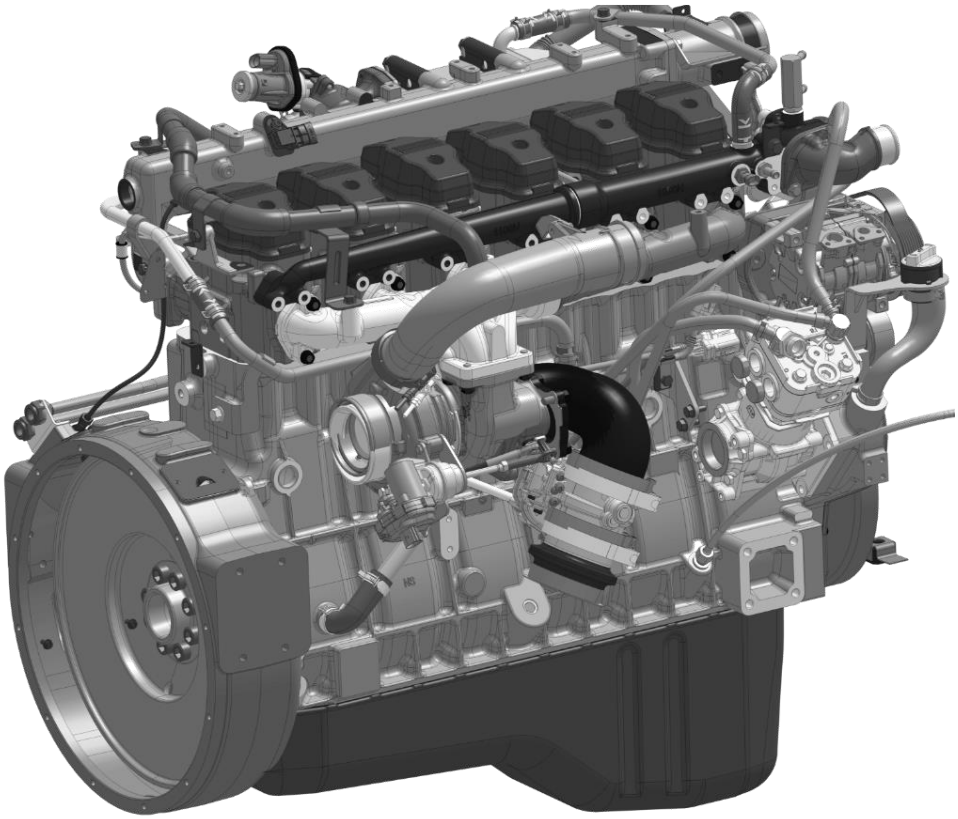
ENGINE

D72 280HP CR BS6

WORKSHOP MANUAL

2 ENGINE

2.1 General Information



The mPower 7.2 BSVI Engine is a 6-cylinder, 4-stroke diesel engine and has a displacement of 7.2 liters, and a CRDe (Common Rail Direct Injection Engine) type fuel injection system.
Bosch CRDe injection system is used and controlled by an Electronic Control Unit (ECU). The engine performance is optimized for various engine speed, load and operating conditions depending upon the various sensors input.
It is an in-line type engine featuring a waste-gate turbocharger, intercooler and an electronically controlled fuel injection system. It has a 4-valves per cylinder design with injectors centrally located on the combustion chamber, delivering fuel directly into the combustion chamber over the piston head for improved performance and reduced emission levels. It also has an enlarged oil cooler, environment friendly filter.
The fuel system comprises the injectors which have no contact with the camshaft but are controlled by the engine control unit instead. The pressurized fuel for all injectors is stored in the common rail.
ECU acts as a brain of the engine which keeps the engine functioning at its optimum conditions. It continuously receives signal from various sensors to calculate the timing and quantity of fuel required by the engine

2.2 Technical Specifications

Parameter	Description
Model	6.12 TCE
Type	6 cylinder, In-line Diesel
No. of valves / cylinder	4
Firing Order	1-5-3-6-2-4
Bore / Stroke	105 × 137 mm
Compression Ratio	16.8:1
Displacement	7.12 Ltrs.
Charging system	Waste-Gate turbocharger
Fuel system	1600 bar CR system
Injection Type	CRDe (Common Rail Direct injection Engine)
Max power	280 HP @2200 RPM
Max Engine Speed	2400 rpm
Max. torque	960 Nm @1100 RPM to 1700 RPM
Emission level	BSVI
After Treatment System	Bosch DNox 2.2
Qty of coolant (Engine + Radiator) Ltr	25
Max Permissible Temperature Deg C	105
Lube oil system capacity (lit)	27.2

2.3 Service Standards

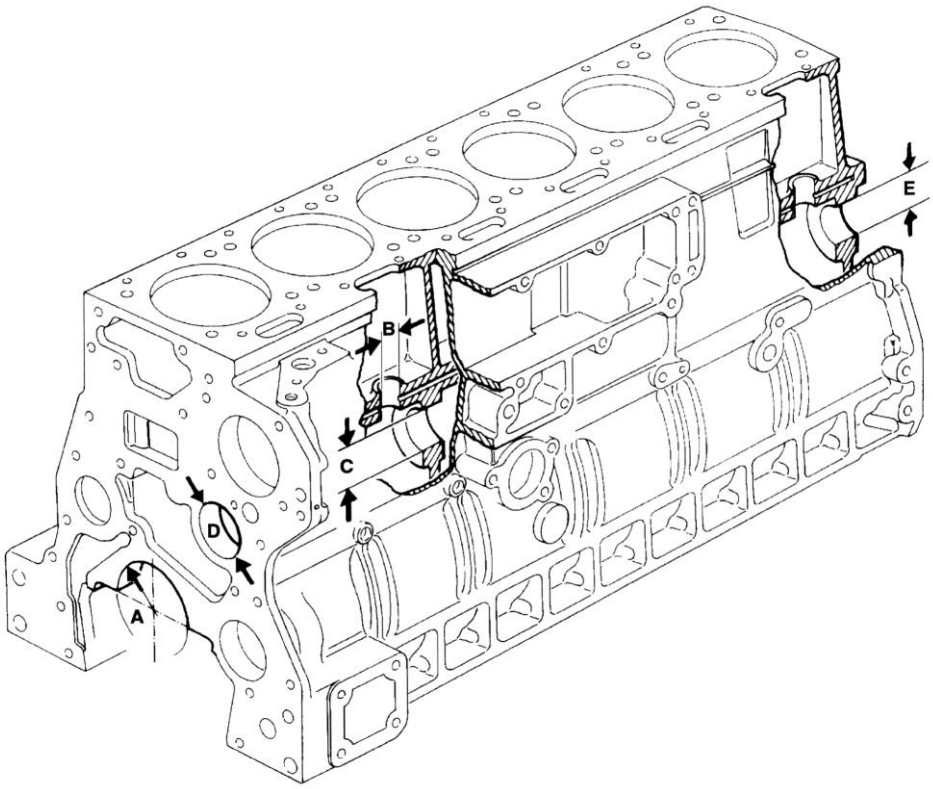
2.3.1 Assembly Clearances

Place of Application	Value (mm)
Compression pressure	23 bar (max) 20 bar (min)
Liner projection over cylinder block	0.02 mm
Crankshaft end float	0.08 - 0.25 0.4 (max)
Connecting rod end float	0.30 - 0.50 0.9 (max)
Camshaft end float	0.10 – 0.19
Nozzle tip protrusion	7.00 - 7.05
Valve Clearance	
Intake valve	0.20 - 0.40
Exhaust valve	0.20 - 0.40
Piston ring details	
Top ring groove clearance	0.25
Middle ring groove clearance	0.2
Oil ring groove clearance	0.15
Top ring end gap	0.3-0.55
Middle ring end gap	0.60-0.85
Oil ring end gap	0.25-0.55
Gear backlash	
Timing gear backlash	0.05 to 0.25
Idler gear to idler shaft clearance	0.013 - 0.075
Flywheel	
Flywheel friction surface distortion	0.1
Flywheel height to friction surface	9.5 10.5 (max)
Flywheel friction surface runout	0.1

2.3.2 Crankshaft

Place of Application	Value (mm)	Service Limit (mm)
Crank shaft Main journal dia	85.942 - 85.964	1st repair 85.692 - 85.714
		2nd repair 85.442 - 85.464
		3rd repair 85.192 - 85.214
		4th repair 84.942 - 84.964
Crank shaft pin dia	62.951 - 62.970	1st repair 62.701 - 62.720
		2nd repair 62.451 - 62.470
		3rd repair 62.201 - 62.220
		4th repair 61.951 - 61.970
Crank shaft radial clearance	0.036- 0.096	0.245
Connecting rod bearing dia	62.992 - 63.037	1st repair 62.746 - 62.791
		2nd repair 62.496 - 62.541
		3rd repair 62.246 - 62.291
		4th repair 61.996 - 62.041
Roundness of pins & journals	0.01	0.01
Cylindricity of pins & journals	0.01	0.01
Bend in crankshaft	0.02	0.02
Fillet radius of crank shaft	3.8 - 4	3.8 - 4
Thrust washer thickness	STD = 3.42-3.47	STD = 3.42-3.47
	Oversize = 3.67-3.72	Oversize = 3.67-3.72

2.3.3 Cylinder Block

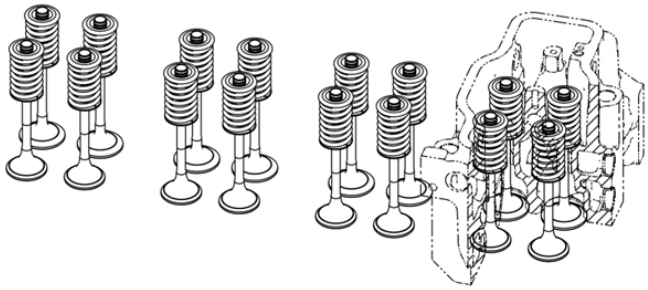


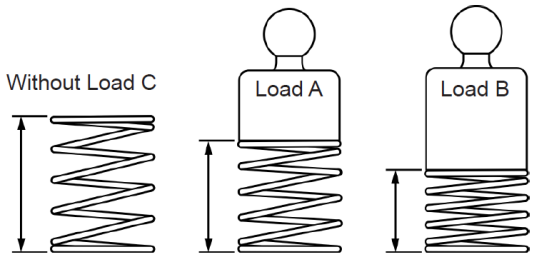
Place of Application	Value (mm)	Service Limit
Cylinder sleeve	ID=Dia.105.022-105	ID=Dia.105.022-105
	Roundness = 0.02	Roundness = 0.02
	cylindricity = 0.04	cylindricity = 0.04
Cylinder block to sleeve interference	STD = 0.045	No interference
	Oversize = 0.13	
Tappet to tappet hole clearance (B)	0.006 - 0.035	0.035
Cylinder block main journal parent bore diameter (A)	92.000 - 92.022	92.000 - 92.022
Cam shaft journal to bushing clearance (C), (D), (E)	1, 2 & 3	0.05 - 0.19
Cam shaft height difference between cam height & base circle diameter	7.52 to 7.60	7.52 to 7.60
Cam shaft bent	0.02	0.05

NOTE

1st Camshaft bearing has a bushing, the others do not. When it is necessary the other bearings can receive bushing as repair.

2.3.4 Valve Spring





Place of Application	Value (mm)	Service Limit
Inner valve spring free length (without Load C)	60.59	60. 59

Place of Application	Load A	Load B
Inner valve spring load	350.0 ± 29 N	520.0 ± 32 N
Inner valve spring length	40. 0	30. 0

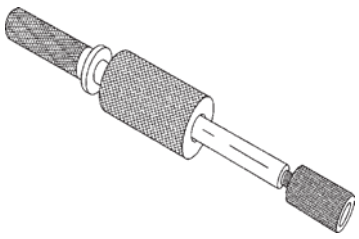
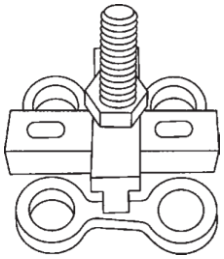
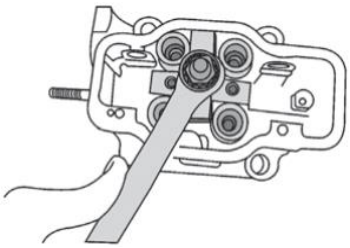
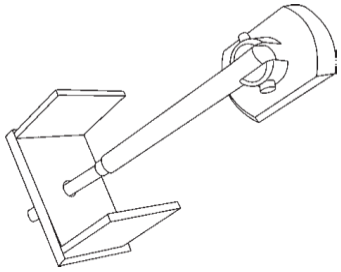
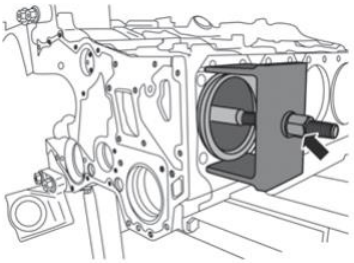
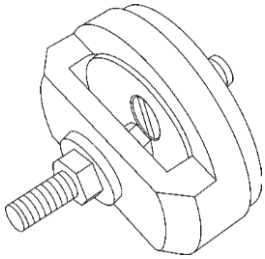
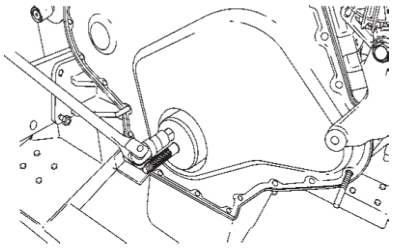
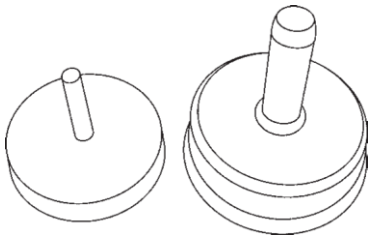
2.3.5 Piston and Cylinder Bore Sizes

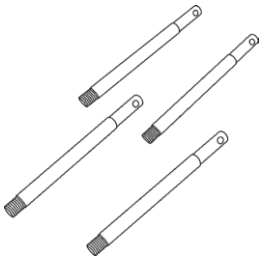
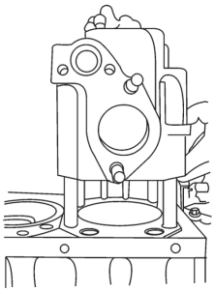
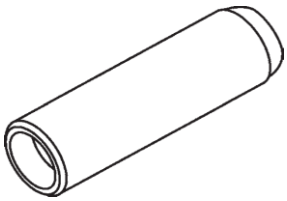
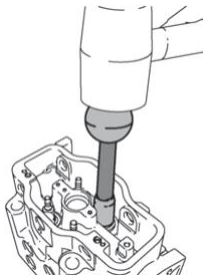
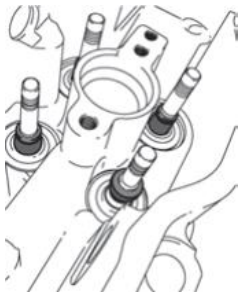
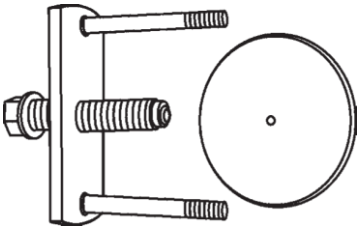
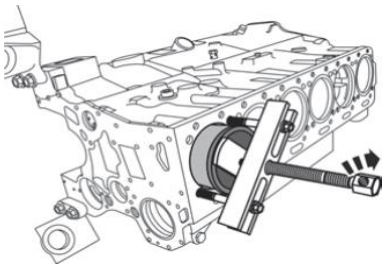
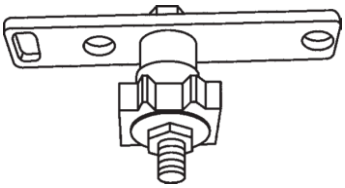
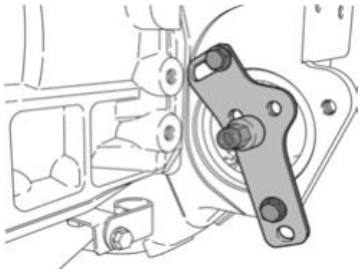
Place of Application	Value (mm)	Service Limit
Piston projection from cylinder block top surface	0.5	0.5
Piston Pin Nominal Diameter	37.994 to 38.000	37.900
Piston pin to piston pin hole clearance	0.04	0.04
piston pin to connecting rod small end bush clearance	0.15	0.15

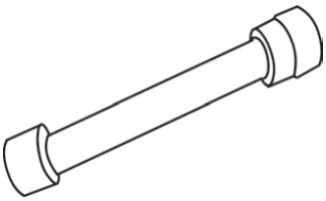
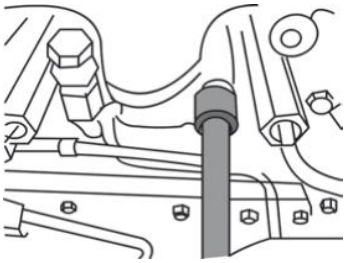
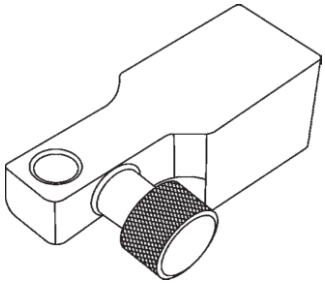
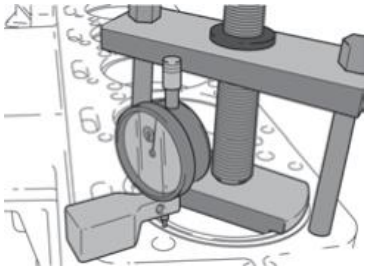
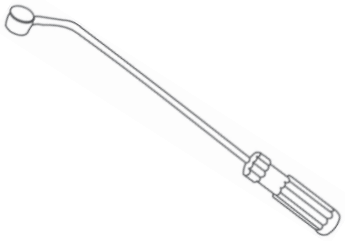
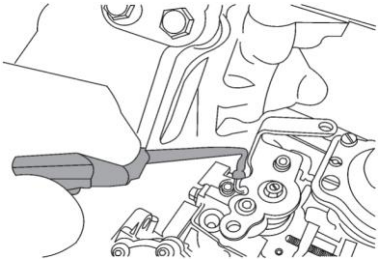
2.3.6 Cylinder Head

Place of Application	Value (mm)	Service Limit
Cylinder head bottom surface distortion	0.04	0.04
Height of cylinder head from top to bottom surface	135 ± 2	135 ± 2
Rocker to rocker shaft clearance	0. 022 – 0. 051	0. 022 – 0. 051
Push rod run out	0.5	0.5

2.4 Special Tools

Part No. & Description	Purpose	Image	Application
6204BAB0001ST Nozzle removal device	To remove injector adaptors		-
6209DAB0001ST Valve spring removal / assembling device	To remove/install cylinder valves in cylinder head		
6202AAB0001ST Cylinder liner disassembling device	To remove cylinder liner from Engine block		
6210AAB0001ST Front seal assembly device	To install Front Oil Seal		
6210AAB0002ST Rear seal assembly device	To install Rear Oil Seal		

Part No. & Description	Purpose	Image	Application
6202BAB0001ST Guide pins for cylinder head & main bearing assembly	Guide the engine head to install on the engine		
6209EAB0001ST Valve guide assembly device	Install valve guides in the head		
6209BAB0001ST valve seal assembly device	Install valve stem seal		
6202AAB0002ST Cylinder liner assembly device	To assemble cylinder liner in the block		
6211CAB0001ST Flywheel locking device	To lock the flywheel and arrest the rotation of the engine crankshaft		

Part No. & Description	Purpose	Image	Application
6202CAB0001ST Plug for intake manifold screw	To torque the intake manifold bolts		
6202BAB0002ST Dial indicator adaptor for measuring cylinder height	To measure cylinder protrusion/height		
6202AAB0003ST Compressor pressure measuring adaptor (acton)	To check engine compression pressure		
6204HAB0002ST FIP 3rd bolt removal spanner	To access the 3rd bolt of the HPP mounting		
8503AAJ00030N Engine barring tool	To rotate the flywheel		

2.5 Tightening Torques

Description	Fastener Type	Tightening Torque (Nm)
Main bearing caps mounting bolts	M14	Torque - 50 ± 5 Nm Angular Torque - 155° ± 5°
Connecting rod bearing cap screws	M12 X 1.5 X 58	Torque - 40 ± 5 Nm Angular Torque - 80° ± 5°
Cylinder head bolts	M14 X 152 X 2 X 10.9	Pre-Torque - 40 ± 2 Nm Torque - 60 ± 10 Nm 1st Angular Torque - 60° ± 3° 2nd Angular Torque - 60° ± 3° 3rd Angular Torque - 90°± 3°
Camshaft gear to camshaft securing bolts	M8×25	Torque - 15 ± 1 Nm Angular Torque - 30° ± 2°
Camshaft lock securing bolts	M8×16	30±5
Piston cooling jets mounting bolts	M8 X 1.25 X 30	10 ± 1.5
Valve cover assembly mounting bolts	M6 X 60 X 1 X 8.8	10 ± 1
Valve clearance adjustment nut	M8 X 10	20 ± 5
Lubrication pipe mounting bolts	M5 X 10 X 0.8 X 8.8	5 ± 1
Alternator mounting bracket bolts	1. M10 X 35 X 1.5 X 8.8 2. M10 X 110 X 1.5 X 8.8 3. M12 X 35 X 1.75 X 8.8	1. 45 ± 3 2. 50 ± 5 3. 50 ± 5
Idler pulley	M12 X 1.75	83 ± 5
Gear Case mounting bolts	1. M8 X 20 X 1.25 X 8.8 2. M8 X 50 X 1.25 X 8.8	30 ± 3
Intermediate bearing with gear to block	M10 X 70	60 ± 5
Banjo Bolt	M8 X 1	7.5 ± 2.5
Oil pressure sensor	M12 X 1.5	20 ± 2
Engine breather assembly mounting bolts	1. M8 X 20 X 1.25 X 8.8 2. M8 X 16 X 1.25 X 8.8	25 ± 5
Lube Oil pump mounting bolts	M8 X 20 X 1.25 X 8.8	20 ± 2
Oil filter head assembly mounting bolts	M8 X 40 X 1.25 X 10.9	25 ± 3
Oil filter head to oil cooler mounting bolts	M8 X 45	25 ± 5
Oil Suction strainer mounting bolts	M20 X 20 X 1.25 X 11.9	25 ± 4

Description	Fastener Type	Tightening Torque (Nm)
Water pump mounting bolts	M8 X 20 X 1.25 X 8.8	20 ± 2
Thermostat assembly mounting bolts	M8 X 30 X 1.25 X 8.8	25 ± 4
Front cover assembly mounting bolts	1. M8 X 16 X 1.25 X 8.8 2. M8 X 55 X 1.25 X 11.9	25 ± 3
Water inlet connection mounting bolts	M8 X 20 X 1.25 X 11.9	20 ± 3
Injector holding clip bolts	M6 X 30 X 1 X 8.8	Pre-torque – 1±0.5 Nm Torque - 4 ± 1 Nm 1st Angular Torque - 90° 2nd Angular Torque - 90° 3rd Angular Torque - 30 °
High pressure fuel adaptor nut	M22 X 1.5	50 ± 5
Cylinder head fuel return connector nut	M8 X 1	8 ± 1
Fuel filter assembly mounting nut	M10 X 30 X 1.5 X 8.8	35 ± 4
High Pressure tubes	M14 X 1.5	34 ± 3
Fuel return manifold mounting bolts	M8 X 16 X 1.25 X 8.8	25 ± 3
High pressure pump	M10 X 1.5 X 30 X 8.8	40 ± 6
Fuel line connector nut	M16 X 1.5	25 ± 3
EGR temperature sensor	M14 X 1.5	35 ± 4
EGR assembly mounting bolts	M10 X 110 X 1.5 X 8.8	50 ± 5
EGR pipe mounting bolts	M12 X 20 X 1.25 X 8.8	50 ± 5
EGR mounting bracket bolts	M8 X 12 X 1.25 X 8.8	23 ± 3
Coolant temperature sensor	M12 X 1.5	23 ± 2
Coolant vent adaptor	-	25 ± 3
Turbocharger mounting nuts	M10 X 1.5	60 ± 10
Turbocharger oil outlet to block	M22 X 1.5	18 ± 2
Turbocharger mounting bracket bolts	M8 X 20 X 1.25 X 11.9	27 ± 3
Turbocharger oil pipe bolts	M8 X 20	12 ± 2
Turbocharger banjo bolts	M14 X 1.5	25 ± 5

Description	Fastener Type	Tightening Torque (Nm)
Intake manifold mounting bolts	1. M8 X 1.25 X 35 2. M8 X 1.25 X 80	1st Torque - 20 ± 3 2nd Torque - 28 ± 3
Intake curve mounting bolts	M8 X 25 X 1.25 X 8.8	20 ± 3
Boost pressure sensor mounting bolt	M6 X 16 X 1 X 8.8	3.5 ± 0.5
Exhaust Manifold mounting bolts	1. M10 X 45 2. M10	70 ± 10
Exhaust Curve V-Band	-	11 ± 1
Steering Pump mounting bolts	M10 X 25	45 ± 5
Oil sump mounting bolts	M8 X 16	25 ± 5
Oil drain plug	1/2”	65 ± 10
Flywheel mounting bolts	M16 X 35 X 2 X 10.9	1st Torque - 100 ± 10 2nd Torque - 275 ± 15
Flywheel Housing bolts	M12 X 30 X 1.75 X 11.9	100 ± 10
Flywheel inspection cover bolts	M6 X 12 X 1.75 X 11.9	10 ± 1.5
Crankshaft Position Sensor	M6 X 16 X 1 X 8.8	8.5 ± 1
Engine mounting bracket bolts	1. M12 X 45 2. M16 X 60	1. 100 ± 15 2. 250 ± 20
Starter Motor mounting bolts	M10 X 1.5 X 30	45
Electro-Viscous Fan	M8 X 110	40 ± 6
Air compressor mounting bolts	M10 X 30	45 ± 5
Air connector coolant inlet hose connector	M14 X 1.5	20 ± 6
Air connector coolant outlet hose connector	M16 X 1.5	20 ± 6
Air compressor gear mounting nut	M18 X 1.5	200 ± 10
Air compressor mounting bracket bolts	M8 X 16	20 ± 6
Belt tensioner pulley mounting bolts	M10 X 35 X 1.5 X 8.8	40 ± 6
AC compressor pulley mounting bolts	M12 X 1.75	83 ± 5
Crankshaft damper pulley mounting bolts	M16 X 65 X 2 X 10.9	1st Torque - 100 ± 10 2nd Torque - 275 ± 15
Crankshaft damper pulley mounting bolts	M8 X 35 X 1.25 X 11.9	35 ± 5

2.6 Regular Maintenance

2.6.1 Engine Oil Replacement

Engine Oil Level Check

1. Stop the engine and wait 30 minutes for the oil to flow back to the oil pan.
2. Make sure that the vehicle is on a level surface.
3. Before pulling oil dipstick, clean the surroundings.
4. Pull the dipstick and check the oil level on the dipstick scale.
5. If necessary, top up to the upper mark (MAXIMUM), without exceeding it. Always use the same brand and type of recommended oil to refill upto the level.

NOTE

- *Do not operate the engine with the level below the lower mark (MINIMUM).*
- *Use only recommended oil.*
- *Do not mix different oil brands. Use Mahindra specified oil for filling and topping up.*

Engine Oil Change

1. Ensure the oil is at operating temperature and engine is not running.
2. Place a suitable container below the oil sump to collect the drained oil.
3. Loosen the drain plug and drain the oil completely.

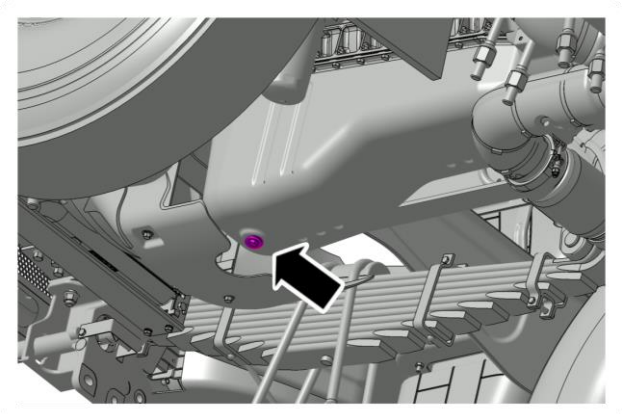
NOTE

- *Ensure that oil is warm enough while draining in order to drain complete oil from oil sump.*
- *Visually check the oil for contamination and foreign particles in drained oil.*

CAUTION

Suitably dispose the used oil according to the applicable laws.

4. Clean and install the plug with a new washer.
   Refer to: **2.5 Tightening Torques**

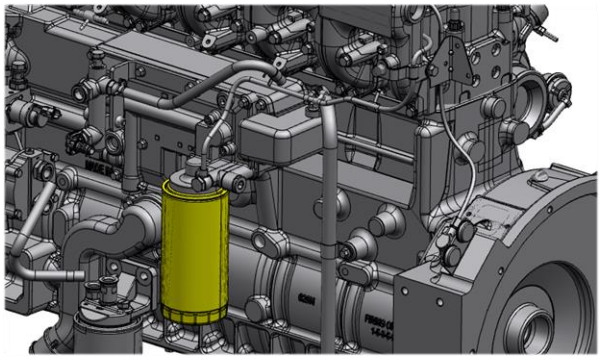


5. Tilt the cabin and remove the oil filler cap.
6. Fill with recommended oil to the upper level mark (MAXIMUM) of the dipstick.

Engine Oil Filter Change

Removal

1. Drain the Engine Oil.
2. Clean the sealing area of the filter with a clean, lint free cloth.
3. Using your hands, unscrew the filter.



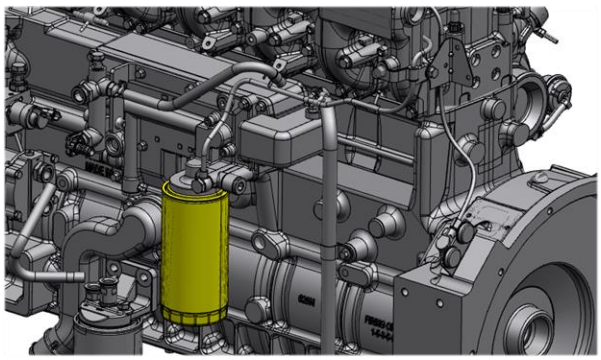
4. Remove the filter.

NOTE

Resistance during element removal is normal due to O-Ring pressure in its header housing.

Installation

1. Fill the new oil filter with fresh recommended oil.
2. Lubricate the filter gasket and install the filter.
3. Hand-tighten one turn after the gasket first contact the filter's head.



4. Fill up with new oil. In a leveled vehicle, the oil level must reach the MAXIMUM mark of the dipstick.
5. Run the engine checking the sealing of the filter and drain plug.
6. Stop the engine and, after 30 minutes, check oil level again, top it up if necessary.

CAUTION

Always use a genuine recommended Oil filter.

NOTE

- *The oil is very important for protection of the inner engine components. Oil contaminated with sand, soil, dust, water or fuel cause damage to the engine.*
- *Check the appearance of the engine lubricant oil. A dark coloration and low viscosity indicate presence of fuel in the lubricant oil. The presence of bubbles or a milky coloration indicates presence of water in the oil.*

CAUTION

Do not use any brand other than Mahindra authorized brand. Use only Mahindra authorized oil always when filling or topping up.

2.6.2 Check Engine Oil Consumption

CAUTION

Do not make a rough estimate of engine oil consumption by noting the kilometers covered by the vehicle at any random stage and finding oil consumed from the topped-up position taking into consideration dipstick level and oil sump capacity.

Procedure

1. If engine oil consumption is higher, park the vehicle on a level ground.
2. Top up the engine oil to the max level on the dipstick.
3. Warm up the engine so that the oil temperature is 75°- 80° C.
4. Take a clean vessel, place it below the drainplug of oil sump.
5. Drain the hot oil into a clean vessel. Drain completely.
6. Install the oil sump drain plug and tighten it.
7. Weigh the vessel along with oil.
8. Refill the weighed oil into the oil sump.

NOTE

- *Do not spill any oil.*
- *The vessel used for draining should not have been used for any other purpose.*

9. Drive the vehicle approx. 1000 km This drive should include at least 100-120 km of highway or similar road, vehicle running at about 60 kmph.
10. Immediately after the test drive, park the vehicle at the same spot from where it started.
11. Place the same previously used vessel below the Oil sump.
12. Unscrew the drain plug and drain off oil into the vessel. Drain the sump completely.
13. Weigh the vessel along with oil, now calculate the oil consumption as follows.

Find out standard oil consumption as follows:

$$\text{Std. oil consumption “C” (liters)} = \frac{\text{Weight of oil consumed (Gms)}}{\text{Sp. Gravity of Oil (g/L)}}$$

2.7 Removal and Installation

CAUTION

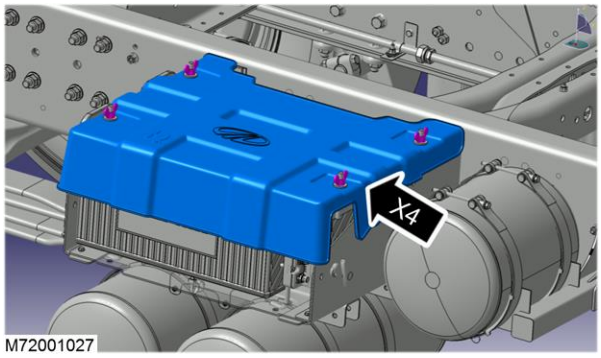
- **Always use proper protective covers over any openings or joints immediately after removal to avoid dust, cloth or any other debris from entering the system.**
- **Do not use loose cloth or similar covering material which may enter the system and burn out to damage/prematurely choke the EGR, Turbocharger, ATS components like DPF, DOC etc.**
- **If any wiring connectors or harness is disconnected from its parking during maintenance procedure, the original clamping and routing should be ensured while refitment.**

2.7.1 Removal of Engine from Vehicle

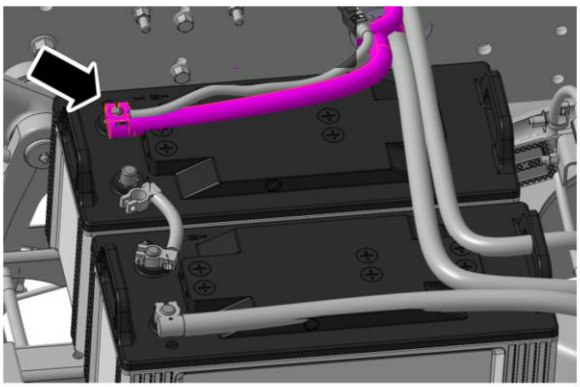
WARNING

Use proper safety equipment, metal toe end safety shoes while working with heavy aggregates

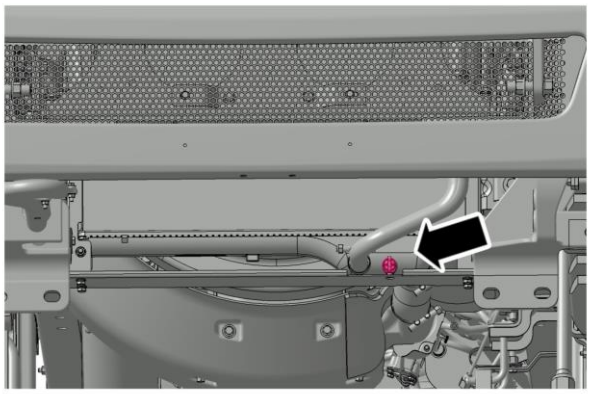
1. Park the vehicle on a flat surface.
2. Apply the parking brakes and chock the wheels.
3. Loosen the securing wing nuts and remove the battery cover.



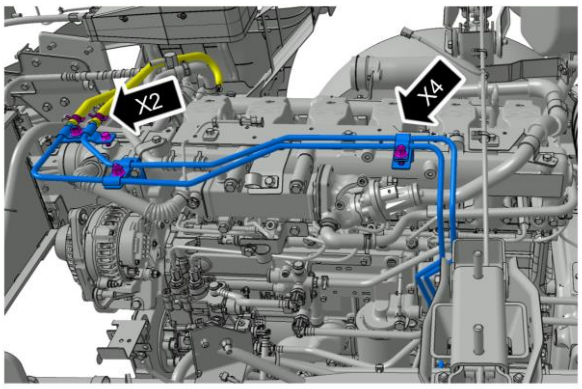
4. Disconnect the battery negative cable and position it properly aside.



5. Drain the cooling system.
   Refer to: **Cooling system draining and filling**



6. Drain the engine oil.
   Refer to: **2.6.1 Engine Oil Replacement**
7. Operate the cabin tilting pump mechanically and tilt the cabin.
   Refer to: **Cabin Tilting**
8. Disconnect the Engine to Front Chassis wiring connectors.
9. Disconnect Electro-Viscous fan pigtail connector.
10. Disconnect the securing electrical connector to the alternator and position them properly aside.
11. Disconnect the ATS coolant lines and remove the ATS coolant pipes and brackets.

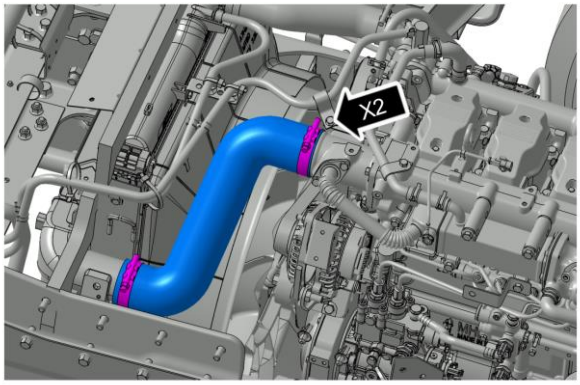


12. Disconnect the water separator to High-pressure pump connector and the fuel return manifold return line to fuel tank connector on flywheel housing.

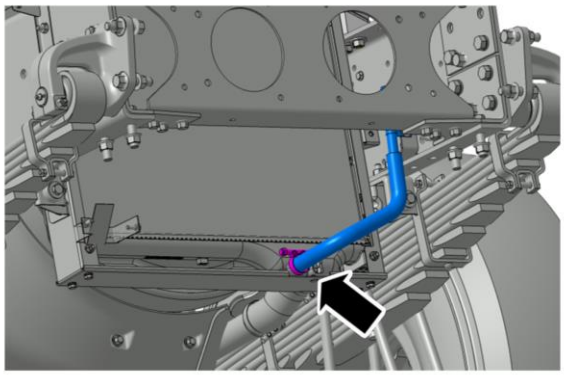
CAUTION

Prevent the residual fuel from falling over the aggregates or the surrounding area.

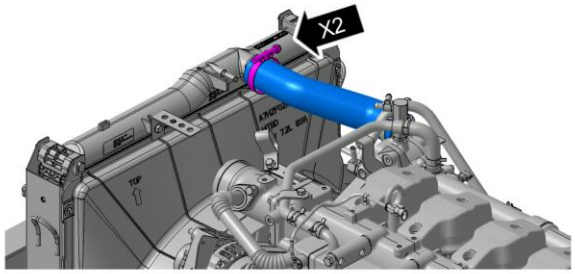
13. Disconnect the intercooler to air inlet pipe hose and keep it aside.



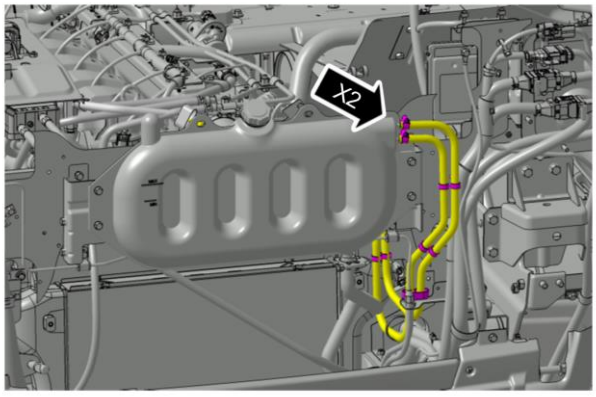
14. Disconnect the radiator bottom to oil cooler assembly hose and keep it aside.



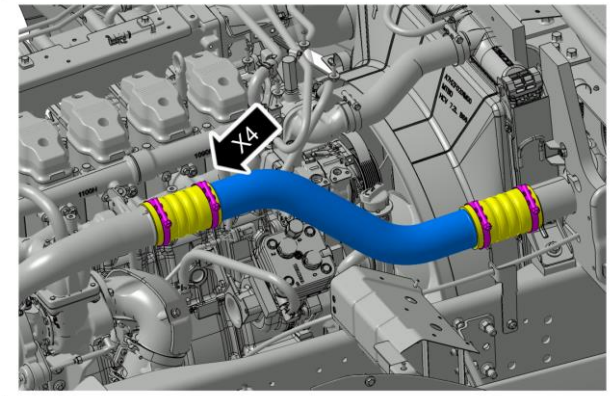
15. Disconnect the radiator top to thermostat hose and keep it aside.



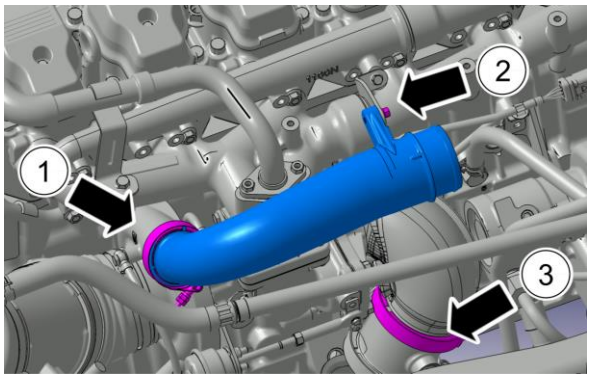
16. Disconnect the degassing tank vent hoses and keep it aside.



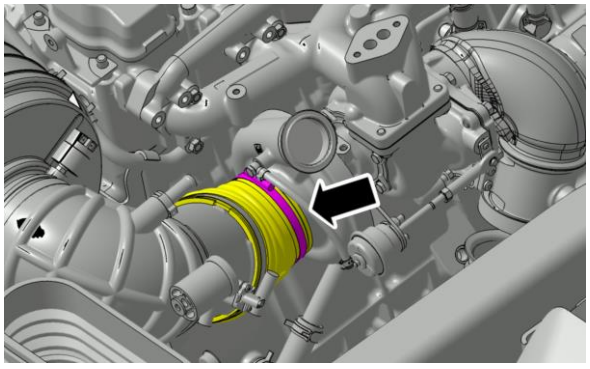
17. Loosen the hose clip and disconnect the turbocharger outlet to intercooler air hose and keep it aside.



18. Remove the Turbocharger to Intercooler pipe.
    1. Loosen the turbocharger to intercooler pipe clamp and keep it aside.
    2. Loosen the turbocharger to intercooler pipe mounting bolt.
    3. Loosen the Turbocharger exhaust outlet pipe clamp.

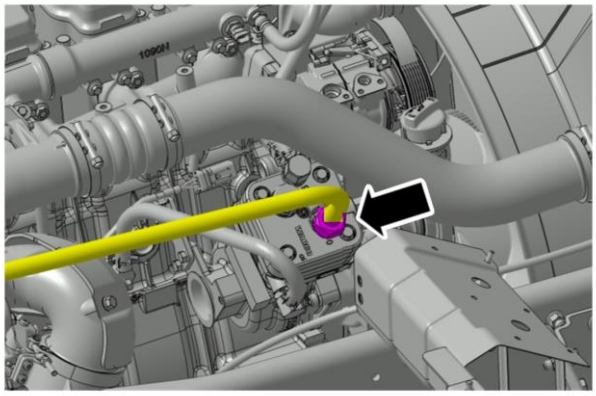


19. Disconnect the air filter housing to turbocharger air hose and keep it aside.

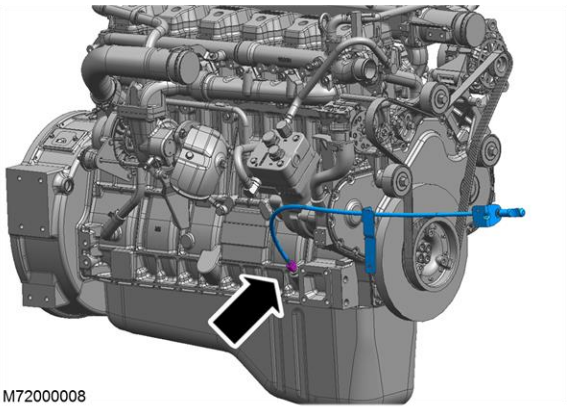


20. Disconnect the power steering pump oil hoses and keep it aside.

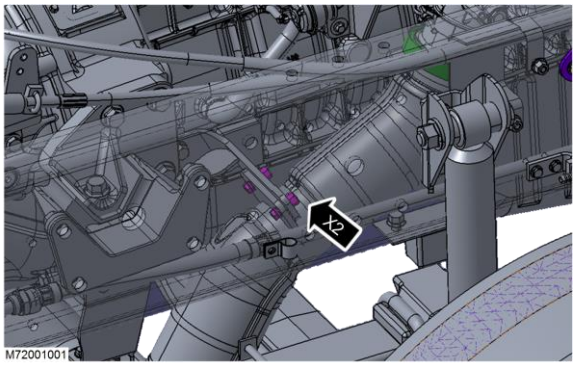
21. Loosen the nut and disconnect the air compressor air supply hose pipe.



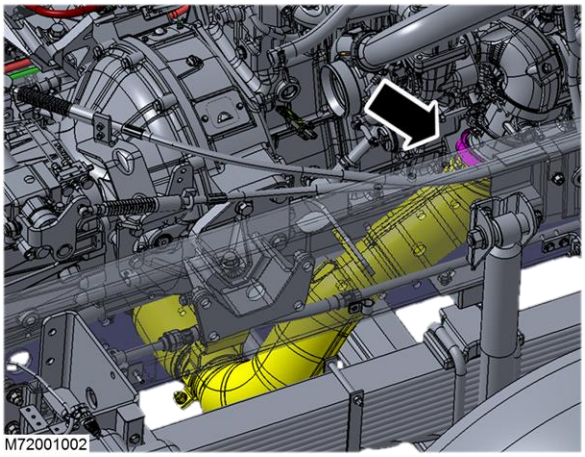
22. Loosen and remove the dipstick securing nut on the engine.



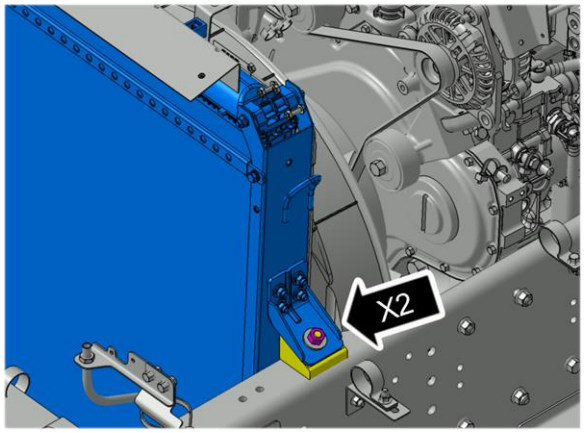
23. Loosen and remove the exhaust pipe mounting bracket bolts.



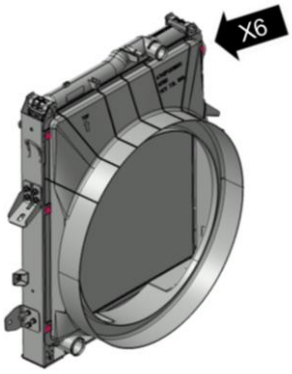
24. Disconnect the exhaust elbow pipe from the Exhaust Throttle Valve (ETV).



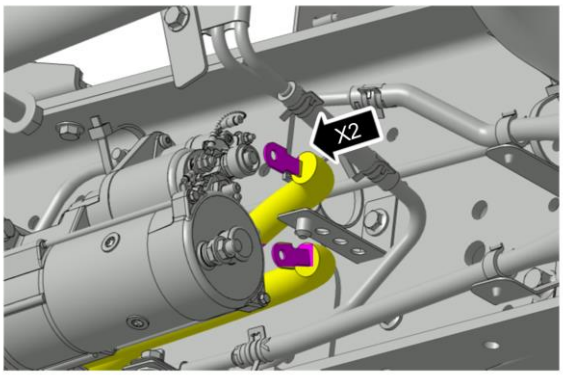
25. Loosen the mounting bolts and move the radiator.



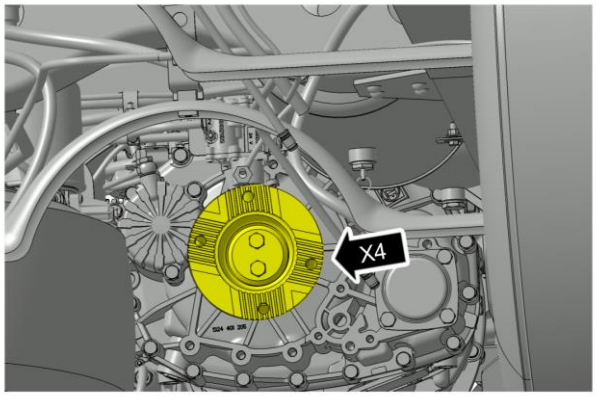
26. Loosen and remove the radiator shroud mounting bolts.



27. Disconnect the securing electrical connection to the starter motor and position them properly aside.



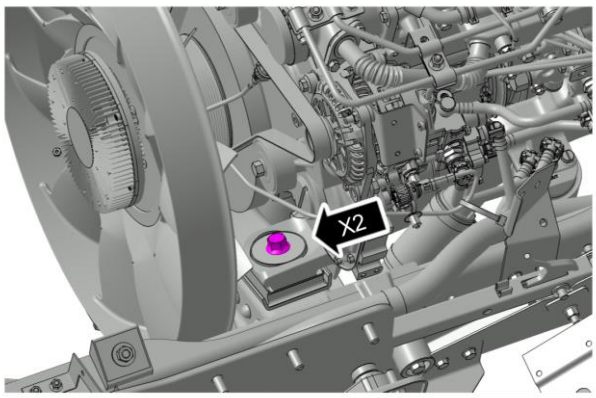
28. Disconnect the propeller shaft flange secured at transmission end.



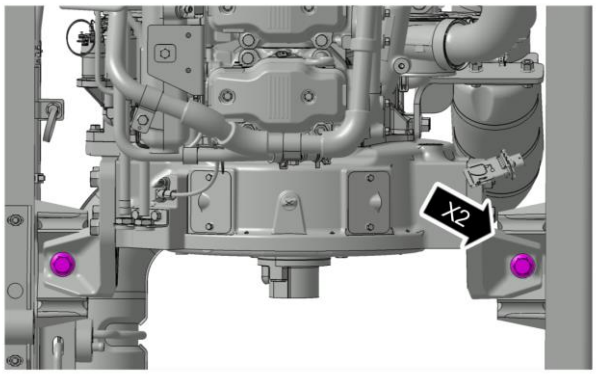
NOTE

Place jack stand under the propeller shaft to support during removal process. Do not disconnect the propeller shaft without supporting the shaft with a jack or appropriate support.

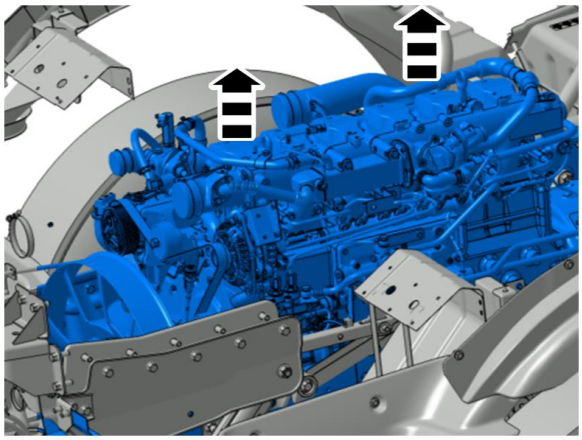
29. Loosen the transmission mounting bolts secured to the bell housing and move the transmission assembly back using a trolley jack.
30. Loosen the securing bolts remove the bolts from the front engine mounting bracket and keep them aside.



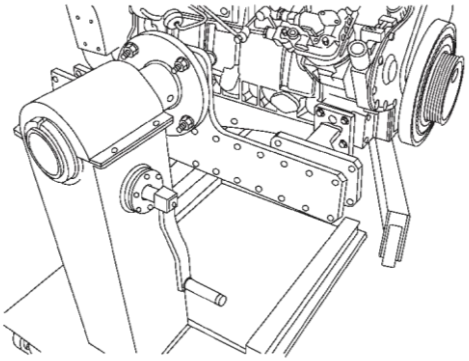
31. Loosen the securing bolts at rear end of the engine assembly and remove the bolts from the rear engine mounting bracket.



32. Using the engine lifting rope and hydraulic jack lift the engine from the vehicle.



33. Fix the engine on to its stand.



Installation

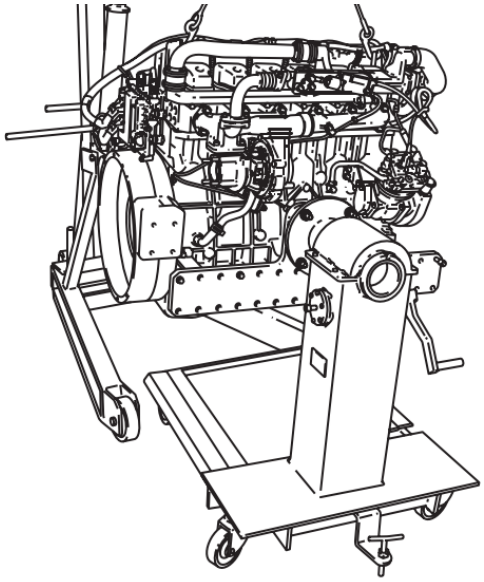
1. To install, reverse the removal procedure.
2. Tighten the fasteners.
   Refer to: **2.5 Tightening Torques**

2.7.2 Disassembly

CAUTION

- **During engine repair procedures, cleanliness is extremely important. Any foreign material, including any material created while cleaning gasket surfaces that enters the oil passages, coolant passages or the oil pan, can cause engine failure.**
- **The turbocharger compressor vanes can be damaged by even the smallest particles. When removing any turbocharger or engine air intake system component, ensure that no debris enters the system. Failure to do so may result in damage to the turbocharger.**
- **Special attention needs to be given to the sealing ports for the oil feed, the oil drain, and the coolant tubes, on turbocharged engines. The sealing ports must be totally clean and free from O-ring residue, have no damage to the sealing surface and the tubes to ensure that there are no leaks or repeat repairs.**

1. Fix the engine on the engine stand.



2. Loosen and remove the engine mounting bracket bolts and remove both the engine mounting bracket.
3. Loosen the mounting nuts and remove the electro-viscous fan.

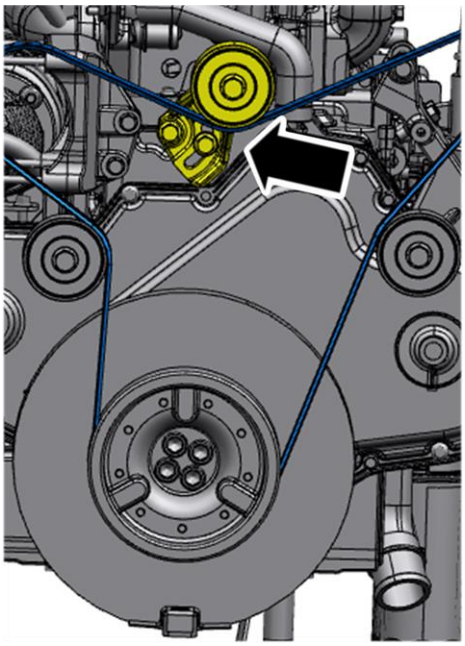
NOTE

The location of the belt tensioner can vary depending on the front engine accessory arrangement.

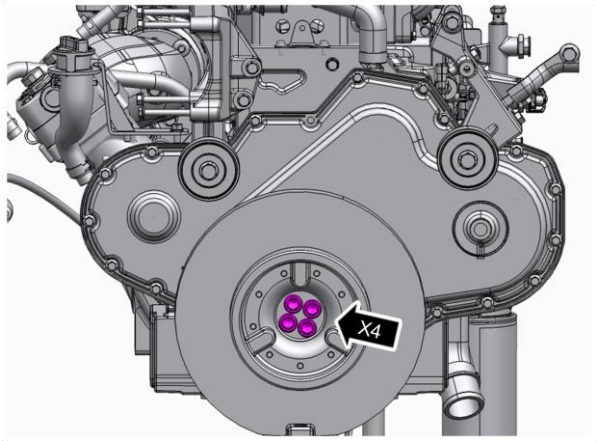
CAUTION

The belt tensioner is bolted and must be loosened.

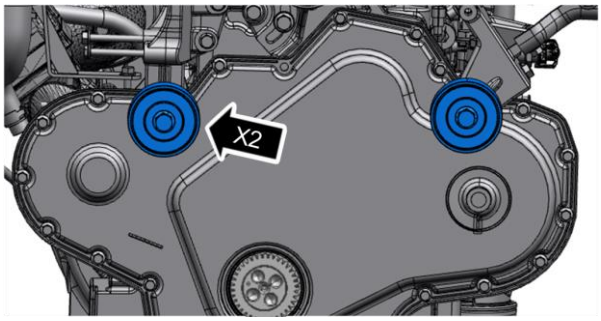
4. Loosen the tensioner pulley and remove the drive belt.



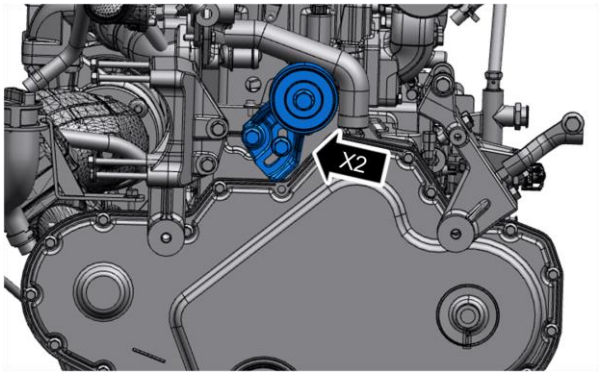
5. Loosen the crankshaft damper pulley mounting bolts and remove the damper pulley.



6. Loosen and remove the idler pulley mounting bolts and remove the idler pulley.

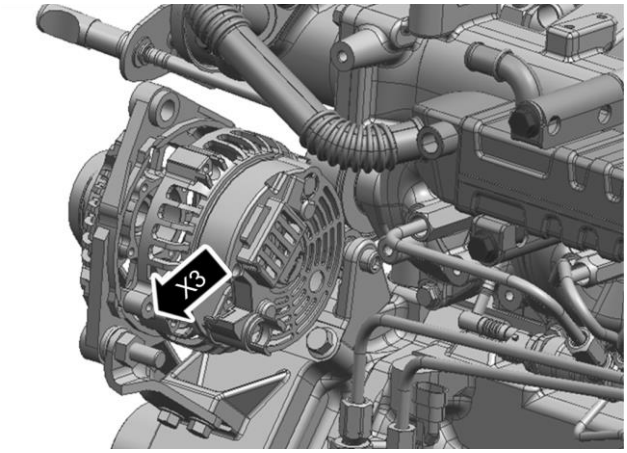


7. Loosen and remove the tensioner pulley mounting bracket bolts and remove the tensioner pulley.

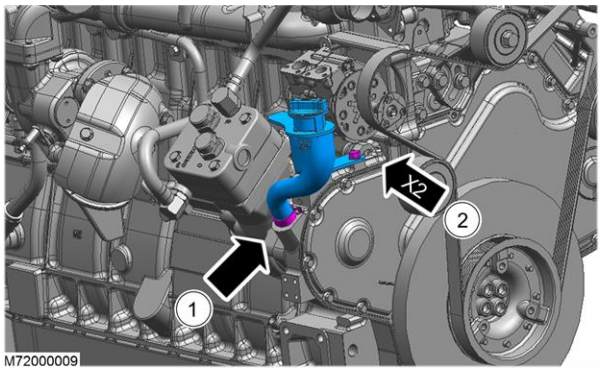


Alternator

1. Remove the alternator mounting bolts and remove the alternator.

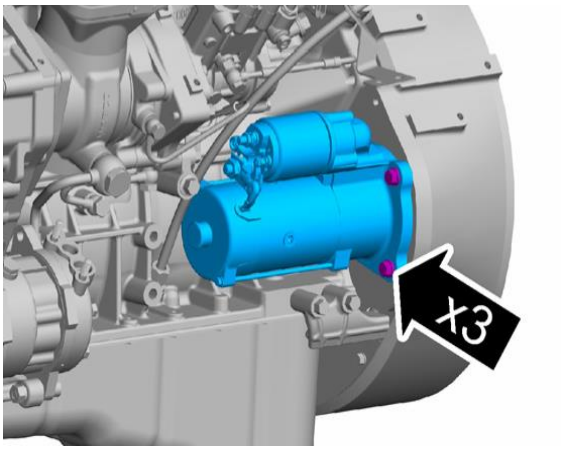


2. Remove the upper alternator bracket mounting cap screws.
3. Remove the lower alternator bracket mounting cap screws.
4. Loosen and remove the oil filler bracket mounting bolts and remove the oil filler assembly.



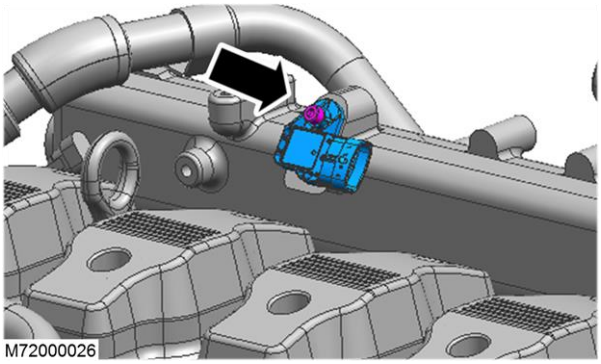
Starter Motor

1. Loosen the mounting bolts and remove starter motor.



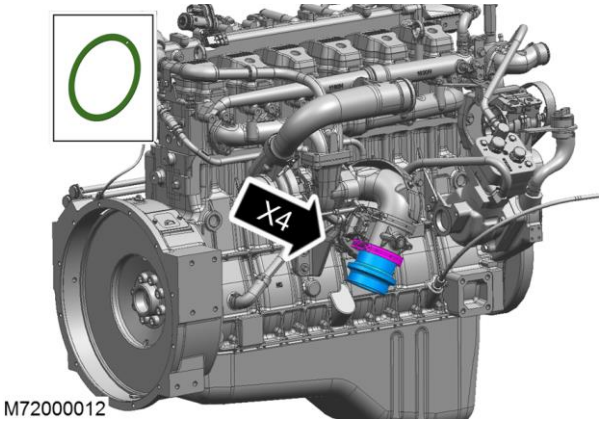
Sensors

1. Remove the Boost Pressure and Temperature sensor.

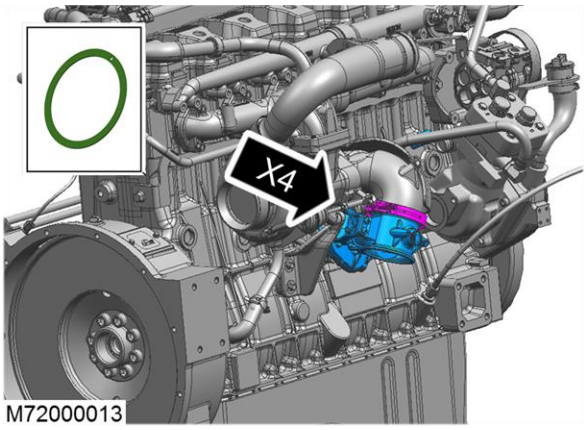


Exhaust Throttle Valve

1. Disconnect the Exhaust Throttle Valve electrical connector.
2. Loosen the clamp and remove the exhaust elbow.

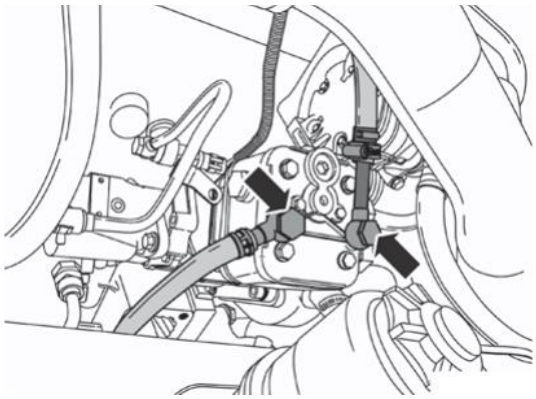


3. Loosen the mounting clamp and remove the exhaust throttle valve.

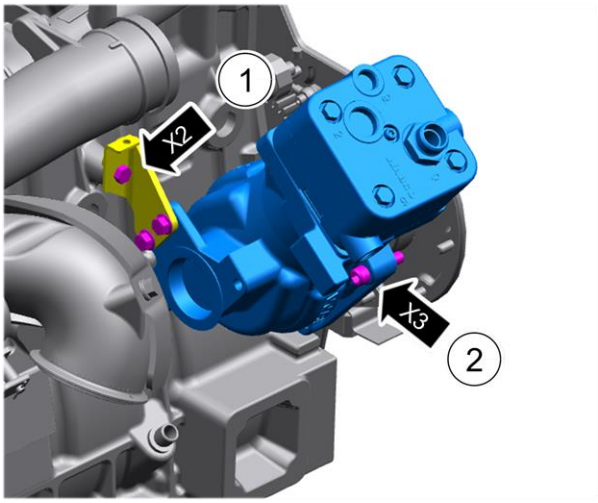


Air Compressor

1. Disconnect the air compressor securing coolant hose pipes.

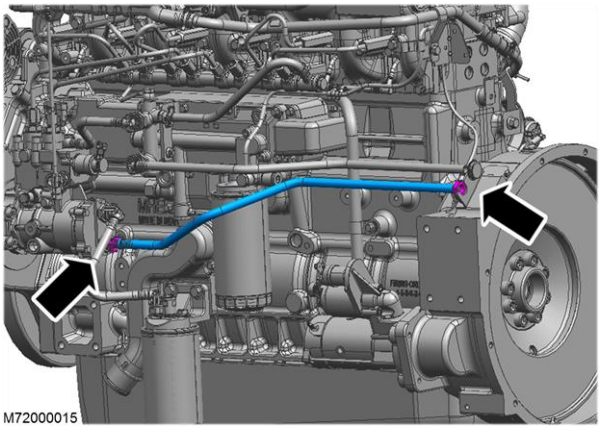


2. Remove the Air compressor assembly.
   1. Loosen the mounting bracket securing bolts and disconnect the air compressor.
   2. Loosen the air compressor mounting bolts and remove the same.

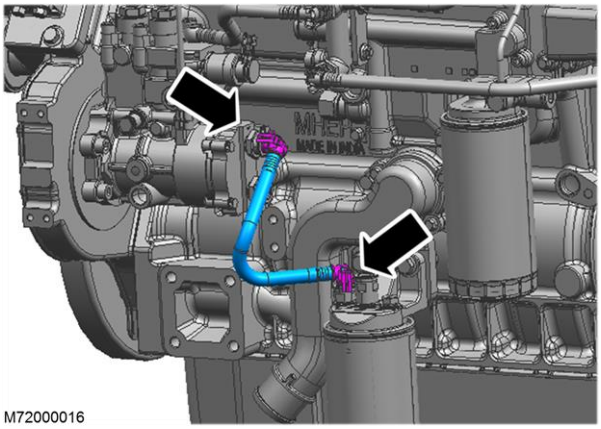


High Pressure Pump

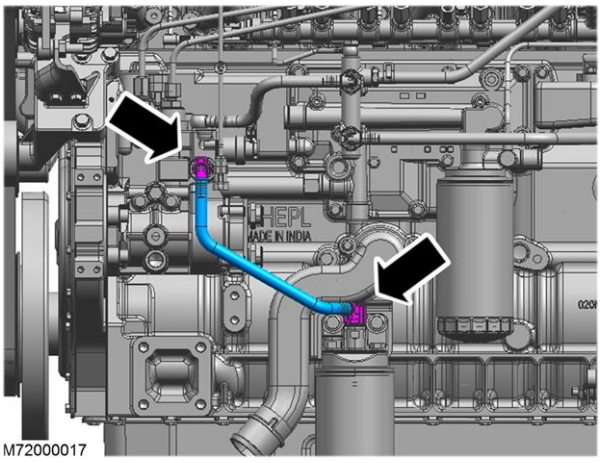
1. Remove the Fuel supply pipe from primary fuel filter to HP vane pump.



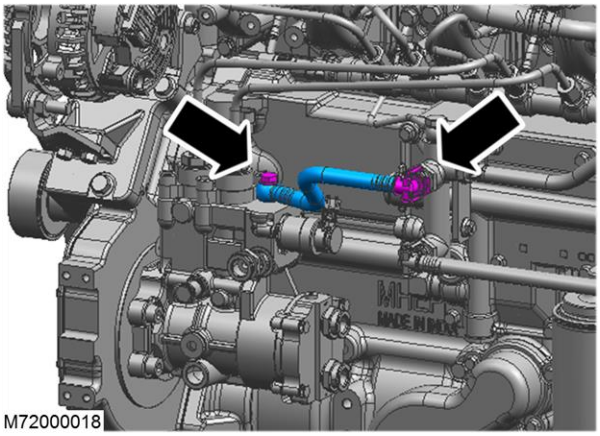
2. Remove the fuel pipe from HPP vane pump to secondary fuel filter.



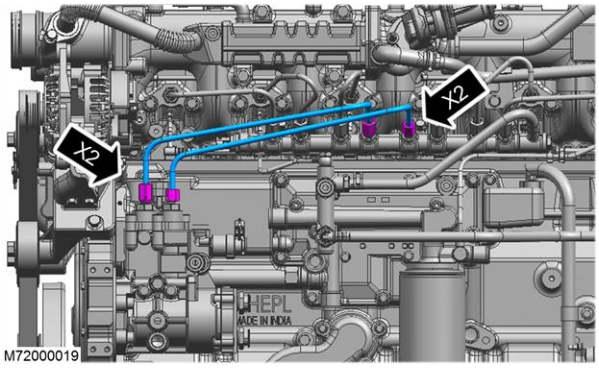
3. Remove the fuel pipe from secondary fuel filter to HP pump.



4. Remove HPP fuel return pipe.



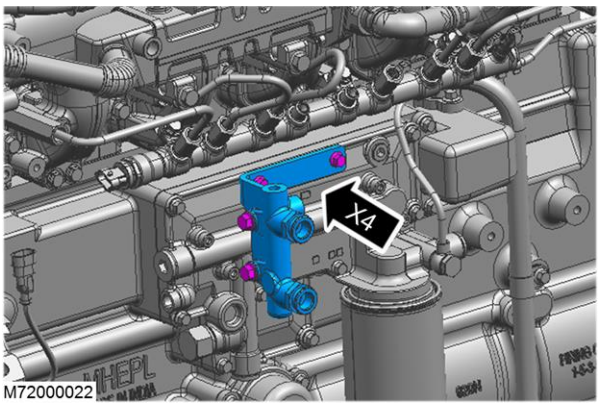
5. Loosen the connector and remove high-pressure pipe to common rail.



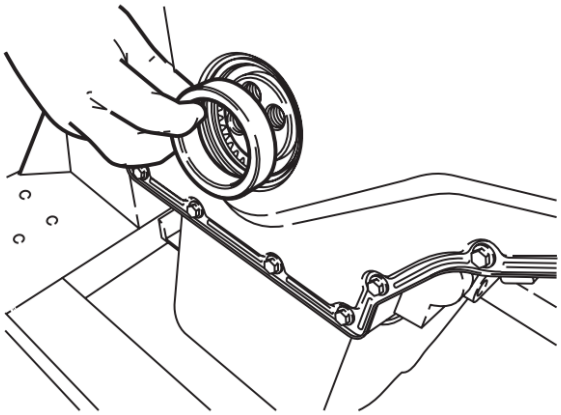
CAUTION

Plug all the openings in CR system after removal of the connectors.

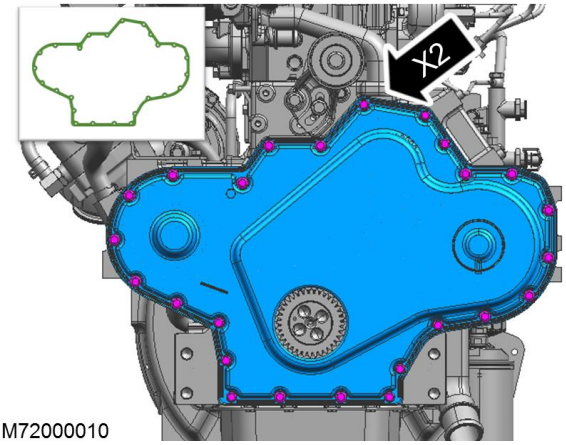
6. Remove all inlet and outlet pipes from Fuel return Manifold (FRM).
7. Remove Fuel Return Manifold (FRM).



8. Remove the crank shaft front end oil seal spacer.



9. Loosen the mounting bolts and remove timing gear cover. Discard the gasket.



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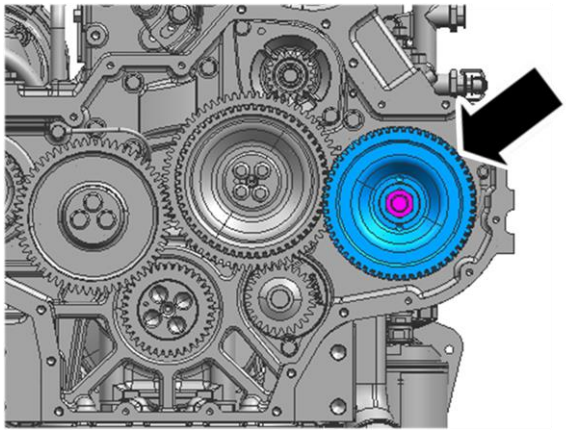
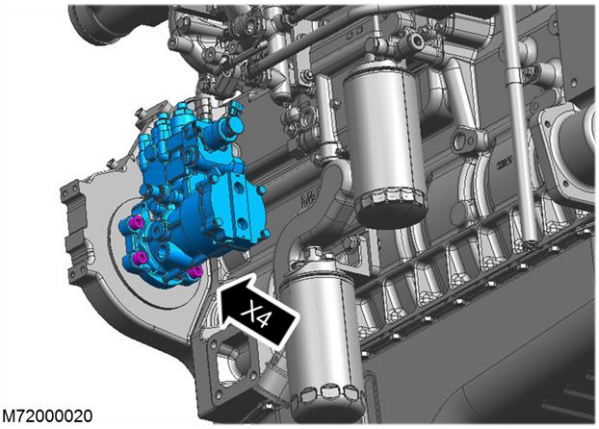
10. Remove HPP gear nut along with washer.



11. Loosen the HPP mounting bolts.



M72000020

12. Disengage the HPP gear by using gear puller and remove the HPP.

CAUTION

Plug all the openings in HPP immediately after removal of the connectors.

High Pressure Fuel Lines

CAUTION

Do not bend, pry, or Kink the fuel supply lines during the removal

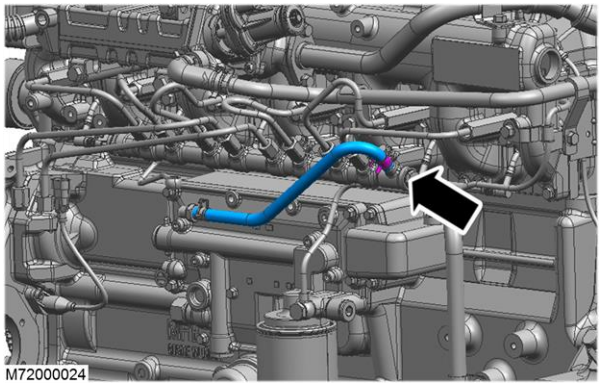
WARNING

The High-pressure Pump, High pressure fuel lines and Fuel rail contains very high pressure fuel. Do not loosen any fittings while the engine is running. Wait for at least 10 min after shutting down the Engine before loosening any fittings in the High-pressure fuel system to allow pressure to decrease to a lower level

CAUTION

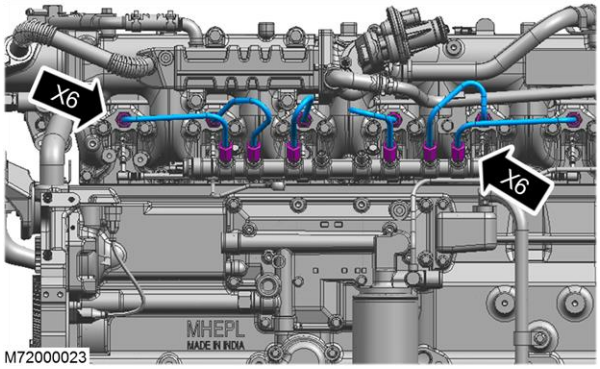
Clean all fittings before disassembly. Entry of any Dirt or contaminant can damage to fuel system

13. Remove the common rail return line.



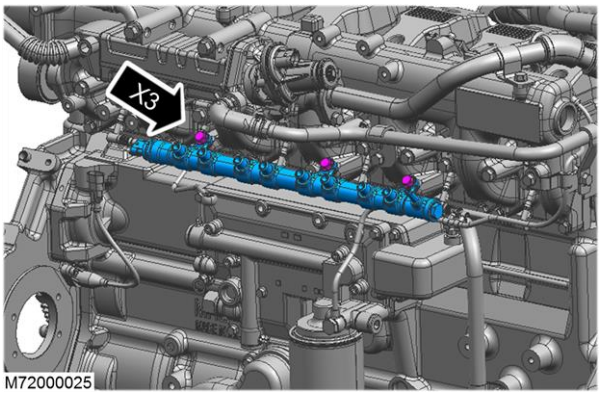
M72000024

14. Remove the High-pressure pipes from common rail to injector adaptors.

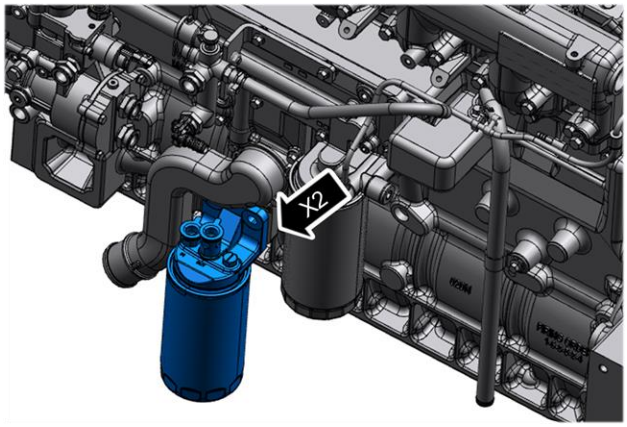


M72000023

15. Remove the Common Rail mounting bolts and remove the common rail.



16. Loosen the mounting bolts and remove the secondary fuel filter.

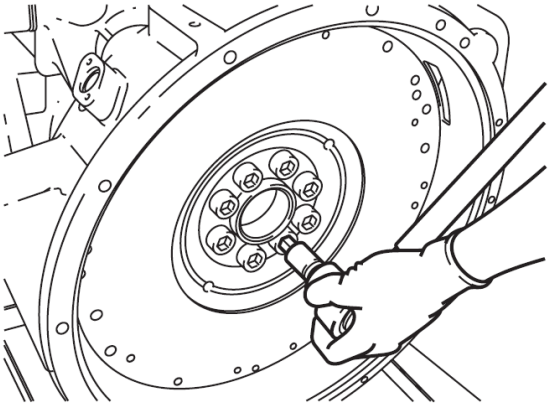


Flywheel

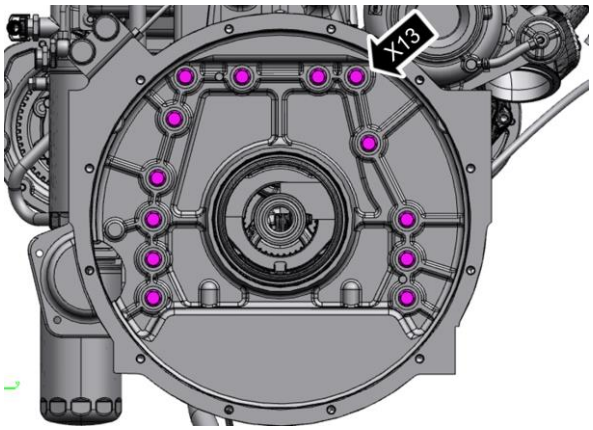
WARNING

Many components are too heavy to lift or move. To reduce the possibility of personal injury, use a hoist or get assistance to lift this component.

1. Loosen the mounting bolts and remove the flywheel.



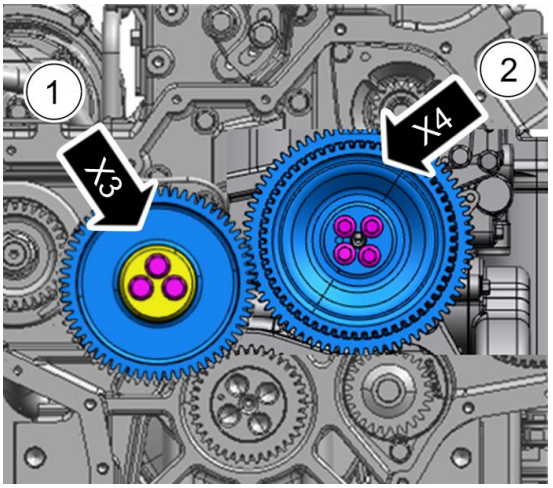
2. Loosen the mounting bolts and remove the flywheel housing.



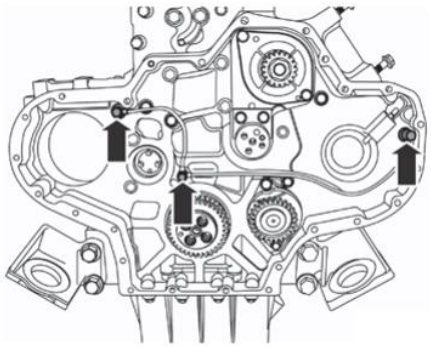
3. Remove and discard the crank shaft rear end oil seal.

Timing Gear System

4. Remove the timing gears.
   1. Loosen the securing bolts and holding plate and remove the idler gear.
   2. Loosen the securing bolts and remove both the front and back camshaft timing gears.



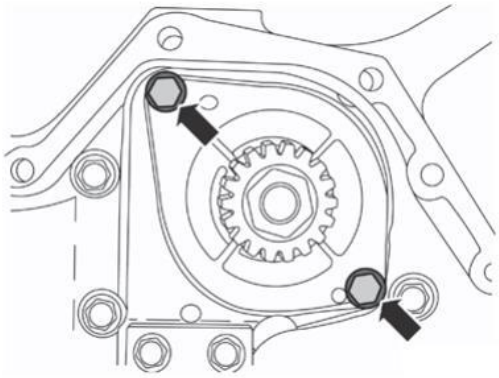
5. Loosen the mounting banjo screws and remove the lubrication pipe.



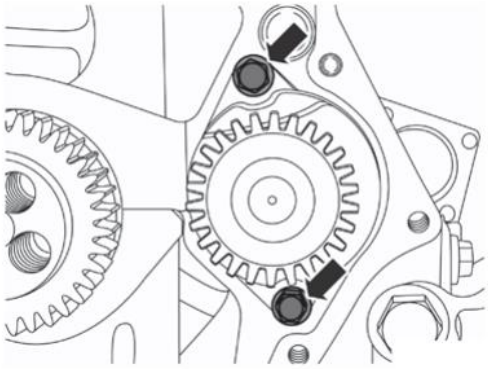
6. Loosen the mounting bolts and remove the water pump and discard the O-ring.

NOTE

Insert the same bolt to the holes secured by the side of water pump mounting bolts and tighten it so as to remove the water pump.

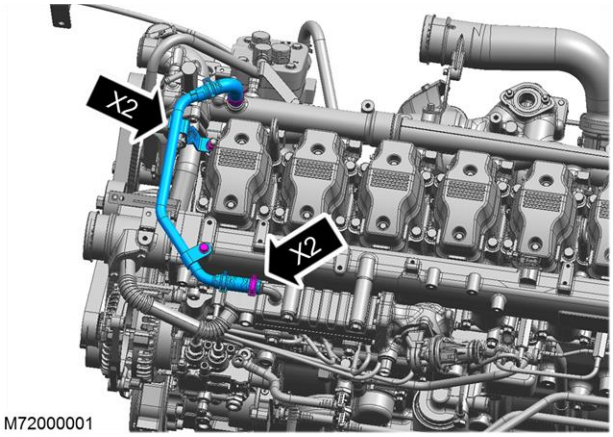


7. Loosen mounting bolts and remove the oil pump.

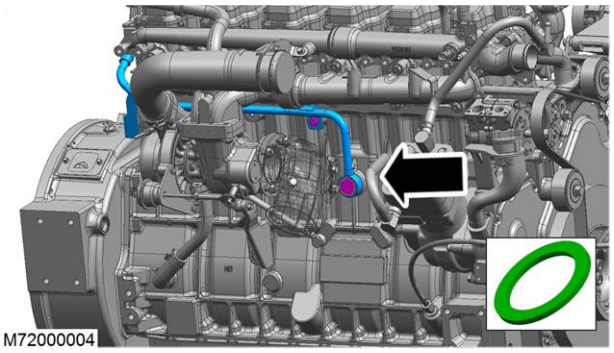


EGR System

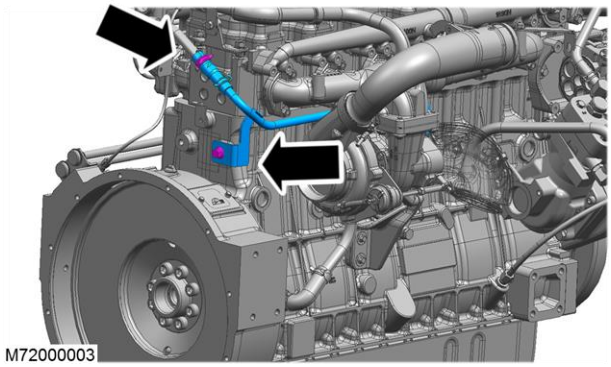
1. Loosen the hose clips and remove the EGR cooler outlet pipe.



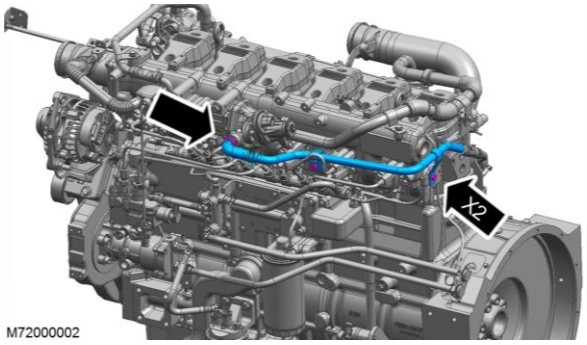
2. Loosen and disconnect the engine block to EGR coolant supply pipe nut.



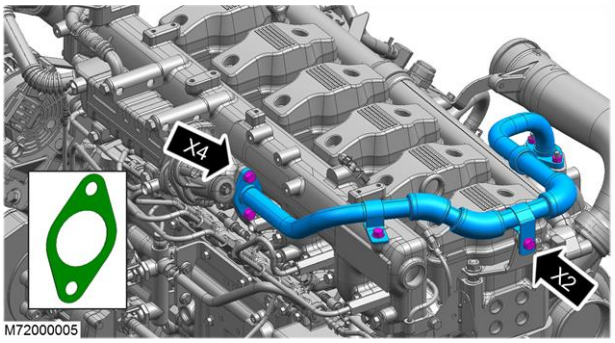
3. Loosen the mounting bracket bolts and remove the EGR cooler inlet pipe.



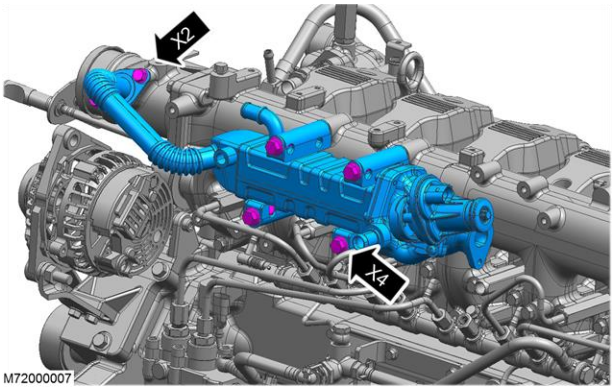
4. Loosen and remove the EGR cooler inlet pipe mounting bolts on EGR cooler and remove the EGR cooler inlet pipe.



5. Loosen and remove the EGR hot end pipe securing bolts.

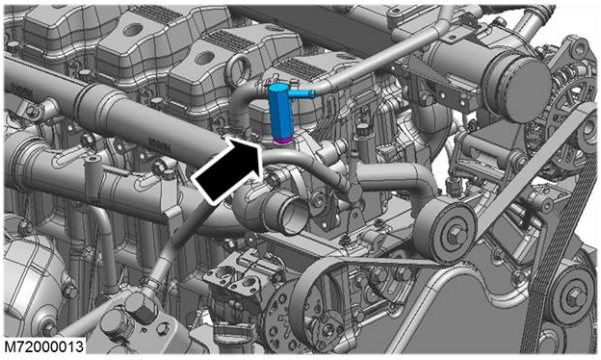


6. Loosen and remove the EGR mounting bolts and remove the EGR assembly.

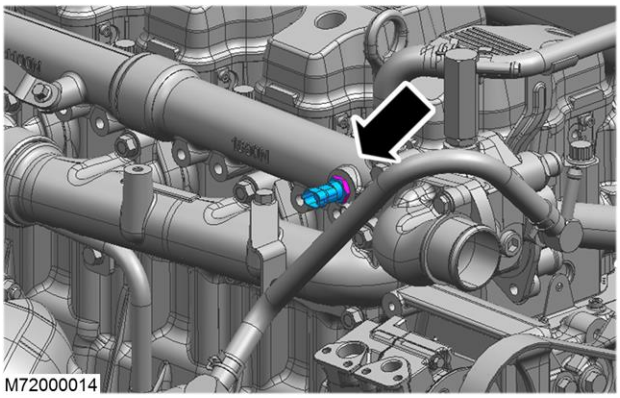


Coolant Manifold

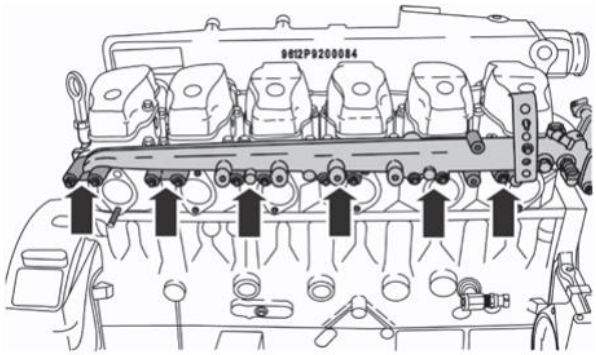
1. Remove the vent plug on the coolant manifold.



2. Loosen and remove the coolant temperature sensor.

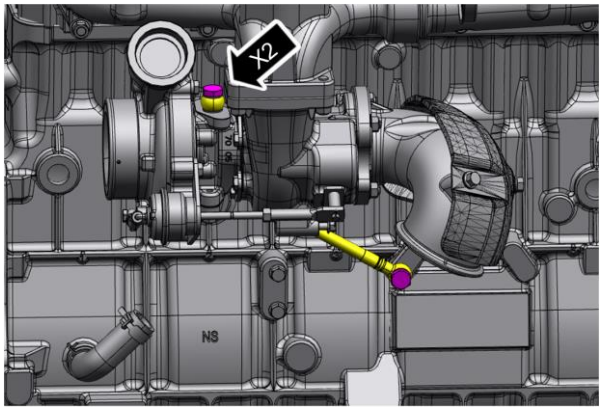


3. Loosen the mounting cap screws and remove the coolant manifold and discard the O-rings.

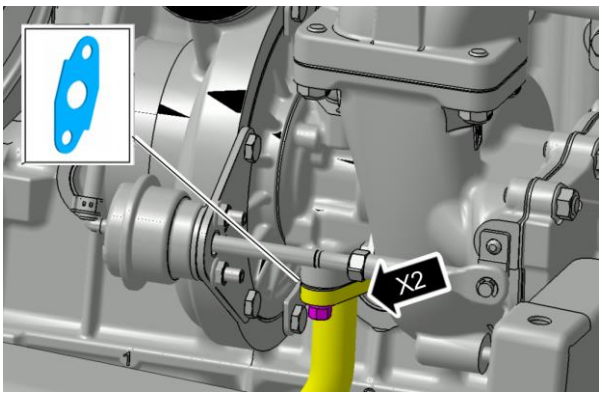


Turbocharger

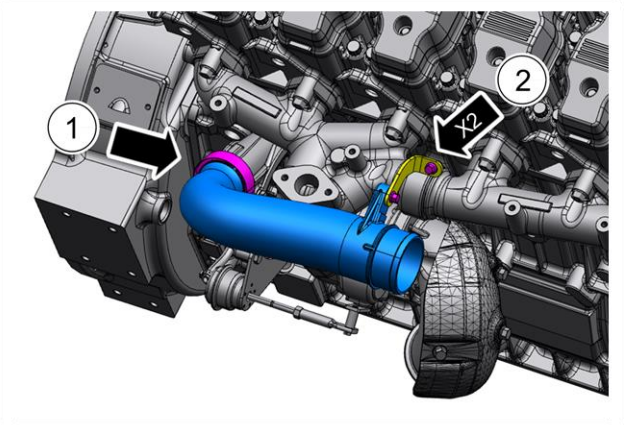
1. Remove the oil supply line from the turbocharger bearing housing and from the cylinder block.



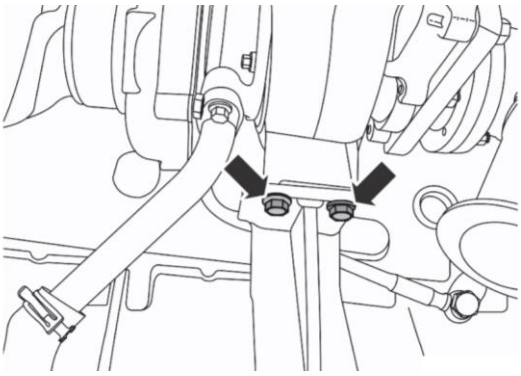
2. Remove the two cap screws that hold the oil drain line to the turbocharger.



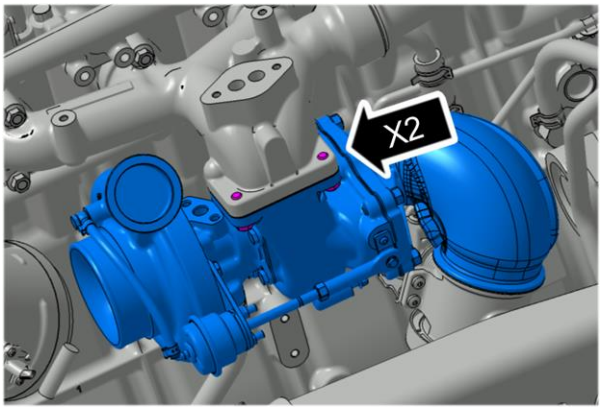
3. Pull the oil drain line out of the cylinder block.
4. Remove the turbocharger compressor outlet elbow.
   1. Loosen the V-band clamp.
   2. Loosen and remove the compressor outlet pipe mounting bracket bolts and remove the compressor outlet elbow. Discard O-ring.



5. Loosen the mounting bracket securing bolts and disconnect the turbocharger.

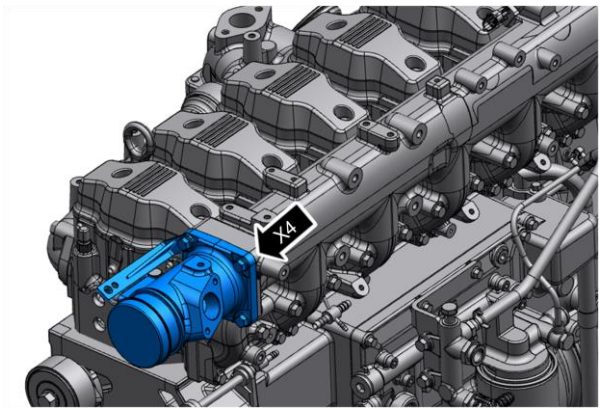


6. Loosen and remove the mounting nuts and remove the turbocharger.

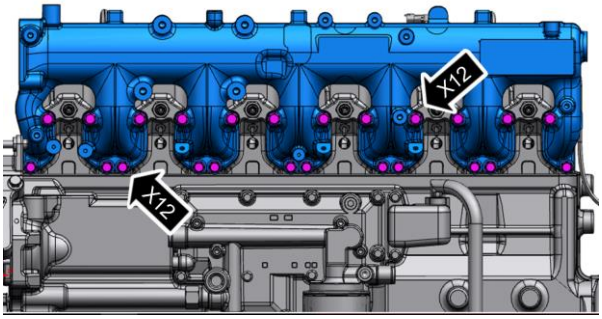


Air Intake Manifold

1. Loosen and remove the mounting bolts and remove the air intake curve.

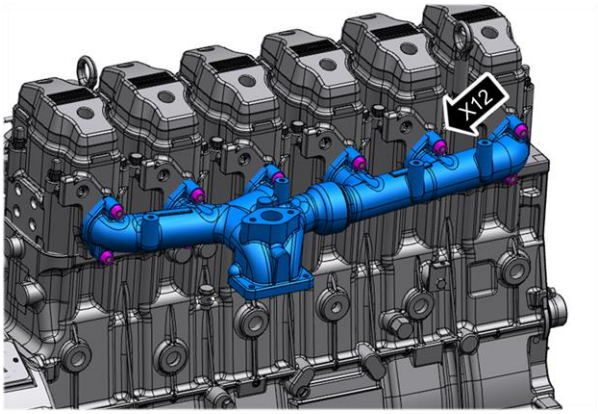


2. Loosen and remove the mounting bolts and remove the intake manifold. Discard the gaskets.



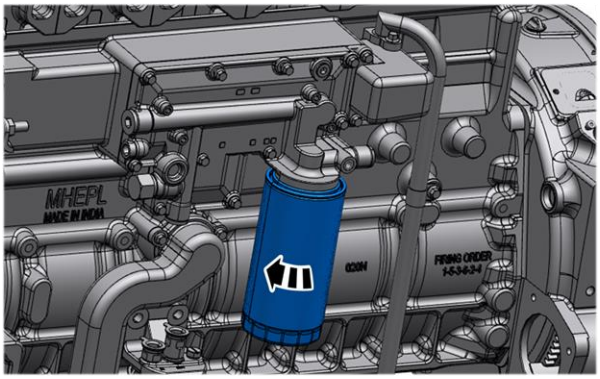
Exhaust Manifold

1. Loosen the mounting bolts and remove the exhaust manifold. Discard the gaskets.

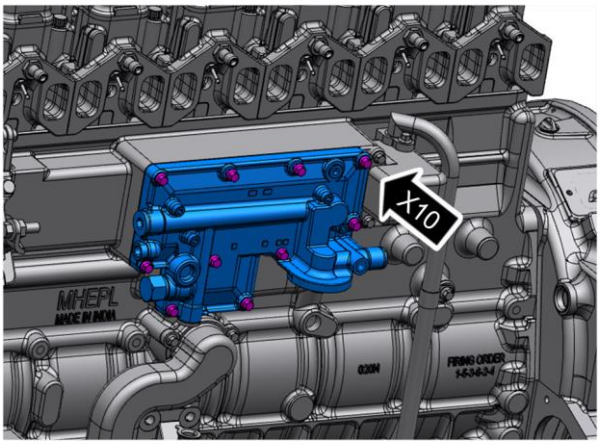


Oil Cooler and Filter Assembly

1. Use the oil filter wrench and remove filter.



2. Loosen the oil cooler housing cap screws and remove the housing and discard the gasket.

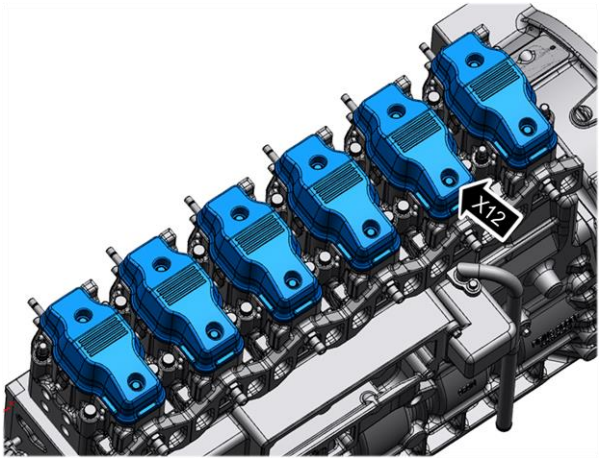


Engine Head

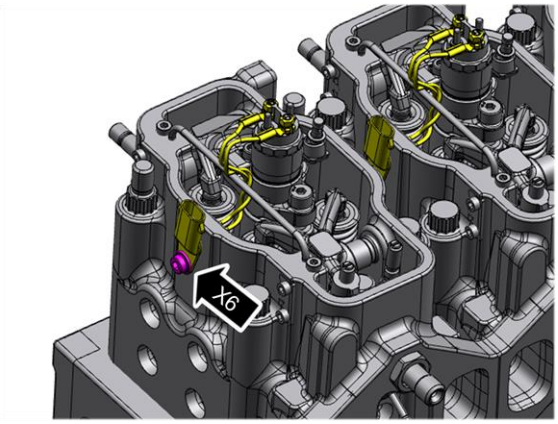
NOTE

- *After removing the HP pipes cover the opening with suitable caps*
- *Use compressed air and remove any dirt or foreign material from the cylinder head, block and general surrounding area of the fuel rail and injectors*

1. Loosen the cylinder head cover mounting bolts and remove the same.

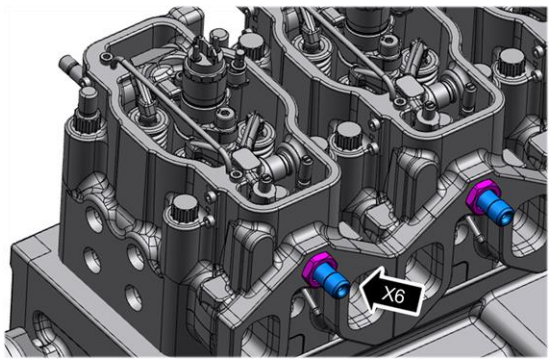


2. Remove the nuts and disconnect the electrical wiring from the cylinder head to the injector connectors.

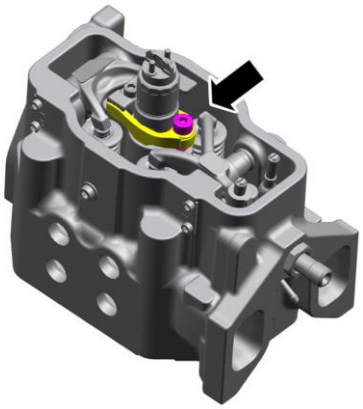


3. Loosen the nut and remove the injector adaptor from the cylinder head block.

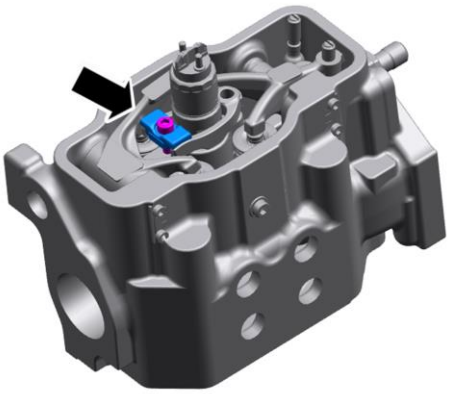
Special Tool No. 6204BAB0001ST



4. Remove special step bolt.

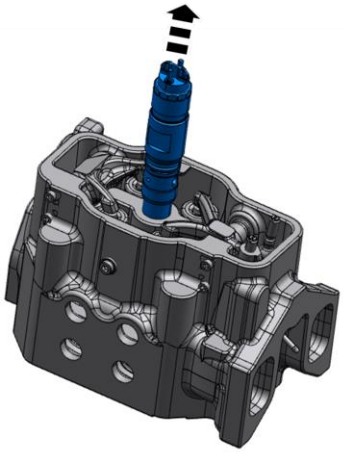


5. Loosen the injector holder bridge bolt and remove the holder bridge.



6. Remove the injector holder clip.

7. Remove the fuel injector from the cylinder head.



NOTE

Keep the injector and adaptor pair together for each cylinder.

8. Repeat for the rest of the cylinder heads to remove all the injectors.

CAUTION

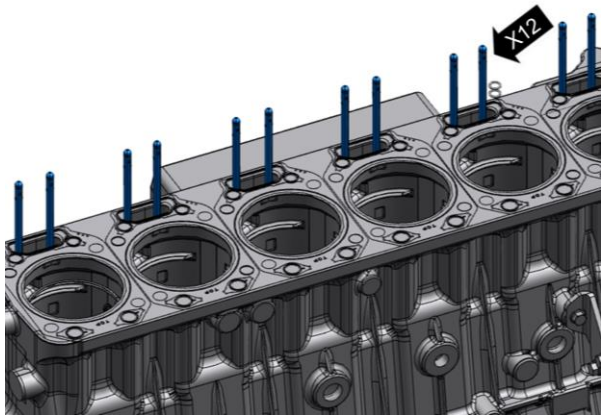
The injector and adaptor pair should not be interchanged as the factory clearances are set for a given pair of injector with its adaptor.

WARNING

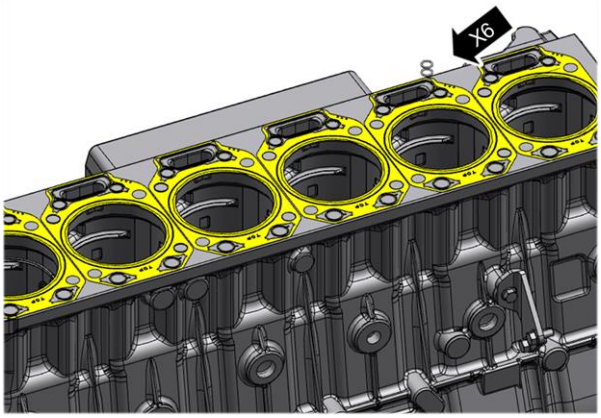
This component or assembly are too heavy to lift or move. To reduce the possibility of serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

9. Loosen and remove the cylinder head bolts and remove the cylinder head.

10. Remove the push rod from its position.

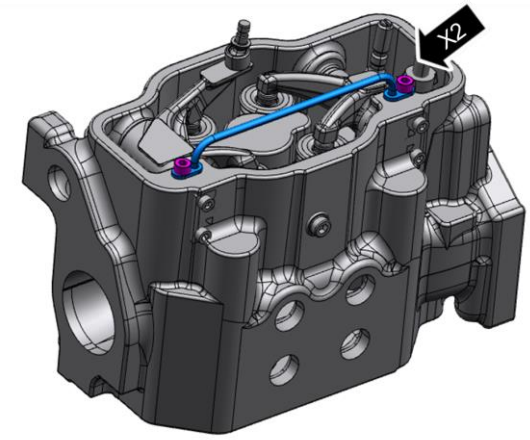


11. Remove and discard the cylinder head gasket.

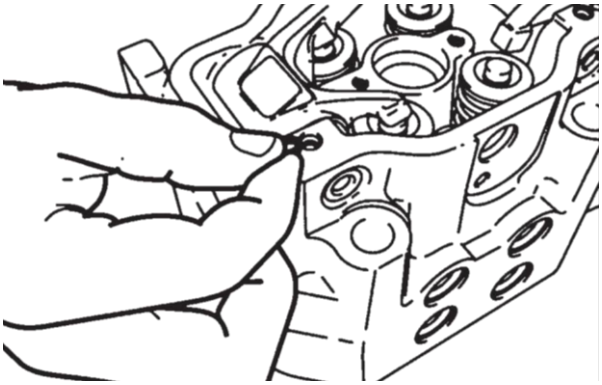


Engine Head Disassembly

12. Loosen the oil pipe mounting bolts and remove the balancer shaft lubrication pipe.

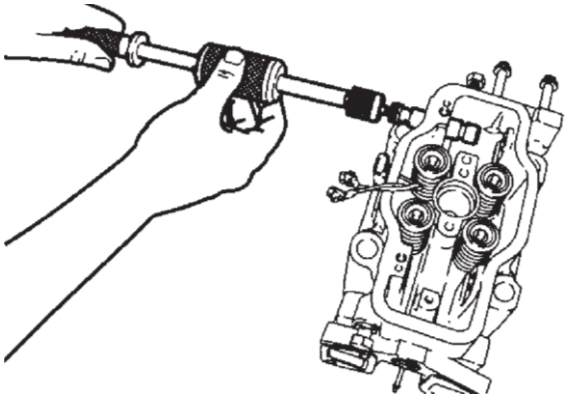


13. Remove and discard the O-Ring.

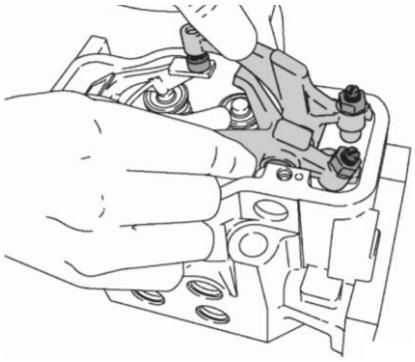


14. Install the rocker arm shaft guide special tool and remove the balancer shaft and rocker arms along with it from its position.

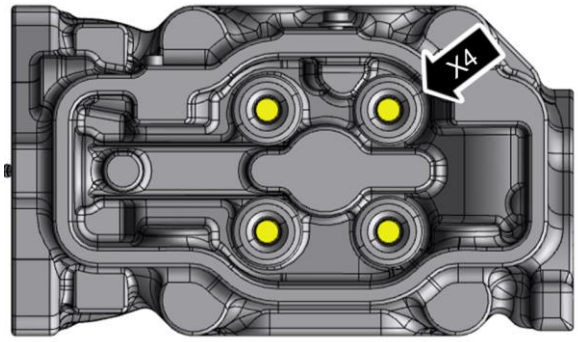
Special Tool No. 6204BAB0001ST



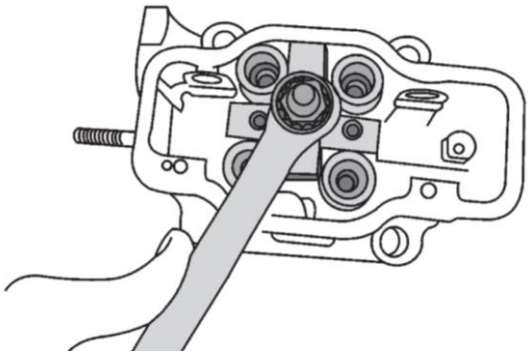
15. Remove the rocker arms.



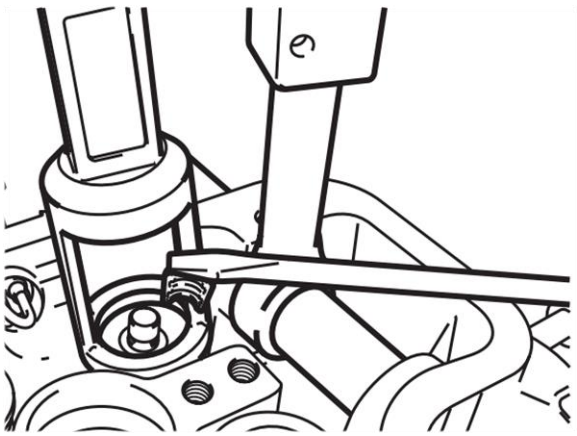
16. Using suitable nose plier, remove the valve stem cap mounted on its top.



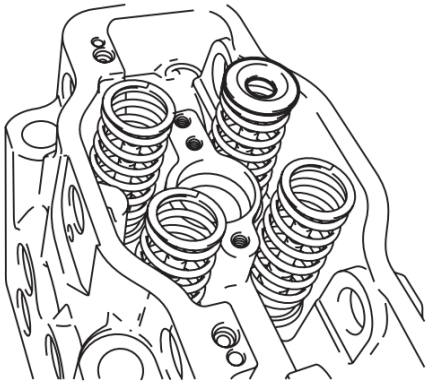
17. Using valve spring compressor special tool compress the valve stem spring.
    Special Tool No. 6209DAB0001ST



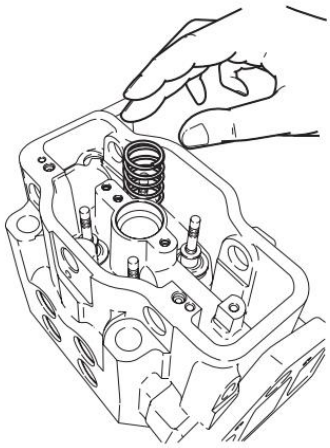
18. Use a suitable nose pliers or magnetic stick to remove the securing collet from valve stem and keep them aside.



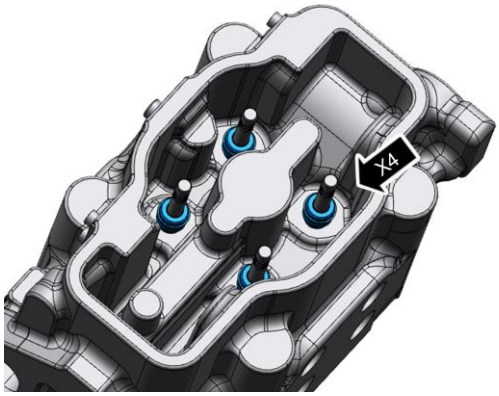
19. Loosen the special tool bolt slowly and remove the upper securing valve spring plate from its position. And keep them aside.



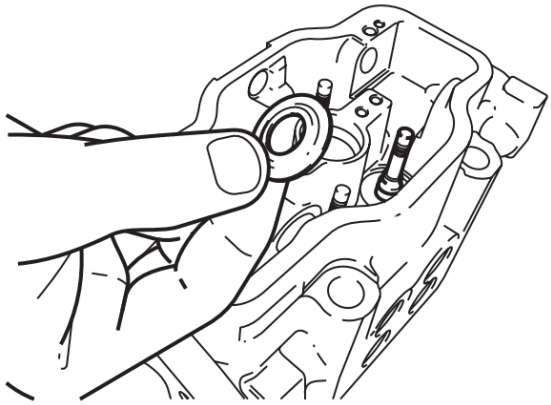
20. Remove the valve spring from valve stem and keep them aside.



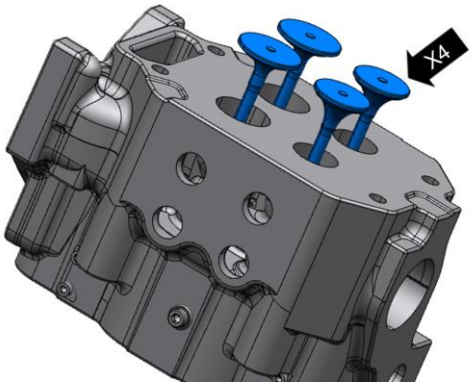
21. Remove the valve stem oil seal and discard the same.



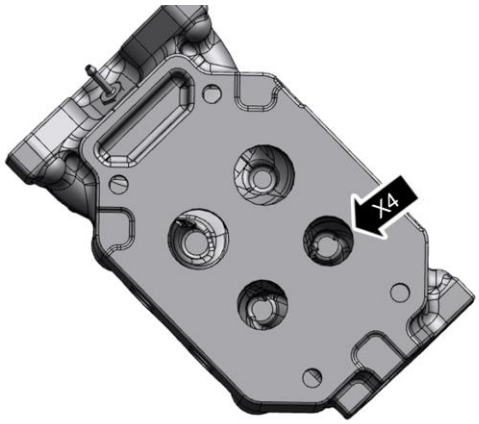
22. Remove the valve lower spring discs.



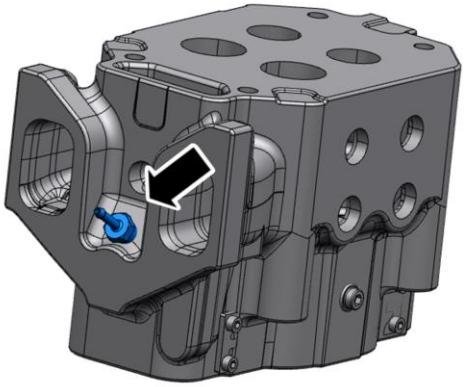
23. Gently push the valve stem to remove it from its location.



24. Remove the valve seats.

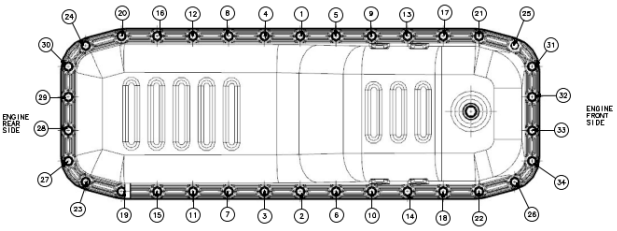


25. Loosen the securing nut of the fuel overflow pipe and remove the same.

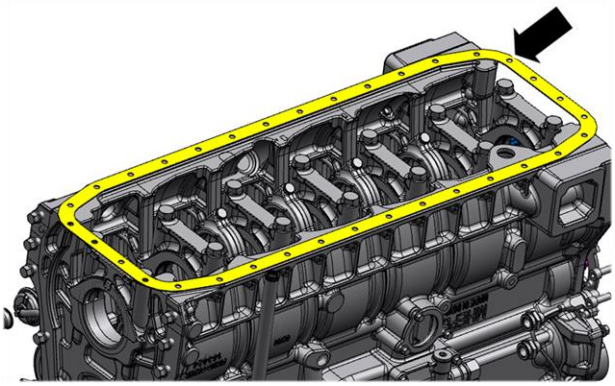


Oil Sump

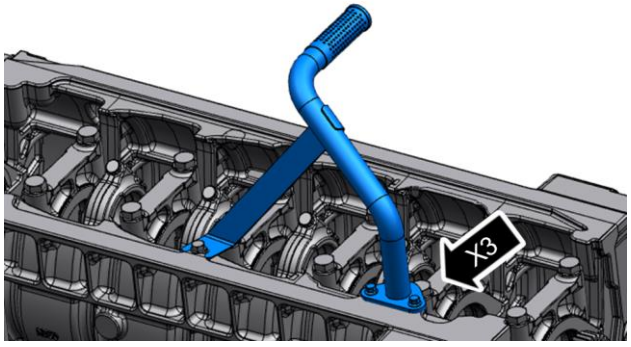
1. Loosen and remove the mounting bolts and remove the oil sump.



2. Scrap out the sump gasket.

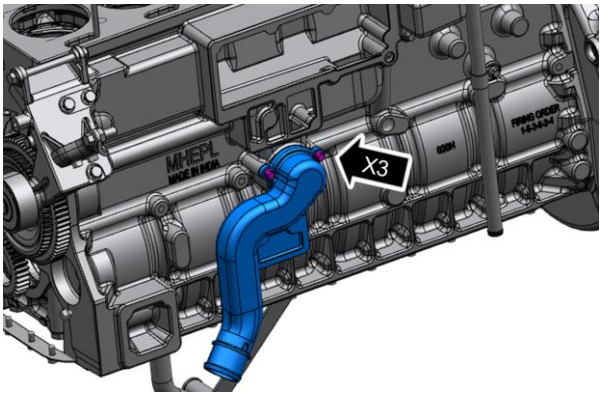


3. Loosen and remove the holding bolts and remove the oil strainer.



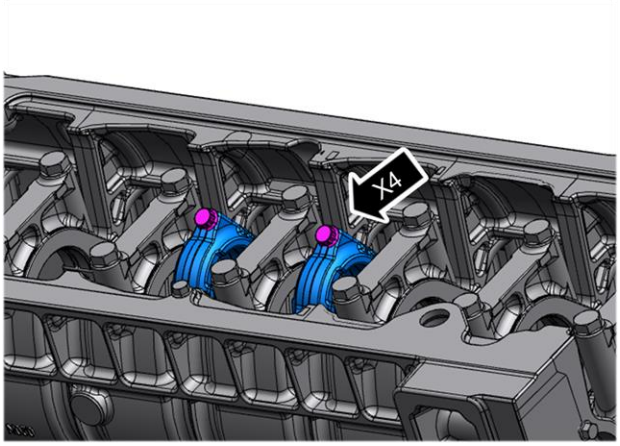
Water Inlet Connection

1. Remove the cap screws, water inlet connection, and gasket.



Piston and Connecting Rod Assembly

1. Loosen the securing bolts and remove the connecting rod big end bearing cap.

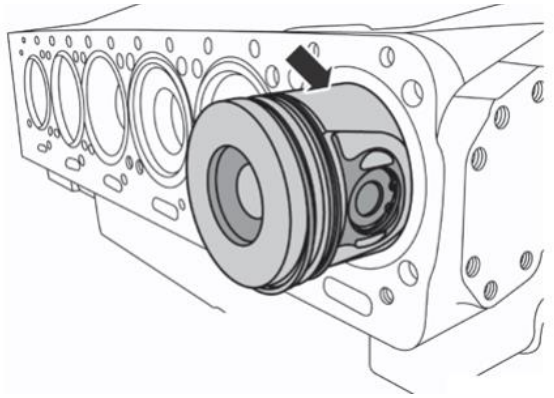


2. Rotate the crankshaft and remove the other connecting rod big end bearing caps.

NOTE

Keep the connecting rod and cap in the same sequence.

3. Tap the piston from the bottom side with a soft punch and remove the piston carefully out of the cylinder.

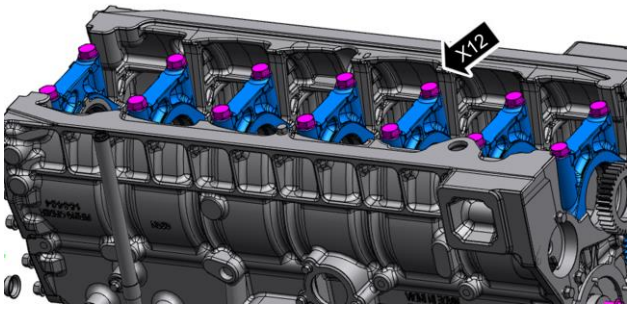


CAUTION

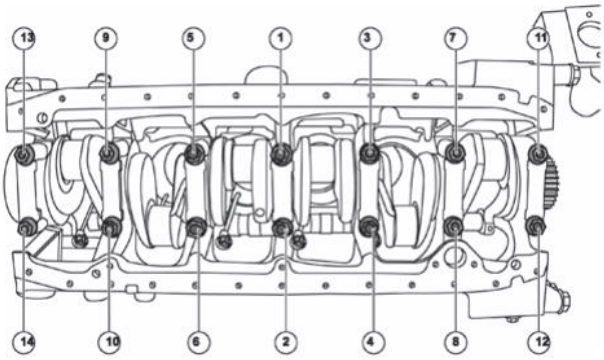
Do not damage the connecting rod big end bearing while tapping.

Crankshaft

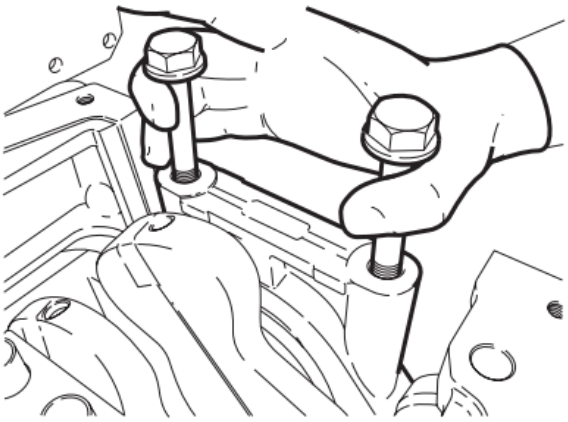
4. Loosen the crank shaft main bearing cap retaining cap bolts.



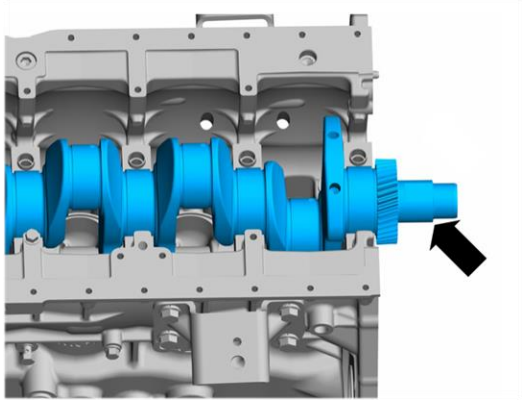
5. Loosen the main bearing cap bolt in the same sequence as mentioned below.



6. Remove the bearing caps and position them properly aside.



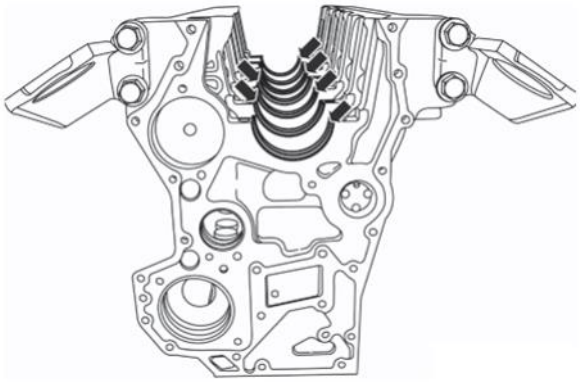
7. Remove the crank shaft carefully from its position and place it properly aside.



NOTE

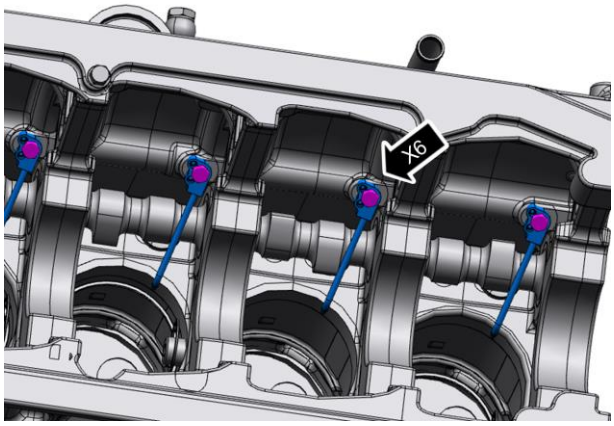
Keep the crank shaft in a vertical position.

8. Remove the securing bearing shells on the lower bearing caps.



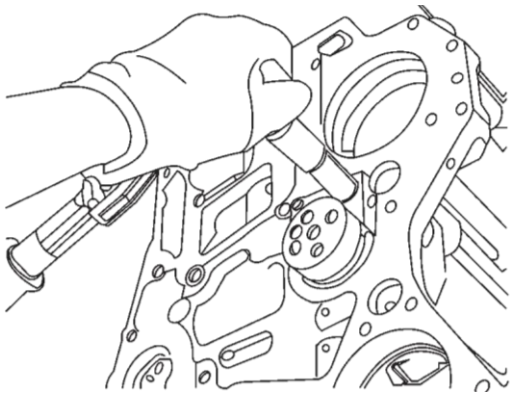
Piston Cooling Jets

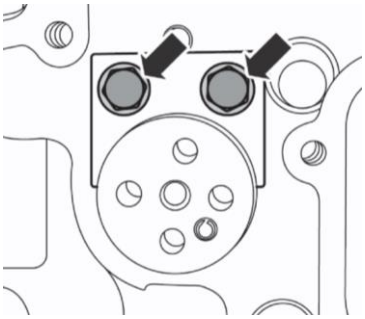
1. Loosen the securing bolts and remove the piston cooling jets from its position.



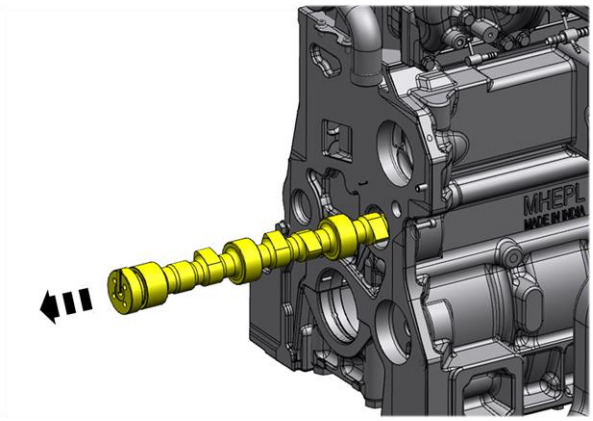
Camshaft

1. Loosen the cap screws and remove the camshaft thrust plate.

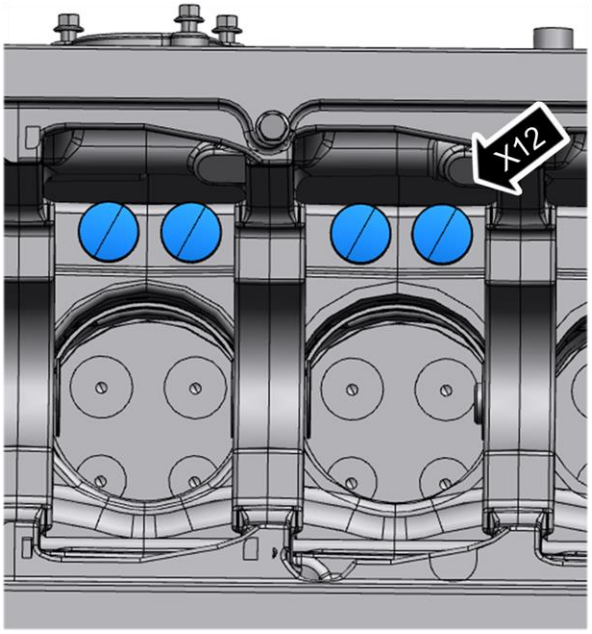




2. Remove the camshaft carefully from the engine block by continuously rotating the shaft.



3. Remove the tappets secured in its housing.



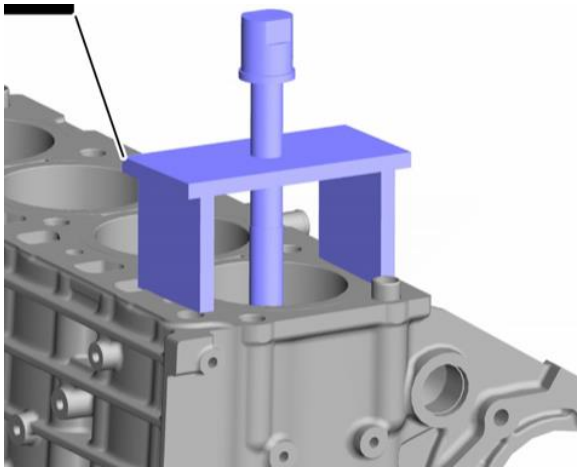
Cylinder Liner

CAUTION

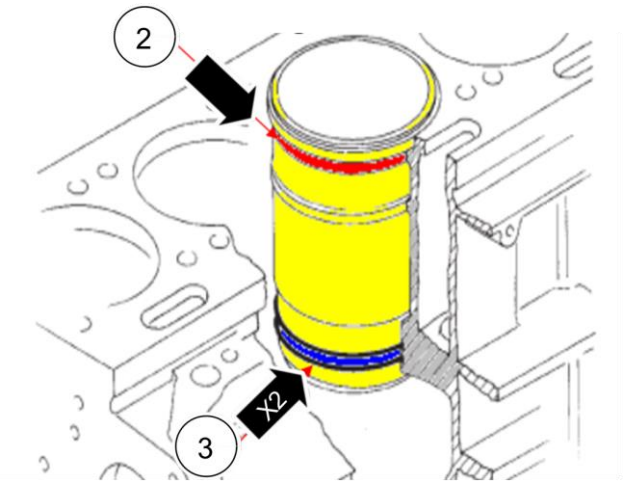
Cylinder liner puller must be installed and used as described to avoid liner / block damage.

1. Insert the cylinder liner puller in the top of the cylinder block.

   Special Tool No. 6202AAB0001ST



2. Turn the cylinder liner jackscrew clockwise to loosen the cylinder liner from the cylinder block.
3. Remove and discard the O-rings.



NOTE

Mark the cylinder number on each cylinder liner.

2.7.3 Inspection and Measurements

Measurement of Engine Oil Pressure

NOTE

The oil pressure depends on various factors (engine speed, oil temperature, oil viscosity, extent of oil filter contamination).

NOTE

Measure the oil pressure at the specified engine speed.

1. Park the vehicle on a level surface.
2. Apply the parking brake and chock the wheels.
3. Disconnect the oil pressure switch electrical connector from the oil pressure switch.
4. Remove the oil pressure switch.
5. Discard the washer.
6. Attach the oil pressure gauge with the oil pressure gauge connector and position it to allow reading from above.

NOTE

Measure the oil pressure at respective oil temperature.

7. Measure the oil pressure.

Oil Pressure Condition	Service Limit (mm)
Idling RPM	> 1.5 bar
Max RPM	> 3.5 – 5.3 bar

8. Remove the oil pressure gauge and the oil pressure gauge connector.

NOTE

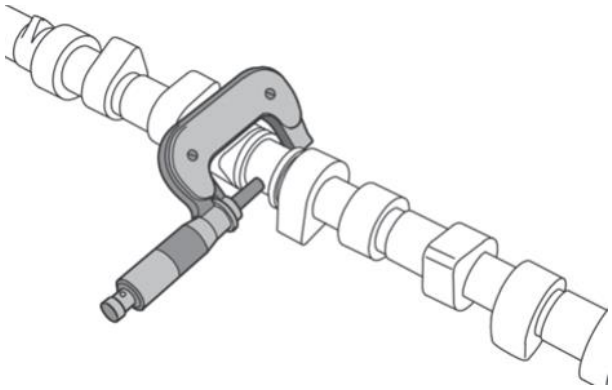
Install a new oil pressure switch washer.

9. Install the oil pressure switch.
10. Connect the oil pressure switch electrical connector to the oil pressure switch.

Camshaft

Camshaft Journal

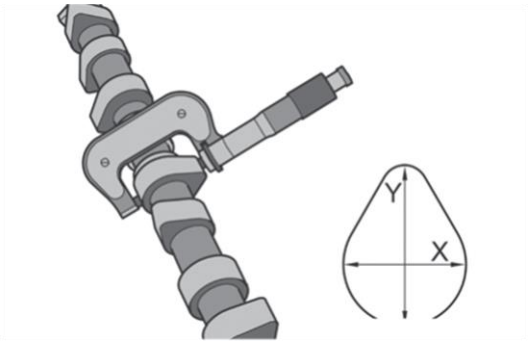
1. Measure the diameter of the camshaft journals.
2. Using a micrometer measure the diameter at 90° intervals to determine if the journals are out-of-round.
3. Measure at two different points on the journal to determine if there is any tapering.
4. If the measurements are out of the specified range (Refer specification), install a new camshaft.



Camshaft Bearing (D)	Service Limit (mm)
Without bushing	54.000 - 54.030
With bushing	49 .990 - 50.050
Main Journals	**Service Limit (mm)**
Standard Diameter (C)	49.873 - 49.897

Camshaft Lobe Lift

1. To determine the cam lift.
2. Using a micrometer measure the cam in two directions.
3. The difference between the two measurements is the cam lift.



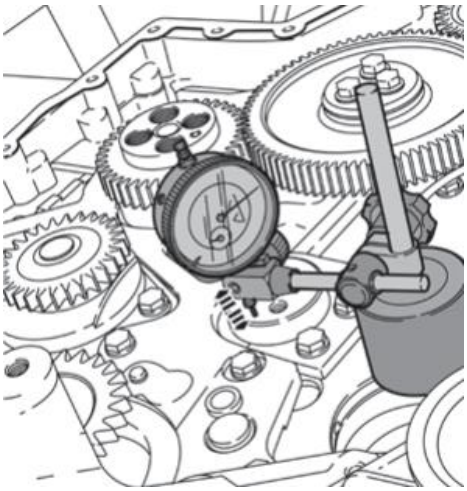
Parameter	Service Limit (mm)
Cam shaft height difference between cam height and base circle diameter (Y - X)	7.52 to 7.60

Camshaft End Play

NOTE

Make sure that the camshaft is according to specification.

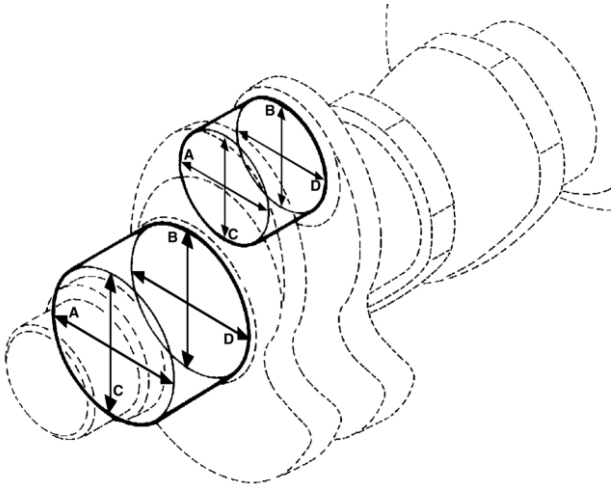
1. Using a Dial Indicator Gauge, measure the end play.
2. Read and note the maximum and minimum values on the Dial Indicator Gauge.
3. Measure the axial play.



Parameter	Service Limit (mm)
Camshaft End Play	0.10 - 0.15 Max 0.20

Crankshaft Main Bearing Journal Diameter

1. Measure the diameter of the main bearing journals and the big-end bearing journals.
2. Repeat the measurement with the micrometer offset by 90°, in order to determine any eccentricity which may be present.



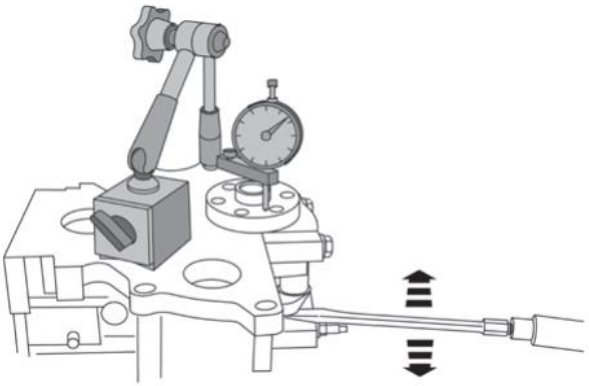
3. Measure the journal at two different positions to determine any conicity which may be present.

Parameter	Service Limit (mm)
MAIN JOURNAL REPAIR SIZES	
Standard	85.942 – 85.964 (mm)
1st repair	85.692 – 85.714 (mm)
2nd repair	85.442 – 86.464 (mm)
3rd repair	85.192 – 85.214 (mm)
4th repair	84.942 – 84.964 (mm)

Crankshaft End Play

To determine the end float

1. Place the dial indicator on the crankshaft rear end.

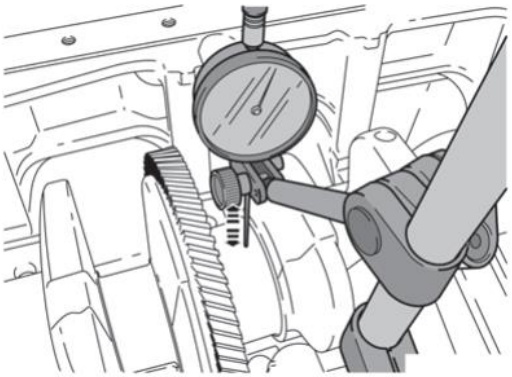


2. Determine the end float by raising the crankshaft with the aid of a screwdriver. If necessary, correct the end float by using new thrust washer of different size.

Parameter	Service Limit (mm)
Crankshaft End Play	0.08 - 0.25 Max 0.4

Crankshaft Warpage

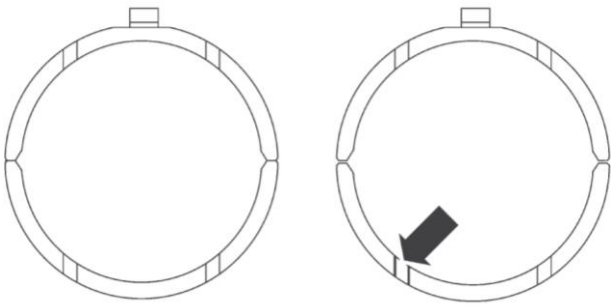
Place crankshaft with the bearing shells of the first and last bearings only installed and oiled. With a dial indicator gauge on the central main journal, turn crankshaft and measure warping.



Maximum Warping**: 0.15 mm**

Crankshaft Thrust Washer

1. Check crankshaft thrust washers. Check for damages existence or excessive wear. During assembly, the side with two grooves must be toward the crank shaft.



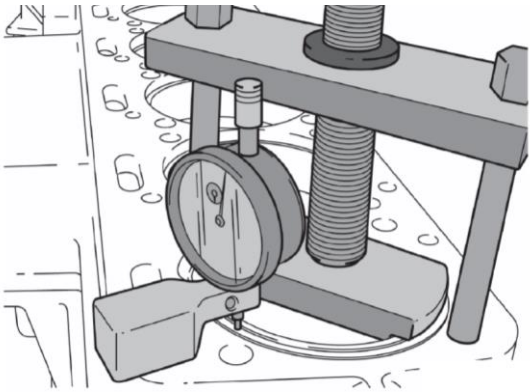
2. When needed, it may utilize over-sized thrust washer, which must have its flat surface adjusted, in order to provide the correct axial clearance.

Crank Shaft Thrust Washer	Repair Size (mm)
Standard	3.42-3.47
Oversize	3.67-3.72

Cylinder Liner Protrusion

1. Using a dial indicator gauge, measure the liner protrusion to the block surface.

Special Tool No. 6202BAB0002ST



2. The protrusion must be measured considering 4 points at equal distance from each other.
3. The protrusion must be within limits, otherwise the liner must be removed and a new inox ring should be installed.

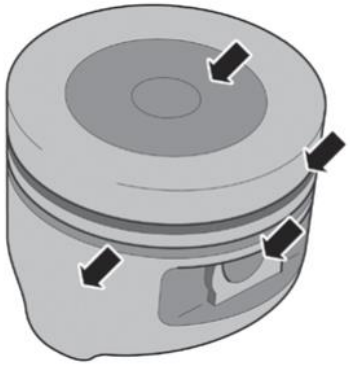
Cylinder Liner Protrusion: **0.03-0.10 mm**

Piston Inspection

CAUTION

Do not use any aggressive cleaning fluid or a wire brush to clean the piston.

1. Carry out a visual inspection.
2. Clean the piston skirt, pin bush, ring grooves and crown and check for wear or cracks.



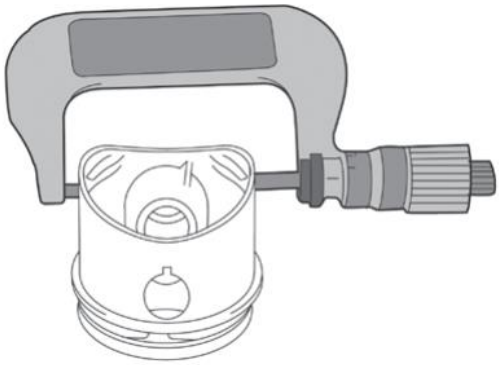
3. If there are signs of wear on the piston skirt, check whether the connecting rod is twisted or bent.

Piston Diameter

NOTE

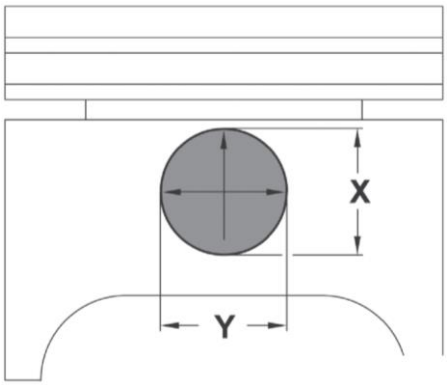
The piston and piston pin form a matched pair. Do not mix up the components.

1. Using a Micrometer measure the piston diameter. Compare with specification, if required replace the piston.



Piston Pin Bore Diameter

1. Measure the diameter of the piston pin bore.
2. Measure the diameter in two directions.



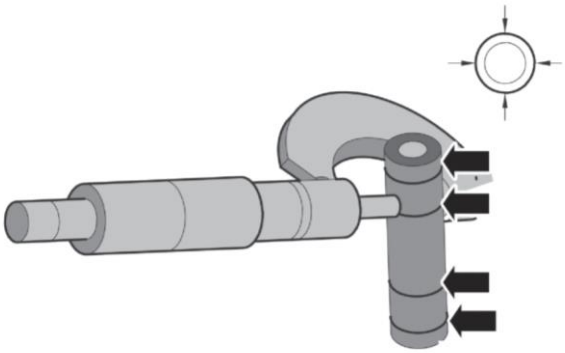
3. If the values are not to the specification chart, then replace both the piston and piston pin.

Piston Pin Bore Diameter

Nominal: **38.005 to 38.018 mm**

Piston Pin Diameter

1. Measure the piston pin diameter.
2. Measure the diameter in two directions.

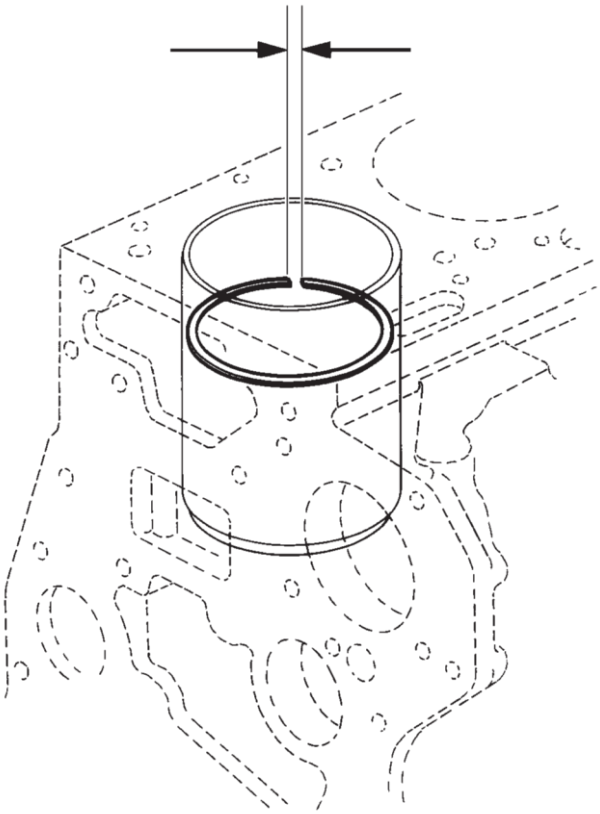


3. If the values are not to the specification, install a new piston and a new piston pin.

Piston Pin Diameter	Service Limit (mm)
Nominal	37.994 to 38.000
Maximum	37.900

Piston pin to piston pin hole clearance (Max): **0.04 mm**

Piston Ring End Gap

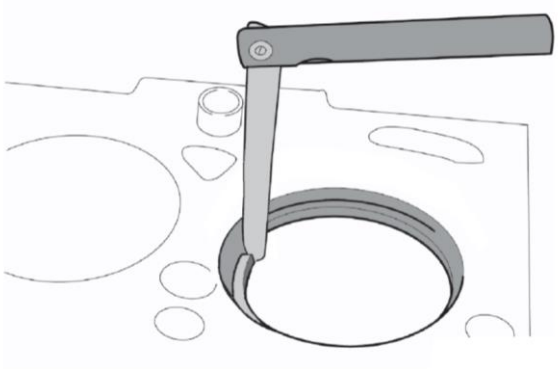


CAUTION

Do not mix up the piston rings. Install the piston rings in the same position and location.

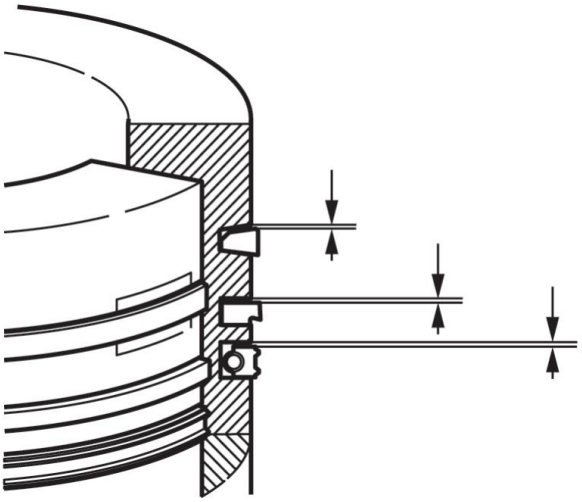
1. Take the piston ring and use a piston without rings to push the piston ring about 30 mm into the cylinder bore.

2. Using the Feeler Gauge, measure the piston ring gap.



Piston Ring End Gap	Service Limit (mm)
1st Compression Ring	0.30 – 0.55 mm
2nd Compression Ring	0.30 – 0.55 mm
3rd Oil Ring	0.25 – 0.55 mm

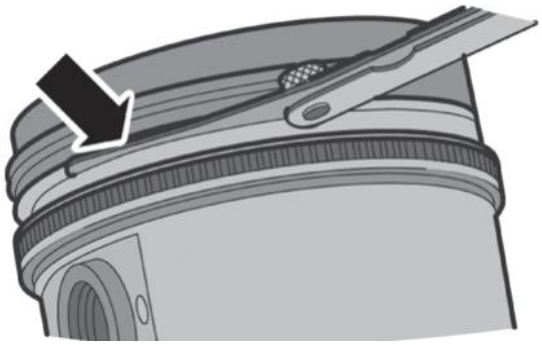
Piston Ring-To-Groove Clearance



NOTE

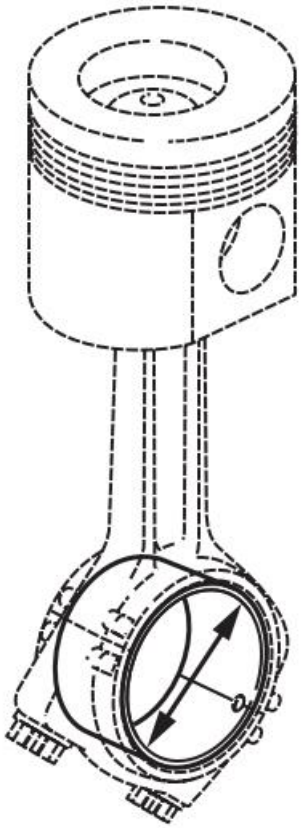
The piston and piston pin are a matched pair. Do not mix up the components.

1. Using the Feeler Gauge, measure the piston Ring clearance. Compare the measurement with specification. Replace either ring or piston as per the measurement.



Piston Groove Clearance	Service Limit (mm)
1st Compression Ring	0.25
2nd Compression Ring	0.05 to 0.09
3rd Oil Ring	0.07 to 0.11

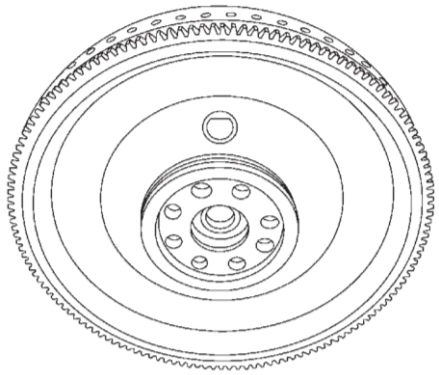
Connecting Rod Bearing Bore



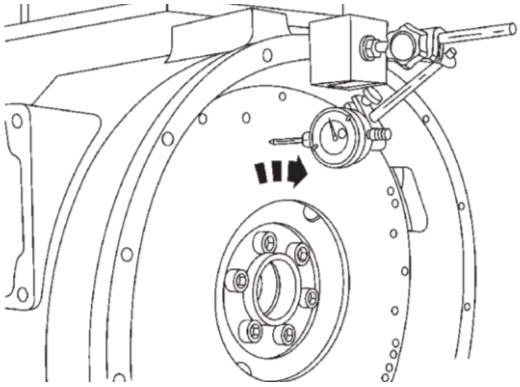
CONNECTING ROD BEARING	Service Limit (mm)
Standard	62.992 to 63.037
Repair 1	62.746 to 62.791
Repair 2	62.496 to 62.541
Repair 3	62.246 to 62.291
Repair 4	61.996 to 62.041
Pre-tension	0.06 to 0.12

Flywheel Inspection

1. Inspect the flywheel. If there is evidence of the following, install a new flywheel.



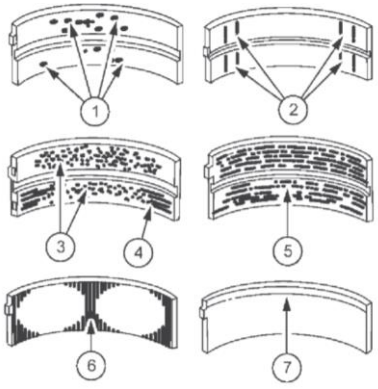
- Cracks
- Worn ring gear teeth
- Chipped or cracked ring gear teeth
- Check the side oscillation of the fly wheel



- Maximum side oscillation = **30 mm**

Bearing Inspection

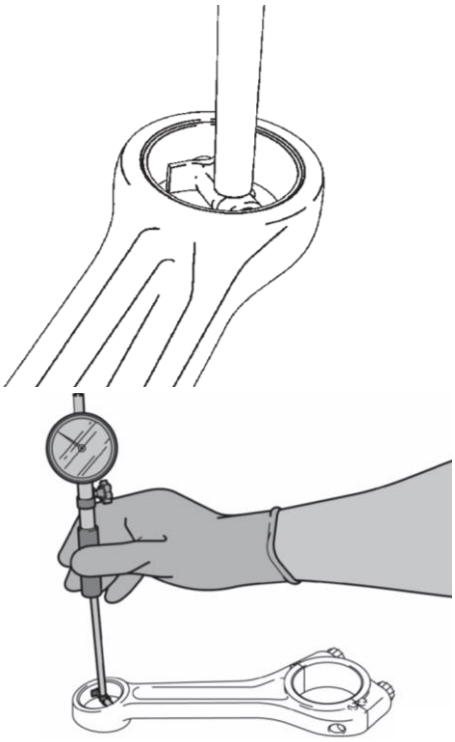
1. Inspect bearings for the following defects.



- Cratering - fatigue failure
- Spot polishing - incorrect seating
- Imbedded dirt engine oil
- Scratching - dirty engine oil
- Base exposed - poor lubrication
- Both edges worn - journal damaged
- One edge worn - journal tapered or damaged

Connecting Rod Small End

1. Measure the clearance of the connecting rod bushing housing to the piston pin.

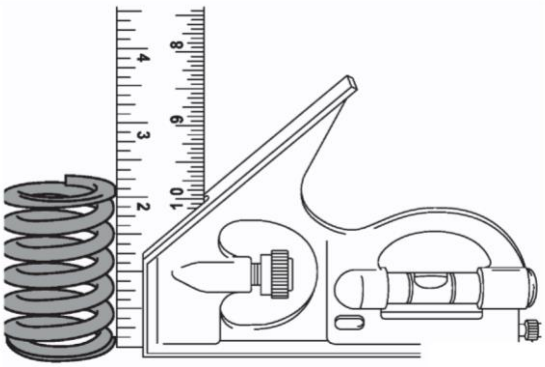


2. Check connecting rod for possible damages, marks or burrs.
3. Damage on the connecting rod stem could cause cracks and rupture of the connecting rod.

Connecting Rod Small End ID with Bush	Service Limit (mm)
Nominal	38.037 – 38.095
Maximum	38.140

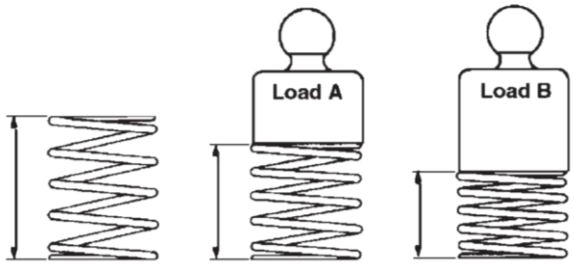
Cylinder Head

1. Using a special spring measuring device check the length of the valve spring at different load conditions.



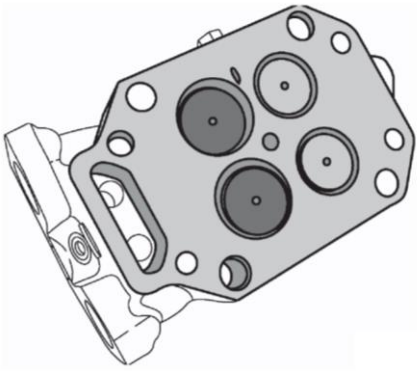
2. Valve spring is tested at no load, min load and max load conditions as shown.

3. Respective load and length variation observed are tabulated below.

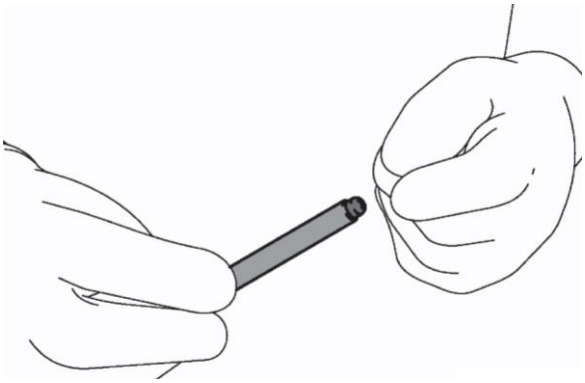


Intake and Exhaust valve		Service Limit (mm)	
Spring Wire D		3.50	
Load (N)		**Length (mm)**	
C	0.0	C	60.59
A	350 ± 29	A	40.0
B	520.0 ± 32	B	30.0

4. Check the cylinder head visually, for any leaks.

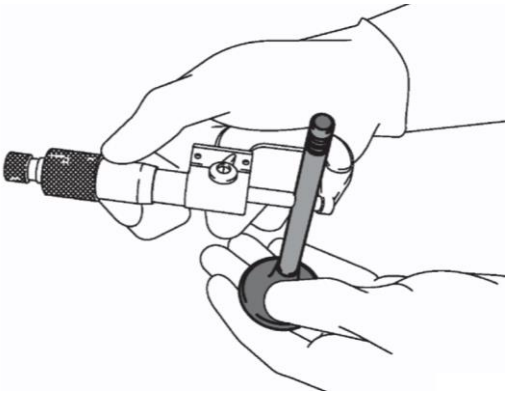


5. Check that the push rods lubrication holes are not blocked, and its ends must not be loosened or cracked, and push rods are not warped.



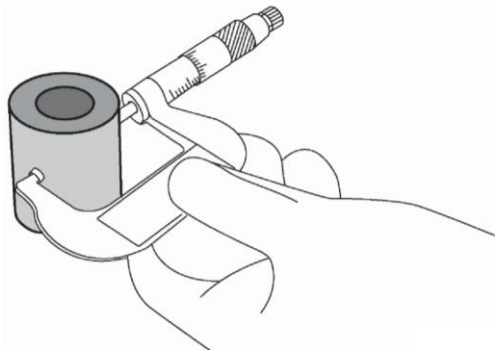
6. Using micrometer, measure the outer diameter of the valve stem at three different points.

- Middle part
- Lower part
- Upper part



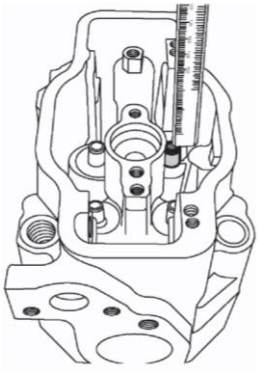
Nominal - **6.956 - 6.970 mm**

7. Using the micrometer, measure the outer diameter of the valve guide.

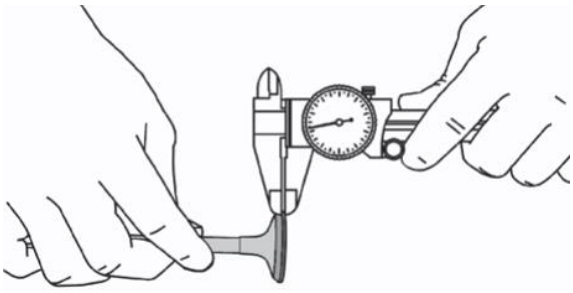


Valve to valve guide clearance	Service Limit (mm)
Nominal (Inlet)	0.03
Nominal (Exhaust)	0.03-0.07

8. Using the Vernier calipers, measure the valve guide height in relation to the cylinder head.



9. Using the Vernier calipers, measure the width of the valve seat.

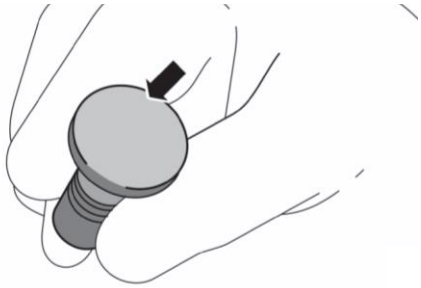


Valve Margin: **Intake-2.2 mm, Exhaust- 2.1 mm**

10. Using dial bore gauge, check the rocker arm end axial clearance in the shafts and deformities like roundness and taper.

Rocker to rocker shaft clearance: **0. 022 – 0. 051 mm**

11. Visually check the tappets.

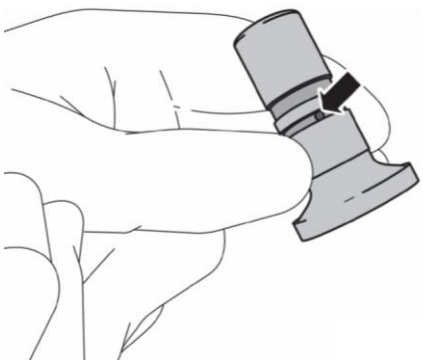


12. Check if there are marks of excessive wear on the contact area with the cams of the camshaft.

NOTE

During its operation the tappets perform a rotating movement, responsible for a uniform distribution of the force and a uniform wear. It must not have wear on only one area.

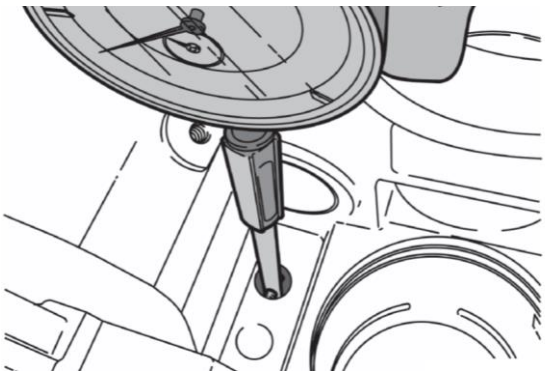
13. Visually check tappet lubrication holes.



NOTE

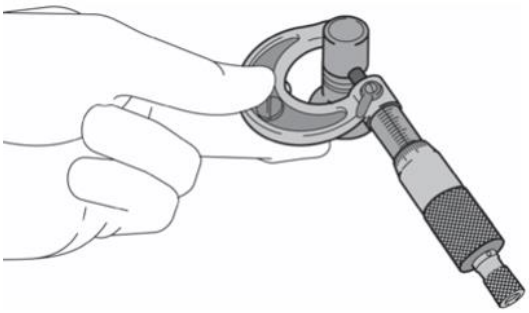
The lubrication holes of the tappets should not be obstructed.

14. Measure the diameter and out-of-roundness of the tappet housing.



Tappet Hole Bore Diameter	Service Limit (mm)
Nominal	18.000 - 18.018
Maximum	18.020
1st Repair	18.500-18.518

15. Comparing the performed measurements, obtain the clearance between the tappet and the housing.



Tappet Hole Bore Diameter	Service Limit (mm)
Nominal	17.983 - 17.994
1st Repair	18.483 - 18.494

Tappet to Tappet Hole Clearance: **0.006 – 0.035 mm**

2.7.4 Assembly

WARNING

Do not smoke or carry lighted tobacco or open flame of any type when working on or near any fuel related components. Highly flammable mixtures are always present and may ignite. Failure to follow these instructions may result in personal injury.

CAUTION

Before assembling the cylinder block, all sealing surfaces must be free of chips, dirt, paint and foreign material. Also, make sure the coolant and oil passages are clear.

NOTE

For Tightening Torque specifications for installation and assembly, refer to: ***2.5 Tightening Torques***

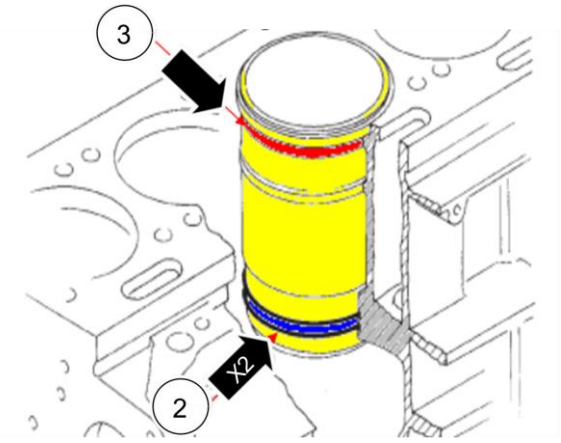
Cylinder Block

1. Mount the engine block on the engine stand.
2. Apply a thin film of fresh engine oil to the new sealing O-rings and install it to the cylinder block.

NOTE

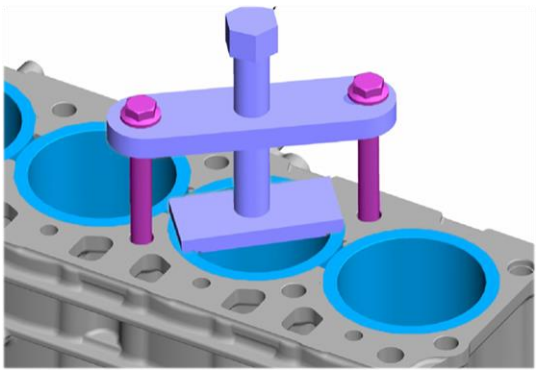
Don't reuse the removed O-rings and INOX rings of the liner. It may leak & lead to mixing of oil and water inside the engine assembly.

3. Install the new INOX rings.



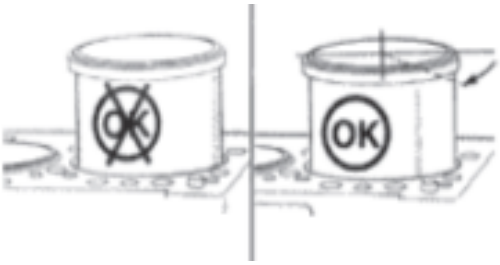
4. Compress the liner to the housing with the help of the special tool. For cylinder liner protrusion check inspection section.

   Special Tool No. 6202AAB0002ST



NOTE

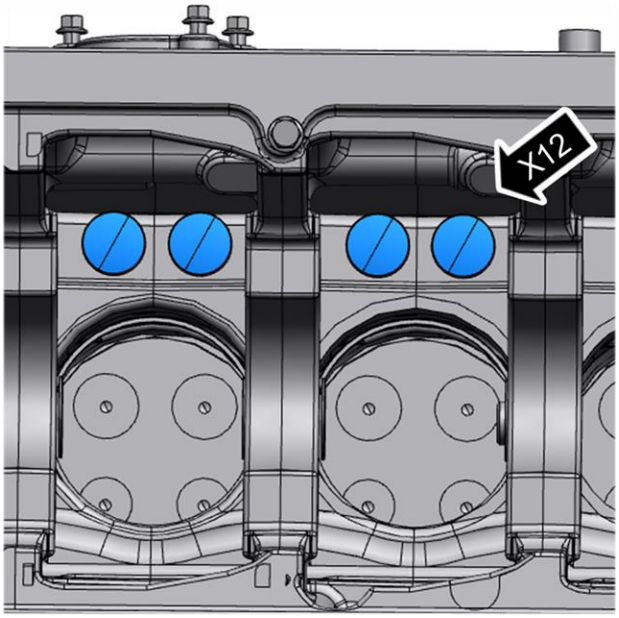
When reusing cylinder liners, install them in the same cylinder from which they were removed and rotate them by 45° from the original position.



NOTE

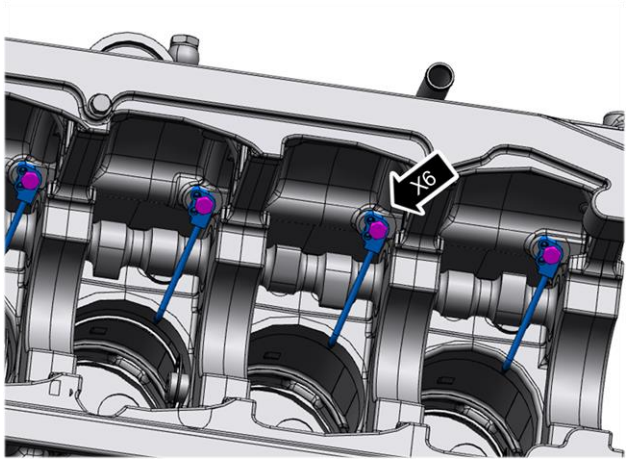
Clean and lubricate the tappets and tappet housing with clean recommended Engine Oil before installing.

5. Install the tappets to its housing.



6. Install cooling injectors for all the cylinders.

   Torque: 10 ± 1.5 Nm

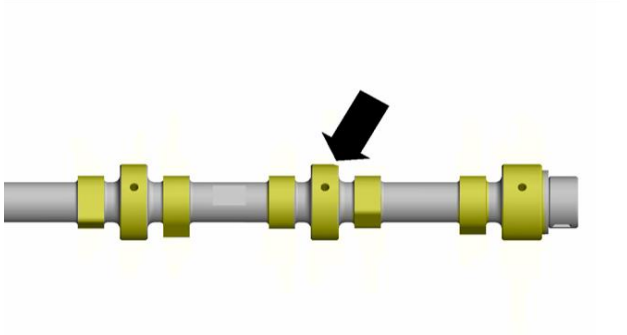


NOTE

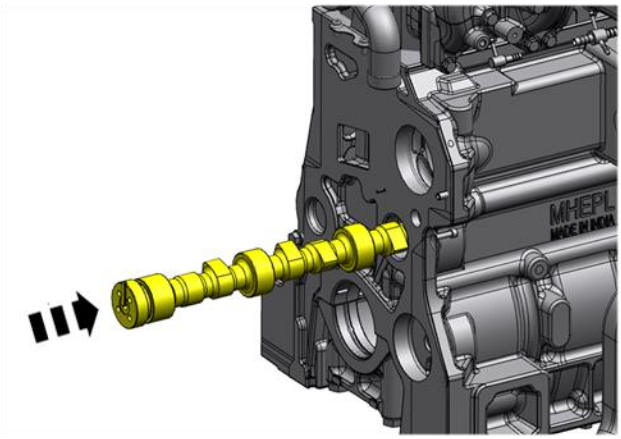
- *Ensure the guide pins are correctly fitted to the block holes before tightening.*
- *Check if the oil injector is aimed direct to the piston hole otherwise it may cause excessive piston heat and damage the engine.*

Camshaft

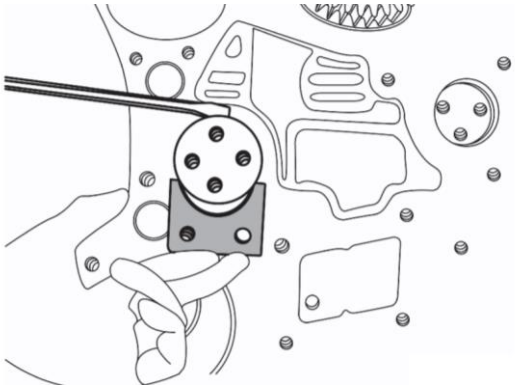
1. Lubricate the surface of the camshaft bearings with clean engine oil.



2. Insert the cam shaft into the engine block carefully.

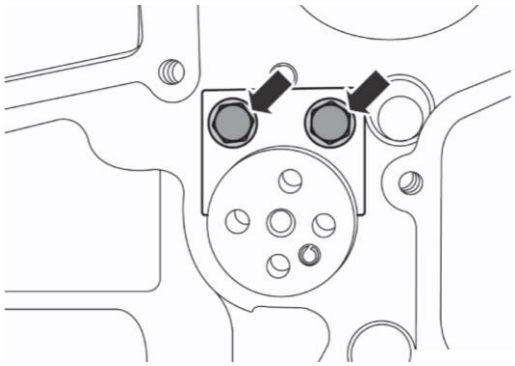


3. Install it with the hands making rotating movements. Take care not to damage the bushings in the engine block.



4. After camshaft installation, install the axial lock and tighten securing bolts.

Torque: 30 ± 5 Nm

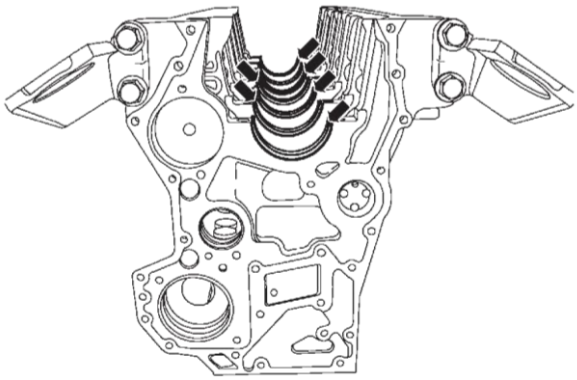


Crankshaft

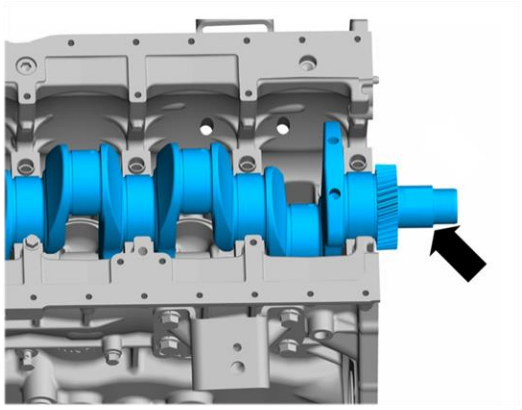
NOTE

Ensure that bearing sits exactly in its position and no dust particles are present while installing the bearing.

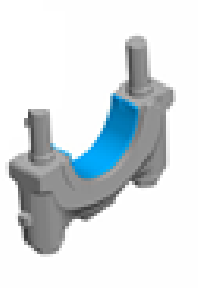
1. Install the bearing shells on lower bearing caps.



2. Place the crank shaft aligned on the bearing shells.



3. Clean the bearing cap properly and Install the bearing shell on to the upper bearing cap and lubricate it properly.



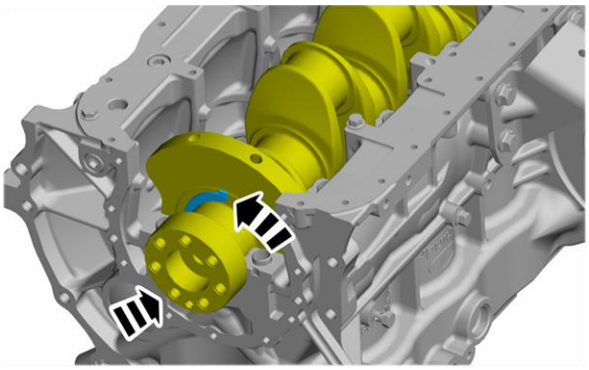
NOTE

Do not install the upper thrust bearings until the crankshaft is installed.

NOTE

Lubricate the thrust surfaces of the crankshaft with clean engine oil.

4. Position the upper bearing cap with bearing shell and install the upper and lower thrust washer to it.

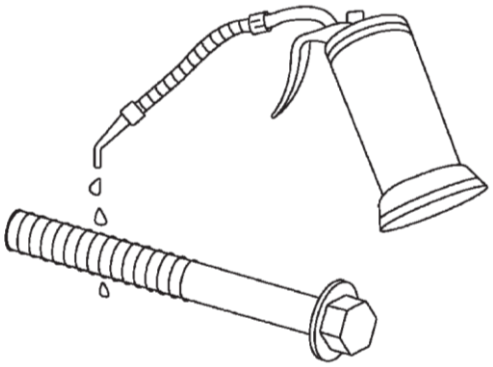


NOTE

Ensure that bearing sits exactly in its position and no dust particles are present while installing the bearing.

NOTE

Use clean engine oil to lubricate the cap screw threads. Clean the excess oil from the cap screws before installing them.

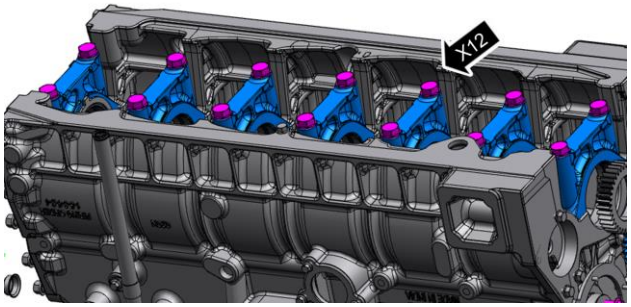


NOTE

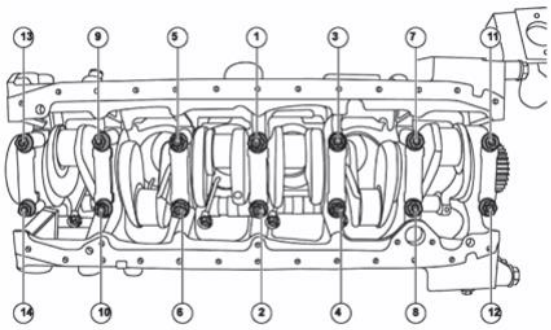
Identification marks i.e. 1 to 7 is punched on the main bearing caps. Starting from the flywheel side, install the bearing caps from 1 to 7.

5. Install the crank shaft main bearing caps in its position as per the sequence.

   Torque – 1st - 50 ± 5 Nm, 2nd - 155° ± 5°



6. Torque must be applied from centre to extremities in the sequence as shown below.



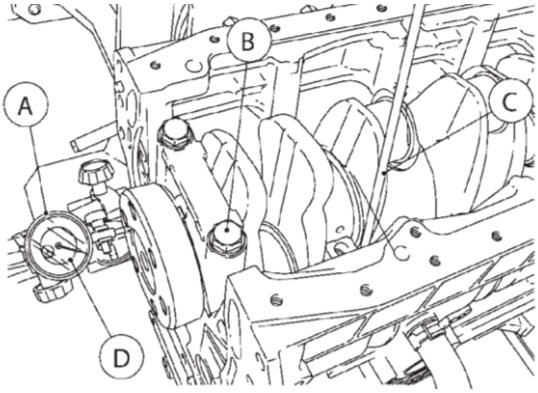
   Follow the sequence as mentioned above while tightening the crankshaft bearing caps.

NOTE

After securing bearing cap bolts, make sure crankshaft turns smoothly by hand.

14. Inspect crankshaft.
    1. Position the crankshaft to the rear of the cylinder block.
    2. Set a preload on the Dial Gauge of 2-5mm and set the main scale to zero.
    3. Move the crankshaft to the front of the cylinder block. Measure and record the crankshaft end play.

       End Play: 0.08 - 0.25 (0.4 (max))



NOTE

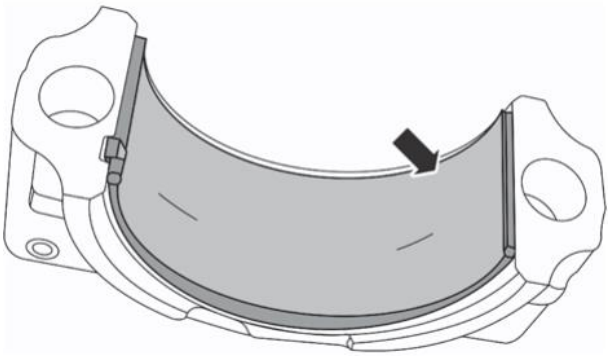
- *Identification number is punched on the connecting rod cap for pairing connecting rod and caps.*
- *Make sure that connecting rod cap is installed on connecting rod as per same identification number provided on both parts.*
- *Lubricate the connecting rod cap mounting bolts with clean engine oil. Clean excess oil from the connecting rod cap mounting bolts before installing them.*

7. Install connecting rod big end bearing in its position correctly.

8. Confirm that correct size bearings are used.

NOTE

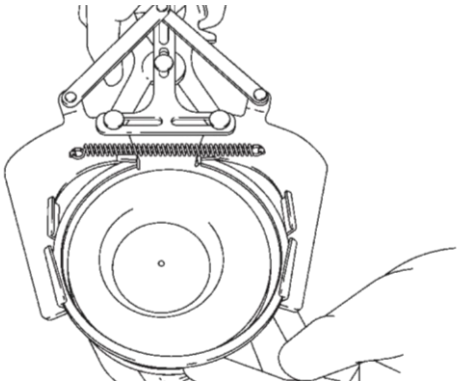
- *Ensure that bearing sit exactly in its position and no dust particles present while installing the bearing.*
- *Install bearings so that the groove in connecting rod aligns with the notch of bearing shell.*



NOTE

Apply clean recommended engine oil to bolt threads and bearing surfaces before installing.

9. Assemble the piston rings to the piston,



NOTE

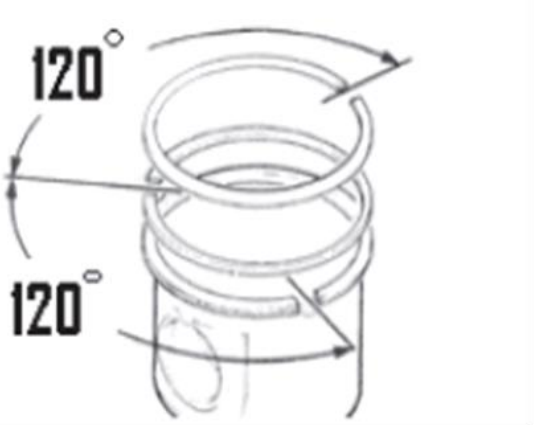
Ensure that CTOPW, CTOPK, CTOP marks must be upward.

10. Install the piston with the connecting rod to their respective cylinders and lubricate it properly.
11. Install them in the corresponding cylinders with tool.

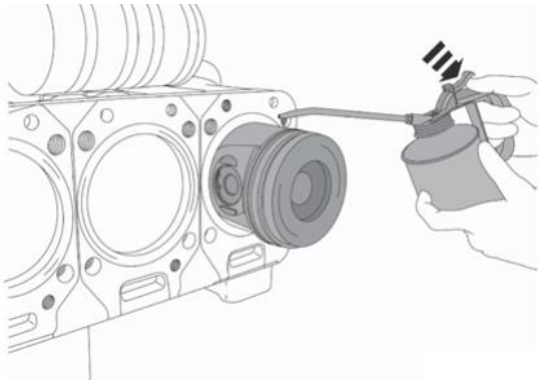
CAUTION

- **Make sure connecting rod does not scratch cylinder wall.**
- **Make sure the connecting rod bolts do not scratch crankshaft main bearing journals.**

12. Before installing the pistons in the cylinder bore, position the piston ring 120° apart from each other.



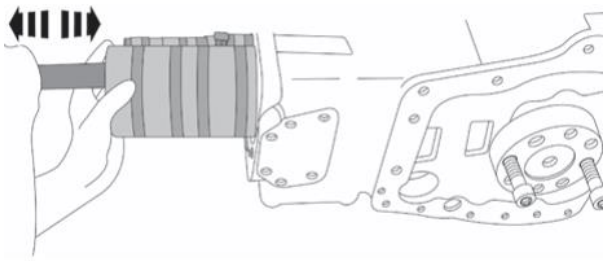
13. Apply new engine oil to piston rings and sliding surface of piston.



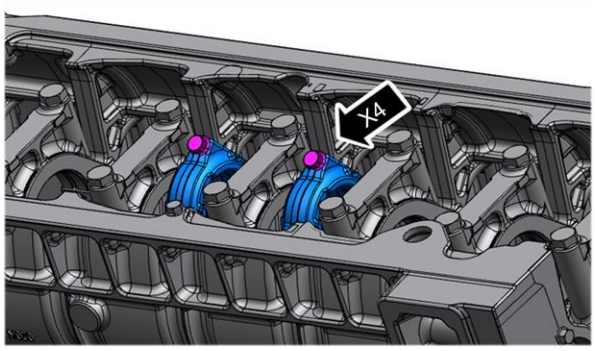
NOTE

Make sure the arrow indication on the piston is towards the flywheel side or the 1st cylinder side.

14. Tap the piston into the housing with the help of the piston ring compressor tool and mallet.



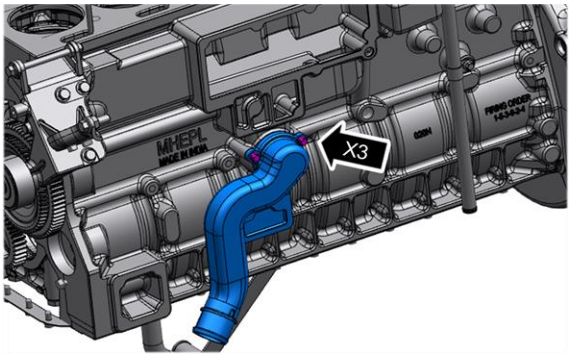
15. Repeat the same for the remaining cylinders.
16. Apply new engine oil to bolt threads and install the connecting rod big end bearing capscrews.
    Torque: 1st:40±5, 2nd:80°±2°



17. Rotate the crankshaft and tighten the rest of the connecting rod capscrews.

Water Inlet Connection

1. Install the cap screws, water inlet connection, and gasket.
   Torque: 20 ± 3 Nm



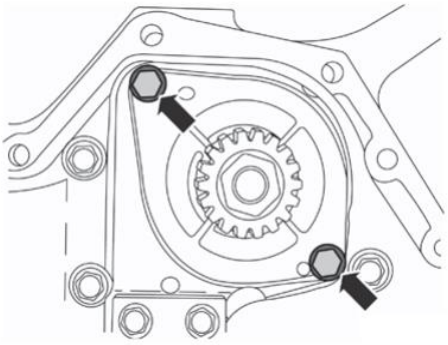
Timing Gear System

1. Install the new gasket for the gear casing.
2. Install the gear housing assembly to block with the gasket.
3. Install the gear housing and tighten the fixation bolts.
   Torque: 15 ± 5 Nm

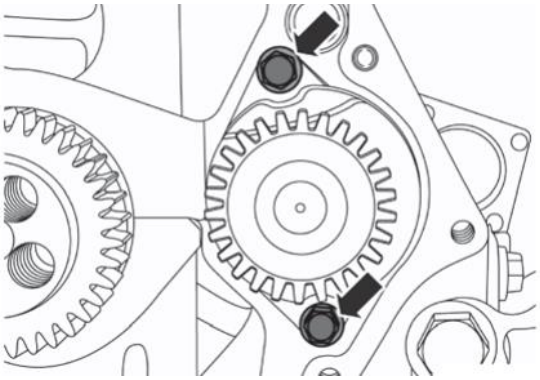
NOTE

- *The centralization of the gear housing is important to guarantee the specified clearances of the distribution gears.*
- *When removing/installing only water pump, lock the crankshaft and timing gears.*

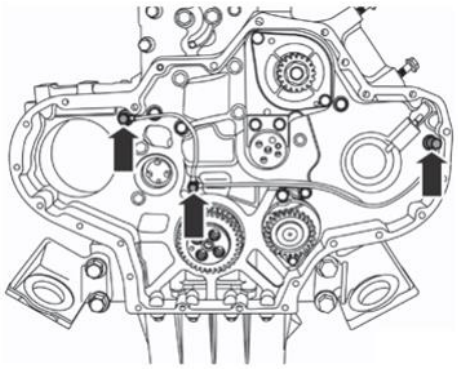
4. Install the water pump, tighten the mounting bolts. Take care not to damage the sealing ring
   Torque: 20 ± 2 Nm



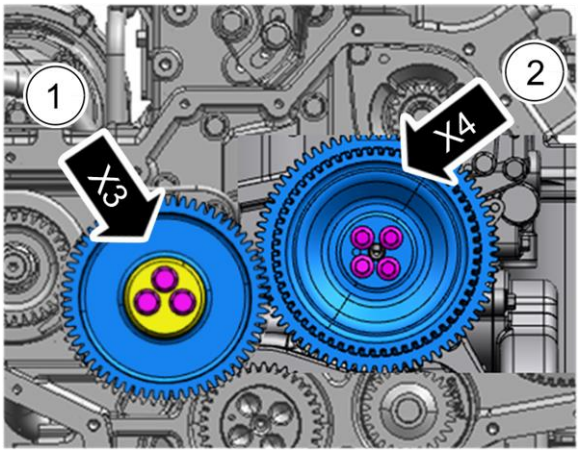
5. Install lubricant oil pump and tighten the mounting bolts. Take care not to damage the sealing ring
   Torque: 20 ± 2 Nm



6. Install the lubrication pipe and tighten the mounting banjo screws.
   Torque: 7.5 ± 2.5 Nm



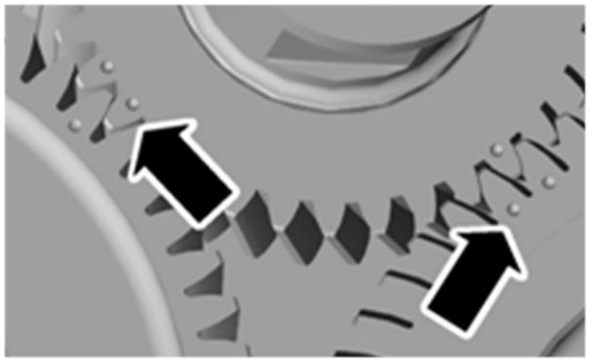
7. Install the timing gears.
   1. Install the idler gear and tighten the securing bolts with holding plate.
      Torque: 60±5 Nm
   2. Install both the front and back camshaft timing gears and tighten the securing bolts.
      Torque: 1st: 15 to 25 Nm; 2nd: 28° to 32°
      (Torque range from 35 to 65 Nm)



8. To assemble the gears in the correct timing position, use a screwdriver to make short turns.
   Observe the timing gear marks.

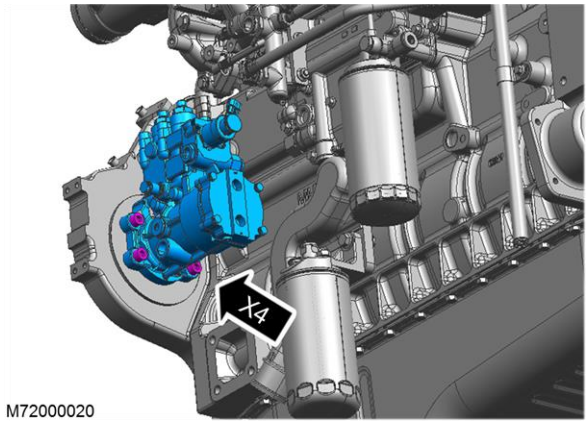
NOTE

Match the timing mark on the cam shaft and crankshaft gears for correct timing before installing the gears.



High Pressure Pump

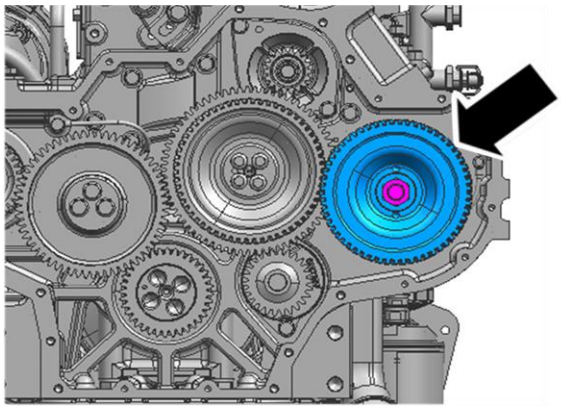
1. Install high pressure pump to the gear housing. Position the pump with the bolts until it touches the mounting face.
   Torque 40 ± 6 Nm.



NOTE

Note there is no timing on this gear to the pump shaft and does not need cotter for positioning.

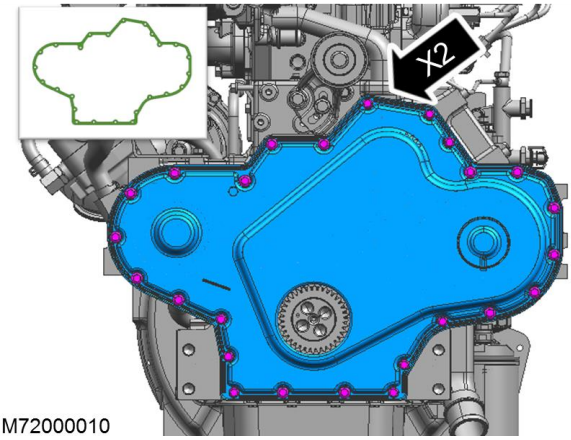
2. Install the HPP gear on the HPP shaft.



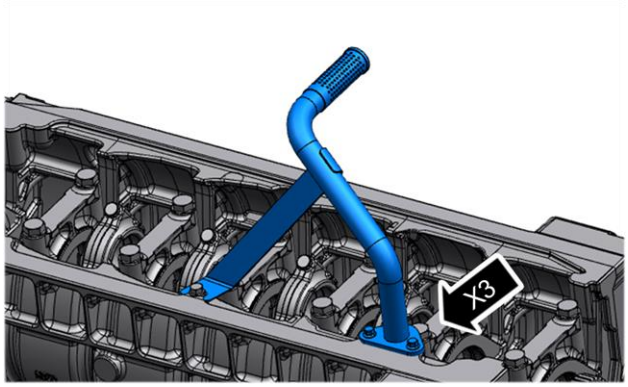
NOTE

The protective caps must be removed only immediately before the piping is installed in order to avoid contamination.

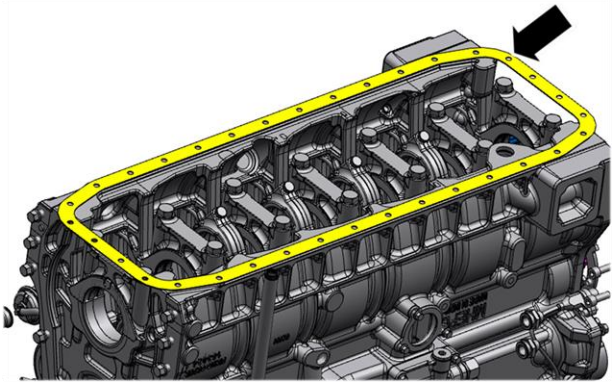
3. Apply a new gasket and install the timing case upper cover and its holding bolts and tighten it firmly.
   Torque: 30 ± 3 Nm



4. Place the bolts without tightening to allow the movement of the cover.
5. Tighten the fixation bolts of the front cover.
   Torque: 25 ± 3 Nm
6. Install new O-ring to the oil strainer pipe before assembly.
7. Install the oil suction pipe to the engine assembly and tighten its bolts.
   Torque: 25 ± 4 Nm

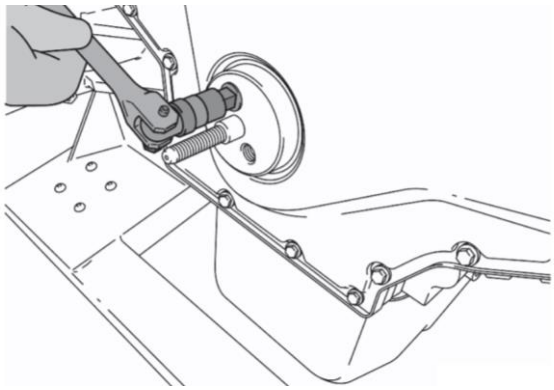


8. Apply gasket on the oil sump mating surface. Install the oil sump and tighten the oil sump mounting bolts.

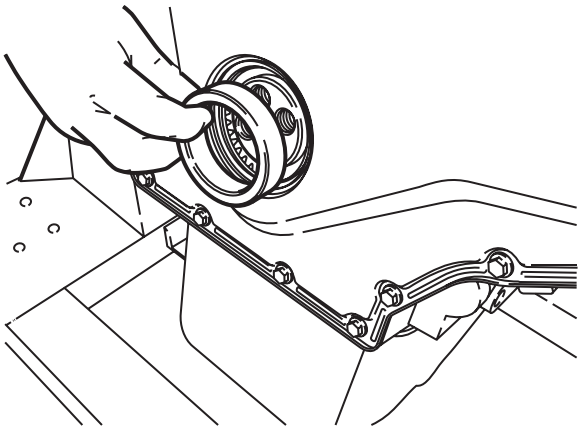


9. Tighten the 2 bolts indicated to fit the tool onto the crankshaft gear.

Torque: 1st: 100 ± 10 Nm

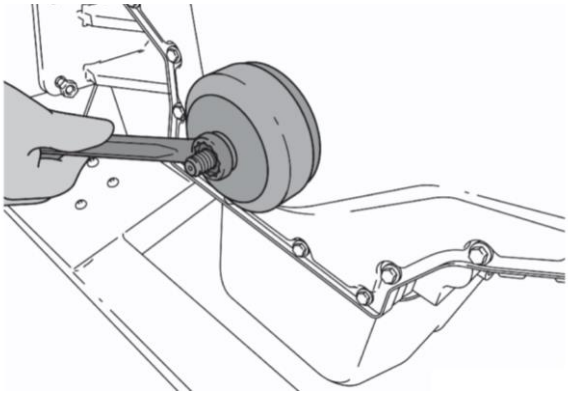


10. Install a new front-end spacer properly.

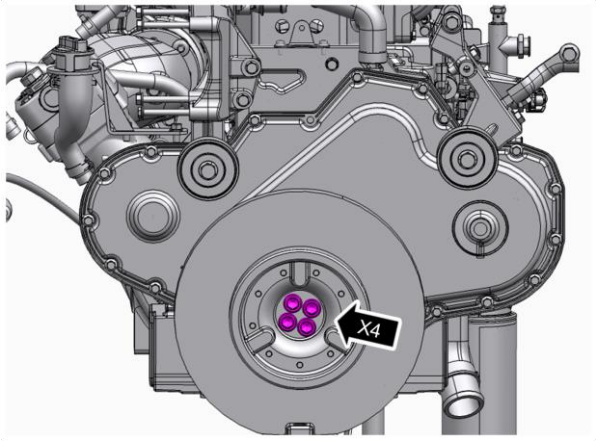


11. Install the special tool hub and tighten as indicated placing the seal to its housing.

Special Tool No. 6210AAB0001ST



12. Install the front pulley with the damper.

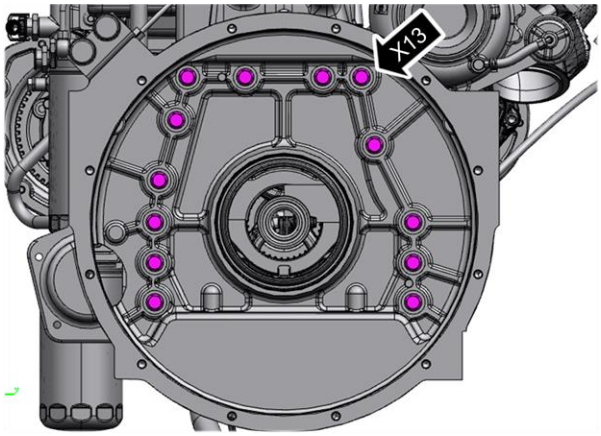


Flywheel

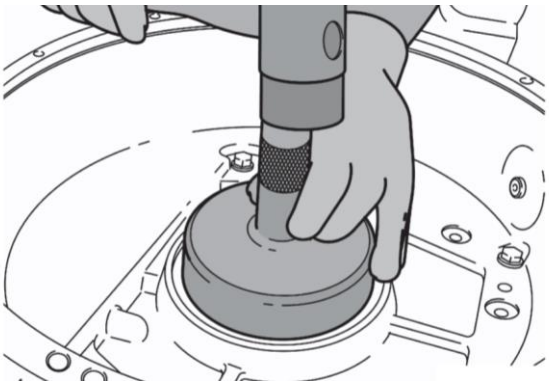
1. Inspect the fly wheel visually for any cracks.

2. Clean the housing and the engine block. Apply Loctite 515 / Anabond 683 K on the contact surface between the engine block / oil sump and the housing, surrounding the bolt holes.
3. Assemble the flywheel housing on the engine block and tighten the bolts

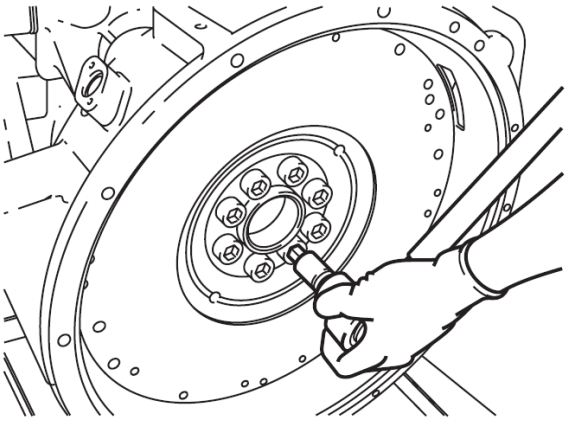
Torque: 100±15 Nm



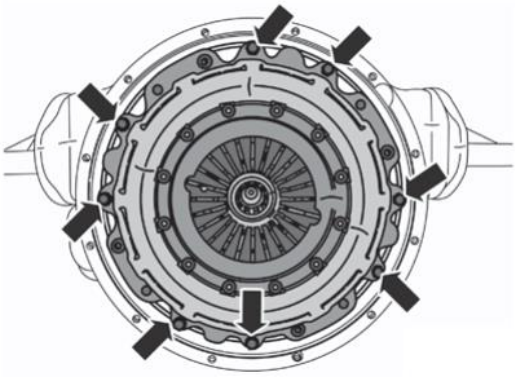
4. Install the rear seal with the special tool.
   Special Tool No. 6210AAB0002ST



5. With the fly wheel locked assemble the fly wheel. Tighten the crank shaft securing bolts.
   Torque: 1st: 100±10 Nm; 2nd: 275±15 Nm



6. Install the clutch cover and its holding bolts and tighten it according to the specification. (Refer to clutch section)
   Torque: 100±15 Nm

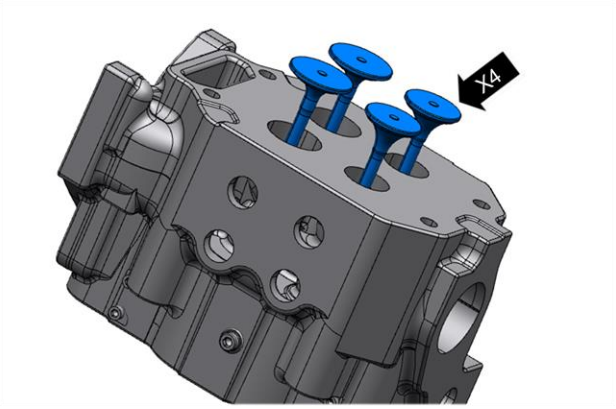


Engine Head

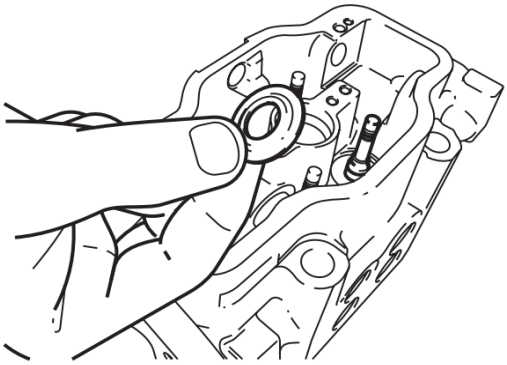
NOTE

Before you begin the cylinder head assembly; all the part must be well cleaned.

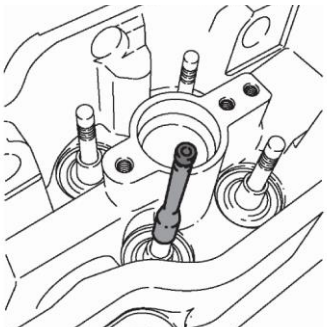
1. Position the cylinder head on the worktable.
2. Install the valve stem in the cylinder head assembly and do the same for remaining valves.



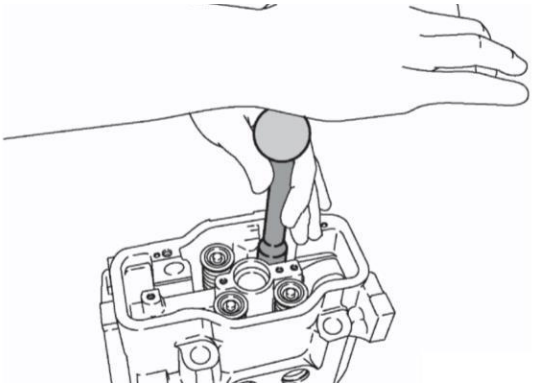
3. Install the lower spring's disc on to valve stem.



4. Slide the valve retainer on the valve stem.



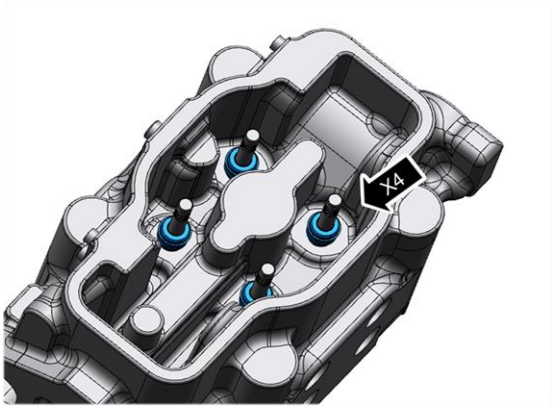
5. Using the special tool and its Spacer, install the valve retainer in its housing.
   Special Tool No. 6209BAB0001ST



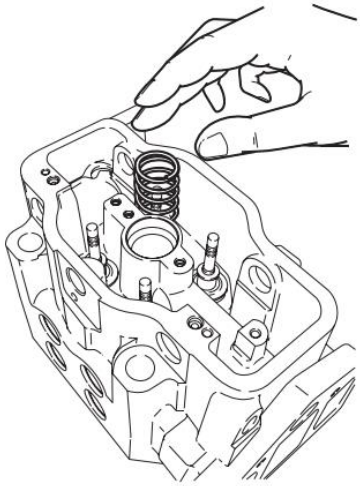
NOTE

To assure that the valve retainer is fully fitted onto the stem of cylinder head valve guide, use a rubber hammer and apply light blows over the special tool observing the spacer reaches such position.

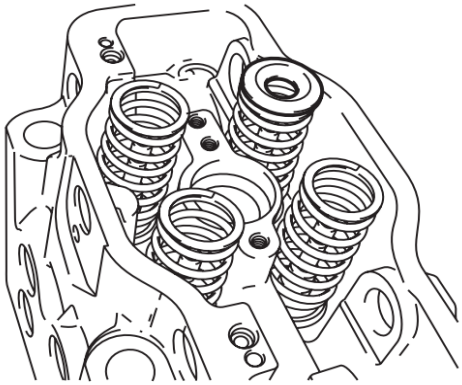
6. Install the valve stem seal, as shown in its position.



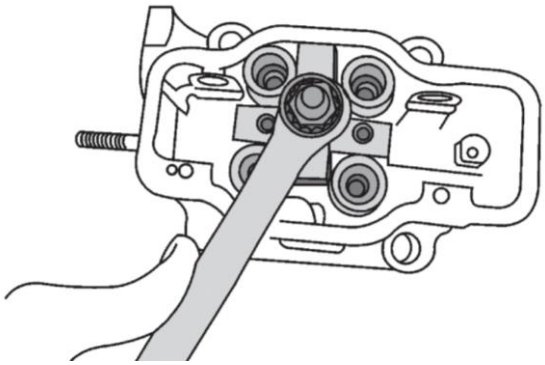
7. Install the valve springs, on to the valve stems.



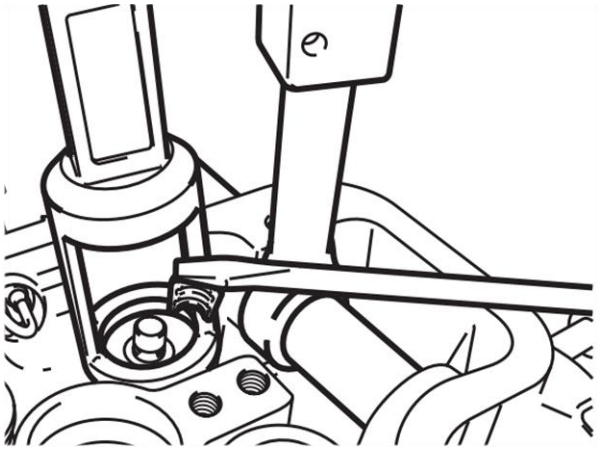
8. Install the valve spring upper disc.



9. Install the special tool on to the four-valve spring upper disc.

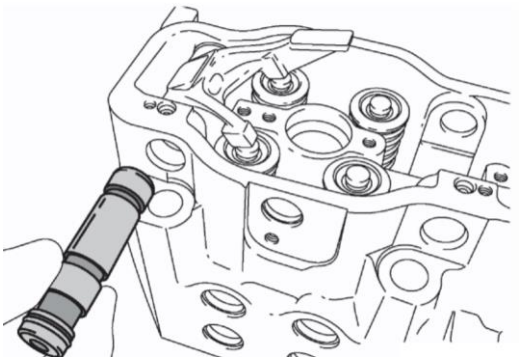


10. Using special tool **6209DAB0001ST**, Compress the valve springs and install the spring locks and install the valve stem cap.

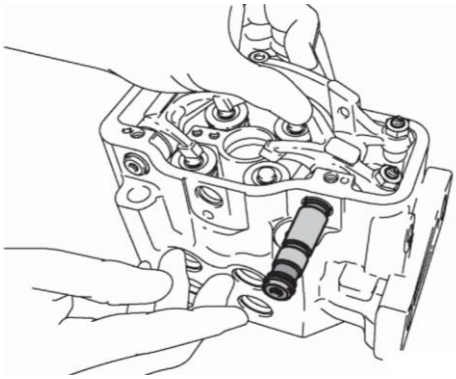


11. Install O-ring to the balancer shaft and make sure that it fits correctly, to avoid any damage.

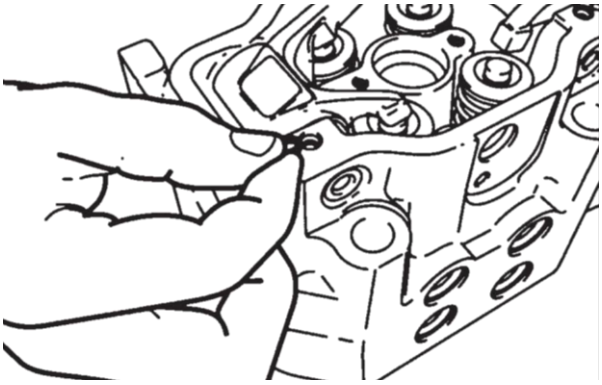
12. Mount the exhaust rocker arms and install the balancer shaft with O-ring pointing the outer side.



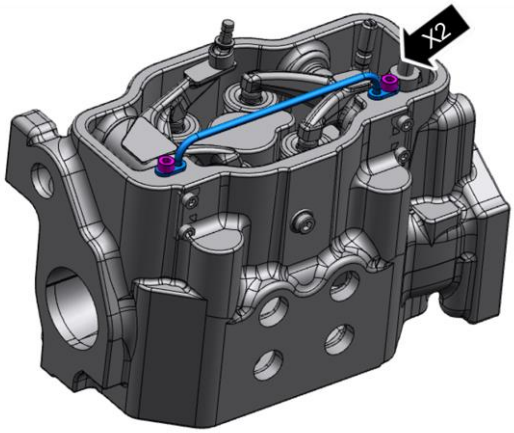
13. Install the balancer rocker arm shaft, with O-ring pointing to the outer side to fit the rocker arms in place.



14. Install the O-ring to the balancer shaft lubrication locker hole.



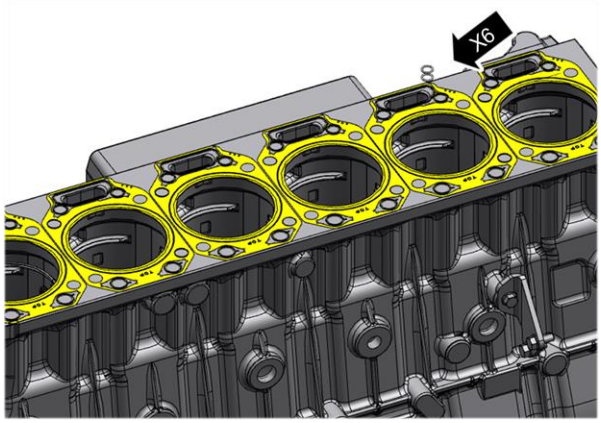
15. Install the balancer shaft lubrication pipe.
Torque 10±5 Nm



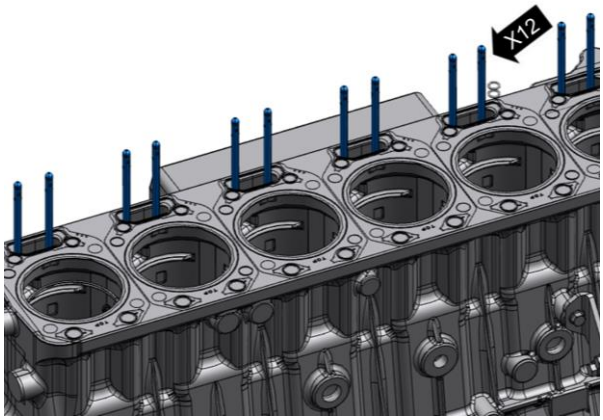
16. Install the guide bushing, two guides at either side of each cylinder.

NOTE
Make sure to install the head gaskets with "TOP" mark facing upwards.

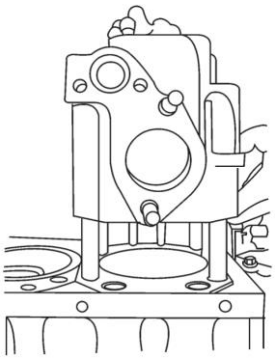
17. Install the gasket, as if it fits exactly to guide bushing.



18. Install the push rods.



19. Install the guide pin special tool to align the cylinder heads and the pushrods.
Special Tool No. 6202BAB0001ST



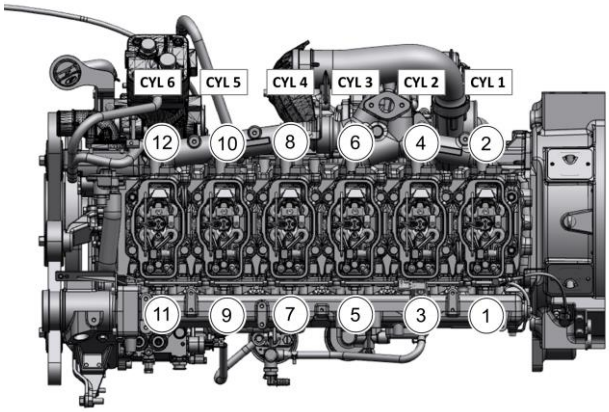
20. Install the cylinder head assembly, on to the engine block carefully.
    Torque – 1st - 40 ± 2 Nm, 2nd - 60 ± 10 Nm, 3rd - 60° ± 3°, 4th - 60° ± 3°, 5th - 90°± 3°

Valve Adjustment Procedure

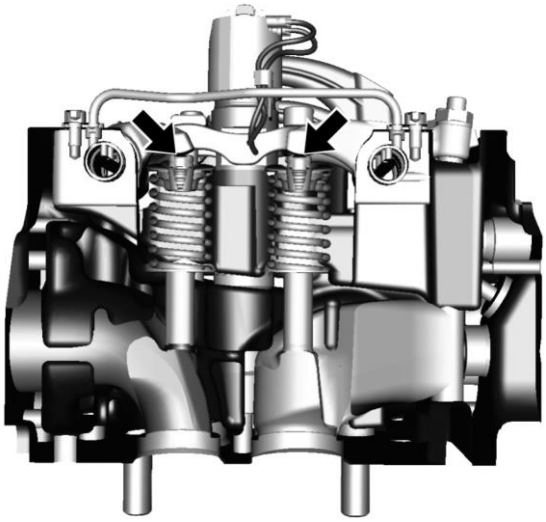
1. To adjust the valve clearance, follow the procedure given below.

NOTE

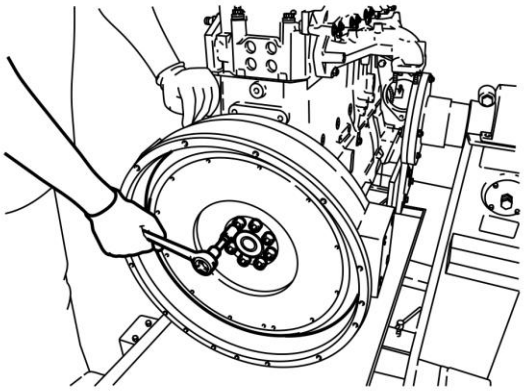
Cylinder no.1 is to be counted from flywheel housing side.



2. When the engine is cold, turn the crankshaft until the cylinder 6 intake and exhaust valve are closed ensuring that cam shaft is not acting on the rocker arm that will be adjusted.



3. Make sure the 6th cylinder is in compression TDC to ensure the valves are closed completely.



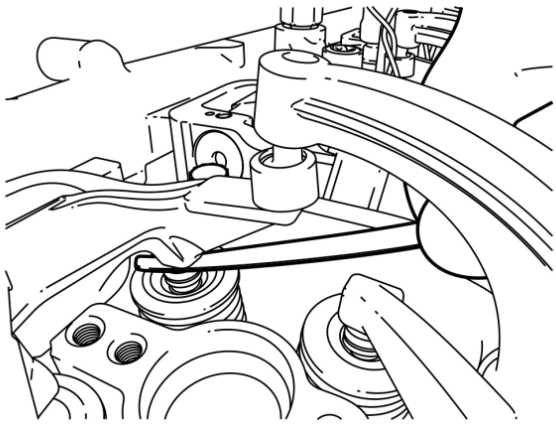
NOTE

The valves of the 6th cylinder will be closed and the rocker arms will be free. The rocker ams of the opposite cylinder i.e. Cylinder 1 will be tight signifying the exhaust stroke.

Procedure to check and set Valve Clearances

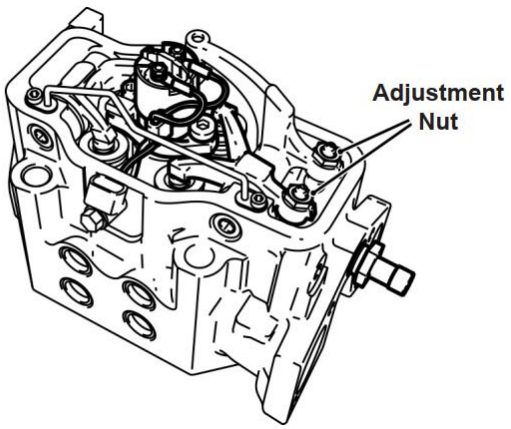
Valve Clearance: Inlet/Exhaust:

Range: 0.20 –0.40 mm

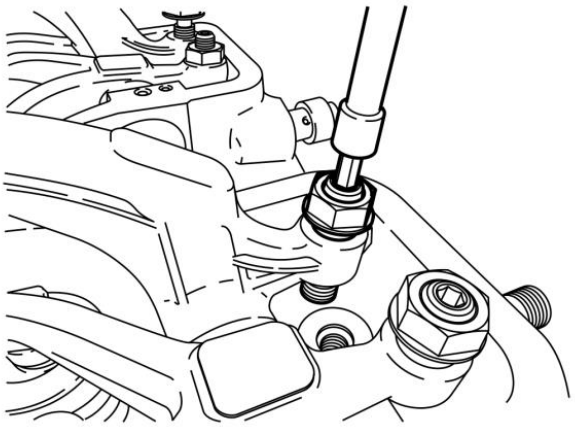


NOTE

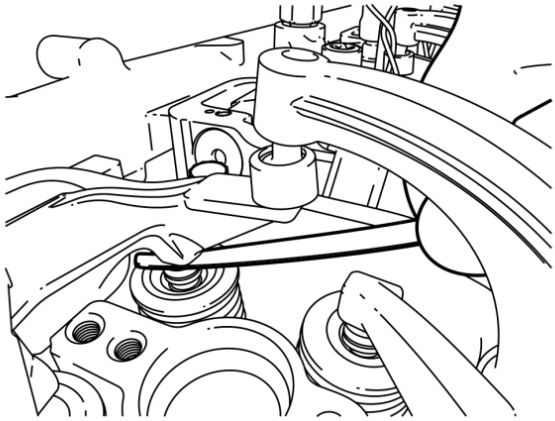
- *For checking the clearance: 0.20 mm & 0.40 mm feeler gauge to be used.*
- *For setting the clearance: 0.30 mm feeler gauge to be used.*



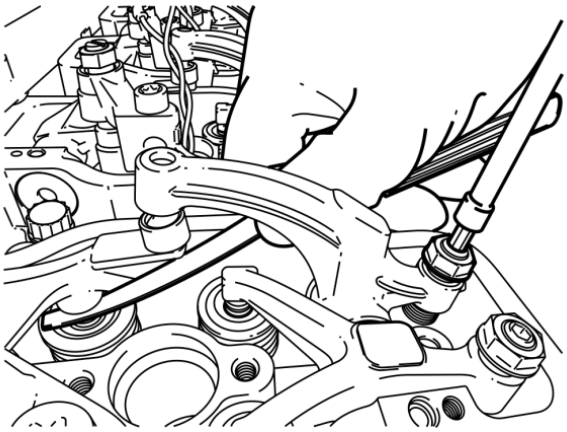
4. To adjust the valve clearance, loosen the clearance valve lock nut and adjusting bolt, located on rocker arm (intermediary rocker arm for exhaust valves), using a screwdriver and a ring spanner.



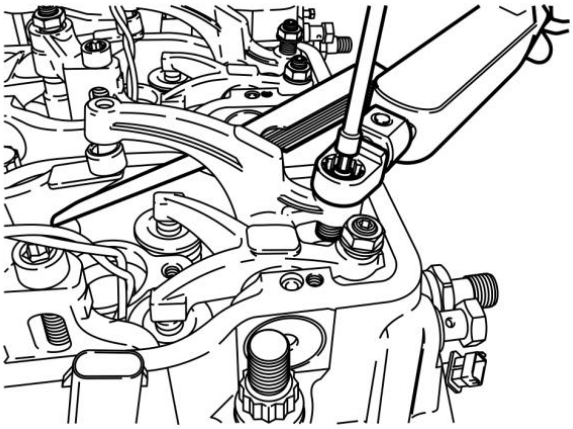
5. Loosen such that the adjusting bolt is free to rotate.
6. Insert the 0.3 mm filler gauge between the valve cap and the rocker arm, at the side without actuator.



7. Using a screwdriver, lean the valve clearance adjusting bolt on in the rocker arm, until the filler gauge slides with light attrition between the valve cap and the rocker arm.



8. Remove the adjusting filler gauge after applying a torque of **22 Nm** on the lock nut, ensuring the bolt does not turn or move from its position using a screwdriver.



9. Insert a 0.2 mm and a 0.4 mm adjusting filler gauge between the valve cap and the rocker arm.

NOTE

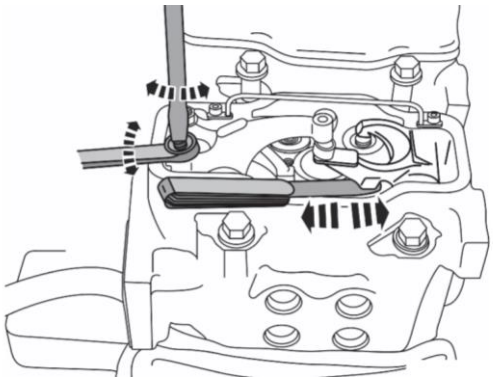
To verify that the clearance is between the limits, the 0.20 mm filler gauge should 'GO', and the 0.40 mm filler gauge should 'NOT GO' between the valve cap and the rocker arm.

10. If the clearance is not between 0.2 mm to 0.4 mm, follow the above procedure to adjust and check again if both the valve clearances are between 0.2 mm to 0.4 mm.
11. If still the valve clearances of both the valves are not set between the recommended value, replace the valve caps and again set the valve clearances.

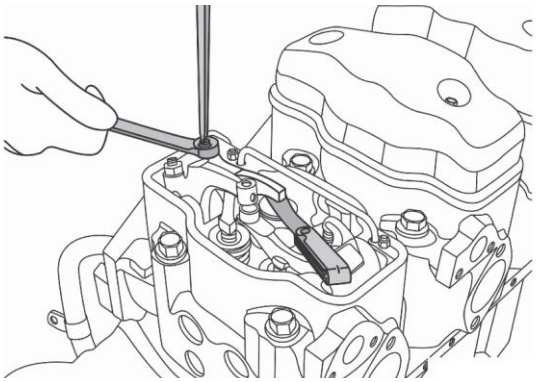
NOTE

- *Tighten the adjustment screw until there is no clearance between feeler gauge and both at contact front, (rocker arm and valve cap).*
- *It is necessary to insert the feeler with fingers for removing any scrub, compressing the analysis just in contact zone between the rocker arm and valve cap.*
- *If adjustment clearance of the second valve is larger than 0.4 mm, it is necessary to return to the first valve and to readjust it with a smaller clearance, using the feeler gauge of 0.2 mm instead of 0.3mm. then check the clearance of the second valve, it must be between 0.2mm and 0.4 mm. However, if the adjustment of the second valve will be less than 0.2mm, it's necessary to return to the first valve and to re-adjust with larger clearance, using the feeler gauge of 0.4mm instead of 0.3mm.*

12. After this operation, tighten with 20±6 Nm the adjustment nut.



13. Perform the same procedure for intake valve. The valve clearances must be between 0.2mm and 0.4mm.



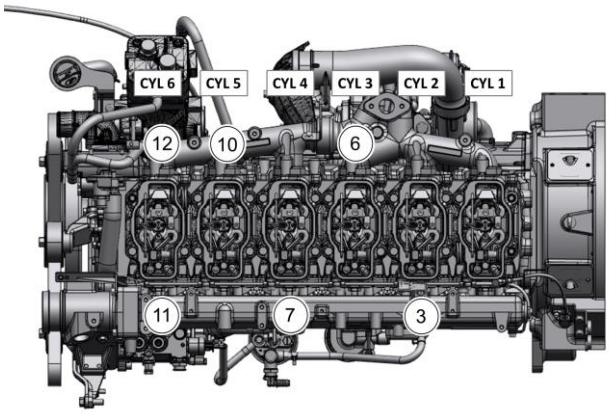
14. To finish, all these clearances must be in tolerance zone to 0.2mm to 0.4mm.

Sequence to set valve clearance for all cylinders when 6th Cylinder is at firing TDC

1. Perform the above procedure for individual valves of each cylinder valve of the engine as per the below sequence.

- Set cylinder no. 6 (damper side) at firing TDC.
- Set clearance in valve 3 of cylinder 2
- Set clearance in valve 6 of cylinder 3
- Set clearance in valve 7 of cylinder 4
- Set clearance in valve 10 of cylinder 5
- Set clearance in valve 11 of cylinder 6
- Set clearance in valve 12 of cylinder 6

Firing cylinder no 6

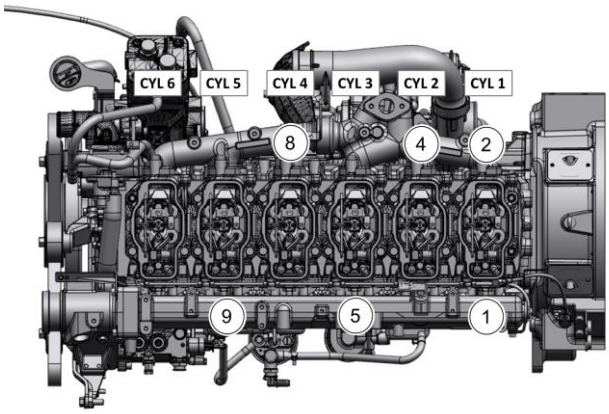


CYL 6		CYL 5		CYL 4		CYL 3		CYL 2		CYL 1	
IN.	EX.	IN.	EX.	IN.	Ex	IN.	EX	IN.	EX	IN.	EX
12	11	10	9	8	7	6	5	4	3	2	1

2. For setting remaining valve adjustment turn the fly wheel by 360 deg. (one full rotation) to set cylinder no 1 at firing.

- Take a reference of damper marking
- Set cylinder no.1 at firing and follow the steps:
- Set clearance in valve 1 of cylinder 1
- Set clearance in valve 2 of cylinder 1
- Set clearance in valve 4 of cylinder 2
- Set clearance in valve 5 of cylinder 3
- Set clearance in valve 8 of cylinder 4
- Set clearance in valve 9 of cylinder 5

FIRING: cylinder no 1



CYL 6		CYL 5		CYL 4		CYL 3		CYL 2		CYL 1	
IN.	EX.	IN.	EX.	IN.	Ex	IN.	EX	IN.	EX	IN.	EX
12	11	10	9	8	7	6	5	4	3	2	1

Fuel Injector Installation

1. Install new O-Ring and sealing washer to the injector and observe its correct position.

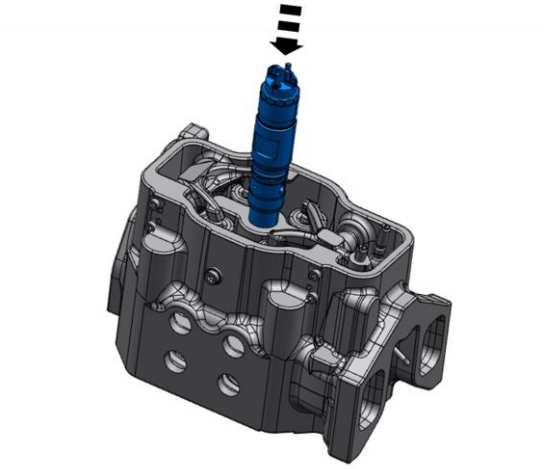
CAUTION

The injector and adaptor pair should not be interchanged as the factory clearances are set for a given pair of injectors with its adaptor.

CAUTION

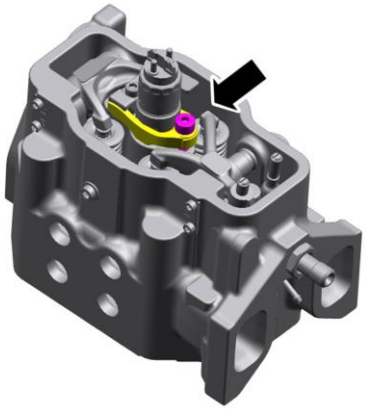
Failure to follow the below steps for installing the injectors may lead to improper combustion pressure and reduce efficiency of combustion or damage the engine components.

2. Install the fuel injector to the cylinder head.

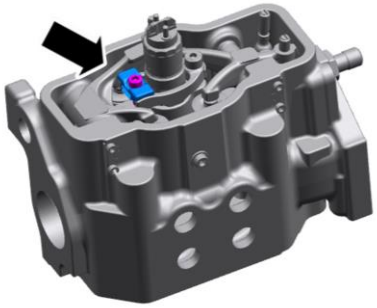


3. Manually mount the clip, bridge and the two bolts.

4. Apply a torque of **4 Nm**. to the special step bolt of the injection nozzle holder clip.

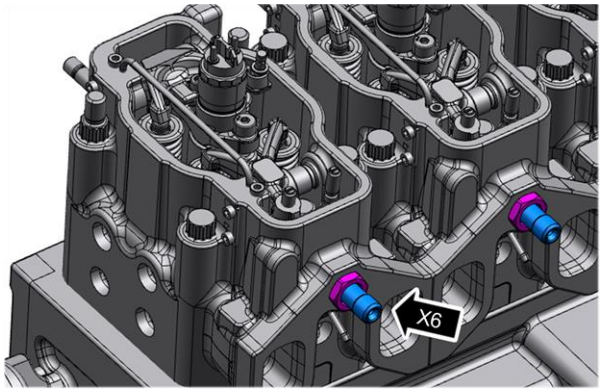


5. Apply **1 to 1.5 Nm** torque to the M6X30 bolt of the injection nozzle holder bridge.

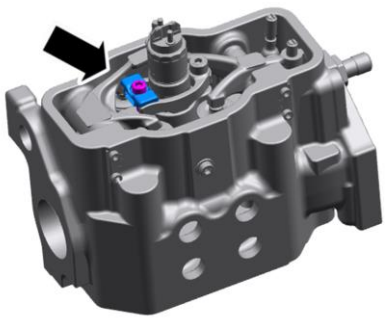


6. Relieve the torque for the M6X30 bolt of the injection nozzle holder clip bridge to 0 Nm.
7. Install the High-pressure connector on its correct position.

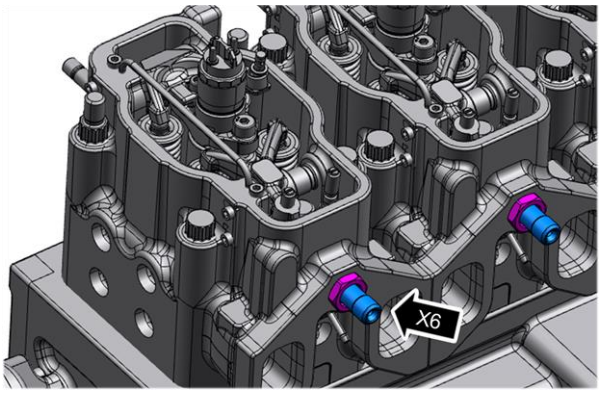
8. Mount the high-pressure connector and apply a torque of **10 to 20 Nm**.



9. Apply 4 Nm torque to the M6X30 bolt of the injection nozzle holder clip bridge



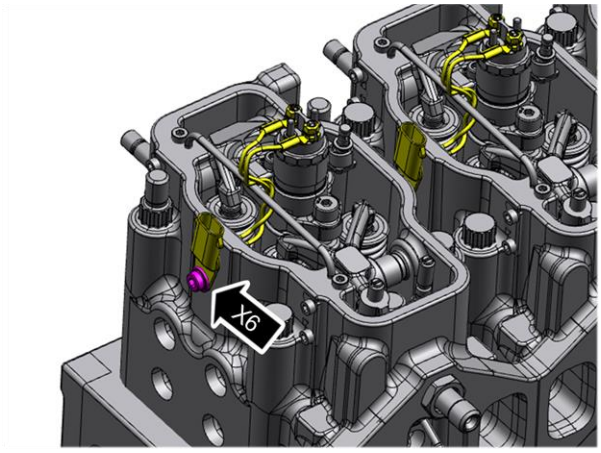
10. Apply three more 90° + 90° + 30° angular torque steps to the M6X30 bolt of the injection nozzle holder clip bridge (7 to 13 Nm torque window).
11. Apply a torque of **50 to 55 Nm** to the high-pressure connector.



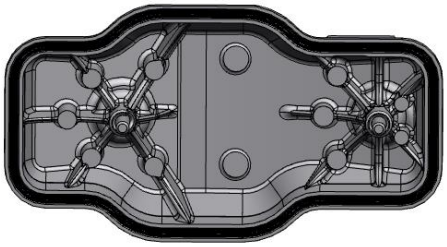
NOTE

This procedure is necessary to assure the correct seating and aligning from Injector and high-pressure connector.

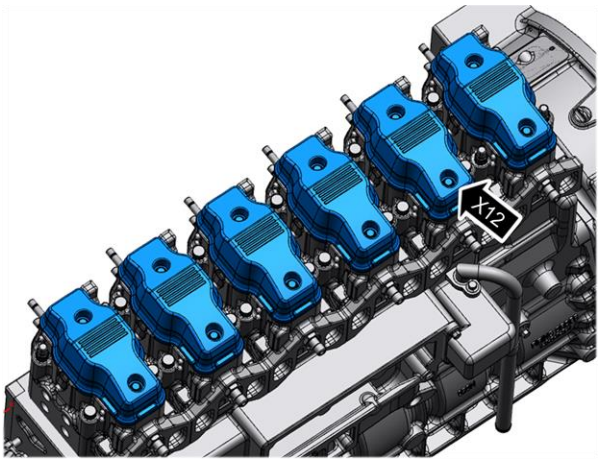
12. Using an M4 nut, connect the electrical wires from the cylinder head to the injector connectors. Apply the torque to the nut.
    Torque: 1.25 to 1.75 Nm



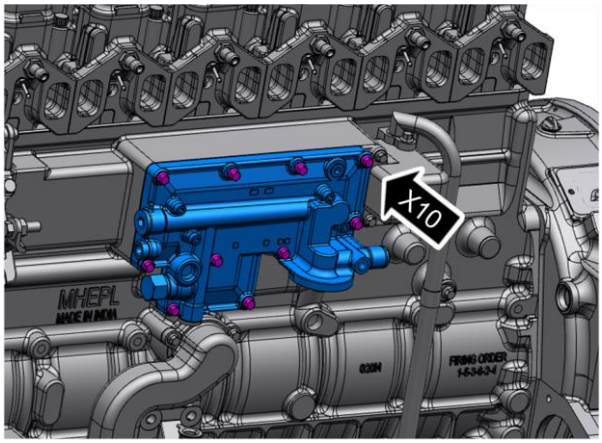
13. With a M6×12 bolt, tighten the external injection nozzle connector, applying the correct torque. **Torque: 7.5 to 9.5 Nm.**
14. Utilize a new valve cover gasket, ensure it is fitted correctly.



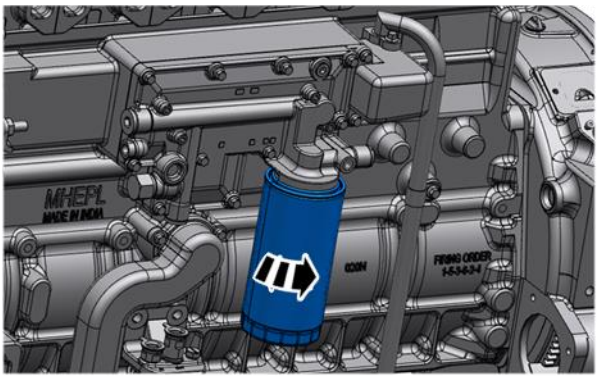
15. Using a M6×60 bolt, install the valve cover applying the correct torque.
    Torque: 7.5 to 9.5 Nm.



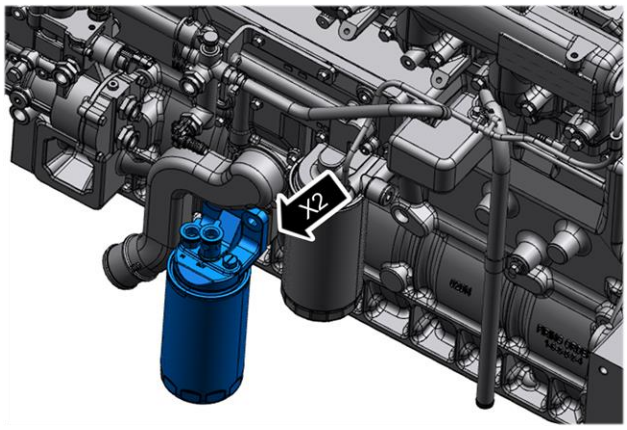
16. Install the oil cooler assembly on to the engine block.
    Torque:25±3 Nm



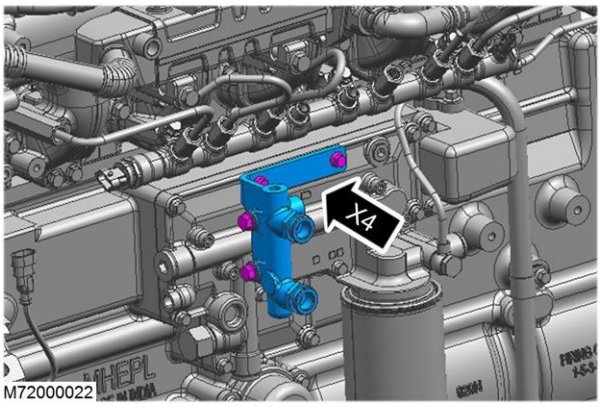
17. Fill the new oil filter with fresh recommended engine oil.
18. Install a new oil filter and rotate it in anti-clockwise direction.



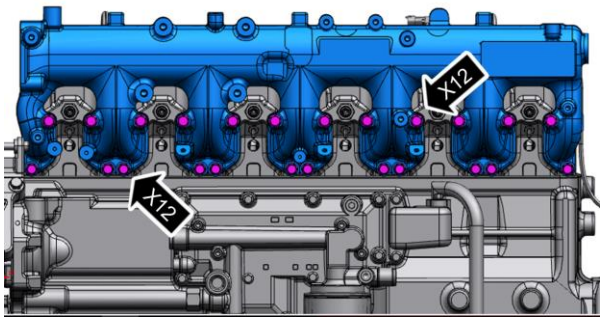
19. Install the secondary fuel filter and tighten the mounting bolts.
    Torque:25±3 Nm



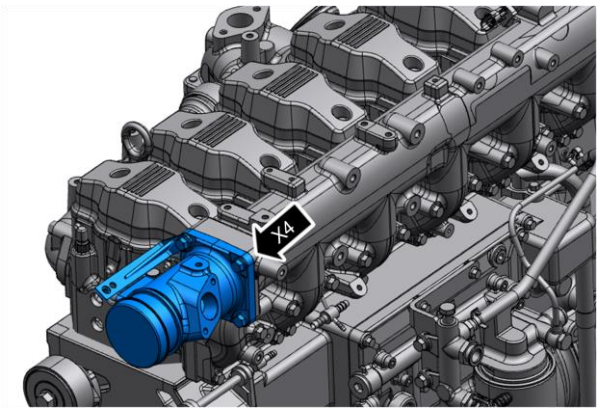
20. Install the fuel return manifold.



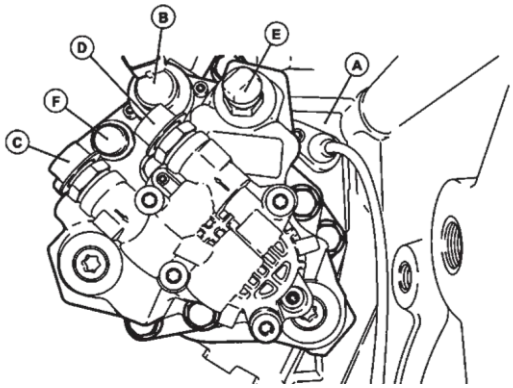
21. Install the Engine head oil return line.
22. Install the Injector return line.
23. Install the intake manifold.
    Torque: 20 ± 3 Nm (apply crossed torque from center to the outside).



24. Install the air intake curve.
    Torque:20±3 Nm

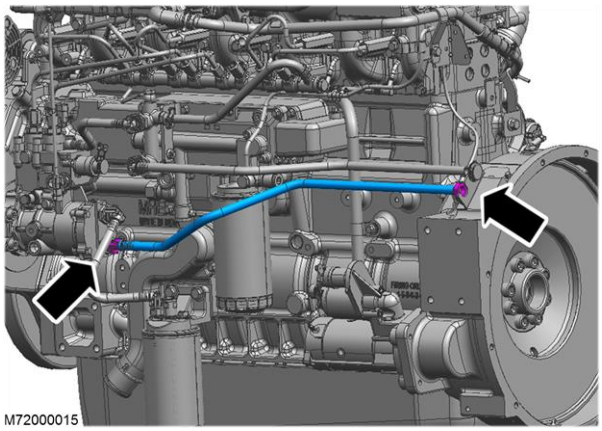


25. Install the High-pressure pump as per the sequence below.

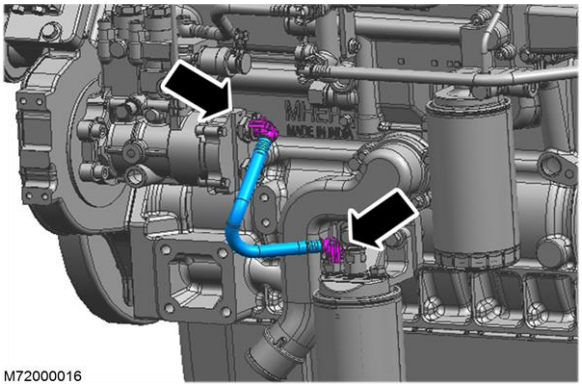


A. Camshaft position sensor (CMP)
B. Rail pressure control valve (M-PROMPT)
C. Fuel inlet from the tank to High Pressure pump
D. Fuel outlet from High pressure pump to filter
E. Fuel outlet to the rail (High Pressure)
F. Fuel inlet (from filter)

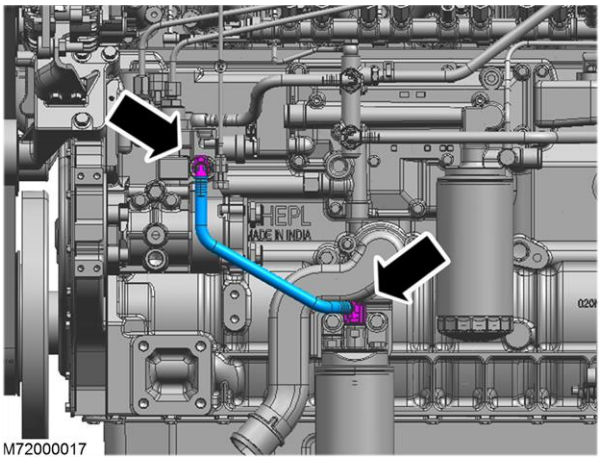
26. Connect electrical wiring harness connector to camshaft position sensor, inlet metering valve and rail pressure sensor.
27. Install fuel supply line to High pressure pump.



28. Install the fuel supply line connecting the high-pressure pump outlet to the inlet fuel filter head inlet.

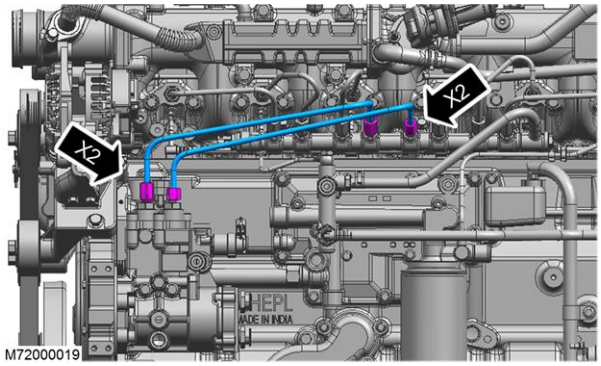


29. Install the fuel supply line connecting the pressure side fuel filter head outlet to the fuel pump inlet.



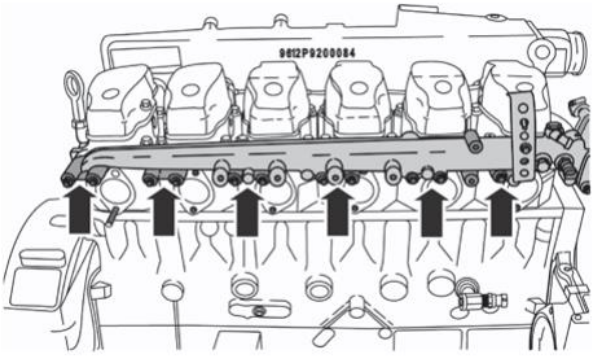
30. Connect the high-pressure common rail supply pipe from the fuel pump to the common rail.

Torque:34±3 Nm



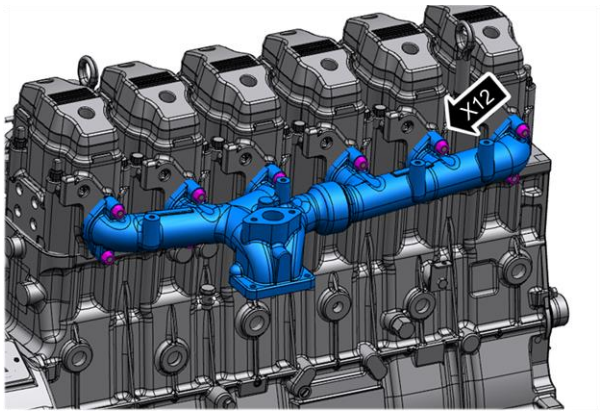
31. Install the engine coolant manifold and tighten.

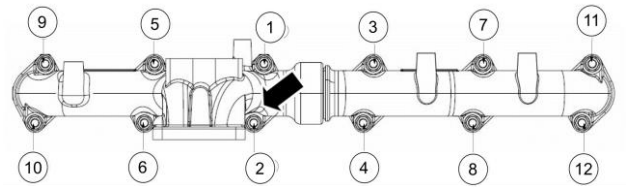
Torque: 25±4 Nm



32. Install the exhaust manifold assembly and tighten it as per the sequence below.

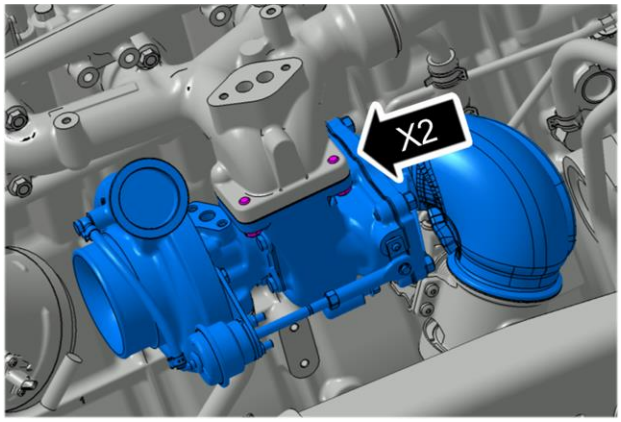
Torque: stud 6±2 Nm, Stover nut: 70 ±10 Nm





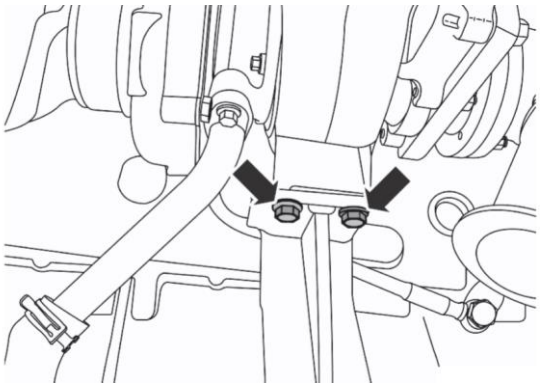
33. Install the turbocharger to the exhaust manifold and tighten its mounting nut to stud.

Torque: 60 ±2 Nm

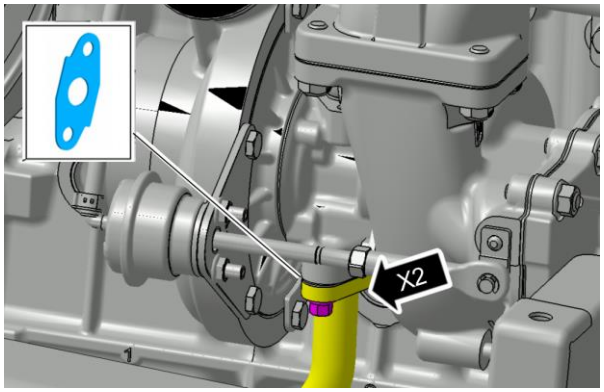


34. Position the turbo charger to its mounting bracket and tighten its bolts.

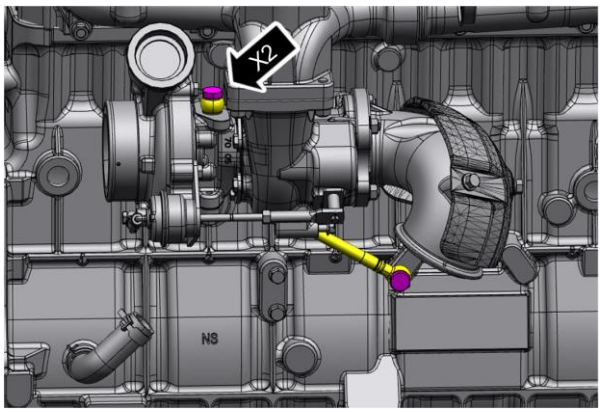
Torque: 27 ± 3 Nm



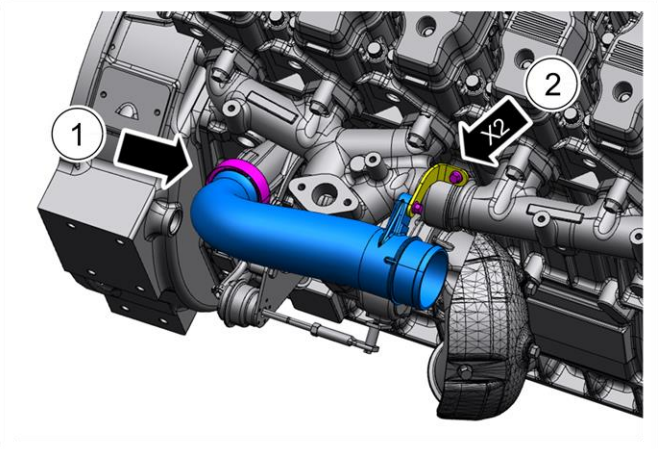
35. Install a new gasket and install the turbocharger oil return pipe from the turbocharger to the engine block.



36. Install the turbocharger oil supply pipe.
    Torque: 37 ± 3 Nm

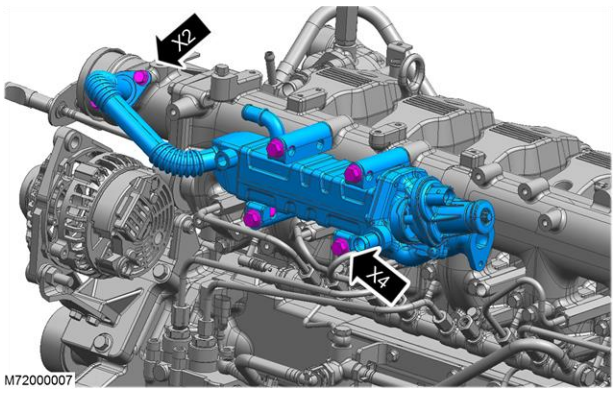


37. Install the turbocharger compressor outlet elbow.
    1. Tighten the V-band clamp.
    2. Install the compressor outlet elbow with new O-ring. Install and tighten the compressor outlet pipe mounting bracket bolts.

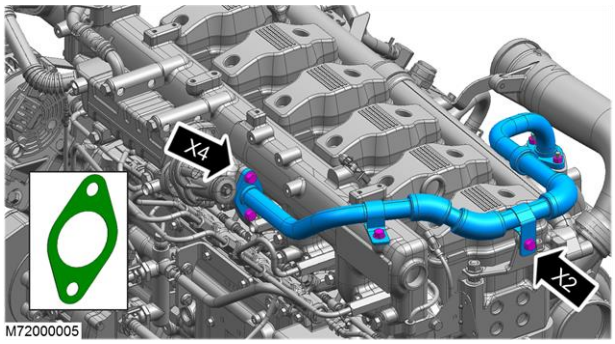


EGR System

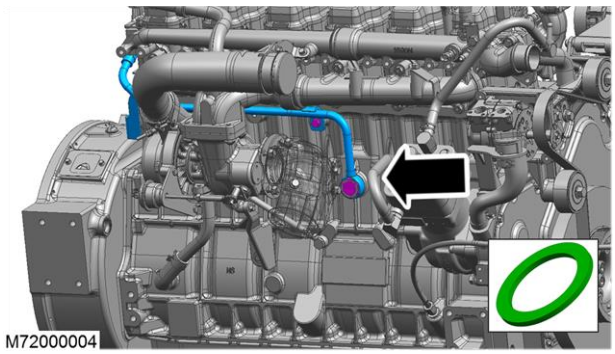
1. Install the EGR valve assembly.
   Torque: 50 ± 5 Nm



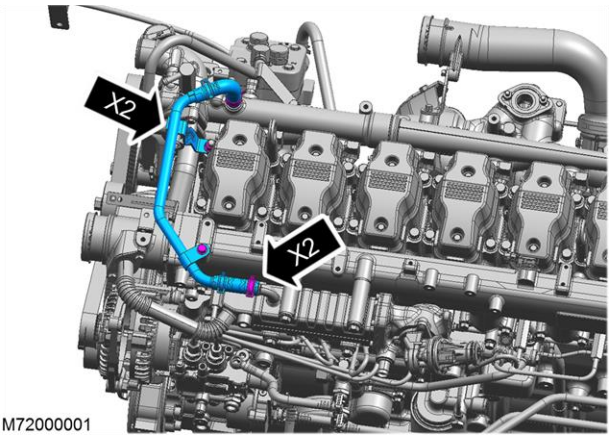
2. Install the EGR hot end pipe.



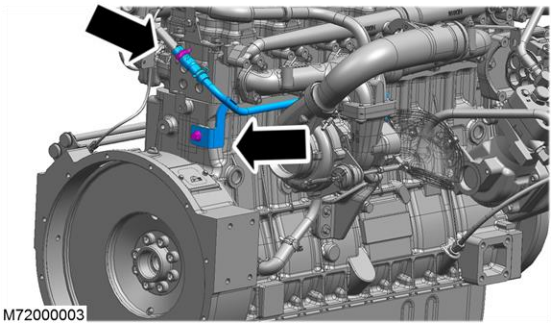
3. Install the engine block to EGR coolant supply pipe.
   Torque: 45 ± 3 Nm



4. Install the EGR cooler outlet hose.

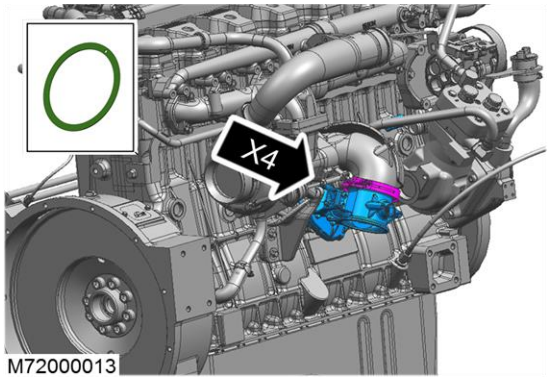


5. Install the EGR coolant inlet hose pipe mounting bolts.

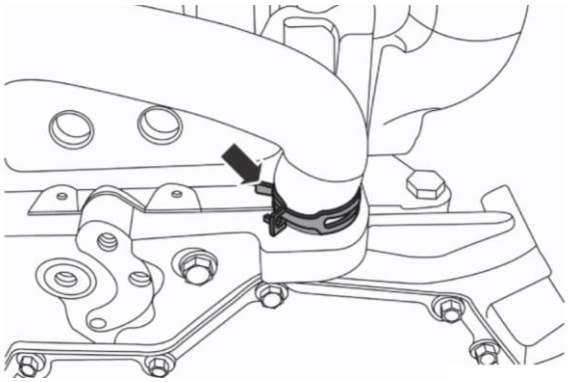


Exhaust Throttle Valve

6. Install the Exhaust throttle valve and tighten the exhaust throttle valve mounting clamp.

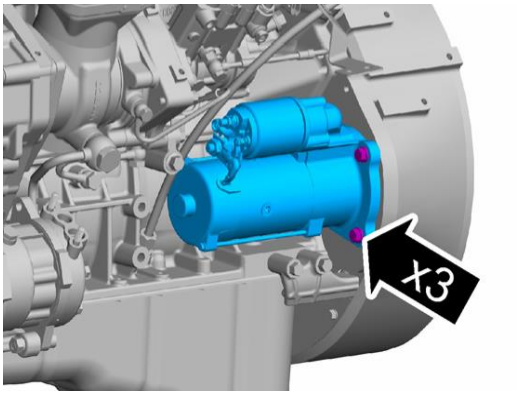


7. Connect the Exhaust Throttle Valve electrical connector.
8. Install the hose pipe connecting water pump assembly and lock the clamp firmly.



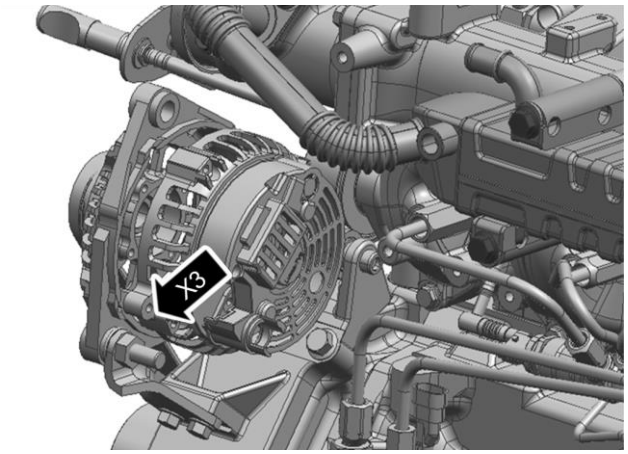
9. Install the starter motor and its holding bolts, tighten it firmly.

Torque: 40±6 Nm

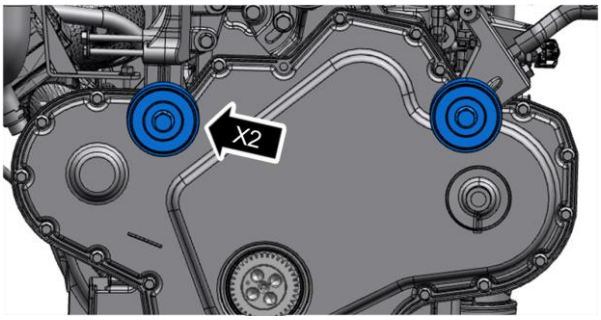


10. Install the alternator on the engine assembly and tighten it firmly

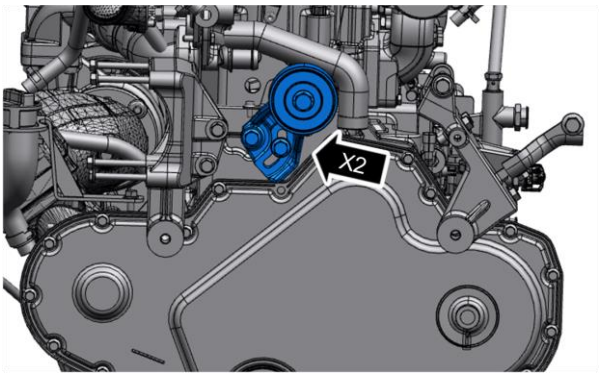
Torque: 40±6 Nm



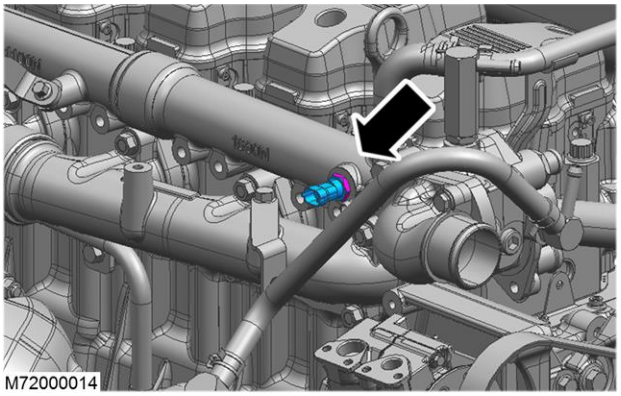
11. Install the idler pulley along with its holding bolts and tighten the mounting bolts.



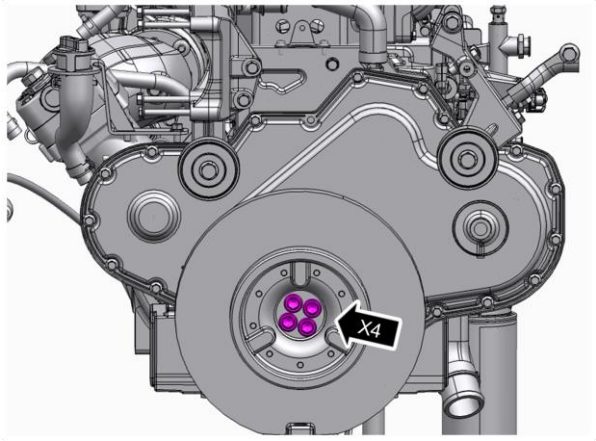
12. Install the tensioner pulley with its holding bolt and tighten the mounting bolts.



13. Install the engine coolant temperature sensor to the coolant manifold.



14. Install the damper pulley.



15. Install the electro-viscous fan and tighten it.
    Torque: 35±1 Nm
16. Install the drive belt.