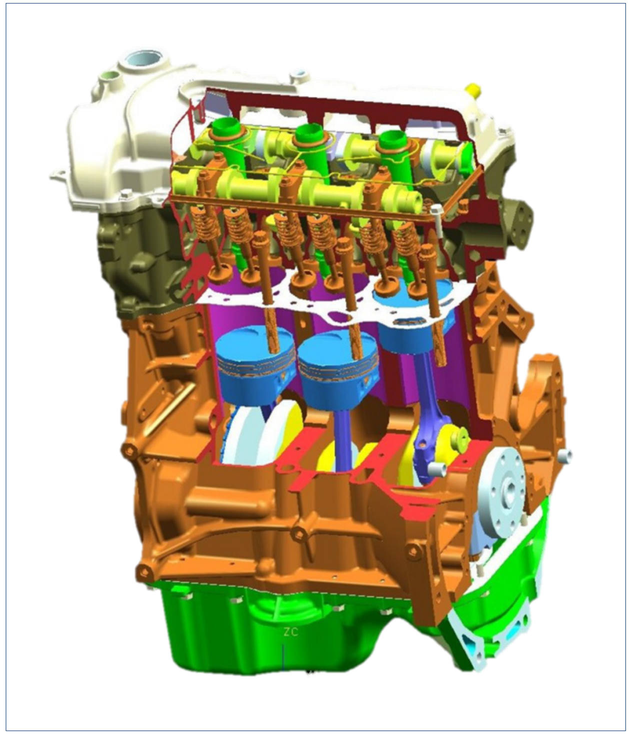
Engine fundamentals



SUZUKI
TRAINING ACADEMY

Engine Mechanical I
Course code: EN02

Student training manual
Suzuki Online Training

Foreword

The internal combustion engine converts chemical energy to mechanical energy. In this training course, you will study the basic fundamentals of engine construction. The basics of the engine top end construction and bottom end construction will be described in lesson 1. Basic engine checks and maintenance are described in lesson 2.

Smart manuals

Some sections of this training manual contain videos with detailed information on the topics you are studying. If you are studying this training manual on a PC, look out for the "green play video" symbol on any part of this manual, click on the green button to watch a video providing you with detailed information on that topic. Note: Internet connection required to view online videos.

This document is intended exclusively for training purposes only. All vehicle repairs, service, maintenance, adjustments must be carried out according to the procedures stipulated in current service manuals and technical bulletins.

Suzuki Technician curriculum

This training manual is part of the Non Suzuki Technician to Suzuki Technician curriculum. The curriculum consists of the following modules:

1. GE01 Suzuki Introduction
2. GE02 Electrical / Electronics
3. GE03 Diagnostics
4. EN02 Engine Mechanical part I
5. EN03 Engine Mechanical part II
6. EN04 Engine Mechanical part III
7. EN05 Engine Auxiliary systems
8. DS01 Driveshaft/Axle
9. DS02 Driveshaft/Axle - transfer case
10. BR02 Brake control systems
11. TR02 Manual transmission / transaxle
12. CS02 Control system / body electrical
13. CS03 Communication / bus systems

You are currently studying DS02 Driveshaft/Axle Transfer case. This module consists of the following courses:

- Engine fundamentals
- K10B, K14B/K12B Engine general information

Table of contents

Lesson 1:

Engine fundamentals

Objectives

At the end of this lesson, you will be able to:

- Describe the intake, compression, combustion and exhaust strokes of the internal combustion engine.
- Explain the construction/design of each of the engine components/parts discussed in this lesson.
- Describe the functions of each of the engine components/parts discussed in this lesson.

1.1 Basic engine operation

An engine has 4 strokes: air fuel mixture intake → compression → combustion → exhaust. The engine extracts its power from the force that pushes down the piston in the combustion stroke. A good air fuel mixture, good compression and good spark are necessary for the best power output.

"A good air fuel mixture" means that the ratio to which fuel and oxygen are mixed is appropriate for fully burning the mixture.

"A good compression" means that the air fuel mixture sucked into the cylinder is compressed until it reaches an appropriate pressure and appropriate temperature. When the air fuel mixture is compressed, its density is increased, enabling it to be burned rapidly. This means that even though the mixture itself is the same, it generates a greater force than when it is not compressed.

"A good spark" means that a spark is generated that is sufficient for burning the compressed air fuel mixture.

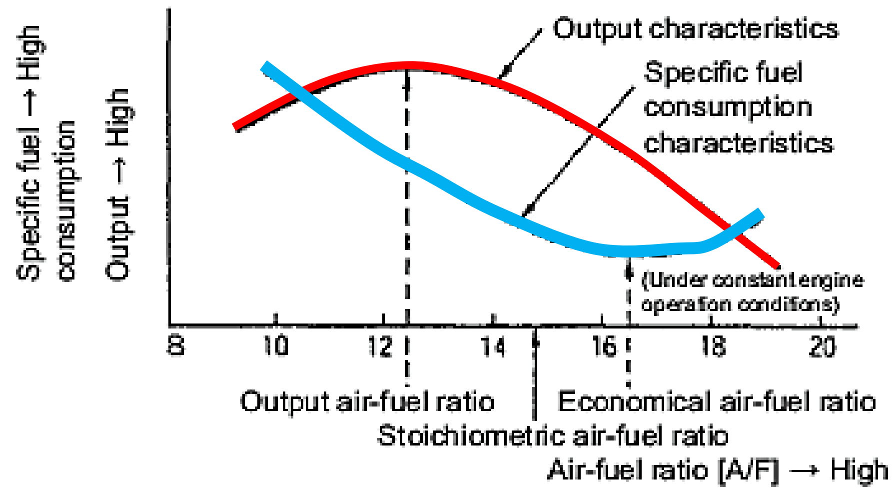
In other words, for an engine to operate normally, it is important that "a good air fuel mixture" is supplied in the intake stroke so that thermal energy is efficiently extracted from the gasoline. To fully burn this air fuel mixture, "a good compression" must be performed for the mixture in the compression stroke, and the mixture must then be ignited with "a good spark" in the combustion stroke.

The thermal energy that is generated by the burning must be efficiently converted into kinetic energy, and the exhaust gas must be fully expelled in the exhaust stroke (so that "a good air fuel mixture" can be sucked into the cylinder in the next intake stroke).

1.1.1 Intake

As the crankshaft rotates, the connecting rod that is connected to the crankshaft moves the piston down from near to top dead center to near to bottom dead center. This lowers the pressure in the cylinder. At this time, the intake valve is open and the exhaust valve is closed. The drop in pressure inside the cylinder sucks the air fuel mixture into the cylinder from the intake pipe.

(i) Air-fuel ratio



Relationship between the air-fuel ratio, engine output and fuel economy

Burning is an oxidation reaction that is accompanied by heat and light generation. Burning requires a substance to burn, a supply of oxygen, and that the substance's temperature is equal to or greater than its ignition point. In other words, the mixture between the gasoline and air (oxygen) must be thoroughly mixed and it must have an appropriate concentration (air-fuel)

The "air-fuel ratio" is the mix ratio between fuel and air. The standard air-fuel ratio for gasoline combustion is called the "stoichiometric air-fuel ratio". The ideal amount of air required for burning 1 g of petrol is calculated as 14.7 g of air.

1.1.1.1 Start up and low temperatures

Petrol that is injected at low temperatures has difficulty vaporizing. Sometimes it adheres to the intake manifold and only some of the gasoline is sucked into the cylinder. Also, if the gasoline does not vaporize and is sucked into cylinder in particle form, it is difficult to burn and may be expelled.

For this reason, to make sure that the vaporized mixture reaches the stoichiometric air-fuel ratio, extra gasoline must be supplied.

1.1.1.2 Acceleration

During acceleration, a large amount of air is sucked in. The air fuel mixture becomes leaner because of the air that was suddenly increased. To deal with this, more fuel than normal is injected during acceleration.

On the other hand, during deceleration, engine output is not required. The fuel supply is stopped in some operating ranges to make the exhaust gas cleaner. Looking at the relationship between the air-fuel ratio, the engine output and the fuel economy, we can see that the air-fuel ratio greatly affects the output and fuel economy.

The ideal solution is to set different air-fuel ratios for different conditions. An economical air-fuel ratio is best for economical operation under partial loads, which is the normal usage range of a vehicle. An output air-fuel ratio is best for generating more output near to the full load range, where greater output is required.

Examples of air-fuel ratios for different conditions

Operating condition	Air-Fuel ratio
Cold start (in cold temperatures)	1:1 – 5:1
Cold start (in normal temperatures)	5:1 – 10:1
Low speed operation	14:1 – 15:1
Maximum output operation	12:1 – 13:1
Economical operation	16:1 – 17:1

1.1.2 Compression

While both the intake and exhaust valves are closed, the piston moves up from near to bottom dead center to near to top dead center. This raises the pressure inside the cylinder, and the air fuel mixture inside the cylinder reaches a high temperature and high pressure.

The movement of the air fuel mixture during compression mixes the mixture well, and the increased mixture temperature makes it easier for the gasoline to vaporize. As a result, the mixture is easier to burn. Further, the mixture density increases due to the compression, which enables rapid combustion.

The mixture compression amount is expressed with the compression ratio. This value indicates by how much the air fuel mixture that was sucked into the cylinder has been compressed by the time of ignition.

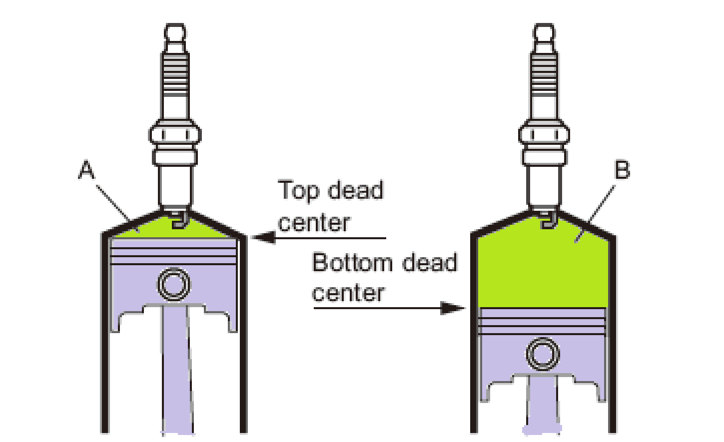


Figure 1: Compression ratio= Intake air/compressed air

If the compression ratio is made too high in an attempt to obtain a strong explosive force, engine knocking will occur. An appropriate compression ratio for a 4-cycle petrol engine is 8 to 10.

Key Points

When engine knocking occurs, the pressure rise caused by burning vibrates the gas inside the combustion chamber and makes a scratching sound

1.1.3 Combustion

When the piston is near to (compression) top dead center and the air fuel mixture is compressed, the spark plug generates an electrical spark to burn the mixture.

The electrical spark generated by the spark plug forms a flame kernel in the air fuel mixture near to the spark plug's electrode. This flame kernel grows and the flame surface acts as a new ignition source to ignite the air fuel mixture that is next to it. The burning continues and spreads in this way and generates heat. The pressure inside the cylinder rises in accordance with the amount of heat and pushes the piston to bottom dead center.

In other words, an easy-to-burn air fuel mixture and sufficient ignition energy to ignite the mixture are required for ignition. Further, the combustion timing must be optimized to apply the appropriate combustion pressure to the piston. It follows that the ignition timing must be earlier when the engine rotation speed is high.

1.1.4 Exhaust

While the intake valve is closed and the exhaust valve is open, the piston moves up from near to bottom dead center to near to top dead center. This expels the exhaust gas from the cylinder into the atmosphere via the exhaust system. Because the pressure of the exhaust gas inside the cylinder is higher than the atmospheric pressure, the pressure of the exhaust gas itself also works to expel the gas.

The exhaust valve closes after the piston passes (exhaust) top dead center and the intake valve starts to open before the piston reaches (exhaust) top dead center. In other words, at (exhaust) top dead center, both the intake and exhaust valves are open. This condition is called "valve overlap".

During valve overlap, the air fuel mixture that is sucked into the cylinder pushes out the exhaust gas, and the force of the rapidly expelled exhaust gas pulls in more of the mixture. This has the benefit of pulling in more of the air fuel mixture for the next stroke.

1.2. Engine unit

1.2.1 General

The engine unit is constructed from many different parts. The combustion chambers are made up of pistons, cylinders and cylinder heads. The valve mechanism sucks intake air into the combustion chambers and expels exhaust gas from the combustion chambers. The connecting rods and crankshaft convert the reciprocating action of the pistons over the 4 strokes (intake, compression, combustion and exhaust) into rotating action.

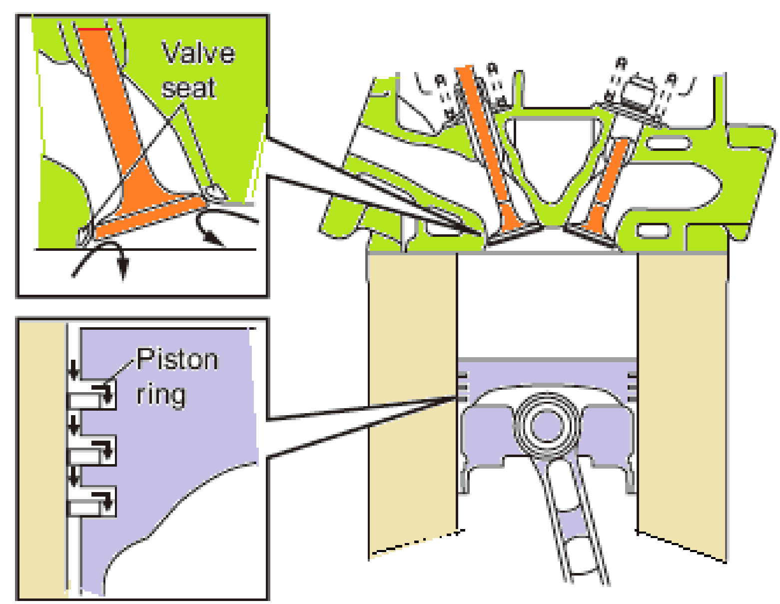


Figure2: Sealing of combustion chamber to prevent compression loss

In these systems, compression loss must be prevented for the high-temperature and high-pressure air fuel mixture. The pressure from the thermal energy that is obtained from the combustion stroke must be applied to the piston without any loss. In other words, if pressure is lost, an equivalent amount of energy is lost. The engine unit is designed with good sealing for each part to prevent compression loss.

1.2.2 Piston

The area between the piston and the cylinder is sealed with a piston ring to prevent compression loss. But for the piston to move, a clearance is required. For this reason, the piston is designed to maintain an appropriate clearance when the piston becomes hot during combustion and is subjected to thermal expansion.

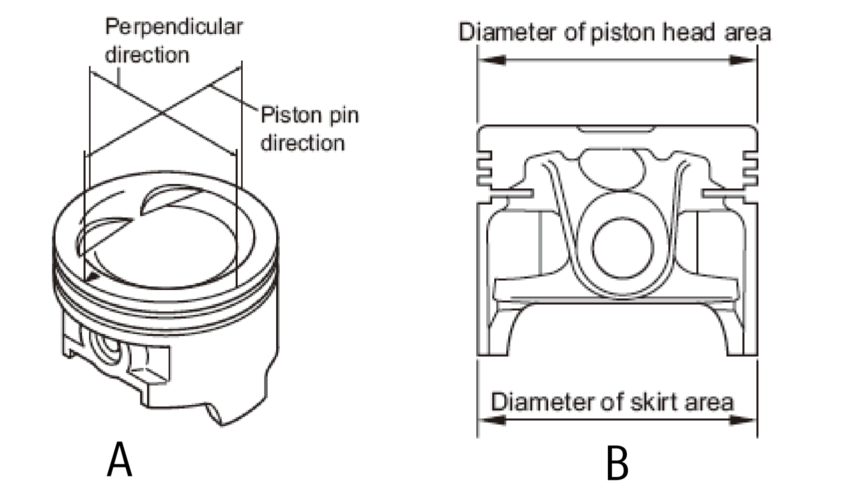


Figure 3: Piston construction

[A] Piston pin direction diameter < Perpendicular direction diameter
[B] Piston head diameter < skirt diameter

The piston is designed in a slight ellipse so that the diameter of the piston in the piston pin direction is smaller than in the perpendicular direction. This is because the piston pin boss is quite thick, so the thermal expansion coefficient is different from other areas.

The piston head forms a part of the combustion chamber, it gets much hotter than the skirt area. Taking into account this temperature difference and the resulting difference in expansion, during normal temperatures, the head diameter is smaller than the skirt diameter. This construction ensures good sealing between the piston and the cylinder.

The piston has a predetermined direction for assembly with the connecting rod and cylinder. Marks on each part show the correct direction.

During assembly, make sure that these directions are correct.

When reusing a piston, to maintain its familiarity with the cylinder and the piston clearance, it must be assembled to a cylinder in the same position as before disassembly.

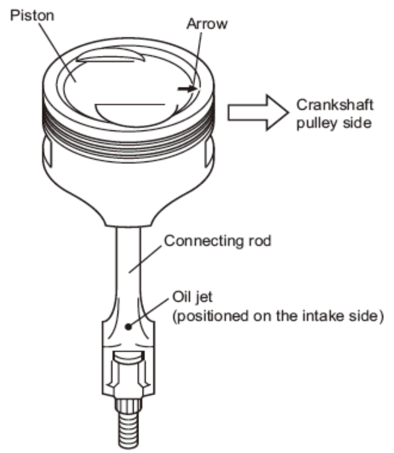


Figure 4: Piston (installation direction)

To improve durability, hard alumite treatment has been performed on the top of the piston. It also has a valve recess to avoid interference with the valve.

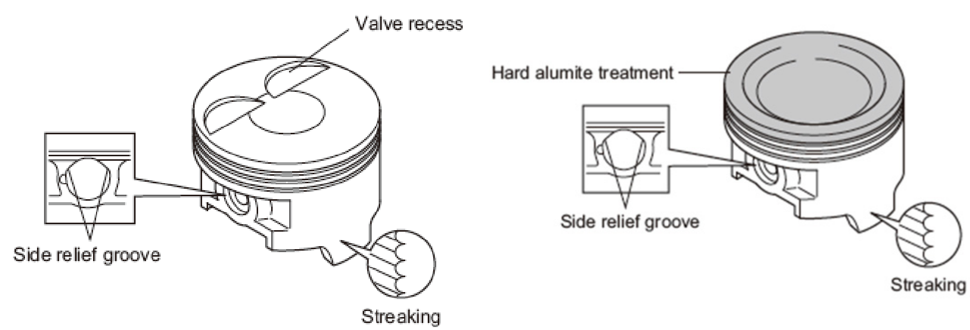


Figure5: Piston

Key Points

- Piston types

One piston type is a casting piston that is made by pouring molten aluminum into a casting mold. Another type is a forging piston that is made by applying pressure to it under high temperatures. In general, casting pistons are most commonly used. Compared with casting pistons of the same weight, forging pistons are stronger, but they have the disadvantage of a higher production cost.

- Streak and microgroove finishing

This is a process for making grooves similar to the groove on a vinyl record. This finish reduces friction and improves familiarity and oil film retention.

1.2.3 Piston ring

The piston rings seal the clearance between the piston and the cylinder. Usually, there are 3 piston rings. The top 2 rings are compression rings and are called the first ring and the second ring. They seal the combustion chamber and transfer the piston heat to the cylinder wall.

Meanwhile, the oil ring scrapes the oil on the cylinder wall to form the minimum required oil film and prevent the excess oil from entering the combustion chamber.

The end gap of the piston ring is installed after taking into account the piston ring expansion caused by temperature. If the end gap of the piston ring is too large, it will result in compression loss. If the gap is too small, when the ring expands the ends may make contact with each other and be damaged. Also, the outer diameter may increase and scratch the cylinder wall, causing a seizure.

Note that because the piston ring has an end gap, slight compression loss is certain to occur. To minimize this compression loss, the end gap of each piston ring must be positioned as far away from each other as possible during assembly.

To make the most of the functionality of the piston rings, in addition to maintaining a proper piston groove clearance and end gap, it is important to assemble the rings the correct side up. If you assemble a ring in the incorrect direction, the oil scraping performance will drop and oil may leak into the combustion chamber via the piston rings. To prevent this, there is a mark on the top side of the piston ring.

Most engines use a barrel face type for the first ring to prevent initial familiarity wear (a taper type is used in a 2-ring piston), and a taper under cut type for the second ring that has a good scraping performance and prevents oil from entering the combustion chamber.

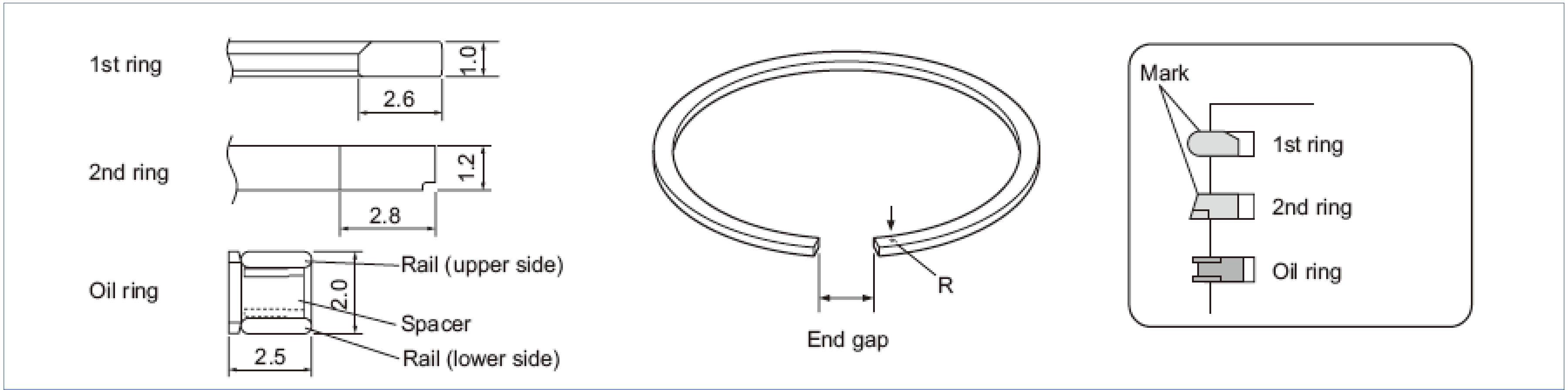


Figure 6: Piston rings

Problems that originate in the piston rings include the following.

- Scuffing

This occurs when there is insufficient oil, excessive loads or overheating. The oil film on the cylinder wall breaks up and the piston ring and cylinder directly contact each other, scratching their surfaces.

The sealing and oil scraping performance will deteriorate and oil may leak into the combustion chamber via the piston ring or the output may drop.

- Sticking

Carbon and sludge (burned substances) harden through heat and stop the piston ring from moving. Causes the same problems as scuffing.

- Fluttering

The piston ring vibrates in the ring groove, reducing the ring performance. Abnormal wear may occur in the piston groove and on the top and bottom ring surfaces, resulting in seizure.

1.2.4 Cylinder block

The cylinder block functions together with the pistons to maintain the compression and receive the combustion pressure. The cylinder bore is made to a precise cylinder shape. However, the top of the cylinder tends to wear easily, because it is exposed to high temperature and high pressure. The piston thrust side that receives the piston's lateral pressure also wears easily. In this way, sometimes the cylinder bore wears in some areas and becomes elliptical or tapered. When the cylinder wears like this, the clearance between it and the piston becomes larger and compression loss occurs.

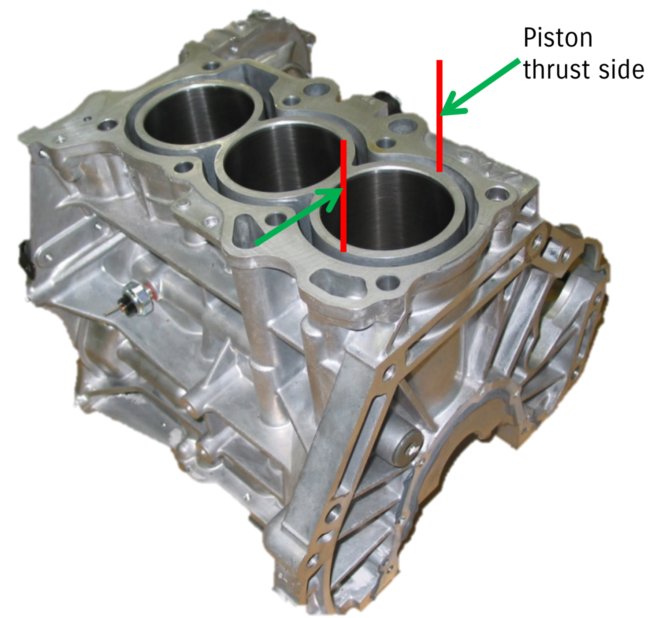


Figure 7: Cylinder block – AMF310

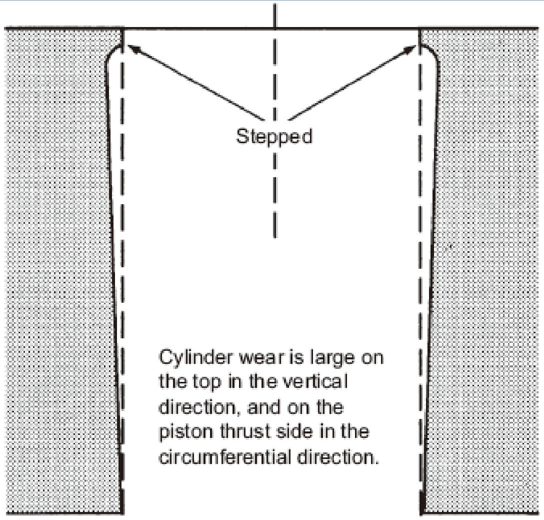


Figure 8: Cylinder wall trends

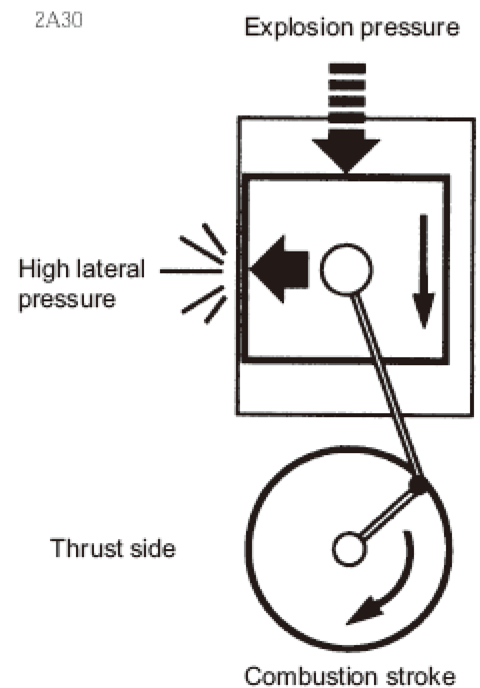


Figure 9: Piston lateral pressure

If the piston hits the cylinder wall, it makes a side knock noise. This is because as the cycle moves from the compression stroke to the combustion stroke, the direction of the lateral pressure changes and a high lateral pressure is generated from the explosion pressure.

The side knock noise occurs when the piston clearance is too large. Because the piston clearance is larger when the engine is cold, the noise is louder. The noise gets quieter as the engine warms up.

1.2.5 Connecting rod

In an engine, the air fuel mixture is burned inside the cylinders. The generated pressure is received by the piston, which pushes the connecting rod and rotates the connected crankshaft to generate power. The motion system converts the reciprocating Action of the pistons into rotating action.

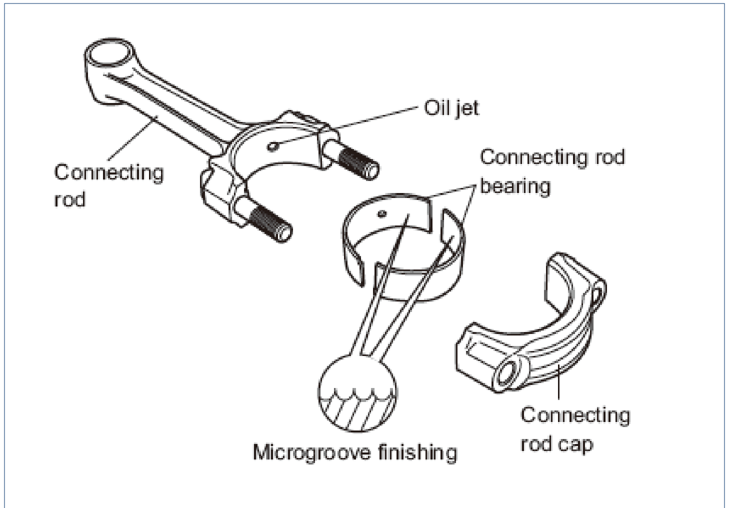


Figure 10: Connecting rod

The piston side of the connecting rod is called the small end and the crankshaft side is called the big end. The connecting rod connects the piston to the crankshaft and transmits the piston force to crankshaft. The connecting rod is continuously and repeatedly subjected to compression and pulling force. It must have sufficient strength and rigidity to withstand this force.

In addition, the connecting rod and bearing cap have a set assembly method. There are marks that show the correct assembly direction, so make sure that the directions are correct during assembly.

1.2.6 Crankshaft

The crankshaft converts the reciprocating action of the pistons into rotating action via the connecting rod.

The crankshaft is subjected to large forces while rotating at high speed. This means it must be strong and rigid, and have good static and dynamic balance.

The crankpins and weights are arranged so that there is a good balance after taking into account the firing order and weight distribution. To achieve equal combustion intervals and a uniform rotation force, the crankshaft pin arrangement is every 120° in 3- and 6-cylinder engines, and every 180° in 4-cylinder engines.

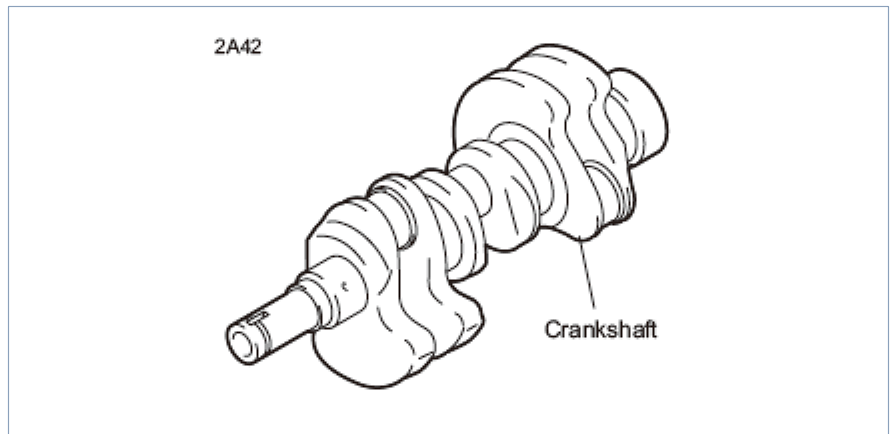


Figure 11: Crankshaft

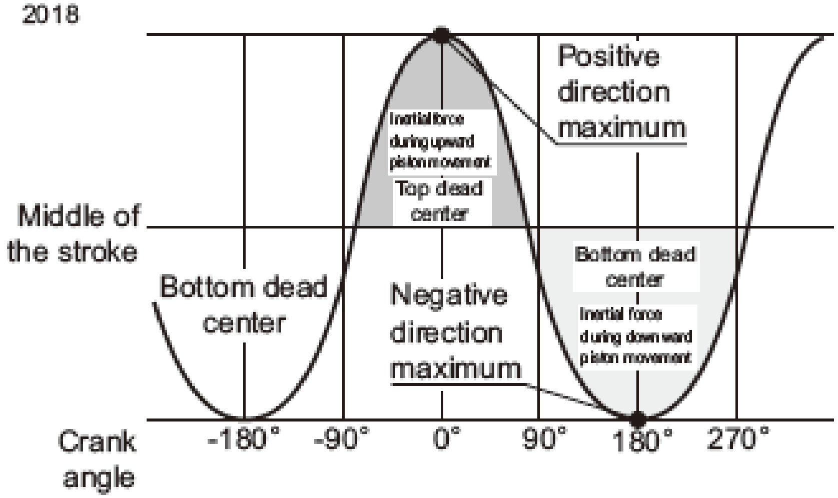
Key point

Forces act on the rotating crankshaft, such as the inertial force from the reciprocating action of the pistons, and the centrifugal force that is generated during the conversion to rotating action. These forces are not useful for smooth engine operation, and result in noise and vibration. In response, an engine is equipped with a balancer mechanism to minimize the vibration.

To reduce the inertial force, which is one of the sources of engine vibration, balance weights are installed on the crankshaft. This reduces primary inertial force (1 cycle of inertial force that is generated during 1 crankshaft rotation).

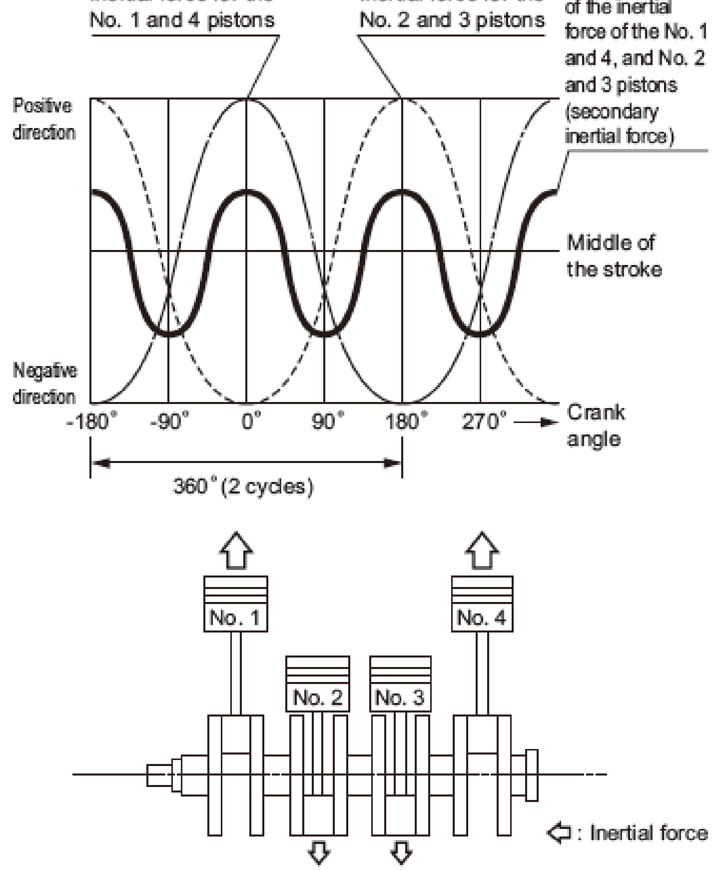
However, the piston speed during engine operation is fastest in the area from the middle of the stroke to a position near to the top dead center side, both when the piston is going up and when it is going down. For this reason, the inertial force that is generated in 1 crankshaft rotation is not equal during the upward and downward movements of the piston.

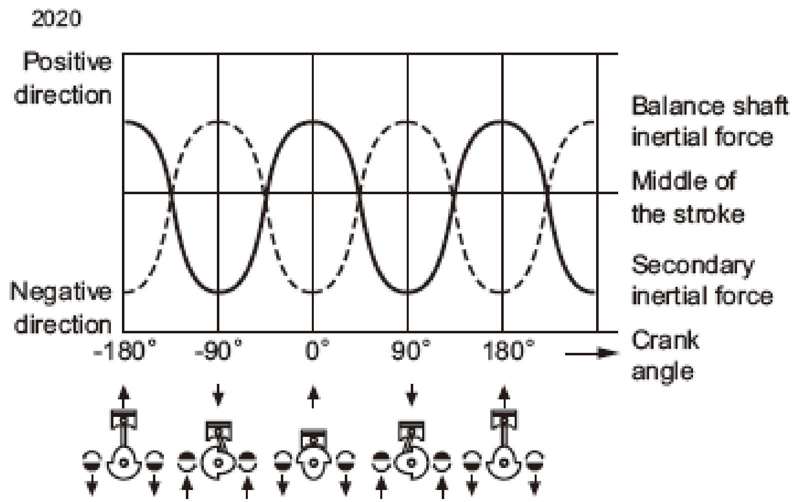
2018



In engines where the phases are staggered by 180°, such as 4-cylinder engines, 2 cycles of inertial force are generated during 1 rotation of the crankshaft. This inertial force is called secondary inertial force. Because secondary inertial force cannot be reduced with balance weights, some engines are equipped with a balancer shaft that rotates at twice the rotation speed of the crankshaft. Here, the phase generates a reverse inertial force that counteracts the secondary inertial force.

2019





1.2.7 Crankshaft and connecting rod bearings

Bearings support rotating parts such as the journal area of the crankshaft and the crankpin.

An appropriate oil film is formed on the bearing surfaces. The bearings absorb the large loads and impacts that the rotating parts are exposed to during the combustion stroke. The bearings have a crush height to improve the sealing with parts such as the cylinder block and bearing cap. This also improves heat dissipation. The surfaces have an appropriate oil film to prevent seizure and minimize friction loss.

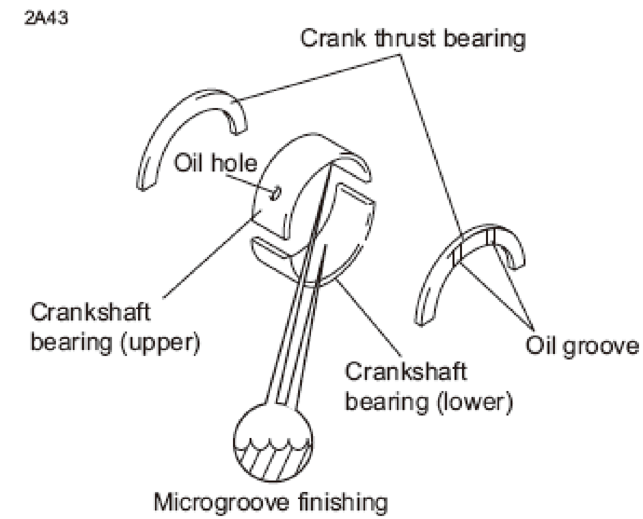


Figure 12: Bearings

1.2.7.1 Crush height

The crush height is the difference between the bearing outer circumference and the installation surface inner circumference. At the appropriate tightening pressure, the crush height functions to compression fit the bearing against the bearing installation surface.

Using a crush height means that the bearing can transfer its heat more efficiently to the installation surface. However, if oil adheres between the back metal of the bearing and the housing, the heat dissipation worsens. Oil adhesion must not be allowed to occur.

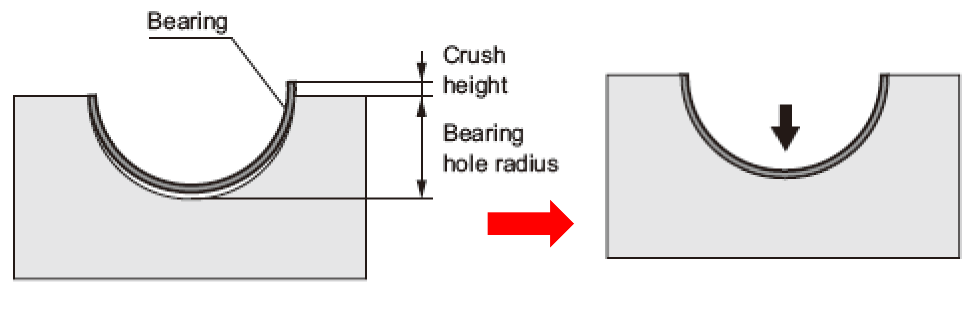


Figure 13: Crush height

1.2.7.2 Thrust bearing

The thrust bearing receives the force from the crankshaft thrust direction. If this part wears, an abnormal noise may occur when the crankshaft moves in the thrust direction.

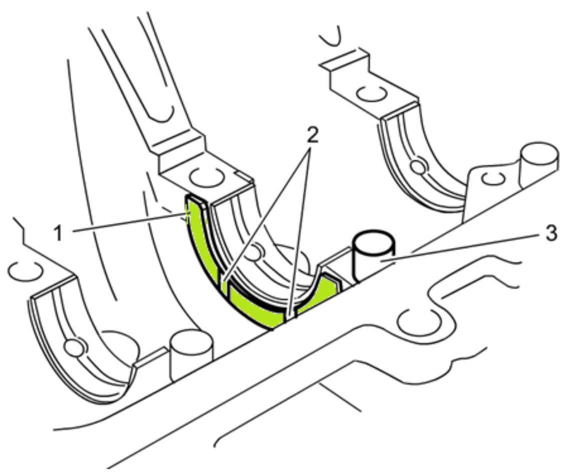


Figure 14: Thrust bearing (1)

1.2.7.3 Oil clearance

The gap between the bearing and the shaft is called the oil clearance. Its function is to spread out the oil so that metal parts do not directly contact each other. If the clearance is too small it may cause seizure. If the clearance is too large, it may cause a drop in hydraulic pressure or abnormal noise.

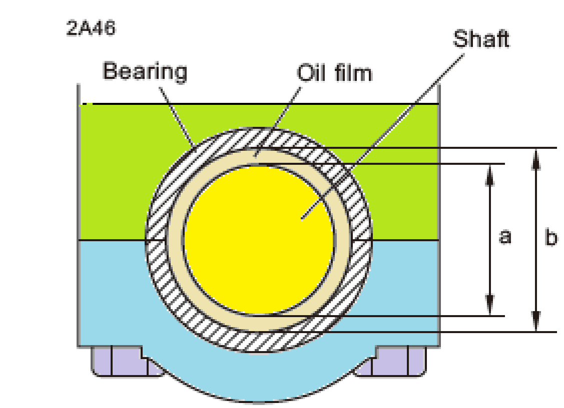


Figure 15: b – a = oil clearance

If the oil clearance of the crankshaft bearing deviates from the standard, check the size of the bearing's lower hole. Make sure that an appropriate bearing is assembled.

Note that the size of the bearing's lower hole is a dimension of the bearing installation surface.

There are different ones for each size. These sizes are stamped on the crankshaft, cylinder block and connecting rod.

Crankshaft bearing lower hole diameter = hole diameter of connecting rod big end.

1.2.8 Flywheel, drive plate and torque converter

The flywheel uses rotating inertial force to make sure that the engine operates evenly. It transmits force to the transmission through the clutch cover. The ring gear on the outside of the flywheel is rotated by the starting motor when starting the engine. In automatic transmission vehicles, the drive plate and torque converter perform the functions of the flywheel.

1.2.9 Valve mechanism

The valve mechanism is a system for sucking in a large amount of air fuel mixture into the cylinder for combustion and for efficiently expelling the burned gas to the outside. It opens and closes the intake valves and exhaust valves at the appropriate times.

1.2.9.1 Drive

The crankshaft rotation is transmitted to the camshaft via a timing chain or timing belt. The number of teeth on the camshaft side pulley is twice the number on the crankshaft side. When crankshaft rotates twice, the camshaft rotates once. (The camshaft makes half a rotation for every crankshaft rotation.) This camshaft rotation repeatedly opens and closes the valves.

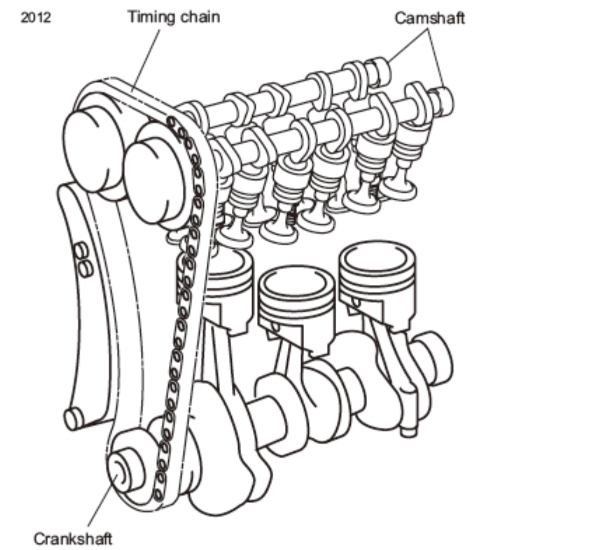


Figure 15: Camshaft & valve arrangement

1.2.9.2 Valve timing

The valve timing is the timing at which the intake valves and exhaust valves open and close. This timing is expressed by the crank angle. A graphic representation of this timing is called a valve timing diagram. The valves are not opened and closed exactly at the piston's top dead center and bottom dead center.

Rather, the intake valve opens before the piston enters the intake stroke; in other words, before top dead center. The valve closes after the end of the intake stroke; in other words, after bottom dead center.

The exhaust valve opens before the piston enters the exhaust stroke; in other words, before bottom dead center. The valve closes after the end of the exhaust stroke; in other words, after top dead center.

In this way, the valve opens earlier and closes later relative to the piston position. This improves the filling efficiency through inertia supercharging. As can be seen from the figure, near to top dead center at the end of the exhaust stroke, there is a period when the intake valve and the exhaust valve are both open. This is called the valve overlap.

During medium to high rotation speeds, it ensures the full expulsion of the burned gas and improves the filling efficiency for the air fuel mixture. In high-speed engines, a large valve overlap is desirable to increase the intake and exhaust efficiency at high engine rotation speeds. But at low speeds, air fuel mixtures with a slow flow rate will be blown back and the intake and exhaust rhythm will be disrupted, resulting in unstable idling. This means that normal engines have a smaller overlap to improve the performance and fuel economy at low speeds.

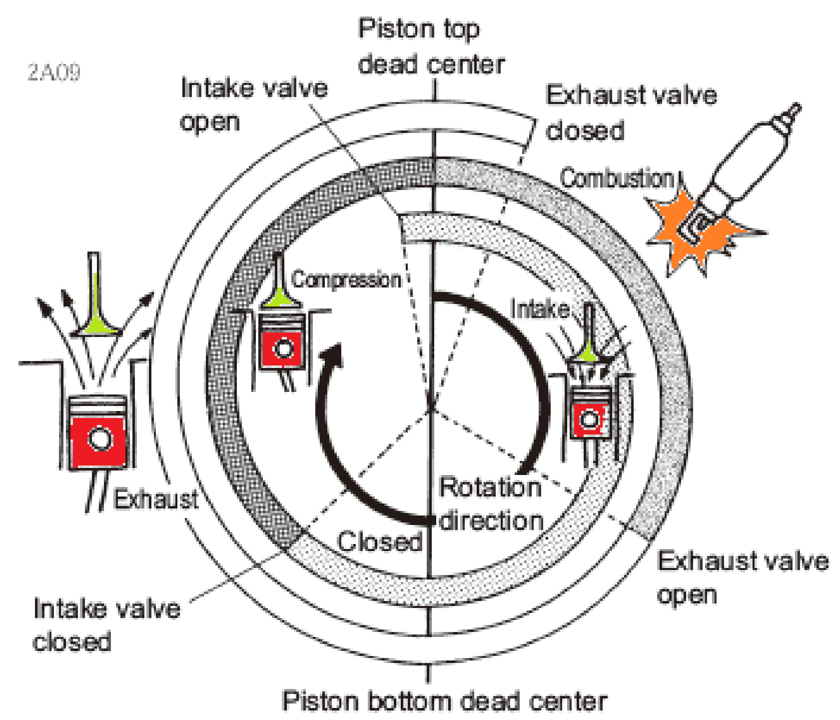


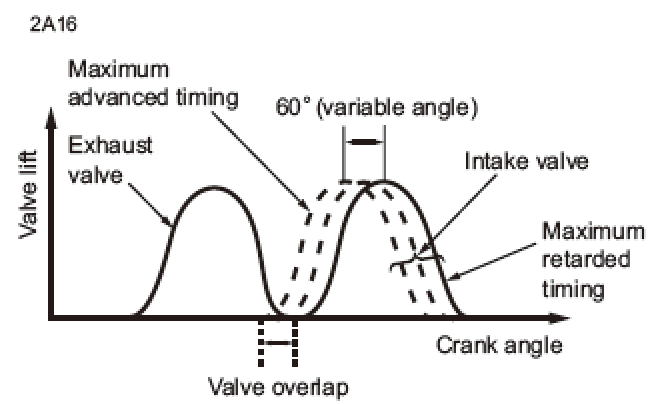
Figure 16: Valve timing

Key Points

To express the amount of air that can be sucked in during the engine's intake stroke, the volume of the air that is actually sucked in is divided by the displacement. This is called the "volumetric efficiency".
But the volumetric efficiency varies according to atmospheric conditions such as the air temperature and the ambient pressure. The "filling efficiency" is the volumetric efficiency that is calculated under standard atmospheric conditions.
In certain rotation ranges, the force of the air flow continues to suck air fuel mixture into the cylinder even after the piston finishes the intake stroke and enters the compression stroke. Taking advantage of this phenomenon to improve the filling efficiency is called "inertia supercharging".

Key Points

If a valve timing is set that is suitable for low and medium speed ranges, the performance in high speed ranges will be poor. The reverse is also true. In response to this issue, VVT (Variable Valve Timing) was developed. This is a system that continuously changes the timing at which the valves are opened and closed, in accordance with the engine operation conditions. VVT uses hydraulic pressure to shift the camshaft phase relative to the cam timing sprocket. This improves the torque in all ranges and the exhaust gas performance.



1.2.9.3 Types

Mechanisms with the following structure types are available for opening and closing the valves. They have different camshaft layouts.

1.2.9.3.1 OHC (Over Head Camshaft)

This is also called the SOHC (Single Over Head Camshaft). A single camshaft is positioned on the cylinder heads. It opens and closes the intake and exhaust valves via rocker arms.

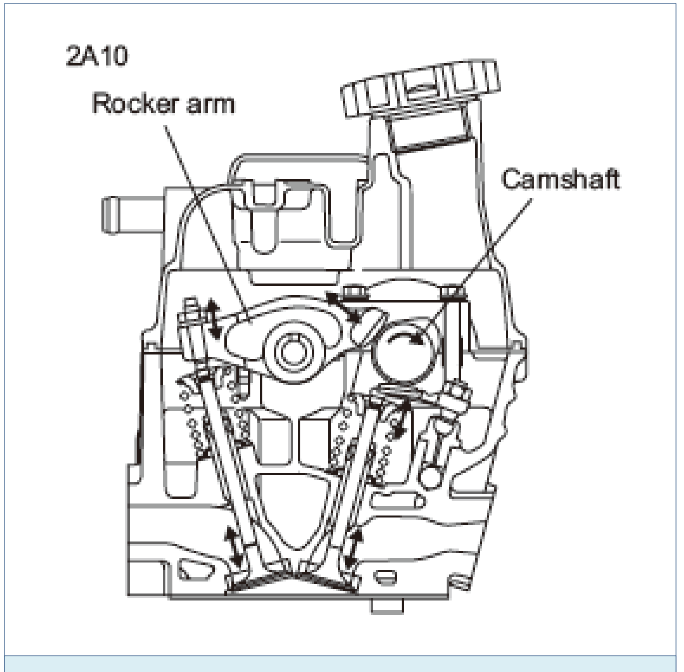


Figure 17: OHC valve mechanism layout

1.2.9.3.2 DOHC (Double Overhead Camshaft)

This is an advanced version of the OHC. It operates the valves using separate camshafts for the intake valves and the exhaust valves.

The intake and exhaust camshafts are separate, thus the valves can be positioned more freely. It also enables the spark plugs to be positioned in the center of the combustion chamber. Although the structure is more complex, the opening and closing of the valves are more accurate, which improves the intake and exhaust efficiency and raises the output and fuel economy.

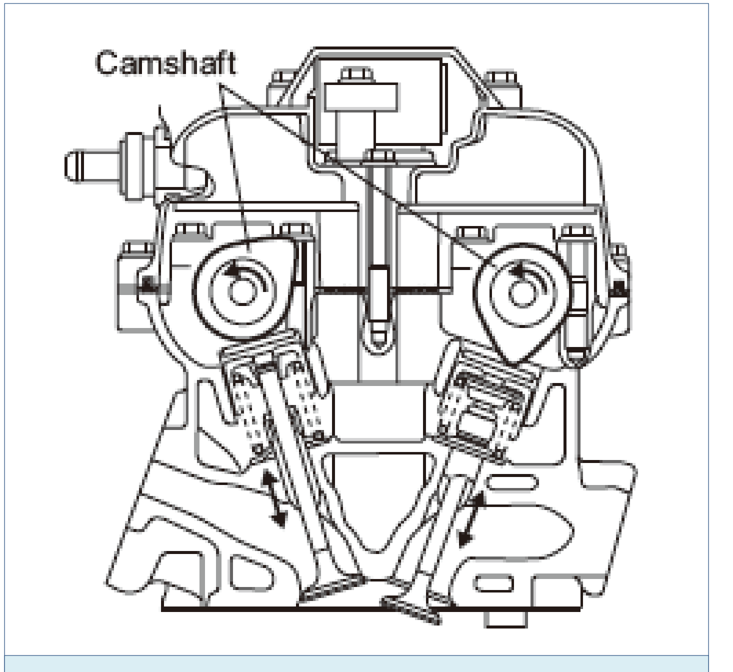


Figure 18: DOHC valve mechanism layout

1.2.9.4 Components

1.2.9.4.1 Camshaft

The camshaft has a row of cams that are shaped like an egg cut in half. It is synchronized with and driven by the crankshaft at half the crankshaft's rotation speed. This means that the intake valves and exhaust valves open and close correctly in accordance with the piston's movement.

The camshaft is driven via a timing chain or timing belt. A timing chain system has excellent durability, while a timing belt system generates low noise. The tension of a timing chain and timing belt is adjusted with a tensioner.

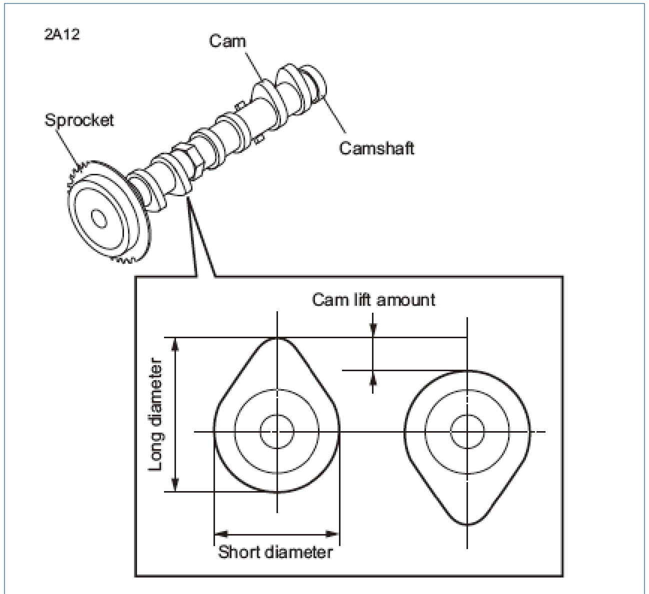


Figure 19: Camshaft

The camshaft is an important part that gives an engine its personality. Whether an engine is a high rotation speed or low rotation speed type is determined through the cam profile (shape of the cam outer circumference). The cam's short diameter subtracted from its long diameter is called the cam lift amount.

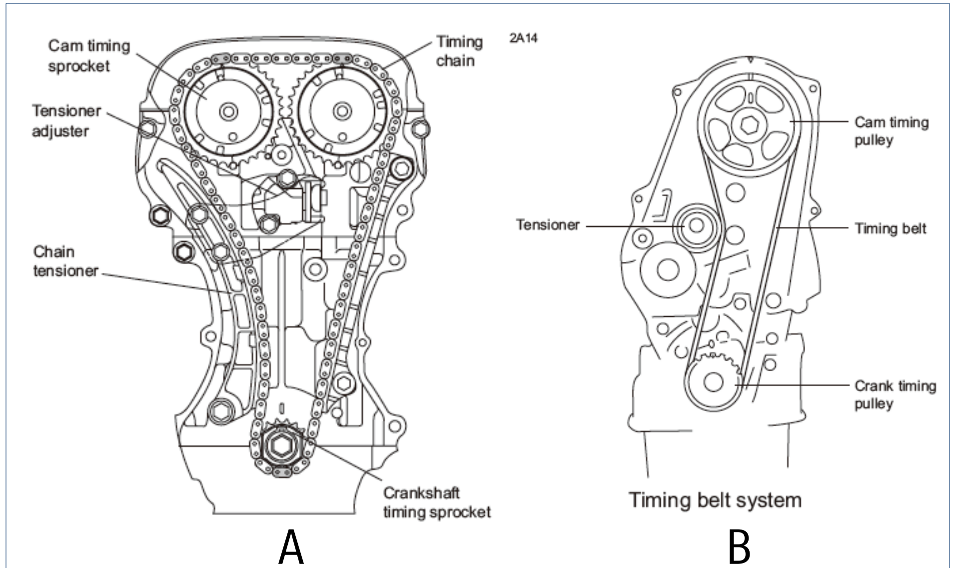


Figure 20: Camshaft drives mechanisms

[A] Timing chain system
[B] Timing belt system

1.2.9.4.2 Valves

Valves open in the intake stroke and exhaust stroke to ensure smooth intake and exhaust. They are closed in the compression stroke and combustion stroke to seal the combustion chamber and ensure powerful compression and combustion.

The diameter of the valve head is slightly larger on the intake valve than on the exhaust valve. This is because in the intake stroke the air fuel mixture is sucked in through negative pressure, so to increase the intake efficiency the intake valve diameter must be enlarged. In the exhaust stroke, because the exhaust gas is expelled by the pressure of the rising piston and the pressure of the burned gas, the exhaust valve diameter must be slightly smaller.

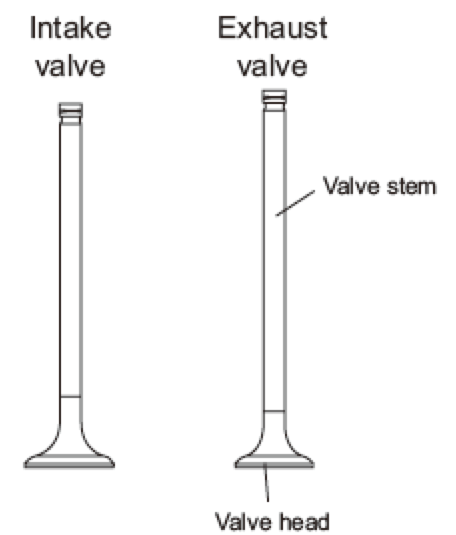


Figure21: Valves

1.2.9.4.3 Valve seats

The valve seats are the areas at the combustion chamber openings of the intake and exhaust ports with which the valves make contact. Because strong contact is made with the seats each time the valves open and close, they are made from a special sintered alloy that has excellent durability and they are press fitted into the cylinder head.

When a valve is closed, the valve face and valve seat make contact and are sealed. The valve heat is transferred to the cylinder head. If the valve makes wide contact with the valve seat, the valve cooling effect will be higher but it will trap more carbon and the sealing will be worse. On the other hand, if the contact width is thin, the sealing will be better but the valve cooling effect will be lower.

1.2.9.4.4 Valve guides

The valve guides are press fitted into the cylinder heads and guide the valves. To prevent engine oil from entering the combustion chamber from the clearance between the valve stem and the valve guide, a valve stem oil seal is installed on the top of the valve guide.

The exhaust valve becomes hotter than the intake valve. Taking into account thermal expansion, the clearance between the valve guide and valve stem is made slightly larger on the exhaust side than on the intake side.

When the valve stem sticks onto the valve guide or the valve does not move smoothly, it is called valve stick. If valve stick occurs, it may worsen the sealing between the valve and the valve seat and cause compression loss. Valve stick may be caused by insufficient clearance between the valve and the valve guide bush, engine overheating, or seizure or trapped carbon due to lubrication defects.

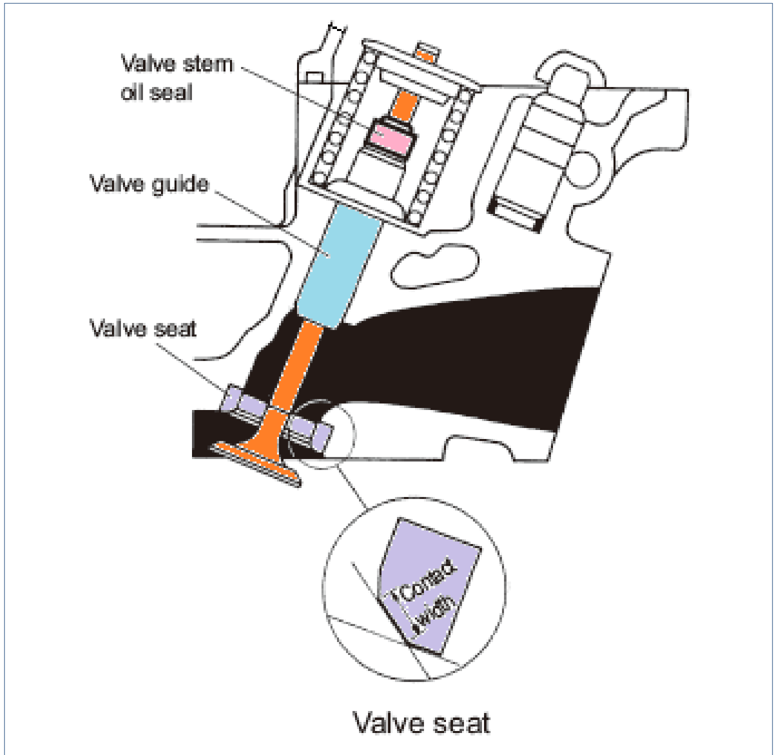


Figure22: Valve stem

1.2.9.4.5 Valve springs

The valve springs are coil springs that apply the force to close the valves. Valve springs have a natural frequency. If an integral multiple of the number of valve openings and closings is reached, resonance occurs and the valves will no longer open and close correctly. This phenomenon is called valve surging. Other phenomena may also result in the valves not opening and closing correctly.

For example, in valve bounce, the valve does not fully return during high engine rotation speeds. In valve jump, the spring force is too weak and the valve jumps because it cannot keep up with the cam projection. If these occur, the valve spring may break, or it may result in interference between the valve and piston. To prevent these phenomena, a double spring is used that combines springs with different resonance frequencies. Alternatively, a variable pitch spring is used that is lighter on the moving side.

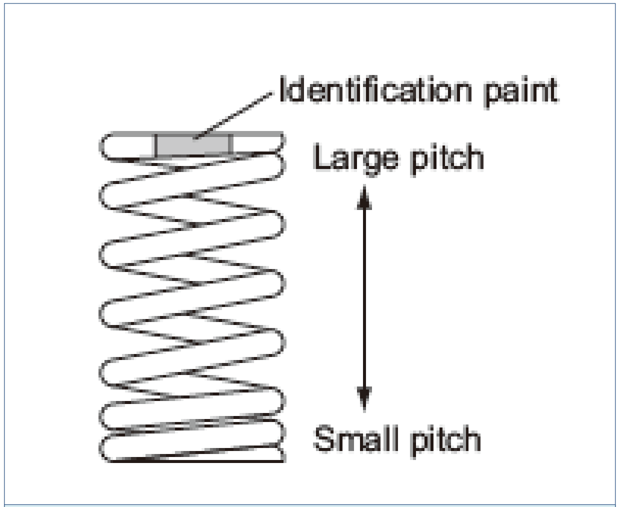


Figure23: Valve spring

1.2.9.4.6 Tappets and shims

A tappet is the projection that makes direct contact with the valve in the direct system. A shim is used to adjust the clearance with the valve.

1.2.9.4.7 Valve lash adjuster

A valve lash adjuster improves serviceability by automating the adjustment of the valve clearance. It also reduces noise by eliminating the tappet sound.

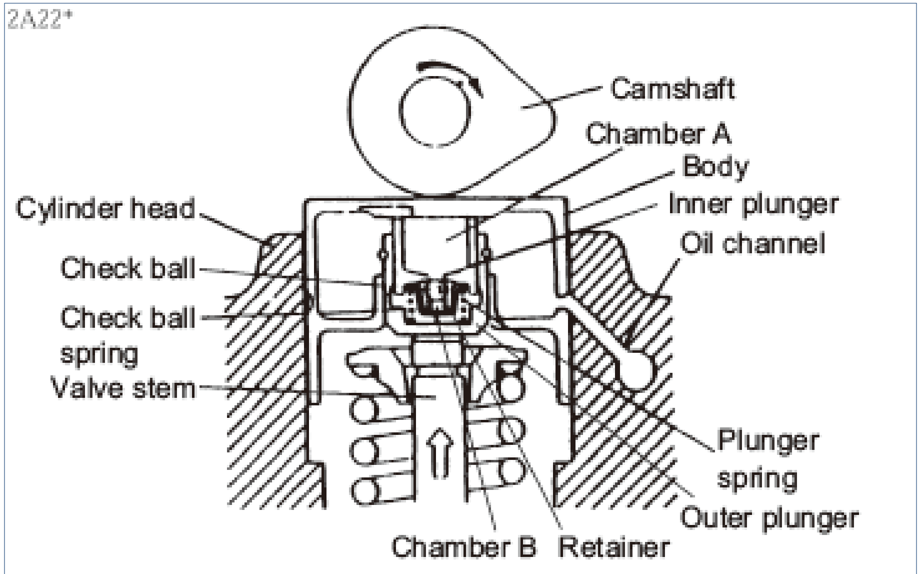


Figure24: Valve lash adjuster

1.2.10 Cylinder head

On the lower side of the cylinder head are the piston and a hollow that forms part of the combustion chamber.

Various changes can be made to the combustion chamber for more efficient burning of the air fuel mixture. For example, positioning the plugs in the center as much as possible, or increasing the valve area.

The inside of the cylinder head contains the valve mechanism and spark plugs, and the water jackets and oil channels for cooling these parts.

In 4-valve engines, a pent-roof shaped combustion chamber is often used that has a cross-section similar to a roof.

This pent-roof type has a large squish effect and the spark plugs are positioned in the center of the combustion chambers. This achieves a shorter flame propagation distance and burning time.

The most commonly used intake and exhaust layout is a cross-flow type where the air fuel mixture flows horizontally across the combustion chambers.

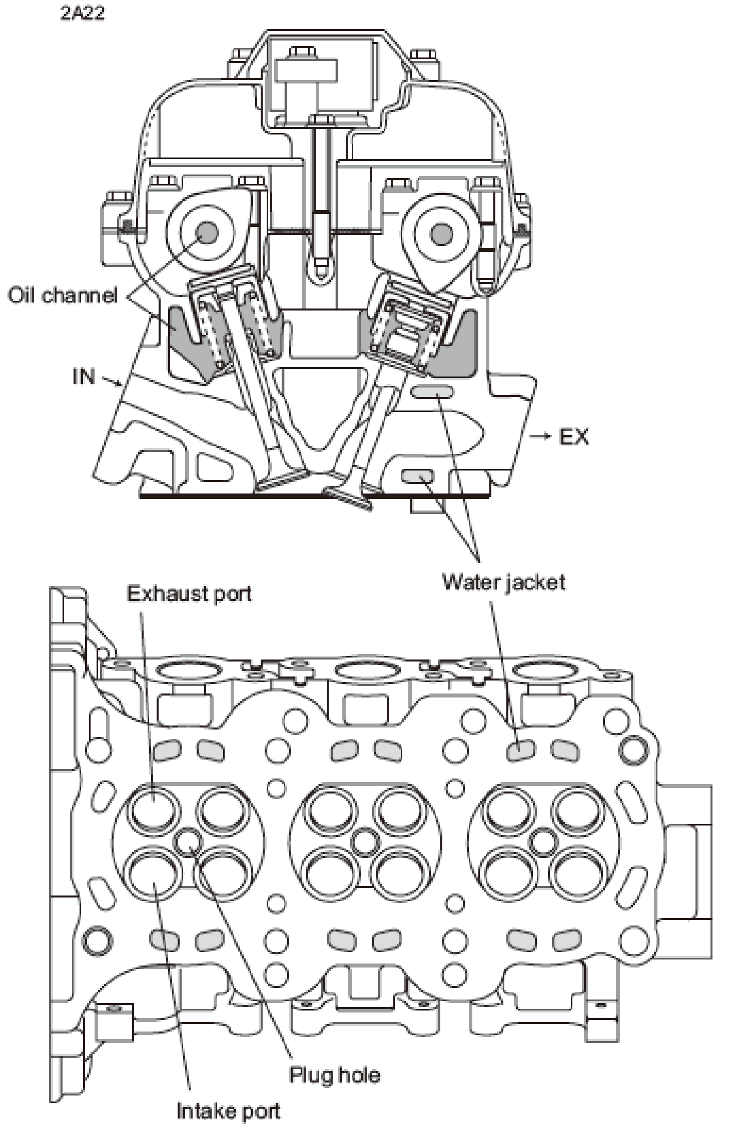
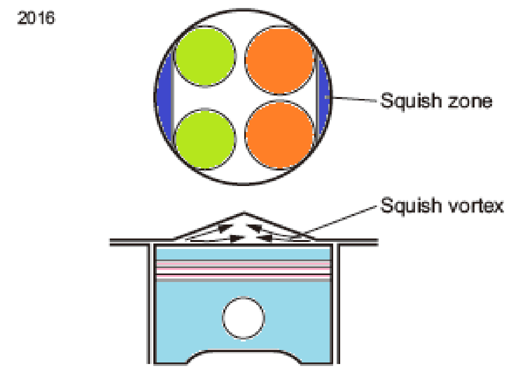


Figure25: Cylinder head

Key Points

The squish zone in the combustion chamber generates a strong turbulence (squish) from the later stages of the compression stroke and into the combustion stroke. This turbulence increases the burning speed and makes sure that the air fuel mixture is fully burned.



1.2.11 Cylinder head gasket

The cylinder head gasket prevents leaks of burned gas, coolant and oil from the assembly surface between the cylinder head and the cylinder block. The gasket is made from materials that can withstand high temperature and high pressure.

In the K10B engine for example, a two-layer metal gasket is used to improve durability and reliability.

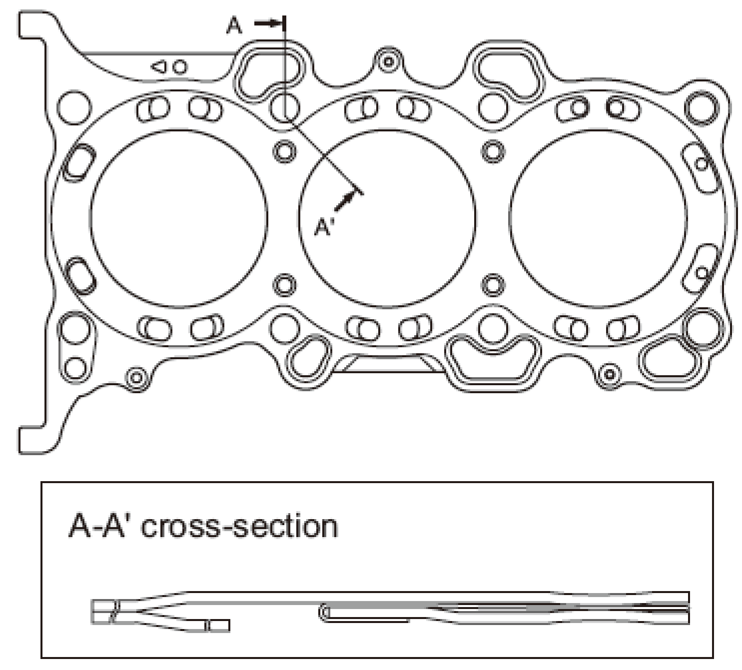


Figure26: Cylinder head gasket

Lesson 2:

Basic engine maintenance

Objectives

At the end of this lesson, you will be able to:

- Describe the basic checks and inspection for each engine parts during service and maintenance on the engine.
- Describe all the important points to be considered during removal and installation of all engine parts/components.

2.1 Cylinder head checks and corrections

2.1.1 Check for carbon, water scale and rust

- Check for carbon adherence around the exhaust ports and valve seats. Do not use a sharp blade to remove carbon from the combustion chamber. Use a method that does not damage the metal surfaces.
- Check the water jacket for water scale and rust.

Clean any significant scale or rust. Accumulated carbon causes overheating and engine knocking, while water scale and rust cause overheating.

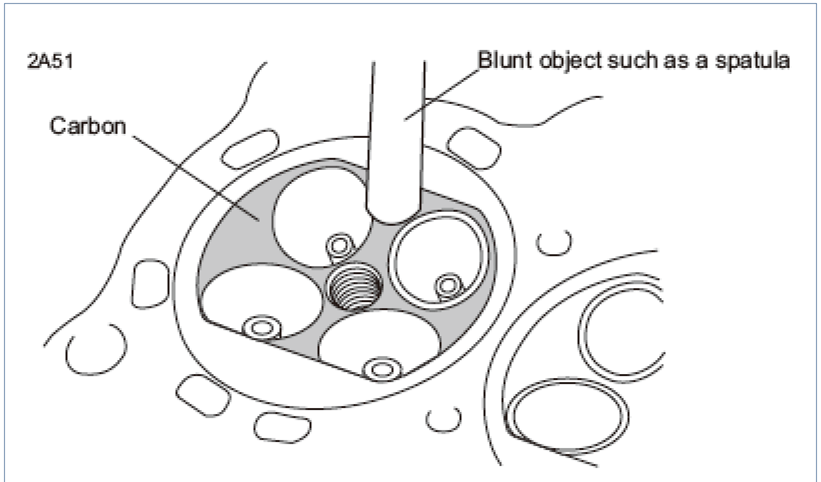


Figure1: Check cylinder head

Significant oil adherence on an intake port is often caused by oil leaking into the combustion chamber via valve guides. Dust adherence is often caused by an air cleaner defect. Using this information, you can judge conditions before performing disassembly.

2.1.2 Crack check

Remove any carbon that is adhered to the cylinder head lower surface. Then, check for cracks in the intake port, exhaust port, combustion chamber and cylinder head surface. Use dye penetrant testing as required when checking for cracks. Replace any cracked parts.

2.1.3 Distortion check

Check for distortion on the cylinder head lower surface and the manifold installation surface. Measure by pressing a straight edge in the 6 directions from A to F on the cylinder head lower surface and the 3 directions from A to C on the manifold installation surface, and by inserting a thickness gauge in all the directions.

The straight edge used at this time must be long enough to make contact with the entire surface of the cylinder head.

If the distortion slightly exceeds the limit, correct with a fine oil stone or lapping machine. Replace if the distortion significantly exceeds the limit. If the gasket installation surface of the cylinder head is distorted, the burned gas may leak and result in overheating or a drop in output.

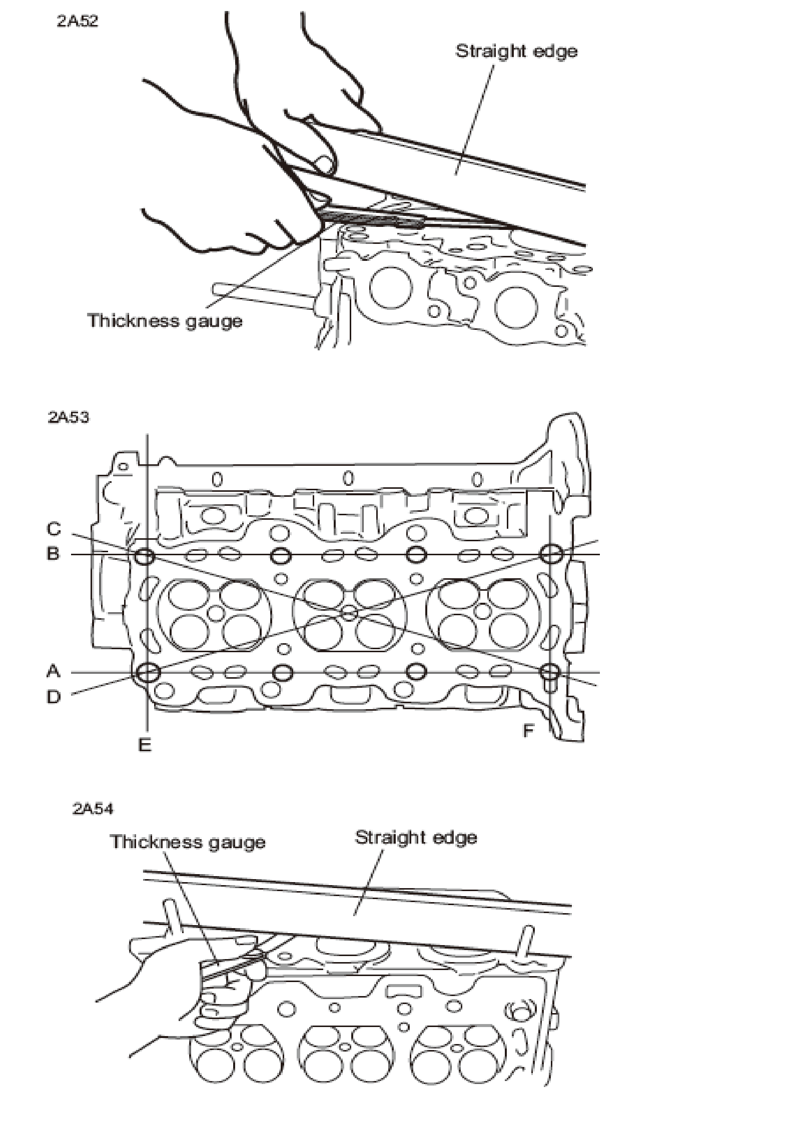


Figure 3: Cylinder head distortion check

2.1.4 Important points for cylinder head removal and installation

2.1.4.1 Cylinder head removal

Remove the cylinder head tightening bolts in the specified order, moving from the outer side to the center. Loosen the bolts alternately in 2 cycles and remove. Be especially careful when the cylinder head is hot, because removal may cause distortion of the cylinder head. Also, the tightening bolts have different lengths. Store them so that you remember their correct positions during assembly.

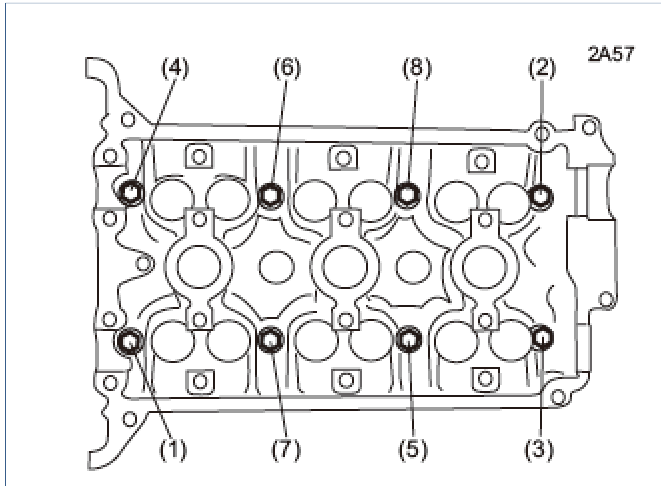


Figure 4: Cylinder head bolts removal

2.1.4.2 Cylinder head installation

Make sure that the cylinder head gasket is the correct side up during assembly. Align it properly with the knock pins on the top of the cylinder block. Before installing the cylinder heads, clean any moisture or oil from the bolt holes on the cylinder block and degrease the mating surfaces. When installing the cylinder head bolts, lightly apply oil to the threads and the seating surfaces, and tighten the bolts from the center to the outer side in 2 cycles. Then, in the reverse order, loosen the bolts until their torque is 0, and tighten them again in 2 cycles. Do not tighten the bolts while there is moisture or oil in the bolt holes, because it could damage the cylinder block.

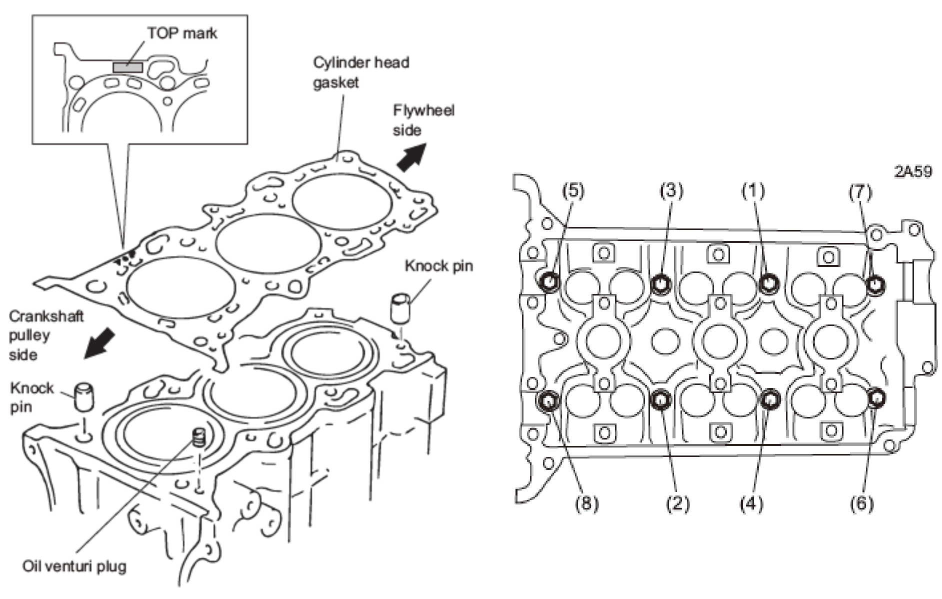


Figure 5: Cylinder head installation

Key Points

The cylinder head bolts in small vehicle M-engines are tightened to the plastic range. With conventional bolts, the axial force is controlled with tightening torque that is within the elastic range of the bolt. But with plastic range tightening bolts, the bolts are tightened beyond the elastic range and into the plastic range, achieving a more stable control of the axial force. For this reason, the tightening method for the M-engine is to tighten to the specified torque over 2 cycles, and then to tighten by the specified angle over 2 cycles. The connecting rod also uses bolts that are tightened to the plastic range.

2.1 Cylinder and cylinder block checks and corrections

2.1 Cylinder check

Check the cylinder for scratches or abnormal wear on the cylinder wall. The cylinder tends to wear as shown in the figure 6. As such, check by using the bore gauge to measure the bore in 3 locations (top, middle and bottom) and in the crankshaft axial direction (3) and thrust direction (4), in a total of 6 locations.

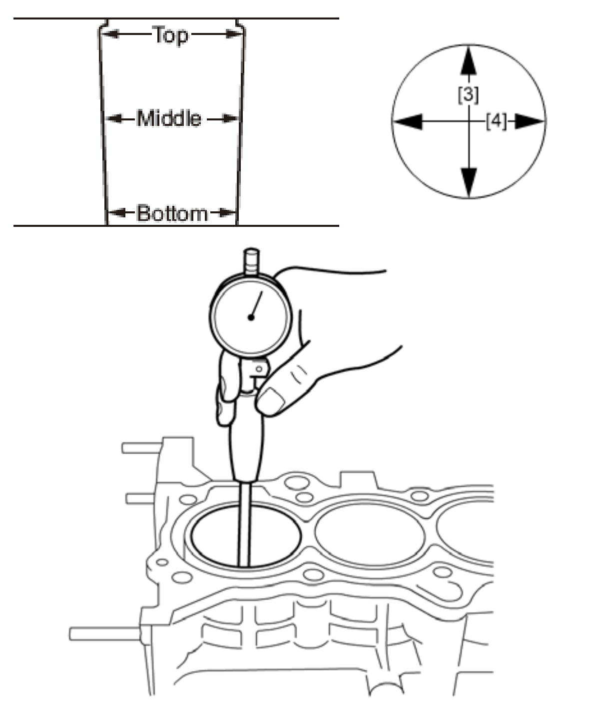


Figure 6: Cylinder bore inspection

2.2 Cylinder block check

Check the cylinder block for distortion on the upper surface, cracks, water scale or rust in the water jackets, and coolant channel or oil channel clogging.

When checking for distortion on the cylinder block upper surface, use the same procedure as when measuring the distortion on the cylinder head lower surface. Measure with a straight edge and thickness gauge, and if the distortion slightly exceeds the limit, correct with a fine oil stone or lapping machine.

Replace if the distortion significantly exceeds the limit. Check the thread holes of the cylinder head bolts for cracks, using dye penetrant testing as required. Coolant channel or oil channel clogging can be cleaned with an air gun, but be aware that water scale or rust may have accumulated in the lower area of the water jackets.

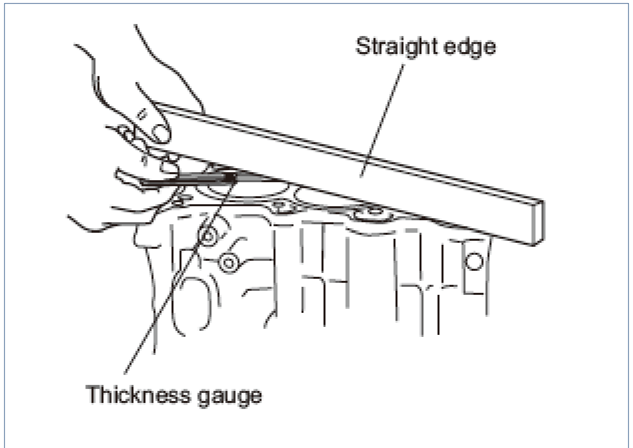


Figure 7: Inspection of cylinder block

If the gasket installation surface of the cylinder block is distorted, the burned gas may leak and result in overheating or a drop in output, and water scale or overheating may result in overheating.

2.3 Piston, piston pin and piston ring checks and corrections

2.3.1 Piston check

Remove any carbon from the piston head and the ring groove, and check the piston for cracks, scratches and damage. Replace if there are any problems.

Check carefully the areas that are difficult to see at the back of the piston ring groove. Check the piston head carefully, because sometimes it receives burn damage from abnormal combustion.

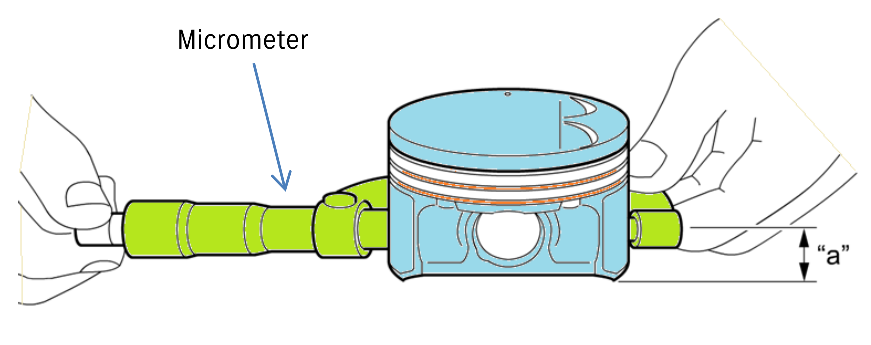


Figure 8: Piston checks

[a] Piston should be measured at specified position (refer to service manual)

Measure the piston outside diameter by using a micrometer in the specified positions "a" in the piston boss direction and the perpendicular direction.

Piston clearance

Calculate the piston clearance from the difference between the outside diameter and the cylinder bore inside diameter.

Piston groove clearance

To measure the wearing of the piston ring groove, clean the ring groove and after it dries insert a new piston ring into the ring groove. Use a thickness gauge to measure the clearance between the ring and the ring groove in several locations on the outer circumference. If the values deviate from the standard, replace the piston.

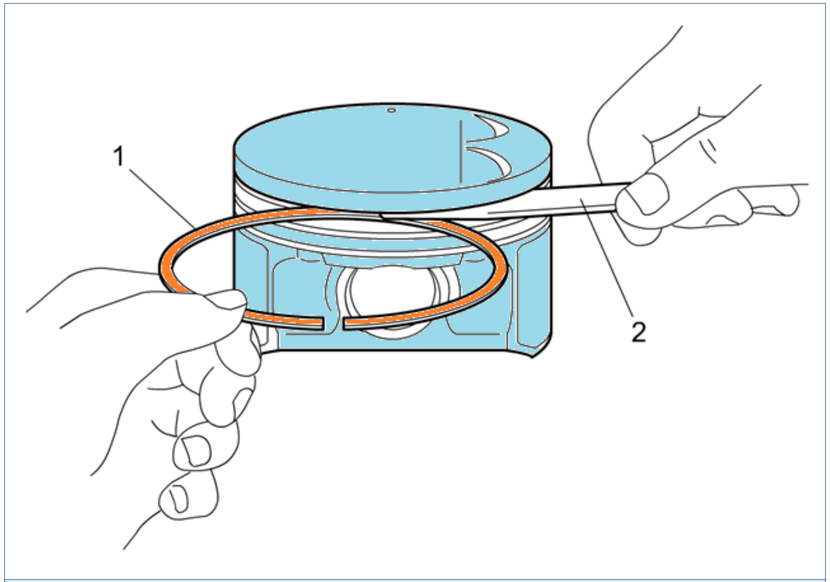


Figure 9: Piston groove measurements

Piston problems may lead to issues such as starting defects, rough idling, engine operation problems, insufficient output, overheating, engine knocking, excessive oil consumption and defects in the exhaust gas system.

2.4 Piston pin check

Use a micrometer and bore gauge to measure the outside diameter of the piston pin, the bore of the piston boss area, and the bore of the connecting rod small end. Use these values to calculate the clearance between the piston pin and the piston boss area, and between the piston pin and the connecting rod small end. If a clearance deviates from the standard, replace the piston pin, piston and connecting rod as a set. Also, check the inner and outer surfaces of the piston pin for cracks. If there are cracks, replace the piston and piston pin as a set.

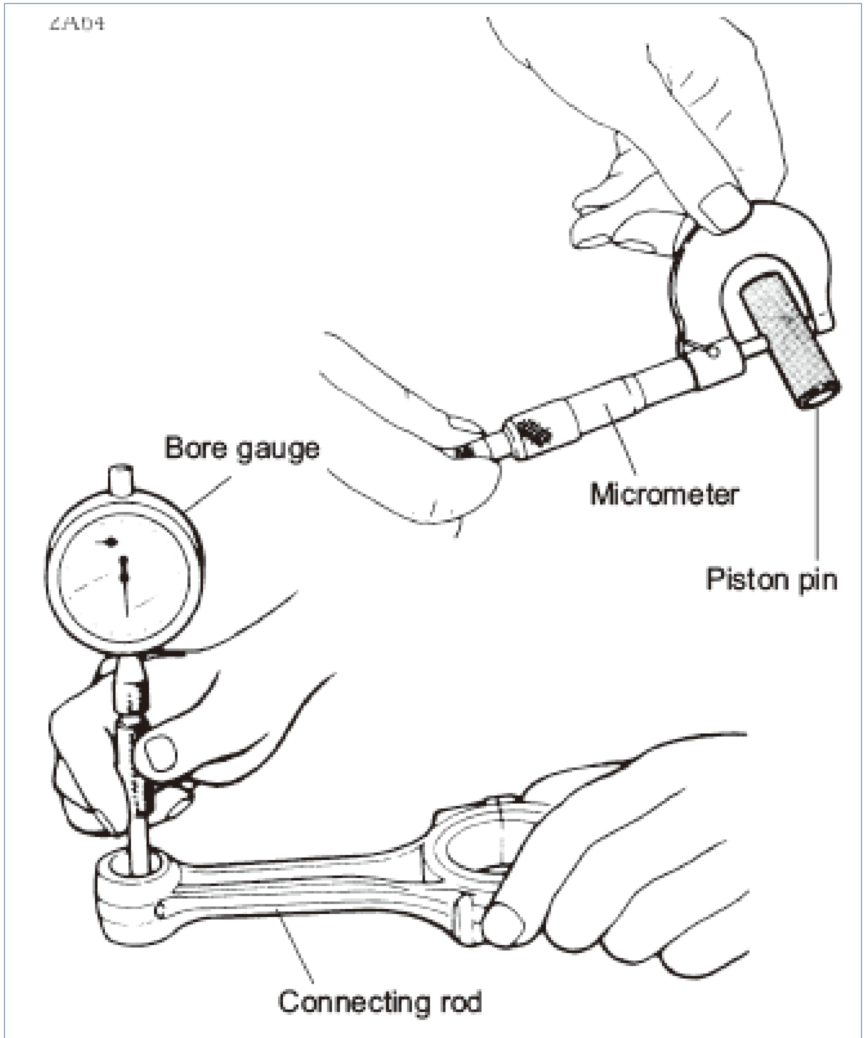


Figure10: Piston pin & connecting rod check

2.5 Piston ring check

Check the end gap of the piston ring. The end gap is the clearance between the 2 ends of the ring while it is assembled in the cylinder, as shown in the figure. Its purpose is to prevent the ends from making contact with each other when the ring expands in high temperatures during engine operation. When the ring wears and its thickness is reduced, the end gap becomes larger. Check the end gap by pressing the ring down to the bottom of the cylinder with the piston head so that the ring is perpendicular to the cylinder and measuring the gap with a thickness gauge. If the end gap exceeds the limit, replace the ring.

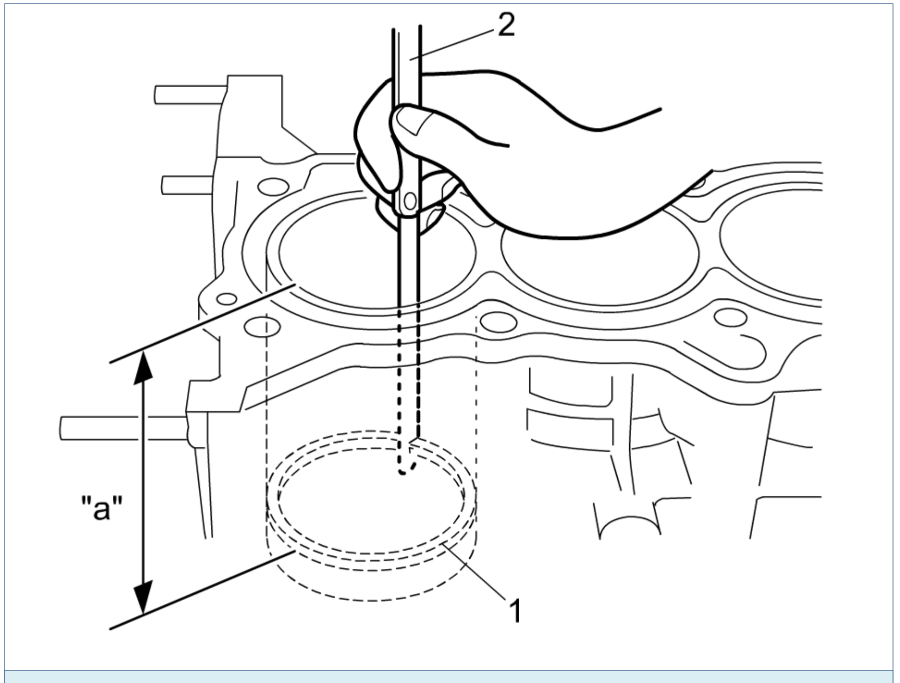


Figure11: Piston ring end gap check

Piston ring problems may lead to issues such as starting defects, rough idling, engine operation problems, insufficient output, excessive oil consumption and defects in the exhaust gas system.

2.5.1 Important points for piston removal and installation

2.5.1.1 Piston removal

- Before removing the pistons from the cylinders, use a quick-drying ink pen to mark the corresponding cylinder number on all the pistons, connecting rods and bearing caps.

- After removing the connecting rod cap, install the guide hoses to the connecting rod bolts and remove the piston after making sure it will not damage the cylinder wall. This will be easier if you remove in advance any carbon that is adhered to the top of the cylinder wall, so that the piston ring does not catch against it. If you cannot remove the piston by hand, put a wooden block or something similar on the connecting rod and hit it gently.

2.5.1.2 Piston assembly

There are 2 different piston sizes. When replacing a piston with a new part, be sure to check the cylinder’s identification color or stamped number and select the correct piston. If the clearance is too small, it may cause piston seizure. If the clearance is too large, compression loss may cause a drop in output or a slapping noise.

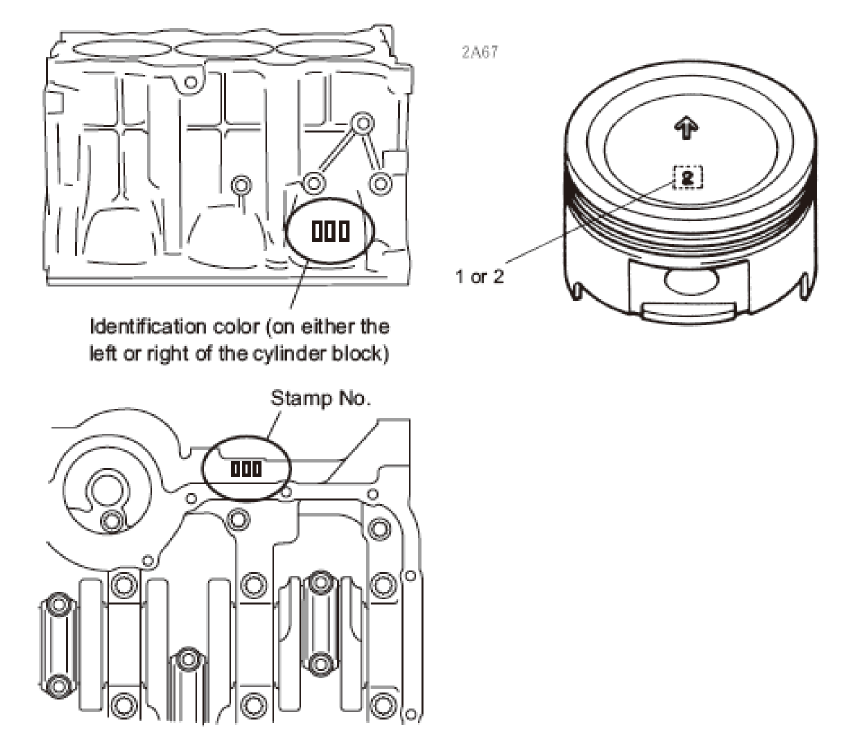


Figure12: Piston identification

When assembling the piston and the connecting rod, make sure that the front marks on the piston head and the oil hole of the connecting rod are aligned as shown in the figure 13.

Do not assemble the piston ring in the wrong position or the wrong way up. There is a mark on the top side of the first ring and second ring to show which is the correct side up (Refer to figure 14)

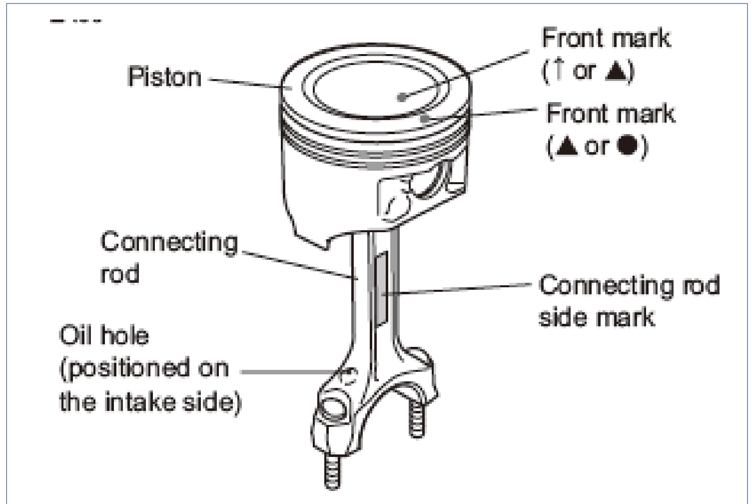


Figure13: Piston front marks

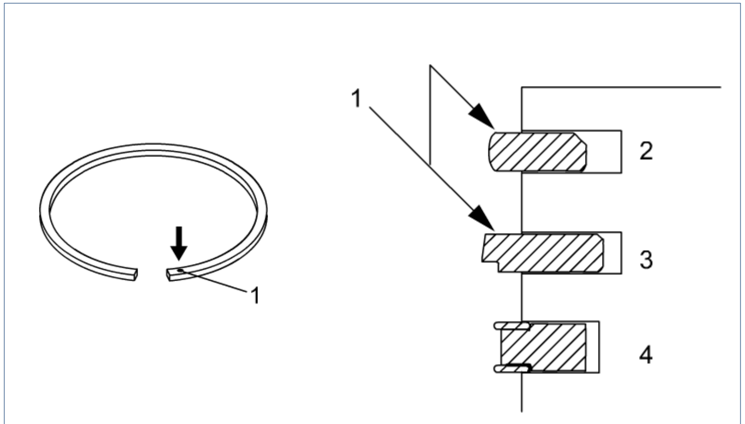


Figure14: Piston ring installation

Figure 14

[1] Mark on ring	[2] Top ring
[3] 2nd ring	[4] Oil ring

2.5.1.3 Piston installation

When inserting a piston that is assembled to a connecting rod into a cylinder, stagger the end gaps of the piston rings so that the end gaps of adjacent rings are not in the same position. If the gaps match, it is easy for burned gas to leak from this area. Further, assembly the end gaps so that they do not face the piston lateral pressure direction (the direction in which the piston pushes the cylinder wall during combustion) or the crankshaft axial direction.

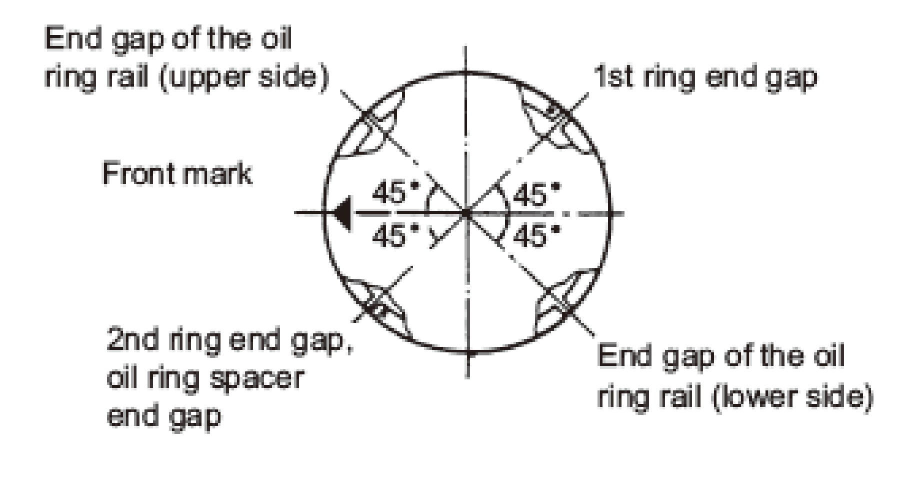


Figure15: Installation of piston rings

When installing the piston, install the guide hoses to the connecting rod bolts and be careful not to damage the cylinder wall.

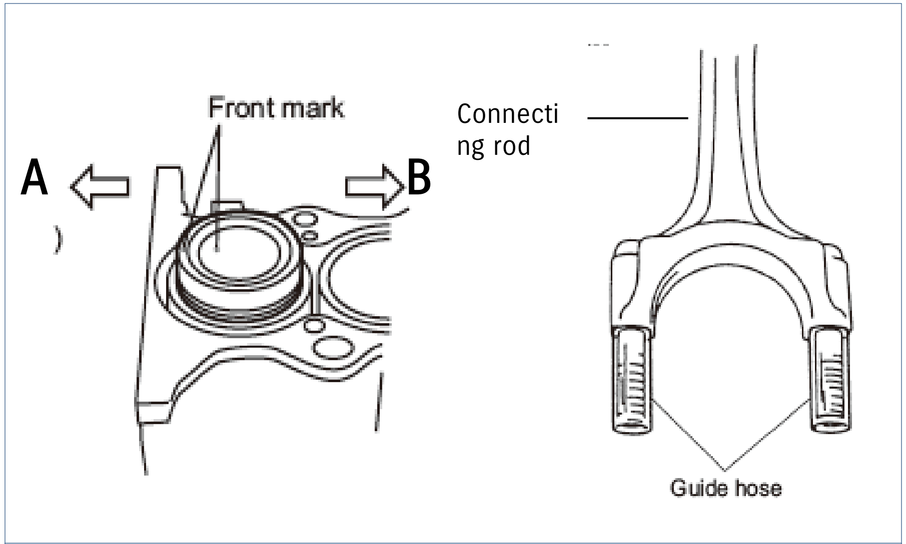


Figure16: Piston installation

[A] Crankshaft pulley side

[B] Flywheel side

Apply engine oil to the piston, piston ring, cylinder wall, connecting rod bearing and crankshaft pin. Then insert the piston into the cylinder so that the front mark on the piston head faces the engine front side.

Use the piston ring compressor to compress the piston ring in advance. While gently hitting the piston head with the handle of a hammer, push the piston in until the connecting rod bearing makes contact with the crankpin.

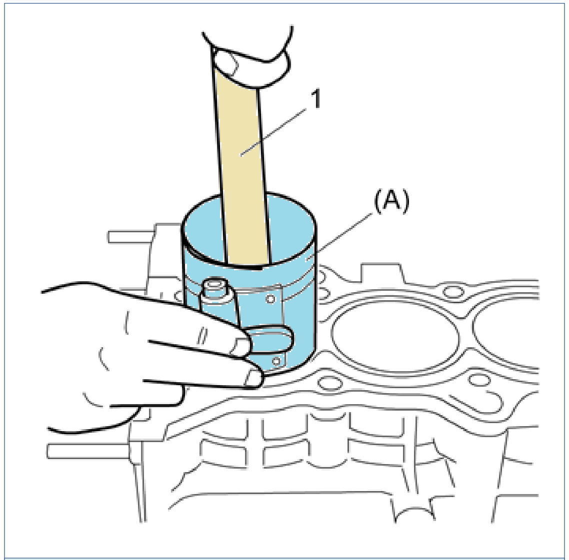


Figure17: Piston installation

Figure 16
[1] Hammer handle
[A] Piston ring compressor

Assemble the connecting rod cap so that that the arrow faces the front side. Apply engine oil to the bolt threads and nut seating surfaces, and then tighten them alternately to the specified torque. After tightening, check that the crankshaft rotates smoothly. If there are any abnormalities, remove the corresponding piston and check again.

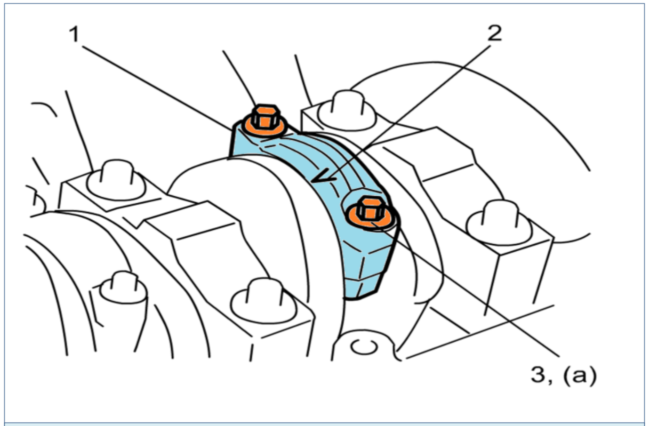


Figure18: Connecting rod bearing cap installation

Figure 17
[1] Connecting rod bearing cap
[2] Arrow
[3] Bearing cap bolt

2.6 Connecting rod and connecting rod bearing checks and corrections

2.6.2 Connecting rod check

Install the connecting rods to each crankshaft pin and measure the thrust clearance of the big end with the thickness gauge (figure 19A). If a measured value exceeds the standard, replace the connecting rod. If there is significant wear and the allowance is too large, the connecting rod will move in the thrust direction and generate noise.

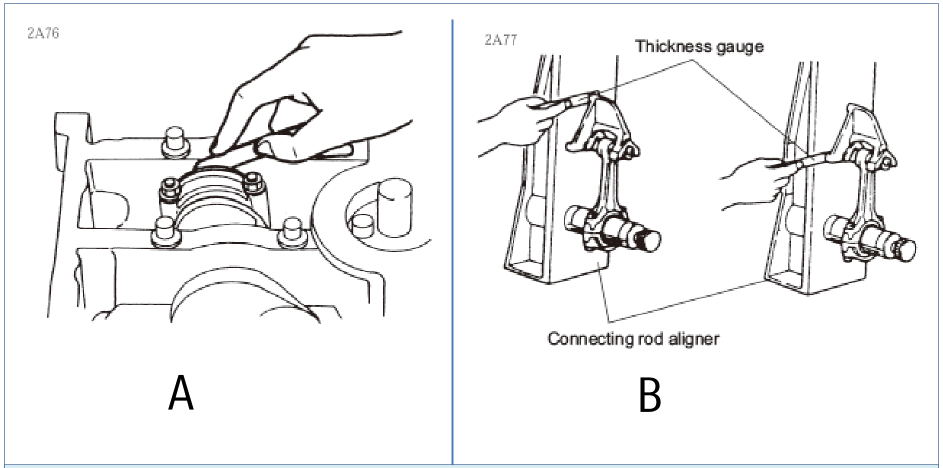


Figure 19: Connecting rod check

Use the connecting rod aligner to measure the bending and twisting of the connecting rod (figure 19B). If a measured value deviates from the standard, replace the connecting rod.

2.6.3 Connecting rod bearing check

Check the surface of the connecting rod bearing for peeling, melting damage, seizure and abnormal wear. If there are any problems, replace the connecting rod bearing. The bearing tension gradually drops as it is repeatedly exposed to loads.

Be very careful if you are reusing the bearing.

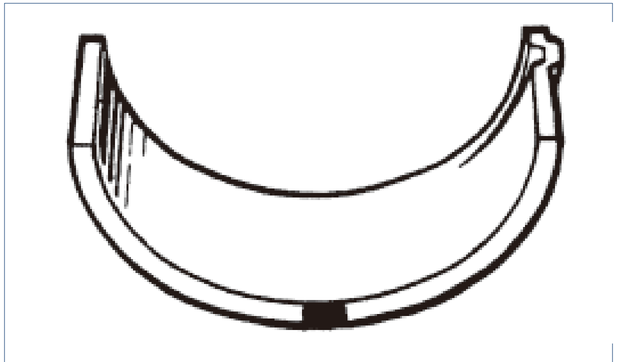


Figure 20: Connecting rod bearing

2.7 Crankshaft and crankshaft bearing checks and corrections

2.7.1 Crankshaft check

2.7.1.1 Out-of-round and taper of journals

Use a micrometer to measure the outside diameters of the crankshaft pin and the crankshaft journal. Then calculate the deflection (A - B) and the taper (1 - 2). If the deflection or taper is equal to or greater than the limit, replace the crankshaft. Wearing of the crankshaft journal and pin may cause the bearing to wear and the oil clearance to increase, resulting in a drop in hydraulic pressure and abnormal engine noise.

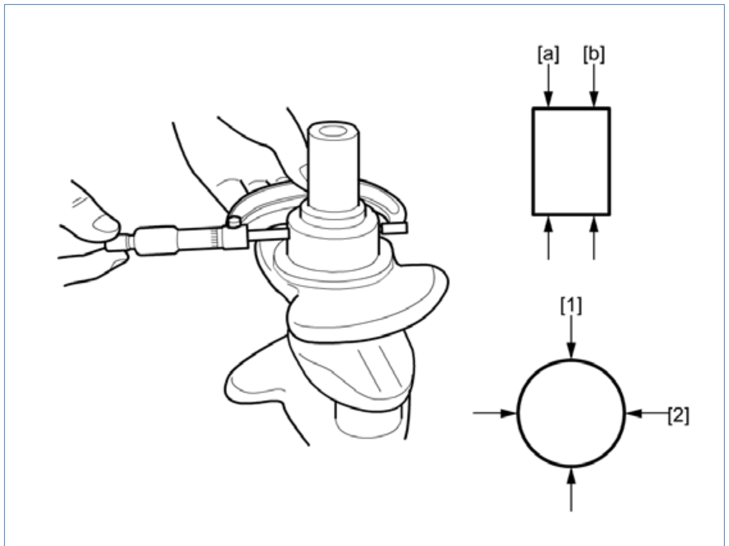


Figure 21: Crankshaft check

2.7.1.2 Crankshaft run-out check

Check the crankshaft deflection by placing the crankshaft on a V block and set the dial gauge against the journal. In this condition, gently rotate the crankshaft in one direction with your hand and measure the deflection. If the measured value exceeds the standard, replace the crankshaft.

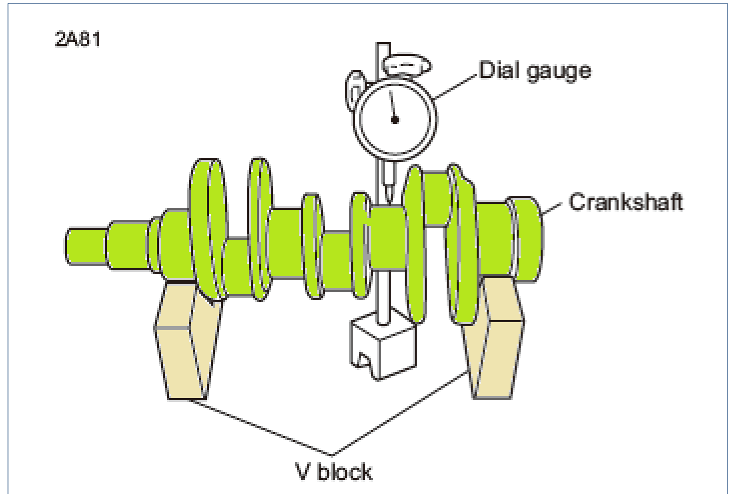


Figure 22: Crankshaft deflection check

2.7.1.3 Crankshaft thrust play

Use the dial gauge to check the allowance in the crankshaft axial direction while the crankshaft is assembled. If the measured value is equal to or greater than the limit, replace the thrust bearing with a new bearing that is the standard size or oversize. Then perform the measurement again.

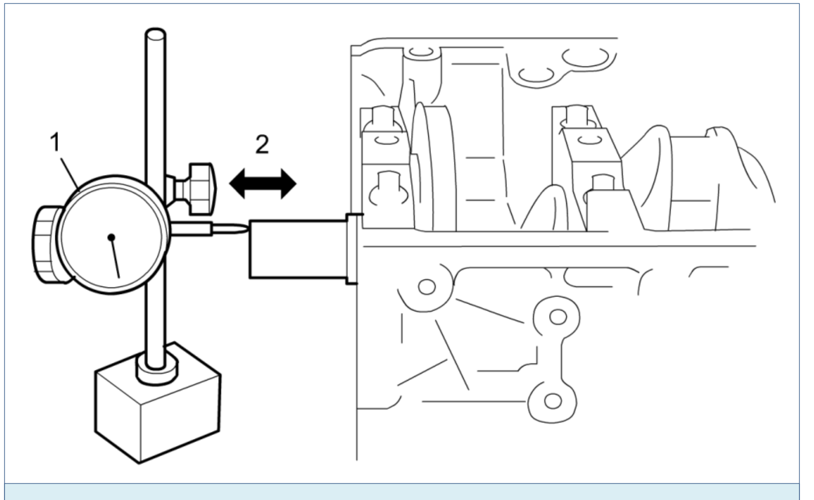


Figure 23: Crankshaft thrust play check

2.7.2 Crankshaft bearing check

2.7.2.1 Crankshaft bearing installation

Check the crankshaft bearing for peeling, melting damage, seizure and abnormal wear. If there are any problems, do not correct them. Replace the crankshaft bearing

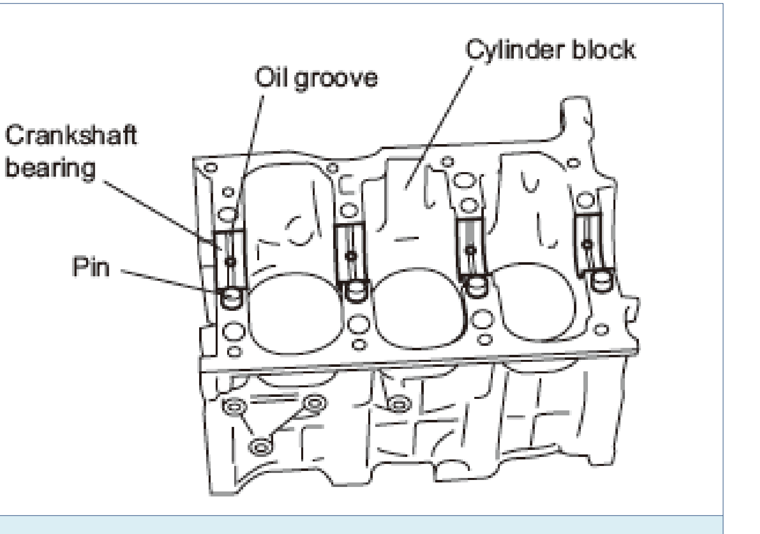


Figure 24: Crankshaft bearing installation

2.7.2.2 Lower crankcase installation

When installing the lower crankcase, apply engine oil to the bolts and tighten the bolts with a torque wrench from the center to the outer sides, in order from (1) to (8) as shown in the figure. Then, in the reverse order, loosen the bolts until their torque is 0. After this, tighten to the specified torque in 2 cycles. After tightening bolts (1) to (8), tighten bolts (9) to (16) to the specified torque in the order shown in figure 25.

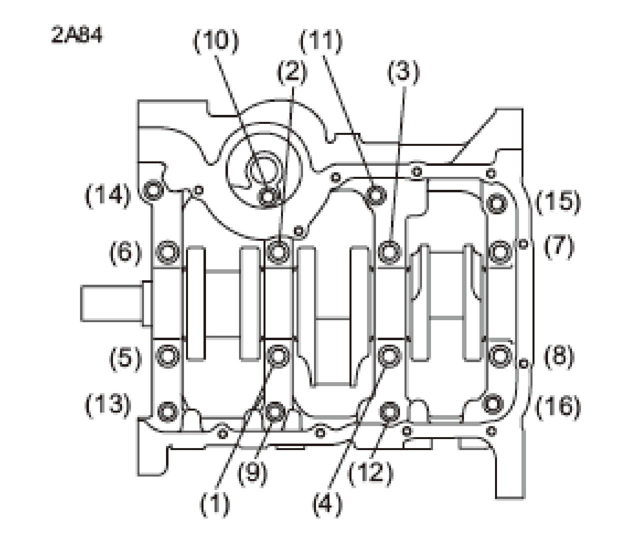


Figure 25: Lower crankcase installation (K10B)

2.8 Flywheel and ring gear checks and corrections

2.8.1 Flywheel check

Flywheel deflection may cause problems such as clutch connection defects. Measure the deflection with a dial gauge and if it exceeds the limit, replace the flywheel.

The contact surface may develop cracks or stepped wear due to repeated friction with the clutch disc. Check for these issues, and if there are any problems, grind or replace.

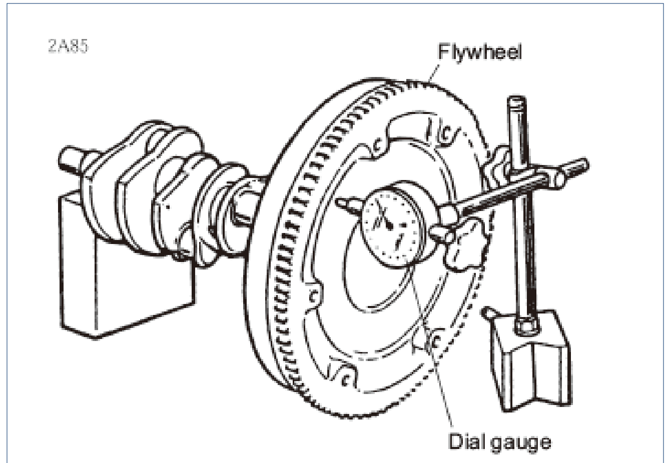


Figure 26: Flywheel check

2.8.2 Ring gear check

Check the ring gear for cracks and missing teeth. If there are any burrs on the teeth surfaces, correct with a file.

2.9 Valve mechanism checks and corrections

2.9.1 Valve check

After removing any carbon that is adhered to the valves, check each valve for wear, burning and distortion. If there are any problems, replace the valve.

When checking the clearance between the valve guide and valve stem, use a bore gauge to measure the valve guide bore. Use a micrometer to measure the outside diameter of the valve stem. Calculate the clearance from the difference between the bore and the outside diameter. If the clearance exceeds the limit, replace the valve and valve guide as a set.

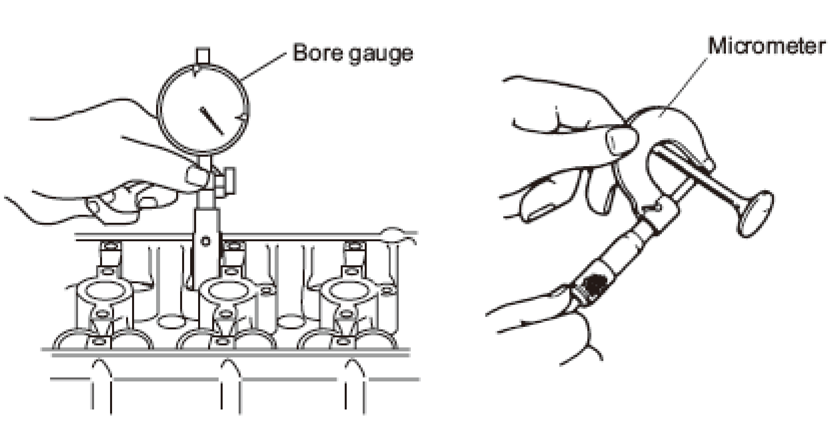


Figure 27: Valve check

When checking the valve installation height (figure 28A), assemble the valve to the cylinder head and measure the length from the cylinder head to the end of the valve stem.

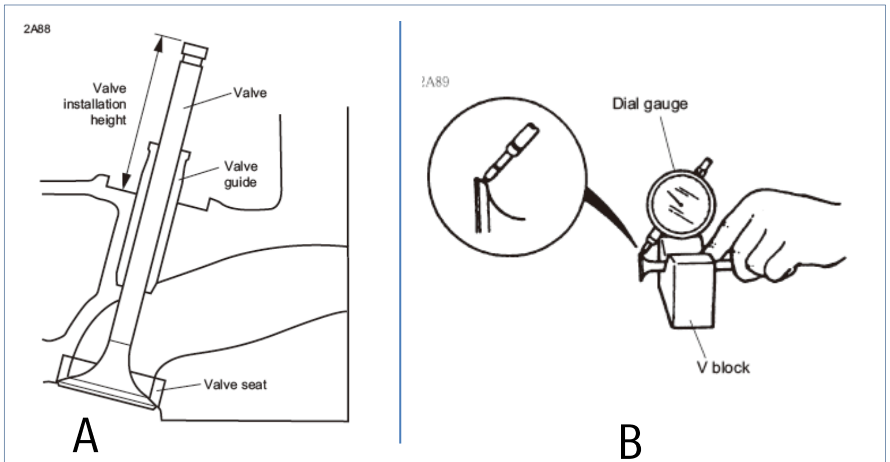


Figure 28: Valve installation

When checking the valve face deflection (figure 28B), place the valve on a V block and rotate it slowly. Measure the valve head and valve face deflection with a dial gauge. If the measured value exceeds the limit, replace the valve.

When checking the valve contact width, first clean the valve and the valve seat. Apply red lead primer to the valve seat, lap the valve to the valve seat and check the width. The condition is good if the red lead primer adheres uniformly to the specified width in the valve face center. If the contact width deviates from the standard, correct the valve seat in order to correct the contact width.

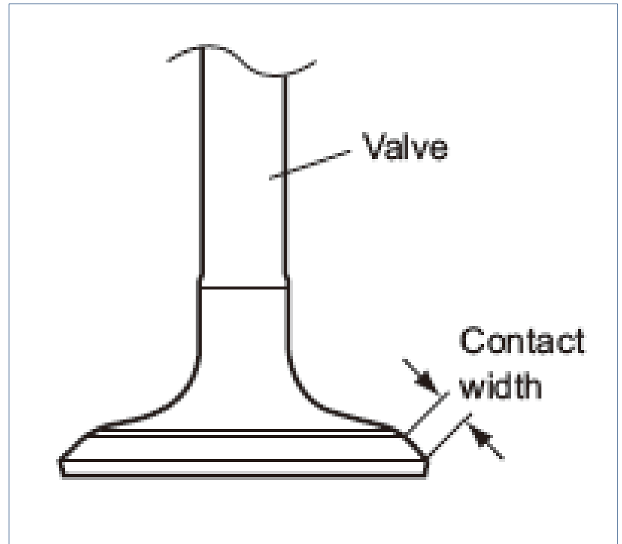


Figure 29: Valve check

2.9.2 Valve spring check

Use a slide gauge to measure the valve spring free length. If the measured value does not satisfy the limit value, replace the valve spring.

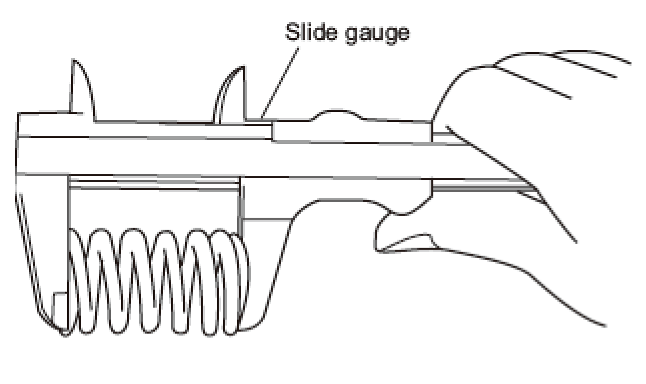


Figure 30: Valve spring check

Spring tension check

Measure the valve spring installation tension with a spring tester and by compressing the spring until it reaches the installation height. If the measured value does not satisfy the limit value, replace the spring. If a spring with reduced elastic force is used, the valve will not be properly fixed, which could result in reduced combustion chamber sealing and a drop in output. It could also cause abnormal noise.

Spring perpendicularity check

Check the perpendicularity of the valve spring by placing the spring on a level block. Place a right angle gauge against the valve spring and measure the clearance between the spring end and the right angle gauge. If the measured value deviates from the standard, replace the spring

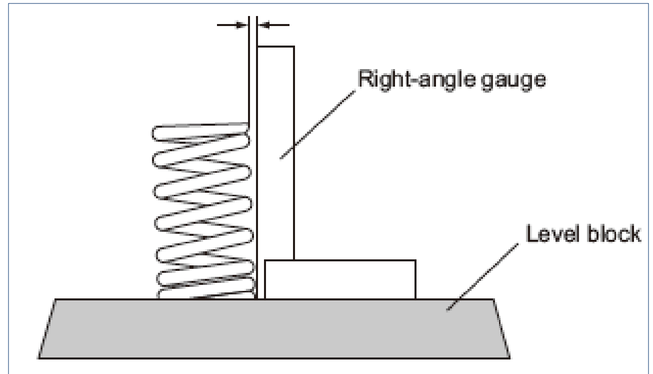


Figure 31: Valve spring check

2.9.3 Tappet and shim check

Check the shim and valve contact surfaces for damage and wear, and replace them if there are any problems.

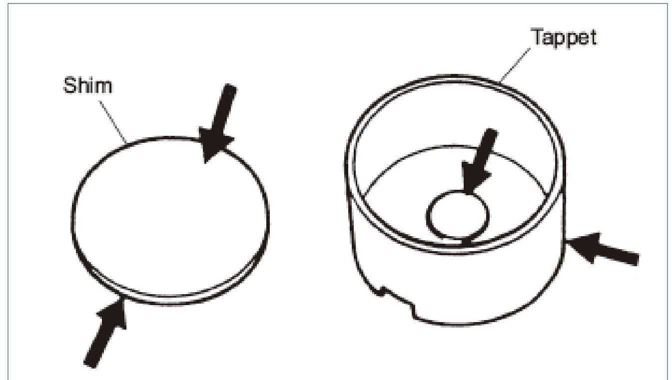


Figure 32: Tappet and shim

Use a micrometer and a bore gauge to measure the outside diameter of the tappet and the tappet installation bore of the cylinder head, and then calculate the clearance.

If the clearance is equal to or greater than the limit, replace the tappet or the cylinder head (as required).

2.9.4 Camshaft check

In the same way as for the crankshaft, when checking the camshaft deflection, use a V block to support both ends of the camshaft. Set a dial gauge on the center journal area and measure the deflection (figure 33A)

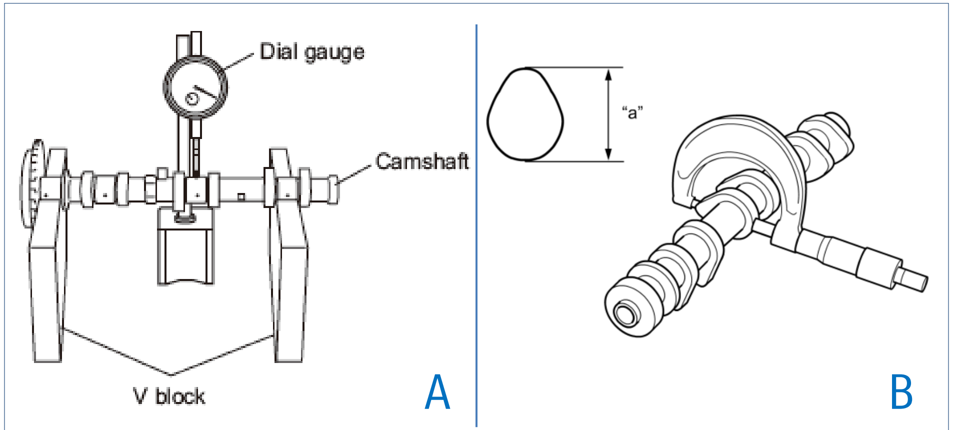


Figure 33: Camshaft check

Use a micrometer to measure the cam height (figure 33B). If the measured value is less than the standard, replace the camshaft.

2.9.5 Camshaft housing check

Check the camshaft housing contact surface for peeling, melting damage and seizure. If there are any problems, replace the cylinder head.

When checking the clearance of the camshaft housing (figure 34),

1. Set the camshaft on cylinder heads from which the tappets have been removed. Cut a plastigauge with a length that is the same as the camshaft housing width. Place it on the camshaft while avoiding the oil holes.

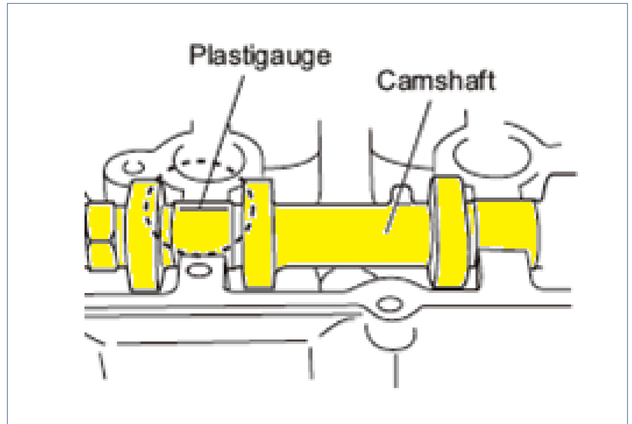


Figure 34: Clearance check

2. Next, assemble the camshaft housing, apply engine oil to the bolts and tighten them to the specified torque. At this time, do not rotate the camshaft.

3. Leave the parts in the above condition for at least 3 minutes. Then remove the camshaft housing and measure the clearance from the plastigauge width. If the measured value is equal to or greater than the limit, measure the outside diameter of the camshaft journal and the journal bore of the cylinder head.

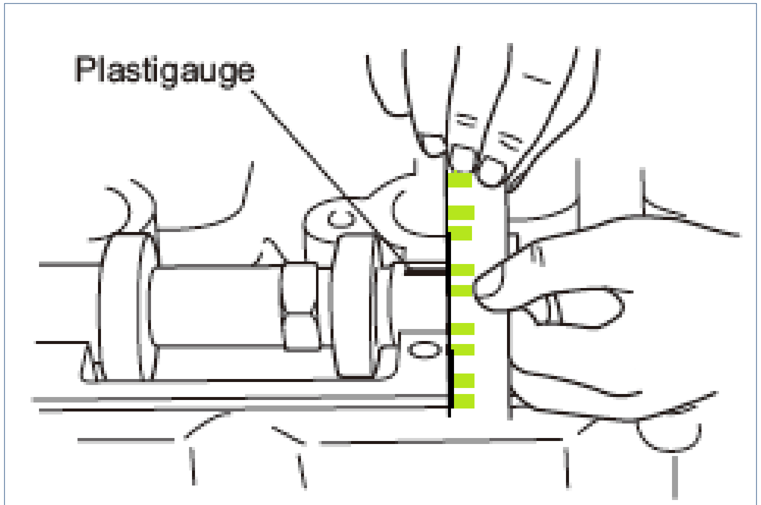


Figure 35: Clearance check

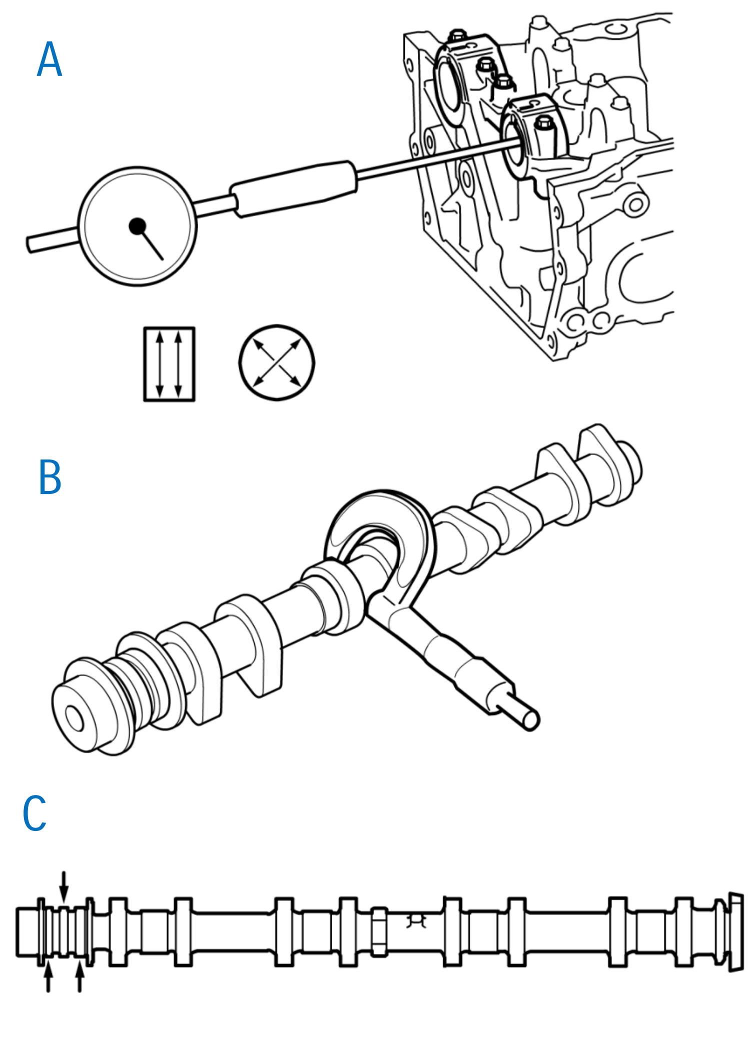


Figure 36: Camshaft inspection

Use a micrometer and a bore gauge to measure the outside diameter of the camshaft journal and the journal bore of the cylinder head. If a measured value deviates from the standard, replace the camshaft or the cylinder head. In the case of intake side No. 1 in the VVT specification, use the micrometer to measure the outside diameter in the locations shown in the figure 36C. If it deviates from the standard, replace the intake camshaft.

When checking the camshaft thrust clearance, assemble the camshaft to cylinder heads from which the tappets and shims have been removed, and measure with the dial gauge.

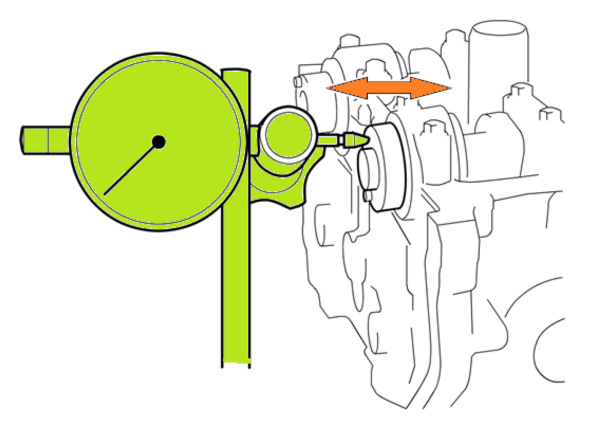


Figure 37: Camshaft thrust clearance check

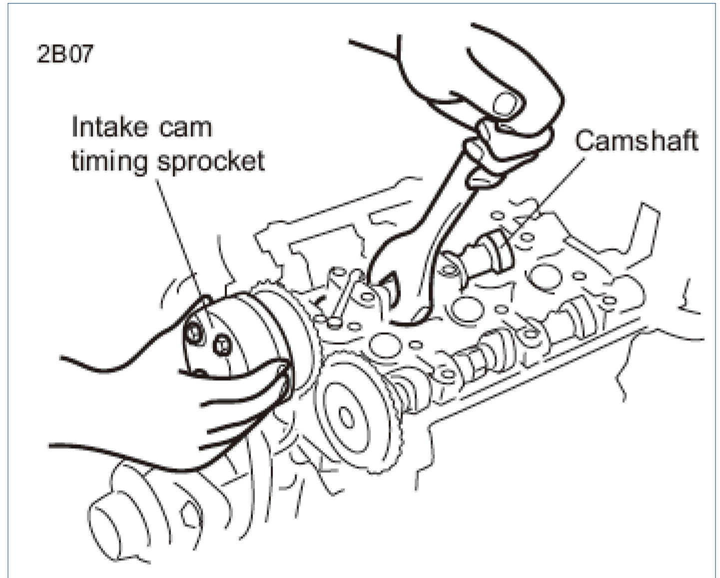


Figure 38: VVT check

2.9.6 Cam timing sprocket check

Check the cam timing sprocket for wear or damage and replace if there are any problems.

2.9.7 Intake cam timing sprocket check (VVT)

Install the intake cam timing sprocket onto a camshaft that has been fixed. Check that the hydraulic actuator does not move when you try to rotate it with your hand. If it does move, it means that the lock pin inside the hydraulic actuator is not working. Replace the intake cam timing sprocket.

2.10 Important points for valve mechanism disassembly and assembly

2.10.1 Valve mechanism disassembly

Store the removed parts such as the valve and valve spring separately for each cylinder. This will ensure that you assemble the parts back to their original positions.

2.10.2 Valve mechanism assembly

If the valve spring has a variable pitch, install with the smaller pitch side toward the cylinder head side. After assembling the valve to the cylinder head, use a plastic hammer to gently hit the end of the valve to set the valve spring.

Before assembling the camshaft housing, check the number and arrow on the camshaft housing and apply engine oil to the bolts.

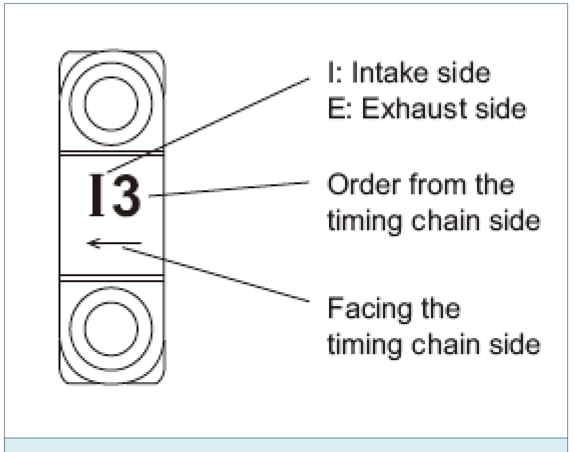


Figure 39: Camshaft housing markings

2.11 Timing chain (timing belt) and tensioner checks

If the tension of the timing belt or timing chain is too loose, it will disrupt the valve timing. The timing belt requires periodic maintenance, with replacement at the specified service interval (see vehicle specific service & maintenance schedule)

2.11.1 Timing belt check

Check the timing belt for issues such as fissures, wear, cracks, damage and missing teeth, and replace if there are any problems.

2.11.2 Timing chain and crank timing sprocket check

Check the timing chain and crank timing sprocket for wear or damage and replace if there are any problems.

2.11.3 Chain tensioner and chain guide check

Check the timing chain contact surfaces of the chain tensioner and timing chain guide for wear or damage and replace them if there are any problems.

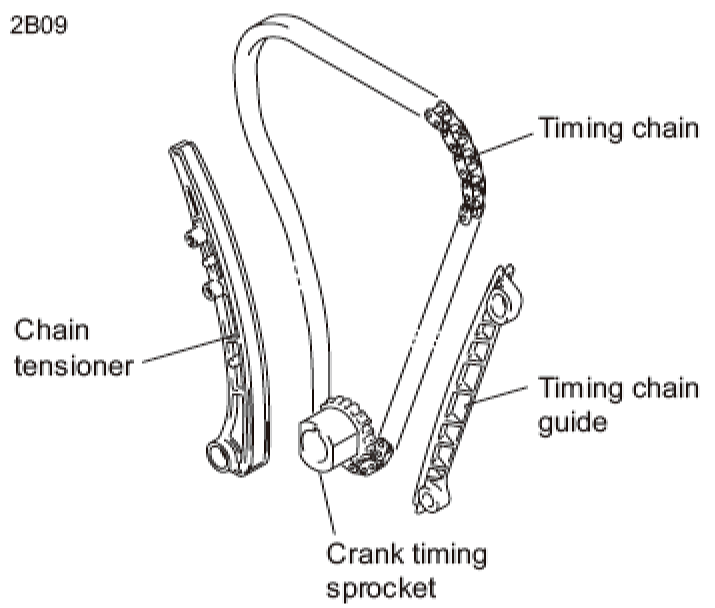


Figure 40: Timing chain tensioner & guide

2.11.4 Tensioner adjuster check

Press the latch in the direction of the arrow and check that the plunger moves smoothly. Replace if there are any problems.

2.11.5 Important points for timing chain (timing belt) assembly

When assembling the timing chain or the timing belt, make sure that the "Δ" mark on the crankshaft timing sprocket and the slit on the camshaft timing sprocket are aligned. When these timing marks are aligned, a correct relationship is always maintained between the piston position and the valve timing.

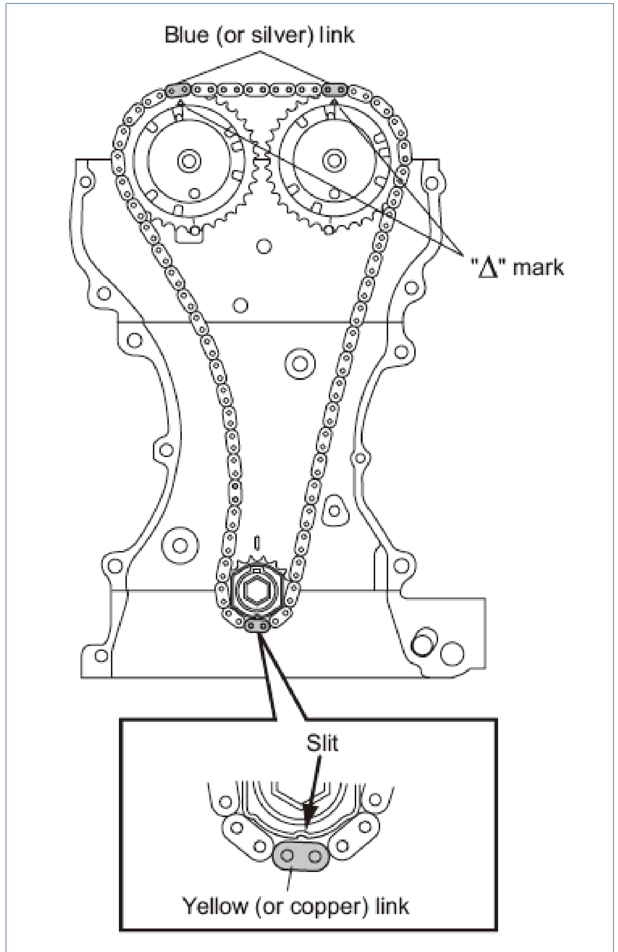


Figure 41:Timing chain marking

Be careful not to twist or strongly bend the timing belt, or bend it in reverse. Do not let water or oil adhere to the timing belt.

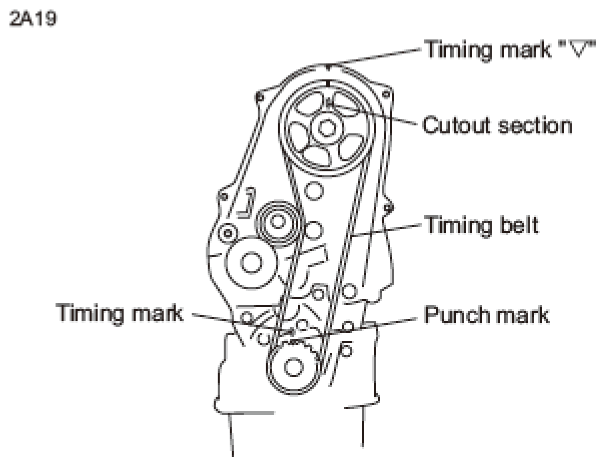


Figure 42: Timing marks

Summary

This section describes the important points for the check, correction, disassembly and assembly of the main parts that make up the reciprocating engine unit. For specific engine maintenance and checks procedures, please refer to the vehicle specific service manual.

Reference

The following abbreviations can be used in this training manual

A

A/B	Air Bag
ABDC	After Bottom Dead Center
ABS	Anti-lock Brake System
AC	Alternating Current
A/C	Air Conditioning
A-ELR	Automatic-Emergency Locking Retractor
A/F	Air Fuel Ratio
ALR	Automatic Locking Retractor
API	American Petroleum Institute
APP	Accelerator Pedal Position
A/T	Automatic Transmission, Automatic Transaxle
ATDC	After Top Dead Center
ATF	Automatic Transmission Fluid, Automatic Transaxle Fluid
AWD	All Wheel Drive
API	American Petroleum Industry

B

BARO	Barometric Pressure
BBDC	Before Bottom Dead Center
BCM	Body electrical Control Module
BTDC	Before Top Dead Center
B+	Battery Positive Voltage
BB+	Battery Positive Voltage for Backup

C

CAN	Controller Area Network
CKP	Crankshaft Position
CMP	Camshaft Position
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPP	Clutch Pedal Position
CPU	Central Processing Unit
CVT	Continuously Variable Transmission, Continuously Variable Transaxle

D

DC	Direct Current
D/C	Driving Cycle
DLC	Data Link Connector
DOHC	Double Over Head Camshaft
DOJ	Double Offset Joint
DOT	Department of Transportation
DPF®	Diesel Particulate Filter
DRL	Daytime Running Light
DTC	Diagnostic Trouble Code (Diagnostic Code)
D/C	Driving Cycle

E

EBD	Electronic Brake Force Distribution
ECM	Engine Control Module
ECT	Engine Coolant Temperature
ECU	Electronic Control Unit
EEPROM	Electrically Erasable Programmable Read Only Memory
EFE Heater	Early Fuel Evaporation Heater
EGR	Exhaust Gas Recirculation
EGT	Exhaust Gas Temperature
ELR	Emergency Locking Retractor
ENG A-Stop	Engine Auto Stop Start
EPS	Electronic Power Steering
ESP®	Electronic Stability Program
EVAP	Evaporative Emission

G

GND	Ground
GPS	Global Positioning System
GL	Gear libricant

H

HVAC	Heating, Ventilating and Air Conditioning
HC	Hydrocarbons
HFC	Hydro Fluorocarbon
HI	High
HO2S	Heated Oxygen Sensor

I

IAC	Idle Air Control
IAT	Intake Air Temperature
IMT	Intake Manifold Tuning
ISC	Idle Speed Control
ISO	International Organization for Standardization

J

JIS	Japanese Industrial Standards
J/B	Junction Block
J/C	Junction Connector

L

L	Left
LCD	Liquid Crystal Display LED Light Emitting Diode
LHD	Left Hand Drive vehicle
LIN	Local Interconnect Network
LO	Low
LSPV	Load Sensing Proportioning Valve

M

MAF	Mass Air Flow
MAP	Manifold Absolute Pressure
Max	Maximum
MFI	Multiport Fuel Injection
Min	Minimum
MIL	Malfunction Indicator Lamp ("CHECK ENGINE" Light or "SERVICE ENGINE SOON" Light)
M/T	Manual Transmission, Manual Transaxle

N

NOx	Nitrogen Oxides

O

OBD	On-Board Diagnostic system
OCM	Occupant Classification Module
OCV	Oil Control Valve
O/D	Overdrive
OHC	Over Head Camshaft
O2S	Oxygen Sensor

P

PCM	Powertrain Control Module
PCV	Positive Crankcase Ventilation
PM	Particulate Mater
PNP	Park / Neutral Position
P/S	Power Steering
PSP	Power Steering Pressure

R

R	Right
RAM	Random Access Memory
RHD	Right Hand Drive Vehicle
ROM	Read Only Memory
RPM	Engine Speed

S

SAE	Society of Automotive Engineers
SDM	Sensing and Diagnostic Module (Air Bag Controller, Air bag Control Module)
SDT	Smart Diagnostic Tester
SFI	Sequential Multiport Fuel Injection
SI	System International
SOHC	Single Over Head Camshaft
SRS	Supplemental Restraint System

T

TCC	Torque Converter Clutch
TCM	Transmission Control Module
TCSS	Traction Control Support System
TDC	Top Dead Center
TP	Throttle Position
TPMS	Tire Pressure Monitoring System
TWC	Three-Way Catalytic converter

U

UART	Universal Asynchronous Receiver / Transmitter
USB	Universal Serial Bus

V

VFD	Vacuum Fluorescent Display
VIN	Vehicle Identification Number
VSS	Vehicle Speed Sensor
VVT	Variable Valve Timing

W

WU-OC	Warm Up Oxidation Catalytic converter
WU-TWC	Warm Up Three-Way Catalytic converter

Other

2WD	2-Wheel Drive
4WD	4-Wheel Drive

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