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SUPPLEMENT TO:

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MAGAZINE



TECH SOLUTIONS

guide

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NOTE: All tech bulletins, unless otherwise noted, have been provided by Automotive Production Remanufacturers Association (APRA).

Timing Chain Service on Ford 3.0L Duratec Engines

If you have to remove or replace a cylinder head for any reason, or replace the timing chain on a 3.0L Duratec, it can be a bit of a challenge because Ford doesn't provide a Top Dead Center (TDC) timing reference mark on the crankshaft.

You will have to use a dial indicator to find the TDC position of the number one cylinder on Ford's 3.0L Duratec to make sure the crank and camshafts are all properly aligned.

Ford says that when the crankshaft keyway is positioned at roughly the 11 o'clock position, the number one cylinder should be at TDC.

Before you can remove the timing chain, the front cover has to come off the engine. Then you have to remove the crank sensor pulse wheel. Note the sensor wheel's location before you remove it.

Rotating the crank until the keyway is

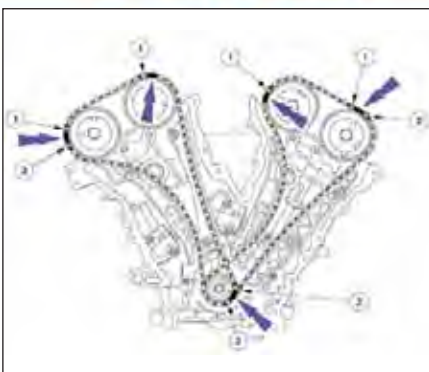


Figure 1 You will have to use a dial indicator to find the TDC position of the number one cylinder on Ford's 3.0L Duratec to make sure the crank and camshafts are all properly aligned.

at the 3 o'clock position will move the right cylinder head camshafts to the neutral position. The timing mark on the intake cam should be pointing to the right when viewed from the front, and the timing mark on the exhaust cam should be pointing

straight up if both cams are in the correct position. You can now remove the chain tensioner arm, chain guide and right timing chain.

To remove the left timing chain, rotate the crank clockwise 600° (1-2/3rds turn) until the keyway is again at the 11 o'clock position. This will position the left cylinder head cams in the neutral position. This time, the timing mark on the intake cam should be pointing to the left when viewed from the front, and the mark on the exhaust cam should be pointing straight up. As before, you can now remove the chain tensioner arm, chain guide and left timing chain.

Before you can reinstall the timing chains, you need to compress the left and right chain tensioners in a vise. Compress the piston until it is fully bottomed, then temporarily lock it in place with a pin or paper clip.

If the replacement timing chain does not have timing marks for aligning with the cam gears, you'll have to mark the left and right side chains. Start with the left chain, and mark one link as the starting crankshaft timing mark. Then count 29 links and make a second mark (for the exhaust cam). Continue counting to link number 42 and make a third mark (for the intake cam). The second and third marks should align with the timing marks on the intake and exhaust cams when the chain is slipped into place. The chain tensioner and arm can now be installed.

Next, you do the same procedure for the right cam. But first, you need to rotate the crankshaft 120° clockwise so the crankshaft keyway is at the 3 o'clock position. Mark the right timing chain and install it the same as before.

Once both chains are in place, remove the locking pin or paper clip from the left and right chain tensioners.

Rotate the crankshaft 120° counter-clockwise so the keyway is back at the 11 o'clock position and number one piston is at TDC. Check to make sure all the timing marks are aligned as shown in the illustration (**Figure 1**).

There should be 12 chain links between the right and left intake and exhaust cam sprocket marks, 27 chain

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links between the cam gears and crank on the non-tensioned side of each chain, and 30 links between the cam gears and crank on the tensioned side of each chain.

By Larry Carley

2003-2004 Ford 3.8L, 3.9L and 4.2L Balance Shaft Gear Clarifications

To deal with certain engine harmonics (particularly, inherent second-order or twice engine rpm vibration), engine designers often incorporate two balance

so that the inertial reaction to their counter-rotation cancels out in the horizontal plane, but adds in the vertical plane. This gives a net force equal to, but 180 degrees out of phase with, the undesired second-order vibration of the basic engine, thereby canceling it. In a "V" configuration the same may be accomplished by opposite counter weights on the same/single shaft. The ultimate result is to eliminate NVH (Noise Vibration Harshness).

This fact is understood, and the Ford 3.8L, 3.9L and 4.2L engines in the same family configuration have had these shafts at various times and in different vehicles – however recognizing changes in the amount of teeth of the drive and driven gears of certain vehicles is critical.

The drive and driven gears of the balance shaft

appear to have changed in August of 2003 for vans and August of 2004 in the truck. The driven gear on the balance shaft



Figure 2 Ford increased the number of teeth in the drive and driven gears on several Ford engine balance shafts in 2003 and 2004.

shafts rotating in opposite directions at twice engine speed. Equal size eccentric weights on these shafts are sized and phased



Figure 3 It's easy to confuse the two gears, but putting the wrong driven gear into a Ford engine will cause real problems.

changed from 31 to 38 teeth, and as you can see in the illustrations (**Figures 2, 3**) it would not be hard to confuse the two.

The change in teeth was to further reduce the NVH of the gears that drive the balance shaft. Obviously a mix up would result in a catastrophic failure. However, what I have found is that as long as you keep the camshaft drive gear and balance shaft gear matched it makes no difference which ones you use.

By Roy Berndt



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Oil Leak Repair for 1990-1993

4.0L Ford V6 Engines

The 4.0L Ford V6, used in the Aerostar, Explorer and Ranger pickups, has been a problem engine for oil leaks for years.

The most common oil leak on '90-'93 4.0L engines is often diagnosed as a rear seal leak, but in most cases, the problem is usually found to be the rear of the oil pan gasket. Since 1990, when the 4.0L was first introduced, Ford redesigned the gasket twice and even the oil pan casting to eliminate the leaking issue.

The following installation tips from Canada Engines should help to prevent this costly and aggravating oil pan gasket leak.

The '90 to '93 gasket set will include a plastic wedge seal that goes into a groove in the main cap (see **Figure 4**).

The oil pan was redesigned in 1994 and so was the gasket (**Figure 5**). The wedge seal is no longer used because its shape is

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Figure 4 The oil pan gasket for the '90 to '93 4.0L Ford engine (top) will include a plastic wedge seal (bottom) that goes into a groove in the main cap

built into the gasket. Silicone is still necessary across the main cap and in the cavities between the cap and the block.

The oil pan must be aligned with a straight edge to the back of the block before it is torqued down.

Source: Canada Engines LTD

Rattle Noise From Primary Chain Drive on Ford 4.0L SOHC Engine

There have been complaints of a rattle coming from the primary timing chain drive area on some 1999-2002 Ford 4.0L SOHC engines during cold engine operation.

The 4.0L SOHC engine is one of Ford's Cologne V6 engines, a line of 60°, cast iron block, V6 engines produced continuously by Ford in Cologne, Germany since 1968. It uses a jackshaft in place of a camshaft to drive a timing chain to each cylinder head. The patented "Offset Y-drive" (see **Figure 6**) uses three timing chains, one from the crank to the jackshaft, one in the front of the engine to drive the cam for the left bank and one on the back of the engine to drive the cam for the



Figure 5 The oil pan was redesigned in 1994 and so was the gasket. The wedge seal is no longer used because its shape is built into the gasket. Silicone is still necessary across the main cap and in the cavities between the cap and the block.

right bank.

The noise is audible during hot and cold engine operation (but predominantly found on cold engines) under acceleration, typically at 2,400-2,500 rpm. To confirm presence of this noise, accelerate in 2nd gear between 2,000-3,000 rpm and listen for a rattle noise that sounds similar to spark knock. This may be caused by the primary timing chain tensioner system.

Replace the primary timing chain tensioner, chain guide, jackshaft, and crankshaft sprockets with a primary timing chain tensioner kit. The kit includes an improved primary chain Tensioner, as well as updated primary chain guide, jackshaft, and crankshaft sprockets. Required fasteners, primary timing chain, and front cover gaskets are also included.

Use kit **2U3Z-6D256-AA** (balance shaft engines) for:

- '99-'01 4x4 Explorer/Mountaineers;
- '01-'02 4x4 Sport/Sport Tracs; and
- All '02 Explorer/Mountaineers, except engine codes 2G-960-AA and 2G-964-



Figure 6 The patented "Offset Y-drive" uses three timing chains, one from the crank to the jackshaft, one in the front of the engine to drive the cam for the left bank and one on the back of the engine to drive the cam for the right bank.

AA.

Use kit **2U3Z-6D256-BA** (non-balance shaft engines) for:

- '99-'01 4x2 Explorer/Mountaineers;
- '01-'02 4x2 Sport/Sport Tracs;
- '02 Explorer/Mountaineers with engine codes 2G-960-AA and 2G-964-AA; and
- All 2001-02 Rangers. TSG

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TECH SOLUTIONS *guide* GENERAL MOTORS

Deciphering The Differences In The Chevy 2.2L Engine

The very popular Chevrolet 2.2L/ four-cylinder engine has been a solid steed in GM's FWD/RWD stable. But even after all these years, it still manages to raise questions surrounding the Gen

presents us with the 2.2L now being both FWD and RWD, which you would think would mean numerous differences. Actually, that's not so. GM used two different head gaskets through 1997, and in 1998 went to a common head gasket for both FWD and RWD. Using the incorrect head gasket will result in almost immediate overheating. The castings made changes in those years but they followed suit in both FWD and RWD configurations.

In 1994, the valve stem diameter went from 8 mm to 7 mm as well as going to a roller lifter and assembled camshaft.

The FWD version requires the use of a 34.4 mm soft plug in front of the head while the RWD model is open and must have the bolt holes drilled and tapped (see **Figure 1**). The 1994 motor could have casting number 10112391 or 10112391S that is the service replacement. This same pattern was followed throughout

the 1997 production cycle.

In 1998, a new cylinder head (c/n 24575507) arrived with a heart-shaped combustion chamber against a D shape. The engine also had smaller 1-1/8" diameter exhaust ports vs. 1-3/8", and a triangular top of the intake ports vs. a smaller eyebrow top. This version of the GM 2.2L engine – a single-year configuration – must have an open and drilled EGR port.

Since 1999 to present, the same cylinder head (c/n 24576146) has been used. It is basically the same as c/n 24575507 except for crucial long flat bosses that are now between the first

two and last two exhaust ports (see **Figure 2**). The latest exhaust manifolds have a balance channel that runs between ports 1-2 and ports 3-4 that must seal against the cylinder head. As you can see, that exhaust manifold configuration assembled against the 507 head would leak.

One last quirk: the 146 head may also be drilled for the EGR port as a service replacement for the 507 head in 1998. All later applications would require the use of an EGR block-off plate (GM p/n 24575919) when used without EGR.

Special Note: 1998 applications all required an open EGR port; 1999-2002 are closed EGR, w/exhaust manifold port balance mounting face, (see Illustration D and observe area that arrows are pointing to). P/N 24576146 cylinder head may also have open EGR port and will retro for 24575507 in 1998, or may be used 1999-2002 with the use of EGR block off plate part P/N24575919.

– By Roy Berndt

Timing Chain Tensioner Installation Caution on GM 2.3L Quad 4

The timing chain tensioner on GM's 2.3L "Quad 4" engine is of the spring-loaded ratchet design (See **Figure 3**). The tensioner assembly consists of a housing, spring, and ratcheting plunger. The plunger is locked into the housing and plunger to prevent the accidental release of the spring before or during installation.

Once the tensioner is installed and the chain is in place, the anti-release device must be removed and the plunger manually depressed into the housing to unlock the plunger and release spring tension on the chain.

Inadequate tension placed on the chain will eventually result in chain breakage and the consequential piston to valve contact.

Failure to perform this important final step can lead to severe engine damage.

– From MAHLE Clevite

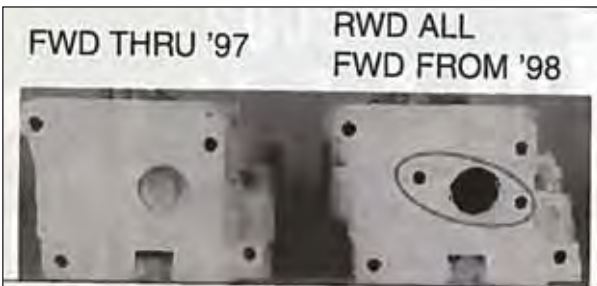


Figure 1 The FWD 2.2L engine (left) requires the use of a soft plug in the front of the head. The RWD model is open and must have the bolt holes drilled and tapped.



Figure 2 The GM 2.2L cylinder head in use since 1999 has long flat bosses between the exhaust ports (top). The latest exhaust manifolds have a balance channel that runs between ports 1 - 2 and 3 - 4.

II engine casting configurations, in particular the cylinder head.

Since its birth in 1990, when the old Chevy 2.0L engine was upgraded with a stroke increased from 3.15" to 3.46", the 2.2L/134CID, OHV four-cylinder engine powerplant has been upgraded several times: the block has been revised four times and the head has been changed three times (it was discontinued after 2003, replaced by the 2.2L Ecotec). Let's start in 1994 and see if we can't clear up some of the confusion.

In 1994 the 2.2L Chevrolet became the base engine in the S-series truck line, replacing the 2.5L Pontiac engines. This

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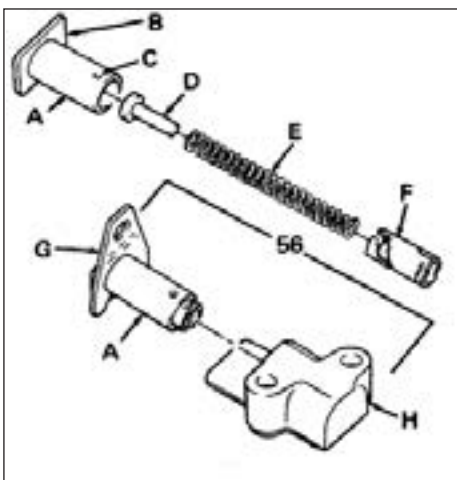


Figure 3 GM 2.3L Quad 4 Timing Chain Tensioner Assembly. This is the late production piece, although early production is similar. Components include: A. Plunger assembly; B. Long end; C. Peg; D. Nylon Plug; E. Spring; F. Restraint cylinder; G. J-36589 Anti-release device; H. Tensioner body.

Chevy 3.1L/191 Cam Bearing Bore Issues

Some of the later roller cam 3.1L blocks for the '93-'94 Chevy VIN M are showing up with oversize cam bearing bores that appear to have been caused by spun cam bearings.

If a new cam bearing is installed in a bore that has been damaged, it will spin in the block, cut off the oil to the cam, and cause an immediate failure (**Figure 4**).

Inspect the cam bores in all of the late 3.1L castings (10137093/ 10191737/ 24504089/ 24504150/ 10224227) very carefully, paying special attention to the #2 bore that seems to be the most prone to failure.

If the cam bore is oversize, there are only two choices:

1) You can either knurl the O.D. of the cam bearing to get enough press fit, or 2) you can junk the block.

— By Doug Anderson



Figure 4 Some of the later roller cam 3.1L Chevy blocks have oversize cam bearing bores that may have been caused by spun cam bearings. Inspection will reveal if you can repair the damage or junk the block.

Noise Complaints with 2004-2005 3.6L Cadillac Engines

If a whine, ringing or whistling noise is reported in several 3.6L Cadillac engines, replacement of the crankshaft harmonic balancer is recommended if

noise is isolated to the front of engine and balancer is three-spoke design.

Models affected include the 2004-2005 Cadillac CTS and SRX; and 2005 Cadillac STS with 3.6L engine (VIN 7 - RPO LY7) and without heavy duty cooling (RPO V03tV92).

Other complaints of a faint engine whine-type noise have been reported at speeds of 0-30 mph (0-48 km/h) at 1,000-2,500 rpm and may be caused by the primary camshaft drive chain. This type of noise may be amplified by the vehicle's body structure.

Some installers/customers may comment on a whine, whistle, or ringing type noise from the front of the engine that increases in intensity as engine rpm increases. This noise is most audible standing in front of the vehicle with the hood opened. If the noise fades into the ambient engine noise by 2,000 rpm the harmonic balancer may be the culprit.

Refer to **Figure 5** and inspect the

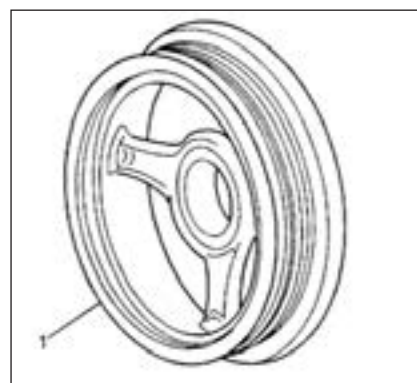


Figure 5 Refer to the above graphic illustration and inspect the crankshaft harmonic balancer for design type. After the inspection, if the vehicle was built with three spoke (1) design crankshaft harmonic balancer, replace the harmonic balancer with p/n 12597654.

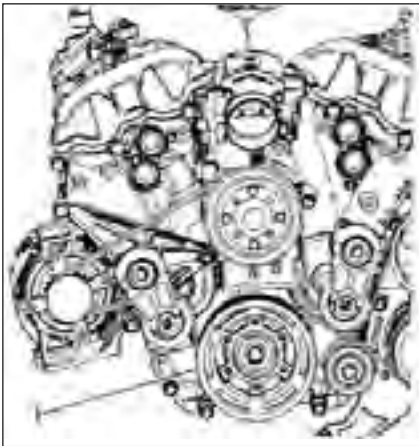


Figure 6 Refer to the above graphic illustration and if the vehicle was built with the NEW DESIGN six spoke (1) crankshaft harmonic balancer, DO NOT replace it. Continue on with routine diagnosis to isolate the noise.

crankshaft harmonic balancer to determine the design type. If the vehicle was built with a three-spoke design crankshaft harmonic balancer, replace the harmonic balancer with a new unit (P/N 12597654.)

However, if the vehicle is equipped with the V03N92 Heavy Duty Cooling package, DO NOT replace the six-spoke design crankshaft harmonic balancer (see **Figure 6**). Continue with routine diagnosis to isolate the noise.

Close-Coupled Converter Caution On Late Model GM Vehicles

Certain late model General Motors vehicles may be equipped with a new style of catalytic converter, technically known as the close-coupled catalytic converter (see **Figure 7**).

This new-style converter provides quick catalyst warm-up, resulting in lower tailpipe emissions earlier in the operating cycle. If an engine failure occurs (such as a broken intake/exhaust valve or piston), debris may be deposited in the converter through the engine exhaust ports.

If the engine failure is due to a severe overheating event, damage to the ceramic "brick" inside of the catalytic converter may occur. This could then result in ceramic debris being drawn into the engine through the cylinder head

exhaust ports.

If a replacement engine is installed due to either of these instances, the replacement engine may ultimately fail due to the debris being drawn into the combustion chamber upon startup.

Remind your installers that when they replace an engine due to a failure of this type, they must inspect the converters and ALL transferred components such as the intake and exhaust manifolds. Remove any debris that is found.

In cases where engine failures occurred as a result of severe overheating, installers should inspect each catalytic converter for signs of melting or cracking of the ceramic "brick." If damage is observed, the converter should be replaced.

Cadillac 4.6L DOHC Aluminum Cylinder Head and Block Crack Cautions

Cadillac 4.6L DOHC engines may be prone to cracking of the aluminum block casting around the cast iron liner



Figure 7 Certain late model General Motors vehicles may be equipped with a new style of catalytic converter, technically known as the close-coupled catalytic converter. Engine failures can damage the converters which, if not inspected properly, can then cause subsequent damage to a replacement engine.

(**Figure 8**). Knowing that this possibility exists, make a close examination of the deck prior to doing any machining at all – and before you then spend

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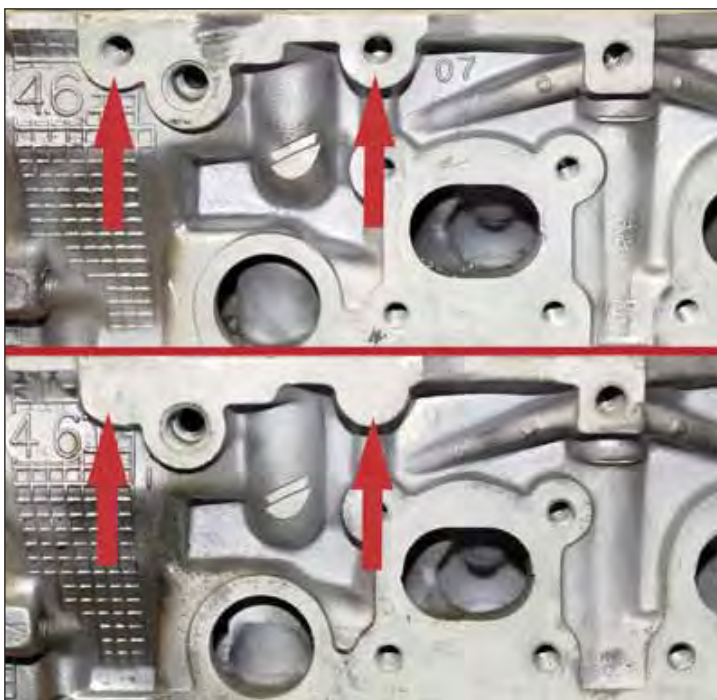


Figure 9 The cylinder head on the top has the bolt holes drilled and tapped for the alternator bracket when used. The head below does not but both have the same casting number. To avoid potential warranty issues drill and tap all heads.



Figure 8 The aluminum 4.6L Cadillac block may crack outside the cast iron cylinder liner and is extremely hard to detect. The above crack became visible only after the deck face was machined.

numerous hours on cylinder head bolt repairs.

The second tip involves cylinder head c/n 3533989 and 12554607, which would be the left head (or front, in the transverse mount engine) that has an alternator bracket bolted onto it in some applications. This head will always have the bosses for this mounting bracket but both of them may or may not be drilled (see **Figure 9**).

If you want to avoid problems I recommend that you drill all of the bosses, thereby eliminating the possibility of having a warranty problem upon installation and also reducing head proliferation.

– By Roy Berndt

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GM Belt Tensioner Failure May Cause Supercharger Failure

All GM vehicles equipped with superchargers may be prone to premature failure of supercharger bearings.

When the belt tensioner starts to fail, belt tension increases as side-loading in the supercharger rear bearing.

Periodic inspection of the belt tensioner should be part of the regular maintenance routine. Before operating the replacement supercharger, the tensioner must be inspected and replaced if defective. Unless the tensioner is checked and replaced as needed, supercharger-bearing failure will occur, causing premature catastrophic failure.

While this problem is prevalent on GM vehicles, this inspection should be performed on all belt-driven supercharged vehicles. Please check the service manual for the recommended inspection and service.

Note: This bulletin is supplied as technical information only and is not an authorization for repair.

– By CARDONE Industries TSG

TECH SOLUTIONS *guide* CHRYSLER

1995-2005 Chrysler 2.4L Cylinder Block Casting Identification

Chrysler replaced its old SOHC four cylinders with an all-new family of SOHC and DOHC engines in 1995.



Figure 1 The hole for the oil sender on the passenger side of the 2.4L was moved back about 6" in 2001 so it's much closer to the bell housing

There were 2.0L SOHC and DOHC versions, along with a 2.4L DOHC that was installed in the FWD cars and minivans. Over the years, this engine has been used in several other applications including the PT Cruiser, the RWD Liberty and Wrangler, and the SRT4 Neon. It has evolved over the years, too, so there are seven short blocks that use six block castings. So, let's take a look and see if we can make some sense out of all the changes to the blocks.

1995-2000: The original casting was a 4621443 block that had a 4621445 bedplate. It was used up through 2000.

2001: The hole for the oil pressure sender on the passenger side was moved back about 6" in 2001 so it was much closer to the bell housing. It's a 4621443AB casting.

2002: The oil drainback hole in the head was enlarged in '02 so there was another "bulge" added to the block on the driver's side, between the third and fourth cylinders. It's an all new casting that has 4781655AA on the driver's side.

2003-2006: There was another all new FWD block in '03 that incorporated several more changes, but the most noticeable one was the change in the location of the hole for the crank sensor; it was moved from the front of the block

on the passenger side to the back of the block on the driver's side in order to accommodate the new, bolt-on "target ring" for the crank sensor.

There were some other changes made to accommodate the turbo motor, too, including a boss on the passenger side that can be drilled for the oil return from the turbo and an additional oil galley inside the block that's machined for the four "oil squirters" that are used to help cool the pistons on the turbo motors. Look for a 4781632AA/AB casting.

2003-2004 RWD: Chrysler installed the 2.4L motor in both the RWD Jeep Wrangler and Liberty beginning in 2003. The RWD block is a unique casting (53010502AA) that doesn't have the "ear" that sticks out from the front of the block down by the

pan rail on the passenger side of the FWD blocks.

These blocks have "RWD" cast on the passenger side so they're easy to spot. The Catch-22 is that this block was used for both the Wrangler and Liberty in '03, but only for the Wrangler in '04 because the Wrangler platform continued to use the old style computer and crankshaft (without "NGC") through '04 even though the Liberty got the "NGC" computer along with a new block and crank in '04.

2004-2005 RWD: The RWD block was revised in 2004 to accommodate the bolt-on "target ring" with more notches that was used with the new "NGC" computer so the hole for the sensor was moved over to the driver's side and back toward the bell housing, just like it was on all the '03 cars. The revised 53010502AB casting was used for the Liberty in '04 and '05 and the Wrangler in '05 and '06.

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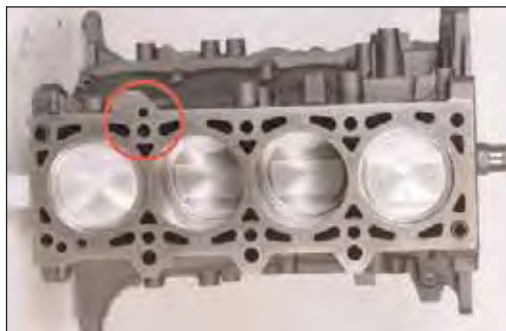


Figure 2 The oil drainback hole in the head on the 2.4L was enlarged in 2002, so the block had a pronounced bulge on the driver's side between the third and fourth cylinders.

Multiple Cylinder Misfire or Rough Idle on 2004-'06 Chrysler 3.5L Engines

This information for installers applies to Chrysler models built after Feb. 1, 2004 (MDH 0201XX) equipped with a 3.5L engine.

This bulletin involves rotating all engine exhaust valves, replacing the valve spring retainer locks with a new design to increase valve rotation at lower rpm, inspecting/replacing the MAP sensor (as necessary) and decarbonizing the combustion chamber.

The customer may experience occasional engine misfire (rough-running engine) during certain vehicle operating conditions.

In addition, MIL illumination may also have occurred due to DTC P0300 - Multiple Cylinder Misfire. Various single cylinder misfire DTCs may also be present. If the frequency of misfire is high, the powertrain control module (PCM) may place the engine in "limp-in" mode.

The misfire condition may be caused by one or more engine exhaust valves that are slow to close due to a buildup of carbon on the valve stem.

Diagnosis

1. This condition may occur when the engine is not allowed to run at engine rpms that are greater than 3,500. At 5,000 rpm or higher, the engine exhaust valves will rotate if not impeded by high carbon deposits. Low engine rpms and high carbon deposits are associated with short-trip driving where the engine is not allowed to fully warm to normal engine operating temperatures.

Cold ambient temperatures will

increase engine warm-up time and increase the likelihood of carbon deposit buildup on the stem of the engine exhaust valve. Fuel detergent quality may also contribute to the condition; the customer may want to try a different brand of fuel.

2. Verify that the engine misfire condition is not caused by faulty engine mechanical or electrical components.

3. If the engine mechanical and electrical systems are operating properly, perform the Repair Procedure.

Repair Procedure

- 1) Relieve the fuel pressure.
- 2) Remove the upper intake manifold.
- 3) Remove the cylinder head cover(s).
- 4) Remove the rocker arm and shaft assembly.
- 5) Clean and mark the tip of each exhaust valve stem at the 12 o'clock position with a paint marker. The paint mark will be used later to assist with determining the amount of valve rotation.
- 6) Remove the spark plugs.
- 7) Rotate the crankshaft clockwise, until the number 1 piston is at Top Dead Center (TDC) on the compression stroke.
- 8) Install the compression tester spark plug adapter in cylinder #1 spark plug hole. With the air hose attached to the spark plug adapter, apply 90 to 100 psi air pressure. This is to hold the valves

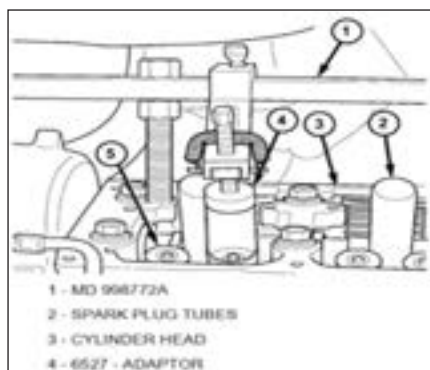


Figure 3 Using a valve spring compressor tool with the valve spring adapter, slightly compress the exhaust valve spring to release tension against the valve and valve spring retainer on 3.5L engines.

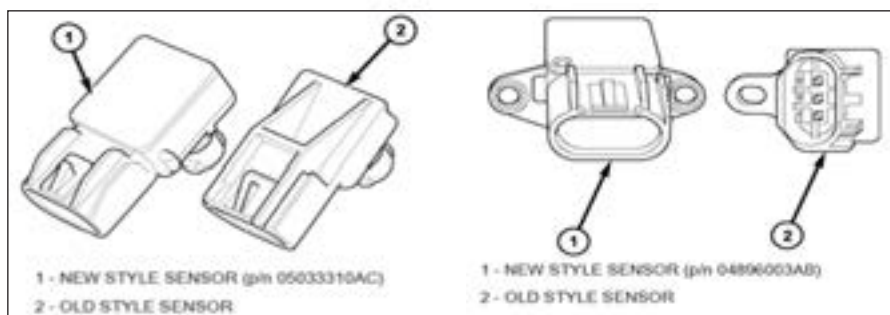


Figure 4 Inspect the MAP sensor for LX models (left) or for CS models (right). If the MAP sensor is the new style, no further action is necessary for the MAP sensor.

into place while servicing the components.

9) Using a valve spring compressor tool (MD 998772A) with the valve spring adapter (6527 or equivalent), slightly compress the exhaust valve spring to release tension against the valve and valve spring retainer (see **Figure 3**).

10) Remove the valve spring retainer locks and discard the locks.

Note: It is important that the valve rotation section of this repair procedure be performed.

Caution: Only grab the valve stem tip, being careful not to cause damage.

11) Using needle-nose pliers, grab the tip of the valve stem and rotate the exhaust valve 90° (move the mark to the 3 o'clock position).

12) Install two new valve spring retainer locks (p/n 53022277AA).

13) After installing the locks, release the tension on the valve spring and verify proper installation.

14) Remove Special Tool MD 998772A (1) and the spark plug adapter tool.

15) Repeat steps 7-14 on the remaining five cylinders using the firing sequence 1-2-3-4-5-6. Make sure the piston is at TDC in each cylinder of the exhaust valve spring retainer lock that is being removed. When all the exhaust valves have been rotated 90° and all the exhaust valve spring retainer locks have been replaced, proceed to the next step.

16) Install the rocker arm and shaft assembly.

17) Install the cylinder head cover(s).

18) Install the upper intake manifold

MAP Sensor Inspection

1) Inspect the MAP sensor – **Figure 4**

for LX models or CS models. If the MAP sensor is the new style, no further action is necessary for the MAP sensor. If the MAP sensor is the old style, proceed to the next step.

2) Replace the MAP sensor with p/n 05033310AC for LX models or p/n 04896003AB for CS models. If the vehicle is a CS model, be sure the new sensor opening is facing a downward direction when installed and only use one fastener.

–From ALLDATA

Keeping Your Balance With 3.7L Chryslers

While an optimally balanced V6 engine would have either 60 or 120 degree angles between the two banks of cylinders, many current V6 engines are derived from 90 degree angle V8 engines. While this configuration gives an evenly spaced firing order in an 8-cylinder engine, a 6-cylinder engine develops a loping rhythm.

During each rotation of the crankshaft three of the cylinders fire at 90-degree intervals, followed by a gap of 90 degrees



Figure 5 The circle shows where the roll pin (arrow) and spline gear should be aligned for proper timing of the balance shaft on the 3.7L. This assembly has spun on the center shaft over 90 degrees.

with no power pulse. Much of this issue was eliminated by the use of the split journal crankshaft.

Recently many manufacturers have found it wise to adapt the balance shaft concept as well, using a single shaft with counterweights spaced so as to provide a vibration which cancels out the shake inherent in the 90 degree V6. If you buy a new vehicle today, you most likely have an engine with a balance shaft.

One of those V6 engines that incorporate the single balance shaft technology is the 3.7L Chrysler engine that utilizes the split journal crankshaft. The single balance shaft goes down the center of the block in an area that you may have thought the camshaft would reside. Since the 3.7L is a SOHC engine it was a perfect spot to drop the single balance shaft unit.

What would happen if you put a balance shaft into the engine out of time? It would just exacerbate the problem and the result would be a shaker instead of a smoothie. Imagine if you did time it correctly but you were actually duped into thinking that you were in time? Unfortunately, that is exactly what happens if certain components don't live up to expectations.

The 3.7L engine has a gear cluster in the center of the engine that drives not only the balance shaft but the two timing chains as well. And many say it is a brave man who takes on timing these engines – there are four chains: one “Morse” type chain for timing to the crank; two sprocket type chains for the two camshafts; and a spline type gear for the balance shaft all installed simultaneously.

The spline gear drives that balance shaft and the two sprocket gears drive the timing chains. On the spline gear side of the gear cluster there is a roll pin that locates the index of the gear. Numerous examples have been cited where the spline gear has “shifted” and the roll pin sheared.

It is not always easy to see but if you look closely at **Figure 5** you will see that the roll pin has been sliced in half and is now out of time and will cause a vibration rather than a counter measure to vibration.

Be aware of this situation because it can be easily missed, especially when the gear cluster appears to be perfect in every other way. TSG

Diagnosing VW 16V Cylinder Head Ticking Noise at 2,000 RPM

Dimensional differences between the camshaft sprockets and the cam timing chain create a rattling noise that can be heard from the cylinder head at approximately 2,000 rpm (**Figure 1**).

This bulletin refers to all MY Volkswagen 16-valve engines.

As of 11/88, starting with VIN 067 722 a manufacturing tolerance change has been made to the camshaft sprockets. If a customer complains because of persistent noise, replace both camshafts with the following:

Intake cam p/n: 027 109 021 AJ

Exhaust cam p/n: 027 109 022 F



Figure 1 Dimensional differences between the camshaft sprockets and the cam timing chain may create a rattling noise on some Volkswagen 16-valve engines that can be heard from the cylinder head at approximately 2,000 rpm.

1996 Audi 2.8L V6 Rear Crankshaft Seal Leaks After Replacement

Oil may leak from the rear crankshaft seal after seal replacement due to the seal lip rolling while installing the new seal (**Figure 2**).

This condition affects 1996 A4 with 2.8L V6 (engine code AFC). When replacing the seal, the new seal is supplied pre-installed in the flange.

- Seal/Flange P/N: 078 103 171H;
- Flange gasket p/n: 078 103 181 (must be ordered separately).

Caution: Part numbers are for reference only.

- 1) Carefully remove installation

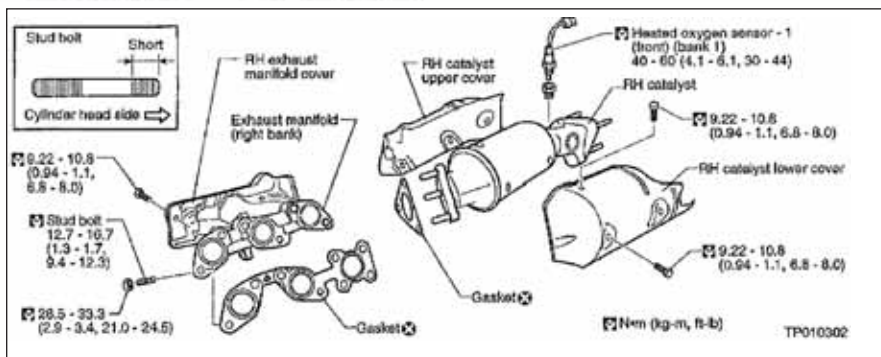


Figure 3 A ticking noise may be heard from a cracked exhaust manifold on certain Nissan engines. Typically, inspection for cracks between the #1 and #3 ports should be conducted.

tool that comes with seal and apply a small amount of engine oil to the inner lip of the seal.

Note: Lubricating the seal lip will ease seal installation and reduce the tendency of the seal to roll as it is being installed.

- 2) Carefully reinstall the seal installation tool.

- 3) Install oil seal and flange with new gasket.

- 4) Torque reusable flange bolts to 7 ft.lbs. (10Nm).

1999-2001 Exhaust Manifolds Cracked in Nissan VGS33E Engines

A ticking or exhaust noise has been reported coming from the right-hand exhaust manifold area of some 1999-2001 Nissan VGS33E engines.

If a cracked right-hand exhaust manifold on a 1999-2001 Nissan VGS33E engine is discovered when

the exhaust heat shield is removed, installers must replace the exhaust manifold (**Figure 3**).

If one of these symptoms should occur, use the following to diagnose the condition, replacing the right-hand exhaust manifold and related parts as described.

Diagnosis

- 1) Installers should verify the source of the noise with the engine running that it is coming from the right-hand manifold area.

- 2) If the noise is coming from the right-hand manifold area, remove the heat shield and inspect for cracks between the #1 and #3 ports on the manifold.

Repair

- 1) Separate the catalyst from the right-hand exhaust manifold and remove it to allow for clearance.

Caution: The nuts that attach the catalyst to the exhaust manifold have a self-locking design and require some effort to remove. Apply penetrating oil to the threads and allow it to soak in before attempting to remove the nuts.

Use a tight-fitting six-point socket to avoid rounding off the corners of the nuts during removal. If any of the nuts or studs are damaged during removal, replace them as needed.

- 2) Remove the exhaust manifold from the head (See **Figure 4** for loosening sequence of manifold nuts). NOTE: If any of the nuts or studs are damaged during removal, replace them

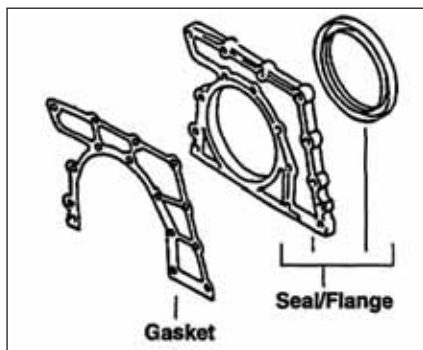


Figure 2 When replacing the oil seal on 1996 Audi A4 models with V6 engines, make sure the new seal is supplied pre-installed in the flange.

I M P O R T

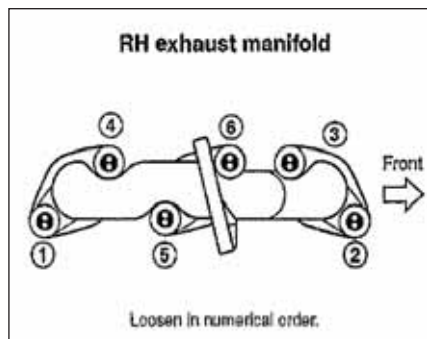


Figure 4 Sequence for loosening the exhaust manifold nuts on the Nissan VG33E.

as needed.

3) Install the replacement manifold with a new gasket onto the head. See **Figure 5** for tightening sequence of manifold nuts. See Figure 3 for manifold nut torque specifications.

4) Re-attach the catalyst to the exhaust manifold. NOTE: Ensure that

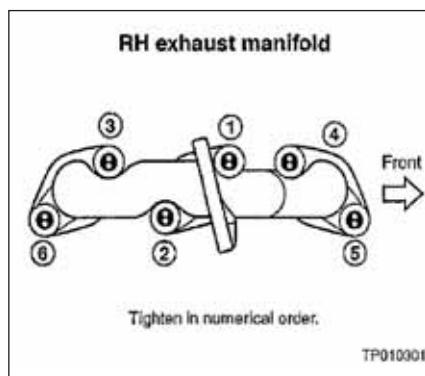


Figure 5 Sequence for tightening the exhaust manifold nuts on the Nissan VG33E.

all bolts securing the manifold and heat shields are installed and are torqued to the specifications shown in Figure 3.

Variable Valve Timing Noise Complaints When Starting 2006-2007 Mazda MZR Engines

Customers may complain of a loud ticking noise from the variable valve timing (VVT). This is caused by the lock pin of the variable valve timing actuator not fully engaging.

Affected models with MZR engine:

- 2007 Mazdaspeed3 vehicles produced before April 1, 2007;
- 2006-2007 Mazdaspeed6 vehicles produced before April 1, 2007;

• 2007 Mazda CX-7 vehicles produced before April 1, 2007.

When the engine is first started, some vehicles may exhibit a loud ticking noise from the variable valve timing (VVT). This is caused by the lock pin of the variable valve timing actuator not fully engaging.

Heat treatment has now been added around the hole of the variable valve timing rotor lock pin to prevent this from happening.

Customers having this concern should have their vehicle repaired using the following repair procedure.

Repair

1) Verify variable valve timing noise.

2) After the engine cools down, replace the variable valve timing actuator.

NOTE: Do not use the printed service manual as the procedure has been updated online.

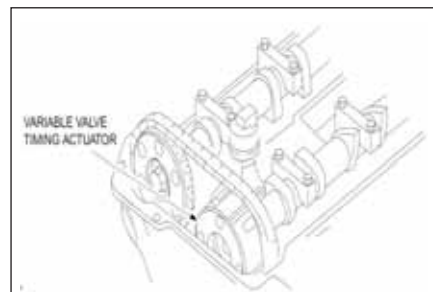


Figure 6 Location of the variable valve actuator for the Mazda MZR engine.

3) Change the engine oil (5W-30) only, then start and let the engine idle for 5 minutes. This is to remove contaminants from the engine.

4) Make sure there is no fuel leakage around the high pressure fuel pump.

5) After the engine cools down, change the engine oil (5W-30) again, and the filter.

6) Verify repair.

NOTE: This repair calls for the oil to be changed two times. TSG



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TECH SOLUTIONS *guide* PERFORMANCE

Understanding Spark Plug Heat Range
Finding the right spark plugs for a modified engine is a little more involved than just looking in a catalog for make and model.

Depending on the engine modifications you've made, you'll need to take a few extra factors into consideration before settling on the right spark plugs (**Figure 1**). These factors include spark plug seat design, thread length and diameter, and reach. One of the most important – and least understood – factors in choosing aftermarket spark plugs is the heat range.

Heat range is the speed at which a spark plug can transfer heat from the firing tip to the cylinder head water jacket and into the cooling system. Choosing the right heat range is crucial for high performance engines. If the heat range is too cold, the spark plug will be unable to



Figure 1 As a rule of thumb, you can expect to require one heat range colder than the factory-supplied plugs for every 75-100 horsepower you've add with your modifications.

properly self-clean by burning off carbon deposits.

If it the heat range is too hot, your

engine could experience detonation, pre-ignition, or power loss. Most spark plug manufacturers recommend that the tip temperature remain between 900° F (500° C) and 1,500° F (850° C).

Heat ranges are designated by each spark plug manufacturer with a number. In broad terms, spark plugs are often referred to as “hot plugs” or “cold plugs.” A cold plug has a shorter insulator nose length – the distance from tip to spark plug shell – and transfers heat rapidly from its firing tip to the cylinder head water jacket.

Cold plugs are ideal for high rpm engines, forced induction applications, and other instances where the engine produces high operating temperatures. Conversely, hot plugs are good for applications that operate mainly at low rpms. Because they have a longer insulator nose length, heat is transferred from the firing tip to the cooling system at slower pace. This keeps the spark plug temperature high, which allows the plug to self clean and prevent fouling.

Unfortunately, heat range numbers are not universal – each brand has its own method for assigning heat ranges. You'll need to talk with your sales rep or consult with the manufacturer to find the best heat range for your application and spark plug brand. Be prepared to supply some basic vehicle information, including any modifications you've made.

As a rule of thumb, you can expect to require one heat range colder than the factory-supplied plugs for every 75-100 horsepower you've added with your modifications, according to Champion Spark Plugs. Here are some more basic guidelines to get you pointed in the right direction:

- **Supercharging/turbocharging:**

For-ced induction leads to increased cylinder pressure and temperature, which could lead to detonation. Depending on the exact application, you'll need to go with a significantly colder heat range (faster heat transfer) over stock.

- **Nitrous oxide:** The high cylinder

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temperatures caused by nitrous usually requires a colder heat range over the stock plug.

- **Methanol:** Since it has a higher octane level than standard gasoline, methanol delivers more complete combustion. As a result, you'll need a colder plug to transfer more heat from the combustion chamber.

- **Increased compression ratio:** Higher compression ratios mean higher cylinder pressure and temperature. Once again, you'll need a colder heat range to rapidly transfer all that extra heat to the cooling system.

- **Air/fuel mixture modifications:** Lean air/fuel mixtures raise the operating temperature, along with the plug tip temperature, possibly causing knock or pre-ignition. Use a colder heat range for leaner air/fuel mixtures. Rich air/fuel mixtures can cause the plug temperature to dip, allowing carbon deposits to build up on the tip. Use a hotter heat range for rich air/fuel mixtures.

- **Advanced ignition timing:** In

general, advanced ignition timing will raise the spark plug temperature. In fact, NGK estimates an increase of 70° to 100° for every 10° advance in ignition timing. For this reason, you may need to go with a colder heat range to prevent knock or pre-ignition.

- **Prolonged acceleration/high speed driving:** Frequent and drawn-

out acceleration and high-rpm driving raises combustion temperatures and generally requires a colder heat range.

– From Summit Racing

Influence of Grooved Main Bearings on Engine Performance

Manufacturers are frequently asked what difference grooving makes. Various forms of main bearing grooving have been used over the years.

It's essential to understand that bearings depend on a film of oil to keep them separated from the shaft surface. This oil film is developed by shaft rotation. As the shaft rotates it pulls oil into the loaded area of the bearing and rides up on this film much like a tire hydroplaning on wet pavement.

Grooving in a bearing acts like tread in a tire to break up the oil film. While you want your tires to grip the road, you don't want your bearings to grip the shaft, so grooving is bad for maintaining an oil film. The primary reason for having any grooving in a main bearing is to provide oil to the connecting rods. Without rod bearings to feed, a simple oil hole would be sufficient to lubricate a main bearing.

Many early engines used full grooved bearings and some even used multiple grooves. Those choices were based on what engineers knew at the time. As engine and bearing technology developed, the negative effect of grooving was recognized and bearing grooving was removed from modern lower main bearings. The result is in a thicker film of oil for the shaft to ride on.

This provides a greater safety margin and improved bearing life. Upper main shells, which see lower loads than the lowers, and hence don't apply the same load to the oil film, have retained a groove to supply the connecting rods with oil.

In an effort to develop the best possible main bearing designs for high performance engines, manufacturers have investigated the effects of main bearing grooving on bearing performance. The graph (**Figure 2**) illustrates that a simple 180° groove in the upper main shell is still the best overall design.

While a slightly shorter groove of

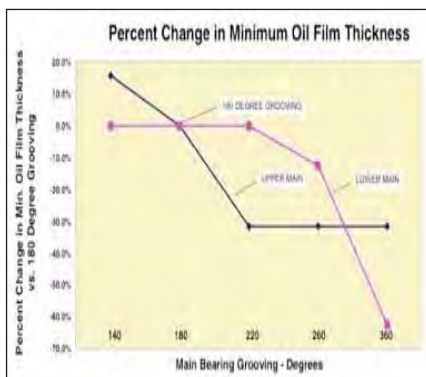


Figure 2 As engine and bearing technology developed, the bearing grooving was removed from modern lower main bearings creating a thicker oil film.

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140° provides a marginal gain, most of the benefit is to the upper shell, which doesn't need improvement. On the other hand, extending the groove into the lower half, even as little as 20° at each parting line (220° in total), takes away from upper bearing performance without providing any benefit to the lower half. It's also interesting to note that as groove length increases so does horsepower loss and peak oil film pressure, which is transmitted directly to the bearing.

Notes: You will still find some full-grooved main sets offered for older engines where demand is low and the engineering cost to bring the sets to current standards is not warranted (bearings generally represent the technology of the time the engine was developed).

— From MAHLE Clevite Inc.

Holley Power Valve Myths

The power enrichment system supplies additional fuel to the main system during heavy load or full power situations.

There still seems to be a lot of misconception about Holley carburetors blowing power valves. According to the manufacturer, this should be of no concern. Holley performance carburetors since 1992 have utilized a power valve check system that effectively eliminated this infrequent problem. Consisting of a spring, brass seat and check ball, the check ball system is 100% effective protecting the power valve diaphragm from damage due to engine backfire.

The power valve check ball is designed to be normally open but quickly seals to close off the internal vacuum passage when a backfire occurs. Once closed, the check valve interrupts the pressure wave generated by the backfire, thus protecting the power valve diaphragm. This prevents the power valve's diaphragm from rupturing due to an engine backfire, according to the company.

Holley carburetors utilize a

vacuum operated power enrichment system (**Figure 3**) and a selection of power valves is available to "time" this system's operation to your specific needs. Each Holley power valve is stamped with a number to indicate the vacuum opening point. For example, the number "65" indicates that the power valve will open when the engine vacuum drops to 6.5" or below.

An accurate vacuum gauge should be used when determining the correct power valve to use. A competition or race engine which has a long duration high overlap camshaft will have low manifold vacuum at idle speeds. If the vehicle has a manual transmission, take the vacuum reading with the engine thoroughly warmed up and at idle.

If the vehicle is equipped with an automatic transmission, take the vacuum reading with the engine thoroughly warmed up and idling in gear. In either case, the power valve selected should be half the intake manifold vacuum reading taken.

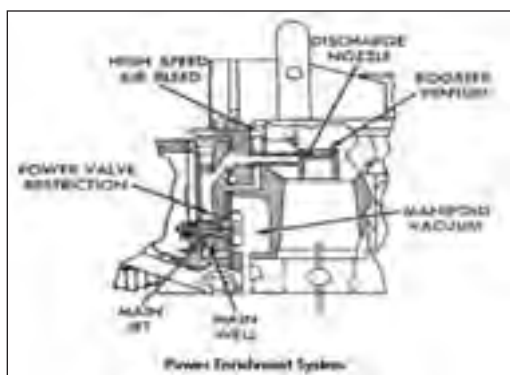


Figure 3 Holley carbs use a vacuum operated power enrichment system and a selection of power valves is available to "time" this system's operation to your specific needs

EXAMPLE: 13" Hg vacuum reading divided by 2 = 6.5 power valve. If your reading divided by 2 lands on an even number you should select the next lowest power valve.

EXAMPLE: 8" Hg vacuum reading divided by 2 = 4 power valve. Since there is no #4 power valve you should use a 3.5.

Most of Holley's "Street Legal" and "Street Performance" carburetors incorporate a power valve blow-out protection system. A special check valve is



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located in the throttle body expressly for this purpose. This check valve is designed to be normally open but will quickly seat to close off the internal vacuum passage when a backfire occurs. Once closed, the check valve interrupts the pressure wave caused by the backfire, thus protecting the power valve.

If you have a carburetor older than 1992 (or you have experienced an extreme backfire) and expect a blown power valve, use this simple test. At idle turn the idle mixture screws (found on the side of the metering block) all the way in. If the engine dies the power valve is not blown.

— From *Holley Performance*

Tips For Selecting The Proper Circle Track Cam

An engine builder is only as good as his customer's information, and if your circle track customer doesn't give you the necessary answers, he may not be pleased with the cam you choose.

This isn't always the builder's fault, but is often followed by the racer selling the cam to another racer who thinks it's the best cam he ever ran. Why did this cam work so well for one racer and not for another? The reasons can be many. The following are some tips for selecting the proper cam for circle track applications.

- Longer duration cams require tighter lobe separation to have any power off the corner (not usually a preferable combination in 2 bbl classes). Shorter duration cams with wider lobe separations usually yield much flatter torque curves. Longer rod engines seem to prefer shorter durations and wider lobe separation (**Figure 4**).

- Stock exhaust manifolds or a highly restricted exhausts usually respond well to shorter exhaust duration and wider lobe separation. Power increases are most evident at higher rpm where exhaust backpressure is greatest and reversion is most prevalent.

- Most unported heads approach 85 or 95 % of peak flow at .400" to .450" lift and do not need or want a maximum valve lift over .540" to .555". Often a low cam lift with 1.65 or 1.7 ratio rockers is very helpful on the intake side as long as lift is kept to about .550". Exhaust is less critical with 1.5 or 1.55 being the most popular. Dyno testing doesn't test dri-



Figure 4 Longer rod engines seem to prefer shorter durations and wider lobe separation.

vability or throttle response of the engine.

- The important numbers on a dyno sheet are about a thousand RPM above and below peak torque and peak horsepower. Peak numbers are for bragging purposes and high peak numbers do not win races.

- The benefit of high ratio rockers is faster valve movement and the added lift is frequently detrimental in unported heads. It often helps to utilize a lower cam lift with high ratio rockers.

- Changing the valve lash is a good way to get an indication of which way to go for your next cam change. You won't hurt anything by going too tight but too loose will let the valves slam shut causing damage to valves and seats. .004" to .006" loose is usually OK.

- Look at the "major intensity" numbers to get an idea as to how radical the profile is (major intensity is the difference between the .020" duration and the .050" duration). Lower numbers are more radical but anything less than 26 or 27 degrees may be very hard on the valve train.

- Camshaft Intensity is a measurement term coined by Harvey Crane to compare ramp characteristics of camshafts.

- Hydraulic Intensity is the difference between .004" duration and .050" duration.

- Minor Intensity is the difference between .010" duration and .050" duration.

- Major Intensity is the difference between .020" duration and .050" duration.

- Lower numbers indicate more radical profiles, but too low can be too radical and lead to noisy valve train operation and even to broken parts.

— From *Camcraft Performance Cams* TSG

Circle 122 for more information

TECH SOLUTIONS GUIDE SHOP TIPS

Quick Test For Water in Methanol

Most engine builders know that methanol absorbs water from the day you break the seal. But racers don't usually carry a specific gravity gauge to the track. Here's what you may wish to tell your customers. Once the motor is up to full temperature with the ignition off, remove the air cleaner and open the throttle all the way, holding it open for about 30-45 seconds. With the throttle open, take a light and look through the carburetor to the floor of the manifold. With the motor being "hot" the methanol evaporates quickly and if you have water in the fuel you will see drops of water sitting at the bottom of the manifold. This is a quick way to tell how good your methanol is.

Mark Those Guides

When installing more than one valve guide in an OHC cylinder head, it's often difficult to see well enough to get the depth correct every time, so I just lay



Figure 1 It's often difficult to see when installing guides in OHC heads. Mark with graphite spray for correct depth.

out all the guides in line, side-by-side, then use a piece of tape across all of them at the desired depth to be installed and spray them with a can of graphite. Remove the tape and you'll have a line to drive the guide to every time, and the graphite helps to prevent galling during installation.

Oil Pump and Engine Priming

A crucial step in any engine build is the priming of the oil pump and the engine lubrication system prior to initial start-

up. Proper priming will help assure a trouble-free rebuild. There are two preferred methods to prime oil pumps and newly rebuilt engines. The first method listed covers oil pumps driven by the camshaft and the second covers those driven by the crankshaft.

Priming camshaft driven oil pumps: These pumps are typically referred to as wet sump pumps since they sit low in the engine oil pan and are partially submerged in the engine oil. To prime, first submerge the inlet of the oil pump in clean oil and rotate the drive shaft in the correct direction. If it does not pump, change direction of shaft rotation until oil flows from the pump outlet. Drain excess oil from the pump and install it on the engine.

Fill the oil filter and install it; then fill the engine with oil. Install the correct priming tool, which can be a modified

distributor drive shaft into the engine and engage the oil pump drive shaft. Attach a 1/2" electric drill to the exposed end of the priming tool and spin the oil pump at a minimum of 500 rpm. Continue to spin the oil pump until oil reaches the rocker arms. It is a good idea to rotate the crankshaft 360 degrees while spinning the oil pump



Figure 2 Attach a drill to the end of a priming tool and spin oil pump at a minimum of 500 rpm until oil reaches rockers.



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S H O P T I P S

during priming. The oil pump and engine are now primed.

Priming crankshaft driven oil pumps: This type of oil pump cannot be turned with a priming tool so we recommend using the Melling MPL-101 pressure priming tank or a similar pre-lube tank to prime the engine with oil before initial startup. Before assembling the oil pump to the engine, pour a small amount of engine oil into the oil pump and rotate the rotor set by hand to allow the oil to coat the internal surfaces of the pump and rotor. Once the engine is fully assembled fill the oil filter with oil and install it. Attach the pre-lube tank to the oil pressure port on the engine.

Now fill the pre-lube tank with up to four quarts of engine oil and close the valve on the top of the tank. Pressurize the pre-lube tank with shop air and slowly open the valve on the tank which will release the oil and send it into the engine oil galleries. While the oil is being transferred from the pre-lube tank to the engine rotate the engine 360 degrees. Once the oil is transferred to the engine you will hear a gurgling sound from the tank. The engine is now primed.

Vacuum Check That Engine

With the advent of foreign castings, some less than stellar, it is important to be more critical than before during inspection. One engine builder uses a large vacuum pump to vacuum check every engine's water jacket before it leaves his shop. His pump pulls around 22 inches of vacuum. When it reaches that point he closes the valve to check for leaks.

Some engine builders have found a few brand new castings to have porosity



Figure 3 Ream to one half the distance of the dowel, then do the same with the caps. Be sure to sink the holes at least .015" to keep from bottoming the dowels into the cap.

holes in them after they were torqued down. All of these heads were aluminum SB Chevy heads and were made overseas. These heads were "good" prior to proper installation.

One a few occasions, brand new water pumps have been found to have leaking seals at the weep holes. Air is much less dense than water, so any small leaks are easy to find. With a vacuum pump you can check all freeze plugs, gallery plugs, intake and head gaskets (for sealing) and block and head castings.

For a test, one engine builder drilled a .006" hole in a freeze plug – it failed miserably. He says he even used the pump as a "reverse" pressure tester on cylinder heads where he couldn't find an external leak, but knew the head was bad. He says it's sort of a "second opinion" that confirmed his suspicions.

How to Keep Chevrolet 4-Bolt Mains From 'Walking'

All four-bolt small block Chevy main caps "walk" when used with either studs or bolts. The factory cap or a splayed cap relies on the register to locate itself because bolts and studs don't fit well enough to keep the cap from walking. What one engine builder does when working with a stock block is to eliminate cap walk altogether. Here is how to do it:

Place 7/16" x 1/2" dowels as used in aftermarket connecting rods in the outer bolt holes. Since the O.D. of the dowel is 1/2" it is easy to locate the proper reamer. No drilling is necessary.

Set the block up and indicate hole locations. The bolt holes are already recessed. Ream to one half the distance of the dowel, and then do the same with the caps. Be sure to sink the holes at least .015" to keep from bottoming the dowels into the cap (**Figure 3**). This also leaves room for line honing.

Done correctly, the line hone should not change. The block that was used (pictured) required line honing anyway for the proper tolerance. TSG



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- The conveniently mounted PLC control on the SV-10 allows adjustments to be made safely even while the machine is in operation, unlike competitive models where the operator must reach around moving components.
- The SV-10 can handle bore diameters from .75 to 8 inches, a much wider range than competitive units.
- Sunnen's innovative DH Diamond Hone Head centers the stones so they do not need to be reversed — as with competitive hone heads — which can cause taper problems. Also Sunnen stones are radius ground so they can be used right out of the box without being trued.
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