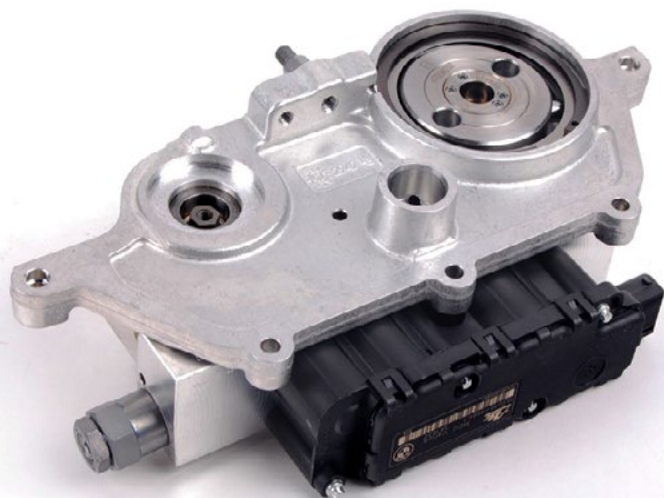




# BMW S54 Vanos Rebuild Kit Installation Instructions



Proper service and repair procedures are vital to the safe, reliable operation of all motor vehicles as well as the personal safety of those performing the repairs. Standard safety procedures and precautions (including use of safety goggles and proper tools and equipment) should be followed at all times to eliminate the possibility of personal injury or improper service which could damage the vehicle or compromise its safety.

## INTRODUCTION

### BMW S54 Dual Vanos Rebuild

BMW's Vanos variable valve timing system is one of the most recognized systems in the industry. There are a number of different designs, and they all work off of ingeniously simple mechanical principals. Their notoriety, however, is not likely to be from their design and performance, but more so from the fact that they frequently wear out. Today we're going to be working on the dual Vanos unit that is found in the 6 cylinder S54 engines. The most common Vanos problem is worn out seals. We'll be replacing them all, and in the case of the S54 Vanos, there are a few other well known issues that we will also be dealing with. The oil pump drive tabs on the Vanos exhaust hubs are known to break. The problem is caused by improperly sized holes in the oil pump rotor, and we'll show you how to replace it. Another common problem, known as Vanos "rattle", is one we will take care of by repairing the Vanos transfer gear sets and replacing the diaphragm springs behind the Vanos hub. To finish things off we'll also replace the Vanos hub bolts and cam sprocket hub bolts - which are known to loosen over time, and the upper timing chain guide as well. Rebuilding the S54 dual Vanos is time consuming due to a lot of steps, but overall it's not too difficult of a job. The best part is that it'll restore smooth, consistent performance, some of which you may not even realize you've lost.

### ECS Difficulty Gauge



1 - Easy Pro - 4

**2 - Moderate** Advanced - 3

An experienced technician can complete the job in a day, however if this is the first time you've done one or if you're light on experience, it's best to plan a couple days - a perfect weekend project. There are a number of steps that require precision and patience, and this is not something you want to rush through. The best advice, as always, is to read through these instructions first to familiarize yourself with the project and make sure you have all of the required tools on hand.

While you're in the middle of this, there are a few jobs that you'll have the perfect opportunity to do. Take a look at the list below and consider these before you start. It'll save you a lot of time down the road!

- Valve cover gasket replacement
- Spark plug replacement
- Valve adjustment

*Thank you for looking to ECS Tuning for all your performance and repair needs.*

*We appreciate your business!*

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Due to the depth of this repair, there are a lot of different components that you may choose to replace or leave alone if they have already been done. These instructions are designed around a complete Vanos service, as well as replacement/repair of the most common problems that develop in the related areas. As you work your way through the repair, be sure and closely follow the links/directions next to any of the yellow street signs. These will direct you where to go depending on the step you are on or the components that you are replacing.

## REQUIRED TOOLS

Note: The tools required for each step will be listed by the step number throughout these instructions.

### Standard Automotive Tools

### Required For This Install

### Available On Our Website

- Protecta-Sockets (for lug nuts).....[ES#2221243](#)
- **3/8" Drive Ratchet** .....[ES#2765902](#)
- **3/8" Drive Torque Wrench**.....[ES#2221245](#)
- **3/8" Drive Deep and Shallow Sockets**.....[ES#2763772](#)
- **3/8" Drive Extensions**.....[ES#2804822](#)
- Hydraulic Floor Jack .....[ES#240941](#)
- **Torx Drivers and Sockets** .....[ES#11417/8](#)
- **1/2" Drive Deep and Shallow Sockets**.....[ES#2839106](#)
- **1/2" Drive Ratchet**
- 1/2" Drive Extensions
- **1/2" Drive Torque Wrench**.....[ES#2221244](#)
- 1/2" Drive Breaker Bar .....[ES#2776653](#)
- File Set
- Air Nozzle/Blow Gun
- **Bench Mounted Vise**
- Crows Foot Wrenches
- **Hook and Pick Tool Set**.....[ES#2778980](#)

- **1/4" Drive Ratchet**.....[ES#2823235](#)
- **1/4" Drive Deep and Shallow Sockets** .....[ES#2823235](#)
- **1/4" Drive Extensions** .....[ES#2823235](#)
- **1/4" Drive Torque Wrench**
- **Plier and Cutter Set** .....[ES#2804496](#)
- **Flat and Phillips Screwdrivers** .....[ES#2225921](#)
- Jack Stands .....[ES#2763355](#)
- Ball Pein Hammers
- Pry Bar Set.....[ES#1899378](#)
- Electric/Cordless Drill
- Wire Strippers/Crimpers
- Adjustable (Crescent) Type Wrenches
- Drill Bits
- Punch and Chisel Set
- **Hex Bit (Allen) Wrenches and Sockets** .....[ES#11420](#)
- Thread Repair Tools .....[ES#1306824](#)
- **Open/Boxed End Wrench Set** .....[ES#2765907](#)

### Specialty Tools

- **BMW Fan Clutch Tool Set**.....[ES#2627584](#)

- **S54 Camshaft Alignment Tool Kit**.....[ES#3145744](#)

*See Page 5 for additional information on specialty tools.*



## SPECIALTY TOOLS

The BMW fan clutch tools are very helpful for removing the fan/clutch. The wrench fits the large nut that holds the fan/clutch to the water pump and the holding fixture will lock onto two of the water pump bolts so you can hold it stationary to break the fan loose.



**ES#2627584**

The BMW S54 camshaft alignment tool set is required for engine timing. During this repair, you will need to lock the crankshaft in place and use the camshaft bridge and pins to properly time the engine. For some cars, you will also need the special crankshaft socket.



**ES#3145744**

## SHOP SUPPLIES AND MATERIALS

**Standard Shop Supply Recommendations:** We recommend that you have a standard inventory of automotive shop supplies before beginning this or any automotive repair procedure. The following list outlines the basic shop supplies that we like to keep on hand. Shop supplies with a hyperlink are available on our website.

- Hand Cleaner/Degreaser - [Click Here](#)
- Pig Mats - for protecting your garage floor and work area from spills and stains - [Click Here](#)
- Spray detailer - for rapid cleaning of anything that comes into contact with your paint such as brake fluid - [Click Here](#)
- Micro Fiber Towels - for cleaning the paint on your car - [Click Here](#)
- Latex Gloves - for the extra oily and dirty jobs - [Click Here](#)
- **Medium and High Strength Loctite Thread lock compound** - to prevent bolts from backing out - [Click Here](#)
- Anti-Seize Compound - to prevent seizing, galling, and corrosion of fasteners - [Click Here](#)
- Aerosol Brake/Parts Cleaner - for cleaning and degreasing parts
- Shop Rags - used for wiping hands, tools, and parts
- Penetrating oil - for helping to free rusted or stuck bolts and nuts
- Mechanics wire - for securing components out of the way
- Silicone spray lube - for rubber components such as exhaust hangers
- Paint Marker - for marking installation positions or bolts during a torquing sequence
- Plastic Wire Ties/Zip Ties - for routing and securing wiring harnesses or vacuum hoses
- Electrical tape - for wrapping wiring harnesses or temporary securing of small components



Note that both **medium** and **high strength** thread locking compounds are **required** for the S54 Dual Vanos repair.

## INSTALLATION NOTES

- **RH** refers to the *passenger side* of the vehicle.
- **LH** refers to the *driver side* of the vehicle.
- Always use the proper torque specifications.
- If applicable to this installation, torque specifications will be listed throughout the document and at the end as well.
- Please read all of these instructions and familiarize yourself with the complete process **BEFORE** you begin.

## PREPARATION AND SAFETY INFORMATION

ECS Tuning cares about your health and safety. Please read the following safety information. This information pertains to automotive service in general, and while it may not pertain to every job you do, please remember and share these important safety tips.

- Park your car in a safe, well lit, level area.
- Shut the engine off and remove the key from the ignition switch.
- Make sure any remote start devices are properly disabled.
- **ALWAYS** wear safety glasses.
- Make sure the parking brake is applied until the vehicle is safely lifted and supported.
- If using an automotive lift, be sure and utilize the factory specified lift points. Lifting a vehicle in an incorrect location can cause damage to the suspension/running gear.
- When lifting a vehicle using a jack, always utilize the factory specified lift points. Lifting a vehicle in an incorrect location can cause damage to the suspension/running gear. **ALWAYS** support the vehicle with jack stands.
- **ALWAYS** read and follow all safety information and warnings for the equipment you are using.



**Never get underneath a vehicle that is supported only by a jack. Always make sure that the vehicle is securely supported on jack stands.**

## VANOS REPAIR PROCEDURES

### Section 1: Getting Started

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### Section 2: Valve Block Service

2a: Removing the valve block .....	<a href="#">Page 11</a>
2b: Cleaning and solenoid/valve operation .....	<a href="#">Page 13</a>
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### Section 3: Piston Housing Service

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3c: Intake piston seal replacement .....	<a href="#">Page 39</a>
3d: Exhaust piston seal replacement .....	<a href="#">Page 49</a>

### Section 4: Anti Rattle Repairs

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4b: Vanos hub service .....	<a href="#">Page 71</a>
4c: Cam sprocket service .....	<a href="#">Page 76</a>
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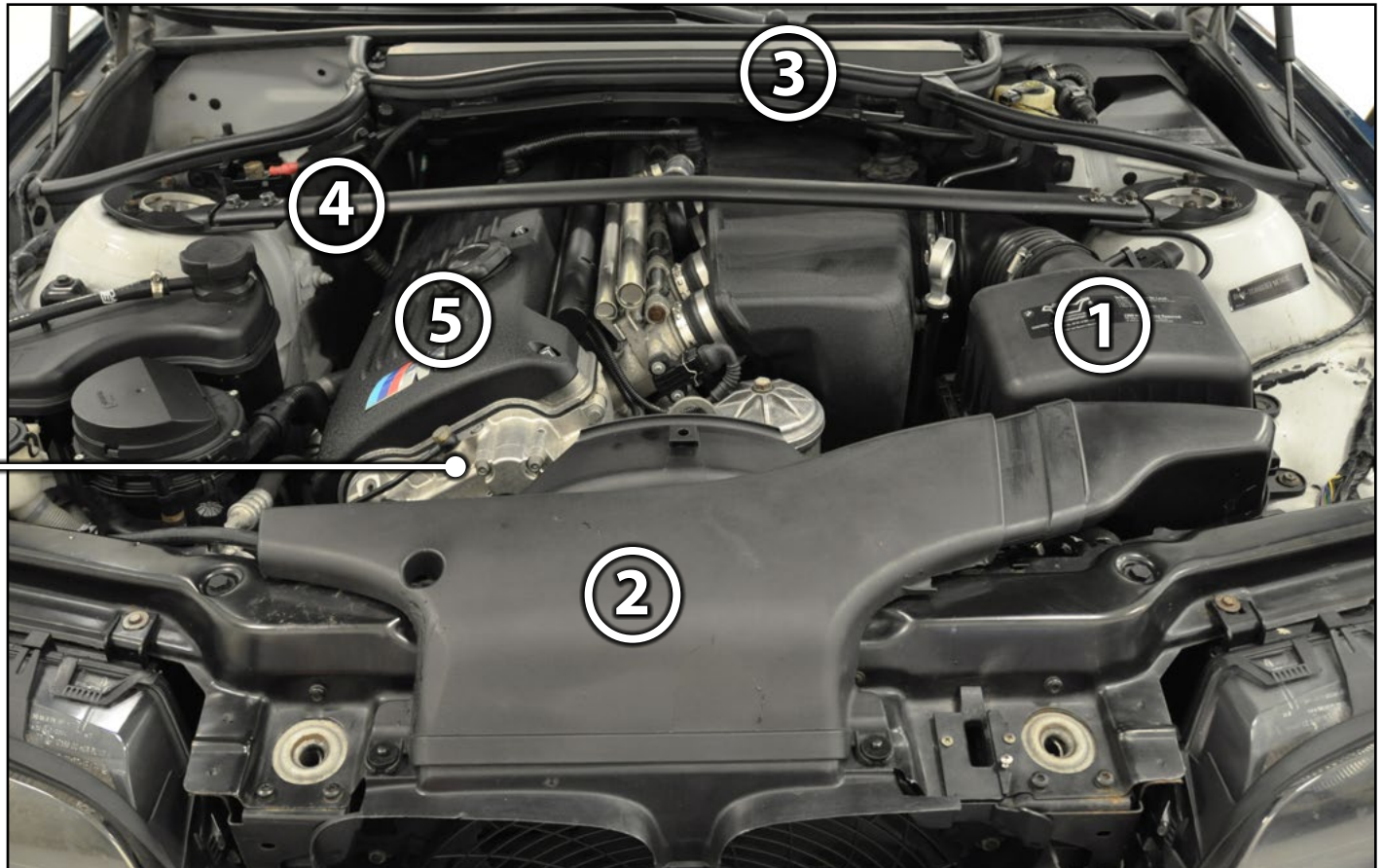
### Section 5: Reassembly

5a: Reassembly .....	<a href="#">Page 85</a>
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## SECTION 1A: VANOS SYSTEM ACCESS

Component removal to get down to the Vanos system is pretty basic, and we're betting if you're going to tackle this job you don't need us to step you through the easy stuff, but we'll give you a quick run-down anyhow. The following items will need to be removed:

1. Air Box
2. Radiator Fan and Shroud
3. Cabin Filter Housing
4. Suspension Cross Brace
5. Engine Top Cover, Valve Cover, and Ignition Coils



The Vanos system is located on the front of the engine at the top.



## SECTION 1A: VANOS SYSTEM ACCESS

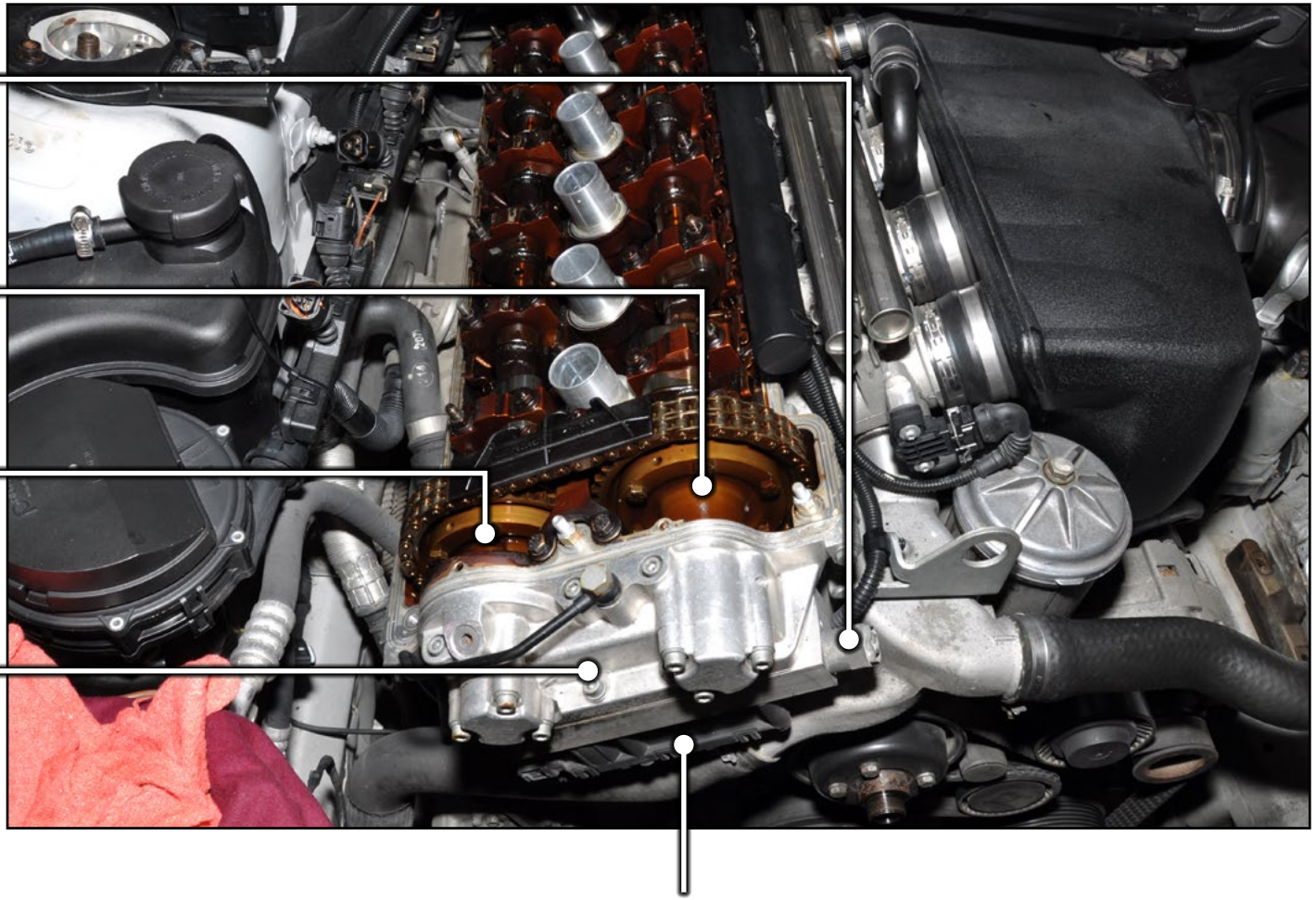
With all the preliminary components removed, you'll have plenty of room to access the Vanos system, timing chains, and camshafts. As we mentioned in the introduction, this is a perfect time to perform a valve adjustment.

Pressure  
Limiting  
Valve

Vanos Transfer  
Gear Set and  
Vanos Hub  
(Intake)

Vanos Transfer  
Gear Set and  
Vanos Hub  
(Exhaust)

Vanos Piston  
Housing



Vanos Valve Block w/Coil Pack

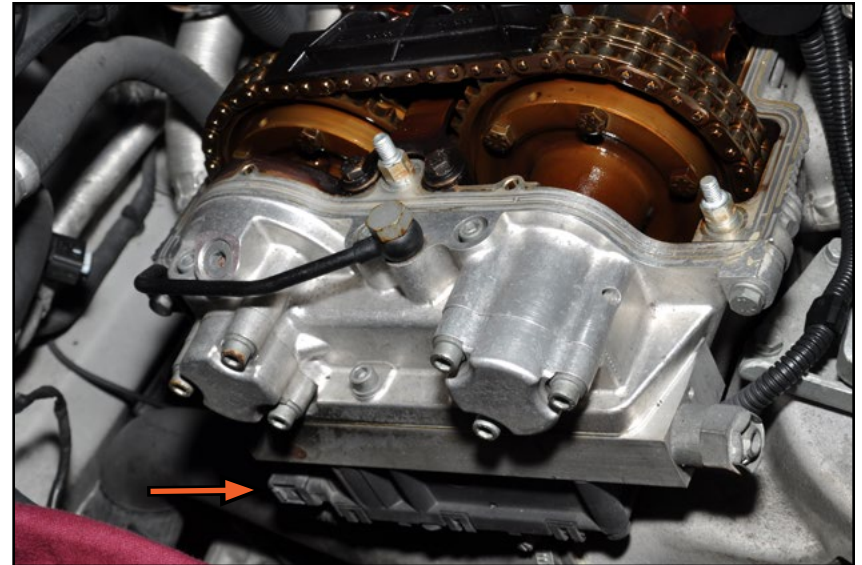
**- End of Section 1a -**

## SECTION 2A: REMOVING THE VALVE BLOCK

### Step 1:

Disconnect the electrical plug from the coil pack. It's located on the lower left side, and should unplug pretty easily by hand.

There may be a cable tie near the plug that secures the harness in place. If so, remove it by cutting it off.



### Step 2:

Place shop rags underneath the valve block to protect the coolant hose and belts from oil that you'll lose when you loosen the bolts.





## SECTION 2A: REMOVING THE VALVE BLOCK

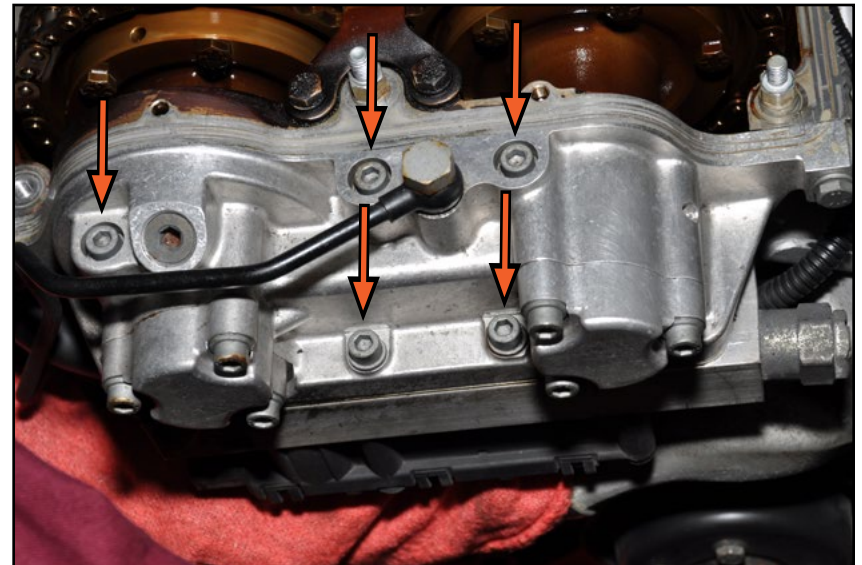
### Step 3: 22mm Wrench

Loosen the pressure limiter in the valve block. Do not remove it at this time, just break it loose.



### Step 4: 5mm Allen (Hex Bit)

Remove the five mounting bolts, then pull the valve block out from underneath the piston housing and remove it along with the sealing plate.

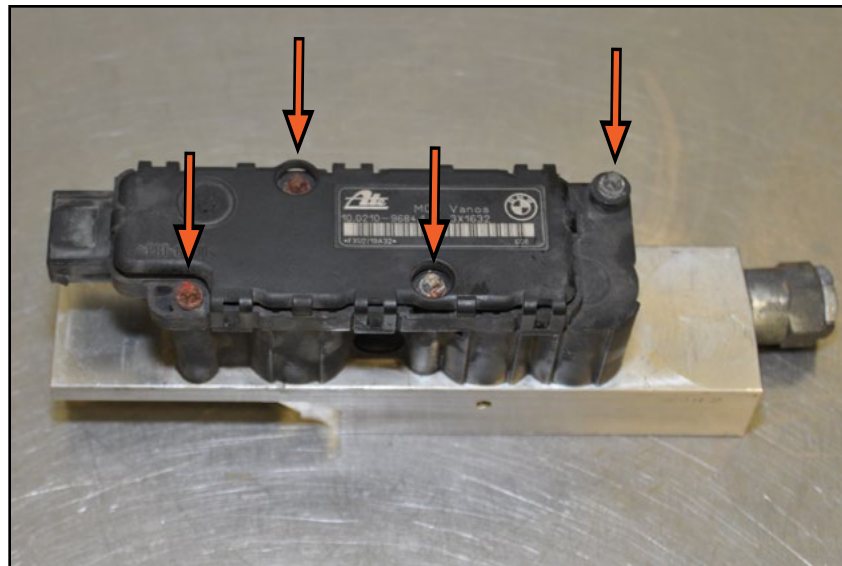


*- End of Section 2a -*

## SECTION 2B: CLEANING AND VALVE OPERATION

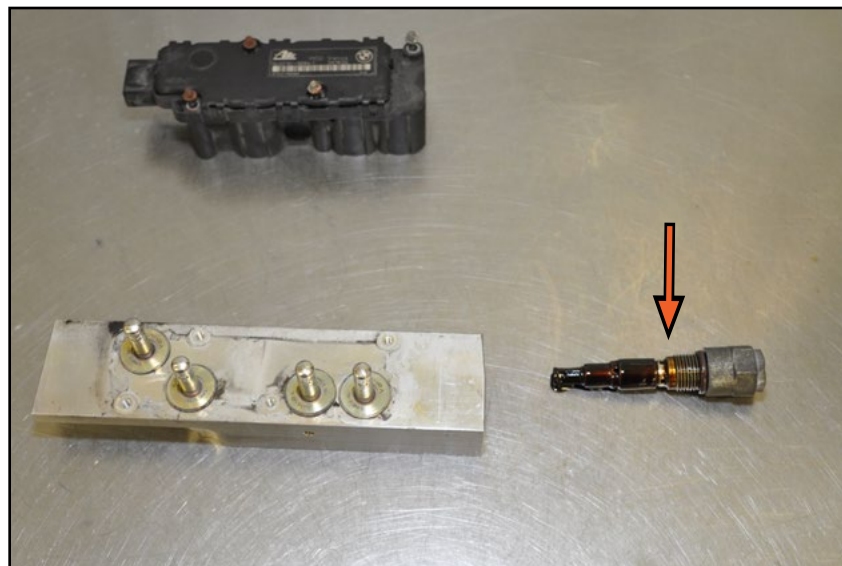
### Step 1: E5 Torx Socket

Remove the four coil pack mounting screws and lift the coil pack off of the valve block.



### Step 2:

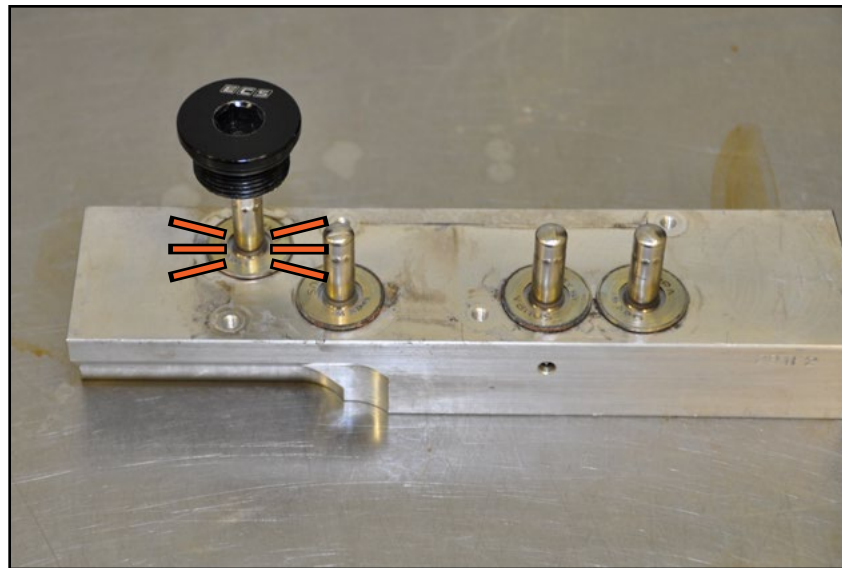
Unthread and remove the pressure limiter from the valve block (you should have loosened this on page 12).



## SECTION 2B: CLEANING AND VALVE OPERATION

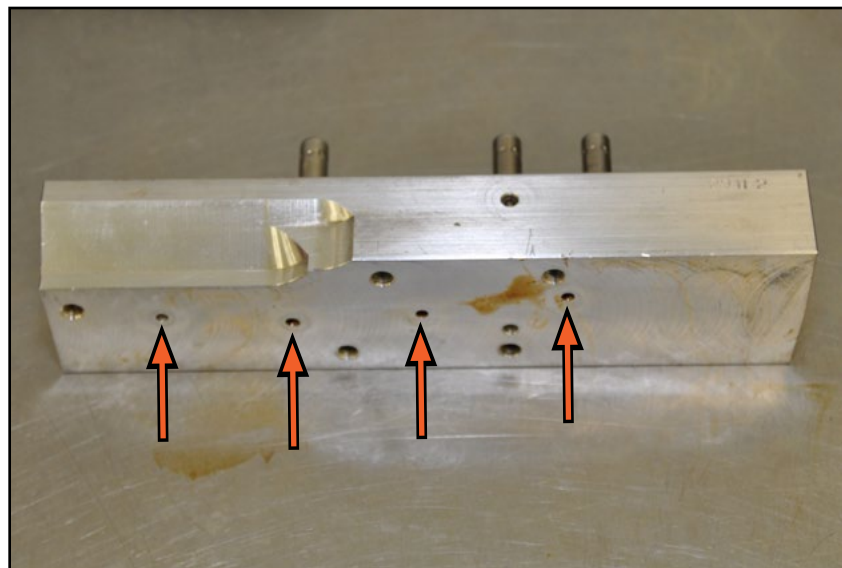
### Step 3: Strong Magnet

Clean the outside of the valve block thoroughly. Next, place a magnet onto the end of each solenoid plunger. We are using a large drain plug magnet here. Listen very closely as you place the magnet onto the plunger, then remove it. You will hear a faint "click" as the valve opens and closes.



### Step 4:

One at a time, place the magnet on top of each plunger and confirm that you hear the "click" of the valve opening. With the valve open, spray brake cleaner into the corresponding hole underneath to flush out any debris.



*- End of Section 2b -*

## SECTION 2C: SEAL AND FILTER REPLACEMENT - REQUIRED PARTS

### ES#23069

Description.....Vanos Filter  
 Location .....Pressure Limiting Valve  
 Quantity .....1



### ES#3138145

Description.....14mm OD x 2.0mm o-Ring  
 Location .....Pressure Limiting Valve Small  
 Quantity .....1



### ES#3138146

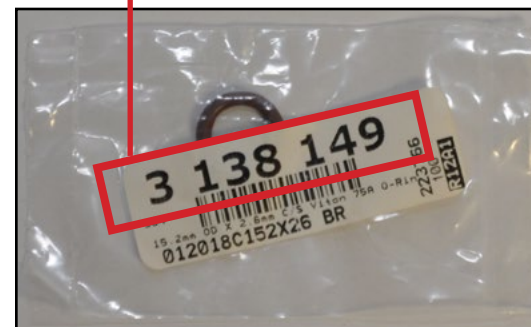
Description.....14.5mm ID x 3mm o-Ring  
 Location .....Pressure Limiting Valve Large  
 Quantity .....1



### NOTE:

All o-rings and Teflon rings will be sealed in individual poly bags - do not unpack them until you are ready to install them. Prior to use, always positively identify each seal by the ES# on the label.

ES#





## SECTION 2C: SEAL AND FILTER REPLACEMENT

### Step 1:

Remove the large o-ring, small o-ring, and the screen from the pressure limiter, using the following guidelines:

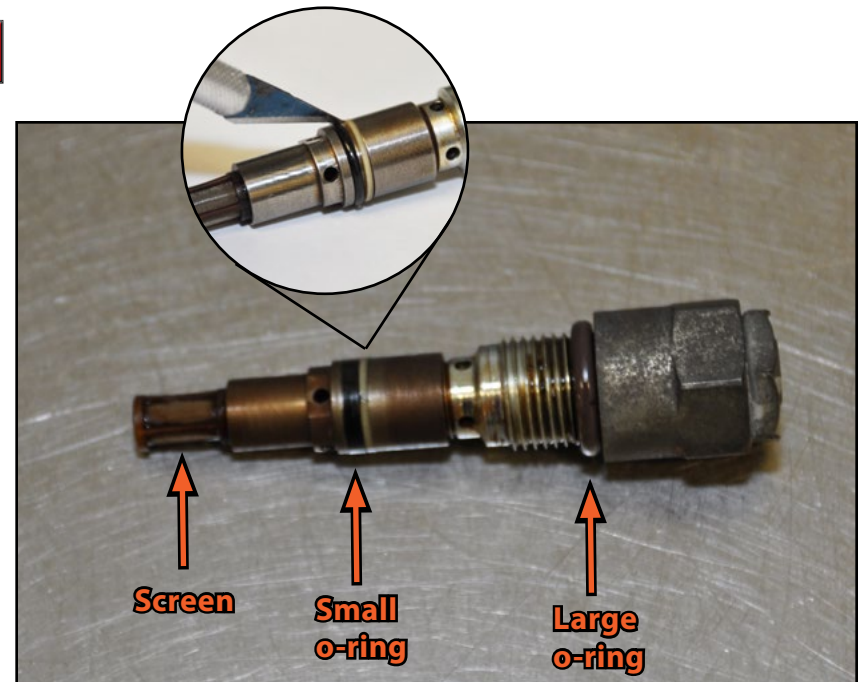
- 1) Pull the screen off the end of the limiter using a pair of pliers.
- 2) Carefully cut the small o-ring off using an exacto knife.
- 3) Remove the large o-ring.



Be careful not to cut the nylon washer when removing the small o-ring. You may also notice a split in the washer. This is normal. The washer is split for the purpose of installation.

### Step 2:

Install the new large and small o-rings, and the new screen onto the pressure limiter.



## SECTION 2C: SEAL AND FILTER REPLACEMENT

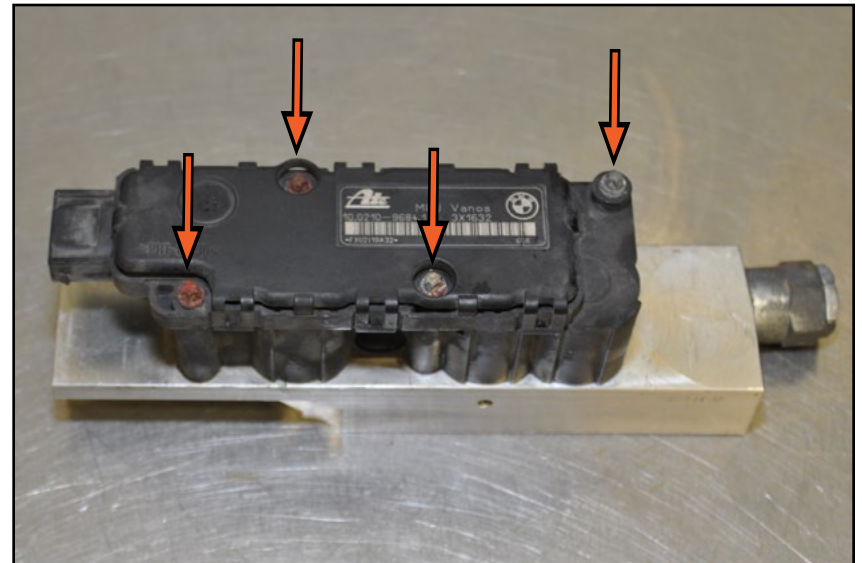
### Step 3:

Lubricate the o-rings with clean engine oil, then thread the pressure limiter back into the valve block. You do not have to tighten it at this point, you'll tighten it later after it is installed.



### Step 4: E5 Torx Socket, 1/4" Torque Wrench

Reinstall the coil pack and torque the mounting screws in an even manner to 4 Nm (3 Ft-lbs).



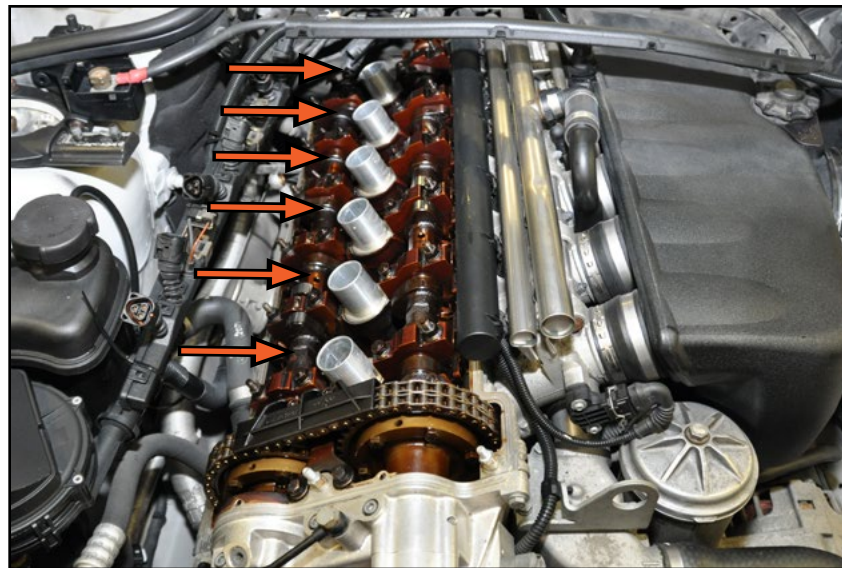
*You're all done with the valve block! You can set it aside for now until it's time for reassembly.*

**- End of Section 2c -**

## SECTION 3A: PISTON HOUSING REMOVAL

### Step 1:

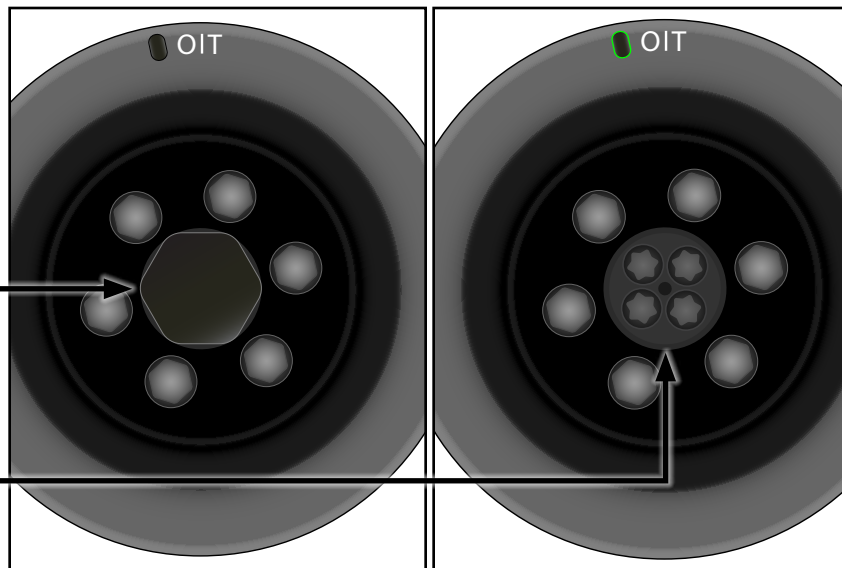
Remove the spark plugs. You're going to have to rotate the engine over a few times during this repair, and this will make it much easier.



### Step 2:

Inspect the front of the crankshaft pulley (you may need to use a mirror). You will see either a large hex or four Torx bolts. The large hex will require a 32mm socket, and if equipped with the four Torx bolts, you will need the special socket that is included in the S54 camshaft alignment tool kit.

Requires 32mm  
Socket

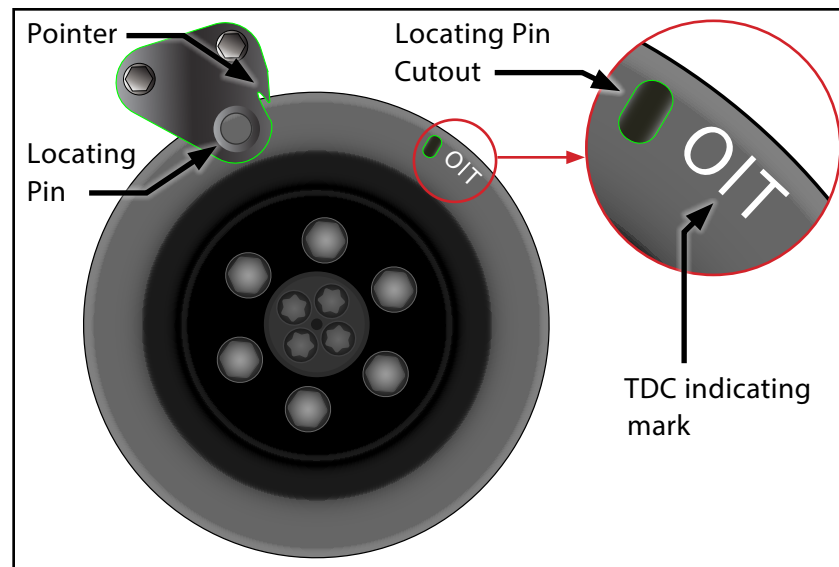




## SECTION 3A: PISTON HOUSING REMOVAL

### Step 3:

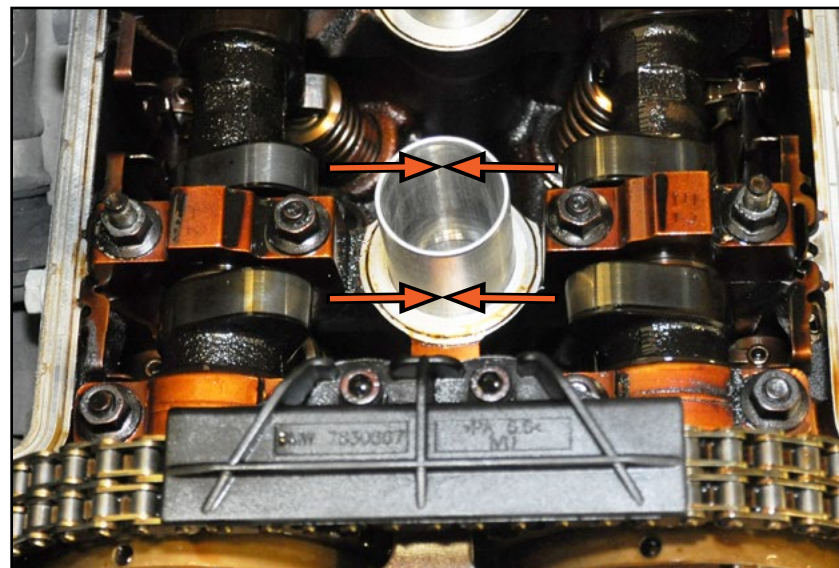
The crankshaft pulley has a line that indicates top dead center and a small recessed cutout for the crankshaft locating pin. Locate these marks and also note that there is a fixed pointer that is located in approximately the 11 o'clock position. The pointer also has a hole in it to accept the crankshaft locating pin.



### Step 4: 1/2" Drive Ratchet

Using a long ratchet and the socket needed for your engine (step 2), rotate the engine in a clockwise direction until the intake and exhaust cam lobes on cylinder #1 are pointing together in an approximate 45 degree angle.

When the cylinder #1 cam lobes are pointing at each other, this indicates that the engine is at (approximately) TDC.

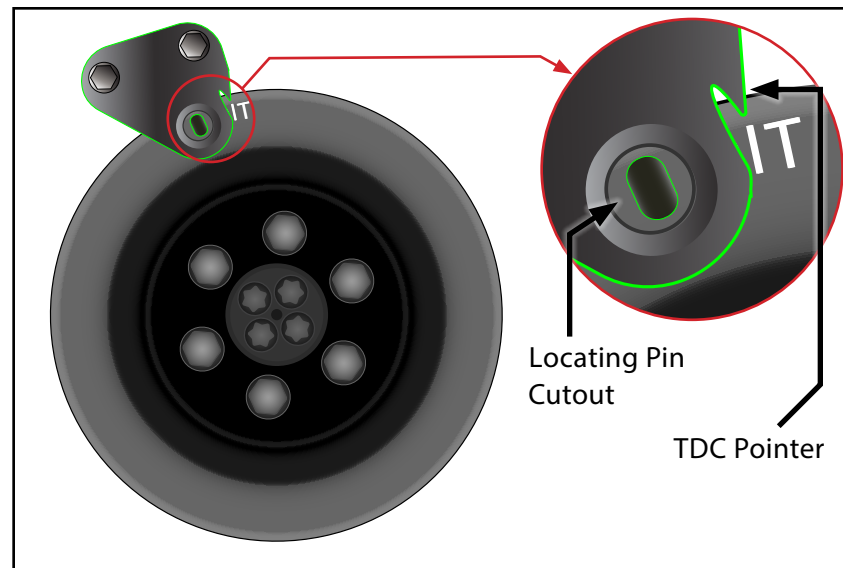


## SECTION 3A: PISTON HOUSING REMOVAL

### Step 5:

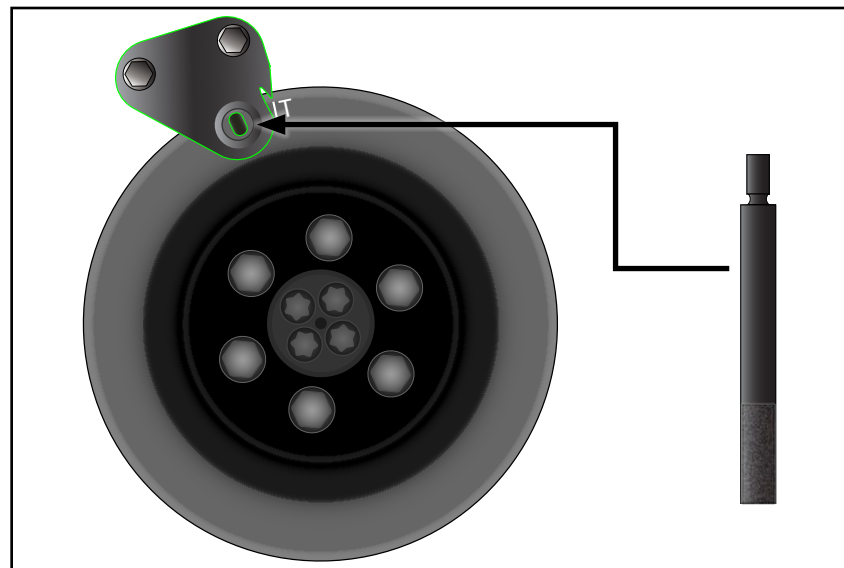
Make fine adjustments as needed so the TDC pointer is lined up with the TDC indicating mark on the crank pulley. In this position, the locating pin cutout will be centered perfectly in the hole in the pointer.

It is OK to rotate the crankshaft counter clockwise in order to line up the marks.



### Step 6:

Insert the crankshaft locking pin into the hole in the pointer and into the crankshaft pulley. Make sure that the end of the pin is fully seated into the crank pulley.



## SECTION 3A: PISTON HOUSING REMOVAL

### Step 7: 24mm Open End Wrench

Fully retard the exhaust camshaft by rotating it counter clockwise. There is a hex on the camshaft so you can engage a 24mm wrench.

*Reference Step 9 for fully retarded position*

Doing this causes the transfer gear to extend fully out the front of the Vanos hub, making it easier to disconnect it from the Vanos piston.



You may have to rock the cam back and forth at first to get it to rotate, and it does not have to rotate very far for the transfer gear to fully extend.



### Step 8: 24mm Open End Wrench

Fully retard the intake camshaft by rotating it counter clockwise. There is a hex on the camshaft so you can engage a 24mm wrench.

*Reference Step 9 for fully retarded position*

Doing this causes the transfer gear to extend fully out the front of the Vanos hub, making it easier to disconnect it from the Vanos piston.



You may have to rock the cam back and forth at first to get it to rotate, and it does not have to rotate very far for the transfer gear to fully extend.





## SECTION 3A: PISTON HOUSING REMOVAL

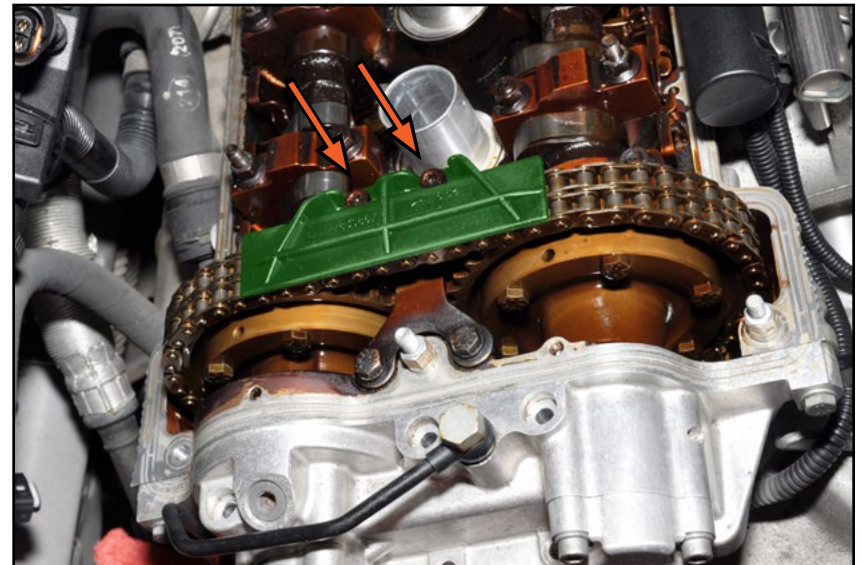
### Step 9:

There is a hole in each camshaft between cylinders 2 and 3. When both cams are fully retarded, the holes will be facing upward in approximately a 90 degree angle to the cylinder head.



### Step 10: 5mm Allen (Hex Bit)

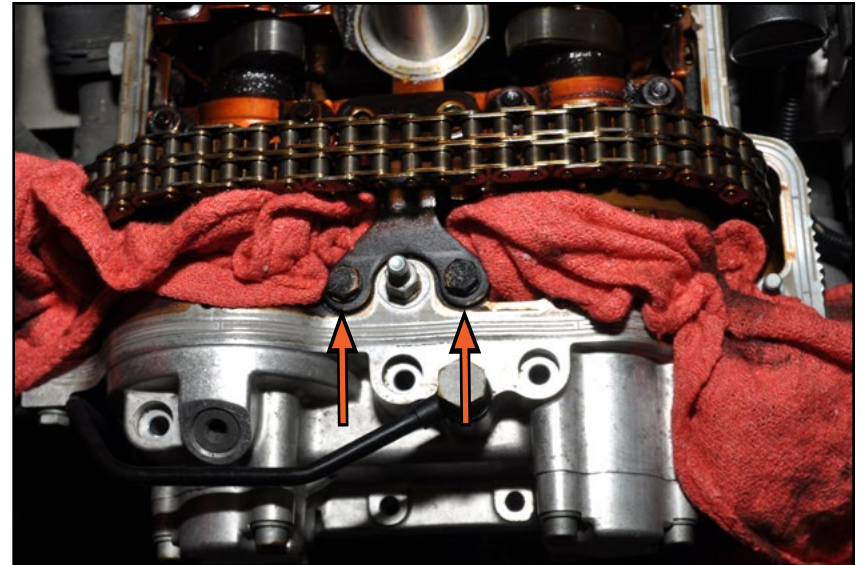
Remove the two screws and lift off the cam chain guide.



## SECTION 3A: PISTON HOUSING REMOVAL

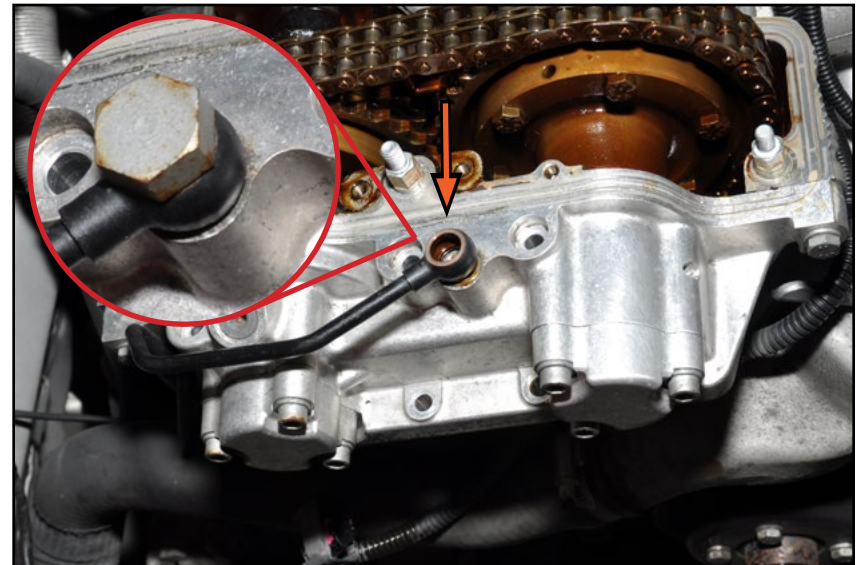
### Step 11: 10mm Socket, Ratchet

Cover the area between the Vanos hubs and piston housing to keep from dropping anything down into the engine, then remove the two bolts and remove the Vanos bracket.



### Step 12: 14mm Socket, Ratchet

Remove the banjo bolt holding the oil pipe to the top of the Vanos piston housing.

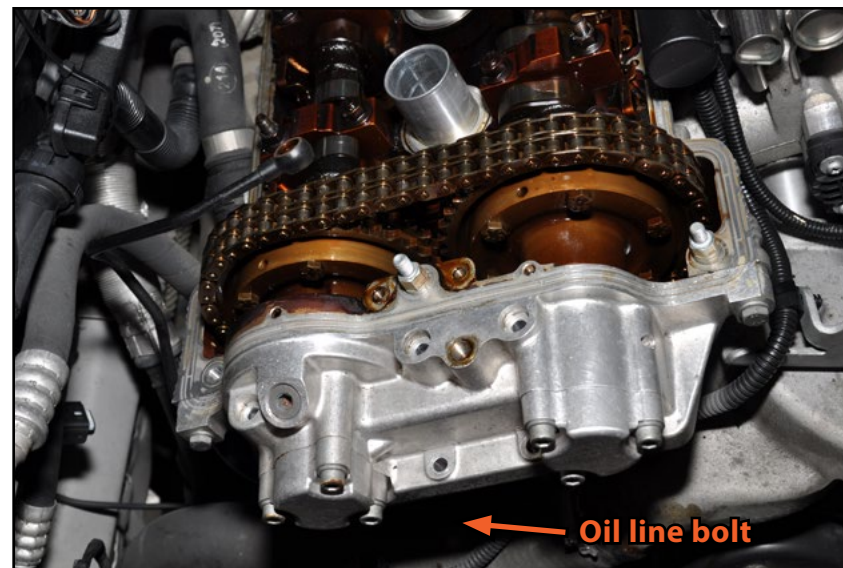




## SECTION 3A: PISTON HOUSING REMOVAL

### Step 13: 10mm Socket, Ratchet, Extension

Difficult to see but easy to remove, there is a 10mm bolt that holds the oil pipe in place. It's located on the front of the engine behind the lower radiator hose. Remove it and then you can move the oil pipe out of the way.



### Step 14: 10mm Socket, 5mm Allen (Hex) Socket, Ratchet, Extension

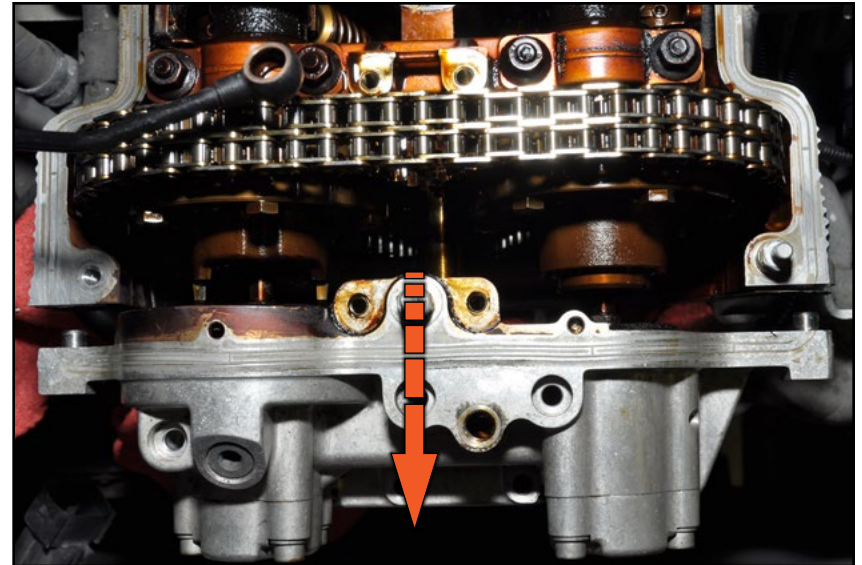
Remove the five piston housing mounting bolts. There are two hex bolts in the upper corners, and three Allen bolts along the bottom edge. You can see them all in this picture.



## SECTION 3A: PISTON HOUSING REMOVAL

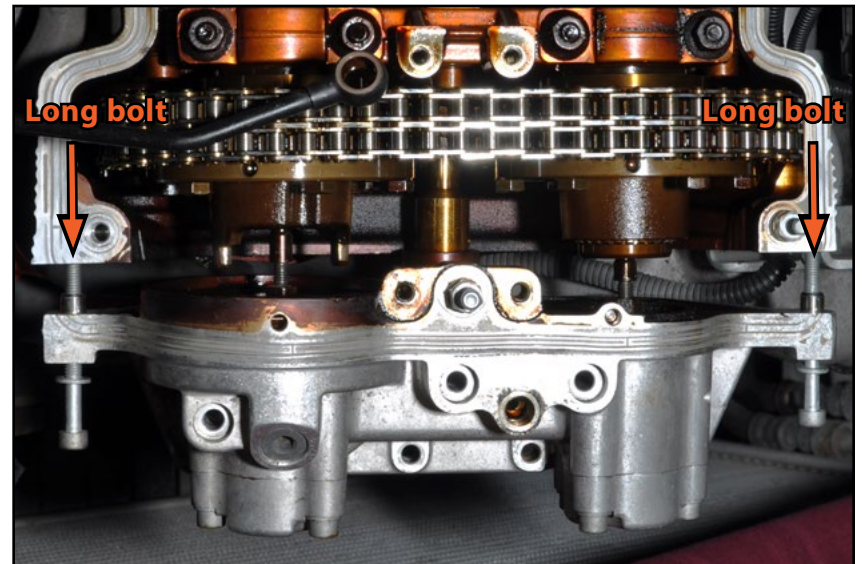
### Step 15:

Gently pry the piston housing forward off of the cylinder head so you can access the transfer gear sets in order to disconnect them from the Vanos pistons.



### Step 16:

“Borrow” the two long bolts from the valve block and install them through the upper corners of the piston housing, then thread them into the cylinder head. This will support the piston housing as you disconnect the transfer gear sets in the next step.

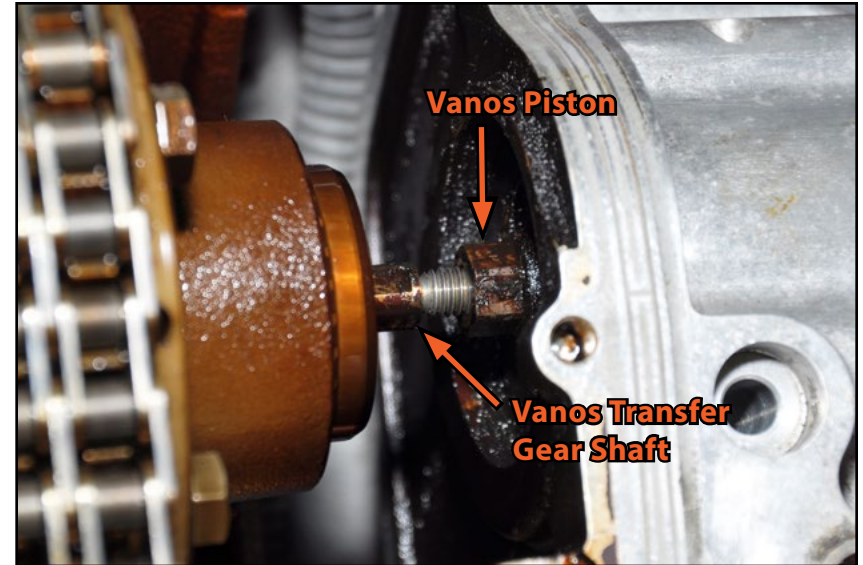




## SECTION 3A: PISTON HOUSING REMOVAL

### Step 17: 7mm, 10mm Open End Wrench

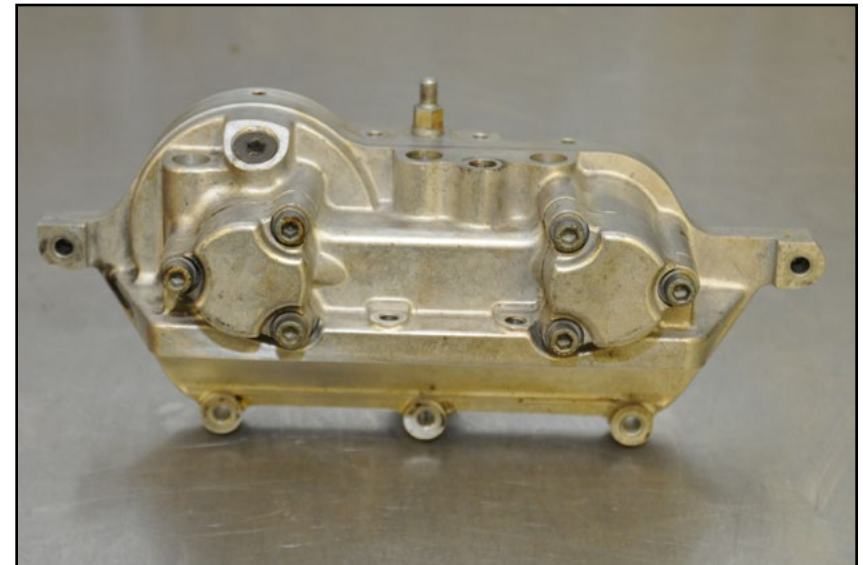
Disconnect both transfer gear sets from the Vanos pistons. These are **LH Thread**, so you will loosen them in the **opposite** direction as normal. The picture on the right shows the Vanos transfer gear shaft unthreaded most of the way from the Vanos piston. The shaft is 7mm and the piston is 10mm.



### Step 18:

With both transfer gear shafts disconnected from the Vanos pistons, remove the long valve block mounting bolts, then remove the piston housing from the engine and place it on a clean workbench.

**- End of Section 3a -**



## SECTION 3B: VANOS OIL SYSTEM SERVICE - REQUIRED PARTS

### ES#3138159

Description.....Revised Oil Pump Rotor

Location.....Vanos Oil Pump

Quantity.....1



### ES#3138142

Description.....20mm OD x 2.0mm o-Ring

Location.....Oil Regulator Large End

Quantity.....1



### ES#3138143

Description.....15mm OD x 2.0mm o-Ring

Location.....Oil Regulator Small End

Quantity.....1



### NOTE:

All o-rings and Teflon rings will be sealed in individual poly bags - do not unpack them until you are ready to install them. Prior to use, always positively identify each seal by the ES# on the label.

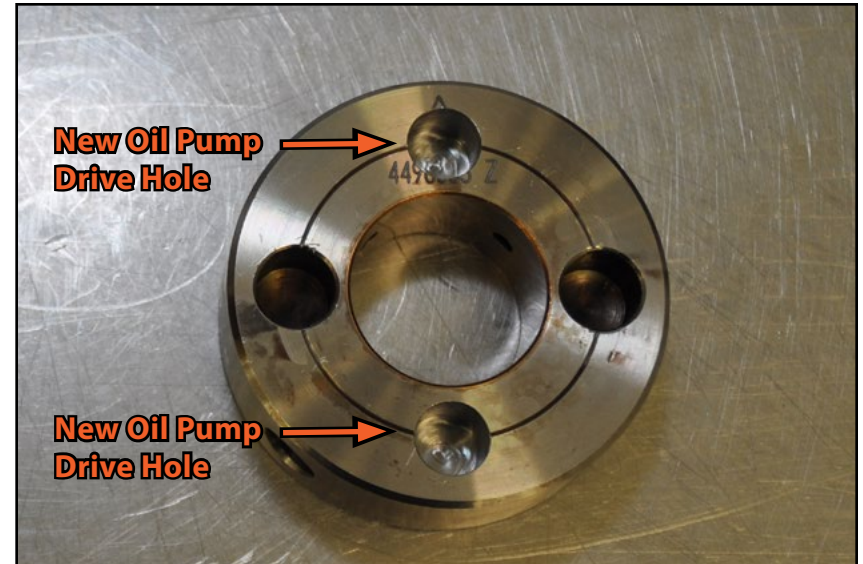
ES#



## SECTION 3B: VANOS OIL SYSTEM SERVICE

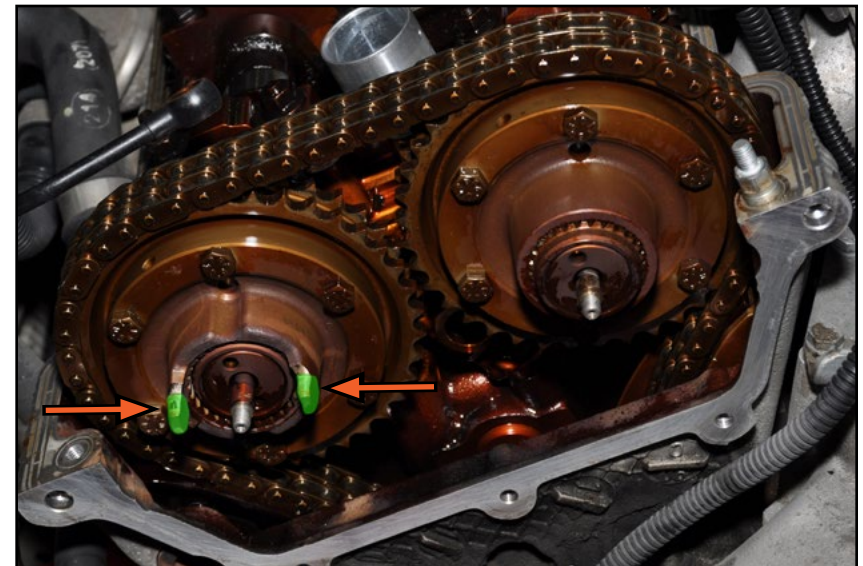
### Step 1:

Inspect the revised oil pump rotor in your kit. Two new holes have been machined into it and sized properly to fit the oil pump drive tabs on the Vanos exhaust hub. You'll notice that the new holes are smaller, which will eliminate tab breakage over time resulting from a continuous impacting between the tabs and the large holes.



### Step 2:

Closely inspect the oil pump drive tabs on the Vanos exhaust hub. Make sure they are not worn or cracked. If these are visibly worn, you will have to order a replacement hub.





## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 3:

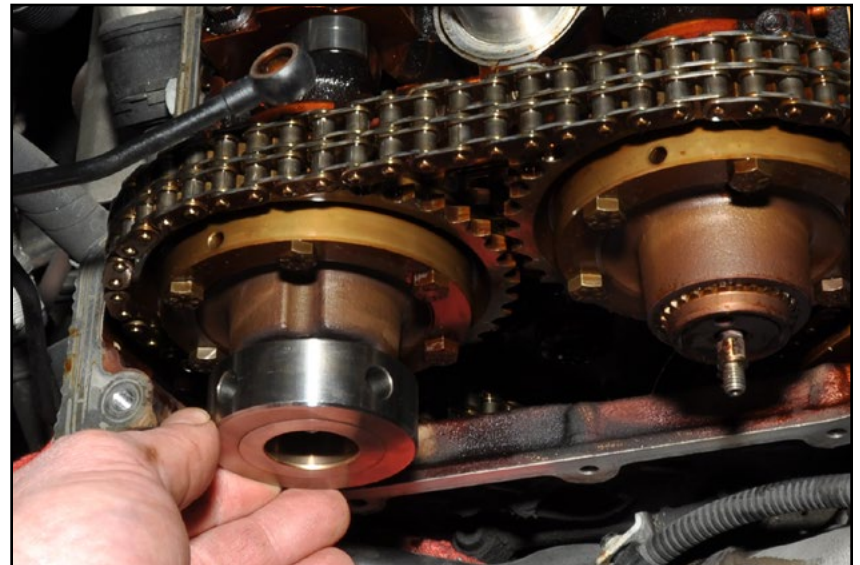
Now we're going to check the fit of the revised oil pump rotor to the drive tabs. Align the new (smaller) holes in the rotor with the tabs on the Vanos exhaust hub.



### Step 4:

Slide the revised oil pump rotor onto the drive tabs. It should slide easily into place and only have very slight back and forth movement.

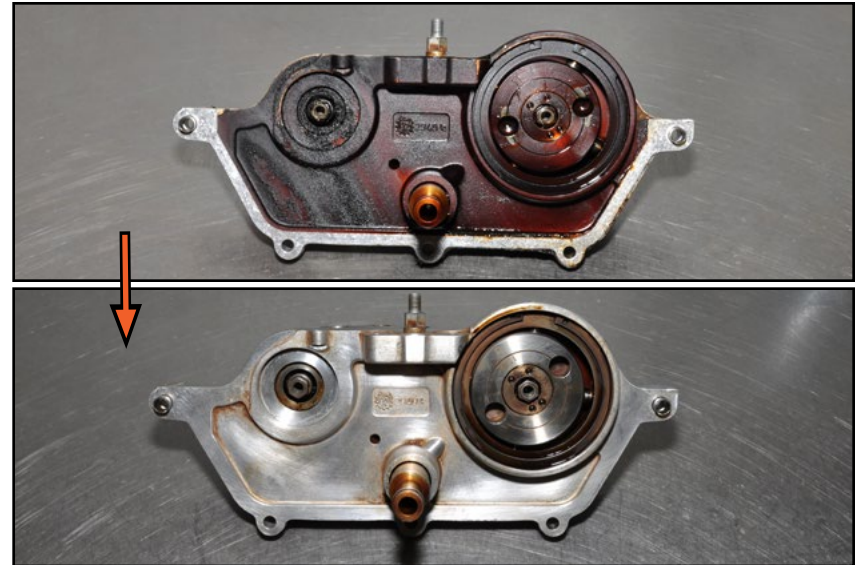
Once you have confirmed fit of the revised oil pump rotor, pull it back off and set it aside for the moment.



## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 5:

Thoroughly clean the piston housing using brake cleaner and shop rags, then rest it on the front side so you are looking at the oil pump.



### Step 6: Snap Ring Pliers

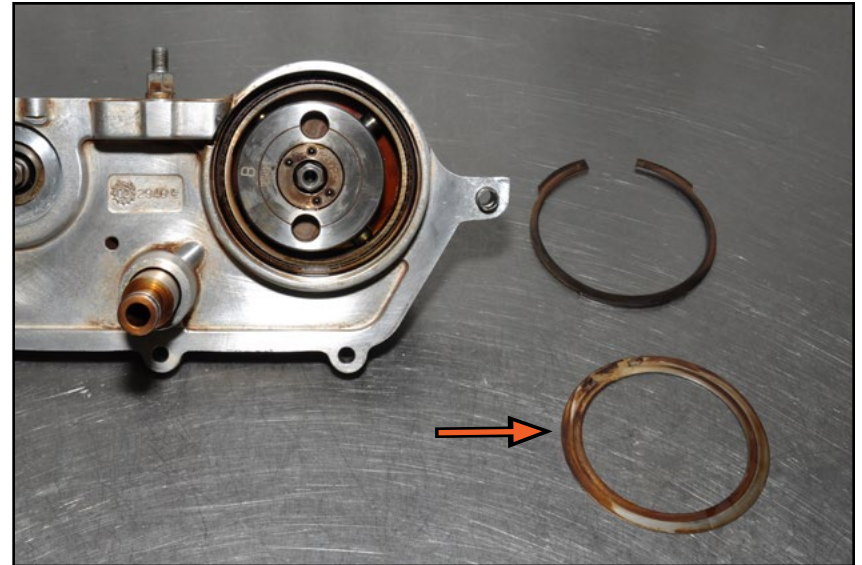
Remove the oil pump snap ring.



## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 7: Small Angled Pick

Remove the oil pump retaining washer.



### Step 8:

Place the piston housing into a plastic bag as shown.





## SECTION 3B: VANOS OIL SYSTEM SERVICE

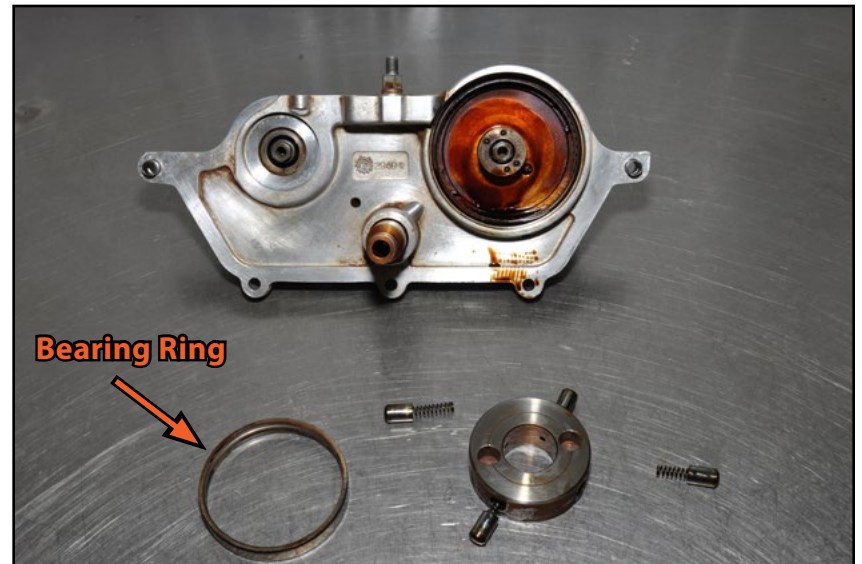
### Step 9:

Turn the housing over and bump it against your hand or a piece of wood until the oil pump pops out of the housing. You will see that many of the small pieces of the oil pump will shoot out and be caught by the bag.



### Step 10:

Remove all parts from the bag. If the bearing ring is still inside the housing, remove it at this time as well.

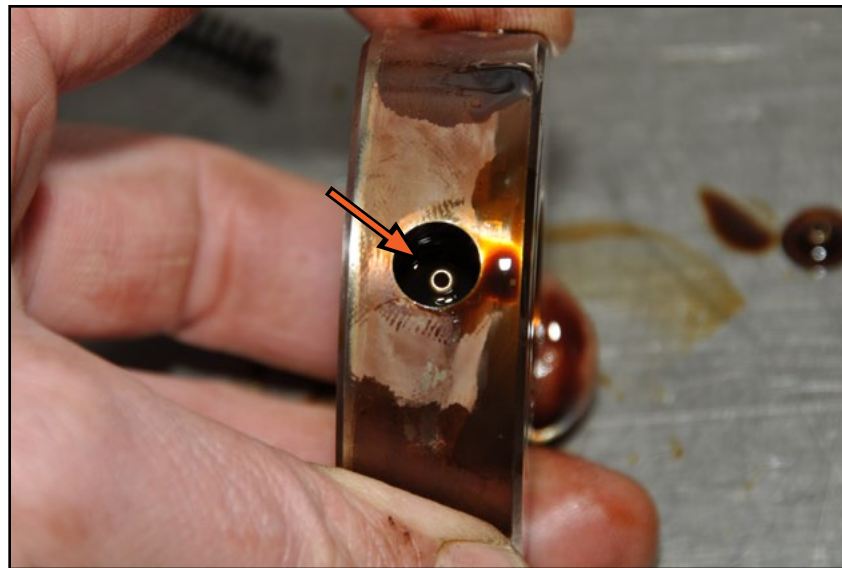




## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 11:

Look into the four holes around the perimeter of the oil pump rotor. There is a spring seat in the bottom of each one. Some of these may have fallen out already, but if any are remaining, gently pull them out with a small angled pick.



### Step 12:

Take stock of what you have to make sure nothing has been lost. The oil pump components should consist of:

- (1) Oil Pump Rotor
- (1) Bearing Ring
- (4) Spring Seats
- (4) Springs
- (4) Spring Caps

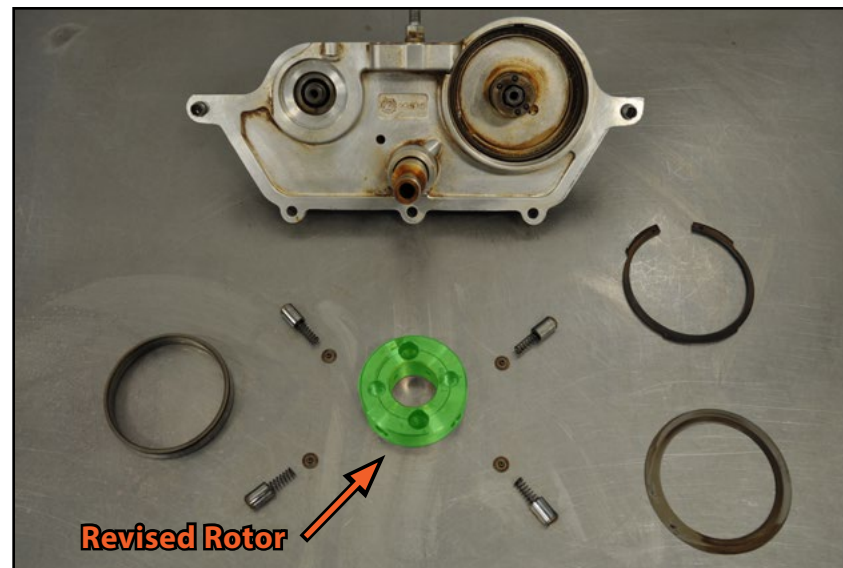


## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 13:

Thoroughly clean all oil pump components including the oil pump bearing which is still located in the piston housing.

Lay the components out in preparation for reassembly and replace the original oil pump rotor with the new revised rotor.



### Step 14:

Note the reassembly position of the components. When placed back into the holes in the perimeter of the oil pump rotor, the spring seat nipples must face up, or outward.

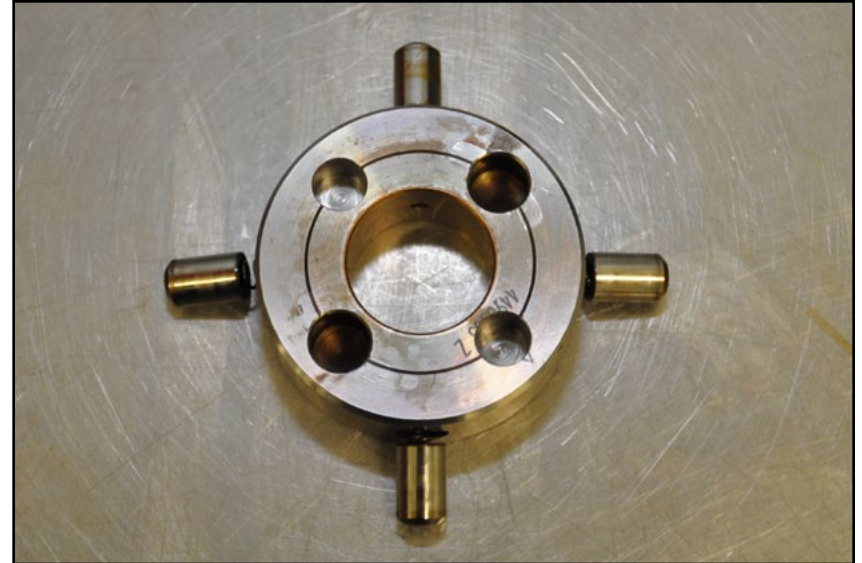
As demonstrated in the RH photo, the spring seat nipple must protrude into the spring.



## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 15:

Reassemble the oil pump rotor by inserting the spring seats, springs, and spring caps into each of the four holes in the rotor perimeter.



### Step 16:

Pushing and holding the spring caps into the rotor, insert the rotor into the middle of the bearing ring as shown.





## SECTION 3B: VANOS OIL SYSTEM SERVICE

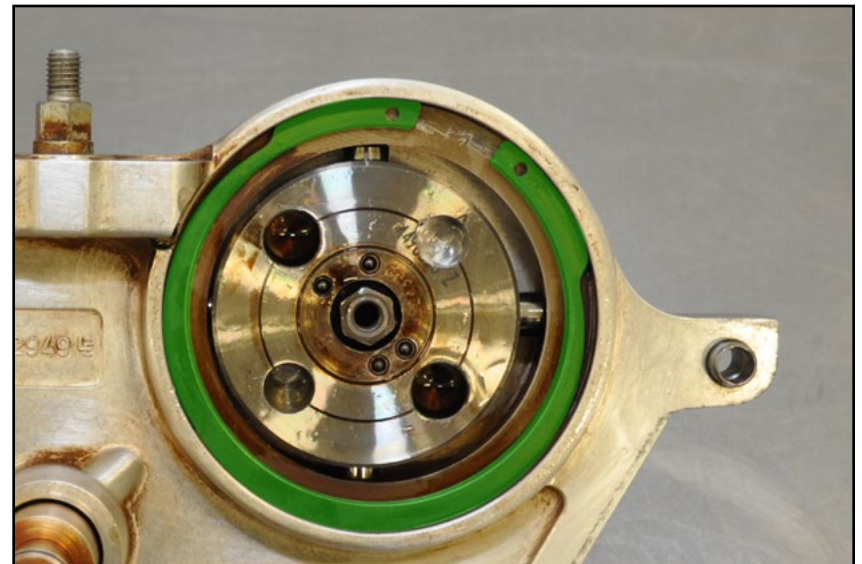
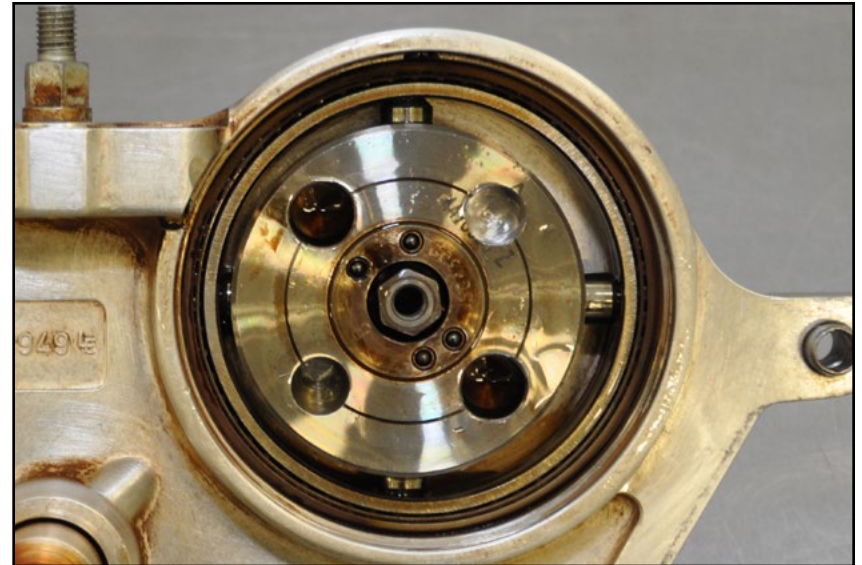
### Step 17:

Lubricate the oil pump bearing and rotor with clean engine oil, then reinstall the rotor and bearing ring assembly into the piston housing.

Note that the rotor is off center in relation to the bearing ring. As you slide the rotor into place, you'll have to adjust the position of the bearing ring to line up with the bearing.

### Step 18: Snap Ring Pliers

Install the oil pump retaining washer and snap ring.

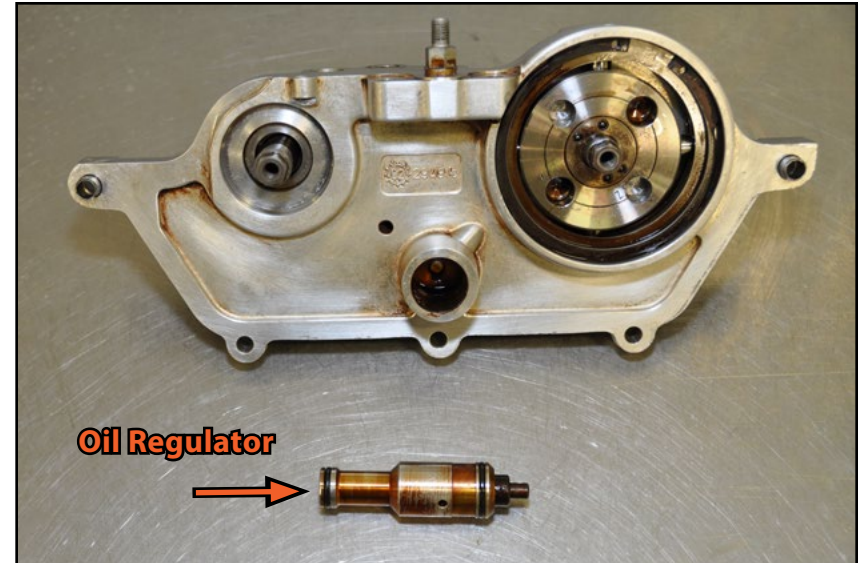




## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 19:

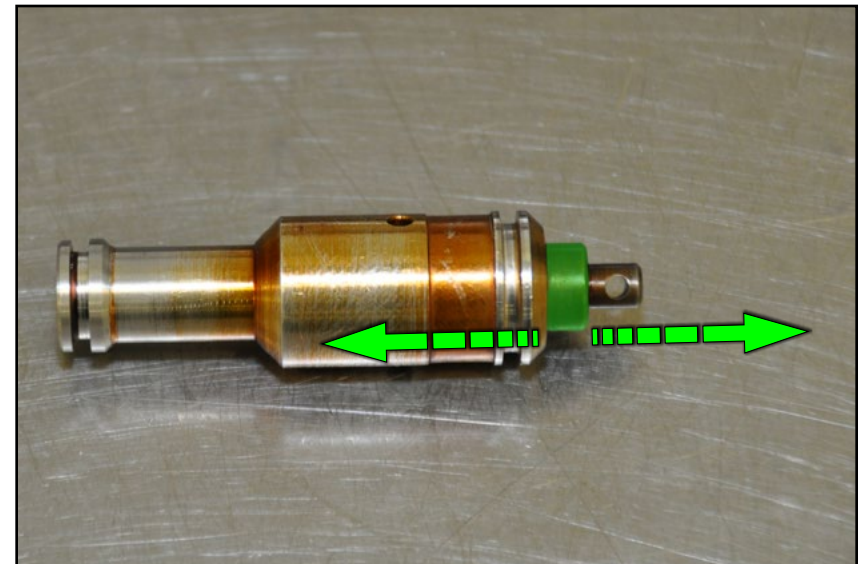
Pull the oil regulator out of the piston housing.



### Step 20:

Remove the original o-rings and thoroughly clean the oil regulator using brake clean to flush out any old oil.

Check the operation of the oil flow regulator valve. The highlighted component should push into the regulator and spring back out.



## SECTION 3B: VANOS OIL SYSTEM SERVICE

### Step 21:

Install the new o-rings into place on the large and small ends.



### Step 22:

Lubricate the large o-ring with clean engine oil and push the oil regulator into place in the piston housing. Be sure to locate the holes at the sides as shown.



*- End of Section 3b -*

## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT - REQUIRED PARTS

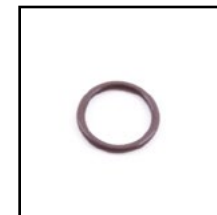
### \* ES#3138134

Description.....Large Teflon Sealing Ring  
 Location .....Intake Piston  
 Quantity .....1



### \* ES#3138139

Description..... 13mm ID x 1.7mm o-Ring  
 Location .....Intake Piston  
 Quantity .....1



### ES#3138138

Description.....Inverted Teflon Sealing Ring  
 Location .....Intake Piston Cylinder  
 Quantity .....1



### ES#3138141

Description..... 15.5mm ID x 1.7mm o-Ring  
 Location .....Intake Piston Cylinder  
 Quantity .....1



### \* ES#3138144

Description.....36mm OD x 2.0mm o-Ring  
 Location .....Intake Piston Cap  
 Quantity .....1



### NOTE:

All o-rings and Teflon rings will be sealed in individual poly bags  
 - do not unpack them until you are ready to install them. Prior to use, always positively identify each seal by the ES# on the label.

ES#



\* Identical seal also used on exhaust piston - a total of two are included in the kit.

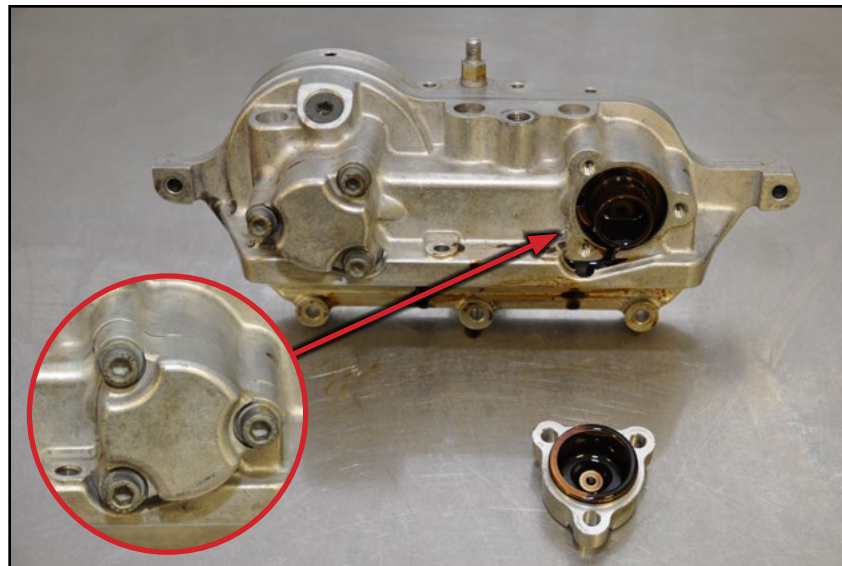
## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

### Step 1: 5mm Allen (Hex Bit) Socket, Ratchet

Remove the three bolts and pull off the intake piston cap.

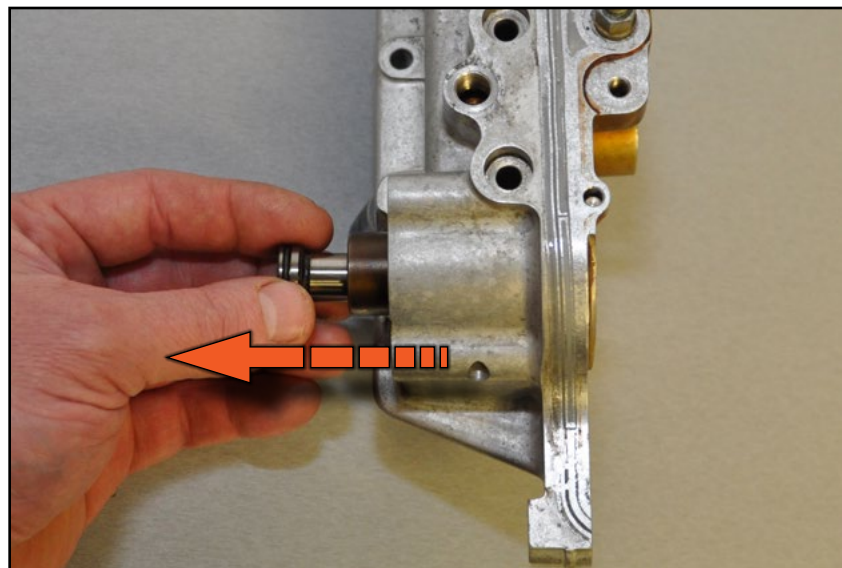


These can be difficult to remove due to a stuck seal. You may have to use a thin scraper/putty knife or similar tool to help pry the cap loose.



### Step 2:

Push/pull the intake piston out of its cylinder towards the direction of the cap.





## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

### Step 3:

Inspect the intake piston. One end has a groove with a rubber o-ring surrounded by a Teflon sealing ring.

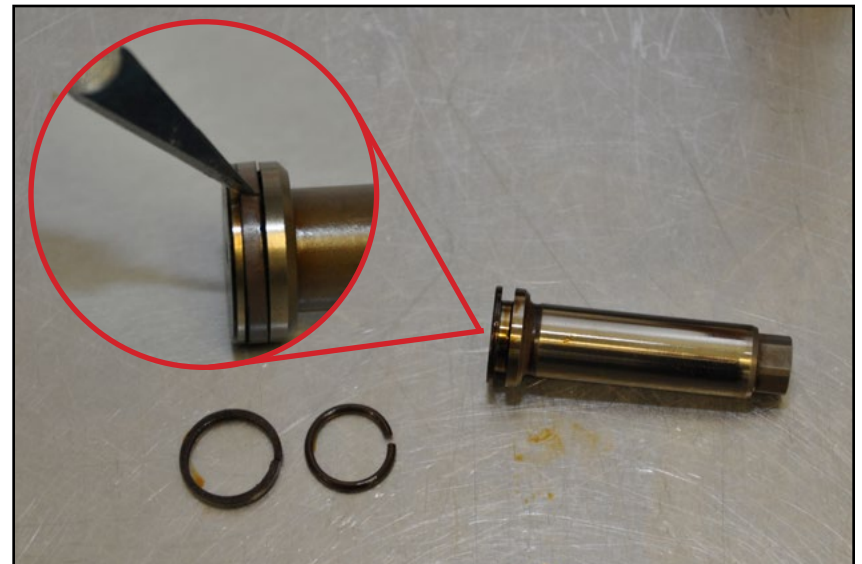


### Step 4: Exacto Knife

Carefully cut the sealing ring and o-ring using an exacto knife, then remove them from the piston ring groove.



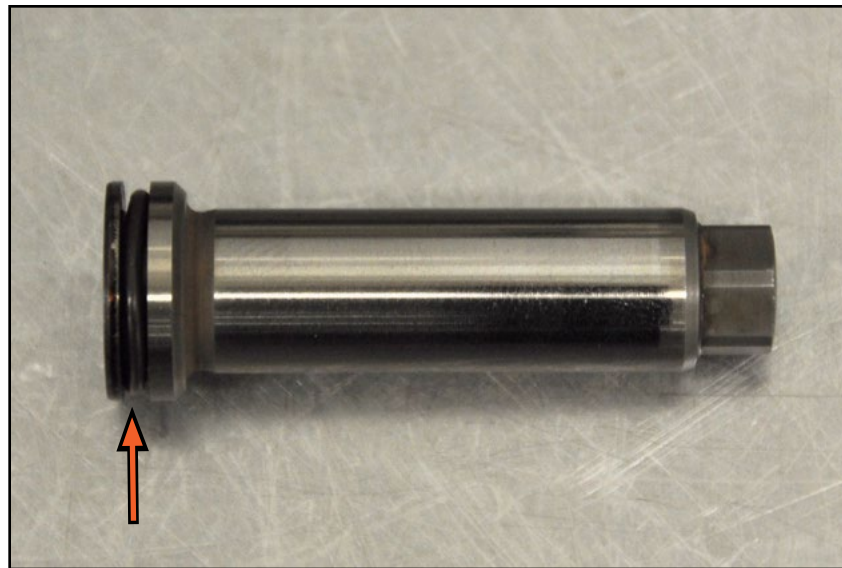
Use caution not to cut or damage the surface of the intake piston.



## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

### Step 5:

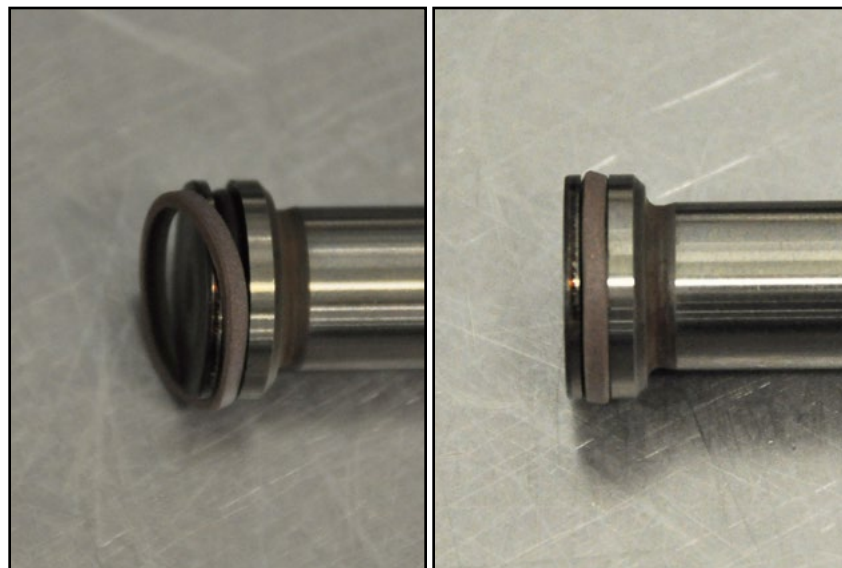
Clean the piston thoroughly then install the new o-ring into the groove.



### Step 6:

Warm the Teflon sealing ring slightly by dipping it in warm water, or even holding it in your hand and blowing on it for a minute.

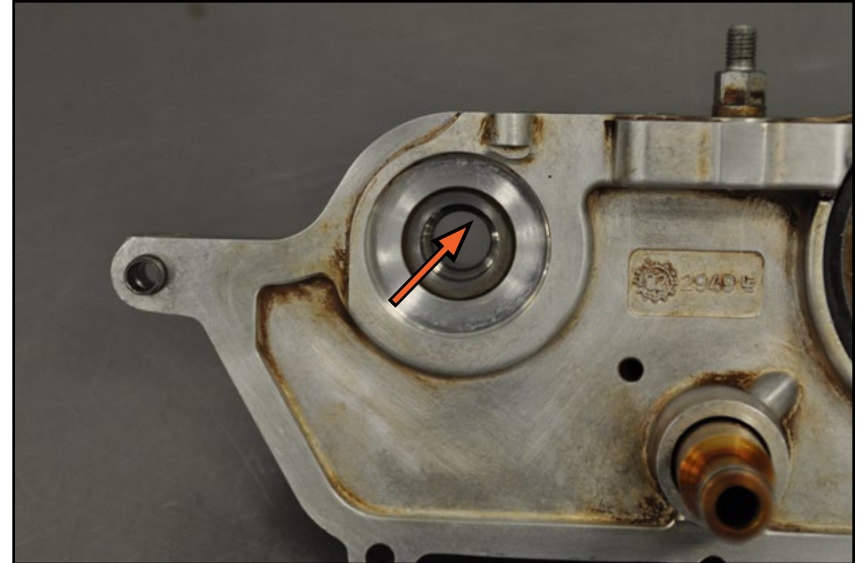
Start the Teflon sealing ring on one side of the groove as shown, then keeping constant tension on it with your finger(s), slowly stretch it and little by little work it around the edge of the piston and into the groove.



## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

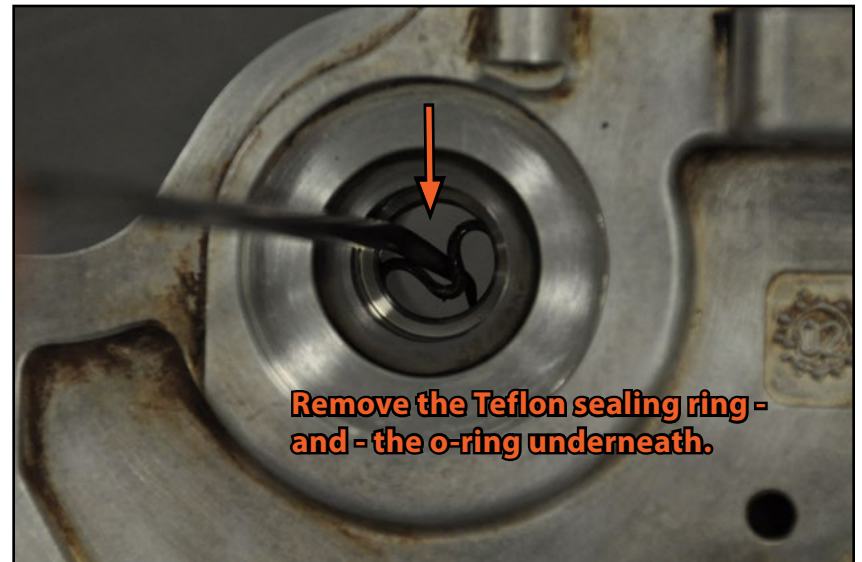
### Step 7:

Look into the intake piston cylinder. You will see a Teflon sealing ring, and like the piston, there is an o-ring underneath.



### Step 8: Angled Pick

Use an angled pick to snag the Teflon sealing ring and pull it out, then do the same for the o-ring. The Teflon ring is a little trickier, and you may have to dig down into a little with the pick to get a hold of it.



## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

### Step 9: Needle Nose Pliers

Clean out the groove and cylinder, then install the new o-ring into the cylinder. You can guide the o-ring into place using needle nose pliers and a small pick.



### Step 10: Needle Nose Pliers

The Teflon sealing ring is a little trickier. First, warm the Teflon sealing ring slightly by dipping it in warm water, or even holding it in your hand and blowing on it for a minute. Next, fold it inward and grab it with a pair of needle nose pliers as shown in the picture. This might seem damaging at first, but the Teflon is very resilient and will return to shape after it is installed.



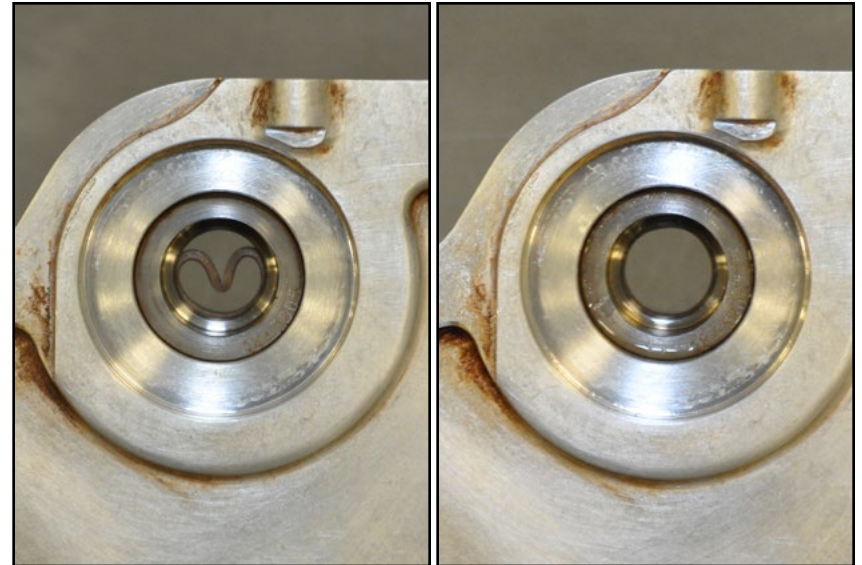


## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

### Step 11: Needle Nose Pliers

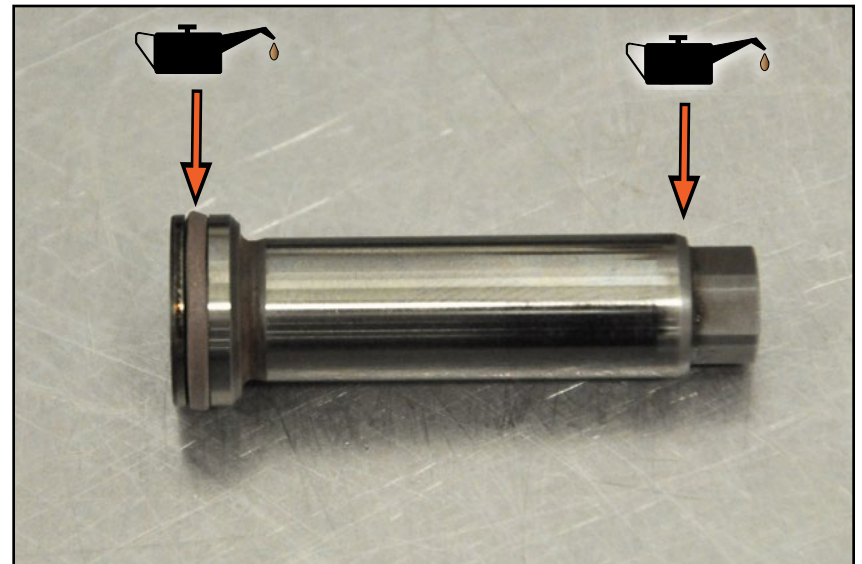
Guide the Teflon sealing ring into the groove as shown, then once it is seated on top of the o-ring, use the end of the pliers to push the folded part of the seal upward until it returns to its normal shape.

Use the rounded edge of the pliers to work the seal around its circumference, helping it to seat fully on top of the o-ring.



### Step 12:

Lubricate both ends of the intake piston with clean engine oil.



## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

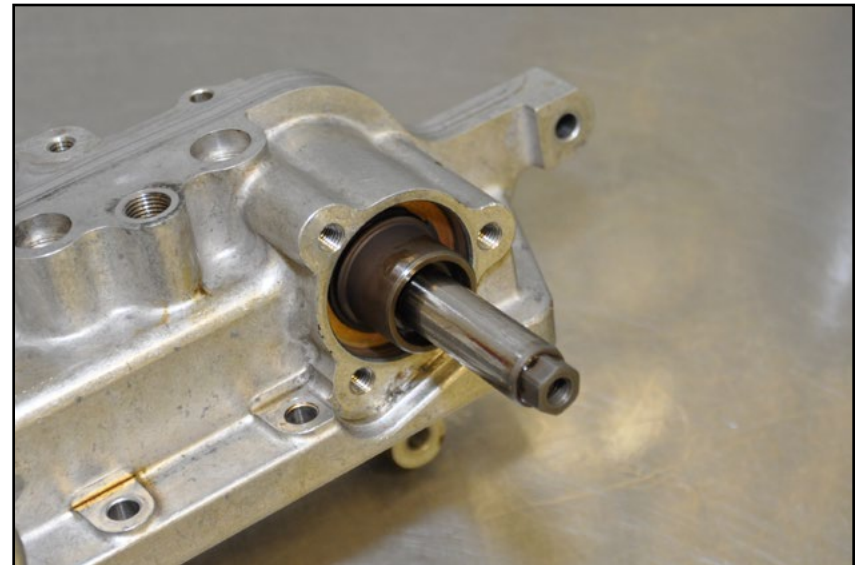
### Step 13:

Insert the intake piston into the cylinder from the inboard side (opposite the cap) and wiggle it around gently until it slides through the new Teflon sealing ring in the cylinder. Allow it to remain installed for one minute, then remove it. This process will fully seat the Teflon ring in the cylinder.



### Step 14:

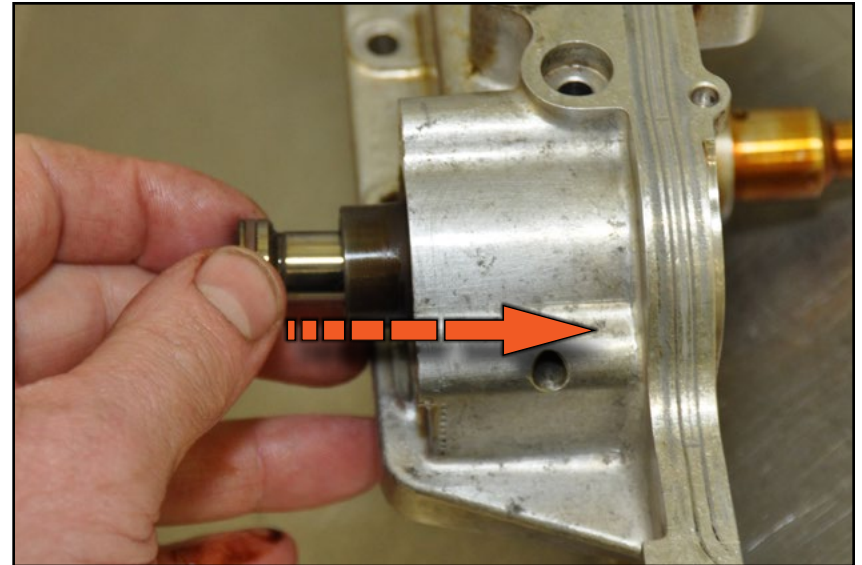
Now insert the piston into the outboard side (cap end) of the cylinder as shown, wiggling it around gently as needed until it pushes into the cylinder. Allow it to remain installed for one minute, then remove it. This process will fully seat the Teflon ring onto the intake piston.



## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

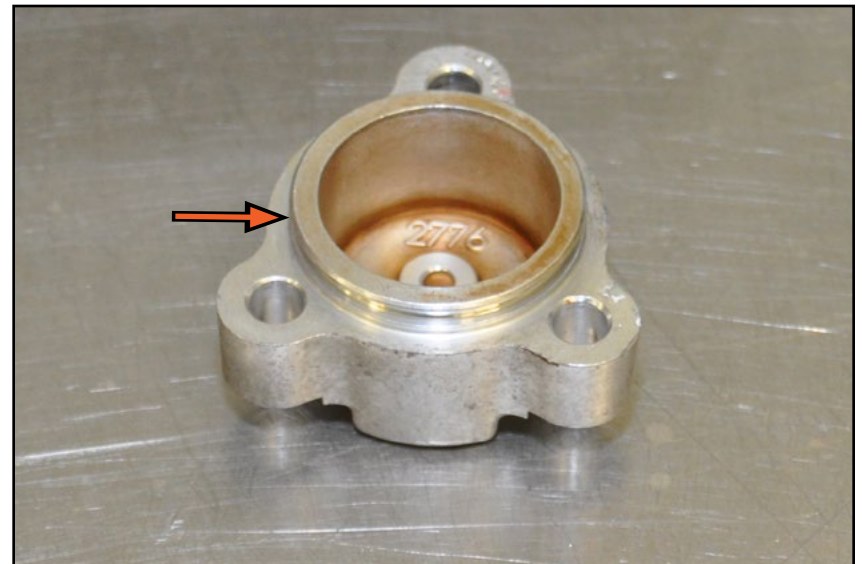
### Step 15:

Insert the intake piston into the cylinder for the final time from the outboard side and push it all the way into the cylinder.



### Step 16: Angled Pick

Remove the old seal from the piston cap and clean the groove thoroughly.

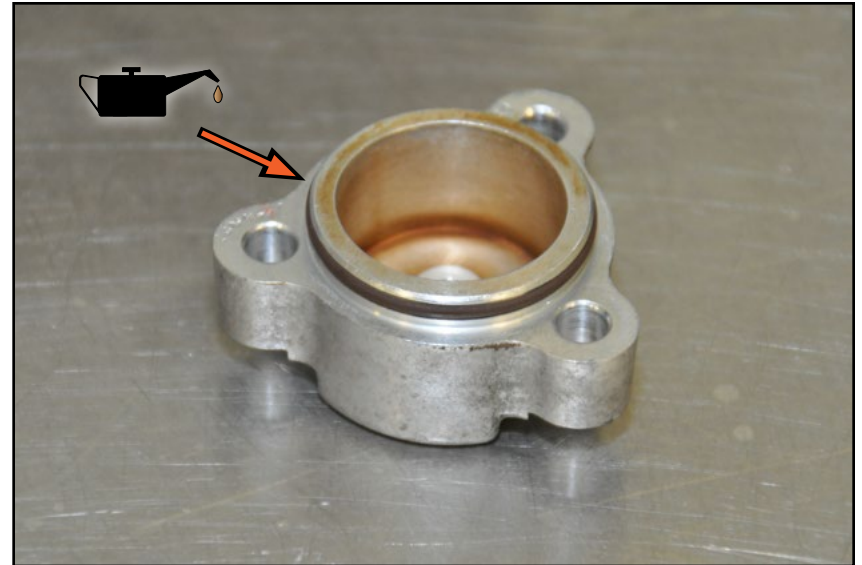




## SECTION 3C: INTAKE PISTON SEAL REPLACEMENT

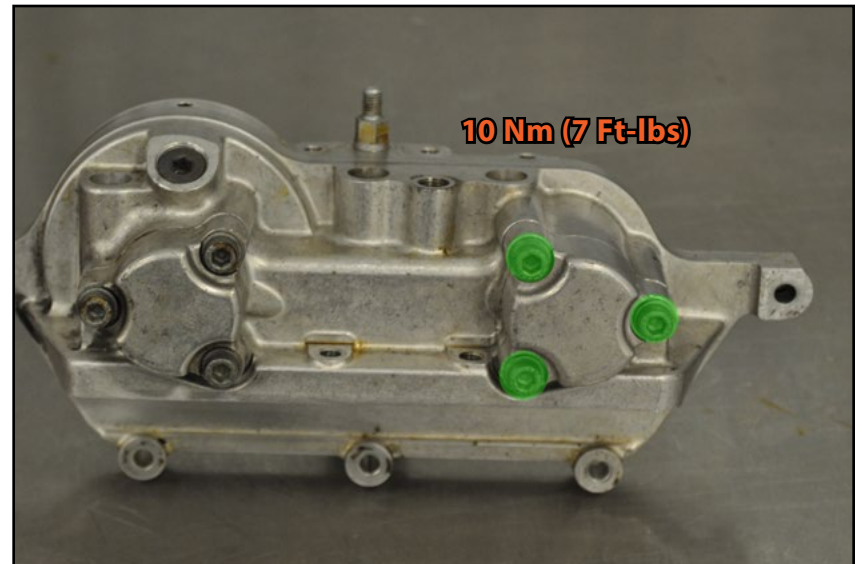
### Step 17:

Install the new seal onto the piston cap and lubricate it with clean engine oil.



### Step 18: 5mm Allen (Hex Bit) Socket, Torque Wrench

Install the intake piston cap and torque the bolts to 10 Nm (7 Ft-lbs).



*- End of Section 3c -*



## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT - REQUIRED PARTS

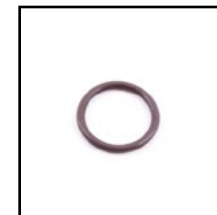
### \* ES#3138134

Description.....Large Teflon Sealing Ring  
Location .....Exhaust Piston Large End  
Quantity .....1



### \* ES#3138139

Description.....13mm ID x 1.7mm o-Ring  
Location .....Exhaust Piston Large End  
Quantity .....1



### ES#3138136

Description.....Small Teflon Sealing Ring  
Location .....Exhaust Piston Small End  
Quantity .....1



### ES#3138140

Description.....8.75mm ID x 1.7mm o-Ring  
Location .....Exhaust Piston Small End  
Quantity .....1



### \* ES#3138144

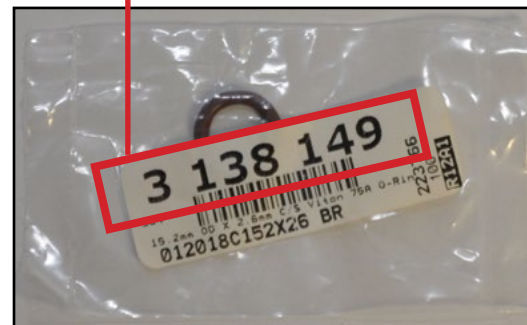
Description.....36mm OD x 2.0mm o-Ring  
Location .....Exhaust Piston Cap  
Quantity .....1



### NOTE:

All o-rings and Teflon rings will be sealed in individual poly bags - do not unpack them until you are ready to install them. Prior to use, always positively identify each seal by the ES# on the label.

ES#



\* Identical seal also used on intake piston - a total of two are included in the kit.

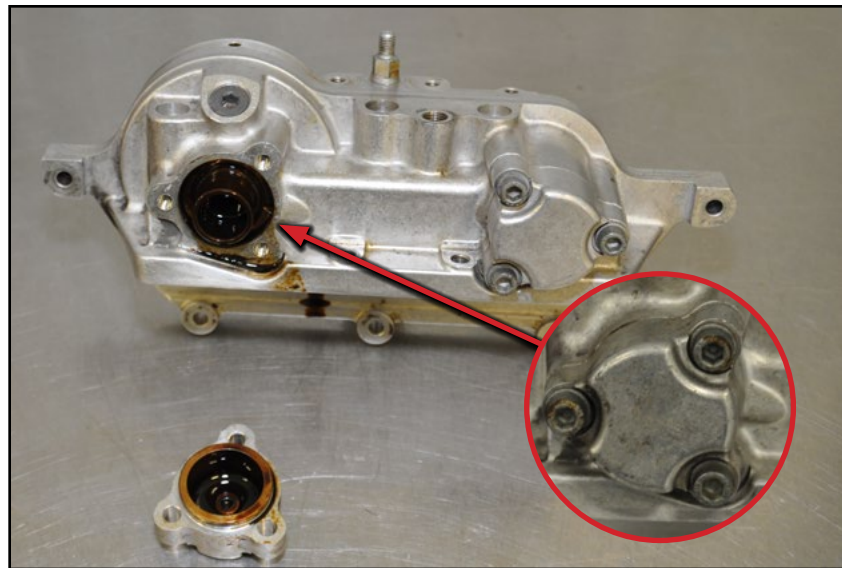
## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

### Step 1:

Remove the three bolts and pull off the exhaust piston cap.

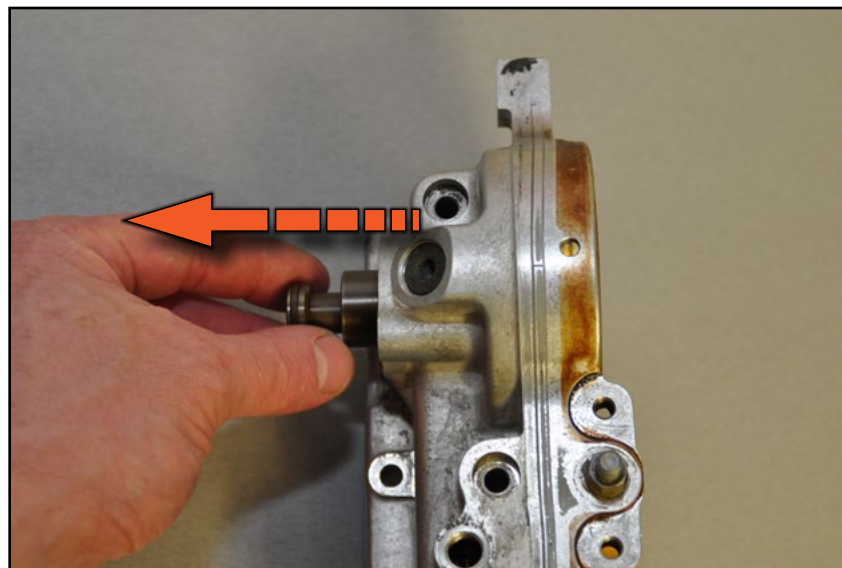


These can be difficult to remove due to a stuck seal. You may have to use a thin scraper/putty knife or similar tool to help pry the cap loose.



### Step 2:

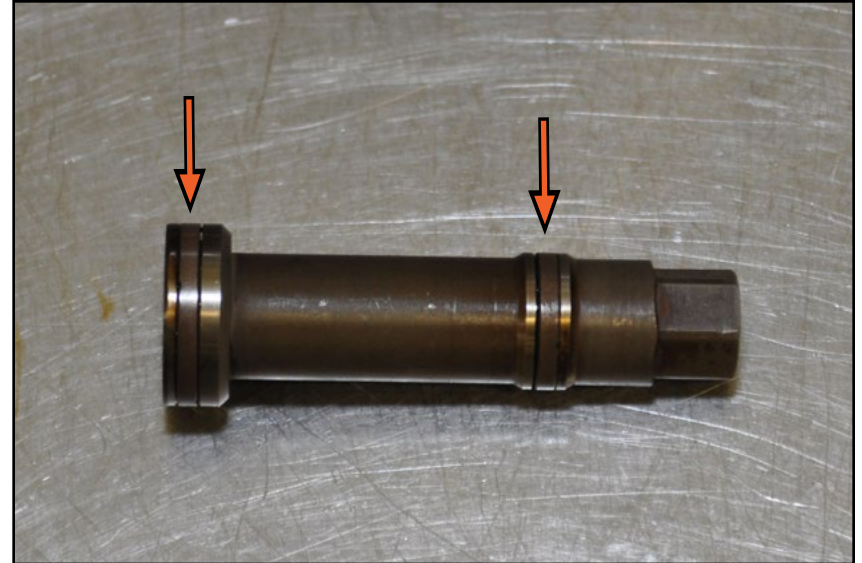
Push/pull the exhaust piston out of its cylinder towards the direction of the cap.



## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

### Step 3:

There are two grooves in the exhaust piston and each one has a rubber o-ring surrounded by a Teflon sealing ring.

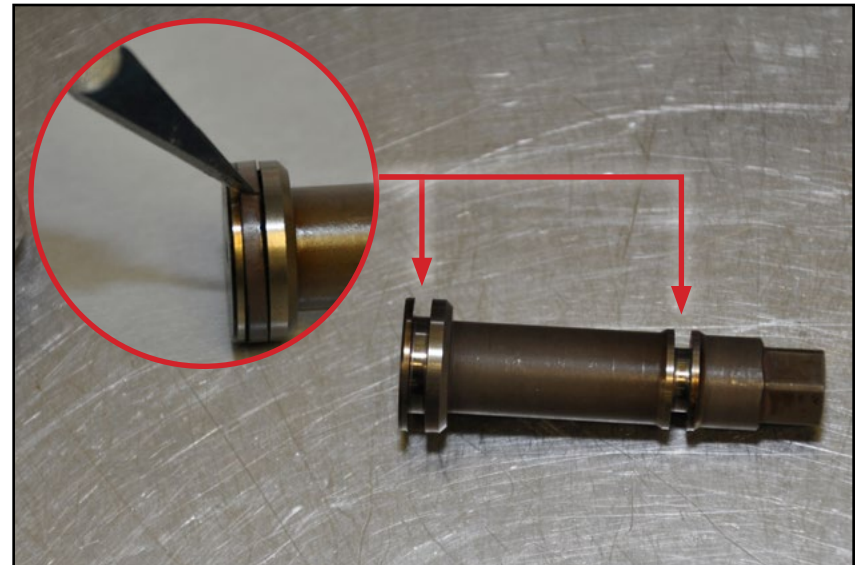


### Step 4: Exacto Knife

Carefully cut the sealing rings and o-rings using an exacto knife, then remove them from the piston ring grooves.



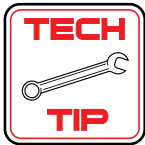
Use caution not to cut or damage the surface of the exhaust piston.



## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

### Step 5:

Clean the ring grooves, then install the new o-rings and Teflon sealing rings onto the exhaust piston.

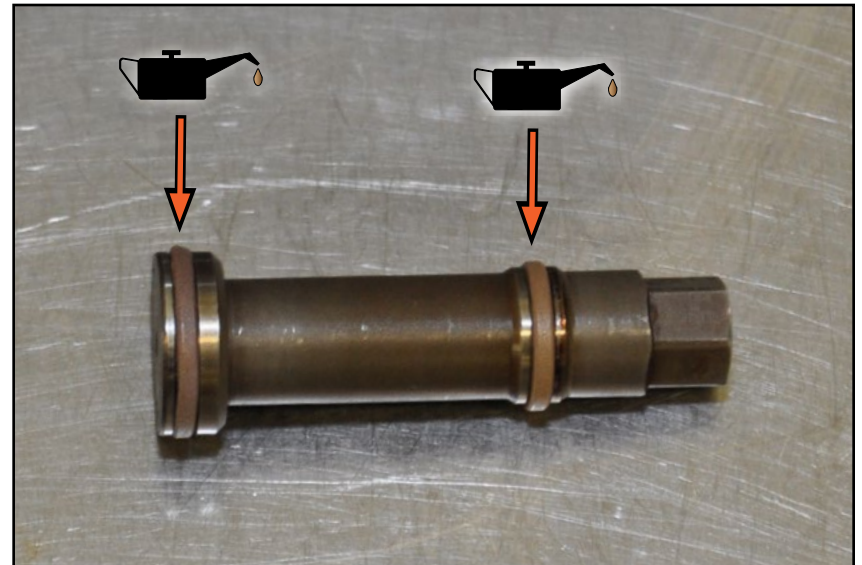


Be sure and use the o-ring and Teflon sealing ring installation tips and procedures learned during intake piston seal replacement.



### Step 6:

Lubricate the Teflon seals with clean engine oil.

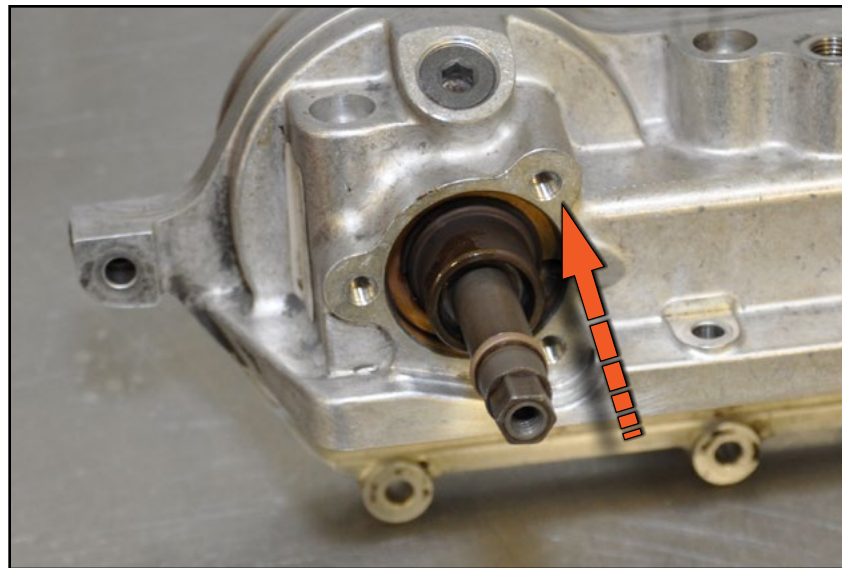




## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

### Step 7:

Insert the large end of the exhaust piston into the exhaust cylinder on the outboard side (cap end), wiggling it around gently until it pushes into the cylinder. Allow it to remain installed for one minute, then remove it. This process will fully seat the Teflon ring onto the large end of the exhaust piston.



### Step 8:

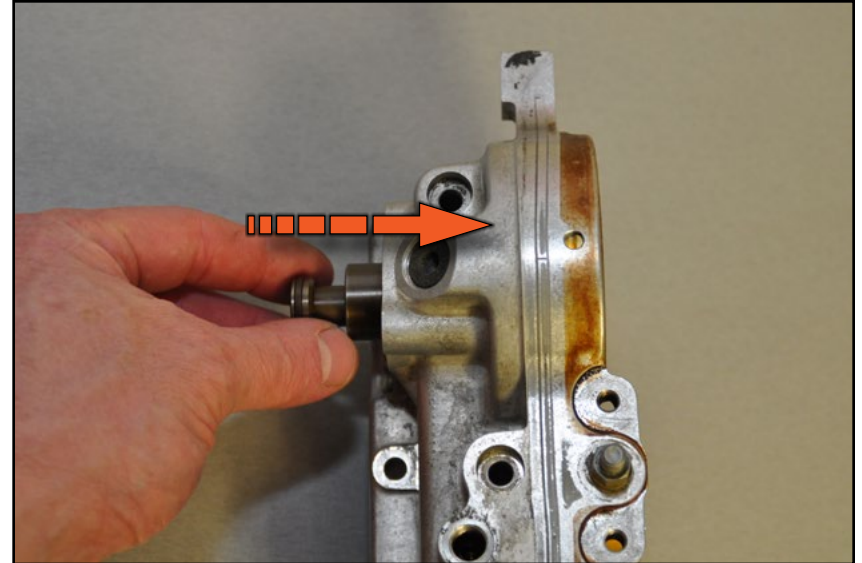
Install and lightly tighten a small hose clamp onto the small Teflon ring of the exhaust piston. Leave it installed for a minute, then remove it. This process will fully seat the Teflon ring onto the small end of the exhaust piston.



## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

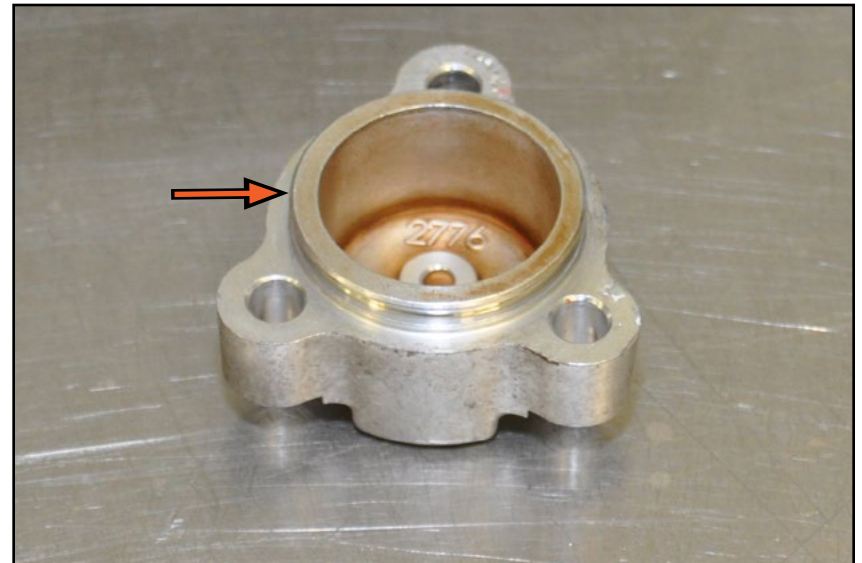
### Step 9:

Insert the exhaust piston into the cylinder for the final time from the outboard side and push it all the way into the cylinder.



### Step 10: Angled Pick

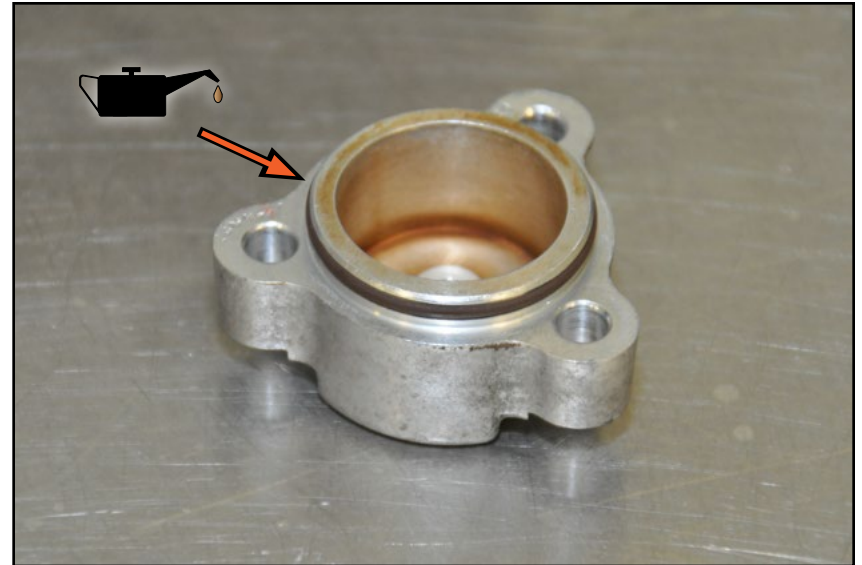
Remove the old seal from the piston cap and clean the groove thoroughly.



## SECTION 3D: EXHAUST PISTON SEAL REPLACEMENT

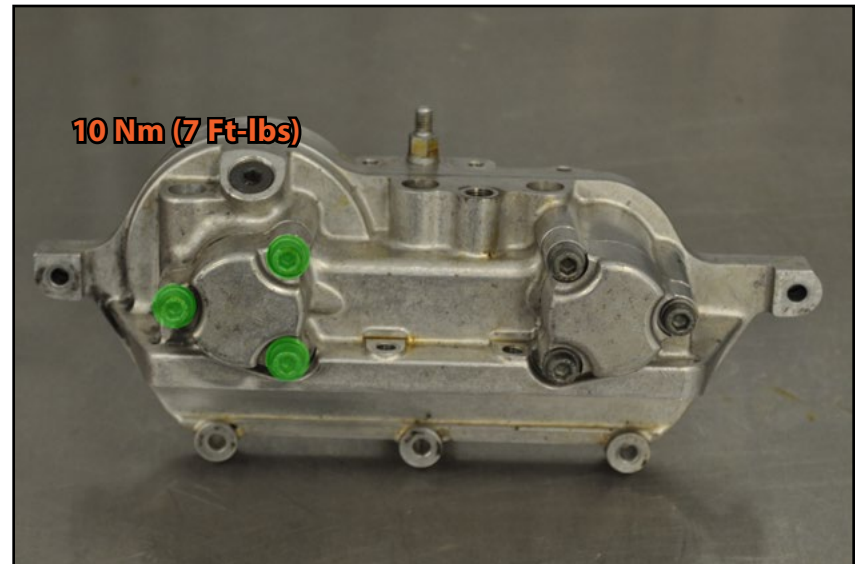
### Step 11:

Install the new seal onto the piston cap and lubricate it with clean engine oil.



### Step 12: 5mm Allen (Hex Bit) Socket, Torque Wrench

Install the exhaust piston cap and torque the bolts to 10 Nm (7 Ft-lbs).



*- End of Section 3d -*

## SECTION 4A: VANOS TRANSFER GEAR SERVICE - REQUIRED PARTS

### ES#3138157

Description.....Bearing Ring  
Location .....Vanos Transfer Gear  
Quantity .....2



### ES#3138155

Description.....End Washer  
Location .....Vanos Transfer Gear  
Quantity .....4



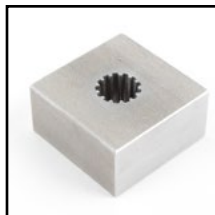
### ES#3138151

Description.....Transfer Gear Cap Socket  
Location .....N/A  
Quantity .....1



### ES#3138153

Description.....Transfer Gear Holding Tool  
Location .....N/A  
Quantity .....1





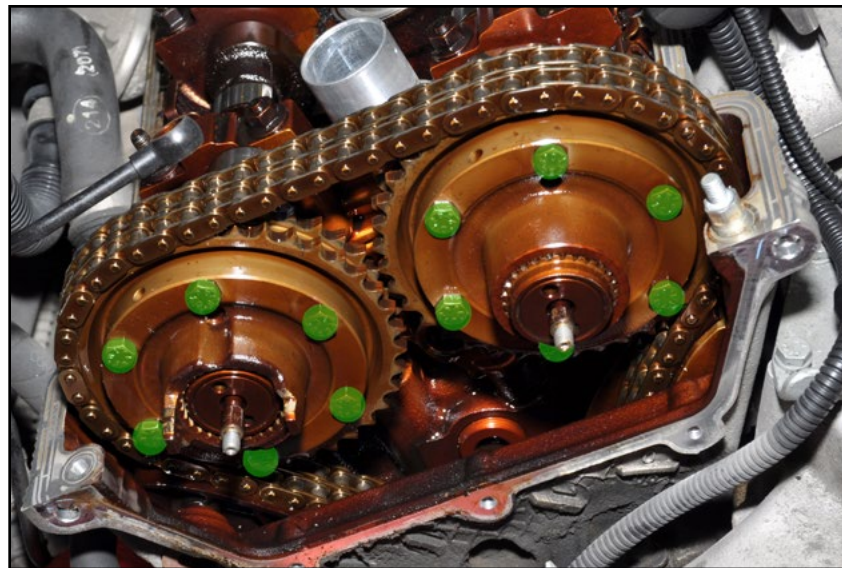
## SECTION 4A: VANOS TRANSFER GEAR SERVICE

**Step 1:** 10mm Socket, Ratchet



The engine should still be at TDC and the crankshaft pulley should be locked in position with the crankshaft locking pin.  
*View pages 18 through 22 for reference.*

Begin by loosening each of the Vanos hub bolts (6 on each hub for a total of 12) by approximately 3 full turns.

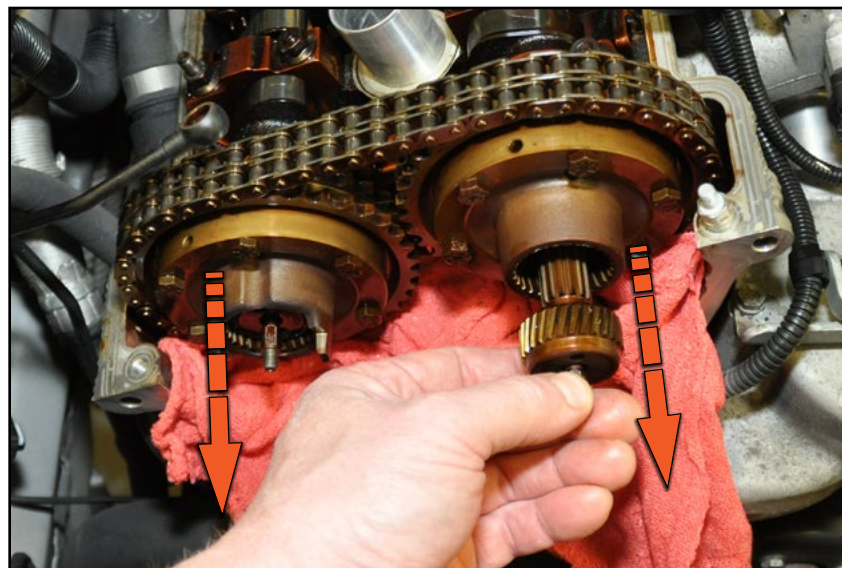


**Step 2:**

Cover the open area underneath the camshaft sprockets with a rag, then pull both transfer gears out of the Vanos hubs.



The Vanos hubs will rotate slightly as you pull out the transfer gears. If you are unable to easily pull out them out, you may need to loosen the hub bolts an additional turn.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 3:

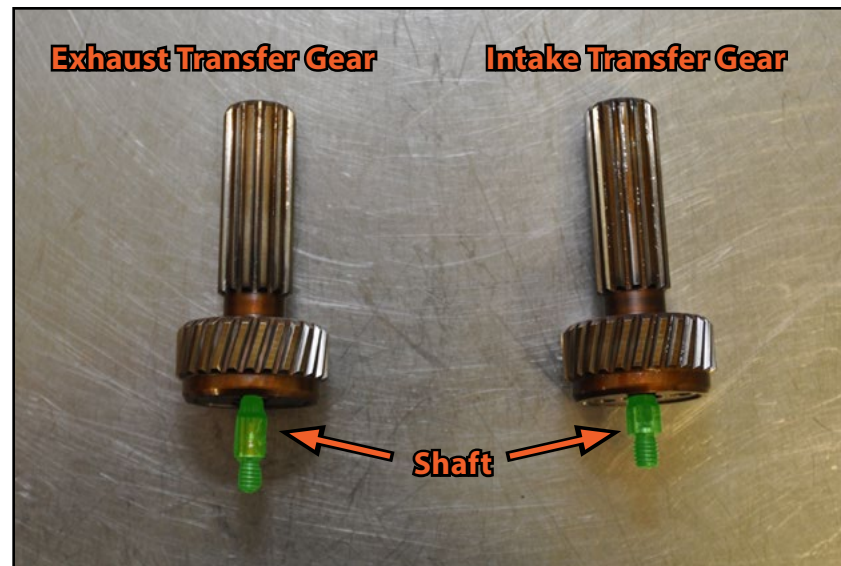
Inspect the transfer gears. Notice the length of each transfer gear shaft. The shaft on the exhaust transfer gear is longer than the one on the intake transfer gear.



The following transfer gear service procedure is the same for both gears. Begin with either one, then once finished, repeat the process on the other.

### Step 4:

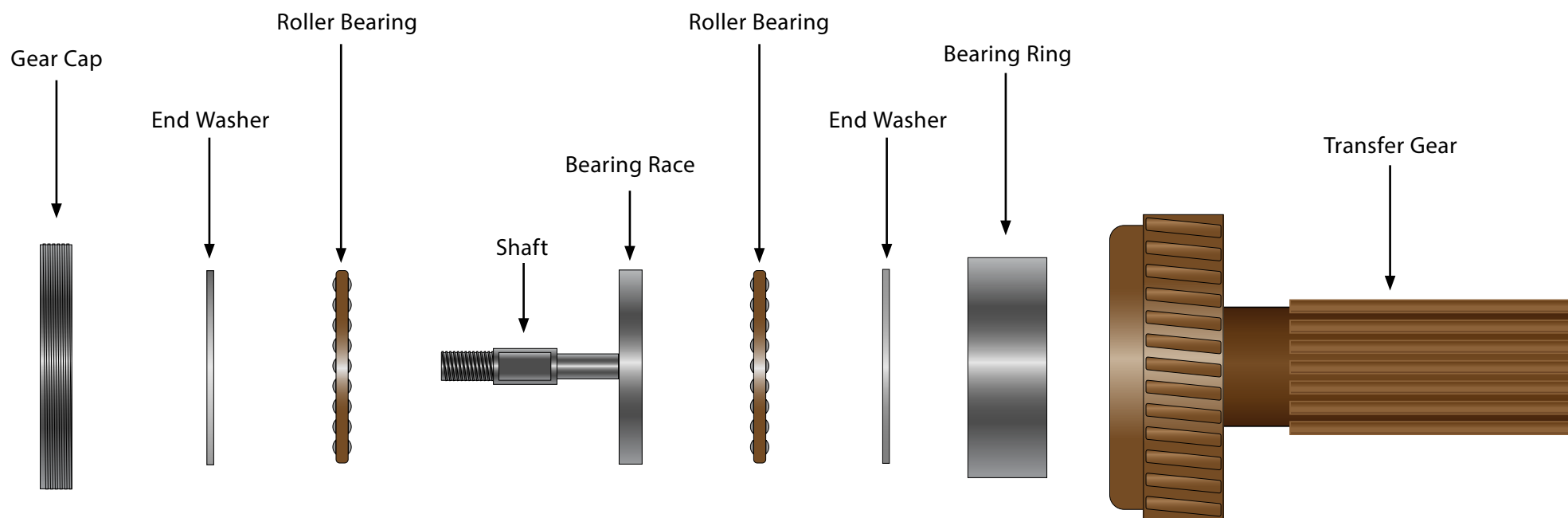
Using brake cleaner, thoroughly clean the transfer gear and flush out the oil through the two holes in the cover plate.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

*Before you keep going, here's a quick run down on the internal components and workings of the transfer gears.*

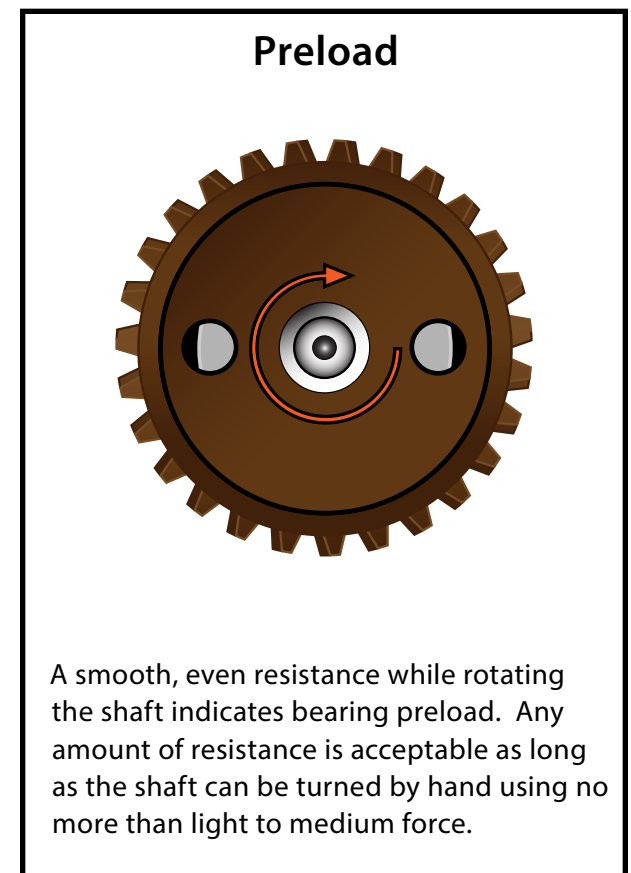
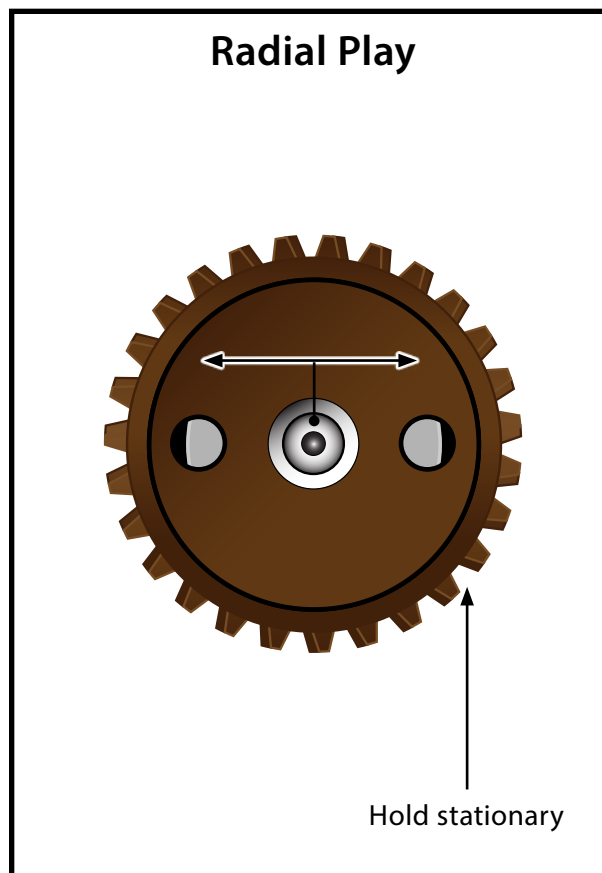
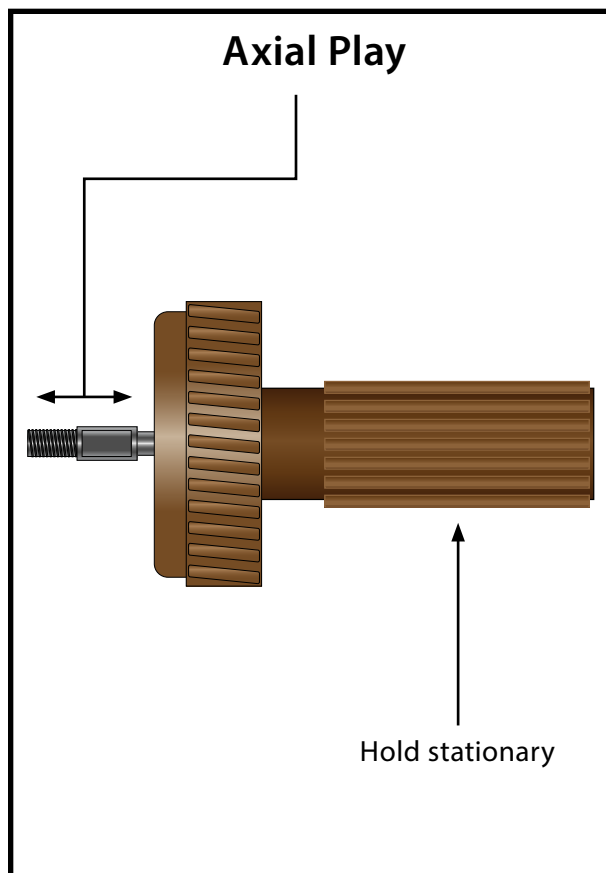
The actual Vanos "rattle" is caused by axial play in the bearings which are housed inside the transfer gear. The key to solving this problem is to remove the axial play (tighten), and ideally, provide a slight preload on the roller bearings. To accomplish this, you'll check the amount of play, install the new bearing rings and end washers in place of the originals, then recheck the amount of play. Due to very strict tolerances and the different rates of component wear from car to car, some fine tuning may be required. After bearing ring installation, you may find that the bearings are still too loose (axial play), that they are too tight (not good), or that they have no axial play and a slight preload (perfect). If necessary, adjustments are made by removing material from either the new bearing ring (tightening the bearing) or the end washers (loosening the bearing). This is a very critical adjustment, (approximately .005 -.015mm), but it's easy to do. We'll show you how in just a little bit, but first, use the exploded view below to familiarize yourself with all of the transfer gear components, then continue on the next page.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Axial Play, Radial Play, and Preload:

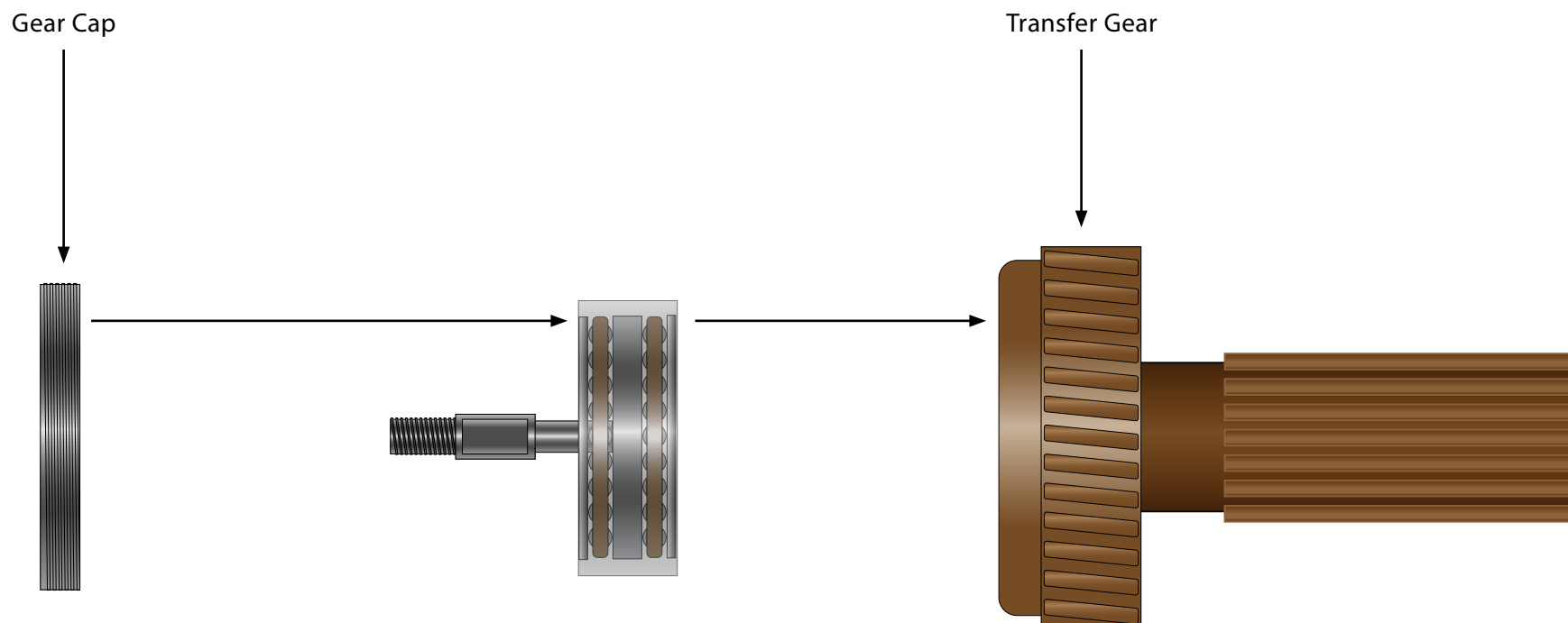
Any in and out movement of the transfer gear shaft is axial play. This measurement is strictly determined by “feel” and is easily detectable. The way you check it is by holding the transfer gear stationary with one hand and gently moving the shaft in and out with the other. Side - to - side, or radial play, which is felt by moving the transfer gear shaft left and right when looking directly at the face of the transfer gear, is normal.





## SECTION 4A: VANOS TRANSFER GEAR SERVICE

When the transfer gear is assembled, the bearing race, roller bearings, and end washers fit inside the bearing ring (which we have made transparent in this illustration), and are then “sandwiched” in place as they are installed in the transfer gear and the gear cap is tightened. For Vanos rattle to be eliminated, the gear cap must apply a consistent, even pressure against the bearing ring and end washers, creating bearing preload and allowing no clearance between the roller bearings, the bearing race, and the end washers.

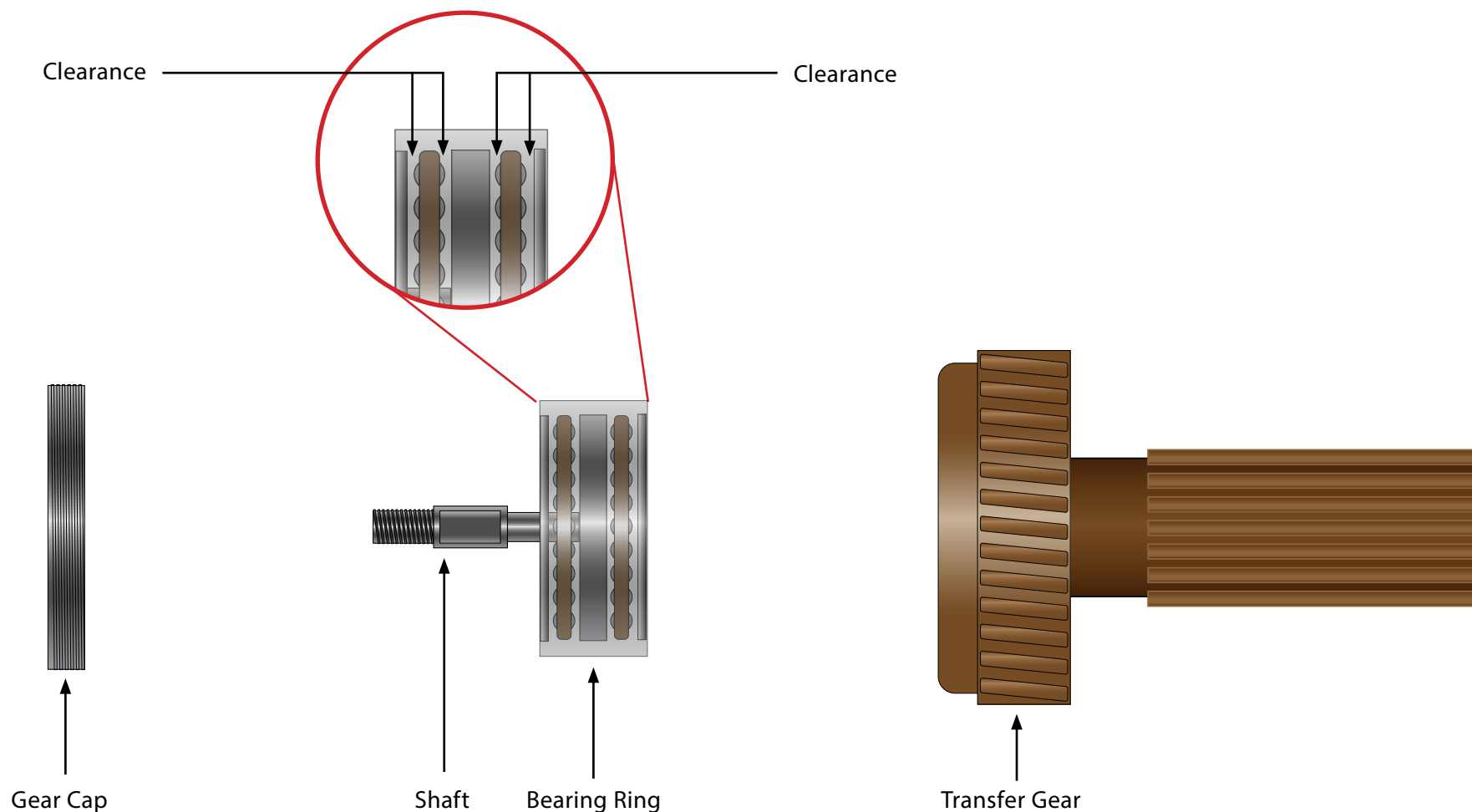


**Q:** What is the difference between the original bearing ring and the new ECS bearing ring, if an adjustment may still need to be made after installation?

**A:** The ECS Tuning bearing ring is narrower than the original, getting the adjustment very close, so fine tuning is a quick and easy procedure.

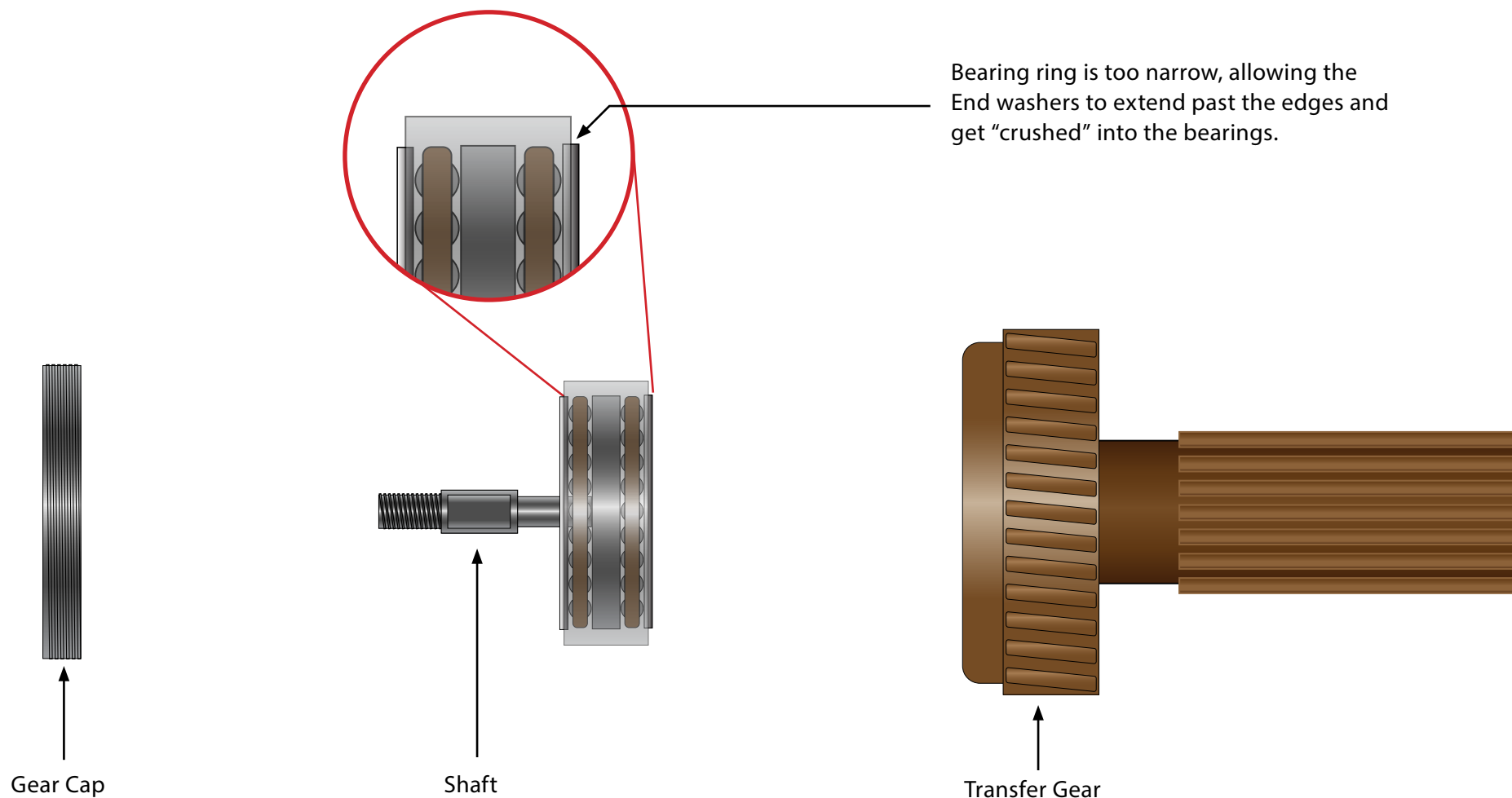
## SECTION 4A: VANOS TRANSFER GEAR SERVICE

This illustration shows the cause of axial play in the bearings (Vanos rattle). When the transfer gear is assembled and the gear cap is tightened, there is clearance between the roller bearings, the bearing race, and the end washers. The bearing in this case is too loose and must be tightened. The clearance is eliminated and the bearing tightened by decreasing the width of the bearing ring until all axial play is removed and bearing preload is created.



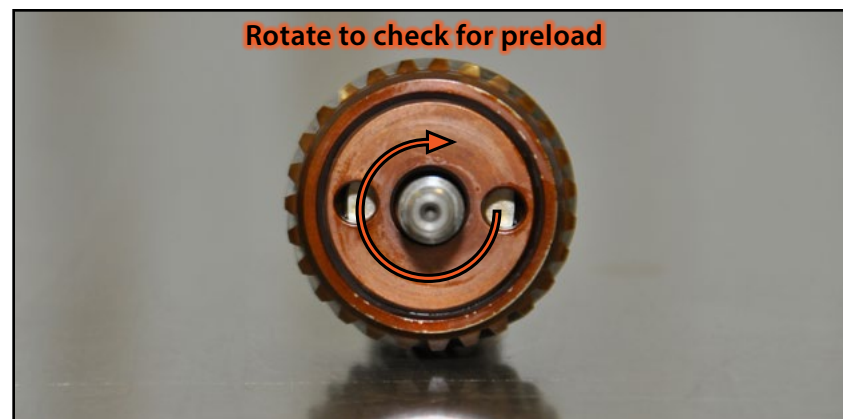
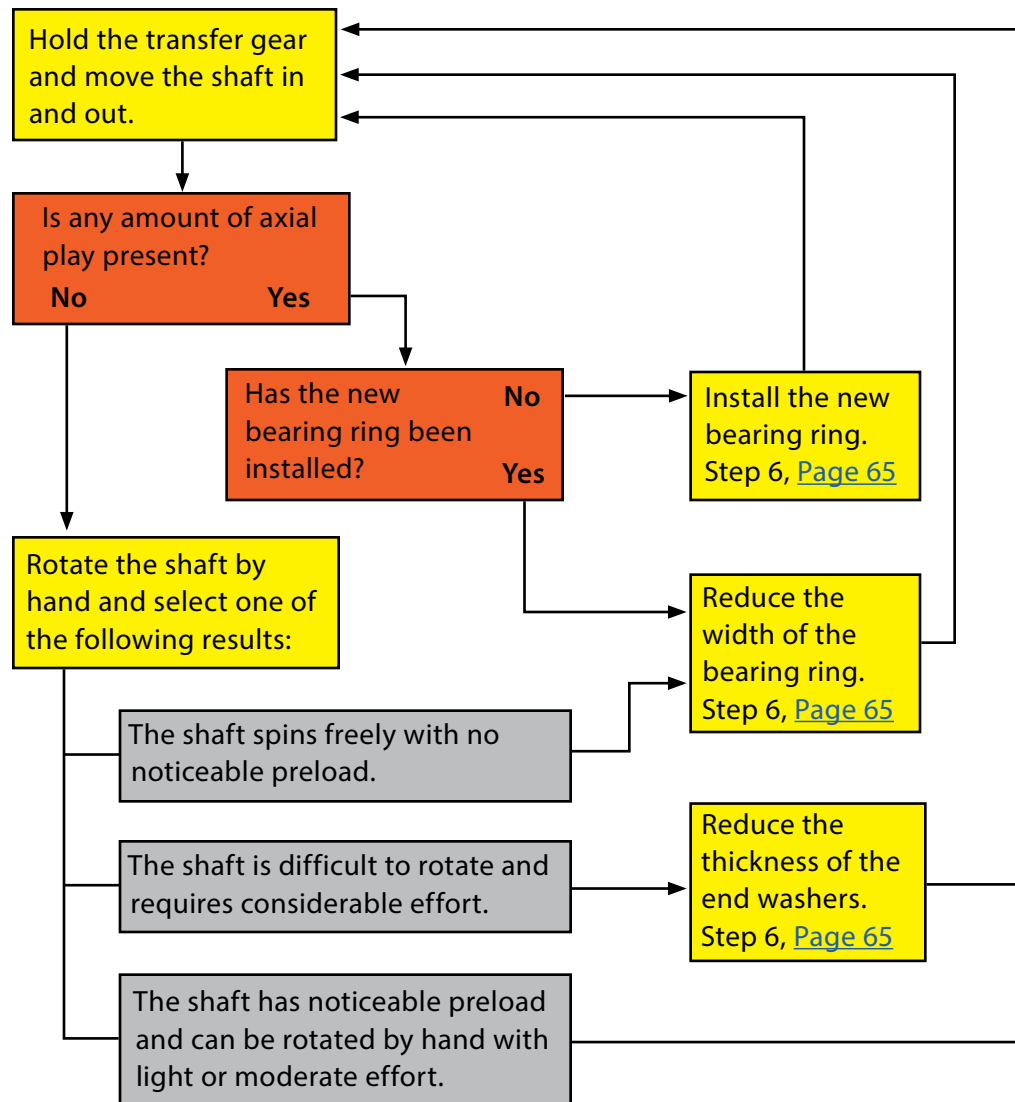
## SECTION 4A: VANOS TRANSFER GEAR SERVICE

This illustration shows what would cause the bearings to be too tight and make the shaft difficult to turn. The bearing ring in this case is, in effect, too narrow. When the transfer gear is assembled and the gear cap tightened, the end washers will “crush” the bearings as the gear cap attempts to seat against the bearing ring. In this situation, since you cannot increase the width of the bearing ring, to solve the problem you would decrease the thickness of each of the end washers, until the gear cap can apply a consistent, even pressure against both the bearing ring and the end washers.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

**Step 5:** Now, getting back to it, follow the flow chart below to check and adjust axial play/preload of the transfer gear shaft.



*Remember, radial play is normal.*

**Preload and axial play are set perfectly! Skip to Step 15 on [Page 70](#) to continue.**



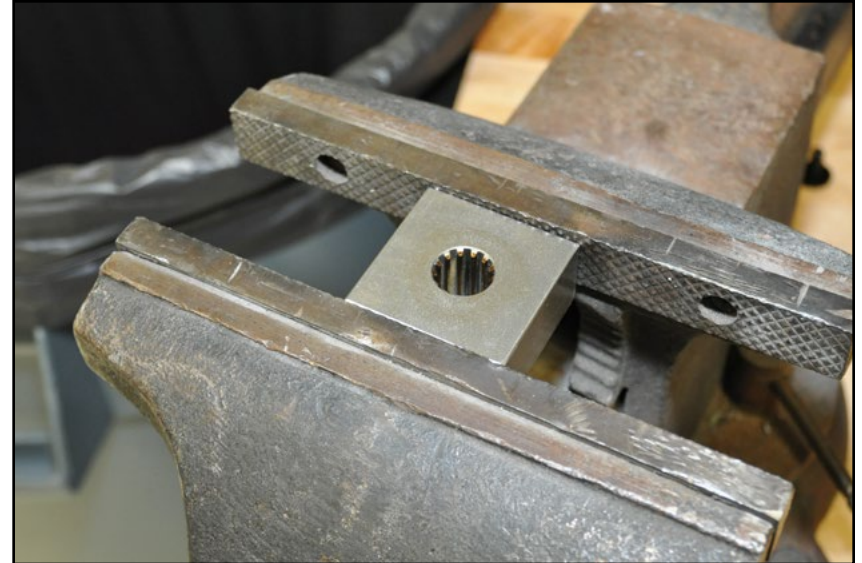
## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 6:

Tighten the transfer gear holding tool in a vise.

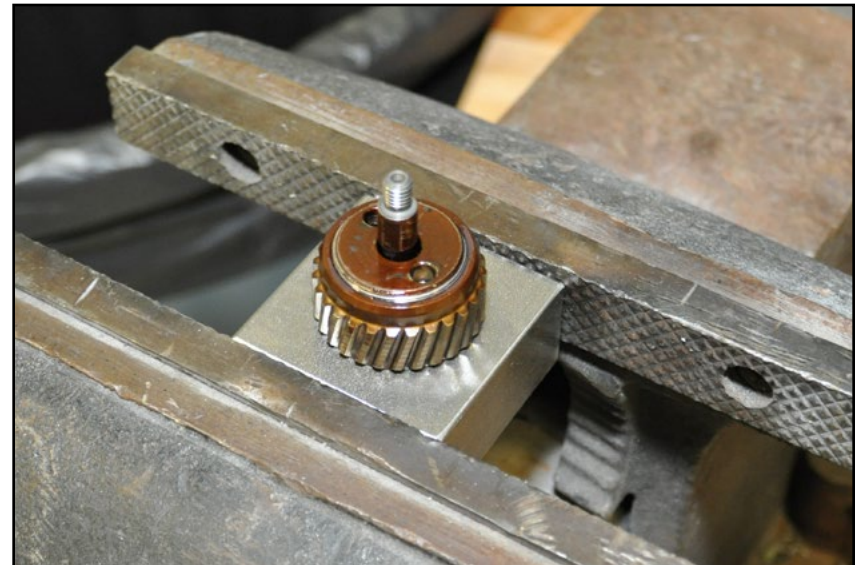


One side is beveled and should face "up" to make it easier to slide the transfer gear in place.



### Step 7:

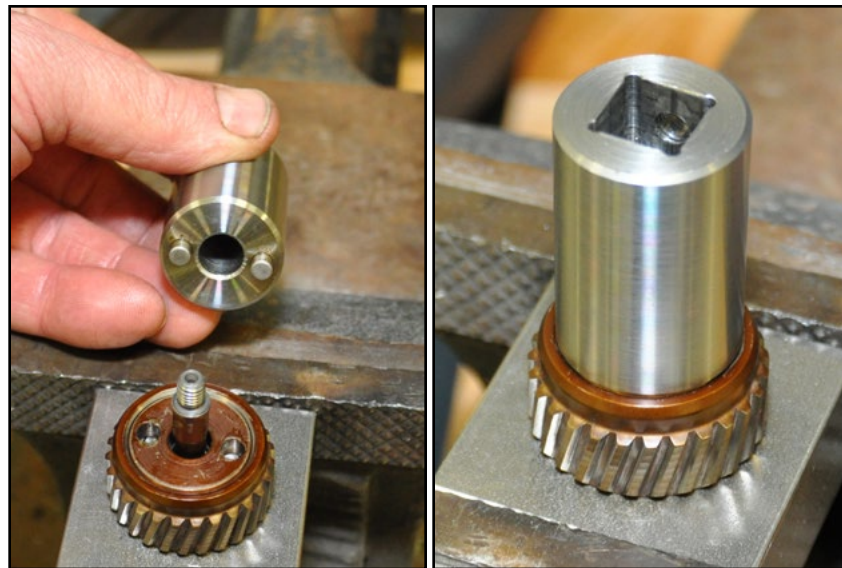
Slide the transfer gear into the holding tool.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 8:

Engage the transfer gear cap socket into place.



### Step 9:

Keep the socket squarely installed with even downward pressure, then loosen the transfer gear cap with a 1/2" impact wrench by giving it **brief repeated blasts** until it breaks loose. Do not hold the trigger and apply continuous impacting. Once it is loose, you can remove it the rest of the way using a ratchet. It will not spin off freely due to loctite on the threads.



Using an impact is the recommended and only procedure that should be used to loosen the transfer gear cap. Using a ratchet shifts the weight distribution on the socket, and it is very easy for the socket to slip out and damage the shaft.



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 10: Small Angled Pick

Once you have removed the gear cap, remove all of the internal components and lay them out in order.

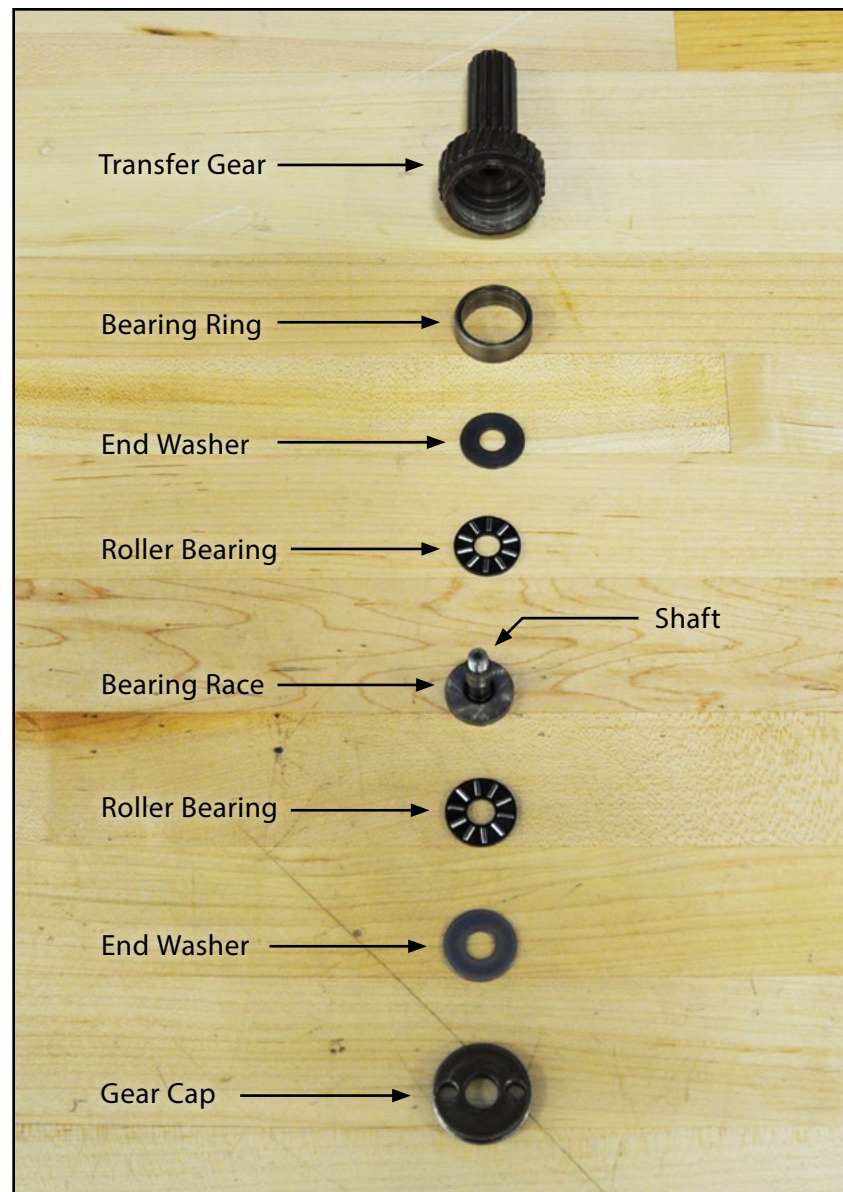
Thoroughly clean all components using brake cleaner.

*Choose the appropriate action below, based on your results from the Page 64 flow chart:*

▶ If you are installing the new bearing ring and end washers for the first time, continue with Step 11 on [Page 68](#).

▶ If you have axial play or no preload present and need to tighten the bearing by reducing the thickness of the bearing ring, skip to Step 13 on [Page 69](#).

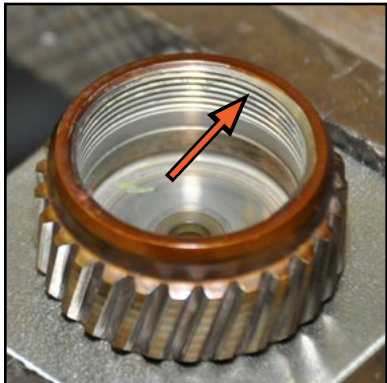
▶ If the transfer gear shaft is too tight and you need to loosen the bearing by reducing the thickness of the end washers, skip to Step 14 on [Page 70](#).





## SECTION 4A: VANOS TRANSFER GEAR SERVICE

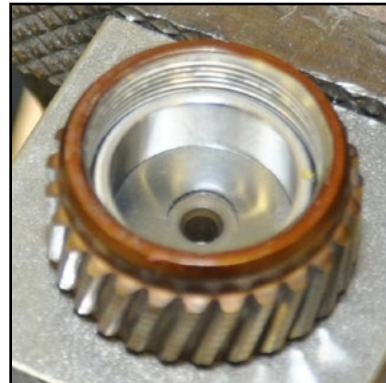
**Step 11:** Using the new bearing ring and end washers, reassemble the transfer gear in the following order:



Clean all remaining thread locking compound out of the transfer gear threads



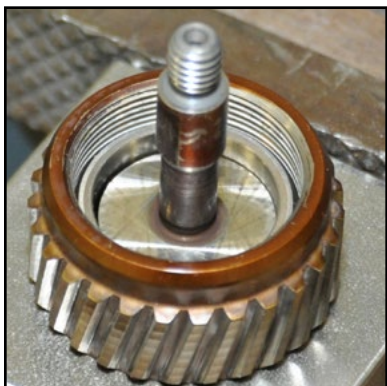
Install the bearing ring



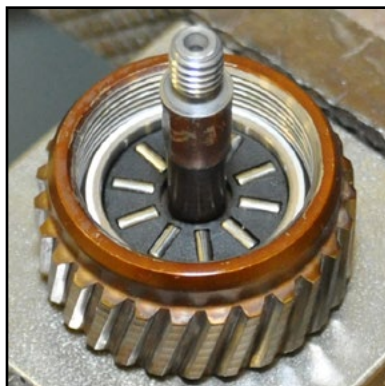
Install one end washer



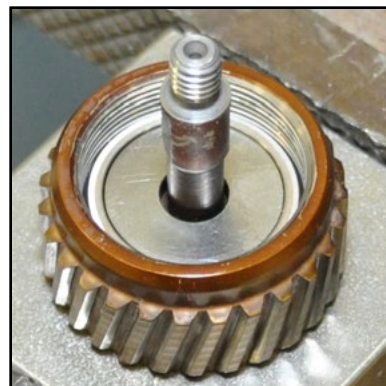
Install one bearing



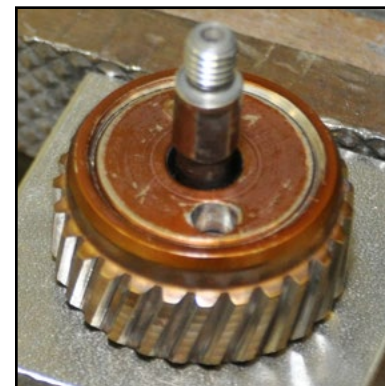
Install the bearing race/shaft



Install the other bearing



Install the other end washer



Thread the gear cap into place

*Continue with Step 12 on the next page.*



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 12: Torque Wrench, Gear Cap Socket

Torque the transfer gear cap to 55 Nm (40.5 Ft-Lbs).



Follow the flow chart on [Page 64](#) to check and adjust axial play/preload of the transfer gear shaft.



### Step 13: 400 Grit Sandpaper

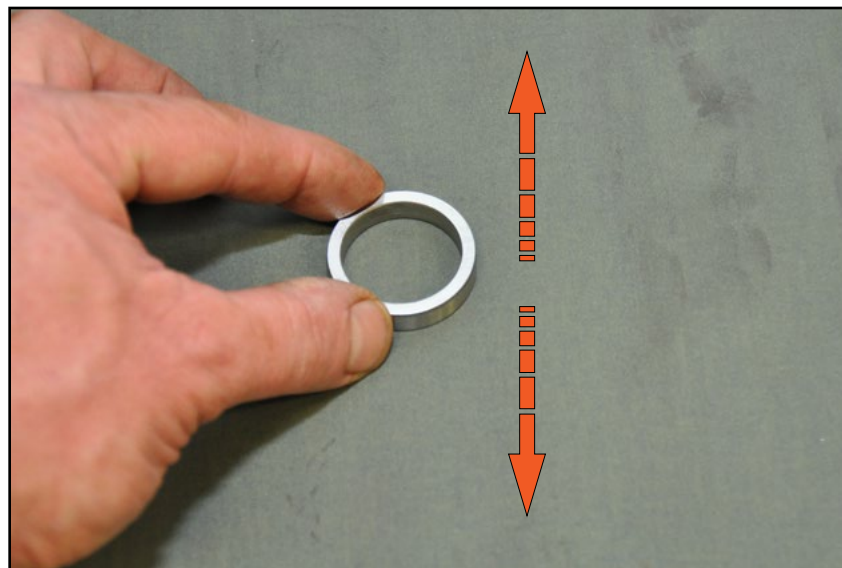
To tighten the bearing (when axial play or no preload is present) - sand the bearing ring using the following procedure:

1. Place a sheet of 400 grit sandpaper on a solid, flat surface.
2. **Using medium pressure, sand one surface of the ring back and forth 6-8", approximately 30-40 times.**
3. Rotate the ring 90 degrees, and repeat the sanding procedure.
4. Flip the ring over and repeat the sanding procedure.
5. Rotate the ring 90 degrees and repeat the sanding procedure.

This procedure will remove a very small amount of material, approximately .004 - .006mm from the total thickness of the ring.



Thoroughly clean the bearing ring and continue with Step 11 on [Page 68](#).



## SECTION 4A: VANOS TRANSFER GEAR SERVICE

### Step 14: 400 Grit Sandpaper

To loosen the bearing (when excessive force is required to rotate the shaft)  
- sand both of the end washers using the following procedure:

1. Place a sheet of 400 grit sandpaper on a solid, flat surface.
2. *Using medium pressure, sand one surface of the washer back and forth 6-8", approximately 30-40 times.*
3. Rotate the washer 90 degrees, and repeat the sanding procedure.
4. Flip the washer over and repeat the sanding procedure.
5. Rotate the washer 90 degrees and repeat the sanding procedure.

This procedure will remove a very small amount of material, approximately .0025mm from the total thickness of each washer.



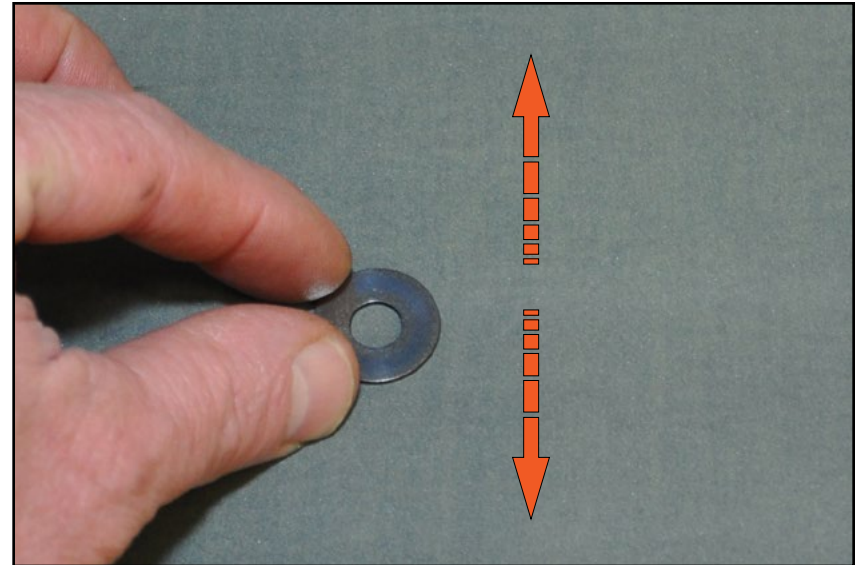
Thoroughly clean the end washers and continue with Step 11 on [Page 68](#).

### Step 15: Torque Wrench, Gear Cap Socket

Once you have achieved no axial play and have sufficient preload on the transfer gear bearing, remove the gear cap, apply high strength (red) threadlocker, then reinstall the cap for the final time, torquing it to 55 Nm (40.5 Ft-Lbs).

Do not install the transfer gears back into the vanos hubs. Set them aside for now as you complete sections 4B and 4C. Installation will be covered in section 5.

**- End of Section 4a -**



## SECTION 4B: VANOS HUB SERVICE - REQUIRED PARTS

### ES#23235

Description.....Vanos Diaphragm Spring Sets

Location .....Vanos Hubs

Quantity .....2



### ES#15158

Description.....M6 x 25 Hex Bolt

Location .....Vanos Hubs

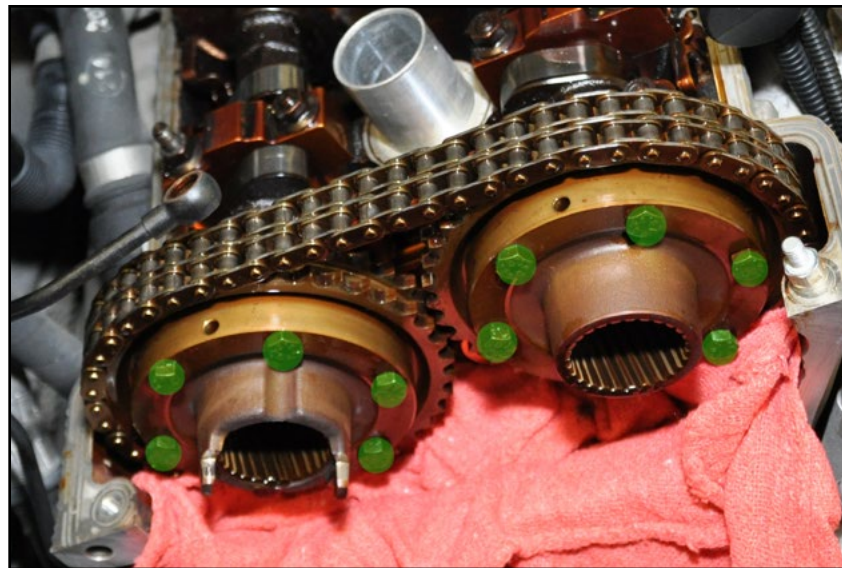
Quantity .....12



## SECTION 4B: VANOS HUB SERVICE

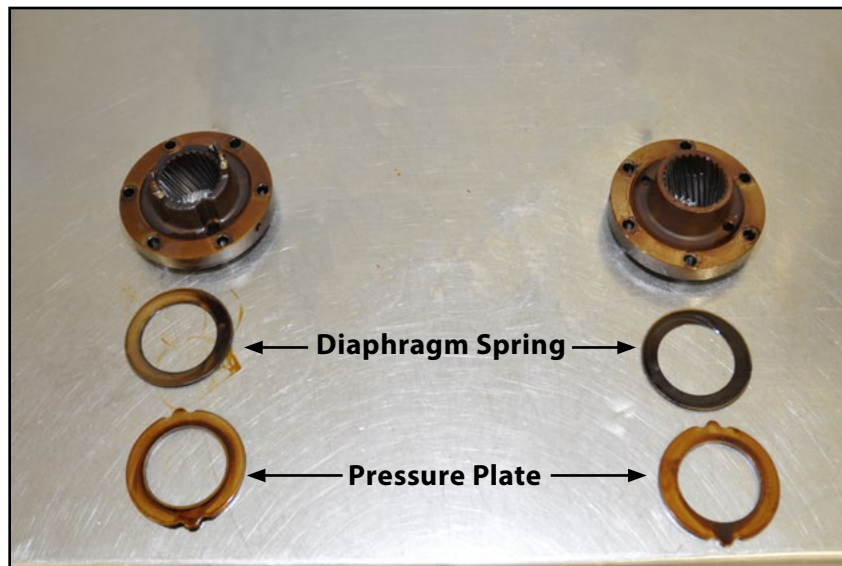
### Step 1: 10mm Socket, Ratchet

Make sure a rag is still in place to keep anything from falling into the engine, then remove the Vanos hub bolts (6 on each hub for a total of 12). These should already be loose from section 4A.



### Step 2:

Remove both Vanos hubs. You will notice that underneath each one is a diaphragm spring and pressure plate, remove these as well. Occasionally, the springs and plates will remain in the back of the Vanos hubs. Make sure you remove them.





## SECTION 4B: VANOS HUB SERVICE

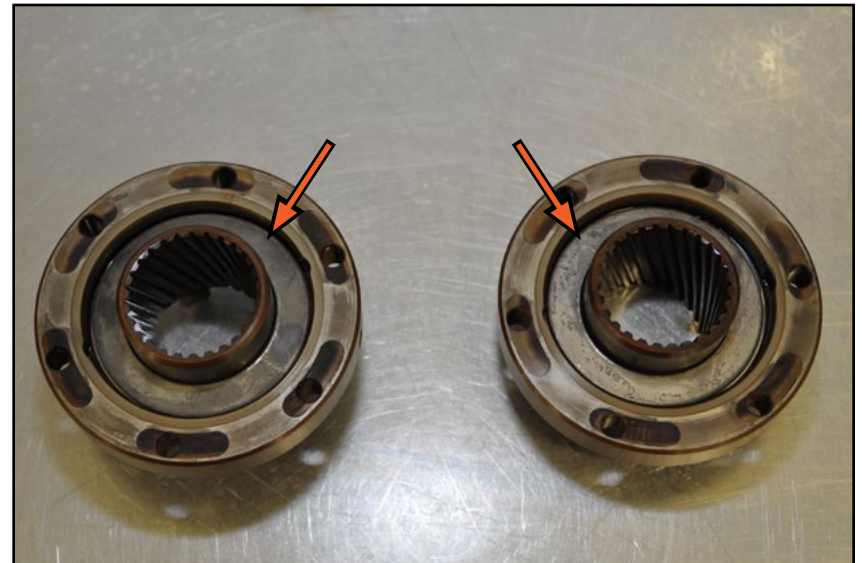
### Step 3:

Thoroughly clean the Vanos hubs.



### Step 4:

Install the new diaphragm spring into the back side of each Vanos hub with the *cupped side down*.



## SECTION 4B: VANOS HUB SERVICE

### Step 5:

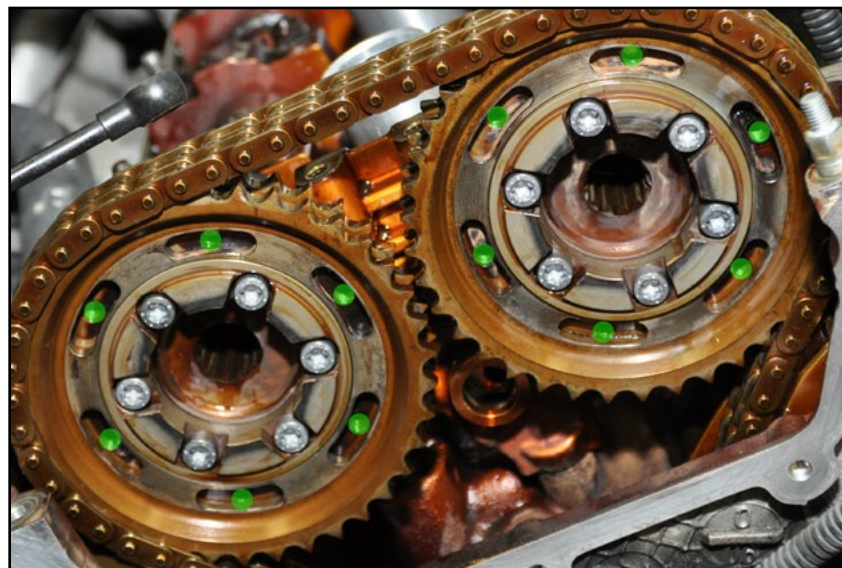
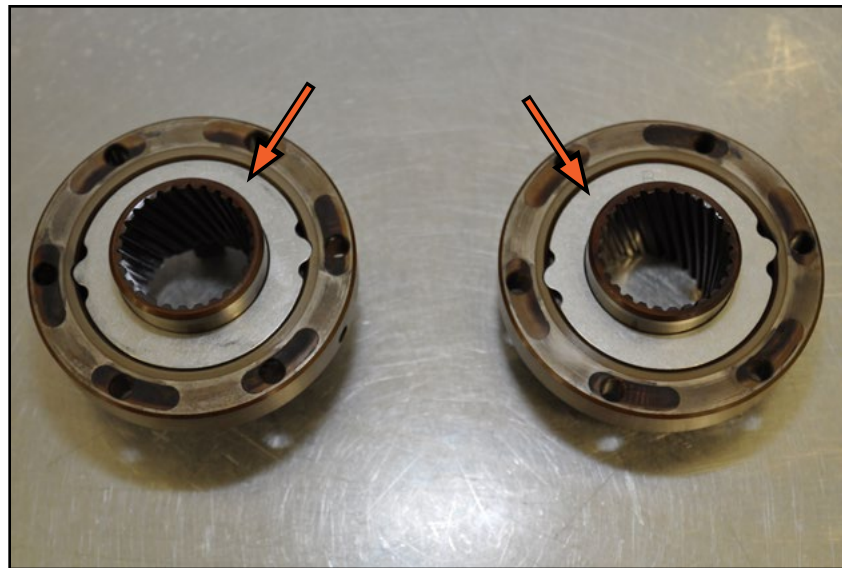
Install a new pressure plate into the back of each Vanos hub, on top of the diaphragm spring.



If you are replacing the cam sprocket bolts and upper timing chain guide, proceed with section 4c on [Page 76](#). You will be directed to return back to this step at a later point.

### Step 6: Small Pick or Screwdriver

Rotate the cam sprocket rear plates so that the bolt holes are centered in the slots of the cam sprockets.



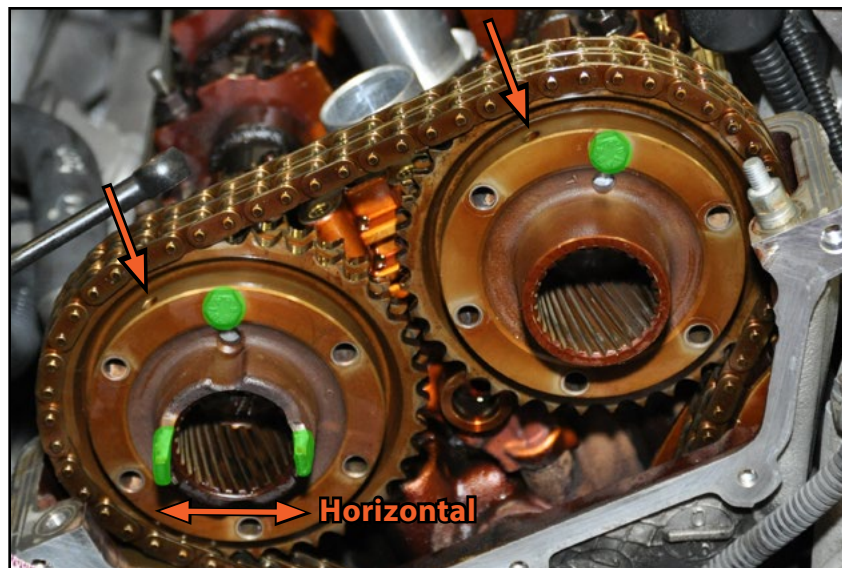


## SECTION 4B: VANOS HUB SERVICE

### Step 7:

Install the Vanos hubs onto the cam sprockets using one new M6 x 25 bolt at the top of each one. Make sure the following points apply:

- A:** Make sure the diaphragm springs and pressure plates remain in place during installation.
- B:** Make sure one of the Vanos hub side holes is located at the top for each hub (arrows).
- C:** The oil pump drive tabs on the exhaust hub will be in a horizontal position.
- D:** Install one bolt, hand tight only, in the positions shown.



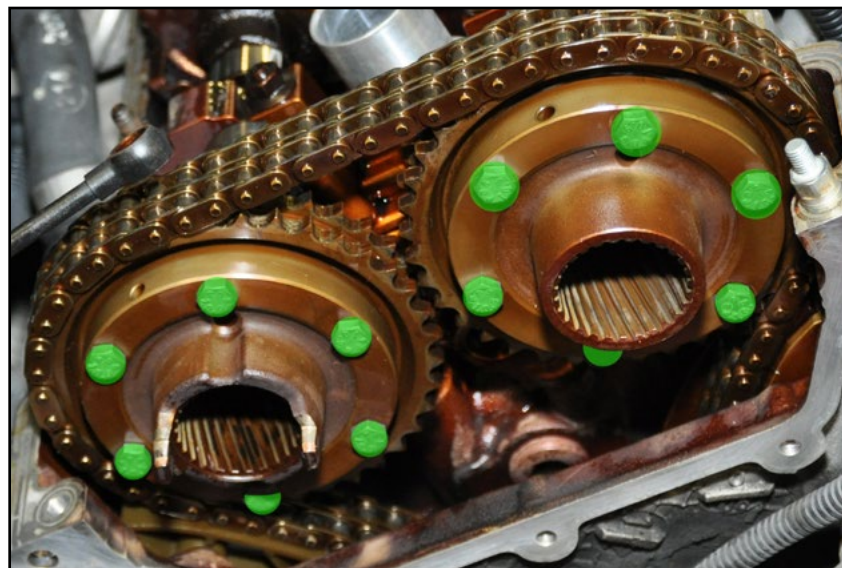
### Step 8:

Install the remaining new M6 x 25 bolts into the Vanos hubs. Thread them in by hand, and leave them *hand tight only*.

**- End of Section 4b -**



You are now ready to completely reinstall the Vanos and finish the job. Continue with section 5A on [Page 85](#).



## SECTION 4C: CAM SPROCKET SERVICE - REQUIRED PARTS

### ES#16140

Description.....M6 x 16 Torx Bolt

Location .....Camshaft Sprocket Hubs

Quantity .....12



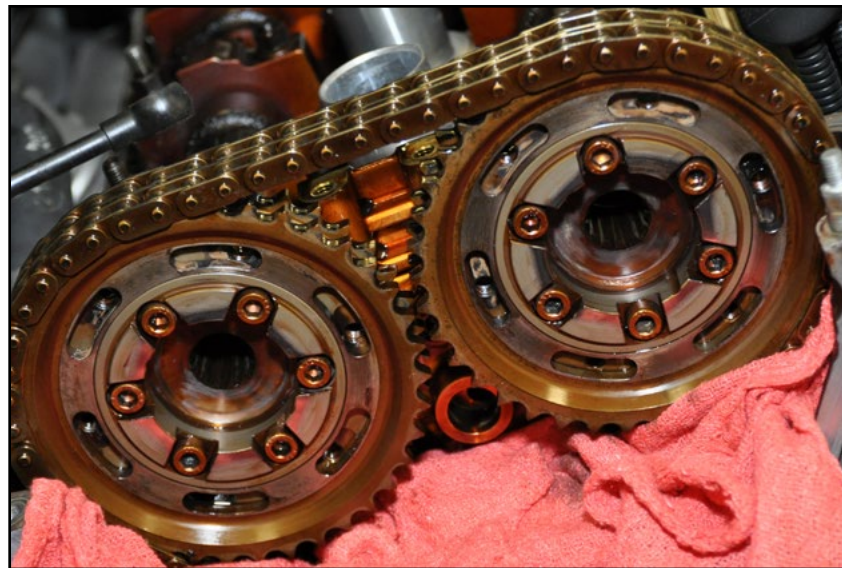
The original cam sprocket hub bolts commonly loosen up, and this service replaces the original bolts which addresses the problem and prevents it from reoccurring.



## SECTION 4C: CAM SPROCKET SERVICE

### Step 1:

Clean the face of the camshaft sprockets with brake cleaner and rags.

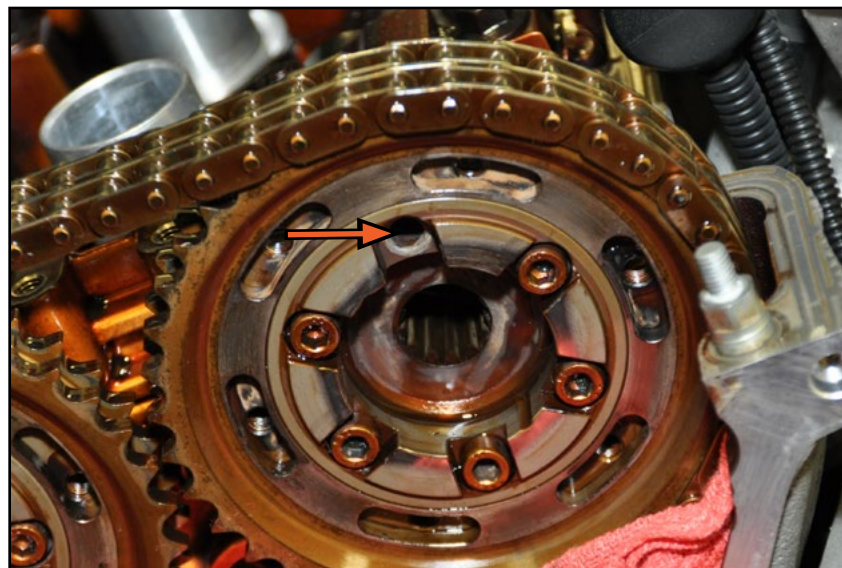


### Step 2: 5mm Hex Bit (Allen) Socket

Remove the top most bolt on one of the sprocket hubs, then clean the hole with brake cleaner and dry it with a shop rag.



You will be replacing these bolts one at a time, working from top to bottom in order to prevent the cleaning solvent from getting onto the newly installed bolts.



## SECTION 4C: CAM SPROCKET SERVICE

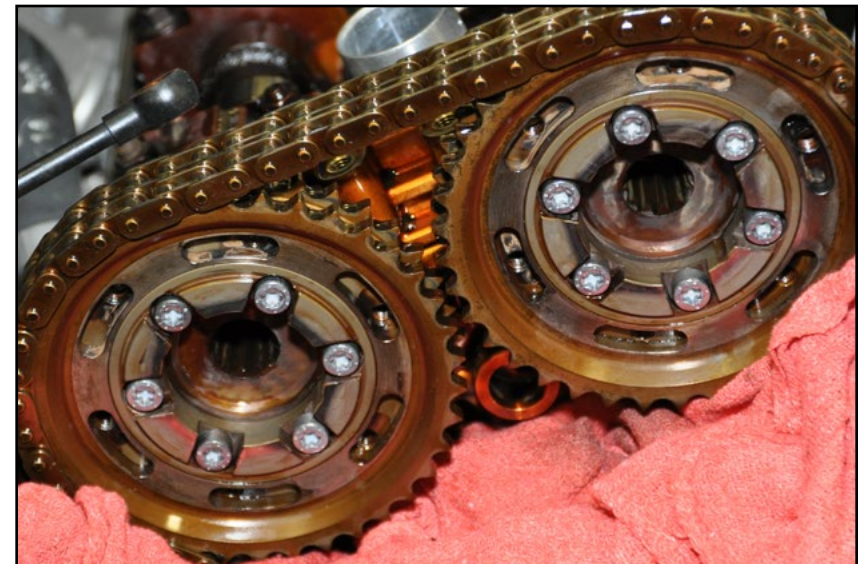
### Step 3: T30 Torx Socket, Torque Wrench

Apply medium strength (**BLUE**) threadlocker to the threads of a new M6 x 16 Torx bolt, then install the bolt and torque it to 12 Nm (9 Ft-lbs).

### Step 4:

Repeat the procedure for all of the remaining cam sprocket hub bolts and once you are complete, clean any debris/solvent out of the internal camshaft splines.

*- End of Section 4c -*



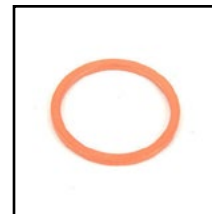
## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT - REQUIRED PARTS

### ES#3038773

Description.....Upper Timing Chain Guide

Location .....Engine Front RH Side

Quantity .....1



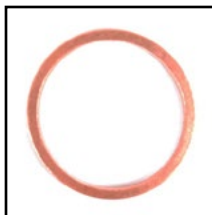
ES#3038773 also includes the Timing Chain Guide mounting bolt sealing washer.

### ES#2603148

Description.....Chain Tensioner Sealing Washer

Location .....Chain Tensioner Large End

Quantity .....1





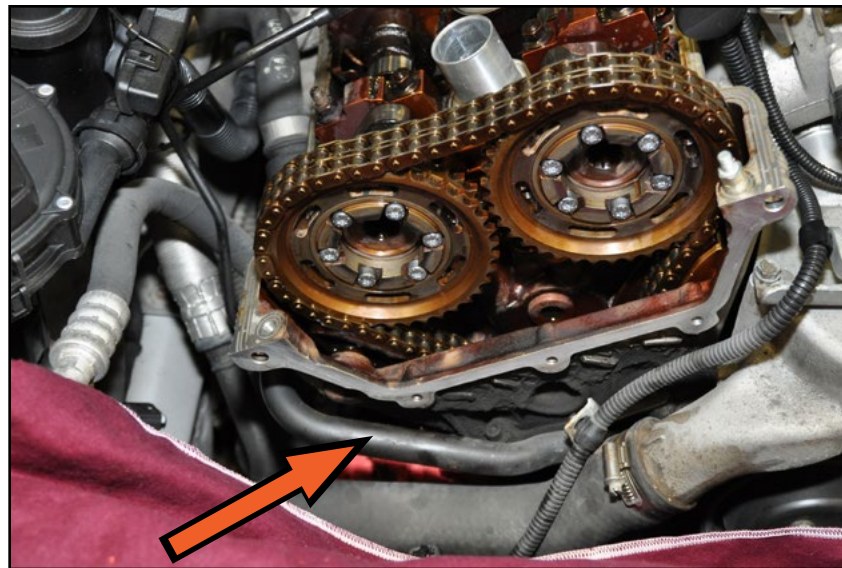
## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT

### Step 1: 32mm Deep Socket, Ratchet

Remove the timing chain tensioner. It's located on the RH (Passenger) side front of the engine, just a little bit below the exhaust cam sprocket.

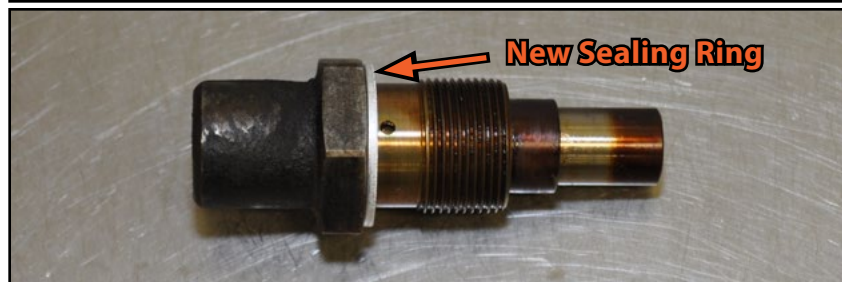
You can't see it in this picture, but it's down there, and easy to find. There's also plenty of room between the engine and body to get a socket and ratchet in to loosen it up.

You'll want to stuff an extra rag underneath because you'll lose some oil when you remove it.



### Step 2:

Remove the old sealing ring, clean up the tensioner, and install the new sealing ring. Set the tensioner aside for now.





## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT

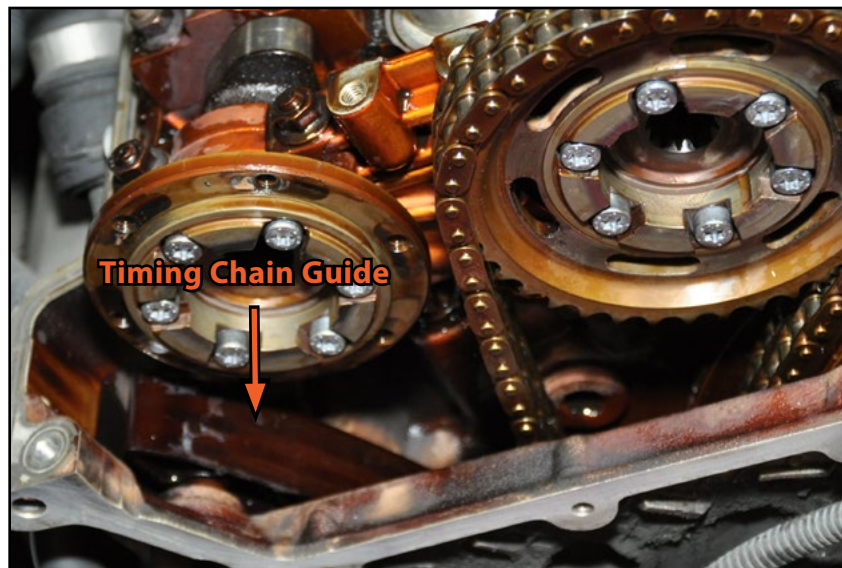
### Step 3:

Slide the exhaust cam sprocket forward off the cam sprocket hub, then remove it from the chain.



### Step 4:

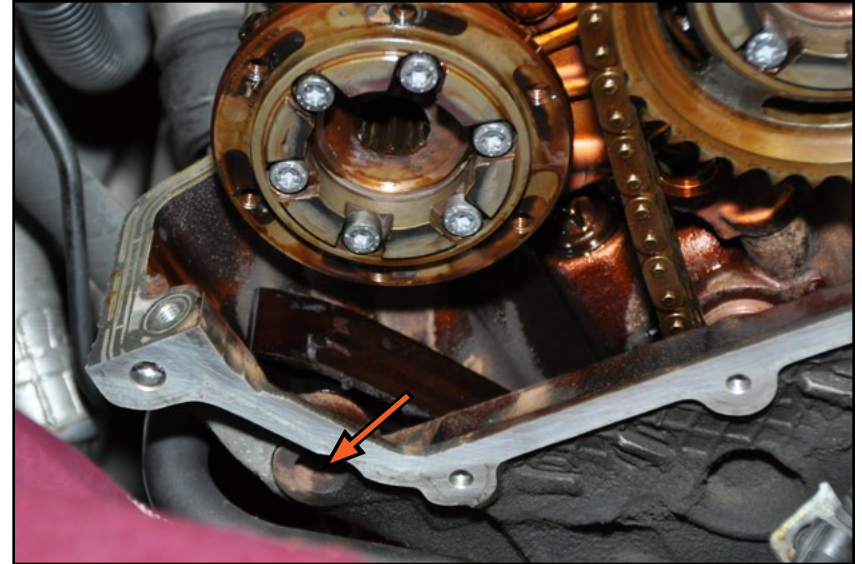
Allow the chain to hang over the intake sprocket so it is out of the way of the timing chain guide.



## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT

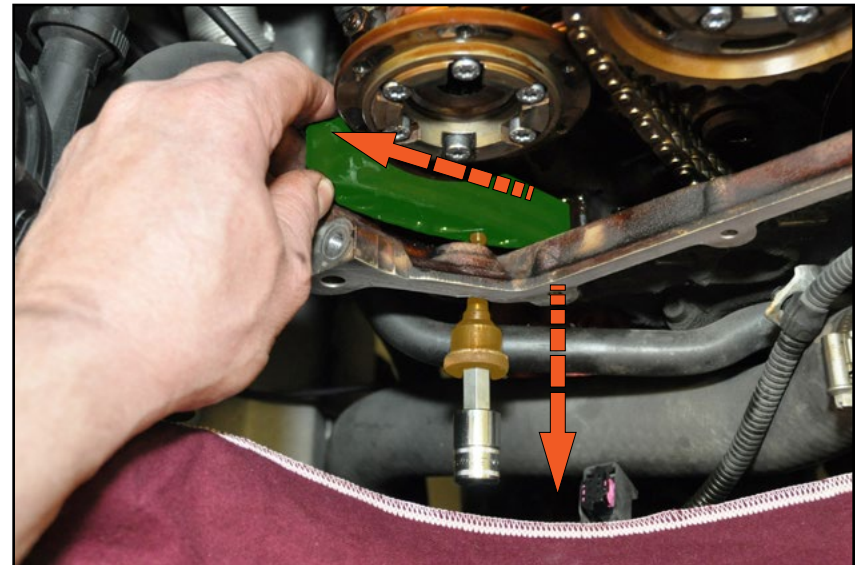
### Step 5:

The upper timing chain guide bolt is located on the RH (Passenger) side of the front timing cover, near the top where the Vanos piston housing is mounted.



### Step 6: 10mm Hex Bit (Allen) Socket, Ratchet

Loosen the upper timing chain guide bolt, then pull it part way out. Make sure you get a good grip on the timing chain guide, then pull the bolt the rest of the way out and remove the guide.





## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT

### Step 7:

Inspect the original upper timing chain guide, and compare it to the new one. It is common for the ends to crack or break, if yours is broken, make sure you find and remove the broken piece.

Clean the timing chain guide bolt, remove the old sealing ring and install the new one.



### Step 8: 10mm Hex Bit (Allen) Socket, Torque Wrench

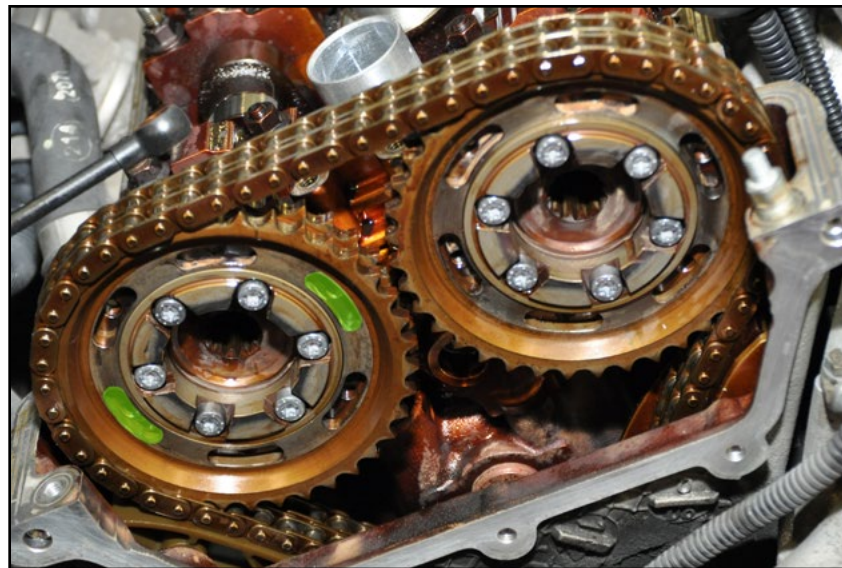
Lower the new Upper timing chain guide into place and install the guide bolt. Torque the bolt to 24 Nm (18 Ft-lbs).



## SECTION 4D: UPPER TIMING CHAIN GUIDE REPLACEMENT

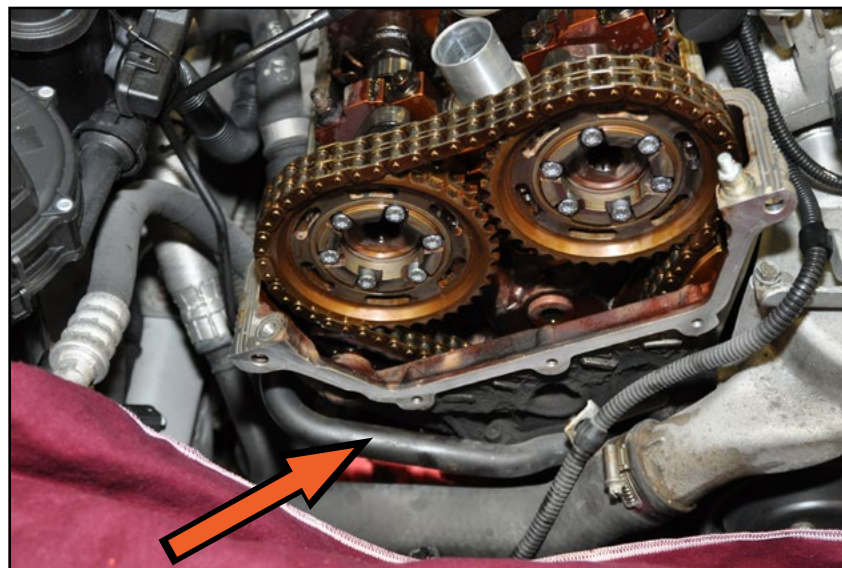
### Step 9:

Reinstall the timing chain onto the exhaust sprocket, then the sprocket onto the exhaust hub. Precise positioning is not necessary, however it is important to make sure that two of the bolt slots are located approximately on the left and right as shown.



### Step 10: 32mm Deep Socket, Ratchet

Reinstall the timing chain tensioner and once it is snug, tighten it approximately an additional 1/2 turn to "crush" the sealing washer.



Proceed with step 6 on [Page 74](#).

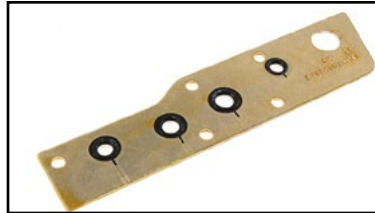
**- End of Section 4d -**



## SECTION 5A: REASSEMBLY - REQUIRED PARTS

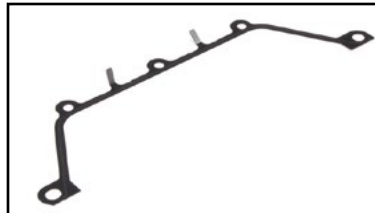
### ES#23224

Description.....Vanos Valve Block Sealing Plate  
Location.....Between Coil Pack and Valve Block  
Quantity.....1



### ES#2702388

Description.....Piston Housing Gasket  
Location.....Between Piston Housing and Cyl Head  
Quantity.....1



## SECTION 5A: REASSEMBLY

### Step 1:

Make sure the engine is still at TDC and the crankshaft pulley is locked in position with the crankshaft locking pin. *View pages 18 through 22 for reference.*

Place the camshaft alignment bridge onto the cylinder head between cylinders 2 and 3. Note the two holes in the bridge that correspond with a hole in each of the intake and exhaust camshafts.

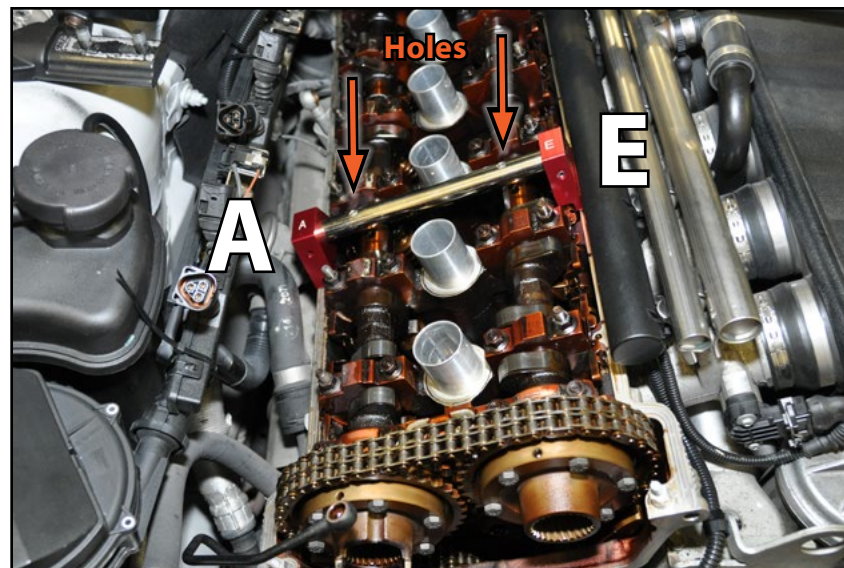


Our Schwaben camshaft bridge, as well as many others, is marked with the letter “E” for the intake side and “A” for the exhaust side, abbreviating the German words. Make sure it is installed properly.

### Step 2:

On the intake, or “E” side, insert the dowel pin through the alignment bridge and into the hole in the camshaft. Move the camshaft back and forth as necessary using a 24mm wrench in order to align the pin. Once the pin is fully inserted, rotate the cam as required until the camshaft bridge sits flat against the cylinder head.

Once the intake camshaft is aligned as described above, pull out the dowel pin.



## SECTION 5A: REASSEMBLY

### Step 3:

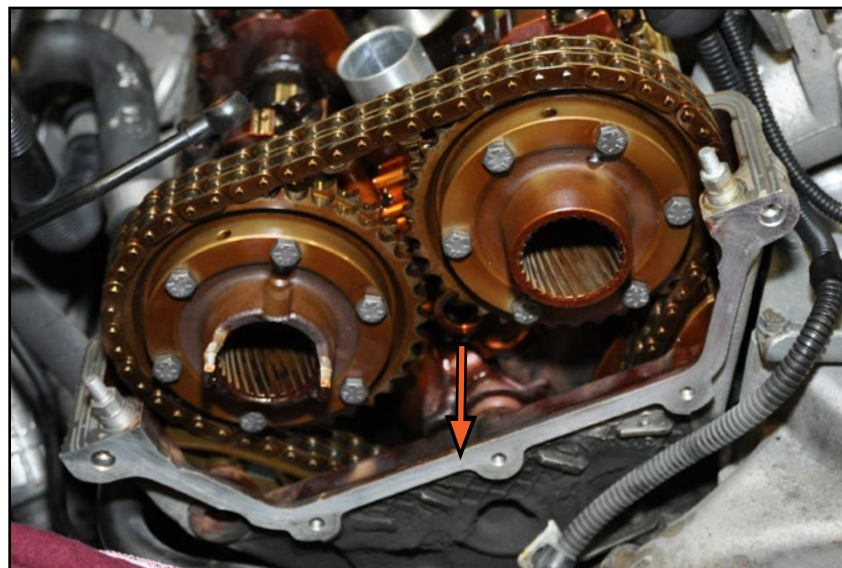
On the exhaust, or "A" side, Insert the dowel pin through the alignment bridge and into the hole in the camshaft. Move the camshaft back and forth as necessary using a 24mm wrench in order to align the pin. Once the pin is fully inserted, rotate the cam as required until the camshaft bridge sits flat against the cylinder head.

Once the exhaust camshaft is aligned as described above, pull out the dowel pin and remove the camshaft bridge.



### Step 4:

Thoroughly clean the Vanos gasket surface on the front of the cylinder head.

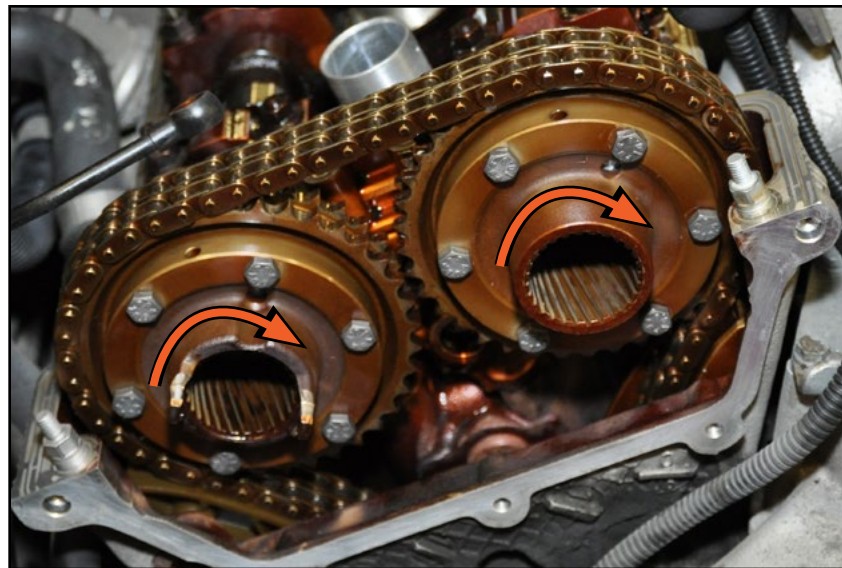




## SECTION 5A: REASSEMBLY

### Step 5:

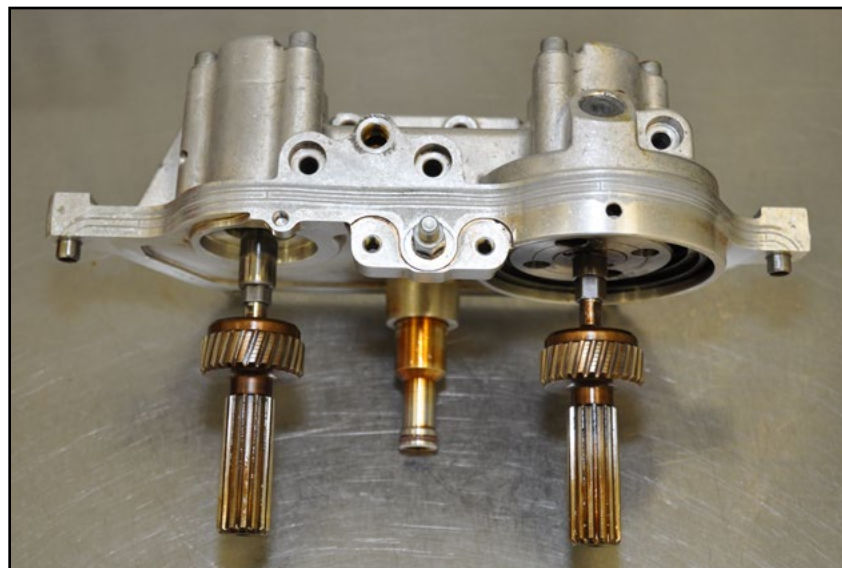
Rotate the intake and exhaust Vanos hubs by hand in a clockwise direction as far as they will go. The bolts should only be hand tight and the hubs should rotate easily. Loosen the bolts a few turns if necessary.



### Step 6: 7mm, 10mm Open End Wrench

Install both transfer gears onto the Vanos pistons, paying attention to the following points:

- 1)** Be sure to install the exhaust transfer gear (with the longer shaft) on the exhaust side (with the oil pump rotor).
- 2)** The thread is reverse thread.
- 3)** Tighten them by hand and be careful not to over tighten them. Due to the left hand thread, they do no need to be excessively tightened.

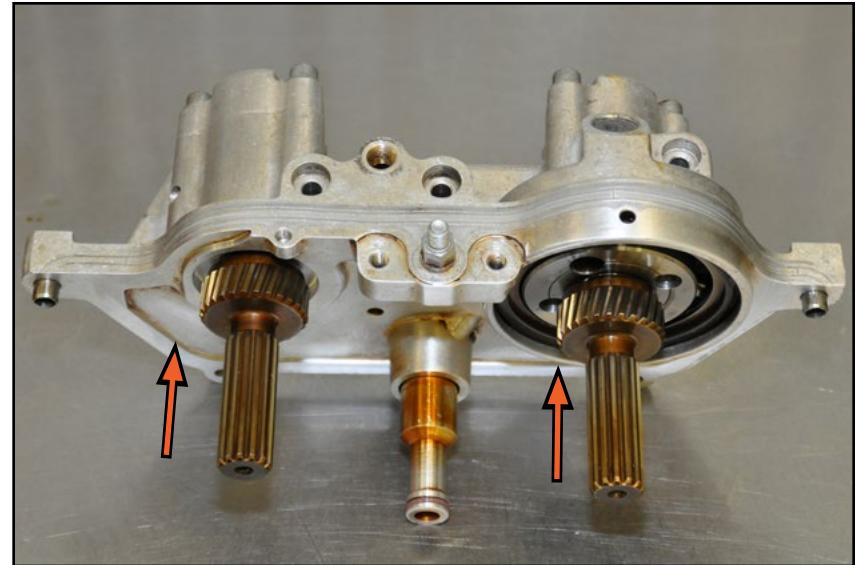




## SECTION 5A: REASSEMBLY

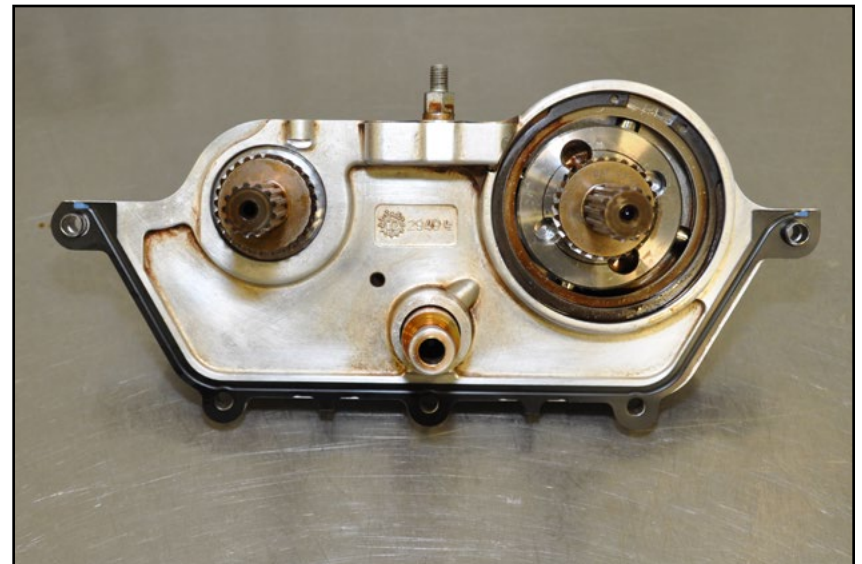
### Step 7:

Push the vanos pistons all the way into the housing.



### Step 8:

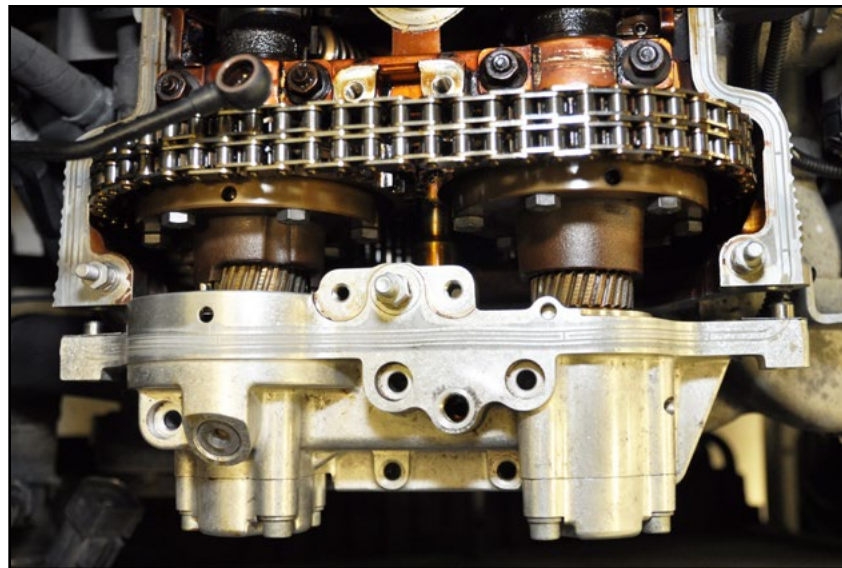
Install the new piston housing gasket into place. Here we have placed it onto the piston housing. The dowels will hold it in place. You may find that the dowels have remained in the cylinder head and you can install the gasket there instead. It works either way. If you have a preference, you can move the dowels from one component to the other - your call.



## SECTION 5A: REASSEMBLY

### Step 9:

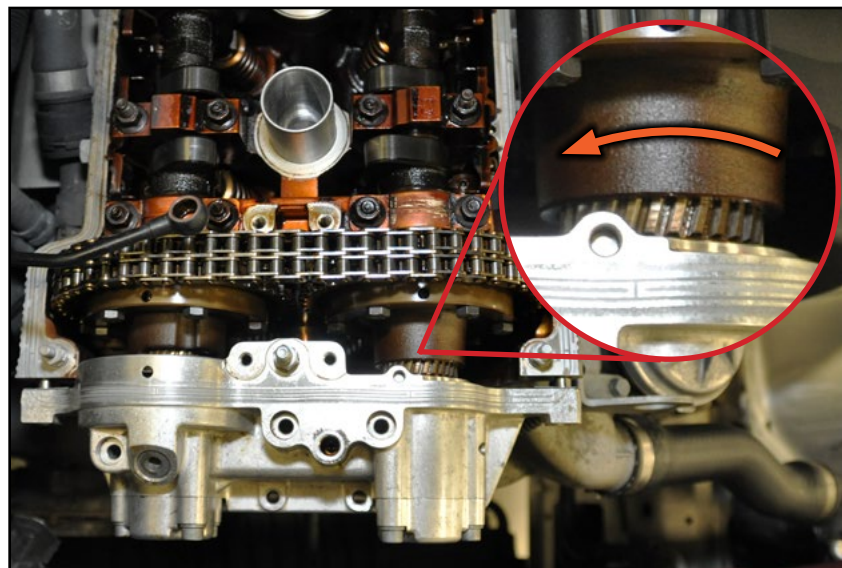
Align the straight splines on each transfer gear with the splines in the center of each camshaft, then slide the piston housing inward until the angled splines meet the end of the vanos hubs.



### Step 10:

Rotate *each* Vanos hub *just slightly* counter-clockwise until the angled splines line up, allowing the transfer gear to slide further into the hub. Keep in mind the following points:

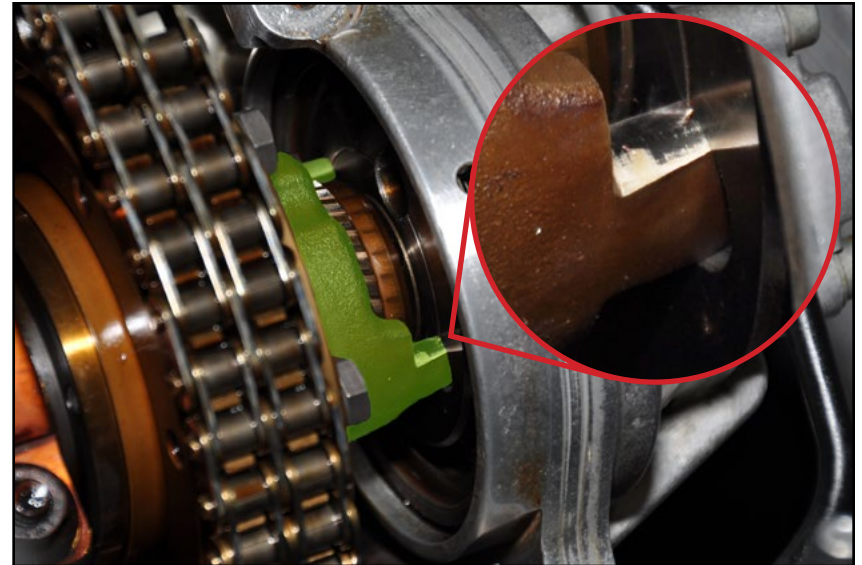
- 1) It will only take slight rotation of the hubs until the splines engage.
- 2) Once engaged, only push them in a short way, the oil pump rotor still need to be aligned.
- 3) The Vanos hubs will rotate counter-clockwise as the transfer gears are pushed in.



## SECTION 5A: REASSEMBLY

### Step 11:

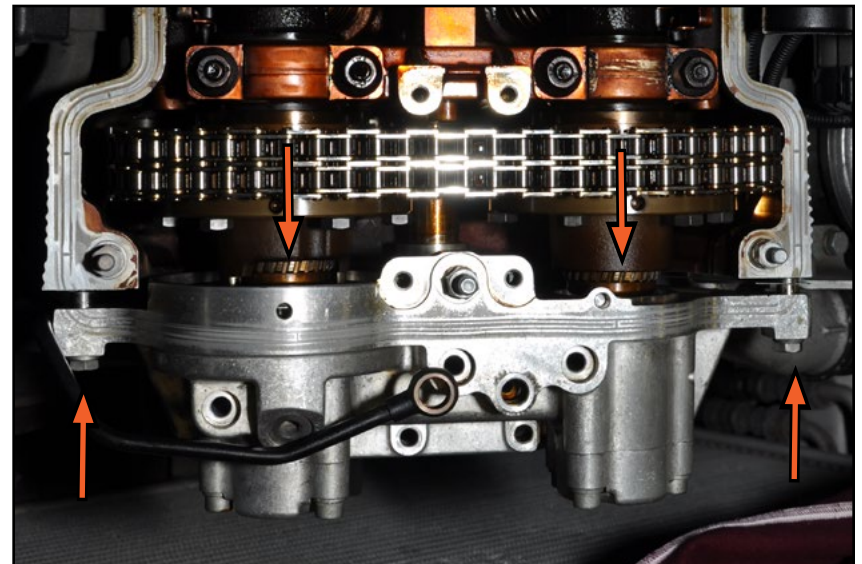
Look between the Vanos piston housing and the exhaust cam and align the oil pump drive tabs with the new (smaller) holes in the oil pump rotor.



### Step 12:

Push the piston housing further in until it reaches the dowels, then thread the top corner mounting bolts in just until they contact the piston housing. Do not tighten them.

Confirm that the Vanos pistons are pushed all the way back into the housing. Push them back in if necessary.



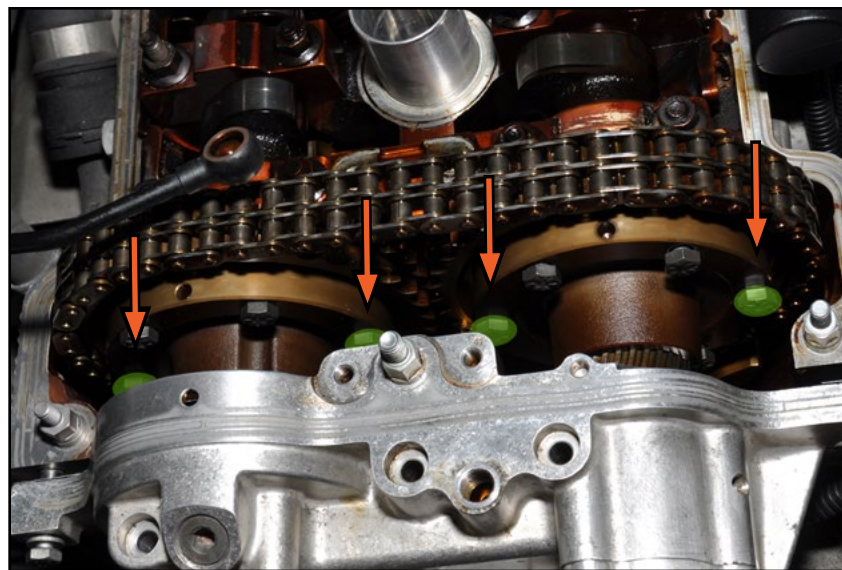


## SECTION 5A: REASSEMBLY

### Step 13: 10mm Wrench

First, tighten the four side bolts (highlighted) evenly on the vanos hubs, until they are fully seated.

Next, loosen each of them ¼ turn.

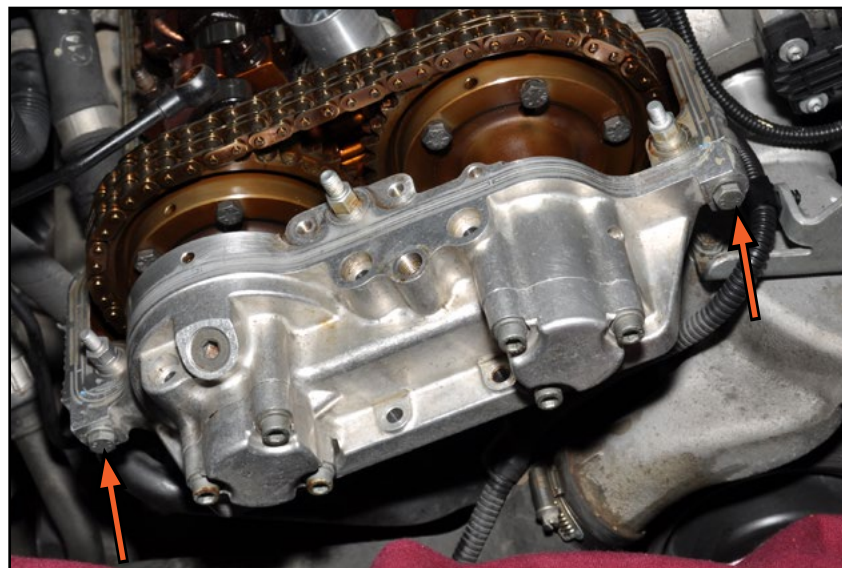


### Step 14: 10mm Socket, Ratchet

Double check to make sure the gasket is still in place, then tighten the two Vanos piston housing corner bolts evenly until the piston housing is fully seated onto the cylinder head.



The Vanos hubs will rotate, but the **camshafts should not rotate** when drawing the piston housing into place. If the camshafts rotate, the bolts in step 13 are not loose enough. You will have to remove the Vanos piston housing w/transfer gears, reset the cam position, then reinstall it, making sure the bolts are loose enough.





## SECTION 5A: REASSEMBLY

### Step 15: 5mm Allen, 10mm Socket, Torque Wrench

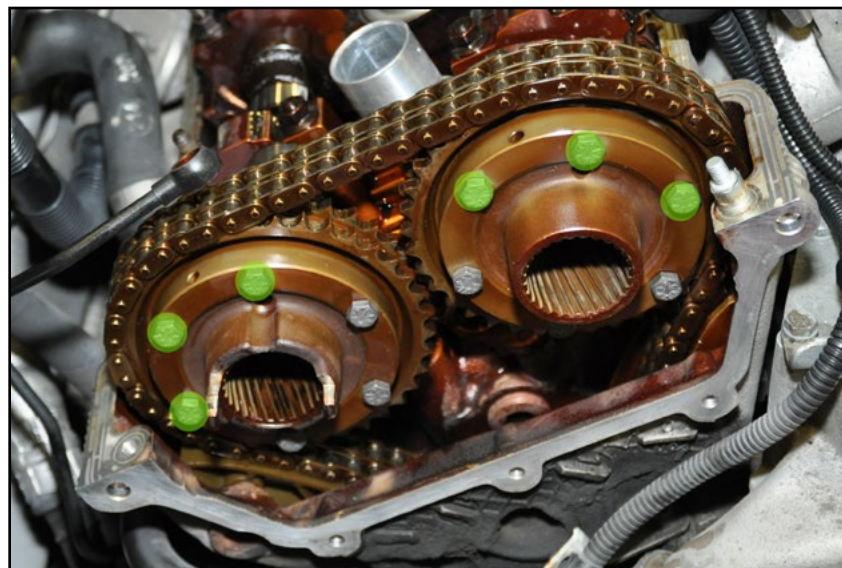
Install the lower three Vanos piston housing mounting bolts, then torque them all to 10 Nm (7 Ft-lbs).



### Step 16: 10mm Wrench

On the intake hub, evenly tighten the two upper and RH bolts (highlighted), on the exhaust hub, evenly tighten the two upper and LH bolts (highlighted). Note the following:

- 1) For clarity, the photo is shown *without the piston housing installed*.
- 2) Tighten the bolts only until they are snug.



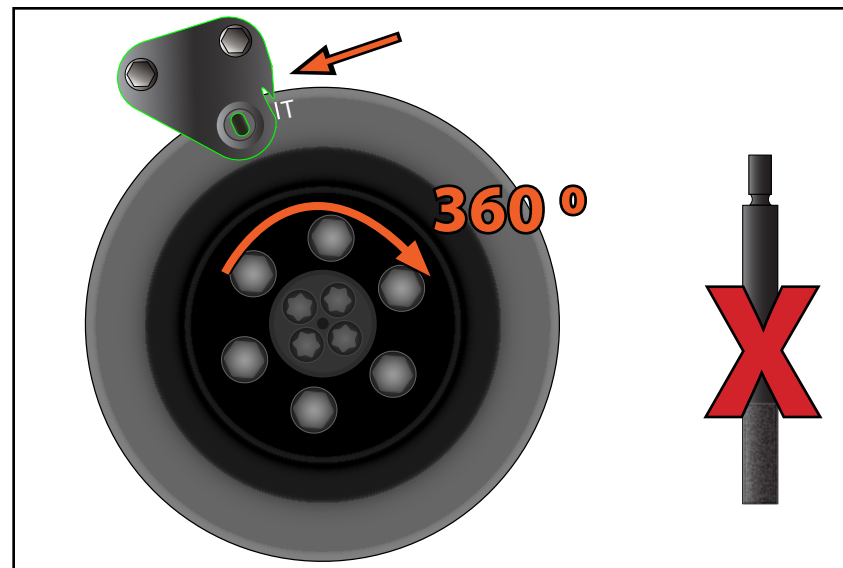
## SECTION 5A: REASSEMBLY

### Step 17: 32mm or Special Crank Socket, 1/2" Ratchet

Remove the crankshaft locking pin, then rotate the engine clockwise 360 degrees (one full rotation) and line up the TDC timing mark.



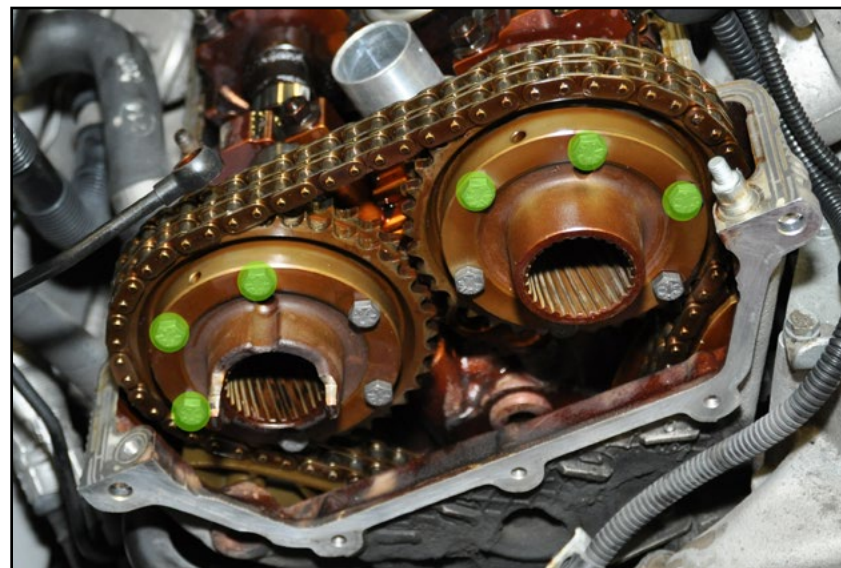
Do not reinstall the crankshaft locking pin.



### Step 18: 10mm Wrench

On the intake hub, evenly tighten the two upper and RH bolts (highlighted), on the exhaust hub, evenly tighten the two upper and LH bolts (highlighted). Fully tighten these bolts to 14 Nm (10.5 Ft-lbs). Note the following:

- 1) For clarity, the photo is shown *without the piston housing installed*.
- 2) There is not enough room for a torque wrench, so you will have to estimate the torque by feel.

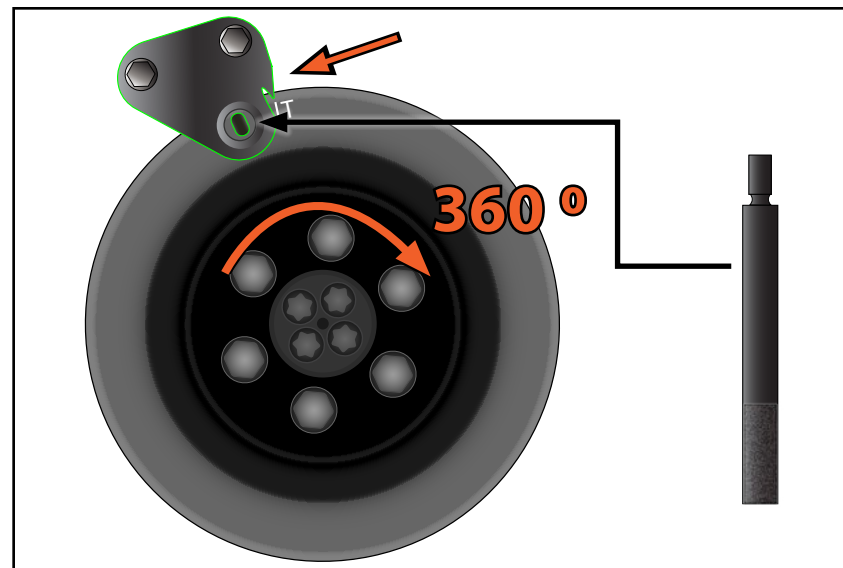


## SECTION 5A: REASSEMBLY

### Step 19: 32mm or Special Crank Socket, 1/2" Ratchet

Rotate the engine clockwise 360 degrees (one full rotation) and line up the TDC timing mark.

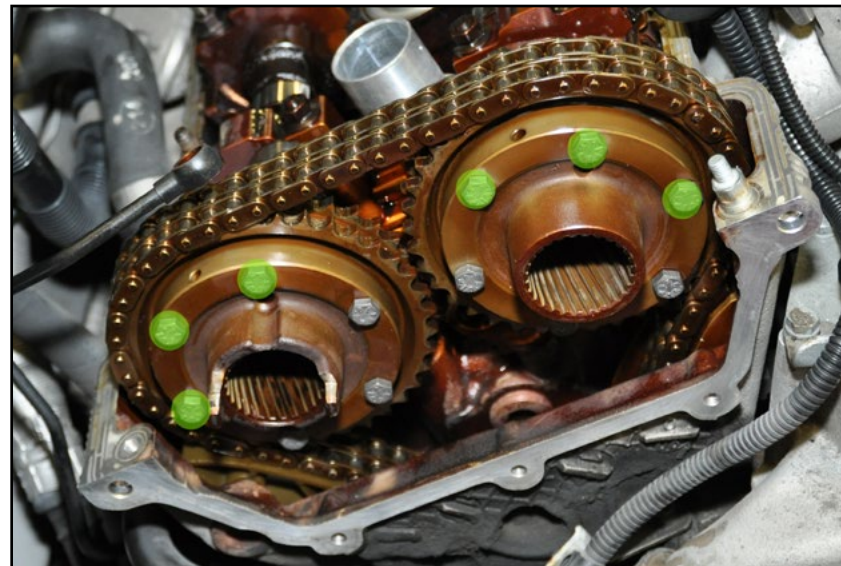
Reinstall the crankshaft locking pin.



### Step 20: 10mm Wrench

On the intake hub, fully tighten the two upper and RH bolts (highlighted), on the exhaust hub, fully tighten the two upper and LH bolts (highlighted) to 14 Nm (10.5 Ft-lbs). Note the following:

- 1) For clarity, the photo is shown *without the piston housing installed*.
- 2) There is not enough room for a torque wrench, so you will have to estimate the torque by feel.





## SECTION 5A: REASSEMBLY

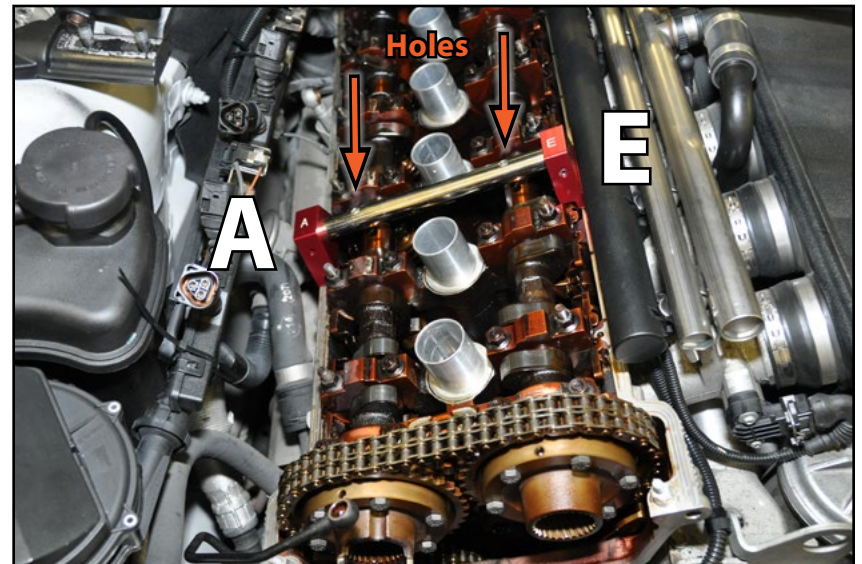
### Step 21:

Fully retard the intake and exhaust camshafts. Reference page 21 for additional information.



### Step 22:

Install the alignment bridge between cylinders 2 and 3 as you did before.



## SECTION 5A: REASSEMBLY

### Step 23:

Insert the alignment dowel through the bridge and into the intake camshaft. If engine timing is correct, the alignment bridge will remain flat on the cylinder head (a small gap - approximately .5mm - between the head and the feet of the bridge is acceptable).



### Step 24:

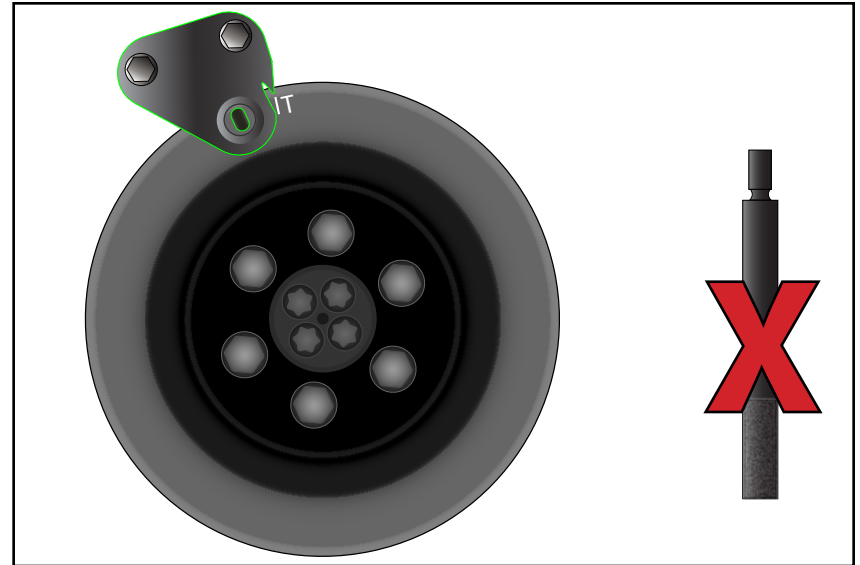
Insert the alignment dowel through the bridge and into the exhaust camshaft. If engine timing is correct, the alignment bridge will remain flat on the cylinder head (a small gap - approximately .5mm - between the head and the feet of the bridge is acceptable).



## SECTION 5A: REASSEMBLY

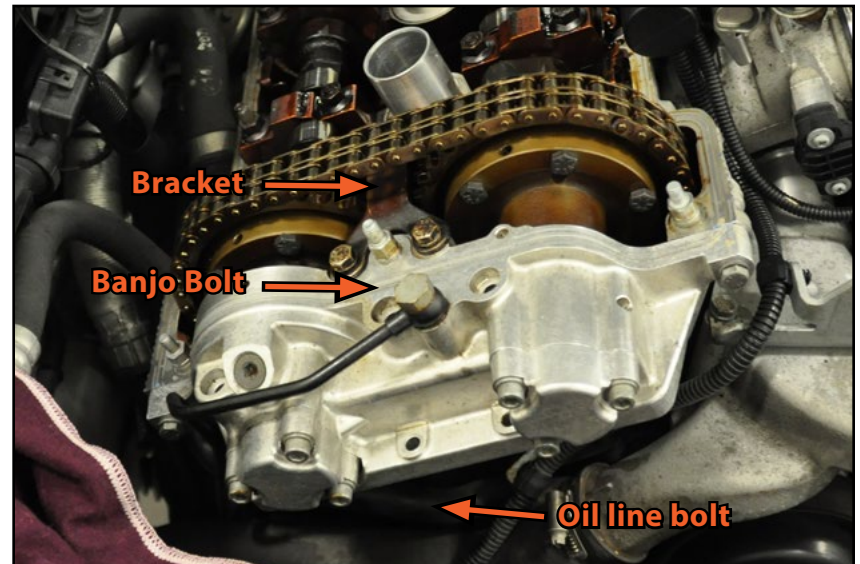
### Step 25:

Remove the crankshaft locking pin.



### Step 26: 5mm Allen Socket, Torque Wrench

Reinstall the oil pipe banjo bolt, the oil pipe securing bolt, and the Vanos bracket.

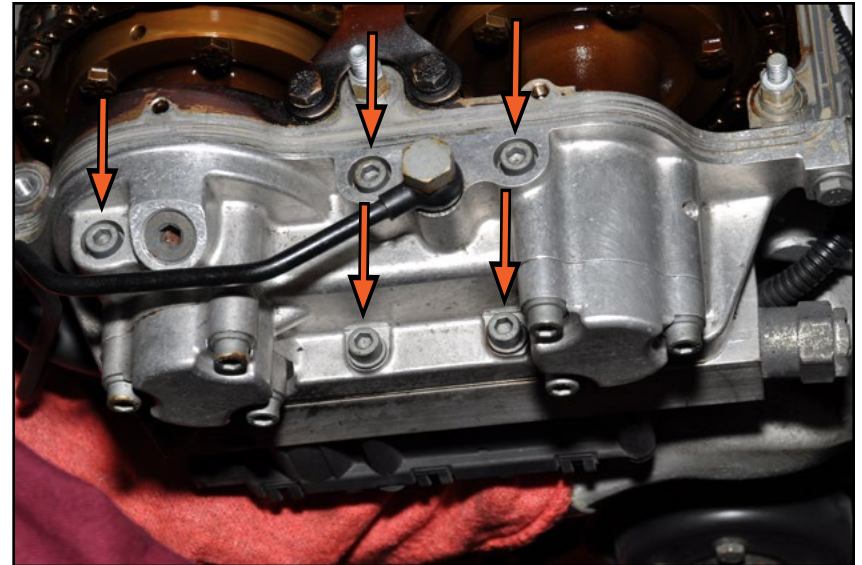




## SECTION 5A: REASSEMBLY

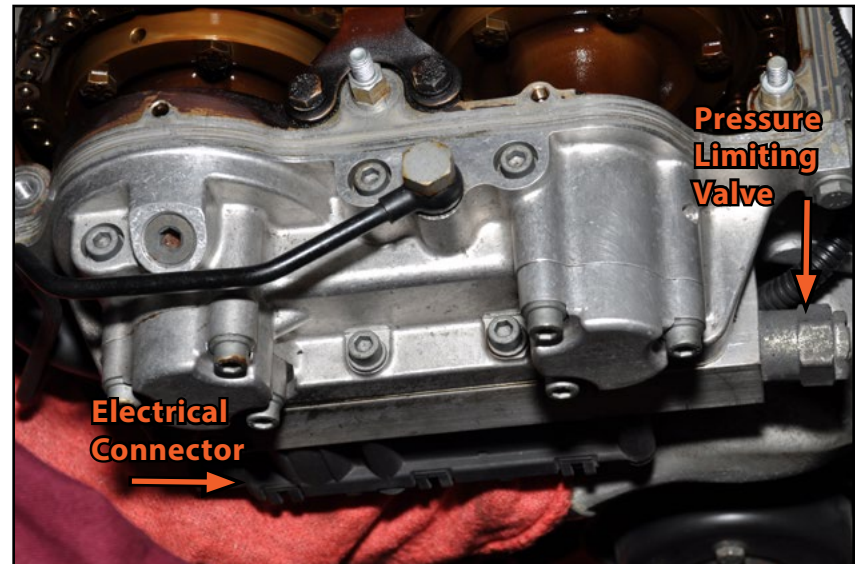
### Step 27: 5mm Allen Socket, Torque Wrench

Reinstall the valve block using the new sealing plate and torque the bolts to 10 Nm (7 Ft-lbs).



### Step 28:

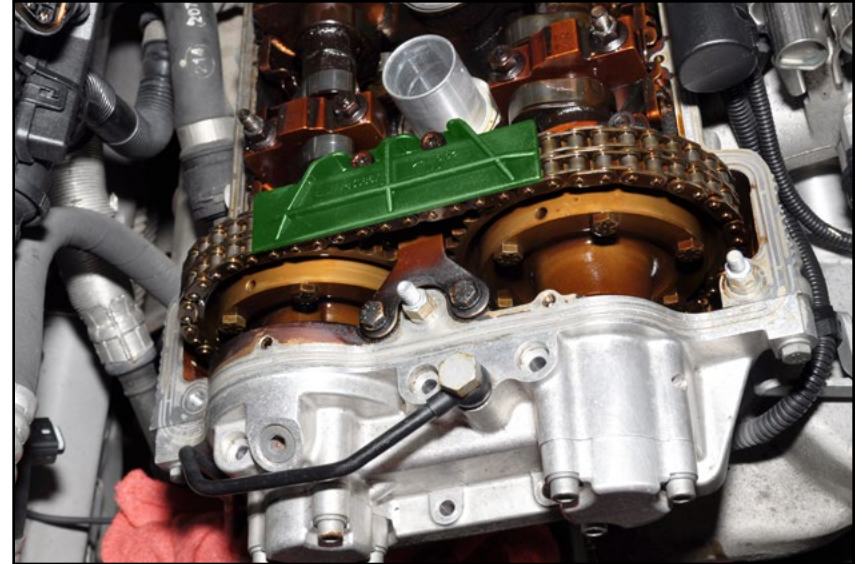
Tighten the pressure limiting valve and connect the electrical connector.



## SECTION 5A: REASSEMBLY

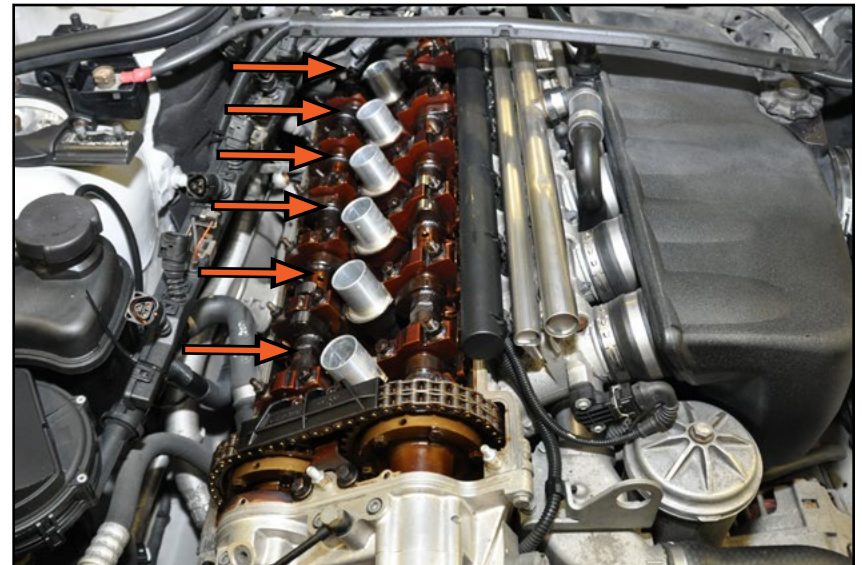
### Step 29:

Install the cam chain guide.



### Step 30:

Reinstall the spark plugs and torque them to 25 Nm (18 Ft-lbs).

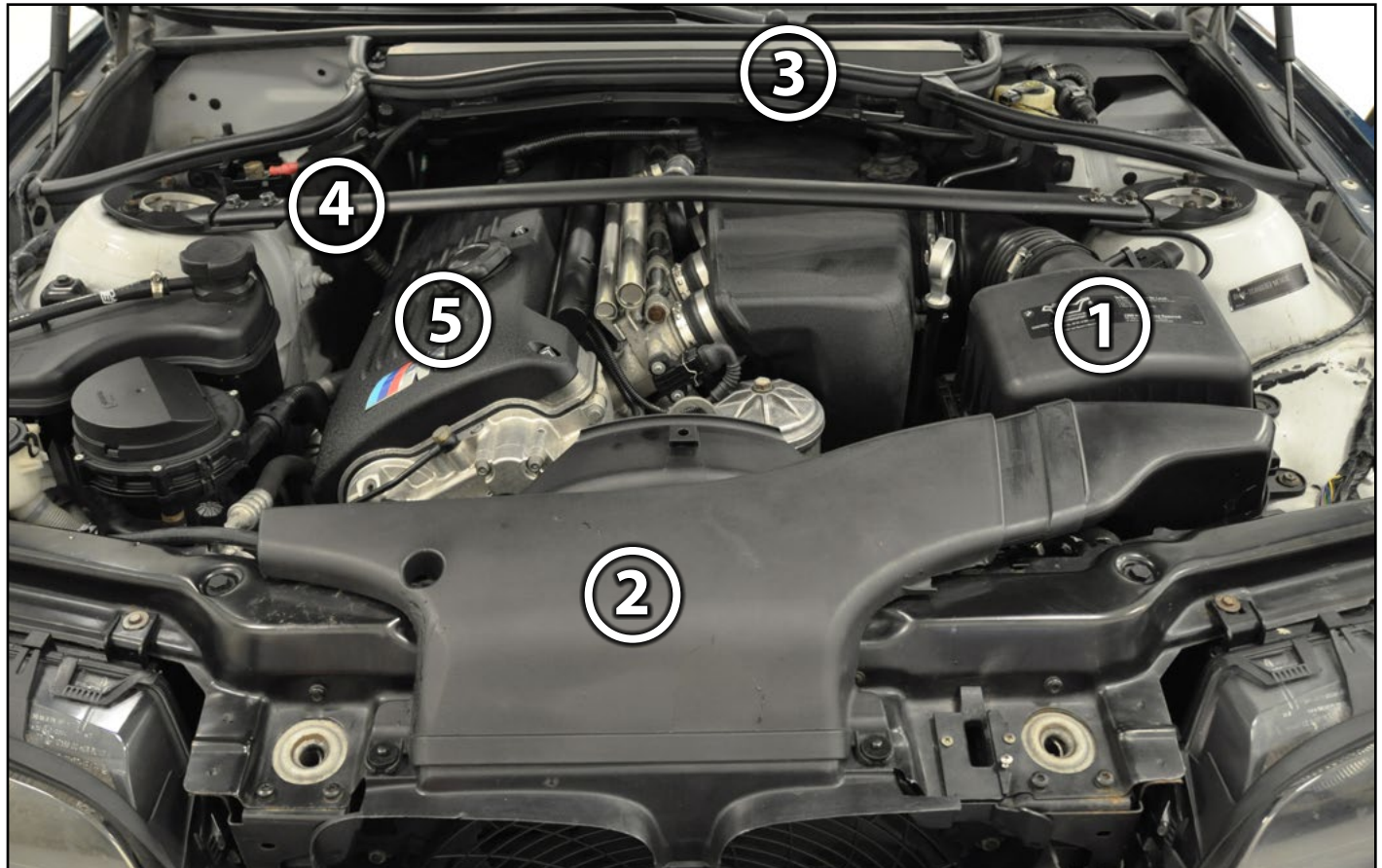




## SECTION 5A: REASSEMBLY

Reinstall all components that were removed for Vanos access.

1. Air Box
2. Radiator Fan and Shroud
3. Cabin Filter Housing
4. Suspension Cross Brace
5. Engine Top Cover, Valve Cover, and Ignition Coils





## TORQUING TIPS

### Torque to Yield or "Stretch" Bolts

Many bolts will have a torque specification listed in the format - xx Nm (xx Ft-lbs) + xx degrees. These bolts are torque to yield bolts, commonly referred to as "stretch" bolts. The correct procedure for torquing these bolts is:

**Stage One** - Torque the bolt(s) to the initial Nm or Ft-lb specification. If there is more than one, be sure to torque them in the correct sequence.

**Stage Two** - Tighten or "stretch" the bolt(s) the additional specified number of degrees. If there is more than one, be sure to follow the correct sequence.

**Note** - Some bolts may have two or more stages of torquing before the final stage of "stretching" the bolts.

When tightening more than one bolt in a specified sequence, be sure to mark each fastener with paint **immediately** after performing the final stage or "stretching" of the bolts. This will ensure that you keep track of which bolts have already been "stretched".

All Torque to Yield bolts should only be used once and should be replaced each time they are removed. If they are reused, they will not be able to achieve the proper clamping force with the specified torque.

### Lubrication

Torque specifications are always listed for a dry fastener (**no** lubrication) unless specified otherwise.

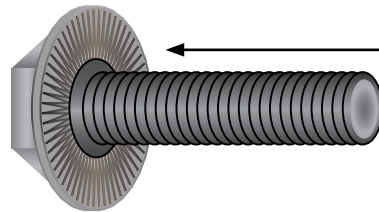
Some fasteners require lubrication on the threads -or- on the contact surface while torquing. These fasteners will be listed with the specific location and type of lubrication required. Always follow manufacturers recommendations exactly.

Lubricating a fastener that is intended to be installed dry and then torquing it to factory specifications will increase the clamping force and stress on the fastener and components, which can result in damage or failure.

Do not lubricate the threads of any fastener unless it is specifically recommended by the manufacturer.

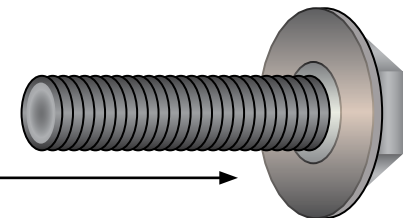
### Ribbed vs. Non-Ribbed Bolts

Ribbed and Non-Ribbed bolts in the same location generally require a different torque specification.



A ribbed bolt is identified by the ribs on the contact surface

A non-ribbed bolt is identified by the smooth contact surface



## TORQUE SPECIFICATIONS

Cam Sprocket M6 x 16 Torx Bolt w/Medium Threadlocker .....	12 Nm (9 Ft-lbs)
Coil Pack Mounting Screws .....	4 Nm (3 Ft-lbs)
Exhaust Piston Cap Bolts.....	10 Nm (7 Ft-lbs)
Intake Piston Cap Bolts .....	10 Nm (7 Ft-lbs)
Spark Plugs.....	25 Nm (18 Ft-lbs)
Transfer Gear Cap Bolts .....	55 Nm (40.5 Ft-lbs)
Upper Timing Chain Guide Bolt .....	24 Nm (18 Ft-lbs)
Valve Block Mounting Bolts.....	10 Nm (7 Ft-lbs)
Valve Cover Mounting Bolts .....	8 Nm (6 Ft-lbs)
Valve Cover Oil Drain Hose Banjo Bolt.....	25 Nm (18.5 Ft-lbs)
Vanos Hub Mounting Bolts.....	14 Nm (10.5 Ft-lbs)
Vanos Oil Line Banjo Bolt .....	13 Nm (9.5 Ft-lbs)
Vanos Piston Housing Mounting Bolts .....	10 Nm (7 Ft-lbs)

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