POWER SOLUTIONS INTERNATIONAL

40L SERVICE MANUAL

Large Spark Ignited Engine

PSI ENERGY

7610020-10

A Product by Power Solutions International
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	04/03/2020	Initial Release
2	06/30/2020	Updated torque sequence for the cylinder head bolts
3	09/24/2020	Updated torque sequence for the cylinder head bolts and updated oil pump images.
4	02/05/2021	Updated torque specifications chart to include new supply line to water pump banjo bolts.
5	04/20/2020	Updated oil filter installation procedure.
6	01/31/2023	Added speed sensor installation
7	02/07/2024	Added ignition coil bolt torque specs and requirement for dielectric grease when re-installing ignition coils
8	6/04/2024	Added Oil Cooler Removal and Installation procedures. Updated Valve Lash specification
9	10/08/2024	Updated flywheel torque specifications. Corrected Speed Sensor installation, added removal and installation of Crankshaft Position Sensor
10	08/22/2025	Added note stating cylinder head bolts may be used a maximum of three times before needing to be replaced in Cylinder Head Removal/Installation and torques pec chart

WARNING SUMMARY

- Failure to comply with the below warnings may result in serious injury to personnel.
- Avoid prolonged exposure to used oil.
- Wear protective clothing and waterproof gloves.
- Do not put oily rags in your pocket.
- Do not wear oil-saturated clothing.
- Wash work clothes frequently. Discard clothes and shoes that are soaked with oil and cannot be cleaned.
- In the event of personal injury, take first aid measures immediately.
- Always apply protective cream before work, which can help remove the oil when the skin is contaminated with mineral oil.
- Upon detection of skin irritation, seek medical treatment immediately.
- Do not use faulty or unsuitable tools.
- Stop the engine during maintenance or repair work.
- Do not touch hot parts of an engine that is running or that has just been stopped.
- Do not touch the engine when it is running.
- Let the engine cool down before carrying out any maintenance operation.
- Release the pressure in the fuel and cooling systems before disconnecting or removing hoses or associated parts.
- At operating temperature, the coolant is hot and pressurized. When the pressure is released the burning-hot liquid may be transformed into fumes.
- Any contact with this burning-hot liquid or fumes may cause serious burns.
- Let the components in the coolant system cool down before draining the system.
- Only check the coolant level when the engine has been stopped.
- Slowly unscrew the filler plug to release the pressure.
- Hot oil can cause injury. Avoid contact with the skin.
- Sulfuric acid contained in batteries is toxic and corrosive. It can burn clothing and skin, or even cause blindness in case of contact with the eyes.
- When starting the engine, use ear protection.

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GENERAL PRECAUTIONS FOR OPERATIONS

INTRODUCTION

Most accidents related to the use, maintenance and repair of the engine are due to failure to comply with the safety regulations and basic precautions. They could therefore be avoided by acknowledging the risks that you face and by taking the corresponding preventive measures. To operate, maintain and repair this PSI equipment, you need to have the appropriate training, skills, and tooling.

Failure to comply with the instructions set out in this manual may result in serious or even fatal accidents. PSI cannot foresee every possible risk. As such, the rules and instructions set out in this Manual are not exhaustive.

BEFORE ANY OPERATION INVOLVING A PSI PRODUCT

- Before carrying out any maintenance or repair work, fix a "Do not use" sign or a similar sign to the starter switches.
- Turn off the circuit breaker located on the engine connection box if applicable.
- Turn the engine room cabinet starter switch to OFF (optional feature).
- For engines fitted with a pneumatic starter system, isolate the tanks, and drain the pipes between the tanks and the starter.
- For engines fitted with an automatic starter control device, lock the starting order on the control box.
- Before using the barring tool, always take the necessary safety precautions.
- Do not allow any unauthorized person near the engine.
- Make sure that the repair premises and surrounding area are suitable to carry out the work safely.
- Always make sure that the repair workshop or the area around the engine is clean and tidy.
- Remove any rings, chains, and watches before starting work. Wear suitable and close-fitting work wear.
- Lock the emergency buttons.
- Check that the expiry date of the protection equipment (glasses, gloves, shoes, masks, overalls, helmet, etc.) is not exceeded before starting work.
- Do not use faulty or unsuitable tools.
- Stop the engine during maintenance or repair work.

START-UP

- Never use any product to facilitate start-up (risk of explosion).
- Never start an engine, engage a gear reducer, or touch a propeller pitch control without having checked beforehand that this operation can be carried out in complete safety for the people or the equipment.

- When starting the engine, use ear protection to prevent hearing loss.
- Only start or stop the engine using the switches designed for this in the engine room control box, the bridge console, control boxes, etc.

SEALS

- If the temperature exceeds 300°C (572°F), the engine seals may produce corrosive hydrofluoric acid. Always use protective gear when touching seals subject to high temperatures.
- Always use rubber thick gloves and safety glasses during decontamination operations.
- Clean the seals and the contaminated surfaces using a 10% calcium dioxide solution or another cleaning product.
- Keep any parts which have been removed in a sealed plastic bag and store them in a dedicated area.

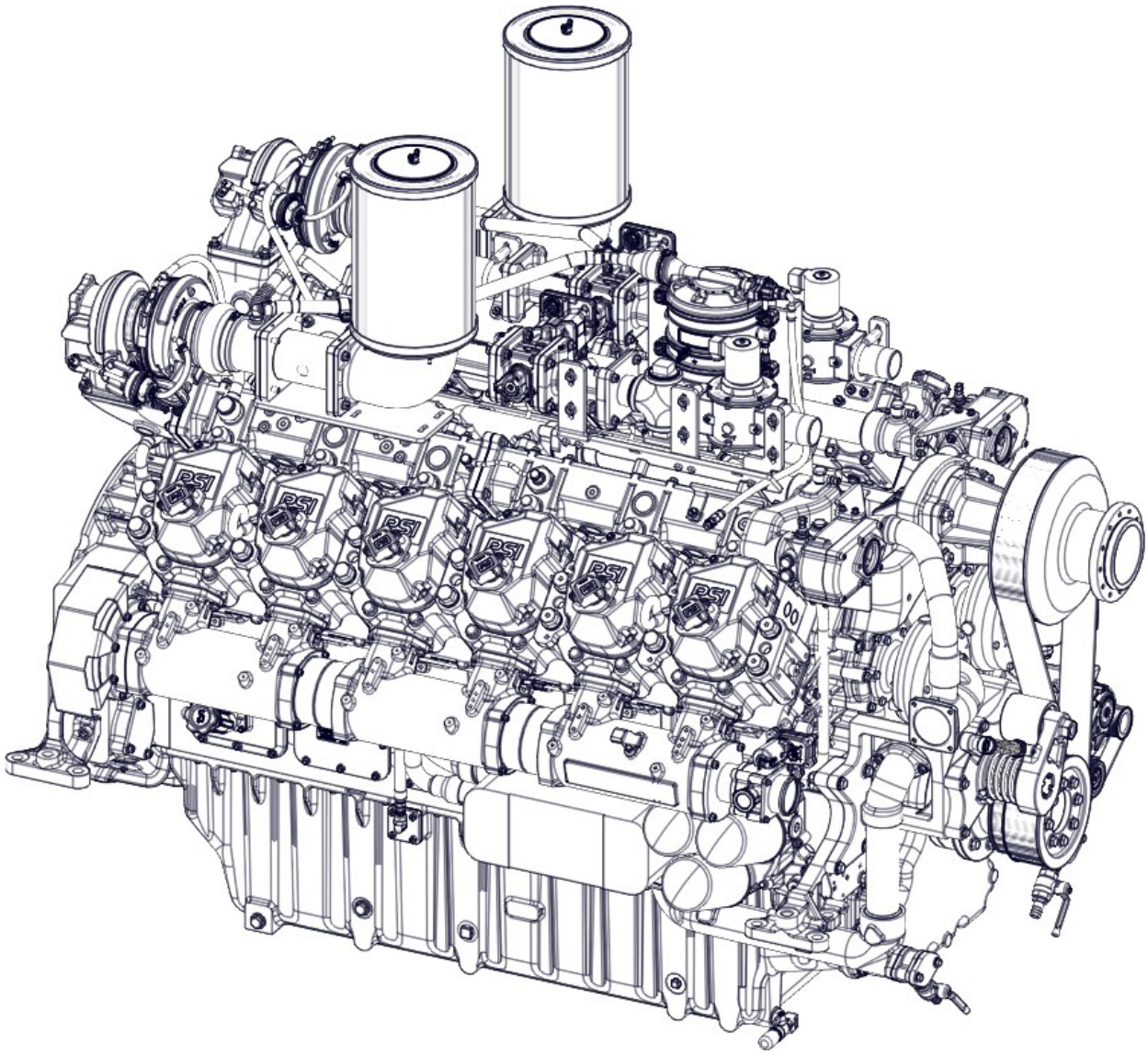
STARTER BATTERY

- Disconnect the batteries before any operation involving the electrical circuit.
- As the battery gas is explosive, keep it away from naked flames and any source of sparks.
- Do not smoke near the fuel system and batteries.
- Never check battery charge by short circuiting it.
- Do not charge a frozen battery. Heat it up to 16°C (60°F) beforehand.
- Sulphuric acid contained in batteries is toxic and corrosive; it can burn clothing and skin, or even cause blindness in case of contact with the eyes.
- To prevent accidents:
  - Fill the batteries in well-ventilated premises.
  - Wear suitable gloves and glasses.
  - Do not inhale the fumes.
- In the event of contact with a part of the body:
  - Rinse the affected part with plenty of water.
  - Apply bicarbonate of soda or lime to neutralize the acid.
  - Rinse the eyes for 10 to 15 minutes.
  - See a doctor as soon as possible.
- In the event of ingestion:
  - See a doctor as soon as possible.
- Do not smoke in areas where batteries are charged.
- The batteries give off flammable fumes which can explode.
- If the batteries are in a closed area, make sure there is sufficient ventilation.
- Make sure the batteries are clean and that covers are fitted.
- The battery cables must be fitted with a circuit breaker to isolate the circuit if there is a problem. Electric wiring must be kept in good condition, properly positioned, and soundly attached

WELDING

- Unplug all engine wiring harnesses before doing welding operations (ECU, engine cabinets, control boxes, ETC..).
- Do not use open fires.
- For all electrical or autogenous welding, use a welding permit to make the area safe.
- Make sure that the work will not affect the onboard electrical and electronic equipment.
- Make sure that the automatic fire extinguishing system is disabled before any welding or grinding work.
- Make sure that the premises where the welding will be done are suitably ventilated.
- Do not weld and do not use a torch on pipes or hoses containing flammable liquids.

THEORY OF OPERATION AND ENGINE COMPONENTS



CYLINDER BLOCK

The cast iron cylinder block is configured in a “V” shape with two banks of six integral cylinder bores at an included angle of 90 degrees. Coolant jackets surround each cylinder bore. Seven cast iron main bearing caps are each fastened by four bolts, with the crankshaft thrust taken up by the rear main bearing cap. Oil cooling for each cylinder is furnished by a dedicated oil jet, which is part of the pressurized lubrication system passages machined into the block.

CRANKSHAFT

The 40L engine uses a hardened steel forged crankshaft with seven hardened main bearing journals and six connecting rod journals oriented with 90-degree phasing. Four counterweights to provide internal balance of the rotating assembly.

PISTON AND CONNECTING ROD

All twelve pistons utilize three piston rings. One keystone ring, twist tapered ring and a coil spring loaded ring. All of which are attached to a two-piece forged steel connecting rod and a floating piston pin, retained in location by a circlip at each end of the piston pin. The forged steel connecting rod cap is retained to the connecting rod via two cap screws.

CYLINDER HEADS

All twelve cast iron cylinder heads equipped with four valves are located on the upper part of the cylinder block and forms the top of the combustion chamber. The parts connected to the cylinder head include the intake manifold, exhaust manifold, spark plug, cylinder head cover, cylinder head gasket, valves, and rocker assemblies.

CAMSHAFT

The camshaft utilizes seven cam journals and twenty-four cam lobes which is assembled into the cylinder block above the crankshaft. With the rotation of the camshaft the flat tappets follow the lobes machined integral to the camshaft, opening, and closing the respective valve line (push rod, rocker arm, valve, and valve spring) in proper sequence.

EXHAUST MANIFOLD

A cast material exhaust manifold is attached to each cylinder head; each exhaust manifold port collects exhaust gases from the cylinders, which is attached to two separate sections of the exhaust pipe system, which are water cooled.

INTAKE MANIFOLD

The intake manifold starts by passing through the charge air cooler and then running through the throttle body and then into the cast material intake manifold.

ENGINE CONTROL MODULE (ECM)

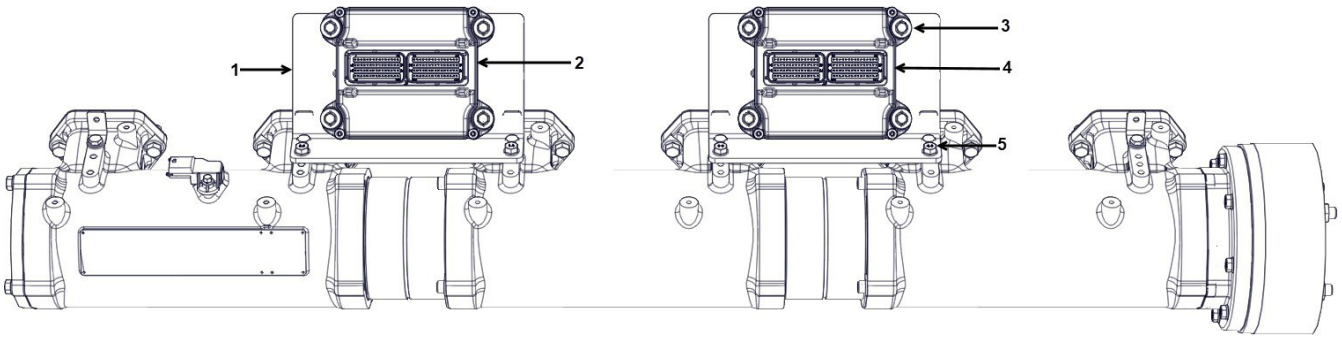


Figure 1. ECM Assembly

No.	Name
1	ECM Mounting Bracket
2	ECM
3	ECM Bolt
4	ECM
5	ECM Mounting Bracket Bolt

The 40L engine comes equipped with two Engine Control Modules (ECM), one for the slave side (right side) and one for the master side (left side) of the engine. The ECM monitors various engine sensors via 0–5-volt signals, this allows for optimal engine performance.

REMOVAL

1. Remove the four bolts from each ECM.
2. Remove the ECM.
3. Remove the two bolts from the ECM mounting bracket.
4. Remove the ECM mounting bracket.

INSTALLATION

1. Place the ECM mounting bracket over the intake manifold.
2. Insert and torque down the two mounting bracket bolts to 22 ft/lbs.
3. Place the ECM on the ECM mounting bracket.
4. Insert and torque the four ECM bolts to the ECM mounting bracket to 10 ft/lbs.

HOISTING OF ENGINE

The engine crankshaft centerline should remain horizontal when hoisting and no vertical or incline hoisting is allowed. The engine should always be raised and lowered slowly. Lifting rings resistance is reduced when the angle between the slings or the chains and the engine fall below 90°.

Use a lifting device as illustrated below. Avoid any contact between the slings and the engine parts. Use the fastening links and slings or properly calibrated chains.

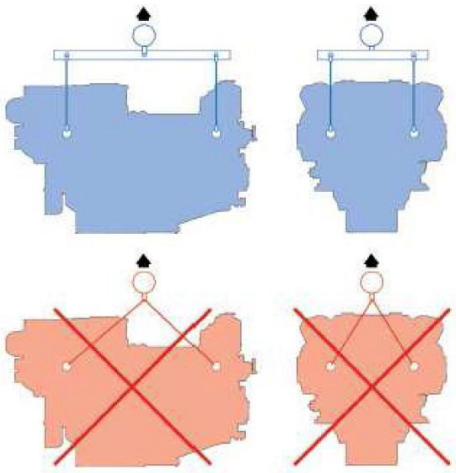


Figure 2. Hoisting Engine

NOTE:

- All fasteners and bolts should be tightened to a given torque. If a special torque is not provided, see the *TIGHTENING TORQUES FOR STANDARD BOLTS AND NUTS* CHART.

LIFTING EYES

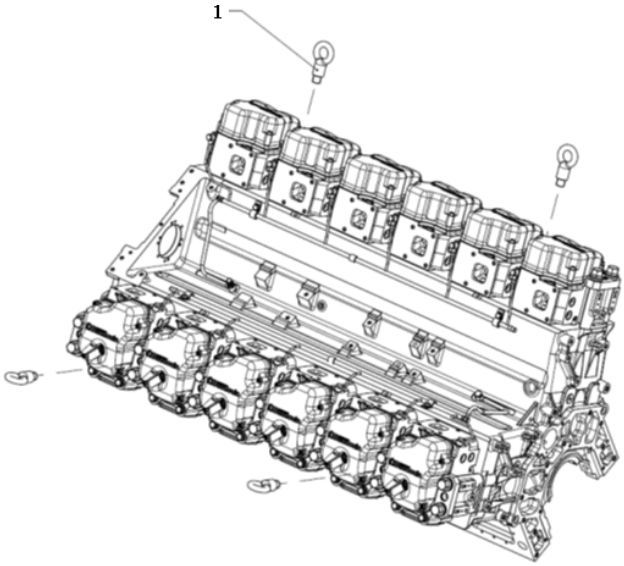


Figure 3. Lifting Eyes Assembly

NO.	Name
1	Lifting Eye

REMOVAL

1. Loosen and remove all four fitting eyes.

WARNING:

- Check front and rear lifting eyes for cracks or any damage, replace if any cranks or other damage are found.

INSTALLATION

2. Insert and torque all four lifting eyes to 538 ft/lbs.

ENGINE BRACKETS

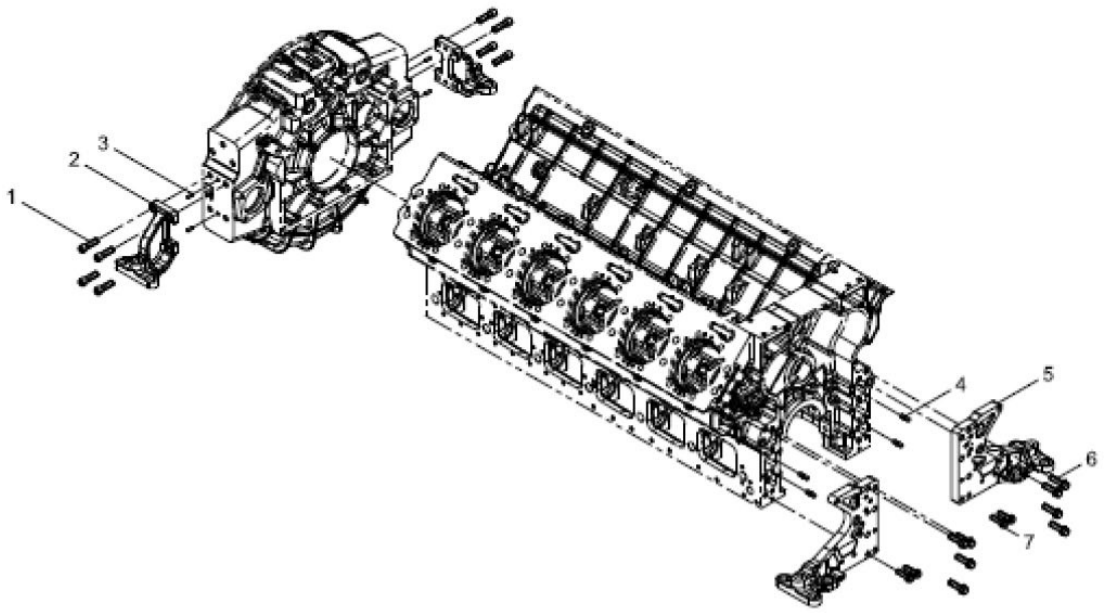


Figure 4. Engine Bracket Assembly

NO.	Name
1	Bolt
2	Rear Engine Bracket
3	Dowel Pin
4	Dowel Pin
5	Front Engine Bracket
6	Bolt
7	Bolt

REMOVAL

1. Loosen and remove bolts (Figure 4, items 1 & 6).
2. Remove engine mounts (Figure 4, items 2 & 5).

INSTALLATION

1. Place engines mount on cylinder block and flywheel housing (Figure 4, items 2 & 5).
2. Insert and tighten bolts (Figure 4, items 1 & 6).

CYLINDER BLOCK CLEANING AND INSPECTION

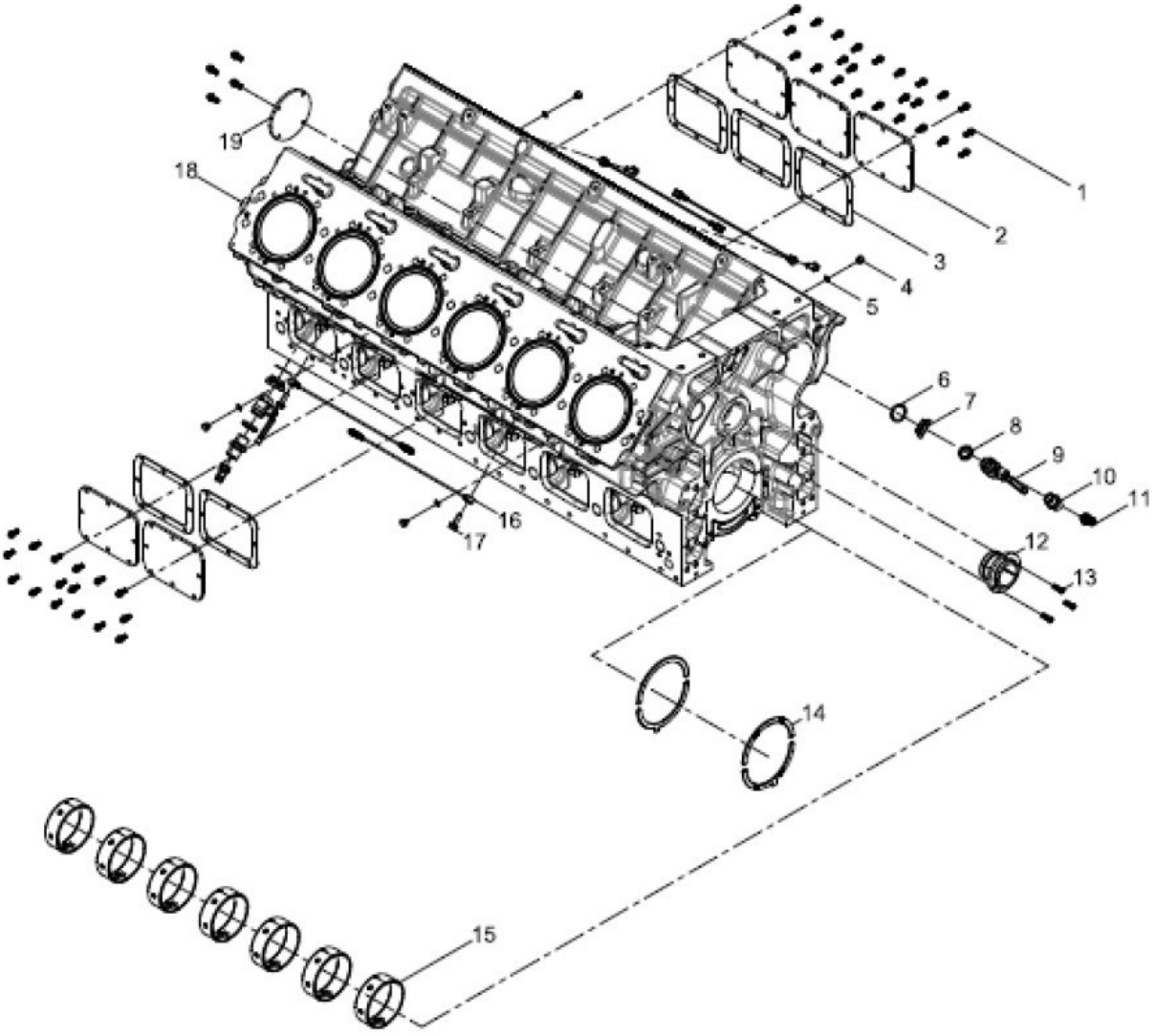


Figure 5. Cylinder Block Assembly

NO.	Name	NO.	Name	NO.	Name	NO.	Name
1	Bolt	6	Washer	11	Connector	16	Knock Sensor
2	Cover	7	Connector	12	Camshaft Bushing	17	Bolt
3	Gasket	8	Nut	13	Bolt	18	Engine Block
4	Plug	9	Shut Off Valve	14	Thrust Bearing	19	Cover Plate
5	Washer	10	Connector	15	Main Bearing		

WARNING:

- Always wear protective clothing and proper eye protection when cleaning components.

1. Boil cylinder block in caustic solution.
2. Flush cylinder block with water or steam.
3. Clean the following areas:
   a. All gasket surfaces.
   b. Cylinder bores, remove excessive cylinder ridge as required.
   c. Main bearing caps.
   d. Oil galleries, remove all sludge and restrictions.
   e. Scale deposits from coolant passages
   f. All dirt and debris from threaded holes

WARNING:

- Wear approved safety glasses or face shield when cleaning components. Failure to comply may result in personal injury.
- Wear rubber gloves and protective clothing when cleaning components. Failure to comply may result in personal injury.

4. Dry cylinder block with compressed air.
5. Lubricate cylinder bores with PSI approved motor oil to prevent rust.
6. Inspect the cylinder block for the following conditions:
   g. Gasket surfaces for deep gouges or other damage.
   h. All machined surfaces for burrs, oil stains and scratches.
   i. Oil and water passages for burr, metal chips or any restrictions.
   j. Tappet holes should be free for any and all restrictions.
   k. Outer cracks or dents of cylinder block.

ENGINE LUBRICATION

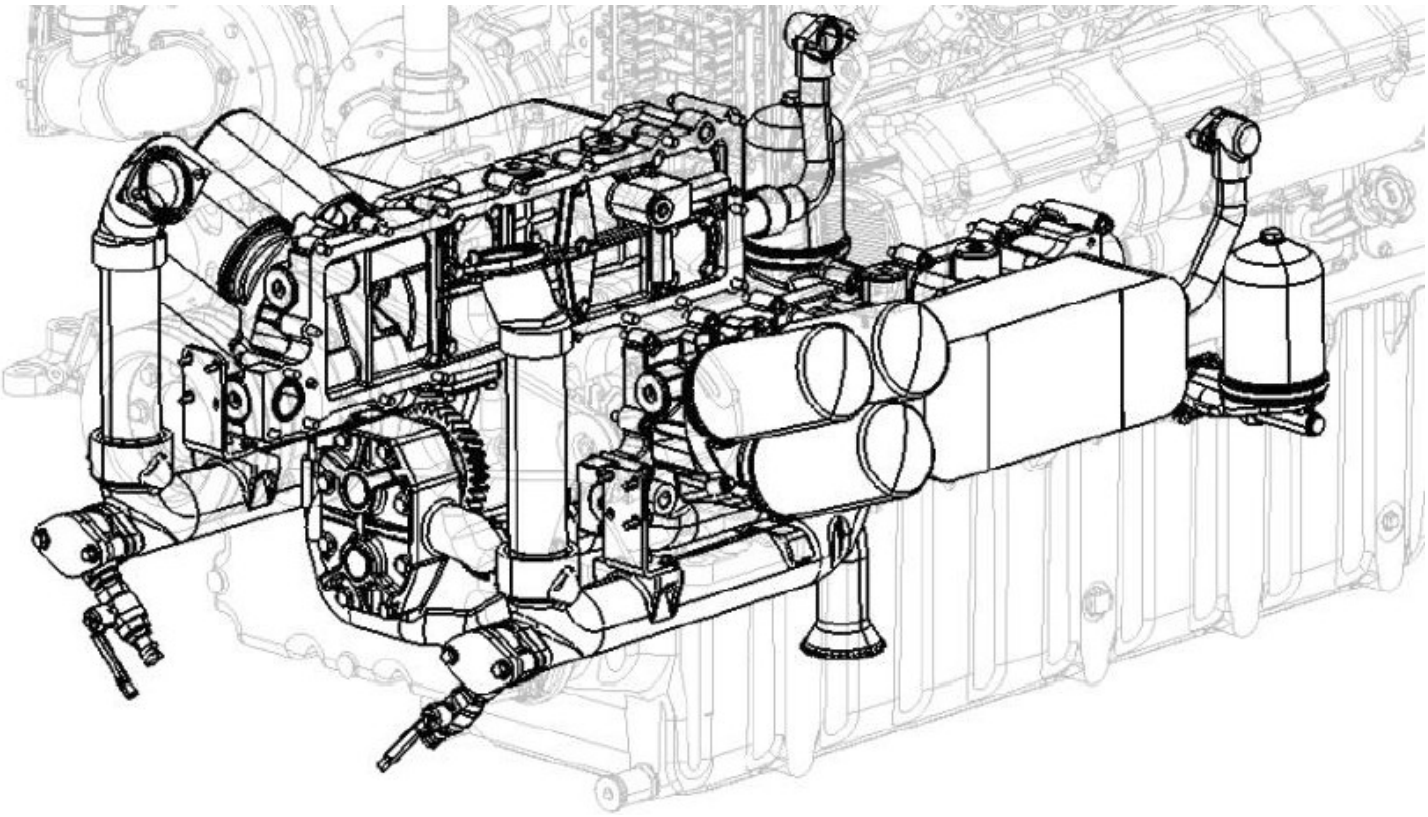


Figure 6. Lubrication System

An oil pump is driven by the front crankshaft gear train connected to the oil pump assembly. A series of control valves are located inside the oil pan. All control valves lead to the oil filter support assembly, which holds all oil filters. The oil pump is connected to both oil cooler sumps, along with the connecting elbows.

Engine Oil Pressure Chart

Model	At Rated Engine RPM	At Low Idle Speed
	1500-1800	
40L	58- 87 PSI (0.4-0.6 MPa)	More than 17 PSI (0.12 MPa)

LUBRICATION SYSTEM DIAGRAM

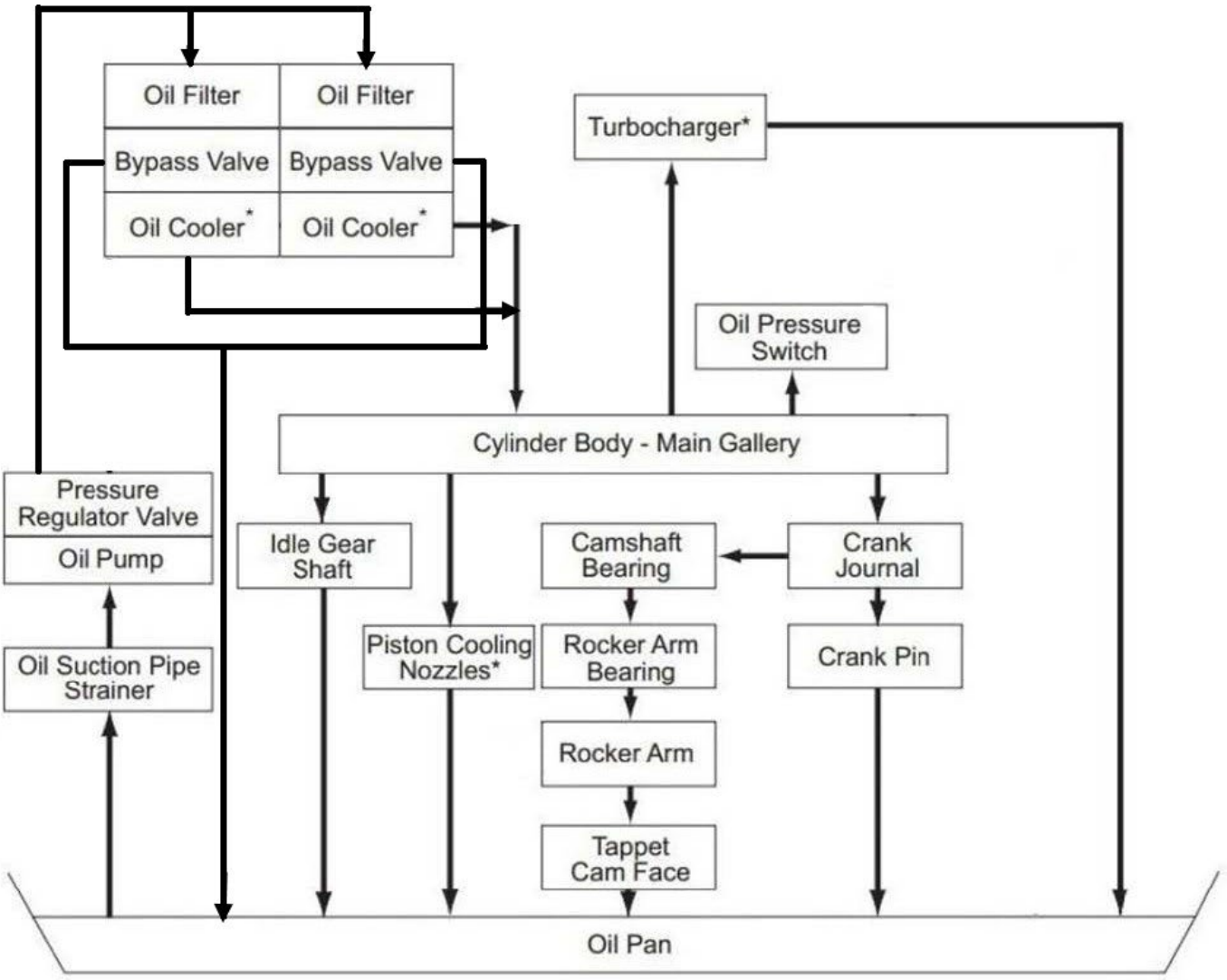


Figure 7. Lubrication System Diagram

ENGINE OIL DIPSTICK TUBE

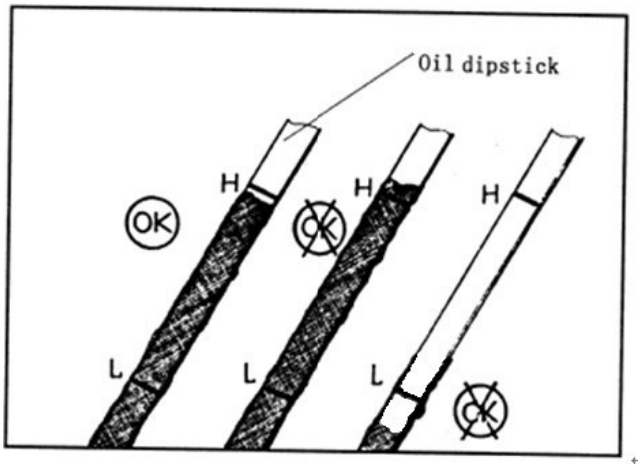


Figure 8. Engine Oil Dipstick

REMOVAL

1. Remove engine oil dipstick from engine oil dipstick tube.
    a. Check oil level. (Refer to Figure 8.)
2. Remove upper oil dipstick tube from oil pan.
3. Remove washer and nut and then remove lower dipstick from oil pan.

INSTALLATION

1. Install washer and nut and tighten down onto oil pan.
2. Install upper oil dipstick tube to oil pan.
3. Install engine oil dipstick tube in engine oil dipstick tube.

OIL FILLING TUBE

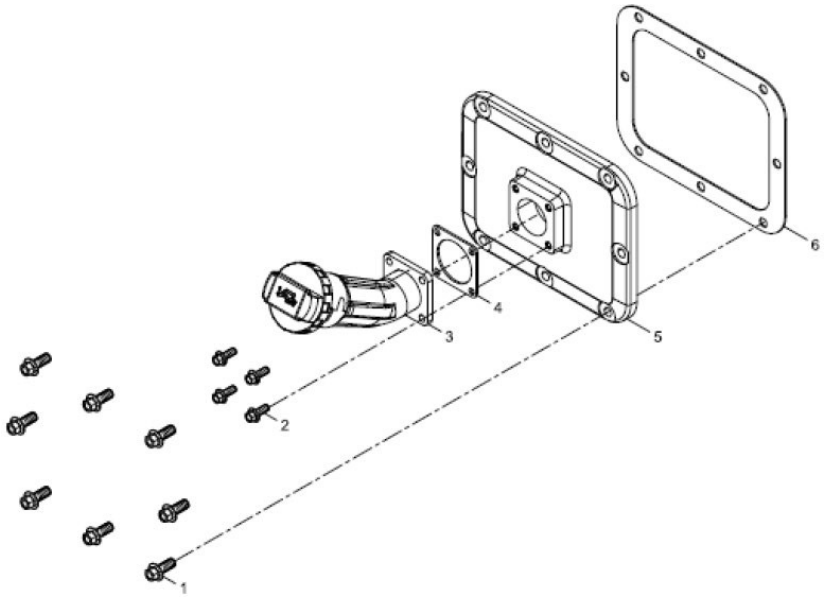


Figure 9. Oil Filling Tube Assembly

NO.	Name
1	Bolt
2	Bolt
3	Oil Filling Tube
4	Filler
5	Cover
6	Gasket

REMOVAL

1. Loosen and remove bolts (Figure 9, items 1 and 2).
2. Remove oil fitting tube (Figure 9, item 3).
3. Remove oil filler tube gasket (Figure 9, item 4).

INSTALLATION

1. Place oil filler tube gasket (Figure 9, item 4) on the cover (Figure 9, item 5)
2. Place oil filling tube (Figure 9, item 3) onto gasket (Figure 9, item 4).
3. Insert and tighten bolts (Figure 9, items 1 and 2).

ENGINE BELT ROUTING

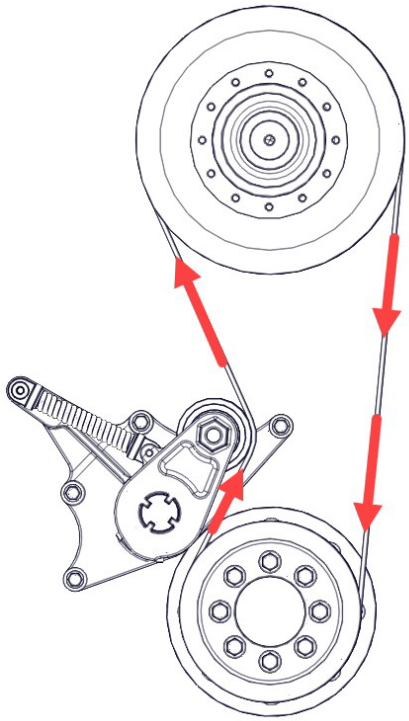


Figure 10. Serpentine Belt Routing

The grooved serpentine belt runs under the crankshaft pulley, to the left of the automatic belt tensioner and over and around the fan pulley.

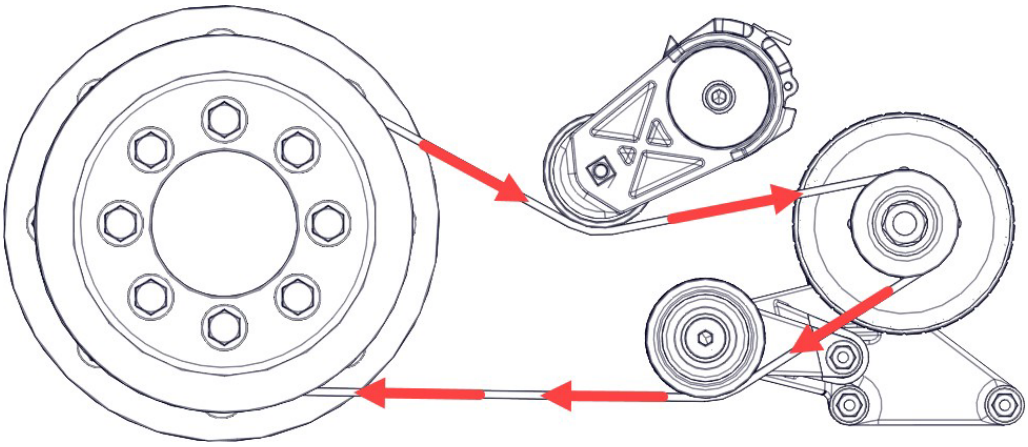


Figure 11. Left-Hand Belt Routing

The left-hand belt runs under and around the crankshaft pulley, under the automatic belt tensioner, over and around the alternator pulley and under the idler pulley.

FRONT ENGINE ACCESSORY DRIVE (FEAD)

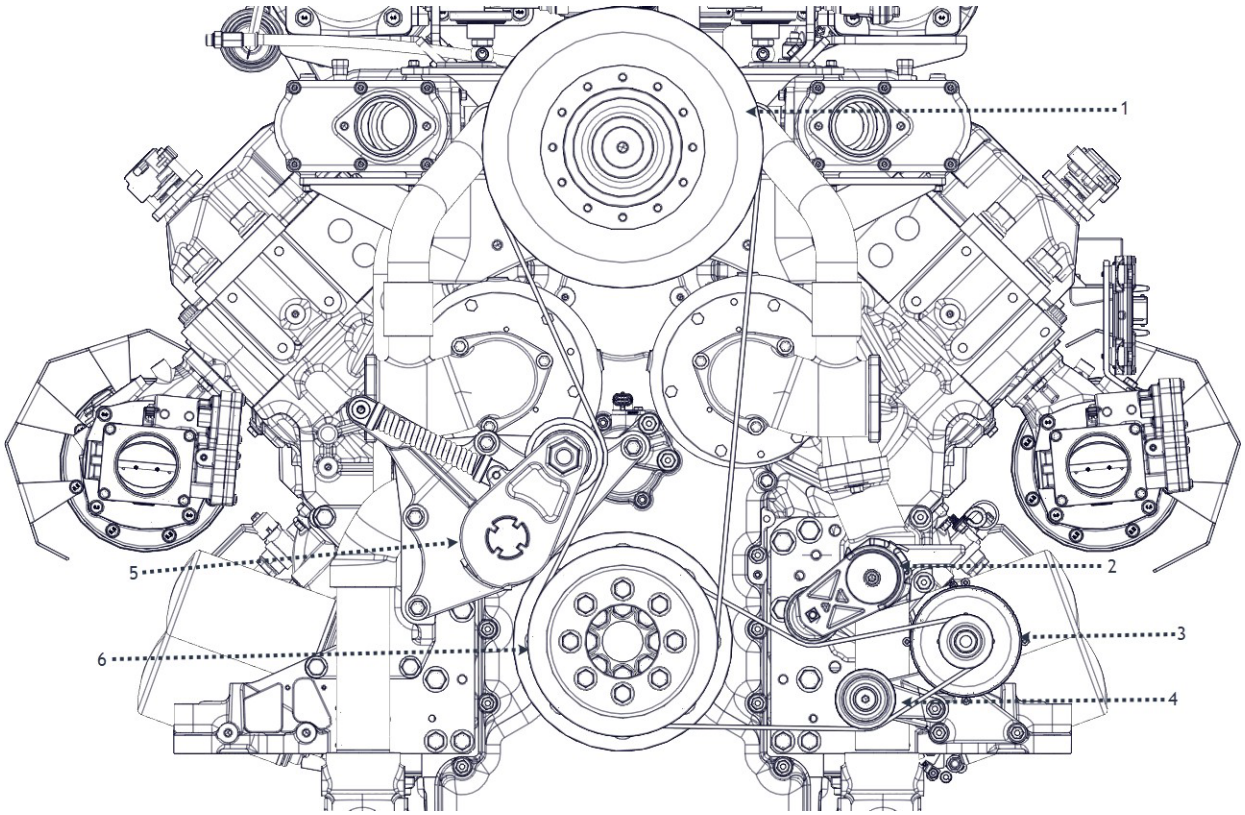


Figure 12. Front Engine Accessory Drive Assembly

NO.	Name
1	Fan Pulley
2	Left-Hand Automatic Belt Tensioner
3	Alternator Pulley
4	Idler Pulley
5	Automatic Fan Belt Tensioner
6	Crankshaft Pulley

ALTERNATOR PULLEY ASSEMBLY

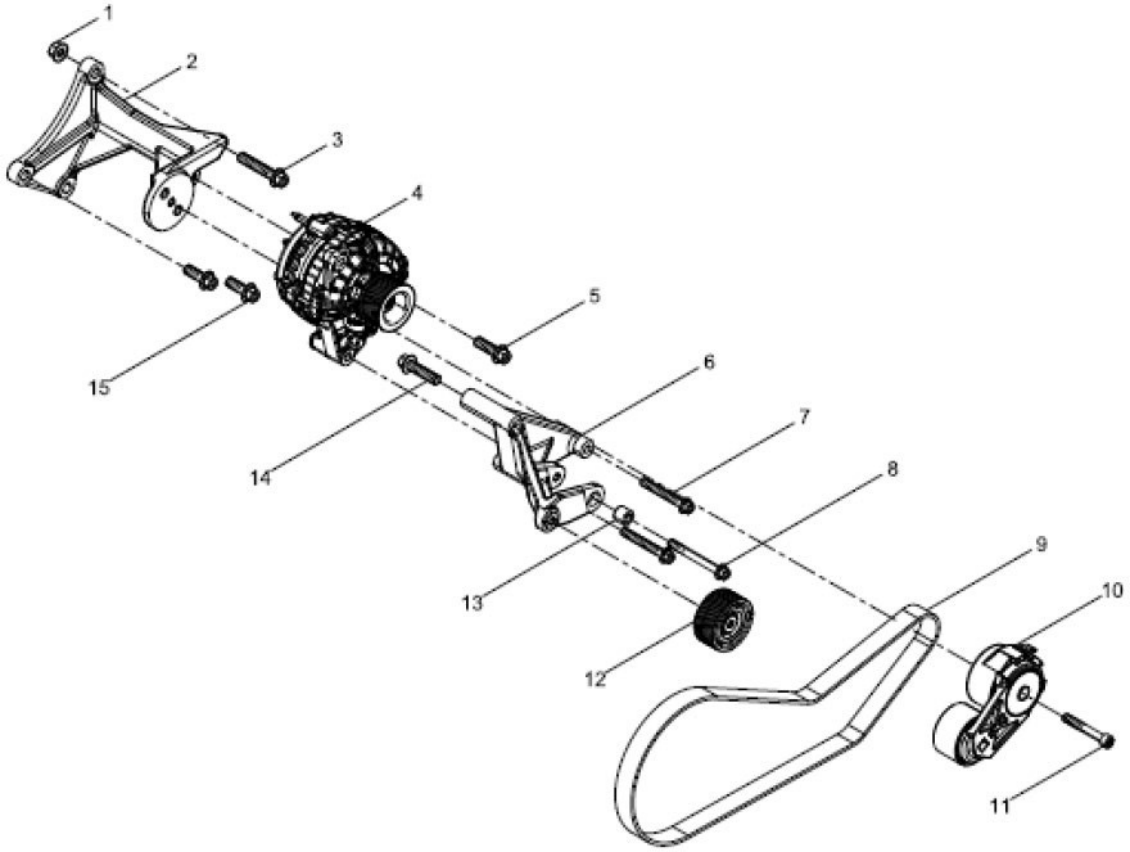


Figure 13. Alternator Pulley Assembly

NO.	Name	NO.	Name
1	Nut	9	Belt
2	Alternator Bracket	10	Tensioner
3	Bolt	11	Bolt
4	Alternator	12	Idler
5	Bolt	13	Sleeve
6	Bracket	14	Bolt
7	Bolt	15	Bolt
8	Bolt		

REMOVAL

1. Disconnect both the battery and electrical wires from the alternator.
2. Loosen the serpentine belt (Figure 13, item 9) by operating the tensioner (Figure 13, item 10).
3. Remove the bolts (Figure 13, items 3 and 5). Remove the alternator (Figure 13, item 4)
4. Loosen and remove the remaining bolts on the alternator bracket (Figure 13, item 2). Remove the idler pulley bracket bolts if necessary (Figure 13, item 6).

INSTALLATION

1. Install the alternator bracket (Figure 13, item 4).
2. Insert and torque down the alternator bracket bolts (Figure 13, items 3 and 5). Insert the idler pulley bracket bolts if necessary (Figure 13, item 6).
3. Insert and torque down the alternator.
4. Insert the serpentine belt.
5. Reconnect both battery and electrical wires from the alternator.

LEFT-HAND AUTOMATIC BELT TENSIONER

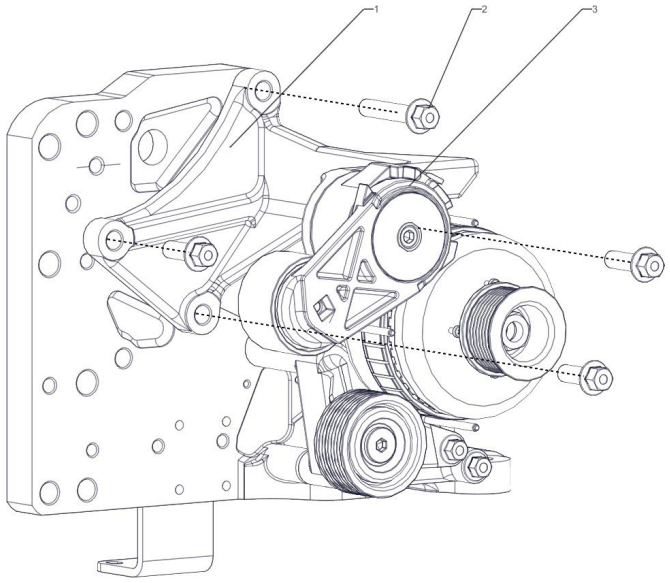


Figure 14. Left-Hand Automatic Belt Tensioner Assembly

NO.	Name
1	Left-Hand Automatic Belt Tensioner Bracket
2	Bolt
3	Left-Hand Automatic Belt Tensioner

REMOVAL

1. Remove bolts (Figure 14, item 2) from the left-hand automatic belt tensioner bracket (Figure 14, item 1).
2. Remove the left-hand automatic belt tensioner (Figure 14, item 3).
3. Remove the Left-hand automatic belt tensioner bracket (Figure 14, item 1).

INSTALLATION

1. Place the left-hand automatic belt tensioner bracket onto the cylinder block.
2. Insert and torque the bolts (Figure 14, item 2) onto the left-hand automatic belt tensioner bracket.
3. Place the left-hand automatic belt tensioner (Figure 14, item 3) onto the bracket (Figure 14, item 1).
4. Insert and torque down the bolt going into the automatic belt tensioner (Figure 14, item 3).

LEFT-HAND IDLER PULLEY ASSEMBLY

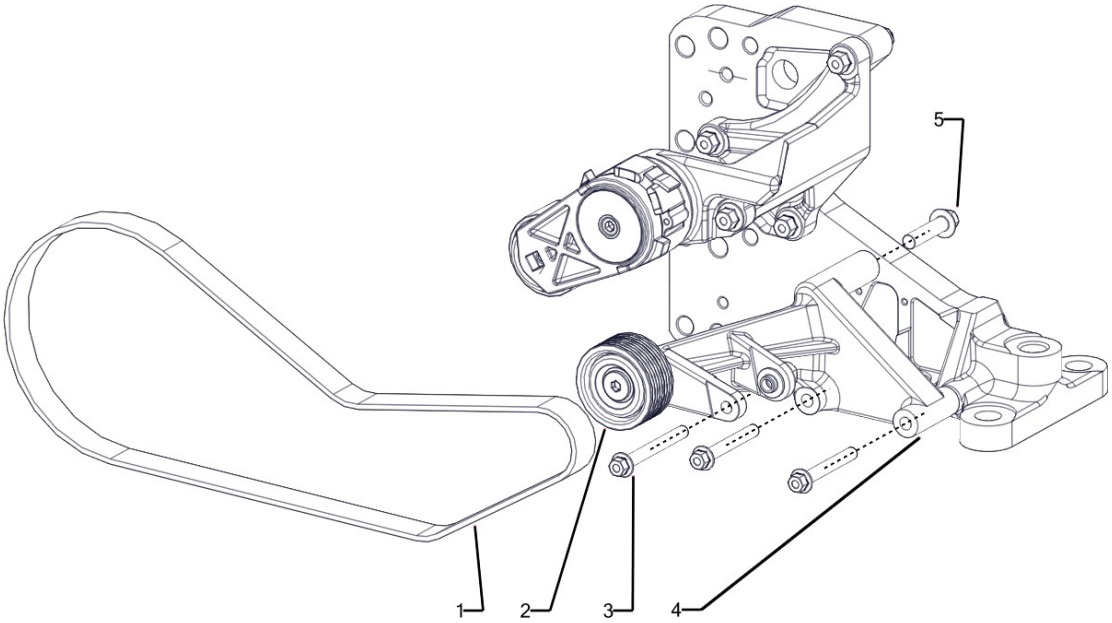


Figure 15. Left-Hand Idler Pulley Assembly

NO.	Name
1	Belt
2	Pulley
3	Bolt
4	Pulley Bracket
5	Rear Bolt

Removal

1. Loosen serpentine belt if not already loose (Figure 15, item 1).
2. Remove bolts (Figure 15, item 3) and rear bolt (Figure 15, item 5).
3. Remove the left-hand Idler pulley bracket (Figure 15, item 4).

Installation

1. Place the left-hand idler pulley bracket (Figure 15, item 4) onto the engine mount bracket.
2. Insert and torque down the bolts (Figure 15, items 3 and 5).
3. Insert the serpentine belt (Figure 15, item 1).

AUTOMATIC FAN BELT TENSIONER ASSEMBLY

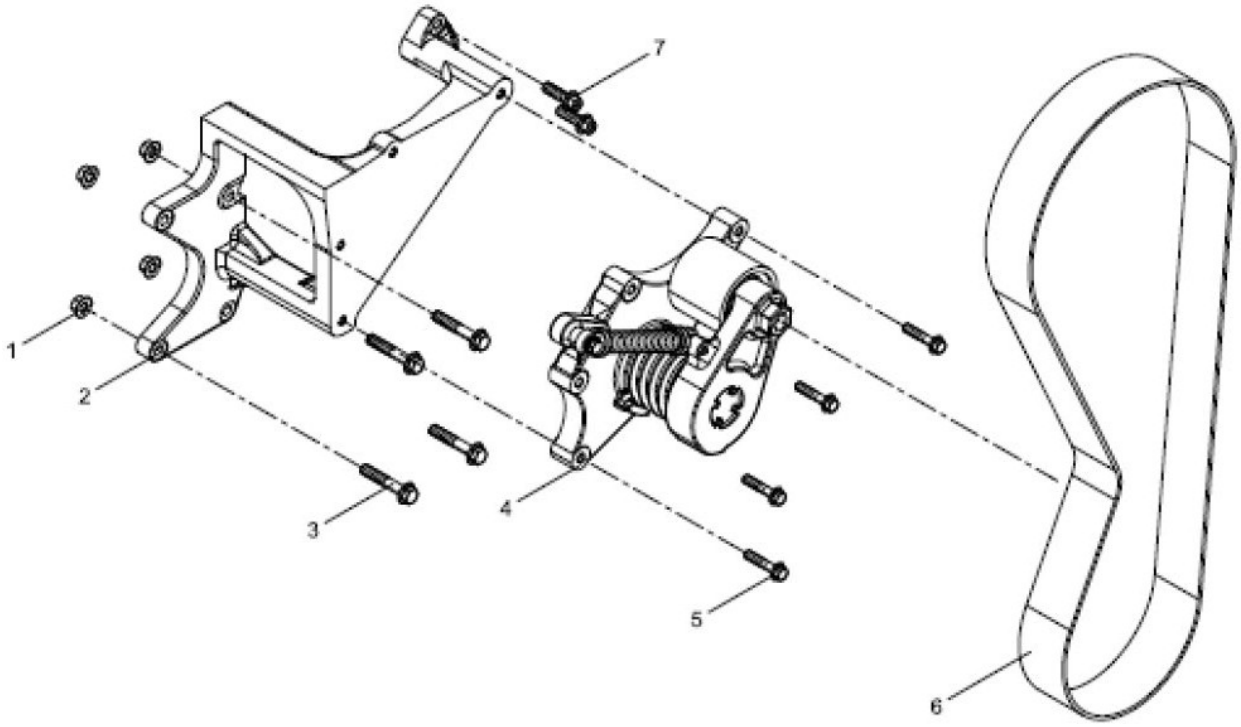


Figure 16. Automatic Fan Belt Tensioner Assembly

NO.	Name
1	Nut
2	Pulley Bracket
3	Bolt
4	Pulley
5	Bolt
6	V-Belt
7	Bolt

REMOVAL

1. Remove belt (Figure 16, item 6).
2. Remove bolts (Figure 16, item 5).
3. Remove the automatic fan belt tensioner pulley (Figure 16, item 4).
4. Remove the bolts (Figure 16, items 7 and 3) and nuts (Figure 16, item 1) from the automatic fan belt.
5. tensioner bracket (Figure 16, item 2).
6. Remove the bracket (Figure 16, item 2).

INSTALLATION

1. Place the automatic fan belt tensioner bracket (Figure 16, item 2) onto the cylinder block.
2. Insert and torque down both bolts and nuts (Figure 16, items 1, 3 and 7).
3. Place the automatic fan belt tensioner pulley (Figure 16, item 4) onto the bracket (Figure 16, item 2).
4. Insert and torque down the bolts (Figure 16, item 5).
5. Insert belt (Figure 16, item 6).

FAN ASSEMBLY

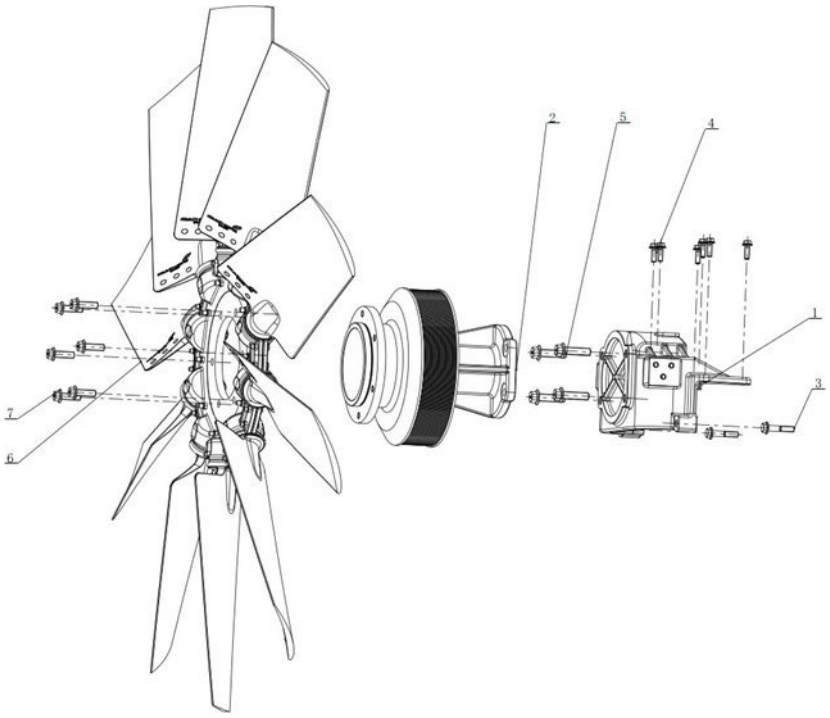


Figure 17. Fan Assembly

NO.	Name
1	Fan Support
2	Fan Support Bracket
3	Bolt
4	Bolt
5	Bolt
6	Fan
7	Fan Bolts

REMOVAL

1. Remove the six fan bolts (Figure 17, item 7).
2. Remove the fan (Figure 17, item 6).
3. Remove the four fan support bracket bolts.
4. Remove the fan support assembly.

INSTALLATION

1. Clean all debris from the following components:
   a. Fan support
   b. Fan support assembly
   c. Fan
2. Place the fan support bracket above the front cover.
3. Insert and torque down the four fan support bracket bolts.
4. Place the fan onto the fan support bracket.
5. Apply blue Loctite to all six fan bolts.
6. Insert and torque down the six fan bolts to 140 ft/lbs.

FRONT COVER

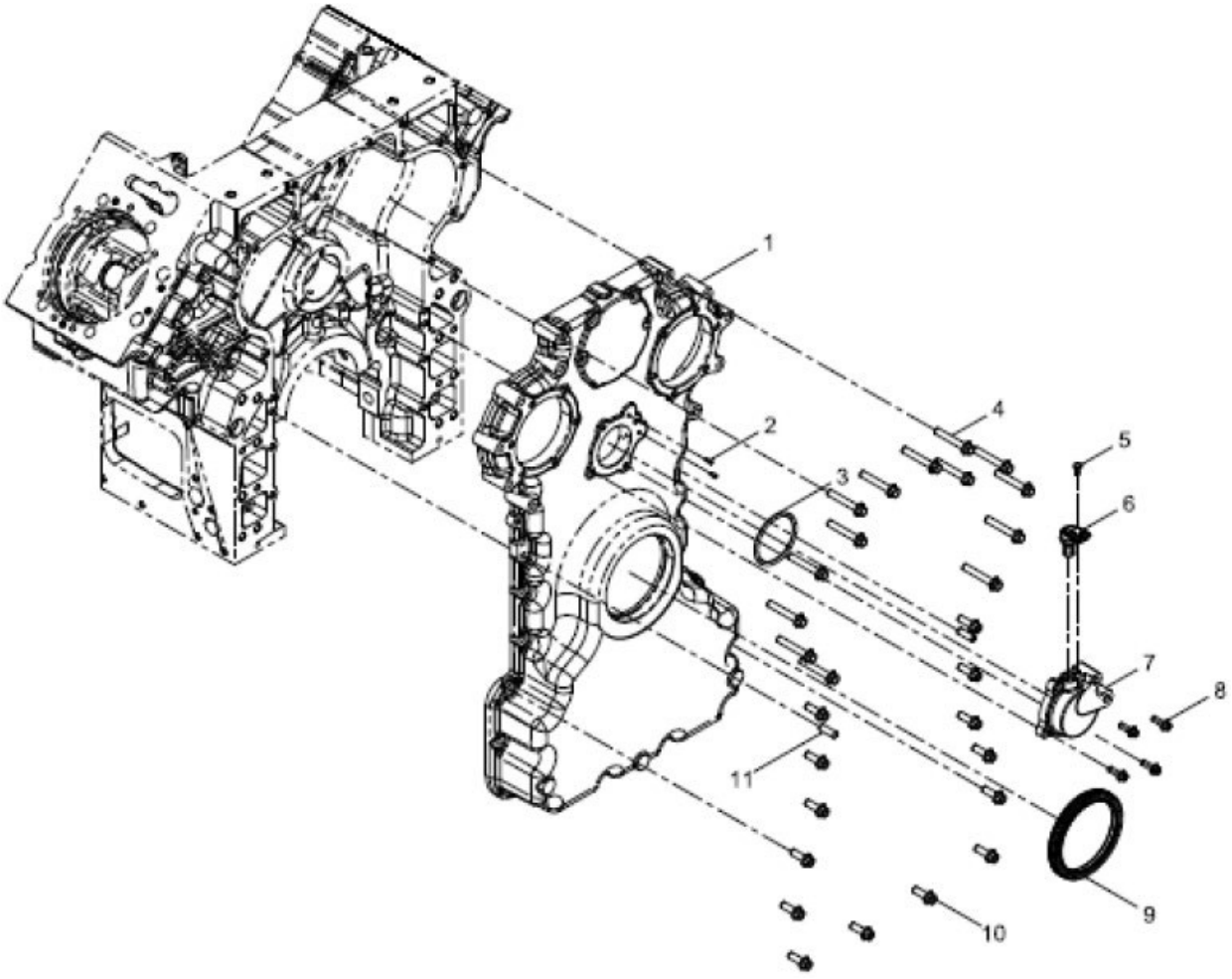


Figure 18. Front Cover Assembly

NO.	Name	NO.	Name
1	Front Cover	7	Sensor Seat
2	Dowel Pin	8	Bolt
3	O-Ring	9	Front Oil Seal
4	Bolt	10	Bolt
5	Bolt	11	Dowel Pin
6	Speed Sensor		

REMOVAL

1. Remove the FEAD assembly. (Refer to the FEAD section)
2. Remove the fan pulley assembly.
3. Remove the front cover bracket.
4. Remove the fourteen bolts on the front cover.
5. Remove the front cover.

INSTALLATION

1. Clean any debris from both surfaces of the cylinder block and rear of the front cover.
2. Place the front cover onto the front of the cylinder block.
3. Insert and tighten the fourteen front cover bolts to 50 ft/lbs.
4. Insert the fan pulley assembly.
5. Install the FEAD assembly. (Refer to the FEAD section)

TURBOCHARGERS

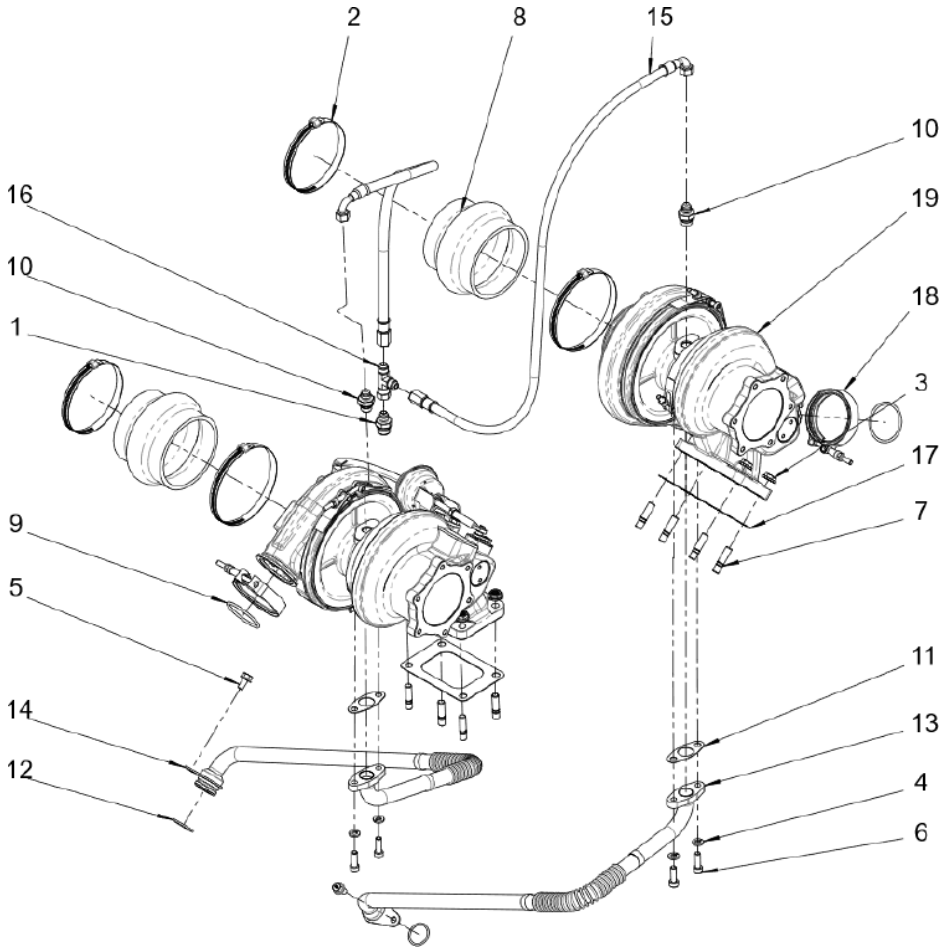


Figure 19. Turbocharger Assembly

NO.	Name	NO.	Name	NO.	Name	NO.	Name
1	Fitting	6	Upper Oil Drain Bolt	11	Gasket	16	Fitting
2	Clamp	7	Stud	12	O-Ring	17	Gasket
3	Nut	8	Hose	13	Oil Drain Tube	18	Clamp
4	Lock Washer	9	O-Ring	14	Oil Drain Tube	19	Turbo
5	Lower Oil Drain Bolt	10	Oil Inlet Valve	15	Oil Supply Line		

REMOVAL

1. Remove both turbo oil supply lines from the oil inlet valve. (Refer to Figure 20.)

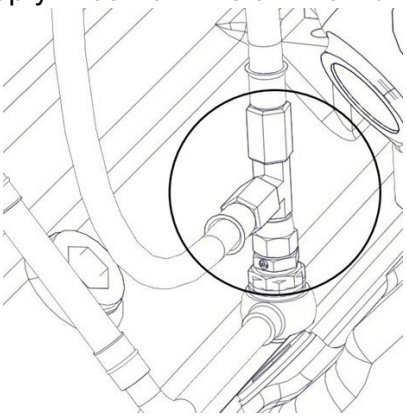


Figure 20. Turbocharger Oil Supply Lines

2. Remove the top two oil drain bolts and gasket from each turbocharger.
3. Remove the lower two oil drain bolts and gasket from each turbocharger.
4. Carefully remove both oil drain tubes.
   a. Ensure not to dent, damage, or scrape the oil drain tubes upon removal.
5. Remove Oil inlet valve. (If Necessary)
6. Loosen both turbocharger hose clamps (Figure 19, items 2 and 18) from each turbocharger.
7. Remove the four turbocharger nuts (Figure 19, item 3) from each turbocharger.
8. Carefully remove both turbochargers.
9. Remove both turbocharger gaskets from the exhaust manifolds.

INSTALLATION

1. Clean any debris from both ends of the exhaust manifold and bottom of both turbochargers.
2. Place both new turbocharger gaskets over the four studs on the ends of the exhaust manifolds.

NOTE:

- Both Turbocharger gaskets should be placed with the round edges facing up and away from the exhaust manifolds.

3. Install both turbochargers over the turbocharger gaskets.
4. Insert and torque down all eight nuts over the four studs on the exhaust manifolds to 40 ft/lbs.
5. Level the oil inlet on both turbos using a level. (Refer to Figure 21).

a. Loosen the V-bands on the inside of each turbo and rotate the oil inlet.
b. Level the oil inlet.
c. Tighten the inside bolts of each turbo.

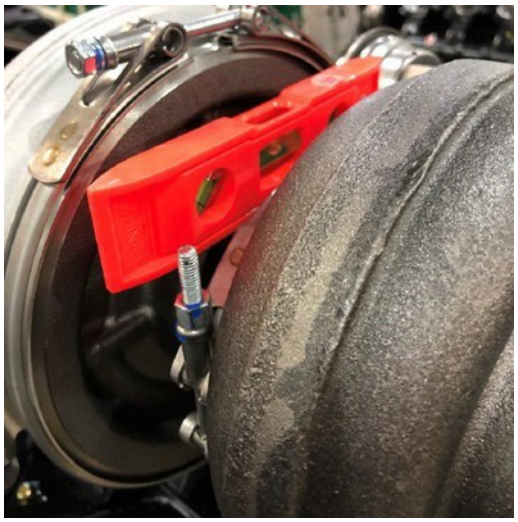


Figure 21. Oil Inlet Leveling

6. Orient both turbocharger compressor housings. (Refer to Figure 22)

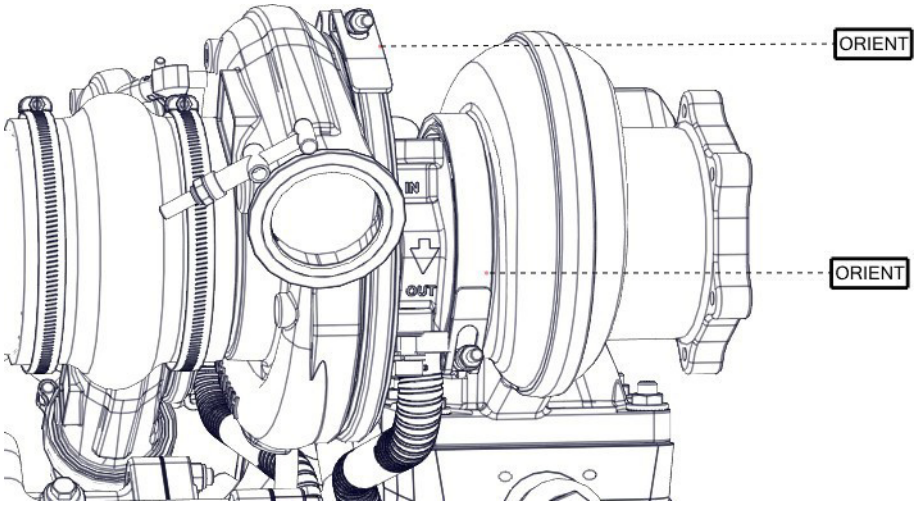


Figure 22. Compressor Housing Orientation

7. Place both washers into the oil inlet. (Refer to Figure 23.)
8. Insert both oil inlet fittings and torque fittings to 21 ft/lbs. (Refer to Figure 23.)

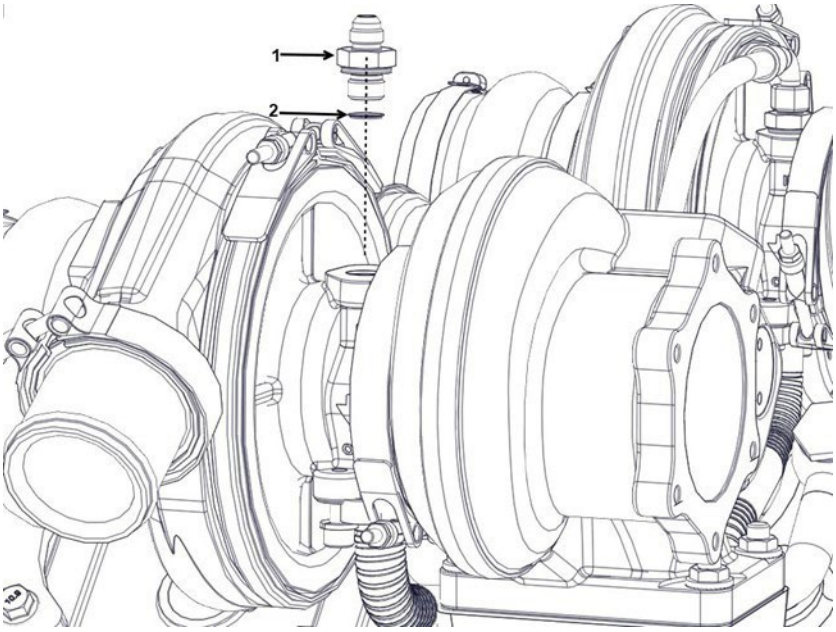


Figure 23. Oil Inlet Assembly

9. Clean any debris from the bottom of the oil outlet on both turbochargers.
10. Clean any debris from the top of the cylinder block.
11. Place the lower drain gasket over the cylinder block and install the oil drain tube.
12. Insert and torque down both oil drain bolts to 51 ft/lbs.
13. Place the upper drain gasket onto the bottom of the oil drain housing.
14. Apply PSI approved 242 Loctite to both upper oil drain tube bolts.
15. Insert both washers then insert and torque down both upper oil drain tube bolts to 30 ft/lbs.
16. Install both oil supply lines to the oil inlet fittings.

FUEL SYSTEM

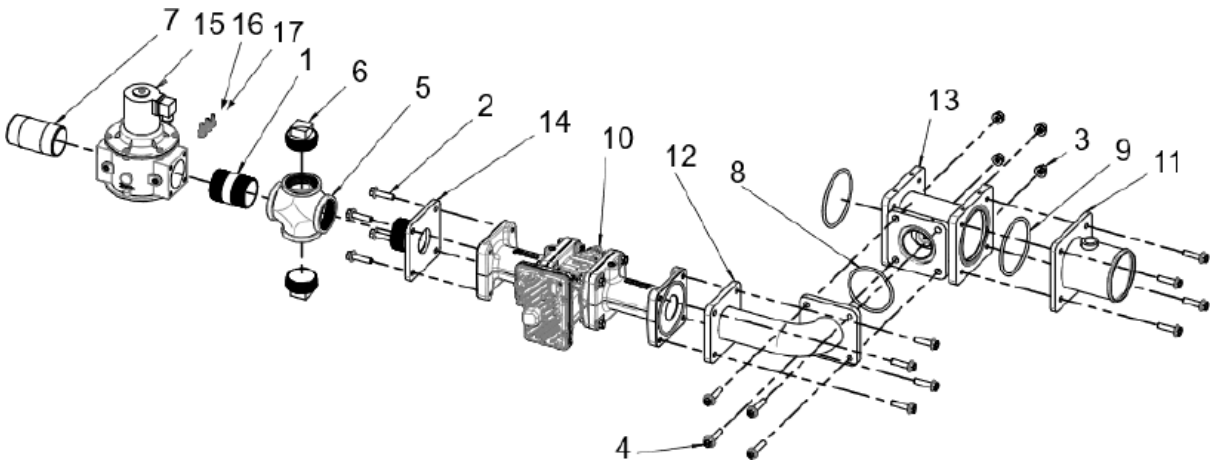


Figure 24. Fuel System Assembly

NO.	Name	NO.	Name
1	Pipe Nipple	11	Adapter
2	Flange Bolt	12	Adapter
3	Nut	13	Nozzle
4	Bolt	14	Adapter
5	2X Cross Fitting	15	L/O 2” Valve
6	Plug	16	¼ “Terminal
7	Nipple	17	¼” Terminal
8	O-Ring Seal		
9	O-Ring Seal		
10	Mass Flow Gas Valve		

REMOVAL

1. Remove all four bolts underneath the nozzle (Figure 25).

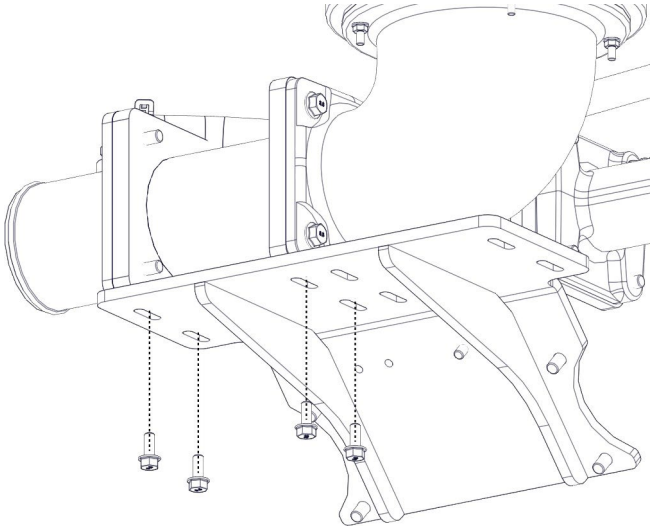


Figure 25.

2. Loosen and remove the U-bolts on the adapter (Figure 24, item 12).
3. Loose and remove the U-bolts on the Mass Flow Gas (MFG) Valve (Figure 24, item 10).
4. Remove the four bolts from the MFG Valve leading into the adapter (Figure 26).

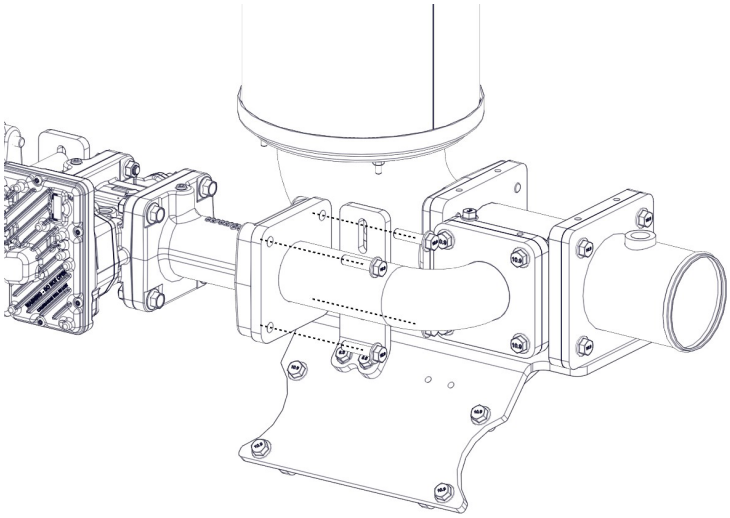


Figure 26.

5. Remove the adapter (Figure 24, item 12).
6. Loosen and remove the U-bolts from the fuel kit.
7. Remove the four bolts on the fuel kit leading into the MFG Valve (Figure 27).

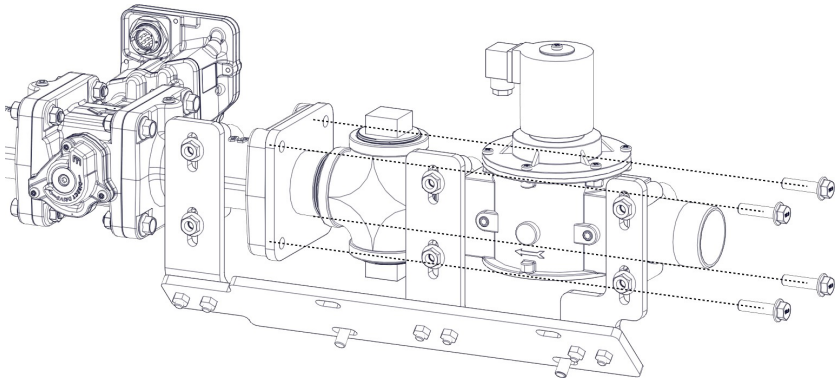


Figure 27.

8. Remove the MFG Valve (Figure 24, item 10).
9. Remove the lock off valve (Figure 24, item 15).

INSTALLATION

1. Place the nozzle (Figure 24, item 13) on top of the MFG bracket.
2. Insert and torque the four bolts (Figure 28) to 22 ft/lbs.

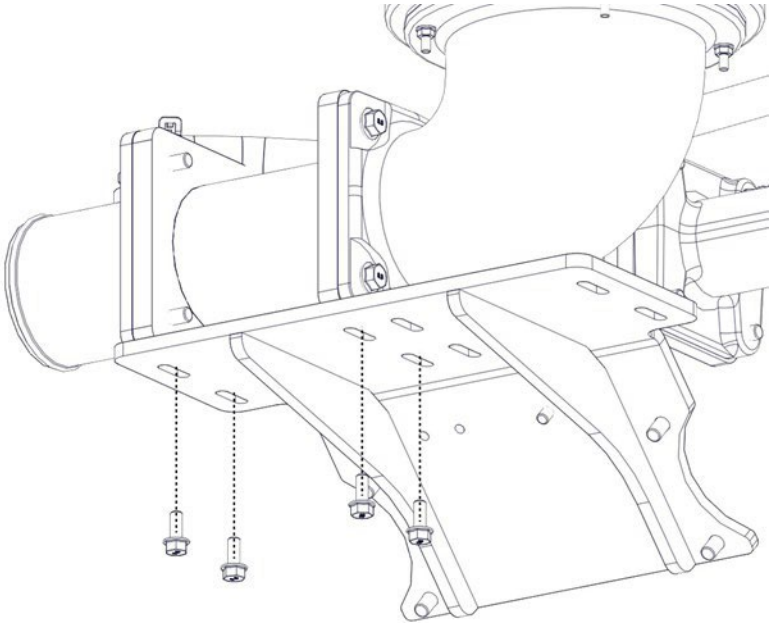


Figure 28.

3. Secure the nozzle adapter (Figure 24, item 12) by inserting and torquing down the U-clamps (Figure 29) to 12 ft/lbs.

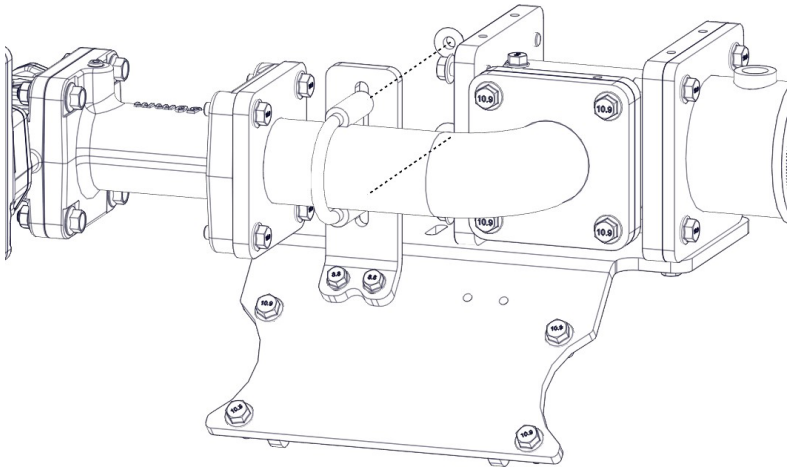


Figure 29.

4. Insert the MFG Valve (Figure 1, item 10) onto the open end of the adapter (Figure 24, item 12).

NOTE:

- Ensure the arrow on the MFG Valve is pointing toward the rear of the engine (Figure 30).

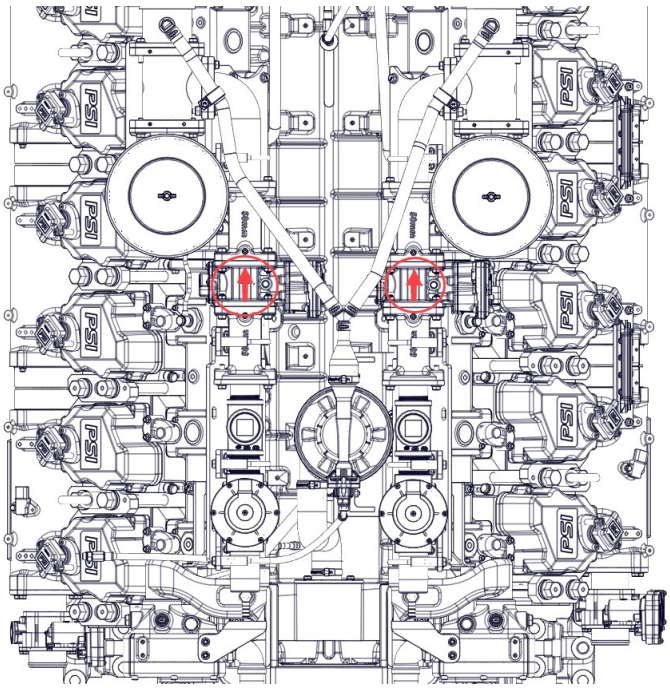


Figure 30.

5. Insert and torque the four MFG Valve bolts (Figure 31) to 30 ft/lbs.

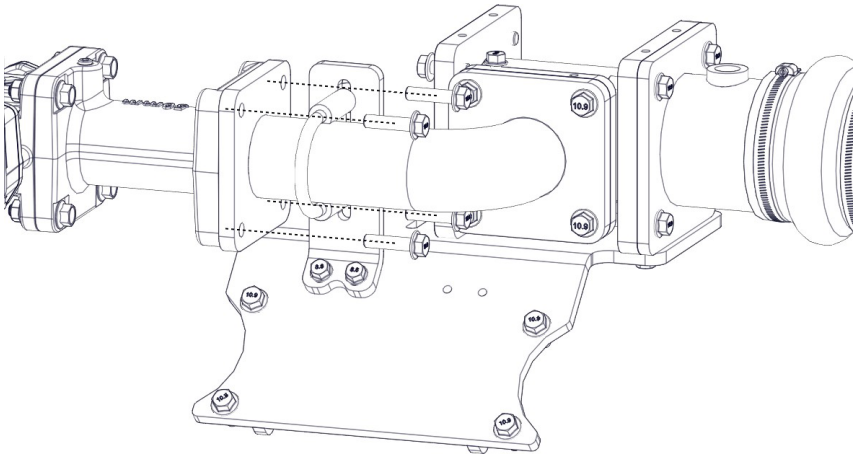


Figure 31.

6. Secure the MFG Valve by inserting and torquing down the U-clamps (Figure 32) to 12 ft/lbs.

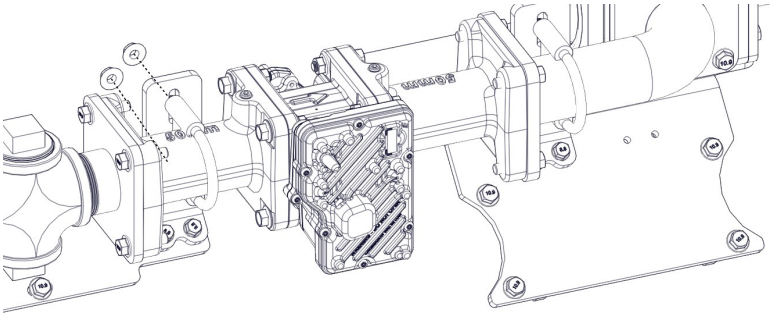


Figure 32.

7. Place the Lock-off valve kit (Figure 24, items 15 and 5) onto the open end of the MFG Valve (Figure 24, item 10).
8. Insert and torque down all four bolts (Figure 33) to 30 ft/lbs.

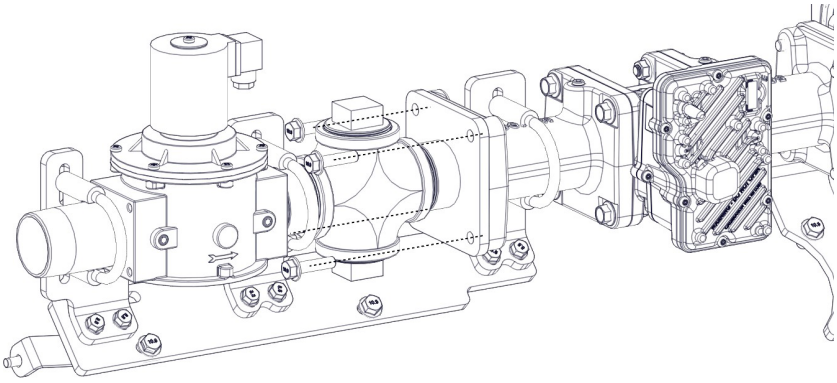


Figure 33.

10. Secure the Lock-off valve kit (Figure 24, items 15 and 5) by inserting and torquing down the U-clamps (Figure 34) to 12 ft/lbs.

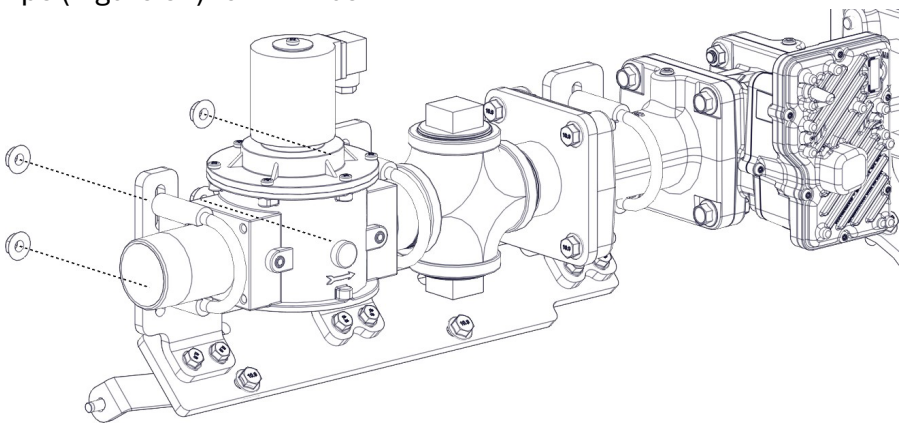


Figure 34.

11. Ensure all fuel kits are leveled parallel from front to back (Figure 35).

Figure 35.

FAST START FUEL SYSTEM

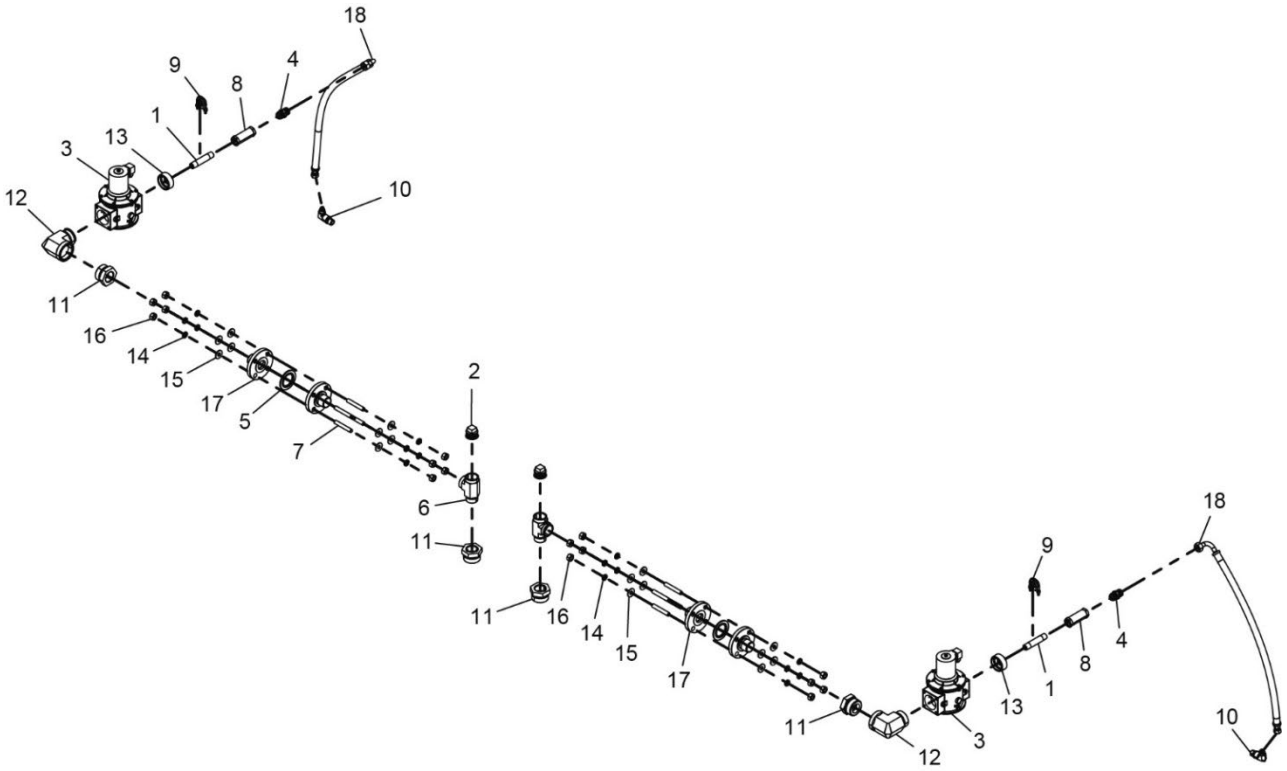


Figure 36. Fast Start Fuel System Assembly

NO.	Name	NO.	Name
1	Nipple	11	Straight Adapter Fitting
2	Plug	12	90° Fitting Adapte
3	Lock-Off Valve	13	Bushing Fitting
4	½ Fitting	14	Split Lock Washer
5	Gasket	15	Flat Washer
6	Tee Fitting	16	Hex Nut
7	Stud	17	Fast Start Flg Connector Pipe Assy
8	Check Valve	18	Straight Hose
9	U-Bolt Clamp		
10	90° Fitting Adapter		

CRANK CASE VENTILATION CANISTER (CCV)

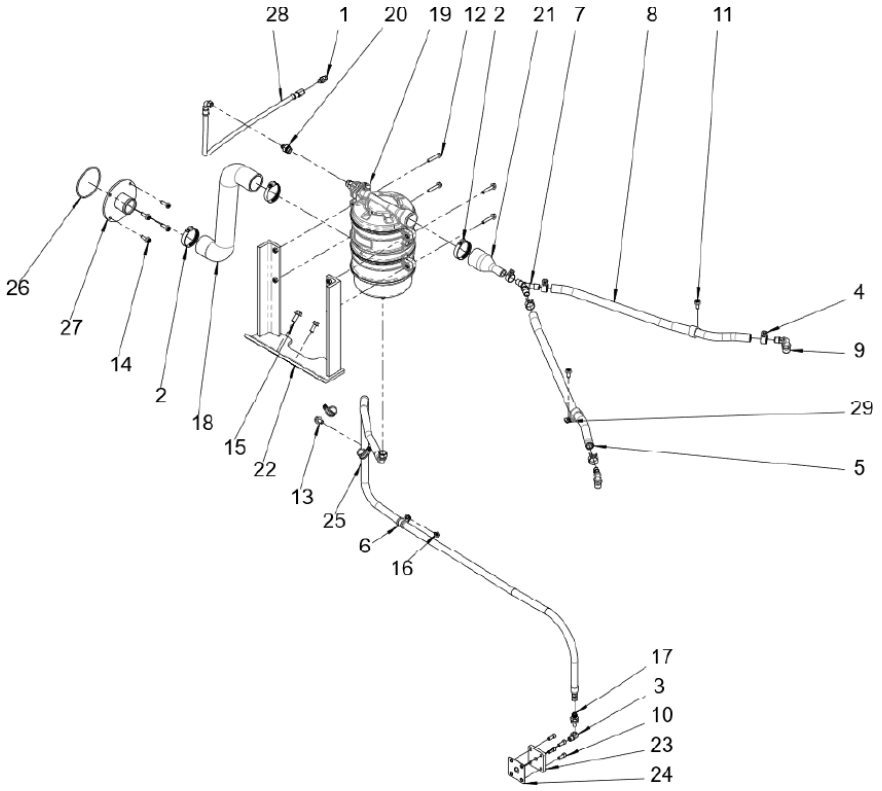


Figure 37. Crank Case Ventilation Assembly

NO.	Name	NO.	Name	NO.	Name
1	Fitting	11	Bolt	21	Hose
2	Clamp	12	Bolt	22	Breather Bracket
3	Elbow	13	Bolt	23	Plate
4	Clamp	14	Flange Bolt	24	Gasket
5	Vapor Hose	15	Bolt	25	Hose
6	Clamp	16	Bolt	26	O-Ring
7	“Y” Fitting	17	Breather	27	Adapter
8	Insulation	18	Hose	28	Hose
9	Fitting	19	Crankcase Valve	29	Clamp
10	Bolt	20	Fitting		

REMOVAL

1. Disconnect the CCV hose from the oil drain valve and the boost pressure hose.
2. Remove all clamps holding down the CCV hose against the cylinder block.
3. Disconnect the CCV hose from the canister.
4. Unscrew the CCV adapter hose clamp.
5. Remove all four CCV canister bolts.
6. Remove the CCV canister.

INSTALLATION

1. Place the CCV canister onto the CCV bracket.
2. Insert and torque down all four CCV canister bolts onto the CCV canister bracket.
3. Clamp down the CCV adapter hose.
4. Insert and connect the CCV hose to the bottom of the CCV canister and boost pressure hose.
5. Secure the CCV hose by clamping down the hose onto the cylinder block.

NOTE:

- Ensure the CCV hose is routed behind the oil filters then into the oil drain valve.

6. Connect the CCV hose to the oil drain valve.

AIR FILTERS

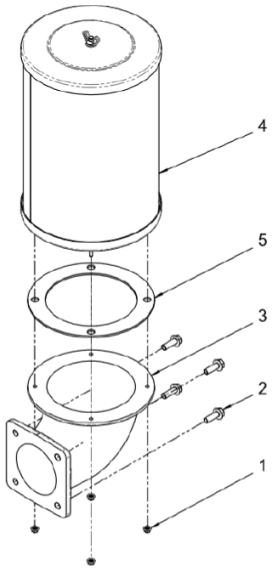


Figure 38. Air Filter Assembly

NO.	Name
1	Nut
2	Bolt
3	Elbow
4	Air Filter
5	Air Filter Gasket

REMOVAL

1. Remove the four bolts (Figure 38, item 2) from the elbow (Figure 38, item 3).
2. Remove the four nuts (Figure 38, item 1) from the air filter (Figure 38, item 4).
3. Remove the air filter (Figure 38, item 4) and gasket (Figure 38, item 5).

INSTALLATION

1. Place the elbow (Figure 38, item 3) onto the end of the turbo air inlet adapter.
2. Insert and torque down the four bolts (Figure 38, item 2) into the elbow (Figure 38, item 3).
3. Place gasket (Figure 38, item 5) onto the elbow.
4. Insert the air filter (Figure 38, item 4) and insert and torque down the four nuts (Figure 38, item 1).

FUEL MOUNTING BRACKETS

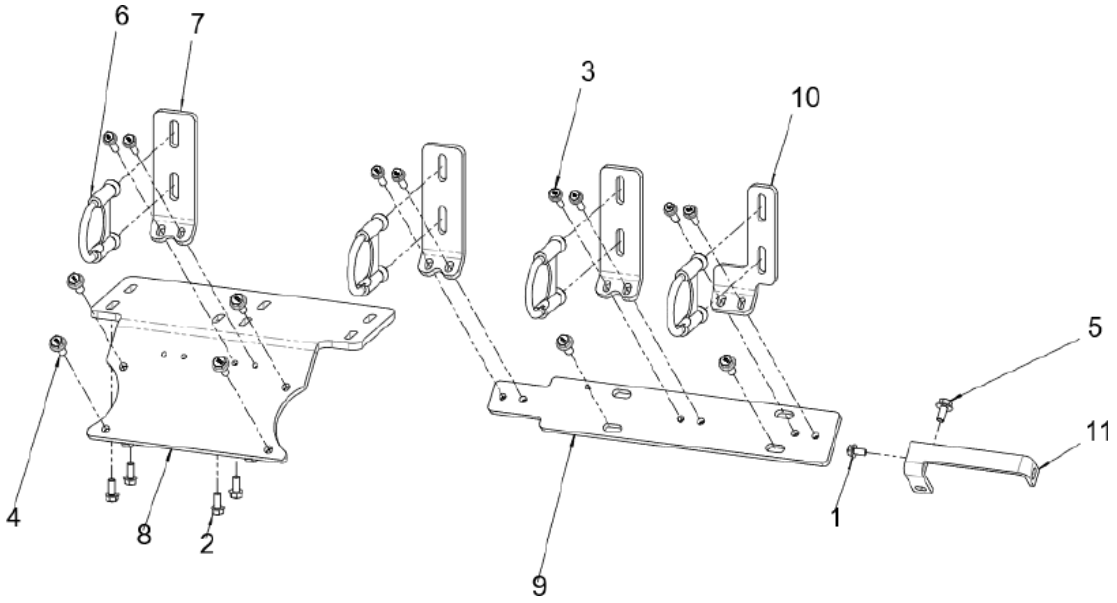


Figure 39. Left Fuel Mounting Bracket Assembly

NO.	Name	NO.	Name
1	Thermostat Housing Bolt	7	MFG Support Bracket
2	Bolt	8	MFG Bracket
3	MFG Support Bracket Bolt	9	Lock-Off Plate
4	MFG Bracket Bolt	10	Left Lock-Off Plate Bracket
5	Thermostat Housing Bolt	11	Left Thermostat Housing Bracket
6	U-Clamp		

NOTE:

- Hand tighten all fuel mounting brackets bolts before torquing to the specified torque value.

REMOVAL

1. Remove the U-clamps (Figure 39, item 6) and bolts (If not already removed).
2. Remove the bolts (Figure 39, item 3) from all supporting brackets on the lock-off plate (Figure 39, item 9).
3. Remove the two bolts on the lock-off plate (Figure 39, item 9) and remove the thermostat housing bolts (Figure 40).

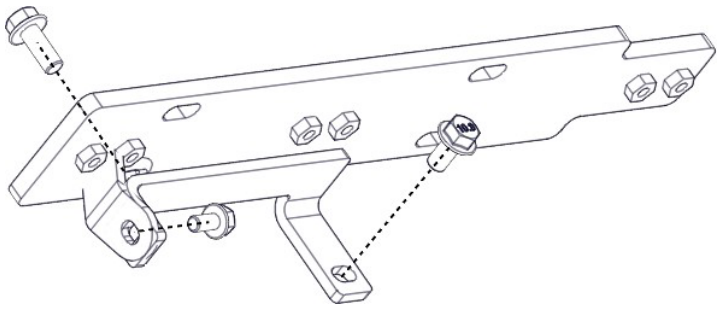


Figure 40.

4. Remove the lock-off plate (Figure 39, item 9) and the thermostat housing bracket (Figure 39, item 11).
5. Remove the U-clamp (Figure 39, item 6) from the MFG bracket (Figure 39, item 8).
6. Remove the two bolts from the MFG supporting bracket (Figure 39, item 7).
7. Remove the MFG supporting bracket.
8. Remove the four bolts (Figure 39, item 4) on the MFG bracket (Figure 39, item 8).
9. Remove the MFG bracket (Figure 39, item 8).

INSTALLATION

1. Place the MFG bracket (Figure 39, item 8) on top of the exhaust manifold and insert and torque down the four MFG bracket bolts (Figure 39, item 4) to 60 ft/lbs.
2. Place the MFG support bracket (Figure 39, item 7) onto the MFG bracket (Figure 39, item 8) and insert and torque down the two MFG support bracket bolts to 22 ft/lbs.
3. Place the Thermostat housing bracket onto the exhaust manifold and insert and torque down the two bolts (Figure 41.) to 22 ft/lbs.

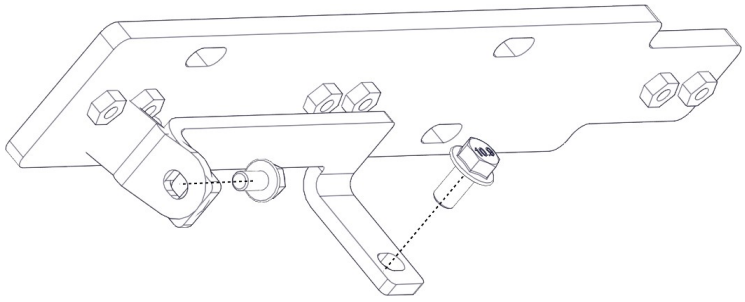


Figure 41.

4. Place the lock-off plate (Figure 39, item 9) onto the exhaust manifold and insert and torque down the two lock-off plate bolts (Figure 42) to 60 ft/lbs.

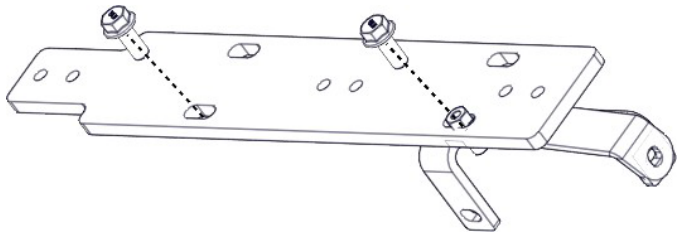


Figure 42.

5. Place the MFG supporting brackets and the lock-off supporting bracket (Figure 39, items 7 and 10) onto the lock-off bracket (Figure 39, item 9).
6. Insert and torque down the two bolts to all supporting brackets (Figure 43) on the lock-off plate to 22 ft/lbs.

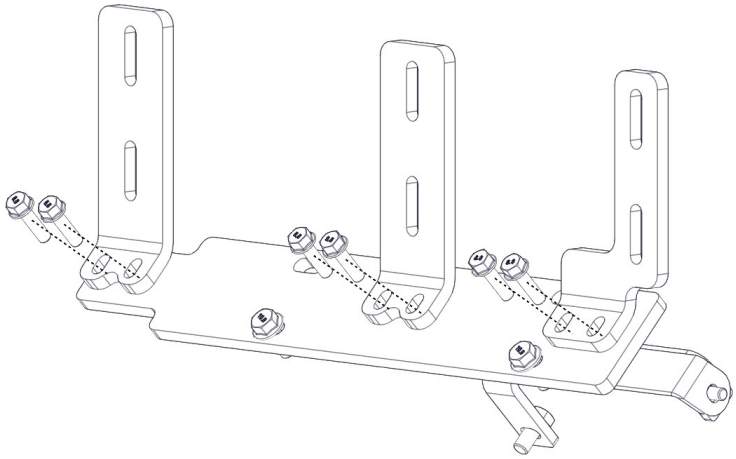


Figure 43.

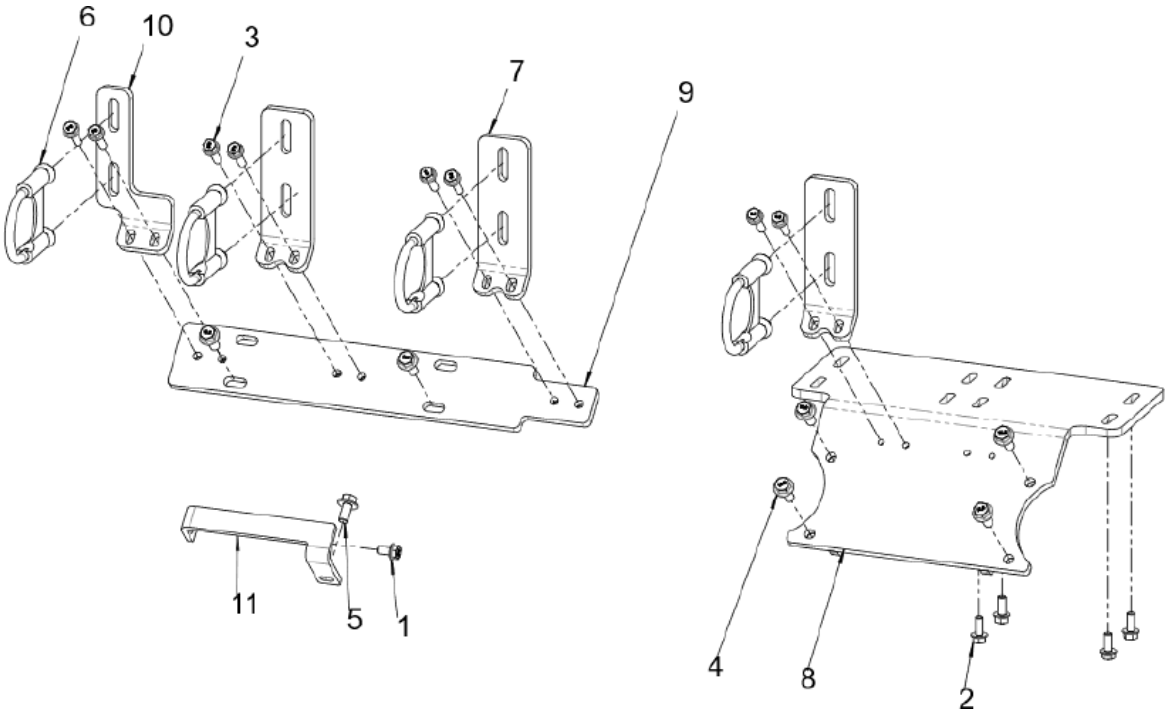


Figure 44. Right Fuel Mounting Bracket Assembly

NO.	Name	NO.	Name
1	Thermostat Housing Bolt	7	MFG Support Bracket
2	Bolt	8	MFG Bracket
3	Bolt	9	Lock-Off Plate
4	Bolt	10	Right Lock-Off Bracket
5	Bolt	11	Right Thermostat Housing Bracket
6	U-Clamp		

REMOVAL

1. Remove all U-clamps (Figure 44, item 6) and bolts (If not already removed).
2. Remove the two bolts (Figure 44, item 3) from all supporting brackets on the lock-off plate (Figure 44, item 9).
3. Remove all supporting brackets on the lock-off plate.
4. Remove the bolts (Figure 45) from the thermostat housing bracket.

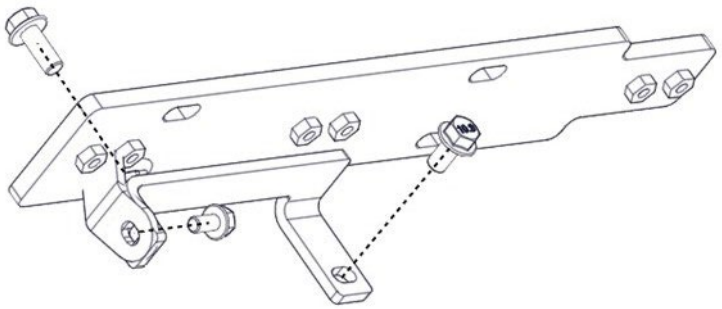


Figure 45.

5. Remove the two bolts on the lock-off plate bracket (Figure 46).

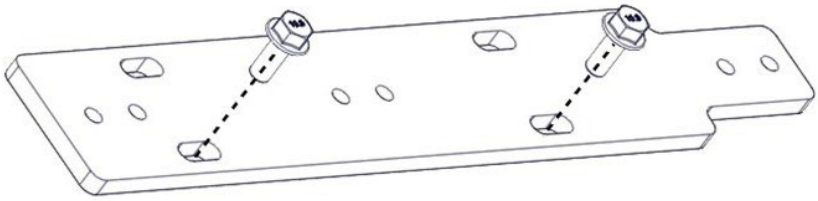


Figure 46.

6. Remove the thermostat housing bracket and the lock-off plate bracket (Figure 44, items 9 and 11).
7. Remove the U-clamp from the MFG bracket (Figure 44, item 8).
8. Remove the two bolts on the MFG supporting bracket (Figure 47).

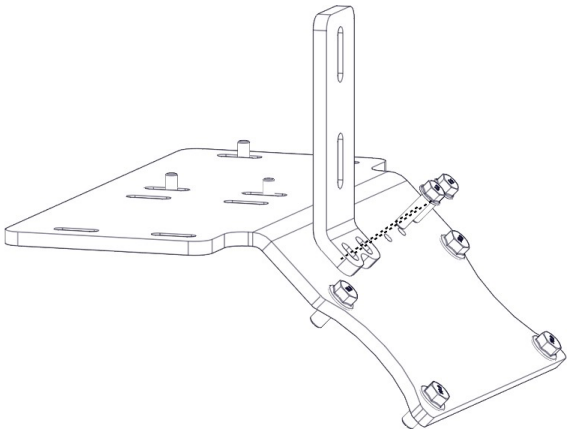


Figure 47.

9. Remove the MFG supporting bracket (Figure 44, item 7).
10. Remove the four bolts (Figure 44, item 4) from the MFG bracket (Figure 44, item 8).
11. Remove the MFG bracket (Figure 44, item 8).

INSTALLATION

1. Place the MFG bracket (Figure 44, item 8) on top of the exhaust manifold and insert and torque down the four MFG bracket bolts (Figure 44, item 4) to 60 ft/lbs.
2. Place the MFG support bracket (Figure 44, item 7) onto the MFG bracket (Figure 44, item 8) and insert and torque down the two MFG support bracket bolts to 22 ft/lbs.
3. Place the Thermostat housing bracket onto the exhaust manifold and insert and torque down the two bolts (Figure 48) to 22 ft/lbs.

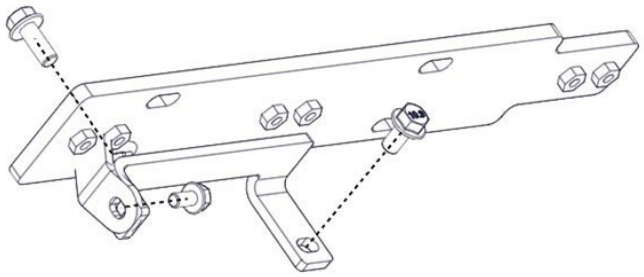


Figure 48.

4. Place the lock-off plate (Figure 44, item 9) onto the exhaust manifold and insert and torque down the two lock-off plate bolts (Figure 49) to 60 ft/lbs.

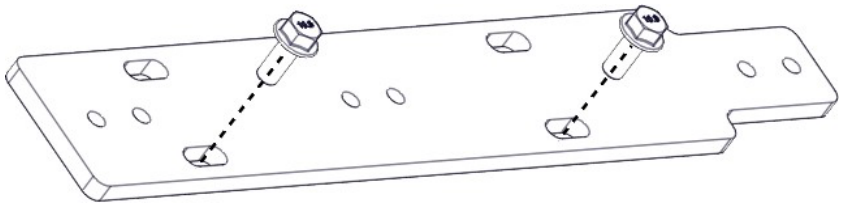


Figure 49.

5. Place the MFG supporting brackets and the lock-off support bracket (Figure 44, items 7 and 10) onto the lock-off bracket (Figure 44, item 9).
6. Insert and torque down the two bolts to all supporting brackets (Figure 50) on the lock-off plate to 22 ft/lbs.

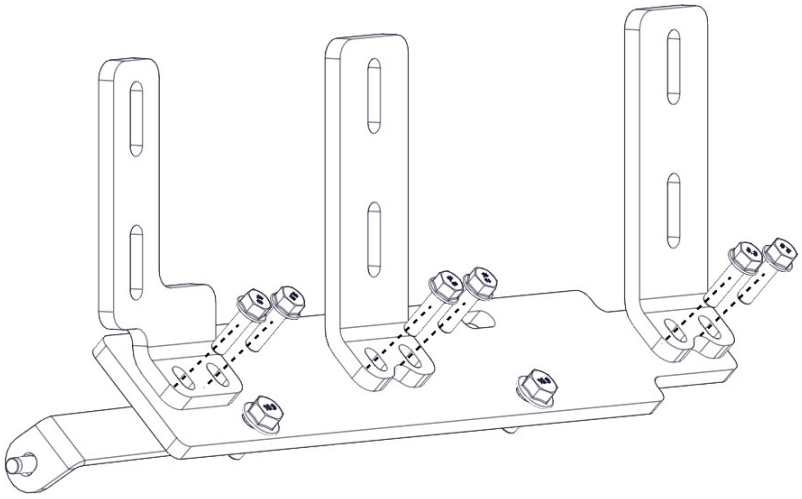


Figure 50.

EXHAUST MANIFOLD

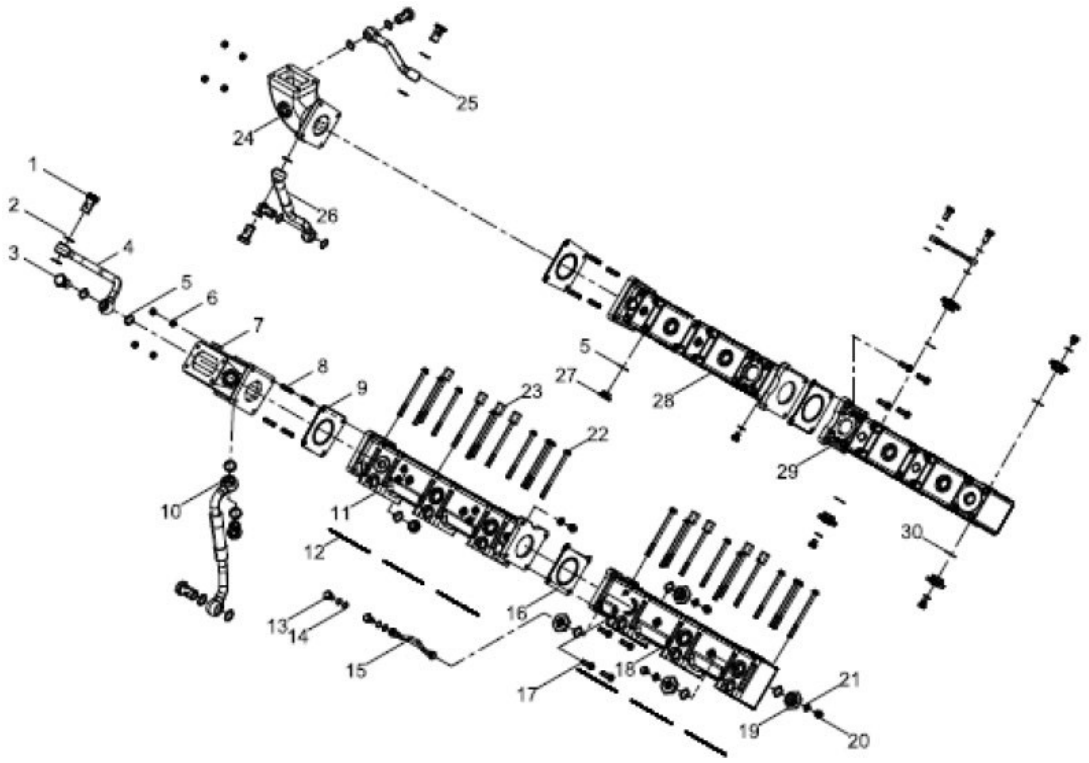


Figure 51. Exhaust Manifold Assembly

NO.	Name	NO.	Name	NO.	Name
1	Bolt	11	Exhaust Manifold	21	Washer
2	Washer	12	Exhaust Manifold Gasket	22	Bolt
3	Bolt	13	Bolt	23	Bolt
4	Coolant Outlet Pipe	14	Washer	24	Exhaust Pipe
5	Washer	15	Vent Pipe	25	Coolant Outlet Pipe
6	Lock Nut	16	Exhaust Manifold Gasket	26	Water Pipe
7	Exhaust Pipe	17	Bolt	27	Plug
8	Nut	18	Exhaust Manifold	28	Exhaust Manifold
9	Exhaust Manifold Gasket	19	Plug	29	Exhaust Manifold
10	Water Pipe	20	Plug	30	O-Ring

NOTE:

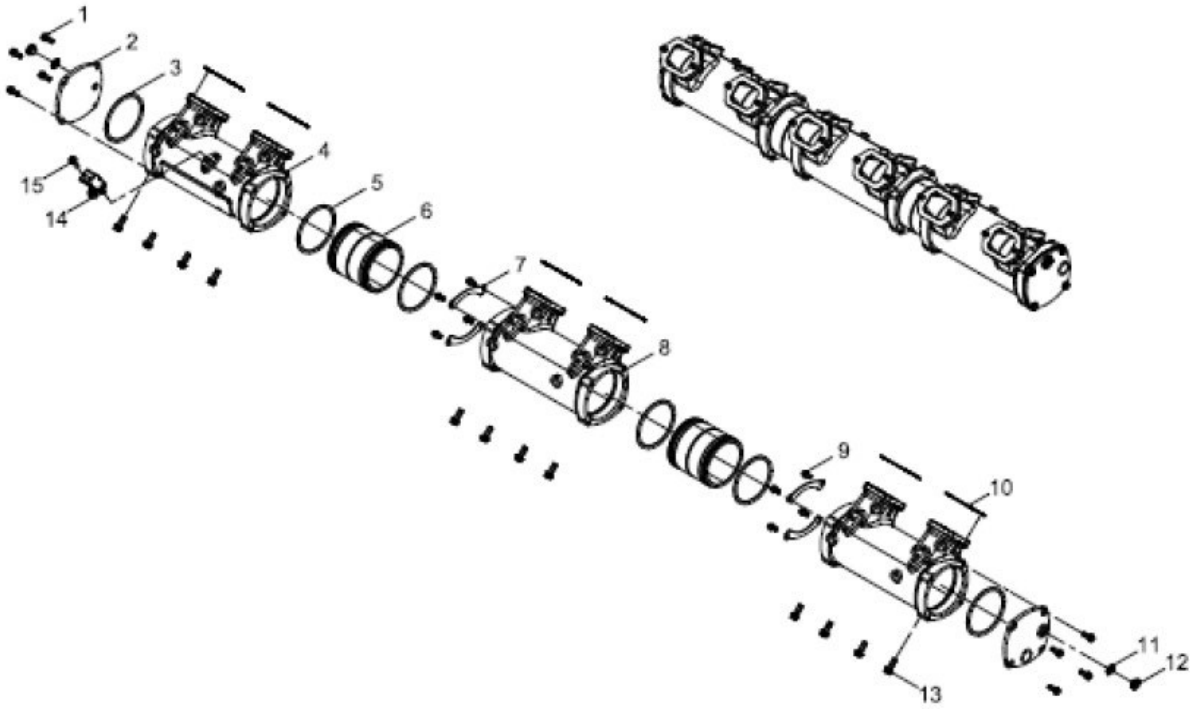
- The exhaust manifold is made up of three different sections.
- All fuel system components must be removed before dissembling the exhaust manifold.
- Banjo Bolts (Figure 51, Item 1) should be torqued to 52±5 ft/lb.

REMOVAL

1. Drain the coolant from the engine into a suitable container.
2. Remove the water pump tubes leading to the mid-section of the exhaust manifold.
3. Remove all exhaust manifold assembly bolts.
4. Loosen the exhaust manifold and cylinder head fastening bolts and remove the exhaust manifold and gasket in sections to ensure safe removal.
5. Loosen the connecting bolts between the exhaust manifolds and remove the exhaust manifold gasket.

INSTALLATION

1. Clean any debris from the cylinder head.
2. Insert and tighten the water pump tubes.
3. Place the exhaust manifold gasket onto the cylinder head. While ensuring the manifold sealing surfaces are level to each other (use straight edge or tighten when installed), tighten the connecting bolts between the exhaust manifold sections.
4. Apply thread sealant on the exhaust manifold bolts that protrude into the crankcase near the push rods.
5. Place the exhaust manifold onto the gaskets already installed on the cylinder heads. Insert and tighten the cylinder head fastening bolts.
6. Insert and tighten the exhaust manifold stud nut.



INTAKE MANIFOLD

Figure 52. Intake Manifold Assembly

NO.	Name	NO.	Name
1	Bolt	11	Washer
2	Plate	12	Plug
3	O-Ring	13	Bolt
4	Intake Manifold	14	Sensor
5	O-Ring	15	Bolt
6	Connecting Pipe		
7	Thrust Ring		
8	Intake Manifold		
9	Bolt		
10	Intake Manifold Gasket		

REMOVAL

1. Remove the two bolts on each ECM bracket.
2. Remove all intake manifold bolts.
   a. Remove the intake manifold in sections to ensure careful disassembly.
3. Loosen the hexagon flange bolts to remove the intake manifold cover and O-ring.
4. Loosen the thrust ring bolts and remove the intake manifold, connecting pipe and O-ring.

NOTE:

- All section-to-section bolts should not be tightened until it is installed and squared. If tighten before, one of the sealing surfaces to the heads may not be seated correctly and could cause a leak.

INSTALLATION

1. Clean any debris from the cylinder head.
2. Insert intake manifold gasket on cylinder head.
3. Insert intake manifold, connecting pipe and O-ring and tighten the thrust ring bolts.
4. Insert the intake manifold cover and O-ring and tighten the hexagon flange bolts.
5. Insert and tighten the intake manifold bolts.
6. Insert and torque down both the ECM bracket bolts to the intake manifold.

EXPLOSION RELIEF VALVE

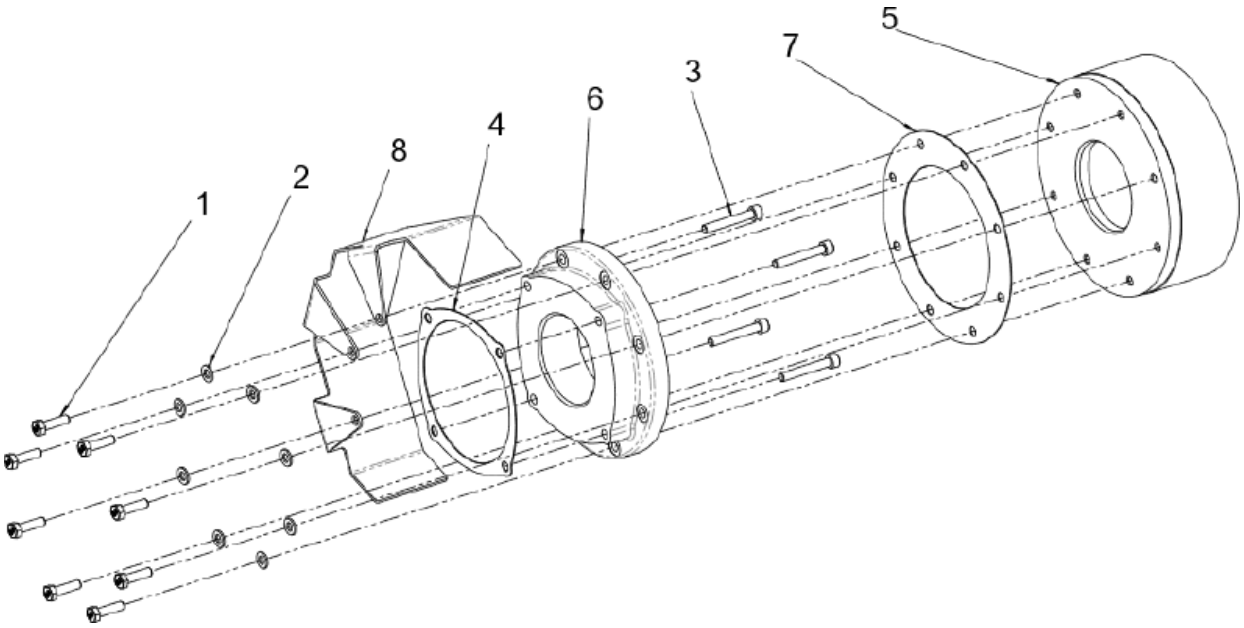


Figure 53. Explosion Relief Valve Assembly

NO.	Name	NO.	Name
1	Bolt	7	Explosion Relief Gasket
2	Washer	8	Pressure Relief Shield
3	Bolt		
4	Throttle Adapter Gasket		
5	Explosion Relief Valve		
6	Explosion Relief Adapter		

WARNING:

- **Do not remove valve unless specifically requested by PSI.**
- **The relief valve is 22 pounds and could cause extreme harm if not handled accordingly.**

REMOVAL

1. Remove the eight bolts from the rear of the relief valve.
2. Remove the explosion relief shield.

3. Remove the relief valve.
4. Remove the relief valve gasket.
5. Remove the four bolts from the relief valve adapter.
6. Remove the throttle adapter gasket.

INSTALLATION

1. Clean any debris from both intake manifolds.
2. Place relief valve adapter gasket onto the relief valve adapter.
3. Insert both relief valve adapter and gasket onto the end of the intake manifold.
4. Apply PSI approved Loctite to all four relief valve adapter bolts.
5. Insert and torque down all four relief valve adapter bolts to 27 ft/lbs.
6. Clean any debris from the surface of the relief valve.
7. Place all eight washers onto the eight relief valve bolts.
8. Carefully place the relief valve gasket and relief valve onto the relief valve adapter.
9. Place the explosion relief shield on the back of the relief valve and ensure the shield is pointed out and away from the engine.
10. Insert and torque down the eight washers and bolts in the below sequence to 27 ft/lbs. (Refer to Figure 54.)

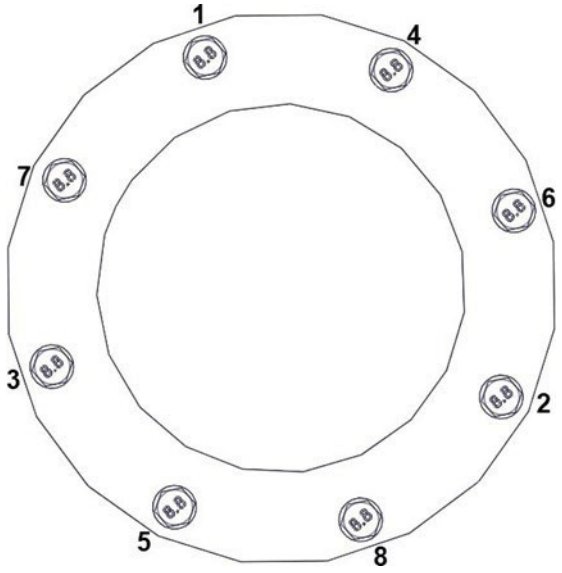


Figure 54. Explosion Relief Valve Torquing Sequence

IGNITION COIL

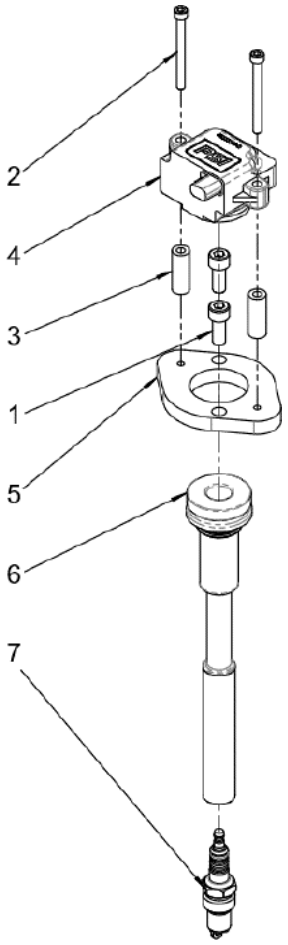


Figure 55. Ignition Coil Assembly

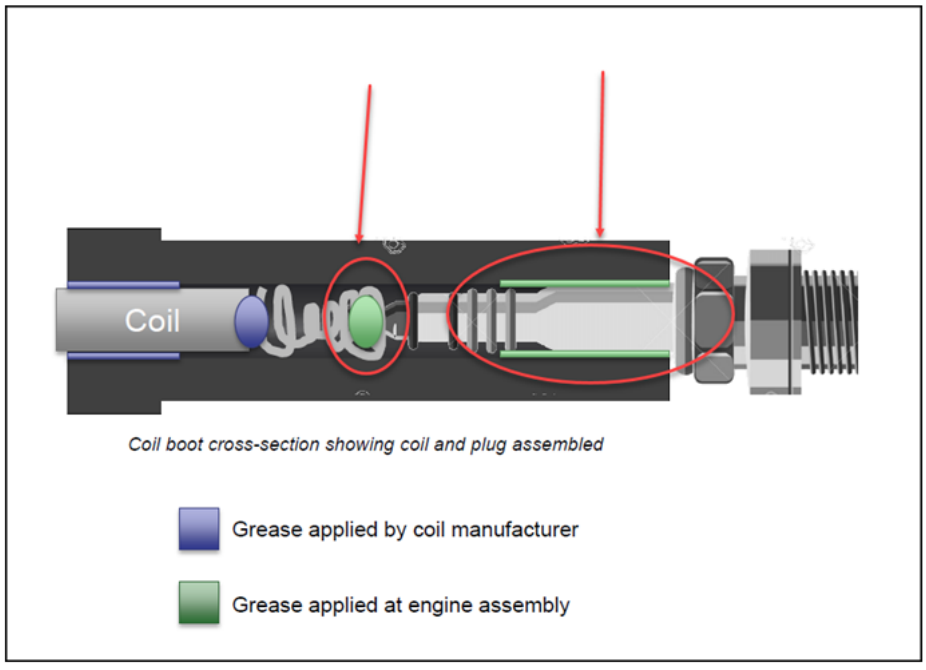
NO.	Name
1	Bolt
2	Bolt
3	Spacer
4	Ignition Coil
5	Ignition Coil Bracket
6	Ignition Coil Boot
7	Spark Plug

REMOVAL

1. Remove the two bolts (2) on the ignition coil (4).
2. Remove the ignition coil (4).
3. Remove the two spacers (3) directly below the ignition coil (4).
4. Remove the two bolts (1) on the ignition coil bracket (5).
5. Remove the ignition coil bracket (5).
6. Remove ignition coil boot (6) if necessary.
7. Remove spark plug (7).

INSTALLATION

1. Apply dielectric grease to each spark plug end of the coil boot (6).
2. Carefully insert and torque down the spark plug (7) to 28 ft/lbs.
3. Apply dielectric grease to each coil (4).
4. Install ignition coil bracket (5) and torque down the two ignition coil bracket bolts (1) torque down the two ignition coil bracket bolts (1) to 17 ft-lbs.
5. Install the two spacers (3) and place the ignition coil (4) over the spacers (3).
6. Insert and torque down the two ignition coil bolts (2) and torque the bolts to 80 in-lbs.



CYLINDER HEAD COVER

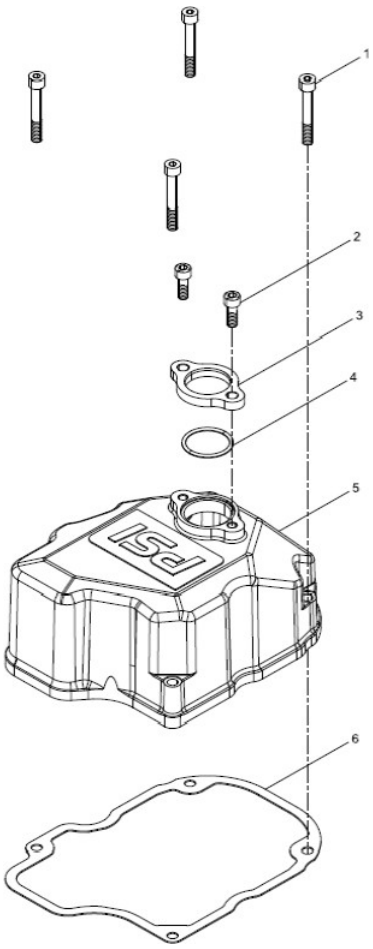


Figure 56. Cylinder Head Cover

NO.	Name
1	Bolt
2	Bolt
3	Cover
4	O-Ring
5	Cylinder Head Cover
6	Cylinder Head Cover Gasket

NOTE:

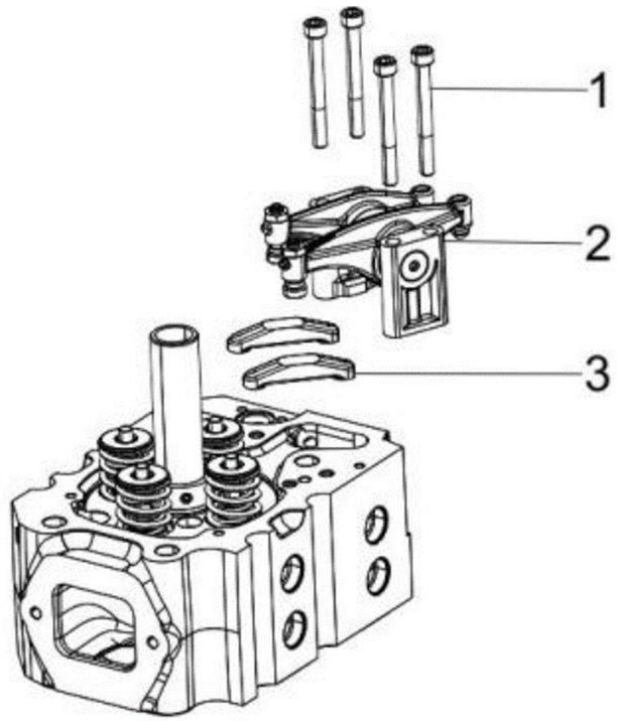
- Removing the cylinder head requires that the spark plugs be removed in advance. Failure to remove the spark plugs in advance could result in damages to the spark plugs because their tips are protruding from the cylinder head combustion chamber surface.

REMOVAL

1. Remove all four-cylinder head cover bolts.
2. Remove the cylinder head cover and gasket.

INSTALLATION

1. Clean the top of cylinder head of any debris.
2. Install gasket onto cylinder head.
3. Install cylinder head cover and tighten all four bolts to 20 ft/lbs.
4. Place the cylinder head ignition coil O-ring in preparation for ignition coil installation.



ROCKER ARMS

Figure 57. Rocker Arm

NO.	Name
1	Bolt
2	Rocker Arm Shaft Assembly
3	Valve Bridge

1. Remove the bolts (Figure 57, item 1) that retain the rocker arm shaft support.
2. Remove the rocker arm shaft assembly (Figure 57, item 2) from the cylinder head.
3. Remove the valve bridge (Figure 57, item 3).

NOTE:

- Identify the push rods and rocker assembly components, so they can be reinstalled in their original locations.

4. Remove the push rods and identify for installation.
5. Remove the rocker arm support (Figure 58, item 1).
6. Slide the exhaust rocker arm assembly (Figure 58, item 2) out of the rocker arm shaft assembly (Figure 58, item 4), rocker arm shaft sleeve (Figure 58, item 3), and intake rocker arms assembly (Figure 58, item 5).

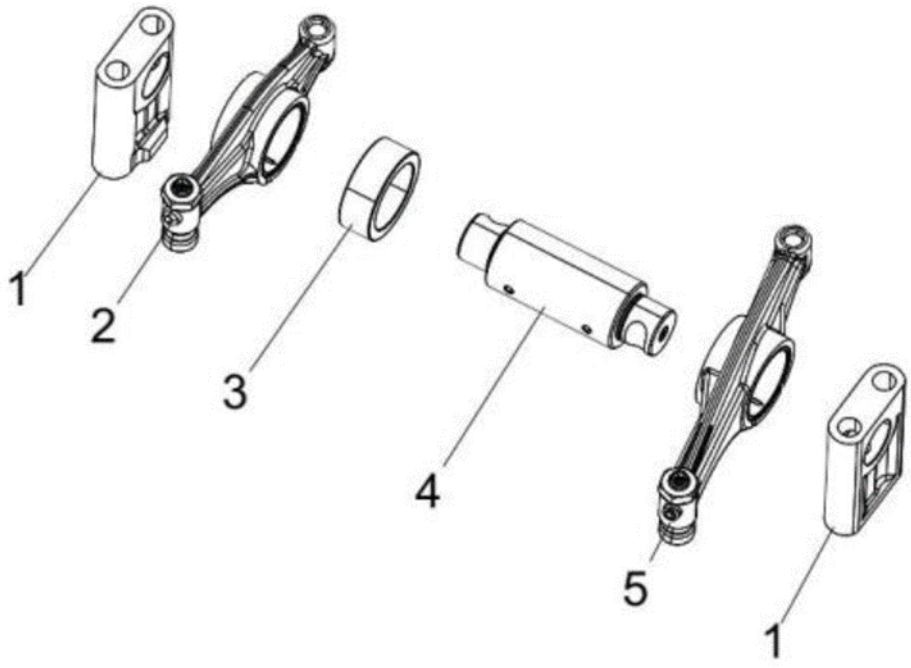


Figure 58. Rocker Arm Assembly

NO.	Name
1	Rocker Arm Support
2	Exhaust Rocker Arm
3	Shaft Sleeve
4	Rocker Arm Shaft
5	Intake Rocker Arm

NOTE:

- Removing the cylinder head requires that the spark plugs be removed in advance. Failure to remove the spark plugs in advance could result in damages to the spark plugs because their tips are protruding from the cylinder head combustion chamber surface.

CYLINDER HEAD REMOVAL

1. Loosen the cylinder secondary bolts in the following order A-N (Figure 59).

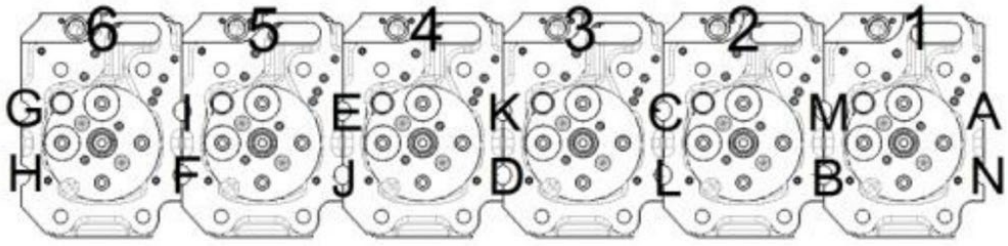


Figure 59. Cylinder Head Removal Order

NOTE:

- Primary and secondary head bolts may be reused a maximum of three times and MUST be discarded after allowed usage.

2. Remove the cylinder secondary bolts (Figure 60, item 1). Remove the gasket (Figure 60. item 2), clamping block (Figure 60, item 3) and end plate (Figure 60, item 4).

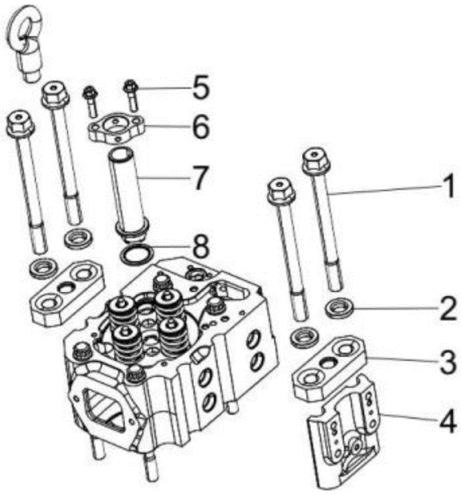


Figure 60. Cylinder Head Assembly

NO.	Name	NO.	Name
1	Bolt	5	Bolt
2	Gasket	6	Clamp
3	Clamping Block	7	Ignition Coil Bush
4	End Plate	8	Gasket

3. Loosen the bolts (Figure 60, item 5) and remove tube clamp (Figure 60, item 6).
4. Remove the ignition coil bush (Figure 60, item 7) and the gasket (Figure 60, item 8).
5. Remove the cylinder head main bolts in the following order 1-24 (Figure 61).

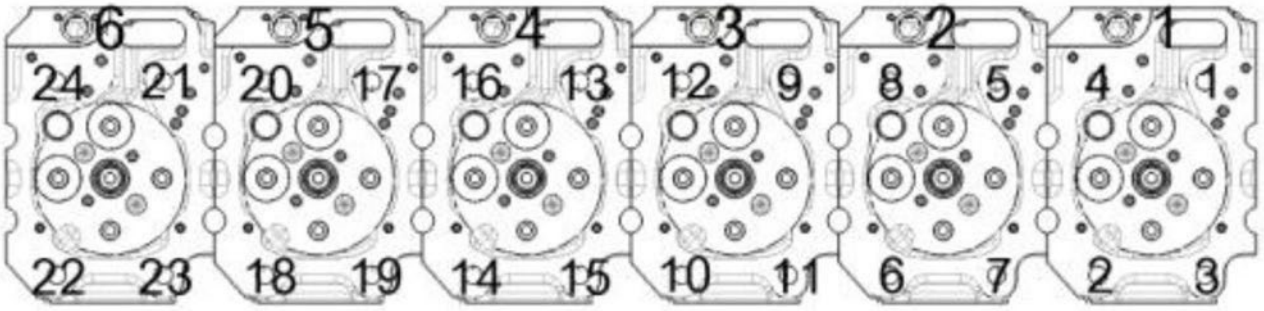


Figure 61. Cylinder Head Main Bolt Assembly

6. Lift the cylinder head away from the cylinder block (Figure 62, item 2). Discard the cylinder head gasket (Figure 62, item 3).

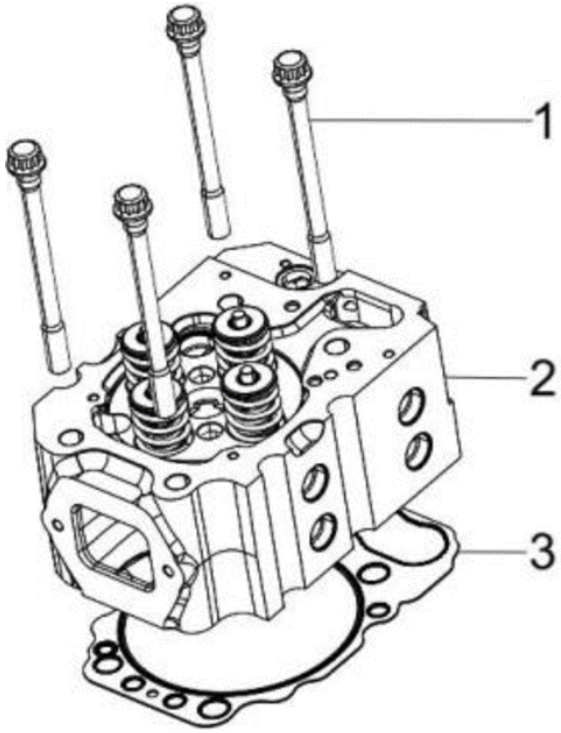


Figure 62. Cylinder Head Assembly

NO.	Name
1	Bolt
2	Cylinder Head
3	Cylinder Head Gasket

7. Place the cylinder head on the work bench with the combustion side down.
8. Using the valve spring compressor tool, compress the valve springs (Figure 63).

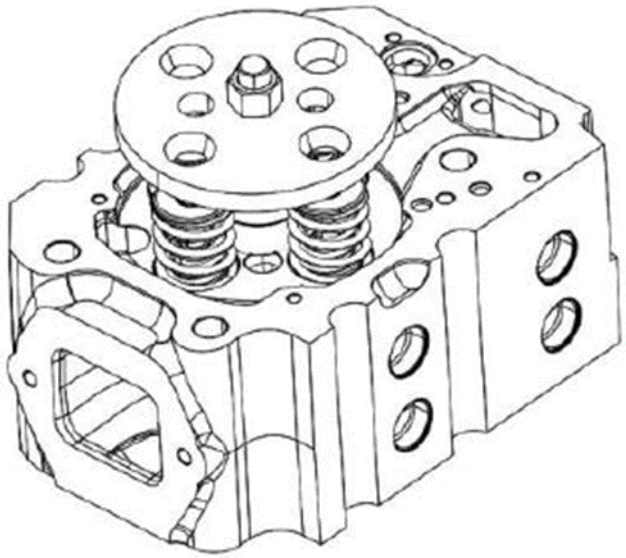


Figure 63. Valve Spring Compressor Assembly

9. Remove the valve keeper (Figure 64, item 1).
10. Slowly release the tension on the valve spring.
11. Remove the spring top retainer (Figure 64, item 2) and outer/inner valve spring (Figure 64, items 3 and 4).
12. Repeat the procedure with all remaining valves.

NOTE:

- If the valves are to be reused, identify them so they can be installed in their original location.

13. Turn the cylinder head so the exhaust port side faces down. Remove the intake and exhaust valves (Figure 64, items 7 and 8) from the cylinder head.
14. Remove the valve stem seals (Figure 64, item 5).
15. Remove the spring bottom retainer (Figure 64, item 6).

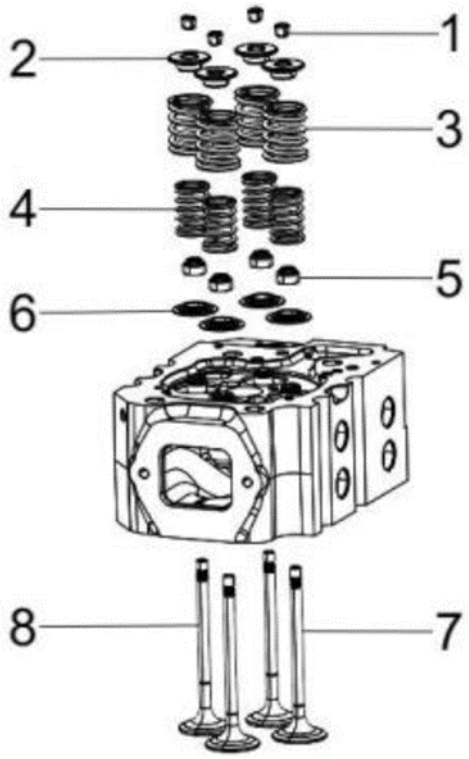


Figure 64. Cylinder Head Assembly

NO.	Name	NO.	Name
1	Valve Keeper	5	Valve Stem Seals
2	Spring Retainer	6	Spring Bottom Retainer
3	Outer Valve Spring	7	Valve
4	Inner Valve Spring	8	Valve

NOTE:

- Removal of the valve guides should be postponed until inspection and measurement procedures have been performed.

16. If the valve guides are not within specifications, use a hydraulic press to drive the valve guides (Figure 65, item 1) out of the cylinder head.

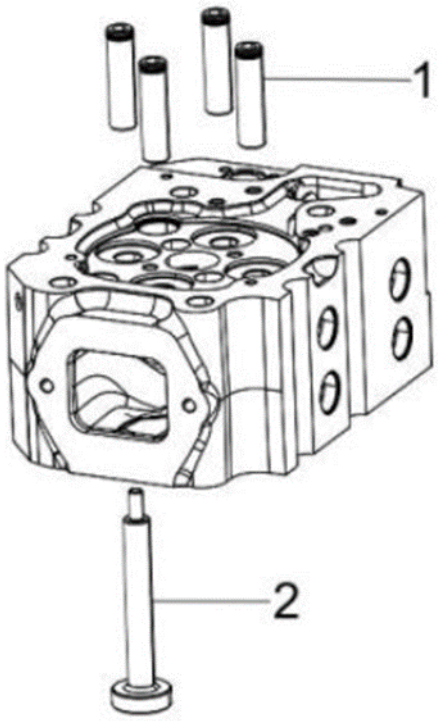


Figure 65. Cylinder Head Valve Guides

NO.	Name
1	Valve Guides
2	Press

CYLINDER HEAD CLEANING AND INSPECTION

Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants, and sealant removers. Failure to comply could result in death or serious injury.

Thoroughly clean all components using a nonmetallic brush and an appropriate solvent. Each part must be free of carbon, metal filings and other debris. Inspection of Cylinder Head Components Visually inspect the parts. Replace any parts that are obviously discolored, heavily pitted or otherwise damaged. Discard any parts that do not meet its specified limit.

NOTE:

- Any part which is found defective because of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.
- Any part determined to not meet the service standard or limit before the next service, as determined from the state of current rate of wear, should be replaced even though the part currently meets the service standard limit.

INSPECTION OF PUSH RODS

Determine if the bend of the push rods is within the specified limit.

V-blocks must be used to inspect push rods due to the welds on the ends of the pushrods.

1. Place the push rods on a flat inspection block or layout bed.
2. Roll the push rods until a gap can be observed between a portion of the push rods and the surface of the block or layout bed.
3. Use a feeler gauge to measure the gap (Figure 66).

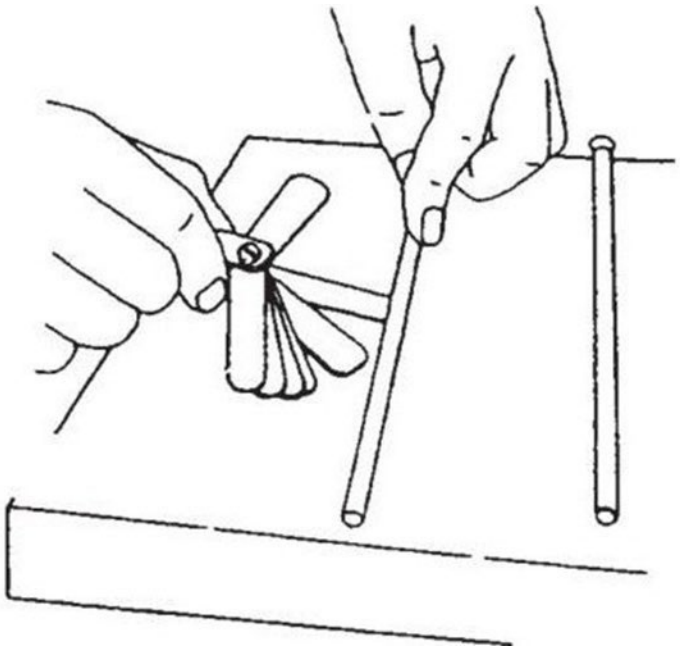


Figure 66. Push Rod Measurement

INSPECTION OF ROCKER ARM ASSEMBLY

Use a test indicator and micrometer to determine if the inside diameter of all the rocker arm support brackets and the rocker arms are within the specified limits.

Inspect the contact areas for excessive wear or damage.

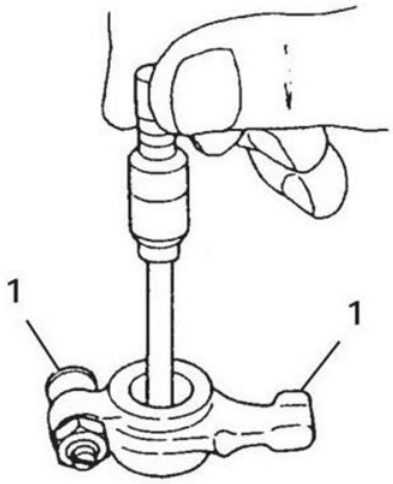


Figure 67. Rocker Arm Diameter Measurement

Use a micrometer to measure the rocker arm shaft diameter. Measure at each rocker arm location in two directions 90° apart (Figure 67).

VALVE GUIDE INSPECTION

Visually inspect the valve guides for distortions, scoring or other damages.

NOTE:

- Measure the valve guides while they are installed in the cylinder head.

Use a telescoping gauge and micrometer to measure the inside diameter at each end of the valve guide. Measure in three places and 90° apart (Figure 68). See Intake / Exhaust Valve and Guide chart for the service limit. Replace valve guides if not within specification.

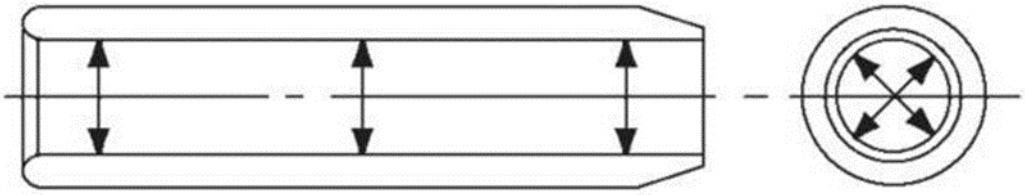


Figure 68. Valve Guide Measurement

CYLINDER HEAD INSPECTION

1. Equip the cylinder head with the water jacket tool (leak test).
2. Connect an air inlet onto the water outlet of the cylinder head. Immerse the cylinder head in a tank of water and increase pressure up to 73 PSI or 5 bar (Figure 69).
3. Check that there are no leaks in the intake ducts, exhaust ducts, spark plug sleeve, oil passages, cylinder combustion side, valve seat housings, discard the cylinder head if necessary.

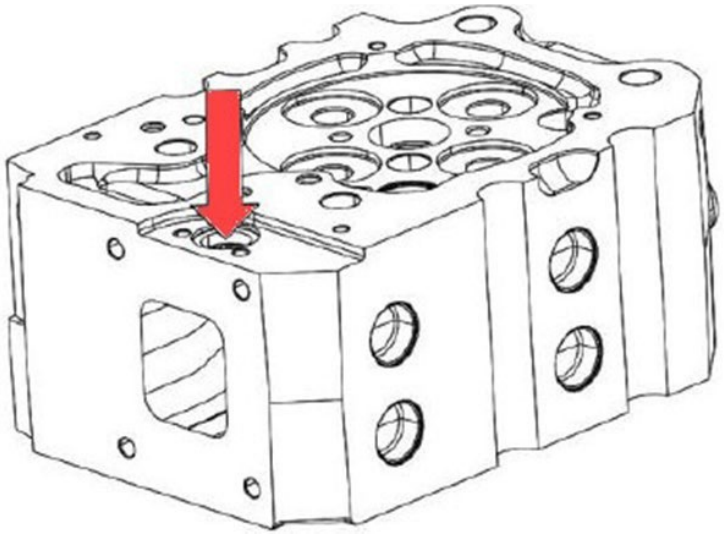


Figure 69. Cylinder Head Outlet

INTAKE AND EXHAUST VALVE INSPECTION

1. Visually inspect the intake and exhaust valves.
2. Replace any valves that are obviously discolored, heavily pitted or otherwise damaged.
3. Use a micrometer to measure the valve stem diameter. Measure the valve stem near the combustion end and near the opposite end (Figure 70). See Intake / Exhaust Valve and Guide chart for the service limit.

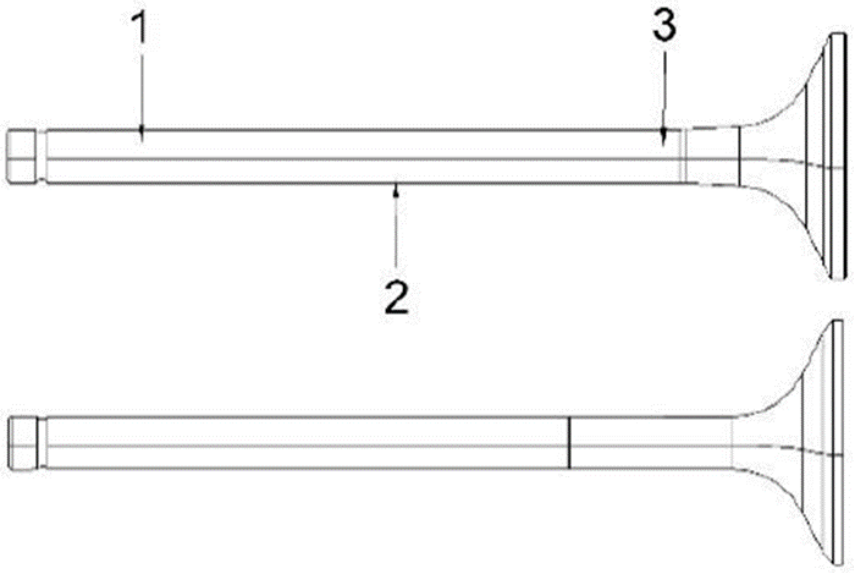


Figure 70. Valve Stem Diameter

4. Place the valve stem on a flat inspection block or layout bed. Roll the valve until a gap can be observed between a portion of the valve stem and the surface of the block or bed. Use a feeler gauge to measure the gap (Figure 71). See Intake / Exhaust Valve and Guide chart for the service limit.

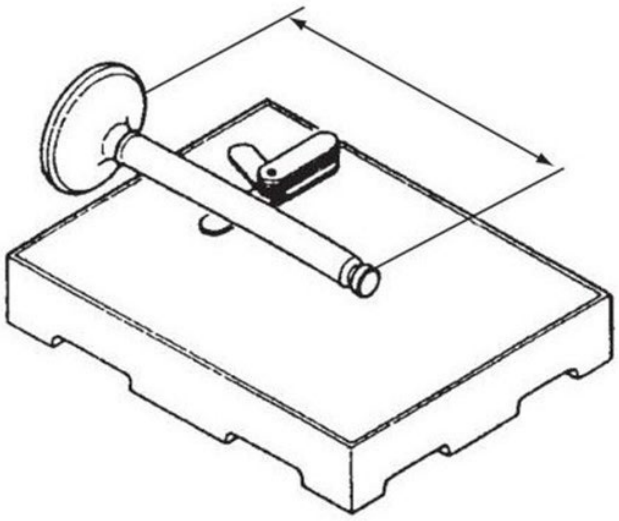


Figure 71. Valve Inspection Block

5. Insert the valves into their original locations and press them down until they are fully seated. Use a depth micrometer (Figure 72) to measure the difference between the cylinder head gasket surface and the combustion surface of each exhaust and intake valve. See Cylinder Head specification chart for the service limit.

NOTE:

Valve guides must be installed to perform this check.

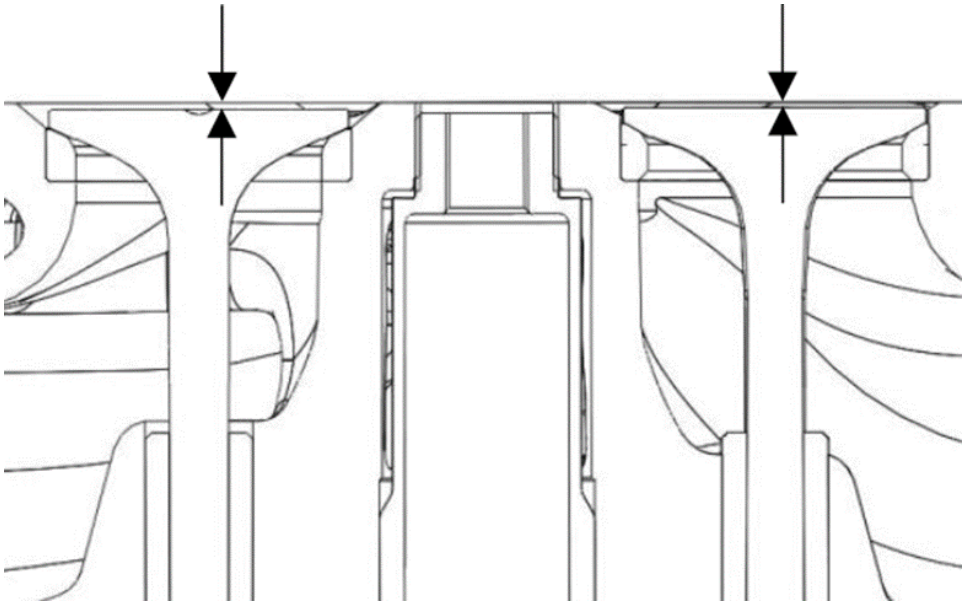


Figure 72. Valve Recession Check

VALVE SPRING INSPECTION

1. Inspect the valve springs. If damage or corrosion is seen, or if measurements exceed the specified limits, replace the springs.
2. Check for fractures on the inside and outside portions of the springs. If the valve spring is fractured, replace the valve spring.
3. Check for corrosion of the spring material caused by oxidation.
4. Use a flat surface and a square to check each spring for squareness (Figure 73). See Valve Spring specification chart for the service limit.

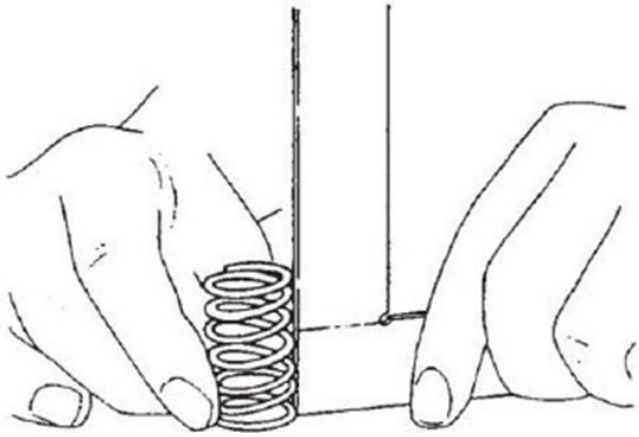


Figure 73. Valve Spring Squareness Measurement

5. Use a caliper to measure the length of the spring (Figure 74). See Valve Spring Mechanical chart for the service limit.

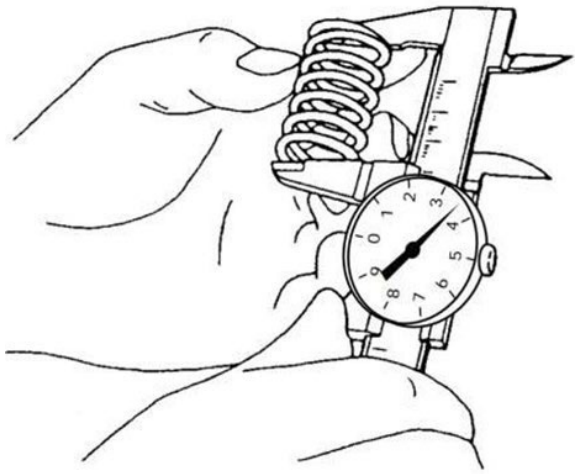


Figure 74. Valve Spring Measurement

CYLINDER HEAD REASSEMBLY

NOTE:

- Lubricate all components with oil during reassembly to prevent premature wear or damage.
- Use new gaskets, O-rings, and seals for cylinder head installation.
- Ensure all debris is removed from all components before installation.

VALVE SEAT INSTALLATION

The valve seats are installed from the desk side of the cylinder head and must be pressed in and fully bottomed out. All installation of valve seats (Figure 75A, Item 1) must be pre-approved by PSI manufacturing.

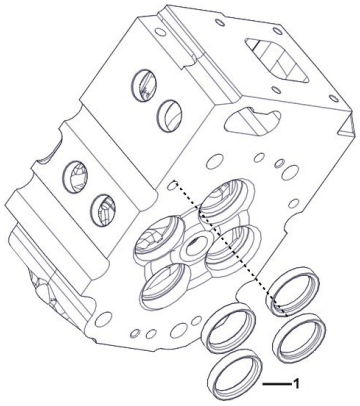


Figure 75A. Valve Seat Assembly

VALVE GUIDE INSTALLATION

The valve guides are installed into the cylinder head with an extremely tight press fit. Before installing the valve guides, place the valve guides in a freezer for at least twenty minutes. This will cause the valve guides to contract, making it easier to install the valve guides into place.

Immediately after removing the valve guides from the freezer, insert the valve guides (Figure 75B, item 1) in their proper positions.

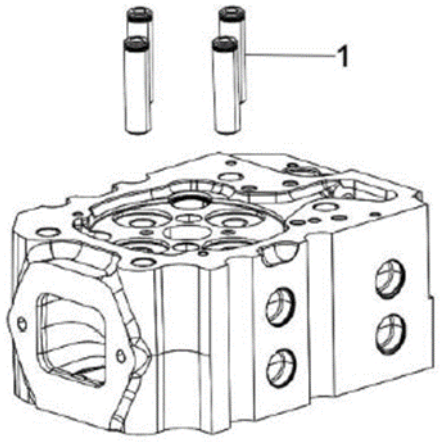


Figure 75B. Valve Guide Assembly

NO.	Name
1	Valve Guides

Finish installing the valve guides into the cylinder head to the proper height using the valve guide installation tool (Figure 76). See Valve Guide Projection specification chart.

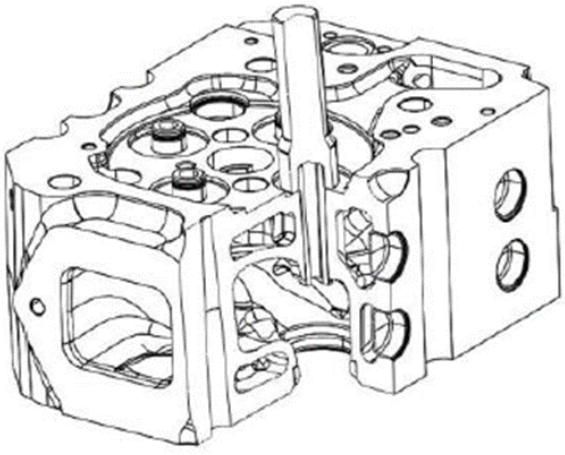


Figure 76. Valve Guide Installation Tool

INTAKE AND EXHAUST VALVE INSTALLATION

NOTE:

- Always install new valve stem seals.
- The exhaust valve stem seals are different than the intake valve stem seals and can be identified by either the paint marks on the outside of the seals or by the color of the compound. Ensure they are installed in the correct locations.
- Always apply PSI approved engine oil to all valve stems.

Engine Model	Marking	
	Intake	Exhaust
40L	Brown	Blue

Figure 77. Valve Steam Seal Color Chart

1. Install the valve spring bottom retainer (Figure 78, item 1).

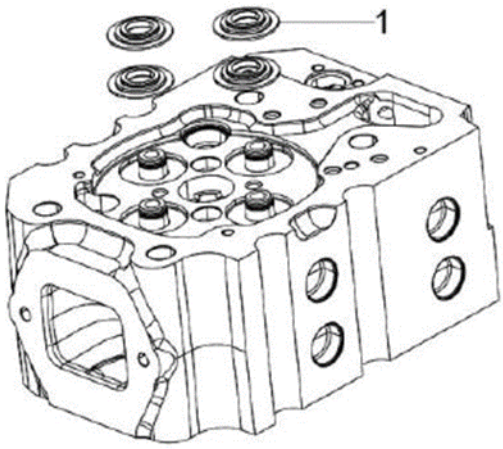


Figure 78. Valve Spring Retainer

NO.	Name
1	Valve Spring Bottom Retainer

2. Oil the lip of the valve stem seal (Figure 79, item 2). Using the valve stem seal installation tool (Figure 79, item 1), install a new valve stem seal on each of the valve guides.

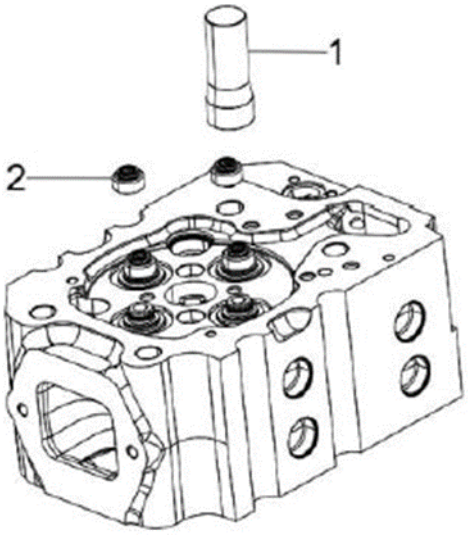


Figure 79. Valve Steam Seal Installation Tool

NO.	Name
1	Valve Stem Installation Tool
2	Valve Seal

3. Place the cylinder head assembly on its exhaust port side.
4. Place all the valves (Figure 80, items 1 and 2) in their proper location in the cylinder head.

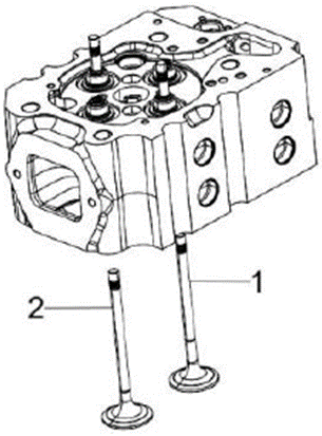


Figure 80. Valve Assembly

NO.	Name
1	Valve
2	Valve

5. Place the cylinder head on the workbench with the combustion side down to install the valve springs. Install the valve springs (Figure 81, items 3 and 4) and the spring retainer (Figure 81, item 2).

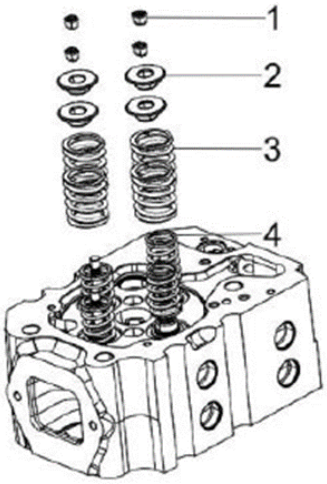


Figure 81. Valve Spring Assembly

NO.	Name
1	Keeper
2	Spring Retainer
3	Valve Spring
4	Valve Spring

6. Insert the valve keepers (Figure 81, item 1) and slowly release the tension on the valve spring.
7. Repeat the steps on all the remaining cylinder head valves.

CYLINDER HEAD INSTALLATION

NOTE:

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

1. Carefully clean both the combustion surface of the cylinder head and the top surface of the cylinder block. Then place a new cylinder head gasket (Figure 82, item 7) on the cylinder block.
2. Position the cylinder head (Figure 26, item 6) on the cylinder head gasket.

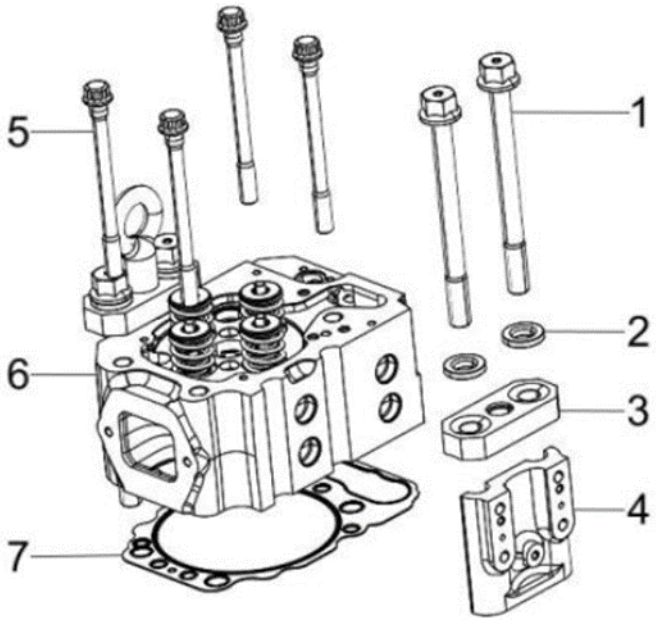


Figure 82. Cylinder Head Assembly

NO.	Name	NO.	Name
1	Bolt	5	Bolt
2	Gasket	6	Cylinder Head
3	Clamping Block	7	Gasket
4	End Plate		

NOTE:

- Primary and secondary head bolts may be reused a maximum of three times and MUST be discarded after allowed usage.

3. Lightly oil the threads and shoulder of the cylinder head main bolts (Figure 82, item 5) and cylinder head secondary bolts (Figure 82, item 1). Lightly oil the clamping block (Figure 82, item 3) and end plate (Figure 82, item 4).
4. Tighten the main bolts in order (Figure 83) 1 through 24 to a torque of 59 ft/lbs.

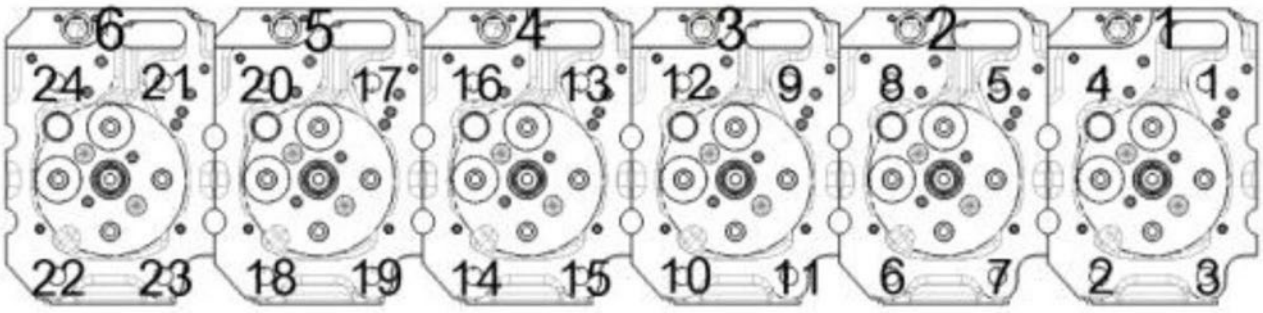


Figure 83. Main Bolt Torquing Order

5. Tighten the secondary bolts in order (Figure 84) A through N to 59 ft/lbs.

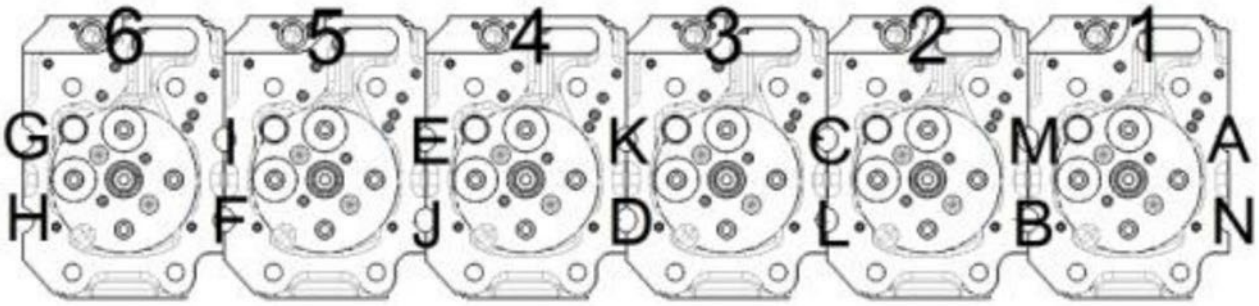


Figure 84. Secondary Bolt Torquing Order

6. Tighten the main bolts in order 1 through 24 to 59±7 ft/lbs, then tighten the bolts to an angle of 60°±5°.
7. Tighten the secondary bolts in order A through N to 59±7 ft/lbs, then tighten the bolts to an angle of 60°±5°.
8. Tighten the main bolts to an angle of 60±5°.
9. Tighten the secondary bolts to an angle of 60±5°.
10. Tighten the secondary bolts to an angle of 60±5°.
11. Tighten the main bolts to an angle of 45±5°.

ROCKER ARM INSTALLATION

NOTE:

- Ensure the lubrication holes (Figure 85, item 1) in the rocker arm shaft are oriented correctly with respect to the rocker arms (Figure 85, item 2).

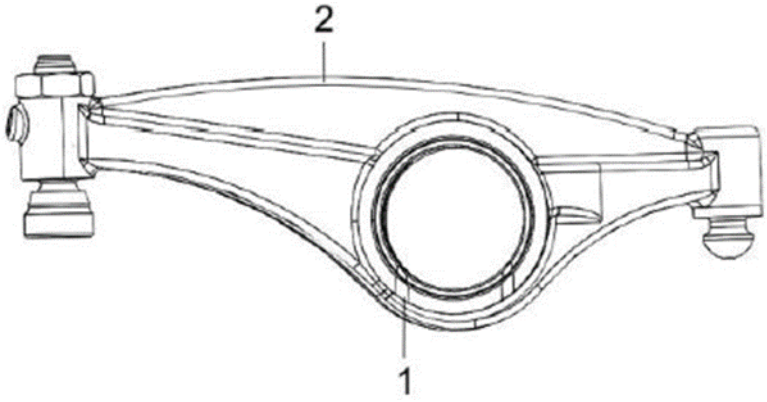


Figure 85. Rocker Arm

1. Lubricate the rocker arm shaft. Slide the rocker arm supports (Figure 86, item 1), and rocker arms (Figure 86, items 2 and 5) onto the shaft.

NOTE:

- Align the hole in the rocker arm shaft (Figure 86, item 4) and the hole in the rocker arm support (Figure 86, item 1).
- In order to orient the valve bridge correctly, the full circle side of all valve bridges should go on the top valve while the open side goes over the bottom valve.

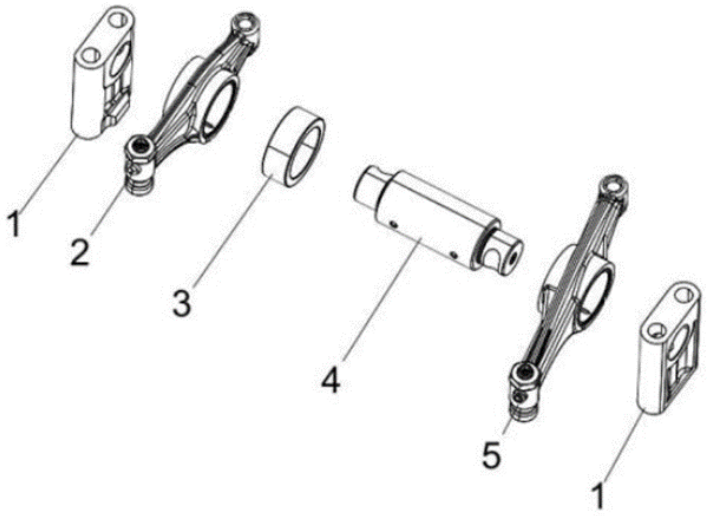
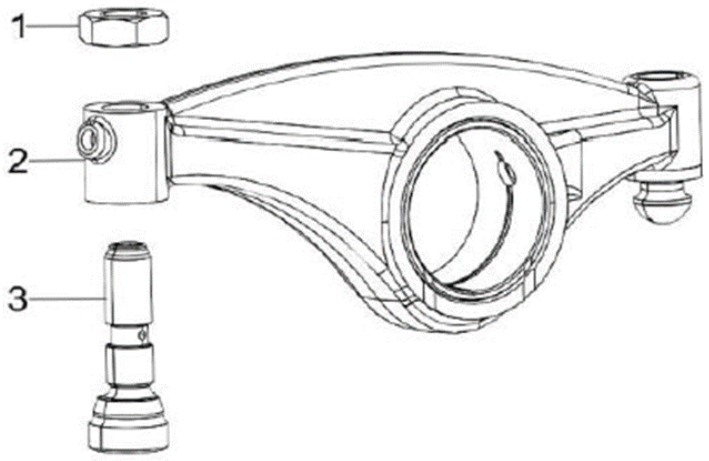


Figure 86. Rocker Arm Assembly

NO.	Name	NO.	Name	NO.	Name
1	Rocker Arm Support	3	Sleeve	5	Rocker Arm
2	Rocker Arm	4	Rocker Arm Shaft		

2. Install the tube clamp with the gasket.
3. Oil and put the valve bridges on the valves.
4. Place the rocker arm shaft assembly onto the cylinder head.
5. Insert a 0.4~0.6 mm feeler gauge between rocker arm shaft sleeve (Figure 86, item 3), and intake rocker arms assembly (Figure 86, item 5). If outside of specifications replace rocker arms.

6. If removed, reinstall the valve adjusting screws (Figure 87, item 3) and the lock the nuts (Figure 87, item 1).
7. Align the push rods with their respective rocker arms.
8. Reinstall and tighten the rocker arm shaft retaining bolts to the specified torque.



9. Adjust the valve clearance. See Measuring and Adjusting Valve Clearance Chart.

Figure 87. Rocker Arm Assembly

NO.	Name	NO.	Name	NO.	Name
1	Nut	2	Rocker Arm	3	Screw

MEASURING AND ADJUSTING VALVE CLEARANCE

NOTE:

- Measure and adjust while the engine is cold.

1. Remove the timing access cover on the flywheel to expose the timing marks on the flywheel surface (Figure 88). Remove all twelve valve covers from the engine.

Figure 88.

2. Rotate the engine until it is at TDC #1.
3. Check the rockers on cylinder #1 (Left side of the engine closest to the rear (flywheel) end of the engine). If both rockers are loose, the valves shown below with BLUE ARROWS can be adjusted. If both valves are tight the valves shown below with RED ARROWS can be adjusted see Figure 89.

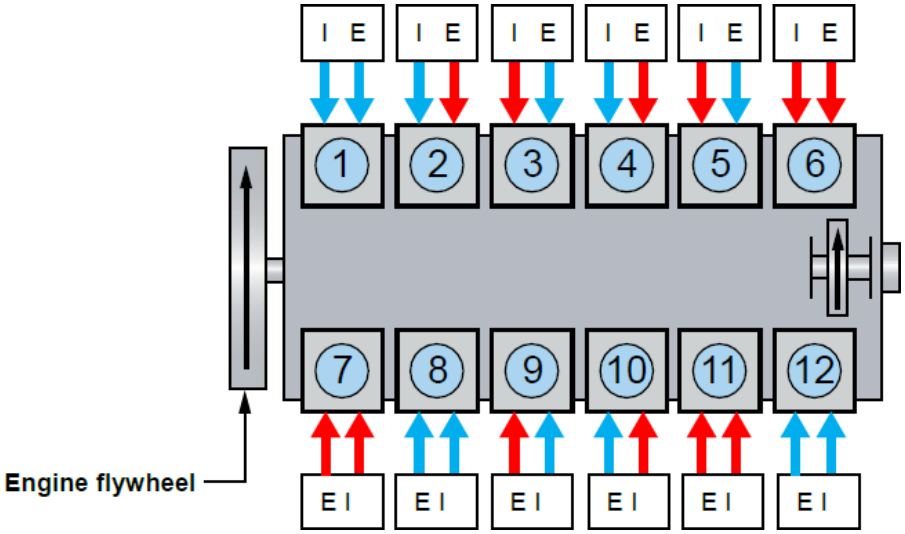


Figure 89.

4. Use a feeler gauge to check the clearance between the rocker arm and the valve bridge (Figure 90). Lash should be set to 0.022” (0.55 mm) for the intake and 0.039" (1.00 mm) for the exhaust. Repeat on all other valves with arrows of the same color as shown below.

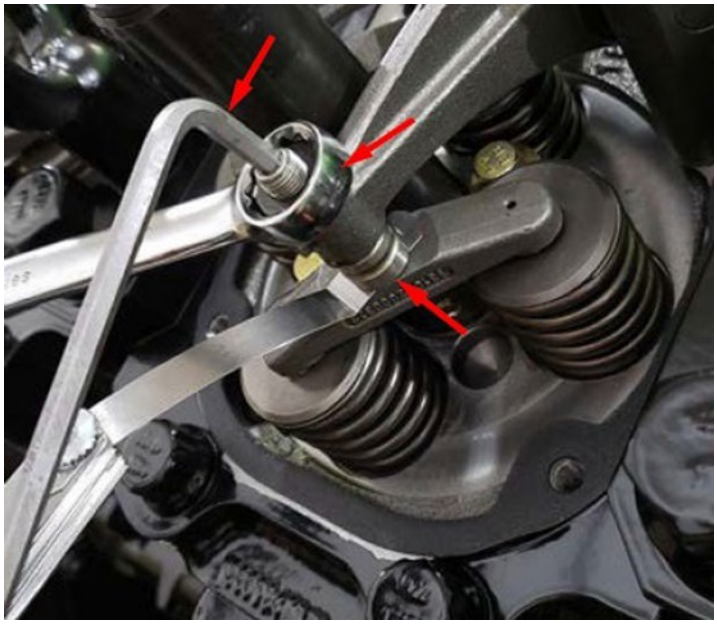


Figure 90.

5. Rotate the crankshaft 360 degrees until the timing mark is back at TDC #1 again. If the valves with the blue arrows were checked first, the valves with the red arrows may now be checked. If the valves with the red arrows were checked first, the valves with the blue arrows may now be checked.
6. Check valve lash on all rockers that were not previously checked. Adjust as necessary.
7. Reinstall valve covers.

THROTTLE BODY

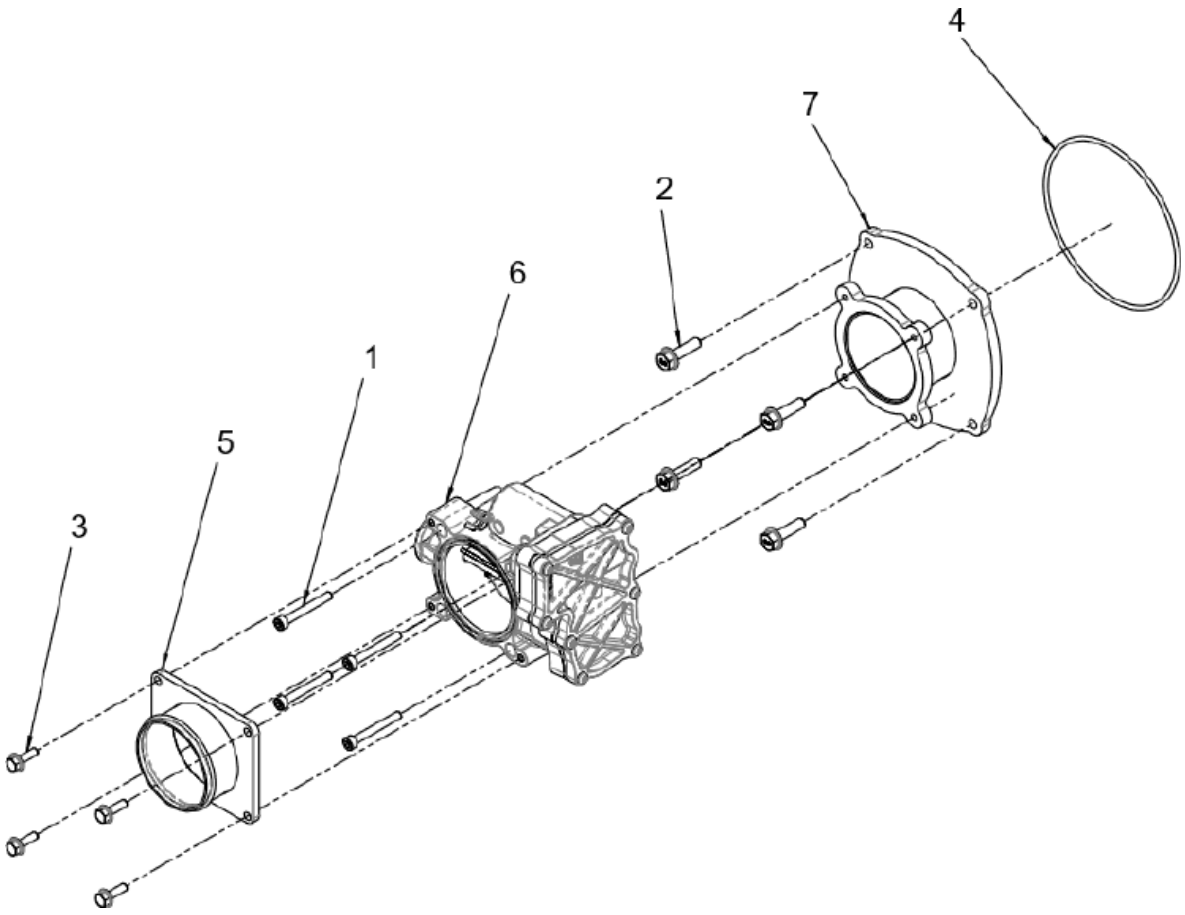


Figure 91. Throttle Body Assembly

NO.	Name
1	Bolt
2	Bolt
3	Bolt
4	O-Ring
5	Throttle Adapter
6	Throttle Body
7	Throttle Adapter

NOTE:

- All 40L engines are equipped with two throttle bodies, one on the end of each intake manifold.

REMOVAL

1. Remove the four flange bolts.
2. Remove the throttle inlet adapter.
3. Remove the four bolts from the throttle body.
4. Carefully remove the throttle body.
5. Remove the four throttle body adapter bolts.
6. Remove the throttle body adapter and gasket.

INSTALLATION

1. Clean any debris from the end of the intake manifold.
2. Clean the throttle body adapter from any debris and place the throttle adapter gasket onto the throttle body adapter.
3. Place both the throttle body adapter and gasket onto the end of the intake manifold.
4. Insert and torque down the four throttle body adapter bolts to 22 ft/lbs.
5. Carefully install the throttle body onto the throttle body adapter.
6. Apply PSI approved 242 Loctite to all four-throttle body bolts.
7. Insert and torque down the four throttle body bolts to 11 ft/lbs.
8. Place the throttle body inlet adapter onto the throttle body.
9. Insert and torque down the four-throttle body inlet adapter bolts to 10 ft/lbs.

TAPPET AND PUSHRODS

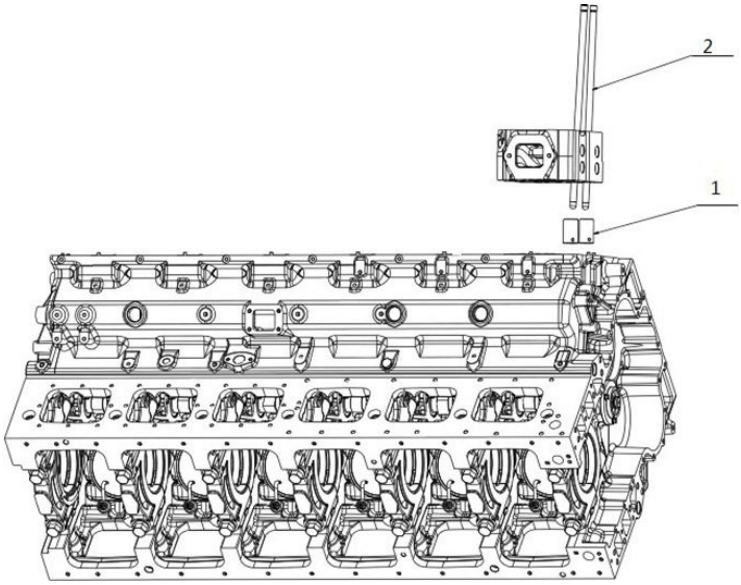


Figure 92. Tappet and Push Rod Assembly

NO.	Name
1	Tappet
2	Push rod

REMOVAL

1. Once the rocker arm and rocker arm shaft are removed you may remove the push rod.
2. Remove cylinder head in order to remove tappet. (See “CYLINDER HEAD” section)

NOTE:

- Mark each individual push rod and tappet to ease installation process.
- Tappets can stick to end of the push rod and fall into the oil pan.

INSTALLATION

1. Before assembling the tappet, clean with compressed air and inspect the oil hole is smooth and clean of all debris.
2. Apply clean PSI approved motor oil to the bottom of the valve tappet.
3. Apply clean PSI approved motor oil to the push rod and ensure that the ball and socket heads of the push rod are sufficiently lubricated.
4. Lightly put the tappet into the tappet hole.
5. Assemble the push rod and lightly put the pushrod through the cylinder head and into the tappet socket end.

CYLINDER HEAD OIL PIPE

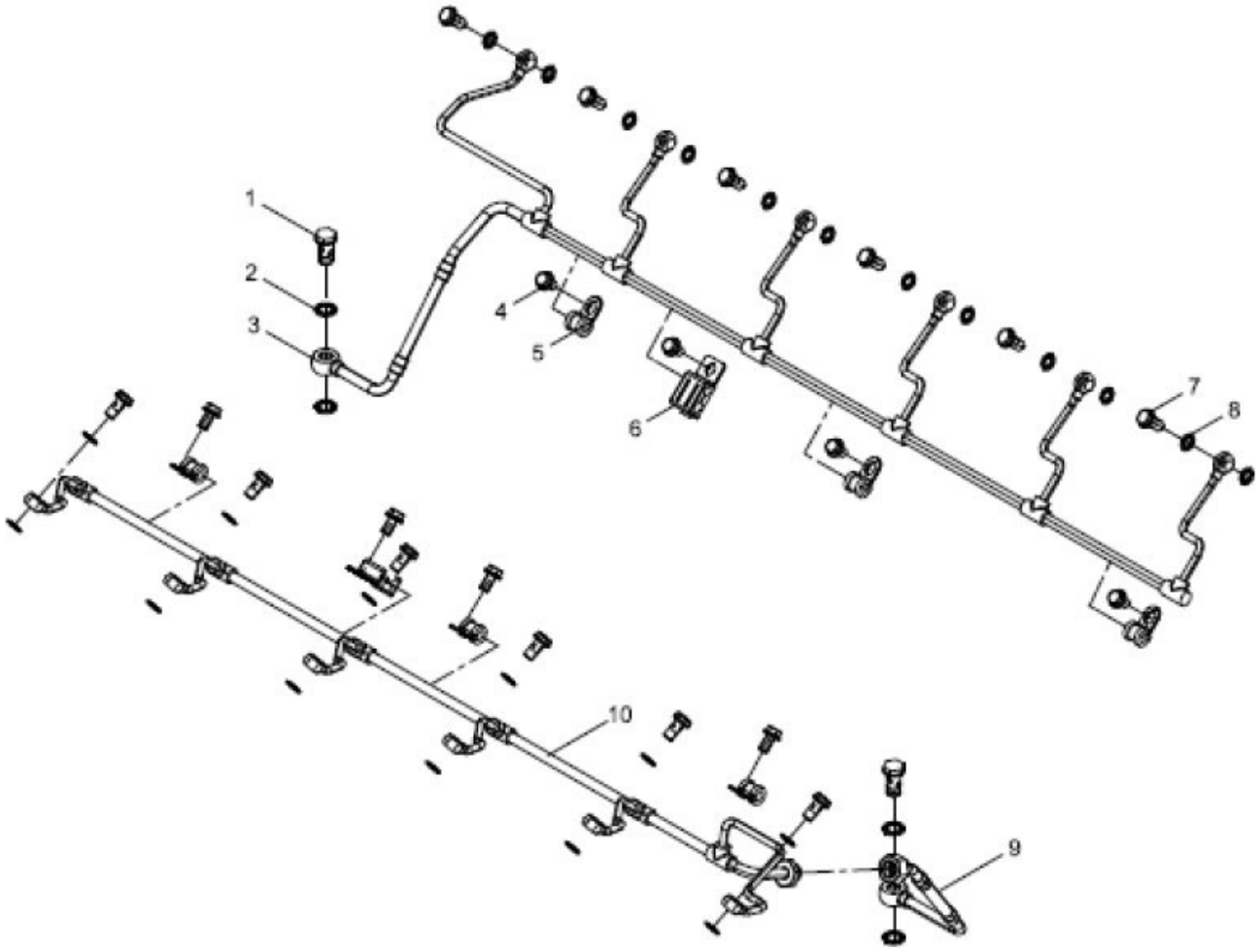


Figure 93. Cylinder Head Oil Pipe Assembly

NO.	Name	NO.	Name
1	Bolt	6	Clip
2	Washer	7	Bolt
3	Rocker Arm Tube	8	Washer
4	Bolt	9	Oil Pipe
5	Clamp	10	Rocker Arm Tube

REMOVAL

1. Remove all fuel system components from the top of the engine. (Refer to the FUEL SYSTEM section)
2. Loosen and remove the hollow bolts on both ends of the lubricating oil inlet pipe which is fixed onto the engine block and cylinder heads.
3. Remove the lubricating oil inlet pipe.
4. Loosen the flange bolts fixing the pipe clamp and remove the bolts and pipe clamps.
5. Loosen and remove the hollow bolts fixed on the cylinder head and remove the cylinder head lubricating oil pipe.

INSTALLATION

1. Align the lubricating oil pipe onto the cylinder heads.
2. Insert the hollow bolts and tighten.
3. Insert the flange bolts and pipe clamp and tighten.
4. Insert the oil inlet pipe into the engine block and cylinder heads.
5. Insert the hollow bolts on both ends of the lubricating oil inlet pipe fixed into the engine block and cylinder heads.

TIMING GEARS

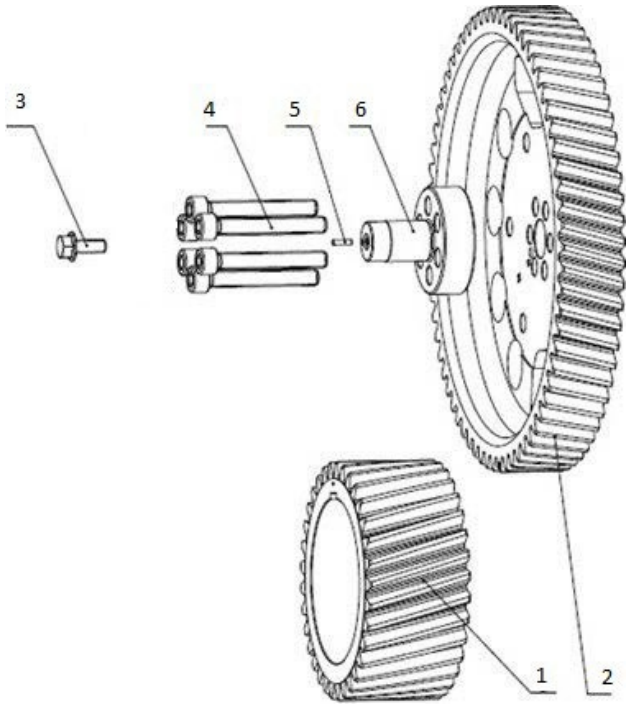


Figure 94. Timing Gears

NO.	Name
1	Crankshaft Timing Gear
2	Camshaft Timing Gear
3	Bolt
4	Hexagon Socket Head Cap Screw
5	Cylindrical Pin
6	Connecting Shaft

CHECKING CLEARANCE

1. Release the camshaft by unscrewing the adjustment screws for the entire rocker systems.
2. Verify the condition of the pinions.
3. Measure the backlash at 4 points at 90° to each pinion as well as the axial play of the camshaft.

TIMING VERIFICATION

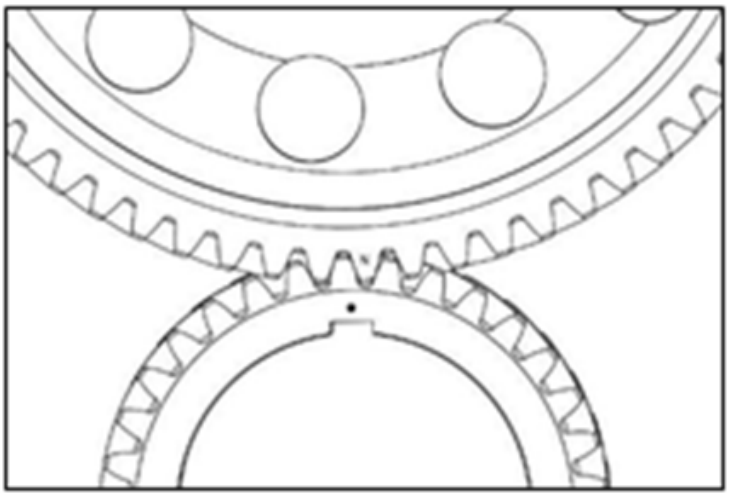


Figure 95. Timing Marks

1. Turn the crankshaft to make its gear mark "•" straight up and then locate the camshaft timing gear (Figure 95, item 2) via the cylindrical pin on the camshaft, adjust the camshaft timing gear (Figure 95, item 2), align the mark "N" on the gear end face with the mark "•" of the crankshaft timing gear (Figure 95, item 1) as shown below. And then install the connecting shaft (Figure 95, item 7) on the camshaft timing gear, and make sure to align the connecting shaft with the pin hole on the camshaft shaft timing gear. And then tighten the connecting shaft and camshaft timing gear to the camshaft with hexagon socket head cap screw (Figure 95, item 5). Tightening torque: 52 ft/lbs. Check the backlash between the crankshaft gear and camshaft gear, and the meshing clearance should be 0.09mm-0.15mm. Then connect the signal panel (Figure 95, item 4) to the connecting shaft (Figure 95, item 7) via the cylindrical pin (Figure 95, item 6) and tighten it with hexagonal flange bolt (Figure 95, item 3). (Refer to figures 94 & 95)

CRANKSHAFT AND CAMSHAFT REMOVAL, CLEANING, INSPECTION AND INSTALLATION

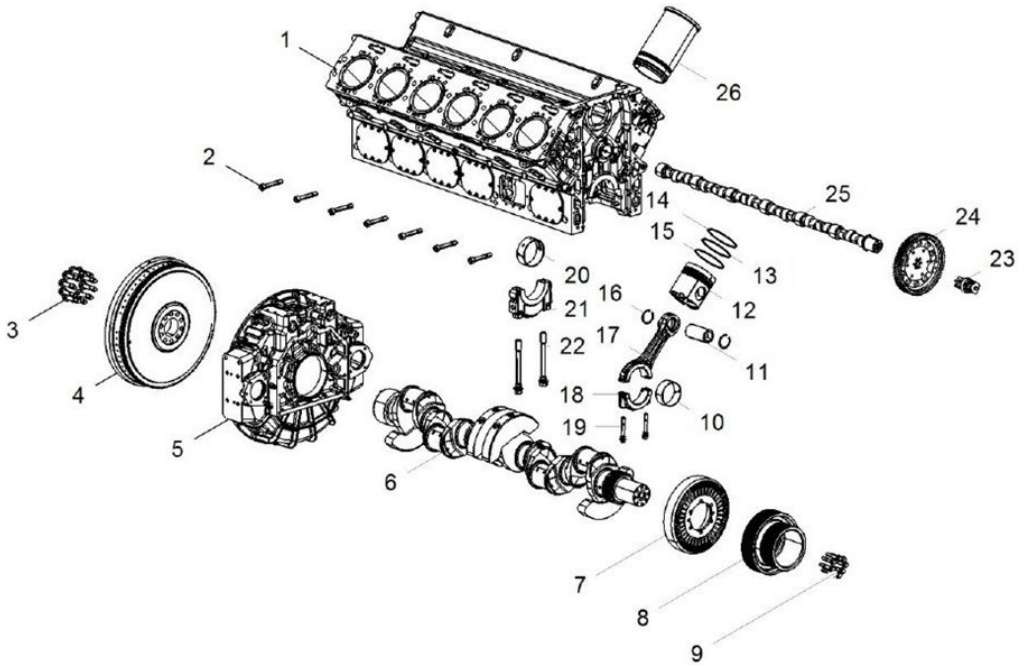


Figure 96. Engine Components

NO.	Name	NO.	Name	NO.	Name
1	Cylinder head assembly	11	Piston Pin	21	Main Bearing Cover
2	Auxiliary screw	12	Piston	22	Main Bearing Bolt
3	Flywheel bolt	13	Second Ring	23	Bolt
4	Flywheel	14	First Ring	24	Camshaft Timing Gear
5	Flywheel housing	15	Oil Ring	25	Camshaft
6	Crankshaft	16	Piston Pin Retainer	26	Cylinder Liner
7	Torsional vibration damper	17	Connecting Rod		
8	Crankshaft pulley	18	Connecting Rod Cover		
9	Bolt	19	Connecting Rod Bolt		
10	Connecting Rod Bearing	20	Main Bearing		

NOTE:

- Prepare a clean, flat working surface on a workbench large enough to accommodate the engine components. Discard all used gaskets, O-rings, and seals. Use new gaskets, O- rings and seals on reassembly of engine.
- Identify all parts and their location using an appropriate method. It is important that all parts are returned to the same position during the reassembly process.

If the engine will be completely disassembled, the following preliminary steps should be performed:

1. Disconnect the battery cables at the battery. Always disconnect the negative (-) cable first.
2. Remove the throttle cable, electrical connections, intake and exhaust system connections, and gas supply lines from the engine.
3. Remove the alternator.
4. Drain the engine coolant from the radiator and cylinder block. See Drain, Flush and Refill Cooling System with New Coolant and remove the cooling system components from the engine.
5. Remove the engine from the machine. Mount the engine to a suitable engine repair stand having adequate weight capacity.

NOTE:

- Be sure to secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.

1. Clean the engine by washing with solvent, air, or steam cleaning. Carefully operate to prevent any foreign matter or fluids from entering the engine or electrical components remaining on the engine.
2. Drain the engine oil into a suitable container. Remove the oil filter.
3. Remove the cylinder heads and related components.
4. Remove the starter motor.

DISASSEMBLY OF CAMSHAFT AND TIMING COMPONENTS

NOTE:

- Discard all gaskets, O-rings, and seals. Use new gaskets, O-rings, and seals on reassembly of the camshaft and timing components.
- Use care not to damage the threads in the end of the crankshaft when removing the crankshaft pulley.

5. Remove the thermostat assembly. *(Refer to WATER CROSSOVER PIPE AND THERMOSTAT)*.
6. Remove the fan bracket assembly.
7. Remove the tensioner and belt assembly.
8. Remove the crankshaft pulley assembly.
9. Disconnect the connecting wiring harness of speed sensor (If necessary).
10. Remove the speed sensor (If necessary).
11. Remove the bolts that retain the gear case cover to the cylinder block and oil pan.
12. Remove the front case cover.

CHECKING TIMING GEAR BACKLASH

Prior to removing the timing gears, measure the gear backlash and determine the gear wear.

Check the backlash between each pair of mating gears (Figure 97). If not within specification, replace both mating gears. See Timing Gear Backlash on specifications for service limits.

NOTE:

- Do not allow the gear being checked to move axially as excess end play could cause a false reading.

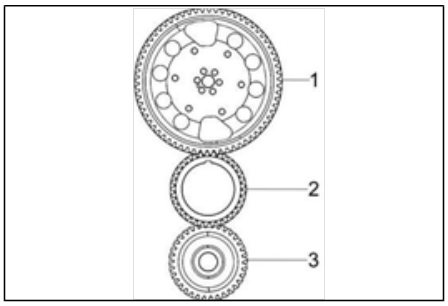


Figure 97.

NO.	Name
1	Camshaft Drive Gear
2	Crankshaft Drive Gear
3	Oil Pump Drive Gear

MEASURING CAMSHAFT GEAR-TO-CRANKSHAFT GEAR BACKLASH

1. Install a dial indicator as shown in Figure 98.
2. Rotate the camshaft gear back and forth to check the camshaft gear-to- crankshaft gear backlash. The total indicator reading is the backlash. Record the measurement.

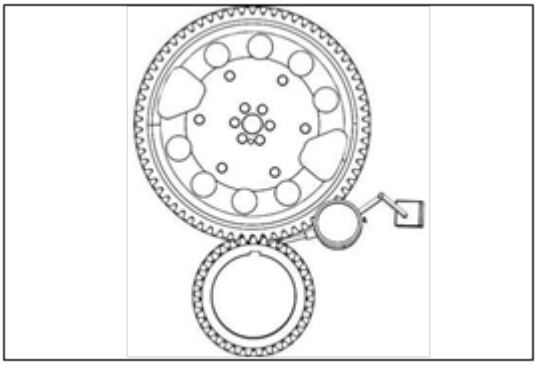


Figure 98.

REMOVAL OF CAMSHAFT

NOTE:

- Before removing the camshaft, check the camshaft end play.
- Do not remove the crankshaft gear unless it is damaged and requires replacement. If the gear must be removed, remove it using a gear puller.

1. Install a dial indicator (Figure 99, item 1) on the cylinder block. Move the camshaft (Figure 99, item 2) back and forth to measure the end play. Record the measurement. See Camshaft specifications for the service limit.

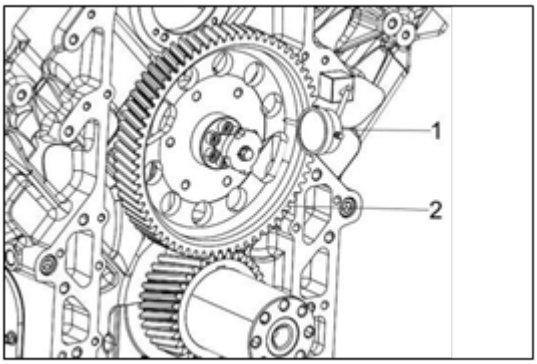


Figure 99.

NO.	Name	NO.	Name
1	Dial Indicator	2	Camshaft

2. Loosen the tightening bolt and remove the trigger wheel (Figure 100, item 2).
3. Remove the bolts (Figure 100, item 3) from the connecting shaft (Figure 100, item 4) of trigger wheel. Remove the connecting shaft, camshaft gear (Figure 100, item 5).

4. Before removing the camshaft, take out the tappet first.
5. Remove the three bolts retaining the camshaft thrust bearing.
6. Slowly pull the camshaft assembly out of the engine being careful not to damage the camshaft bushing.

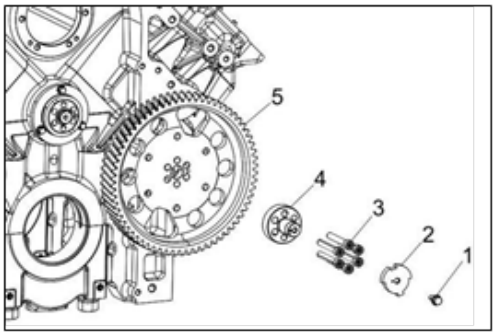


Figure 100.

NO.	Name	NO.	Name
1	Bolt	4	Connecting Shaft
2	Trigger Wheel	5	Camshaft Gear
3	Bolt		

REMOVAL OF PISTONS

NOTE:

- Keep the piston pin parts, piston assemblies, and connecting rod assemblies together to be returned to the same position during the reassembly process. Label the parts using an appropriate method.

- Engines with high operating hours may have a ridge near the top of the cylinders that will catch the piston rings and make it impossible to remove the pistons. Use a suitable ridge reamer to remove ridges and carbon prior to removing the pistons.

1. Remove the oil cooler assembly.
2. Remove the water inlet assembly.
3. Remove the oil filter assembly.
4. Remove the hand-hole covers.
5. Remove the oil filling pipe.
6. Remove the oil dipstick and dipstick pipe upper set.
7. Bar over the engine so that the upper fixing bolts of the cap of the connecting rod to be removed is in line with the inspection door opening. Loosen and remove the connecting rod bolts.
8. Remove the connecting rod cap with the lower half bearing.
9. Mark the connecting rod caps and connecting rods so the caps and connecting rods stay together.

NOTE:

- Do not allow the connecting rod to contact the crankshaft journal during piston removal. Damage to the bearing journal may result.

1. Use a wooden dowel against the connecting rod and tap the piston / connecting rod assembly out of the cylinder.
2. Mark the cylinder number on the piston and connecting rod.
3. Remove the connecting rod bearings (Figure 101, item 9).

4. Remove the compression rings (Figure 101, item 1) from the piston using a piston ring expander.
5. Remove the oil ring (Figure 101, item 2) from the piston using a piston ring expander.
6. Remove the circlips (Figure 101, item 4) from the piston pin.
7. Remove the piston pin (Figure 101, item 5) and connecting rod (Figure 101, item 6) from the piston (Figure 101, item 3).
8. Repeat the steps until all pistons are removed and disassembled.

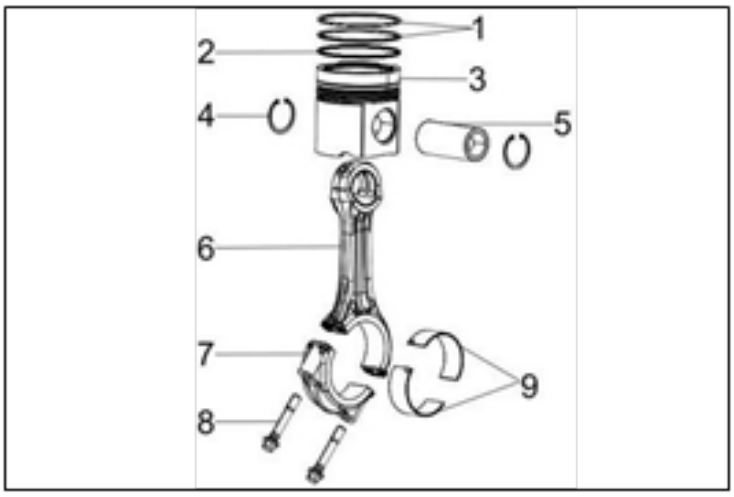


Figure 101.

NO.	Name	NO.	Name	NO.	Name
1	Compression Ring	4	Circlip	7	Connecting Rod Cap
2	Oil Ring	5	Piston Pin	8	Connecting Rod Bolt
3	Piston	6	Connecting Rod	9	Connecting Rod Bearing

REMOVAL OF CYLINDER LINER

NOTE:

- Take care not to damage the piston jet when removing and installing the mobile coupling to the cylinder block.

1. Use cloths to protect the crankshaft tang and the bottom of the block to minimize any pollution with oil compartment.
2. Install the extraction tool (Figure 102, item 1).
3. Slowly turn the nut and remove the cylinder liner and tool together.

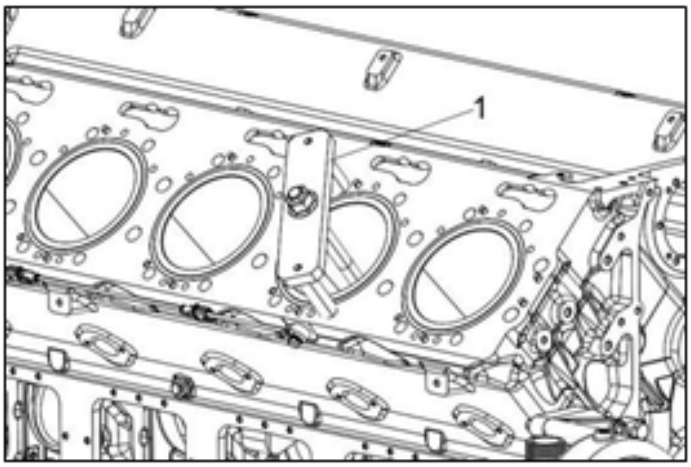


Figure 102.

NO.	Name
1	Extraction Tool

4. Disassemble the O-rings from the cylinder liner (Figure 103).
5. Repeat the steps until all liners are removed.
6. Clean the inside of the oil sump. Remove the protective covers.

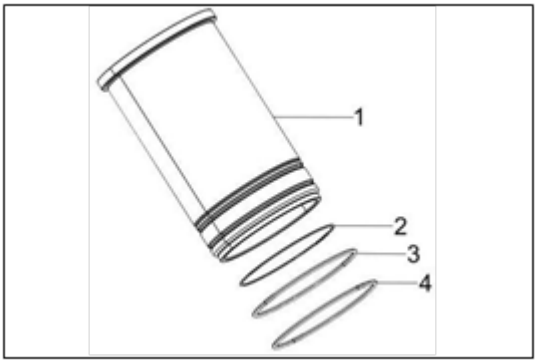


Figure 103.

NO.	Name	NO.	Name
1	Cylinder Liner	3	Oil Ring
2	Oil Ring	4	Oil Ring

REMOVAL OF OIL PAN AND OIL PIPELINE

NOTE:

Replace all O-Rings if removed.

1. Remove the water pump assembly and oil pump.
2. Invert the engine (Oil pan up) on the engine stand.
3. Remove the oil pan (Figure 104, item 1).

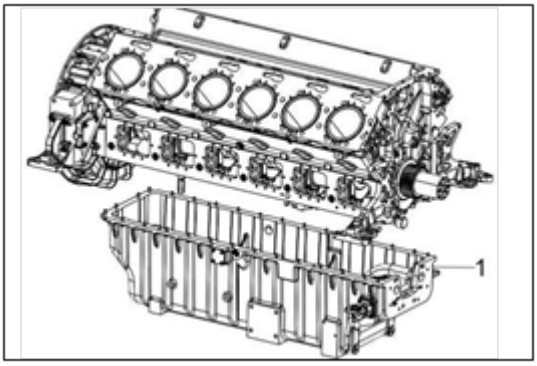


Figure 104.

NO.	Name
1	Oil Pan

4. Remove the oil strainer (Figure 105, item 1) in two stages.
5. Remove the pipe joints (Figure 105, item 2).
6. Remove the supporting seat (Figure 105, item 3) oil pipe and oil pump pressure limiting valve.
7. assembly (Figure 105, item 4).

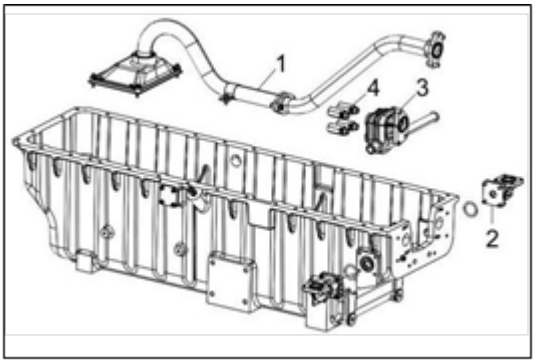


Figure 105.

NO.	Name	NO.	Name
1	Oil Strainer	3	Supporting Seat
2	Pipe Joints	4	Limiting Valve

8. Remove the oil pipeline group (Figure 106, item 1) and disassemble the oil pressure limiting valve (Figure 106, item 2) if necessary.

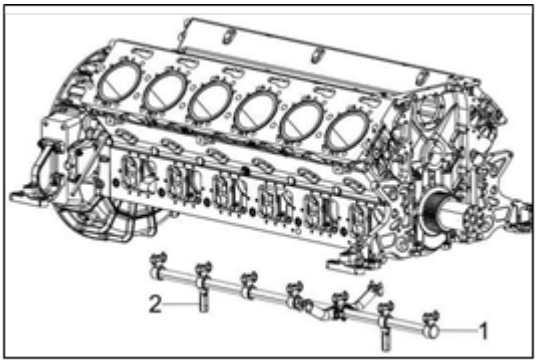


Figure 106.

NO.	Name
1	Oil Pipeline
2	Limiting Valve

REMOVAL OF FLYWHEEL

NOTE:

Weight of flywheel is 255 lbs (116.8 kg).

1. Remove the starter from the flywheel housing.
2. Remove two diametrically opposed bolts from the flywheel. Fit the flywheel guides (Figure 107, item 1) instead.

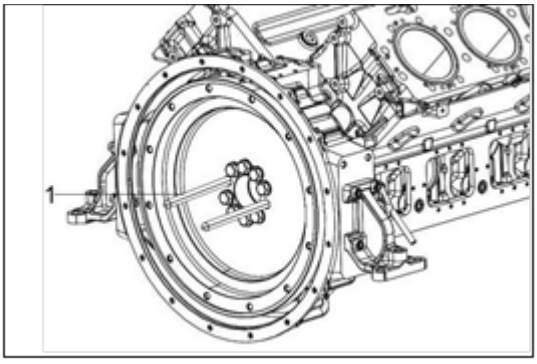


Figure 107.

NO.	Name
1	Flywheel Guides

3. Remove all the flywheel fixing bolts (Figure 108, item 1).
4. Fit suitable handling equipment for removing the flywheel. If it is difficult to remove the flywheel, use an appropriate tool to facilitate dismantling by levering at the starter hatch.
5. Remove the flywheel (Figure 108, item 2) from the crankshaft.
6. Disassemble the flywheel gear ring from the flywheel if necessary.

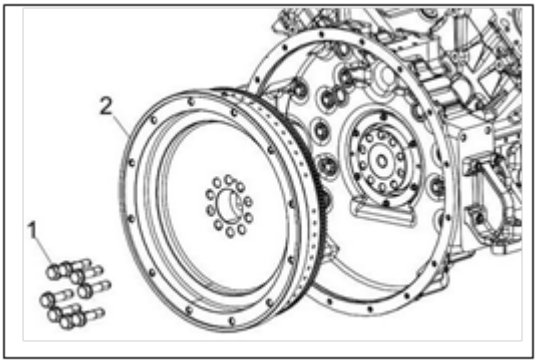


Figure 108.

NO.	Name
1	Bolts
2	Flywheel

REMOVAL OF CRANKSHAFT POSITION SENSOR

1. Remove bolt (Figure 109, Item 3) from flywheel housing.
2. Remove crankshaft sensor (Figure 109, Item 2) from flywheel housing.
3. Remove shim(s) (Figure 109, Item 1) from flywheel housing.

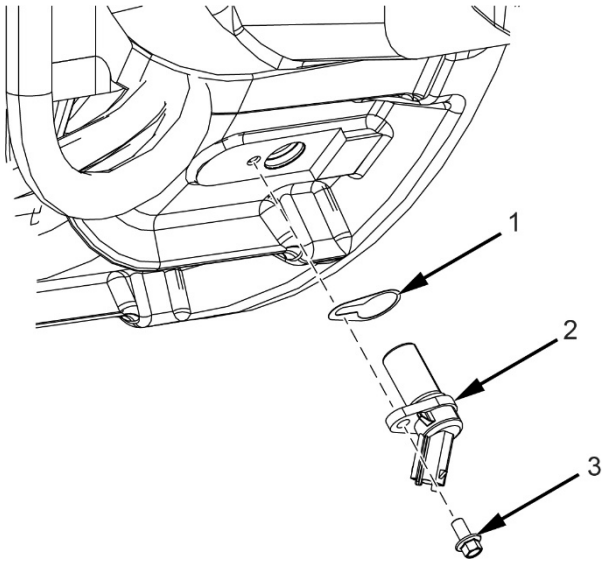


Figure 109.

NO.	Name
1	Shim
2	Crankshaft Sensor
3	Bolt

REMOVAL OF FLYWHEEL HOUSING

1. Secure and support the engine block.
2. Remove the engine bracket group (Figure 110).

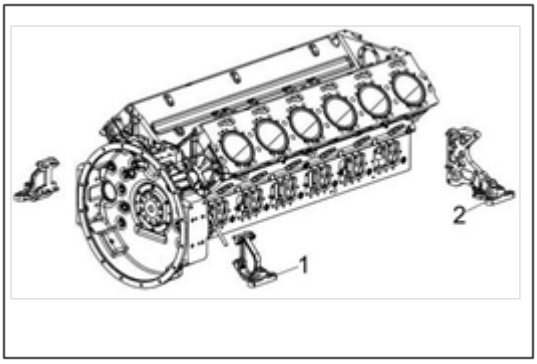


Figure 110.

NO.	Name
1	Rear Engine Bracket
2	Front Engine Bracket

3. Loosen and remove the flywheel housing fasten bolts (Figure 111, item 1).
4. Remove flywheel housing group (Figure 111, item 2).

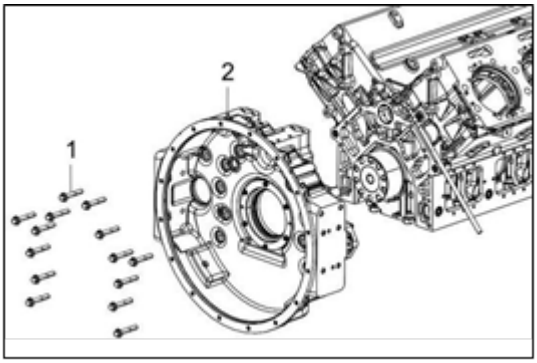


Figure 111.

NO.	Name
1	Bolts
2	Flywheel Housing

5. Remove the rear oil seal group from the flywheel housing.
6. Disassemble the rear oil seal (Figure 112, item 2) from the rear oil seal seat (Figure 112, item 3).

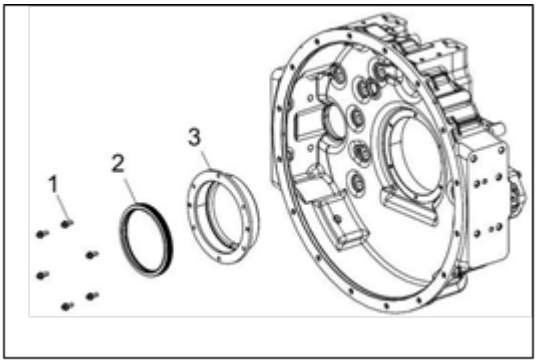


Figure 112.

NO.	Name
1	Bolt
2	Rear Oil Seal
3	Rear Oil Seal Seat

MEASURING CRANKSHAFT END PLAY

Before removing the main bearing caps, measure the crankshaft end play by using either of the below methods:

METHOD A: Install a dial gauge (Figure 113, item 1) on the cylinder block. Move the crankshaft (Figure 113, item 2) front to rear to measure the end play. Record the measurement.

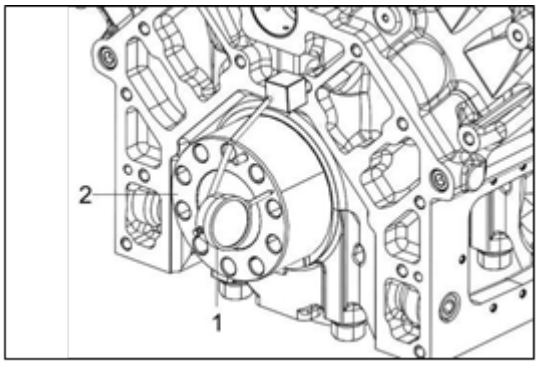


Figure 113.

NO.	Name
1	Dial Gauge
2	Crankshaft

METHOD B: Use a feeler gauge to measure the clearance (Figure 114, item 3) between the thrust bearing (Figure 114, item 1) and crankshaft (Figure 114, item 2). Record the measurement. See Thrust Bearing specifications for the service limit.

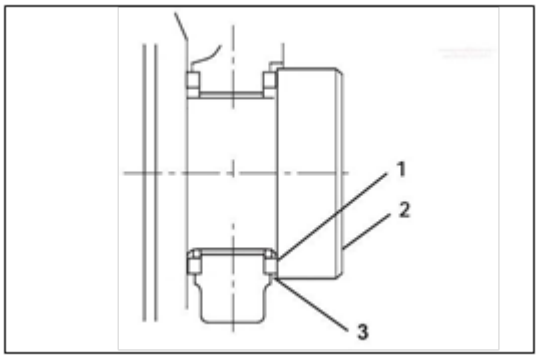


Figure 114.

REMOVAL OF CRANKSHAFT

NOTE:

- Do not remove the crankshaft gear unless the gear or crankshaft is damaged and require replacement.

1. Loosen and remove the main bearing cap auxiliary bolts (Figure 115, item 1) and washer (Figure 115, item 2).
2. Loosen and remove the main bearing bolts (Figure 116, item 1).
3. Remove the main bearing caps (Figure 116, item 2). Be sure to note the markings on the main bearing caps, or mark them yourself, so they can be reinstalled in the same order as they were removed. **DO NOT REMOVE THE BEARING INSERTS AT THIS TIME.**

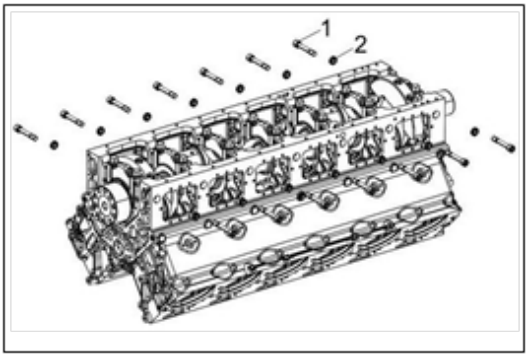


Figure 115.

NO.	Name	NO.	Name
1	Bolt	2	Washer

4. Remove the upper main bearings (Figure 116, item 4) and thrust plates (Figure 116, item 3).

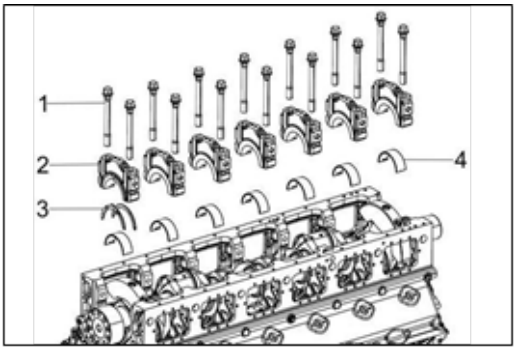


Figure 116

.NO.	Name	NO.	Name
1	Bolt	3	Thrust Plates
2	Main Bearing Caps	4	Upper Main Bearings

5. Remove the crankshaft (Figure 117, item 1) from the engine.
6. Remove the bearing inserts (Figure 117, item 2) and thrust plates (Figure 117, item 3).

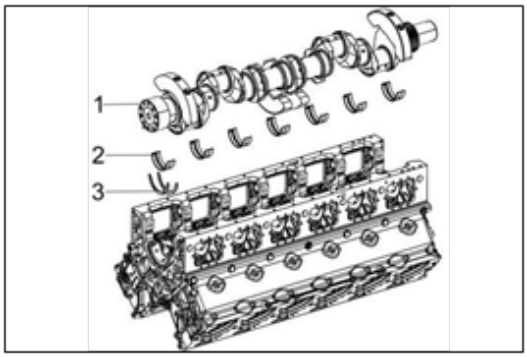


Figure 117.

NO.	Name	NO.	Name	NO.	Name
1	Crankshaft	2	Bearing Inserts	3	Thrust Plates

INSPECTION OF CRANKSHAFT AND CAMSHAFT COMPONENTS

Thoroughly clean all components using a brush and appropriate solvent. Each part must be free of carbon, gasket material, metal filings and other debris.

Oil clearance should be checked during disassembly to determine the extent of wear, and during assembly to ensure long engine life. The same procedure is done for both connecting rods and main bearings.

INSPECTION OF CYLINDER LINER

1. Check for discoloration or evidence of cracks. If a fracture is suspected, use the color check method or the Magnaflux method to determine if the cylinder liner is fractured.
2. Inspect cylinders liner for roundness, taper, or evidence of scoring. Collect and record the measurements. Replace the cylinder liner if the measurements are not within specification.
3. Take measurements at three places (Figure 118) (a, b, c), and in two directions (d and e) in each cylinder liner.

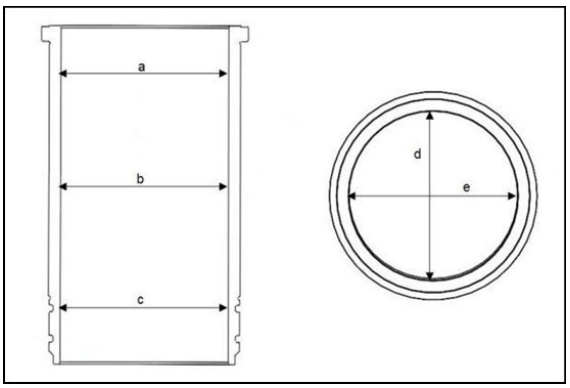


Figure 118.

INSPECTION OF PISTONS, RINGS AND PISTON PIN

NOTE:

- On an engine with low hours, the pistons and piston rings may be reused if they are found to be within specifications. The pistons and piston rings must be reinstalled in the same cylinders from which they were originally removed.

- On an engine with high hours, the pistons rings should be replaced. The piston and cylinder liner should be replaced as necessary.

1. Clean piston ring grooves using a piston ring groove cleaning tool. Follow manufacturer's instructions for correct operation.
2. Wash the pistons in an appropriate solvent using a soft brush.
3. Visually inspect each piston for cracks. Pay attention to the ring lands between the piston ring grooves.
4. Measure the diameter of the piston skirt at 90° to the wrist pin bore as shown (Figure 119). Measurements must be taken at a specified distance (Figure 119, item 1) from the bottom of the piston. Record measurements. See *Mechanical Specifications Chart*.

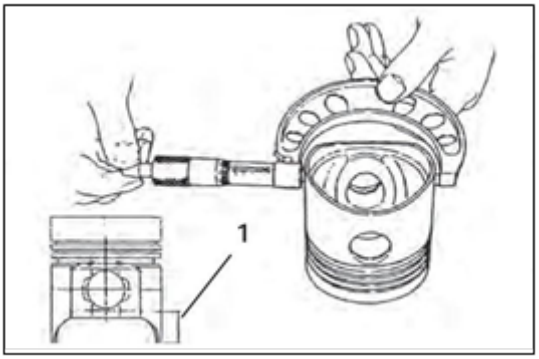


Figure 119.

5. Subtract the piston measurement from the greatest measurement acquired during cylinder inspection to obtain piston-to-cylinder clearance. Record the Measurement. Measure the diameter of the piston pin bore on both sides of the piston (Figure 120). See the mechanical specifications chart. Record the measurements.

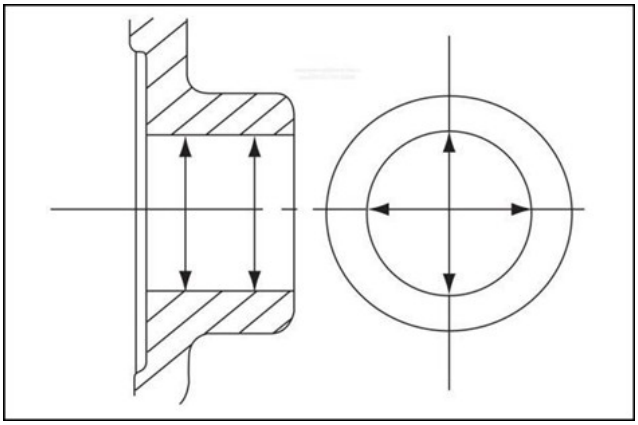


Figure 120.

6. Measure the outside diameter of the piston pin in three places and at 90° (Figure 121). See the mechanical specifications chart. Record the measurements.

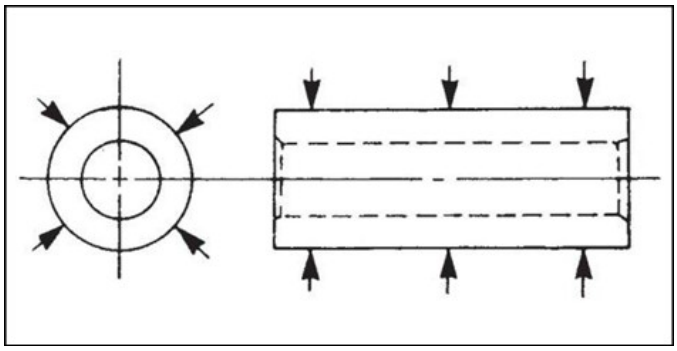


Figure 121.

7. Use a micrometer, measure the thickness of each piston ring. See the piston mechanical specifications chart. Record the measurements.
8. Place each compression piston ring in the groove as shown (Figure 122). Use a feeler gauge to measure the clearance between the piston ring and the piston ring land. Record the measurements. See Piston Ring mechanical specifications chart. Replace the piston if not within specification.

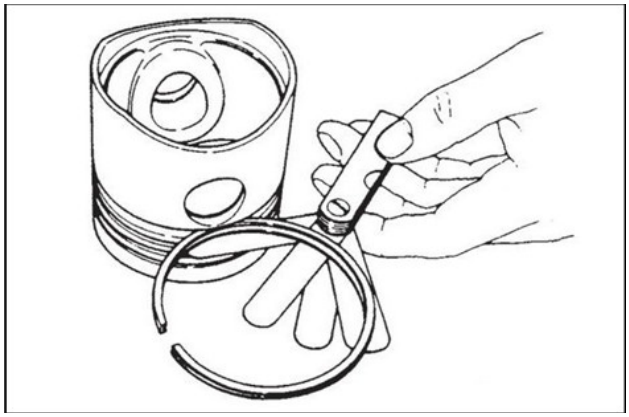


Figure 122.

9. To measure piston ring end gap, insert each compression piston ring (Figure 123, item 1), one at a time, into the cylinder. Use a piston with the piston rings removed to slide the ring into the cylinder bore until it is approximately 1.18 in. (30 mm) (Figure 123, item 2) from the bottom of the bore. Remove the piston. Measure the end gap (Figure 123, item 3) of each piston ring. Record the measurements. See Piston Ring mechanical specifications chart.

NOTE:

- Always check the piston ring end gap when installing new piston rings.

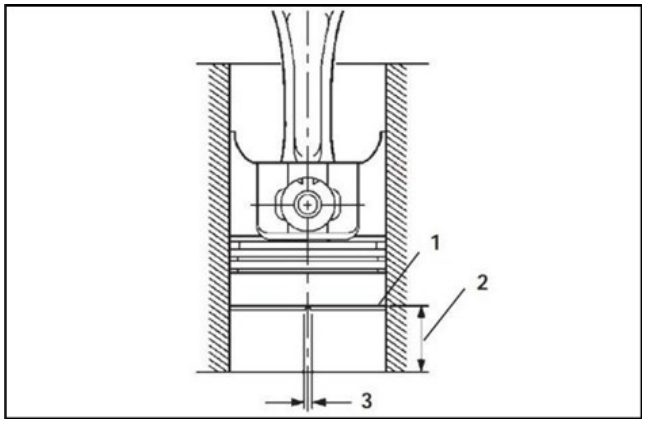


Figure 123.

10. Repeat the above steps for each cylinder and piston assembly.

INSPECTION OF CONNECTING ROD

1. Measure the piston pin bushing bore using a bore gauge (Figure 124, item 1). Replace the bushing if not within specifications. If the bushing has been removed, measure the inside diameter of the connecting rod small end (Figure 124, item 2). See Connecting Rod mechanical specifications.

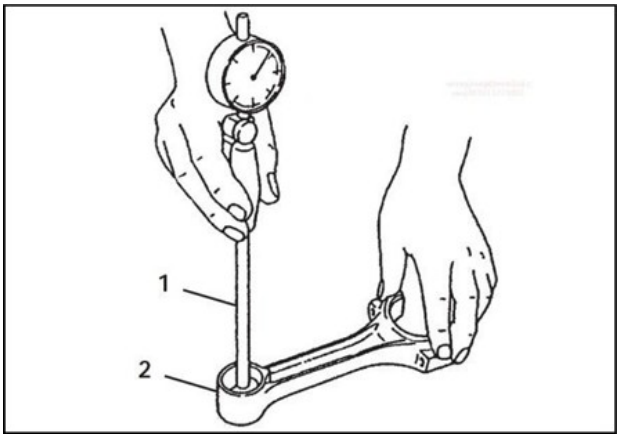


Figure 124.

NO.	Name	NO.	Name
1	Bore Gauge	2	Connecting Rod

2. Place the connecting rod bearing inserts into the connecting rod and connecting rod cap. Install the rod cap and tighten the bolts to the specified torque.
3. Measure the inside diameter. See Crankshaft mechanical specifications chart.

INSPECTION OF TAPPETS

1. Inspect the tappet contact surfaces for abnormal wear (Figure 125, item 1).
2. Measure the outside diameter of the tappet stem (Figure 125, item 2). See the mechanical specifications chart for the service limit.

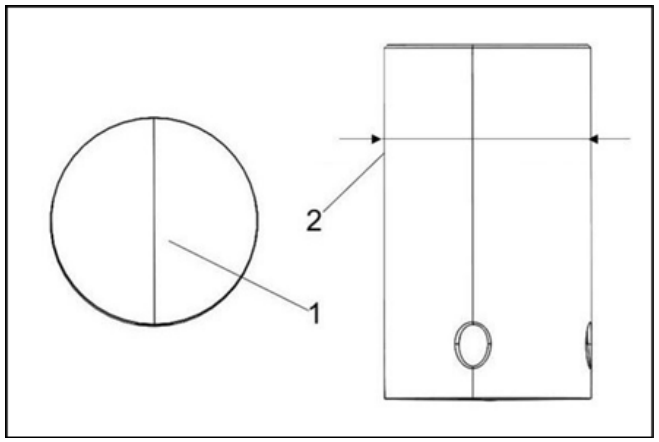


Figure 125.

INSPECTION OF CRANKSHAFT

1. Place the crankshaft end journals (Figure 126, item 4) on V-blocks.
2. Place a dial indicator (Figure 126, item 3) on the center main bearing surface.

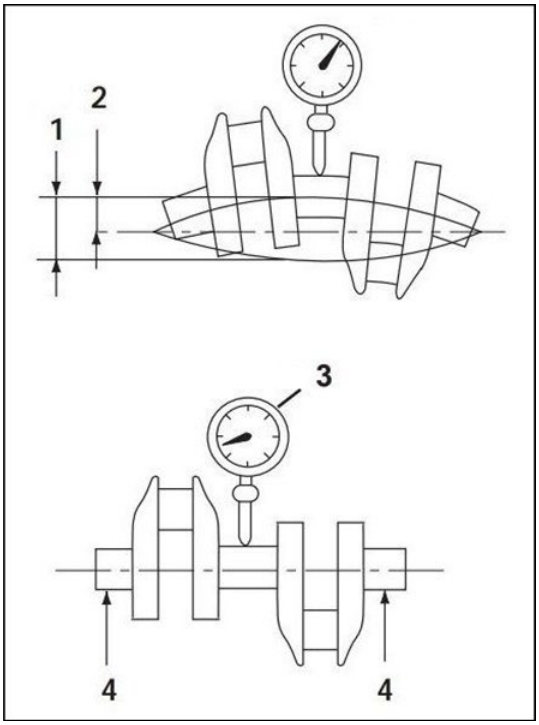


Figure 126.

NO.	Name	NO.	Name
1	Runout Measurement	3	Dial Indicator
2	Runout Measurement	4	End Journals

3. Rotate the crankshaft and observe runout. See Crankshaft Mechanical Specifications chart.
4. Use the color check method or Magnaflux® to inspect the crankshaft for cracks. Replace the crankshaft if evidence of fractures is found.

5. Measure the outside diameter of each crankpin (Figure 127, item 2) and main bearing journal (Figure 127, item 1). See the Crankshaft mechanical specifications chart. Take measurements at several places around each bearing surface. If not within specification, grind the journals and install undersize bearings, or replace the crankshaft.

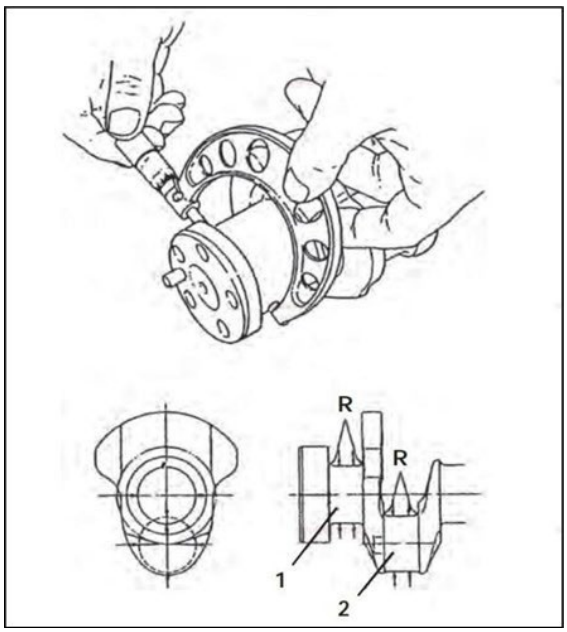


Figure 127.

INSPECTION OF CAMSHAFT

1. Use V-blocks and a dial indicator to check camshaft bend (Figure 128). Place the indicator on the center bearing journal.

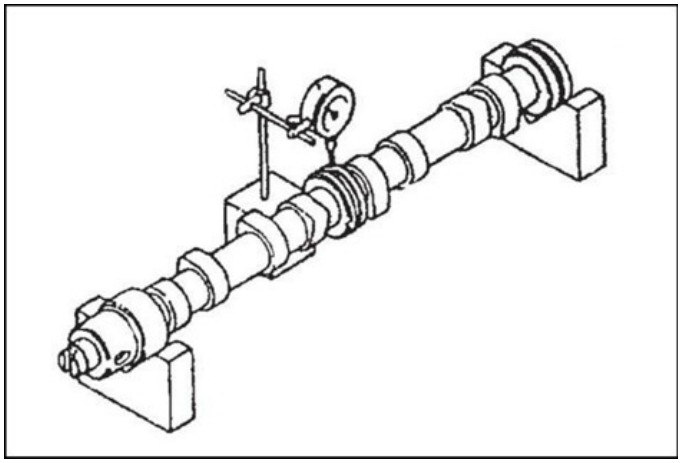


Figure 128.

2. Rotate the camshaft and observe the runout. See the Camshaft specifications chart.
3. Measure the height of each lobe (Figure 129, item 1). See the Camshaft specifications chart.

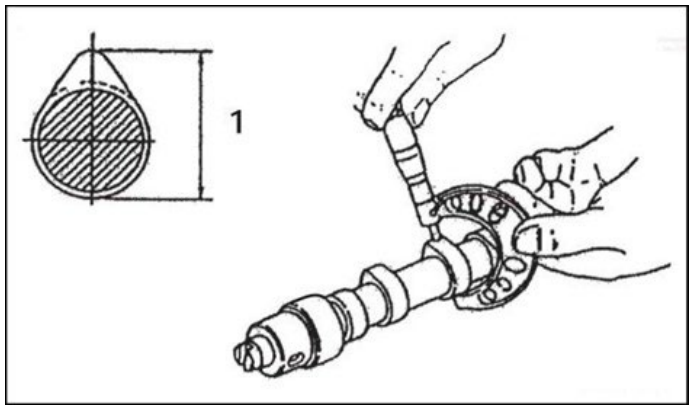


Figure 129.

4. Measure the diameter of the gear end, intermediate, and flywheel end bearing journals. See the Camshaft specifications chart.
5. Measure the I.D. of the front bushing and the remaining bores in the cylinder block. See the Camshaft specifications chart.
6. If the camshaft bushing is not within specification, replace it using the appropriate service tool. If the remaining bores are not within specification, the cylinder block will require replacement as there are no bearing inserts used.

INSTALLATION OF CYLINDER LINER

NOTE:

- Proceed slowly. Make no forced assemblies unless a pressing operation is called for. All parts must be perfectly clean and lightly lubricated when assembled.
- Use new gaskets, seals, and O-rings during assembly.
- Apply clean engine oil to all internal parts during assembly.
- All fasteners should be tightened to a given torque. If a special torque is not provided in the Special Torque Chart, tighten to standard torque specifications. See Tightening Torques for Standard Bolts and Nuts chart.
- The O-rings can be used only once.
- The liner has no pre-defined orientation.

1. Equip the liner with new seals (Figure 130) coated with grease or clean oil.

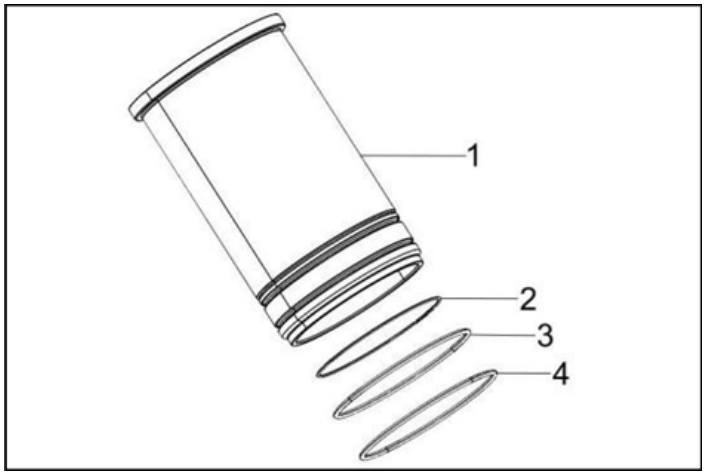


Figure 130.

NO.	Name	NO.	Name
1	Cylinder Liner	3	Oil Ring
2	Oil Ring	4	Oil Ring

2. Carefully clean the liner housing. Visually inspect and dimensionally check the bores.
3. Coat the bore contact areas with grease or clean oil. Slide the liner into its housing.
4. Manually, center the liner and apply vertical pressure to initiate nesting.
5. Install the cylinder liner installer (Figure 131, item 1) on the engine block and nest the liner (Figure 131, item 2) using the special tool.
6. Install the liner back in the same position it was in before. For a new liner, the supplier mark should always be at 12 o'clock.
7. Remove the tool, taking care not to bump or scratch the liner bore.
8. Measure cylinder liner protrusion, the value is 0.05-0.10mm.

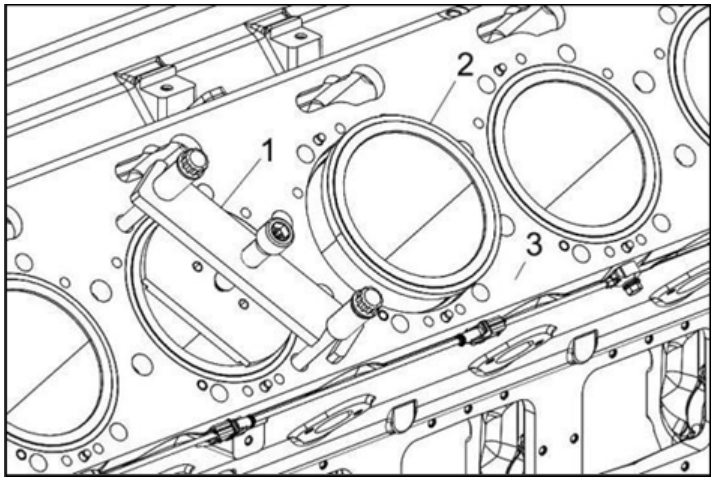


Figure 131.

NO.	Name
1	Cylinder Liner Installer

REASSEMBLY OF PISTONS

NOTE:

- The actual appearance of the match marks on the piston and connecting rod may vary, but they will always be in the same locations.
- The rings must always be replaced when fitting a new liner.

1. Select the parts needed to reassemble the piston and connecting rod for one cylinder.
2. Carefully clean the ring grooves of the piston (Figure 132, item 3). Fit the piston rings (Figure 132, items 1 & 2) with the special tool.
3. After fitting the rings, check that the rings move easily and do not catch on the grooves. Make sure the marking faces the top of the piston.

NOTE:

- **1st groove:** Keystone Ring – The marking "TOP" must face the top of the piston.
- **2nd groove:** Sealing Ring – The marking "CYPR" must face the top of the piston.
- **3rd groove:** Scraper Ring – No marking, does not matter which way up it is fitted.

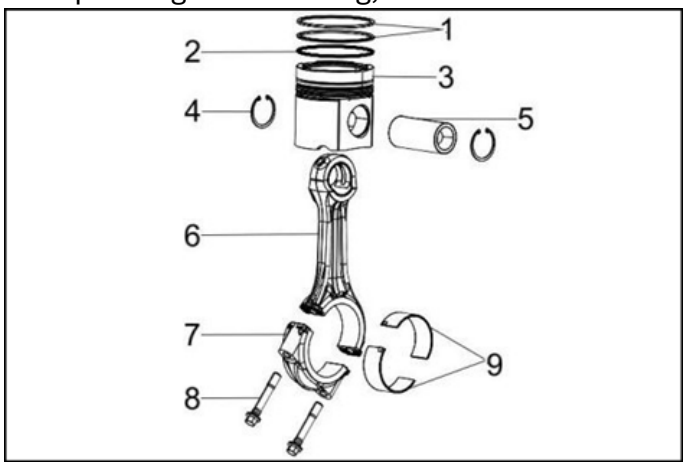


Figure 132.

NO.	Name	NO.	Name	NO.	Name
1	Compression Ring	4	Circlip	7	Connecting Rod Cap
2	Oil Ring	5	Piston Pin	8	Connecting Rod Bolt
3	Piston	6	Connecting Rod	9	Connecting Rod Bearing

4. Check all the connecting rods (Figure 132, item 6) and make sure that the connecting rods are in the same weight group.

NOTE:

- The piston does not have a mounting direction. In principle, the manufacturer marking on the top of the piston will be oriented towards the flywheel side.
- In case of difficulty inserting the piston pin, you can heat the piston in an oven to a temperature of about 43°F.

5. Fit the 1st circlip (Figure 132, item 4) onto one end of the piston.
6. Lightly oil the bore openings and insert the piston pin (Figure 132, item 5) into the first part of the bore.
7. Present the connecting rod and continue to insert the piston pin until it butts up against the circlip on the opposite bore.
8. Fit the second circlip.
9. Stagger the piston ring end gaps at 120° intervals (Figure 133). Do not position the top piston ring end gap in line with the piston pin.

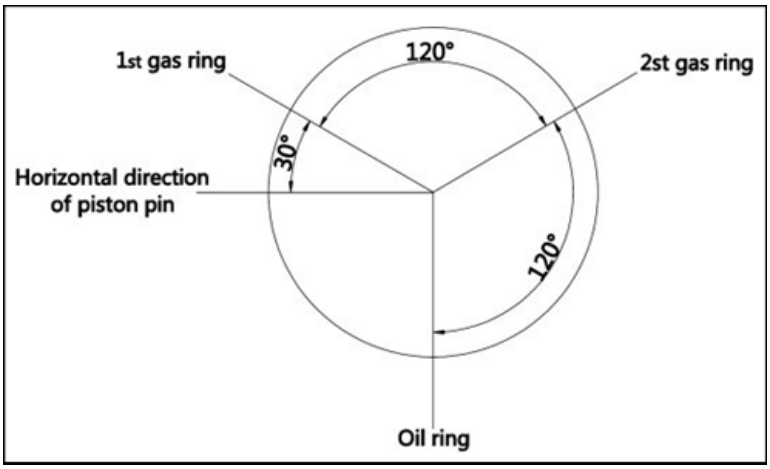


Figure 133.

INSTALLATION OF CRANKSHAFT

1. Install the piston cooling jet.
2. If removed, reinstall the timing gear on the crankshaft.
3. Reinstall new main bearing (Figure 134, item 2) and thrust plate (Figure 134, item 3) in the cylinder block and main bearing caps.

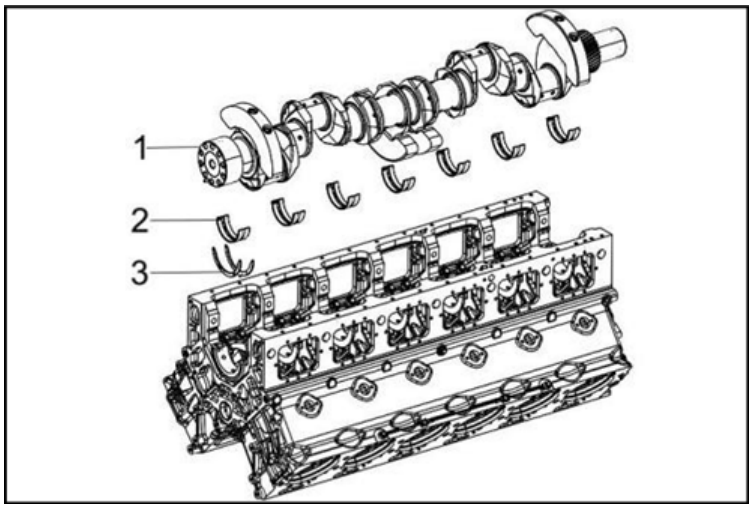


Figure 134.

NO.	Name	NO.	Name	NO.	Name
1	Crankshaft	2	Main Bearing	3	Thrust Plate

4. Apply a liberal coat of clean engine oil to the bearings and crankshaft journals.
5. Place the crankshaft (Figure 134, item 1) into the engine.
6. Reinstall new main bearing (Figure 135, item 4) and thrust plate (Figure 135, item 3) in the main bearing caps (Figure 135, item 2).

NOTE:

- Make sure the lubrication grooves face the area of friction.
- If it is difficult to install the main bearing caps, put a wall spreader between the wall of the two rear bearings. Perform stressing of the cylinder block (max. 0.25 mm).
- After the first disassembling of the main bearing bolts by the user, the original main bearing bolts can be reused for at most 4 times.

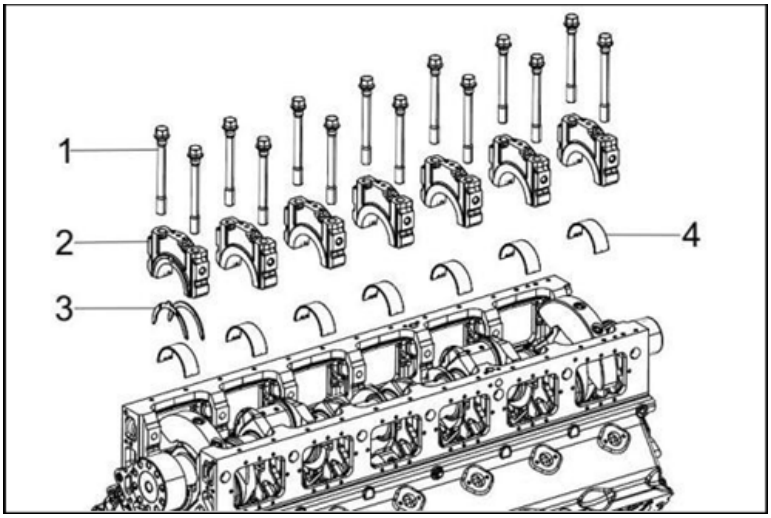


Figure 135.

NO.	Name	NO.	Name
1	Bolt	3	Thrust Plate
2	Main Bearing Caps	4	Main Bearing

7. Reinstall the main bearing caps (Figure 135, item 2).
8. Apply a light coat of clean engine oil to the bearing cap main bolts (Figure 135, item 2) and auxiliary bolts (Figure 136, item 1) with washer (Figure 136, item 2).

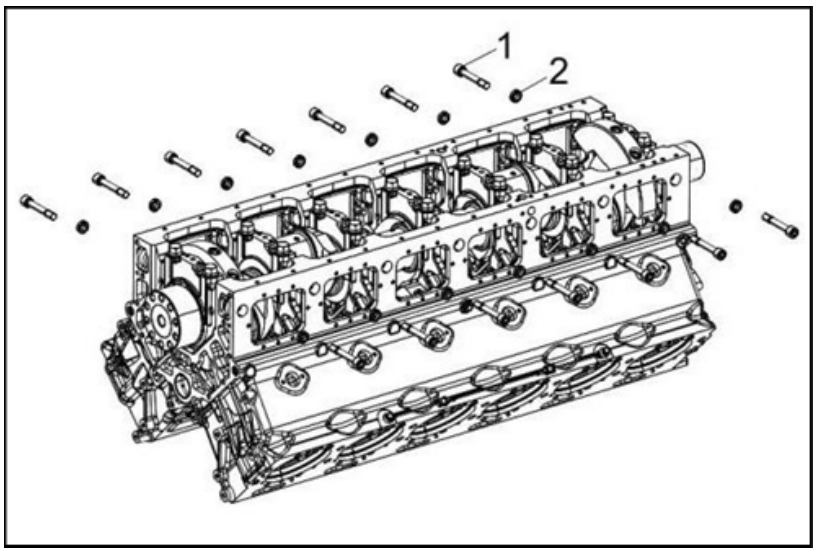


Figure 136.

NO.	Name
1	Bolt
2	Washer

9. Tighten the main bearing bolts in the following sequence (Figure 137):
    i. Tighten them to a torque of 133 ft/lbs.
    ii. Tighten each cap screw in alphabetical order (A to N) to an angle of 60°.
    iii. Tighten each cap screw in alphabetical order (A to N) to an angle of 60°.
10. Tighten all the side bolts in numerical order (1 to 7) to a torque of 200 ft/lbs.
11. Rotate the crankshaft to assure it turns freely.

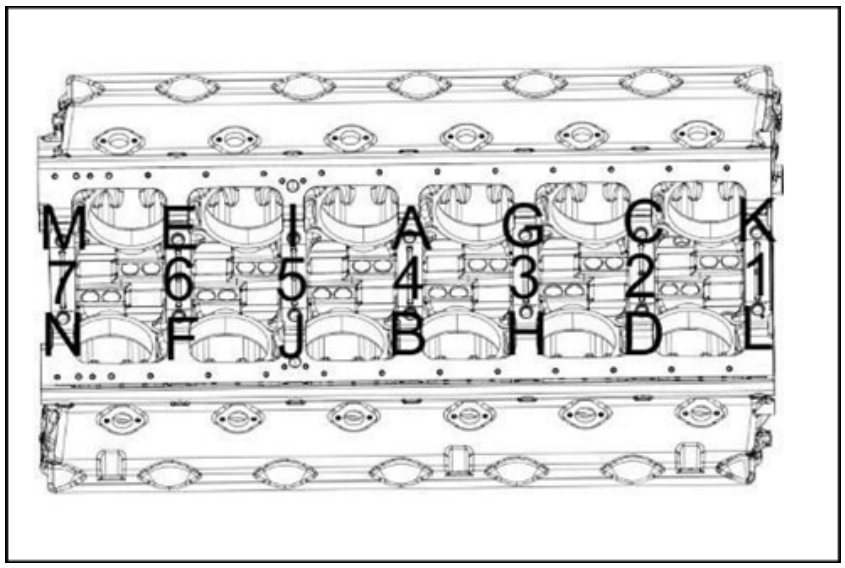


Figure 137.

INSTALLATION OF FLYWHEEL HOUSING AND FLYWHEEL

1. If removed, install the camshaft first.
2. Assemble the rear oil seal group on the flywheel housing (Figure 138).

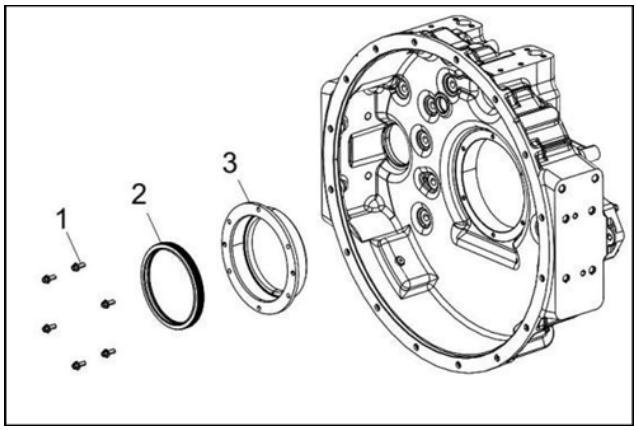


Figure 138.

NO.	Name	NO.	Name	NO.	Name
1	Bolt	2	Rear Oil Seal	3	Rear Oil Seal Seat

3. Knock the grooved pin into the pin hole in the rear end of engine body if removed.
4. Apply silicone sealant to the joint face of flywheel housing.
5. Install the flywheel housing (Figure 139, item 2) to the rear end of engine block by using guide rod.
6. Apply Loctite 242 sealant coated at the threads of the flywheel housing bolts (Figure 139, item 1).

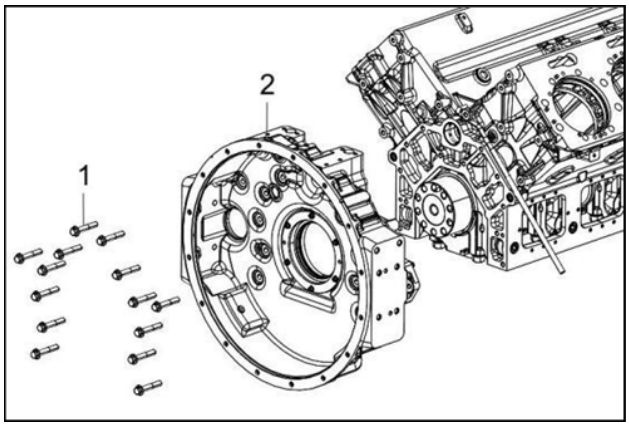


Figure 139.

NO.	Name
1	Bolt
2	Flywheel Housing

7. Tighten the bolts in two steps in the following sequence (Figure 140).
    i. Tighten the bolts to 59 ft/lbs.
    ii. Tighten the bolts to 133 ft/lbs.

NOTE:

- The flywheel cover bolts can be used twice only.
- When installing the flywheel ring, heat the ring gear to 482°F.

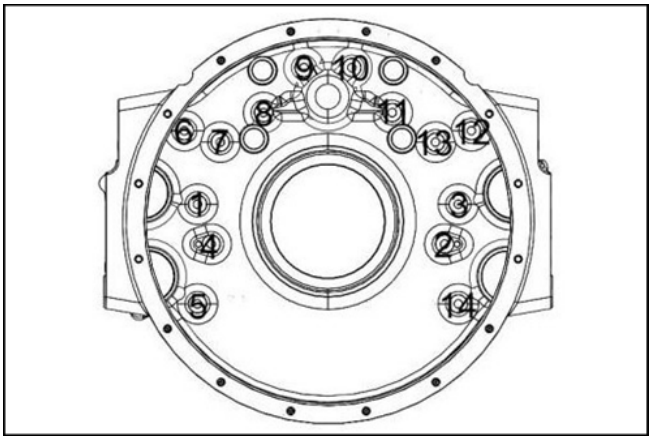


Figure 140.

8. Assemble the flywheel ring to the flywheel if removed.
9. Fit the flywheel guide rods on the crankshaft.
10. Apply a film of oil to the threads and under the head of the flywheel fixing bolts (Figure 141, item 1).
11. Using suitable handling, install the flywheel (Figure 45, item 2) on the crankshaft.

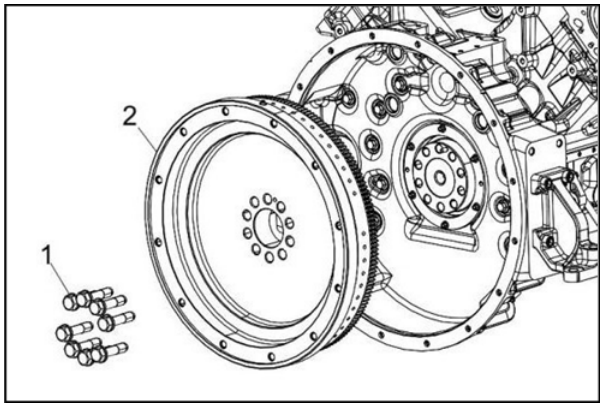


Figure 141.

NO.	Name
1	Bolt
2	Flywheel

12. Tighten the bolts in three steps in the following sequence (Figure 142).
    i. Tighten the bolts (1-10) to 66 ft/lb.
    ii. Tighten the bolts (1-10) to 133 ft/lb.
    iii. Then rotate an angle of 90°, and then apply paint to the bolts.

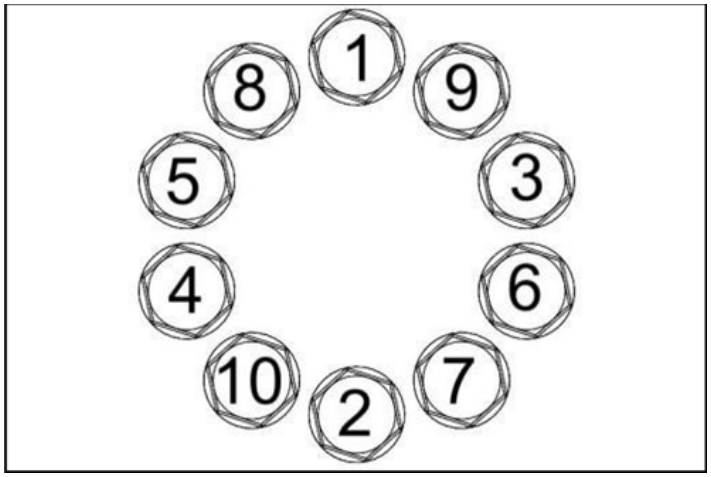


Figure 142.

13. Install the engine bracket group.

CRANKSHAFT POSITION SENSOR GAP

Correct crankshaft position sensor (“CKP”) gap is critical for proper engine performance. The gap
between the sensor and reluctor is adjusted by adding or removing the sensor shim.

In cases where the gap is not correct utilize the 0.010” shim(s) to obtain the desired gap. If the gap is not within the specification the ECM may lose the crank/cam sync which can lead to
an unintended backfire condition.

Tools Required:

Digital measuring tool or dial indicator (as shown in images B, C, D, E, and F)
0.01-inch shims (as shown in Image G)
Impact wrench with extended 8mm socket

Tolerance:

Crank sensor gap tolerance: 0.110 ± 0.005 in.

Step-by-Step Instructions

1. Remove the Crank Sensor
(Refer to Image A)
Use an impact wrench with an extended 8mm socket to remove the bolt holding the crank sensor in place. Pull the crank sensor out by wiggling it back and forth.
Reason: The crank sensor needs to be removed to measure and adjust the gap.

2. Zero Out the Tool
(Refer to Image B and D)
Zero out the crank sensor gap tool by pressing the ZERO button on the tool.
Key Point: Ensure the tool is accurate before proceeding to the next steps.
Reason: This step ensures the tool is ready to measure correctly.

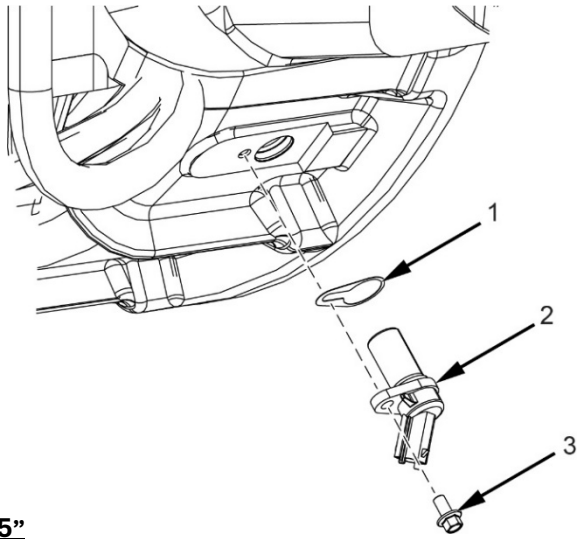
3. Measure the Crank Sensor Gap
(Refer to Image C)
Line the crank sensor up with the measuring tool so that the sensor sits securely in the adapter. Hold the tool with the crank sensor upside down, and press the ZERO button. Ensure the tool is set to measure in inches.
Key Point: The measuring tool will now register the crank sensor gap.
Reason: This step sets the tool for measuring the correct gap between the sensor and flywheel.

4. Measure the Crank Sensor Gap
(Refer to Images E and F)
Insert the measuring tool so that the tip of the adapter you measured the crank sensor from sits flush with the flywheel housing.
Target Gap: The gap should measure 0.110 ± 0.005 in.

5. Install Shim(s) if Necessary
(Refer to Image G)
If the measured gap is below 0.105 in., place one or more 0.01 in. shim(s) over the crank sensor to adjust the gap to the required specification.
Key Point: Ensure the shims are placed properly to adjust the gap within the acceptable range.

6. Reinstall the Crank Sensor
(Refer to Image H)
Reinstall the crank sensor into its position in the engine. Tighten the bolt to secure the crank sensor in place.
Reason: Proper installation of the crank sensor ensures the engine runs efficiently and the sensor functions correctly.

NO.	Name
1	Shim
2	Crankshaft Sensor
3	Bolt

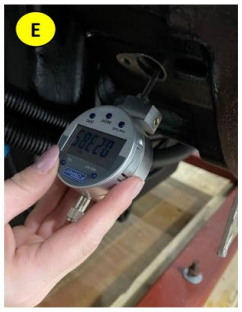


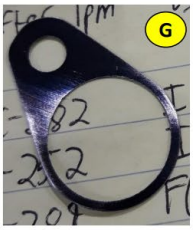
Example Measurement Shown Below

Sensor	1.363”
Depth (flywheel hsg. to flywheel)	1.408”
Sensor Gap	0.035”
Target Gap (+/- .015”)	0.110”
Difference	0.075”

Add 7 .010” shims to achieve target gap of .110” +/- 0.015”

SEQ	STEP (What)	SYM	KEY POINT (How)	REF	REASON (Why)
1	Remove crank sensor.		Remove the bolt holding the crank sensor in place. Use an impact wrench with an extended 8mm socket. Pull the crank sensor out by wiggling it back an d forth.	A	The crank sensor needs to be removed in order to be measured and for the gap to be measured.
2	Zero out the tool	C	Zero out the crank sensor gap tool by pressing the ZERO button in face off the tool.	B	This needs to be done to make sure the tools reading is accurate for the next step.
3	Measure the Crank Sensor	C	Line the crank sensor up with the measuring tool so that the sensor sits nicely in the adapter. It helps if you hold the tool and crank sensor upside down. Press “ZERO”. Make sure you are measuring in inches.	C,D	This sets the measuring tool up to measure the gap relative to the crank sensor. Whatever distance is registered by the tool will be the size of the gap.





SEQ	STEP (What)	SYM	KEY POINT (How)	REF	REASON (Why)
4	Measure the crank sensor gap.	C	Insert the measuring tool so that the end of the adapter you measured the crank sensor from sits flush with the flywheel housing.	E,F	The gap needs to be .110 ± .005 in. If the gap is measured to be below this range, then insert one or more .01 in. shim(s) so that the gap is within range.
5	Install shim(s) if needed	C	Place one or more 0.01 in. shim(s) over the crank sensor	G	By inserting one or more .01 in. shim(s) will make the gap within range
6	Reinstall crank sensor	C	Reinstall the crank sensor into the engine. Reinstall the bolt to hold the crank sensor in place	H	The crank sensor needs to be installed to allow the engine to run properly.

INSTALLATION OF CONNECTING ROD AND PISTON

NOTE:

- Do not allow the connecting rod to contact the crankshaft journal during piston installation. Damage to the crankshaft bearing journal may result.
- Apply a film of oil onto the ring set before compressing.
- Ensure the piston ring gaps are located correctly (Figure 144).

1. Lubricate the piston, piston rings, and cylinder with clean engine oil or assembly lubricant.
2. Rotate the crankshaft so the crankpin for the piston being installed is near bottom dead center.

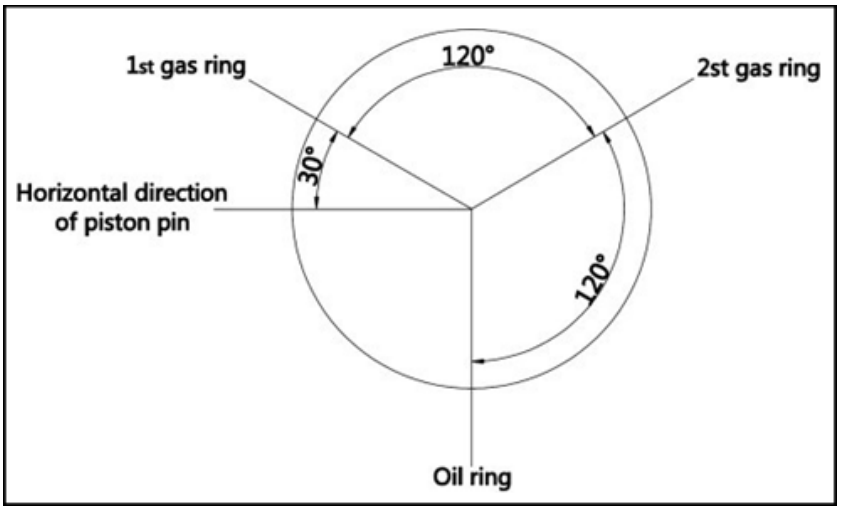


Figure 144.

3. Using a piston ring compressor (Figure 145, item 1), compress the piston rings.
4. Apply a film of oil to the liner, crank pin, rod bearings and the connecting rod bolts.
5. Lower the mobile coupling (Figure 145, item 2) until the connecting rod big end and its half-bearing are in place on the crank pin.
6. Reinstall the connecting rod cap (Figure 145, item 3). Fit the connecting rod bolts (Figure 145, item 4) and fully engage the cap (turn the crankshaft to facilitate fitting of bolts).
7. Tighten the connecting rod bolts (Figure 145, item 4) in two steps:
    i. Pre-tighten the bolts to 52 ft/lbs.
    ii. Tighten the bolts to 258 ft/lbs.

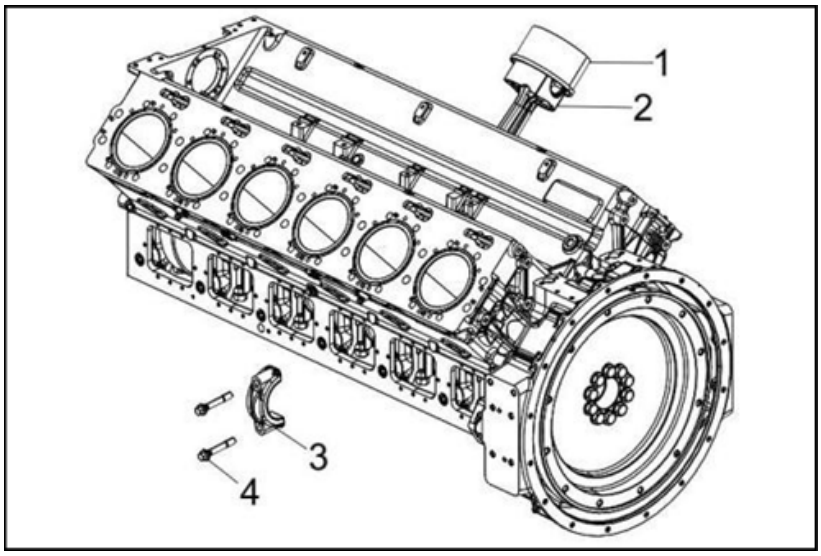


Figure 145.

NO.	Name	NO.	Name
1	Piston Ring Compressor	3	Connecting Rod Cap
2	Mobile Coupling	4	Bolt

8. Check the radial play of the connecting rod with a feeler gauge set.
9. Reinstall the remaining pistons in their respective cylinders.
10. Install all the handhole covers.

INSTALLATION OF CAMSHAFT

NOTE:

- It is better to install the camshaft before installing the flywheel housing and flywheel.
- Use the camshaft installment tool (Figure 146, item 1) if necessary.

1. If removed, install a new camshaft bushing using the appropriate service tool.
2. Apply a film of oil to the camshaft and the camshaft bushing.
3. Install the camshaft (Figure 146, item 2), gradually rotating it as you insert it.
4. Apply a film of oil to the bearing bore. Fit the bearing (Figure 146, item 3), taking care to position the lubrication groove at the top at 12 o'clock.
5. Apply a film of Loctite 242 to the fasten bolts (Figure 146, item 4) and tighten to a torque of 23 ft/lbs.

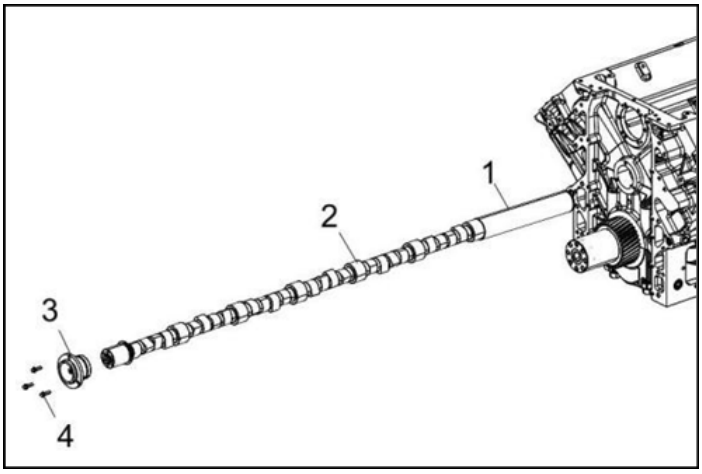


Figure 146.

NO.	Name	NO.	Name
1	Camshaft Installation Tool	3	Bearing
2	Camshaft	4	Bolt

INSTALLATION OF TIMING GEARS

1. Turn the crankshaft so that the “0” engraved on the pinion is at 12 o’clock. (The pinion keyway is also positioned at 12 o’clock).
2. Install the camshaft gear (Figure 147, item 5) and the connecting shaft (Figure 147, item 4) of trigger wheel (Figure 147, item 2).

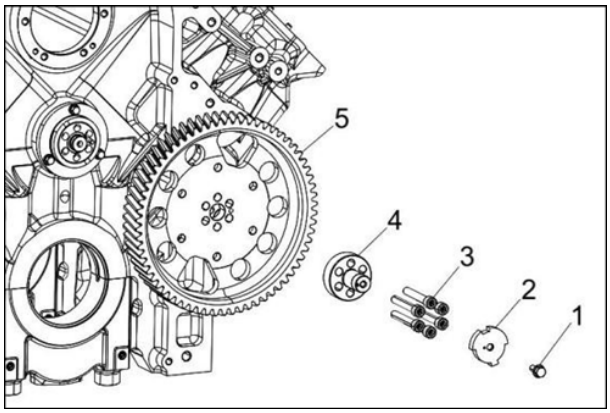


Figure 147.

NO.	Name	NO.	Name
1	Bolt	4	Connecting Shaft
2	Trigger Wheel	5	Camshaft Gear
3	Bolt		

NOTE:

- The “N” mark on the camshaft gear must be facing the “0” on the crankshaft timing gear (Figure 148).

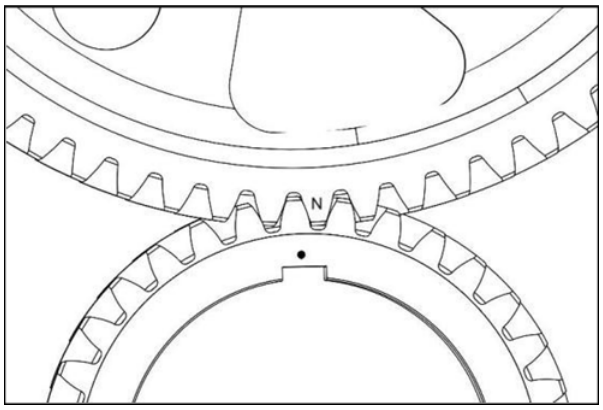


Figure 148.

3. Apply a film of Loctite 242 to the fastening bolts (Figure 148, item 3) and tighten the bolts.
4. Install the trigger wheel (Figure 148, item 2).

INSTALLATION OF OIL PAN AND OIL PIPELINE

1. Assemble the oil pressure limiting valve if removed (Figure 149, item 2).
2. Install the oil pipeline group (Figure 149, item 1).

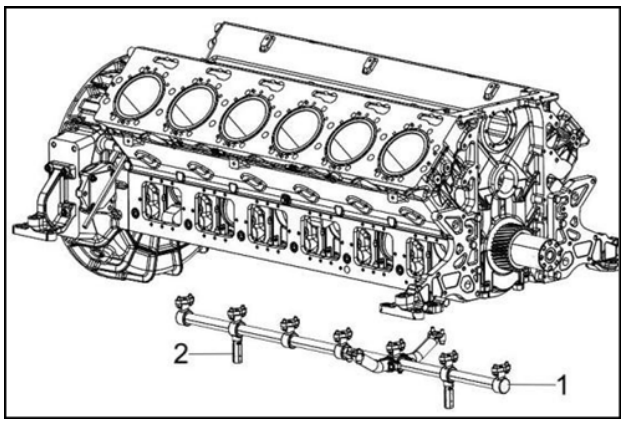


Figure 149.

NO.	Name
1	Oil Pipeline
2	Limiting Valve

3. Assemble the oil pan group if disassembled (Figure 150).

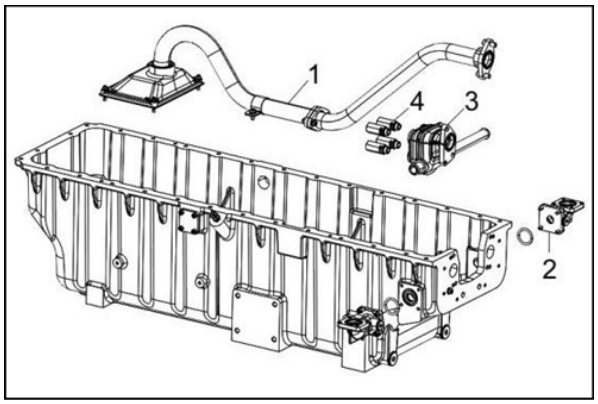


Figure 150.

NO.	Name	NO.	Name
1	Oil Strainer	3	Supporting Seat
2	Pipe Joints	4	Limiting Valve

4. Install the oil pan on the engine block.

NOTE:

- Replace all the O-Seal rings if removed.
- Check oil pump gear lash once installed.

INSTALLATION OF FRONT-END COVER

1. Put a new O-seal ring (Figure 151, item 1) on the oil pump (Figure 151, item 2).
2. Install the oil pump onto the bottom end of the cylinder block.

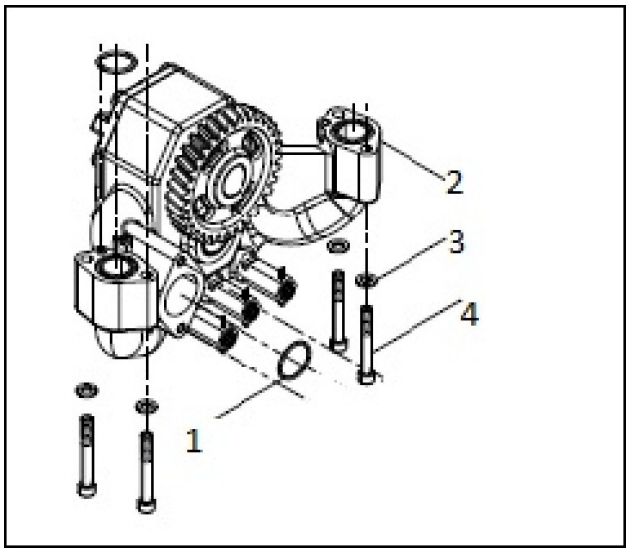


Figure 151.

NO.	Name	NO.	Name
1	Oil Seal Ring	3	Washer
2	Oil Pump	4	Bolt

3. Apply a film of sealant on the joint surface.
4. Install the front-end cover (Figure 152, item 1) to the engine block. Pay attention to the locating pin.
5. Apply Loctite sealant 242 to the threads of the bolts (Figure 152, item 4). Tighten the bolts to recommended torque.
6. Install the front oil seal (Figure 152, item 9).

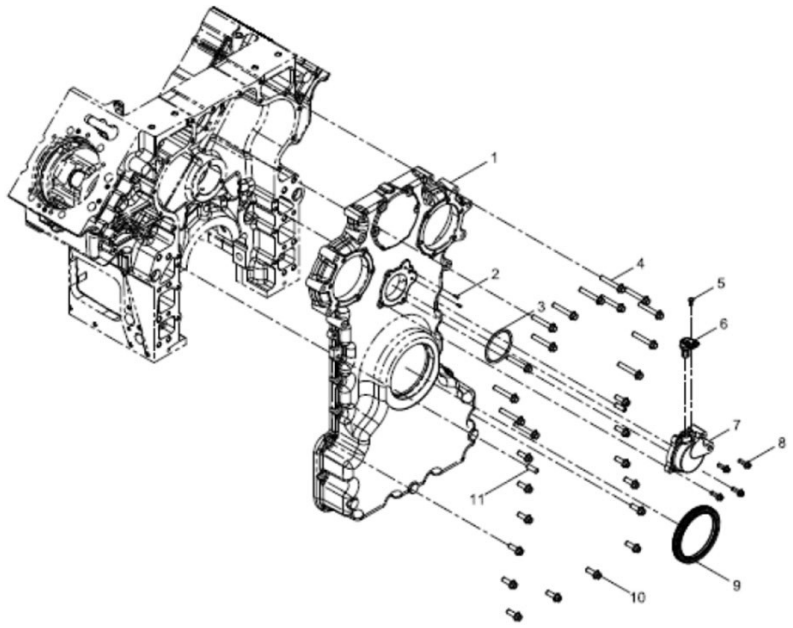


Figure 152.

NO.	Name	NO.	Name	NO.	Name
1	Front Cover	5	Bolt	9	Front Oil Seal
2	Bolt	6	Speed Sensor	10	Bolt
3	O-Ring	7	Front Cover Nozzle	11	Pin
4	Bolt	8	Bolt		

7. Reinstall the speed sensor (Figure 153, item 2).
8. Loctite sealant 242 to the threads and install bolt (Figure 153, item 1) and secure speed sensor (Figure 153, item 2) to speed sensor seat (Figure 153, item 3). Tighten the bolt to recommended torque.
9. Connect the connecting wiring when the engine harness is installed.

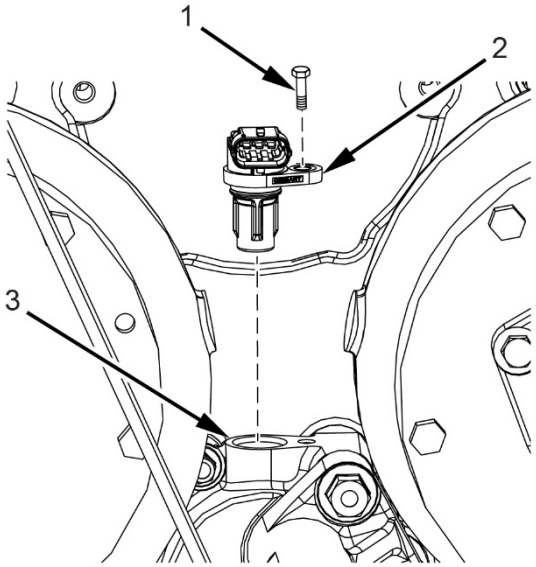


Figure 153.

OIL PAN

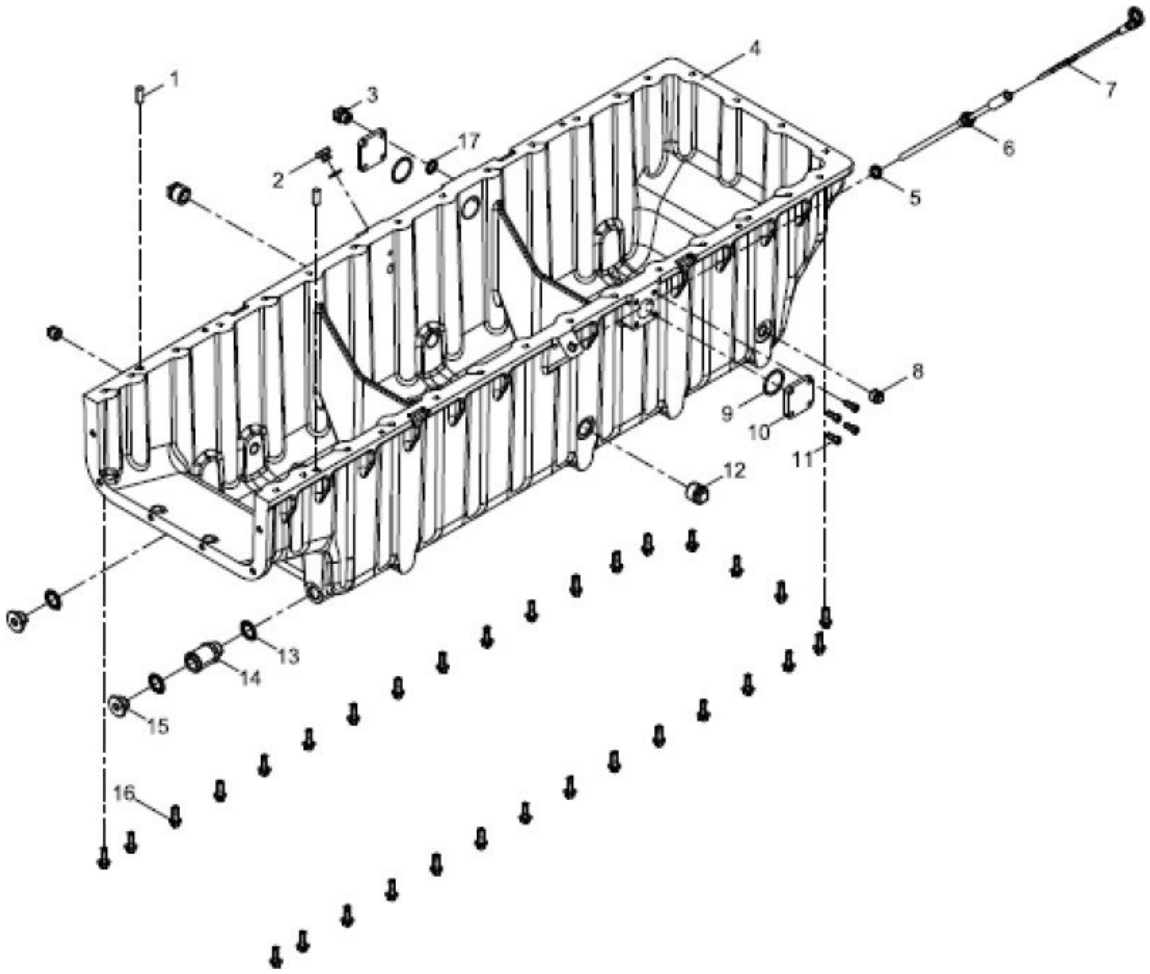


Figure 154. Oil Pan Assembly

NO.	Name	NO.	Name	NO.	Name
1	Dowel Pin	7	Dipstick	13	Washer
2	Plug	8	Plug	14	Pipe
3	Plug	9	O-Ring	15	Plug
4	Oil Pan	10	Cover	16	Bolt
5	Washer	11	Bolt	17	Washer
6	Dipstick Tube	12	Plug		

REMOVAL

1. Drain Oil.
2. Remove oil dipstick assembly and be careful not to damage the dipstick.
3. Remove all oil pan bolts from the engine block, be sure to use a crane to lift the cylinder block off the oil pan.

INSTALLATION

1. Clean the surface of the oil pan and underneath the cylinder block from any debris.
2. Apply silicone to the oil pan surface, which should be continuous without interruption.
3. Lift the cylinder block onto the oil pan.
4. Apply PSI approved sealant to the threads of the oil pan bolts, tighten the bolts, and wipe off the excessive silicone.

OIL TEMPERATURE/PRESSURE SENSOR

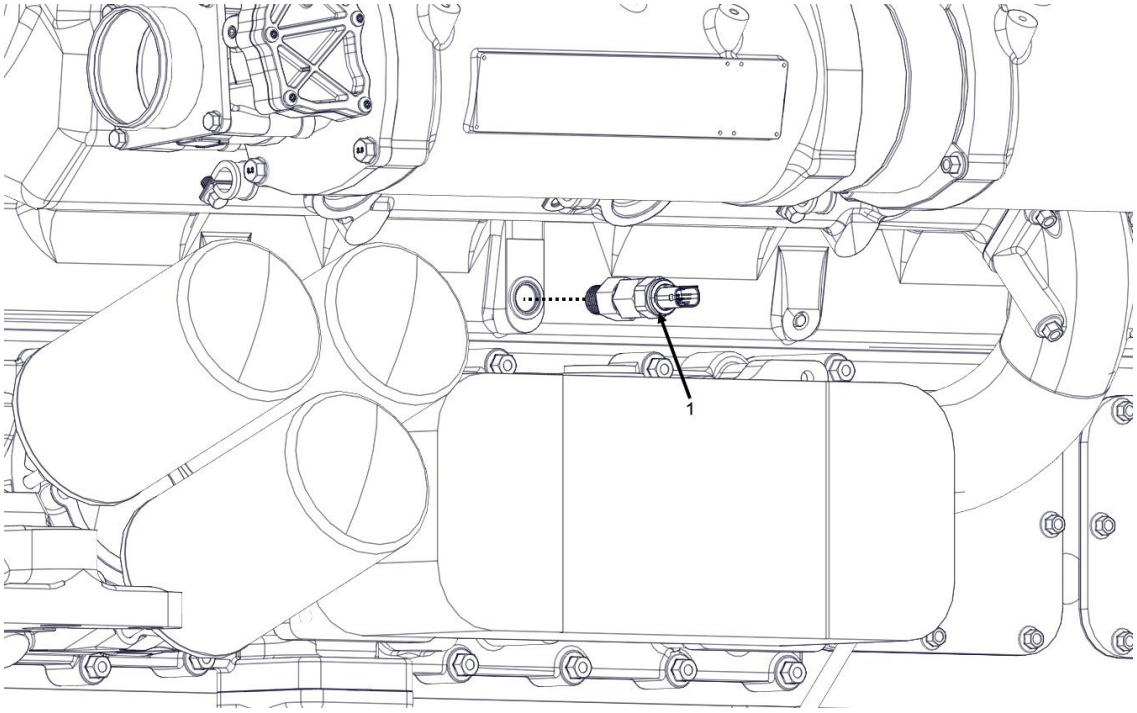


Figure 155. Oil Temperature/Pressure Sensor Assembly

NO.	Name
1	Oil Temp/Pressure Sensor

NOTE:

- There are two oil temperature/pressure sensors, located directly above the oil coolers on each side of the cylinder block.

REMOVAL

1. Disconnect both oil temperature/pressure sensor harnesses.
2. Remove each oil temperature/pressure sensor from the cylinder block above the oil coolers.

INSTALLATION

1. Apply PSI approved sealant to the threads of both oil temperature/pressure sensors.
2. Insert and torque down both oil temperature/pressure sensors to 65 ft/lbs. if equipped with adapter, if only installing the sensor torque down to 25 ft/lbs.
3. Reconnect both oil temperature/pressure sensor harnesses.

COOLING SYSTEM DIAGRAM

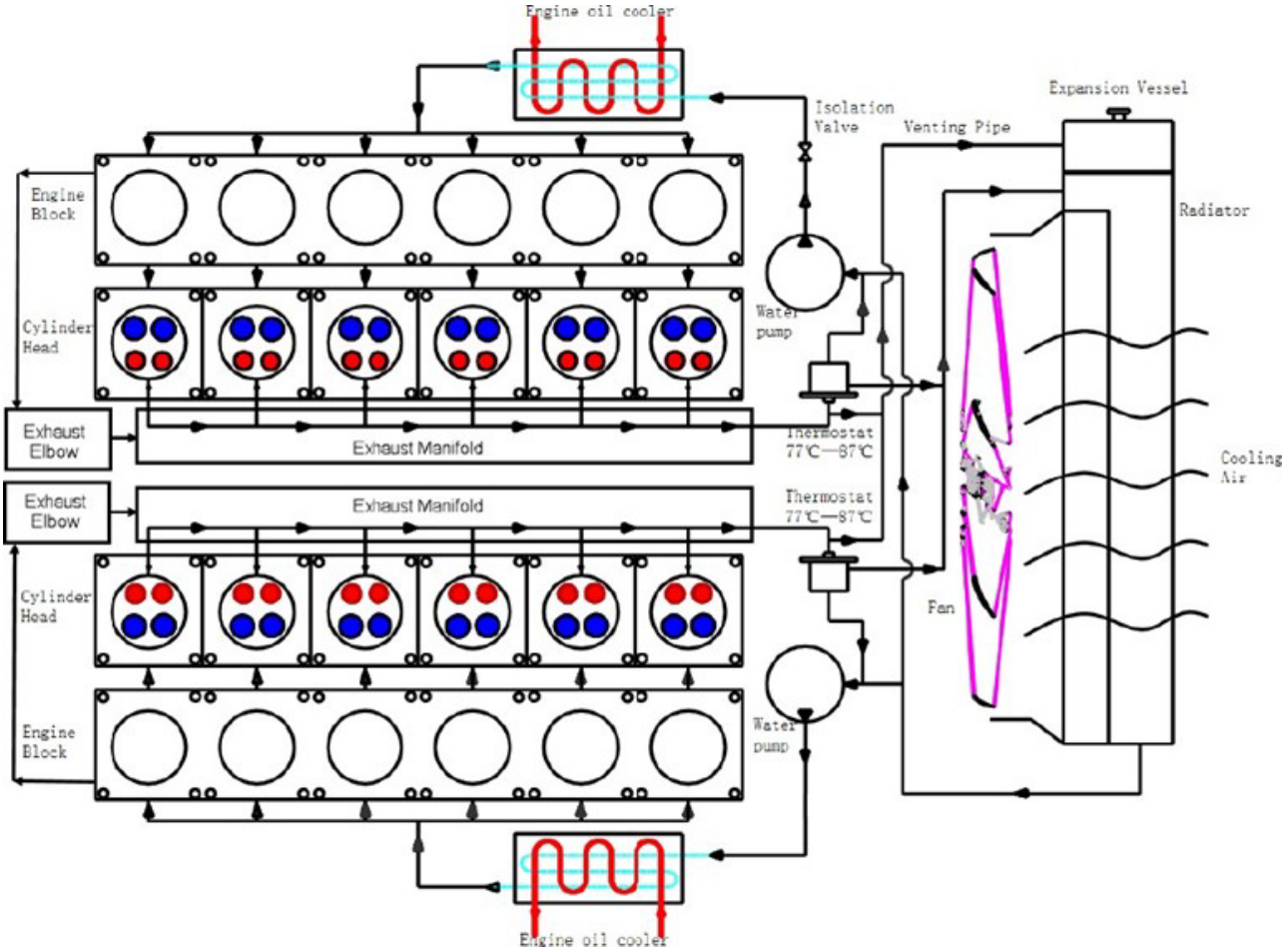


Figure 156. Cooling System Diagram

WATER PUMPS

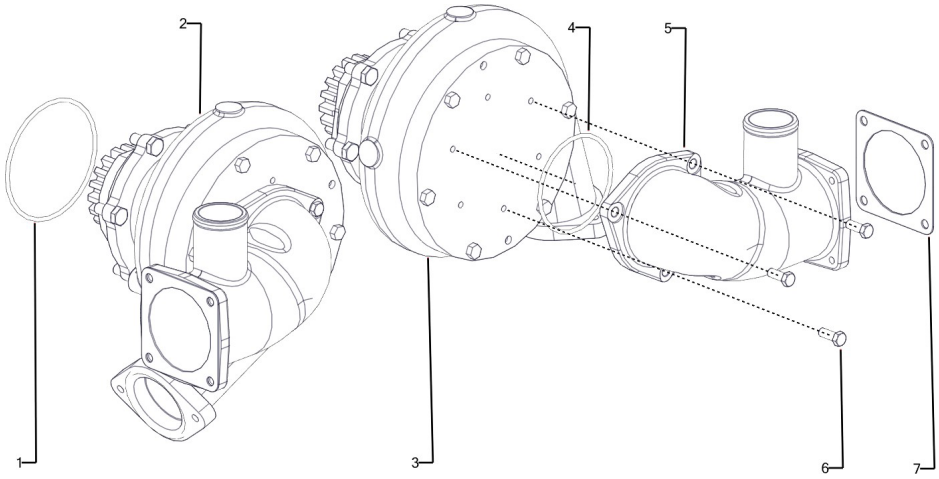


Figure 157. Water Pump Assembly

NO.	Name	NO.	Name
1	O-Ring	5	Water Pump Pipe
2	Right-Hand Water Pump	6	Bolt
3	Left-Hand Water Pump	7	Gasket
4	O-Ring		

NOTE:

- Water pumps are gear driven and should not be removed unless specifically requested by PSI.

REMOVAL

1. Drain the coolant in the cooling system.
2. Loosen and remove the connecting pipes going into both water pumps.
3. Remove the six bolts behind each water pump.
4. Remove each water pump.
5. Remove the O-ring.

INSTALLATION

1. Insert new O-ring onto the front cover.
2. Carefully insert both water pumps.
3. Insert and torque down the six bolts behind each water pump.
4. Connect the connecting pipes going into both water pumps.

WATER CROSSOVER PIPE AND THERMOSTAT

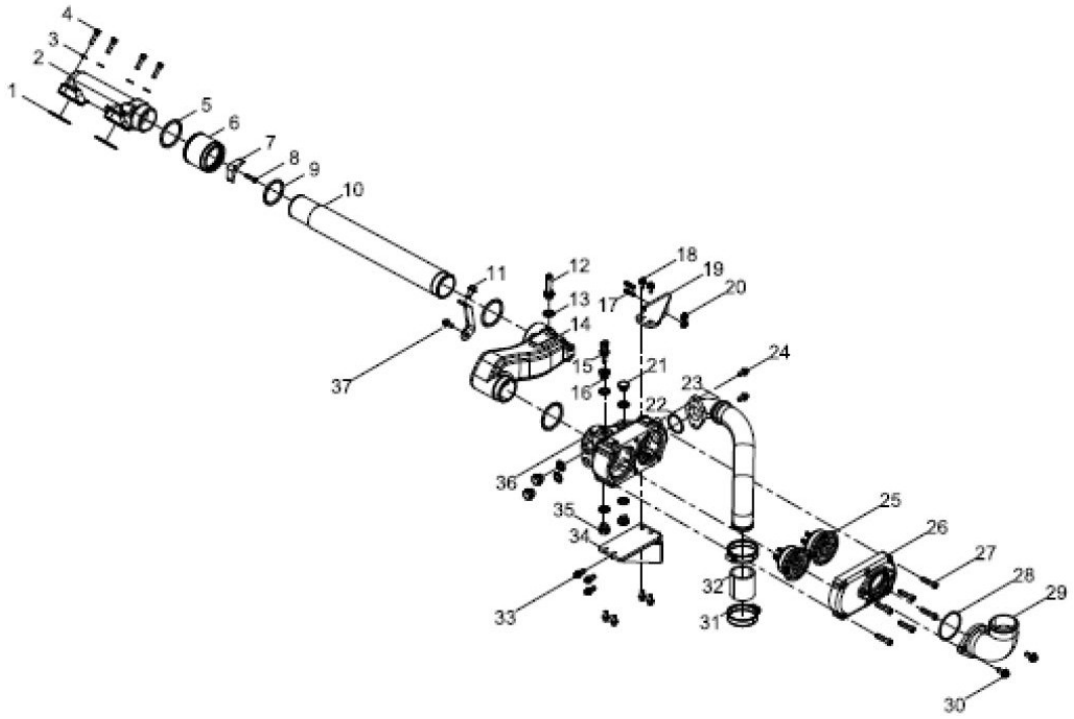


Figure 158. Thermostat Assembly

NO.	Name	NO.	Name	NO.	Name	NO.	Name
1	O-Ring	12	Water Pipe	23	Outlet Pipe	34	Bracket
2	Water Outlet Pipe	13	Washer	24	Bolt	35	Plug
3	Washer	14	Outlet Pipe	25	Thermostat	36	Housing
4	Bolt	15	Temp Sensor	26	Thermostat Cover	37	Bolt
5	O-Ring	16	Seal	27	Bolt		
6	Water Pipe	17	Stud	28	O-Ring		
7	Bracket	18	Bolt	29	Outlet Pipe		
8	Bolt	19	Bracket	30	Bolt		
9	O-Ring	20	Nut	31	Clamp		
10	Water Pipe	21	Plug	32	Hose		
11	Bolt	22	O-Ring	33	Bolt		

REMOVAL

1. Drain coolant into suitable container.
2. Remove the pump water pipe and mounting bracket.
3. Remove the thermostat body, thermostat cover and thermostat bracket.
4. Remove the water outlet pipe.
5. Separate the thermostat body from its cover and remove the thermostat.

NOTE:

- Inspect O-rings and pipes for any damage.
- Inspect thermostat, opening temperature is 168°F (76°C).

INSTALLATION

1. Insert thermostat into the thermostat body cover and install.
2. Insert the water outlet pipe into the thermostat body.
3. Insert the thermostat bracket.
4. Insert the mounting bracket and the pump water pipe.

OIL COOLER

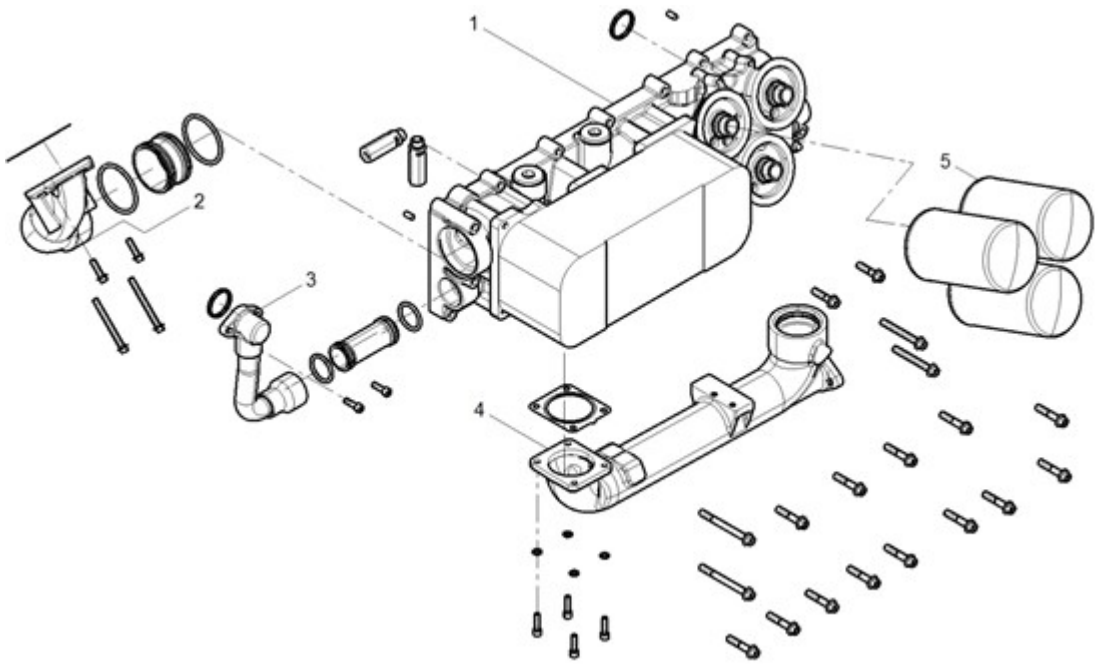


Figure 159. Oil Cooler

NO.	Name	NO.	Name	NO.	Name
1	Oil Cooler	2	Oil Cooler Water Outlet Pipe	3	Oil Cooler Oil Outlet Pipe
4	Oil Cooler Water Inlet Pipe	5	Oil Filter		

Removal of Oil Cooler Assembly

Note!

Prior installation, the adhesive residue must be scraped and cleaned.

Use new seals and gaskets whenever the oil cooler in replaced.

Note!

The outlet pipe is connected with the oil cooler as plug type, and there is an O-ring (at each end of the pipe joint.

1. Remove the oil cooler oil outlet pipe (Fig 160, item 2), loosen the fixed bolts (Fig 160, item 3) take the oil outlet pipe, pay attention to the seal ring (Fig 160, item 1).

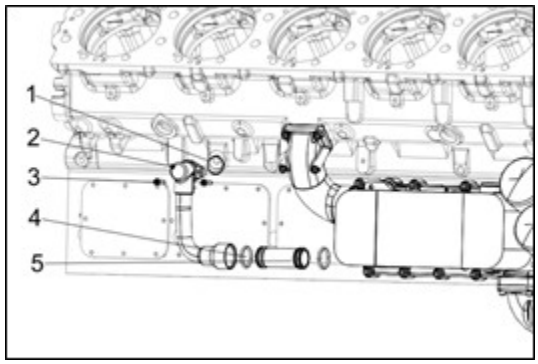


Figure 160

2. Remove the oil cooler water outlet pipe (Fig 161, item 2), loosen the fixed bolts (Fig 161, items 3 and 4) take the water outlet pipe, pay attention to the gasket (Fig 161, item 1).

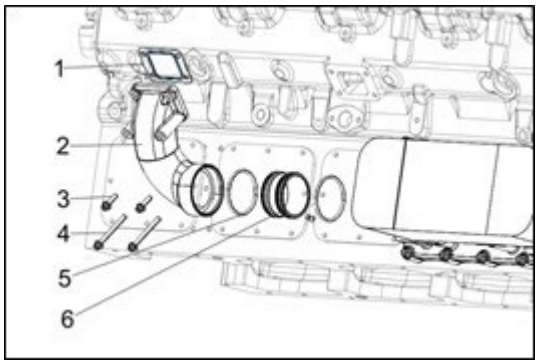


Figure 161

3. Remove the oil cooler inlet pipe, loosen the fixed bolts (Fig 162, item 4) and take the washer (Fig 162, item 3), remove the water inlet pipe, pay attention to the gasket (Fig 162, item 1).

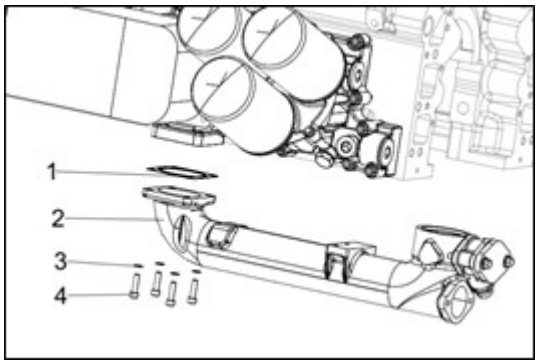


Figure 162

4. Remove the oil filter (Fig 163, item 1) with the special tool.

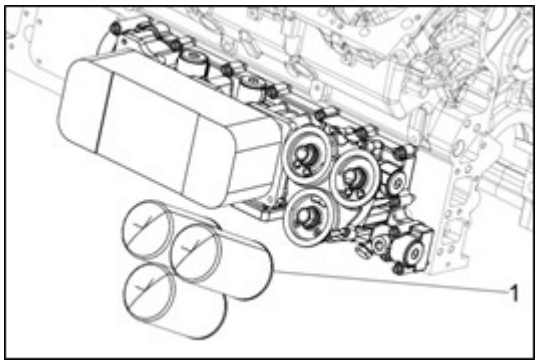


Figure 163

5. Remove the oil cooler seat (Fig 164, item 3), loosen the fixed bolts (Fig 164, item 4), remove the oil cooler seat, pay attention to the O-ring (Fig 164, item 2), remove the locating pins (Fig 164, item 1) if necessary.

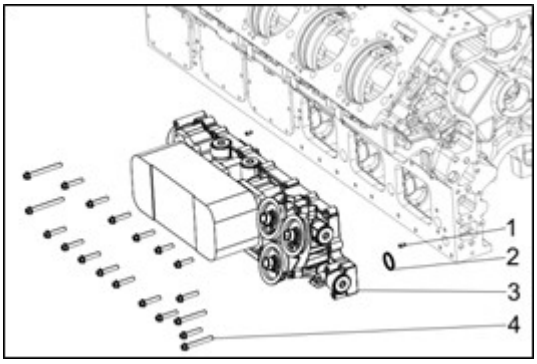


Figure 164

Removal of Pressure-limiting Valve of Main Oil Passage

1. Remove the pressure-limiting valve (Fig 165, item 1) of the main oil passage.

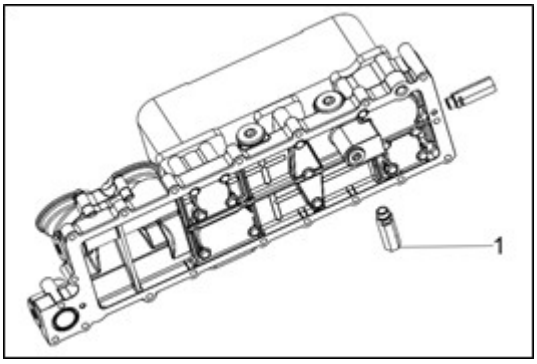


Figure 165

Clean and Inspect Oil Cooler Assembly

1. Check the inner cavity of the main oil gallery pressure relief valve for cleanliness, touch by hand to check for burrs, iron swarf, etc., if present, replace valve.

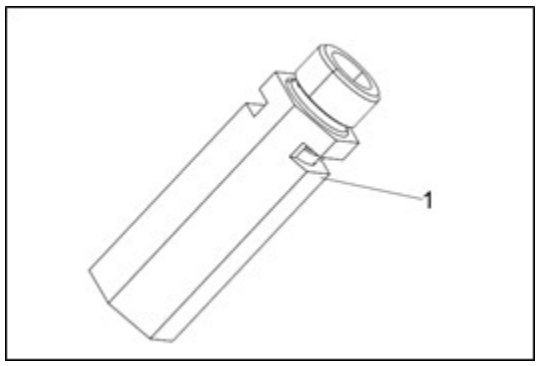


Figure 166

2. Inspect the oil filter, when the oil temperature is 80 ±3℃ and the rated flow is 90L/Min, the original resistance of the assembly is ≤35Kpa.

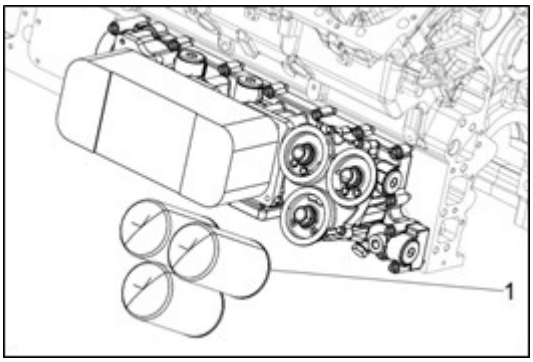


Figure 167

3. Check the condition of the oil cooler assembly, the parts must not be damaged or corroded. Check the oil cooler oil holes and the cleanliness inside the water channel. Metal and other impurities are not allowed in the cavity.

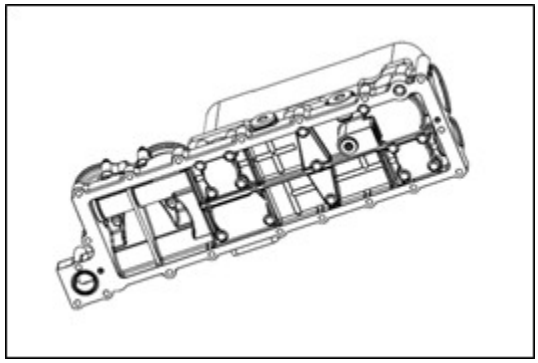


Figure 168

Assembly of Oil Cooler Assembly

1. At the end face of the orifice (1～2) mm and width (3～5) mm, apply 242 sealant to the half-turn thread range, install the pressure- limiting valve of the main oil passage.
2. Tighten the main oil gallery pressure relief valve to the oil cooler assembly, with the following tightening torque: M20 tightening torque (60 ± 5) N.m, paint mark after tightening.

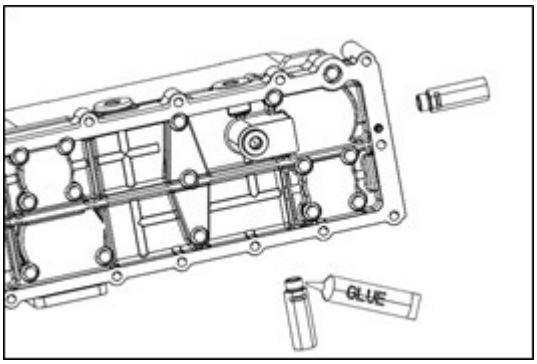


Figure 169

Installation of Oil Cooler Assembly

1. Apply a film of sealant to the oil cooler seat, it is recommended that apply sealant uniformly and continuously without fracture.

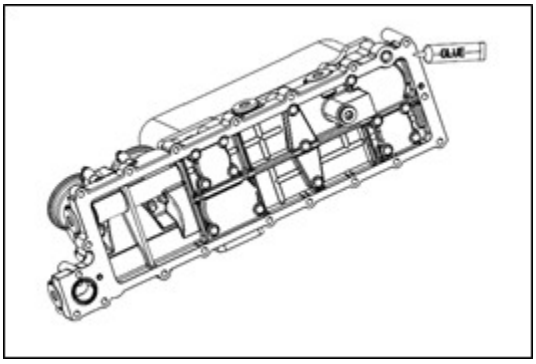


Figure 170

2. Install the two threaded alignment rods (Figure 171, item 1) into any two of the holes that will be used for the fixed bolts (Figure 172, item 4).

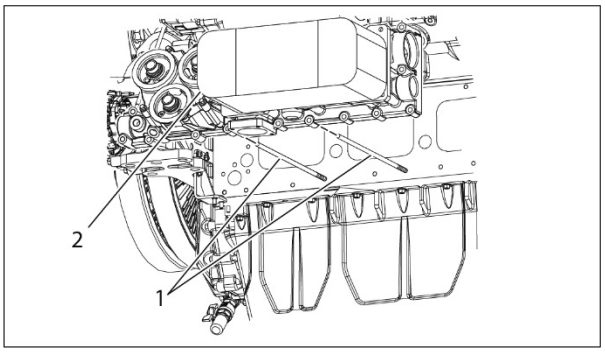


Figure 171

NOTE

Apply sealant 242 to threads of the lower bolts and sealant 567 to threads of upper bolts

3. Install the oil cooler seat (Fig 172, item 3), install the locating pin (Fig 172, item 1) firstly, pay attention to the O-ring (Fig 172, item 2). Install and tighten the fixed bolts (Fig 172, item 4), except the remaining two where the two threaded alignment rods are installed. After the bolts are tightened, remove the two threaded alignment rods and install and tighten the remaining fixed bolts.
4. Tightening torque: Flange head bolts M10: Class 10.9 (70 ± 5) N·m, Grade 12.9 (82 ± 5) N·m; Flange head bolts M8: Class 10.9 (35 ± 5) N·m, Hexagon socket bolt M8: Class 10.9 (33 ± 5) N·m, Class 12.9 (39 ± 3) N·m; the bolt tightening sequence is to tighten the four diagonal bolts first, then the remaining bolts in a clockwise direction. Two of the M10 bolts for the pipe clamp are left loose and will be tightened after installing oil cooler water outlet pipe during step 8.

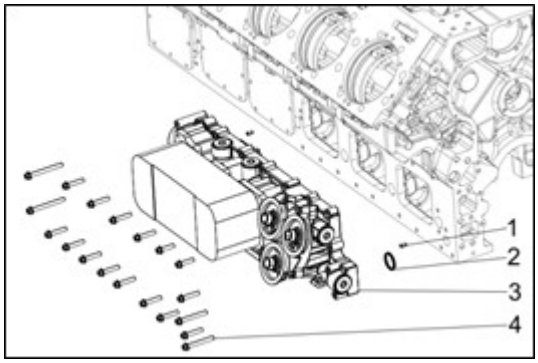


Figure 172

5. Apply a film of oil to the sealing gasket.


Figure 173

6. Install the oil filter, tighten the oil filter by hand and rotate by approximately 1/2 turn.

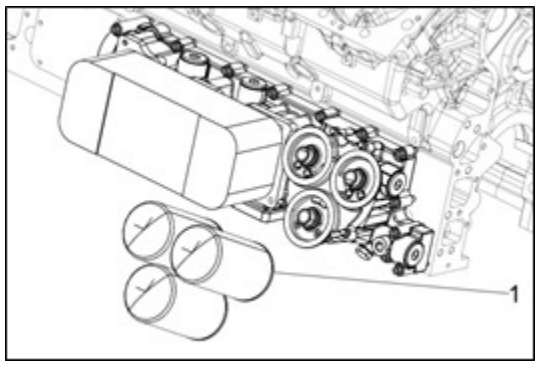


Figure 174

7. Install the water inlet pipe, fit the gasket (Fig 175, item 1) firstly, tighten the fixed bolts (Fig 175, item 4) with the washer (Fig 175, item 3). Torque bolts to 37 N·m.

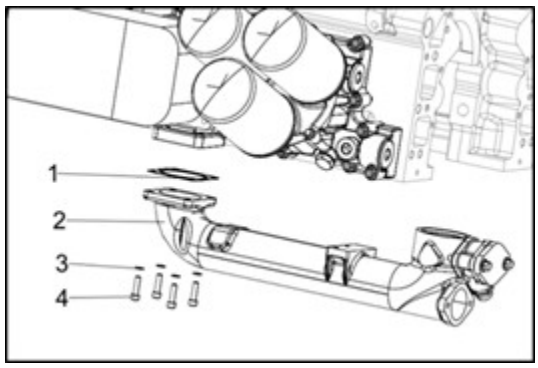


Figure 175

8. Install the oil cooler water outlet pipe (Fig 176, item 2), fit the O-ring (Fig 176, item 5) to the joint pipe (Fig 176, item 6), connect the water outlet pipe with the oil cooler, tighten the fixed bolts (Fig 176, item 3) with washers (Fig 176, item 1). Torque bolts to 35 N·m. Tighten remaining fixed bolts (Fig 176, item 7) left loose in Figure 176.

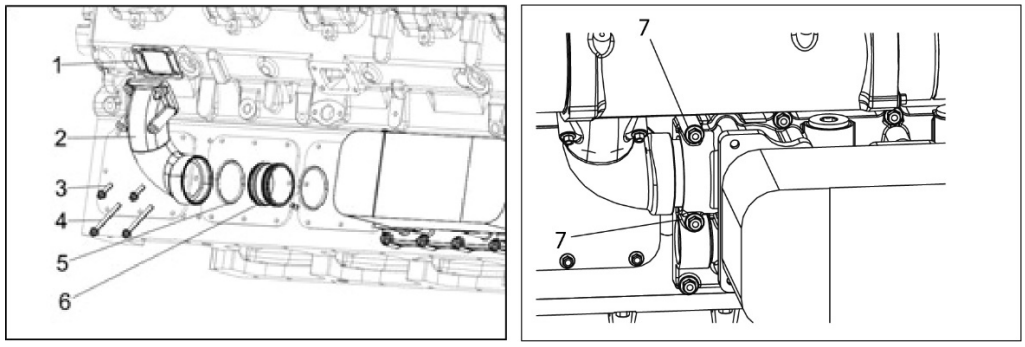


Figure 176

9. Install the oil cooler oil outlet pipe (Fig 177, item 20), fit the O-ring (Fig 177, item 4) to the joint pipe (Fig 177, item 5), connect the oil outlet pipe with the oil cooler, tighten the fixed bolts (Fig 177, item 3) with O-ring (Fig 177, item 1). Torque bolts to 35 N·m.

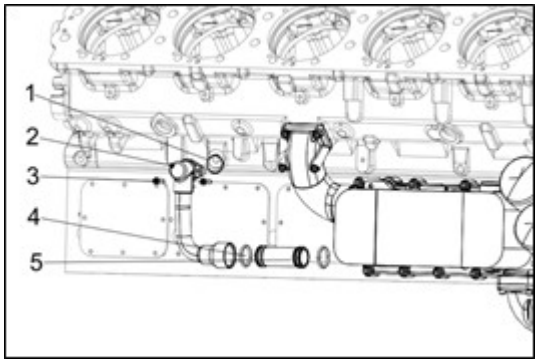


Figure 177

OIL PUMP

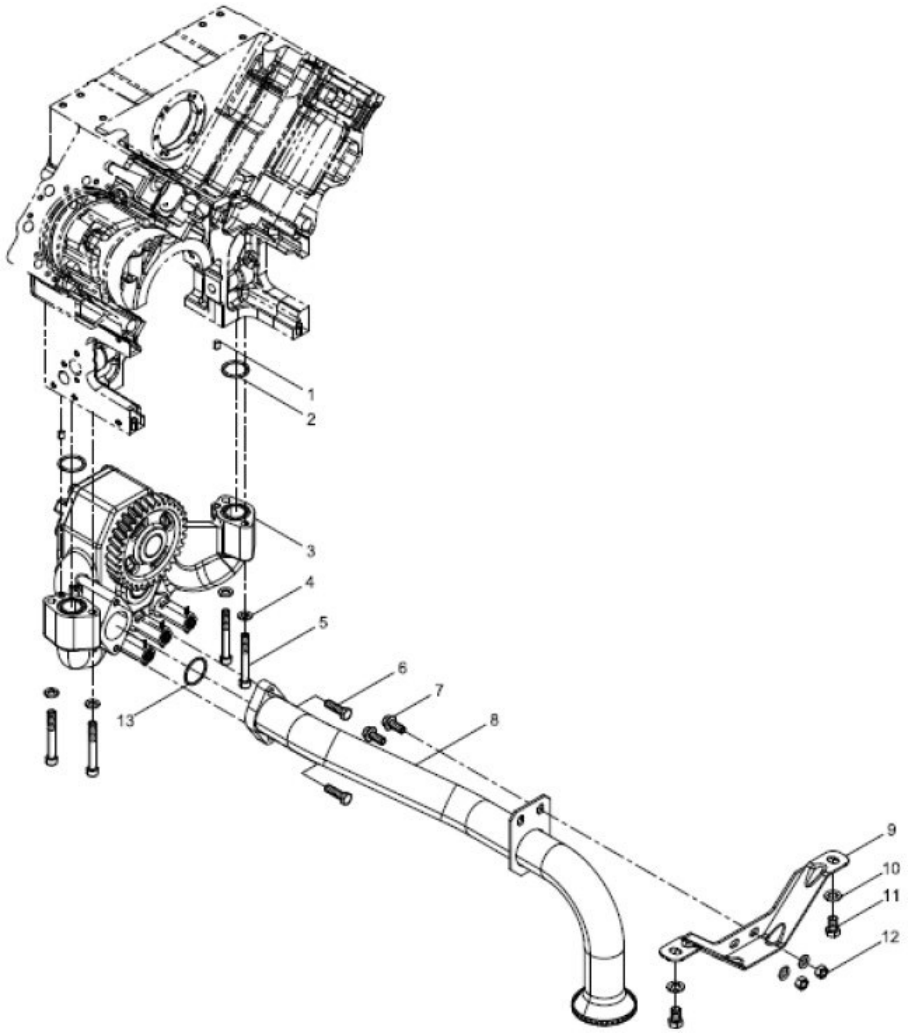


Figure 178. Oil Pump Assembly

NO.	Name	NO.	Name	NO.	Name
1	Dowel Pin	6	Bolt	11	Bolt
2	O-Ring	7	Bolt	12	Nut
3	Oil Pump	8	Oil Strainer	13	O-Ring
4	Washer	9	Oil Strainer Bracket		
5	Bolt	10	Washer		

REMOVAL

1. Loosen the oil pump mounting bolts.
2. Remove the oil pump assembly.
3. Remove the oil pump inlet and outlet O-ring.

INSTALLATION

1. Install the oil pump inlet and outlet O-ring.
2. Install the oil pump assembly.
    a. Ensure to check for proper oil pump gear lash.
3. Install the oil pump mounting bolts.

FLYWHEEL HOUSING

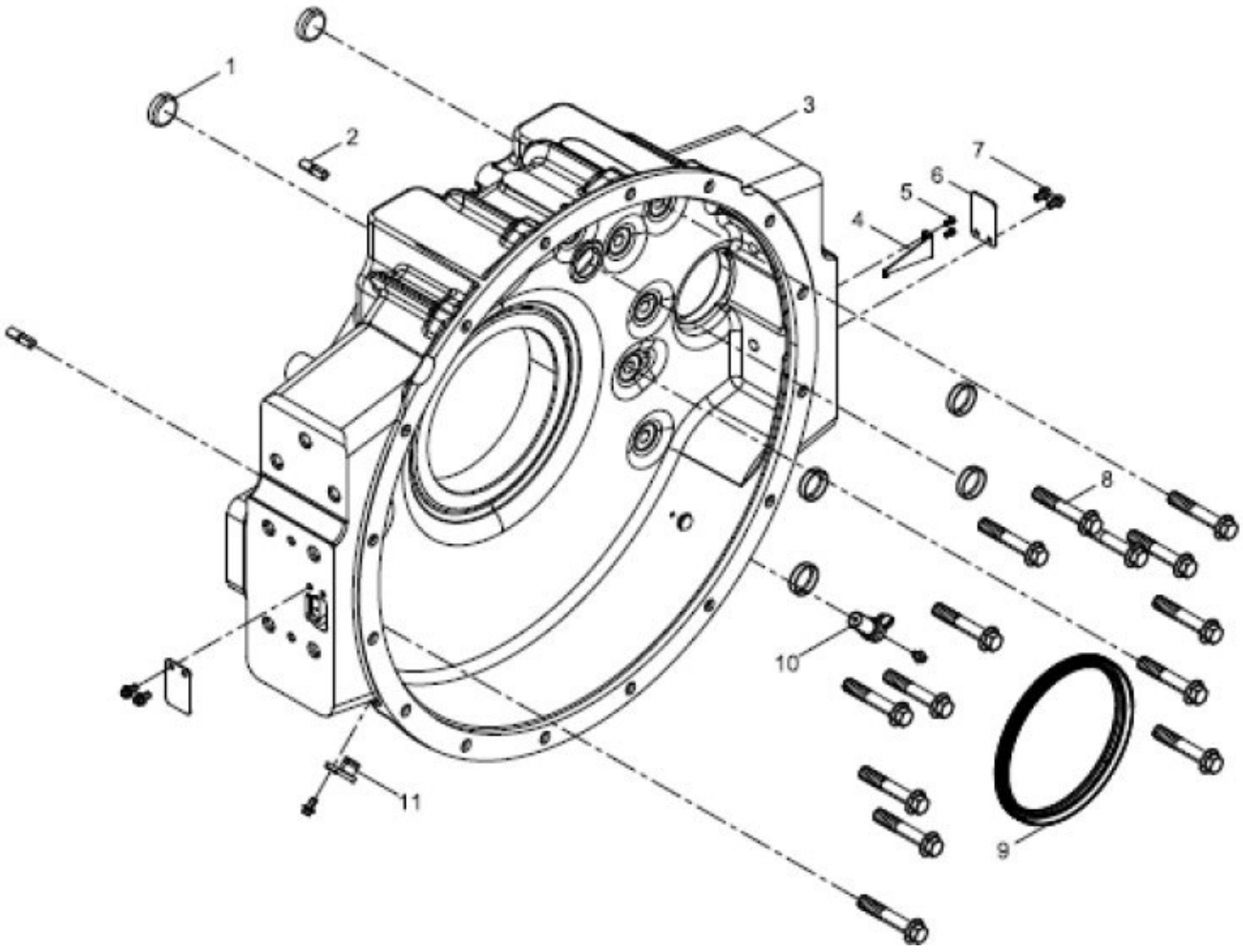


Figure 179. Flywheel Housing Assembly

NO.	Name	NO.	Name	NO.	Name
1	Bowl Plug	5	Bolt	9	Rear Oil Seal
2	Dowel Pin	6	Cover Plate	10	Camshaft Sensor
3	Flywheel Housing	7	Bolt	11	Plug
4	Timing Pointer	8	Bolt		

REMOVAL

1. Remove all bolts from the flywheel housing.

NOTE:

- The flywheel should be hoisted and seated slowly.

2. Remove rear oil seal (If necessary).
3. Remove Dowel pin.

INSTALLATION

1. Install the cover and insert the three bolts.
2. Insert the two pins into the flywheel housing.
3. Attach a washer to the head screw plug and then screw it into the flywheel housing.
4. Apply PSI approved motor oil onto the rear main oil seal.
5. Press the rear main oil seal into the flywheel housing.
6. Clean all debris from the cylinder block and flywheel housing surfaces.
7. Apply sealant to the rear of the flywheel housing surfaces.
8. Install the flywheel cover guide rods onto the flywheel cover, pass the flywheel cover through the slotted pin by means of flywheel cover slings.
9. Apply PSI approved sealant to all flywheel housing bolts.
10. Insert and tighten the bolts in the below sequence to 133 ft/lbs (See Figure 180).

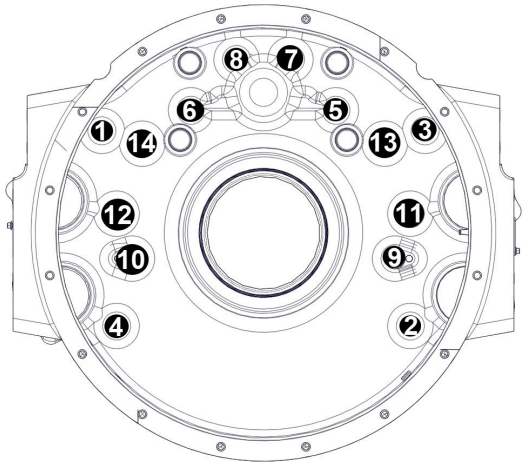


Figure 180. Flywheel Housing Bolt Sequence

OIL RECOMMENDATION

When the 40L engine is being filled for the first time, oil should be filled to the max scale of 145 liters.

40L engine oil should be determined according to the temperature. (See Figure 181)

SAE Viscosity Level	Applicable Ambient Temperature (°F)
15W-40	-4-104

Figure 181. Oil Recommendation Chart

ENGINE OIL FILTER AND OIL REPLACEMENT

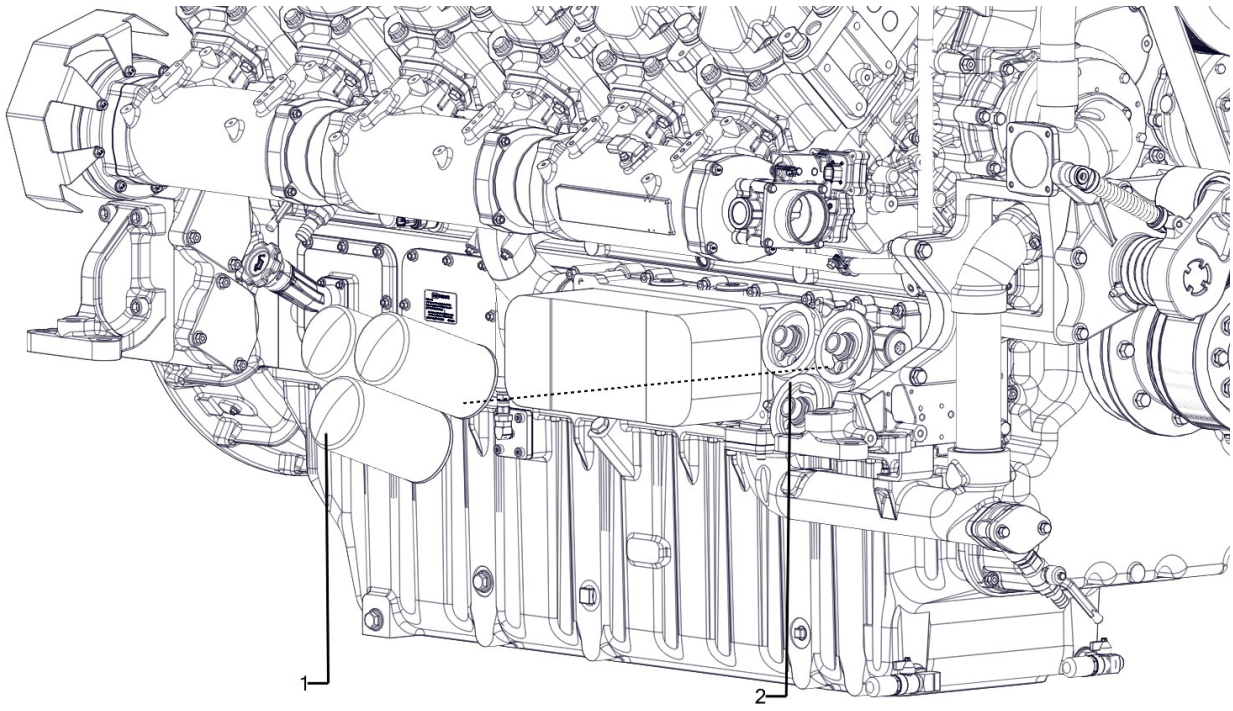


Figure 182. Engine Oil Filter Assembly

NO.	Name
1	Oil Filters
2	Oil Filter Seat

REMOVAL

1. Separate the oil filter from the oil filter seat.
2. Remove the coupling bolts between the oil filter seat and the engine block.
3. Remove the pressure limiting valve in the secondary oil pressure.

INSTALLATION

1. Install the secondary oil pressure along with the pressure limiting valve.
2. Installing the coupling bolts between the oil filter seat and the engine block.
3. Apply oil onto the oil filter seal.
4. Hand tighten the oil filters onto the oil filter seat.
5. Tighten each oil filter a 1/2 turn past hand tighten.

OIL DRAIN AND OIL SAMPLE VALVE

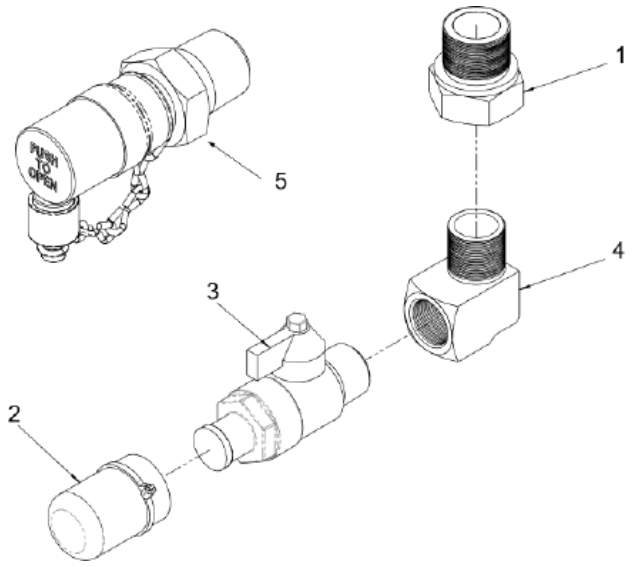


Figure 183. Oil Drain and Oil Sample Valve

NO.	Name	NO.	Name
1	Adaptor	4	Elbow
2	Rubber Cap	5	Oil Sample
3	Oil Drain Valve	6	Bushing

1. If the engine is cold, start it and allow it to run for a few minutes to get the oil warm and circulating. Shut the engine down and disconnect the negative battery cable from the battery.
2. Attach a collection hose to the fitting (Figure 182). Drain the oil into a suitable 40-gallon container. When the oil has completely drained, close the valve, remove the hose, and reinstall the dust cap. Dispose of the drained oil in accordance with environmental regulations.
3. Open the filler cap and add engine oil (up to 145 liters) until the level reaches the high mark on the dipstick.
4. Reinstall the filler cap.
5. Start the engine and run at idle with no load applied.
6. Inspect the engine and filters for any oil leaks.
7. Shut the engine down, wait at least five minutes for the oil to drain back into the sump pump and recheck the oil level. More oil may need to be added to replace the oil that filled the filters.

ALTERNATOR

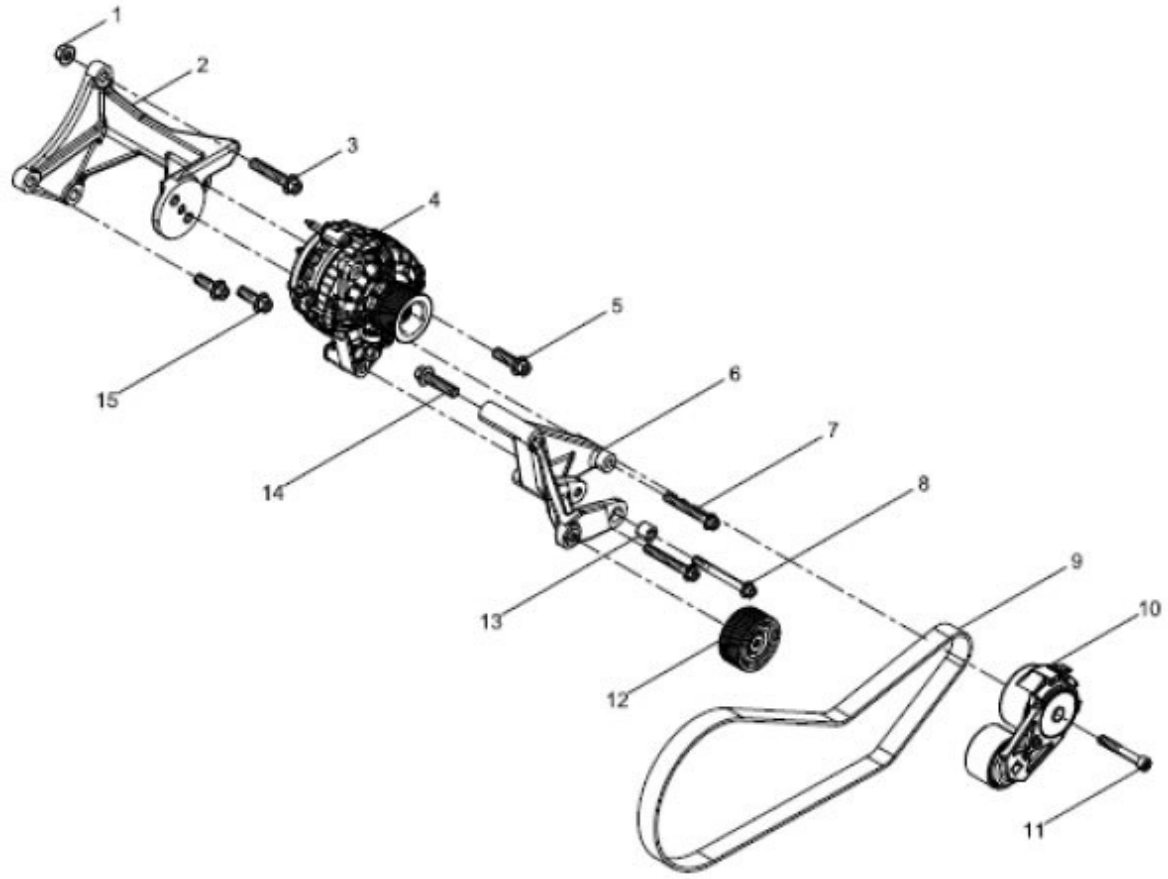


Figure 184. Alternator Assembly

NO.	Name	NO.	Name	NO.	Name
1	Nut	6	Bracket	11	Bolt
2	Alternator Bracket	7	Alternator Bracket	12	Idler
3	Bolt	8	Bolt	13	Sleeve
4	Alternator	9	Belt	14	Bolt
5	Bolt	10	Tensioner	15	Bolt

REMOVAL

1. Disconnect all battery power.
2. Disconnect wires from the back of the alternator.
3. Insert a ½” ratchet or breaker bar into the belt tensioner hole and pull to relieve belt tension. Slip the belt off the tensioner pulley and remove from the engine.
4. Loosen the bolts securing the alternator to the bracket and remove the alternator.

INSTALLATION

1. Place the alternator on the bracket and install the bolts.
2. Insert a ½” ratchet or breaker bar into the hole on the belt tensioner and pull to move the pulley. Loop the alternator belt around the alternator pulley, crank pulley, and tensioner. Slowly release the tension on the ratchet to apply tension to the belt. Verify that the belt is fully seated in all grooves on the alternator and crank pulleys.
3. Reconnect the wires on the back of the alternator.

STARTER MOTOR

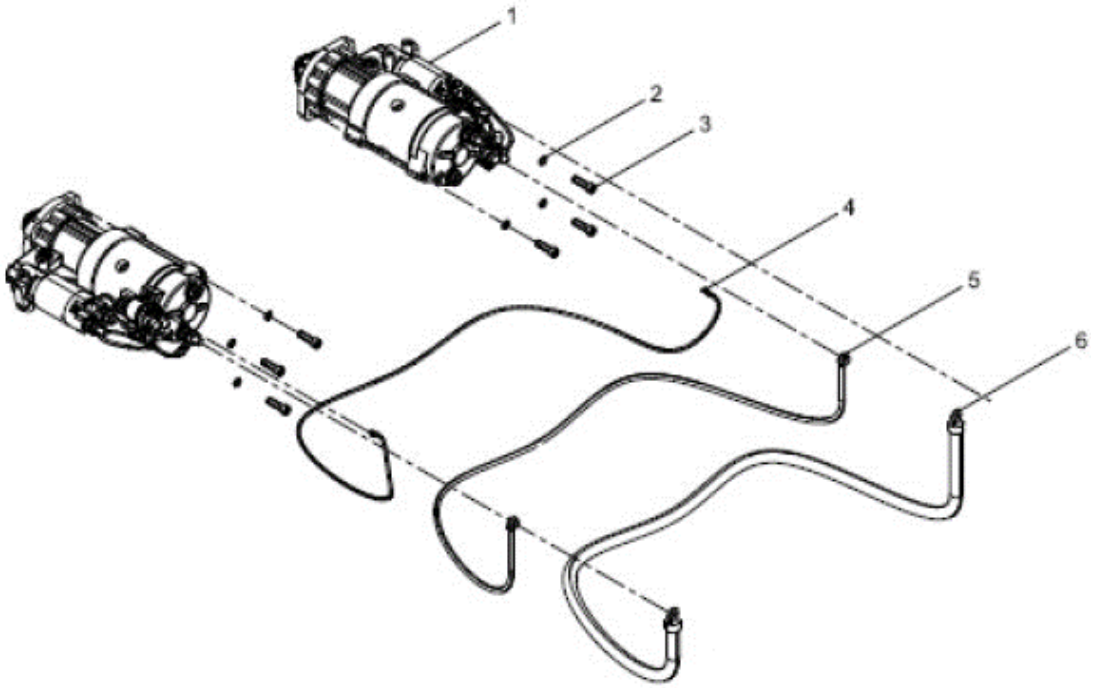


Figure 185. Starter Motor Assembly

NO.	Name
1	Starter
2	Washer
3	Stud
4	Wire
5	Wire
6	Wire

WARNING:

- To avoid accidental engine starting, disconnect the battery cable from the negative (-) battery terminal. Completely tape all metal surfaces of the disconnected battery cable end to prevent contact with other metal surfaces.

REMOVAL

1. Loosen and remove the starter wires (Figure 185, items 4 thru 7) with both hands to remove it along the starter gear rotation axis.
2. Loosen and remove the stud bolts (Figure 185, item 3) and the washers (Figure 185, item 2).

INSTALLATION

1. Install the studs onto the flywheel housing.
2. Install the starter and make sure to keep the motor drive gear opening direction towards the flywheel ring gear.
3. Reconnect the starter wires.
4. Install the washers and torque down the stud bolts.

TORQUE SPECIFICATIONS

Data for Tightening Torque			
Tightening of screws and nuts	**Thread**	**Assembly**	**Recommended tightening torque (ft/lbs)**
Injector pipe nut	M14×1.5	Lub. oil	29
	M16×1.5	Lub. oil	
Screw for return pipe of injector	M8×1	Lub. oil	6
Screw for adjust plate of alternator	M8 (10.9)	Lub. oil	26
Screw for fixing bracket rod of alternator	M10 (10.9)	Lub. oil	48
Exhaust manifold bolt	M10 (10.9)	Loctite 242	48
Intake manifold bolt	M10 (10.9)	Loctite 242	48
Engine hanger plate screw	M12 (10.9)	Lub. oil	81
Screw for fixing turbocharger oil outlet pipe	M10 (10.9)	Loctite 242	48
Screw for fixing fuel injection pump bracket onto pump	M10 (10.9)	Lub. oil	33
Nut for fixing fuel injection pump bracket onto block (double end stud)	M8 (12.9)	Lub. oil	30
Fuel injection pump inter gear screw	M10 (10.9)	Loctite 242	48
Fuel injection pump gearing screw	M12 (12.9)	Loctite 242	81
Injection pump camshaft nut	M24×1.5	Loctite 242	125
Oil cooler screw	M8 (10.9)	Loctite 242	26
Oil pump screw	M14 (10.9)	Loctite 242	132
Valve bridge adjusting nut	M10（10.9）	Loctite 242	33

Data for Tightening Torque			
Tightening of screws and nuts	**Thread**	**Assembly**	**Recommended tightening torque (ft/lbs)**
Connecting Rod Bolt	M16×1.5	Loctite 242	Tighten the screws to a torque of 147 ft/lbs
			Tighten the screws to an angle of 60°
			Tighten the screws to an angle of 45°
Main Bearing Bolt	M24×2	Lub. oil	Tighten the screws to a torque of 133 ft/lbs
			Tighten the screws to an angle of 60°
			Tighten the screws to an angle of 60°
Cylinder head bolt	M16 (Main Bolt) M20 (Secondary)	Lub. oil	Tighten the M16 screws in order 1-2-3-4 ...24 to a torque of 59 ft/lbs; Tighten the M20 screws in order A-B-C-D...N to a torque of 59 ft/lbs
			Tighten the M16 and M20 bolts to 59±7 ft/lbs, then tighten the bolts to an angle of 60°±5°.
			Tighten the M16 bolts to an angle of 60°±5° Tighten the M20 bolts to an angle of 60°±5°
			Tighten the M20 bolts to an angle of 60°±5° Tighten the M16 bolts to an angle of 45°±5°
			The reuse of the primary and secondary cylinder head bolts is limited to no more than 3 times. New bolts **MUST** be used after that.
Screw for fixing rocker Arm bracket onto cylinder head	M10 (10.9)	Lub. oil	48 ft/lbs
Crankshaft damper bolt	M12 (10.9)	Loctite 242	92 ft/lbs
Flywheel screw	M20×2.0	Lub. oil	Tighten the screws to a torque of 140 ft/lbs
			Tighten the screws to a torque of 55 ft/lbs
Screw for fixing camshaft Thrust Plate	M8 (12.9)	Loctite 242	Tighten the screws to a torque of 15 ft/lbs
			Tighten the screws to a torque of 29 ft/lbs
Camshaft timing gear screw	M10 (10.9)	Loctite 242	52 ft/lbs
Screw for fixing oil pan onto block	M10 (10.9)	Loctite 242	55 ft/lbs
Screw for adjusting rocker arm	M10（10.9）	Lub. oil	33 ft/lbs
Flywheel housing screw	M14 (10.9)	Lub. oil	133 ft/lbs
Nut for fixing starter (double end stud)	M10 (10.9)	Loctite 242	48 ft/lbs

Valve bridge screw	M10 (12.9)	Loctite 242	55 ft/lbs
Water pump screw	M8 (10.9)	Loctite 242	26 ft/lbs
Crankshaft pulley bolt	M14 (10.9)	Loctite 242	159 ft/lbs
Oil Supply line to water bolt (Banjo Bolt)	M10X1 (10.9)		20 ft/lbs
Oil Supply line to water bolt (Banjo Bolt)	M12X1.5		23 ft/lbs

MECHANICAL SPECIFICATIONS

SN	Item	Unit	40L
1	Intake Mode	-	Inter-cooling
2	Cylinders	-	12
3	Bore/Stroke	mm	150/185
4	Displacement	L	39.2
5	Compression Ratio		15:1
6	Operating Oil Pressure	MPa	0.40-0.65 (rated power)
7	Oil Temperature After Cooling	°F	185-221
8	Thermostat Opening Temperature	°F	176
9	Exhaust Temperature After Turbine	°F	1022
10	Opening of Intake Valve	°CA	34±5 °CA before TDC
11	Closing of Intake Valve	°CA	40±5 °CA after BDC
12	Opening of Exhaust Valve	°CA	47±5 °CA before BDC
13	Closing of Exhaust Valve	°CA	13±5 °CA after TDC
14	Firing Order	-	1-8-5-10-3-7-6-11-2-9-4-12
15	Rotation Direction	-	Counter-Clockwise (facing flywheel)
16	Starting Method	-	Electric Starter Motor
17	Lubrication Method	-	Forced Lubrication
18	Cooling Method	-	Water Cooling Forced Circulation
19	Intake Valve Gap (Cold State)	mm	0.55
20	Exhaust Valve Gap (Cold State)	mm	1.0
21	Oil Capacity	L	155
22	Length (with radiator)	mm	2524
23	Width (with radiator)	mm	1393
24	Height (with radiator)	mm	1708
25	Net Weight	Kg	3390
26	Main Bearing Clearance	mm	0.116-0.196
27	Connecting Rod Bearing Clearance	mm	0.08-0.15
28	Crankshaft Axial Clearance	mm	0.15-0.346
29	Connecting Rod Axial Clearance	mm	0.20-0.081
30	Clearance between connecting rod small end bush and piston pin	mm	0.031-0.081
31	Piston 1 ring gap working clearance at cold state	mm	0.45-0.6
32	Piston 2 ring gap working clearance at cold state	mm	0.75-1.0
33	Oil control ring gap working clearance at cold state	mm	0.45-0.7
34	Clearance between piston pin and pin seat	mm	0.015-0.03
35	Clearance between intake valve stem and valve guide	mm	0.035-0.065

36	Clearance between exhaust valve stem and valve guide	mm	0.055-0.085

37	Intake valve sinkage from cylinder head bottom plane	mm	0.60-1.10
38	Exhaust valve sinkage from cylinder head bottom plane	mm	1.20-1.70
39	Upper plane of cylinder liner support shoulder above the engine body upper plane (integral cylinder gasket, at compacted state)	mm	0.07-0.13
40	Camshaft axial clearance	mm	0.10-0.25
41	Camshaft bearing clearance	mm	0.055-0.128
42	Camshaft bearing clearance (thrust bearing)	mm	0.06-0.12
43	Clearance between tappet and hole	mm	0.025-0.066
44	Clearance between the outer diameter of cylinder liner and the cylinder hole of engine body (upper part)	mm	0.014-0.079
45	Clearance between the outer diameter of cylinder liner and the cylinder hole of engine body (lower part)	mm	0.03-0.095
46	Intake valve gap (cold state)	mm	0.55
47	Exhaust valve gap (cold state)	mm	1.0
48	Rocker arm axial clearance	mm	0.4-0.6
49	Clearance between crankshaft gear and camshaft gear	mm	0.07-0.25

MECHANICAL SPECIFICATIONS - CONTINUED

SN	Item	Theoretical Value (mm)	Wear Limit
50	Height of cylinder head	125~125.025	124.75
51	Diameter of intake valve	9.965~9.80	
52	Diameter of exhaust valve	9.945~9.960	
53	Sinkage of intake valve	1.20~1.70	2.00
54	Sinkage of exhaust valve	0.60~1.10	1.70
55	Clearance between intake valve and valve guide	0.035~0.065	0.10
56	Clearance between exhaust valve and valve guide	0.065~0.085	0.10
57	Diameter of intake valve seat	49~49.016	
58	Diameter of exhaust valve seat	42~42.015	
59	Clearance between intake valve seat and cylinder head	0.065~0.097	
60	Clearance between exhaust valve seat and cylinder head	0.065~0.097	
61	Inner diameter of valve guide	9.995~10.015	
62	Outstanding amount of valve guide	16.03~16.07	
63	Clearance between valve guide and cylinder head	0~0.29	
64	Inner diameter of injection sleeve	31~31.5	
65	Clearance of intake and exhaust valve	0.22" & 0.39"	
66	Diameter of valve bridge	13.966~13.984	13.92
67	Inner diameter of valve bridge seat	14~14.018	14.15
68	Clearance between valve bridge and its seat	0.016~0.052	0.10
69	Inner diameter of rocker arm bushing	24.017~24.03	
70	Clearance between rocker and its bushing	0.05~0.115	
71	Diameter of rocker arm shaft	23.96~24	23.9
72	Clearance between rocker arm and rocker arm seat	0.15~0.20	
73	Clearance between rocker arm shaft and seat	0.017~0.043	0.10
74	**Valve Mechanism**		
75	Diameter of front part of camshaft	57.91~57.94	
76	Diameter of end part of camshaft	60.002~60.021	
77	The length of push rod	462.4	
78	Inner diameter of camshaft front bearing	58~58.030	

79	Clearance between cylinder block and front bearing	0.15~0.25	0.35

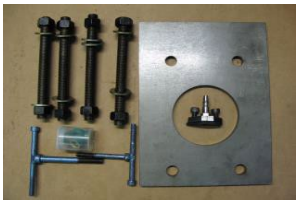
80	Clearance between cylinder block and front Bearing (Radial)	0.6~0.12	0.16
81	Out diameter of camshaft bearing	71.988~72.018	
82	Inner diameter of normal camshaft bearing	60.076~60.1	60.2
83	Out diameter of normal camshaft bearing	65~65.03	
84	Out diameter of tappet	34.967~34.975	34.9
85	Inner diameter of tappet install hole	35~35.025	35.10
86	Clearance between tappet and cylinder block	0.025~0.066	0.15
87	Inner diameter of camshaft install hole	72~72.03	72.08
88	**Piston Specifications**		
89	Diameter of install hole of piston pin	60.007-60.014	
90	Diameter of piston pin	59.99-59.997	
91	Piston Pin Hole	28	
92	Inner Diameter of Connecting Rod Bushing	60.028-60.071	
93	Inner Diameter of Bearing	105.095-105.147	

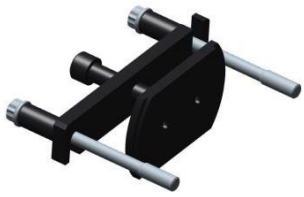
SPECIAL TOOLS

NOTE:

- All parts cannot be individually purchased, all parts must be purchased as an entire kit.

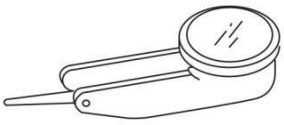
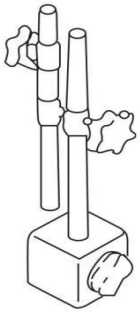
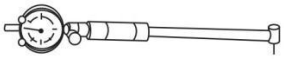
Description	PSI P/N	OEM P/N	Illustration
Valve Guide Remover	Z799002	1002777012	
Valve Guide Installer	Z799002	1002777012	

Intake Valve Insert Installer	Z799002	1002777012	
Exhaust Valve Insert Installer	Z799002	1002777012	
Cylinder Head Hydraulic test plate	Z799002	1002777012	
Valve Remover	Z799002	1002777012	
30mm Socket	Z799002	1002777012	

Flywheel Locating Pin	Z799003	1002813557	
Liner Remover	Z799002	1002777012	
Liner Installer	Z799002	1002777012	
Rear Seal Installer	Z799003	1002813557	
Flywheel Guide Rods	Z799003	1002813557	

Front Oil Seal Installer	Z799003	1002813557	
Wall Spreader for Crankshaft Bearing	Z799003	1002813557	
Piston Handle	Z799002	1002777012	
Piston Ring Pliers	Z799002	1002777012	

Piston Guide Cylinder	Z799002	1002777012	
Camshaft Fitting Guide	Z799003	1002813557	
Tappet Tool	Z799002	1002777012	
Camshaft Bearing Fitting/ Removal Tool	Z799003	1002813557	
Turning Tool	Z799002	1002777012	

Vibration Damper Guide Rod	Z799003	1002813557	
Test Indicator	N/A	N/A	
Magnetic Stand	Z799002	1002777012	
Injector Bushing Removal Tool	Z799003	1002813557	
Cylinder Bore Gauge	Z799003	1002813557	

21mm Socket	Z799002	1002777012	
Valve Keeper Remover	Z799004	N/A	

SEALANT APPLICATION CHART

Mark	Main use	List of locations for application of sealant	Supplement
Loctite 242	It's applied onto the threads to prevent being vibrated to looseness, with moderate strength.	Screw plug	Alternatively, the thread preapplication sealant DriLoc 204 can be preapplied.
		Control valve	
		Oil cooler bolt	
		Engine oil cooler	
		Flywheel cover bolt	
		Front end cover bolt	
		Engine oil filter base	
		Intermediate idler bolt	
		Camshaft thrust plate bolt	
		Camshaft timing gear bolt	
		Bolt, fuel return pipe fixing device, fuel pump	
		Air compressor shaft end thread Strainer bolt	
		Bolts of sensor and harness fixing device	
Loctite 262	Applied onto outer threads for locking, sealing, preventing vibration from causing looseness	Auxiliary bolt, cylinder head	
Loctite 271	Preventing looseness	Cup plug, oil drain hole	N/A
Loctite 277	For sealing between element and bore	Other cup plugs	N/A
Loctite 270	Sealing cylinder head top	Push rod, cylinder head	N/A

TIGHTENING TORQUES FOR STANDARD BOLTS AND NUTS

Friction Coefficient	0.125 (zinc plated)				0.14 (polished)			
Strength Grade	6.9	8.8	10.9	12.9	6.9	8.8	10.9	12.9
Bolt Size	Recommended Torque (ft/lbs)							
M4	2	2	3	3	2	2	3	4
M5	3	4	6	7	4	4	6	7
M6	6	7	10	12	6	7	10	13
M8	14	17	24	29	15	18	26	30
M10	29	34	47	57	30	36	51	61
M12	49	59	81	96	53	63	87	107
M14	77	92	133	159	85	100	140	170
M16	122	144	203	243	133	155	218	262
M18	166	199	288	336	181	214	299	358
M20	240	284	398	479	254	302	428	509
M22	321	376	531	642	343	406	575	686
M24	413	487	686	811	443	524	738	885
M27	612	723	1033	1217	656	774	1106	1328
M30	811	996	1364	1660	885	1069	1475	1770
M8X1	15	18	26	31	17	20	28	33
M10X1.25	30	36	49	60	32	38	54	65
M12X1.25	55	65	92	111	59	70	100	114
M12X1.5	52	61	85	103	56	66	92	111
M14X1.5	85	103	144	173	92	111	155	184
M16X1.5	129	155	218	258	140	166	232	280
M18X1.5	188	225	313	376	203	240	339	406
M20X1.5	266	313	442	531	284	339	472	568
M22X1.5	354	420	590	708	384	450	634	774
M24X1.5	450	531	738	885	479	575	811	959
M27X1.5	656	774	1106	1328	715	848	1180	1438
M30X1.5	922	1069	1512	1844	996	1180	1660	1991

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