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(2) 3CA1

2) 3CA1

Engine model	—	3CA1												
Version	—	CL	VM						CH	VH				
Type	—	Vertical inline water cooled diesel engine												
Combustion system	—	Swirl chamber (ball type)												
Aspiration	—	Natural												
No. of cylinder	—	3												
Bore × Stroke	mm	70×74												
Displacement	L	0.854												
Continuous rated output / Engine speed	kW/min ⁻¹ (PS)	6.09/ 1500 (8.27)	7.29/ 1800 (9.91)			—				8.16/ 3000 (16.5)	9.76/ 3600 (19.7)		—	
Max. rated output(net) / Engine speed	kW/min ⁻¹ (PS)	6.69 1500 (9.1)	8.02/ 1800 (10.9)	8.97/ 2000 (12.2)	9.93/ 2200 (13.5)	11.0/ 2400 (14.9)	11.8/ 2600 (16.1)	12.8/ 2800 (17.4)	13.7/ 3000 (18.6)	13.3/ 3000 (18.1)	16.0/ 3600 (21.7)	14.0/ 3200 (19.0)	14.7/ 3400 (20.0)	15.4/ 3600 (21.0)
High idling	min ⁻¹	1585± 25	1880± 25	2160± 25	2355± 25	2570± 25	2780± 25	2995± 25	3210± 25	3165± 25	3760± 25	3390± 25	3605± 25	3815± 25
Engine mass(dry)** with flywheel housing	kg	83												
P.T.O position	—	Flywheel side												
Direction of rotation	—	Counter-clockwise (viewed from flywheel side)												
Cooling system	—	Water cooled (radiator)												
Lubricating system	—	Forced lubrication with trochoid pump												
Starting system	—	Electric starting (Starter motor: DC12V1.0kW, Alternator: DC12V18A) (Recommended battery capacity:12V36Ah (5h rating) for 12V1.0kW S.motor)												
Dimensions(L×W×H)**	mm	504×427×506								504×427×536		504×427×506		
Engine oil capacity (Oil pan)	L	2.8/1.5 (Dipstick upper limit / lower limit)								3.5/2.0 (←)		2.8/1.5 (←)		
Cooling water capacity(engine)	L	0.9												
Cooling fan(std.)	—	310mm O/D												
		5 blades pusher type												

** Engine mass and dimensions without radiator

1.6.3 Guarantee Conditions for the EPA Emission Standard

The following guarantee conditions are set down in the instruction manual. In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

(1) Requirement on engine installation condition

(a) Intake air depression

KPa (mmAq)	
Initial	Permissible
≤ 2.94 (300)	≤ 6.23 (635)

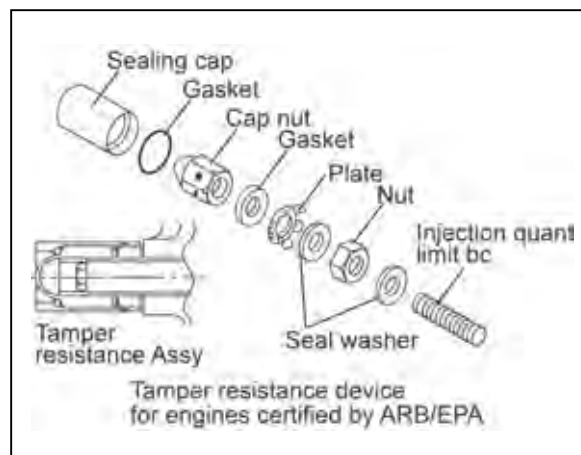
(b) Exhaust gas back pressure

kPa (mmAq)	
Initial	Permissible
≤ 12.75 (1300)	≤ 15.3 (1560)

(2) Fuel oil

Fuel: The diesel fuel oil US No.2 diesel fuel oil.

(3) Do not remove the seals restricting injection quantity and engine speed.



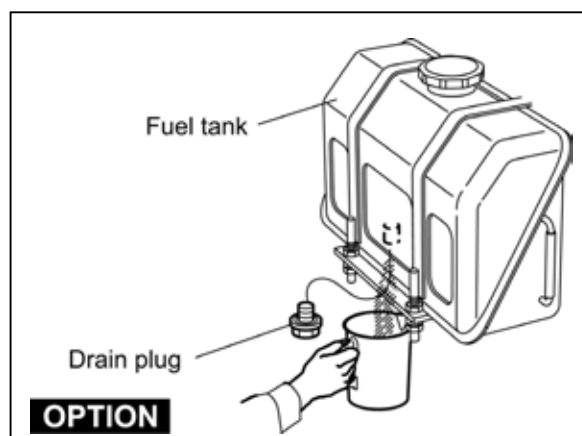
2.2.3 Inspection every 50 hours

Be sure to check the following points every 50 hours operation.

No.	Inspection Item
(1)	Fuel tank draining
(2)	Water separator draining
(3)	Bleeding the fuel system
(4)	Battery electrolyte level check and battery recharging

(1) Fuel tank draining

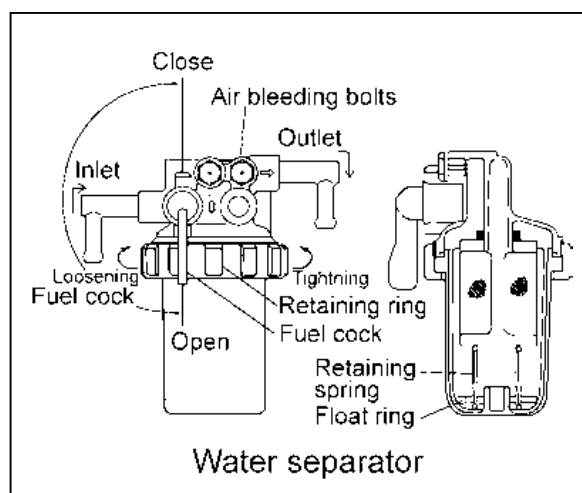
- 1) Prepare a waste oil container.
- 2) Remove the drain plug of the fuel tank to drain (water, dust, etc.) from the fuel tank bottom.
- 3) Drain until fuel with no water and dust flow out. Then tighten the drain plug firmly.



(2) Water separator draining

Drain off the water separator whenever there is a lot of drain collected in the water separator at the bottom of the cup even if not the time for periodic inspection hour. The cup of the water separator is made from semi-transparency material and in the cup, the red colored float ring which rises on the surface of the drain is installed to visualize the amount of drain. Drain off the water separator in the following manner.

- 1) Close the fuel cock.
- 2) Loosen the retainer ring, and remove the cup, then throw collected water and trash away.
- 3) Put a float ring and a spring in the cup, and tighten the retainer ring.
Tightening torque: 13-16 N·m (1.3-1.6 kgf·m)
- 4) Be sure to bleed air in the fuel system.



2.2.5 Inspection every 500 hours or 6 months

Be sure to check the following points every 500 hours or 6 months operation, whichever comes first.

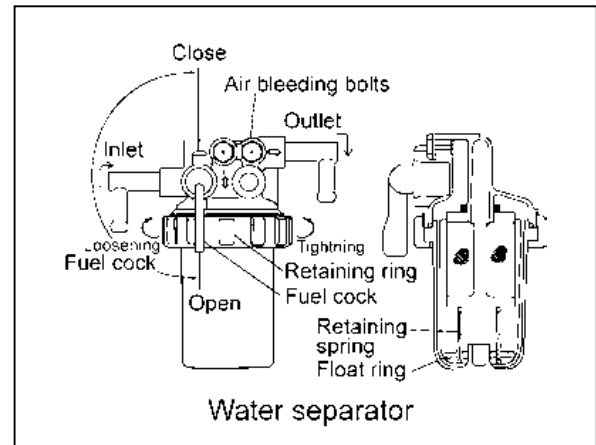
No.	Inspection Item
(1)	Water separator cleaning
(2)	Fuel filter element replacement
(3)	Air cleaner cleaning and element replacement

(1) Water separator cleaning

The cup of an water separator is translucent, and the inside can be seen. The float ring rises when water collects at the bottom of the cup.

Periodically wash the water separator element and inside cup with clean fuel oil.

- 1) Close the fuel cock.
- 2) Loosen the retaining ring and remove the cup. Take the water and trash in the cup out.
- 3) Wash the element with clean fuel oil. Replace the element with new one if any damaged.



Applicable element	Part No.
	586400-8320

- 4) Insert the element to the bracket and put the float ring and spring in the cup. Tighten the retaining ring.
Tightening torque: 13 to 16 N·m (1.3 to 1.6 kgf·m)
- 5) Bleed the fuel system. Refer to 2.2.3.(3)

- 7) Read the timing scale on the flywheel from the hole on the flywheel housing. It is standard fuel injection timing if the timing mark position meets the fuel injection timing of the below table.

Model name	Class		VM				CH	VH	
	Engine speed	min ⁻¹	2000 to 2100	2200	2300 to 2600	2700 to 3000	3000 / 3600	3100 to 3400	3500 to 3600
2CA1	Injection timing (FID) bTDC ± 1 deg.	Deg.	15		16	18	-	-	-
3CA1			15		16	18	21	20	21
3CB1			15	16		18	21	20	21

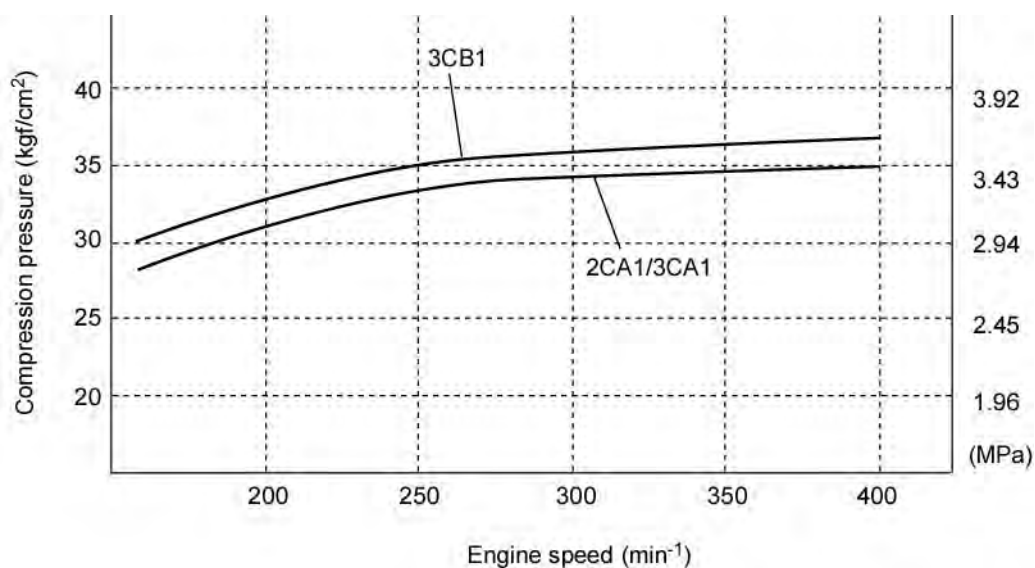
- 8) Repeat steps 5) to 7) a few times.

Note:

Injection timing check for one cylinder is generally sufficient. If it is to be checked for all cylinders of 3-cylinder engine, check each cylinder in the ignition order of: 1-3-2-1 by turning at each 240 degrees. The cylinder to be checked is not limited to the No.1 cylinder and any cylinder may be checked.

- 9) If the injection timing is out of the standard value, loosen the fuel pump mounting nut and incline the fuel injection pump toward or away from the engine for adjustment. Incline toward the engine to delay the timing, and away from the engine to advance it.
(One graduation of the timing scale on gear case corresponds to two degrees in injection timing.)

(3) Engine speed and compression pressure (for reference)



(4) Measured value and troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective action
1	● Air cleaner element	● Clogged element ● Broken element ● Defect at element seal portion	● Clean the element. ● Replace the element.
2	● Valve clearance	● Excessive or no clearance	● Adjust the valve clearance. (See 2.2.6.(3) in Chapter 2.)
3	● valve timing	● Incorrect valve clearance	● Adjust the valve clearance. (See 2.2.6.(3) in Chapter 2.)
4	● Cylinder head gasket	● Gas leak from gasket	● Replace the gasket. ● Retighten the cylinder head bolts to the specified torque. (See 4.2(2)12) in Chapter 4.)
5	● Intake/exhaust valve ● Valve seat	● Gas leak due to worn valve seat or foreign matter trapping ● Sticking valve	● Lap the valve seat. (See 4.2(6) in Chapter 4.) ● Replace the intake/exhaust valve.
6	● Piston ● Piston ring ● Cylinder	● Gas leak due to scratching or wear	● Perform honing and use an oversized part. (See 4.4.5 and 4.4.6 in Chapter 4.)

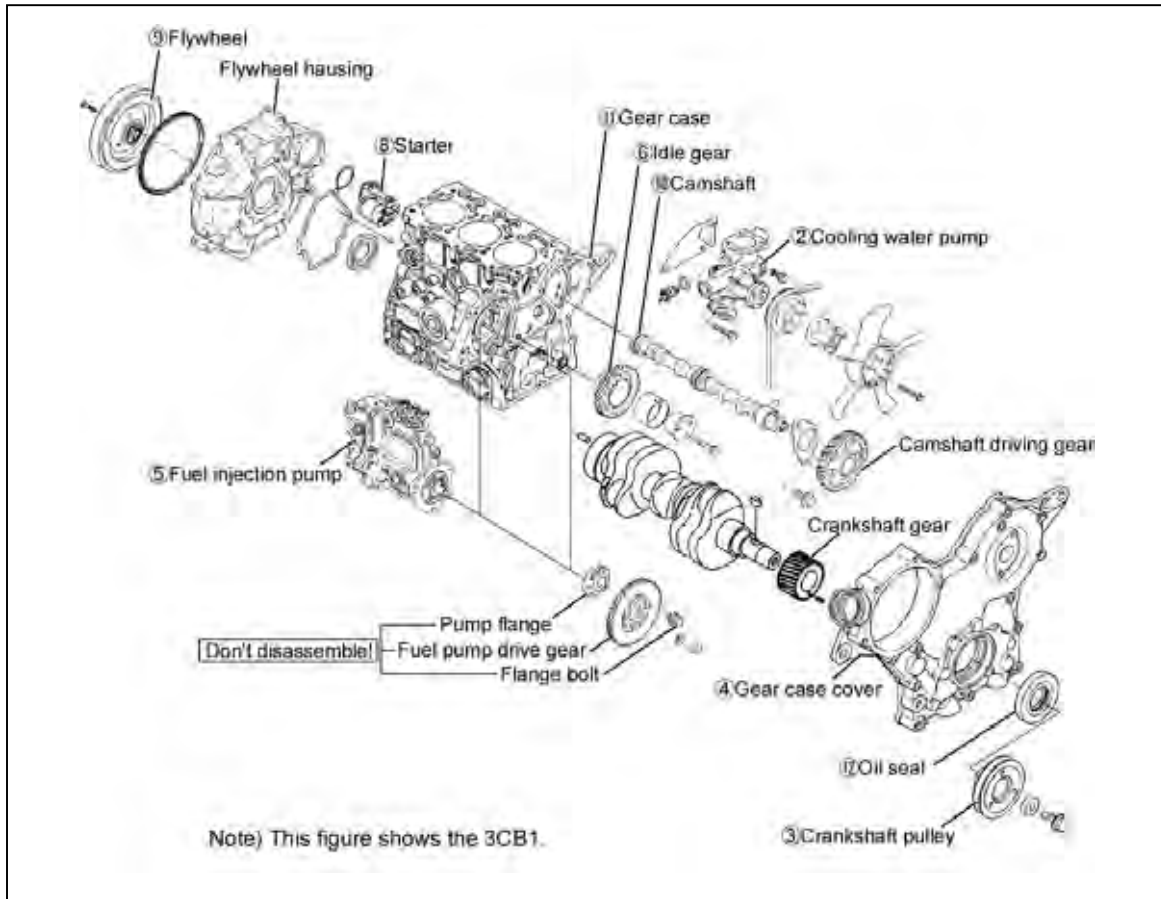
4.1.3 Complete disassembly

Peripheral parts such as air cleaner, muffler and radiator differ in installation and types for each application. Therefore, description in this Chapter is started with the steps to be taken just after the peripheral parts have been removed.

Step	Removal Parts	Remarks
1	1) Thoroughly remove sand, dust, dirt and soil from the surface of the engine. 2) Drain coolant water and lubricating oil from the engine.	
2	1) Remove exhaust manifold. 2) Remove intake manifold.	
3	1) Close the fuel cock valve of the fuel tank. 2) Remove high-pressure fuel pipe. 3) Remove fuel return pipe. 4) Remove fuel injection nozzle. *) Fuel injection nozzle for Indirect injection system is screwed type.	1) If nozzle seat is left on the cylinder head, remove the cylinder head before extracting nozzle seat. 2) To prevent dust from entering fuel injection nozzle, fuel injection pump and high-pressure fuel pipe, seal their respective threads with a tape or the like. 3) Whenever extracting fuel injection nozzle, replace nozzle protector with a new one.
4	1) Remove rocker arm cover assembly.	
5	1) Remove valve rocker arm shaft assembly. 2) Remove push rod.	1) Attach a tag to push rod for each cylinder No. to put the push rod in order. 2) Remove valve cap from the intake/exhaust valve head. 3) Tappet can be removed at the same time when push rod is extracted. 4) Attach a tag to tappet for each cylinder No. to put the tappet in order.
6	1) Remove fan mounting bolt, and then remove fan. 2) Loosen adjusting bolt for the V-belt adjuster, and then remove V-belt. 3) Remove alternator. 4) Remove the spacer for cooling fan and V-pulley.	1) Never turn down alternator vigorously toward the cylinder block. Otherwise, your finger may be nipped and alternator broken.
7	1) Remove lubricating oil filter assembly. 2) Extract dipstick from the oil dip-stick hole.	
8	1) Disconnect fuel return pipes to. 2) Remove fuel filter.	

4.3 Gear Train and Camshaft

4.3.1 Components



4.3.2 Disassembly procedure:

Disassemble in the order of the numbers in the illustration.

- 1) Perform steps 1) to 12) of the cylinder head disassembly procedure.
- 2) Remove the cooling water pump.
- 3) Remove the crankshaft pulley. (See **Point 1** of 4.3.4)
- 4) Remove the gear case cover. (See **Point 2** of 4.3.4)
- 5) Remove the fuel injection pump. (See **Point 3** of 4.3.4)
- 6) Remove the idle gear Assy. (See **Point 4** of 4.3.4)
- 7) Remove the PTO drive gear. (See **Point 5** of 4.3.4)
- 8) Remove the starting motor.
- 9) Remove the flywheel. (See **Point 6** of 4.3.4)
- 10) Remove the camshaft Assy. (See **Point 7** of 4.3.4)
- 11) Remove the gear case. (See **Point 8** of 4.3.4)
- 12) Remove the oil seal from the gear case cover. (See **4.3.6**)

4.3.3 Reassembly procedure:

Reverse of the disassembly procedure.

Crankpin

If a clearance is necessary, measure the inside diameter by following (5) d) " Rod big end measurement ", and calculate it.

mm

Model & Item	Standard	Limit
Pin outside diameter	41.952 to 41.962	41.902
Oil clearance	0.020 to 0.050	0.110
Roundness	0.01 or less	0.02

If the oil clearance exceeds the limit, use an undersized bearing.

Undersized crankpin bearing (0.25 mm)

Code No. (assy)
586400-6970

Pin machining dimension

Pin machining dimension (mm)
$\Phi 41.702$ to 41.712

Crank journal mm

Item	Standard	Limit
Journal O.D.	46.952 to 46.962	46.902
Oil clearance	0.020 to 0.050	0.120
Roundness	0.01 or less	0.02

If the clearance limit is exceeded, use an undersized bearing and machine the crank journal into the valve of the below table.

Undersized bearing (0.25mm)

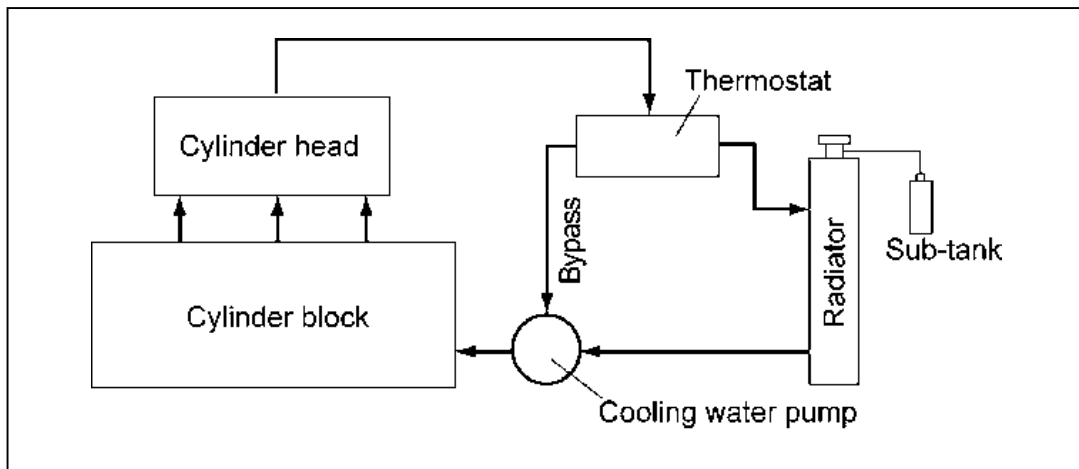
Code No. (assy)
586400-8740

Crankshaft Journal machining dimension

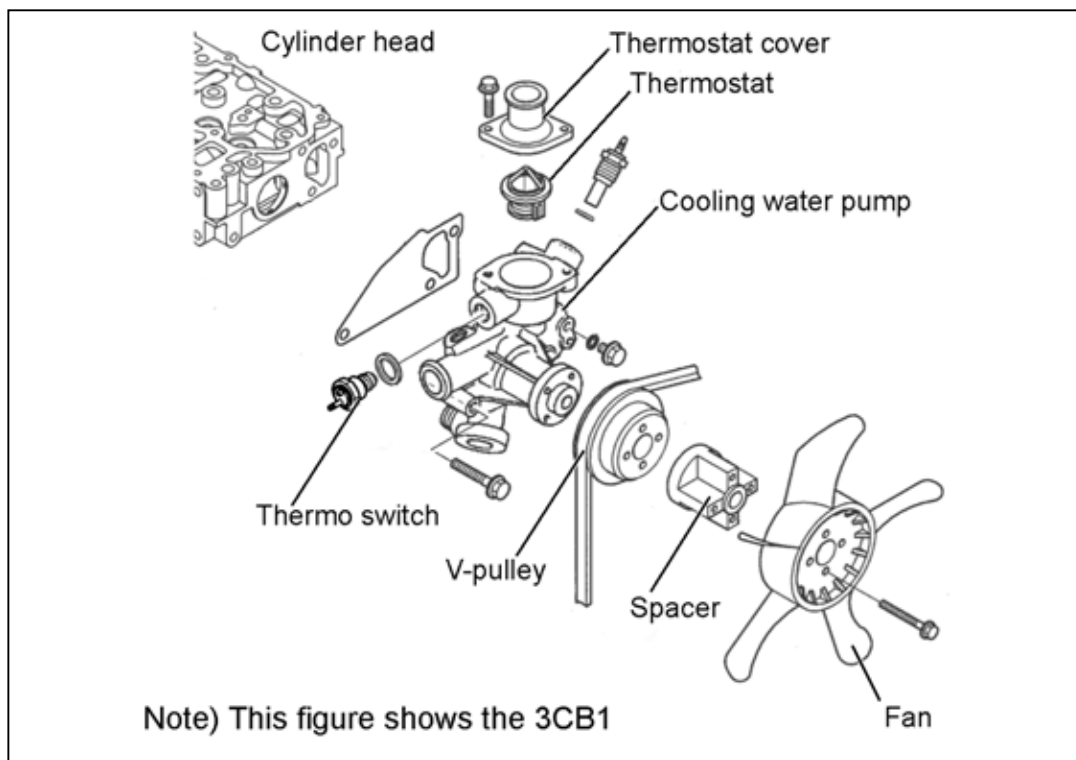
Journal machining dimension (mm)
$\Phi 46.702$ to 46.712

6. COOLING SYSTEM

6.1 Cooling Water System



6.2 Cooling Water Pump Components



11.2 Engine Body

11.2.1 Cylinder head

(1) Cylinder head

Inspection item		Standard	Limit	Reference page
Combustion surface distortion mm		0.05 or less	0.15	4.2.5.(1)
Valve sink mm	Intake	0.4 to 0.6	0.9	
	Exhaust	0.4 to 0.6	0.8	
Valve seat	Seat angle Deg.	Intake	120	4.2.6.
		Exhaust	90	
	Seat correction angle deg.		40, 150	

(2) Intake/exhaust valve and guide

Inspection item		Standard	Limit	Reference page
Intake	Guide inside diameter	6.000 to 6.012	6.08	4.2.5.(2)
	Valve stem outside diameter	5.960 to 5.975	5.90	
	Clearance	0.025 to 0.052	0.16	
Exhaust	Guide inside diameter	6.000 to 6.012	6.08	
	Valve stem outside diameter	5.945 to 5.960	5.90	
	Clearance	0.040 to 0.067	0.17	
Valve guide projection from cylinder head		9.8 to 10.0	-	4.2.7.
Valve guide driving-in method		Cold-fitted	-	

(3) Valve spring

Inspection item		Standard	Limit	Reference page
Free length		37.8	-	4.2.5.(4)
Inclination		-	1.3	