

S54 Vanos Rattle Procedure

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Introduction

“Vanos” is BMW’s name for its variable valve timing units. Vanos units take on various shapes and design according to car year and model (engine model). The vanos discussed here is BMW part # 11-36-7-838-161. It’s a double vanos, meaning both the intake and exhaust valve timing is varied. This vanos unit is part of BMW 6-cylinder engine S54. This engine is incorporated into the M3 E46 00-06, Z3 E36 M Roadster & M Coup 00-02, Z4 E85 M3.2 Roadster 05-08, Z4 E86 M3.2 Coup 06-08.

This vanos, like most vanos designs, can develop a rattle. The vanos rattle is caused by wear in the variable valve timing helical (slanted) gears. These gears are found on the camshaft sprocket and splined shaft, which attaches to the vanos. The helical gear wear allows the camshaft to have lash movements that engage the splined shaft axially. At certain RPMs these movements resonate and engage axial play (free space) and cause associate components to hit and rattle. The axial play that facilitates the rattle is found on the helical gears and the splined shaft bearing. Replacing the helical gear components is expensive and the gears will wear again and the rattle will return. Removing the splined shaft bearing axial play significantly reduces the rattle to the point where it’s barely heard or not heard at all in the passenger compartment. Performance cams like the ones on this engine create stronger camshaft lash forces and thus are more susceptible to causing a rattle.

Another component that addresses the rattle is the diaphragm spring that’s incorporated in the intake and exhaust sprockets. This spring loads the sprocket rotational movement to dampen the rattle quick movements. Over time the diaphragm spring weakens and degrades in function. Replacing the diaphragm spring with a new one is often needed to fully resolve the rattle. This diaphragm spring design is used on the S54 and S62 engines. On the S54 engine the part number is 11-36-7-830-684. On the S62 engine the part number is 11-36-7-833-218. But with the S62 engine BMW redesigned the diaphragm spring to thicken it. This part is more effective and lasts longer.

For an in depth discussion of the rattle cause and solution reference the Beisan single and double rattle procedure and single diaphragm spring procedure introductions.

The splined shaft bearing is made of a thick washer and two thrust (roller) bearings. The washer incorporates a stud that's mounted to the vanos piston. The two thrust bearings sandwich the washer facilitating the splined shaft to rotate at camshaft speed without rotating the vanos piston. The washer and two thrust bearings are incased in a ring and two outer flat washers. The complete bearing is housed inside a splined shaft cavity and is closed off with a threaded cover.

Removing the splined shaft bearing axial play requires modifying or replacing one or more bearing components. The thrust bearings are a standard part and are manufactured to tight tolerances. It's not feasible to modify or replace them. The center washer is also manufactured to a tight tolerance. The ring is a non-standard part and is manufactured to loose tolerance. It's also made of standard steel that is annealed (soft). This is causing it to be scored by the center washer and thrust bearing. The outer flat washers reside inside the ring and thus influence the bearing axial fit. The washers are a standard bearing part, but due to their stamped manufacturing have a notable tolerance range which can significantly affect the bearing axial fit.

The ring can be replaced with a ring made of bearing steel that's hardened and ground to bearing standards. Its height can be tightly controlled to provide a tight bearing axial fit. Standard bearing washers that have been measured and sorted can be combined to provide the needed height to provide a tight bearing axial fit. A bearing adjustment can be made at installation to address any minor axial fit variation.

The vanos rattle repair kit includes two sets of replacement bearing ring and two outer washers.

Opening the splined shaft to modify the bearing requires counter holding the splined shaft and unscrewing the cover. The splined shaft doesn't have a built in area for tool holding, and the cover only has two holes in it for manipulation. The cover threads also have high strength thread locker which makes cover removal difficult.

A splined shaft holder tool is needed to receive and hold the splined shaft, and a socket tool with dowels is needed to insert into the holes in the splined shaft cover and open and close it.

The vanos rattle tools includes a splined shaft holder and splined shaft socket. The holder is square and mounts in a vise and receives and counter holds the splined shaft. The socket is a standard 1/2" drive size and has dowels that mount into the splined shaft cover holes to open and close the cover. The socket is designed to be used with an impact wrench to overcome the cover thread locker. The socket is also used with a torque wrench for final tightening.

The vanos rattle repair kit and rattle tools can be acquired through Beisan Systems (bee-saan), www.beisansystems.com/products.

Symptoms

Vanos rattle at a certain RPM range, often 1800-2200 RPM. Rattle can also occur at idle.

Repair Procedure

The following is an S54 vanos splined shaft bearing rattle repair procedure. As part of the repair the sprocket hub diaphragm springs and associate pressure plates are replaced with S62 parts. The S62 parts have been redesigned and have a thicker/stronger diaphragm spring to better control the rattle.

The procedure also addresses replacing the sprocket sleeve bolts that come loose on the intake side, and implicitly covers replacing the exhaust sprocket hub that can experience broken driver tabs.

This repair is performed in conjunction with the S54 vanos seals and oil pump disk repair.

[S54 Vanos Procedure](#)

Repair time: 3 hours mechanic, 4+ hours DIY.

Parts, Tools, and Shop Supplies



S54 vanos rattle repair kit (BS022) \$80/each (www.beisansystems.com), S54/S62 vanos rattle tools (BS095) \$20/each (www.beisansystems.com)



2 x S62 sprocket hub diaphragm spring and pressure plate (11-36-7-833-218)
\$30.89/each



12 x sprocket sleeve bolts (07-12-9-905-536) \$.74/each



Exhaust upper chain tensioner guide (11-31-7-830-159) \$16.83/each
Chain guide mounting bolt washer (07-11-9-963-342) \$1.11/each
Crankshaft chain tensioner washer (07-11-9-963-418) \$1.04/each



10mm hex bit socket 3/8", 32mm deep socket 1/2"



BMW camshaft alignment bridge (83-30-0-493-749) \$97.66/each

BMW crankshaft locking pin (83-30-0-490-861) \$20.86/each

The above S54 timing tools can be rented in the US from Bimmer Tool Rental, www.bimmertoolrental.com.

Rental is \$25 for 30 days, \$11 USPS Priority medium flat rate shipping, and refundable deposit of \$130.

Return shipping is responsibility of renter (\$11 USPS Priority medium flat rate).

Late returns will receive an automatic rental renewal for an extra 30 days with \$25 deduction from deposit.



4", or larger, swivel vise

Note: Vise must be mounted for use.



1/2" impact wrench



High strength thread locker (Loctite Threadlocker Heavy Duty (Euro Green, US Red), Permatex Threadlocker High Strength Red)
Medium strength thread locker (Loctite Threadlocker Medium Duty Blue, Permatex Threadlocker Medium Strength Blue)
300-400 grit sandpaper (not shown)

Repair

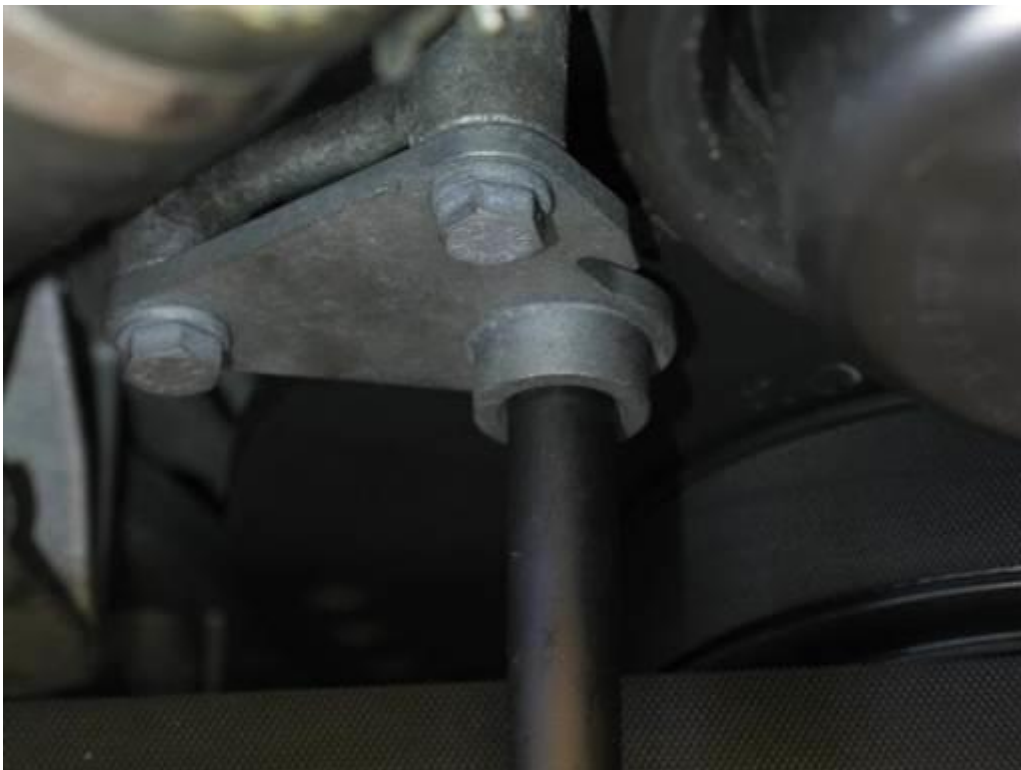
Repair is performed once vanos is removed from engine. Refer to S54 vanos procedure, [S54 Vanos Procedure](#)



Inspect TDC (top dead center) timing marks on engine timing cover and crankshaft harmonic balancer at ~11 o'clock position (mirror).

Slightly adjust crankshaft pulley as needed to precisely align TDC timing marks (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

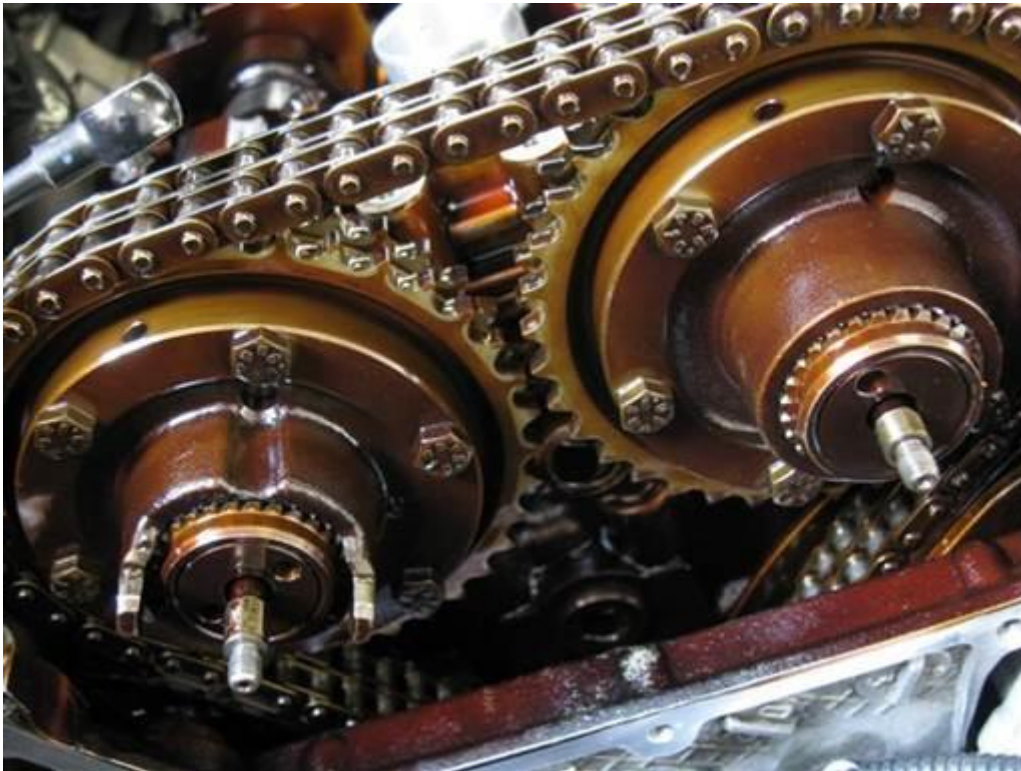
Note: Align pointer on timing cover bracket with 1 mark on harmonic balancer.



Install crankshaft locking pin in timing cover bracket hole.

If pin not inserting repeat above step to achieve precise timing mark alignment.

Removal of splined shafts and sprocket hubs



Before removing splined shafts and sprocket hubs, inspect their installed positions as a reference for reinstallation.

Note hole at the top of each sprocket hub.

Note exhaust hub front protruding tabs are oriented horizontal with the floor.

Note intake splined shaft splines are protruding slightly from hub.

Note exhaust splined shaft splines are recessed slightly into hub.

Note (feel) amount hub bolts protruding from rear of sprockets (slightly protruding).



Insert double length double layer folded towels under sprockets (towels).
Note: Towels prevent parts and tools from dropping into engine.
Note: Be sure to completely cover holes.



Loosen sprocket hub mounting bolts.
Loosen each of 6 mounting bolts on intake and exhaust sprocket hubs by 2.5 turns
(10mm socket 3/8" / 3/8" ratchet & extension).



Remove splined shafts from intake and exhaust sprocket hubs.
Grasp and pull out each splined shaft. Hub will rotate as splined shaft is removed.
If splined shaft resistant, further loosen hub mounting bolts. Bolts should have no tension.



Remove intake and exhaust sprocket hubs.

For each hub, remove 6 mounting bolts then pull off hub from sprocket (fingers, hands).

Note: Hubs have a diaphragm spring and pressure plate at their rear center. Remove these parts with hub.

Replacement of sprocket sleeve bolts



Clean intake and exhaust sprocket fronts.
Place more folded towels underneath each sprocket to catch cleaning fluid and oil.
Thoroughly spray clean sprocket fronts (brake cleaner).
Note: Be sure to spray clean sprocket slots and bolt holes in slots.
Insert small piece of towel in each camshaft center to prevent further oil leakage (towels).



Remove one intake sprocket sleeve bolt (5mm hex bit socket 3/8" / 3/8" ratchet &

extension).

Note: Unlike indicated by picture, start with a top bolt.



Spray clean bolt hole (brake cleaner).

Wipe dry bolt hole by inserting towel in bolt hole (towels).



Apply thread locker to new sprocket hub bolt (medium strength thread locker).



Install new hub bolt with thread locker (T30 torx bit socket 1/4" / 1/4" ratchet & extension).

Fully tighten, 12 Nm (9 ft-lb) (T30 torx bit socket 1/4" w/ 3/8" to 1/4" socket adapter / 3/8" torque wrench & extension).



Perform above bolt replacement procedure for all intake sprocket sleeve bolts.

Note: Replace bolts from top down so cleaning spray will not drain over new bolts.



Perform above bolt replacement procedure for all exhaust sprocket sleeve bolts.
Note: Replace bolts from top down so cleaning spray will not drain over new bolts.

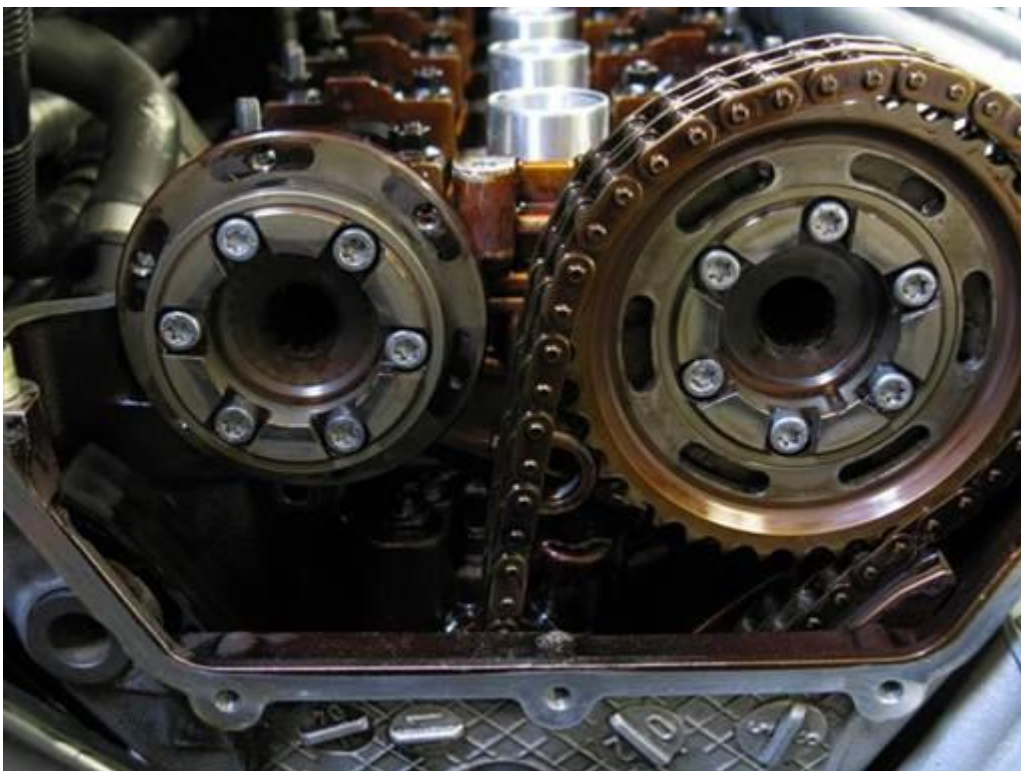
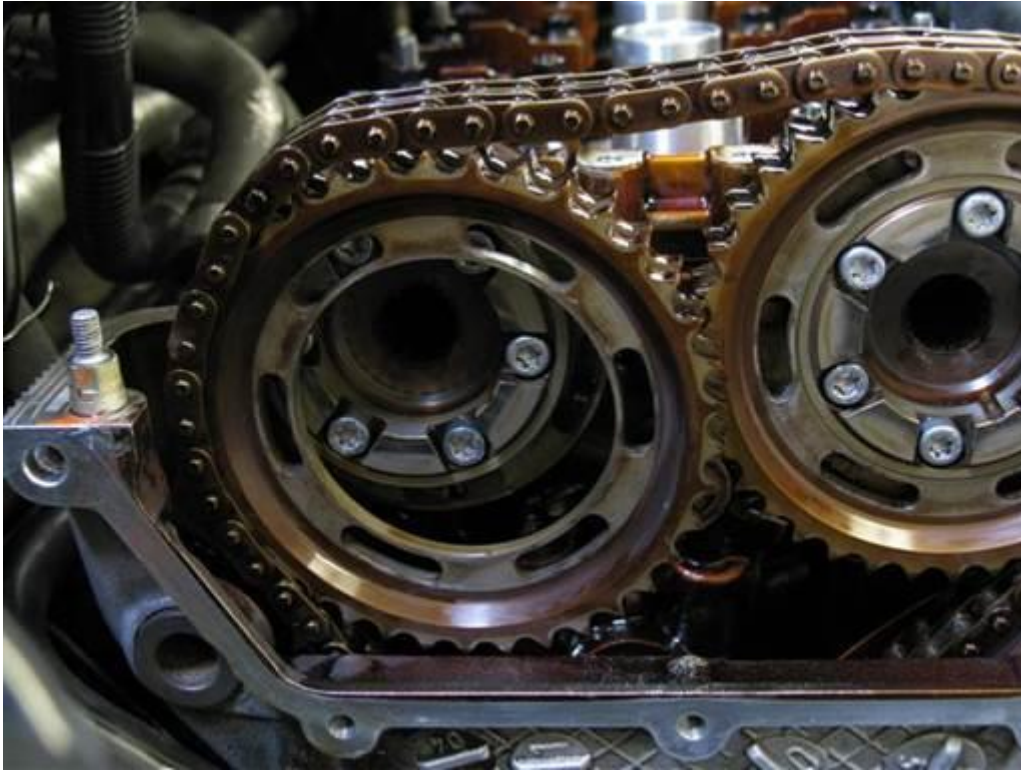
Remove top layer of towels under sprockets used to catch cleaning fluid and oil.

Replacement of chain guide

Remove towels under sprockets.



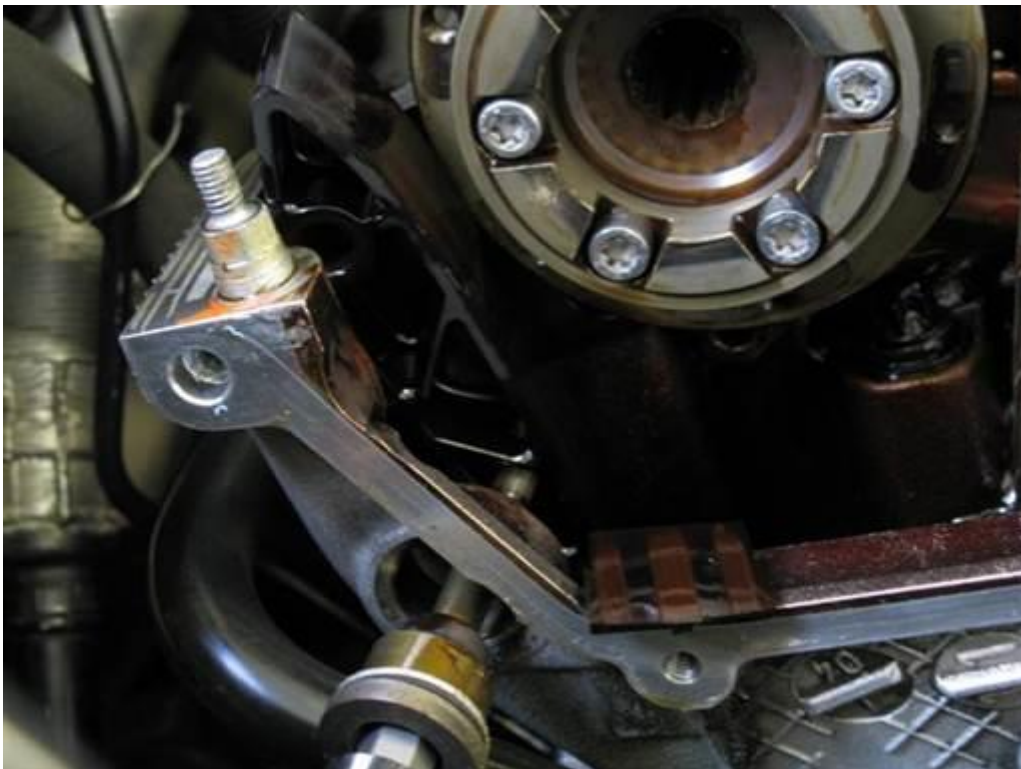
Remove crankshaft chain tensioner at engine exhaust side.
Insert towel below tensioner to catch draining oil.
Remove chain tensioner (32mm deep socket 1/2" / 1/2" long-arm ratchet & short extension).
Remove and discard crush washer at base of chain tensioner.



Remove exhaust sprocket.
Pull forward on exhaust sprocket to remove from exhaust camshaft and remove chain from exhaust sprocket.



Loosen chain guide mounting bolt (10mm hex bit socket 3/8" / 3/8" long-arm ratchet & extension).



Remove chain guide mounting bolt and chain guide (10mm hex bit socket 3/8" / 3/8" extension).

If chain guide lower piece broken, also remove this.

Note: Picture shows chain guide pulled up and maintained in place by mounting bolt. Also chain guide broken lower piece is removed and on timing cover.



Clean chain guide mounting bolt and bolt mounting points on engine (brake cleaner & towels).





Install chain guide.

Install new washer on chain guide mounting bolt.

Insert chain guide in engine and mount with mounting bolt (10mm hex bit socket 3/8" / 3/8" extension).

Fully tighten, 30 Nm (22 ft-lb) (10mm hex bit socket 3/8" / 3/8" torque wrench & extension).



Install exhaust sprocket.

Position exhaust sprocket so that bolt slot is positioned approximately at right and left side of sprocket (picture).

Mount chain on sprocket and sprocket on camshaft.

Remove and reinstall sprocket as needed to achieve bolt slot orientation.

Note: Sprocket rotational position on chain and camshaft is not significant to timing. Bolt slot orientation at right and left side facilitates hub tab positioning needed to access vanos piston and splined shaft stud joint.

Position intake and exhaust sprocket rear ring forward and sprocket against ring.

Note: Precise positioning is not important.





Install crankshaft chain tensioner with new crush washer (32mm deep socket 1/2" / hand).



Fully tighten tensioner (32mm deep socket 1/2" / 1/2" long-arm ratchet & short extension).

Tighten tensioner a further ~1/2 turn after initial tightness to crush washer.

Reinstall towels under sprockets.

Installation of sprocket hubs

Clean sprocket hubs 12 mounting bolts (brake cleaner & towels).

Remove sprocket hubs old pressure plate and diaphragm springs.
Spray clean sprocket hubs (brake cleaner & towels). Note: Be sure to clean bolt holes.





Install new diaphragm spring, cup side down, into each sprocket hub.

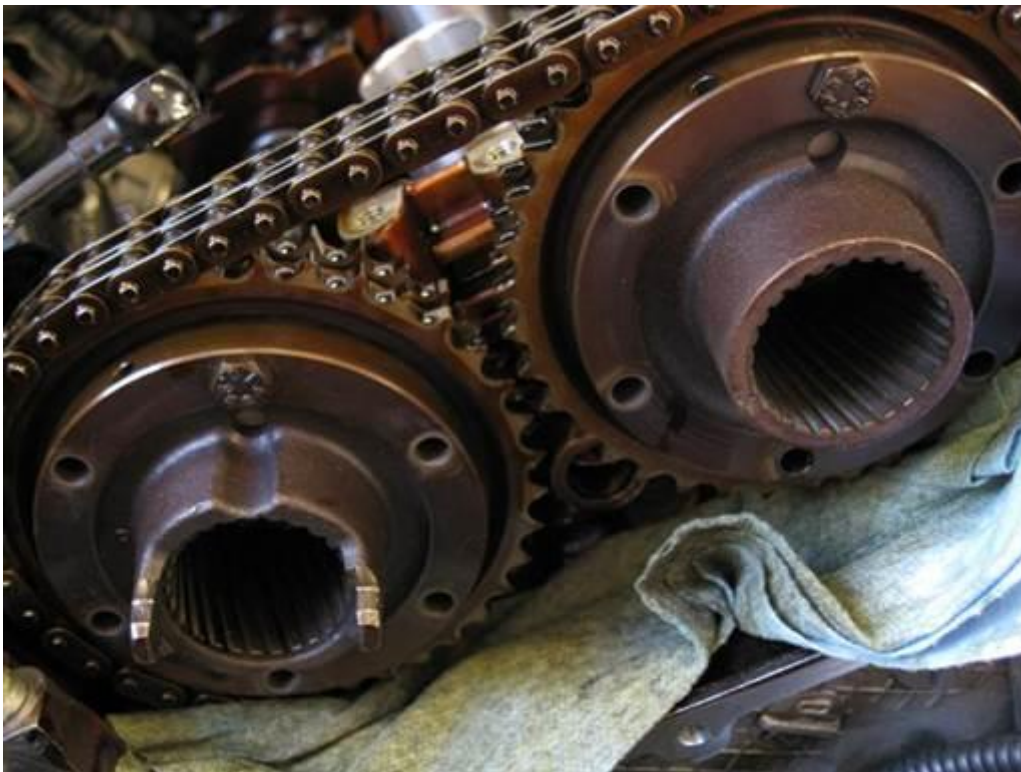


Install new pressure plate into each sprocket hub. Align pressure plate and hub keys.

Warning: Do not mix combine old and new diaphragm spring and pressure plate parts as dimensions have been changed.



Adjust position of bolt hole in sprocket slot to be at center of slot (strait pick).
Note: Bolt hole is part of sprocket rear plate and plate is free and can rotate.
Remove towels from camshaft holes.

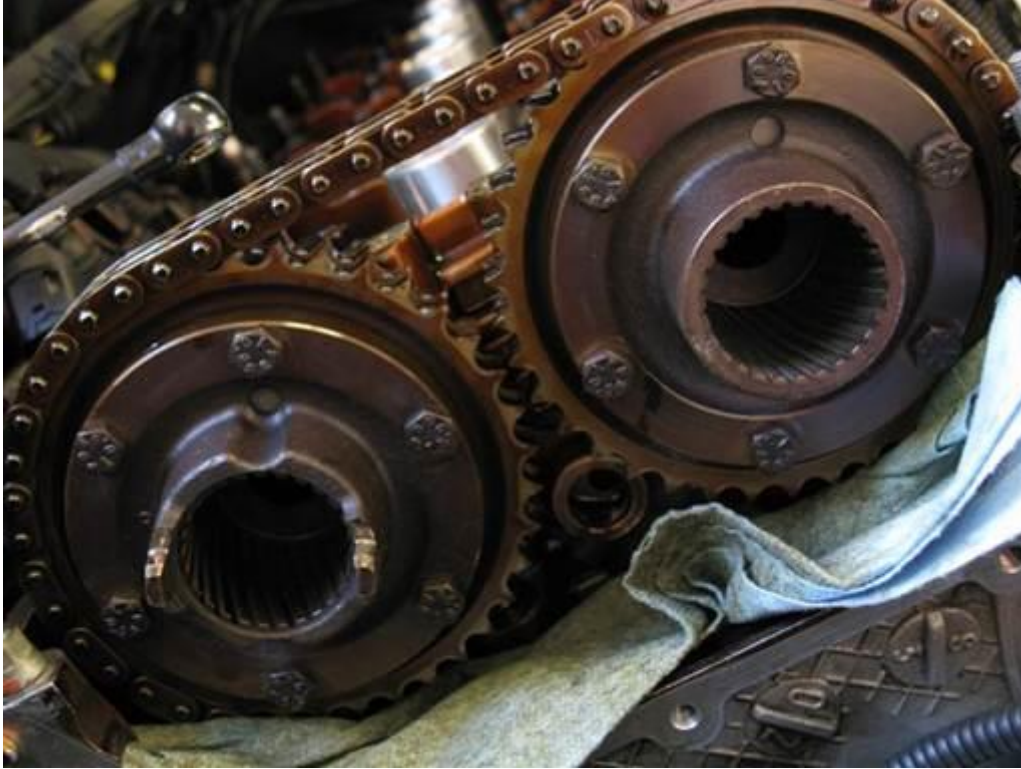


Install hubs onto sprockets with one mounting bolt.
Align hub on sprocket with one of two side holes at top (picture). Note: Hub side holes are on opposite sides of hub.
Align hub bolt hole to right of top hole with bolt hole in sprocket slot.

Insert mounting bolt in hub top hole and rotate sprocket rear plate as needed to align and insert bolt.

Tighten bolt until initial resistance (hand).

Note exhaust hub protruding front tabs are aligned horizontal with floor.



Install remaining hub mounting bolts.

Tighten bolts until initial resistance (hand).

Note: Bolts will be fully tightened in upcoming steps of procedure.

Installation of splined shaft rattle kit

Following procedure shows exhaust splined shaft but applies for both intake and exhaust splined shafts.

Perform following for each splined shaft.

Removal of Splined shaft bearing

Clean splined shaft (brake cleaner & towels).

Spray then drain cleaner through splined shaft cover holes to clear oil from bearing (brake cleaner).

Note: Removing oil from splined shaft bearing allows for bearing fit assessment in next step.

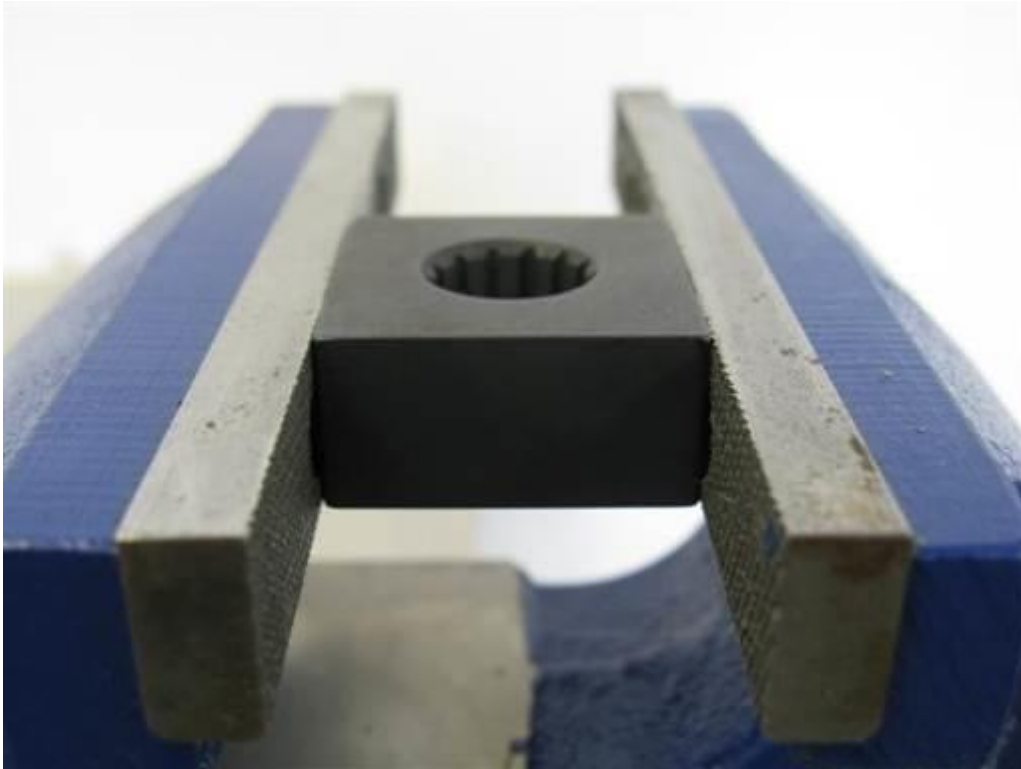


Inspect splined shaft bearing axial play.

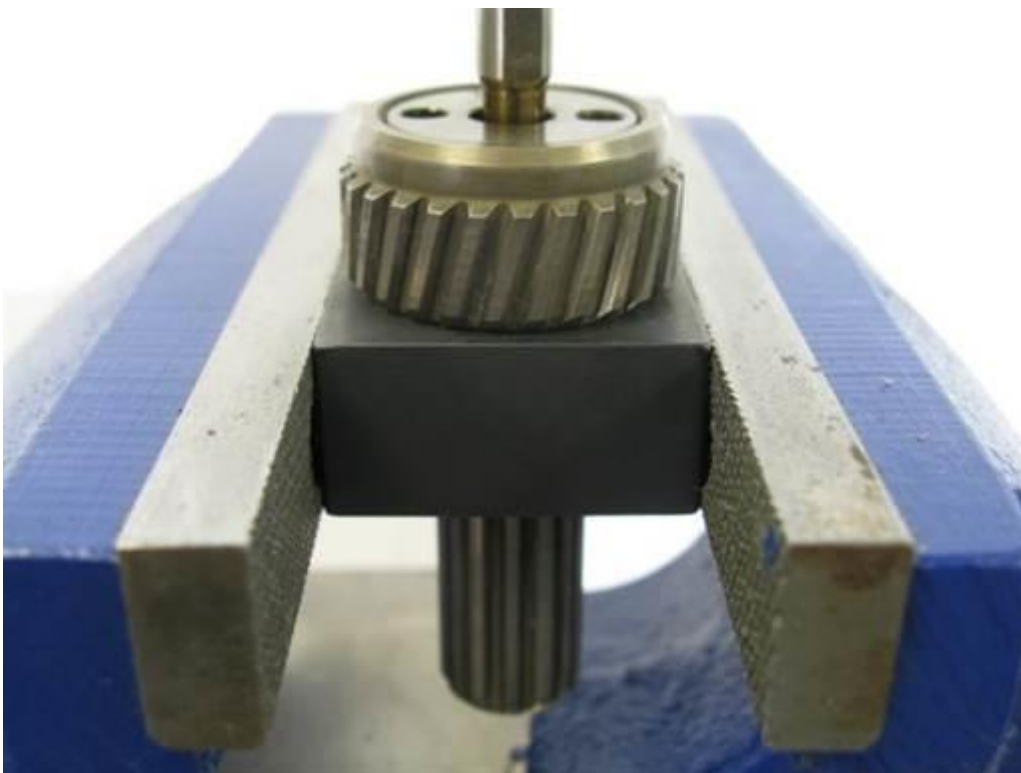
Hold splined shaft and tilt (rock) splined shaft stud to each side to note bearing axial play (free space).

Axial play can also be checked by repeated insertion and withdrawal of stud in/out of splined shaft.

Note: Radial play, side to side movement, is normal and necessary. This should not be confused with axial play, in/out movement.



Open vise jaws as far as necessary to insert splined shaft holder.
Insert splined shaft holder in vise and align top to vise jaw top. Strongly tighten
vise on splined shaft holder.



Insert splined shaft in splined shaft holder.



Install splined shaft socket on splined shaft and insert socket pins into splined shaft cover holes.

Note: Socket pins will fit tightly in splined shaft cover holes and rocking of socket might be needed to fully insert pins into holes.

Verify socket pins are fully inserted in splined shaft cover holes and socket is fully seated on splined shaft cover.



Loosen (break seize) splined shaft cover (splined shaft socket / 1/2" impact

wrench).

If available, set impact wrench power to lowest setting.

Engage impact wrench in reverse for 3 second intervals at a time until cover loosens (seize breaks).

Note: Hold down impact wrench for control.

Warning: Do not use ratchet to open splined shaft cover as this will likely cause socket to slip and break splined shaft stud. Only use an impact wrench.





Remove splined shaft cover (splined shaft socket / 1/2" ratchet).
Note: Splined shaft cover will turn with difficulty due to thread locker.
Bearing top washer will likely be bound to splined shaft cover and come out with cover.



Remove splined shaft center washer / stud (hand).
Note: Splined shaft stud is integral with bearing center washer.
Bearing top thrust (roller) bearing will come out with stud and center washer.



Remove bearing bottom thrust (roller) bearing.
Insert pick tip between thrust bearing inner bottom and bottom washer and pry thrust bearing out (90 degree pick).



Remove bearing outer ring.
Place towel on table.
Remove splined shaft from holder, tilt upside down, and hit on towel on table.
Bearing ring will dislodge in splined shaft. Remove bearing ring with index finger.

If bearing ring tilts and binds in splined shaft, press ring down in splined shaft to remount, then reattempt removal.
Reinstall splined shaft in splined shaft holder.



Remove bearing bottom washer.
Insert pick tip between washer inner bottom and splined shaft and pry washer out (90 degree pick).



Cleaning of splined shaft parts

Clean bearing parts (brake cleaner & towels).

Note: It is important bearing parts are thoroughly cleaned. This is needed to properly assess new bearing axial fit.

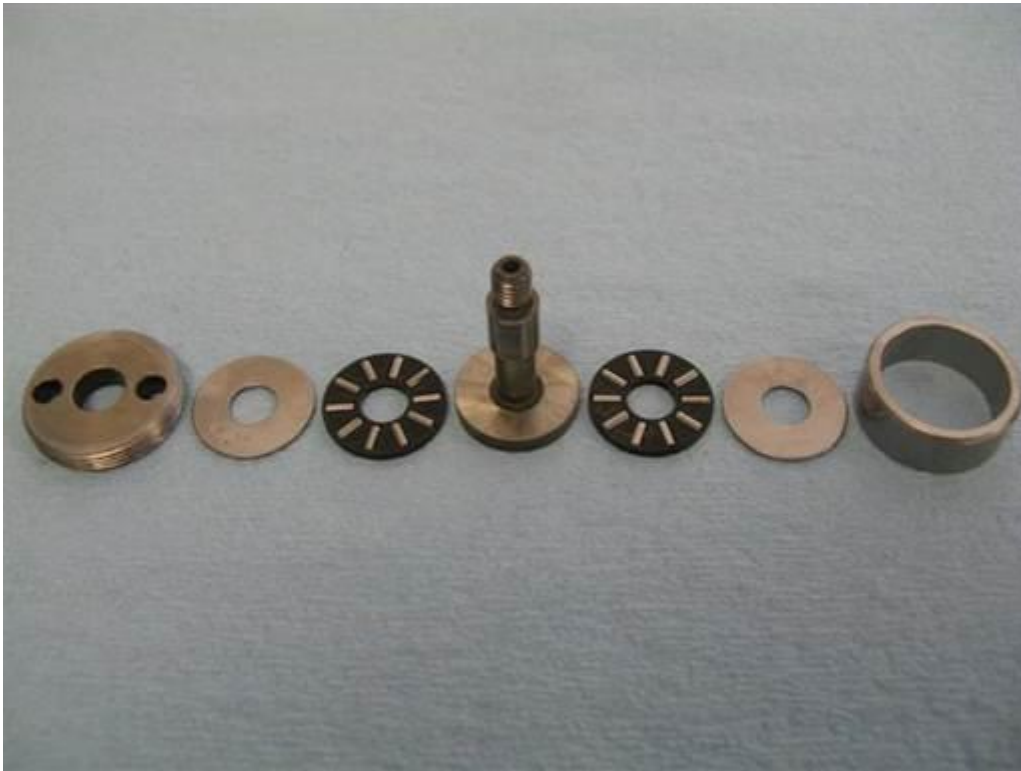
Remove old thread locker on cover and housing thread. Use pick tool to press tip into thread valley and run pick throughout thread (90 degree pick).

Note: It is critical old thread locker be fully removed to allow new thread locker to bond with parts.

Clean splined shaft bearing cavity and cover (brake cleaner & towels).

Installation of splined shaft bearing

Replace bearing ring and top and bottom washers with new parts.



Bearing parts installation sequence from right to left.

Bearing parts from left to right: Cover, top washer, top thrust bearing, center washer / stud, bottom thrust bearing, bottom washer, bearing ring.



Insert splined shaft in splined shaft holder.



Insert new bearing ring in splined shaft (fingers).

Note: New ring is marked "BS" on outer perimeter.

Initially insert ring in splined shaft.

Insert right and left index fingers into ring. Press fingers against ring inner right and left walls and manipulate ring side to side while slightly pressing down to facilitate ring full insertion.

Rotate position of fingers 90 degrees and repeat ring insertion to verify full insertion.

Note: Ring should fully mate with splined shaft bottom (picture).

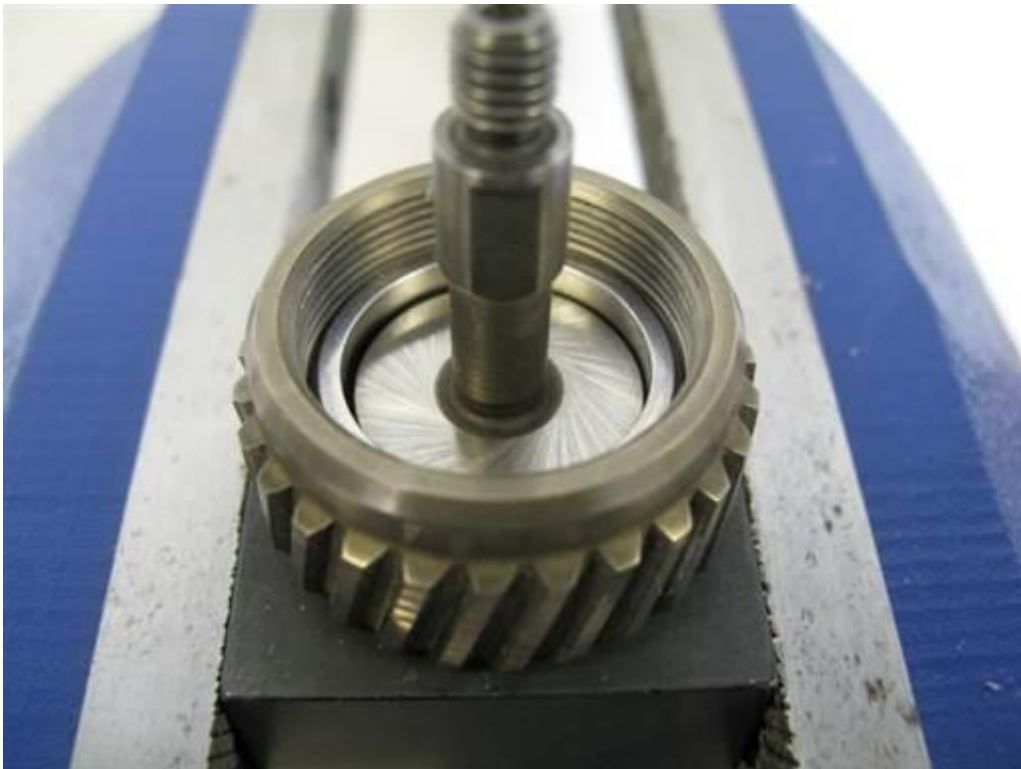


Insert bearing bottom washer in splined shaft bearing ring.

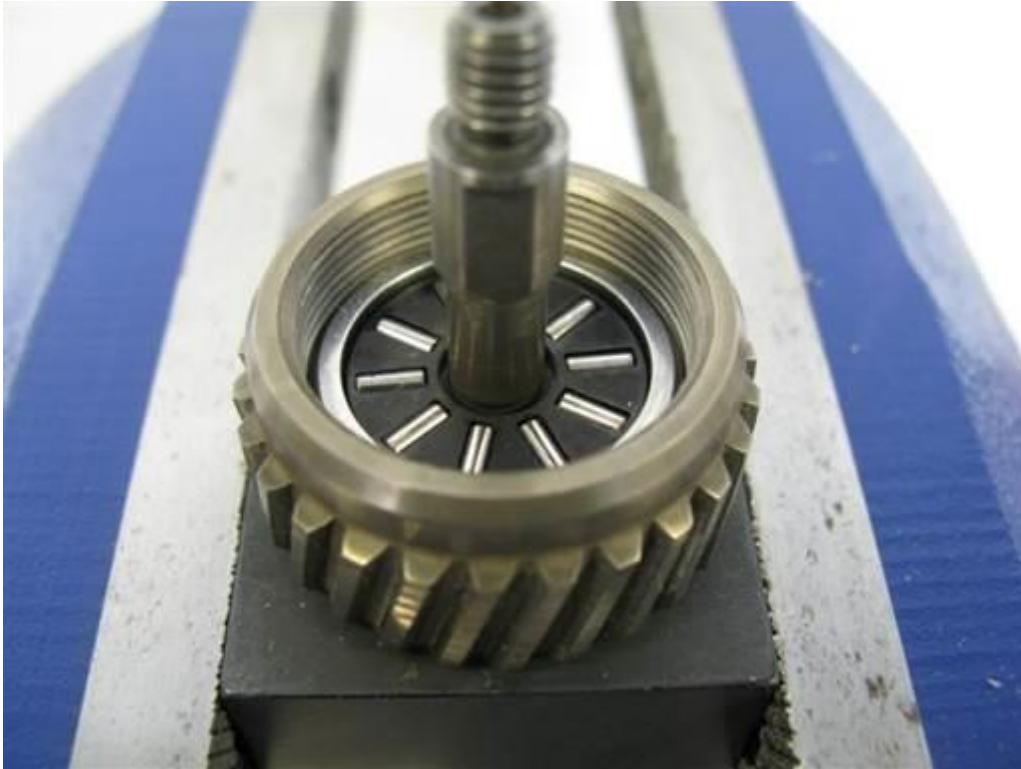
Note: Splined shaft bearing top and bottom washers are interchangeable. Also washer faces are same thus washer can be inserted in either orientation.



Insert bearing bottom thrust (roller) bearing in splined shaft bearing ring.
Note: Splined shaft bearing top and bottom thrust bearings are interchangeable.
Also thrust bearing faces are functionally same thus thrust bearing can be inserted in either orientation.

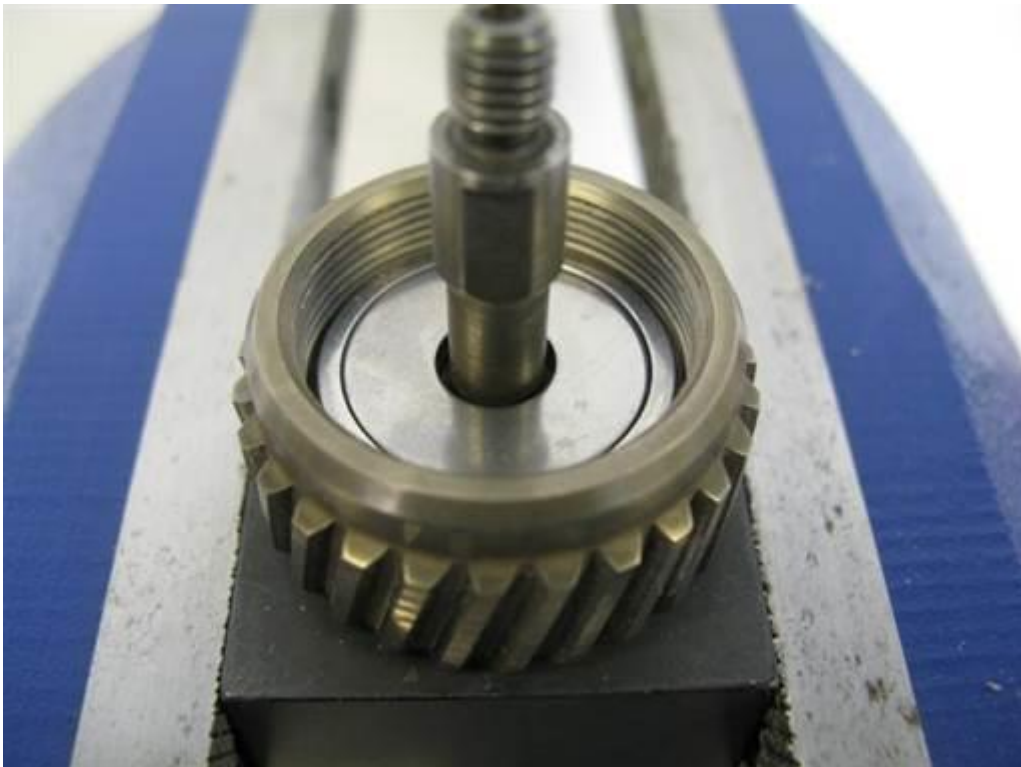


Insert bearing center washer / stud in splined shaft bearing ring.



Insert bearing top thrust (roller) bearing onto splined shaft stud and in splined shaft bearing ring.

Note: Thrust bearing faces are functionally same thus thrust bearing can be inserted in either orientation.



Insert bearing top washer onto splined shaft stud and in splined shaft bearing ring.

Note: Washer faces are same thus washer can be inserted in either orientation.



Install splined shaft cover onto splined shaft (splined shaft socket / 1/2" ratchet).



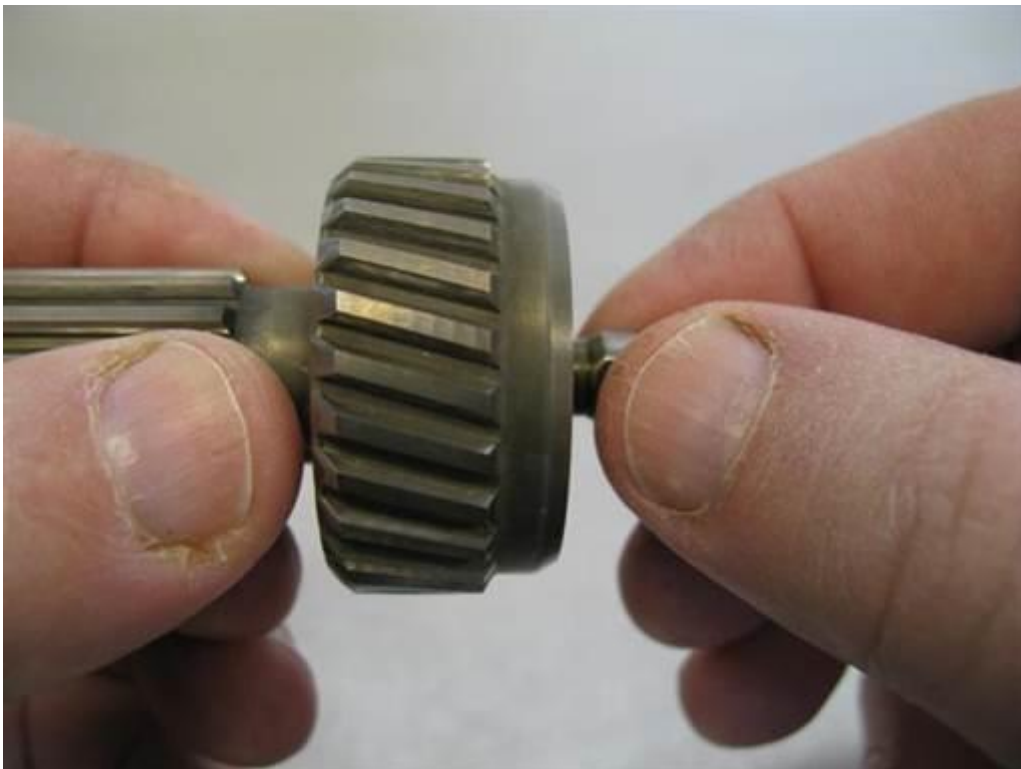
When splined shaft cover is fully installed its top will be even with splined shaft rim (picture).

If cover is higher than splined shaft rim then bearing parts are not installed correctly and interfering with cover installation. Remove cover and reinstall bearing parts.



Fully tighten splined shaft cover, 55 Nm (40.5 ft-lb) (splined shaft socket / 3/8" torque wrench & 3/8" to 1/2" socket adapter).

Inspection and adjustment of splined shaft bearing



Inspect splined shaft bearing axial play.
Hold splined shaft and rotate splined shaft stud to note resistance to rotation.
Hold splined shaft and tilt (rock) splined shaft stud to each side to note bearing

axial play (free space).

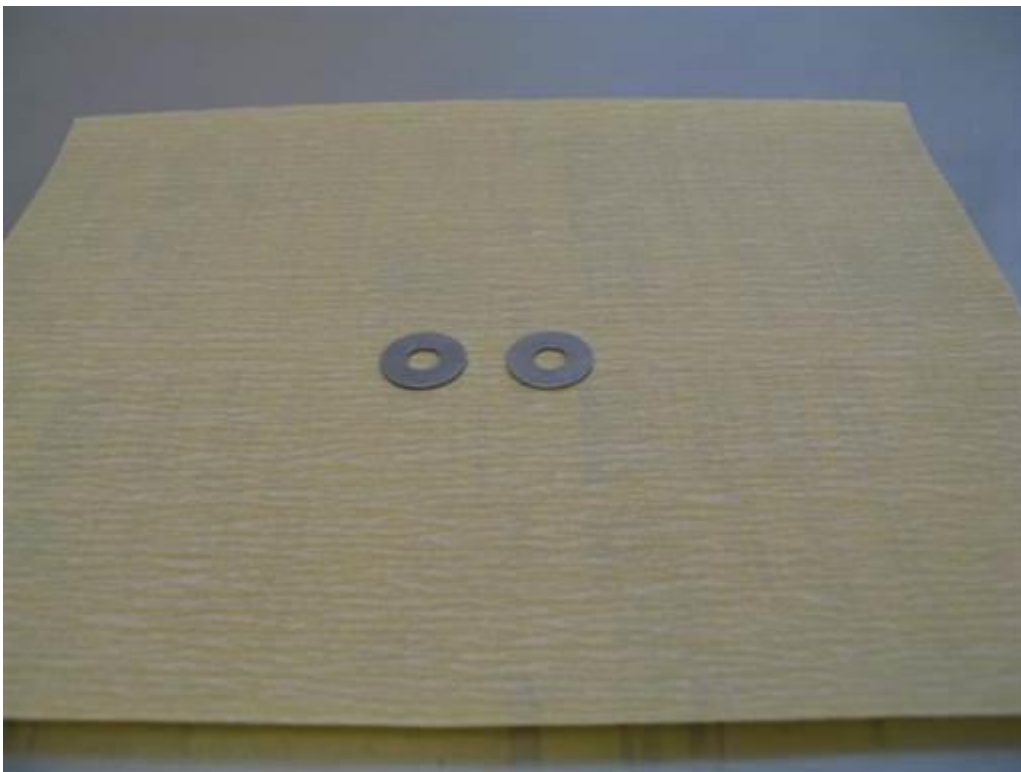
Note: Axial fit cannot be properly assessed until splined shaft cover is fully tightened.

Note: Radial play, side to side movement, is normal and necessary. This should not be confused with axial play, in/out movement.

If splined shaft stud binds and is difficult to rotate then axial fit is too tight and loosening adjustment is needed.

If splined shaft stud has any tilt movement then axial play is present and tightening adjustment is needed.

Any level of resistance (pre-load), without binding, in splined shaft stud rotation indicates no axial play and is considered an optimal fit.



Bearing loosening adjustment.

If splined shaft binds and is difficult to rotate then axial fit is too tight and loosening adjustment is needed.

Disassemble splined shaft bearing per above procedure.

Place sandpaper (300-400 grit) on flat table top. Place bearing outer washer on sandpaper.

Slide washer side to side on sandpaper ~6" back and forth while moderately pressing washer on sandpaper. Perform sanding for 10 seconds.

Rotate washer 90 degrees and repeat sanding process.

Flip washer to opposite side and repeat above sanding procedure; 10 seconds sanding, rotate 90 degrees, 10 seconds sanding.

Clean washer (brake cleaner & towels).

Repeat washer sanding for second outer washer.

Reassemble splined shaft bearing per above procedure and reassess bearing axial fit.

Note: Washers are made from hardened steel and do not easily wear. Sanding procedure will remove $\sim .0025$ mm washer height, total $\sim .005$. Washers might need max $.01$ mm height adjustment.



Bearing tightening adjustment.

If splined shaft has any tilt movement then axial play is present and tightening adjustment is needed.

Disassemble splined shaft bearing per above procedure.

Place sandpaper (300-400 grit) on flat table top. Place bearing ring on sandpaper. Slide ring side to side on sandpaper ~ 6 " back and forth while moderately pressing ring on sandpaper. Perform sanding for 5 seconds.

Rotate ring 90 degrees and repeat sanding process.

Flip ring to opposite side and repeat above sanding procedure; 5 seconds sanding, rotate 90 degrees, 5 seconds sanding.

Clean ring (brake cleaner & towels).

Reassemble splined shaft bearing per above procedure and reassess bearing axial fit.

Note: Ring is made from hardened steel and does not easily wear. Sanding procedure will remove $\sim .005$ mm ring height. Ring might need max $.01$ mm height adjustment.



Once splined shaft bearing fit is assessed, and if needed adjustment performed, thread locker needs to be applied to splined shaft cover.
Remove splined shaft cover from splined shaft per above procedure.
Apply thread locker at middle of threads along perimeter of cover (high strength thread locker).
Reinstall splined shaft cover and fully tighten per above instructions.

Installation of vanos with splined shafts



Install splined shafts onto vanos pistons.

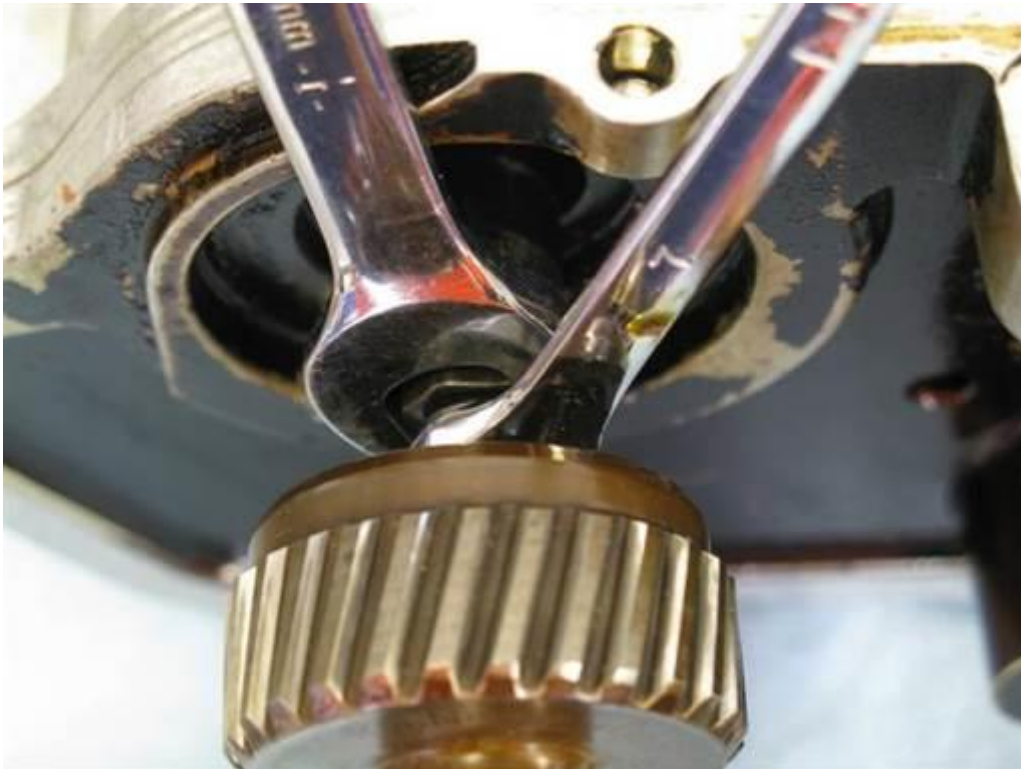
Splined shaft with longer protruding stud is exhaust splined shaft and splined shaft with shorter stud is intake splined shaft.

Vanos piston at center of oil pump disk is exhaust piston and other side piston is intake piston.

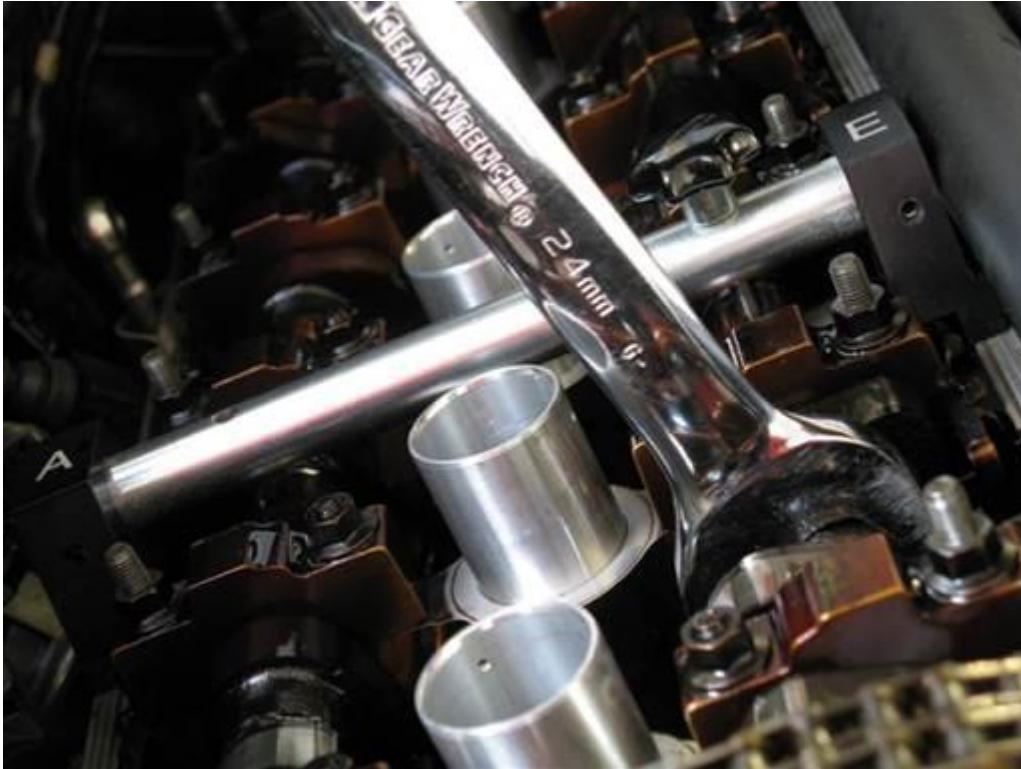
Thread splined shaft studs into their corresponding pistons; left hand thread.

Note: Splined shaft studs and piston threads are left hand thread. Thus turn splined

shaft stud counter clockwise to thread into piston thread.
Thread splined shaft studs fully into corresponding pistons by rotating splined shaft studs; left hand thread (hand).



Tighten splined shaft studs to their corresponding pistons; left hand thread (10mm open wrench / 7mm open wrench).
Note: Due to left hand thread, it is not necessary to over tighten joint.



Install vanos alignment bridge without alignment dowel on engine head between cylinders 2 & 3 (picture).

Note: Bridge has intake and exhaust orientation. Note: E is intake and A is exhaust in German.

Insert bridge alignment dowel through bridge intake side hole and insert dowel into intake camshaft alignment hole.

Note: Lift up bridge intake or exhaust end as necessary to align and insert dowel into camshaft hole.

Rotate intake camshaft at hex between cylinder 1 & 2 to align camshaft alignment hole perpendicular to engine head and allow bridge ends to sit on engine head (24mm open wrench).

Fully insert bridge dowel into camshaft and onto bridge (picture). Turn and press down dowel as needed to fully insert.

Place hand on middle of bridge and rock intake camshaft back and forth to identify and set camshaft in position where bridge intake and exhaust ends are sitting flat on engine head.

Remove alignment dowel from bridge.



Insert bridge alignment dowel through bridge exhaust side hole and insert dowel into exhaust camshaft alignment hole.

Note: Lift up bridge intake or exhaust end as necessary to align and insert dowel into camshaft hole.

Rotate exhaust camshaft at hex between cylinder 1 & 2 to align camshaft alignment hole perpendicular to engine head and allow bridge ends to sit on engine head (24mm open wrench).

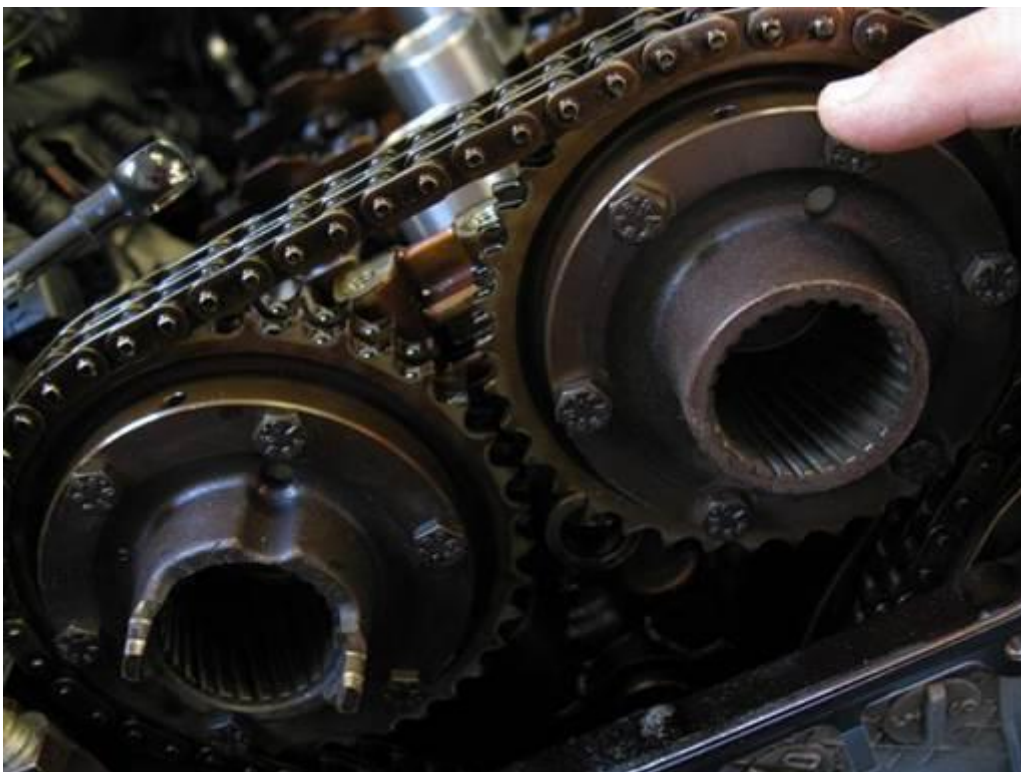
Fully insert bridge dowel into camshaft and onto bridge (picture). Turn and press down dowel as needed to fully insert.

Place hand on middle of bridge and rock exhaust camshaft back and forth to identify and set camshaft in position where bridge intake and exhaust ends are sitting flat on engine head.

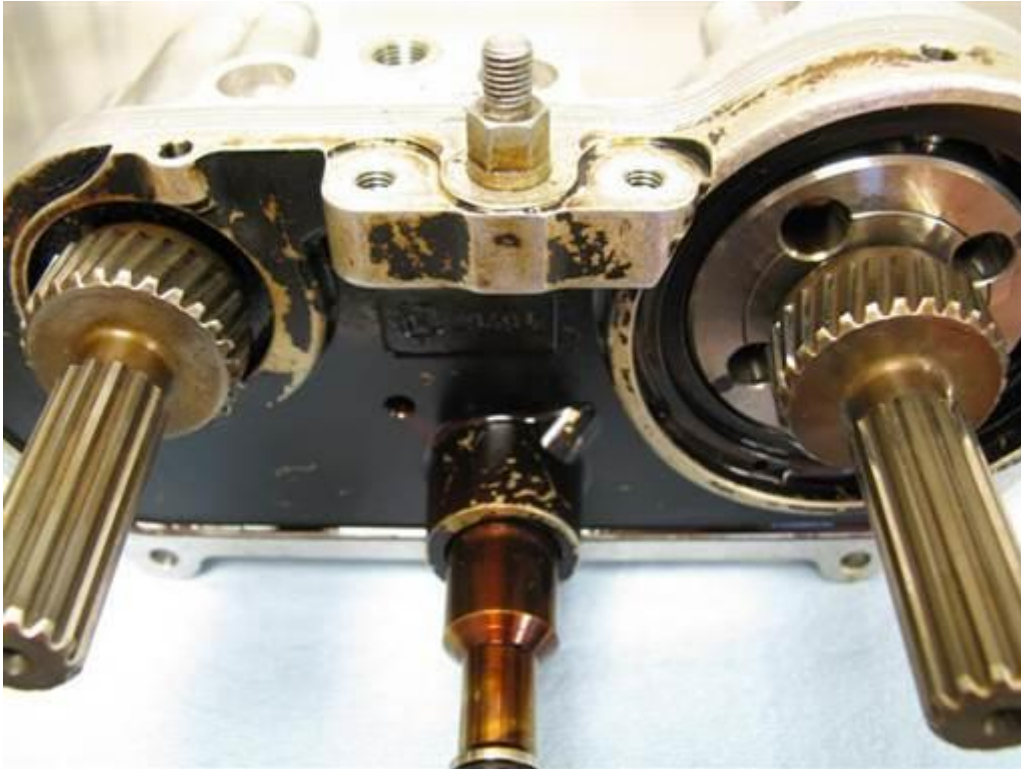
Remove alignment dowel from bridge. Remove bridge from engine head.



Install new vanos gasket on engine head.
Clean engine head gasket/vanos mating surface and head top front surfaces (remove old sealant) (brake cleaner & towels).
Place gasket on head with gasket ridge to vanos (front). Gasket two lower tabs will point to vanos (front) (picture).

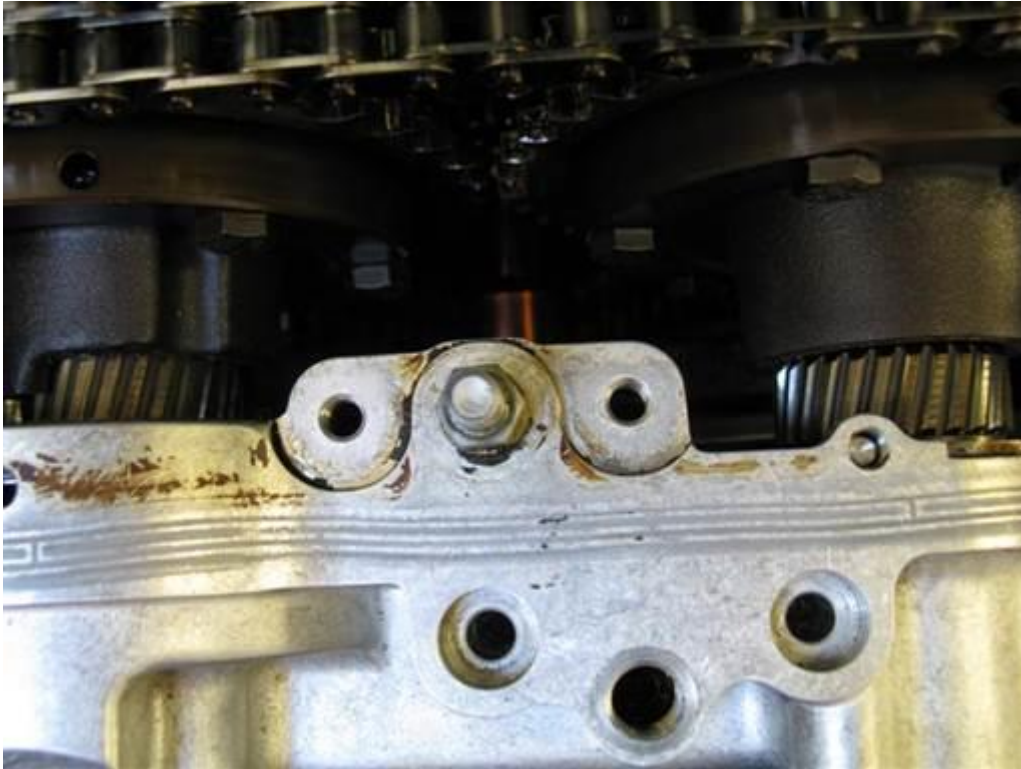


Rotate intake and exhaust hubs clockwise as far as possible (hand).



Insert vanos splined shafts with pistons fully into vanos.
Clean vanos all matting surfaces (brake cleaner & towels).





Install vanos with splined shafts onto sprocket hubs.

Align and initially insert exhaust and then intake spline shafts into corresponding hubs.

Align exhaust splined shaft to insert into exhaust camshaft hole at center of hub.

Rotate and insert splined shaft to insert into camshaft.

Align intake splined shaft to insert into intake camshaft hole at center of hub.

Rotate and insert splined shaft to insert into camshaft.

Press vanos onto engine to insert splined shafts into camshafts and bring splined shafts slanted splines up to hubs.

Vanos press will also reinsert splined shafts and pistons fully into vanos if they came out.



Insert exhaust splined shaft slanted splines into exhaust hub.
Rotate hub counter clockwise while pressing vanos onto hub.
Splined shaft will insert into hub at first alignment of splines.

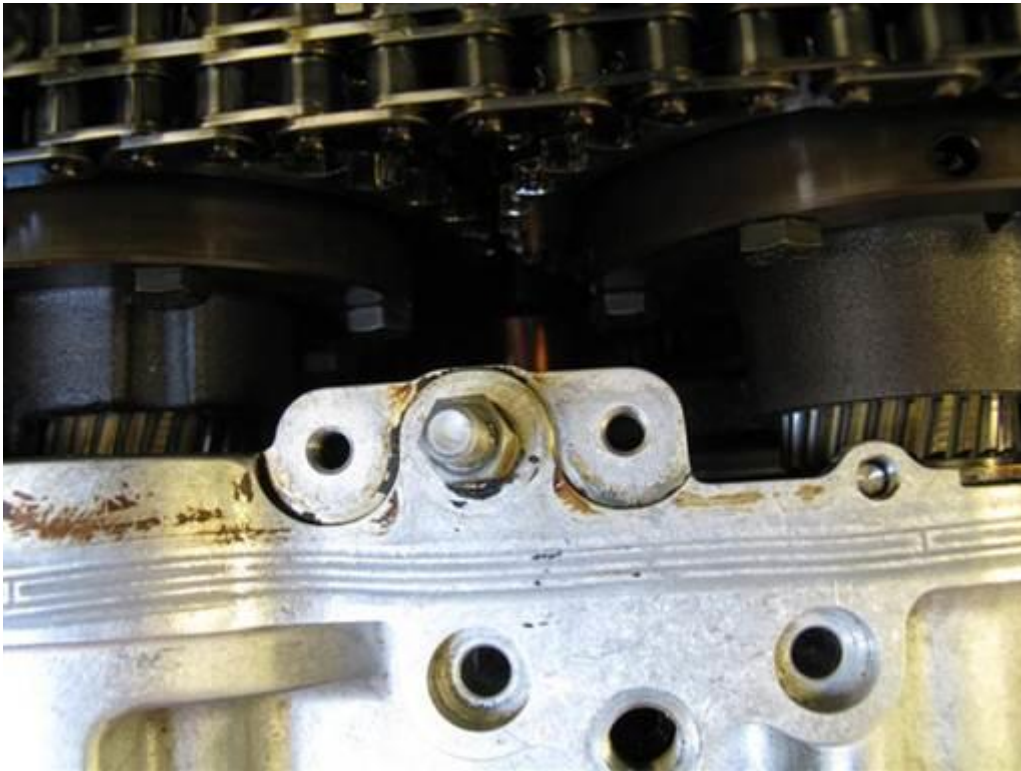
Caution: Splined shaft must insert into first available aligned hub splines.



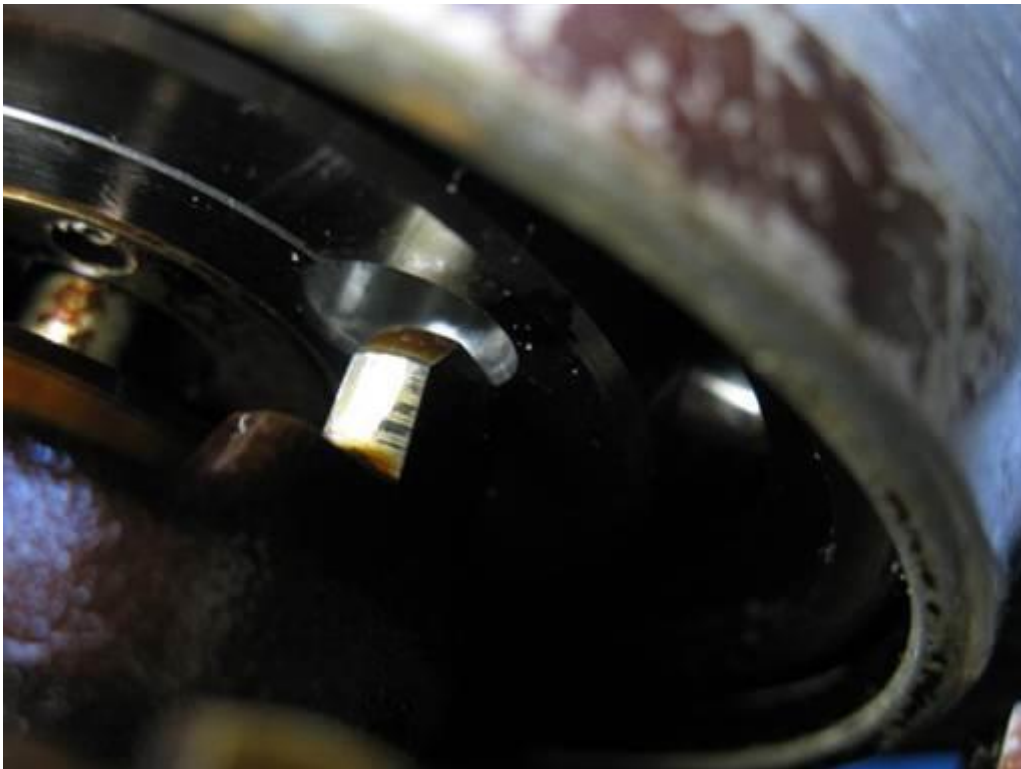
Insert intake splined shaft slanted splines into intake hub.
Rotate hub counter clockwise while pressing vanos onto hub.

Splined shaft will insert into hub at first alignment of splines.

Caution: Splined shaft must insert into first available aligned hub splines.



Press vanos onto engine head and splined shafts will insert further into hubs.
Do not fully install vanos onto engine head.





Inspect vanos oil pump side hole and exhaust sprocket hub side tab for alignment.
Rotate vanos oil pump as needed to achieve alignment (fingers).





Press vanos onto engine head until vanos reaches alignment dowels at top corners of head.



Verify exhaust hub tab insertion into vanos oil pump hole.
Realign vanos pump as need to facilitate tab insertion (fingers).

Clean vanos 5 mounting bolts (brake cleaner & towels).



Install vanos top corner mounting bolts and thread up to vanos (hand). Do not tighten.

Press splined shafts into vanos to verify splined shafts and pistons are fully inserted into vanos (hand).



Tighten intake and exhaust hubs right and left side bolts (10mm ratcheting wrench).

Tighten each hub 2 bolts (right and left) evenly in multiple passes.
Loosen 4 tightened bolts 1/4 turn.



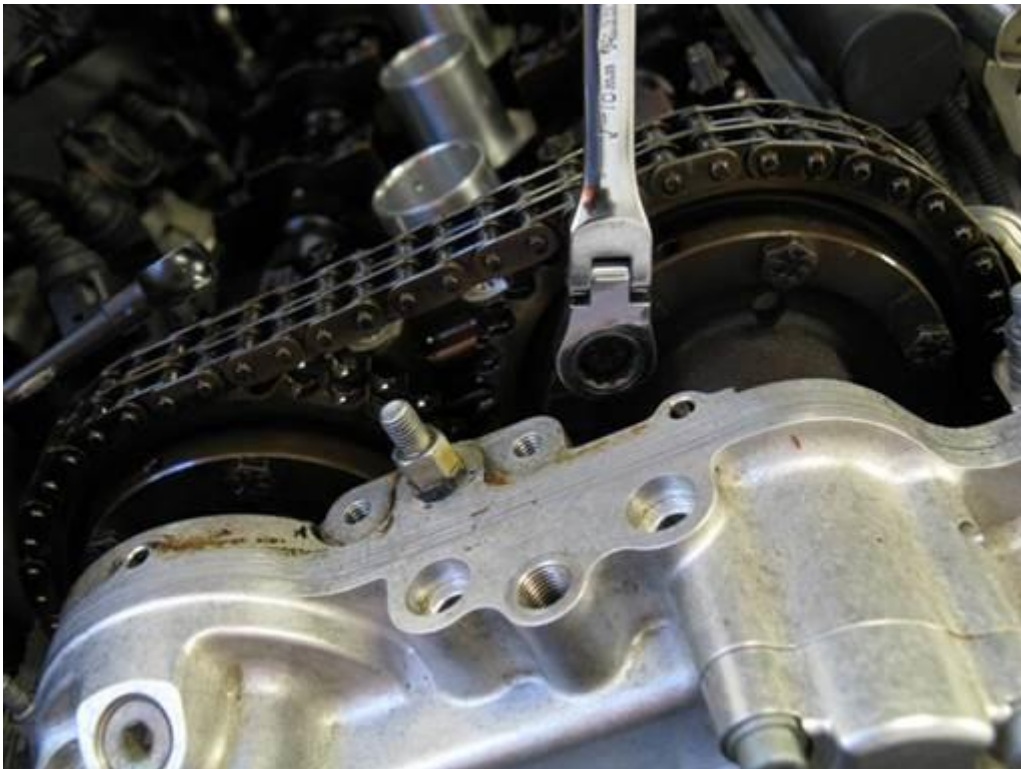
Tighten vanos two corner mounting bolts evenly to draw vanos evenly onto engine head (10mm socket 3/8" / 3/8" ratchet & extension).
Note: Camshafts should not rotate. If they do then hub bolts were not loosened sufficiently in previous step.



Install vanos lower 3 mounting bolts (5mm hex bit socket 3/8" / 3/8" ratchet & extension).

Fully tighten all mounting bolts, 10 Nm (7 ft-lb) (10mm socket & 5mm hex bit socket 3/8" / 3/8" torque wrench & extension).

Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully tightened.



Tighten intake hub top two and right (3 total) mounting bolts and exhaust hub top

two and left (3 total) mounting bolts (10mm ratcheting wrench).

Tighten bolts evenly in multiple passes.

Note: Intake hub right mounting bolt and exhaust hub left mounting bolt will be mostly tightened since they were tightened in previous step.

Note: Bolts will be tightened further in below step, thus do not overly tighten at this time.



Remove crankshaft locking pin from timing cover bracket.



Turn crankshaft pulley clockwise one full rotation until timing marks match again (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

When 3/4 through turn start inspecting 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 (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

Note: Align pointer on timing cover bracket with 1 mark on harmonic balancer.

Note: Precise alignment is not necessary.

Note: Turning crankshaft counter clockwise is acceptable.

Note: Do not reinstall crankshaft locking pin.



Tighten intake hub top two and right (3 total) mounting bolts and exhaust hub top two and left (3 total) mounting bolts (10mm ratcheting wrench).

Tighten bolts evenly in multiple passes.

Note: Intake hub right mounting bolt and exhaust hub left mounting bolt will be mostly tightened since they were tightened in previous step.

Fully tighten bolts, 14 Nm (by feel) (10.5 ft-lb) (10mm ratcheting wrench).

Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully

tightened.

Note: When bolts fully tightened they will protrude slightly from sprocket rear face (picture). Check by feel and compare bolts.



Turn crankshaft pulley clockwise one full rotation until timing marks match again (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

When 3/4 through turn start inspecting TDC (top dead center) timing marks on engine timing cover and crankshaft harmonic balancer at ~11 o'clock position (mirror).

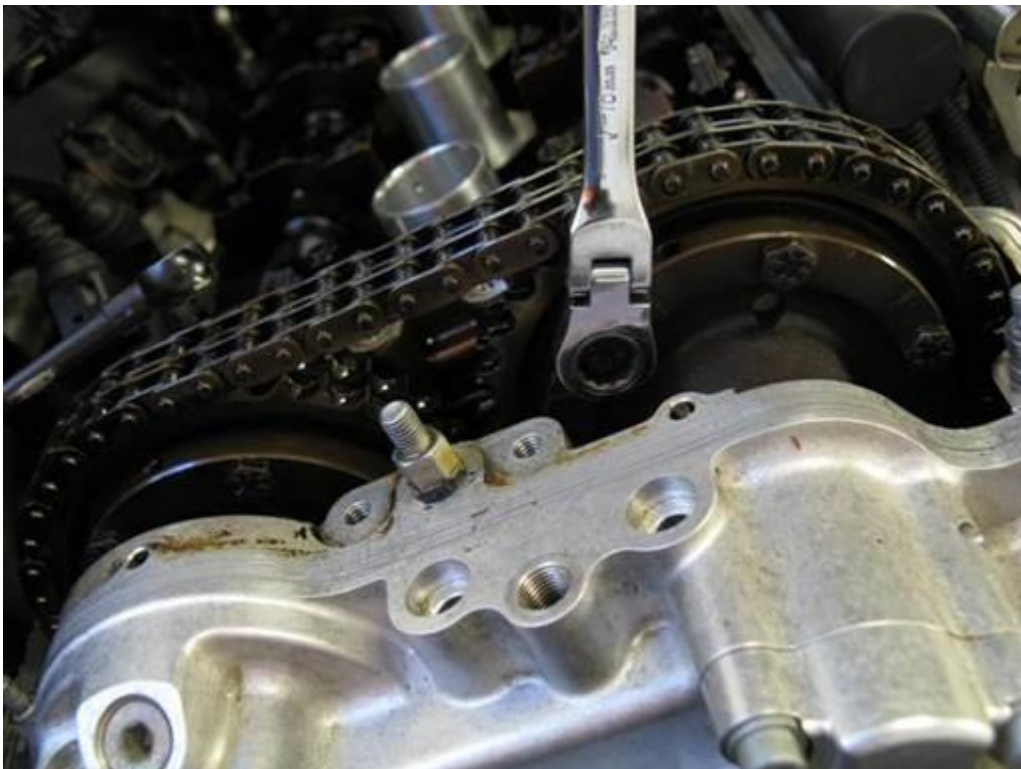
Adjust crankshaft pulley to precisely align TDC timing marks (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

Note: Align pointer on timing cover bracket with 1 mark on harmonic balancer.

Note: Turning crankshaft counter clockwise is acceptable.



Install crankshaft locking pin in timing cover bracket hole.
If pin not inserting repeat above step to achieve precise timing alignment.





Tighten intake hub top two and right (3 total) mounting bolts and exhaust hub top two and left (3 total) mounting bolts (10mm ratcheting wrench).

Tighten bolts evenly in multiple passes.

Note: These bolts were all tightened in previous step.

Fully tighten bolts, 14 Nm (by feel) (10.5 ft-lb) (10mm ratcheting wrench).

Tighten bolts evenly in multiple passes. Verify one pass with all bolts fully tightened.

Note: When bolts fully tightened they will protrude slightly from sprocket rear face (picture). Check by feel and compare bolts.

Checking of engine timing



Fully retard intake and exhaust camshafts.

For each camshaft, place open wrench (24mm combo wrench) on camshaft hex between cylinders 1 & 2 and turn camshaft counter clockwise to adjustment end position.

Note: Camshaft rotation is most effective when standing at exhaust side of car.

Note: Rock camshaft back and forth to release bind and allow rotation.

Note: Camshafts should already be in fully retarded position.



Install vanos alignment bridge without alignment dowel on engine head between cylinders 2 & 3 (picture).

Note: Bridge has intake and exhaust orientation. Note: E is intake and A is exhaust in German.

Insert bridge alignment dowel through bridge intake side hole and insert dowel into intake camshaft alignment hole.

Note: Lift up bridge intake or exhaust end as necessary to align and insert dowel into camshaft hole.

Fully insert dowel into camshaft and onto bridge (picture). Rotate and press down dowel as needed to fully insert.

Bridge intake and exhaust ends should be sitting flat on engine head. Press down on each end to assess any space between bridge end and head surface.

Timing is wrong if bridge end is lifted from engine head more than .5mm.

Remove alignment dowel from bridge.



Insert bridge alignment dowel through bridge exhaust side hole and insert dowel into exhaust camshaft alignment hole.

Note: Lift up bridge intake or exhaust end as necessary to align and insert dowel into camshaft hole.

Fully insert dowel into camshaft and onto bridge (picture). Rotate and press down dowel as needed to fully insert.

Bridge intake and exhaust ends should be sitting flat on engine head. Press down on each end to assess any space between bridge end and head surface.

Timing is wrong if bridge end is lifted from engine head more than .5mm.

Remove alignment dowel from bridge then bridge from engine head.



Remove crankshaft locking pin from timing cover bracket.

Adjustment of timing

If timing alignment is found to be incorrect, perform following procedure to adjust timing.

Timing adjustment procedure presumes engine position at end of timing checking; crankshaft at TDC with lock pin removed, intake and exhaust camshaft cylinder 1 cams pointing in to each other at ~45 degree angle.

Perform timing adjustment for camshaft(s) with incorrect timing alignment.

Turn crankshaft pulley clockwise one full rotation until timing marks match again (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

Loosen sprocket hub 3 top mounting bolts (10mm ratcheting wrench). Note: Bolts need to be notably loose so once opposite side 3 bolts are loosened hub will be free.

Turn crankshaft pulley clockwise one full rotation until timing marks match again (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

Adjust crankshaft pulley to precisely align TDC timing marks (crankshaft turning socket 1/2" / 1/2" long-arm ratchet & short extension).

Install crankshaft locking pin in timing cover bracket hole.

Fully retard camshaft timing.

Place open wrench (24mm combo wrench) on camshaft hex at front of camshaft.

Rotate camshaft counter clockwise to adjustment end position. If camshaft resistant to rotation rock camshaft back and forth to release seize.

Note: Camshaft rotation is most effective when standing at exhaust side of car.

Note: Splined shaft can be seen protruding from sprocket hub front when camshaft is at adjustment end position.

Loosen sprocket hub 3 top mounting bolts (10mm ratcheting wrench).

Note: All sprocket hub bolts are now loose.

Install vanos alignment bridge without alignment dowel on engine head between cylinders 2 & 3.

Note: Bridge has intake and exhaust orientation. Note: E is intake and A is exhaust in German.

Insert bridge alignment dowel through bridge hole and insert dowel into camshaft alignment hole.

Note: Lift up bridge intake or exhaust end as necessary to align and insert dowel into camshaft hole.

Rotate camshaft at hex between cylinder 1 & 2 to align camshaft alignment hole perpendicular to engine head and allow bridge ends to sit on engine head (24mm open wrench).

Fully insert bridge dowel into camshaft and onto bridge. Turn and press down dowel as needed to fully insert.

Place hand on middle of bridge and rock camshaft back and forth to identify and set camshaft in position where bridge intake and exhaust ends are sitting flat on engine head.

Remove alignment dowel and bridge.

Follow above procedure starting at step just after mounting and tightening all vanos mounting bolts.

Perform sprocket hub bolt tightening only for adjusted camshaft(s).

Continue repair referencing S54 vanos procedure, [S54 Vanos Procedure](#)

Perform cleaning section in procedure then start at step after installing vanos mounting bolts.

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