



**POWER SOLUTIONS
INTERNATIONAL**

PSI 4.5L NATURAL GAS SERVICE MANUAL

**CERTIFIED
ENERGYPRODUCT
LINE**



PSI ENERGY

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Wood Dale, IL

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Note: Engine accessory and component locations may differ from those presented in the images within this manual based on various applications and package manufacturers using this engine.

REVISION CONTROL INFORMATION

Revision Level	Release Date	Change Description (s)
1	07/02/2021	Initial Release
2	07/29/2022	Updated Intake Manifold Torque Specs and Installation Procedure. Reformatting
3		
4		
5		
6		
7		

Purpose

This manual is intended to inform customers on how to assemble and disassemble the 4 Liters naturally aspirated engine. This document will be provided to customer so they can incorporate this information into their manuals and service documents.

Maintenance Providers

Maintenance and repair services may be performed by you or any qualified engine service provider that you choose. However, your engine warranty does not cover damage or failure caused by improper maintenance or repairs.

Owner's Manual & Maintenance Records Storage & Use

Store this Owner's Manual and Maintenance Records in a safe, visible place by your engine. The maintenance log must be updated whenever your engine is serviced. If repairs are being done under warranty be sure to follow proper warranty procedures. (see Weichai America Corp Warranty Procedure Manual)

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1 Disassembly & Assembly of Engine

1.1. Safety Precautions

Please strictly comply with instructions in this manual to disassemble and assemble the engine safely and properly.

1.2. Environmental Protection Measures

Please comply with relevant laws and regulations on environmental protection when handling oil and hydrocarbon waste. For further instructions please contact your local officials.

1.3. Notes for Disassembly and Assembly of Engine

Failure in complying with safety regulations and basic safety practices causes most engine-related accidents. Proper training is required for all engine operators and maintenance personnel. Any violation of instructions in this manual may result in serious injury or death.

Note: Before proceeding with any maintenance or repair operation, place a sign clearly stating “Maintenance in Progress, Do Not Use” on the engine starter switch.

Take the following precautions before using a lockout tool and beginning maintenance or repair:

- Ensure the maintenance site and surrounding area are clean and suitable for safe operation.
- Remove any rings, necklaces, watches, or other jewelry and wear appropriate close-fit work clothes before entering the maintenance site.
- Wear relevant protective devices (goggles, gloves, shoes, masks, work clothes, helmet, etc.) that are in good condition prior to entering the maintenance site.
- Do not use any defective, worn, broken, or inappropriate tools.

NOTICE: THE ENGINE MUST BE COMPLETELY SHUT DOWN PRIOR TO MAINTENANCE.

2 Engine block group

2.1 Engine block group assembly and disassembly

2.1.1. Engine block group exploded view

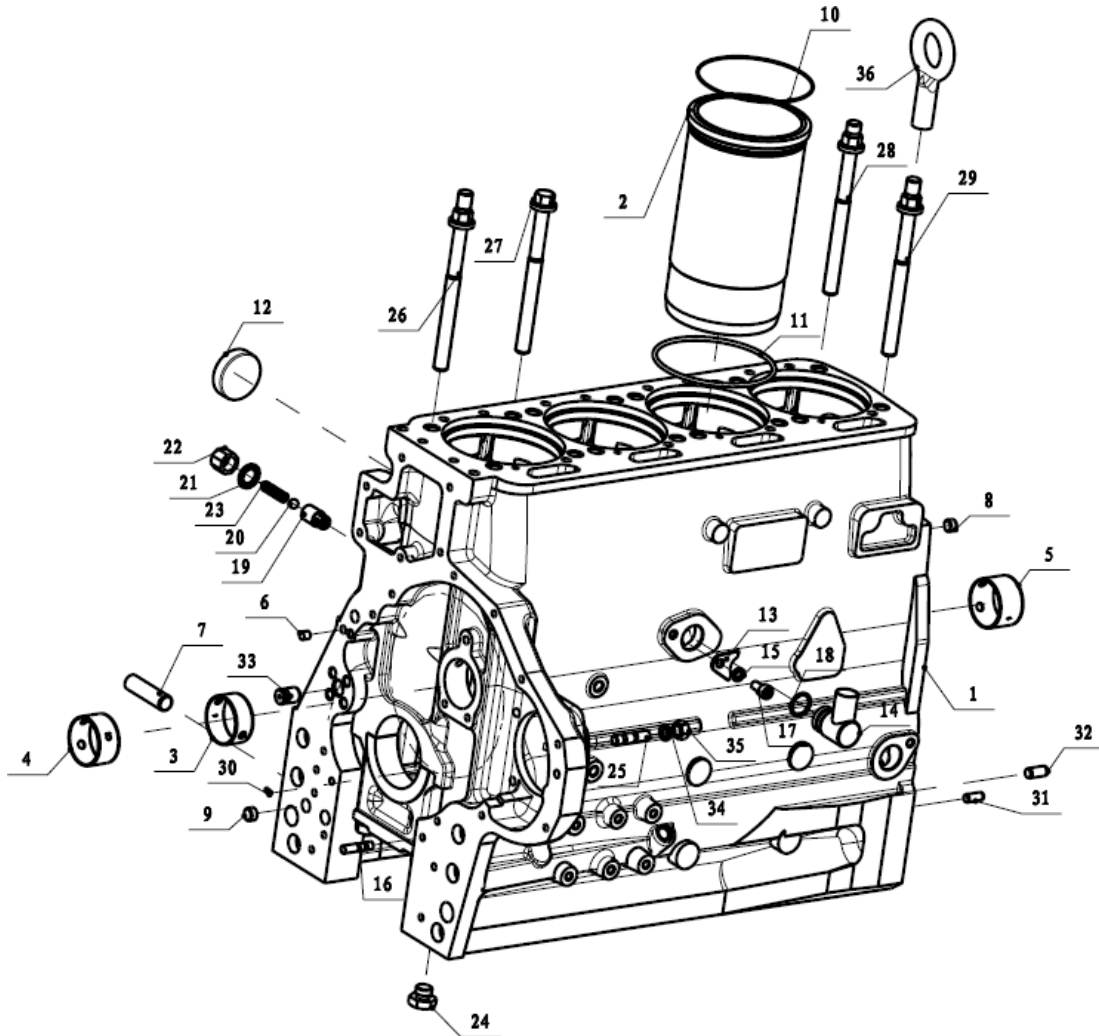


Figure 1

Pos	Name	Pos	Name	Pos	Name
1	Engine block	13	Fixing plate	25	stud
2	Cylinder liner	14	Welding elbow	26	Cylinder head bolt
3	Camshaft bushing	15	washer	27	Cylinder head bolt
4	Camshaft bushing	16	stud	28	Cylinder head bolt

5	Camshaft bushing	17	Screw	29	Cylinder head bolt
6	Plug	18	O-ring	30	pin
7	Sleeve	19	Screw	31	pin
8	Plug	20	Ball	32	pin
9	Plug	21	Seal ring	33	Shaft
10	O-ring	22	Nut	34	Washer
11	O-ring	23	Spring	35	Nut
12	Freeze Plug	24	Hex Plug	36	Lifting Bolt

2.1.2. Steps to disassemble engine block group

- 1) Remove cylinder head bolts (key point 1)
- 2) Remove main oil gallery plug and nut
- 3) Remove cylinder liners (key point 2)
- 4) Remove camshaft bushings (key point 3)

2.1.3. Steps to assemble engine block group

Assembling steps are contrary to disassembling ones.

2.1.4. Inspection and maintenance of engine block group

Key point 1: assembly

- 1) Apply oil on connecting area and thread of cylinder head bolt, then tightening them
as below: Tightening by torque spanner:

a. Pre-tighten to 30N.m b. turn $120^{\circ}\pm 4^{\circ}$ c. turn $120^{\circ}\pm 4^{\circ}$ again.

The figure below shows the tightening sequence of cylinder head bolt in every cylinder head.

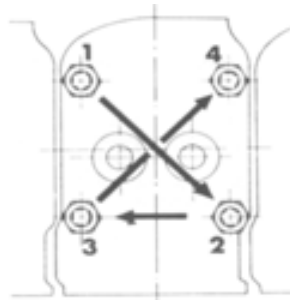


Figure 2

- 2) The tightening sequence of cylinder head is: 2-3-4-1
- 3) The torque range of cylinder head bolt
should be: M14—12.9: (230~300) N·m
M14—10.9: (190~285) N·m

Key point 2:

Inspection:

- 1) Measure the protrusion of cylinder sleeve (0.05mm~0.10mm is qualified).

Note that protrusion of cylinder sleeve is average value of X direction and Y direction; and the measurement should be done without seal rings. Cylinder sleeve for the same engine should be uniform.

-
- 2) No corrosion, scratch and crash damage is allowed for fitting surface and friction surface, wipe them out and apply clean lubricating oil or grease before assembling.

Assembly:

Place cylinder sleeve vertically on engine block, install seal rings on the sleeve and engine block and then assemble the sleeve, knock it to the right place evenly with nylon rod.

Key point 3:

Disassembly:

Use dedicated tool to disassemble the camshaft sleeve and try to protect other sleeves during disassembling.

Inspection:

Before assembling, grease on sleeve back, bush surface and fitting hole inner surface must be wiped out, and make sure there is no burr, overlap and scrap iron.

Assembly:

Apply oil on engine block hole, put camshaft sleeve into the dedicated tool and guide it into engine block, in the meantime align oil gallery holes on the sleeve and engine block.

2.2 Engine block assembly and disassembly

2.2.1. Exploded view of engine block

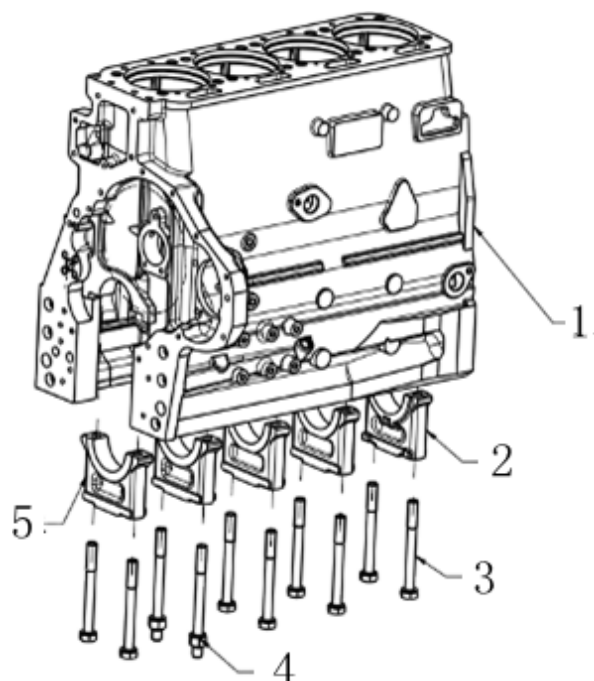


Figure 3

Pos.	Name	Pos.	Name	Pos.	Name
1	Engine block	3	Bolt of main bearing	5	Cap of main bearing
2	Cap of thrust main bearing	4	Bolt of main bearing		

2.2.2. Step to disassemble Engine Block

- 1) Remove main bearing bolts (key point 1);
- 2) Remove main bearing caps (key point 2);

2.2.3. Steps to assemble engine block

Reverse disassembly procedure to assemble engine block

2.2.4. Inspect and repair engine block

key point 1:

Inspection:

Check and clean engine block. Including but not limited to: Assembly environment must be clean; check engine block finished surfaces for crash damage, scratch and rust; do not bump and scratch the parts during assembling, and besides special requirements, sharp corner and edge on parts must be smoothed.

Installation:

For 4-cylinder engine, 10 of M14—10.9 main bearing bolts are used to fix the bearings. As shown in Fig. below, tighten from the middle bolts, and then move to two ends alternately, follow the procedures below: pre-tighten each bolt to 70Nm, then turn the bolts for further $90^{\circ}\pm 4^{\circ}$.

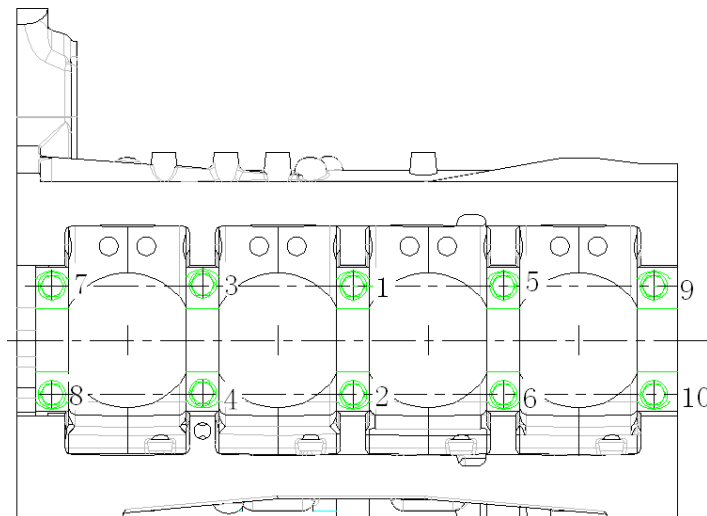


Figure 4

Key point 2: Installation

Install the thrust bearing cap on rear end of engine block, and the others are non-thrust bearing caps. Take the cap two ends as locating basis when assembling; the main bearing bolts cannot be screwed on if the cap is inversely placed.

2.3 Gear housing group assembly and disassembly

2.3.1. Exploded view of gear housing group

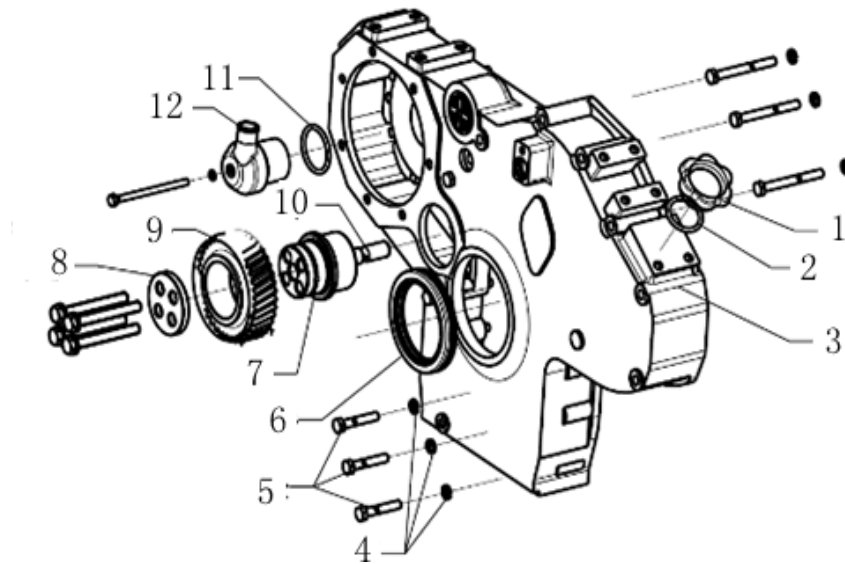


Figure 5

Pos	Name	Pos	Name	Pos	Name
1	plug	5	Bolt	9	Intermediate gear
2	O-ring	6	Front seal	10	shaft
3	Front cover plate	7	Intermediate gear shaft	11	O-ring
4	washer	8	baffle	12	breather

2.3.2. Steps to disassemble gear housing group

- 1) Remove breather
- 2) Remove plug
- 3) Remove gear housing (key point 1)
- 4) Remove front oil seal (key point 2)

2.3.3. Steps to assemble gear housing group

Reverse the Disassembly Procedure to assemble the Gear Housing

2.3.4. Gear housing group inspection and repair

Key point 1:

Inspection:

Check the gear housing to ensure that it is clean and without any damage or burrs on the fitting surface. Check the O-Rings to ensure that they are in good condition. Replace the O-Rings if necessary.

Assembling:

- 1) Knock the locating pins into place, as shown in the figure below.



Figure 6

- 2) Apply sealant on the sealing surface of the Gear Housing. Ensure that the sealant is evenly distributed and continuous.



Figure 7 Sealing surface of Gear Housing

-
- 3) Place the gear housing with alignment pins in the pin holes. Knock the cover edge gently with a nylon rod such that the cover and engine block can fit together closely.

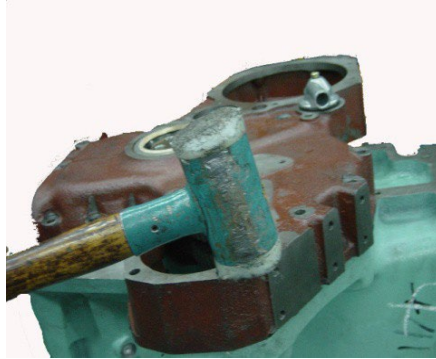


Figure 8 Gear Housing installation

- 4) Place the bolts with gaskets in their corresponding holes. Tighten them with a pneumatic impact wrench and an open-end wrench.

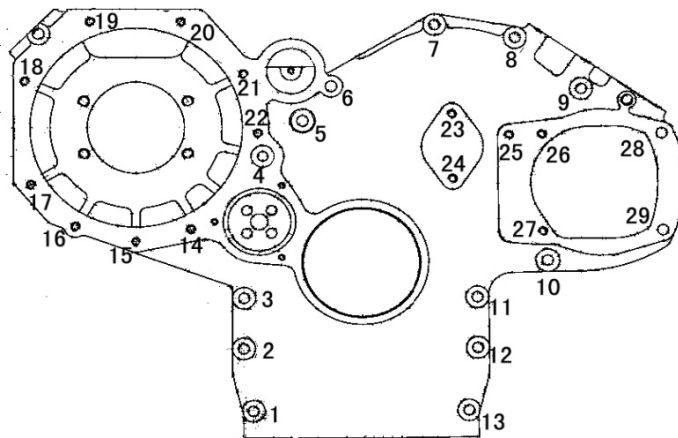


Figure 9 Tighten sequence of gear housing bolts

Key Point 2:

Assembly:

Oil seals and seal rings should be checked before assembling. Ensure there is no damage or dirt. For a tight seal, apply some clean engine oil on the shaft first, and then press the seal in slowly with the dedicated tool, ensuring that the pressing force is evenly distributed on the seal.

Disassembly:

The removed oil seal cannot be reused; replace it with a new one.

2.4 Piston nozzle assembly and disassembly

2.4.1. Exploded view of piston nozzle

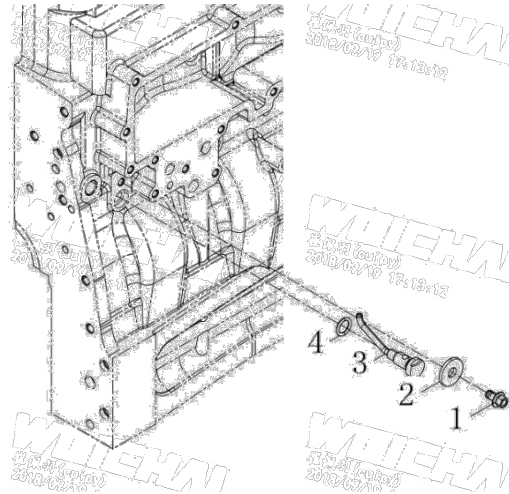


Figure 10

Pos	Name	Pos	Name
1	Bolt	3	Nozzle
2	Washer	4	O-ring

2.4.2. Steps to disassemble nozzle

- 1) remove bolt (key point 1)
- 2) Remove bolt (key point 2)

2.4.3. Steps to assemble nozzle

Reverse the disassembly procedure to assemble nozzle.

2.4.4. Nozzle inspection and repair

Key point 1:

Assembly

- 1) Compress nozzle module tightly with bolt (with spring washer) and pressing plate.
- 2) Place the pressing plate in nozzle end face groove.
- 3) Tighten bolt.

Key point 2: inspection

Check O-shape seal ring for damage; make sure the nozzle is clean and free of burr.

2.5 Thrust plate assembly and disassembly

2.5.1. Exploded view of thrust plate

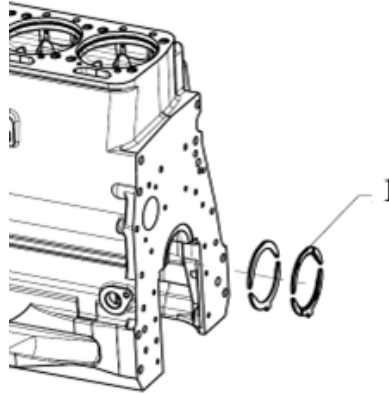


Figure 11

Pos	Name
1	Thrust plate

2.5.2. Steps to disassemble thrust plate

- 1) remove main bearing cap
- 2) remove crankshaft
- 3) Remove thrust plate (key point 1)

2.5.3. Steps to assemble thrust plate

Reverse disassembly procedure to assemble thrust plate

2.5.4. Thrust plate inspection and repair

Key point 1:

Assembly

Thrust plate should be used in pairs and the side with oil groove should be outward during assembling. Put the anti-misloading lug in corresponding groove of thrust bearing cap.

2.6 Front & rear oil seal assembly and disassembly

2.6.1. Exploded view of front & rear oil seal

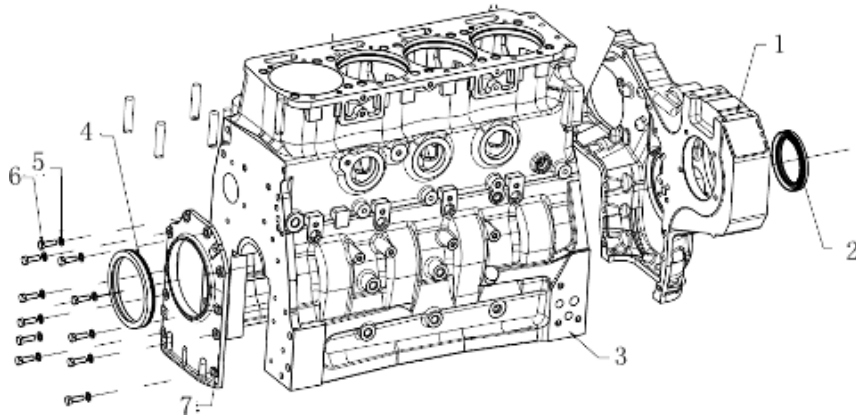


Figure 12

Pos	Name	Pos	Name	Pos	Name
1	Front cover plate	4	Rear oil seal cap	7	bol t
2	Front oil seal	5	Rear oil seal		
3	Engine block	6	washer		

2.6.2. Steps to disassemble oil seal

- 2.6.1.1 Remove gear housing plate
- 2.6.1.2 Remove front oil seal
- 2.6.1.3 Remove rear oil seal cap (key point 1)
- 2.6.1.4 Remove rear oil seal (key point 2)

2.6.3. Steps to assemble front & rear oil seal

Reverse disassembly procedure to assemble front & rear oil seal.

2.6.4. Front & rear oil seal inspection and repair

Key point 1:

Inspection:

Check whether the junction surface between rear oil seal cover and engine body is cleaning or knocking wound.

Assembly:

- 2.6.4.1. Clean the junction surface and install 2 pins into engine body.
- 2.6.4.2. Apply sealant on the junction surface of rear oil seal cover.
- 2.6.4.3. Apply oil on surface of crankshaft flange, assemble rear oil seal and tighten bolt. Bolt tightening sequence is: 1-2-6-7-3-4-5-8-9-10.

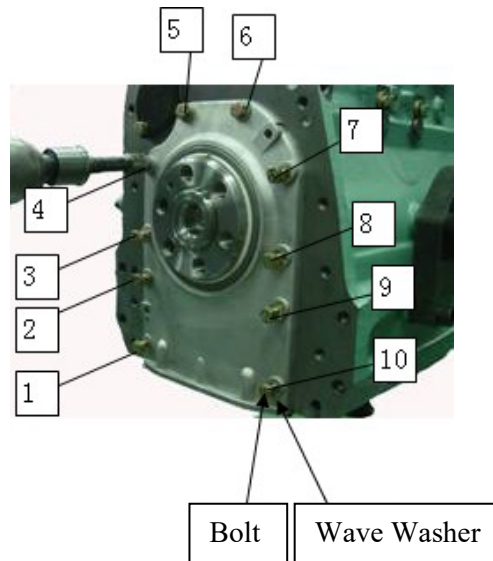


Figure 13

Key point 2:

Inspection:

Oil seals and seal rings should be checked before assembling, make sure there is no damage. Check whether rear oil seal cover is clean and whether its finished surface is free of obvious scratch.

Assembly:

Apply sealant on the rear oil seal outer ring first, and then press-in the seal slowly with dedicated tool. NOTICE: Do not damage the seal during assembling, and seal outer ring should be parallel and level to oil seal cap plane.

2.7 Flywheel housing assembly and disassembly

2.7.1. Exploded view of flywheel housing

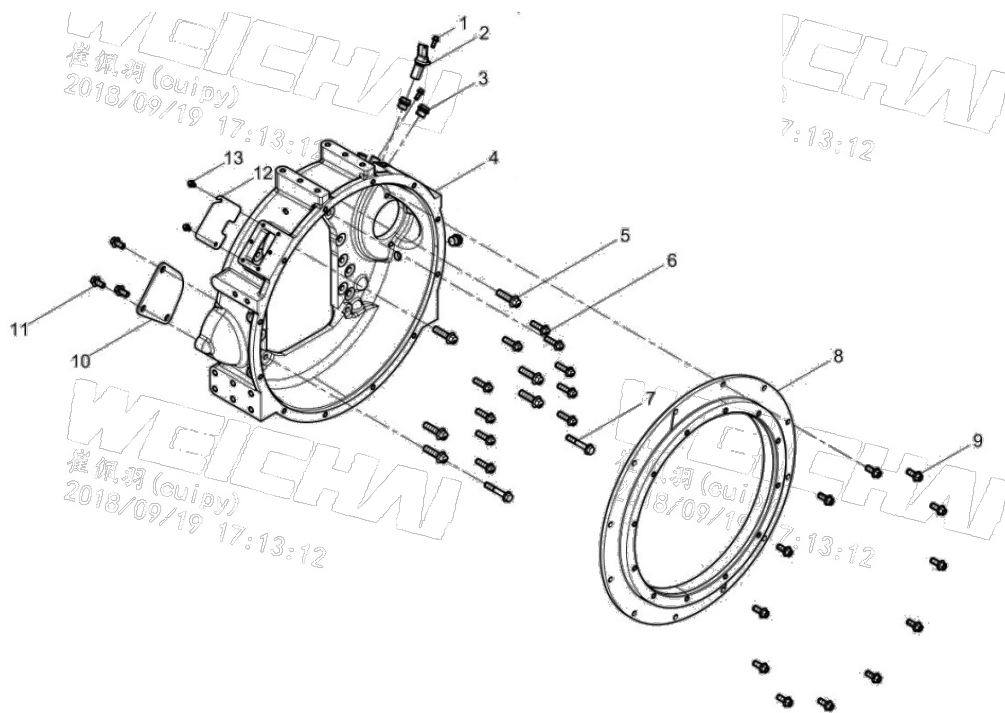


Figure 14

Pos	Name	Pos	Name	Pos	Name
1	Bolt	6	Bolt	11	Bolt
2	Speed sensor	7	Bolt	12	Prothole cover
3	Plug	8	Flywheel housing adapter	13	Bolt
4	Flywheel housing	9	Bolt		
5	Bolt	10	Plug		

2.7.2. Steps to disassemble flywheel housing

- 2.7.2.1. Remove fixing bolts of flywheel housing adapter and take out the adapter.
- 2.7.2.2. Remove speed sensor
- 2.7.2.3. Remove fixing bolts of monitoring window cap on flywheel housing, take out the cap.
- 2.7.2.4. Remove flywheel housing (key point 1).

2.7.3. Steps to assemble flywheel housing

Reverse disassembly procedure to assemble flywheel housing.

2.7.4. Flywheel housing inspection and repair

Key point 1:

Assembly

Check whether flywheel is cleaned up. Debur the corresponding fitting surface on engine block with 240# fine oil stone and clean the surface with ethyl alcohol. Apply sealant on fitting surfaces of flywheel housing and engine block. Bolts and tools: M10-10.9 hexagon bolts (×12), M12-10.9 hexagon bolts (×6), 17mm and 19mm socket spanner.

Step 1: Preassemble the bolts

Step 2: Follow the sequence of arrow to tighten the M10 bolts, tighten torque for M10 bolts is 80~85Nm. And then tighten the M12 bolts according to the marked order 1-2-3-4-5-6, tighten torque for M12 bolts is 140~145Nm.

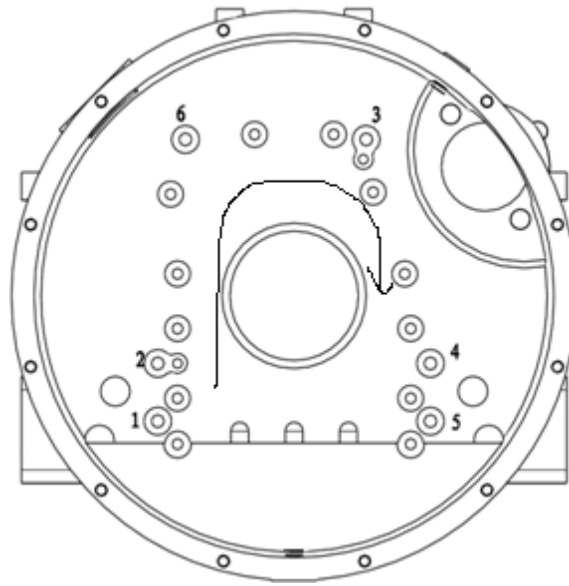


Figure 15. Tighten sequence of flywheel housing bolt

NOTICE: For the strengthening bolts listed above, the thread and bearing surface of each bolt should be applied with lubricating oil before assembling.

2.8 Oil pan assembly and disassembly
2.8.1. Exploded view of oil pan

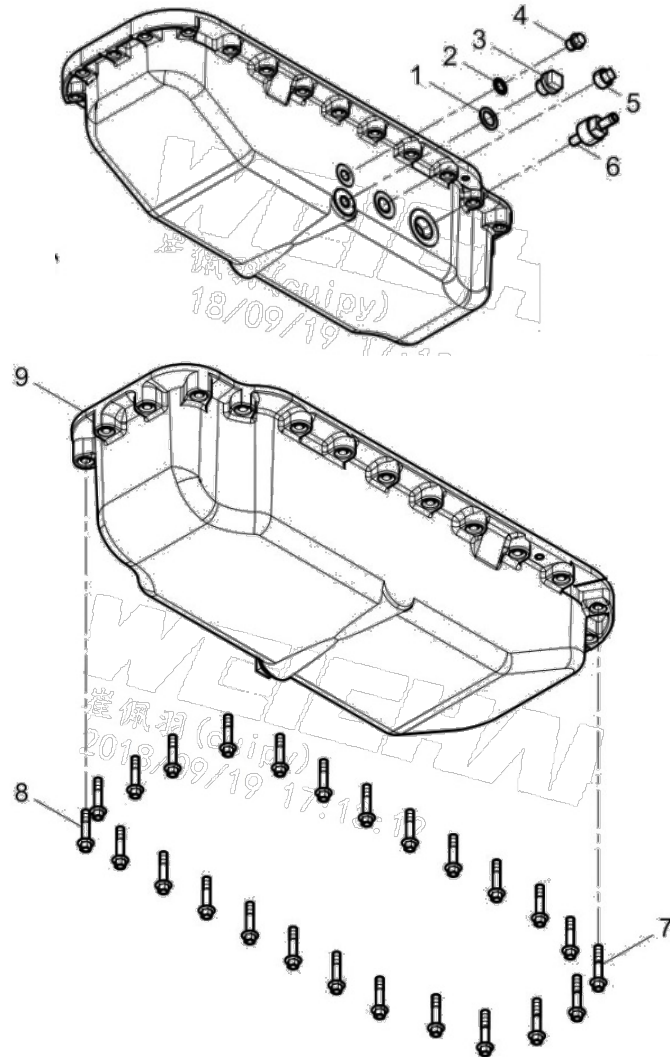


Figure 16

Pos	Name	Pos	Name	Pos	Name
1	Seal washer	4	Plug	7	Bolt
2	Washer	5	Plug	8	Bolt
3	Magnetic plug	6	Pipe connector	9	Oil pan

2.8.2. Steps to disassembly oil pan

- 1) Remove oil drain bolt
- 2) Remove fixing bolts
- 3) Remove oil pan
- 4) Remove plugs and connectors

2.8.3. Steps to assemble oil pan

Reverse disassembly procedure to assemble oil pan.

2.8.4. Oil pan inspection and repair

Key point 1

Before the disassembling, all engine oil should be drained out. Put an engine oil container under drain screw plug of oil sump, screw off the plug with a plug wrench to drain oil out.

Key point 2:

Assembling

- 1) Apply sealant on fitting surface of engine block and partially apply sealant on oil sump, place sealing gasket on the fitting surface.
- 2) Lift and place oil sump, be careful and avoid crashing the fitting surface.
- 3) Install bolts and gaskets and tighten the bolts with pneumatic impact wrench to 20~35.5Nm.

2.9 Cylinder head assembly and disassembly

2.9.1. Exploded view of cylinder head

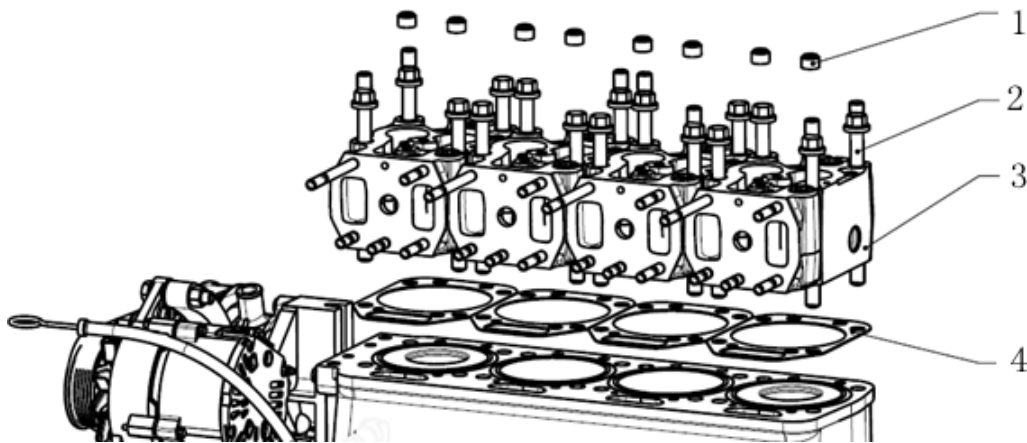


Figure 17

Pos.	Name	Pos.	Name
1	Valve seal	3	Cylinder head
2	Cylinder head bolt	4	Cylinder head gasket

2.9.2. Steps to disassemble cylinder head

- 1) Loosen the cylinder head bolts and remove them.
- 2) Pull the cylinder head up vertically to take it down. If the cylinder head gasket is attached on the removed cylinder head, remove it and place it back on engine block. Put the removed cylinder head on cardboard to prevent damage to the upper surface of the combustion chamber and other sealing surfaces. If more than one cylinder head needs to be disassembled, mark the cylinder number on the head for reference.
- 3) Remove the cylinder head gasket. If more than one cylinder head gasket needs to be disassembled, mark the cylinder number on the gaskets for reference.
- 4) Remove the intake and exhaust valve module. Refer to disassembly of valve mechanism (9.6) for details.
- 5) Remove the valve seal. Valve seals can't be reused.

2.9.3. Steps to assemble cylinder head

- 1) Insert the seal valve into the valve guide pipe.
- 2) Install the intake valve and exhaust valve onto the cylinder head.
- 3) Install new cylinder head gaskets. Cylinder head gaskets cannot be reused.
- 4) Assemble the cylinder head to the engine block.
- 5) Thread the cylinder head bolts into the cylinder head.

NOTE:

- Leave the four cylinder heads loose at this time. Alignment of cylinder heads must be completed after installing intake pipe to ensure alignment to prevent coolant leaks. Reference [5.1.3. Steps to assemble air intake and exhaust system](#).
 - Use the intake pipe to locate the cylinder head and use the intake pipe to level the four cylinder heads to ensure the coplanarity of the four cylinder heads (coplanarity requirement < 0.07mm, theoretical value \neq 0.10mm, greater than this standard may cause water damage There is a risk of water leakage at the joint surface of the intake pipe and the cylinder head.).
- 6) Once cylinder heads are aligned after installing intake pipe, tighten the cylinder head bolts (See Key Point 1 in 9.5.4).

2.9.4. Cylinder head inspection and repair

Key point 1:

Assembling

- 1) Refer to the Figure for the bolt pre-tightening and tightening order for each individual cylinder head. The cylinder heads should be tightened in the order 3-2-4-1.

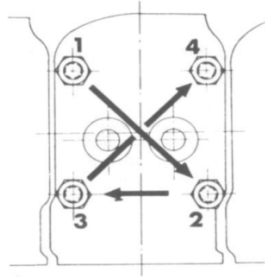


Figure 18 Tighten sequence of cylinder head bolts

- 2) The cylinder head bolt will stretch and deform between 0.2~0.6mm after tightening. The bolt can't be reuse if the length over 160.5mm.
- 3) Install the valve oil seal.

NOTE:

- The engine **MUST** be barred over three complete rotations before starting the engine once new cylinder heads are installed.

导杆密封安装工具

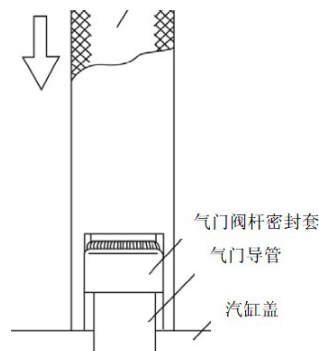


Figure 19

Key point 2:**Inspection**

Clean the cylinder head, focusing on the combustion chamber surface, valve seat, intake and exhaust valves, and intake and exhaust passages. Remove the carbon deposits and mucilage glue and check the surface condition.

Appearance Inspection:

Check the cylinder cover for any discoloration or cracks. If any cracks are discovered, a leak test should be done.

1. Valve Recession:

Valve recession is the vertical distance between valve undersurface and cylinder cover undersurface. Any difference between the measured and required values of valve recession can reflect the degree of wear on the valve and valve seat. A depth micrometer can be used to measure valve recession, as shown in Figure below:

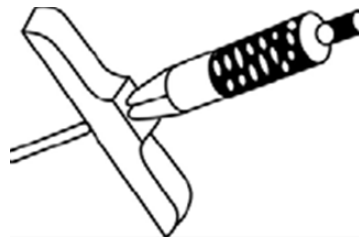


Figure 20

Reference Table below for valve recession requirements. If valve recession exceeds the allowed range, the cylinder cover must be replaced to ensure engine reliability. If valve recession doesn't exceed allowed range, disassemble the valve, and check the sealing surface between the valve and valve seat for wear and abnormal damage.

Table: Valve Recession Specifications

	Required value of valve recession (mm)
Intake valve	1.00~1.45
Exhaust valve	1.00~1.45

2. Clearance between valve rod and valve guide pipe:

Internal surface of valve guide pipe is the contacting surface between valve rod and valve guide pipe, if clearance between valve rod and valve guide pipe exceeds allowed value due to abrasion, then the guide effect will at state, which may affect reliability of the engine. The inner diameter of guide pipe can be measured with an inside micrometer, as shown in Fig. 3-5. Outer diameter of valve rod can be measured with an outside micrometer. Both allowed ranges for clearance between intake valve rod and its guide pipe, exhaust valve rod and its guide pipe are 0.03~0.06mm. If clearance exceeds allowed range, the cylinder cover must be replaced to ensure reliability of diesel engine.

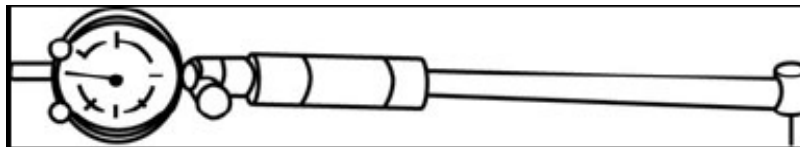


Figure 21

3. Cylinder head gasket:

If there is air leakage, water leakage or oil leakage in cylinder head gasket, then the gasket should be checked and replaced; Check the gasket for visible damage and analyze the cause, cylinder cover gaskets are disposable, and should be replaced during maintenance.

2.10 Valve cover assembly and disassembly
2.10.1. Exploded view of valve cover

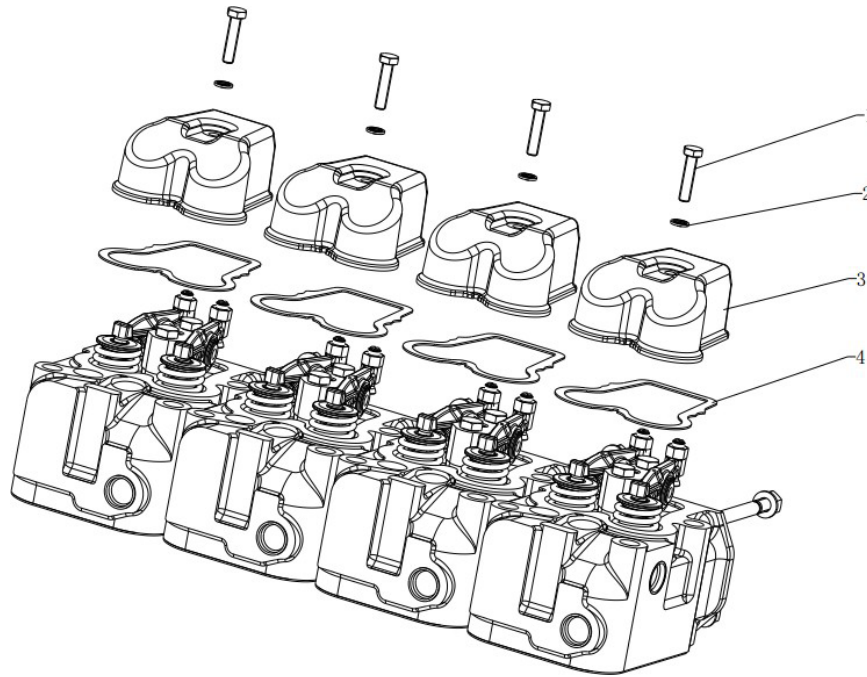


Figure 22

Pos	Name	Pos	Name
1	Bolt	3	Valve cover
2	Washer	4	Gasket, valve cover

2.10.2. Steps to disassemble valve cover

- 1) Loosen the valve cover bolts. Remove the bolts and the washers.
- 2) Pull the covers up vertically to remove them. Remove all gaskets.

2.10.3. Steps to assemble valve cover

- 1) Use new valve cover gaskets for all assemblies and inspect them for any defects or damage prior to assembly.
- 2) Clean the upper surface of the cylinder head. Install valve cover gaskets.
- 3) Clean and install cylinder head cover.
- 4) Install the bolts and fasten. The required torque is 10~15Nm.

2.10.4. Valve cover inspection and repair

Key point 1: Assembly

Valve cover gaskets are disposable and should be replaced during maintenance.

Key point 2: Inspection

- 1) Check the covers for any cracks or other damage. Replace if damaged.
- 2) If there is leakage through the valve cover gaskets, then all gaskets should be checked and replaced.

2.11 Lifting lug assembly and disassembly

2.11.1. Exploded view of lifting lug

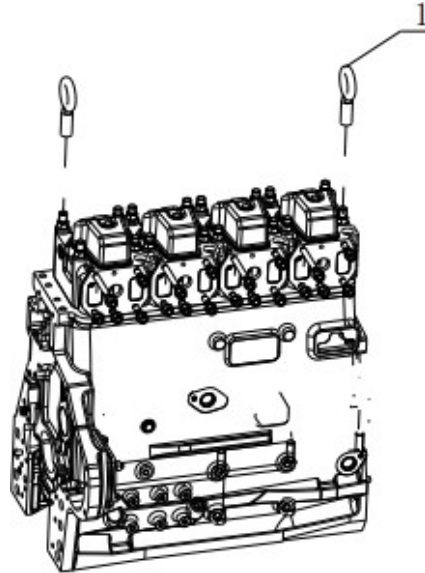


Figure 23

Pos	Name	Pos.	Name	Pos.	Name
1	Lifting lug				

2.11.2. Steps to disassemble lifting lug

Loosen and remove the lifting lugs.

2.11.3. Steps to assembly lifting lug

Check the lifting lugs and standoffs for any damaged threads. Replace either if damage is found. Tighten the lugs after installing them.

2.12 CCV system assembly and disassembly

2.12.1. Exploded view of CCV system

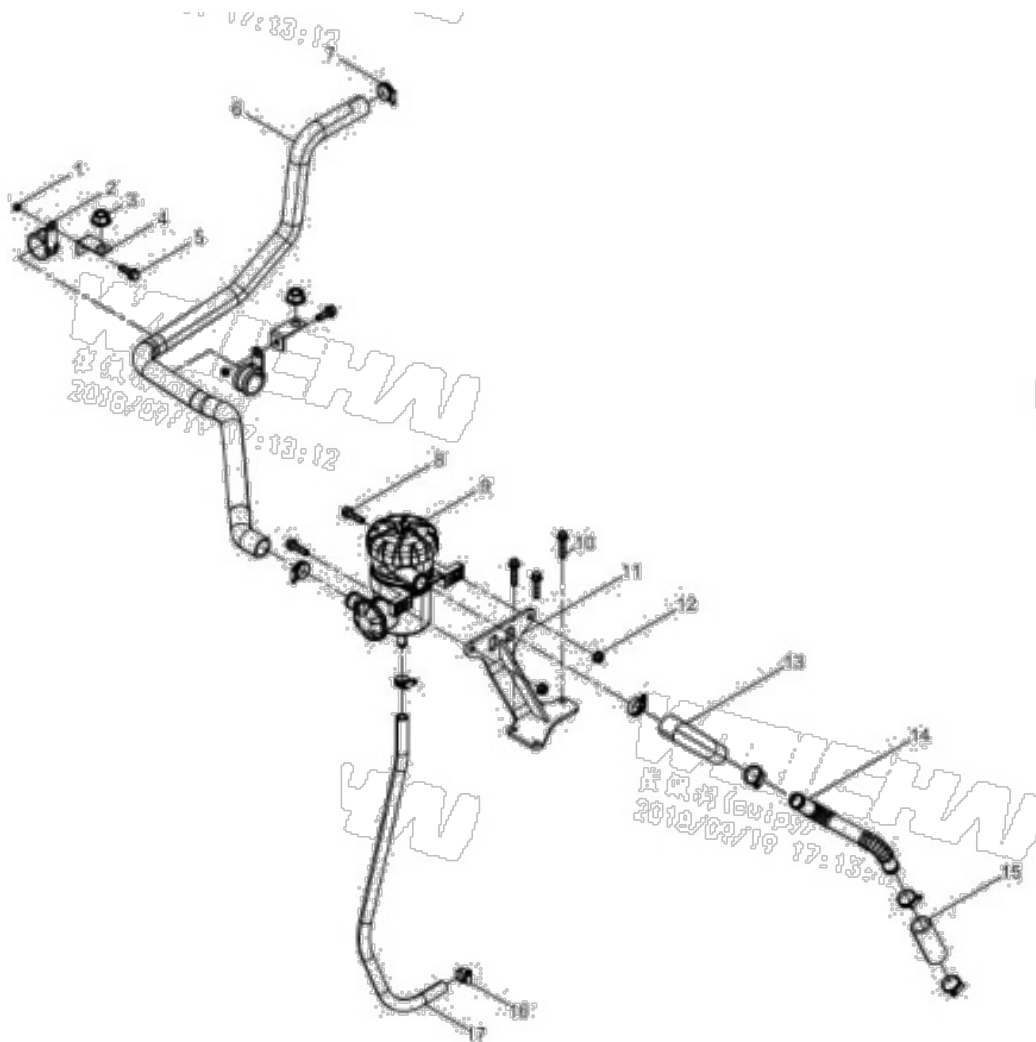


Figure 24

Pos	Name	Pos	Name	Pos	Name
1	Nut	7	Clamp	13	Nut
2	Clamp	8	Nut	14	Air intake pipe
3	Nut	9	CCV breather	15	Hose, air
4	Bracket	10	Bolt	16	Clamp
5	Nut	11	Bracket	17	Pipe
6	Hose, air	12	Nut		

2.12.2. Steps to disassemble CCV system

- 1) Loosen the clamps on the air outlet. Remove rubber hoses.
- 2) Loosen the clamps on the oil return pipe. Remove the oil return pipe and hose.
- 3) Loosen the clamps on the air inlet. Remove all air inlet formed and rubber hoses.
- 4) Loosen the bolts fixing the breather to the breather bracket. Remove the breather completely.
- 5) Loosen the bolts fixing the breather bracket to the engine block. Remove the breather bracket.

2.12.3. Steps to assemble CCV system

- 1) Install the breather bracket.
- 2) Install the breather.
- 3) Install all formed and rubber hoses, oil pipes and hoses, and clamps.

2.12.4. CCV system inspection and repair

Inspection:

- 1) Check the breather system appearance for any parts that are damaged or flawed.
Replace the damaged or flawed parts.
- 2) Check for any oil leakage in the system.
- 3) Check for proper air flow by blowing air into the CCV breather. If resistance is high, clean the breather element. If the problem persists, replace the breather element.

2.13 CCV breather assembly and disassembly

2.13.1. Exploded view of CCV breather

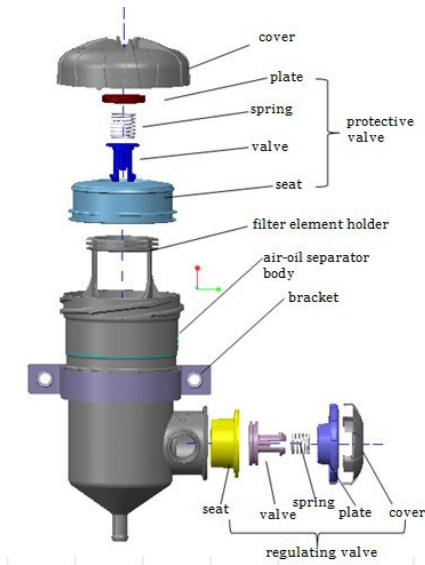


Figure 25 Exploded view of CCV breather

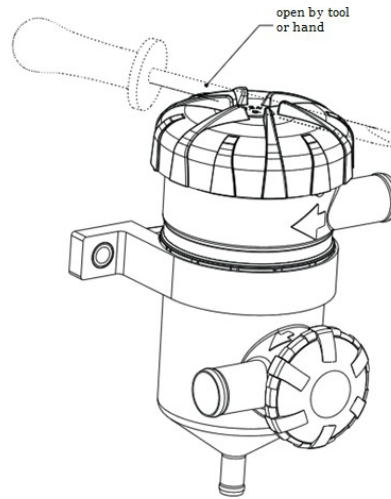


Figure 26. Schematic diagram of disassembly

2.13.2. Steps to disassemble CCV Breather

Open the top cover of the breather by tool or hand. Remove the breather filter element.

2.13.3. Steps to assemble CCV breather

- 1) Clean the inside of the breather. Insert a new breather filter element.
- 2) Screw the top cover back onto the breather.

2.13.4. CCV Breather Inspection and Maintenance

Check the breather filter element for any damage, replace it if necessary.

3 Crank-rod mechanism

3.1 Crank-rod mechanism assembly and disassembly

3.1.1. Exploded view of Crank-rod mechanism

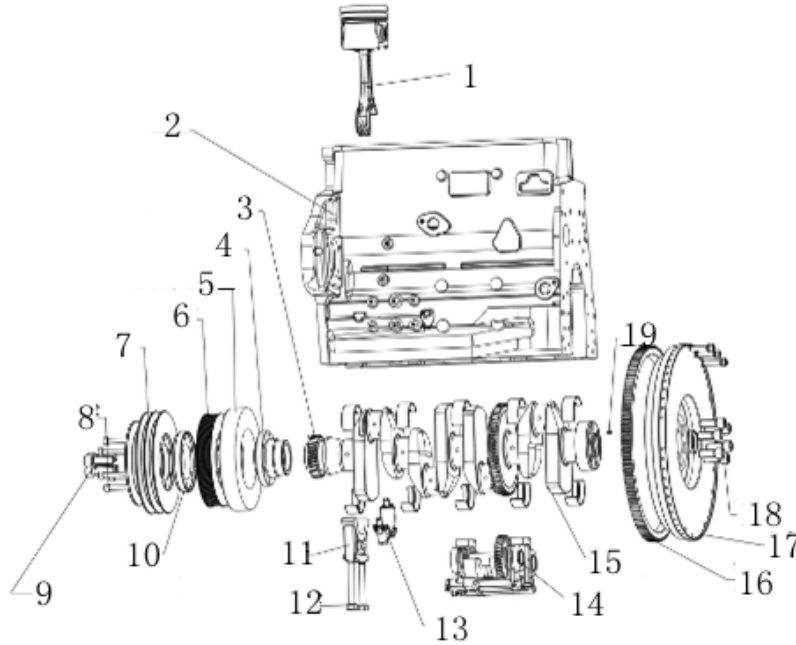


Figure 27

Pos	Name	Pos	Name	Pos	Name
1	Piston-rod assembly	8	Bolt	15	Crankshaft
2	Engine block	9	Bolt	16	Flywheel gear
3	Crankshaft gear	10	Connecting plate	17	Flywheel
4	hub	11	Main bearing cap	18	Flywheel bolt
5	damper	12	Main bearing bolt	19	Pin
6	Crankshaft pulley	13	Connecting rod cap		
7	Pulley	14	Balance mechanism		

3.1.2. Steps to disassemble connect-rod mechanism

- 1) Check before disassembling. Check connecting rod axial backlash, check tightening torque of connecting rod bolts; Tilt and lay the engine on its side, rotate the flywheel until the to-be removed piston is in BDC, remove connecting rod bolts and cap; Rotate the flywheel until the to-be removed piston is in TDC, knock the piston out with wooden hammer, proceed with caution to avoid jamming cylinder block with connecting rod tip. Remove other pistons in the same way, number and place them orderly.
- 2) Screw off fastening bolts of torque vibration damper and fastening bolts of hub, take down crankshaft pulley, torque vibration damper and hub.
- 3) Screw off flywheel bolts, take down flywheel assembly, bearing, etc.

3.1.3. Steps to assembly connect-rod mechanism

Reverse disassembly procedure to assemble connect-rod mechanism

3.2 Crankshaft group assembly and disassembly

3.2.1. Exploded view of crankshaft group

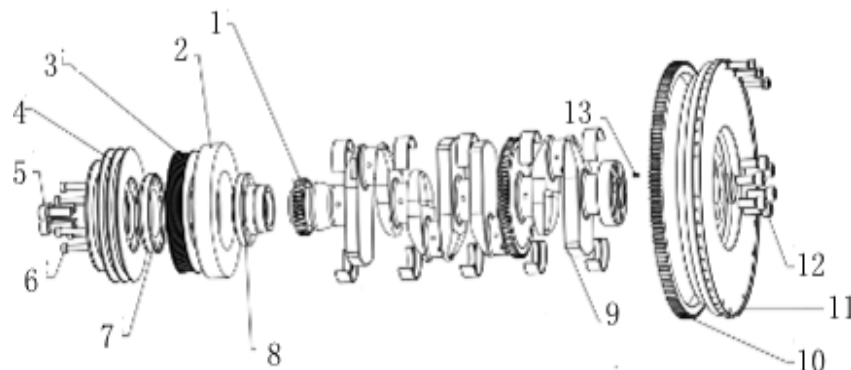


Figure 28

Pos	Name	Pos	Name	Pos	Name
1	Crankshaft gear	6	Pulley bolts	11	Flywheel
2	Damper	7	Connecting plate	12	Flywheel bolt
3	Crankshaft pulley	8	Hub	13	Pin
4	Pulley	9	Crankshaft		
5	Bolt	10	Flywheel gear		

3.2.2. Steps to disassemble crankshaft group

- 1) Put the engine crankcase upward, and then remove main bearing bolts and place them orderly.
- 2) Take down crankshaft and flywheel, remove front and rear thrust plates and flywheel bearing. Remove oil seals; place the crankshaft on bracket (for long time storage, the crankshaft should be placed vertical);
- 3) Classify the removed parts according to the requirements

3.2.3. Steps to assemble crankshaft group

- 1) Clean up cylinder bottom holes.
- 2) Press main bearing upper shell into cylinder bottom holes and clean up scraped foreign matters.

a: The bearing shell should be strictly inspected for bump damage before assembling, and shell with bump damage should not be reused even if repaired.

b: The assembled upper bearing shell should be aligned to oil hole and oil groove on cylinder body, misalignment exceeds $1/5 \sim 1/4$ of oil hole is strictly forbidden. The assembled upper bearing shell should be closely fit with cylinder bottom holes.

- 1) Apply clean lubricating oil on inner surface of upper bearing shell.
- 2) Clean up undersurface of cylinder block, and make sure there is no grease.
- 3) Apply sealant on undersurface of cylinder block properly.
- 4) Lift up crankshaft, and clean up oil holes with compressed air, wipe out main journal and connecting rod journal with a towel, and then drop the crankshaft into cylinder body slowly, prevent crashing the crankshaft in this process.
- 5) Clean up upper thrust plate and press it into cylinder body. Then side with oil groove should face outward (face to crankshaft).
- 6) Check and make sure the oil seal is flat and free of distortion, and then place it into seal groove on cylinder undersurface with dedicated tool.

-
- 7) Press lower bearing shell and lower thrust plate (the side with oil groove should face crankshaft) into crankcase and assemble the crankshaft.
 - 8) Apply clean lubricating oil on crankcase bolt bearing surface and main bearing bolt thread. Place main bearing bolts and pre-tighten them according to the order shown in Figure below. Firstly, pre-tighten to 70Nm, and then tighten each bolt for another $90^{\circ} \pm 4^{\circ}$. Assembly of crank shaft is finished.

3.2.4. Inspection and maintenance of crankshaft system

- 1) Check whether there is crack on fillet area of crankshaft main journal and neck of crankshaft; Check the joint part of crankshaft and main bearing for crack, check and dredge the oil gallery.
- 2) Check the wear condition of crankshaft main journal and neck of crankshaft, and check whether there is line-like puckering, metal peeling and crack.
- 3) Check the wear condition of front and rear oil seals.
- 4) Check whether there is failure like thread damage on main bearing bolts
- 5) Check crankshaft flange bolt holes for crack.
- 6) Check wear condition of crankshaft journal, check bend and distortion condition of crankshaft.

3.3 Main bearing assembly and disassembly

3.3.1. Exploded view of main bearing

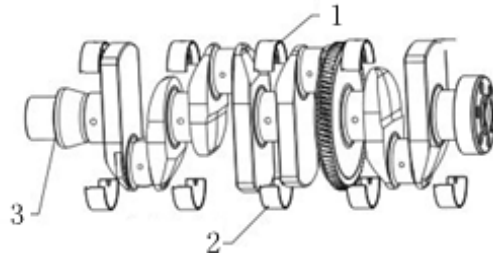


Figure 29

Pos	Name	Pos	Name	Pos	Name
1	Upper main bearing	2	Lower main bearing	3	Crankshaft

3.3.2. Steps to disassemble crankshaft bearing shell

Push the shells out with hand and mark the removed shells (should be corresponded with holes on engine block and crankcase).

3.3.3. Steps to assemble crankshaft bearing shell

- 1) Clean up main bearing shells and the fitting holes.
- 2) If no shell is replaced, then install the two shells into engine block (upper) and crankcase (lower) respectively (pay attention to the mark, shells should be installed into corresponding holes on engine block and crankcase), do not mix upper and lower shells, the one with oil groove is upper one. The shell lips should be aligned and applied with engine oil.

3.3.4. Inspection and maintenance of crankshaft bearing shell

- 1) Clean the bearing shells and check their wear condition
- 2) Check and ensure there is no peeling, locating lip damage and transverse crack on the shell.

3.4 Balance mechanism assembly and disassembly

3.4.1. Exploded view of balance mechanism

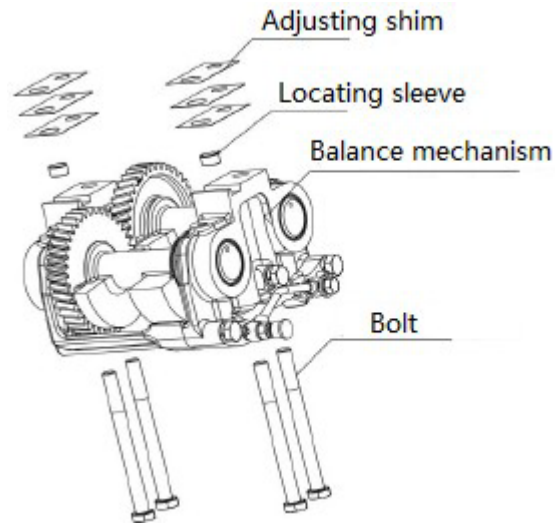


Figure 30

3.4.2. Steps to assemble balance mechanism

- 1) Install 2 locating sleeves.
- 2) Install 3 adjusting shims on each locating sleeve.
- 3) Rotate crankshaft until the 2 gear teeth with "0" marked arrive at the location which is marked by red circle on following figure, then mark these two gear teeth's crest and flank by marking pen.

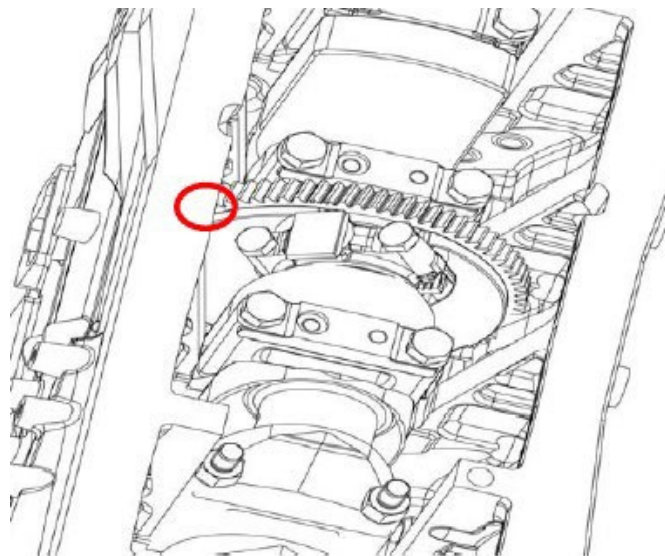


Figure 31

-
- 4) Rotate the gear on the balance mechanism until the gear tooth with “0” marked arrive at the location which is pointed by red circle on following figure, then mark this gear tooth’s crest and flank by marking pen.

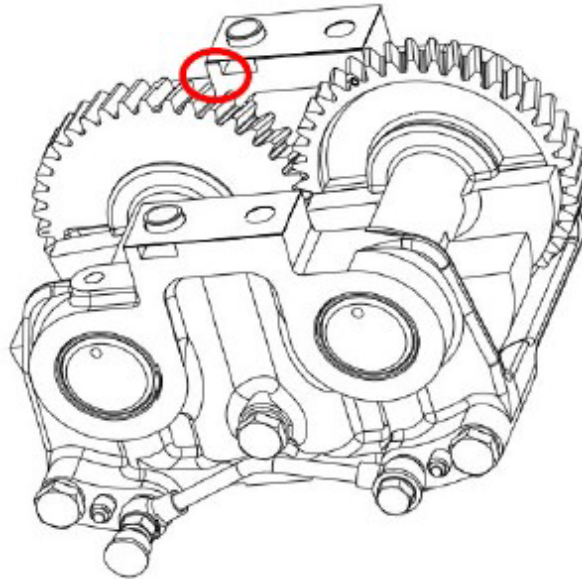


Figure 32

- 5) Install balance mechanism, ensure that the gear teeth with “0” marked on crankshaft gear and balance mechanism gear engage.

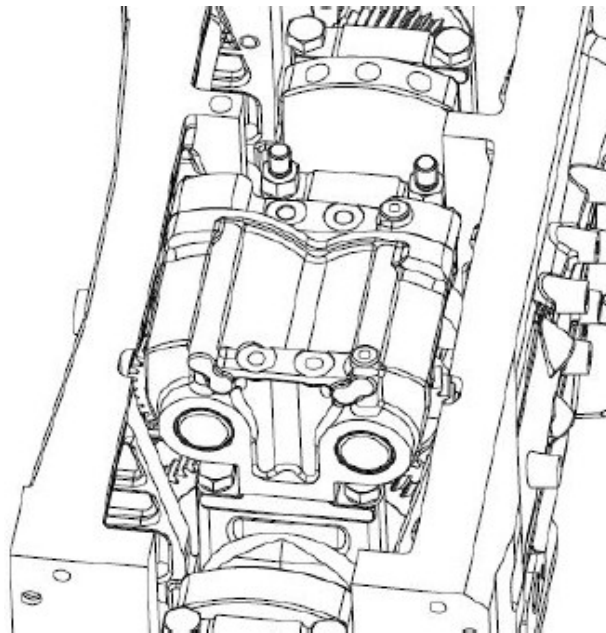


Figure 33

6) Install bolts, pay attention on distinguish bolt's length, do not install bolts in wrong location, and note that there is no washer.

7) Tighten bolts and measure the gear clearance.

Note: The gear clearance should be between 0.3mm to 0.4mm. Remove balance mechanism and change quantity of adjusting shims on each side if the clearance is less than 0.3mm or greater than 0.4mm, replace complete balance mechanism if adjustment doesn't work. The max quantity of shims on each side is 5 pieces.

8) Tighten bolts after clearance adjustment is completed. The torque of bolt (4Xm10) is (40-45) N·m.

3.5 Flywheel and gear assembly and disassembly

3.5.1. Exploded view of flywheel

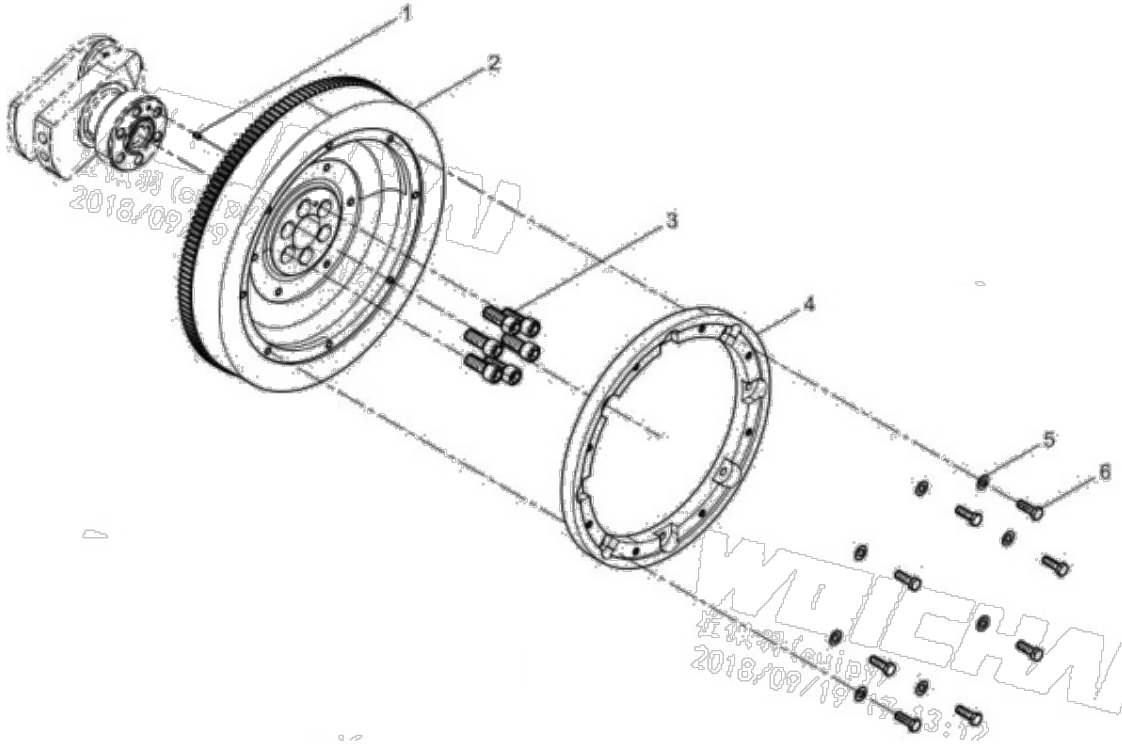


Figure 34

Pos	Name	Pos	Name	Pos	Name
1	Pin	3	Bolt	5	Washer
2	Flywheel	4	Flywheel adapter	6	Bolt

3.5.2. Steps to disassemble flywheel

Reverse assembly procedure to disassemble flywheel and gear.

3.5.3. Steps to assemble flywheel

- 1) Fix the flywheel ring gear on flywheel with bolts.
- 2) Knock the pin into crankshaft rear end fully.
- 3) After inserting flywheel guide rod into crankshaft threaded hole, install flywheel and pre-tighten the bolts diagonally. Apply lubricating oil on bolt thread and bearing surface.

Flywheel bolts:

Bolt specification M16-12.9 (×6); Tightening torque: 285~295Nm; Test value: 285~340Nm.

3.5.4. Inspection and maintenance of flywheel and gear

- 1) Check whether there is failure like thread damage on flywheel bolts.
- 2) Check flywheel surface for conquassation.
- 3) Check whether flywheel ring gear is damaged.

3.6 Piston-rod group assembly and disassembly

3.6.1. Exploded view of piston-rod group

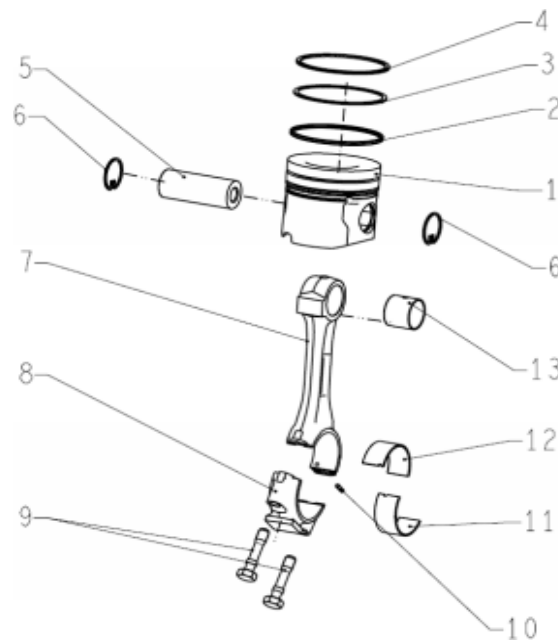


Figure 35

Pos	Name	Pos	Name	Pos	Name
1	Piston	6	Piston pin retainer	11	Connecting rod lower bearing
2	Oil seal ring	7	Connecting rod body	12	Connecting rod top bearing
3	Air seal ring	8	Connecting rod body	13	Connecting rod bushing
4	Air seal ring	9	Connecting rod bolt		
5	Piston pin	10	Pin		

3.6.2. Steps to disassemble piston-rod group

- 1) Check before disassembling. Check connecting rod axial backlash, check tightening torque of connecting rod bolts.
- 2) Tilt and lay the engine on its side, rotate the flywheel until the to-be removed piston is in BDC, and then remove connecting rod bolts and cap.
- 3) Rotate the flywheel until the to-be removed piston is in TDC, knock the piston out with wooden hammer, proceed with caution to avoid jamming cylinder block with connecting rod tip.
- 4) Remove other pistons in the same way, number and place them orderly.
- 5) Remove circlip on two sides of piston with internal circlip plier and push piston pin out, take down the connecting rod body. Number the piston pins, connecting rod bodies and place them orderly.
- 6) Remove first compression ring, second compression ring and oil ring with piston ring plier and mark them.

3.6.3. Steps to assemble piston-rod group

- 1) Install one circlip into piston circlip groove with internal circlip plier and rotate the circlip to ensure it is properly fitted. The end with corner angle should face inward, and its opening should be upward.
- 2) Insert small end of connecting rod into piston inner cavity and align it to piston pin holes, and then install piston pin, finally install the other circlip to the other side of the piston. Note that connecting rod oblique incision and piston cooling oil gallery inlet should be in the same direction, apply proper clean lubricating oil on connecting rod small end hole and piston pin.
- 3) Arrange the assembled piston-rod assembly in cylinder number order, and then install oil ring, second compression ring and first compression ring into piston ring grooves orderly with piston ring plier. The face with mark "TOP" should be upward, and the ring should be flexible in ring groove.

-
- 4) Clean up cylinder inner wall, crankshaft connecting lever and piston-rod assembly, and apply clean lubricating oil on each motion pair.
 - 5) Adjust opening direction of each ring: The opening direction of first compression ring should be 30° to piston pin center line, opening direction of the second compression ring should be 120° to that of the first compression ring, and opening direction of oil ring should be 120° to both that of first compression ring and second compression ring, also should be perpendicular to piston pin center line. As shown in Figure below.

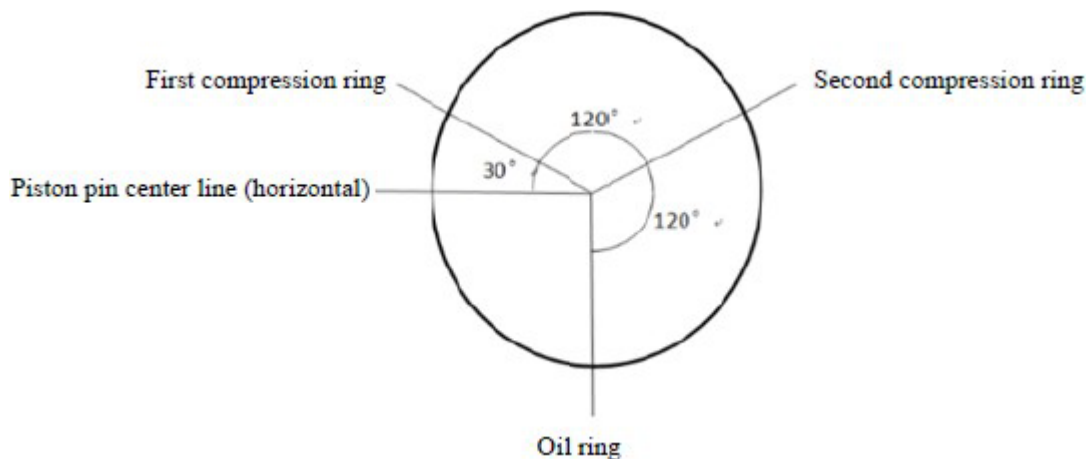


Figure 36

- 6) Rotate the flywheel with external force until cylinder 1, 6 get to BDC, install thrust plates of cylinder 1 and 6, and screw on connecting rod bolts. Rod parting surface should face left side of cylinder block (i.e., engine oil cooler side). The numbered pistons should not be mixed, install each piston to the corresponding cylinder; connecting rod cap and connecting rod should be used in pairs, apply clean lubricating oil on connecting rod bolts before assembling.
- 7) Tighten connecting rod bolts: Firstly, tighten the bolts to 30Nm in symmetry, and then tighten each bolts for another $60^\circ \pm 4^\circ$.
If it is M10x1 bolts, tighten to 30Nm and turn $120^\circ \pm 5^\circ$.
Do not reuse the bolts.

3.6.4. Inspection and maintenance of piston-rod group

- 1) Check whether there is crack on combustor throat fillet and piston pin boss; Check piston skirt and piston head for cylinder scoring phenomenon; Check wear condition of piston pin hole.
- 2) Check wear condition of piston ring outer edge; Check wear condition of piston ring upper and lower end face.
- 3) Check wear condition of piston pin external surface.
- 4) Check whether there is crack on connecting rod tip bottom hole, connecting rod body and connecting rod small end oil hole; Check alloy layer of connecting rod shell for abnormal wear and peeling phenomenon; Check wear condition of connecting rod side faces, check crooking condition of connecting rod body.
- 5) Check wear condition of connecting rod bearing shell, check its alloy layer for discoloration, peeling and slippage phenomenon.

3.7 Damper, crankshaft pulley and hub assembly and disassembly

3.7.1. Exploded view of damper, crankshaft pulley and hub

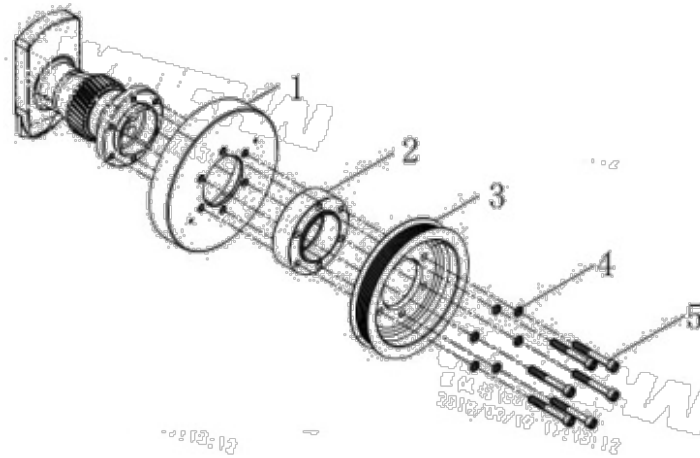


Figure 37

Pos	Name	Pos	Name	Pos	Name
1	damper	3	Crankshaft pulley	5	bolt
2	Connecting plate	4	washer		

3.7.2. Steps to disassemble damper, crankshaft pulley.

Remove pulley bolts, take pulley/ connecting plate and damper down.

3.7.3. Steps to assemble damper and crankshaft pulley.

Install the hub, damper and crankshaft pulley as follows:

- 1) Fasten the hub to crankshaft with the hub fastening bolts and tighten.
- 2) Torque the hub fastening bolts:
Bolt specification M16-12.9
(×4); Tightening torque:
300~310Nm; Test value:
300~360Nm.
- 3) Fasten the torque vibration damper and crankshaft pulley to the hub with the damper fastening bolts and tighten.
- 4) Torque vibration damper fastening bolts:
Bolt specification M10-10.9 (×6);
Tightening torque: 60~70Nm;
Test value: 65~80Nm.

3.7.4. Inspection and maintenance of damper, crankshaft pulley and hub.

- 1) Check the crankshaft pulley for any damage and distortion. Replace if necessary.
- 2) Check the torque vibration damper and hub for damage. Replace either if necessary.
- 3) Check the hub fastening bolts and damper fastening bolts for damaged. Replace any if necessary.

4 Timing mechanism

4.1 Exploded view of timing mechanism

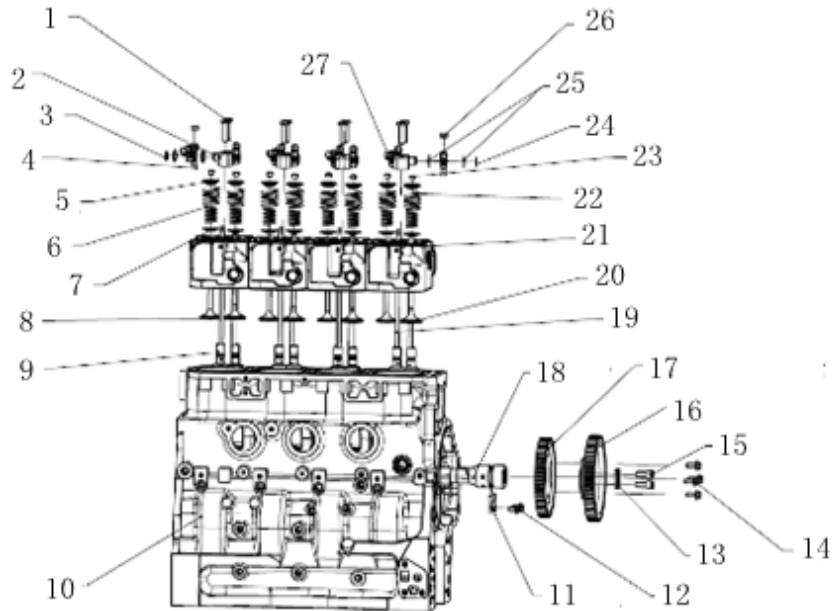


Figure 38

Pos	Name	Pos	Name	Pos	Name
1	Bolt	10	Engine block	19	Push rod
2	Rocker seat	11	Plate	20	Intake valve
3	clip	12	Bolt	21	Cylinder head
4	Adjusting bolt	13	Flange	22	Valve spring
5	Top seat of valve spring	14	Bolt	23	Collet
6	Valve spring	15	Bolt	24	Washer
7	Valve spring seat	16	Camshaft gear	25	Washer
8	Exhaust valve	17	Gear	26	Nut
9	Tappet	18	Camshaft	27	Rocker arm

4.2 Camshaft assembly and disassembly

4.2.1. Exploded view of camshaft

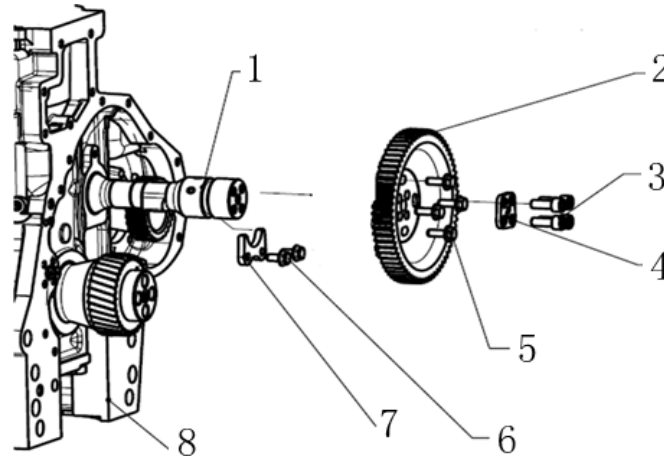


Figure 39

Pos	Name	Pos	Name	Pos	Name
1	Camshaft	4	Flange	7	Plate
2	Camshaft gear	5	Bolt	8	Engine block
3	Bolt	6	Bolt		

4.2.2. Steps to disassemble camshaft

- 1) Rotate the camshaft, check whether the camshaft and timing gear are flexible and moving without clamping stagnation.
- 2) Rotate camshaft until the #1 piston is at the top dead center, check fitting bolts for looseness. Remove bolts, take flange and camshaft gear down.
- 3) Remove camshaft thrust plate fixing bolts, take the thrust plate down and remove camshaft, prevent bump against camshaft bush.

4.2.3. Steps to assemble camshaft

After disassembling, check camshaft and timing gear, repair or replace it if there is severe wear or large parameter deviation.

-
- 1) Check camshaft for blur and bump damage, and make sure there is no rust, scratch and scrap iron.
 - 2) Apply clean engine oil on camshaft hole and tappet hole inner surface. Install camshaft, do not damage camshaft surface and engine block hole during the push-in process of camshaft and the push-in strength should be equally, the end with thread should be on gear housing side.
 - 3) Install sector plate, tightening torque of bolts should be $35\pm 10\text{Nm}$, seal up the bolts with lacquer.
 - 4) Install gaskets, flange, washers, and hexagon bolts on camshaft threaded end. Measure the axial clearance of camshaft, which should be $0.1\sim 0.29\text{mm}$, if the clearance is too small, check whether there is burr between camshaft and sector plate. If fail to adjust the clearance to required range after deburring, then the camshaft should be replaced.
 - 5) Rotate the crankshaft until 0 tick on timing gear is closest to camshaft, install camshaft timing gear, make sure 0 tick of timing gear is engaged with 0 tick of crankshaft gear.

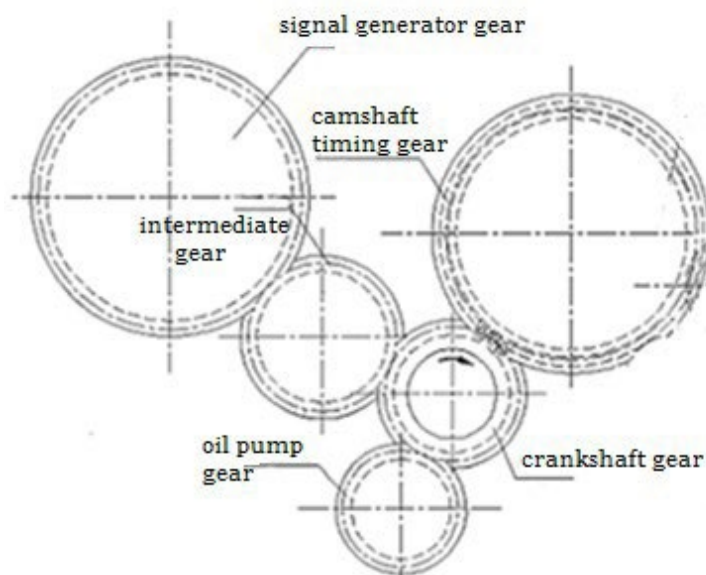


Figure 40

- 6) After correctly installed the gears, mark 0 tick position of camshaft timing gear and crankshaft timing gear with a marking pen.
- 7) After adjusting the holes, install camshaft bolts (cleaned and applied with KB277 sealant) through flanges holes; pre-tighten camshaft timing gear fixing bolts with pneumatic impact wrench, and pre-tighten connecting bolts between camshaft timing gear and fuel injection pump driven gear. Tighten the bolts with torque spanner, tightening torque for M10 bolts: 85~90 Nm, tightening torque for M8 bolts: 55~60.5 Nm, seal up the bolts with lacquer after tightening

4.2.4. Inspection and maintenance of camshaft

- 1) Check whether there is wear trace on cam face that contacting tappet, check main journal for seizure and abrasion.
- 2) Check whether timing gear and hexagon bolts are distorted.

4.3 Intermediate gear assembly and disassembly

4.3.1. Exploded view of intermediate gear

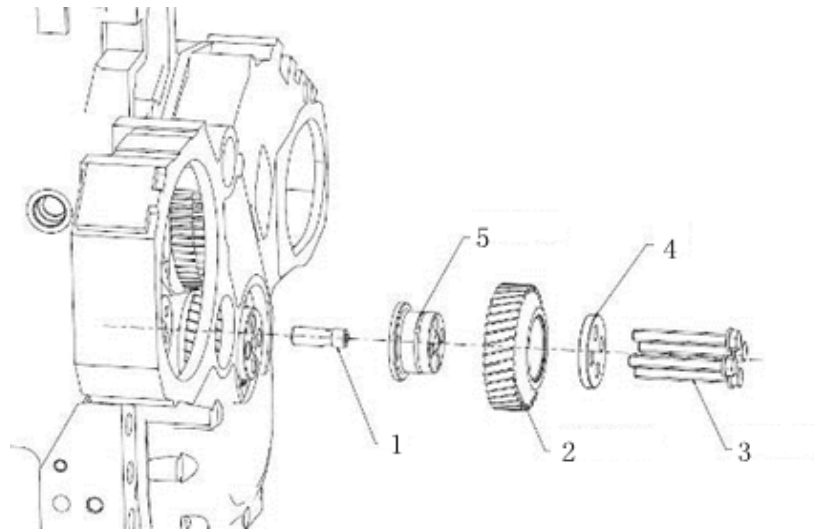


Figure 41

Pos.	Name	Pos.	Name	Pos.	Name
1	Shaft	3	Bolt	5	Intermediate shaft
2	Intermediate gear	4	Washer		

4.3.2. Steps to remove intermediate gear

- 1) Remove four M10 bolts and the washer.
- 2) Insert a M8 bolt into the pin-shaft. Pull the pin-shaft out along this bolt. Take care to ensure that the intermediate gear does not slide off and get damaged.

4.3.3. Steps to assemble intermediate gear

- 1) Assemble the front cover according to the front cover assembly procedure
- 2) Assemble the intermediate gear. Apply oil on the contact surface of the intermediate gear and intermediate shaft.
- 3) Put the intermediate gear module in the front cover. Install the pin-shaft.
- 4) Insert the four M10 bolts after installing the washer. Torque the bolts to 65~70 Nm.
- 5) Rotate the gear by hand after tightening the bolts. Check the clearance and ensure the gear turns smoothly.

4.3.4. Inspection and maintenance of intermediate gear

- 1) Check the bolt thread for good quality.
- 2) Check the tooth of the gear for any damage or spalling.
- 3) Check the intermediate shaft and the interface between the intermediate shaft and the bushing or pin-shaft for any wear. Check the oil passage for any blockage.

4.4 Push rod and tappet assembly and disassembly

4.4.1. Exploded view of tappet and push rod

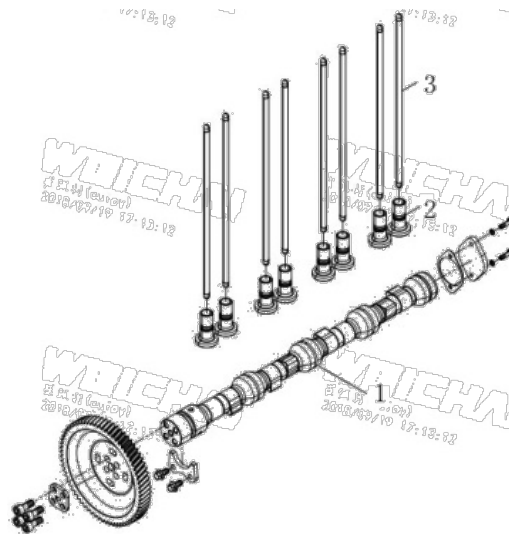


Figure 42

Pos	Name	Pos	Name	Pos	Name
1	Camshaft	2	Tappet	3	Push rod

4.4.2. Steps to disassemble tappet and push rod

- 1) After removing rockers and rocker shafts, pull the pushrods out vertically.
- 2) After removing camshaft, directly take out valve tappet, place them orderly.

4.4.3. Steps to assemble tappet and push rod

- 1) Check valve tappets and push rod, replace them if necessary. Before installing the tappet, it must be cleaned with compressed air. Check to ensure that the oil channel is smooth.
- 2) Apply clean lubricating oil evenly onto the engine block tappet-fitting hole and valve tappet fitting surface.
- 3) Install the valve tappet into the engine block tappet-fitting hole. The tappet should rotate freely in the hole. Install the camshaft, refer to camshaft assembly (11.9.3) for details.
- 4) Loosely fit the rocker seat onto the cylinder cover. Check to ensure that the pushrod is clean, and the welding area is intact.

-
- 5) Apply clean lubricating oil on the pushrod and ensure that the round head is applied with sufficient oil.
 - 6) Install the pushrod by putting the pushrod into the valve tappet through the cylinder cover.

4.4.4. Inspection and maintenance of tappet and push rod

- 1) Clean the valve tappet and pushrod.
- 2) Ensure that the oil channels of valve tappet and pushrod are smooth.
- 3) Ensure that the pushrod is not crooked. Check wear condition on the outside surface.
- 4) Ensure that the two ends of the pushrod are not worn.
- 5) Ensure that the valve tappet surface and undersurface are not worn.
- 6) Ensure that the valve tappet inner socket head is not worn.

4.5 Valve assembly and disassembly

4.5.1. Exploded view of valves

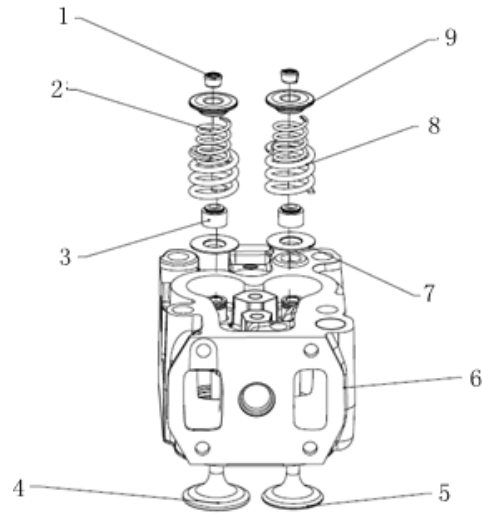


Figure 43

Pos	Name	Pos	Name	Pos	Name
1	Valve collet	4	Intake valve	7	Valve seat
2	Valve spring	5	Exhaust valve	8	Valve spring
3	Valve seal	6	Cylinder head	9	Upper valve seat

4.5.2. Steps to disassemble valves

- 1) Depress valve springs with valve spring compressor or valve overhead plier or other tools, take out valve lock clamp, upper valve spring seat and lower valve spring seat and valve springs orderly.
- 2) Take valve out of valve seat.

4.5.3. Steps to assemble valves

- 1) A valve with severe wear or carbon deposit or sintering should be replaced.
- 2) Apply molybdenum disulfide cream on intake and exhaust valve rod, and then install intake and exhaust valve into cylinder cover, ensure the valve can slide smoothly in valve guide pipe; NOTICE: Check and ensure spring in valve rod seal cartridge is in good condition before assembling.

-
- 3) Install valve inner and outer spring.
 - 4) Assemble upper valve spring seat, depress the springs and install valve lock clamp.
 - 5) Knock the valve with rubber hammer to settle the lock clamp, if the valve lock clamp or upper valve spring seat cannot be settled, please find out the cause and eliminate it.

4.5.4. Inspection and maintenance of valves

- 1) Check whether valve rod and its end faces are worn.
- 2) Check whether valve conical surface is worn or damaged.
- 3) Check valve conical surface and retainer end faces for carbon deposit.

4.6 Rocker arm and shaft assembly and disassembly

4.6.1. Exploded view of rocker arm and shaft

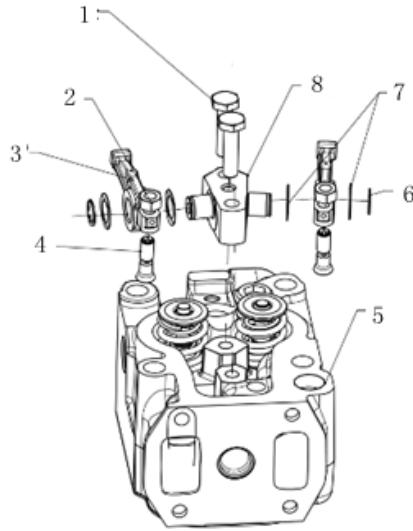


Figure 44

Pos	Name	Pos	Name	Pos	Name
1	Bolt	4	Adjust bolt	7	Washer
2	Nut	5	Cylinder head	8	Rocker arm seat
3	Rocker arm	6	clip		

4.6.2. Steps to disassemble rocker arm and shaft

- 1) Rotate the crankshaft to ensure that the rocker moves smoothly.
- 2) Measure each valve clearance and check any changes in valve clearance.
- 3) If the rocker is not flexible or the valve clearance is too big, loosen the hex screw and then remove the rocker seat, shaft circlip, butterfly spring washer, rocker and the other butterfly spring washer. Mark the items to prevent improper assembly.

4.6.3. Steps to assemble rocker arm and shaft

- 1) Check whether all to-be assembled parts are clean, free of bump damage, scratch, and rust.
- 2) Install rocker adjusting screw and lock nut, the screw should be fully screwed in, while the lock nut only needs to be screwed in for 2~3 thread pitches.

-
- 3) Apply lubricating oil on rocker seat and rocker inner hole, and install butterfly spring washer, rocker assembly, the other butterfly spring washer and circlip for shaft on rocker seat.
 - 4) Loose-fit rocker seat on cylinder cover with hexagon bolts.
 - 5) Install valve pushrod, refer to assembly of valve pushrod for details.
 - 6) Pre-tighten rocker seat, align rocker adjusting screw socket head to valve pushrod round head, tighten the hexagon bolts to 40~45Nm.

◆ Inspect and adjust valve lash

NOTE:

Measure and adjust while the engine is cold.

- 1) Rotate the crankshaft until phase pointer points at 0 tick on phase plate, observe and make sure 0 tick of crankshaft timing gear is engaged with 0 tick of camshaft gear. Then adjust valve clearance of No. 1-2-3-6 rocker (count from the front end), intake valve adjustment: firstly fill in a 0.2mm plug gauge, and tighten the nuts with torque spanner to 20 ± 5 Nm, pull out the gauge (make sure the gauge can be easily pulled out), and check the clearance with a 0.25mm plug gauge (make sure the gauge cannot get through), adjusting of intake valve is finished. Exhaust valve adjustment: firstly, fill in a 0.3mm plug gauge, and tighten the nuts with torque spanner to 20 ± 5 N·m, pull out the gauge (make sure the gauge can be easily pulled out), and check the clearance with a 0.35mm plug gauge (make sure the gauge cannot get through), adjusting of exhaust valve is finished.
- 2) Further rotate crankshaft until phase pointer points at 0 tick on phase plate, observe and make sure 0 tick of crankshaft timing gear is engaged with the symmetry point of 0 tick (180°) on camshaft gear. Then adjust valve clearance of No. 4-5-7-8 rocker (count from the front end), refer to ① for adjusting method.

4.6.4. Inspection and maintenance of rocker arm and shaft

- 1) Clean the rocker and check for any cracks.
- 2) Check the rocker inner hole for abrasion and scratches and measure its diameter.
- 3) Check the rocker adjusting screw and the other end arc surface for abrasion.
- 4) Check to ensure that all oil galleries are smooth.
- 5) Measure the diameter of rocker inner hole and rocker shaft. Calculate the fitting clearance.

5 Air intake and exhaust system

5.1 Air intake and exhaust system assembly and disassembly

5.1.1. Exploded view of air intake and exhaust system

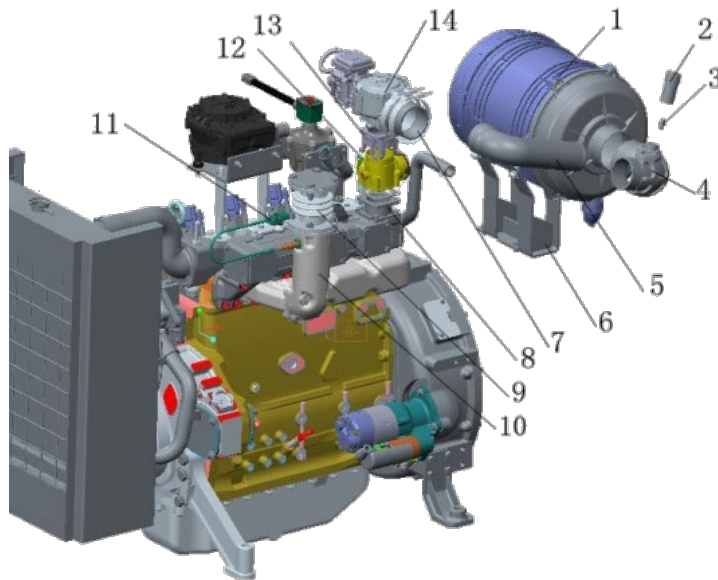


Figure 45

Pos	Name	Pos	Name	Pos	Name
1	Air filter	6	Air filter bracket	11	Oxygen sensor
2	Intake pressure reminder	7	Hose	12	Throttle
3	Pipe connector	8	Connecting pipe	13	Flange
4	Connecting pipe	9	Expansion joint	14	Mixer
5	Connecting pipe	10	Exhaust tail pipe		

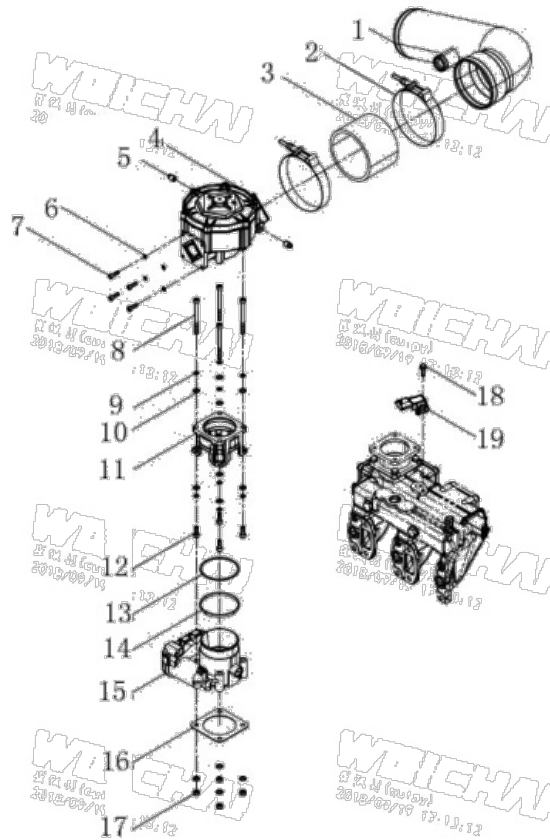


Figure 46

Pos	Name	Pos	Name	Pos	Name
1	Mixing air intake pipe	8	Bolt	15	throttle
2	Clamp	9	Washer	16	Gaske t
3	Hose	10	Washer	17	Nut
4	Mixer	11	Flange	18	Bolt
5	Screw plug	12	Bolt	19	Air intake temperature and pressure sensor
6	Washer	13	O-ring		
7	Bolt	14	Gasket		

5.1.2. Steps to disassemble air intake and exhaust system

- 1) Remove air filter fixing bolts, loosen clamps to remove air filter and connecting hose.
- 2) Loosen clamps to remove connecting pipe.
- 3) Loosen the bolts fixing mixer and flange, take mixer and gasket down.
- 4) Loosen the bolts fixing throttle and adapter, remove adapter.
- 5) Loosen the bolts fixing throttle and air intake elbow, remove throttle and gasket.
- 6) Loosen the bolts fixing air intake elbow and air intake manifold, remove intake elbow and gasket.
- 7) Remove exhaust manifold bolts to take exhaust manifold and gaskets down.
- 8) Remove air intake manifold bolts to take air intake manifold and gaskets down.

5.1.3. Steps to assemble air intake and exhaust system

NOTE:

- If cylinder heads were removed, do not tighten the four cylinder heads until after intake manifold is installed to ensure coolant ports are aligned to prevent coolant leaks. After intake manifold is aligned and tightened the cylinder heads may then be torqued. Reference 2.9.3. [Steps to assemble cylinder head](#)
- Use the intake pipe to locate the cylinder head and use the intake pipe to level the four cylinder heads to ensure the coplanarity of the four cylinder heads (coplanarity requirement < 0.07mm, theoretical value \neq 0.10mm, greater than this standard may cause water damage There is a risk of water leakage at the joint surface of the intake pipe and the cylinder head.).

Reverse disassembly procedure to assemble air intake and exhaust system.

5.2 Air intake manifold assembly and disassembly

5.2.1. Exploded view of air intake manifold

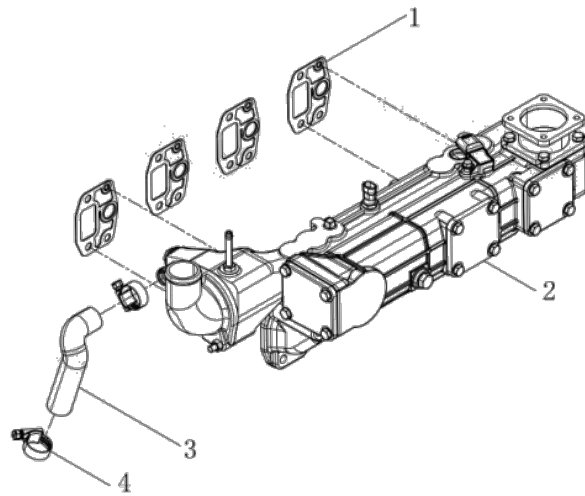


Figure 47

Pos.	Name	Pos.	Name
1	Air intake manifold gasket	3	Hose
2	Air intake manifold	4	Clamp

5.2.2. Steps to disassemble air intake manifold

- 1) Remove nuts to take air intake manifold and gasket down.
- 2) Loosen clamps to take hose down.

5.2.3. Steps to assemble air intake manifold

Reverse disassembly procedure to assemble air intake manifold, the torque of intake manifold bolt is 40-60N·m.

5.2.4. Inspection and maintenance of air intake manifold

- 1) Check the intake manifold for weld defects. Replace the pipe if necessary.
- 2) Check the intake pipe gaskets for damage and tears. Replace the gaskets if necessary.

Note: Tighten the intake bolts again as required torque above after commissioning test.

5.3 Exhaust assembly and disassembly

5.3.1. Exploded view of exhaust manifold

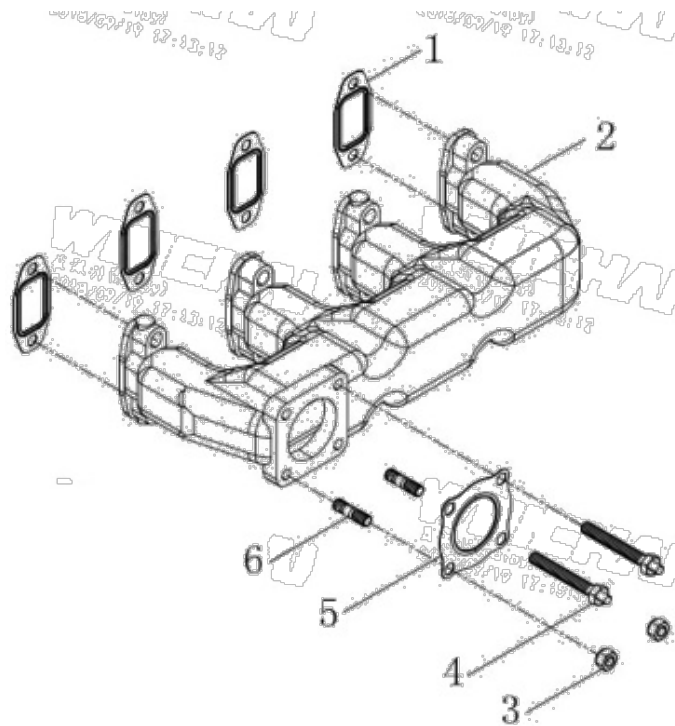


Figure 48

Pos.	Name	Pos.	Name
1	Gasket	4	Bolt
2	Exhaust manifold	5	Gasket
3	Nut	6	Stud

5.3.2. Steps to disassemble exhaust manifold

- 1) Remove nuts to take exhaust tail pipe and gaskets down.
- 2) Remove bolts to take exhaust manifold and gasket down.

5.3.3. Steps to assemble exhaust manifold

Reverse disassembly procedure to assemble exhaust manifold.

NOTE:

- The recommended tightening torque of exhaust manifold bolt is 50 N·m~55 N·m and do not reuse this bolt more than twice.

5.3.4. Inspection and maintenance of exhaust manifold

- 1) Check for cracks in the exhaust manifold and deformations in the exhaust elbow flange. Replace the exhaust manifold and exhaust elbow if necessary.
- 2) Check the exhaust elbow flange for any air leakage. Replace the exhaust elbow gasket if necessary.
- 3) Check exhaust elbow gasket for any deformation, tearing, or deficiencies. Replace it if necessary.

5.4 Exhaust tail pipe assembly and disassembly

5.4.1. Exploded view of exhaust tail pipe

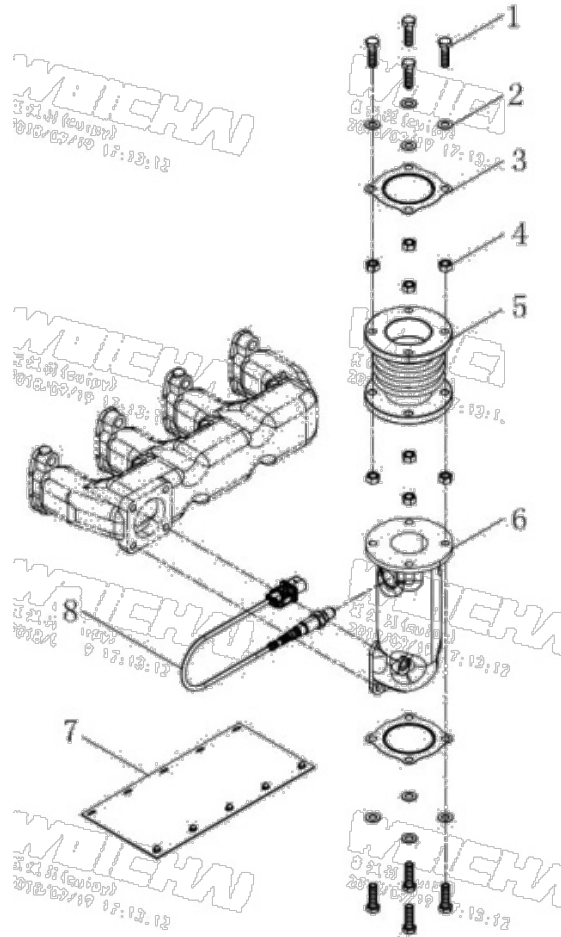


Figure 49

Pos	Name	Pos	Name	Pos	Name
1	Bolt	4	Nut	7	Protective cover
2	Washer	5	Expansion joint	8	O2 sensor
3	Gasket	6	Heat shield		

5.4.2. Steps to disassemble exhaust tail pipe

- 1) Remove nuts and bolts to take expansion joint and gasket down.
- 2) Remove nuts and bolts to take exhaust tail pipe and gasket down.
- 3) Remove protective cover and take O2 sensor down.

5.4.3. Steps to assemble exhaust tail pipe

Reverse disassembly procedure to assemble exhaust manifold.

Note: the recommended tightening torque of exhaust manifold bolt is $65\text{N}\cdot\text{m}\sim 80\text{N}\cdot\text{m}$ and do not reuse this bolt more than twice.

5.4.4. Inspection and maintenance of exhaust tail pipe

- 1) Check for cracks in the exhaust tail pipe and deformations in the expansion joint.
Replace them if necessary.
- 2) Check the exhaust tail pipe and expansion joint for any air leakage. Replace the exhaust elbow gasket if necessary.

6 Ignition system

6.1 Ignition system assembly and disassembly

6.1.1. Exploded view of ignition system

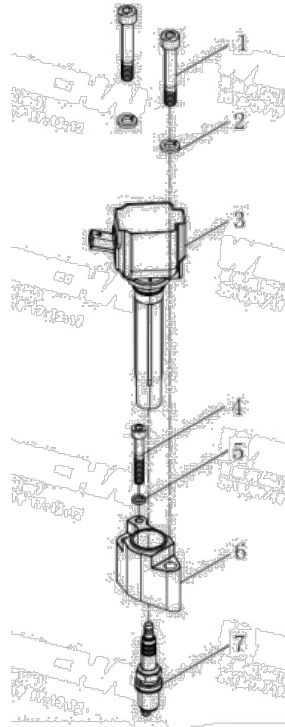


Figure 50

Pos	Name	Pos	Name	Pos	Name
1	Bolt	4	Bolt	7	Spark plug
2	washer	5	washer		
3	Ignition coil	6	Coil seat		

6.1.2. Steps to disassemble ignition coil

- 1) Remove the fixing bolt to take ignition coil down.
- 2) Remove the fixing bolt to take coil seat down.
- 3) Remove spark plug.

6.1.3. Steps to assemble ignition coil

Reverse the disassembly procedure to assemble ignition coil.

6.2 Signal generator assembly and disassembly

6.2.1. Exploded view of signal generator

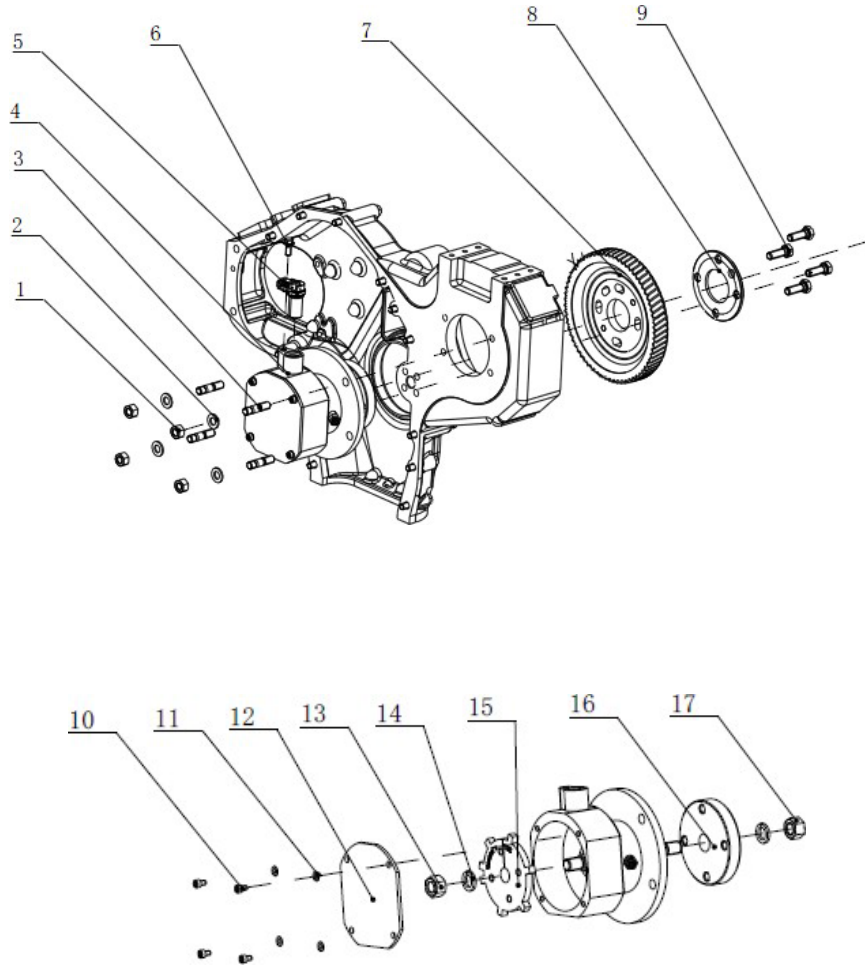


Figure 51

Pos	Name	Pos	Name	Pos	Name
1	Nut	7	Gear	13	Nut
2	Washer	8	Filling plate	14	washer
3	stud	9	Nut	15	Toothed disc
4	Signal generator	10	Bolt	16	Filling plate
5	Speed sensor	11	Washer	17	Nut
6	Bolt	12	Cover plate	18	

6.2.2. Steps to disassemble signal generator

- 1) Remove cover plate on the gear housing.
- 2) Remove nut #9, take gear out.
- 3) Remove nut #1 and take signal generator down.
- 4) Remove bolt #6 and take camshaft sensor down.

6.2.3. Steps to assemble signal generator

- 1) Install camshaft sensor on the signal generator, tighten the bolt.
- 2) Install stud #3 on the gear housing.
- 3) Make sure the O-ring is intact, otherwise replace it.
- 4) Install signal generator on the gear housing, tighten nut #1.
- 5) Install gear #7, tighten bolt #9.

6.2.4. Steps to adjust signal generator

- 1) Rotate crankshaft to "OT", make sure that the first cylinder piston is in its compression stroke.
- 2) Remove bolt #10 and take the cover plate down.
- 3) Remove nut #3 and washer #14.
- 4) Adjust toothed disc #15, align the "TDC" line with the center of camshaft sensor.
- 5) Install washer #14 and tighten nut #13 with the torque of (90 ± 4) N.m.
- 6) Install cover plate #12 and tighten bolts.

NOTE:

- The clearance between the phase sensor and gear is 0.8mm~1.5mm.

6.2.5. Inspection and maintenance of signal generator

- 1) Check the signal generator shaft threads for damage.
- 2) Check that the locknuts of the signal generator fluted disc are tightened, and the ignition angle of the signal generator is correct.
- 3) Check the head of cam sensor for damage and foreign matter.

6.3 ECM assembly and disassembly

6.3.1. Exploded view of ECM

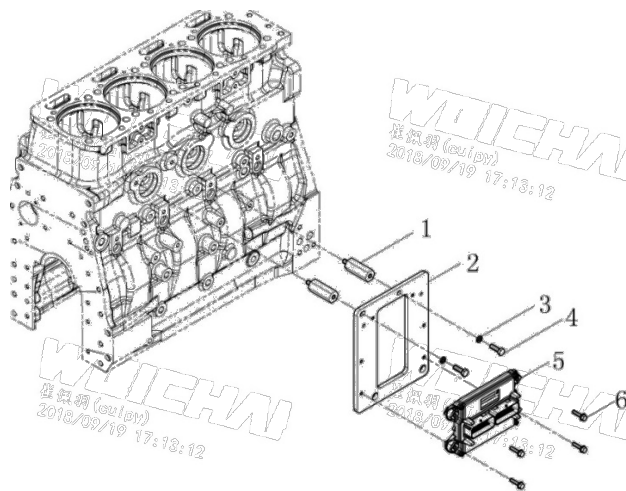


Figure 52

Pos	Name	Pos	Name	Pos	Name
1	Support block	3	Washer	5	ECU
2	ECM bracket	4	Bolt	6	Bolt

6.3.2. Steps to disassemble ECM

- 1) Remove bolt #6.
- 2) Remove ECM and washer.
- 3) Remove bolt #4 and washer #3.
- 4) Remove ECM bracket.

6.3.3. Steps to disassemble ECM

Reverse assembly procedure to assemble ECM.

6.3.4. Inspection and maintenance of ECM

- 1) Check to see if any ECU connection pins are corroded, bent, broken, missing, or damaged. Replace the pins if necessary.
- 2) Check the plastic portion of the ECU connection for damage. Replace the ECU if there is any damage.

7 Fuel system

7.1 Fuel system assembly and disassembly

7.1.1. Exploded view of fuel system

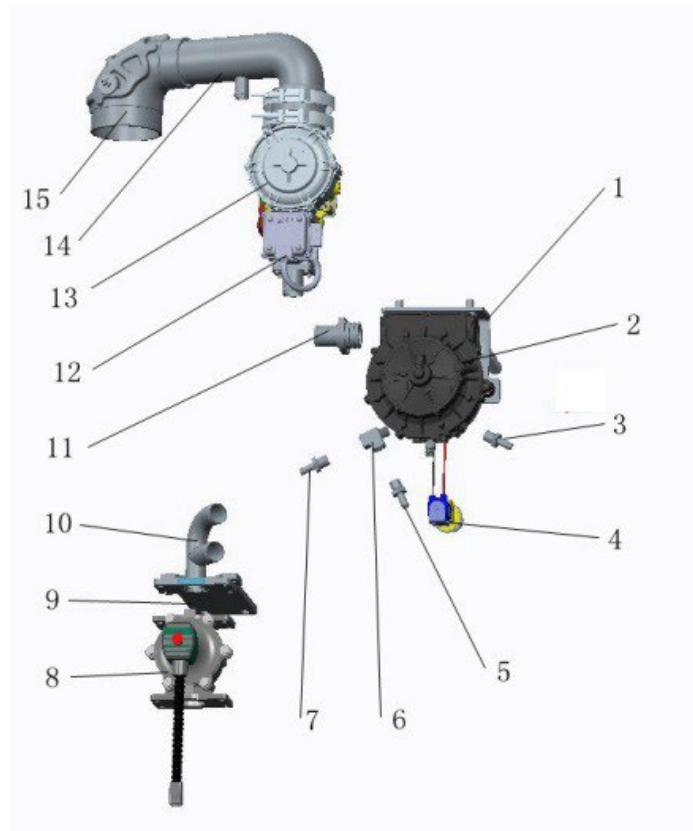


Figure 53

Pos	Name	Pos	Name	Pos	Name
1	Bracket	6	T-junction	11	Pipe connector
2	LPG evaporator	7	Pipe connector	12	EPR
3	Pipe connector	8	Shut-off valve	13	Mixer
4	Shut-off valve	9	bracket	14	Mixed air intake connecting pipe
5	Pipe connector	10	Gas pipe	15	Air intake elbow

7.2 LPG system assembly and disassembly

7.2.1. Exploded view of LPG system

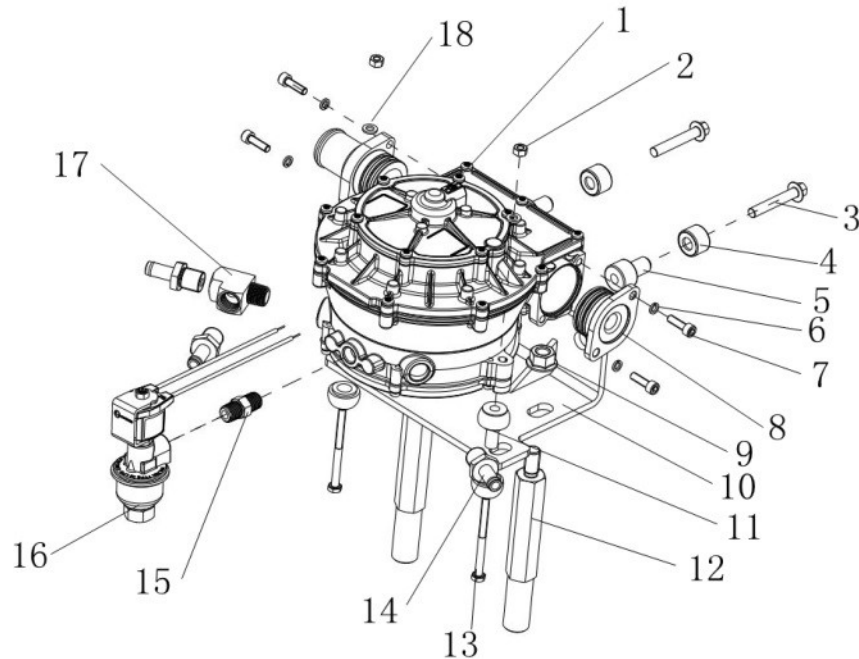


Figure 54

Pos	Name	Pos	Name	Pos	Name
1	LPG evaporator	7	Bolt	13	Bolt
2	Nut	8	Pipe connector	14	Shock pad
3	Bolt	9	Nut	15	Pipe connector
4	Shock pad	10	Bracket	16	Shut-off valve
5	Shock pad	11	Shock pad	17	T-junction
6	Washer	12	Bolt	18	Washer

7.2.2. Steps to disassemble LPG evaporator

- 1) Remove gas connecting hose and clamps to separate LPG supply system and NG supply system.
- 2) Remove bolts and nuts to separate LPG supply system and cylinder head.
- 3) Remove water inlet and outlet connectors to separate LPG supply system and engine cooling system.

- 4) Remove fitting bolts and shock pads to remove LPG evaporator from its bracket.
- 5) Remove shut-off valve from LPG evaporator.
- 6) Remove all connectors and plugs on the evaporator.

7.2.3. Steps to assemble LPG evaporator

Reverse disassembly procedure to assemble the LPG evaporator.

7.2.4. Inspection and maintenance of LPG evaporator

- 1) Check the LPG gas valve and hoses for leaks.
- 2) Check the coolant fittings and hoses for leaks.

7.3 NG shut-off valve assembly and disassembly

7.3.1. Exploded view of NG shut-off valve

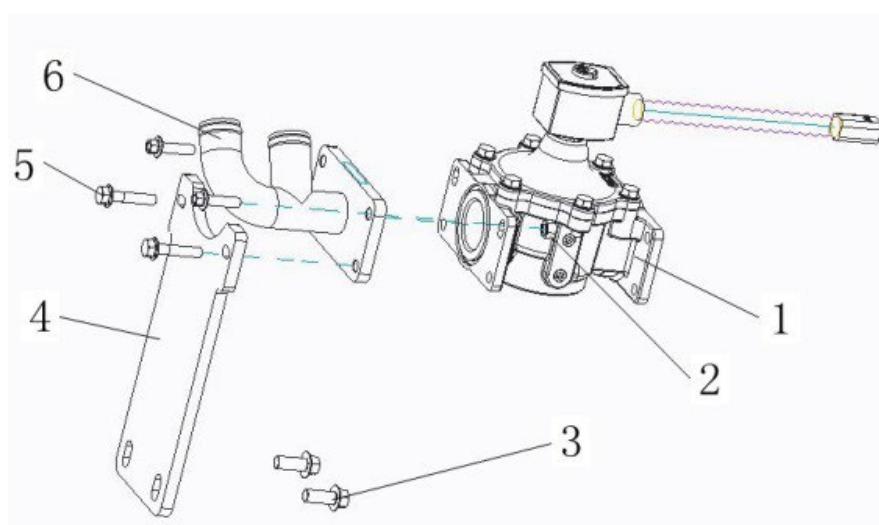


Figure 55

Pos	Name	Pos	Name	Pos	Name
1	Shut-off valve	3	Bolt	5	Bolt
2	Nut	4	Bracket	6	Gas pipe

7.3.2. Steps to disassemble NG shut-off valve

- 1) Remove the bolts and nuts bolting the NG shut-off valve to the gas pipe joint.
- 2) Remove the bolts and nuts bolting the NG bracket to the NG shut-off valve. Remove the NG shut-off valve.

7.3.3. Steps to assemble NG shut-off valve

Reverse disassembly procedure to assemble NG shut-off valve.

7.4 EPR assembly and disassembly

7.4.1. Exploded view of EPR

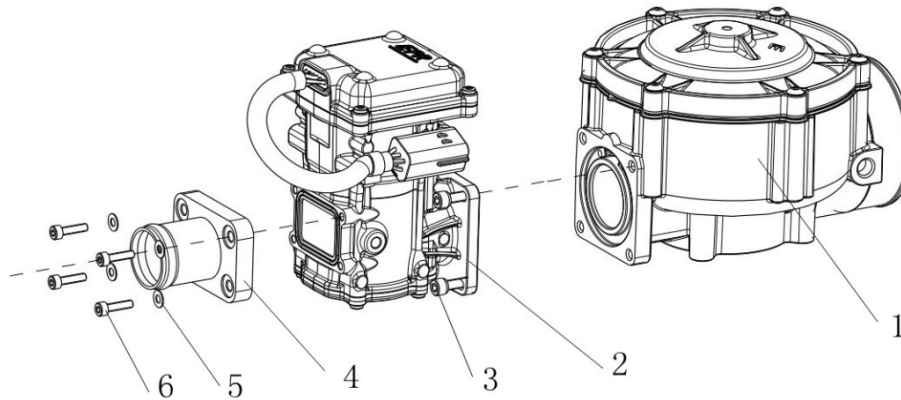


Figure 56

Pos	Name	Pos	Name	Pos	Name
1	Mixer	3	Bolt	5	Washer
2	EPR	4	Gas pipe	6	Bolt

7.4.2. Steps to disassemble EPR

- 1) Remove the socket head bolts bolting the gas pipe joint to the EPR, take gas pipe down.
- 2) Remove the hex bolts and washers bolting the EPR to the mixer. Take the EPR down.

7.4.3. Steps to assemble EPR

Reverse disassembly procedure to assemble EPR

7.5 Mixer assembly and disassembly

7.5.1. Exploded view of Mixer

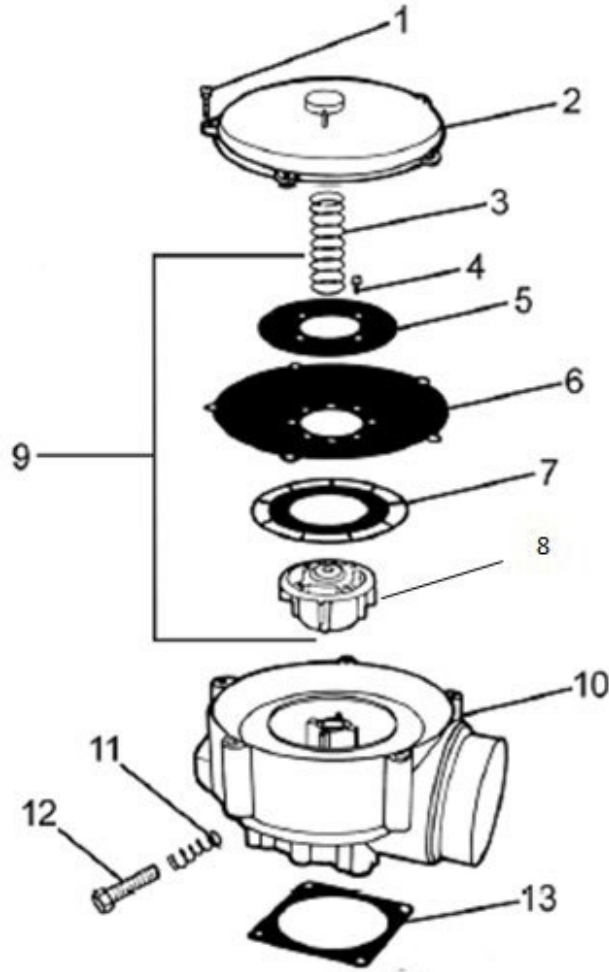


Figure 57

No.	Part Name	No.	Part Name	No.	Part Name
1	Screws	6	Diaphragm	11	Spring
2	Mixer Cover	7	Ring	12	Adjustment Screw
3	Spring	8	Air Fuel Regulator Valve	13	Gasket
4	Screws	9	Diaphragm Assembly		
5	Board	10	Mixer body		

7.5.2. Steps to disassemble mixer

- 1) Remove the screws on the mixer cover. Remove the mixer cover.
- 2) Remove the diaphragm spring.
- 3) Remove the diaphragm assembly.

7.5.3. Steps to assemble mixer

Reverse the Disassembly Procedure to assemble the Mixer.

7.5.4. Inspection and maintenance of mixer

If gas flow is insufficient:

- 1) Rotate the adjustment screw clockwise to increase the flow of gas.
- 2) Replace the gas diaphragm with a biogas diaphragm to increase the flow of gas. To replace the mixer diaphragm according to maintenance specifications:
- 3) Remove the old mixer diaphragm.
- 4) Check the diaphragm for deformation, tears, and deficiencies. Replace it if necessary.
- 5) Check the diaphragm for oil contamination and corrosion. Clean it if necessary.
- 6) Clean the diaphragm with a special cleaning agent.

8 Cooling system

8.1 Cooling system assembly and disassembly

The cooling system of 4M11 engine is mainly composed of water pump and intermediate pad, water jacket (engine block, cylinder head, oil cooler), water outlet pipe, thermostat, radiator, fan, and the cooling pipelines of other accessories. The structural and principal diagram of the system is shown in the picture.

The heat transmitted from the engine to the coolant is taken away by the coolant passage of enclosed circulation. Cooling outside the engine block is not allowed. The cooling circulation pipeline must be subject to enclosed over-pressure system design. The engine is equipped with centrifugal water pump for coolant circulation. A coolant controller - a thermostat is installed on the coolant pipeline. When the engine is running at a temperature lower than the normal, the thermostat will be disconnected to the large circulation of cooling system. By this way, the engine will achieve the regular operating temperature soon. The thermostat will be turned on at a specified temperature to send the hot coolant into the large circulation of cooling system for fan cooling.

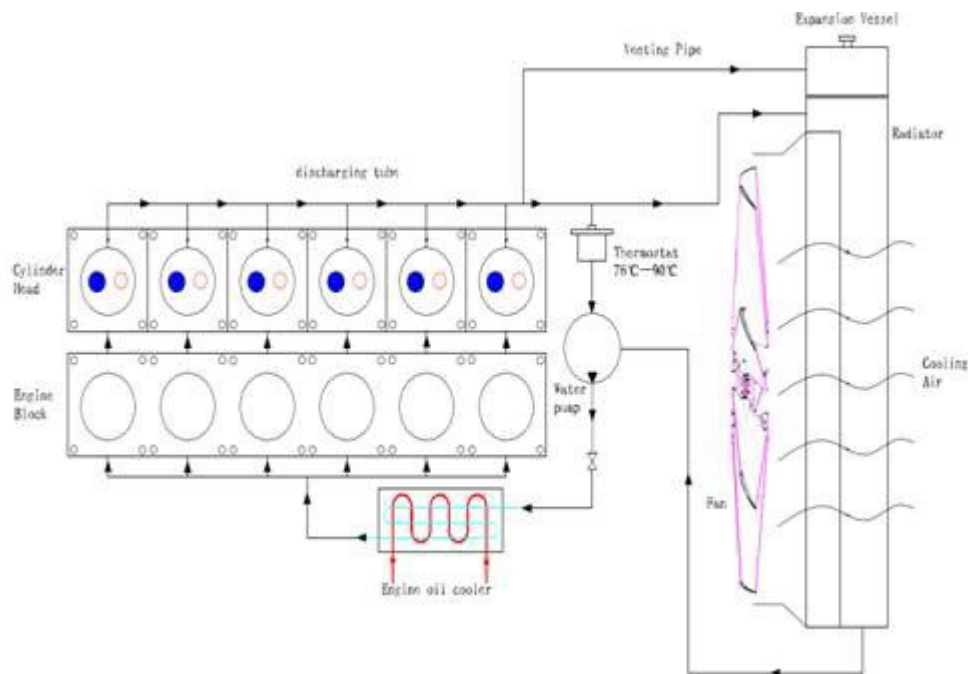


Figure 58

8.1.1. Exploded view of cooling system

The cooling system ensures that the engine can operate at the proper operating temperature. Forced circulation cooling is most effective at keeping the engine within the normal operating temperature range. The cooling system primarily consists of the water pump, fan, expansion water tank, water tank and thermostat.

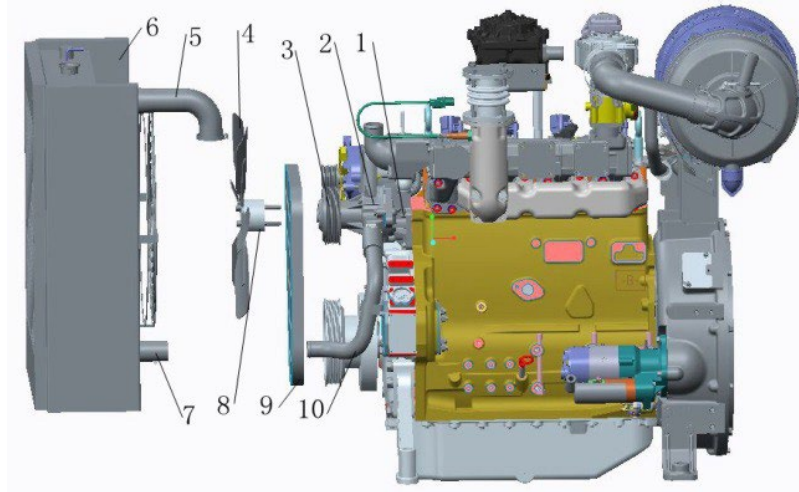


Figure 59

No.	Part Name	No.	Part Name	No.	Part Name
1	Water pump filling	5	Hose	9	Fan belt
2	Water pump	6	Radiator	10	Water inlet pipe
3	Water pump pulley	7	Hose		
4	Fan	8	Flange		

8.2 Fan assembly and disassembly

8.2.1. Exploded view of fan

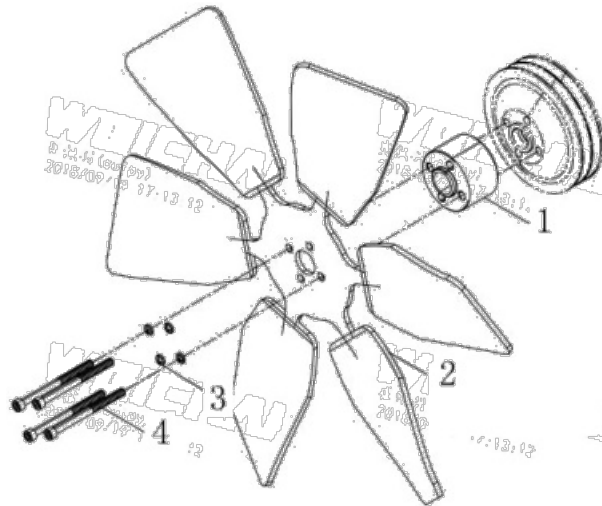


Figure 60

No.	Part Name	No.	Part Name
1	Flange	3	Washer
2	Fan	4	Bolt

8.2.2. Steps to disassemble fan

- 1) Loosen 4 fixing bolts on the fan and take fan down.
- 2) Remove flange.

8.2.3. Steps to assemble fan

- 1) Prior to assembling, check the fan, flange and fastening bolts for any manufacturing defects or damage. Replace them if necessary.
- 2) Reverse the Disassembly Procedure to assemble the Fan (Note: do not install fan outside in).

8.2.4. Inspection and Maintenance of Fan

Check the fan, flange, and water pump pulley for any cracks or damage. Replace if necessary.

8.3 Water pump assembly and disassembly

8.3.1. Exploded view of water pump

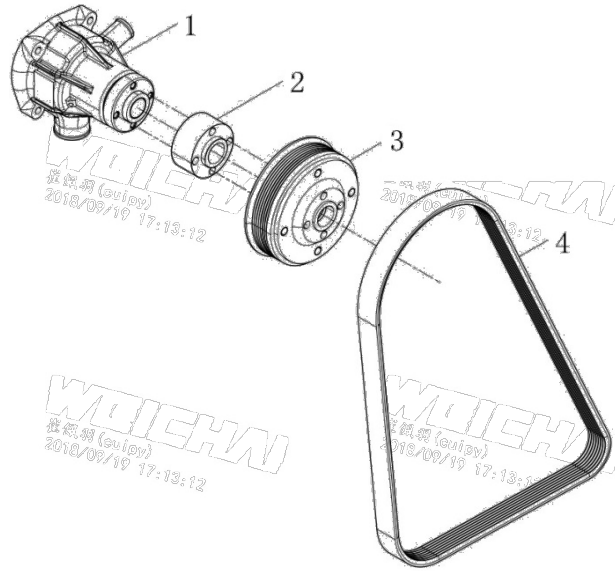


Figure 61

No.	Part Name	No.	Part Name
1	Water pump	3	Belt pulley
2	Flange	4	Belt

8.3.2. Steps to disassemble water pump

- 1) Remove water pump pulley
- 2) Remove thermostat connecting hose and clamps.
- 3) Remove bolts on the water pump.
- 4) Remove water pump gasket and filling spacer.

8.3.3. Steps to assemble water pump

Reverse the Disassembly Procedure to assemble the Water Pump.

8.3.4. Water Pump Inspection and Maintenance

- 1) Check the water pump gasket for any cracks or damage. Replace it if necessary.
- 2) Check the bolts and studs for any damage to the threads. Replace any if necessary.
- 3) Check water pump and middle cushion block for cracks. Replace them if necessary.

8.4 Thermostat assembly and disassembly

8.4.1. Exploded view of thermostat

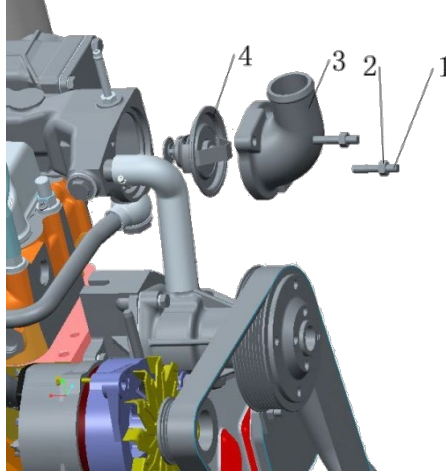


Figure 62

No.	Part Name	No.	Part Name
1	Stud	3	Thermostat cap
2	Nut	4	Thermostat

8.4.2. Steps to disassemble thermostat

- 1) Remove the connecting hose between thermostat and water outlet pipe.
- 2) Remove the connecting hose between thermostat and water pump.
- 3) Remove thermostat.

8.4.3. Steps to assemble thermostat

Reverse disassembly procedure to assemble thermostat

8.4.4. Inspection and maintenance of thermostat

- 1) Check the clamps to ensure good condition. Replace any if necessary.
- 2) Check the coolant rubber hoses for cracks or damage. Replace them if necessary.
- 3) Check the thermostat for fracturing or damage. Replace it if necessary.

9 Lubricating system

9.1 Exploded view of lubricating system

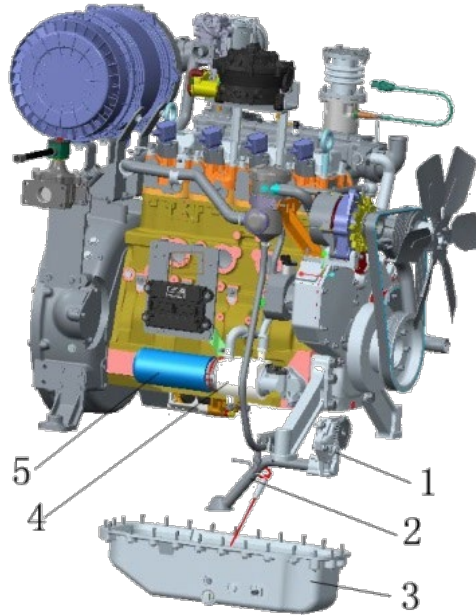


Figure 63

No.	Part Name	No.	Part Name	No.	Part Name
1	Oil pump	3	Oil pan	5	Oil filter
2	Oil strainer	4	Oil cooler		

9.2 Oil pump assembly and disassembly

9.2.1. Exploded view of oil pump

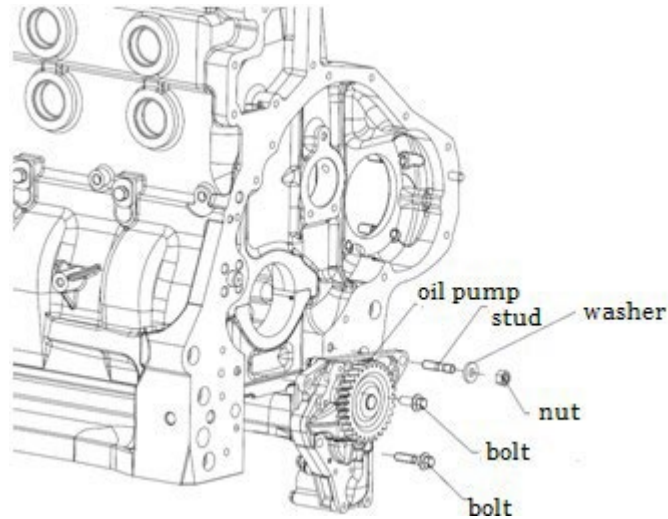


Figure 64

9.2.2. Steps to disassemble oil pump

Remove the two hexagon bolts and self-locking nut, take down engine oil pump, as shown in Fig. 63.

9.2.3. Steps to assemble oil pump

- 1) Check the pump before assembling, make sure there is no manufacturing defect and damage.
- 2) Clean up the fitting surface between oil pump and engine block.
- 3) Install engine oil pump.
- 4) Install and tighten the two toothed hexagon bolts and self-locking nut.

9.2.4. Inspection and maintenance of oil pump

- 1) Check the engine oil pump for crack damage, check whether its inner cavity is smooth, replace it if necessary.
- 2) Check whether engine oil pump shaft can rotate smoothly, replace it if necessary.

9.3 Oil filter, oil cooler assembly and disassembly

9.3.1. Exploded view of oil filter and cooler

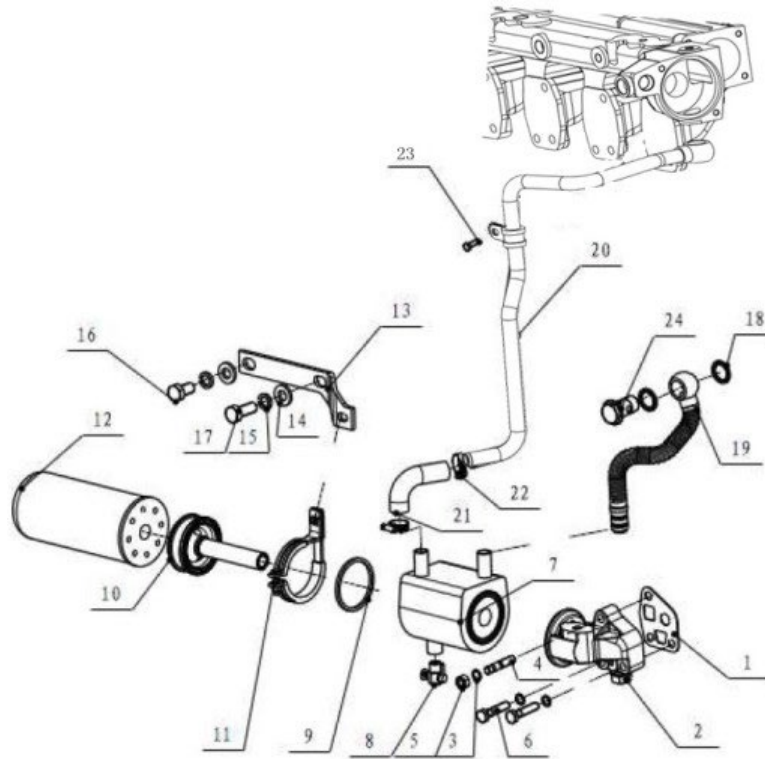


Figure 65

No.	Part Name	No.	Part Name	No.	Part Name
1	Gasket	9	O-ring	17	Bolt
2	Oil filter seat	10	Connecting adapter	18	Seal washer
3	Washer	11	Clamp	19	Water inlet pipe
4	Stud	12	Filter	20	Water outlet pipe
5	Nut	13	Bracket	21	Hose
6	Bolt	14	Washer	22	Clamp
7	Oil cooler	15	Washer	23	Bolt
8	Water drain valve	16	Bolt	24	Hollow bolt

9.3.2. Steps to disassemble oil filter and cooler

- 1) Remove oil filter by filter spanner.
- 2) Loosen #10 connecting barrel and clamps.
- 3) Loose clamps on the water outlet pipe.
- 4) Remove water inlet pipe.
- 5) Remove the bolts fitting the oil cooler and take oil cooler down.

9.3.3. Steps to assemble oil filter and cooler

- 1) Check oil filter's O-ring and oil cooler for manufacturing defect and damage before installing them.
- 2) Clean up the junction surface of oil cooler seat.
- 3) Install oil cooler and connecting barrel then tighten them, hook up water inlet pipe and outlet pipe, and tighten clamps.
- 4) Install and tighten oil filter.

9.3.4. Inspection and maintenance of oil filter and cooler.

- 1) Check oil filter for damage, replace it if there is damage.
- 2) Check oil cooler for crack, replace it if there is crack or leakage.

9.4 Pressure-limiting valve of main oil gallery assembly and disassembly

9.4.1. Exploded view of pressure-limiting valve

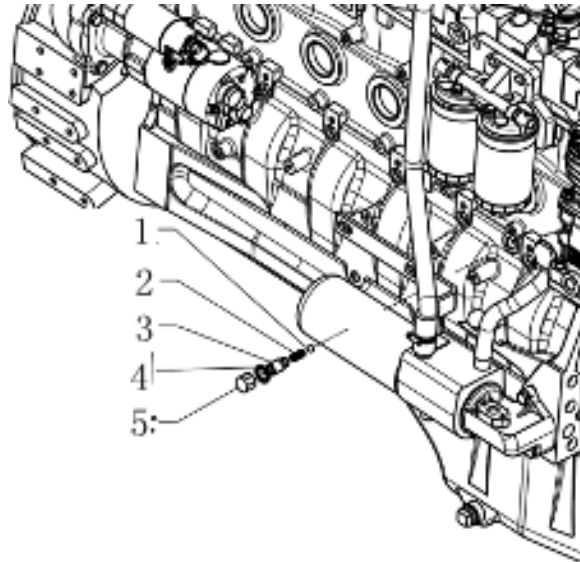


Figure 66

No.	Part Name	No.	Part Name	No.	Part Name
1	Ball	3	Push rod	5	Nut
2	Spring	4	Washer	6	

9.4.2. Steps to disassemble pressure-limiting valve

Loose the nut to take pressure-limiting valve down.

9.4.3. Steps to assemble pressure-limiting valve

- 1) Check the valve before assembling, make sure there is no manufacturing defect and damage.
- 2) Clean up the pressure limiting valve and pressure limiting valve fitting hole on the module.
- 3) Install the valve and tighten it.

9.4.4. Inspection and maintenance of pressure-limiting valve

- 1) Check the condition of valve spring, replace the spring if necessary.
- 2) Check the valve for crack damage, replace it if necessary.

9.5 Oil strainer assembly and disassembly

9.5.1. Exploded view of oil strainer

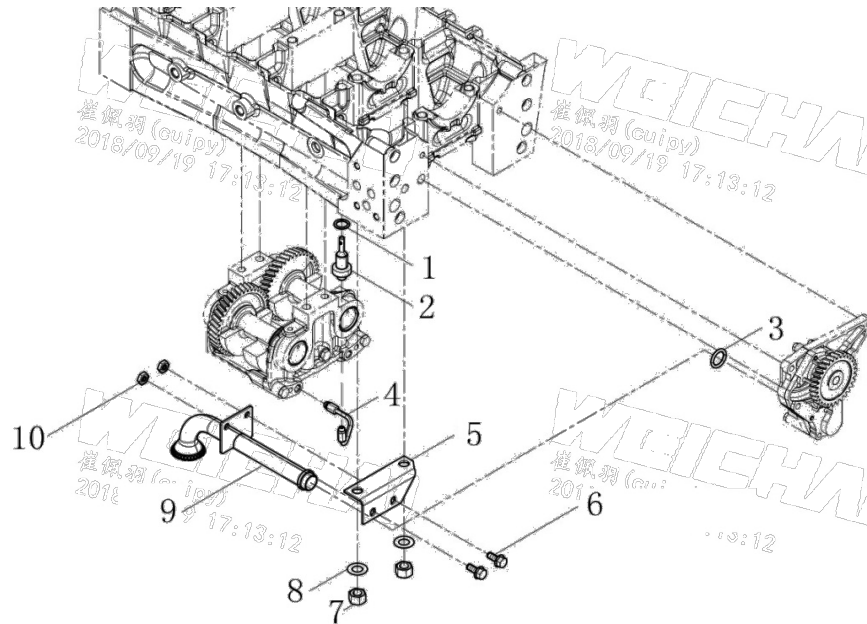


Figure 67

No.	Part Name	No.	Part Name	No.	Part Name
1	Washer	5	Bracket	9	Pipe
2	Pipe connector	6	Bolt	10	Nut
3	O-ring	7	Nut		
4	Oil pipe	8	Washer		

9.5.2. Steps to disassemble oil strainer

Screw off two hexagon flange bolts and the hexagon nuts on the bended plate, take down the oil strainer.

9.5.3. Steps to assemble oil strainer

- 1) Check the strainer before assembling, make sure there is no manufacturing defect and damage. Replace new O-ring at the same time.
- 2) Clean up the oil supply hole of oil pump and the strainer inner cavity.
- 3) Install the strainer.
- 4) Assemble and tighten the two hexagon flange bolts and the hexagon nuts.

9.5.4. Inspection and maintenance of oil strainer

Check the strainer for crack and damage, replace it if necessary.

10 Starting system

10.1 Exploded view of starting system

The starter is the core component of the starting system. The starter converts battery power to electromagnetic torque. The ring gear mechanism drives the starting engine rotation. The starter motor's main components are the DC motor, one-way clutch, reduction gear train, electromagnetic switches, and the starter relay.

See exploded view of starting system as following:

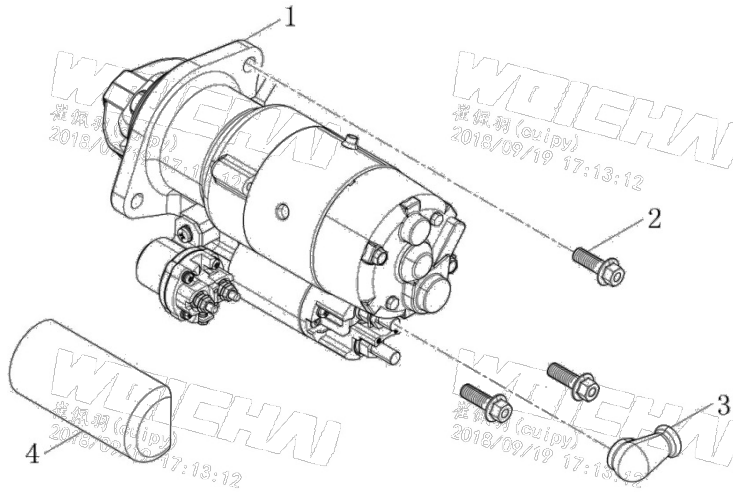


Figure 68

No.	Part Name	No.	Part Name
1	Starter	3	Protective cap
2	Bolt	4	Protective cap

10.1.1. Steps to disassemble starting system

- 1) Fully disconnect all harness connections from the starter.
- 2) Remove the three hex bolts between the starter and the flywheel housing.
- 3) Hold the starter motor firmly and pull it out from the flywheel housing.

10.1.2. Steps to assemble starting system

Reverse disassembly procedure to assemble starting system.

10.1.3. Inspection and maintenance

- 1) Check the starter motor gear for damage, replace it if necessary.
- 2) Check the starter wiring to ensure that it is correct, tight, and secure.

11 Alternator

11.1 Alternator assembly and disassembly

11.1.1. Exploded view of alternator

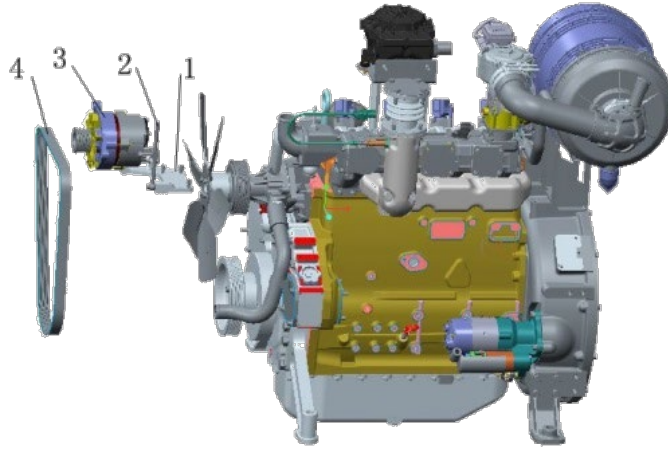


Figure 69

No.	Part Name	No.	Part Name
1	Bracket	3	Alternator
2	Bolt	4	Belt

11.2 Exploded view of alternator

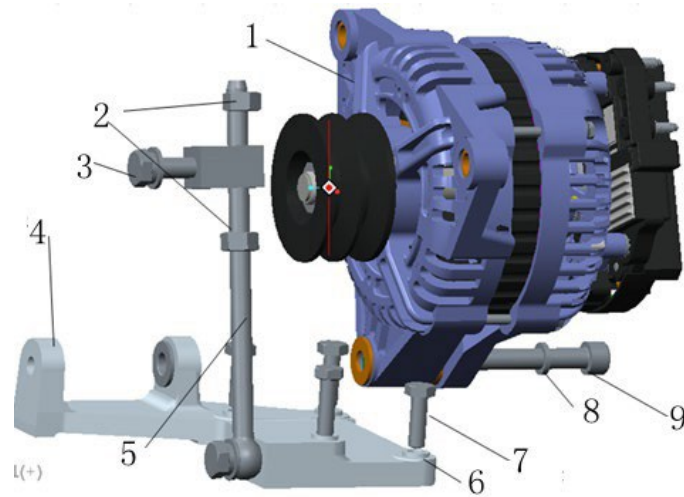


Figure 70

No.	Part Name	No.	Part Name	No.	Part Name
1	Alternator	4	Bracket	7	Bolt
2	Locknut	5	Bolt	8	Washer
3	Bolt	6	Washer	9	Bolt

11.1.2. Steps to disassemble alternator

- 1) Remove the alternator lock nut to loosen the belt, then remove the belt from the alternator pulley.
- 2) Remove the ground cable and the battery cable from the alternator.
- 3) Remove all bolts bolting the alternator to the bracket. Remove the alternator from its bracket.
- 4) Remove the bolts bolting the alternator bracket to the engine block. Remove the alternator bracket from the engine block.

11.1.3. Steps to assemble alternator

Reverse disassembly procedure to assemble alternator.

APPENDIX A

Appendix A: Torsional Torque and Tightening Method for Main Bolts and Nuts

Bolts	Bolts Specification	Tightening torque(N·m)	Inspect value (N·m)
Intake manifold bolt	M10	45~50	40~60
Exhaust manifold bolt	M10	45~50	45~60
Flywheel bolt	M16-10.9	285~295	285~340
Fastening bolt of crankshaft pulley	M16-12.9	300~310	300~360
Damper fastening bolt	M10-10.9	65~70	65~80
Camshaft gear bolt	M10×1.25-12.9	85~90	85~110
Bolt of Intermediate Gear Shaft	M10	65~70	65~80
Fastening Nut of Signal Generator Driving Gear	M10-10.9	65~70	65~80
Nuts of Signal Generator Shaft	M14×1.5	85~100	85~110
Hexagon bolts and stud of flywheel	M12-12.9	140~145	140~170
	M10-12.9	80~85	80~95
Bolts of Oil Pan	M8-8.8	20~25	20~35
Socket head screws of oil pan	M8-10.9	30~35	30~45
Bolts of Oil Pump	M8-12.9	30~40	30~50
Stud with self-locking nuts	M8-8.8	20~25	20~35
Bolt of Rocker-Arm Seat	M10-8.8	40~45	40~55
Rocker adjusting nut	M9×1	20~25	20~35
Spark Plug	M14	25 N·m	
Oxygen sensor	M18×1.5	40 N·m±5 N·m	
Fastening bolt of cylinder head cover	M8-8.8	10~15	10~25
Fastening bolt of pulley on hub	M10-10.9	65~70	65~80

APPENDIX B

Appendix B: Tolerance Clearance for Main Parts of Gas Engine (Reference value)

#	Items		Theoretical value (mm)	
1	Main bearing clearance		0.05~0.11	
2	Connecting rod bearing clearance		0.045~0.09	
3	Crankshaft axial clearance		0.04~0.25	
4	Connecting rod planar axial clearance		0.30~0.50	
5	Clearance between the connecting rod small end bushing and piston pin		0.03~0.08	
6	Clearance between piston pin hole and piston pin		0.003~0.015	
7	Clearance between valve stem and valve guide pipe		0.03~0.06	
8	Piston ring's gap in cold state	The first (top) ring	0.35~0.55	
		The second ring	0.75~1.05	
		Oil ring	0.3~0.6	
9	Piston ring end face gap in cold state	The first (top) ring	—————	
		The second ring	0.06~0.095	
		Oil ring	0.05~0.085	
10	Plane values of valve bottom recess cylinder head		1.0~1.45	
11	Plane values of cylinder liner top above the engine body		0.05~0.10	
12	Camshaft axial clearance		0.10~0.29	
13	Camshaft bearing clearance		0.04~0.08	
14	Clearance between valve tappet and tappet hole		0.006~0.035	
15	Plane clearance between the piston top and the cylinder head bottom		0.88~1.11	
16	Plane values of piston top above the engine block		0.25~0.57	
17	Valve clearance (cold state)	Intake	0.18~0.25 (final assembly)	0.2~0.3 (after trial run)
		Exhaust	0.38~0.45 (final assembly)	0.4~0.5 (after trial run)
18	Clearance between rocker arm and rocker arm shaft		0.016~0.052	
19	Gear backlash between timing gear and the intermediate gear		0.07~0.24	
20	Spark plug electrode clearance for 1000450457 and 612600192176		0.35±0.05	
	Spark plug electrode clearance for 1002141825		0.45±0.5	

APPENDIX C

Appendix C: The Evaluation Criteria for Main Friction Wear of Gas Engine (Reference value)

	Wear limit (mm)	Clearance limit (mm)	Parts life (hours)
Closed clearance of the first (top) ring	1.70	-	
The height of first ring	0.10	-	
Closed clearance of the second ring	1.50	-	
The height of second ring	0.10	-	
Closed clearance of oil ring	1.50	-	
The height of oil ring	0.15	-	
The outer diameter of the piston skirt	0.25	0.60	
The inner diameter of the cylinder liner	0.50		
The outer diameter of the piston pin	0.04	0.10	
The inner diameter of the piston pin hole	0.08		
The inner diameter of connect rod small end bushing	0.08		
The inner diameter of camshaft main journal	0.06	0.10	
The inner diameter of camshaft bushing	0.06		
The height of cam peach tip	2.00	-	
The outer diameter of the cam base circle	0.05	-	
The outside diameter of crankshaft journal	0.12	0.15	
The diameter of connecting rod bearing bore	0.10		
The outer diameter of the crankshaft main journal	0.08	0.15	
The inner diameter of main bearing bore	0.10		
Thickness of thrust bearing	0.40	-	
The subsidence value of intake valve	0.04*d(1)		
Intake valve seals	0.75		
Intake valve seat	0.75		
The subsidence value of exhaust valve	0.04*d(1)		
Exhaust valve seals	0.85		
Exhaust valve seat	0.85		
The inner diameter of the intake valve guide	0.06	0.1	
The outer diameter of the intake valve stem	0.06		
The inner diameter of the exhaust valve guide	0.06	0.1	
The outer diameter of the exhaust valve stem	0.06		
The inner diameter of rocker arm shaft bushing	0.10	0.12	
The outer diameter of rocker arm shaft	0.05		
(1) d is the diameter of intake or exhaust valve plate			



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