

Document Title: Engine, description	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
Profile: CEX, ECR88 [GB]			

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Engine, description

- The engine is a 4-cycle, 4-cylinder, direct injected, water cooled diesel engine.
- The engine produces powerful performance using direct injection type combustion chamber.

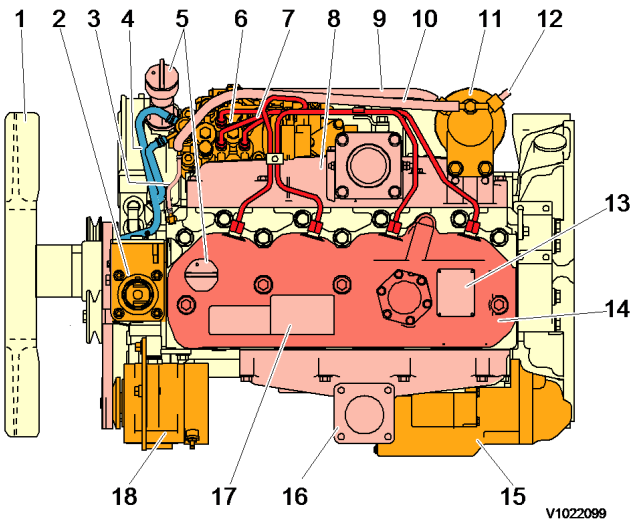


Figure 1
Engine, top side view

1	Cooling fan	7	Fuel pipe	13	Engine data plate
2	Thermostat housing	8	Intake manifold	14	Rocker arm cover
3	Fuel return line	9	Fuel supply line to fuel injection pump	15	Start motor
4	Hose for thermostat element	10	Fuel return line	16	Exhaust manifold
5	Oil filler port	11	Fuel filter	17	Engine data plate
6	Fuel injection pump	12	Fuel supply line to fuel filter	18	Alternator

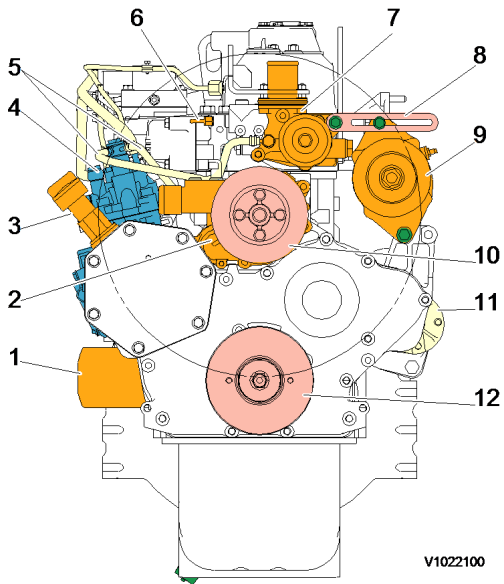


Figure 2
Engine, front side view

- | | | | | | |
|---|------------------------|---|-----------------------------|----|---------------------|
| 1 | Engine oil filter | 5 | Hose for thermostat element | 9 | Alternator |
| 2 | Cooling water pump | 6 | Fuel return line | 10 | Fan pulley |
| 3 | Engine oil filler port | 7 | Thermostat housing | 11 | Starter motor |
| 4 | Fuel injection pump | 8 | Adjuster | 12 | Crankshaft V-pulley |

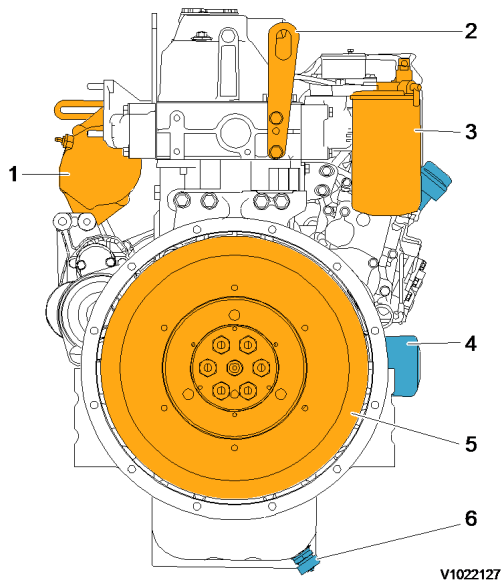
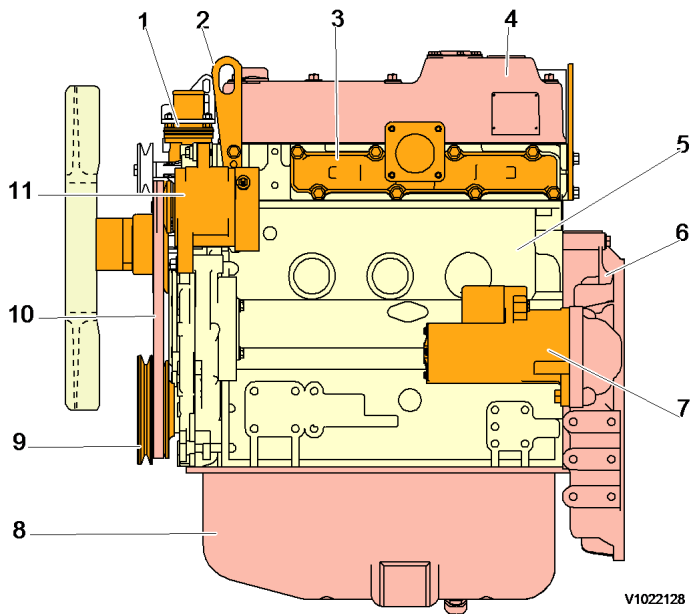


Figure 3
Engine, rear side view

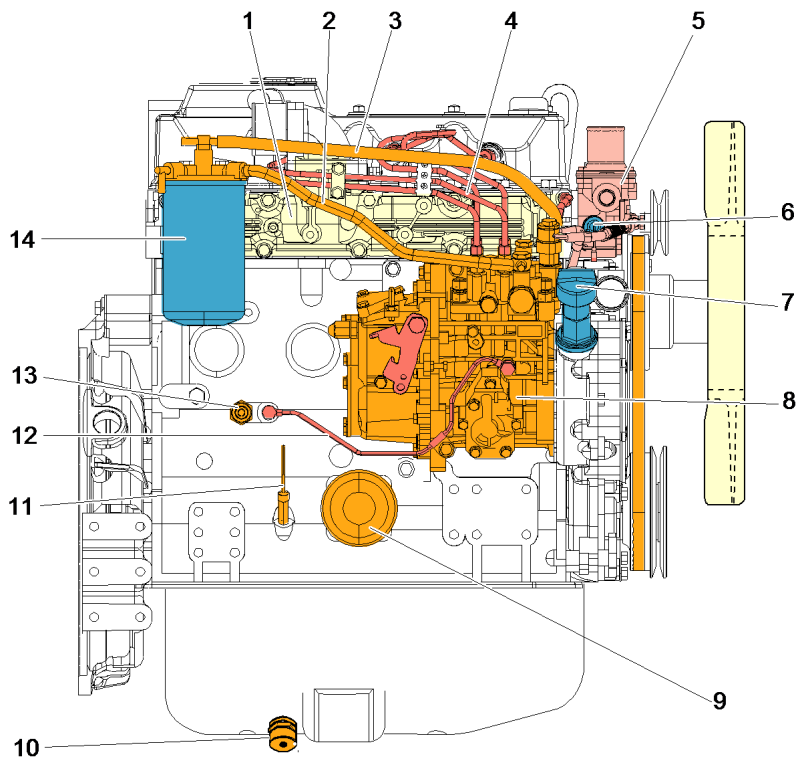
1. Alternator
2. Lifting bracket
3. Fuel filler
4. Engine oil filter
5. Flywheel
6. Oil drain valve (M22 x 1.5P)



V1022128

Figure 4
Engine, starter motor side view

- | | | | |
|---|--------------------|----|--------------------|
| 1 | Thermostat housing | 7 | Starter motor |
| 2 | Lifting eye | 8 | Engine oil pan |
| 3 | Exhaust manifold | 9 | Crankshaft V-pully |
| 4 | Rocker arm cover | 10 | V-belt |
| 5 | Cylinder block | 11 | Alternator |
| 6 | Flywheel housing | | |



V1022129

Figure 5
Engine, fuel filter side view

- | | | | | | |
|---|---------------------|----|------------------------|----|-------------------------------|
| 1 | Intake manifold | 6 | C. W. switch | 11 | Engine oil dipstick |
| 2 | Fuel supply line | 7 | Oil filler port | 12 | Injection pump lubricant pipe |
| 3 | Fuel return line | 8 | Fuel injection pump | 13 | Oil pressure switch |
| 4 | Fuel injection pipe | 9 | Engine oil filter | 14 | Fuel filter |
| 5 | Thermostat housing | 10 | Engine oil drain valve | | |

Document Title: Engine, description	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
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Engine, description

D3.4D Engine

The D3.4D configuration is a four stroke, straight four cylinder, direct injected, water cooled diesel engine.

The engine produces powerful performance using direct injection type combustion chamber.

The valve mechanism receives its movement from the camshaft via rods and rocker arms. Turning direction is counter-clockwise seen from the flywheel. Firing order is 1-3-4-2 and the first cylinder is on the flywheel side.

The lubrication system consists of forced lubrication with trochoid pump.

The cooling of the engine is performed by a high capacity radiator and a hydraulic oil cooler.

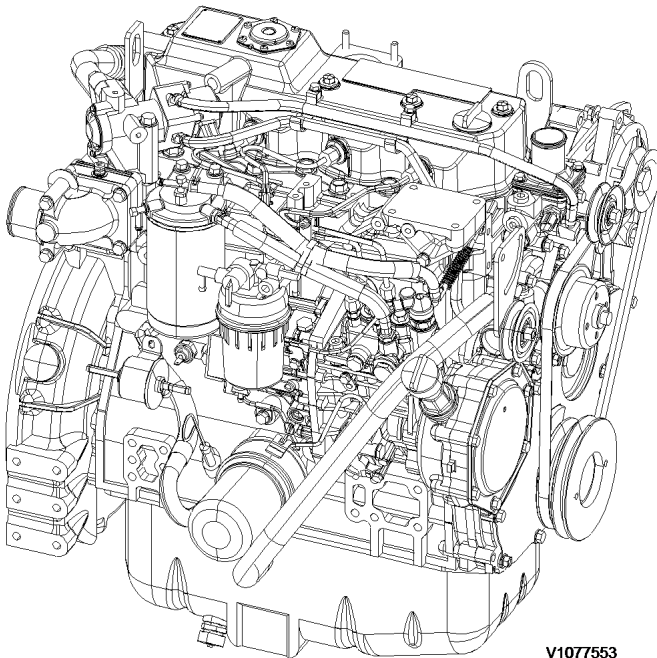


Figure 1
Engine, D3.4D

Document Title: Engine, identification	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
Profile: CEX, ECR88 [GB]			

Engine, identification

Identification plate

The engine model, serial number and performance data are stamped on an identification plate which is attached on the cylinder head cover. The engine model designation and serial number must be indicated when ordering spare parts.

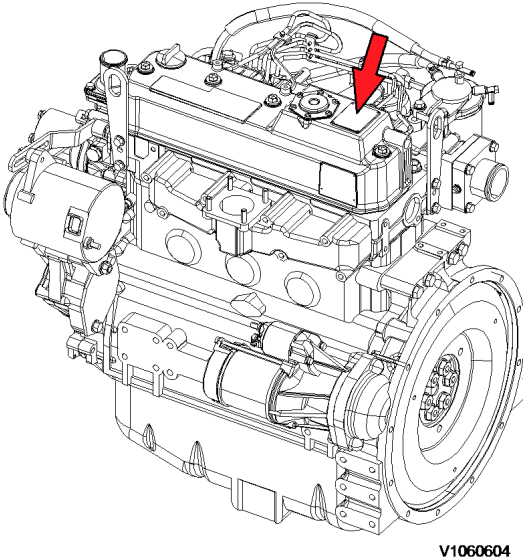


Figure 1
Engine identification

Document Title: Engine, tightening torque	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
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Engine, tightening torque

Tightening torque, unit: Nm (lbf ft)

Item	Nominal size	Tighten torque	Lubricating oil application (thread portion, and seat surface)
Cylinder head screw	M 11 × 1.25	103.1 ~ 112.9 (76 ~ 83)	Applied
Connecting rod screw	M10 × 1.0	53.9 ~ 58.8 (40 ~ 43)	Applied
Flywheel set screw	M14 × 1.5	186.2 ~ 205.8 (137 ~ 152)	Applied
Bearing cap set screw	M 11 × 1.25	108.1 ~ 117.9 (80 ~ 87)	Applied
Crankshaft pulley set screw	M14 × 1.5	107.9 ~ 127.5 (80 ~ 94)	Applied
Fuel injection nozzle set screw	M 8 × 1.25	22.6 ~ 28.4 (17 ~ 21)	Not applied
Fuel feed pump drive gear set nut	M 18 × 1.5	113 ~ 123 (83 ~ 90)	Not applied
High-pressure fuel lines screw	M 12 × 1.5	19.6 ~ 24.5 (174 ~ 217)	Not applied
Fuel return pipe joint screw	M 6 × 1.0	7.8 ~ 9.8 (70 ~ 86)	Not applied

Tightening torque for standard screws and nuts, unit: Nm (lbf ft)

Item	Nominal size	Tighten torque	Lubricating oil application (thread portion, and seat surface)
Screw (7T) and nut	M 6 × 1.0	9.8 ~ 11.8 (7 ~ 9)	<ul style="list-style-type: none"> Use 80% of the value at left when the tightening part is aluminium. Use 60% of the value at left for 4T screws and lock nuts.
	M 8 × 1.25	22.6 ~ 28.4 (17 ~ 21)	
	M 10 × 1.5	44.1 ~ 53.9 (33 ~ 40)	
	M 12 × 1.75	78.4 ~ 98 (58 ~ 72)	
	M 14 × 1.5	127.5 ~ 147.1 (94 ~ 108)	
	M 16 × 1.5	215.7 ~ 235.4 (157 ~ 174)	
PT plug	1/8	9.8 (7)	
	1/4	19.6 (14)	
	3/8	29.4 (22)	
	1/2	58.5 (43)	
Pipe joint screw	M 8	12.7 ~ 16.7 (9 ~ 12)	
	M 10	19.6 ~ 25.5 (14 ~ 19)	
	M 12	24.5 ~ 34.3 (18 ~ 25)	
	M 14	39.2 ~ 49 (29 ~ 36)	
	M 16	49 ~ 58.8 (36 ~ 43)	

NOTE!

Lubricating oil is not applied to threaded portion and seat surface.

Document Title: Precautions	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
Profile: CEX, ECR88 [GB]			

Precautions

Make preparation as follows before starting engine inspection and service.



Risk of personal injury. Very heavy object.

Be sure to fix the engine securely to prevent injury or damage due to parts falling during the work.



Risk of personal injury! Wear safety glasses and use protective gloves.

Always wear glasses or a protective face shield when using compressed air or steam to prevent any foreign matter from getting into the eyes.

- Fix the engine on a horizontal base.
- Remove the coolant hoses, fuel oil pipes, wire harness, control wires etc. connecting the driven machine and engine, and drain coolant, lubricating oil and fuel.
- Remove soil, oil, dust, etc. from the engine by washing with solvent, air, steam, etc. Carefully operate so as not to let any foreign matter enter the engine.
- Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit shall be replaced.
- Any part predicted to dissatisfy the standard or limit before the next service as estimated from the state of use should be replaced even when the measured value then satisfies the standard or limit.

Document Title: Periodic inspection and maintenance procedure	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
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Periodic inspection and maintenance procedure

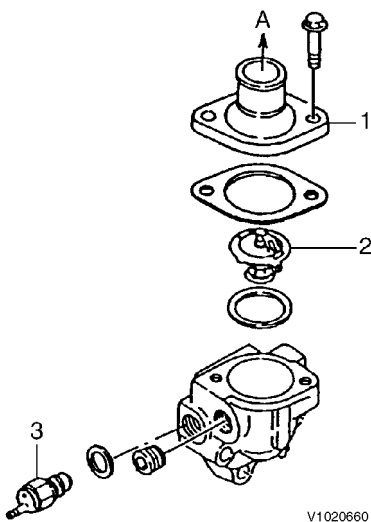
Check before daily operation

Be sure to check the following points before starting the engine every day.

If any problem is found, do not use the machine before the engine repairs have been completed.

- Oil leak from the lubrication system
- Fuel leak from the fuel system
- Coolant leak from the cooling system
- Damaged parts
- Loosened or lost screws
- Fuel, radiator rubber hoses cracked, loosened clamp

Thermostat and Thermal Switch Inspection



V1020660

Figure 1
Thermostat

1. Cover
2. Thermostat
3. Thermostat switch

A. To radiator

1. Thermostat
Place the thermostat in a container filled with water.

Heat it while measuring the water temperature, and see that the thermostat is actuated at the temperature of following table.

Valve opening temperature, °C (°F)	Full open lift, mm (°C, °F)
69.5 ~ 72.5 (157.1 ~ 162.5)	8 mm or more (85 °C, 185 °F)

NOTE!

Valve opening temperature is scribed on the flange.

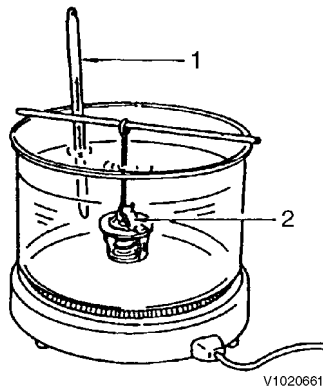


Figure 2
Thermostat inspection

1. Thermometer
2. Thermostat

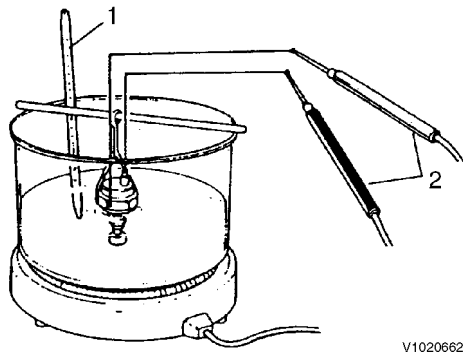


Figure 3
Thermostat switch inspection

1. Thermometer
2. Tester probes

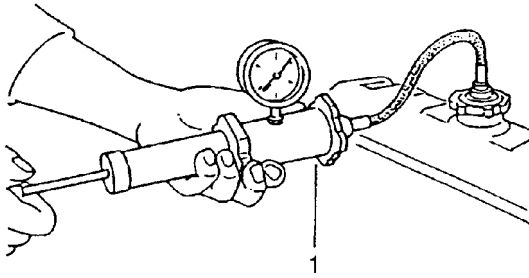
2. Thermostat switch
Place the thermostat switch in a container filled with antifreeze or oil. Heat it while measuring the fluid temperature. The switch is normal if the multi-meter shows continuity when the fluid temperature is 107 ~ 113 °C (225 ~ 235 °F).
- Inspection and replacement of fuel pipe and cooling pipes/hoses.
 - Regularly check the rubber hoses of the fuel system and cooling system. If cracked or degraded, replace them with new ones. Replace the rubber hoses at least every 2 years.
- Lapping the intake and exhaust valves
 - The adjustment is necessary to maintain proper contact of the valves and seats.
- Fuel injection timing inspection and adjustment

Sensor inspection

- Oil pressure switch
Disconnect the connector from the oil pressure switch. Keep the multi-meter probes in contact with the switch terminal and cylinder block while operating the engine. If is abnormal if circuit is closed.
- Thermostat switch

Coolant leak check in cooling system

- Check coolant leakage from the cooling system visually. If any problem is found, Inspect as follows :

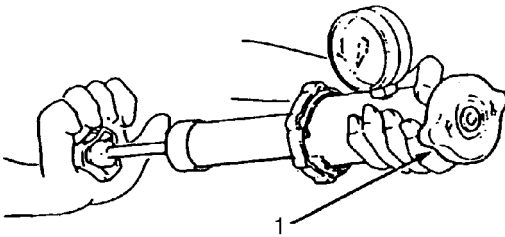


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Figure 5
Water leak check in coolant system

1. Cap tester
 - Fill coolant to the normal level in the radiator, and install the cap tester on the radiator.
 - Operate the manual pump to set the pressure to $0.9 \pm 0.15 \text{ kgf/cm}^2$ ($12.8 \pm 2.1 \text{ psi}$). If the cap tester pressure gage reading drops then, coolant is leaking from the cooling system. Check and repair the coolant leaking point.

Radiator cap inspection



V1020665

Figure 6
Radiator cap inspection

1. Radiator cap
 - Install the radiator cap on the cap tester. Set the tester pressure to $0.9 \pm 0.15 \text{ kgf/cm}^2$ ($12.8 \pm 2.1 \text{ psi}$) and check that the cap relief valve is opened. If the relief valve does not open, replace the cap since it is abnormal.

Document Title: Component locations	Function Group: 200	Information Type: Service Information	Date: 2014/4/20
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Component locations

Component position, engine D3.4D. The following figures show the position of a number of components on engine D3.4D.

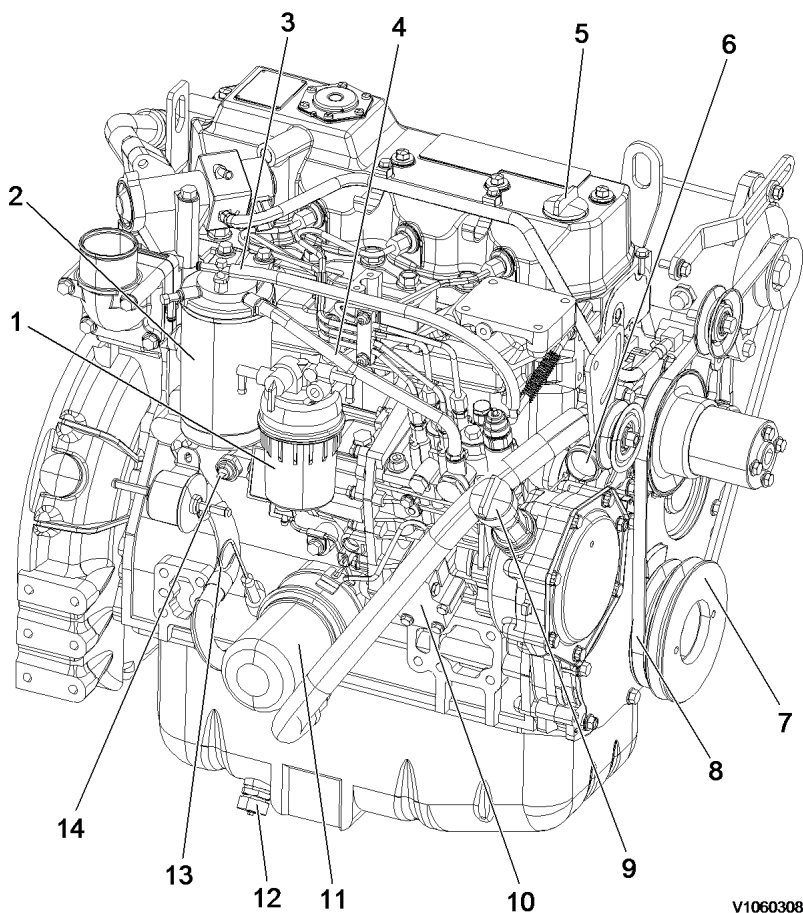
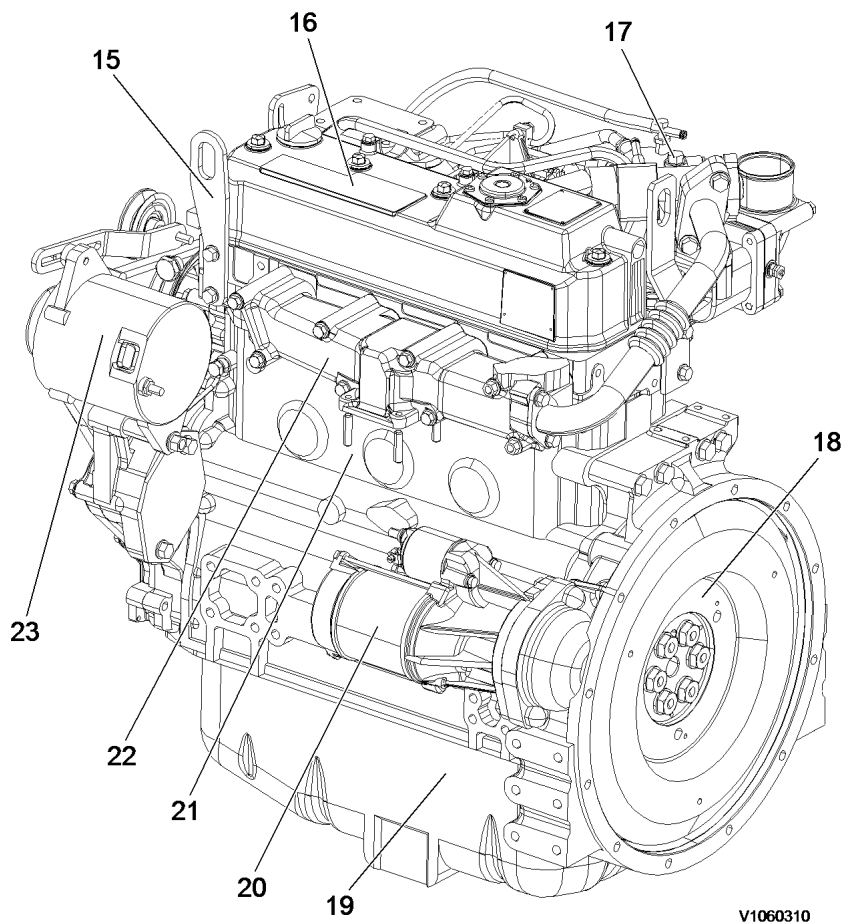


Figure 1
Component locations, front side

1	Water separator	8	V-belt
2	Fuel filter	9	Side filler port (engine oil)
3	Fuel return line	10	Fuel injection pump
4	Fuel supply line	11	Engine oil filter
5	Top filler port (engine oil)	12	Engine oil drain plug
6	Engine coolant pump	13	Engine oil dipstick
7	Crankshaft V-pulley	14	Oil pressure switch



V1060310

Figure 2
Component locations, flywheel side

15	Lifting bracket (engine cooling fan end)	20	Starter motor
16	Rocker arm cover	21	Cylinder block
17	EGR valve	22	Exhaust manifold
18	Flywheel	23	Alternator
19	Oil pan		

Document Title: Adjusting operation	Function Group: 210	Information Type: Service Information	Date: 2014/4/20
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Adjusting operation

Perform adjusting operation as follows after the maintenance job:

- Supply the fuel oil, lubricating oil and coolant.

NOTE!

Check the levels of the lubricating oil and coolant again after test running (for about 5 minutes) and add as required.

- Start the engine, and carry out idling at a low revolution (700 ~ 900 rpm) for a few minutes.
- Run in the engine for about five minutes at the rated revolution (no-load). Check for coolant, fuel or oil leaks and existence of abnormal vibration or noise. Also check the oil pressure, coolant temperature and exhaust gas color.
- Adjust the no-load minimum and maximum revolutions according to the specifications.
- Perform loaded operation as required.

Long storage

Observe the following instructions when the engine is to be stored for a long period without operation:

- Always drain coolant in a cold season or before extended storage. (This is unnecessary when antifreeze is used.)

NOTE!

Negligence of water draining will cause the water remaining inside the engine to freeze and expanded, damaging the engine cooling system components.

- Coolant draining procedure
 1. Remove the radiator cap.
 2. Loosen the draining cock under the radiator to drain coolant.
 3. Loosen the drain cock on the side of the engine block to drain coolant.
 4. After draining coolant, tighten the radiator cap and drain plug and cocks.
- Remove all mud, dust, oil deposits and thoroughly clean the engine and attached components.
- Perform the nearest periodic inspection before the storage.
- Drain or fill the fuel oil fully to prevent condensation in the fuel tank.
- Disconnect the battery cable from the battery negative terminal.
- Cover the silencer, air cleaner and electric parts with PVC cover to prevent water and dust from depositing or entrance.
- Select a well-ventilated location without moisture and dust for storage.
- Perform battery recharging once a month during storage to compensate for self-discharge.

Checking and adjusting radiator fan V-belt

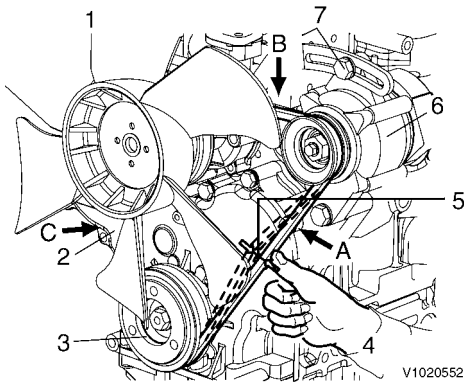


Figure 1
Checking and adjustment, radiator fan V-belt

1. Radiator fan
2. V-belt
3. Crankshaft V-pulley
4. Press with thumb
5. Deflection
6. Alternator
7. Set screw

When there is not enough tension in the V-belt, the V-belt will slip making it impossible for the alternator to generate power and water pump and cooling fan will not work causing the engine to overheat. Check and adjust the V-belt tension (deflection) in the following manner.

- Press the V-belt with your thumb [approximately 98N (10kgf)] at the middle of the V-belt span to check the tension (deflection). Available positions to check and adjust the V-belt tension (deflection) are at the A, B or C direction as shown in the illustration right. You may choose a position whichever you can easily carry out the check and adjustment on the machine unit.

- "New V-belt" refers to a V-belt which has been used less than 5 minutes on a running engine.
- "Used V-belt" refers to a V-belt which has been used on a running engine for 5 minutes or more.
- The specified deflection to be measured at each position should be as follows.

V-belt deflection, unit: mm (in)

Direction	A	B	C
For used V-belt	10 ~ 14 (0.39 ~ 0.55)	7 ~ 10 (0.28 ~ 0.39)	9 ~ 13 (0.35 ~ 0.51)
For new V-belt	8 ~ 12 (0.31 ~ 0.47)	5 ~ 8 (0.20 ~ 0.31)	7 ~ 11 (0.28 ~ 0.43)

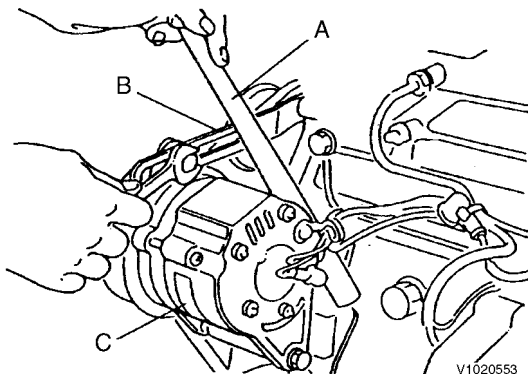


Figure 2
Adjustment, V-belt tension

- A. Bar
- B. Adjuster
- C. Alternator

- If necessary, adjust the V-belt tension (deflection).
To adjust the V-belt tension, loosen the set screw and move the alternator to tighten the V-belt. After replacing with a new V-belt and adjusting it, run the engine for 5 minutes and readjust the deflection to the value in the table above.
- Visually check the V-belt for cracks, oiliness or wear.
If any, replace the V-belt with a new one.
- Inspection and adjustment: Injection pressure and spray pattern of fuel injection valve

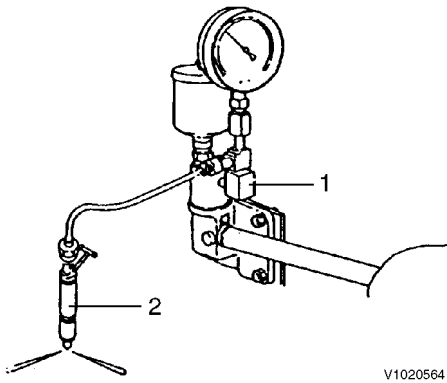


Figure 3
Injection pressure measurement

- 1. Nozzle tester
- 2. Injection nozzle

- Injection pressure measurement
: $225 \pm 5 \text{ kgf/cm}^2$ ($3200 \pm 71 \text{ psi}$)
Remove carbon deposit at the nozzle hole thoroughly before measurement.
 - Connect the fuel injection valve to the high pressure pipe of the nozzle tester.
 - Operate the nozzle tester lever slowly and read the pressure at the moment when the fuel injection from the nozzle starts.
 - If the measured injection pressure is lower than the standard level, replace the pressure adjusting shim with a thicker one.

Injection pressure adjustment

Type of pressure adjusting shim thickness, mm (in)	Injection pressure adjustment
0.13(0.0051), 0.15(0.0059), 0.18(0.0071), 0.4(0.0157), 0.5(0.0197), 0.8(0.0315)	The injection pressure is increased by approximately 19 kgf/cm^2 (270 psi) when the adjusting shim thickness is increased by 0.1 mm (0.004).

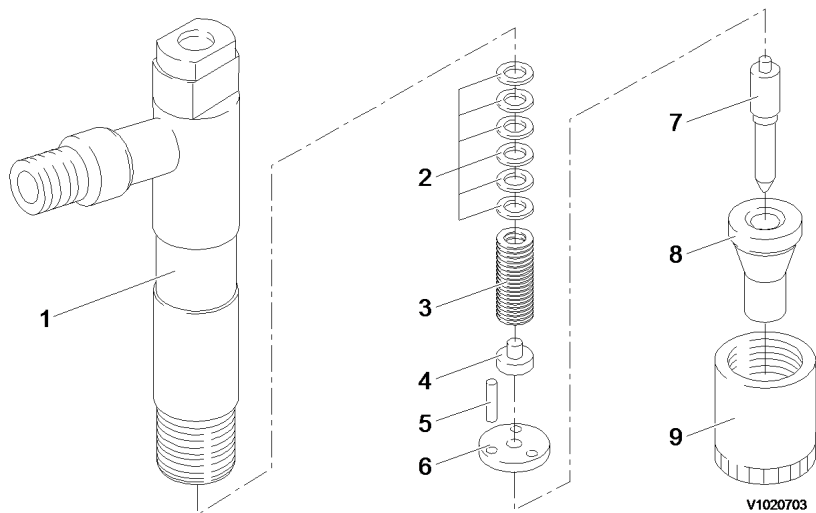


Figure 4
Exploded view, fuel injection valve

1	Nozzle holder
2	Pressure adjusting shim
3	Nozzle spring
4	Nozzle spring seat
5	Dowel pin
6	Valve stop spacer
7	Nozzle valve
8	Nozzle body
9	Nozzle case nut (tightening torque : 4.25 ± 0.25 kgf-m (30.7 ± 1.8 lbf-ft))

- Spray pattern inspection
After adjustment to the specified valve opening pressure, use a nozzle tester and check the spray pattern and seat oil-tightness.

1. Seat oil tightness check

- After injecting a few times, increase the pressure gradually.
- Hold the pressure for about 5 seconds at a little before the valve opening pressure of 20 kgf/cm² (285 psi), and check to see that oil does not drip from the tip end of the nozzle.
- If extreme oil leak from the overflow joint exists during injection by the nozzle tester, check after retightening. If excessive oil is leaking, replace the nozzle assembly.

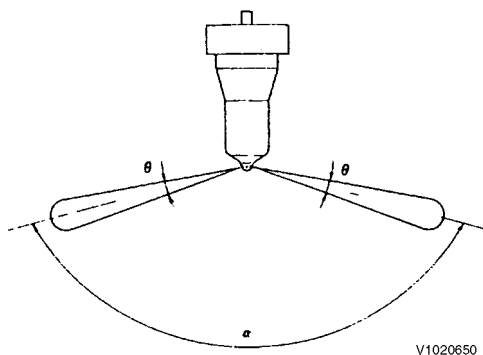


Figure 5
Uniform spray pattern from each nozzle (normal)

2. Spray and injection states

- Operate the nozzle tester lever at a rate of once or twice a second and check for abnormal injection.
- If normal injection as shown below cannot be obtained, replace the fuel injection valve.
 - No extreme difference in angle (θ)
 - No extreme injection angle difference (α)
 - Finely atomized spray
 - Excellent spray departure

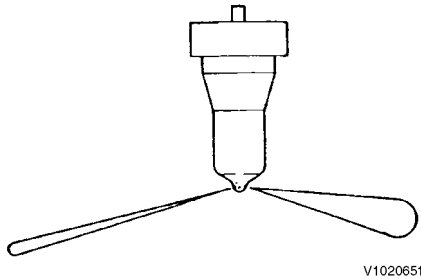


Figure 6
Non-uniform spray pattern from each nozzle (abnormal)

- Nozzle valve sliding test
Wash the nozzle valve in clean fuel oil.
Place the nozzle body vertically and insert the nozzle into the body to about 1/3 of its length.
The valve is normal if it smoothly falls by its own weight into the body.
In case of a new nozzle, remove the seal peel, and immerse it in clean diesel oil or the like to clean the inner and outer surfaces and to thoroughly remove rust-preventive oil before using the nozzle.

NOTE!

New nozzle is coated with rust-preventive oil and is pasted with the seal peel to shut off outer air.

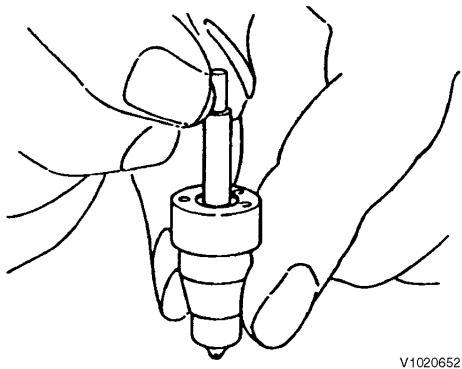


Figure 7
Nozzle valve sliding check by gravity

- The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

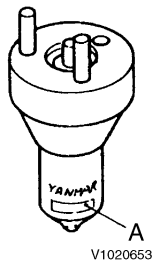


Figure 8
Nozzle body identification number

A. Identification number

- **Nozzle body identification number**

Symbol	Description	Remarks
Y	YANMAR	
DLL	Type (DLL : semi-long type)	
A	Nozzle insertion angle Code A : angled No code : no angle	
150	Injection angle	
P	Nozzle size : size P, size S	
244JO	Design code	

- Measuring and adjusting valve clearance
Make measurement and adjustment while the engine is cold.

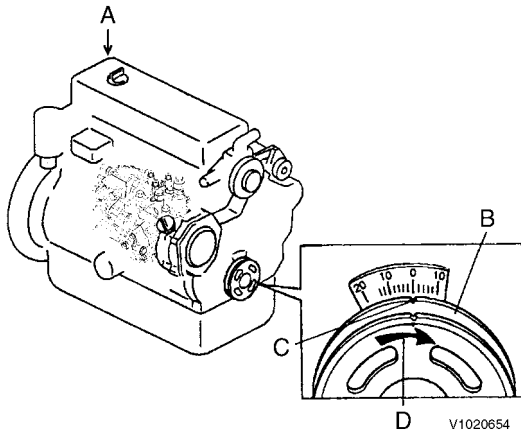


Figure 9
Valve clearance measurement

- A. No.1 cylinder
- B. Crankshaft pulley
- C. Top mark
- D. Rotational direction

1. Valve clearance measurement

- Remove the rocker cover on cylinder head.
- Turn the crankshaft to bring the piston of the No.1 cylinder to its compression top dead center while watching the rocker arm motion, timing scale and the top mark position of the crankshaft pulley.
(Position where both the intake and exhaust valves are closed.)

NOTE!

The crankshaft shall be turned clockwise as viewed from the pulley side.

NOTE!

The No.1 cylinder position is on the flywheel side and the ignition order shall be 1-3-4-2-1 at 180° intervals.

NOTE!

Since the intake and exhaust valve rocker arms are operated the same and there is a clearance between the arm and valve generally at the top dead center, the position can be checked by means of the play when the arm head is held with a hand. Also see that the crankshaft pulley top mark is positioned at zero on the timing scale. If there is no valve clearance, inspection in the disassembled state is necessary since the valve seat may be worn abnormally.

- Insert a thickness gage between the rocker arm and valve cap in case of 2-valve cylinder head, or insert between the rocker arm and the valve bridge in case of 4-valve head, and record the measured valve clearance. (Use it as the data for estimating the wear state.)

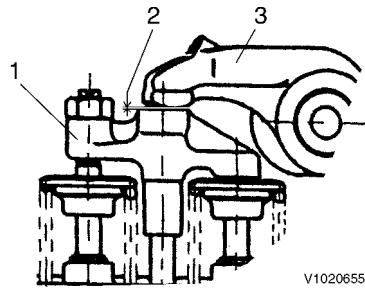


Figure 10
Valve clearance

1. Valve bridge
2. Valve clearance
3. Rocker arm

- Turn the crankshaft 180° then and make adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders in this order. The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

2. Valve clearance inspection and adjustment

- In case of 4-valve cylinder head loosen the lock nut and adjusting screw of rocker arm. Be careful that excessive tension isn't applied to the valve bridge, and loosen a lock nut of valve bridge.

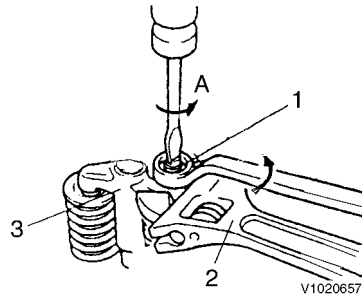


Figure 12
Adjustment, screw

1. Adjusting screw
 2. Wrench
 3. Valve bridge
- A. Loosen

NOTE!

When loosening a lock nut of a valve bridge, loosen the lock nut while holding the valve bridge with a wrench so that the valve bridge can not lean.

- Insert a 0.2 or 0.3 mm thickness gage between the rocker arm and valve cap / valve bridge, and adjust the valve clearance. Tighten the adjusting screw. Recheck the valve clearance.

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the Complete Manual.

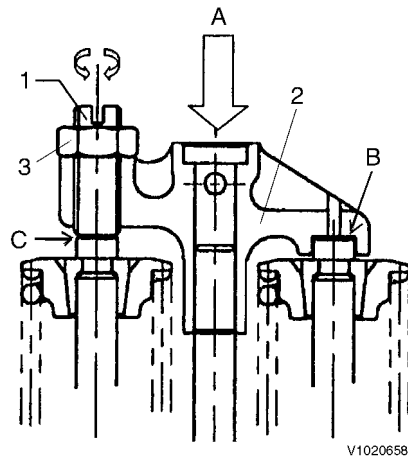


Figure 13
Adjustment, valve clearance

- 1. Adjusting screw
 - 2. Valve bridge
 - 3. Rocker nut
- A. Hold
 - B. Clearance 0
 - C. Adjust clearance to 0

- Apply oil to the contact surface between adjusting screw and push rod.

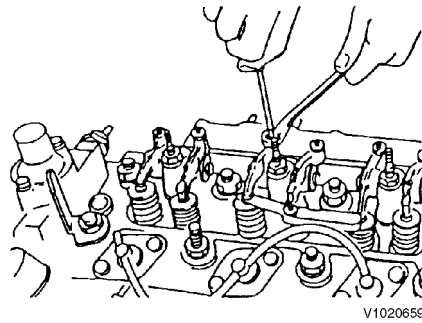
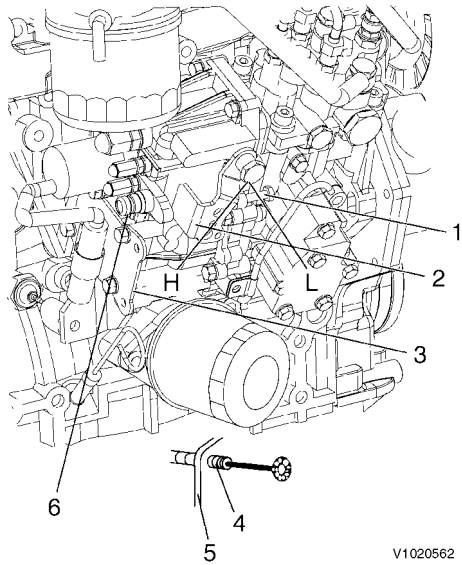


Figure 14
Adjustment, valve clearance

- Turn the crankshaft 180° then and make adjustment for the No.3 cylinder. Then adjust the No.4 and No.2 cylinders in this order.
The cylinder to be adjusted first does not have to be the No.1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

Adjusting the no-load maximum or minimum speed

- After warming the engine, gradually raise the speed and set it at the no-load maximum revolution.



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Figure 15
Adjustment, governor lever and accelerator device

1	Low idle limiting screw
2	Governor lever
3	Accelerating cable bracket
4	Accelerating cable fixing nut
5	Accelerating cable bracket
6	High idle limiting screw
H	High
L	Low

- If the no-load maximum revolution is out side the standard range, adjust it by turning the high idle limiting screw.
- Then set the no-load minimum speed by adjusting the low idle limiting screw.

Document Title: Cylinder head, description	Function Group: 211	Information Type: Service Information	Date: 2014/4/2 0
Profile: CEX, ECR88 [GB]			

Cylinder head, description

The cylinder head, which covers all cylinders, is a sixteen valve cylinder head. The cylinder head has two inlet valves and two exhaust valves for each cylinder.

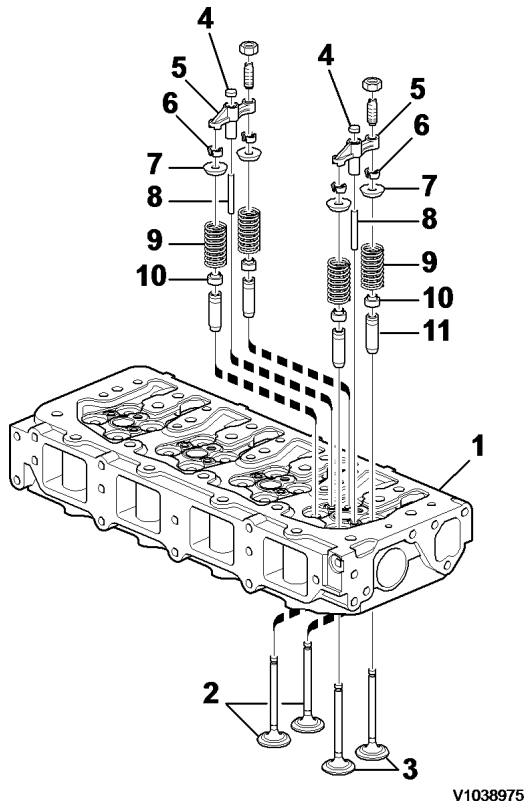


Figure 1
Cylinder head with valve mechanism

1.	Cylinder head	7.	Spring guide
2.	Exhaust valve	8.	Guide
3.	Inlet valve	9.	Spring
4.	Plug	10.	Seal
5.	Yoke	11.	Guide
6.	Valve collet		