



Service Manual

6M60-TL Diesel Engine

6M6

(for industrial use)

Shop Manual

diesel engine

FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of the Mitsubishi 6M60-TL series diesel engine, and includes procedures for adjustment and maintenance services.

We earnestly look forward to seeing that this manual is made full use of in order to perform correct services with no wastage.

For more details, please consult your nearest authorized Cat® lift truck dealer.

Kindly note that the specifications and maintenance service figures are subject to change without prior notice in line with improvement which will be effected from time to time in the future.

SEPTEMBER 2006

Applicable models
6M60-TL

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GROUP 00 GENERAL

00

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HOW TO READ THIS MANUAL

This manual consists of the following parts:

- Specifications
- Structure and Operation
- Troubleshooting
- General Inspection and Adjustment
- Service procedures

General Inspection and Adjustment

- Procedures for inspection and adjustment of individual parts and assemblies as mounted on the machine are described including specific items to check and adjust. Specified or otherwise, inspection should be performed for looseness, play, backlash, crack, damage, etc.

Service procedure

- Procedures for servicing components and parts off the machine are described centering on key points in their removal, installation, disassembly, reassembly, inspection, etc.

Inspection

- Check items subject to “acceptable/unacceptable” judgement on the basis of service standards are all given.
- Some routine visual checks and cleaning of some reused parts are not described but must always be included in actual service work.

Caution

- This service manual contains important cautionary instructions and supplementary information under the following four headings which identify the nature of the instructions and information:

DANGER ⚠

Precautions that should be taken in handling potentially dangerous substances such as battery fluid and coolant additives.

WARNING ⚠

Precautionary instructions, which, if not observed, could result in serious injury or death.

CAUTION ⚠

Precautionary instructions, which, if not observed, may result in damage to or destruction of equipment or parts.

NOTE

Suggestions or supplementary information for more efficient use of equipment or better understandings.

Terms and Units

- Front and rear
The forward running direction of the machine is referred to as the front and the reverse running direction is referred to as the rear.
- Left and right
Left hand side and right hand side, when facing the forward running direction of the machine, are respectively left and right.

Standard value

- Standard value dimensions in designs indicating: the design dimensions of individual parts, the standard clearance between two parts when assembled, and the standard value for an assembly part, as the case may be.

Limit

- When the value of a part exceeds this, it is no longer serviceable in respect of performance and strength and must be replaced or repaired.

Tightening torque

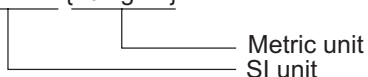
- Values are directly specified for out-of-standard tightening torques for bolts and nuts.
- Where there is no specified figure for tightening torque, follow the table covering standard tightening torques.
- When the item is to be tightened in a wet state, "wet" is indicated. Where there is no indication, read it as dry.

Units

- Tightening torques and other parameters are given in SI* units with metric units added in brackets { }. Values in engine specifications, performance curves, and other items taken from official approval documents are given only in metric units.

*SI: Le Système International d'Unités

Example: 390 N·m {40 kgf·m}

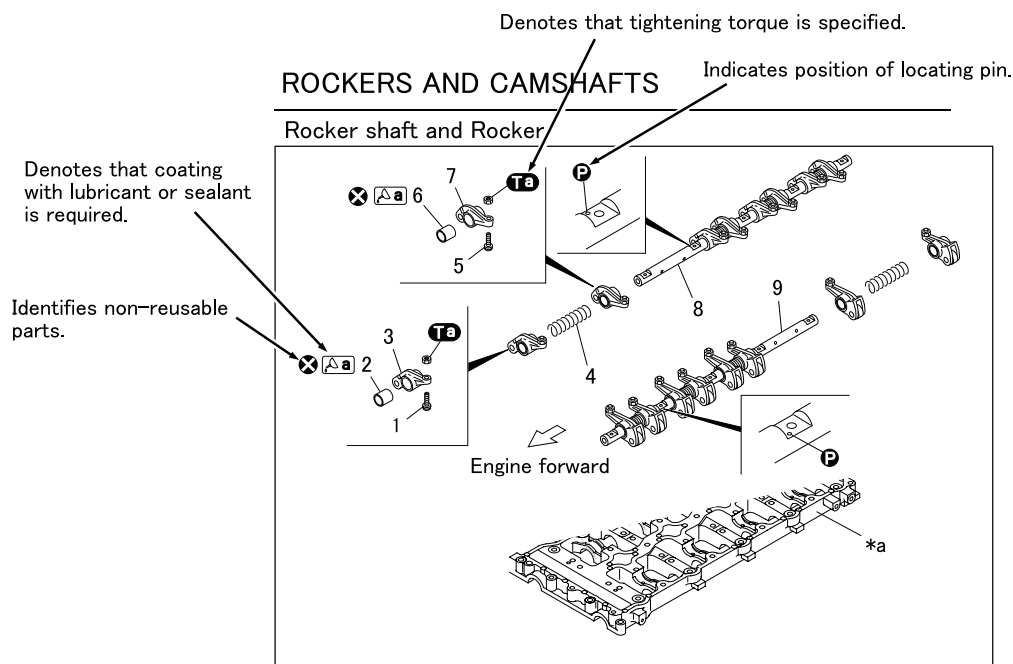


Item		SI unit {metric unit}	Conversion factor
Force		N {kgf}	9.80665 N {1 kgf}
Moment of force		N·m {kgf·m}	9.80665 N·m {1 kgf·m}
Pressure	Positive pressure	kPa {kgf/cm ² }	98.0665 kPa {1 kgf/cm ² }
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmH ₂ O}	9.80665 Pa {1 mmH ₂ O}
Volume		dm ³ {L}	1 dm ³ {1 L}
Heat quantity		J {kcal}	4186.05 J {1 kcal}
Heat flow		W {kcal/h}	1.16279 W {1 kcal/h}
Power		kW {PS}	0.7355 kW {1 PS}
Angle		°	—
Temperature		°C	—
Electric current		A	—
Voltage		V	—
Resistance		Ω	—
Electric power		W	—

Unit	SI unit	Foot-pound unit	Conversion rate
Force	N (Newton)	lbf	1 N = 0.2248 lbf
Moment of force	N·m	lbf.ft	1 N·m = 0.7375 lbf.ft
Pressure	kPa (kilopascal)	lbf/in. ²	1 kPa = 0.145 lbf/in. ² 1 kPa = 0.2953 in. Hg
Volume	L	gal.	1 L = 0.2642 gal. (U.S.)
	cm ³	oz	1 L = 0.220 gal. (Imp.) 1 cm ³ = 0.033814 oz (U.S.)
	cm ³	cu.in.	1 cm ³ = 0.035195 oz (Imp.) 1 cm ³ = 0.061023 cu.in.
Power	kW (kilowatt)	HP	1 kW = 1.34 HP
Temperature	°C	°F	t°C = (1.8t°C + 32)°F
Mass quantity of matter	kg	lb	1 kg = 2.2046 lb
	g	oz	1 g = 0.035274 oz
Dimension	m	ft.	1 m = 3.2808 ft.
	mm	in.	1 mm = 0.03937 in.
Stress	N/cm ²	lbf/in. ²	1 N/cm ² = 1.45 lbf/in. ²

HOW TO READ THIS MANUAL

Symbol	Denotation	Application	Remarks
Ta	Tightening torque	Parts not tightened to standard torques (standard torques specified where necessary for servicing)	Specified values shown in table See Table of Standard Tightening Torques for parts for which no tightening torques are specified.
P	Locating pin	Parts to be positioned for installation	
X	Non-reusable parts	Parts not to be reused	
a	Lubricant and/or sealant	Parts to be coated with lubricant or sealant for assembly or installation	Necessary lubricant and/or sealant, quantity required, etc. are specified in table.
Ca	Special tool	Parts for which special tools are required for service operation	Tool name/shape and part number are shown in table.
*a	Associated part	Parts associated with those removed/disassembled for servicing	



Disassembly sequence

- 1 Adjusting screw
- 2 Rocker bushing
- 3 Short rocker
- 4 Rocker shaft spring
- 5 Adjusting screw
- 6 Rocker bushing

- 7 Long rocker
- 8 Exhaust rocker shaft
- 9 Intake rocker shaft

*a: Camshaft frame

P: Hole for camshaft frame locating pin

X: Non-reusable parts

Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION

- The short rockers and long rockers must be installed alternately. Be aware that the order of installation for the intake rockers is different from the order of installation for the exhaust rockers.

"Wet" is indicated when part is to be tightened with oil or grease applied to its threaded section.

Service standard (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
2, 6, 8, 9	Rocker bushing-to-rocker shaft clearance	0.01 to 0.08	0.12	Replace
3, 7	Rocker (roller) radial play	0.038 to 0.100	-	Replace

These location numbers correspond with disassembly sequence numbers.

Tightening torque (Unit: N·m [kgf·m])


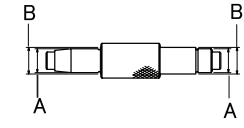
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Lock nut (adjusting screw stopping)	11.2 {1.14}	Wet

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rocker bushing inner surface	Engine oil	As required

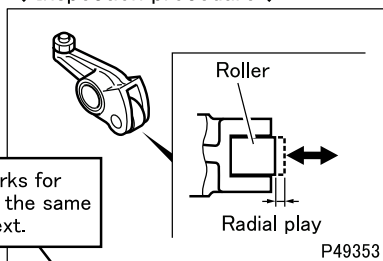
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Special tools (Unit: mm)

Special Tools (Continued)							
Mark	Tool name and shape	Part No.	Application				
	<div>Rocker bushing puller</div> <div><table><tr><td>A</td><td>B</td></tr><tr><td>φ22</td><td>φ24.5</td></tr></table></div> <div></div> <div>P29932</div>	A	B	φ22	φ24.5	MH062536	Removal and installation of rocker bushing
A	B						
φ22	φ24.5						

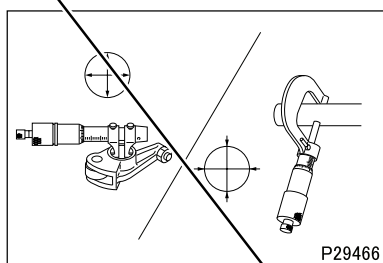
◆ Inspection procedure ◆

Identification marks for special tools are the same as used in the text.



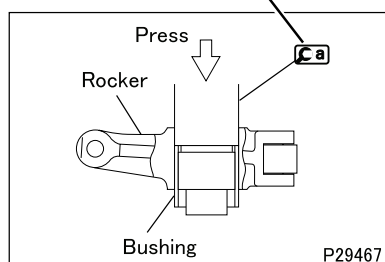
■ Inspection : Rocker (roller) radial clearance

- Replace the rocker if the radial play measurement is not within the standard value range.



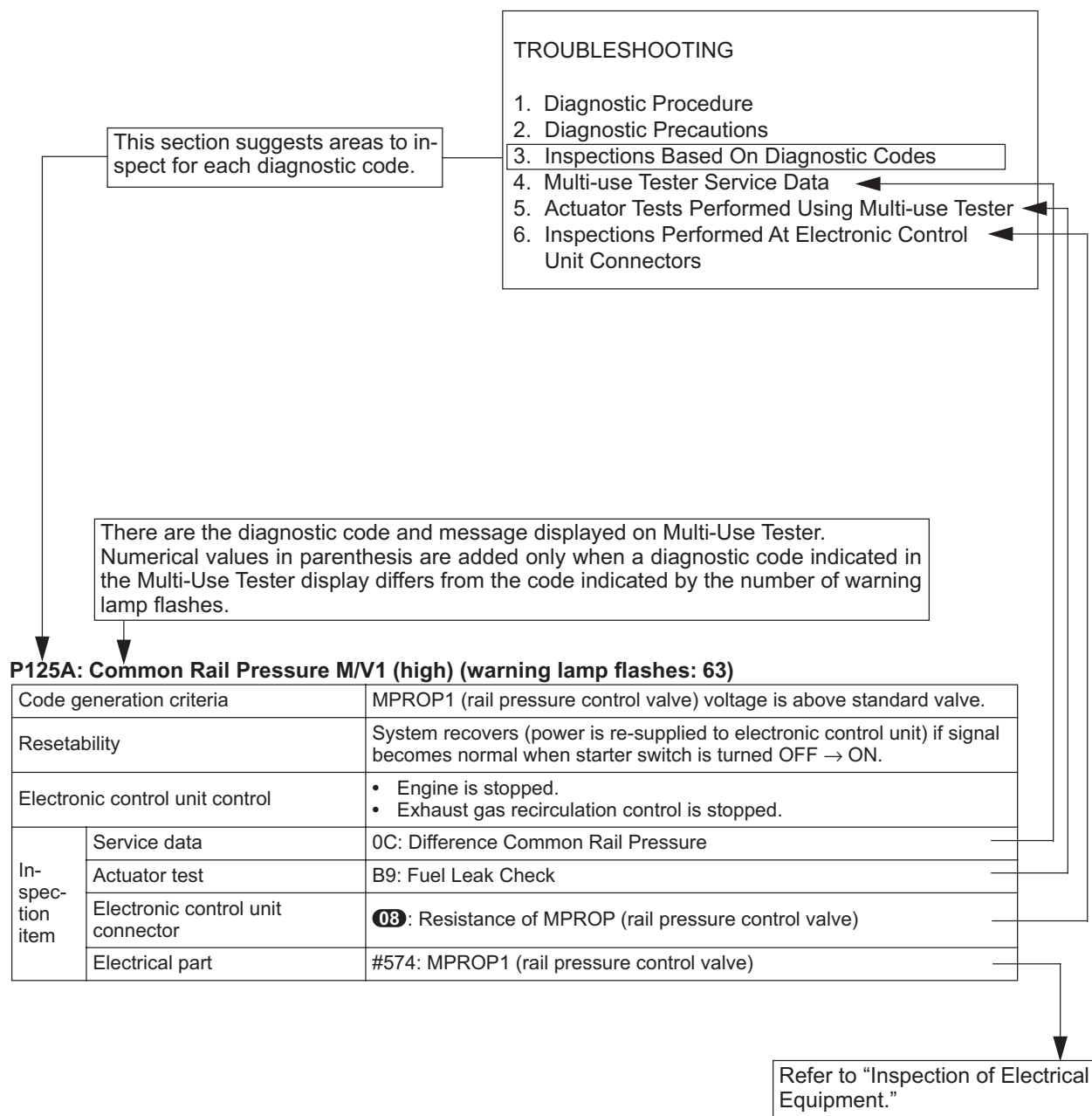
■ Inspection : Rocker bushing-to-rocker shaft clearance

- Replace the bushing if the measurement exceeds the specified limit.

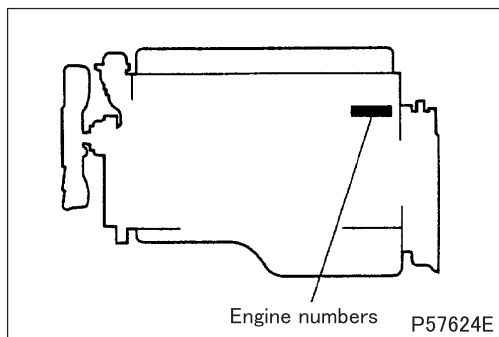
Replacement of rocker bushing
[Removal]

HOW TO READ THIS MANUAL

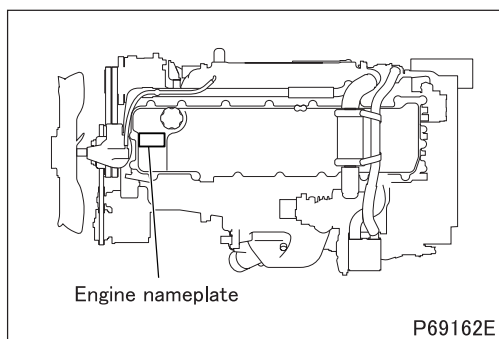
How to Use Diagnostic Codes <Electronically Controlled Fuel System (Gr13E)>



The contents of this manual include functions and parts that are not used in your truck depending on the truck specifications. Please refer to the chassis service manual for the details.



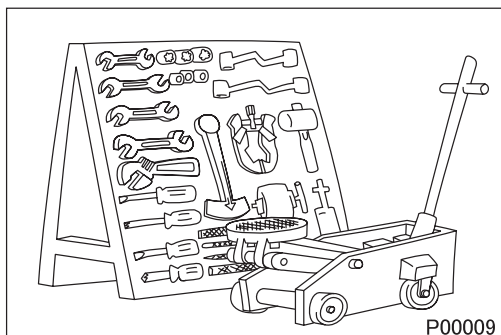
- Serial engine numbers are assigned to the engines in manufacturing sequence. Every engine has its own number. These numbers are required for registration and related inspection of the vehicle.



- An engine nameplate indicates the following item.
 - Engine model

PRECAUTIONS FOR MAINTENANCE OPERATION

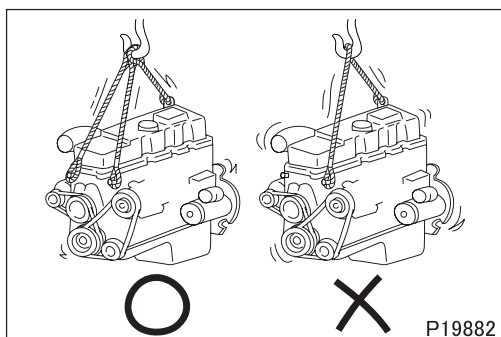
- Before performing service operations, inquire into the customer's complaints and ascertain the conditions by checking the total distance traveled, the conditions under which the vehicle is operated, and other relevant factors about the vehicle. And note the necessary information. This information will help you to service the truck efficiently.
- Check the location of the fault, and identify its cause. Based on your findings, determine whether parts must be removed or disassembled. Then, follow the service procedure given in this manual.



- Prepare all the general and special tools necessary for the job.

WARNING

- **Special tools must be used wherever specified in this manual. Do not attempt to use other tools since they could cause injuries and/or truck damage.**



- Take extreme care when removing/installing heavy items such as engine, transmission and axle. When lifting heavy items using a cable etc., observe the following precautions.

- Identify the weight of the item being lifted. Use a cable that is strong enough to support the weight.

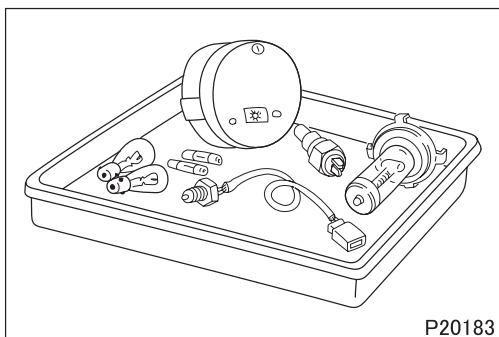


- If lifting eyes are not provided on the item being lifted, tie a cable around the item taking into account the item's center of gravity.



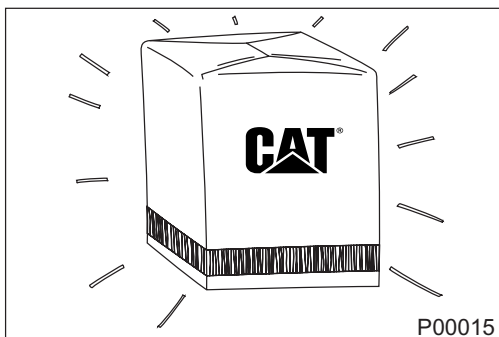
- Never work in shoes that have oily soles. When working with a partner or in a group, use pre-arranged signals and pay constant attention to safety. Be careful not to touch switches and levers unintentionally.

- Inspect for oil leakage etc. before washing the vehicle. If the order is reversed, any oil leakage or fault that may exist could go unnoticed during inspection.



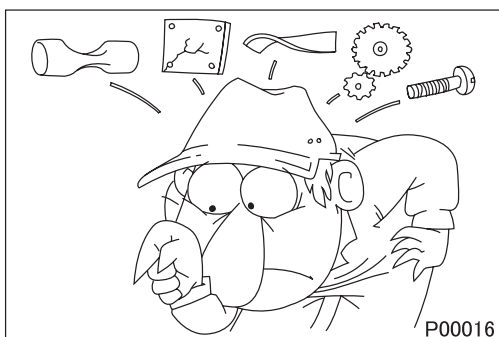
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- Prepare replacement parts ready for installation.



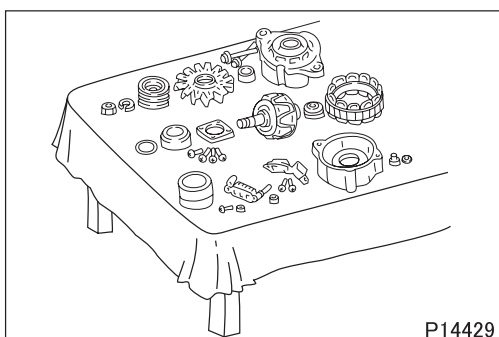
P00015

- Oil seals, packings, O-rings and other rubber parts, gaskets, and split pins must be replaced with new ones after removal. Use only genuine Cat replacement parts.



P00016

- When disassembling parts, visually check them for wear, cracks, damage, deformation, deterioration, rust, corrosion, defective rotation, fatigue, clogging and any other possible defect.

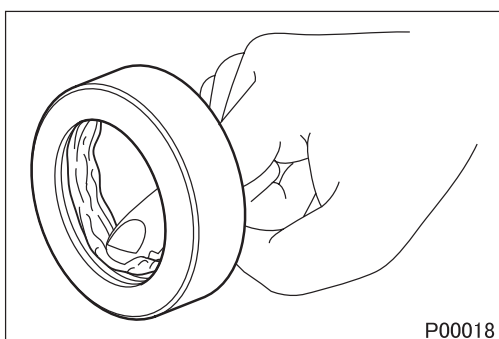


P14429

- To facilitate correct reassembly of parts, make alignment marks on them before disassembly and arrange disassembled parts neatly. Make punch marks and other alignment marks where they will not detract from parts' functionality and appearance.
- After removing parts from the vehicle, cover the area to keep it free of dust.

CAUTION ⚠

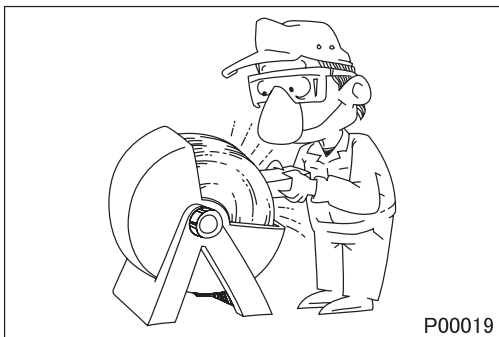
- **Be careful not to mix up identical parts, similar parts and parts that have left/right alignments.**
- **Keep new replacement parts and original (removed) parts separately.**



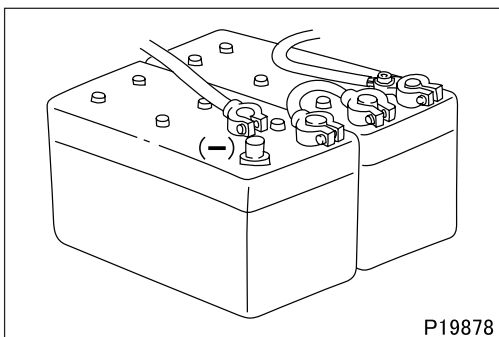
P00018

- Apply the specified oil or grease to U-seals, oil seals, dust seals and bearings before reassembly.
- Always use the specified oils and greases when performing inspection or replacement. Immediately wipe away any excess oil or grease with a rag.

PRECAUTIONS FOR MAINTENANCE OPERATION



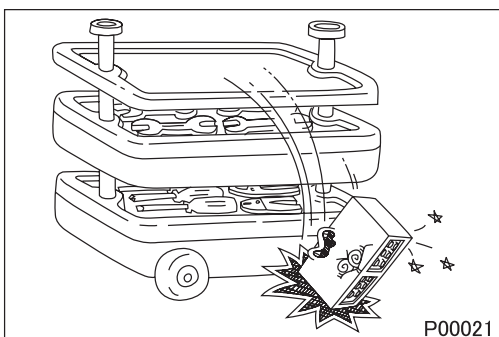
- Wear safety goggles when using a grinder or welder. Wear gloves when necessary, and watch out for sharp edges and other items that might wound your hands.



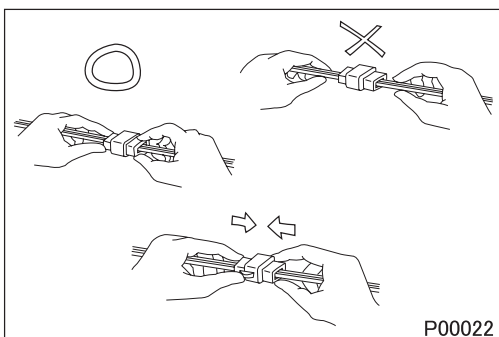
- Before working on the electrical system, disconnect the (-) battery cable to prevent short circuits.

CAUTION

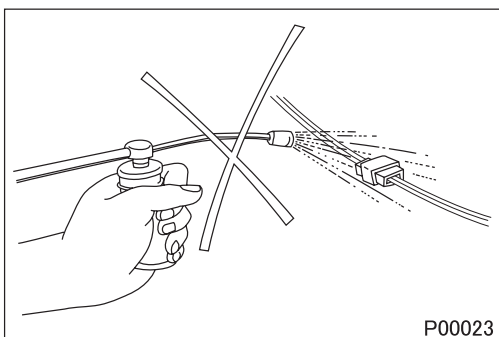
- **Make sure the starter switch and lighting switches are OFF before disconnecting or connecting battery cable. Semiconductor components may otherwise be damaged.**



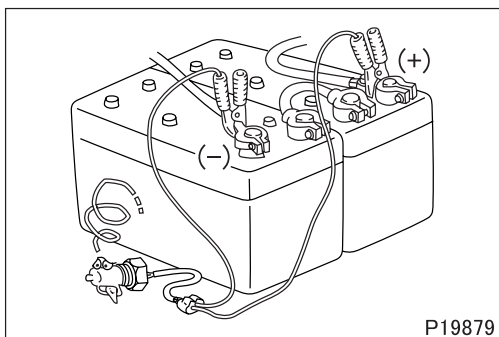
- Carefully handle sensors, relays, and other items that are sensitive to shock and heat. Do not remove or paint the cover of any control unit.



- When separating connectors, grasp the connectors themselves rather than the harnesses.
- To separate locking connectors, first push them in the direction of the arrows. To reconnect locking connectors, push them together until they click.

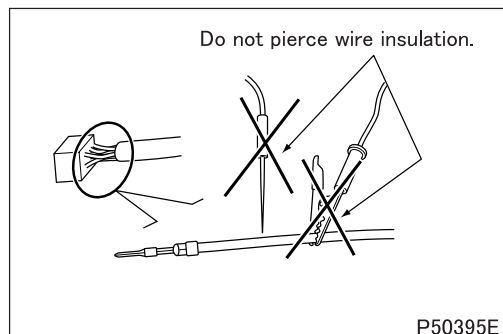


- Before washing the vehicle, cover electrical parts to keep them dry. (Use plastic sheets or the like.) Keep water away from harness connectors and sensors and immediately wipe off any water that gets on them.



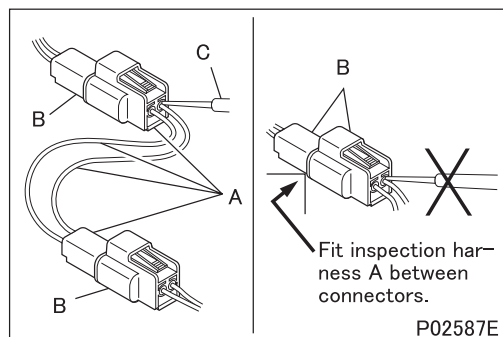
- When applying a voltage to a part for inspection purposes, check that the (+) and (-) cables are connected properly then gradually increase the voltage from zero. Do not exceed the specified voltage.
Remember that control units and sensors do not necessarily operate on the battery voltage.

1. Handling Precautions for Electric Circuits



CAUTION

- Do not pierce wire insulation with test probes or alligator clips when performing electrical inspections. Piercing the wire harness will cause corrosion.

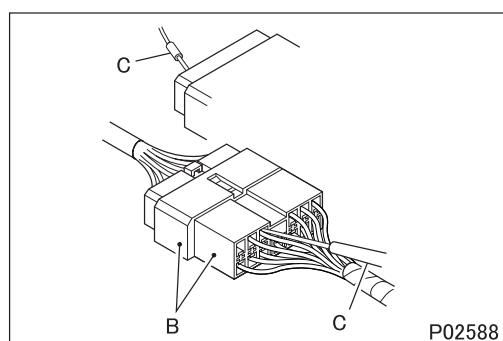


1.1 Inspection of harnesses

(1) Inspections with connectors fitted together

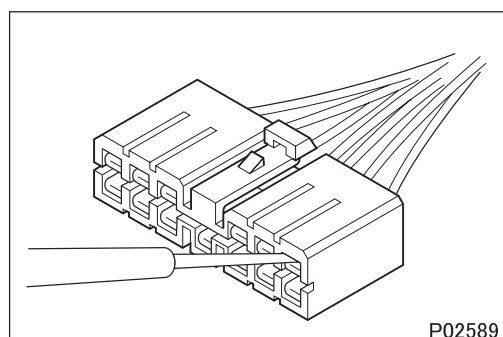
(1.1) Waterproof connectors

- Connect an inspection harness and connector **A** between the connectors **B** of the circuit to be inspected. Perform the inspection by applying a test probe **C** to the connectors of the inspection harness. Do not insert the test probe **C** into the wire-entry sides of the waterproof connectors since this would damage their waterproof seals and lead to rust.



(1.2) Non-waterproof connectors

- Perform the inspection by inserting a test probe **C** into the wire-entry sides of the connectors. An extra-narrow probe is required for control unit connectors, which are smaller than other types of connector. Do not force a regular-size probe into control unit connectors since this would cause damage.

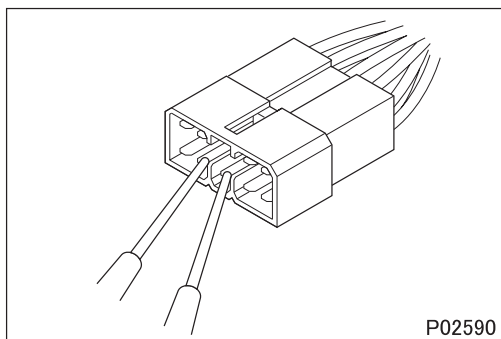


(2) Inspections with connectors separated

(2.1) Inspections on female terminals

- Perform the inspection by carefully inserting a test probe into the terminals. Do not force the test probe into the terminals since this could deform them and cause poor connections.

PRECAUTIONS FOR MAINTENANCE OPERATION

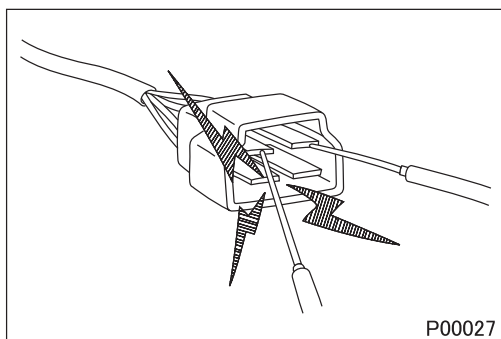


(2.2) Inspections on male terminals

- Perform the inspection by applying test probes directly to the pins.

CAUTION

- Be careful not to short-circuit pins together with the test probes. With control unit connectors, short-circuiting of pins can cause damage to the control unit's internal circuitry.

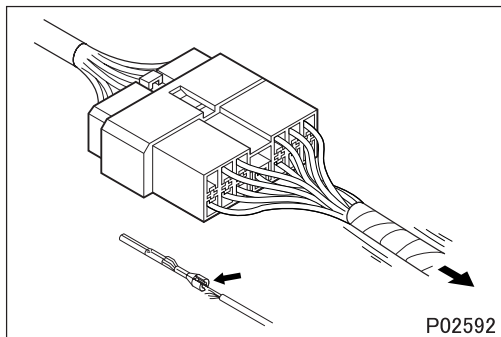
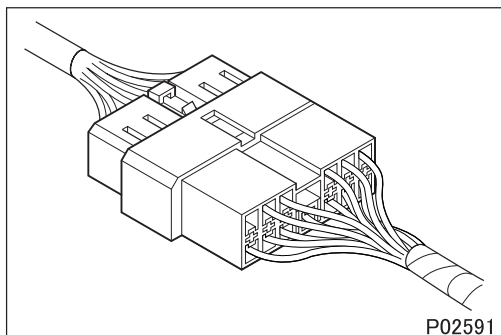


- When using a multimeter to check continuity, do not allow the test probes to touch the wrong terminals.

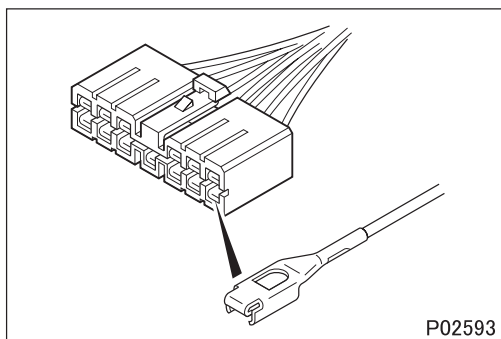
1.2 Inspection of connectors

(1) Visual inspection

- Check that the connectors are fitted together securely.

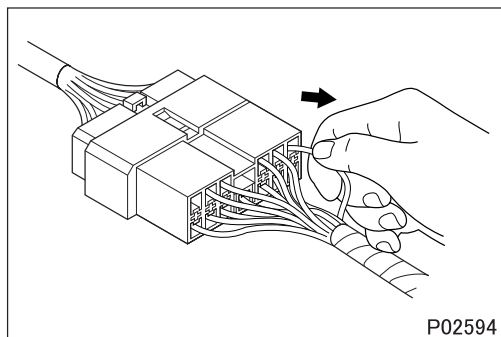


- Check whether wires have been separated from their terminals due to pulling of the harness.



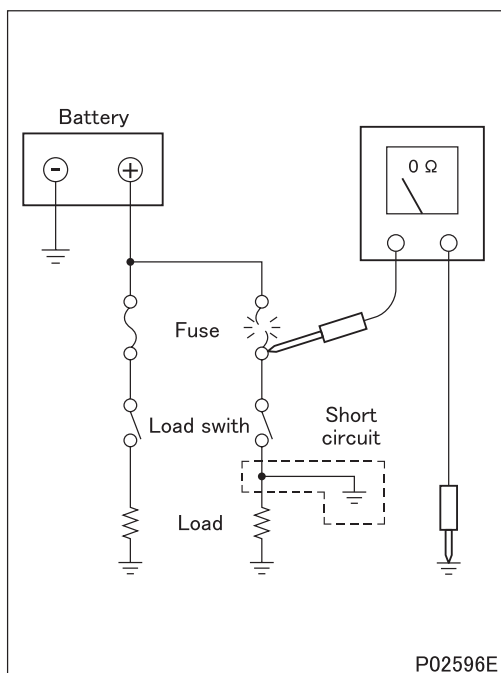
- Check that male and female terminals fit together tightly.

- Check for defective connections caused by loose terminals, by rust on terminals, or by contamination of terminals by foreign substances.



(2) Checking for loose terminals

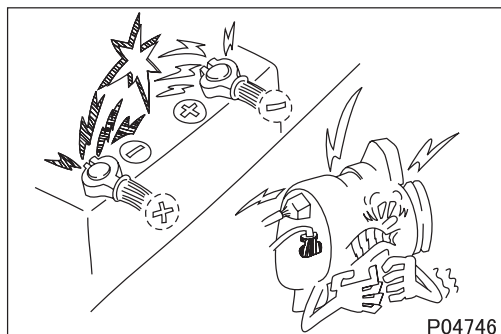
- If connector terminal retainers become damaged, male and female terminals may not mate with each other when the connector bodies are fitted together. To check for such terminals, gently pull each wire and see whether any terminals slip out of their connector housings.



1.3 Inspections when a fuse blows

- Remove the fuse, then measure the resistance between ground and the fuse's load side. Next, close the switch of each circuit connected to the fuse. If the resistance measurement between any switch and ground is zero, there is a short circuit between the switch and the load. If the resistance measurement is not zero, the circuit is not currently short-circuited; the fuse probably blew due to a momentary short circuit.
- The main causes of short circuits are as follows:
 - Harnesses trapped between chassis parts
 - Harness insulation damage due to friction or heat
 - Moisture in connectors or circuitry
 - Human error (accidental short-circuiting of components)

2. Service Precautions for Alternators



- When servicing alternators, observe the following precautions:
 - Never reverse the polarity of battery connections. If the polarity of the battery connections were to be reversed, a large current would flow from the battery to the alternator, damaging the diodes and regulator.

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