Contents

Chapter 1 General Information of Engine

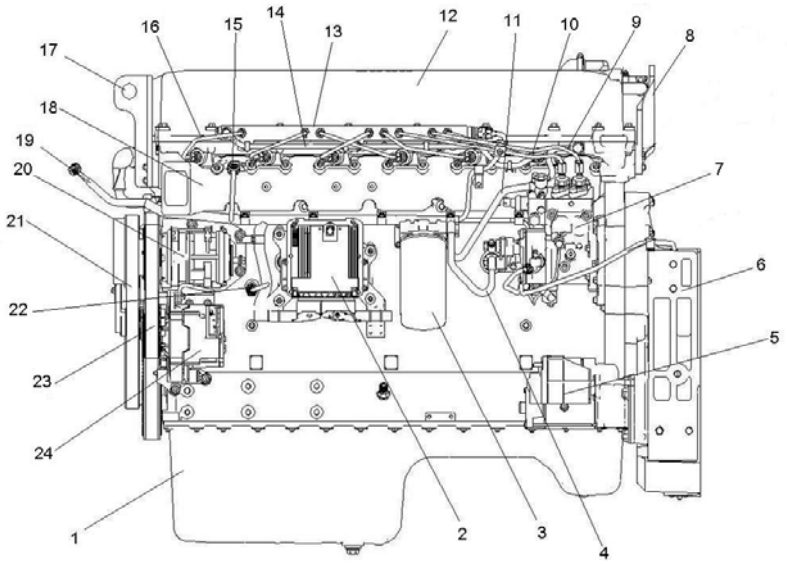
1.1 Main Performance Data

Displacement	11.8L
Arrangement	In-line 6-cylinder
Fuel injection system (injection pressure)	Common rail (1600 bar)
Supercharging system	Single stage supercharger, air bleeder
Emission standard	Euro Ⅳ
Bore [mm]	128
Piston stroke [mm]	153
Single cylinder volume [L]	1.97
Swept volume [L]	11.81
Bore spacing [mm]	162
Explosion pressure [bar]	190
Rated power [kW] @ speed [rpm]	353@1900
Max. torque [Nm] @ speed [rpm]	2250@1100-1450
Regulated speed [rpm]	2000
Max. continuous overspeed rate [rpm]	2560
Max. instantaneous overspeed rate [rpm]	2850
Cylinder liner type	Wet/Overhead
Crankshaft	Forged counterweight
Piston	Aluminium alloy
Valve mechanism	SOHC, 4-valve
Gear drive mechanism	End, cylindrical spur gear
Cooling system	Cylinder head “top down” cooling system
Main purpose	Truck

1.2 Outline drawing of diesel engine

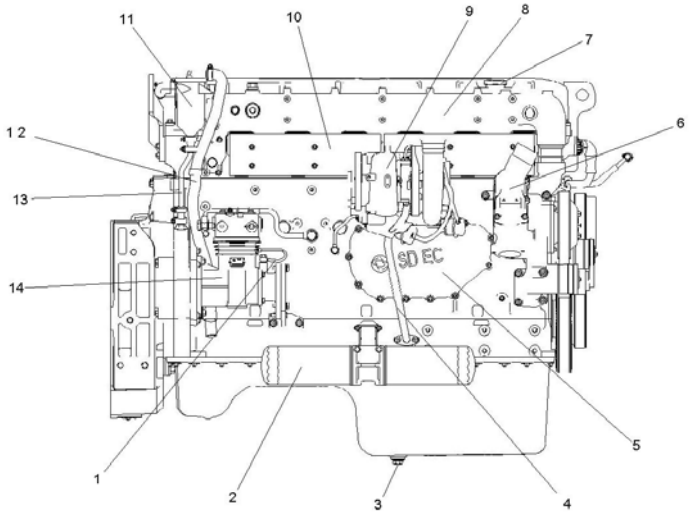
1.2.1 Outline drawing of 10L diesel engine

Left view



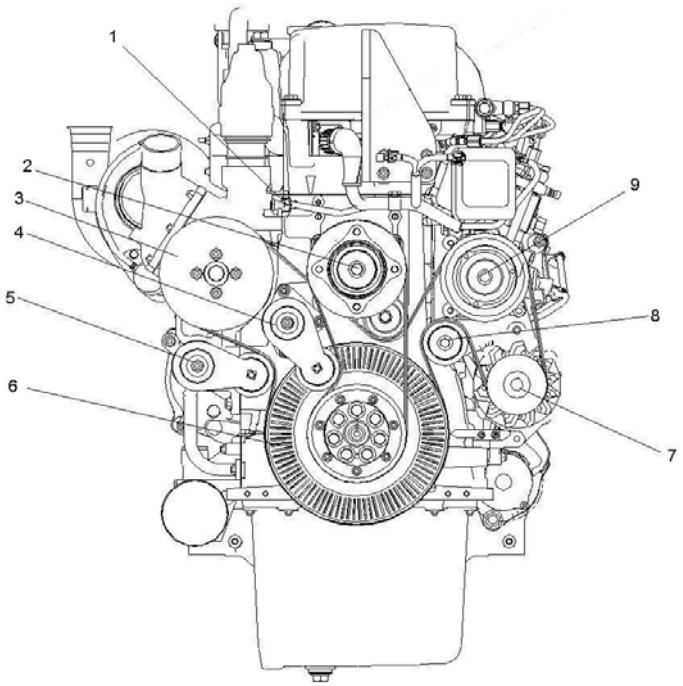
1. Oil pan 2. ECU 3. Fuel filter 4. Fuel filter inlet pipe 5. Starting motor 6. Flywheel housing 7. Fuel pump 8. Rear lifting eye 9. Fuel pump outlet pipe 10. Fuel pump outlet pipe 11. Fuel filter outlet pipe 12. Cylinder head cover 13. High-pressure fuel common rail 14. High-pressure common rail fuel return pipe 15. Intake temperature and pressure sensor 16. High-pressure fuel pipe 17. Front lifting eye 18. Intake pipe 19. Harness 20. A/C compressor 21. Fan belt 22. Oil pressure sensor 23. Alternator belt 24. Alternator

Right view



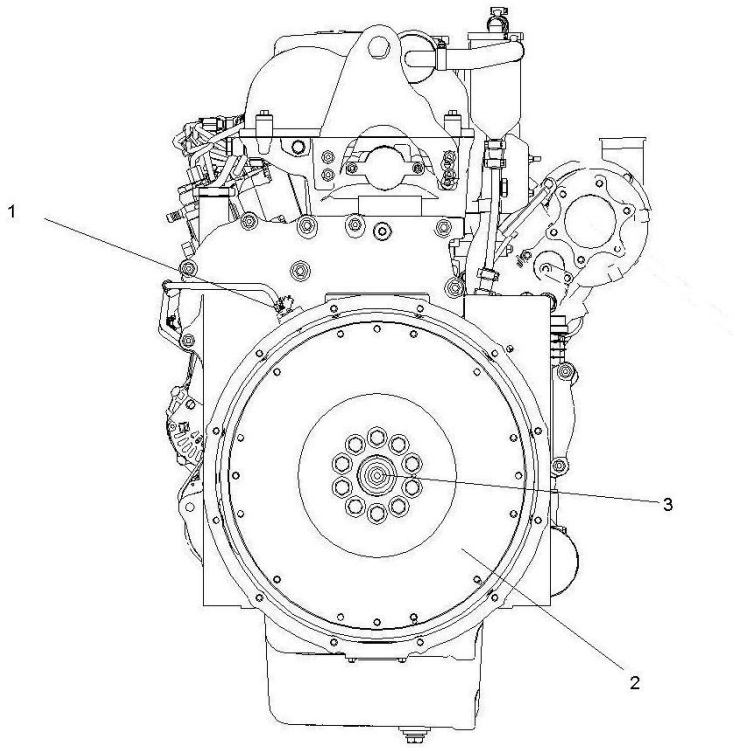
1. Air compressor pump oil inlet pipe 2. Oil filter 3. Oil pan drain plug 4. Supercharger oil return pipe 5. Oil cooler 6. Water pump assembly 7. Filler cap 8. Water inlet manifold 9. Turbocharger 10. Exhaust pipe and heat shield 11. Oil-gas separator 12. Oil-gas separator gas outlet pipe 13. Oil-gas separator oil return pipe 14. Air compressor

Front view



1. Water temperature sensor 2. Fan belt pulley 3. Water pump belt pulley 4. Fan belt tensioner (external) 5. Alternator belt tensioner (internal) 6. Vibration damper 7. Alternator 8. Idler component 9. A/C compressor belt pulley

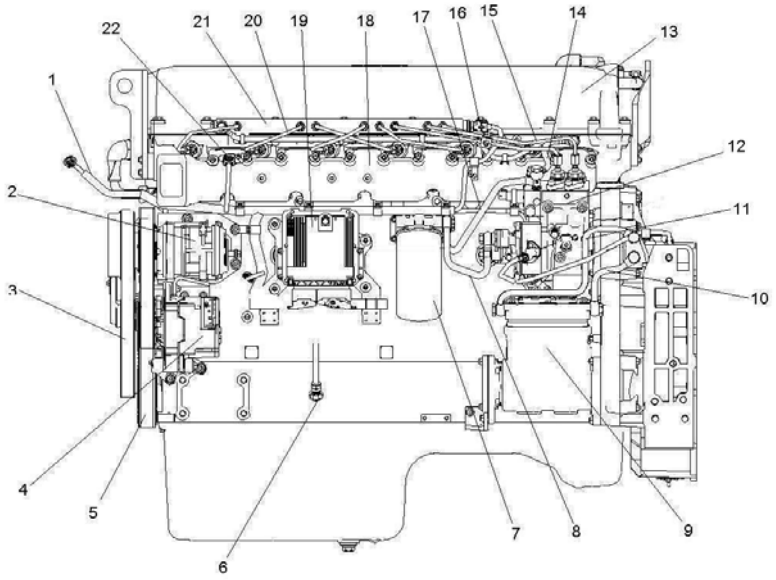
Rear view



1. Speed sensor 2. Flywheel 3. Bearing

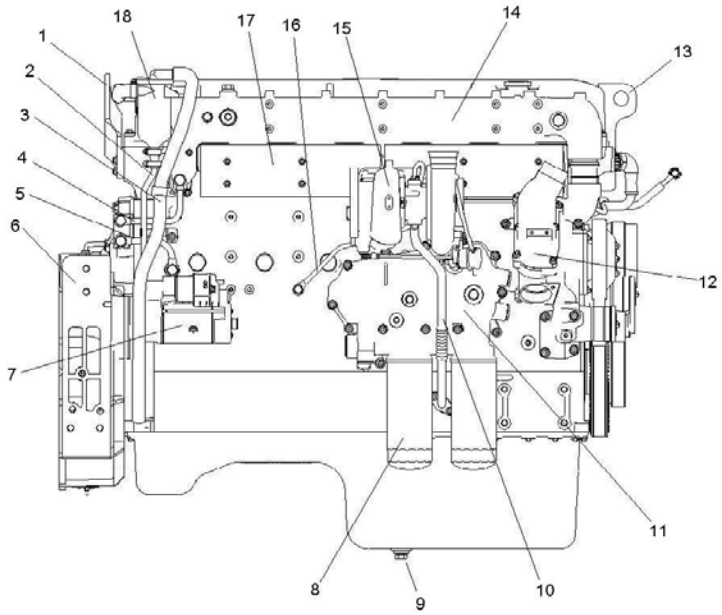
1.2.2 Outline drawing of 12L diesel engine

Left view



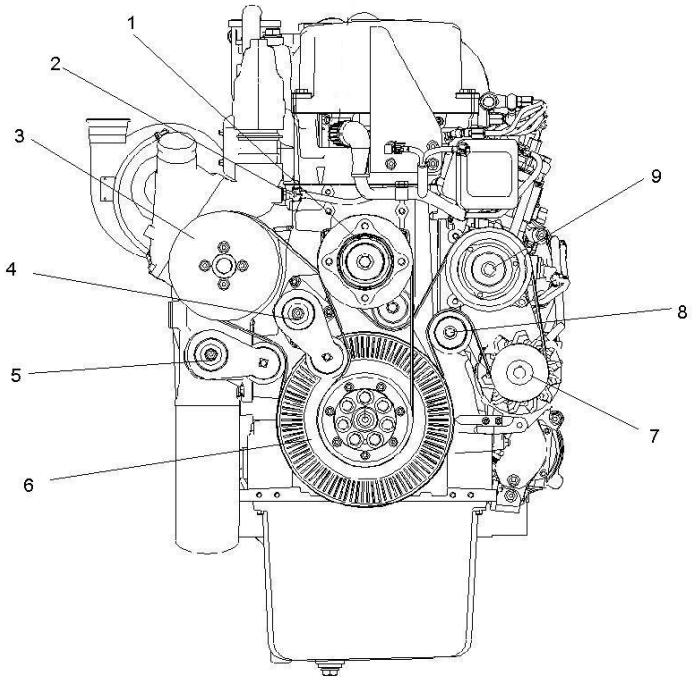
1. Harness 2. A/C compressor 3. Fan belt (external) 4. Alternator 5. Alternator belt (internal) 6. Oil dipstick 7. Fuel filter 8. Fuel filter inlet pipe 9. Air compressor 10. Air compressor pump water outlet pipe ① 11. Air compressor pump water inlet pipe ② 12. Fuel pump 13.Cylinder head cover 14. Injector fuel return pipe component 15. Fuel pump outlet pipe (2 pcs) 16. Common rail pressure sensor 17. Fuel filter outlet pipe 18. Intake pipe 19. ECU 20. High pressure fuel pipe (6 pcs) 21.High pressure fuel common rail 22. Intake temperature and pressure sensor

Right view



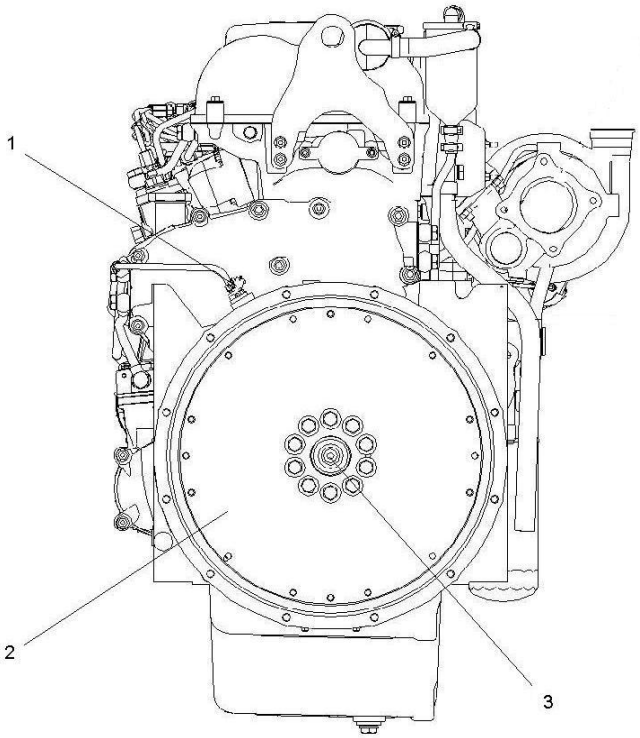
1. Rear lifting eye 2. Oil-gas separator oil return pipe 3. Oil-gas separator gas outlet pipe 4. Air compressor pump water inlet pipe ① 5. Air compressor pump water outlet pipe ② 6. Flywheel housing 7. Starting motor 8. Oil filter (2 pcs) 9. Oil pan drain plug 10. Supercharger oil return pipe 11.Oil cooler 12. Water pump component 13. Front lifting eye 14. Water inlet manifold 15. Supercharger 16. Supercharger oil inlet pipe 17. Exhaust pipe and heat shield 18. Oil-gas separator

Front view



1. Fan belt pulley 2. Water temperature sensor 3. Water pump belt pulley 4. Fan belt tensioner (external) 5. Alternator belt tensioner (internal) 6. Vibration damper 7. Alternator 8. Idler component 9. A/C compressor belt pulley

Rear view

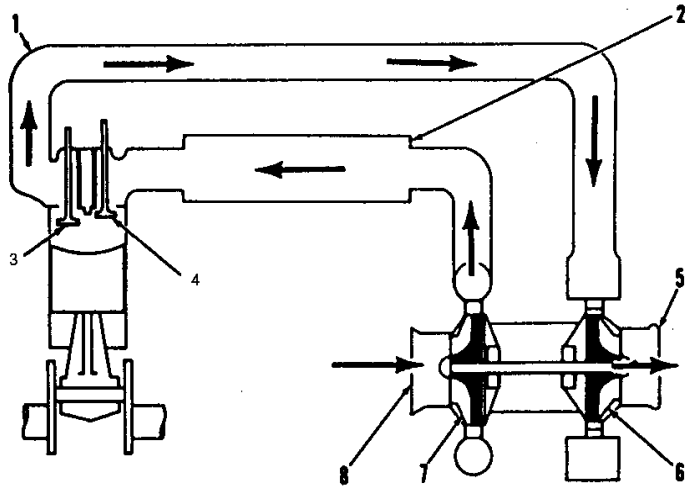


1. Speed sensor 2. Flywheel 3. Bearing

Chapter 2 Brief Introduction to Main Systems of Diesel Engine

2.1 Intake and exhaust system

The structure and work flow of the intake and exhaust system is shown below. The intake and exhaust system mainly consists of air filter, intake compressor (turbocharger), intercooler, intake pipe, cylinder head, intake valve, combustion chamber, exhaust valve, exhaust pipe, exhaust turbine (turbocharger), muffler, etc.



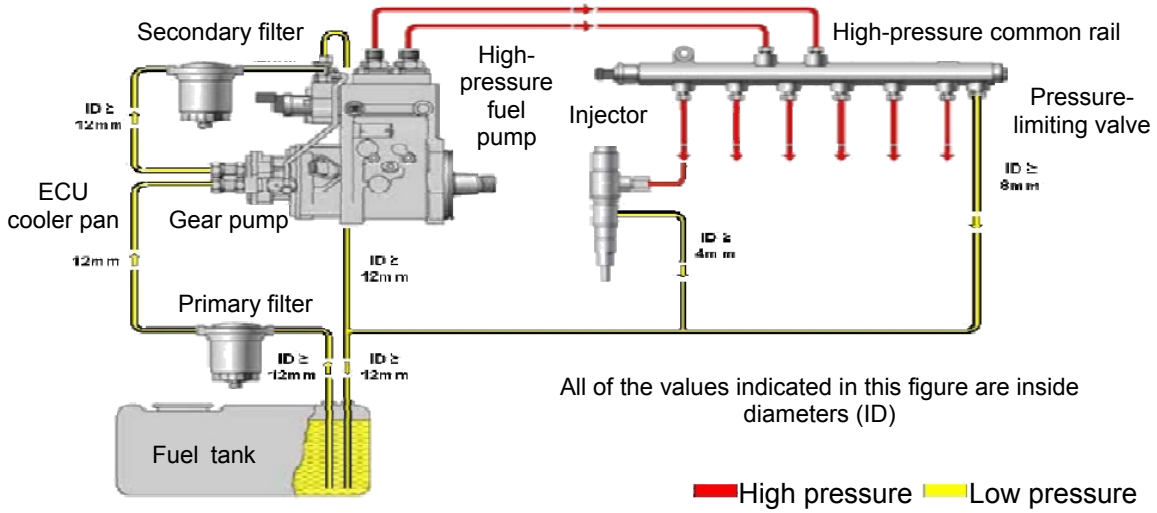
1. Exhaust pipe 2. Intercooler & intake pipe 3. Exhaust valve 4. Intake valve 5. Exhaust gas outlet 6. Exhaust turbine (turbocharger) 7. Intake air compressor (turbocharger) 8. Air inlet through filter

Fig. 2-1 Engine Intake and Exhaust System

The following is a brief description of the operating principle: Starting from the air filter, the intake air enters the compressor (turbocharger) through the compressor inlet. The compressed air is cooled by the intercooler, and then enters the combustion chamber through the intake pipe. In the combustion chamber, the air is mixed with the injected fuel and the mixture burns, pushing the piston to work. The exhaust gas from the combustion chamber enters the exhaust turbine (turbocharger) through the exhaust pipe, and rotates the turbine shaft. Afterwards, the exhaust gas flows out from the muffler. The rotating turbine shaft offers the compression power to the turbocharger.

2.2 Fuel system

The fuel system mainly consists of high pressure pump, common-rail pipe, injector, ECU, and sensor (including NE sensor, G sensor, intake pressure and temperature sensor, oil pressure sensor, water temperature sensor and so on). The sketch is as follows:



The following is a brief description of the operating principle: When the engine is working, the fuel in the fuel tank is pumped through the primary filter, then filtered by the secondary filter and stored in the high-pressure chamber of fuel pump. Afterwards, the fuel is pressed by the fuel pump to the high-pressure common rail, which delivers high-pressure fuel to the injector. From the injector, the fuel is injected into the combustion chamber and provides energy for engine operation. The fuel pump, high-pressure common rail and injector are all equipped with pressure limiting valves. When the fuel pressure exceeds the set value, the fuel overflows from the pressure limiting valve to the fuel tank.

Note: The fuel filter must be renewed according to the stipulated period; otherwise, the power of diesel engine may be decreased and even serious faults of injection pump and injector may be caused.

2.3 Lubrication system

The lubrication system mainly consists of oil pan, oil pump, pressure-reducing valve, oil cooler, oil filter, all oil pipes, oil paths on engine block and cylinder head, and all working parts of engine. See the sketch below:

10L Lubrication System Sketch

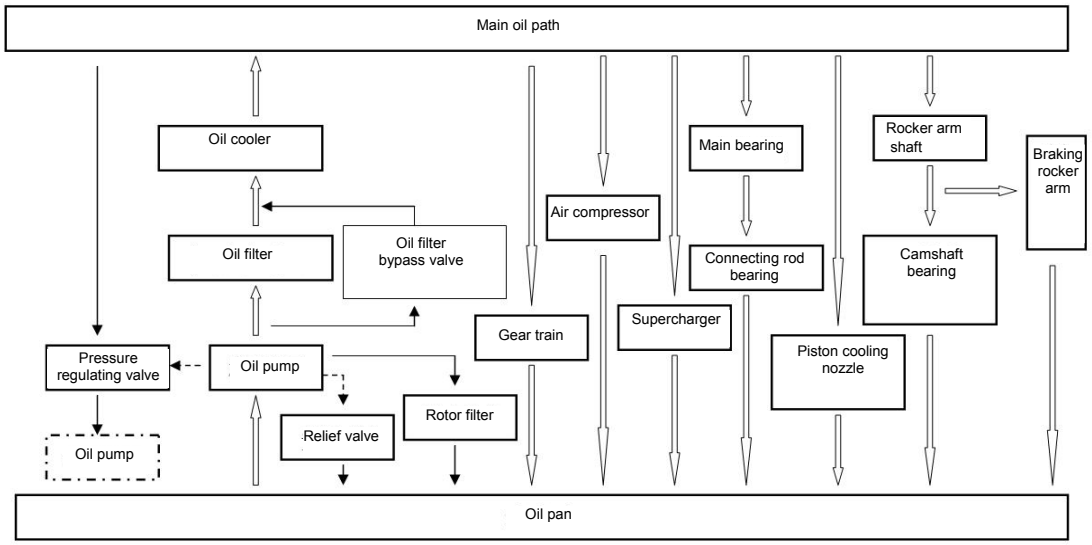


Fig. 2-3 Lubrication System (warm-up state)

The following is a brief description of the operating principle: When the engine is working, the oil pump pumps oil from the oil pan. Oil enters the main oil path through the oil cooler and other two parallel oil filters, and then the main oil path can provide lubrication oil for each working part. The oil pump, oil cooler and oil filters are all equipped with pressure limiting valves. In case the pressure is too high, for example during cold start or when the fuel filter is blocked; the corresponding bypass valve will open for relief.

2.4 Cooling system

The cooling system consists of expansion tank, water pump component (including thermostat), water filter, oil cooler, water paths on engine block and cylinder head, main water return pipe, radiator and all connecting pipes. See the sketch below:

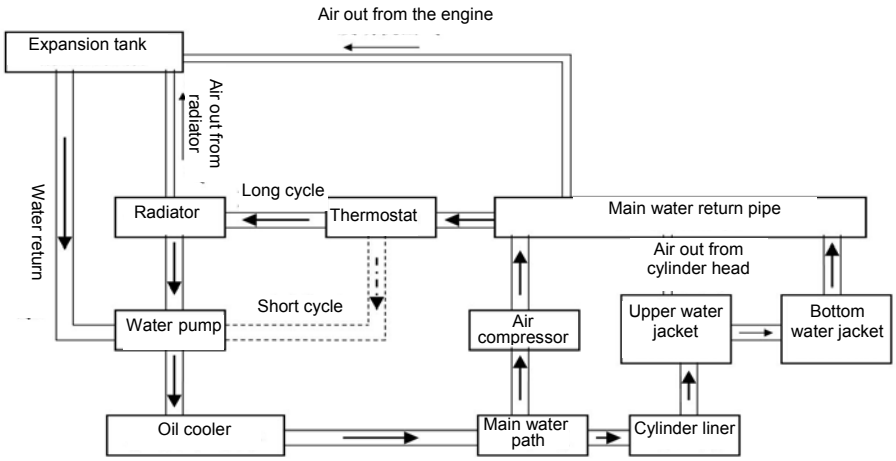


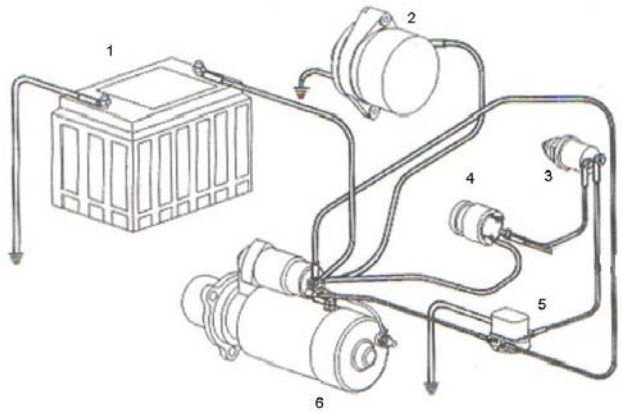
Fig. 3-4 Engine Cooling System

The main function of cooling system is to take away the heat produced by the diesel engine, oil and related parts. The residual heat that is not taken away by the cooling system is taken away by exhaust gas or discharged to the air.

The operation principle is as follows: After pumped by the water pump, the engine coolant enters the water cavity of oil cooler to cool the oil, and then enters the water jackets of engine block and cylinder head in order. After cooling the engine, the coolant enters the main water return pipe, and flows through the thermostat installed in the volute casing of water pump. When the drainage temperature of the coolant of the engine is lower than the opening temperature of the thermostat, the coolant will flow to the water pump inlet directly; when the drainage temperature of the coolant of the engine is up to the opening temperature of the thermostat, the coolant will enter the water tank for cooling and then flow to the water pump inlet.

2.5 Electrical system

The starting motor and alternator are the fundamental components of the electrical system as shown below:



1. Battery 2. Alternator 3. Start button 4. Key switch 5. Starting relay 6. Starting motor

Fig. 3-5 Engine Electrical System

The operation principle is as follows: To start the engine, the battery offers power to the starting motor. After the engine is started, the pulley drives the alternator to run and produce electricity, and charge the battery which can offer electricity to other systems (such as vehicle lamps and stereo) when the engine is shut down.

Chapter 3 Technical Requirements for Engine Servicing

3.1 Torque requirements for fasteners

The tightening torque specifications of key bolts of E112 engine are given in the table blow.

Designation	I Tightening torque (N.m)			II Tightening angle (º) ±5º		
	Nominal	Min	Max	Nominal	Min	Max
Main bearing bolts	225±12	213	237	60+180	230	250
Base plate bolts	80±3	77	83			
Connecting rod bolts	105±5	100	110	60+60	110	130
Cylinder head bolts	155±8	147	163	90+180	260	280
Vibration damper bolts	85±4	81	89	60	55	65
Flywheel bolts	155±8	147	163	90+90	170	190

The tightening torque specifications of main bolts of E112 engine are given in the table blow.

	Specifications	Tightening Torque (N.m)
Fastening bolts of exhaust manifold		60
Fastening nuts of high-pressure fuel pump gear		Min.250;Max.300
Injector pipe hold-down nuts		53-58
Injector pressure plate	M7×1 (10.9)	17±1N.m 90±5º
Injector spacer		25
High-pressure fuel pipe 1-6		Recommend: 25; Max.33
Pipe of high-presser fuel pump through common rail		Recommend: 25; Max.33
Fastening nuts of air compressor gear		Max.170
Belt tensioner fastening		50±5
Speed sensor	M6	8
Supercharging pressure sensor	M5	5.3
Coolant temperature sensor	M12×1.5	25
Oil pressure and temperature sensor	M6	11.5
Drain plug on oil pan	M10×1.5	80
Drain cock		22-24

3.2 Technical requirements for assembling and adjustment of key parts

Assembling clearance, projection and sinkage are given in the table below.

No.	Measurement items	Nominal value (mm)	Remarks
1	Thrust clearance of crankshaft	0.17-0.40	
2	Connecting rod large end clearance	0.20-0.45	
3	Thrust clearance of camshaft	0.15-0.35	
4	Cylinder liner projection	0.03-0.08	Projection out of engine block
5	Cylinder liner bore (upper)	Φ156 (0-0.04)	Φ146 (0-0.04) (bottom)
6	Inside diameter of cylinder liner	Φ128 (0-0.025)	
7	Sinkage of intake valve	0±0.2	
8	Sinkage of exhaust valve	1±0.2	
9	The projection of injector out of cylinder head bottom	2.85	
10	Thrust clearance between idle gear of high-pressure pump and idler shaft	0.08-0.25	
11	Thrust clearance between idle gear of air compressor pump and idler shaft	0.08-0.25	
12	Thrust clearance between idle gear of camshaft and idler shaft	0.08-0.25	
13	Backlash in gear pair of duplex gear	0.06-0.26	
14	Backlash in gear pair of air compressor pump	0.06-0.26	
15	Backlash in gear pair of high pressure pump	0.06-0.26	
16	Backlash in gear pair of camshaft	0.06-0.26	
17	Clearance of intake valve	0.40±0.05	
18	Clearance of exhaust valve	0.65±0.05	
19	Clearance of exhaust brake valve	4.30±0.05	
20	Projection of piston out of the top of engine block	0.99-1.46	
21	Slewing torque of crankshaft (after assembling piston)	≦80N.m	

3.3 Main adjusting and control parameters of diesel engine

Items		10L, 12L
Valve clearance (mm)	Intake valve	0.40±0.08
	Exhaust valve	0.65±0.08
Valve timing (º) Crankshaft rotating angle	Intake valve open	11º before top dead center
	Intake valve close	29º behind bottom dead center
	Exhaust valve open	50º before bottom dead center
	Exhaust valve close	11º behind top dead center

3.4 Oiling and gluing requirements for parts

3.4.1 Lubricating oil application requirements

Before assembling all the kinematic friction pairs, wipe their fitting surfaces clean with non-woven cloth or silk and then apply clean lubricating oil to the surfaces uniformly; clean lubricating oil must be applied to some threaded surfaces as detailed in the following table.

Connecting rod bearing (except the back)	Main bearing (except the back)
Profile and journal of camshaft	Cylinder head bolts
Piston	Main bearing bolts
Piston pin	Connecting rod bolts
Piston ring	Flywheel bolts
All O seal rings	Fixing bolts of vibration damper
Valve stem	Seal ring of diesel filter (upper)
Rocker arm components	Seal ring of oil filter (upper)
Tooth surface of every drive gear	

3.4.2 Sealant application requirements

Before assembling the following parts, be sure to apply the sealant of stipulated grade to them:

(1) Apply TONSAN 1591 between front/rear gear chamber and cylinder block;

(2) Apply TONSAN 1591 between flywheel housing and rear gear chamber;

(3) Apply TONSAN 1596 between cylinder head cover and labyrinth plate, except assembled part;

(4) Apply TONSAN 1591 between intake pipe cover plate and cylinder head;

(5) Apply TONSAN 1591 on the joint of oil pan, engine block and front/rear gear chamber;

(6) Apply TONSAN 1680 on the mounting surface of dipstick pipe;

(7) Apply LOCTITE 515 on the joints of all screw plug pipes;

(8) Apply LOCTITE 680 on the circumferential surfaces of all expansion plugs;

(9) Apply TONSAN 1262 on the fastening nuts of fan connecting disc;

(10) Apply TONSAN 1262 on double-ended bolts of fuel injection pump (on the gear chamber);

(11) Apply TONSAN 1767 heat-resistant adhesive on the bolts of exhaust pipe and supercharger;

(12) Apply LOCTITE 648 on the threads of injector spacer evenly with appropriate amount.

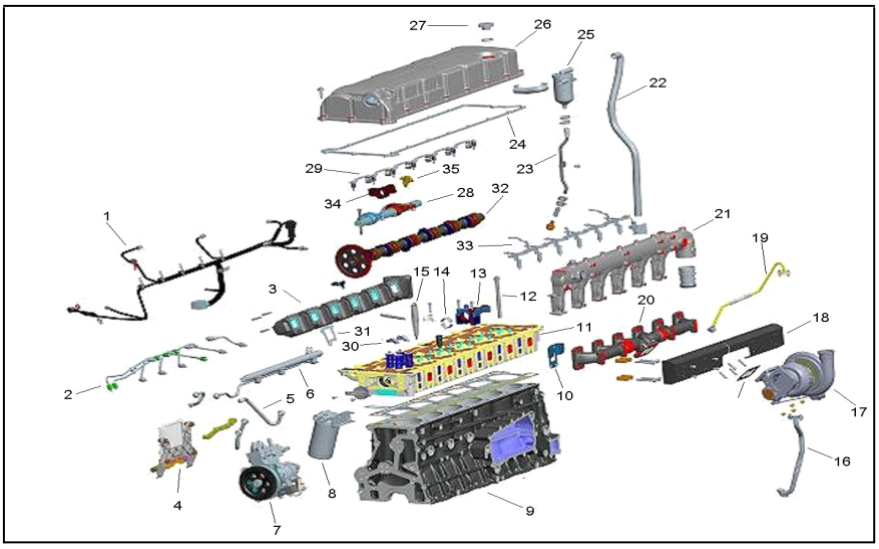
Note: The sealing surfaces of crankshaft journals at front and rear oil seal lips of crankshaft must be clean and dry without any residual oil.

Chapter 4 Installation and Adjustment of Main Components of Engine

4.1 Mechanical parts of engine

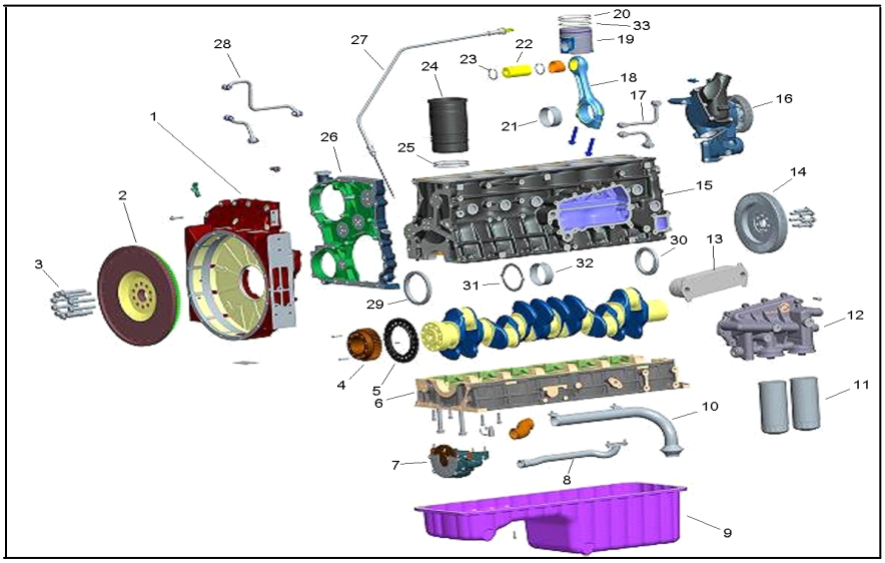
4.1.1 Layout

Exploded view of cylinder head, intake and exhaust system, and fuel system assembly



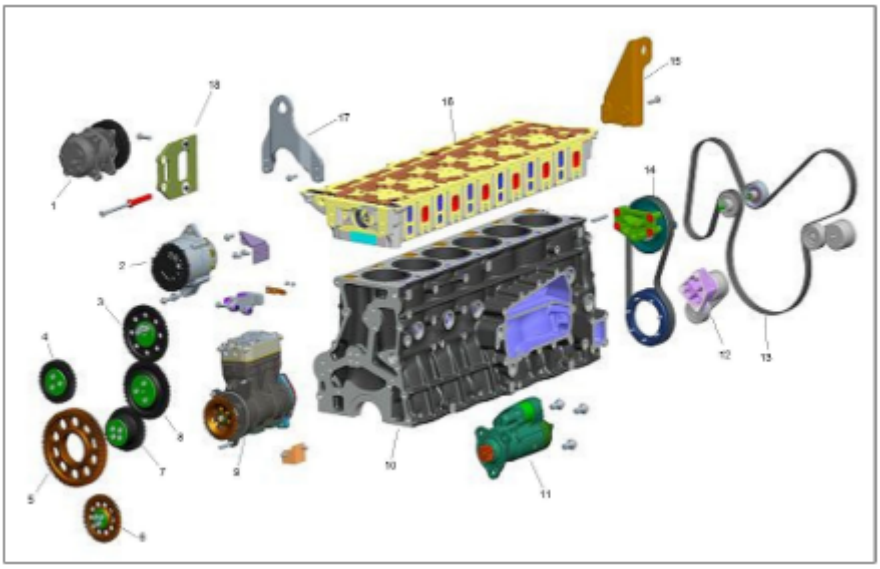
1. Engine harness 2. High-pressure common rail fuel inlet pipe and high-pressure fuel pipe 3. Air inlet pipe 4. ECU 5. Fuel filter inlet pipe 6. High-pressure common rail 7. High-pressure fuel pump 8. Fuel filter 9. Engine block 10. Exhaust pipe gasket 11. Cylinder head 12. Cylinder head bolts 13. Camshaft support 14. Camshaft upper and lower bearings 15. Injector 16. Supercharger oil return pipe 17. Turbocharger 18. Exhaust pipe heat shield 19. Turbocharger oil inlet pipe 20. Exhaust pipe 21. Main water inlet pipe 22. Gas outlet pipe of oil-gas separator 23. Oil return pipe of oil-gas separator 24. Cylinder head cover gasket 25. Oil-gas separator 26. Cylinder head cover 27. Filler cap 28. Rocker arm shaft 29. Clamping component of braking rocker arm 30. Valve bridge 31. Intake pipe gasket 32. Camshaft 33. Valve chamber harness 34.Braking rocker arm 35. Solenoid valve

Exploded view of engine block and cylinder powertrain



1. Flywheel housing 2. Flywheel 3. Flywheel bolts 4. Crankshaft gear 5. Drive gear of oil pump 6. Base plate of engine block 7. Oil pump 8. Oil pump outlet pipe 9. Oil pan 10. Oil pump suction pipe 11. Oil filter 12. Oil cooler base 13. Oil cooler core 14. Torsional damper 15. Engine block 16. Water pump and thermostat 17. Water inlet and outlet pipes of air compressor 18. Connecting rod 19. Piston 20. Piston compression ring (two) 21. Connecting rod bearing 22. Piston pin 23. Psion pin retainer ring 24. Cylinder liner 25. Cylinder liner seal ring 26. Gear chamber 27. Oil dipstick 28. Water inlet and outlet pipes of air compressor 29. Rear oil seal for crankshaft 30. Front oil seal for crankshaft 31. Crankshaft thrust bearing 32. Crankshaft bearing 33. Piston oil ring

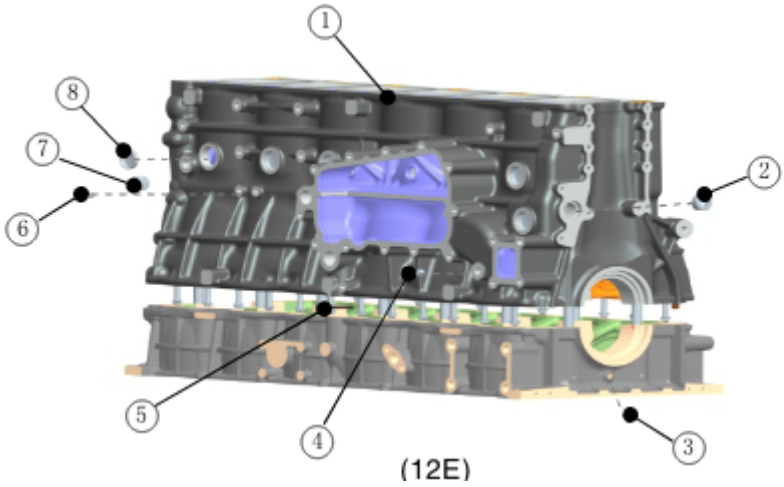
Exploded view of front timing and accessory assembly



1. A/C compressor 2. Alternator 3. Camshaft idle gear ① 4. High-pressure pump idle gear 5. Duplex gear 6. A/C idle gear 7. Duplex pinion 8. Camshaft idle gear ② 9. Air compressor 10. Engine block 11. Starting motor 12. Tension pulley 13. Main drive belt 14. Fan drive belt 15. Front lifting eye 16. Cylinder head 17. Rear lifting eye 18. A/C bracket

4.2 Assembling of main parts and components

4.2.1 Assembling of engine block assembly



(12E)

①Machining parts
②Hex socket tapered screw plug (NPT1)
③Steel ball
④Hex socket tapered screw plug (NPT1/4)
⑤Rubber O-ring
⑥Hex socket tapered screw plug (NPT1/8)
⑦Expansion plug
⑧Expansion plug

***Sealant requirements*:** Before assembly, precoat the hex socket tapered screw plugs with Loctite 515, and the expansion plugs with Loctite 680.

Assembling requirements:

1. Press in the expansion plugs ⑦⑧ with tools with the end surfaces of plugs 1~2mm lower than the chamfer of the hole;

2. Tighten the hex socket tapered screw plugs ②④⑥ to specified torque values;

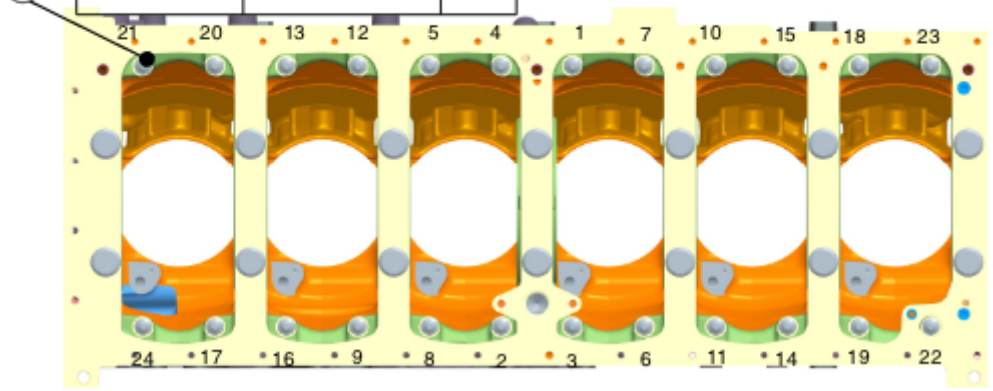
3. Press steel ball ③ into oil path, and install the O seal ring ⑤;

4. Lift the base plate of engine block. Before lifting, install the assembly guide pin (×4).

4.1 Assembling requirement for base plate bolts:

Tighten base plate bolt (M10) ⑨ to specified torque 80N.m in the illustrated order below.

Mark	A	B
Torque (N.m)	225+240°	80

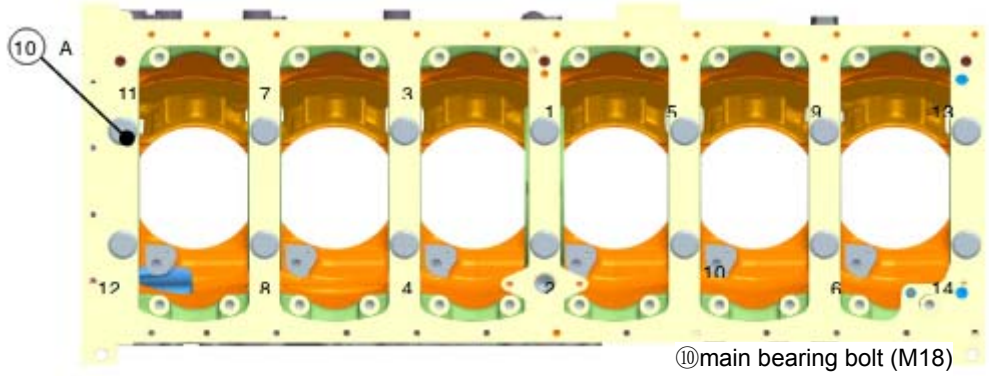


⑨Base plate bolt (M10)

After lifting the base plate, install main bearing bolt ⑩, and oil the threads.

4.2 Assembling requirements for main bearing bolts:

Tighten main bearing bolt (M18) ⑩ in the illustrated order below; tightening way: 225N.m+60°+180° (total 240°); the reference value of tightening torque is 419-472N.m.



⑩main bearing bolt (M18)

4.2.2 Assembling of cylinder liner

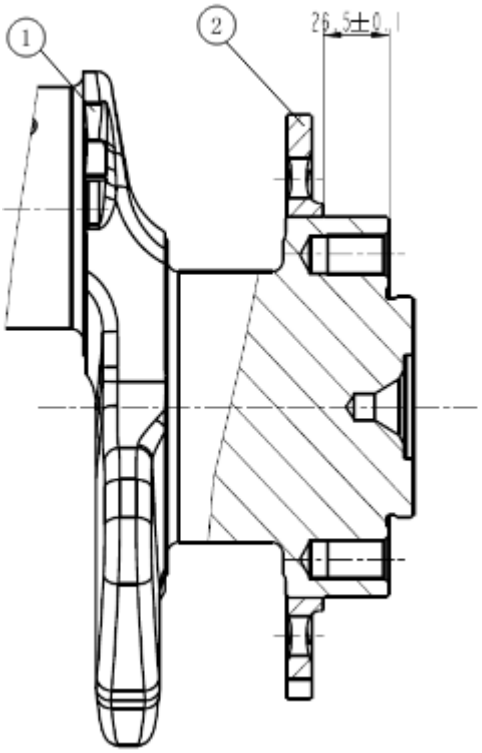
①Cylinder liner
②Water seal ring of cylinder liner

Assembling requirements:

1. After oiling, assemble the water seal ring ② of cylinder liner into the groove of cylinder liner ①, and press it into the cylinder liner hole;

2. Measure and record the inner diameter roundness of cylinder liner which should be Φ128 (+0.025/0). Measure and record the projection *&* of 0.03-0.08;

4.2.3 Assembling of crankshaft



① Crankshaft
② Drive gear of oil pump

Assembling requirements:

1) Assemble drive gear ② of oil pump on the crankshaft ① by heating; the temperature should refer to the assembling requirement of gear. Note to use tooling for locating, and guarantee the relative axial dimensions;

2) Turn over the engine block, and remove the base plate;

3) Assemble upper 1-7 gear main bearing into the main shaft hole, and notice that the surface of the bearing (except its back) should be evenly coated with appropriate amount of clean oil;

4) Lift the crankshaft, insert the upper thrust plate (×2), and notice that the end faces of two drain pans in the thrust plate should face to the thrust surface of crankshaft;

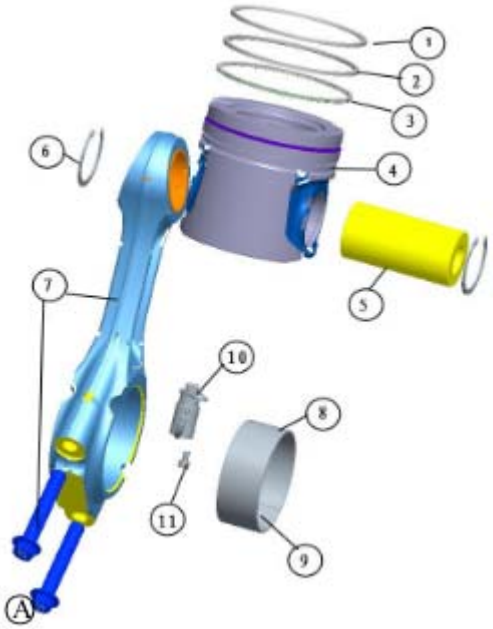
5) Assemble the lower 1-7 gear main bearing on the base plate, and note that the surface of the bearing (except its back) should be evenly coated with appropriate amount of clean oil;

6) Lift the base plate to the end of engine block, insert the lower thrust plate (×2), and notice that the end faces of two drain pans in the thrust plate should face to the thrust surface of crankshaft;

7) Install the base plate:

8) Measure and record the thrust clearance after assembling the crankshaft which should be 0.17-0.40mm; measure and record the slewing torque which should be not more than 40 N.m.

4.2.4 Assembling of piston & connecting rod assembly



①. Barrel faced keystone ring
②. Inscribed conical ring
③. Oil ring component
④. Piston
⑤. Piston pin
⑥. Piston pin retainer ring
⑦. Machining part of connecting rod
⑧. Upper bearing of connecting rod
⑨. Lower bearing of connecting rod
⑩. Piston cooling nozzle component
⑪. Piston cooling nozzle fastening bolt

Assembling requirements:

1) One engine should use connecting rods in the same weight group, and the weight group marks are made with letters A, B, C, D, and E on the side of connecting rod large end;

2) The beveling position of connecting rod large end should be opposite to the pit of piston cooling nozzle.

3) Oil and then install the piston pin into piston and connecting rod, and install lock spring retainer rings on both sides of pin hole;

4) Successively install oil ring with “TOP” side up and the butting position of inner spring opposite to the opening of the oil ring;

Install the conical torsional ring with “TOP” side up;

Install the barrel faced keystone ring with “TOP” side up;

5) The piston axis should be horizontal, and after it is turned by 180º, the piston ring should be able to move evenly in the groove with the help of its deadweight.

6) The piston & connecting rod assembly and the wall of cylinder liner should be coated with clean oil evenly and appropriately;

7) The openings of piston ring should be staggered by 120º;

8) Turn the crankshaft to the top dead center, and press the piston into cylinder block with tool; the direction indicating arrow on the top of piston should point to front;

9) Assemble the connecting rod cover according to the number on it.

10) Alternately and symmetrically tighten the bolt (M14×1.5) of connecting rod in three steps:

The first step: 105±5N.m

The second: turn 60º±5º

The third: turn 60º±5º

11) Measure and record the backlash of the assembled connecting rod large end, which should be 0.20-0.45mm; measure and record the slewing torque of crankshaft, which should not be more than 80N.m;

12) The tightening torque of fastening screw of piston cooling nozzle is 10 N.m.

4.2.5 Assembling of oil pump

① Oil pump component
② Fastening bolt

Assembling requirement:

1. Fastening bolt 3×M8×65 10.9J

Tightening torque: 32±2N.m

2. Measure and record the clearance between oil pump and its drive gear, which should be 0.087-0.25mm.

4.2.6 Assembling of rear gear train

4.2.6.1 Assembling of gear chamber

Assemble the locating sleeve pin (2x) of gear chamber (S00002057) on the engine block side;

Install the temporary steel ball plug for the PTO of gear chamber;

Install the choke plug for oil path on the end of air compressor pump;

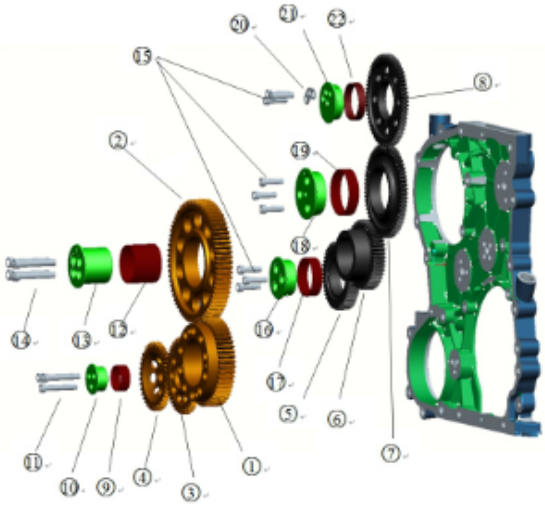
Clean the jointing surface of engine block and gear chamber;

The joint face of engine block and gear chamber should be coated with LOCTITE 510 evenly and appropriately;

Tighten the fastening bolt of gear chamber M10×45 (5×).

4.2.6.2 Assembling of gear train

12E



①Crankshaft gear
②Duplex gear
③Air compressor idle gear
④Air compressor gear
⑤High-pressure pump idle gear
⑥Duplex pinion
⑦Camshaft idle gear 2
⑧Camshaft idle gear
⑨Air compressor idle gear bushing
⑩Air compressor idler shaft
⑪Hex socket cap screw
⑫Duplex gear bushing
⑬Duplex gear shaft
⑭Hex socket cap screw
⑮Hex socket cap screw
⑯High-pressure pump idler shaft
⑰High-pressure pump idle gear bushing
⑱Camshaft idler shaft 2
⑲Idle gear bushing 2 of camshaft
⑳Shim block for camshaft idler shaft
㉓ Camshaft idler shaft
㉒ Camshaft idler shaft bushing

*Note: The difference between the structure of 10E gear train and that of 12E is:
No high-pressure pump idle gear is provided for 10E gear train

Assembling requirements:

1) The duplex gear should be pre-assembled with the direction mark "↑" on the shaft forward; check the pre-assembled gear's running condition and the thrust clearance (0.10-0.25), and then remove it;

2) Assemble the high-pressure idle gear and idler shaft with the direction mark "↑" on the shaft forward; tighten the fastening bolt and hex socket cap screw GB/T70.1-M10×45-10.9 (3×); after tightening , check the running condition and thrust clearance (0.10-0.25mm);

3) Assemble the camshaft idle gear 2 and idler shaft; tighten the fastening bolt and hex socket cap screw GB/T70.1-M10×45-10.9 (3×); after tightening, check the running condition and thrust clearance (0.10-0.25mm);

4) Assemble the air compressor idle gear and idler shaft; tighten the fastening bolt and hex socket cap screw GB/T70.1-M10×80-10.9 (3×); after tightening, check the running condition and thrust clearance (0.10-0.25mm);

5) Assemble the locating pin (GB/T119-A8*14) of crankshaft gear, and knock it in place with tool;

6) Assemble the crankshaft gear and tighten the hex socket cap screw GB/T70.1-M6×40-8.8 (2×);

7) Assemble the high-pressure pump gear, and tighten the high-pressure pump fastening nut to the torque of 250±10N.m;

8) Assemble the air compressor idle gear, and tighten the idle gear fastening nut (left-hand threaded nut) to the torque of 170±8N.m;

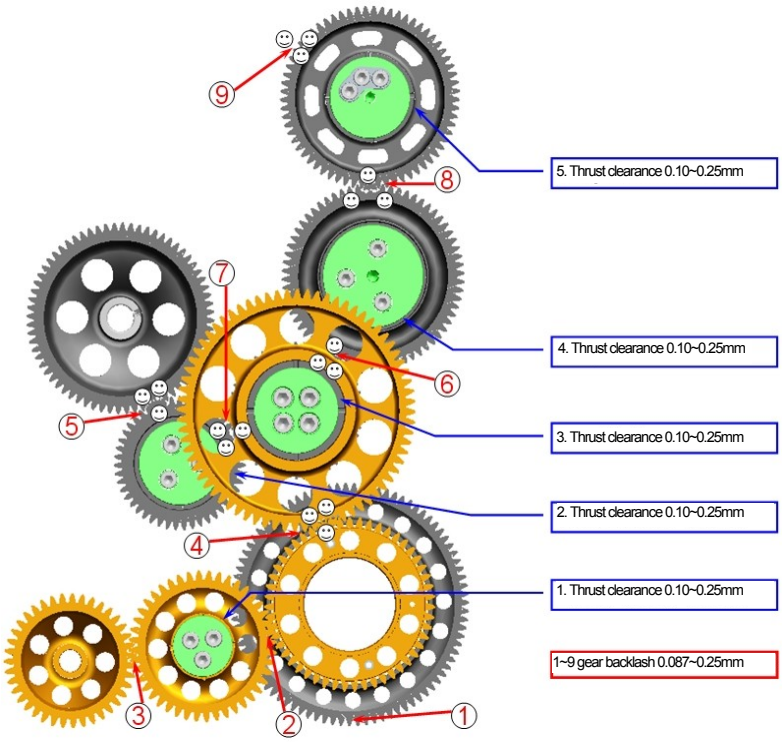
9) Assemble the duplex gear and idler shaft, and tighten the hex socket cap screw GB/T70.1-M12×90-10.9;

10) Adjust the backlash between the camshaft idle gear (7, 8) and the camshaft gear;

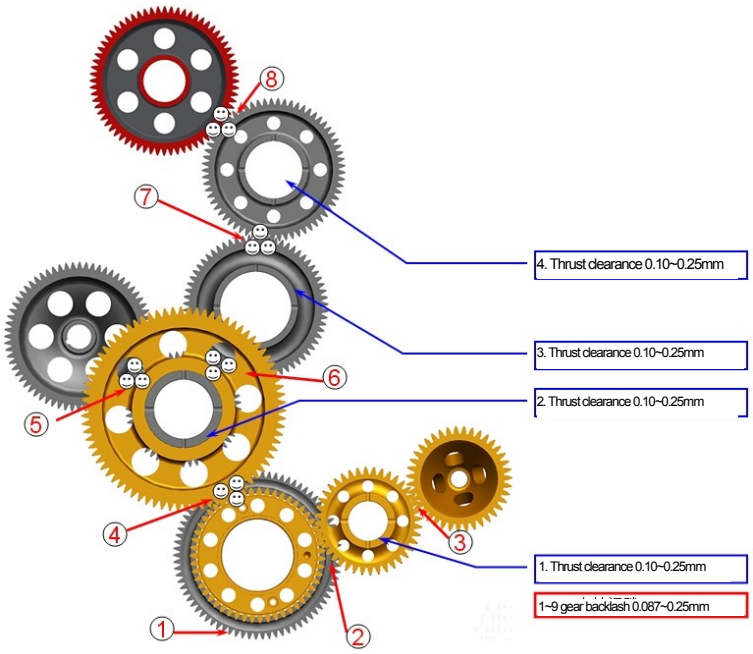
11) Adjust timing according to the mark on the gear during assembly;

12) Check the backlash of gear pair, which should be 0.087-0.25mm.

12E

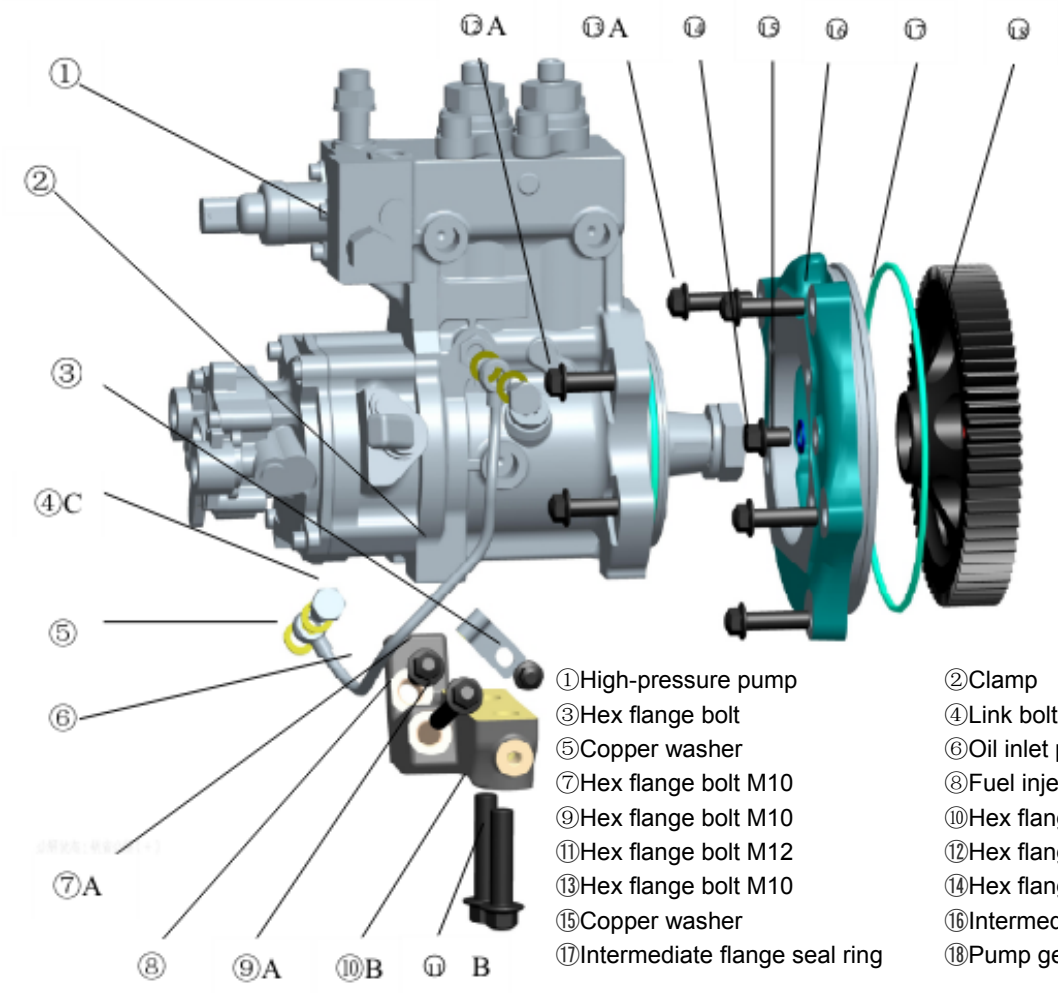

9
8
7
6
5
4
3
2
1
5. Thrust clearance 0.10~0.25mm
4. Thrust clearance 0.10~0.25mm
3. Thrust clearance 0.10~0.25mm
2. Thrust clearance 0.10~0.25mm
1. Thrust clearance 0.10~0.25mm
1~9 gear backlash 0.087~0.25mm

10E


8
7
6
5
4
3
2
1
4. Thrust clearance 0.10~0.25mm
3. Thrust clearance 0.10~0.25mm
2. Thrust clearance 0.10~0.25mm
1. Thrust clearance 0.10~0.25mm
1~9 gear backlash 0.087~0.25mm

4.2.7 Assembling of fuel pump

Mark	A	B	C
Torque (N.m)	58	112	25–30



①High-pressure pump
②Clamp
③Hex flange bolt
④Link bolt M12×1.5
⑤Copper washer
⑥Oil inlet pipe assembly of pump
⑦Hex flange bolt M10
⑧Fuel injection pump holder
⑨Hex flange bolt M10
⑩Hex flange bolt M12
⑪Hex flange bolt M12
⑫Hex flange bolt M10
⑬Hex flange bolt M10
⑭Hex flange bolt M10×1.25
⑮Copper washer
⑯Intermediate flange of pump
⑰Intermediate flange seal ring
⑱Pump gear

Assembling requirement:

1. The crankshaft timing is required for the fuel pump. Before assembly, make sure that No. 1 cylinder of diesel engine is at top dead center;

2. After applying vaseline evenly and appropriately to the fuel injection pump intermediate flange seal ring □, install the seal ring into the seal ring groove □, and then tighten the high-pressure pump intermediate flange fastening bolt □ M10 (4×). Special attention should be paid to avoid bumping the seal ring during assembly;

3. After applying vaseline evenly and appropriately to the attached O seal ring of high-pressure pump, install the high-pressure pump into the intermediate flange, and the tighten the bolt 12 M10(4×);

4. Install the mounting bracket of high-pressure pump ⑧, and tighten its fastening bolts ⑦, ⑨, ⑩, and

 (one each); (if no bracket is provided, omit this procedure);

5. Check whether the key groove of camshaft of high-pressure pump is 90º left to the vertical centerline of pump; if not, turn the camshaft of pump to make the key groove at this position. Make sure the phase of the camshaft is correct;

6. Install high-pressure pump gear in relation to the key groove, check whether the assembly mark matches the groove, and tighten the fastening nut to the torque of 250±10N.m;

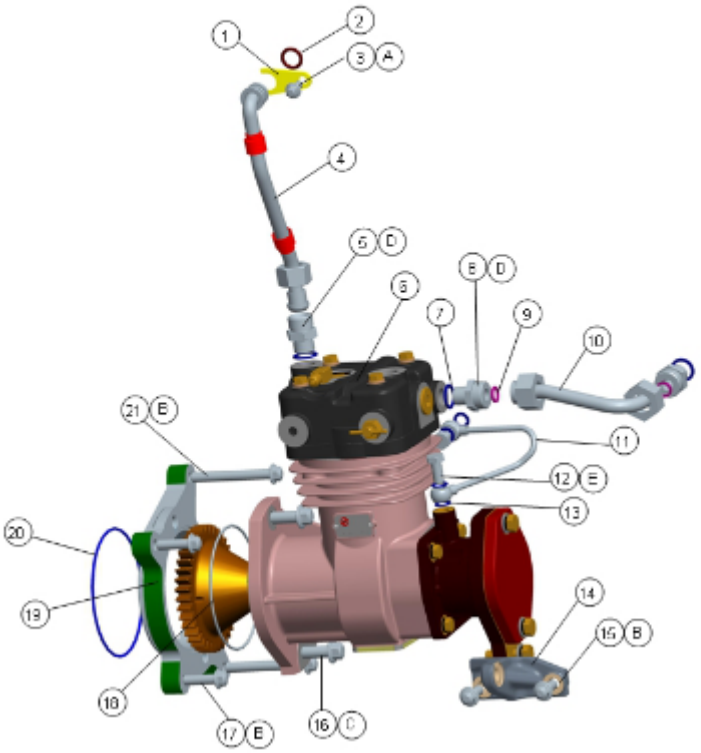
7. Check the backlash of gear pair, which should be 0.087-0.25mm, and make a mark with white paint marker after the check;

8. Install the oil inlet pipe ⑥, the link bolts ④ M10×1.5 (2×), and the gaskets (4×).

4.2.8 Installation of air compressor

4.2.8.1 Installation of 10E air compressor

Mark	A	B	C	D	E
Torque (N.m)	30	58	112	50	50



① Pressure plate
② Rubber O-ring
③Hex flange bolt M8
④Air compressor water outlet pipe component
⑤Screw-on joint M18
⑥Air compressor component
⑦Copper washer
⑧Air compressor water inlet pipe joint M18
⑨Rectangular rubber seal ring
⑩Air compressor water inlet pipe component
 Air compressor pump oil inlet pipe
 Link bolt M10
 Copper washer
 Air compressor bracket

Assembling requirements:

(1) Assemble the gear chamber with reference to assembling requirements for gear chamber. Then fit the seal ring onto the air compressor pump intermediate flange, and apply vaseline to O seal ring evenly. Later, install the intermediated flange, and tighten the fastening bolt M8×35 (2×) and M8×85 (2×);

(2) Fit the O-ring to the end face of air compressor flange, install the air compressor onto the intermediate flange, and tighten the fastening bolt M12×30 (2×) 10.9;

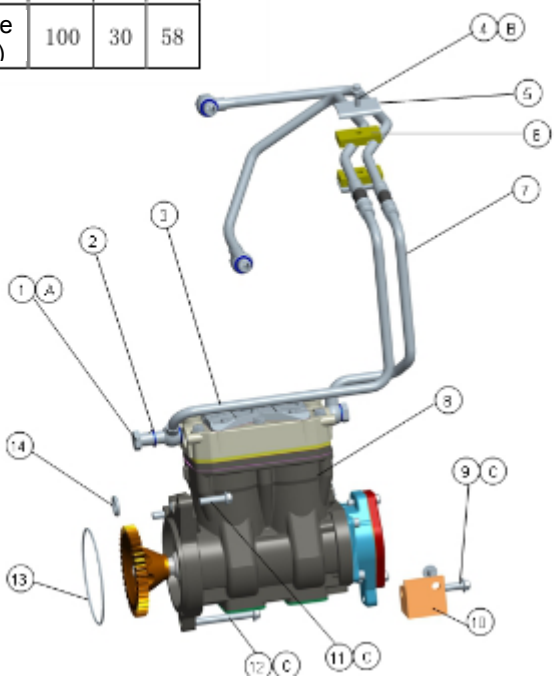
(3) Remove the lower fastening bolt next to the steering pump end of air compressor, and note not to throw away the plain washer and spring washer. Then thread it through the air compressor bracket, and tighten it after tightening the bolt M10×25 (2×) 8.8 which is used to fix the air compressor on the engine block;

(4) After assembling the water inlet pipe joint M18×1.5 and corresponding copper washer on the engine block and air compressor, install the water inlet pipe and corresponding rectangular seal ring. Note to fix the both ends properly before tightening the nuts on them in turn. After assembling the screw-on joint M18×1.5 of air compressor pump water return pipe and the corresponding copper washer onto the air compressor, press the O ring into the groove of water return pipe. After applying the vaseline, insert it into the outlet of main water return pipe. Fix the water return pipe to the main water return pipe with hex flange bolt M8×16;

(5) Install the oil inlet pipe of air compressor and tighten the link bolt M10×1 at both ends of the pipe. Note that copper washers should be installed on both sides of each link bolt.

4.2.8.2 Assembling of 12E air compressor

Mark	A	B	C
Torque (N.m)	100	30	58



① Link bolt M18
② Copper washer
③ Water inlet pipe component of air compressor
④ Hex flange bolt M8
⑤ Clamping plate of air compressor water inlet and outer pipes
⑥ Gasket for clamping plate
⑦ Water outlet pipe component
⑧ Air compressor component
⑨ Hex flange bolt M10
⑩ Air compressor bracket

□ Hex flange bolt M10

□ Link bolt M10

Assembling requirements:

(1) Assemble the gear chamber with reference to assembling requirements for gear chamber and install the flywheel housing with reference to assembling requirements for flywheel. Then fit the rubber O-ring on the end face of air compressor pump flange, and press the other O-ring into the oil inlet of air compressor. Afterwards, tighten the fastening bolts M10×35 (2×) and M10×80;

(2) Fix the air compressor bracket on the end face of flange at the side of air compressor connecting to steering pump, tighten the fastening bolt M10×25, and fix the bracket on the engine block with bolt M10×25;

(3) Install the water inlet pipe of air compressor and tighten the link bolts M18×1.5 (2×); note that copper washers should be fixed on both sides of link bolts;

(4) Install the oil inlet pipe of air compressor, and tighten the link bolts M10×1 on both ends of the pipe; note that both sides of each link bolts should be installed with copper washers;

(5) Install the clamping plate and gasket for air compressor water inlet and outlet pipes, fix the water inlet pipe of air compressor, and tighten the bolt M8×40 on the flywheel housing.

4.2.9 Assembling of flywheel housing

Assemble the locating sleeve pin (2x) on the gear chamber side;

Install the oil path plug and gasket for the flywheel housing PTO;

Clean the joint face of gear chamber and flywheel housing, and remove the fastening bolts M12×65 (4×);

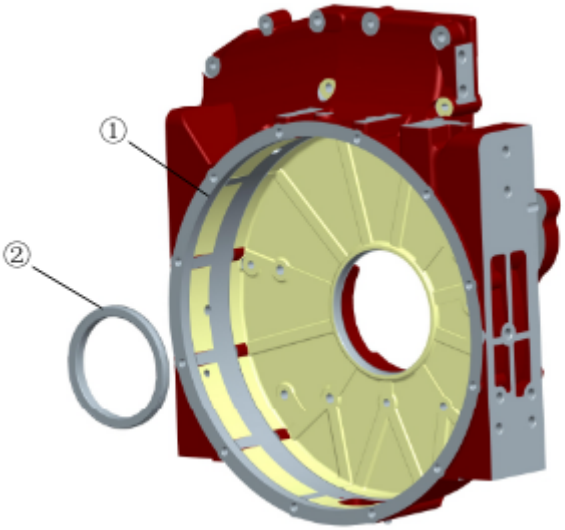
The joint face of gear chamber and flywheel housing should be coated with Loctite 510 evenly and appropriately;

Tighten the fastening bolts M10×20 (1×), M10×50 (3×), M10×70 (6×), M12×120 (9×), and M12×130 (2×) for flywheel housing;

Install the cover plate of PTO and tighten the bolts GB/T16674.1-M12×30 (3×) and M12×170;

Install the cover plate of steering pump and tighten the bolt GB/T16674.1-M8×35 (3×).

4.2.10 Installation of front and rear oil seals



①Flywheel housing
②Rear oil seal of crankshaft

①Front oil seal
②Engine block
③Base

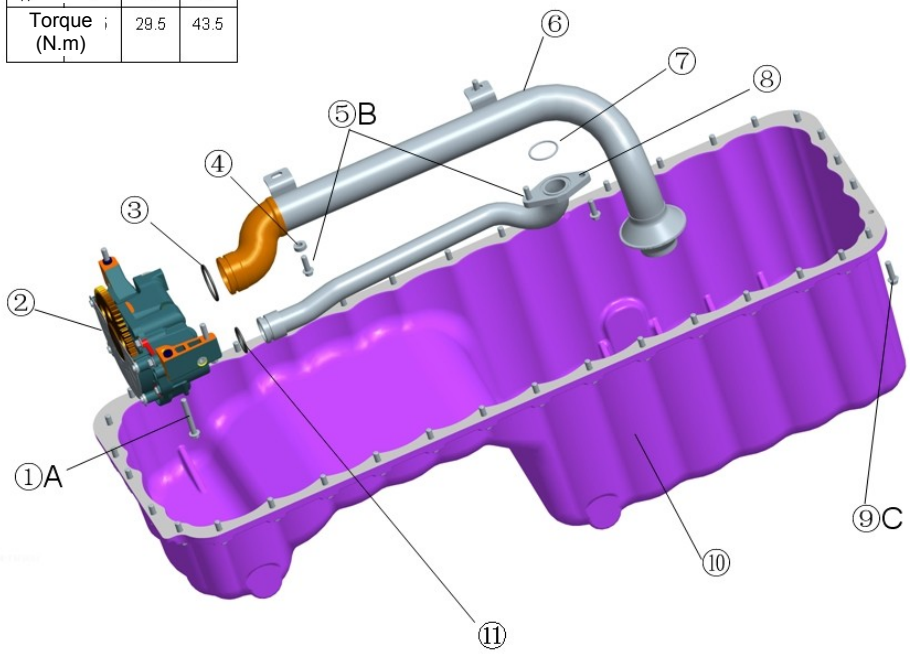
Assembling requirements:

1) The front oil seal and the external assembling surface of rear oil seal ring of crankshaft should be coated with vaseline;
2) Press in the front and rear oil seal with tool.

*Note: The crankshaft journal sealing surface at the lips of front and rear oil seals must be clean and dry, without residual oil.

4.2.11 Installation of suction pipe and oil pan

标Mark A	B	C
Torque (N.m)	29.5	43.5



①Hex flange bolt M8×60 (3×)
②Oil pump component
③Rubber O-ring (48.7×3.55)
④Shim block (2X)
⑤Hex flange bolt M8×25 (4X)
⑥Welding parts of suction pipe
⑦Rubber O-ring (37.5×2.65)
⑧Welding parts of oil pipe
⑨Hex flange bolt M8×30 (37×)
⑩Oil pan assembly parts
⑪Rubber O-ring (32.5×3.55)

Assembling requirements:

1. Install the oil pump
2. Installation of suction pipe

1) Install the rubber O-ring ③ and the O seal rings ⑦ and ⑧ on the welding parts of suction pipe;

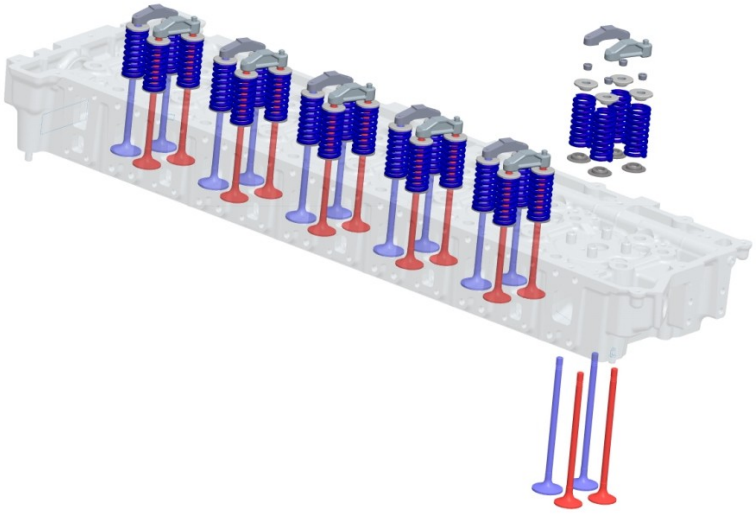
2) Lubricate the heads of welding parts of the suction pipe and the oil pipe with grease, and then insert them into the assembly hole. Finally tighten the bolts;

3. Installation of oil pan

1) The bottom surface of oil pan should be lubricated with silica gel;
2) Install the oil pan and tighten the bolts one by one from the middle to both sides alternately.

4.2.12 Assembling of cylinder head assembly

4.2.12.1 Assembling of valve assembly



Assembling requirements:

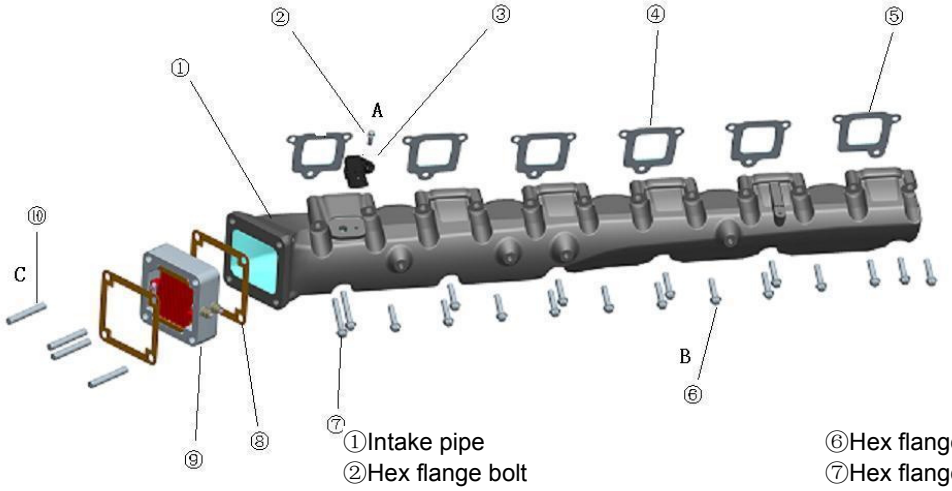
1. Plug the valve into the cylinder head, and successively install the oil seal ring of valve stem, valve spring, upper seat of valve spring and valve collet; press them with tool;

2. Measure and record the valve sinkage;

3. Install the intake valve bridge (with the opening toward camshaft) and the exhaust valve bridge (with the slide block end toward camshaft).

4.2.12.2 Installation of intake system

Mark	A	B	C
Torque (N.m)	8	20	30



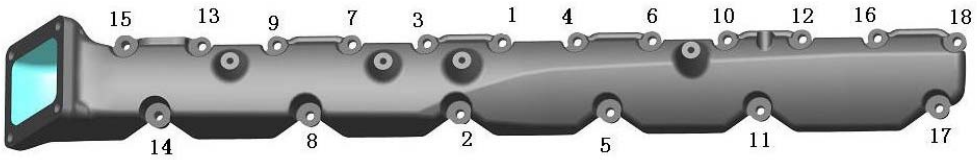
①Intake pipe
②Hex flange bolt
③Intake temperature and pressure sensor
④Intake pipe gasket
⑤Intake pipe gasket
⑥Hex flange bolt
⑦Hex flange bolt
⑧Intake heating flange gasket
⑨Resistor heater component
⑩Stud

Assembling requirements:

1. Install the intake pipe gasket, and fasten the intake pipe to the cylinder head with 18 bolts M8 (16 short bolts + 2 long bolts). The bolts should be tightened to the torque of 20±2N.m in the illustrated order below;

2. Screw the short ends of 4 studs M10 into the intake pipe with the tightening torque of 30±3N.m, and then successively install the gasket and the resistor heater component as shown above;

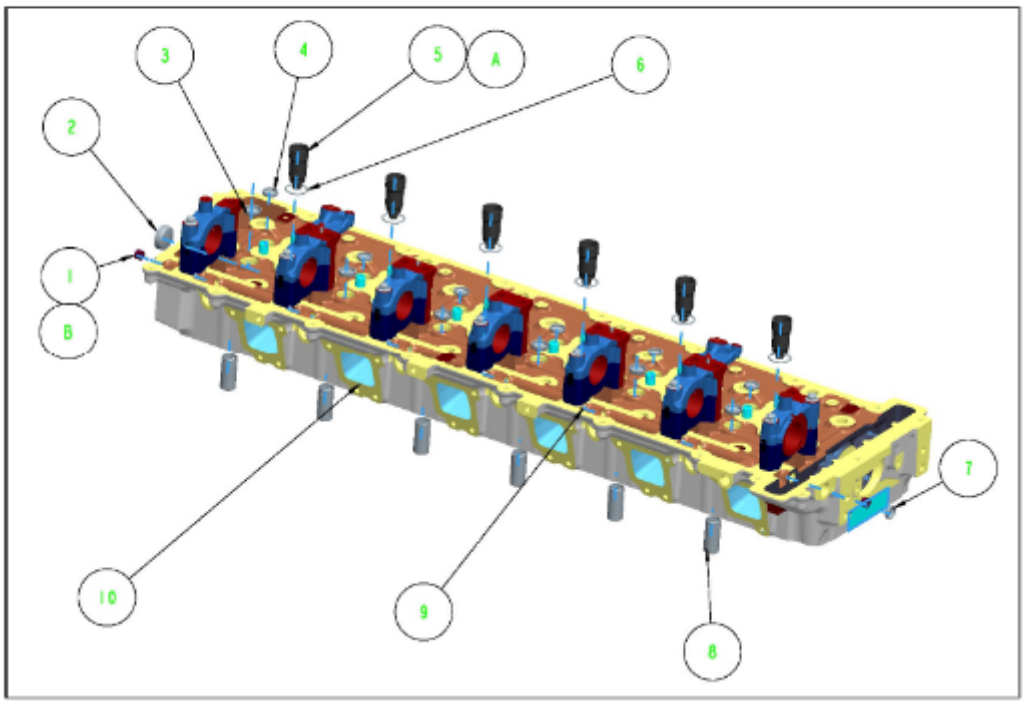
3. Fasten the intake temperature and pressure sensor on the intake pipe with bolt M6. The tightening torque is 8±1N.m.



4.2.12.3 Assembling of cylinder head

4.2.12.3.1 Assembling of cylinder head assembly parts

Mark	A	B
Torque (N.m)	25	20



①Hex socket head plug ②Expansion plug ③Choke plug (Φ25) ④Choke plug (Φ22) ⑤Injector spacer ⑥Rubber O-ring ⑦Choke plug (Φ20) ⑧Upper water pipe of cylinder head ⑨Steel ball ⑩Cylinder head machining parts

Sealant requirements:

Before the assembly, coat the hex socket head plug (1) with Loctite 515 or equivalent, coat the choke plugs (3, 4, 7), expansion plug (2) and steel ball (9) with Loctite 680 or equivalent, and the thread and bottom surface of injector spacer (5) with Loctite 648 or equivalent. After pressing the rubber O-ring (6) into cylinder head, lubricate it with vaseline or grease.

Assembling requirements:

1) Install the rubber O-ring (6) on the injector hole groove of cylinder head machining parts (10);

2) Press in the injector spacer (5), and tighten it to 25N.m with special tool;

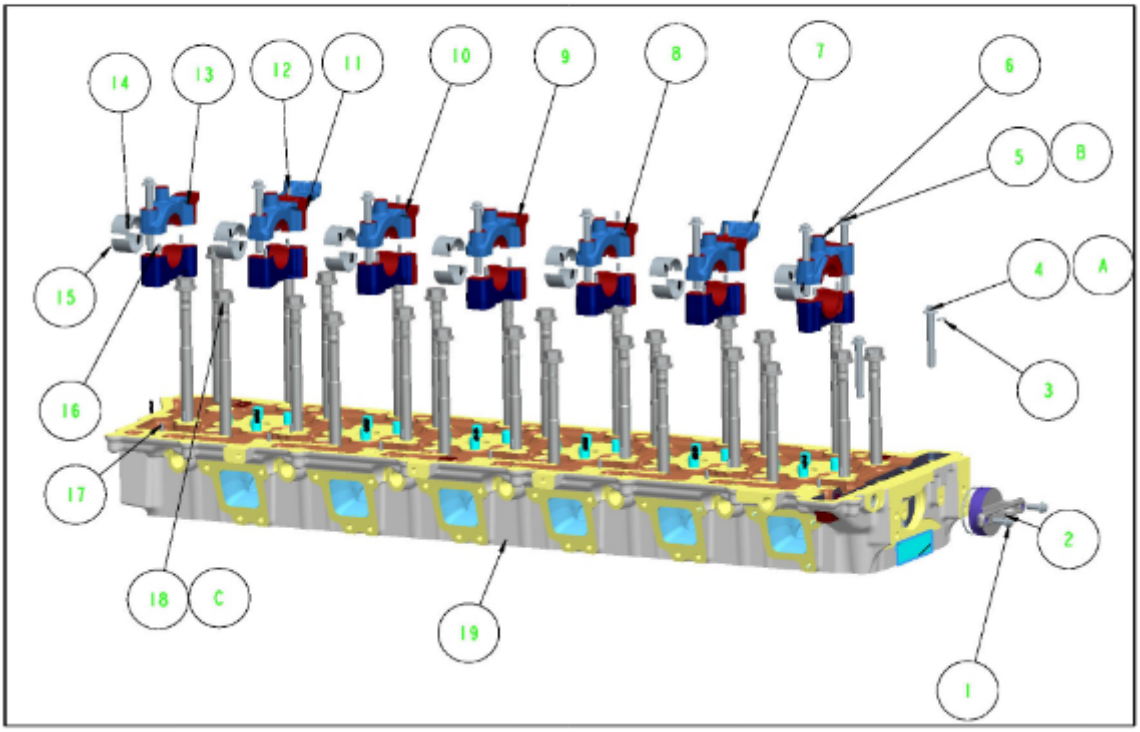
3) Tighten the hex socket head plug (1), hex socket head S=6. The projection of plug out of the mounting surface is 1.45+0.5-1.0;

4) Press in the choke plugs (3, 4, 7), expansion plug (2) and steel ball (9);

5) Press in the upper water pipe of cylinder head (8); note that the side with a little hole should face to the inside.

4.2.12.3.2 Installation of cylinder head assembly:

Mark	A	B	C
Torque (N.m)	60	60	Angle



(1) Hex flange bolt (2)Rear cover component*(3) Rubber O-ring (4)Hex flange bolt (5)Hex flange bolt (6) Camshaft support(7) (7)Camshaft support(6) (8)Camshaft support(5) (9)Camshaft support(4) (10)Camshaft support(3) (11)Camshaft support(2) (12)Cylindrical pin (13)Camshaft support(1) *(14)Camshaft upper bearing *(15)Camshaft lower bearing (16)Cylindrical pin (17)Cylindrical pin (18)Cylinder head bolts (19)Cylinder head assembly parts

***Note:** In some configurations, there is no (3), (14), or (15).

***Sealant requirements**:*

Before assembling the rear cover component (2), lubricate the O seal ring with vaseline or grease. When assembling the hex flange bolt (4), fit rubber O-ring (3) on it and lubricate the ring with vaseline or grease. When assembling the cylinder head bolt (18), oil the threads. And after installing the upper and the lower bearings (or no bearing), the fitting surface should be coated with clean lubricating oil evenly.

Assembling requirements:

Remove camshaft supports (Note: The camshaft supports should be used with numbers. If no marks are found, indicate the corresponding numbers with conspicuous marks before removal. Do not mix them).

1. Install the cylinder head guide pin (4×);

2. Install the cylinder head locating pin GB/T119A10×22 at the top of the engine block;

3. Install the cylinder head gaskets;

4. Install the special cylinder head bolts M16 (26×), and oil the threads;

5. Alternately and symmetrically tighten the bolts (M16×2) (26×) of cylinder head in three steps by socket S=21" in the illustrated order below:

The first step: pretighten 25±5N.m, and then tighten to 155±5N.m;

The second: turn by 90º±5º;

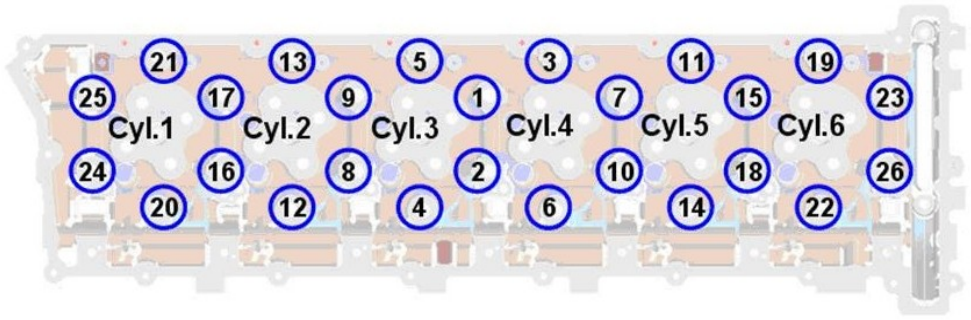
The third: turn by 180º±5º;

Tighten the cylinder head gear chamber fastening bolt M10 10.9J (2×) to the torque of 60±3N.m;

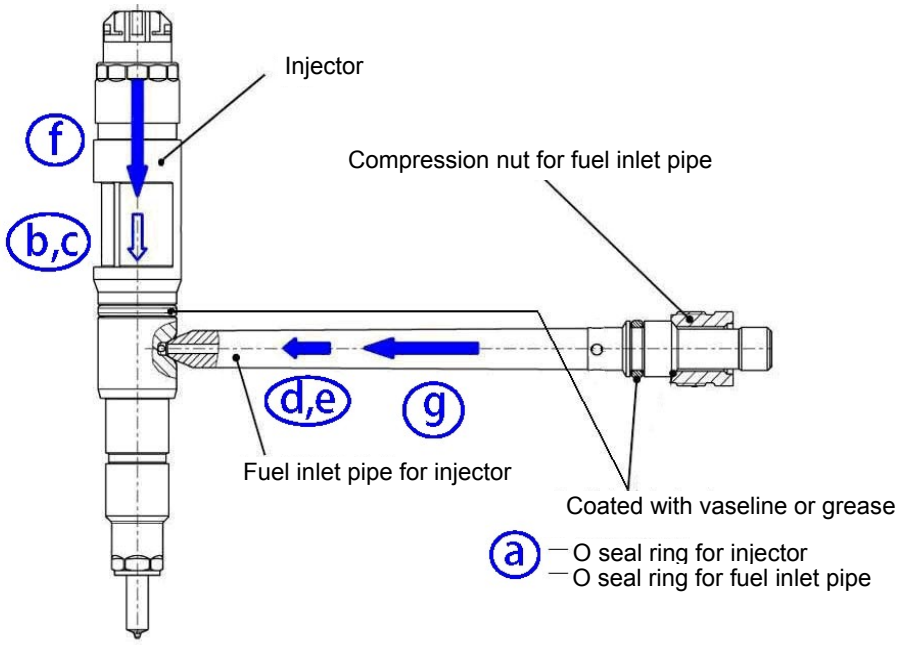
6. Install the base of upper camshaft support;

7. Install the camshaft in accordance with corresponding technical requirements;

8. Install the upper cover of camshaft support.



4.2.13 Installation of Injector



Precautions:

a) Before the installation, check whether the gasket, O seal ring and the fuel inlet pipe for the injector are intact. If there is missing or damage, replace with intact components;

b) Do not reuse gaskets or O seal ring;

c) Do not bump the injector, especially the nozzle on the bottom and the solenoid valve on the top;

d) Before installed and after removed, the injector should be placed at a designated clean place;

e) Before the installation, do not remove the protective cap of injector;

Installation procedures:

a) The surfaces of O seal rings for injector and fuel inlet pipe should be lubricated with grease or vaseline;

b) Insert the pressure plate of injector into the injector neck, align the injector with the injector hole on cylinder head in right direction (with the inlet facing the high-pressure fuel joint), and then push the injector with force (note not to exert force on the terminals) axially to the bottom and install it in the cylinder head;

c) Install the injector pressure plate bolt and pretighten it to the torque 10N.m, and then loosen it completely to make sure the correct locating of the injector in the cylinder head (clearance fit);

d) Push the fuel inlet pipe with force axially to the bottom to make it contact with the fuel inlet of injector; the fuel inlet pipe is provided with a locating steel ball, which must enter into the locating groove of the cylinder head;

e) Tighten the compression nut for the fuel inlet pipe to the torque 18±2N.m (this value is not the final tightening torque for the high-pressure fuel joint fixing nut);

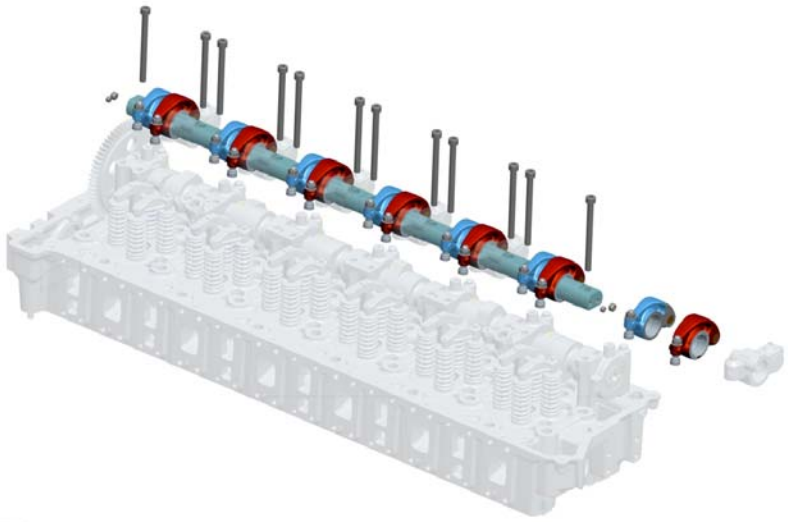
f) Tighten the injector pressure plate bolt to torque 17±2N.m, and then turn it by 90º±5º;

g) Tighten the clamp nut for fuel inlet pipe to torque 55±2N.m;

h) After completely installing the injector, check the tightness of its gaskets and O seal rings. At the fuel return port of the cylinder head, blast with pressure 300-500kPa for 30s, and check whether there is leakage at the mounting position of injector. If leakage exists, according to the procedures reverse to the above, remove the injector and the fuel inlet pipe, and check the gaskets and O seal rings. If there is damage, replace the components of injector and the fuel inlet pipe. After reinstallation, re-check the tightness of gaskets and O seal rings until no leakage exists.

4.2.14 Installation of components in cylinder head cover

4.2.14.1 Assembling of rocker arm components



Sealant requirements: Screw plugs should be coated with Loctite 567 or equivalent.

Assembling requirements:

1) Install the screw plugs into both ends of rocker arm shaft without extending out of the shaft ends;

2) Successively install the intake valve rocker arm, the exhaust valve rocker arm and the braking rocker arm (if no braking rocker arm is provided, shim block should be installed) into the rocker arm shaft, then fit rocker arm shaft bolt to the shaft, and install the rocker arm shaft on the camshaft support;

3) Adjust the intake valve clearance to 0.40±0.05mm, the exhaust valve clearance to 0.65±0.05mm, and adjust the tightening torque of nuts to 40 N.m.

***Note:** The rocker arm shaft now used is of non-brake type, and its difference is that the oil duct on the end of braking rocker shaft has been plugged and the braking rocker arm is replaced by spacer ring, and there is no need to install braking valve bridge or braking rocker arm compression spring.

4.2.14.2 Assembling of valve train

Check the number and successively install the base of camshaft;

Install the lower bearing of camshaft, and oil the bearing surface;

Preassemble the adjusting gear, gear shaft and pressure plate of camshaft according to corresponding marks;

Pretighten the hex socket head cap screw GB/T70.1-M10×45-10.9 (3×);

Check the rotating condition of adjusting gear and the thrust clearance;

Preassemble the camshaft and gear components according to corresponding marks;

Install the upper bearing of camshaft, and oil the bearing surface;

Check the number and successively install the upper cover of camshaft;

Install the intake valve bridge with the opening toward camshaft;

Install the exhaust valve bridge with the brake end toward camshaft;

Install the locating pin GB/T119-A5×12 (4×), the rocker arm and rocker arm shaft components;

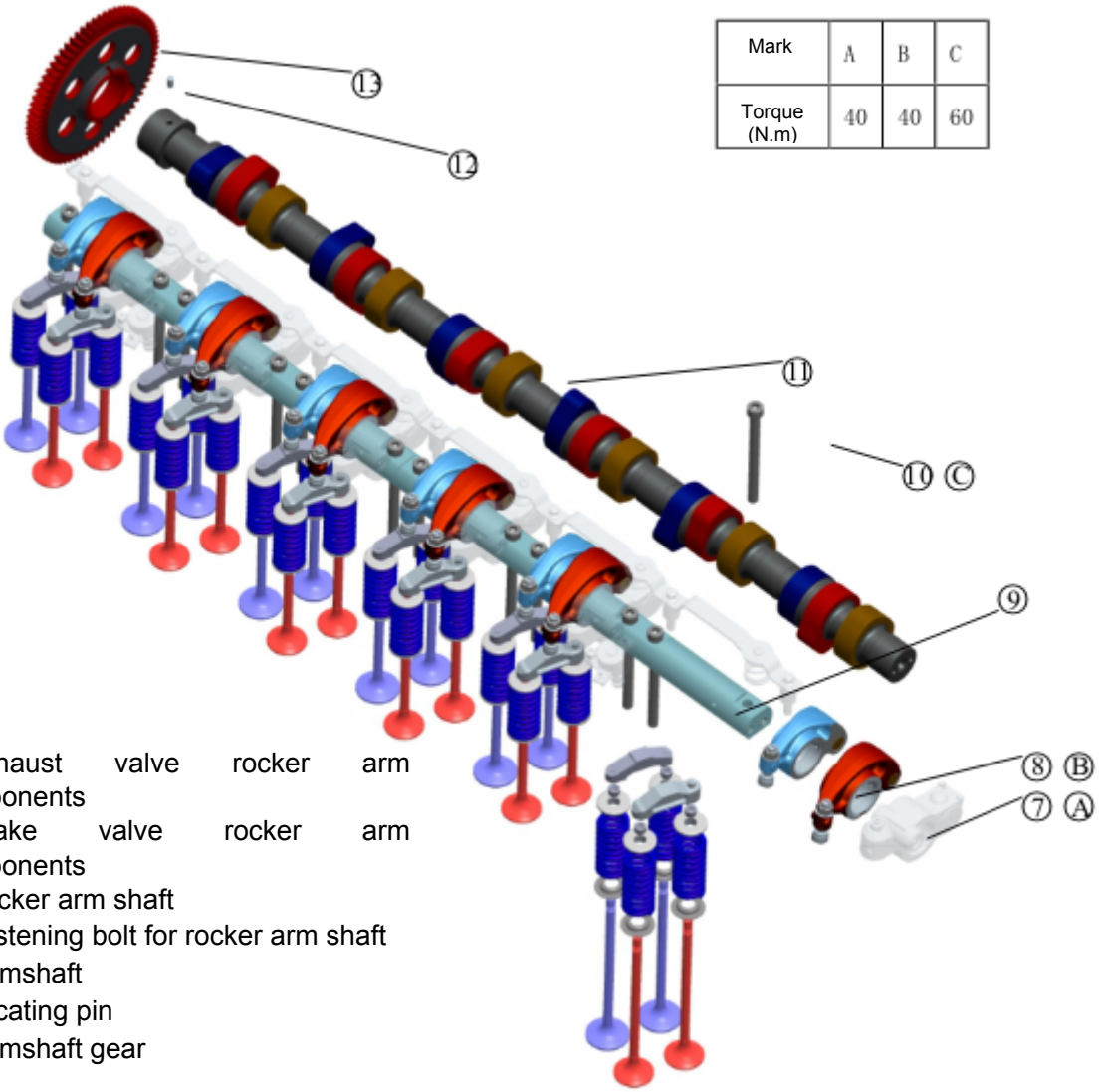
Fasten the bolts for rocker arm and camshaft;

Measure the thrust clearance of camshaft;

Adjust the clearance of the camshaft adjusting gear, and tighten the bolts for adjusting gear. Then check the backlash of gear pair which should be 0.087-0.25mm. After the check, make a mark with white paint marker;

The seal ring for the adjusting gear cover plate should be oiled with vaseline before installed; tighten the fastening bolts M8×20 (2×);

Adjust the intake valve clearance to 0.40±0.05mm, the exhaust valve clearance to 0.65±0.05mm, and the exhaust braking valve clearance to 4.10±0.05mm.



Mark	A	B	C
Torque (N.m)	40	40	60

⑦Exhaust valve rocker arm components
⑧Intake valve rocker arm components
⑨Rocker arm shaft
⑩Fastening bolt for rocker arm shaft
⑪Camshaft
⑫Locating pin
⑬Camshaft gear

Assembling requirements:

1) Successively install valve spring, the upper seat of valve spring and the valve locker, and press them with special tool. Then install the intake valve bridge with the opening toward camshaft and the exhaust valve bridge with the slide block end toward camshaft;

2) Press the locating pin into the camshaft, heat the camshaft gear and fit it into camshaft;

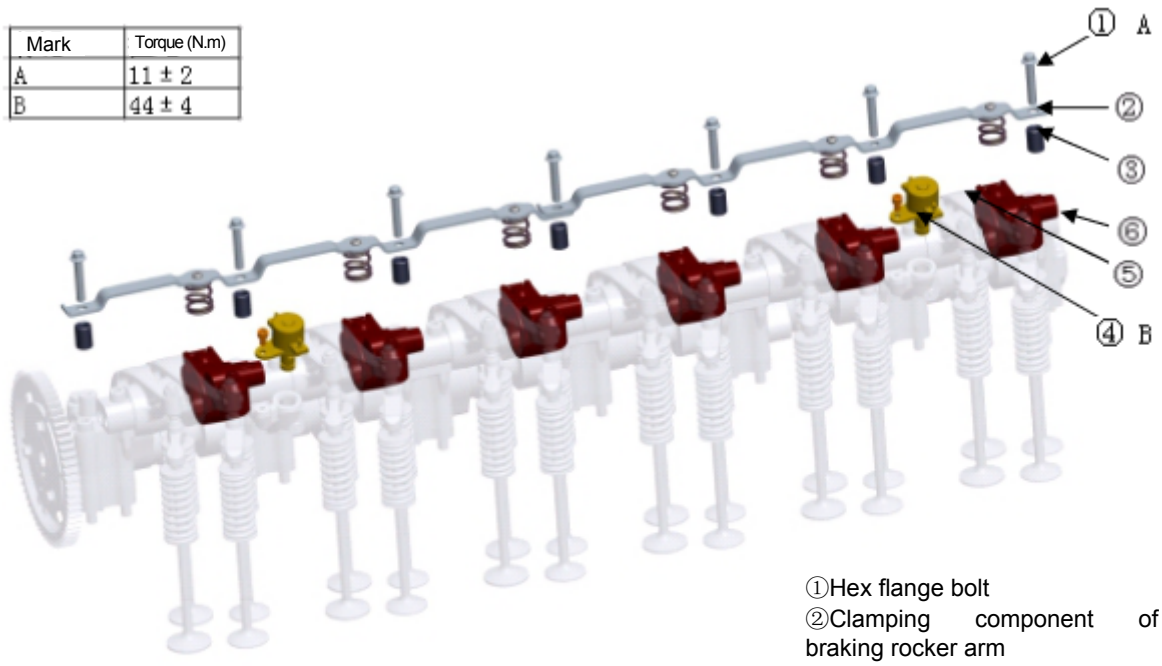
3) When installing the camshaft supports (refer to the above chapter), place the camshaft before tightening the bolts;

4) Successively install the intake valve rocker arm, the exhaust valve rocker arm and the braking rocker arm (if no braking rocker arm is provided, shim block should be installed) into the rocker arm shaft, then fit rocker arm shaft bolt to the shaft, and install the rocker arm shaft on the camshaft support;

5) Adjust the intake valve clearance to 0.40±0.05mm and the exhaust valve clearance to 0.65±0.05mm, and adjust the tightening torque for bolt nut referring to A and B.

4.2.12.3 Installation of engine retarder (exhaust brake assembly)

Mark	Torque (N.m)
A	11 ± 2
B	44 ± 4



①Hex flange bolt
②Clamping component of braking rocker arm
③Shim block
④Hex socket head cap screw
⑤Solenoid valve
⑥Braking rocker arm component

Assembling requirements:

1. Install the braking rocker arm component

Fit the braking rocker arm component ⑥×6 into the rocker arm shaft (at the same time, fit the intake rocker arm and exhaust rocker arm), and fasten the rocker arm shaft on the seat with long bolt.

2. Install the solenoid valve

Install the solenoid valve ⑤×2 into hole on the rocker arm seat, and fasten it with hex socket head cap screw ④×2 (torque 11±2N.m).

*Note: When installing the solenoid valve, the joint face should fit to avoid leakage.

3. Install the clamping component of braking rocker arm

Install the clamping component ②×2 of braking rocker arm, press the components with spring and install shim block ③×7, and fasten the blocks on the seat of rocker arm with hex flange bolts ①×7 (torque 44±4N.m).

4. Adjust the braking clearance

Open the engine hood, check the gear flange of camshaft numbered with 1-5-3-6-2-4 and the groove position on the rocker arm seat of No. 6 cylinder, and turn the engine with barring tool. Then adjust the braking clearances of corresponding cylinders in relation to the groove respectively in accordance with number on the camshaft gear, and use feeler gauge to adjust the clearance between braking rocker arm and exhaust valve to be 4.25mm.

***Note:** The No. 6 cylinder is on the gear end of engine, and the No. 1 cylinder is on the belt end.

4.2.14.4 Installation of harness in cylinder

Install the brake solenoid valve and its O seal ring B00002472, and tighten the bolt M6×10;

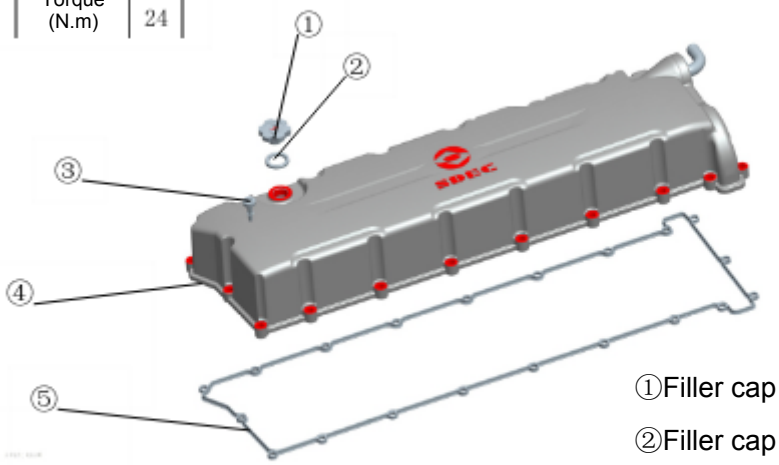
Mount the harness support, shim block, and gaskets, and tighten the bolt GB/T5783-M6*50;

Connect the harness in the cylinder, apply vaseline to the seal ring for the harness connector, and then put the connector through the cylinder head hole. Afterwards, insert the plate spring and fasten it with bolt;

Connect injectors of all cylinders and the terminal bolts of solenoid valve, and then fasten them with nylon cable ties.

4.2.15 Installation of cylinder head cover assembly

Mark	A
Torque (N.m)	24



①Filler cap

②Filler cap seal ring

③Bolt for cylinder head cover

④Cylinder head cover assembly

⑤Gasket for cylinder head cover

Assembling requirement:

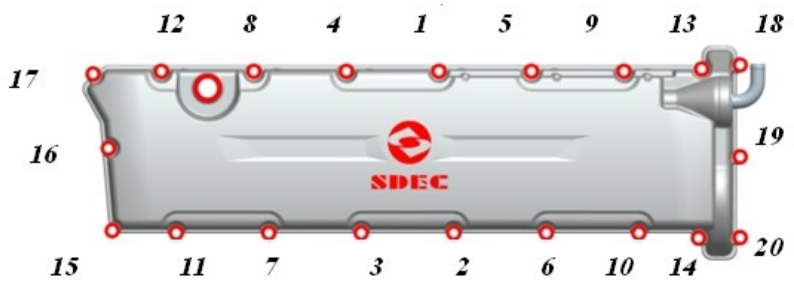
1) Install the cylinder head cover gasket ⑤ into the groove of cylinder head cover component ④;

2) Install 20 bolts ③ for cylinder head cover into the mounting holes of cylinder head cover component ④, and alternately tighten the bolts (size M8) to torque 24N.m in the illustrated order below;

3) Install the filler cap seal ring ② onto the filler cap ①;

4) Install the filler cap ① on the cylinder head cover assembly, and tighten it with hand.

Note: Before tightening bolts ③ for cylinder head cover, check whether the gasket for cylinder head cover is at the right position or not.



4.2.16 Installation of fuel pipe

When installing high-pressure fuel pipe, do not tighten it by force, just turn it with hand and then tighten it with tool to avoid higher installation stress.

When screwing the fuel rail to the high-pressure pipe, make sure the fuel rail is loose, and then screw in sequence the high-pressure fuel pipe (do not tighten it), the fuel rail, and the high-pressure fuel pipe.

The fuel inlet and outlet of fuel transfer pump for 12L and 10L engines are just opposite; note not to install the low-pressure pipe mistakenly.

The torque of nut for fastening fuel pump and fuel rail is 33±2N.m.

Change the installation torque for high-pressure fuel pipe in the tightening table to 33±2N.m.

4.2.16.1 Assembling of high-pressure pipe

Install the high-pressure common rail, and tighten the special hex head bolt;

Install the common rail fuel return pipe bracket, and tighten the nuts;

Successively install the high-pressure fuel pipes of No. 1 to 6 cylinders;

Install the common rail fuel inlet pipe;

Tighten the high-pressure pipe to the torque of 45±2N.m.

4.2.16.2 Installation of low-pressure pipe

Install the support for fuel filter, and tighten the bolts M8×35 (4×);

Install the fuel filter assembly, and tighten the bolts M10×35 (2×);

Install the common rail fuel return pipe and link bolt M14×1.5;

Install the clamps (3×) for common rail fuel return pipe;

Install the fuel return pipe of cylinder cover and link bolt;

Install the fuel pump return pipe joint and link bolt;

Install the fuel filter inlet pipe and link bolt M16×1.5;

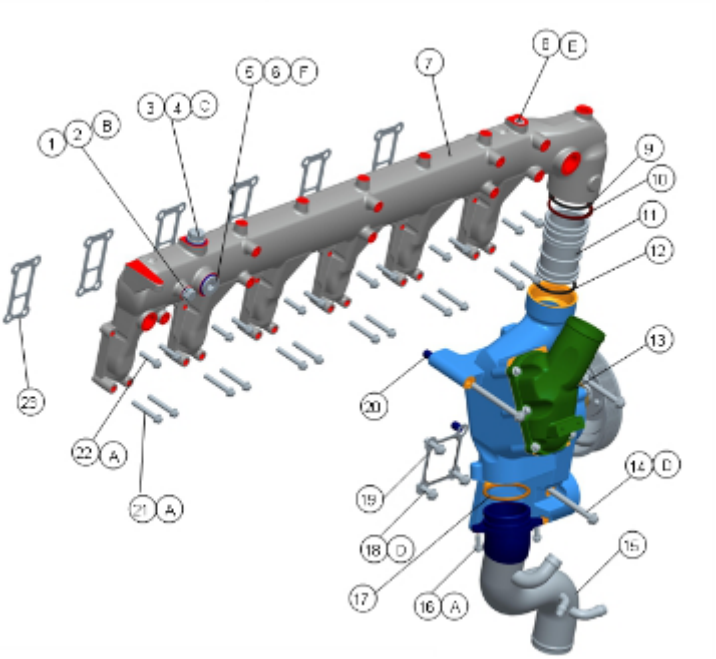
Install the fuel filter outlet pipe and link bolt M16×1.5;

Install the fuel transfer pump inlet joint and link bolt M16×1.5.

4.2.17 Installation of lubrication system

10.17.1 Installation of cooling system

Mark	A	B	C	D	E	F
Torque (N.m)	30	—	—	58	25	—



① Hex head plug M14 ② Copper washer

③ Hex head plug M22 ④ Copper washer

⑤ Hex socket head plug M27 ⑥ Copper washer

⑦ Main water return pipe ⑧ Hexagon socket tapered screw plug NPT3/8

⑨ Rubber O-ring ⑩ Shaft retainer ring

. Water pump return pipe . Rubber O-ring

. Fresh water pump assembly .Hex flange bolt M10

. Water pump inlet pipe . Hex flange bolt M8

. Rubber O-ring . Hex flange bolt M10

 Gasket for water pump outlet . Locating sleeve

21. Hex flange bolt M8 22. Hex flange bolt M8

23. Gasket for main water return pipe

Assembling requirements:

(1) Install the locating sleeve (2×) on the engine block, successively install gasket for water pump outlet and the water pump, and tighten the bolts M10×105 (3×) and M10×30 (3×);

(2) Install the rubber O-ring into the groove of water pump inlet pipe, and after oiling it with vaseline, assemble it into the inlet. Finally tighten bolts M8×20 (2×);

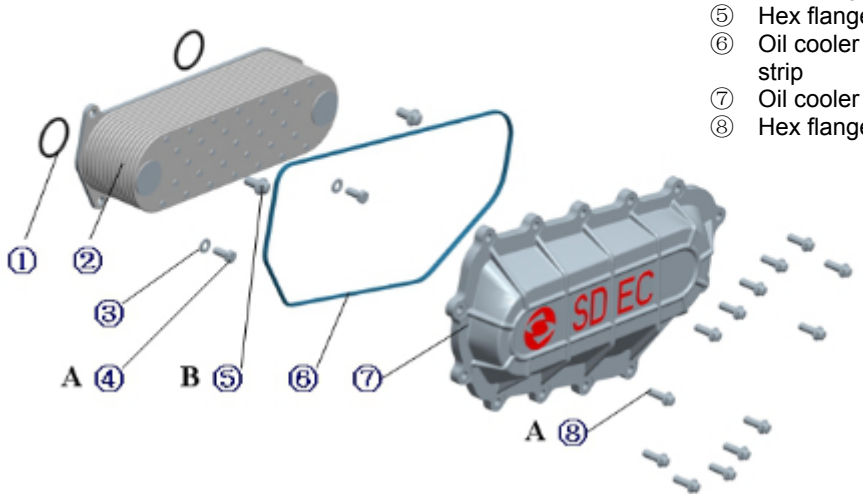
(3) Install one rubber O- ring into the groove on each end of water return connecting pipe. The upper seal ring is S00006560 and the lower is S00006561; do not install them reversely. Install the shaft retainer ring on the water return connecting pipe with lock spring clamp. After applying vaseline to O-rings on both ends, install the pipe to the water return port;

(4) Install the gaskets (6×) for main water return pipe and the pipe, and insert the main water return pipe to the water pump return connecting pipe from top down. Then tighten the bolts M8×55 (12×) and M8X35 (12×) onto the cylinder head from the middle to both sides alternately. Finally, install the hex head plugs M14×1.5 and M22×1.5, hex socket head plug M27×1.5 and corresponding gaskets, as well as the hexagon socket tapered screw plug.

4.2.17.2 Installation of oil cooler

4.2.17.2.1 Installation of 10E oil cooler

Mark	A	B
Torque (N.m)	21.6	43



① Rubber O-ring
② Oil cooler
③ Washer
④ Hex flange bolt
⑤ Hex flange bolt
⑥ Oil cooler sealing strip
⑦ Oil cooler cover
⑧ Hex flange bolt

Assembling requirements:

Installation of oil cooler and oil cooler cover:

1. Install the seal ring for oil path of oil cooler;

2. Install the oil cooler:

Fastening bolt ④ (GB/T5783-M8*20-ZN.D)

Plain washer ③ (GB/T97.1-8-200HV-ZN.D)

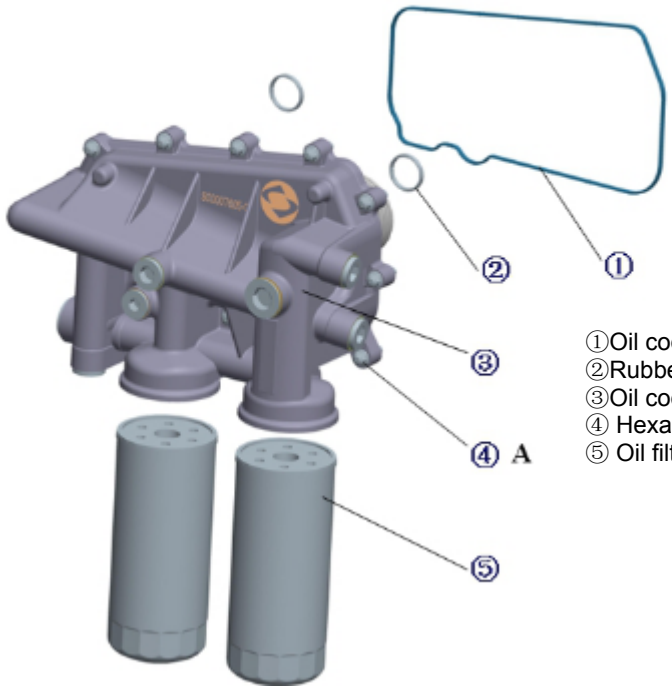
Fastening bolt ⑤ (Q/SC622-M10*20-ZN.D);

3. Install the oil cooler sealing strip ⑥, which should fit the groove closely without twisting;

4. Install the oil cooler cover and the fastening bolt ⑧ (Q/SC622-M8×25).

4.2.17.2.2 Installation of 12E oil cooler

Mark	A
Torque (N.m)	43



①Oil cooler sealing strip
②Rubber O-ring
③Oil cooler and oil filter head assembly parts
④ Hexagon flange bolt
⑤ Oil filter component

Assembling requirements:

1. Install the oil cooler sealing strip ①, which should fit the seal groove closely without twisting;

2. Install the rubber O-ring of the oil path ②;

3. Use the guide pin to install the oil cooler and the oil filter head assembly parts ③;

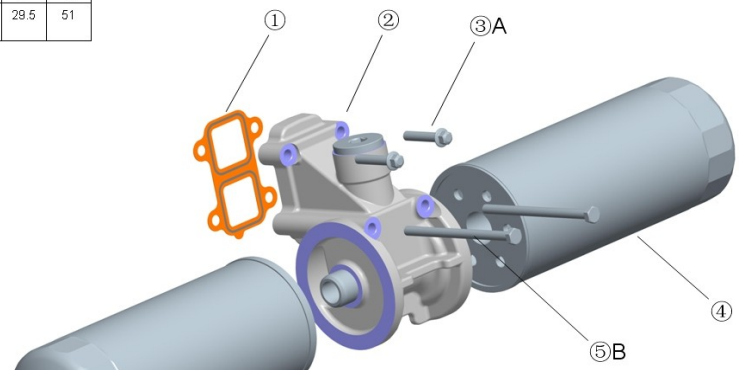
Tighten the bolt ④ (GB/T16674.1-M10×35);

4. Install the oil filter component

Note: Apply clean oil onto the oil filter sealing surface, fill the oil filter with clean oil, and install the filter on the filter head according to the oil filter manufacturer's instructions.

4.2.17.3 Installation of oil filter

Mark	A	B
Torque (N.m)	29.5	51



①Oil filter head gasket
②Oil filter head assembly
③Hexagon flange bolt M8×40 (2×)
④Oil filter component
⑤Hexagon head bolt M8×120 (2×)

Assembling requirements:

1) Install the oil filter head component, and tighten the fastening bolts ③ and ⑤;

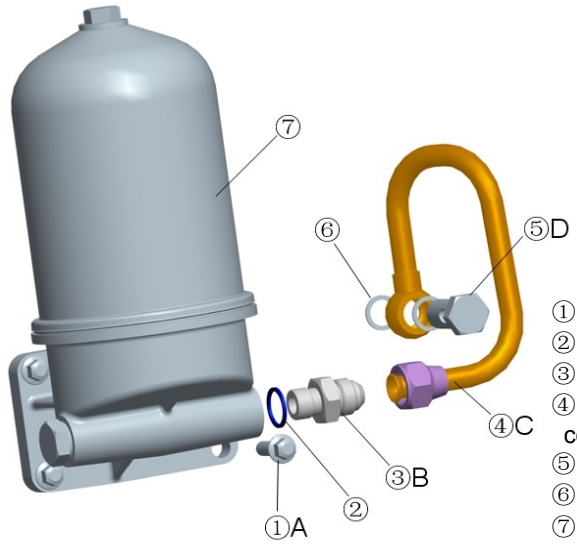
2) Install the oil filter component;

***Note:** 1) The oil filter head gasket should be placed with the flange downwards.

3) Apply clean oil onto the oil filter sealing surface, and install the filter on the filter head according to the oil filter manufacturer's instructions.

4.2.17.4 Installation of rotor filter

Mark	A	B	C	D
Torque (N.m)	29.5	35	45	38



① Hexagon flange bolt M8×25 (4×)
② Copper washer 18×22
③ Rotor filter oil inlet joint
④ Oil rotor filter connecting pipe components
⑤ Link bolt (M16)
⑥ Washer Q/SC642.1-03-14 (2×)
⑦ Centrifugal oil filter components

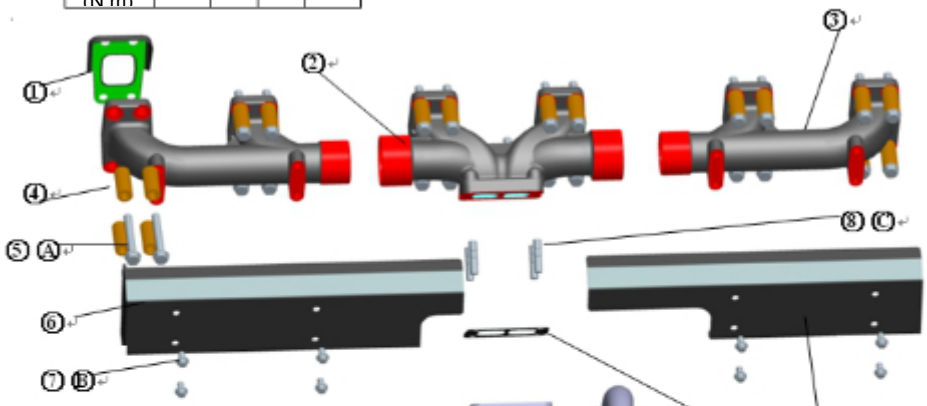
Assembling requirements:

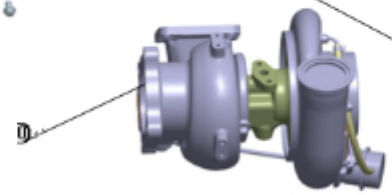
1) Install the centrifugal oil filter components;

2) Install the oil rotor filter connecting pipe components.

4.2.18 Installation of exhaust pipe and supercharger

Mark	A	B	C	D
Torque (N.m)	65	32	65	65





①Exhaust pipe gasket
②Intermediate part of exhaust pipe
③Front and rear parts of exhaust pipe
④Exhaust pipe bolt shim block
⑤Exhaust pipe bolt
⑥Heat shield (front)
⑦Heat shield fastening bolt
⑧Double-ended bolt
⑨Turbine inlet gasket
⑩Supercharger

⑪Supercharger self-locking nut

Sealant requirements:

Before the assembly, precoat heat shield fastening bolt (7), front and rear parts of exhaust pipe (3) and double ended bolt (8) with Loctite 7673 anti-caking agents or the equivalent.

Assembling requirements:

1) Connect the front and rear parts of exhaust pipe (2) with the intermediate part of exhaust pipe (3), and install the exhaust pipe gasket (1), bolt shim block (4) and exhaust pipe bolt (5). Then tighten the exhaust pipe bolt (5) to the specified torque value of 65N.m (bolt M10) in the order shown below;

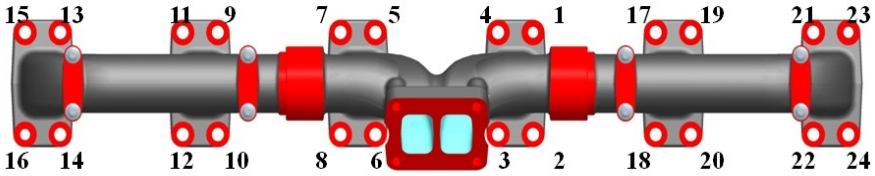
2) Screw the round head end of the double ended bolt (8) into the exhaust pipe and check if it is completely tightened;

3) Install the turbine inlet gasket;

4) Install the supercharger, and tighten the supercharger self-locking nut (11);

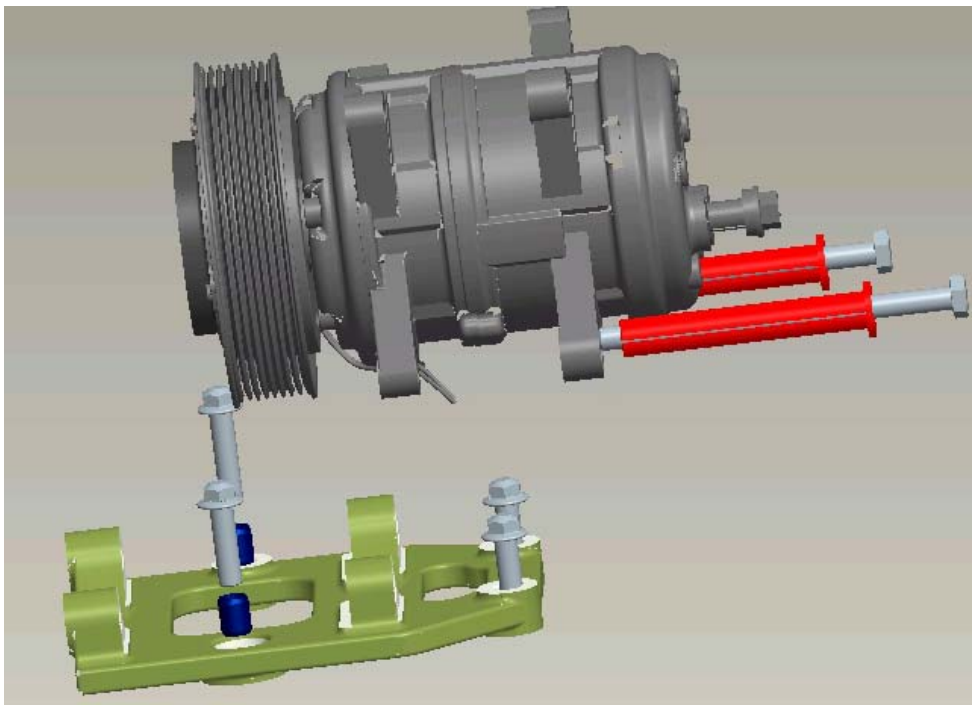
5) After installing the supercharger, add a little oil to the filler;

6) After installing the front and rear exhaust pipe heat shields, tighten the heat shield fastening bolts (7).



4.2.19 Installation of A/C and alternator, etc.

10.19.1 Installation of A/C compressor



1. A/C compressor assembly 2. Fastening bolt M10 3. Locating sleeve

4. Fastening bolt M10 5. A/C bracket 6. Bracket spacer

7. Fastening bolt M8

Assembling requirements:

1. Install the locating sleeve (2×) (3) and the bracket (5) onto the engine block. During the installation, align the locating sleeve with the hole on the bracket, and tighten the fastening bolts 2 and 4 to the torque value of 85 N.m;

2. Install A/C (1), insert the spacer (2×) (6) into the installation feet of the bracket and A/C, and tighten fastening bolt M8 (2×) (7) to the value of 63N.m.

4.2.19.2 Installation of alternator

Install the alternator bracket locating spacer (2×);

Install the alternator bracket, and tighten the fastening bolt GB/T16674.1-M10×45-8.8 (2×);

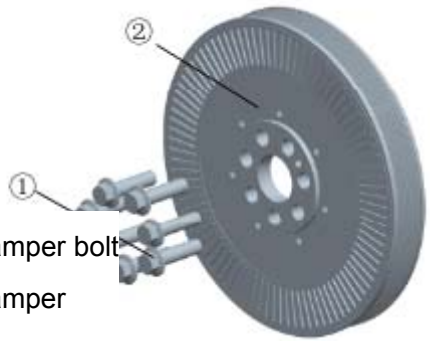
Install the alternator brace, and tighten the fastening bolt GB/T16674.1-M10×20-8.8 (2×);

Install the alternator, split socket pin, and tighten the fastening bolt GB/T16674.1-M10×90-8.8;

Tighten the brace fastening bolt GB/T16674.1-M10×30-8.8.

4.2.20 Installation of front accessory drive system of vibration damper

4.2.20.1 Installation of vibration damper



① Vibration damper bolt

② Vibration damper

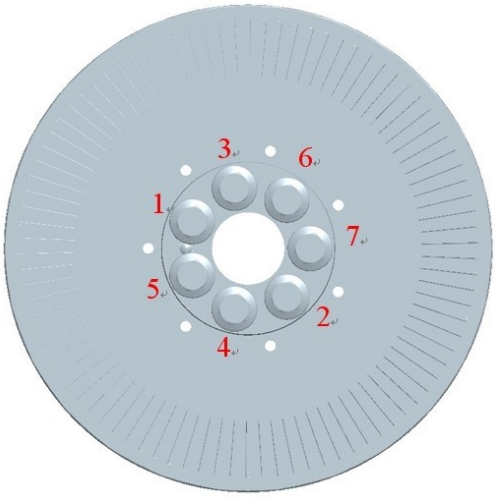
Installation requirements:

1) Install the vibration damper and the fastening bolts (M14×1.5);

2) The vibration damper bolts should be tightened by turns in two steps as follows:

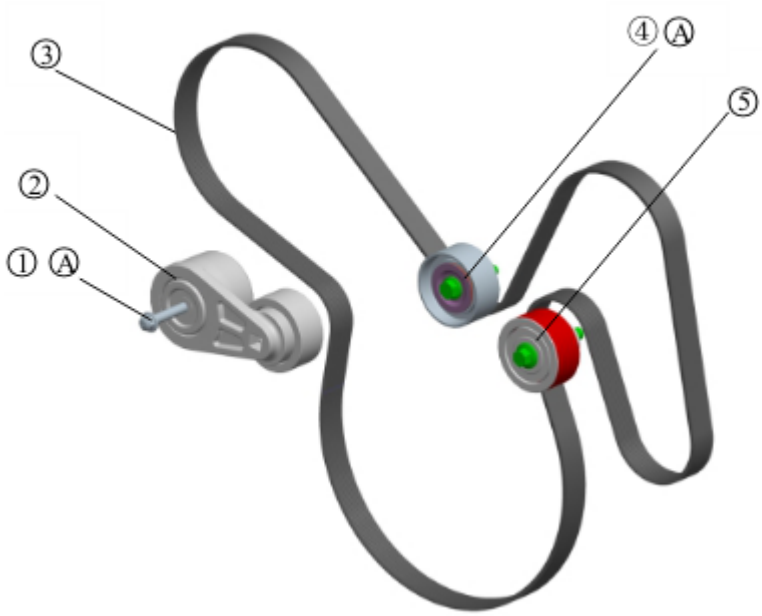
Tool S=18” socket

1st step: 85±4N.m
2nd step: turning angle 60º±5º.



4.2.20.2 Installation of front accessory drive system

4.2.20.2.1 Installation of accessory main drive system



Mark	A	B
Torque (N.m)	50	105

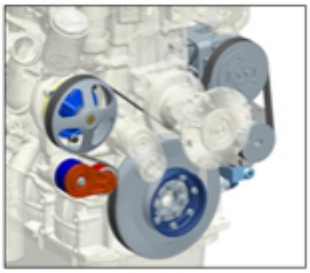
① Tensioner fastening bolt

② Tensioner component

③ Poly V-belt

④ Idler component (with fastening bolt)

⑤ Idler component (with fastening bolt)

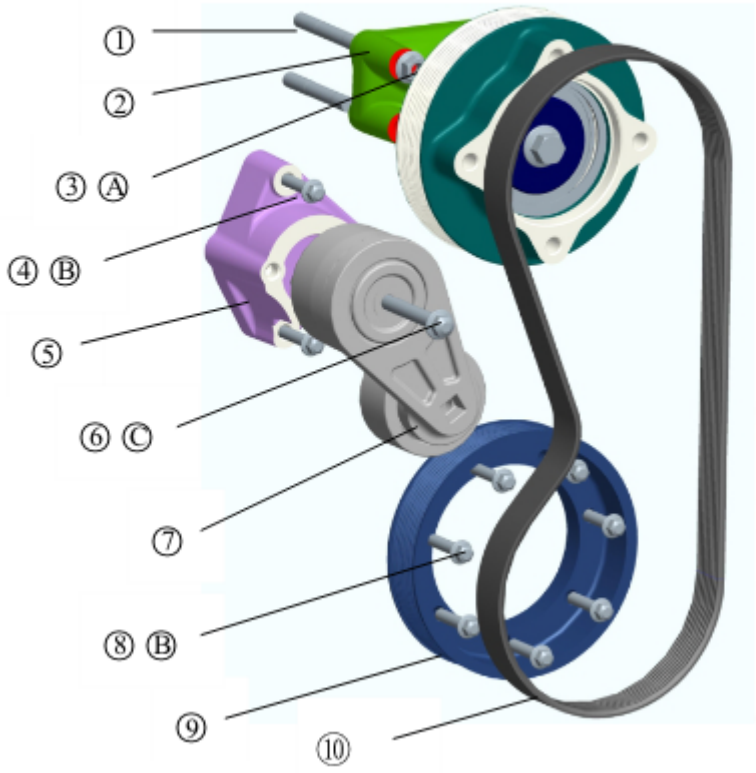


Assembling requirements:

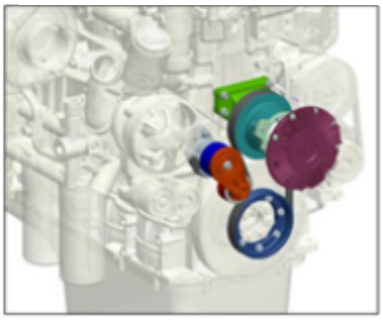
Install the belt onto each accessory pulley and the idler in accordance with the path shown above. Rotate the tension arm (13mm) clockwise, and install the belt onto the tensioner. Make sure that the belt is installed in the center of the pulley.

4.2.20.2.2 Installation of fan drive system

Mark	A	B	C
Torque (N.m)	45	22	50



① Stud
② Fan bearing seat component
③ Fan bearing seat fastening nut
④ Tensioner bracket fastening bolt
⑤ Tensioner bracket
⑥ Tensioner component fastening bolt
⑦ Tensioner component
⑧ Crankshaft front end pulley fastening bolt
⑨ Crankshaft front end pulley
⑩ Poly V-belt



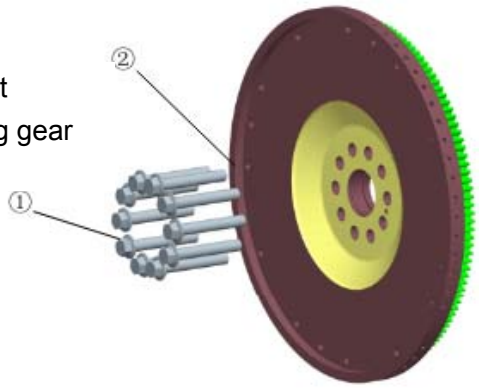
Assembling requirements:

Install the belt onto the crankshaft front end pulley and fan pulley. Rotate the tension arm (13mm) clockwise, and install the belt onto the tensioner. Make sure that the belt is installed in the center of the pulley.

4.2.21 Installation of flywheel ring gear assembly parts and starting motor

4.2.21.1 Installation of flywheel ring gear assembly parts

① Flywheel bolt
② Flywheel ring gear assembly parts



Assembling requirements:

1) When installing the flywheel screw bolt ①, apply a little oil to its threads and support surfaces;

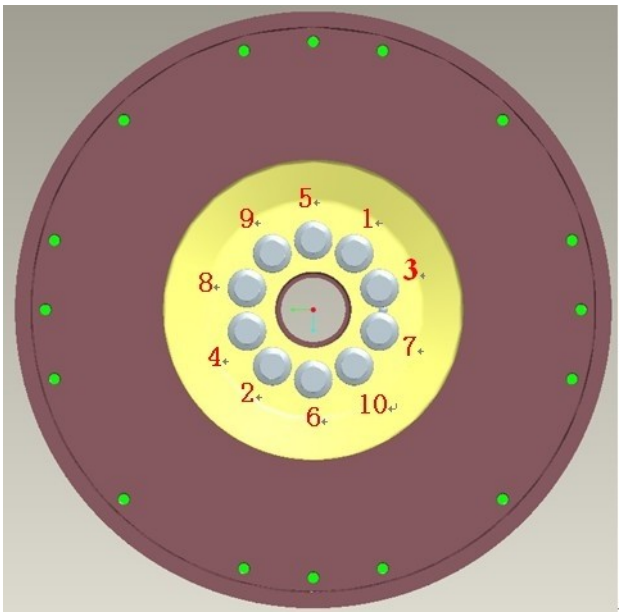
2) The flywheel screw should be tightened as per the sequence shown below and in three steps by turns:

1st step: 155±8N.m

2nd step: 90º±5º

3rd step: 90º±5º

3) After the flywheel is installed, check that the circular runout of clutch fitting surface against the crankshaft centerline should not exceed 0.20mm, and the radial runout of clutch bearing hole not exceed 0.15mm.



Chapter 5 Operation and Maintenance of Diesel Engine

5.1 Selection and use of fuel

The sulfur content of diesel fuel directly influences the emission of diesel engine. The sulfur content of diesel fuel of diesel engine should be lower than 0.05%; the grade of diesel fuel used by the diesel engine should be determined according to the ambient temperature. The diesel fuel with low condensation point is recommended for winter and that with high condensation point for summer. The specifications of fuel used by the diesel engine should conform to the provisions of GB/T 19147-2003. The applicable region of fuel grade should refer to GB/T 19147-2003. Users can select the fuel according to the suggestions in the following table: for example, -35# diesel fuel for ambient temperature -27°C.

Relationship between diesel fuel grade and applicable minimum air temperature

Diesel fuel grade	0#	-10#	-20#	-35#
Cetane number	50	50	45	43
Condensation point (°C)	0	-10	-20	-35
Applicable min. air temperature (working environment temperature of diesel fuel, °C)	Above 4°C	Above -5°C	Above -14°C	Above -29°C

The diesel fuel must be kept very clean, and not polluted by dust or sundries. Before being filled into the fuel tank, the diesel fuel should be placed statically for more than 72 hours, and the upper layer is recommended for use. This is vital for the prevention of early wear of fuel injection pump plunger.

5.2 Selection and use of oil

In order to ensure the normal operation and long life of diesel engine and to reduce the emission of diesel engine, the special “Shangchai” CH-4 lubricating oil should be used. In case that “Shangchai” oil is inapplicable, the lubricating oil meeting the requirements of API is recommended: CH-4 multi-stage oil. The appropriate oil viscosity grade is determined according to the minimum ambient temperature when the diesel engine is cold and the maximum ambient temperature when the diesel engine is running.

The data in the minimum temperature column in the following table should be used to determine the oil viscosity required for starting a cold diesel engine.

The data in the maximum temperature column in the following table should be used to select the oil viscosity for the expected maximum operating temperature.

Applicable working temperature range of lubricating oil

Viscosity of engine lubricating oil		
Viscosity grade of Shangchai and API CH-4	Ambient temperature	
	Min.	Max.
SAE 0W20	-40°C	10°C
SAE 0W40	-40°C	40°C
SAE 5W40	-30°C	40°C
SAE 10W30	-20°C	40°C
SAE 15W40	-10°C	40°C
SAE 20W50	0°C	50°C

5.3 Selection and use of coolant

The coolant should meet the following requirements:

The antifreeze can not only avoid coolant freezing, but also increase the boiling point of coolant. Therefore, we require the use of antifreeze under any weather conditions.

The specific heat and thermal conductivity of water and glycol are higher so their mixture is recommended as the antifreeze of diesel engine cooling system. The content of silicate (sodium silicate anhydrous), oxide and acetic acid in the antifreeze should not exceed 1000PPM, 5PPM and 100PPM respectively.

The concentration of glycol in the antifreeze within 40%~60% is recommended.

The water and glycol should be mixed uniformly before adding the coolant into the engine.

Normally, the freezing pint of selected antifreeze should be lower than the minimum temperature of applicable region of diesel engine by about 10°C.

Note: The coolant should be changed once every two years.

5.4 Starting of diesel engine

Before operating the engine, the oil, fuel and coolant with suitable specifications should be selected according to the specific operation environment and conditions. Before starting, the following tasks are required:

1) Check the diesel engine and starting system, and timely solve the trouble if any;

2) Check if the maintenance indicator of air filter has red plunger.

Note: Never start the engine without air filter, so as to avoid its early wear.

3) Check if the oil level is within the stipulated scope.

4) Check if the cooler fluid level is within the stipulated scope.

5) If there is any air in the fuel system because the diesel engine is out of use for days, or the fuel filter is justly renewed, the fuel system should be oiled and exhausted.

6) Check if the electric starting circuit is normal.

7) All safety protectors must be installed in place. Check if the accelerator pedal moves freely.

5.4.1 Normal start

Notices for normal starting of diesel engine:

Detach the diesel engine from the drivetrain or set the transmission into neutral gear.

Turn on the electrical switch and the mechanical controller.

Note: To avoid damaging the starting motor, the engagement time should not exceed 30s, and the secondary starting interval is 2 min.

(1) The oil pressure gauge of diesel engine must show a reading within 15s after the engine starts. If no oil pressure is shown within 15s, shut down the engine immediately and find out the cause in order to avoid damaging the diesel engine.

(2) After the cold start of diesel engine, firstly run the engine at low idle speed for 3-5min till the water temperature shown on the gauge starts to increase, and slowly accelerate the engine to ensure that the bearing is well lubricated and the oil pressure is stable.

(3) Idle the engine (at 600-800 r/min) for 3-5min before increasing the load. No acceleration or loading is allowed immediately after the diesel engine starts and before the oil pressure shown on the oil pressure gauge is normal.

(4) When the diesel engine is running under small load, preheat it till the systems reach the operating temperature. During the preheating and working period, check if the operation of every instrument is normal.

5.4.2 Cold start

At temperature above -10°, the diesel engine can be started smoothly without any preheating. According to the different matching requirements of vehicle, in winter when the temperature is lower, the intake air preheater is used as auxiliary starter.

Note: If the engine is not or cannot be started within 30s after the indicator begins to flash, the electronic controller will automatically cut off the preheating circuit, solenoid valve circuit and indicator circuit to perform delay protection. At this time, turn the key back to OFF position, keep it at this position for 5s, and repeat the steps above to start the engine.

5.4.3 First start after long-time shutting down and oil change

To start the engine after the oil is changed or the shutting-down lasts for more than 30 days, the lubrication system must be fully oiled.

(1) Release the accelerator pedal to avoid the ignition and starting of diesel engine.

(2) Rotate the crankshaft with starting motor till the oil pressure gauge shows the pressure.

(3) Press the accelerator pedal.

(4) Start the diesel engine according to the normal or cold start procedures.

(5) Bleed the air in the fuel system.

5.5 Operation of diesel engine

At a speed lower than the maximum torque, the continuous running of the diesel engine at full throttle (accelerator pedal pressed to the bottom) can last for 1min at most.

Regularly check the oil pressure gauge and coolant temperature gauge; in case of abnormality, shut down the vehicle to check the engine.

Note: The continuous running of diesel engine with the coolant temperature lower than 60°C. or higher than 100°C. will damage the engine.

If the diesel engine is too hot, it is required to decelerate and/ gear down till the engine temperature becomes normal; otherwise, check and repair the engine according to “Troubleshooting”.

When driving down a steep slope, it is required to use the transmission gear and brake to control the speed of both vehicle and diesel engine; when climbing a slope with a gear engaged, a suitable transmission gear matching with the vehicle speed during climbing should be engaged; and when the climbing speed is high, higher gear should be engaged to avoid the backward hauling and overspeed running of diesel engine because of vehicle rushing.

Note: Running the diesel engine at overspeed (the rotation speed is higher than no-load permissible maximum speed) may damage it.

5.6 Shutdown of diesel engine

Before stopping the engine, it is required to unload and decelerate the engine. Run the engine at a low speed for 3-5min, and decrease the speed of supercharger sharply, in order to do good the diesel engine and supercharger.

The “acceleration – shutdown – neutral coasting” running of diesel engine is prohibited.

If the diesel engine will be out of use for some time, it should be well cleaned and necessary oil seal measures should be taken to prevent rust.

5.7 Maintenance schedule of diesel engine

The maintenance period and content of diesel engines of this series are listed in the following table. Users should perform periodic service and maintenance according to this table. If the diesel engine often operates in a region with temperature lower than -18°C. or higher than 38°C. or in a dusty area, or in case of frequent vehicle shutdown, the maintenance period should be shortened properly.

	Routine maintenance or oiling	Every 2.5 weeks, 50 hours or 2,000km	Every 3 months, 250 hours or 10,000km	Every 6 months, 500 hours or 19,000km	Every 12 months, 1,000 hours or 38,000km	Every 2 years, 2,000 hours or 77,000km
Check the engine periphery	●	●	●	●	●	●
Check the fuel tank	●	●	●	●	●	●
Check the maintenance indicator of air filter	●	●	●	●	●	●
Check the oil level	●	●	●	●	●	●
Check the coolant level	●	●	●	●	●	●
Check the oil and water separator	●	●	●	●	●	●
Check the drive belt	●	●	●	●	●	●
Check the cooling fan	●	●	●	●	●	●
Replace the oil and oil filter			●	●	●	●
Replace the diesel fuel filter				●	●	●
Change the coolant						●
Adjust the valve clearance					●	●
Adjust the exhaust brake					●	●
Check the air filter		●	●	●	●	●
Check the intake system			●	●	●	●
Check the air bleed of fuel system				●	●	●
Check the belt tensioner bearing					●	●
Check the tension of belt					●	●
Check the fan drive bearing						●
Check the thermostat						●
Check the injector						●

Chapter 6 Engine Electronic Control System

6.1 Fuel system and electronic components

The fuel system structure of the Shangchai E-series diesel engine is as shown in Fig. 1-1, including high pressure fuel path and low pressure fuel path.

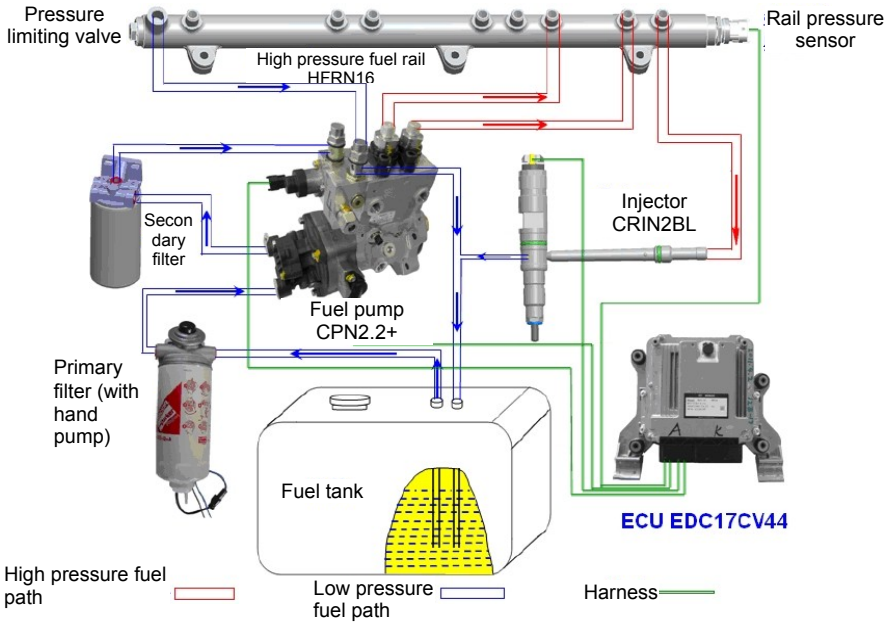


Fig. 1-1 Sketch of fuel system structure of Shangchai E-series diesel engine

6.1.1 High pressure fuel pump

The fuel system high pressure pump of the Shangchai E-series diesel engine adopts Bosch in-line plunger pump. The models of SC10E and SC12E high pressure fuel pumps are CPN2.2 and CPN2.2+ respectively. The outlines of these two pumps are basically the same. See Fig.1-2 sectional view of the high pressure fuel pump. You cannot distinguish them from the appearance, but from the Shanghai diesel engine models. The characteristics comparison between these two pumps is made in Table 1.1.

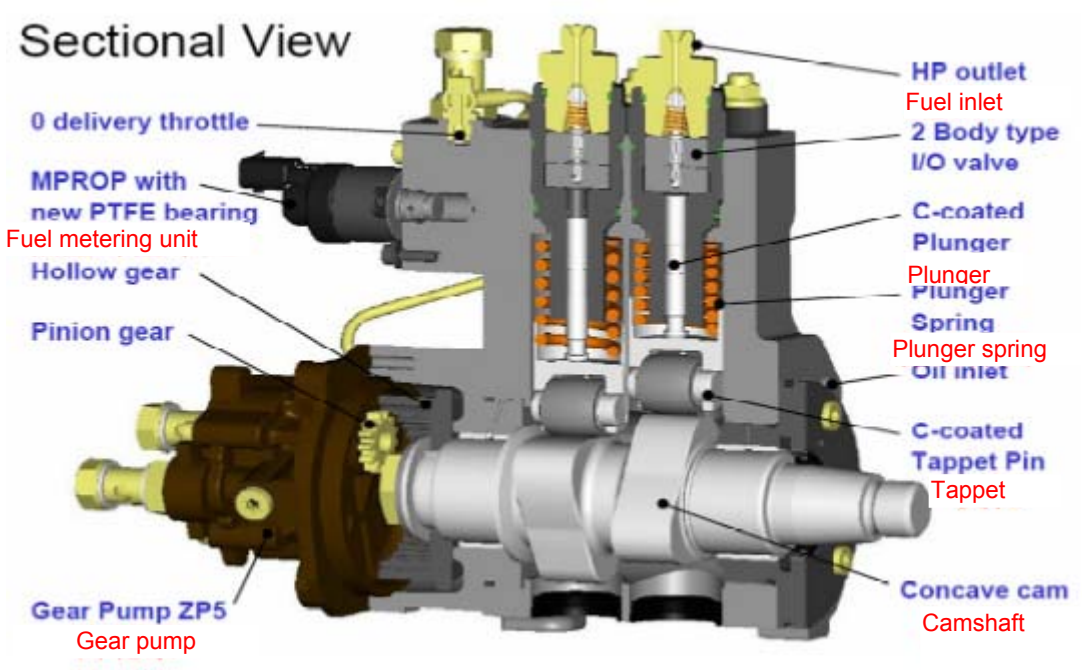


Fig.1-2 Sectional view of high pressure fuel pump

Table 1.1 Characteristic parameters of high pressure fuel pump

Item	Unit	CNP2.2	CPN2.2+
Diameter of plunger	mm	18	8
Stroke	mm	12	15
Theoretical fuel delivery	cm^3/Rev	3.619	4.524
Rated rail pressure	bar	1,600	1,600
Rated speed	rpm	1,250	1,250
Drive ratio		1:2	1:2
Rotation direction (seen from the drive end)		Anticlockwise	Clockwise
Bearing load	N/mm^2	≤11.8	≤11.8
Fuel inlet and outlet of gear pump		From inside to outside	From outside to inside

Function description: Inline 2-cylinder plunger high pressure pump provides the required injection pressure for all working conditions of the engine to the common rail injection system. The fuel delivery of the high pressure pump is controlled by controlling fuel metering unit (FMU) installed on the pump, which realizes the adjustment of the system pressure. The fuel is extracted from the fuel tank by the gear pump (ZP5) integrated on CPN2.2 (+) BL. The fuel filter is located between the fuel outlet of the gear pump and the fuel inlet of the high pressure pump.

CPN2.2+ (SC12E engine) and CPN2.2 (SC10E engine) high-pressure pumps differ in fuel inlet and outlet to some extent. Always pay attention to distinguish them. The structure drawings are shown in Fig. 1-3 and 1-4.

Outline drawing of CPN2.2+ fuel

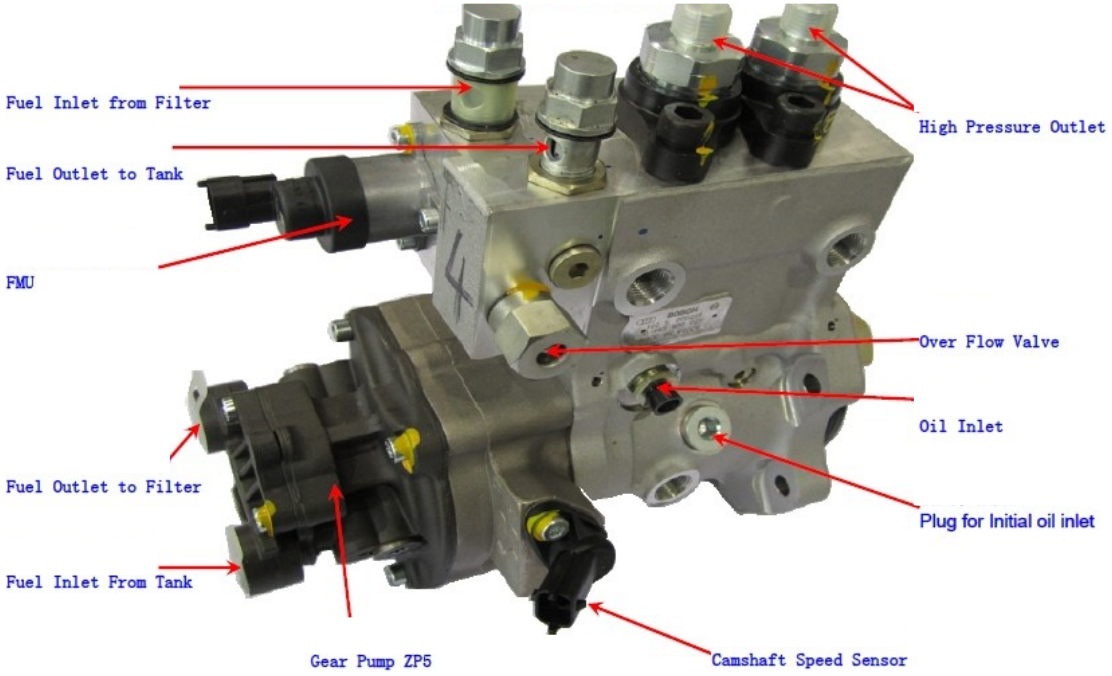


Fig.1-3 Outline structure drawing of CPN2.2+ high pressure fuel pump

Outline drawing of CPN2.2 fuel

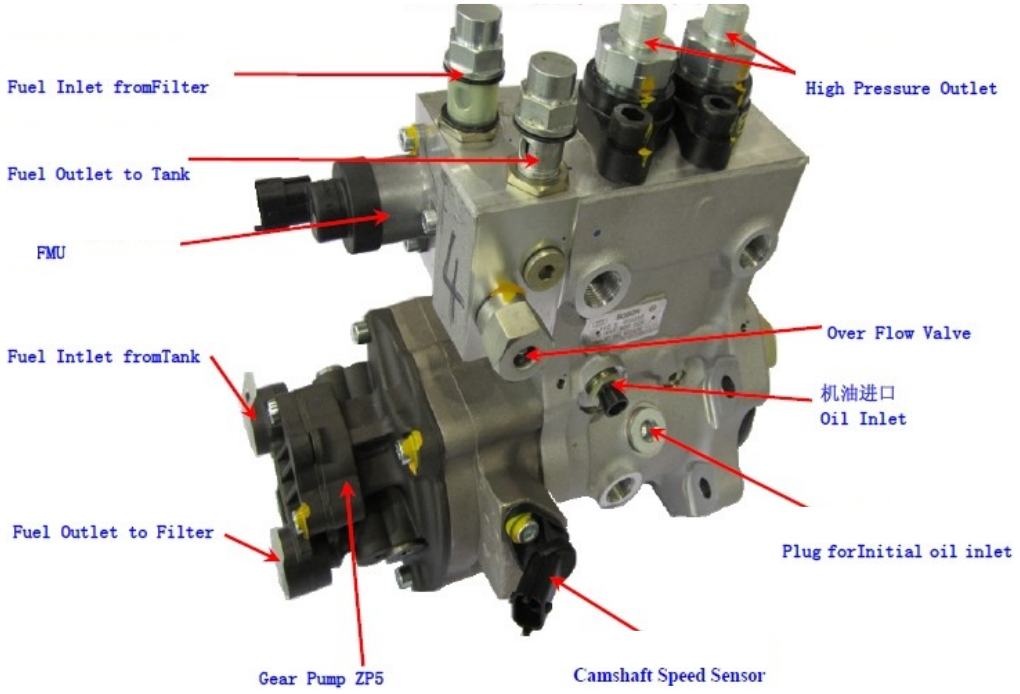


Fig.1-4 Outline structure drawing of CPN2.2 high pressure oil pump

The function of FMU: By controlling the fuel delivery of the high pressure pump, FMU realizes the system pressure adjustment. The high pressure fuel pump can realize zero fuel supply, and can control the fuel delivery continuously between the maximum and zero fuel supply, and thus the system pressure is continuously and smoothly controlled.

6.1.2 High pressure common-rail pipe

The structure of the high pressure common-rail pipe is shown in Fig. 1-5, and its model and function are listed as follows:

Name: Hot forged Rail (HFR)

Model: HFRN-16

Function: To distribute the fuel pressurized by high-pressure pump to injector of each cylinder

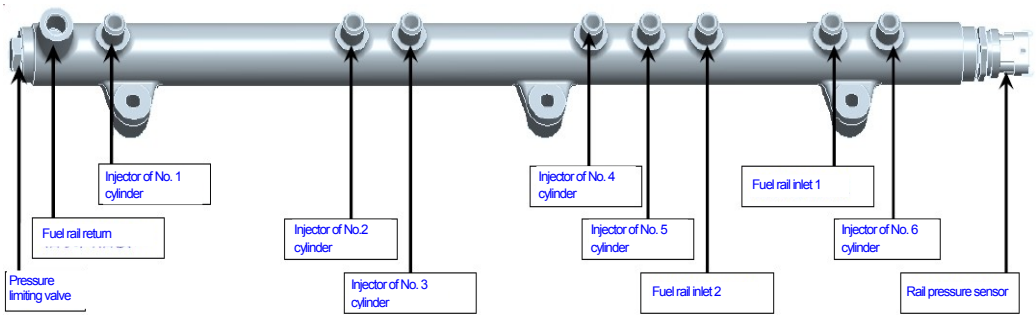


Fig.1-5 Structure drawing of high pressure common-rail pipe

Note: the mechanical stress produced from bump, drop or similar accidents will lead to the leakage of the high pressure contact surface and the failure of common-rail pipe components (rail pressure sensor and pressure limiting valve).

The high pressure common-rail pipe consists of the common-rail pipe, rail pressure sensor and the pressure limiting valve (DBV). The principles and functions of parts are given in Table 1.2.

Table 1.2 Introduction to rail pressure sensor and pressure limiting valve

Parts	Specification	Introduction	Function
Rail pressure sensor	RDS4.2 180MPa	The sensing element, according to the resistance change of the diaphragm strain gauge on it, converts the common-rail pressure into voltage signal and sends it to ECU, and then controls the fuel delivery to the rail through FMU in order to control the rail pressure.	Measure the pressure of the high pressure common-rail, and send the signal to ECU
Pressure limiting valve	DBV4	It opens when the rail pressure is 5MPa higher than the limit value, and the system enters the limp home mode; when the pressure limiting valve opens more than 50 times or the operating time of system at the limp home mode after the pressure limiting valve opens is up to 5 h, the pressure limiting valve should be replaced; the pressure limiting valve should be removed and refitted with reference to the customer's technical document for common rail.	It opens when the rail pressure is abnormal to protect the system.

6.1.3 Injector

Shangchai E-series diesel engine adopts Bosch commercial vehicle electronic injector, with the technical specification as follows:

Name: Commercial vehicle common-rail injector

Model: CRIN2 BL

Function: According to the need of engine characteristic curve, the injector prepares for the metering and injection of the diesel fuel, and performs pilot injection, main injection and post injection. ECU controls the system common-rail pressure and the power-on time so as to realize the control of injection quantity and times.

Injection times: at least 3 times

Power-on time: Min. 220μs, max 4000μs

Working rail pressure: Min. 250bar, max 1,600bar

Fuel return pressure (in relation to the atmospheric pressure): 0.5bar, min 0bar, max 1bar

The outline structure of the injector and the high pressure extension is shown in Fig. 1-6:

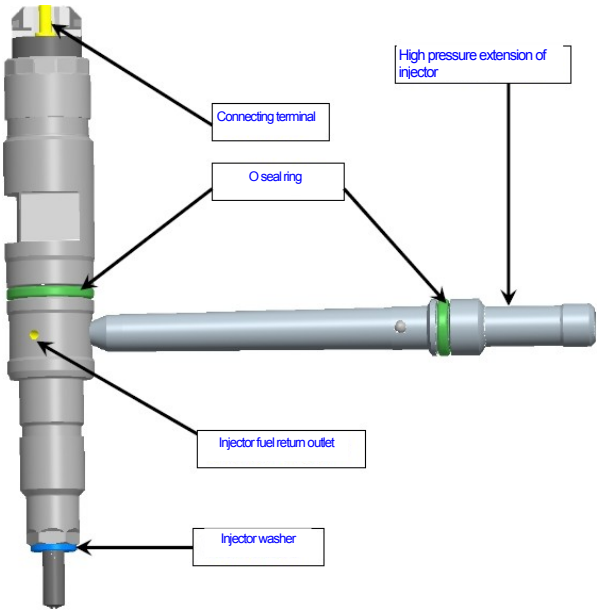


Fig. 1-6 Sketch of injector and high pressure extension

Working principles:

1) Solenoid valve is powered off: With the ball valve closed when the pressure of the control chamber plus the pressure of the needle valve spring is higher than the pressure of the needle valve chamber, the needle valve will close without injection;

2) Solenoid valve is power on: With the ball valve open, when fuel flows out from the drain outlet and the pressure of the control chamber plus the pressure of the needle valve spring is lower than the pressure of the needle valve chamber, the needle valve will open and start injecting. See the sectional view of the injector in Fig. 5-7.

The opening speed of the needle valve depends on the flow difference between the fuel drain outlet and the fuel inlet; and its closing speed relies on the flow of the fuel inlet. Injection response time is the sum of solenoid valve response time and hydraulic system response time. The injection response time is 0.1ms-0.3ms (required for injection rate control).

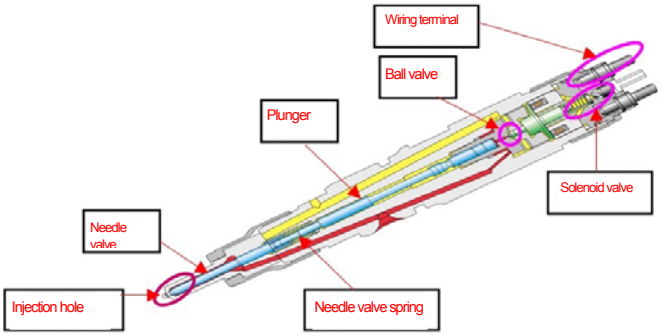


Fig. 1-7 Sectional view of the injector

6.1.4 G sensor

G sensor, namely the camshaft speed sensor, is installed on the high pressure fuel pump.

Working principles: Electromagnetic induction

Function: It works with NE sensor to determine the compression top dead center of No. 1 cylinder and provide it to ECU as the basis of the injection timing.

6.1.5 NE sensor

NE sensor, namely the engine speed sensor, is installed on the flywheel housing.

Working principles: Electromagnetic induction

Function: It measures the engine speed and send signal to ECU. It works with G sensor to determine the compression top dead center of No. 1 cylinder.

6.1.6 Rail pressure sensor

It is installed on the high pressure common rail pipe.

Working principles: The sensing element, according to the resistance change of the diaphragm strain gauge on it, converts the common-rail pressure into voltage signal and sends it to ECU, and then controls the fuel delivery to the rail through FMU in order to control the rail pressure.

Function: It measures the pressure of the high pressure common-rail and send the signal to ECU.

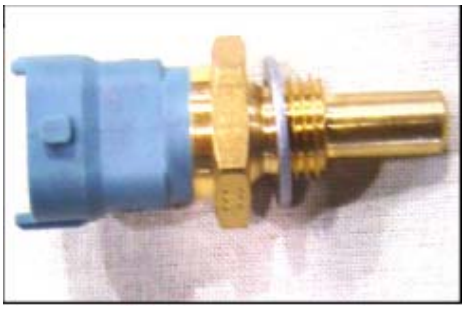
6.1.7 Intake temperature and pressure sensor

It is installed on the intake pipe of the engine.

Working principles: Through the resistance change of its inside thermistor and of the diaphragm strain gauge, it converts the temperature and pressure value into voltage signal and sends it to ECU.

Function: It measures the intake pressure and temperature and sends the signal to ECU.

6.1.8 Water temperature sensor



Water temperature sensor, namely the coolant temperature sensor, is installed on the cylinder head of the engine.

Working principles: High sensitivity NTC (negative temperature coefficient thermistor), whose resistance value increases with the decrease of the temperature.

Function: It measures the coolant temperature and offers signal to ECU.

6.1.9 Oil pressure sensor

It is installed on the main oil path of the engine block.

Working principles: The resistance of strain gauge inside the sensor changes with the pressure and the changing voltage is produced and sent to ECU which will calculate the pressure according to the voltage.

Function: It measures the oil pressure of the main oil path and offers signal to ECU.

6.2 ECU overview

6.2.1 Outline and pin distribution of ECU

The electronic control system of the Shangchai E-series diesel engine adopts Bosch EDC17 system and the model of ECU is EDC17CV44. The ECU of this model is fully integrated with Bosch DeNOX2.2SCR post processing system. There are two independent connectors on the sides of ECU. The smaller one is engine control connector, where all the pins marked with letters starting from A in the ECU wiring diagram are distributed. The bigger one is the vehicle control function and SCR post processing system control connector, where all the pins marked with letters starting from K in the ECU wiring diagram are distributed. The outline drawing is shown in Fig. 2-1:

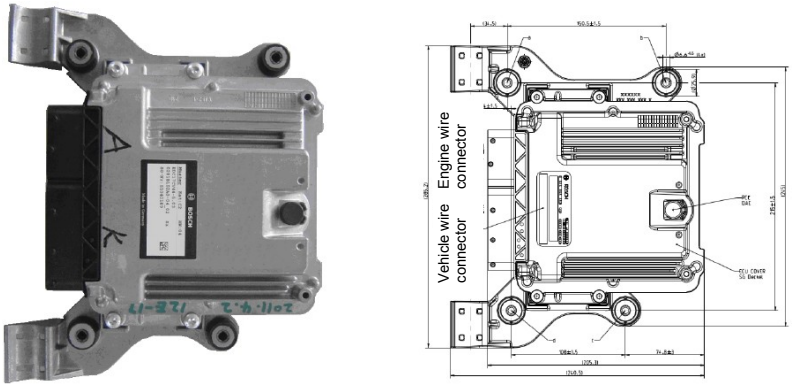


Fig. 2-1 Outline drawing of ECU

In ECU, there are total 60 pins on A side controlling the diesel engine, and 94 pins on K side controlling the vehicle function and SCR post processing system. The distribution diagram of the pins is shown in Fig. 2-2:

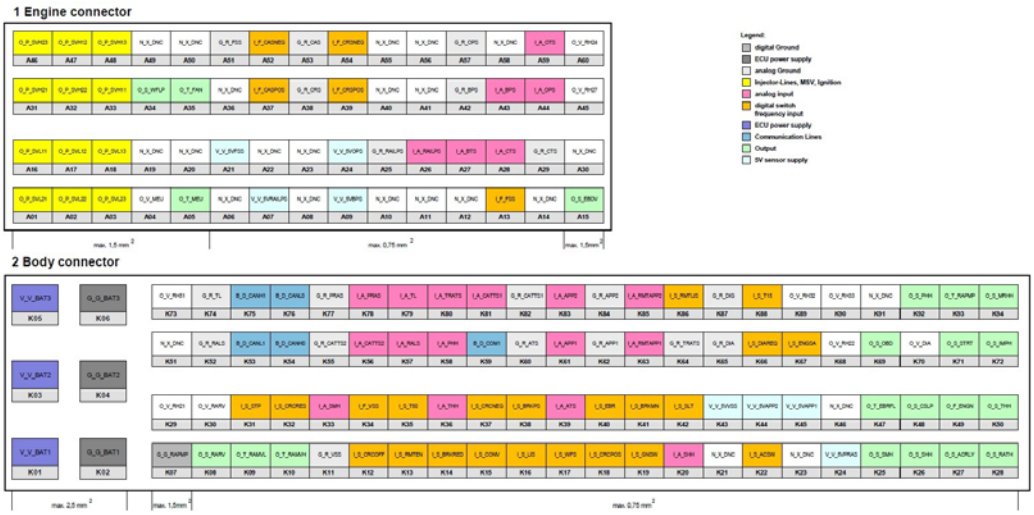


Fig. 2-2 Distribution diagram of ECU pins of EDC17 system

As shown above, ECU pins are in different colors according to different functions for distinguishing. For example, the light grey pin is digital signal ground, dark grey pin is the negative terminal of ECU power supply, white pin is analog signal ground, pale yellow pin is the injector terminal, pink pin is the input terminal of the analog signal, orange yellow pin is digital switch or frequency signal input terminal, purple pin is the positive terminal of ECU power supply, baby blue pin is the communication line, aquamarine pin is the output signal and light cyan pin is 5V sensor power supply.

6.2.2 Definitions of ECU pins

Below is the brief description of remarks of the definitions of ECU pins:

I_A_XXXX	Analog signal input	O_P_SVHXY	High side of the injector
I_S_XXXX	Digital signal input	O_P_SVLXY	Low side of the injector
I_F_XXXX	Frequency signal input	O_V_XXXX	To the high side drive of the positive terminal of the power supply
O_F_XXXX	Frequency signal output	B_D_XXXX	Two-way communication line
O_S_XXXX	Low side (ON/OFF)	V_V_XXXX	Sensor power supply
O_T_XXXX	PWM input	G_R_XXXX	Sensor ground
G_G_XXXX	Ground terminal		

Special notes:

For in-line 6-cylinder diesel engine, the ECU controlled firing order: 1-5-3-6-2-4, and the injector number is as listed in the table below:

Firing order of ECU controlled injector											
1		2		3		4		5		6	
No. 1 cylinder		No. 5 cylinder		No. 3 cylinder		No. 6 cylinder		No. 2 cylinder		No. 4 cylinder	
SV11		SV21		SV12		SV22		SV13		SV23	
A16	A33	A01	A31	A17	A47	A02	A32	A18	A48	A03	A46

6.2.3 ECU power supply requirements

ECU power pin: K01, K03 and K05 power pins are connected to the positive pole of the power supply via the fuse, and K02, K04 and K06 pins are connected to the negative pole of the power supply.

Rated voltage: 24V direct current (DC)

Nominal voltage: positive pole: 28.8V (alternator voltage), negative pole: 0 V

Operating voltage range: 9-32V, ultimate withstand voltage within maximum 5 min: 36V (-20°C.).

Supply current: T15 OFF (ECU in Stand-By mode), measured at the ambient temperature (25°C.), I<100μA (24V).

Max. power: 30W, the actual power depends on the working condition of the engine and the vehicle.

Special notes: Bosch EDC17 ECU is provided with self-protection circuit. The fuse will melt if the positive and negative poles of the power supply are reversely connected.

To protect ECU, and make it work normally and reliably, you need to notice the following 3 points: ① The positive pole of ECU power supply passes 30A fuse (Bosch recommended). ② The positive pole of ECU power supply is connected to the positive pole of the vehicle battery; never connect it to the positive terminal of the alternator. ③ The negative pole of ECU power supply is connected to the negative pole of the battery and reliably grounded.

6.2.4 ECU ground requirements

The ECU of Shangchai E-series diesel engine is installed on the engine block directly through the mounting bracket. The vehicle manufacturer adopts the following ECU grounding way: The positive and negative terminals of the ECU are directly connected to the battery; meanwhile, the ground terminals of the starting motor and the alternator are directly connected to the negative pole of the battery. Never make the negative poles of the starting motor and the alternator grounded directly through the engine block.

ECU grounding way of Shangchai E-series diesel engine is as shown in Fig. 2-3. The grounding way as shown in Fig. 2-4 is not allowed.

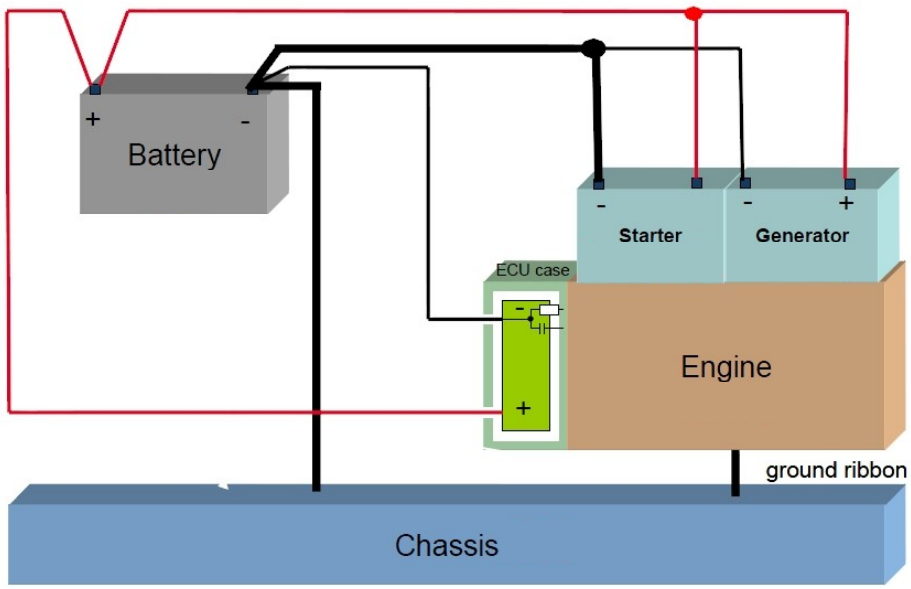


Fig. 2-3 ECU grounding way of Shangchai E-series diesel engine

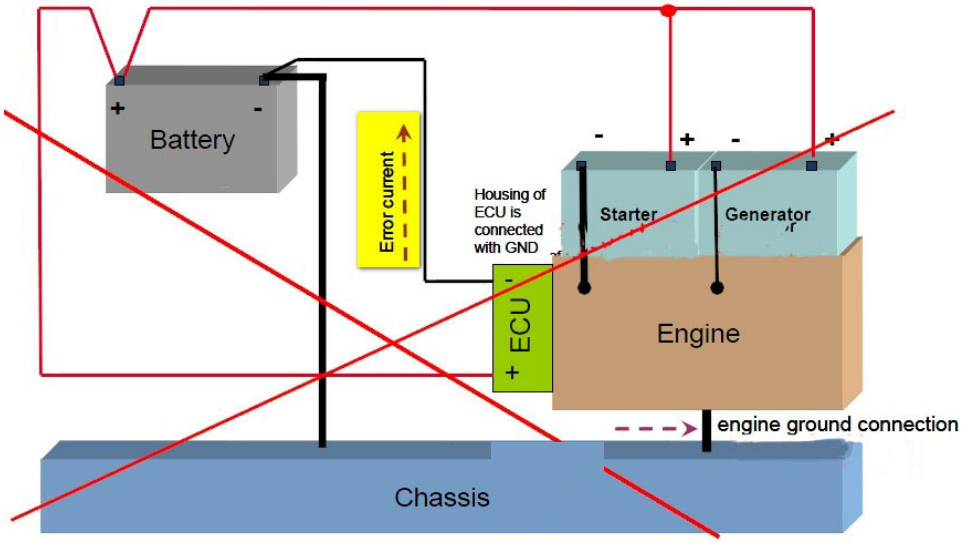


Fig. 2-4 Wrong ECU grounding way

6.3 ECU engine control functions

6.3.1 ECU engine control principles

ECU engine consists of sensors and actuators. Sensors: fan speed sensor, rail pressure sensor, charge air pressure and temperature sensor, oil pressure and temperature sensor, coolant temperature sensor, crankshaft speed sensor, camshaft speed sensor and so on. Actuators: Injectors of No. 1 to 6 cylinders, fuel metering valve, in-cylinder brake solenoid valve, electronic fan clutch, water in fuel indicator lamp and so on. The control principle diagram is given in attached page 1 and the functions are as follows:

S/N	Part name	Pin No.	Function	Remarks
1	Fan speed sensor	A21, A13, A51	To measure the electronically controlled clutch fan speed and offer the input signal for fan speed closed loop control	
2	Rail pressure sensor	A07, A26, A25	To offer ECU the high pressure fuel rail pressure signal	When it is disabled, the limp home mode is activated.
3	Charge air pressure and temperature sensor	A09, A43, A42, A27	To offer ECU the intake temperature and supercharging pressure signals	When it is disabled, the default value will be given as a substitute. The engine emits black smoke and lacks of power
4	Oil temperature and pressure sensor	A24, A44, A59, A57	To offer oil temperature and pressure signals	Oil pressure alarm will be activated after it is disabled
5	Coolant temperature sensor	A28, A29	To offer coolant temperature signal, and the input signal for the fan control, engine thermal protection, intake preheating, etc.	When it is disabled, the default value will be given as a substitute and the limp home mode will be activated.
6	Crankshaft speed sensor	A39, A54, A38	To offer crankshaft speed and position signals	When it is disabled, the engine will be hard to start
7	Camshaft speed sensor	A37, A52, A53	To offer camshaft speed signal and cylinder detection signal	When it is disabled, the engine will be hard to start and smoke
8	Injector	A01, A02, A03, A16, A17, A18, A31, A32, A33, A46, A47, A48	A key part for fuel injection and atomization	When it is disabled, the engine will be hard to start and smoke, or works unstably and lacks of power
9	Fuel metering valve	A04, A05	A key part of high-pressure fuel pump, used to control the rail pressure exactly	When it is disabled, the power will be insufficient and the limp home mode will be activated.
10	In-cylinder braking solenoid valve	A15, A45	A switch controlling the oil path during engine braking	When it is disabled, the in-cylinder brake will become invalid.
11	Electronic fan clutch	A35, A45	To control the engagement and disengagement of fan clutch	When it is disabled, the fan speed will become out of control.
12	Water-in-fuel indicator lamp	A34, A60	To remind the driver that there is water in the fuel, and the fuel primary filter should be handled and replaced in time	

6.3.2 Functions of engine electronics and sensors

1) Electromagnetic clutch fan

Pin: A21A13A51 (fan speed sensor), A15A45 (electromagnetic clutch)

Function: The electromagnetic clutch fan, under the coordinated management of ECU, can realize the closed-loop control of fan speed with the engine coolant (or oil) temperature as the feedback signal, the speed signal from fan speed sensor as the ECU input signal, and the electromagnetic clutch as the actuator. When the engine water temperature is too high, the ECU drives the electromagnetic clutch of fan and engages the clutch to accelerate the fan and ensure the maximum engine cooling and heat dispersion; when the engine water temperature is lower, the ECU drives the electromagnetic clutch of fan and disengages the clutch to decelerate or stop the fan, lower the power consumption of engine driving the fan and thus reduce the fuel consumption.

Selection and configuration requirements: The maximum input current of the fan electromagnetic clutch should be less than 3A (A35), and maximum low level should be less than 1.65V (A35). The supply voltage of the electromagnetic clutch is 24V (A45), the input frequency range of PWM: the supply voltage of the fan speed sensor is 5V. The electronic fan clutch and the electronic fan are as shown in Fig. 3-1.

Fig. 3-1 Electronic fan clutch and electronic fan

3) Intake air preheating grid (intake air preheater)

Drive pin: K72 (low side drive), K68 (high side drive)

Control mode: relay controlled (the ECU drives intake air to preheat the relay). Max. current of the relay coil should not exceed 1.3A.

Power: 2.5kw, rated voltage: 24V

Function: When the ambient temperature is lower, the engine will be more difficult to start and emit smoke. In order to assist the cold start and improve the cold start performance of diesel engine, an intake air preheating grid is added on the intake pipe of diesel engine to preheat the air entering into the engine before starting the engine, and thus to make the gas entering into the diesel engine more easier to burn. Based on the ambient temperature, the ECU determines if the intake air preheating is needed; when the intake air preheating is needed, the K72 pin produces a low level, the preheating relay switch circuit is connected, and the preheating relay starts to work. After the successful starting, the K72 pin of ECU produces a high level, the relay is disconnected, and the preheating stops. The duration of intake air preheating is completely under the ECU logic control. The wiring diagram is as shown in the following Fig. 3-2.

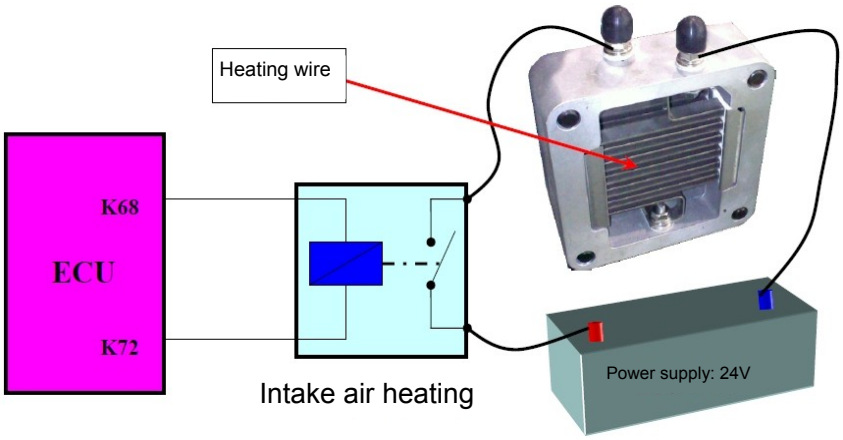


Fig. 3-2 Wiring diagram of intake air preheater and its relay

3) In-cylinder braking solenoid valve

Pin: A15 (low-side drive), A45 (high-side drive, ECU drive voltage 24V, maximum current of the ECU drive pin: 3A, maximum voltage of the output low level: 1.68V.

Drive type of the solenoid valve: ON/OFF and PWM (pulse width modulation)

Max. withstand voltage of the solenoid valve: 32V

Solenoid coil resistance: 32.6-39.8Ω (at the ambient temperature of 25°C.)

Inductance: 63-72mH (at the ambient temperature of 25°C.)

Min. holding current under the oil pressure of 50PSI: 0.14A; Min. opening current under the oil pressure of 50PSI: 0.5A.

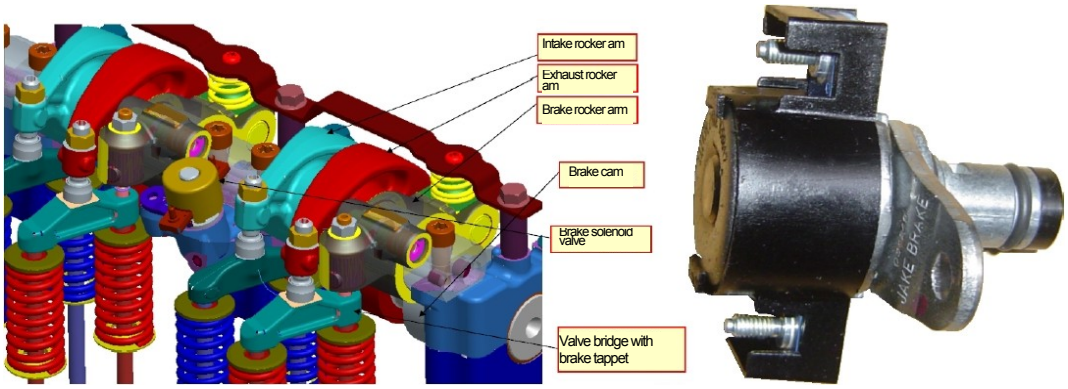


Fig. 3-3 In-cylinder brake system structure and braking solenoid valve

In-cylinder brake principle: When the diesel engine is at the brake mode, the injector will stop fuel injection, the diesel engine will run reversely, and there will be still suction, compression, power and exhaust strokes. But there are 3 different points: ① The exhaust valve is open when the suction stroke is about to end to increase the air input of the cylinder; ② During the compression stroke, the piston compresses the air and produce the negative energy. The air input is more than normal, so the produced negative energy is more than normal; ③ At the end of the compression stroke, the exhaust valve is open to exhaust the high pressure air in the cylinder and decreases the positive energy produced by the high pressure air in lowing the piston. The exhaust stroke is the same as the normal. The exhaust valve opens twice in the normal condition and changes the pressure in the cylinder, making the engine negative energy much higher than the reverse operation energy in the normal condition.

Accomplishment way: When the brake condition is met, the brake solenoid valve is open by the ECU, and the brake oil path of the rocker arm shaft is connected to the oil path of the brake rocker arm. The high pressure oil pushes the check valve of the brake rocker arm and fills the brake piston chamber. Then the brake piston is open to hold the slide block of the valve bridge. Driven by the brake cam, the brake rocker arm exactly controls the opening of the exhaust valve in one cycle (each cylinder opens an exhaust valve) to perform brake. The in-cylinder brake diagram is as shown in Fig. 3-4.

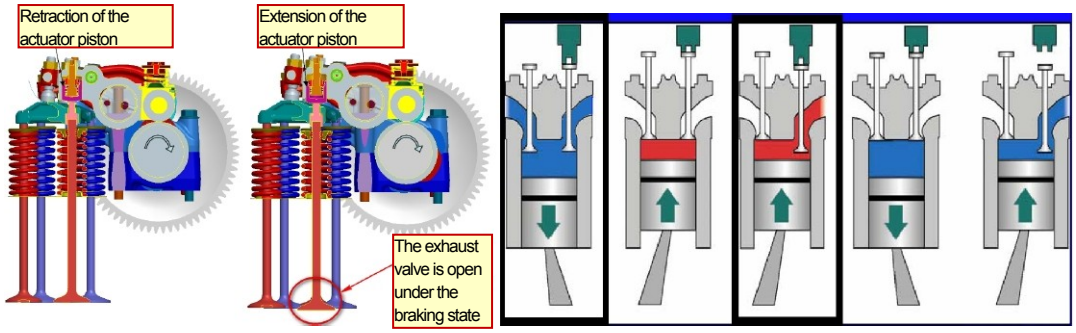


Fig. 3-4 In-cylinder brake principle diagram

4) Fuel metering unit

Functional pin: A04 (high side), A05 (low side)

Driving voltage: 8-32V

Control mode: PWM, frequency range: 120-200Hz

Max. current: 1.8A, coil resistance: 2.6-3.15Ω

Function description: The proportional solenoid valve controls the fuel volume and flow rate in the plunger, and the pressure of the high pressure fuel rail. It is open (limp home mode) when the power is cut off.

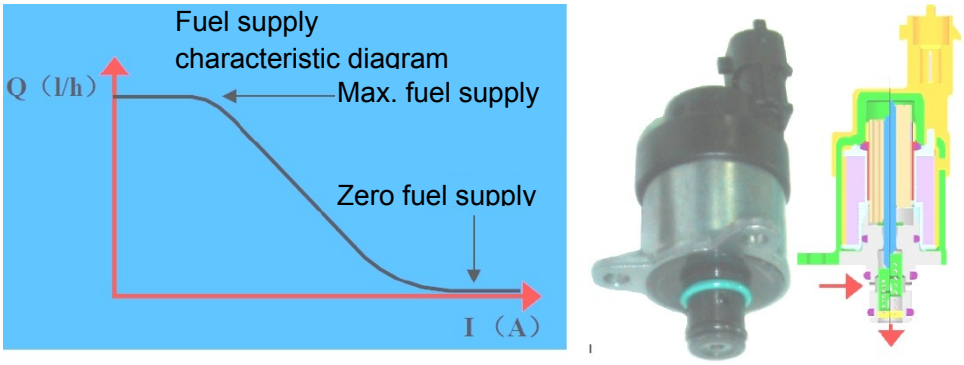


Fig. 3-5 Diagram of common characteristic, outline and inner structure of fuel metering unit of high pressure fuel pump

5) Injector

Shangchai E-series diesel engine adopts Bosch CRINZ Injector, which adopts high speed solenoid valve with fast response. Driven by ECU, the injector injects fuel 3 times in a cycle per cylinder. The electrical characteristics of the injector solenoid valve are as shown in the following table, which can be reference for repair and test.

Electrical characteristics of injector solenoid valve

Injector solenoid coil resistance	230mΩ	Opening voltage	48V (increased by ECU)
Load inductance (when the solenoid valve is open)	150μH	Opening current	24-26A
Insulation resistance	1000kΩ	Holding current	11-13A

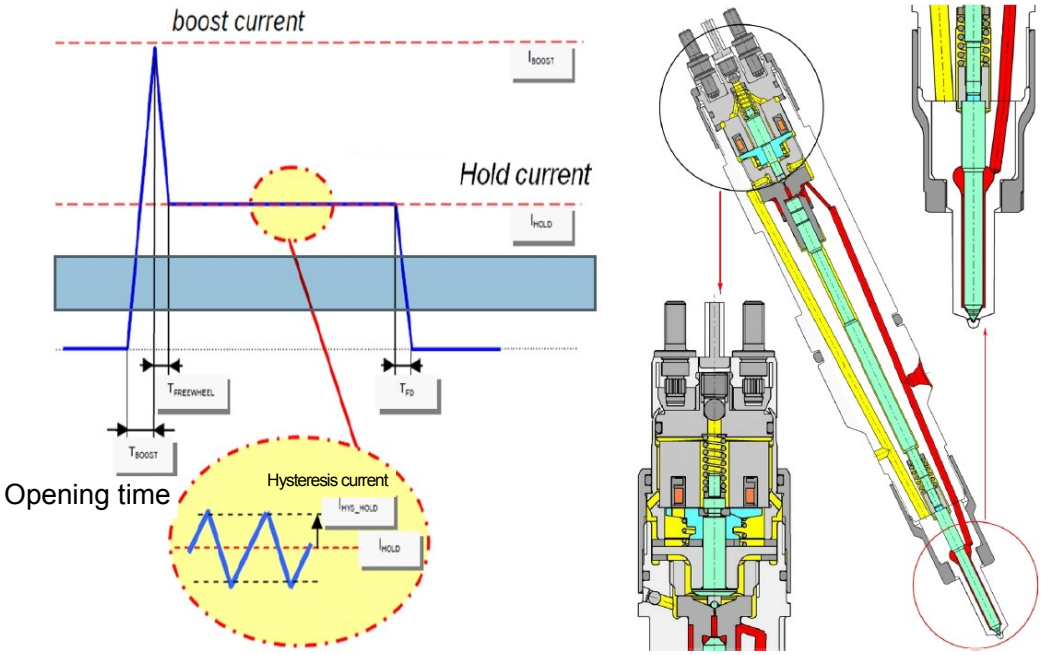


Fig. 3-6 Diagram of the current characteristics and the inner structure of the injector

6.3.3 Engine harness

The harness of the Shangchai E-series diesel engine is divided into two parts: one is valve chamber harness, which is installed inside the cylinder head cover of the diesel engine and whose main function is to realize the control of 6 injectors and 2 in-cylinder brake solenoid valves. These two in-cylinder brake solenoid valves are parallel connected by the valve chamber harness, and finally driven by the ECU A15 pin. The other part is the engine harness, which is connected to the valve chamber harness by a through cylinder connector. The engine harness consists of the connectors of the sensor and the actuator component.

6.3.4 ECU protection

1) During the welding operation for the vehicle chassis, firstly cut off the power supply of ECU, disconnect it from two harness connectors to avoid large current produced in the operation from damaging the ECU inner circuit board. Then use sheath (anti-static one is better) to cover and protect the ECU connectors to prevent the particles like the welding slag and welding spark from entering into the ECU connector and damaging ECU. Do not touch ECU pins.

2) When inserting and removing the ECU connectors, firstly cut off the power supply of ECU to avoid damaging ECU or other components;

3) When connecting the power supply of ECU, firstly check if the positive and negative poles of the power supply are properly connected, to avoid damaging ECU due to the reverse connection;

4) When inserting and removing the ECU and its connectors, make sure that the connectors are operated in place to avoid bending or breaking the ECU pin and affecting ECU functions due to improper operation, such as loose insertion, improper insertion, wrong inserting way, or forced insertion.

5) When assembling the vehicle, after all electrical equipment have undergone power-on test right, test the ECU. This way helps avoiding the impact of unpredictable large current to ECU or other system components, and prevents the ECU against storage failure or wrong information due to misoperation which affects vehicle delivery inspection.

6) ECU can be operated normally at -40℃-105℃, and necessary protective measures should be taken during the operation to avoid the ECU temperature from exceeding the normal operating temperature range.

6.4 Electrical characteristics of ECU input and output interfaces

Pin No.	Function abbreviation	Function description
A01	O_P_SVL21	Injector 1 'low' Bank 2
A02	O_P_SVL22	Injector 2 'low' Bank 2
A03	O_P_SVL23	Injector 3 'low' Bank 2
A04	O_V_MEU	Fuel metering unit supply (BAT+)
A05	O_T_MEU	Fuel metering unit
A06	N_X_DNC	Do not connect, function not classified
A07	V_ V_5VRAILPS	Rail Pressure sensor supply
A08	N_X_DNC	Do not connect, function not classified
A09	V_V_5VBPS	Boost pressure sensor supply
A10	N_X_DNC	Do not connect, function not classified
A11	N_X_DNC	Do not connect, function not classified
A12	N_X_DNC	Do not connect, function not classified
A13	I_F_FSS	Fan speed sensor signal
A14	N_X_DNC	Do not connect, function not classified
A15	O_S_EBDV	Engine brake decompression valve
A16	O_P_SVL11	Injector 1 'low' Bank 1
A17	O_P_SVL12	Injector 2 ‘low' Bank 1
A18	O_P_SVL13	Injector 3 ‘low' Bank 1
A19	N_X_DNC	Do not connect, function not classified
A20	N_X_DNC	Do not connect, function not classified
A21	V_V_5VFSS	Fan speed sensor supply
A22	N_X_DNC	Do not connect, function not classified
A23	N_X_DNC	Do not connect, function not classified
A24	V_V_5V0PS	Oil pressure sensor supply
A25	G_R_RAILPS	Rail pressure sensor ground
A26	I_A_RAILPS	Rail pressure sensor signal

A27	I_A_BTS	Boost pressure temperature sensor signal
A28	I_A_CTS	Coolant temperature sensor signal
A29	G_R-CTS	Coolant temperature sensor ground
A30	N_X_DNC	Do not connect, function not classified
A31	O_P_SVH21	Injector 1 'high' Bank 2
A32	O_P_SVH22	Injector 2 'high' Bank 2
A33	O_P_SVH11	Injector 1 'high' Bank 1
A34	O_S_WFLP	Water in fuel lamp
A35	O_T_FAN	Motor fan relay
A36	N_X_DNC	Do not connect, function not classified
A37	I_F_CASP0S	Segment (camshaft) speed sensor signal plus
A38	G_R_CRS	Crankshaft speed sensor ground
A39	I ⊥ CRSPOS	Crankshaft speed sensor signal plus
A40	N_X_DNC	Do not connect, function not classified
A41	N_X_DNC	Do not connect, function not classified
A42	G_R_BPS	Boost pressure sensor ground
A43	I_A_BPS	Boost pressure sensor signal
A44	I_A_0PS	Oil pressure input signal
A45	O_V_RH27	Battery plus output 27(High side driver)
A46	O_P_SVH23	Injector 3 'High' Bank 2
A47	O_P_SVH12	Injector 2 ‘High' Bank 1
A48	O_P_SVH13	Injector 3 'High' Bank 1
A49	N_X_DNC	Do not connect, function not classified
A50	N_X_DNC	Do not connect, function not classified
A51	G_R_FSS	Fan speed sensor ground
A52	I_F_CASNEG	Segment (Camshaft) speed sensor signal minus
A53	G_R_CAS	Segment (Camshaft) speed sensor ground
A54	I_F_CRSNEG	Crankshaft speed sensor signal minus
A55	N_X_DNC	Do not connect, function not classified
A56	N _X-DNC	Do not connect, function not classified
A57	G_R_0PS	Oil pressure sensor ground
A58	N_X_DNC	Do not connect, function not classified
A59	I_A_0TS	Oil temperature sensor signal
A60	0.VRH24	Battery plus output 24 (High side driver)
K01	V_V_BAT1	Battery plus 1
K02	G_G_BAT1	Battery minus 1
K03	V_V_BAT2	Battery plus 2
K04	G_G_BAT2	Battery minus 2
K05	V_V_BAT3	Battery plus 3
K06	G_G_BAT3	Battery minus 3
K07	G_GJAPMP	Ground for reduction agent pump motor

K08	O_S_RARV	Reduction agent reverting valve
K09	O_T-RAMVL	Reduction agent metering valve (Low-side)
K10	O_T-RAMVH	Reduction agent metering valve (high-side)
K11	G_R__VSS	Vehicle speed sensor ground
K12	I_S_CRCOFF	Cruise control activator 'OFF'
K13	I_SJMTEN	Remote accelerator pedal enable switch
K14	I_S_BRKRED	Redundant brake switch signal
K15	I_S_CONV	Clutch switch signal (Torque convertor)
K16	I_S-LIS	Low idle position switch input signal
K17	I_S_WFS	Water in fuel sensor signal
K18	I_S_CRCPOS	Cruise control activator "Set/accelerate"
K19	I_S_GNSW	Gear neutral switch
K20	I_A_SHH	Reduction agent suction hose heater relay feedback
K21	N _X-DNC	Do not connect, function not classified
K22	I_S_ACSW	A/C request switch
K23	N_X_DNC	Do not connect, function not classified
K24	V_V_5VPRAS	Reduction agent pressure sensor supply
K25	O_S_SMH	Supply module heater
K26	O_S_SHH	Reduction agent auxiliary relay (suction hose relay)
K27	O_S_ACRLY	A/C compressor relay AC/OUT
K28	O_S_RATH	Reduction agent tank heating valve
K29	O_V_RH21	Battery plus output 21 (high side driver)
K30	O_V_RARV	Reduction agent reverting valve supply (BAT+output)
K31	I_S_STP	Engine stop switch signal
K32	I_S_CRCRES	Cruise control activator 'Resume'
K33	I_A_SMH	Reduction agent supply module heater relay feedback
K34	I_F_VSS	Vehicle speed sensor input signal
K35	I_S_T50	Start switch term. 50 input signal
K36	I_A_THH	Reduction agent throttle heater relay feedback
K37	I_S_CRCNEG	Cruise control activator ‘‘SET/decelerate"
K38	I_S_BRKPS	Parking brake signal
K39	A_A_ETS	Ambient temperature sensor signal
K40	I_S_EBR	Engine brake switch signal
K41	I_S_BRKMN	Brake main switch signal
K42	I_S_SLT	Speed set limit switch signal

K43	V-V-5WS	Vehicle speed sensor supply
K44	V_V_5VAPP2	Accelerator pedal position sensor 2 supply
K45	V_V_5VAPP1	Accelerator pedal position sensor 1 supply
K46	N_X_DNC	Do not connect, function not classified
K47	O_T_EBRFL	Engine brake flap
K48	O_S-CSLP	Cold start lamp
K49	O_F_ENGN	Engine speed output signal
K50	O-S-THH	Reduction agent auxiliary relay 2 (throttle heater)
K51	N_X-DNC	Do not connect, function not classified
K52	G_R_RALS	Reduction agent level sensor ground
K53	B_D_CANL1	Controller Area Network 1 (Low)
K54	B_D_CANLO	Controller Area Network O (High)
K55	G _R-CATTS2	Catalyst temperature sensor2 ground
K56	I_A_CATTS2	Catalyst temperature sensor2 signal
K57	I_A_RALS	Reduction agent level sensor signal
K58	I_A_PHH	Reduction agent auxiliary relay 3 (pressure hose heater)feedback signal
K59	B_D_C0M1	Communication interface 1
K60	G _R-ETS	Ambient temperature sensor ground
K61	I_A_APP1	Accelerator pedal position sensor 1 signal
K62	G_R_APP1	Accelerator pedal position sensor 1 ground
K63	I_A_RMTAPP1	Remote accelerator pedal 1 input signal
K64	G _R-TRATS	Reduction agent tank temperature sensor ground
K65	G_R_DIA	Error memory read switch ground
K66	I_S_DIAREQ	Diagnosis request switch
K67	I_S_ENGSA	Engine start switch signal
K68	0-V-RH22	Battery plus output 22 (high side driver)
K69	0 _S_OBD	OBD lamp
K70	O_ V-DIA	Diagnostic lamp supply (BAT+)
K71	O-S-STRT	Starter relay
K72	O_S_IMPH	Intake manifold preheating (Grid heater)
K73	O_ V-RH51	Battery plus output 51 (High side driver)
K74	G_R_TL	Torque limitation ground
K75	B_D_CANH1	Controller Area Network 1 (High)
K76	B_D_CANLO	Controller Area Network 0 (Low)
K77	G_R_PRAS	Reduction agent pressure sensor ground
K78	I_ A-PRAS	Reduction agent pressure sensor signal
K79	I_A_TL	Torque limitation signal

K80	I_A_TRATS	Reduction agent tank temperature sensor signal
K81	I_A_CATTS1	Catalyst temperature sensor 1 signal
K82	G_R_CATTS1	Catalyst temperature sensor 1 ground
K83	I_A_APP2	Accelerator pedal position sensor 2 signal
K84	G_R_APP2	Accelerator pedal position sensor 2 ground
K85	I_A_RMTAPP2	Remote accelerator pedal 2 input signal
K86	I_A_RMTLIS	Remote accelerator pedal Low idling switch
K87	G_R_DIG	Ground digital
K88	I_S_T15	Terminal 15 (switched BAT+)
K89	0_V_RH32	Battery plus output 32 (high side driver)
K90	0_V_RH33	Battery plus output 33 (high side driver)
K91	N_X_DNC	Do not connect, function not classified
K92	0_S_PHH	Reduction agent auxiliary relay 3 (pressure hose heater)
K93	0_T_RAPMP	Reduction agent pump motor
K94	0_S_MRHH	Reduction agent electro-mechanical relay

6.4.1 Functional specifications for all switch pins

1) Terminal T15

ECU pin: K88

Functional specification: T15 is the terminal of ECU. ECU is powered on when this terminal is turned off and powered off when this terminal is disconnected, and the engine will shut down when this terminal is turned off, so this terminal is used as a power switch of ECU.

Electrical characteristics: the allowable working current is 1.0 mA < Ion < 3.6 mA.

Precautions: for this terminal, mixed connection with other terminals is not allowed in order to prevent other equipment from interfering with this terminal. After turning off T15 terminal to shut down the engine, the battery main switch should be held for 1-2 min at least so that information (such as oil consumption and mileage, etc.) for this driving cycle can be written into ECU memory, and the urea pump in SCR post processing system can complete the reverse pumping.

2) Starting (ignition) switch T50

ECU pin: K35

Functional specification: if start switch signal of ECU is input, when this switch is turned off, and the starter motor is controlled by ECU, the ECU will drive the starter motor relay and then the starter motor drives the engine.

Electrical characteristic: the allowable working current is 0.47 mA < Ion < 1.90 mA, for normally open switch.

Precautions: ① for starting controlled by ECU, this switch must be selected;

② when neutral signal indicates the switch is turned to Neutral position, and in start protection mode, and if starting is required, please press and hold the ignition switch for more than 5 s, and the starter motor will run (emergency starting function);

③ Failure occurs after the switch is closed for 30 s (this time can be calibrated), protect the starter motor.

3) Main brake switch

ECU pins: K41, K68 (ECU power output)

Functional specification: this switch can be used to judge driver's driving intention and provide ECU with input signal for safe judgment check. If this switch is used for cruise quitting, PTO mode quitting and other functions that require braking signal. If this switch used together with an auxiliary brake switch is turned off, K41 and K68 is switched on, including K41 pin with high level, and ECU will judge that the main brake pedal is depressed.

Electrical characteristic: the allowable working current is 1.9 mA < Ion < 7.3 mA, K41 pin input resistance is 9.51 kΩ < Rin < 9.84 kΩ, for normally open switch.

Precautions: this switch is a required switch for the complete vehicle plant, and used together with an auxiliary brake switch.

4) Auxiliary brake switch

ECU pins: K14, K68 (ECU power output)

Functional specification: as a normally closed switch, this switch is in switch-on state in normal conditions (no braking), i.e. K14 and K68 are switched on. It can be used together with a main brake switch, and keeps a reciprocal relationship with the main brake switch. The purpose is to facilitate ECU to check the condition of main brake switch and diagnose fault, because ECU is unable to diagnose the switch (excluding clutch switch and multi-function switch) and circuit independently. The ECU cannot detect the braking signal when open circuit occurs if one switch is applied. If both switches are applied, and one of them is faulty, the other switch will change its status on the condition that the brake pedal is depressed by the driver so that ECU is able to detect which one is faulty, thus enhancing the safety.

Electrical characteristic: K14 pin input resistance is 9.51 kΩ < Rin < 9.84 kΩ, for normally closed switch.

Precautions: it is a required switch that should be used together with the main brake switch.

5) Cruise (PTO, idling fine adjustment) and multi-function switch

ECU pins: K18, K37, K12, K32, K68 (ECU power output)

Functional specification: functions such as cruise control, PTO control and idling fine adjustment control can be achieved through this switch, and this switch includes four keys, acceleration (K18 and K68 switched on), deceleration (K37 and K68 switched on), resume (K32 and K68 switched on) and OFF (K12 and K68 switched on) respectively. It is required that both switches are inching automatic resume switches. Choosing Key OFF indicates that this switch will be in a normally closed condition and others indicates that this switch will be in a normally open condition. This switch is mainly for cruising/PTO/idling fine adjustment. With various activation modes for these functions, cruising is enabled by pressing cruise acceleration and deceleration; PTO is enabled by pressing Resume key; and idling fine adjustment is enabled by pressing and holding the Resume key for more than 3 s.

Electrical characteristic: the input resistance of K18, K37, K12, K32 pins is 9.51 kΩ < Rin < 9.84 kΩ.

Precautions: this switch should be selected for any function of cruising, PTO and idling fine adjustment.

6) Auxiliary brake request switch

ECU pins: K40, K68

Functional specification: when the auxiliary brake request switch is off, the K40 and K68 pins are switched on, with high level for the K40 pin. Receiving auxiliary brake request signal, ECU starts to determine braking conditions, and drives butterfly valve exhaust brake relay and brake solenoid valve A15 if drive conditions are met, thus realizing engine auxiliary braking function.

Electrical characteristic: K40 pin input resistance is 9.51 kΩ < Rin < 9.84 kΩ.

Precautions: the Butterfly valve exhaust brake and brake solenoid valve are under linkage control of this switch. When this switch is off and meets all braking conditions, the engine auxiliary brake will function (other braking conditions such as requirements of engine speed and water temperature, etc.).

7) Diagnosis request switch

ECU pins: K66, K68

Functional specification: it is a normally open automatic reset switch. ECU can test malfunction indicator lamp (MIL) which will illuminate later (normally on if the request switch is not disconnected) after pressing this switch. After releasing the fault diagnosis request switch, the malfunction indicator lamp (MIL) will flash if the system is faulty. The flash code is the times for flashing and the specific fault type can be determined by reference to the Fault Flash Code Table according to the flash code.

Electrical characteristic: K66 pin input resistance is 9.51 kΩ < Rin < 9.84 kΩ

Precautions: it is a normally open switch, and the flash code lamp will be normally on if the diagnosis switch is off. If it is not an automatic reset switch, the flash code lamp may be normally on due to the switching-off of diagnosis switch, which will mislead the driver.

8) Clutch switch

ECU pins: K15, K68

Functional specification: the switch will be switched on when depressing the clutch pedal to the end; the switch will be switched off after releasing the clutch. Clutch status signal will be input into ECU for the complete vehicle functions such as cruise quitting for which the clutch status should be considered.

Electrical characteristic: normally open switch

9) Parking brake switch (hand brake switch)

ECU pins: K38, K68

Functional specification: when the vehicle stops, pull up the hand brake, and the parking brake switch will be disconnected; after starting the vehicle, release the hand brake and the parking brake switch will be off.

10) Neutral switch

ECU pins: K19, K68

Functional specification: when the transmission is shifted the neutral gear, the neutral switch is off so as to input neutral signal into ECU for engine starting judgment.

Precautions: when the transmission is not shifted to the neutral gear or the neutral switch is damaged, press and hold the start switch for more than 5s, and the starter motor starts to run (emergency starting function). In order to avoid danger, make sure that the transmission is shifted to the neutral gear when starting.

11) Low idling switch/low idling switch of remote accelerator

ECU pins: K16, K87

Functional specification: when a signal modulus accelerator pedal is used, the low idling switch must be installed. When the accelerator pedal position is 0, the idling switch is off so as to input signal to ECU to give information that the engine is at idling state.

Precautions: when a signal modulus accelerator pedal is used, the low idling switch must be installed; when a double modulus accelerator pedal is employed, it’s better to install an idling switch.

12) Remote start/stop switch

ECU pins: K67 (remote start switch), K31 (remote flameout/stop switch), K87 (ground terminal).

Functional specification: this switch is used for starting/stopping the engine outside the cab, especially for convenient maintenance and when the starting/stopping outside the cab of the engine is required. The switch should be an automatic reset switch, and some favorable water-proof and shock-proof measures should be taken so as to avoid faulty operation caused by non-human factors.

Precautions: for the remote starting function, the starting will be controlled by ECU with the key turned to ON position; when there is vehicle speed signal, the remote flameout is disabled; when the flameout switch is turned to ON position, the engine cannot be started.

13) Remote accelerator enable switch

ECU pins: K13, K86

Functional specification: when both service accelerator and remote accelerator are installed, the remote accelerator enable switch should be used for switching. Under normal conditions, ECU, by default, employs the service accelerator in the main cab; when the remote accelerator is required, turn off the remote accelerator enable switch, and the remote accelerator is enabled, and the service accelerator will be invalid.

14) Speed limit switch

ECU pins: K42, K87 (ECU ground terminal, low level output terminal)

Functional specification: after the switch is turned off, K22 pin is set as low level, and ECU enables the function of vehicle limit speed.

15) A/C request switch

ECU pins: K22, K87

Functional specification: it is used for informing ECU of that A/C has been started in order to control the engine idling speed. When A/C is turned on, the A/C request switch is off and the engine idling speed increases to the A/C idling speed (specific speed depends on the rated data).

16) Multi-state switch

ECU pins: K74 (ground terminal), K79

Functional specification: according to the load of the complete vehicle, switch the multi-state switch to different positions to make engine working within different power ranges under different load conditions, and run the engine in fuel saving condition to save fuel.

Precautions: it can be used together with PTO switch.

6.4.2 Functional specification for each indicator lamp

1) Cold start (intake preheating) indicator lamp

ECU pins: K48 (driving terminal), K68 (24V)

Functional specification: At cold starting, ECU drives intake preheater to heat the air in the intake pipe, and this indicator lamp functions to make the driver know the air heating status. The intake preheating indicator lamp is always on when preheating the air, and flashes 3 times after the preheating is completed to remind the driver to start the engine. After 3 flashes, the indicator lamp will be off if any no heating is carried out during starting or heat after starting is detected.

2) OBD indicator lamp (MIL lamp)

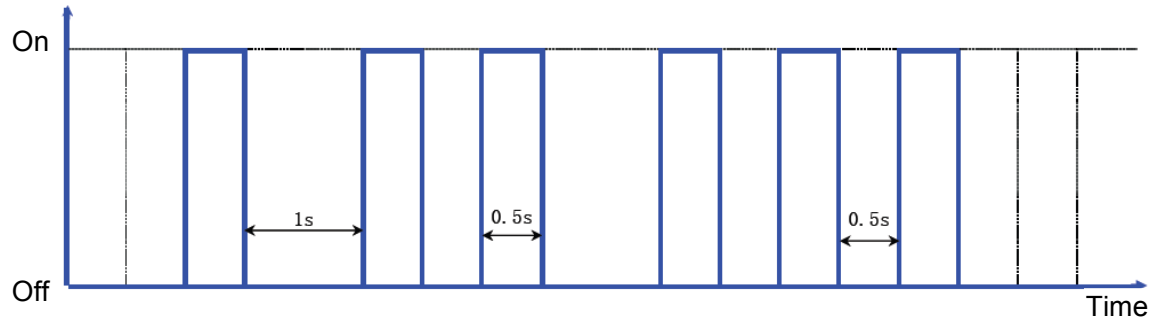
ECU pins: K69 (driving terminal), K68 (24V)

Functional specification: it is used to indicate faults related to emission, including flashing and illumination. This lamp will illuminate or flash when emission is out of standard or fault on emission occurs.

3) SVS Malfunction indicator lamp (flash code lamp)

ECU pins: K70 (driving terminal), K65 (ground)

Functional specification: it is used to indicate fault state for the engine. When any fault code is found in the ECU, the switch should be disconnected after switching on the fault request switch (one pulse signal), and the flash code lamp starts to inform user of the fault code in the form of a flash code. As each flash code consists of three codes, the time interval for reporting two adjacent codes should be 1s. The details for flash code modes are shown in the following diagram 1-2-3:



Schematic diagram 1-2-3 for fault flash code

4) Water in fuel indicator lamp

ECU pins: A34 (driving terminal at the lower side), A60

Functional specification: when the water level in the water cup of fuel coarse filter (oil and water separator) is tested higher than the upper limit, ECU will drive this lamp on (A34 pin set level), and prompt the user to drain the water from the oil and water separator.

6.4.3 Functional specification for complete vehicle sensors

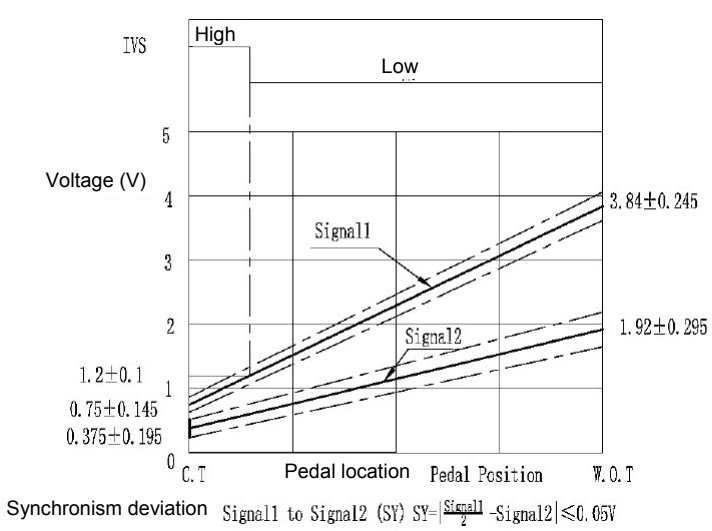
1) (Service) accelerator pedal

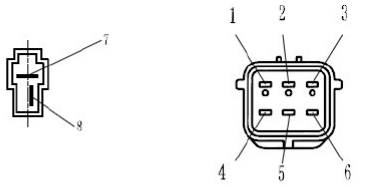
ECU pins: K45 (pedal 1 with 5V power supply), K61 (pedal 1 with signal), K62 (pedal 1 grounded); K44 (pedal 2 with 5V power supply), K83 (pedal 2 with signal), K84 (pedal 2 grounded);

Functional specification: driving intention of driver can be transferred into electrical signal, which will be sent to ECU, and ECU will calculate fuel injection quantity according to received voltage signal of accelerator pedal. The accelerator pedal is mainly used during driving.

Electrical characteristic: the working voltage of accelerator pedal is 5 V, and output signal voltage is 0.5V ~ 4.5V.

Precautions: it is recommended to use a double signal (modulus) accelerator pedal, with output signal voltage ratio of 1:2, and the advantage of mutual check for two-way accelerator will be helpful for accelerator fault diagnosis, thus strengthening the safety resulted from accelerator failure. See Fig. 4-1 for typical electrical characteristic of output voltage of accelerator pedal. While if a single modulus accelerator pedal is employed, an idling switch must be used.





Connector: DJ7022-6.3-10 Connector: 174264-2

Pin	Pin function	Color
1	Pedal power	Red
2	Pedal signal output	Green
3	Ground 1	Black
4	Pedal power supply 2	White
5	Pedal signal output 2	Orange
6	Ground 2	Purple
7	IVS power (24V)	Pink
8	Idling switch (IVS)	Yellow

Fig. 4-1 Typical electrical characteristic of accelerator pedal and definition for interface pin

2) Remote accelerator pedal

ECU pins: K45 (pedal 1 with 5V power supply), K63 (remote pedal 1 with signal), K62 (pedal 1 grounded); K44 (pedal 2 with 5V power supply), K85 (remote pedal 2 with signal), K84 (pedal 2 grounded);

Functional specification: some special vehicles require a remote accelerator installed to control the engine to assist power output, e.g. auto-crane requires the support of remote accelerator to control the engine during hoisting, but it will switch back to service accelerator at normal driving. The transfer switch is a remote accelerator enable switch.

Electrical characteristic: it coincides exactly with service accelerator;

Precautions: when using remote accelerator, the remote accelerator enable switch should be installed. It is recommended to keep the remote accelerator pedal consistent with the service accelerator pedal exactly. Faulty remote accelerator will affect normal driving.

3) Vehicle speed sensor

ECU pins: K43 (5V power supply), K34 (square signal input), K11 (ground)

Functional specification: ECU receives speed signal for cruise controlling, gear identification, low idling control, maximum speed limit and mileage calculation, etc.

Electrical characteristic: square signal output, duty ratio of 50%, frequency f=0~1.5 kHz, low level input voltage of 0~1.71V and high level input voltage of 3.22~12V.

4) Water in fuel sensor

ECU pins: K17, K87 (ground)

Functional specification: It is used to test water in the water cup of fuel coarse filter. When the water level is higher than the upper limit, the water level sensor (on-off signal) inputting voltage signal low level to EUC is valid;

Electrical characteristic: digital on-off signal input, low level input voltage of 0~ 2.09V, and high level input voltage of 4.6~24V.

Precautions: this sensor should be installed at the bottom of water cup of fuel coarse filter as required.

6.4.4 Communication functional specification

1) ECU calibration, CAN communication flash

ECU pins: K75 (CANH1), K53 (CANL1)

Functional specification: it is used for ECU calibration, fault code reading and ECU data flash, etc.

2) Instrument communication, CAN communication between diagnostor and controller

ECU pins: K54 (CANH0), K76 (CANL0)

Functional specification: It refers to communication with the complete vehicle CAN instrument and other instrument and apparatus as well as controller. The connection interface of fault diagnosis tester based on the protocol of SAEJ1939 is employed for fault diagnosis. It also acts as the interface for communication with SCR post processing system control unit (in case of adopting the SCR post processing system from other manufacturers instead of BOSCH SCR).

3) K wire communication

ECU pin: K59

Functional specification: it is used for fault diagnosis, ECU calibration and ECU data flash, etc. As K wire communication function is weakened in the EDC17 system and the communication rate is lower than that of CAN, it is rarely used now.

4) Engine speed output

ECU pin: K49

Functional specification: it is used for outputting signal of diesel engine speed to the complete vehicle instrument, and the square signal output will facilitate the receiving by normal instrument.

6.5 Description of complete vehicle function

This chapter mainly introduces the function of ECU, which consists of starting control, cruise control, exhaust braking control, intake heating control at low temperature, multi-state switch, remote accelerator control and malfunction indicator lamp, etc.

6.5.1 Starting control

1) Neutral start protection

The vehicle can be started only at neutral gear. When engaging a gear, there will be no response after pressing the start switch. The neutral signal should be loaded into ECU.

2) Starting speed protection

When the engine speed is higher than a set value during starting (default: 400r/min, relative to coolant temperature), it is considered that combustion in the cylinder has been started, and the starter relay has been switched off. The continuous pressing the start switch will not realize the starting.

3) Avoid the starter out of gear

During starting, as the engine speed is always lower than a set value (52 r/min currently) for more than a certain time (20s currently), it deems that the engagement between the starter gear and the fly wheel starting gear ring is poor, and the relay has been switched off. Keeping pressing the start switch will be in vain at this time, and restarting can be obtained after the switch is turned off.

4) Avoid no returning of start switch

The relay will be switched off if the start switch is powered on for more than a certain time (30s currently). Keeping pressing the start switch will be in vain at this time, and restarting can be obtained after the switch is turned off. The aim is to prevent the start switch from getting stuck at the starting position, which may cause damage to the starter and the battery.

5) Preventing abnormal repeated starting

After the engine is started, there will be no response after pressing the start switch again, and abnormal repeated starting should be prevented.

6) Preheating control

If coolant temperature is lower, intake preheating is required for restarting after the engine is powered on. The preheating is controlled by ECU. Usually, the engine starting is not allowed in the course of preheating; otherwise the preheating should be stopped; Incomplete intake preheating may affect starting effect.

7) Emergency starting

When the neutral switch is disabled, emergency starting is possible. The starter will run after pressing and holding the start switch for more than a certain duration (default: 5s), and the engine will be in emergency starting mode.

8) Remote start and stop

During vehicle service, it is possible to start or stop the engine outside of the cab. The remote start switch and stop switch must be controlled by ECU, and the vehicle speed should be 0 km/h.

6.5.2 Cruise control

1) Cruise switch

The cruise switch will be switched on or off by pressing 3# key or 4# key. It is recommended to pressing 4# key to reset the switch automatically, including “cruise reset”, “cruise cancel”, “cruise acceleration” and “cruise deceleration”. According to the length of triggering time, the switch operation can be divided into pressing and pressing and holding. The pressing time is not more than 0.5s, while the pressing and holding time is more than 0.5s. Anyway, two or more than two switches should not work at the same time. Otherwise, an error occurs.

2) Cruise enabling

Cruise is enabled on condition that:

A) Vehicle speed is higher than 28 km/h and lower than 100 km/h;

B) The engine speed is not lower than 700r/min;

C) The gear is above 2nd gear;

D) Pressing “cruise acceleration” or “cruise deceleration” switch to enter the cruise state.

3) Cruise adjustment

After getting in to the cruise state, the switch of “cruise acceleration” or “cruise deceleration” can be used to adjust the vehicle speed. The adjustment range is 2 km/h for pressing and1.6 km/(h·s) for pressing and holding.

4) Cruise quitting and resuming

A) During the cruise, depress the clutch or brake, or turn on exhaust brake switch to quit the cruise mode. Press “cruise resetting” switch to resume the cruise state. The signal should be loaded into ECU.

B) During the cruise, depress the accelerator pedal to quit the cruise mode. When the ECU recognizes that the accelerator pedal torque is more than current cruise torque, the cruise quits and the vehicle starts to speed up. Cruise mode will recover automatically after releasing the accelerator.

C) During the cruise, press “cruise cancel” switch to quit the cruise mode. Press the switch of “cruise acceleration” or “cruise deceleration” to resume the cruise state.

5) Cruise disabling

Any one of following cases may disable the cruise (the signal should be loaded into ECU):

A) Wrong cruise switch;

B) Wrong braking switch signal;

C) Wrong vehicle speed signal;

D) Wrong engine speed signal;

E) Wrong clutch switch signal;

F) Vehicle acceleration exceeds the limit value (more than 5 m/s currently) for more than a certain time (0.5s currently);

G) Vehicle deceleration exceeds the limit value (less than -3m/s currently) for more than a certain time (0.5s currently).

6.5.3 Exhaust brake

The exhaust brake consisting of butterfly valve exhaust brake and engine brake functions as auxiliary brake. Exhaust brake also functions when the driver drives down at a long slope.

1) Butterfly valve exhaust brake

Butterfly valve exhaust brake functions as auxiliary brake by controlling butterfly valve installed on the vehicle exhaust pipe to block exhaust flow and increase engine exhaust back pressure and braking power. The exhaust brake switch signal and butterfly valve exhaust relay should be connected to ECU.

A) Butterfly valve exhaust brake is enabled.

The Butterfly valve exhaust brake is enabled on condition that:

a) The engine speed is higher than the limit value (current value: 1100 r/min);

b) The accelerator position is 0%;

c) The exhaust brake switch is switched on.

B) The butterfly valve exhaust brake quits.

When any situation below happens, the butterfly valve exhaust brake will quit:

a) The engine speed is lower than the limit value (current value: 900 r/min);

b) The accelerator opening is more than 0%;

c) The exhaust brake switch is switched off.

2) Engine brake

The auxiliary braking effect can be realized by using compression and release brake to change engine exhaust phase and opening the exhaust valve at the end of compression stroke to release power from air in the engine compression cylinder to the exhaust system, without power returning back to the piston, thus increasing braking power for engine reverse-drive. The exhaust brake switch signal and engine brake relay should be connected to ECU. The engine brake can be used alone, or together with butterfly valve exhaust brake.

A) Engine brake is enabled.

The engine brake is enabled on condition that:

a) The engine speed is higher than the limit value (current value: 1100 r/min);

b) The accelerator position is 0%;

c) The exhaust brake switch is on.

B) The engine brake exits.

When any situation below happens, the engine brake will exit:

a) The engine speed is lower than the limit value (current value: 900 r/min);

b) The accelerator position is more than 0%;

c) Exhaust brake switch is off.

6.5.4 Intake heating

When starting the engine, ECU will judge whether to perform intake heating according to coolant temperature so as to facilitate cold start of engine. Intake heating mainly includes the following steps:

Turn on T15 switch to power on the engine; start intake preheating, and the preheating lamp turns on; intake preheating ends, and the preheating lamp flashes, and the engine is ready to be started; when the preheating lamp turns off, switch on the start switch (T15) to start the engine; After a smooth start, switch the start switch off, and the engine runs at idle speed (heating time is controlled by ECU after air drawing-in, and at this time, the preheating lamp is off).

6.5.5 Multi-state switch

A multi-state switch which can change output torque of the engine is applied in the engineering vehicles (like auto-crane) and trucks. As the auto-crane requires a bigger torque when travelling on the road, the multi-state switch can be operated to enable the engine output power according to maximum external characteristic torque; while smaller torque is required for hoisting, the multi-state switch can be operated to enable the engine output power according to smaller external characteristic torque. It is the same for a truck, and when the multi-state switch is operated, the engine can output bigger torque under heavy load, and smaller torque under light load so as to optimize engine running condition.

6.5.6 Remote accelerator

A remote accelerator may be used for some engineering vehicles (like auto-crane) during engineering work. The remote accelerator and the transfer switch must be connected to ECU. The transfer switch should be switched on for use so that the remote accelerator starts to work, resulting in cab accelerator failure. Switch off the transfer switch, the remote accelerator failure occurs and the cab accelerator functions.

6.5.7 Malfunction indicator lamp

The malfunction indicator lamp includes “MIL” lamp (displays a fault related to discharge) and “SVS” lamp (displays a fault unrelated to discharge). Schematic diagrams for these two lamps are shown in the Fig. 5-1:

“MIL” lamp “SVS” lamp

Fig. 5-1 Schematic diagrams for MIL lamp and SVS lamp

Once the ECU detects a fault, it will store the corresponding fault code promptly, and handle it according to fault type and severity. ECU can store 10 fault codes at most.

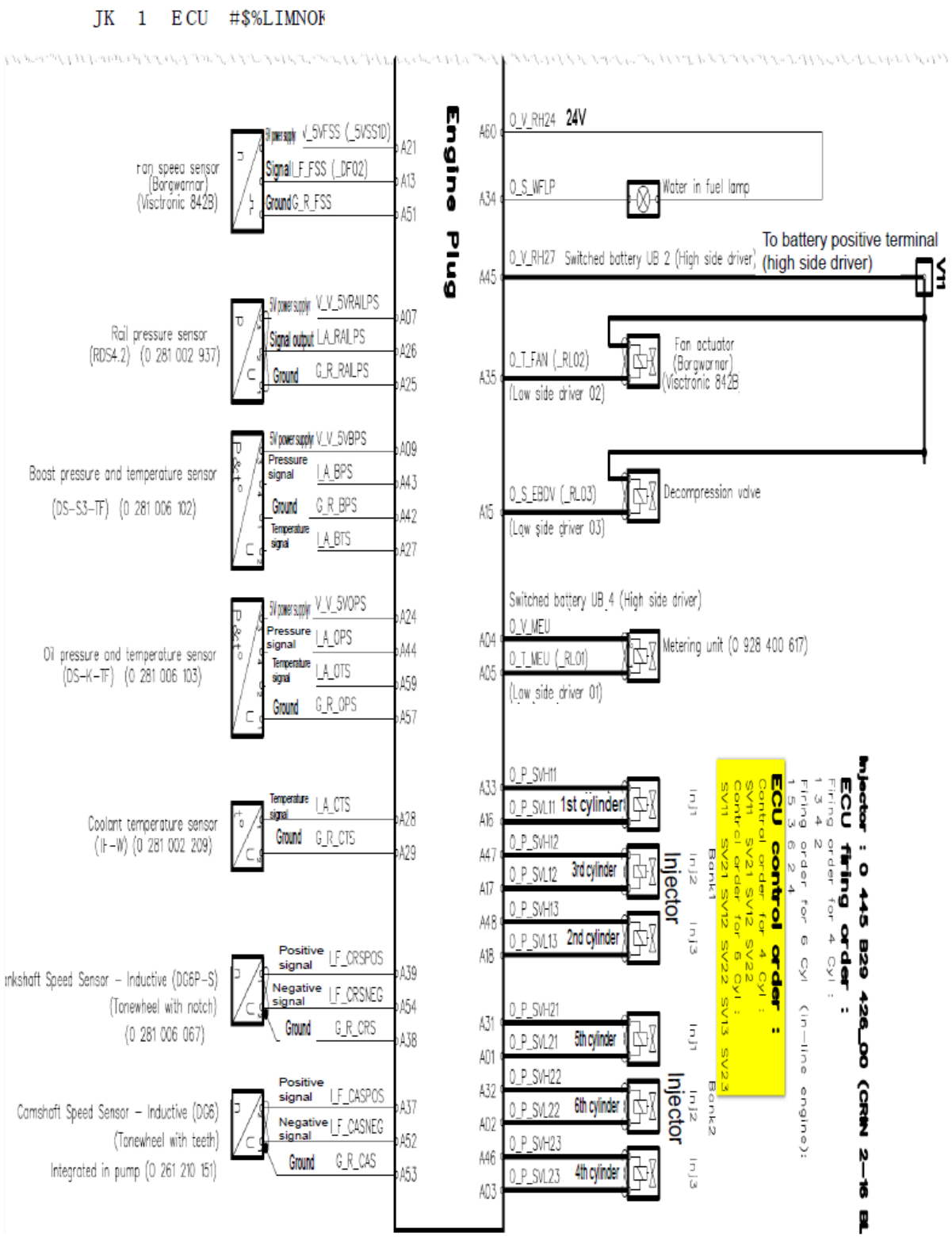
1) If a fault exists, but the “SVS” lamp and the “MIL” lamp are both off, it indicates that it is a slight fault and will not affect normal driving and discharge. The driver cannot notice the fault.

2) If the “SVS” lamp lights up, it indicated that the fault is serious but unrelated to discharge, check and remove the fault timely. Some serious faults may lead to engine limit torque, making the vehicle into “limp home” mode, but a few extremely serious faults may lead to injection stop and engine flameout. When these faults are cleared, the “SVS” lamp will be off;

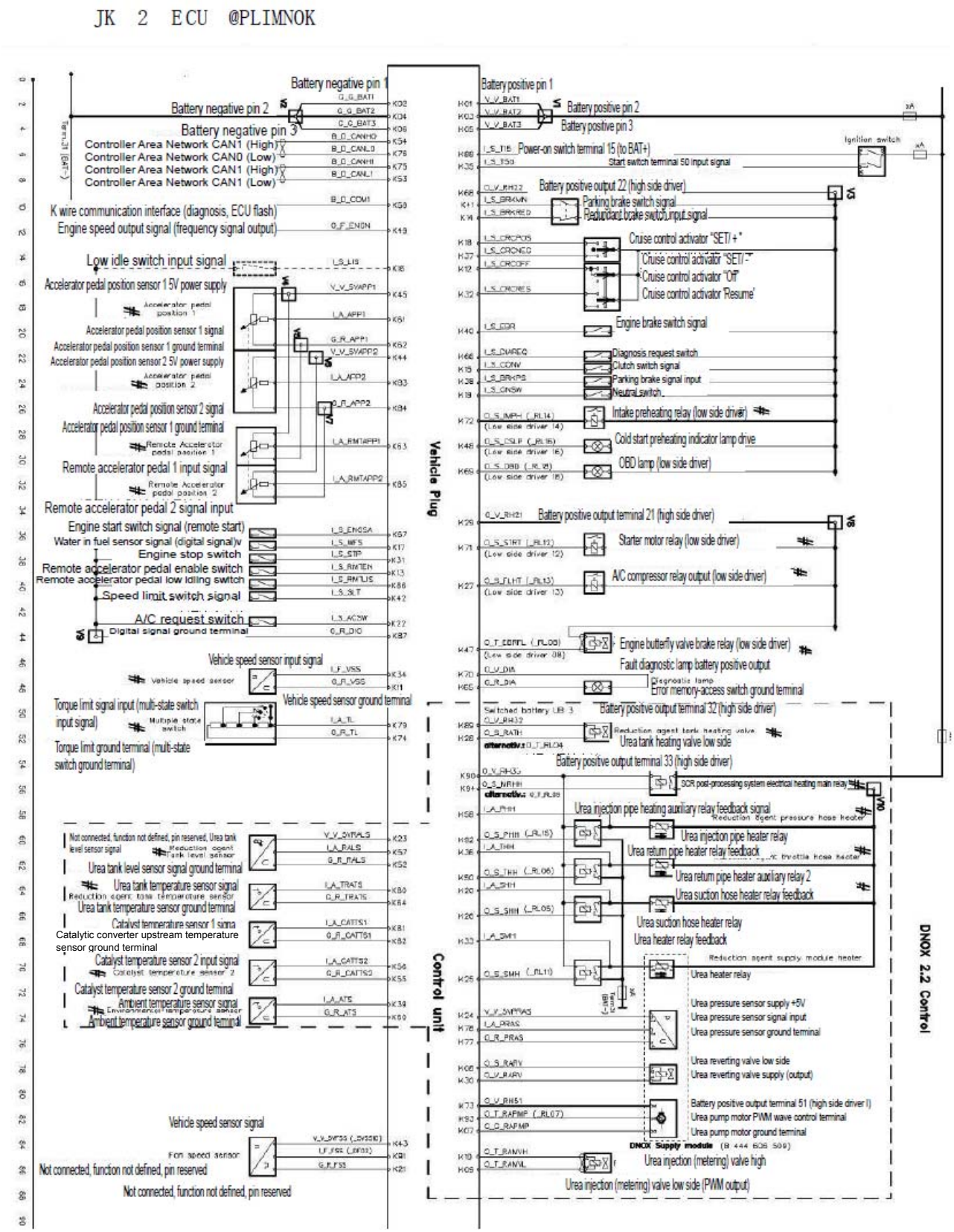
3) If the “MIL” lamp turns on, it indicated that the fault is serious and related to discharge, check and remove the fault timely. Some serious faults may lead to engine limit torque, making the vehicle into “limp home” mode. When these faults are cleared, the “MIL” lamp will not go out immediately, and it will go out on after three continuous working cycles without any fault.

The history fault codes unrelated to discharge can be cleared manually. The solution is to press the diagnostic switch before powering on the engine, hold it for 4 s to 8 s after powering on, and then release the diagnostic switch. At this time, the history fault codes unrelated to discharge are cleared. If the “SVS” lamp is still on, it indicates there are faults currently.

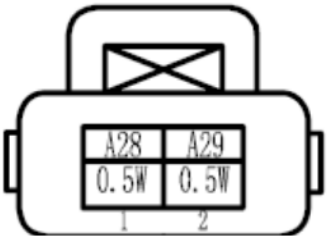
Attached diagram 1 Control schematic diagram for ECU engine terminal



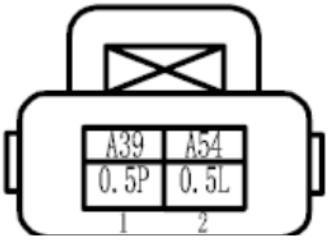
Attached diagram 2 Control schematic diagram for ECU complete vehicle terminals



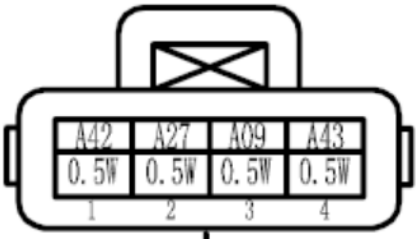
Attached diagram 3: Engine harness connectors



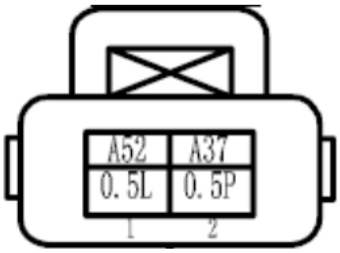
Water temperature sensor



NE sensor

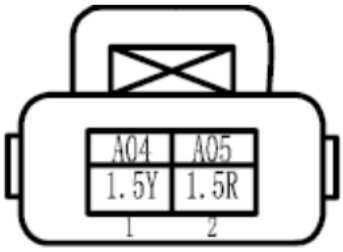


Intake pressure/temperature sensor

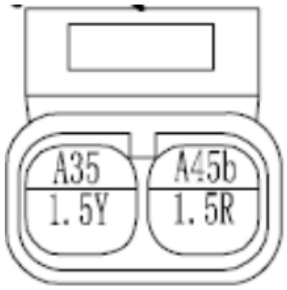


G sensor

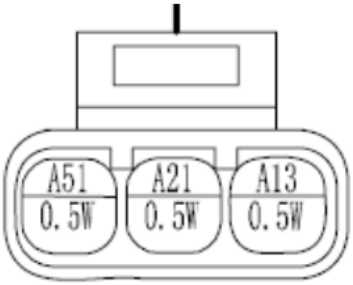
Oil-water indicator lamp



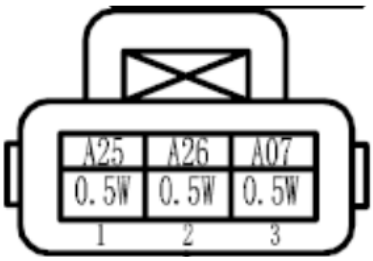
Flow metering valve



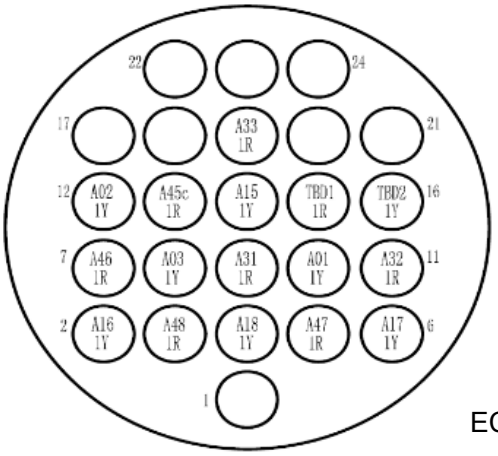
Fan electronic clutch



Fan speed sensor

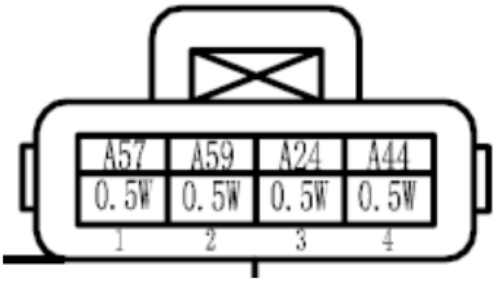


Common rail pressure sensor

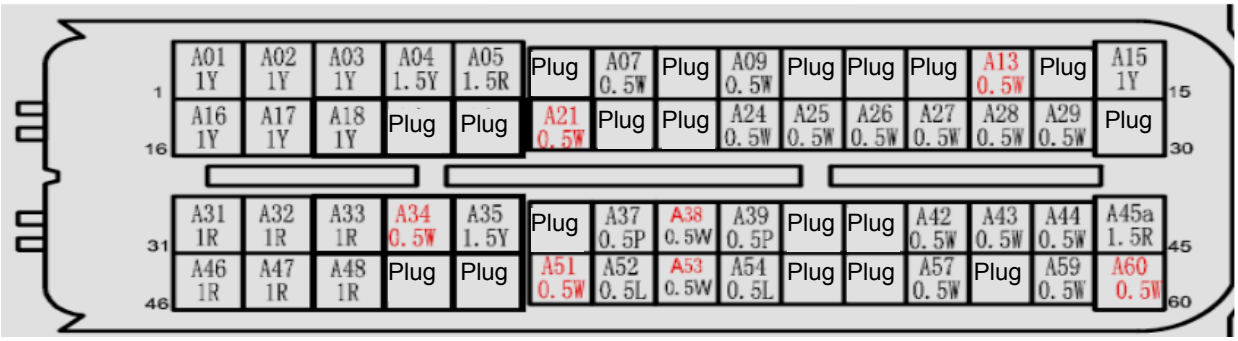


Engine harness connector

ECU engine socket



Oil pressure/temperature sensor



Attached table 4: Fault code table

Fault No.	Fault code	Flash code	Description
P0645	00B	313	The control drive circuit of A/C compressor (ON-OFF type) is open.
P0645	00C	313	The control drive chip of A/C compressor (ON-OFF type) is overheated.
P0645	00D	313	The drive circuit of A/C compressor (PWM) is open.
P0645	00E	313	The drive chip of A/C compressor (PWM) is overheated.
P0647	00F		The control drive circuit of A/C compressor (PWM) is short to positive terminal of power supply.
P0646	010	313	The control drive circuit of A/C compressor (PWM) is short to ground.
P0647	011	313	The control drive circuit of A/C compressor (ON-OFF type) is short to positive terminal of power supply.
P0646	012	313	The control drive circuit of A/C compressor (ON-OFF type) is short to ground.
U0424	013	314	A/C switch signal of CAN bus is not reliable. (A/C switch signal based on CAN bus)
U0466	014	314	A/C switch signal of CAN bus is wrong (A/C switch signal based on CAN bus)
P2609	01A	323	Test fault for intake heater grille.
P2609	01B	323	Test fault for intake heater grille
P2609	01C	323	Test fault for intake heater grille
P2609	01D	323	Test fault for intake heater grille
P2609	01E	322	The intake heater control switch is normally closed.
P0110	120	321	The intake heater drive circuit is open.
P0110	121	321	The intake heater drive chip is overheated.
P0113	122	321	The intake heater drive circuit is short to positive terminal of power supply.
P0112	123	321	The intake heater drive circuit is short to ground.
P0659	025	114	ECU internal relay 0 is short to positive terminal of power supply.
P2671	026	115	ECU internal relay 1 is short to positive terminal of power supply.
P2686	027	116	ECU internal relay 2 is short to positive terminal of power supply.
P0658	028	114	ECU internal relay 0 is short to ground.
P2670	029	115	ECU internal relay 1 is short to ground.
P2685	02A	116	ECU internal relay 2 is short to ground.
P0563	02B	124	Battery voltage exceeds the upper limit.
P0562	02C	124	Battery voltage is lower than the lower limit.
P0563	02D	124	Battery voltage sensor signal exceeds the upper limit.
P0562	02E	124	Battery voltage sensor signal is lower than the lower limit.
P0504	02F	223	The braking signal is not reliable or signal line is in open circuit.
P0504	2D2	223	The braking signal is not reliable or signal line is in open circuit.
P0571	030	223	The braking signal of CAN bus has error.
U0073	031	411	CAN bus 0 communication has error.
U0073	035	411	
U0073	032	412	CAN bus 1 communication has error.

U0073	036	412	
U0074	03F	222	The clutch signal is not reliable or signal line is in open circuit.
U0073	040	222	The clutch signal of CAN bus is wrong.
P0116	039	242	The reasonableness check for absolute value of water temperature is reported wrong.
P0116	03A	242	The reasonableness check for absolute value of water temperature is reported wrong.
P0118	03C	241	The voltage signal of water temperature sensor of engine exceeds the upper limit. The voltage signal of water temperature sensor of engine is lower than the lower limit.
P0117	03D	241	
P0575	0B9	341	The logic of cruise control button is not reasonable. ECU internal chip communication has error (integrated in the ECU).
P0607	0BA	111	
P0607	0BB	111	ECU internal chip communication has error (integrated in the ECU).
P0563	0BC	124	The battery voltage is higher than the upper limit of actuator supply voltage.
P0562	0BD	124	The battery voltage is lower than the lower limit of actuator supply voltage.
P1500	0BE	342	The status for exhaust braking request button is not reasonable.
P2536	0BF	343	The engine compartment stop button (auxiliary stop button) signal of CAN bus is wrong.
P2536	0C0	343	The engine compartment start button (auxiliary start button) signal of CAN bus is wrong.
P0475	0C1	315	The drive circuit of decompression brake valve of engine is open.
P0475	0C2	315	The drive chip of decompression brake valve of engine is overheated.
P0478	0C3	315	The drive circuit of decompression brake valve of engine is short to power supply.
P0477	0C4	315	The drive circuit of decompression brake valve of engine is short to ground.
P062F	0C5	117	EEPROM erasure fault occurs, and erasure is not allowed.
P062F	0C6	117	EEPROM reading fault occurs, and reading is not allowed.
P062F	0C7	117	EEPROM writing fault occurs, and writing is not allowed.
P1008	0DE	512	The injection is broken off.
P0219	0DF	513	Overspeed protection for the engine.
P100A	0E1	344	The speed output signal is in open circuit.
P100B	0E2	344	The speed output drive chip is overheated.
P100C	0E3	344	The speed output signal is short to positive terminal of power supply.
P100D	0E4	344	The speed output signal is short to ground.
U1401	0E5	232	The signal of ambient pressure sensor from CAN bus has error.
P2229	0E6	232	The signal of ambient pressure sensor exceeds the upper limit. (integrated in the ECU)
P2228	0E7	232	The signal of ambient pressure sensor is lower than the lower limit. (integrated in the ECU)
P0073	0E9	235	The voltage signal of ambient pressure sensor exceeds the upper limit.
P0072	0EA	235	The voltage signal of ambient pressure sensor is lower than the lower limit.
P0341	0EB	123	The camshaft sensor signal has error.
P0340	0EC	123	The camshaft sensor has no signal.
P0340	0ED	123	The timing signal of camshaft sensor deviates too much.
P0336	0EE	122	The crankshaft sensor has error.

P0335	0EF	122	The crankshaft sensor has no signal.
P0475	0F0	311	The exhaust braking drive circuit is open.
P0475	0F1	311	The exhaust braking drive chip is overheated.
P0478	0F2	311	The exhaust braking drive circuit is short to positive terminal of power supply.
P0477	0F3	311	The exhaust braking drive circuit is short to ground.
P0481	0FF	312	Fan (PWM type) drive circuit is open.
P0481	100	312	The drive circuit chip of fan (PWM type) is overheated.
P0694	101	312	Fan (PWM type) drive circuit is short to positive terminal of power supply.
P0693	102	312	Fan (PWM type) drive circuit is short to ground.
P0480	0F7	312	Fan (ON-OFF type) drive circuit 0 is open.
P0480	0F8	312	Fan (ON-OFF type) drive circuit 1 is open.
P0480	0F9	312	The drive circuit 0 chip of fan (ON-OFF type) is overheated.
P0480	0FA	312	The drive circuit 1 chip of fan (ON-OFF type) is overheated.
P0692	0FB	312	Fan (ON-OFF type) drive circuit 0 is short to positive terminal of power supply.
P0692	0FC	312	Fan (ON-OFF type) drive circuit 1 is short to positive terminal of power supply.
P0691	0FD	312	Fan (ON-OFF type) drive circuit 0 is short to ground.
P0691	0FE	312	Fan (ON-OFF type) drive circuit 1 is short to ground.
P0480	103	316	The signal period of fan speed is too long.
P0495	104	316	Fan speed exceeds the upper limit.
P0494	105	316	Fan speed is lower than the lower limit.
P2269	116	211	Alarm of too much water in the filter.
P0381	11C	332	The preheating indicator lamp is damaged or the circuit is open.
P0381	11D	332	The drive chip of preheating indicator lamp is overheated.
P0381	11E	332	The drive circuit of preheating indicator lamp is short to positive terminal of power supply.
P0381	11F	332	The drive circuit of preheating indicator lamp is short to ground.
P0087	129	276	The rail pressure is lower than min. injection pressure.
P062D	130	151	Injection module 0 is in short circuit.
P062E	131	151	Injection module 1 is in short circuit.
P062B	132	153	Injection control chip has error.
P0201	133	141	Injector (firing order 1) is in open circuit.
P0205	134	142	Injector (firing order 2) is in open circuit.
P0203	135	143	Injector (firing order 3) is in open circuit.
P0206	136	144	Injector (firing order 4) is in open circuit.
P0202	137	145	Injector (firing order 5) is in open circuit.
P0204	138	146	Injector (firing order 6) is in open circuit.
P0262	13F	141	Injector (firing order 1) is in short circuit.
P0274	140	142	Injector (firing order 2) is in short circuit.
P0268	141	143	Injector (firing order 3) is in short circuit.
P0277	142	144	Injector (firing order 4) is in short circuit.
P0265	143	145	Injector (firing order 5) is in short circuit.
P0271	144	146	Injector (firing order 6) is in short circuit.

P0261	145	141	Injector (firing order 1) is in short circuit.
P0273	146	142	Injector (firing order 2) is in short circuit.
P0267	147	143	Injector (firing order 3) is in short circuit.
P0276	148	144	Injector (firing order 4) is in short circuit.
P0264	149	145	Injector (firing order 5) is in short circuit.
P0270	14A	146	Injector (firing order 6) is in short circuit.
P0251	14D	133	The drive circuit of fuel metering unit is open.
P0252	14E	133	The drive chip of fuel metering unit is overheated.
P0254	14F	133	The high end of drive circuit of fuel metering unit is short to positive terminal of power supply.
P0253	150	133	The high end of drive circuit of fuel metering unit is short to ground.
P0254	151	133	The low end of drive circuit of fuel metering unit is short to positive terminal of power supply.
P0253	152	133	The low end of drive circuit of fuel metering unit is short to ground.
P0650	155	331	The drive circuit of OBD malfunction indicator lamp (MIL) is open.
P0650	156	331	The drive chip of OBD malfunction indicator lamp (MIL) is overheated.
P0650	157	331	The drive circuit of OBD malfunction indicator lamp (MIL) is short to positive terminal of power supply.
P0650	158	331	The drive circuit of OBD malfunction indicator lamp (MIL) is short to ground.
P060B	15A	262	ADC null position test fault.
P060B	15B	262	ADC self-test fault.
P060B	15C	262	ADC transfer voltage is not accurate.
P060C	15D	262	The internal response communication fault of ECU.
P060C	15E	262	The internal SPI communication fault of ECU.
P060C	15F	262	The internal ROM self-test fault of ECU.
P060C	160	263	Communication between SOP_CPU and control module is missing synchronously.
P060C	161	263	SOP_fault is used to limit torque before being reported.
P060C	162	263	SOP_communication response time has error.
P060C	163	263	SOP_SPI communication fault occurs for many times.
P060C	164	263	SOP_voltage is too low.
P060C	165	263	SOP_monitoring module WDA cannot work regularly.
P060C	166	263	SOP_operating system runs overtime.
P060C	167	263	SOP_active closing injection test fails.
P060C	168	263	SOP_communication is overtime.
P060C	169	263	SOP_voltage is too high.
P1012	16A	264	The accelerator pedal is faulty.
P1013	16B	264	The engine speed has error.
P101A	172	261	Under reverse running condition, the injector power-on time exceeds the allowance.
P101A	2ED	261	Under reverse running condition, the power-on time for injector cooling injection exceeds the allowance.
P1600	17A	265	The voltage of power supply of sensor exceeds the upper limit.
P1601	17B	265	The voltage of power supply of sensor is lower than the lower limit.
P068A	17C	125	The main relay is switched on too early (integrated in the ECU).
P068B	17D	125	The main relay cannot be switched off (integrated in the ECU).
P060C	1B7	111	ECU internal chip communication has error (response communication).

P060C	1B8	111	ECU internal chip communication has error (low voltage).
P060C	1B9	111	ECU internal chip communication has error (high voltage).
P060C	1BA	111	ECU internal chip communication has error (for other reasons).
P160B	1C0	334	The drive circuit of oil pressure lamp is open.
P160C	1C1	334	The drive chip of oil pressure is overheated.
P160D	1C2	334	The drive circuit of oil pressure lamp is short to positive terminal of power supply.
P160E	1C3	334	The drive circuit of oil pressure lamp is short to ground.
P0524	1C4	243	The oil pressure is lower than the lower limit.
P0521	1C5	243	The reasonable test fault for oil pressure.
P0523	1C6	243	The oil pressure exceeds the upper limit.
P0524	1C7	243	The oil pressure is lower than the lower limit.
P0520	1C8	243	The oil pressure signal of CAN bus has error.
P0523	1C9	243	The voltage signal of oil pressure sensor exceeds the upper limit.
P0522	1CA	243	The voltage signal of oil pressure sensor is lower than the lower limit.
P0196	1CB	244	The oil temperature exceeds the upper limit.
U1403	1CC	244	The signal of oil temperature sensor of CAN bus has error.
P0198	1CD	244	The voltage signal of oil temperature sensor exceeds the upper limit.
P0197	1CE	244	The voltage signal of oil stability sensor is lower than the lower limit.
P2263	1D0	282	The boost pressure is lower than the limit value.
P2263	1D1	282	The boost pressure is higher than the limit value.
P006D	1D3	231	The reasonableness check deviation between boost pressure and ambient pressure exceeds the upper limit.
P006D	1D4	231	The reasonableness check deviation between boost pressure and ambient pressure is lower than the lower limit.
P0238	1D5	231	The voltage signal of boost pressure sensor exceeds the upper limit.
P0237	1D6	231	The voltage signal of boost pressure sensor is lower than the lower limit.
P0099	0FE	233	The signal of intake temperature sensor of CAN bus has error.
P0098	0FF	233	The voltage signal of intake temperature sensor exceeds the upper limit.
P0097	100	233	The voltage signal of intake temperature sensor is lower than the lower limit.
P0096	101	233	The signal reasonable fault of intake temperature sensor occurs.
P0113	270	236	The voltage signal of intake temperature sensor exceeds the upper limit.
P0112	271	236	The voltage signal of intake temperature sensor is lower than the lower limit.
P0089	1DF	134	The opening frequency of decompression valve exceeds max. permissible value.
P0089	1E2	135	Decompression valve is opened.
P1037	1E4	136	After opening decompression valve, the average rail pressure exceeds the limit value.
P0089	1E5	136	The accumulative opening time of decompression valve exceeds the limit value.
U1404	223	345	The signal of multi-state switch of CAN bus has error.
P253E	191	345	The voltage signal of multi-state switch is not reasonable.
P251C	14B	345	The voltage signal of multi-state switch exceeds the upper limit.
P251B	159	345	The voltage signal of multi-state switch is lower than the lower limit.
P0251	1E7	251	The actual rail pressure is lower than the set value.
P0251	1E8	252	The actual oil quantity of system exceeds the required value range.
P0251	1E9	255	Under fuel metering unit in small opening, the rail pressure is too high.

P0251	1EA	253	Under fuel metering unit in small opening, the rail pressure is too high.
P0087	1EB	256	The rail pressure is seriously low.
P0088	1EC	271	The rail pressure is too high.
P0088	1ED	272	The rail pressure is seriously high.
P1050	1EE	273	Under reverse running condition, the flow of fuel metering unit is too large.
P0251	1EF	274	Under idling condition, the flow of fuel metering unit is too large.
P0194	1F0	275	The signal jump of rail pressure is excessive.
P0088	1F3	136	After opening decompression valve, the rail pressure is too high.
P0088	2EE	136	After opening decompression valve, the rail pressure too high.
P0088	1EF	136	After opening decompression valve, the rail pressure too high.
P0191	1F1	132	The signal of rail pressure sensor shows positive deviation.
P0191	1F2	132	The signal of rail pressure sensor shows negative deviation.
P0193	1F4	131	The voltage signal of rail pressure sensor exceeds the upper limit.
P0192	1F5	131	The voltage signal of rail pressure sensor is lower than the lower limit.
P0123	22B	221	The voltage signal of accelerator pedal 1 exceeds the upper limit.
P0223	22C	221	The voltage signal of accelerator pedal 2 exceeds the upper limit.
P0122	22F	221	The voltage signal of accelerator pedal 1 is lower than the lower limit.
P0222	230	221	The voltage signal of accelerator pedal 2 is lower than the lower limit.
P2135	24C	221	The accelerator pedal signal has synchronous fault.
P2135	24D	221	There are reasonable fault between accelerator pedal and idling switch.
P1501	22D	229	The voltage signal of remote accelerator pedal 1 exceeds the upper limit.
P1502	22E	229	The voltage signal of remote accelerator pedal 2 exceeds the upper limit.
P1503	231	229	The voltage signal of remote accelerator pedal 1 is lower than the lower limit.
P1504	232	229	The voltage signal of remote accelerator pedal 2 is lower than the lower limit.
P1505	24E	229	Remote accelerator pedal has synchronous fault.
P0643	235	112	The sensor power supply module 1 is faulty
P0653	236	112	The sensor power supply module 2 is faulty.
P0699	237	112	The sensor power supply module 3 is faulty.
P1602	238	113	The voltage of 12V sensor power supply 1 exceeds the upper limit.
P1603	239	113	The voltage of 12V sensor power supply 1 is lower than the lower limit.
P1602	23A	113	The voltage of internal 12V sensor power supply exceeds the upper limit.
P1603	23B	113	The voltage of internal 12V sensor power supply is lower than the lower limit.
P060C	23C	111	ECU internal clock comparison has error.
P1615	241	121	Starter drive circuit is open.
P1615	242	121	Starter drive chip is overheated.
P1617	243	121	Starter drive circuit is short to positive terminal of power supply.
P1616	244	121	Starter drive circuit is short to ground.
P1604	245	333	SVS lamp drive circuit is open.
P1605	246	333	SVS lamp drive chip is overheated.
P1606	247	333	SVS lamp drive circuit is short to positive terminal of power supply.
P1607	248	333	SVS lamp drive circuit is short to ground.

P1608	249	118	Software reset 0
P1609	24A	118	Software reset 1
P160A	24B	118	Software reset 2
P2530	24F	345	T50 signal has error.
P0669	258	119	The voltage of ECU internal temperature sensor exceeds the upper limit. (integrated in the ECU)
P0668	259	119	The voltage of ECU internal temperature sensor is lower than the lower limit. (integrated in the ECU)
U1405	2C3	224	The vehicle speed signal of CAN bus is wrong.
P0279	2C4	224	The vehicle speed is higher than permissible maximum value.
P2162	2C5	224	There is no speed signal.
P0501	2C6	224	The vehicle speed is not reasonable.
P0503	2C7	224	The voltage signal of vehicle speed sensor exceeds the upper limit.
P0502	2C8	224	The voltage signal of vehicle speed sensor is lower than the upper limit.
P2158	2C9	225	The signal pulse width of vehicle speed sensor is too large.
P2160	2CA	225	The signal pulse width of vehicle speed sensor is too small.
P2161	2CB	225	The signal average period of vehicle speed sensor is too short.