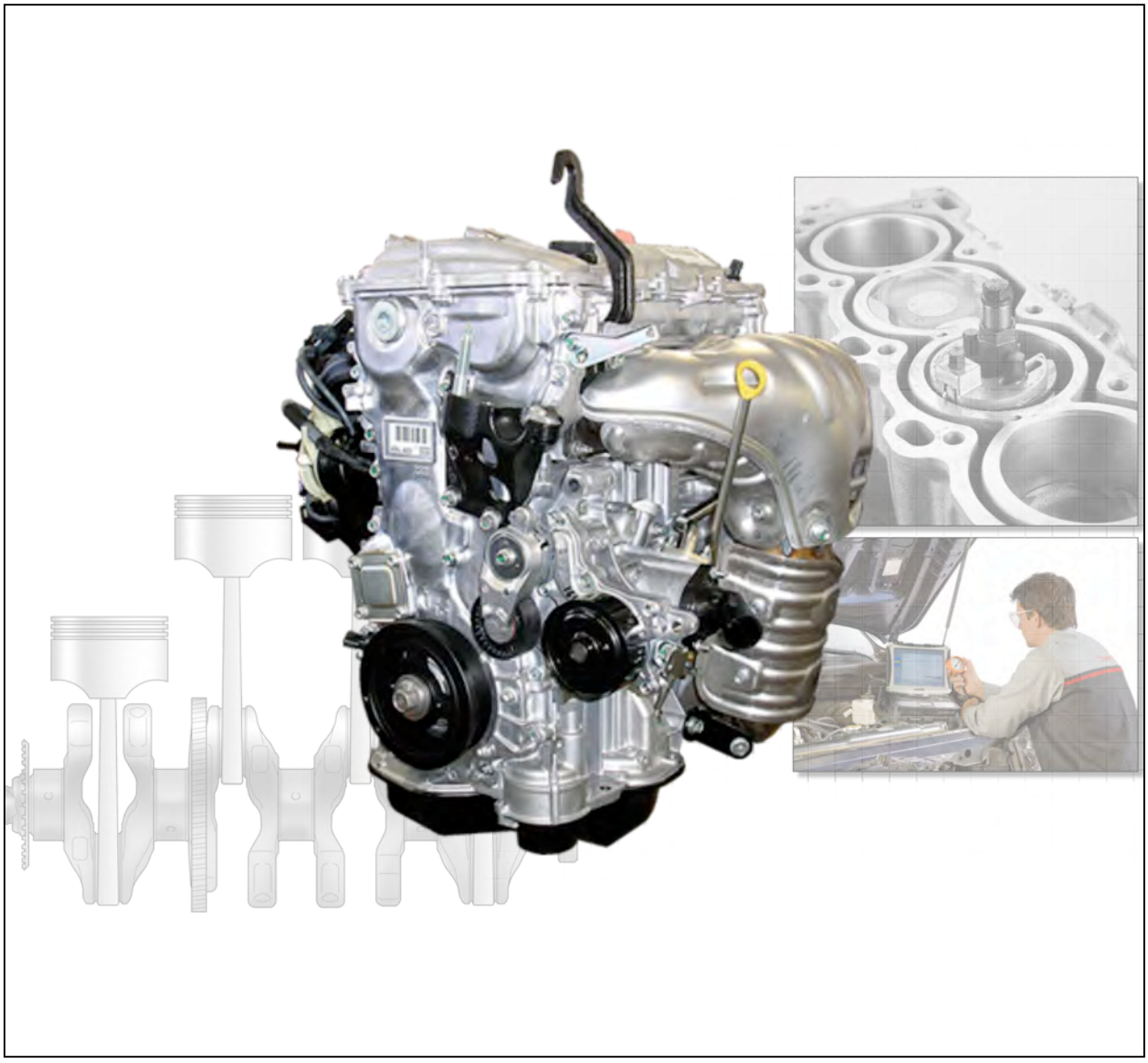
ENGINE SERVICE AND REPAIR
Course 151 Technician Handbook



University of Toyota

Continuing Automotive Service Education ASE CERTIFIED TRAINING PROVIDER

Toyota Motor Sales, U.S.A., Inc.

TOYOTA Technical Training

Revision Date: June 20, 2017

Section 5: Cylinder Head Diagnosis and Repair

Section 6: Cylinder Block Diagnosis and Repair

Section 7: Lubrication System

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Course 151: Engine Service and Repair
Welcome

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Course Menu

Engine Service and Repair

- 1. Internal Combustion Engine Operation
- 2. Basic Engine Components
- 3. Tools, Materials, and Equipment
- 4. Engine Removal and Disassembly
- 5. Cylinder Head Diagnosis and Repair
- 6. Cylinder Block Diagnosis and Repair
- 7. Lubrication System
- 8. Cooling System
- 9. Engine Reassembly
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Section 1 Topics

Internal Combustion Engine Operation

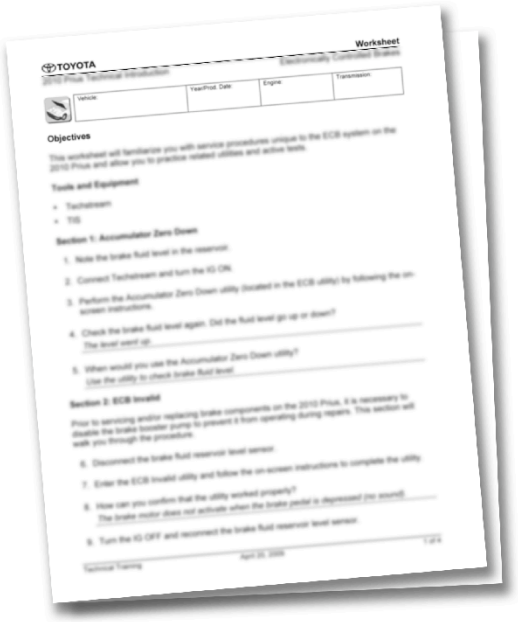
- Primary Engine Components
- 4-Stroke Cycle
- Intake
- Compression
- Combustion
- Exhaust
- Engine/Block Designs
- Engine Position and Cylinder Identification
- Engine Serial Number Location
- Engine Decoder

- Internal Combustion Engine Worksheet

Worksheet

Internal Combustion Engine

This worksheet is to evaluate what you already know about internal combustion engine operation and components.


TOYOTA
Worksheet
Electronically Controlled Brakes
2010 Prius Technical Introduction
Vehicle | Year/Prod. Date | Engine | Transmission
Objectives
This worksheet will familiarize you with service procedures unique to the ECB system on the 2010 Prius and allow you to practice related utilities and active tests.
Tools and Equipment
• Techstream
• TIS
Section 1: Accumulator Zero Down
1. Note the brake fluid level in the reservoir.
2. Connect Techstream and turn the IG ON.
3. Perform the Accumulator Zero Down utility (located in the ECB utility) by following the on-screen instructions.
4. Check the brake fluid level again. Did the fluid level go up or down?
The level went up.
5. When would you use the Accumulator Zero Down utility?
Use the utility to check brake fluid level.
Section 2: ECB Invalid
Prior to servicing and/or replacing brake components on the 2010 Prius, it is necessary to disable the brake booster pump to prevent it from operating during repairs. This section will walk you through the procedure.
6. Disconnect the brake fluid reservoir level sensor.
7. Enter the ECB invalid utility and follow the on-screen instructions to complete the utility.
8. How can you confirm that the utility worked properly?
The brake motor does not activate when the brake pedal is depressed (no sound).
9. Turn the IG OFF and reconnect the brake fluid reservoir level sensor.
Technical Training
April 20, 2009
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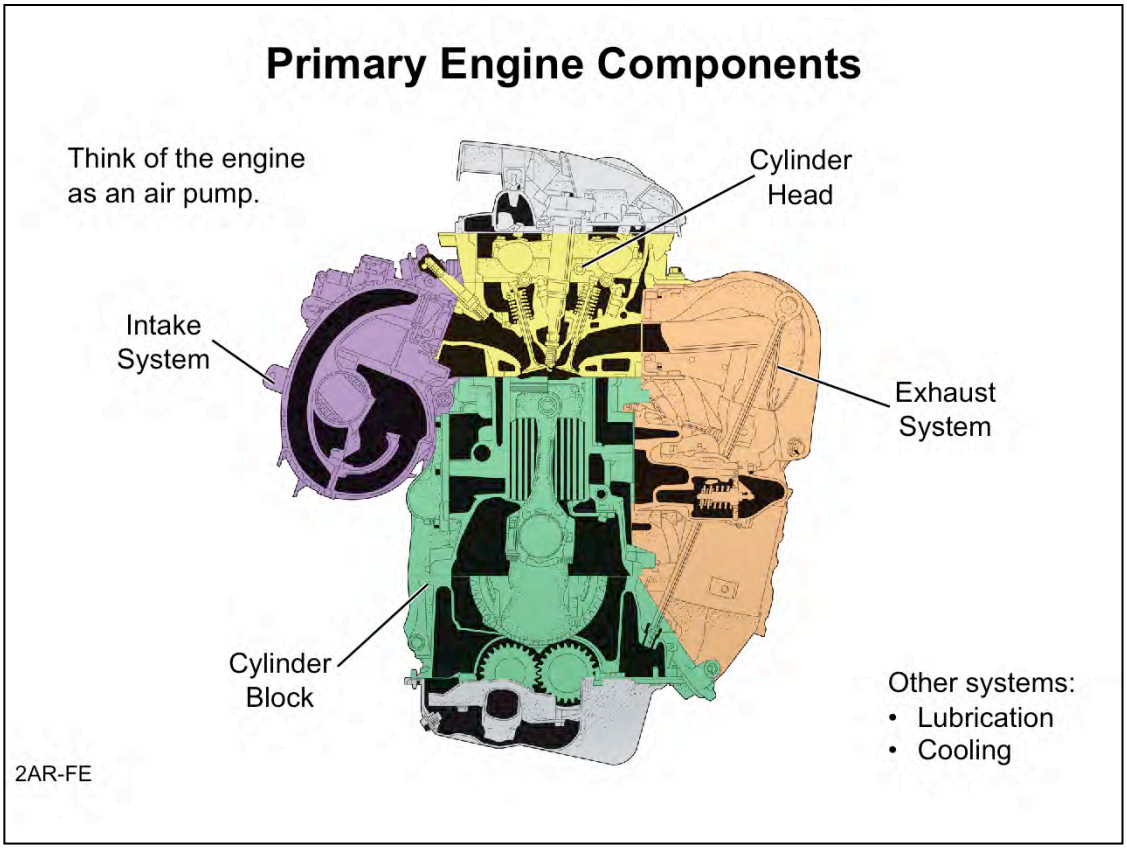
Use this space to write any questions you may have for your instructor.

NOTES:



Primary Engine Components

The internal combustion engine is made up of four major systems/components.

Intake – The intake system channels air to the intake side of the cylinder head.

Exhaust – The exhaust system channels the combusted air-fuel mixture away from the combustion chamber and vehicle.

Cylinder Head – The cylinder head seals the top of the combustion chamber and controls the incoming air-fuel mixture and exiting exhaust gases.

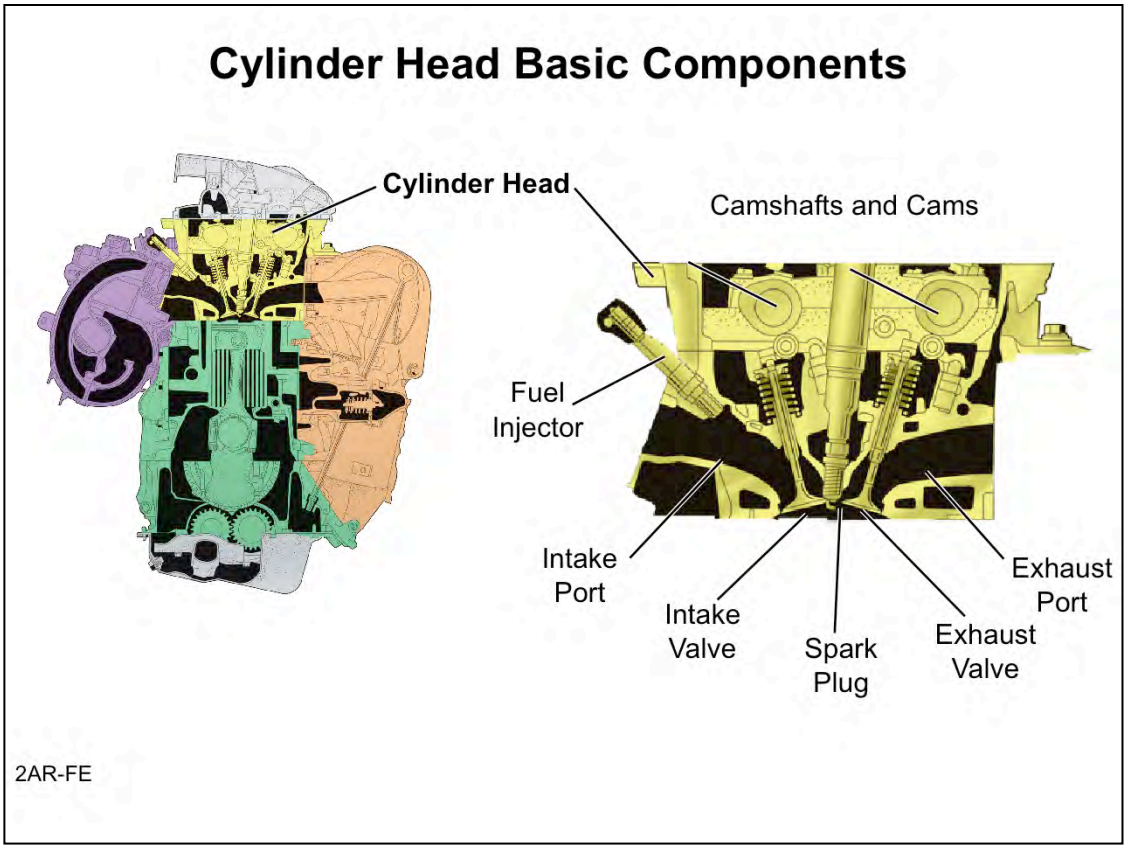
Cylinder Block – The cylinder block houses the piston and crankshaft assembly. These two components convert linear (up and down) motion into rotational motion.

Other Engine Systems

Other primary engine systems include:

Lubrication System – The lubrication system uses a pump to deliver oil to all necessary components within the engine.

Cooling System – As a result of burning fuel, **i**nternal combustion engines produce heat. The cooling system keeps the engine's internal temperature regulated.



Cylinder Head Components

The cylinder head is bolted to the top of the cylinder block and provides a path for the air-fuel mixture to enter the cylinder (intake port), and a path for spent gases to exit the cylinder (exhaust port). It also controls the timing of the opening and closing of the ports, and houses the fuel injectors and spark plugs.

Cylinder head components and their functions are:

Intake Port – The intake port is the passageway through which fuel and air enter the cylinder.

Exhaust Port – The exhaust port is the passageway through which exhaust gases exit the cylinder.

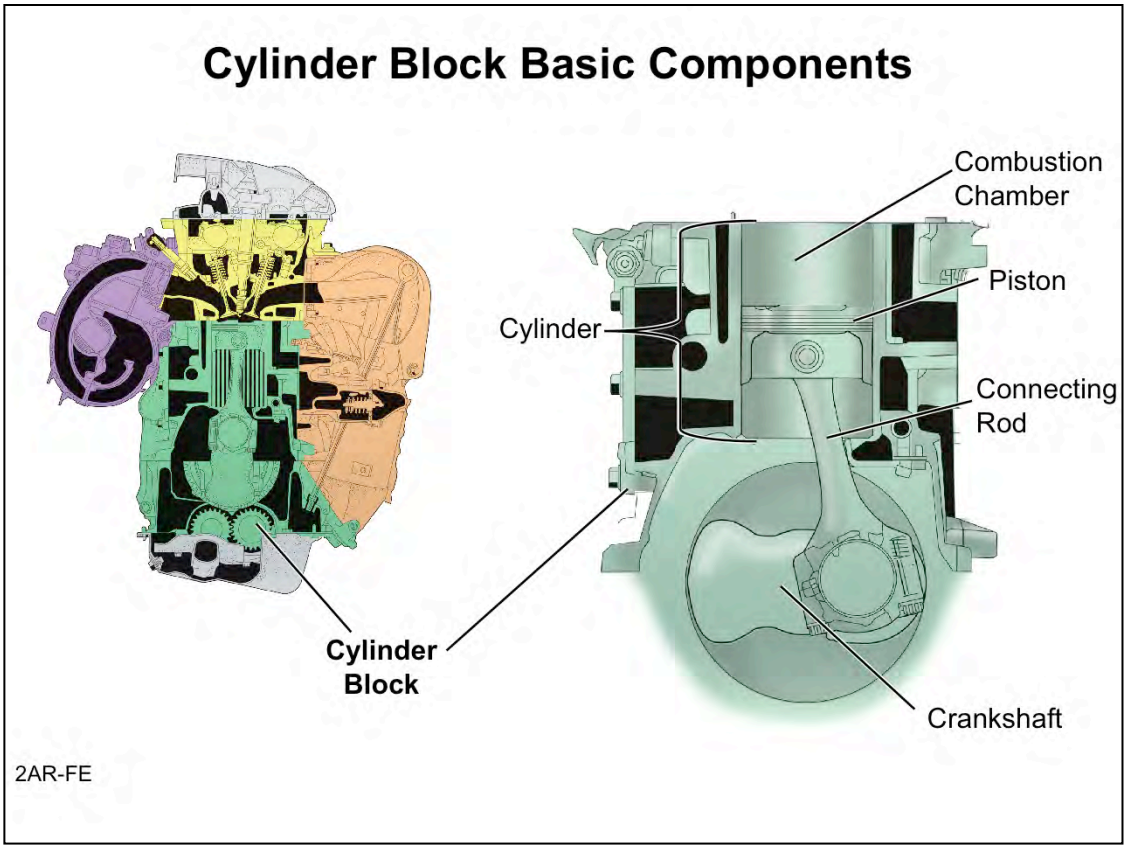
Intake Valve – When closed, the intake valve seals the passageway between the intake port and the cylinder. When opened by the rotating cam, air and fuel are able to enter the cylinder.

Exhaust Valve – When closed, the exhaust valve seals the passageway between the exhaust port and the cylinder. When opened by the rotating cam, exhaust gasses are able to exit the cylinder.

Fuel Injector – Just prior to the intake stroke, this high pressure valve opens and sprays fuel into the intake port.

Spark Plug – At the appropriate moment, the spark plug ignites the air-fuel mixture and the resulting expansion of hot gases powers the engine.

Camshafts and Cams – The rotating cams on the camshafts control the timing of intake and exhaust valve opening and closing. In the dual overhead cam (DOHC) engine design, one camshaft controls the intake valves and the other camshaft controls the exhaust valves.



Cylinder Block Components

The cylinder block houses the cylinders, and the piston and crankshaft assemblies.

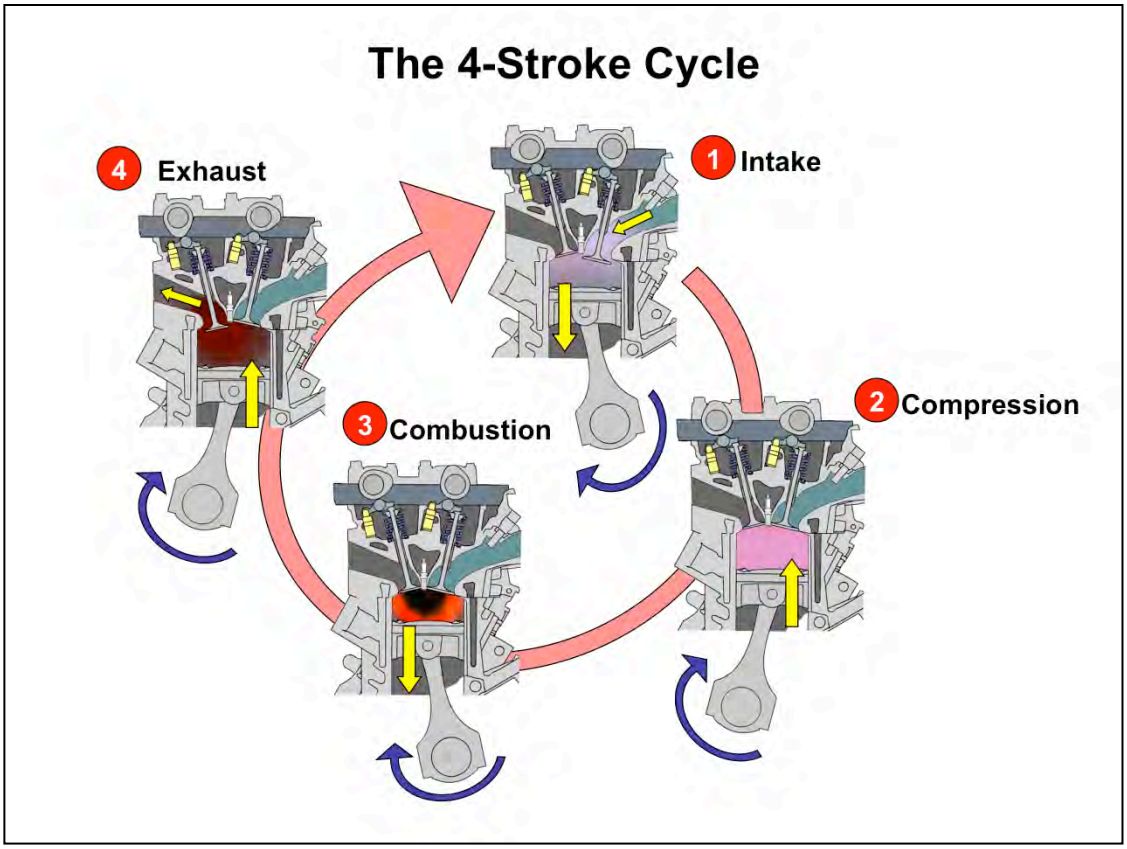
Cylinder – The cylinder is a relatively large hole bored into the block providing a hollow chamber in which the piston operates.

Piston – The piston and piston rings fit snugly inside the cylinder, effectively creating a seal. The piston is able to move up and down inside the cylinder, allowing the air-fuel mixture to enter the cylinder as the piston moves downward, and allowing exhaust gases to exit as it moves upward.

Combustion Chamber – The combustion chamber refers to the sealed portion of the cylinder above the piston where combustion takes place.

Connecting Rod – The connecting rod attaches the piston to the crankshaft.

Crankshaft – The crankshaft converts the up-and-down motion of the piston into rotary motion. This is accomplished by attaching the connecting rod off-center to the crankshaft.

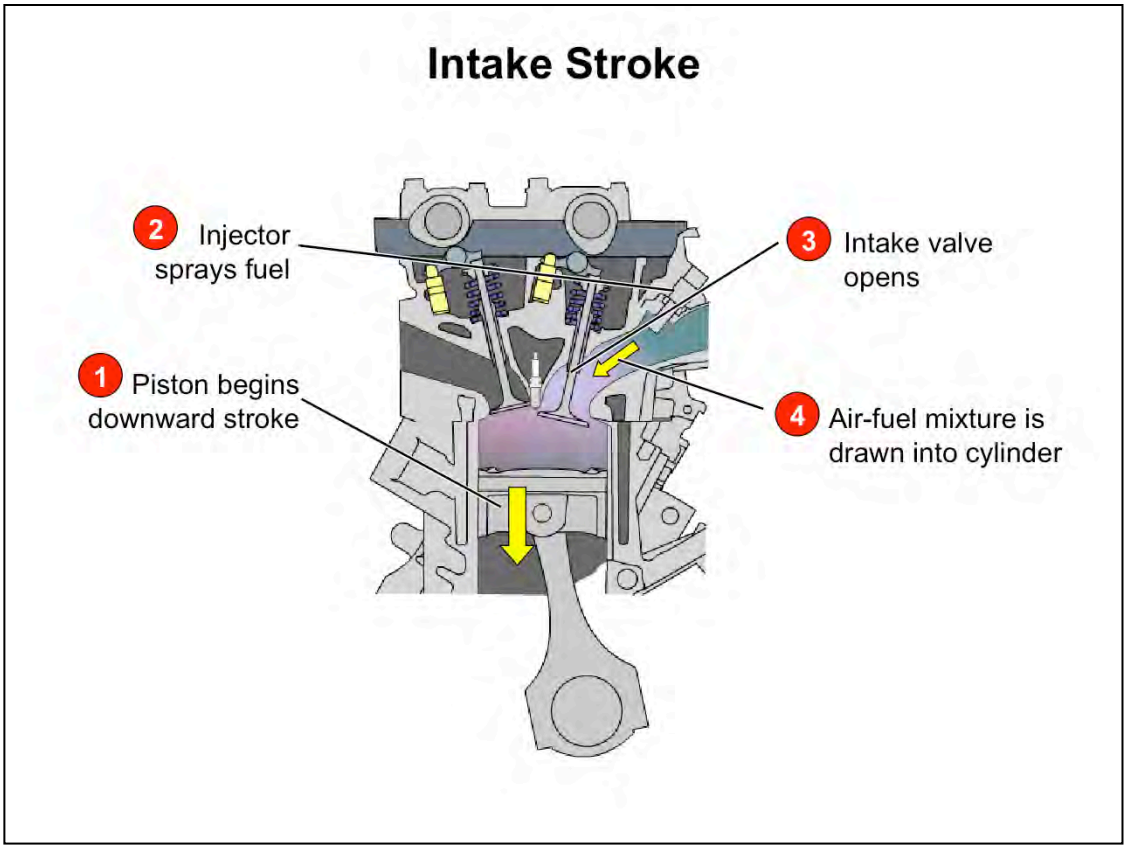


The 4-Stroke Cycle

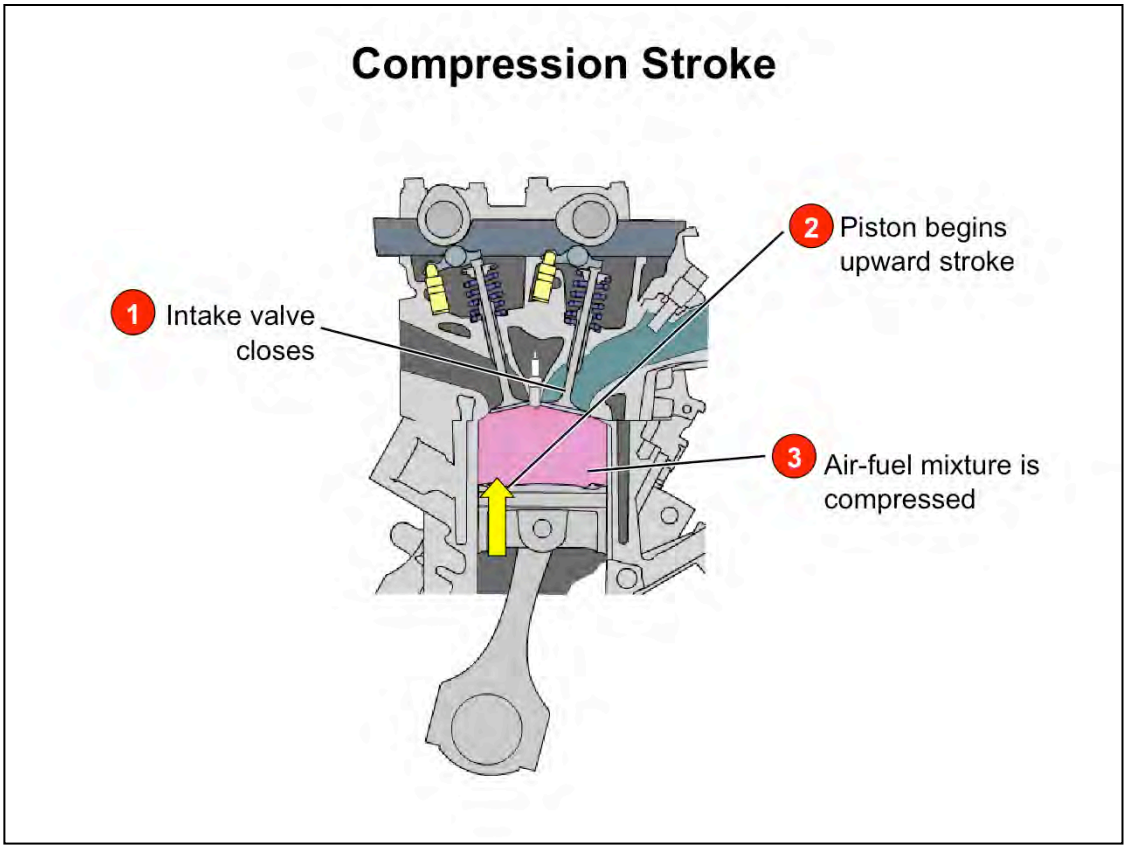
Nikolaus Otto invented the basic 4-stroke internal combustion engine in 1867. Although modern engineering and electronics have completely revolutionized engine technology, today's engines still operate on the principals of Otto's 4-stroke cycle.

The four strokes are:

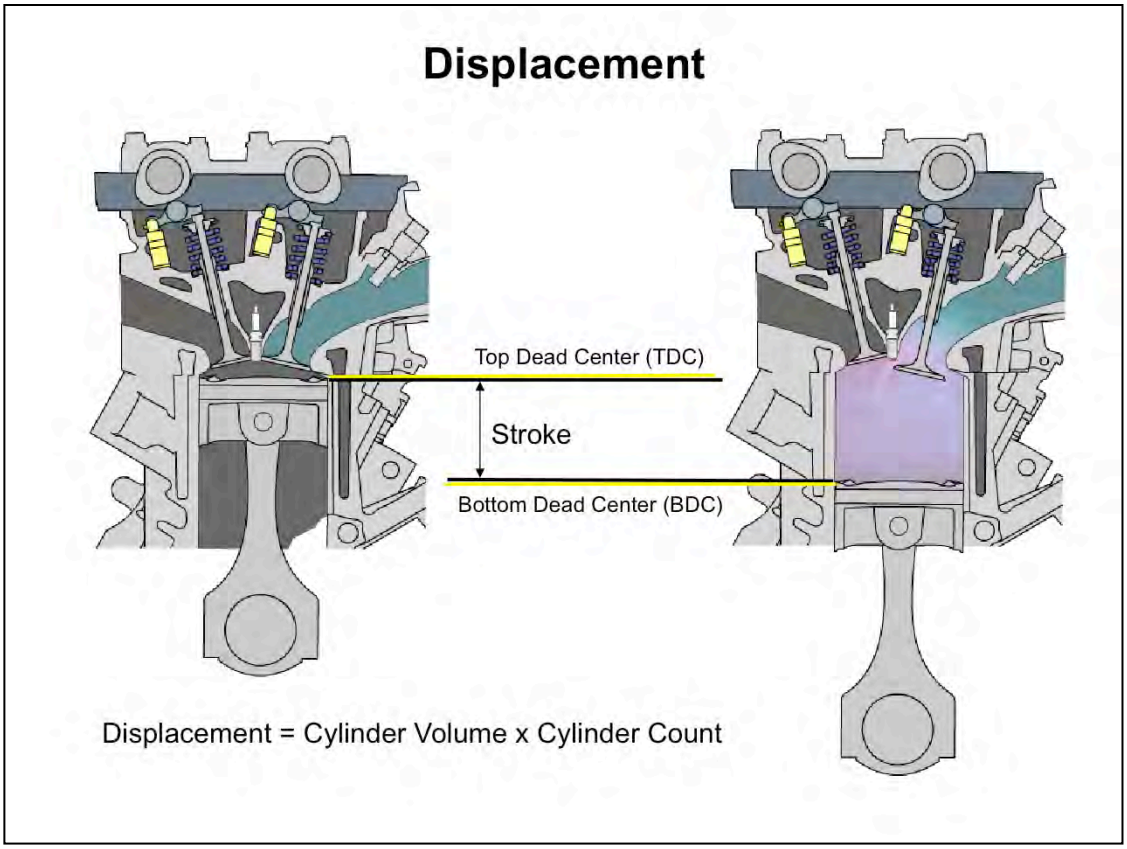
- Intake Stroke
- Compression Stroke
- Combustion (Power) Stroke
- Exhaust Stroke



Intake Stroke Just before the camshaft opens the intake valve, the injector sprays fuel into the intake port. As the camshaft opens the intake valve, the piston is traveling downward creating a negative pressure in the cylinder. Atmospheric pressure pushes the air-fuel mixture into the cylinder to fill the vacuum.



Compression Stroke At the beginning of the compressions stroke, the intake valve closes and the piston begins traveling upward compressing the air and fuel mixture. Compressing the mixture raises the temperature of the gas mixture within the cylinder and increases its potential energy. The rising temperature pre-heats the mixture and helps further vaporize the fuel.

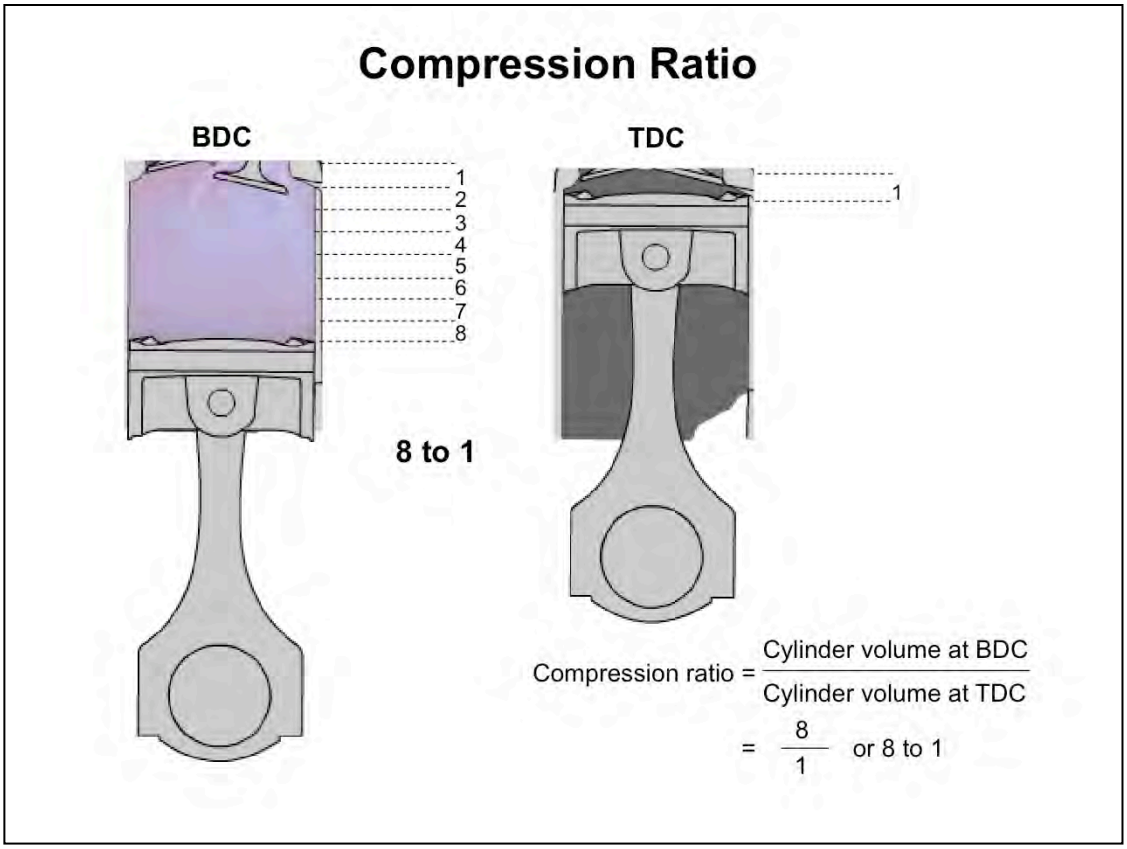


Displacement

The piston's stroke is the distance between the farthest points on the piston's path of travel.

- Top dead center (TDC) is the highest point of the piston's stroke.
- Bottom dead center (BDC) is the lowest point of the piston's stroke.

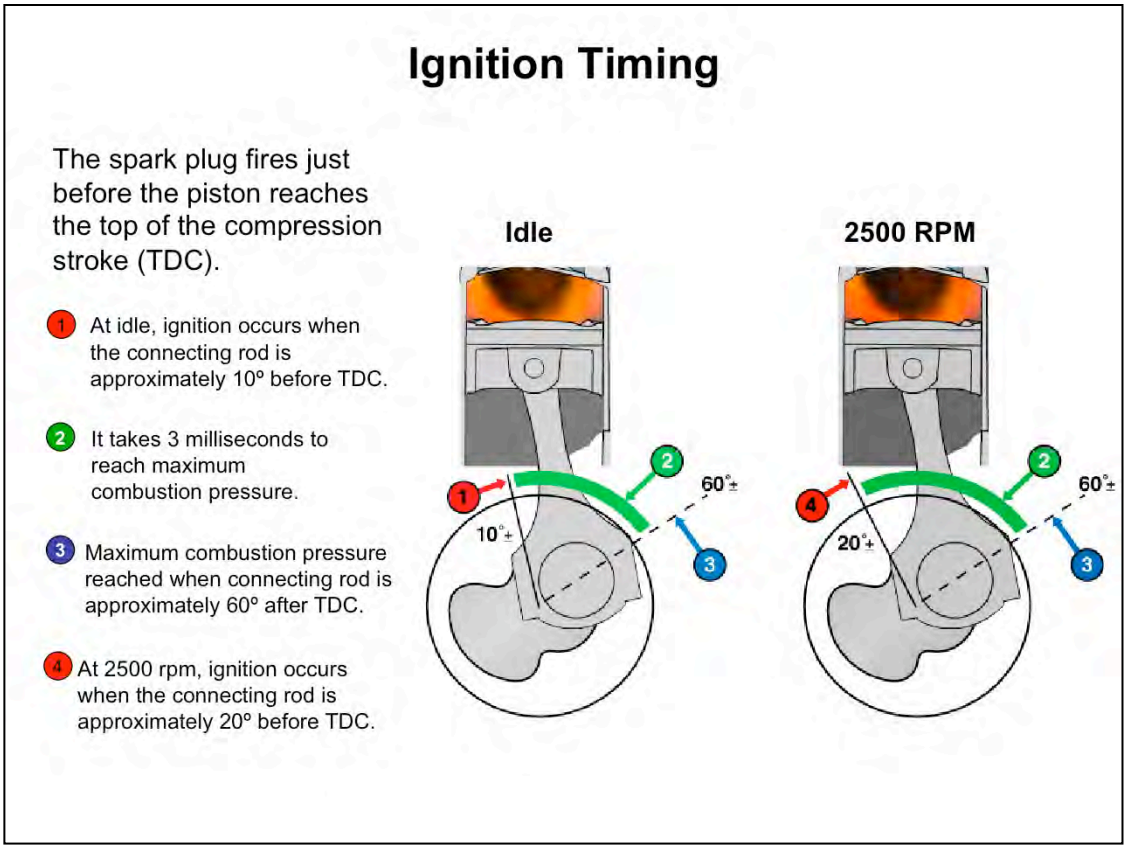
To calculate the engine's **displacement** (such as 5.7 liters), determine the cylinder volume when the piston is at BDC and multiply it by the number of cylinders.



Compression Ratio

At BDC, the combustion chamber is at its maximum volume. At TDC, the chamber reaches its minimum volume. The ratio of these two volumes is the engine's compression ratio.

The higher the compression ratio, the more energy can be extracted from the combustion process.



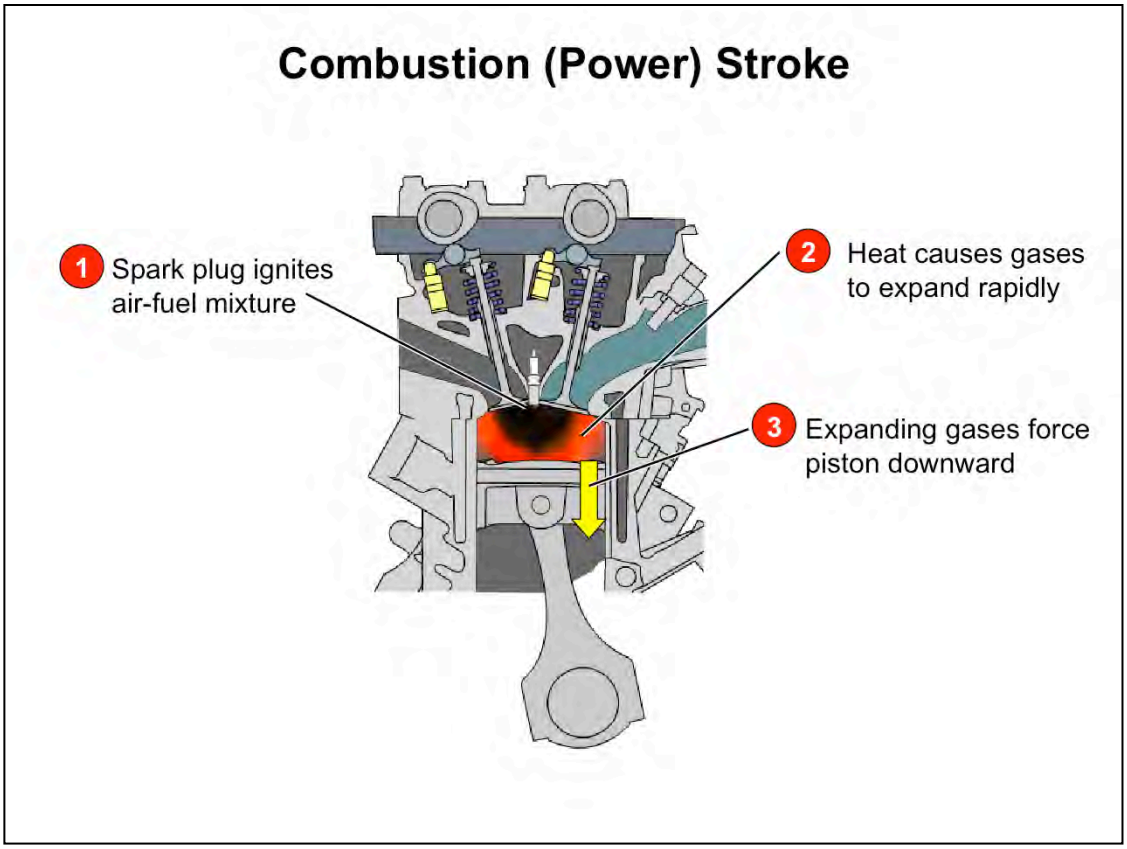
Ignition Timing

The spark plug ignites the fuel just before the piston reaches Top Dead Center (TDC) so that when gas expansion occurs, the piston is beginning its downward stroke. To obtain optimum power transfer from combustion, maximum combustion pressure should occur when the connecting rod reaches approximately 60º after TDC.

As RPM increases, keeping maximum combustion pressure occurring at 60º after TDC can require ignition to occur sooner. This is referred to as timing advance (or ignition advance). Timing advance enables the engine to continuously operate at maximum power

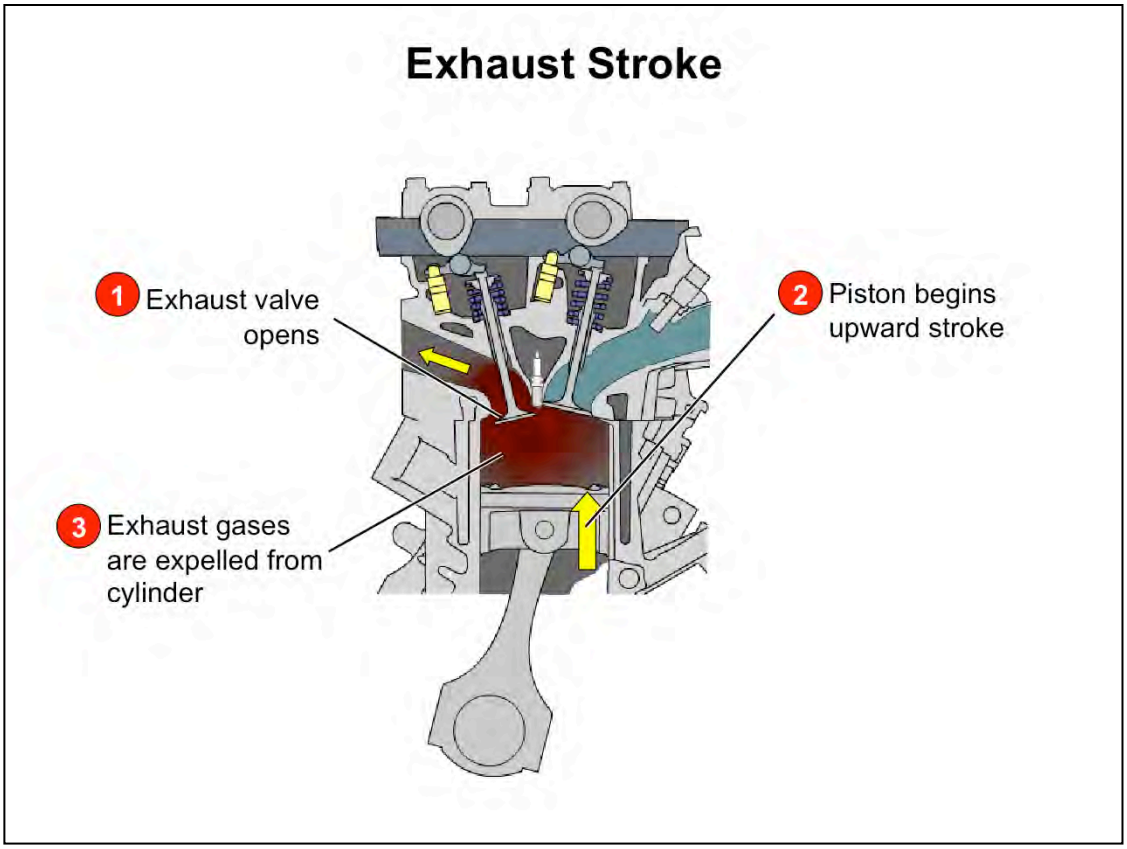
The ECM controls ignition timing based on:

- Engine speed
- Air-fuel ratio
- Engine load

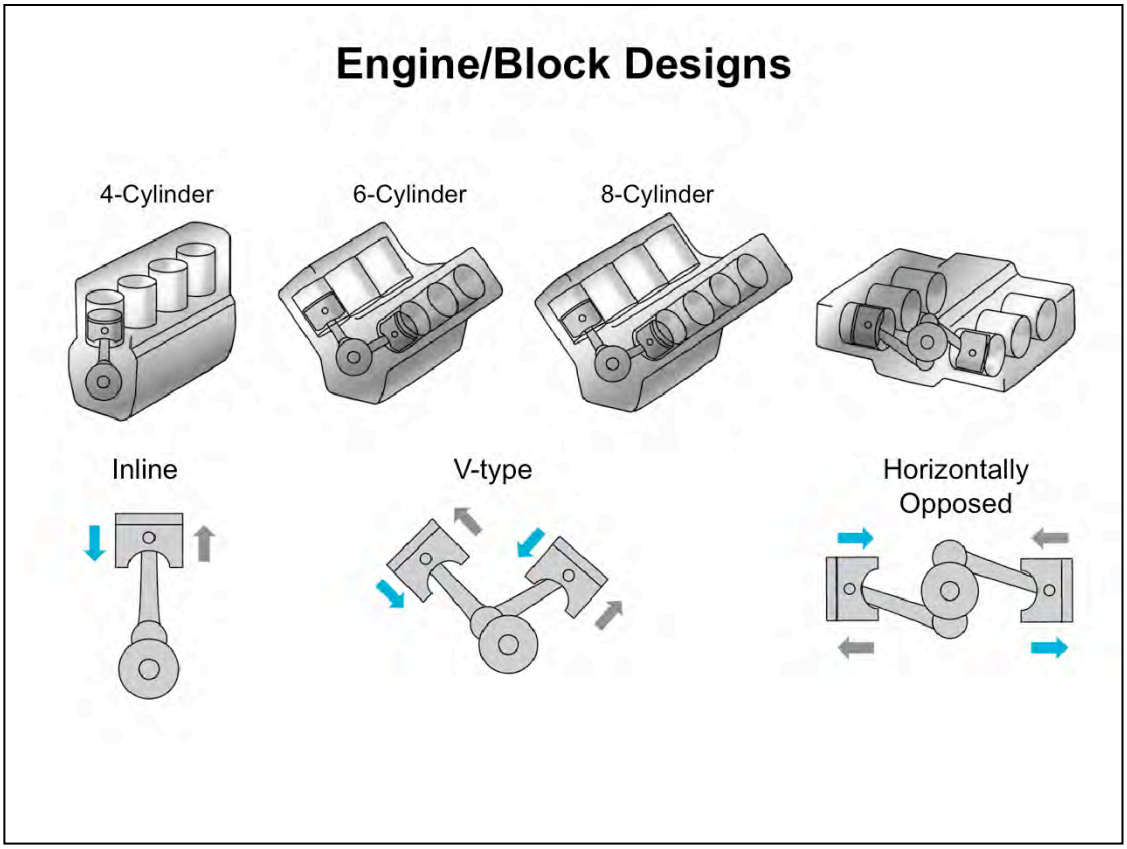


Combustion (Power) Stroke

The spark plug ignites the fuel within the cylinder. The burning fuel consumes the available oxygen and creates heat. This heat energy causes the combustion gases within the cylinder to expand forcing the piston downward and rotating the crankshaft to produce rotational power.



Exhaust Stroke After the piston reaches the bottom of its stroke, the exhaust valve opens and the piston begins traveling upward, forcing the spent exhaust gasses out of the cylinder. This completes the 4-stroke process and the cycle begins again with the intake stroke.



Engine and Block Designs

Adding cylinders to the automotive engine has been a popular way to increase power. With the increase in cylinder count, engineers were tasked with finding the best configuration to fit the engine compartment. Over the years, engineers have developed several options for cylinder arrangement.

Inline

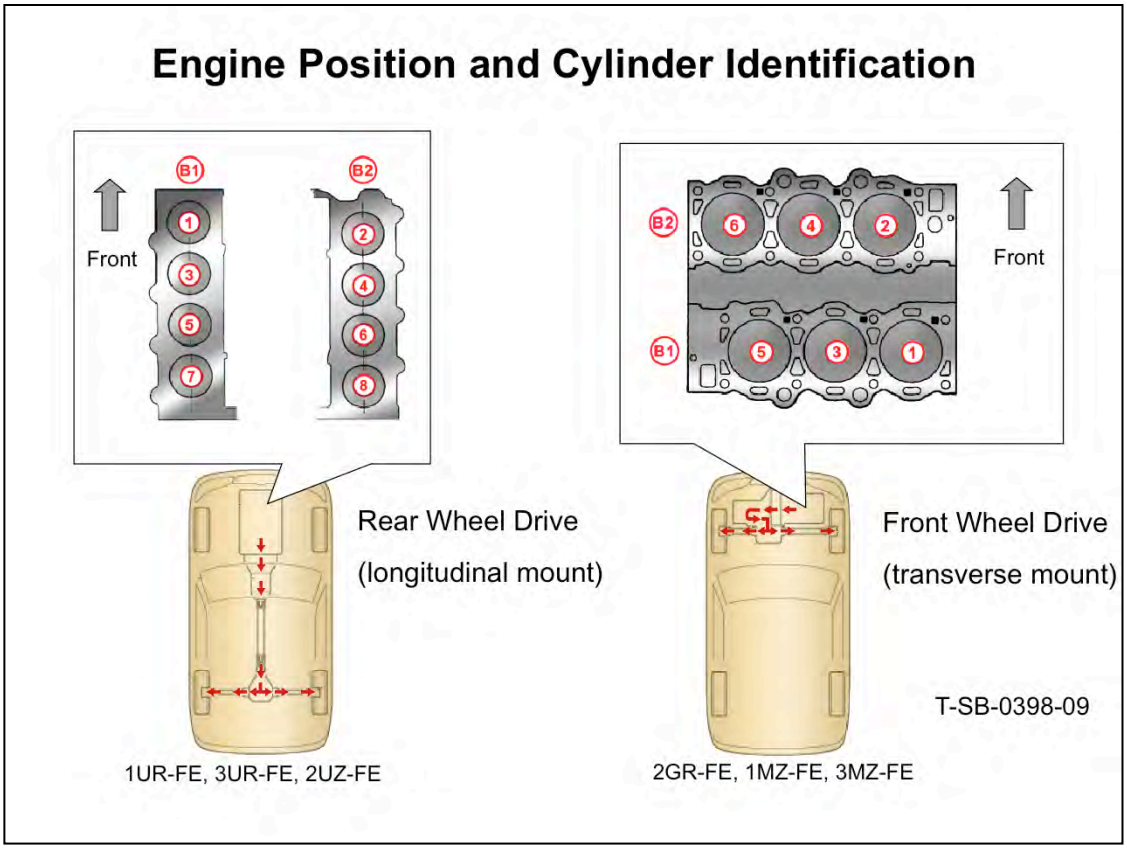
Pistons in **inline** engines are all arranged in a **single row**. In years past, inline engines had 4 to as many as 12 cylinders. In current Toyota vehicles, however, 4-cylinder engines are the only models that use the inline design.

V-type

The V-type engine arranges the pistons into two banks that are offset approximately 90º. Compared to in-line engines, V-type engines are more compact and typically lighter. Toyota V-type models are typically V-6 and V-8.

Horizontally Opposed

Horizontally opposed engines arrange the pistons in two banks that are offset 180º. This design is sometimes used in air-cooled engines, and the 4 or 6 cylinder models may be referred to as a “flat 4” or “flat 6” engines. Toyota does not currently have any horizontally opposed engines in production.



Engine Position

Toyota engines are mounted in the front of the vehicle. However, the engine can be oriented in the engine compartment two different ways – longitudinally or transversely.

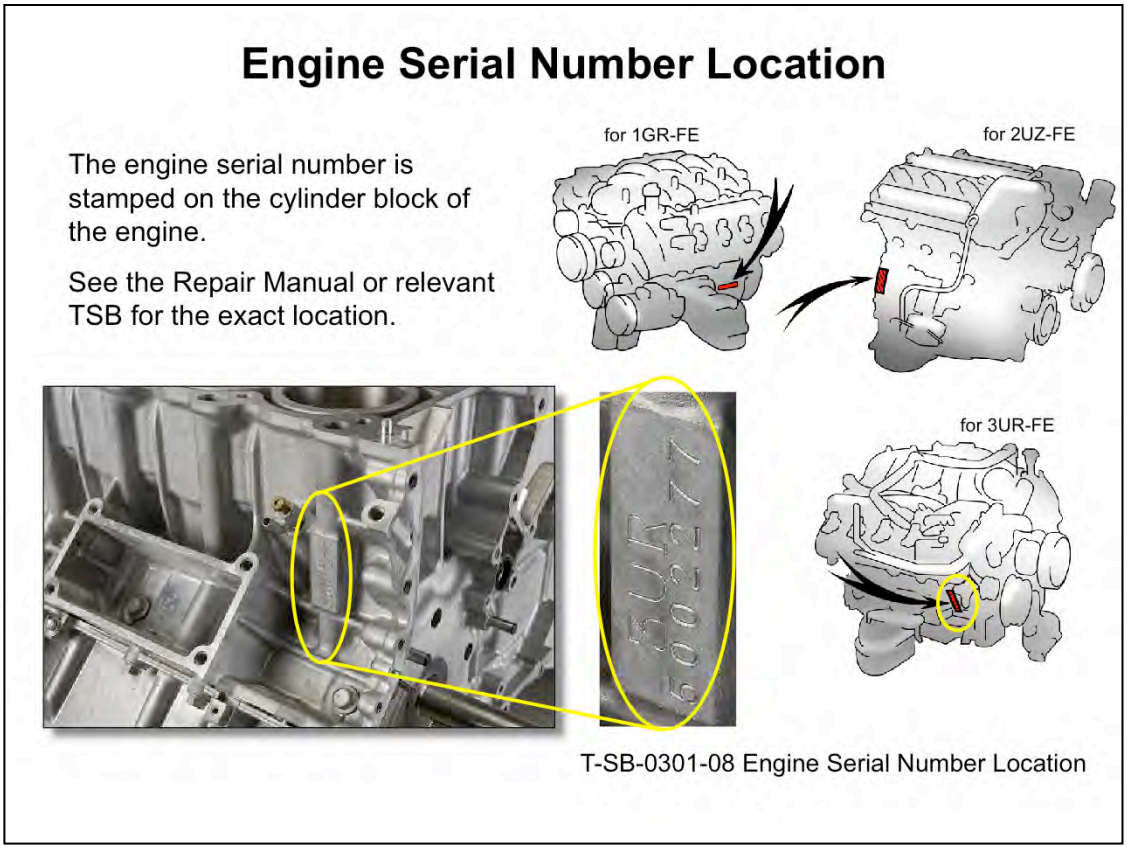
- In rear wheel drive models, the engine is typically mounted longitudinally (crankshaft aligned front-to-back).
- In front wheel drive models, the engine is mounted transversely (crankshaft aligned side-to-side).
- In 4-wheel drive vehicles, the engine is typically mounted longitudinally (similar to rear wheel drive vehicles), with the transfer case redirecting part of the engine's power to the front wheels.

Cylinder Identification

Many service procedures require you to identify a particular cylinder based on its cylinder number. Although the cylinder-numbering-patterns for longitudinally mounted engines or transversely mounted engines are often similar, you can't assume every vehicle is the same. Always refer to the vehicle's Repair Manual to be certain of cylinder numbers.

NOTE

You can also find cylinder identification information in T-SB-0389-09 for the following engines: 1AZ-FE, 2AZ-FE, 2AZ-FE (PZEV), 1GR-FE, 2GR-FE, 2JZ-GE, 1MZ-FE, 3MZ-FE, 1UR-FE, 3UR-FE, 2UZ-FE, 5VZ-FE, and 1ZZ-FE.

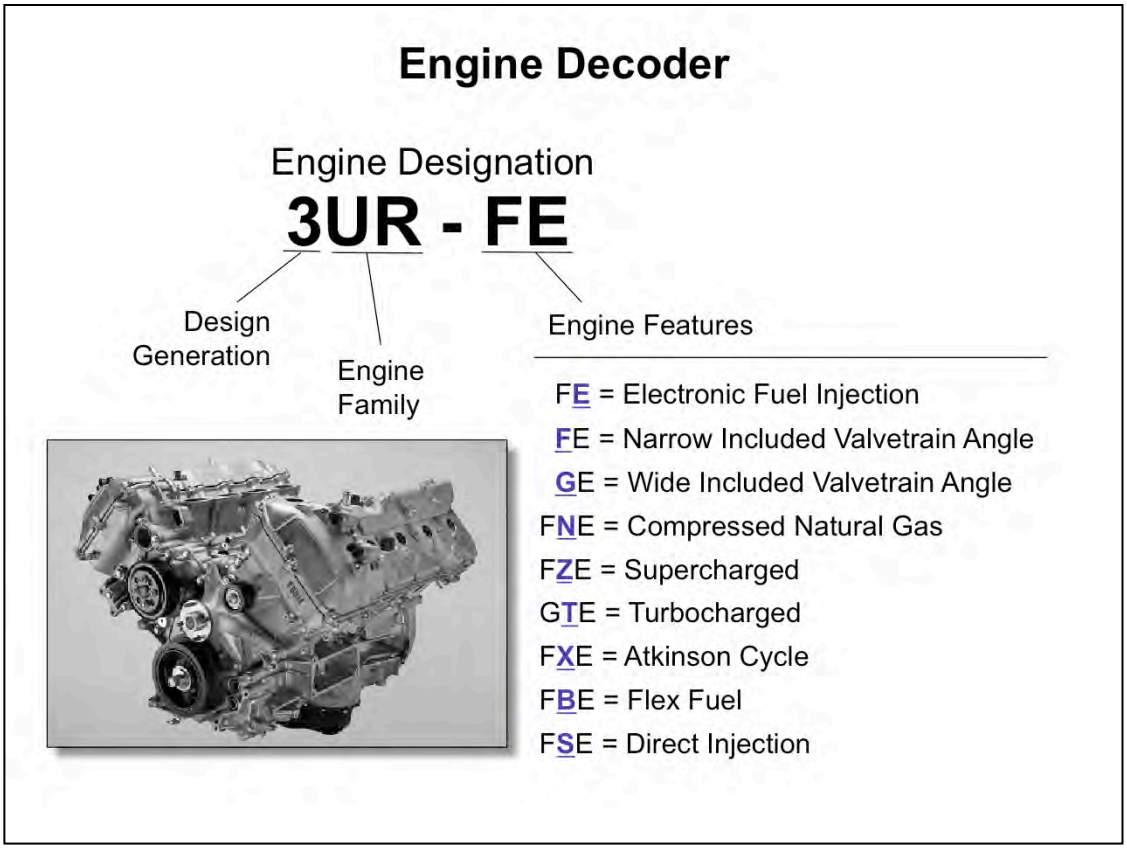


T-SB-0301-08 Engine Serial Number Location

Engine Serial Number

Engine serial numbers provide valuable information about where and when that particular engine was manufactured. Currently, the automotive industry, including Toyota, relay on parts sourced from multiple manufacturers and suppliers. If a quality issue arises and the manufacturer needs to evaluate the range of products affected. The serial number is used to determine the plant where it was manufactured and when it was made in the series of production.

Typically, when a TAS case or product report is opened, the part serial number will be required to process that report. It is important to have this information ready when contacting TAS.



Engine Decoder

4 cylinder engines:

- 5S-FE
- 2AZ-FE
- 1NZ-FE
- 3S-FE
- 2TR-FE

6 cylinder engines:

- 1MZ-FE
- 3MZ-FE
- 2GR-FE

8 cylinder engines:

- 2UZ-FE
- 1UR-FE
- 3UR-FE

Engines in series:

- 1AR-FE – 2AR-FE
- 1GR-FE – 2GR-FE
- 1UR-FE – 3UR-FE – 3UR-FBE

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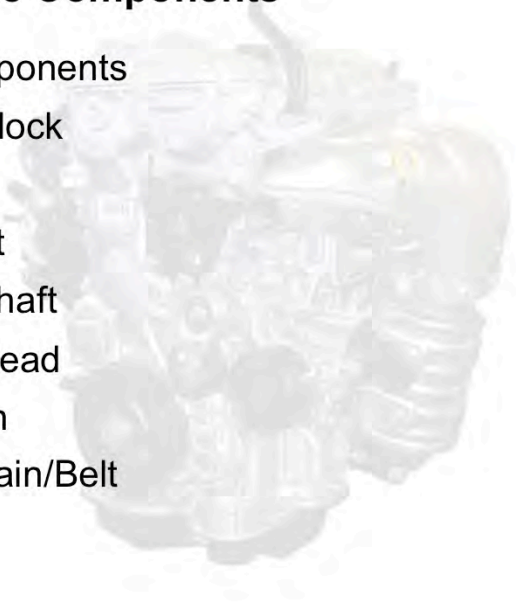
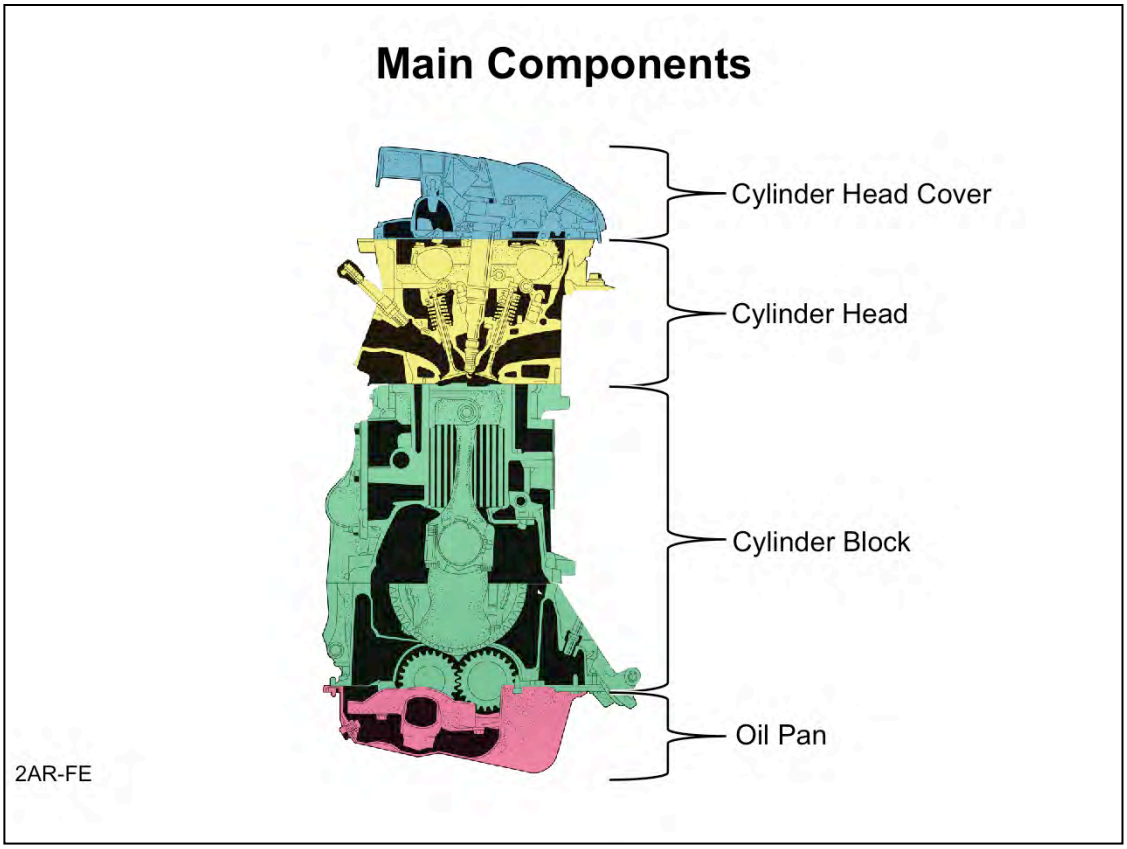
Section 2 Topics

Basic Engine Components

- Main Components
- Cylinder Block
- Pistons
- Crankshaft
- Balance Shaft
- Cylinder Head
- Valve Train
- Timing Chain/Belt





Main Components

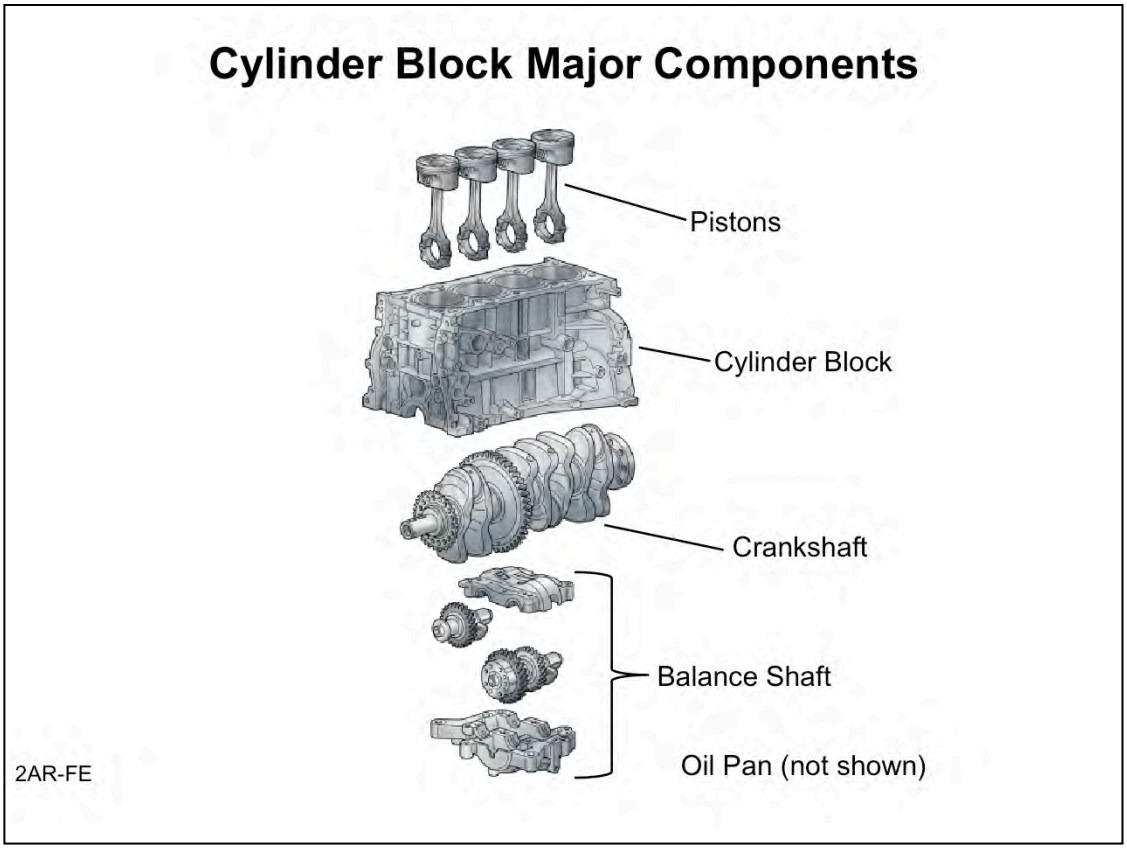
When you remove the intake system and exhaust system from the engine, the main engine components that remain are the:

- **Cylinder Head Cover** – Seals the top end of the engine to keep lubricating oil in and dirt and contaminants out.
- **Cylinder Head** – Houses the valve assemblies and is the attachment point for the intake and exhaust manifolds. In engines with overhead cam (OHC), the camshaft and cams are also in the cylinder head.
- **Cylinder Block** – Houses the pistons and crankshaft. In engines equipped with a balance shaft, the balance shaft is contained in the cylinder block.
- **Oil Pan** – Seals the bottom end of engine and provides a collection point for lubricating oil to be recirculated by the oil pump.

Short Block vs. Long Block

A short block is a replacement cylinder block containing the crankshaft, connecting rods, and pistons.

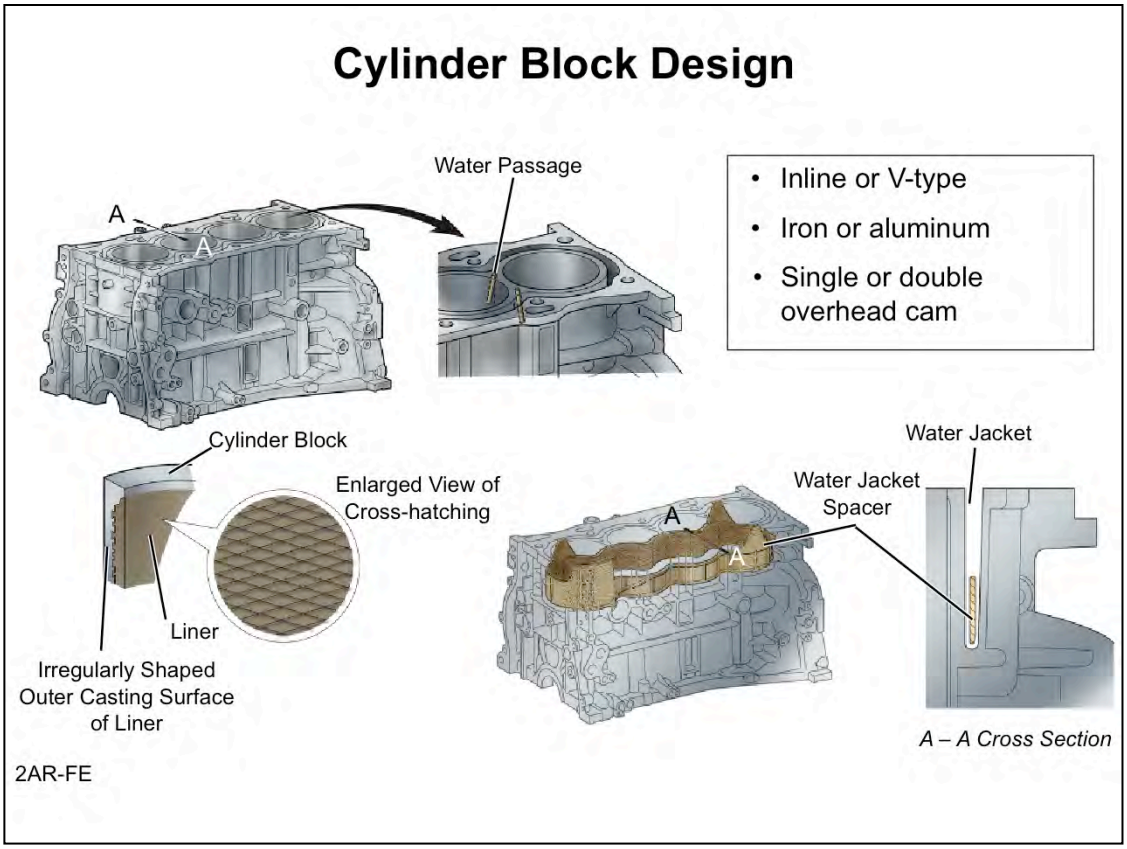
A long block, otherwise known as a Partial Engine Assembly, is a fully assembled engine without manifolds or most accessories.



Cylinder Block Major Components

The major components in the cylinder block are:

- Pistons
- Crankshaft
- Balance Shaft



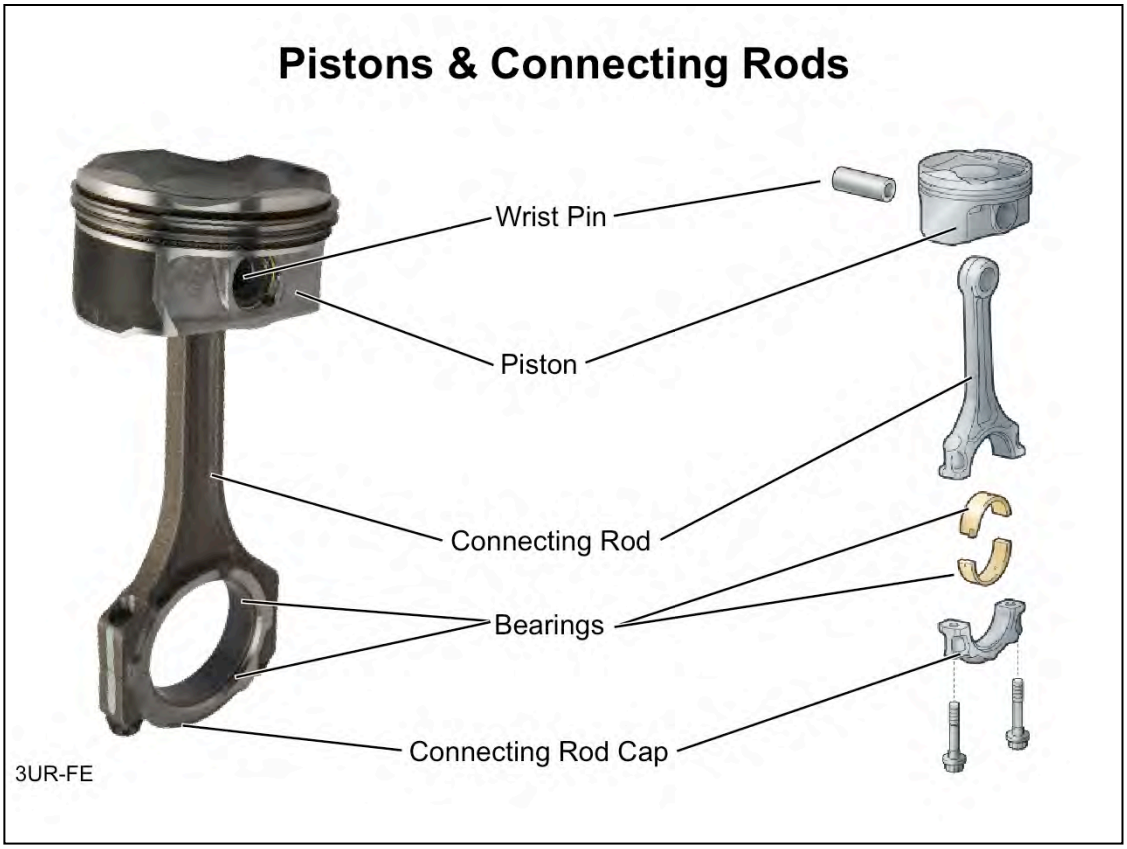
Cylinder Block Designs

Engine designs based on piston count and piston arrangement – such as inline, v-type, or horizontally opposed – are only the beginning of engine design evolution.

Some engines are manufactured with **iron cylinder blocks** and some are **made of aluminum**. Iron blocks are strong and lower cost but aluminum blocks are much lighter weight and dissipate heat better.

In an engine with a single overhead cam design, the cam lobes that open and close the intake and exhaust valves are on the same camshaft. Most Toyota engines use the double overhead cam design that provides individual camshafts for the intake valves and exhaust valves.

These are only a few of the more significant differences in cylinder block designs.



Pistons and Connecting Rods

Because pistons are subject to extremely **high temperatures and pressures**, they are normally made of aluminum for durability and reduced weight.

NOTE The piston skirt has a resin coating to reduce friction. Be careful not to remove this coating.

The **piston** is fastened to a **connecting rod** by a wrist pin that allows the rod to move back and forth as the crankshaft rotates. In some designs, the wrist pin is **press-fit** into the connecting rod leaving the piston to rotate freely. In other designs, the wrist pin is held in place by **snap rings** at each end.

A pair of **bearings** provide the proper oil clearance where the connecting rod fastens to the crankshaft. Bearings are held in place by the **connecting rod cap**.

NOTE The connecting rod and connecting rod cap are a matched set. If the connecting rod cap is removed, be sure it is reassembled with the correct connecting rod and in the correct direction.

Piston Rings

Piston rings create the seal to prevent combustion gases from leaking into the crankcase (blow-by) and prevent crankcase oil from entering the combustion chamber.

To prevent blow-by, the piston uses two compression rings. Ring tension and compression/combustion pressure seat the rings in the bottom of their grooves thus creating a seal.

The oil ring is designed to scrape oil from the cylinder walls and return it to the crankcase. When an oil ring fails, oil is burned in the combustion chamber resulting in bluish exhaust smoke.

NOTE Note the 2nd compression ring has a lip and must be installed with the correct side up.

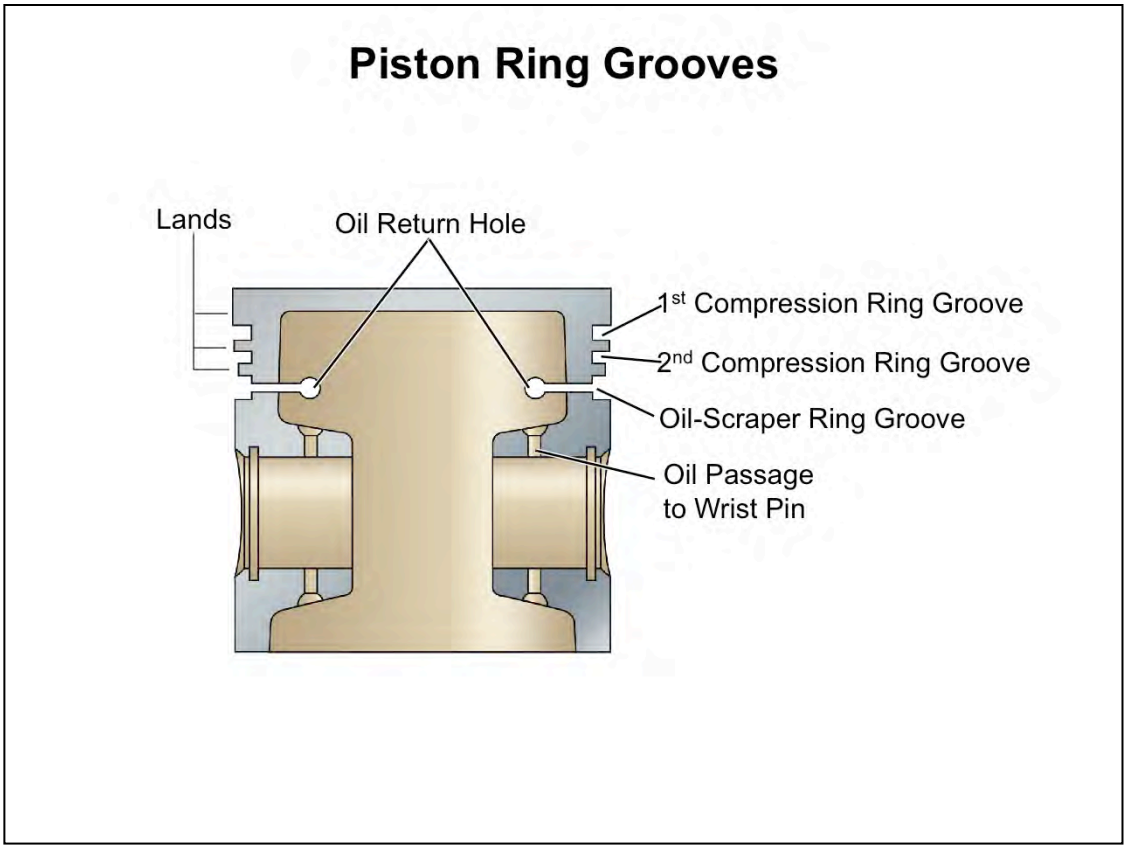
High vs. Low Tension Rings

In older engines, piston rings were made of high tension steel. Because of their spring strength, they pressed tightly against cylinder walls and were difficult to remove from the piston without a special tool.

Piston rings in modern Toyota engines are low tension to reduce friction and increase gas mileage. The use of low tension rings has been made possible in part by low viscosity oils such as 5W20 and 0W20.

NOTE Although low tension rings are easy to remove without a special tool, they are also easier to break, so remove piston rings with care.

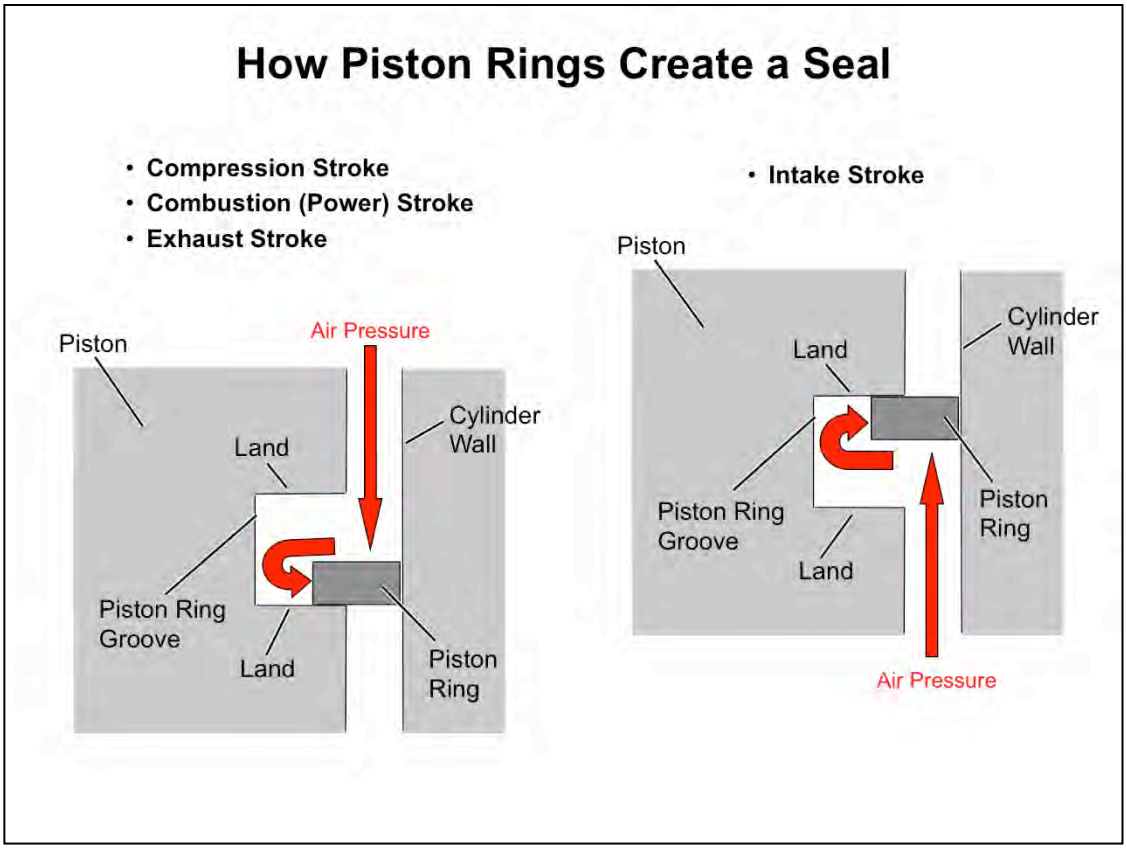
A *physical vapor deposition* (PVD) coating on ring #1 creates an ultra-hard surface that reduces wear and increases ring life.



Piston Ring Grooves

The groove for the oil ring has two passages within the piston body that allow oil to flow back to the wrist pin and ultimately back into the crankcase.

Piston rings are not solid, but have a gap resembling a snap ring, though the piston ring gap is very small. The gap allows the ring to be expanded and slipped over the piston for installation. Piston rings sometimes have an “up” side, and the gaps in the rings must be arranged on different sides of the piston.

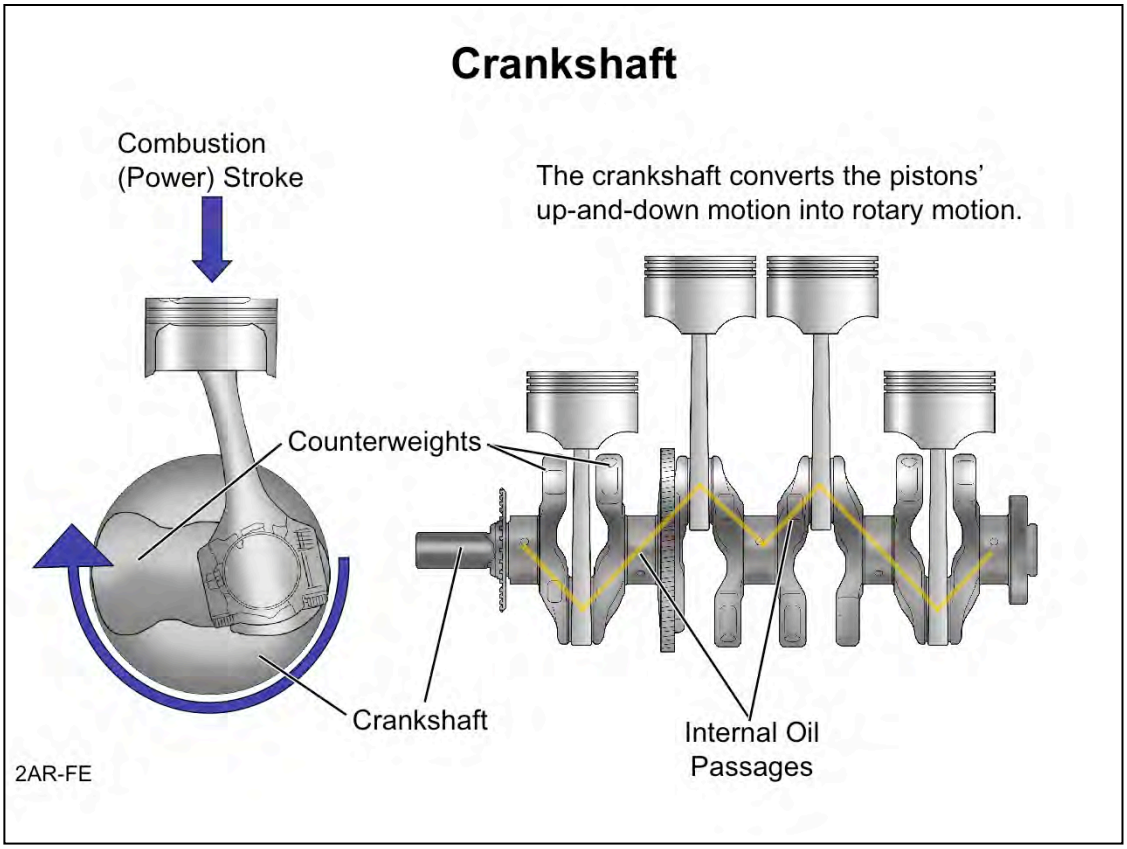


Piston Ring Function

The flat surfaces at the top and bottom of the piston ring groove are called “lands.”

During the compression, combustion, and exhaust stroke, higher air pressure above the piston forces the ring tightly against the lower land. Air pressure behind the ring then forces it tightly to the cylinder wall creating a seal.

During the intake stroke, the higher pressure is below the ring which forces it to seal against the upper land.



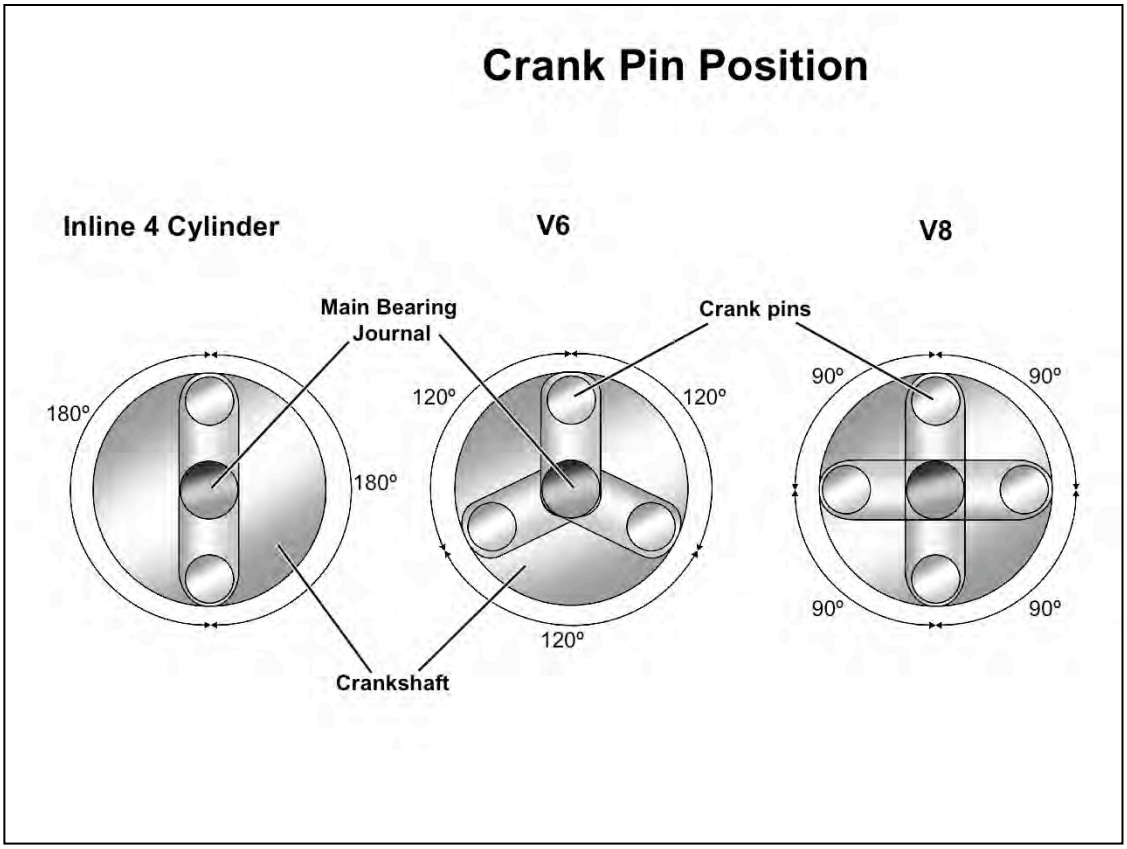
Crankshaft The crankshaft converts the pistons' up and down motion into rotary motion that is transmitted to the transmission and drive axles. It is a one-piece component made of cast iron or forged steel. Components of the crankshaft include:

- Main bearing journals
- Rod bearing journals
- Counterweights

Oil Passages The crankshaft rotates on an axis formed by the main bearing journals. Rod bearing journals are offset from the crankshaft center so the rod and piston move up and down as the crankshaft rotates. Oil passages within the crankshaft direct oil to main bearing journals and rod bearing journals.

Counterweights Because the rods and pistons are offset from the crankshaft center, their weight when in motion can induce tremendous vibration. To prevent this vibration, the crankshaft has counter weights built into it that are offset in the opposite direction from each piston and rod.

Flywheel To absorb rotational pulses generated by the sequential firing of the cylinders, a flywheel is attached at the rear end of the crankshaft outside the engine.

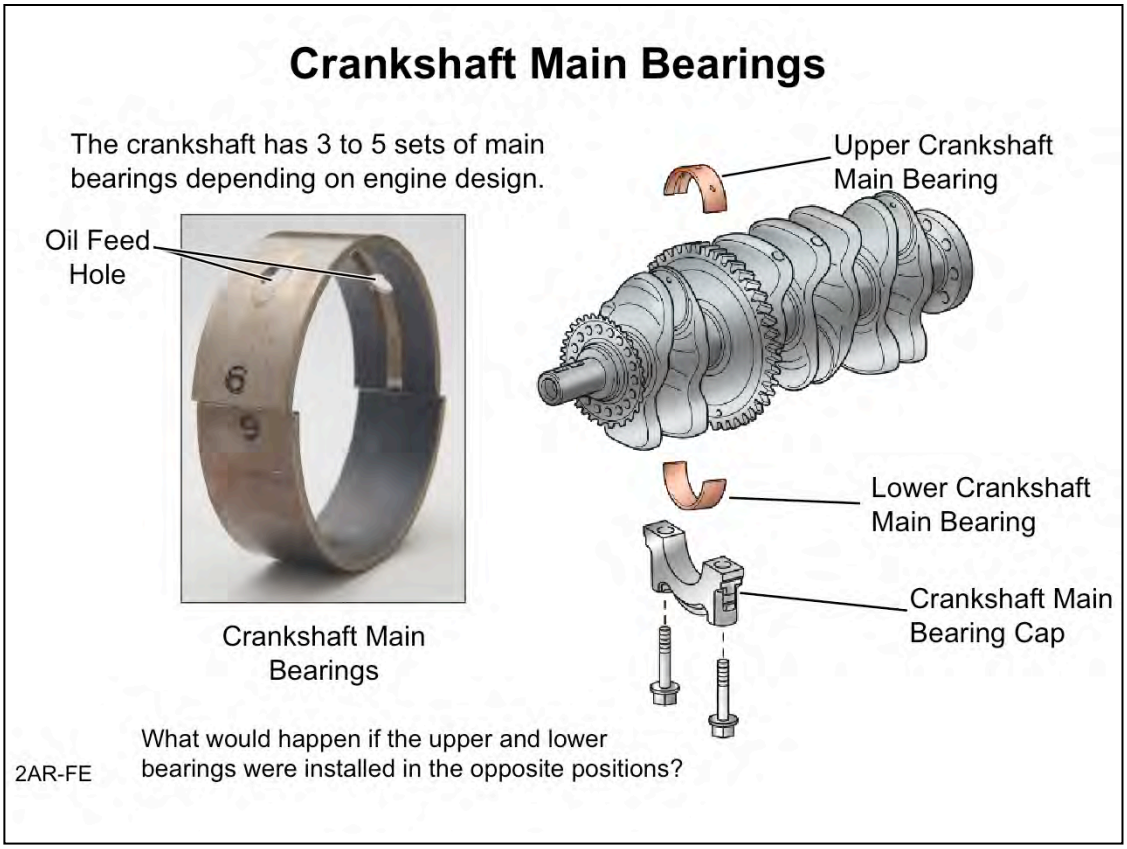


Crank Pin Position

Rod bearing journals (also called “crank pins”) are offset from the crankshaft center so the rod and piston move up and down as the crankshaft rotates.

In 4 cylinder engines, the crank pins are offset 180º. For example, crank pins for pistons 1 and 4 are on the opposite side of the crankshaft from the crank pins for pistons 2 and 4.

In 6 cylinder engines, the crank pins are 120º apart, and in 8 cylinder engines, they are 90º apart.



Crankshaft Main Bearings

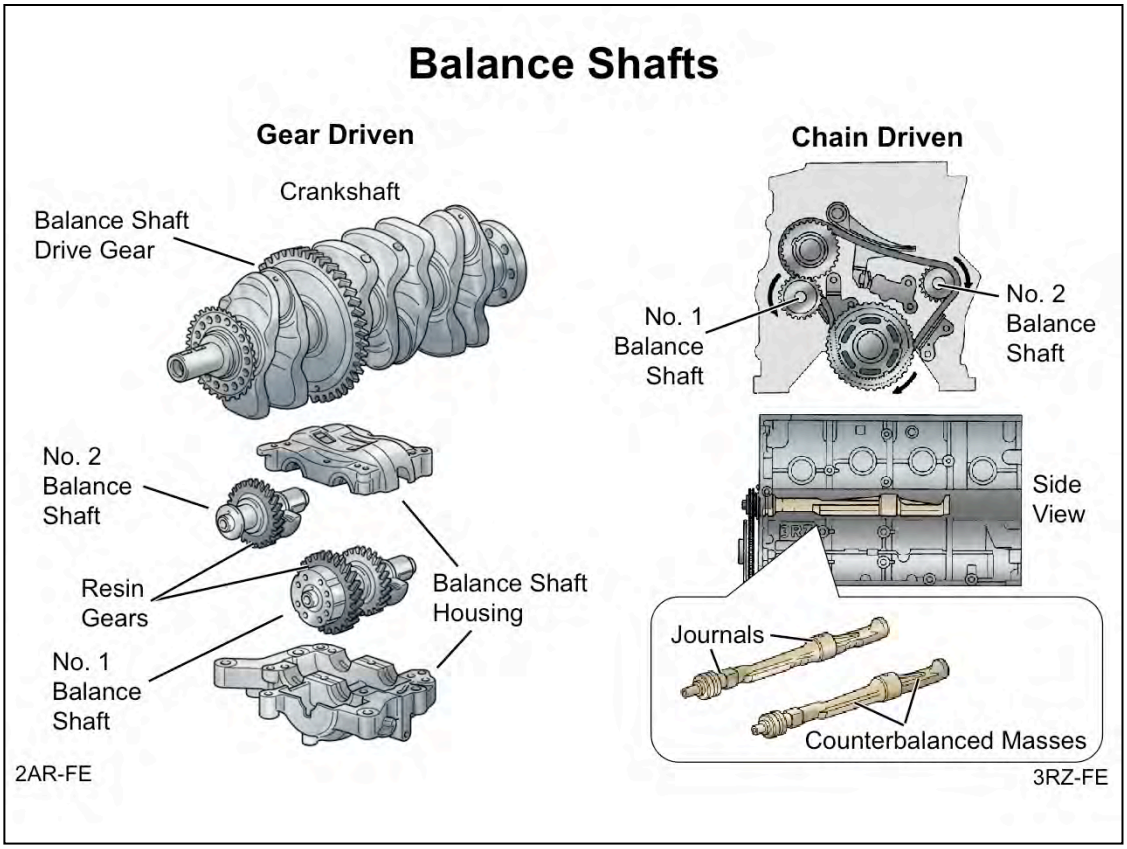
Crankshaft main bearings are held in place by a bearing cap. The bearing is just a few thousandths of an inch larger in diameter than the shaft rotating inside it. The thin space between the bearing and the shaft is filled with oil, and therefore the shaft rotates on a film of oil rather than on the metal bearing itself.

The part of the shaft that rotates inside the bearings is called a journal. Main bearings are inspected by visually looking for wear and by measuring the clearance between the bearing and the journal. This clearance is called the **oil clearance**. The procedure for measuring oil clearance is described later in this handbook.

Because of the forces on the crankshaft applied by the pistons, the crankshaft will have more than just two end bearings – usually from 3 to 5 pair.

NOTE

Oil is supplied to the crankshaft main bearings and journals through oil passages in the cylinder block above the upper bearing. The upper bearing has oil feed holes to allow oil to reach the inner bearing surfaces and crankshaft journals. If the upper and lower bearings were installed in the opposite positions, the bearings would quickly fail from insufficient lubrication.



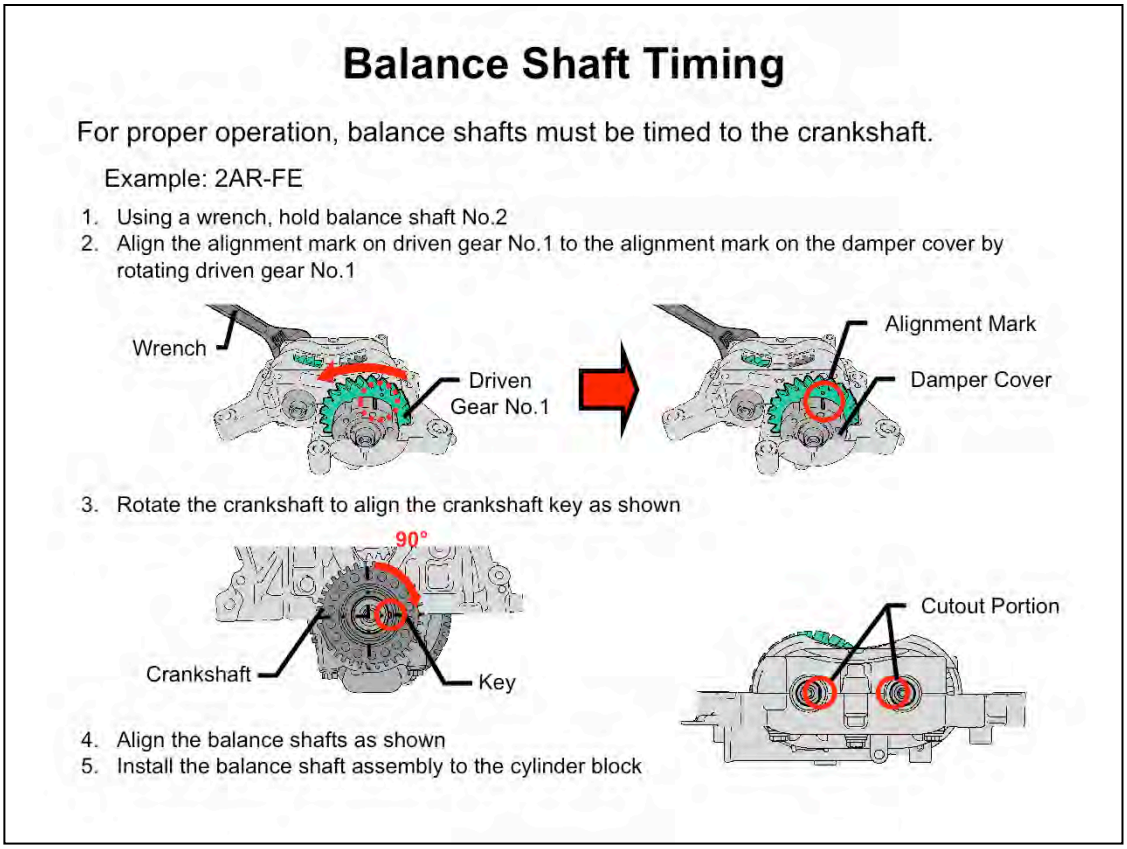
Balance Shafts

The crankshaft is designed with counterweights specifically calibrated to balance out the uneven momentum of piston motion. Balancing this momentum is essential for eliminating potentially violent vibration.

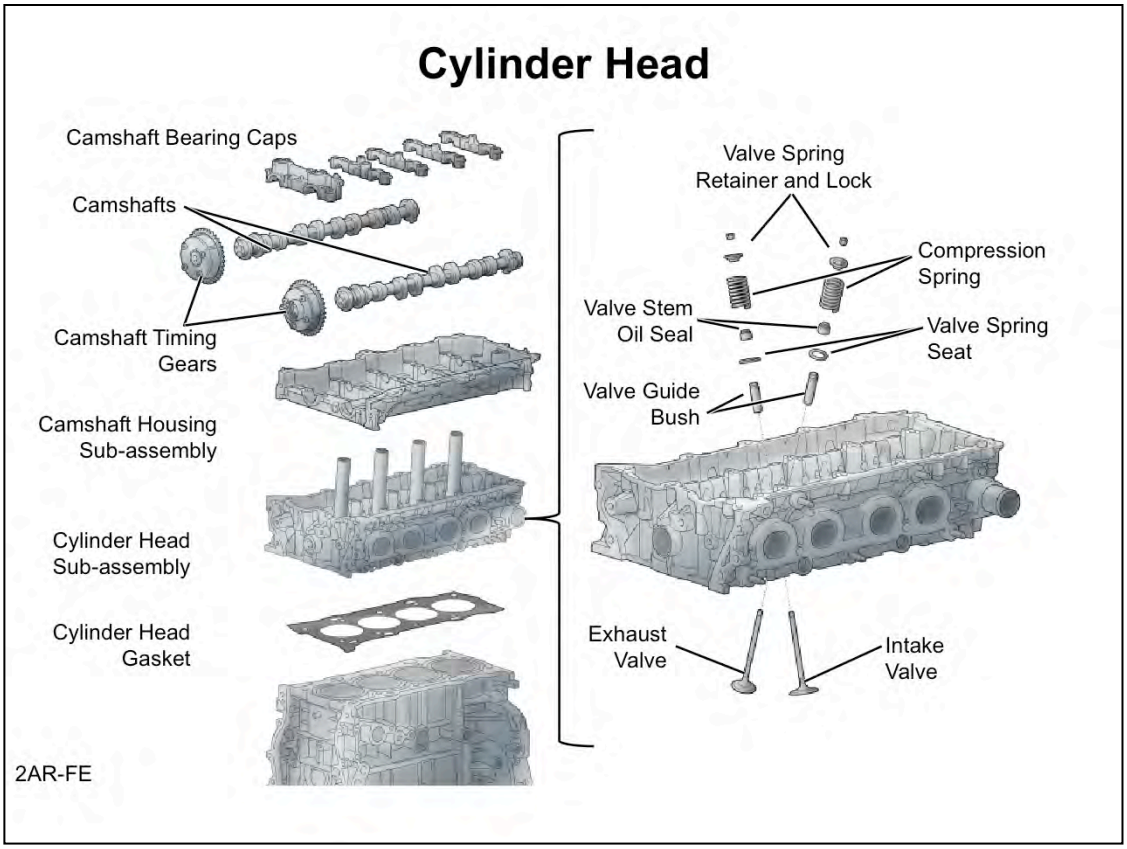
Because dynamic forces acting on the pistons vary as engine speed increases, static counterweights on the crankshaft can't eliminate absolutely all vibration. Therefore, some engine designs include additional rotating shafts with counterweights that create equal but opposite dynamic forces to more effectively cancel out engine vibration.

Balance shafts are typically found in pairs so they balance each other and don't introduce any new unbalanced vibration.

To be effective, these balance shafts must be properly timed to the crankshaft and to each other so all the opposing rotational forces are in correct alignment.



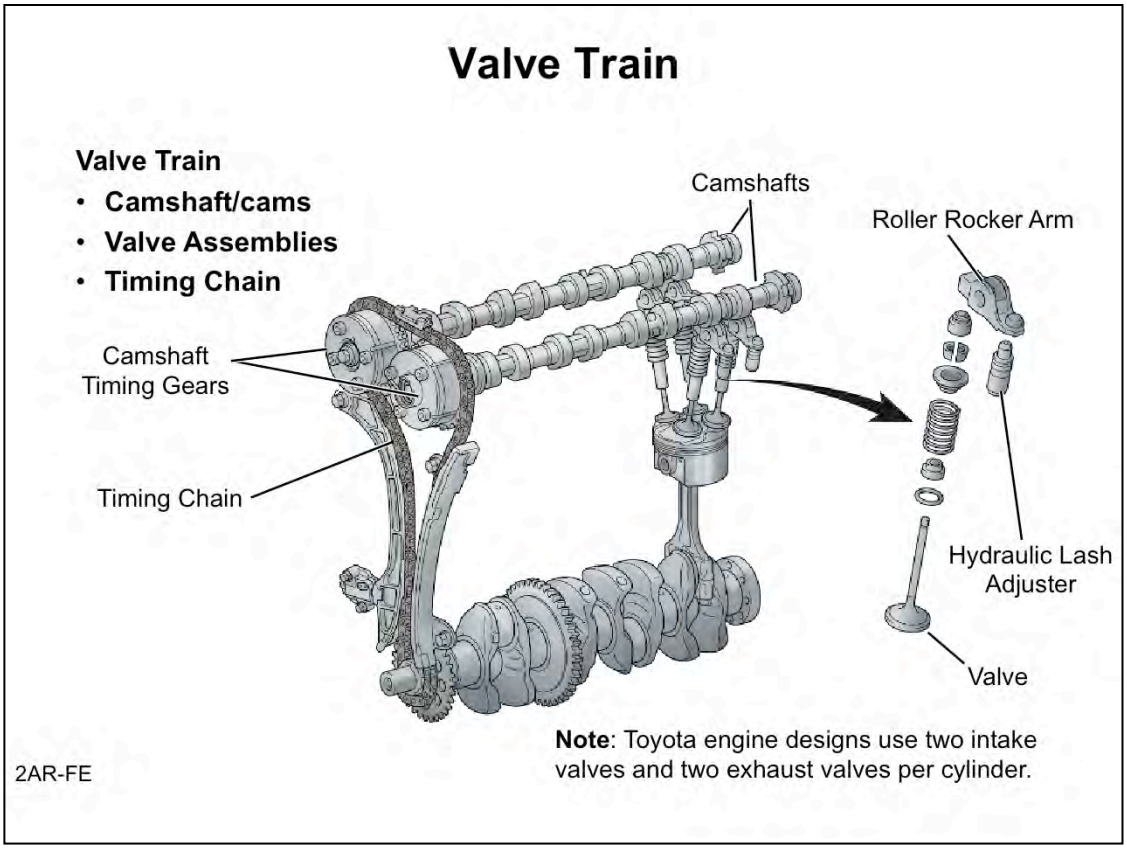
Balance Shaft Timing Toyota's balance shaft assemblies have resin gears to reduce gear noise. During installation it is extremely important to properly time and torque the balance shaft assembly to the cylinder block.



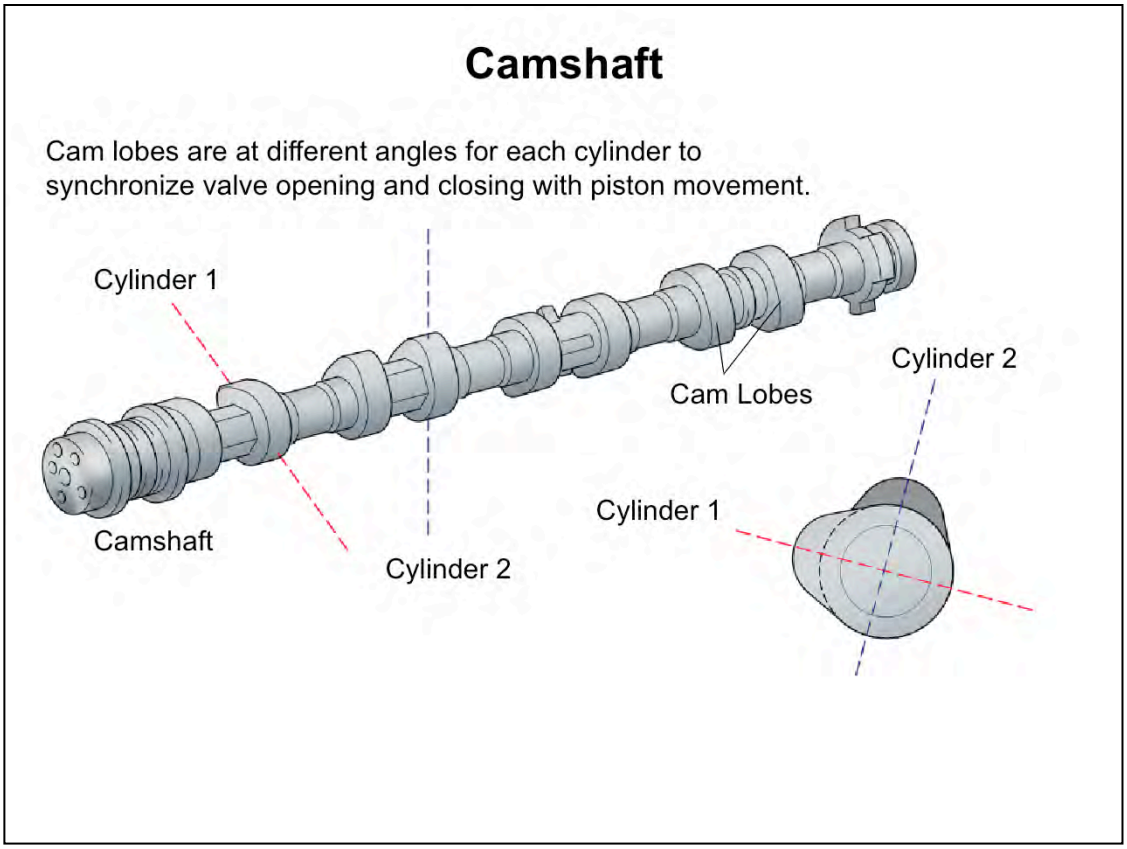
Cylinder Head

The cylinder head is bolted to the top of the cylinder block, forming the “roof” of the combustion chamber and sealing it. Valve-regulated openings over each cylinder allow the air-fuel mixture to enter the combustion chamber and exhaust gases to exit. In the dual overhead cam (DOHC) design, the camshafts are also located in the cylinder head above the valve assemblies.

The fuel injectors and spark plugs are also located in the cylinder head.



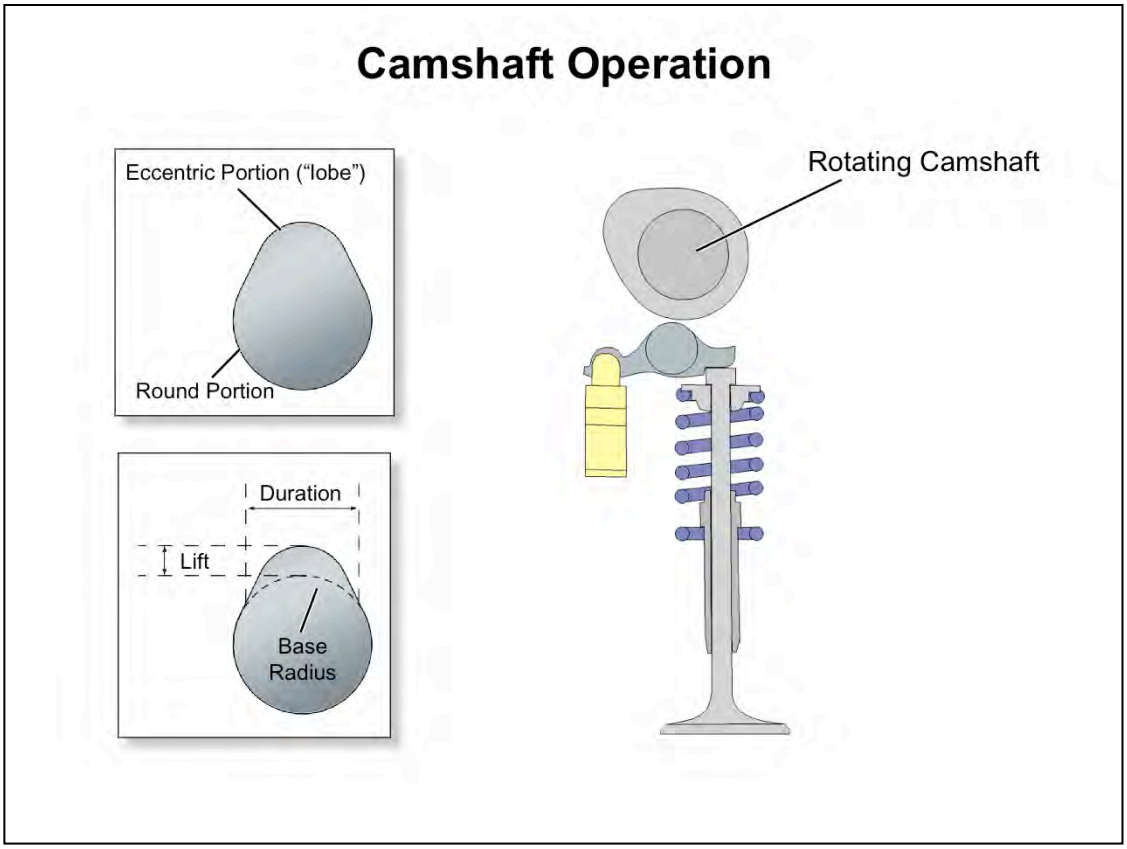
Valve Train The valve train refers to the valve assemblies, camshaft/cams, and timing chain. Together, these mechanisms form the system that synchronizes the opening of the intake and exhaust valves in time with the pistons' strokes. This synchronization is referred to as "engine timing." Precise engine timing is critical to engine performance.



Camshaft

Because of the arrangement of the valves, the dual overhead cam (DOHC) design uses two camshafts – one for the intake valves and one for the exhaust valves. Toyota engines use two intake valves and two exhaust valves per cylinder.

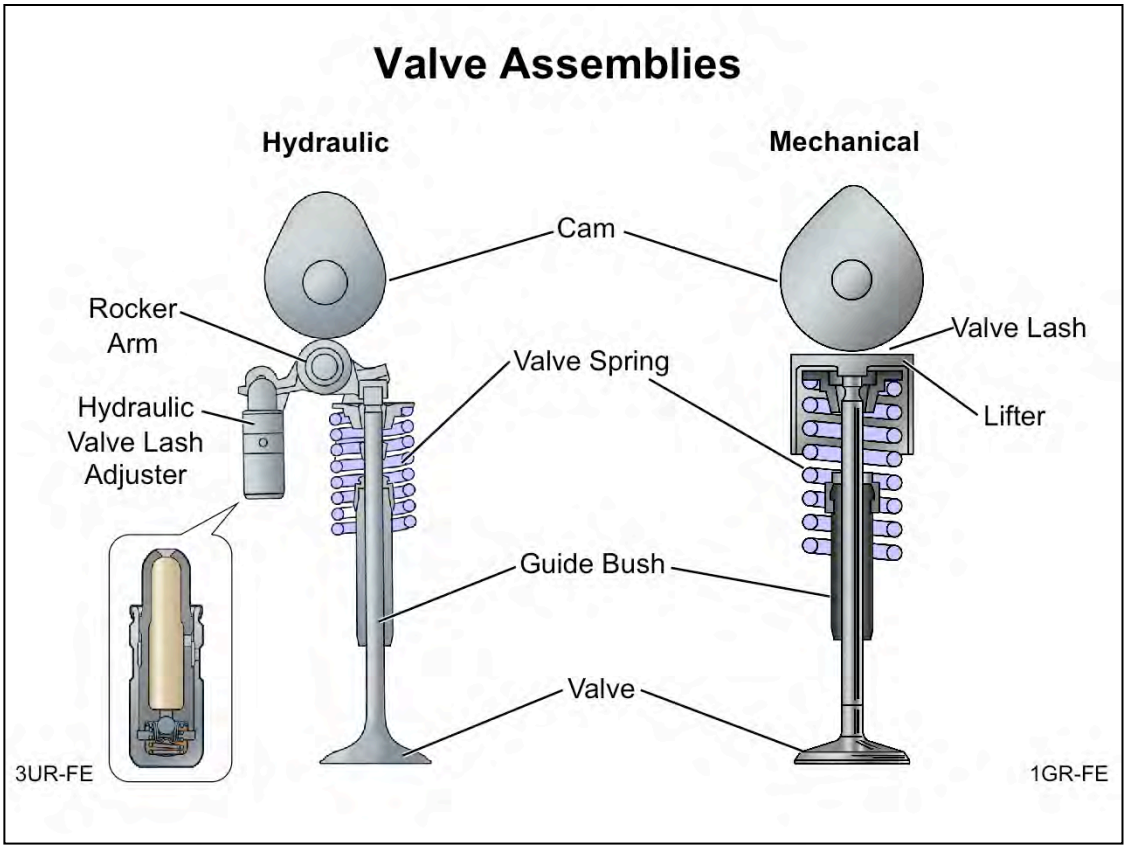
On the intake camshaft for example, there are two cam lobes for each cylinder to operate the two intake valve assemblies simultaneously. Also note that the cam lobes are at different positions for each cylinder to synchronize valve opening and closing with piston movement.



Camshaft Operation

While the round portion of the cam is in contact with the valve assembly, the valve spring holds the valve **closed**. When the eccentric portion of the cam (the ”lobe”) contacts the valve assembly, it forces the valve **open**.

The shape of the cam determines how far the valve opens and how long it remains open. How far the valve opens is determined by the cam’s lift, which is the height of the lobe above the cam’s base radius. The duration of the valve opening is determined by the width of the lobe.



Valve Assemblies

The valve assemblies in overhead cam engines may be mechanical or hydraulic.

Mechanical Lifters and Valve Lash

The mechanical lifter is a metal cap that covers the valve spring and valve stem. As the cam rotates, it presses against the cap, which in turn pushes the valve down to open it.

When the valve is closed, a very small clearance is required between the lifter and the cam. This allows for expansion of components as the engine reaches operating temperature. Without this clearance, the cam could press down slightly on the lifter at all times after engine warm-up, preventing the valve from closing fully. This clearance is called valve lash.

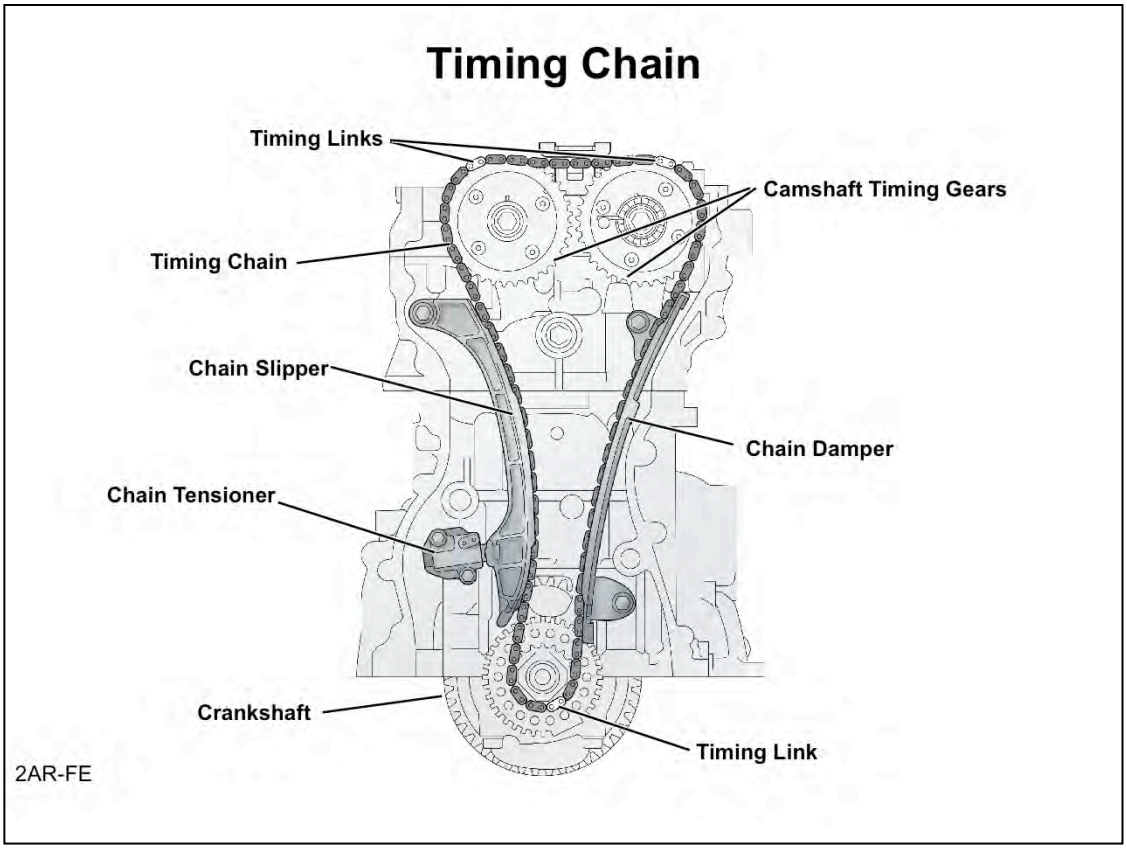
But as the surfaces of the cam and lifter wear, the valve lash increases. At some point, the cams striking the top of the lifters create an audible clicking sound. This requires the valve lash be adjusted to return it to specifications.

Hydraulic Valve Lash Adjuster

The hydraulic valve lash adjuster uses oil pressure and spring force to maintain a constant zero valve lash throughout a variety of engine operating conditions, including wear.

This design uses a rocker arm positioned on top of the lash adjuster and the valve stem. When the cam lobe presses down on the rocker arm, it pushes down on the lash adjuster's plunger and the valve stem at the same time. A sealed oil-filled chamber keeps the lash adjuster from compressing, resulting in the rocker arm forcing the valve open.

As the parts wear, oil pressure keeps extending the lash adjuster plunger to eliminate any clearance that might otherwise develop between the cam lobe and rocker arm.



Timing Chain

The timing chain is driven by the crankshaft and turns the camshaft timing gears to open and close the intake and exhaust valves at the precise moment required. Since the valves open once for every two revolutions of the engine, the crankshaft and timing gears have a 2 to 1 gear ratio.

A chain slipper, chain damper, and chain tensioner are used to eliminate the slack after the chain is installed.

Installing the timing chain correctly is critical for proper engine performance.

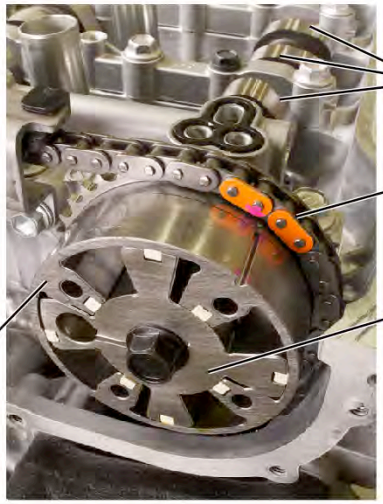
Interference Engines

Incorrectly timing the engine can result in a valve being open when the piston reaches top dead center. In some engine designs, this could cause the piston to actually come into contact with the valve resulting in a bent valve, damaged piston, and/or broken chain. This type of engine is called an **interference engine.** Most timing chain engines are interference engines.

Variable Valve Timing – Intelligent (VVT-i)

To improve operation under varying conditions, the ECM controls the VVT-i actuator to advance or retard valve timing as needed.

Warning: The bolts on the VVT-I cover should never be removed. The cover is shown removed here for training purposes only.

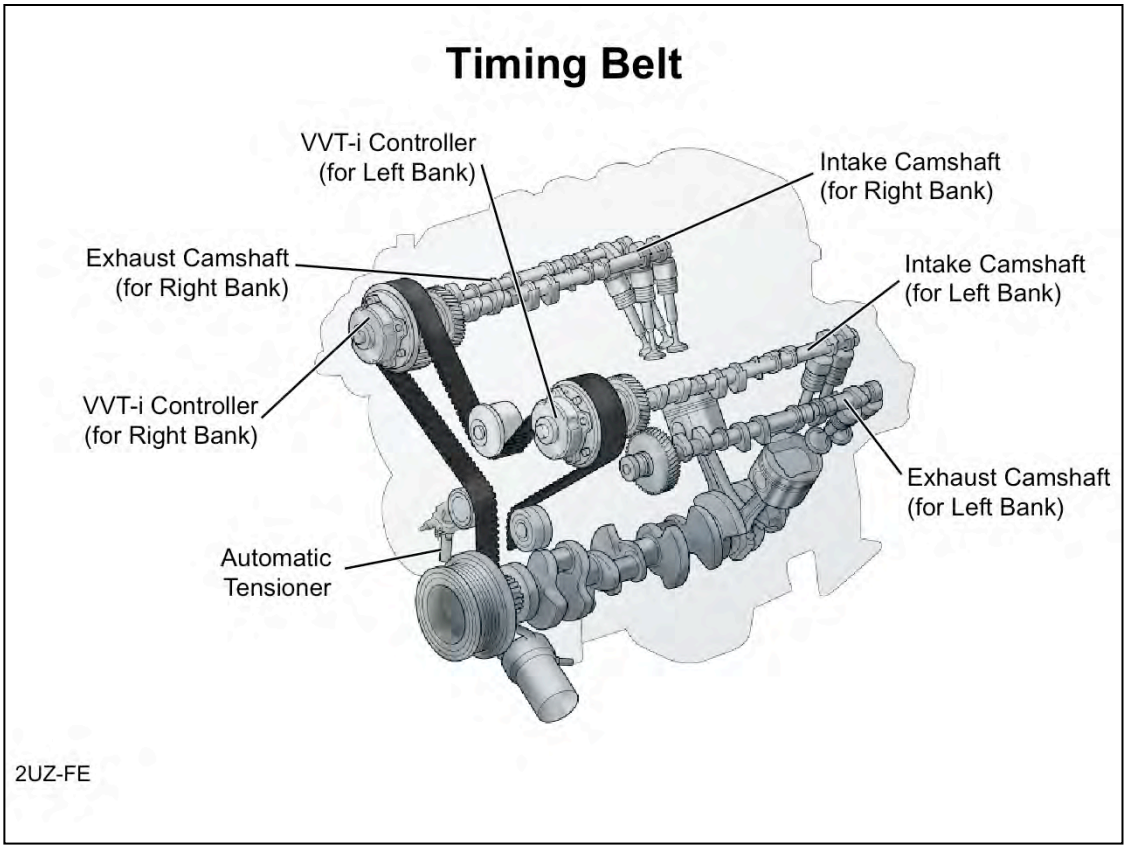


VVT-i Under some load conditions, the engine operates more efficiently if the exhaust valve closes before the intake valve opens.

Under other conditions, efficiency improves if the exhaust valve closes after the intake valve opens.

To improve operation under varying conditions, the ECM controls the VVT-i actuator to advance or retard valve timing as needed. This is referred to as **Variable Valve Timing – intelligent (VVT-i).**

To vary valve timing, the actuator rotates the camshaft slightly in relation to the timing gear. The actuator is driven by oil pressure from an oil control valve controlled by the ECM.



Timing Belt

A timing belt performs the same function as a timing chain; it's just made of a different material. A timing belt is "toothed" so that it doesn't slip, an event which would clearly alter engine timing and performance.

Timing belts also have a different maintenance interval and inspection procedure than timing chains.

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Section 3 Topics
Tools, Materials and Equipment
Shop Safety
Engine Lift
Parts Washers
Engine Sealing
Seal Installation
Seal Packing
Dye Penetrant
Plastigage®
Thread Cleaning
Vernier Caliper
Micrometer
Inside Diameter Gauges
Dial Indicator
Using a Micrometer Worksheet

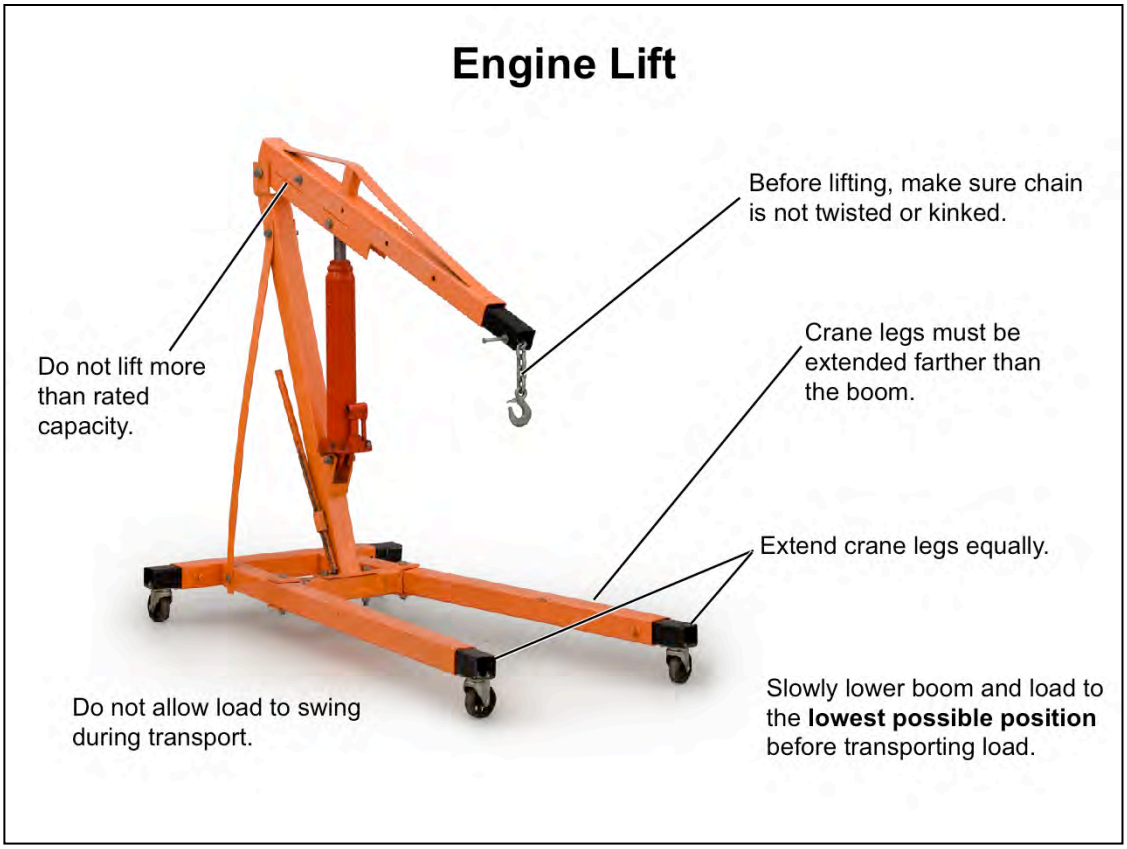
Shop Safety

Be sure to watch out for the **safety of coworkers** when working together. Keep the work area clean and neat.

When working with the engine running, make sure to provide **ventilation for exhaust fumes** in the workshop.

If working on high temperature, high pressure, rotating, moving, or vibrating parts, wear appropriate safety equipment and **take extra care** not to injure yourself or others.

When lifting the vehicle, be sure to support the specified location with a **safety stand** and use appropriate **safety equipment**.



Engine Lift Always follow the safety procedures outlined by your dealership and/or the lift manufacturer. Use extreme caution when lifting, lowering and moving heavy loads. Always use proper engine mounting equipment and make sure they are securely connected. Refer to the Repair Manual for proper service procedures.

Parts Washers

- All parts must be cleaned before reassembly
- Know what type of solvent the washer uses. Some types are harmful to aluminum
- Immersion cleaners may be most effective at cleaning a cylinder head's oil galleys and blind passages

Manual Parts Washer

Parts Washers

Parts washers will use either a water-based solvent or a solvent-based solution. Be sure you know which type is used because some solvents are harmful to aluminum parts.

- For water based solvent, be sure to blow parts dry and lightly oil them.
- For a solvent-based washer, wash with water, then dry and lightly oil.
- Use a wire wheel to clean bolts, if necessary, to remove rust corrosion, loctite, sealant, etc.

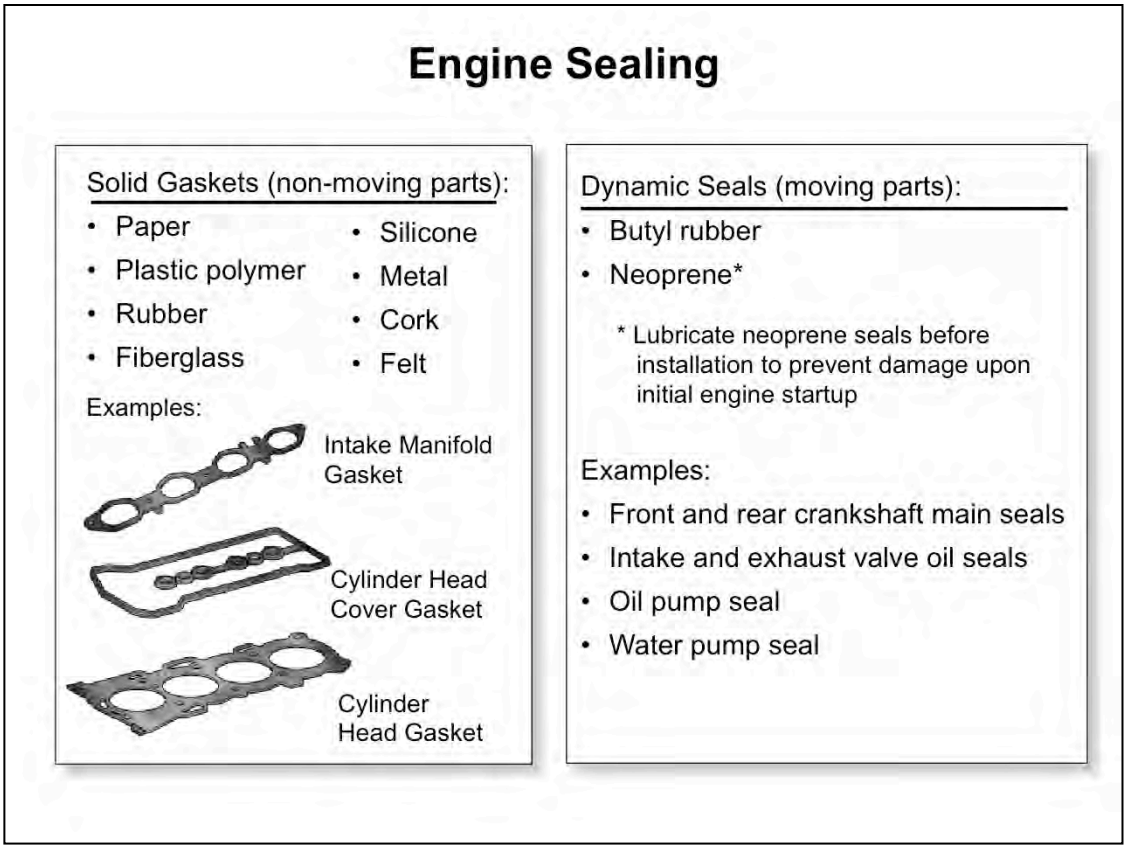
Cylinder Head Cleaning

Clean the entire cylinder head prior to disassembly if it has excessive residue.

- After the parts are removed, wash the cylinder head again separately.
- Cleaning valves – Use a wire wheel to remove carbon buildup.
- Immersion cleaners may be most effective at cleaning a cylinder head's oil galleys and blind passages.

Cylinder Block Cleaning

- Remove plugs from oil galleries and coolant passages.
- Remove all gasket material and/or seal packing.
- Do not hot tank aluminum parts as they will be damaged.
- Spray with an appropriate water and solvent mixture following supplier's precautions.
- Have a variety of wire brushes available to clean with. Use a rifle brush to clean oil galleries.
- Spray iron/ferrous components thoroughly with a rust inhibitor and dry immediately.
- Dry thoroughly with compressed air and paper towels.



Engine Sealing

Automotive engines have dozens of mated surfaces and moving parts. For the engine to function properly these surfaces, orifices, and moving parts need to be sealed off from one another depending on their function or design.

Toyota uses various methods for engine sealing depending on application or function. Solid gaskets are typically used to seal between non-moving parts. These gaskets can be made of various material such as paper, cork, plastic polymer and rubber. For moving parts such as oil or water pumps a dynamic seal is used. These seals are often made of rubber or neoprene.

NOTE It is important to always clean mating surfaces before installing gaskets or seals. Some dynamic seals may require a small amount of lubrication upon installation. See the Repair Manual for proper installation procedure.

Seal Installation

Front Crankshaft Oil Seal Driver

SST: 09223-22010
SST: 09506-35010

Rear Crankshaft Oil Seal Driver

SST: 09223-15030
SST: 09950-70010

Note:
- Keep the lip free of foreign matter
- Do not tap oil seal at an angle

Seal Installation To ensure seals are not damaged during installation, special SSTs are available. It is important to use these SSTs to ensure the seal is properly aligned, at the correct depth, and not damaged during installation.

NOTE Care must also be taken when removing seals so as not to scratch or otherwise damage the contact surfaces. If using a screwdriver to pry out a seal, tape the screwdriver tip to reduce the risk of scratching the contact surface.

FIPG Form-in-place gasket (FIPG) is used to seal a multitude of surfaces on modern Toyota engines. There are many different types of FIPG on the market for various applications. It is important to use the proper sealer for each application.

For sealing against oil leaks, use Toyota Formed-In-Place Gasket - Oil Pan (part no. 00295-00103). Also known as Toyota Seal Packaging 102, this product replaces Toyota Genuine Seal Packing Black, (or Three Bond 1207B, or equivalent) that is specified in the Repair Manuals.

For sealing against water leaks, use Toyota Genuine Seal Packing 1282B (part no. 08826-00100). The Repair Manual specifies Three Bond 1282B or equivalent as alternatives.

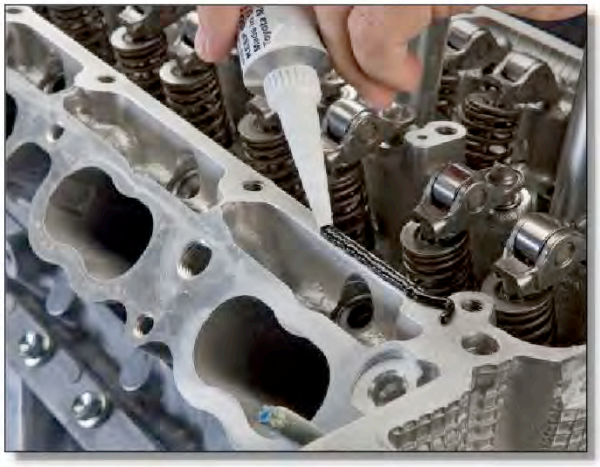
Seal Packing Application

Preparation

- Remove any old material
- Be sure contact surfaces are clean, dry and oil free

Application

- Apply bead of specified width (usually between 2 mm and 4 mm)
- Apply in a continuous line
- Assemble parts within 3 minutes of application
- Allow to dry as specified (one to two hours) before putting assembly into operation



Seal Packing Application

During application, it is crucial that certain protocols are followed to ensure the mating surfaces seal. The surface must be thoroughly cleaned of used FIPG as well as oil and any other residues. Caution must be taken while cleaning the surface. To prevent damage to the mating surface do not use abrasive pads or pneumatic tools. Consult the Repair Manual for where to apply the sealer and the correct amount to use.

NOTE

It is important to apply sealer in the correct diameter and only in the prescribed areas. This minimizes seepage and most importantly prevents FIPG from entering and blocking oil feed holes or coolant passages.

Dye Penetrant

- Reveals cracks and surface defects in metal parts

Dye Penetrant System

- Cleaner
- Penetrant
- Developer

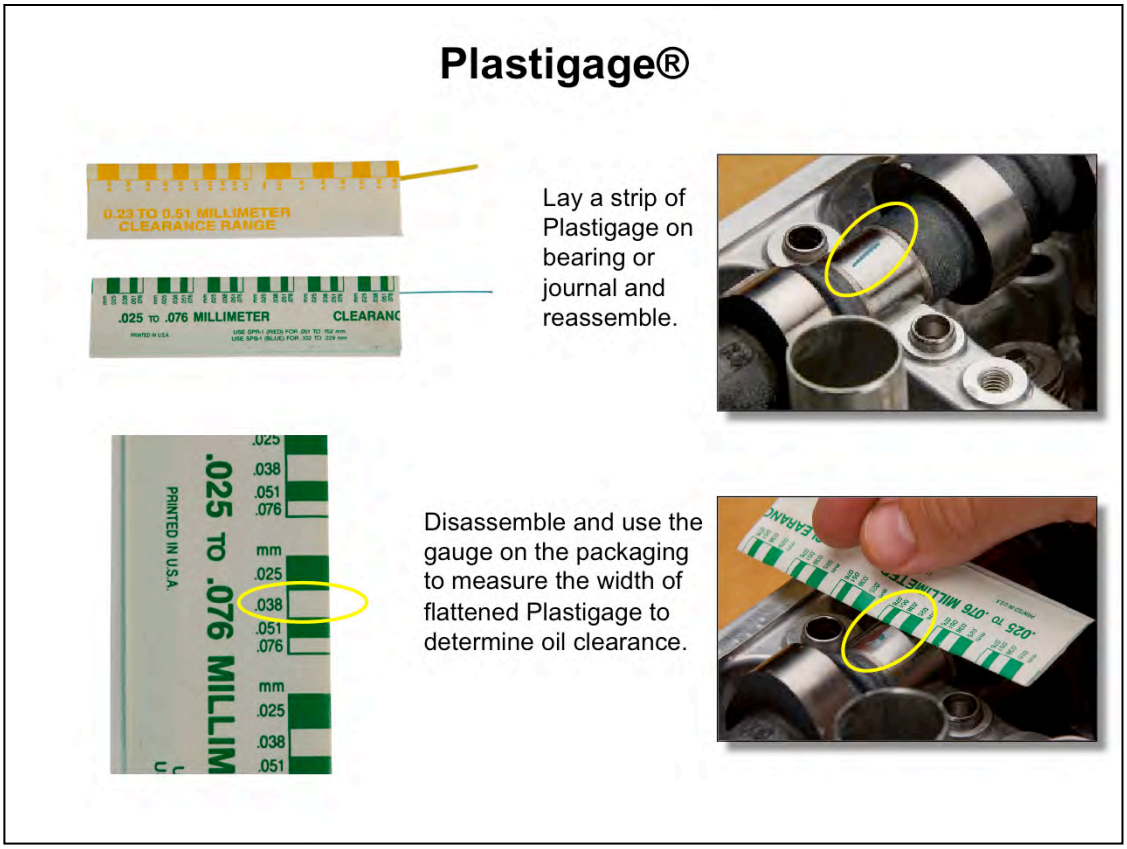
Application

- Clean surface thoroughly with cleaner
- Spray or brush on penetrant and allow to soak for 15 minutes
- Remove penetrant using cleaner and a rag
- Apply developer evenly over the surface and inspect for red marks indicating defects

Dye Penetrant

Although cracks in the cylinder head or cylinder block are not common, un undiscovered crack can result in a misdiagnosis and a failed repair attempt. It's important to check for cracks, especially around the combustion chamber, coolant passages and oil passages.

One way to check for cracks is to use dye penetrant. This multistep application uses various dyes and chemicals to highlight trouble areas that could be otherwise hard to see. If you are not confident using this product it's advisable to send the components to a professional machine shop to have the component checked using alternative methods.

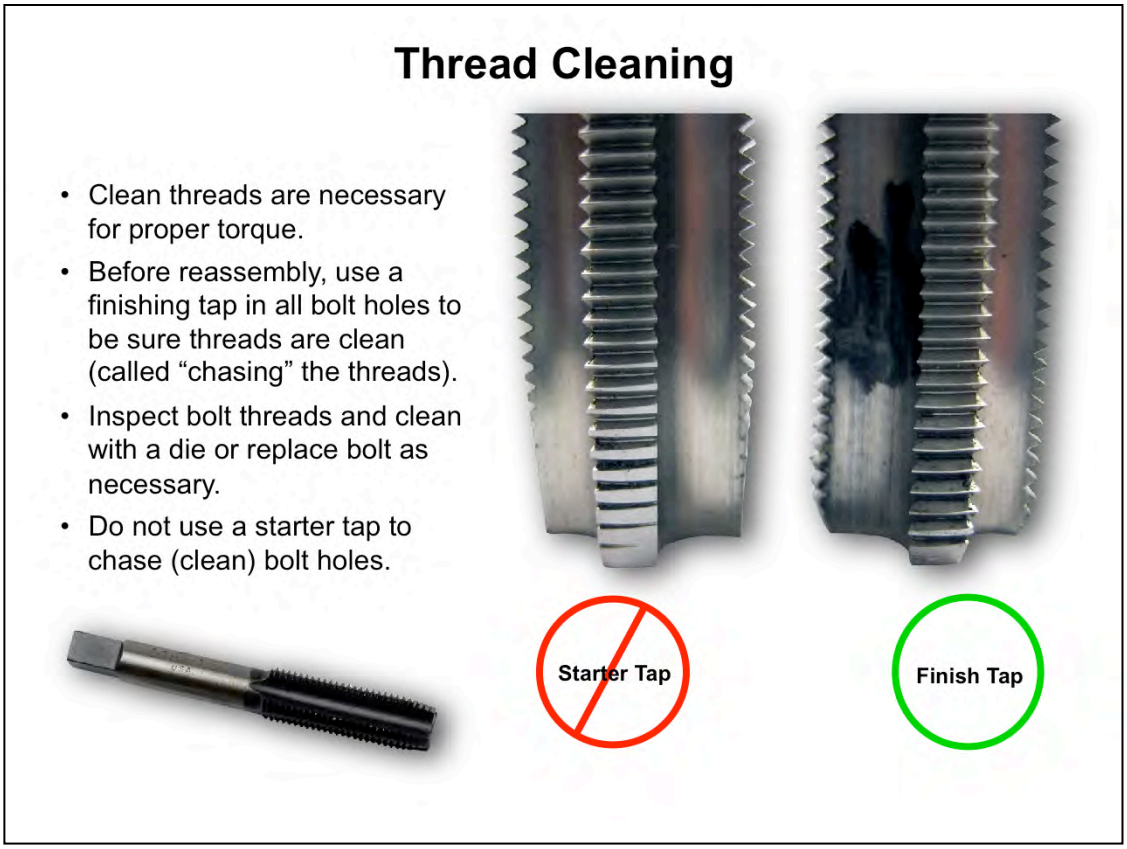


Plastigage

Plastigage provides an effective method for measuring clearances between fitted surfaces such as bearings and journals. Plastigage is ideally suited for measurements on components such as crankshaft journals because clearances can be measured without removing the component.

Plastigage is a thin plastic thread that is placed between two surfaces where clearance is to be measured. When the components are assembled and properly torqued, the plastic thread is compressed and flattened. The width of the flattened plastic is then compared to a measurement chart to determine the clearance between the two mating surfaces. Plastigage comes in different diameters suitable for different clearance ranges.

NOTE It is important to clean the bearing and journal surfaces beforehand, and to remove the Plastigage residue with a clean cloth afterward.



Thread Cleaning

Bolt threads and threads in bolt holes must be free of FIPG and oily dirt in order to achieve proper torque during reassembly.

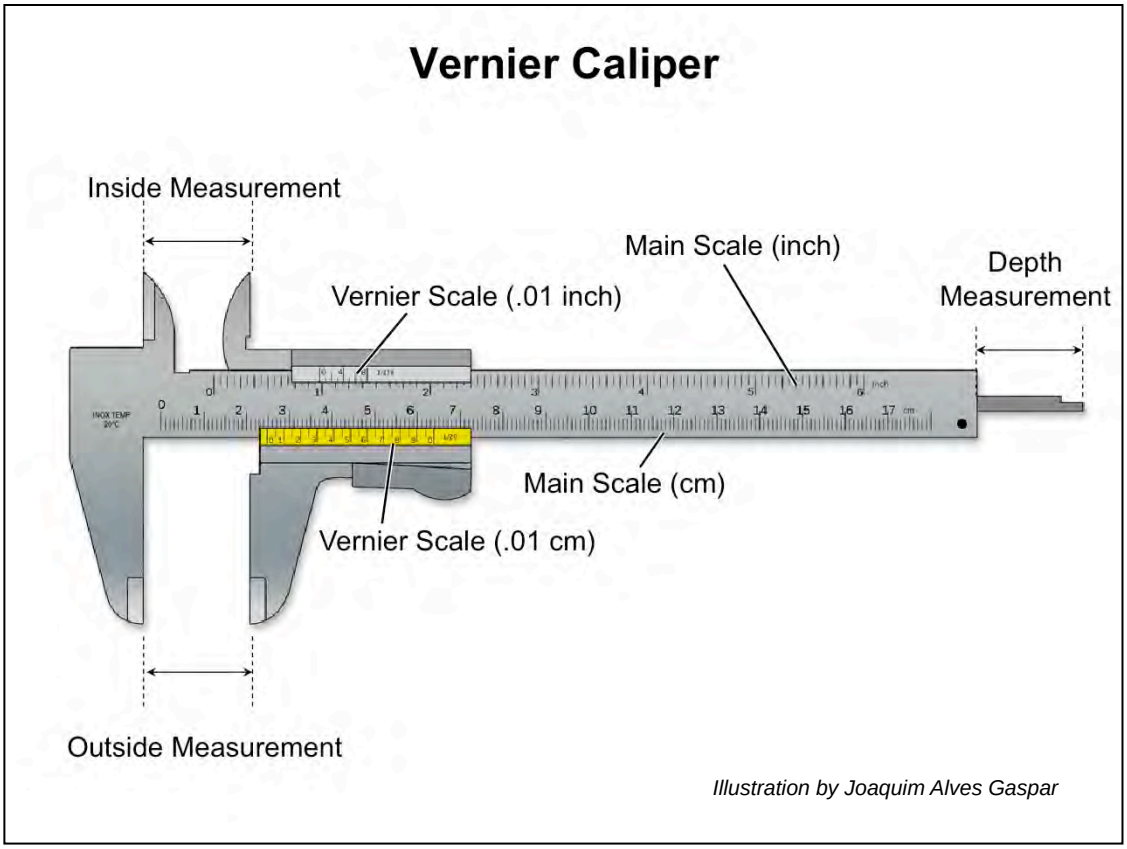
A finishing tap should be used to “chase” (clean) bolt holes. Do not confuse a finishing tap with a starter tap. A starter tap is tapered at the end to gradually begin the thread cutting in a new hole. In a blind hole that is already threaded, the tapered end will not clean the threads at the bottom of the hole.

NOTE A finishing tap may not be included in every tap and die set.

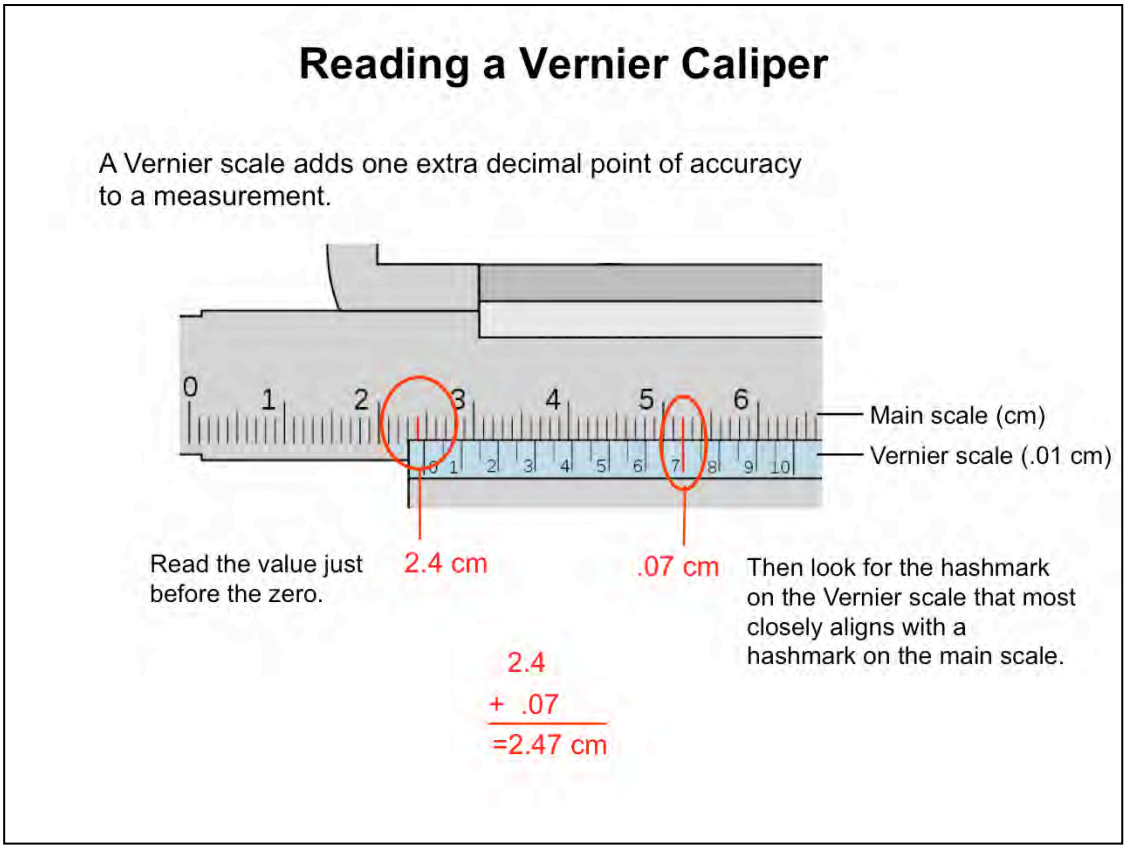
Use an appropriate size die to clean bolt threads. Inspect threads for damage and replace as necessary.

Start all bolts by hand. If the bolt gets too tight to turn by hand, stop. Remove the bolt and inspect it, and chase the bolt hole.

Be careful that there is no coolant or oil in a blind bolt hole. When the bolt reaches the uncompressible liquid, it cannot be tightened any further.



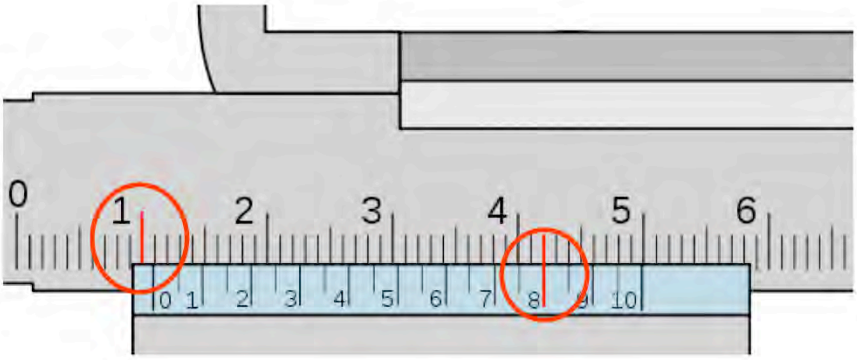
Vernier Caliper The caliper, in this case a Vernier caliper, is a versatile measuring tool that can be used for making inside, outside, and even depth measurements. The Vernier caliper is different from traditional calipers because of the addition of the Vernier scale. The Vernier scale allows for an additional decimal point of accuracy.



Reading a Vernier Caliper To read the Vernier scale, find a hash mark on the Vernier scale that aligns perfectly with any hash mark on the main scale. Then read the value from the Vernier scale associated with that hash mark.

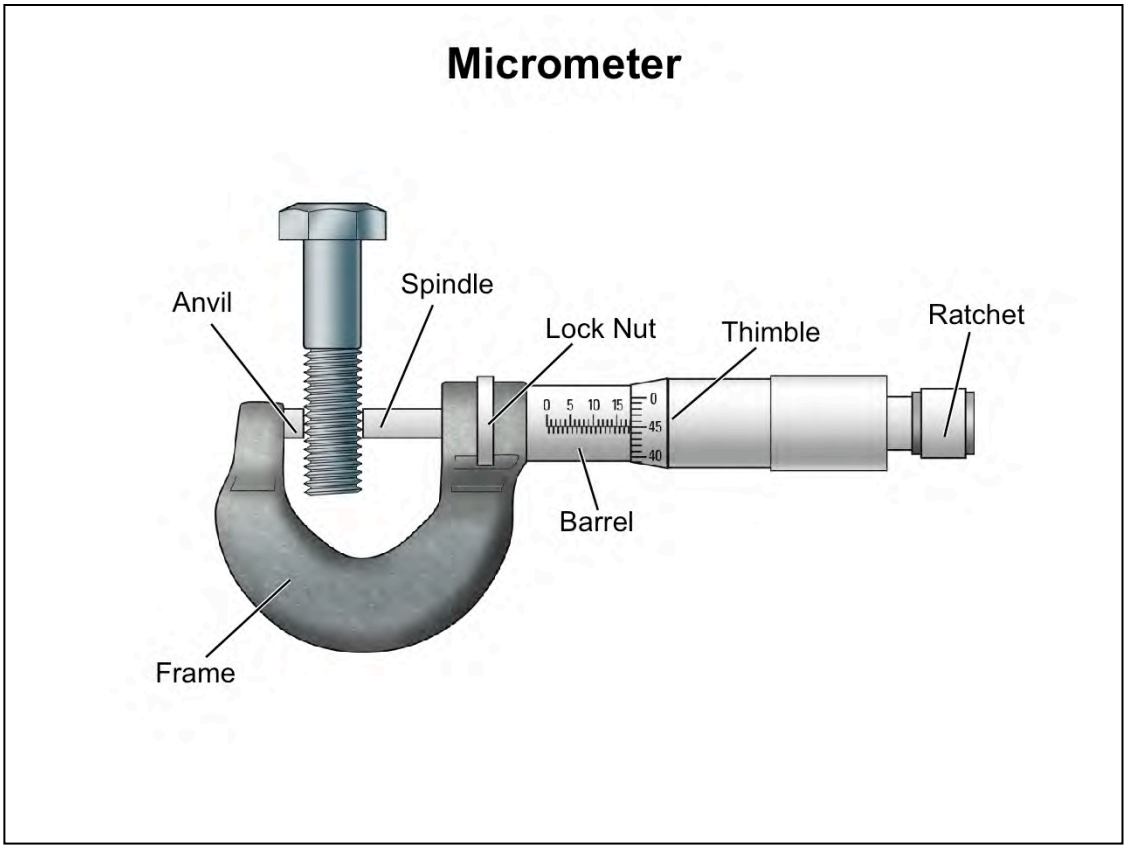
Reading a Vernier Caliper

What is the reading on this caliper?

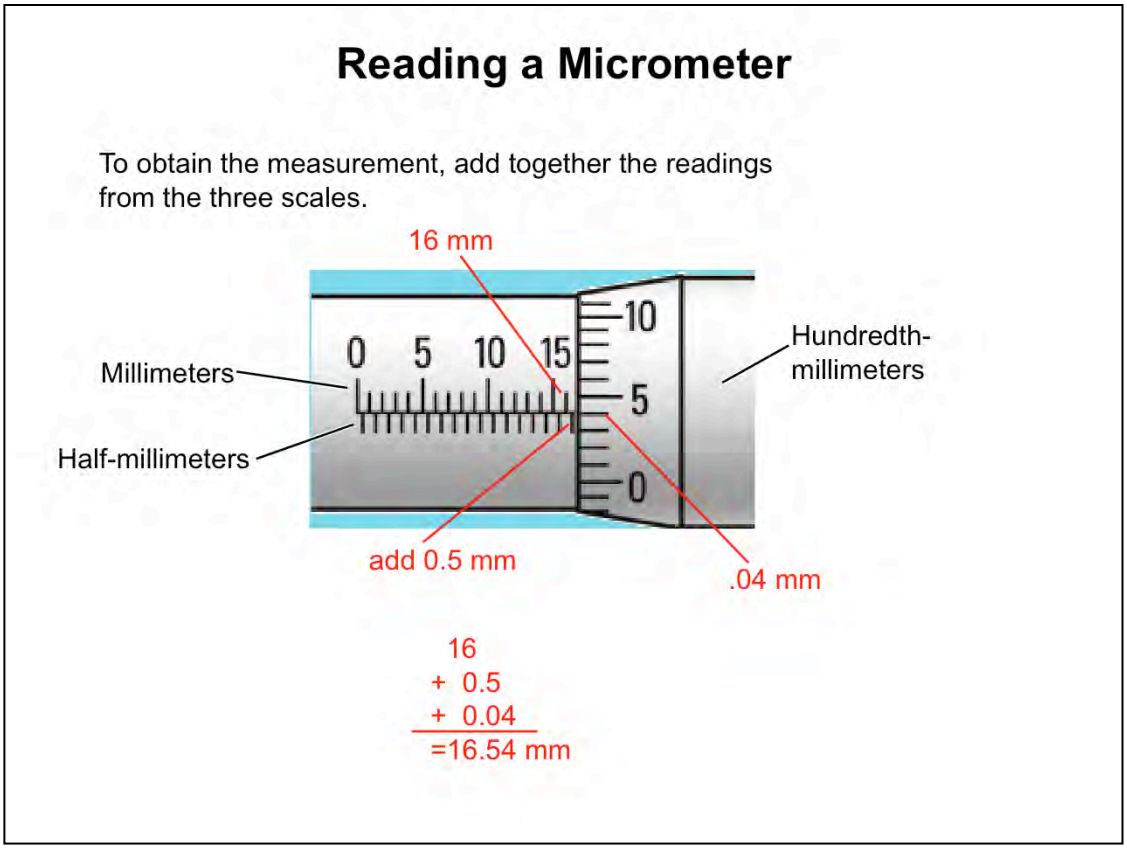


1.0
+ .08
=1.08 cm

NOTES:



Micrometer The micrometer is used exclusively for outside diameter measurements. Micrometers come in ranges of measurement diameters. It is important to select a micrometer with the correct measurement range for the component being measured.



Reading a Micrometer

The micrometer is fairly easy to read. First, note the largest value visible on the millimeter scale. In the example above, the reading is 16 mm.

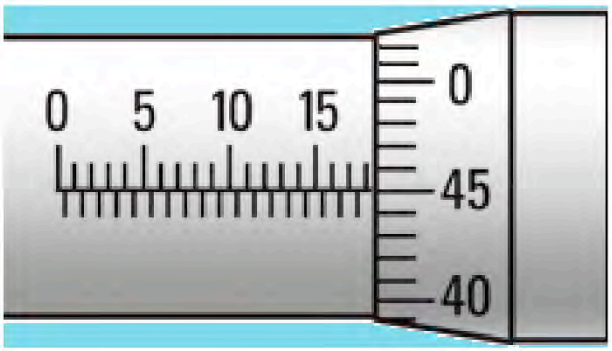
Next note if there is a half-millimeter mark displayed. In the example above, there is a half-millimeter mark showing, so we add 0.5 mm to the measurement.

Finally, we take the reading on the thimble that aligns most closely with the millimeter scale, in this case 0.04mm.

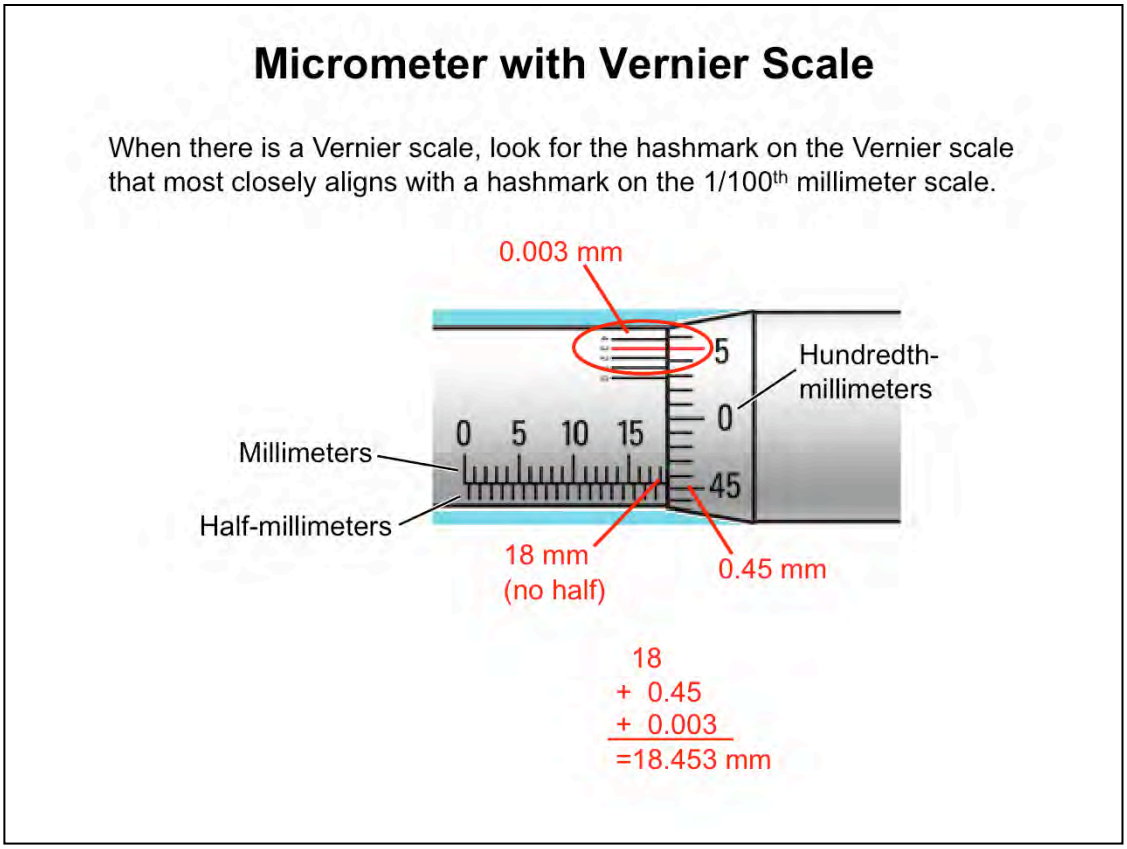
Adding all the readings together we obtain a measurement of 16.54 mm.

Reading a Micrometer

What is the reading on this micrometer?



NOTES:

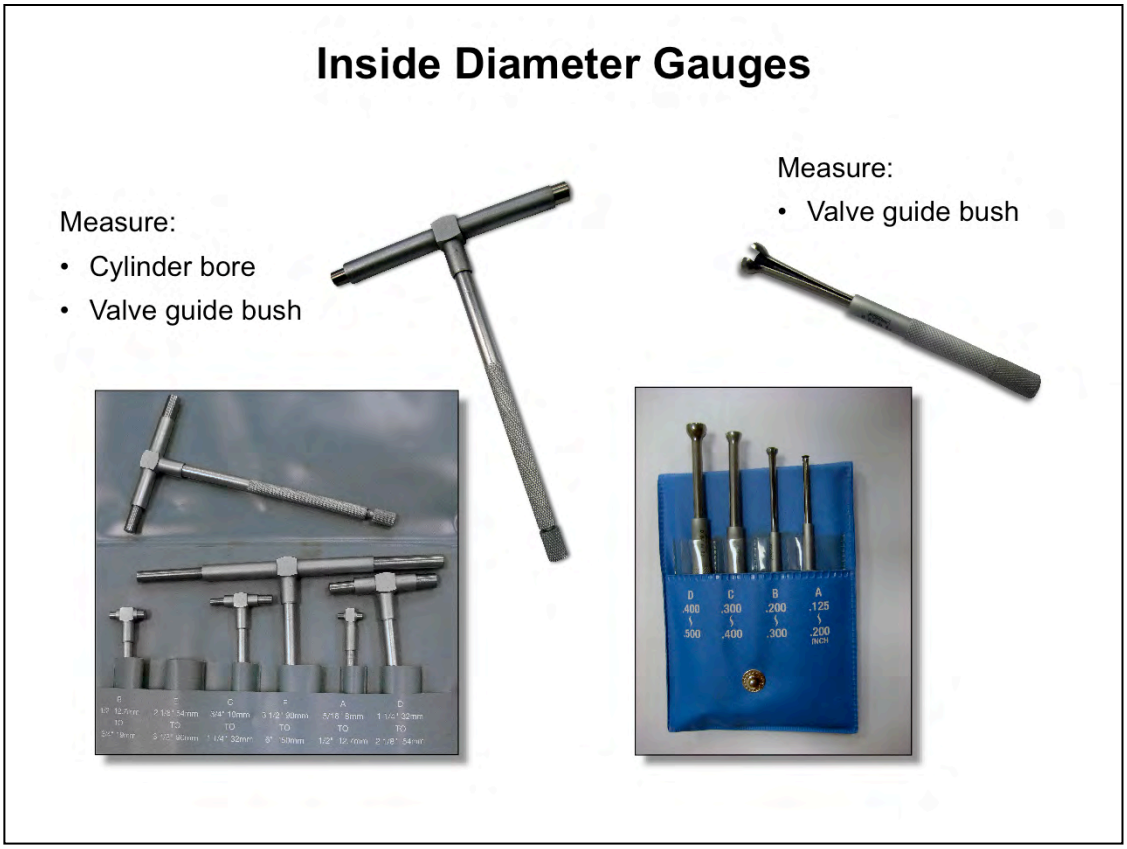


Micrometer with Vernier Scale

As with the calipers, micrometers often come equipped with a Vernier scale. The Vernier scale allows us to obtain an extra decimal place of accuracy on our measurements.

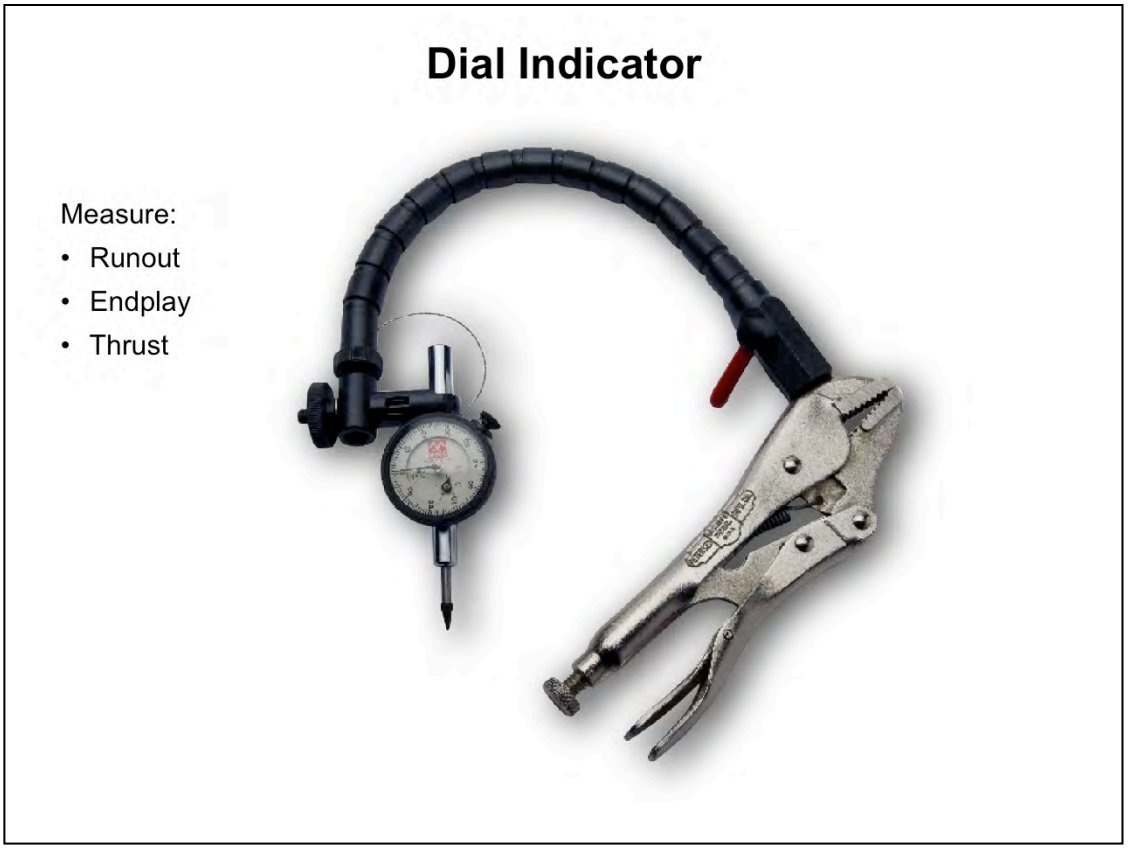
When there is a Vernier scale, look for the hashmark on the Vernier scale that most closely aligns with a hashmark on the 1/100th millimeter scale.

Digital Micrometer Some technicians prefer the speed and simplicity of a digital micrometer.



Inside Diameter Gauges

Inside diameter gauges come in a variety of different configurations and designs to fit a variety of applications. Typically, the inside diameter gauge is inserted and expanded to the dimension to be measured, and then locked in place. It is then removed and measured with a micrometer to obtain the actual measurement.



Dial Indicator

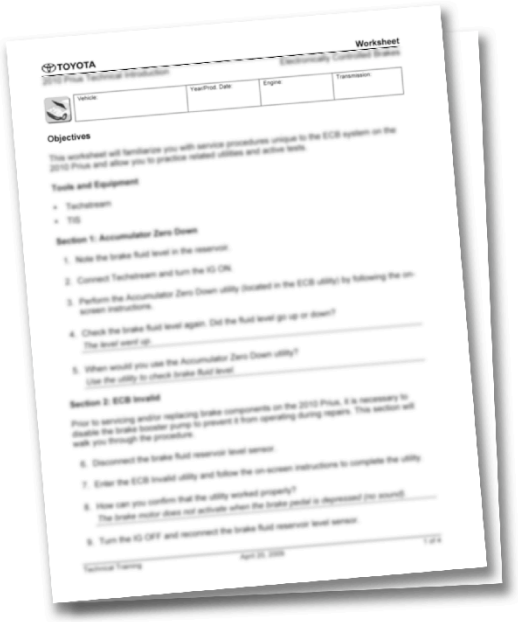
Dial indicators use a spring loaded pin to translate up and down movement into an incremental measurement. Dial indicators are extremely useful for measurements of surface variation such as run-out or allowable movement between components such as endplay.

Typically, dial indicators need to be firmly mounted to a fixed surface or component. This is accomplished by either a magnetic base or, as shown in the image above, a pair of vise grip pliers.

Worksheet

Using a Micrometer

In this worksheet you will practice making measurements using a micrometer.


TOYOTA

Worksheet

Vehicle | Year/Prod. Date | Engine | Transmission

Objectives

Tools and Equipment

- Techstream
- TIS

Section 1: Accumulator Zero Down

1. Note the brake fluid level in the reservoir.
2. Connect Techstream and turn the IG ON.
3. Perform the Accumulator Zero Down utility (located in the ECB utility) by following the on-screen instructions.
4. Check the brake fluid level again. Did the fluid level go up or down?
   The level went up.
5. When would you use the Accumulator Zero Down utility?
   Use the utility to check brake fluid level.

Section 2: ECB Invalid

Prior to servicing and/or replacing brake components on the 2010 Prius, it is necessary to disable the brake booster pump to prevent it from operating during repairs. This section will walk you through the procedure.

6. Disconnect the brake fluid reservoir level sensor.
7. Enter the ECB invalid utility and follow the on-screen instructions to complete the utility.
8. How can you confirm that the utility worked properly?
   The brake motor does not activate when the brake pedal is depressed (no sound).
9. Turn the IG OFF and reconnect the brake fluid reservoir level sensor.

Technical Training April 20, 2009 1 of 4

Use this space to write any questions you may have for your instructor.

NOTES:

Section 4 Topics

Engine Removal and Disassembly

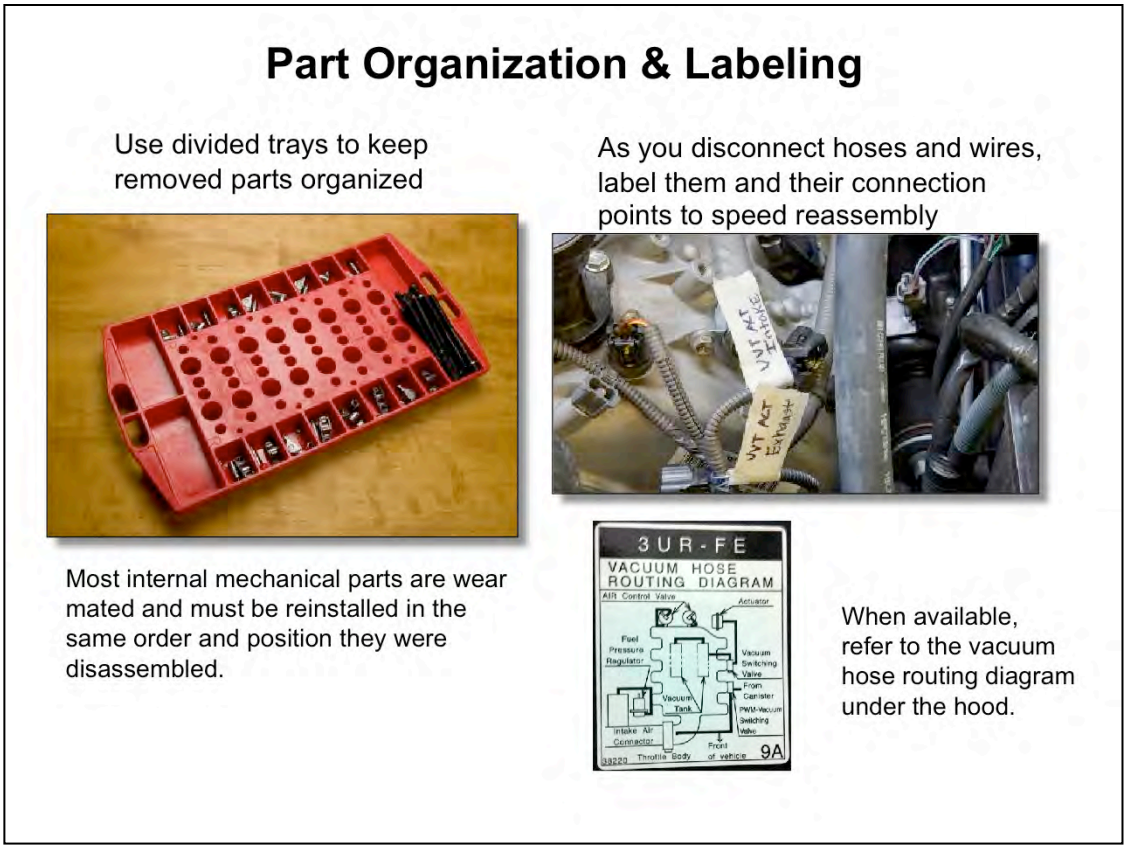
- Engine Removal Precautions
- Part Organization & Labeling
- Fuel Pressure Discharge
- Fluid Drain
- Hood Removal
- Engine Removal
- Engine Stand Mounting
- Disassembly
  - Engine Disassembly Worksheet

Engine Removal Precautions

General Precautions

- Work in a well ventilated area
- Wear safety glasses
- Avoid sparks or open flame around fuel lines
- Do not disconnect refrigerant lines unless you are certified to service A/C systems
- Protect fenders, grille, and windshield
- Always disconnect the negative battery terminal

NOTES:



Parts Organization and Labeling

Keeping parts organized is especially important because rocker arms, valve springs and other valve components must be reinstalled in their original locations.

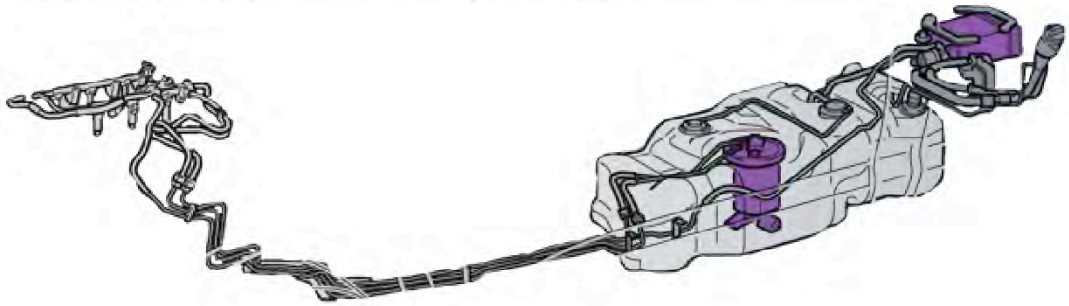
- Rolls of numbered tape can be used to mark hoses or wires and their connection points.
- Have a marking pen handy for marking components.
  - For alignment
  - For marking bolt holes for different size bolts
- Use plastic sandwich bags to keep small components together.
- Masking tape can also be used to label components.
- When removing accessory brackets, label them or attach them to the accessory, and mark their location on the engine block.

Fuel Pressure Discharge

Overview

- Disable fuel pump according to RM instructions.
- Start engine and let it run until it stops.
- Crank engine to verify it will not start.
- Remove cap from gas tank to discharge air from tank.

Note: This is a generic description. Always follow the specific instructions in the Repair Manual for the vehicle you're servicing.



Fuel Pressure Discharge

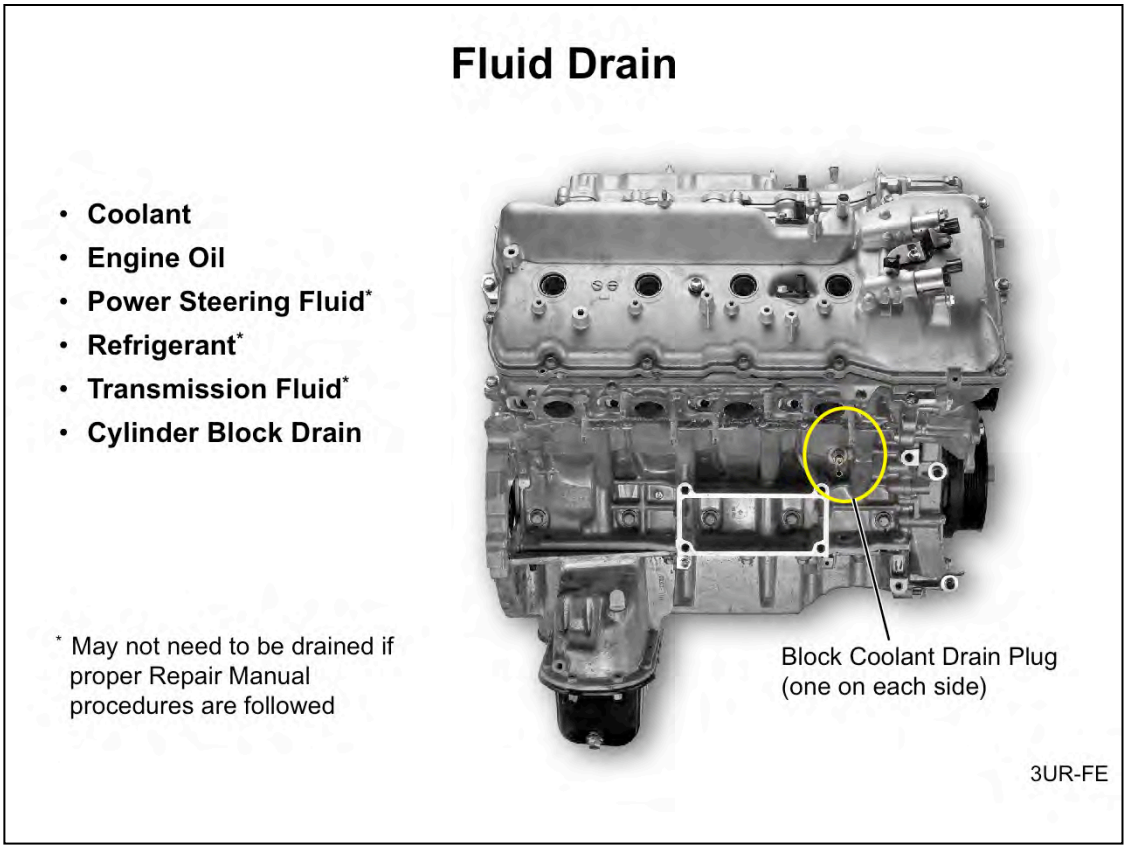
Be sure to plug all fuel lines to keep dirt and contaminants from entering the fuel system. Remove the gas cap to depressurize the fuel tank.

CAUTION

Do not disconnect any part of the fuel system until you have discharged the fuel system pressure.

Some pressure may remain in the fuel line after this procedure. To reduce the risk of fuel spray when disconnecting the fuel line, place a cloth or equivalent over fittings before loosening.

Some fuel lines are rubber coated plastic and cannot be crimped without damaging the fuel line.



Fluid Drain

Coolant

- Drain coolant from radiator
- If block has a coolant drain plug, drain coolant from block
- Dispose of coolant properly

Engine Oil

- Drain engine oil
- Remove oil filter

Power Steering Fluid

Power steering fluid does not need to be drained if the engine can be removed without disconnecting hoses from the power steering pump.

A/C Refrigerant

In many cases, A/C refrigerant does not need to be drained if the engine can be removed without disconnecting hoses from the compressor.

CAUTION

Refrigerant lines are under pressure and refrigerant can cause serious bodily injury. Lethal gas (phosgene) can result if refrigerant is discharged onto hot components. Refrigerant must be recovered and recycled by a technician certified to operate approved refrigerant recovery equipment.

Transmission Fluid

In most cases, some transmission fluid may be spilled during engine removal, but draining the transmission is not necessary. If the engine has a transmission cooler, however, the lines from the transmission to the cooler must be plugged after they are removed.

Hood Removal

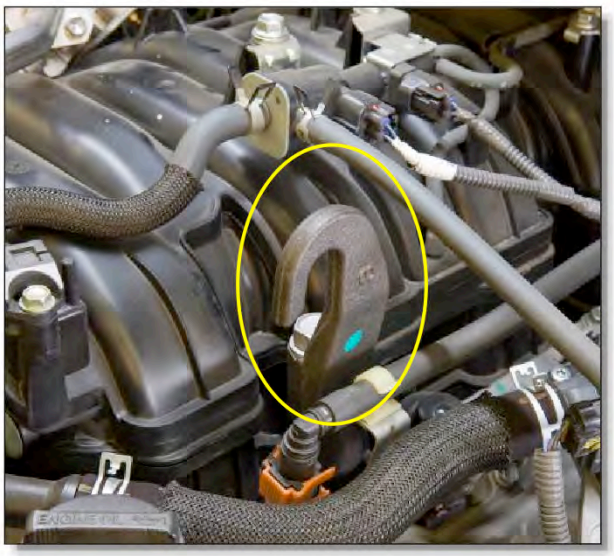
- Mark the hood hinge to the hood so it can be reinstalled properly.
- To avoid damage, do not store the hood on its corners or on edge. Lay hood flat on a protective surface.

Hood Removal During engine removal it might be necessary to remove the hood to allow maximum access to the engine compartment. Extreme caution should be taken when removing the hood to not damage the windshield or exterior paint. The hood should be stored flat and away from the work area.

Engine Hangers

Some engines have built-in lifting brackets, but most require installing special engine hangers.

Part No.: 12281-38150 (hook)
90119-A0166 (bolt)



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Engine Hangers Though some engines have built-in lifting brackets, most require installing special engine hangers.

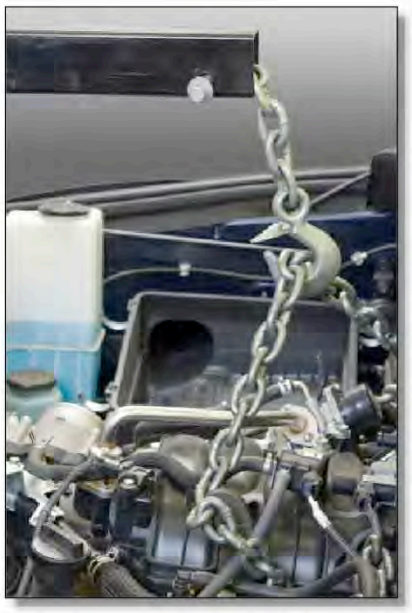
- Engine hangers and bolts are **separate parts** installed when the engine needs to be removed.
- Engine hangers are **specific to each engine** model. Use only the correct parts for the engine you're servicing.

NOTE The engine removal procedure in the Repair Manual typically specifies the part numbers for engine hangers and bolts when needed.

Engine Lifting

- Verify hoist and chains are rated for engine weight
- Engine hanger bolts must be fully tightened
- Properly support the transmission if left in vehicle
- Be sure fender and grille are protected
- Keep engine as level as possible while lifting

Note: Some front-wheel drive models may require placing the vehicle on a lift and lowering the engine through the bottom.



What's wrong with this picture?

Engine Lifting

Before attempting to lift the engine:

- Be certain that all relevant components have been disconnected according to Repair Manual procedures.
- Properly support the transmission if it is left in the vehicle.
- Verify that the hoist and chains you are using are rated for the engine weight.
- Check that the engine hangers are installed securely.
- Ensure that the fenders and grille are protected.
- Check that the engine hoist is stable

When lifting the engine:

- Keep it as level as possible while lifting.
- Lower the engine immediately after it is clear of the vehicle.

NOTE Do not attempt to lift the engine by bolting the chains directly to the block without the proper hangers. The chains can possibly crack the intake manifold.

Engine Stand Mounting

- Attach the engine stand adapter to the engine while the engine is on the hoist
- When the engine and adapter is secured to the engine stand, the hoist can be disconnected and stowed

Installing Engine Stand Adapter

Mating Adapter to Stand

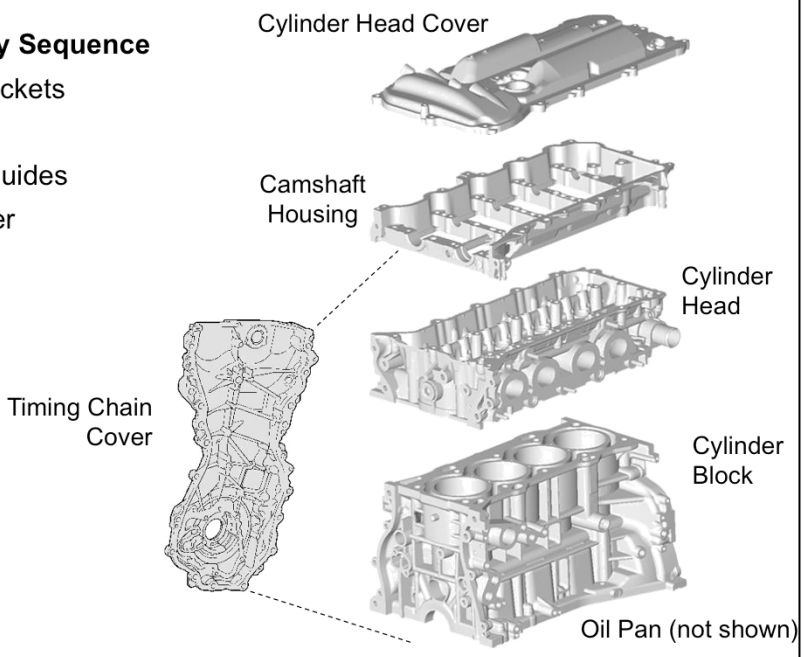
Engine Stand Mounting

When connecting the engine stand adapter to the engine, try to center the point of rotation with the engine's center of gravity. If too much weight is above or below the engine stand's rotation point, the engine will want to rotate so that the excess weight is at the bottom. This can make the engine difficult to rotate the other way or cause unexpected and unwanted rotation.

Disassembly

Typical Disassembly Sequence

- Water pump & brackets
- Timing chain cover
- Timing chain and guides
- Cylinder head cover
- Camshaft housing
- Cylinder head
- Oil pan



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NOTES:

Worksheet

Engine Unit Disassembly

Using this worksheet, you will follow Repair Manual procedures to disassemble an engine unit.

Please note the following symbols you will encounter in this and other worksheets:

SKIP = *Read the procedure but DO NOT perform it.*

STOP = *STOP until you have checked with your instructor.*

Use this space to write any questions you may have for your instructor.

NOTES:

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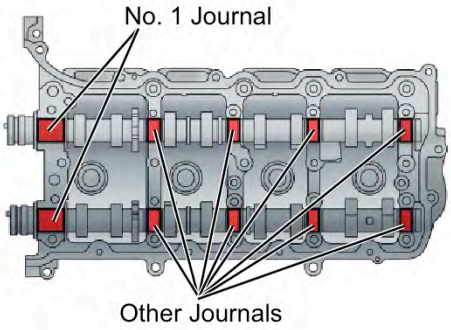
Section 5 Topics

Cylinder Head Diagnosis and Repair

- Camshaft Inspection
- Valve, Guide, and Spring Inspection
- Warpage Inspection
- Crack Inspection
- Head Bolt Inspection
- Timing Chain Inspection
- Hydraulic Valve Lash Adjusters
- Mechanical Valve Lash Adjustment
  - Cylinder Head Disassembly Worksheet
  - Valve Lash Adjustment Worksheet

Camshaft Oil Clearance

- Apply Plastigage® on all journals
- Install bearing caps following the proper torque sequence
- Remove bearing caps and measure oil clearance



- If oil clearance exceeds specifications, replace parts as needed

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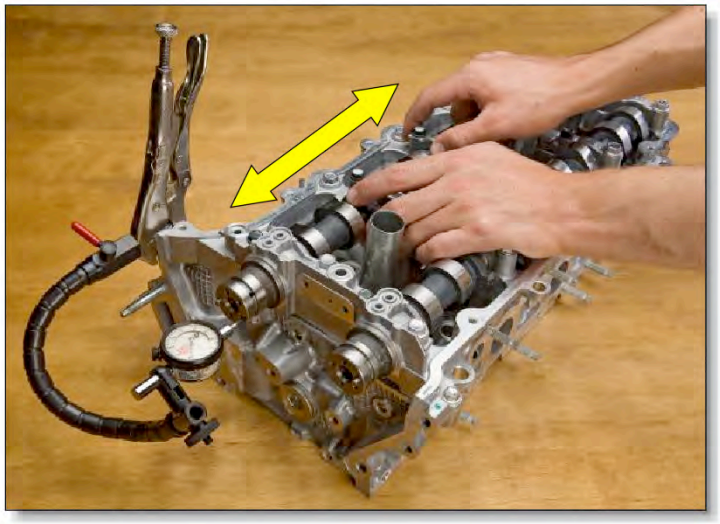
Camshaft Oil Clearance

Always inspect camshaft journals for visual wear or damage. If there are no visual indications of wear, inspect the camshaft oil clearance with Plastigage. Be sure to properly clean the oil clearance surfaces and use the proper torque sequence. Do not to rotate the camshafts during this inspection.

Camshaft Thrust Clearance

With bearing caps properly torqued, measure thrust clearance with a dial gauge.



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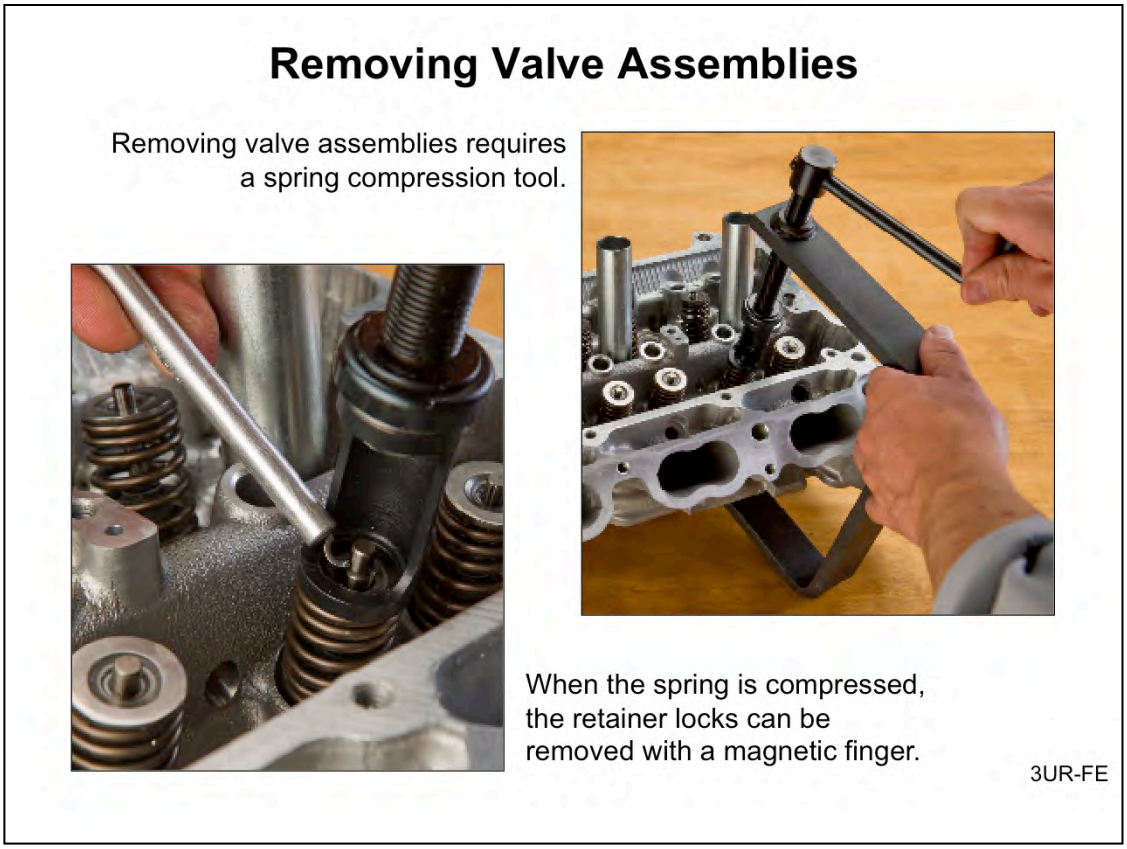
Camshaft Thrust Clearance

The camshaft thrust clearance ensures the camshaft journals and lobes are properly aligned. Excessive clearance may cause noise or premature wear to other valvetrain components.

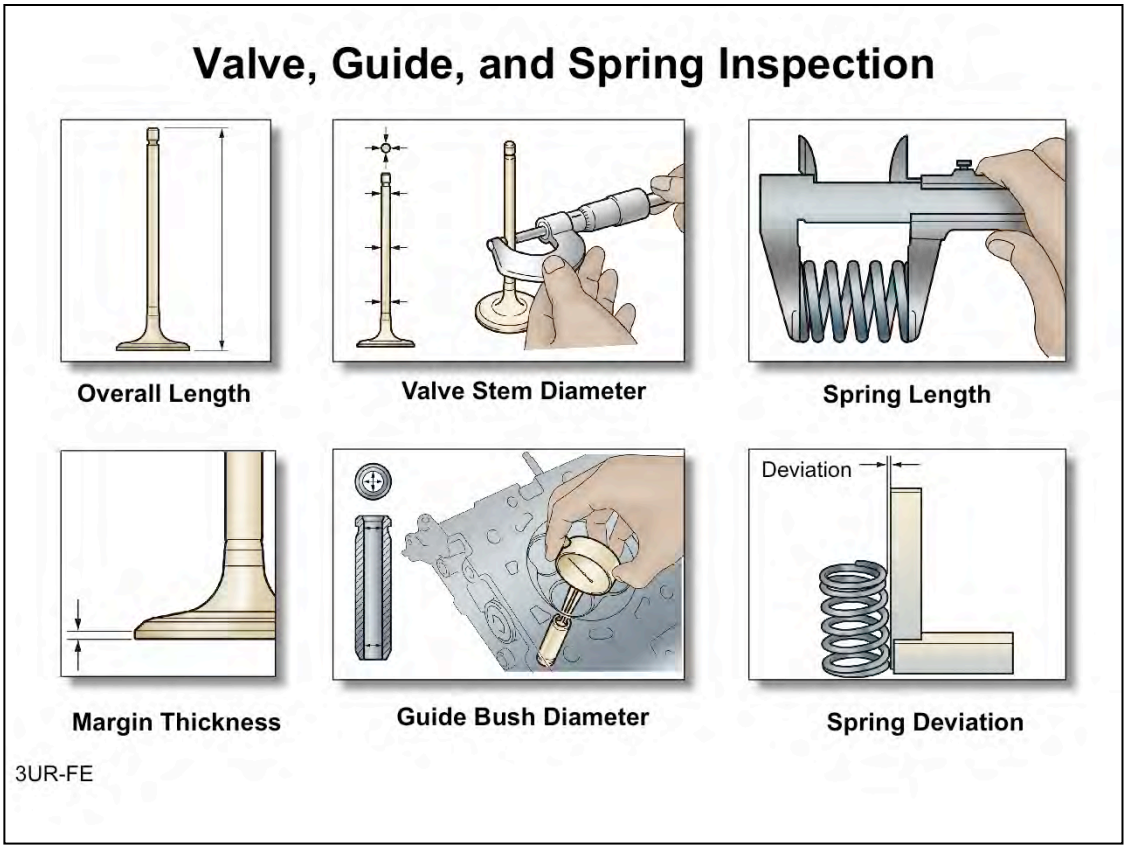


Removing Valve Assemblies

Removing valve assemblies requires a spring compression tool. The tools pictured above are SST 09202-70020 (the part with the crank) and SST 09202-00010 (the adapter that fits over the spring). Note that different engines may require different adapter SSTs.

Other types of spring compression tools are commercially available.

When the spring is compressed, the retainer locks can be removed with a magnetic finger. After removing the retainer locks, the valve and spring can be removed for inspection.



Valve, Guide, and Spring Inspection

Overall Length:

The overall length is crucial for proper valve opening. Excessively long or short valves may cause the valve to be held open or may cause excessive noise. If a valve is too long or short, that cylinder's performance is reduced.

Valve Stem Diameter:

Valve stem diameter ensures proper clearance between the stem and the valve guide bushing and allows for proper heat transfer.

Spring Length:

Spring length or spring height ensures the spring has not deformed or lost its spring tension.

Margin Thickness:

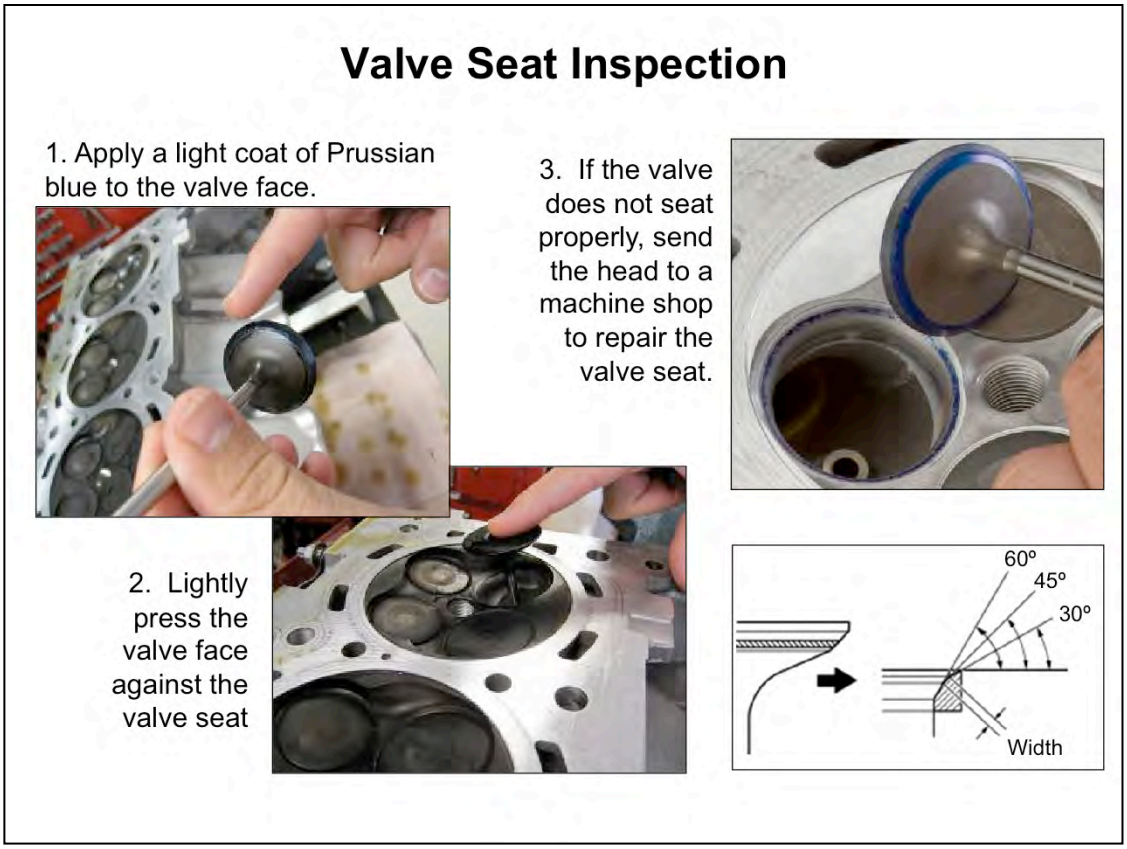
A great deal of heat is generated in the combustion chamber, and extremely hot exhaust gases pass by the exhaust valve. If the valve head thickness is not enough the exhaust valve may fail (burn) causing compression loss. The margin thickness ensures proper valve head thickness at the point where the valve seats to the cylinder head.

Guide Bushing Diameter:

The correct guide bushing diameter ensures the proper clearance between the valve stem and the guide bushing and allows for proper heat transfer.

Spring Deviation:

A spring with excessive deviation may cause uneven valve guide wear or possibly allow valve stem keepers to become dislodged.



Valve Seat Inspection

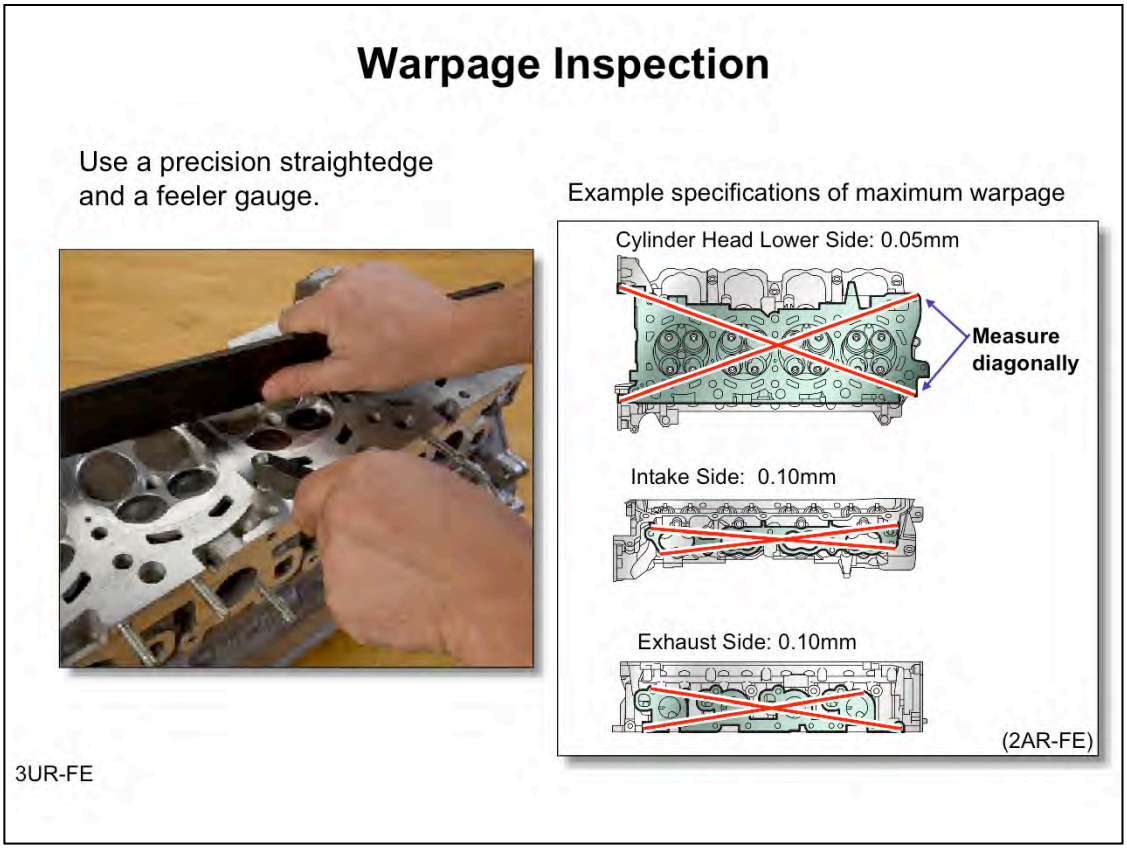
To inspect valve seats, use Prussian blue. Prussian blue is an oil paint traditionally used to identify high or low spots in machining applications.

To check valve seat fit, apply a light coat of Prussian blue to the valve face and lightly press it against the valve seat. (Do not rotate the valve while pressing.)

Carefully remove the valve and inspect the stain on the valve face and valve seat.

- The contact surfaces of the valve seat and valve face should be in the middle area of their respective surfaces, with the width as specified in the Repair Manual.
- The evidence of contact between the valve seat and valve face should be even around the entire valve seat.

If either of these conditions is not met, send the cylinder head to a machine shop to have the valve seats corrected.



Warpage Inspection

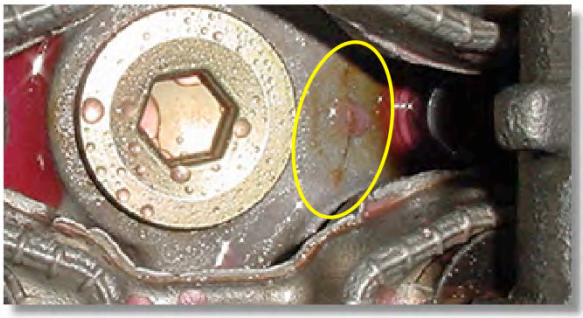
If an engine overheats or has a head gasket failure, it is extremely important to verify mating surface flatness. When engines overheat the likelihood of component warping increases. Mating surfaces in an engine must be within a certain tolerance of flatness to properly seal.

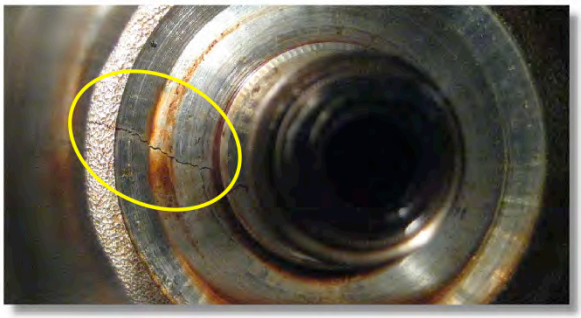
To check for warpage, thoroughly clean the cylinder head and visually inspect mating surfaces for pitting, nicks, or other imperfections. Place a long, precision straightedge along the length of the cylinder head and check the clearance between the straightedge and the cylinder head mating surface with a feeler gauge. Refer to the Repair Manual for vehicle-specific warpage tolerance.

Crack Inspection

Cracks in the cylinder head or cylinder block can result in:

- Compression loss
- Oil consumption
- Coolant loss





Crack Inspection

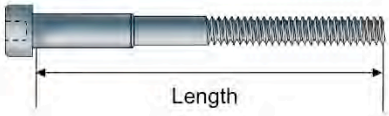
Although, cracks in the cylinder head or cylinder block are not common, an undiscovered crack can result in a misdiagnosis and a failed repair attempt. It's important to check for cracks, especially around the combustion chamber, coolant passages and oil passages.

One way to check for cracks is to use dye penetrant. This multistep application uses various dyes and chemicals to highlight trouble areas that could be otherwise hard to see. If you are not confident using this product it's advisable to send the components to a professional machine shop to have the component checked using alternative methods.

Head Bolt Inspection

Inspection for Stretching

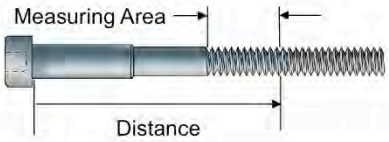
Using a vernier caliper, measure the length of the cylinder head bolt from the seat to the end.



Standard length: 141.3 to 142.7 mm
Maximum length: 143.7 mm

If the length is more than the maximum, replace the cylinder head bolt.

Using a micrometer, measure the thread diameter at the measuring area.



Distance:

- 103 mm for intake side bolt.
- 108 mm for exhaust side bolt

Standard diameter: 10.85 to 11.00 mm
Minimum diameter: 10.60 mm

If the diameter is less than the minimum, replace the cylinder head bolt.

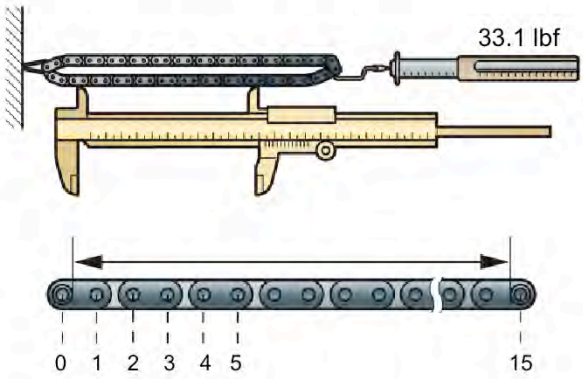
Head Bolt Inspection

When torqued properly, cylinder head bolts undergo a process called bolt stretch. This stretch provides a “spring loaded” tension against the part it’s fastening. A bolt can only be stretched so far before it runs the risk of deformation or breakage. With this in mind, it is important to inspect each head bolt or any other stretch bolt for signs of excessive stretching.

This inspection should be done by measuring the length of the bolt, and the diameter of the bolt in a prescribed area. It’s also important to visually inspect the bolt outside of the measurement area for places that may appear deformed or stretched. If a bolt does not meet specifications, replace it.

Timing Chain Inspection

Using a spring scale, pull the chain with a force of 33.1 lbf.



- Measure the length of 15 pins using a vernier caliper. Perform the measurement at 3 random places.
- Maximum chain length: 136.9 mm

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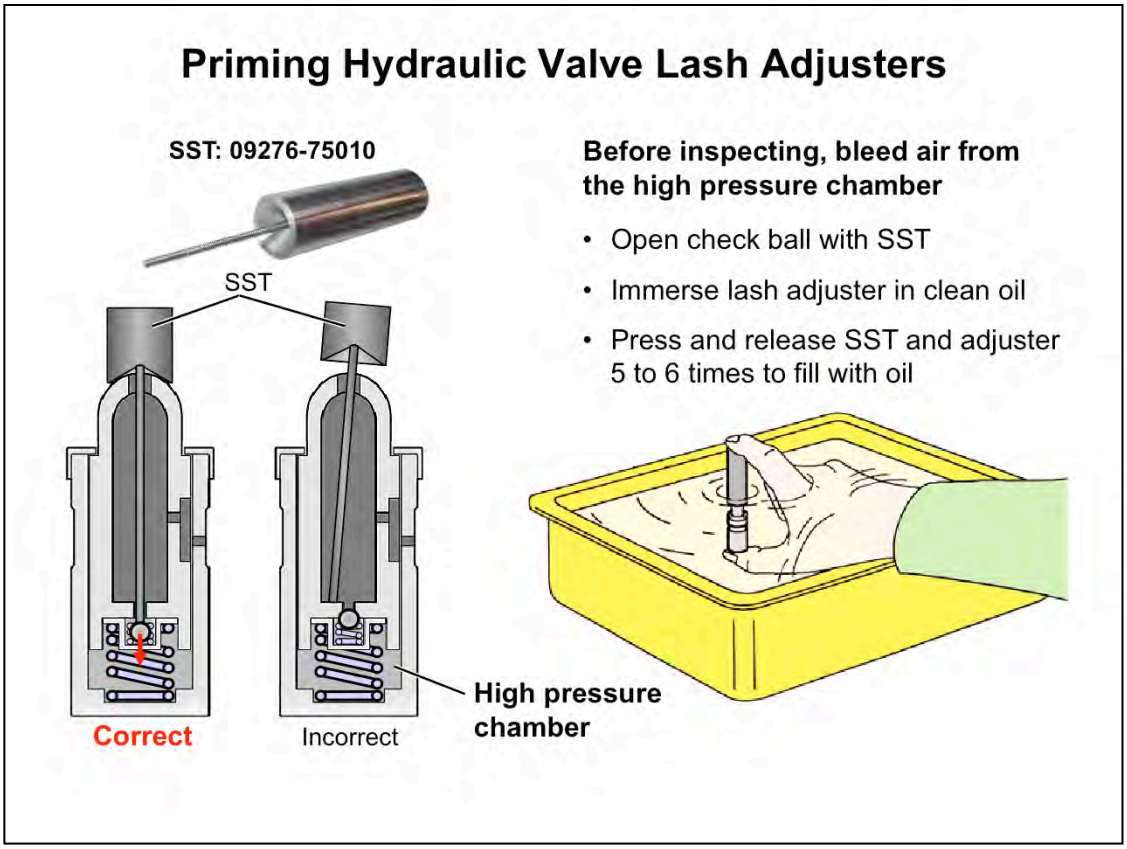
Timing Chain Inspection

Although extremely rare, it is important to inspect the timing chain for stretching. If a timing chain is stretched, various engine timing issues may occur. To inspect, use a spring scale to apply a specified tension on the chain. Then count a specified number of chain link pins and measure the length. Do this in at least three different locations around the chain.



Priming Hydraulic Valve Lash Adjusters

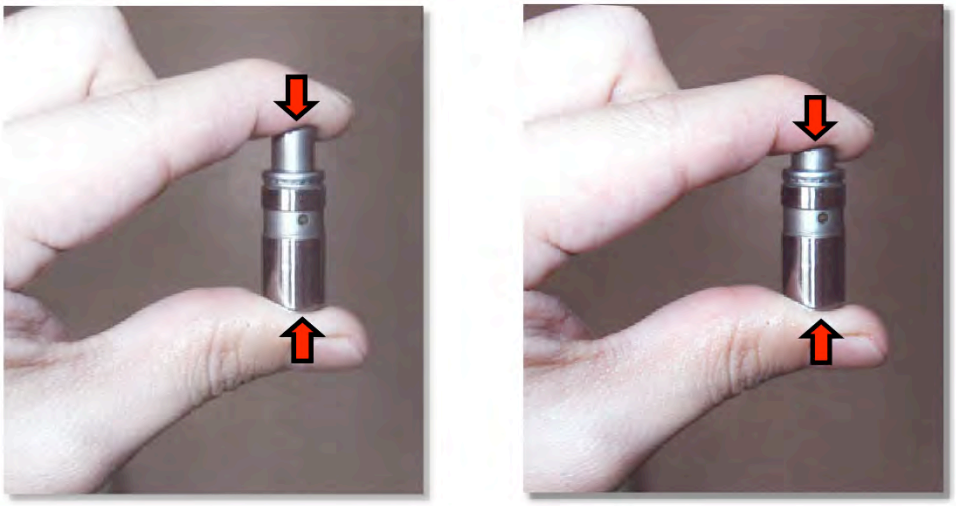
Hydraulic lash adjusters work using oil pressure. Oil pressure is feed to the high pressure chamber and sealed off by a check ball. The check ball prevents oil from leaking out of the high pressure chamber keeping the hydraulic lash adjuster primed prior to engine starting. It is important to check the operation of the lash adjusters and prime each adjuster before installation.

Use the SST to push on the check ball and immerse the lash adjuster in clean oil. Squeeze the lash adjuster several times to prime the high pressure chamber.

Hydraulic Valve Lash Adjusters Inspection

Press the plunger several times to test the operation of the check ball.

If the plunger can be compressed more than 3 times, replace the adjuster.

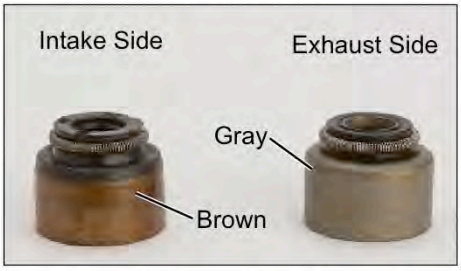


Lash Adjuster Inspection

After the lash adjuster has been properly primed, it is important to test whether or not the check ball is properly seated. Hold the adjuster as pictured and squeeze the plunger several times. If the plunger moves up and down in the bore more than three times, the check ball is defective and the lash adjuster must be replaced.

Installing Valve Spring Seats, Oil Seals

- Install the valve spring seats to the cylinder head.
- Apply a light coat of engine oil to new oil seals and push in the oil seals using SST 09201-41020



Note: Installing the intake oil seal into the exhaust side or installing the exhaust oil seal into the intake side can cause problems later.

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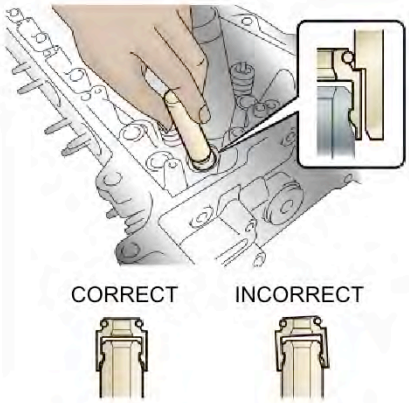
Failure to use the SST correctly will cause the seal to be damaged or improperly seated.



Oil Seals The intake and exhaust oil seals are different colors because the exhaust oil seal must withstand higher temperatures, and is therefore made of a different material. Use the applicable SST to install the seals correctly.

NOTE If oil seals are removed during disassembly, replace them; do not reuse.

Installing Valves

- Apply plenty of engine oil to the tip area of the valve stem
- Install the valve, compression spring and spring retainer to the cylinder head
- Using SST 09202-70020, compress the spring and install the retainer locks

Note: Install the same parts in the same combination to their original locations.

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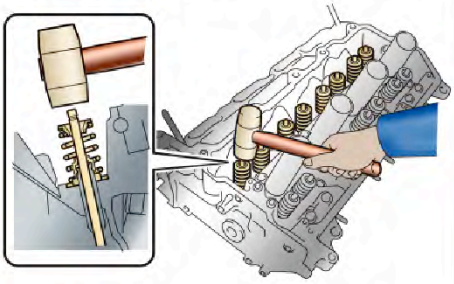
Using a plastic-faced hammer, lightly tap the valve stem tip to ensure a proper fit.



Note: Be careful not to damage the retainer.

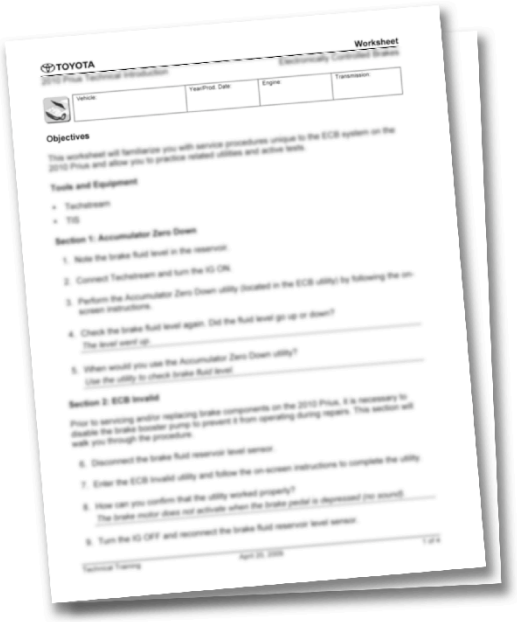
Installing Valves Make sure the work area is clean and well lit. Valve stem keepers are extremely easy to misplace or loose during installation. Take particular care during installation to properly seat each keeper before releasing the spring compressor. After installation is complete and a good visual check is made, tap each valve stem with a plastic-faced hammer to ensure valve stem keepers are properly seated.

Worksheet

Cylinder Head Disassembly and Inspection

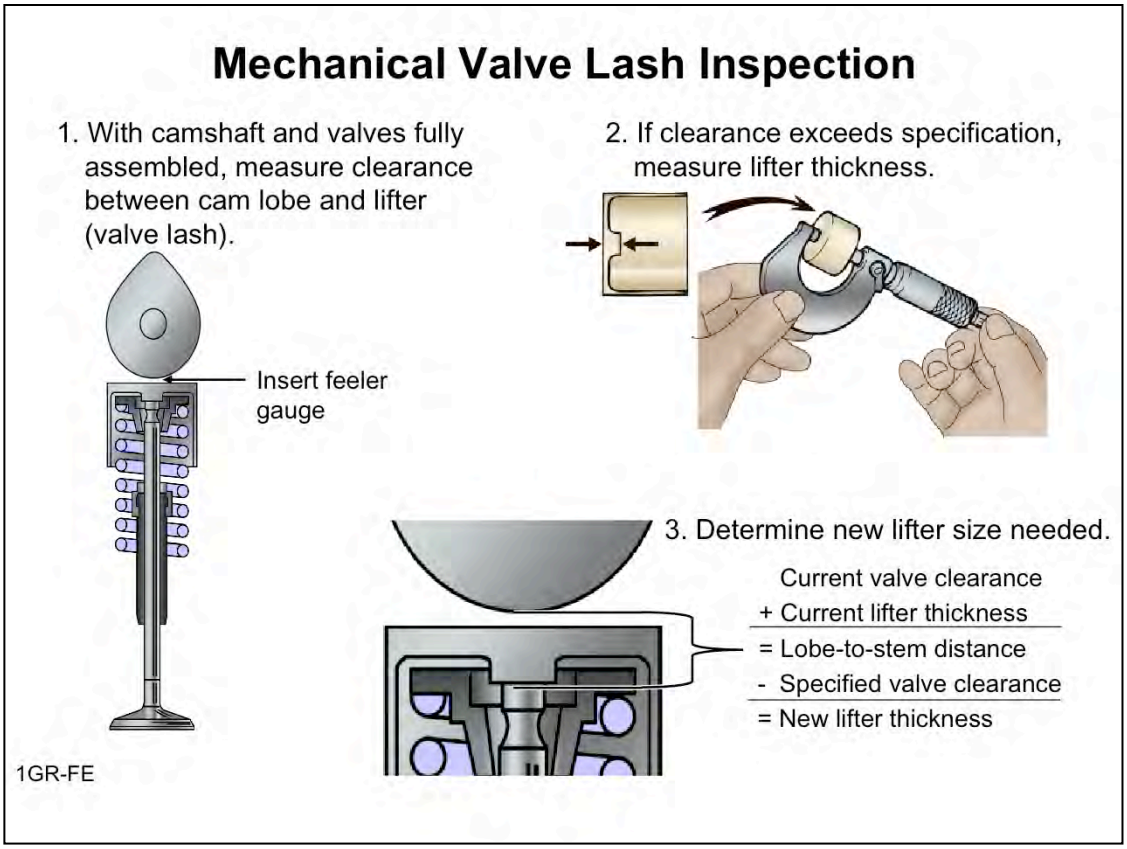
In this worksheet you will:

- Partially disassemble a cylinder head
- Perform component inspections
- Reassemble the cylinder head



Use this space to write any questions you may have for your instructor.

NOTES:



Mechanical Valve Lash Inspection

Engines with mechanical valve lash have a specified range of clearance between the heel of the cam lobe and the top of the valve. This space is necessary to provide adequate room for the components to expand during engine warm up. If the clearance is zero or less, the valve can be held open once the engine has reached operating temperature. If there is too much clearance, excessive noise will result.

To inspect mechanical valve lash, insert a feeler gauge into the space between the heel of the cam lobe and the valve. If the clearance is out of the specified range for that vehicle, then adjustment is necessary.

Valve Lash Adjustment

In some vehicles, valve lash is adjusted by replacing the lifter with another one of a specified thickness. The correct thickness can be calculated or looked up in a chart from the Repair Manual.

Calculation Example

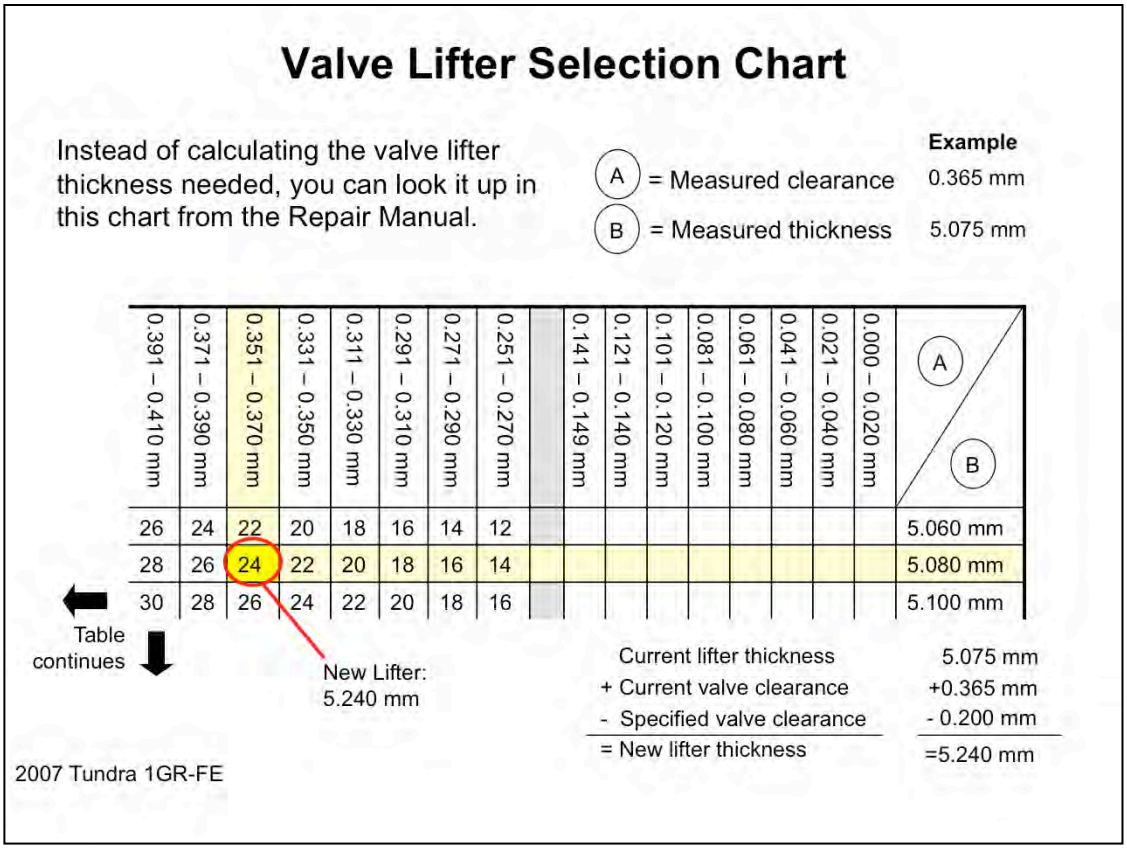
The specified valve clearance (cold) is 0.15 to 0.25 mm (0.20 mm ± 0.05).

The lifter measures 5.075 mm and the measured valve clearance is 0.365 mm. Using the formula, we can calculate the ideal replacement lifter size.

Current lifter thickness	5.075
+ Current valve clearance	+ 0.365
- Specified valve clearance	- 0.200
= New lifter thickness	5.240

If the calculation results in a size in between two available lifter (shim) sizes, select the larger of the two for longer service.

SHIM NO.	THICKNESS	SHIM NO.	THICKNESS	SHIM NO.	THICKNESS
06	5.060 mm	30	5.300 mm	54	5.540 mm
08	5.080 mm	32	5.320 mm	56	5.560 mm
10	5.100 mm	34	5.340 mm	58	5.580 mm
12	5.120 mm	36	5.360 mm	60	5.600 mm
14	5.140 mm	38	5.380 mm	62	5.620 mm
16	5.160 mm	40	5.400 mm	64	5.640 mm
18	5.180 mm	42	5.420 mm	66	5.660 mm
20	5.200 mm	44	5.440 mm	68	5.680 mm
22	5.220 mm	46	5.460 mm	70	5.700 mm
24	5.240 mm	48	5.480 mm	72	5.720 mm
26	5.260 mm	50	5.500 mm	74	5.740 mm
28	5.280 mm	52	5.520 mm	–	–



Selection Chart Example

This is an example of how to use the Valve Lifter Selection Chart from the Repair Manual. (See the complete chart on the next page.)

Using the same measurements for the lifter and valve clearance as in the previous example:

- Look in column B of the chart (right side) to find the row with the value closest to the measured lifter thickness.
- Then in row A (top of the chart) find the column that matches the measured valve clearance.
- Where the column and row meet, you will find the optimum size for the replacement lifter (No. 24, which is 5.240 mm thick).

Valve Lifter Selection Chart (Intake)

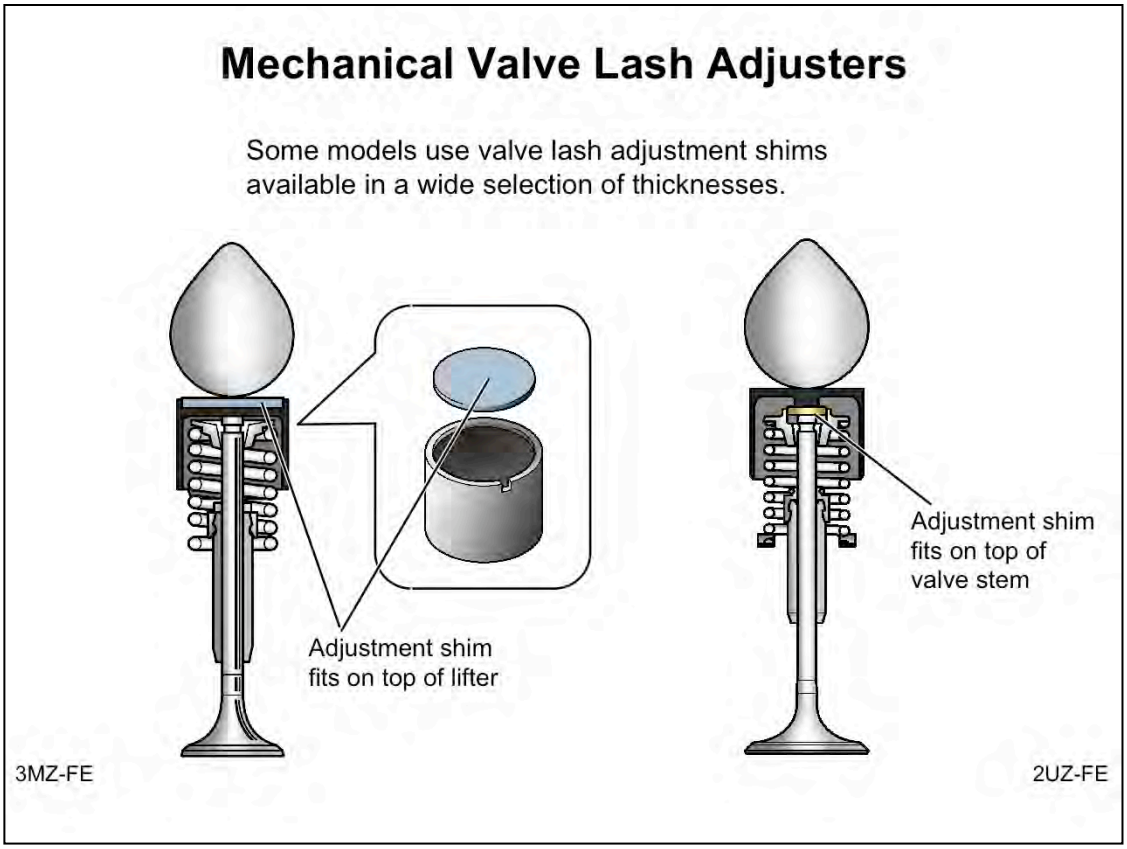
An example of how to use this chart appears on the previous page.

0.851 - 0.870 (0.0335 - 0.0343)	0.831 - 0.850 (0.0327 - 0.0335)	0.811 - 0.830 (0.0319 - 0.0327)	0.791 - 0.810 (0.0311 - 0.0319)	0.771 - 0.790 (0.0304 - 0.0311)	0.751 - 0.770 (0.0296 - 0.0303)	0.731 - 0.750 (0.0288 - 0.0295)	0.711 - 0.730 (0.0280 - 0.0287)	0.691 - 0.710 (0.0272 - 0.0280)	0.671 - 0.690 (0.0264 - 0.0272)	0.651 - 0.670 (0.0256 - 0.0264)	0.631 - 0.650 (0.0248 - 0.0256)	0.611 - 0.630 (0.0241 - 0.0248)	0.591 - 0.610 (0.0233 - 0.0240)	0.571 - 0.590 (0.0225 - 0.0232)	0.551 - 0.570 (0.0217 - 0.0224)	0.531 - 0.550 (0.0209 - 0.0217)	0.511 - 0.530 (0.0201 - 0.0209)	0.491 - 0.510 (0.0193 - 0.0201)	0.471 - 0.490 (0.0185 - 0.0193)	0.451 - 0.470 (0.0178 - 0.0185)	0.431 - 0.450 (0.0170 - 0.0177)	0.411 - 0.430 (0.0162 - 0.0169)	0.391 - 0.410 (0.0154 - 0.0161)	0.371 - 0.390 (0.0146 - 0.0154)	0.351 - 0.370 (0.0138 - 0.0146)	0.331 - 0.350 (0.0130 - 0.0138)	0.311 - 0.330 (0.0122 - 0.0130)	0.291 - 0.310 (0.0115 - 0.0122)	0.271 - 0.290 (0.0107 - 0.0114)	0.251 - 0.270 (0.00988 - 0.0106)	0.141 - 0.149 (0.00555 - 0.00587)	0.121 - 0.140 (0.00476 - 0.00551)	0.101 - 0.120 (0.00398 - 0.00472)	0.081 - 0.100 (0.00319 - 0.00394)	0.061 - 0.080 (0.00240 - 0.00315)	0.041 - 0.060 (0.00161 - 0.00236)	0.021 - 0.040 (0.000827 - 0.00157)	0.000 - 0.020 (0.0000 - 0.000787)	A / B
72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14	12									5.060 (0.1992)
	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16	14									5.080 (0.2000)
		72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	16									5.100 (0.2008)
			72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	18	06								5.120 (0.2016)
				72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	20	08	08								5.140 (0.2024)
					72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	22	10	10	08								5.160 (0.2031)
						72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	24	12	12	10	08							5.180 (0.2039)
							72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	26	14	14	12	10	08						5.200 (0.2047)
							74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	16	14	12	10	08	06					5.210 (0.2051)
								72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	28	16	16	14	12	10	08					5.220 (0.2055)
								74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	18	16	14	12	10	08	06				5.230 (0.2059)
									72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	30	18	18	16	14	12	10	08				5.240 (0.2063)
									74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	20	18	16	14	12	10	08	06			5.250 (0.2067)
										72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	32	20	20	18	16	14	12	10	08			5.260 (0.2071)
										74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	22	20	18	16	14	12	10	08			5.270 (0.2075)
											72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	34	22	22	20	18	16	14	12	10			5.280 (0.2079)
											74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	24	22	20	18	16	14	12	10			5.290 (0.2083)
												72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	36	24	24	22	20	18	16	14	12			5.300 (0.2087)
												74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	26	24	22	20	18	16	14	12			5.310 (0.2091)
													72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	38	26	26	24	22	20	18	16	14			5.320 (0.2094)
													74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	28	26	24	22	20	18	16	14			5.330 (0.2098)
														72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	40	28	28	26	24	22	20	18	16			5.340 (0.2102)
														74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	30	28	26	24	22	20	18	16			5.350 (0.2106)
															72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	42	30	30	28	26	24	22	20	18			5.360 (0.2110)
															74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	32	30	28	26	24	22	20	18			5.370 (0.2114)
																72	70	68	66	64	62	60	58	56	54	52	50	48	46	44	32	32	30	28	26	24	22	20			5.380 (0.2118)
																74	72	70	68	66	64	62	60	58	56	54	52	50	48	46	34	32	30	28	26	24	22	20			5.390 (0.2122)
																	72	70	68	66	64	62	60	58	56	54	52	50	48	46	34	34	32	30	28	26	24	22			5.400 (0.2126)
																	74	72	70	68	66	64	62	60	58	56	54	52	50	48	36	34	32	30	28	26	24	22			5.410 (0.2130)
																		72	70	68	66	64	62	60	58	56	54	52	50	48	36	36	34	32	30	28	26	24			5.420 (0.2134)
																		74	72	70	68	66	64	62	60	58	56	54	52	50	38	36	34	32	30	28	26	24			5.430 (0.2138)
																			72	70	68	66	64	62	60	58	56	54	52	50	38	38	36	34	32	30	28	26			5.440 (0.2142)
																			74	72	70	68	66	64	62	60	58	56	54	52	40	38	36	34	32	30	28	26			5.450 (0.2146)
																				72	70	68	66	64	62	60	58	56	54	52	40	40	38	36	34	32	30	28			5.460 (0.2150)
																				74	72	70	68	66	64	62	60	58	56	54	42	40	38	36	34	32	30	28			5.470 (0.2154)
																					72	70	68	66	64	62	60	58	56	54	42	42	40	38	36	34	32	30			5.480 (0.2157)
																					74	72	70	68	66	64	62	60	58	56	44	42	40	38	36	34	32	30			5.490 (0.2161)
																						72	70	68	66	64	62	60	58	56	44	44	42	40	38	36	34	32			5.500 (0.2165)
																						74	72	70	68	66	64	62	60	58	46	46	42	40	38	36	34	32			5.510 (0.2169)
																							72	70	68	66	64	62	60	58	46	46	44	42	40	38	36	34			5.520 (0.2173)
																							74	72	70	68	66	64	62	60	48	46	44	42	40	38	36	34			5.530 (0.2177)
																								72	70	68	66	64	62	60	48	48	46	44	42	40	38	36			5.540 (0.2181)
																								74	72	70	68	66	64	62	50	48	46	44	42	40	38	36			5.550 (0.2185)
																									72	70	68	66	64	62	50	50	48	46	44	42	40	38			5.560 (0.2189)
																									74	72	70	68	66	64	52	50	48	46	44	42	40	38			5.570 (0.2193)
																										72	70	68	66	64	52	52	50	48	46	44	42	40			5.580 (0.2197)
																										74	72	70	68	66	54	52	50	48	46	44	42	40			5.590 (0.2201)
																											72	70	68	66	54	54	52	50	48	46	44	42			5.600 (0.2205)
																												72	70	68	56	56	54	52	50	48	46	44			5.620 (0.2213)
																													72	70	58	58	56	54	52	50	48	46			5.640 (0.2220)
																														72	60	60	58	56	54	52	50	48			5.660 (0.2228)
																															62	62	60	58	56	54	52	50			5.680 (0.2236)
																															64	64	62	60	58	56	54	52			5.700 (0.2244)
																															66	66	64	62	60	58	56	54			5.720 (0.2252)
																															68	68	66	64	62	60	58	56			5.740 (0.2260)

Ⓐ Measured clearance mm (in.)

Ⓑ Removed lifter thickness mm (in.)

2007 Tundra, 1GR-FE



Mechanical Valve Lash Adjusters

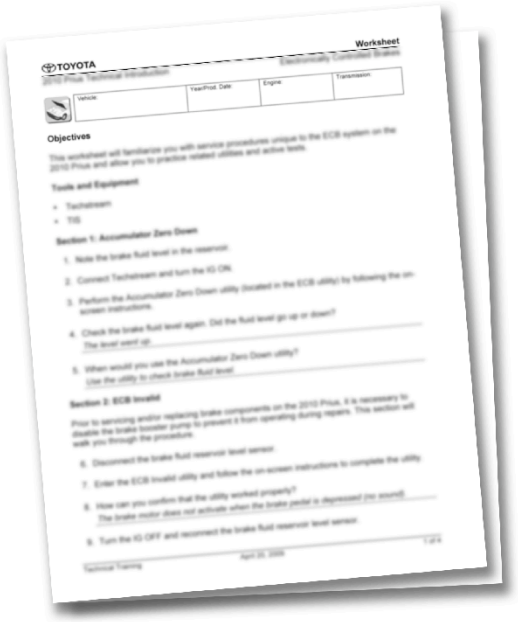
There are several different styles of mechanical valve lash adjusters. These are examples of replacing shims instead of lifters to change valve lash clearance. In one example, the shim is placed on top of the lifer. In the other example, the shim is placed on top of the valve stem. Refer to the Repair Manual for specific adjustment procedures for each vehicle.

Worksheet

Valve Lash Adjustment

In this worksheet you will:

- Measure valve clearance
- Measure lifter thickness
- Determine the correct size replacement lifter



Use this space to write any questions you may have for your instructor.

NOTES:

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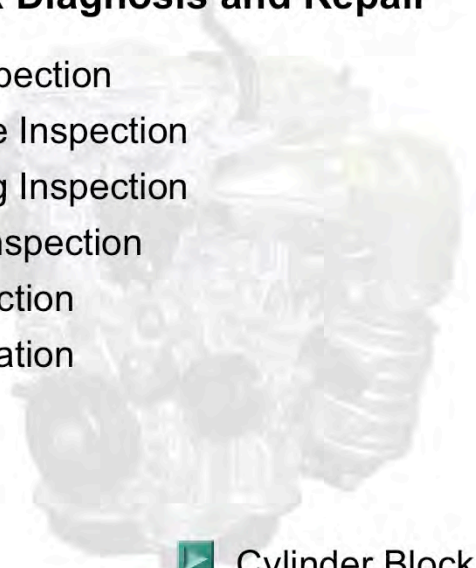
Section 6 Topics

Cylinder Block Diagnosis and Repair

- Warpage Inspection
- Cylinder Bore Inspection
- Piston & Ring Inspection
- Crankshaft Inspection
- Bearing Selection
- Piston Installation



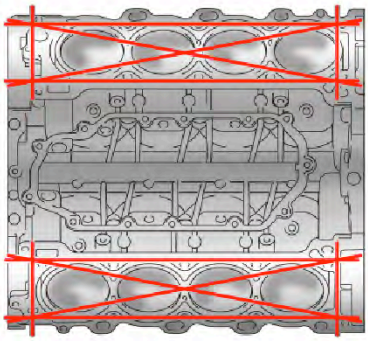
- Cylinder Block Worksheet

Warpage Inspection

Using a precision straightedge and a feeler gauge.

Measure the contact surfaces of the cylinder head gaskets at 6 locations as shown.

Maximum warpage: 0.07 mm



If the warpage is greater than the maximum, replace the cylinder block.

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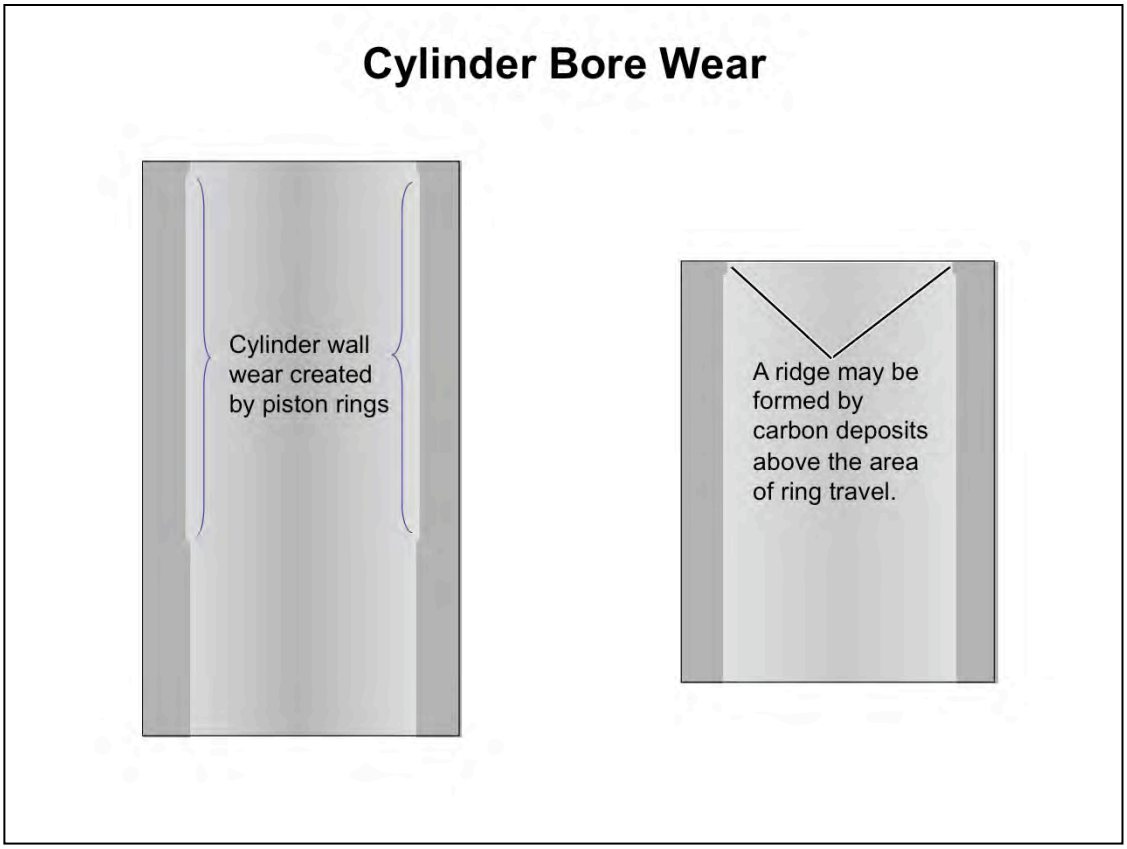
Warpage Inspection Just like the cylinder head, a warpage check is necessary to verify the flatness of the cylinder block mating surface. Be sure the surface is clean and free of nicks, pitting, corrosion, or any other imperfections before measuring.



Cylinder Bore Wear

Piston rings rubbing against the cylinder wall can eventually wear away the cylinder wall lining. This can be detected by measuring the cylinder diameter and comparing to specifications.

Cylinder bore wear from today's low tension piston rings is much less than with earlier high tension rings. If cylinder bore wear exceeds specifications, however, a new short block is needed. Boring out the cylinders is not an option for many Toyota engines because oversize replacement pistons are not available.

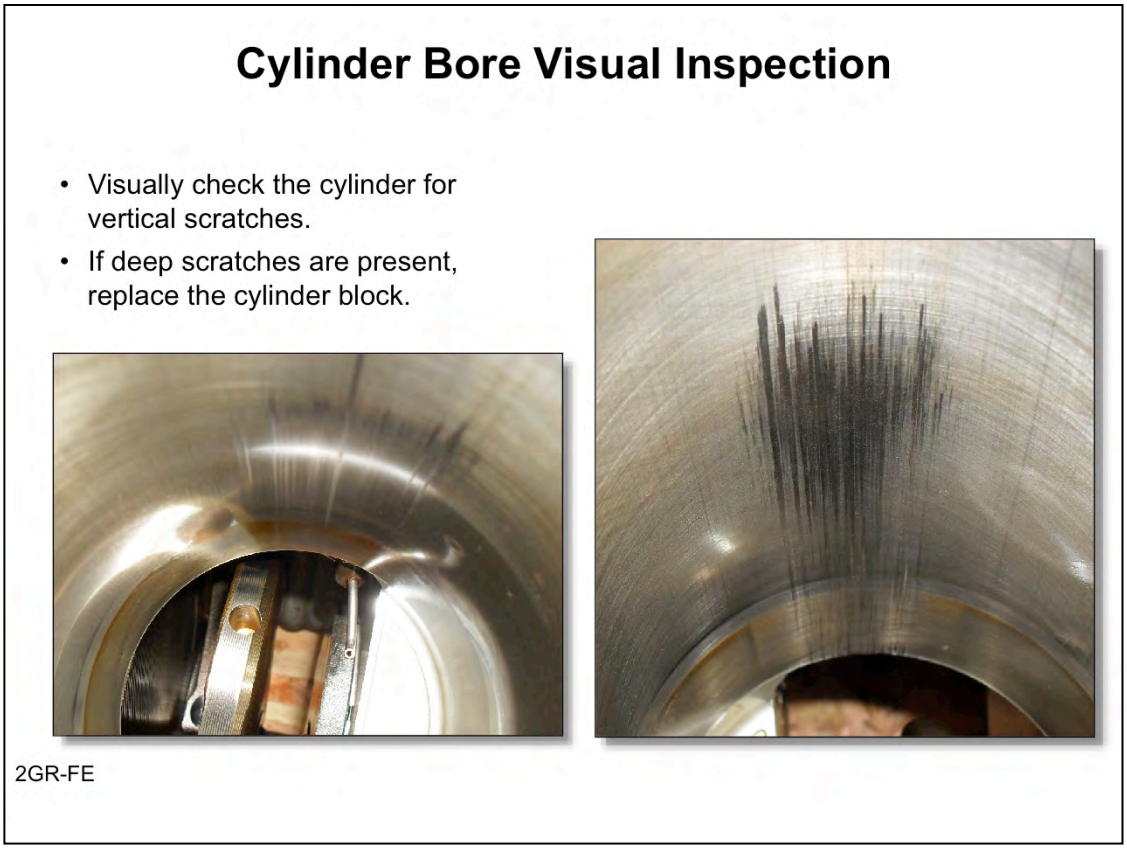
Ridge Reamer

A ridge of carbon deposits at the top of the cylinder can be removed using a ridge reamer.

Ridge Reamer

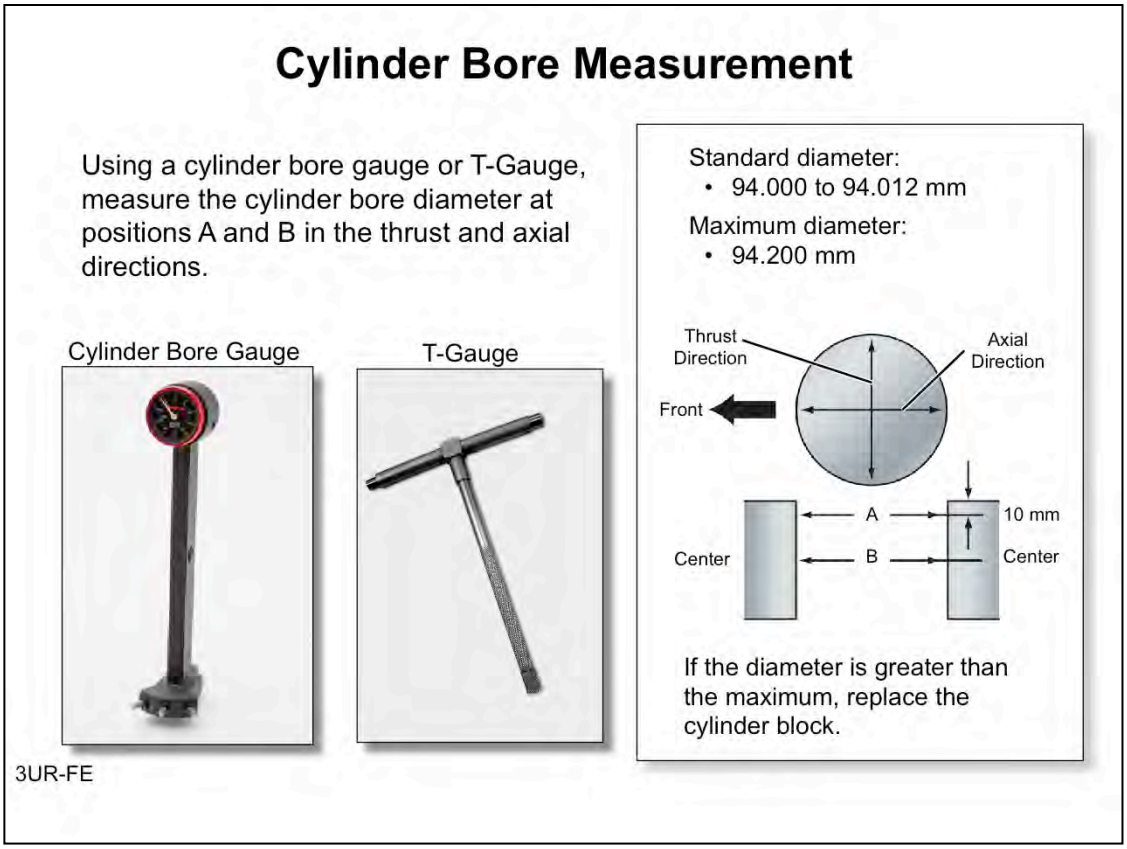
Before removing a piston, check the cylinder for a ridge of carbon deposits above the area of ring travel. If present, the ridge can interfere with the piston rings during removal.

When necessary, remove the ridge of carbon using a ridge reamer.



Cylinder Bore Visual Inspection

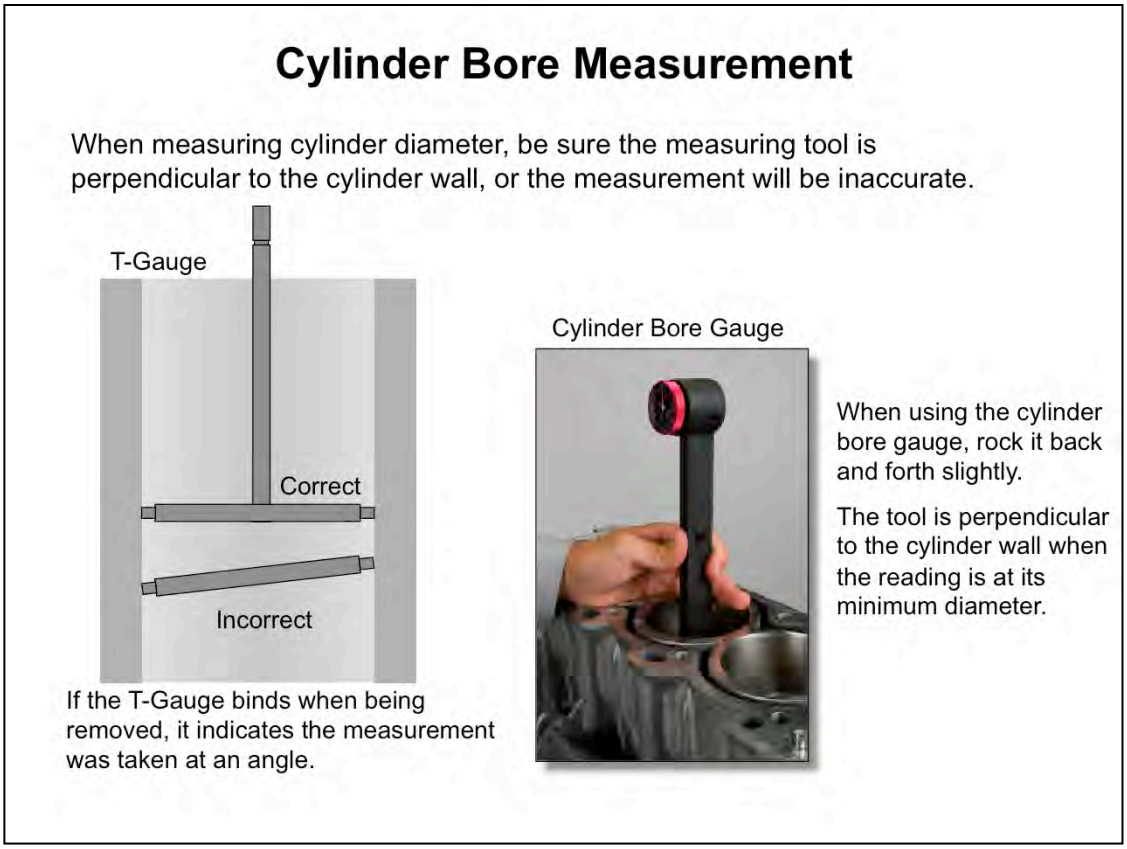
Visually check the cylinder bore for vertical scratches. If deep scratches are present, replace the cylinder block. Remember to always ask the question, “Why?” If vertical scratches are present; what are the most likely causes? If it was a lack of lubrication problem, the lubrication system should be diagnosed before replacing the short block.



Cylinder Bore Measurement

Measuring the diameter of the cylinder bore reveals whether cylinder wear exceeds specifications. Excessive cylinder wear can cause oil consumption, smoky exhaust and engine noise.

Using a cylinder bore gauge or T-Gauge, measure the cylinder bore diameter at positions A and B in the thrust and axial directions. If the diameter is greater than the maximum specified in the Repair Manual, replace the cylinder block.



Cylinder Bore Measurement (cont'd)

When measuring the diameter of the cylinder bore, it is important to know your measurement instrument. T-Gauges take some practice to confidently find true 90 degrees to the cylinder bore. The bore gauge, however, uses a dial indicator that allows for a confident measurement of the cylinder bore with little set up time. Always refer to the Repair Manual for cylinder bore specifications.

Piston Inspection

Pistons are subject to extreme heat, pressure, and motion. Pistons must withstand this abuse under varying operating conditions. When an engine fails, it is important to inspect the condition of the pistons to evaluate the root cause.

Inspect pistons for the following:

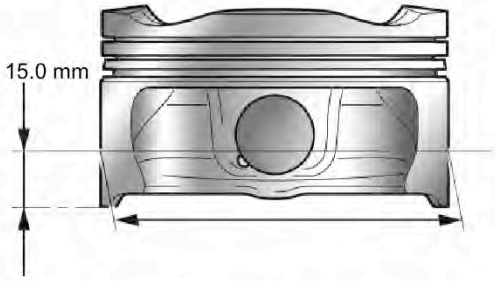
Scoring – Scoring is an indication of improper piston to cylinder wall clearance or insufficient lubrication.

Broken or Stuck Rings – Inspect for broken rings and ring lands. Inspect for stuck rings, especially oil rings. Stuck rings are a good indicator of an oil consumption issue.

Piston Oil Clearance

Inspect Piston Diameter

- Using a micrometer, measure the piston diameter at a position that is 15.0 mm (0.591 in.) from the bottom of the piston.



- If the diameter is less than the specification in the Repair Manual, replace the piston.

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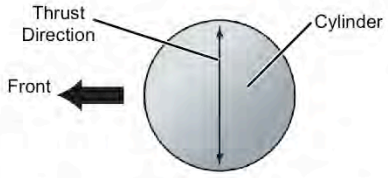
Determine Piston Oil Clearance

- Measure the cylinder bore diameter in the thrust direction.



- Subtract the piston diameter measurement from the cylinder bore diameter measurement.
- If the oil clearance is greater than the maximum, replace **all the pistons**. If necessary, replace the cylinder block.

Piston Oil Clearance Piston oil clearance is extremely important in modern internal combustion engines. The fine layer of oil on the cylinder wall must be thick enough to provide adequate lubrication but thin enough to be wiped away by the rings to avoid oil getting into the combustion chamber.

NOTE When measuring piston diameter, be sure the micrometer does not damage the resin coating on the piston.

Crankshaft Journal Visual Inspection

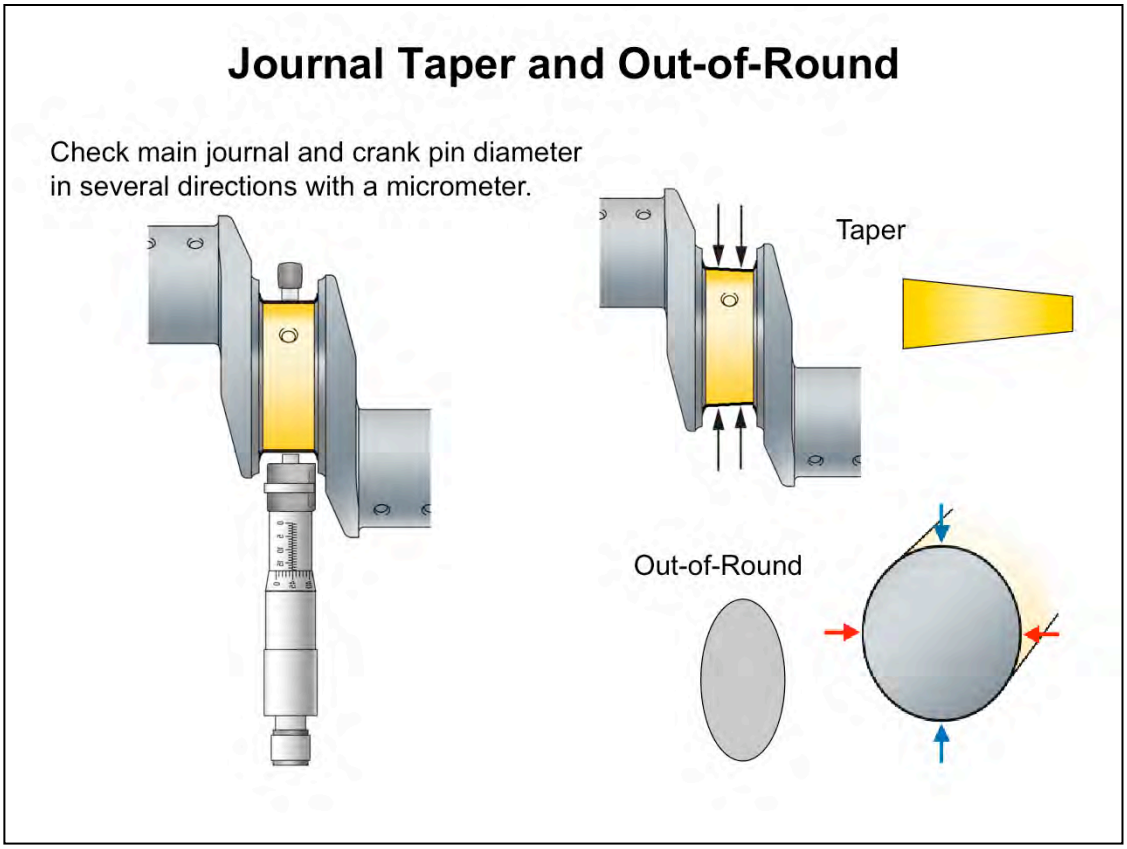
Visually inspect each main journal and crank pin for signs of wear or bluing/darkening indicating excessive heat.

- If signs of wear or excessive heat are seen, measure and compare the journal or crank pin diameter to specifications, and check for taper and out-of-round
- If necessary, replace the crankshaft

Crankshaft Journal Visual Inspection

Crankshaft journals should look just as they looked when the vehicle rolled off the assembly line. The crankshaft journals withstand extreme pressure and motion. Without proper lubrication bearings and crankshaft journals deteriorate very fast. Journals should be smooth and your finger nail should not catch on any vertical scratches. Some bluing or darkening may be seen at the edges of the journal/crankpin. This is considered normal and is part of the hardening process from the factory.

If significant wear is present, replacement is necessary. Remember to ask why this wear happened. If lack of lubrication is suspected, further diagnosis of the lubrication system is necessary to determine the root cause.



Journal Taper and Out-of-round

Check each main journal and crank pin for taper by measuring with a micrometer at the front and back of the journal. The difference in the two measurements is the taper.

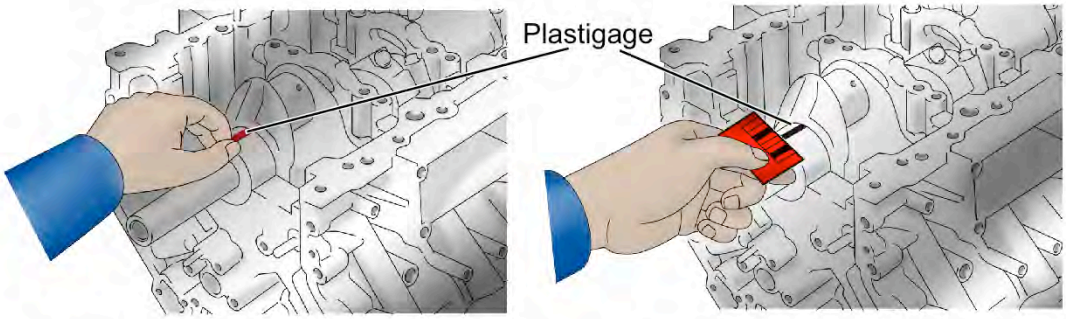
Check each main journal and crank pin for out-of-round by measuring with a micrometer at 90 degree angles. The difference in the two measurements is the out-of-round.

If the taper or out-of-round is greater than the maximum specified in the Repair Manual, replace the crankshaft.

Crankshaft Oil Clearance

With the crankshaft in the cylinder block and the main bearing caps removed, lay a strip of Plastigage on each journal.

Remove bearing caps and use the gauge on the packaging to measure the width of flattened Plastigage to determine oil clearance.



Install all bearing caps and torque to specifications.

If the oil clearance is greater than the maximum specified in the Repair Manual, replace the bearings. If necessary, replace the crankshaft.

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Crankshaft Oil Clearance

Modern Toyota engines use extremely tight oil clearance specifications. Verification of these oil clearances is very important to maintain the integrity of the engine. Using Plastigage is a simple but effective way to measure crankshaft oil clearance. Be sure to select the proper diameter Plastigage for the range being measured.

Bearing Selection and Replacement

If replacing a bearing, replace it with one that has the same number.

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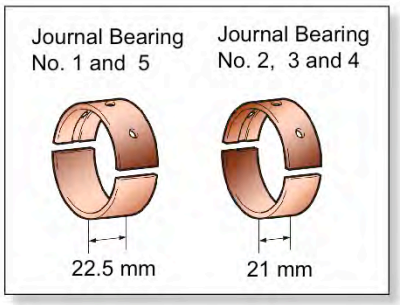
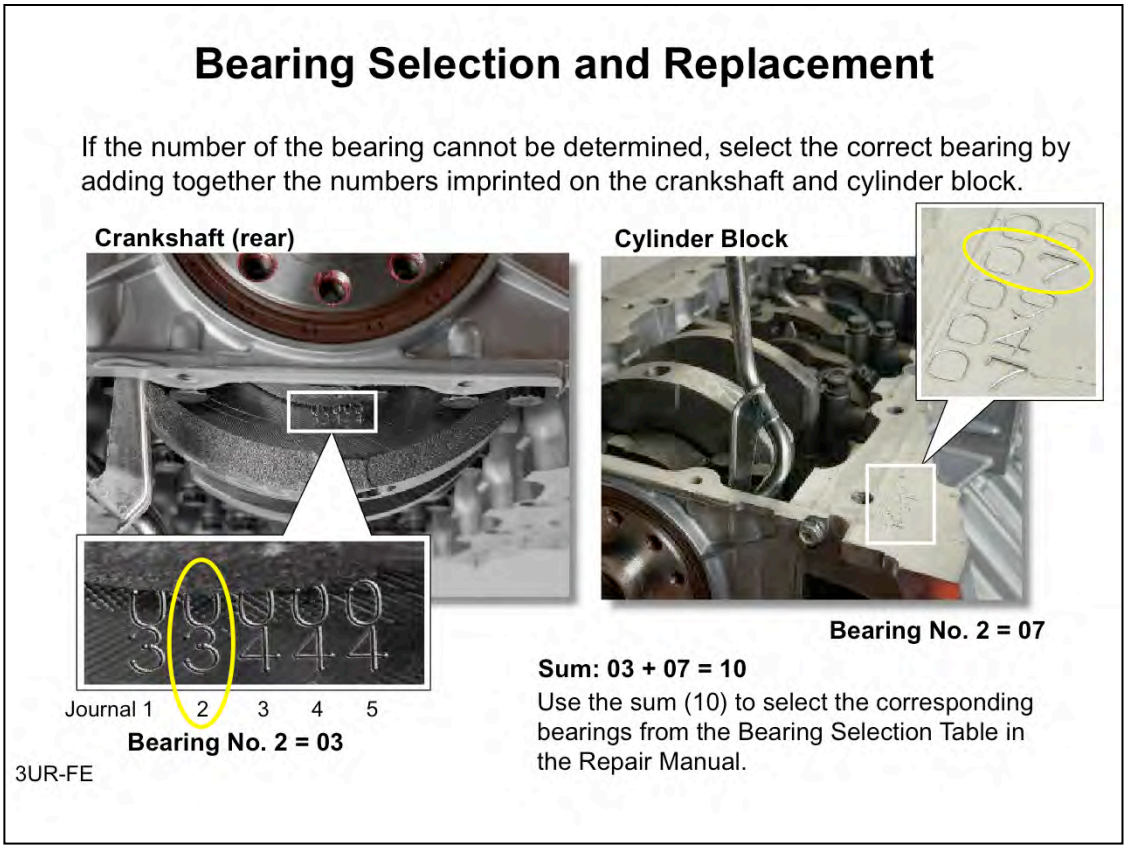


There are 6 sizes of standard bearings.

- For the No. 1 and No. 5 position bearings, use bearings marked 4, 5, 6, 7, 8 and 9.
- For other bearings, use bearings marked 3, 4, 5, 6, 7 and 8.

Bearing Selection and Replacement

From the factory, each journal bearing is select fit to ensure the proper oil clearance. When selecting bearings it is important to look at the number marks on the back side of the bearings. Replace the bearings with the same number selection that was originally used.



Bearing Selection and Replacement (cont'd)

If bearing numbers are not marked on the back of the main bearings, use the numbers inscribed on the crankshaft and cylinder block.

- On the rear of the crankshaft counterweight you'll find a group of numbers corresponding to the main bearing journals.
- On the underside of the cylinder block you'll find another group of numbers corresponding to the main bearing journals.
- Adding together the appropriate numbers for a specific journal gives you a value you can use to select the correct bearing from the Bearing Selection Table in the Repair Manual. (See the example on the next page.)

For connecting rod/crank pin journals, you'll use the numbers on the front of the crankshaft counterweight and the numbers stamped on the connecting rods to select bearings.

Using the Bearing Selection Table

For the desired journal, add the respective numbers from the crankshaft and cylinder block:

Example:

Cylinder Block Stamp for Main Bearing No. 2: 07

Crankshaft Stamp for Main Bearing No. 2: + 03

Total: = 10

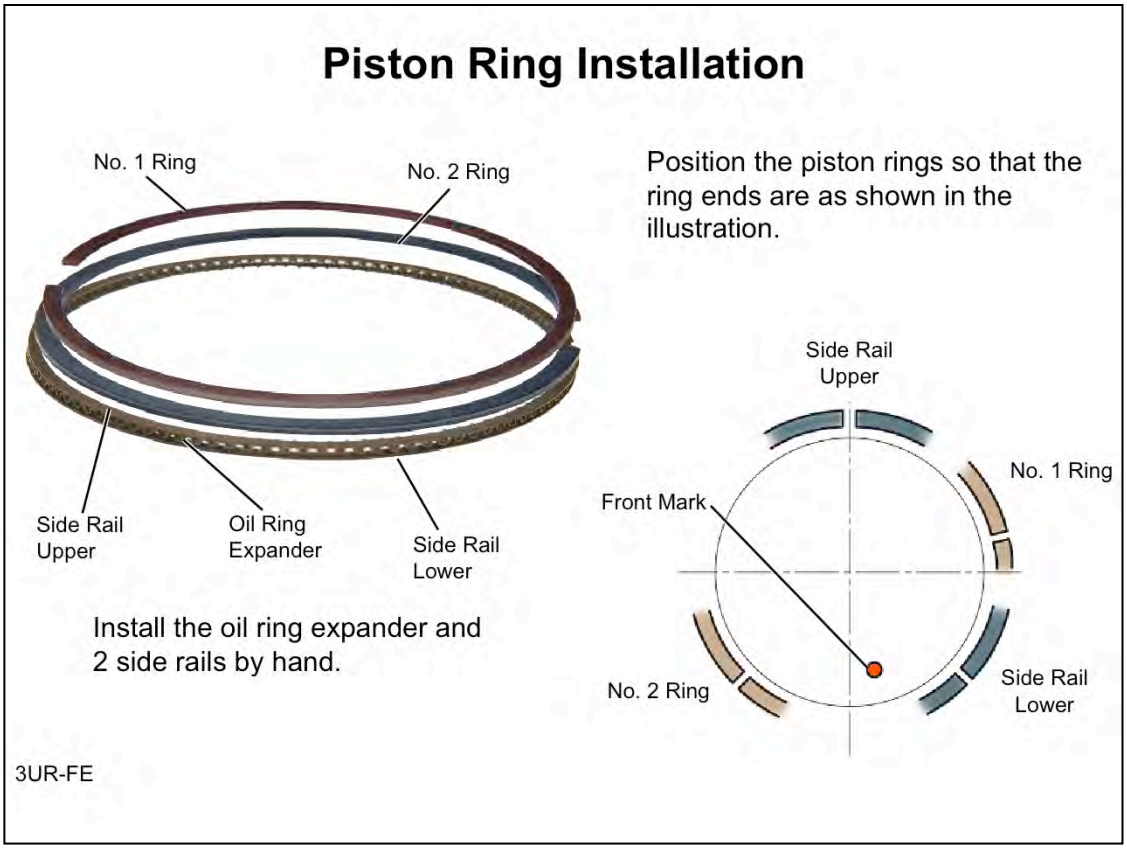
In the appropriate table below, find (A) + (B) = 10.

No. 1 and No. 5 Journals

(A) + (B)	Upper Bearing		Lower Bearing	
	Number Mark	Specified Condition	Number Mark	Specified Condition
00 to 02	4	2.501 to 2.504	5	2.488 to 2.491
03 to 05	5	2.504 to 2.507	5	2.488 to 2.491
06 to 08	5	2.504 to 2.507	6	2.491 to 2.494
09 to 11	6	2.507 to 2.510	6	2.491 to 2.494
12 to 14	6	2.507 to 2.510	7	2.494 to 2.497
15 to 17	7	2.510 to 2.513	7	2.494 to 2.497
18 to 20	7	2.510 to 2.513	8	2.497 to 2.500
21 to 23	8	2.513 to 2.516	8	2.497 to 2.500
24 to 26	8	2.513 to 2.516	9	2.500 to 2.503
27 to 28	9	2.516 to 2.519	9	2.500 to 2.503

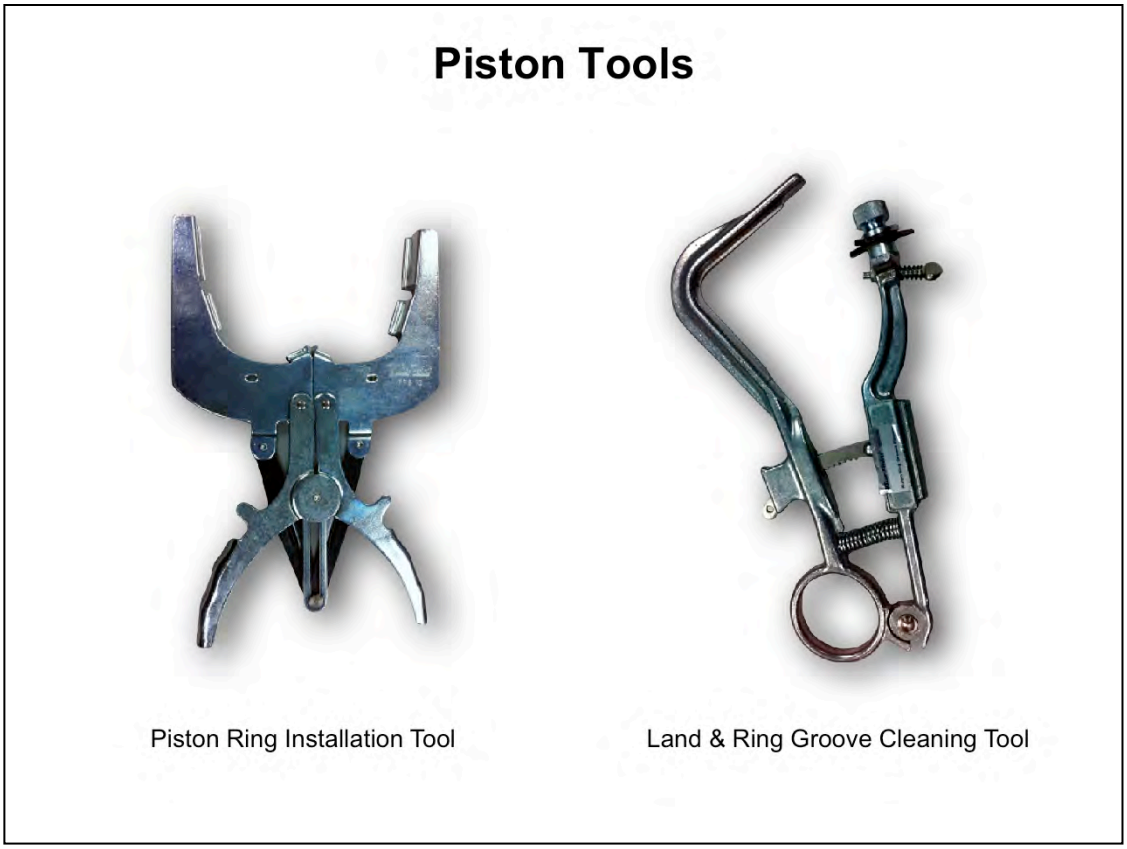
Other Journals

(A) + (B)	Upper Bearing		Lower Bearing	
	Number Mark	Specified Condition	Number Mark	Specified Condition
00 to 02	3	2.482 to 2.485	4	2.501 to 2.504
03 to 05	4	2.485 to 2.488	4	2.501 to 2.504
06 to 08	4	2.485 to 2.488	5	2.504 to 2.507
09 to 11	5	2.488 to 2.491	5	2.504 to 2.507
12 to 14	5	2.488 to 2.491	6	2.507 to 2.510
15 to 17	6	2.491 to 2.494	6	2.507 to 2.510
18 to 20	6	2.491 to 2.494	7	2.510 to 2.513
21 to 23	7	2.494 to 2.497	7	2.510 to 2.513
24 to 26	7	2.494 to 2.497	8	2.513 to 2.516
27 to 28	8	2.497 to 2.500	8	2.513 to 2.516



Piston Ring Installation

Assemble and install the oil ring by hand. Then, using a piston ring expander, install the 2 compression rings, and align the ring gaps as shown in the illustration.



Piston Tools

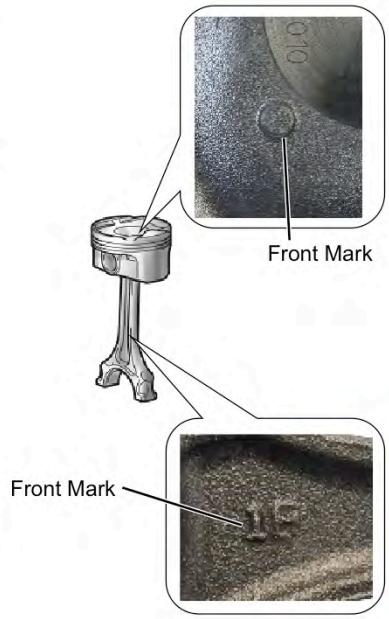
The piston ring tool can be used to install or remove piston rings. Today's low tension rings are extremely easy to break and should be installed carefully.

The land and ring groove cleaner is used to clean any carbon or other contaminants from the ring grooves. It is important to thoroughly clean the ring grooves before ring installation so compression rings seal properly, and so oil drains properly through the piston oil passages.

Piston Installation

Apply engine oil to the cylinder walls, the pistons, and the surfaces of the connecting rod bearings.

Using a hammer handle and piston ring compressor, push the correctly numbered piston and connecting rod into the cylinder with the front mark of the piston facing forward.



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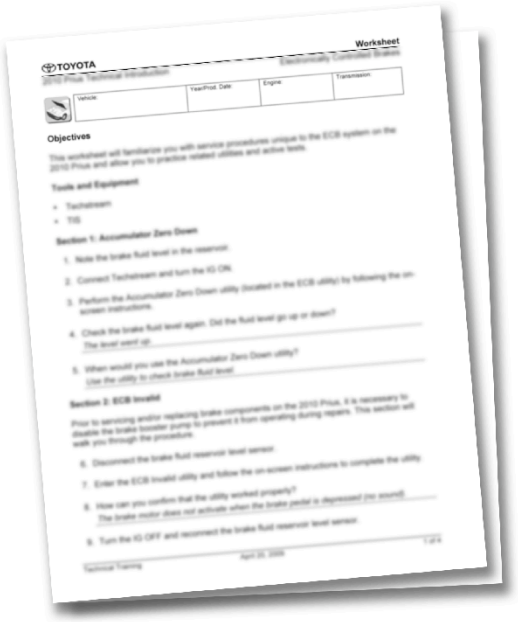
Piston Installation Before installing the piston, apply engine oil to the cylinder walls, the pistons, and the surfaces of the connecting rod bearings. Firmly seat the ring compressor and piston into the bore. Tap gently on the head of the piston; do not use excessive force. Make sure the connecting rod does not come in contact with the cylinder wall, and guide the connecting rod onto the crankshaft journal.

Worksheet

Cylinder Block Inspection

In this worksheet, you will use Repair Manual procedures to perform inspections of cylinder block components.



Use this space to write any questions you may have for your instructor.

NOTES:

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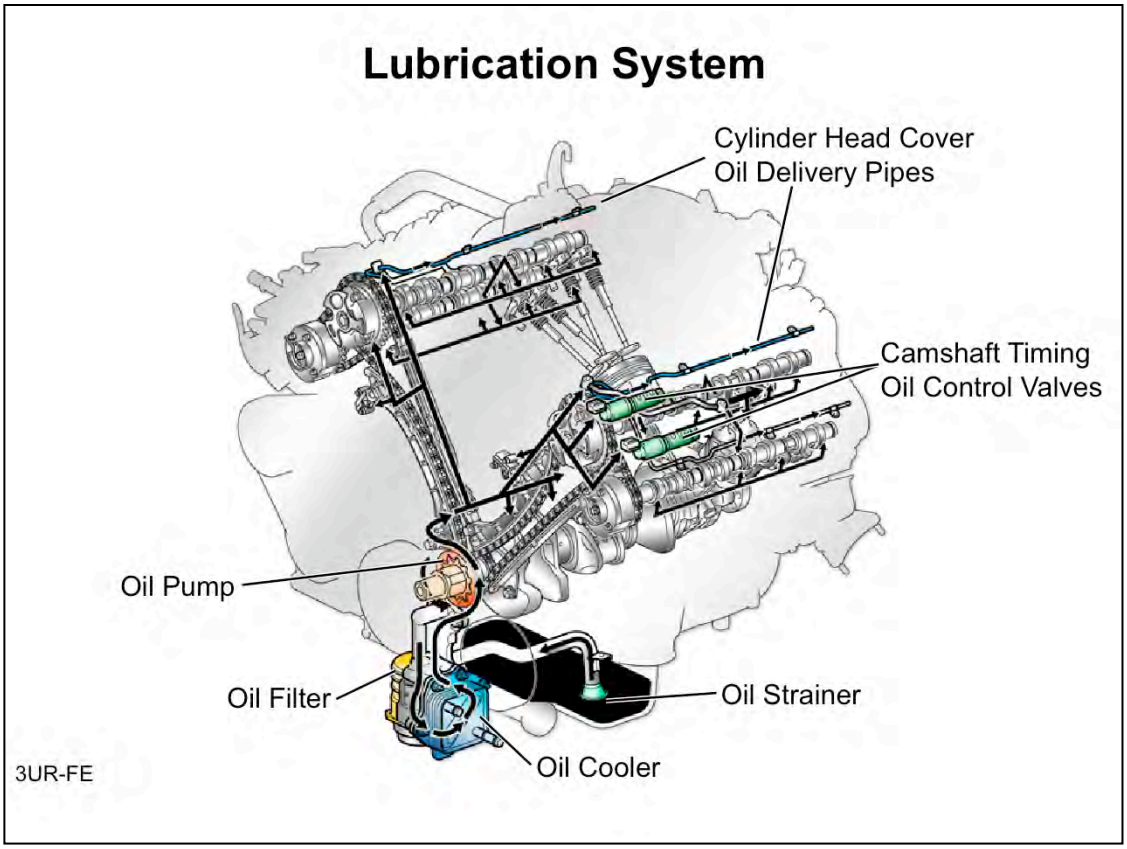
Section 7 Topics

Lubrication System

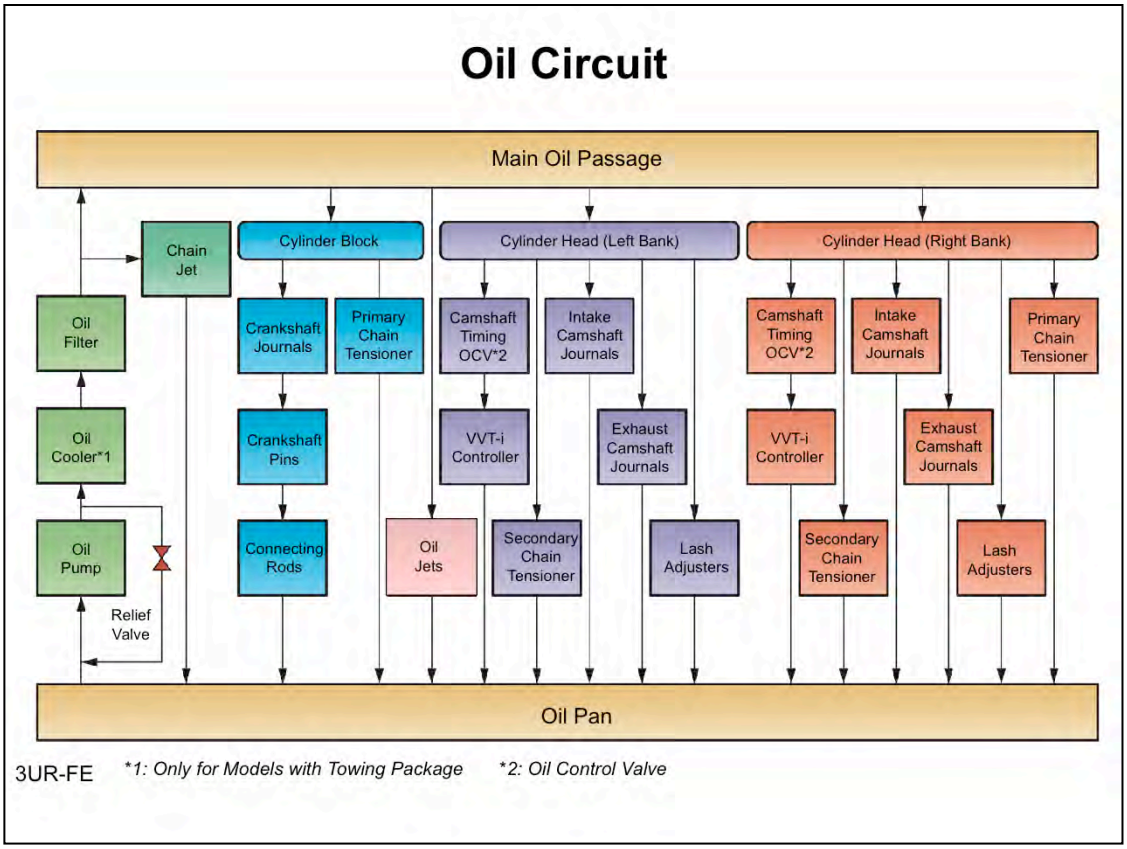
- System
- Oil Circuit
- Oil Pump
- Oil Jets
- Oil Filter
- Oil Cooler
- Oil Properties and Grades
- Oil Inspection
- Oil Pressure Test
- Causes of High or Low Oil Pressure
- Oil Pump Clearance



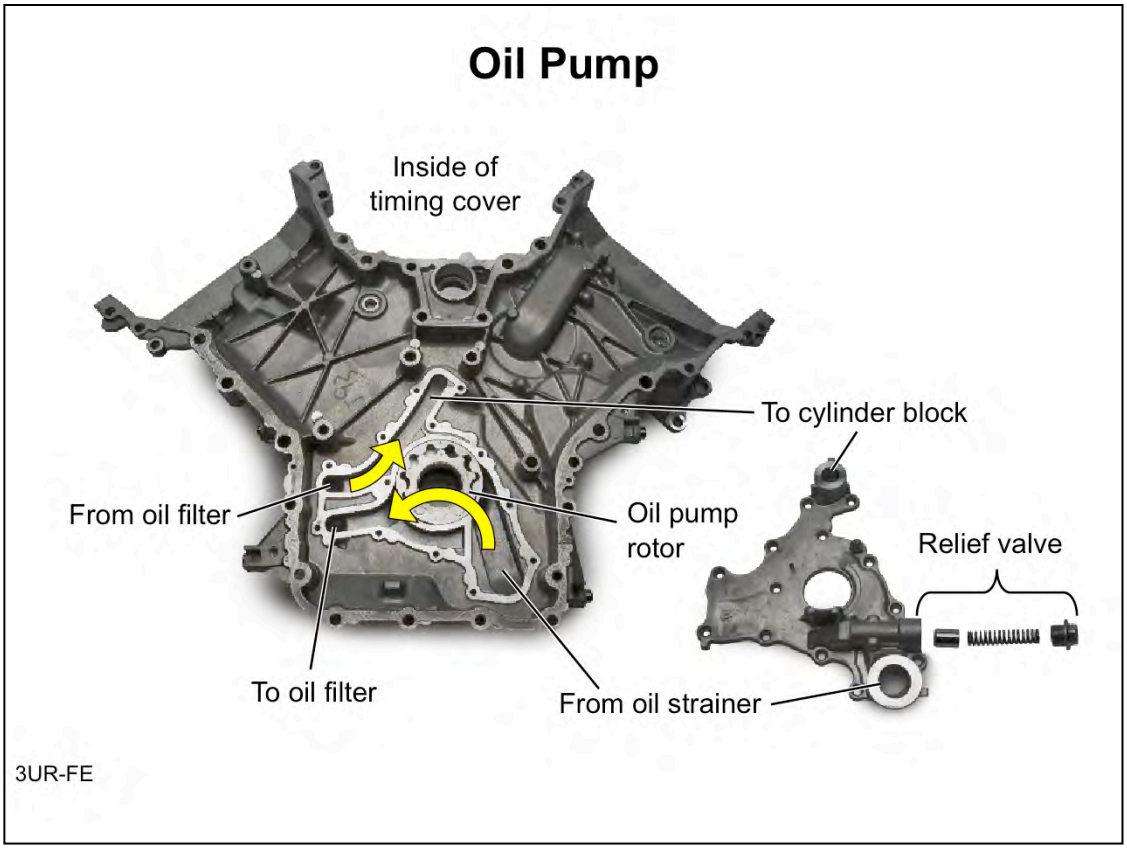
Lubrication System

Oil is the life blood of the engine. Oil cannot be compressed, so when it forms a thin film on engine components, it keeps them from contacting each other. If an engine component is starved for oil for just a short period of time irreversible damage can occur.

The purpose of the lubrication system is to be certain oil is constantly supplied to all components that require it. It pumps oil throughout the engine through small passages and tubes in the engine block and cylinder head.

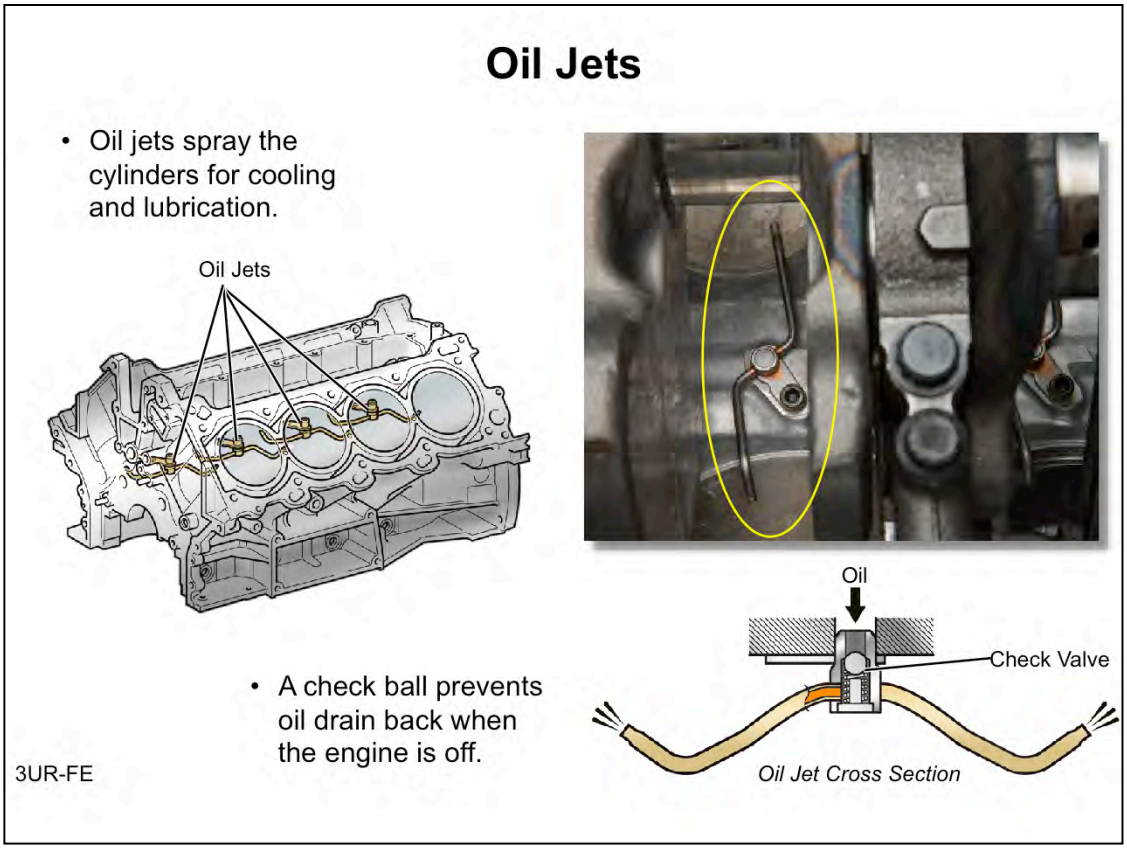


Oil Circuit These components and passages make up the oil circuit. The oil circuit starts with the oil pan or sump. The oil pump draws oil from the pan through a pick up screen and filter. The oil is then pressurized and sent to the main oil passage. From here the oil flows through a multitude of circuits and passages to feed various components and moving parts. Eventually, the oil drains back to the oil pan to start the journey all over again.



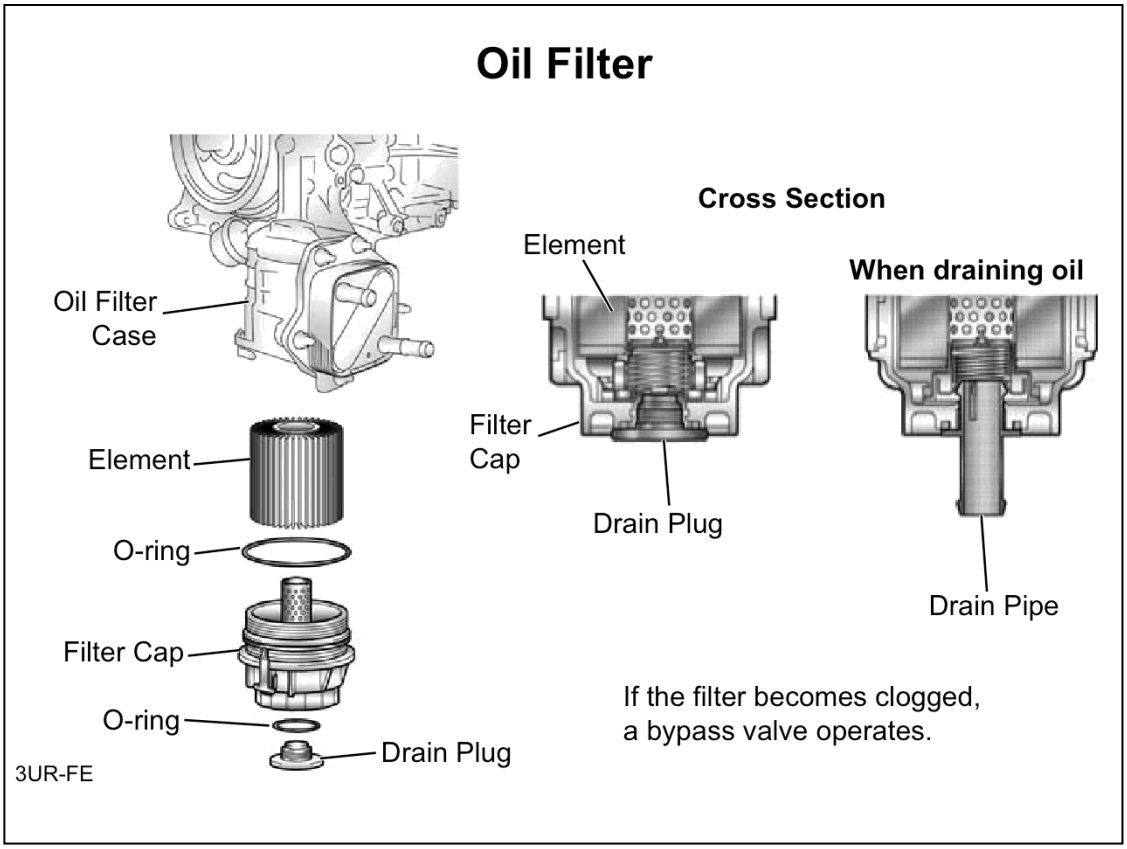
Oil Pump Modern Toyota engine oil pumps are mounted in the front timing cover. The oil pump is driven by the front shaft of the crankshaft. The oil pump draws oil from the oil pan and directs it through the oil filter then on to the main oil passage in the cylinder block.

NOTE When installing the timing cover, it is important to remember to install the o-rings for the oil pump and oil filter. Low oil pressure may result if these o-rings are not installed.



Oil Jets In the past, oil was splashed onto the cylinder walls either by excess oil from crankshaft journals or oil slung from the crankshaft passing through oil in the pan. Today, the crankshaft does not pass through the oil in the pan as it rotates thus reducing friction and engine load. Instead, oil is sprayed directly into the lower end of the cylinder by oil jets mounted in the cylinder block.

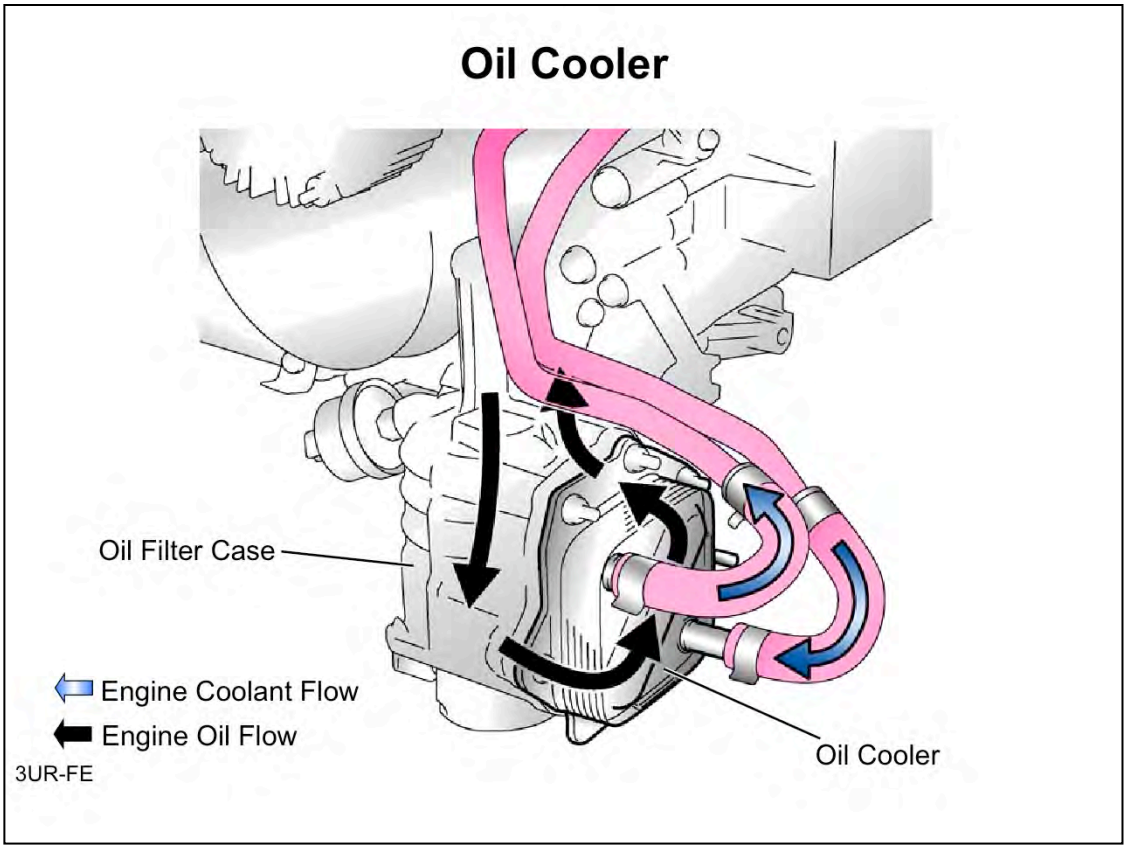
NOTE When inspecting for a lack of lubrication concern or during engine block replacement, it is important to check oil jet function. Use compressed air to test the check ball and make sure the oil passages are not blocked.



Oil Filter

The oil filter illustrated above uses a replaceable paper element that comes with a drain tube. Before removing the filter cap to replace the element, remove the drain plug and insert the drain tube in the cap to drain the oil from the filter.

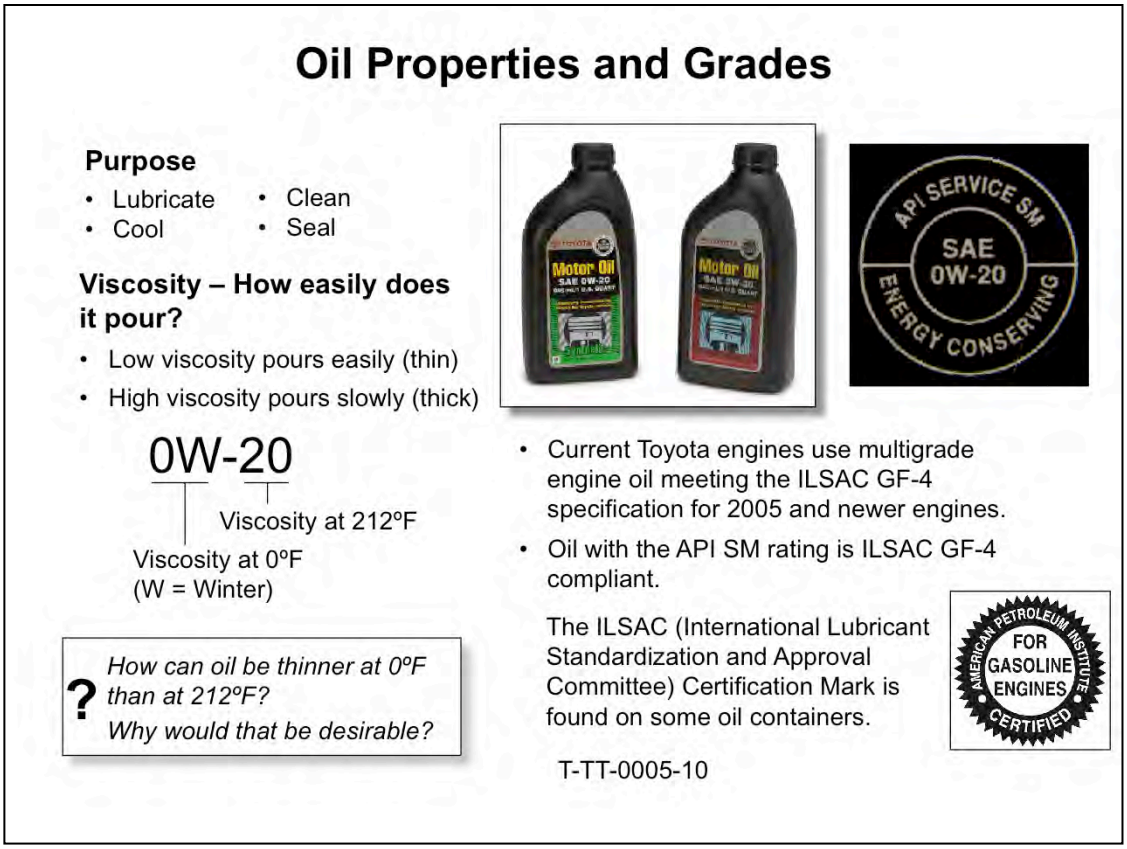
This type of oil filter requires SST 09228-06501 to remove and replace the filter cap. When tightening the filter cap, be careful not to over tighten. If the filter cap is over tightened, it might be damaged the next time someone attempts to remove it.



Oil Cooler

Like most automotive fluids, excessive heat reduces engine oil life. Under certain operating conditions – such as towing – auxiliary oil coolers are installed to help maintain engine oil temperature.

Oil coolers may introduce oil into the cooling system or vise versa if o-rings or other internal components fail. It is important to inspect oil coolers if fluids become cross contaminated.



Oil Properties and Grades

The purpose of oil is not just to lubricate to reduce wear. Oil also cools, cleans and helps seal the pistons.

Multigrade oil is signified with two **viscosity** measurements. Look at 0W-20 grade motor oil for example. The 0W indicates a low viscosity when cold. Oils with a low value before the W allow for easier engine starting in cold weather.

The 20 in 0W-20 indicates a higher viscosity when the oil is at its operating temperature. An oil with an even higher viscosity may be recommended if the vehicle is operated at high speeds, or under extreme load conditions.

Viscosity and Temperature

Viscosity describes how easily a liquid pours. Low viscosity liquids pour easily. They may be described as “thin.” Water has a low viscosity. High viscosity liquids pour slowly. They may be described as “thick.” Pancake syrup has a higher viscosity than water,

As temperature decreases, a liquid’s viscosity goes up. Example: syrup pours more slowly when it’s cold. As temperature increases, a liquid’s viscosity goes down. Example: syrup pours more easily when it’s hot.

NOTE

Multigrade oils include additives that cause the oil to become thicker when heated. That is why 0W-20 is thinner when it’s cold and thicker when it’s hot.

Current Toyota engines use multigrade engine oil meeting the ILSAC GF-4 specification for 2005 and newer engines. Oil with the API SM rating is ILSAC GF-4 compliant.

Oil Inspection

Oil Condition	Indication
Brown (coffee-with-cream color)	Coolant in the oil; blown head gasket; cracked block/ head
Thick, sludgy	Overheating or long time since last oil change
Gritty or visible metallic material	Excessive wear of internal components
Thin, smells of fuel	Fuel in the oil

Thick, sludgy oil deposits in the camshaft housing

Oil Inspection

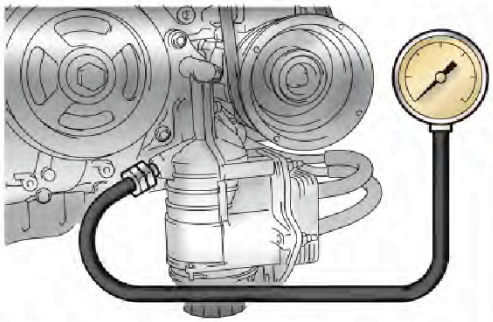
An initial oil inspection should be performed during every service.

First, the engine oil level should be noted. If the engine oil level is low and there are no signs of an external leak it may be necessary to pursue a possible oil consumption concern.

Second, the oil should be inspected for its condition. Note color, smell, and quality. If any of these seem out of the ordinary, further inspection may be necessary.

Oil Pressure Test

Remove the oil pressure sender gauge and install an oil pressure gauge.



- Warm up the engine and record oil pressure at the engine RPMs specified in the Repair Manual.
- If the oil pressure is not as specified, inspect the oil pump.
- After reinstalling the oil pressure sender gauge, inspect for oil leaks

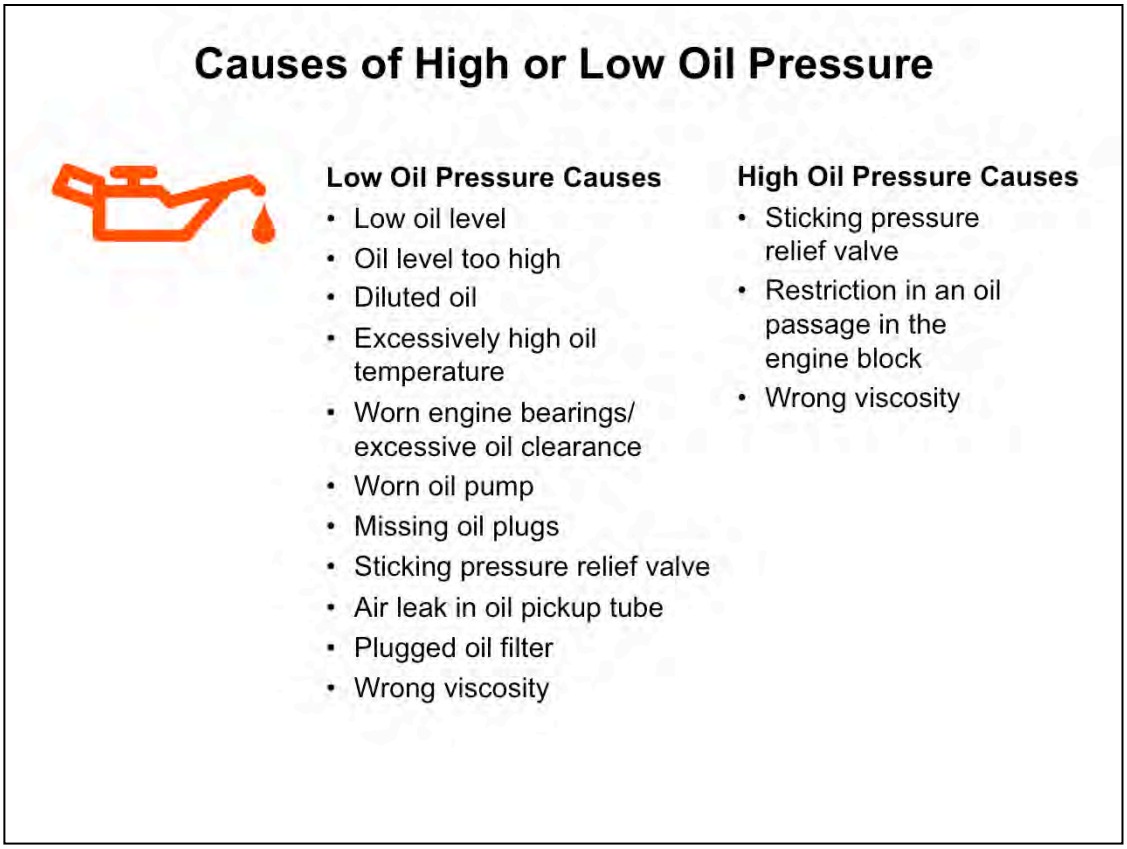
Oil Pressure Gauge and Adapters

Oil Pressure Test

An oil pressure test provides a good indication of oil pump operation. Unfortunately, this test does not guarantee oil pressure is being delivered throughout the entire lubrication system.

For example, if good readings are shown at idle with the oil pressure tester but severe lifter noise is present, this may indicate a restriction is present somewhere in the system.

Like a good doctor does, however, you should verify the “heart” or pump is working adequately first before condemning another component or system.



Causes of High or Low Oil Pressure

Some of the causes of low or high oil pressure include:

Oil Level Too High – When the oil level is too high, the crankshaft may splash the oil, causing it to become aerated. Air in the oil is compressible and reduces pump efficiency.

Missing Oil Plugs – Some of the oil passages are formed by drilling into the block and then plugging the entry hole. A missing plug creates a leak in the system preventing it from being able to pressurize.

Plugged Oil Filter – A plugged oil filter creates a restriction in the system that reduces the oil pressure in the oil circuit after the filter. Most filters have a bypass valve that opens when the restriction from a plugged filter becomes too high. The oil still flows, but the oil pressure is reduced to what is permitted by the bypass valve.

Sticking Pressure Relief Valve – The oil pump pressure relief valve is designed to open when oil pressure is too high, allowing some of the pressurized oil to leak back into the oil pan. If the relief valve is sticking, it may not be able to open when necessary to reduce oil pressure. If the relief valve is stuck open, the system will be unable to pressurize adequately.

Worn Engine Bearings or Excessive Oil Clearance – The tiny space between the bearings and journals creates the resistance necessary to pressurize the oil system. If the space between bearings and journals is greater than normal, then it allows oil to leak out faster than normal resulting in lower oil pressure.

Air Leak in Oil Pickup Tube – If the oil pump is getting air in it, the pump will not work efficiently because the air is compressible.

Inspect Oil Pump Tip Clearance

Measure the clearance between the drive and driven rotor tips.

If the tip clearance is greater than the maximum specified in the Repair Manual, replace the timing chain cover sub-assembly.

Oil Pump Inspection-Tip Clearance

The tip clearance dictates the oil pump's effectiveness. The greater the clearance, the less effective the pump is at generating output pressure.

Typically, modern engine oil pumps generate adequate pressure when driving down the road but it is important to generate sufficient pressure at all driving conditions, even idle. A too-tight clearance may cause the pump to bind and prematurely fail.

Inspect Oil Pump Side Clearance

Measure the clearance between the rotors and a steel square.

If the side clearance is greater than the maximum specified in the Repair Manual, replace the timing chain cover sub-assembly.

Oil Pump Inspection-Side Clearance

Oil pump side clearance ensures the pump does not bind inside the housing. If clearance is too excessive, oil pressure will be low. If clearance is too tight, the pump will prematurely wear and eventually fail.

Inspect Oil Pump Body Clearance

Measure the clearance between the timing chain cover and driven rotor .

If the body clearance is greater than the maximum specified in the Repair Manual, replace the timing chain cover sub-assembly.

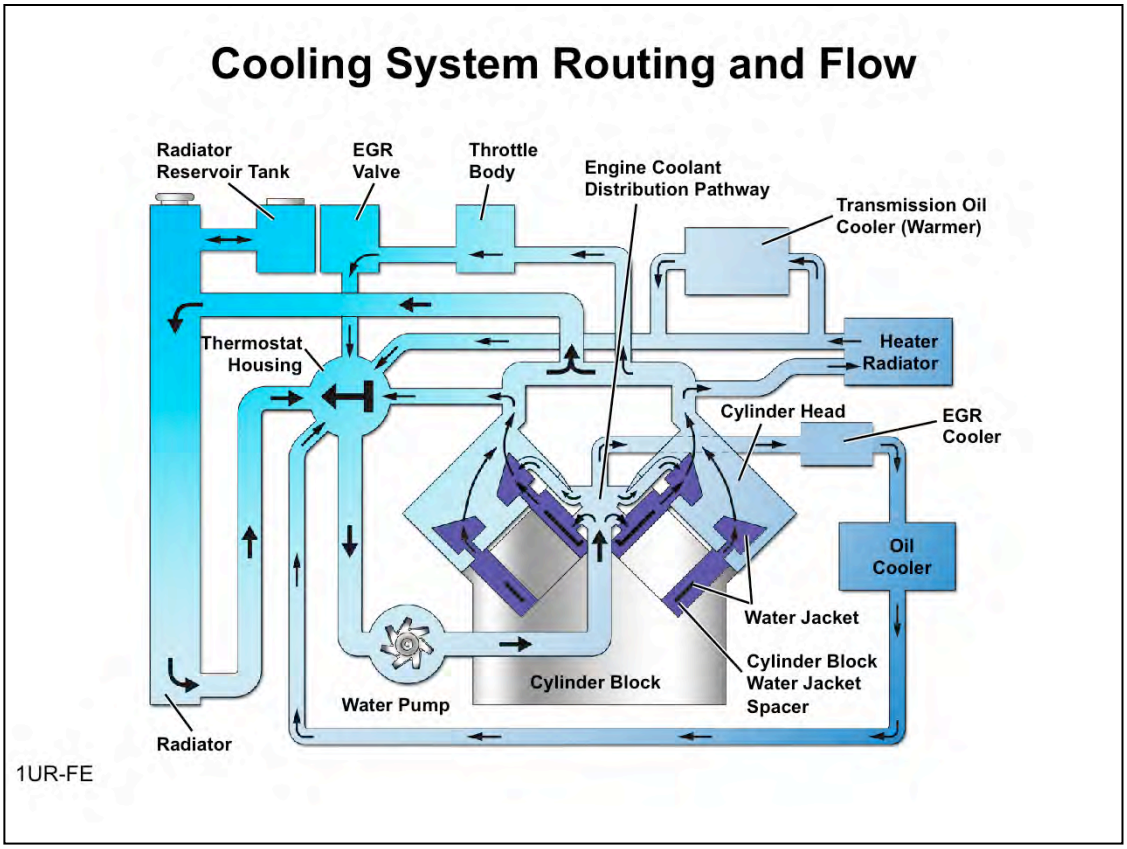
Oil Pump Inspection-Body Clearance

Oil pump body clearance ensures the pump does not bind inside the housing. If clearance is too excessive, oil pressure will be low. If clearance is too tight the pump will prematurely wear and eventually fail.

Section 8 Topics

Cooling System

- Cooling System Routing and Flow
- Coolant Passages
- Water Pump
- Thermostat
- Radiator
- Cooling Fan
- Engine Coolant
- Cooling System Problems
- Coolant Leak Test
- Cooling Fan Inspection
- Service



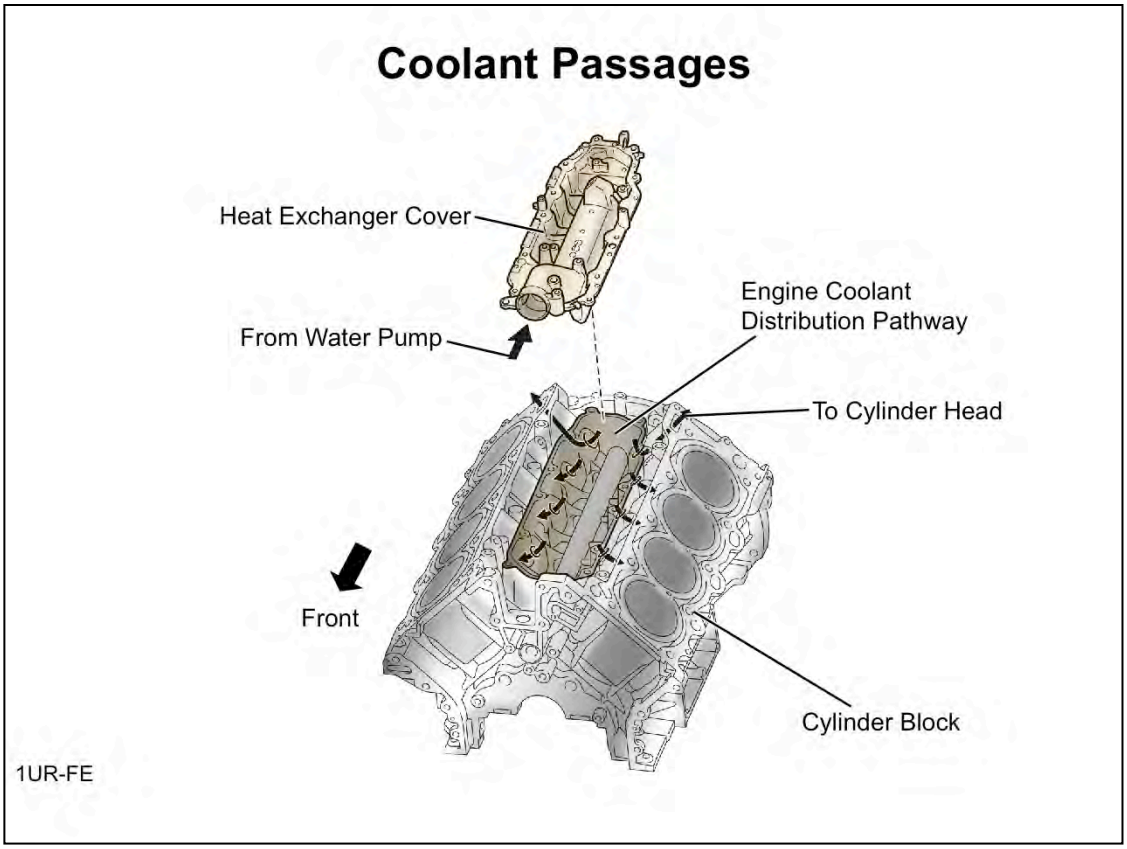
Cooling System Routing and Flow

Engine coolant serves two main purposes:

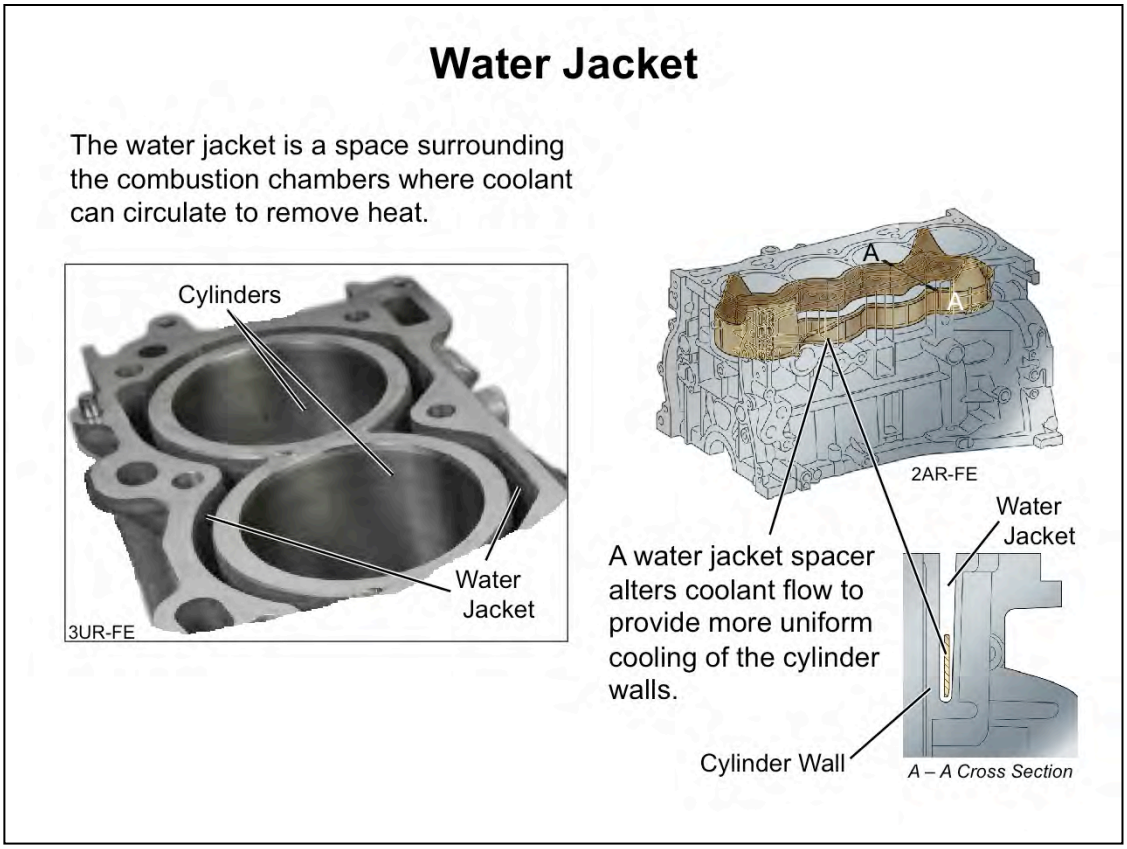
- Exchange the byproduct of combustion (heat) with the atmosphere to maintain a constant operating temperature
- Provide heat to the occupants inside the cabin.

Engineers have found that an engine regulated at a constant temperature produces the maximum efficiency and power, and the least emissions.

As seen in the illustration above, the cooling system routes coolant throughout the vehicle for use in a variety of different systems.



Coolant Passages In the UR engine family, the water pump circulates the engine coolant and directs it to the engine coolant distribution pathway located between the left and right banks. From there, the engine coolant is uniformly distributed to each cylinder of the cylinder block, and is also directly discharged to the cylinder heads. As a result, the cooling performance of the cylinder heads is assured and reliability is improved.



Water Jacket

Heat is produced inside the combustion chamber where temperatures can exceed 1800ºF. Therefore, cooling the engine requires cooling the combustion chambers.

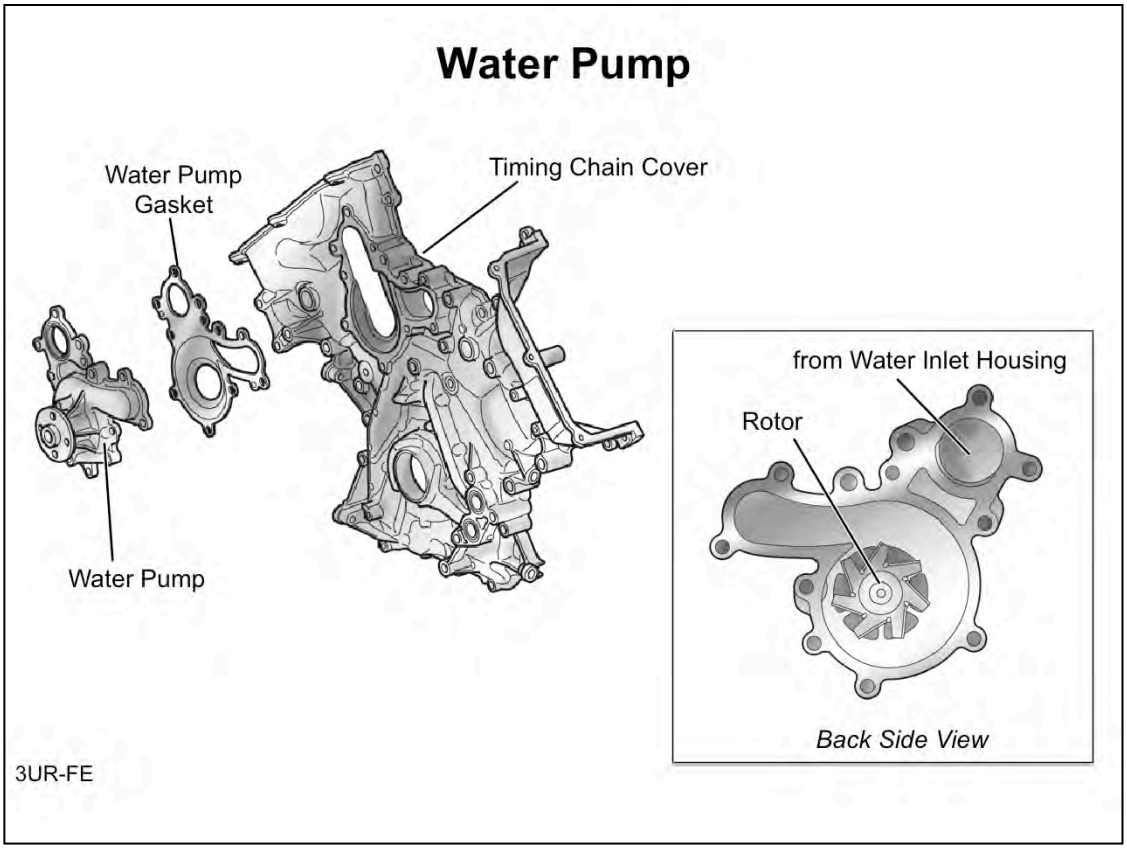
To achieve cooling, the upper half of the cylinders are surrounded by a cavity called a water jacket, where coolant can circulate to absorb heat from the cylinders.

Water Jacket Spacer

A plastic insert called a water jacket spacer is sometimes placed in the water jacket. The spacer alters coolant flow to provide more uniform cooling of the cylinder walls to avoid “cool” spots.

NOTE

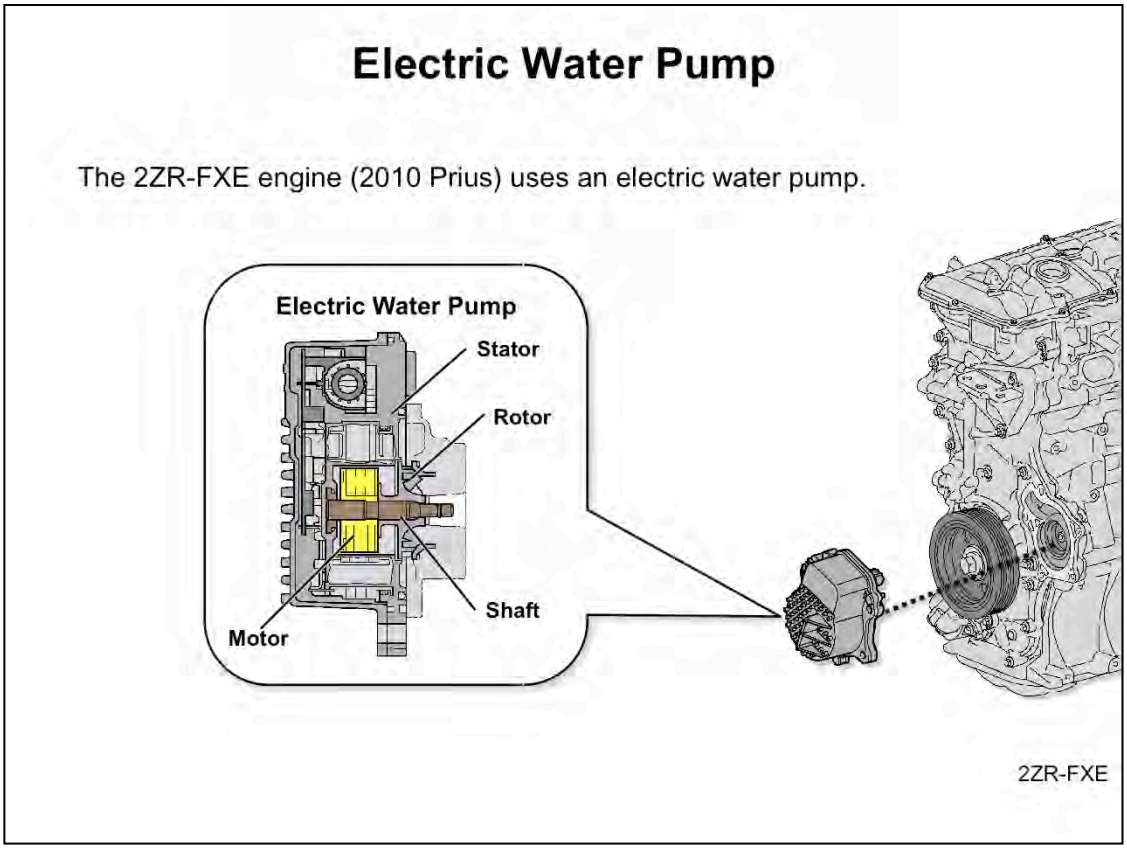
If the engine is subjected to severe overheating, the water jacket spacer may melt. Be sure to inspect the water jacket spacer if cooling problems persist after the engine has overheated.



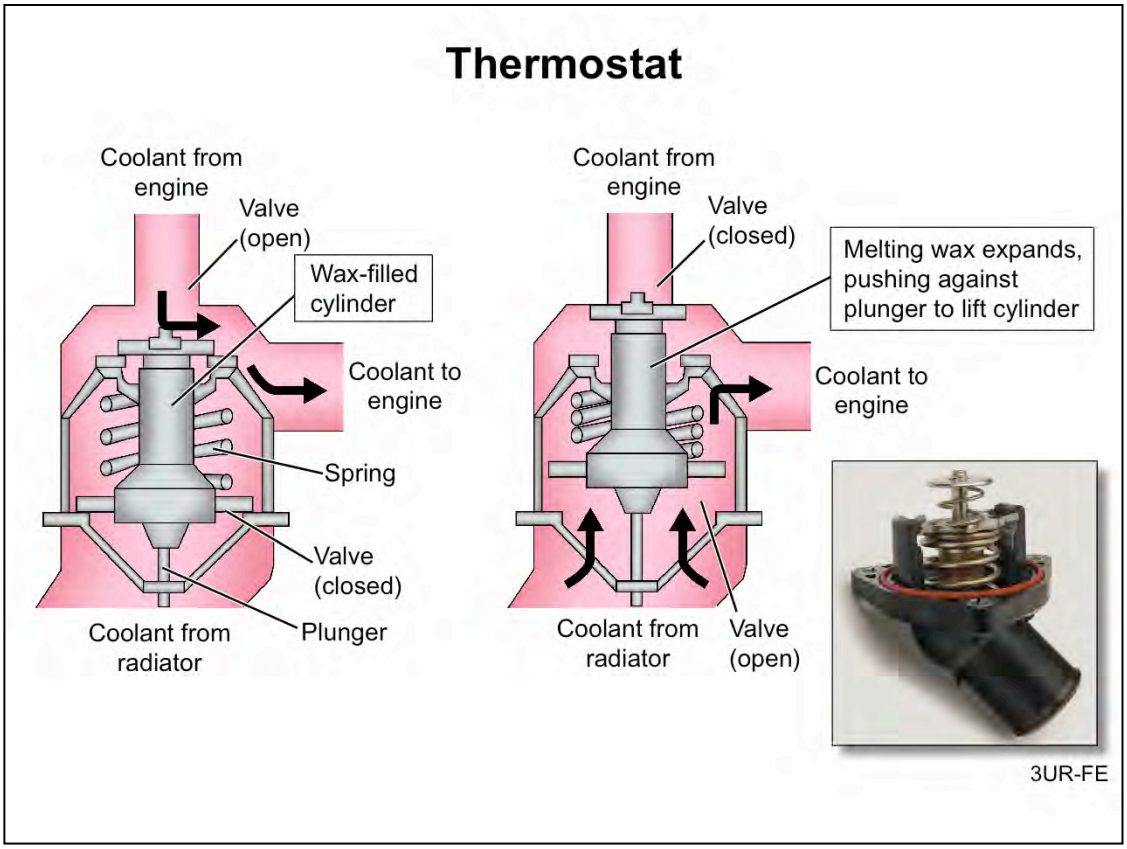
Water Pump

The water pump in modern Toyota engines is mounted to the timing cover. The timing cover is equipped with inlet and outlet passages and sealed by a water pump gasket.

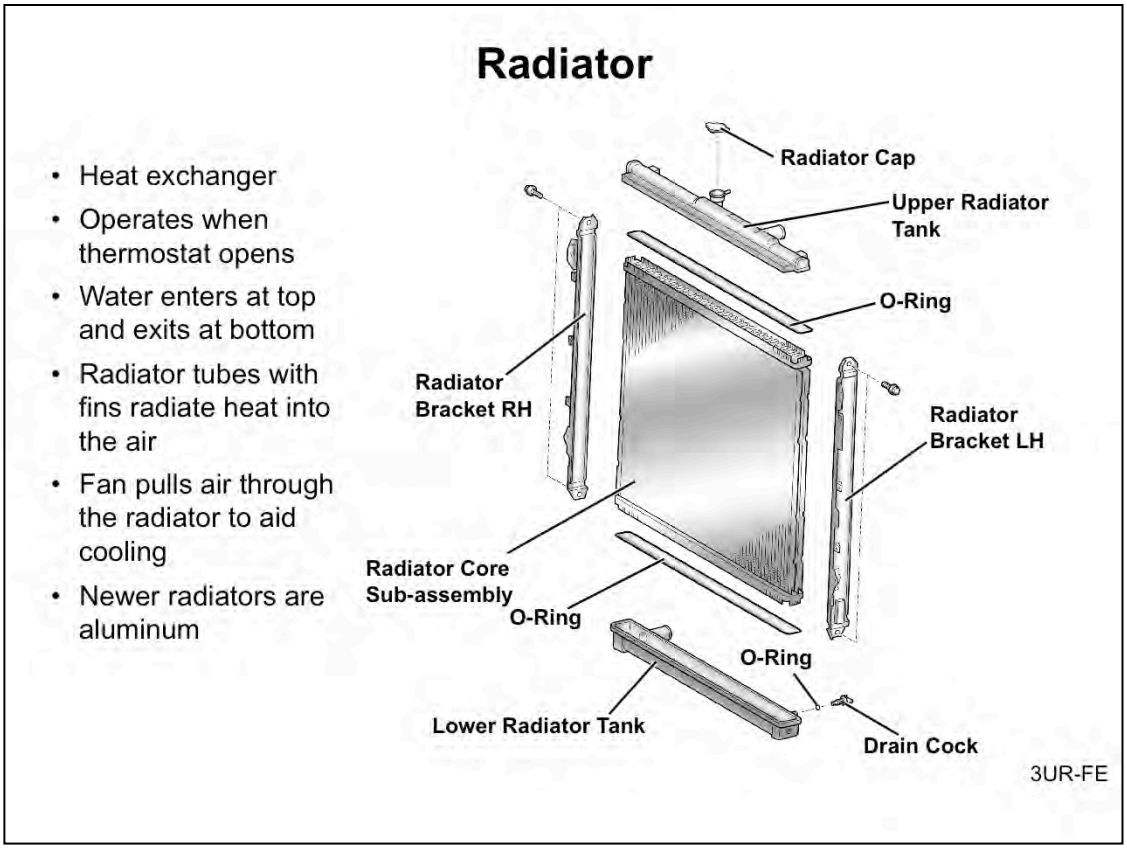
The water pump is belt-driven by the crankshaft. The water pump rotor that forces the coolant through the engine is mounted on a shaft, that is mounted to the housing on a sealed bearing. On the exterior of the water pump, the shaft is attached to the water pump pulley which is driven by the crankshaft. When the bearing begins to fail coolant will slowly begin to leak through the housing. This leak will be noticed coming through the “weep hole.” If and when this condition happens, the water pump must be replaced.



Electric Water Pump The 2ZR-FXE engine (2010 Prius) has one electric water pump. Other hybrid models have both a belt-driven main water pump and a smaller electric water pump. The electric water pump allows coolant to be circulated through the heater core when the engine is off.



Thermostat A thermostat with a bypass valve is located on the water inlet housing. Based on the coolant temperature, the thermostat opens and closes to control coolant flow to the radiator. Its purpose is to regulate coolant temperature for optimum engine operation.

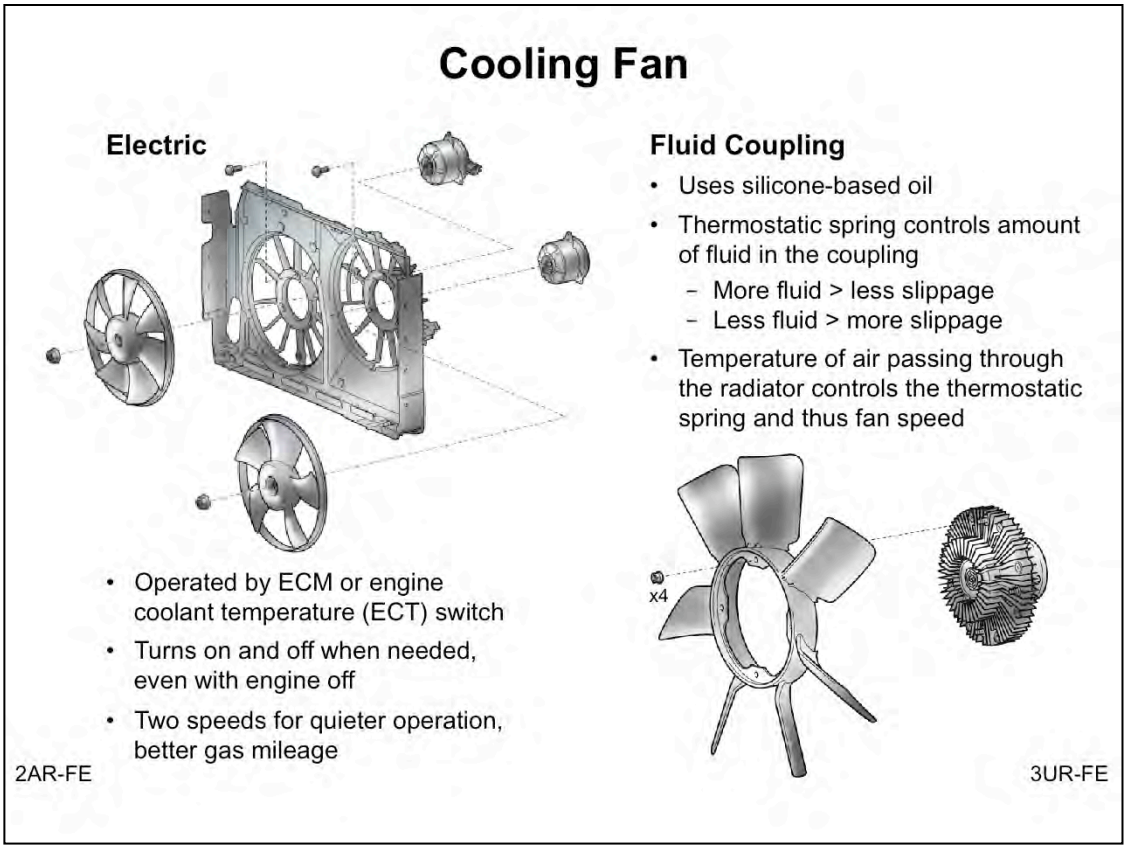


Radiator

The radiator is the heat exchanger for the cooling system. The radiator is made up of an upper and lower radiator tank with hundreds of small pipes connecting them. Between these pipes are thin metal fins.

Coolant flowing through the engine absorbs heat. As hot coolant flows through the radiator, air passes over the fins removing heat. After the heat is absorbed by the atmosphere, the coolant is then routed back to the engine to begin the process again.

For the radiator to operate efficiently, air must be able to pass through the fins and coolant needs to be able to pass through the tubes. Debris on the fins or bent cooling fins will lower the radiator's ability to exchange heat. Internal scaling or impurities will also restrict coolant flow lowering the radiator's performance.



Cooling Fan

Cooling fans operate when coolant temperature reaches a predetermined threshold or when the A/C is on. Fans mounted on back of the radiator (engine side) are designed to pull air through the radiator. Fans mounted in front of the radiator push air through it.

Toyota typically uses two types of cooling fans; electric or fluid coupling. Electric fans are ECM controlled and can have multiple speeds. Fluid coupling fans use a thermostatic spring to control the amount of fluid in the coupling, and thus control the fan speed.

Engine Coolant

Toyota Super Long Life Coolant (SLLC)

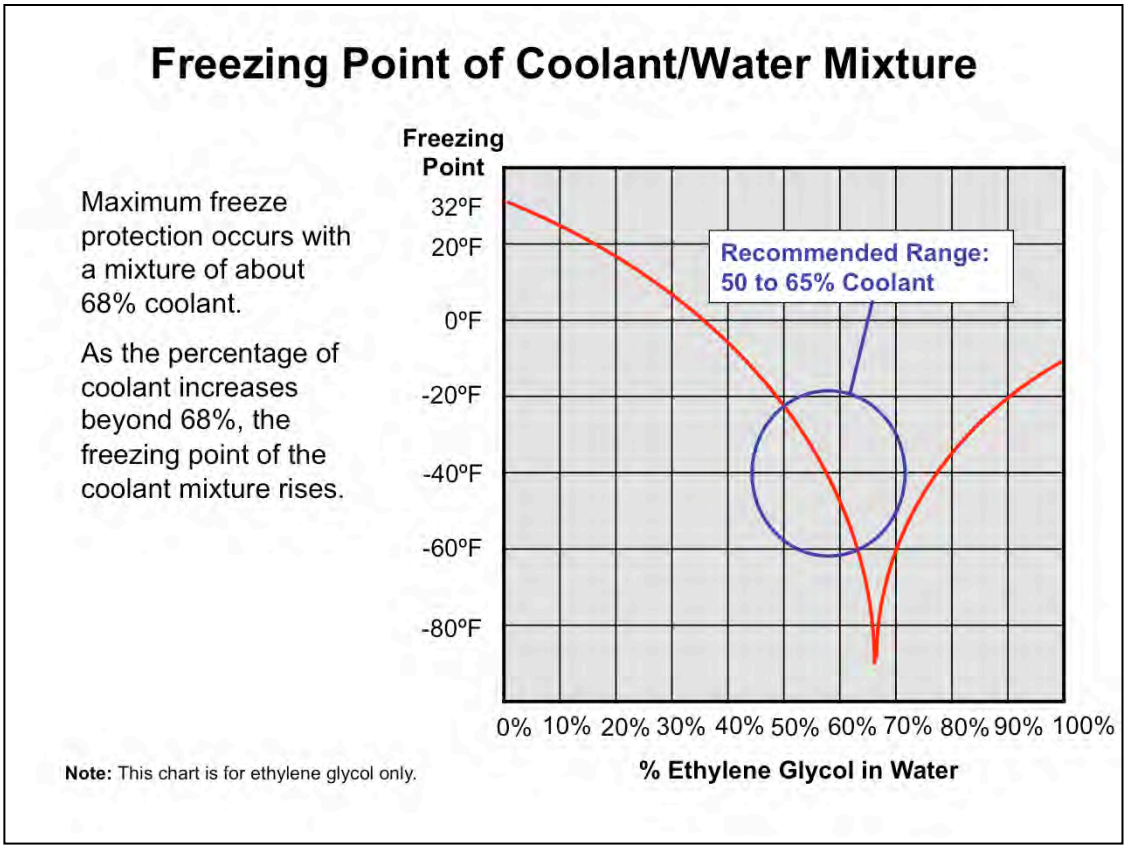
- Provides extended maintenance interval
  - First time maintenance: 100,000 miles
  - Next Maintenance: Every 50,000 miles
- SLLC is pre-mixed:
  - P/N 08889-80070
  - 50% coolant and 50% water
  - Does not need dilution
- If LLC is mixed with SLLC, use the maintenance interval for LLC
  - Every 30,000 miles or 24 months, whichever comes first

Note: Coolant provides lubrication for the water pump.

Engine Coolant

TOYOTA Genuine Super Long Life Coolant (SLLC) is a high quality ethylene-glycol-based, non-silicate, non-amine, non-nitrite and non-borate coolant with long-life hybrid organic acid technology. Coolant with long-life hybrid organic acid technology uses a combination of low phosphates and organic acids.

Pre-mixing the coolant with pure water is what gives SLLC its long life. Do not dilute with water.



Coolant Dilution

Adding coolant to water lowers the water's freezing point. This protects the engine from the damaging effects that can occur from the expansion of water when it turns to ice. Maximum freeze protection occurs with a mixture of about 68% coolant. As the percentage of coolant increases beyond 68%, the freezing point of the coolant mixture actually rises. The recommended range for diluting coolant is to a mixture of 50% to 65% coolant.

Another reason for diluting coolant is that water is much more efficient at removing heat from the engine than coolant. Therefore, including the right percentage of water in the coolant mixture is necessary for optimum cooling system performance.

Effect of Pressure on Boiling Point

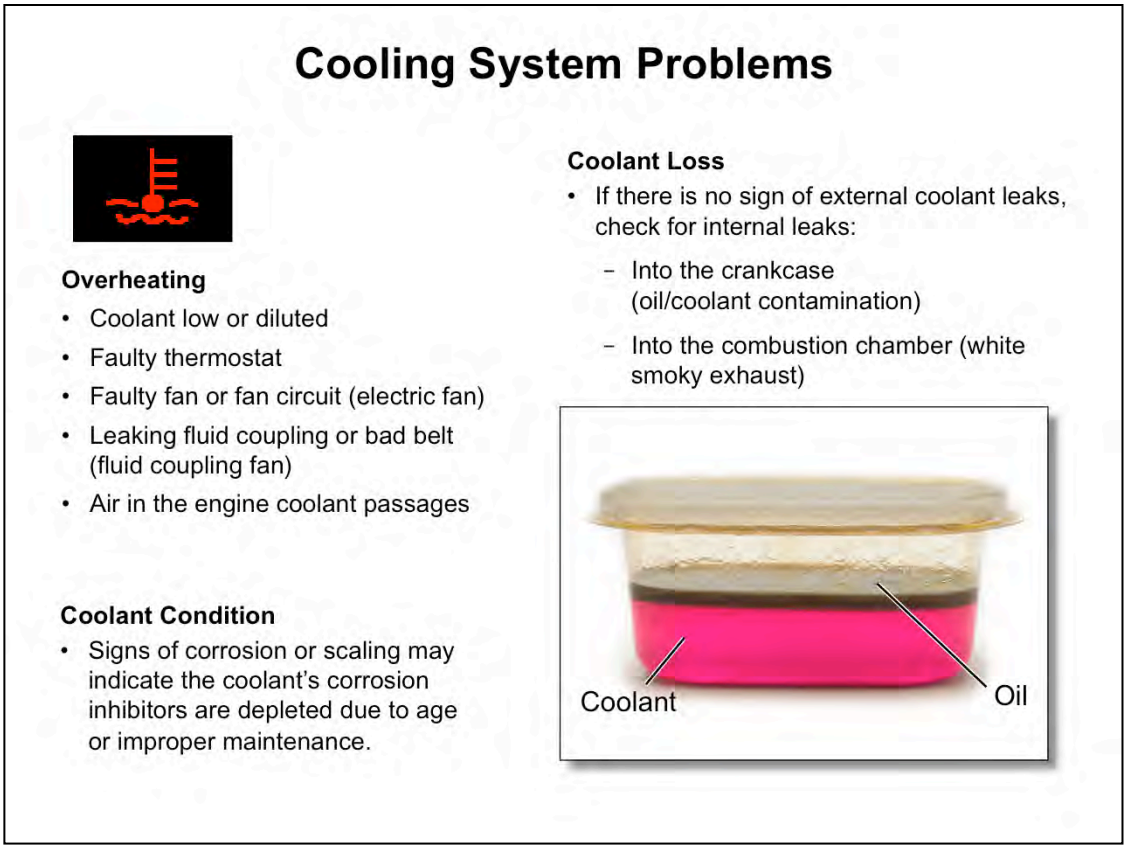
When under pressure, the boiling point of water increases. In fact, the boiling point increases 3º F for each 1 psi of added pressure. Therefore a radiator cap capable of holding 13 psi will increase the water's boiling point to 251º F.

Cooling System Safety

Pressurization of the cooling system is why it is dangerous to loosen the radiator cap when the engine is warmed up. When the pressure is released, the boiling point drops suddenly and the water turns instantly to steam. Because of the amount of calories of heat water must absorb to turn into steam, steam burns are much worse than burns from boiling water.

CAUTION

Before loosening the radiator cap, carefully test the radiator hose to see if it is hot. If it is not too hot to touch, squeeze it with your hand to determine if the radiator system is pressurized. Do not loosen the radiator cap until you are sure the radiator system has cooled.



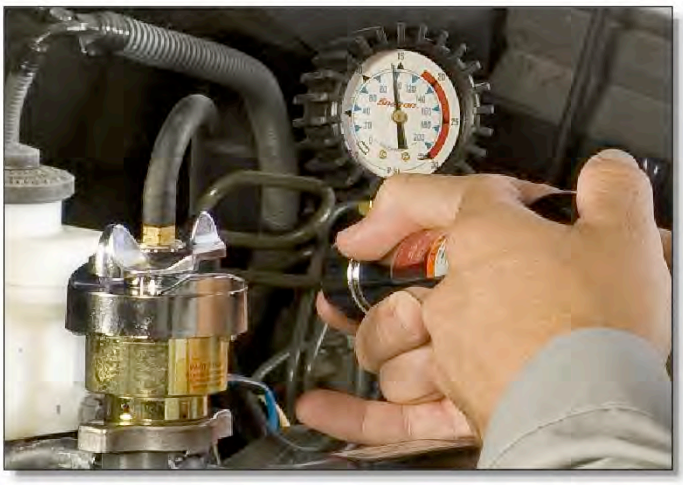
Cooling System Problems

Heat is very detrimental to the internal combustion engine. If the cooling system does not do its job and the engine is allowed to operate at temperatures higher then normal, then components and fluids such as oil will start to break down and eventually fail. A properly operating cooling system is very important for the long life of an engine, and it's your job to ensure the cooling system is operating properly.

Coolant Leak Test

After filling the radiator and reservoir with coolant, attach a radiator pressure tester.

Pump the radiator pressure tester to 17.1 psi, and check that the pressure does not drop.



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- If the pressure drops, check the hoses, radiator and water pump for leakage.
- If there are no signs of external coolant leaks, check the heater core, cylinder block and head.

Coolant Leak Test

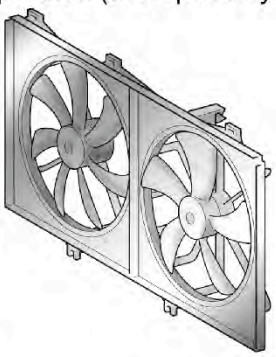
The cooling system is designed to operate under pressure. This pressure is regulated by the radiator cap. Water normally boils at 212 degrees F, but increasing the pressure in the cooling system raises the boiling point and allows the cooling system to operate above 212 degrees F.

When testing cooling systems for leaks, it is important to simulate the same operating conditions. To do this a cooling system tester pressurizes the system to enable technicians to check for leaks and verify the system can hold pressure.

Cooling Fan Inspection

Electric Fan Inspection

- Visual inspection
- Techstream active test
- Observe operation:
  - When temp sensor is disconnected
  - When engine is warm
- Observe speed difference when A/C is operated (two-speed system)



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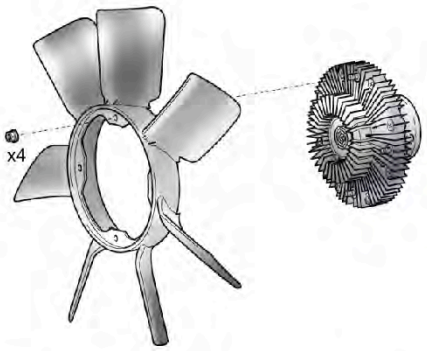


Fan Fluid Coupling Inspection

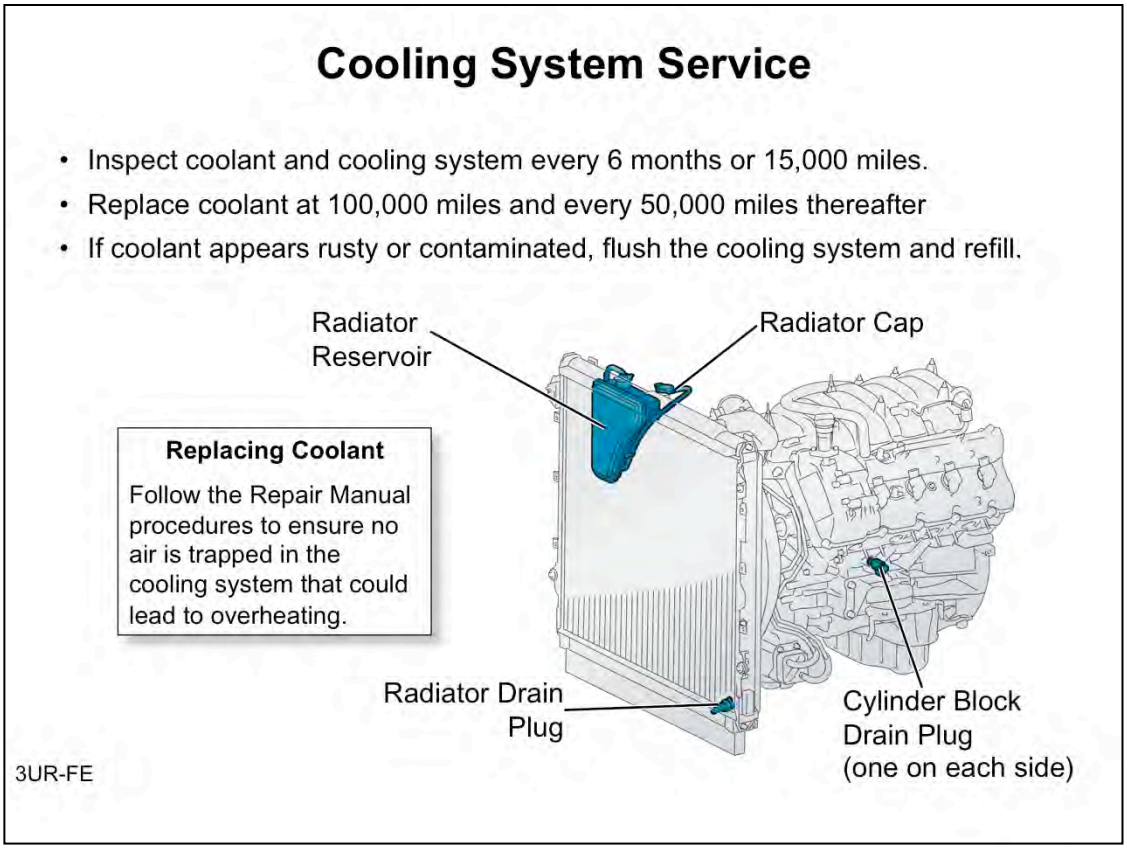
- Check the fluid coupling for damage or silicon oil leaks.

3UR-FE

Cooling Fan Inspection

To inspect the cooling fan, allow the engine to reach operating temperature and verify the cooling fan is activated when the cooling system temperatures start to rise above normal. You may need to hold the engine RPM above idle to raise cooling system temperatures above normal.

Depending on vehicle model and year, electric fans may be activated through Techstream. This will ensure the fan functions and can be operated by the ECM. However, this does not confirm the ECM will trigger the fans under the proper operating conditions. Always allow the cooling system to reach normal operating conditions and verify the fans are activated.



Cooing System Service

When servicing the cooling system; drain and refill the radiator with the proper Toyota genuine coolant. SLLC comes premixed with water; do not dilute.

To ensure proper cooling system operation, all air must be purged from the system:

- Squeeze both inlet and outlet radiator hoses and recheck the level in the radiator. If low, add coolant to the reservoir and replace the radiator cap.
- Start the engine and allow the engine to reach operating temperature. If coolant temperature exceeds normal operating temperatures, stop the engine and wait for it to cool down. Check coolant level, refill reservoir and restart.

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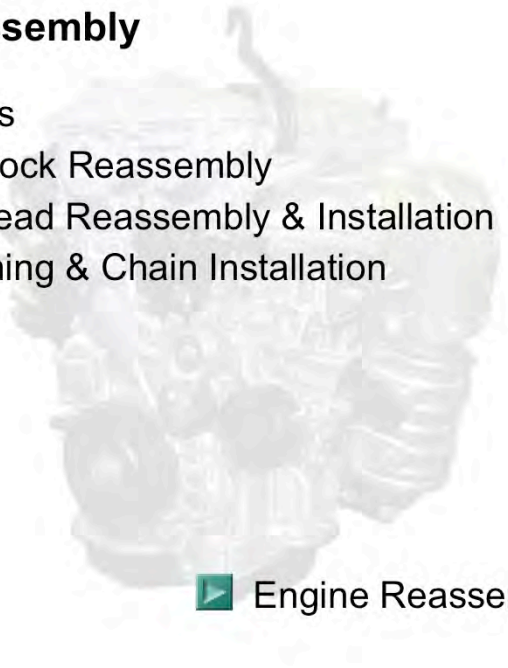
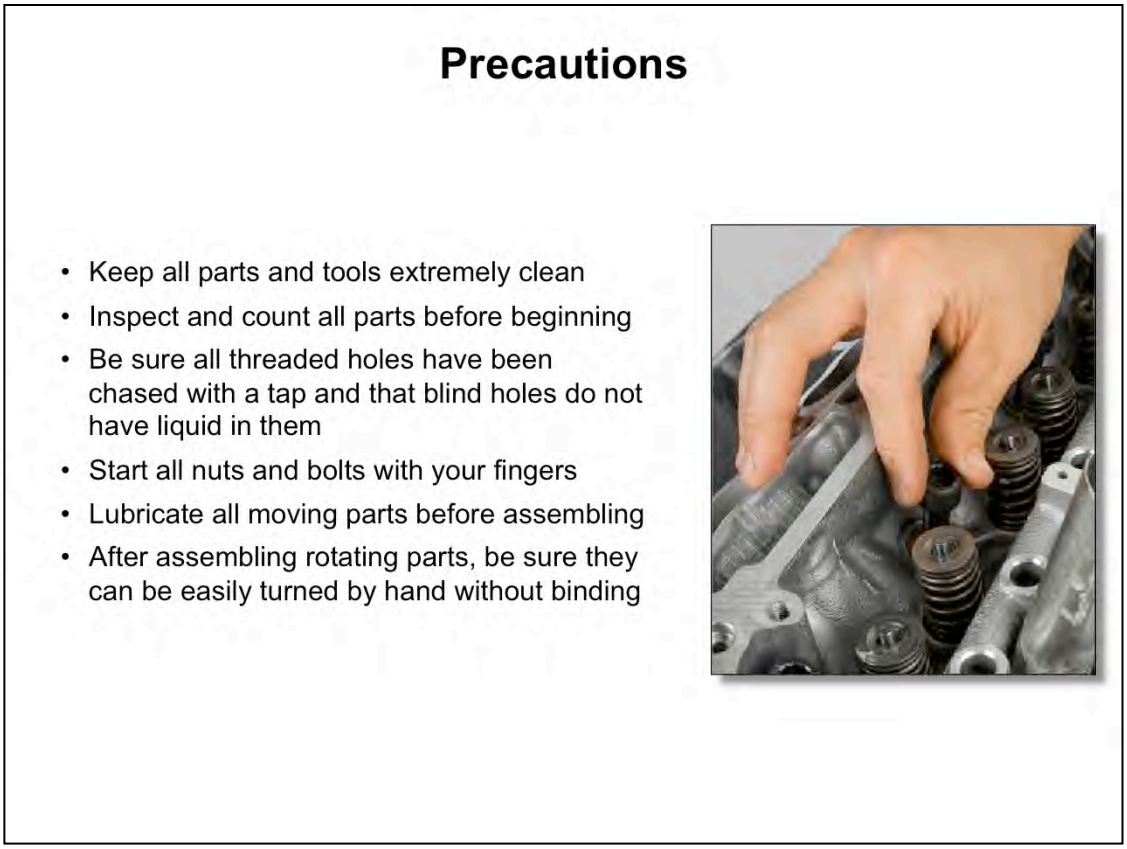
Section 9 Topics

Engine Reassembly

- Precautions
- Cylinder Block Reassembly
- Cylinder Head Reassembly & Installation
- Engine Timing & Chain Installation



- Engine Reassembly Worksheet



Engine Reassembly Precautions

Keep all parts and tools extremely clean.

- Dirt or contaminants in the engine can cause premature wear or failure.
- When you stop working on the engine, put a clean cover over it.

Inspect and count all parts before beginning to avoid discovering:

- An extra bolt or piston ring AFTER assembly.
- You don't have all the parts you need to complete the job.

Be sure all threaded holes have been chased with a tap.

- Use antiseize on bolts threaded into aluminum to prevent corrosion.

Start all nuts and bolts with your fingers.

- If a bolt or nut won't turn by hand, don't force it.
- Figure out what the problem is.

Lubricate all moving parts before assembling.

- The engine will have no lubrication for the first few seconds after it is first started.

Cylinder Block Reassembly - Overview

Overview of Procedure

- Install stud bolts
- Install oil jets
- Assemble pistons and connecting rods
- Install piston rings
- Install crankshaft and main bearings
- Install pistons and connecting rod bearings
- Install oil pan

Note: This section does not cover every step in the engine reassembly procedure. It focuses on selected steps only.

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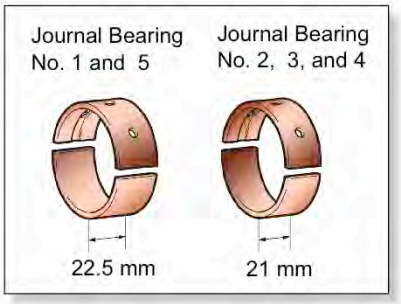
NOTES:

Crankshaft and Bearing Installation

General

- Clean each main journal and bearing before installation
- Do not apply engine oil to the cylinder block contact surfaces.
- Install 22.5mm bearings at journals No. 1 and 5; install 21mm bearings at journals No. 2, 3, and 4.



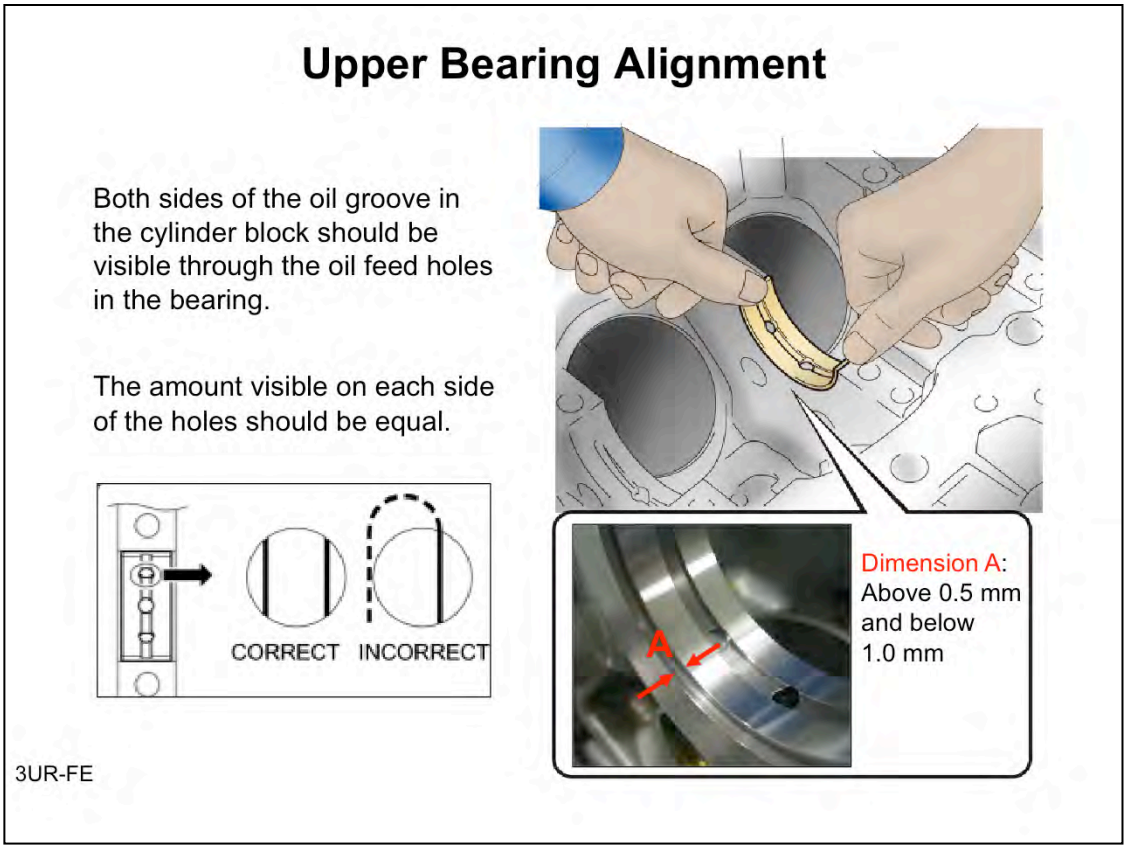
Note: Do not allow coolant to come into contact with the bearing inner surface. If any coolant comes into contact with the bearing inner surface, replace the bearing with a new one.

3UR-FE

Crankshaft and Bearing Installation

Be sure to use the correct select fit bearings for each journal. Bearings may be different sizes on the front and rear journals compared to the middle journals. Be sure to install the bearing with the oil holes toward the cylinder block and not the bearing cap. This is a crucial step to ensure oil is fed to that journal. Do not apply oil to the back of the bearing surface or to the mating surface of the cylinder block.

When installing the crankshaft, apply a light coat of engine oil to the inner bearing surface and gently install the crankshaft. Once the crankshaft is installed and the bearing caps are temporarily installed, insert the thrust bearings.



Upper Bearing Alignment Since bearings no longer have an alignment tang, they must be centered in the journal. Make sure the oil supply hole properly lines up with the feed holes in the bearing. Use a caliper (depth measurement) to center the bearing in the journal.

Lower Bearing Alignment

Using a Vernier caliper, measure the distance between the bearing cap's edge and the lower bearing's edge.

"A" and "B" must be equal or within 0.7mm of being equal.

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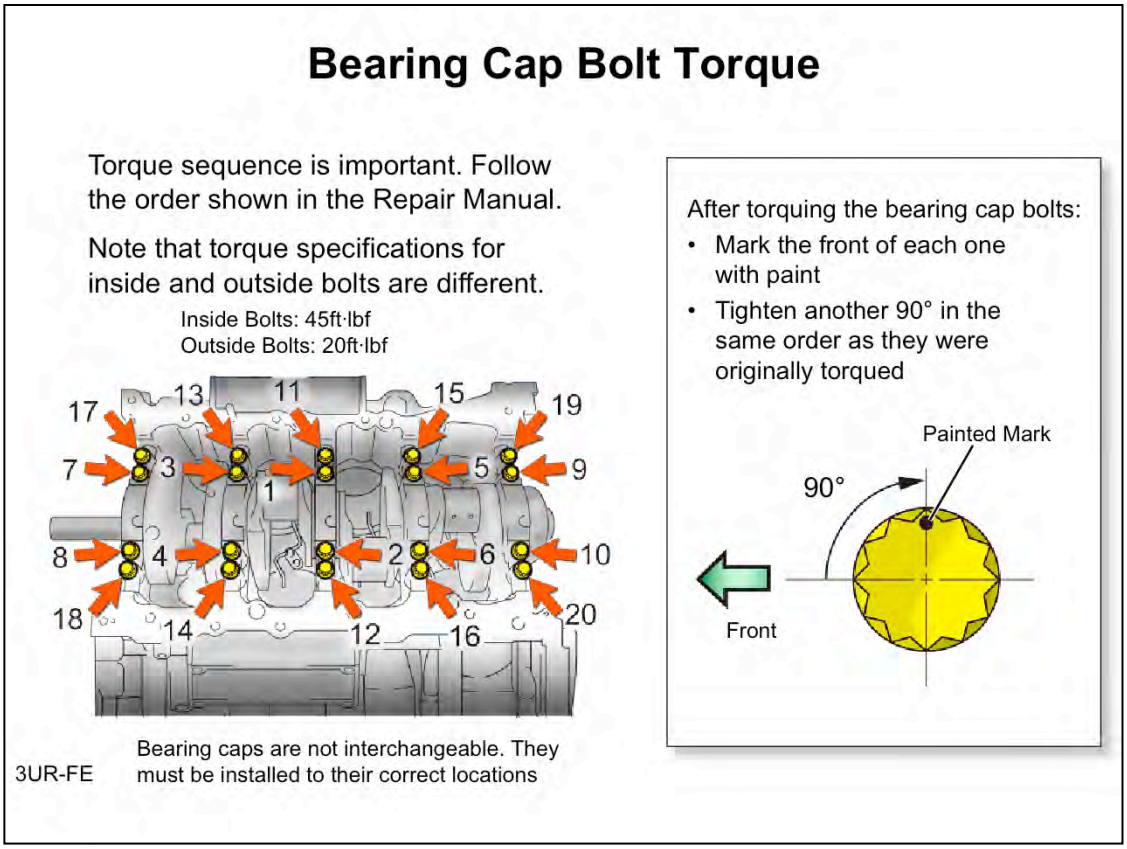
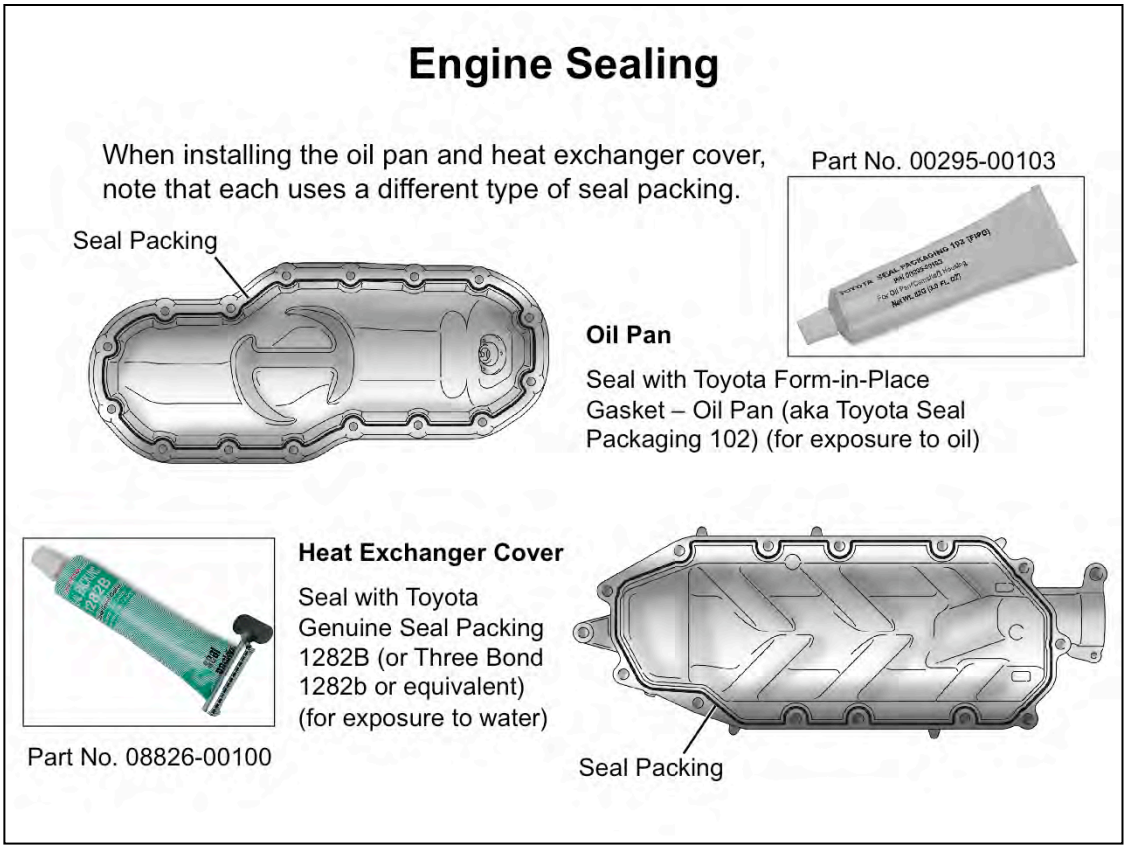
Lower Bearing Alignment

Do not apply engine oil to the back side of the bearing. There are no moving parts on the back side of the bearing and the oil will interfere with heat transfer.

Use a caliper to measure the depth on either side of the bearing. The measurement on either side of the bearing should be within 0.7mm of each other.



Bearing Cap Bolt Torque With all main caps temporarily installed, torque the main cap bolts in sequence. This torque procedure ensures the crankshaft is not damaged during installation. Stretching the bolts ensures the proper spring tension to keep the bolt from loosening over time.

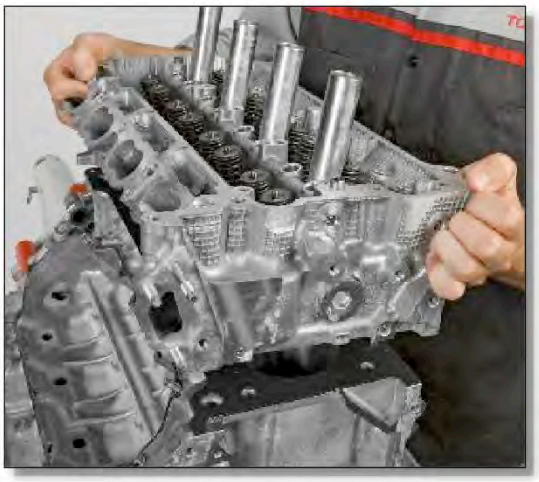


Engine Sealing Make sure the sealing surface is extremely clean and the proper sealant is used. Apply the specified amount of FIPG only in the areas specified in the Repair Manual. Follow the recommendations in the Repair Manual for setup and cure time. Do not fill with fluid or operate engine for at least two hours after applying sealant.

Cylinder Head Installation - Overview

Overview of Procedure

- Install cylinder head gasket
- Install cylinder head
- Install valve train components
- Install camshaft housing subassembly
- Install camshaft



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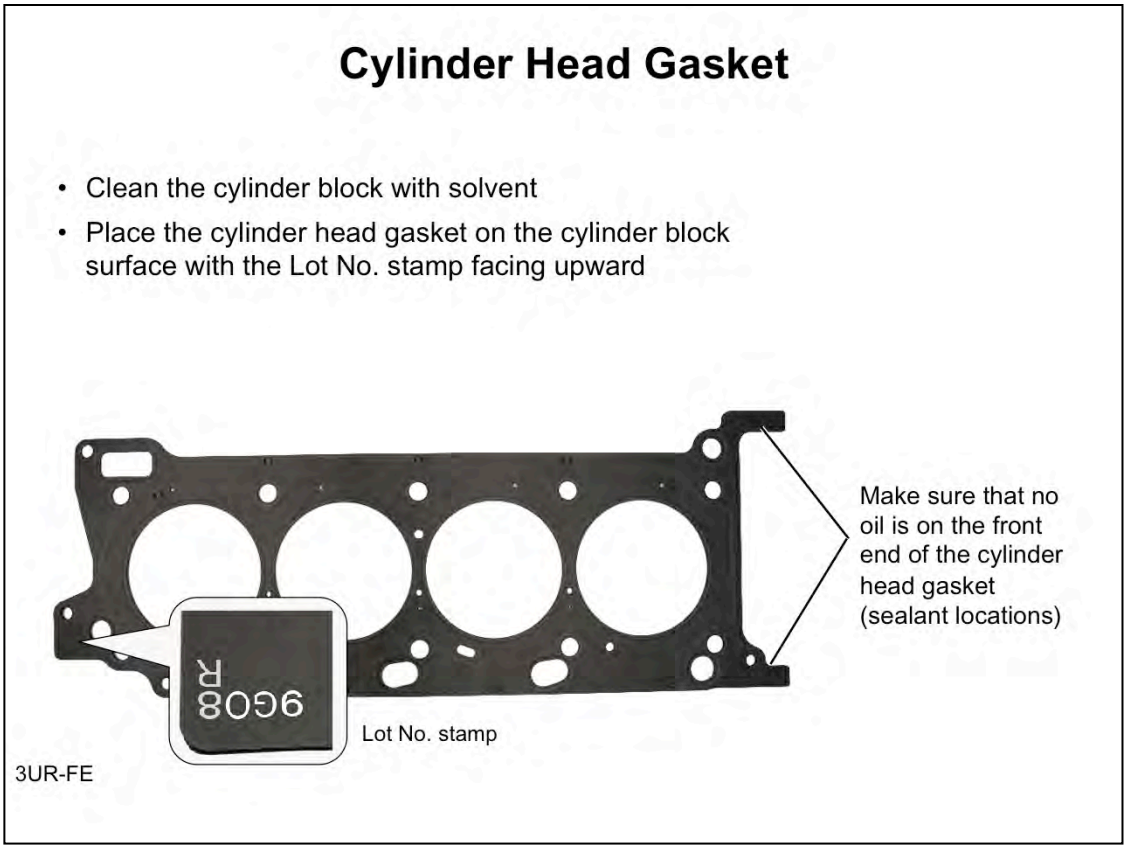
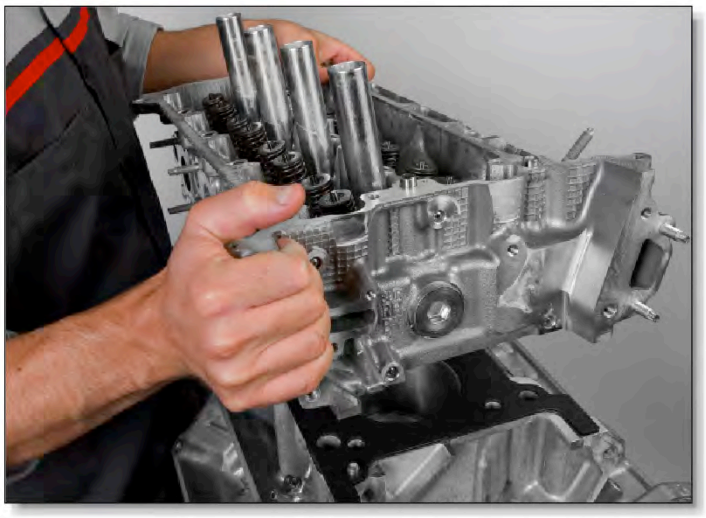


Cylinder Head Gasket

The cylinder head gasket is one of the most important gaskets in the engine. This gasket is under extreme pressure and temperatures. The cylinder head gasket has passages that allow oil and coolant to flow from the cylinder block to the cylinder head and back again which makes installing the correct gasket very important. When installing the cylinder head gasket be sure to reference the Lot No. stamp to determine the side and orientation of the gasket. DO NOT reuse cylinder head gaskets.

Cylinder Head Installation

- Make sure that no oil is on the mounting surface of the cylinder head.
- Gently place the cylinder head on the cylinder block so as not to damage the gasket.



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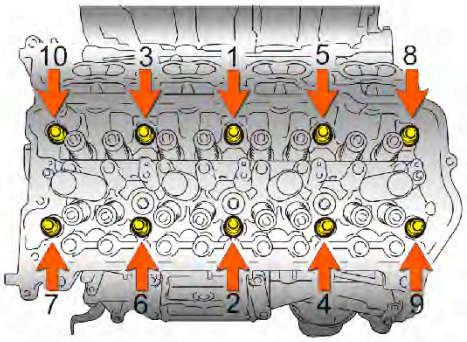
Cylinder Head Installation

Be sure all surfaces are clean and dry before installing the cylinder head. Make sure the alignment pins are in place and gently place the cylinder head on the cylinder block without causing any damage to the gasket.

Torquing the Head Bolts

- Apply a light coat of engine oil to the threads and under the heads of the cylinder head bolts
- In the sequence given in the Repair Manual, install and uniformly tighten the cylinder head bolts with the plate washers in 3 progressive steps



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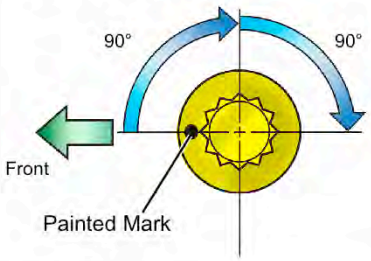
Torque: 27ft·lbf

After torquing the cylinder head bolts:

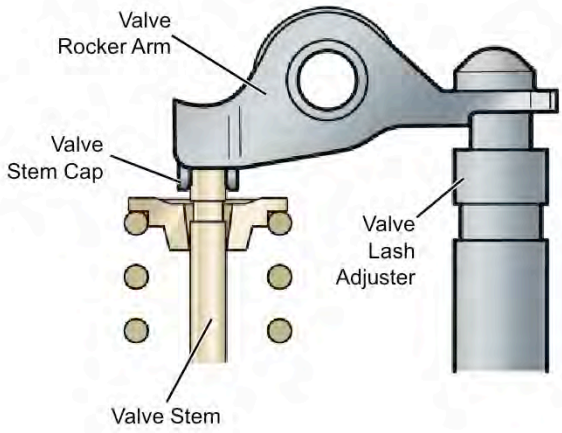
- Mark each cylinder head bolt with paint as shown in the illustration.
- Tighten the cylinder head bolts another 90° in the original tightening sequence
- Tighten the cylinder head bolts again an additional 90° in the original tightening sequence



Torquing Head Bolts DO NOT short cut this step. As mentioned in the beginning of this course, the cylinder head is the roof of the cylinder block and when in operation is under extreme pressure. The torque sequence is divided into three steps to ensure the cylinder head is tightened evenly. This ensures the cylinder head gasket is compressed evenly as well. The 90 degree turns in addition to the torque provides the stretch tension. This stretch or spring tension from the bolts keeps the bolts from working loose over time.

Installing Valvetrain Components

- Apply a light coat of engine oil to the valve stem caps and install them on the valve stems
- After inspecting the valve lash adjusters, install them in the cylinder head
- Apply engine oil to the lash adjuster tips and valve stem cap ends, then install the valve rocker arms



Note: Install the same parts in the same combination to their original locations.

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Installing Valvetrain Components

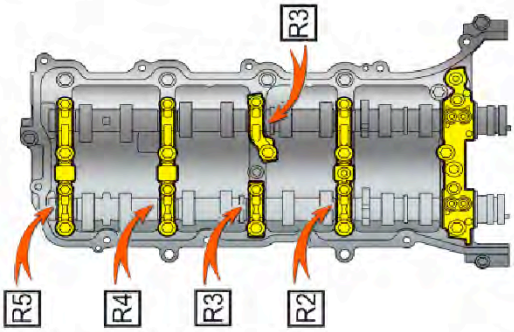
Do not use force to install any valvetrain components. Valve lash adjusters should slide easily into the bore. Lightly coat with oil prior to installing.

NOTE

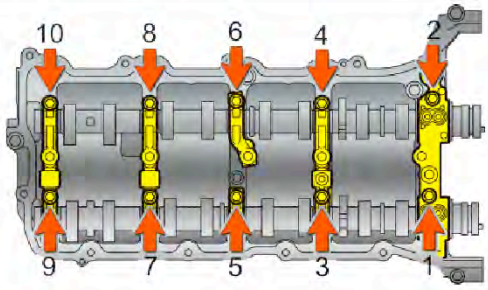
Use extreme caution when installing valve stem caps. They are extremely small and if dropped could fall into oil return holes in the cylinder head.

Installing Camshafts

- Apply a light coat of engine oil to the camshaft journals, camshaft housings and bearing caps
- Install the No. 1 and No. 2 camshafts to the camshaft housing
- Confirm the marks and numbers on the camshaft bearing caps and place them in their proper positions and directions



- Temporarily install the bearing cap bolts in the order shown in the Repair Manual.



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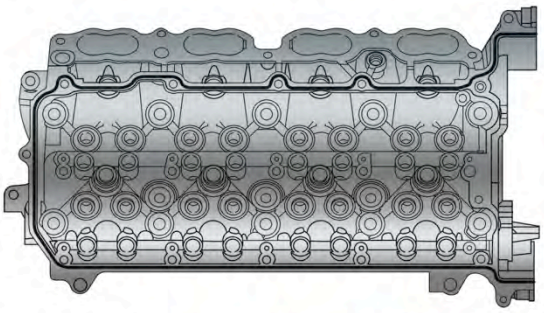
Installing Camshafts

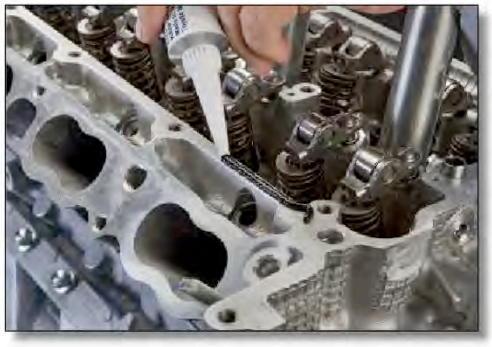
Make sure the intake and exhaust camshafts are installed in the proper orientation. Bearing caps should be installed in the same places from which they were removed. Bearing caps have numbers as well as arrows to aid in installation.

Tighten the bearing cap bolts with the subassembly on the bench, but do not torque. Final torque is done when the subassembly is installed on the cylinder head.

Camshaft Housing Subassembly Sealing

- Remove any oil from the contact surface
- Apply seal packing in a continuous line as specified in the Repair Manual
- Install the camshaft housing within 3 minutes
- Tighten the bolts within 15 minutes after applying seal packing





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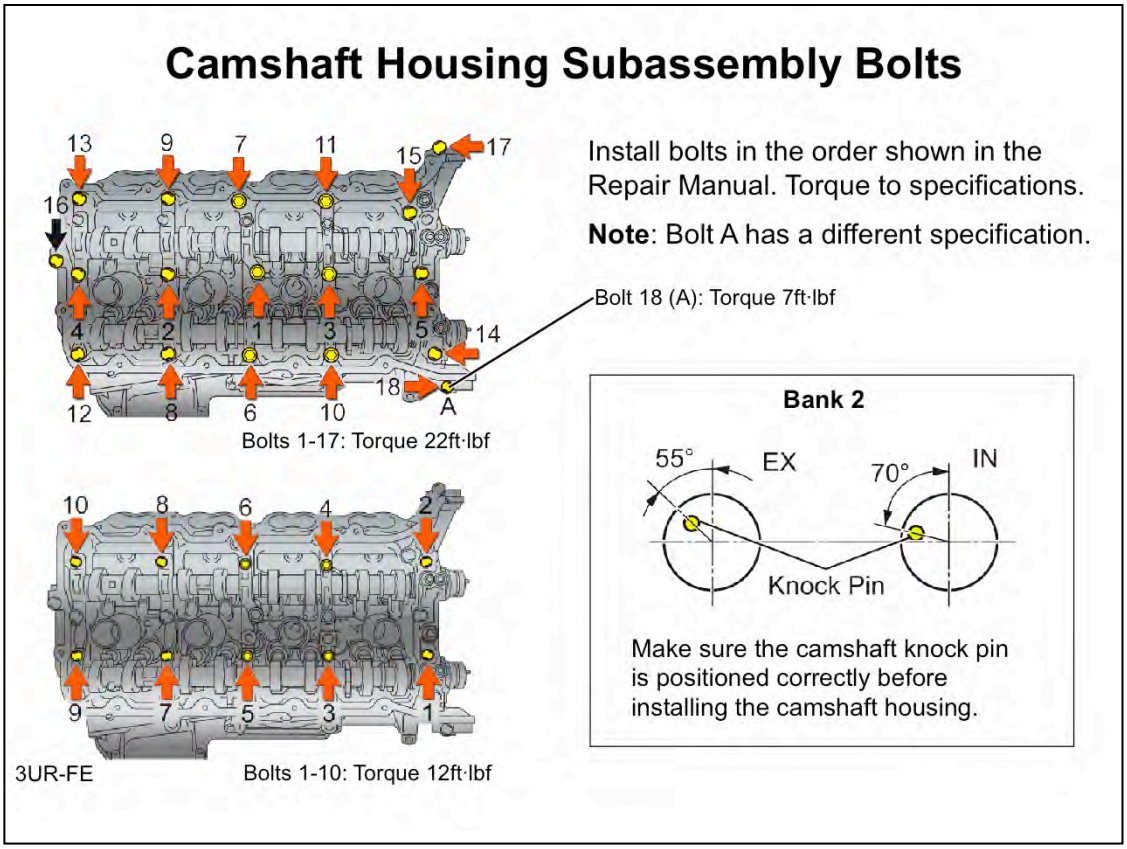
Camshaft Housing Subassembly Sealing

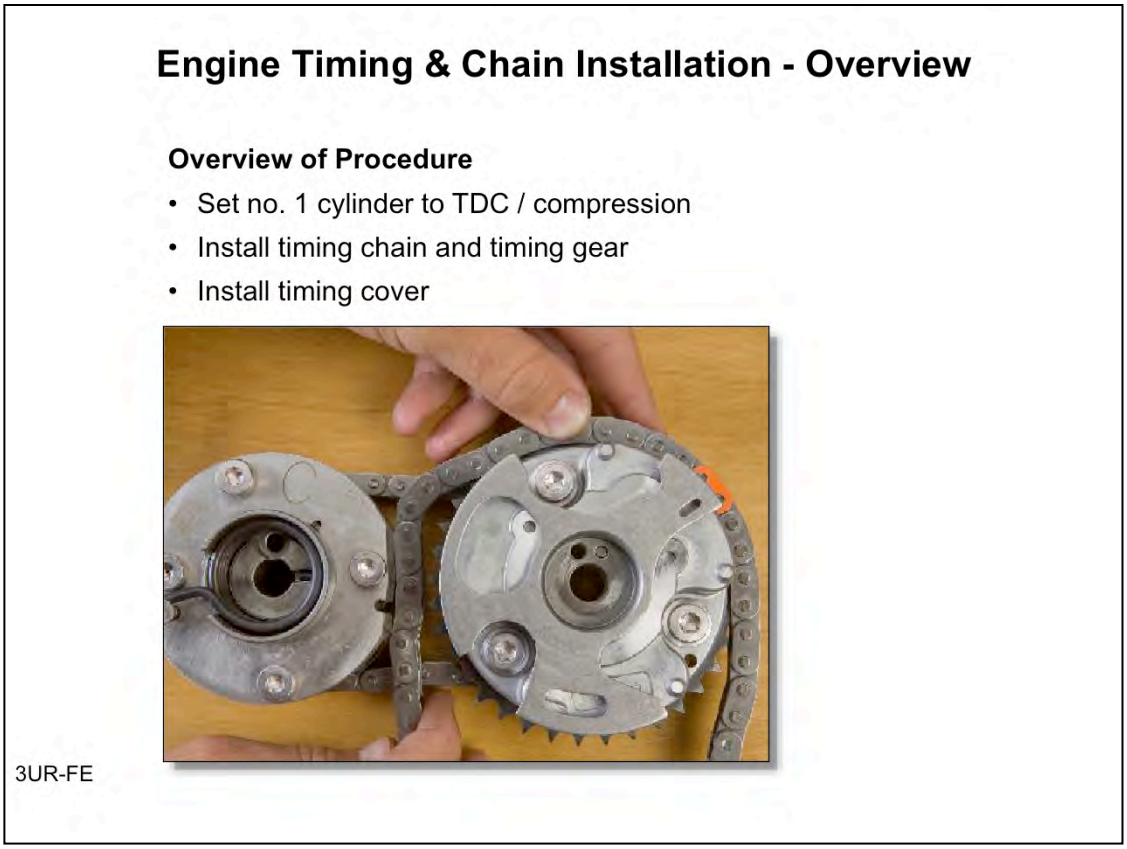
The cylinder head as well as the camshaft housing subassembly has various oil passages which feed crucial oil to components. It is extremely important to only apply sealer in the areas referenced in the Repair Manual. If sealant is misapplied to areas near oil passages, they may become clogged, and possible component or engine failure my result.



Camshaft Housing Subassembly Bolts

When installing the camshaft housing subassembly, it is extremely important to rotate the camshafts to the positions shown in the Repair Manual. This ensures the lobes on the camshaft are in the relaxed position when they contact the rocker arms. This also minimizes the pressure on the subassembly during the torque sequence.

As with the cylinder head, the camshaft housing must be torqued evenly to avoid warpage or possible fracture to the camshafts or the housing itself. Refer to the Repair Manual for proper torque specification and sequence.



Engine Timing & Chain Installation

Engines with timing chains use a slightly different concept for timing compared to earlier engines with timing belts.

Timing belt engines used marks on the cylinder head and block aligned with timing marks on the gears themselves. The gears were then held in place and the belt was installed.

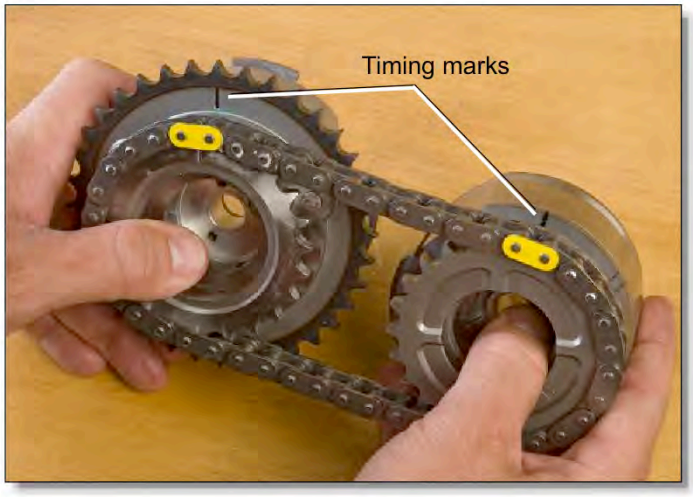
Timing chain engines typically do not align the gears to any particular marks on the cylinder block or heads, but instead focus mainly on the number of links between marks on the timing gears (crankshaft and camshaft gears). If the chain is set to the correct marks on the timing gears then installed on the crankshaft key and camshaft knock pins the engine will be in time regardless of the cylinder or camshaft positions.

CAUTION

Always use caution when rotating camshafts or crankshaft when they are not properly synchronized by the timing chain. Rotating the crankshaft or camshafts independently may cause valves to come in contact with pistons resulting in damage.

Installing No. 2 Timing Chain

- Align the No. 2 chain's mark plates (yellow) with the timing marks of the camshaft timing gear and camshaft timing exhaust gear
- Attach the No. 2 chain to the gears



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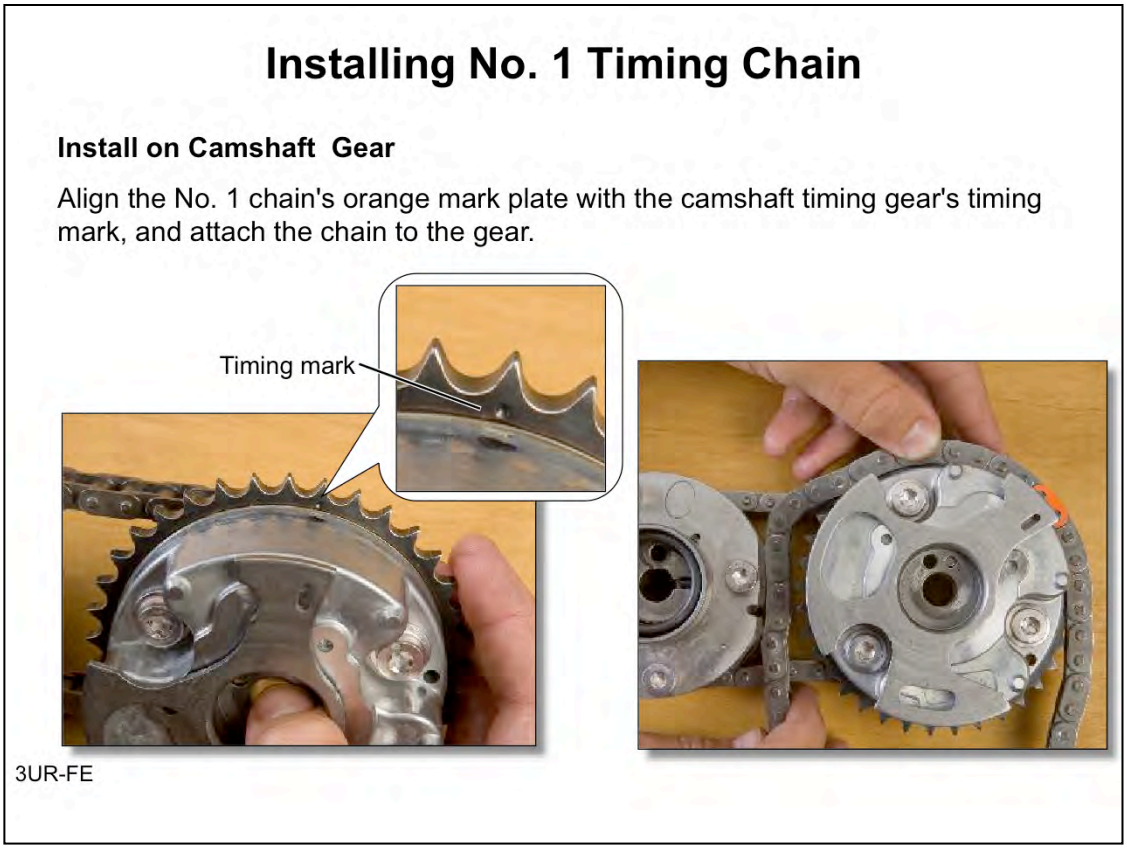
Note: The crankshaft timing gear and camshaft exhaust gear will be installed to the camshaft with the No. 1 and No. 2 chains connected to the gears.

Installing No. 2 Timing Chain

The No. 2 chain times the intake camshaft to the exhaust camshaft. Some timing gear actuators are used on multiple engine lines and have multiple timing marks. The correct timing mark to use depends on the particular engine model, and may vary between cylinder banks. Be sure to use the proper timing marks illustrated in the Repair Manual, or verify the correct marks before disassembly.



Installing No. 1 Timing Chain

The No. 1 chain (the primary timing chain) times the camshaft timing gears to the crankshaft. This chain may have two orange links or four orange links.

As with the No. 2 chains, it is highly advisable to note which timing marks are used before disassembly.

Installing No. 1 Timing Chain

Install on Crankshaft Gear

Align the No. 1 chain's second orange mark plate with the crankshaft timing gear's timing mark, and attach the chain to the gear.

3UR-FE

Install Crankshaft Gear Be sure to install the crankshaft gear with the alignment dot facing out. Do not lubricate the timing gear or apply any sealers. The timing gear should slide onto crankshaft easily. Do not force the timing gear onto the shaft. Be sure the crankshaft is clean and the crankshaft keys are properly in place.

Installing Timing Gears

- Install the crankshaft timing sprocket to the crankshaft
- Align and attach the knock pin of the No. 1 camshaft with the pin hole of the camshaft timing gear

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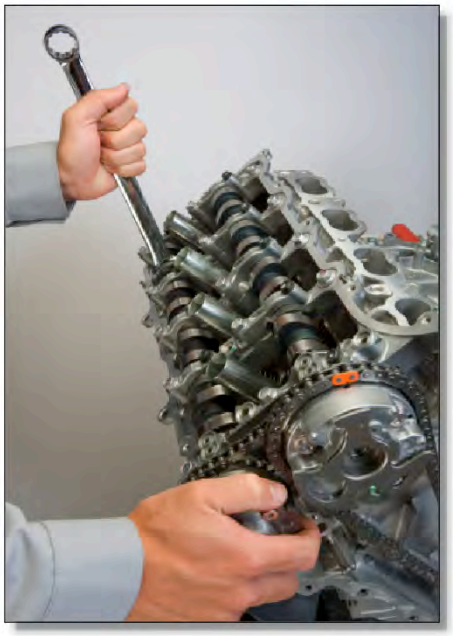
Installing Timing Gears

With the camshaft knock pins in the orientation stated in the Repair Manual, they will not always be in perfect alignment with both timing gears. Therefore, when placing both timing gears on the camshaft, first apply slight pressure to the intake timing gear while rotating it back and forth slightly until you feel the knock pin slide into the gear.

Installing Timing Gears

- Using the hexagonal portion of the No. 2 camshaft, align and attach the knock pin of the No. 2 camshaft with the pin hole of the camshaft timing exhaust gear



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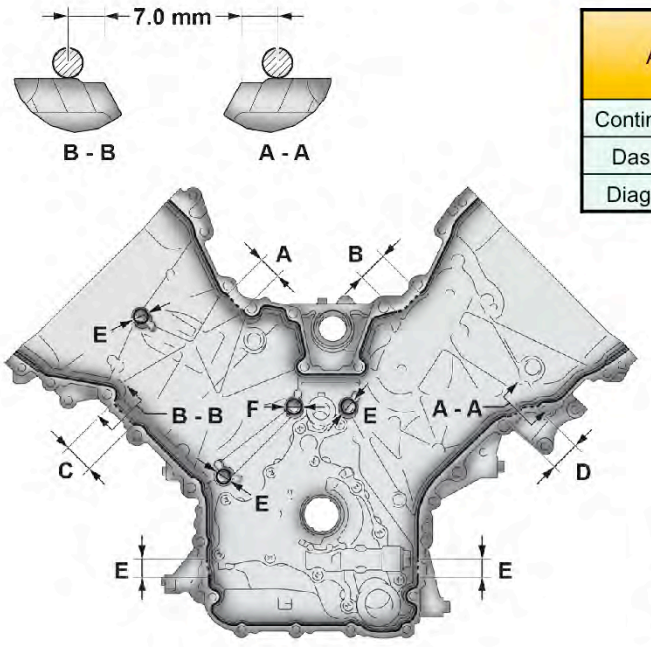
Installing Timing Gears (cont'd)

After the intake timing gear is properly placed on its camshaft, rotate the exhaust camshaft back and forth with a wrench while applying slight pressure to the exhaust timing gear until the knock pin slides into place.

When tightening the timing gear bolts, DO NOT use air tools. Always support the camshaft with a wrench to keep the camshaft from turning, and refer to the Repair Manual for the proper torque specification.

Timing Chain Cover Seal Packing



Area	Seal packing diameter	Distance from edge of cover
Continuous line	3.0 – 4.0 mm	2.5 mm
Dashed line	6.4 mm+	7.0 mm
Diagonal line	3.0 – 4.0 mm	5.5 mm

A: 27.5 mm
B: 32.5 mm
C: 35.0 mm
D: 34.5 mm
E: 16.0 mm
F: 18.0 mm

Continuous line area
Dashed line area
Diagonal line area

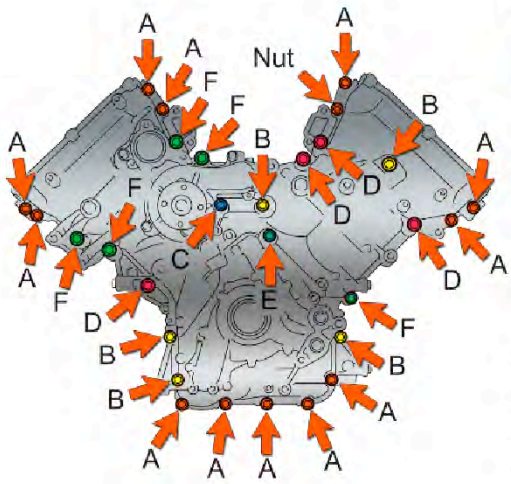
Timing Cover Installation

When installing the timing cover, be sure (as with all other mating parts) that the mating surfaces are clean and dry.

Timing covers house several integral components that may need new o-rings or additional gaskets.

It is advisable to do a trial fitting of the timing cover to the engine before applying sealer. This allows you to align the oil pump rotor spline and crankshaft without having to work around sealer.

Installing Timing Chain Cover



Note the different bolt sizes.

Item	Length	Thread Diameter	Qty
Bolt A	25 mm (0.984 in.)	8 mm (0.315 in.)	12
Bolt B	55 mm (2.17 in.)	8 mm (0.315 in.)	5
Bolt C	70 mm (2.76 in.)	8 mm (0.315 in.)	1
Bolt D	35 mm (1.38 in.)	10 mm (0.394 in.)	4
Bolt E	55 mm (2.17 in.)	10 mm (0.394 in.)	1
Bolt F	80 mm (3.15 in.)	10 mm (0.394 in.)	4

- Make sure that there is no oil on the bolt threads
- Follow the tightening sequence specified in the Repair Manual
- After the installation, if the seal packing has seeped out at the areas labeled A in the illustration, wipe it off.

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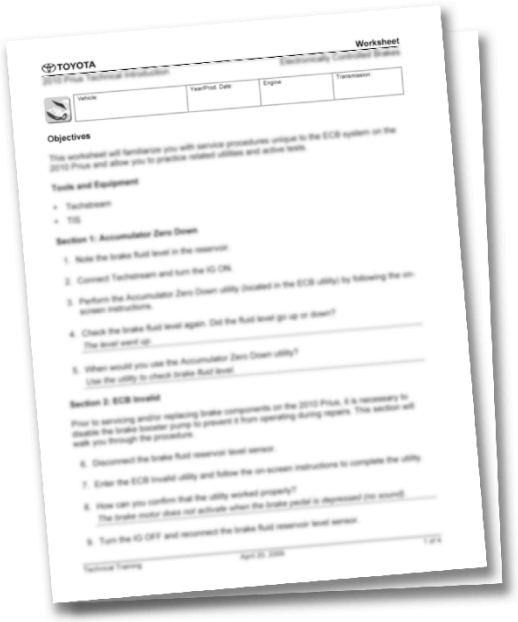
Bolt Chart The Repair Manual includes a bolt placement chart that is extremely helpful for making sure bolts are installed in their correct locations.

Worksheet

Engine Reassembly

In this worksheet you will use Repair Manual procedures to reassemble the engine unit.


TOYOTA
Worksheet
Electronically Controlled Brakes
2010 Prius Technical Introduction
Vehicle
Year/Prod. Date
Engine
Transmission
Objectives
This worksheet will familiarize you with service procedures unique to the ECB system on the 2010 Prius and allow you to practice related utilities and active tests.
Tools and Equipment
• Techstream
• TIS
Section 1: Accumulator Zero Down
1. Note the brake fluid level in the reservoir.
2. Connect Techstream and turn the IG ON.
3. Perform the Accumulator Zero Down utility (located in the ECB utility) by following the on-screen instructions.
4. Check the brake fluid level again. Did the fluid level go up or down?
The level went up.
5. When would you use the Accumulator Zero Down utility?
Use the utility to check brake fluid level.
Section 2: ECB Invalid
Prior to servicing and/or replacing brake components on the 2010 Prius, it is necessary to disable the brake booster pump to prevent it from operating during repairs. This section will walk you through the procedure.
6. Disconnect the brake fluid reservoir level sensor.
7. Enter the ECB invalid utility and follow the on-screen instructions to complete the utility.
8. How can you confirm that the utility worked properly?
The brake motor does not activate when the brake pedal is depressed (no sound).
9. Turn the IG OFF and reconnect the brake fluid reservoir level sensor.
Technical Training
April 20, 2009
1 of 4

Use this space to write any questions you may have for your instructor.

NOTES:

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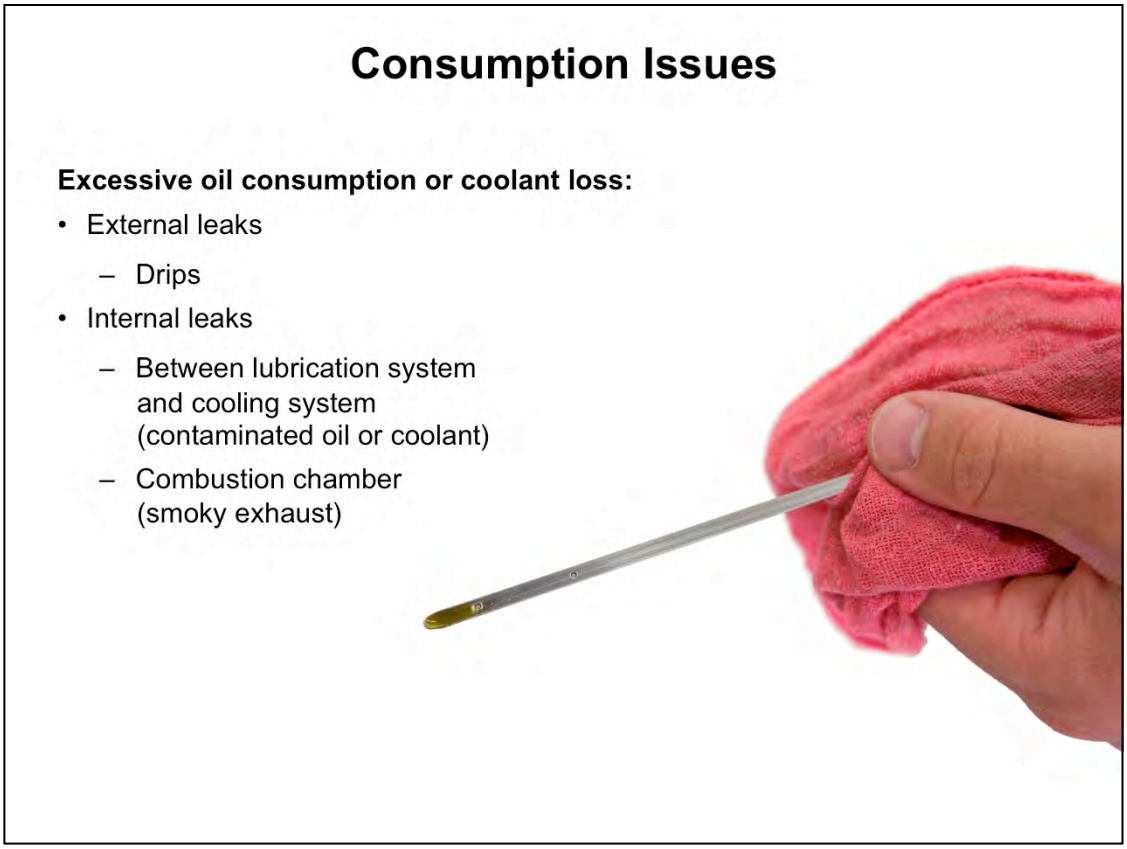
Section 10 Topics

General Engine Mechanical Diagnosis

- Consumption Issues
- Leak Inspection
- Exhaust Discoloration
- Noise and Vibration
- Compression Loss
- Diagnostic Tests
  - Diagnosis Theory Worksheet
  - Compression Test Worksheet
  - Cylinder Leakage Test Worksheet



Consumption Issues

Operating a vehicle while it's low on oil or coolant can result in serious engine damage. With extended oil change intervals and low viscosity oils, consumption issues or leaks can turn into very costly repairs if not identified and corrected in time. Therefore, it's important to always check the level of all fluids every time the vehicle is serviced and document low levels on the RO.

Complete the maintenance service interval as directed by the Repair Manual. Return the vehicle to the customer and have the customer return to the dealership at a predetermined mileage interval. Advise the customer not to adjust oil level during this process. When the customer returns, verify the oil level by checking the dipstick. It may be necessary to add oil to determine the quantity of oil consumed. Refer to the Warranty Manual for the allowable consumption rate and document your findings on the repair order.

Leak Inspection

Inspect for:

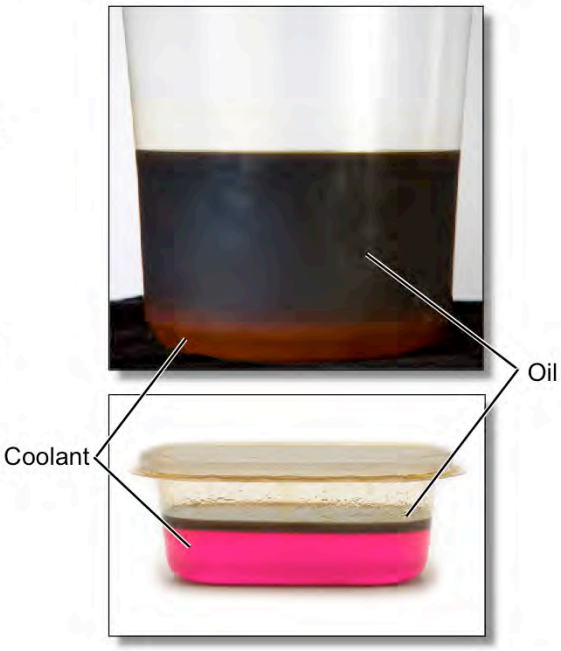
- Drips under vehicle
- Streaks or puddles on the engine
- Loose fittings or connections
- Leaking gaskets or seals

Use UV dye if necessary:

- Clean the engine
- Let engine run (or have customer bring vehicle back)
- Examine with ultraviolet light

Inspect oil and coolant:

- Oil and/or coolant cross contamination



Leak Inspection

When fluid levels are low, the first check should be for an external leak. External leaks can typically be diagnosed by visual inspection.

First, place the vehicle on a lift. Watch for leaks when the engine is cold and after it has reached operating temperature. If a leak is visible, but the source is unclear, thoroughly clean the area where fluid is observed and recheck.

If you're having difficulty pinpointing the source of an oil leak, it may be necessary to use a UV dye. Add the dye to the engine oil per the manufacturer's directions, then run the engine or return it to the customer and have the customer bring it back. Inspect the engine with an ultraviolet light to trace the source of the oil leak.

Exhaust Discoloration

Oil or coolant leaking into the combustion chamber can cause exhaust discoloration:

Fluid	Exhaust Discoloration	Possible Problem Area
Oil	Grayish-blue smoke	Rings, head gasket, valve guides or oil seals
Coolant	White smoke (sometimes with a sweet smell)	Head gasket

Note: Black smoke indicates an excessively rich fuel mixture

Hint: To find the cylinder that is smoking, examine the spark plugs:

- Oily deposit indicates oil leaking into the combustion chamber
- Grayish-white deposit indicates coolant leaking into the combustion chamber

Exhaust Discoloration

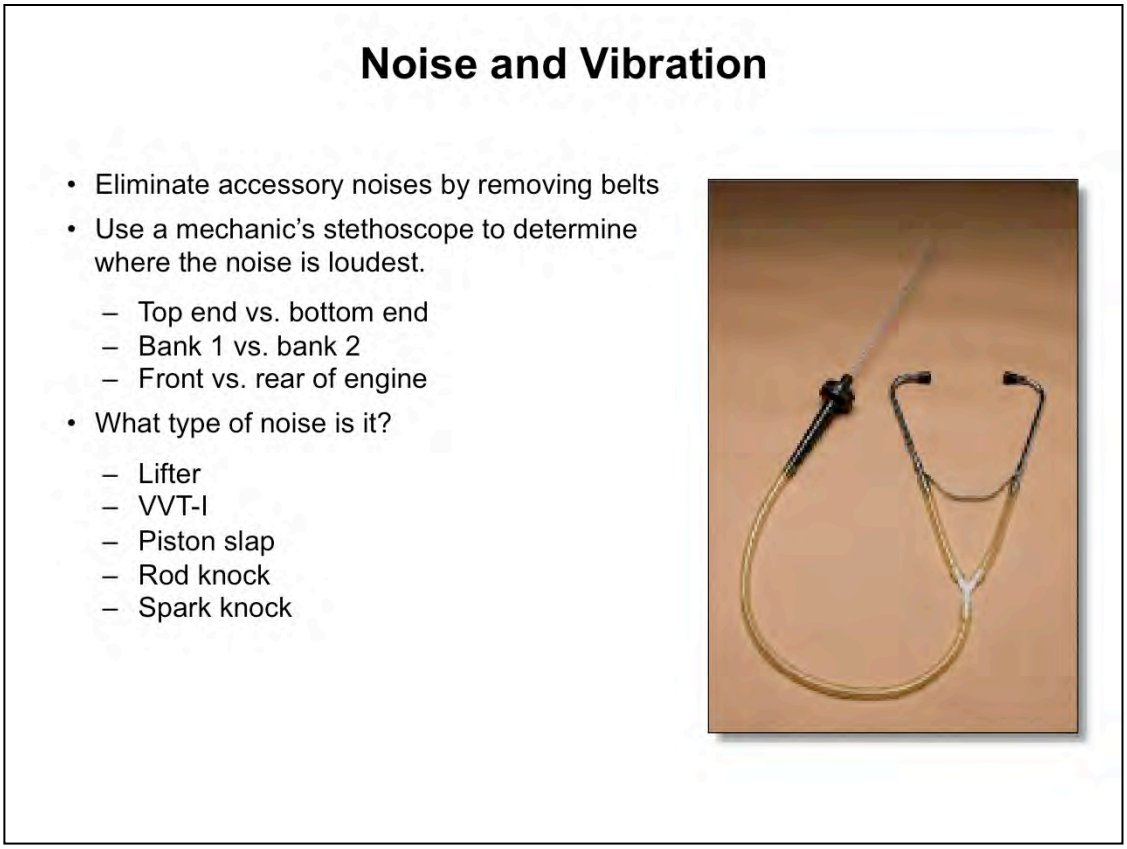
Normal exhaust gases go unnoticed most of the time and for good reason. Seasoned technicians, however, know that the condition of the engine can often be evaluated by the color of the exhaust.

Smoky or discolored exhaust gases are clear indicators of failures in combustion chamber sealing. If anything other than air or fuel enter the combustion chamber, exhaust gases typically are the tell-tale sign there's something wrong.

When burned in the combustion chamber, oil typically produces a grayish-blue exhaust smoke. Often, technicians mistakenly confuse black smoke for oil but this is an indication of a rich fuel mixture, which can be considered normal under certain operating conditions.

When coolant is burned, it creates a white smoke that sometimes smells sweet. Don't confuse this with exhaust condensation, which is normal when the vehicle has not reached normal operating conditions.

When investigating exhaust discoloration complaints it is a good idea to look at the spark plug to identify which cylinders are involved. The spark plug is the only component that resides in the combustion chamber that can be easily removed for inspection. Signs of black oily residues on the spark plug indicate oil is entering the combustion chamber. Gray-white deposits indicate coolant is being burned.



Noise and Vibration

In modern Toyota engines, noise or vibration concerns are slightly more difficult to pinpoint due to the materials used and the greater number of parts. Noise diagnosis is a skill that only comes with experience and seasoned technicians take great pride in this fact.

When diagnosing engine noises, you can follow these basic steps until you fine tune your own diagnostic ear.

Component removal:

- Remove accessory equipment temporarily, if the noise is no longer present it is possible the noise is not in the engine.
- Remember to remove components one at a time (if possible).
- Only remove equipment that will not cause damage to the engine.

Pinpoint noise location:

- Aluminum engines are very good at transferring noises originating in one part of the engine to a different area.
- Use a stethoscope (or use a long screwdriver as a stethoscope) to isolate the loudest area
- Load or unload the engine to make the noise more pronounced.

Compression Loss

Causes

Loss of combustion chamber seal:

- Rings
- Valve timing
- Bent or broken valve
- Burn hole in a piston or valve
- Head gasket

Restricted airflow:

- Clogged intake
- Restricted exhaust

Diagnostic Tests

- Cylinder Balance Test
- Cylinder Compression Test
- Cylinder Leakage Test

Compression Loss

Diagnosing a misfire or no-start concern should start with checking the ability of the engine to pump and compress the air/fuel charge. Since the combustion chamber is hard to visually inspect we must rely on several static and dynamic tests to evaluate the components involved in sealing the combustion chamber. The tests described in the following pages are relatively easy to perform and can quickly evaluate the efficiency of the engine.

Cylinder Balance Test

One way to find a cylinder that is losing compression or has some other issue that prevents it from contributing power is to perform a cylinder balance test.

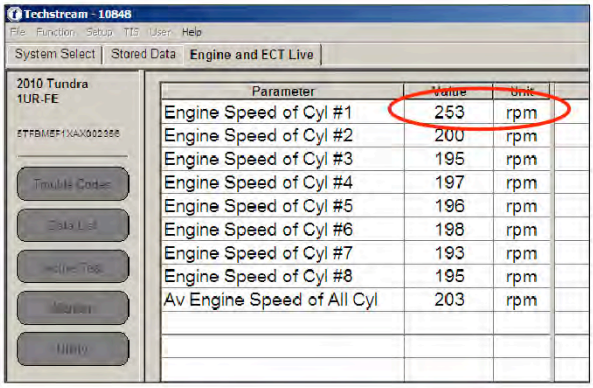
In this test, you disable each cylinder one at a time while observing RPM. When a good cylinder is disabled, the RPM will change. If any cylinder is already not working, disabling it will have little effect on the RPM.

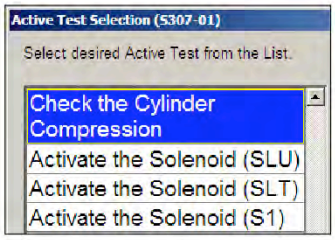
Ideally, the decrease in RPM should be roughly the same for all cylinders. If the RPM drop is noticeably less for any cylinder, then that cylinder is contributing less power than the others and should be diagnosed.

The cylinder balance test is not very effective in late model Toyota engines, however, because the ECM is programmed to adjust idle to compensate for a weak cylinder. Therefore the change in RPM may not be significant enough to tell you much about each cylinder's performance.

Techstream Compression Test

- Techstream can determine relative cylinder compression without a cylinder compression pressure gauge
- Techstream measures the engine RPM during each cylinder's compression stroke
- The piston moves faster during the compression stroke when the compression is low





Note: The Techstream Compression Test procedure is in the Repair Manual under SFI System > Data List / Active Test.

Techstream Compression Test

When you're set up to perform this Techstream Active Test, display the Data List for engine compression as shown above. The list will initially display 51199 RPM for each cylinder indicating Techstream has not yet calculated an actual value.

Next, begin cranking the engine for 20 to 45 seconds. (Techstream will keep the engine from starting.) When Techstream has calculated the RPM values, they will display as shown above.

When cranking stops, the RPM values will revert to 51199, so you will have to take a snapshot as soon as the RPM values appear in order to preserve and analyze them.

If any cylinder has a noticeably higher RPM than all the others, it means its compression is low and requires further diagnosis.

Compression Gauge Test

Basic Procedure

- Disable the engine so it will not start
- Remove the spark plug from the cylinder to be tested and attach a cylinder pressure test gauge
- Crank for 10 seconds and record the highest pressure reading
- All cylinders should be approximately equal and within Repair Manual specifications*

*Specifications can range from 140 to 210 psi

Standard Compression Test

Before Techstream, a cylinder compression test was performed with a compression gauge.

In this type of test, the cylinder's actual compression pressure is measured by installing a pressure gauge in place of the spark plug. After disabling the engine so it will not start, crank the engine for 10 seconds, and then record the highest pressure reading displayed on the gauge.

Compare the pressure readings between the cylinders. They should all be approximately equal. Also compare the pressure readings to the Repair Manual specifications.

Wet Compression Test

If one cylinder's compression is lower than the others, perform a Wet Compression Test:

- Remove the spark plug and squirt a little SAE 30 oil in the cylinder
- Repeat the compression test
- If the cylinder's compression improves, the problem is the piston rings
  - Compression improves because the oil temporarily seals the piston rings
- If the compression does not improve, the problem is with the valves

Note: This test is not in the Repair Manual but is recognized as an industry standard test.

Wet Compression Test

If the conventional compression test determines that one or more cylinders are below specification, then further investigation will narrow your list of potential causes and aid in your consult with the ASM.

One way to determine the cause for low compression is a wet compression test. The wet compression test is similar to a conventional compression test except you squirt a small amount of oil into the combustion chamber first. This oil forms a temporary seal around the piston to cylinder wall.

- If compression pressure increases with the addition of the oil, the most likely cause for low compression is worn rings.
- If compression pressures remains low, the cause may be related to valves and further testing will be required.

CAUTION Only use a small amount of oil. Too much oil may potentially cause damage.

Cylinder Leakage Test

How it Works

- Indentifies poorly sealed combustion chamber by measuring pressure loss
- The cylinder is set at TDC on the compression stroke so that both valves are closed
- A leak-down tester is connected to the spark plug hole
- Pressure loss is shown on the gauge

Problem Identification

To determine the problem, find where you can hear air escaping.

Location of Escaping Air	Possible Faulty Component
Exhaust pipe	Exhaust valve
Throttle body	Intake valve
Cylinder head, radiator	Cracked block, head gasket
PCV, oil filler cap	Rings

Note: This test is not in the Repair Manual but is recognized as an industry standard test.

Cylinder Leakage Test

Although conventional compression gauges can determine cylinders with lower than normal sealing, they cannot determine which internal component has failed inside the combustion chamber. When diagnosing a mechanical failure, you as technicians may save yourself a great deal of work if you know how to isolate the root cause without tearing an engine down for visual inspection. One method is by using a cylinder leakage tester.

A cylinder leakage tester regulates air pressure into the combustion chamber (while at TDC compression) as the technician listens for leaks. If significant leakage is evident, escaping air from the combustion chamber can be heard leaking from the defective component. If air is found to be leaking into the exhaust system this would indicate a possible burnt or bent exhaust valve. If air bubbles are found in the coolant system this might indicate a possible head gasket failure or cracked water jacket.

By using a cylinder leakage tester to narrow the potential type of engine repair needed, you can improve management of customer expectations and speed up the pinpoint diagnosis and repair.

Worksheets

Compression Test

In this worksheet you will:

- Use Techstream to perform a relative compression test
- Perform engine cylinder compression test; determine necessary action

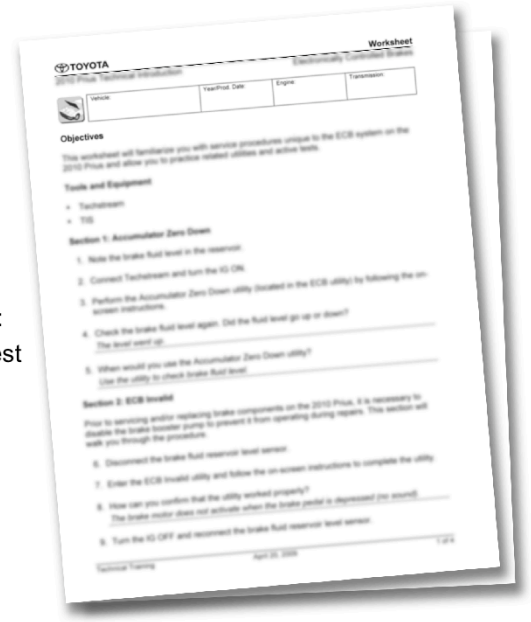
Cylinder Leakage Test

In this worksheet you will demonstrate :

- How to perform a cylinder leakage test
- How to isolate a cylinder leak

Diagnosis Theory

In this worksheet you will demonstrate your understanding of general engine mechanical diagnosis principles.


TOYOTA

Worksheet

Vehicle | Year/Prod. Date | Engine | Transmission

Objectives

Tools and Equipment

- Techstream
- TIS

Section 1: Accumulator Zero Down

1. Note the brake fluid level in the reservoir.
2. Connect Techstream and turn the IG ON.
3. Perform the Accumulator Zero Down utility (located in the ECB utility) by following the on-screen instructions.
4. Check the brake fluid level again. Did the fluid level go up or down?
   The level went up.
5. When would you use the Accumulator Zero Down utility?
   Use the utility to check brake fluid level.

Section 2: ECB Invalid

Prior to servicing and/or replacing brake components on the 2010 Prius, it is necessary to disable the brake booster pump to prevent it from operating during repairs. This section will walk you through the procedure.

6. Disconnect the brake fluid reservoir level sensor.
7. Enter the ECB invalid utility and follow the on-screen instructions to complete the utility.
8. How can you confirm that the utility worked properly?
   The brake motor does not activate when the brake pedal is depressed (no sound).
9. Turn the IG OFF and reconnect the brake fluid reservoir level sensor.

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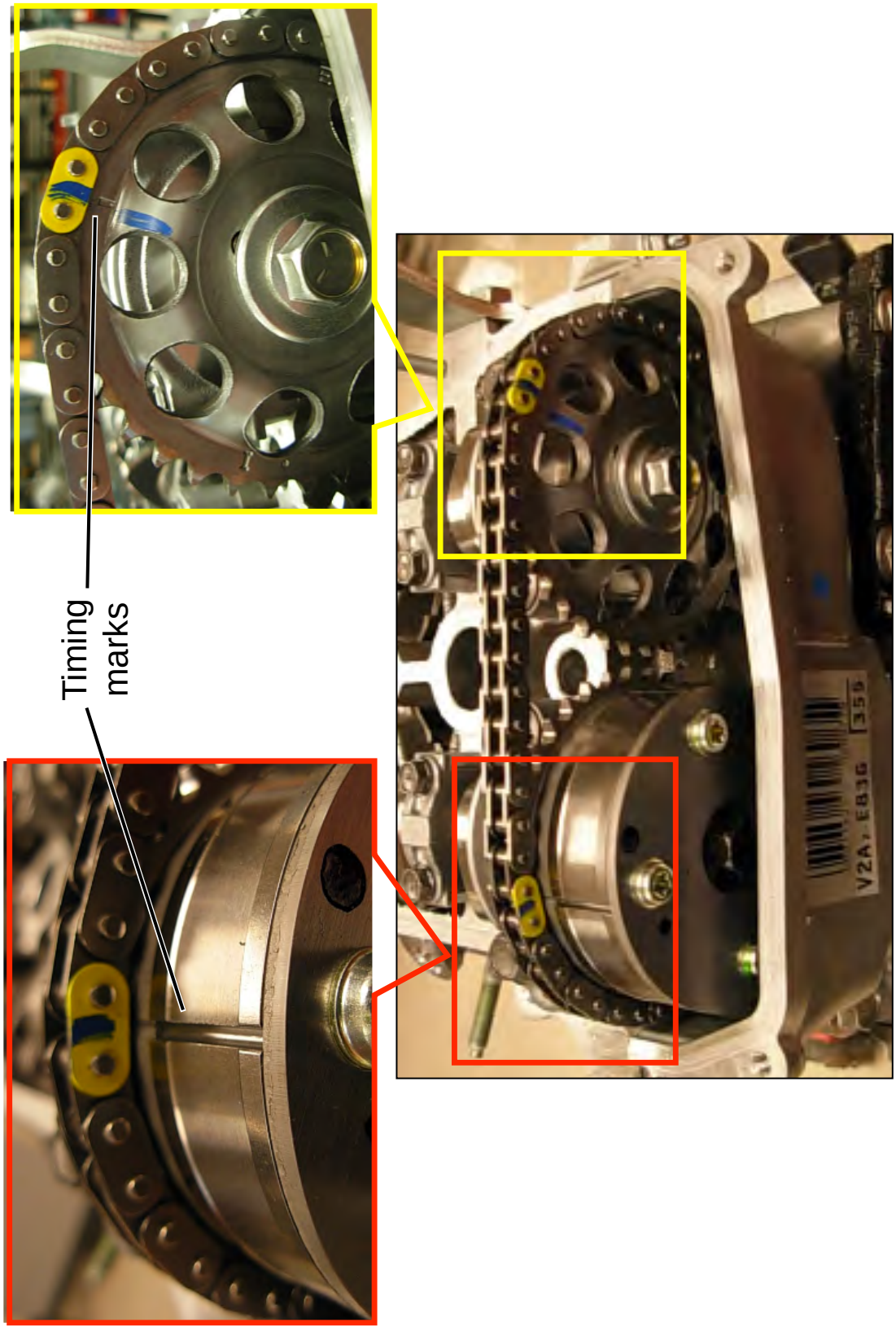
Use this space to write any questions you may have for your instructor.

NOTES:

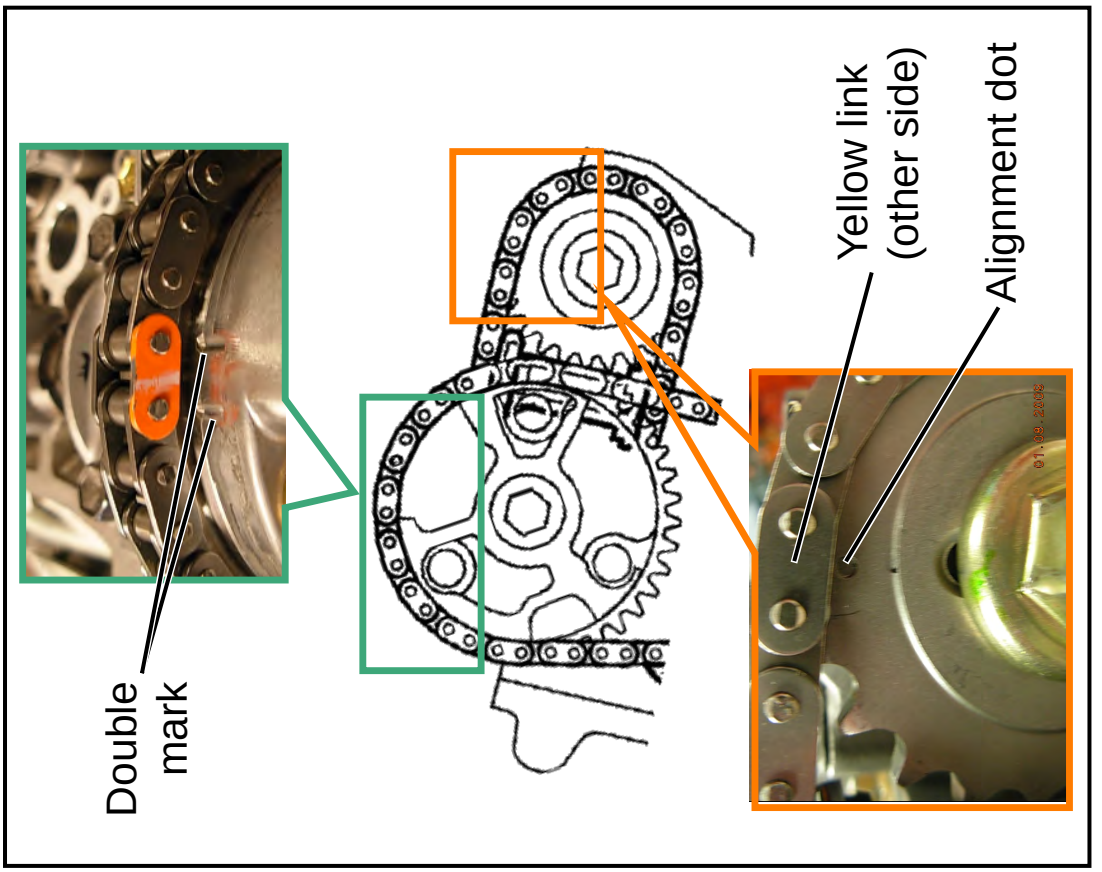
Appendix

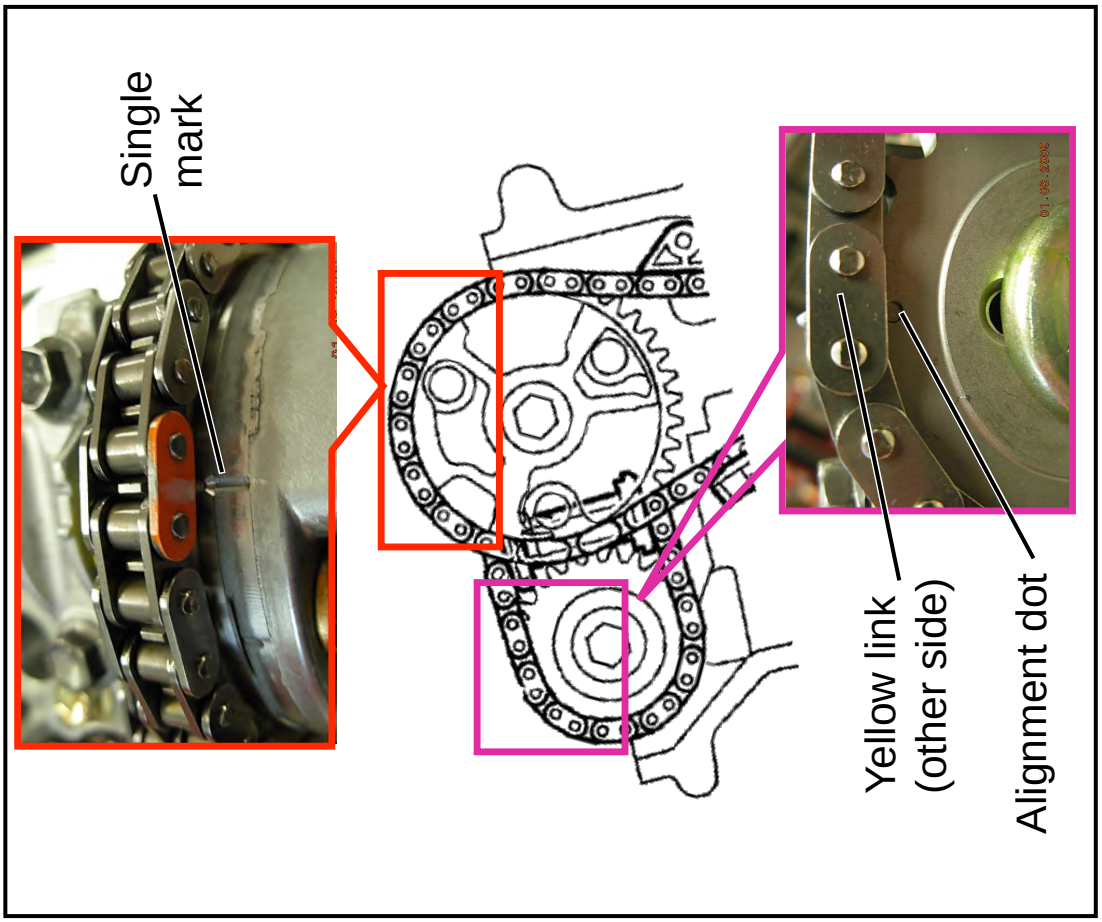
- Timing Mark Differences
- Standard Bolt Specifications
- Tools and Equipment List

2AZ-FE Timing Marks

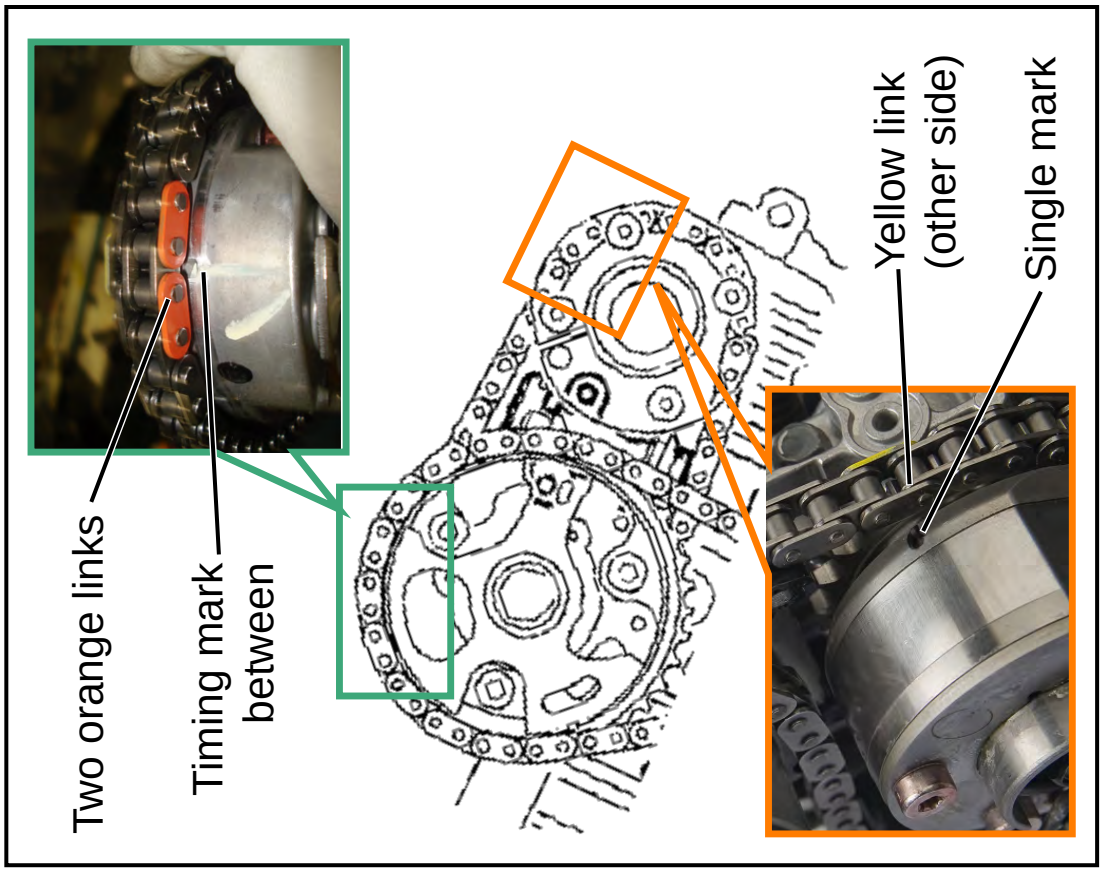


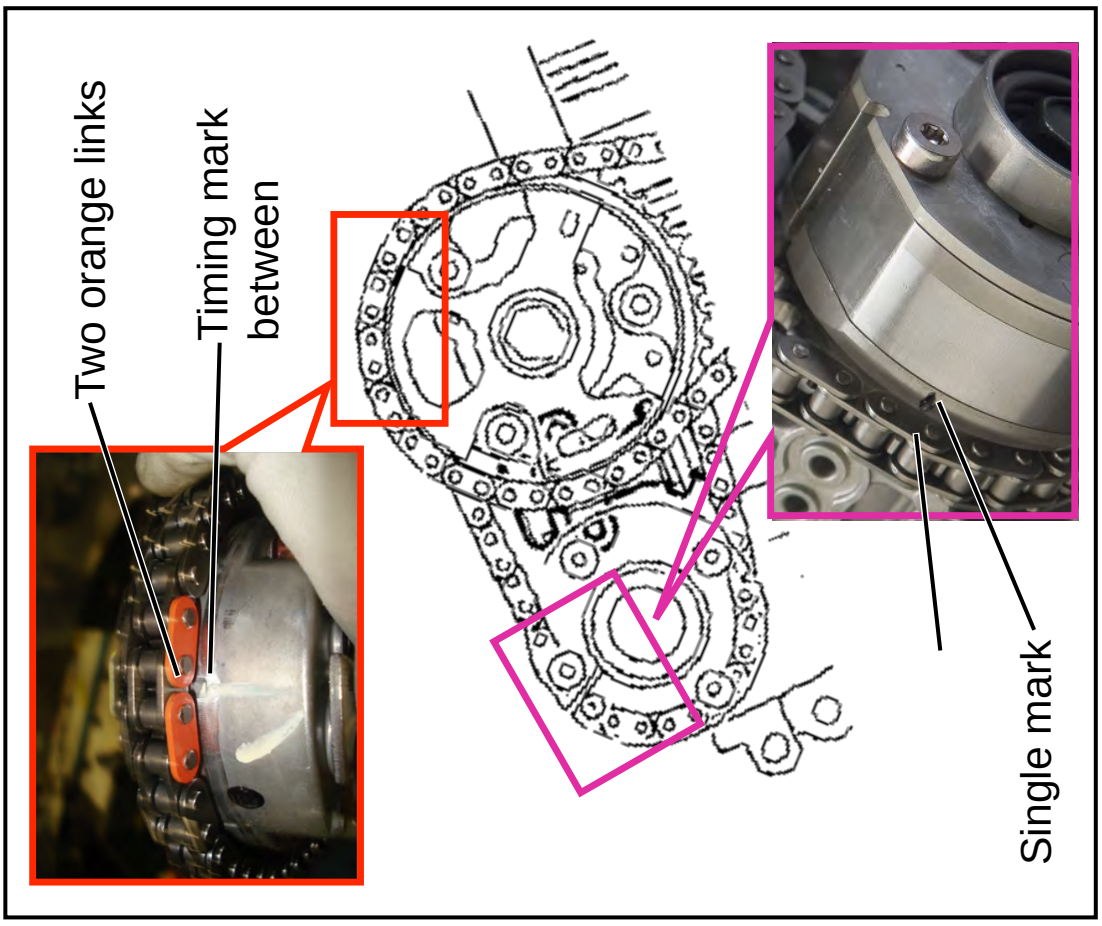
1GR-FE Timing Marks



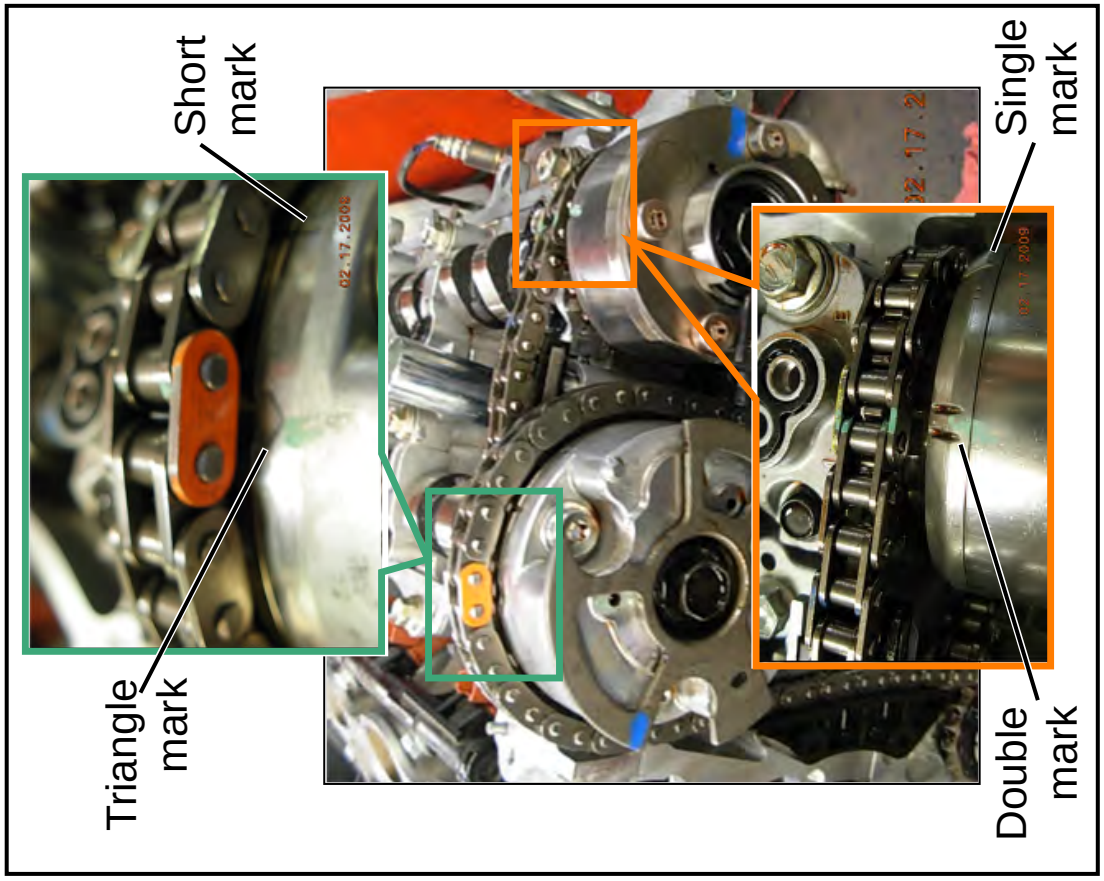


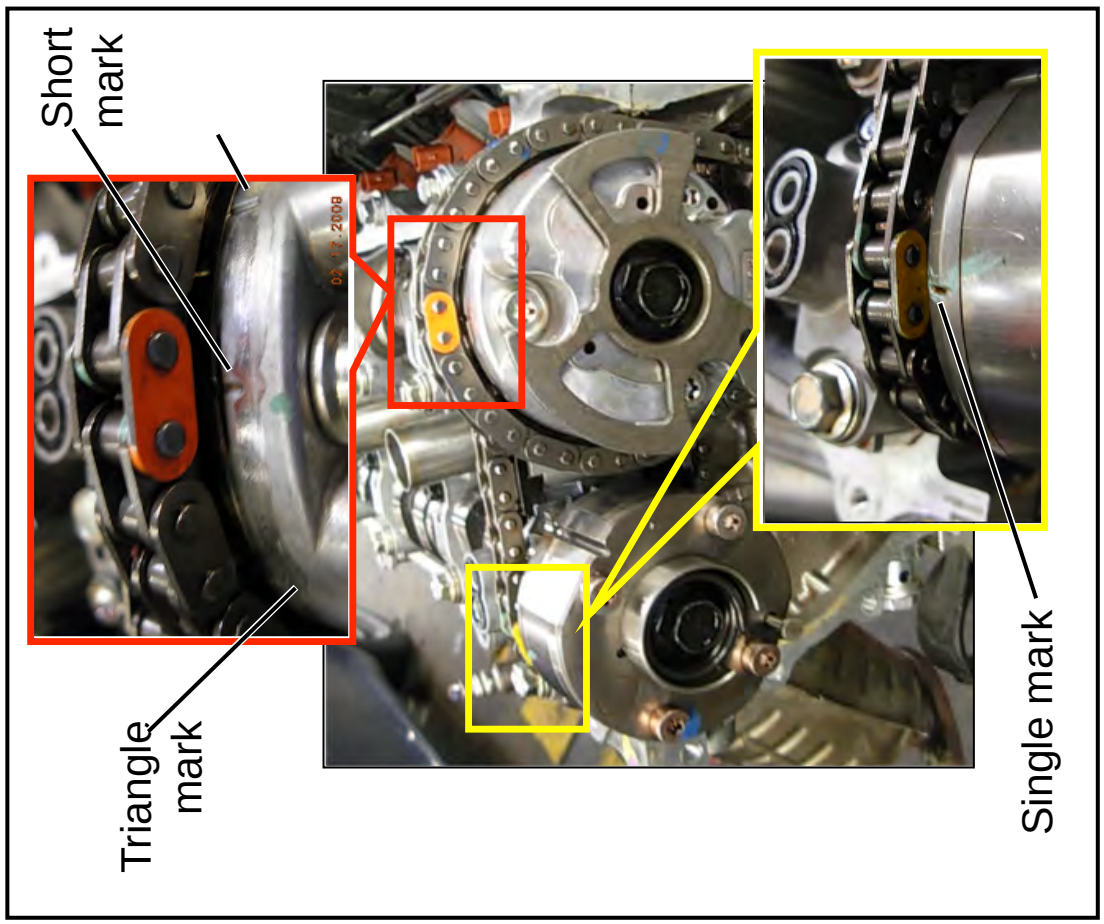
1UR-FE Timing Marks





2GR-FE Timing Marks





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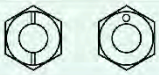
How to Determine Nut Strength (1 of 2)

Use a nut with the same nut strength classification number (or more) as the bolt strength classification number when tightening parts with a bolt and nut.

Example:
- Bolt = 4T
- Nut = 4N or more

Present Standard Hexagon Nut	Old Standard Hexagon Nut		Class
	Cold Forging Nut	Cutting Processed Nut	
No Mark 			4N
No Mark (w/washer) 	No Mark (w/washer) 	No Mark 	5N (4T)
			6N
			7N (5T)

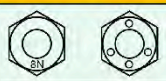
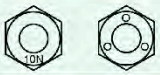
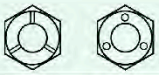
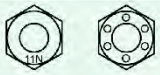
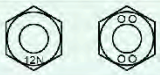
*: Nut with 1 or more marks on one side surface of the nut.

NOTES:

How to Determine Nut Strength (2 of 2)

Use a nut with the same nut strength classification number (or more) as the bolt strength classification number when tightening parts with a bolt and nut.

Example:
- Bolt = 4T
- Nut = 4N or more

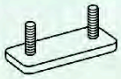
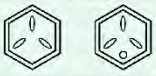
Present Standard Hexagon Nut	Old Standard Hexagon Nut		Class
	Cold Forging Nut	Cutting Processed Nut	
			8N
		No Mark 	10N (7T)
			11N
			12N

NOTES:

How to Determine Bolt Strength (1 of 2)

Use a nut with the same nut strength classification number (or more) as the bolt strength classification number when tightening parts with a bolt and nut.

Example:
- Bolt = 4T
- Nut = 4N or more

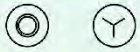
Hexagon Head Bolt			Stud Bolt	Weld Bolt	Class
Normal Recess Bolt		Deep Recess Bolt			
	 No Mark	 No Mark	 No Mark		4T
					5T
	 w/washer	 w/washer			6T
					7T

NOTES:

How to Determine Bolt Strength (2 of 2)

Use a nut with the same nut strength classification number (or more) as the bolt strength classification number when tightening parts with a bolt and nut.

Example:
- Bolt = 4T
- Nut = 4N or more

Hexagon Head Bolt		Stud Bolt	Weld Bolt	Class
Normal Recess Bolt	Deep Recess Bolt			
				8T
				9T
				10T
				11T

NOTES:

Specified Torque for Standard Bolts (1 of 2)

Class	Diameter (mm)	Pitch (mm)	Specified Torque	
			Hex Head Bolt Ft*LBF	Hex Flange Bolt Ft*LBF
4T	6	1	48 in*lbf	52 in*lbf
	8	1.25	9	10
	10	1.25	19	21
	12	1.25	35	39
	14	1.5	55	61
	16	1.5	83	--
5T	6	1	56 in*lbf	65 in*lbf
	8	1.25	12	13
	10	1.25	24	26
	12	1.25	43	48
	14	1.5	67	76
	16	1.5	101	--

Class	Diameter (mm)	Pitch (mm)	Specified Torque	
			Hex Head Bolt Ft*LBF	Hex Flange Bolt Ft*LBF
6T	6	1	69 in*lbf	78 in*lbf
	8	1.25	14	15
	10	1.25	29	32
	12	1.25	53	59
	14	1.5	80	90
	16	1.5	127	--
7T	6	1	8	9
	8	1.25	19	21
	10	1.25	38	43
	12	1.25	70	76
	14	1.5	108	123
	16	1.5	166	--

NOTES:

Specified Torque for Standard Bolts (2 of 2)

Class	Diameter (mm)	Pitch (mm)	Specified Torque	
			Hex Head Bolt Ft*LBF	Hex Flange Bolt Ft*LBF
8T	8	1.25	22	24
	10	1.25	45	50
	12	1.25	80	90
9T	8	1.25	25	27
	10	1.25	51	57
	12	1.25	94	105
10T	8	1.25	28	31
	10	1.25	58	64
	12	1.25	105	116
11T	8	1.25	31	35
	10	1.25	64	72
	12	1.25	116	130

NOTES:

Required Tools and Equipment

Course Materials	Part #	Producer	Source	Quantity
Technician Handbooks	N/A	POD	Region	N/A

SSTs Required	Part #	Producer	Source	Quantity
Valve Spring Compressor	09202-43013-01	SPX	TMS	4
Crankshaft Pulley Holding Tool	09213-70011-01	SPX	TMS	2
Companion Flange Holding Tool	09330-00021	SPX	TMS	2
10 mm Bi-Hexagon Socket	09043-50100-01	SPX	TMS	4
Universal Puller Set C Drawer # 24	09950-50013	SPX	Region	1
Variable Pin Wrench Drawer # 1	09960-10010	SPX	Region	1
Valve Lifter Tool Drawer # 1	09276-75010	SPX	Region	1
Gasket Seal Cutter	09032-00100	SPX	Region	1

Tools Required:	Part #	Producer	Source	Quantity
Allen Wrench	AWM2/2D	Snap-on	TMS	8
Compression Tester	MT308M	Snap-on	TMS	4
Cylinder Bore Gauge	72-646-220	Fowler	TMS	2
Cylinder Head Organizing Tray	VTO-80	Goodson	TMS	4
Cylinder Head Stand Set	HH-100-G	Goodson	TMS	4
Part Tray Organizer	SPP804-1	Snap-on	TMS	4
Cylinder Leakage Tester	EEPV309A	Snap-on	TMS	1
Dial Indicator w/ Vise Grip	72-520-730	Fowler	TMS	2
Feeler Gauge Set (.05 - .10 mm)	FBM320	Snap-on	TMS	4
Inside Diameter Caliper Gauge	72-472-104	Fowler	TMS	4
Micrometers	72-229-220	Fowler	TMS	4
Piston Ring Compressor	RC40C	Snap-on	TMS	2
Ridge Reamer	WR30A	Snap-on	TMS	1
Metric Ruler	RULER602	Snap-on	TMS	4
Steel Square	FFL52432006	Snap-on	TMS	4
Straightedge	GA438A	Snap-on	TMS	4
Vernier Caliper	MCAL6A	Snap-on	TMS	4

Required Tools and Equipment (cont'd)

Miscellaneous Tools & Equipment	Part #	Producer	Source	Quantity
3UR-FE Engine	N/A	TMMAL	TMS	2
Engine Stands (Crank Type)	N/A	N/A	Region	2
1GR-FE Cylinder Heads	N/A	TMMAL	TMS	4
Plastigage 0.018 – 0.045 mm	PL-X	Plastigauge	Region	1 Box
Prussian Blue	PTX-80038	Permatex	Region	4 Tubes
Toyota Genuine Seal Packing Black	00295-00103	Toyota	Region	1 Tube
Toyota Genuine Seal Packing 1282B	08826-00100	Toyota	Region	1 Tube
Lifter Buckets 5.06 mm	13751-46030	Toyota	TMS	8

3UR-FE Engine Parts	Part #	Producer	Source	Quantity
Piston Sub-Assy, W/Pin, Std	131010S011	Toyota	Region	N/A
Rod Sub-Assy, Connecting	132010S010	Toyota	Region	N/A
Lock, Valve Spring Retainer	90913A3001	Toyota	Region	N/A
Arm Sub-Assy, Valve Rocker	138010P010	Toyota	Region	N/A
Retainer, Valve Spring	137410P010	Toyota	Region	N/A
Cap, Valve Stem	1371675020	Toyota	Region	N/A
Spring, Compression	9050132065	Toyota	Region	N/A
Seal, Exhaust Valve Stem Oil	9008031101	Toyota	Region	N/A
Seal, Intake Valve Stem Oil	9008031043	Toyota	Region	N/A
Seat, Valve Spring	137340P010	Toyota	Region	N/A
Valve, Exhaust	137150S020	Toyota	Region	N/A
Valve, Intake	137110P010	Toyota	Region	N/A
Bolt, W/Washer	9011914120	Toyota	Region	N/A
Bolt, W/Washer	90119A0166	Toyota	Region	N/A
Hanger, Engine, No. 1	1228138150	Toyota	Region	N/A
Bolt (For Cylinder Head Set)	90910A2009	Toyota	Region	N/A
Washer, Plate (For Cylinder Head)	9020111034	Toyota	Region	N/A
Bolt, Connecting Rod	1326531020	Toyota	Region	N/A
Adjuster Assy, Valve Lash	137500P010	Toyota	Region	N/A

Required Tools and Equipment (cont'd)

Company/Vendor	Contact Person	Phone	Website
SPX	N/A	1-800-933-8335	Toyota.spx.com
Snap-on	N/A	N/A	www.snapon.com
Fowler	N/A	1-800-788-2353	www.fvfowler.com
Permatex – Prussian Blue	N/A	877-376-2839	www.permatex.com
Plastigauge	Greg Fletcher	949-395-6918	www.plastigaugeusa.com

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