CAT® Lift Trucks

Service Manual

K15, K21, K25 Gasoline Engine

K15
K21
K25

For use with GP15N-GP35N, GPE15N-GPE35N Chassis Service Manual.

99789-87100

Parts Requiring Angle Tightening

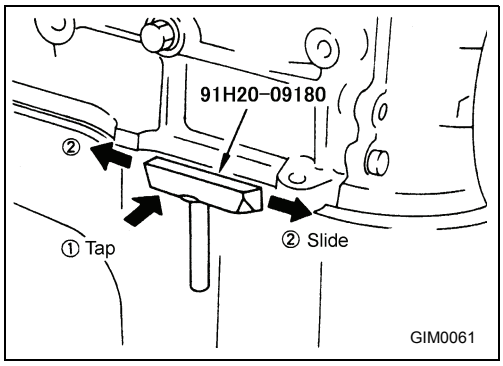
- When tightening the following parts, use an angle wrench (ST).
- Cylinder head bolt
  Before assembly, verify that no grease/oil and dust are present on the cylinder head, cylinder block mounting face, and head gasket. Then apply antirust oil or engine oil to the threads and head bottoms of the head bolts.

Caution With Use of Power Tools

- The use of power tools such as pneumatic air tools are only allowed for disassembly. Do not use them for assembly.

Precautions for Liquid Gasket Application

REMOVING PARTS ATTACHED WITH LIQUID GASKET



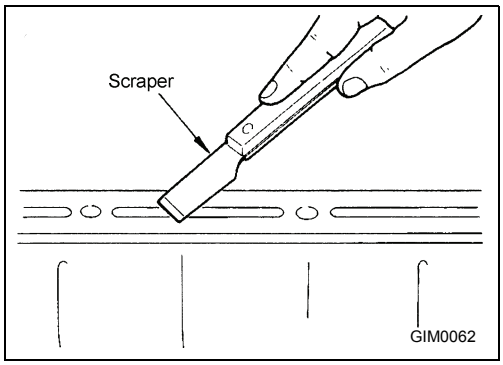
- Remove mounting nuts and bolts. Remove liquid gasket using a seal cutter (ST).

CAUTION:
Be careful not to damage the mating surfaces.

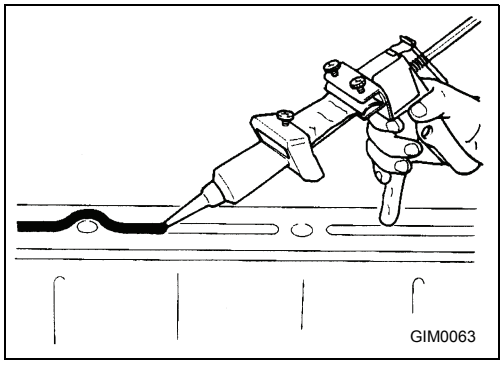
- In positions where a seal cutter is difficult to use, lightly tap with a plastic hammer, and remove.

CAUTION:
Be careful not to scratch the mating surfaces when using a screwdriver.

LIQUID GASKET APPLICATION INSTRUCTION



1. Remove any old liquid gasket remaining on the gasket application surface and its mating surface using a scraper.
   - Remove any old liquid gasket remaining in the gasket application groove and on the threads of bolts and bolt holes.
2. Wipe the gasket application surface and its mating surface using Isozole or any equivalent thinner to remove any moisture, oil, and foreign material.
3. Set genuine liquid gasket to tube presser (commercial service tool).



4. Apply a continuous bead of liquid gasket to the specified position at the specified diameter.

- Apply liquid gasket in the application groove.
- Apply liquid gasket inside bolt holes as a rule. Make sure to carefully read the relevant instructions.
- Attaching should be done within 5 minutes after gasket application.
- Immediately wipe off any protruding liquid gasket.
- Do not retighten nuts and bolts after installation.
- After finishing work, wait at least 30 minutes before refilling engine oil and coolant.

CAUTION:
Follow any directions specified in the text on the following pages.

INSPECTION AND ADJUSTMENT

- Oil capacity H line (L)
  3.5
- Oil capacityL line (L)
  2.5
- (Oil filter capacity) (L)
  0.3
- Fan belt deflection (When pressed by a force of approximately 10 kgf) (mm)
  Standard 11 - 13
- Compression [MPa (kgf/cm^2)/rpm]
  Standard Electric controlled specifications:
  1.45 (14.8) / 250 (K21: Gasoline/Combined)
  1.51 (15.4) / 250 (K25: Gasoline/Combined)
  Carburetor specifications:
  1.4 (14.5) / 250 (K15: Gasoline/Combined)
  1.45 (14.8) / 250 (K21: Gasoline/Combined)
  1.51 (15.4) / 250 (K25: Gasoline/Combined)
  Limit Electric controlled specifications:
  1.25 (12.7) / 300 (K21: Gasoline/Combined)
  1.31 (13.4) / 300 (K25: Gasoline/Combined)
  Carburetor specifications:
  1.22 (12.4) / 300 (K15: Gasoline/Combined)
  1.25 (12.7) / 300 (K21: Gasoline/Combined)
  1.31 (13.4) / 300 (K25: Gasoline/Combined)
- Difference between each cylinder [MPa (kgf/cm^2)/rpm]
  Repair limit 0.1 (1.0) / 300
- Spark plug gap (mm)
  Standard 0.8 - 0.9
- Distributor (Full transistor type) air gap (mm)
  Standard 0.35 - 0.45
- Valve clearance (Hot) (mm)
  Standard Intake: 0.38 ± 0.03
  Exhaust: 0.38 ± 0.03
- Thermostat valve opening temperature (STD) (°C)
  Standard 76.5
- Idle speed and ignition timing (BTDC°/rpm)
  Standard 0/700±50 (K21, electric controlled spec.)
  0/700±50 (K25, electric controlled spec.)
  4/700±50 (K15, carburetor spec.)
  2/700±50 (K21, carburetor spec.)
  0/700±50 (K25, carburetor spec.)

CYLINDER HEAD

- Cylinder head (mm)
  Material Aluminum alloy
  Distortion limit 0.1

Engine Adjustment (Cont'd)

Condition	Possible causes	Action
Piston and cylinder slapping	• Mechanical rapping noise that increases according to the engine speed but decreases as the engine is warmed up is attributed to the pistons and cylinders.	This noise is caused by excessive wear of cylinders and accompanied by engine power deterioration and excessive oil consumption.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	For corrective action, an engine overhaul is needed.
Piston pin slapping	• This noise is generated at piston TDC and BDC positions.	A possible cause is wear of the piston pin hole or piston pin.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	Need to replace piston and piston pin assembly.
Water pump noise	• This noise is generated from worn or damaged bearing(s) due to the uneven sliding faces.	Replace water pump.
Excessive oil consumption		
Oil leakage	• Worn piston ring groove(s) and ring(s)	Replace piston(s) and piston ring(s).
	• Deteriorated valve oil seal lip(s)	Replace valve oil seal(s).
	• Worn valve stem(s)	Replace valve(s).
Other	• Use of inappropriate quality of oil	Use specified oil.
	• Engine overheat	Already described
Inappropriate fuel consumption		
Refer to description of engine power deterioration. Other Refer to EF section for the LPG model.	• Excessive idling speed	Adjust to specified level.
	• Insufficient throttle return	Adjust.
	• Fuel leakage	Repair fuel piping and additionally tighten connections.
Incident due to other factors		
Low oil pressure	• Use of inappropriate quality of oil	Replace specified oil.
	• Engine over temperature (Overheat)	Already described.
	• Oil pump regulator valve malfunction	Overhaul or replace oil pump.
	• Oil pump malfunction	Overhaul or replace oil pump.
	• Oil filter malfunction	Replace with a new one.
	• Enlarged clearance of each sliding component	Disassemble and replace relevant sliding component(s).
	• Clogged oil strainer	Wash.
	• Malfunction of oil pressure gauge pressure switch	Replace with a new one.
Excessive wear of sliding part(s)	• Low oil pressure	Already described.
	• Poor quality of oil or foreign objects in oil	Replace oil element and oil with appropriate ones.
	• Poor performance of air cleaner	Check element.
	• Overheat or excessive cooling	Already described.
	• Inappropriate air-fuel ratio	Check fuel system.
Bite of sliding parts	• Low oil pressure	Already described.
	• Insufficient clearance	Adjust clearance to specified value.
	• Engine over temperature (Overheat)	Already described.
	• Inappropriate air-fuel ratio	Check fuel system.

Maintenance Schedule (Cont'd)

Engine system inspection (LPG models)

No.	Inspection items	Applicable control system	Months of use	1	2	3	4	5	6	7	8	9	10	11	12
			Operation hours (x 100 hours)	2		5			10			15			20
1	Tar in vaporizer	EC/CAB	(3)	D		D			D			D			D
2	Injection nozzle	EC		I		I			I			I			I
3	LPG filter	EC/CAB	(3)			C			C			C			R
4	Vaporizer rubber parts	EC/CAB													R

CAUTION:

- **(1) The maintenance work should be performed more frequently if the vehicle is being used in dusty and dirty environments.**
- **(2) Apply soap suds to the piping joints to check for any gas leakage after replacing the LPG tank.**
- **(3) When fuel with poor quality is used, check, drain, clean and change more frequently.**

Meanings of symbols:

I = Inspection. Repair or replace if necessary.
R = Replacement
C = Cleaning
D = Draining
T = Tightening (Retightening)

Oil and Grease, and Capacity

OIL, LLC

Items	Specification	Remarks
Engine oil	10W-30 (Class SJ)	Class SL: Factory shipping
Antifreeze		Automotive

FILLING CAPACITY (GUIDELINE)

Items		Capacity (Liter)
Engine oil	K15	3.8 (including filter)
	K21	3.8 (including filter)
	K25	3.8 (including filter)

Condition	Possible causes	Action
Engine noise		
Knocking	• Engine overload	Operation with light load
	• Knocking due to carbon deposits	Remove cylinder head and eliminate carbon deposits
	• Knocking due to inappropriate ignition timing	Adjust ignition timing
	• Knocking due to inappropriate octane rating of fuel	Use specified octane rating of fuel.
	• Too advance ignition (Inappropriate spark plug selection)	Use specified type of spark plug.
Mechanical slapping		
Crankshaft bearing slapping	• Strong and heavy noise from engine during acceleration	A possible cause is in damage/wear of bearing or uneven wear of crankshaft.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	Need to replace bearing and adjust or replace crankshaft.
	• If it misfires at a particular cylinder it stops the noise, that cylinder is the noise source.	
Connecting rod bearing slapping	• This noise is also generated during engine acceleration but at a little more rapid pitch than crank slapping.	Take the same action as that for crankshaft bearing.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	
	• If it misfires at a particular cylinder it almost stops the noises, that cylinder is the noise source.	
Piston and cylinder slapping	• Mechanical rapping noise, which increases according to the engine speed but decreases as the engine is warmed up, is attributed to the pistons and cylinders.	This noise is caused by excessive wear of cylinders and accompanied by engine power deterioration and excessive oil consumption.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	For a corrective action, engine overhaul is needed
Piston pin slapping	• This noise is generated at piston TDC and BDC positions.	A possible cause is wear of the piston pin hole or piston pin.
	• To identify the noise generation point, attempt to cause misfires at each cylinder.	Need to replace piston and piston pin assembly.
Water pump noise	• This noise is generated from worn or damaged bearing(s) due to the uneven sliding faces.	Replace water pump.
Excessive oil consumption		
Oil leakage	• Worn piston ring groove(s) and ring(s)	Replace piston(s) and piston ring(s).
	• Deteriorated valve oil seal lip(s)	Replace valve oil seal(s).
	• Worn valve stem(s)	Replace valve(s).
Other	• Use of inappropriate quality of oil	Use specified oil.
	• Engine overheat	Already described
Inappropriate fuel consumption		
Refer to description of engine power deterioration. Other Refer to EF section for the LPG model.	• Excessive idling speed	Adjust to specified level
	• Insufficient throttle return	Adjustment
	• Fuel leakage	Repair fuel piping and additionally tighten connections.

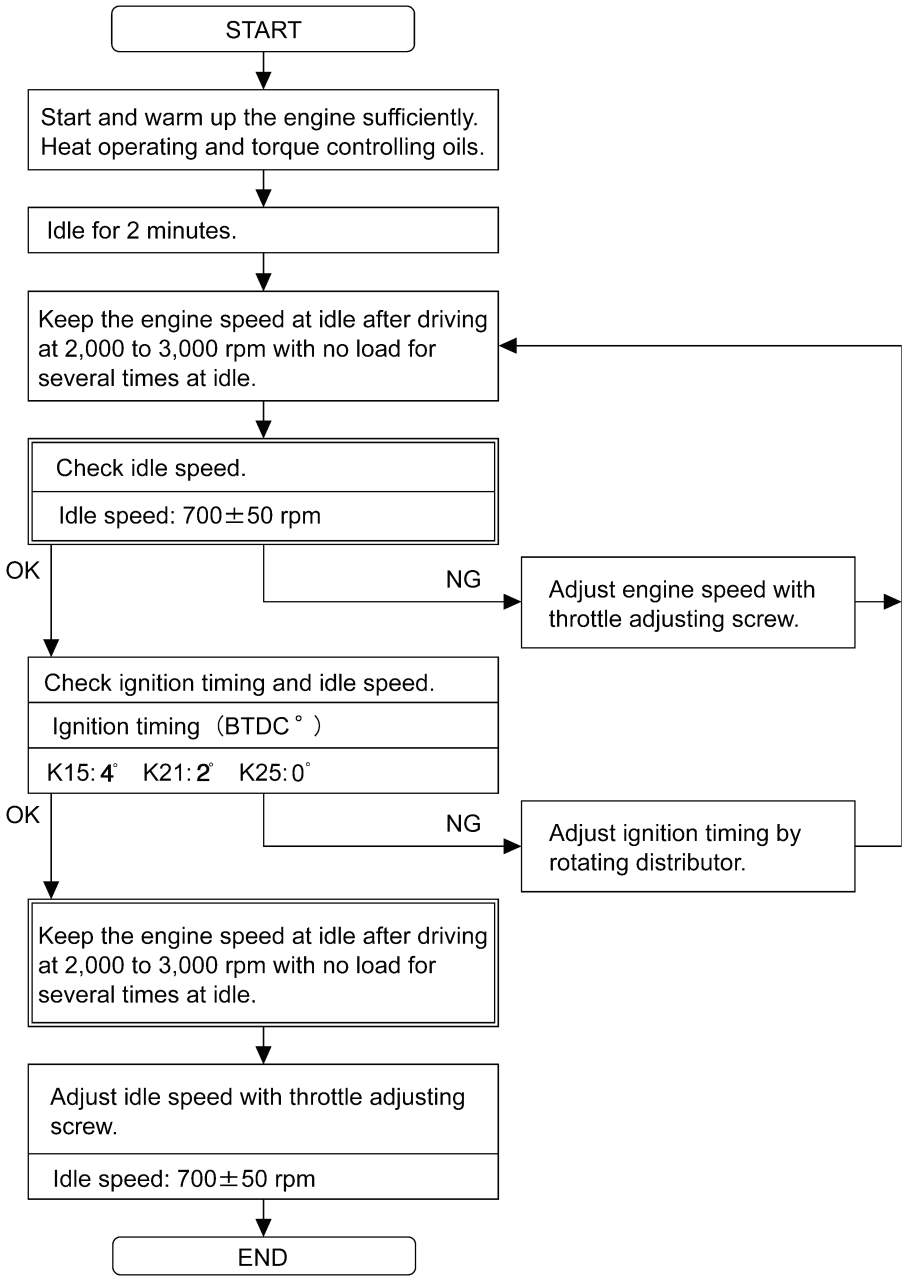
Ignition and Fuel Systems (Cont'd)

INSPECTION AND ADJUSTMENT OF IGNITION TIMING, IDLE SPEED, AIR-FUEL RATIO (CARBURETOR MODEL ONLY)

a. In general, the engine requires no idle speed adjustment because it is adjusted properly before shipment. If the idle speed must be adjusted in any means, follow the procedure below.
b. Do not fully tighten the idle adjusting screw. Doing so damages the screw end and leads to loss of functionality.

Preparation

1. Make sure that the following parts conditions are good.
   - Ignition system
   - Lubricant and coolant levels
   - Valve clearance
   - Fuel level at idle
2. Set selector lever to the neutral position.



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EXHAUST GAS CLEANUP DEVICE LIST

Engine type		K25			
Engine control system		Electric controlled specifications		Carburetor specifications	
Fuel specification		Gasoline	Combined	Gasoline	Combined
Total displacement (cc)		2,488			
Shape of combustion chamber		Bathtub			
Valve mechanism		OHV			
Bore x stroke mm (in)		89 x 100 (3.50 x 3.94)			
Compression ratio		8.7			
Compression pressure [kPa (bar, kg/cm^2, psi)/rpm]		1,510 (15.1, 15.4, 219)			
Engine speed control system		Engine Control System, electric controlled throttle		Pneumatic governor	
Fuel in use (Note)		Unleaded regular gasoline	At 20P	Unleaded regular gasoline	At 20P
Valve opening/closing timing (degree)	Intake open (ATDC)	4		14	
	Intake close (ABDC)	40		30	
	Exhaust open (BBDC)	36		32	
	Exhaust close (ATDC)	0		12	
Valve clearance mm (in)	Intake (when engine is hot)	0.38 (0.0150)			
	Exhaust (when engine is hot)	0.38 (0.0150)			
Firing order		1-3-4-2			
Ignition timing (idling)	degree (BTDC°/rpm)	0±2/700			
On board idle speed (rpm)	ATM	700±50			
	MTM	700±50			
PTO system		Silent chain-driven/side PTO			
Engine oil (originally fitted)	Specification	10W-30 (Class SL)			
	Amount l (US qt, Imp qt)	3.8 (4, 3-3/8) (including oil filter)			

Note: Fuel
Gasoline: Use unleaded regular gasoline with an octane rating of 91 or more.
LPG: Use a fuel of 30P or more in cold seasons. In ambient temperature of -5°C (23°F) or less, use a 100P fuel.

CAUTION:
- **Always pay attention to safety.**
- **Do not remove engine until exhaust system and engine coolant have completely cooled off.**
- **Support the vehicle at the specified lift points.**
- **For operation procedure for components other than engine, refer to appropriate sections.**

Removal

[OPERATION DESCRIPTION]
- Remove engine by pulling up after removing transmission.

[PREPARATION WORK]
1. Release the fuel pressure. Refer to “Release of Fuel Pressure” in EC section.
2. Remove radiator drain plug and drain engine coolant.
3. Remove the following parts.
   - Undercover of battery
   - Radiator, shroud, and radiator hose
   - Engine drive belt and cooling fan
4. Disconnect accelerator cable from throttle drum and move it out of position.

[LEFT SIDE OF ENGINE ROOM]
5. Remove air duct and air cleaner case.
6. Disconnect heated oxygen sensor harness connector and ground (between exhaust manifold cover and body).

[RIGHT SIDE OF ENGINE ROOM]
7. Disconnect vacuum hose (for brake booster and for differential lock) on engine side.
8. Remove fuel hose.

CAUTION:
After disconnecting hoses, plug them immediately to prevent fuel from draining.

9. Disconnect all harness connectors on engine side, and then move harnesses to body side.
10. Remove starter motor.
11. Remove transmission.

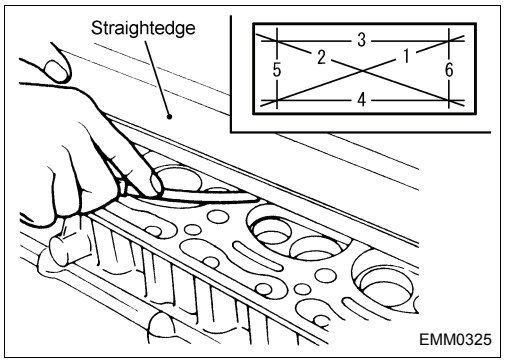
[REMOVAL]
12. Engage chain block hook in front/rear engine slingers and support.

CAUTION:
Be careful not to contact hook and chain with body and piping when engaging hook in slingers

13. Remove engine mount insulator LH/RH nuts.
14. Pull up and remove engine by adjusting the position diligently.

CAUTION:
- **Make sure that all wires and piping were disconnected while removing.**
- **Be careful not to contact with body side parts.**

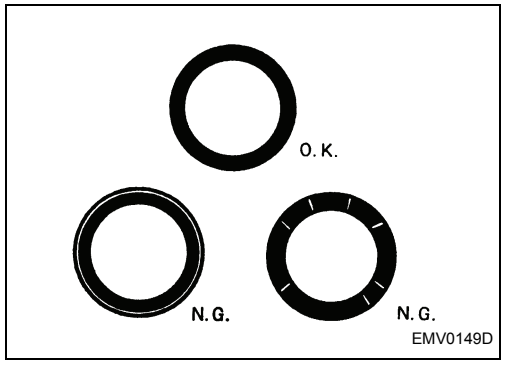
Inspection and Correction (Cont'd)



MEASURING CYLINDER HEAD DISTORTION

- Visually check for any cracks and damages.
- Measure distortion at six points on the head bottom face. If the measured distortion exceeds the specified limit, correct the head bottom face with a surface grinder or an equivalent tool, or replace the head.

Surface flatness	**0.1 mm or less**
Grinding limit	**0.2 mm or less**



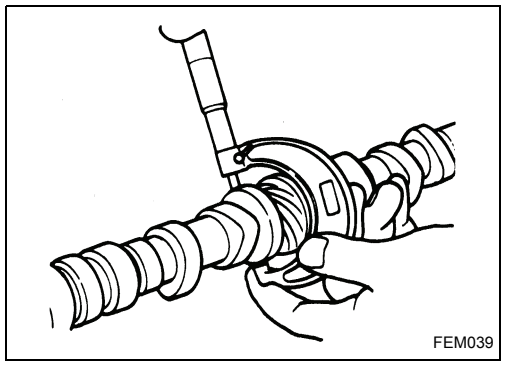
VALVE SEAT CONTACT

- This inspection must be done after ensuring that the dimensions of the valve guide and the valve are within the standard.
- Check valve contact by applying DICATOL PL-1 to valve seat contact surface.
- Make sure that areas around all connect surfaces are connected.
- If seating condition is not correct, reseat the valve and check again.
  If seating condition cannot be corrected by reseating, replace valve seat.

Inspection and Correction (Cont'd)

CAMSHAFT JOURNAL INSPECTION (EC spec.)

- Inspect the camshaft journal and replace it if any damage or uneven wear is observed.
- If wear is found to exceed the limit by measurement with a micrometer, replace the camshaft.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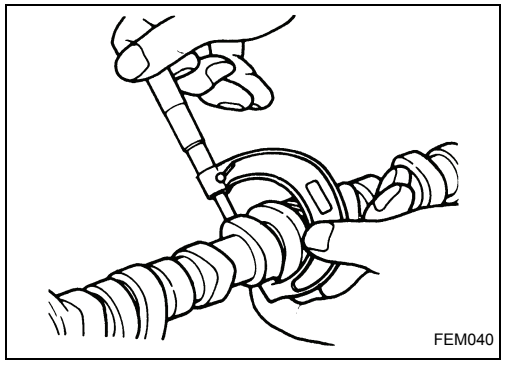
Camshaft journal inspection

Unit: mm (in)

Camshaft journal	Standard (Shall not exceed the value)	Usable limit
Taper Out-of-round	0.01(0.0004)	0.03 (0.0012)
Journal wear		0.05 (0.0020)

MEASURING CAMSHAFT HEIGHT (EC spec.)

- Measure the camshaft height by applying calipers to the camshaft nose.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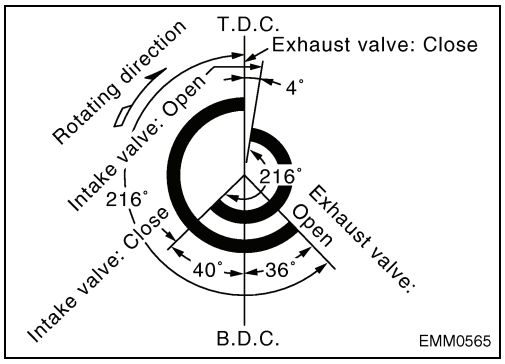
Unit: mm (in)

	Camshaft height
Standard	Intake/exhaust 36.695 - 36.875 (1.4447 - 1.4518)
Usable limit	36.5 (1.437)

- Inspect the oil pump and distributor drive gear. If excessive wear or damage is observed, replace the camshaft.

VALVE TIMING (EC spec.)



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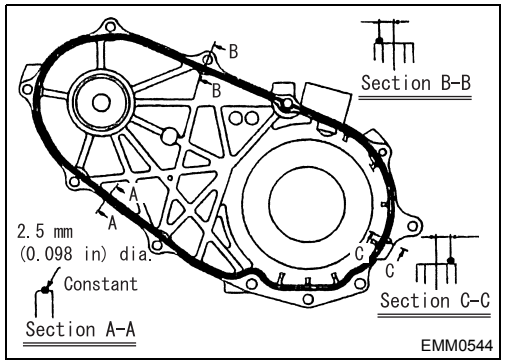
The figure on the left is applicable to all cylinders.
If any of the valves deviate from the specifications, the camshaft ridges may be worn out or damaged. The camshaft must be replaced.
Camshaft bushing inspection

- Check for bend, melting, uneven contact or peeling.
- If any damage is found, replace the camshaft bushing.

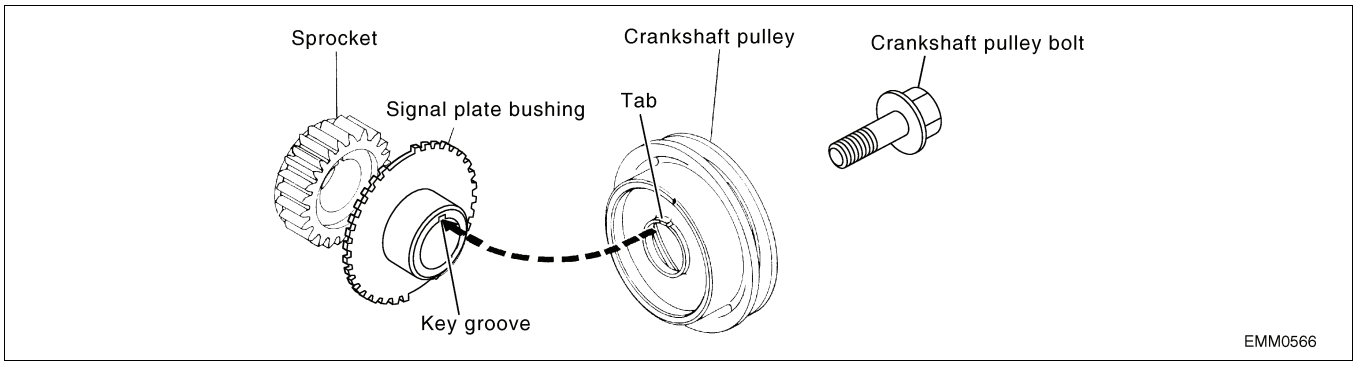
Measuring camshaft journal clearance

Engine Assembly (Cont'd)



- Install the bushing crankshaft pulley for the crankshaft position sensor.
  Before installing the front cover, apply liquid packing to the cover as shown in the figure. (Refer to the rear oil seal retainer installation procedure.)
  M8 x 25 (thread length) 7T bolt:
  : 15.7 - 17.7 N·m (1.6 - 1.8 kg-m, 12 - 13 ft-lb)

16. Installation of crankshaft pulley



(1) Set the crankshaft pulley by aligning the pulley claws to the groove of the bushing.
(2) Tighten the crankshaft pulley bolt.
Crankshaft pulley bolt:
: 220.5 - 240.1 N·m (22.5 - 24.5 kg-m, 163 - 177 ft-lb)

CAUTION:
When assembling, do not apply engine oil to crankshaft pulley bolt.

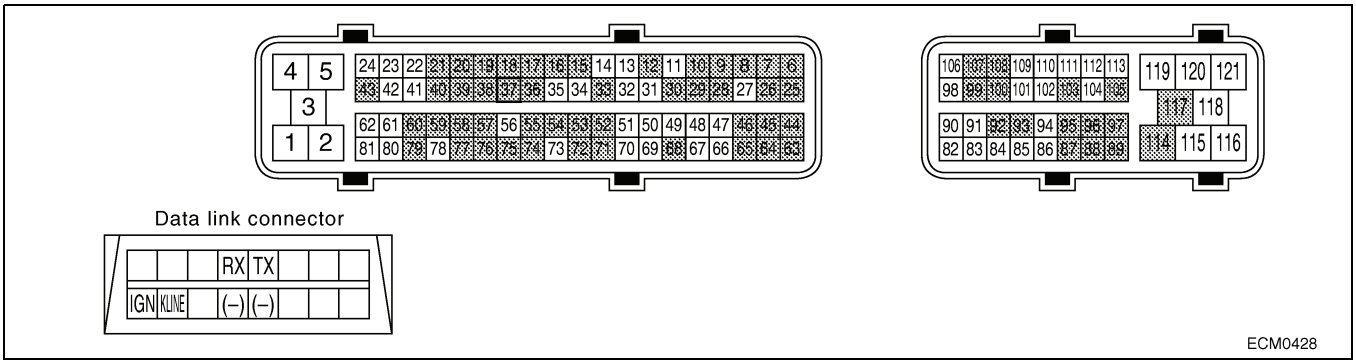
17. Installation of cylinder head
(1) Both ends of cylinder block top
Drive in dowels into the head bolt holes (two positions).
(2) Place the head gasket on the block top with the copper side facing up.

Description

- Adopts Engine Control Module (ECM). Fuel injection control, ignition timing control, idle speed control, and electric controlled governor control etc. are all performed by a single control unit.
- Adopts electric throttle control actuator system to control electric controlled governor.
- Adopts Hall IC type crankshaft position sensor (POS) and camshaft position sensor (PHASE).

Items	Description
Electric throttle control actuator	• Adopts electronic throttle control actuator with integrated throttle control motor to adjust throttle valve opening optimally according to driving conditions or to improve safety and operability by electric controlled governor.
Fuel injection control	• With fuel injection control, air-fuel ratio is optimized to improve exhaust performance and response. • Using feedback control through learning of air-fuel ratio compensation, the system corrects the ratio during transitional conditions, such as sudden sharp changes in the ratio, in order to improve drivability.
Ignition timing control	• Uses Hall IC crankshaft position sensor (POS) and camshaft position sensor (PHASE) to perform controls so that optimum ignition timing is obtained for every operating condition. Optimum ignition timing setup according to each fuel is also enabled at the time of a combined use formula. • Adopts electronic distribution system in which each cylinder is equipped with an ignition coil incorporating a power transistor for better ignition performance.
Idle speed control	• Adopts electronic throttle control actuator that continuously regulates intake air amount required for idling.
Maximum speed regulation control	• Performs maximum speed regulation by vehicle speed sensor signal. Also, performs variable control of maximum speed by changeover switch.
Idling area torque up control	• Performs torque up control in idling area by engine speed signal in order to also enable cargo work at idling.
Overheat prevention control	• Reduces engine heat generation by reducing maximum engine speed and regulating maximum throttle opening when engine coolant temperature reaches approximately 110°C (230°F). • Prevents resulting in engine breakage by overheat by performing fuel cut at 1,000 rpm or more when engine coolant temperature reaches approximately 135°C (275°F).
Power/Soft mode control	• Changes throttle opening characteristic of throttle position by power/Soft mode control switch, and then minute operation of engine speed is enabled. (Option setting)
Fuel pump control (gasoline)	• Turns fuel pump relay ON/OFF depending on engine speed signal.
LPG interception valve control	• Turns interception valve relay ON/OFF depending on engine speed signal and fuel pressure sensor signal.
Fail-safe function	• Ensures vehicle's safe operation and enables vehicle to be driven in an emergency when any of the major system components (mass air flow sensor, engine coolant temperature sensor, etc.) have malfunctioned.
Diagnostic system	• Adopts self-diagnosis system for easier trouble diagnosis.

ECM Terminal



REFERENCE VALUE LIST

Voltage is measured with a circuit tester, and the sample waveforms obtained with an oscilloscope are shown below for each ECM terminal. Measurement data varies depending on variation in parts as well as many other factors. Such factors include vehicle history, driving conditions, environmental conditions, maintenance status, measuring instrument/method, etc. Data shown below are reference values.

Terminal signal	Description	Measurement condition	Measured value
1 2 115 116	ECM ground	Always	Approx. 0V
66	Sensor ground (Throttle position sensor)	At idle after warming up	Approx. 0V
		At approx. 2,000 rpm	
67	Mass air flow sensor ground	Always	Approx. 0V
78	Heated oxygen sensor ground	Always	Approx. 0V
82	Accelerator pedal position sensor 1 ground	Always	Approx. 0V
83	Accelerator pedal position sensor 2 ground	Always	Approx. 0V
32	Fuel changing switch 2 (Gasoline)	Changing switch ON (At gasoline side)	Approx. 5V
		Changing switch ON (At LPG side)	Approx. 0V
70	Fuel changing switch 1 (LPG)	Changing switch ON (At LPG side)	Approx. 5V
		Changing switch ON (At GAS side)	Approx. 0V
84	Headlamp switch	Lighting switch OFF	Approx. 0V
		Lighting switch ON	Battery voltage
101	Brake switch	Brake pedal released	Approx. 0V
		Brake pedal depressed	Battery voltage
102	Neutral switch	N position	Approx. 0V
		Other than above	Battery voltage
109 (IGN)	Ignition switch	Ignition switch OFF	Approx. 0V
		Ignition switch ON	Battery voltage

Diagnosis Chart by Symptom

RELATIONSHIP BETWEEN MALFUNCTIONING SYMPTOMS AND THE SENSOR CIRCUIT

The table below shows the possible symptoms caused by the malfunction of each sensor circuit.

Symptoms			Impossible to start		Poor starting		Poor idle					Poor driving control								Engine stall				Other		Check that symptoms are detected with self-diagnosis.	Check that symptoms are in fail-safe condition.	Description/notable characteristics of the symptom
Sensor malfunction ⊕: Highly possible ♦: Possible			No initial combustion	Initial combustion	When engine is cold	When engine is warming up	Fast idle is not effective	High idle rpm	Low idle rpm	Inconsistent idle when engine is cold.	Inconsistent idle when warming up	Poor power output	Poor acceleration	Engine rpm does not increase smoothly.	During surge and acceleration	During surge and constant speed driving	Knocking	Backfire	After-burn	At Idle	Driving	During deceleration	During a heavy load	Engine over temperature (Overheat)	Poor fuel consumption efficiency			
Crankshaft position sensor (POS, PHASE)		OPEN	⊕																	⊕	⊕	⊕	⊕			♦		• An open circuit in either PHASE or POS signal makes it impossible for the vehicle to start. • Control signals for fuel system and ignition system are not output.
		Momentarily open			♦	♦				♦	♦		♦	♦	♦	♦				⊕	♦	♦	♦			♦		• The symptom depends on the duration of momentarily open circuit and the operating conditions. Slight shocks and surges may be sensed during driving, while engine stall may be caused during idle.
Mass air flow sensor	Signal	OPEN			♦	♦		⊕		♦	♦	♦	♦	♦	♦	♦							♦		♦			• It will be in fail-safe condition, and vehicle runs at an engine speed from 800 rpm to 1,600 rpm.
		High output			♦	♦				♦	♦	♦	♦	♦	♦	♦				♦	♦	♦	♦		♦	♦		• The air-fuel ratio becomes rich. Black smoke may accompany. Poor connection of grounding may be a possible cause.
		Low output			♦	♦				♦	♦	♦	♦	♦	♦	♦	♦	♦		♦	♦	♦	♦		♦	♦		• The air-fuel ratio becomes lean. Contaminated hot wire or suction of air may be suspected.
	Ground	OPEN	⊕																	⊕	⊕	⊕	⊕		♦			• It will be over-rich.
	Power supply	OPEN			♦	♦		⊕		♦	♦	♦	♦	♦	♦	♦							♦		♦			• It will be in fail-safe condition, and vehicle runs at an engine speed from 800 rpm to 1,600 rpm.
Intake air temperature sensor		OPEN/ SHORT																							♦			
Engine coolant temperature sensor		OPEN/ SHORT		♦	♦	♦		♦		♦	♦	♦	♦	♦	♦	♦	♦								♦	♦		• It will be in fail-safe condition and then Engine Warning lamp turns ON. This malfunction tends to occur when engine coolant temperature is high.
		Resistance is large.		♦	♦	♦		♦			♦	♦	♦	♦	♦	♦				♦	♦	♦	♦	♦	♦	♦		• The engine coolant temperature is judged as low. This malfunction tends to occur after warming up.
		Resistance is small.		♦	♦	♦	♦		♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		♦	♦		• The engine coolant temperature is judged as high. This malfunction tends to occur when engine is cold.
Heated oxygen sensor		OPEN/ SHORT								♦	♦	♦				♦				♦		♦	♦		♦	♦		• It will be base air-fuel ratio.

Table of DTC (Cont'd)

DTC	Name	Engine warning lamp	DTC for GST	Malfunction return condition	Diagnosis outline	Trip
E-32	Overheat signal (STEP1)	ON*	P1218	Engine coolant temp. sensor output voltage has been approx. 0.35V or less for a predetermined period (with the coolant temp. sensor normal)	—	1
E-33	Overheat signal (STEP2)	ON	P1217	Engine coolant temp. sensor output voltage has been approx. 0.35V or less for a predetermined period (with the coolant temp. sensor normal)	Detects overheat condition by water temperature sensor that causes the MIL to go on.	1
E-34	Ignition signal circuit malfunction	ON	P0350	Ignition signal has not been continuously generated while the engine is running.	Detects electric current in an ignition coil circuit, abnormal ignition interval causes the MIL to go on.	2
E-35	LPG fuel injection open circuit malfunction	ON*	P1240	Over current flows into LPG injector 1 (injection area).	Detects abnormal electric current in an LPG injector driving circuit that causes the MIL to go on.	1
			P1241	Over current flows into LPG injector 1 (no injection area).		
E-38	LPG vaporizer malfunction	ON	P1249	• LPG fuel pressure sensor circuit is open. • LPG fuel pressure in fuel piping from LPG Vapo to injector has been excessively increased for a predetermined period.	Detects abnormally high fuel pressure caused by LPG fuel pressure sensor that causes the MIL to go on.	1
E-41	Stop lamp switch malfunction	ON*	P1805	Brake switch signal circuit is open or shorted.	—	1
E-36	LPG fuel pressure sensor malfunction	ON*	P1245	LPG fuel pressure sensor circuit is shorted.	Detects disconnections and short circuits that causes the MIL to go on.	1

Fuel Pressure Inspection (Cont'd)

4. Turn ignition switch ON, and then make sure that there is no fuel leakage.
5. Start engine, and check for fuel leakage.
6. Make sure that fuel pressure is within the standard.

   At idle: 353 kPa (3.53 bar, 3.6 kg/cm^2, 51 psi)

- If the vehicle shows poor starting, check fuel pressure with fuel pump operating for approximately 1 second after ignition switch is turned ON, and during cranking.

  For 1 second after ignition switch is turned ON and during cranking:

  353 kPa (3.53 bar, 3.6 kg/cm^2, 51 psi)

- Check the following items if a malfunction is detected.

CAUTION:
Also check fuel pressure at increased engine speed.

- Malfunctioning pressure regulator (integrated with fuel pump)
- Clogged fuel piping
- Clogged fuel filter (with fuel pump)
- Poor fuel pump discharge

FUEL PRESSURE RELEASE

CAUTION:
Relieve fuel pressure before removing fuel piping to secure safety.

Accelerator Pedal Fully Released Position Learning

With Active Test:
1. Perform "Fuel pressure clear" of ECM Active Test.
2. Crank engine 2 or 3 times to consume the fuel in the fuel line after it stalls.
3. Turn ignition switch OFF.

Without Active Test:
1. Disconnect fuel pump fuse.
2. Start engine.
3. Crank engine 2 or 3 times to consume the fuel in the fuel line after it stalls.
4. Turn OFF the ignition switch, and install the fuel pump fuse.

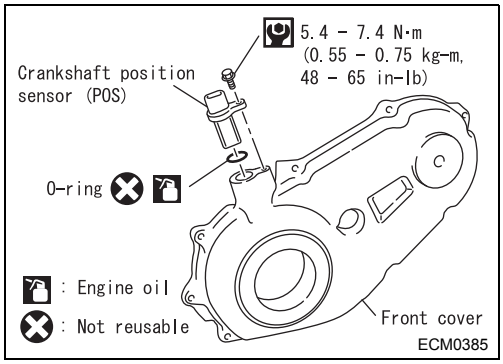
Removal and Installation

ECM

CAUTION:
Disconnect the negative battery cable from the battery.

1. Disconnect ECM connector.
2. Remove ECM together with ECM bracket.
3. Remove ECM bracket.
4. Install in the reverse order of removal.

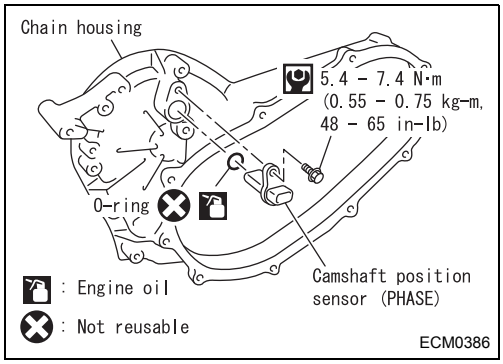
CAUTION:
Perform "Throttle Valve Closed Position Learning and Idle Air Volume Learning" after installation if replacing ECM. (Refer to "Throttle Valve Closed Position Learning and Idle Air Volume Learning".)



CRANKSHAFT POSITION SENSOR (POS)

1. Remove fan.
2. Remove harness connector.
3. Remove crankshaft position sensor (POS).

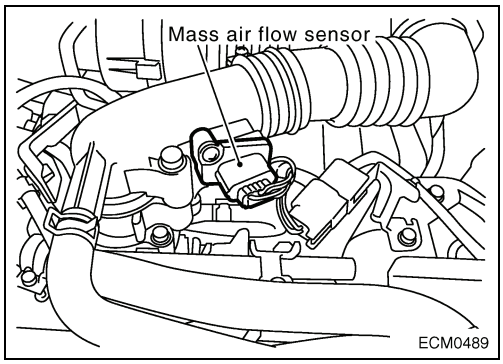
NOTE:
- Make sure that there is no foreign material on sensor flange, O-rings, and cylinder block.
- Keep away from magnetized objects.
- Make sure that the sensor is inserted securely into front cover before tightening bolts.



CAMSHAFT POSITION SENSOR (PHASE)

1. Remove fan.
2. Remove harness connector.
3. Remove camshaft position sensor (PHASE).

NOTE:
- Make sure that there is no foreign material on sensor flange, O-rings, and chain housing.
- Keep away from magnetized objects.
- Make sure that the sensor is inserted securely into cylinder head front cover before tightening bolts.



MASS AIR FLOW SENSOR

1. Remove harness connector.
2. Remove mass air flow sensor assembly from air horn.

Thermostat

REMOVAL

1. Remove the radiator upper hose from the water outlet and extract coolant.

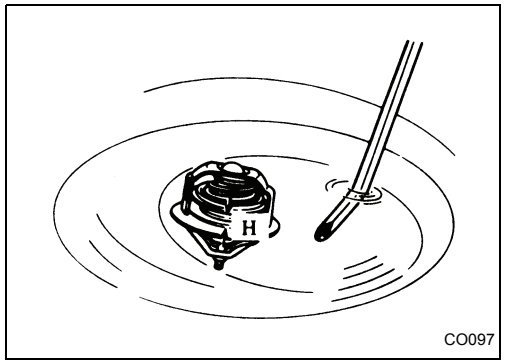
WARNING:
Do not drain coolant when engine is still hot. Hot coolant could result in burns and serious injury.

2. Remove water inlet and remove thermostat.

INSPECTION

Inspect the thermostat as instructed below and replace it as necessary.

1. Inspect valve seating status under ordinary temperature. The valve must be seated firmly.
2. Inspect the opening temperature and maximum valve lift by heating the valve in a container.



CAUTION:
Do not touch the thermostat, container, or hot water inside until the temperature lowers sufficiently. A hot thermostat, container or hot water may result in burns and injury.

3. make sure that the valve closing temperature is approx. 5°C lower than the opening temperature. Also perform the same inspection before installing a new thermostat.

INSTALLATION

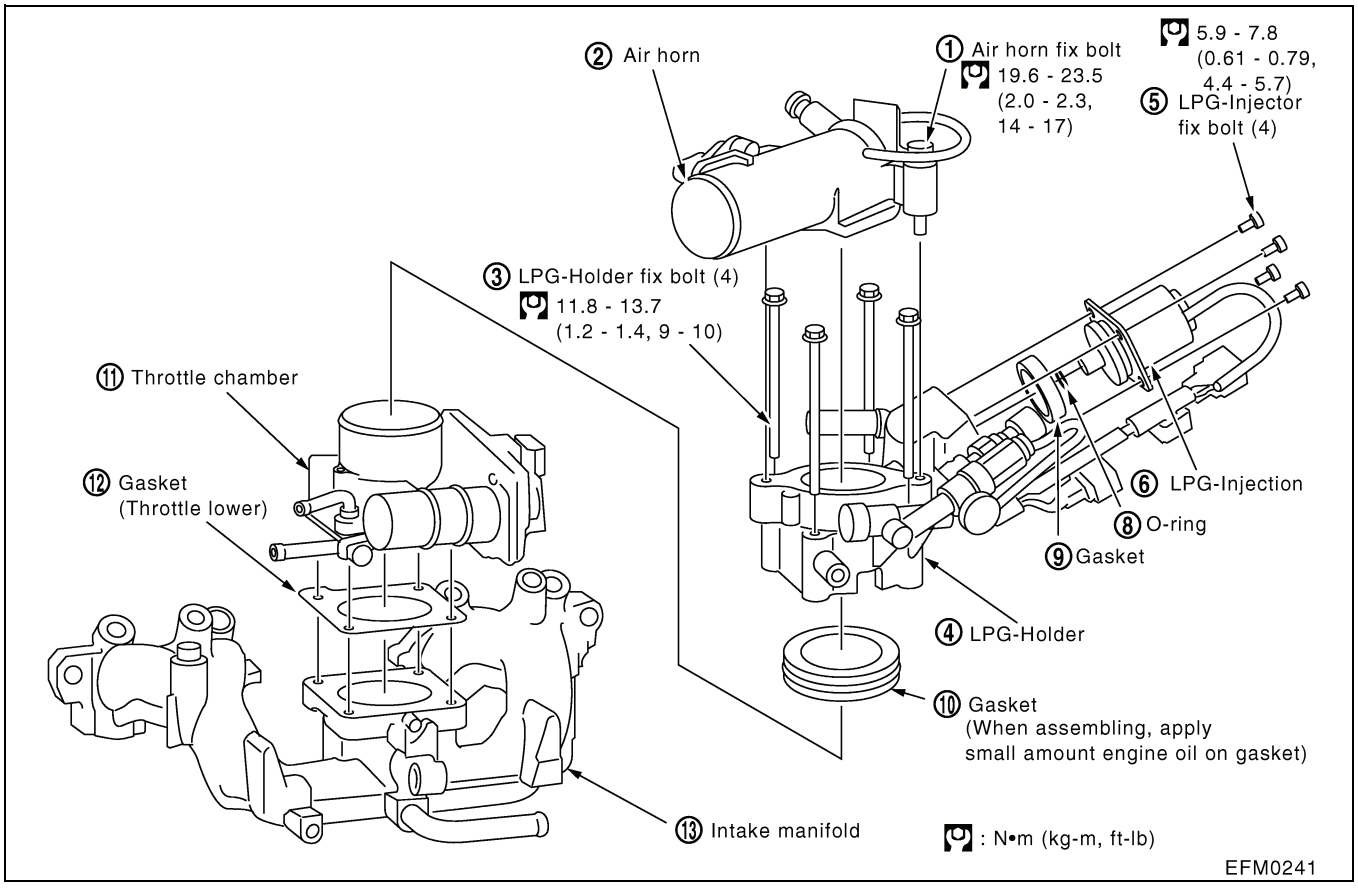
Install in the reverse order of removal.
Always use a new water inlet gasket.

Electric Control Throttle Assembly

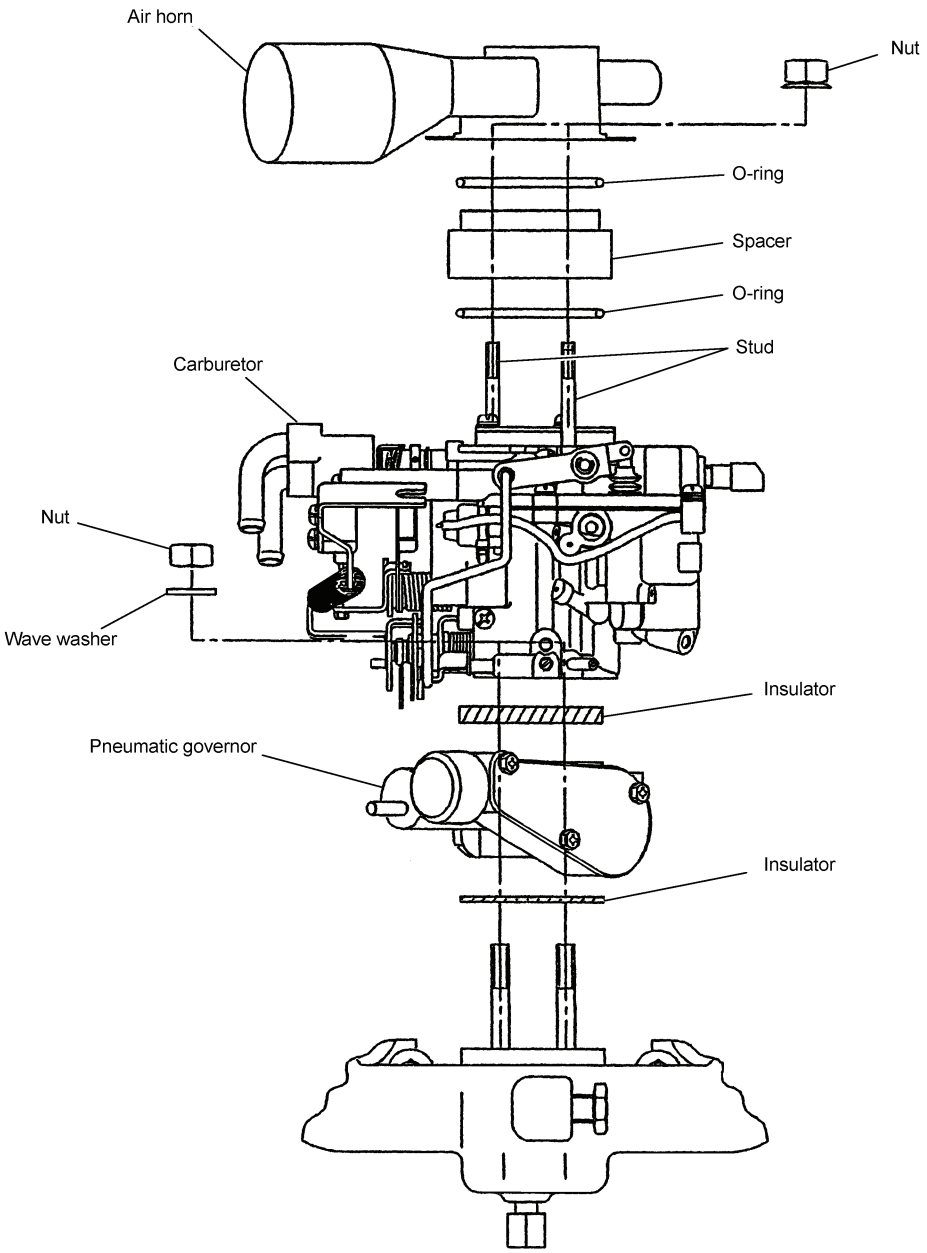
REMOVAL

1. Remove air duct.
2. Remove harness connector. (Mass air flow sensor, LPG injector, LPG assistance injector, LPG fuel pressure sensor and electric throttle control actuator)
3. Loosen air horn bolts in turns, and then remove them.
4. Loosen injector holder bolts in turns, and then remove them.
5. Also loosen chamber bolt of electric control throttle, and then remove the chamber.

ELECTRIC CONTROLLED SYSTEM COMPONENT VIEW



Components Around Carburetor and Pneumatic Governor (Carburetor Specifications)



Component	Items		Description
Distributor	• Integrated ignition coil		Primary coil resistance: 0.9 - 1.2 Ω Secondary coil resistance: 20 - 29K Ω
	• Pickup assembly		Pickup coil resistance: 420 - 540 Ω
	• Air gap between signal rotor and pickup assembly		0.35 - 0.45 mm
Starter motor	• Brush dimensions	Dry type	5.5 - 12.3 mm (0.217 - 0.484 in) (Wear margin 6.8 mm (0.27 in))
		Wet type	12.0 - 16.0 mm (0.472 - 0.630 in) (Wear margin 4 mm (0.16in))
	• Brush spring pressure	Dry type	15.0 - 20.4 N (1.53 - 2.08 kg, 3.4 - 4.59 lb)
		Wet type	17.7 - 21.6 N (1.81 - 2.20 kg, 3.98 - 4.86 lb)
Alternator	• Stator		Resistance between respective lead wires: 0.05 - 0.5 Ω Resistance between stator core and lead wire: ∞
	• Rotor coil		Standard resistance between slip rings: 2.41 - 2.82 Ω Standard resistance between slip ring and rotor core: ∞
	• Snap ring		Snap ring outer diameter: Standard: 22.7 mm (0.894 in) Repair limit: 22.1 mm (0.870 in)
	• Brush		Projected length from holder: Standard: 10.0 mm (0.394 in) or more

Specifications

Item		Specifications
Part type		For wet type clutch
Type		Built in reduction gear
Output	(kW)	1.4

Components