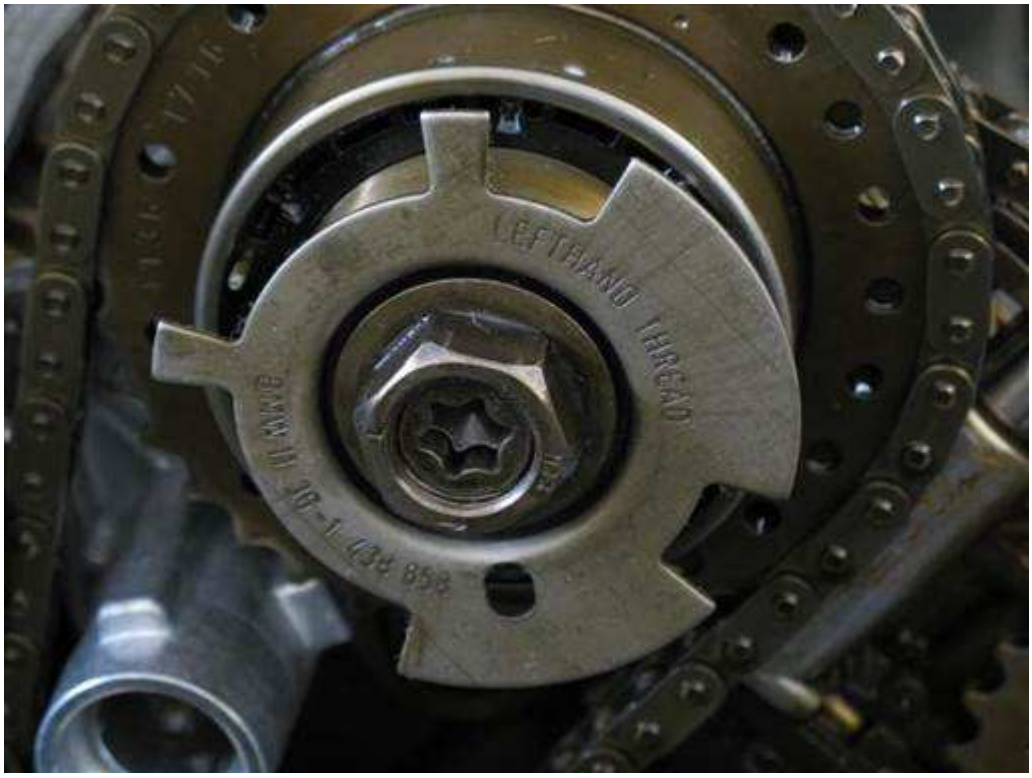
Tighten bank 2 then bank 1. Note: This assures any chain looseness it drawn to chain tensioner.

Counter hold exhaust camshaft and fully tighten exhaust sprocket mounting bolt, first pass 20 Nm (15 ft-lb), second pass 125 Nm (92 ft-lb); left hand

thread (T55 torx bit socket 3/8" w/ 1/2” to 3/8” socket adapter / 1/2" torque wrench, 27mm open wrench).
Note: Verify tool inserts fully into sprocket bolt head (T55 torx bit 3/8”).
Note: Exhaust camshaft is counter held by locking block. But do not rely on this alone as camshaft can be damaged. Further counter hold camshaft at camshaft hex.

Check and realign camshafts and camshaft locking blocks as necessary.
Check if bank 1 & 2 exhaust camshaft locking block is lifted from engine head.
If exhaust camshaft locking block is lifted more than 1mm from engine head then loosen exhaust camshaft bolt and repeat above procedure for retightening bolt.
Rotate bank 1 & 2 intake camshaft counter clockwise as far as possible and note if locking block is lifted from engine head.
If intake locking block is lifted more than 1mm from engine head then loosen vanos mounting bolt and repeat above procedure for retarding vanos and retightening bolt.





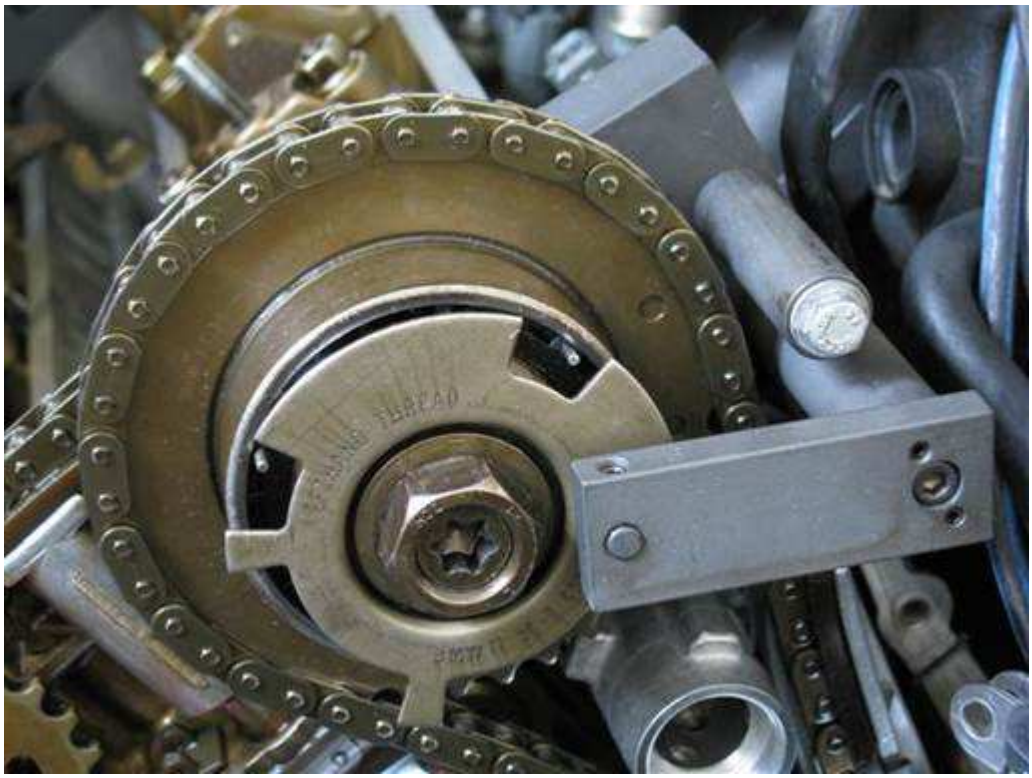
Mount bank 1 & 2 intake camshaft timing wheel. For each timing wheel perform following.

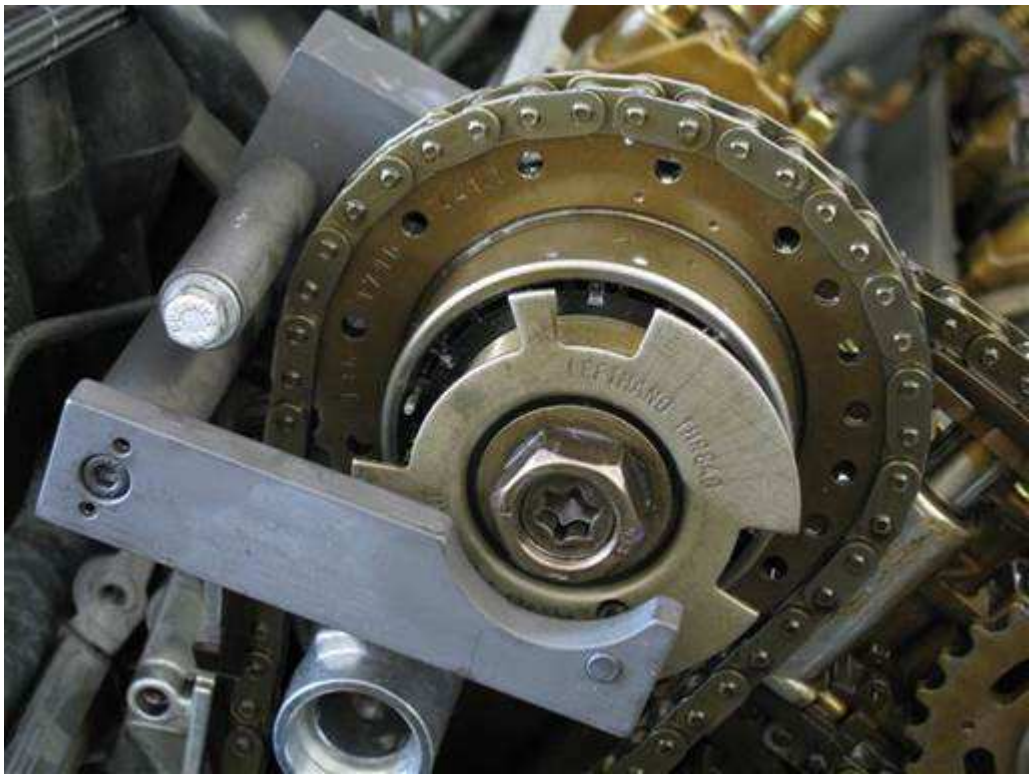
Mount timing wheel on vanos mounting bolt and install mounting nut; left hand thread (hand).

Note: Timing wheel rear has center protruding neck which mounts into vanos.

Do not tighten mounting nut at this time.

Rotate timing wheel to position reference hole approximately as shown (picture).



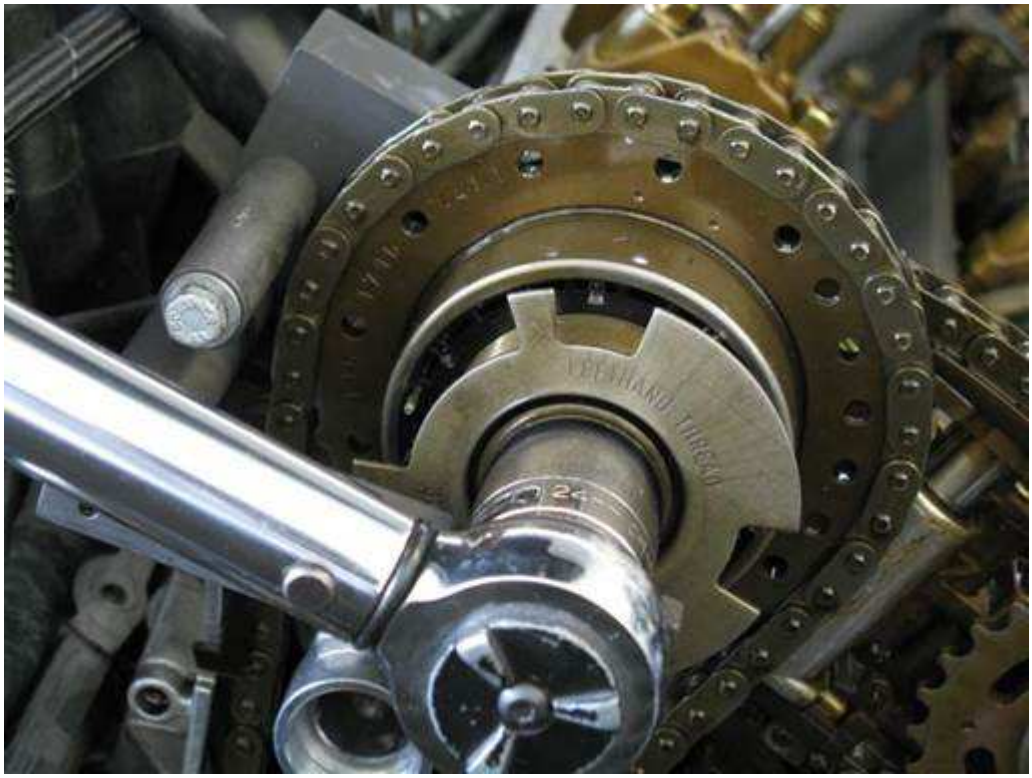


Install bank 1 & 2 timing wheel positioning tool. For each timing wheel perform following.

Mount corresponding timing wheel positioning tool at timing cover head surface and insert tool pin in timing wheel hole. Rotate timing wheel as needed for pin/hole alignment.

Mount positioning tool with upper timing cover long bolt at top and short

bolt at bottom. Rest positioning tool top bracket on head top to align positioning tool and facilitate bolt insertion. Do not fully tighten bolts at this time.
Precisely align positioning tool by aligning top bracket onto head top surface. Lightly tighten mounting bolts (10mm socket 3/8” / 3/8” extension).



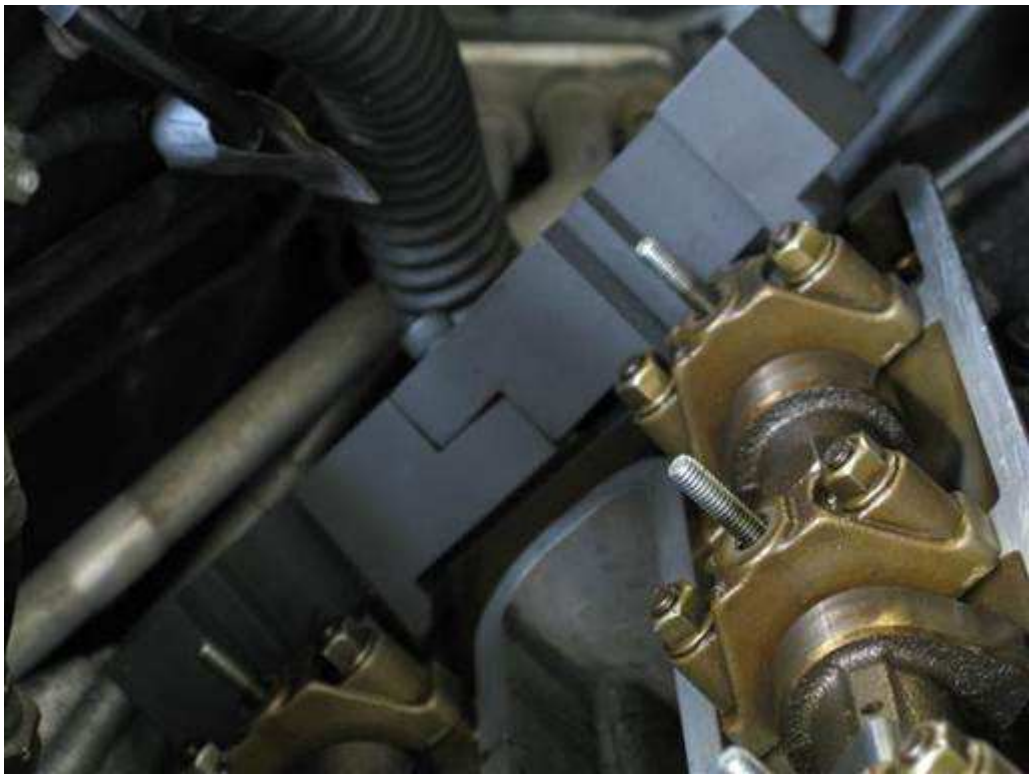
Tighten bank 1 & 2 timing wheel mounting nut. For each timing wheel

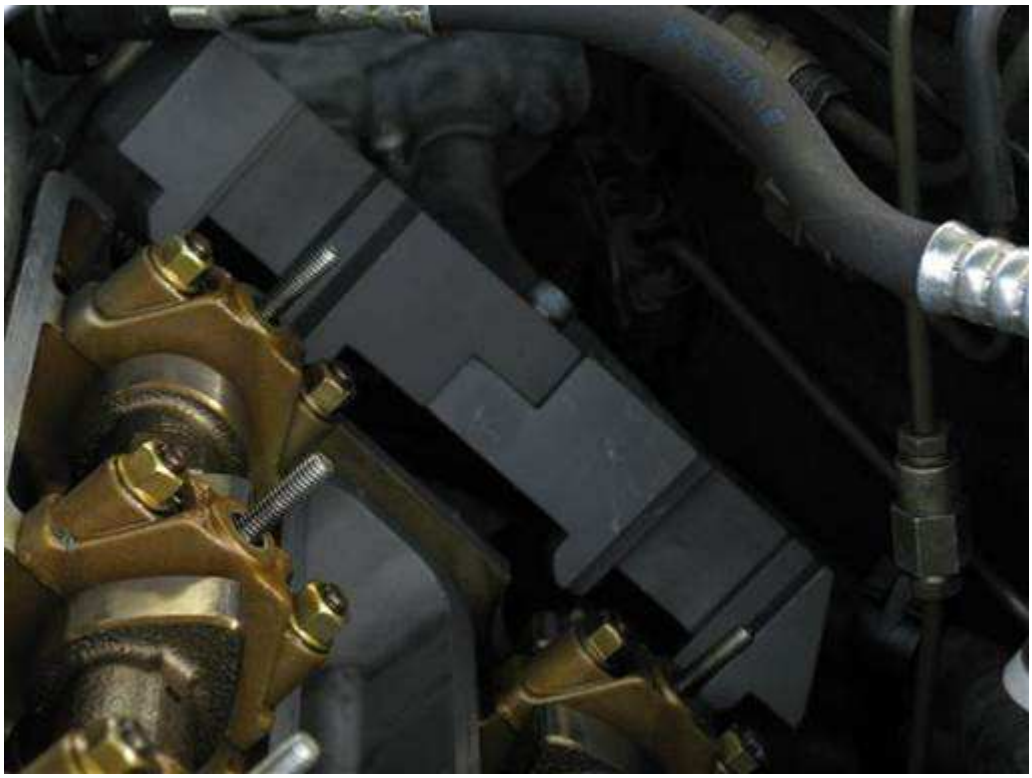
perform following.
Fully tighten timing wheel mounting nut, 40 Nm (29.5 ft-lb); left hand thread (24mm socket 1/2" / 1/2" torque wrench).

Remove bank 1 & 2 timing wheel positioning tool mounting bolts and remove positioning tools (10mm socket 3/8” / 3/8” extension).

Loosen chain tensioning tool spindle (8mm socket 1/4" / fingers).
Remove tool block 2 mounting bolts and remove chain tensioning tool (10mm socket 3/8” / 3/8” extension).
Remove tool spindle nut from tool block.

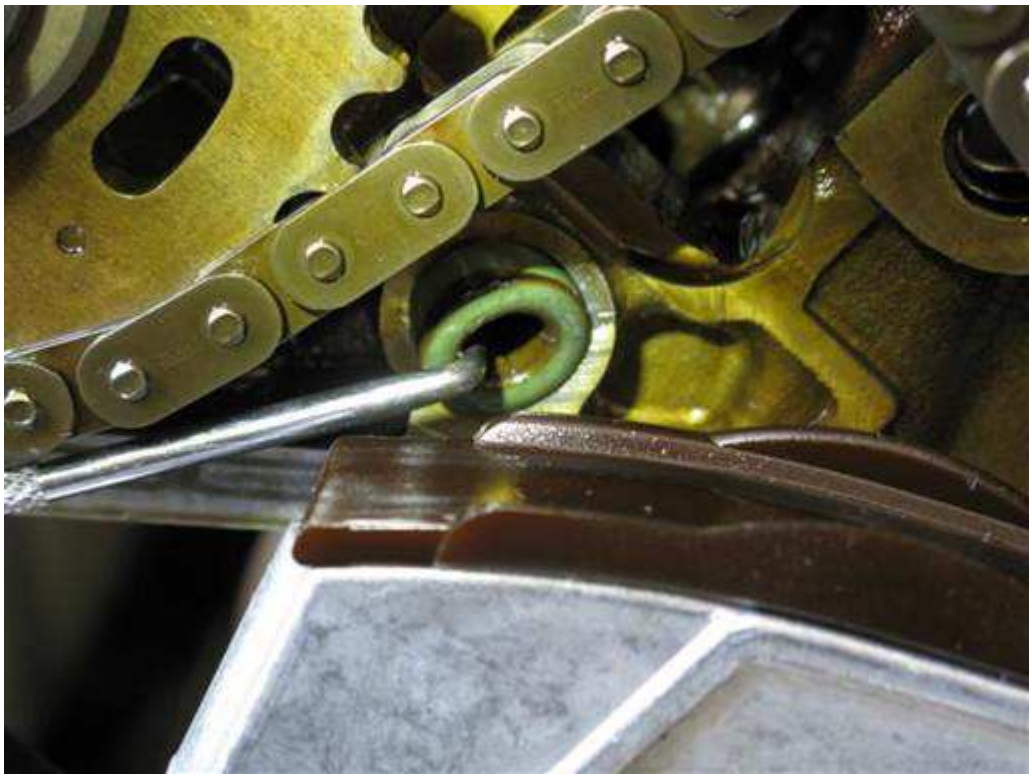
Unlocking of camshafts



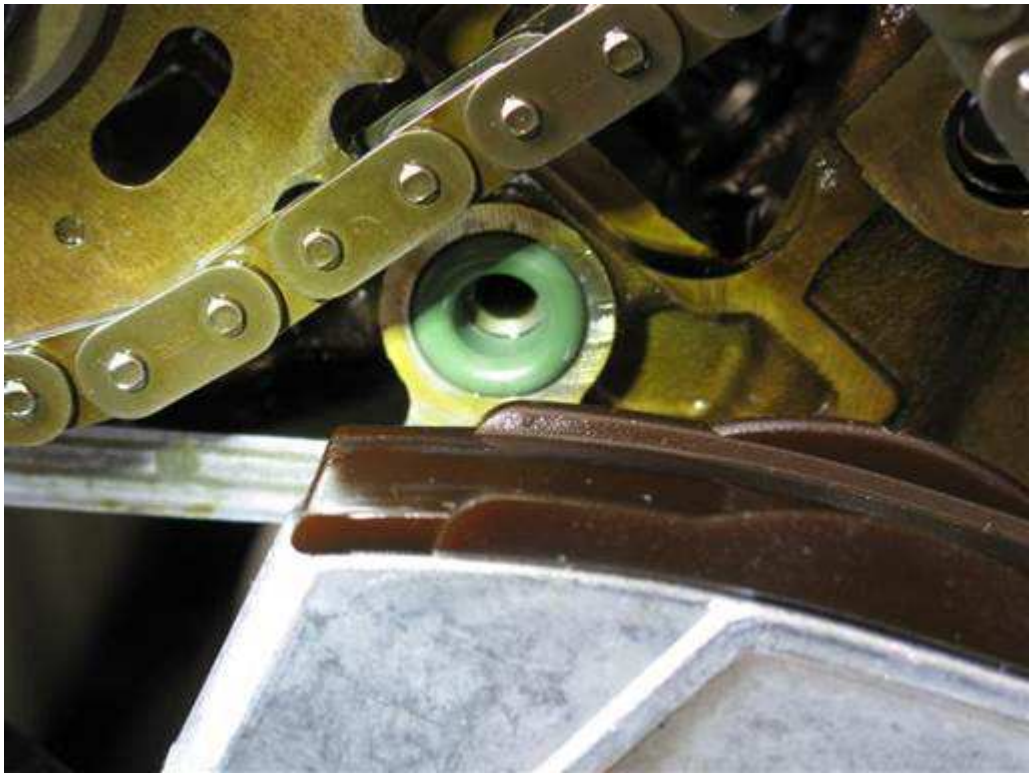


Remove bank 1 & 2 camshaft locking blocks. For each camshaft set perform following.
Loosen locking blocks matting bolt (6mm hex bit socket 3/8” / 3/8” ratchet).
Dislodge and remove locking blocks.
Note: Bank 1 intake camshaft will rotate clockwise when locking block is removed. This is due to valve spring load.

Installation of upper timing covers

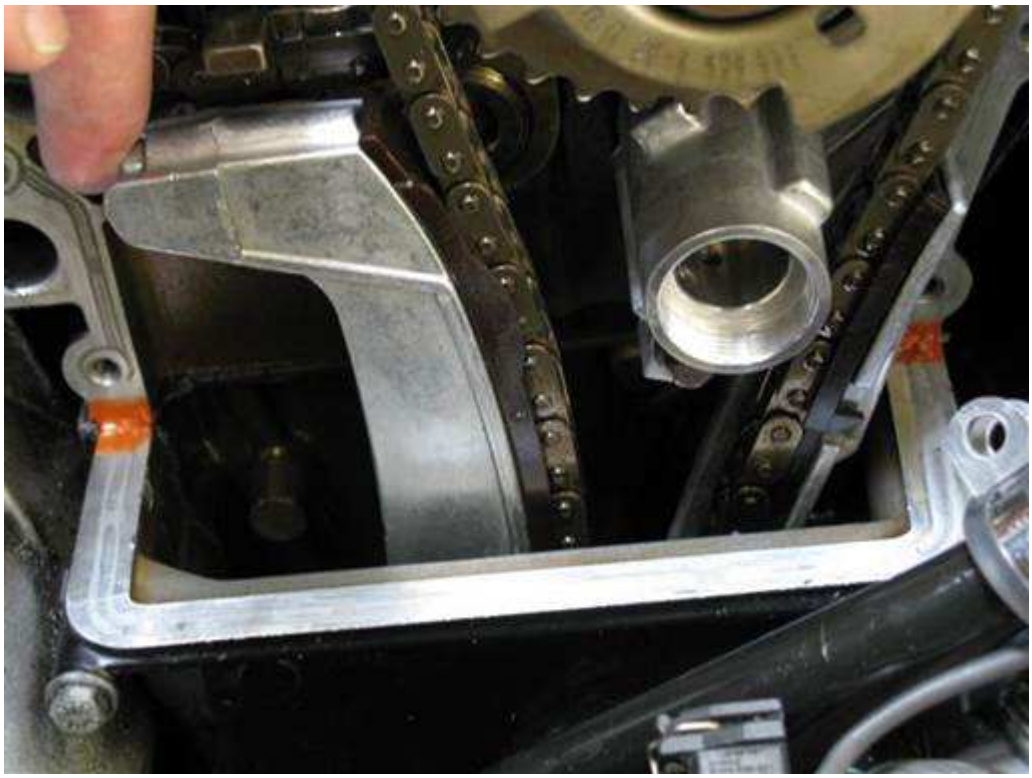


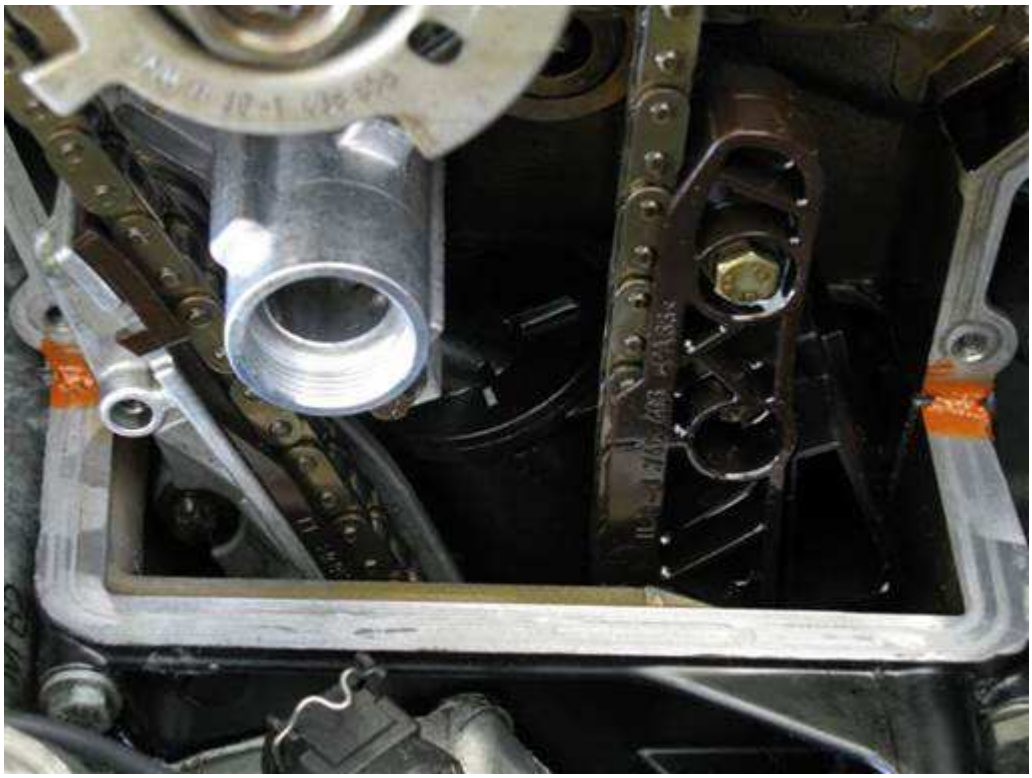
Remove bank 1 crankshaft chain tensioner rubber grommet.
Pry out grommet (90 degree pick tool).



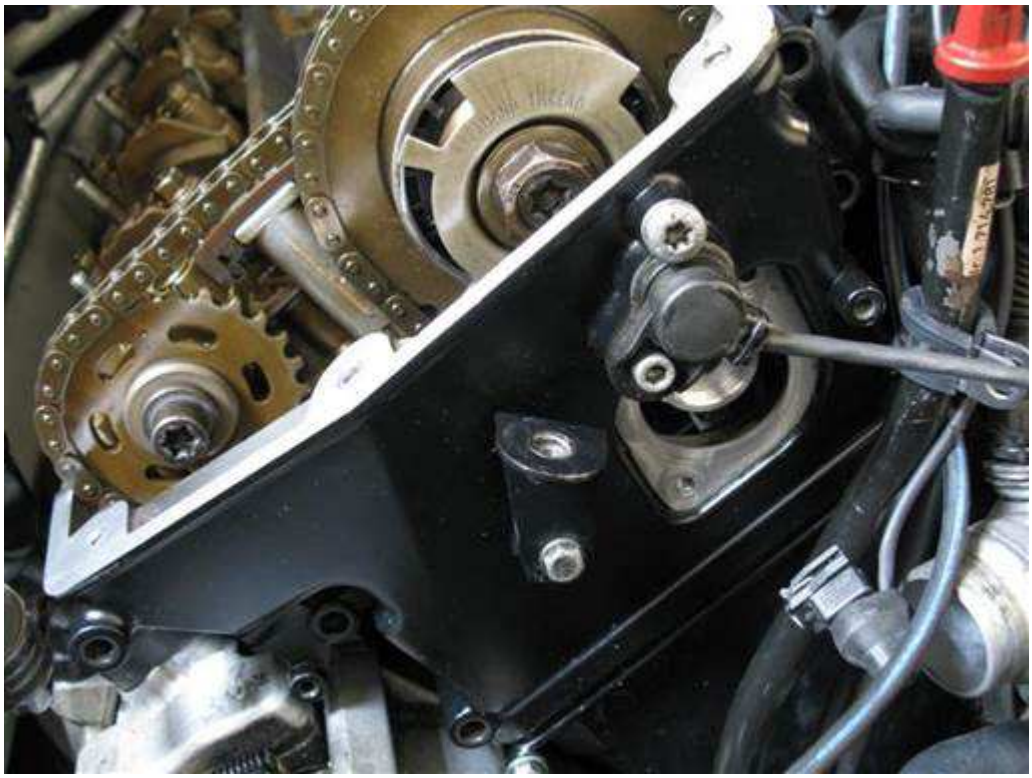
Install bank 1 crankshaft chain tensioner new rubber grommet.
Clean grommet mounting hole (brake cleaner & towels).
Fully press in new grommet into mounting hole (fingers).

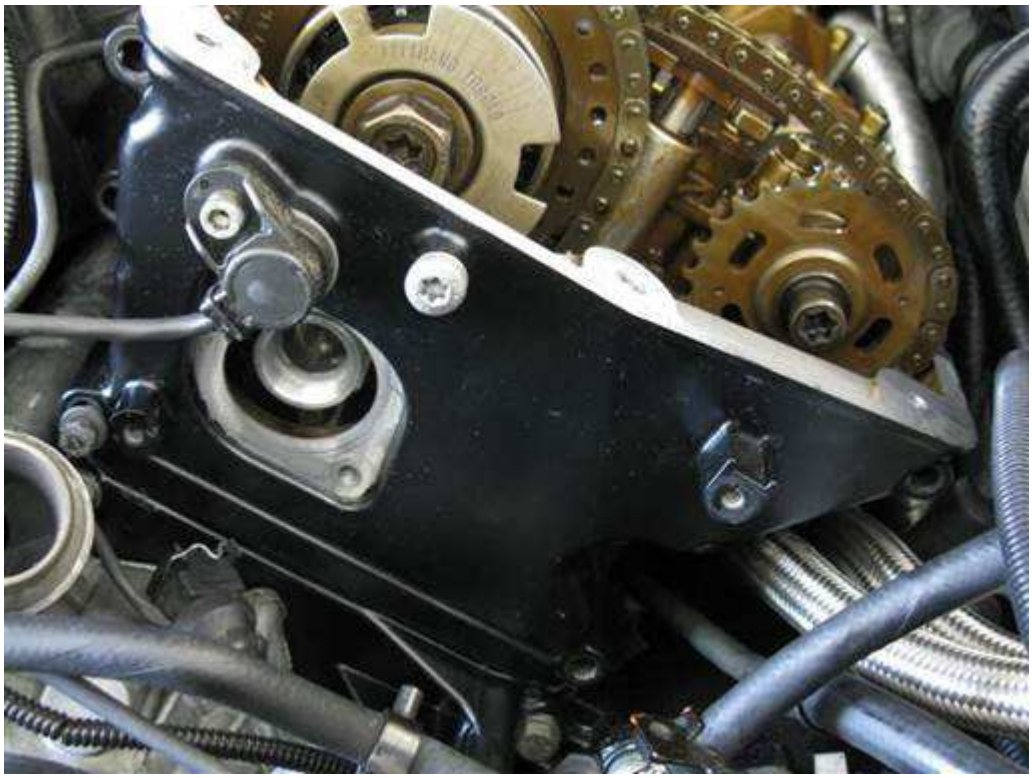
Install bank 1 & 2 upper timing cover gasket. For each upper timing cover perform following.
Note: Bank 1 & 2 gaskets are different.
Align gasket with timing cover perimeter groove.
Insert gasket, ridge side, into cover groove.
Align and fully press in gasket into cover groove.





Apply bank 1 & 2 upper timing cover lower rear gasket sealant. For each upper timing cover perform following.
Place thin coat of gasket sealant at timing cover engine lower rear corners.
Allow sealant to solidify for 2 minutes before mounting timing cover.

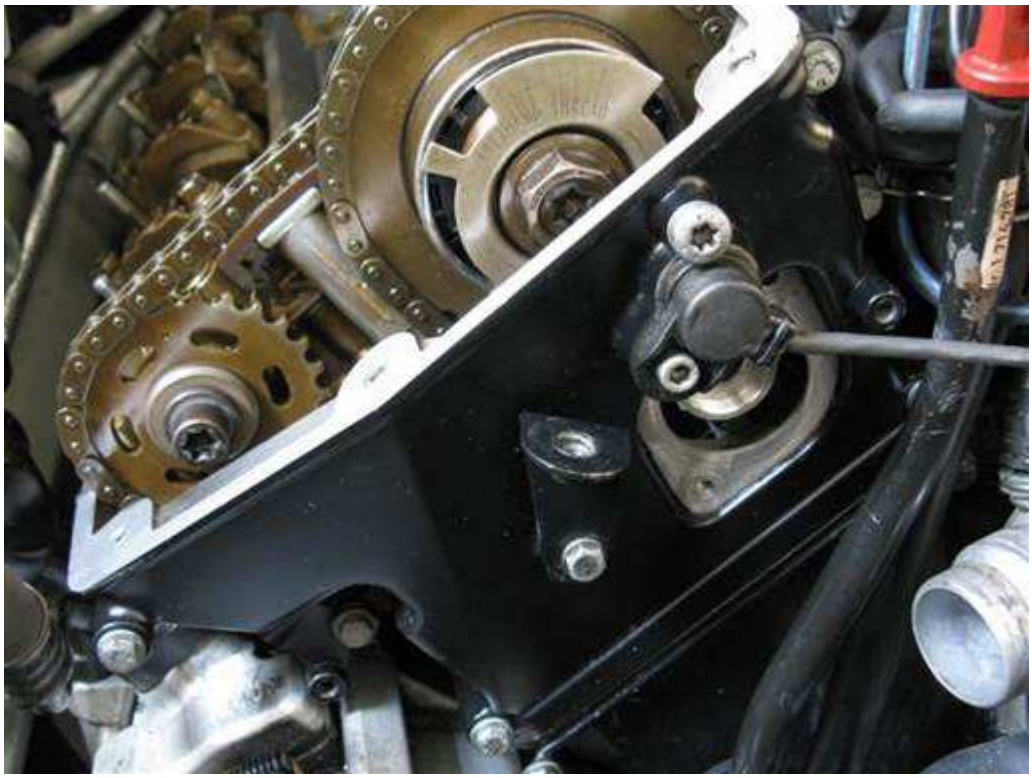


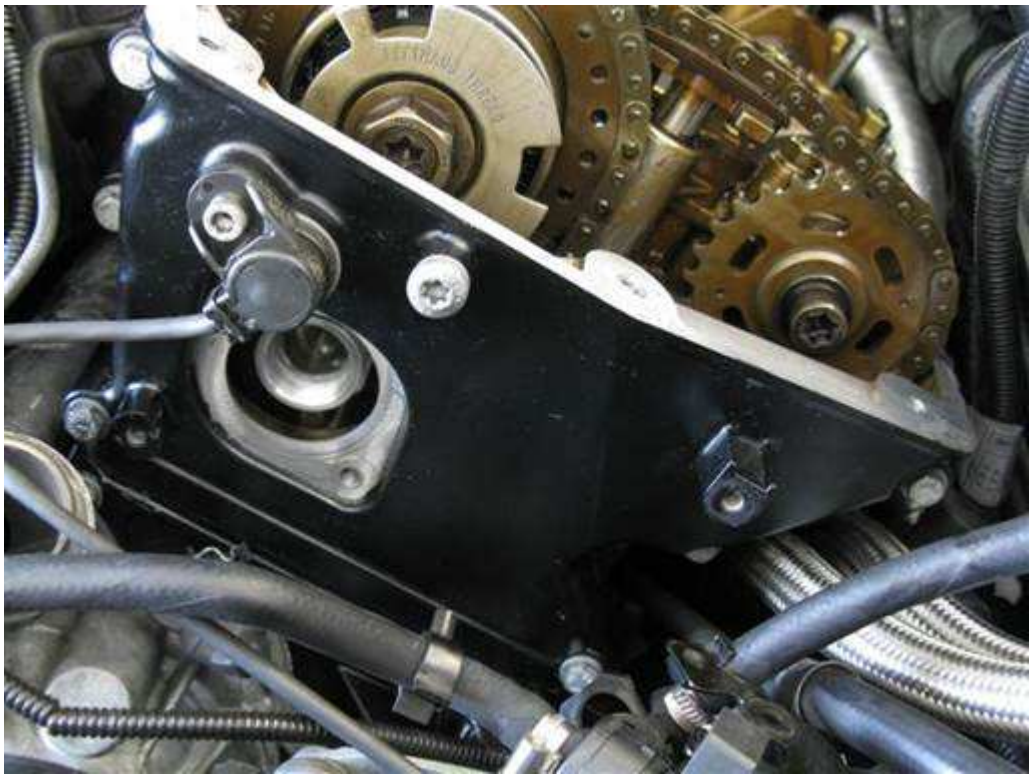


Mount bank 1 & 2 upper timing cover. For each upper timing cover perform following.

Mount upper timing cover on engine head.

Note: Bank 2 lower left mounting bolt must be installed in timing cover before installing cover on head. This is due to access restriction. Bolt is long with smooth neck.





Install bank 1 & 2 upper timing cover bolts. For each upper timing cover perform following.
Install 6 mounting bolts, 3 at each side of cover (10mm socket 3/8” / 3/8” extension).
Bank 2 lower left mounting bolt requires a low profile tool for access (10mm ratcheting wrench).

Note: Upper and lower bolts are long with smooth neck and middle bolt is short and fully threaded. Bank 2 right side upper bolt is short and fully threaded.
Screw in bolts until snug. Do not tighten at this time.

Assemble 8 valve cover side bolts with 2 washers and new rubber grommet each.
Note: Bolts are used in following step to mount valve cover without gasket and apply downward pressure on upper timing cover to position properly for mounting.
Note: Second bolt washer is needed to fill in space usually taken by valve cover gasket.

Install bank 1 & 2 valve cover without gasket. For each valve cover perform following.
Mount valve cover on engine head. Position ground strap in sparkplug well.
Install valve cover 4 side mounting bolts with 2 washers and new rubber grommet each at two front side bolt holes (10mm socket 3/8” / 3/8” ratchet & extension).

Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully tightened.
Tight bolts until moderate resistance is reached. Do not over tighten bolts.

Tighten bank 1 & 2 upper timing cover bolts. For each upper timing cover perform following.
Tighten 6 mounting bolts (10mm socket 3/8” / 3/8” ratchet & extension).

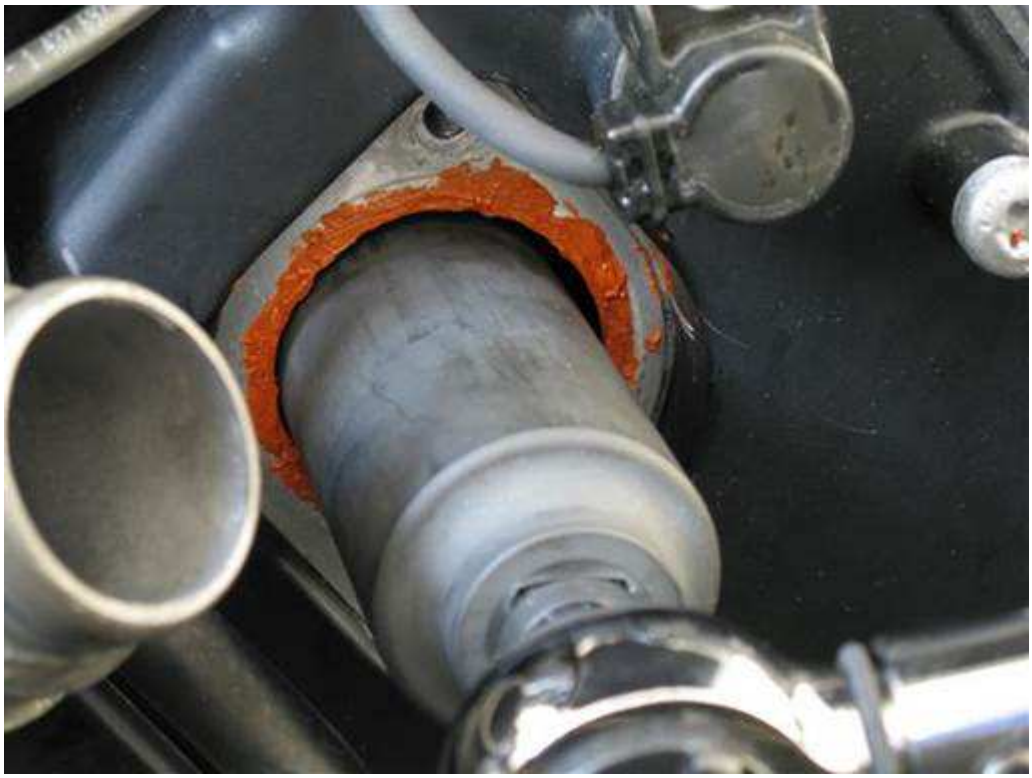
Bank 2 lower left mounting bolt requires a low profile tool for access (10mm ratcheting wrench).
Fully tighten 6 mounting bolts, 9 Nm (6.5 ft-lb) (10mm socket 3/8” / 3/8” torque wrench & extension).
Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully tightened.

Remove bank 1 & 2 valve cover. For each valve cover perform following.
Remove valve cover 4 front side mounting bolts with 2 washers and grommet (10mm socket 3/8” / 3/8” ratchet & extension, flathead).
Loosen bolts evenly in multiple passes.
Remove valve cover from engine head.

Installation of solenoids

Apply bank 1 & 2 vanos solenoid gasket sealant. For each solenoid perform following.
Apply thin layer of sealant at timing cover solenoid hole perimeter (gasket sealant).

Note: Solenoid gasket inner gasket is Buna and is susceptible to leaking. Sealant will allow longer functional life of gasket.



Install bank 1 & 2 vanos solenoid. For each solenoid perform following.
Screw solenoid into engine head (hand).
Fully tighten solenoid, 25 Nm (18.5 ft-lb) (32mm special deep socket 1/2” w/ 3/8” to 1/2" socket adapter / 3/8” torque wrench).

Install bank 1 & 2 solenoid gasket. For each solenoid perform following.
Note: Gasket flat side faces timing cover and gasket protruding side faces front (pictures).
Press gasket onto solenoid and wiggle and slide gasket until it reached timing cover.
Fully press gasket onto timing cover.

Note: Timing cover gasket matting surface is slanted. Gasket will press in further at bottom and engine outer side.

Install bank 1 & 2 solenoid gasket bolts. For each solenoid perform following.
Install gasket 2 mounting bolts (10mm socket 3/8” / 3/8” ratchet & extension).

Tilt first mounting bolt to side as needed to align gasket with bolt hole.
Fully tighten 2 mounting bolts, 9 Nm (6.5 ft-lb) (10mm socket 3/8” / 3/8” torque wrench & extension).
Tighten bolts evenly. Verify one pass with both bolts fully tightened.

Install bank 1 & 2 solenoid electrical cable connector. For each solenoid perform following.

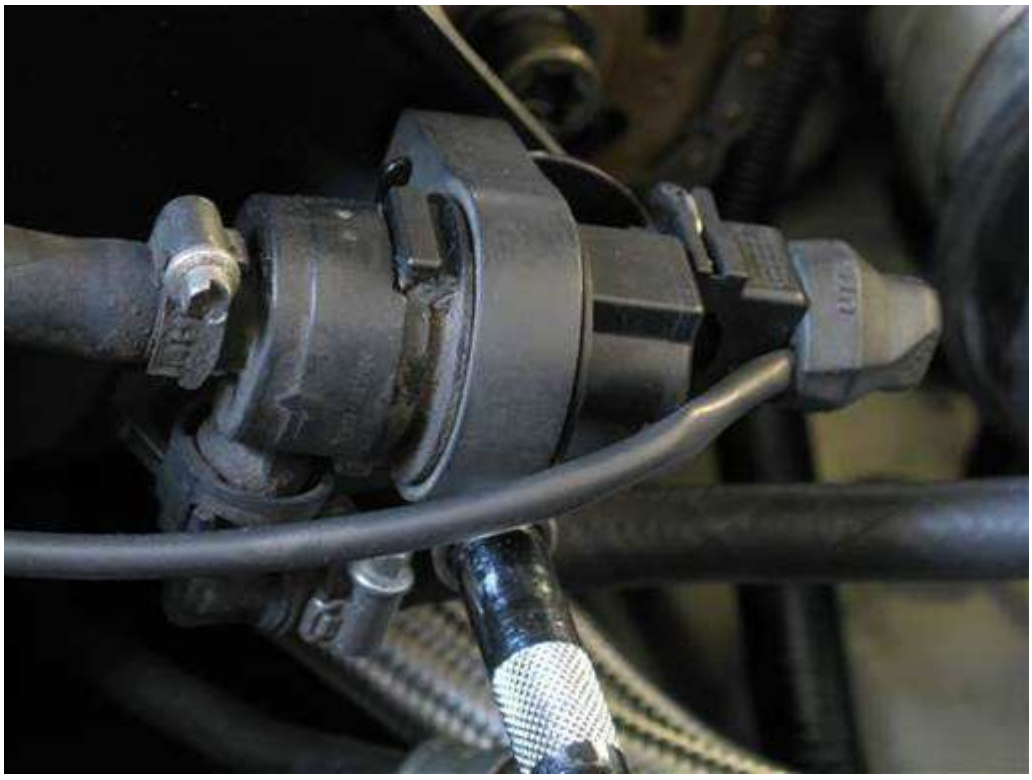
Press solenoid electrical cable connector onto solenoid electrical connector until connector wire clip snaps into place.

Installation of engine front components

Install new crankshaft chain tensioner.
Install new base crush washer on chain tensioner.
Press in and thread chain tensioner into engine (19mm deep socket 3/8” / hand).
Note: Touch socket against AC compressor to properly align tensioner.
Verify crankshaft chain is positioned on chain rail guides at bank 1 & 2.
Fully tighten chain tensioner, 40 Nm (29.5 ft-lb) (19mm deep socket 3/8” / 3/8” torque wrench).

Install oil dip stick pipe clamp mounting bolt (10mm socket 3/8” / 3/8” ratchet & extension).

5 series



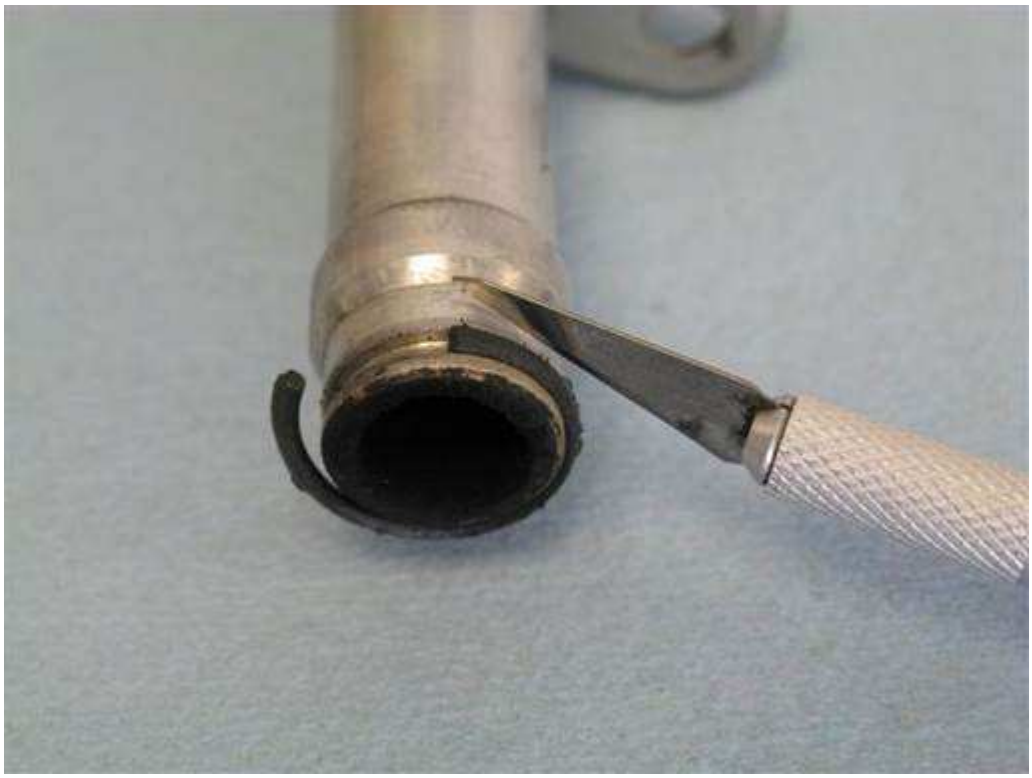
Install fuel purge valve bracket mounting bolt (10mm socket 3/8” / 3/8” ratchet & extension).

7 series

Install hose/cable bracket mounting bolt just to left of bank 2 solenoid (10mm socket 3/8” / 3/8” ratchet & extension).

Install hose bracket mounting bolt at middle bank 2 upper timing cover (10mm socket 3/8” / 3/8” ratchet & extension).

Install hose bracket mounting bolt at oil filter housing (10mm socket 3/8” / 3/8” ratchet & extension).



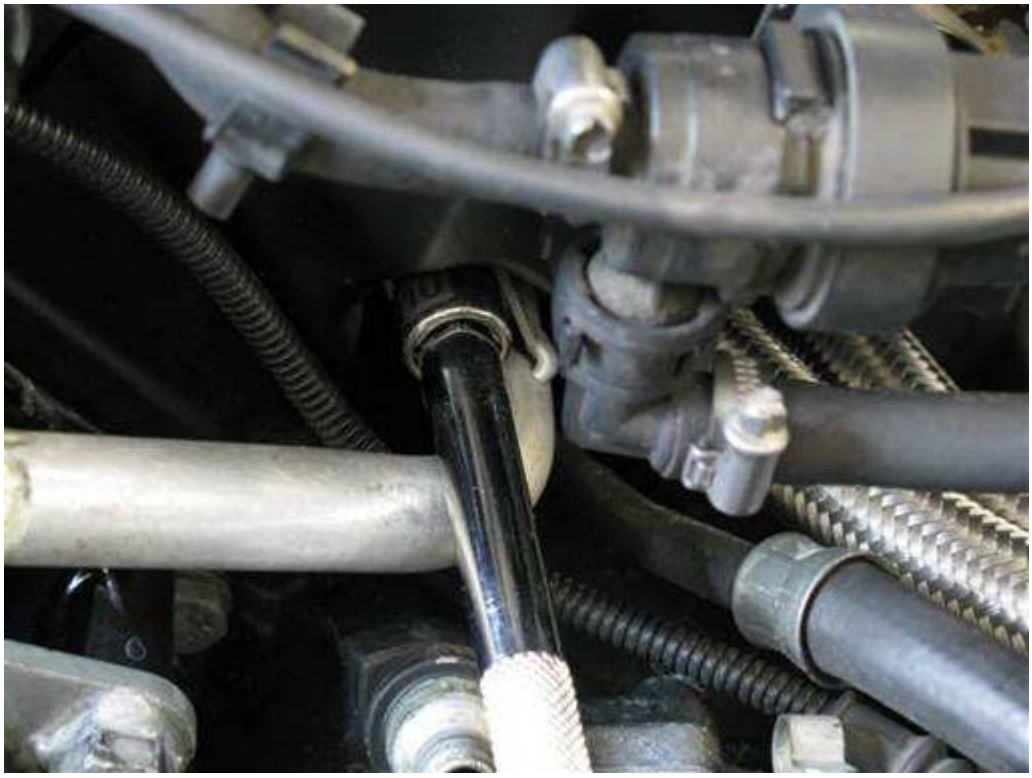
Remove secondary air pipe 2 pipe end O-rings. For each pipe end perform following.
Cut and remove O-rings (razor knife).
Note: Rocking of blade while pressing helps create cutting motion.

Install secondary air pipe 2 pipe end O-rings. For each pipe end perform following.
Insert new O-ring in pipe groove at one end and stretch other end over pipe and drop into groove (hands/fingers).
Lightly lubricate O-ring to ease pipe installation (assembly oil).

Install secondary air pipe onto engine and insert right and left ends into

engine mount holes (see next two pictures).
Align pipe left mounting bracket with bank 1 upper timing cover mount hole.
Move pipe ends some while pressing in to align pipe and insert into mount hole.
Second pipe end insertion might need pipe bent in for hole alignment.
Wiggle and press in pipe ends. Pipe ends might not fully insert into holes. This will be addressed in next step when mounting bolts are installed.

Install secondary air pipe left mounting bolt (10mm socket 3/8” / 3/8” ratchet & medium extension).



Install secondary air pipe right mounting bolt (10mm socket 3/8” / 3/8” ratchet & medium extension).

Install secondary air pipe center mounting bolt (T30 torx bit 1/4” / 1/4” ratchet & extension).
If hole alignment is difficult, loosen pipe end mounting bolts, install center mounting bolt, then retighten pipe end mounting bolts.

Install secondary air blower hose and secondary air vacuum control hose onto secondary air exhaust valve.
Press blower hose onto valve connector until hose clips snap into place.
Press vacuum hose onto valve hose pipe.

Install radiator lower hose onto thermostat.
Press hose connector wire clip onto hose connector before mounting hose.

Install hose connector onto thermostat and align hose notch with thermostat notch.
Press hose connector onto thermostat until wire clip snaps into place.

Install radiator lower hose onto radiator lower neck.
Press hose connector wire clip onto hose connector before mounting hose.
Install hose connector onto radiator lower neck and align hose notch with radiator neck notch.
Press hose connector onto radiator neck until wire clip snaps into place.
Install temperature sensor electrical cable connector. Press cable connector onto sensor until connector wire clip snaps into place.

Install radiator upper hose onto alternator.
Press hose connector wire clip onto hose connector before mounting hose.
Install hose connector onto alternator and align hose notch with alternator notch.
Press hose connector onto alternator until wire clip snaps into place.

Install radiator upper hose onto thermostat.

Press hose connector wire clip onto hose connector before mounting hose.
Install hose connector onto thermostat and align hose notch with thermostat notch.
Press hose connector onto thermostat until wire clip snaps into place.

Install radiator upper hose onto radiator upper neck.
Press hose connector wire clip onto hose connector before mounting hose.
Install hose connector onto radiator upper neck and align hose notch with radiator neck notch.
Press hose connector onto radiator neck until wire clip snaps into place.

Unlocking crankshaft

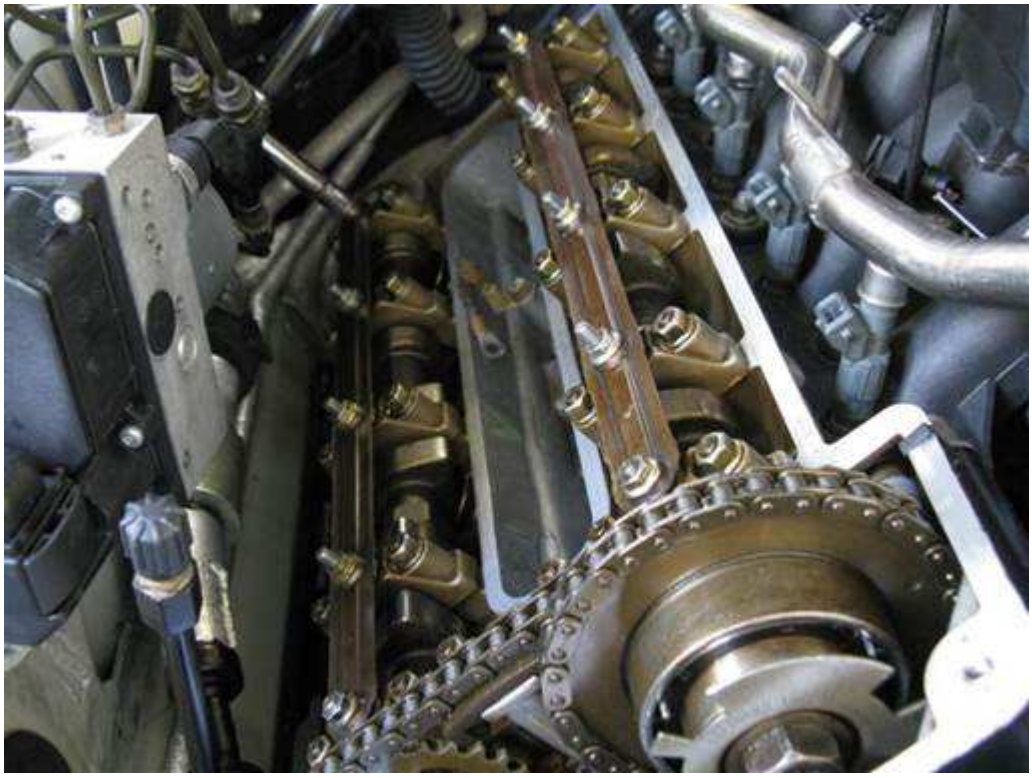
Raise front of car and place on jack stands (follow appropriate procedure; chock both sides of both rear wheels).

Pull out crankshaft lock pin from crankshaft lock hole.

Install inspection hole cap.
Orient cap with handle ridge vertical.
Insert cap side tabs into inspection hole, then cap lower tab into hole.
Note: Picture cap orientation wrong.

Lower car from jack stands (follow appropriate procedure).

Installation of valve covers



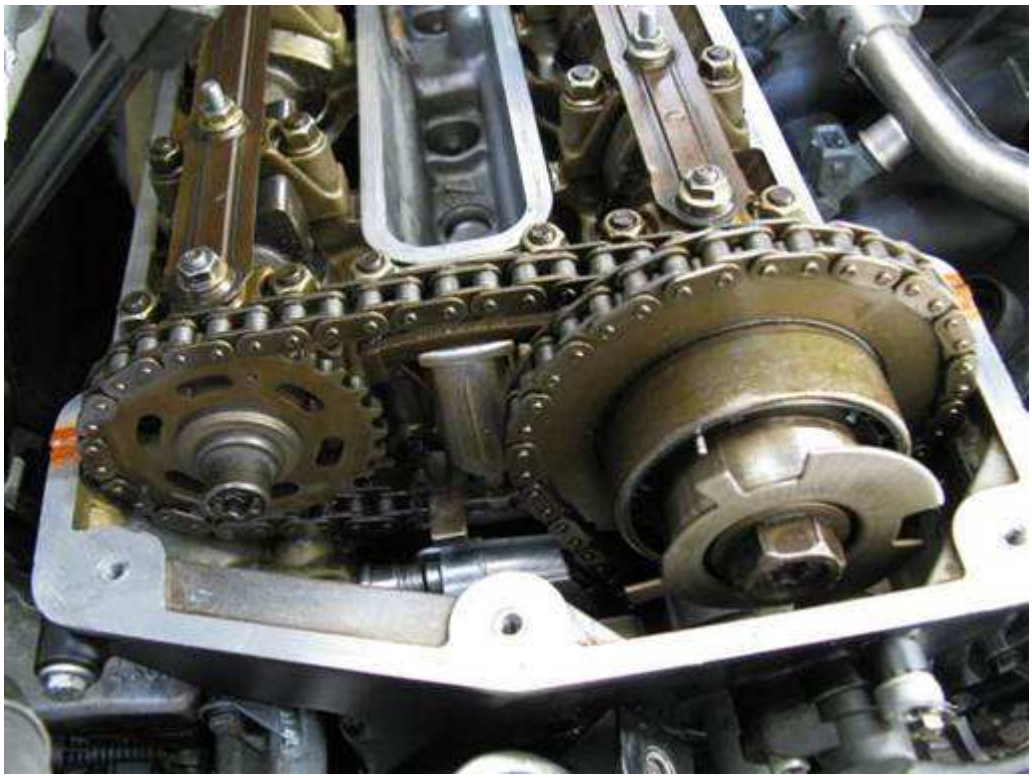
Install bank 1 & 2 camshaft oil rails. For each set of camshafts perform following.
Note: Bank 1 & 2 camshaft oil rails are different.
Note: Oil rail front is denoted by dimple between first and second hole.
Note: Intake and exhaust oil rails are same and can be switched, and oil rail

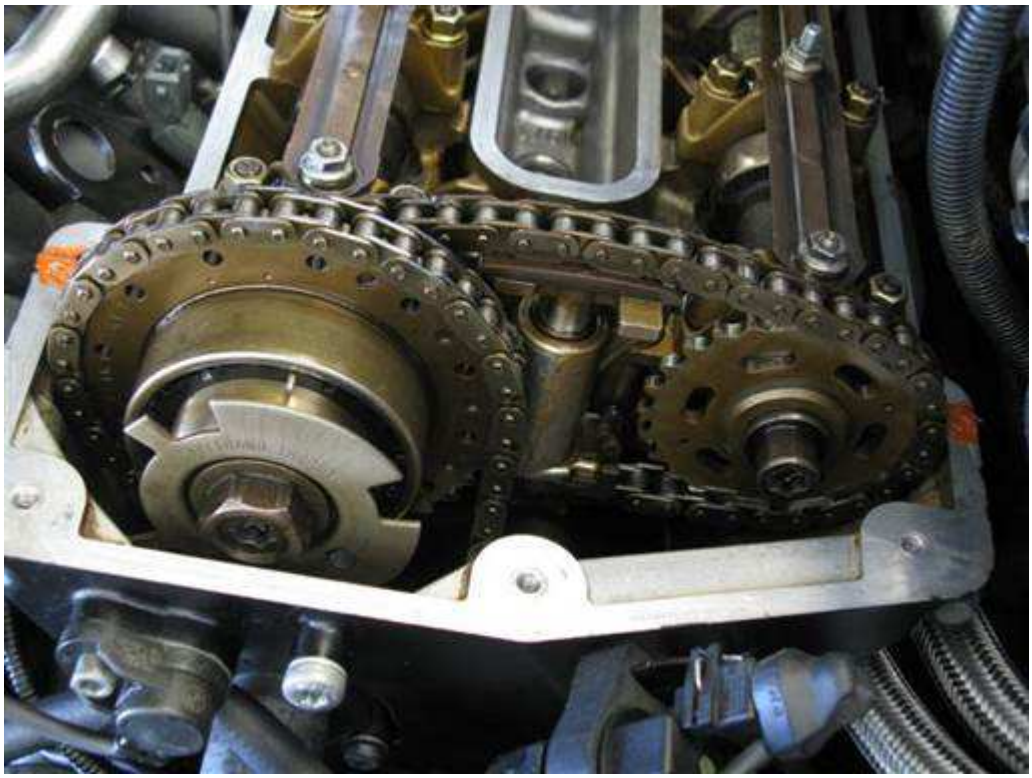
top and bottom are same and can be installed either ways.
Install intake and exhaust camshaft oil rails in position over bearing cap studs.
Install 5 mounting nuts at each oil rail (10mm deep socket 3/8” / 3/8” ratchet, 10mm ratcheting wrench).
Fully tighten, 8 Nm (6 ft-lb) (10mm deep socket 3/8” / 3/8” torque wrench, 10mm ratcheting wrench).
Tighten nuts evenly. Verify one pass with all nuts fully tightened.

Install bank 1 & 2 valve cover gaskets. For each valve cover perform following.
Note: Bank 1 & 2 gaskets are different.
Note: Orientation of sparkplug well gasket tab is of no significance.
Align perimeter gasket with valve cover perimeter groove and sparkplug well gasket with valve cover sparkplug well groove.
Insert gaskets, ridge side, into cover grooves.
Align and fully press in gaskets into cover grooves.

Note side flaps on rear half-moon gasket section. These flaps must straddle head rear when valve cover is installed.

Apply bank 1 & 2 head rear half-moon gasket sealant. For each head perform following.
Place thin coat of gasket sealant at head rear half-moon corners.
Allow sealant to solidify for 2 minutes before mounting valve cover.





Apply bank 1 & 2 head front timing cover gasket sealant. For each head perform following.
Place thin coat of gasket sealant at each side of timing cover gasket joint with head.
Allow sealant to solidify for 2 minutes before mounting valve cover.

Install bank 1 & 2 valve cover. For each valve cover perform following. Place valve cover with gaskets on engine head. Position ground strap in sparkplug well.

Note: On 540, bank 2 valve cover is difficult to install due to fuel hose. Cover perimeter gasket will come off due to being hit by intake camshaft bearing cap stud. Reinstall gasket in cover once cover is in position above

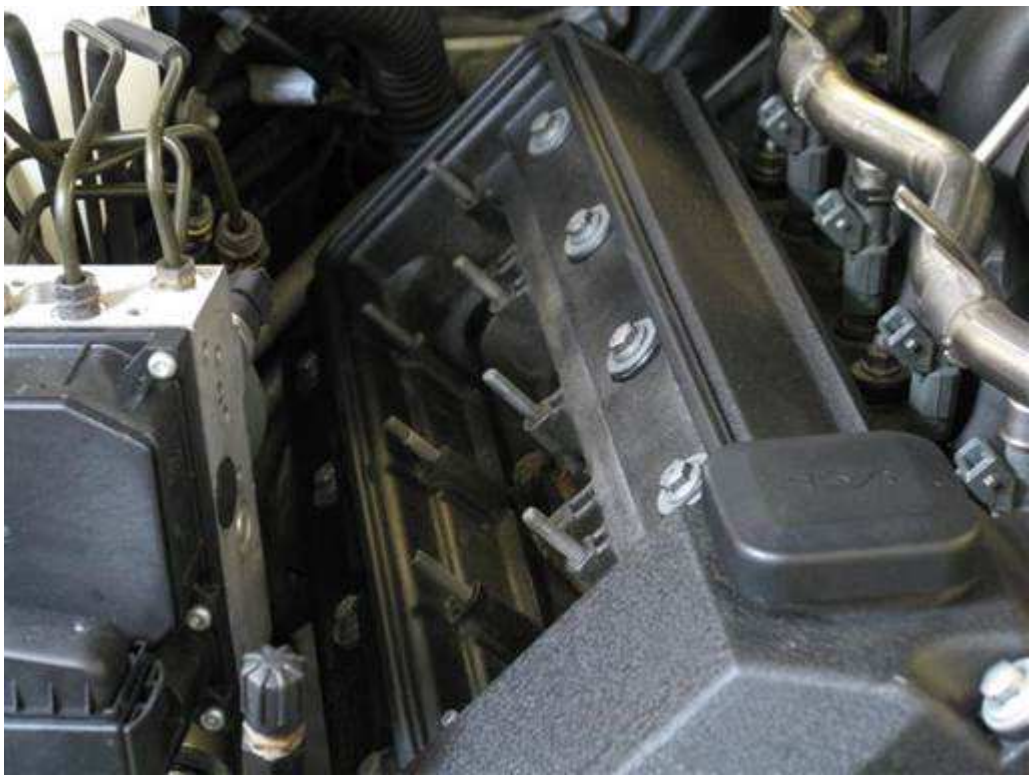
head.
Install 2 side bolts w/ washer and grommet at front top and rear bottom of valve cover.
Adjust cover position to center cover holes with studs and screw on bolts to position cover on head (hands).
Install bolts with only one turn to allow valve cover to stay loose.

Verify bank 1 & 2 valve cover seating. For each valve cover perform following.
Inspect valve cover gasket seating along valve cover perimeter and sparkplug well (mirror & flashlight).
Verify gasket 2 rear half-moons are properly inserted in head half-moons (mirror & flashlight).
Half-moon rear flaps should be seated to rear of head (pictures).
Reposition cover and gaskets as needed to correctly align gaskets.

Install bank 1 & 2 valve cover mounting bolts. For each valve cover perform following.
Install 11 valve cover mounting bolts w/ washers & grommets, 3 at front and 4 at each side (10mm socket 3/8” / 3/8” ratchet & extension).
Note: Front 3 bolts are different than remaining 8 bolts.
Tighten bolts evenly working back and forth, assuring even pressure

distribution on cover. Tighten until bolts bottom out (stop turning). Fully tighten, 8Nm (6 ft-lb) (10mm socket 3/8” / 3/8” torque wrench & extension).

Install battery positive cable on bank 2 valve cover and insert into cable box. Install battery positive cable on stud and mount with nut (19mm socket 1/2" / 1/2" ratchet).



Install bank 1 & 2 top cover gasket. For each valve cover perform following. Install top cover gasket on valve cover.

Install bank 1 & 2 electrical housings.
Press bank 1 & 2 electrical housings fuel injector electrical connector wire clips onto connectors.
Release bank 1 & 2 electrical housings tie (bungee cord).
Position bank 1 & 2 electrical housings with fuel injector electrical connectors on fuel injectors.
Press down on bank 1 & 2 electrical housings to press on each fuel injector electrical connector until connector wire clip snaps into place.
Note: Electrical housing mounting studs will be inserted into mounting brackets.

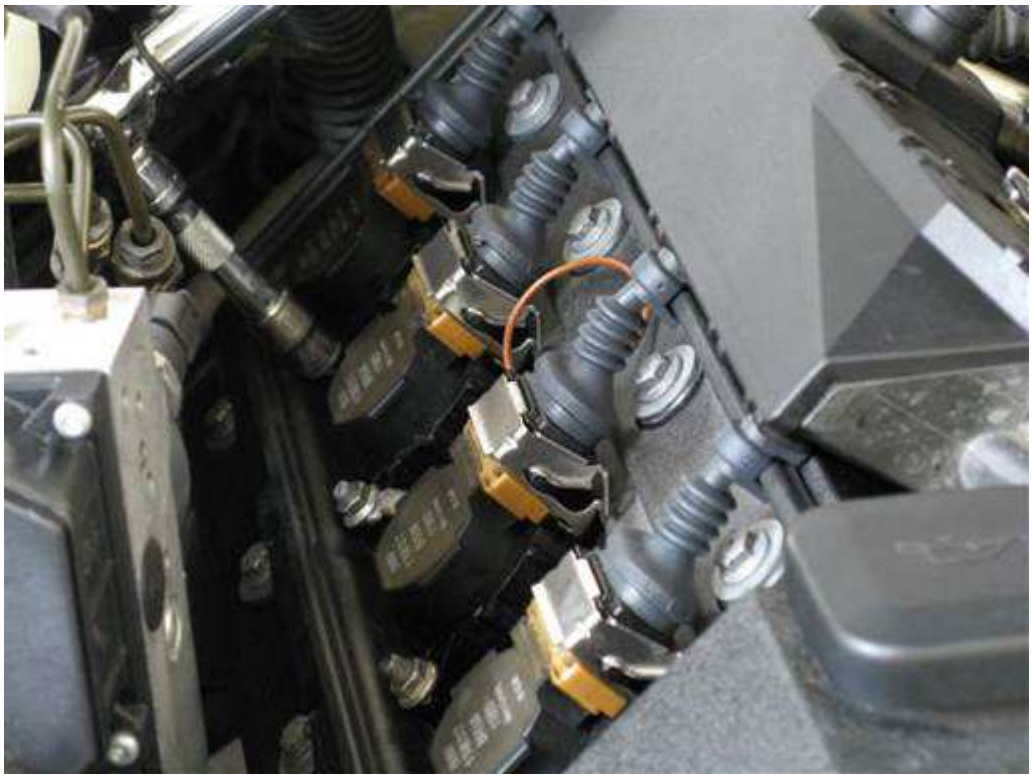
Install secondary air solenoid mounting bracket onto bank 1 electrical housing front stud.
Install vacuum accumulator mounting bracket onto bank 2 electrical housing front stud.

Install bank 1 & 2 2 electrical housing mounting nuts (10mm deep socket 3/8” / 3/8” ratchet & extension).
Press down on housing while mounting nut to keep housing stud from slipping out of mounting bracket.

Install bank 1 & 2 O2 sensor cable connector. For each O2 sensor perform following.
Press O2 sensor electrical cable connector onto electrical housing top middle connector until connector tabs snaps into place.

Install bank 1 & 2 camshaft position sensor cable connector. For each camshaft position sensor perform following.
Press camshaft position sensor cable connector onto electrical housing top front connector until connector wire clip snaps into place.

Install secondary air control solenoid cable connector. Press cable connector onto secondary air solenoid connector at top left middle intake manifold until connector wire clip snaps into place.

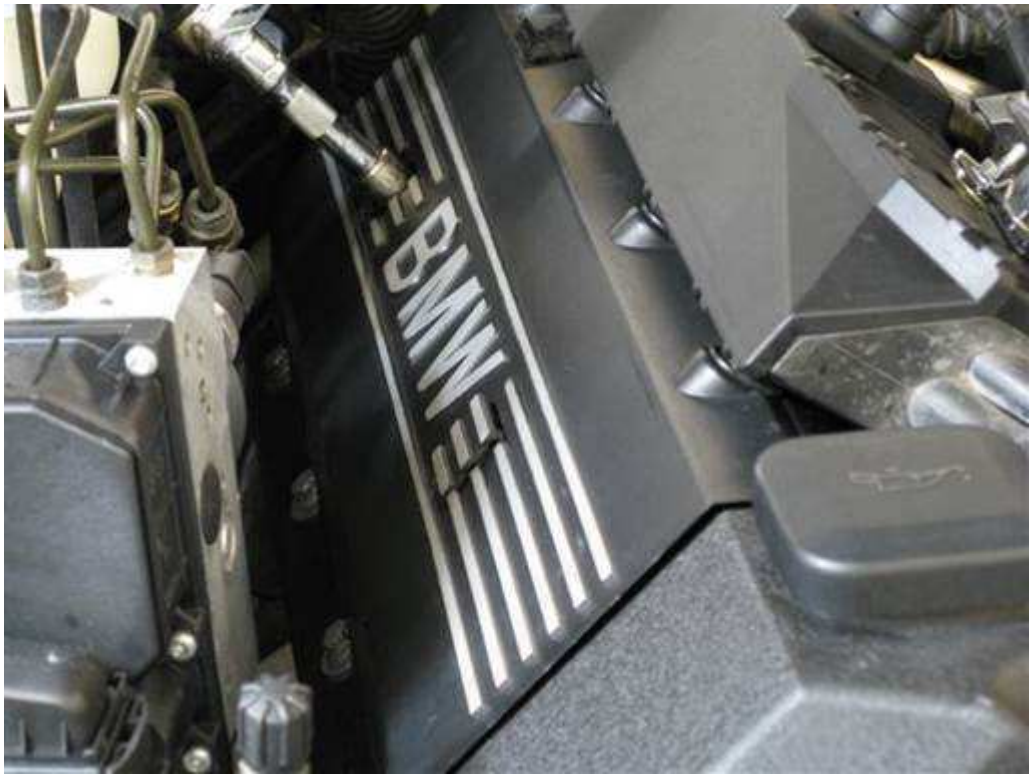


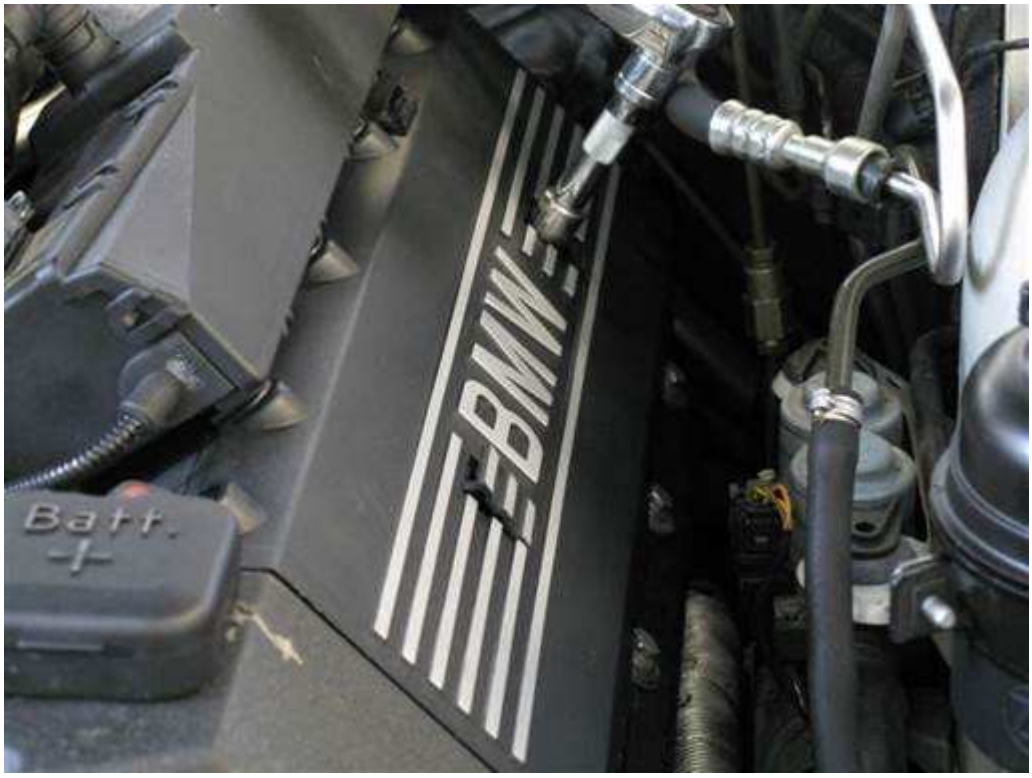
Install bank 1 & 2 ignition coils. For each bank perform following.
Install each coil into original sparkplug well and onto mounting studs and mount with 2 nuts (10mm socket 3/8” / 3/8” ratchet & extension).
Install on coil studs, coil harness ground wires at coils 2 & 7 and coil ground straps at coils 3 & 6.
Tighten coil mounting nuts evenly to mount coil evenly.

Note: Coil boot will not fully insert onto sparkplug during initial mount. This is normal.
Fully tighten, 9Nm (6.5 ft-lb) (10mm socket 3/8” / 3/8” torque wrench & extension).

For each coil, lift up on connector metal lock, press in cable electrical connector, and push down on connector metal lock.
Seat each coil connector cable rubber bracket onto top cover gasket.

Remove 4 top cover mounting bolt shaft O-rings (90 degree pick tool).
Install 4 top cover mounting bolt shaft new O-rings.
Note: Bolt shafts will be in top cover holes if not previously removed with bolts.





Install bank 1 & 2 top cover. For each bank perform following.
Note: Bank 1 & 2 top covers are different. Bank 2 top cover has 5th slot for batter positive cable.
Install top cover on valve cover. Verify 4 coil cable rubber brackets insert into cover slots. Verify banks 2 battery positive cable inserts into cover slot.
Install 2 cover mounting bolts with shafts (10mm socket 3/8” / 3/8” ratchet & extension).
Install 2 bolt cover caps. Align silver lines on cap with cover. Insert clip at an angle and gently press down on other end (picture).

Install battery negative cable at battery.
Open rear trunk lid. Open right fender cabin door (at trunk orientation).
Install negative cable clamp on battery negative post.
Tighten battery negative cable mounting nut (10mm socket 3/8" / 3/8"