



# Service Manual

## Chassis & Mast

**MC**

<b>GC20N</b>	AT90-10121 to 30120
<b>GC25N</b>	AT90-10121 to 30120
<b>GC28N</b>	AT83F-10121 to 30120
<b>GC30N</b>	AT83F-10121 to 30120
<b>GC33N</b>	AT83F-60121 to 80120

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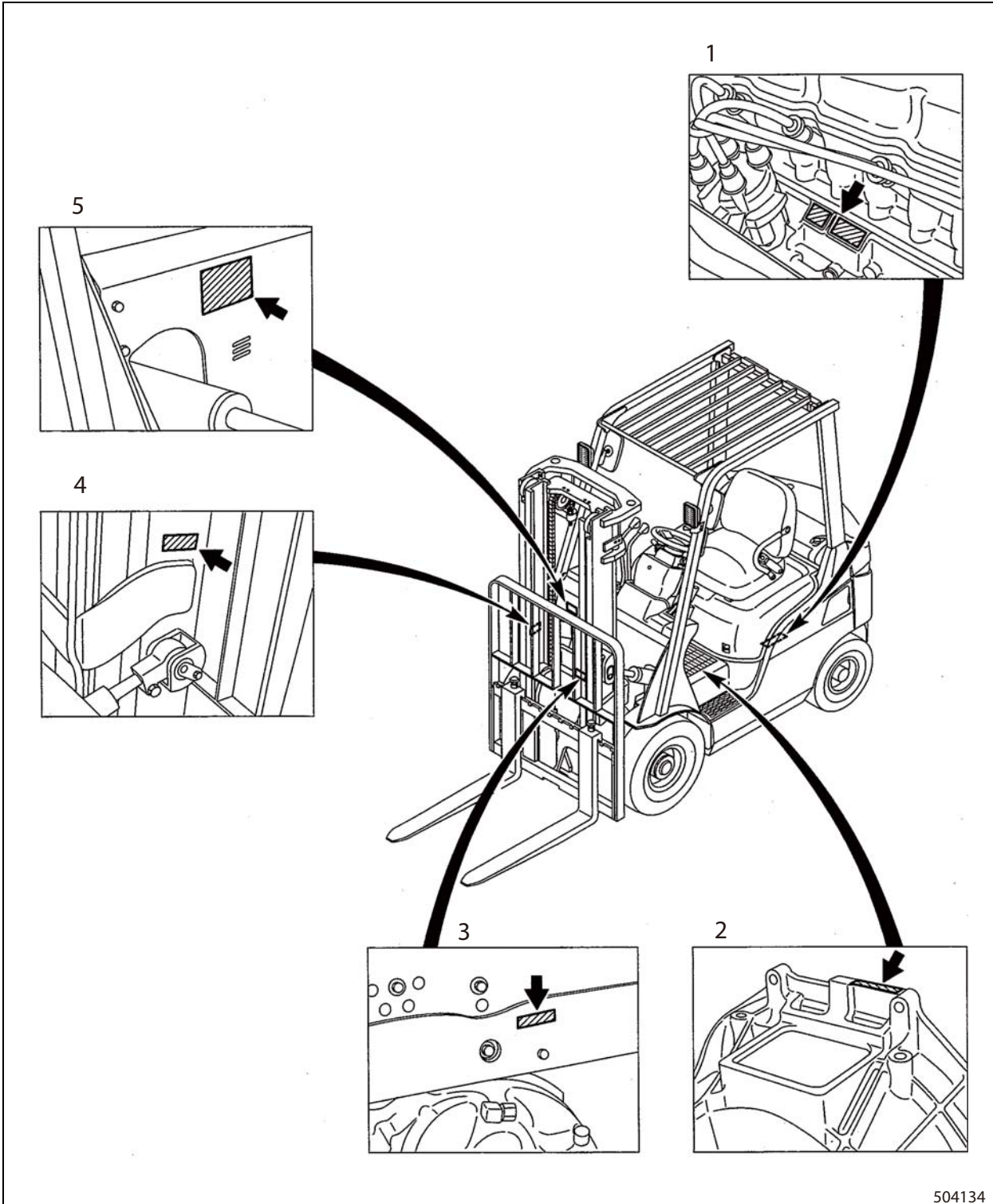
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## Chapter 8 REAR AXLE

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### 3. Serial Number Locations



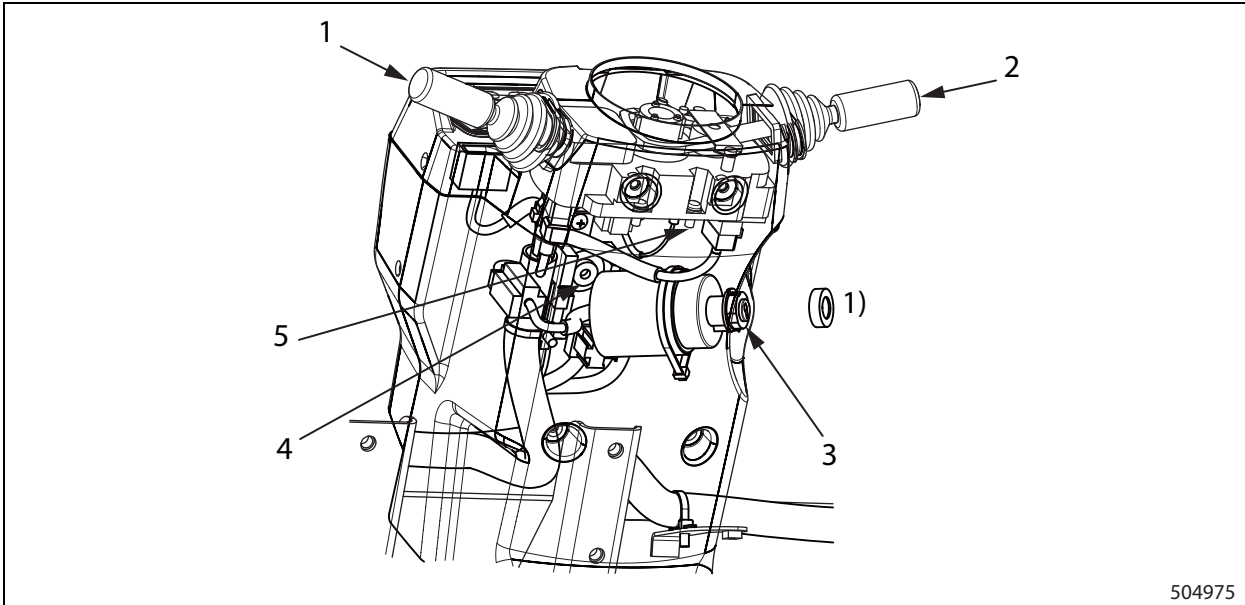
504134

- 1. Gasoline engine serial number
- 2. Transmission serial number
- 3. Chassis serial number

- 4. Mast serial number
- 5. Name plate

## 2. Console Box

### 2.1 Console Box Outline



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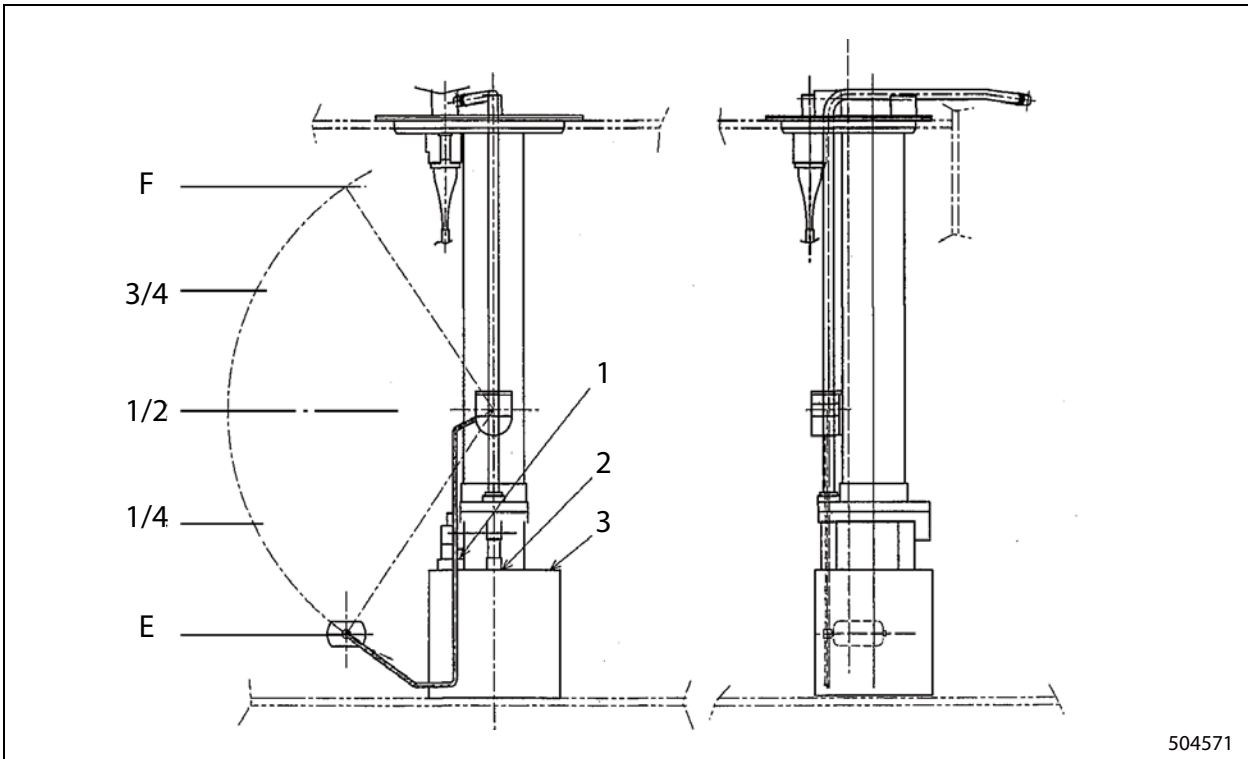
- |                                       |                                    |
|---------------------------------------|------------------------------------|
| 1. Direction (FNR) lever              | 4. Warning buzzer, Tapping screw   |
| 2. Light switch and turn signal lever | 5. Machine screw                   |
| 3. Key switch                         | 1) Apply Loctite 242 or equivalent |

Ref.	Item	Tightening torque
3	Key switch	3.92 to 5.88 N·m (0.40 to 0.60 kgf·m) [2.89 to 4.34 lbf·ft]
5	Machine screw	2.32 to 3.48 N·m (0.24 to 0.35 kgf·m) [1.71 to 2.57 lbf·ft]

Note:

- Tighten the nut with specified tightening torque after applying Loctite 242 or equivalent to the thread of nut when key switch must be installed on column cover.
- No Loctite leakage on the out side.

4.7 Tank Unit



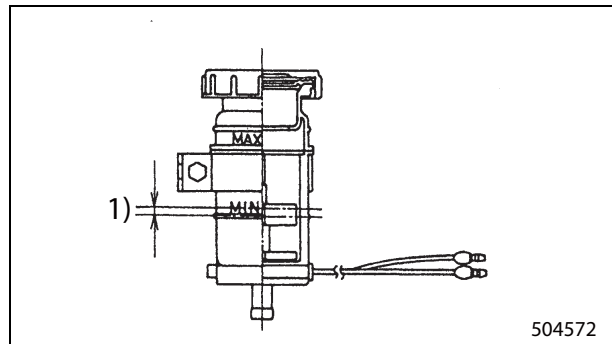
- 1. Fuel pump
- 2. Pressure relief valve
- 3. Fuel filter

Specifications

Float position	E	1/4	1/2	3/4	F
Standard resistance (ohm)	80	49.5	32	19	10
Tolerance (ohm)	+12 +2	-	±3	-	+1.0 -3.0

4.8 Brake Oil Sensor

Refer to the brake system.



Ref.	Indicator ON activating position
1)	3 ± 2mm (0.12 ± 0.08 in.)

## 5. Battery and Maintenance

### 5.1 State of Charge and Electrolyte Specific Gravity (S.G.) Adjustment

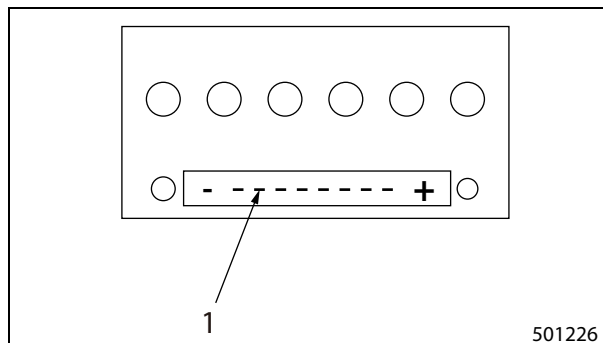
Specific gravity reading at 20 °C (68°F)	Condition	Adjustment
1.280-1.265	Good	If the difference in S.G. between any two cells is 0.020 or less, continue to use as is. If the difference is more than 0.020, discharge the battery in an efficient manner. If the battery recovers, charge the battery to adjust the electrolyte S.G.
1.260 to 1.225	Half charged	Recharge battery to adjust electrolyte S.G. Check for any short-circuited cables or corroded cable connections in the electrical system.
1.220 or less	Low battery (caution required)	Recharge battery. If the difference in S.G. is too much, charge the battery to adjust the electrolyte S.G.
If the difference in S.G. is more than 0.040.	A cell with a low S.G. may cause a short circuit. It is caused when electrolyte leaks or electrolyte rate is too high or too low.	Recharge the battery until its voltage and S.G. stabilize and remain constant for more than 2 hours. Charge the battery to adjust the electrolyte S.G. It should read between 1.280 and 1.265. If the difference in S.G. is more than 0.040 and a low S.G. is found in any of the cells, replace the battery with a new one. Conduct a high current discharge test after leaving the battery for 12 to 96 hours.

### 5.2 Specific Gravity Reading and State of Charge

Fully charged condition can be verified by the electrolyte S.G. (1.280 to 1.265), and also the reduction speed of electrolyte implies the battery condition. If the electrolyte in battery cell decreases to the level where the pole plates are exposed within one month, it may be overcharged. If the electrolyte amount remains sufficient for more than three months, the battery may be charged less.

### 5.3 Precautions for Battery Charging

- (1) In slow charging, the charging current should be about 1/10 the capacity of the battery being charged.
- (2) In quick charging, the battery capacity in ampere should not be exceeded.
- (3) During charging, adjust the charging current so that the electrolyte temperature does not exceed 45°C (113°F).
- (4) When connecting cables to battery terminals, always connect the (+) terminal first, and when disconnecting, remove the (-) terminal first.
- (5) During charging, hydrogen gas is generated, which requires attention to ventilation.



1. Identification

## ⚠ CAUTION

Be sure to turn OFF the key switch and lighting switch before disconnecting or connecting the battery cables (to prevent IC regulator from damage).

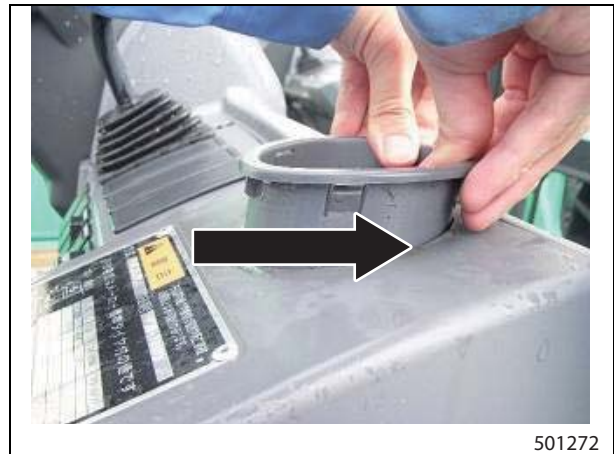
## 2.4 GSE Connector

The GSE connector is used to connect the PC and truck, It is located under the cup holder on the right side of dashboard.

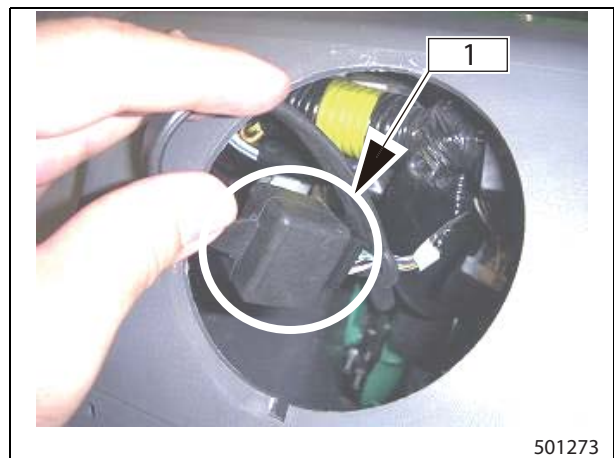
- (1) Pull up the upper side rim of the cup holder.



- (2) With the rim of the cup holder raised, push the cup holder in the direction of the mast.



- (3) Remove the cup holder and remove the GSE connector from inside.



1. GSE Connector



- (8) The unload solenoid output and the lift lock solenoid output will turn OFF when the mast interlock system is activated.

Under this condition, operate the lift lever to make sure that the forks will not move up and down. Also operate the tilt lever to make sure that the mast will not tilt FORWARD and BACKWARD.

Item	Normal Range	Value
Solenoid output (ATT3 valve 2) outp...	* - *	0
Solenoid output (ATT3 valve) feedba...	* - *	0
Solenoid output (ATT3 valve 1) output	* - *	Normal
Solenoid output (ATT3 valve 2) output	* - *	Normal
Solenoid output (ATT3 valve) status	* - *	Normal
PWM voltage (RI01) [V]	* - *	0
PWM voltage (RI01)	* - *	Normal
Unload solenoid	* - *	OFF
Unload solenoid feedback [mA]	* - *	9.67
Liftlock solenoid	* - *	OFF
Liftlock solenoid feedback [mA]	* - *	9.67
Tiltlock solenoid feedback [mA]	* - *	19.35
Park brake alarm	* - *	OFF
Over load alarm 1	* - *	OFF
Over speed alarm	* - *	OFF
Angle adjust solenoid	* - *	OFF
Angle adjust tilt lock current [mA]	* - *	19.35
Auto light OUT	* - *	OFF
AUX out 1	* - *	OFF
AUX out 2	* - *	OFF
AUX out 3	* - *	OFF
Limp home	* - *	OFF

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**If seat switch is not turned ON**

Check the seat switch operation and wiring connections by referring to 4-38 "Harness Codes", 4-40 "VCM (Vehicle Control Module)", and 4-46 "Seat Switch"

**If unload solenoid is not turned ON**

Check the solenoid output according to 4-24 "Active Test Inspection Procedure" If the solenoid output will not turn ON even after the active test inspection, refer to 4-53 "Truck Status Display and Troubleshooting" and check for the possible causes of the diagnostic code F-75 and F-79.

**If lift lock solenoid is not turned ON**

Check the solenoid output according to 4-24 "Active Test Inspection Procedure" If the solenoid output will not turn ON even after the active test inspection, refer to 4-53 "Truck Status Display and Troubleshooting" and check for the possible causes of the diagnostic code F-77 and F-79.

## 6.2 Checking the Operation of Seat Belt Warning Light

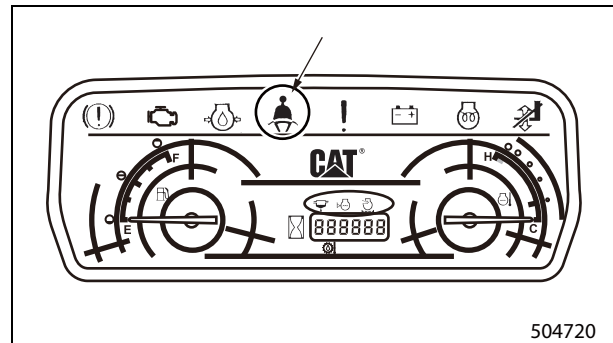
- (1) Connect the service tool to the VCM controller.
- (2) Turn the key switch to the ON position and start the engine.
- (3) Display the input monitor screen of the service tool.
- (4) Make sure that the seat switch status is turned OFF when the seat belt is not fastened or not buckled properly. Also check that the seat belt warning light in the meter panel glows.

Item	Normal Range	Value
Seat Switch	* - *	ON
Seat Switch timer	* - *	ON
Seatbelt Switch	* - *	OFF
Accel Switch	* - *	ON
Park brake Switch	* - *	ON
Direction lever F	* - *	OFF
Direction lever N	* - *	ON
Direction lever R	* - *	OFF
FNR lever	* - *	Neutral
Joystick (Lift lever 1) signal [%]	-100 - 100	0
Joystick (Lift lever 1) status	* - *	Normal
Joystick (Lift lever 2) signal [%]	-100 - 100	0
Joystick (Lift lever 2) status	* - *	Normal
Joystick (Tilt lever 1) signal [%]	-100 - 100	0
Joystick (Tilt lever 1) status	* - *	Normal
Joystick (Tilt lever 2) signal [%]	-100 - 100	0
Joystick (Tilt lever 2) status	* - *	Normal
Joystick (ATT1 lever 1) signal [%]	-100 - 100	0
Joystick (ATT1 lever 1) status	* - *	Normal
Joystick (ATT1 lever 2) signal [%]	-100 - 100	0
Joystick (ATT1 lever 2) status	* - *	Normal
Joystick (ATT2 lever 1) signal [%]	-100 - 100	0
Joystick (ATT2 lever 1) status	* - *	Normal
Joystick (ATT2 lever 2) signal [%]	-100 - 100	0

501411

### If Seat belt switch does not indicate ON

Check the seat belt switch operation and wiring connections by referring to "8. Harness codes", "9.1 VCM controller", and "9.2 Seat switch".



- (5) Make sure that the seat belt switch turns ON and the seat belt warning light in the meter panel goes out when the seat belt is properly fastened.

Item	Normal Range	Value
Seat Switch	* - *	ON
Seat Switch timer	* - *	ON
Seatbelt Switch	* - *	ON
Accel Switch	* - *	ON
Park brake Switch	* - *	ON
Direction lever F	* - *	OFF
Direction lever N	* - *	ON
Direction lever R	* - *	OFF
FNR lever	* - *	Neutral
Joystick (Lift lever 1) signal [%]	-100 - 100	0
Joystick (Lift lever 1) status	* - *	Normal
Joystick (Lift lever 2) signal [%]	-100 - 100	0
Joystick (Lift lever 2) status	* - *	Normal
Joystick (Tilt lever 1) signal [%]	-100 - 100	0
Joystick (Tilt lever 1) status	* - *	Normal
Joystick (Tilt lever 2) signal [%]	-100 - 100	0
Joystick (Tilt lever 2) status	* - *	Normal
Joystick (ATT1 lever 1) signal [%]	-100 - 100	0
Joystick (ATT1 lever 1) status	* - *	Normal
Joystick (ATT1 lever 2) signal [%]	-100 - 100	0
Joystick (ATT1 lever 2) status	* - *	Normal
Joystick (ATT2 lever 1) signal [%]	-100 - 100	0
Joystick (ATT2 lever 1) status	* - *	Normal
Joystick (ATT2 lever 2) signal [%]	-100 - 100	0

501416

## VCM controller signal allocation (Electronic control LPG model)

Pin No.	Circuit No.	Harness destination	Pin No.	Circuit No.	Harness destination
1	-		1	610	Seat
2	-		2	609	Seat
3	-		3	-	
4	-		4	-	
5	-		5	-	
6	-		6	345	Coolant level sensor
7	722	Power select SW	7	346	Air dust sensor
8	-		8	343	Oil temperature sensor
9	-		9	374	W/SEPA sensor
10	-		10	702	Speed sensor
11	-		11	703	Speed sensor
12	-		12	-	
13	-		13	-	
14	662	Hydraulic sensor (OP)	14	-	
15	663	Hydraulic sensor (OP)	15	670	T/M control solenoid
16	-		16	671	T/M control solenoid
17	664	Hydraulic sensor (OP)	17	672	T/M control solenoid
18	600	Fuse box	18	-	
19	-		19	-	
20	-		20	-	
21	-		21	-	
22	-		22	127	ECM
23	-		23	-	
24	-		24	-	
25	975	GND	25	-	
26	601	Circuit No. 600 (Fuse box)	26	866	GSE connector
27	-		27	240	GSE connector
28	-		28	241	GSE connector
29	-		29	242	GSE connector
30	630	Unload solenoid	30	865	GSE connector
31	628	Lift lock solenoid	31	155	ECM
32	631	Unload solenoid	32	156	ECM
33	625	Circuit No. 371 (Warning buzzer to Relay box)	33	-	
34	976	Circuit No. 975 (ECM to GND)	34	-	

# 10. Truck Status Display and Troubleshooting

## 10.1 Truck Status Display

### Truck status display

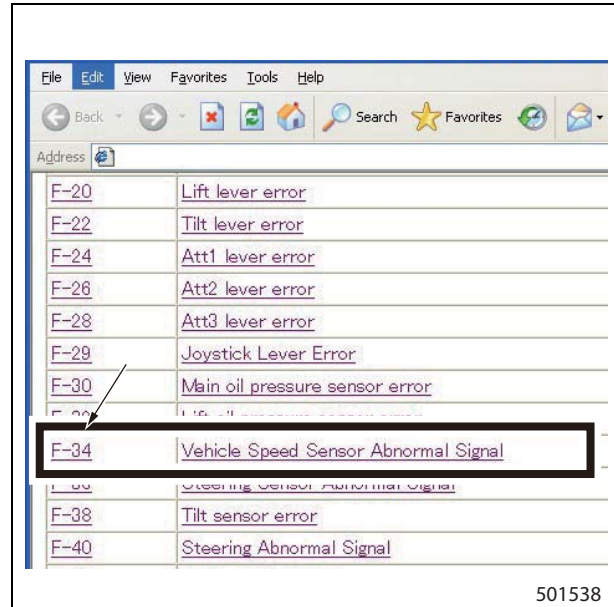
All self diagnostics that have been present are displayed.

### Troubleshooting

Display the truck status screen by clicking the truck status button either from the monitor menu or toolbox. When the screen is displayed, press the troubleshooting button on the bottom right of the screen to display a list of diagnostic codes and their descriptions.

### Example: Diagnostic code 34 (Speed sensor warning probable cause)

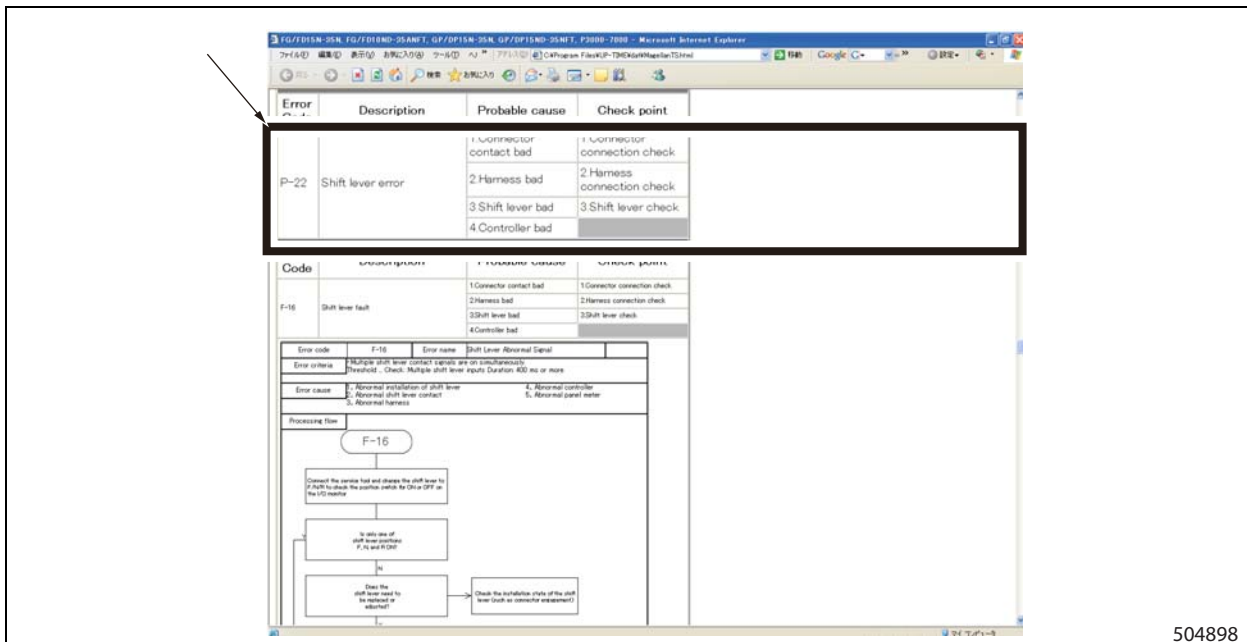
- Connector contact bad
- Harness bad
- Speed sensor bad
- Controller bad



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### Check items

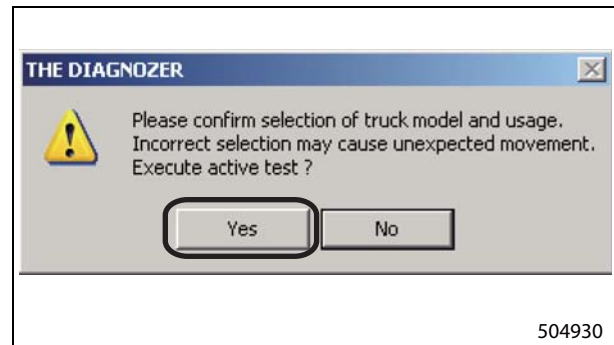
- (1) Connector connection check
- (2) Harness connection check
- (3) Sensor connection check



504898

Diagnostic code	Diagnostic code name	Probable cause	Check items
F-79	Unload solenoid, lift lock valve leak	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. Unload solenoid bad	4. Unload solenoid connection check
		5. Controller bad	
F-80	Power steering correction solenoid warning	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. Power steering correction valve solenoid bad	4. Power steering correction valve solenoid connection check
		5. Controller bad	
F-82	Tilt lock solenoid warning	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. Tilt lock solenoid bad	4. Tilt solenoid connection check
		5. Controller bad	
F-84	Power steering correction solenoid, tilt lock valve leak	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. Power steering correction valve solenoid bad	4. Power steering correction valve solenoid connection check
		5. Controller bad	
F-85	T/M forward travel solenoid warning	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. T/M forward solenoid bad	4. T/M FW solenoid connection check
		5. Controller bad	
F-87	T/M backward travel solenoid warning	1. Connector contact bad	1. Connector connection check
		2. Diode bad	2. Diode connection check
		3. Harness bad	3. Harness connection check
		4. T/M backward solenoid bad	4. T/M BW solenoid connection check
		5. Controller bad	

After removing the check marks you will need to click on the Write tab to achieve the standard settings.



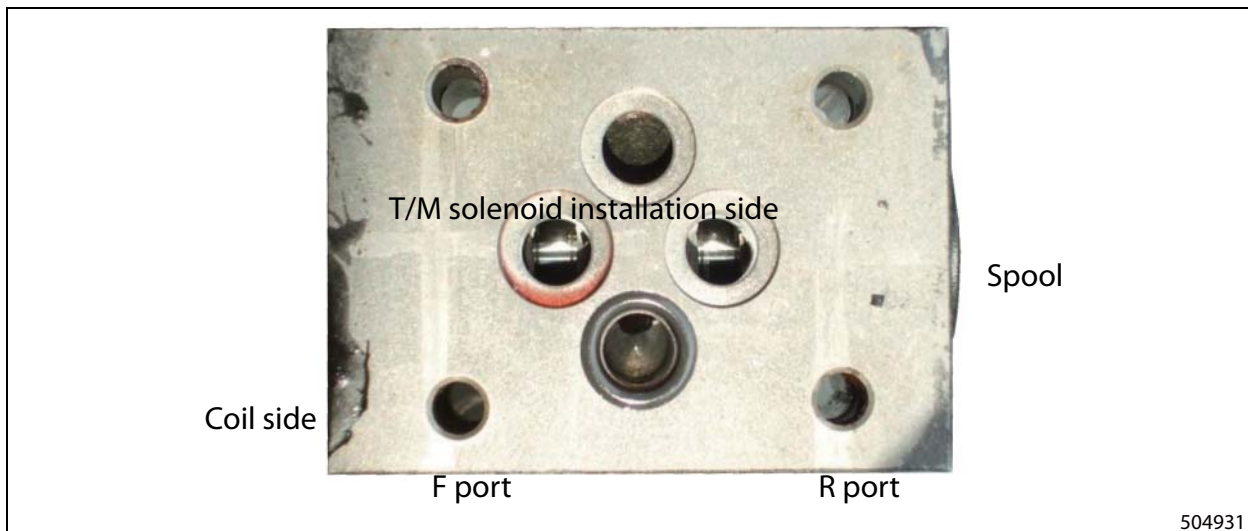
Click Yes

### Check SOL Movement Procedure

- (1) Remove T/M solenoid from T/M while T/M solenoid connects to truck side.
- (2) Shift lever N position & seat switch ON.
- (3) Key switch ON (Engine OFF)

Note: Don't start engine or oil will spray from T/M.

- (4) Check movement of T/M solenoid spool while shifting lever (R<-N->F).



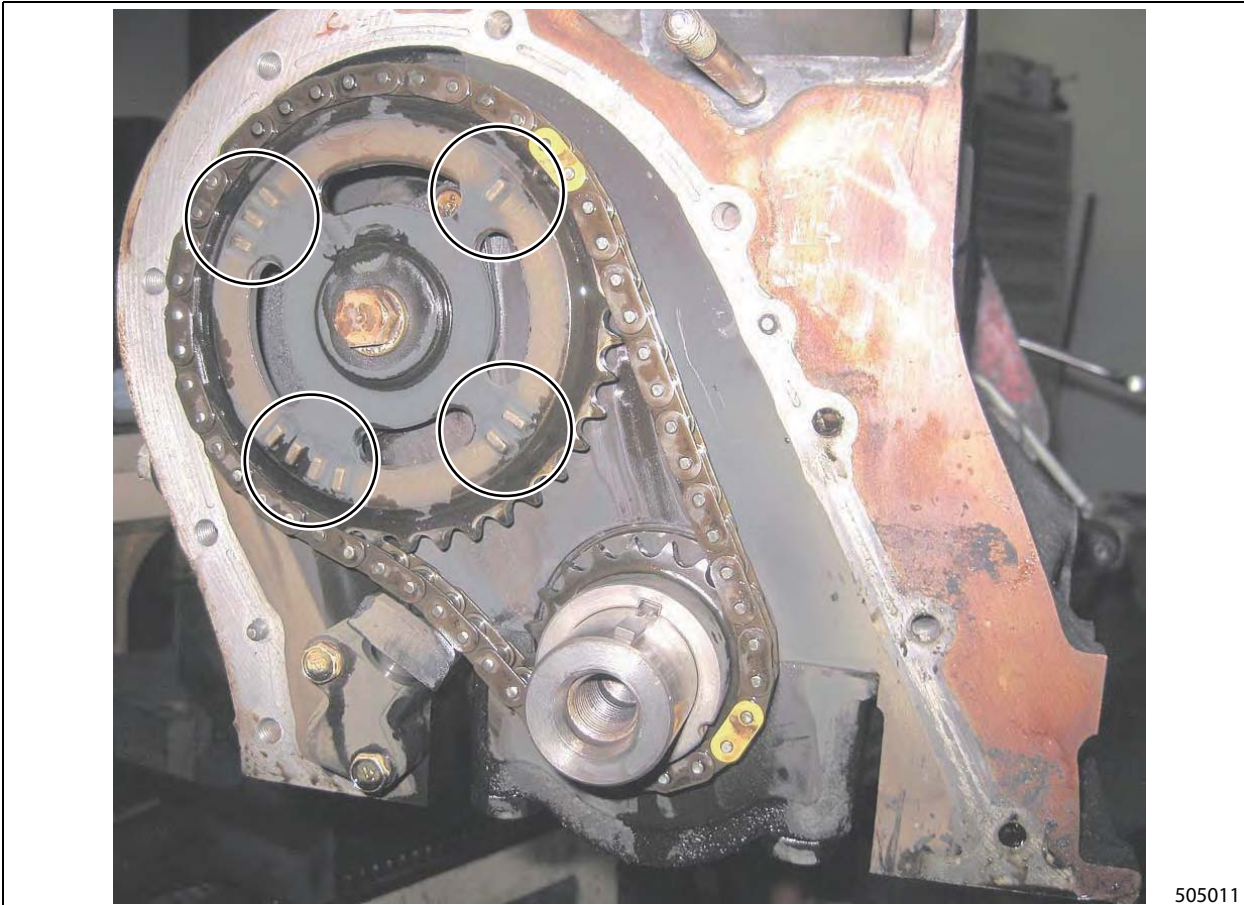
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**Camshaft position sensor:**

The camshaft position (Phase) sensor is a hall effect sensor mounted adjacent to the camshaft sprocket. The camshaft sprocket has 4 sets of raised tips I III IIII II (1, 3, 4, 2) which is also the firing order and are detected by the sensor as these tips pass in close proximity.

The sensor detects the position of the camshaft by creating a magnetic field when any of the tips are close. As the tip passes the field is broken. This acts as an ON and OFF switch (pulse signal).

Camshaft trigger wheel has raised tips that indicate cylinder firing order of 1-2-4-3 as the tips pass the sensor



The phase sensor will identify when piston No. 1 is on its compression stroke. A signal is then sent to the Electronic Control Module (ECM) and used for synchronizing the firing of Sequential Fuel Injectors (Gasoline) or TBI Single (LPG) Fuel Injector and the Coil On Plug (COP) ignition applications.

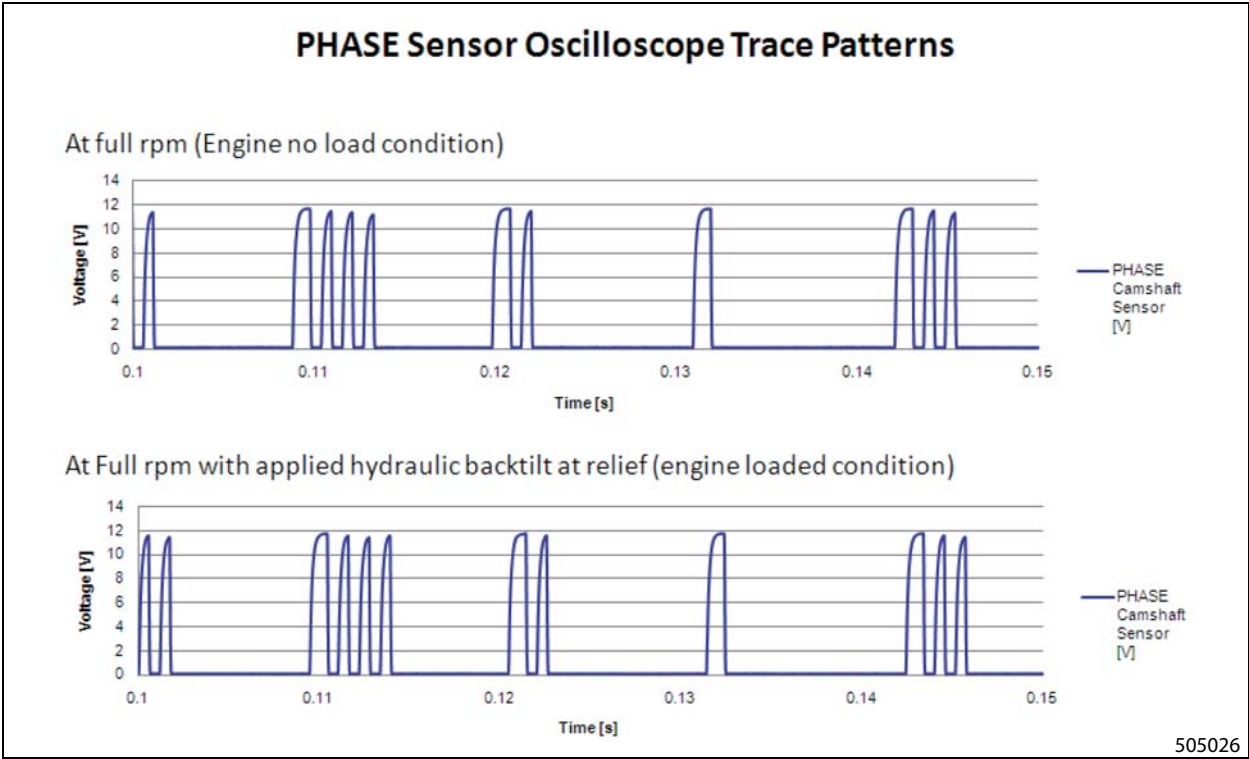
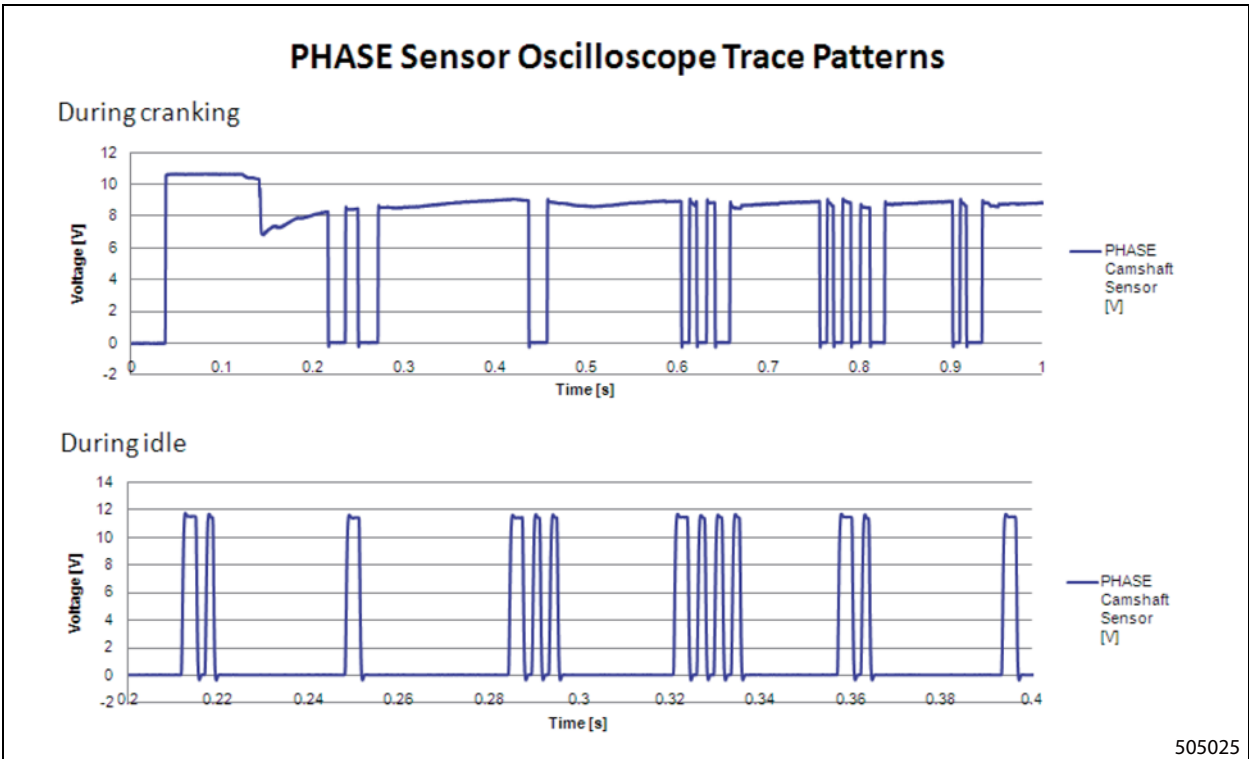
**Crankshaft Position Sensor:**

The Crankshaft Position (POS) sensor is a Hall Effect sensor mounted on the engine block adjacent to a pulse wheel located on the crankshaft. By monitoring the crankshaft mounted trigger wheel, the POS is the primary sensor for ignition information to the Electronic Control Module (ECM).

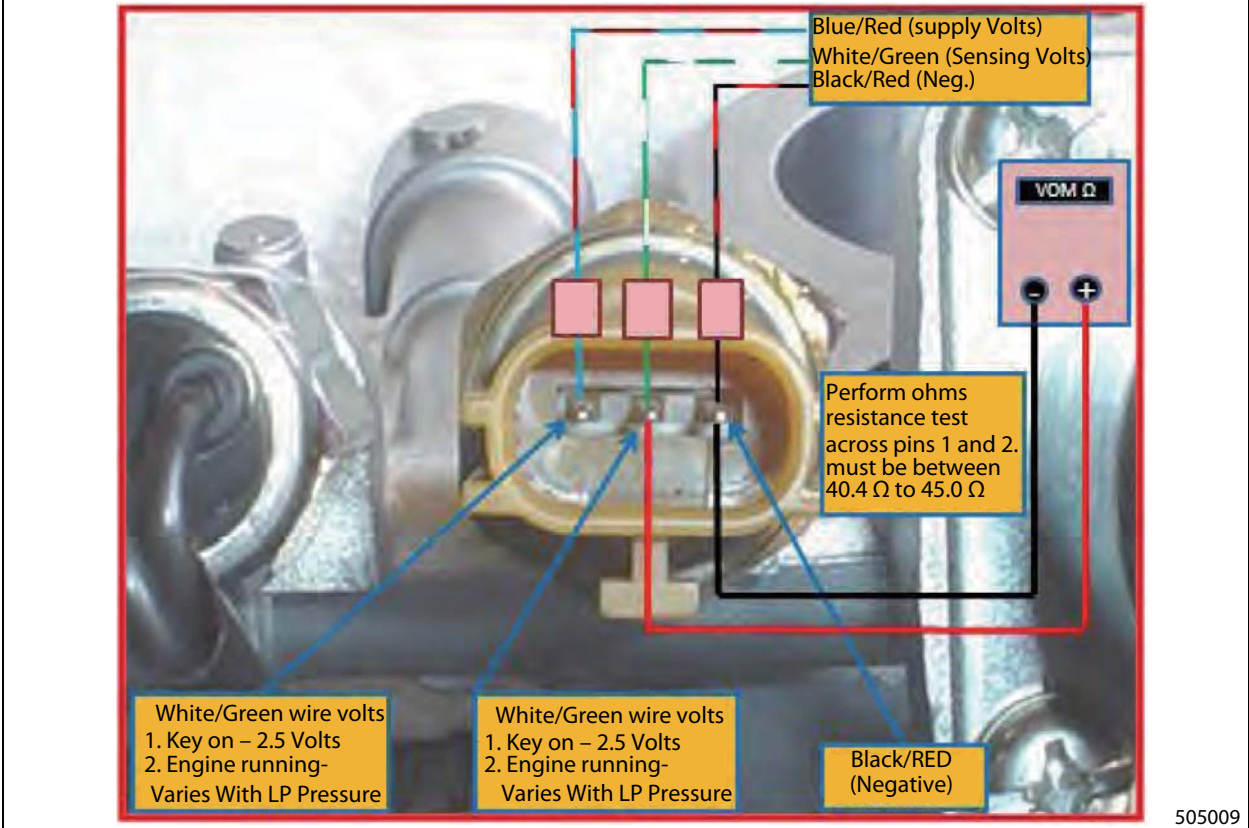
**TDC = Top Dead Center:**

The trigger wheel has a total of 31 teeth spaced 10 degrees apart with 2 empty spaces set at 180 degrees apart that indicate No.1 TDC and No.4 TDC positions.

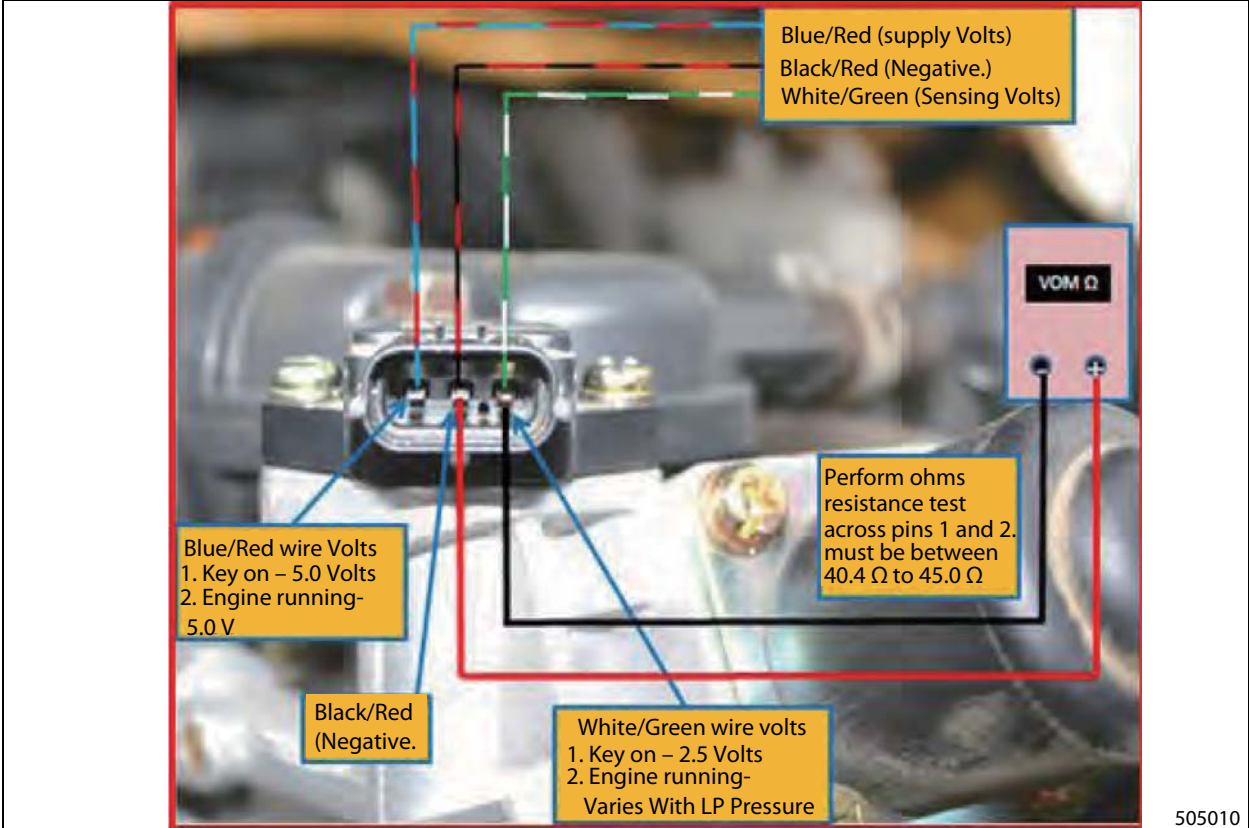
PHASE sensor oscilloscope trace patterns



Year 2005 through 2010 fuel pressure sensor



Year 2004 fuel pressure sensor



### 1.16 Suggestions for Installation of Engine and Transmission Assembly

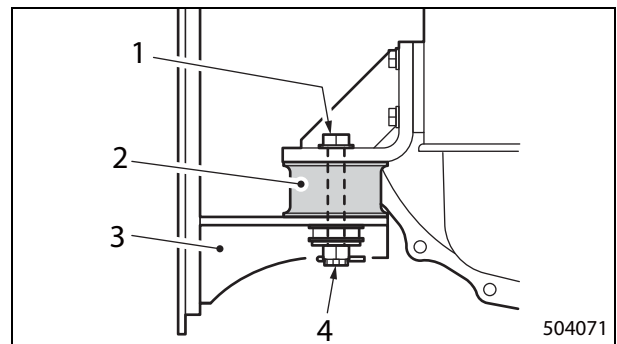
Follow the removal sequence in reverse.

(1) **Engine and transmission assembly**

- Apply sealant (oil resistant liquid gasket such as ThreeBond #1104) on the transmission mounting surface of the front axle.
- Slowly lift the assembly.

Item	Weight
Engine and transmission assembly	315 kg (695 lb)

- While aligning the holes in the rubber cushions and those in the left and right engine supports, lower the assembly.
- On each side, first insert the engine mounting bolt and align the bolt holes in the transmission and front axle, then fasten the bolts (12 places).
- Fasten each engine mounting bolt with the castle nut and lock the nut with the split pin.



1. Engine mount bolt                      3. Engine support  
2. Rubber cushion                        4. Castle nut

- (2) Check that the clutch valve plunger is pushed out completely when the cable connected between the inching pedal and the transmission.
- (3) Bleed the air out of the brake oil line after connecting the brake pipe.
- (4) When installing the exhaust pipe, use a new gasket.
- (5) Connect the ground (negative) cable to the battery only after making sure that all wiring is connected properly.
- (6) Refill the engine, radiator, front axle, and transmission with oils/coolant, and check for leakage. Unless otherwise specified, use distilled water mixed with LLC at a concentration of 35%.

**⚠ WARNING**

Antifreeze solution is TOXIC. In case of contact with your skin, FLUSH IMMEDIATELY WITH WATER. Have your truck dealer discard antifreeze solution drained from the engine.

- (7) Bleed the air out of the fuel circuit of engine.
- (8) After checking the parts, start the engine. Operate the mast lifting/tilting and steering, and check the hydraulic oil level. Also recheck the engine oil, coolant, and transmission oil levels.



**6.2 Suggestions for Assembly**

**Cleaning oil passages**

The oil passages in the valve housing must be cleaned thoroughly. Make sure there is no clogging in any passage before assembling the control valve.

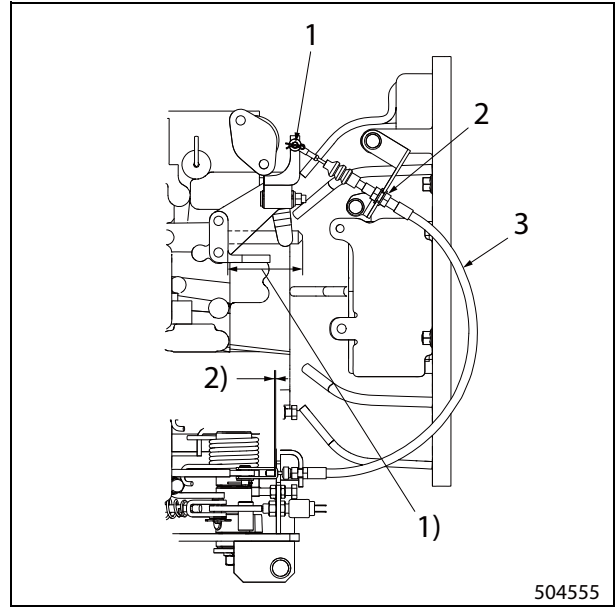
**Tightening torques**

Tighten the following parts to the specified torques.

<b>Ref.</b>	<b>Item</b>	<b>Tightening torque</b>
1	Solenoid valve, Bolt	2.94 to 3.82 N·m (0.3 to 0.39 kgf·m) [2.17 to 2.82 lbf·ft]
5, 6	Relief valve plug, Regulator valve plug	19.6 to 29.4 N·m (2.0 to 3.0 kgf·m) [14.5 to 21.7 lbf·ft]
15	Side plate, Bolt	15.7 to 20.6 N·m (1.6 to 2.1 kgf·m) [11.6 to 15.2 lbf·ft]

### 12.3 Adjusting Inching Cable

- (1) Block the rear wheels, then raising the front wheels following the procedure described in the preceding oil pressure measurement section.
- (2) Connect an oil pressure gauge to the oil pressure tap.
- (3) Make sure that inching rod extension amount 1) is within the following range.



- |                         |                                 |
|-------------------------|---------------------------------|
| 1. Inching lever pin    | 1) Inching rod extension amount |
| 2. Outer tightening nut | 2) Inching cable play           |
| 3. Inching cable        |                                 |

Ref.	Item	Standard
1)	Inching rod extension amount	82.3 ± 1 mm (3.24 ± 0.04 in.)

- (4) Connect the inching cable to the inching lever pin.
- (5) Adjust play 2) on the pedal end of inching cable to a value within the following range by turning the outer tightening nut.

Ref.	Item	Standard
2)	Play of inching cable	0.5 to 1.5 mm (0.02 to 0.06 in.)

- (6) Check that the play of inching pedal is within the following range.

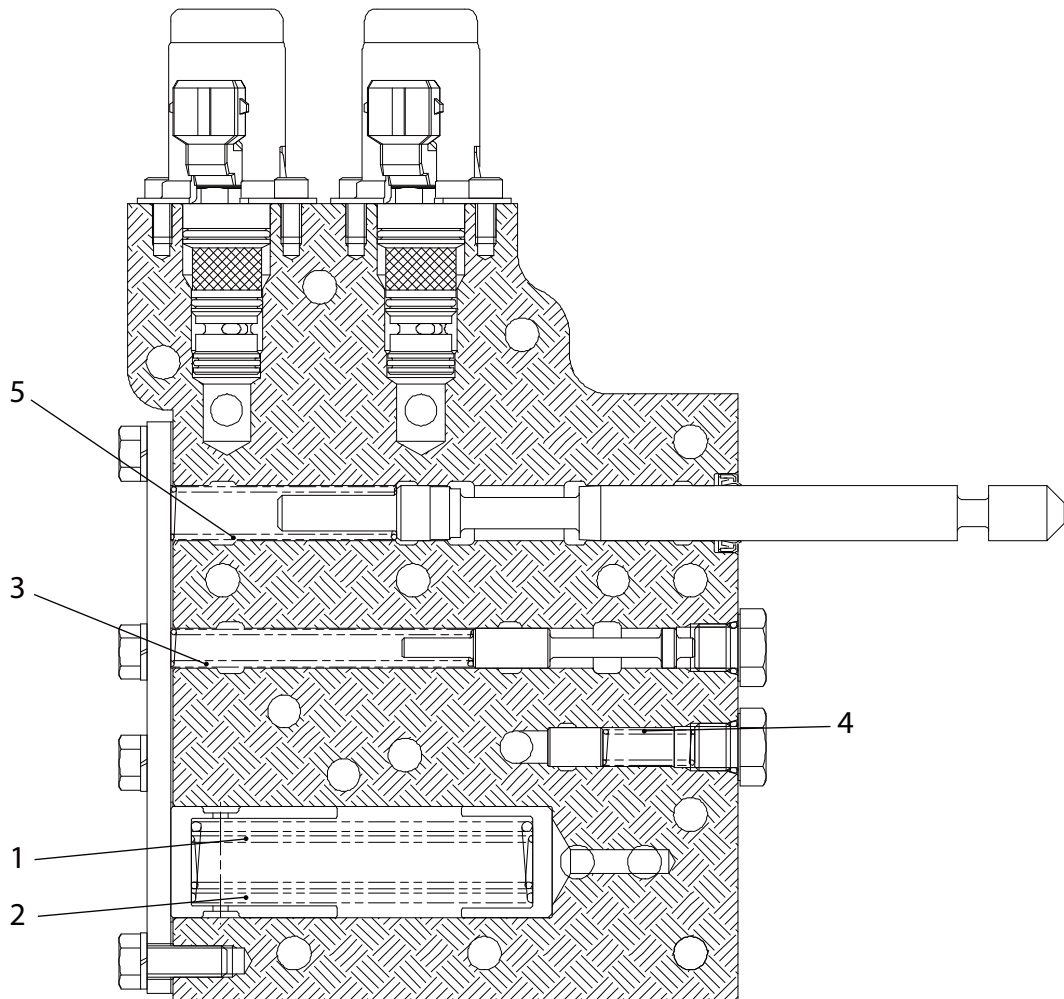
Item	Standard
Play of inching pedal	0.5 to 1.5 mm (0.02 to 0.06 in.)

- (7) Start the engine, then place the direction lever in the FWD position.
- (8) Depress the inching pedal. Make sure that inching rod extension amount 1) does not exceed the following value and the forward clutch oil pressure is zero.

Ref.	Item	Standard
1)	Inching rod extension amount	71.7 mm (2.82 in.)

15.1 Control Valve

Ref.	Item	Specified value		
1	Accumulator piston spring (inner)	Free length	Standard	102 mm (4.02 in.)
		Load at height 86.1 mm (3.39 in.)	Standard	40.2 N (4.1 kgf) [9.04 lbf]
2	Accumulator piston spring (outer)	Free length	Standard	110 mm (4.33 in.)
		Load at height 86.1 mm (3.39 in.)	Standard	107 N (10.9 kgf) [24 lbf]
3	Regulator valve spring	Free length	Standard	87.2 mm (3.43 in.)
		Load at height 75.8 mm (2.98 in.)	Standard	49 N (5 kgf) [11 lbf]
4	Converter relief valve spring	Free length	Standard	27.9 mm (1.1 in.)
		Load at height 23 mm (0.91 in.)	Standard	22.1 N (2.25 kgf) [4.97 lbf]
5	Inching valve spring	Free length	Standard	81 mm (3.19 in.)
		Load at height 56.5 mm (2.22 in.)	Standard	32 N (3.26 kgf) [7.19 lbf]

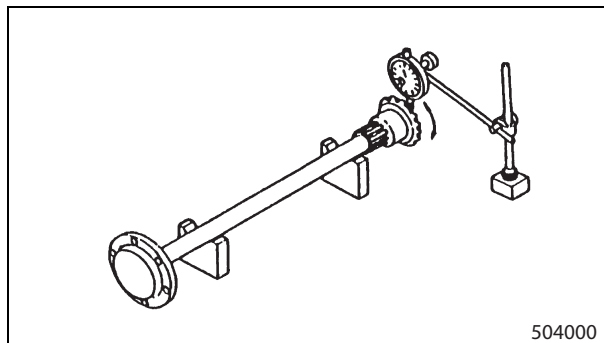


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### 4.3 Inspection after Disassembly

#### Axle shaft

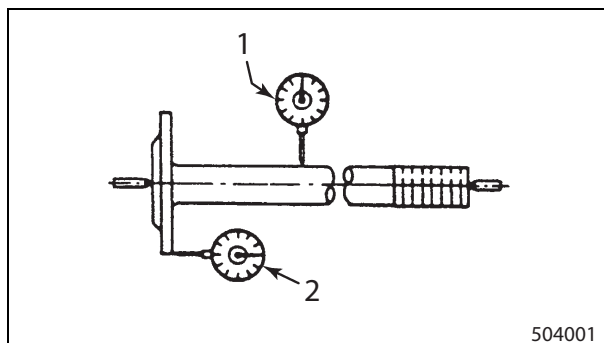
- (1) Looseness of mating splines  
Mount the differential bevel gear on the splined end of the shaft and set a dial indicator as shown. Rotate the bevel gear in the direction shown and read the free play (looseness of mating splines).



Free movement (looseness of mating splines)	
Standard value	0.07 to 0.15 mm (0.0028 to 0.0059 in.)
Repair or service limit	0.5 mm (0.020 in.)

#### Shaft deflection and flange runout

- (1) Set a dial indicator at the middle part of the axle shaft. Rotate the shaft and read the dial indicator (deflection of axial shaft).



1. Deflection of shaft                      2. Face runout of flange

Deflection of axle shaft (1/2 of dial indicator reading)	
Standard value	0.5 mm (0.020 in.) maximum
Repair or service limit	1.0 mm (0.039 in.)

- (2) Set a dial indicator against the flange of the axle shaft as shown. Rotate the shaft and read the face runout of flange.

Face runout of axle shaft flange	
Standard value	0.08 mm (0.0031 in.)
Repair or service limit	0.5 mm (0.020 in.)

#### Axle housing

- Check the surfaces of axle housing in contact with the mast bearing for damage.
- Check the entire axle housing for distortion, dents and other defects. Pay particular attention to the welds to see if any weld is cracked or requires repair.

#### Others

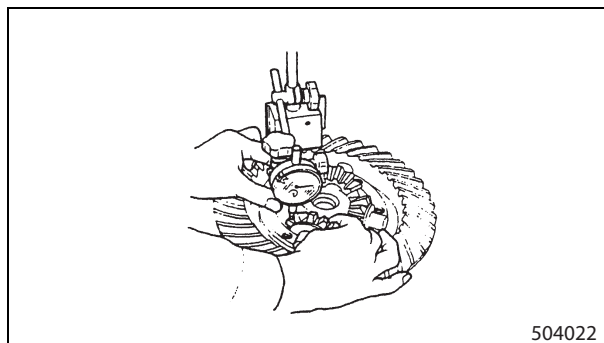
Check the oil seals and retainer for wear or damage.

### 7.3 Assembly

To assemble, follow the disassemble sequence in reverse.

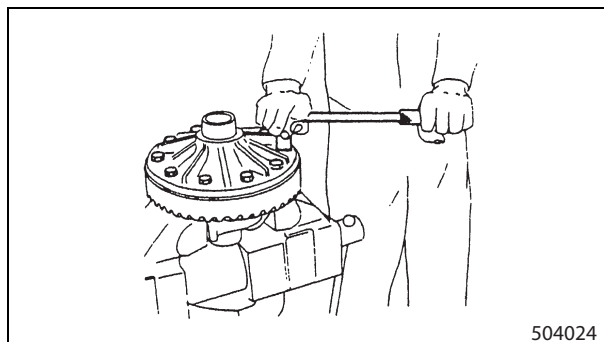
#### ⚠ CAUTION

- Arrange shims, washers and the like to install correctly.
  - Thoroughly clean the surfaces on which shims, washers, bearings, and bearing caps are to be installed.
  - Apply gear oil when installing bearings.
  - Pack recommended multi-purpose grease into cavity between lips when fitting oil seal.
- (1) Install pinion mate gears and, side gears together with their thrust washers onto differential case.
  - (2) Measure backlash between side gear and pinion mate gear using dial gauge.  
If out of specification, change side gear thrust washers so that specified backlash can be obtained.



Backlash	
Standard value	0.15 to 0.20 mm (0.0059 to 0.0079 in.)

- (3) Place the ring gear on the differential case.  
Tighten bolts in a diagonal sequence, lightly tapping bolt head with a hammer.



Tightening torque for ring gear bolt
196 to 226 N·m (20 to 23 kgf·m) [145 to 167 lbf·ft]

## 2. Removing Rear Wheels

- (1) Apply the parking brake, and block the front wheels
- (2) Loosen the wheel nut about two turns and raise the rear end of the truck by using a jack or crane at the specified point.

<b>Capacity of jack or crane</b>
5 ton or more

### Method using a jack

Position the jack at the jacking point and raise the rear tire.

### Method using a crane

Attach lifting sling to the drawbar pin in the counterweight, and lift it.

## **⚠ CAUTION**

When the truck is raised by either method, place wood blocks under the frame to support it securely.

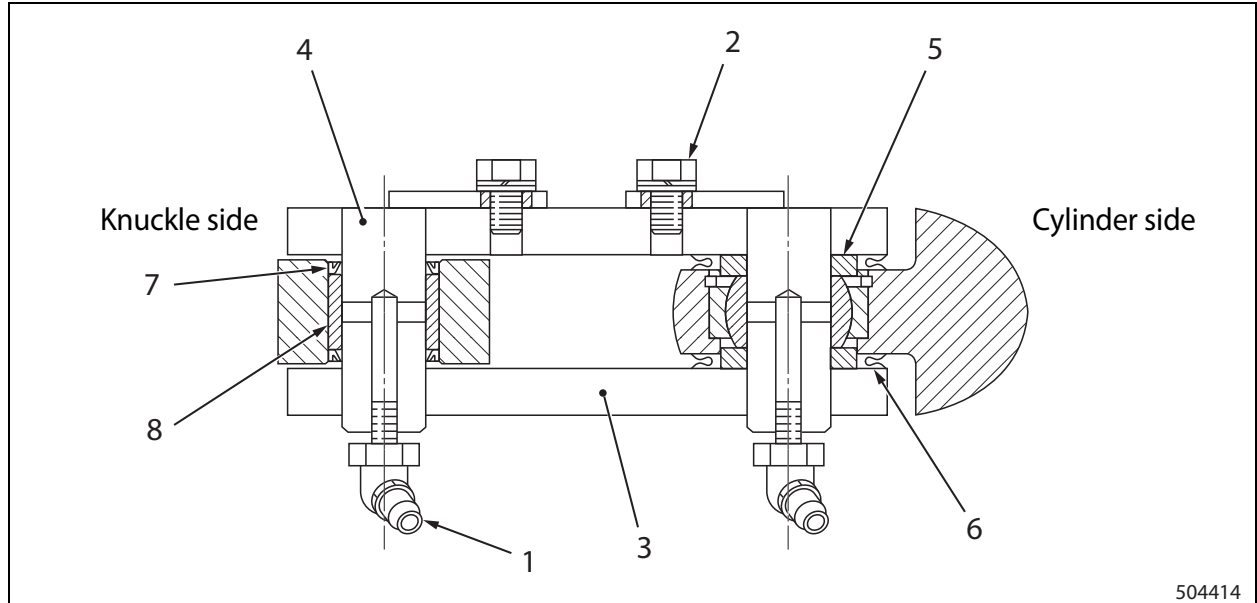
- (3) Remove the wheels.

## 3. Installing Rear Wheels

Follow the disassembly sequence in reverse.

## 15. Disassembling and Assembling Tie Rod

### 15.1 Disassembly Sequence



- |                             |              |
|-----------------------------|--------------|
| 1. Grease nipple            | 5. Retainer  |
| 2. Bolt and washer assembly | 6. Dust seal |
| 3. Spacer                   | 7. Dust seal |
| 4. Tie rod pin              | 8. Bushing   |

## 16. Assembling Tie Rod

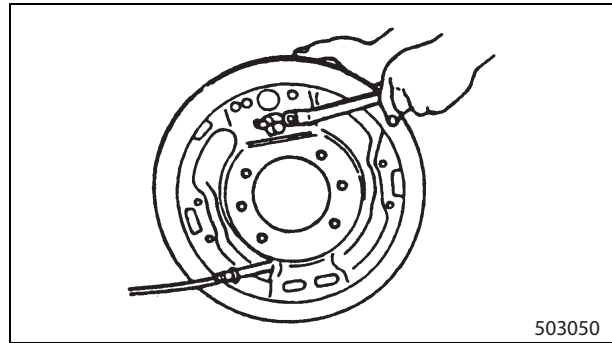
Follow the disassembly sequence in reverse, paying attention to the following points.

- (1) Replace a damaged or worn dust seal with a new one.
- (2) Apply sufficient amount of grease after assembly.  
Apply grease until it comes out of the dust seal.

## 8.2 Suggestions for Assembly

### Installing wheel cylinder

Apply liquid packing to the mounting face of the wheel cylinder before installing it. Tighten to the specified torque.



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Item	Specified value
Tightening torque	17.65 to 26.48 N·m (1.8 to 2.7 kgf·m) [13 to 19.5 lbf·ft]

### Applying grease

Apply a thin coat of the specified brake grease on the following areas:

- Shoe ledges (6 locations)

The ledges are those portions of the backing plate in contact with the shoe.

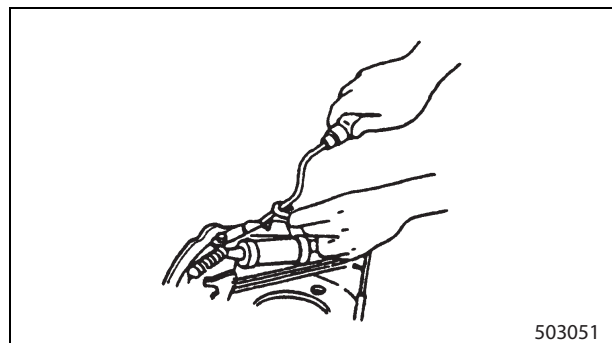
- Anchor pin surface in contact with the shoe ends

### Installing shoe and lining

Ensure that each connector link of the wheel cylinder has been correctly inserted into the shoe web.

### Installing return spring

Use a special tool to install the return springs to the backing plate pins.



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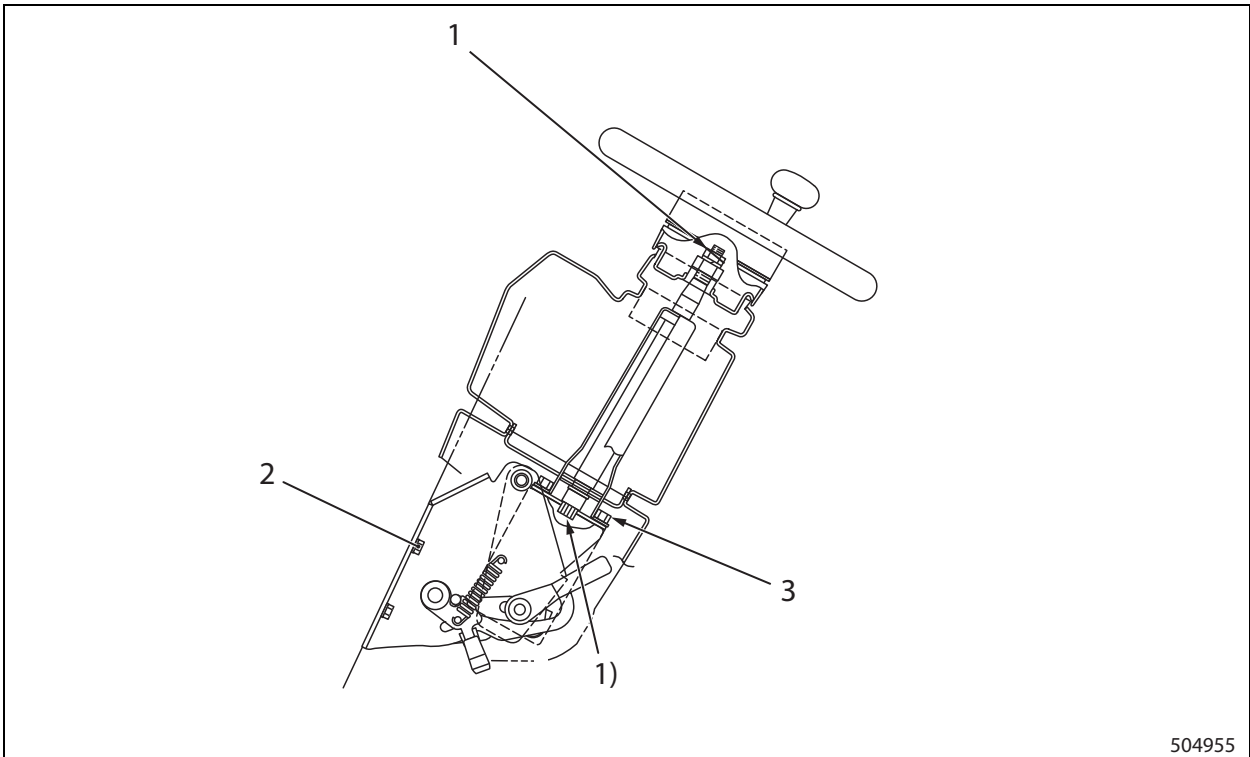
Special tool	Part number
Spring installer	64309 - 15413

## 13. Troubleshooting

### 13.1 Service Brake

Condition	Possible causes	Action
Lack of braking force	Oil leaking past primary cup in master cylinder	Replace piston cup(s) if cylinder is free from unacceptable wear. Replace the cup(s) and brake oil with genuine parts if the cup(s) is distorted
	Oil leaking past cups in wheel cylinder	
	Oil leaking from oil pipe connection	Retighten, or replace pipe and connector
	Shoe linings worn	Replace
	Shoe linings dirty with oil or grease	Clean or replace
Excessive pedal stroke	Air trapped in brake oil lines	Bleed air at master and wheel cylinders
	Piston cup defective in master cylinder	Replace
	Not enough brake oil in reserve tank	Refill
	Push rod to piston clearance too large in master cylinder	Readjust
	Brake oil leakage	Replace piston cup(s) if cylinder is free from unacceptable wear. Replace the cup(s) and brake oil with genuine parts if the cup(s) is distorted
	Automatic adjuster inoperative	Ensure that cable guide and adjusting spring are correctly installed. If still inoperative, replace cable with spring, lever, and adjusting screw
Uneven braking (wheel brake is more effective on one side than on the other)	Lining or drum dirty with oil or grease in less effective brake	Clean with gasoline. If lining still dirty, replace.
	Wobbly or loose-mounted drum in less effective brake	Replace drum. If loose, readjust and retighten.
	Wheel tires inflated unequally	Reinflate to specification
Brake squeals	Lining glazed	Sand
	Worn linings	Replace shoe and lining assemblies
	Backing plate securing bolts loose	Retighten
	Wheel bearings loose	Readjust preload and retighten
	Brake drum dirty	Clean with cleaning solvent
Brake chatters or clatters	Anchored ends of shoes rattling on anchor	Repair or replace
	Shoe ledges badly worn	Replace backing plate
	Pistons badly worn in wheel cylinder	Replace wheel cylinder

### 3.3 Installing Steering Wheel and Steering Valve



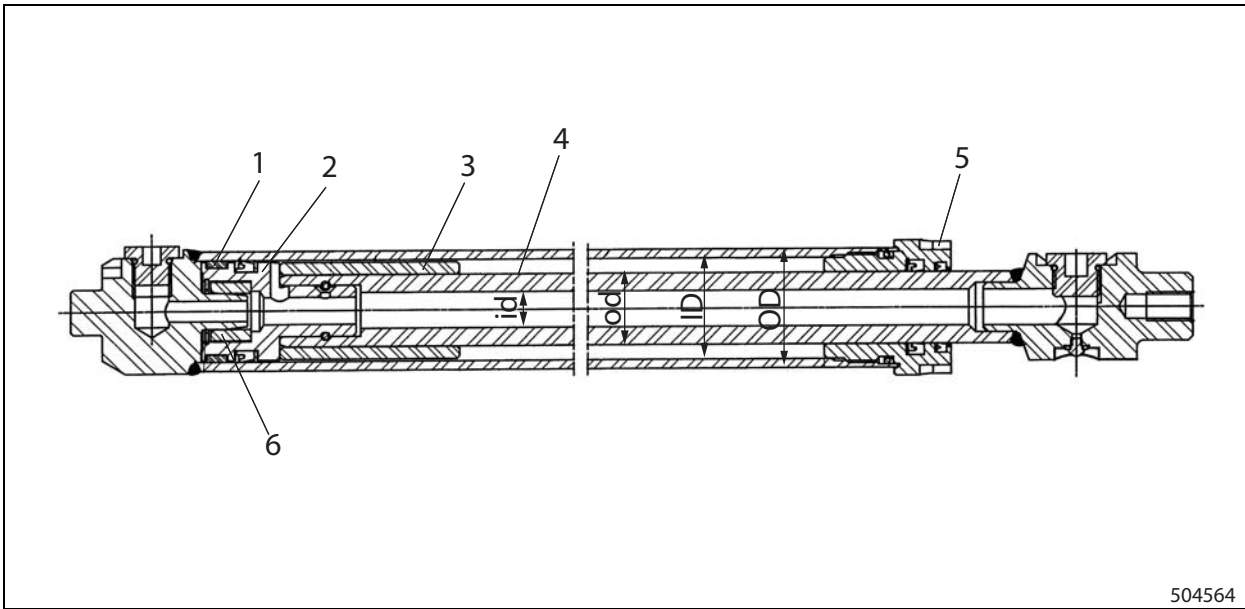
1) Apply grease.

Ref.	Item	Tightening torque
1	Steering wheel nut	$58.5 \pm 5.9 \text{ N}\cdot\text{m}$ ( $6.0 \pm 0.6 \text{ kgf}\cdot\text{m}$ ) [ $43.1 \pm 4.35 \text{ lbf}\cdot\text{ft}$ ]
2	Steering valve mounting bolt	$39 \pm 5 \text{ N}\cdot\text{m}$ ( $4.0 \pm 0.5 \text{ kgf}\cdot\text{m}$ ) [ $29 \pm 3.7 \text{ lbf}\cdot\text{ft}$ ]
3	Steering column assembly	27 to 35 N·m (2.8 to 3.6 kgf·m) [19.9 to 25.8 lbf·ft]

## 12. Troubleshooting

Condition	Possible Causes		Action
Stiff steering wheel operation	Defect in flow priority valve	No steering flow - Foreign materials clogged in spool pit - Fatigued or damaged spring in the spool	Disassemble and clean Replace spring
		Malfunction of relief valve - Low relief pressure - Damaged valve seating surface - Fatigued or damaged spring	Adjust relief pressure Replace valve assembly Replace springs and adjust relief pressure
		Oil leak from relief valve	
		- Damaged O-rings on the valve body circumference	Replace O-rings
	Defect in steering valve	Clogging in gerotor	Disassemble and clean
		Malfunction by spool seizure due to foreign material	Replace
		Damaged bearing	Replace
		Excessive tightening of end cap mounting bolt	Assemble
	Defect in steering cylinder	Bent piston rod	Repair or replace
		Faulty piston seal	Replace
	Misalignment	Faulty installation of steering valve to tilt column	Readjust
	Other defects	Flattened pipe	Replace
Unstable steering operation	Defect in steering valve	Seizure of spool or sleeve	Replace
		Breakage of centering spring	Replace
	Other defects	Trapped air	Bleed
		Flattened pipe	Replace
		Faulty piston seal of steering cylinder	Replace

1.9 Structure of Lift Cylinder (Second Lift Cylinder for Duplex Mast)



- |                  |               |
|------------------|---------------|
| 1. Cylinder tube | 4. Piston rod |
| 2. Piston        | 5. Retainer   |
| 3. Spacer        | 6. Sleeve     |

**Cylinder dimensions**

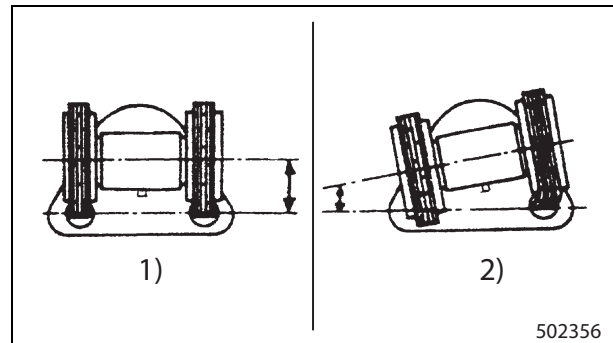
Truck model	Rod inside diameter (id)	Rod outside diameter (od)	Cylinder inside diameter (ID)	Cylinder outside diameter (OD)
2 ton class	16 mm (0.63 in.)	35 mm (1.38 in.)	45 mm (1.77 in.)	53 mm (2.09 in.)
3 ton class	20 mm (0.79 in.)	40 mm (1.57 in.)	50 mm (1.97 in.)	58 mm (2.28 in.)
3.3 ton class	24 mm (0.94 in.)	42 mm (1.65 in.)	55 mm (2.17 in.)	65 mm (2.56 in.)

## 11. Installing Lift Cylinder (Duplex and Triplex Mast)

To install, follow the removal sequence in reverse.

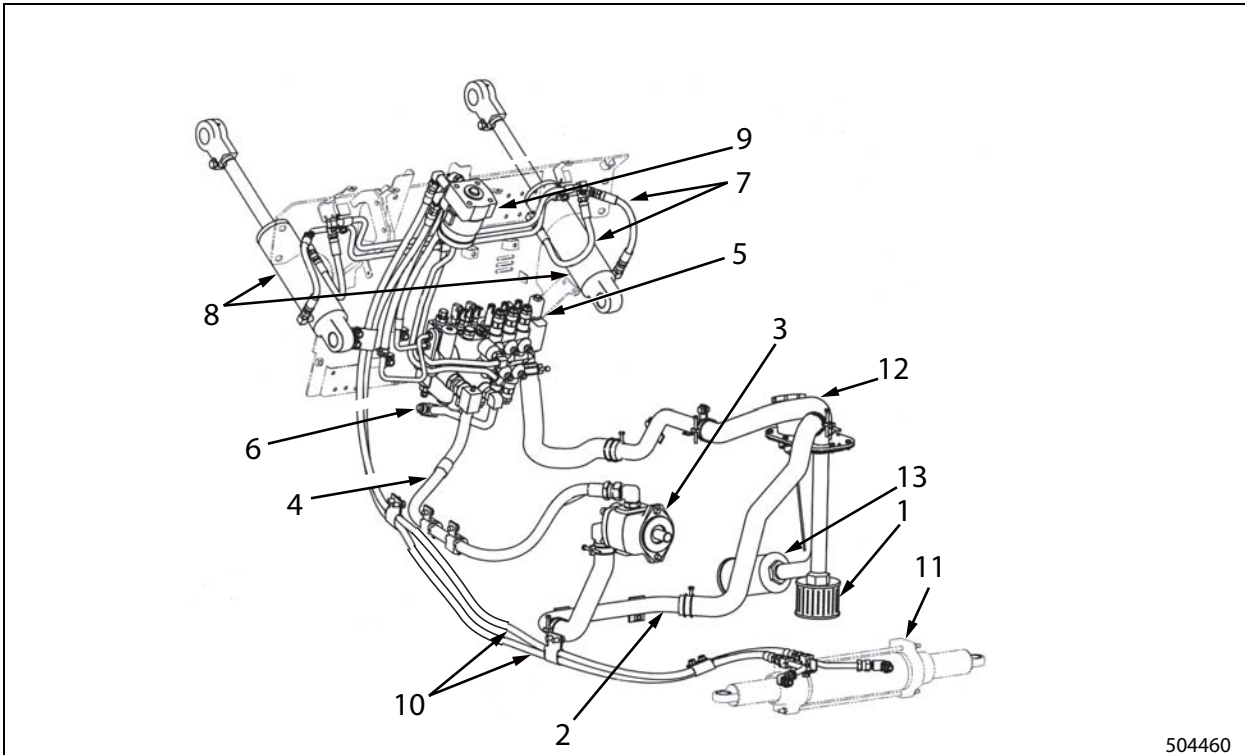
### 11.1 Suggestions for Installation

- (1) Install chain wheel support assembly 4 parallel to a line connecting the centers of chain anchor bolt holes on first lift cylinder 3 to prevent chains from twisting.
- (2) Adjust the chain tensions. Refer to "MAST AND FORKS".
- (3) Extend and retract the lift cylinders several times under no load condition to bleed air out of the cylinder circuits and to make sure that the cylinders move smoothly.
- (4) After proper operation is confirmed, check the oil level.



## 25. Piping

(For piping around the mast, refer to CHAPTER "MAST AND FORKS".)

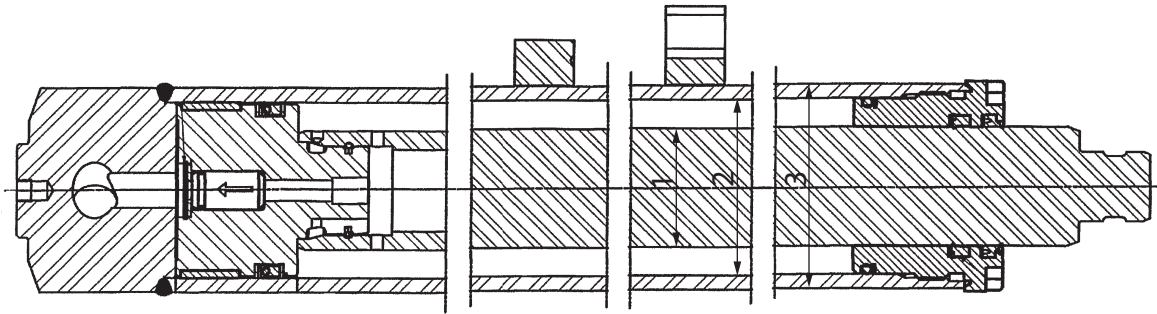


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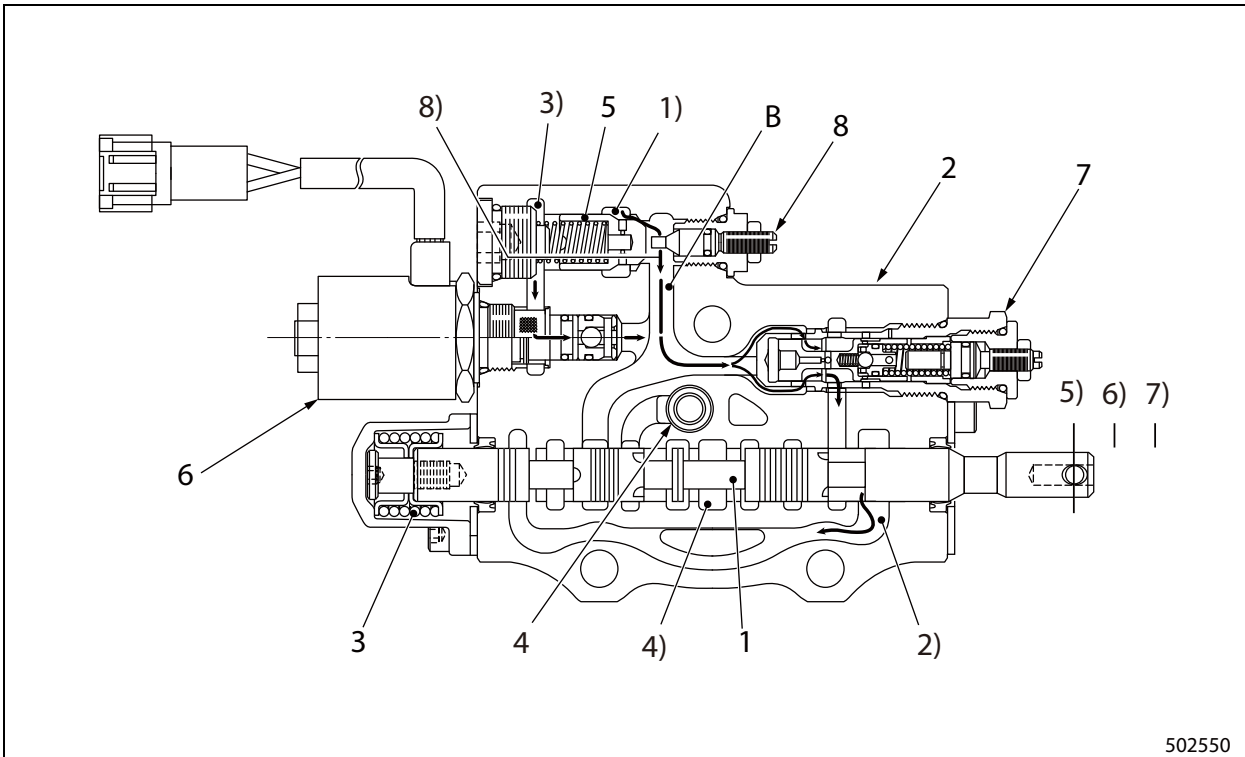
- |   |                                |
|---|--------------------------------|
| 1. Suction strainer   | 8. Tilt cylinder               |
| 2. Pump suction line (low pressure)                           | 9. Steering valve              |
| 3. Hydraulic pump<br>(located on the left side of truck body) | 10. Steering hydraulic line    |
| 4. Pump discharge oil line (high pressure)                    | 11. Steering cylinder          |
| 5. Control valve  | 12. Return line (low pressure) |
| 6. Lift line (high pressure)                                  | 13. Return filter              |
| 7. Tilt line  |                                |

31.1 First Cylinder for Duplex Mast and Triplex Mast

Ref.	Item		Specified value		
			2 ton class	3 ton class	3.3 ton class
1	Rod outside diameter	Standard	50.8 mm (2.00in.)	55 mm (2.17 in.)	55 mm (2.17 in.)
2	Cylinder inside diameter	Standard	75 mm (2.95 in.)	85 mm (3.35 in.)	90 mm (3.54 in.)
3	Cylinder outside diameter	Standard	87 mm (3.43 in.)	97 mm (3.82 in.)	102 mm (4.02 in.)



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- |                         |   |
|-------------------------|---|
| 1. Lift spool           | 1) A1: Lift cylinder port                   |
| 2. Valve body           | 2) T2: Tank port                            |
| 3. Return spring        | 3) Oil passage for opening load check valve |
| 4. Check valve          | 4) Center bypass port                       |
| 5. Load check valve     | 5) Descent                                  |
| 6. Solenoid valve       | 6) NEUTRAL                                  |
| 7. Flow regulator valve | 7) Ascent                                   |
| 8. Shut-off valve       | 8) Pilot oil                                |

**Descending position of lift cylinder**

The above illustration shows the lift control valve when spool 1 is at “descending position”.

Spool 1, pushed in body 2, is at the position as shown in the illustration. The center bypass port is not blocked. The secondary port of flow regulator valve 7 is open to the T2 port (return passage).

When spool 1 is pushed in the body, roller 9 of the lift lowering limit switch is pushed in, turning the switch ON. The truck body controller (VCM-1) detects this and feeds current to solenoid valve 6 to activate. When the solenoid activates, pilot oil behind load check valve 5 is released to the passage B. Thus, load check valve 5 moves to the left (in the illustration) by pressure of the A1 port and oil in the A1 port flows to the T2 port via flow regulator valve 7.

Shut-off valve 8 forcibly opens load check valve 5 if the load check valve does not automatically activate due to malfunction of solenoid 6 or any other reason. Just loosen the locknut and push in the screw.

## 40. Assembling MC Control Valve

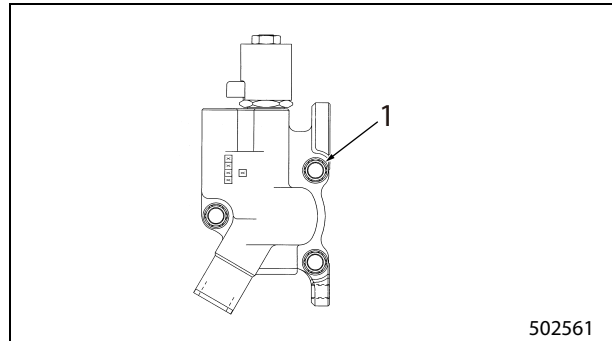
To assemble, follow the reverse of disassembly sequence.

### 40.1 Suggestions for Assembly

- (1) Clean disassembled parts with an appropriate solvent. Remove foreign matters with compressed air.
- (2) Apply hydraulic oil on all parts.
- (3) Replace O-rings.
- (4) Tighten tie bolts. Tighten tie bolts evenly. Tightening them unevenly or to inadequate torque can distort the valve body, resulting in unsmooth movement of the spool.
- (5) Install component valves after appropriate valve bodies are installed with tie bolts.
- (6) Check that the spools slide smoothly.

Note: The valve body and spool have been lapped as a set. Do not change the combination. When either one of the two becomes necessary to replace, replace them together as an assembly.

- (7) Check that the micro-switch is in position. Adjust its position if necessary.

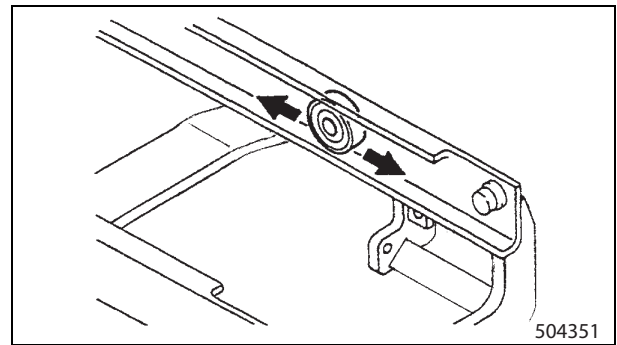


1. Tie bolt

### 1.8 Inspecting Mast and Lift Bracket (All Mast Models)

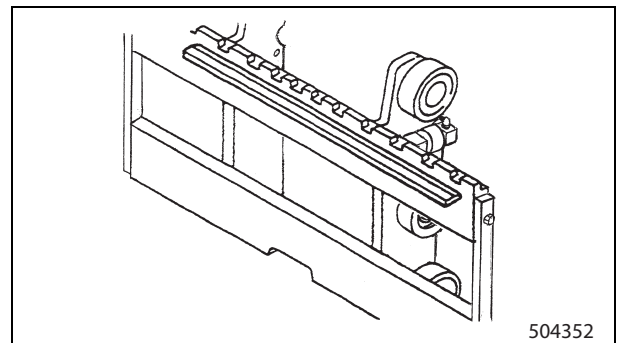
**Mast**

- (1) Check each roller for wear, binding, or other defects.
- (2) Check each roller on rolling surface for pitting or other defects.
- (3) Check the mast member and the welded joints of crossmembers, shafts, and supports for cracks.
- (4) Check the mast support bushings for wear or other defects.



**Lift bracket**

- (1) Check the main rollers and side rollers for smooth rotation. Inspect each roller for wear and cracks.
- (2) Check the welded portions of the bracket for cracks.
- (3) Check the finger bar for bend or distortion.



Item	Standard
Distortion of finger bar	5 mm (0.2 in.) or less

**Lift chains, chain wheels, and chain wheel supports**

- (1) Measure the length of each chain to make sure that two chains are equal in length. Also check the chains for wear, indication of breakage, link binding, and twist.
- (2) Check each chain anchor bolt for cracks or defects on thread.
- (3) Check each chain wheel support and chain wheel for cracks or wear. Check that the wheels rotate smoothly.

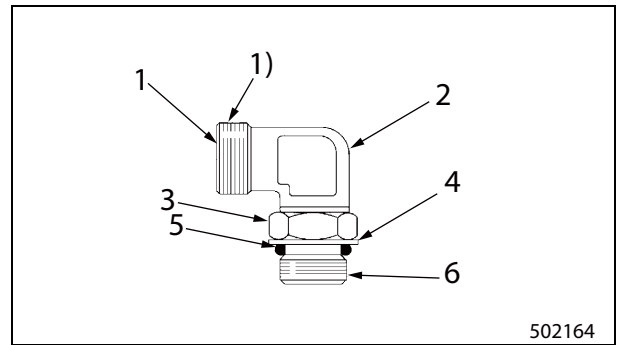
Item		2 ton class	3 ton class
Chain length (20 links)	Standard	381 mm (15 in.)	508 mm (20 in.)
	Limit	392 mm (15.4 in.)	523 mm (20.6 in.)

**Mast strips**

Check the mast strips for damage, wear or distortion.

**Installation of a fitting with straight threads and O-ring seal**

- (1) Apply grease or hydraulic oil on O-ring and O-ring seat in the housing side.
- (2) Turn locknut 3 to move it as close to fitting body 2 as possible. Place washer 4 and O-ring seal 5 against the locknut.
- (3) Tighten the fitting by hand. Once O-ring 5 is placed in the position of housing and washer 4 comes in contact with the surface of housing, turn it back to adjust the mounting direction. Never loosen more than 1 turn.
- (4) Tighten locknut 3 to the specified torque.

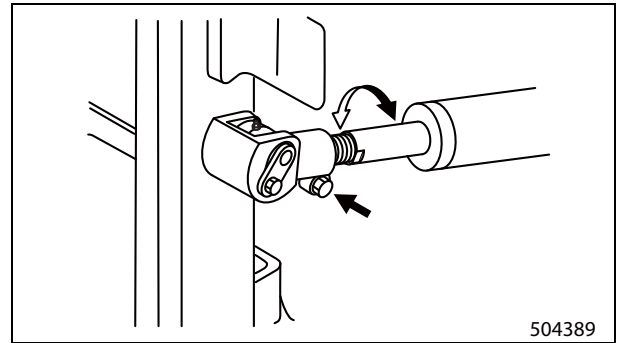


- |   |                                       |
|---|---------------------------------------|
| 1. End of fitting body<br>(for hose connection) | 5. O-ring seal                        |
| 2. Fitting body                                 | 6. Threaded portion to the<br>housing |
| 3. Locknut                                      | 1) Shape varies by fitting type       |
| 4. Back-up washer                               |                                       |

**1.24 Adjusting Mast Tilt Angle (All Mast Models)**

- (1) Adjust the tire pressure correctly and park the truck on level ground.
- (2) Tilt the mast fully BACKWARD and turn the engine OFF.
- (3) Measure the backward tilt angle of the mast at both sides.
- (4) To adjust the tilt angle, loosen the bolt of tilt cylinder socket, and adjust the rod length by turning the rod. Adjust cylinder so that there is no difference in stroke tilt angle between the cylinders, right and left.

Note: It is not necessary to adjust the forward tilt angle if the backward tilt angle is properly adjusted.



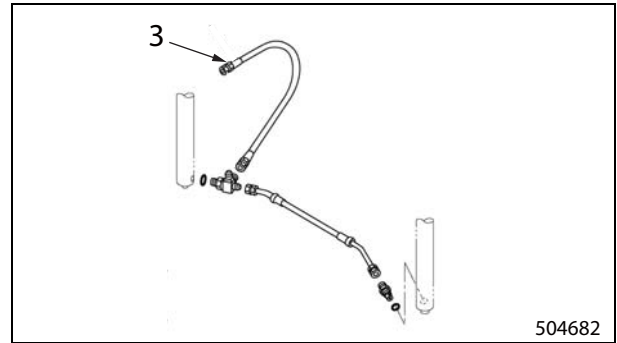
Item	Forward tilt angle	Backward tilt angle	
		2 ton class	3 ton class
Simplex Mast	5°	9°	6°

- (5) After adjusting the tilt angle, tighten the socket bolts to the specified torque.

Item	Tightening torque
Tilt cylinder socket bolt	157 to 182 N·m (16.0 to 18.6 kgf·m) [115.80 to 134.24 lbf·ft]

**Disconnecting high-pressure hoses for lift cylinder**

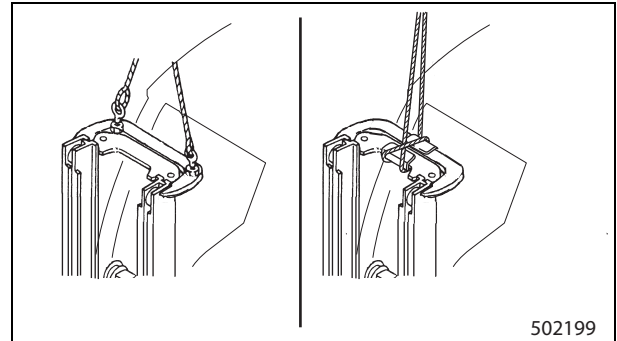
Place the mast in the bottom position, disconnect the hose 3 at the arrow position in the illustration on the previous page.



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**Separating tilt cylinders**

- (1) Attach a sling on the upper crossmember of the outer mast, then lift with a hoist.

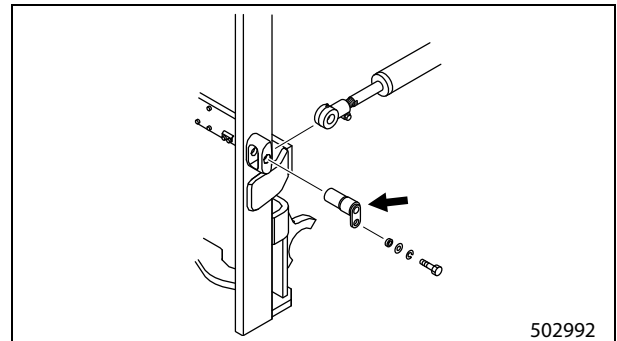


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**CAUTION**

Be sure to use a hoist with enough capacity to support the mast assembly.

- (2) Place wood blocks under the tilt cylinder mounting section and remove the tilt socket pins, and separate the mast from the tilt cylinders.
- (3) Start the engine, and pull back the tilt lever to retract.



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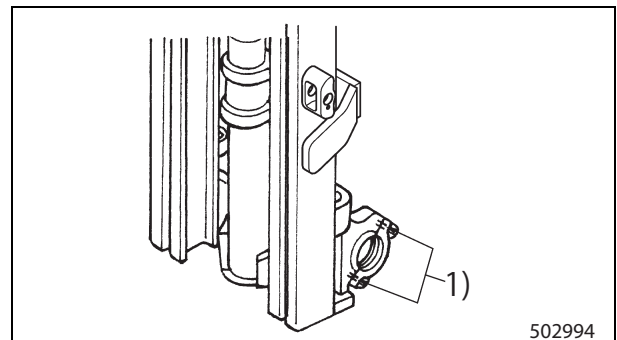
**CAUTION**

- Do not touch any levers except the tilt lever while the engine is running.
- Never loosen tilt socket bolts except for tilt cylinder disassembly.

**Removing mast support bearing caps**

- (1) Mark caps to ensure the caps are installed in original positions during assembly.
- (2) Remove cap mounting bolts. Dismount the mast assembly from truck in the suspended condition. With the lift bracket side facing up, place the mast assembly horizontally on wood blocks on the level ground.

Note: Lay the mast assembly on a space large enough to disassemble the parts.

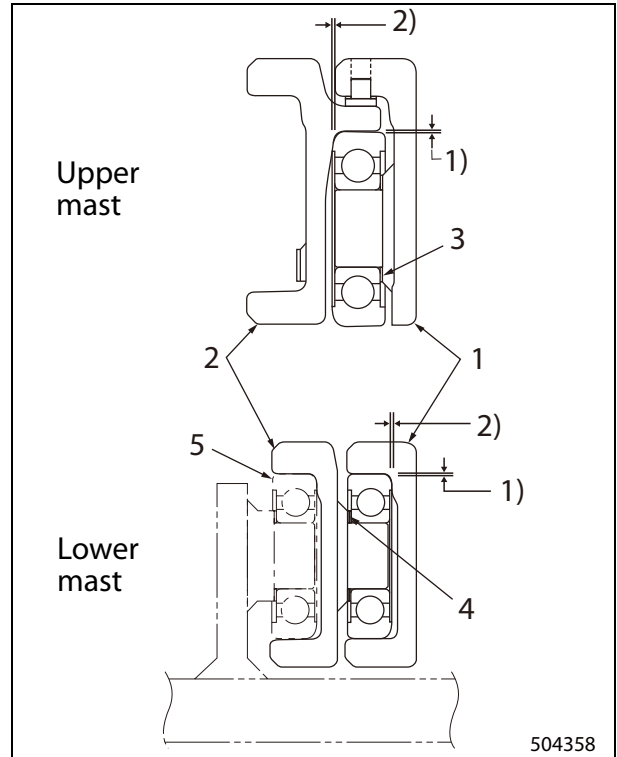


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1) Matchmark

**2.13 Installing Mast Rollers (All Mast Models)**

Mast rollers are identical in shape and size with lift bracket lower rollers.



- 1. Outer mast
  - 2. Inner mast
  - 3. Shim (e)
  - 4. Shim (f)
  - 5. Lift bracket lower roller
- 1) Clearance between main roller rolling face and mast
  - 2) Clearance between main roller side face and mast thrust face

Ref.	Item	Standard
1)	Clearance between main roller rolling face and mast	1 mm (0.04 in.) or less
2)	Clearance between main roller side face and mast thrust face	0.1 to 0.5 mm (0.004 to 0.020 in.)

**Measuring clearance 1) between main roller rolling face and mast**

Measure clearance 1) between the rollers' rolling contact surfaces and masts. If the measured clearances do not conform to the standard value, replace with rollers of correct diameters listed in the table below.

Note: For measuring procedures, refer to 12-58 "Inspection and Adjustment".

Item	Specified value
Roller size (outside diameter)	S 113.8 mm (4.48 in.)
	M 115 mm (4.53 in.)
	L 116 mm (4.57 in.)
	LL 117 mm (4.61 in.)

Installation of mast rollers follows the same procedures for the lift-bracket rollers.

2.22 Inspecting and Adjusting Chain Tension (All Mast Models)

**⚠ CAUTION**

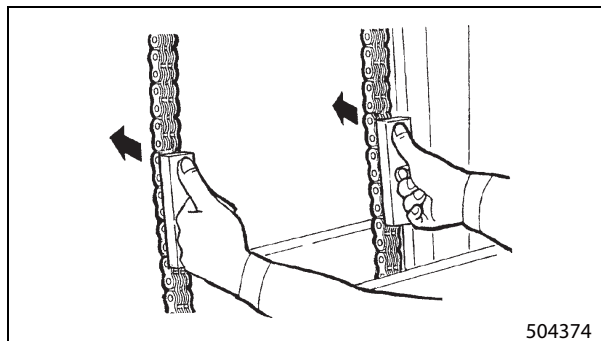
Turn the engine/main key to the OFF position before making the inspection or adjustment of lift chains, anchor bolts and nuts. Place blocks below the forks when they are lifted.

**Inspecting chain tension**

- (1) Place the mast vertically on level ground, then lower the forks to the ground. Make sure that the lift cylinders are fully retracted.
- (2) Raise the forks Pyrex. 100 mm (4.0 in.) from the ground.

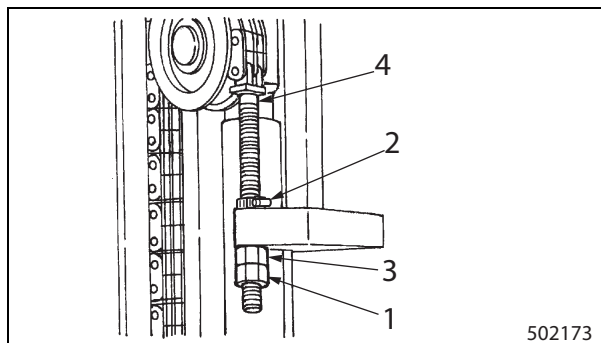
Note: While having the mast at vertical (90 degrees) the measurement from the bottom of the carriage to the ground should be 75 to 80 mm [3.95 to 3.15 in.].

- (3) Turn the key to the OFF position.
- (4) Place blocks Pyrex. 90 mm (3.5 in.) high below the forks.
- (5) Push the chains at the middle point between the chain wheel and chains fixed end on the lift bracket. Check the right and left chains for even tightness.



**Adjusting right and left chain balance**

- (1) Remove the blocks below the forks. Start the engine.
- (2) Lower the forks to the ground and tilt FORWARD until the tips come in contact with the ground. The chains are now slack to facilitate the adjustment.
- (3) Turn the engine OFF.
- (4) Loosen double nut (lower) 1, then clip 2.
- (5) Turn double nut (upper) 3 to adjust the chain tension.
- (6) Start the engine, and place the mast vertically again.
- (7) Repeat Steps (2) through (5) of procedure 1, to check the chain tension and adjust it as needed.



- 1. Double nut (lower)
- 2. Clip
- 3. Double nut (upper)
- 4. Anchor bolt

2.30 Service Data

Item				Specified value	
				2 ton class	3 ton class
Chain length (20 links)		Standard	381 mm (15.0 in.)	508 mm (20.0 in.)	
		Limit	392 mm (15.43 in.)	523 mm (20.59 in.)	
Main roller outside diameter		S	Standard	113.8 mm (4.48 in.)	113.8 mm (4.48 in.)
		M	Standard	115 mm (4.53 in.)	115 mm (4.53 in.)
		L	Standard	116 mm (4.57 in.)	116 mm (4.57 in.)
		LL	Standard	117 mm (4.60 in.)	117 mm (4.60 in.)
Side roller external diameter		Standard	42 mm (1.65 in.)	42 mm (1.65 in.)	
Duplex mast size (reference)	1	Width of outer mast	Standard	670 mm (26.38 in.)	670 mm (26.38 in.)
	2	Width of inner mast	Standard	568 mm (22.36 in.)	568 mm (22.36 in.)
	3	Width of lift bracket	Standard	458 mm (18.03 in.)	458 mm (18.03 in.)
Mast	4	Clearance between main roller rolling face and mast	Standard	1.0 mm (0.04 in.) or less	
	5	Clearance between main roller side face and mast thrust face	Standard	0.1 to 0.5 mm (0.004 to 0.020 in.)	
	6	Clearance between mast and mast strip	Standard	0.1 to 0.5 mm (0.004 to 0.020 in.)	
Lift bracket	4	Clearance between main roller rolling face and inner mast	Standard	1.0 mm (0.04 in.) or less	
	5	Clearance between middle roller side face and inner mast thrust face	Standard	0.1 to 0.5 mm (0.004 to 0.020 in.)	
	5	Clearance between lower roller side face and inner mast thrust face	Standard	0.1 to 0.5 mm (0.004 to 0.020 in.)	
	7	Clearance between side roller rolling face and inner mast	Standard	0.1 to 0.5 mm (0.004 to 0.020 in.)	
Distortion of finger bar		Standard	5 mm (0.2 in.) or less		

### 3.7 Preparation for Disassembling Mast and Lift Bracket

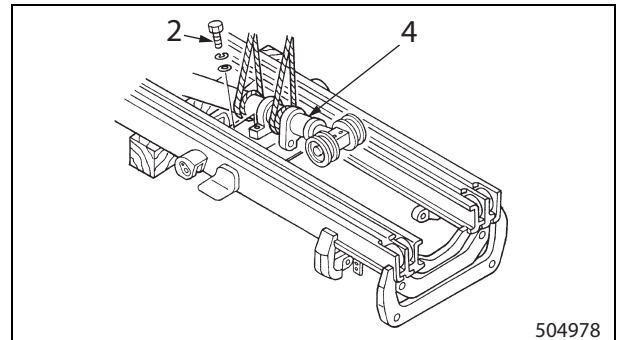
With the lift bracket facing up, place the mast horizontally on wood blocks. Place a wood block as a wedge to prevent the inner and middle masts from sliding.

Before disassembling the mast and fork assembly, measure and record all clearances between each lift bracket and roller and between each mast and roller. Recorded measurements will be helpful when replacing rollers or selecting shims to adjust clearances.

### 3.8 Suggestions for Disassembling Mast and Lift Bracket

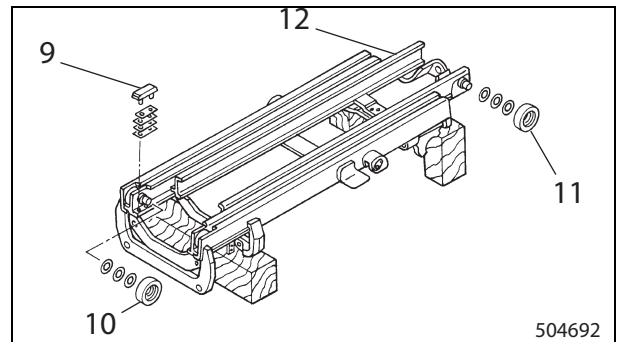
#### Removing first lift cylinders 4

- (1) Remove retaining bolts 2 from the first lift cylinder.
- (2) Attach slings on the cylinder, and gently remove the cylinder. Use two slings. Wind or tie slings securely to prevent slipping.



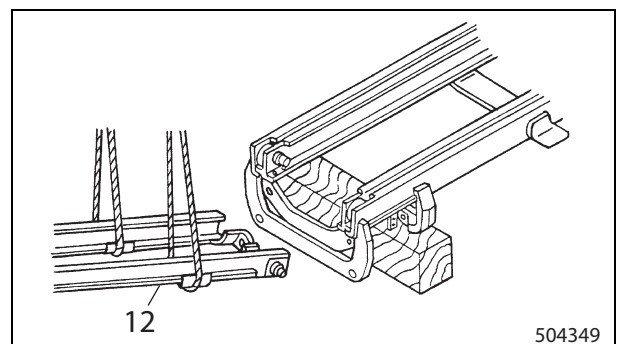
#### Removing inner mast 12 and main rollers 10 and 11

Lower inner mast 12 until the main rollers 10 and 11 can be removed. Remove the rollers and mast strips 9.



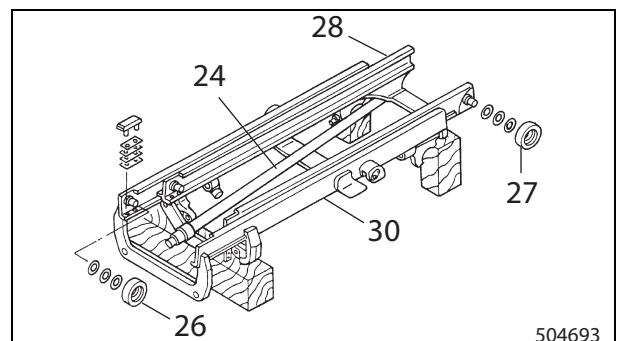
#### Removing inner mast 12

Using slings, lift and remove the inner mast 12, steering it clear of the roller shaft sections of the middle mast.



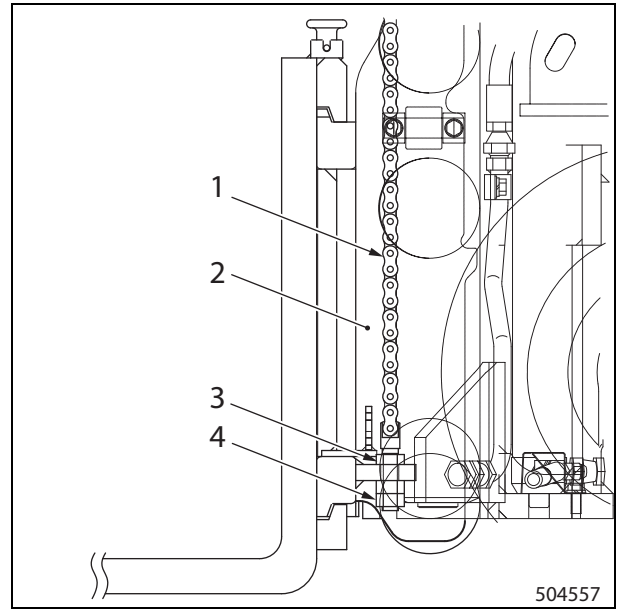
#### Removing main rollers 26 and 27 from middle mast 28 and outer mast 30

Remove the bolts that are holding second lift cylinders 24. Place the cylinder rod ends on the outer mast. Lower middle mast 28 until main rollers 26 and 27 can be removed. Then, remove the main rollers.

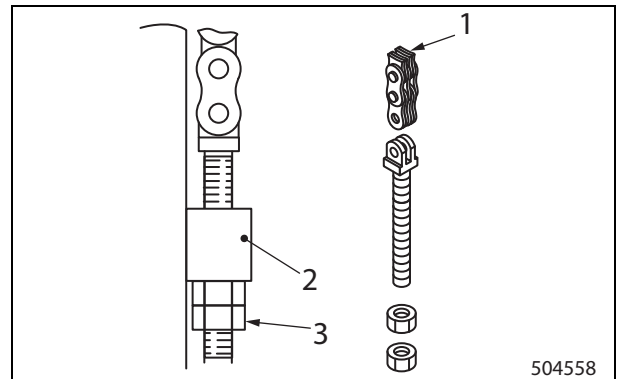


### 3.16 Connecting Chains

Assemble chains to the lift bracket as shown in the figure. After assembly is completed, maintain clearance 1) between chains with locknuts to allow for chain tension.



1. Chain  
2. Lift bracket  
3. Locknut (double nut side)



1. Chain  
2. Inner mast  
3. Locknut (double nut side)

Item	Tightening torque	
	2 ton class	3 ton class
3 Locknut (single nut side)	56.8 <sup>0</sup> <sub>-9.8</sub> N·m (5.8 <sup>0</sup> <sub>-1.0</sub> kgf·m) [41.894 <sup>0</sup> <sub>-7.23</sub> lbf·ft]	84.3 <sup>0</sup> <sub>-11.8</sub> N·m (8.6 <sup>0</sup> <sub>-1.2</sub> kgf·m) [62.175 <sup>0</sup> <sub>-8.70</sub> lbf·ft]
4 Locknut (double nut side)	98 <sup>+49</sup> <sub>0</sub> N·m (10 <sup>+0.5</sup> <sub>0</sub> kgf·m) [72.280 <sup>+36.14</sup> <sub>0</sub> lbf·ft]	147 <sup>+49</sup> <sub>0</sub> N·m (15 <sup>+0.5</sup> <sub>0</sub> kgf·m) [108.420 <sup>+36.14</sup> <sub>0</sub> lbf·ft]

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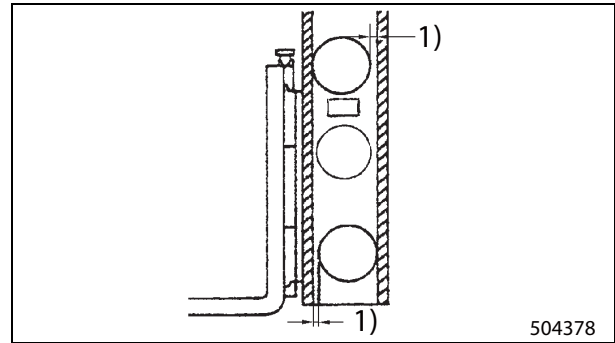
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3.23 Adjusting Clearance Between Lift Bracket Roller and Inner Mast (All Mast Models)

**Measuring back-to-front clearance on lift bracket main rollers**

- (1) Raise the forks a little from the ground.
- (2) Insert a bar between the upper part of lift bracket and the inner mast, and push the inner mast to one side. Using feeler gauges, measure the clearance 1) between the main roller and inner mast on the opposite side.
- (3) If clearance 1) is out of specification, use oversize rollers. Remove lift bracket from mast and replace rollers with proper sized rollers. For roller replacement procedure, refer to 12-83 "Selecting roller of correct outer diameter".

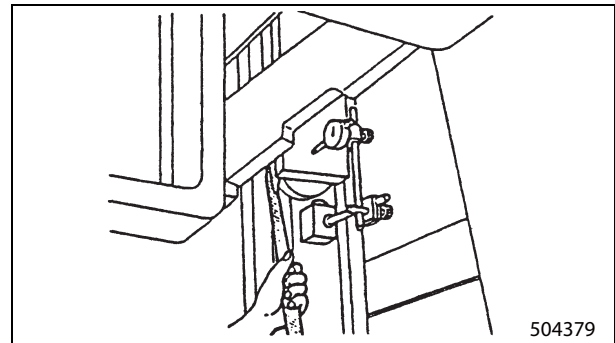


1) Clearance between main roller rolling face and inner mast

Ref.	Item	Standard
1)	Clearance between main roller rolling face and inner mast	1.0 mm (0.039 in.) or less

**Measuring right-to-left clearance on lift bracket main rollers and side rollers**

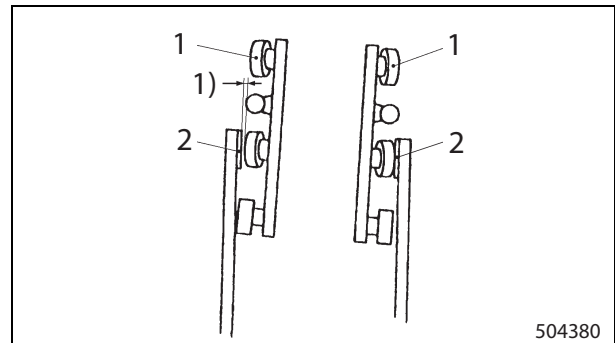
- (1) Raise the mast to the top.
- (2) Set a dial indicator on the inner mast with its contact point rested on the side of the lift bracket.
- (3) Go over to the opposite side of the mast, and push the lift bracket to one side with a bar. Set the indicator to zero.
- (4) Insert a bar between the inner mast and lift bracket on the indicator side, and push the lift bracket to the opposite side.



- (5) Read the indicator. This reading is the clearance 1) between middle roller and thrust plate. If clearance 1) is out of specification, it is necessary to add shims to the seat of the roller to adjust to correct clearance.

Note: Upper rollers are free from checking and adjusting.

For adjustment, refer to 12-84 "Adjusting clearance 2) between middle roller side face and thrust plate".



1. Upper roller  
2. Thrust plate

1) Clearance between middle roller side face and inner mast thrust plate

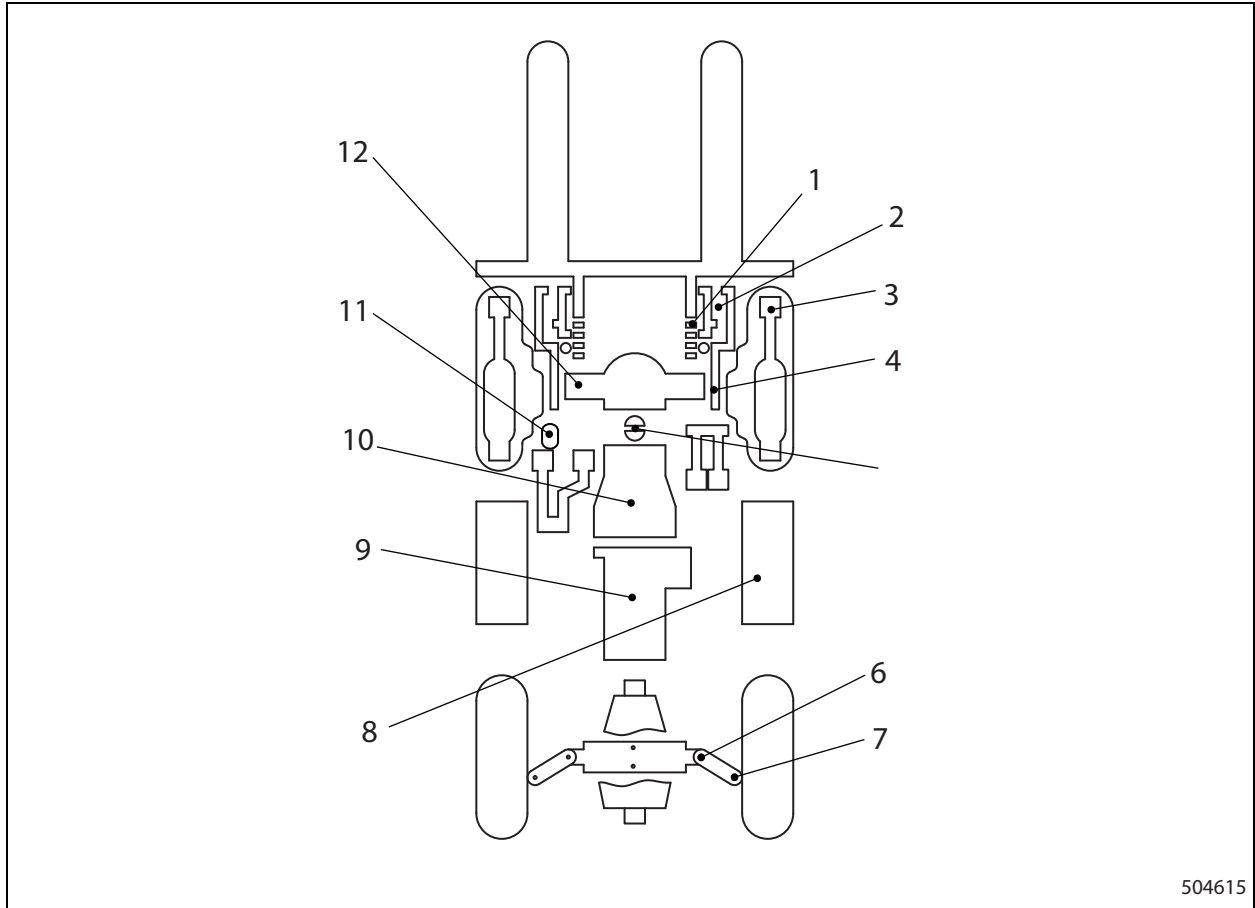
Ref.	Item	Standard
1)	Clearance between middle roller side face and inner mast thrust plate	0.1 to 0.5 mm (0.004 to 0.020 in.)

**CHAPTER 13 SERVICE DATA**

System	Check items		Pre-start (daily/10 hrs)	Every 50 hrs or weekly	1st month (200 hrs)	Every 500 hrs or 3 months	Every 1000 hrs or 6 months	Every 2000 hrs or 12 months	Others (see note 1)	Service data
Cooling	Radiator fin (see Note 2)	Visual			C	C				
	Cooling fan	Visual/feel	X							
	Engine coolant level	Visual	X							
	Radiator filler cap	Visual/feel			X			X		
	Rubber hose condition	Visual/feel			X			X		
	V-belt (fan & alternator) tension (deflection)	Scale		X						11 to 13 mm (0.43 to 0.51 in.)
	Engine coolant (incl.reserve tank)							R		7.4 L (1.96 gal.)
Electrical	Alternator	Operation/visual			X		X			
	Backup lights	Visual	X							
	Battery electrolyte level	Visual	X							
	Battery electrolyte specific gravity	Hydrometer			X	X				
	Driving interlock system	Operation/visual	X							
	Electrical wires	Visual/feel			X	X				
	Horn	Operation/visual	X							
	Meter panel lights (incl. parking brake and seat belt)	Operation/visual	X							
	Mast interlock system	Operation/visual	X							
	Parking brake buzzer	Operation/aural	X							
	Starter	Operation/aural			X		X			
	Stop lights	Operation/visual	X							
	Working & head lights	Operation/visual	X							
Engine	Cylinder head bolt & manifold nut	Wrench			X					
	Engine (exhaust, noise, vibration)	Visual/feel	X							
	Engine oil level	Dip stick	X							
	Intake & exhaust valve clearance	Feeler gauge			X	X		X		0.38 mm (0.015 in.)(hot)
	Positive crankcase ventilation valves & hoses	Air blow/visual				X				
	Engine oil				R	R				
	Engine oil filter				R	R				

## 4. Lubrication Instructions

### 4.1 Lubrication Chart



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Ref.	Lubricating places and oil changes	Lubrication/greasing	Replace interval
1	Lift chains (each side)	Engine oil	
2	Mast strips, roller surface (each side)	Multi-purpose type grease	Every 200 hrs or monthly
3	Tilt socket (each side)	Multi-purpose type grease	Every 500 hrs or 3 months
4	Mast supports (each side)	Multi-purpose type grease	
5	Universal joint (2 places)	Multi-purpose type grease	
6	Tie rod pins (4 places)	Multi-purpose type grease	
7	King pins (4 places)	Multi-purpose type grease	
8	Oil change (Hydraulic tank)	Hydraulic oil	Every 1000 hrs or 6 months
9	Oil change (Engine)	Engine oil	Every 500 hrs or 3 months (incl. 1st month after purchase)
10	Oil change	Differential oil	Every 1000 hrs or 6 months
11	Oil change (Reserve tank)	Brake oil	Every 2000 hrs or 12 months
12	Oil change (Front axle)	Differential oil	Every 1000 hrs or 6 months



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Hefbrugweg 77  
1332 AM Almere,  
The Netherlands**

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## Correct Operation

- Make sure that you understand the symptoms before starting trouble diagnosis.
- Check correct installation status prior to removal or disassembly. Make sure that they do not interfere with the function of the parts they are applied to if matching marks are required.
- Once they are removed, always replace parts indicated as “do not reuse” with new ones. This includes: oil seals, gaskets, packings, O-rings, lock washers, cotter pins, and self-locking nuts.
- Replace inner and outer races of tapered or needle roller bearings as a set.
- Arrange disassembled parts in order and prevent them from being mixed-up.
- Clean or flush disassembled parts prior to inspection or assembly.
- Use Genuine Cat parts for replacement.
- Use authorized grease and sealer.
- Release the pressure before disconnecting pressurized piping or hoses.
- Be sure to check for leakage after repairing fuel, oil, coolant, exhaust, or vacuum systems.

## Precautions for Radio Equipment Installation

Check the following when installing a commercial/ham radio or mobile phone. If mounting position is not chosen carefully, the unit may interfere with the electronic control system.

- Separate the antenna as far from the Engine Control System as possible.
- Route an antenna feeder line at least 20 cm apart from the control unit harness.
- Adjust antenna and feeder line to eliminate radio wave interference.

# MAIN SPECIFICATIONS

## MAIN SPECIFICATIONS OF IGNITION SYSTEM

Engine type		K21	K25	
Engine control system		Electronic controls		
Fuel specification		Gasoline	LPG	Combined
Ignition device		Non-contact type (Engine Control System)		
Ignition coil (with power transistor)		Hanshin Electric type AIC-4002G		
Crankshaft position sensor	Crankshaft position sensor (POS)	Hitachi Unisia Automotive A29-640		
	Camshaft position sensor (PHASE)	Hitachi Unisia Automotive A29-660		
Spark plug		NGK type FR2A-D		
		Gap (mm) 0.9		

## FUEL SYSTEM AND ENGINE SPEED CONTROL SYSTEM

Engine type		K21	K25	
Engine control system		Electronic controls		
Fuel specification		Gasoline	LPG	Combined
Fuel device standard type		Electronically controlled fuel injection device (Engine Control System)		
Fuel device		Gasoline injector	LPG injector	Gasoline & LPG
Air-fuel ratio control device		Air-fuel ratio feedback control		
Starting auxiliary device		Electric throttle control actuator		
Idle load control type		Electric throttle control actuator		
Engine speed control type		Electric throttle control actuator		

## EXHAUST GAS CLEANUP DEVICE LIST

Engine type		K21	K25	
Engine control system		Electronically controls		
Fuel specification		Gasoline	LPG	Combined
Catalytic device (Reducing HC, CO, NOX)	Type	Three-way catalyst (Monolith)		
	Location	In counter weight with muffler separated		
	Capacity	0.45L		
PCV gas recirculation device		Closed type		

# TROUBLE DIAGNOSIS

## Engine Adjustment (Cont'd)

Condition	Possible causes	Action
Incident in fuel system  Refer to EF section for the LPG model.	• Malfunction of carburetor choke system	Adjust.
	• Plugged fuel piping	Clean
	• Plugged or contaminated fuel filter	Replace.
	• Fuel pump malfunction	Repair or replace
	• Plugged carburetor jet or needle valve	Disassemble and clean.
	• Poor throttle valve opening	Adjust.
	• Fuel pump malfunction	Adjust.
Incident in intake system	• Plugged air cleaner	Replace element
	• Air leakage from electronic throttle insulator	Replace insulator.
	• Air leakage from manifold gasket or carburetor insulator	Replace gasket or insulator.
Engine over temperature (Overheat)	• Insufficient amount of coolant	Fill coolant.
	• Loose fan belt.	Adjust belt tension.
	• Worn or loose fan belt	Replace.
	• Malfunctioning thermostat	Replace.
	• Water pump malfunction	Replace.
	• Plugged or leaking radiator	Wash, repair, or replace.
	• Radiator cap damage	Replace.
	• Air in cooling system piping	Retighten cooling system piping, bleed system.
	• Improper engine oil grade	Replace with appropriate grade of engine oil.
	• Inappropriate ignition timing	Adjust.
• Carburetor malfunction (too lean air-fuel mixture)	Overhaul carburetor.	
Overcool	• Malfunctioning thermostat	Replace.
Other	• Inappropriate octane rating of fuel	Replace with specified octane rating of fuel.
	• Insufficient tire air pressure	Charge to specified air pressure.
	• Brake dragging	Adjust.
	• Clutch slippage	Adjust.
Engine noise		
Knocking	• Engine overload	Operate 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 misfires at a particular cylinder stop 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 misfires at a particular cylinder almost stop the noises, that cylinder is the noise source.	

# ENGINE MAINTENANCE

## Maintenance Schedule

Make sure to perform appropriate maintenance and service work to maintain the initial performances of the MITSUBISHI Forklift Trucks.

### PERFORM INSPECTION

Make sure to perform the periodical inspections at appropriate times, according to the month basis or the operating hour basis, whichever comes first. .... Inspection period

### DAILY / WEEKLY INSPECTION

No.	Inspection items	Operator's inspection	
		Days of use	Weekly
		Operation hours	50
1	Cooling fan (rotation & damage)		I
2	Engine coolant level		I
3	V-belt (fan & alternator) tension		I
4	Battery electrolyte level		I
5	Engine (exhaust, noise, & vibration)		I
6	Engine oil level		I
7	Fuel hose, pipes & joints	(2) for LPG	I
8	Fuel level (leakage)		I
9	Air cleaner element	(1)	I

### FIRST MONTH / PLANNED INSPECTION

See "CAUTION" for figures in ( ) and symbols on the next page.

No.	Inspection items	Engine system inspection (except LPG fuel system)																		
		Months of use	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
		Operation hours (x 100 hours)	2	5	10	15	20	25	30											
1	Intake/exhaust valve clearance		A	A		A		A		A		A		A		A		A		A
2	Cylinder head bolt and manifold nut		T																	
3	Radiator	(1)	Fin	I	I		I		I		I		I		I		I		I	
	Filler cap		I																	
4	Engine oil	(1)	R	R		R		R		R		R		R		R		R		R
5	Oil filter	(1)	R	R		R		R		R		R		R		R		R		R
6	Engine coolant													R						
7	Spark plug		I	I		I		I		I		I		I		I		I		R
8	PCV valve	(1)		I		I		I		I		I		I		I		I		I
9	PCV hose			I		I		I		I		I		I		I		I		I
10	Air cleaner element							R						R						R
11	Rubber hose condition		I											I						
12	Battery electrolyte specific gravity		I	I		I		I		I		I		I		I		I		I

# TROUBLE DIAGNOSIS

Condition	Possible causes	Action
Inappropriate idling		
Incident in fuel system  Refer to EF section for the LPG model.	• Plugged or damaged carburetor jet	Clean or replace
	• Damaged or plugged fuel injector	Clean or replace
	• Inappropriate idle adjustment	Adjustment
	• Plugged air cleaner	Replace element
	• Damaged manifold gasket or carburetor insulator	Replace gasket or insulator.
	• Inappropriate carburetor float level adjustment	Adjustment
Lowered compression pressure		Already described
Engine power does not increase to an appropriate level		Adjustment
Lowered compression pressure		Already described
Incident in ignition system	• Inappropriate ignition timing	Adjustment
	• Spark plug malfunction	Clean, adjust or replace.
Incident in fuel system  Refer to chapter EF section for the LPG model.	• Malfunction of carburetor choke system	Adjustment
	• Plugged fuel piping	Clean
	• Plugged or contaminated fuel filter	Replacement
	• Fuel pump malfunction	Repair or replace
	• Plugged carburetor jet or needle valve	Disassemble and clean.
	• Poor throttle valve opening	Adjustment
	• Fuel pump malfunction	Adjustment
Incident in intake system	• Plugged air cleaner	Replace element
	• Air leakage from electronic throttle insulator	Replace insulator.
	• Air leakage from manifold gasket or carburetor insulator	Replace gasket or insulator.
Engine over temperature (Overheat)	• Insufficient amount of coolant	Fill coolant.
	• Loose fan belt.	Belt tension adjustment
	• Worn or loose fan belt	Replacement
	• Malfunctioning thermostat	Replacement
	• Water pump malfunction	Replacement
	• Plugged or leaking radiator	Wash, repair, or replace
	• Radiator cap damage	Replacement
	• Air in cooling system piping	Retighten cooling system piping, bleed system.
	• Improper engine oil grade	Replace with appropriate grade of engine oil.
	• Inappropriate ignition timing	Adjust.
	• Carburetor malfunction (too lean air-fuel mixture)	Overhaul carburetor
	Overcool	Malfunctioning thermostat
Other	• Inappropriate octane rating of fuel	Replace with specified octane rating of fuel.
	• Insufficient tire air pressure	Charge to specified air pressure.
	• Brake dragging	Adjustment
	• Clutch slippage	Adjustment

## PRECAUTIONS

---

### Precautions for Draining Engine Coolant

- Drain coolant only after the engine has cooled down.

### Precautions for Disconnecting Fuel Piping

- Operation should be done in a place free from fire.
- Release fuel pressure before operation. (Electronic controlled specifications): Refer to “Release of Fuel Pressure” in EC section.
- After disconnecting, plug the pipe to prevent fuel from draining.

### Precautions for Removing and Disassembling

- Use correct STs in the specified position. Always pay attention to safety.
- Be careful not to lose surface accuracy of mating or sliding surfaces.
- To prevent foreign material from entering the engine, close openings with appropriate tape as necessary.
- Arrange disassembled parts in their normal positions in order to simplify locating the cause of damage or excessive wear and to ensure correct reassembly.
- As a rule, nuts and bolts must be loosened in a diagonal manner starting from an outer one. If a particular tightening sequence is provided separately, follow the sequence.

### Precautions for Inspection, Correction, and Replacement

- Following the inspection procedure, inspect the parts adequately and repair or replace as necessary. Perform the same inspections even for new parts and replace them if necessary.

### Precautions for Assembly and Installation

- Always use a torque wrench when tightening nuts and bolts.
- Unless otherwise specified, tighten bolts and nuts from inside to outside in a crisscross pattern. Tighten them gradually and evenly in 2 to 3 steps.
- Always replace gasket, packing, oil seals, and O-rings with new ones.
- For each part, perform adequate cleaning/washing and drying with a dryer. In particular, ensure that the oil and coolant passages are free from plugging and clogging.
- Remove any dirt and lint on sliding and mating surfaces. Before assembly, apply ample amount of engine oil to sliding surfaces.
- If coolant was drained, bleed air from the system.
- After assembly, start engine and increase the engine speed, then check coolant, fuel, oil, grease, and exhaust gas for leakage.

# TIGHTENING TORQUE

**Tightening procedure**

Tightening torque (Reference)		N·m (kgf·m)
①	19.6 - 23.52 (2.0 - 2.3)	Tightening for brake-in
②	68.6 (7.0)	
③	0.0	Return
④	19.6 - 23.52 (2.0 - 2.3)	Retightening
⑤	90° - 92°	

**Assembly sequence**

**Precautions before assembling**

- Do not allow oil or dust to get on cylinder head, mounting surface of cylinder block, and head gasket.
- Apply anticorrosive oil onto head bolt thread and surface under the head.

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## CYLINDER HEAD

Tightening torque for general service is 68.6 N·m (7.0 kgf·m) in the place of the tightening torque (5) as shown in the figure.

**Assembly sequence**

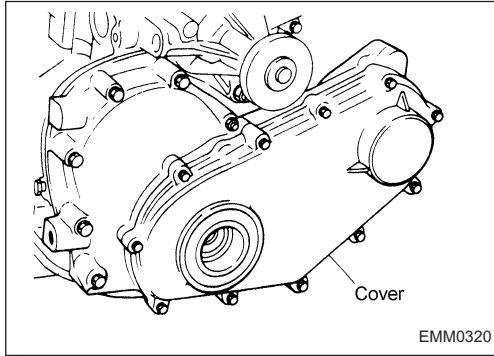
**MAIN BEARING CAP**

☑ : 83.4 - 93.2 N·m (8.51 - 9.51 kgf·m)

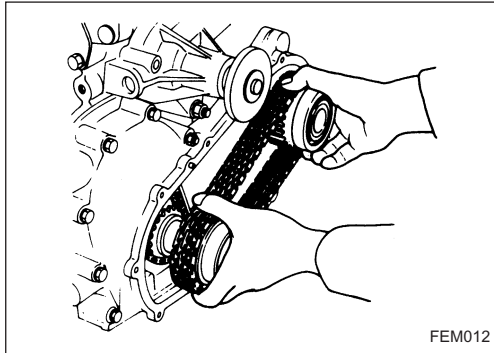
- Apply antirust oil or engine oil to the bolt threads and head bottom.
- Do not use any power tools such as an air runner for assembly.

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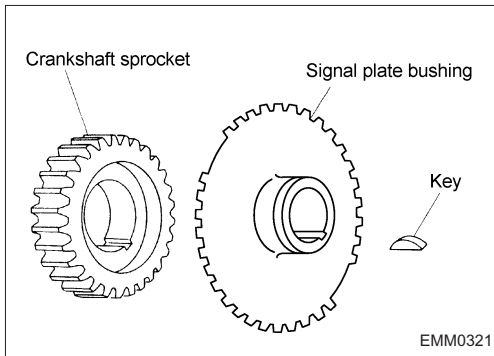
## Engine Disassembly (Cont'd)



- Remove the front cover.
- To remove the cover, remove the bolts and lightly tap on it with a plastic hammer.  
Before installing the cover, apply sealant (liquid packing) to the mounting face.

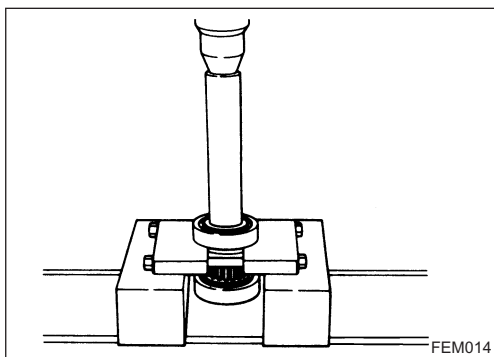


11. Remove the sprocket and chain as an assembly from the oil pump side and the crankshaft side.



After removing the retaining bolts, remove the signal plate bushing and remove the hydraulic pump sprocket along with the bearing by hand.

**⚠ CAUTION:**  
Ensure that the chain is not damaged.

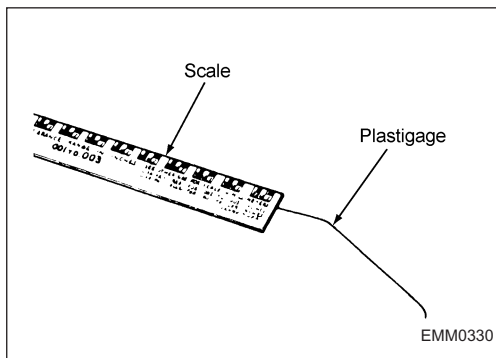


12. To separate the oil pressure pumpside sprocket and the bearing, use the relevant Service Tool with a press.  
91H20-09220      Bearing puller  
91H20-09230      Bearing drift

## Inspection and Correction (Cont'd)

### 12. Connecting rod and bushings

- Check the bushings for bend, melting, or tearing and replace them if damaged.
- Measure the oil clearance using a plastigage.



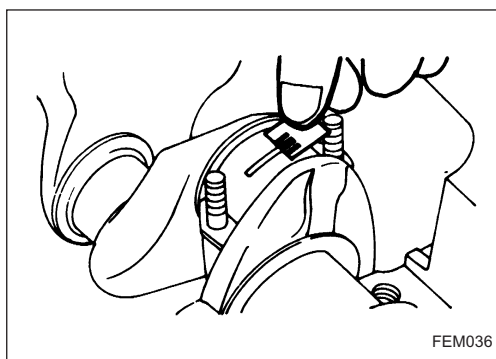
### MEASURING OIL CLEARANCE

- The following paragraphs describe how to use a plastigage.
  - Remove any oil and dust from the bearing inner/outer faces and journal faces. Cut off the plastigage to a length slightly shorter than the bearing width. Place the cut plastigage on the journal face so as not to cover any oil holes.
  - Assemble the bearing cap and tighten it to the specified torque.

### ⚠ CAUTION:

**Do not turn the crankshaft while the plastigage is in the bearing.**

- Remove the cap and read the plastigage width using the scale printed on the bag.
- If the clearance exceeds the limit, use an undersize bearing. At that time, grind the journal or pin.



### Standard

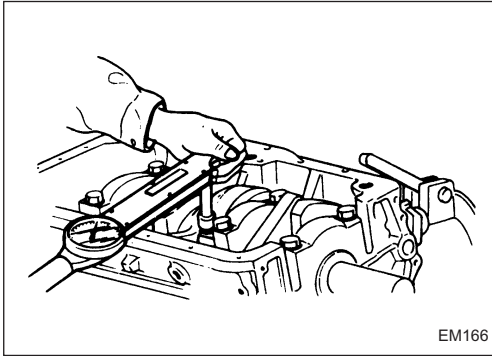
Items	Oil clearance Standard	Oil clearance Limit	Cap tightening torque
Main bearing	0.02 - 0.073	0.1	Lubricated 83.4 - 93.2 N·m (8.51 - 9.51Kgf·m)
Connecting rod bearing	0.032 - 0.066	0.1	Lubricated 31.4 - 37.3 N·m (3.2 - 3.81Kgf·m)

- If the oil clearance exceeds the limit, grind the journal or pin with a surface grinder and use an undersize bearing.

### Undersize bearing list

Main bearing	Connecting rod bearing	
	K21, K25	Pin diameter
STD	STD	44.974 - 44.96
	0.08	44.894 - 44.8
0.02	0.12	44.854 - 44.89
0.25	0.25	44.724 - 44.71
0.50		
0.75		
1.00		

## Engine Assembly (Cont'd)



- (7) Tighten connecting rod cap.  
**Connecting rod cap bolt:**  
 ☞ 3.2 - 3.8 Kgf-m (K21, K25)

### 10. Assembly of valve lifter

- Fit the valve lifter in the correct position. Apply a small amount of oil and press the valve lifter into the hole on the cylinder block.

### 11. Assembly of camshaft

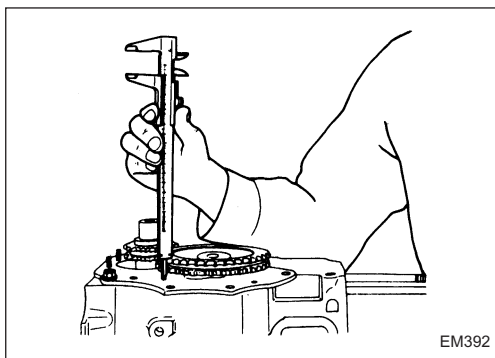
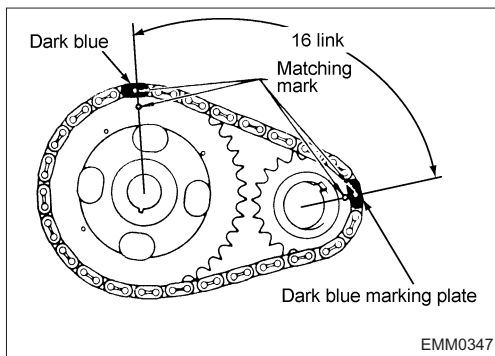
- (1) Gently put the camshaft into the camshaft hole so that the bearing bushings are not damaged.
- (2) Tighten locating plate bolt to the specified torque.

**M6 x 16 (thread length) 7T bolt:**

☞ : 8.43 - 10.8 N·m (0.86 - 1.1 kgf-m)

### 12. Assembly of timing chain/sprocket

- (1) Tighten camshaft bolts.  
Tightening torque: 39.2 - 49 N·m (4.0 - 5.0 Kg-m)
- (2) Check the height of the camshaft gear and crankshaft gear end faces, and adjust the height by adding shims to the crankshaft side as necessary.



- (3) Assemble the sprocket and timing chain simultaneously while aligning their matching marks.

Height difference of gear end faces	Within 0.2 mm
Shim thickness	0.16 mm (per 1 shim)
Shim part number	12299 32200

## PRECAUTIONS

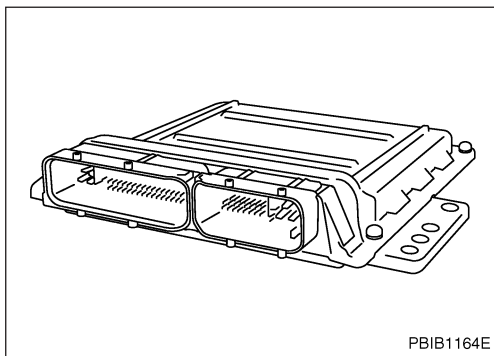
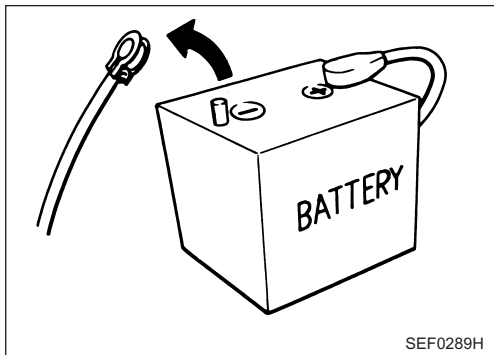
### On Board Diagnostic (OBD) System of Engine

The ECM has an on board diagnostic system. It will light up the malfunction indicator lamp (MIL) to warn the driver of a malfunction causing emission deterioration.

#### ⚠ CAUTION:

- Be sure to turn the ignition switch OFF and disconnect the negative battery cable before any repair or inspection work. The open/short circuit of related switches, sensors, solenoid valves, etc. will cause the MIL to light up.
- Be sure to connect and lock the connectors securely after work. A loose (unlocked) connector will cause the MIL to light up due to the open circuit. (Be sure the connector is free from water, grease, dirt, bent terminals, etc.)
- Certain systems and components, especially those related to OBD, may use a new style slide-locking type harness connector.
- Be sure to route and secure the harnesses properly after work. The interference of the harness with a bracket, etc. may cause the MIL to light up due to the short circuit.
- Be sure to connect rubber tubes properly after work. A misconnected or disconnected rubber tube may cause the MIL to light up due to the malfunction of fuel injection system, etc.
- Be sure to erase the unnecessary malfunction information (repairs completed) from the ECM before returning the vehicle to the customer.

#### Precaution



- Always use a 12 volt battery as power source.
- Do not attempt to disconnect battery cables while engine is running.
- Before connecting or disconnecting the ECM harness connector, turn ignition switch OFF and disconnect battery ground cable. Failure to do so may damage the ECM because battery voltage is applied to ECM even if ignition switch is turned OFF.
- Before removing parts, turn ignition switch OFF and then disconnect battery ground cable.
- Do not disassemble ECM.
- If a battery cable is disconnected, the memory will return to the ECM value. The ECM will now start to self-control at its initial value. Engine operation can vary slightly when the terminal is disconnected. However, this is not an indication of a malfunction. Do not replace parts because of a slight variation.
- If the battery is disconnected, the following emission-related diagnostic information will be lost within 24 hours.
  - Diagnostic trouble codes
  - 1st trip diagnostic trouble codes

# TROUBLE DIAGNOSIS

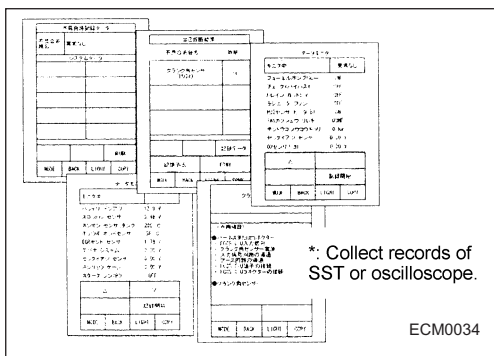
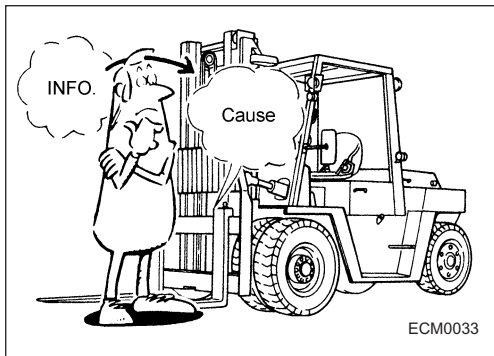
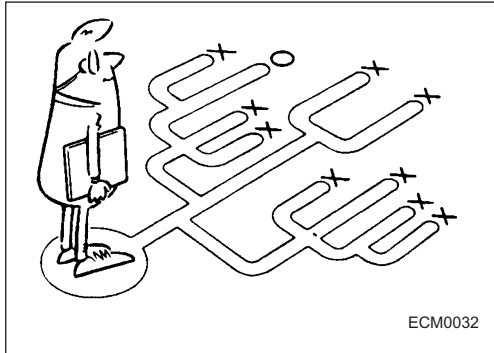
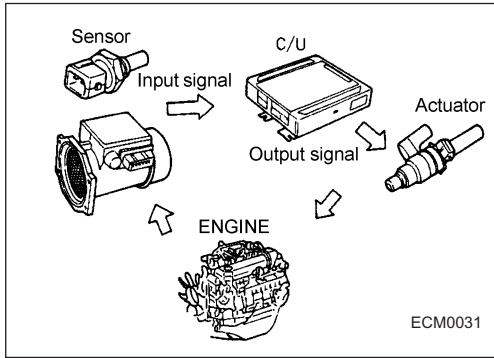
## Component Parts Location (Cont'd)

Main component part			Type	Location	Specifications		
					Gasoline	LPG	Combined
Sensors	Crankshaft position sensor	Crankshaft position sensor (POS)	Hall IC (element)	Front cover	○	○	○
		Camshaft position sensor (PHASE)		Chain housing	○	○	○
	Mass air flow sensor		Hot wire	Air horn	○	○	○
	Accelerator pedal position sensors 1 and 2		Variable resistance	Integrated in accelerator work unit (accelerator pedal assembly)	○	○	○
	Throttle position sensors 1 and 2			Integrated in electronic throttle control actuator	○	○	○
	Engine coolant temperature sensor		Thermistor	Water outlet	○	○	○
	Intake air temperature sensor			With air flow meter	○	○	○
	Heated oxygen sensor		Zirconia (with heater)	Exhaust manifold	○	○	○
ECM			121-pin digital control	Vehicle side	○	○	○
EGI & IGN coil relay			Compact general relay (1M X 2)	Vehicle side	○	○	○

## ECM Component

Component	Location	Specifications			NOTE		
		Gasoline	LPG	Combined	Actuator	Sensor	Other
Gasoline injector	Intake manifold	○		○	○		
LPG injector	Integrated in injector holder (on intake manifold)		○	○	○		
Throttle control motor	Integrated in electronic throttle control actuator	○	○	○	○		
Throttle position sensors 1 and 2		○	○	○		○	
Ignition coil	Cylinder head (on each spark plug)	○	○	○	○		
Crankshaft position sensor (POS)	Front cover	○	○	○		○	
Camshaft position sensor (PHASE)	Front housing	○	○	○		○	
Mass air flow sensor	Air horn	○	○	○		○	
Intake air temperature sensor	With air flow meter	○	○	○		○	
Engine coolant temperature sensor	Water outlet	○	○	○		○	
Accelerator pedal position sensors 1 and 2	Integrated in accelerator work unit (accelerator pedal assembly)	○	○	○		○	
Fuel pump	Integrated in fuel tank	○		○	○		
Fuel pressure regulator		○		○	○		
Heated oxygen sensor	(Vehicle side)	○	○	○		○	
Vehicle speed sensor	(Vehicle side)	○	○	○		○	
ECM	(Vehicle side)	○	○	○			○
EGI & IGN coil relay	(Vehicle side)	○	○	○			○
Stop lamp switch	(Vehicle side)	○	○	○			○
Throttle control motor relay	(Vehicle side)	○	○	○			○
Fuel pump relay	(Vehicle side)	○					○
Vaporizer	(Vehicle side)		○	○			○
LPG interception valve	(Vehicle side)		○	○	○		

## How to Proceed with Trouble Diagnosis



1. The most important point in performing trouble diagnosis of malfunctions is to thoroughly understand the vehicle systems (both control and mechanical).

An ECM-based engine controls actuators such as injectors and the ignition coil according to information from sensors. Then through actuator operation, the engine (mechanical system) runs. Sensors transmit information on the running condition, which changes constantly, to ECM. It is important to understand these cycles.

2. It is also important to clarify customer concerns before starting the inspection.

First of all, reproduce the symptom, and understand it fully. Ask the customer about his/her concerns carefully. In some cases, it will be necessary to check the symptoms by driving the vehicle with the customer.

### ⚠ CAUTION:

**Customers are not professionals. Do not assume “maybe the customer means ...” or “maybe the customer mentioned this symptom”.**

3. It is essential to confirm symptoms right from the beginning in order to ensure all malfunctions are completely repaired.

For an intermittent malfunction, it is important to reproduce the symptom based on an interview with the customer and past examples. Do not perform an inspection on an ad hoc basis. Most intermittent malfunctions are caused by poor contacts. In this case, it will be effective to shake the suspected harness or connector by hand. When repairs are performed without any symptom check, no one can judge if the malfunction has actually been eliminated.

4. The next important thing is to find which system among the following is causing the malfunction: ECM control signal system, or a mechanical system (such as the engine main body and auxiliary component). It is important to inspect the system using Service tool or by checking the ECM input/output signals. When checking the ECM input/output signals, connect a check adapter (Service tool) to ECM in order to prevent misdiagnosis.

#### Special Service Tools (Service tool):

**Check adapter V (91H20-09030) (for SMJ 150-pin connector)**

**Harness adapter (91H20-09040) (150-pin → 121-pin conversion adapter)**

5. Use the reference value of input/output data (guideline) in this manual in order to judge the ECM input/output signals. Measure the data of another vehicle of the same model under the same conditions when it is difficult to judge, and compare the data. It is advisable to collect sufficient data of a normally operating vehicle.

# TROUBLE DIAGNOSIS

## Table of DTC

### SELF-DIAGNOSIS RESULTS

When a malfunction occurs in ECM input/output signal circuit, the malfunctioning circuit is recorded and displayed. Also, the malfunction item that is occurred is displayed.

Display sample [Example: When there is a malfunction in mass air flow sensor] Display DTC and the malfunction item in the alarm monitor screen.

DTC	Name	Engine warning lamp	DTC for GST	Malfunction return condition	Diagnosis outline	Trip
—	NO DTC	—	—	—	—	—
E-03	VCM communication signal circuit malfunction	—	U1001	<ul style="list-style-type: none"> <li>Malfunction occurs in CAN communication transmit/receive data or in VCM, and data transmission/reception cannot be confirmed.</li> <li>CAN communication data is transmitted/received for predetermined period.</li> </ul>	—	2
E-04	ECM communication signal circuit malfunction	—	U1001	<ul style="list-style-type: none"> <li>Malfunction occurs in CAN communication transmit/receive data or in ECM, and data transmission/reception cannot be confirmed.</li> <li>CAN communication data is transmitted/received for predetermined period.</li> </ul>	—	2
E-05	DCM communication signal circuit malfunction	—	U1001	<ul style="list-style-type: none"> <li>Malfunction occurs in CAN communication transmit/receive data or in DCM, and data transmission/reception cannot be confirmed.</li> <li>CAN communication data is transmitted/received for predetermined period.</li> </ul>	—	2
E-07	MP communication signal circuit malfunction	—	U1001	<ul style="list-style-type: none"> <li>Malfunction occurs in CAN communication transmit/receive data or in MP, and data transmission/reception cannot be confirmed.</li> <li>CAN communication data is transmitted/received for predetermined period.</li> </ul>	—	2
E-21	Mass air flow sensor signal circuit malfunction	ON	P0102	When the engine is running and the mass air flow sensor output voltage has been 0.5V or less (open or shorted) for a predetermined period.	Detect disconnection and short circuit and make MIL go on.	1
			P0103	When the engine is stopped (ignition switch ON) and the mass air flow sensor output voltage has been approx. 4.9V or more (open or shorted) for a predetermined period.		
E-22	Engine coolant temperature signal circuit malfunction	ON	P0117	Engine coolant temp. sensor output voltage has been less than 0.06V (open or shorted) for a predetermined period.	Detect disconnection and short circuit and make MIL go on.	1
			P0118	Engine coolant temp. sensor output voltage has been approx. 4.8V or more (open or shorted) for a predetermined period.		

### Throttle Valve Closed Position Learning and Idle Air Volume Learning

#### DESCRIPTION

When electric throttle control actuator or ECM connector is removed, it is necessary for ECM to learn throttle valve closed position (throttle position sensor output with throttle valve fully closed) after reinstallation. Thus, throttle valve closed position learning is performed.

When electric throttle control actuator or ECM is replaced, the minimum required idle air volume needs to be learned. Thus, throttle valve closed position learning and idle air volume learning are performed.

Idle air volume learning is necessary even when idle speed or ignition timing is outside the standard. Note that idle air volume learning is equivalent to the base idle speed adjustment by conventional throttle adjusting screw of carburetor or LPG mixer.

#### OPERATION PROCEDURE FOR THROTTLE VALVE CLOSED POSITION LEARNING

1. Turn ignition switch ON → OFF. (And hold it for approximately 5 seconds after turning it OFF.)
2. Make sure that throttle valve operates. (Check for operating sound.)
3. Upon completion of the above, learning is complete.

#### CAUTION:

**Throttle valve closed position learning cannot be performed with Service tool.**

#### OPERATION PROCEDURE FOR IDLE AIR VOLUME LEARNING

1. Perform throttle valve closed position learning.
2. Fully warm up engine, transmission, and lubricant. [Engine coolant temperature: 70 to 90°C (158 to 194°F)]
3. Set the selector lever to neutral or N position. Make sure that the engine is free of electrical loads, such as air conditioner, oil pressure pump, and other electrical components.
4. Perform "Idle Air Volume Learning" of "ECM Active Test".

#### CAUTION:

**"IDLE AIR VOL LEARN (PLANT)" is the original setting on the vehicle. Do not use it.**

## Removal and Installation

### ECM

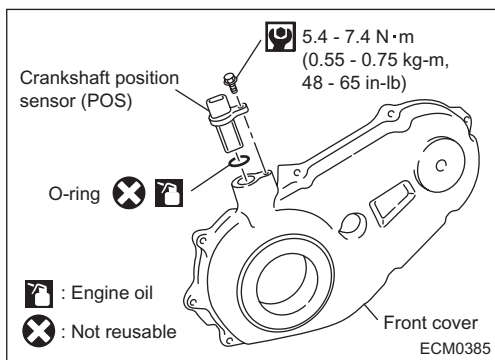
#### ⚠ CAUTION:

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 EC-42, "Throttle Valve Closed Position Learning and Idle Air Volume Learning.")

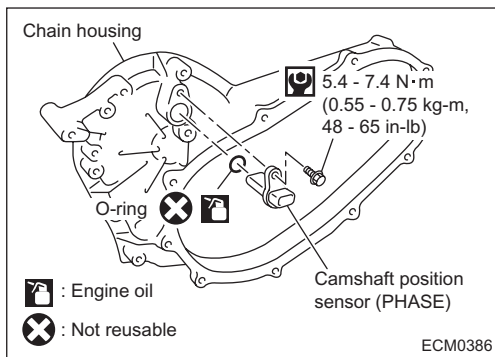


### CRANKSHAFT POSITION SENSOR (POS)

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.

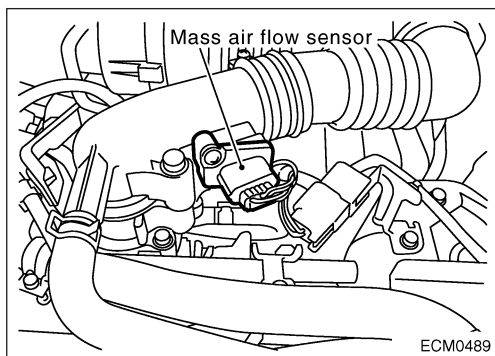


### CAMSHAFT POSITION SENSOR (PHASE)

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.

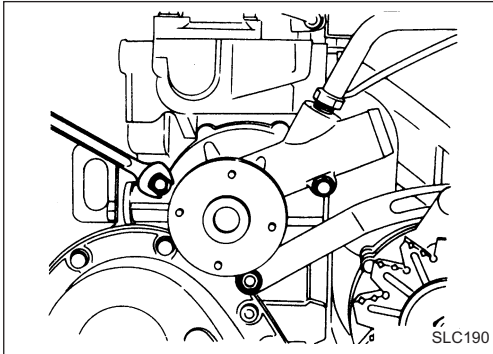
## Water Pump

1. Open the drain of the radiator and extract coolant into an appropriate container.

### ⚠ CAUTION:

**Do not drain coolant when engine is still hot. It may be a cause to get burned.**

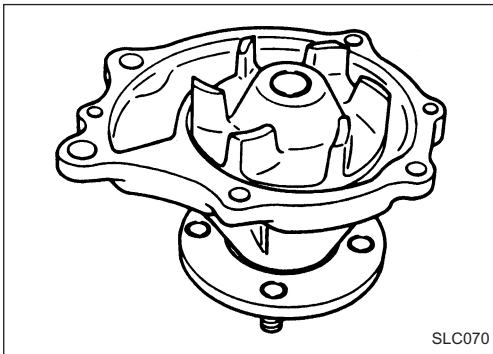
2. Remove the radiator shroud.
3. Loosen the fan belt.
  - Loosen the alternator adjusting bolt.
  - Fully put aside the alternator toward the engine.
  - Remove fan and fan pulley.
  - Remove the water pump together with the gasket.



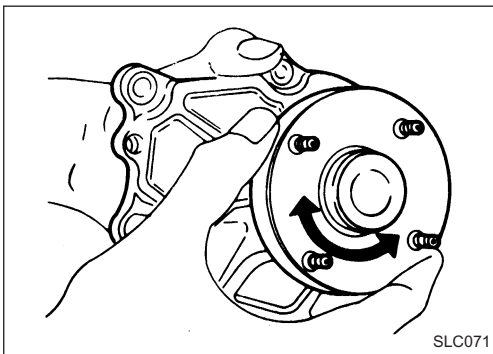
### INSPECTION

Do not disassemble water pump. If any non-standard condition is found, replace the water pump.

1. Check the water pump vanes for rust and pitching.



2. Check the water pump bearing for proper end play and smooth operation.



### ASSEMBLY

1. Install the water pump in the reverse order of removal. Always use a new gasket.
2. Adjust the fan belt tension. For the adjustment value, refer to page MA-section.

### ⚠ CAUTION:

- **Before filling with coolant, always loosen the air purge plug.**
- **After refilling, make sure to tighten the plug.**

### Electronic Control System Specifications

Gasoline electronic injection (injection from each cylinder port)

LPG electronic injection (injection from single point on this side of electric throttle control actuator)

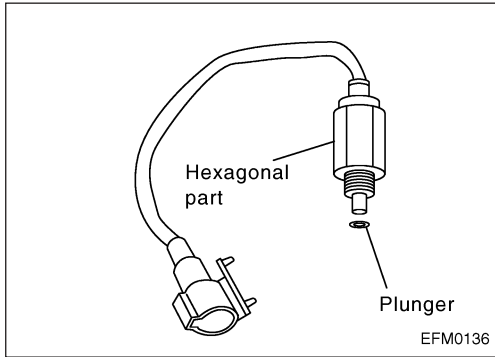
Vaporizer (water heater) .....

Fuel discharge pressure: Approx. 31.9 KPa (0.33 kgf/cm<sup>2</sup>) [4.6 psi]

Throttle body and injector holder bolts tightening torque (Air horn also secures.)

M6 bolt [thread length : 90 mm (3.54 in): 11.8 - 13.7 N·m (1.2 - 1.4 kg-m) [9 - 10 ft-lb]

# DISASSEMBLY AND ASSEMBLY OF INJECTOR HOLDER



## LPG Assist Fuel Injector

### REMOVAL AND INSTALLATION

- Rotate and remove hexagonal part of body using a spanner.
  - When removing hexagonal part of body, inside spring, plunger, and washer are removed together. Do not drop and lose them.
- Install after assembling inner components in their original position. Replace aluminum washer with new ones.
  - Tightening torque: 11.8 - 26.5 N·m (1.2 - 2.7 kg·m) [9 - 19 ft·lb]

### INSPECTION AND CLEANING

- If foreign materials such as tars are applied or collected on plunger or its inside, remove them with compressed air.

## LPG Fuel Pressure Sensor

### REMOVAL AND INSTALLATION

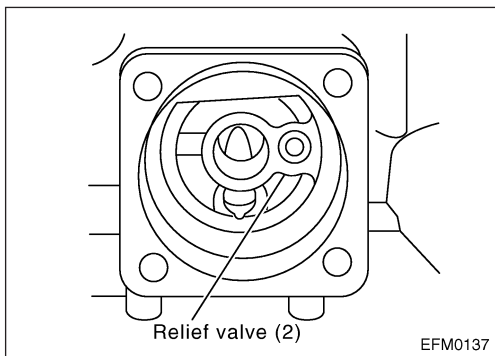
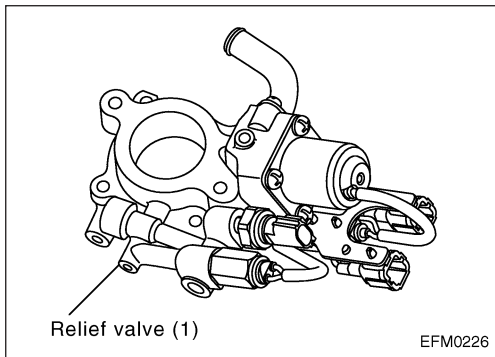
- If foreign materials are applied in the top, remove them with compressed air.
- Replace O-ring with a new one and apply engine oil to the circumference of O-ring lightly. And then, insert LPG fuel pressure sensor straight to holder and install.

## Relief Valve (2 Relief Valves)

- 2 relief valves are built into holder.
- Relief valve (1) setting pressure is 0.08 MPa (0.8 kg/cm<sup>2</sup>) [11 psi].  
Relief valve (2) setting pressure is 0.12 MPa (1.2 kg/cm<sup>2</sup>) [17 psi].

### INSPECTION AND CLEANING

- Seal necessary part of each holder.  
Apply compressed air from fuel connector.  
Raise air pressure from 0.00 MPa (0 kg/cm<sup>2</sup>) [0 psi] (gauge pressure) gradually. Check continuity of the passage at nearly above the setting pressure.  
Clean with compressed air up to 0.49 MPa (5 kg/cm<sup>2</sup>) [71 psi] if continuity should not exist.  
Replace holder with a new one if continuity should not exist after applying compressed air of 0.49 MPa (5 kg/cm<sup>2</sup>) [71 psi].
  - Do not replace relief valve only.



## ADJUSTMENT VALUE

Component	Items	Description
Starter motor	• Brush dimensions	10.0 - 18.0 mm (0.394 - 0.709 in) (Wear margin 8 mm (0.31 in))
	• Brush spring pressure	13.7 - 17.7 N (1.4 - 1.8 kg) [3.1 - 4.9 lb]
Alternator	• Stator	Resistance between respective lead wires: 1 $\Omega$ or less Resistance between stator core and lead wire: $\infty$
	• Rotor coil	Standard resistance between slip rings: 2.9 $\Omega$ Standard resistance between slip ring and rotor core: $\infty$
	• Snap ring	Snap ring outer diameter: Standard: 14.4 mm (0.567 in) Repair limit: 14.0 mm (0.551 in)
	• Brush	Projected length from holder: Standard: 10.0 mm (0.394 in) Repair limit: 2.0 mm (0.079 in)

# ALTERNATOR

## Disassembly (Cont'd)

### BEARING

#### Drive end side

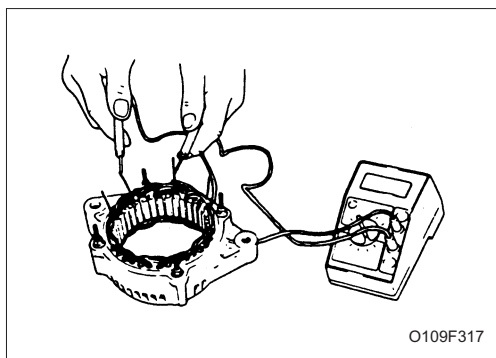
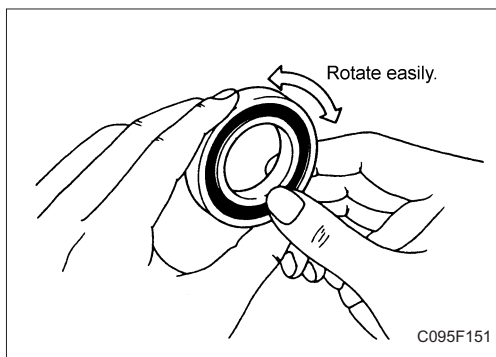
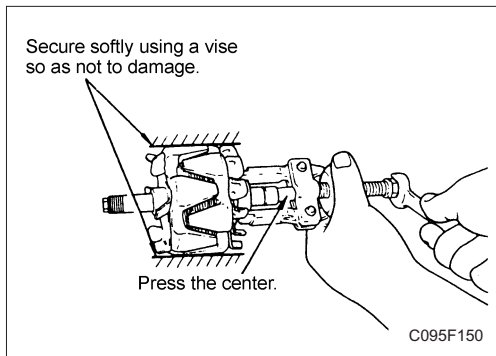
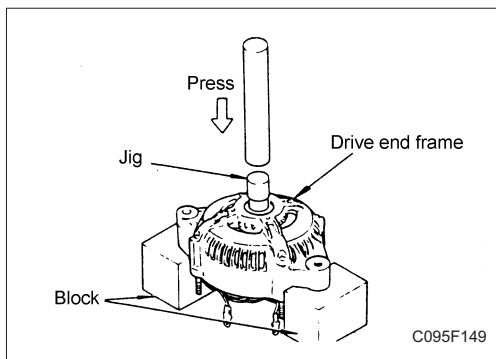
Keep drive end frame level using blocks, and then press out bearing using a jig.

#### Slip ring side

Pull out bearing using a puller.

#### ⚠ CAUTION:

**Bearing for high speed is specified to be used. Always use it when replacing, and do not impact it.**



## Inspection

### BEARING

- Rotate bearing by hand.
- Check for noise or binding.
- Replace if necessary.

### STATOR

- Measure resistance between each lead wire using a circuit tester.  
**Standard: 1  $\Omega$  or less**
- Measure resistance between stator core and lead wire.  
**Standard:  $\infty$**
- Replace if necessary.

#### ⚠ CAUTION:

**Opening of stator coil itself is not considerable. Check the connection part of wires if continuity should not exist.**

## Correct Operation

- Make sure that you understand the symptoms before starting trouble diagnosis.
- Check correct installation status prior to removal or disassembly. Make sure that they do not interfere with the function of the parts they are applied to if matching marks are required.
- Once they are removed, always replace parts indicated as “do not reuse” with new ones. This includes: oil seals, gaskets, packings, O-rings, lock washers, cotter pins, and self-locking nuts.
- Replace inner and outer races of tapered or needle roller bearings as a set.
- Arrange disassembled parts in order and prevent them from being mixed-up.
- Clean or flush disassembled parts prior to inspection or assembly.
- Use Genuine CATERPILLAR parts for replacement.
- Use authorized grease and sealer.
- Release the pressure before disconnecting pressurized piping or hoses.
- Be sure to check for leakage after repairing fuel, oil, coolant, exhaust, or vacuum systems.

## Precautions for Radio Equipment Installation

Check the following when installing a commercial/ham radio or mobile phone. If mounting position is not chosen carefully, the unit may interfere with the electronic control system.

- Separate the antenna as far from the Engine Control System as possible.
- Route an antenna feeder line at least 20 cm apart from the control unit harness.
- Adjust antenna and feeder line to eliminate radio wave interference.

# MAIN SPECIFICATIONS

## MAIN SPECIFICATIONS OF IGNITION SYSTEM

Engine type		K21	K25	
Engine control system		Electronic controls		
Fuel specification		Gasoline	LPG	Combined
Ignition device		Non-contact type (Engine Control System)		
Ignition coil (with power transistor)		Hanshin Electric type AIC-4002G		
Crankshaft position sensor	Crankshaft position sensor (POS)	Hitachi Unisia Automotive A29-640		
	Camshaft position sensor (PHASE)	Hitachi Unisia Automotive A29-660		
Spark plug		NGK type FR2A-D		
		Gap (mm) 0.9		

## FUEL SYSTEM AND ENGINE SPEED CONTROL SYSTEM

Engine type		K21	K25	
Engine control system		Electronic controls		
Fuel specification		Gasoline	LPG	Combined
Fuel device standard type		Electronically controlled fuel injection device (Engine Control System)		
Fuel device		Gasoline injector	LPG injector	Gasoline & LPG
Air-fuel ratio control device		Air-fuel ratio feedback control		
Starting auxiliary device		Electric throttle control actuator		
Idle load control type		Electric throttle control actuator		
Engine speed control type		Electric throttle control actuator		

## EXHAUST GAS CLEANUP DEVICE LIST

Engine type		K21	K25	
Engine control system		Electronically controls		
Fuel specification		Gasoline	LPG	Combined
Catalytic device (Reducing HC, CO, NOX)	Type	Three-way catalyst (Monolith)		
	Location	In counter weight with muffler separated		
	Capacity	0.45L		
PCV gas recirculation device		Closed type		

# TROUBLE DIAGNOSIS

## Engine Adjustment (Cont'd)

Condition	Possible causes	Action
Incident in fuel system  Refer to EF section for the LPG model.	• Malfunction of carburetor choke system	Adjust.
	• Plugged fuel piping	Clean
	• Plugged or contaminated fuel filter	Replace.
	• Fuel pump malfunction	Repair or replace
	• Plugged carburetor jet or needle valve	Disassemble and clean.
	• Poor throttle valve opening	Adjust.
	• Fuel pump malfunction	Adjust.
Incident in intake system	• Plugged air cleaner	Replace element
	• Air leakage from electronic throttle insulator	Replace insulator.
	• Air leakage from manifold gasket or carburetor insulator	Replace gasket or insulator.
Engine over temperature (Overheat)	• Insufficient amount of coolant	Fill coolant.
	• Loose fan belt.	Adjust belt tension.
	• Worn or loose fan belt	Replace.
	• Malfunctioning thermostat	Replace.
	• Water pump malfunction	Replace.
	• Plugged or leaking radiator	Wash, repair, or replace.
	• Radiator cap damage	Replace.
	• Air in cooling system piping	Retighten cooling system piping, bleed system.
	• Improper engine oil grade	Replace with appropriate grade of engine oil.
	• Inappropriate ignition timing	Adjust.
• Carburetor malfunction (too lean air-fuel mixture)	Overhaul carburetor.	
Overcool	• Malfunctioning thermostat	Replace.
Other	• Inappropriate octane rating of fuel	Replace with specified octane rating of fuel.
	• Insufficient tire air pressure	Charge to specified air pressure.
	• Brake dragging	Adjust.
	• Clutch slippage	Adjust.
Engine noise		
Knocking	• Engine overload	Operate 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 misfires at a particular cylinder stop 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 misfires at a particular cylinder almost stop the noises, that cylinder is the noise source.	

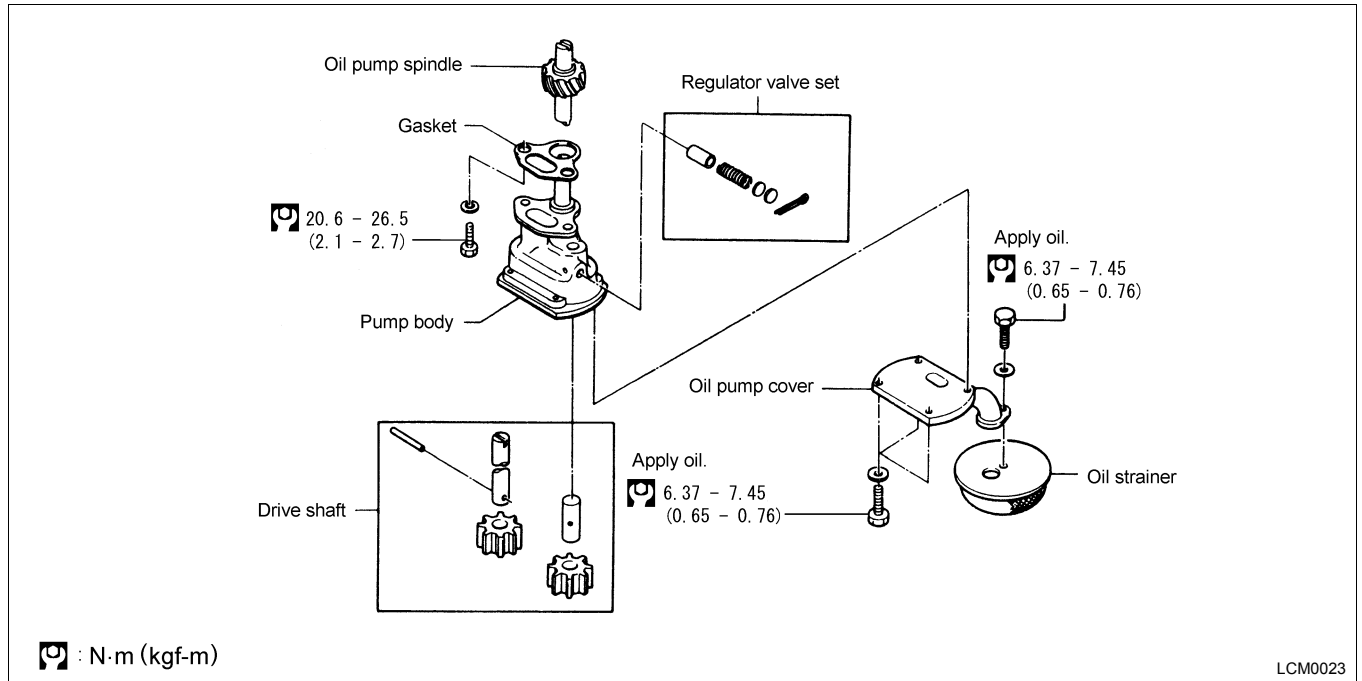
## TROUBLE DIAGNOSIS

Condition	Possible causes	Action
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	Washing
	• 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	Inspect element
	• Overheat or excessive cooling	Already described
	• Inappropriate air-fuel ratio	Inspect 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	Inspect fuel system

# LUBRICATION SYSTEM

## Oil Pump

### COMPONENT PARTS LOCATION



### INSPECTION

1. Check the following items for wear or damages.
  - Pump body and cover
  - Pump gear section
  - Driving spindle

The pump gear section and main body have no internal components that can be serviced separately. If the pump gear or main body is worn or damaged, replace the drive shaft assembly or oil pump assembly.

2. Inspect the clearance at the following points using a feeler gauge.

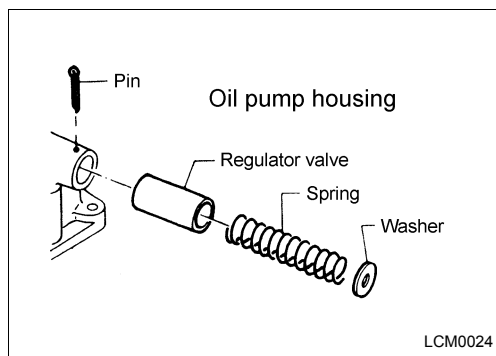
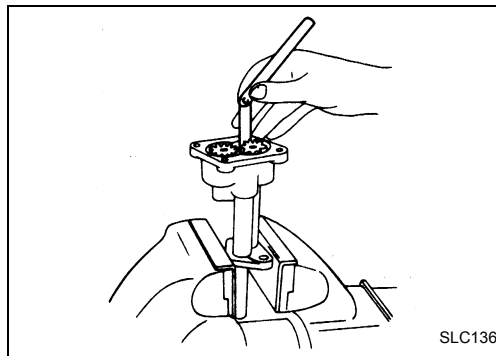
If the clearance exceeds the specified limit, replace the drive shaft assembly or oil pump assembly.

**Clearance between pump gear and main body:**

**0.4 mm or less**

**Backlash of pump gear: 0.5 mm or less**

**Pump gear clearance in vertical direction: 0.3 mm or less**



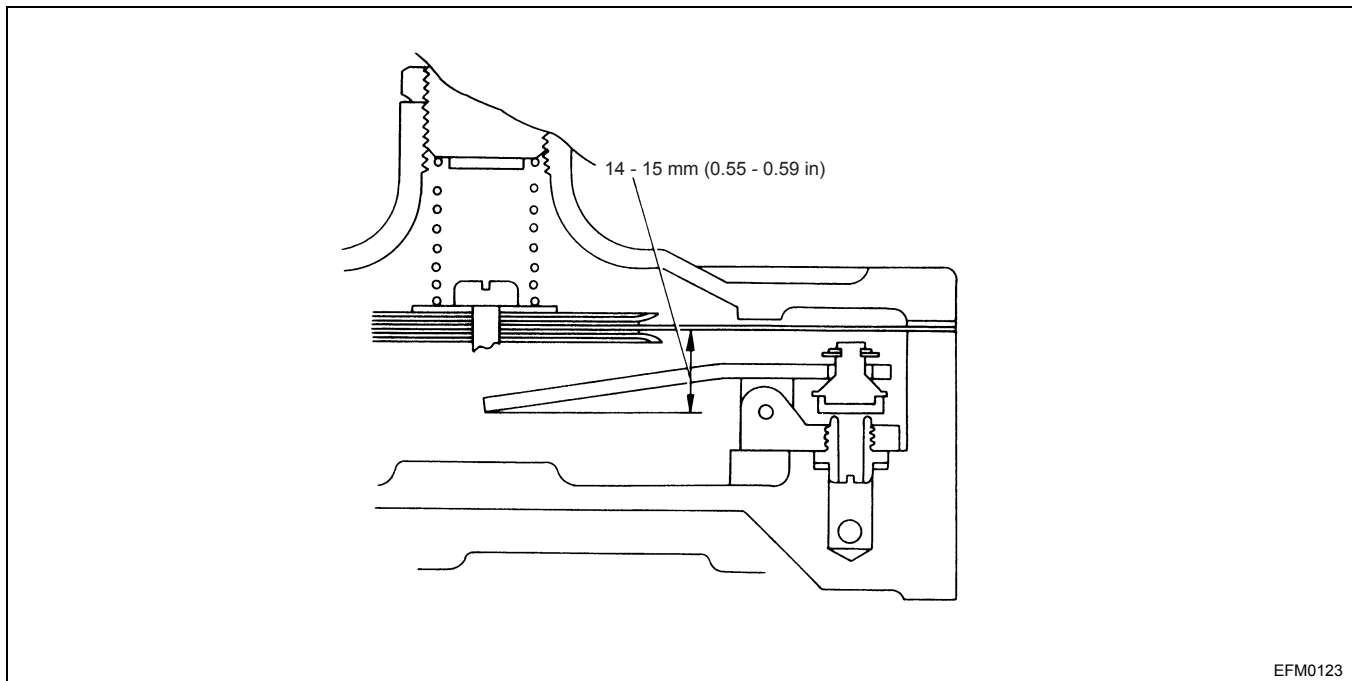
3. Inspect the regulator valve spring of the oil pump. If damaged, replace the spring or pump assembly.

**Free length 41.5±1 mm**

**Repair limit 40.0 mm**



## Vaporizer Mechanism and Operation (Cont'd)



Set primary valve lever as shown in the figure.

### PRESSURE INSPECTION

Check primary room pressure with the following procedure:

1. Remove primary room test hole plug, and install pressure gage using appropriate connector.
2. Start engine, and check for primary room fuel leakage at idle after warming up.  
Standard: 30.7 - 33.1 kPa (0.31 - 0.34 kgf/cm<sup>2</sup>) [4.4 - 4.8 psi]
3. Rotate pressure adjusting screw if measured pressure is outside the standard.

### ⚠ CAUTION:

Apply sealant and keep air tightness when reinstalling test hole plug.

### IDLE ADJUSTMENT IN ELECTRIC CONTROLLED LPG SPECIFICATIONS

It is not necessary because it is performed with control unit.

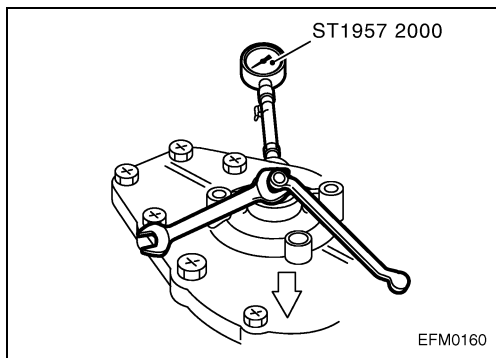
### REMOVAL OF IMPURITIES

LPG includes incombustible materials (e.g. tar).

These materials will be collected in vaporizer. This may cause operating malfunctions of fuel system.

It is necessary to periodically release and drain with engine warmed up.

## DISASSEMBLY AND ASSEMBLY OF VAPORIZER



- Tighten lock nut after setting to standard pressure by rotating primary pressure adjusting screw.
- Tighten primary pressure adjusting screw using double spanner.
- Tightening torque N·m (kg·m) [ft·lb]: 11.8 - 26.5 (1.2 - 2.7) [9 - 19]
- Apply soapy water to mating surface of cover. Check for leakage.
- Place tamperproof bracket over primary chamber cover, and then tighten mounting screw using SST.
- Tightening torque N·m (kg·m) [ft·lb]: 3.8 - 5.1 (0.39 - 0.52) [2.8 - 3.7]

## On Board Inspection and Service

### TIGHTENING OF HEAD BOLT

Tighten head bolts from inside to outside as shown in the figure. Tighten bolts gradually as shown in the figure.

**⚠ CAUTION:**

**Check tightening angle with an angle wrench (SST) or a protractor. Do not simply estimate tightening angle.**

**Tightening procedure**

**Assembly sequence**

Tightening torque (Reference)		N·m (kg·m, ft·lb)
①	19.6 - 23.5	Tightening for brake-in
	(2.0 - 2.3, 14 - 17)	
②	68.6 (7.0, 51)	Return
③	0 (0, 0)	
④	19.6 - 23.5	Retightening
	(2.0 - 2.3, 14 - 17)	
⑤	90° - 92°	

**Precautions before assembling**

- Do not allow oil or dust to get on cylinder head, mounting surface of cylinder block, and head gasket.
- Apply anticorrosive oil onto head bolt thread and surface under the head.

MAM0147

### RETIGHTENING OF MANIFOLD NUT AND BOLT

**⚠ CAUTION:**

**Do not retighten nut and bolt until manifold components get cold. It may cause to get burned.**

#### Tightening torque for manifold and nut

Models	N·m	kg·m	ft·lb
K21	41.2 - 48.1	4.2 - 4.91	30.4 - 35.6
K25	41.2 - 48.1	4.2 - 4.91	30.4 - 35.6

(Do not use power tools such as air runner to tighten.)

### INTAKE/EXHAUST VALVE CLEARANCE ADJUSTMENT

- Adjustment must be made with the vehicle in hot condition.
- Warm up engine until engine coolant temperature gauge shows nearly center, and then stop it.
  - Remove rocker cover.
  - Turn the crankshaft.

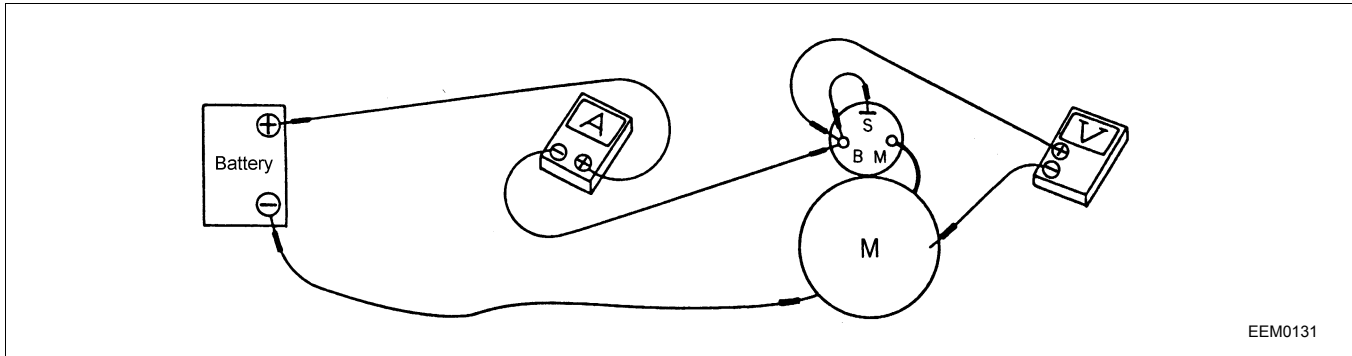
**⚠ CAUTION:**

**Disconnect IGN/coil from ignition coil when rotating crankshaft with starter motor.**

# STARTER MOTOR

## Assembly Inspection

- Inspection for abrasion between the armature core and the ball core.
- Starter motor inspection (performance with no load)



## PROCEDURE

- Connect an ammeter to the battery positive terminal and the B terminal.
- Connect a test wire to the B terminal and S terminal.
- Connect a voltmeter to the B terminal and the starter motor body.
- Connect a test wire to the battery negative terminal and the starter motor body.

## JUDGEMENT

- The pinion gear should pop out and the starter motor should rotate.



# ADJUSTMENT VALUE

---

## VALVE MECHANISM

- Valve clearance (Hot) : mm (in)  
Standard Intake 0.38 (0.015)  
Exhaust 0.38 (0.015)

## VALVE

- Head outer diameter : mm (in)  
Standard Intake 38.0 - 38.3 (1.496 - 1.508)  
Exhaust 32.0 - 32.3 (1.260 - 1.272)
- Valve total length : mm (in)  
Intake 98.85 - 99.45 (3.892 - 3.915)  
Exhaust 98.95 - 99.55 (3.896 - 3.919)
- Valve stem outer diameter : mm (in)  
Standard Intake 6.965 - 6.980 (0.2742 - 0.2748)  
Exhaust 6.945 - 6.960 (0.2734 - 0.2740)
- Valve spring free length : mm (in)  
Intake and exhaust 44.92 (1.769)  
Valve-opening compressed length : mm/N (mm/kg) [in/lb]  
Intake and exhaust  
25.0/347.0 - 391.2 (25.0/35.4 - 39.9) [0.984/78.1 - 88.0]  
Valve spring installation length (when closed) : mm/N (mm/kg)  
[in/lb]  
Intake and exhaust  
33.8/177.9 - 200.7(33.8/18.1 - 20.5) [1.331/40.0 - 45.1]  
Valve spring slant : mm (in)  
Intake and exhaust 1.5 (0.059)
- Clearance between valve stem and valve guide : mm (in)  
Standard Intake 0.015 - 0.048 (0.0006 - 0.0019)  
Exhaust 0.040 - 0.073 (0.0016 - 0.0029)  
Repair limit Intake 0.10 (0.0039)  
Exhaust 0.10 (0.0039)  
Valve seat width : mm (in)  
Intake 1.1 - 1.4 (0.043 - 0.055)  
Exhaust 1.8 - 2.2 (0.071 - 0.087)  
Valve seat angle  
Intake and  
exhaust. 44°23'∧ 45°07'  
Valve face angle  
Intake 45°15'∧ 45°45'  
Exhaust 44°30'∧ 45°

## CAMSHAFT

- Bend : mm (in)  
Repair limit 0.05 (0.0020)
- End play : mm (in)  
Standard 0.15 - 0.23 (0.0059 - 0.0091)  
Repair limit 0.40 (0.0157)
- Journal dimensions : mm (in)  
Standard Front 45.434 - 45.447 (1.7887 - 1.7892)  
Center 43.897 - 43.910 (1.7282 - 1.7287)  
Rear 41.218 - 41.231 (1.6228 - 1.6233)
- Oil clearance at journal : mm (in)  
Standard Front 0.025 - 0.051 (0.0010 - 0.0020)  
Center 0.038 - 0.064 (0.0015 - 0.0025)  
Rear 0.025 - 0.051 (0.0010 - 0.0051)  
Repair limit Front 0.10 (0.0039)  
Center 0.15 (0.0059)  
Rear 0.10 (0.0039)

 **CAUTION:**

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

## **Installation**

Note the following, and install in the reverse order of removal.

- Do not allow oil to get on the engine mount insulator. Be careful not to damage the engine mount insulator.
- Securely insert positioning stopper pin into mating side hole.
- Make sure all mount insulators are seated properly, then tighten mount nuts and bolts.

## **Inspection**

- Before starting engine, check amount of engine coolant, oil and grease. Refill as necessary.
- Start engine and check for any unusual noise and vibration.
- Warm up engine, and then check engine coolant, oil and grease, fuel, and exhaust gas for leakage.

## Inspection and Correction (Cont'd)

### VALVE SEAT PROCESSING

- Cut the valve seat to the specified dimensions using a valve seat cutter set and valve seat grinder (commercial service tool).

#### ⚠ CAUTION:

**Tightly hold the cutter handle with both hands when using a valve seat cutter, and cut the entire periphery of the contacting face without a break while pressing the cutter.**

**Poor pressure onto the cutter or repeated cutting may create steps in the seat.**

- Cut the valve seat to the dimensions specified in the figure.  
Standard processing dimensions

**D1: 35.9 - 36.1 mm**

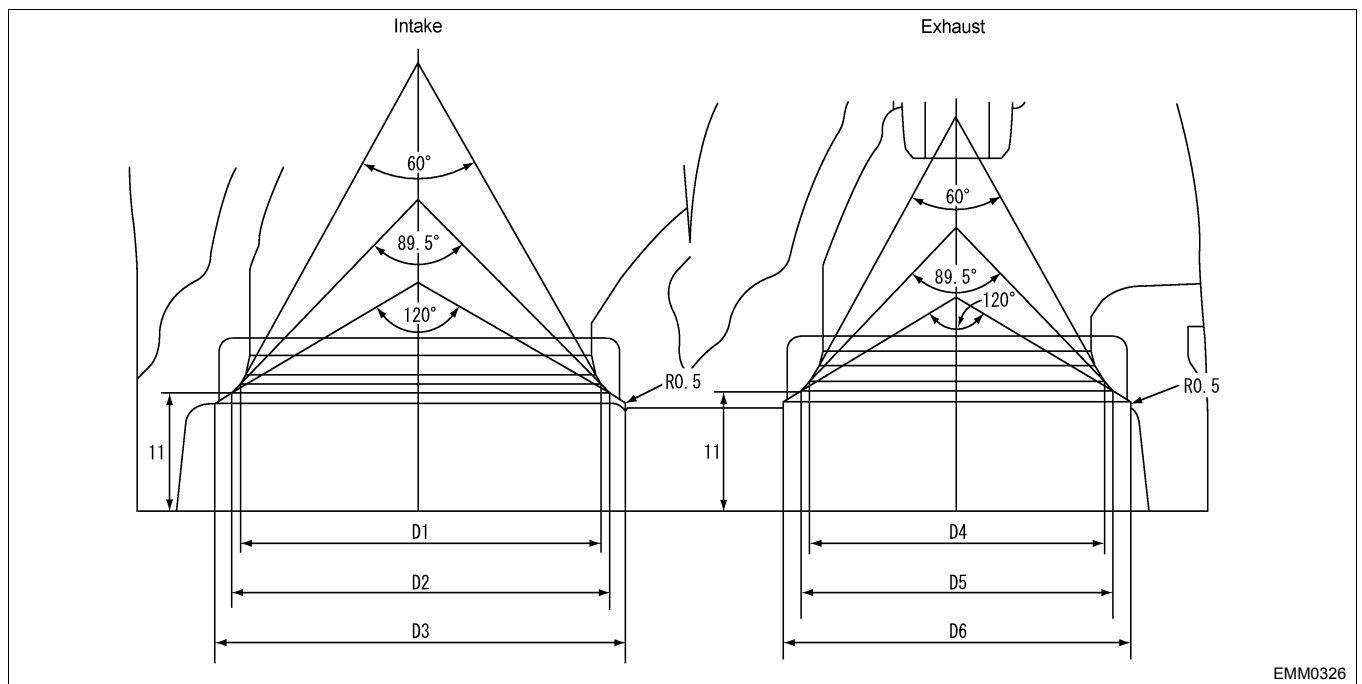
**D2: 37.6 - 37.8 mm**

**D3: 41.0 mm**

**D4: 28.6 - 28.8 mm**

**D5: 31.4 - 31.6 mm**

**D6: 35.0 mm**

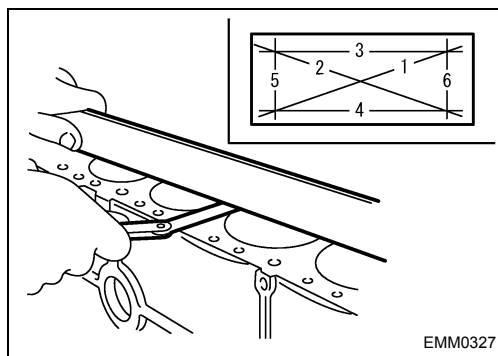


#### 4. Cylinder block

Measure distortion of the cylinder block top face in the longitudinal and lateral directions.

Measuring cylinder block distortion.

- Remove any foreign material deposits such as carbon from the cylinder block.
- (Use a straight ruler and filler gauge for distortion measurement)
- Visually check for any cracks and damages.
- Measure distortion at six points on the head top face. If the measured distortion exceeds the specified limit, correct the head top face with a surface grinder or an equivalent tool, or replace the head.



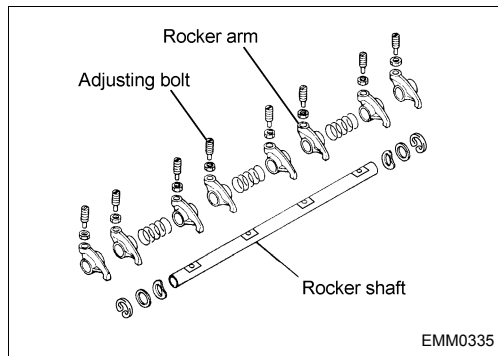
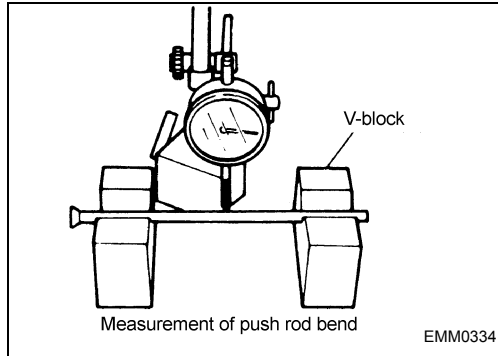
## Inspection and Correction (Cont'd)

### 18. Push rod

- Inspect the push rod and replace it if excessive wear, twist or damage is observed. If a bend of 0.05 mm or more is present, repair or replace the push rod.

### 19. Rocker shaft

- Check the rocker shaft for wear, damage or bend and replace it if wear of 0.05 mm or more is observed.



### 20. Rocker arm and adjusting bolt

- Inspect the valve stem-to-rocker shaft contact face of the rocker arm and adjusting bolt. If excessive wear is found or the rocker shaft clearance exceeds the specified limit, replace the rocker arm (adjusting bolt).

	Standard	Repair limit
Rock arm/shaft Clearance mm (in)	0.020 - 0.054 (0.0008 - 0.0021)	0.1 (0.0039)

### 21. Flywheel

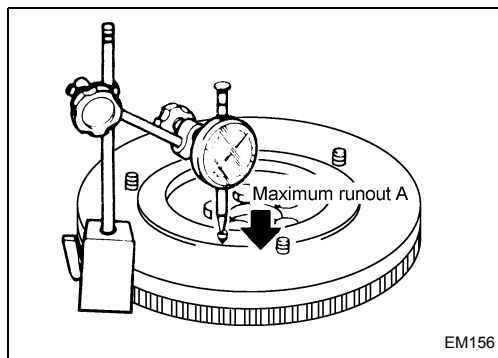
- Inspect the flywheel sliding face and the ring gear teeth.
- If excessive damage or wear is observed, repair or replace the relevant component.
- If the wear of the flywheel ring gear is relatively small, reuse the ring gear by shifting the installation position by 45 degrees.  
To install a new ring gear, heat it to 180°C and use a compression fitting method.

### MEASURING FLATNESS

- Measure the flatness while turning the crankshaft using a dial gauge.
- The flatness limit A is the maximum allowable flatness measured vertically to the flywheel clutch sliding face.

Flywheel flatness limit

**A: 0.1 mm (0.004 in) or less**

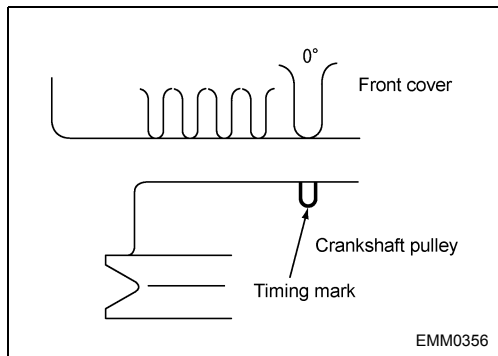


## Engine Assembly (Cont'd)

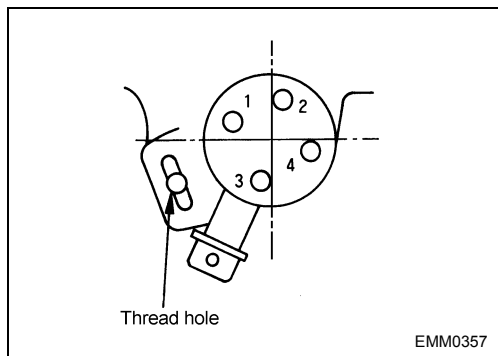
### 19. Installation of engine accessories

- Install the oil pressure switch.
- Installing oil pump (all models) and distributor (carburetor model)

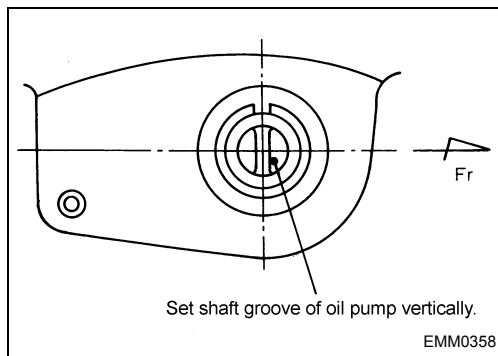
(1) Set the crankshaft position to the compression TDC for cylinder No.1.



(2) Locate the distributor so that the center of its flange long hole aligns to the bolt hole on the cylinder block, and insert the distributor. (Do not turn the distributor to align the holes)



(3) Align the drive shaft groove of the engine lubricating oil pump.



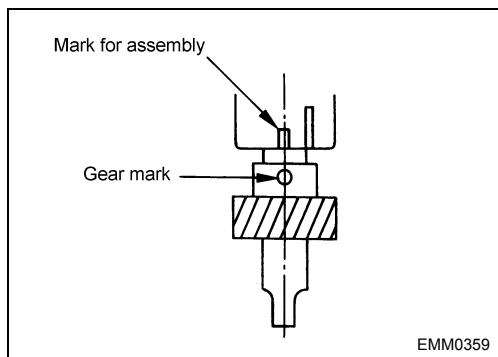
(4) Align the distributor gear mark to the short mark on the housing.

#### ⚠ CAUTION:

**Do not align the gear mark to the gear installation pin or the long mark.**

(5) Tentatively tighten the retaining bolts.

(6) After installing the distributor gear, adjust the ignition timing by using a timing light. Then, fully tighten the retaining bolts.

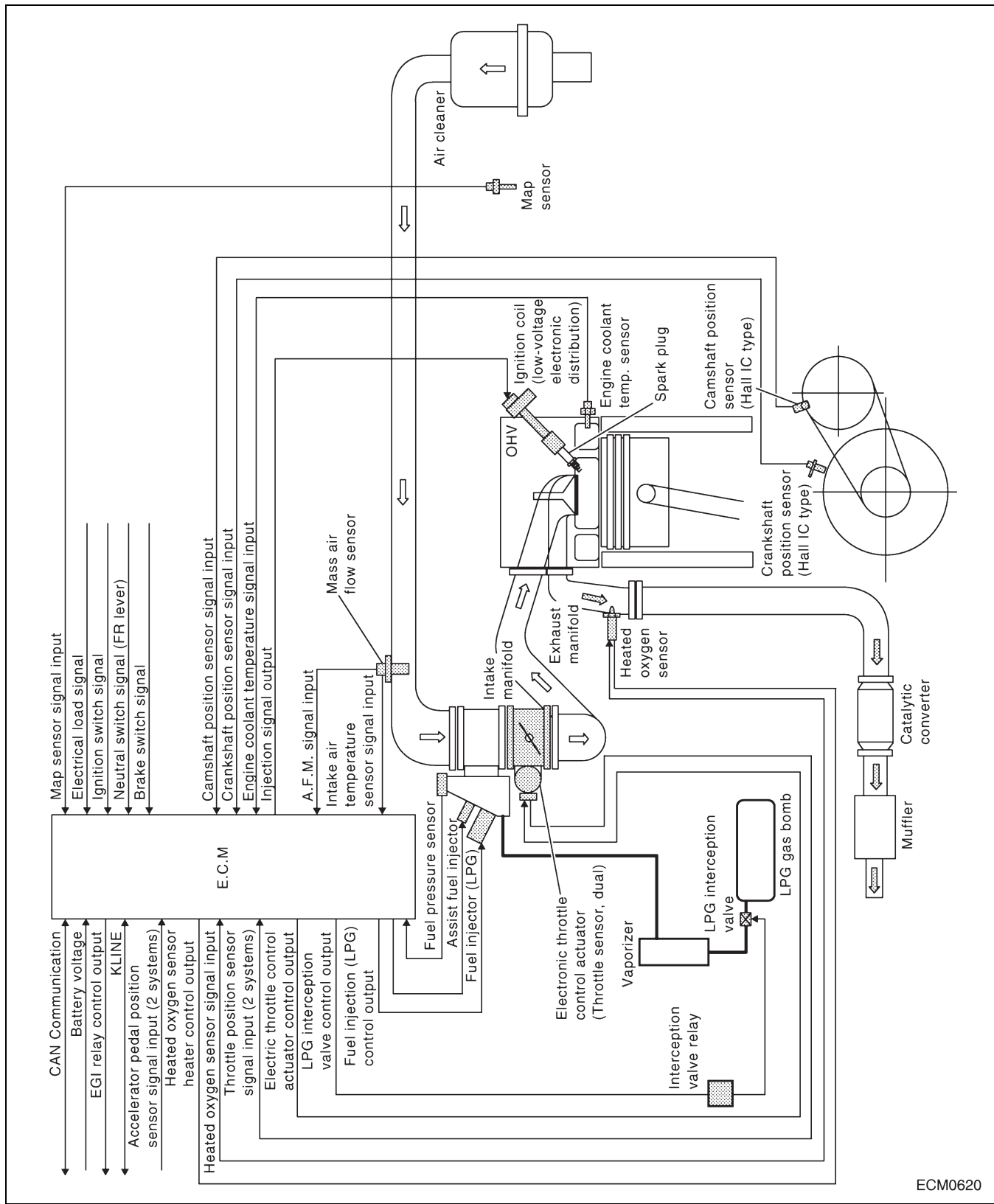


Idle speed and ignition timing (BTDC°/rpm)	Electronic controlled specifications 0°/700 rpm
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# DESCRIPTION

## Description (Cont'd)

### K-ENGINE ELECTRONIC CONTROLLED SYSTEM DIAGRAM (LPG)



# TROUBLE DIAGNOSIS

## ECM Terminal (Cont'd)

Terminal signal	Description	Measurement condition	Measured value
98	Accelerator pedal position sensor 2	At Idle	Approx. 0.335 - 0.435V
		Ignition switch ON with engine stopped Accelerator pedal is fully depressed	Approx. 0.335 - 0.435V
		Ignition switch ON with engine stopped Accelerator pedal is released	Approx. 2.2 - 2.3V
		At approx. 2,000 rpm	Approx. 0.35V
106	Accelerator pedal position sensor 1	At Idle	Approx. 0.67 - 0.87V
		Ignition switch ON with engine stopped Accelerator pedal is fully depressed	Approx. 0.67 - 0.87V
		Ignition switch ON with engine stopped Accelerator pedal is released	Approx. 4.4 - 4.6V
		At approx. 2,000 rpm	Approx. 0.65V
27	PTC heater relay (Except North America)	At idle after warming up	Approx. 0V
		Ignition switch ON when the engine coolant temperature is 30°C (86°F) or less (except for cranking)	Battery voltage
104	Throttle control motor relay	Ignition switch ON, engine running	Approx. 1V
112	LPG interception valve relay	Engine running	Battery voltage
		Ignition switch OFF	Approx. 0V
113	Gasoline F/P relay	For approximately 1 second after ignition switch ON	Approx. 1V
		After that	Battery voltage
		At cranking, engine running	Approx. 1V
3	Throttle control motor relay power supply	Always	Battery voltage
48	Sensor power supply	Ignition switch ON, engine running	Approx. 5V
49	Fuel changing switch power supply	Changing switch ON	Approx. 5V
		Changing switch ON (At neutral)	Approx. 0V
90	Accelerator pedal position sensor 1 power supply	Ignition switch ON, engine running	Approx. 5V
91	Accelerator pedal position sensor 2 power supply	Ignition switch ON, engine running	Approx. 2.5V
110	Power supply for ECM (backup)	Always	Battery voltage
118 121	Power supply for ECM	Ignition switch ON, engine running	Battery voltage
4	Throttle control motor (Close)	At idle after warming up	Approx. 2 - 2.5V
		At approx. 2,000 rpm	
5	Throttle control motor (Open)	At idle after warming up	Approx. 0.1 - 0.15V
		At approx. 2,000 rpm	
11	LPG assistance injector	At idle after warming up	Battery voltage



## Service Tool (Cont'd)

- **Driving condition B**

Driving condition B is the condition that all diagnosis can be performed just once.

Specifically, count up the counter if all of the following conditions are satisfied.

- The engine speed becomes 400 rpm or more.
- The engine coolant temperature becomes 70°C (158°F) or more.
- The vehicle speed of 6 - 40 km/h (4 - 25 MPH) continues for 3 seconds or more at closed loop control.
- The vehicle speed of 4 km/h (2 MPH) or less and the idle determination ON continue for 5 seconds or more at closed loop control.
- Allow 6 minutes or more to pass after starting the engine.

**NOTE:**

- When the same malfunction is detected regardless of the driving condition, the B counter is reset.
- Count up the B counter when the above conditions are satisfied while the same malfunction is not detected.

When the B counter reaches 3 without the malfunctions, MIL turns OFF.

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