MITSUBISHI FORKLIFT TRUCKS

Service Manual

6M60-TL Diesel Engine

For use with the FD80N-FD160N Service Manuals. **99709-51100**

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 Mitsubishi forklift 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

GROUP INDEX

GROUP 00 GENERAL

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

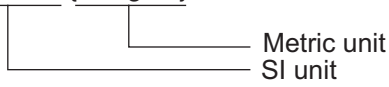
- Values are directly specified for out-of-standard tightening torques for bolts and nuts.
- Where there is no specified figure for tightening torque, follow the table covering standard tightening torques.
- When the item is to be tightened in a wet state, “wet” is indicated. Where there is no indication,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

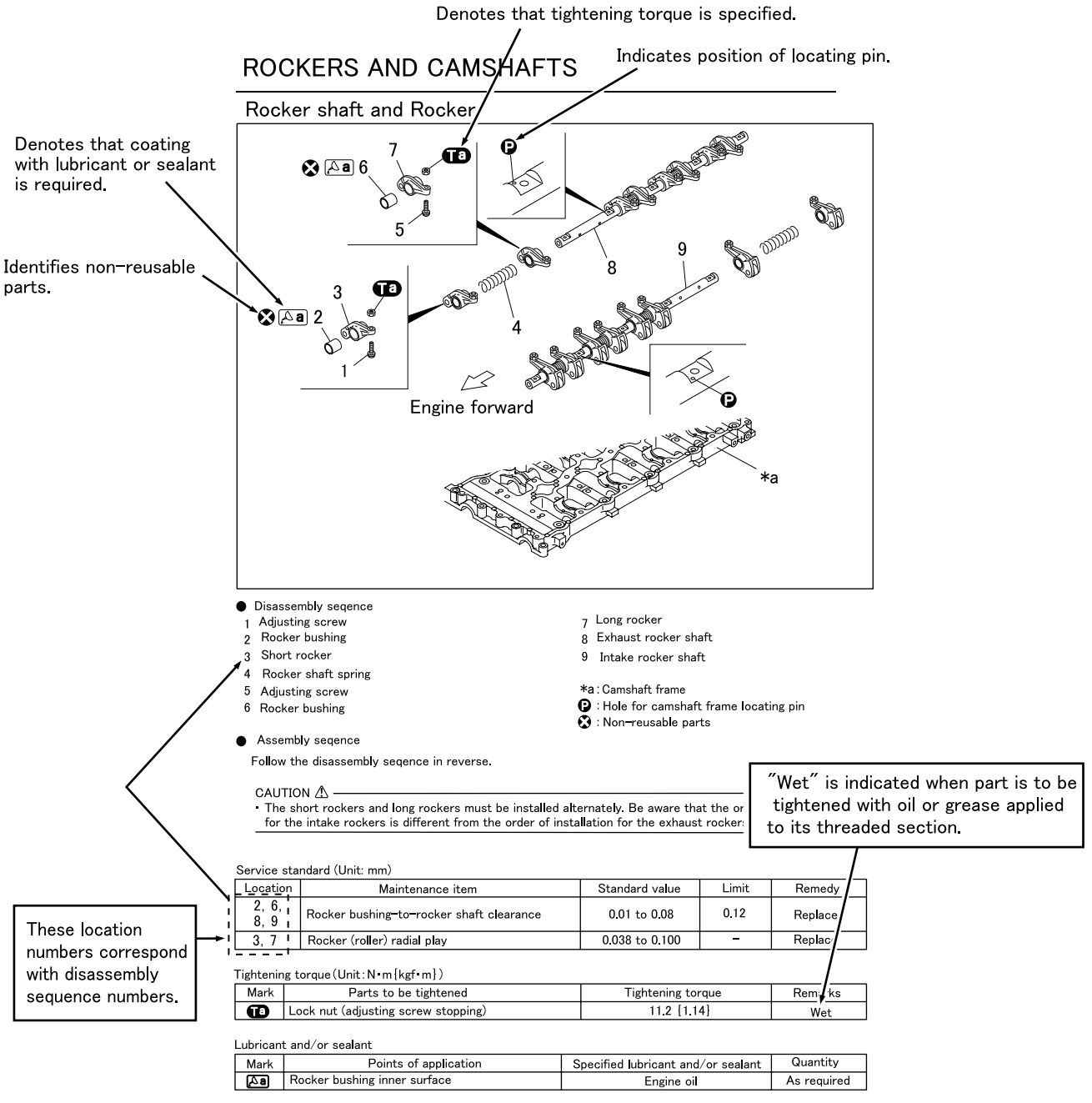


Item		SI unit {metric unit}	Conversion factor
Force		N {kgf}	9.80665 N {1 kgf}
Moment of force		N·m {kgf·m}	9.80665 N·m {1 kgf·m}
Pressure	Positive pressure	kPa {kgf/cm^2}	98.0665 kPa {1 kgf/cm^2}
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmH_2O}	9.80665 Pa {1 mmH_2O}
Volume		dm^3 {L}	1 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 cm^3 cm^3	gal. oz cu.in.	1 L = 0.2642 gal. (U.S.) 1 L = 0.220 gal. (Imp.) 1 cm^3 = 0.033814 oz (U.S.) 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 g	lb oz	1 kg = 2.2046 lb 1 g = 0.035274 oz
Dimension	m mm	ft. in.	1 m = 3.2808 ft. 1 mm = 0.03937 in.
Stress	N/cm^2	lbf/in.^{2}	1 N/cm^2 = 1.45 lbf/in.^{2}

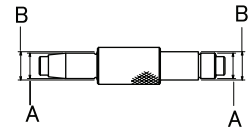
HOW TO READ THIS MANUAL

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	
⊗	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.
a	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	

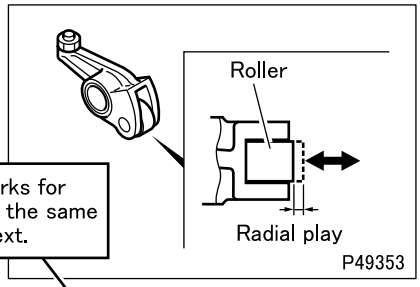


P58002E

Special tools (Unit : mm)

Mark	Tool name and shape	Part No.	Application
ⓒa	Rcker bushing puller A: φ22, B: φ24.5  P29932	MH062536	Removal and installation of rocker bushing

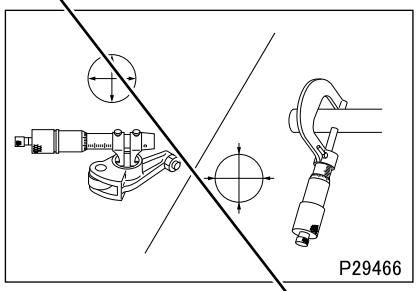
◆Inspection procedure◆



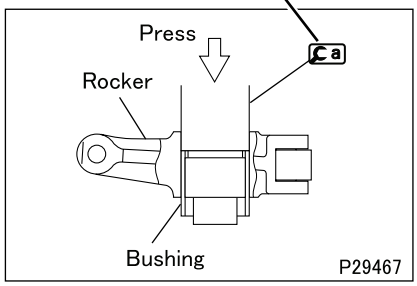
P49353

■ Inspection : Rocker (roller) radial clearance
- Replace the rocker if the radial play measurement is not within the standard value range.

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


P29466

■ Inspection : Rocker bushing–to–rocker shaft clearance
- Replace the bushing if the measurement exceeds the specified limit.

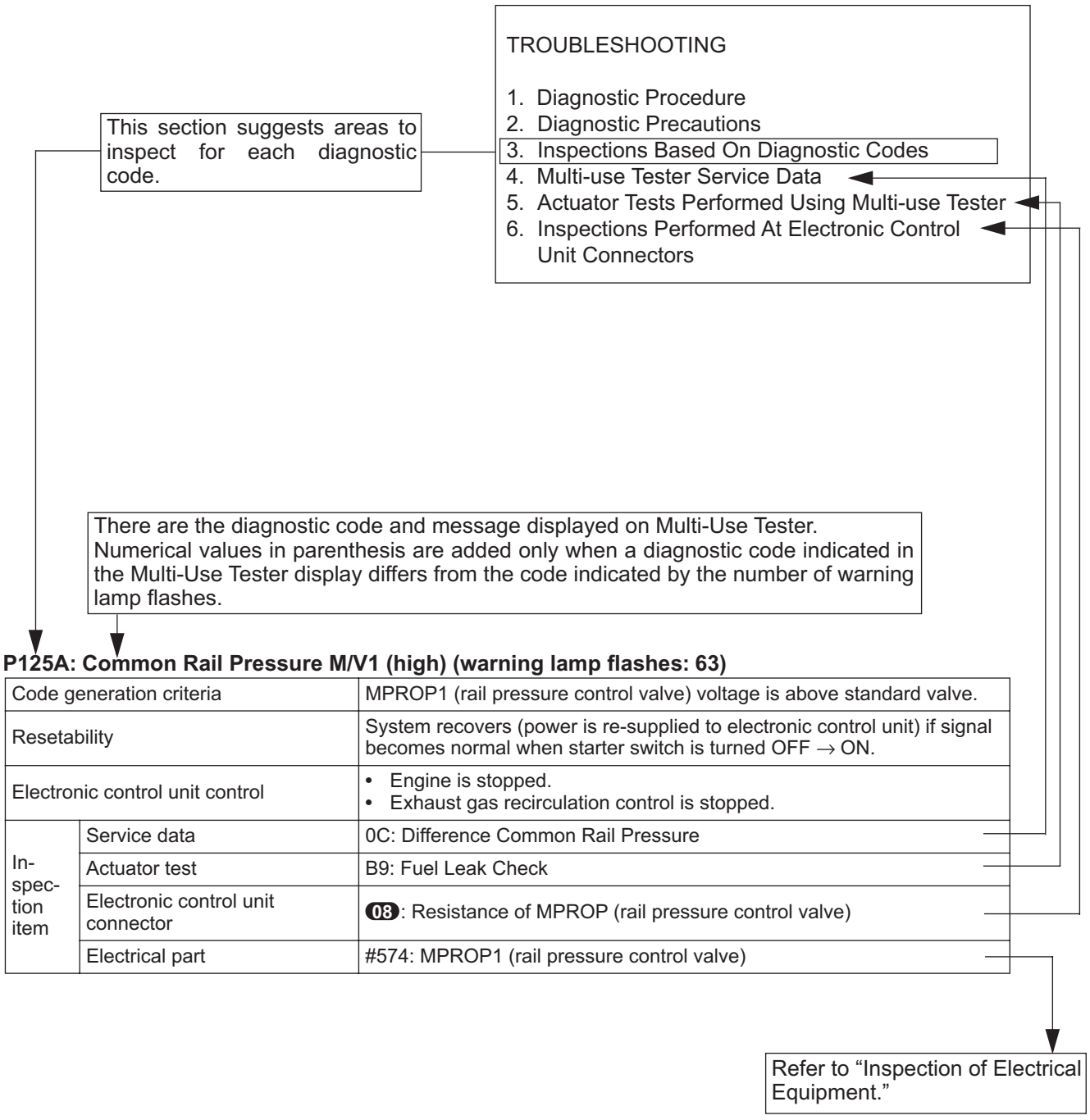


P29467

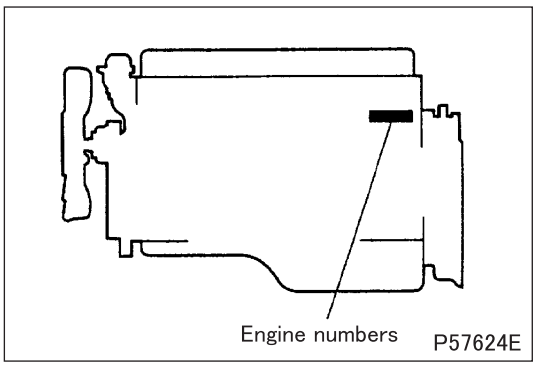
Replacement of rocker bushing
[Removal]

P58003E

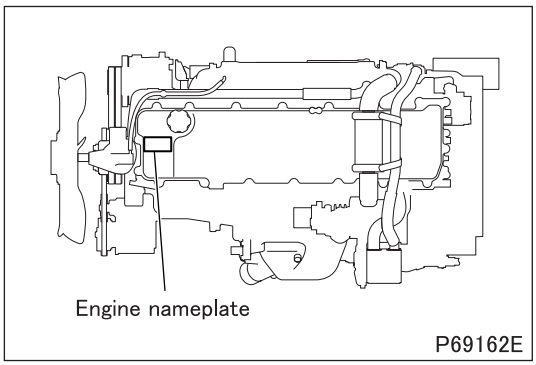
How to Use Diagnostic Codes <Electronically Controlled Fuel System (Gr13E)>



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.



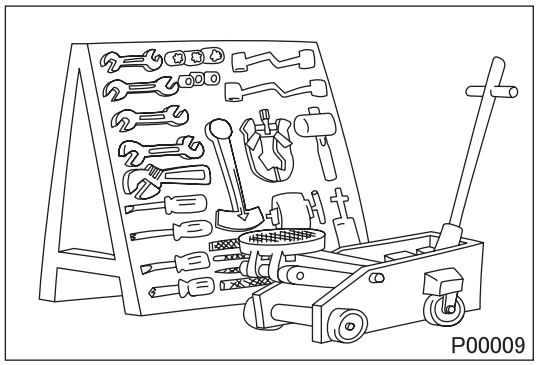
- Serial engine numbers are assigned to the engines in manufacturing sequence. Every engine has its own number. These numbers are required for registration and related inspection of the vehicle.



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

PRECAUTIONS FOR MAINTENANCE OPERATION

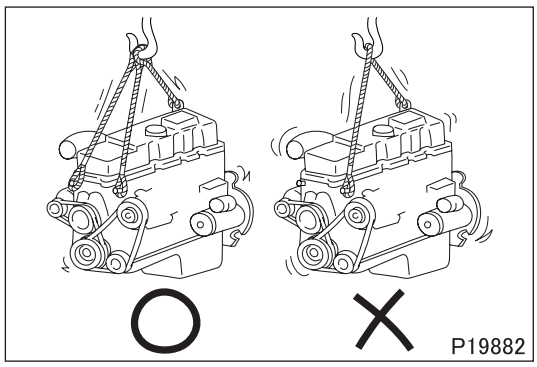
- Before performing service operations, inquire into the customer's complaints and ascertain the conditions by checking the total distance traveled, the conditions under which the vehicle is operated, and other relevant factors about the vehicle. And note the necessary information. This information will 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.


P00009

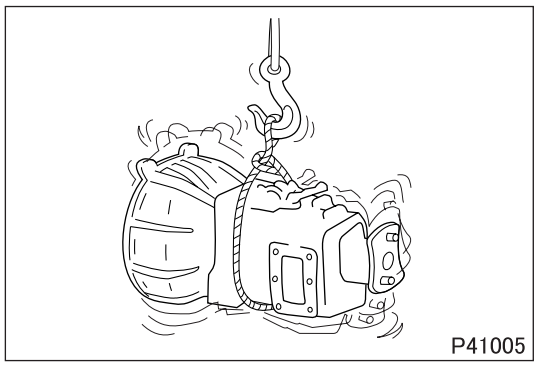
- Prepare all the general and special tools necessary for the job.

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.**


P19882

- 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.

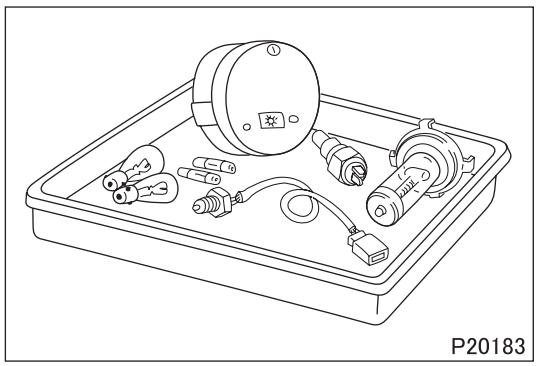

P41005

  - 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.

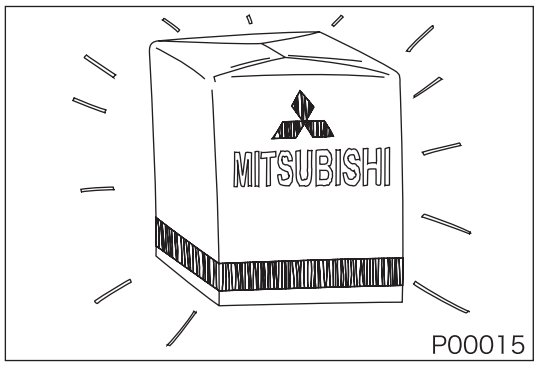

P00012

- 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.

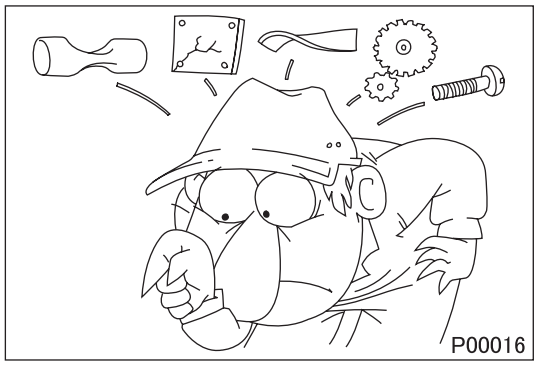

P20183

- Prepare replacement parts ready for installation.

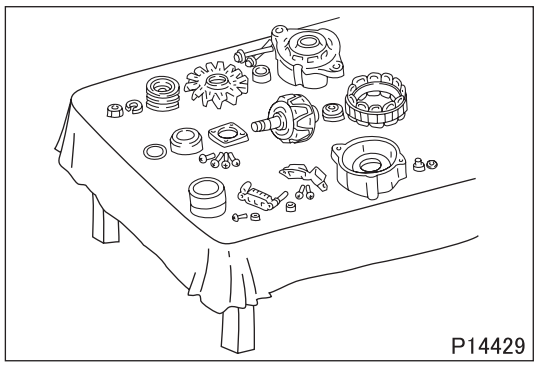


P00015

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


P00016

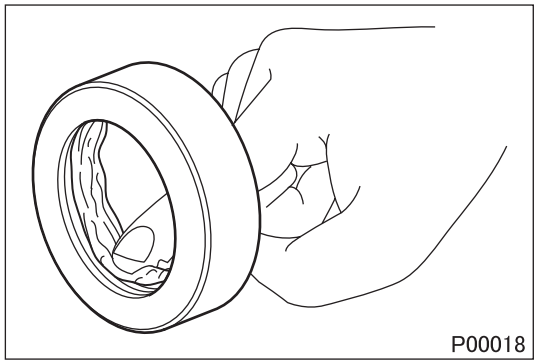
- When disassembling parts, visually check them for wear, cracks, damage, deformation, deterioration, rust, corrosion, defective rotation, fatigue, clogging and any other possible defect.


P14429

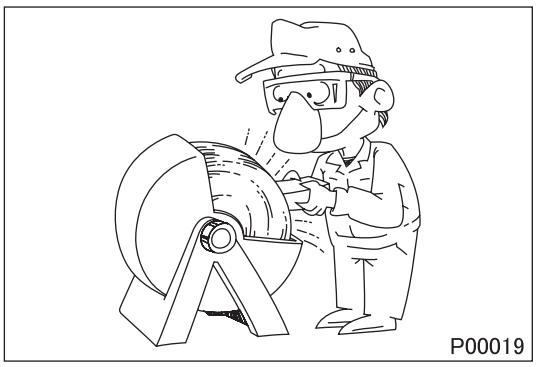
- To facilitate correct reassembly of parts, make alignment marks on them before disassembly and arrange disassembled parts neatly. Make punch marks and other alignment marks where they will not detract from parts' functionality and appearance.
- After removing parts from the vehicle, cover the area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

CAUTION ⚠

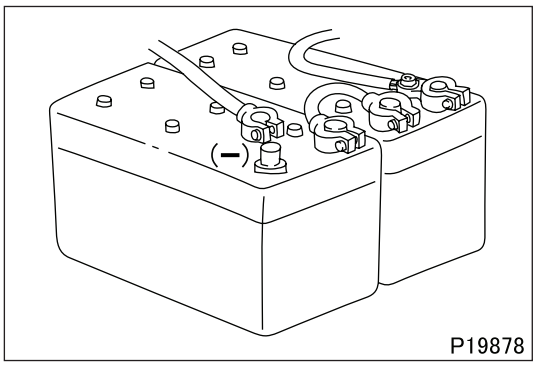
- **Be careful not to mix up identical parts, similar parts and parts that have left/right alignments.**
- **Keep new replacement parts and original (removed) parts separately.**


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.


P00019

- 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.

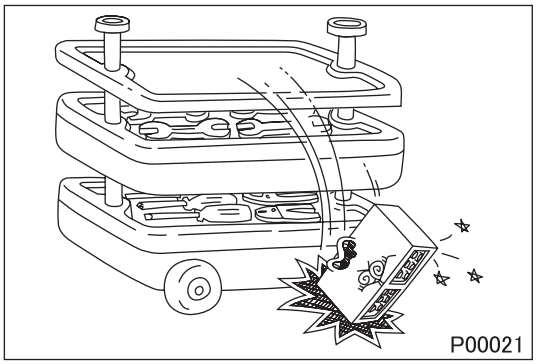


P19878

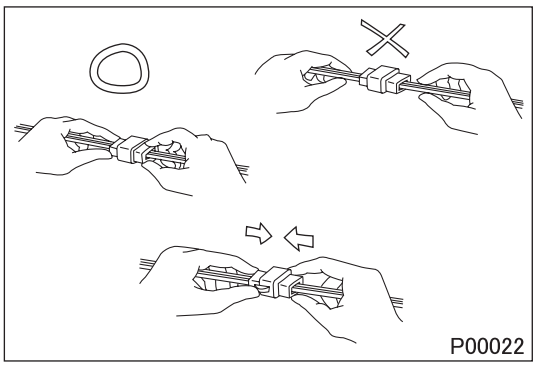
- Before working on the electrical system, disconnect the (–) battery cable to prevent short circuits.

CAUTION ⚠

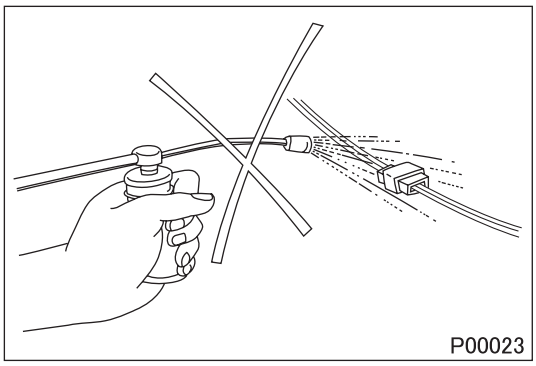
- **Make sure the starter switch and lighting switches are OFF before disconnecting or connecting battery cable. Semiconductor components may otherwise be damaged.**


P00021

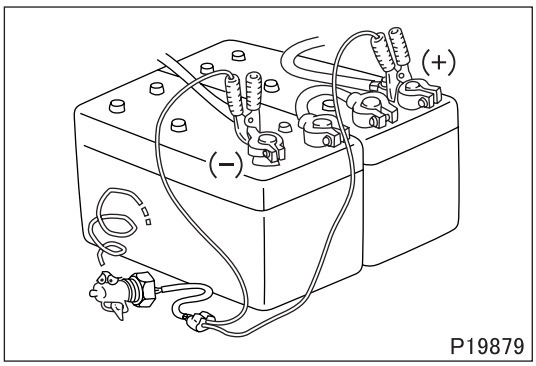
- Carefully handle sensors relays, and other items that are sensitive to shock and heat. Do not remove or paint the cover of any control unit.


P00022

- 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.

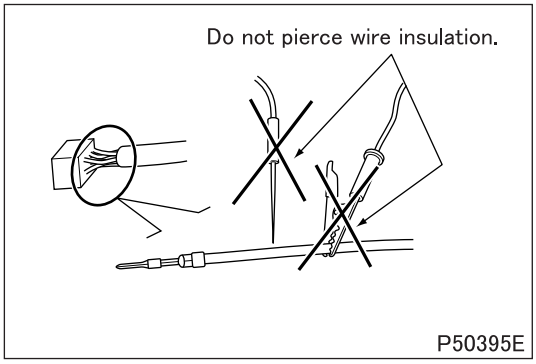

P00023

- 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



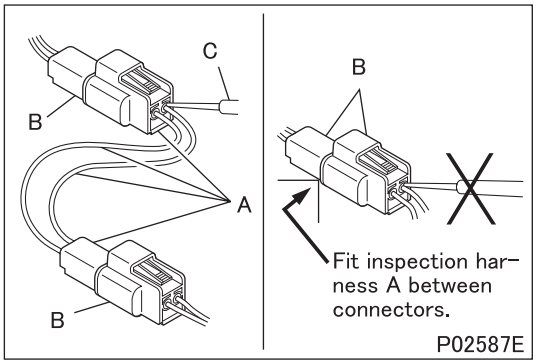
CAUTION ⚠

- **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

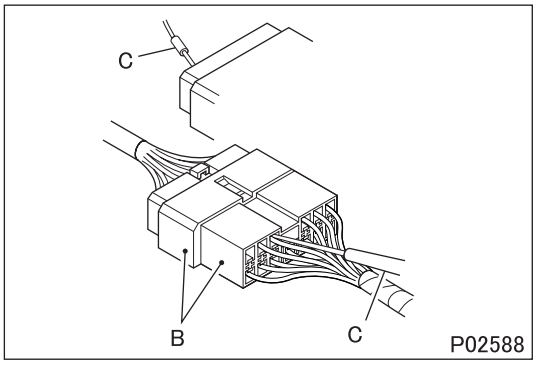
(1) Inspections with connectors fitted together

(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.

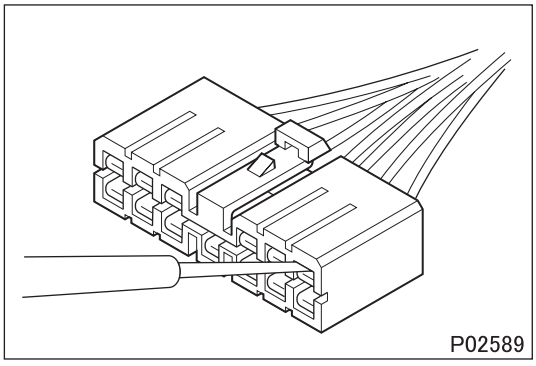
(1.2) Non-waterproof connectors



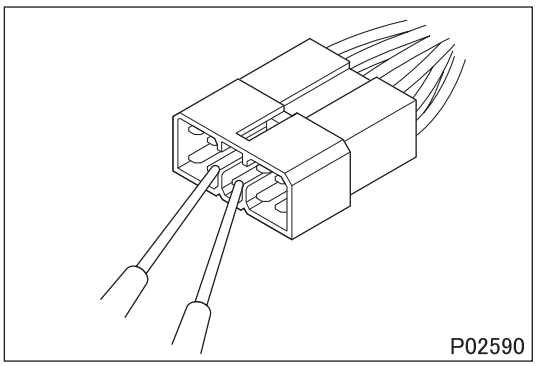
- Perform the inspection by inserting a test probe **C** into the wire-entry sides of the connectors. An extra-narrow probe is required for control unit connectors, which are smaller than other types of connector. Do not force a regular-size probe into control unit connectors since this would cause damage.

(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.

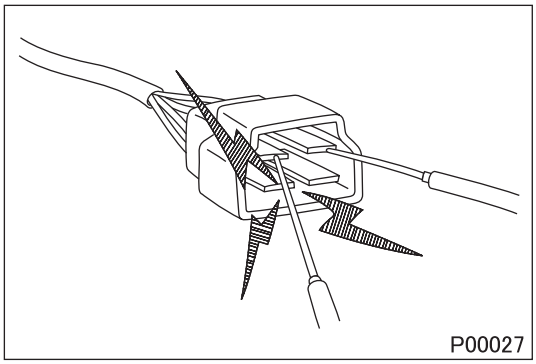


(2.2) Inspections on male terminals

- 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.**

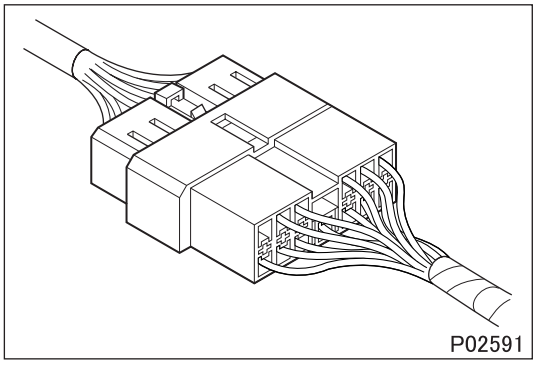


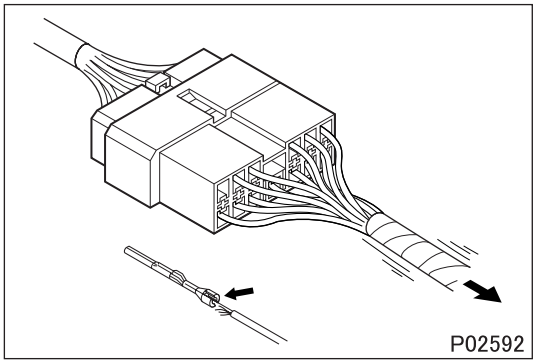
- When using a multimeter to check continuity, do not allow the test probes to touch the wrong terminals.

1.2 Inspection of connectors

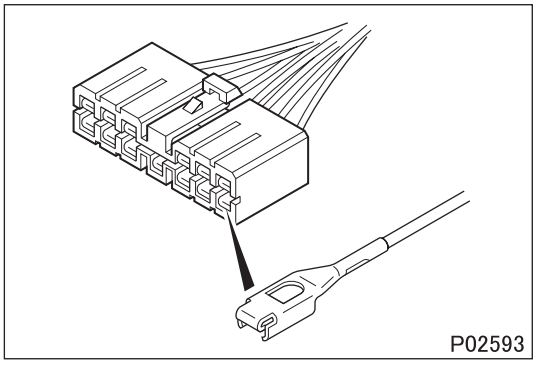
(1) Visual inspection

- Check that the connectors are fitted together securely.



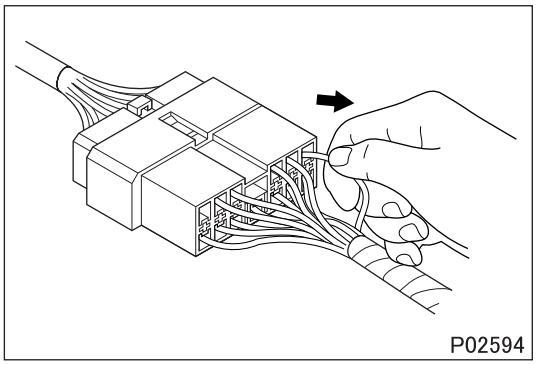


- Check whether wires have been separated from their terminals due to pulling of the harness.



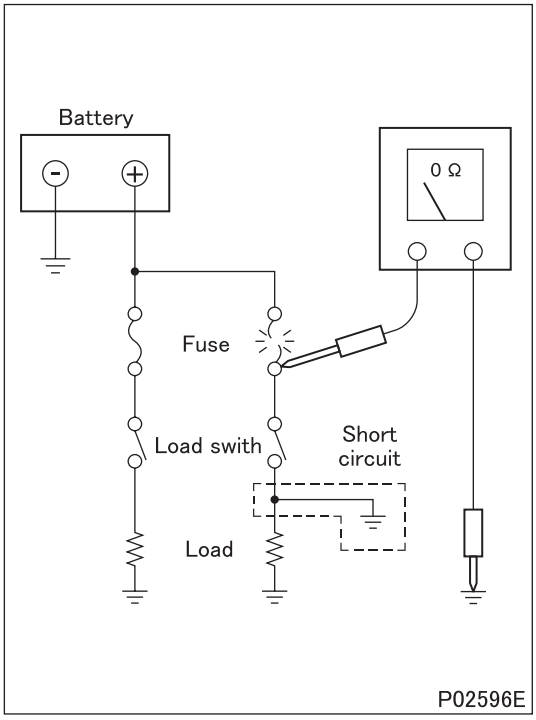
- Check that male and female terminals fit together tightly.

- 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.

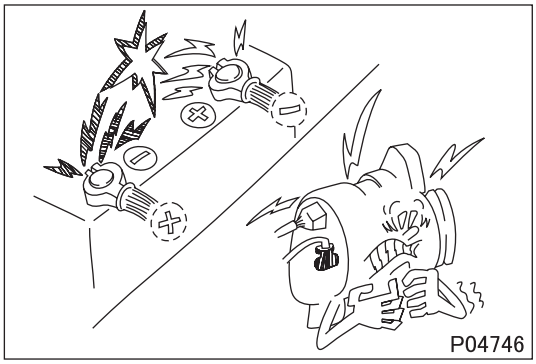


1.3 Inspections when a fuse blows

- 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.

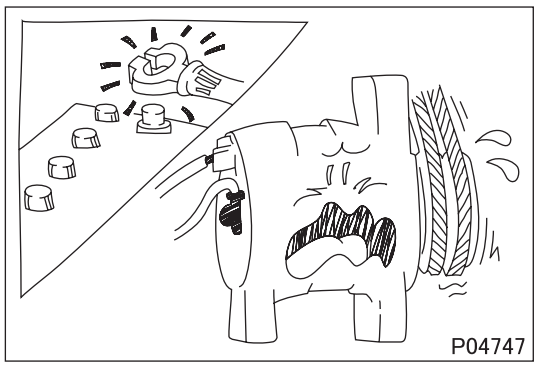
- The main causes of short circuits are as follows:
  - Harnesses trapped between chassis parts
  - Harness insulation damage due to friction or heat
  - Moisture in connectors or circuitry
  - Human error (accidental short-circuiting of components)

2. Service Precautions for Alternators

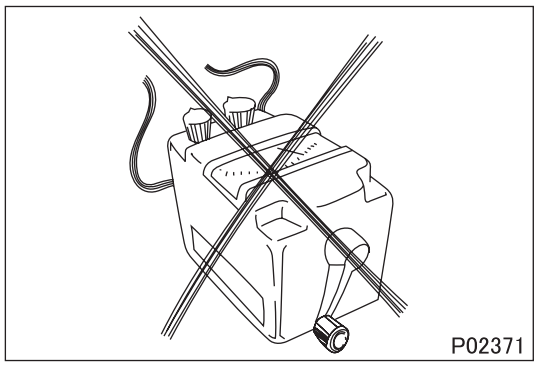


- When servicing alternators, observe the following precautions:
  - Never reverse the polarity of battery connections.
    If the polarity of the battery connections were to be reversed, a large current would flow from the battery to the alternator, damaging the diodes and regulator.

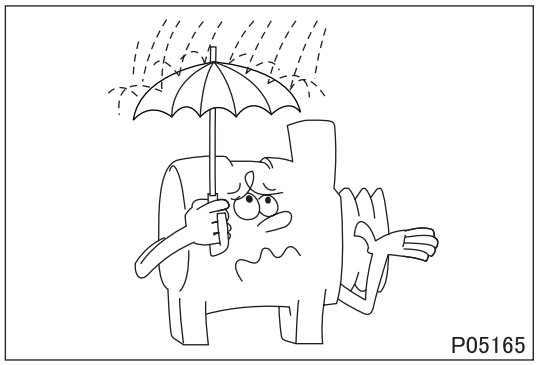
PRECAUTIONS FOR MAINTENANCE OPERATION



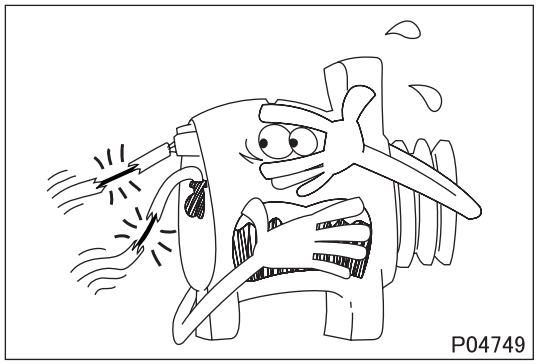
- Never disconnect the battery cables with the engine running.
  Disconnection of the battery cables during engine operation would cause a surge voltage, leading to deterioration of the diodes and regulator.



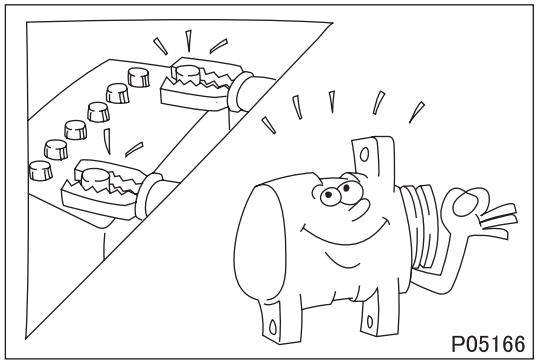
- Never perform inspections using a high-voltage multimeter.
  The use of a high-voltage multimeter could damage the diodes and regulator.



- Keep alternators dry.
  Water on alternators can cause internal short circuits and damage.

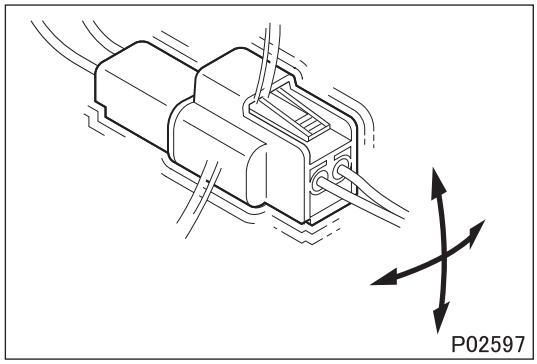


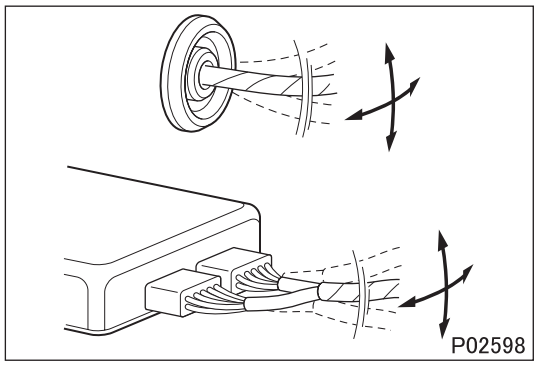
- Never operate an alternator with the B and L terminals short-circuited. Operation with the B and L terminals connected together would damage the diode trio.

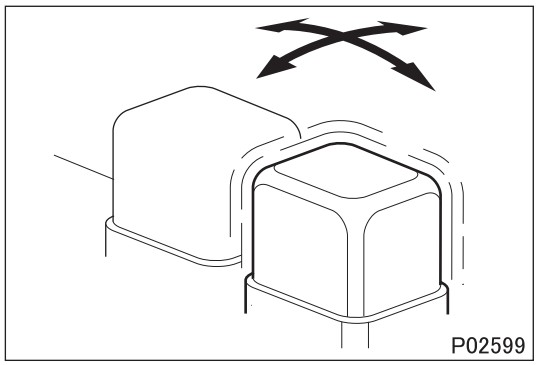


- Disconnect the battery cables before quick-charging the battery with a quick charger.
  Unless the battery cables are disconnected, quick-charging can damage the diodes and regulator.

3. Intermittent Faults





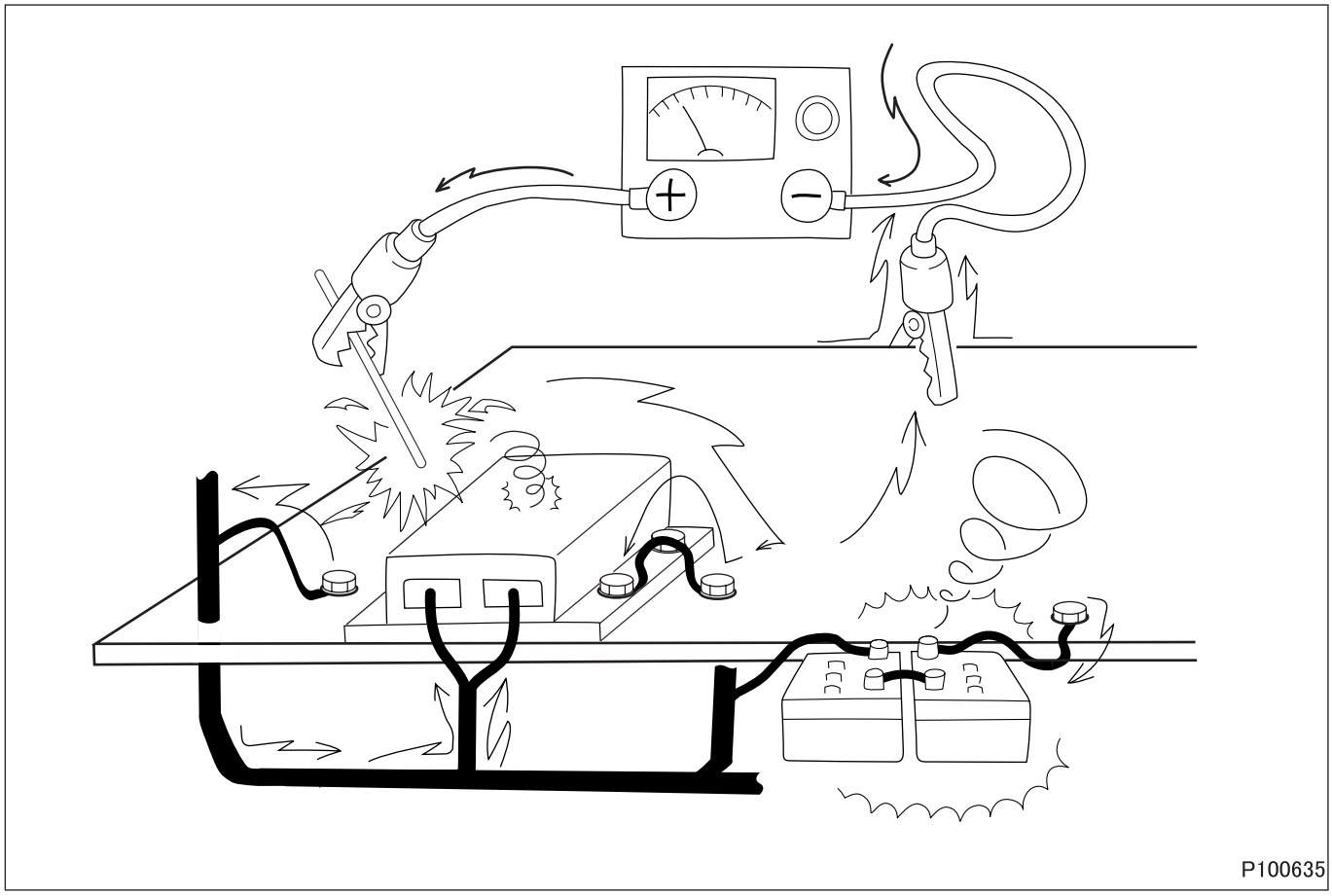


- An intermittent fault typically occurs only under certain operating conditions. Once these conditions have been identified, the cause of the intermittent fault can be ascertained easily. First, ask the customer about the vehicle operating conditions and weather conditions under which the fault occurs. Also ask about the frequency with which the fault occurs and about the fault symptoms. Then, reproduce the fault based on this information.
  In accordance with the conditions under which the fault occurs, determine whether the fault is caused by vibration, heat or other factors. if vibration is a possible factor, see if the fault can be reproduced by performing the following checks on individual connectors and other parts:
  - Gently move connectors up and down and to left and right.
  - Gently move wiring harnesses up and down and to left and right.
  - Gently wiggle sensors and other devices by hand.
  - Gently wiggle wiring harnesses on suspension systems and other moving parts.

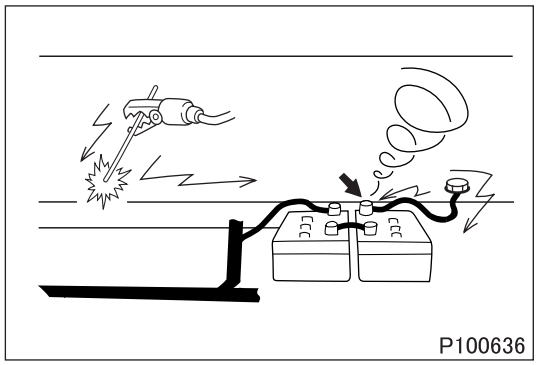
- Connectors and other parts to be checked are those included or given as likely fault locations in inspection procedures corresponding to diagnostic codes and/or fault symptoms.

4. Precautions for Arc Welding

- When arc welding is performed, current from the welder flows to ground via the machine metal parts. Unless appropriate steps are taken, this current can damage control units, other electrical devices and wiring harnesses. And any electrical device near the point on the vehicle to which the (–) cable of the welder is connected, might be largely damaged.



P100635


P100636

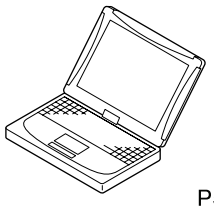
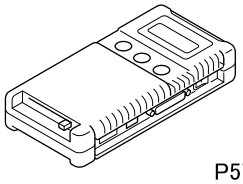
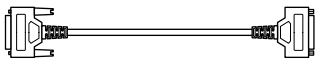
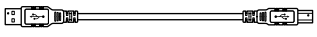
- The current of the welder will flow backward through the battery's (–) cable and damage the battery and electrical systems directly connected to the battery. Be sure to disconnect the battery's (–) cable in the following procedure.
- Turn the battery switch to the LOCK position.
- Turn the starter switch to the LOCK position.
- Disconnect the battery's (–) cable.
- Cover all parts of the machine that may be damaged by welding sparks.
- Connect the welder's (–) cable to the machine as close as possible to the area being welded.
- Set the welding current in accordance with the part being welded.

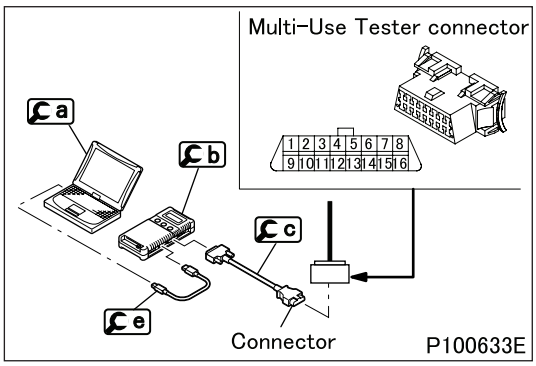
NOTE:
The Multi-Use tester tool will not be used to service the 6M60-TL diesel engine at this time. Please disregard the Multi-Use Tester information. The Up-Time 2.41 or later software must be used to service the 6M60-TL diesel engine.

1. Using Multi-Use Tester

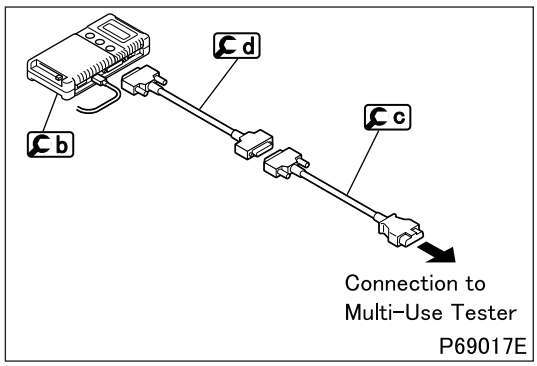
1.1 Connecting Multi-Use Tester

Special tools

Mark	Tool name and shape	Part No.	Application
ⓐ	PC  P57295	FMSi-E06-1 (Multi-Use Tester-III version)	Data transmission to/from V.C.I.
ⓑ	V.C.I.  P57296	N/A	Data transmission between electronic control unit and PC
ⓒ	Multi-Use Tester harness A  P57297	MH062928	Power supply to V.C.I. and communication with electronic control unit
ⓓ	Multi-Use Tester test harness D (used for extension)  P57299	MH062931 (1 m) MH062951 (2 m)	Multi-Use Tester test harness A extension
ⓔ	USB cable  P57300	MB991827	Communication between V.C.I. and PC



- Move the starter switch to the LOCK position.
- Connect ⓐ, ⓑ, ⓒ and ⓔ as illustrated.
- Connect the Multi-Use Tester connector on the vehicle with the connector of ⓒ.



- Use d to extend the cable if c is not long enough such as when using Multi-Use Tester outside the vehicle.

1.2 Access and Clearing of Stored Diagnostic Code

(1) Difference of diagnostic code

- There are two types of diagnostic codes – present code and past code.

(1.1)

(1.2) Present diagnostic code

- Fault developed in the machine after the starter switch is set to ON is indicated by corresponding diagnostic code.
- The fault warning lamp is lit at the same time.

(1.3) Past diagnostic code

- Past fault developed in the machine is indicated by corresponding diagnostic code stored in the memory of the electronic control unit.
- With the machine restored to its normal condition or the starter switch turned from OFF to ON after inspection or repair against present diagnostic codes, the present diagnostic code is stored as past diagnostic codes in the memory of the electronic control unit.
- The warning lamp is not lit because the indicated fault is not present one.

(2) Access of diagnostic code

- Set the starter switch to ON.
- Operate the Multi-Use Tester for a display of necessary diagnostic codes stored in the memory of the electronic control unit and identify the location of the fault.

(3) Clearing of diagnostic code

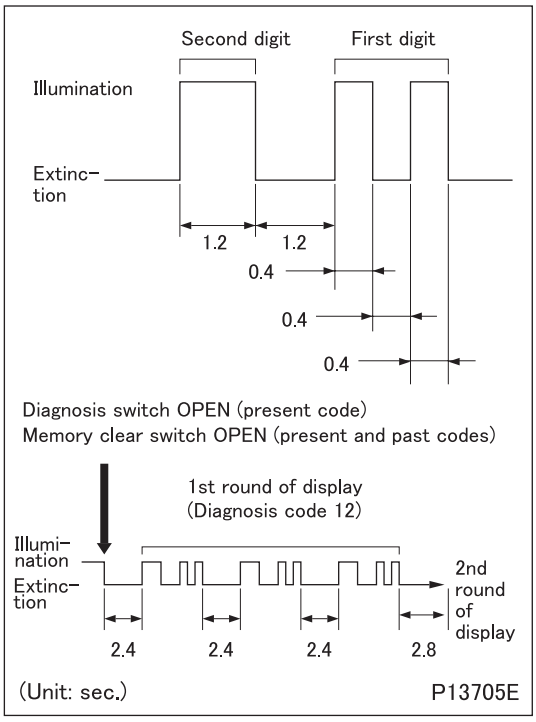
- Set the starter switch to ON (the engine not to be started).
- Operate the Multi-Use Tester to delete all the diagnostic codes stored in the memory of the electronic control unit.

2. Use of Blinking Warning Lamp for Diagnostic Code

- Using the diagnostic and memory clear switches, display diagnostic codes.

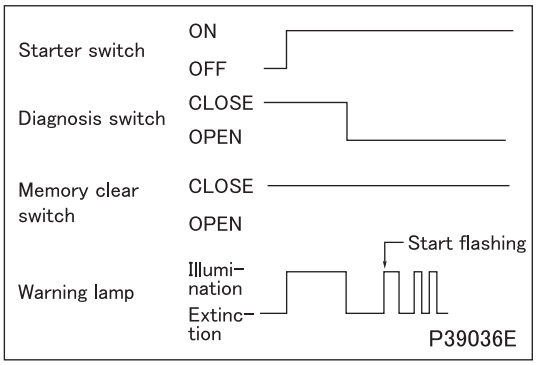
CAUTION ⚠

- **Opening the memory clear switch followed by its reconnection will erase the stored diagnostic codes from the memory. To avoid inadvertently erasing necessary codes, be sure to read well the procedure described below before handling diagnostic codes.**



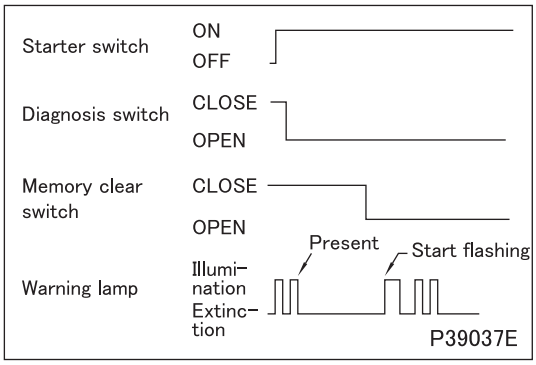
2.1 Reading diagnostic codes

- To read a diagnostic code, observe how may times the warning lamp flashes and how long each illumination lasts.
- The duration of illumination differs between the first and second digits.
  - Second digit: 1.2 sec.
  - First digit: 0.4 sec.
- A diagnostic code consists of the flashing of second digit and the flashing of first digit in that order. If a diagnostic code has “0” in the second digit, only the first digit will be displayed.
- The same diagnostic code will be displayed 3 times in a row before moving to the display of the next code.
- After the last diagnostic code is displayed, the first code will be displayed again 3 times in a row and then the subsequent codes. This will be repeated.



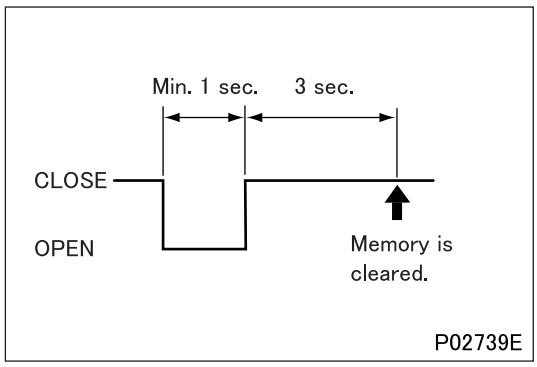
2.2 Present diagnostic codes

- Turn the starter switch ON.
- Remove the diagnostic switch.
- Diagnostic codes will be displayed (flashing of the warning lamp).
- When the diagnostic switch is connected, electronic control unit will immediately stop (terminate) displaying diagnostic codes.



2.3 Present and past diagnostic codes

- Turn the starter switch to the ON position.
- Open the diagnostic switch.
- Open the memory clear switch.
- The corresponding warning lamp will display diagnostic codes by flashing.
- Turn the starter switch to the OFF position, connect the memory clear switch and then connect the diagnostic switch. The electronic control unit terminates (exits) the diagnostic code displaying mode.



2.4 Erasing diagnostic codes

- Turn the starter switch to the ON position (do not start the engine).
- Open the memory clear switch and reconnect it; all diagnostic codes stored in electronic control unit memory will be erased. To erase diagnostic code after opening the memory clear switch, turn the starter switch to the OFF position and then reconnect the memory clear switch.

3. Up-Time Service Tool Functions

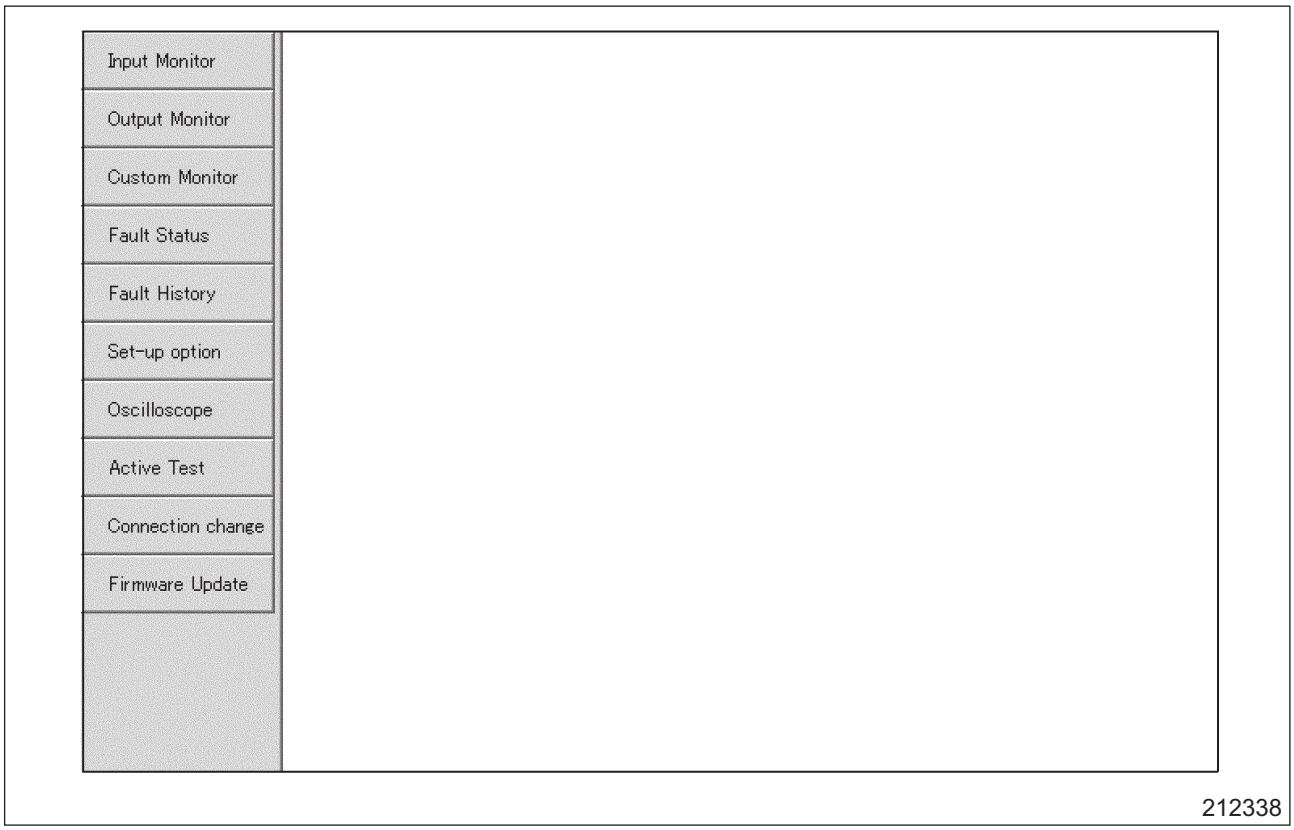
3.1 Menu

Monitor menu

- Input Monitor
  Indicates the input values of the controllers.
- Output Monitor
  Indicates the output values of the controllers.
- Custom Monitor
  Indicates the input/output values of the item selected.
- Fault Status
  Indicates all error codes occurring.
- Fault History
  Indicates the fault data, such as the error codes and hour meter data, stored in the controller.

Tool menu

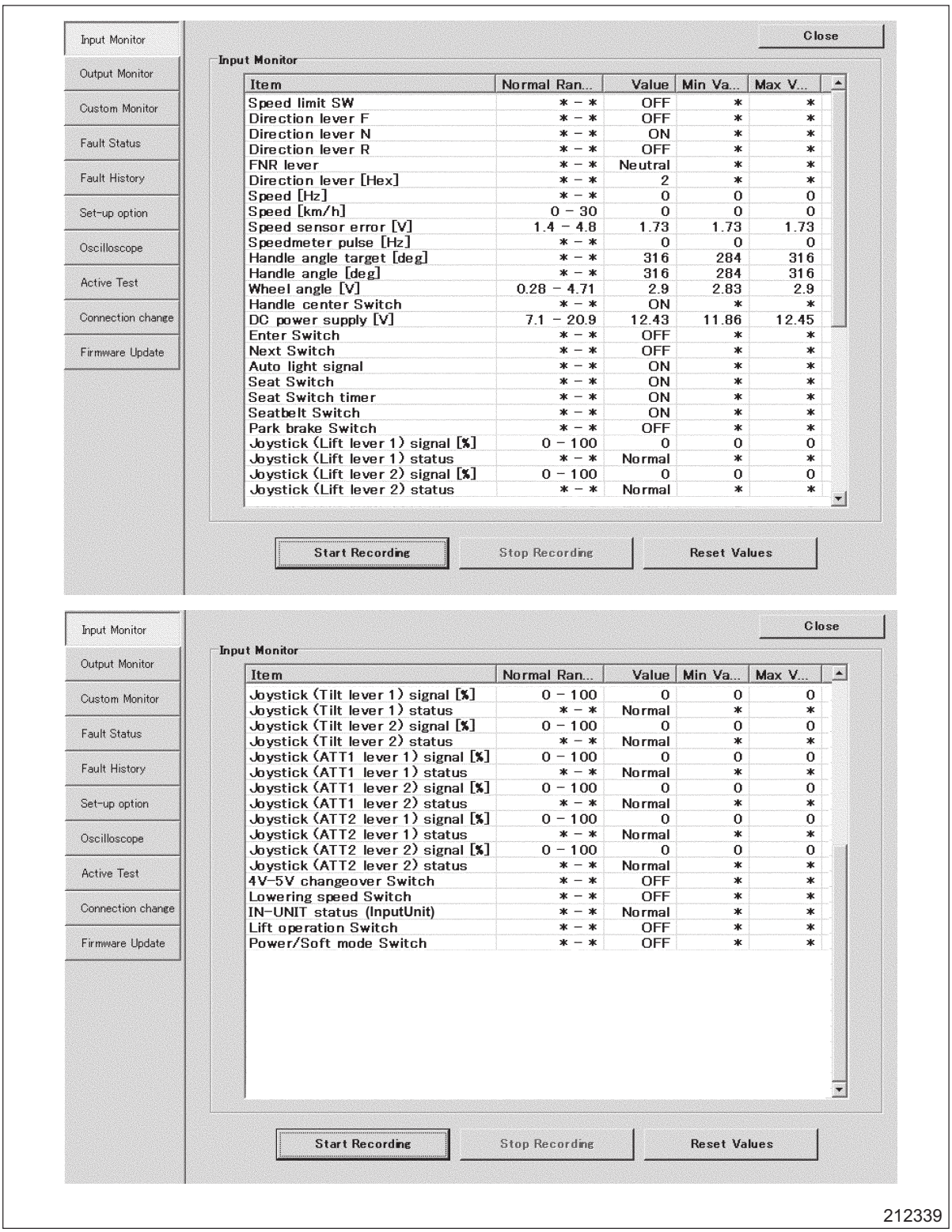
- Set-up Option
  Indicates or sets the Setup Option data.
- Oscilloscope
  Graphs the input/output values. The oscillograph can be stored as data.
- Active Test
  Outputs the signal forcibly to check the operation of the equipment selected.
- Connection Change
  Designates the controller operated by the service tool and the controller connected to it.
- Firmware Update
  Updates the firmware of the controller connected.

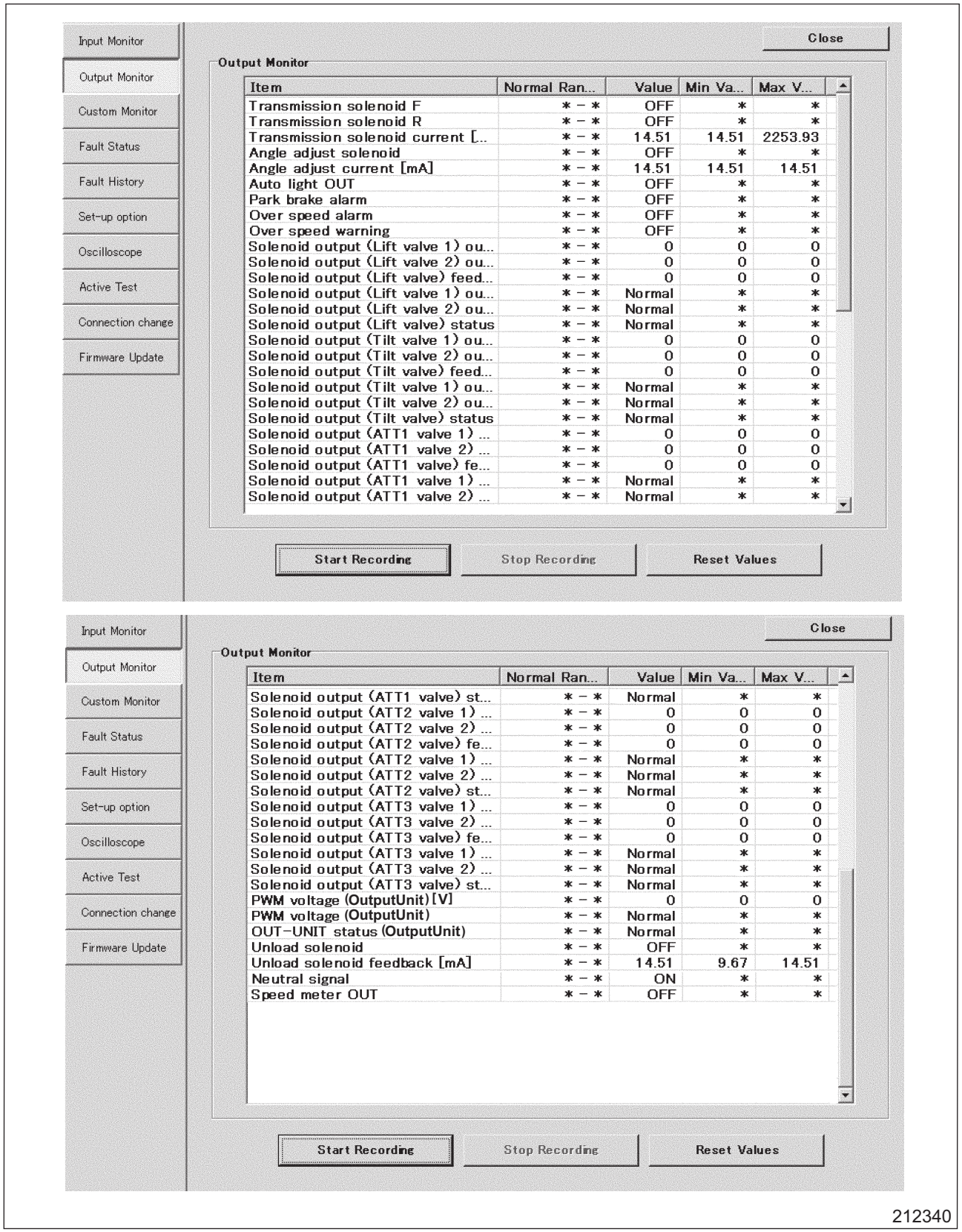


3.2 Input Monitor and Output Monitor

These screens indicate the input and output values of each controller.

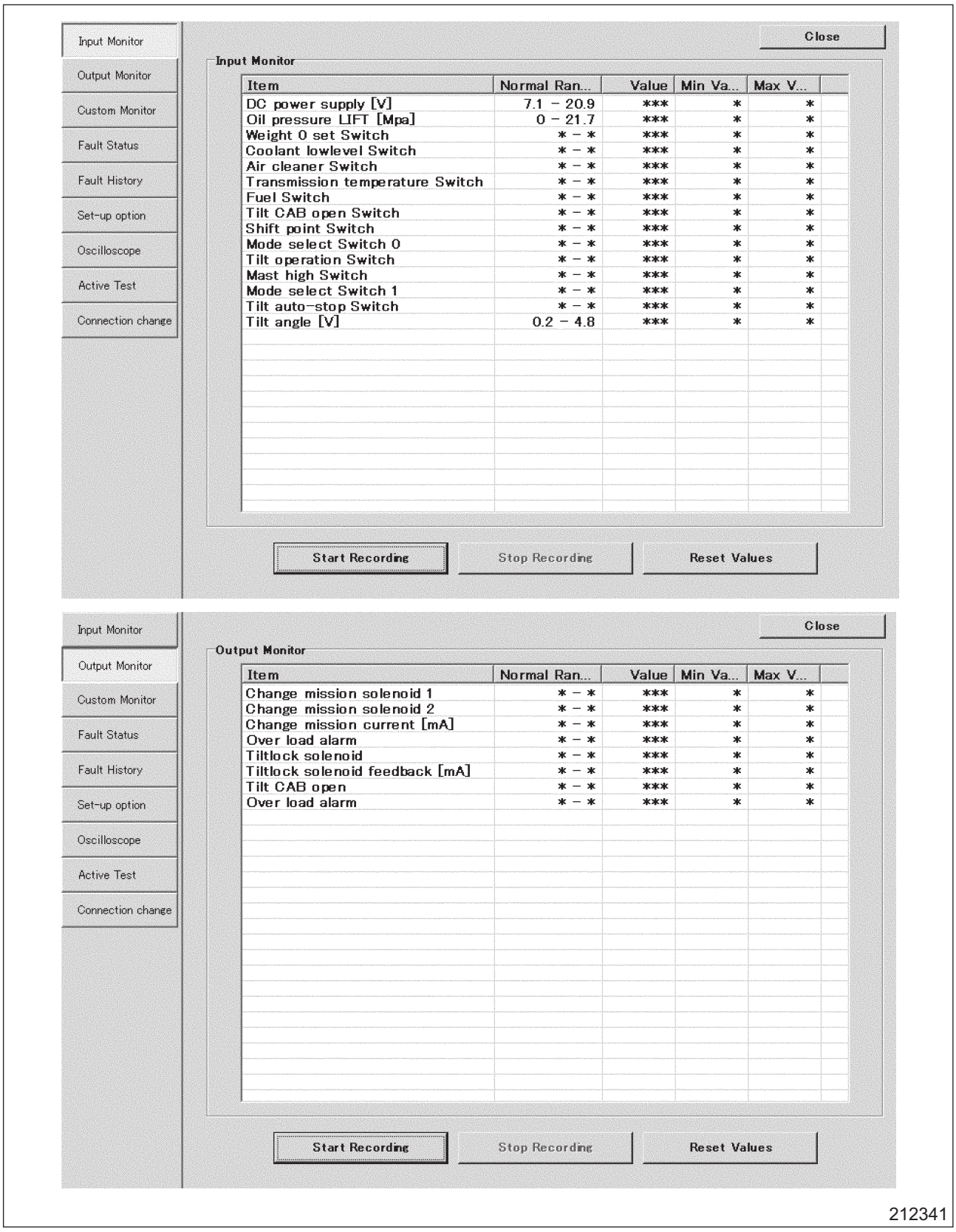
3.2.1 VCM-3 input monitor and output monitor (VCM-3 → VCM-3)




Input Monitor
Output Monitor
Custom Monitor
Fault Status
Fault History
Set-up option
Oscilloscope
Active Test
Connection change
Firmware Update
Close
Output Monitor
Item | Normal Ran... | Value | Min Va... | Max V...
Transmission solenoid F | * - * | OFF | * | *
Transmission solenoid R | * - * | OFF | * | *
Transmission solenoid current [... | * - * | 14.51 | 14.51 | 2253.93
Angle adjust solenoid | * - * | OFF | * | *
Angle adjust current [mA] | * - * | 14.51 | 14.51 | 14.51
Auto light OUT | * - * | OFF | * | *
Park brake alarm | * - * | OFF | * | *
Over speed alarm | * - * | OFF | * | *
Over speed warning | * - * | OFF | * | *
Solenoid output (Lift valve 1) ou... | * - * | 0 | 0 | 0
Solenoid output (Lift valve 2) ou... | * - * | 0 | 0 | 0
Solenoid output (Lift valve) feed... | * - * | 0 | 0 | 0
Solenoid output (Lift valve 1) ou... | * - * | Normal | * | *
Solenoid output (Lift valve 2) ou... | * - * | Normal | * | *
Solenoid output (Lift valve) status | * - * | Normal | * | *
Solenoid output (Tilt valve 1) ou... | * - * | 0 | 0 | 0
Solenoid output (Tilt valve 2) ou... | * - * | 0 | 0 | 0
Solenoid output (Tilt valve) feed... | * - * | 0 | 0 | 0
Solenoid output (Tilt valve 1) ou... | * - * | Normal | * | *
Solenoid output (Tilt valve 2) ou... | * - * | Normal | * | *
Solenoid output (Tilt valve) status | * - * | Normal | * | *
Solenoid output (ATT1 valve 1) ... | * - * | 0 | 0 | 0
Solenoid output (ATT1 valve 2) ... | * - * | 0 | 0 | 0
Solenoid output (ATT1 valve) fe... | * - * | 0 | 0 | 0
Solenoid output (ATT1 valve 1) ... | * - * | Normal | * | *
Solenoid output (ATT1 valve 2) ... | * - * | Normal | * | *
Start Recording
Stop Recording
Reset Values
Input Monitor
Output Monitor
Custom Monitor
Fault Status
Fault History
Set-up option
Oscilloscope
Active Test
Connection change
Firmware Update
Close
Output Monitor
Item | Normal Ran... | Value | Min Va... | Max V...
Solenoid output (ATT1 valve) st... | * - * | Normal | * | *
Solenoid output (ATT2 valve 1) ... | * - * | 0 | 0 | 0
Solenoid output (ATT2 valve 2) ... | * - * | 0 | 0 | 0
Solenoid output (ATT2 valve) fe... | * - * | 0 | 0 | 0
Solenoid output (ATT2 valve 1) ... | * - * | Normal | * | *
Solenoid output (ATT2 valve 2) ... | * - * | Normal | * | *
Solenoid output (ATT2 valve) st... | * - * | Normal | * | *
Solenoid output (ATT3 valve 1) ... | * - * | 0 | 0 | 0
Solenoid output (ATT3 valve 2) ... | * - * | 0 | 0 | 0
Solenoid output (ATT3 valve) fe... | * - * | 0 | 0 | 0
Solenoid output (ATT3 valve 1) ... | * - * | Normal | * | *
Solenoid output (ATT3 valve 2) ... | * - * | Normal | * | *
Solenoid output (ATT3 valve) st... | * - * | Normal | * | *
PWM voltage (OutputUnit) [V] | * - * | 0 | 0 | 0
PWM voltage (OutputUnit) | * - * | Normal | * | *
OUT-UNIT status (OutputUnit) | * - * | Normal | * | *
Unload solenoid | * - * | OFF | * | *
Unload solenoid feedback [mA] | * - * | 14.51 | 9.67 | 14.51
Neutral signal | * - * | ON | * | *
Speed meter OUT | * - * | OFF | * | *
Start Recording
Stop Recording
Reset Values

212340

3.2.2 VCM-3OP input monitor and output monitor (VCM-3 → VCM-3OP)



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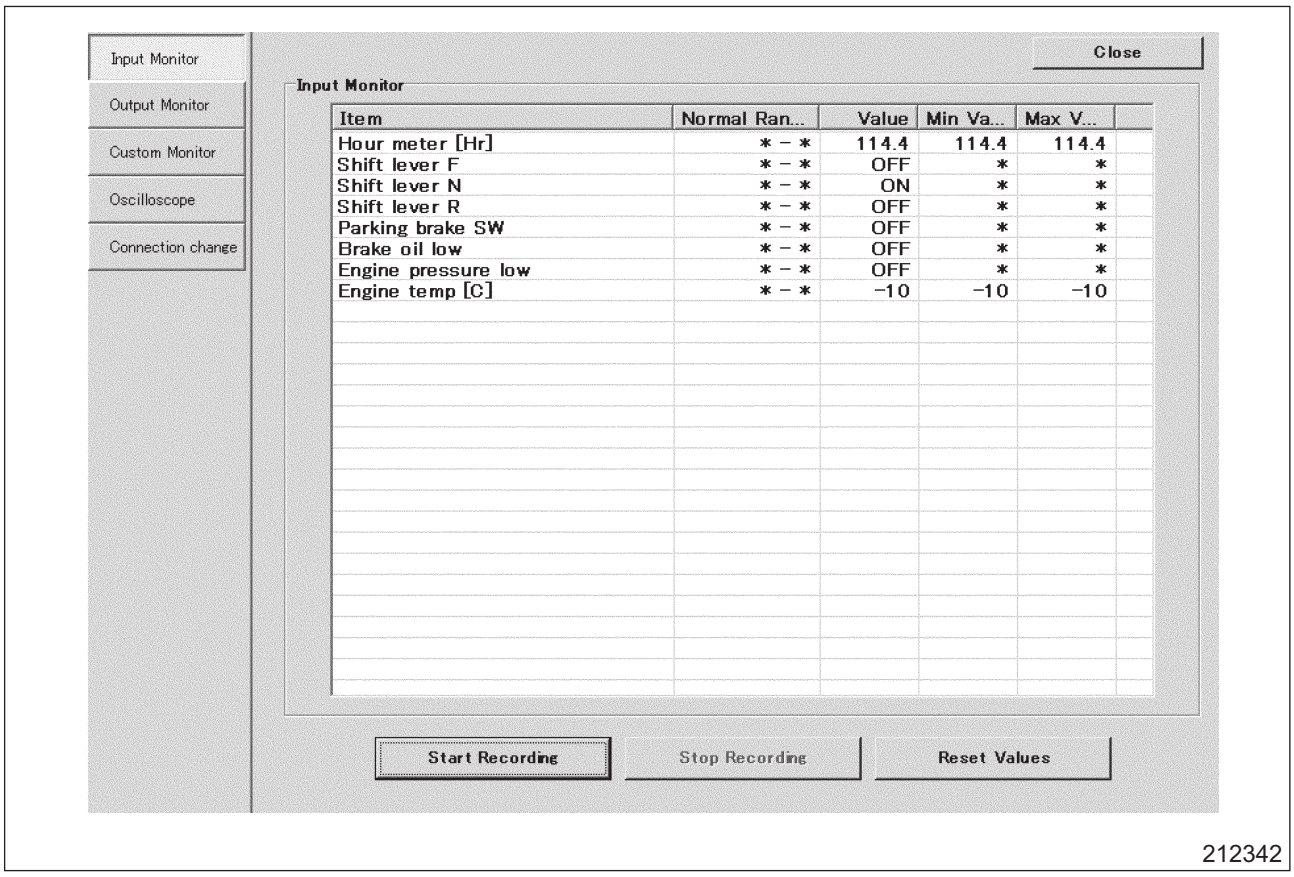
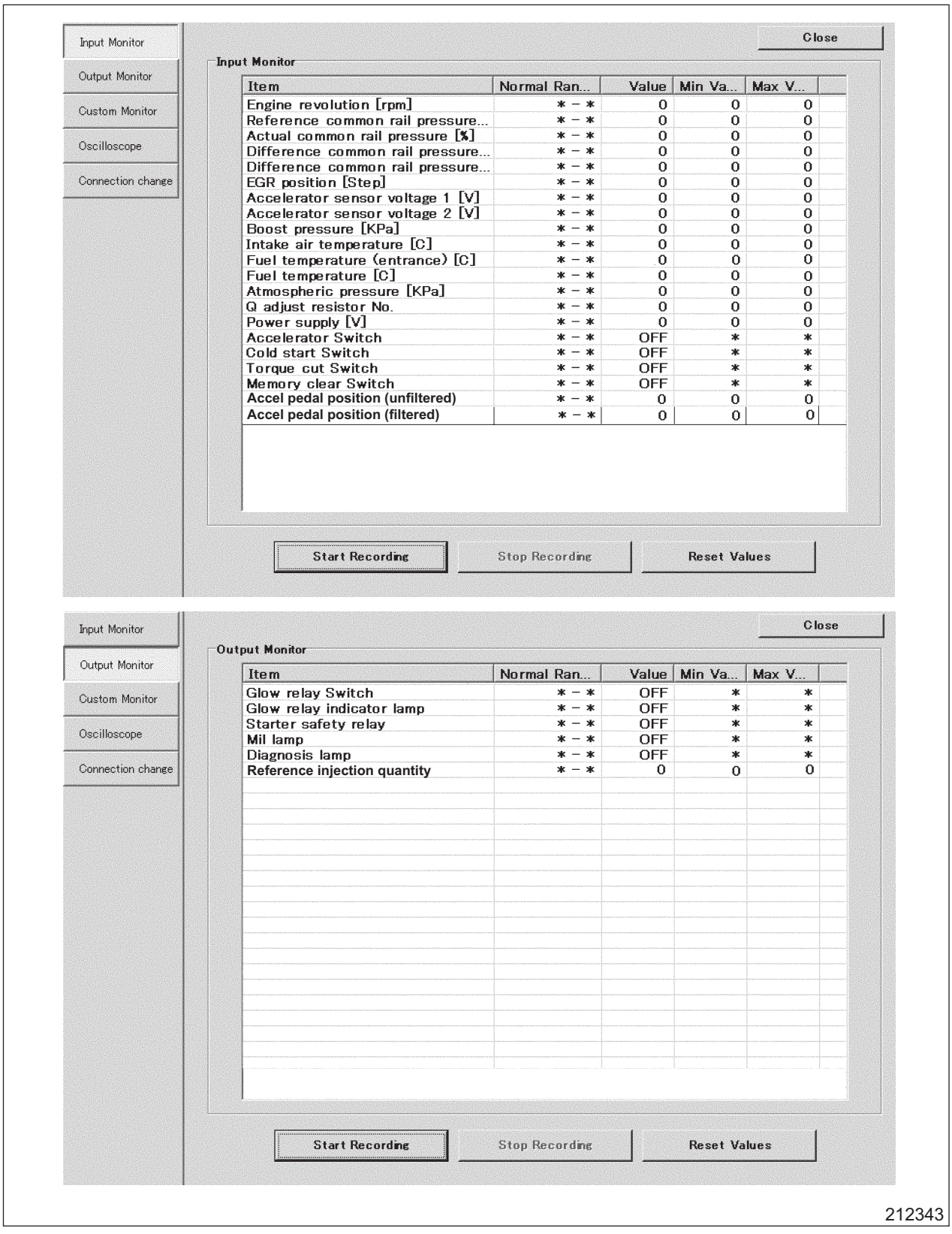
3.2.3 MP input monitor (VCM-3→ MP)

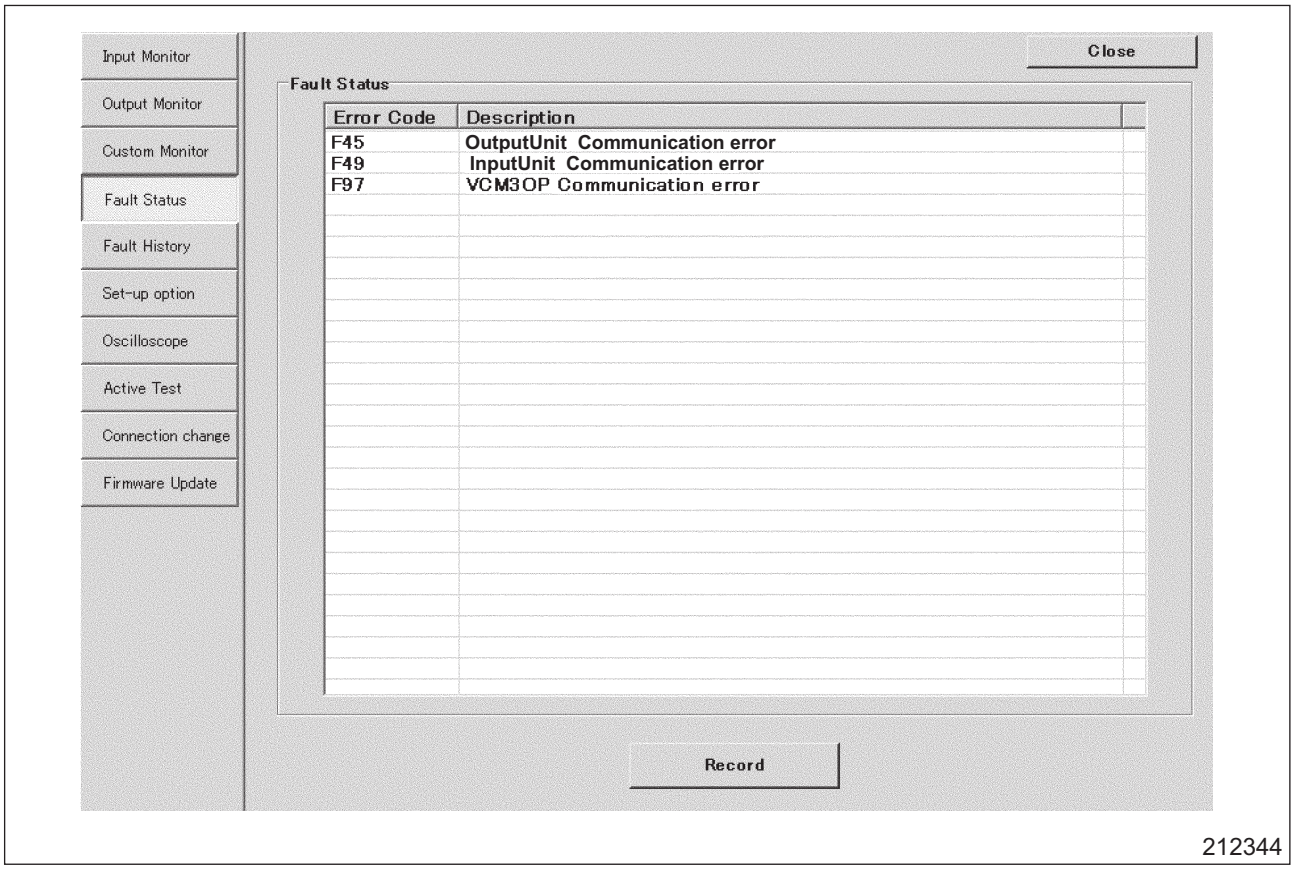


3.2.4 ECU input monitor and output monitor (VCM-3 → ECU)



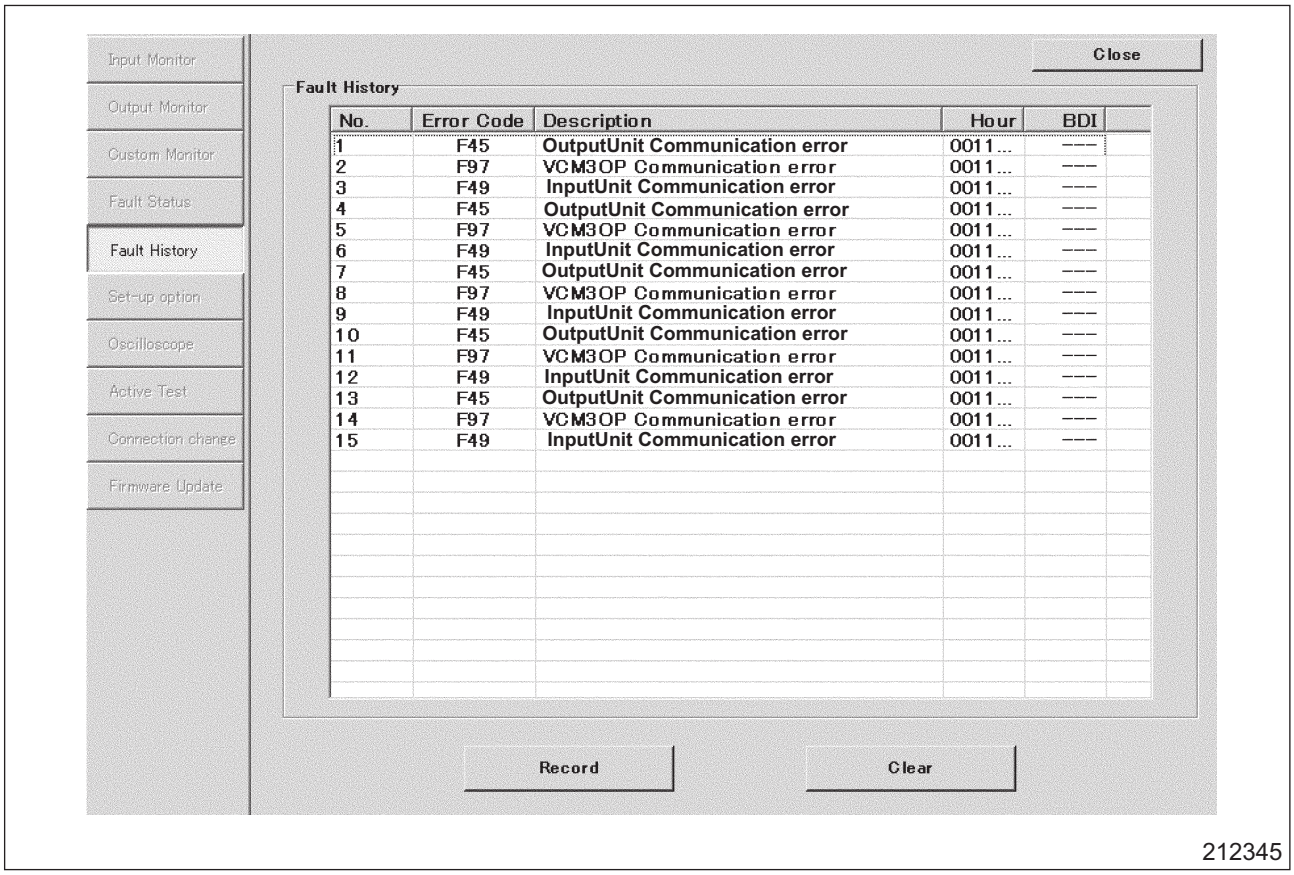
3.3 Fault Status

This screen indicates all error codes occurring.



3.4 Fault History

This screen indicates the fault data, such as the error codes and hour meter data, stored in the controller.



4. Troubleshooting

4.1 General Information

4.1.1 Before replacing controllers

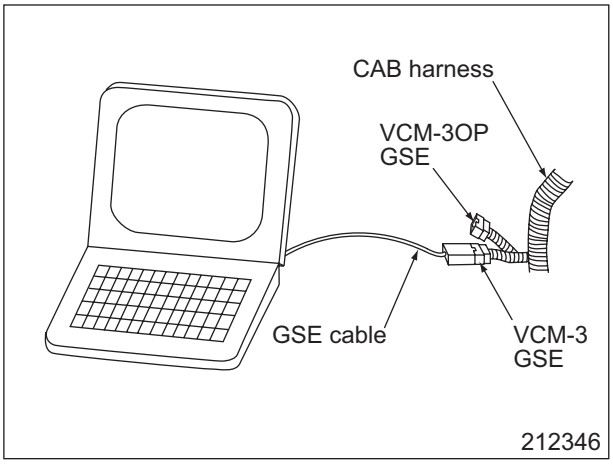
Do not replace controllers casually even if replacement is required as a result of troubleshooting. Be sure to check the following items before replacing controllers.

- Loose battery connectors
- Abnormal wire harness connections
- Loose connectors
- Broken, bent or loose connector pins
- Dirty connectors
  If connectors are dirty, remove the connector and clean connectors. See “How to clean harness connectors and system components” on the next page.
- Ensure that the main harness is not short-circuited to the truck body.

If any of these items (above items) is a source of the trouble, the controller will be damaged even if it is replaced with a new one. Be sure to check the above items and replace carefully.

4.1.2 Connection of service tool

(1) Turn off the truck power.
(2) Find the service tool connector in the CAB harness.
(3) Remove the cover and connect the PC as shown.
(4) Turn on the truck power.
(5) Start the service tool software.



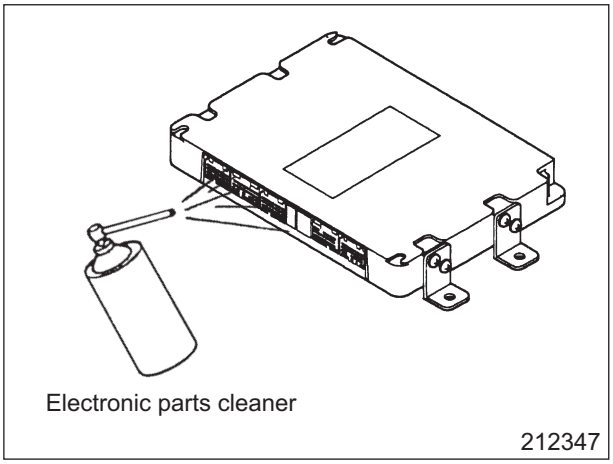
4.1.3 Diagnostic Precautions

(1) Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
(2) To avoid having electrical parts damaged, set the starter switch to OFF before disconnecting and reconnecting battery cables.
(3) Before disconnecting connectors, set the starter switch to OFF then allow at least 20 seconds. Voltage may remain in electric parts or connected circuit.
(4) When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and truck body.
(5) Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C) as the measuring condition.

4.1.4 How to clean harness connectors and system components

(1) Open-circuits are often caused by dirty harness connectors and components. Dust, together with greasy matter, forms grime which, in time, penetrates electrical connections, resulting in loose metal-to-metal contact or, for worse, electrical separation of surfaces in contact. For this reason, it is essential that the connectors and components be cleaned at each periodic inspection and when servicing the truck. Instead of a commonly used solvent, use the electronic parts cleaner (in the manner illustrated on the right).

Electronic parts cleaner	Three Bond 29D or Pow-R-Wash CZ*



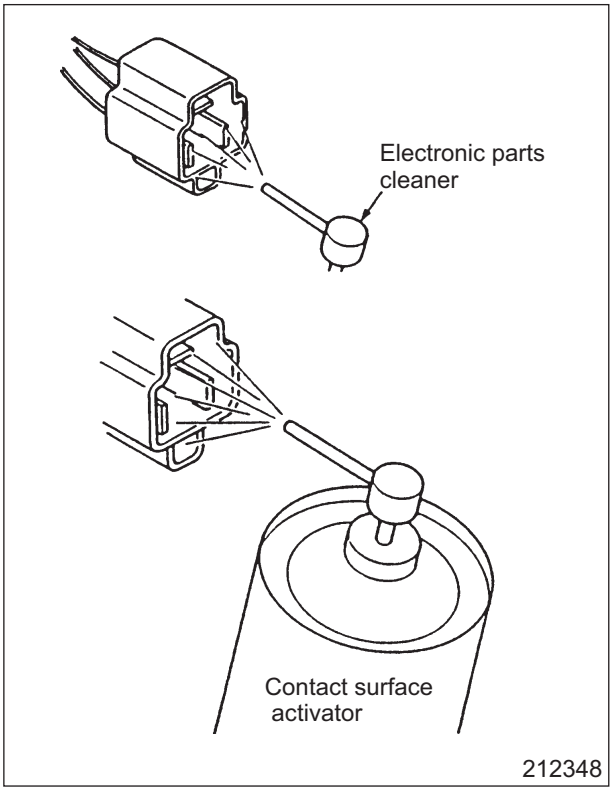
NOTE

- **The cleaner liquid is volatile. All you have to do is just give a strong spray to wash off grime. No need to wipe off the sprayed liquid.**

(2) After checking the connector for continuity, wash it as shown. Then, uncouple the connector and spray the contact surface activator onto contact surfaces.
Install and remove the connector several times to wet the surfaces thoroughly with the activator liquid.
After coupling up the connector, check to be sure that it is in locked state.

Contact surface activator	Three Bond 2501S (aerosol) or Nyogel 760G*

*: Products contained in Terminal Maintenance kit (SE000003)

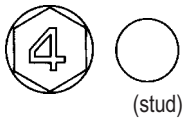
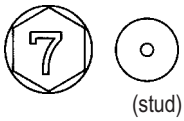
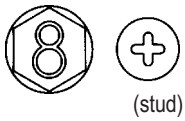


NOTE

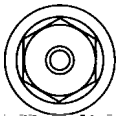
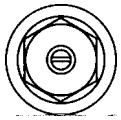
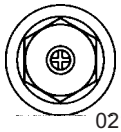
- **Do not spray too much liquid into the connector. Cleaner liquid reacts differently with some resins (plastic materials).**

- Use specified bolts and nuts. Tighten them to the torques shown below as appropriate, unless otherwise specified.
- Threads and bearing surfaces shall be dry.
- If the mating nut and bolt (or stud bolt) are different in level of strength, tighten them to the torque specified for the bolt.

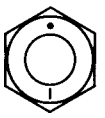
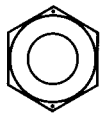
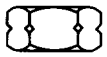
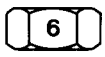
Hexagon Head Bolts and Stud Bolts (Unit: N·m {kgf·m})

Strength	4T		7T		8T	
Identification symbol / Nominal diameter	 (stud)		 (stud)		 (stud)	 02154
M5	2 to 3 {0.2 to 0.3}	–	4 to 6 {0.4 to 0.6}	–	5 to 7 {0.5 to 0.7}	–
M6	4 to 6 {0.4 to 0.6}	–	7 to 10 {0.7 to 1.0}	–	8 to 12 {0.8 to 1.2}	–
M8	9 to 13 {0.9 to 1.3}	–	16 to 24 {1.7 to 2.5}	–	19 to 28 {2.0 to 2.9}	–
M10	18 to 27 {1.8 to 2.7}	17 to 25 {1.8 to 2.6}	34 to 50 {3.5 to 5.1}	32 to 48 {3.3 to 4.9}	45 to 60 {4.5 to 6.0}	37 to 55 {3.8 to 5.7}
M12	34 to 50 {3.4 to 5.1}	31 to 45 {3.1 to 4.6}	70 to 90 {7.0 to 9.5}	65 to 85 {6.5 to 8.5}	80 to 105 {8.5 to 11}	75 to 95 {7.5 to 10}
M14	60 to 80 {6.0 to 8.0}	55 to 75 {5.5 to 7.5}	110 to 150 {11 to 15}	100 to 140 {11 to 14}	130 to 170 {13 to 17}	120 to 160 {12 to 16}
M16	90 to 120 {9 to 12}	90 to 110 {9 to 11}	170 to 220 {17 to 23}	160 to 210 {16 to 21}	200 to 260 {20 to 27}	190 to 240 {19 to 25}
M18	130 to 170 {14 to 18}	120 to 150 {12 to 16}	250 to 330 {25 to 33}	220 to 290 {23 to 30}	290 to 380 {30 to 39}	250 to 340 {26 to 35}
M20	180 to 240 {19 to 25}	170 to 220 {17 to 22}	340 to 460 {35 to 47}	310 to 410 {32 to 42}	400 to 530 {41 to 55}	360 to 480 {37 to 49}
M22	250 to 330 {25 to 33}	230 to 300 {23 to 30}	460 to 620 {47 to 63}	420 to 560 {43 to 57}	540 to 720 {55 to 73}	490 to 650 {50 to 67}
M24	320 to 430 {33 to 44}	290 to 380 {29 to 39}	600 to 810 {62 to 83}	540 to 720 {55 to 73}	700 to 940 {72 to 96}	620 to 830 {63 to 85}

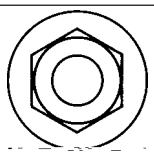
Hexagon Head Flange Bolts (Unit: N·m {kgf·m})

Strength	4T		7T		8T	
Identification symbol / Nominal diameter						 02154
M6	4 to 6 {0.4 to 0.6}	–	8 to 12 {0.8 to 1.2}	–	10 to 14 {1.0 to 1.4}	–
M8	10 to 15 {1.0 to 1.5}	–	19 to 28 {2.0 to 2.9}	–	22 to 33 {2.3 to 3.3}	–
M10	21 to 31 {2.1 to 3.1}	20 to 29 {2.0 to 3.0}	45 to 55 {4.5 to 5.5}	37 to 54 {3.8 to 5.6}	50 to 65 {5.0 to 6.5}	50 to 60 {5.0 to 6.5}
M12	38 to 56 {3.8 to 5.5}	35 to 51 {3.5 to 5.2}	80 to 105 {8.0 to 10.5}	70 to 95 {7.5 to 9.5}	90 to 120 {9 to 12}	85 to 110 {8.5 to 11}

Hexagon Nuts (Unit: N·m {kgf·m})

Strength	4T		6T	
Identification symbol			    02155	
Nominal diameter	Standard screw thread	Coarse screw thread	Standard screw thread	Coarse screw thread
M5	2 to 3 {0.2 to 0.3}	–	4 to 6 {0.4 to 0.6}	–
M6	4 to 6 {0.4 to 0.6}	–	7 to 10 {0.7 to 1.0}	–
M8	9 to 13 {0.9 to 1.3}	–	16 to 24 {1.7 to 2.5}	–
M10	18 to 27 {1.8 to 2.7}	17 to 25 {1.8 to 2.6}	34 to 50 {3.5 to 5.1}	32 to 48 {3.3 to 4.9}
M12	34 to 50 {3.4 to 5.1}	31 to 45 {3.1 to 4.6}	70 to 90 {7.0 to 9.5}	65 to 85 {6.5 to 8.5}
M14	60 to 80 {6.0 to 8.0}	55 to 75 {5.5 to 7.5}	110 to 150 {11 to 15}	100 to 140 {11 to 14}
M16	90 to 120 {9 to 12}	90 to 110 {9 to 11}	170 to 220 {17 to 23}	160 to 210 {16 to 21}
M18	130 to 170 {14 to 18}	120 to 150 {12 to 16}	250 to 330 {25 to 33}	220 to 290 {23 to 30}
M20	180 to 240 {19 to 25}	170 to 220 {17 to 22}	340 to 460 {35 to 47}	310 to 410 {32 to 42}
M22	250 to 330 {25 to 33}	230 to 300 {23 to 30}	460 to 620 {47 to 63}	420 to 560 {43 to 57}
M24	320 to 430 {33 to 44}	290 to 380 {29 to 39}	600 to 810 {62 to 83}	540 to 720 {55 to 73}

Hexagon Flange Nuts (Unit: N·m {kgf·m})

Strength	4T	
Identification symbol	 02155	
Nominal diameter	Standard screw thread	Coarse screw thread
M6	4 to 6 {0.4 to 0.6}	–
M8	10 to 15 {1.0 to 1.5}	–
M10	21 to 31 {2.1 to 3.1}	20 to 29 {2.0 to 3.0}
M12	38 to 56 {3.8 to 5.6}	35 to 51 {3.5 to 5.2}

Tightening Torque for General-Purpose Flare Nut (Unit: N·m {kgf·m})

Pipe diameter	ϕ4.76 mm	ϕ6.35 mm	ϕ8 mm	ϕ10 mm	ϕ12 mm	ϕ15 mm
Tightening torque	17 {1.7}	25 {2.6}	39 {4.0}	59 {6.0}	88 {9.0}	98 {10}

Tightening Torque for General-Purpose Air Piping Nylon Tube (DIN Type) (Unit: N·m {kgf·m})

Nominal diameter × wall thickness	6 × 1 mm	10 × 1.25 mm	12 × 1.5 mm	15 × 1.5 mm
Tightening torque	20^{+6}_{0} {$2.0^{+0.6}_{0}$}	34^{+10}_{0} {$3.5^{+1.0}_{0}$}	49^{+10}_{0} {$5.0^{+1.0}_{0}$}	54^{+5}_{0} {$5.5^{+0.5}_{0}$}

Tightening Torque for General-Purpose Air Piping Nylon Tube (SAE Type) (Unit: N·m {kgf·m})

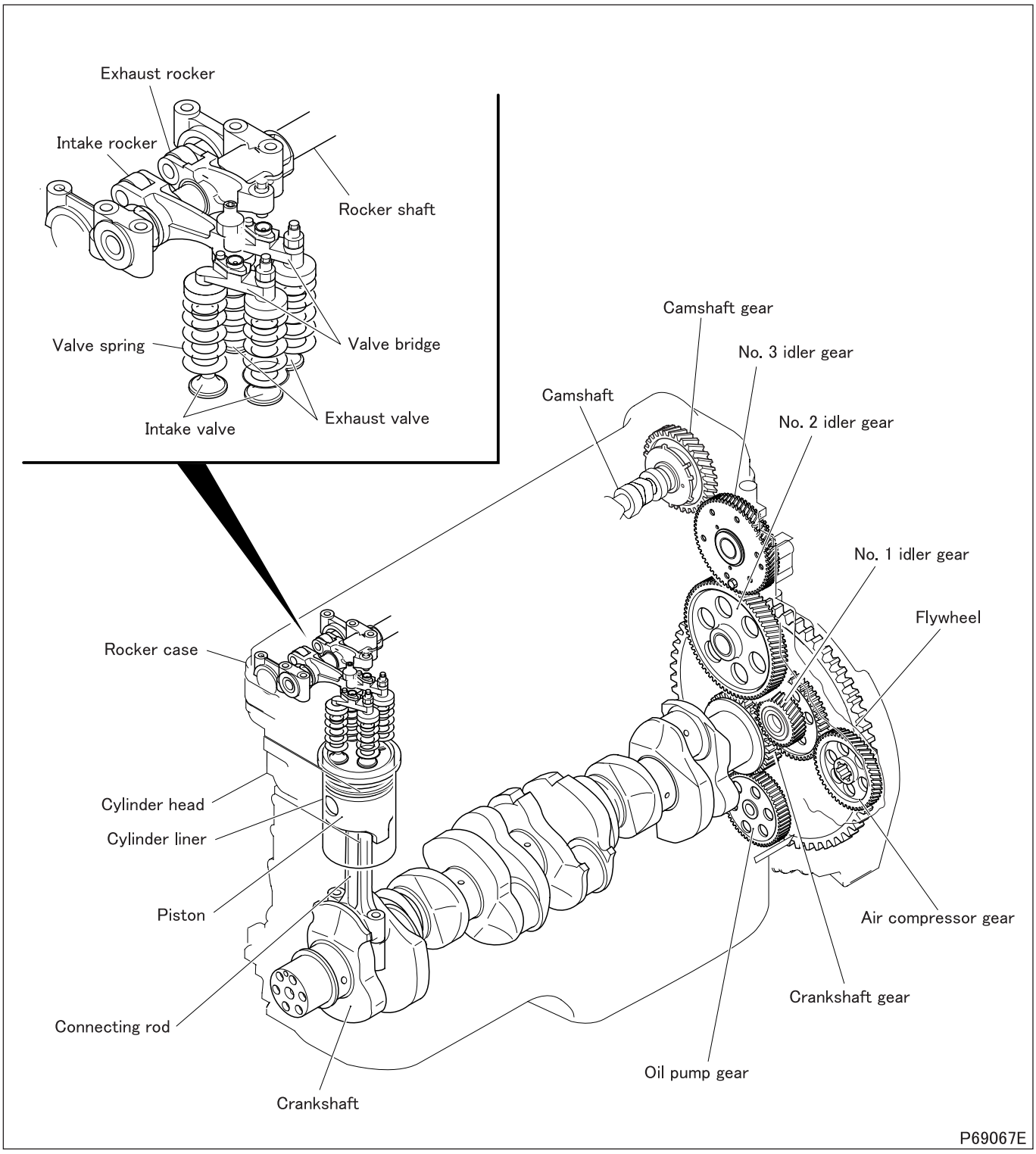
Nominal diameter	1/4 in.	3/8 in.	1/2 in.	5/8 in.
Tightening torque	13^{+4}_{0} {$1.3^{+0.4}_{0}$}	29^{+5}_{0} {$3.0^{+0.5}_{0}$}	49^{+5}_{0} {$5.0^{+0.5}_{0}$}	64^{+5}_{0} {$6.5^{+0.5}_{0}$}

GROUP 11 ENGINE

SPECIFICATIONS

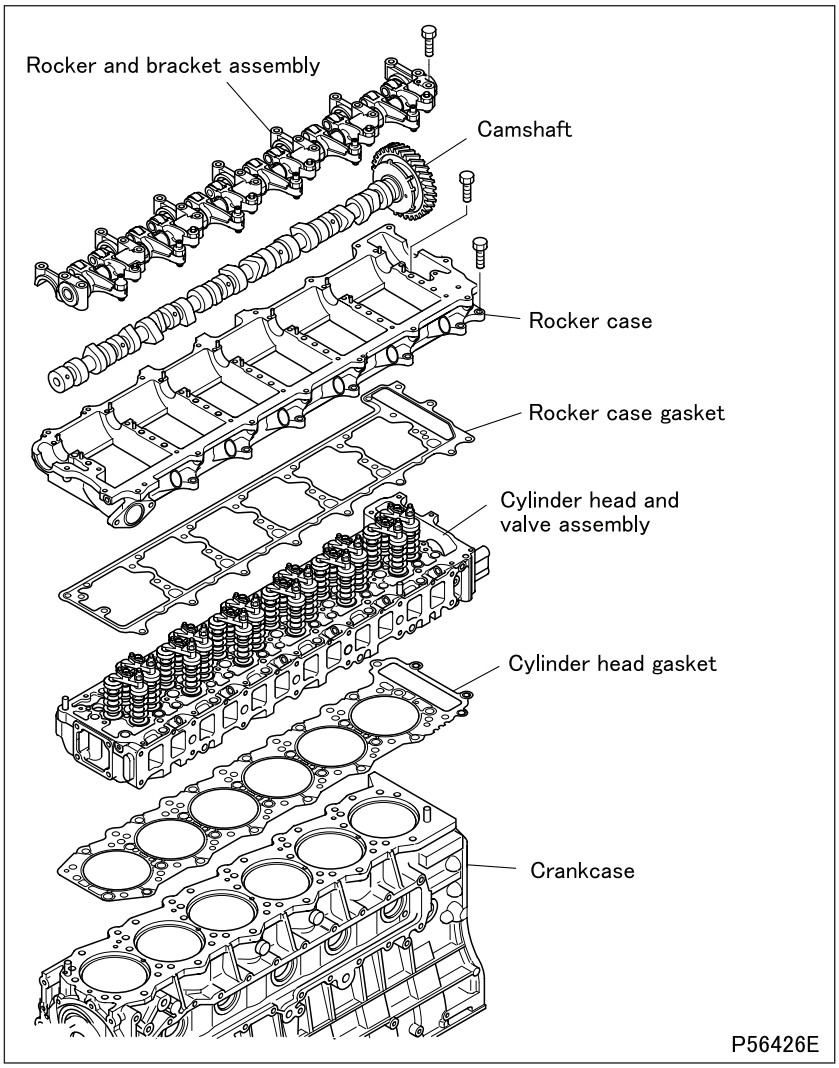
Item		Specifications			
Engine mode		6M60-TL			
Type		6-cylinder, in-line, water-cooled, 4-cycle diesel engine			
Combustion chamber		Direct injection type			
Valve mechanism		Overhead camshaft (OHC) system			
Maximum output	kW {PS} /rpm	110 {150} / 2100	129 {175} / 2100	145 {195} / 2600	200 {270} / 2600
Maximum torque	N·m {kgf·m} /rpm	610 {62} / 1600	700 {71} / 1600	740 {75} / 1400	785 {80} / 1400
Bore × stroke	mm	ϕ118 × 115			
Total displacement	cm^3 {L}	7545 {7.545}			
Compression ratio		17.5			

1. Engine Proper



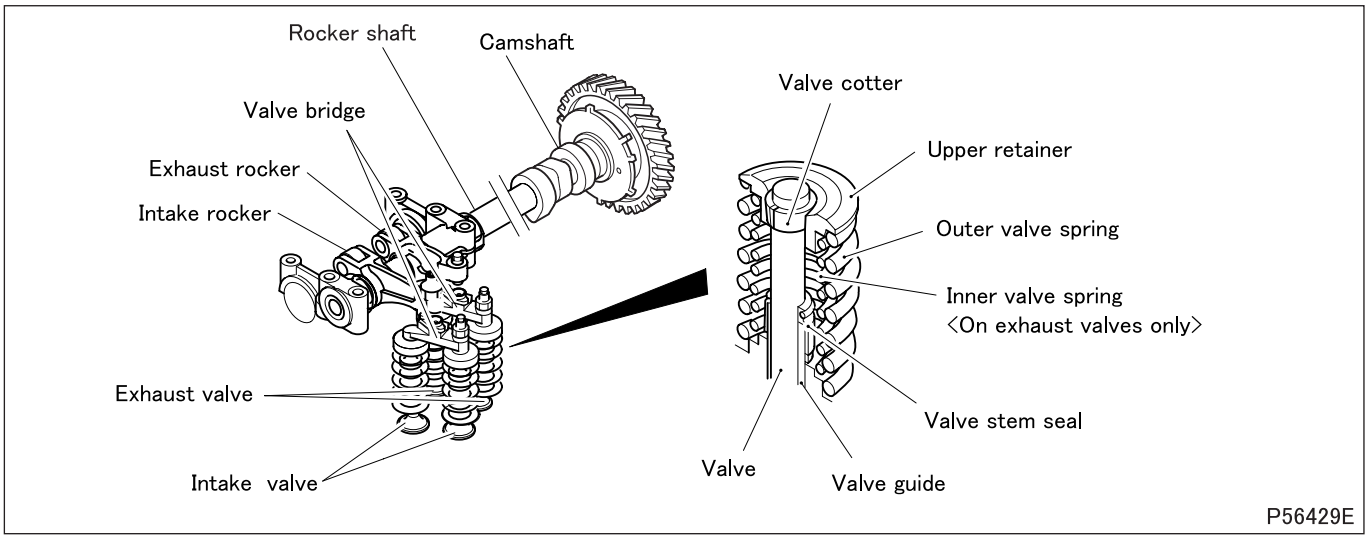
- The 6M60-TL engine employs an overhead camshaft (OHC) system, with the valve mechanism and the timing gears arranged as shown above.

2. Rocker and Bracket Assembly, Camshaft, Rocker Case and Cylinder Head Gasket



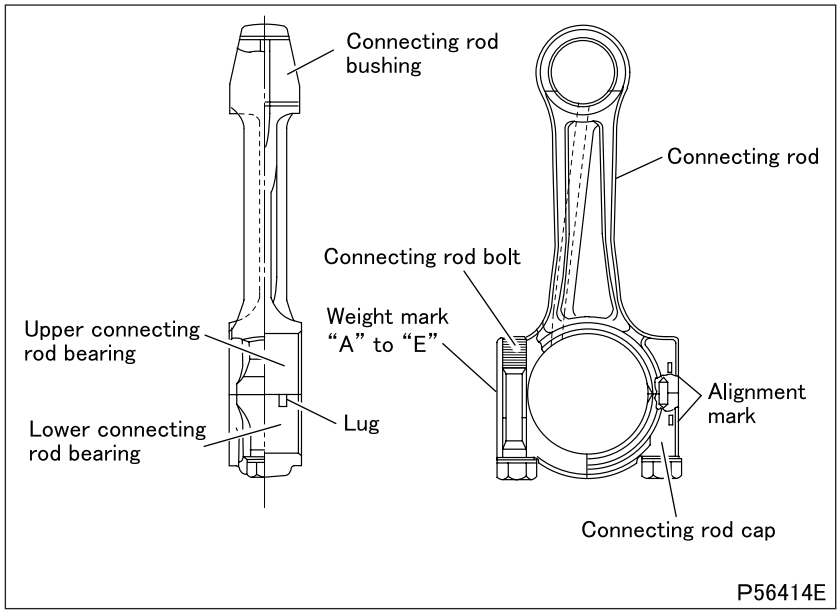
- The camshaft is directly supported at its journals by the rocker case, and is held in place from above by the rocker and bracket assembly.
- The camshaft journals are directly supported by the rocker case and the rocker and bracket assembly, without using any camshaft bearings. The rocker case and brackets have been machined together, meaning that they all need to be replaced with a new set when one of them becomes defective.

3. Valve Mechanism

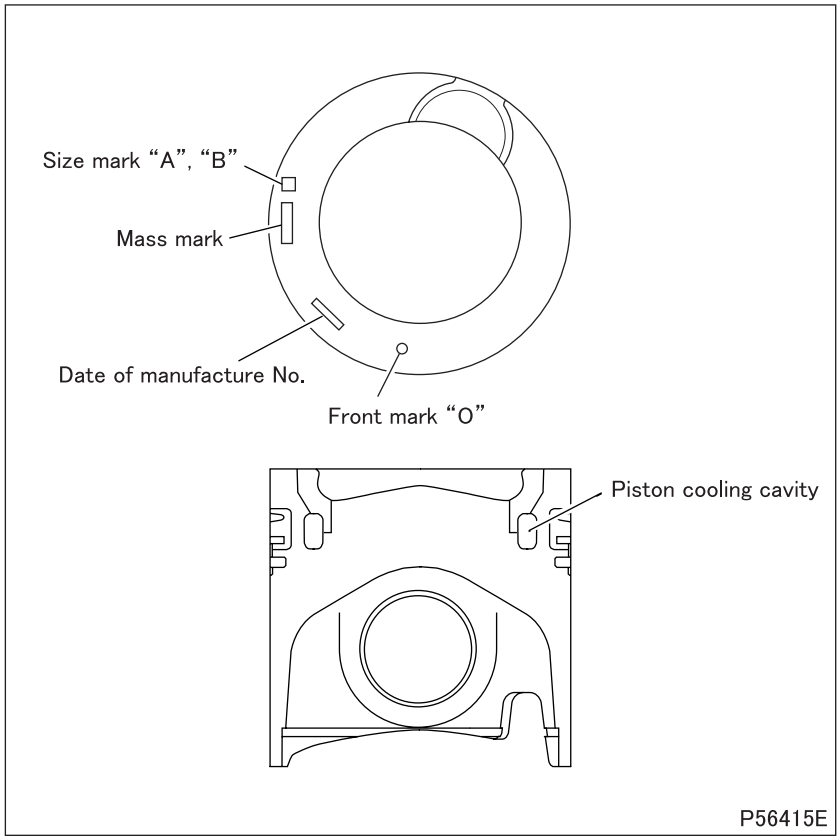


- Each valve has a valve stem seal, which regulates the flow of lubricating oil to the contact surface between the valve and the valve guide.
- The valve springs have a variable pitch to prevent abnormal vibration at high engine speed. The exhaust valves use a double spring, with the inner and outer springs coiled in different directions to prevent them from jamming each other.

4. Connecting Rod

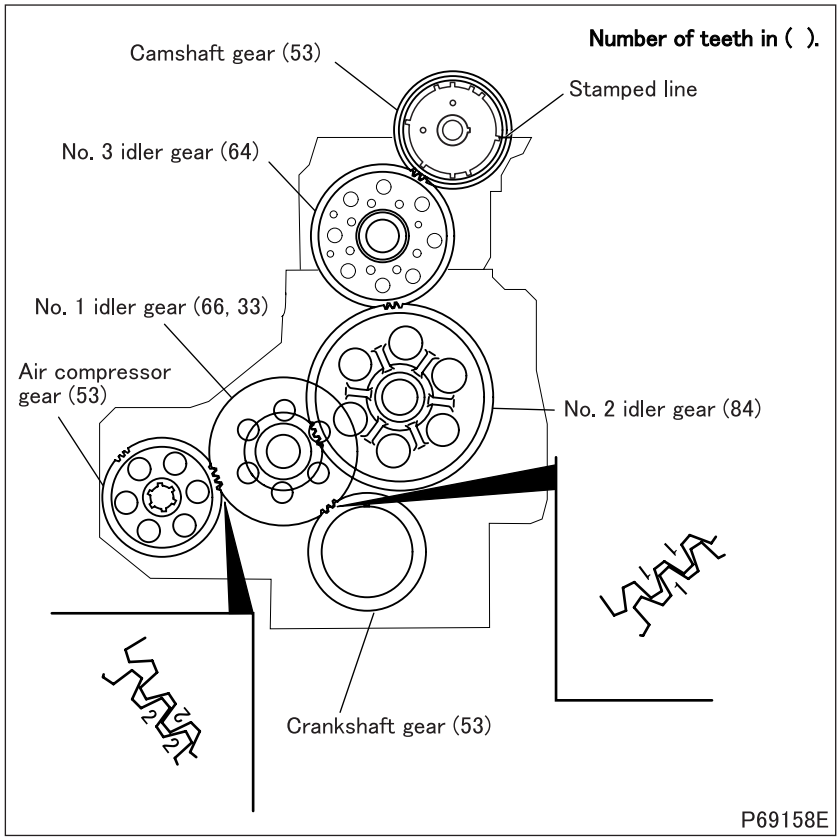


5. Piston

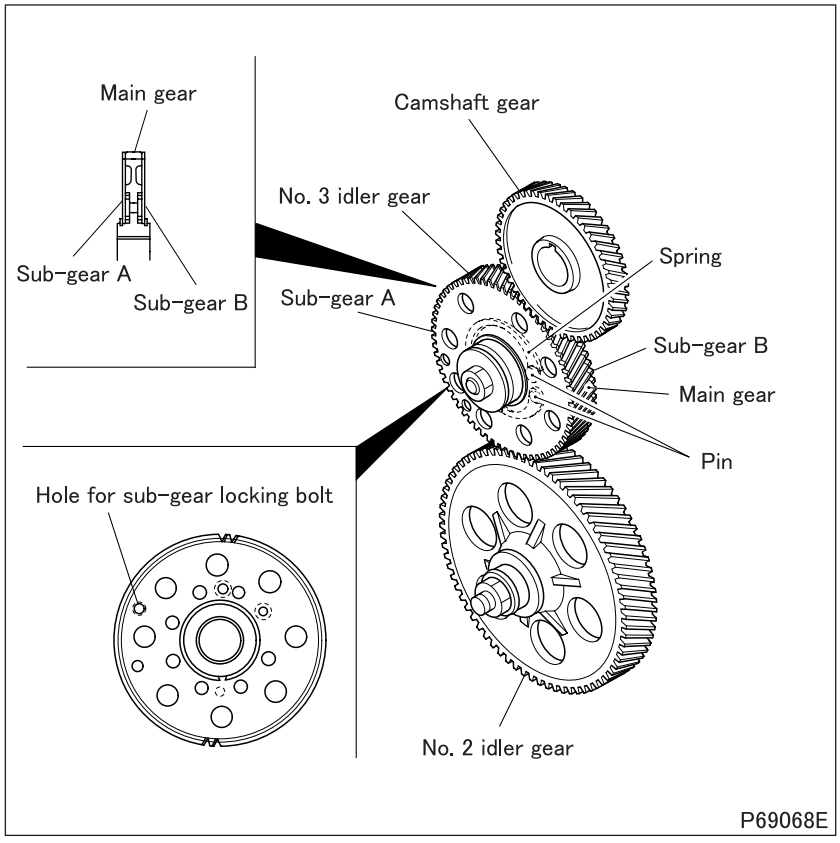


- The piston, the cylinder liner and the crankcase bore all must have the same size marks to ensure a good fit between them.
- The pistons are made of special aluminum alloy, and are provided with a recess on each end of the piston pin boss to reduce weight.

6. Timing Gears

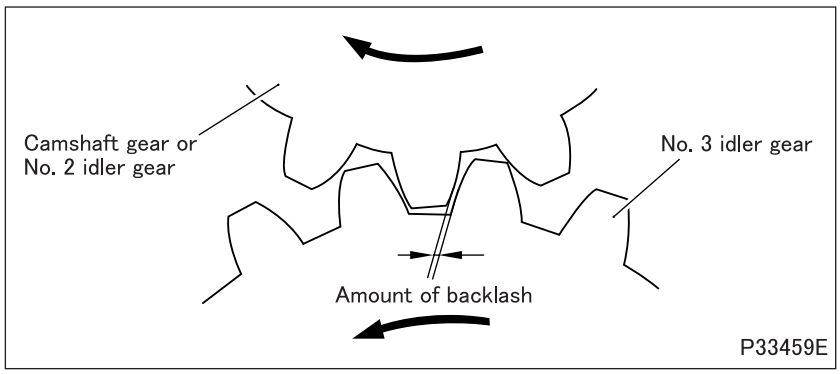


- The timing gears are provided with timing marks to help ensure correct assembly.
- Timing marks are provided on the following gears.
  - Camshaft gear: stamped line
  - Crankshaft gear: “1”
  - Air compressor gear: “2”
  - No. 1 idler gear: “1”, “2”



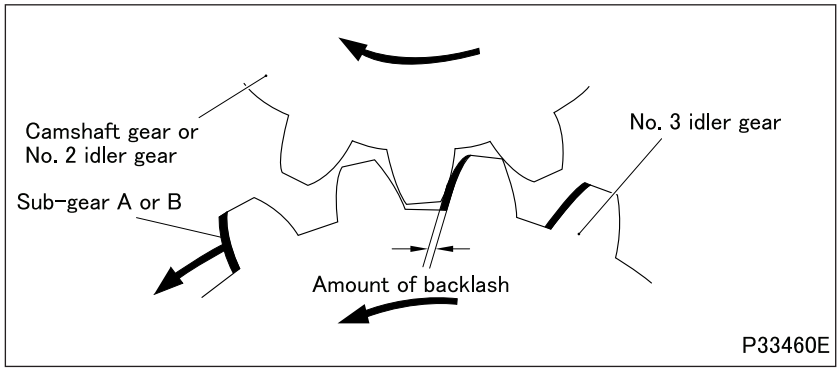
6.1 No. 3 idler gear

- The No. 3 idler gear consists of the sub-gear A, the sub-gear B and the main gear.
- A spring is installed between the sub-gear A and the main gear, as well as between the sub-gear B and the main gear. The springs are locked in place with pins.
- The sub-gears are installed as follows. The sub-gear A has been turned in such a way as to compress the spring before meshing with the camshaft gear. Likewise, the sub-gear B has been turned to compress the spring before meshing with the No. 2 idler gear.



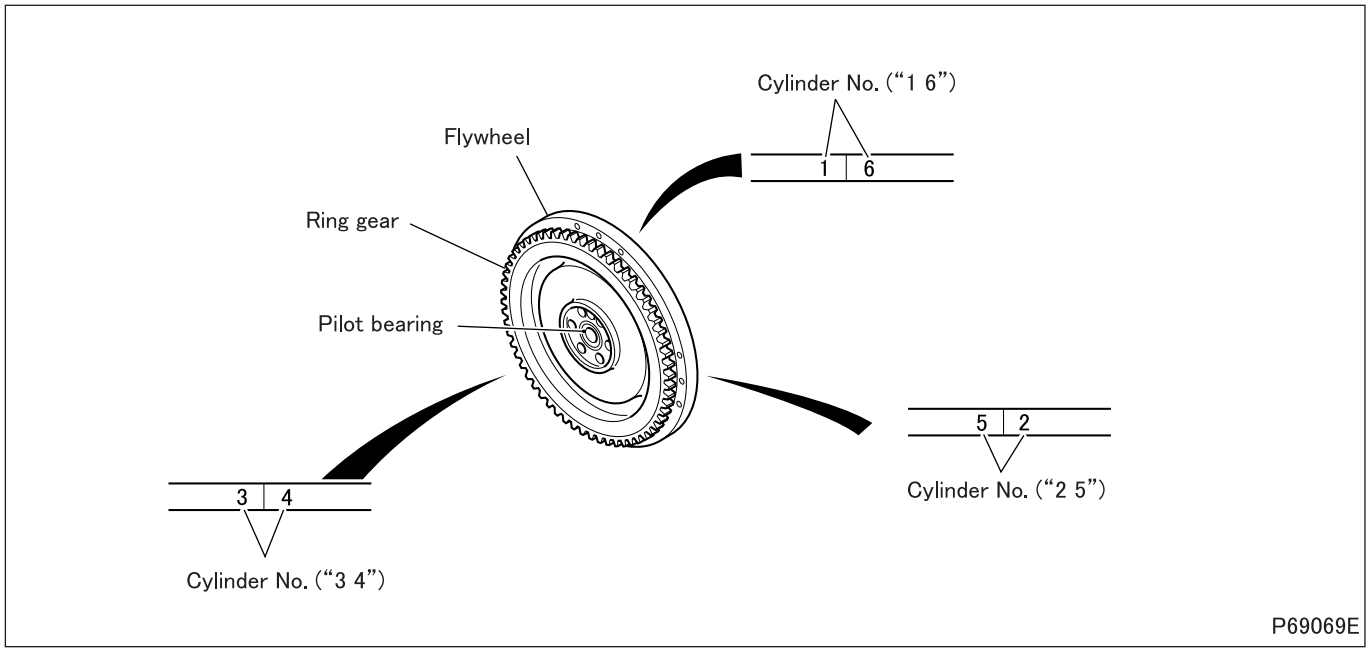
(1) Non-backlash mechanism

- Engine hunting during idling causes fluctuation in the speed of camshaft and No. 2 idler gears.
- Without the non-backlash mechanism, the backlash changes between zero and the maximum, generating gear rattle noise.



- With the non-backlash mechanism equipped on the engine, the sub-gears A and B maintain the backlash to zero even when the engine hunts, eliminating gear rattle during idling.

7. Flywheel



Possible causes / Symptoms		Low power output	Abnormal engine noise	Reference Gr
Cylinder head and valve mechanism	Incorrect valve clearance	O	O	
	Defective cylinder head gasket	O	O	
	Worn valve and valve seat; carbon deposits	O	O	
	Weakened valve spring	O	O	
	Defective rocker shaft and bracket		O	
	Poor lubrication of rocker shaft bracket		O	
Timing gears	Incorrect backlash in timing gears		O	
	Poor lubrication of timing gears and idler shaft		O	
Camshaft	Excessive end play in camshaft		O	
	Worn camshaft		O	
Pistons and connecting rods	Worn/damaged piston ring groove(s)	O	O	
	Worn/damaged piston ring(s)	O	O	
	Worn piston pin and connecting rod small end		O	
Crankshaft	Excessive end play in crankshaft		O	
	Incorrectly fitted crankshaft pulley		O	
	Worn/damaged crankshaft pins and connecting rod bearings		O	
	Worn/damaged crankshaft journals and main bearings		O	
Fuel system	Supply pump faulty	O	O	Gr13E
	Defective injector	O	O	
	Air trapped in fuel system	O		Gr13A
Cooling system	Malfunctioning cooling system components	O		Gr14
	Loose/damaged V-belts		O	
Intake and exhaust system	Clogged air cleaner	O	O	Gr15
	Clogged muffler	O	O	
	Malfunctioning turbochargers	O	O	
Incorrect oil viscosity		O		Gr12
Improper fuel		O		
Incorrectly fitted piping and hoses			O	
Defective/incorrectly fitted alternator and other auxiliaries			O	

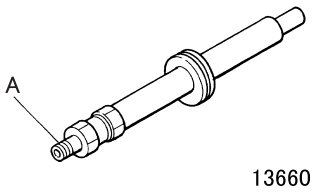
M E M O

1. Measuring Compression Pressure

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
–	Compression pressure	Each cylinder (at 200 rpm)	2,940 kPa {30 kgf/cm^2}	1,960 kPa {20 kgf/cm^2}	Inspect
		Cylinder-to-cylinder pressure difference	–	390 kPa {4 kgf/cm^2} or less	Inspect

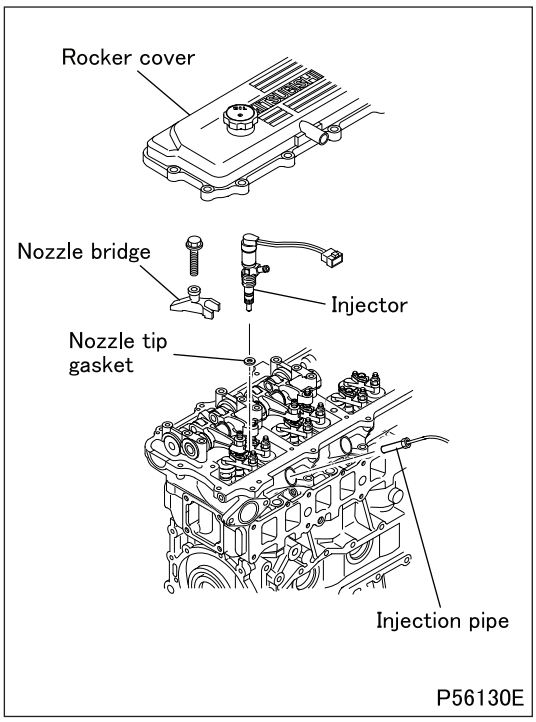
Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Compression gauge adapter A: M16 × 18 	MH063384	Measuring compression pressure

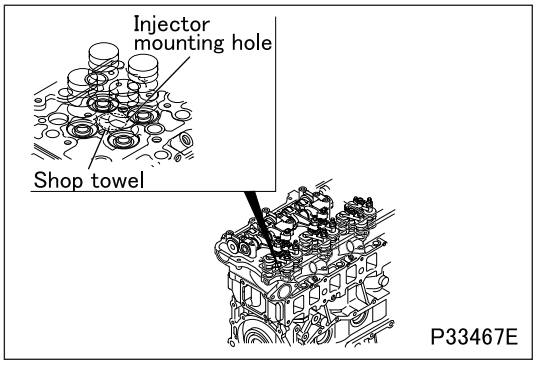
- A drop in compression pressure can be used as a guide to determine when the engine should be overhauled.
- Measure the compression pressure at regular intervals. Keeping track of its transitions can provide a useful tool for troubleshooting. On new vehicles and vehicles with newly replaced parts, the compression pressure will be somewhat higher depending on the break-in condition of piston rings, valve seats, etc., but this will return to normal as the parts wear down.
- Before inspection, confirm that the engine oil, starter, and battery are in normal condition, and satisfy the following conditions.
  - Warm up the engine until the coolant temperature reaches approximately 75 to 85°C.
  - Turn off the lights and auxiliaries.
  - Place the lever in neutral.
  - Remove the fuse for fuel cut to prevent fuel from being injected while the engine is cranked using the starter.

CAUTION ⚠

- **When cranking the engine, never shut off the power supplied to the engine electronic control unit by disconnecting the engine electronic control unit connector or other similar methods. If the engine is cranked with the power to the engine electronic control unit shut off, the supply pump will not be controlled by the electronic control unit, causing the supply pump to be malfunctioned.**



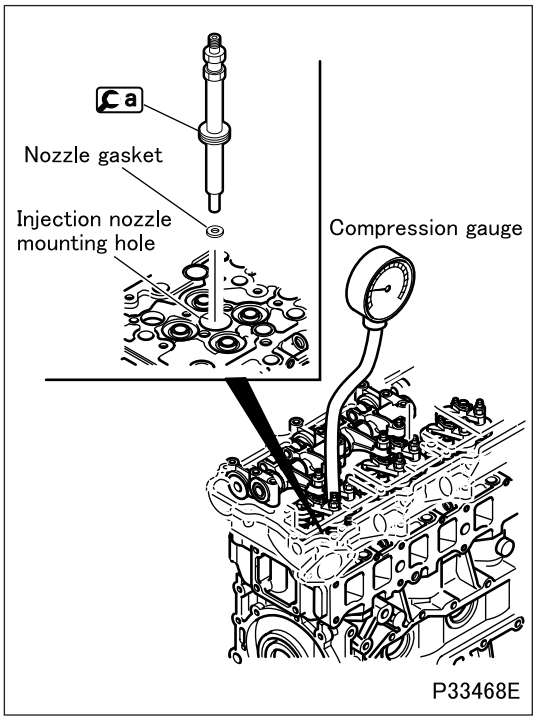
- Remove all the injectors. (See Gr13A.)



- Cover the injector mounting holes with shop towels or other similar cloth. Crank the engine using the starter. Ensure that no foreign matter is attached on the shop towels.

CAUTION ⚠

- **If cracks or any other damage are evident in the cylinders, this means that the coolant, engine oil or fuel, or other substances, has entered the cylinders. If this is the case, it is extremely dangerous to crank the engine as these substances will gush out at high temperature from the injector mounting holes. Stay away from the engine when cranking it.**



- Attach the nozzle gasket and a to one of the injection nozzle mounting holes. Then, connect a compression gauge to a.
- Crank the engine and measure the compression pressure.
- Measure the compression pressure for all the cylinders one after another. Determine the compression pressure difference between the cylinders.
- If the compression pressure is below the limit or the cylinder-to-cylinder pressure differences is not within the limit, pour a small amount of engine oil into the corresponding injection nozzle mounting hole and remeasure the compression pressure.
  - If the compression pressure increases, the piston rings and cylinder surfaces may be badly worn or otherwise damaged.
  - If the compression pressure remains unchanged, there may be seizure in the valves, the valves may be incorrectly seated or the cylinder head gasket may be defective.

- Install the injectors. (See Gr13A.)
- Install the rocker cover and gasket. (See later pages.)

2. Inspection and Adjustment of Valve Clearances

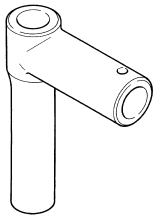
Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
–	Valve clearance (when cold)	0.6	–	Adjust

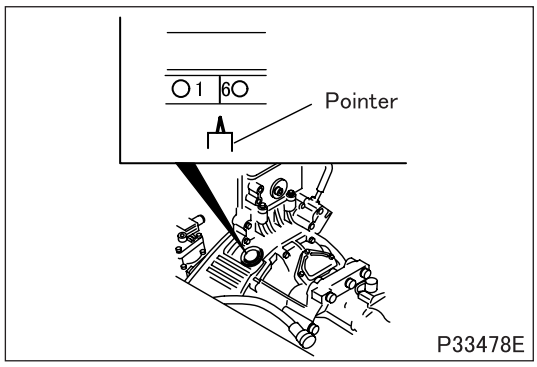
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Lock nut (adjusting screw tightening)	59 {6.0}	–
–	Lock nut (rocker arm adjusting screw tightening)	34 {3.5}	–

Special tools

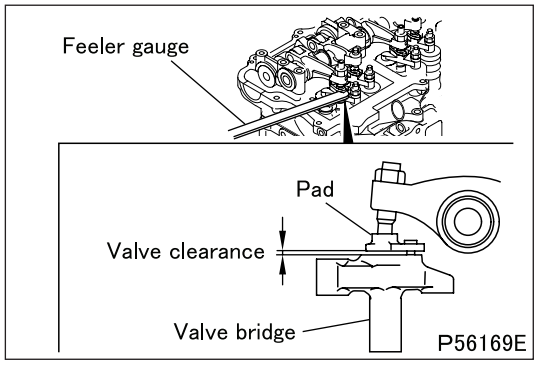
Mark	Tool name and shape	Part No.	Application
a	Socket wrench  14437	MH063003	Tightening the lock nut

- Valve clearances should be checked and adjusted as follows while the engine is still cold.



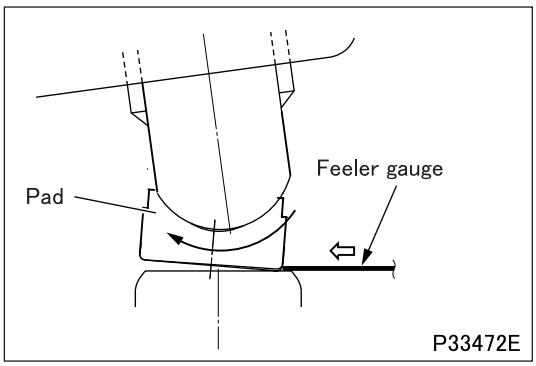
[Inspection]

- Remove the rocker cover.
- Bring the No. 1 or No. 6 cylinder piston to the top dead center (TDC) on the compression stroke according to the following procedure:
  - Rotate the crankshaft until the pointer is aligned with the “1 6” mark on the flywheel.
  - This will place either the No. 1 or No. 6 cylinder piston at TDC on the compression stroke. The cylinder in which the rocker arms for both the intake and exhaust valves can be pushed down by hand by the valve clearance amounts has its piston at TDC. Rotate the engine by one full turn to switch the TDCs of the No. 1 and No. 6 cylinder pistons.

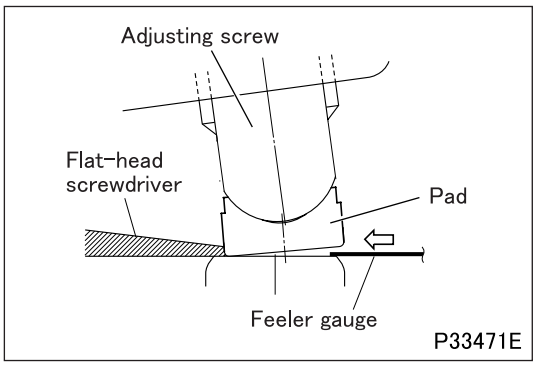


- With the No. 1 or No. 6 cylinder piston at TDC, measure the clearance of the valves (clearance between valve bridge and pad) marked with a circle in the table below.

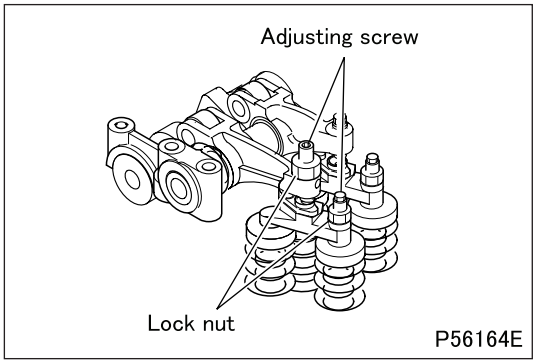
Cylinder No.	1		2		3		4		5		6	
Valve	IN	EX	IN	EX	IN	EX	IN	EX	IN	EX	IN	EX
No. 1 cylinder piston at TDC on compression stroke	O	O	O	–	–	O	O	–	–	O	–	–
No. 6 cylinder piston at TDC on compression stroke	–	–	–	O	O	–	–	O	O	–	O	O



- Any attempt to insert a feeler gauge without first securing sufficient space, as described below, between the pad and the valve bridge will fail, as the pad will tilt as shown in the illustration, thus blocking the entry of a feeler gauge.

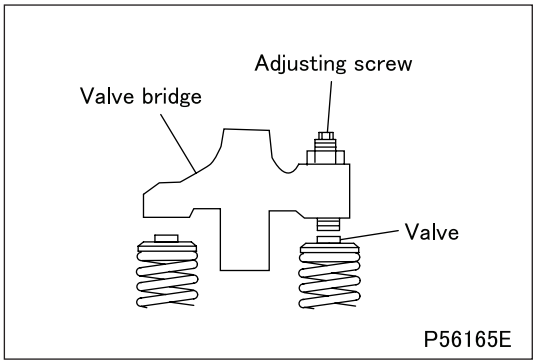


- Before inserting a feeler gauge, push the adjusting screw pad on the side opposite from where a feeler gauge is to be inserted, as shown in the illustration, using a flat-head screwdriver or other similar tool. This will create space necessary for the gauge to be inserted.
- The measurement is correct when the feeler gauge feels slightly resisted as it is inserted.
- The measurement is not yet correct if the feeler gauge can still be inserted smoothly.
- If the measurement deviates from the standard value, adjust as follows.

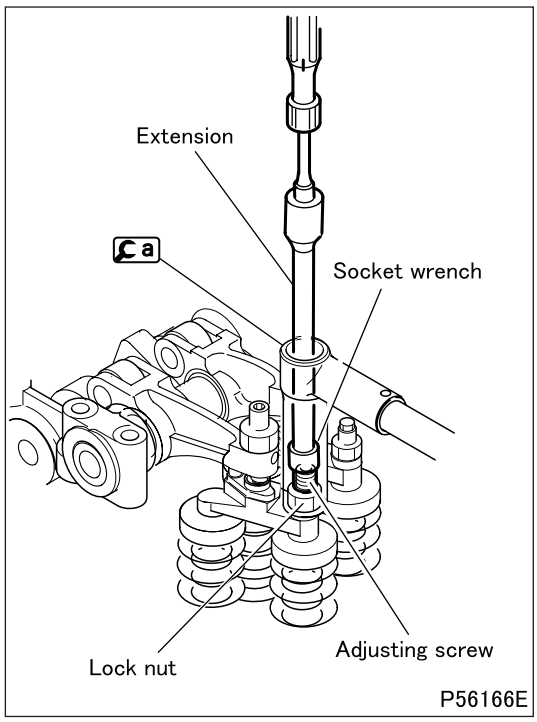


[Adjustment]

- Loosen the lock nuts and adjusting screws on the valve bridge and rocker arm.



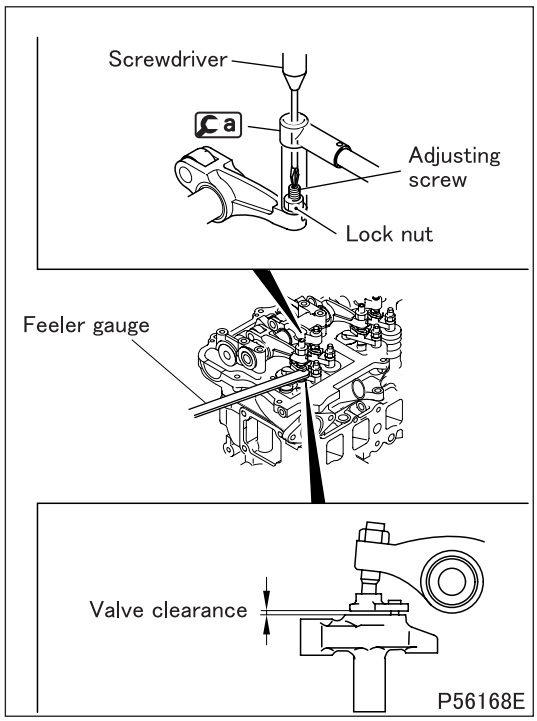
- While holding the valve bridge by hand, screw in the adjusting screw until it lightly contacts the valve stem end.
- Then, further screw in the adjusting screw by 45°.



- While holding the adjusting screw in this position with a socket wrench and extension, tighten the lock nut to the specified torque using a.

CAUTION ⚠

- **After adjusting the adjusting screw, be sure to tighten the lock nut to the specified torque. Insufficient torquing will compromise the parallelism of the valve bridge, damaging the valve mechanism.**

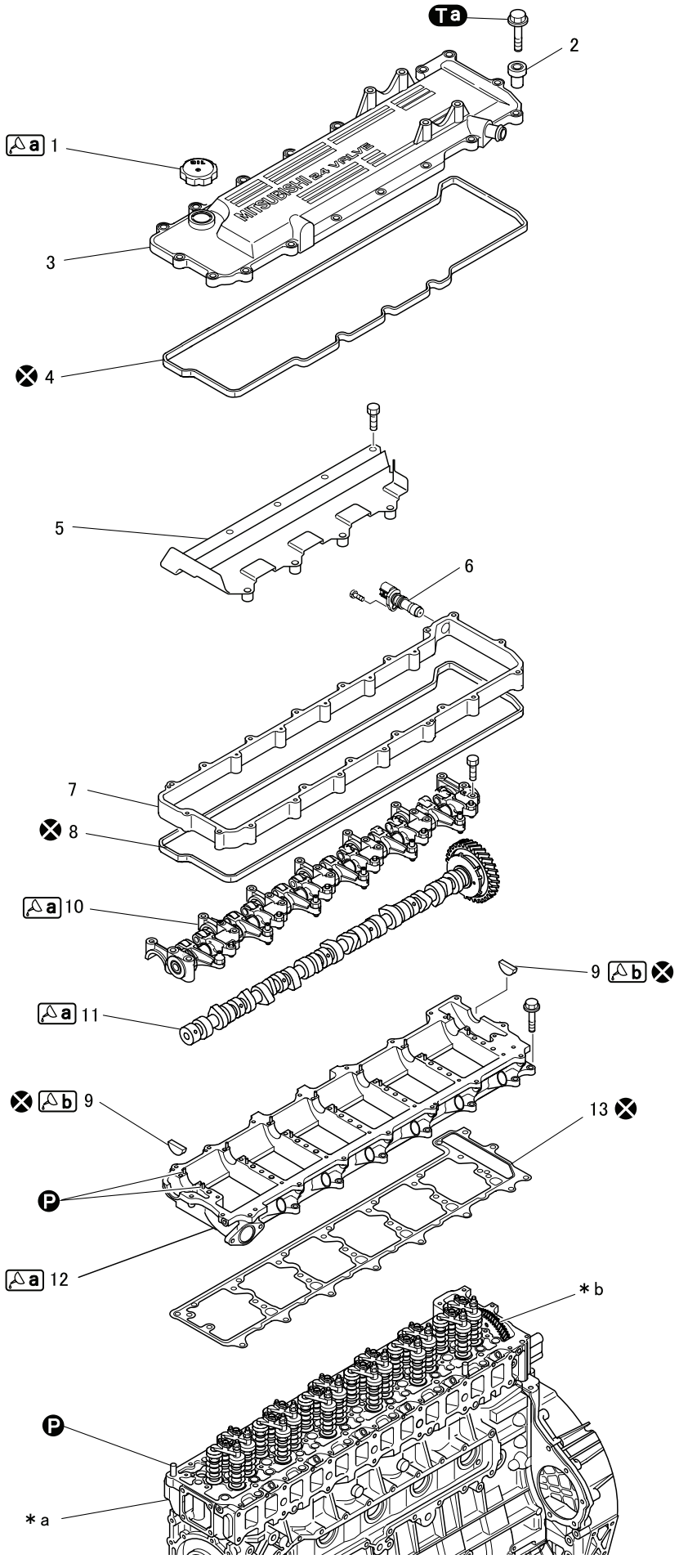


- Screw in or out the adjusting screw on the rocker arm until the correct feeler gauge can be inserted with a slight resistance.
- While holding the adjusting screw in this position with a screwdriver, tighten the lock nut to the specified torque using a.
- Recheck the valve clearance using the correct feeler gauge.

[Installation]

- Install the rocker cover and gasket. (See later pages.)

M E M O



P69070

● Disassembly sequence

1 Oil filler cap
2 Rubber
3 Rocker cover
4 Rocker cover gasket
5 Baffle plate
6 Cylinder recognition sensor
7 Rocker case upper
8 Rocker case upper gasket
9 Packing
10 Rocker and bracket assembly (See later pages.)
11 Camshaft (See later pages.)
12 Rocker case
13 Rocker case gasket

*a: Cylinder head
*b: No. 3 idler gear

Ⓟ: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **The rocker case and the brackets of the rocker and bracket assembly have been machined together, which means that they all must be replaced together. Never swap the locations of the brackets, either.**

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
–	Camshaft end play	0.05 to 0.20	0.4	Inspect
11, *b	Backlash between camshaft gear and No. 3 idler gear	0.18 to 0.26	0.35	Replace

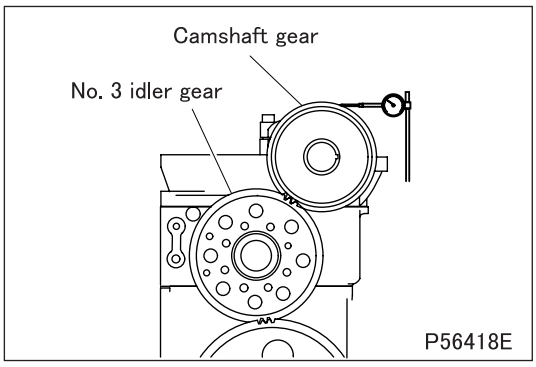
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (rocker cover mounting)	8.8 {0.9}	–

Lubricant and/or sealant

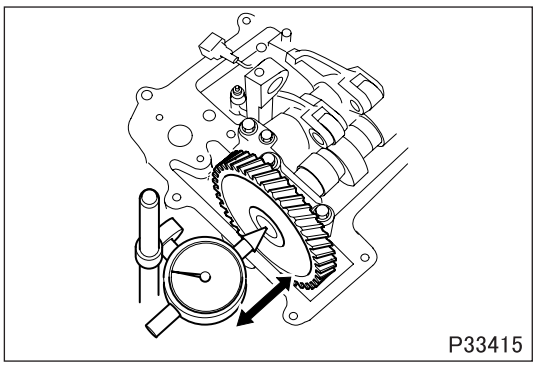
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rubber portion of oil filler cap	Engine oil	As required
	Camshaft journal supports on rocker and bracket assembly		
	Camshaft journals and cams		
	Camshaft journal supports on rocker case		
b	Periphery and top surface of packing	ThreeBond 1217H	As required

◆Work before removal◆



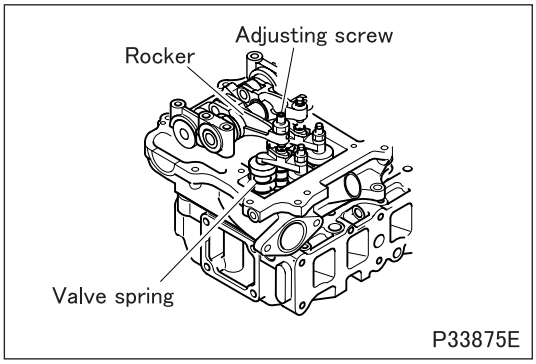
■ Inspection: Backlash between camshaft gear and No. 3 idler gear

- Measure the backlash at least at three different locations. If the measurement exceeds the limit, replace the defective part(s).



■ **Inspection: Camshaft end play**

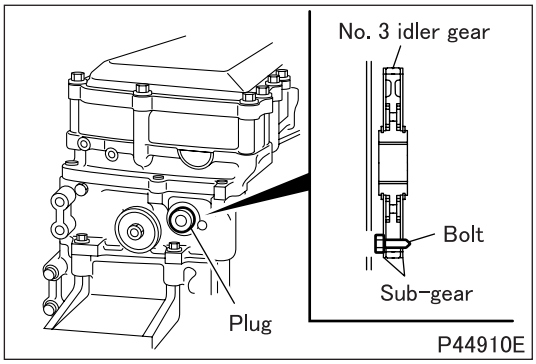
- If the measurement exceeds the limit, replace the defective part(s).



■ **Releasing valve spring force**

- Before loosening the rocker and bracket assembly mounting bolts, check whether the valve springs are compressed by the rockers. If so, loosen the adjusting screws on the rockers to relieve the spring force. This will eliminate the possibility of compressed springs damaging parts when they are released.

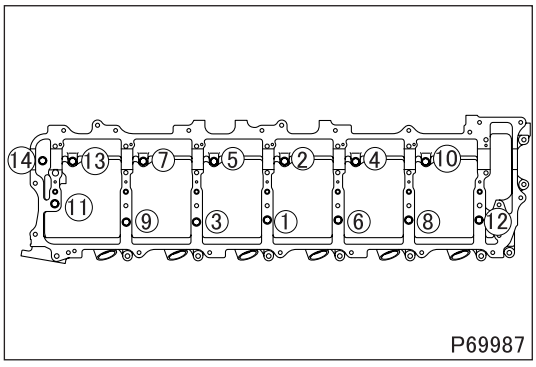
◆Removal procedure◆



■ **Removal: Camshaft**

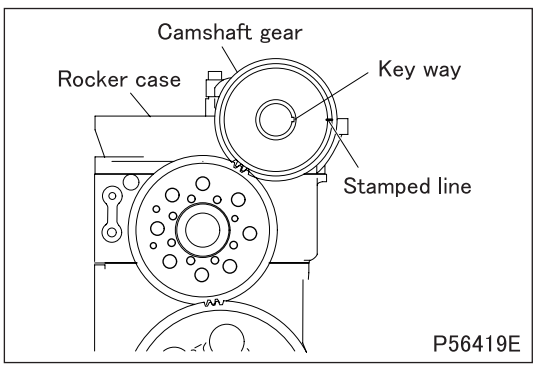
- Remove the plug at the rear end of the cylinder head.
- Insert a sub-gear locking bolt (M8 × 1.25 mm, length 20 mm) into the dedicated hole in the No. 3 idler gear to lock the sub-gears. Remove the camshaft.

◆Installation procedure◆



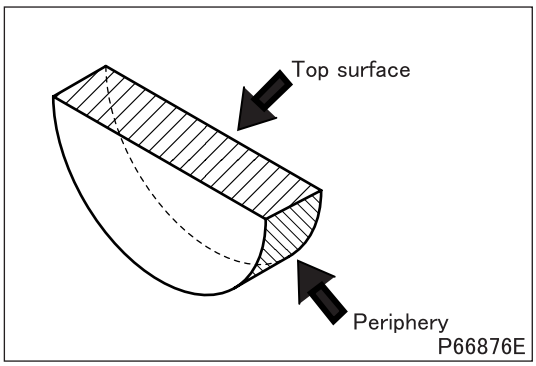
■ **Installation: Rocker case**

- Tighten the rocker case bolts in the order shown in the illustration.



■ **Installation: Camshaft**

- Make sure that the timing marks on the timing gears are aligned with each other.
- Install the camshaft so that the stamped line on the camshaft gear is level with the top surface of the rocker case.
- Install the plug at the rear end of the cylinder head. (See later pages.)

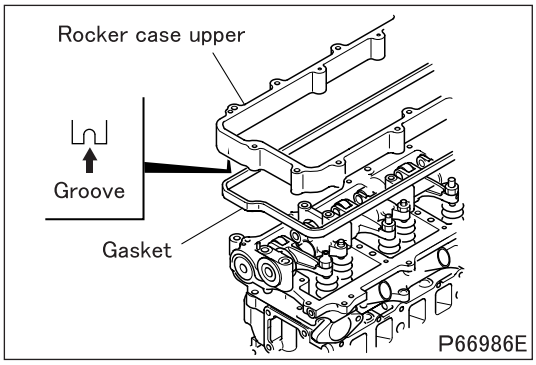


■ **Installation: Packing**

- Apply sealant onto the peripheral surface of the packing.
- Immediately after the sealant application, install the packing to the rocker case.
- After installing it on the rocker case, apply sealant to the top surface of the packing.
- Immediately after the sealant application, install the rocker case upper and rocker case upper gasket in place.

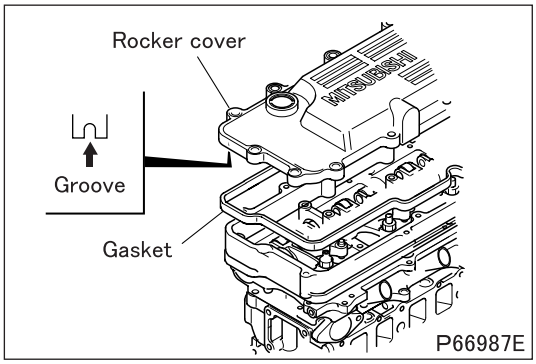
CAUTION ⚠

- **Do not start the engine for one hour after installation.**
- **When removing the rocker cover after installation, never fail to apply sealant again.**



■ **Installation: Rocker case upper gasket**

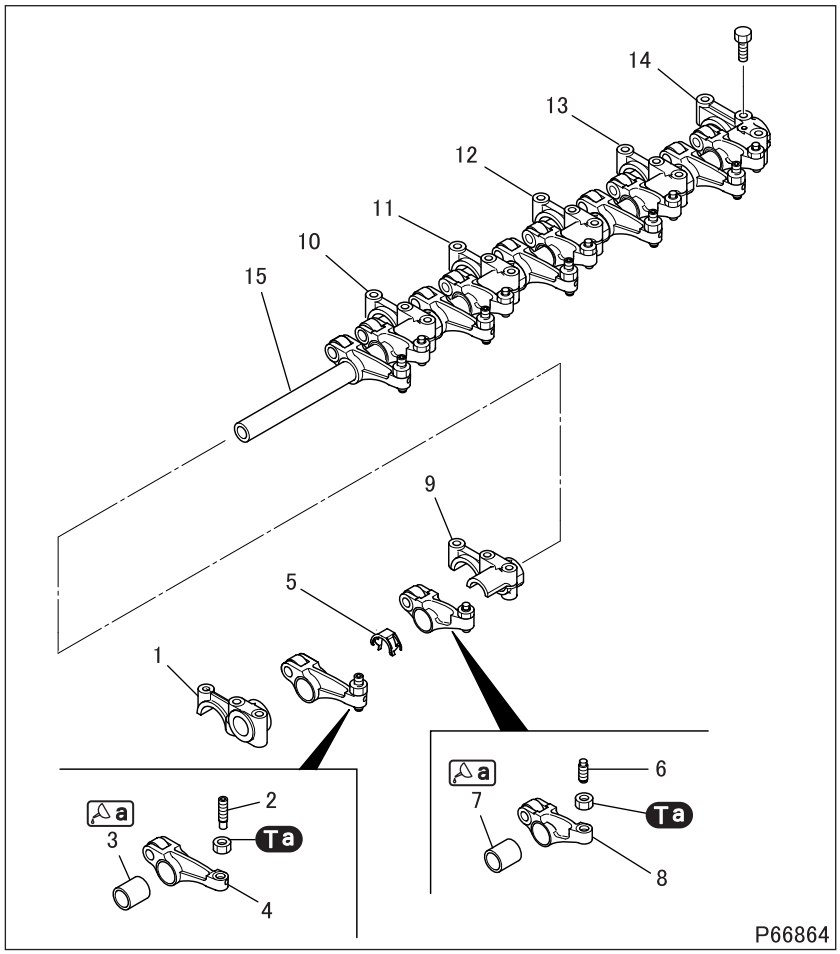
- Make sure that the gasket fitting groove in the rocker case is clear of grease and dirt. Clean if necessary.
- Before installation, make sure that the gasket is free of grease, etc. that could cause an oil leakage.



■ **Installation: Rocker cover gasket**

- Make sure that the gasket fitting groove in the rocker cover is clear of grease and dirt. Clean if necessary.
- Before installation, make sure that the gasket is free of grease, etc. that could cause an oil leakage.

Rocker and Bracket Assembly



● **Disassembly sequence**

1 Front bracket
2 Adjusting screw
3 Rocker bushing
4 Intake rocker
5 Rocker shaft spring
6 Adjusting screw
7 Rocker bushing
8 Exhaust rocker
9 No. 1 center bracket
10 No. 2 center bracket
11 No. 3 center bracket
12 No. 4 center bracket
13 No. 5 center bracket
14 Rear bracket
15 Rocker shaft

CAUTION ⚠

- **The rocker and bracket assembly and the rocker case are assembled together with precise adjustment and therefore they cannot be replaced separately.**
  If the rocker and bracket assembly is to be reused, be sure to reassemble the assembly with the same combinations of its parts as before.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
3, 7, 15	Clearance between rocker shaft and bushing	0.006 to 0.076	0.114	Replace
4, 8	Radial clearance of rocker (roller)	0.035 to 0.078	–	Replace

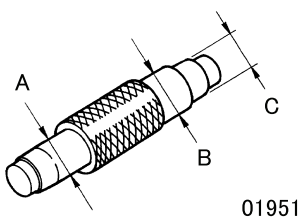
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Lock nut (adjusting screw tightening)	34 {3.5}	–

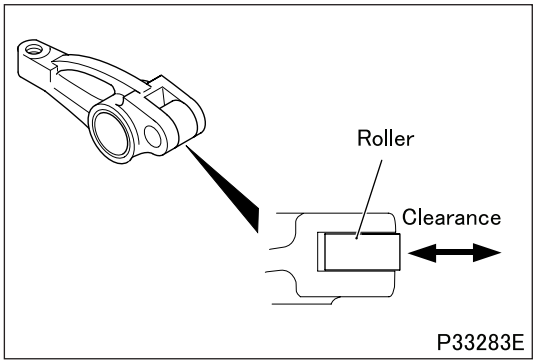
Lubricant and/or sealant

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

Special tools (Unit: mm)

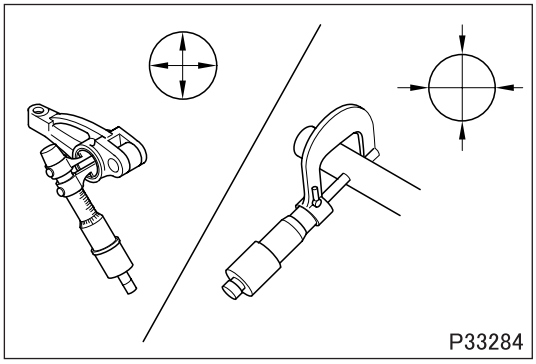
Mark	Tool name and shape	Part No.	Application
Ca	Rocker bushing puller A: ϕ25, B: ϕ27.5, C: ϕ25 	MH062727	Removal and installation of rocker bushing

◆Inspection procedure◆



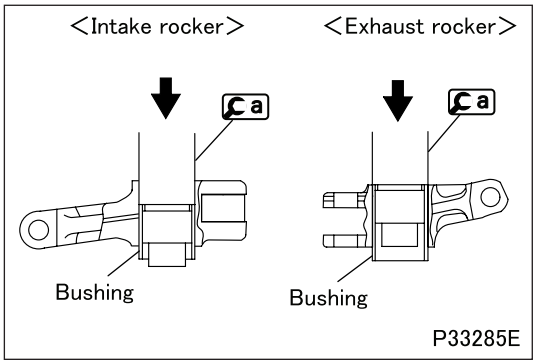
■ **Inspection: Radial clearance of rocker (roller)**

- If the measurement deviates from the standard value, replace the defective part(s).

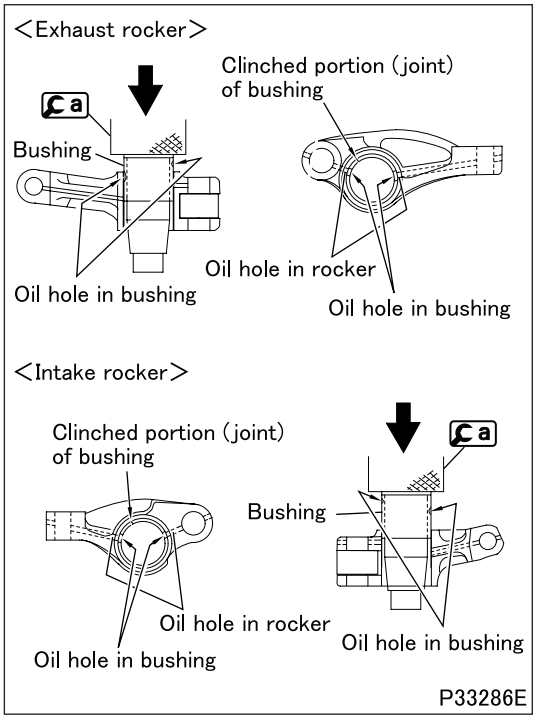


■ **Inspection: Clearance between rocker shaft and bushing**

- If the measurement exceeds the limit, replace the bushing.



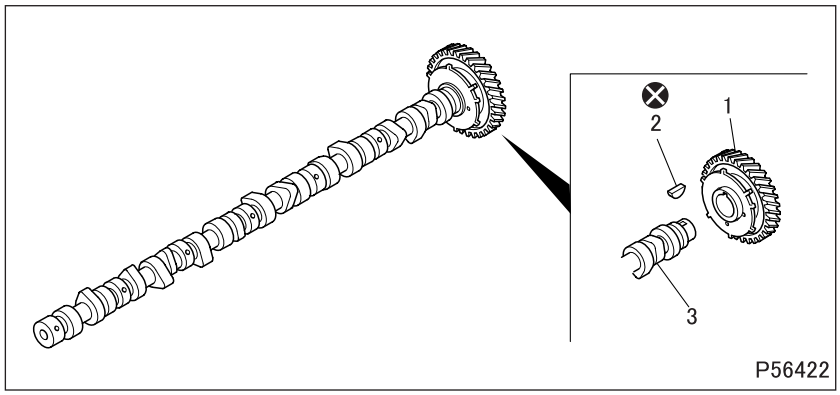
Replace of rocker bushing
[Removal]



[Installation]

- Assemble the bushing onto the rocker such that the oil holes are aligned as shown in the illustration.
- After assembly, recheck the clearance.
- If the measurement is less than the standard value, ream the bushing.

Camshaft



● **Disassembly sequence**

1 Camshaft gear
2 Key
3 Camshaft

⊗: Non-reusable parts

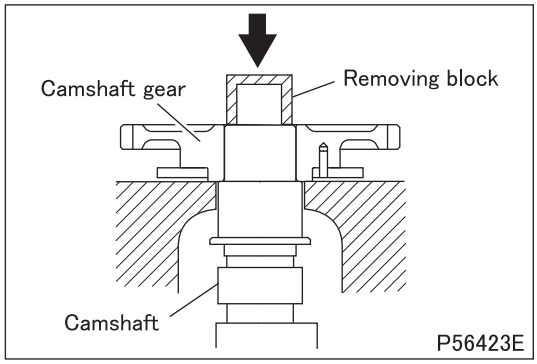
● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy	
1, 3	Interference between camshaft gear and camshaft			0.017 to 0.062	–	Replace	
3	Camshaft	Cam lift	Intake	5.023	4.973	Replace	Lobe diameter: 45.110 Base circle diameter: 40.087
			Exhaust	7.084	7.034		Lobe diameter: 47.370 Base circle diameter: 40.286
		Bend		0.02 or less	0.04	Replace	
		Oil clearance at journal		0.075 to 0.12	0.25	Inspect	

◆**Removal procedure**◆



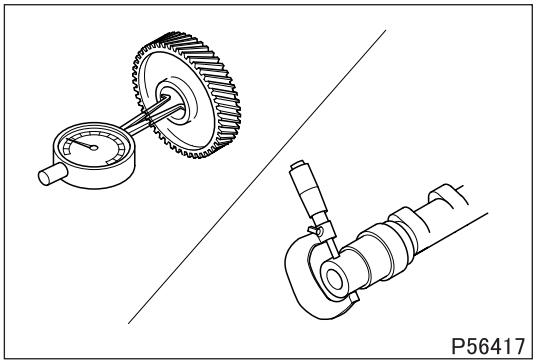
■ **Removal: Camshaft gear**

- Remove the camshaft gear by pushing on the end of the camshaft with a press or other similar tool.

CAUTION ⚠

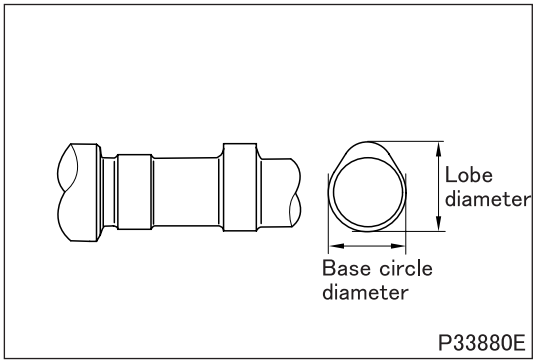
- **Do not attempt to remove the camshaft gear with a hammer as damage will result. Use a press or other similar tool.**

◆Inspection procedure◆


P56417

■ **Inspection: Interference between camshaft gear and camshaft**

- If the measurement deviates from the standard value, replace the defective part(s).

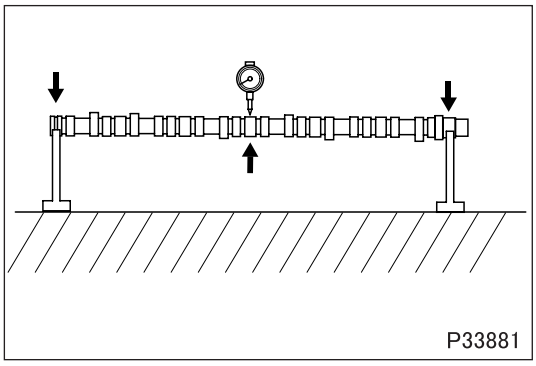


P33880E

■ **Inspection: Camshaft**

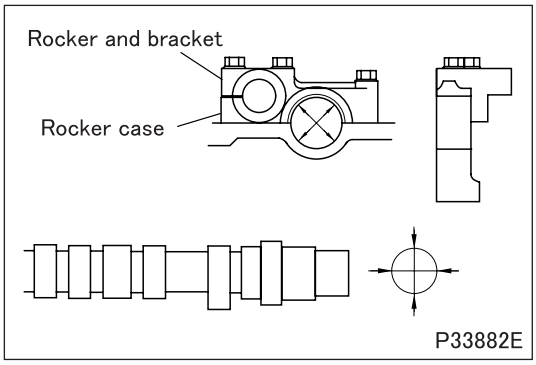
(1) Cam lift

- If the measurement (difference between lobe diameter and base circle diameter) is less than the limit, replace the camshaft.


P33881

(2) Bend

- Measure the camshaft at the center journal for bend while supporting the shaft at the end journals.
- A half of the dial gauge reading obtained as the camshaft is rotated by a full turn represents the bend of the camshaft.
- If the measurement exceeds the limit, replace the camshaft.



P33882E

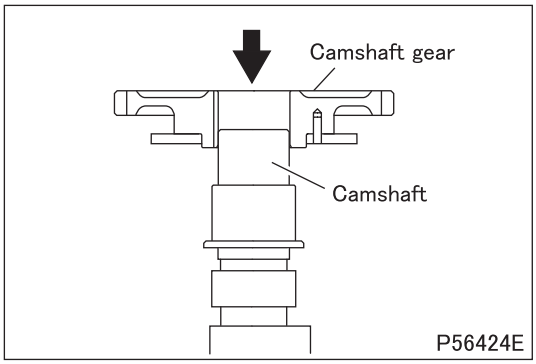
(3) Oil clearance at journal

- If the measurement exceeds the limit, replace the defective part(s).

CAUTION ⚠

- **The rocker case and the brackets of the rocker and bracket assembly have been machined together, which means that they all must be replaced together.**

◆Installation procedure◆



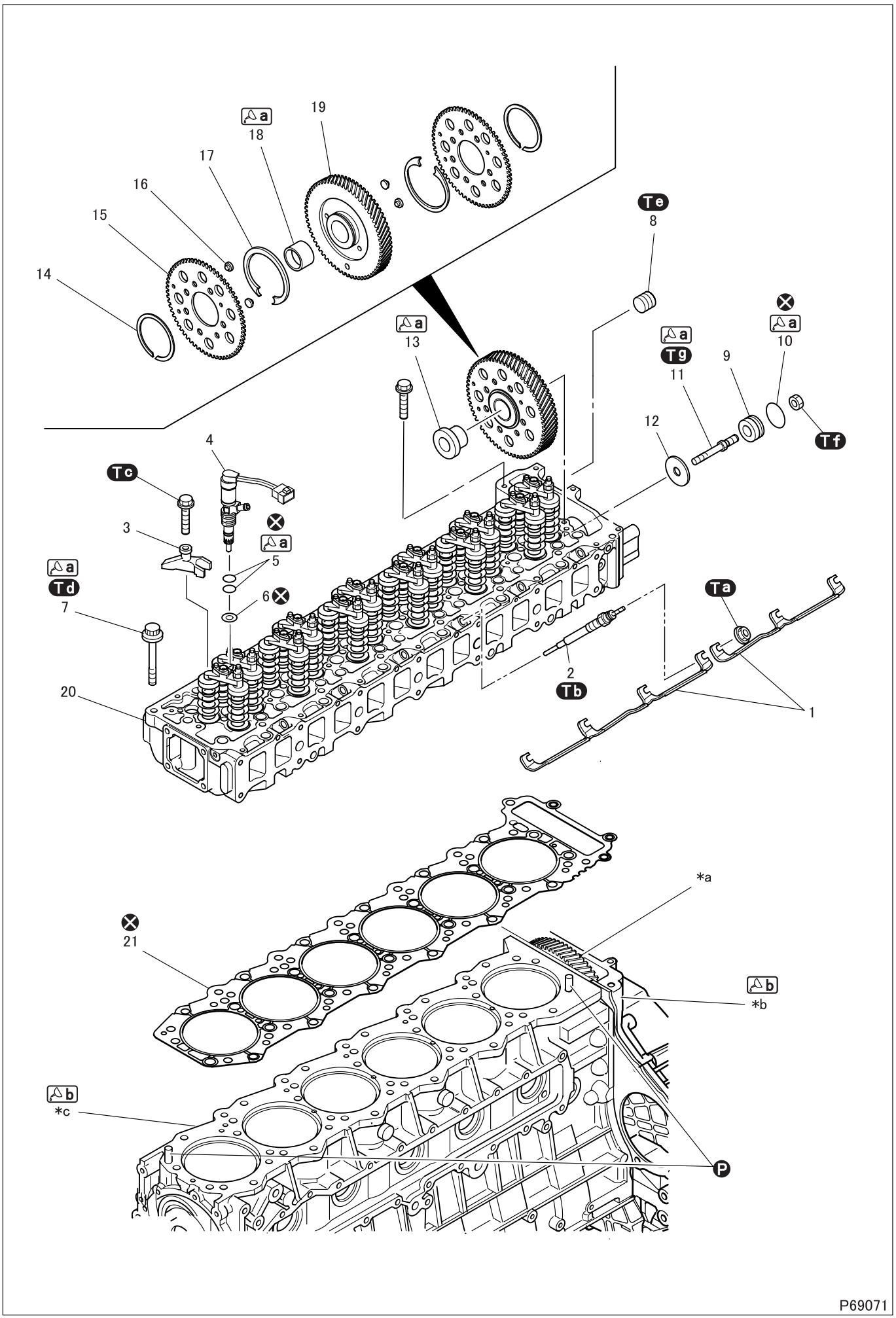
P56424E

■ **Installation: Camshaft gear**

- Heat the camshaft gear to approximately 150°C using a gas burner.
- While facing the camshaft gear as shown in the illustration, press it onto the camshaft until it seats snugly on the camshaft.

WARNING ⚠

- **The camshaft is extremely hot. Be careful not to touch it.**


a
18
19
17
16
15
14
Te
8
a
13
a
Tg
11
9
a
10
12
Tf
4
Tc
3
a
5
a
Td
7
6
Ta
2
Tb
1
20
*a
21
b
*b
b
*c
P
P69071

● Disassembly sequence

1 Connecting plate
2 Glow plug
3 Nozzle bridge
4 Injector (See Gr13A.)
5 O-ring
6 Nozzle tip gasket
7 Cylinder head bolt
8 Plug
9 Collar
10 O-ring
11 No. 3 idler bolt
12 Thrust plate
13 No. 3 idler shaft
14 Snap ring
15 Sub-gear
16 Pin
17 Spring
18 No. 3 idler gear bushing
19 No. 3 idler gear
20 Cylinder head (See later section.)
21 Cylinder head gasket

*a: No. 2 idler gear
*b: Flywheel housing
*c: Crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **After the No. 3 idler gear has been reassembled onto the cylinder head, remove the locking bolt from the sub-gears.**

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
–	Backlash between No. 3 and No. 2 idler gears	0.17 to 0.25	0.35	Replace
	No. 3 idler gear end play	0.05 to 0.15	0.3	Replace
13, 18	Clearance between No. 3 idler shaft and No. 3 idler gear bushing	0.01 to 0.05	0.2	Replace

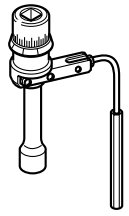
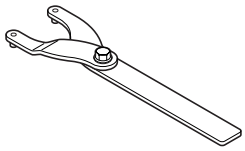
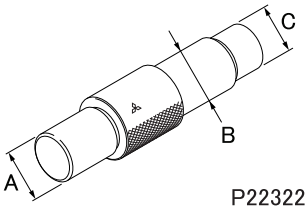
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (connecting plate mounting)	1.0 to 1.5 {0.1 to 0.15}	–
Tb	Glow plug	20 to 25 {2.0 to 2.5}	–
Tc	Bolt (nozzle bridge mounting)	33 to 38 {3.4 to 3.9}	–
Td	Cylinder head bolt	78 {8} + 90° $^{+5°}_{0}$ + 90° $^{+5°}_{0}$	• Wet • Reusable up to 3 times
Te	Plug	13 to 17 {1.3 to 1.7}	–
Tf	Nut (collar mounting)	39 to 59 {4.0 to 6.0}	–
Tg	No. 3 idler bolt	59 to 78 {6.0 to 8.0}	–

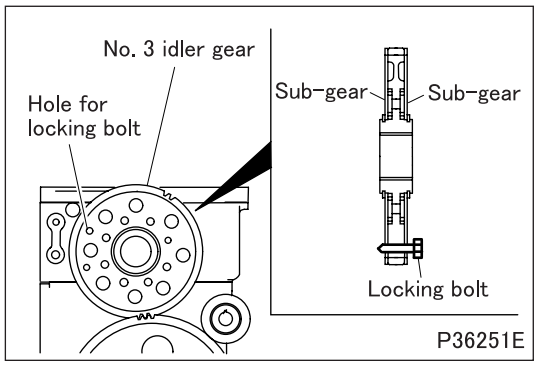
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Threaded portion of cylinder head bolt	Engine oil	As required
	O-ring		
	Threaded portion of No. 3 idler bolt		
	Periphery of No. 3 idler shaft		
	Inside surface of No. 3 idler gear bushing		
b	Top mating surfaces of flywheel housing and crankcase	ThreeBond 1207F	As required

Special tools (Unit: mm)

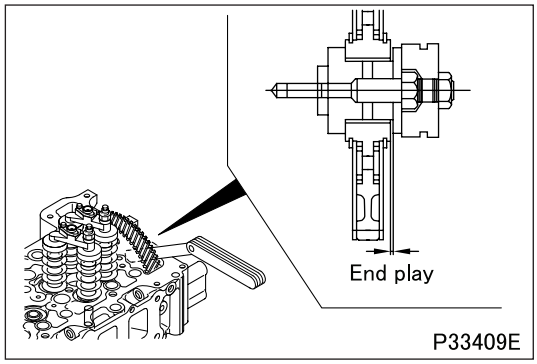
Mark	Tool name and shape	Part No.	Application
a	Socket wrench  P01984	MH063388	Installation of cylinder head
b	Pin wrench arm  P36247	MH063473	Assembly of No. 3 idler gear
c	Idler gear push-puller A: ϕ32, B: ϕ35, C: ϕ32  P22322	MH061779	Removal and installation of No. 3 idler gear bushing

◆Work before removal◆



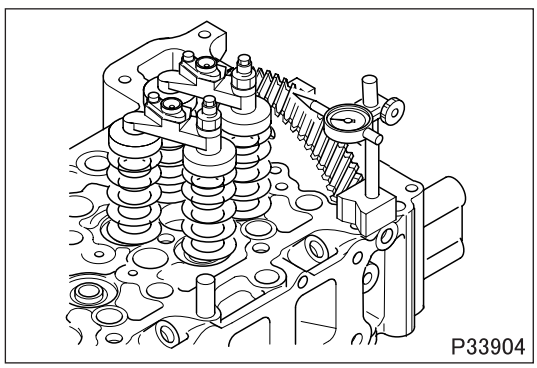
■ Locking sub-gears

- Before removing the No. 3 idler gear, install a locking bolt (M8 × 1.25 mm, length 20 mm) into the dedicated hole to lock the sub-gears.



■ Inspection: End play of No. 3 idler gear

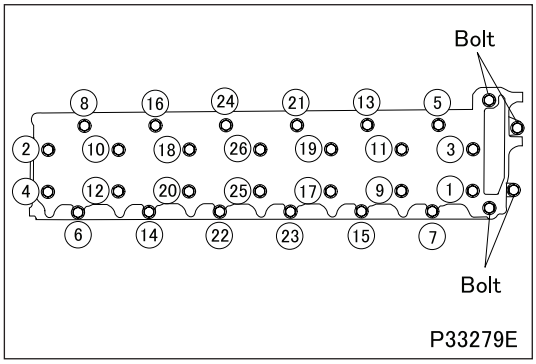
- If the measurement exceeds the limit, replace the defective part(s).



■ Inspection: Backlash between No. 2 and No. 3 idler gears

- If the measurement exceeds the limit, replace the defective part(s).

◆Removal procedure◆



■ **Removal: Cylinder head**

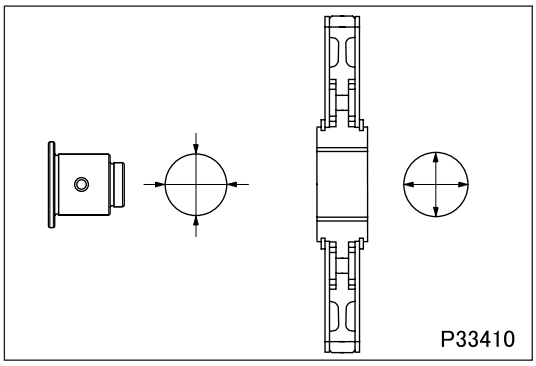
- Remove the bolts (× 4).
- Progressively loosen the cylinder head bolts in the order shown in the illustration, going over them several times, before eventually removing them.

■ **Removal: Cylinder head gasket**

CAUTION ⚠

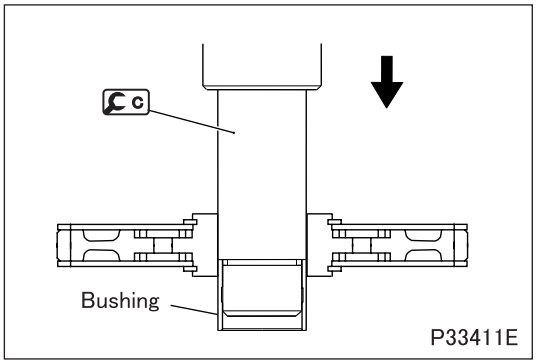
- **Be careful not to scratch the cylinder head, crankcase and flywheel housing when removing the cylinder head gasket.**

◆Inspection procedure◆

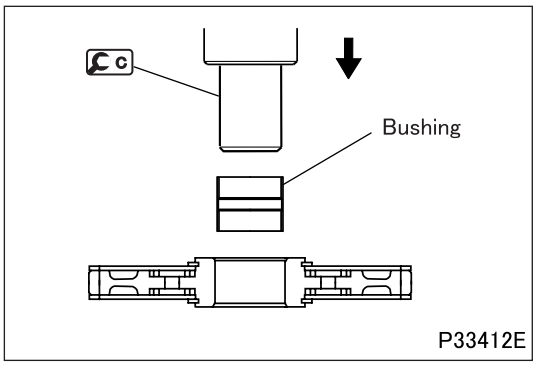


■ **Inspection: Clearance between No. 3 idler shaft and No. 3 idler gear bushing**

- If the measurement exceeds the limit, replace the bushing.



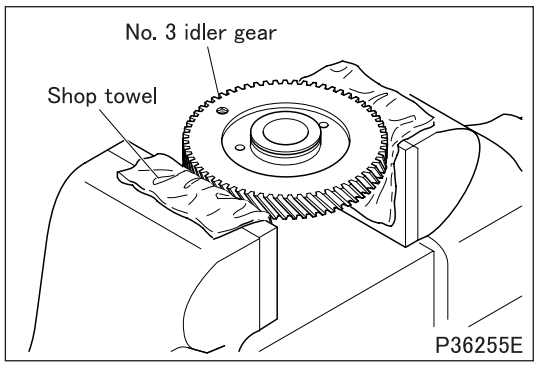
Replacement of No. 3 idler gear bushing
[Removal]



[Installation]

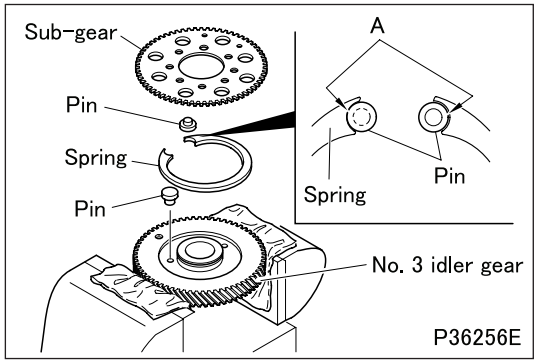
- Using C, press in the bushing until C contacts the No. 3 idler gear.
- After installation, measure the clearance again.
- If the measurement is lower than the standard value, ream the bushing.

◆Installation procedure◆

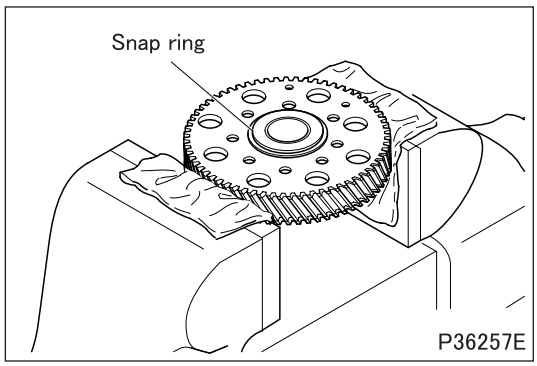


■ **Installation: Sub-gears**

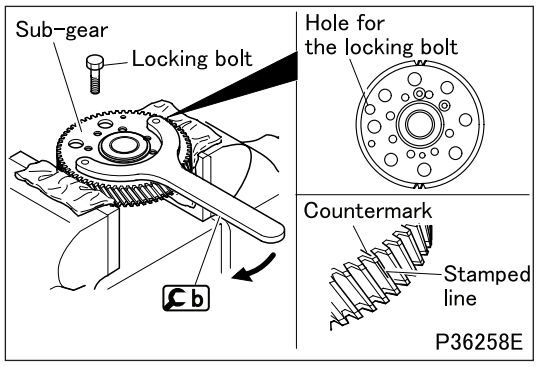
- Install the No. 3 idler gear on a vice. Use shop towel to protect the gear from direct contact with the vice.



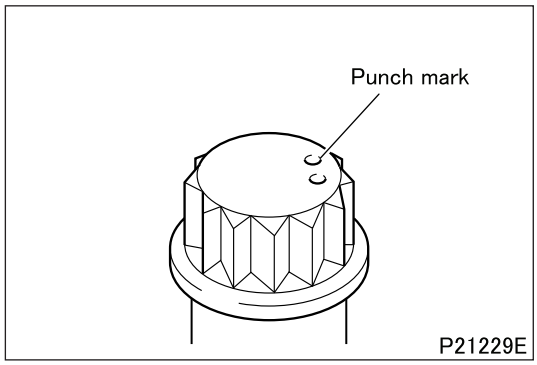
- Install a sub-gear, a spring and pins on one side of the No. 3 idler gear.
- Hook each end A of the spring on a pin.



- Install a snap ring.



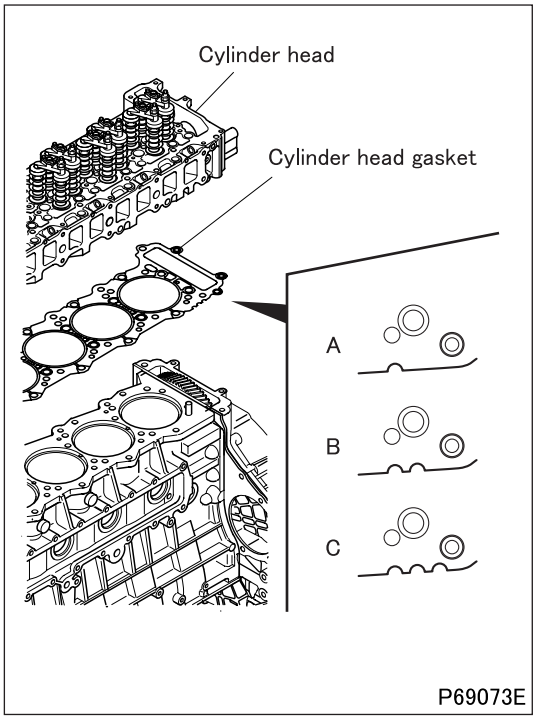
- Using b, turn the sub-gear clockwise until the countermark on the sub-gear is aligned with the stamped line on the No. 3 idler gear. Then, install a locking bolt (M8 × 1.25 mm, 20 mm long) into the dedicated hole.
- Turn over the No. 3 idler gear and repeat the same procedure on the other side of the No. 3 idler gear, installing another sub-gear, a spring, pins and a snap ring.



■ **Installation: Cylinder head**

CAUTION ⚠

- **Before fitting the cylinder head bolts, check the punch marks on each bolt's head. Do not use the bolt if there are three punch marks.**
  The punch marks indicate the number of times each bolt has been tightened using the torque-turn tightening method. Any bolt that already has three punch marks must be replaced.

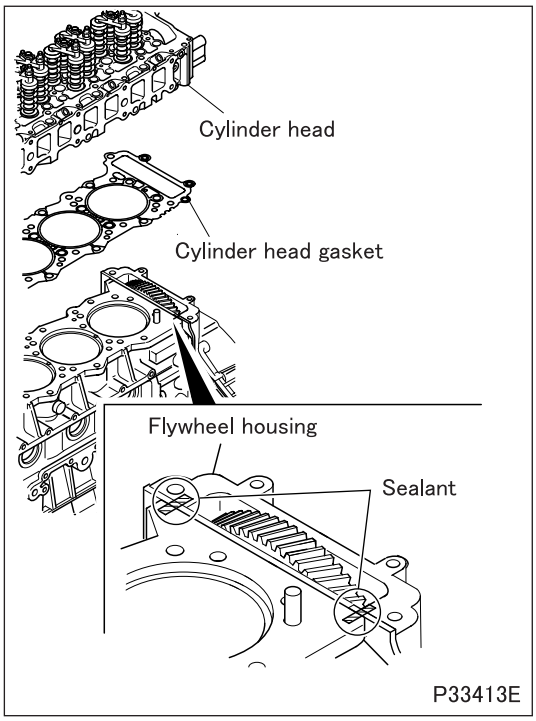


- The cylinder head gasket is a part that needs to be selected for use. Choose the appropriate gasket in the following manner.
- Measure the piston protrusion from each cylinder. (See Piston.)
- Then, from the table below, choose the cylinder head gasket having a thickness appropriate to the average protrusion of the pistons.
- If the cylinder head has even one cylinder that exceeds the largest of the measured piston protrusions by 0.05mm or more, use a gasket at least one size larger in thickness (A → B, B → C).

Unit: mm

Piston protrusion	Cylinder head gasket	
Average piston protrusion	Type by size ( ): No. of notches	Tightened thickness
0.804 to 0.872	A(1)	1.70 ± 0.05
0.873 to 0.941	B(2)	1.75 ± 0.05
0.942 to 1.011	C(3)	1.80 ± 0.05

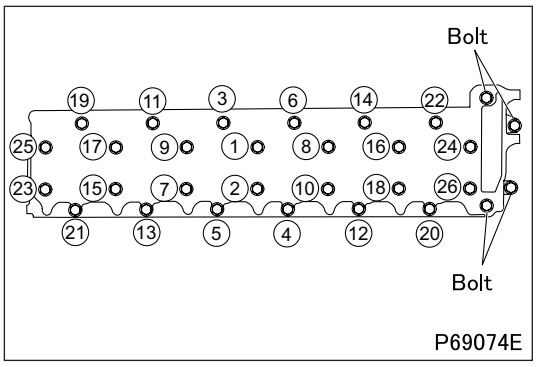
- Identify the appropriate type of cylinder head gasket according to the number of notches in its notched end.



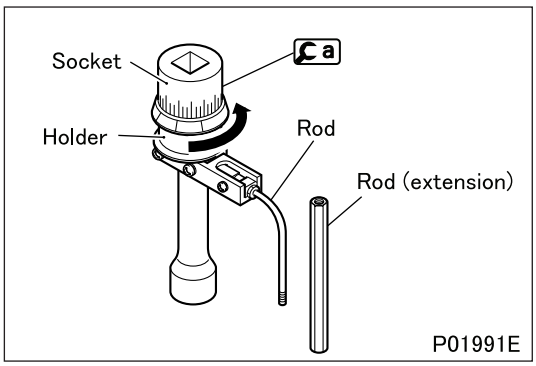
- Remove oil and any other contamination from the surfaces where sealant is to be applied.
- Apply sealant onto the surfaces of the flywheel housing and crankcase that will be fitted together.
- Within three minutes following the sealant application, install the cylinder head onto the crankcase, with the cylinder head gasket in between them, using the cylinder head bolts. Take care so that the applied sealant is not displaced during installation.
  Be sure to install the gasket in the illustrated position.

CAUTION ⚠

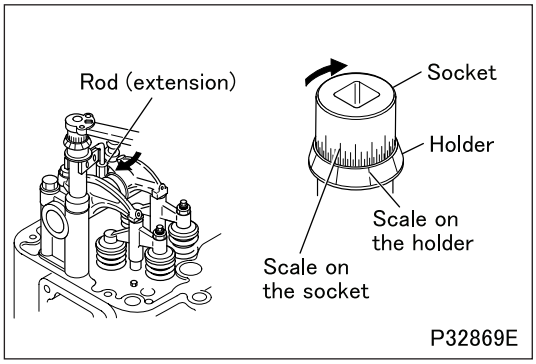
- **Do not start the engine for at least an hour after installation.**
- **Whenever cylinder head bolts are loosened or removed after installation, the cylinder head gasket must be replaced and sealant reapplied.**



- Tighten the cylinder head bolts to a torque of 78N.m {8kgf.m} in the order shown in the illustration.
- Further tighten the bolts in the illustrated order as follows.



- Turn the holder of Ca counterclockwise to pretension the internal spring.



- Set the tool such that the rod (extension) is pressed against the rocker shaft bracket by the force of the spring.
- Align any line on the holder scale with any line on the socket scale. (This will be used as the reference point = 0°.)
- From the reference point, turn the socket by $90° \begin{smallmatrix}+5° \\ 0\end{smallmatrix}$ in the direction shown. Each division on the holder scale represents 5°.
- Further turn the socket by $90° \begin{smallmatrix}+5° \\ 0\end{smallmatrix}$.
- After tightening the cylinder head bolts within the plastic region, punch a mark on the bolt heads to record the number of times that they have been tightened.

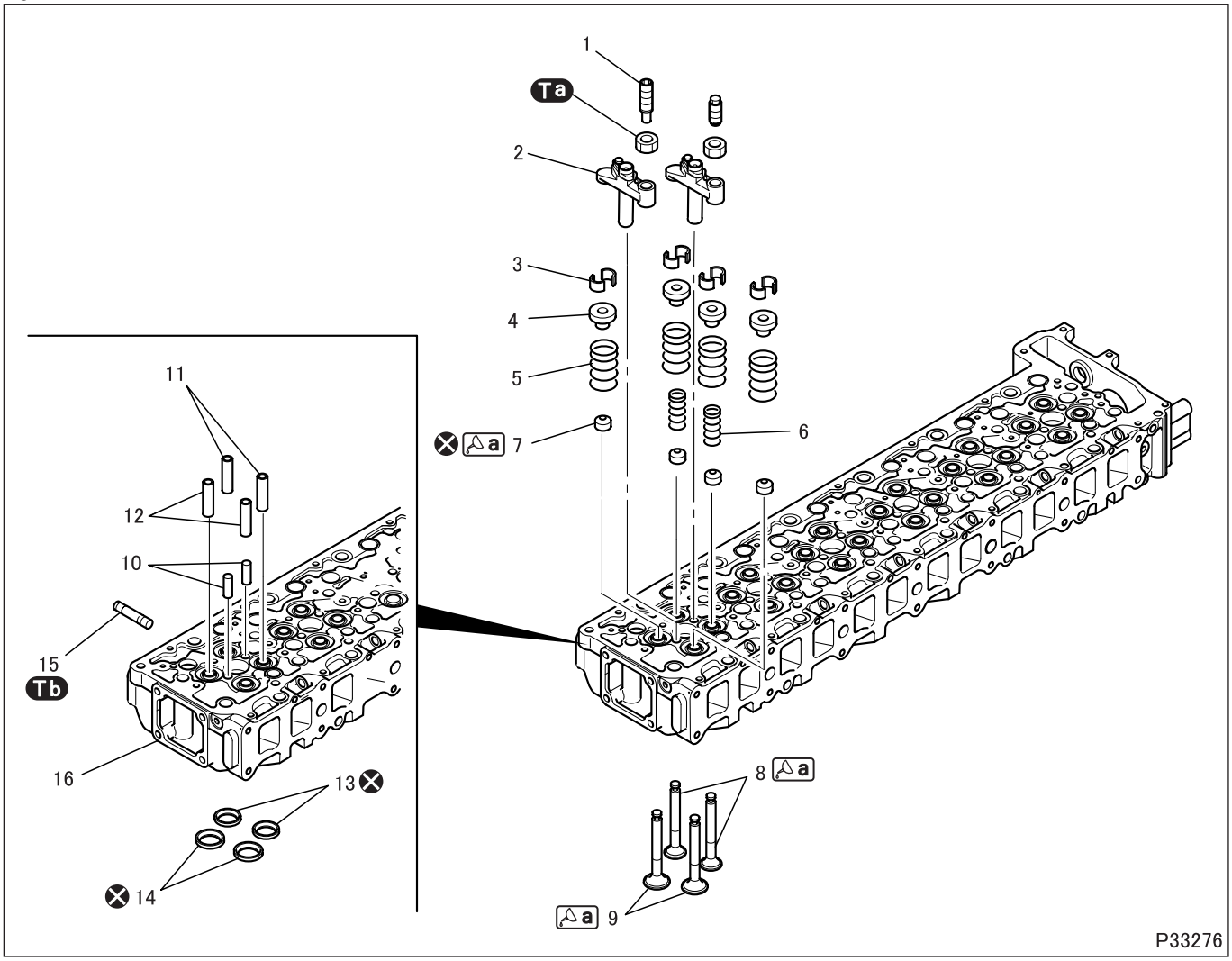
CAUTION ⚠

- **Cylinder head bolts that have been tightened using the torque-turn method must never be additionally tightened after the final angular tightening.**

M E M O

CYLINDER HEAD AND VALVE MECHANISM

Cylinder Head



● Disassembly sequence

1 Adjusting screw
2 Valve bridge
3 Valve cotter
4 Upper retainer
5 Outer valve spring
6 Inner valve spring
<Only exhaust valve>
7 Valve stem seal
8 Exhaust valve
9 Intake valve
10 Valve bridge guide
11 Exhaust valve guide
12 Intake valve guide
13 Exhaust valve seat
14 Intake valve seat
15 Stud bolt
16 Cylinder head

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **When an exhaust valve or intake valve has been removed, make sure to replace the valve stem seal.**

Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy
2, 10	Valve bridge-to-valve bridge guide clearance			0.01 to 0.04	0.1	Replace
5	Outer valve spring	Intake side	Free length	71.7	68.1	Replace
			Installed load (46.5 in installed length)	407 ± 20.6 N {42 ± 2.1 kgf}	367 N {37 kgf}	Replace
			Squareness	–	2° or less	Replace
		Exhaust side	Free length	66.47	63.1	Replace
			Installed load (46.5 in installed length)	280 ± 14 N {29 ± 1.4 kgf}	252 N {26 kgf}	Replace
			Squareness	–	2° or less	Replace
6	Inner valve spring	Free length		60.61	57.6	Replace
		Installed load (41.8 in installed length)		127 ± 6.3 N {12.9 ± 1.9 kgf}	121 N {12 kgf}	Replace
		Squareness		–	2° or less	Replace
8	Exhaust valve	Stem outside diameter		$\phi 8\ ^{-0.060}_{-0.075}$	ϕ7.85	Replace
		Sinkage from cylinder head bottom surface		1.3 ± 0.2	1.55	Inspect
		Valve margin		1.5	1.2	Replace
		Seat angle		45° ± 15’	–	Correct
8, 11	Exhaust valve stem-to-valve guide clearance			0.07 to 0.10	0.2	Replace
9	Intake valve	Stem outside diameter		$\phi 8\ ^{-0.025}_{-0.040}$	ϕ7.85	Replace
		Sinkage from cylinder head bottom surface		1.3 ± 0.2	1.55	Inspect
		Valve margin		1.5	1.2	Replace
		Seat angle		45° ± 15’	–	Correct
9, 12	Intake valve stem-to-valve guide clearance			0.06 to 0.09	0.2	Replace
10	Valve bridge guide in outside diameter			9.989 to 10	9.94	Replace
13	Exhaust valve seat width			2.3 to 2.7	3.3	Correct or replace
14	Intake valve seat width			1.8 to 2.2	2.8	Correct or replace
16	Cylinder head	Bottom surface distortion		0.08 or less	0.2	Correct or replace
		Height from top surface to bottom surface		94.9 to 95.1	94.5	Replace

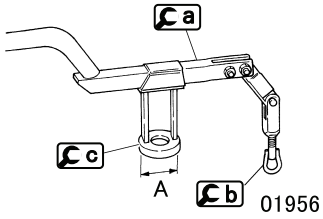
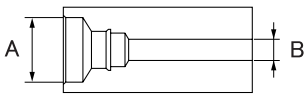
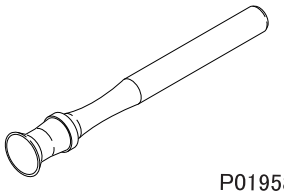
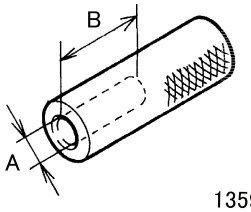
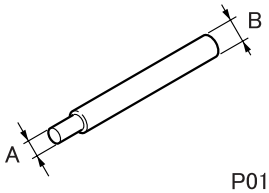
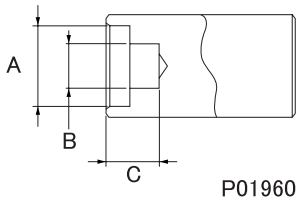
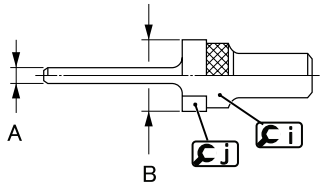
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Lock nut (valve bridge adjusting screw tightening)	59 {6.0}	–
Tb	Stud bolt	20 {2}	–

Lubricant and/or sealant

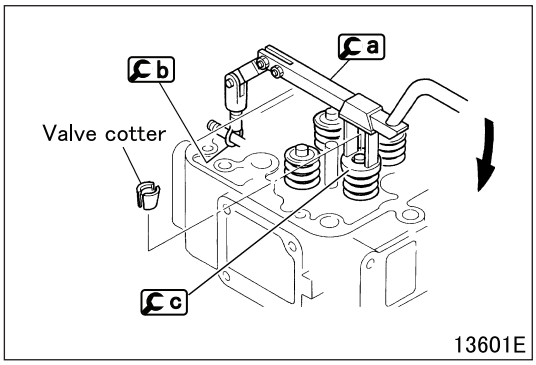
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Lip of valve stem seal	Engine oil	As required
	Stem and end of valve		

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Valve lifter	MH061668	Removal and installation of valve cotters
b	Valve lifter hook	MH061679	
c	Valve lifter seat A: φ38	MH061772	
			
d	Valve stem seal installer A: φ25, B: φ9 	MH062689	Installation of valve stem seals
e	Valve lapper 	30091-07500	Lapping valves and valve seats
f	Valve bridge guide installer A: φ10, B: 37.2 	MH062724	Installation of valve bridge guides
g	Valve guide remover A: φ8, B: φ12 	31391-10500	Removal of valve guides
h	Valve guide installer A: φ25.5, B: φ13, C: 17 	MH062726	Installation of valve guides
i	Caulking tool body 	31391-13100	Installation of valve seat
j	Installer ring	MH062725 <Intake valve> MH063605 <Exhaust valve>	

	A	B
Intake valve	φ8	φ42
Exhaust valve	φ8	φ38

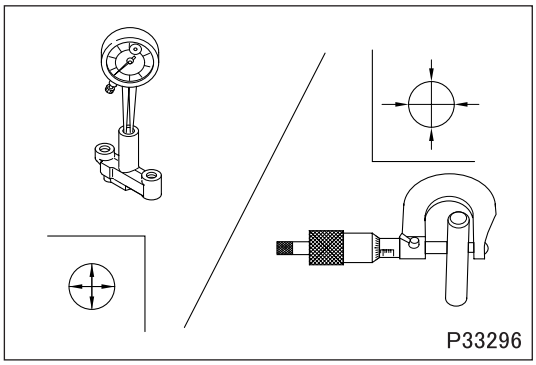
◆Removal procedure◆



■ **Removal: Valve cotters**

- Using a, b and c, remove the valve cotter while compressing the valve spring(s) evenly.

◆Inspection procedure◆



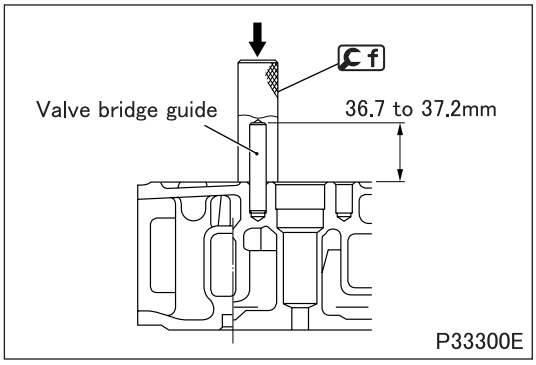
■ **Inspection: Valve bridge and valve bridge guide**

(1) Valve bridge-to-guide clearance

- If the measurement exceeds the limit, replace the defective part(s).

(2) Outside diameter of valve bridge guide

- If the measurement is less than the limit or the valve bridge guide is worn extremely unevenly, replace the valve bridge guide.

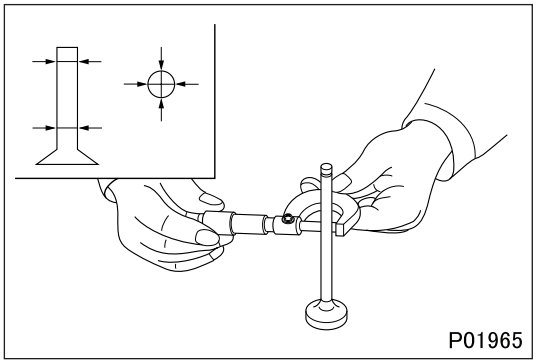


Replacement of valve bridge guide
[Installation]

- Before installation, ensure that no water, oil or other foreign matter is in the installation hole.
- Using f, install the valve bridge guide until f comes into positive contact with the cylinder head.

CAUTION ⚠

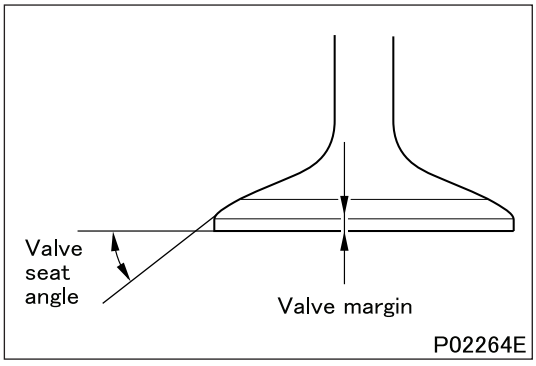
- **The valve bridge guide must be installed to the specified depth of the cylinder head. Correct installation can only be possible by using f.**



■ **Inspection: Intake and exhaust valve**

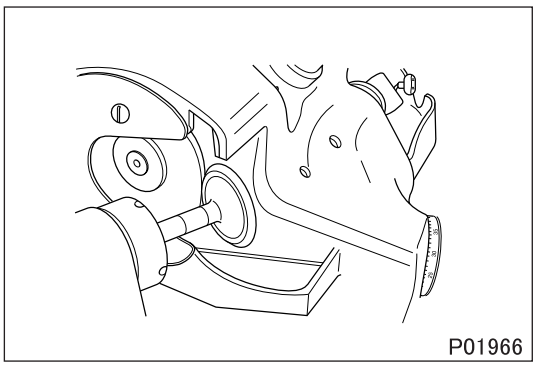
(1) Valve stem outside diameter

- Replace the valve if the stem's outside diameter is below the limit or is severely worn.
- When the valve has been replaced with a new one, make sure to lap the valve and valve seat.



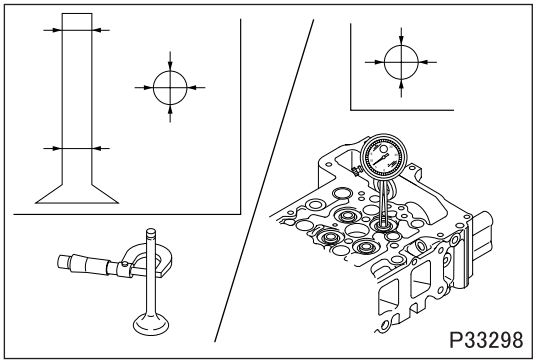
(2) Valve seat angle and valve margin

- Reface or replace the valve if the valve seat angle or valve margin exceeds the specified limits.
- After refacing or replacing the valve seat, make sure to lap the valve and valve seat.



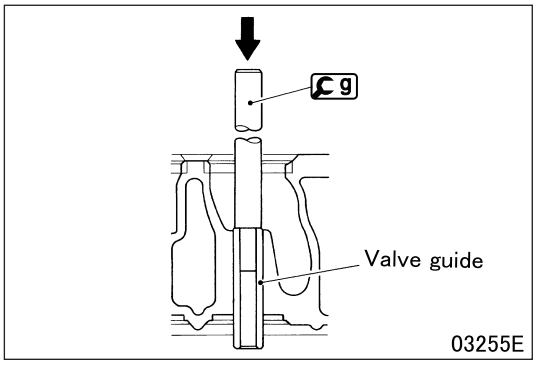
Refacing

- Limit grinding to a necessary minimum.
- If the valve margin is below the limit after grinding, replace the valve.
- After grinding, make sure to lap the valve and valve seat.

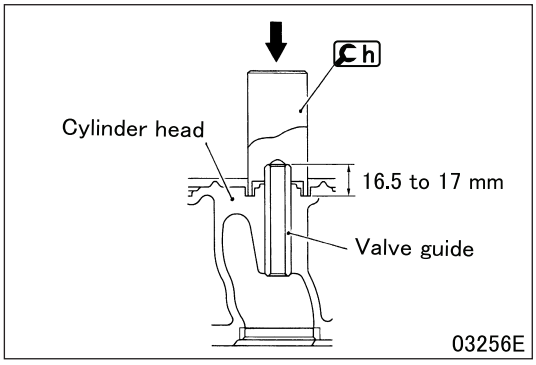


■ Inspection: Valve-to-valve guide clearance

- If the clearance exceeds the specified limit, replace the defective part(s).



Replacement of valve guides
[Removal]

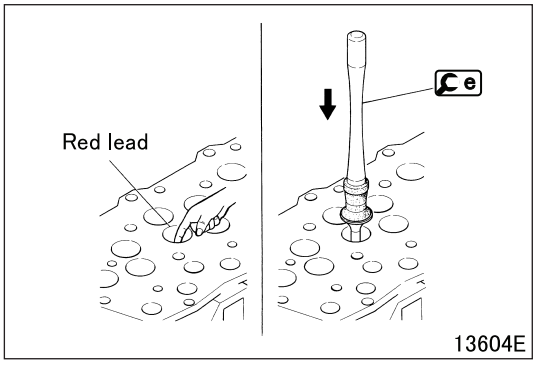


[Installation]

- Install the valve guide until h sits snugly on the cylinder head.

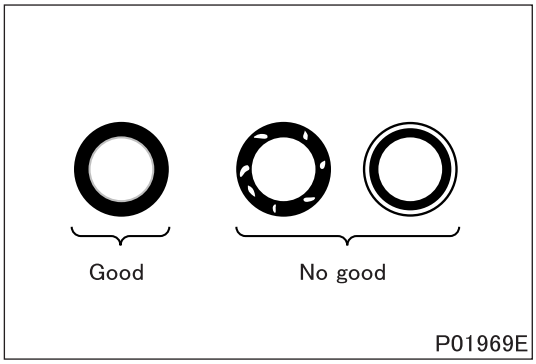
CAUTION ⚠

- **The valve guide must protrude from the cylinder head by the specified amount. Correct installation can only be possible by using h.**
- **The valve guides for the exhaust valves are longer than the valve guides for the inlet valves.**



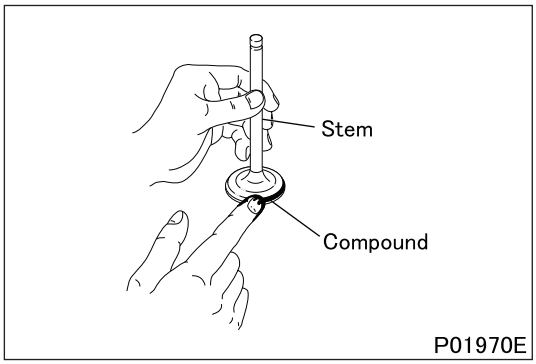
■ Inspection: Contact between valve and valve seat

- Before starting inspection, check that the valve and valve guide are intact.
- Apply an even coat of red lead to the valve contact surface of the valve seat.
- Strike the valve once against the valve seat. Do not rotate the valve during this operation.



- If the red lead deposited on the valve indicates a poor contact pattern, take either of the following corrective actions.

Contact pattern	Corrective action
Minor defect	Lapping
Serious defect	Reface or replace valve and valve seat

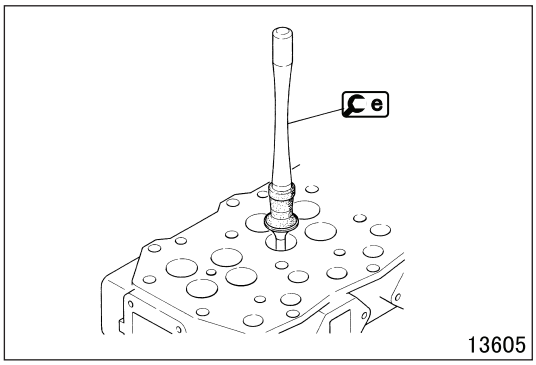


Lapping

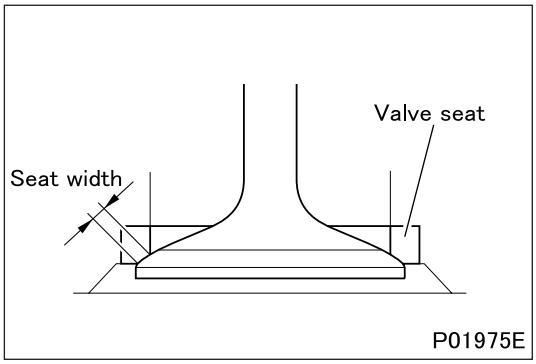
- Lap the valve in the following sequence.
- Apply a thin coat of lapping compound to the seat contact surface of the valve. Adding a small amount of engine oil to the lapping compound can facilitate even application.

CAUTION ⚠

- **Do not put any compound on the stem.**



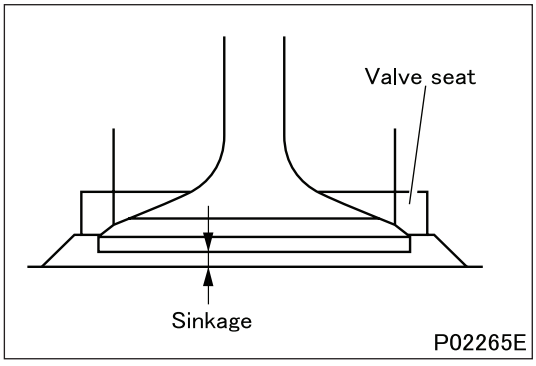
- Start with an intermediate-grit compound (120 to 150 grit) and finish with a fine-grit compound (200 grit or more).
- Strike the valve several times against the valve seat while rotating the valve a little at a time.
- Wash away the compound with diesel fuel.
- Apply engine oil to the valve contact surface of the valve seat and rub in the valve and seat well.
- Inspect the contact pattern of the valve and valve seat again.
- If the contact pattern is still defective, replace the valve seat.



■ Inspection: Valve seats

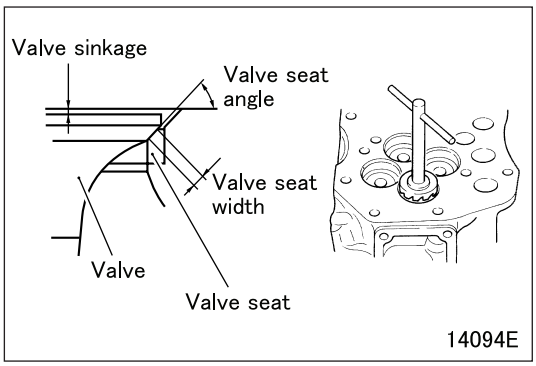
(1) Valve seat width

- If the measurement exceeds the limit, reface or replace the valve seat.
- After refacing or replacing the valve seat, make sure to lap the valve seat and valve.



(2) Valve sinkage from cylinder head bottom surface

- Perform measurement keeping the valve in close contact with the valve seat.
- If the measurement exceeds the limit, adjust or replace the defective part(s).
- After refacing or replacing the valve seat, make sure to lap the valve seat and valve.



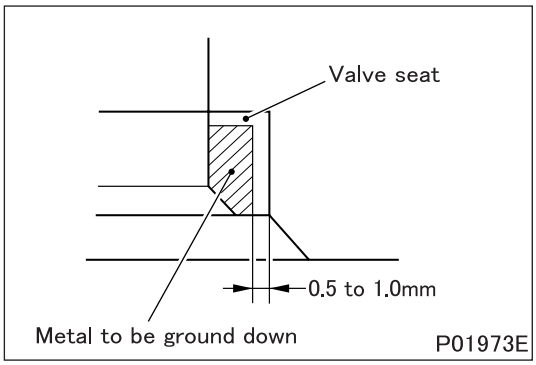
Refacing the valve seat

- Grind the valve seat using a valve seat cutter or valve seat grinder.
- Place a piece of sandpaper of approximately #400 between the cutter and valve seat and grind the valve seat lightly.
- Use a 15° or 75° cutter to cut the valve seat to a width within the standard range.

CAUTION ⚠

- **Make sure that the valve seat refacing does not cause the valve sinkage to exceed the specified limit.**

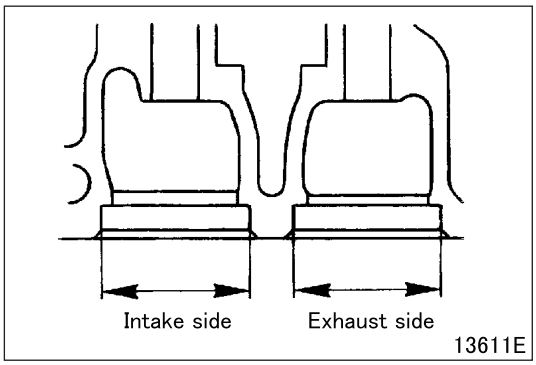
- Lap the valve and valve seat.



Replacement of valve seat

[Removal]

- The valve seats are installed by expansion fitting. To remove a valve seat, grind inside the metal stock to reduce the wall thickness, then remove the valve seat at room temperature.

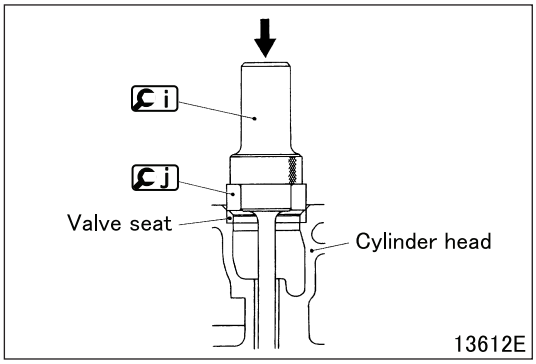


[Installation]

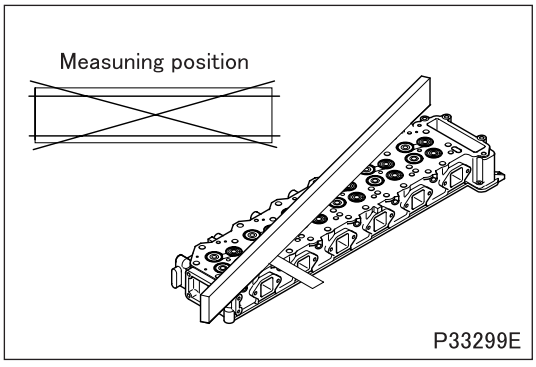
- Check that the diameters of the valve seat holes in the cylinder head conform with the values shown below.

Diameters of the valve seat holes	Intake side	$\phi 42\ ^{+0.025}_{0}$ mm
	Exhaust side	$\phi 38\ ^{+0.025}_{0}$ mm

- Replace the cylinder head if necessary.



- Chill the valve seat thoroughly by immersing in it in liquid nitrogen.
- Install the valve seat in the cylinder head using i and j.
- Lap the valve seat and valve.



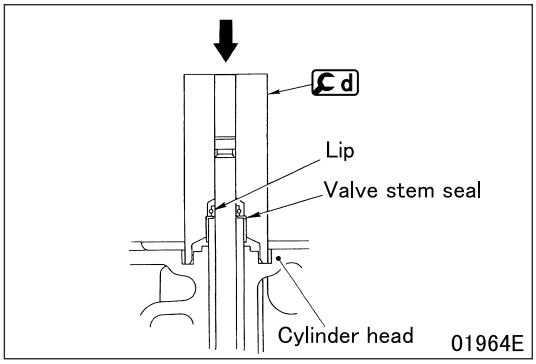
■ Inspection: Cylinder head bottom surface distortion

- If the distortion exceeds the specified limit, rectify it using a surface grinder.

CAUTION ⚠

- **Make sure that the height of the cylinder head from the top surface to the bottom surface is not reduced to a value below the specified limit.**

◆Installation procedure◆

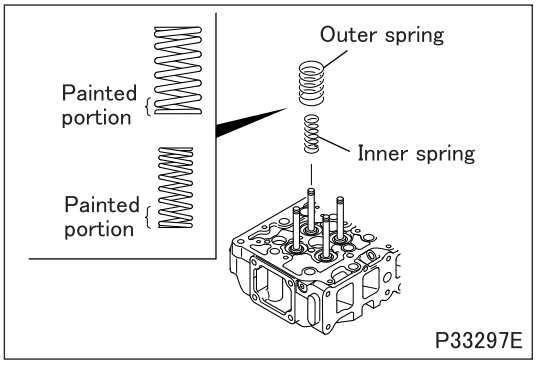


■ Installation: Valve stem seal

- Apply engine oil to the lip of the valve stem seal.
- Install the valve stem seal until d sits snugly on the cylinder head.

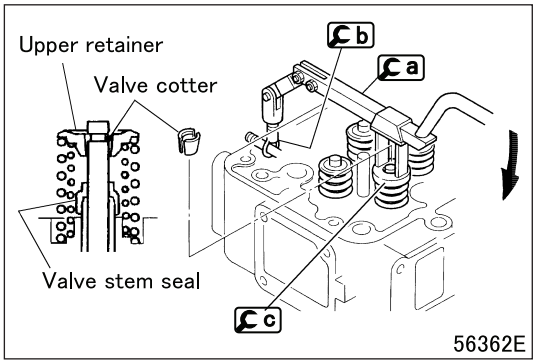
CAUTION ⚠

- **After installing the valve stem seal, check that its spring is not deformed or damaged.**



■ Installation: Valve spring

- Install the outer and inner valve springs onto the cylinder head while facing them as shown in the illustration.



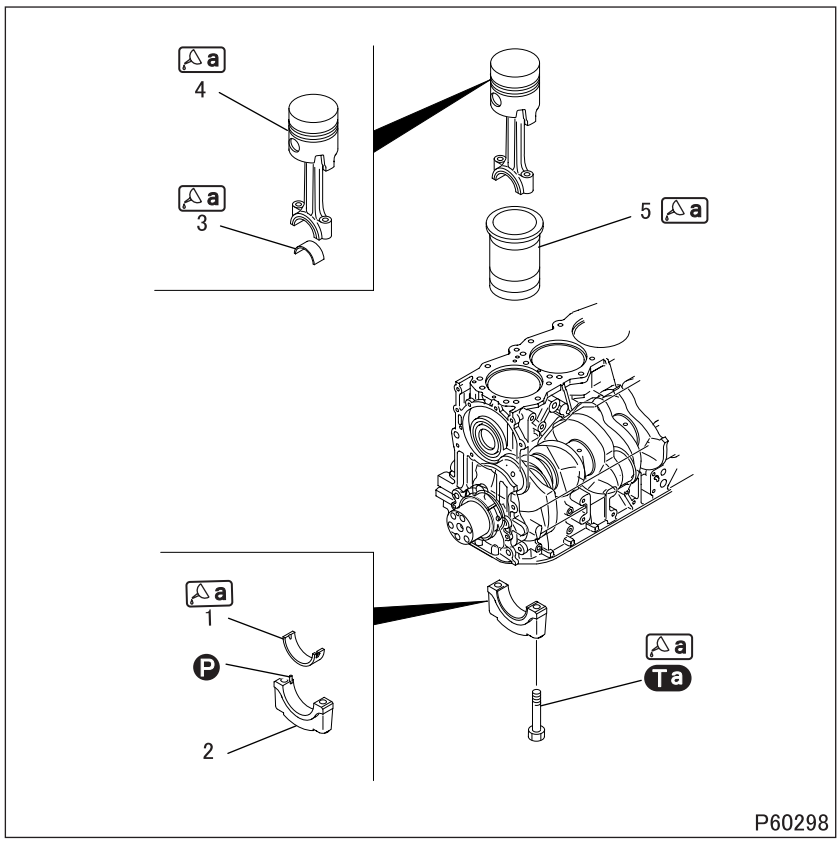
■ Installation: Valve cotter

- Using a, b and c, install the valve cotter while compressing the valve spring(s) evenly.

CAUTION ⚠

- **Do not compress the valve spring(s) too much, or the upper retainer will contact the valve stem seal and damage will result.**

PISTON AND CONNECTING ROD, CYLINDER LINER



● **Disassembly sequence**

1 Lower connecting rod bearing
2 Connecting rod cap
3 Upper connecting rod bearing
4 Piston and connecting rod (See later sections.)
5 Cylinder liner

Ⓟ: Locating pin

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
–	Piston projection from crankcase top surface		0.81 to 1.01	–	Inspect
–	Connecting rod end play		0.15 to 0.45	0.6	Inspect
1, 3	Connecting rod bearing	Oil clearance	0.034 to 0.093	0.2	Replace
		Span when free	–	Less than 74.5	
4, 5	Piston and connecting rod-to-cylinder liner clearance		0.19 to 0.21	–	Replace
5	Cylinder liner	Flange projection	0.03 to 0.10	–	Replace
		Bore	ϕ118 to 118.03	ϕ118.25	
		Out of roundness	0.03 or less	–	

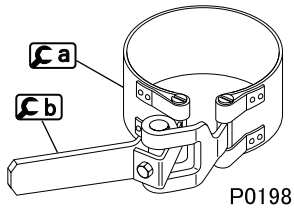
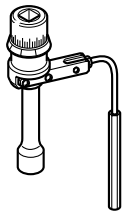
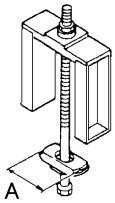
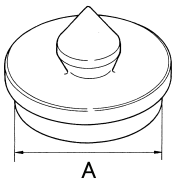
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (connecting rod cap installation)	29 {3} + 90° (± 5°)	Wet

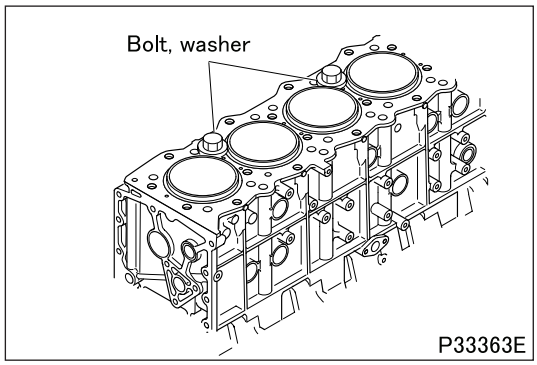
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Threaded portion of connecting rod bolt	Engine oil	As required
	Inside surface of connecting rod bearing		
	Outside periphery of cylinder liner		
	Outside periphery of piston		

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Piston guide clamp  P01981	MH061760	Installation of piston and connecting rod
b	Piston guide lever	MH061658	
c	Socket wrench  P01984	MH061560	
d	Cylinder liner extractor A: ϕ117.5  13615	MH061761	Removal of cylinder liner
e	Cylinder liner installer A: ϕ117.5  01983	MH061771	Installation of cylinder liner

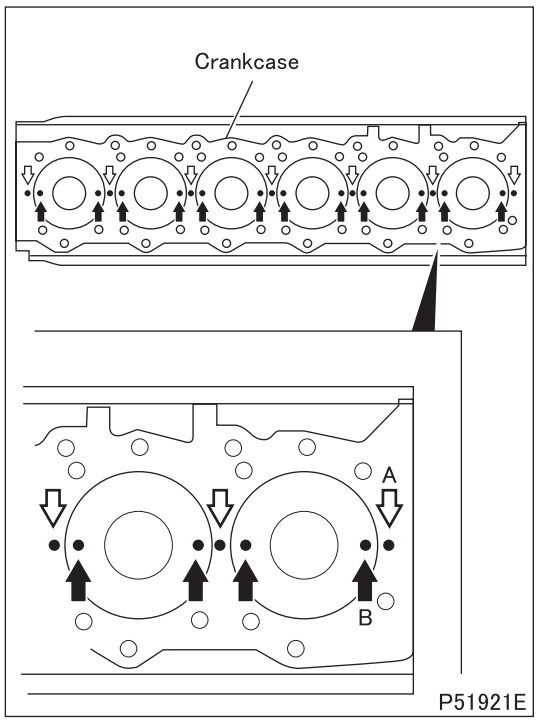
◆Inspection before removal◆



P33363E

■ Retaining cylinder liners

- The cylinder liners may move up when the crankcase is turned over, or the crankshaft is rotated after the pistons are installed. To prevent this, retain the cylinder liners by holding their flanges with bolts and washers.

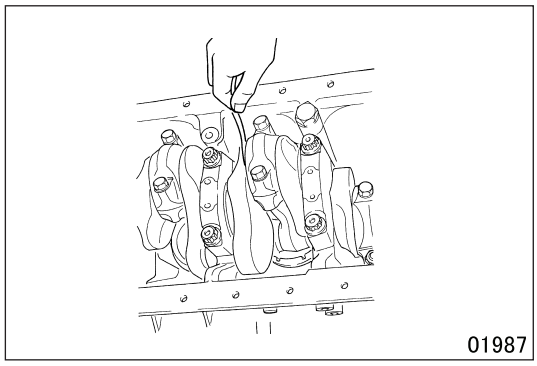


■ **Inspection: Piston projection from crankcase top surface**

CAUTION ⚠

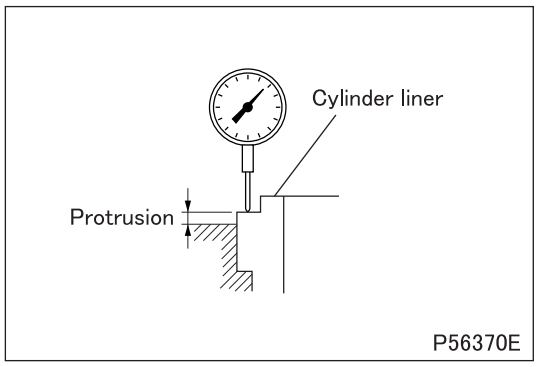
- **The amount of piston projection affects engine performance and must therefore be inspected without fail.**

- Set the piston at the top dead center.
- Mark reference points A (seven points in total) on the top surface of the crankcase as shown in the illustration. Using each of the marks as a zero point, measure the amount of piston projection relative to the zero point (height of measurement point B – height of reference point A).
- Make the measurements at the two measurement points B for each cylinder (twelve points in total) using the reference point A nearest to each measurement point, and calculate the average value of all the measurements.
- If the average value is out of the standard value range, check the clearances between all relevant parts.



■ **Inspection: Connecting rod end play**

- Measure the end play for every connecting rod.
- If any measurement exceeds the specified limit, replace the defective part(s).



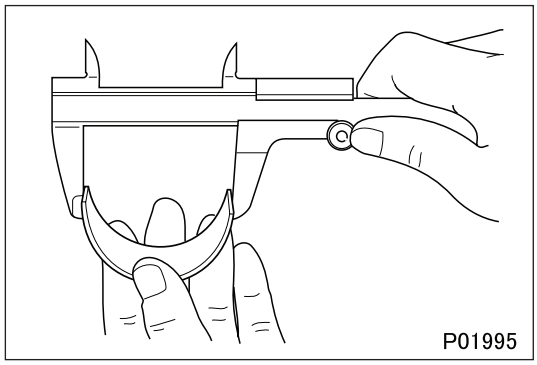
■ **Inspection: Cylinder liner flange projection**

- If the measurement deviates from the standard value, inspect the installation and replace the defective part(s).

CAUTION ⚠

- **If the cylinder liner flange protrusion is less than the specified value, the contact pressure of the cylinder head gasket against the bore of the cylinder will not be high enough to prevent gas leakage.**

◆Inspection procedure◆

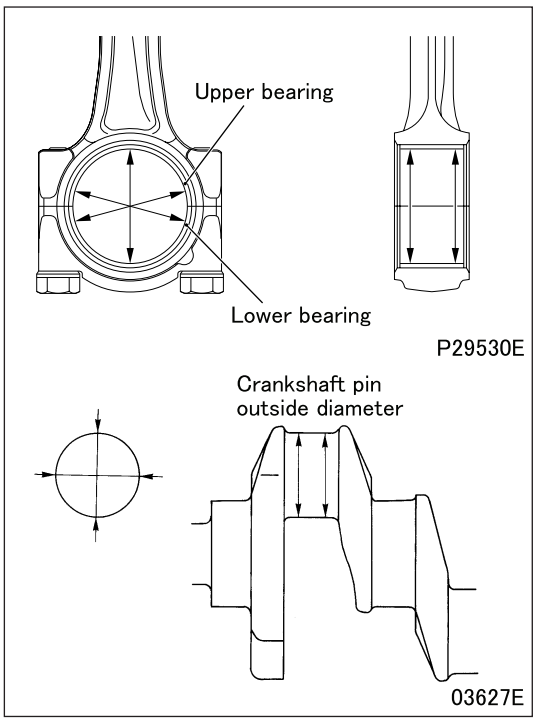


■ **Inspection: Connecting rod bearing span when free**

CAUTION ⚠

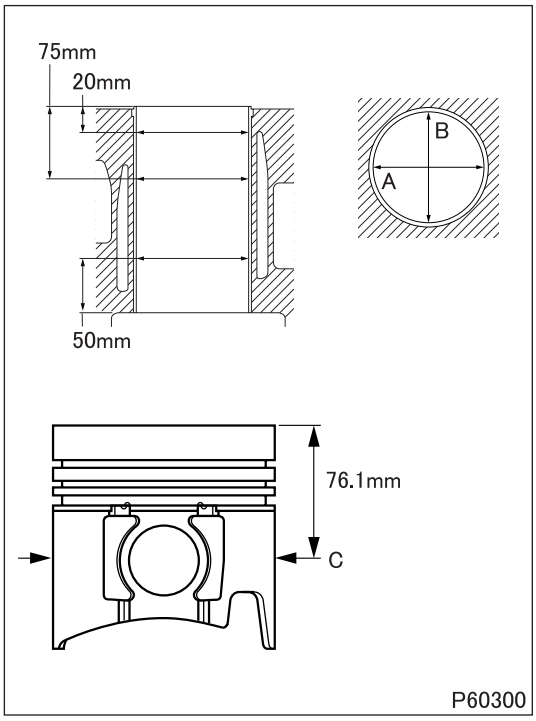
- **Do not attempt to manually expand the bearings.**

- If the span is less than the specified limit, replace both the upper and lower bearings.



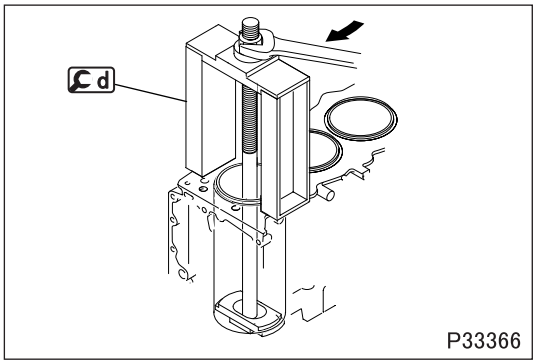
■ **Inspection: Connecting rod bearing oil clearance**

- Fit the lower bearing to the connecting rod cap and the upper bearing to the connecting rod, then tighten the nut to a torque of 29 N·m {3 kgf·m}.
- Measure the inside diameter of the bearing and the outside diameter of the crankshaft pin.
- If the clearance exceeds the limit, replace the defective part(s).
- If a bearing has to be replaced with an undersized one, machine the crankshaft pin to the specified undersize diameter. (See CRANKSHAFT AND CRANKCASE.)



■ **Inspection: Clearance between piston and cylinder sleeve**

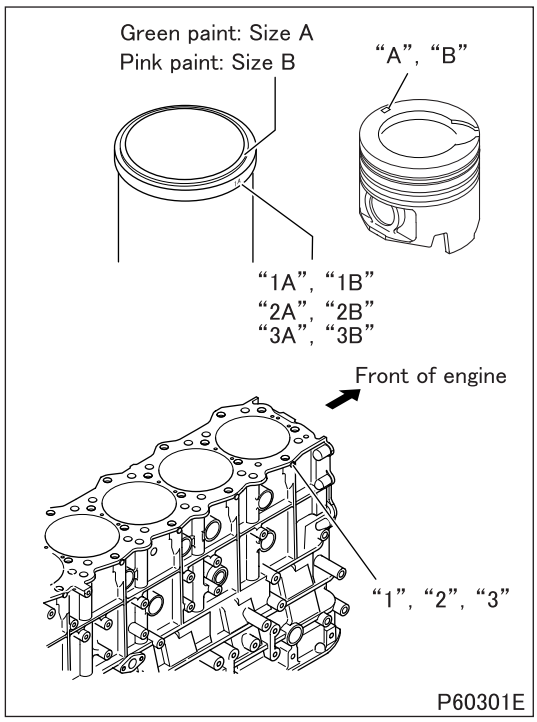
- If the measurement deviates from the standard value, replace the defective part(s).
  A: Measuring point on the crankcase (in direction of the crankcase axis).
  B: Measuring point on the crankcase (vertical to the crankcase axis).
  C: Measuring point on the piston outer diameter (vertical to the piston pin hole).



Replacement of cylinder liner

[Removal]

- If the cylinder liners will need to be reused for some reason or other, make countermarks to ensure correct reassembly.



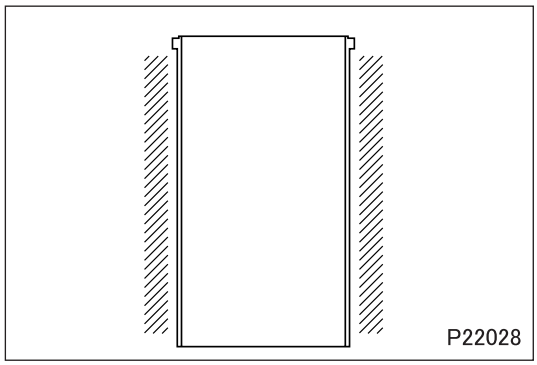
[Installation]

- The cylinder liner being installed must have the same size mark as that on the crankcase as well as that on the piston.

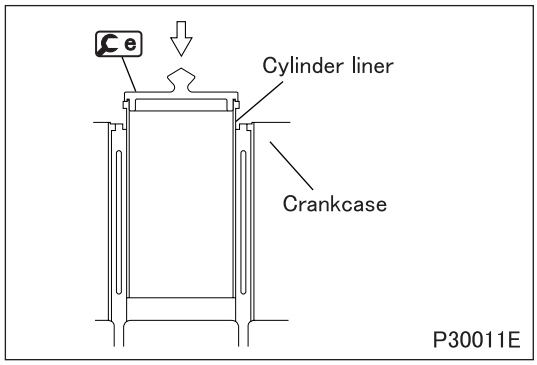
Size mark on crankcase	Size mark on cylinder liner	Size mark on piston
"1"	"1A"	"A"
	"1B"	
"2"	"2A"	
	"2B"	"B"
"3"	"3A"	
	"3B"	

CAUTION ⚠

- **Using a piston with the size mark different from the size mark of the cylinder liner can lead to engine seizure.**



- Apply a thin coat of engine oil onto the outside periphery (hatched area) of the cylinder liner.

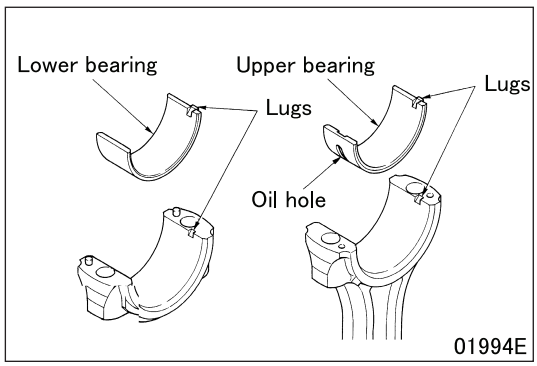


- While pushing the top surface of e evenly with hands, gently insert the cylinder liner into the crankcase.

CAUTION ⚠

- **Cylinder liners are thinly structured. Therefore, they must be handled with extreme care.**

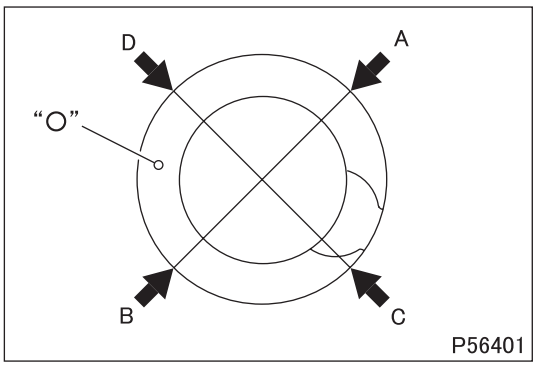
◆Installation procedure◆



■ Installation: Connecting rod bearings

CAUTION ⚠

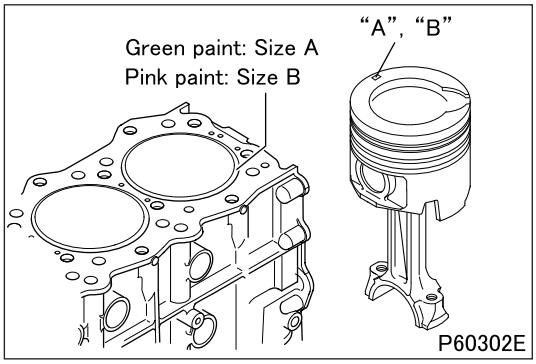
- **Do not reverse the positions of the lower bearing and the upper bearing (with oil hole) when installing, as this may cause seizure in the engine.**



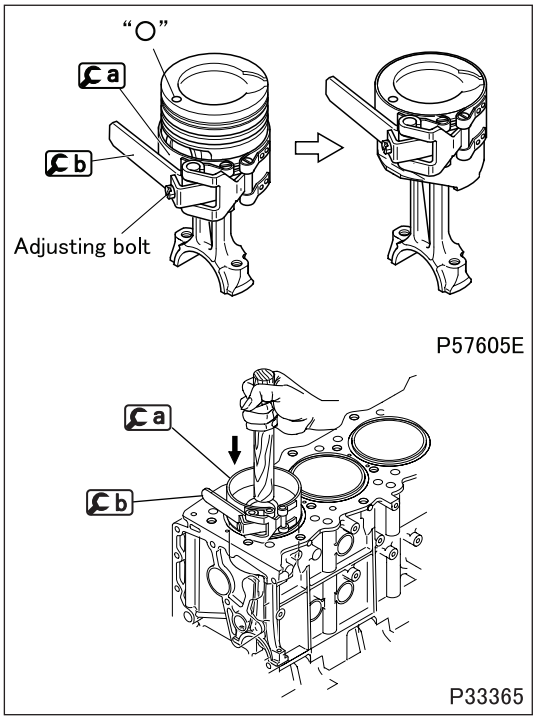
■ **Installation: Piston and connecting rod**

- Check that the piston ring end gaps are in their correct positions.
  - **A:** 1st compression ring gap
  - **B:** 2nd compression ring gap
  - **C:** Oil ring gap
  - **D:** Oil ring expander spring gap

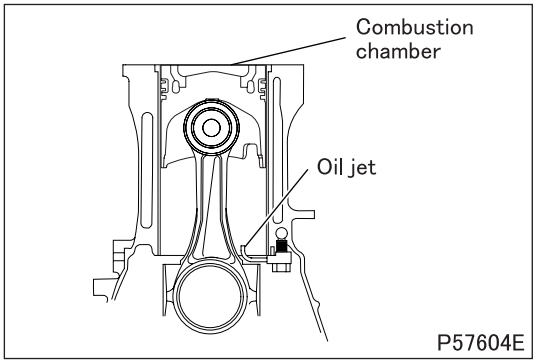
"O": Front mark on piston



- Ensure that the size mark ("A", "B") on the piston is the same as that on the cylinder liner.

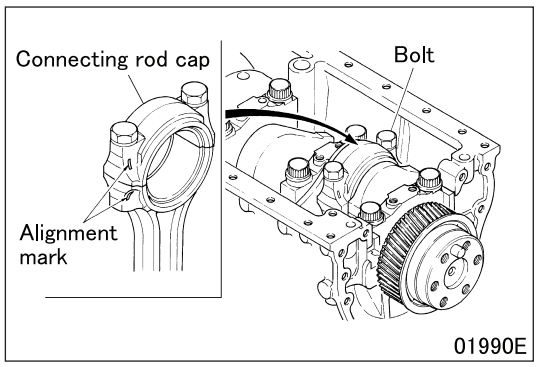


- Face the front mark "O" of the piston toward the front of the engine.
- With a and b installed around the piston skirt, tighten the adjusting bolt of b until the inside diameter of a matches the outside diameter of the piston skirt.
- Remove a and b from the piston. Apply engine oil to the following areas. Then, install a and b over the rings of the piston.
  - Outside surface of piston
  - Inside surface of a
  - Cylinder liner inside surface
- Install the piston and connecting rod, taking care not to damage the inside surface of the cylinder liner or the crank pin with the connecting rod.

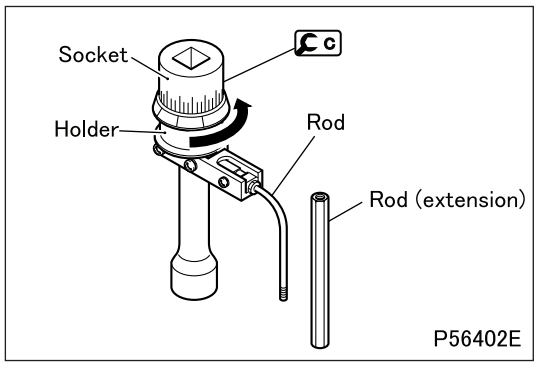


CAUTION ⚠

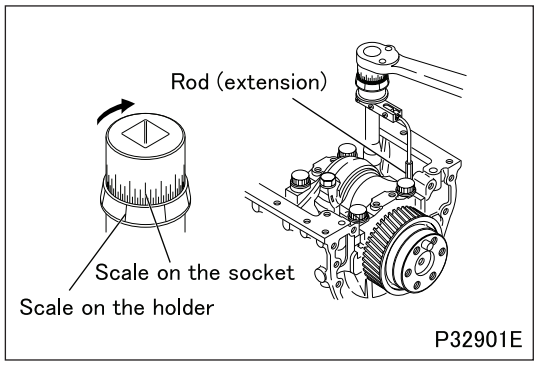
- **Be careful not to scratch or damage head of the piston (a part of the combustion chamber).**
- **Make sure that the connecting rod does not hit oil jet.**



- After the piston and connecting rod have been installed, install the connecting rod cap onto the connecting rod, ensuring that the alignment marks are aligned. Tighten the bolts alternately as follows.
  - Tighten the bolts to a torque of 29 N·m {3 kgf·m}.
  - Further tighten the bolts in the following sequence.



- Turn the holder of C counterclockwise to preload the built-in spring.

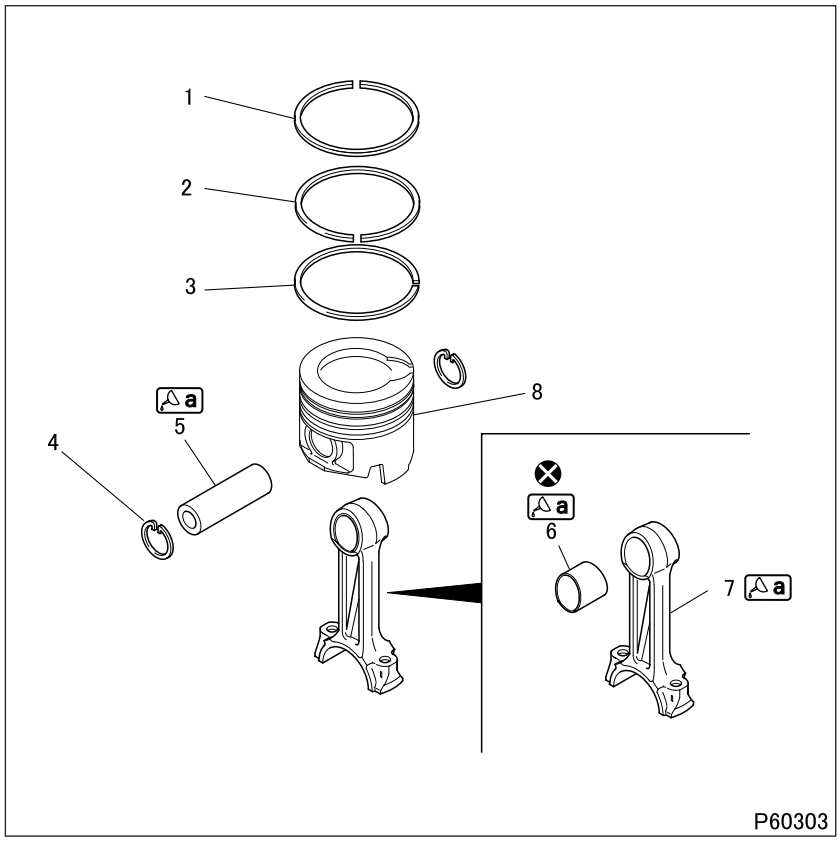


- Set the tool such that the rod (extension) is pressed against the crankshaft by the force of the spring.
- Align any line on the holder scale with any line on the socket scale. (This will be used as the reference point = 0°.)
- From the reference point, turn the socket by 90° ± 5° in the direction shown. Each division on the socket scale represents 5°.
- With the connecting rod cap installed, check the following items.
  - Connecting rod end play
  - Piston protrusion

M E M O

PISTON AND CONNECTING ROD, CYLINDER LINER

Piston and Connecting Rod



● **Disassembly sequence**

1 1st compression ring
2 2nd compression ring
3 Oil ring
4 Snap ring
5 Piston pin
6 Connecting rod bushing
7 Connecting rod
8 Piston

⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

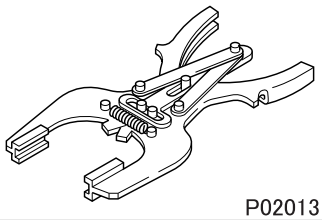
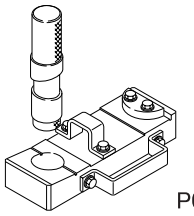
Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
1 to 3	Piston ring end gap	1st compression ring	$0.45\ ^{+0.05}_{-0.10}$	1.5	Replace
		2nd compression ring			
		Oil ring	0.3 to 0.55		
1 to 3, 9	Piston ring side clearance in piston groove	1st compression ring	0.13 to 0.18	0.2	Replace
		2nd compression ring	0.065 to 0.105	0.15	
		Oil ring	0.025 to 0.065		
5, 6	Piston pin-to-connecting rod bushing clearance		0.02 to 0.055	0.1	Replace
5, 8	Piston pin-to-piston clearance		0.004 to 0.022	0.05	Replace
7	Connecting rod	Bend	–	0.05	Replace
		Twist	–	0.1	

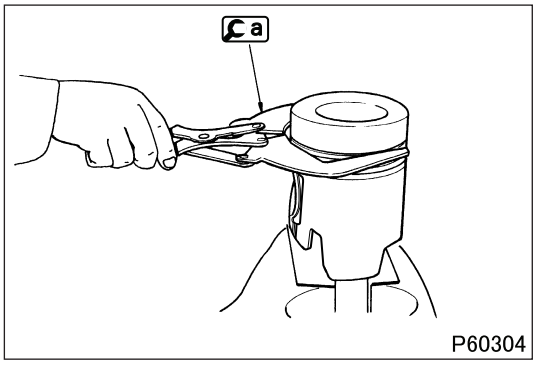
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Piston pin outside surface	Engine oil	As required
	Connecting rod bushing outside surface		
	Connecting rod bushing fitting surface of connecting rod		

Special tools

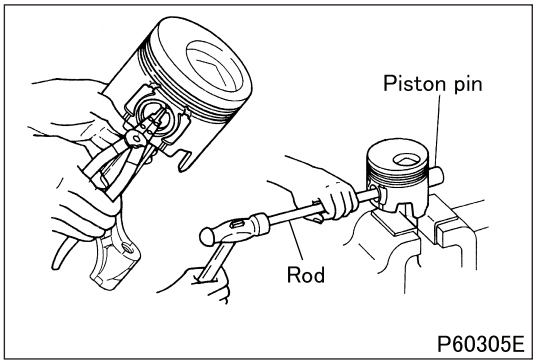
Mark	Tool name and shape	Part No.	Application
a	Piston ring tool  P02013	30091-07100	Removal and installation of piston rings
b	Connecting rod bushing puller kit  P02015	MH062556	Removal and installation of connecting rod bushings

◆Removal procedure◆



P60304

■ **Removal: Piston ring**

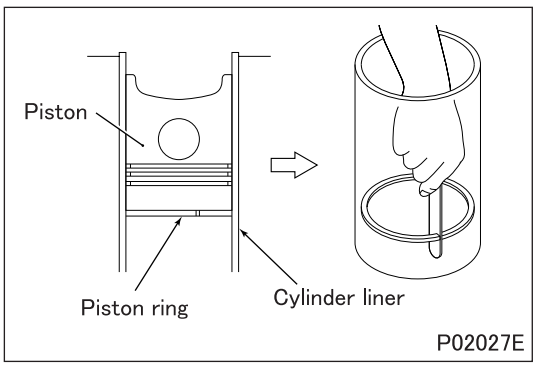


P60305E

■ **Removal: Piston pin**

- Remove the piston pin by striking it with a rod and hammer.
- If the piston pin is difficult to remove, first heat the piston in hot water or with a piston heater.

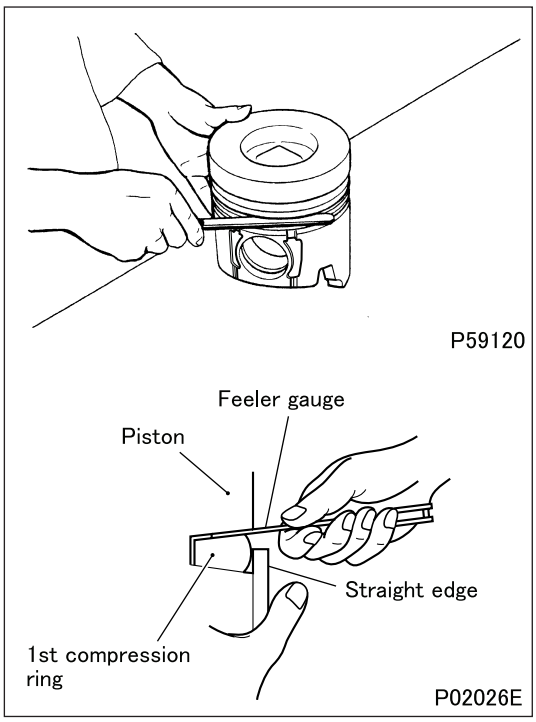
◆Inspection procedure◆



P02027E

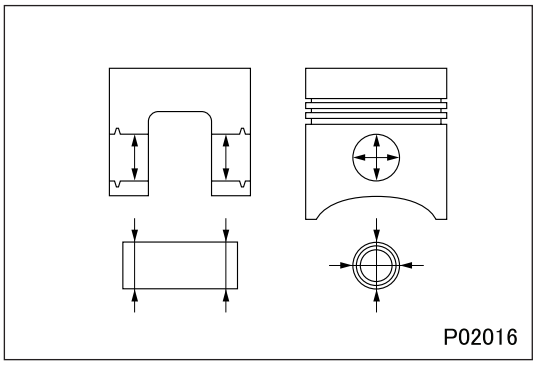
■ **Inspection: Piston ring end gap**

- Using the crown of a piston, push the piston ring horizontally into a cylinder in the crankcase until it reaches the lower part of the cylinder liner, where there is relatively small wear.
- Taking care not to move the piston ring, measure the end gap.
- If any of the rings has a gap exceeding the specified limit, replace all the piston rings as a set.



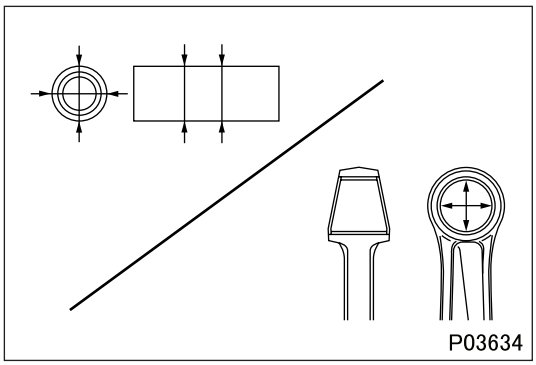
■ **Inspection: Piston ring side clearance in piston groove**

- Remove any carbon deposits from the ring groove in the piston.
- Measure the side clearance of each ring around the piston's entire periphery.
- If any of the measurements exceeds the specified limit, replace the defective part(s). If any of the piston rings is defective, replace all the rings on the piston as a set.
- The side clearance of the 1st compression ring must be measured using a feeler gauge while holding the ring against the piston ring groove with a straight edge.



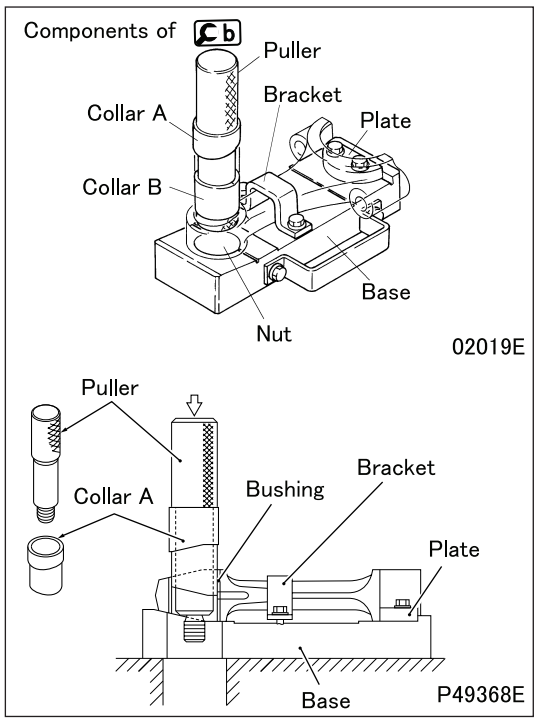
■ **Inspection: Piston pin-to-piston clearance**

- If the measurement exceeds the specified limit, replace the defective part(s).



■ **Inspection: Piston pin-to-connecting rod bushing clearance**

- If any of the measurements exceeds the specified limit, replace the bushing.

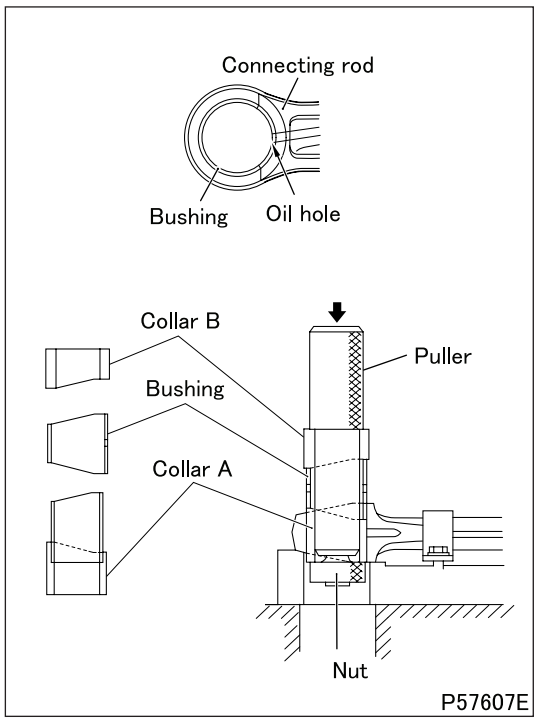


Replacement of connecting rod bushing

- Replace the connecting rod bushing using .

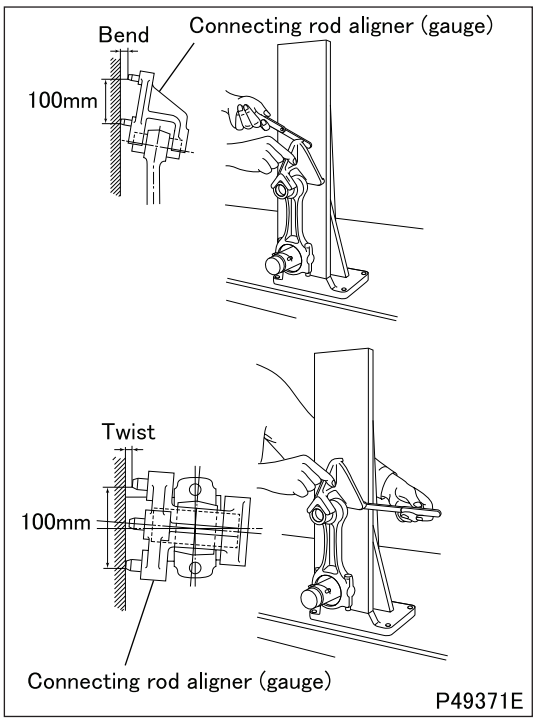
[Removal]

- Remove the upper bearing (if fitted) from the large end of the connecting rod.
- Mount the connecting rod on the base and lock it in position with the bracket and plate.
- Fit collar A over the puller with its ends facing in the illustrated directions. Then, slowly apply a pressure of approximately 49 kN {5,000 kgf} to the puller with a press to force out the connecting rod bushing.



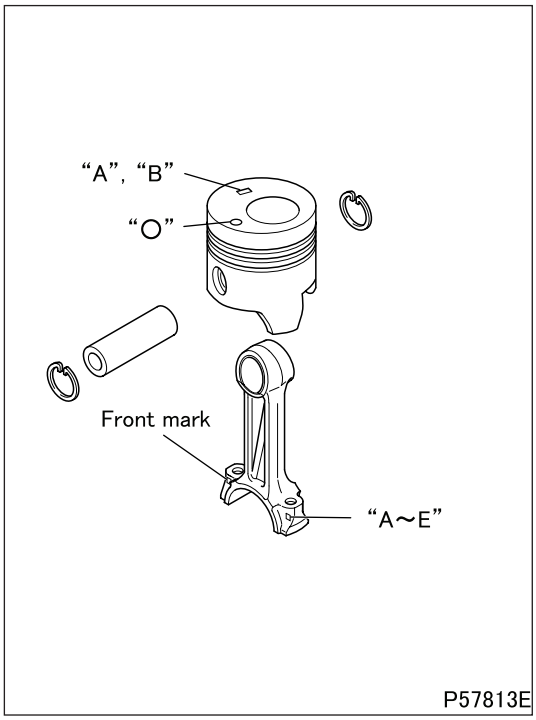
[Installation]

- Apply engine oil to the outside surface of the connecting rod bushing and the bushing fitting surface of the connecting rod.
- Fit collar B, the bushing, and collar A over the puller in the illustrated directions and lock this arrangement together with the nut.
- Align the oil holes in the connecting rod bushing and the connecting rod. Then, use a press to slowly apply a pressure of approximately 49 kN {5,000 kgf} to the puller until the bushing is forced into place.
- After press-fitting the connecting rod bushing, measure the clearance between the piston pin and connecting rod bushing.
- If the measurement is less than the standard clearance range, ream the bushing.



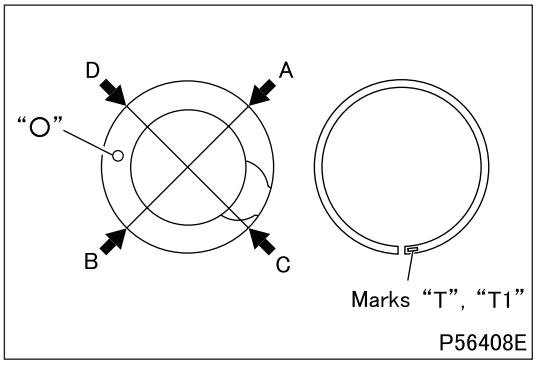
■ **Inspection: Connecting rod bend and twist**

- Mount the connecting rod on the connecting rod aligner. Also mount the connecting rod bearings, piston pin, and connecting rod cap to create the same conditions as are expected when the connecting rod is mounted on a crankshaft. Tighten the nuts of the connecting rod bearing cap to a torque of 29 N·m {3 kgf·m}.
- Measure the extent of bend and twist in the connecting rod.
- If either measurement exceeds the specified limit, replace the connecting rod.



■ **Installation: Piston and connecting rod**

- If the piston and/or connecting rod have been replaced, assemble them while paying attention to the following:
  - The connecting rods on the same engine must all have the same mass mark (A to E).
  - Apply engine oil to the piston pin, and assemble the piston and connecting rod with their marks facing in the illustrated directions.
    “O”: Front mark
  - If the piston pin is difficult to insert, heat the piston in hot water or with a piston heater.



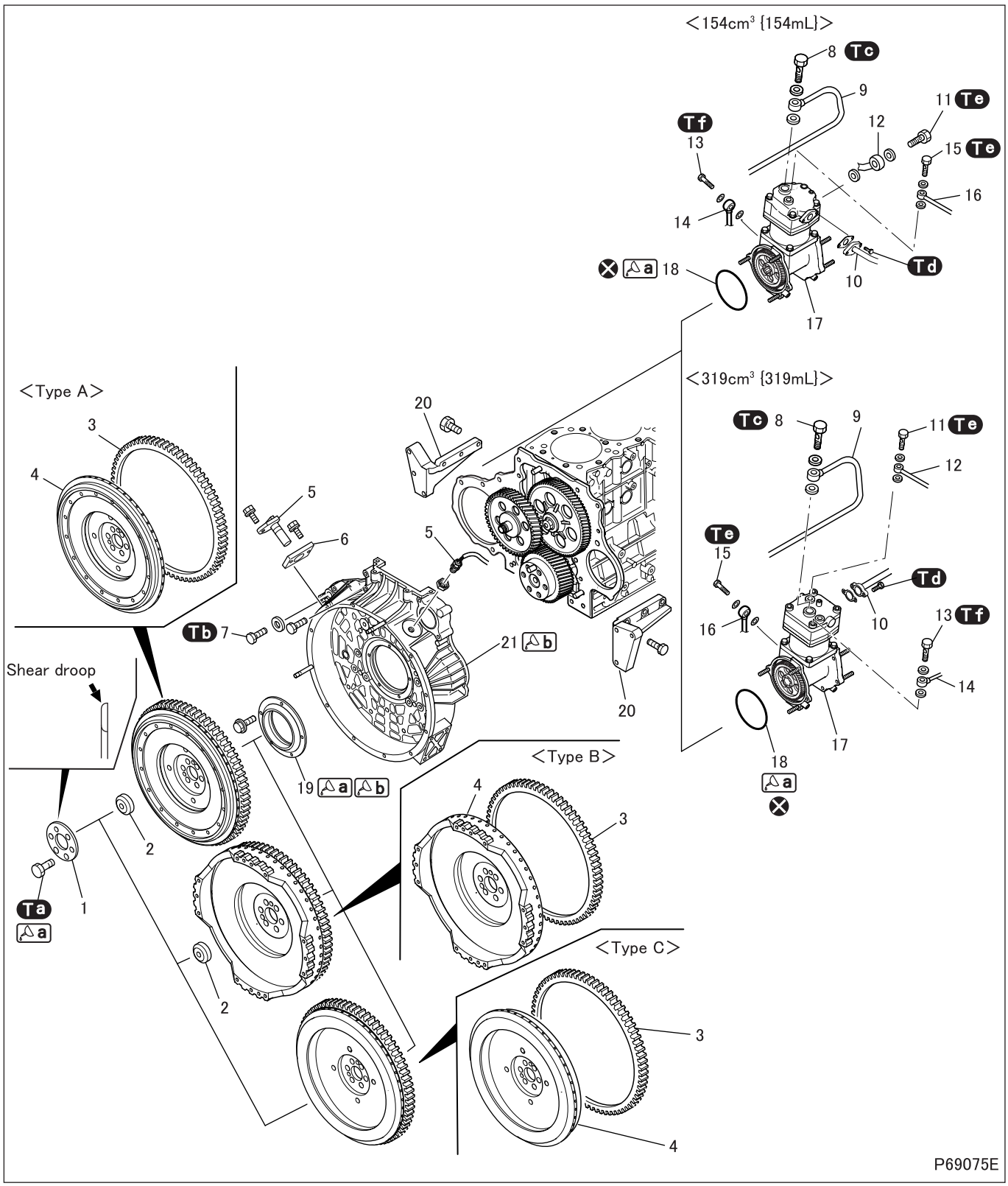
■ **Installation: Piston rings**

- With the manufacturer’s marks (found near the piston ring end gaps) facing up, install the piston rings so that the end gap of each ring is positioned as illustrated.
  A: 1st compression ring end gap
  B: 2nd compression ring end gap
  C: Oil ring end gap
  D: Oil ring’s expander spring end gap

“O”: Front mark on piston

The manufacturer’s marks are present only on the 1st (“T”) and 2nd (“T1”) compression rings.

M E M O



● **Disassembly sequence**

1 Washer plate
2 Pilot bearing <Type A, Type B>
3 Ring gear
4 Flywheel
5 Engine speed sensor
6 Adapter <*a>
7 Plug
8 Eyebolt
9 Air outlet pipe
10 Air suction pipe
11 Eyebolt
12 Water inlet pipe
13 Eyebolt
14 Oil pipe
15 Eyebolt
16 Water outlet pipe
17 Air compressor (See Gr61.)
18 O-ring
19 Rear oil seal
20 Stiffener
21 Flywheel housing

⊗: Non-reusable parts
*a: Varies depending on specifications

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards

Location	Maintenance item			Standard value	Limit	Remedy
4	Flywheel <Type A, Type B>	Friction surface distortion		0.05 or less	0.2	Correct or replace
		Friction surface height	Type A	21	20	Replace
			Type B	44.5	43.5	
		Friction surface runout (when fitted)		–	0.2	Correct or replace
21	Eccentricity of flywheel housing measured at spigot joint section (when fitted)			–	0.2	Inspect or replace

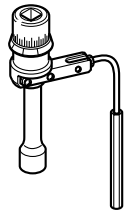
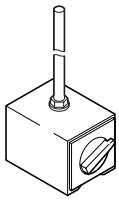
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (flywheel mounting)	98 {10} + 150° $^{+10°}_{0}$	• Wet • Can be reused up to 3 times
Tb	Plug	88 {9}	–
Tc	Eyebolt (air outlet pipe mounting)	98 {10}	–
Td	Bolt (air suction pipe mounting)	19 to 28 {1.9 to 2.8}	–
Te	Eyebolt (water inlet pipe mounting)	50 {5.0}	–
	Eyebolt (water outlet pipe mounting)		
Tf	Eyebolt (oil pipe mounting)	21 {2.1}	–

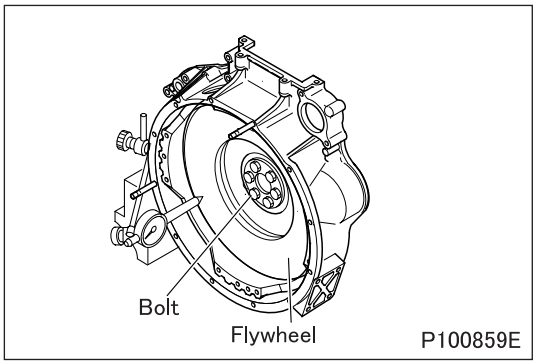
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Thread of bolts	Engine oil	As required
	O-ring		
	Rear oil seal lip		
b	Rear oil seal surface to be mated with flywheel housing	ThreeBond 1207C	As required
	Engine mounting surface of flywheel housing		

Special tools

Mark	Tool name and shape	Part No.	Application
a	Socket wrench  P01984	MH062354	Installation of flywheel
b	Magnet base  P00471	MH062356	

◆Inspection before removal◆

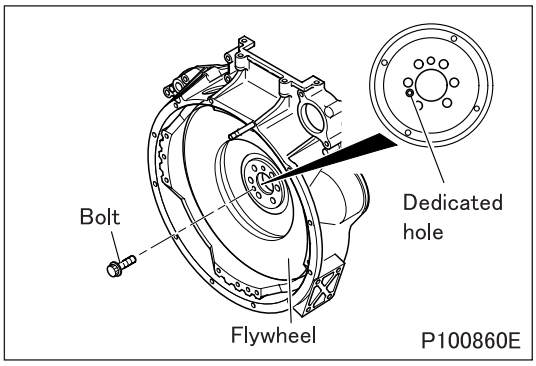


P100859E

■ **Inspection: Flywheel friction surface runout when fitted**

- If the measurement exceeds the limit, check if the bolts are correctly tightened as well as the crankshaft mounting surface. Correct or replace the flywheel as required.

◆Removal procedure◆



P100860E

■ **Removal: Flywheel**

- To remove the flywheel, use bolts (M16 × 1.5 mm, Length 60 mm) inserted into the dedicated holes in the flywheel.

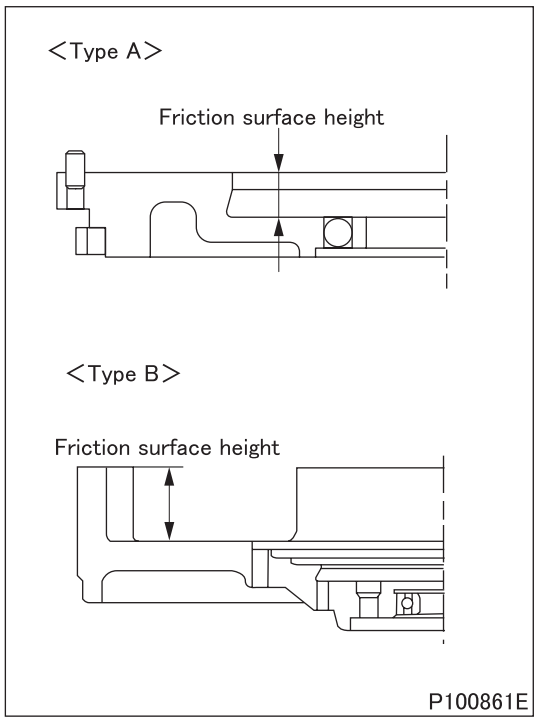
■ **Removal: Ring gear**

- Heat the ring gear evenly with a gas burner or the like until it reaches approximately 200°C, then remove it from the flywheel.

WARNING ⚠

- **You may burn yourself if you touch the heated ring gear.**

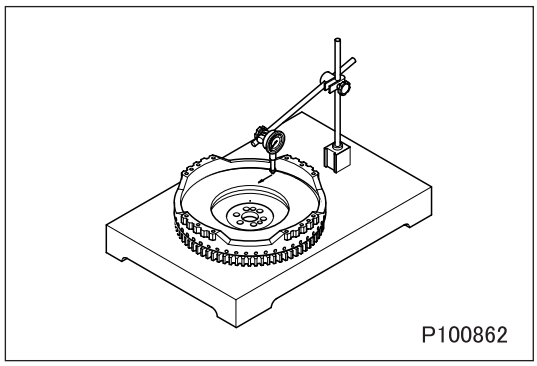
◆Inspection procedure◆



■ Inspection: Flywheel

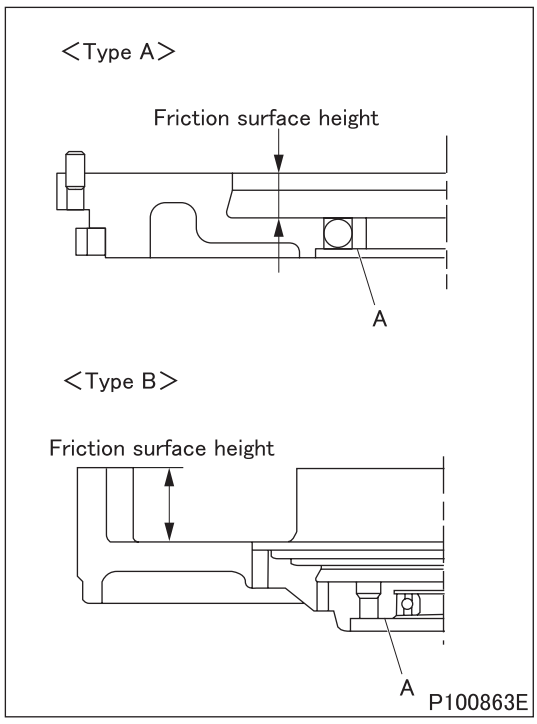
(1) Friction surface height

- If the height is less than the limit, replace the flywheel.



(2) Friction surface distortion

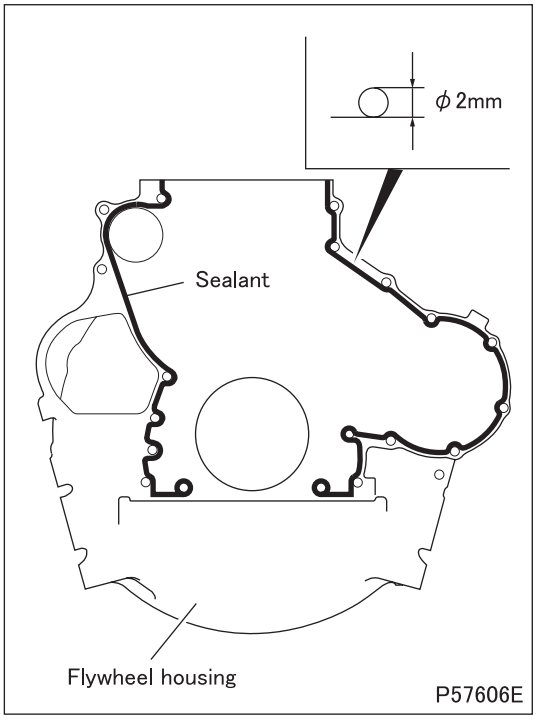
- If the measurement exceeds the limit, rectify or replace the flywheel.
- If the ring gear is evidently defective, replace the ring gear before inspecting the friction surface for distortion.



Rectification of friction surface

- Rectify the friction surface so that its height is not below the specified limit, and it is parallel with surface A with an error not exceeding 0.1 mm.

◆Installation procedure◆



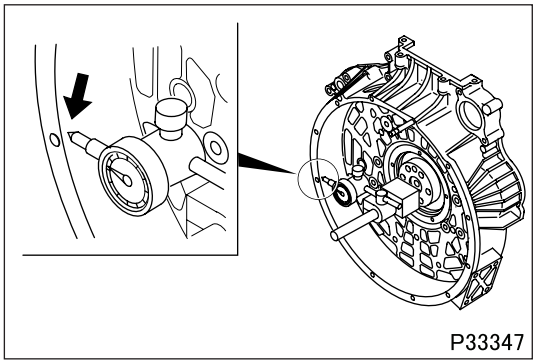
■ Installation: Flywheel housing

[Installation]

- Clean the flywheel housing surface where sealant is to be applied.
- Apply an even and continuous bead of sealant onto the flywheel housing surface where the crankcase is to be mounted.
- Install the flywheel housing onto the crankcase within 3 minutes following the application. Be careful not to smear the sealant bead.

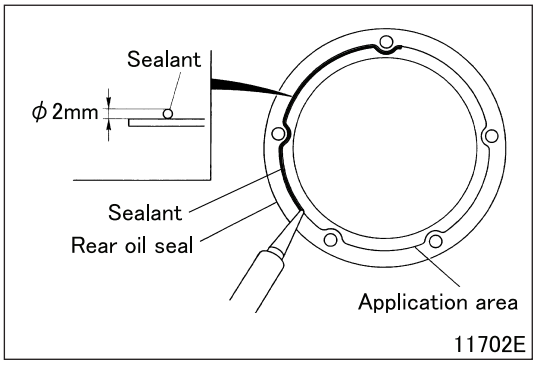
CAUTION ⚠

- **Do not start the engine at least for an hour after the flywheel housing has been installed.**
- **If the flywheel housing mounting bolts are subsequently loosened, be sure to apply sealant again upon reassembly.**



[Inspection]

- While turning the crankshaft, measure the flywheel housing for any eccentricity at the location indicated in the illustration.
- If the eccentricity exceeds the limit, reassemble the flywheel.
- If the eccentricity still exceeds the limit after reassembly, replace the defective part(s).

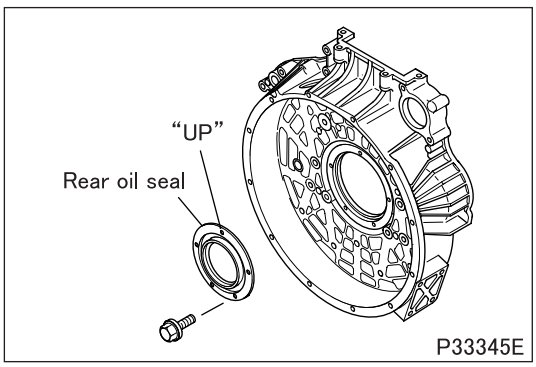


■ Installation: Rear oil seal

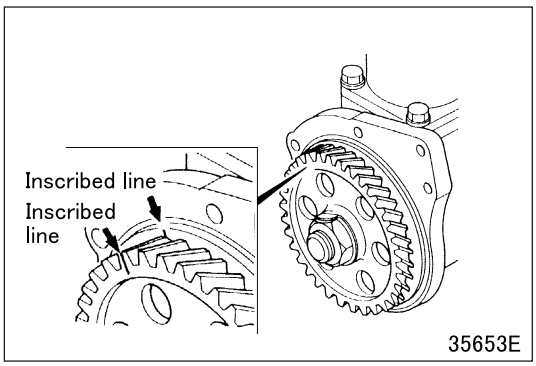
- Clean the rear oil seal surface where sealant is to be applied.
- Apply an even and continuous bead of sealant on the rear oil seal as shown in the illustration.
- Install the rear oil seal onto the flywheel housing within 3 minutes following the application. Be careful not to smear the sealant bead.

CAUTION ⚠

- **Do not start the engine at least for an hour after the rear oil seal has been installed.**
- **If the rear oil seal mounting bolts are subsequently loosened, be sure to apply sealant again upon reassembly.**

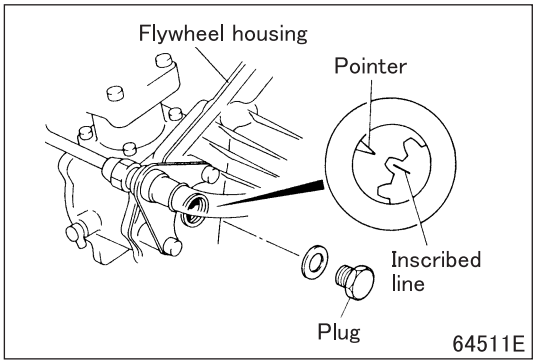


- Apply engine oil to the rear oil seal lip.
- Install the rear oil seal onto the flywheel housing ensuring that the seal is faced in the illustrated direction.

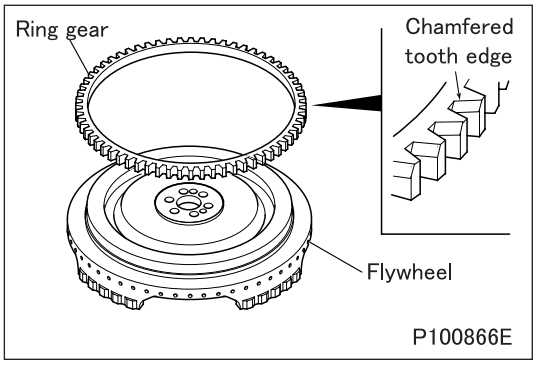


■ **Installation: Air compressor**

- Bring the No. 1 cylinder of the engine to top dead center of the compression stroke.
- After aligning inscribed lines with each other, install the air compressor to the flywheel housing.



- Remove the inspection plug and check if the inscribed line is aligned with the pointer.
- If not aligned, remove and refit the air compressor.



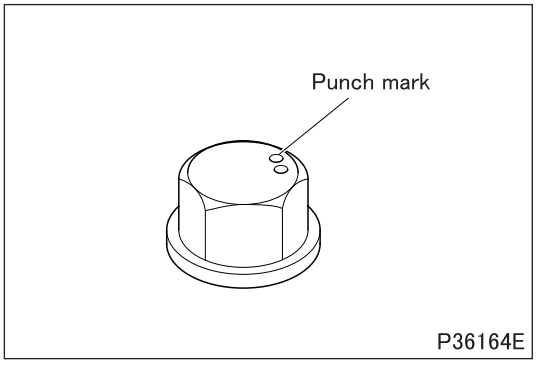
■ **Installation: Ring gear**

- Heat the ring gear evenly with a gas burner or the like until it reaches approximately 200°C.

WARNING ⚠

- **You may burn yourself if you touch the heated ring gear.**

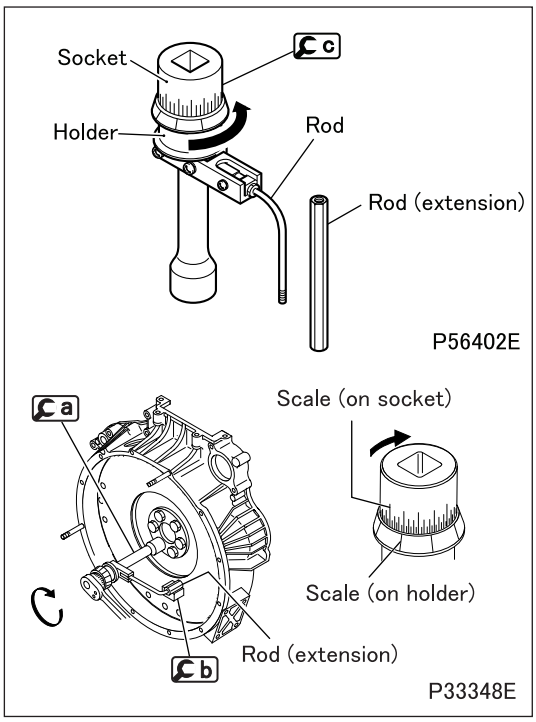
- Fit the ring gear with the side having non-chamfered tooth edges toward the flywheel.



■ **Installation: Flywheel**

CAUTION ⚠

- **Before installing a bolt, check the number of punch marks on the bolt head. (Bolts with up to two punch marks can be reused.)**
  The number of punch marks indicates the number of times the bolt has been tightened in the past within the plastic region. If there are three punch marks (tightened three times in the past), replace the bolt.

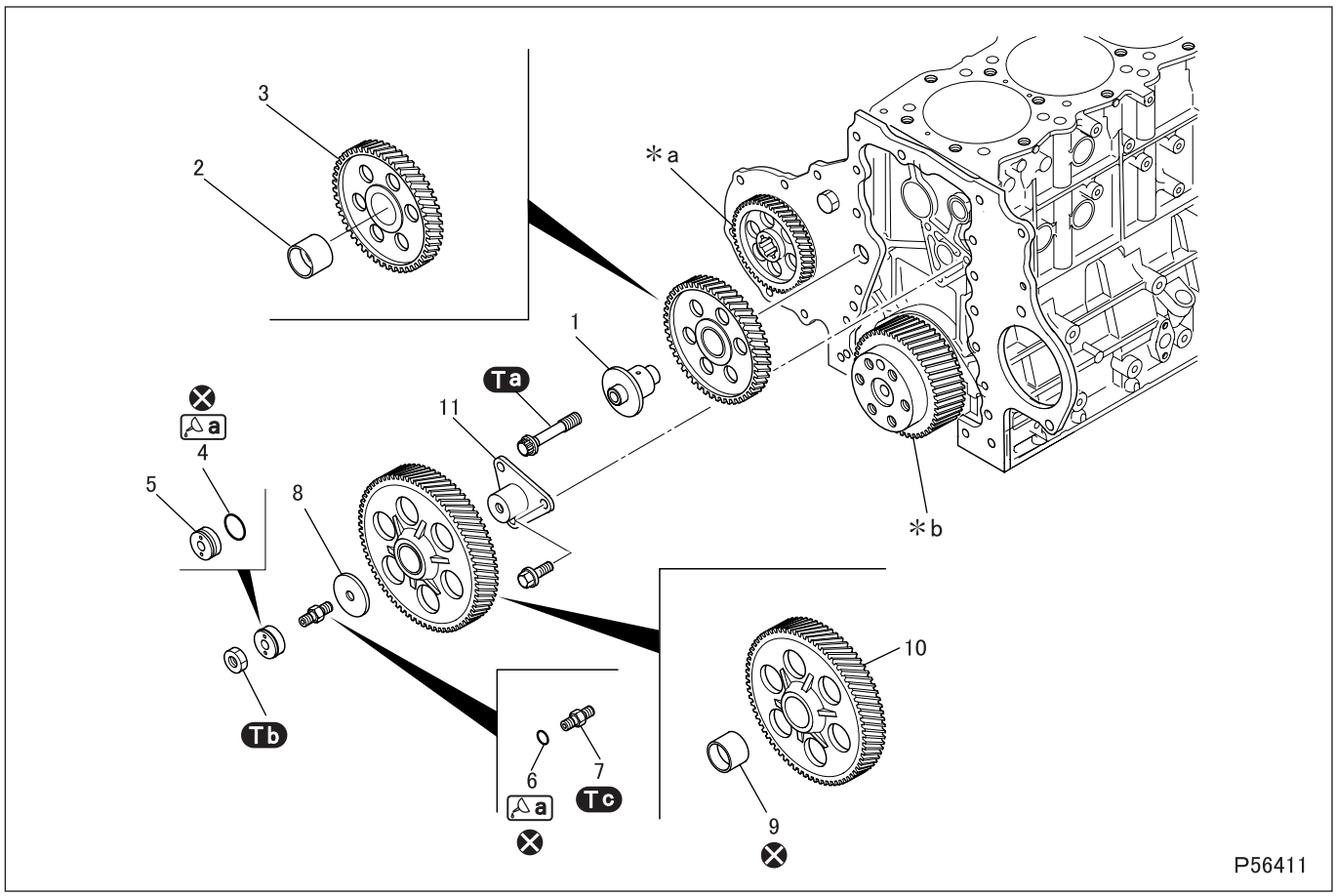


- Tighten the flywheel mounting bolts to a torque of 98 N·m {10 kgf·m}.
- Further tighten the bolts in the following procedure.
  - Turn the holder of a counterclockwise to preload the built-in spring.
  - Set a such that the rod (extension) is pressed against b by the force of the spring.
  - Align any line on the holder scale with any line on the socket scale. (This will be used as the reference point = 0°.)
  - From the reference point, turn the socket by $150^{\circ}\ ^{+10^{\circ}}_{0^{\circ}}$ clockwise. Each division on the socket scale represents 5°.
  - After tightening the bolt within the plastic region, make a punch mark on the bolt head for subsequent identification.

CAUTION ⚠

- **The bolts should be tightened within the plastic region. Never tighten them further than the specified angle.**

M E M O



● **Disassembly sequence**

1 No. 1 idler shaft
2 No. 1 idler gear bushing
3 No.1 idler gear
4 O-ring
5 Collar
6 O-ring
7 No. 2 idler bolt
8 Thrust plate
9 No. 2 idler gear bushing
10 No. 2 idler gear
11 No. 2 idler shaft

*****a: Air compressor gear
*****b: Crankshaft gear

⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
–	Backlash between gears	No. 1 idler gear and air compressor gear	0.08 to 0.15	0.35	Replace
		No. 1 idler gear and No. 2 idler gear	0.08 to 0.15	0.35	Replace
		No. 1 idler gear and crankshaft gear	0.08 to 0.14	0.35	Replace
1, 2	Clearance between No. 1 idler shaft and No. 1 idler gear bushing		0.01 to 0.05	0.2	Replace
3, 10	Idler gear end play		0.05 to 0.15	0.3	Replace
9, 11	Clearance between No. 2 idler gear bushing and No. 2 idler shaft		0.01 to 0.05	0.2	Replace

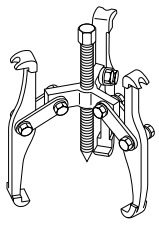
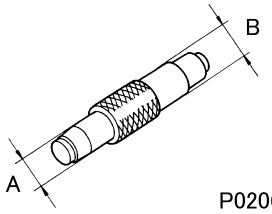
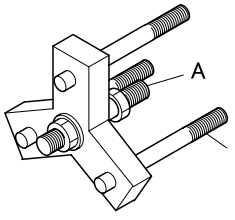
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (No.1 idler gear mounting)	88 {9}	–
Tb	Nut (collar mounting)	82 {8.4}	–
Tc	No. 2 idler bolt	95 {9.7}	–

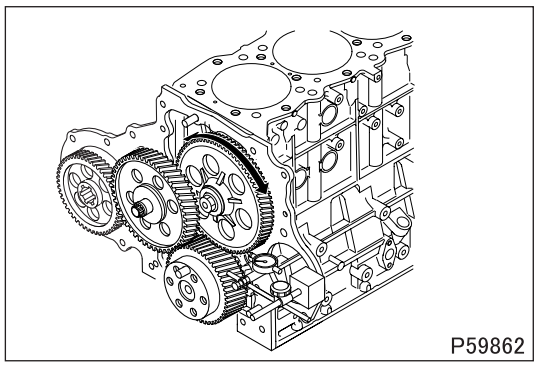
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

Special tools (Unit: mm)

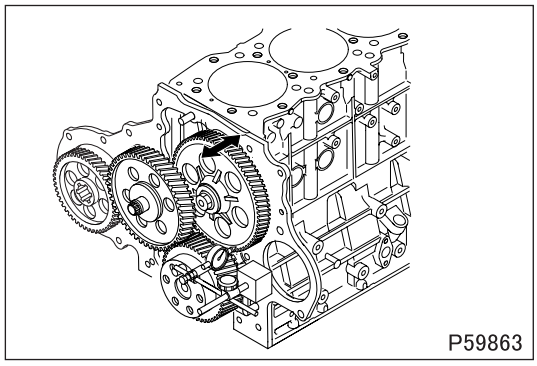
Mark	Tool name and shape	Part No.	Application
Ca	Gear puller  P02065	MH061326	Removal of No. 1 idler shaft and gear
Cb	Idler gear push-puller A: ϕ 37, B: ϕ 40  P02066	MH062601	Removal and installation of No. 1 and No. 2 idler gear bushings
Cc	No. 2 idler shaft puller A: M12 × 1.25, B: M10 × 1.5  P36309	MH062562	Removal of No. 2 idler gear shaft

◆Inspection before removal◆



■ **Inspection: Backlash between gears**

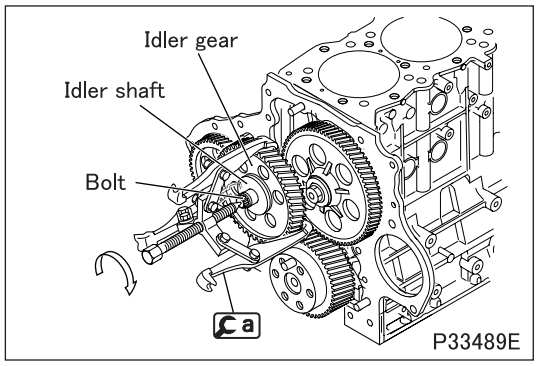
- For each pair of gears, measure the backlash at more than three teeth.
- If any of the measurements exceeds the specified limit, replace the defective part(s).



■ **Inspection: Idler gear end play**

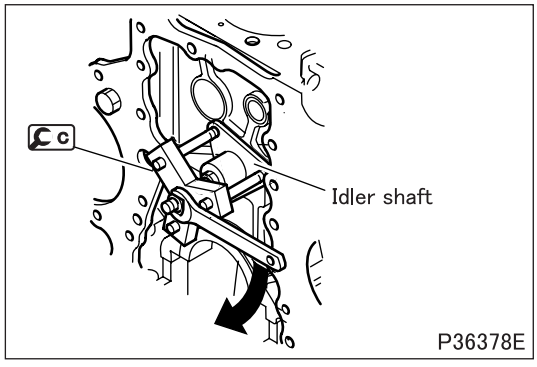
- If the measurement exceeds the specified limit, replace the defective part(s).

◆Removal procedure◆



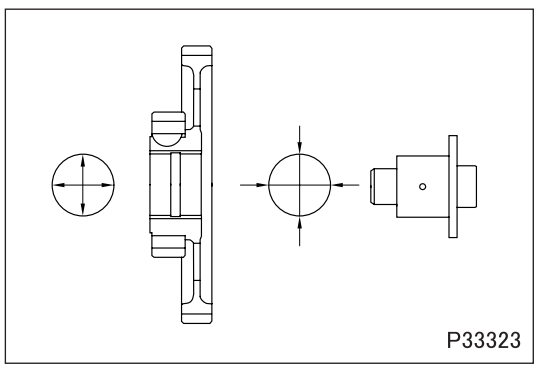
■ **Removal: No. 1 idler shaft and No. 1 idler gear**

- With the bolt loosened by approximately 15 mm, pull out the No. 1 idler shaft from the crankcase using a.
- Remove the bolt. Remove the No. 1 idler shaft and No. 1 idler gear.



■ **Removal: No. 2 idler shaft**

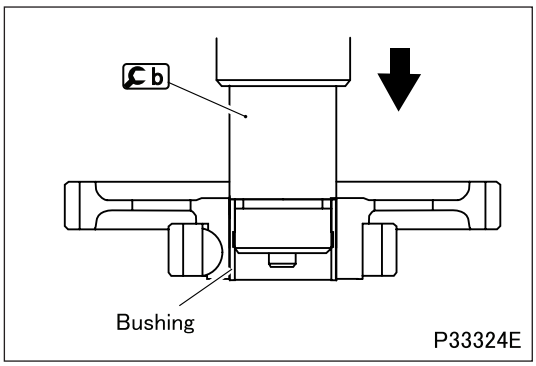
◆Inspection procedure◆



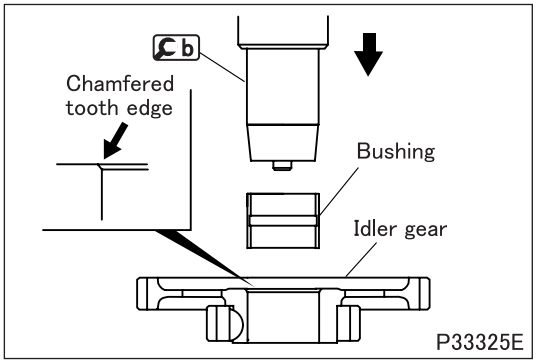
■ **Inspection: Clearance between No. 1 idler shaft and No. 1 idler gear bushing**

[Inspection]

- If the measurement exceeds the limit, replace the bushing.

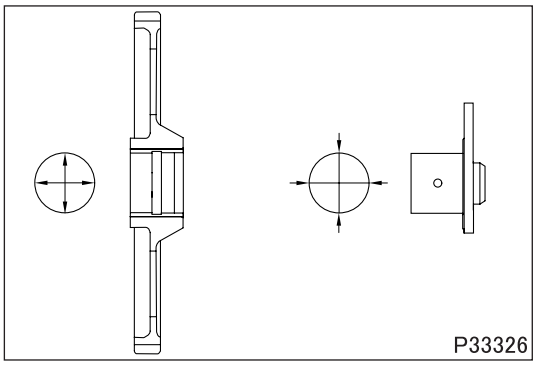


Replacement of No. 1 idler gear bushing
[Removal]



[Installation]

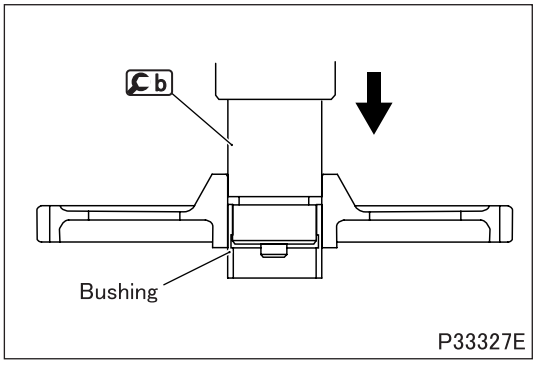
- Place the No. 1 idler gear as shown in the illustration. Using Cb, insert the bushing until Cb contacts the chamfered tooth edge of the gear.
- After installation, measure the clearance again.
- If the measurement is less than the standard value, ream the bushing.



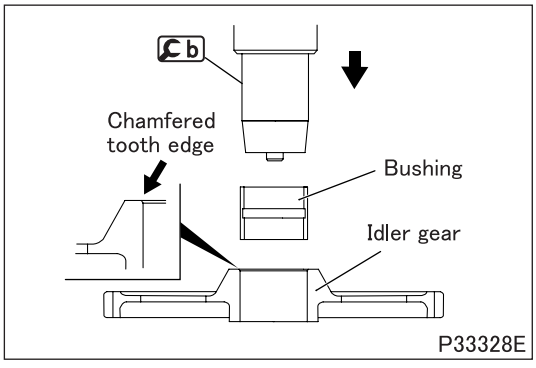
■ Inspection: Clearance between No. 2 idler gear bushing and No. 2 idler shaft

[Inspection]

- If the measurement exceeds the limit, replace the bushing.

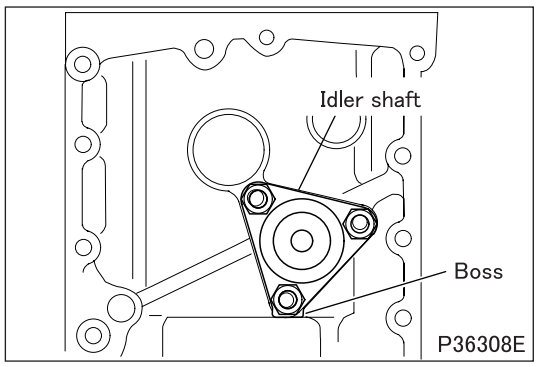


Replacement of No. 2 idler gear bushing
[Removal]



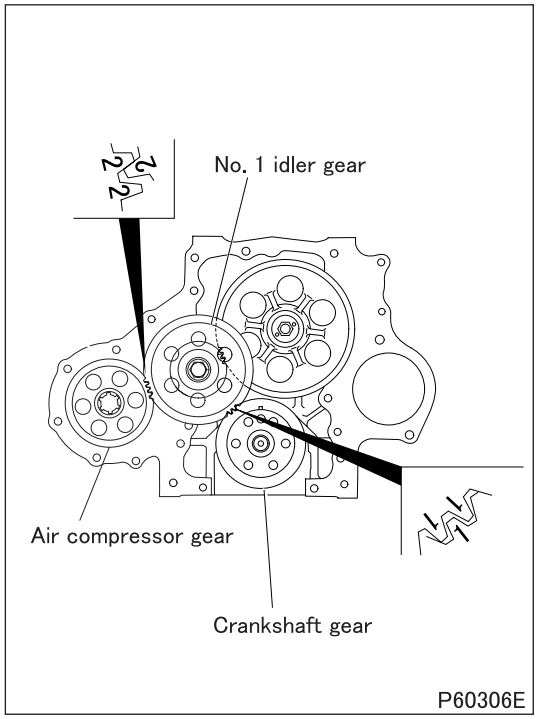
[Installation]

- Place the No. 2 idler gear as shown in the illustration. Using Cb, insert the bushing until Cb contacts the chamfered tooth edge of the gear.
- After installation, measure the clearance again.
- If the measurement is less than the standard value, ream the bushing.



■ **Installation: No. 2 idler shaft**

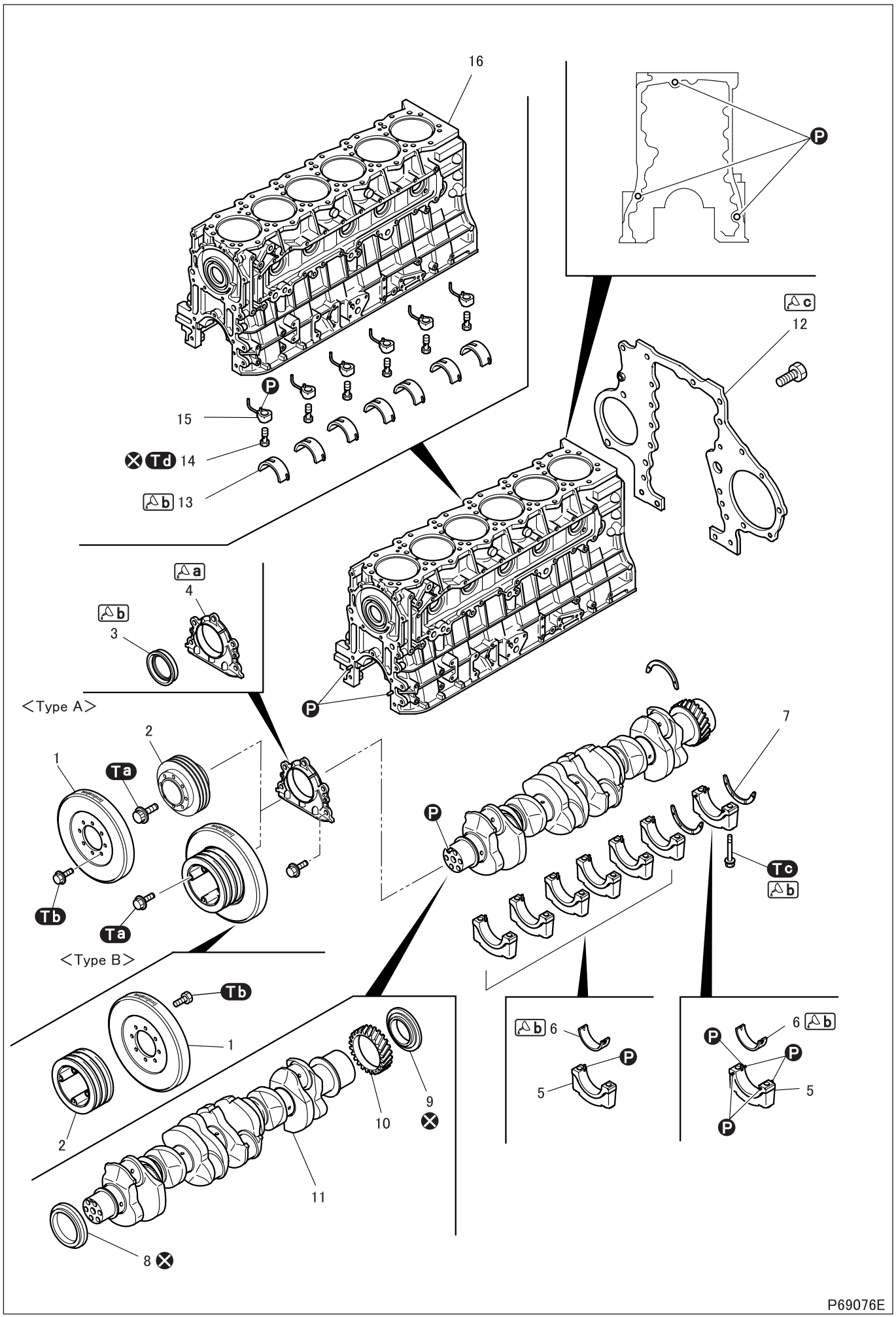
- Install the No. 2 idler shaft onto the crankcase ensuring that the boss of the shaft faces down.



■ **Installation: No. 1 idler gear**

- Install the No. 1 idler gear such that the alignment mark “2” on the gear is aligned with the alignment mark “2 2” on the air compressor gear.
- When installing the No. 1 idler gear, also ensure that the alignment mark “1 1” on the gear is aligned with the alignment mark “1” on the crankshaft gear.

M E M O


16
P
15
Td 14
b 13
c
12
a
4
b
3
<Type A>
2
1
Ta
Tb
Ta
<Type B>
7
P
Tc
b
Tb
1
2
10
9
11
8
b 6
P
5
6 b
P
P
P
5

P69076E

● Disassembly sequence

1 Torsional damper
2 Crankshaft pulley
3 Front oil seal
4 Front cover
5 Main bearing cap
6 Lower main bearing
7 Thrust plate
8 Front oil seal slinger
9 Rear oil seal slinger
10 Crankshaft gear
11 Crankshaft
12 Rear plate
13 Upper main bearing
14 Check valve
15 Oil jet
16 Crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **The check valve has been tightened using thread-locking compound and so, may deform during removal. Once removed, the check valve must not be reused. Do not remove it unless defects are evident.**

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy
6, 13	Main bearing	Oil clearance		0.039 to 0.101	0.15	Replace
		Span when free		–	Less than 89.5	Replace
11	Crankshaft	End play		0.10 to 0.25	0.4	Replace
		Bend		0.025 or less	0.05	Rectify or replace
		Pins and journals	Out-of-round-ness	0.01 or less	0.03	Rectify or replace
			Taper	0.006 or less	–	Rectify or replace
16	Distortion of crankcase top surface			0.07 or less	0.2	Replace

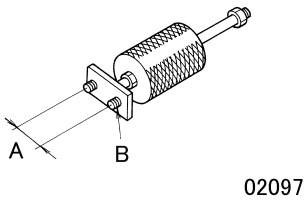
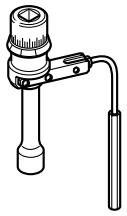
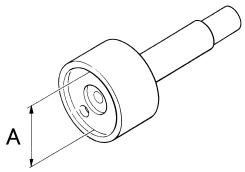
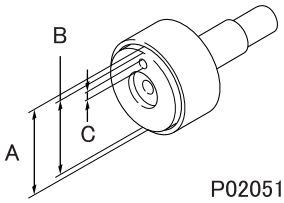
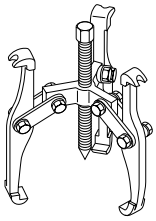
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ⓣa	Bolt (crankshaft pulley installation)	190 {19}	–
Ⓣb	Bolt (torsional damper installation)	78 {8}	–
Ⓣc	Bolt (main bearing cap installation)	$78 + 90^\circ\ ^{+10^\circ}_{0}$ $\{8 + 90^\circ\ ^{+10^\circ}_{0}\}$	• Wet • Reusable up to 3 times
Ⓣd	Check valve	34 {3.5}	–

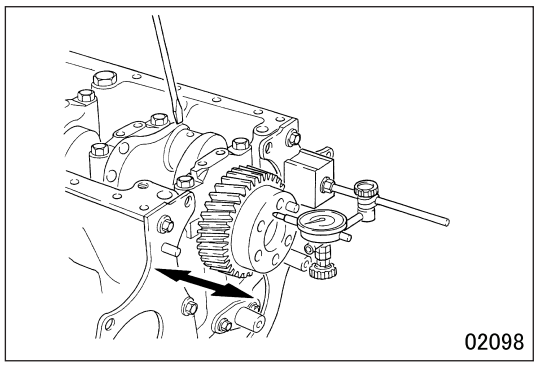
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
ⓐ	Front cover surface to be mated with crankcase	ThreeBond 1207C	As required
ⓑ	Front oil seal lip	Engine oil	As required
	Thread of bolts		
	Inside surface of main bearing		
ⓒ	Crankcase mounting surface of rear plate	ThreeBond 1217H	As required

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Main bearing cap extractor A: 32 B: M8 × 1.25  02097	MH061189	Removal of main bearing cap
b	Socket wrench  P01984	MH061560	Installation of main bearing cap
c	Front oil seal slinger installer A: ϕ 76  13625	MH062710	Installation of front oil seal slinger
d	Rear oil seal slinger installer A: ϕ 104.5 B: ϕ 100 C: ϕ 14  P02051	MH061470	Installation of rear oil seal slinger
e	Gear puller  P02065	MH061326	Removal of crankshaft gear

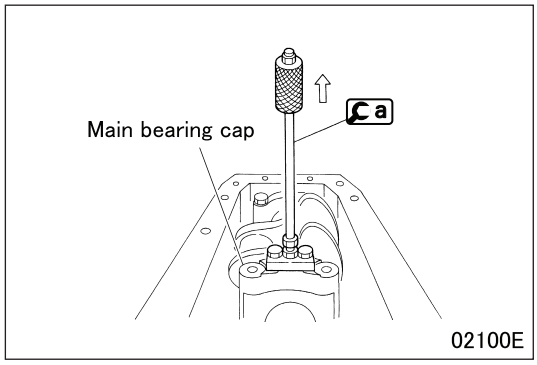
◆Inspection before removal◆



■ **Inspection: Crankshaft end play**

- If the measurement exceeds the specified limit, replace the thrust plates with oversized ones.

◆Removal procedure◆



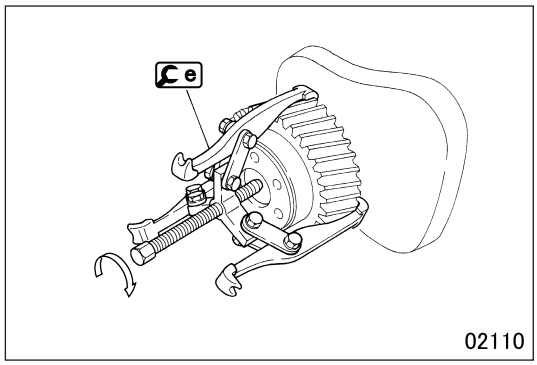
■ **Removal: Main bearing caps**

■ **Removal: Front oil seal slinger**

- Taking care not to damage the crankshaft, split the rear oil seal slinger using a chisel or a similar tool.

■ **Removal: Rear oil seal slinger**

- Taking care not to damage the crankshaft, split the rear oil seal slinger using a chisel or a similar tool.

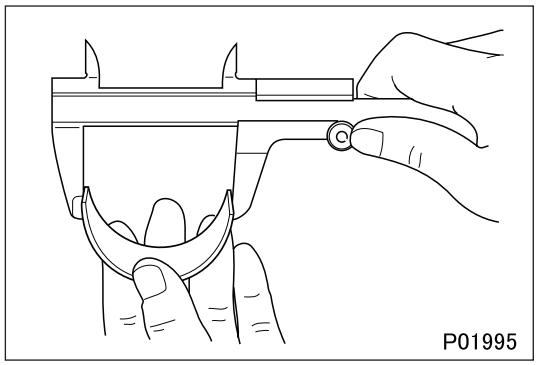


■ **Removal: Crankshaft gear**

CAUTION ⚠

- **Do not tap off the crankshaft gear as this can damage it.**

◆Inspection procedure◆



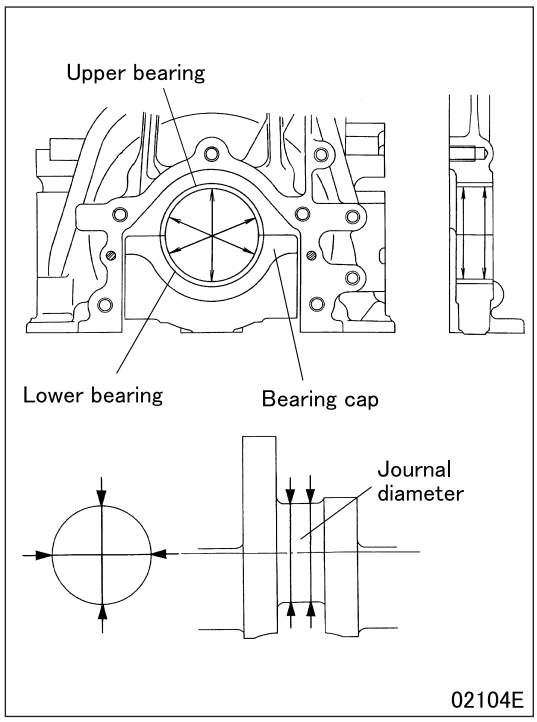
■ **Inspection: Main bearing**

(1) Main bearing span when free

CAUTION ⚠

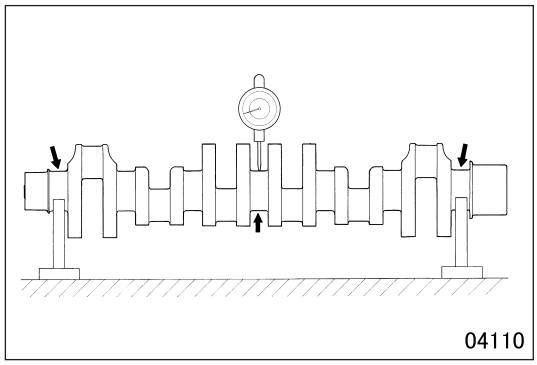
- **Do not attempt to manually expand the bearings.**

- If the measurement exceeds the specified limit, replace the upper and lower bearings as a set.



(2) Main bearing-to-crankshaft clearance (oil clearance)

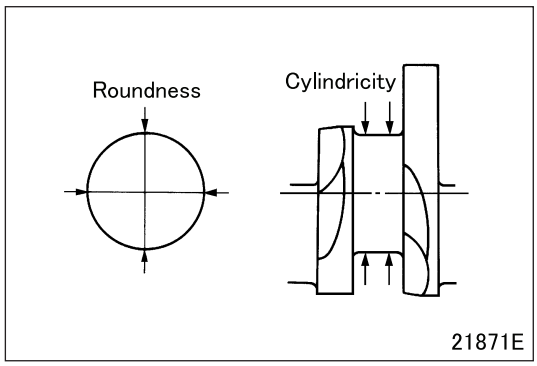
- Fit the upper main bearing into the crankcase and the lower main bearing into the main bearing cap.
- Tighten the main bearing cap bolts to a torque of 78 N·m {8 kgf·m}.
- Measure the inside diameter of the main bearing and the diameter of the corresponding crankshaft journal.
- If the difference between the measurements exceeds the specified limit, machine the crankshaft journal to one of the specified undersize dimensions.



■ Inspection: Crankshaft

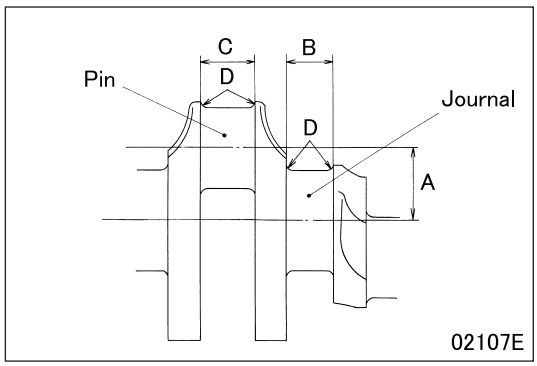
(1) Bend

- Measure the crankshaft at the center journal for bend while supporting the shaft at the end journals.
- A half of the dial gauge reading obtained as the crankshaft is rotated by a full turn represents the bend of the crankshaft.
- If the measurement exceeds the specified limit, replace the crankshaft.



(2) Roundness and cylindricity of crankshaft journals and pins

- If any of the measurements exceeds the specified limits, grind the crankshaft journal(s) and/or pin(s) to undersize(s) or replace the crankshaft.



Grinding of crankshaft

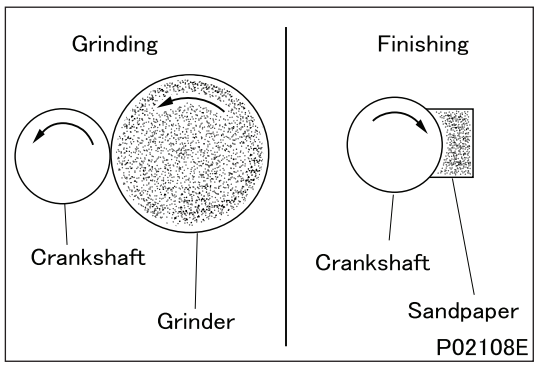
CAUTION ⚠

- **If the crankshaft pins and journals are ground to undersizes, be sure to use bearings of corresponding undersizes.**

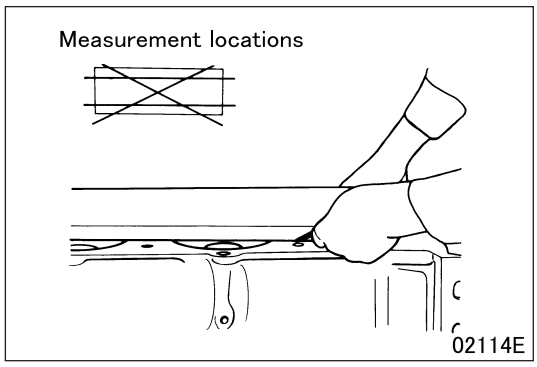
- Do not change the center-to-center distance A between the journal and pin.
  A: 57.5 $^{+0.025}_{-0.075}$ mm
- Do not change the journal width B and the pin width C.
  B: 37 $^{+0.2}_{0}$ mm
  C: 42 $^{+0.2}_{0}$ mm
- Finish the fillets D smoothly.
  D: R4 ± 0.2 mm
- Carry out a magnetic inspection to check for cracks possibly caused by grinding. Also, check that the hardness of the surface has not dropped below Shore hardness number (Hs) 75.
- Replace the crankshaft if defects are evident.

Crankshaft undersize dimensions (Unit: mm)

	Undersizes			
	0.25	0.50	0.75	1.00
Finished journal outside diameter	83.685 to 83.705	83.435 to 83.455	83.185 to 83.205	82.935 to 82.955
Finished pin outside diameter	69.67 to 69.69	69.42 to 69.44	69.17 to 69.19	68.92 to 68.94
Out-of-roundness	0.01 or less			
Taper	0.006 or less			



- When grinding, turn both the crankshaft and the grinder counterclockwise as viewed from the crankshaft front end.
- When finishing the crankshaft with whetstone or sandpaper, rotate the crankshaft clockwise.



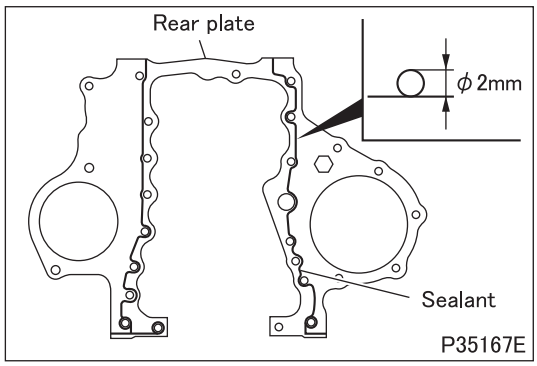
■ Inspection: Distortion of crankcase top surface

- If the measurement exceeds the limit, correct the crankcase top surface with a surface grinder.

CAUTION ⚠

- **Do not grind the crankcase top surface so much as to compromise the correct piston projection.**

◆Installation procedure◆

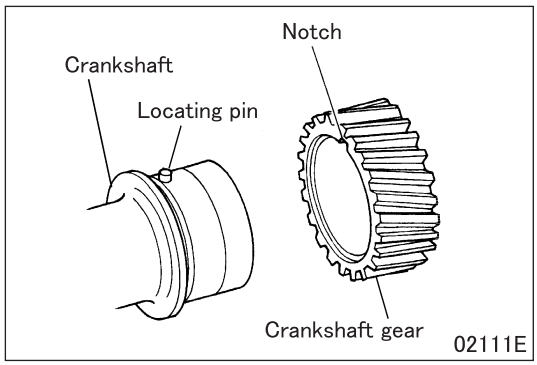


■ **Installation: Rear plate**

- Clean the rear plate surface where sealant is to be applied.
- Apply an even and continuous bead of sealant onto the rear plate surface where the crankcase is to be mounted.
- Install the rear plate onto the crankcase within 3 minutes following the application. Be careful not to smear the sealant bead.

CAUTION ⚠

- **Do not start the engine at least for an hour after the rear plate has been installed.**
- **If the rear plate mounting bolts are subsequently loosened, be sure to apply sealant again upon reassembly.**



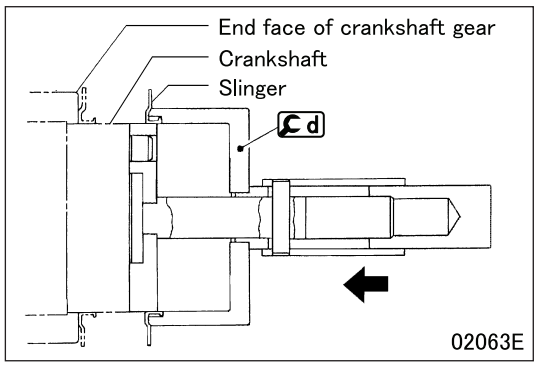
■ **Installation: Crankshaft gear**

- Heat the crankshaft gear to approximately 100°C with a burner or the like.

WARNING ⚠

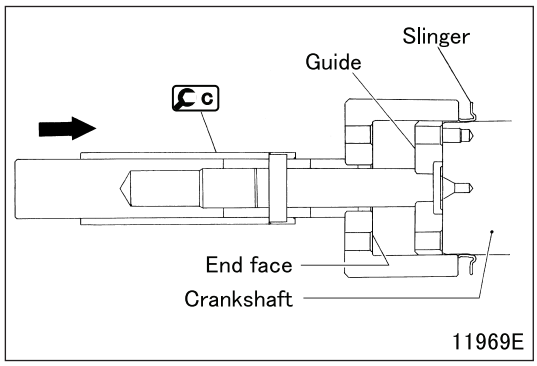
- **Be careful not to get burned.**

- Align the key fitted in the crankshaft with the slot in the crankshaft gear. Drive the gear into position by lightly striking its end face with a plastic hammer.



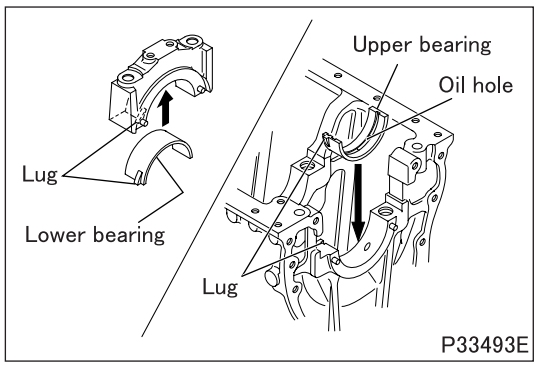
■ **Installation: Rear oil seal slinger**

- Using d, install the rear oil seal slinger onto the crankshaft until d comes into positive contact with the end face of the crankshaft gear.



■ **Installation: Front oil seal slinger**

- Using c, install the front oil seal slinger onto the crankshaft until the end face of c comes into positive contact with the guide.

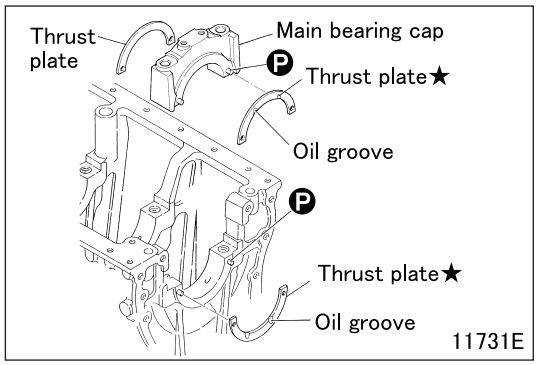


■ **Installation: Main bearing**

- Install the main bearings with their lugs aligned as shown in the illustration. When the crankshaft journals have been ground to an undersize, use undersized main bearings.
  Available main bearing undersizes: 0.25 mm, 0.50 mm, 0.75 mm, 1.00 mm

CAUTION ⚠

- **The upper main bearing has an oil hole. The lower main bearing has no oil hole. Do not confuse the upper and lower bearings, as this can cause seizure in the engine.**



■ **Installation: Thrust plate**

- Install trust plates on both sides of the main bearing cap and the rear end of the crankcase, ensuring that the oil grooves face outside.

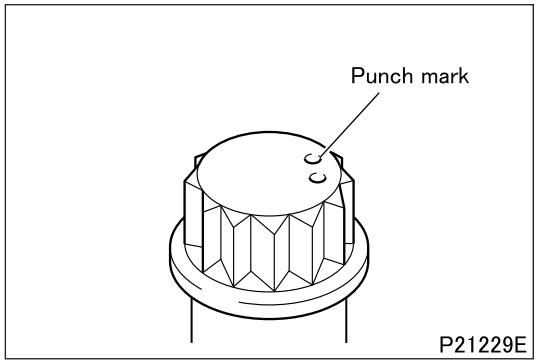
Ⓟ: Locating pin

NOTE

- **If oversized thrust plates are to be used, those with a ★ mark must be the same in size. Oversized thrust plates are available in the following sizes: 2.6 mm, 2.75 mm and 2.9 mm.**

CAUTION ⚠

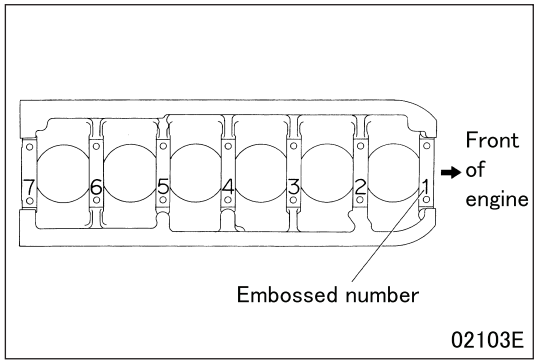
- **If thrust plates are installed with the oil grooves facing inside, the engine may seize.**



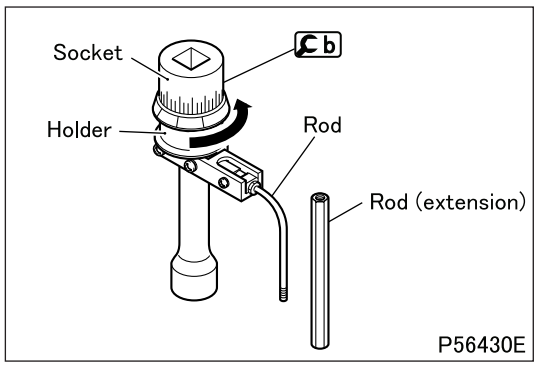
■ **Installation: Main bearing cap**

CAUTION ⚠

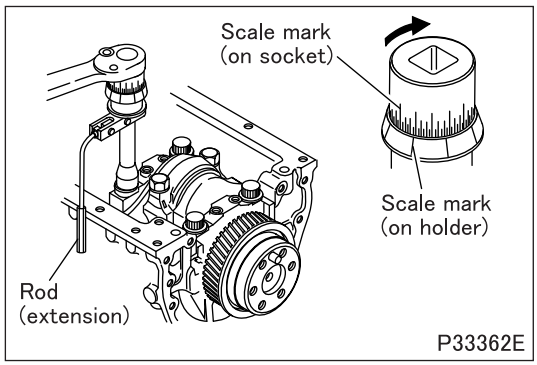
- **Before installing the main bearing cap bolts, check the number of punch marks on the head of each bolt. (A bolt with two or less marks is reusable.)**
- **The number of punch marks corresponds with the number of times the main cap bolt has been tightened using the torque-turn tightening method. Any bolt that has three marks (i.e. that has been used three times) must be replaced.**



- Starting at the front of the engine, fit the main bearing caps in the order of the embossed numbers facing the illustrated direction.



- Tighten all the bolts to 78 N·m {8 kgf·m}, then additionally tighten them according to the following procedure.
- Turn the holder of Cb counterclockwise to pretension the internal spring.

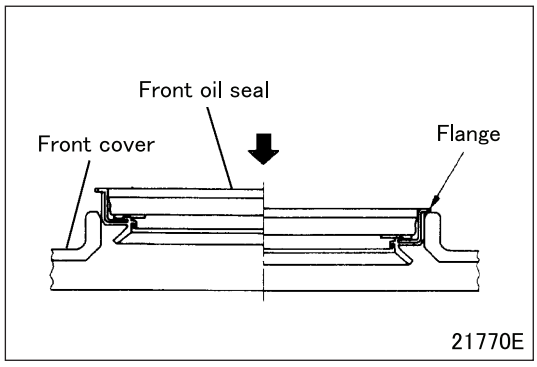


- Set the tool such that the rod (extension) is pressed against the crankshaft by the force of the spring.
- Align a scale mark on the socket with a scale mark on the holder. (This point will be the point of reference, or the 0° point.)
- Starting with this point of reference, turn the socket with a wrench in the illustrated direction until the scale on the socket indicates 90°.
  One graduation on the socket-side scale represents 5°.
- After tightening the bolts using the above torque-turn tightening method, make a punch mark on the head of each bolt to indicate the number of times that it has been used.

CAUTION ⚠

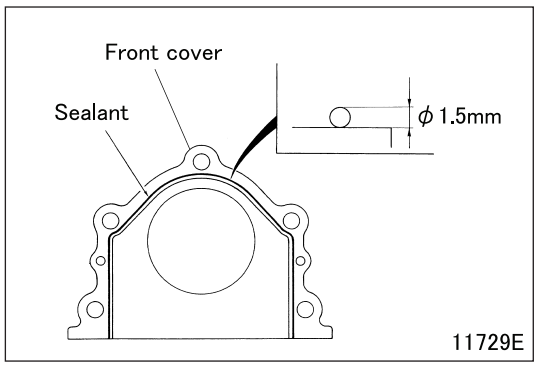
- **The bolts that have been tightened using the torque-turn method must never be additionally tightened after the final angular tightening.**

- After installing the main bearing cap, rotate the crankshaft by hand. If it cannot be rotated smoothly, inspect the main bearing caps for correct installation.



■ Installation: Front oil seal

- Install the front oil seal onto the front cover while pressing the seal's entire periphery evenly to prevent it from tilting.
- Install the front oil seal until its flange comes into positive contact with the front cover.



■ Installation: Front cover

- Clean the front cover surface where sealant is to be applied.
- Apply an even and continuous bead of sealant onto the front cover surface where the crankcase is to be mounted.
- Install the front cover onto the crankcase within 3 minutes following the application. Be careful not to smear the sealant bead.

CAUTION ⚠

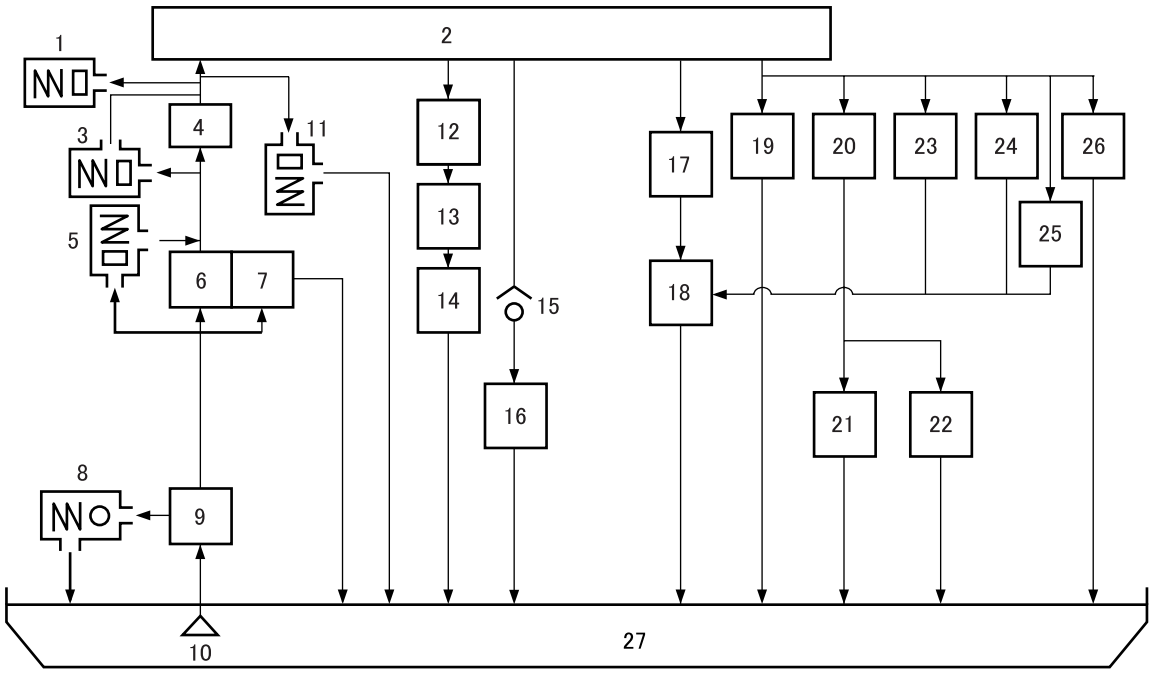
- **Do not start the engine at least for an hour after the front cover has been installed.**
- **If the front cover mounting bolts are subsequently loosened, be sure to apply sealant again upon reassembly.**

GROUP 12 LUBRICATION

SPECIFICATIONS

Item			Specifications
Method of lubrication			Oil pump type
Oil filter			Spin-on paper-filter type
Oil cooler			Shell and plate type (multiple-plate type)
Engine oil	Grade		API classification CD, CD/SF, CE, CE/SF, CF-4
	Quantity dm^3 {L}	Oil pan	Approx. 11 {11}, 12 {12}, 16 {16}, 28 {28},
		Oil filter	Approx. 2.3 {2.3}

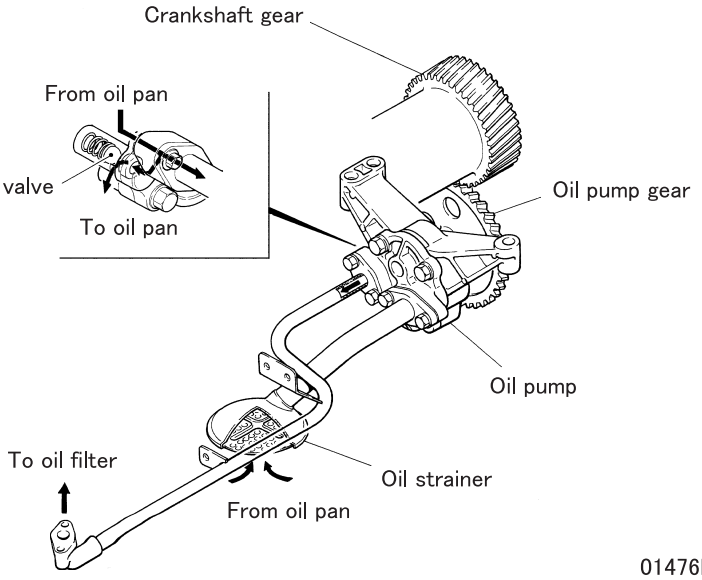
1. Lubrication System



P58084

1 Engine oil pressure switch
2 Main oil gallery
3 Bypass valve
4 Oil cooler
5 Engine oil bypass alarm switch
6 Full-flow filter element
7 Bypass filter element
8 Relief valve (built into oil pump)
9 Oil pump
10 Oil strainer
11 Regulator valve
12 Crankshaft main bearing
13 Connecting rod bearing
14 Connecting rod bushing
15 Check valve for oil jet
16 Piston
17 Air compressor
18 Timing gear
19 Camshaft bushing
20 Rocker bushing
21 Roller
22 Valve bridge
23 No.1 Idler shaft
24 No.2 Idler shaft
25 No.3 Idler shaft
26 Turbocharger
27 Oil pan

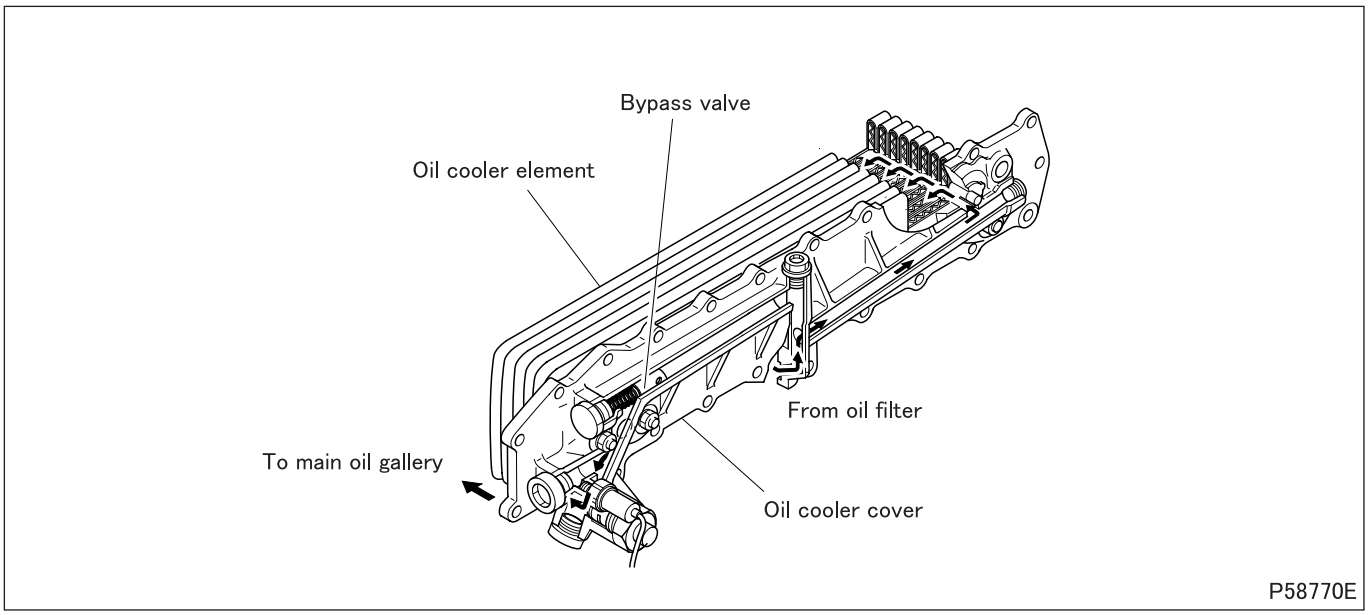
2. Oil Pump

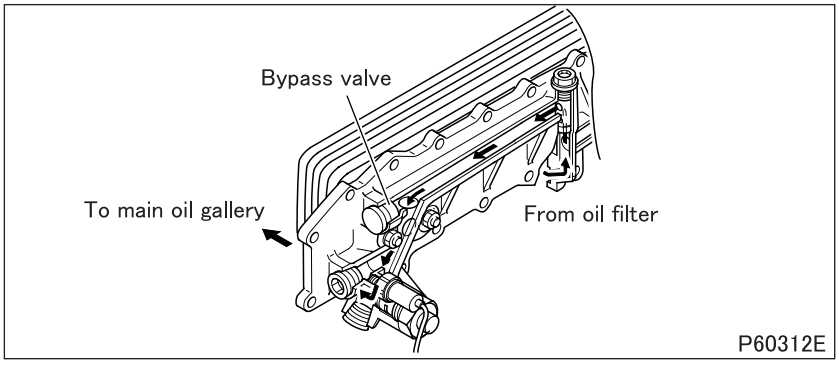


01476E

- This engine uses a gear-type oil pump driven by the rotation of the crankshaft transmitted through the engagement of the crankshaft gear and the oil pump gear.
- The oil pump has a relief valve, which prevents excessive pressure from building up inside the lubricating system by allowing part of the engine oil to escape to the oil pan when the oil pressure exceeds a specified level.

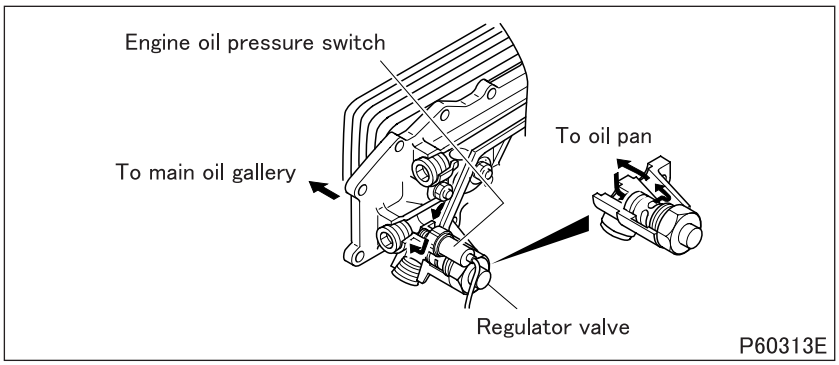
3. Oil Cooler





3.1 Bypass valve

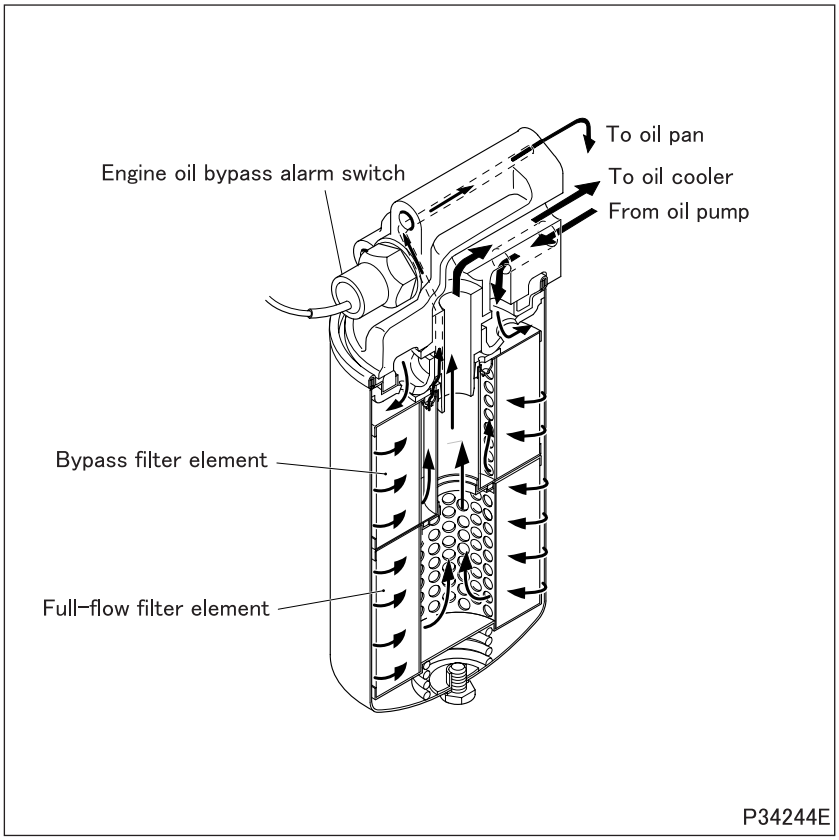
- When the engine oil is cool and its viscosity is high, or when the oil cooler element becomes clogged and restricts the flow of the engine oil, the bypass valve opens to let the engine oil bypass the oil cooler and flow directly to the oil filter.



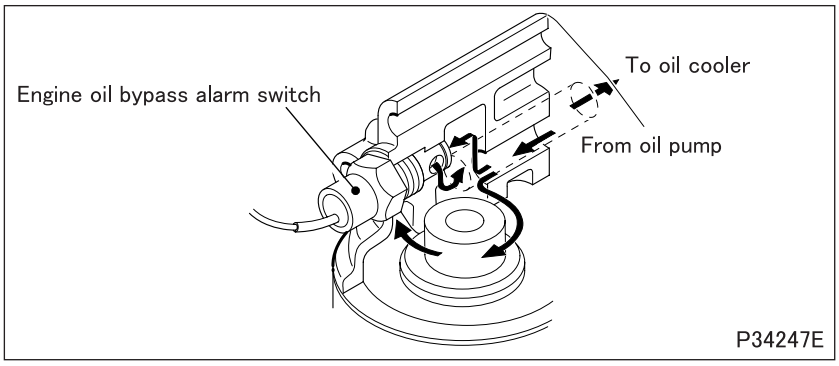
3.2 Engine oil pressure switch and regulator valve

- When the pressure of the engine oil to the main oil gallery drops below the specified level, an electrical contact inside the engine oil pressure switch closes. This causes a warning lamp on the meter cluster to illuminate and notify the operator of the excessive pressure drop.
- When the oil pressure in the main oil gallery exceeds the specified level, the regulator valve opens to adjust the oil pressure by allowing part of the engine oil to escape to the oil pan.

4. Oil filter



- This oil filter is a spin-on paper-filter type that incorporates both a full-flow filter and a bypass filter.



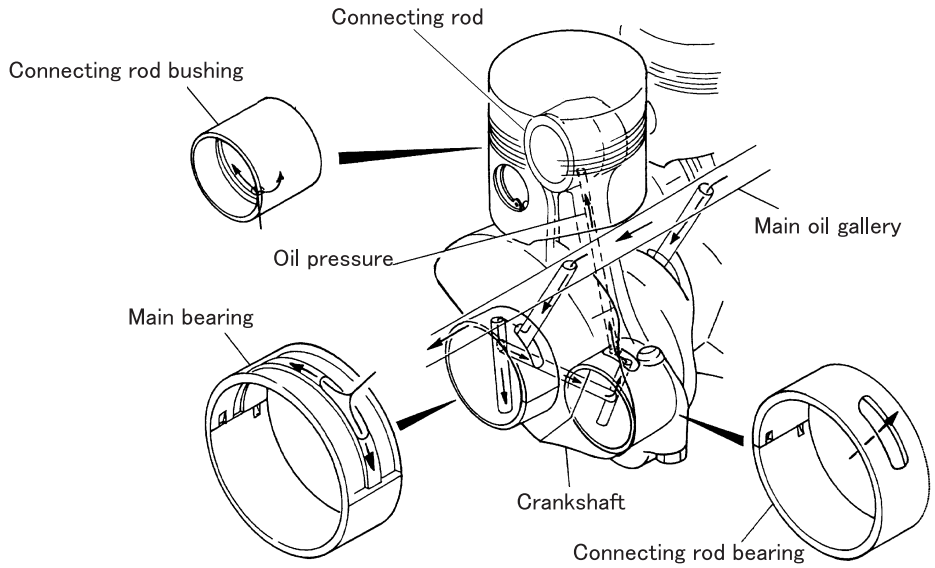
4.1 Engine oil bypass alarm switch

- If the oil filter elements clog up, this will restrict the flow of engine oil, causing the engine to seize. To prevent this, the oil filter is provided with the engine oil bypass alarm switch.
- If the oil filter clogs up, the engine oil bypass alarm switch trips in such a way as to direct the engine oil straight on to the oil cooler, bypassing the full-flow and bypass filter elements. When the switch trips, the relevant warning lamp illuminates to alert the operator to the clogged oil filter.

5. Lubrication of Engine Components

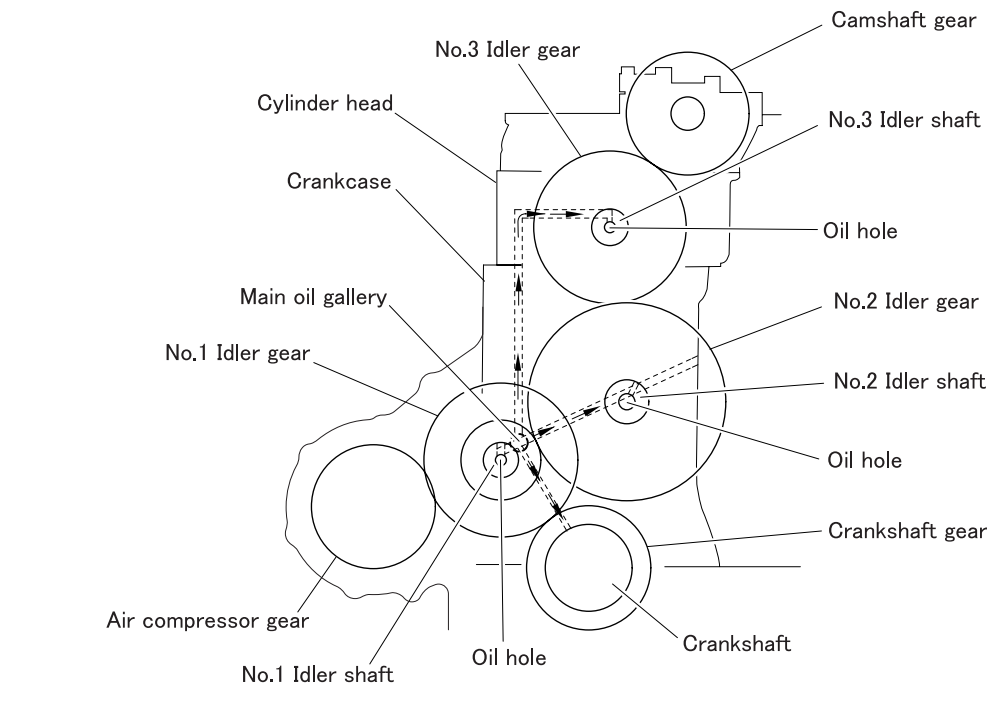
- The engine oil in the main oil gallery lubricates the engine components in the following ways.

5.1 Main bearing and connecting rod bearing



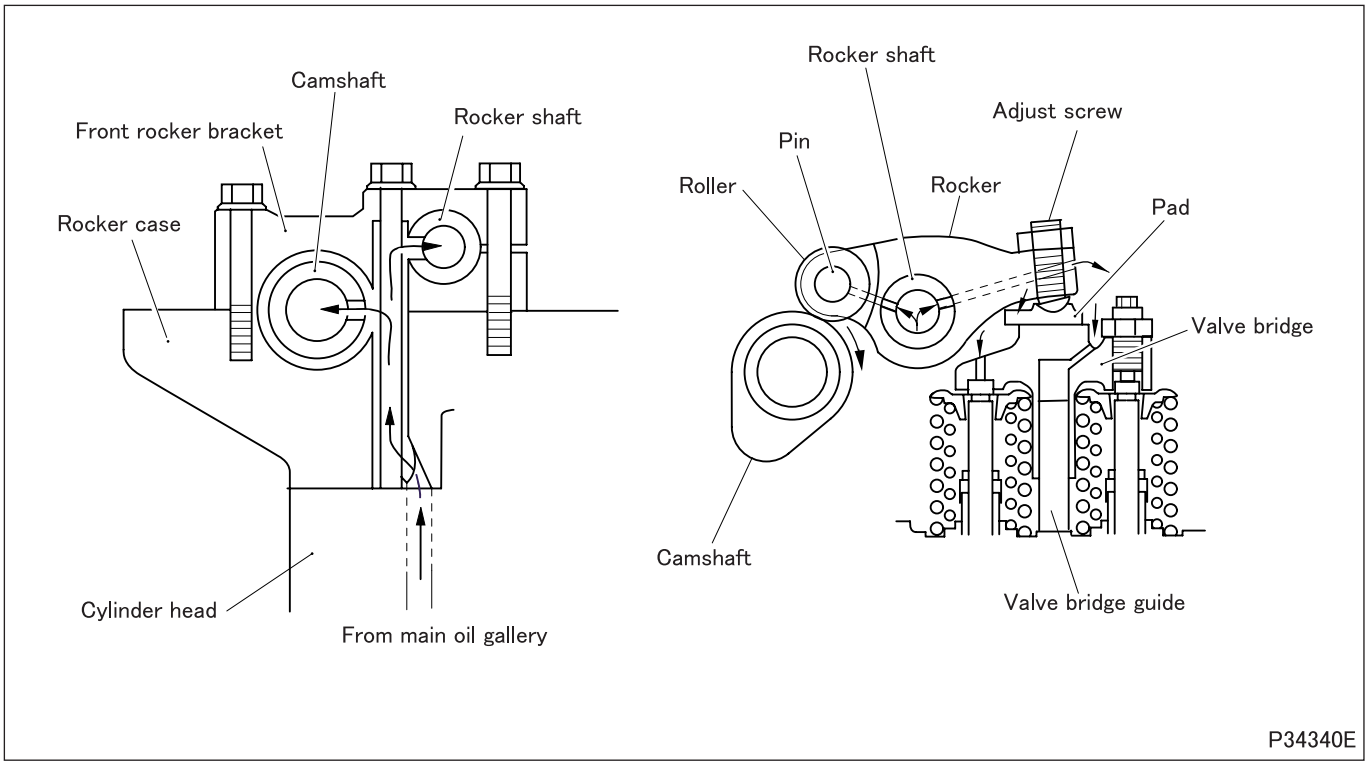
- Engine oil supplied through an oil passage in the crankshaft lubricates the big end (connecting rod bearing) of each connecting rod. Simultaneously, engine oil supplied through an oil passage in the connecting rod lubricates the connecting rod's small end (connecting rod bushing).

5.2 Timing gears

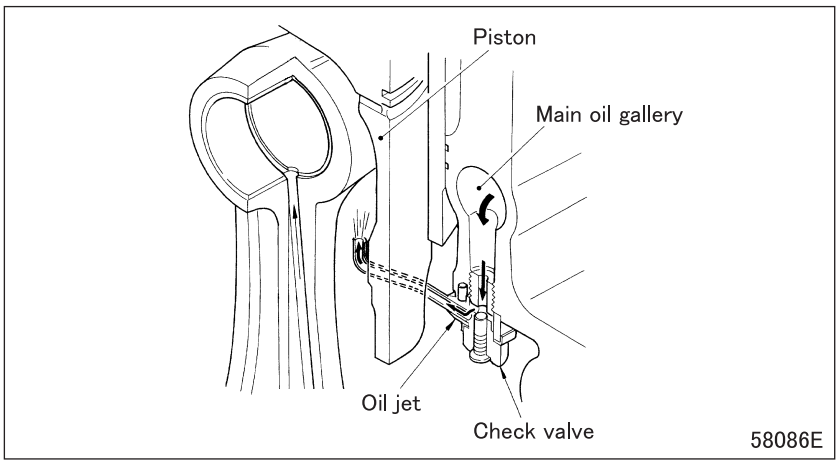


- Engine oil in the main oil gallery is directed through the oil passages in the crankcase and cylinder head and is used to lubricate the various gear shafts. After lubricating the gear shafts, the oil is used to lubricate the gears before returning the oil pan.

5.3 Valve mechanism

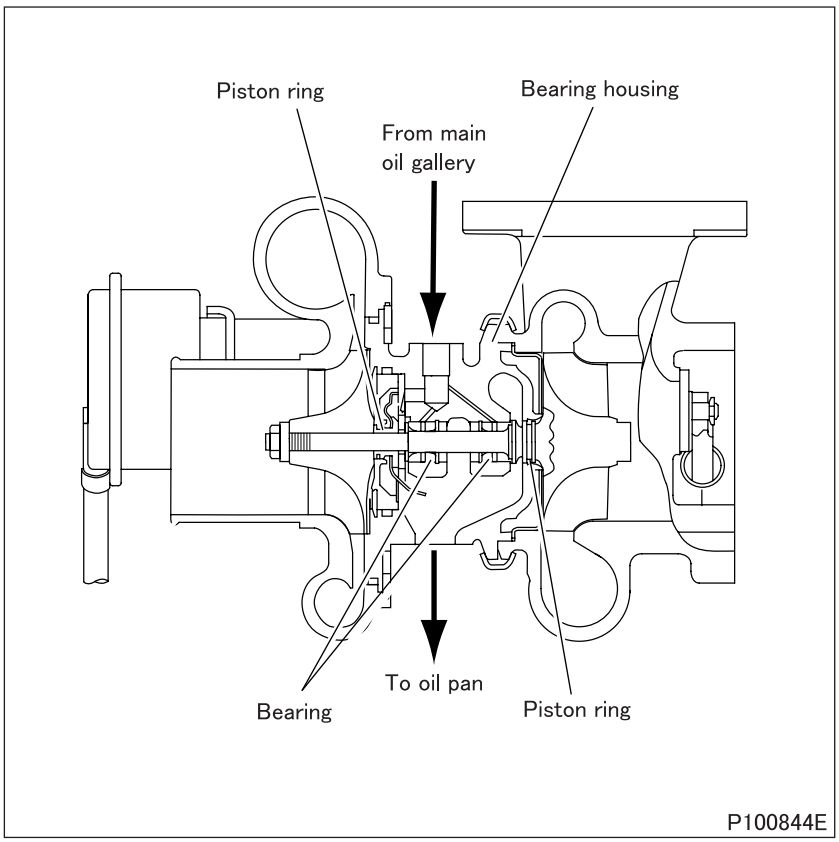


- Engine oil in the main oil gallery is directed through the oil passages in the cylinder head, rocker case and front rocker bracket. The oil is then supplied through the camshaft and rocker shaft. The oil flowing through the camshaft also lubricates the camshaft journals. The oil flowing through the rocker shaft also lubricates the rockers. The oil flowing to the adjusting screws on the rockers also lubricates the valve bridges. After lubricating the various parts, the oil returns to the oil pan.



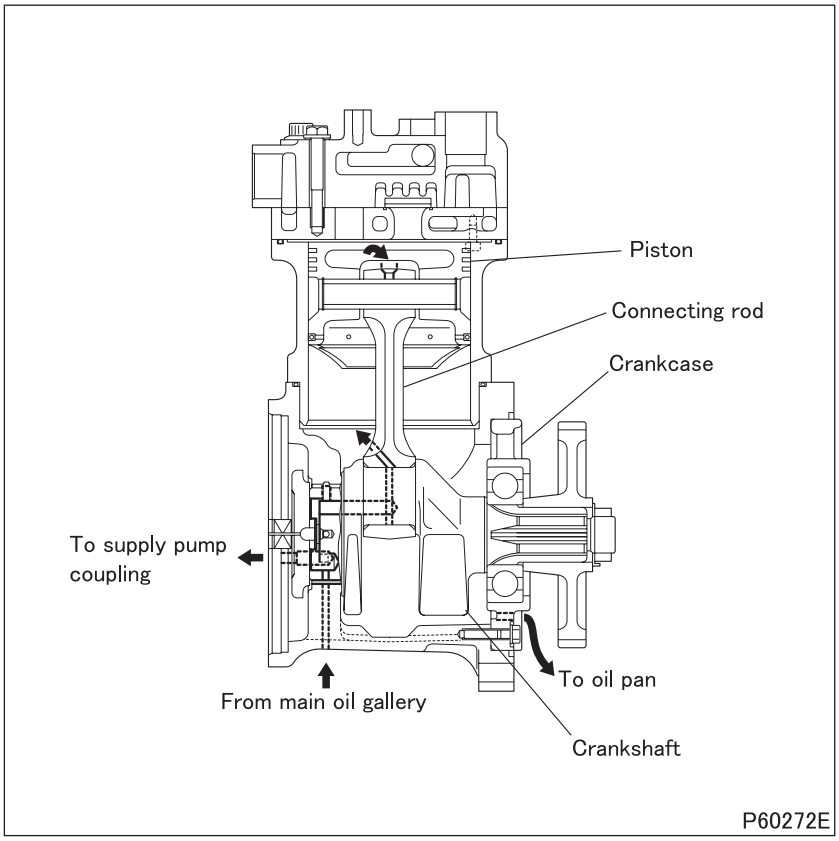
5.4 Check valves and oil jets

- An oil jet is fitted in the lower part of the main oil gallery for each cylinder.
- Engine oil is sprayed out of the oil jet into the piston to cool the piston.
- Each oil jet is fitted with a check valve that opens and closes at predetermined oil pressure levels. At low engine speeds, the check valve closes to maintain the required volume of oil in the lubrication system and prevent reductions in oil pressure.



5.5 Turbocharger

- Engine oil in the main oil gallery is directed through a pipe to the bearing housing to lubricate the inner components.
- A piston ring is provided on each end of the turbine wheel shaft. The rings function as oil sealing.



5.6 Air compressor

- Engine oil in the main oil gallery is directed through a passage in the crankshaft to the supply pump coupling and also to the big ends of the connecting rods to lubricate these parts.
  At the same time, the pistons and the small ends of the connecting rods are splash-lubricated with engine oil by the rotating crankshaft.

Possible causes \ Symptoms		Engine is difficult to start	Overheating	Low oil pressure	Excessive oil consumption (oil leakage)	Reference Gr
Oil cooler	Incorrectly mounted element		O	O	O	
	Defective gasket		O	O	O	
	Defective O-ring		O	O	O	
	Clogged element		O	O		
	Damaged element		O	O	O	
	Weakened bypass valve spring		O			
Oil pump	Malfunctioning oil pump		O	O		
	Interference between oil pump gear and oil pump case and/or cover	O		O		
	Incorrectly connected oil pipe		O	O		
	Clogged oil strainer		O	O		
	Weakened relief valve spring			O		
Oil filter	Incorrect installation				O	
	Clogged element		O	O		
	Defective O-ring			O		
Front cover timing gear case	Defective front oil seal				O	Gr11
	Incorrectly mounted front cover				O	
Flywheel housing	Defective rear oil seal				O	
	Incorrectly mounted gasket				O	
Weakened regulator valve spring				O		
Defective piston cooling oil jet(s)			O			
Oil working its way up into combustion chamber(s) through piston rings					O	Gr11
Oil working its way down into combustion chamber(s) through valves					O	
Too high oil viscosity		O				
Poor oil quality			O			
Deterioration of oil			O			
Excess of oil					O	
Fuel mixed with oil			O			

1. Oil Filter Replacement

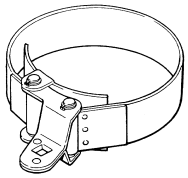
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain plug (oil filter)	7.8 ± 2.0 {0.8 ± 0.2}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Oil filter	Engine oil API classification CD, CD/SF, CE, CE/SF, CF-4	Approx. 2.3 dm^3 {2.3L}

Special tools

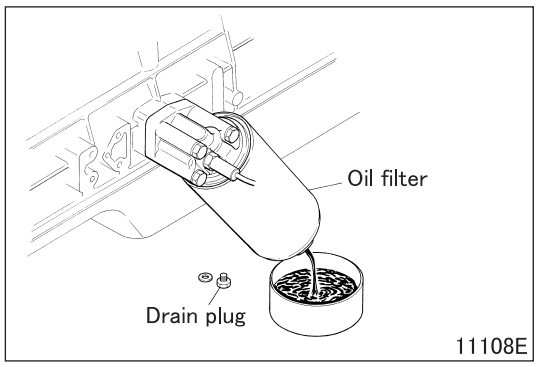
Mark	Tool name and shape	Part No.	Application
ⓒa	Oil filter wrench  01503	MH061537	Removal of oil filter

WARNING ⚠

- **Wipe up any spilled engine oil, as it can cause fires.**

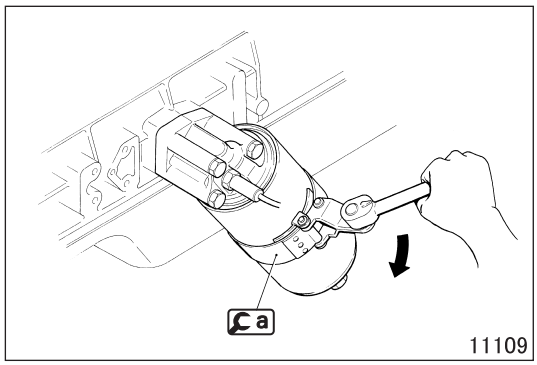
CAUTION ⚠

- **Make sure not to put any engine oil on the V-belt when working on the oil filter. V-belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**

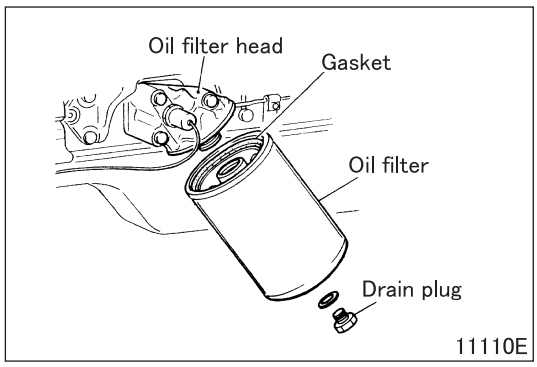


[Removal]

- Remove the drain plug and drain the oil out of the oil filter.



- Remove the oil filter using ⓒa.



[Installation]

- Clean the surface of the oil filter head where the oil filter is to be mounted.
- Apply a thin coat of engine oil onto the oil filter gasket.
- Screw in the oil filter by hand until the gasket contacts the oil filter head. Tighten further by 1 1/8 to 1 3/8 of a turn.
- Install the drain plug.
- With the oil filter installed, start the engine and ensure that there is no oil leakage through the gasket.
- If oil is leaking, remove and reinstall the oil filter.
- Stop the engine and check the engine oil level.
- Add engine oil if the engine oil level is low.

2. Engine Oil Replacement

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain plug (oil filter)	7.8 ± 2.0 {0.8 ± 0.2}	–
–	Drain plug (oil pan)	69 {7}	–

Lubricant and/or sealant

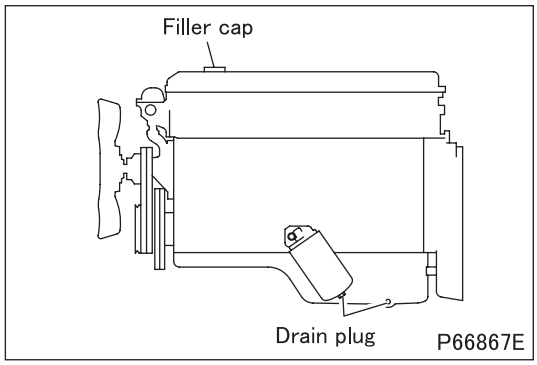
Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Oil filter	Engine oil API classification CD, CD/SF, CE, CE/SF, CF-4	Approx. 2.3 dm^3 {2.3L}
–	Oil pan		Approx. 11 dm^3 {11L}, 12 dm^3 {12L}, 16 dm^3 {16L}, 28 dm^3 {28L}

WARNING ⚠

- **Wipe up any spilled engine oil, as it can cause fires.**

CAUTION ⚠

- **Make sure not to put any engine oil on the V-belt when working on the oil filter. V-belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**



[Draining]

- Remove the filler cap.
- Remove the drain plugs of the oil filter or oil pan to drain out the engine oil.

[Refilling]

- Tighten the drain plug to the specified torque, then pour a specified amount of new engine oil into the engine.
- Stop the engine and check the engine oil level.
- Add engine oil if the engine oil level is low.

CAUTION ⚠

- **Do not add engine oil too much. An excessive oil level can only lead to increased oil consumption or make the positive crankcase ventilation system less efficient.**

3. Oil Pressure Measurement

Service standards

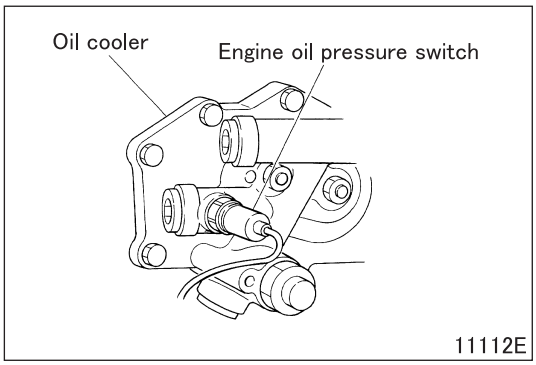
Location	Maintenance item		Standard value	Limit	Remedy
–	Oil pressure (oil temperature at 70 to 90°C)	No-load minimum speed	145 to 295 kPa {1.5 to 3 kgf/cm^2}	49 kPa {0.5 kgf/cm^2}	Inspect
		No-load maximum speed	295 to 490 kPa {3 to 5 kgf/cm^2}	195 kPa {2 kgf/cm^2}	

Tightening torque (Unit: N·m {kgf·m})

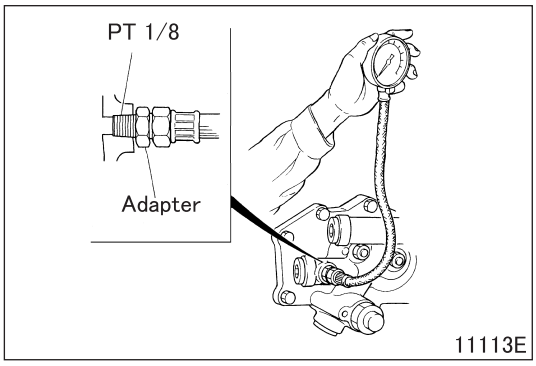
Mark	Parts to be tightened	Tightening torque	Remarks
–	Engine oil pressure switch	15 to 22 {1.5 to 2.2}	Sealant With cold engine

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Engine oil pressure switch threads	Teflon tape	3 1/2 turns



- Remove the engine oil pressure switch.

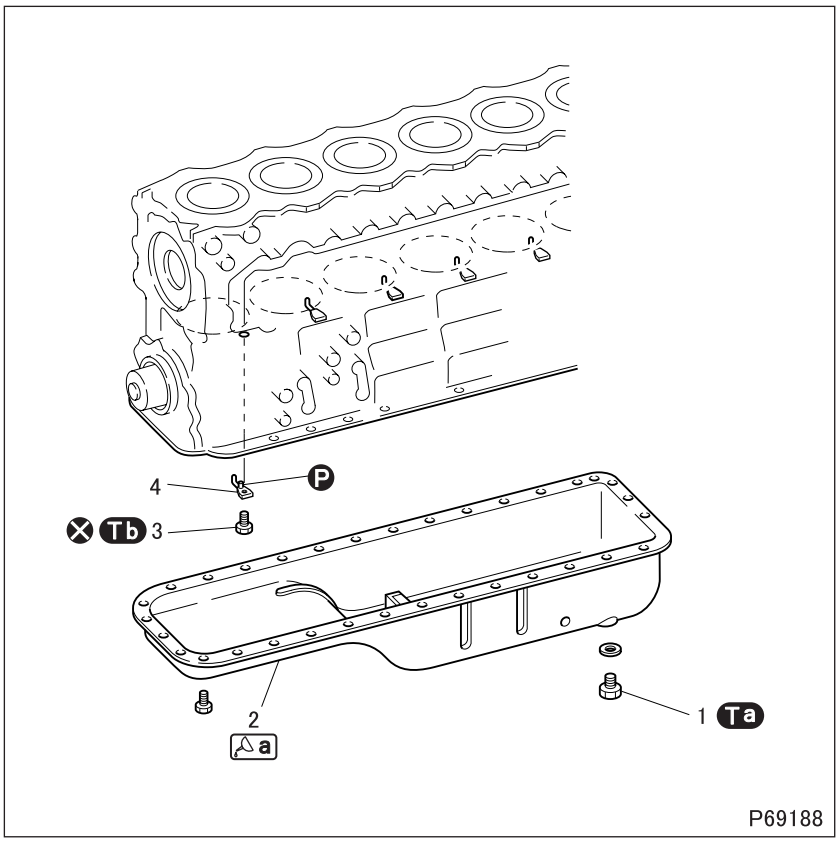


- Using an adapter, connect an oil pressure gauge to the engine oil pressure switch mounting hole.
- Warm up the engine until the oil temperature reaches 70 to 90°C.
- Measure the oil pressure while running the engine at a minimum speed and then at maximum speed, both under no load.
- If the measurements are below the specified limits, overhaul the lubrication system.
- After taking the measurements, wrap the threads of the engine oil pressure switch with teflon tape and then tighten the switch to the specified torque.

CAUTION ⚠

- **Reinstall the oil pressure switch only when the engine is cold.**

OIL PAN, OIL JETS AND OIL LEVEL SENSOR



● **Disassembly sequence**

1 Drain plug
2 Oil pan
3 Check valve
4 Oil jet

Ⓟ: Locating pin
⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **If overtightened, the check valve will not operate properly, leading to engine seizure. Be sure to tighten the check valve to the specified torque.**

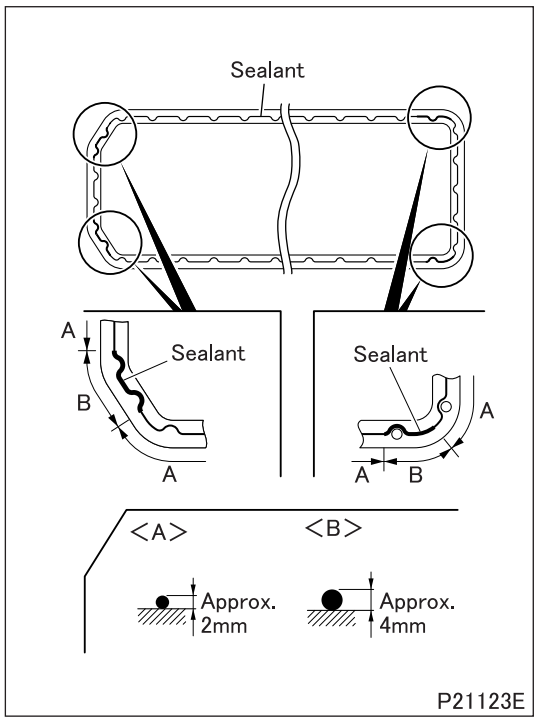
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain plug	69 {7}	–
Tb	Check valve	34 {3.5}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Crankcase mounting surface of oil pan	ThreeBond 1207C	As required

◆Installation procedure◆



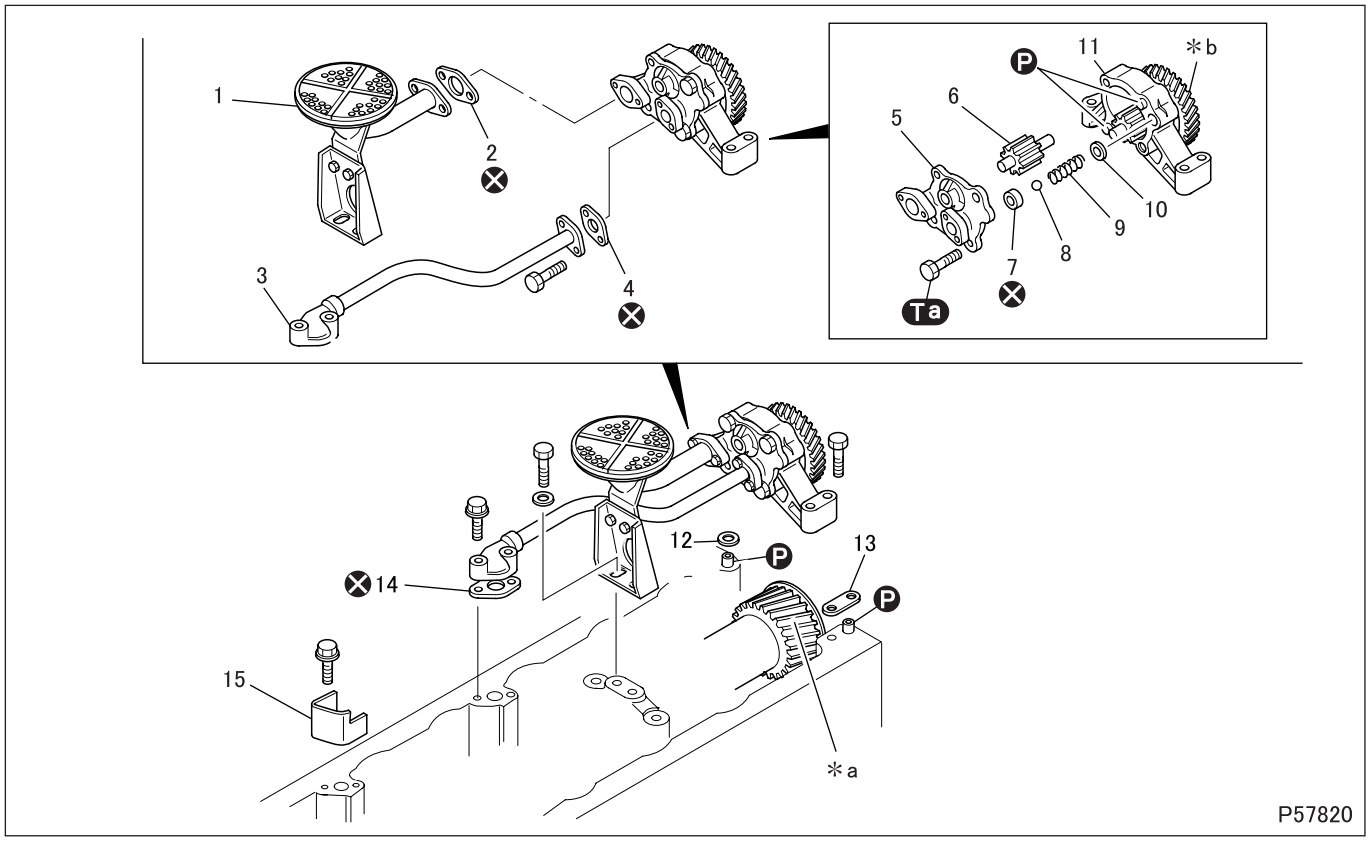
■ Installation: Oil pan

- Clean the mating surfaces of each part.
- Apply a bead of sealant to the mating surface of the oil pan evenly and without any breaks.
- Change the amount of application to A and B at four locations shown in the illustration.
- Mount the oil pan within three minutes of applying the sealant. Make sure that the sealant stays in place.

CAUTION ⚠

- **Do not start the engine for one hour after installation. If the oil pan mounting bolts were loosened or removed, be sure to reapply sealant.**

OIL PUMP, OIL STRAINER



● Disassembly sequence

1 Oil strainer
2 Gasket
3 Oil pipe
4 Gasket
5 Cover
6 Driven gear
7 Ring
8 Relief valve
9 Relief valve spring
10 Washer
11 Gear and case
12 Shim
13 Shim
14 Gasket
15 Oil deflector

***a**: Crankshaft gear
***b**: Oil pump gear

Ⓟ: Locating pin
⊗: Non-reusable parts

- The oil strainer, the oil pipe and the oil pump must all be removed together as an assembly.
- Do not disassemble the oil pump unless defects are evident.
- The gear and case assembly is not serviceable. If the gear and case assembly appears defective, replace it.

● Assembly sequence

Follow the disassembly procedure in reverse.

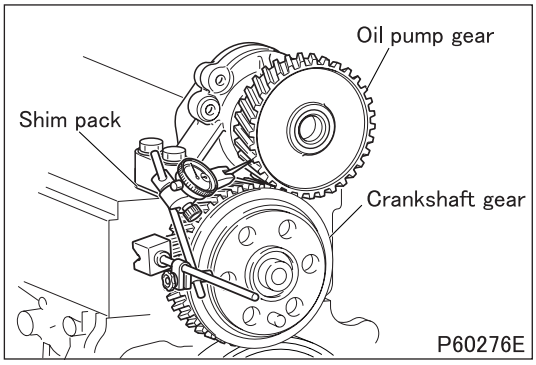
Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
5, 11	Clearance between drive gear shaft and cover	0.04 to 0.07	0.15	Replace
5, 6, 11	Clearance between driven gear shaft and case, and that between the shaft and cover	0.04 to 0.07	0.15	Replace
6, 11	Clearance between case and tooth tips of each gear	0.10 to 0.19	0.2	Replace
	Difference between case depth and height of each gear	0.06 to 0.11	0.15	
8	Relief valve opening pressure	1.1 ± 0.1 MPa {11 ± 1 kgf/cm^2}	–	Replace
9	Relief valve spring installed load (installed length: 30)	84N {8.6 kgf}	–	Replace
***a, *b**	Backlash between crankshaft gear and oil pump gear	0.08 to 0.15	0.35	Adjust

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (oil pump cover mounting)	25 ± 4.9 {2.5 ± 0.5}	–

◆Inspection before removal◆



■ Inspection: Backlash between oil pump gear and crankshaft gear

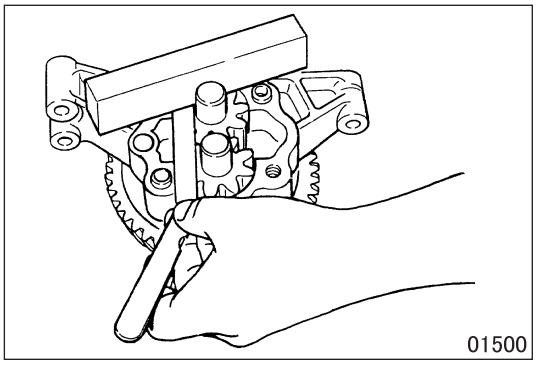
- If the measurement exceeds the limit, adjust by shimming.

Shim feeler	Change in backlash
0.1 mm	0.073 mm
0.2 mm	0.146 mm

CAUTION ⚠

- **Perform shimming such that the shim packs on both sides will have the same feeler.**

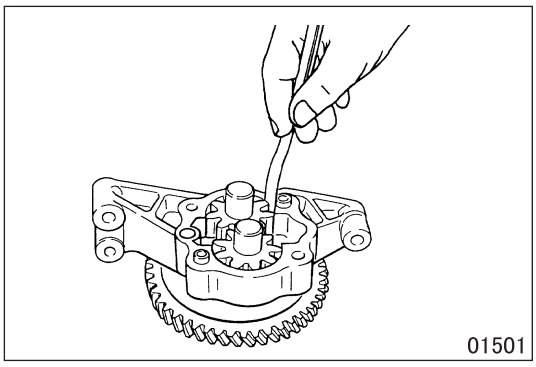
◆Inspection procedure◆



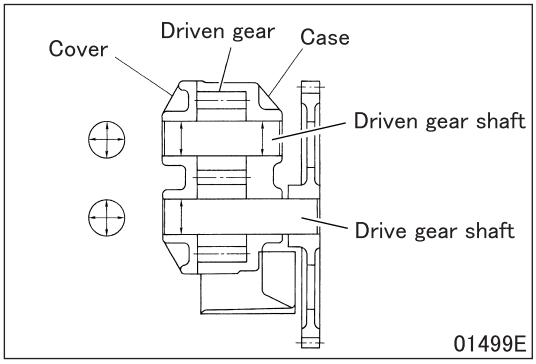
■ Inspection: Driven gear, Gear and case assembly

- Perform the following inspections. Replace the defective part(s) as required.

(1) Difference between case depth and height of each gear



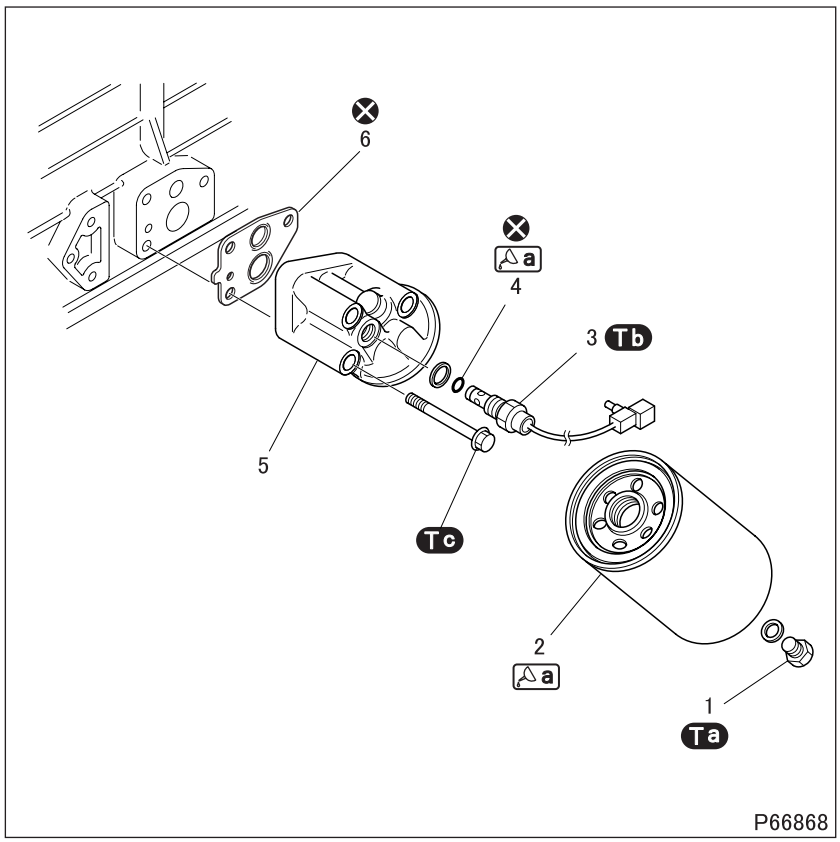
(2) Clearance between case and tooth tips of each gear



(3) Clearance between drive gear shaft and cover

(4) Clearance between driven gear shaft and case, and that between the shaft and cover

OIL FILTER



● **Removal sequence**

1 Drain plug
2 Oil filter
3 Engine oil bypass alarm switch
4 O-ring
5 Oil filter head
6 Gasket

⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse.

WARNING ⚠

- **Wipe up any spilled engine oil, as it can cause fires.**
- **To avoid any risk of burns, take care not to touch the engine oil when the engine is hot.**

CAUTION ⚠

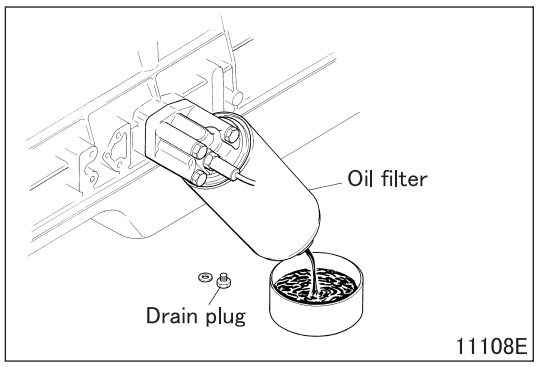
- **When adding engine oil, be careful not to allow engine oil to smear the V-belt. A V-belt smeared with oil will slip, resulting in reduced cooling efficiency.**

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain plug	7.8 ± 2 {0.8 ± 0.2}	–
Tb	Engine oil bypass alarm switch	49 ± 4.9 {5.0 ± 0.5}	–
Tc	Bolt (Oil filter head mounting)	37 to 53 {3.6 to 5.4}	–

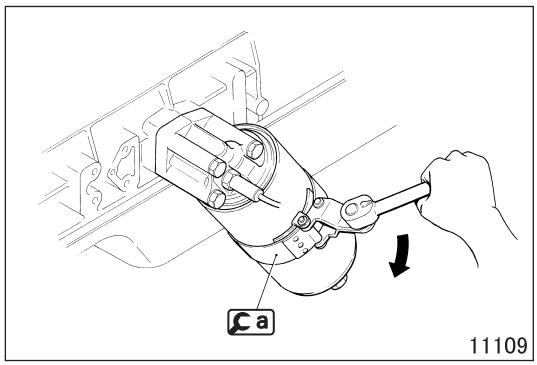
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Oil filter gasket	Engine oil	As required
	O-ring		

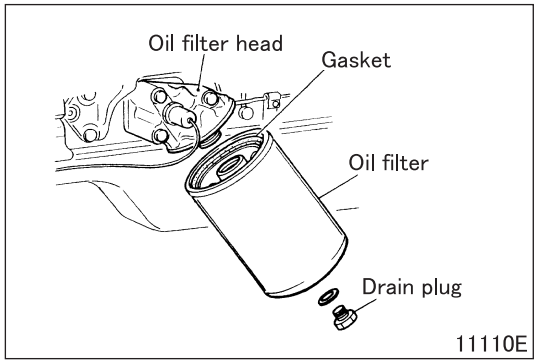


[Removal]

- Remove the drain plug and drain the oil out of the oil filter.



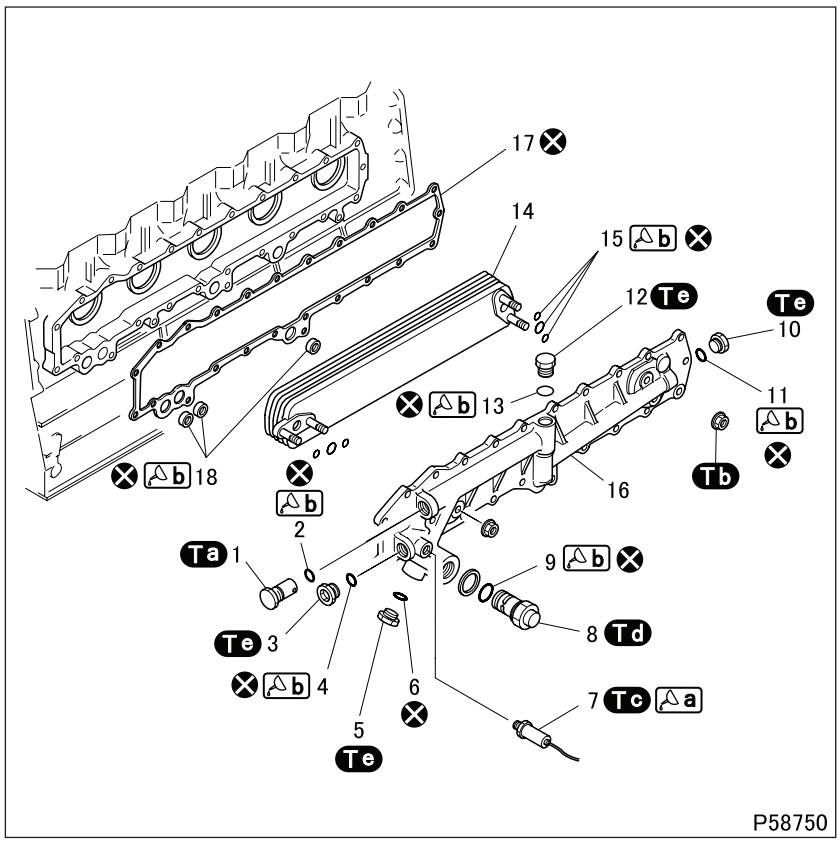
- Remove the oil filter using a.



[Installation]

- Clean the surface of the oil filter head where the oil filter is to be mounted.
- Apply a thin coat of engine oil onto the oil filter gasket.
- Screw in the oil filter by hand until the gasket contacts the oil filter head. Tighten further by 1 1/8 to 1 3/8 of a turn.
- Install the drain plug.
- With the oil filter installed, start the engine and ensure that there is no oil leakage through the gasket.
- If oil is leaking, remove and reinstall the oil filter.
- Stop the engine and check the engine oil level.
- Add engine oil if the engine oil level is low.

OIL COOLER



● **Removal sequence**

1 Bypass valve
2 O-ring
3 Plug
4 O-ring
5 Plug
6 O-ring
7 Engine oil pressure switch
8 Regulator valve
(See later pages.)
9 O-ring
10 Plug
11 O-ring
12 Plug
13 O-ring
14 Oil cooler element
15 Gasket
16 Oil cooler cover
17 Gasket
18 O-ring

⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
14	Air leakage from oil cooler element (air pressure: 1470 kPa {15 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace

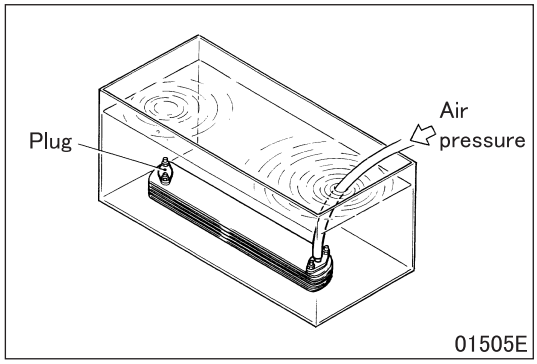
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bypass valve	15 to 20 {1.5 to 2.0}	–
Tb	Nut (oil cooler element mounting)	24.5 to 32.3 {2.5 to 3.3}	–
Tc	Engine oil pressure switch	15 to 22 {1.5 to 2.2}	–
Td	Regulator valve	98 to 118 {10 to 12}	–
Te	Plug	14.7 to 19.6 {1.5 to 2.0}	–

Lubricant and/or sealant

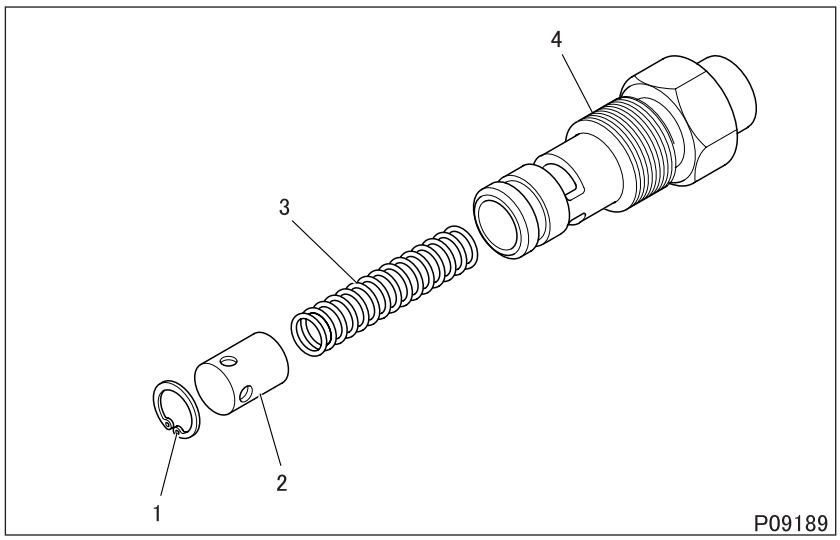
Mark	Points of application	Lubricant and/or sealant	Quantity
a	Engine oil pressure switch threads	Teflon tape	3 1/2 turns
b	O-ring	Engine oil	As required

◆Inspection procedure◆



■ **Inspection: Oil cooler element**

- Plug the outlet of the oil cooler element and connect a hose to the engine oil inlet port. Then, immerse the oil cooler element in a tank of water.
- Apply a specified air pressure for 15 seconds through the hose, and check for any air leaks.
- Replace the element if it leaks air.



● **Disassembly sequence**

1 Snap ring
2 Valve
3 Spring
4 Body

● **Assembly sequence**

Follow the removal sequence in reverse.

Service standards (Unit: mm)

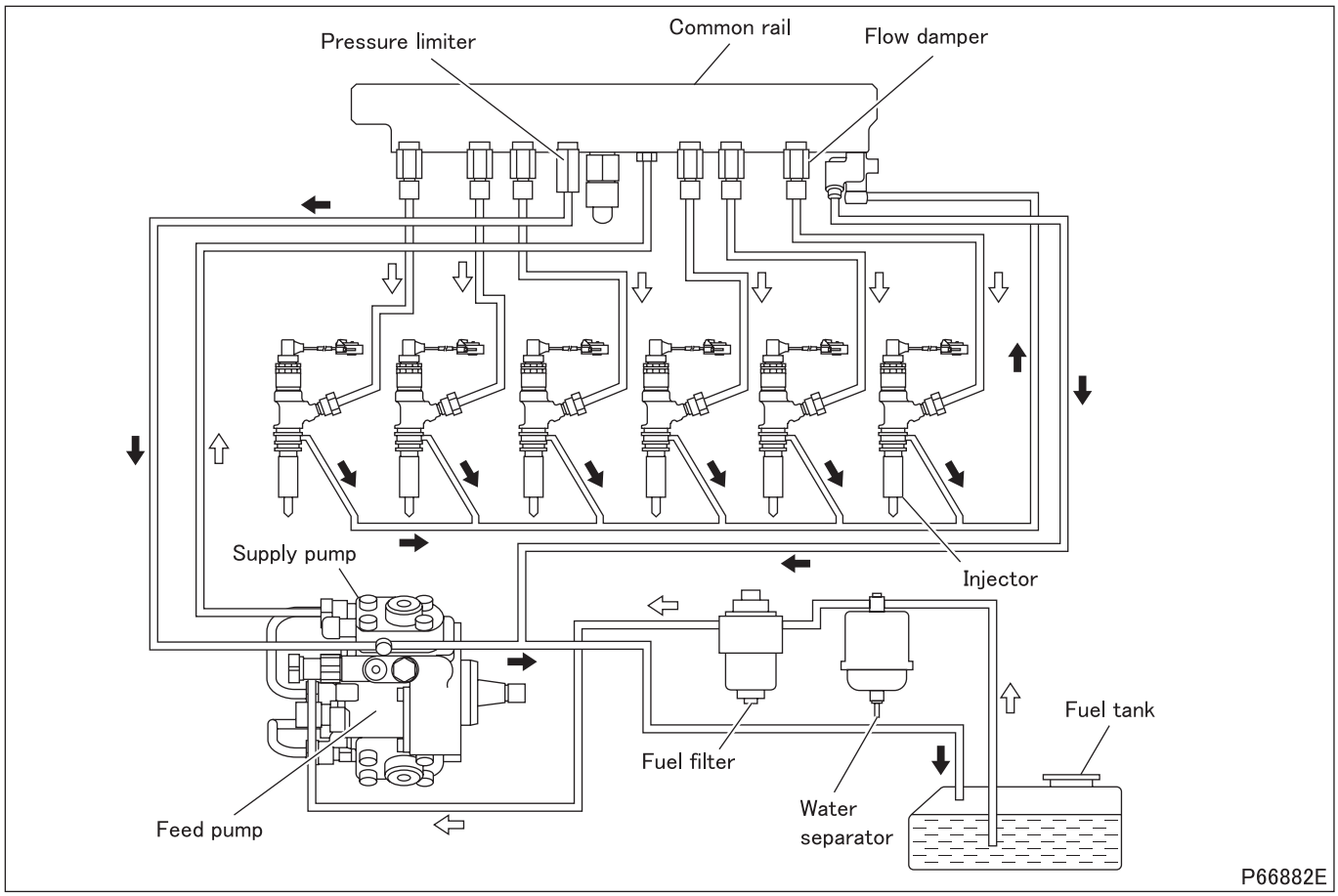
Location	Maintenance item	Standard value	Limit	Remedy
–	Regulator valve opening pressure	392 ± 29 kPa {4.0 ± 0.3 kgf/cm^2}	–	Replace
3	Spring installed load (installed length 48.3)	78.5 ± 1.96 N {8.0 ± 0.2 kgf}	–	Replace

GROUP 13A
FUEL AND ENGINE CONTROL

SPECIFICATIONS

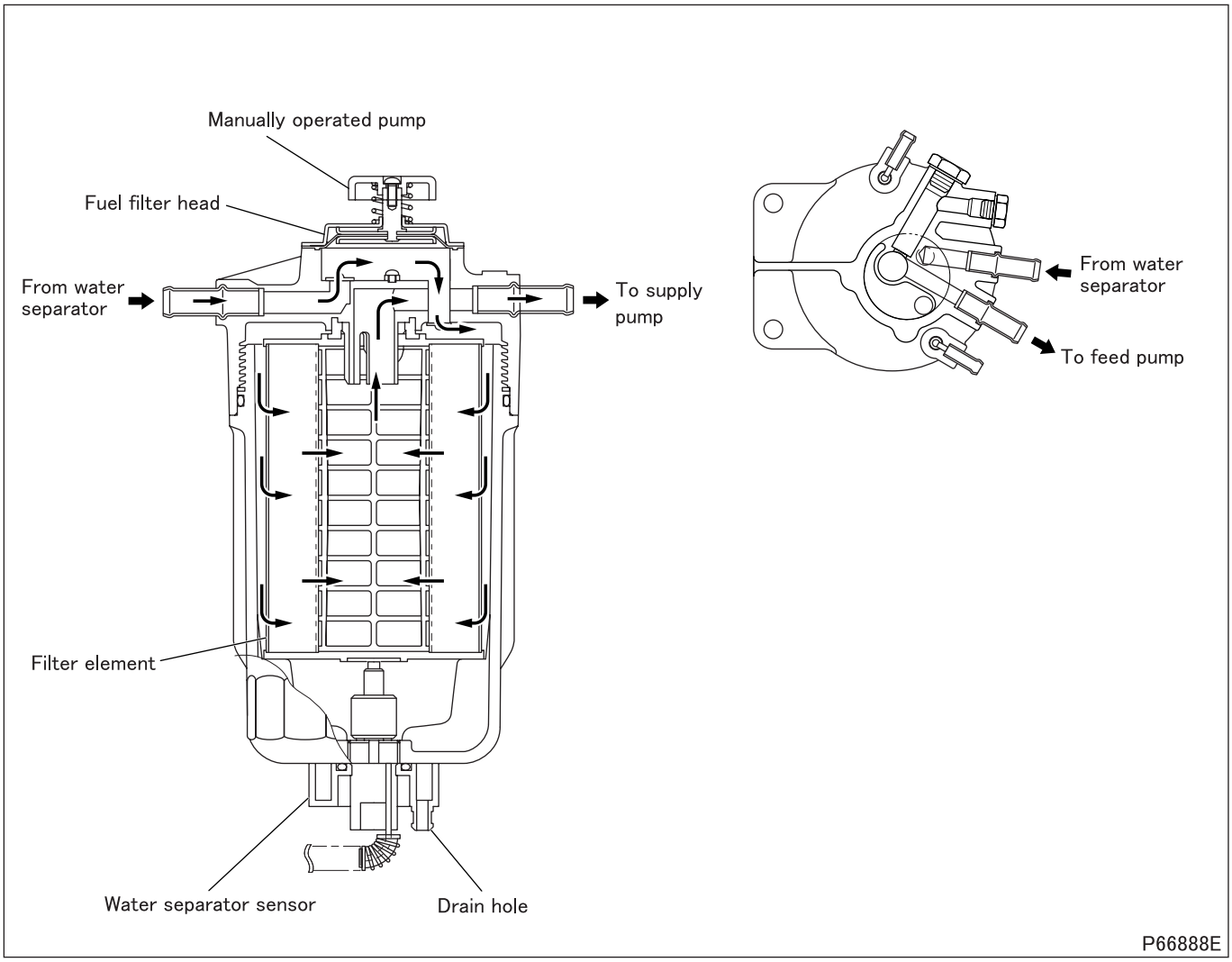
Item		Specifications
Supply pump	Manufacturer	DENSO
	Control system	Electronically-controlled pump
	Type	HP-4
	Feed pump type	Trochoid pump
Common rail system	Manufacturer	DENSO
	Common rail capacity cm^3 {mL}	26 {26}
	Pressure limiter valve opening pressure MPa {kgf/cm^2}	221 ± 9 {2253 ± 91.8}
	Common rail pressure sensor supply voltage V	5
Injector	Manufacturer	DENSO
	Control system	Electronically controlled
	Maximum injection pressure MPa {kgf/cm^2}	155 {1580}

1. Fuel System (Flow of Fuel)



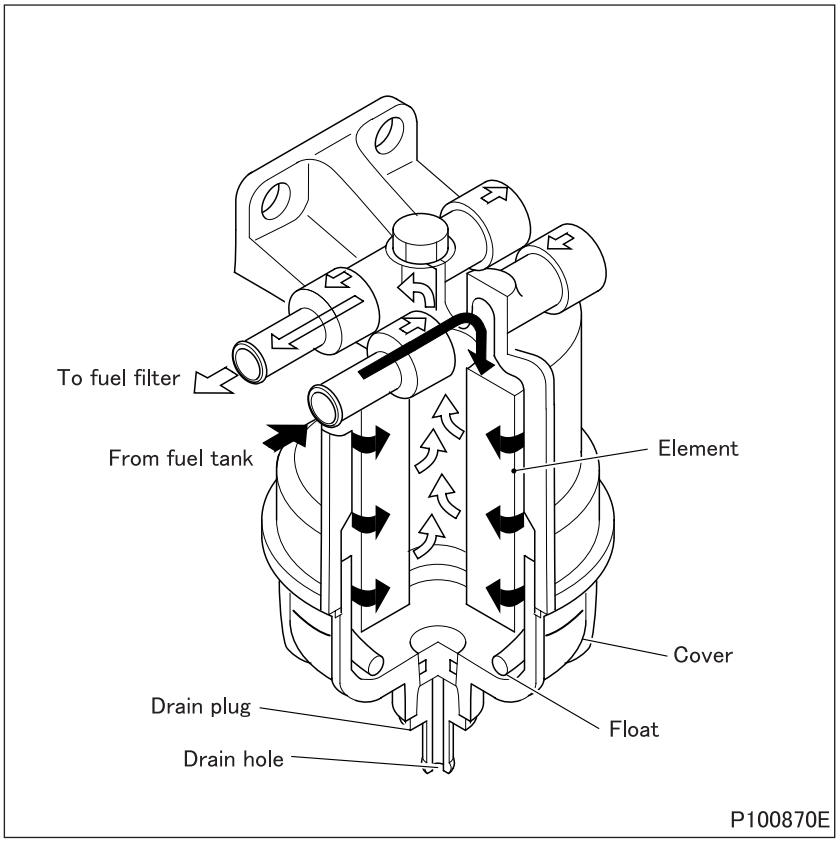
- Fuel in the fuel tank is sucked up by the feed pump, which is driven by the pump camshaft within the supply pump, and is fed through the fuel filter where foreign matter is filtered out.
- The filtered fuel is sent to the supply pump where it is pressurized, and then is accumulated in the common rail. The accumulated fuel is then delivered through the injectors into the combustion chambers.
- If fuel leakage occurs through any of the fuel line connections between the common rail and injectors, the relevant flow damper(s) will close, shutting off fuel supply and thus preventing any further fuel leakage out of the system.
- If the pressure of fuel in the common rail rises above the specified level, the pressure limiter valve opens to allow fuel to return to the fuel tank.
- If the pressure of fuel in the supply pump rises above the specified limit, fuel is allowed to returned to the fuel tank.

2. Fuel Filter



- The fuel filter removes foreign matter from fuel via the filter element. The fuel filter also incorporates a water separator which separates any water from fuel.
- Water separated from fuel accumulates at the bottom of the fuel filter assembly. When water has accumulated to a certain level, this is detected by the water separator sensor, provided on the fuel filter assembly, which then illuminates a warning lamp on the meter cluster.
- The water which has collected in the water separator can be drained through the drain hole by loosening the water separator sensor.
- To bleed air from the fuel system, a manually operated pump is provided on the fuel filter head.

3. Water separator



- The water separator separates water in fuel.
- The float provides visual indication of the level of the water separated from fuel. This enables the water to be drained at an appropriate timing through the drain hole by loosening the drain plug.

Possible causes \ Symptoms		Engine does not start	Engine hard to start	Engine knocks	Engine output unstable	Excessive black smoke	Engine output not sufficient	Engine maximum speed too high	Engine idling unstable	Engine stalls immediately after start	Engine does not reach maximum speed	Fuel supply insufficient	Warning lamp illuminates	Reference Gr
Common rail system abnormal													O	Gr13E
Supply pump	Defective feed pump	O	O				O			O	O	O		*
	Incorrect pump output	O	O				O			O	O			*
	Defective pressurized-fuel delivery system	O	O				O			O	O			*
	Defective SCV; Defective base supply pump	O	O				O			O	O			*
	SCV open-circuited, short, or intermittent connection	O	O				O			O	O		O	Gr13E or *
	Defective sealing		O				O				O			*
Common rail	Pressure limiter valve opening pressure too low		O	O		O	O				O			
	Operation of flow damper		O				O							
	Common rail pressure sensor circuit open, short, or intermittent connection	O	O		O		O			O	O		O	Gr13E
	Defective sealing		O			O	O				O			
Incorrect injector fuel injection	Injector magnetic valve open-circuited, short, or intermittent connection		O	O		O	O	O	O				O	Gr13E or *
	Defective injector, injector magnetic valve, or injection nozzle		O	O		O	O	O	O		O			*
	Orifice clogged				O	O		O	O					
Fuel filter clogged		O	O				O		O	O	O	O		
Clogged water separator		O	O		O				O	O				
No fuel in fuel tank		O	O				O			O	O	O		
High-pressure piping	Defective sealing or sealing surface		O				O			O	O			
	Piping cracked		O	O	O		O			O	O			
	Piping crushed and restricted		O				O			O	O			
	Foreign matter stuck in piping		O				O			O	O			
Low-pressure piping	Defective sealing or sealing surface	O	O				O			O	O	O		
	Piping cracked or clogged	O	O				O			O	O	O		
Air or water in fuel system			O		O		O		O	O	O	O		
Poor quality fuel is used			O	O		O	O	O		O	O			
Engine control	Incorrectly adjusted accelerator pedal stopper bolt						O				O			
	Defective accelerator position sensor												O	Gr13E

SCV: Suction Control Valve

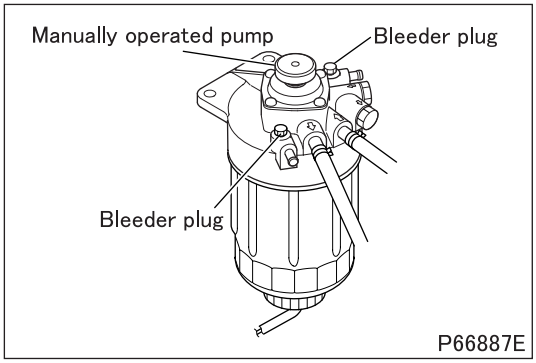
*: Contact DENSO Service Station for repair.

Possible causes \ Symptoms		Engine does not start	Engine hard to start	Excessive black smoke	Engine output not sufficient	Engine maximum speed too high	Engine idling unstable	Engine stalls immediately after start	Engine does not reach maximum speed	Fuel supply insufficient	Warning lamp illuminates	Reference Gr
Oil viscosity unsuitable			O		O							Gr12
Valve clearance incorrect			O		O							Gr11
Defective cylinder head gasket			O		O							
Valve and valve seat worn and carbon deposits			O		O							
Valve spring fatigued			O		O							
Piston ring worn and damaged			O		O							
Piston ring groove worn and damaged			O									
Piston and cylinder liner worn			O		O							
Crankshaft incorrectly sized			O	O	O			O				
Cooling system malfunction			O		O							Gr14
Defective starter switch		O	O		O			O				
Defective glow relay		O	O									
Engine speed sensor; Cylinder recognition sensor	Defective sensor; Sensor open-circuited, short, or intermittent connection		O	O	O			O	O		O	Gr13E
	Each sensor improperly mounted		O	O	O			O	O			Gr11
Defective boost pressure sensor; Boost pressure sensor open-circuited, short or intermittent connection				O	O						O	Gr13E
Defective coolant temperature sensor; Coolant temperature sensor open-circuited, short, or intermittent connection		O	O								O	
Defective fuel injection volume adjusting resistor; Resistor open-circuited, short, or intermittent connection				O	O						O	
Defective idling speed adjustment knob; Idling speed adjustment knob open-circuited, short or intermittent connection							O				O	
Defective electronic control unit main power relay; Relay open-circuited, short or intermittent connection		O	O					O				
Engine electronic control unit	Defective electronic control unit	O	O	O	O	O		O	O		O	
	Not yet initialized for supply pump unit difference		O		O			O	O			
Dead battery		O	O		O			O				
Alternator malfunction			O		O			O				
Blown fuse		O	O					O				

1. Air-bleeding of Fuel System

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Plug	10 ± 2 {1 ± 0.2}	–



- Loosen one of the bleeder plugs on the fuel filter.
- Feed the system with fuel by manually operating the pump up and down.
- Continue pumping until fuel with no bubbles of air comes out of the bleeder plug.
- With no air bubbles coming out with fuel, tighten the bleeder plug to the specified torque.
- Continue operating the pump until there is strong pumping resistance.

CAUTION ⚠

- **If the fuel is cold, pumping resistance may not become strong. Even if this is the case, be sure to cycle the pump several times.**

- Wipe up all spilled fuel, then start the engine.
- Check that no fuel leakage occurs.

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **Be sure to wipe up all spilled fuel. Unless it is wiped up, it could catch fire.**

M E M O

2. Fuel Filter Replacement

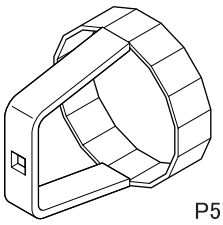
Tightening torque (Unit: N·m {kgf·m})

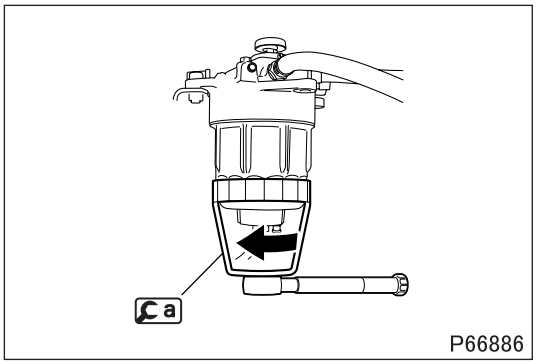
Mark	Parts to be tightened	Tightening torque	Remarks
–	Water separator sensor	5 ± 1 {0.5 ± 0.1}	–
–	Case	30 ± 2 {3.1 ± 0.2}	–

Lubricant and/or sealant

Location	Points of application	Specified lubricant and/or sealant	Quantity
–	O-ring	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Filter wrench  P57179	MH063203	Removal and installation of case



P66886

[Removal]

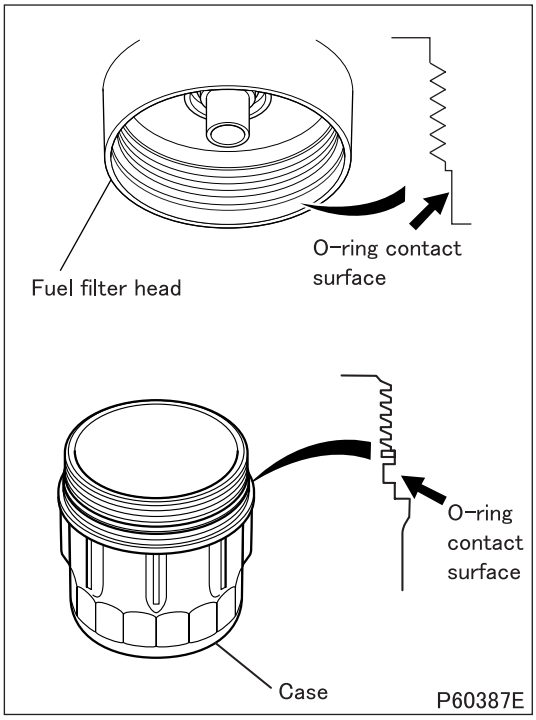
- Drain fuel from the case by loosening the water separator sensor.
- Using a, remove the case.

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **Thoroughly wipe up any spilled fuel. Otherwise, it may catch fire.**

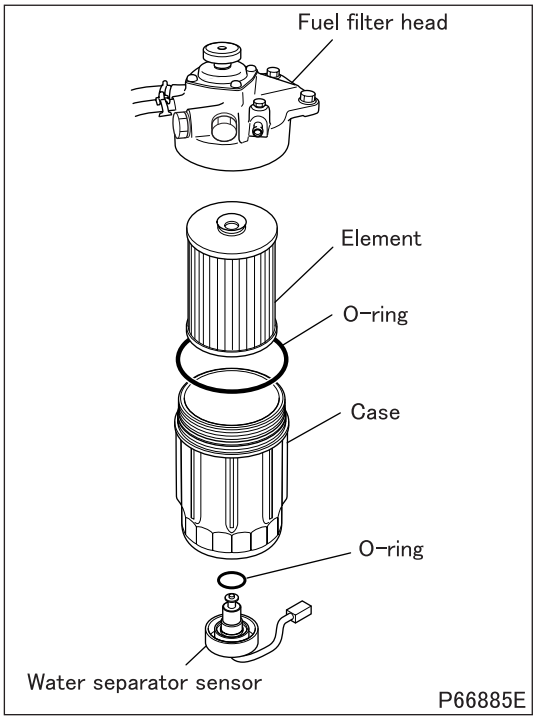
CAUTION ⚠

- **Be careful not to damage the case.**



[Installation]

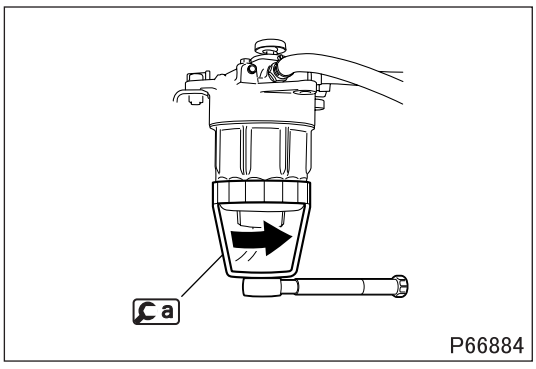
- Clean the surface of the fuel filter head where the O-ring is to be mounted.



- Replace the filter element and O-rings with new parts.
- Apply a thin coat of engine oil to the O-rings. Install the O-rings onto the case and water separator sensor.

CAUTION ⚠

- **The use of non-genuine filter elements will lead to engine problems. Be sure to use only genuine parts.**
- **To help prevent fuel injection problems, keep the fuel filter and hoses free from contamination.**



- Using a, tighten the case to the specified torque.
- Tighten the water separator sensor to the specified torque. With the sensor correctly installed, bleed air from the fuel system.
- Start the engine and ensure that there is no fuel leakage.
- If there is fuel leakage, remove and install the fuel filter correctly.

3. Water Separator Element Replacement

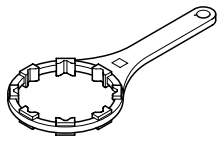
Tightening Torque (Unit: N·m {kgf·m})

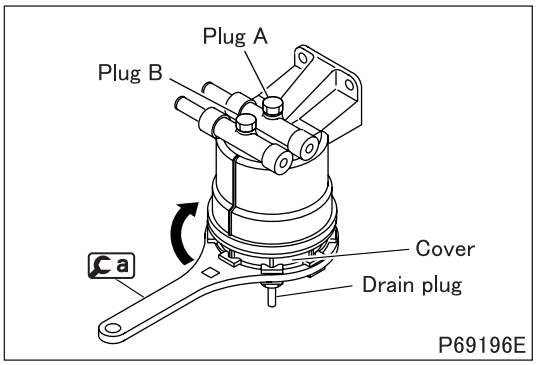
Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain plug	1.47 ± 0.3 {0.15 ± 0.03}	–
–	Cover	19.6 ± 2.5 {2.0 ± 0.3}	–
–	Plug A	12.3 ± 2.5 {1.25 ± 0.3}	–
–	Plug B	17.2 ± 2.5 {1.75 ± 0.3}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	O-ring	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
ⓒa	Filter wrench  P40018	MH063201	Removal and installation of cover



[Removal]

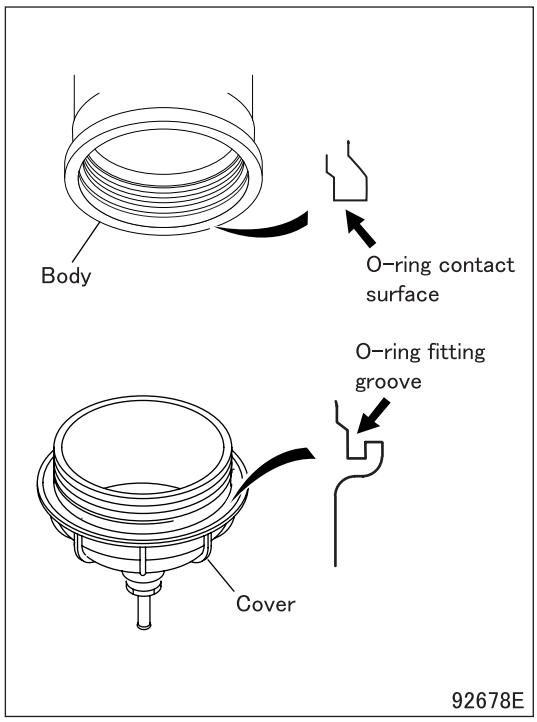
- Loosen the plugs A and B, then loosen the drain plug to let out the fuel in the water separator.
- Remove the cover using the ⓒa.

WARNING ⚠

- **Fuel is highly inflammable. Keep open flame and heat source away from it.**
- **Spilled fuel can easily catch a fire. Wipe it off completely.**

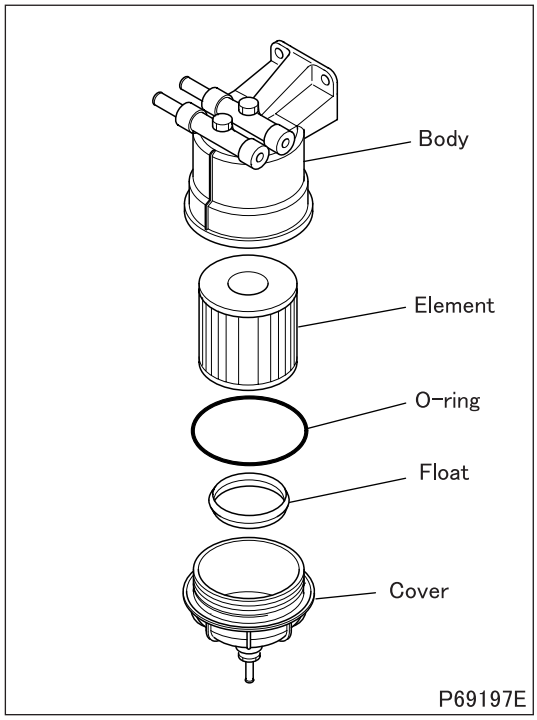
CAUTION ⚠

- **Be careful not to damage the cover.**



[Installation]

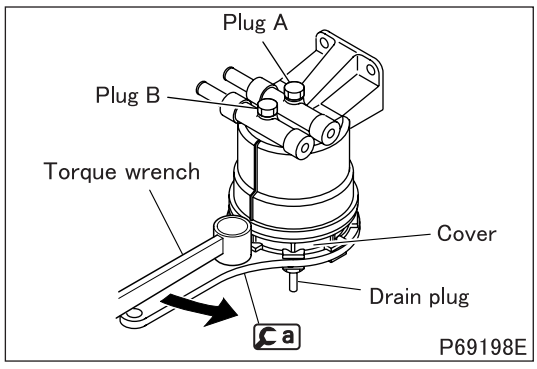
- Clean the O-ring contact surface of the water separator body and the O-ring fitting groove in the cover.



- Replace the element and O-ring with new ones.
- Apply a thin coat of engine oil to the O-ring and fit the O-ring onto the cover.

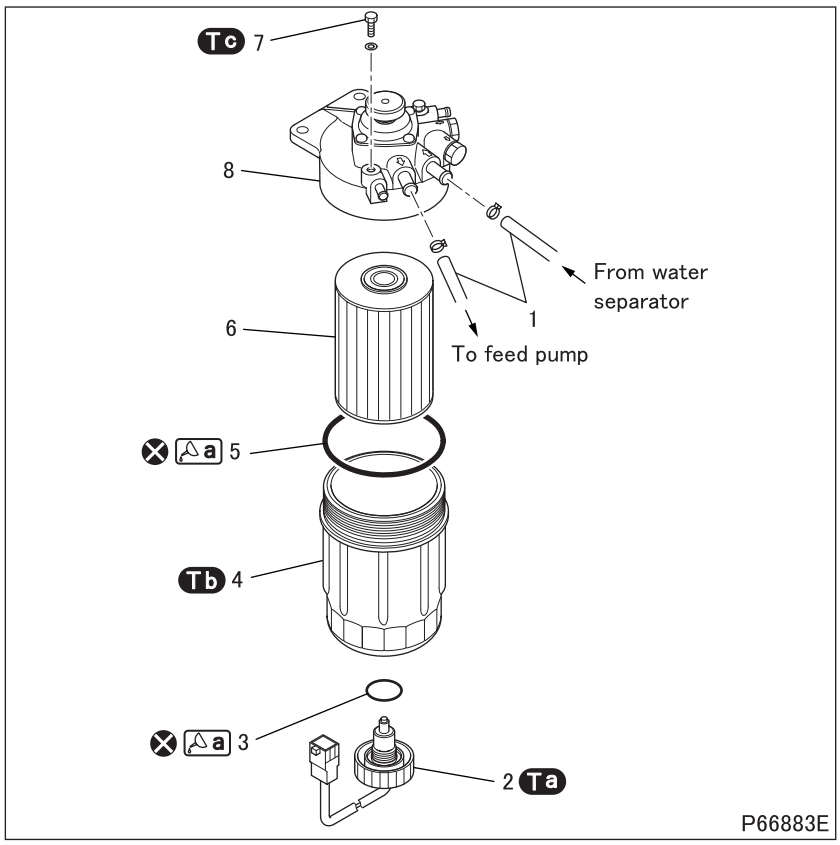
CAUTION ⚠

- **The use of inappropriate element can lead to engine problems. Be sure to use a genuine element.**
- **To prevent fuel injection problems, keep the water separator and fuel hoses clear of fine dirt and other foreign matter.**



- Using the Ca with a torque wrench attached to it, tighten the cover to the specified torque.
- Tighten the drain plug, plug A and plug B to the specified torque. Then, bleed the fuel system of trapped air.
- Start the engine and ensure that there is no fuel leakage.
- If there is any fuel leakage, remove the water separator and reinstall it correctly.

FUEL FILTER



● **Disassembly sequence**

1 Fuel hose
2 Water separator sensor
3 O-ring
4 Case
5 O-ring
6 Element
7 Plug
8 Fuel filter head

⊗: Non-reusable parts

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **Thoroughly wipe up any spilled fuel. Otherwise, it may catch fire.**

● **Assembly sequence**

Follow the disassembly sequence in reverse.

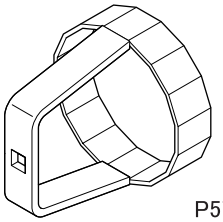
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Water separator sensor	5 ± 1 {0.5 ± 0.1}	–
Tb	Case	30 ± 2 {3.1 ± 0.2}	–
Tc	Plug	10 ± 2 {1 ± 0.2}	–

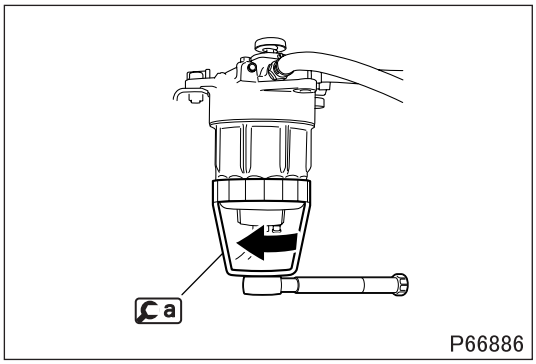
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

Special tools

Mark	Tool name and shape	Part No.	Application
Ca	Filter wrench  P57179	MH063203	Removal and installation of case

◆**Removal procedure**◆



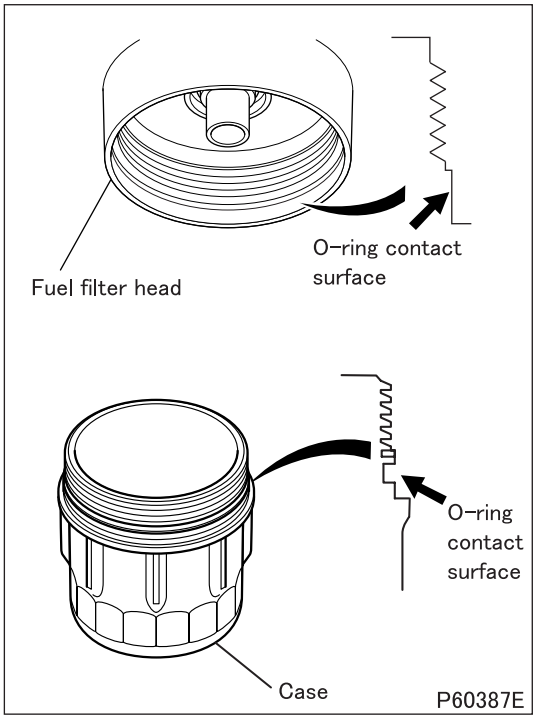
■**Removal: Case**

- Drain fuel from the case by loosening the water separator sensor.
- Using Ca, remove the case.

CAUTION ⚠

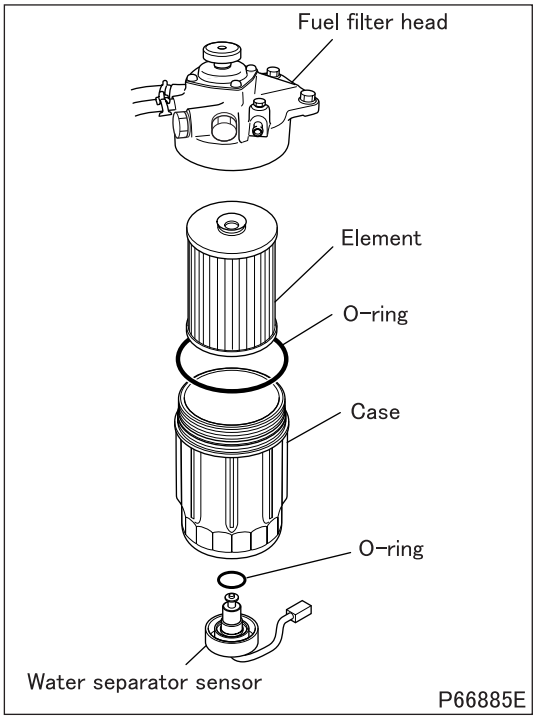
- **Be careful not to damage the case.**

◆Installation procedure◆



■**Installation: Case**

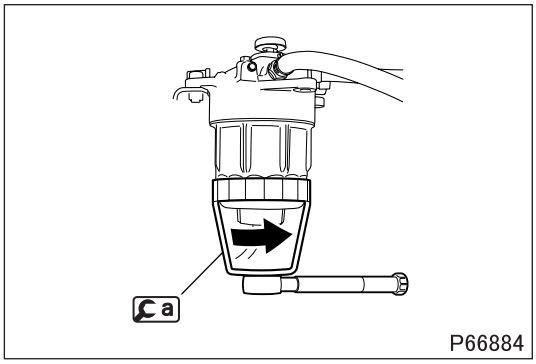
- Clean the surface of the fuel filter head where the O-ring is to be mounted.



- Replace the filter element and O-rings with new parts.
- Apply a thin coat of engine oil to the O-rings. Install the O-rings onto the case and water separator sensor.

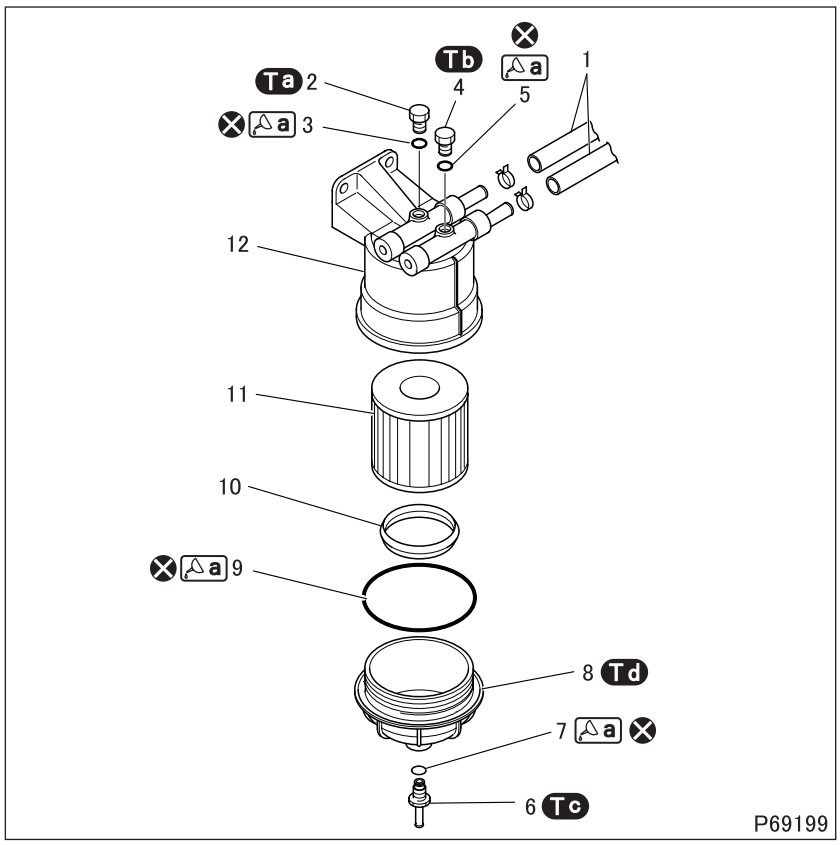
CAUTION ⚠

- **The use of non-genuine filter elements will lead to engine problems. Be sure to use only genuine parts.**
- **To help prevent fuel injection problems, keep the fuel filter and hoses free from contamination.**



- Using a, tighten the case to the specified torque.
- Tighten the water separator sensor to the specified torque. With the sensor correctly installed, bleed air from the fuel system.
- If there is fuel leakage, remove and install the fuel filter correctly.

WATER SEPARATOR



● **Disassembly sequence**

1 Fuel hose
2 Plug A
3 O-ring
4 Plug B
5 O-ring
6 Drain plug
7 O-ring
8 Cover
9 O-ring
10 Float
11 Element
12 Body

⊗: Non-reusable parts

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **Thoroughly wipe up any spilled fuel, otherwise it may catch fire.**

● **Assembly sequence**

Follow the disassembly sequence in reverse.

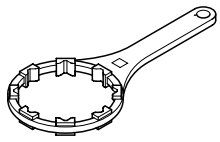
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Plug A	12.3 ± 2.5 {1.3 ± 0.3}	–
Tb	Plug B	17.2 ± 2.5 {1.8 ± 0.3}	–
Tc	Drain plug	1.47 ± 0.3 {0.15 ± 0.03}	–
Td	Cover	19.6 ± 2.5 {2.0 ± 0.3}	–

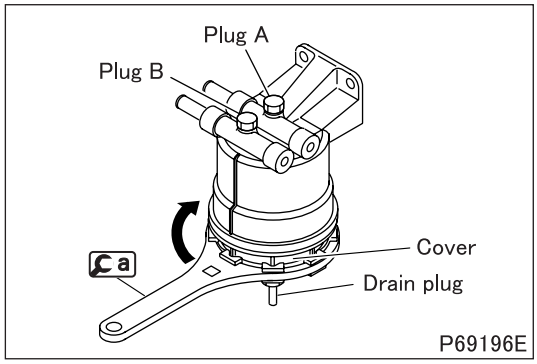
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Filter wrench  P40018	MH063201	Removal and installation of cover

◆Removal procedure◆



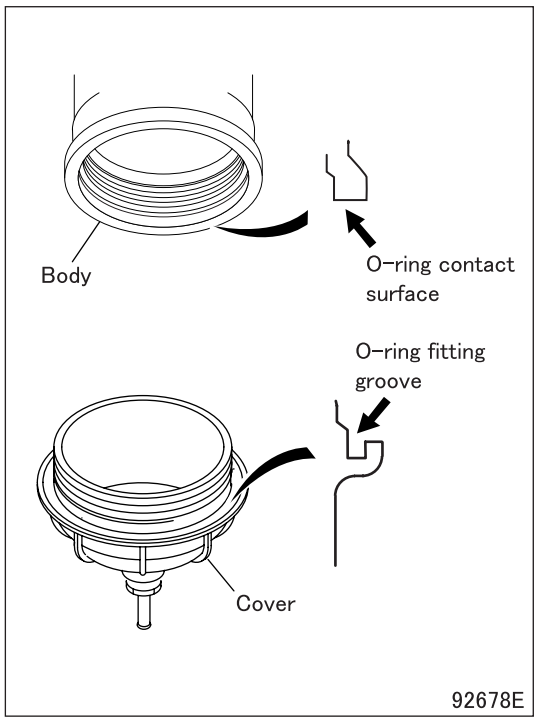
■Removal: Fuel filter

- Drain fuel from the cover by loosening the drain plug after loosening the plug A and B.
- Remove the cover using a.

CAUTION ⚠

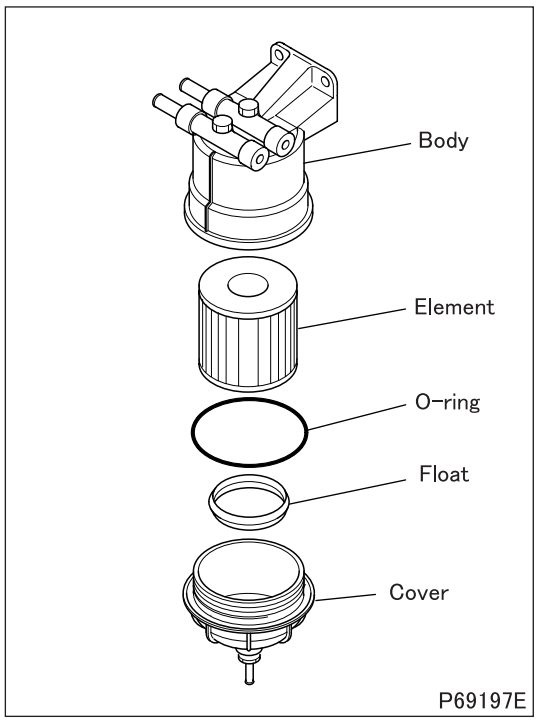
- **Be careful not to damage the case.**

◆Installation procedure◆



■Installation: Cover

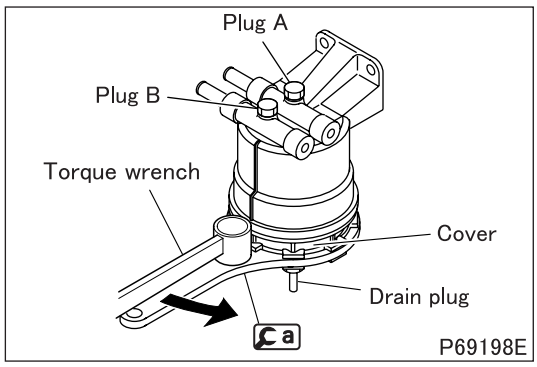
- Clean the O-ring contact surface of the water separator body and the O-ring fitting groove in the body.



- Replace the element and O-ring with new ones.
- Apply a thin coat of engine oil to the O-ring and fit the O-ring onto the cover.

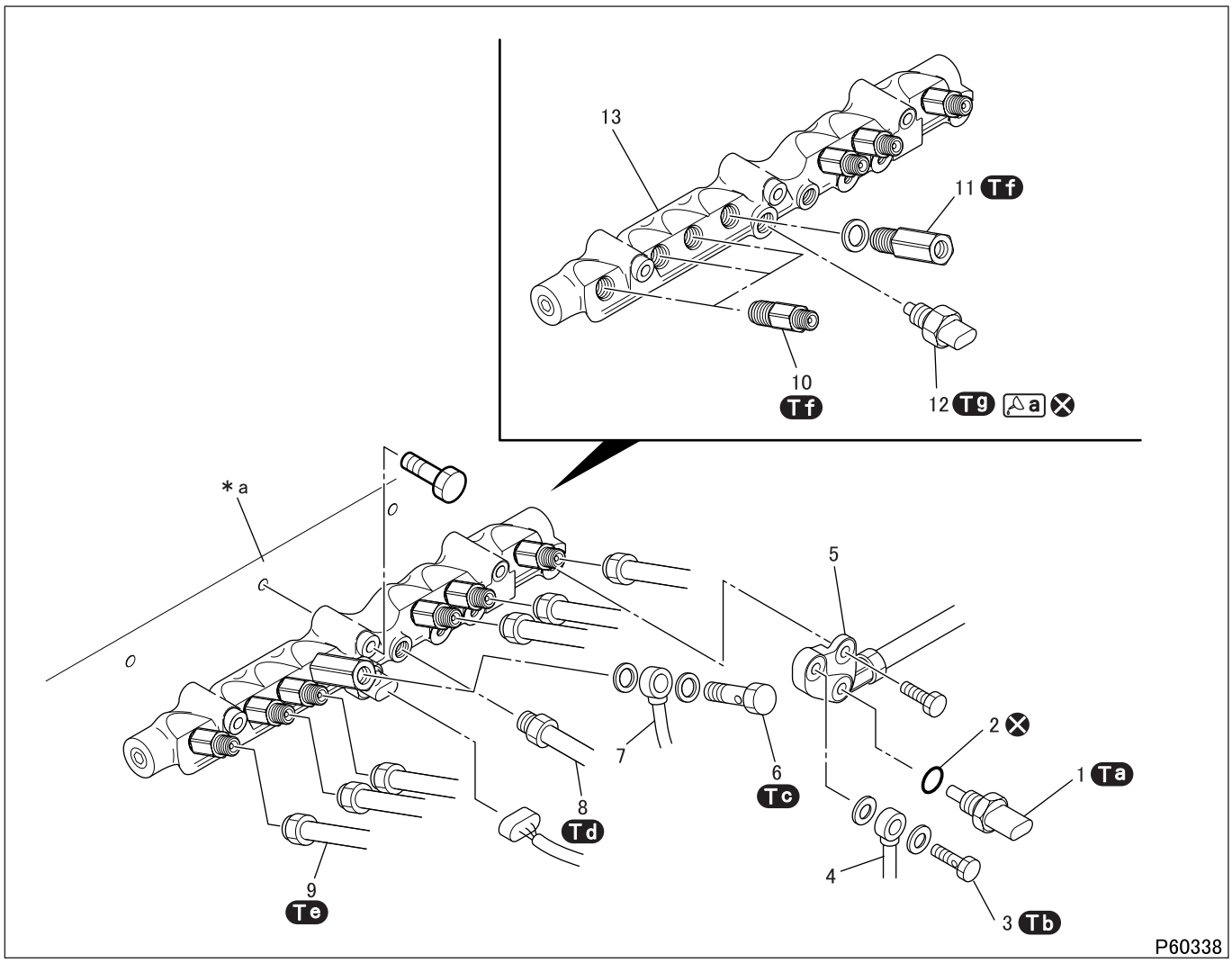
CAUTION ⚠

- **The use of an inappropriate element can lead to engine problems. Be sure to use a genuine element.**
- **To prevent fuel injection problems, keep the water separator and fuel hoses clear of fine dirt and other foreign matter.**



- Using the Ca with a torque wrench attached to it, tighten the cover to the specified torque.
- Tighten the drain plug, plug A and plug B to the specified torque. Then, bleed the fuel system of trapped air.
- Start the engine and ensure that there is no fuel leakage.
- If there is any fuel leakage, remove the water separator and reinstall it correctly.

M E M O



● **Disassembly sequence**

1 Fuel temperature sensor
2 O-ring
3 Eyebolt
4 Fuel return pipe
5 Connector
6 Eyebolt
7 Fuel overflow pipe
8 Fuel pipe
9 Injection pipe
10 Flow damper
11 Pressure limiter
12 Common rail pressure sensor
13 Common rail

***a**: Crankcase
⊗: Non-reusable parts

WARNING ⚠

- **Fuel is highly flammable. Do not handle it near flames or heat.**
- **Spilled fuel may catch fire and therefore, must be wiped up completely.**
- **Any contamination of the common rail, even if it is minor, will greatly affect the performance of the engine. After removing pipes or other parts, plug the openings with covers. Wash eye bolts and gaskets in light oil and keep them away from contaminants.**

- For the maintenance of the common rail, ask Denso Service Station.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

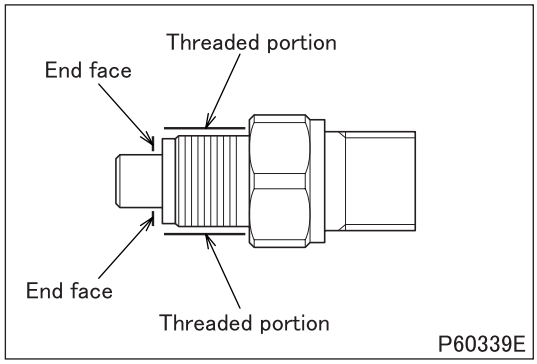
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Fuel temperature sensor	17.6 to 21.5 {1.8 to 2.2}	–
Tb	Eyebolt (for fuel return pipe mounting)	25 {2.6}	–
Tc	Eyebolt (for fuel overflow pipe mounting)	17.7 to 22.6 {1.8 to 2.3}	–
Td	Fuel pipe	49 to 58.8 {5.0 to 6.0}	–
Te	Injection pipe	39.2 to 49 {4.0 to 5.0}	–
Tf	Flow damper	160 to 190 {16 to 19}	–
	Pressure limiter		
Tg	Common rail pressure sensor	98 {10}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Threads and end face of common rail pressure sensor	DENSO Grease 5	As required

◆Installation procedure◆

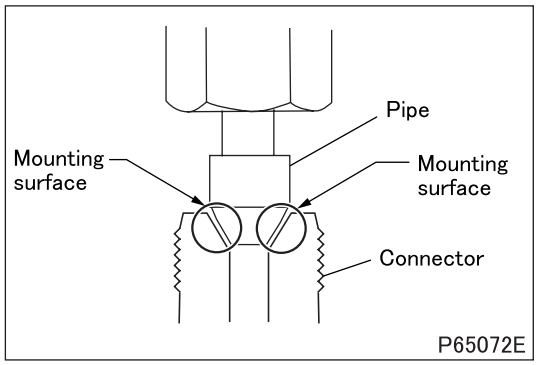


■Installation: Common rail pressure sensor

- Apply grease onto the threaded portion and end face of the sensor.

CAUTION ⚠

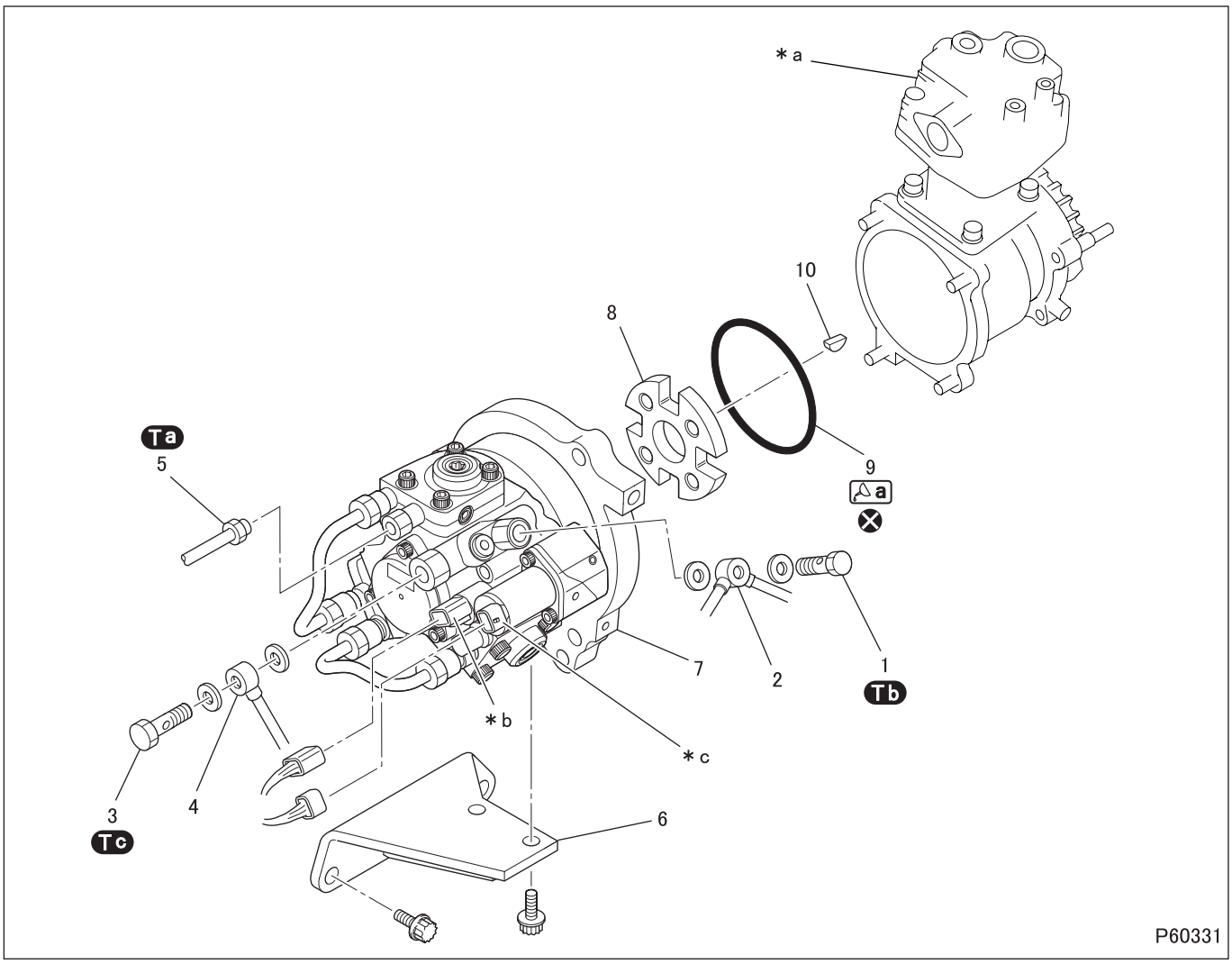
- **Do not touch the connector terminal of the common rail sensor.**



■ Installation: Injection pipe and fuel pipe

- Ensure that the pipe and mounting surfaces of the connector are flat and free from damage.
- Bring the pipe into intimate contact with mounting surfaces of the connector evenly, and temporarily tighten it without applying an excessive force.
- Tighten it to the specified torque after temporary tightening.

SUPPLY PUMP



● Disassembly sequence

1 Eyebolt
2 Fuel return pipe
3 Eyebolt
4 Fuel suction pipe
5 Fuel pipe
6 Supply pump bracket
7 Supply pump
8 Driving disc
9 O-ring
10 Key

***a**: Air compressor
***b**: Fuel temperature sensor
***c**: Suction control valve

⊗: Non-reusable parts

WARNING ⚠

- **Fuel is highly flammable. Do not handle it near flames or heat.**
- **Spilled fuel may catch fire and therefore, must be wiped up completely.**

CAUTION ⚠

- **Any contamination of the supply pump, even if it is minor, will greatly affect the performance of the engine. After removing pipes, hoses, or other parts, plug the openings with covers. Wash eye bolts and gaskets in light oil and keep them away from contaminants.**

- For the maintenance of the supply pump, ask Denso Service Station.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **If the supply pump has been replaced, perform the "initialization of supply pump unit difference learning value" using Multi-Use Tester in order to clear the correction data (learned pump unit difference) from the engine electronic control unit. (See Gr13E.)**

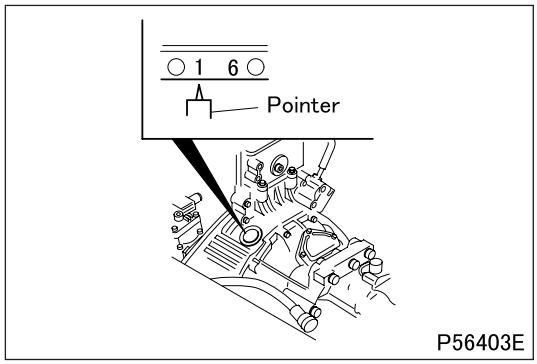
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Fuel pipe	39.2 to 49 {4.0 to 5.0}	–
Tb	Eyebolt (for fuel return pipe mounting)	7.9 to 12.7 {0.8 to 1.3}	–
Tc	Eyebolt (for fuel suction pipe mounting)	14.8 to 19.6 {1.5 to 2.0}	–

Lubricant and/or sealant

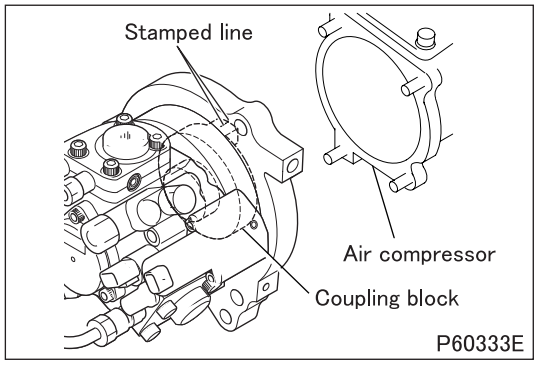
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

◆Installation procedure◆

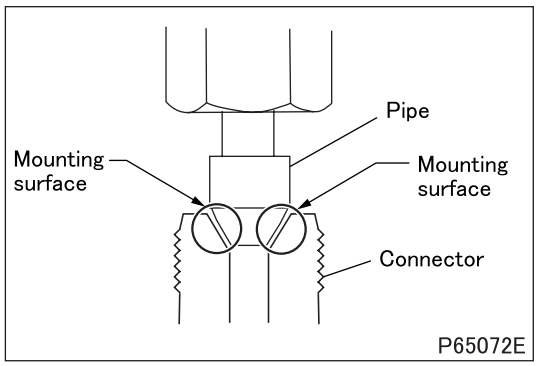


■Installation: Supply pump

- Position the No. 1 piston to the top dead center in the compression stroke in the following manner.
  - Crank the engine to align the pointer with the "1 6" mark on the flywheel.
  - This will bring either the No. 1 piston or the No. 6 piston to the top dead center in the compression stroke. If both the inlet and exhaust rockers can be moved by hand by the amount of valve clearance, that cylinder is at the top dead center in the compression stroke. From that position, every turn of the crankshaft will alternately bring the No.1 and No. 6 pistons to the top dead center in the compression stroke. (See Gr11.)



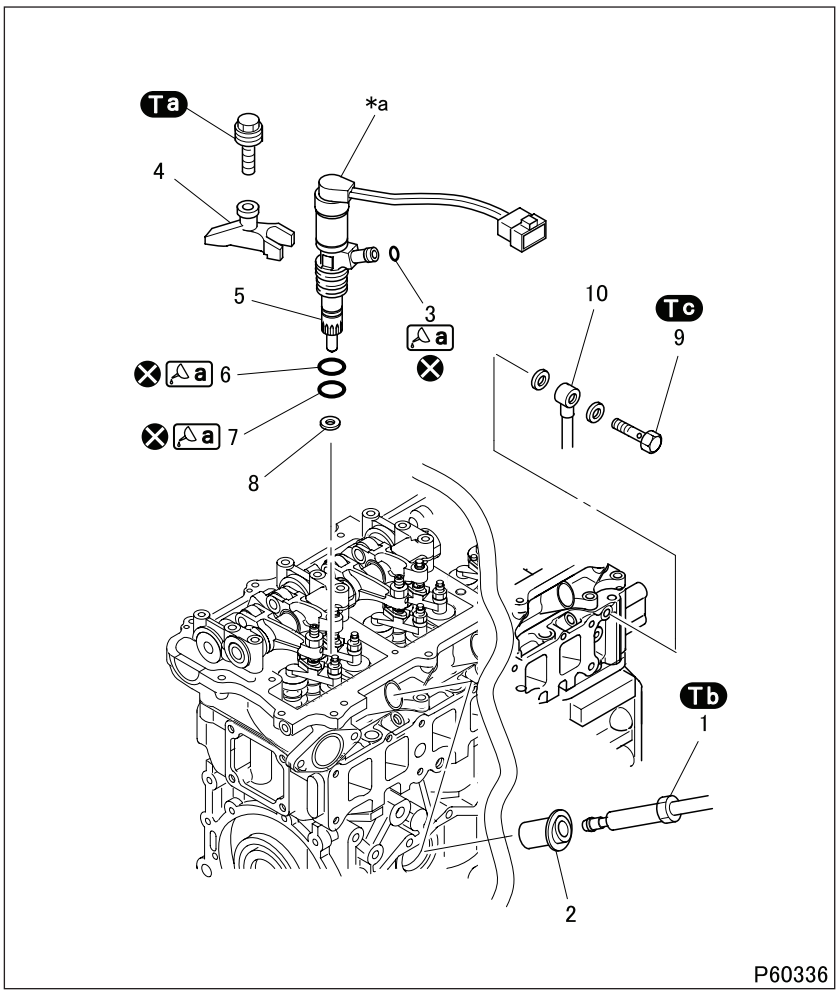
- Install the supply pump while ensuring that the stamped line on the supply pump timing cover is aligned with the stamped line on the coupling block.



■ Installation: Injection pipe and fuel pipe

- Ensure that the pipe and mounting surfaces of the connector are flat and free from damage.
- Bring the pipe into intimate contact with mounting surfaces of the connector evenly, and temporarily tighten it without applying an excessive force.
- Tighten it to the specified torque after temporary tightening.

INJECTOR



● **Disassembly sequence**

1 Injection pipe
2 Injection pipe seal
3 O-ring
4 Nozzle bridge
5 Injector
6 O-ring
7 O-ring
8 Nozzle tip gasket
9 Eye bolt
10 Fuel return pipe

*a: Two-Way electromagnetic Valve
⊗: Non-reusable parts

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **Be sure to wipe up all spilled fuel. Unless it is wiped up, it could catch fire.**

CAUTION ⚠

- **To eliminate fuel injection and other problems, protect the injectors and pipes, that have been removed, from the ingress of contaminants.**

- For the maintenance of the injector, ask Denso Service Station.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Do not attempt to clean the nozzle hole with a wire brush or other similar tools, or the hole can be damaged.**
- **Be sure to tighten the nozzle bridge bolts to the specified torque. Overtightening the bolts can deform the injectors, resulting in incorrect fuel injection.**

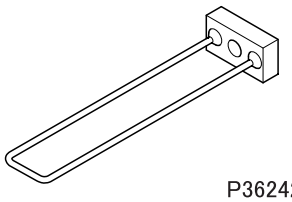
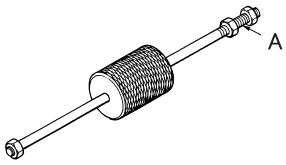
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (for mounting nozzle bridge)	33 to 38 {3.4 to 3.9}	–
Tb	Injection pipe	39.2 to 49 {4.0 to 5.0}	–
Tc	Eyebolt (for mounting fuel return pipe)	25 {2.6}	–

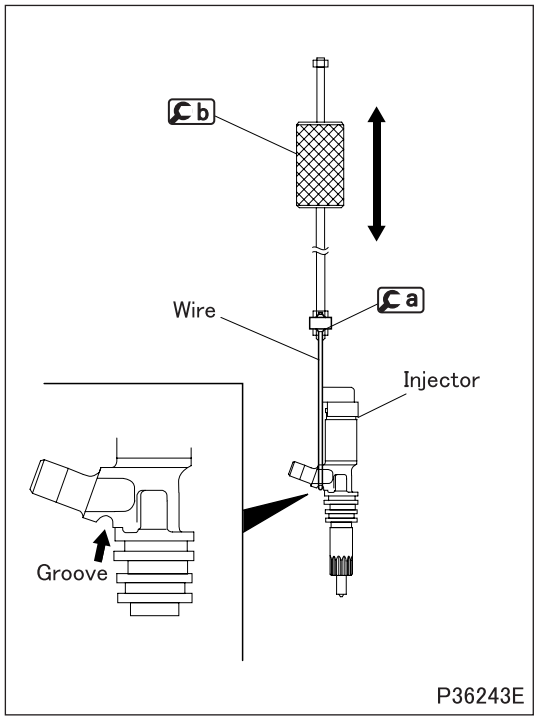
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
ⓐ	Injector extractor adapter  P36242	MH062560	Removing injector (use with MH061071)
ⓑ	Nozzle extractor A: M8 ∞ 1.25  P13523	MH061071	Removing injector

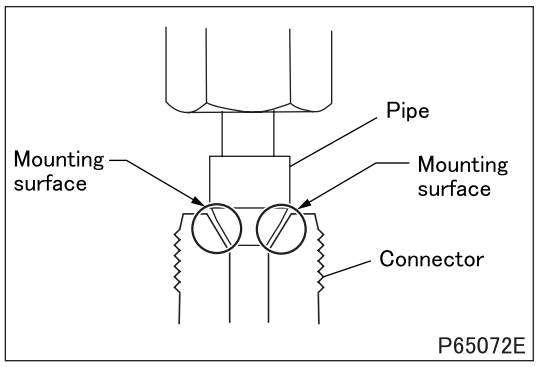
◆Removal procedure◆



P36243E

■**Removal: Injector**

- Using ⓐ and ⓑ and with the wire of ⓐ engaged in the groove on the injector, remove the injector.



P65072E

■ **Installation: Injection pipe and fuel pipe**

- Ensure that the pipe and mounting surfaces of the connector are flat and free from damage.
- Bring the pipe into intimate contact with mounting surfaces of the connector evenly, and temporarily tighten it without applying an excessive force.
- Tighten it to the specified torque after temporary tightening.

GROUP 13E ELECTRONICALLY CONTROLLED FUEL SYSTEM

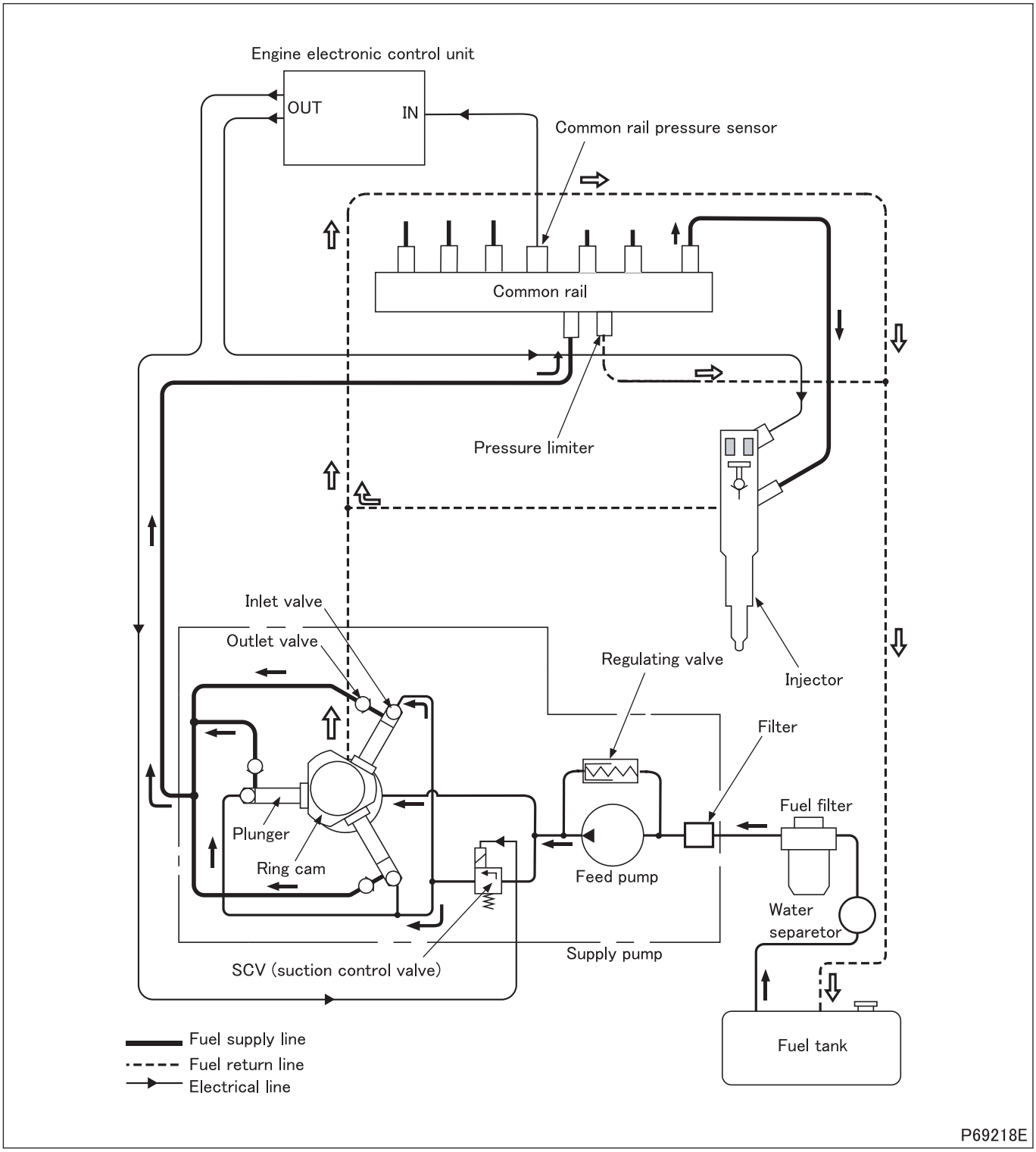
SPECIFICATIONS

Item		Specification
Supply pump	Manufacturer	DENSO
	Model	HP-4
	Control method	Electronic type
	Feed pump type	Trochoid type
	SCV (suction control valve) Rated voltage V	24
	Max. common rail pressure MPa {kgf/cm^2} [psi]	155 {1580} [22473]
Common rail	Manufacturer	DENSO
	Common rail volume cm^3 {mL}	26 {26}
	Pressure limiter opening pressure MPa {kgf/cm^2}	221 ± 9 {2250 ± 92}
	Common rail pressure sensor supply voltage V	5
Injectors	Manufacturer	DENSO
	Control method	Electrical type
	Max. operating pressure MPa {kgf/cm^2} [psi]	155 {1580} [22473]
	Min. operating pressure MPa {kgf/cm^2} [psi]	24 {245} [3485]
Engine electronic control unit	Manufacturer	DENSO
	Rated voltage V	24

M E M O

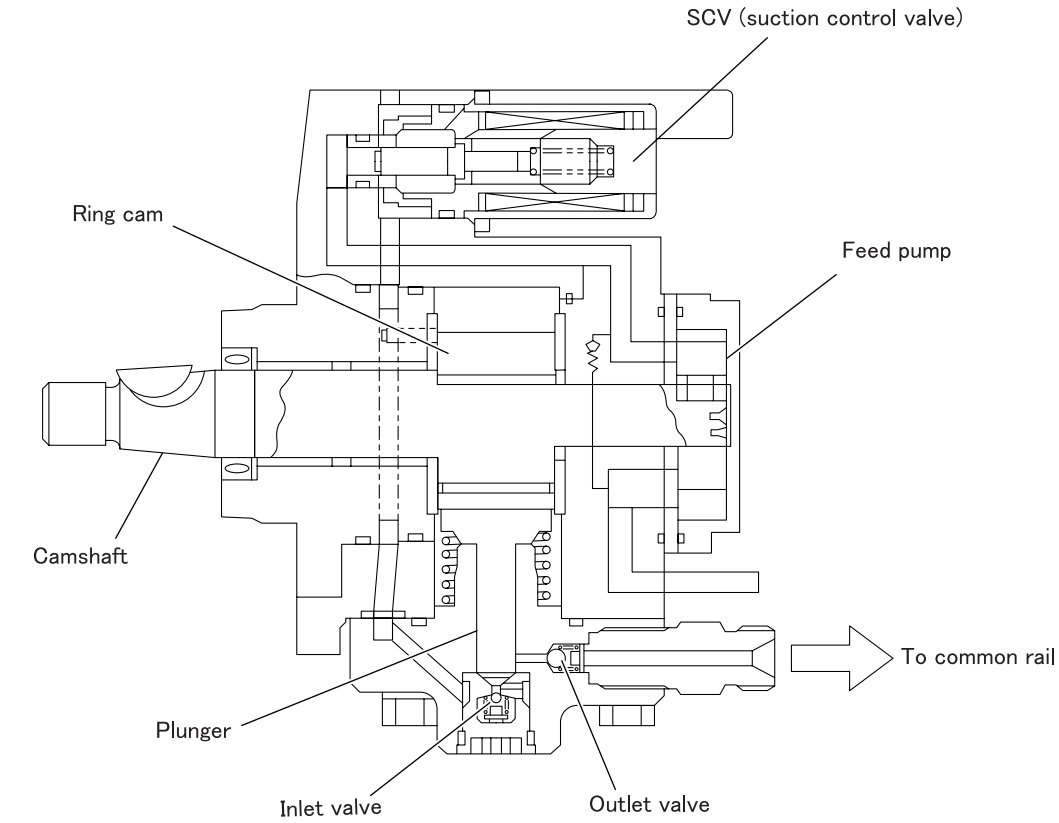
1. Overview

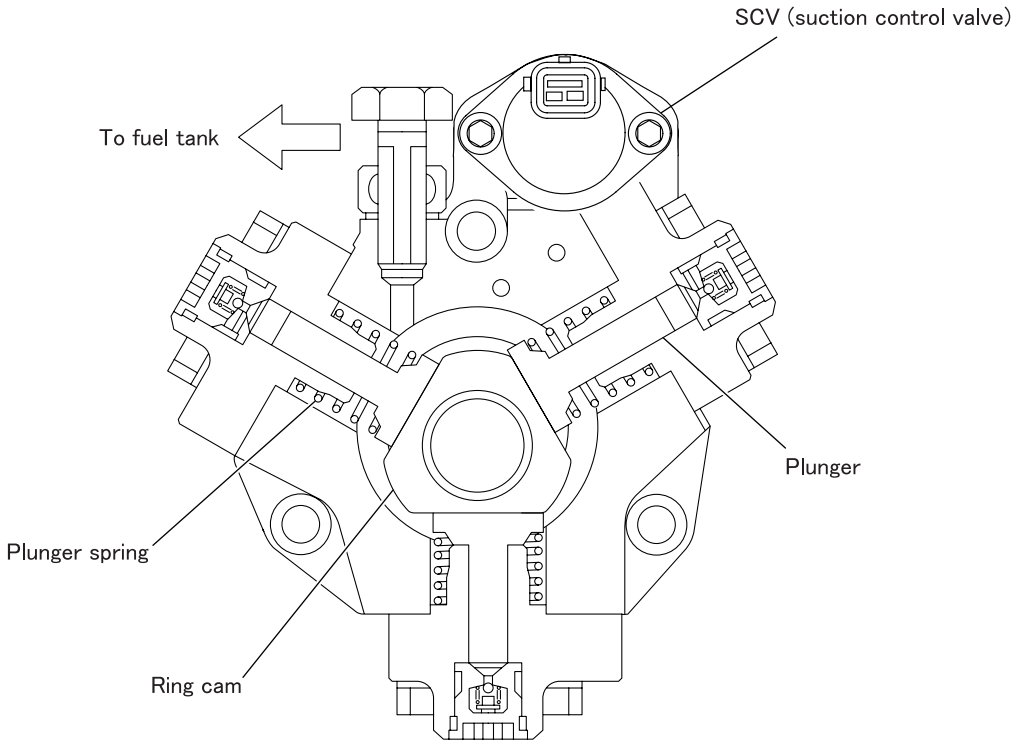
- In the common rail system, an electronic control unit monitors various aspects of the engine (engine speed, throttle opening, coolant temperature, etc.) using information from sensors. In accordance with these data, the electronic control unit effects control over the fuel injection quantity, fuel injection timing, and fuel injection pressure in order to optimize the engine's operation.
- The electronic control unit has a diagnostic function that enables it to recognize abnormalities in the common rail system's major components and alert the driver to them.
- The common rail system consists mainly of an electronically controlled supply pump; injectors; a common rail; and the electronic control unit and sensors that are used to control the other components.



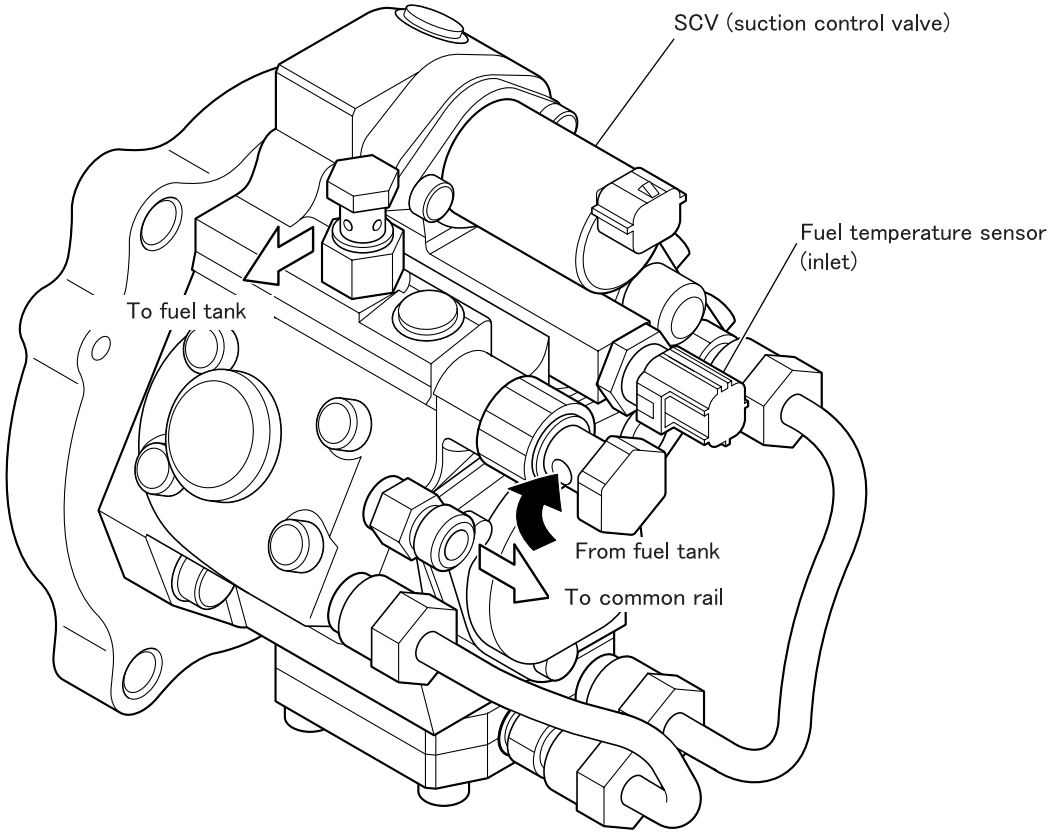
- When the engine is cranked by means of the starter switch, the feed pump (this is located inside the supply pump) simultaneously draws fuel from the fuel tank and feeds it via the water separator and fuel filter to the SCV (suction control valve). A quantity of fuel metered by the SCV (suction control valve) is supplied via the inlet valves to the plunger chambers.
- The fuel in the plunger chambers is pressurized. The outlet valves are then opened, and the fuel is fed under pressure to the common rail.
- The pressurized fuel is held in the common rail and then uniformly fed to the injectors.
- In response to signals from the engine electronic control unit, a solenoid valve in each injector causes the injector to inject fuel into the relevant combustion chamber at the optimal timing and in the optimal quantity.

1.1 Supply pump





P59217E

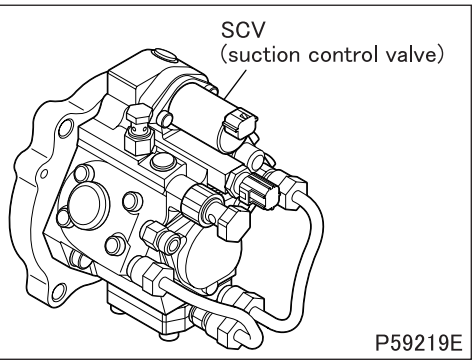


P59218E

CAUTION ⚠

- **Be sure to connect the SCV (suction control valve) connector to the engine harness before starting the engine. If the engine is started with the SCV (suction control valve) connector not connected, control of the supply pump by the engine electronic control unit would not be possible and a fault would ensue.**

- The supply pump pressurizes fuel and supplies it in a highly pressurized state.
- Fuel drawn from the fuel tank by the feed pump is not supplied directly to the plungers. It is supplied first to the common rail pressure solenoid valve, which controls the amount of fuel reaching the plungers.
- If the fuel pressure exceeds a certain level, the regulating valve returns fuel to the inlet side of the feed pump. This operation keeps the pressure of the fuel fed to SVC (suction control valve), constant.
- Rotation of the camshaft causes (via the ring cam) up-down movement of the plungers. Fuel in the plunger chambers is thus highly pressurized.

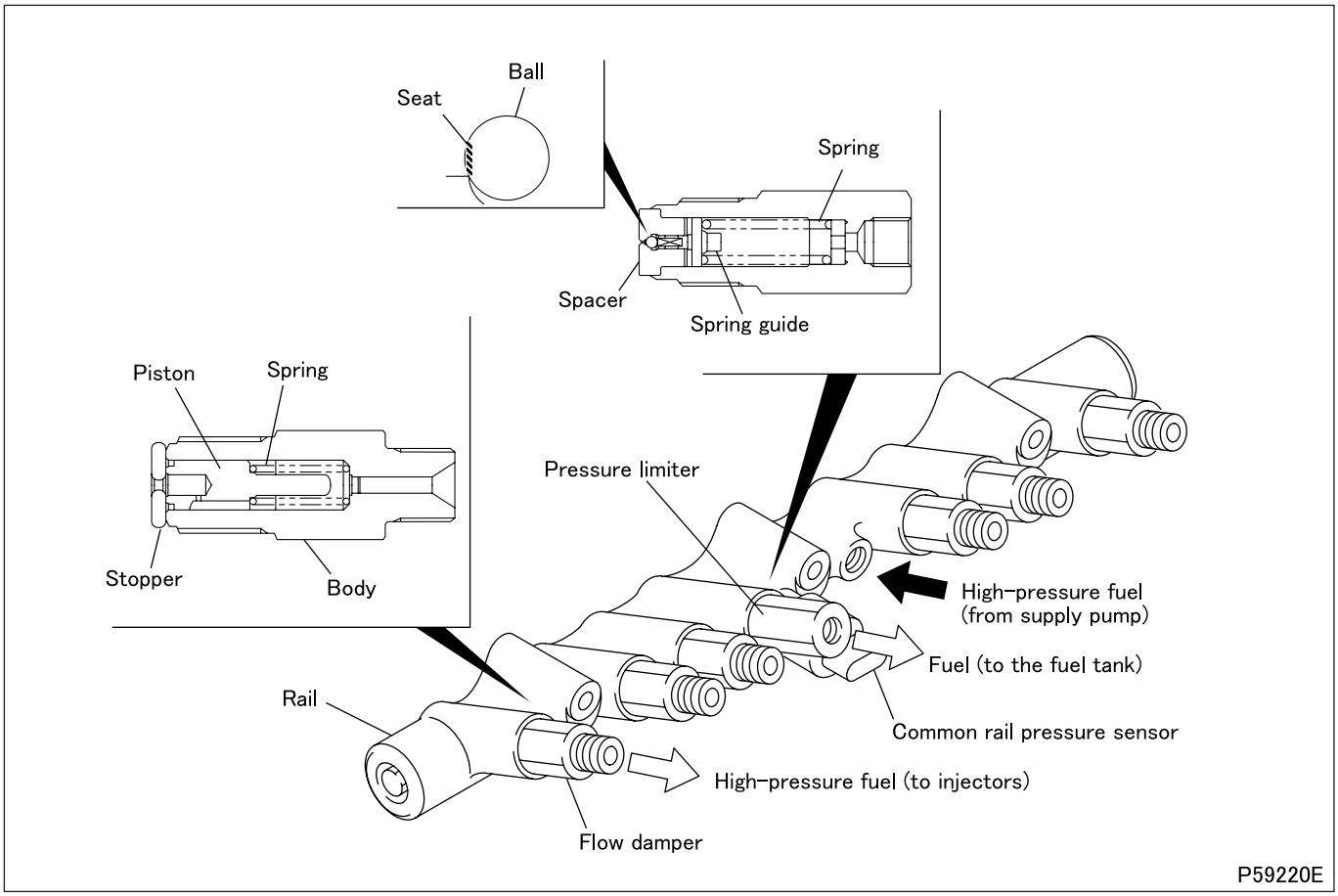


P59219E

(1) SCV (suction control valve)

- The SCV (suction control valve) receives fuel from the feed pump and feeds fuel toward the plungers of the supply pump in such a quantity that the fuel pressure corresponds to that required by the engine electronic control unit.
- When the SCV (suction control valve) is not operating, i.e., when current is not flowing, fuel flows at its maximum rate. When current flows, the piston in the common rail pressure solenoid valve is pressed down such that fuel is not fed toward the plungers.
- The engine electronic control unit controls the ratio of current-off time (duty ratio).

1.2 Common rail



- The common rail distributes to the injectors high-pressure fuel that has been fed from the supply pump.
- Each flow damper prevents an abnormal outflow of fuel. It does so by blocking the fuel passage in the event of fuel leakage from the injection pipe or excessive injection of fuel from the injector.
- The common rail pressure sensor is used in feedback control. It senses the fuel pressure inside the common rail and feeds a corresponding signal to the electronic control unit.
- If the fuel pressure in the common rail exceeds a certain, set level, the piston in the pressure limiter pushes and compresses the spring such that fuel is able to escape. The pressure limiting valve thus prevents the fuel pressure from becoming higher than the set pressure.

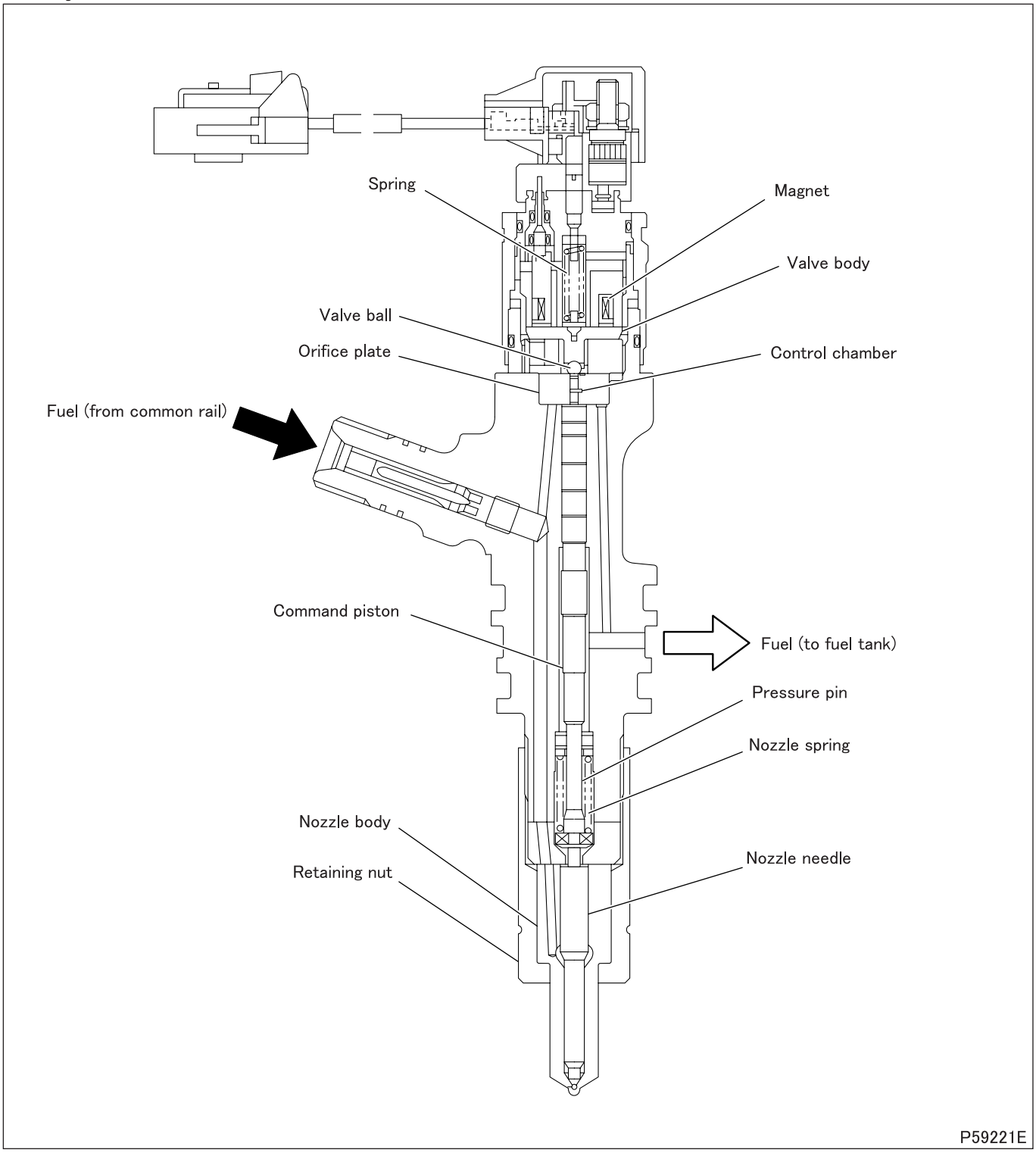
CAUTION ⚠

- **When the pressure limiter is activated, the common rail system is faulty and needs an inspection.**

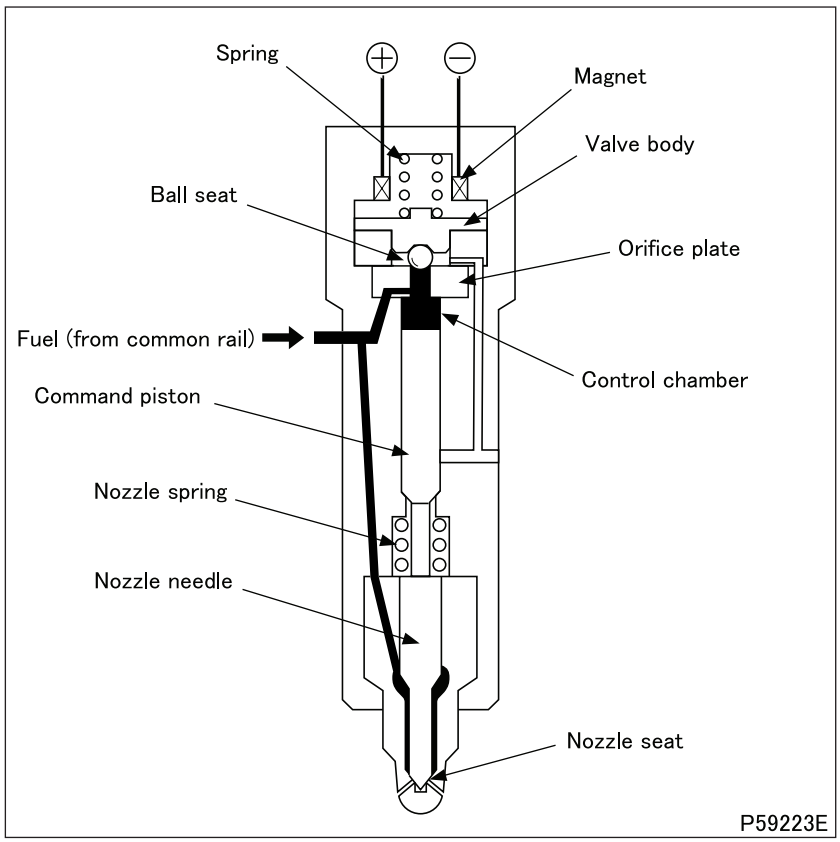
(1) Flow damper

- During normal operation, the piston moves (thus pushing and compressing the spring) to the extent necessary for one injection quantity to pass through. The piston does not make contact with the seat at this time. When injection is complete, the piston is returned to its initial position by the spring.
- If the amount of fuel passing through the flow damper becomes excessively great, the piston presses against the seat, thereby closing the fuel passage and preventing an abnormal outflow of fuel.
  When the piston has pressed against the seat, it does not return to its original position until the engine has been stopped and the pressure in the common rail has come down.

1.3 Injector



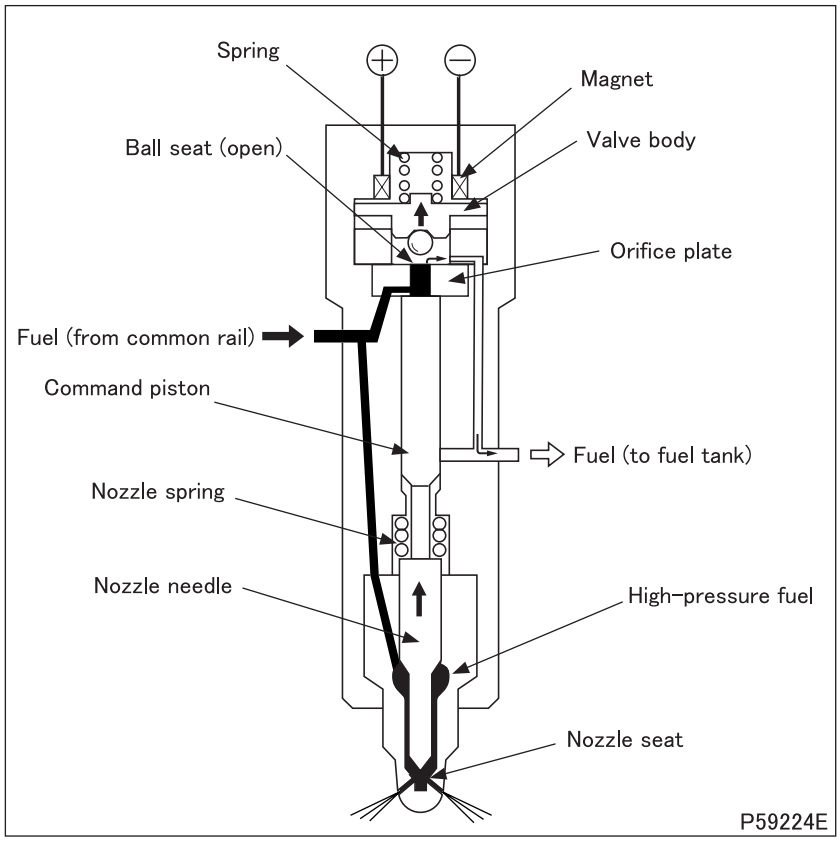
- In accordance with electrical signals from the engine electronic control unit, each injector supplies high-pressure fuel from the common rail to the relevant combustion chamber of the engine at the optimal timing and in the optimal quantity.
- The injector is divided into the control section and the injector section.
  - The control section consists of the control chamber, magnet, spring, valve body, valve ball, pressure pin, command piston, and orifice plate. The pressure pin is located between the control section and the injection section.
  - The injection section consists of the nozzle body, nozzle needle, nozzle spring, and retaining nut.



(1) Operation

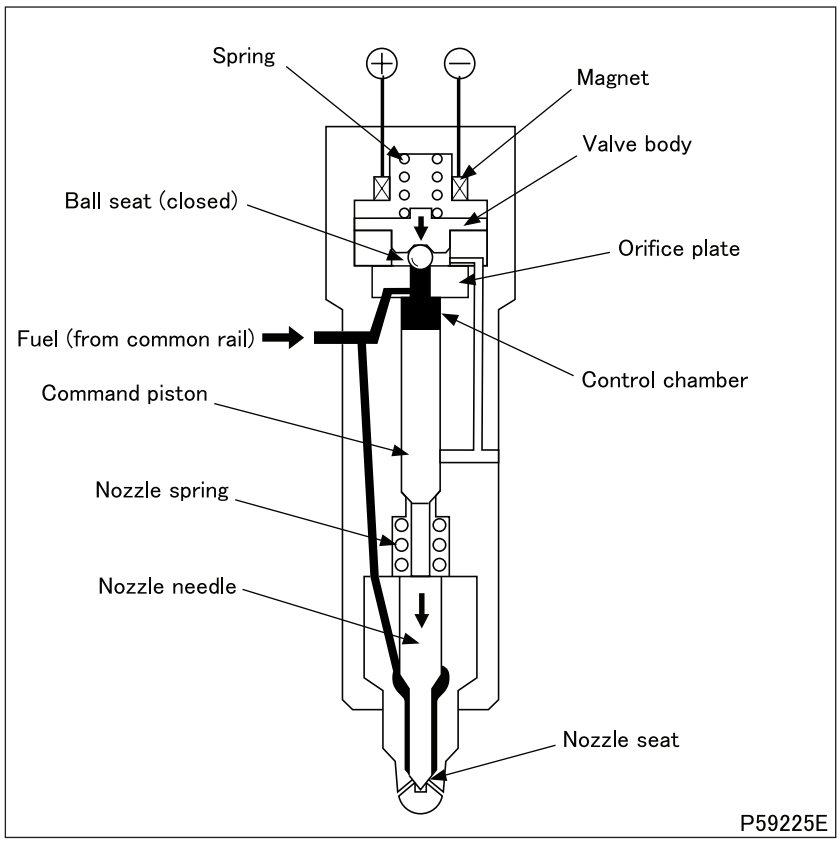
(1.1) Injection not taking place

- With the magnet not energized, the valve body, is pushed up by the spring in the magnet such that the ball seat is closed.
- The high-pressure fuel acts upon the control chamber via orifice plate. The same pressure acts upon the nozzle needle.
- The fuel pressure acting on the nozzle needle cannot overcome the command piston and nozzle spring, so the nozzle needle stays in its downward-pushed position and injection does not take place.



(1.2) Start of injection

- When the magnet is energized, the resulting electromagnetic force draws the valve body upward, causing the ball seat to open.
- Fuel in the control chamber passes through the orifice plate and ball seat and flows to the fuel tank.
- With the pressure in the control chamber reduced, the fuel acting on the nozzle needle overcomes the command piston and nozzle spring, pushing up the nozzle needle such that injection starts.
- If the magnet remains energized, the injection rate reaches its maximum level.

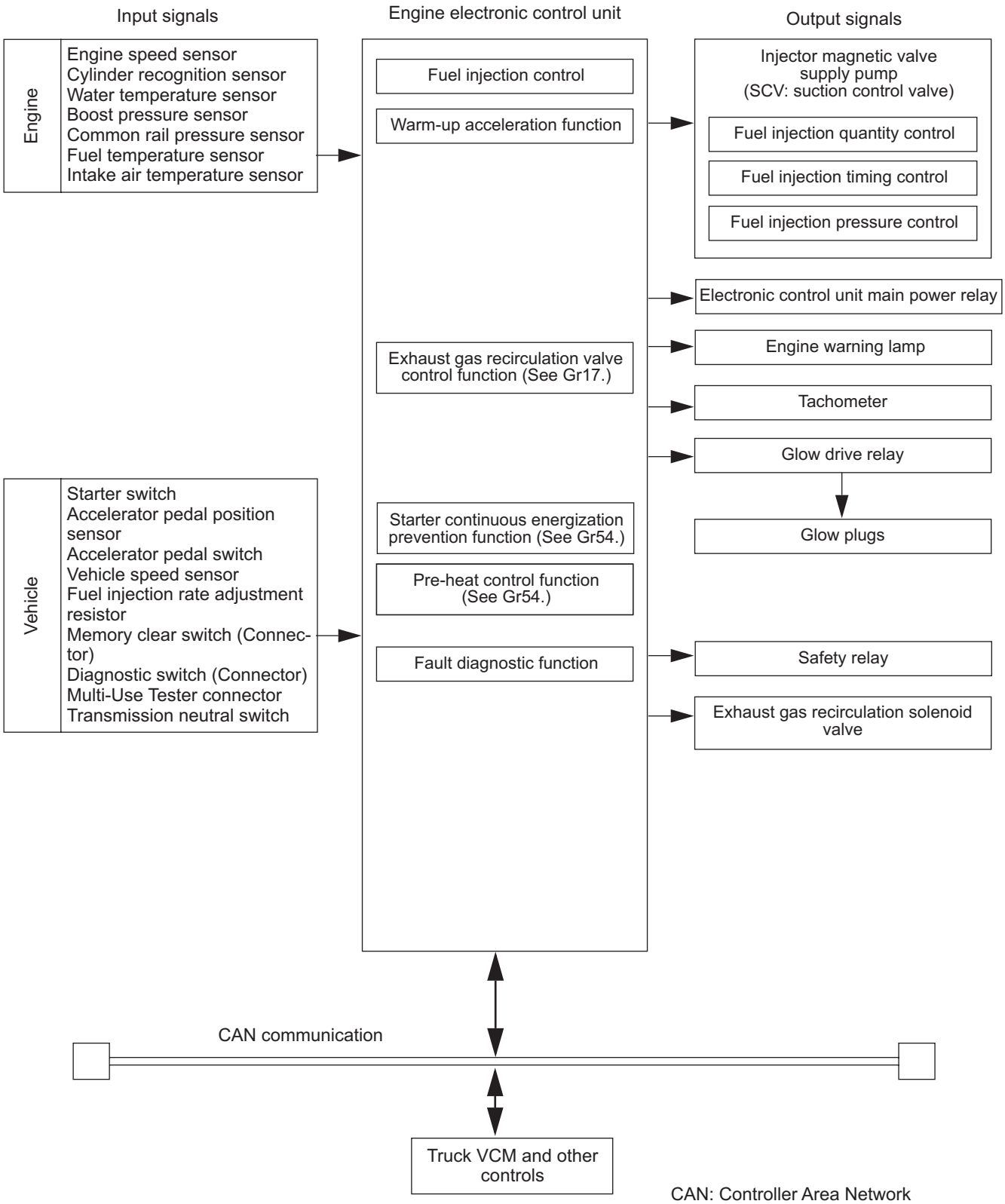


(1.3) End of injection

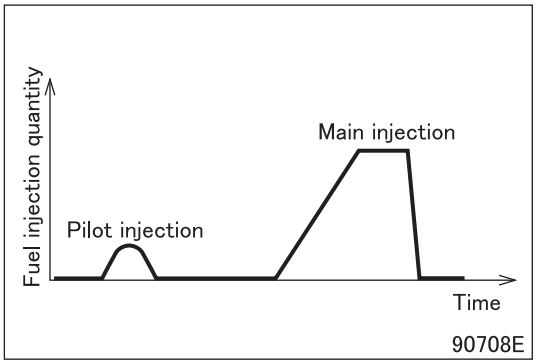
- When energization of the magnet is stopped, the valve body is pushed downward by the spring in the magnet such that the ball seat closes. At this time, fuel flows into the control chamber via orifice plate, pushing down the command piston and nozzle needle such that injection finishes.

2. Electronic Control System

2.1 System block diagram



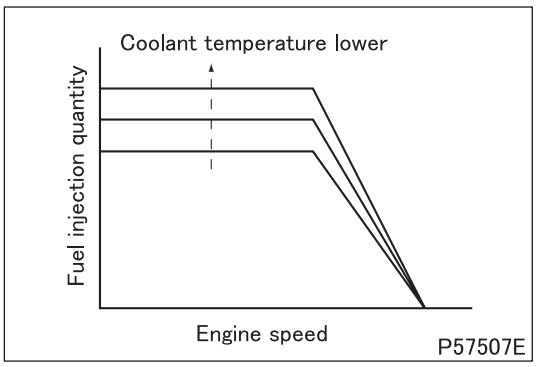
Part	Main function/operation
Engine speed sensor	Sensing of engine speed
Cylinder recognition sensor	Cylinder recognition
Starter switch	Senses that the engine is in starting condition with the starter switch in START position.
Water temperature sensor	Sensing of coolant temperature
Accelerator pedal position sensor	Sensing of extent of accelerator pedal depression
Accelerator pedal switch	Sensing of released/depressed condition of accelerator pedal (OFF with pedal depressed)
Transmission neutral switch	Detecting of neutral position in the transmission (OFF with the transmission in neutral)
Vehicle speed sensor	Sensing of vehicle speed
Fuel temperature sensor	Sensing of fuel temperature
Diagnostic switch	Output of diagnostic codes
Memory clear switch	Deletion of diagnostic codes; output of past diagnostic codes
Fuel injection rate adjustment resistor	Correction of fuel injection rate
Boost pressure sensor	Sensing of boost pressure
Intake air temperature sensor	Sensing of intake air temperature
Multi-Use Tester connector	Communication between Multi-Use Tester and common rail system
Common rail pressure sensor	Sensing of common rail pressure
Injector magnetic valve	Control of fuel injection rate, fuel injection quantity, and fuel injection timing
SCV (suction control valve)	Control of fuel injection pressure
Electronic control unit main power relay	Power on/off of electronic control unit
Engine warning lamp	Indication of system abnormalities
Glow drive relay	ON/OFF control of glow plugs
(Tachometer)	(Indication of engine speed)
Exhaust gas recirculation solenoid valve	Exhaust gas recirculation switching control
Safety relay	Control of starter continuous energization prevention function
CAN communication (Truck VCM and other controls)	Engine data recognized by the engine electronic control unit are outputted to the CAN bus to enable Truck VCM and other controls system to obtain data needed for control. MVCU system issues signals to the engine electronic control unit via the CAN bus to enable it to effect engine control appropriate for each type of system control.



2.2 Fuel injection control

(1) Pilot injection

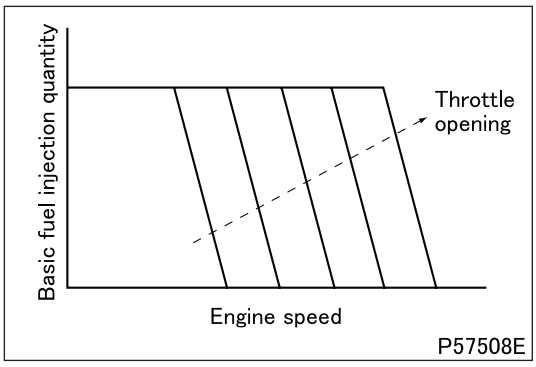
- Pilot injection entails the injection of an extremely small amount of fuel ahead of the main injection.
- Pilot injection suppresses heat generation early in the injection cycle and thus suppresses NOx generation and noise at the start of combustion.



2.3 Fuel injection quantity control

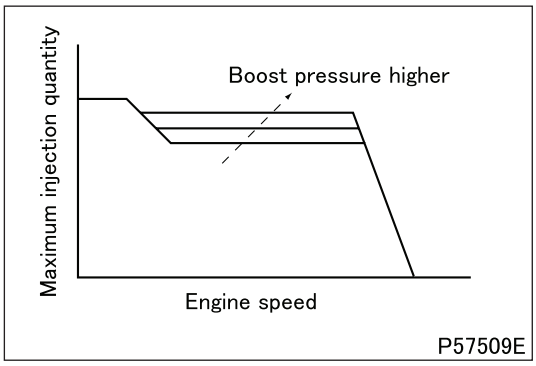
(1) Fuel injection quantity during engine startup

- During engine startup, the fuel injection quantity is determined in accordance with the engine speed and coolant temperature.



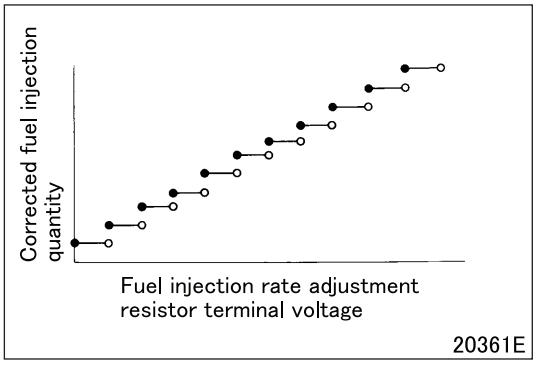
(2) Basic fuel injection quantity

- The basic fuel injection quantity is determined in accordance with the engine speed and throttle opening.



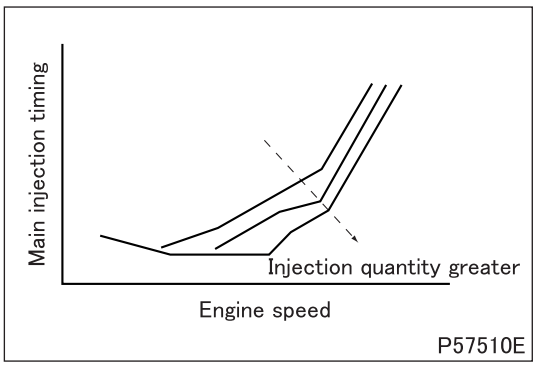
(3) Maximum injection quantity

- The maximum injection quantity is calculated from the engine speed and boost pressure.



(4) Fuel injection rate adjustment resistor correction amount

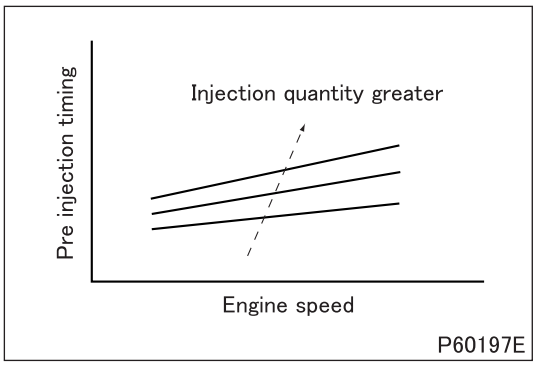
- To limit inconsistency in the injection quantity, the injection quantity is corrected by the fuel injection rate adjustment resistor.



2.4 Fuel injection timing control

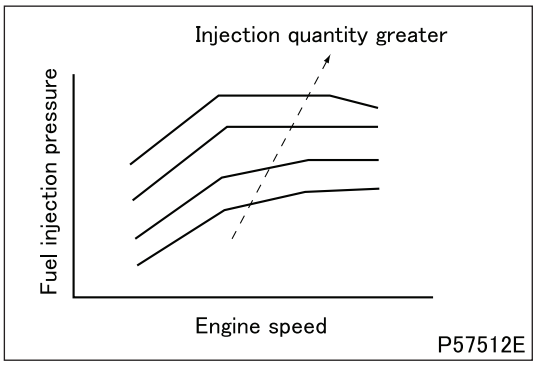
(1) Main injection timing

- The main injection timing is calculated from the fuel injection quantity and engine speed.



(2) Pre injection timing

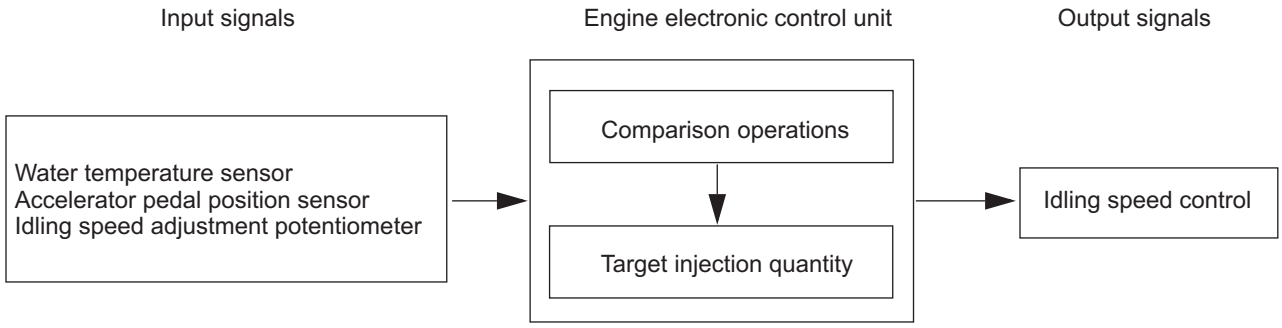
- The pre injection timing is calculated from the fuel injection quantity and engine speed.



2.5 Fuel injection timing control

- The fuel injection pressure is calculated from the fuel injection quantity and engine speed.

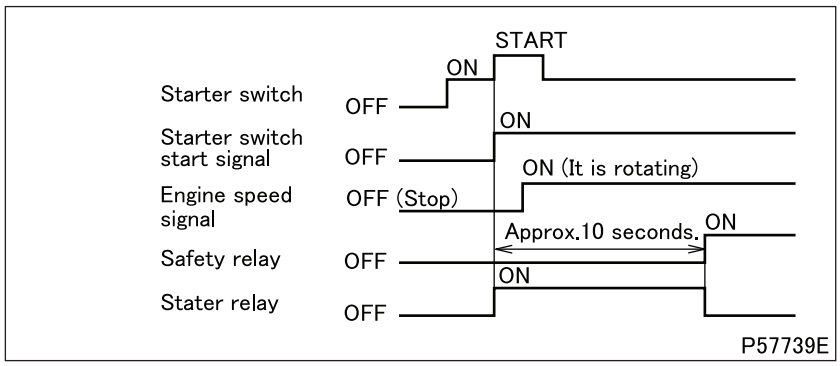
2.6 Warm-up acceleration function



- The warm-up acceleration function increases engine warm-up by varying the engine's idling speed in accordance with the engine's coolant temperature. It can operate either automatically or manually. Selection is made using the idling speed adjustment potentiometer.

2.7 Starter continuous energizing preventing function

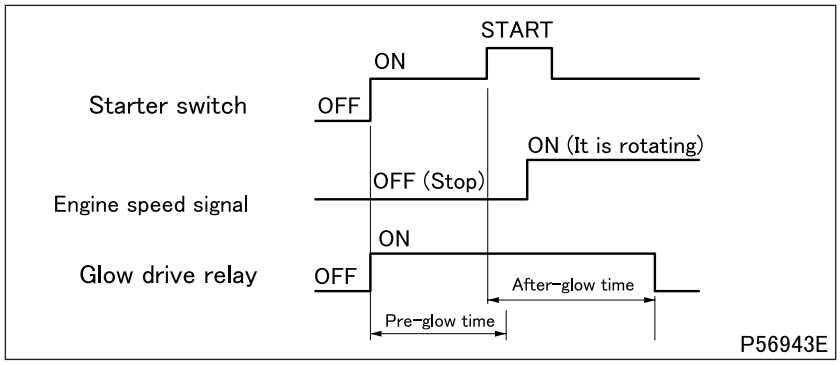
- This function is provided to prevent starter over-run.
- If the starter operates for longer than a predetermined period following engine startup, the Engine electronic control unit deems that it has been energized continuously for too long. The Engine electronic control unit then stops the flow of current to the starter and starter relay, thereby preventing the starter from seizing.
- If the engine electronic control unit determines, based on the engine speed signal it receives, that the engine has run at or above the specified speed for longer than the specified time period after start-up, the unit trips the safety relay open.



(1) Operation mode

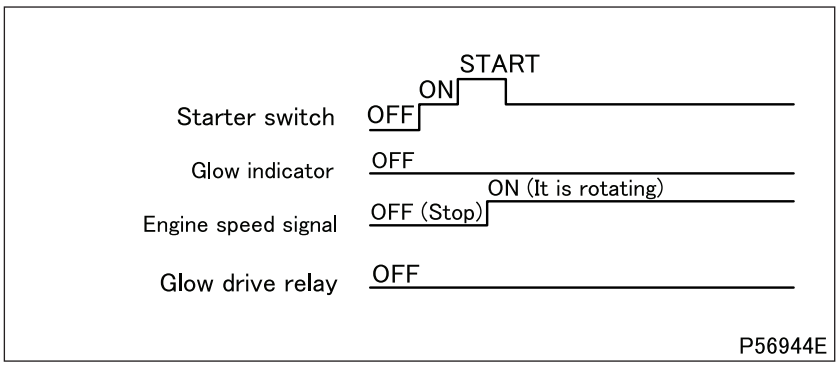
2.8 Preheating function

- This preheating function aims to enhance the engine start up when the engine coolant is low in cold weather or temperature.



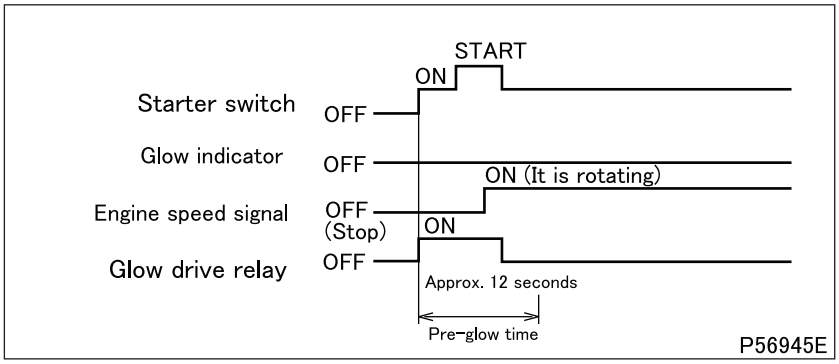
(1) Pre-glow and After-glow

The preheating is operated with a pre-glow before the engine starts and an after-glow after the engine starts. They are controlled by the starter switch (S terminal) signal, engine water temperature signal and the engine rotation signal.

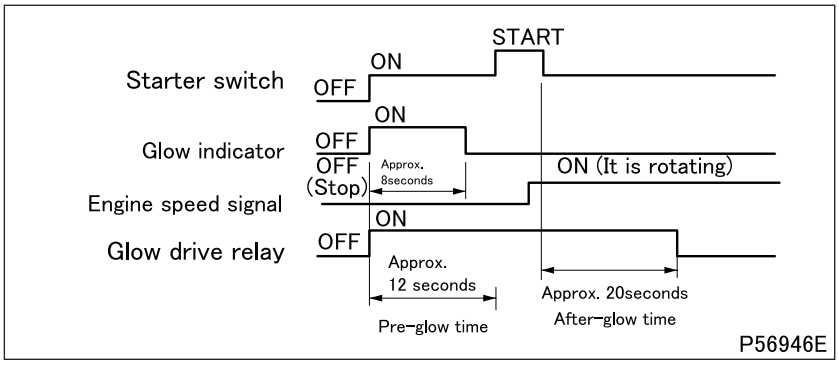


(2) Operation mode

- When the engine coolant temperature is 60°C or more.



- When the engine coolant temperature is 0°C to 60°C.

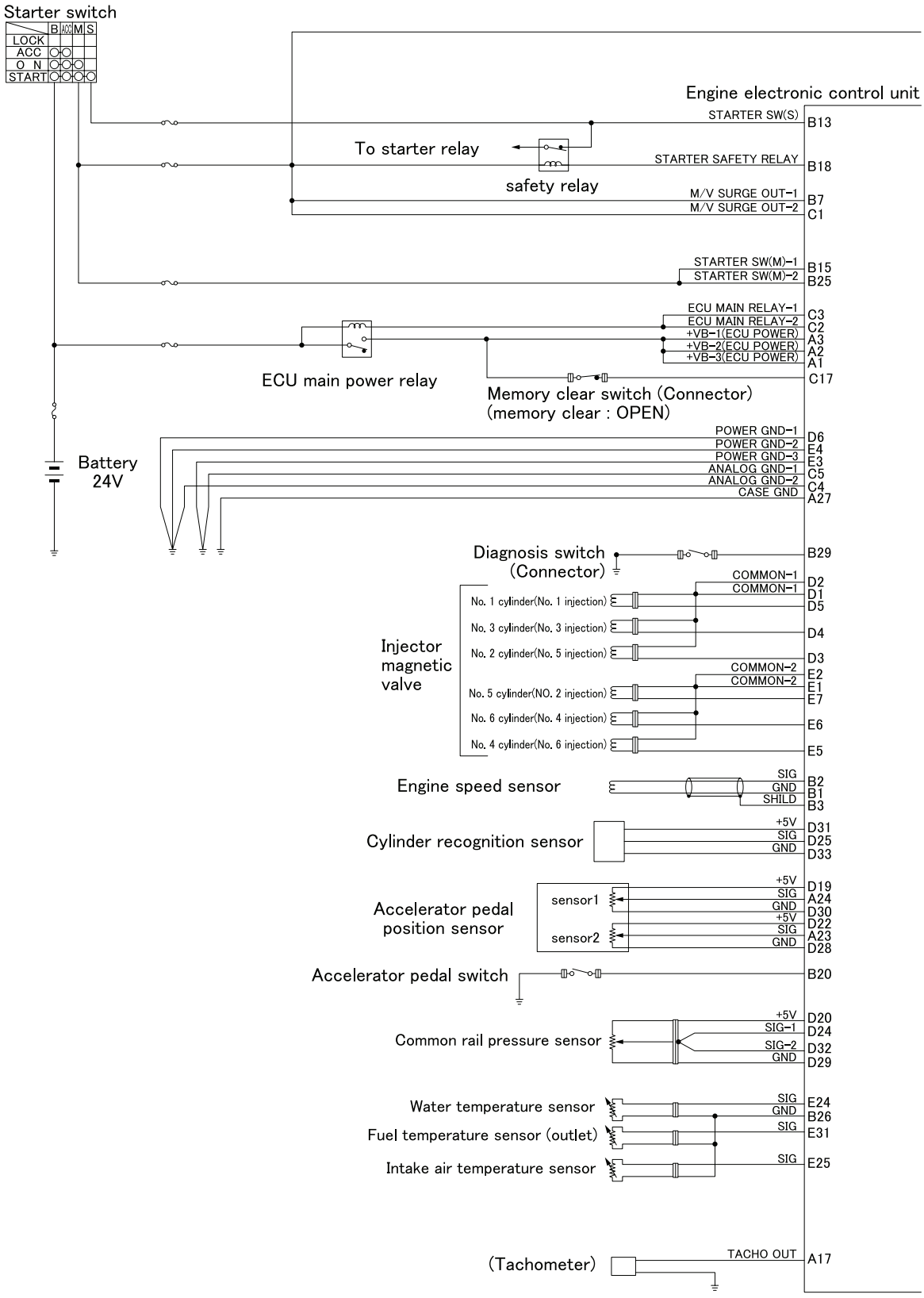


- When the engine coolant temperature is 0°C or less.

2.9 Fault diagnostic function

- When the starter switch is in the ON position, the system continuously monitors the sensors and other system components. If any fault is detected, the system warns the driver of this by illuminating the warning lamp and displaying the error code on the meter panel. At the same time, the system also stores a relevant diagnostic code in the memory and starts operation in the fault mode.
- While the fault is taking place, the control limits the systems functionality to ensure vehicle and driver safety. It is possible to read the memorized diagnostic code using a Multi-Use Tester or from flashing of the warning lamp.
- Diagnostic codes displayed on the meter panel, indicated by flashing of the warning lamp and shown by the Multi-Use Tester are different.
- The Multi-Use Tester is capable of showing more detailed diagnostic codes.

3. Electronic Control Unit Connection Diagram



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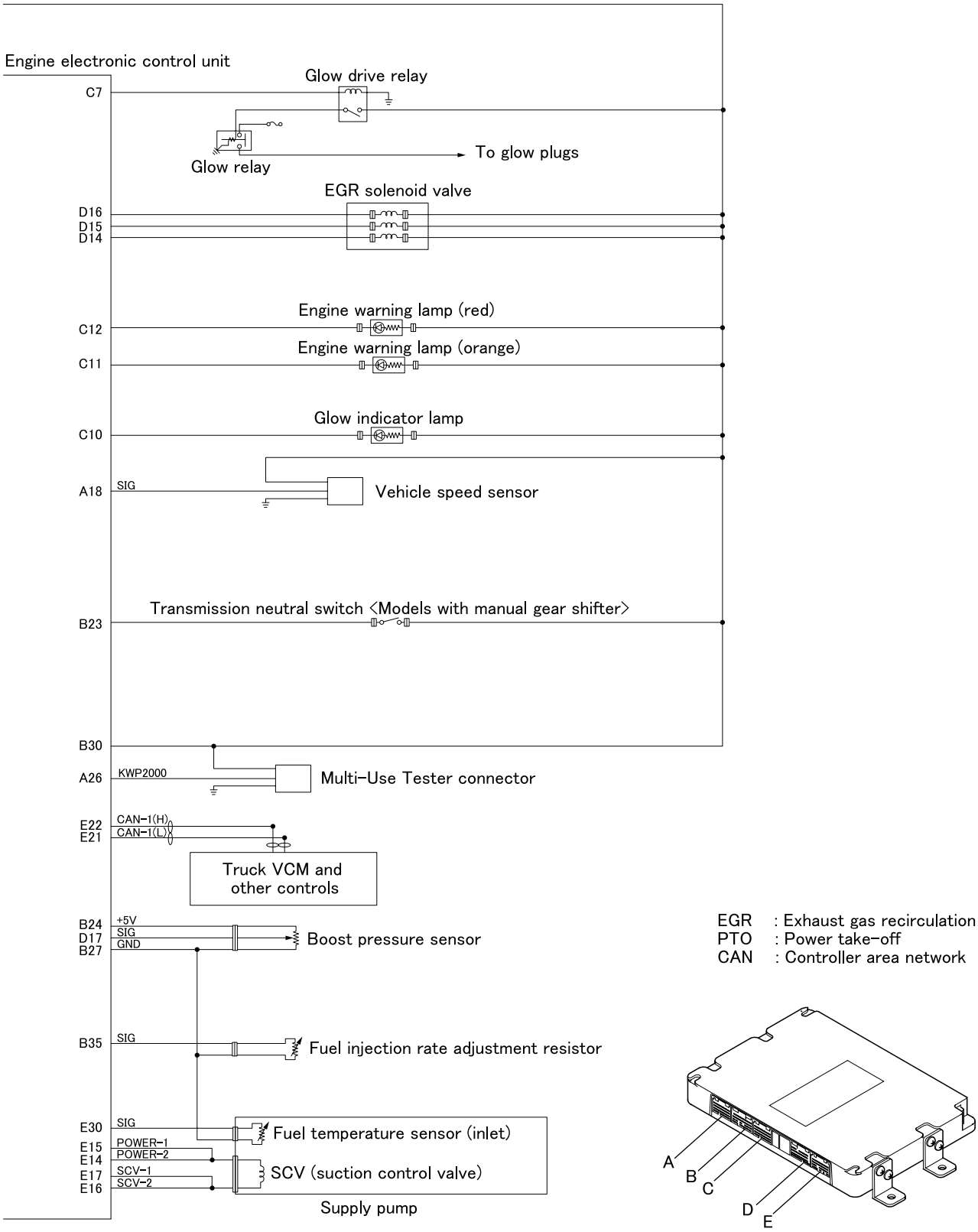
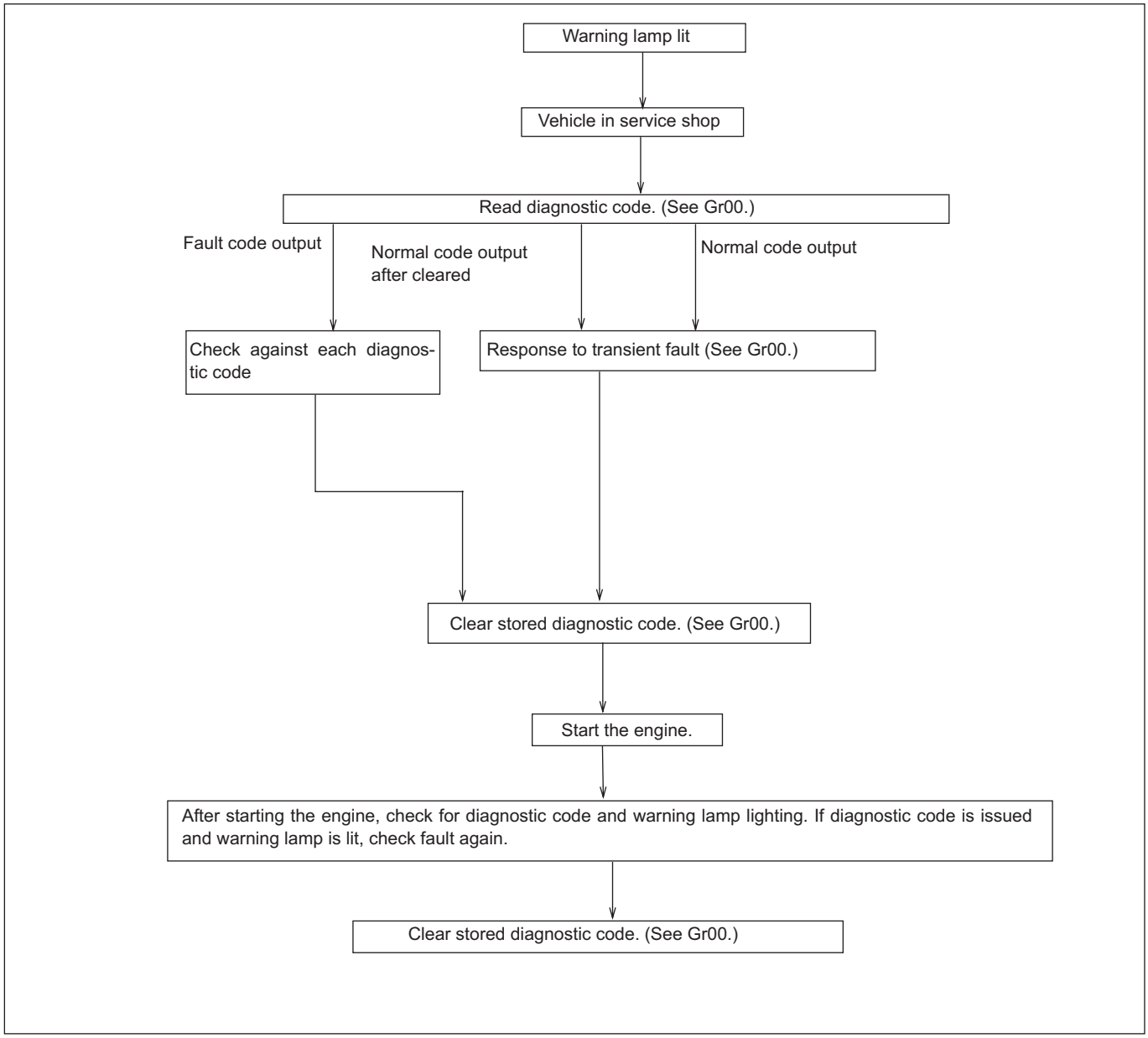

Engine electronic control unit
C7
Glow drive relay
Glow relay
To glow plugs
EGR solenoid valve
D16
D15
D14
Engine warning lamp (red)
C12
Engine warning lamp (orange)
C11
Glow indicator lamp
C10
A18
SIG
Vehicle speed sensor
Transmission neutral switch <Models with manual gear shifter>
B23
B30
A26
KWP2000
Multi-Use Tester connector
E22
E21
CAN-1(H)
CAN-1(L)
Truck VCM and other controls
B24
D17
B27
+5V
SIG
GND
Boost pressure sensor
B35
SIG
Fuel injection rate adjustment resistor
E30
E15
E14
E17
E16
SIG
POWER-1
POWER-2
SCV-1
SCV-2
Fuel temperature sensor (inlet)
SCV (suction control valve)
Supply pump
EGR : Exhaust gas recirculation
PTO : Power take-off
CAN : Controller area network
A
B
C
D
E
A : GF34A
B : GF35A
C : GF32A
D : GF35B
E : GF31A

P69118E-2

1. Diagnostic Procedure

- The system can be efficiently inspected for faults using Up-Time 2.41 or later software or a Multi-Use Tester-III. System inspection can be accomplished basically in two ways according to trouble symptom and diagnostic code as shown below.
  - Check against each diagnostic code stored in memory by the electronic control unit
  - Response to transient fault



2. Diagnostic Precautions

- Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
- To avoid having electrical parts damaged, set the starter switch to LOCK or OFF before disconnecting and reconnecting battery cables.
- Before disconnecting connectors, set the starter switch to LOCK or OFF, then allow at least 20 seconds. Voltage may remain in electric parts or connected circuit.
- When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and car body.
- Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C) as the measuring condition.

3. Inspections Based on Diagnostic Codes

3.1 Diagnostic code list

- Diagnostic codes displayed on the meter panel, indicated by flashing of the warning lamp and shown by the Multi-Use Tester or Up-Time 2.41 or later software are different.
- The Multi-Use Tester or Up-Time 2.41 or later software is capable of showing more detailed diagnostic codes.

GSE	Flash-es	Message	Code
E-01	24	Accel Pedal Sensor 1	P0122
E-01	24	Accel Pedal Sensor 1	P0123
E-02	16	Accel Pedal Sensor 2	P0222
E-02	16	Accel Pedal Sensor 2	P0223
E-03	65	Accel SW	P0510
E-04	12	Camshaft Position SNSR	P0340
E-05	23	Common Rail Pressure Defect	P0254
E-05	23	Common Rail Pressure M/V 1	P0255
E-05	23	Common Rail Pressure M/V 1	P0256
E-05	23	Common Rail Pressure M/V 1	P0257
E-06	36	Common Rail Pressure Defect	P0251
E-06	36	Common Rail Pressure Defect	P0252
E-07	11	CRS Pressure SNSR (Plausibility)	P0191
E-07	11	CRS Pressure SNSR (Low)	P0192
E-07	11	CRS Pressure SNSR (High)	P0193
E-08	58	Accel Pedal Check (Plausibility)	P0121
E-09	37	Injector M/V-Cylinder1 (Load)	P0201
E-10	38	Injector M/V-Cylinder2 (Load)	P0202
E-11	39	Injector M/V-Cylinder3 (Load)	P0203
E-12	08	Injector M/V-Cylinder4 (Load)	P0204
E-13	46	Injector M/V-Cylinder5 (Load)	P0205
E-14	47	Injector M/V-Cylinder6 (Load)	P0206
E-15	71	Flow Limiter -Cylinder1	P1240
E-16	72	Flow Limiter -Cylinder2	P1241
E-17	73	Flow Limiter -Cylinder3	P1242
E-18	74	Flow Limiter -Cylinder4	P1243
E-19	75	Flow Limiter -Cylinder5	P1244
E-20	76	Flow Limiter -Cylinder6	P1245
E-24	15	Engine Revolution SNSR	P0335
E-25	07	Engine Overrunning	P0219
E-26	32	Boost Press SNSR (Low)	P0237
E-26	32	Boost Press SNSR (High)	P0238
E-28	22	Common Rail Pressure Defect	P0253
E-29	19	Atmospheric Pressure Sensor	P0107
E-29	19	Atmospheric Pressure Sensor	P0108
E-30	–	CAN Communication	P0600
E-32	21	Water Temp SNSR (Low)	P0117
E-32	21	Water Temp SNSR (High)	P0118

GSE	Flash-es	Message	Code
E-33	33	ECU Hardware (ROM)	P0605
E-33	33	ECU System (EEPROM)	P1605
E-34	82	Injector Circuit 1	P0200
E-34	82	Injector Circuit 2	P1200
E-34	82	Injector Circuit 3	P1210
E-35	41	Fuel Temp. Sensor (inlet) Low	P0182
E-35	41	Fuel Temp. Sensor (inlet) High	P0183
E-36	56	Fuel Temp. Sensor (outlet)	P0187
E-36	56	Fuel Temp. Sensor (outlet)	P0188
E-37	44	INT Air Temp. SNSR (Low)	P0112
E-37	44	INT Air Temp. SNSR (High)	P0113
E-39	34	Q Adjustment Resistor (Low)	P1171
E-39	34	Q Adjustment Resistor (High)	P1172
E-41	25	Vehicle Speed Sensor	P0500
E-42	63	CRS Press M/V 1 (Low)	P1255
E-42	63	CRS Press M/V 1 (High)	P1256
E-42	63	Common Rail Pressure M/V 1	P1257
E-43	67	EGR 1	P1267
E-43	67	EGR 1	P1268
E-44	68	EGR 2	P1272
E-44	68	EGR 2	P1273
E-45	69	EGR 3	P1277
E-45	69	EGR 3	P1278
E-48	26	Relay for Glow Relay	P0380
E-49	48	Starter Safety Relay (Low)	P0616
E-49	48	Starter Safety Relay (High)	P0617

3.2 Diagnostic code generation conditions and inspection items

E-01: Accel Pedal Sensor 1 (warning lamp flashes: 24) P0122

Generation condition		Accelerator pedal position sensor 1 voltage is below standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using accelerator pedal position sensor 2. • If both sensors 1 and 2 are faulty, control is effected on assumption that accelerator pedal is depressed 30% when accelerator switch is on and the pedal is not depressed when the switch is off.
Inspection	Service data	22: Accel Pedal Position (unfiltered), 23: Accel Pedal Position (filtered), 24: Accel Pedal Sensor Voltage 1
	Electronic control unit connector	03: Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor

E-01: Accel Pedal Sensor 1 (warning lamp flashes: 24) P0123

Generation condition		Accelerator pedal position sensor 1 voltage is above standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using accelerator pedal position sensor 2. • If both sensors 1 and 2 are faulty, control is effected on assumption that accelerator pedal is depressed 30% when accelerator switch is on and the pedal is not depressed when the switch is off.
Inspection	Service data	22: Accel Pedal Position (unfiltered), 23: Accel Pedal Position (filtered), 24: Accel Pedal Sensor Voltage 1
	Electronic control unit connector	03: Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor

E-02: Accel Pedal Sensor 2 (warning lamp flashes: 16) P0222

Generation condition		Accelerator pedal position sensor 2 voltage is below standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using accelerator pedal position sensor 1. • If both sensors 1 and 2 are faulty, control is effected on assumption that accelerator pedal is depressed 30% when accelerator switch is on and the pedal is not depressed when the switch is off.
Inspection	Service data	22: Accel Pedal Position (unfiltered), 23: Accel Pedal Position (filtered), 25: Accel Pedal Sensor Voltage 2
	Electronic control unit connector	03: Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor

E-02: Accel Pedal Sensor 2 (warning lamp flashes: 16) P0223

Generation condition		Accelerator pedal position sensor 2 voltage is above standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using accelerator pedal position sensor 1. • If both sensors 1 and 2 are faulty, control is effected on assumption that accelerator pedal is depressed 30% when accelerator switch is on and the pedal is not depressed when the switch is off.
Inspection	Service data	22: Accel Pedal Position (unfiltered), 23: Accel Pedal Position (filtered), 25: Accel Pedal Sensor Voltage 2
	Electronic control unit connector	03: Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor

E-03: Accel SW (warning lamp flashes: 65) P0510

Generation condition		Accelerator pedal switch signal is abnormal when compared with accelerator pedal position sensor outputs 1 and 2.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Normal control is effected using accelerator pedal position sensor signals.
Inspection	Service data	73: Accel SW
	Electronic control unit connector	10: Accelerator pedal switch
	Electrical equipment	#029: Accelerator pedal switch

E-04: Camshaft Position SNSR (warning lamp flashes: 12) P0340

Generation condition		Cylinder recognition sensor emits no pulses.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using engine speed sensor. (If engine speed sensor also becomes faulty, engine is stopped.)
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	08: Cylinder recognition sensor
	Electrical equipment	#320: Cylinder recognition sensor

E-05: Common Rail Pressure Defect (warning lamp flashes: 23) P0254

Generation condition		Common rail pressure is slightly too high (lower than operating pressure of pressure limiter)
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped. (Common rail pressure and injection quantity are limited.)
Inspection	Actuator test	B9: Fuel Leak Check
	Other	• Inspection of fuel piping (See Gr13A.) • Inspection or replacement of supply pump. (Have work performed by DENSO Service Station.) • Pressure limiter (Have work performed by DENSO Service Station.), main body of common rail • Injectors (Have work performed by DENSO Service Station.)

E-05: Common Rail Pressure M/V 1 (warning lamp flashes: 23) P0255

Generation condition		Common rail pressure exceeds standard value for longer than standard period during low-speed use of supply pump.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Normal control
Inspection	Actuator test	B9: Fuel Leak Check
	Other	• Inspection or replacement of supply pump (Have work performed by DENSO Service Station.) • Pressure limiter (Have work performed by DENSO Service Station.), main body of common rail • Injectors (Have work performed by DENSO Service Station.)

E-05: Common Rail Pressure M/V 1 (warning lamp flashes: 23) P0256

Generation condition		Common rail pressure exceeds standard value for longer than standard period during mid-range-speed or high-speed use of supply pump.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. (Common rail pressure and injection quantity are limited.)
Inspection	Other	• Inspection of fuel piping (See Gr13A.) • Inspection or replacement of supply pump. (Have work performed by DENSO Service Station.) • Pressure limiter (Have work performed by DENSO Service Station.), main body of common rail • Injectors (Have work performed by DENSO Service Station.)

E-05: Common Rail Pressure M/V 1 (warning lamp flashes: 23) P0257

Generation condition		Pressure-feed malfunction occurs because of fault in supply pump assembly (fault in one cylinder).
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. (Common rail pressure and injection quantity are limited.)
Inspection	Other	• Inspection or replacement of supply pump (Have work performed by DENSO Service Station.)

E-06: Common Rail Pressure Defect (warning lamp flashes: 36) P0251

Generation condition		Fuel is leaking from high-pressure part of system (calculated value).
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		–
Inspection	Actuator test	B9: Fuel Leak Check
	Other	• Air-bleeding of fuel system (See Gr13A.) • Inspection of fuel piping (from supply pump to common rail) (See Gr13A.) • Fuel filter (See Gr13A.) • Supply pump (Have work performed by DENSO Service Station.), main body of common rail • Pressure limiter (Have work performed by DENSO Service Station.) • Injectors (Have work performed by DENSO Service Station.)

E-06: Common Rail Pressure Defect (warning lamp flashes: 36) P0252

Generation condition		Common rail pressure is too high and fuel leakage (calculated value) exceeds standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		–
Inspection	Actuator test	B9: Fuel Leak Check
	Other	• Air-bleeding of fuel system (See Gr13A.) • Inspection of fuel piping (See Gr13A.) • Fuel filter (See Gr13A.) • Supply pump (Have work performed by DENSO Service Station.) • Pressure limiter (Have work performed by DENSO Service Station.) • Injectors (Have work performed by DENSO Service Station.)

E-07: CRS Pressure SNSR (Plausibility) (warning lamp flashes: 11) P0191

Generation condition		All three conditions listed below are satisfied simultaneously while engine is being cranked or while vehicle is being driven. • Engine speed, injection amount, common rail pressure and fuel type are within specification. • Difference between actual common rail pressure and target common rail pressure is greater than standard value. • Extent of changes in actual common rail pressure is smaller than standard value.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Common rail pressure open loop control is effected. • Exhaust gas recirculation control is stopped.
Inspection	Service data	07: Reference Common Rail Pressure, 09: Actual Common Rail Pressure, 0B: Difference Common Rail Pressure, 0C: Difference Common Rail Pressure
	Electrical equipment	#319: Common rail pressure sensor

E-07: CRS Pressure SNSR (Low) (warning lamp flashes: 11) P0192

Generation condition		Common rail pressure sensor voltage is below standard value (0.7 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Common rail pressure open loop control is effected. • Exhaust gas recirculation control is stopped.
Inspection	Service data	07: Reference Common Rail Pressure, 09: Actual Common Rail Pressure, 0B: Difference Common Rail Pressure, 0C: Difference Common Rail Pressure
	Electrical equipment	#319: Common rail pressure sensor

E-07: CRS Pressure SNSR (High) (warning lamp flashes: 11) P0193

Generation condition		Common rail pressure sensor voltage is above standard value (4.95 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Common rail pressure open loop control is effected. • Exhaust gas recirculation control is stopped.
Inspection	Service data	07: Reference Common Rail Pressure, 09: Actual Common Rail Pressure, 0B: Difference Common Rail Pressure, 0C: Difference Common Rail Pressure
	Electrical equipment	#319: Common rail pressure sensor

E-08: Accel Pedal Check (Plausibility) (warning lamp flashes: 58) P0121

Generation condition		Output voltage difference of accelerator pedal position sensors 1 and 2 is outside standard range.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is effected using value of 30% with accelerator pedal depressed and using value of 0% with accelerator pedal not depressed. (Output is reduced.)
Inspection	Service data	22: Accel Pedal Position (unfiltered), 23: Accel Pedal Position (filtered), 24: Accel Pedal Sensor Voltage 1, 25: Accel Pedal Sensor Voltage 2
	Electronic control unit connector	03: Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor

E-09: Injector M/V - Cylinder1 (Load) (warning lamp flashes: 37) P0201

Generation condition		Injector magnetic valve (No. 1 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BB: Injector Test 1
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-10: Injector M/V - Cylinder2 (Load) (warning lamp flashes: 38) P0202

Generation condition		Injector magnetic valve (No. 2 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BF: Injector Test 5
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-11: Injector M/V - Cylinder3 (Load) (warning lamp flashes: 39) P0203

Generation condition		Injector magnetic valve (No. 3 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BD: Injector Test 3
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-12: Injector M/V - Cylinder4 (Load) (warning lamp flashes: 08) P0204

Generation condition		Injector magnetic valve (No. 4 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	C0: Injector Test 6
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-13: Injector M/V - Cylinder5 (Load) (warning lamp flashes: 46) P0205

Generation condition		Injector magnetic valve (No. 5 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BC: Injector Test 2
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-14: Injector M/V - Cylinder6 (Load) (warning lamp flashes: 47) P0206

Generation condition		Injector magnetic valve (No. 6 cylinder) is short-circuited or open-circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Fuel injection stopped for faulty cylinder • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BE: Injector Test 4
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-15: Flow Limiter - Cylinder1 (warning lamp flashes: 71) P1240

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	43: Flow Limiter (#1)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-16: Flow Limiter - Cylinder2 (warning lamp flashes: 72) P1241

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	44: Flow Limiter (#2)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-17: Flow Limiter - Cylinder3 (warning lamp flashes: 73) P1242

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	45: Flow Limiter (#3)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-18: Flow Limiter - Cylinder4 (warning lamp flashes: 74) P1243

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	46: Flow Limiter (#4)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-19: Flow Limiter - Cylinder5 (warning lamp flashes: 75) P1244

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	47: Flow Limiter (#5)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-20: Flow Limiter - Cylinder6 (warning lamp flashes: 76) P1245

Generation condition		Inter-cylinder injection amount correction value (FCCB) is higher than standard value and fluctuation in engine speed is greater than standard value.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		FCCB learning is disabled.
Inspection	Service data	48: Flow Limiter (#6)
	Other	• Flow damper (Have work performed by DENSO Service Station.)

E-24: Engine Revolution SNSR (warning lamp flashes: 15) P0335

Generation condition		Engine speed sensor emits no pulses.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected using cylinder recognition sensor. (If cylinder recognition sensor also becomes faulty, engine is stopped.)
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	07: Engine speed sensor
	Electrical equipment	#263: Engine speed sensor

E-25: Engine Overrunning (warning lamp flashes: 07) P0219

Generation condition		Engine speed is higher than specified level.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Common rail system is deactivated (engine stopped immediately).
Inspection	Electrical equipment	Engine electronic control unit

E-26: Boost Press SNSR (Low) (warning lamp flashes: 32) P0237

Generation condition		Boost pressure sensor voltage is below standard value (0.3 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is effected with boost pressure assumed as constant 101 kPa {1.03 kgf/cm^2}.
Inspection	Service data	26: Boost Pressure
	Electrical equipment	#318: Boost pressure sensor

E-26: Boost Press SNSR (High) (warning lamp flashes: 32) P0238

Generation condition		Boost pressure sensor voltage is above standard value (4.7 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is effected with boost pressure assumed as constant 101 kPa {1.03 kgf/cm^2}.
Inspection	Service data	26: Boost Pressure
	Electrical equipment	#318: Boost pressure sensor

E-28: Common Rail Pressure Defect (warning lamp flashes: 22) P0253

Generation condition		Common rail pressure is abnormally high (above 245 MPa (higher than operating pressure of pressure limiter))
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		Common rail system is deactivated (engine stopped immediately).
Inspection	Other	• Inspection of fuel piping (See Gr13A.) • Inspection or replacement of supply pump. (Have work performed by DENSO Service Station.) • Pressure limiter (Have work performed by DENSO Service Station.), main body of common rail • Injectors (Have work performed by DENSO Service Station.)

E-29: Atmospheric Pressure Sensor (warning lamp flashes: 19) P0107

Generation condition		Atmospheric pressure sensor (incorporated into engine electronic control unit) voltage is below standard value (1.9 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected with atmospheric pressure assumed as constant 101 kPa {1.03 kgf/cm^2}. (Exhaust emissions worsen.) • Exhaust gas recirculation control is stopped.
Inspection	Service data	38: Atmospheric Pressure
	Electrical equipment	Engine electronic control unit

E-29: Atmospheric Pressure Sensor (warning lamp flashes: 19) P0108

Generation condition		Atmospheric pressure sensor (incorporated into engine electronic control unit) voltage is above standard value (4.7 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control is effected with atmospheric pressure assumed as constant 101 kPa {1.03 kgf/cm^2}. (Exhaust emissions worsen.) • Exhaust gas recirculation control is stopped.
Inspection	Service data	38: Atmospheric Pressure
	Electrical equipment	Engine electronic control unit

E-30: CAN Communication (warning lamp flashes: –) P0600

Generation condition		Error occurs in CAN communication with machinery side electronic control unit.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Engine speed is limited.
Inspection	Service data	4A: Speed Limiter Reference Speed
	Other	• Combination of engine electronic control unit and machinery side electronic control unit is confirmed. • Vehicle speed sensor error is confirmed.

E-32: Water Temp SNSR (Low) (warning lamp flashes: 21) P0117

Generation condition		Water temperature sensor voltage is below standard value (0.1 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Water temperature is assumed as constant –20°C during engine startup and as constant 80°C while vehicle is being driven. (Exhaust emissions worsen.) • Exhaust gas recirculation control is stopped.
Inspection	Service data	35: Water Temperature
	Electronic control unit connector	02: Water temperature sensor
	Electrical equipment	#262: Water temperature sensor

E-32: Water Temp SNSR (High) (warning lamp flashes: 21) P0118

Generation condition		Water temperature sensor voltage is above standard value (4.8 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Water temperature is assumed as constant –20°C during engine startup and as constant 80°C while vehicle is being driven. (Exhaust emissions worsen.) • Exhaust gas recirculation control is stopped.
Inspection	Service data	35: Water Temperature
	Electronic control unit connector	02: Water temperature sensor
	Electrical equipment	#262: Water temperature sensor

E-33: ECU Hardware (ROM) (warning lamp flashes: 33) P0605

Generation condition		Main CPU in electronic control unit is abnormal.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Common rail system control is disabled (engine is stopped immediately) if mutual diagnoses of main CPU and sub CPU become impossible.
Inspection	Other	Engine electronic control unit

E-33: ECU System (EEPROM) (warning lamp flashes: 33) P1605

Generation condition		CPU in engine electronic control unit is faulty.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		Common rail system control is disabled (engine is stopped immediately) if mutual diagnoses of main CPU and sub CPU become impossible.
Inspection	Other	Engine electronic control unit

E-34: Injector Circuit 1 (warning lamp flashes: 82) P0200

Generation condition		Either one of injector magnetic valves (No. 1, 2 or 3 cylinder) is short-circuited, or open-circuited.
Recoverability		• When short-circuited: System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON. • When open-circuited: System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		<When short-circuited> • Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled. <When open-circuited> • Exhaust gas recirculation control stopped. • Inter-cylinder injection amount correction valve (FCCB) learning disabled.
Inspection	Actuator test	BB: Injector Test 1, BD: Injector Test 3, BF: Injector Test 5
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-34: Injector Circuit 2 (warning lamp flashes: 82) P1200

Generation condition		Either one injector magnetic valves (No. 4, 5 or 6 cylinder) is short-circuited, or open-circuited.
Recoverability		• When short-circuited: System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON. • When open-circuited: System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		<When short-circuited> • Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped. • FCCB learning disabled. <When open-circuited> • Auto cruise control stopped. • Exhaust gas recirculation control stopped. • FCCB learning disabled.
Inspection	Actuator tests	BC: Injector Test 2, BE: Injector Test 4, C0: Injector Test 6
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve

E-34: Injector Circuit 3 (warning lamp flashes: 82) P1210

Generation condition		Injector drive circuit voltage in engine electronic control unit is too low or too high.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		<Too low voltage> • Common rail pressure lower limit provided. • Idling speed is increased. • FCCB learning disabled. • Drive with the constant current. <Too high voltage> • Common rail system control is disabled (engine is stopped immediately).
Inspection	Actuator tests	BB: Injector Test 1, BD: Injector Test 2, BD: Injector Test 3, BE: Injector Test 4, BF: Injector Test 5, C0: Injector Test 6
	Electronic control unit connector	06: Injector magnetic valve
	Electrical equipment	#582: Injector magnetic valve
	Other	Engine electronic control unit

E-35: Fuel Temp. Sensor (inlet) Low (warning lamp flashes: 41) P0182

Generation condition		Fuel temperature sensor (inlet) voltage is below standard value (0.1 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Fuel temperature is assumed to be constant 40°C.
Inspection	Service data	36: Fuel Temperature (inlet)
	Electronic control unit connector	04: Fuel temperature sensor (inlet)
	Electrical equipment	#323: Fuel temperature sensor (inlet)

E-35: Fuel Temp. Sensor (inlet) High (warning lamp flashes: 41) P0183

Generation condition		Fuel temperature sensor voltage is above standard value (4.8 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Fuel temperature is assumed to be constant 40°C.
Inspection	Service data	36: Fuel Temperature (inlet)
	Electronic control unit connector	04: Fuel temperature sensor (inlet)
	Electrical equipment	#323: Fuel temperature sensor (inlet)

E-36: Fuel Temp. Sensor (outlet) (warning lamp flashes: 56) P0187

Generation condition		Fuel temperature sensor (outlet) voltage is below standard value (0.1 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Fuel temperature is assumed as constant 40°C during engine startup and as constant 80°C while vehicle is being driven.
Inspection	Service data	37: Fuel Temperature
	Electronic control unit connector	05: Fuel temperature sensor (outlet)
	Electrical equipment	#323: Fuel temperature sensor (outlet)

E-36: Fuel Temp. Sensor (outlet) (warning lamp flashes: 56) P0188

Generation condition		Fuel temperature sensor (outlet) voltage is above standard value (4.8 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Fuel temperature is assumed as constant 40°C during engine startup and as constant 80°C while vehicle is being driven.
Inspection	Service data	37: Fuel Temperature
	Electronic control unit connector	05: Fuel temperature sensor (outlet)
	Electrical equipment	#323: Fuel temperature sensor (outlet)

E-37: INT Air Temp. SNSR (Low) (warning lamp flashes: 44) P0112

Generation condition		Intake air temperature sensor voltage is below standard value (0.1 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Boost air temperature is assumed as constant –20°C during engine startup and as constant 25°C while vehicle is being driven.
Inspection	Service data	27: Intake Air Temperature
	Electronic control unit connector	01: Intake air temperature sensor
	Electrical equipment	#305: Intake air temperature sensor

E-37: INT Air Temp. SNSR (High) (warning lamp flashes: 44) P0113

Generation condition		Intake air temperature sensor voltage is above standard value (4.8 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Boost air temperature is assumed as constant –20°C during engine startup and as constant 25°C while vehicle is being driven.
Inspection	Service data	27: Intake Air Temperature
	Electronic control unit connector	01: Intake air temperature sensor
	Electrical equipment	#305: Intake air temperature sensor

E-39: Q Adjustment Resistor (Low) (warning lamp flashes: 34) P1171

Generation condition		Fuel injection rate adjustment resistor voltage is below standard value (0.6 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is effected using fuel injection rate adjustment resistor No. 1. (Output is slightly reduced.)
Inspection	Service data	3E: Q Adjustment Resistor No.
	Electronic control unit connector	11: Fuel injection rate adjustment resistor
	Electrical equipment	#828: Fuel injection rate adjustment resistor

E-39: Q Adjustment Resistor (High) (warning lamp flashes: 34) P1172

Generation condition		Fuel injection rate adjustment resistor voltage is above standard value (4.36 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is effected using fuel injection rate adjustment resistor No. 1. (Output is slightly reduced.)
Inspection	Service data	3E: Q Adjustment Resistor No.
	Electronic control unit connector	11: Fuel injection rate adjustment resistor
	Electrical equipment	#828: Fuel injection rate adjustment resistor

E-41: Vehicle Speed Sensor (warning lamp flashes: 25) P0500

Generation condition		No vehicle speed sensor signal is received.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Engine speed is limited
Inspection	Service data	3C: Vehicle Speed

E-42: CRS Press M/V 1 (Low) (warning lamp flashes: 63) P1255

Generation condition		SCV (suction control valve) is short-circuited to ground, or open circuited, or coil is broken.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped.
Inspection	Actuator test	B9: Fuel Leak Check
	Electronic control unit connector	12: SCV (suction control valve)
	Electrical equipment	#574: SCV (suction control valve)

E-42: CRS Press M/V 1 (High) (warning lamp flashes: 63) P1256

Generation condition		SCV (suction control valve) is shorted to power supply circuit.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped.
Inspection	Actuator test	B9: Fuel Leak Check
	Electronic control unit connector	12: SCV (suction control valve) system
	Electrical equipment	#574: SCV (suction control valve) system

E-42: Common Rail Pressure M/V 1 (warning lamp flashes: 63) P1257

Generation condition		SCV (suction control valve) binds and fails to operate.
Recoverability		System recovers (power is re-supplied to electronic control unit) if signal becomes normal when starter switch is turned OFF → ON.
Control effected by electronic control unit		• Main injections only enabled. • Common rail pressure upper limit provided. • Injection rate limited to predetermined value. • Exhaust gas recirculation control stopped.
Inspection	Actuator test	B9: Fuel Leak Check
	Electronic control unit connector	12: SCV (suction control valve)
	Electrical equipment	#574: SCV (suction control valve)

E-43: EGR 1 (warning lamp flashes: 67) P1267

Generation condition		Exhaust gas recirculation solenoid valve (M/V-1) is shorted-circuited to ground, or open circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A1: EGR 1
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-43: EGR 1 (warning lamp flashes: 67) P1268

Generation condition		Exhaust gas recirculation solenoid valve (M/V-1) is shorted to power supply circuit.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A1: EGR 1
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-44: EGR 2 (warning lamp flashes: 68) P1272

Generation condition		Exhaust gas recirculation solenoid valve (M/V-2) is shorted-circuited to ground, or open circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A2: EGR 2
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-44: EGR 2 (warning lamp flashes: 68) P1273

Generation condition		Exhaust gas recirculation solenoid valve (M/V-2) is shorted to power supply circuit.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A2: EGR 2
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-45: EGR 3 (warning lamp flashes: 69) P1277

Generation condition		Exhaust gas recirculation solenoid valve (M/V-3) is shorted-circuited to ground, or open circuited.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A3: EGR 3
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-45: EGR 3 (warning lamp flashes: 69) P1278

Generation condition		Exhaust gas recirculation solenoid valve (M/V-3) is shorted to power supply circuit.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas recirculation control is stopped.
Inspection	Service data	1F: EGR Position
	Actuator test	A3: EGR 3
	Electrical equipment	#530: Exhaust gas recirculation solenoid valve

E-48: Relay for Glow Relay (warning lamp flashes: 26) P0380

Generation condition		Glow drive relay is short-circuited or open circuited or overload.
Recoverability		System recovers if signal becomes normal with starter switch ON position.
Control effected by electronic control unit		• Suspend glow control
Inspection	Service data	8D: Glow relay
	Actuator test	AF: Relay for glow relay
	Electronic control unit connector	13: Glow drive relay
	Electrical equipment	#201: Glow drive relay

E-49: Starter Safety Relay (Low) (warning lamp flashes: 48) P0616

Generation condition		Safety relay is shorted to power supply circuit.
Recoverability		System recovers if signal becomes with starter switch ON position.
Control effected by electronic control unit		• Continuous energization prevention function suspended.
Inspection	Service data	8F: Starter safety relay
	Actuator test	B1: Starter safety relay
	Electronic control unit connector	14: Safety relay
	Electrical equipment	#201: Safety relay

E-49: Starter Safety Relay (High) (warning lamp flashes: 48) P0617

Generation condition		Safety relay is short-circuited to ground circuit, or open circuited.
Recoverability		System recovers if signal becomes with starter switch ON position.
Control effected by electronic control unit		Continuous energization prevention function suspended.
Inspection	Service data	8F: Starter safety relay
	Actuator test	B1: Starter safety relay
	Electronic control unit connector	14: Safety relay
	Electrical equipment	#201: Safety relay

4. Multi-Use Tester Service Data

- It is possible to see service data and actuator tests simultaneously.

No.	Item	Data	Inspection condition	Requirement
01	Engine Revolution	■■■■.rpm	Racing (engine running)	Value corresponds to tachometer indication.
02	Reference Injection Quantity	■■■.■ %	Starter switch ON	0%
07	Reference Common Rail Pressure	■■■.■ %	Starter switch ON	20 to 30%
09	Actual Common Rail Pressure	■■■.■ %	Starter switch ON	0%
0B	Difference Common Rail Pressure	■■■.■ MPa	Engine idling	0 MPa or lower
0C	Difference Common Rail Pressure	■■■.■ %	Engine idling	0% or lower
1F	EGR Position	■■■.■ STEP	Idling	0%
			[Actuator test] A1: EGR 1, A2: EGR 2, A3: EGR 3	
22	Accel Pedal Position (unfiltered)	■■■.■ %	Accelerator pedal not depressed	0%
			Accelerator pedal gradually depressed	Value gradually increases.
			Accelerator pedal fully depressed	100%
23	Accel Pedal Position (filtered)	■■■.■ %	Accelerator pedal not depressed	0%
			Accelerator pedal gradually depressed	Value gradually increases.
			Accelerator pedal fully depressed	100%
24	Accel Pedal Sensor Voltage 1	■.■■■ V	Accelerator pedal gradually depressed from released position	0.85 to 4.15 V
25	Accel Pedal Sensor Voltage 2	■.■■■ V	Accelerator pedal gradually depressed from released position	0.85 to 4.15 V
26	Boost Pressure	■■■.■ KPa (■■■.■ inHg)	Starter switch On (engine stopped)	Equal to atmospheric pressure
			Press the accelerator pedal down after starting the engine	Gradual raise
27	Intake Air Temperature	■■■.■ °C (■■■.■ °F)	Engine cold	Value corresponds to ambient temperature.
35	Water Temperature	■■■.■ °C (■■■.■ °F)	Engine cold	Value corresponds to ambient temperature.
			Engine in process of warming up	Value gradually increases.
			Engine stopped after warming up	Value gradually decreases.
36	Fuel Temperature (inlet)	■■■.■ °C (■■■.■ °F)	Engine cold	Value corresponds to ambient temperature.
			Engine in process of warming up	Value gradually increases.
			Engine stopped after warming up	Value gradually decreases.
37	Fuel Temperature	■■■.■ °C (■■■.■ °F)	Engine cold	Value corresponds to ambient temperature.
			Engine in process of warming up	Value gradually increases.
			Engine stopped after warming up	Value gradually decreases.
38	Atmospheric Pressure	■■■.■ KPa (■■■.■ inHg)	Altitude: 0 m	101 KPa (29.8 in.Hg)
			Altitude: 600 m	95 KPa (28.1 in.Hg)
3C	Vehicle Speed	■■■■ .km/h (■■■■.MPH)	Vehicle in motion	Value corresponds to speedometer indication.

No.	Item	Data	Inspection condition	Requirement
3E	Q Adjustment Resistor No.	1/2/3/4/5/6/7/8/9/10/11/NON	–	Number matches number marked on fuel injection rate adjustment resistor.
42	Power Supply Voltage	■■.■■ V	Starter switch ON	Value matches battery voltage.
43	Flow Limiter (#1)	■■■■.	Starter switch ON	0
44	Flow Limiter (#2)	■■■■.	Starter switch ON	0
45	Flow Limiter (#3)	■■■■.	Starter switch ON	0
46	Flow Limiter (#4)	■■■■.	Starter switch ON	0
47	Flow Limiter (#5)	■■■■.	Starter switch ON	0
48	Flow Limiter (#6)	■■■■.	Starter switch ON	0
4A	Speed Limiter Reference Speed	■■■■.km/h (■■■■.MPH)	Vehicle speed limited	Value is same as vehicle speed during vehicle speed restriction.
4D	Pump Adjustment State	■■■■.	Engine idling	It is adjusting or Temporary end or Complete end.
52	Pump Adjustment Value (Last Time)	■■■.■ mA	Engine idling	–100 to + 100 mA
53	Pump Adjustment Value (This Time)	■■■.■ mA	Engine idling	–100 to + 100 mA
72	Starter SW (M)	ON/OFF	Starter Switch in ON position	ON
			Starter switch in position except ON	OFF
73	Accel SW	ON/OFF	Accelerator pedal not depressed	ON
			Accelerator pedal depressed	OFF
83	Diagnostic SW	ON/OFF	Diagnostic switch OFF (fuse fitted)	ON
			Diagnostic switch ON (fuse removed)	OFF
84	Memory Clear SW	ON/OFF	Memory clear switch OFF (fuse fitted)	ON
			Memory clear switch ON (fuse removed)	OFF
8D	Glow relay	ON/OFF	Actuator test is performed	ON
			Actuator test is not performed	OFF
			[Actuator test] AF: Relay for glow relay	
8E	Glow relay indicator lamp	ON/OFF	Actuator test is performed	ON
			Actuator test is not performed	OFF
			[Actuator test] B0: Glow indicator lamp	
8F	Starter safety relay	ON/OFF	Actuator test is performed	ON
			Actuator test is not performed	OFF
			[Actuator test] B1: Starter safety relay	
91	MIL Lamp	ON/OFF	Starter switch ON (engine not started)	ON
			No error after engine startup	OFF
			[Actuator test] B3: MIL Lamp	
92	Diagnostic Lamp	ON/OFF	Starter switch ON (engine not started)	ON
			No error after engine startup	OFF
			[Actuator test] B4: Diagnostic Lamp	

5. Reading and Erasing Diagnostic Trouble Codes

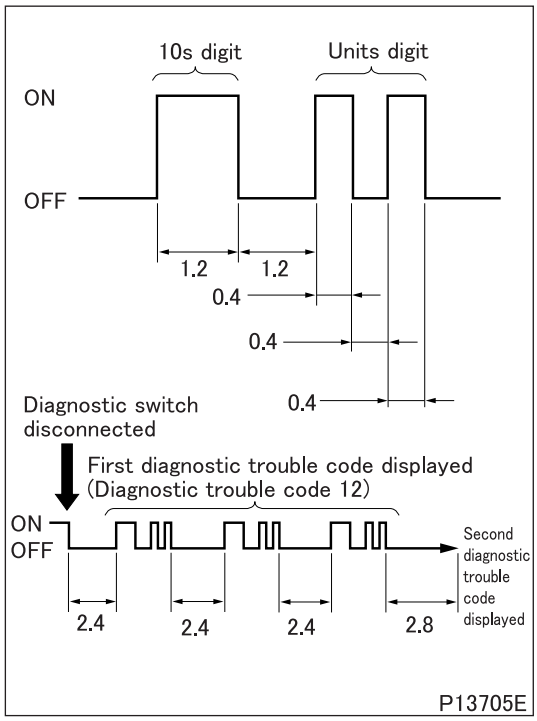
Up-Time or Multi-Use Tester III is used to read or erase the diagnostic trouble code. And also, a method using the diagnostic switch and memory clear switch without these tools is available.

5.1 Method using Up-Time or Multi-Use Tester III

Refer to each service tool manual.

(1) Current diagnostic trouble code

- Set the starting switch to ON.
- Disconnect the diagnostic switch connector.
- The diagnostic trouble code is displayed by flashes of the warning lamp.

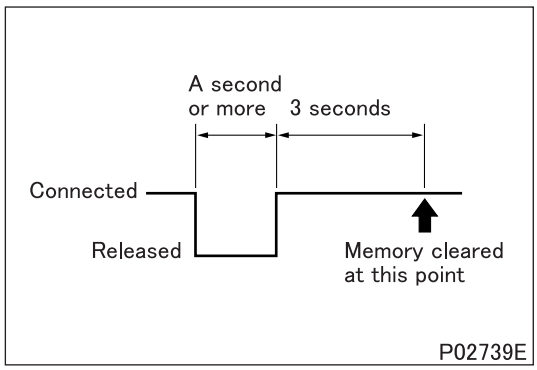


(2) Reading diagnostic trouble code

- Diagnostic trouble codes are indicated by the number of times the warning lamp flashes and their duration.
  - The flashing intervals also differ between the 10s digit and units digit.
  - 10s digit: 1.2 second interval
  - Units digit: 0.4 second interval
- The display of diagnostic trouble codes starts from the 10s digit and next units digit. When the 10s digit of a diagnostic trouble code is 0, only the units code is displayed.
- Some diagnostic trouble codes are displayed from the 10s unit in numeral followed by alphabet in place of the numeral for the units digit, in which case alphabetical letters are represented by the following numbers flashes.
  A: 10 times; B: 11 times; C: 12 times; D: 13 times;
  E: 14 times; F: 15 times
  Example)
  Diagnostic trouble code 8A. The lamp flashes 8 times for the 10s digit, followed by 10 times for A as the unit's digit.
- Each diagnostic trouble code is displayed three times in succession.
- If there is no more code stored, the sequence is then repeated from the beginning with each code indicated three times.
- When the diagnostic switch is connected, the engine control unit will immediately stop displaying codes.

(3) Past diagnostic trouble codes

- After reading the current diagnostic trouble codes (with the diagnostic switch disconnected), disconnect the memory clear switch. Then the warning lamp will restart flashing.
- This time, the warning lamp displays the past diagnostic trouble codes. Determine the fault locations based on the indicated codes.



(4) Erasing diagnostic trouble codes

Disconnect the memory clear switch connector and then reconnect. Then all the diagnostic trouble codes stored in the engine control unit will be cleared.

NOTE

- **Pay attention that the stored codes can be erased only by the operation of memory clear switch.**
- **When you want to keep the memory contents after the indication of stored codes, leave the memory clear switch disconnected and turn the starter switch in the off position. Then connect the memory clear switch connector.**
- **When you change the combination of the injection pump and engine control unit, you must rewrite the pump data stored in the engine control unit. For this purpose, be sure to perform the diagnostic trouble code erasing procedure.**

6. Actuator Tests Performed Using Multi-Use Tester

- **It is possible to see service data and actuator tests simultaneously.**

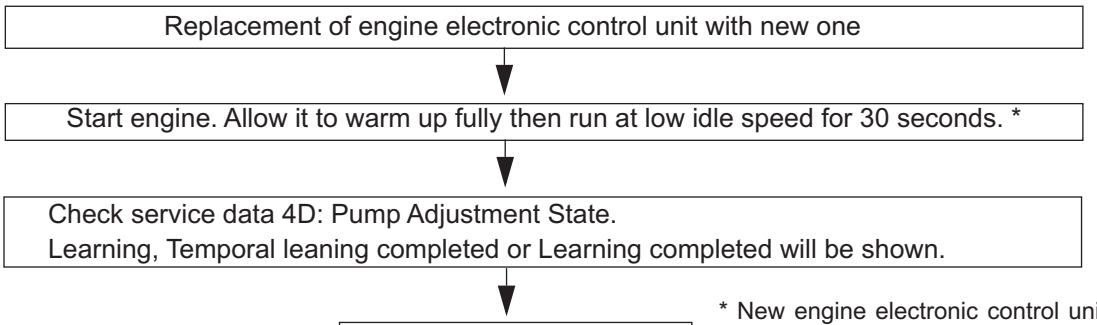
No.	Item	Explanation	Confirmation method
A1	EGR 1	Switch ON/OFF exhaust gas recirculation solenoid valve (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: Stopped	Operating sound of exhaust gas recirculation solenoid valve when turned ON/OFF [Service data] 1F: EGR Position
A2	EGR 2		
A3	EGR 3		
AF	Relay for glow relay	Switch ON/OFF grow drive relay (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: Stopped	Operating sound of glow drive relay when turned ON/OFF [Service data] 8D: Glow Relay
B0	Glow indicator lamp	Switch ON/OFF glow indicator lamp (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: Stopped	ON/OFF condition of indicator lamp [Service data] 8E: Glow Relay Indicator Lamp
B1	Starter safety relay	Switch ON/OFF safety relay (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: Stopped	Operating sound of safety relay when turned ON/OFF [Service data] 8F: Starter Safety Relay
B3	MIL Lamp	Switch ON/OFF engine warning lamp (orange) (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: Stopped	ON/OFF condition of warning lamp (orange) [Service data] 91: MIL Lamp
B4	Diagnostic Lamp	Switch ON/OFF engine warning lamp (red) (automatic reset after six seconds) [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Starter switch: ON • Engine: stopped	ON/OFF condition of warning lamp (red) [Service data] 92: Diagnostic Lamp

No.	Item	Explanation	Confirmation method
B9	Fuel Leak Check	Increase rail pressure for a specified six seconds [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Transmission: neutral • Diagnostic switch: OFF (removal of fuse)	Check that no fuel leaks from fuel system (pipe, hose)
BB	Injector Test 1	Force the selected injector magnetic valve to be deactivated. [Can be executed under the following conditions] • Vehicle: stopped (vehicle speed 0 km/h) • Transmission: neutral • No present diagnostic codes generated	Injector magnetic valve (No.1 cylinder) should stop.
BC	Injector Test 2		Injector magnetic valve (No.5 cylinder) should stop.
BD	Injector Test 3		Injector magnetic valve (No.3 cylinder) should stop.
BE	Injector Test 4		Injector magnetic valve (No.6 cylinder) should stop.
BF	Injector Test 5		Injector magnetic valve (No.2 cylinder) should stop.
C0	Injector Test 6		Injector magnetic valve (No.4 cylinder) should stop.
C2	Pump Adjustment Value Clear	Delete the compensation information (pump learning condition) in engine electronic control unit	The service data “4D: Pump Adjustment State” displays “Unlearned”

7. Initialization of Supply Pump Unit Difference Learning Value in Engine Electronic Control Unit

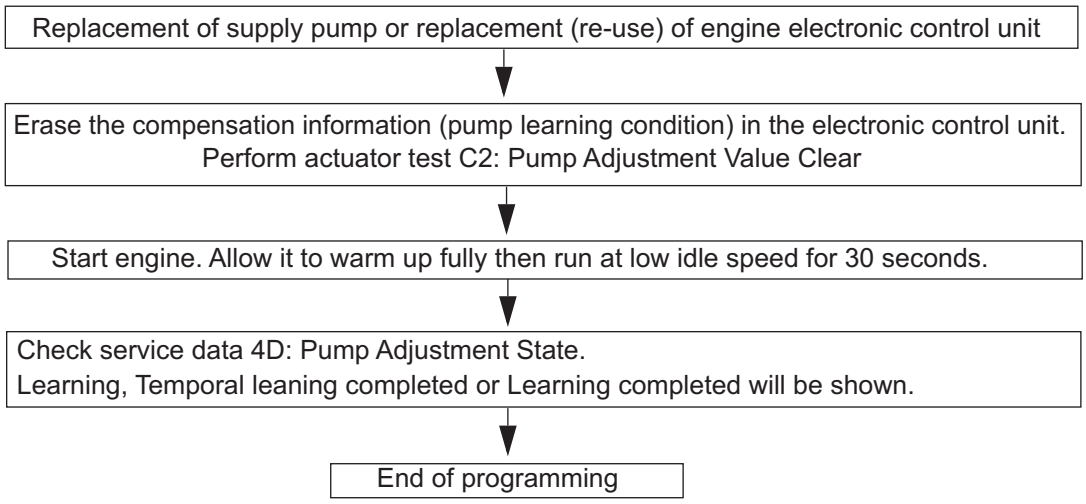
- Following replacement of the engine electronic control unit or the supply pump, this item is used to program the current supply pump data into the engine electronic control unit.

7.1 After replacement of engine electronic unit with new one



* New engine electronic control unit starts auto learning when the truck is in a halt condition, engine low-idling, fuel temperature between 20 and 80˚C (68 and 176˚F) and water temperature 65˚C (149˚F) or higher without any defect.

7.2 After re-installing of other truck's engine electronic control unit or replacement of supply pump without replacing engine electronic control unit. (This operation is available with Multi-Use tester-III.)



7.3 Check after engine electronic control unit programming

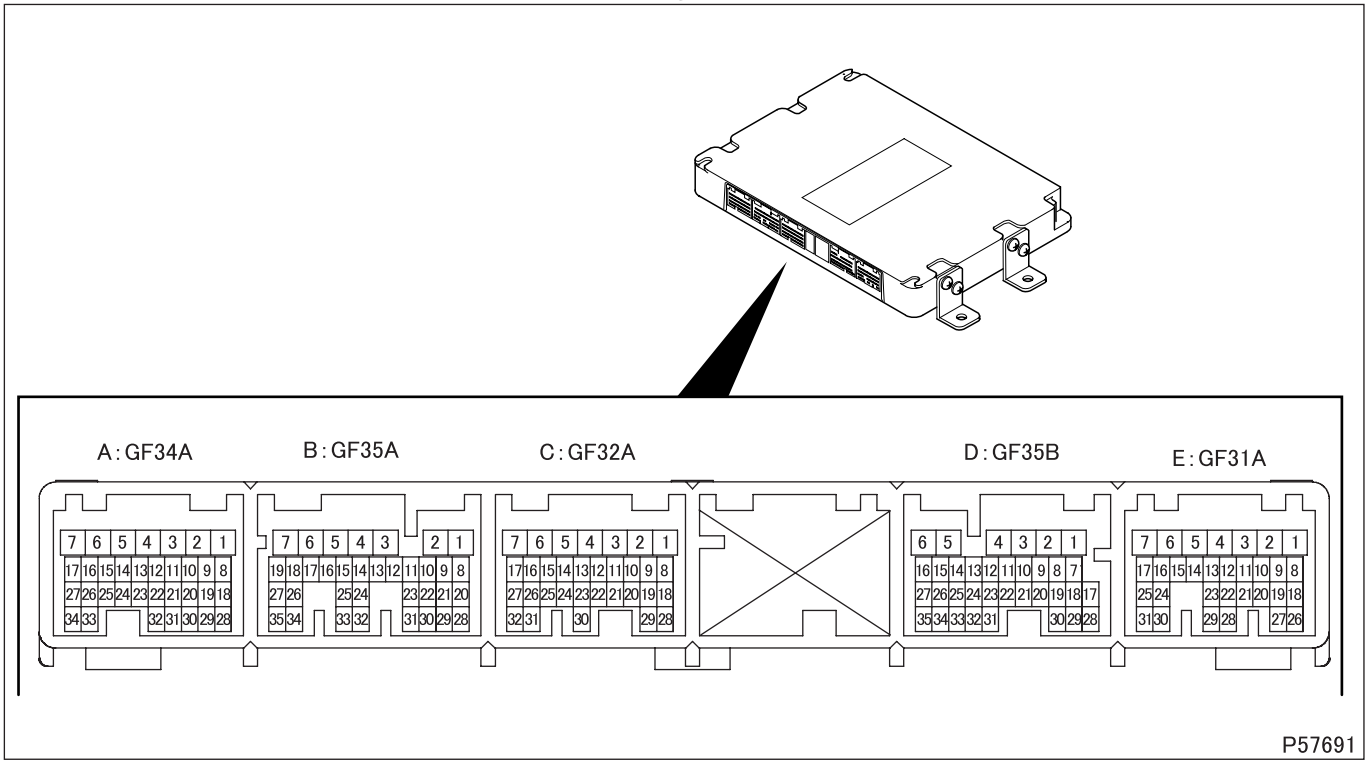
If the measurement values (which show the learning values) shown by service data 52: Pump Adjustment Value (Last Time) and 53: Pump Adjustment Value (This Time) are out of specification, a defect in the supply pump or in the engine electronic control unit is conceivable so you must replace the supply pump or engine electronic control unit. (Initialize the engine electronic control unit again after replacing the supply pump or engine electronic control unit.)

- New engine electronic control unit starts automatic pump adjustment after engine warming-up and various conditions satisfied. To replace the supply pump and engine electronic control unit, complete all the replacement jobs other than the replacement of engine electronic control unit. Then replace the new unit.

8. Inspections Performed at Electronic Control Unit Connectors

- These inspections aid troubleshooting by enabling you to check whether electronic control unit signals are being correctly transmitted via the vehicle harness and connectors.
  The white-on-black numbers (01 , 02 , and so on) correspond to the similarly printed reference numbers in section "**3. Inspections based on diagnostic codes**".

8.1 Electronic control unit connector terminal layout



8.2 Inspection instructions

- Some inspections are performed with the connectors removed. Others are performed with the connectors fitted. Observe the following caution:

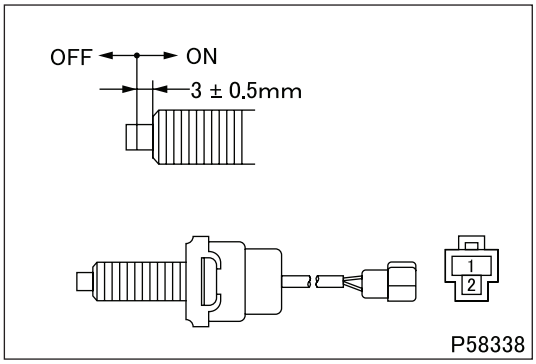
CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**
- **When the supply pump has been replaced, perform the "Initialization of supply pump unit difference learning value" using the MUT and erase the compensation information (pump learning condition) in the ECU.**

Check item	Measurement method
01 Resistance of intake air temperature sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: E25-B26 • 0°C: 5.88 ± 0.588 kΩ • 20°C: 2.45 ± 0.245 kΩ • 80°C: 0.322 ± 0.0483 kΩ
02 Resistance of water temperature sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: E24-B26 • 20°C: 2.45 ± 0.14 kΩ • 80°C: 0.32 kΩ (reference value) • 110°C: 147.1 ± 2 Ω (reference value)

Check item	Measurement method
03 Output voltage of accelerator pedal position sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–) A24-D30 (accelerator pedal position sensor 1) A23-D28 (accelerator pedal position sensor 2) • With accelerator pedal not depressed: 0.85 ± 0.1 V • With accelerator pedal depressed: 4.15 ± 0.1 V
04 Resistance of fuel temperature sensor (inlet)	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: E30-B27 • –20°C: 15.0 ± 1.5 kΩ • 20°C: 2.45 ± 0.24 kΩ • 80°C: 0.318 ± 0.008 kΩ
05 Resistance of fuel temperature sensor (outlet)	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: E31-B26 • 20°C: $2.45^{+0.14}_{-0.13}$ kΩ • 80°C: 0.318 ± 0.01 kΩ • 110°C: 0.1417 ± 0.01 kΩ
06 Resistance of injector magnetic valve	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: D1 or D2-D5 (injector magnetic valve: No. 1 cylinder) D1 or D2-D3 (injector magnetic valve: No. 2 cylinder) D1 or D2-D4 (injector magnetic valve: No. 3 cylinder) E1 or E2-E5 (injector magnetic valve: No. 4 cylinder) E1 or E2-E7 (injector magnetic valve: No. 5 cylinder) E1 or E2-E6 (injector magnetic valve: No. 6 cylinder) • 0.45 ± 0.1 Ω (20°C)
07 Resistance of engine speed sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B2-B1 • 125.5 ± 17 Ω (20°C)
08 Output of cylinder recognition sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: D31-D33 (+5 V to GND) • 200 to 1800 Ω (Resistance serves as rough indication only. Pulse output monitor is needed for confirmation of functionality.)
09 Continuity of accelerator pedal switch	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] • Terminals: B20 and chassis earth • With accelerator pedal depressed: no continuity is found. • With accelerator pedal not depressed: continuity is found.

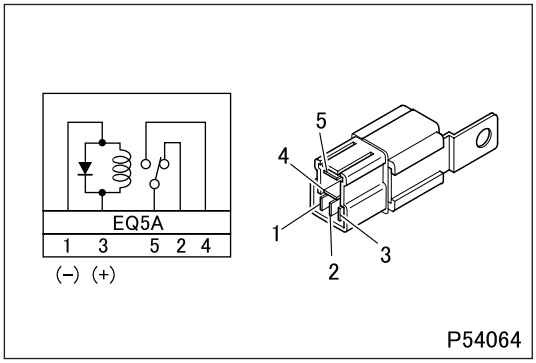
Check item	Measurement method
10 Resistance of fuel injection rate adjustment resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B35-B27 • No. 1 resistor: 270 ± 13.5 Ω • No. 2 resistor: 510 ± 25.5 Ω • No. 3 resistor: 820 ± 41 Ω • No. 4 resistor: 1300 ± 65 Ω • No. 5 resistor: 2000 ± 100 Ω • No. 6 resistor: 3300 ± 165 Ω • No. 7 resistor: 5600 ± 280 Ω • No. 8 resistor: 15000 ± 750 Ω • No. 9 resistor: 390 ± 19.5 Ω • No. 10 resistor: 4300 ± 215 Ω • No. 11 resistor: 9100 ± 455 Ω
11 Resistance of SCV (suction control valve)	[Conditions] Starter switch OFF Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: E14-E16, E14-E17, E15-E16, E15-E17 • 7.9 ± 0.2 Ω
12 Glow drive relay voltage	[Conditions] • Keep the vehicle harnesses connected to the electronic control unit connector halves. (Inspection is made at the back of the vehicle connectors.) • Carry out the actuator test ‘‘AF-Relay for Glow Relay” using Multi-Use Tester. [Normal status] Terminals (+)-(–): C7 and body earth • Battery voltage
13 Safety relay voltage	[Conditions] • Keep the vehicle harnesses connected to the electronic control unit connector halves. (Inspection is made at the back of the vehicle connectors.) [Normal status] Terminals (+)-(–): B18 and body earth • Relay ON: 24 V • Relay OFF: 0 V



#029 Inspection of accelerator pedal switch

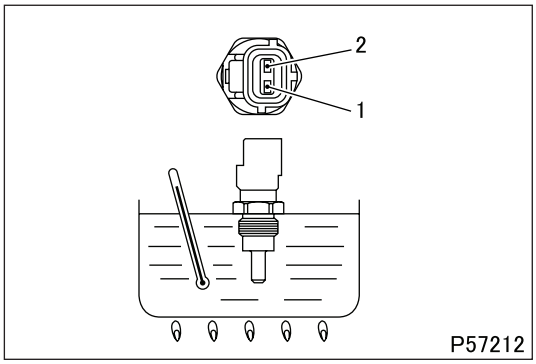
Switch position	Terminals with continuity
OFF	–
ON	1 – 2

- If there is any abnormality, replace the switch.



#201 Inspection of relay (normally open type with 5 pins)

- Test for continuity and proper operation. If there is any abnormality, replace the relay.

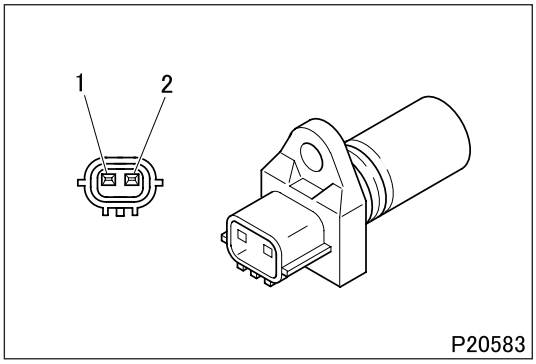


#262 Inspection of water temperature sensor

- Place the water temperature sensor in a container filled with engine oil.
- Heat the oil to each of the specified temperatures. Stir the oil well while doing so.
- Measure the resistance between terminals 1 and 2.

Standard value	20°C	2.45 ± 0.14 kΩ
	80°C	0.32 kΩ (reference value)
	110°C	147.1 ± 2 Ω

- If either measurement is out of specification, replace the sensor.

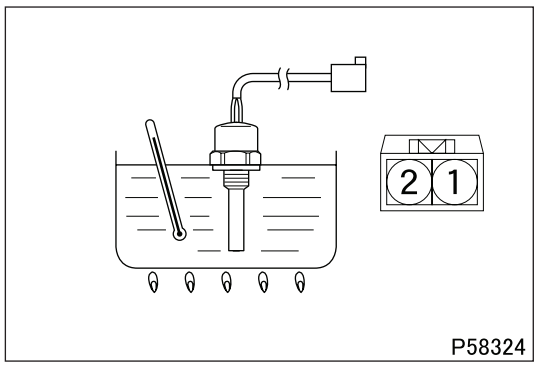


#263 Inspection of engine speed sensor

- Measure the resistance between terminals 1 and 2.

Standard value (at 20°C)	125.5 ± 17 Ω

- If the measurement is out of specification, replace the sensor.

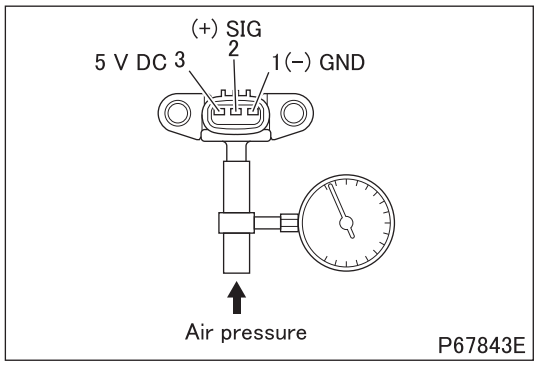


#305 Inspection of intake air temperature sensor

- Clean the sensor as dirty sensor terminals may provide false output signals. (See Gr15.)
- Place the boost air temperature sensor in a container filled with engine oil.
- Heat the oil to each of the specified temperatures. Stir the oil well while doing so.
- Measure the resistance between terminals 1 and 2.

Standard value	0°C	5.88 ± 0.588 kΩ
	20°C	2.45 ± 0.245 kΩ
	80°C	0.322 ± 0.0483 kΩ

- If either measurement is out of specification, replace the sensor.



#318 Inspection of boost pressure sensor

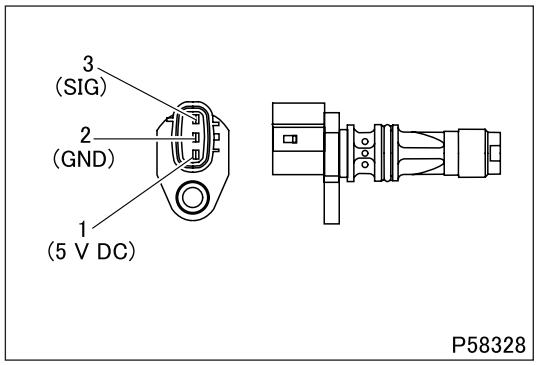
- Apply 5 V DC to terminals 3 and 1.
- Apply air pressure. Gradually increase it and, while doing so, measure the output voltage occurring at terminals 2 and 1 (see the diagram on the left).

	Air pressure (Gauge pressure)	Voltage
Standard value	101.67 kPa {1.0 kgf/cm^2}	Approx. 3.2 V
	165.67 kPa {1.7 kgf/cm^2}	Approx. 4.5 V

- If any measurement is out of specification, replace the sensor.

#319 Inspection of common rail pressure sensor

- The sensor cannot easily be inspected in isolation, so you must evaluate it indirectly by inspection of system harnesses and related parts.
- If there is no abnormality in any related part but the system is abnormal, replace the common rail pressure sensor.

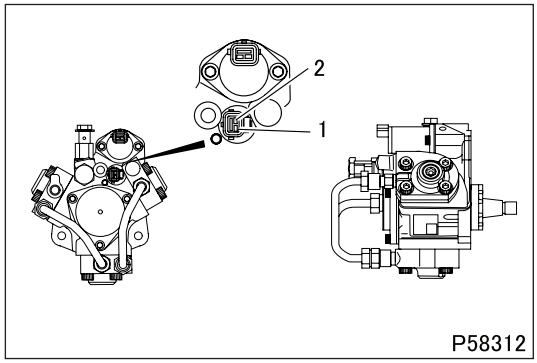


#320 Inspection of cylinder recognition sensor

- Measure the resistance between terminals 1 and 2. (The resistance serves as a rough indication only. A pulse output monitor is needed for confirmation of functionality.)

Standard value	200 to 1800 Ω

- If the measurement is out of specification, replace the sensor.



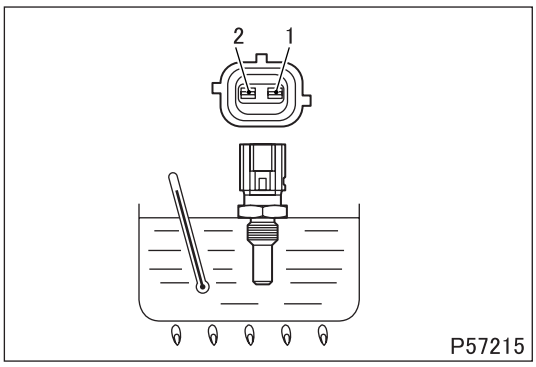
#323 Inspection of fuel temperature sensor

<Fuel temperature sensor (inlet)>

- Measure the resistance between terminals 1 and 2.

Standard value	–20°C	15.0 ± 1.5 kΩ
	20°C	2.45 ± 0.24 kΩ
	80°C	0.318 ± 0.008 kΩ

- If any measurement is out of specification, replace the supply pump.

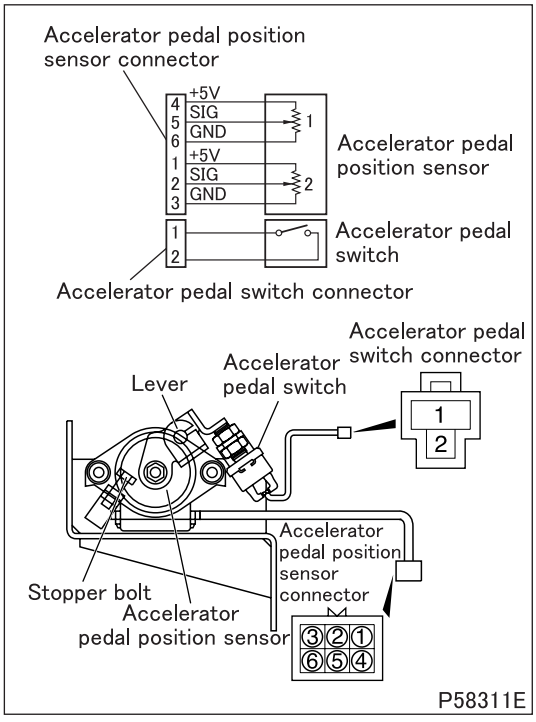


<Fuel temperature sensor (outlet)>

- Measure the resistance between terminals 1 and 2.

Standard value	20°C	$2.45^{+0.14}_{-0.13}$ kΩ
	80°C	0.318 ± 0.01 kΩ
	110°C	0.1417 ± 0.01 kΩ

- If any measurement is out of specification, replace the sensor.



#324 Inspection of accelerator pedal position sensor

[Inspection]

- Apply 5 V DC to terminals 4 and 6 and terminals 1 and 3 of the accelerator pedal position sensor connector.
- Measure the output voltage at terminals 5 and 6 (sensor 1) and the output voltage at terminals 2 and 3 (sensor 2) with the lever in each specified position.

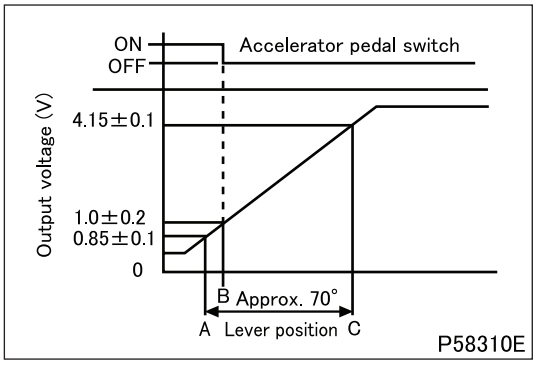
	Lever position	Output voltage
Standard value	Idling position **A**	0.85 ± 0.1 V
	Accelerator pedal switch operating position **B**	1.0 ± 0.2 V
	Full load position **C**	4.15 ± 0.1 V

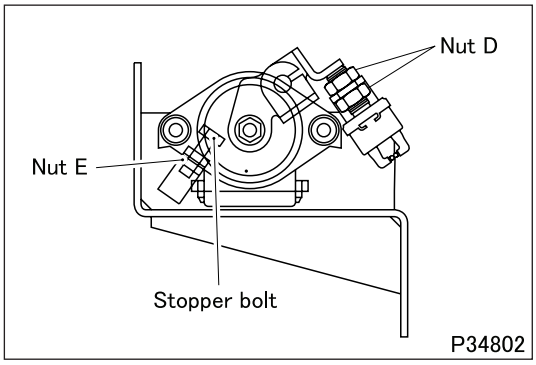
A: Position in which accelerator pedal switch is fully pushed in by lever

B: Position at which continuity between terminals 1 and 2 of accelerator pedal switch connector disappears as accelerator pedal is pushed downward

C: Position in which lever is touching stopper bolt

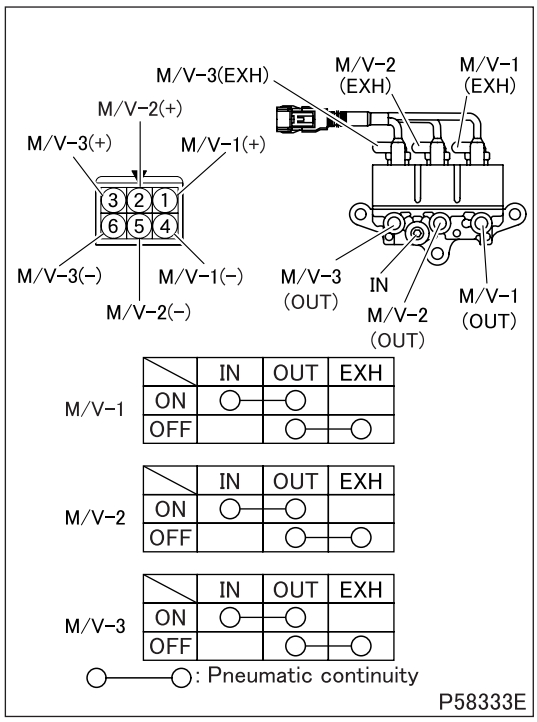
- If any output voltage is out of specification, make an adjustment.
- If any output voltage is still out of specification when you have made an adjustment, replace the sensor.

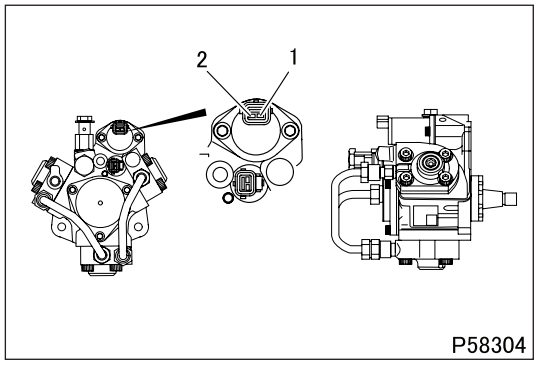


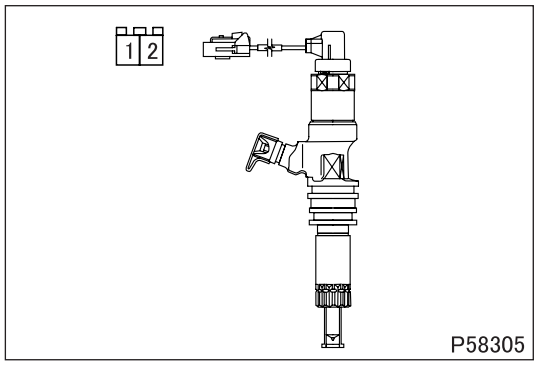


[Adjustment]

- To adjust the output voltage for the accelerator pedal switch operating position **A**, use nut **D**.
- To adjust the output voltage for the full load position **C**, loosen nut **E** and make the adjustment using the stopper bolt.
- After making the adjustment, lock the stopper bolt in position with the nut.







#530 Inspection of exhaust gas recirculation solenoid valve

- Perform the following checks. If there is any abnormality, replace the exhaust gas recirculation solenoid valve.

(1) Check of operation

- Gradually increase from zero the voltage applied to terminals 1 and 4 (M/V-1), 2 and 5 (M/V-2), or 3 and 6 (M/V-3).
- Observe the voltage when the exhaust gas recirculation solenoid valve operates. (Determine the solenoid valve's OFF-ON operation from the operating sound.)

Standard value (min. operating voltage)	18 V or lower

(2) Check of continuity and airtightness

- Air pressure applied during check: 930 kPa {9.5 kgf/cm^2}

#574 Inspection of SCV (suction control valve)

- Measure the resistance between terminals 1 and 2.

Standard value	7.9 ± 0.2 Ω

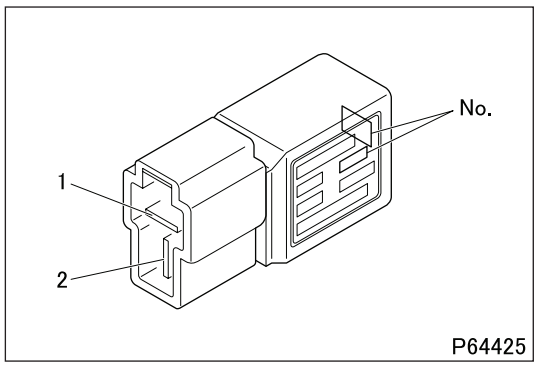
- If the measurement is out of specification, replace the supply pump.

#582 Inspection of injector

- Measure the resistance between terminals 1 and 2.

Standard value (at 20°C)	0.45 ± 0.1 Ω

- If the measurement is out of specification, replace the injector.



#828 Inspection of fuel injection rate adjustment resistor

- Measure the resistance of the resistor number marked on the fuel injection rate adjustment resistor.

Standard value (at 20°C)	Resistor No.	1	270 ± 13.5 Ω
		2	510 ± 25.5 Ω
		3	820 ± 41 Ω
		4	1300 ± 65 Ω
		5	2000 ± 100 Ω
		6	3300 ± 165 Ω
		7	5600 ± 280 Ω
		8	15000 ± 750 Ω
		9	390 ± 19.5 Ω
		10	4300 ± 215 Ω
		11	9100 ± 455 Ω

- If the measurement is out of specification, replace the fuel injection rate adjustment resistor with one that has the same resistor number and same specified resistance.

CAUTION ⚠

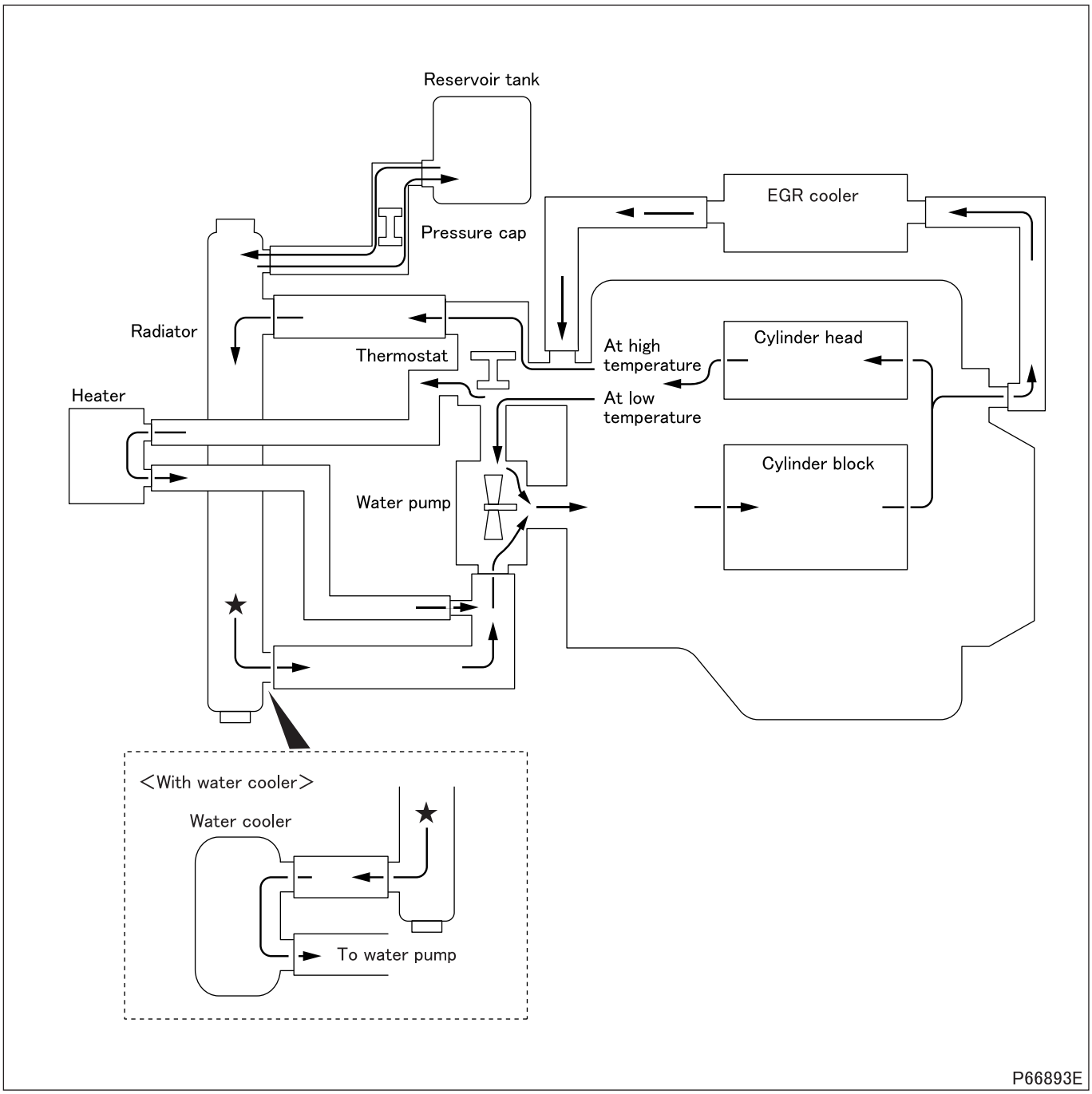
- **The fuel injection rate adjustment resistor is matched to the engine. If you replace it, be sure to replace it with one that has the same resistor number.**

GROUP 14 COOLING

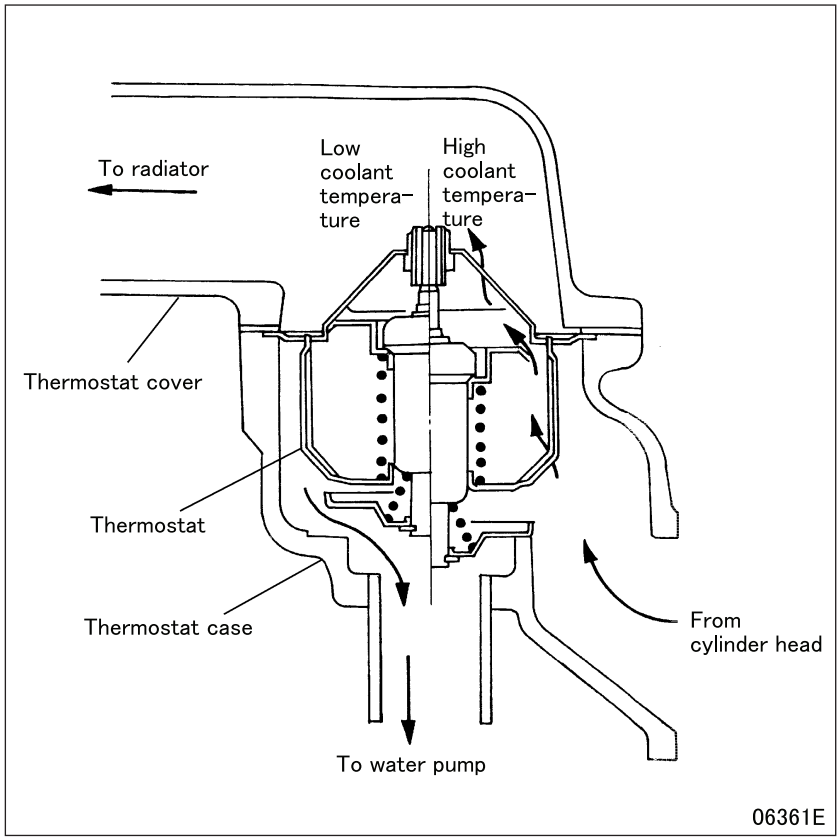
SPECIFICATIONS

Item	Specifications
Cooling system	Forced water circulation system
Water pump	Belt-driven type
Thermostat	Wax pellet, bottom bypass type (with jiggle valve)

1. Cooling System (Flow of Coolant)

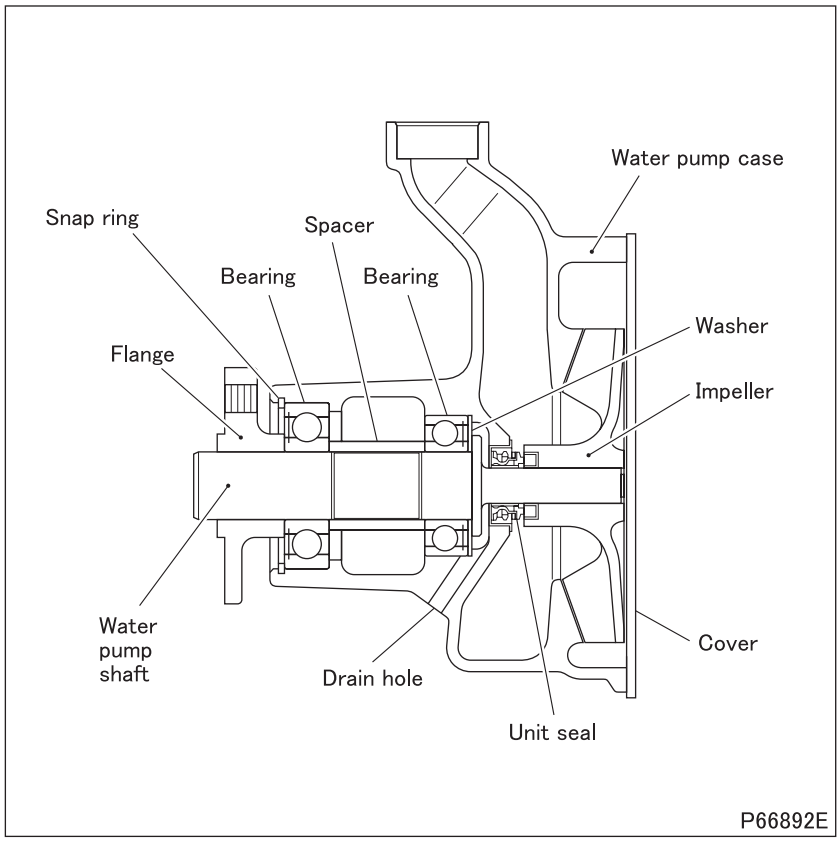


2. Thermostat



- The thermostat is a bottom bypass type that uses a wax-filled pellet as its flow-regulating element. When the wax is heated, it melts from solid to liquid, changing its total volume. This allows the valve to open or close in accordance with the coolant temperature, regulating and adjusting the flow of coolant to the radiator and to the water pump (bypassing the radiator).

3. Water Pump



- The water pump has a drain hole to prevent coolant from entering the unit bearing in case of a defect in the unit seal.

Possible causes \ Symptoms		Overheating (poor cooling)	Overcooling	Abnormal noise	Excessive coolant loss	Engine output insufficient	Reference Gr
V-belt	Loose or damaged	O		O			
	Excessive tension			O			
	Oil on belt	O					
Water pump	Incorrectly mounted water pump	O			O		
	Defective gasket	O			O		
	Defective unit bearing	O		O			
	Defective impeller	O					
	Defective unit seal	O			O		
	Fit of unit bearing on flange and impeller too loose	O		O			
Thermostat	Incorrectly mounted case	O			O		
	Defective gasket	O			O		
	Valve opening temperature too high (valve remains closed)	O					
	Valve opening temperature too low (valve remains open)		O				
Radiator	Clogged core	O					
	Cracked core and/or separation in welds	O			O		
Intercooler	Foreign matter adhered on the core					O	
Oil cooler <For machinery>	Water leaking				O		
EGR system	Defective gasket	O			O		Gr17
	Incorrectly mounted EGR cooler	O			O		
Oil cooler	Incorrectly mounted oil cooler	O			O		Gr12
	Defective gasket	O			O		
	Water leaking from water temperature sensor	O			O		
Cylinder head	Incorrectly mounted cylinder head	O			O		Gr11
	Defective gasket	O			O		
Poorly airtight pressure cap		O					
Coolant quantity insufficient and/or coolant dirty		O					
Coolant passages dirty and/or clogged		O					
Hoses fitted poorly		O			O		
Ambient temperature extremely low			O				

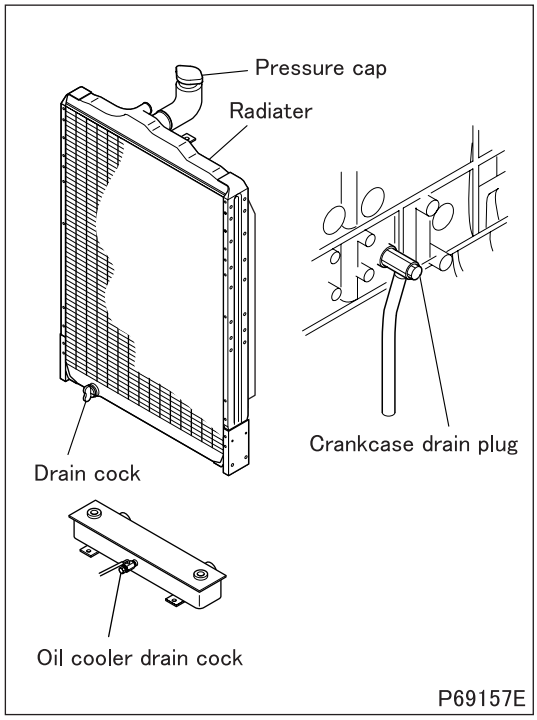
1. Coolant Replacement and Cleaning of Cooling System

- Using the radiator for extended periods of time without cleaning can increase chance of rust and scale formation, which may cause engine overheating. The cooling system must be cleaned periodically.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Radiator drain cock	2 {0.2}	–
–	Crank case drain cock	7 {0.7}	–

1.1 Draining of coolant



- Before draining the coolant, loosen the pressure cap to reduce the pressure in the cooling system. Remember to drain the coolant out of the reservoir tank as well.

WARNING ⚠

- **Drain the coolant only after it has cooled sufficiently to avoid getting scalded.**
- **Opening the pressure cap while the coolant temperature is still high can cause hot coolant to spray out. Cover the pressure cap with a cloth, and loosen it slowly to let the pressure out before opening it fully.**

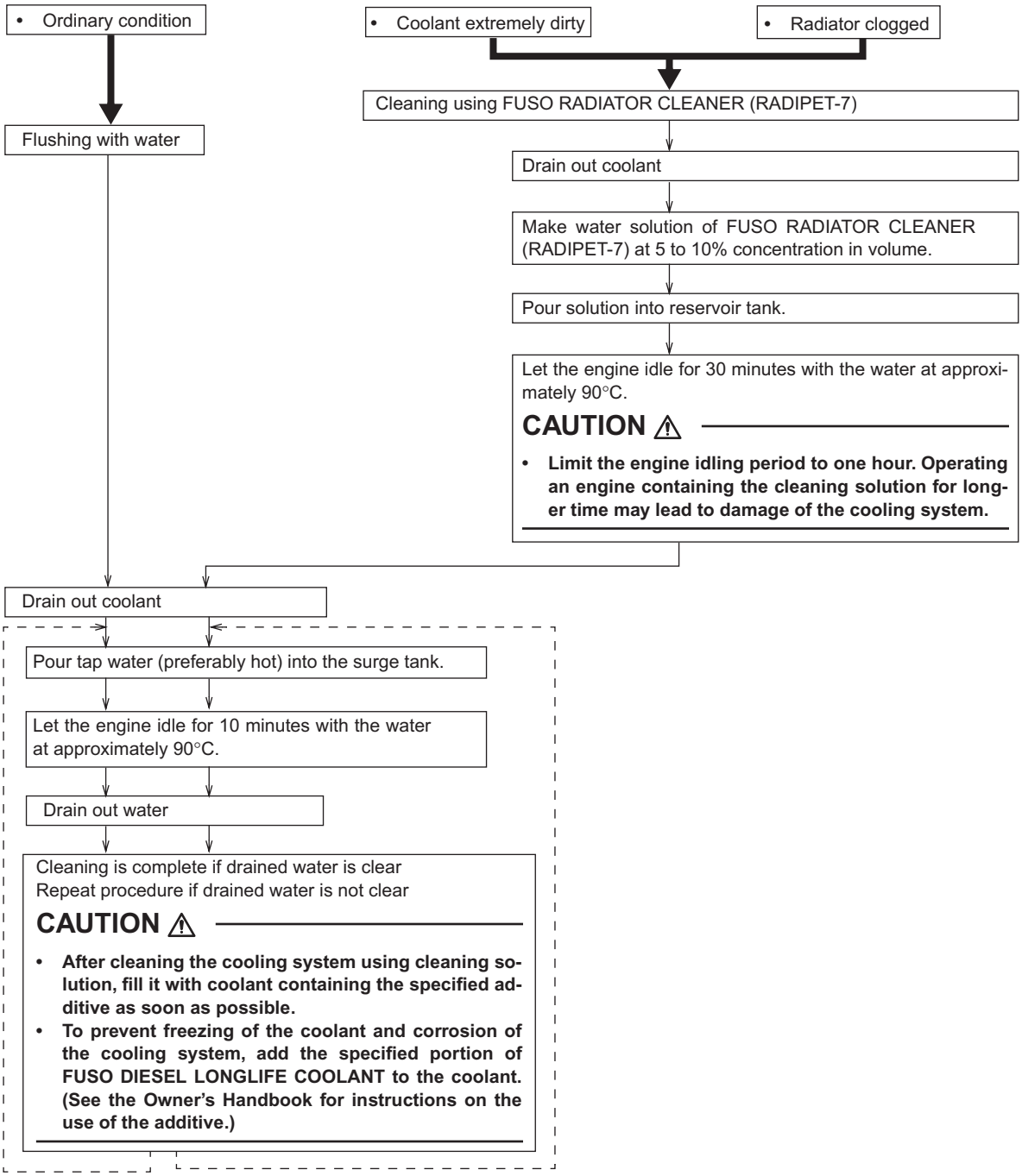
1.2 Cleaning procedure

CAUTION ⚠

- **Water used for flushing the cooling system must be soft water that has a property meeting the requirements indicated below. Using hard water will cause scale and rust to form in the system.**
  Required properties of soft water
  Total hardness ..... 300 ppm or less
  Sulfate SO_4^- ..... 100 ppm or less
  Chloride Cl^- ..... 100 ppm or less
  Total dissolved solids ..... 500 ppm or less
  pH ..... 6 to 8

- Keep the coolant temperature at approximately 90°C so that the thermostat valve remains open and coolant continues to circulate in the radiator.
- For the sake of convenience you can raise the coolant temperature quickly by covering the front of the radiator with corrugated cardboard or something similar.
- In cases where a great amount of rust has accumulated it is common for the radiator to leak as a result of cleaning. Conduct a through check for leakage after cleaning.

- Select an appropriate cleaning method according to the condition of the cooling system as shown below.



DANGER ⚠

- **If you accidentally splash FUSO DIESEL LONGLIFE COOLANT or RADIATOR ANTIRUST (RADIPET9) in your eyes, wash it out immediately with water and seek medical attention.**

WARNING ⚠

- **FUSO DIESEL LONGLIFE COOLANT is flammable. Keep it away from heat and flames.**

2. Air Bleeding of Cooling System

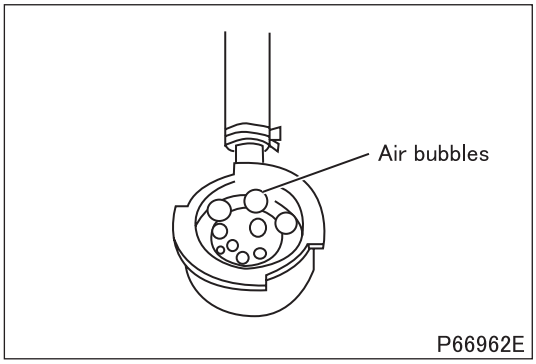
- With the pressure cap removed and the coolant temperature at 90°C, let the engine idle in order to bleed air completely out of the cooling system.
- After air bleeding is completed, refill the reservoir tank with coolant as needed.

3. Gas Leakage Test

- Presence of air or exhaust gas in coolant accelerates corrosion of the cooling system components. To prevent this, carry out air/gas leakage tests in accordance with the following procedure.
- Remove the pressure cap.

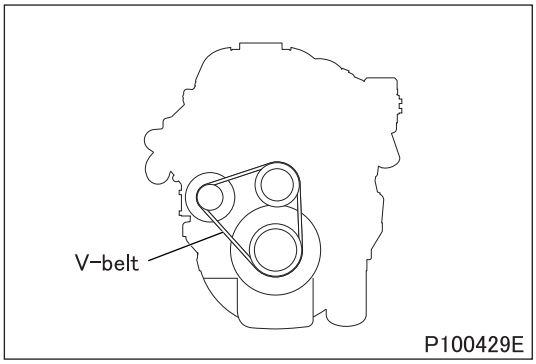
WARNING ⚠

- **If the engine is hot, boiling coolant may spurt out from the filler port when the pressure cap is loosened. To avoid burning yourself, make sure to remove the pressure cap only when the coolant is cold.**

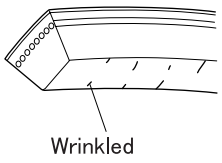
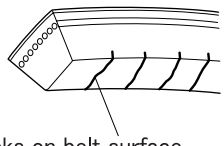
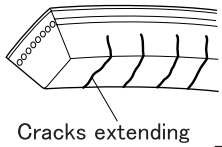
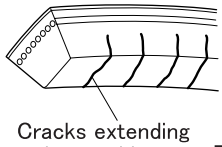
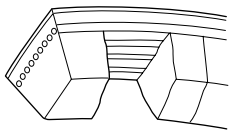


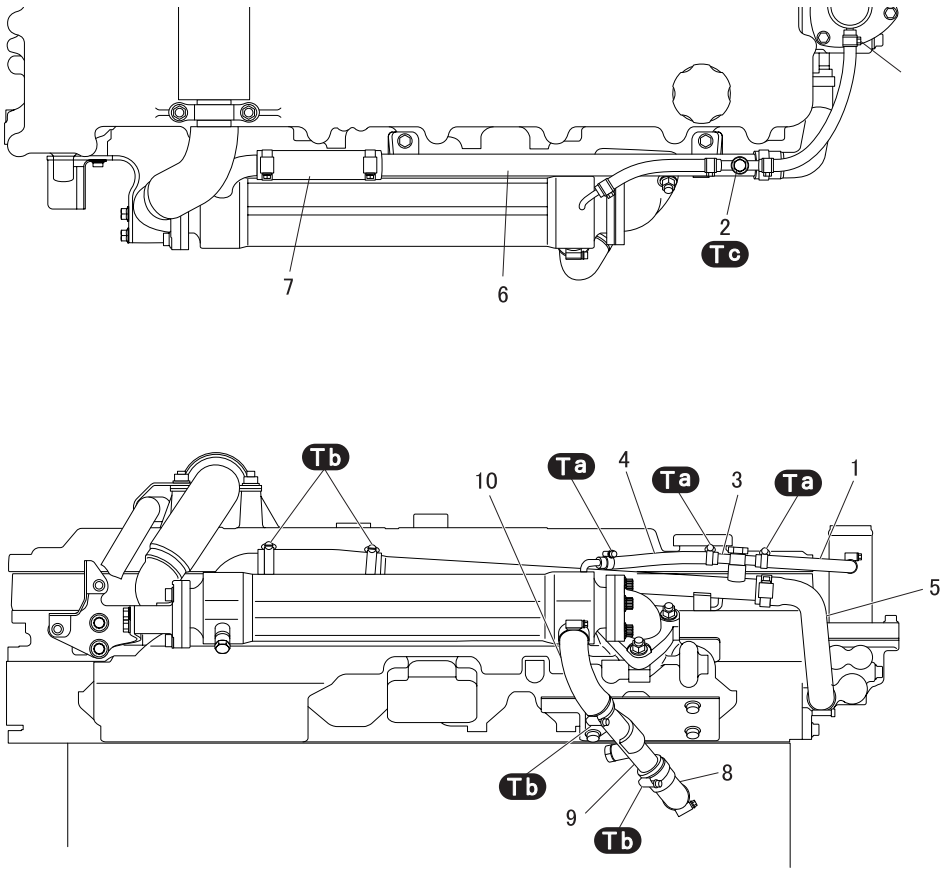
- Run the engine until the coolant temperature rises to approximately 90°C.
- If air bubbles appear continuously through the filler port, there is air or exhaust gas penetrating into the cooling system.
- Presence of air in coolant can be an indication of loose cylinder head bolts, loose water pump mounting bolts, loose hose connections, and/or a damaged hose.
- Presence of exhaust gas in coolant can be an indication of a damaged cylinder head gasket and/or cracks in the cylinder head.

4. Inspection of V-belts



- Visually check the V-belts for possible cracks and damage. V-belt replacement time varies depending on the severity of cracks and damage that may be found through the check. Study the table given below for the applicable replacement time.

Belt condition	Remaining service life (reference)
 P69698E	• The driving distance over the which the belt can still be used is at least as long as that over which the belt has been used since the vehicle was new or since the belt was replaced (whichever is more recent).
 P69699E	• The driving distance over the which the belt can still be used is about half of that over which the belt has been used since the vehicle was new or since the belt was replaced (whichever is more recent).
 P69700E	• The driving distance over the which the belt can still be used is about a quarter of that over which the belt has been used since the vehicle was new or since the belt was replaced (whichever is more recent).
 P69700E  P69702	• The belt has reached the end of its service life and must be replaced.



P66896

● **Removal sequence**

1 Water hose
2 Eyebolt
3 Joint pipe
4 Water hose
5 Water hose
6 EGR cooler water pipe
7 Water hose
8 Water hose
9 EGR cooler water pipe
10 Water hose

EGR: Exhaust gas recirculation

● **Installation sequence**

Follow the removal sequence in reverse.

CAUTION ⚠

- **Install each hose clamp to the angle indicated in the illustration so that sufficient clearance is assured between the hose clamp and its surrounding parts.**

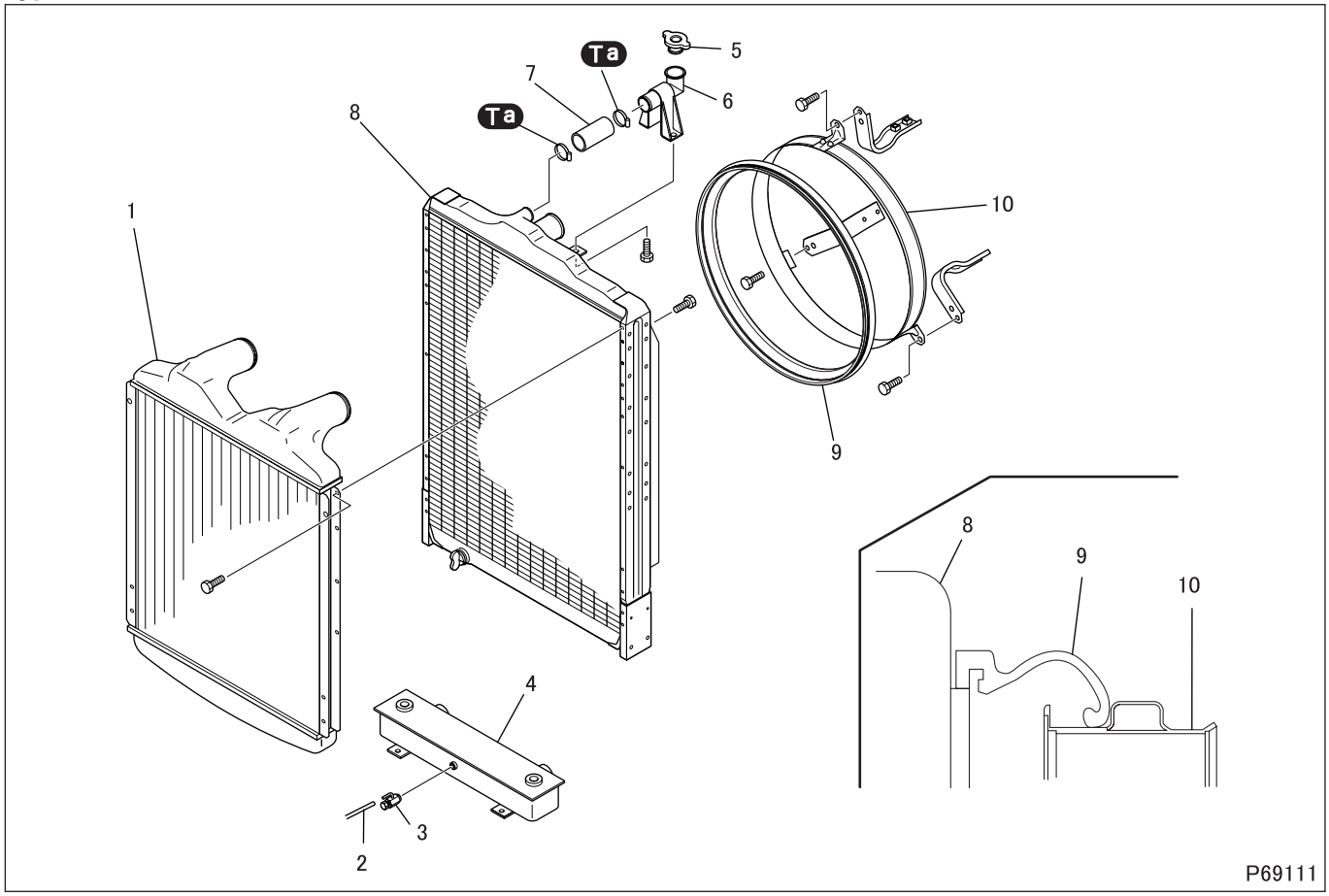
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	3.9 ± 0.6 {0.4 ± 0.06}	–
Tb	Clamp	4 to 5 {0.4 to 0.5}	–
Tc	Eyebolt (joint pipe mounting)	25 {25}	–

M E M O

RADIATOR, OIL COOLER, INTERCOOLER AND FAN SHROUD

Type A



● **Removal sequence**

1 Intercooler
2 Hose
3 Drain cock
4 Oil cooler
5 Pressure cap
6 Filler
7 Filler hose
8 Radiator (See later pages.)
9 Shroud seal
10 Fan shroud

● **Installation sequence**

Follow the removal sequence in reverse.

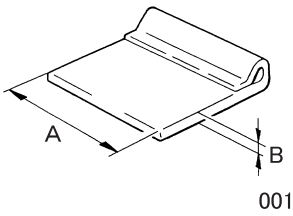
Service standards

Location	Maintenance item		Standard value	Limit	Remedy
1	Air leaks from intercooler (air pressure: 150 kPa {1.5 kgf/cm^2})		0 cm^3 {0 mL}	–	Replace
4	Air leaks from oil cooler	Coolant side (air pressure: 20 kPa {0.2 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace
		Oil side (air pressure: 150 kPa {1.5 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace
5	Pressure cap opening pressure		49 ± 9.8 kPa {0.5 ± 0.1 kgf/cm^2}	–	Replace

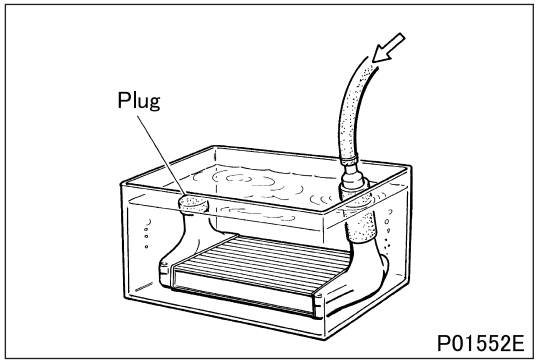
Tightening Torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	3.9 ± 0.6 {0.4 ± 0.06}	–

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
Ca	Tip clearance spacer A: ϕ600: 50, ϕ620: 50 B: ϕ600: 5, ϕ620: 7  00189	<For ϕ600 fan> MC019470 <For ϕ620 fan> ME294842	Adjusting clearance between fan shroud and cooling fan blades

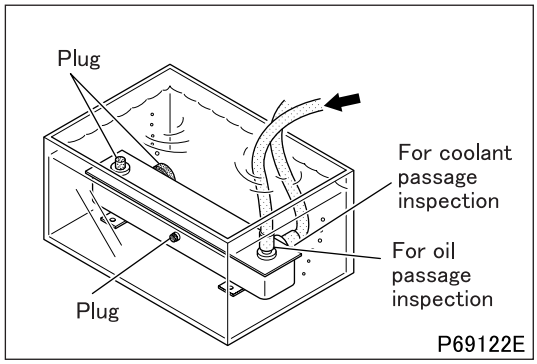
◆Inspection procedure◆



P01552E

■ Inspection: Air leaking of intercooler

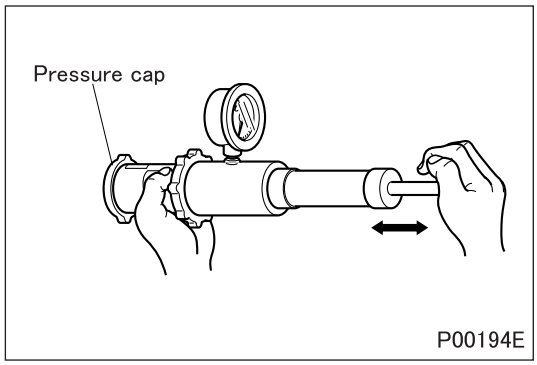
- Plug an end of the intercooler and apply a specified air pressure from the other end with the intercooler immersed in water.
- If any leakage is found, replace the intercooler.



P69122E

■ Inspection: Air leaking of oil cooler

- Plug an end of each coolant passage and oil passage of the oil cooler and apply a specified air pressure from the other end with the oil cooler immersed in water.
- Be sure to check both the coolant passage and oil passage.
- If any leakage is found, replace the oil cooler.

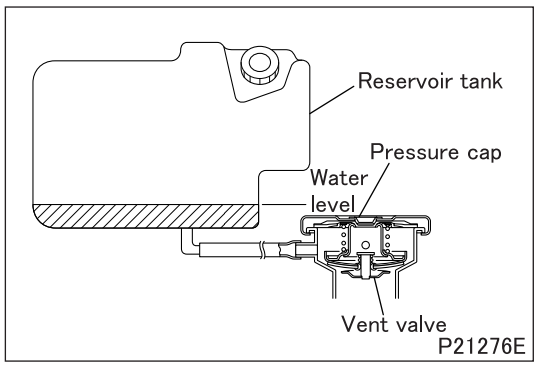


P00194E

■ Inspection: Pressure cap

(1) Pressure valve opening pressure

- If the measurement does not conform to the standard value, replace the pressure cap.



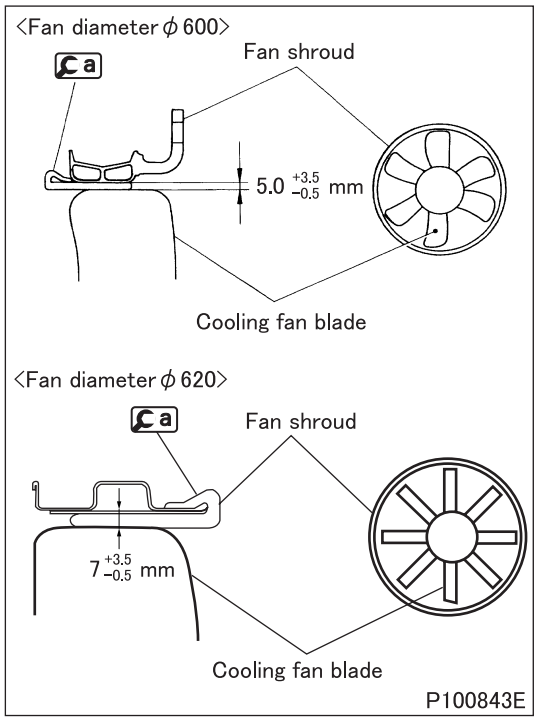
(2) Inspection of vent valve

- Note the coolant level in the reservoir tank.
- Start the engine and run it at high speed until the coolant level in the reservoir tank has risen to a certain degree. Stop the engine.
- Allow the system to cool down. When the coolant temperature has dropped to the atmospheric temperature, check if the coolant level in the reservoir tank has subsided to the original level noted earlier.
- If not, the vent valve is deemed faulty. Replace the pressure cap.

CAUTION ⚠

- **If the pressure cap is opened before the coolant temperature drops to the atmospheric temperature, the negative pressure in the radiator is canceled out. As a result, it is no longer possible for coolant to flow into the reservoir tank. Ensure that this does not happen.**

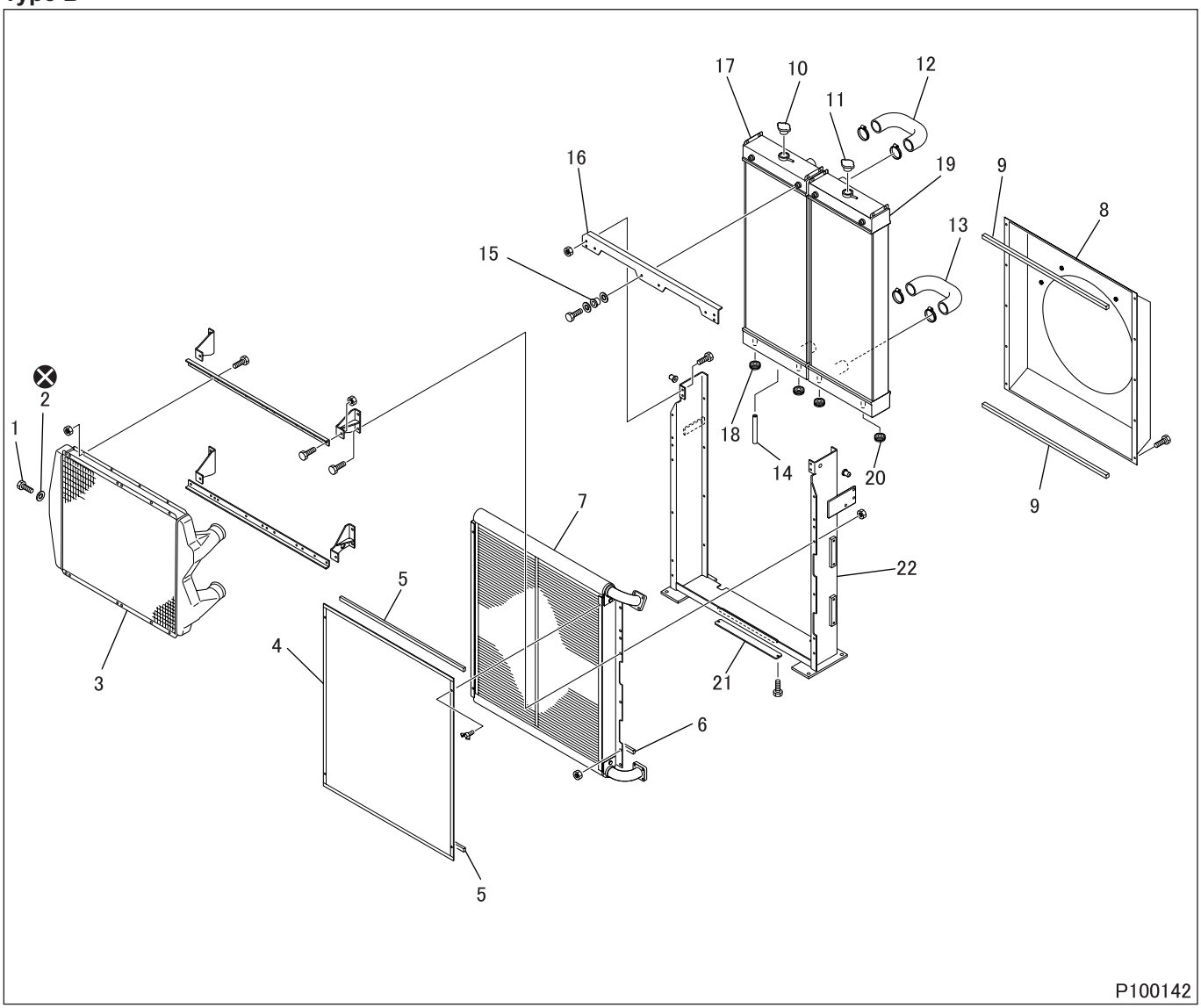
◆Installation procedure◆



■ Installation: Fan shroud

- Using Ca, adjust the clearance between the fan shroud and cooling fan blades to the dimension shown in the illustration.

Type B



● Removal sequence

1 Plug
2 Gasket
3 Intercooler
4 Protector
5 Packing
6 Packing
7 Oil cooler
8 Shroud
9 Packing
10 Pressure cap
11 Pressure cap
12 Water hose
13 Water hose
14 Hose
15 Cushion
16 Bracket
17 Radiator
18 Cushion
19 Radiator
20 Cushion
21 Plate
22 Frame

⊗: Non-reusable parts

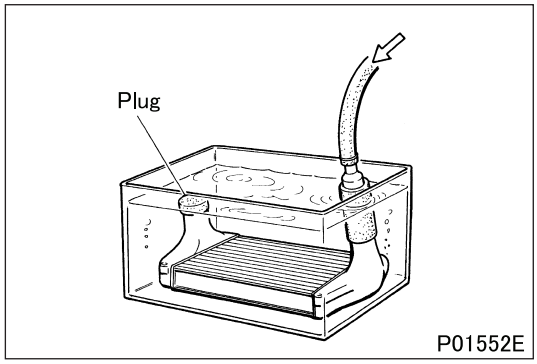
● Installation sequence

Follow the removal sequence in reverse.

Service standards

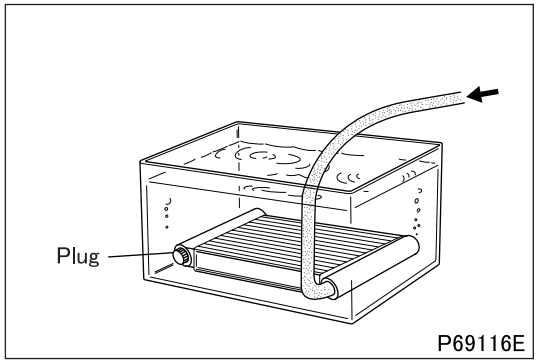
Location	Maintenance item	Standard value	Limit	Remedy
3	Air leaks from intercooler (air pressure: 1.5 MPa {15 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace
7	Air leaks from oil cooler (air pressure: 150 kPa {1.5 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace
10, 11	Pressure cap opening pressure	49 ± 9.8 kPa {0.5 ± 0.1 kgf/cm^2}	–	Replace
17, 19	Air leaks from radiator (air pressure: 100 kPa {1.0 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace

◆Inspection procedure◆



■ Inspection: Air leaking of intercooler

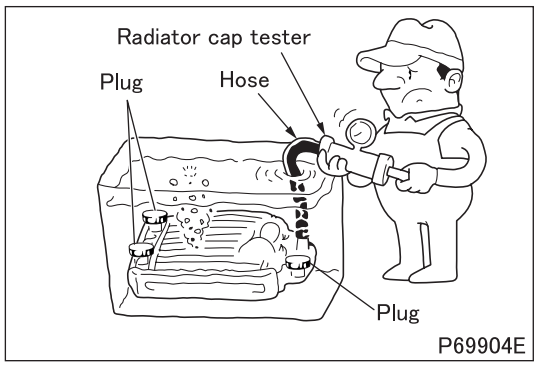
- Plug an end of the intercooler and apply a specified air pressure from the other end with the intercooler immersed in water.
- If any leakage is found, replace the intercooler.



■ Inspection: Air leaking of oil cooler

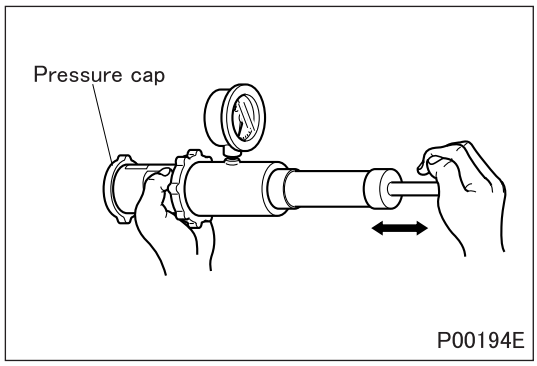
- Plug an end of each coolant passage and oil passage of the oil cooler and apply a specified air pressure from the other end with the oil cooler immersed in water.
- Be sure to check both the coolant passage and oil passage.
- If any leakage is found, replace the oil cooler.

◆Inspection before removal◆



■ Inspection: Air leaking of radiator

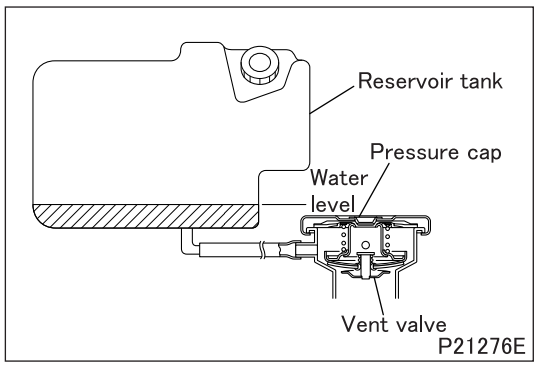
- Install hose and radiator cap tester and plug to upper tank.
- Insert plug in lower tank, and immerse the entire body of the radiator in water.
- Apply a specified air pressure using radiator cap tester, and check for any air leakage.
- If any leakage is found, repair or replace radiator.



■ Inspection: Pressure cap

(1) Pressure valve opening pressure

- If the measurement does not conform to the standard value, replace the pressure cap.



(2) Inspection of vent valve

- Note the coolant level in the reservoir tank.
- Start the engine and run it at high speed until the coolant level in the reservoir tank has risen to a certain degree. Stop the engine.
- Allow the system to cool down. When the coolant temperature has dropped to the atmospheric temperature, check if the coolant level in the reservoir tank has subsided to the original level noted earlier.
- If not, the vent valve is deemed faulty. Replace the pressure cap.

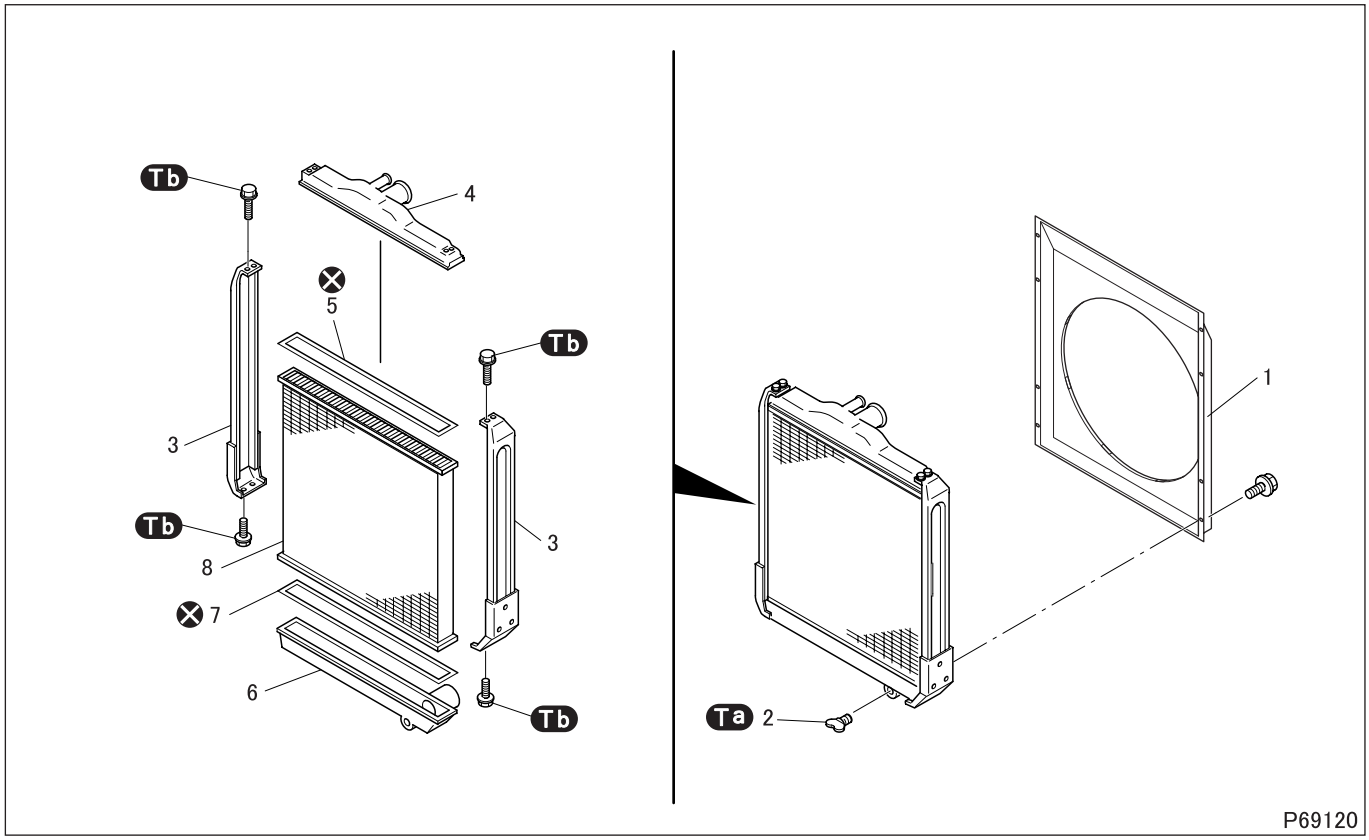
CAUTION ⚠

- **If the pressure cap is opened before the coolant temperature drops to the atmospheric temperature, the negative pressure in the radiator is canceled out. As a result, it is no longer possible for coolant to flow into the reservoir tank. Ensure that this does not happen.**

RADIATOR, OIL COOLER, INTERCOOLER AND FAN SHROUD

Radiator Assembly

- Only the type A radiator can be disassembled.



● Disassembly sequence

1 Radiator shroud
2 Drain cock
3 Side member
4 Upper tank
5 Packing
6 Lower tank
7 Packing
8 Core

⊗: Non-reusable parts

CAUTION ⚠

- **Gently handle upper tank and lower tank, since they are made of a resin that can break on impact.**
- **If there are two paint marks on the joint between the core and upper tank or on the joint between the core and lower tank (which indicates that the tank retaining tabs have been crimped twice before), replace the core with a new part.**

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
8	Air leakage from radiator (air pressure: 177 kPa {1.8 kgf/cm^2})	0 cm^3 {0 mL}	–	Repair or replace

Tightening torque (Unit: N·m {kgf·m})

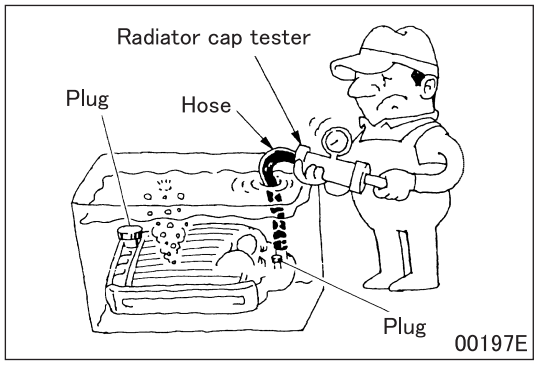
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain cock	2 {0.2}	–
Tb	Bolt (side member mounting)	13 {1.3}	–

Special tools

Mark	Tool name and shape	Part No.	Application
ⓒa	Lock-and-break tool	J94-Z013 -10000	Removal of upper and lower tanks

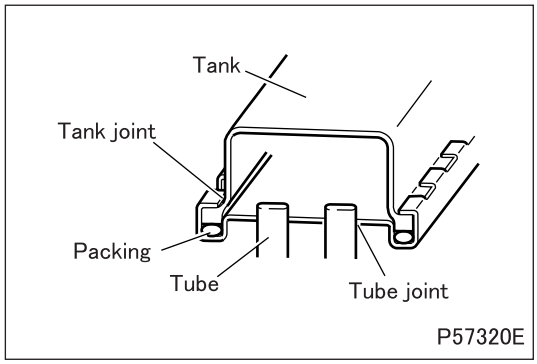
The indicated part number is T. RAD's part number.

◆Inspection before removal◆



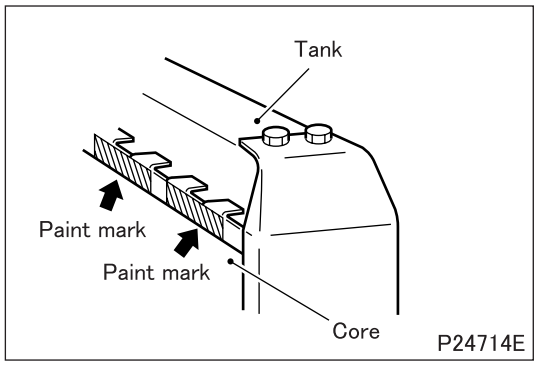
■ **Inspection: Air leaking of radiator**

- Install hose and radiator cap tester and plug to upper tank.
- Insert plug in lower tank, and immerse the entire body of the radiator in water.
- Apply a specified air pressure using radiator cap tester, and check for any air leakage.
- If any leakage is found, repair or replace radiator.



- Replace the following parts according to the leakage location.

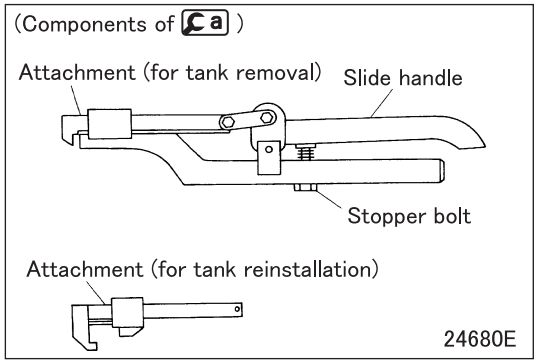
Area of leakage		Cause
Upper tank Lower tank	Tank	Cracked tank
	Tank joint	Defective crimping Defective packing Cracked tank
Tube; Tube joint		Cracked tube



CAUTION ⚠

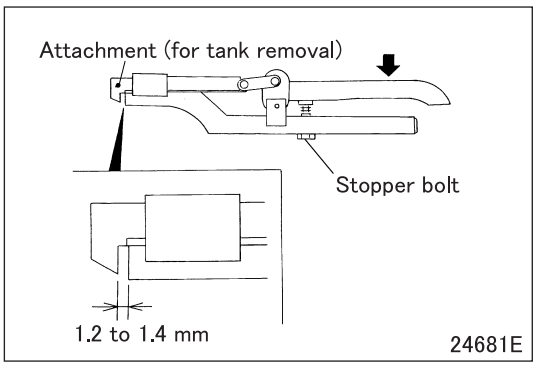
- **If there are two paint marks on the joint between the core and upper tank or on the joint between the core and lower tank (which indicates that the tank retaining tabs have been crimped twice before), replace the core with a new part.**
- **The number of paint marks on the upper tank joint or the lower tank joint corresponds to the number of repairs performed on that joint.**

◆Removal procedure◆



■ **Removal: Upper tank and lower tank**

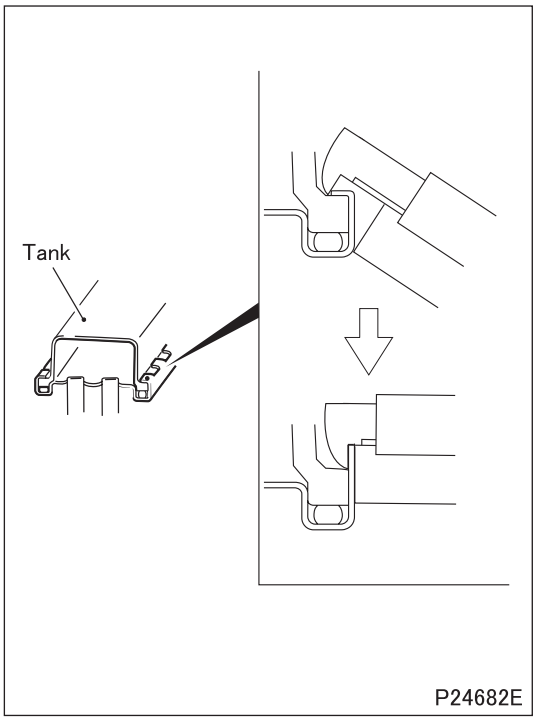
- Use ⓒa for removal and reinstallation of the tanks.



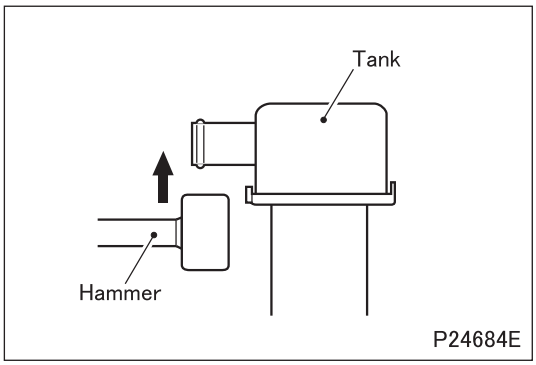
- Adjust the stopper bolt until the gap dimension shown in the illustration is obtained on the attachment of [a].

CAUTION ⚠

- **Before using [a], be sure to set the gap to the specified dimension by adjusting the stopper bolt. Otherwise, [a] will become damaged.**



- Use [a] to bend open tabs of retain tank in place.
- After tabs are bent open, squeeze the handle of [a] to straighten tabs as illustrated.
- After straightening all tabs in the perimeter, hold the pipes connected to the inlet/outlet, and remove tank.

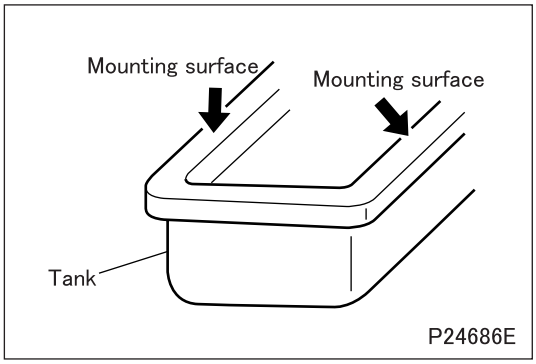


- If it is difficult to remove tank lightly hit with rubber hammer (or plastic hammer) to remove.

CAUTION ⚠

- **Gently handle tanks, since they are made of a resin that can break on impact.**

◆Inspection procedure◆

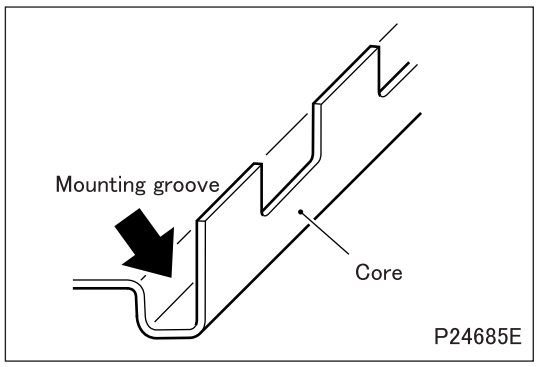


■ Inspection: Tank surface where core is to be mounted

- Check the tank surface where the core is to be mounted for cleanliness, damage, etc. Clean the surface.
- If an abnormality is found on the surface, replace the tank.

CAUTION ⚠

- **To prevent adhesion of foreign substances on mounting surface, conduct work with bare hands.**

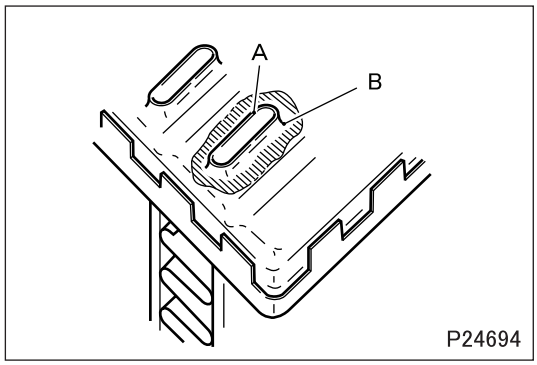


■ **Inspection: Core groove where tank is to be mounted**

- Check the groove on the core where the tank is to be mounted for adhesion of foreign substances or cracks.
- If foreign substances are found, rub the area with #1000 sandpaper or a like gently so as to avoid scratching the surface, or use compressed air to remove them.
- If there are cracks in the groove, repair or replace.

CAUTION ⚠

- **If the packing and tank are installed onto the core without removing foreign substances from the groove, coolant leakage will result. Be sure to inspect and clean the tank mounting groove along the entire periphery (even a hair can cause leakage).**

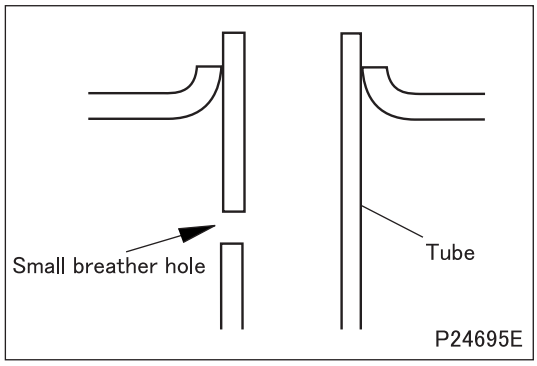


Repairing core

CAUTION ⚠

- **The core is repaired by means of tungsten inert-gas arc welding (TIG welding), which should only be performed by a skilled welder.**
- **It is extremely dangerous to weld on a wet core. Before welding, ensure that the core is completely dry.**

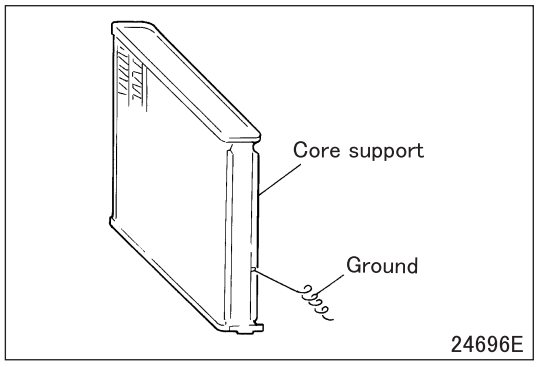
- Using a stainless wire brush, brush both ends **A** of the leaky tube and the areas **B** around the tube ends until the base aluminum is exposed.
- Before closing the tube at both ends by welding, drill a small breather hole in the tube.



CAUTION ⚠

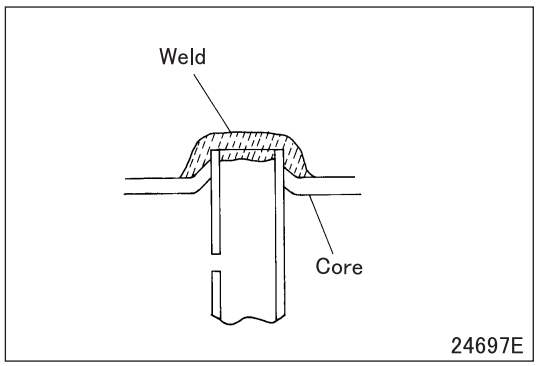
- **If a breather hole is not provided, the tube may develop small pinholes due to escaping air.**

- Ground the core at the support.



CAUTION ⚠

- **If welding is performed without the core properly grounded, this can lead to short-circuit where the base metal may melt.**

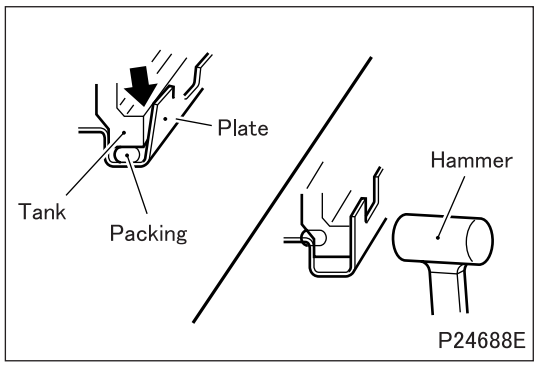


- Close both end of the tube by tungsten inert-gas arc welding (TIG welding).
  Welding conditions
  - Welding rod: A4043 (approx. ϕ2 mm)
  - Welding current: AC80A
- After welding, check for the following problems. If any of them exist, repair again or replace the core.
  - Undercut
  - Bead crack
  - Base metal crack

CAUTION ⚠

- **Improper weld can lead to recurrence of coolant leakage.**

◆Installation procedure◆

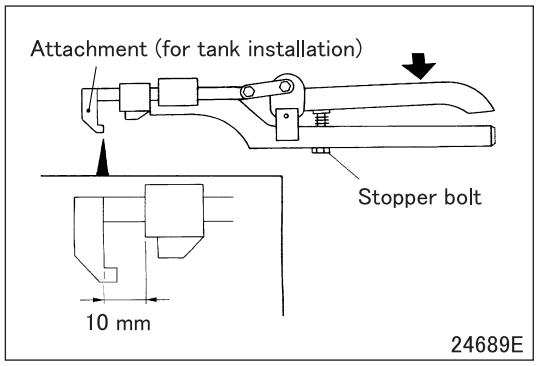


■ Installation: Upper tank, Lower tank

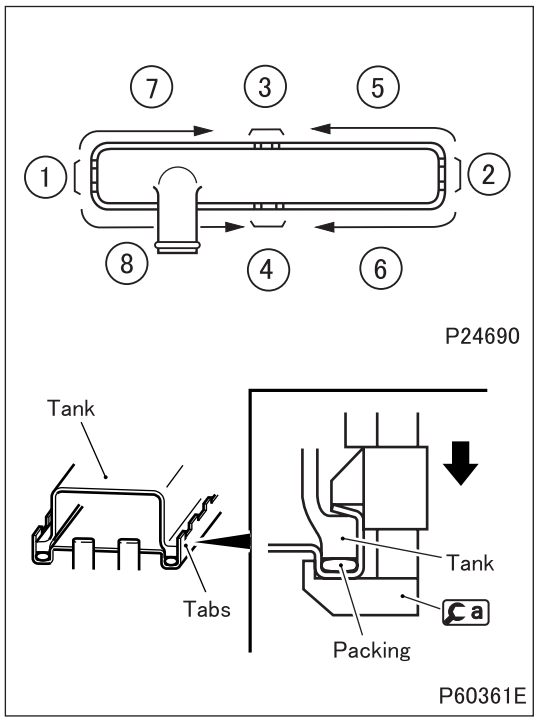
- With the tank installed, eliminate any clearance between the tank and core plate by tapping with a rubber (or plastic) hammer.

CAUTION ⚠

- **To prevent adhesion of foreign matter, use bare hands to install the packing and tank.**

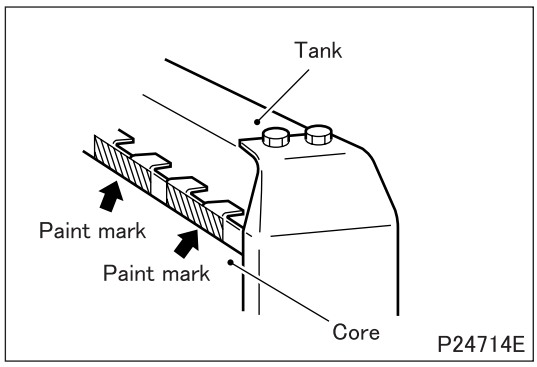


- Adjust the stopper bolt until the gap dimension shown in the illustration is obtained on the attachment of Ⓒa.



- Following the sequence shown in the diagram, bend tabs for caulking tank. To perform this work, since Ⓒa cannot be used to caulk sides 1 and 2, use pliers with the tips wrapped in vinyl tape.
  1 to 4: Bend two tabs at the center.
  5 to 8: Bend other tabs following the direction of the arrow.

- After crimping the tabs onto the tank, check for coolant leakage.

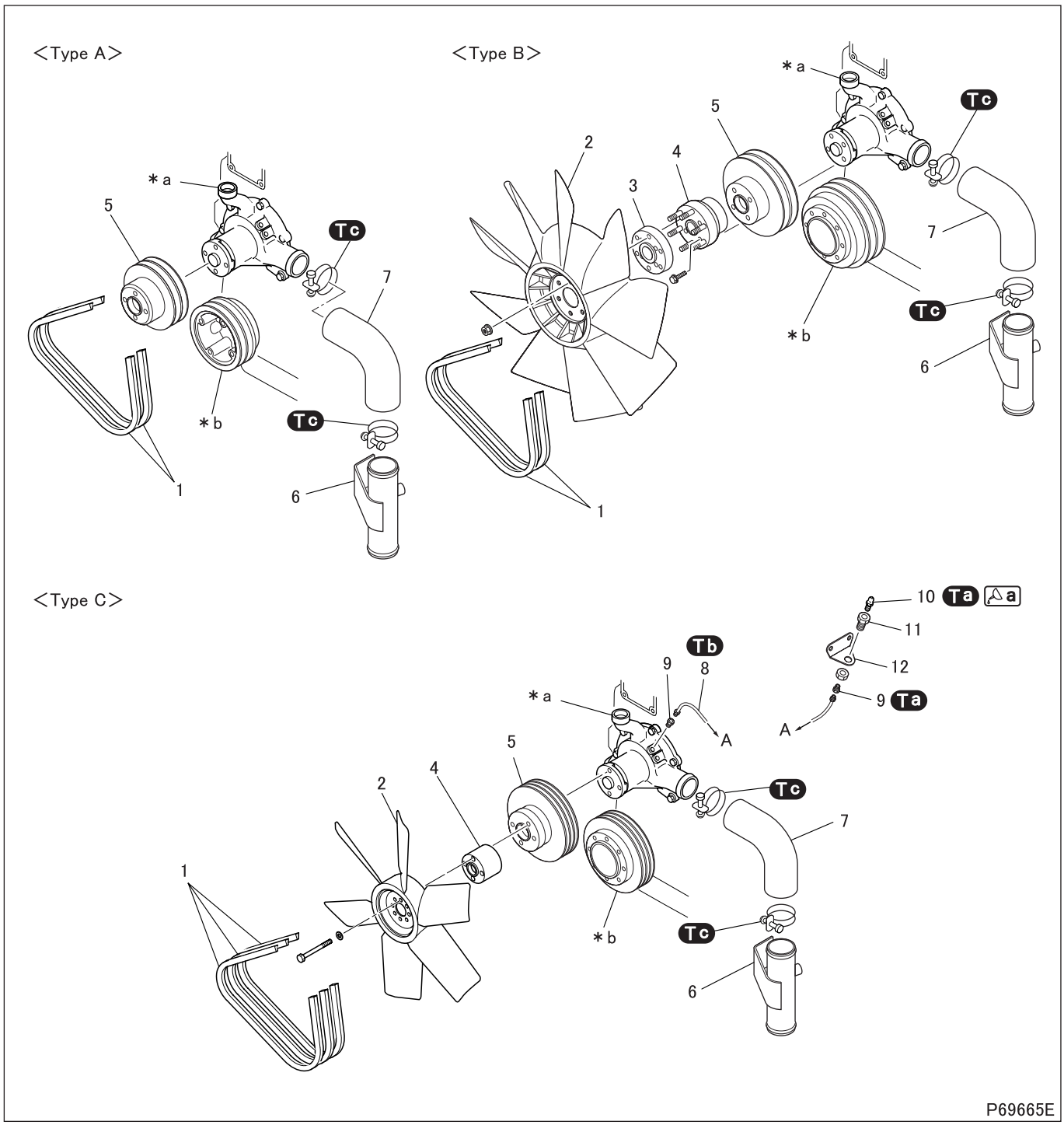


- Paint a mark on the core where it can be easily noticed to indicate that the core has been crimped.

CAUTION ⚠

- **Paint a mark for each repair performed on either the upper or lower tank.**

COOLING FAN AND V-BELT



● **Disassembly sequence**

1 V-belt
2 Cooling fan <Type B and Type C>
3 Fan spacer <Type B>
4 Fan spacer <Type B and Type C>
5 Water pump pulley
6 Inlet pipe
7 Inlet hose
8 Tube <Type C>
9 Straight joint <Type C>
10 Grease nipple <Type C>
11 Connector <Type C>
12 Grease nipple bracket <Type C>

***a:** Water pump
***b:** Crankshaft pulley

● **Assembly sequence**

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **When replacing the V-belts, replace them as a set to prevent differences in tension between the belts.**

Service standards (Units: mm)

Location	Maintenance item	Service standard	Limit	Remedy
1	V-belt tension	10 to 15	–	Adjust

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Grease nipple	12.5 ± 2.5 {1.3 ± 0.3}	–
	Straight joint		
Tb	Tube	2.25 ± 0.25 {0.2 ± 0.03}	
Tc	Clamp	39 {0.4}	–

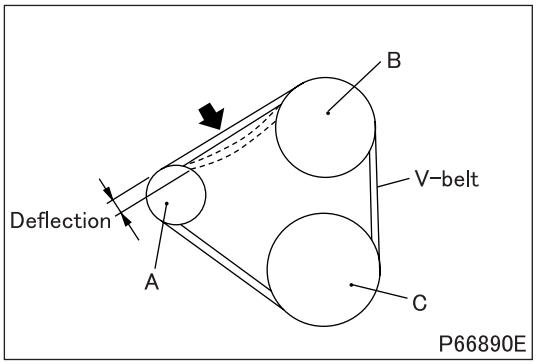
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Grease nipple	Wheel bearing grease [NLGI No. 2 (Li soap)]	As required

Special tools

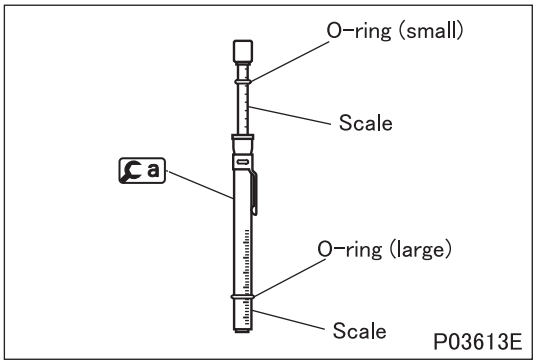
Mark	Tool name and shape	Part No.	Application
a	Belt tension gauge  P03612	MH062345	Measurement of tension of V-belt

◆Inspection procedure◆

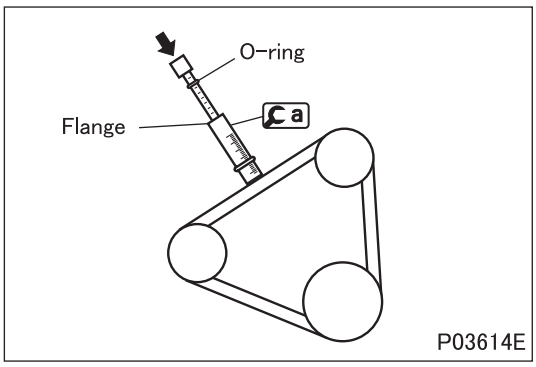


■ Inspection: Tension of V-belts

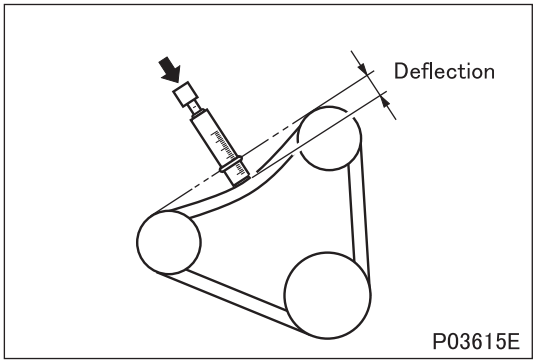
- Press each V-belt at a central portion between pulleys with a force of approximately 98 N {10 kgf} as shown in the illustration and measure the amount of deflection of the belt.
  A: Alternator pulley
  B: Water pump pulley
  C: Crankshaft pulley



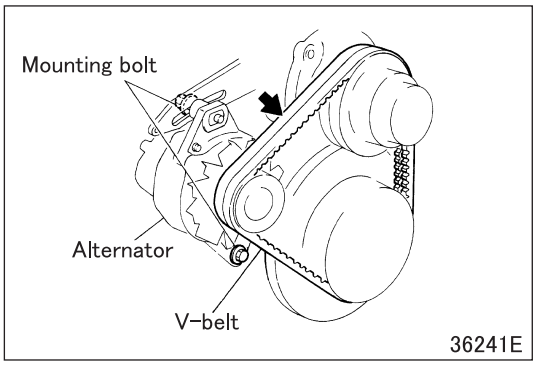
- Place the small O-ring on a at the scale mark corresponding to 98N {10 kgf} (press force).
- Place the large O-ring on a at the scale mark corresponding to the maximum permissible deflection value specified for the belt.



- Place a at a central portion between pulleys of the V-belt and push the handle (indicated by the arrow in the illustration) until the O-ring touches the flange.



- Measure the amount of deflection of the V-belt.
- If the measured value deviates from the standard value range, adjust the tension of the belt as follows.



Adjustment of V-belt

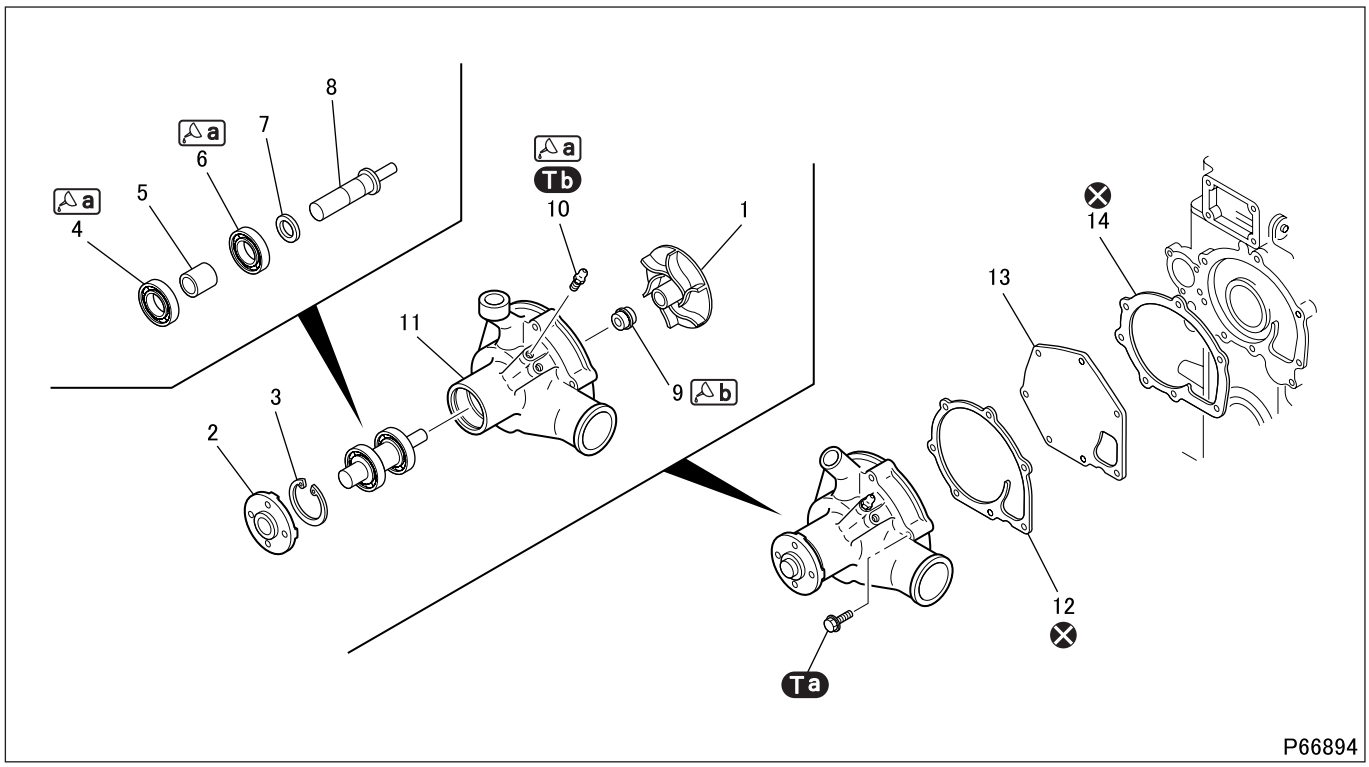
- Loosen alternator mounting bolts (2 locations), then adjust the tension of V-belts by moving the alternator from side to side.
- When the adjustment is completed, tighten the bolts and nuts securely.

CAUTION ⚠

- **Excessive tension in V-belts may damage the belts and related bearings.**
- **When replacing the V-belts, replace them as a set to prevent differences in tension between the two belts.**
- **Keep the V-belts free of oil. If the belts become oily, they may slip, resulting in overheating of the engine and insufficient charging of the battery.**

M E M O

WATER PUMP



● **Disassembly sequence**

1 Impeller
2 Flange
3 Snap ring
4 Bearing
5 Spacer
6 Bearing
7 Washer
8 Water pump shaft
9 Unit seal
10 Grease nipple <If equipped>
11 Water pump case
12 Gasket
13 Cover
14 Gasket
⊗: Non-reusable parts

● **Assembly sequence**

For the sequence not mentioned below, follow the disassembly sequence in reverse.
12 → 8 → 7 → 6 → 5 → 4 → 11 → 3 → 9 → 10

Service standards (Unit: mm)

Location	Maintenance item	Service standard	Limit	Remedy
1, 8	Flange-to-water pump shaft interference	0.03 to 0.06	–	Reassembly allowed only twice
2, 8	Impeller-to-water pump shaft interference	0.03 to 0.08	–	Reassembly allowed only twice

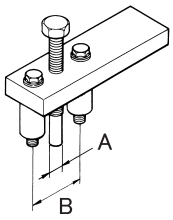
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (water pump mounting)	24 {2.4}	–
Tb	Grease nipple	9.8 to 15 {1 to 1.5}	–

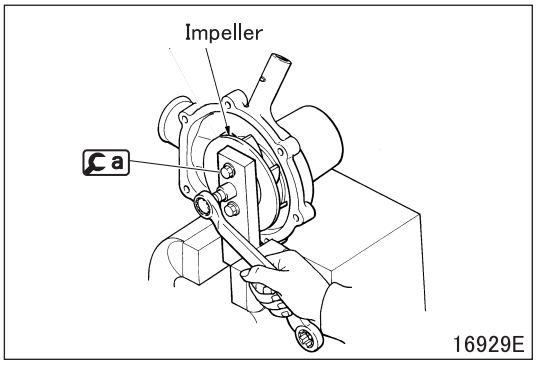
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Pack in bearing	Wheel bearing grease [NLGI No. 2 (Li soap)]	As required
	Fill through grease nipple		60 g
b	Outer periphery of unit seal	ThreeBond 1102	As required

Special tools (Unit: mm)

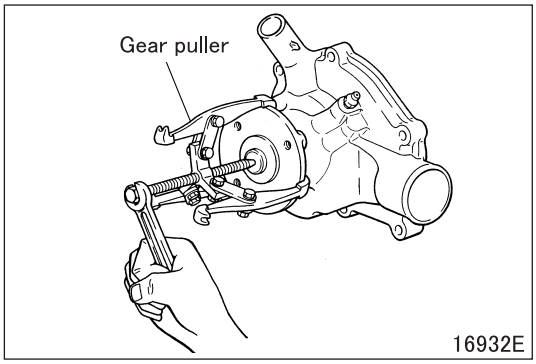
Mark	Tool name and shape	Part No.	Application
a	Impeller puller A: 49 ± 1, B: ϕ 10  21289	MH062192	Removal of impeller puller

◆Removal procedure◆



16929E

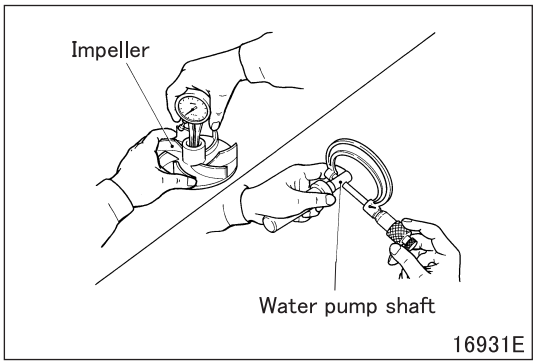
■ **Removal: Impeller**



16932E

■ **Removal: Flange**

◆Inspection procedure◆



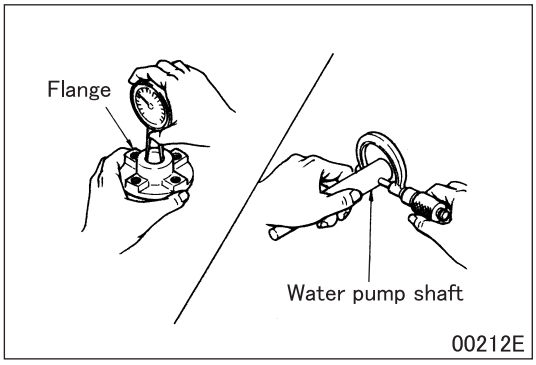
16931E

■ **Inspection: Impeller-to-water pump shaft interference**

- If the measurement does not comply with the standard value, replace the defective part(s).

CAUTION ⚠

- **Even if the measurement complies with the standard value, reassembly must not be carried out more than twice.**



00212E

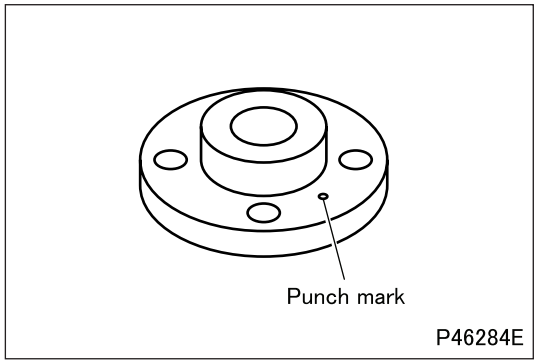
■ **Inspection: Flange-to-water pump shaft interference**

- If the measurement does not comply with the standard value, replace the defective part(s).

CAUTION ⚠

- **Even if the measurement complies with the standard value, reassembly must not be carried out more than twice.**

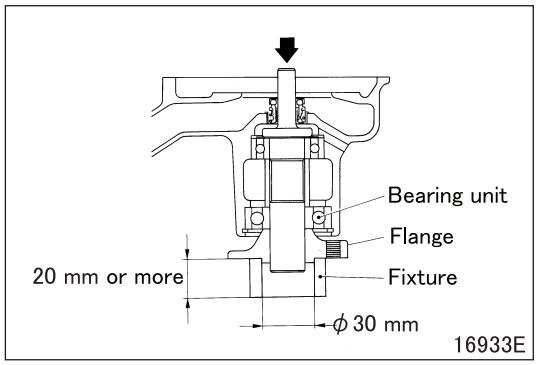
◆Installation procedure◆



■ **Installation: Flange**

CAUTION ⚠

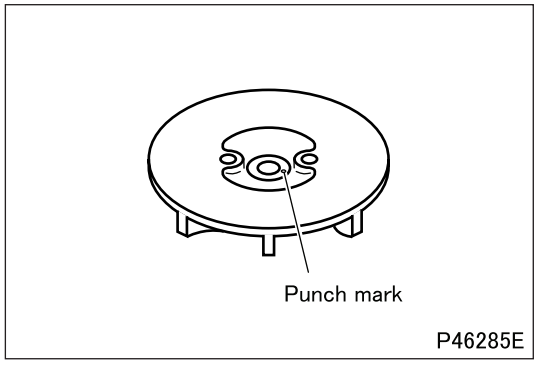
- **Before installing flange, make sure that there is no or only one punch mark in the shown location on the flange. Make an additional punch mark on the flange to indicate that it undergoes the disassembly and reassembly process you are doing now.**
- **Punch mark(s) indicate the number of times the flange was disassembled and reassembled in the past. If there are two marks, the flange must be replaced.**



- Place a fixture under the flange and apply the ram load of a press to the shaft of the bearing unit.
- Ram the shaft of the bearing unit down into the flange until it contacts the fixture.

CAUTION ⚠

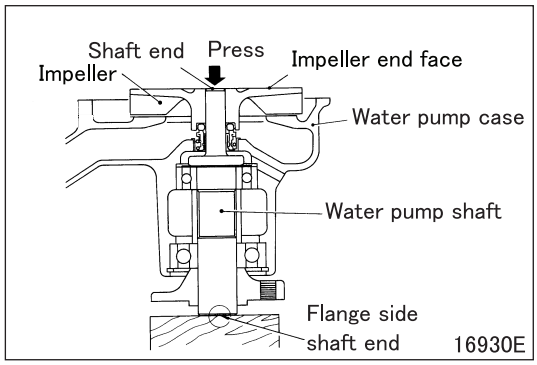
- **If the flange is installed without the fixture, the water pump case will be damaged.**



■ **Installation: Impeller**

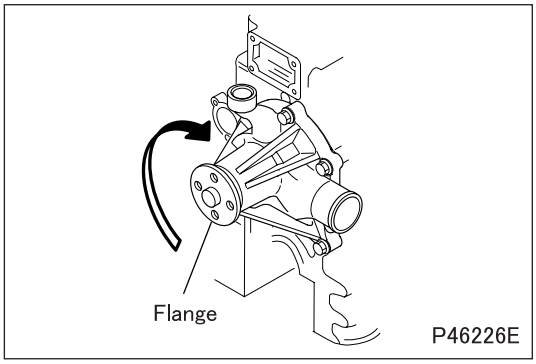
CAUTION ⚠

- **Before installing impeller, make sure that there is no or only one punch mark in the shown location on the impeller. Make an additional punch mark on the impeller to indicate that it undergoes the disassembly and reassembly process you are doing now.**
- **Punch mark(s) indicate the number of times the impeller was disassembled and reassembled in the past. If there are two marks, the impeller must be replaced.**



- Place the water pump so that the flange side end of the water pump shaft becomes the load bearing surface.
- Apply pressure to the impeller with a press and press-fit the impeller so that its end face is flush with the end of the water pump shaft.

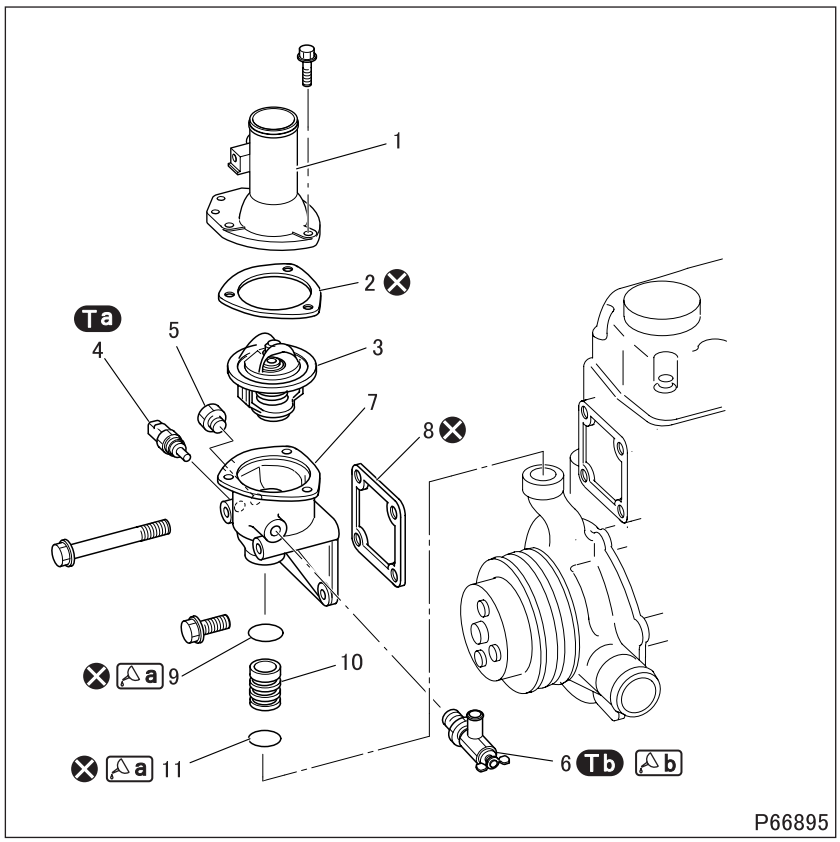
◆Inspection after assembly◆



■ **Inspection: Flange rotation**

- Rotate the flange by hand. The flange should rotate smoothly without any binding.
- If the flange does not rotate freely, disassemble and check.

THERMOSTAT



● **Disassembly sequence**

1 Thermostat cover
2 Gasket
3 Thermostat
4 Water temperature sensor
5 Plug
6 Cock
7 Thermostat case
8 Gasket
9 O-ring
10 Joint
11 O-ring

⊗: Non-reusable parts

CAUTION ⚠

- **Do not remove the thermostat case unless it has a water leak or any other defect.**

● **Assembly sequence**

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
3	Thermostat	Valve opening temperature	76.5 ± 2°C	–	Replace
		Valve lift/temperature	10 or more/90°C	–	

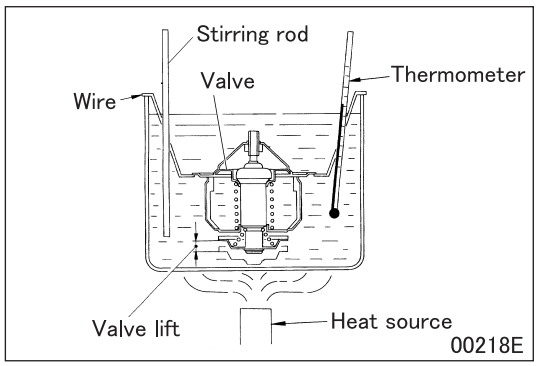
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Water temperature sensor	35 ± 7 {3.6 ± 0.7}	–
Tb	Cock	20 to 26 {2.0 to 2.7}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Soapy water	As required
b	Thread of plug	Loctite 575	As required

◆Inspection procedure◆



■ Inspection: Thermostat

- Stir the water using a stirring rod to maintain an even water temperature in the container, then conduct the tests indicated below.
- If the measured values deviate from the standard value ranges, replace the thermostat.

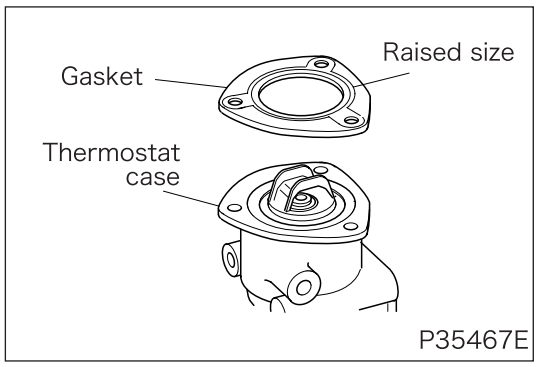
(1) Valve opening temperature

- Hold the thermostat with wire to keep it away from the heat source.
- Heat the water gradually to the valve opening temperature.
- Maintain this temperature for five minutes and make sure that the valve is completely open.
- Make sure that the valve closes completely when the water temperature drops below 65°C.

(2) Valve lift

- Heat the water to a temperature slightly higher than the valve opening temperature. Maintain this temperature for five minutes and measure the valve lift.

◆Installation procedure◆



■ Installation: Gasket

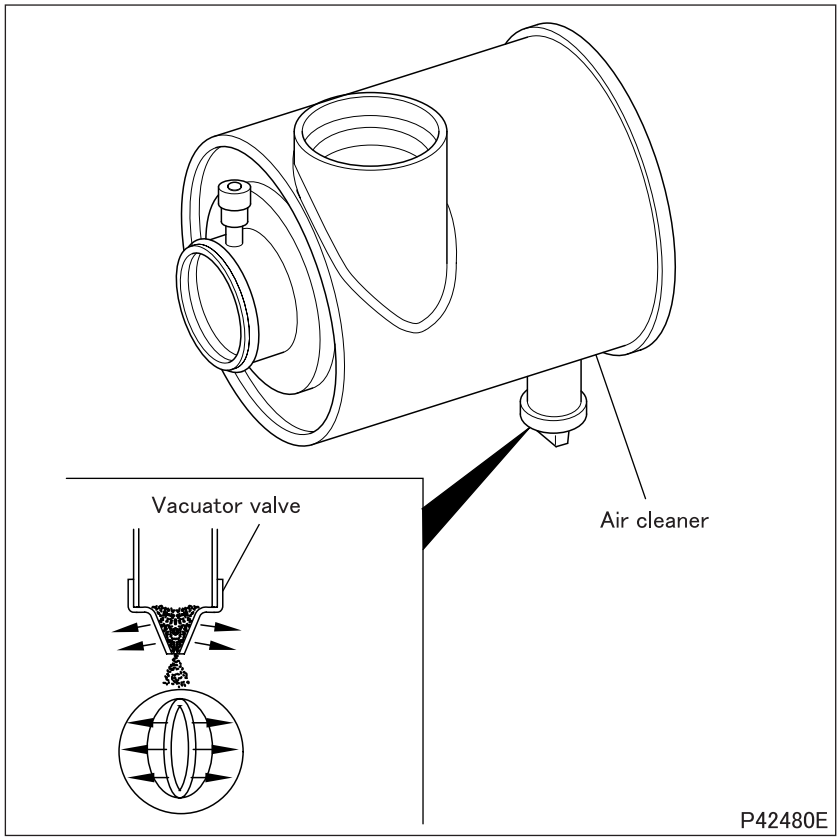
- Fit the gasket onto the thermostat case in the illustrated direction.

GROUP 15 INTAKE AND EXHAUST

SPECIFICATIONS

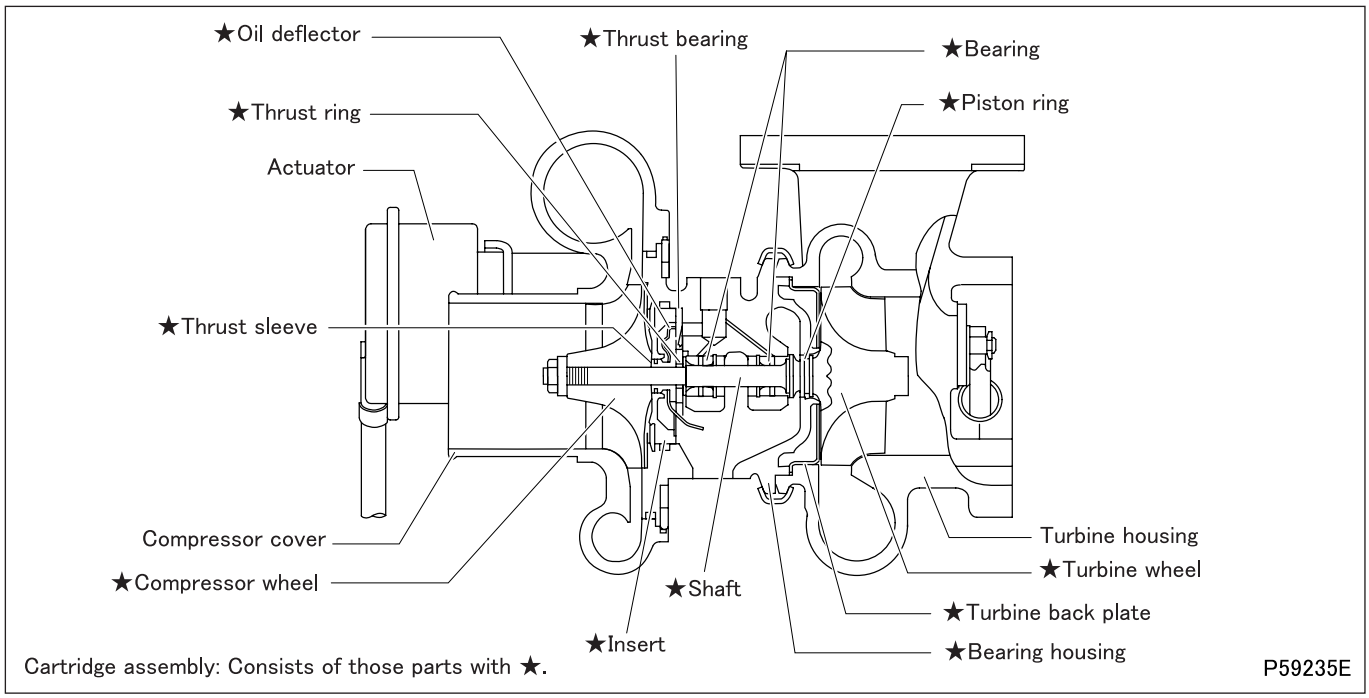
Item		Specifications
Air cleaner element		Cyclone filter paper type
Dust indicator type		Mechanical/electrical
Turbocharger	Model	TD06
	Manufacturer	Mitsubishi Heavy Industries

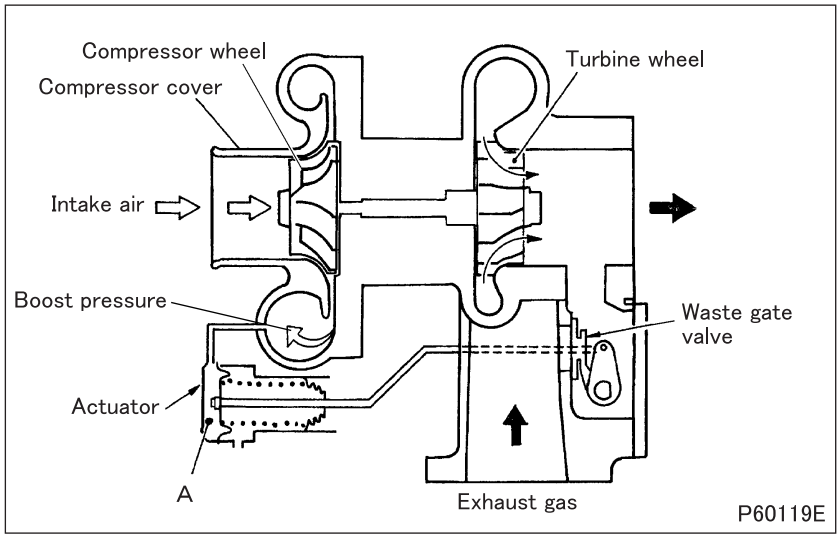
1. Air Cleaner



- The air cleaner utilizes single element.
- The lower air duct incorporate a vacuator valve.
- The vacuator valve automatically works in such a way that when the engine speed drops below a specified level, the valve's rubber boot which is usually subdued by internal vacuum is allowed to spring back and accumulated dust and dirt are discharged as a result.

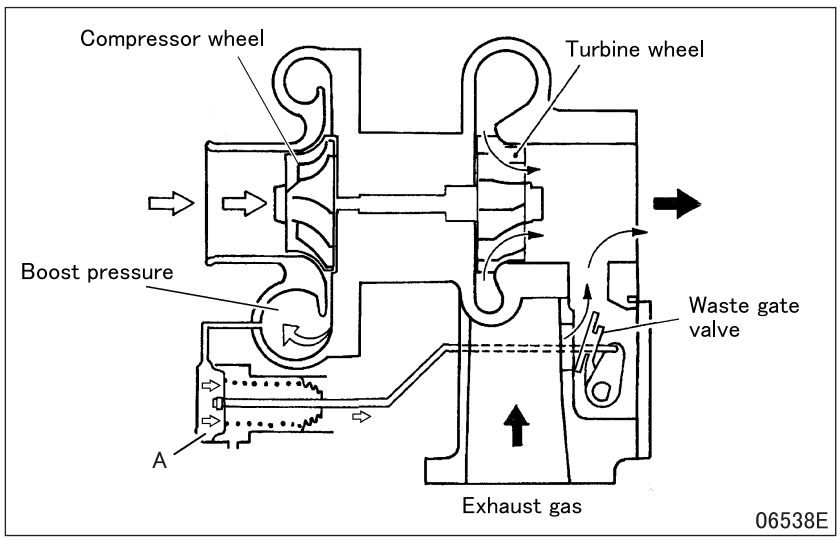
2. Turbocharger





2.1 Waste gate mechanism

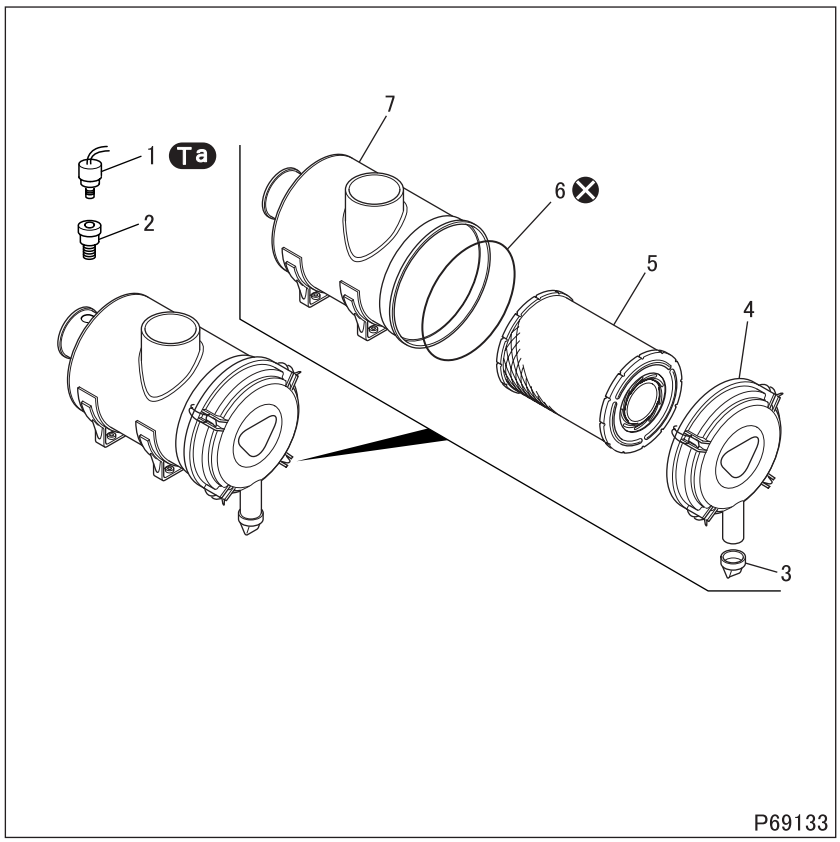
- The waste gate mechanism, which is operated by an actuator, is designed to let excess exhaust gas bypass the turbocharger, thereby preventing the turbocharger from overrunning and the intake manifold pressure from rising excessively. This ensures that the boost pressure is properly controlled.
- The boost pressure is led from the compressor cover into the actuator's chamber **A** through rubber hose. When the boost pressure working on the chamber **A** is lower than the preset level, the actuator remains inactive, allowing exhaust gas to be blown against the turbine wheel with the waste gate valve closed.



- When the boost pressure in the chamber **A** becomes higher than the preset level, it causes the waste gate valve to be opened, and the exhaust gas being blown against the turbine wheel is decreased. This reduces the revolution of the compressor wheel and the boost pressure returns below the preset level as a result.

Possible causes \ Symptoms			Engine hard to start	Black exhaust gas	White exhaust gas	Poor engine power	Excess oil consumption	Abnormal noise or vibration in intake/exhaust system	Reference Gr
Air cleaner		Clogged air cleaner element	O	O		O			
Turbocharger	Cartridge assembly	Carbon deposits on shaft		O		O			
		Interference between turbine wheel and turbine housing		O		O		O	
		Bent shaft		O		O		O	
		Damaged turbine wheel unit		O		O		O	
		Interference between compressor wheel and compressor cover		O		O		O	
		Damaged compressor wheel		O		O		O	
	Compressor cover fitted poorly			O		O	O	O	
	Turbine housing fitted poorly					O		O	
Incorrect valve clearances				O					Gr11
Head gasket defective				O					
Wear/carbon deposits on valves and valve seats				O					
Valve spring weakened				O					
Piston rings worn/damaged					O		O		
Piston ring grooves worn/damaged					O		O		
Cooling system malfunctioning				O					Gr14
Engine oil quantity excessive					O				Gr12
Major moving parts seized				O					Gr11
Uneven or excessive fuel injection				O					Gr13E

AIR CLEANER



● **Removal sequence**

1 Dust indicator
2 Adaptor
3 Vacuator valve
4 Cover
5 Element
6 O-ring
7 Case

⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse.

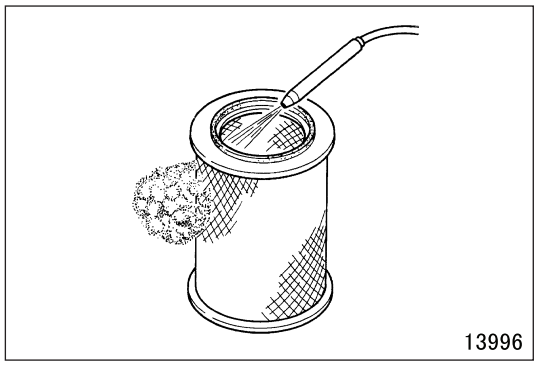
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
1	Operation of dust indicator under specified negative pressure	6.2 ± 0.6 kPa {47 ± 4.3 mmHg}	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Dust indicator	3.0 to 3.5 {0.3 to 0.35}	–

◆Cleaning procedure◆



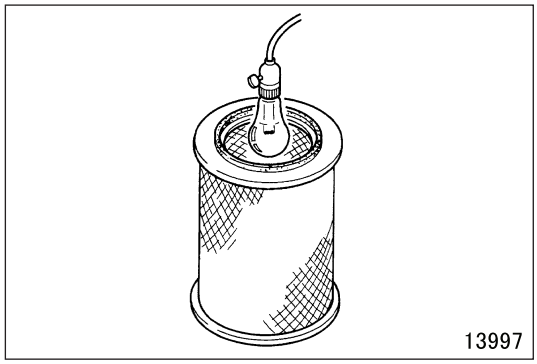
■ **Cleaning: Element**

- Blow a jet of compressed air at a pressure not higher than 685 kPa {7 kgf/cm^2} against the inside surfaces of the element.
- Move the compressed air jet up and down along all pleats of the filter paper element.

CAUTION ⚠

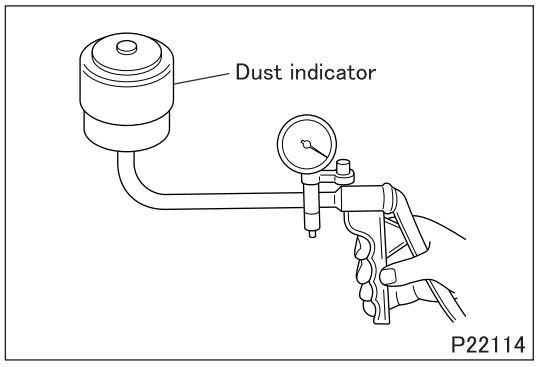
- **For the frequency and timing of cleaning, refer to the relevant instruction manual. More frequent cleaning than necessary could damage the element or cause dust and foreign matter to be sucked into the engine.**
- **Do not strike the element or hit it against another object to remove dust.**
- **Do not blow compressed air against outside surfaces of the element.**

◆Inspection procedure◆



■ **Inspection: Element**

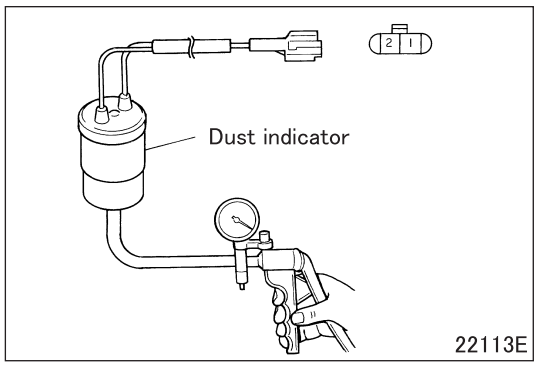
- Shine some electric light inside the element.
- Replace the element if thin spots or broken parts are evident in the filter paper, or if the packing at the top of the element is damaged.
  Also replace the element if the dust on the element is damp with oily smoke or soot, regardless of the replacement schedule.



■ **Inspection: Operation of dust indicator under specified negative pressure**

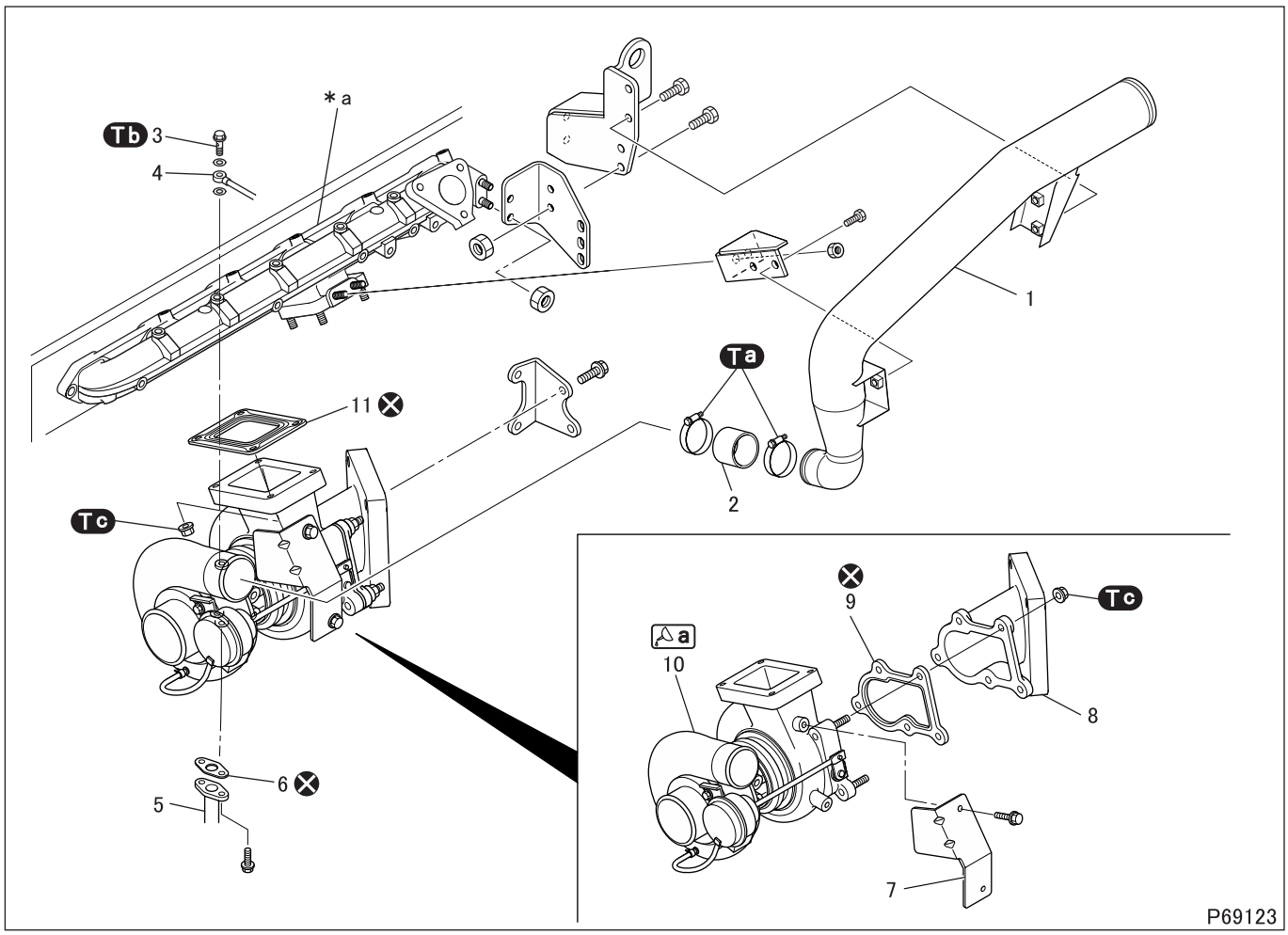
<Mechanical type>

- Apply negative pressure to the dust indicator, and take the reading when the white signal appears in the dust indicator window.
- Replace the dust indicator if found faulty.



<Electrical type>

- Perform the following inspection and, if faulty, replace the dust indicator.
  - With no vacuum applied to the dust indicator, take measurement between the terminals 1 and 2. There should be no continuity.
  - Gradually apply vacuum to the dust indicator. Measure the vacuum when the continuity is made between the terminals 1 and 2.



● Removal sequence

1 Air inlet pipe
2 Rubber hose
3 Eyebolt
4 Oil feed pipe
5 Oil return pipe
6 Gasket
7 Turbocharger cover
8 Exhaust pipe
9 Gasket
10 Turbocharger (See later section.)
11 Gasket

***a:** Exhaust manifold
⊗: Non-reusable parts

● Installation sequence

Follow the removal sequence in reverse.

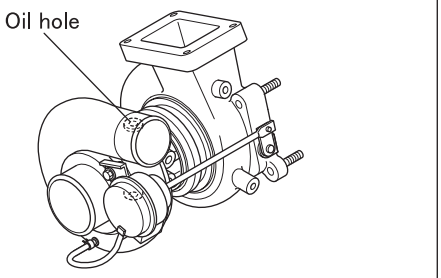
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp (rubber hose mounting)	4.9 {0.5}	–
Tb	Eyebolt (oil feed pipe mounting)	21 {2.1}	–
Tc	Nut (exhaust pipe mounting)	41 {4.2}	–
	Nut (turbocharger mounting)		

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Turbocharger (to be filled with engine oil)	Engine oil	As required

◆Installation procedure◆

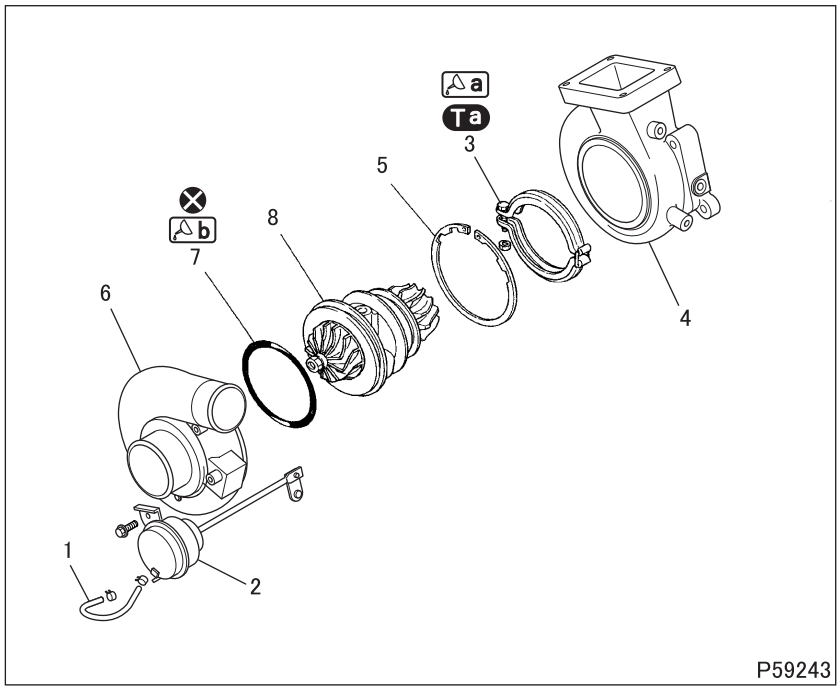


■ **Installation: Turbocharger**

- Before installing the turbocharger, pour engine oil into the oil hole to ensure smooth operation of the internal parts.

TURBOCHARGER

Turbocharger



●Disassembly sequence

1 Hose
2 Actuator
3 Coupling
4 Turbine housing
5 Snap ring
6 Compressor cover
7 O-ring
8 Cartridge assembly

⊗: Non-reusable parts

●Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- The cartridge assembly cannot be taken to pieces. Replace the whole assembly if the turbine wheel or compressor cover is damaged and when the cartridge does not rotate smoothly.

Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy
8	Cartridge assembly	Play in axial direction of shaft		0.05 to 0.09	0.1	Replace
		Play perpendicular to axis of shaft	Turbine wheel end	0.40 to 0.53	0.58	Replace
			Compressor wheel end	0.55 to 0.66	0.72	Replace

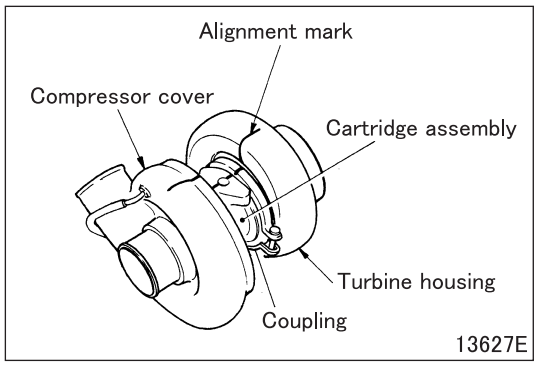
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (coupling tightening)	3.9 to 4.9 {0.4 to 0.5}	Wet

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Thread of bolts	Molybdenum disulfide grease [NLGI No. 2 (Li soap)]	As required
b	O-ring	Engine oil	As required

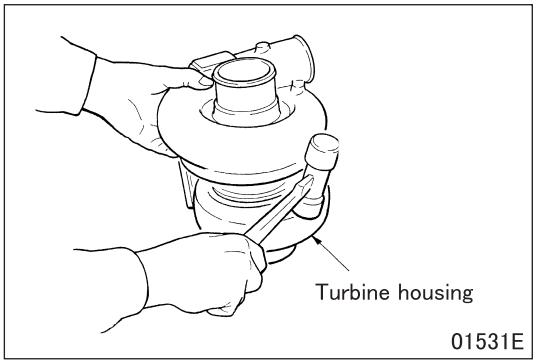
◆Work before removal◆



■ Alignment mark

- Put alignment marks on the coupling, turbine housing, compressor cover and cartridge assembly.

◆Removal procedure◆

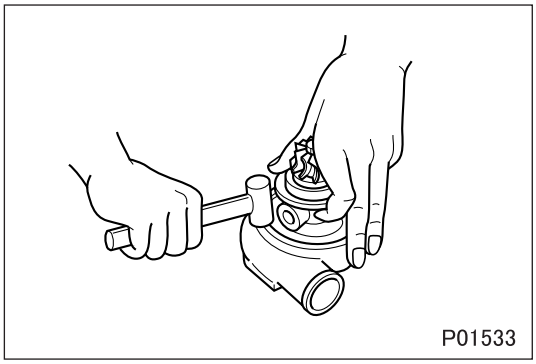


■ **Removal: Turbine housing**

- Lightly tap around the entire periphery of the turbine housing with a rubber-faced hammer, taking care not to cause damage.

CAUTION ⚠

- **The blades on the cartridge assembly are easily bent. Make sure that they do not strike the turbine housing.**



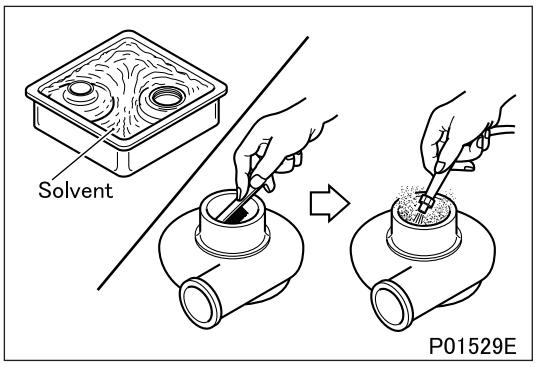
■ **Removal: Compressor cover**

- Lightly tap around the entire periphery of the compressor cover with a rubber-faced hammer, taking care not to cause damage.

CAUTION ⚠

- **The blades on the cartridge assembly are easily bent. Make sure that they do not strike the compressor cover.**

◆Work after disassembly◆



■ **Cleaning**

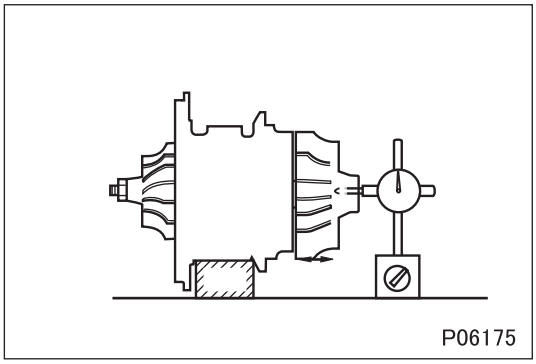
- Before cleaning, visually check the disassembled parts for scorches, abrasion and other marks that may be difficult to see after cleaning. Replace any part that appears defective.
- Immerse the disassembled parts in a non-flammable solvent (a 5 to 10 aqueous solution of Oil Clean from New Hope Co., Ltd.). Take out the parts and blow them dry with compressed air. Remove any hard deposits with a stiff brush or plastic scraper.

CAUTION ⚠

- **Do not immerse the cartridge assembly in the solvent. If the cartridge is immersed in the solvent, O-ring in the cartridge will swell, causing the turbocharger function to be impaired.**

- Again, immerse the parts in the solvent.
- Blow them dry using compressed air.

◆Inspection procedure◆

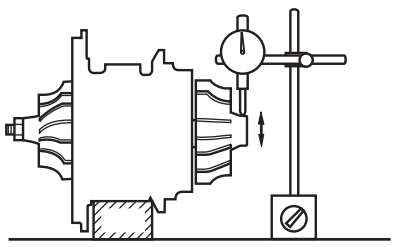


■ **Inspection: Cartridge assembly**

- If the measurement exceeds the specified limit, replace the cartridge assembly.

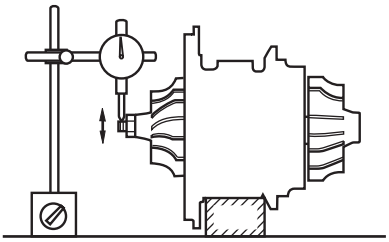
(1) Play in axial direction of shaft

<Turbine wheel end>



P06176E

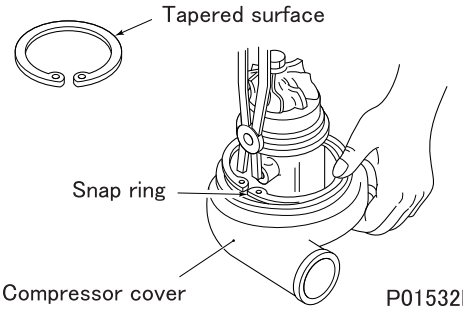
<Compressor wheel end>



P06177E

(2) Play perpendicular to axis of shaft

◆Installation procedure◆



P01532E

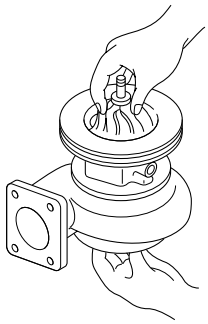
■ **Installation: Snap ring**

- With the tapered surface facing up, install the snap ring into the compressor cover.

CAUTION ⚠

- **Fit the snap ring into place using hands not to let it spring away.**

◆Work after installation◆



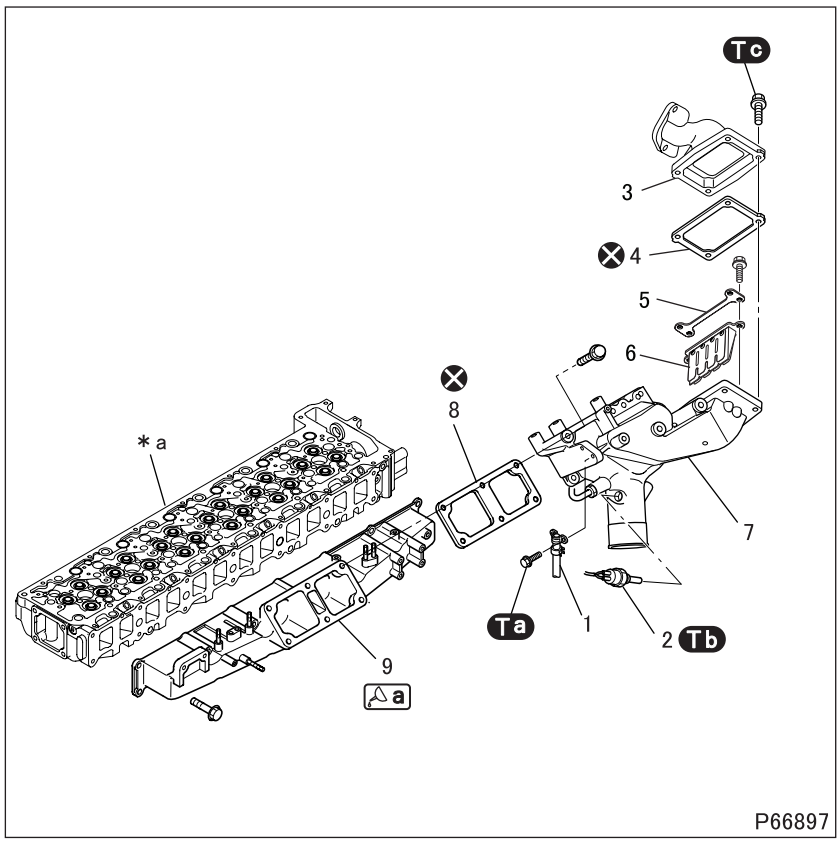
P06170

■ **Inspection: Free rotation of cartridge assembly**

- Turn the wheels of the cartridge assembly. They should turn freely without binding.
- If not, disassemble again and correct.

M E M O

INTAKE MANIFOLD



● **Removal sequence**

1 Boost pressure sensor
2 Intake air temperature sensor
3 Exhaust gas recirculation valve adapter
4 Gasket
5 Plate
6 Reed valve
7 Intake manifold fitting
8 Gasket
9 Intake manifold

*a: Cylinder head (See Gr11.)
⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse.

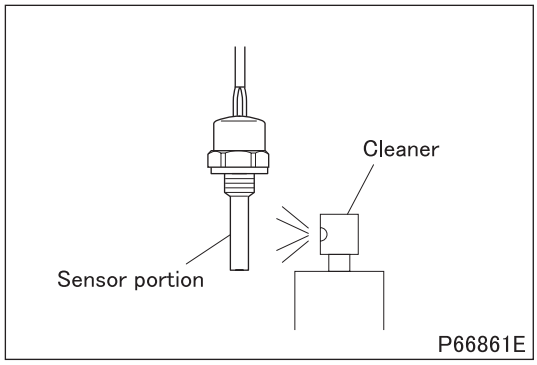
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (boost pressure sensor mounting)	4 to 6 {0.4 to 0.6}	–
Tb	Intake air temperature sensor	14.7 to 24.5 {1.5 to 2.5}	–
Tc	Bolt (exhaust gas recirculation valve adapter mounting)	46 to 54 {4.7 to 5.5}	

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Intake manifold to cylinder head mounting surface	ThreeBond 1217H	As required

◆Inspection procedure◆



■ **Installation: Intake air temperature sensor**

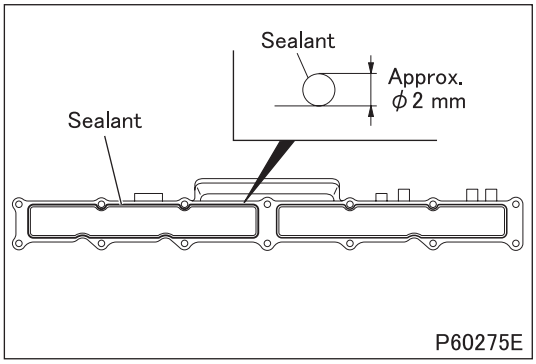
- Check that the sensor portion is free of soot, oily substance, etc.
- If not, clean the sensor portion as follows.
- Spray a cleaner on the sensor portion from 2 or 3 cm away.
  Recommended cleaners:
  Non-chlorinated Brake Parts Cleaner
- In 20 to 30 seconds after spraying, wipe the sensor portion clear of the sprayed cleaner using a soft waste cloth or the like.

CAUTION ⚠

- **Be sure to wait for 20 to 30 seconds before wiping. It takes the cleaner that long to dissolve foreign matter.**

- If the sensor portion is fouled excessively, the positive crankcase ventilation (PCV) may be faulty. Inspect the PCV valve and filter to locate the cause and remove it. (See Gr17.)

◆Installation procedure◆



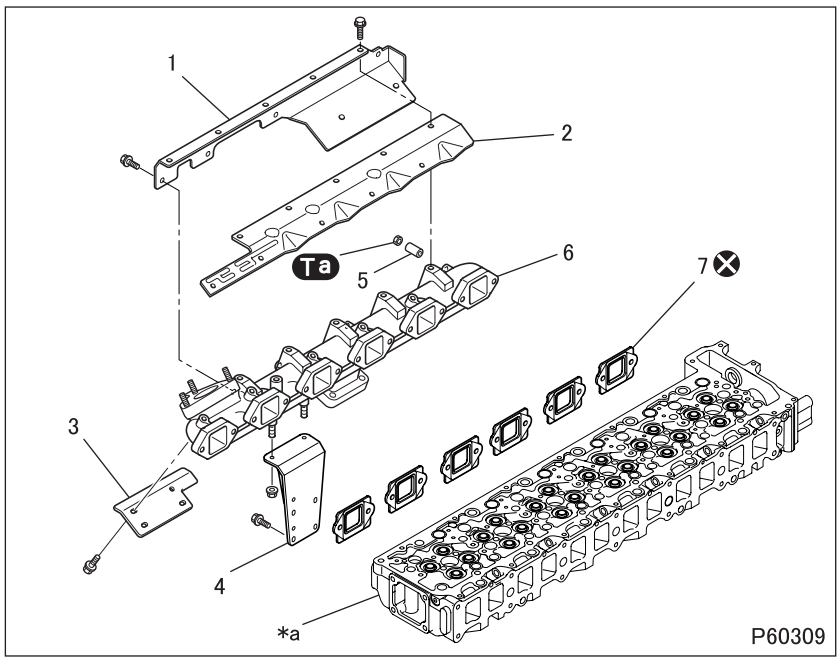
■ **Installation: Intake manifold**

- Clean the sealing surfaces of the intake manifold and cylinder head where they are to be mated with each other.
- Apply an even and continuous bead of sealant onto the intake manifold surface where the cylinder head is to be mounted.
- Install the intake manifold onto the cylinder head within 3 minutes following the application while taking care not to spread the sealant beyond the application area.

CAUTION ⚠

- **Do not start the engine at least for an hour after the intake manifold has been installed.**
- **If the intake manifold mounting bolts are subsequently loosened or removed, be sure to apply sealant again upon reassembly.**

EXHAUST MANIFOLD



● **Removal sequence**

1 Exhaust manifold insulator A
2 Exhaust manifold insulator B
3 Front exhaust manifold insulator
4 Exhaust manifold bracket
5 Distance piece
6 Exhaust manifold
7 Gasket

***a:** Cylinder head (See Gr11.)
⊗: Non-reusable parts

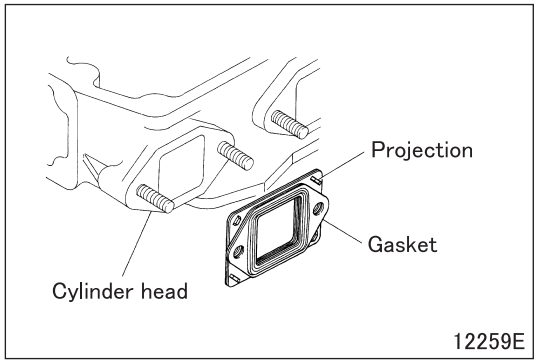
● **Installation sequence**

Follow the removal sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (exhaust manifold mounting)	58 {5.9}	–

◆Installation procedure◆



■ **Installation: Gasket**

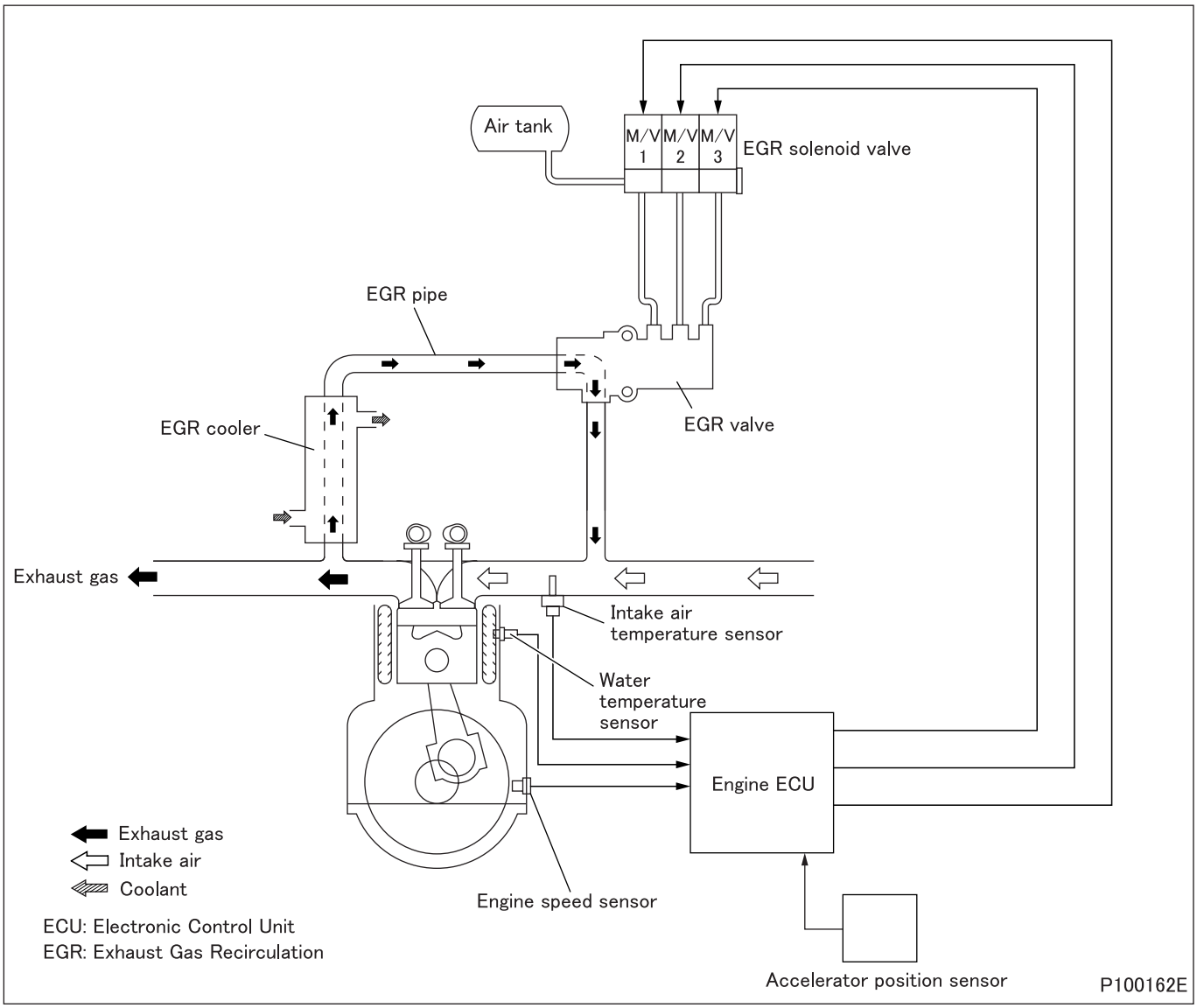
- Fit the gasket to the cylinder head in the illustrated direction.

GROUP 17 EMISSION CONTROL

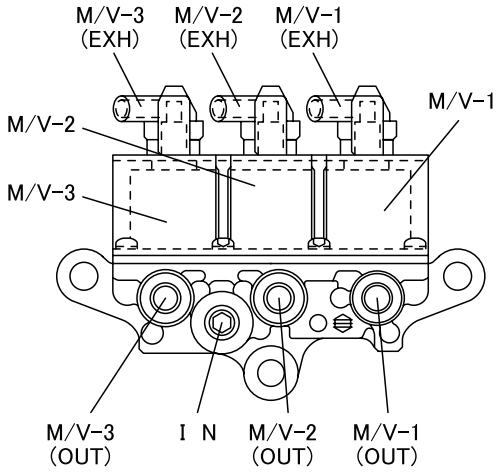
1. Exhaust Gas Recirculation System

1.1 Overview

- EGR mixes inert gases contained in burned exhaust gases with the air on the inlet side (inlet manifold), thereby reducing the combustion temperature and thus reducing the amount of harmful NOx (nitrogen oxides) contained in the exhaust gases.
  The EGR cooler provides cooling to increase the density of the inert gases, thereby achieving a greater EGR effect.
- The EGR system uses various sensors to detect engine operating conditions (engine speed, coolant temperature, accelerator opening) and, based on the information obtained, lets the engine ECU control operation of the EGR solenoid valve. (See Gr13E for the electronic control system and ECU connection diagram.)
- If black smoke occurs or the engine speed becomes erratic under heavy or low load condition of the engine, the EGR valve control function is suspended.



(1) EGR solenoid valves



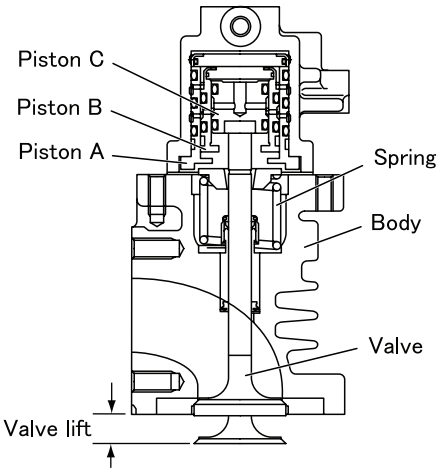
EGR solenoid valve (M/V)			Operating stage	I N	M/V-3 (EXH)	M/V-3 (OUT)	M/V-2 (EXH)	M/V-2 (OUT)	M/V-1 (EXH)	M/V-1 (OUT)
1	2	3								
OFF	OFF	OFF	0		○	○	○	○	○	○
O N	OFF	OFF	1	○		○	○	○	○	○
OFF	O N	OFF	2	○	○			○	○	○
O N	O N	OFF	3	○		○		○	○	○
OFF	OFF	O N	4	○	○	○	○	○		○
O N	OFF	O N	5	○		○	○	○		○
OFF	O N	O N	6	○	○			○		○
O N	O N	O N	7	○		○		○		○

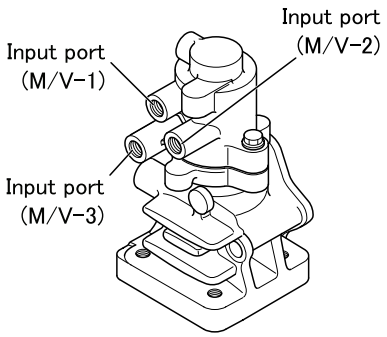
○——○ : Pneumatic continuity

P57892E

- The EGR solenoid valves are each turned ON/OFF by drive signals from the engine electronic control unit to realize a 7-stage supply of air to the EGR valve.

(2) EGR valve



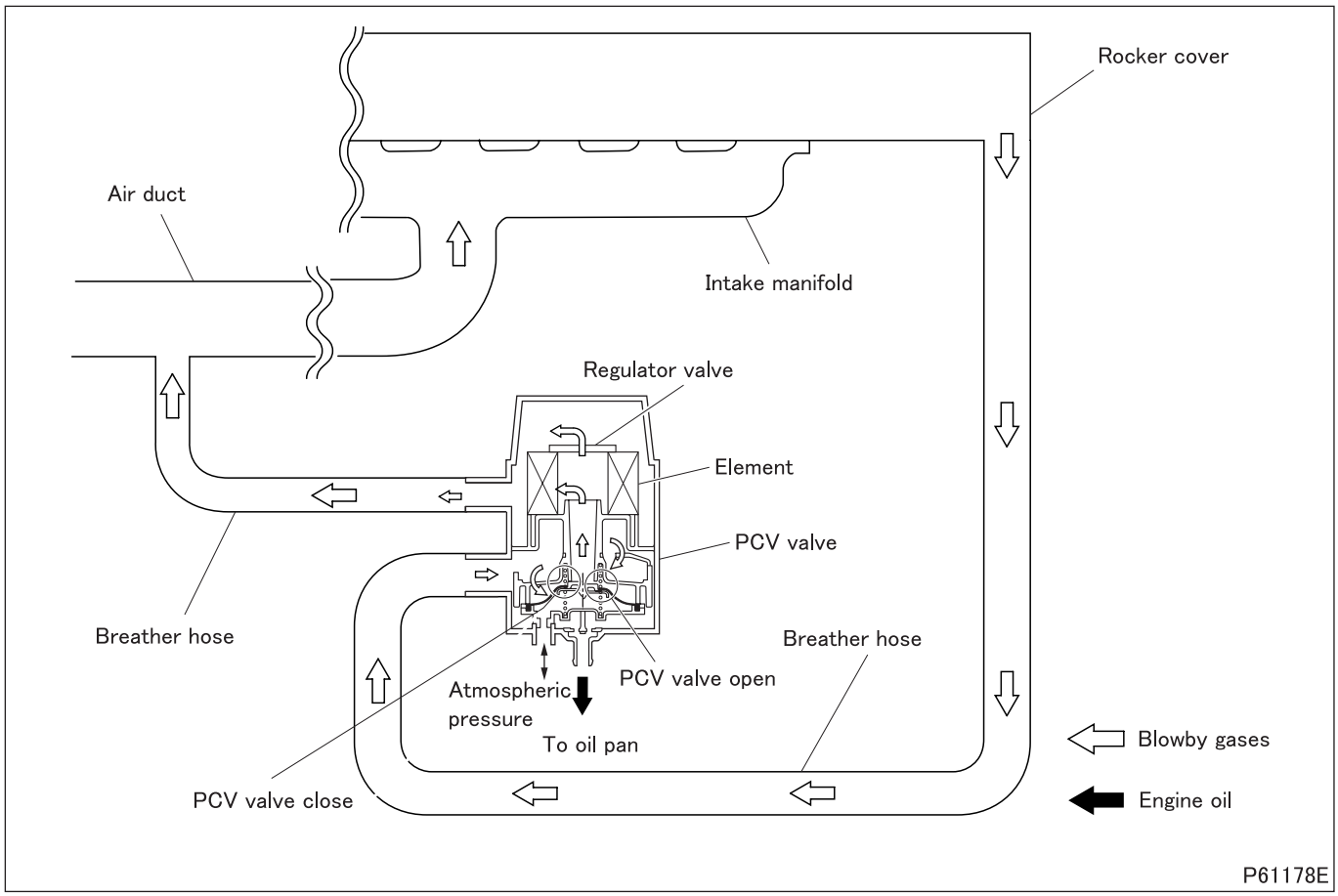


Operating stage	Input port (M/V)			Valve lift (mm)
	1	2	3	
0	OFF	OFF	OFF	0
1	O N	OFF	OFF	1.3±0.3
2	OFF	O N	OFF	2.6±0.3
3	O N	O N	OFF	4.6±0.3
4	OFF	OFF	O N	5.7±0.4
5	O N	OFF	O N	7.7±0.4
6	OFF	O N	O N	9.0±0.3
7	O N	O N	O N	11.0±0.3

P57893E

- The EGR valve realizes 7 stages of valve lift in accordance with the supply of air to its input ports from the EGR solenoid valves.

2. Blowby Gas Return System



PCV: Positive Crankcase Ventilation

- The blowby gas return system returns blowby gases to an air duct to prevent them from being released to the outside air.
- The PCV valve keeps constant the pressure inside the crankcase.
- The oil in the blowby gas is separated by the wire mesh and the element in the PCV valve and is returned to the oil pan.
- When the element is clogged, the regulator valve opens and the blowby gas is returned to the breather hose.

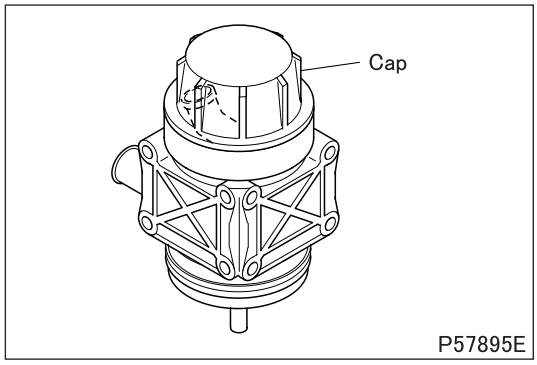
1. Replacement of PCV Valve Element

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	O-ring	Engine oil	As required

CAUTION ⚠

- **For information on the element replacement interval, refer to the element instruction manual. If the element is used beyond its replacement interval, it may become clogged, causing the pressure inside the engine to increase such that oil leakage occurs.**
- **Be sure to remove and install the cap by hand. Using tools could result in damage.**

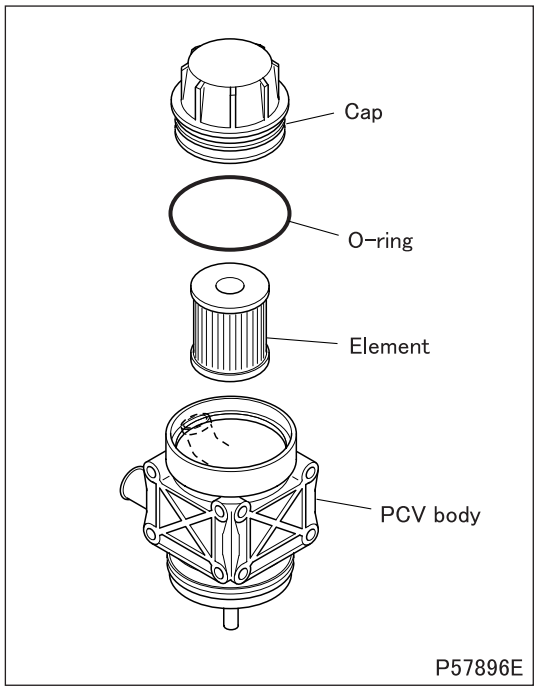


[Removal]

- Loosen the cap by hand.

CAUTION ⚠

- **Do not use any tools to loosen the cap. Otherwise, the cap may become damaged.**



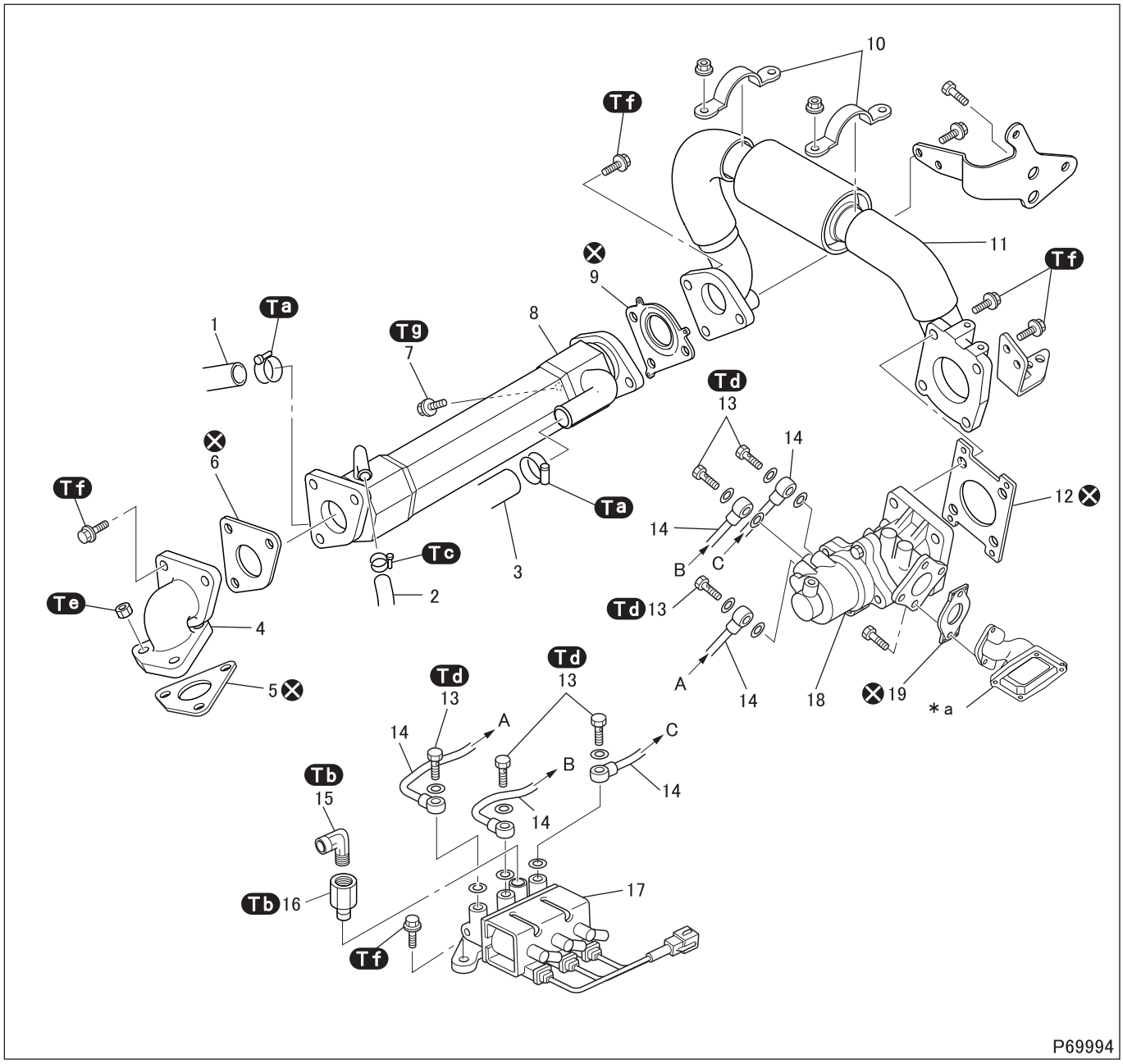
[Installation]

- Clean the thread on the cap.
- Lightly smear the O-ring with engine oil and fit it on the cap.
- Securely tighten the cap until it stops slightly above the PCV body.

CAUTION ⚠

- **Be sure to use a genuine Mitsubishi Fuso element. Using an inappropriate element could result in engine trouble.**
- **When replacing the element, be sure to replace the O-ring also.**

EGR VALVE, EGR SOLENOID VALVE, EGR PIPE AND EGR COOLER



● Removal sequence

1 Water hose
2 Water hose
3 Water hose
4 EGR adapter
5 Gasket
6 Gasket
7 Plug
8 EGR cooler
9 Gasket
10 Upper EGR pipe clamp
11 EGR pipe
12 Gasket
13 Eyebolt
14 EGR air pipe
15 Connector
16 Connector
17 EGR solenoid valve
18 EGR valve
19 Gasket

***a**: EGR valve adapter

⊗: Non-reusable parts
Arrows A to C indicate points to or from which pipes are connected.
EGR: Exhaust Gas Recirculation

● Installation sequence

Perform installation by following the removal sequence in reverse.

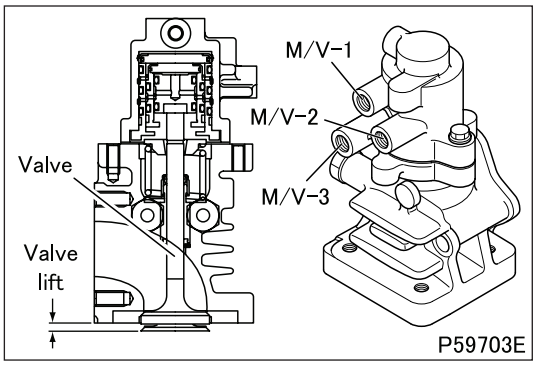
Service standards

Location	Maintenance item			Standard value	Limit	Remedy
18	EGR valve lift	Operating stage	0	0	–	Replace
			1	1.3 ± 0.3	–	
			2	2.6 ± 0.3	–	
			3	4.6 ± 0.3	–	
			4	5.7 ± 0.3	–	
			5	7.7 ± 0.4	–	
			6	9.0 ± 0.3	–	
			7	11.0 ± 0.3	–	

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp (water hose mounting)	4 to 5 {0.4 to 0.5}	–
Tb	Connector (air pipe mounting)	15 to 29 {1.5 to 3.0}	–
Tc	Clamp (water hose mounting)	3.9 {0.4}	–
Td	Eyebolt (water outlet pipe mounting)	25 {2.6}	–
	Eyebolt (EGR air pipe mounting)		
Te	Nut (EGR adapter mounting)	58 {5.9}	–
Tf	Bolt (EGR adapter mounting)	46 to 54 {4.7 to 5.5}	–
	Bolt (EGR pipe mounting)		
	Bolt (EGR solenoid valve mounting)		
Tg	Plug	29 {3.9}	–

◆Inspection procedures◆



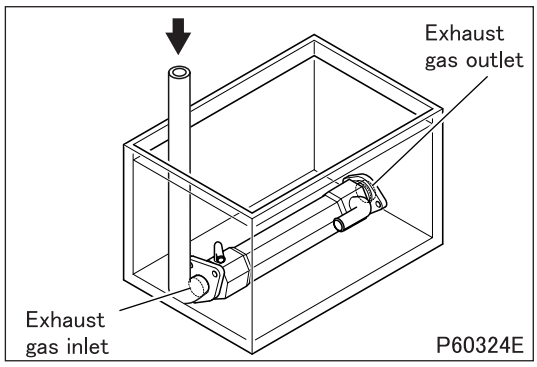
■ Inspection: EGR valve lift

- While applying air pressure of 637 to 932 kPa {6.5 to 9.5 kgf/cm^2} to the ports in accordance with the table below, measure the valve lift in operating steps 0 to 7 on each valve.
- Replace the EGR valve if it does not conform to the standard value.

Operating step	Input port		
	M/V-1	M/V-2	M/V-3
0	–	–	–
1	O	–	–
2	–	O	–
3	O	O	–
4	–	–	O
5	O	–	O
6	–	O	O
7	O	O	O

O: Air applied
–: Air not applied

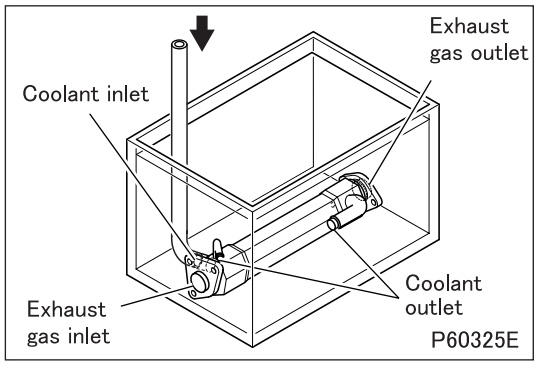
◆Inspection procedures◆



■ Inspection: EGR cooler

(1) Exhaust gas passage side

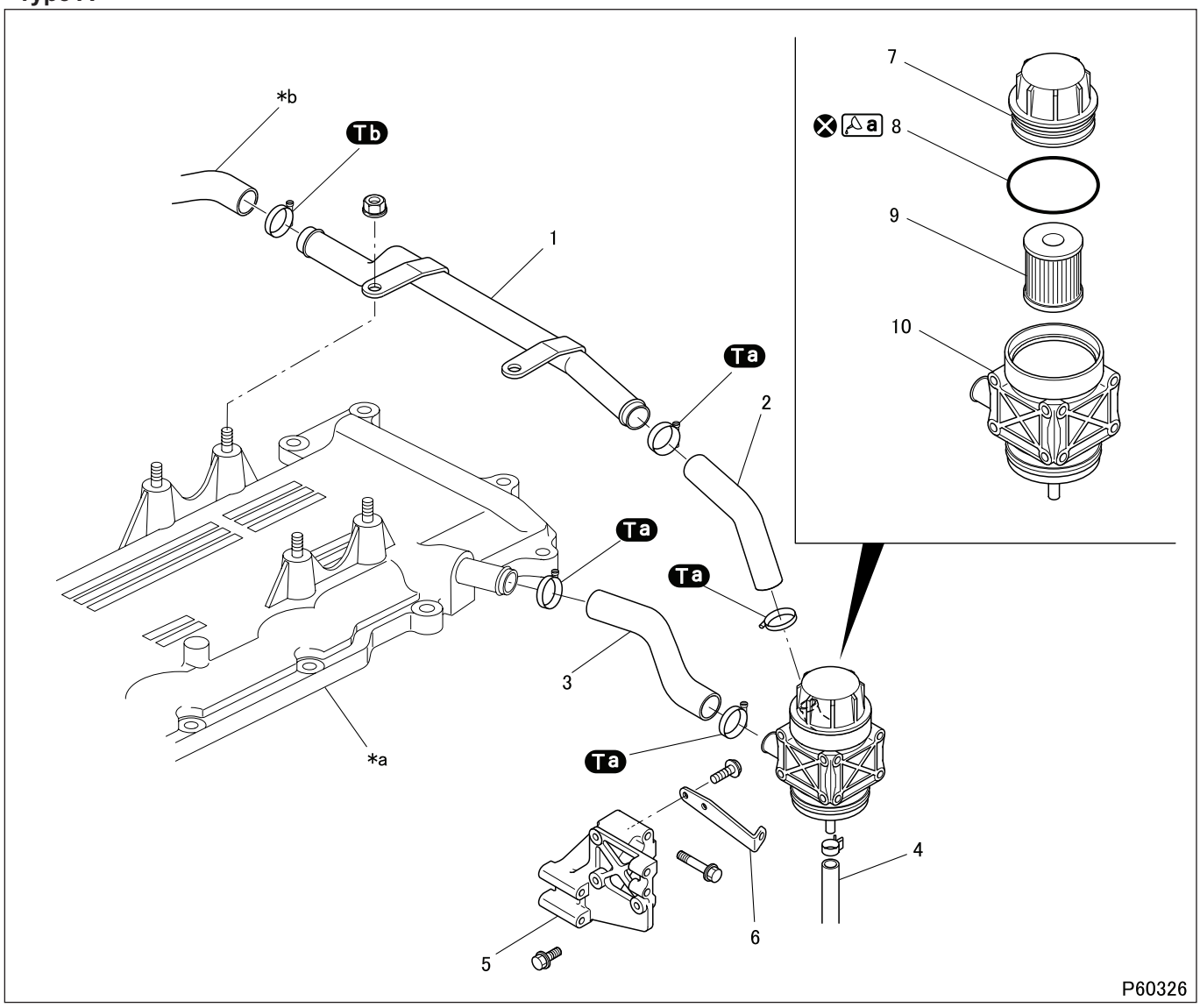
- Fit a cover over the exhaust gas outlet of the EGR cooler, and connect a hose to the exhaust gas inlet. Then, submerge the EGR cooler in a container of water. Make sure the coolant passage is full of water.
- Apply air pressure of 390 kPa {4 kgf/cm^2} through the hose. Check that air does not leak from any part of the EGR cooler.
- If there is any abnormality, replace the EGR cooler.



(2) Coolant passage side

- Fit covers over the EGR cooler's exhaust gas inlet, exhaust gas outlet, and coolant outlet, and connect a hose to the coolant inlet. Then, submerge the EGR cooler in a container of water.
- Apply air pressure of 294 kPa {3 kgf/cm^2} through the hose. Check that air does not leak from any part of the EGR cooler.
- If there is any abnormality, replace the EGR cooler.

<Type A>



● Removal sequence

1 Breather pipe
2 Breather hose
3 Breather hose
4 Oil hose
5 PCV valve bracket
6 Oil hose stay
7 Cap
8 O-ring
9 Element
10 PCV body
***a**: Rocker cover
***b**: Breather hose
⊗: Non-reusable parts
PCV: Positive crankcase ventilation

● Installation sequence

Perform installation by following the removal sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

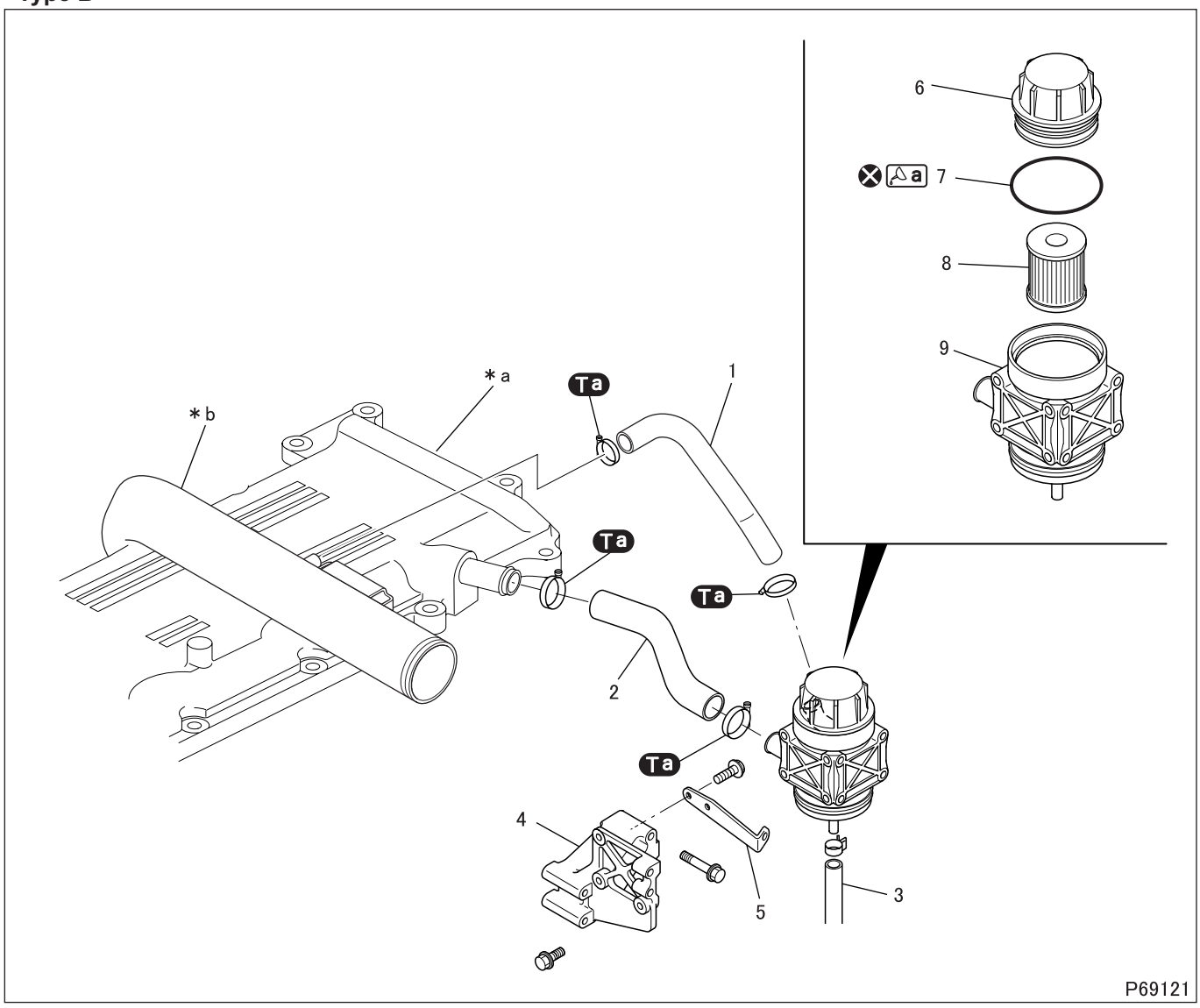
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	4.9 {0.5}	–
Tb	Clamp	4.0 to 5.0 {0.4 to 0.5}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

BLOWBY GAS RETURN SYSTEM

<Type B>



● Removal sequence

1 Breather hose
2 Breather hose
3 Oil hose
4 PCV valve bracket
5 Oil hose stay
6 Cap
7 O-ring
8 Element
9 PCV body

***a**: Rocker cover
***b**: Air suction pipe

⊗: Non-reusable parts
PCV: Positive crankcase ventilation

● Installation sequence

Perform installation by following the removal sequence in reverse.

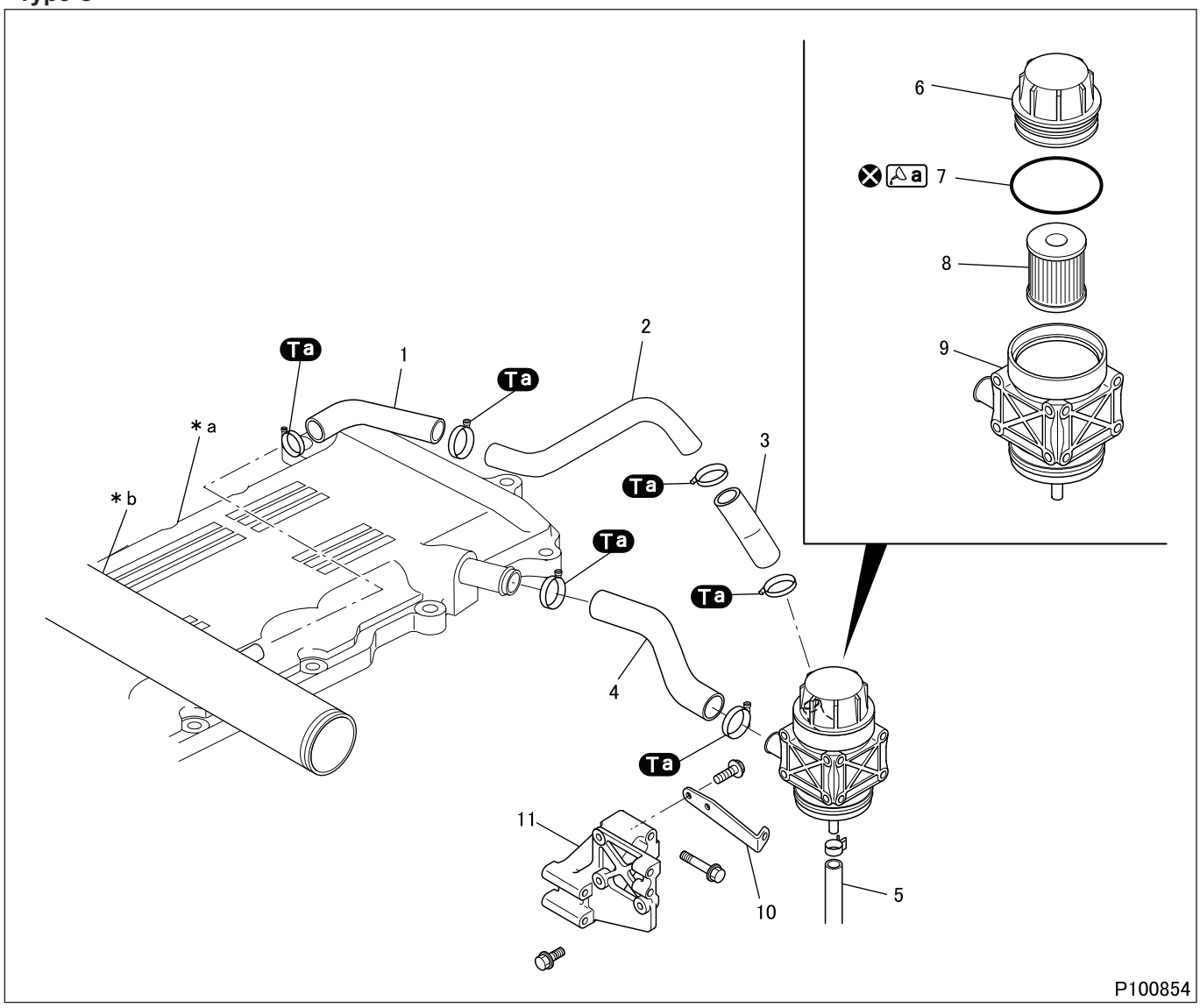
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	4.9 {0.5}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

<Type C>



● Removal sequence

1 Breather hose
2 Breather pipe
3 Breather hose
4 Breather hose
5 Oil hose
6 Cap
7 O-ring
8 Element
9 PCV body
10 Oil hose stay
11 PCV valve bracket

***a**: Rocker cover
***b**: Air suction pipe

⊗: Non-reusable parts
PCV: Positive crankcase ventilation

● Installation sequence

Perform installation by following the removal sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	4.9 {0.5}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

GROUP 54 ELECTRICAL

SPECIFICATIONS

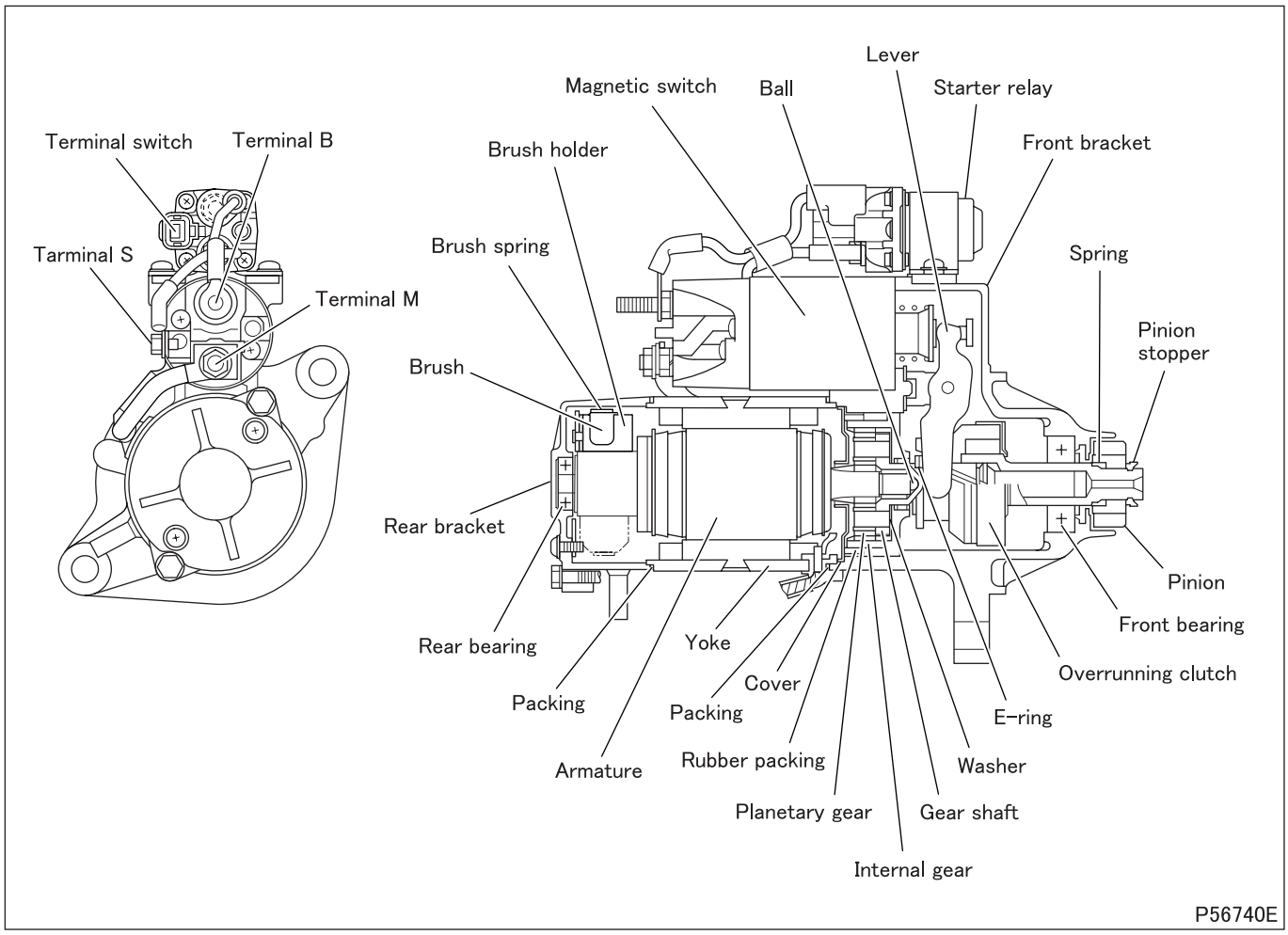
Alternator

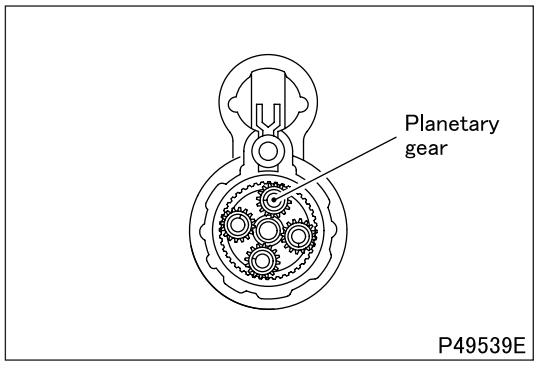
Item		Specifications		
Manufacturer		MITSUBISHI ELECTRIC		
Type		Alternator with built-in regulator (without brush external fan)		
Model		A4T40379	A4T40399	A4TU7686
Output	V–A	24–50		

Starter, Preheat

Item			Specifications
Starter	Manufacturer		MITSUBISHI ELECTRIC
	Model		M008T62271
	Output	V–kW	24–5.0
	Magnetic switch operating voltage	V	16 or less
Starter relay	Model		U001X33472
	Excitation current	V–A	24–2.3
	Closing voltage	V	16 or less
	Opening voltage	V	4 or less
	Allowable cutoff current	A	200
Glow plug	Model		Sheathed type
	Rated voltage and current	V–A	23–2.2 (reference)
Glow relay	Model		U001T41472
	Excitation current	V–A	24–1.8
	Closing voltage	V	16 or less
	Opening voltage	V	4 or less
	Allowable cutoff current	A	60
	Temperature fuse capacity	A	127

1. Starter

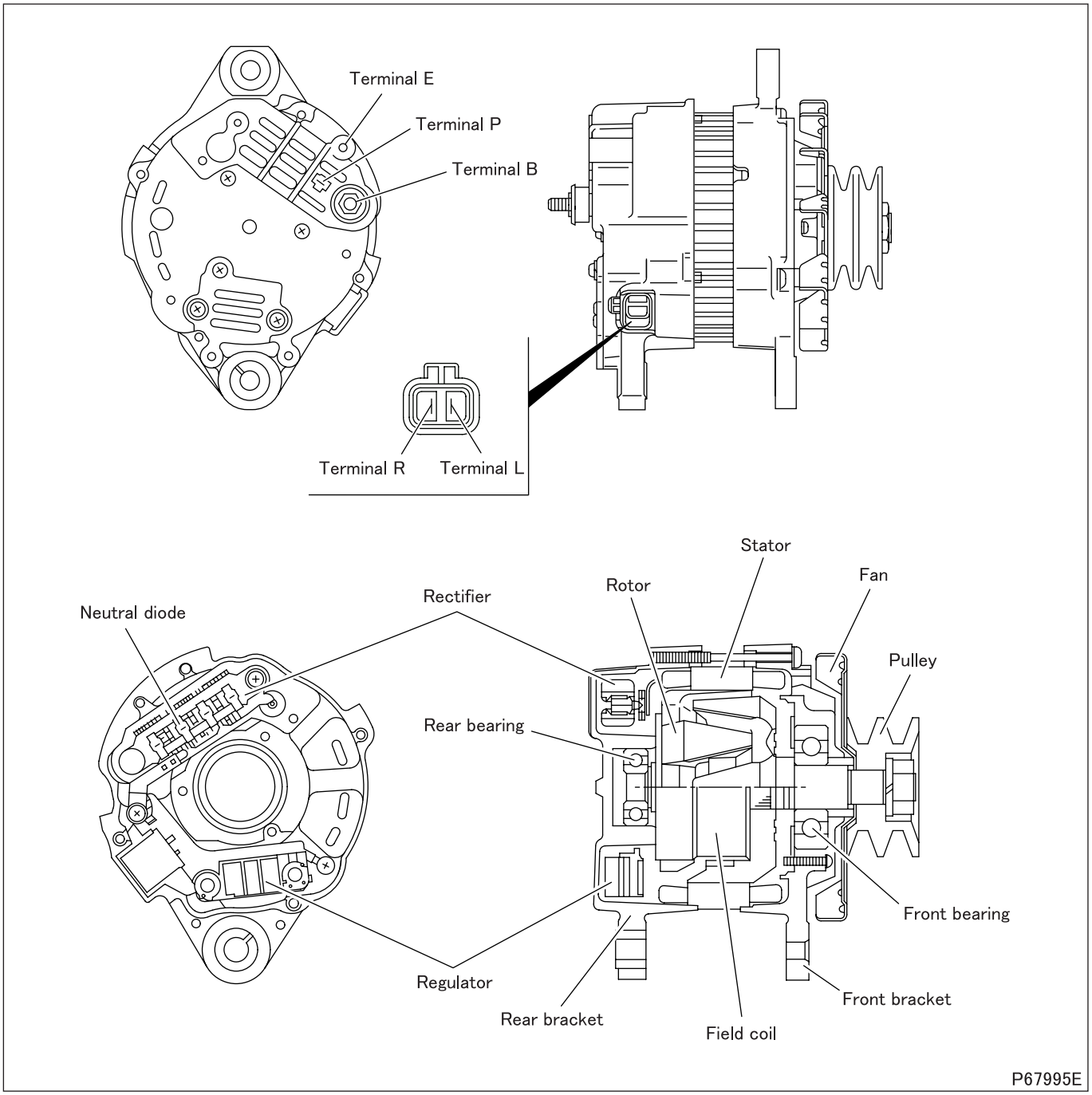




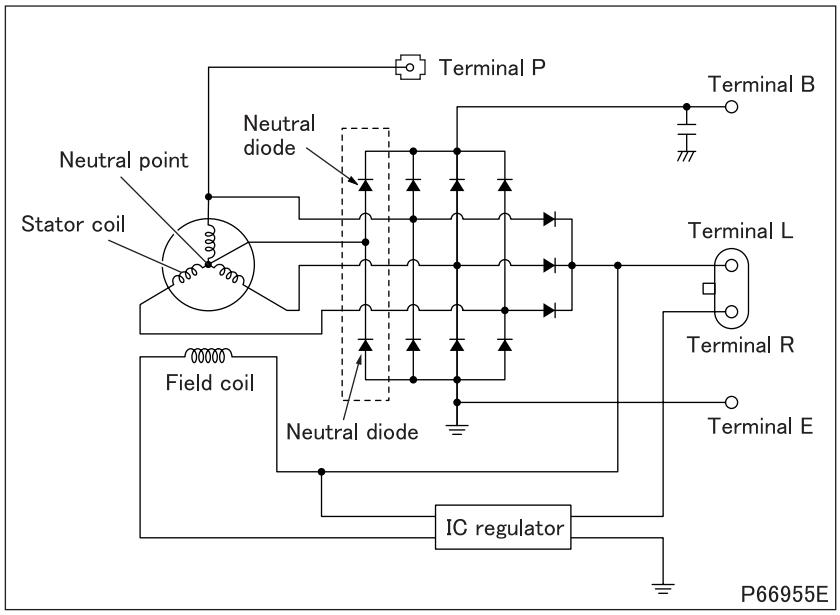
- This starter uses planetary gears as its reduction gearing mechanism.

2. Alternator

<24V–50A>

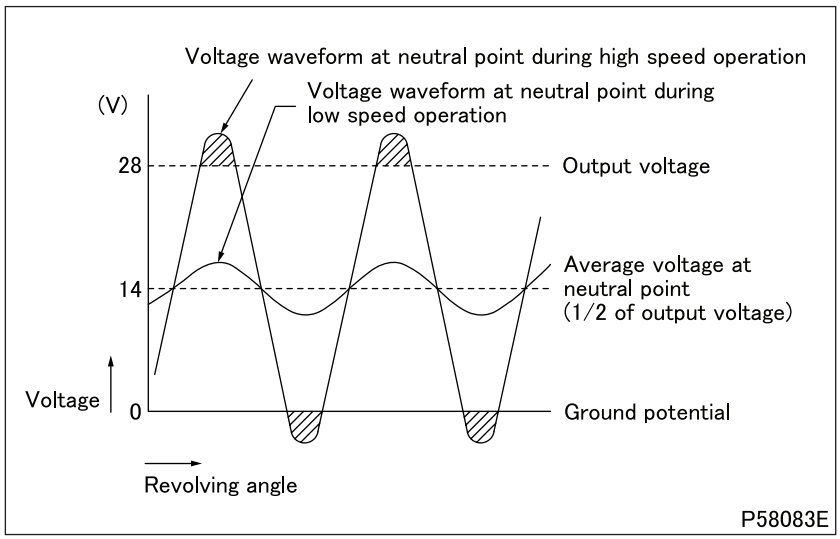


2.1 Alternator with neutral diodes



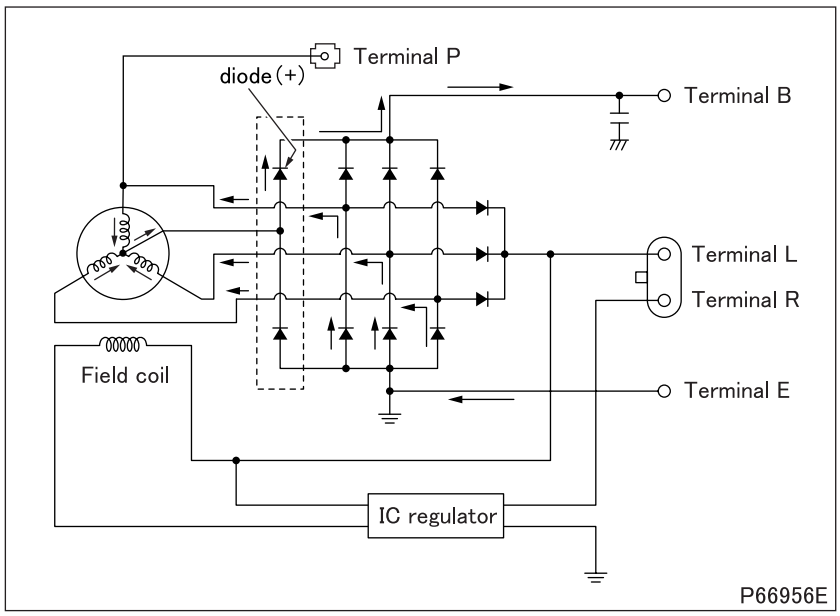
(1) Features

- The alternator with neutral diodes provides higher DC output during operation at high speeds than the alternator without neutral diodes.

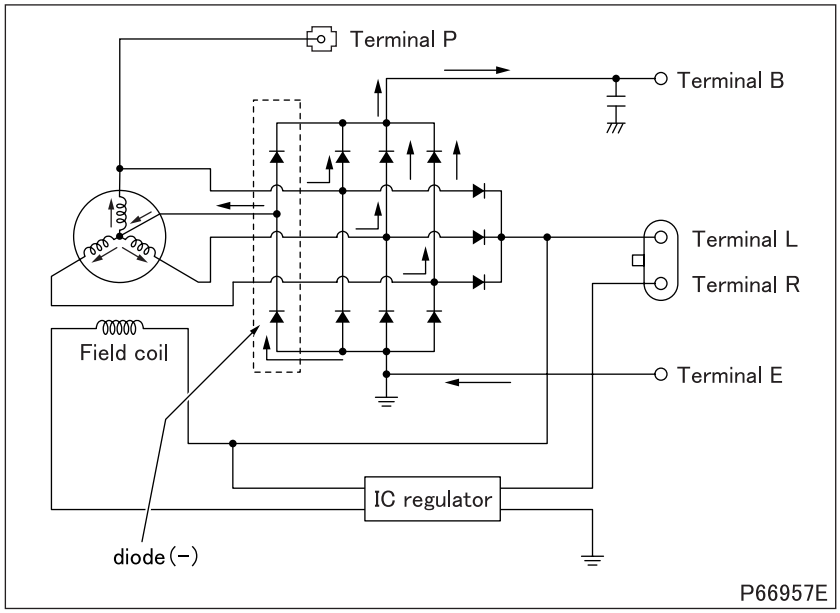


(2) Variations of voltage at neutral point and operation of neutral diodes

- The potential at the neutral point varies up and down with the neutral point DC voltage (1/2 of output voltage) as a center as shown.
- When the alternator is operated at high speeds, the voltage at the neutral point can increase to exceed the output voltage (28 V) and decrease to become lower than the ground voltage (0 V), and these voltages are lost in conventional system. The neutral diodes rectifies these over-voltage and under-voltage (shaded portions of diagram) and adds them to the DC output.
- When the voltage at neutral point is in the range from 0 to 28 V, the conventional diodes (other than neutral diodes) operate.

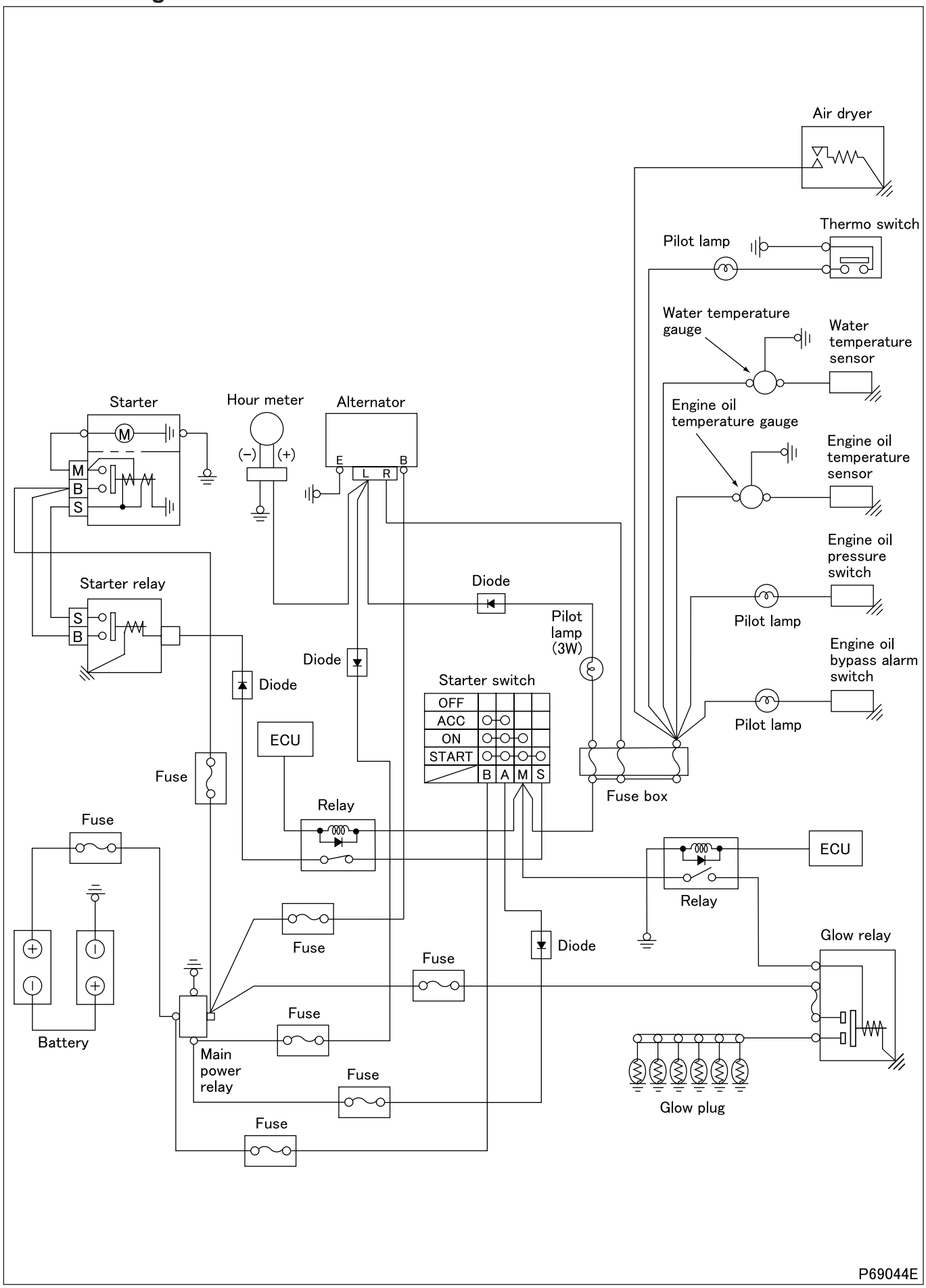


- When the voltage at neutral point exceeds 28 V, the positive diode operates and adds extra output to the DC output for supply to each electric equipment.



- When the voltage at neutral point drops below 0 V, the negative diode supplies the output from neutral point through other three diodes.

3. Circuit diagram

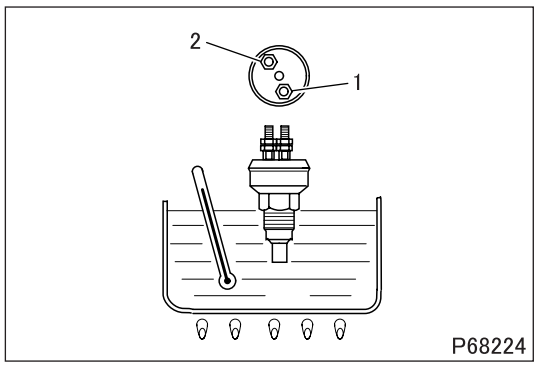


1. Power and Charging

Symptoms / Possible causes		Battery electrolyte decreases too early.	Battery overheating.	Battery is normal but over-discharged.	Charge warning lamp does not light when starter switch is turned ON, with engine stopped.	Alternator is normal but battery over-discharged.	Reference Gr
Connector connection faulty, harness broken, grounding faulty				O		O	
Fuse blown				O	O	O	
V-belts loose				O		O	Gr14
V-belts damaged				O		O	
Battery faulty		O				O	
Alternator	Stator coil broken			O			
	Stator coil short-circuited with core			O			
	Field coil broken			O			
	Rectifier faulty			O			
	Regulator faulty		O	O	O		
	Wiring faulty			O			

2. Engine Starting, Preheating and Stopping

Symptoms / Possible causes		Starter does not operate.	Starter operates but engine does not start.			Engine does not stop.	Engine cannot be preheated.	Engine is hard to start.	Does not operate cold start function.	Reference Gr
			Pinion does not engage with ring gear.	Pinion engages with ring gear but does not rotate.	Flywheel rotates but engine does not start.					
Connector connection faulty, harness broken, grounding faulty		O			O	O	O	O	O	
Fuse blown		O					O		O	
Battery insufficiently charged		O		O						
Starter	Magnetic switch contacts stuck or fused together	O								
	Open circuit in magnetic switch coil	O								
	Overrunning clutch malfunctioning		O							
	Pinion worn or damaged		O							
Starter relay defective		O								
Starter switch defective		O				O				
Flywheel ring gear worn or damaged			O							Gr11
Electronically controlled fuel system	Engine electronic control unit defective					O	O	O	O	Gr13E
	Supply pump defective					O				
Water temperature sensor defective							O	O		
Glow plugs defective							O	O		
Glow relay defective							O	O		
Connecting plate connection faulty							O	O		
Cold start switch defective										
Exhaust brake 3-way magnetic valve defective									O	
Exhaust brake system defective									O	

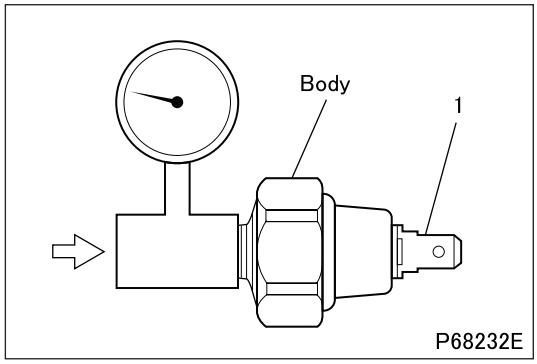


#024 Inspection of thermo switch

- Dip the switch in a container filled with engine oil.
- Raise the oil temperature to the specified one while stirring oil.
- Measure the operating temperature between terminals 1 and 2 respectively.

Standard value	105 ± 2°C

- If the measured value deviates from the standard value, replace the sensor. (See Gr14.)



#044 Inspection of engine oil pressure switch

- Perform the following checks, and if any fault is found, replace the switch. (See Gr12.)

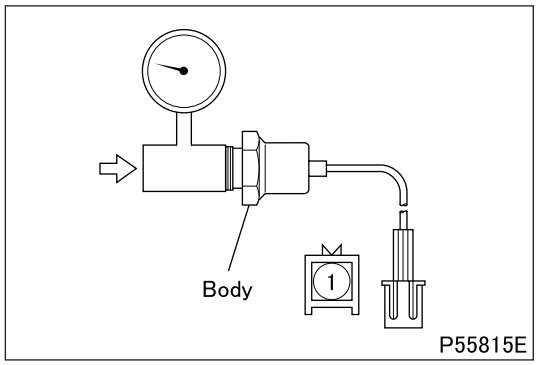
(1) Inspection by without applying air pressure

- Make sure that there is continuity between terminal 1 and body.

(2) Inspection by applying air pressure

- Gradually apply air pressure to the switch starting from 0 kPa {0 kgf/cm^2}.
- Measure the degree of air pressure at the moment when continuity is not detected between terminal 1 and body, and make sure to confirm if the value meets the standard.

Standard value (operating pressure)	50 ± 10 kPa {0.5 ± 0.1 kgf/cm^2}



#053 Inspection of engine oil bypass alarm switch

- Perform the following checks, and if any fault is found, replace the switch. (See Gr12.)

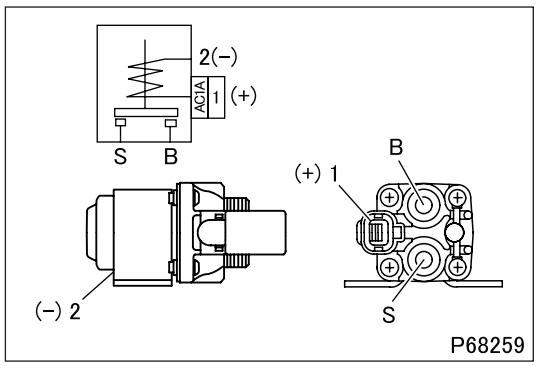
(1) Inspection by without applying air pressure

- Make sure that there is no continuity between terminals 1 and body.

(2) Inspection by applying air pressure

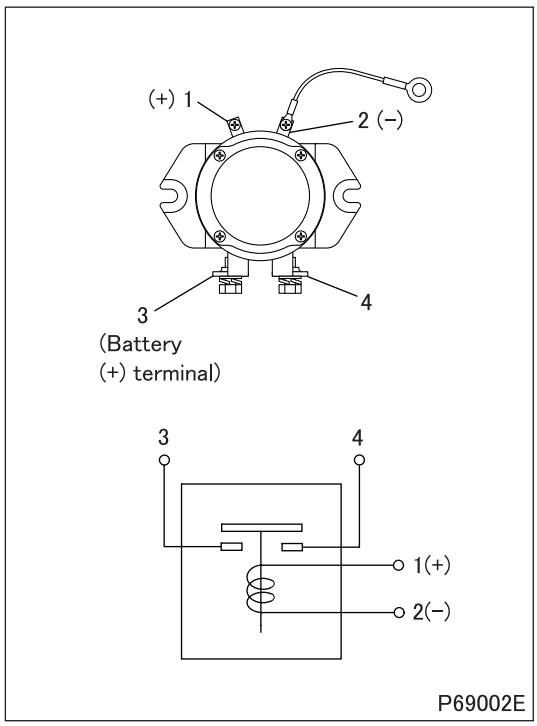
- Gradually apply air pressure to the switch starting from 0 kPa {0 kgf/cm^2}.
- Measure the degree of air pressure at the moment when continuity is detected between terminals 1 and body, and make sure to confirm if the value meets the standard.

Standard value (operating pressure)	$185\ ^{+49}_{0}$ kPa {$1.9\ ^{+0.5}_{0}$ kgf/cm^2}



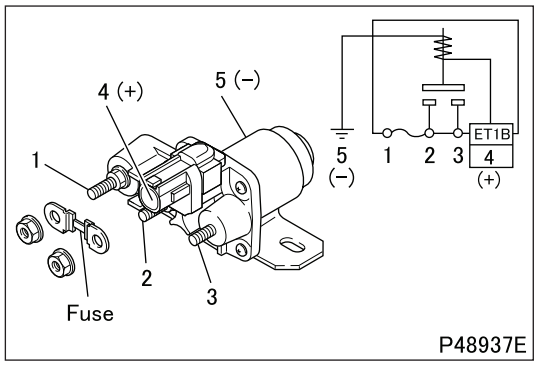
#187 Inspection of starter relay

- Perform continuity check and operation check, and if any fault is found, replace the relay.



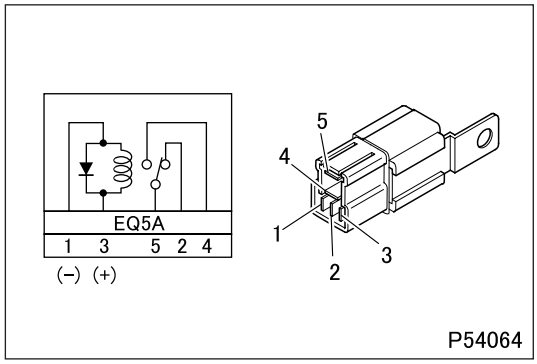
#188 Inspection of main power relay

- Perform continuity check and operation check, and if any fault is found, replace the relay.



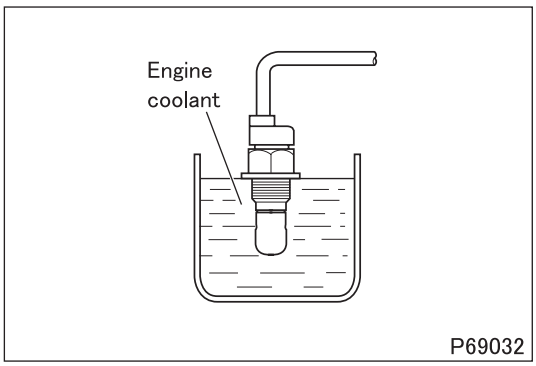
#195 Inspection of glow relay

- Perform continuity check and operation check, and if any fault is found, replace the relay.



#201 Inspection of relay (normally open type 5 pin)

- Perform continuity check and operation check, and if any fault is found, replace the relay.

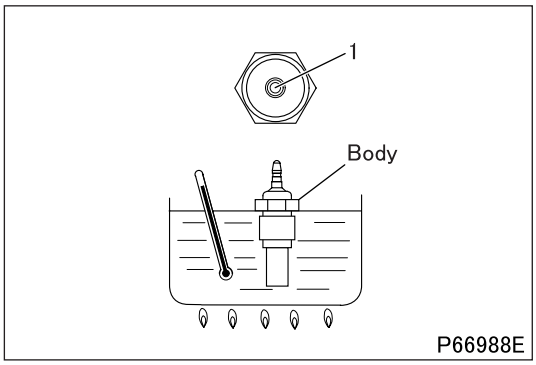


#259 Inspection of water level sensor

- Remove the water level sensor from the radiator.
- Turn the starter switch ON.
- Dip the water level sensor in a container filled with engine coolant, and check that the pilot lamp goes on and out under the following conditions.

Condition	Pilot lamp
When water level sensor is out of the engine coolant	ON
When water level sensor is in the engine coolant	OFF

- If any fault is found, replace the sensor. (See Gr14.)



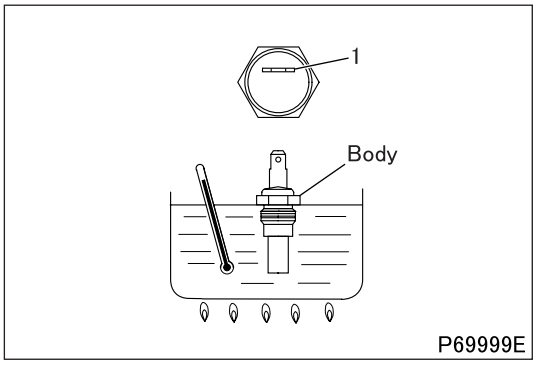
#262 Inspection of water temperature sensor

<For water temperature gauge>

- Dip the sensor in a container filled with engine oil.
- Raise the oil temperature to the specified one while stirring oil.
- Measure the resistance between terminals 1 and the body.

Standard value	50 ± 0.2 °C	80 ± 10 Ω
	60 ± 0.2 °C	56.3 ± 5 Ω
	80 ± 0.2 °C	29.5 ± 2.5 Ω
	100 ± 0.3 °C	16.5 ± 0.9 Ω
	106 ± 0.3 °C	14.3 ± 0.5 Ω
	120 ± 0.3 °C	10 ± 0.3 Ω

- If the measured value deviates from the standard value, replace the sensor. (See Gr14.)

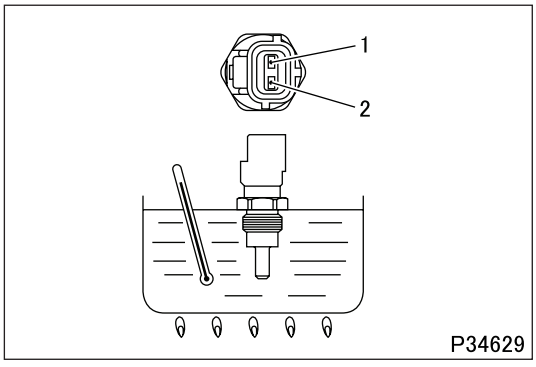


<For water temperature gauge>

- Dip the sensor in a container filled with engine oil.
- Raise the oil temperature to the specified one while stirring oil.
- Measure the resistance values between terminals 1 and the body.

Standard value	50 ± 0.2 °C	80 ± 10 Ω
	60 °C	56.3 Ω (reference value)
	80 °C	29.5 Ω (reference value)
	100 °C	16.5 Ω (reference value)
	106 ± 0.3 °C	14.3 ± 1.0 Ω
	120 °C	10 Ω (reference value)

- If the measured value deviates from the standard value, replace the sensor. (See Gr14.)

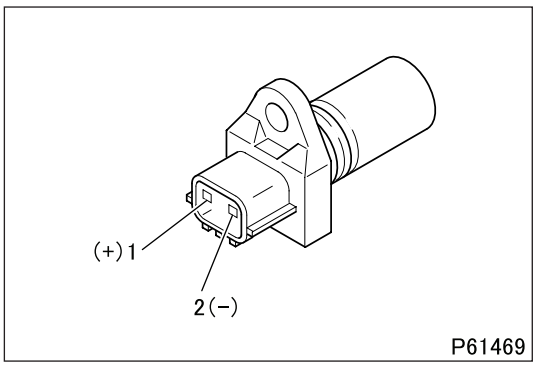


<For engine control>

- Dip the sensor in a container filled with engine oil.
- Raise the oil temperature to the specified one while stirring oil.
- Measure resistance values between terminals 1 and 2.

Standard value	20 °C	2.45 ± 0.14 kΩ
	80 °C	0.32 kΩ (reference value)
	110 °C	147.1 ± 2 Ω

- If the measured value deviates from the standard value, replace the sensor. (See Gr14.)

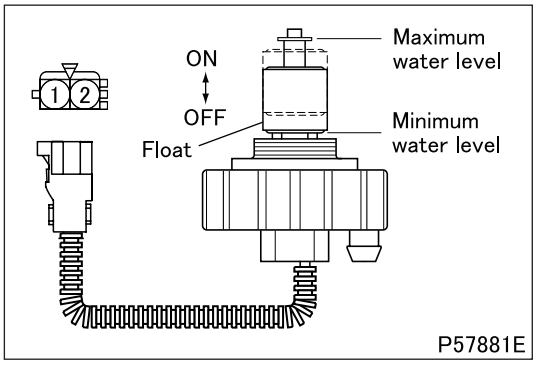


#263 Inspection of engine speed sensor

- Measure the resistance values between terminals 1 and 2.

Standard value (at 20°C)	125.5 ± 17 Ω

- If the measured value deviates from the standard value, replace the sensor. (See Gr13E.)



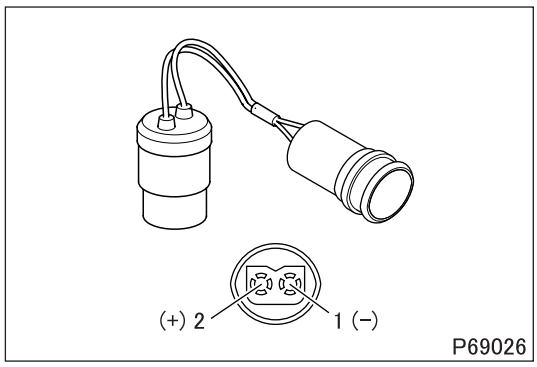
#274 Inspection of water separator sensor

Condition	Continuity terminal
ON (when coolant quantity is approx. 100 cm^3 or more)	1–2
OFF	–

- If any fault is found, replace the sensor. (See Gr13A.)

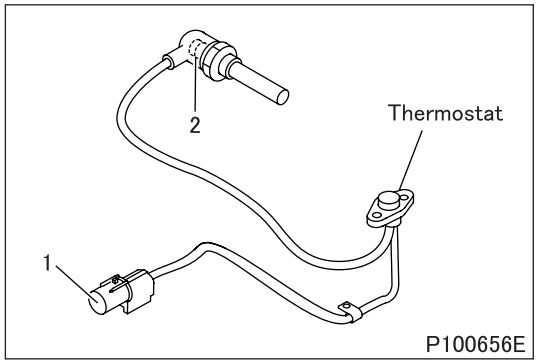
#350 Inspection of control unit and other units

- Since the units alone cannot be readily checked in the off–vehicle state, check the harness, switch and other related parts in each system.
- If any fault is not found in the related parts, and the problem still remains in the system, replace the control units or other units.



#757 Inspection of dust indicator

- Perform the following checks, and if any fault is found, replace the dust indicator.
  - Make sure that there is no continuity between terminals 1 and 2 when air pressure is not applied to the dust indicator.
  - Make sure that there is no continuity between terminals 1 and 2 when negative pressure of 6.23 ± 0.57 kPa {635 ± 58 mmH_2O} is applied to the dust indicator. (See Gr15.)

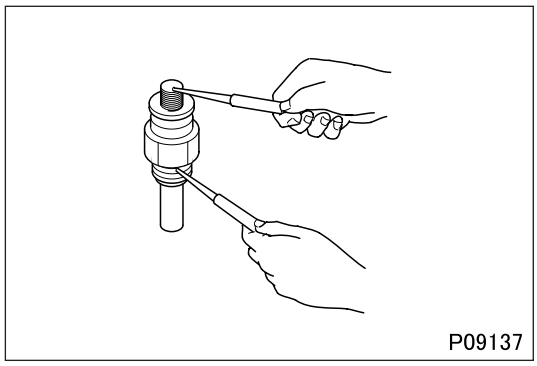


#758 Inspection of air dryer

(1) Inspection of thermostat

- Perform the following check. If any fault is found, replace the thermostat.
- While varying the temperature around the thermostat, measure the temperatures when the continuity is established and is lost between terminals 1 and 2.

Standard value	Lowering the temperature	Temperature when continuity is established (ON temperature)	4 ± 4°C
	Raising the temperature	Temperature when continuity is lost (OFF temperature)	20°C or lower

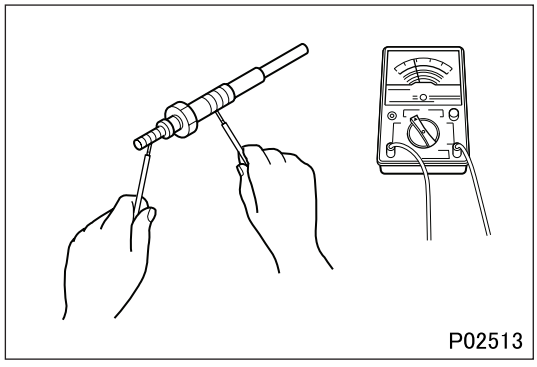


(2) Inspection of heater

- Measure the resistance of heater as shown.

Standard value	8.2 Ω or less

- If the measured value is out of the standard value, replace the heater.

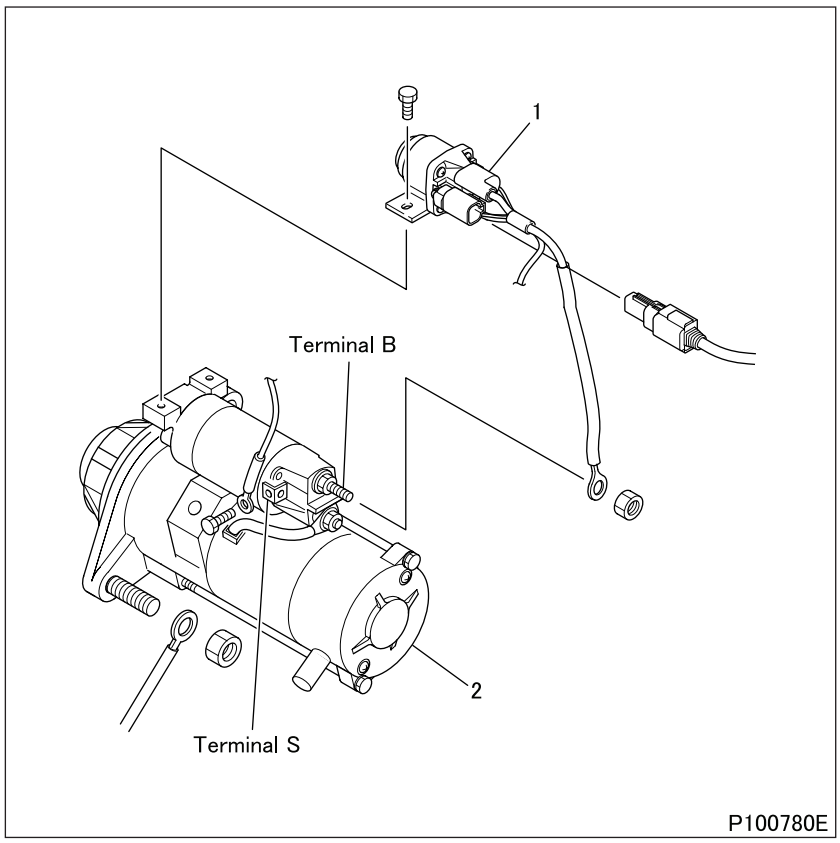


#764 Inspection of glow plug

- Measure resistance value of glow plug as shown.

Standard value (cold resistance of glow plug)	Approx. 4 Ω

- If the measured value deviates from the standard value, replace the glow plug. (See Gr11.)



● **Removal sequence**

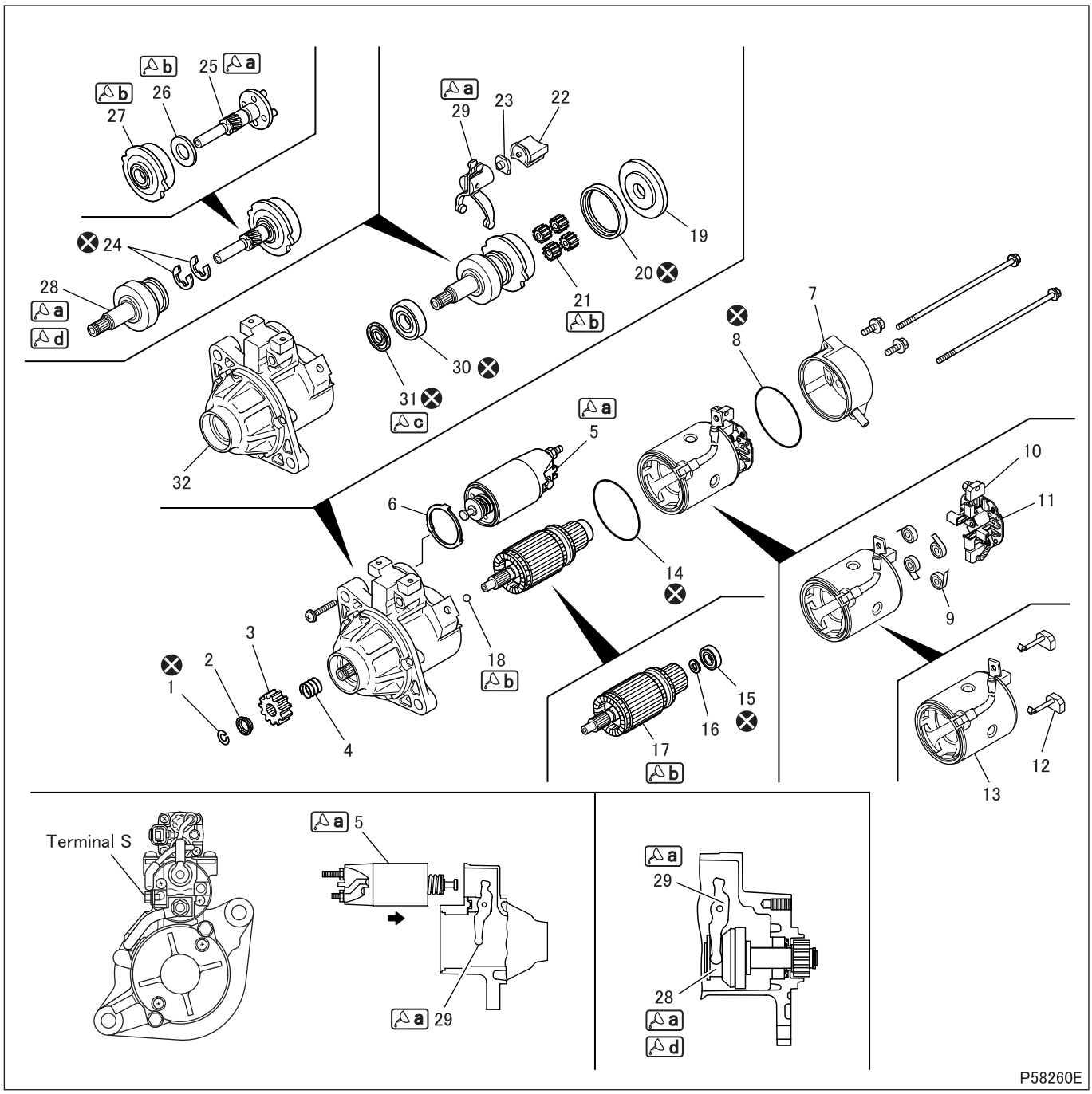
1 Starter relay
2 Starter

WARNING ⚠

- **Before removing the starter, disconnect the (–) battery cable and insulate the cable and the (–) battery terminal with tape.**
- **It is dangerous to leave the (–) battery cable connected since the battery cable voltage is always present at terminal B.**

● **Installation sequence**

Follow the removal sequence in reverse.



● **Disassembly sequence**

1 Stopper ring
2 Pinion stopper
3 Pinion
4 Spring
5 Magnetic switch
6 Shim
7 Rear bracket
8 Packing
9 Brush spring
10 Brush (–)
11 Brush holder
12 Brush (+)
13 Yoke
14 Packing
15 Rear bearing
16 Washer
17 Armature
18 Ball
19 Cover
20 Rubber packing
21 Planetary gear
22 Rubber packing
23 Plate
24 E-ring
25 Gear shaft
26 Washer
27 Internal gear
28 Overrunning clutch
29 Lever
30 Front bearing
31 Oil seal
32 Front bracket

⊗: Non-reusable parts

CAUTION ⚠

- **When the armature is removed, the ball may come out with it. Take care not to lose the ball.**

- Do not remove the bearings and unless defects are evident.
- The rubber packing is serviceable if any defect is not found in it during disassembly.
- It is not necessary to remove the pinion when only the motor section needs to be disassembled for inspection, like when inspecting brushes and related parts.
- Be sure to remove the pinion before disassembling any other parts.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Whenever the magnetic switch is replaced, the pinion gap must be adjusted.**

Service standards (Unit: mm)

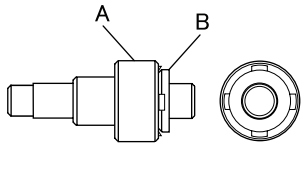
Location	Maintenance item			Standard value	Limit	Remedy
–	Pinion gap			0.5 to 2.0	–	Adjust
–	No-load characteristics	With 23V applied	Current	85 A or less	–	Inspect
			Rotation speed	3300 rpm or higher	–	
9	Brush spring pressure			29.2 to 39.4 N {3 to 4 kgf}	13.7 N {1.4 kgf}	Replace
10, 12	Brush length			18	11	Replace
17	Commutator outside diameter			32	31.4	Replace
	Runout of commutator periphery			–	0.1 or higher	
	Mold depth between segments			–	0.2 or less	Correct or replace

Lubricant and/or sealant

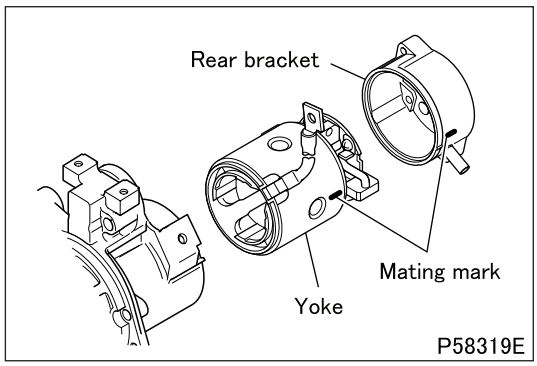
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Lever contact surface of magnetic switch	Multipurpose grease [NLGI No. 2 (Li soap)]	As required
	Sliding surfaces of gear shaft and overrunning clutch		
	Sliding surfaces of lever and overrunning clutch		
b	Sliding surfaces of armature and gear shaft	Molykote AG650	As required
	Ball		
	Teeth of planetary gear and internal gear		
	Washer		
c	Oil seal	Multipurpose grease [NLGI No. 2 (Li soap)] or grease attached to oil seal	As required
d	Splines of overrunning clutch	Multemp OA-171 (Kyodo Yushi Co., Ltd.)	As required

Special tools

Mark	Tool name and shape	Part No.	Application
Ca	Bearing puller and installer A: Bearing puller and installer B: Bearing installer	MH063597 A: MH063615 B: MH063629	Removal and installation of front bearing

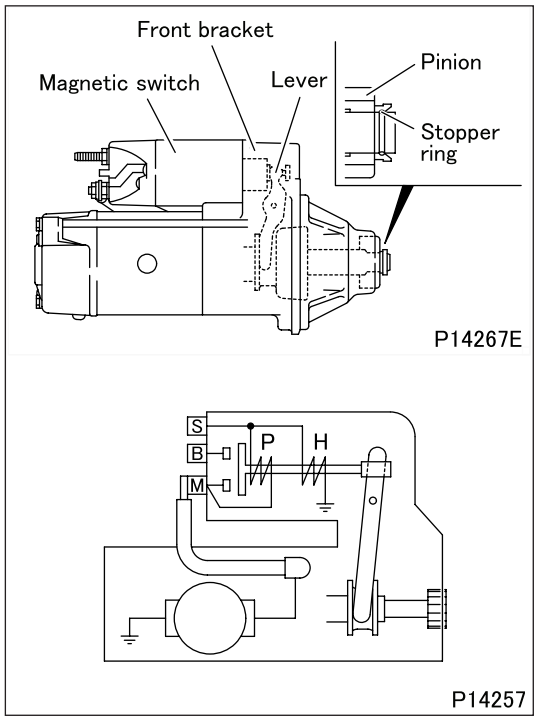


◆Work before disassembly◆



■ **Mating mark: Rear bracket and yoke**

◆Disassembly procedure◆



■ **Disassembly: Pinion**

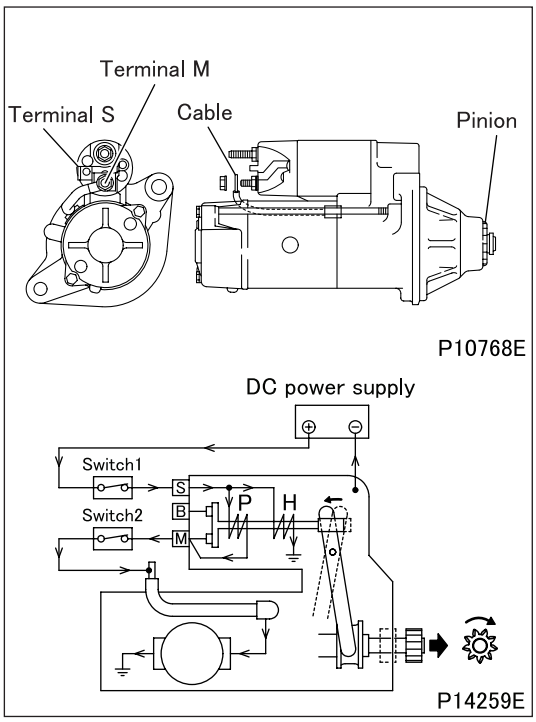
- For removal of the pinion, current must be supplied to the starter such that the pinion springs out.

WARNING ⚠

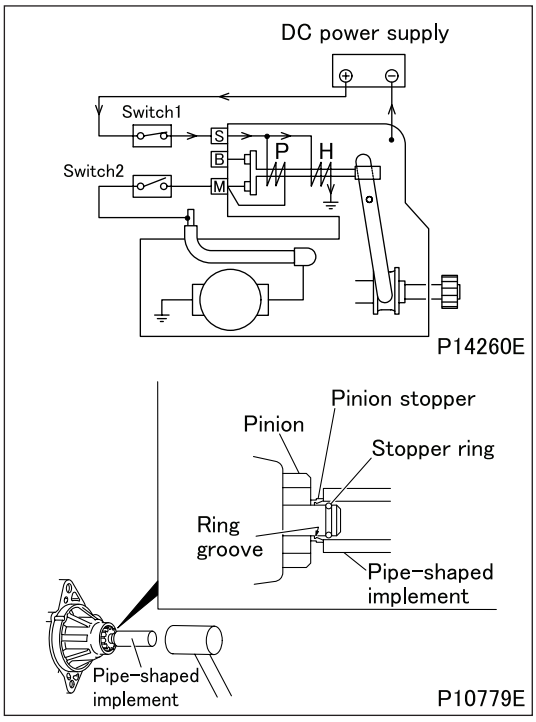
- **When the starter is energized, the pinion will spring out and rotate. Be careful not to touch it with your hands.**
- **The magnetic switch may become very hot during inspections. Be careful when touching it.**

CAUTION ⚠

- **Do not energize the pull-in coil P for longer than 10 seconds, and do not energize the holding coil H for longer than 30 seconds. If these periods are exceeded, the coils may overheat and burn out.**
- **To make the pinion spring out, be sure to energize the starter such that its parts are positioned correctly. If the starter is not energized and the lever is pulled to make the pinion come out, the front bracket and/or lever may be damaged by the shock inflicted upon them when the stopper ring is removed.**
- **When current is supplied to the starter, a large current (100 A or higher) will flow. For inspection purposes, use booster cables or similarly thick cables. It is also important to ensure that all connections are secure.**



- Connect the starter as illustrated.
- The following operations are performed with current supplied to the starter. Thus, the entire procedure for removal of the pinion must be completed within 30 seconds.
  - Turn ON switches 1 and 2 to supply current to the starter. The pinion will spring out and rotate.



- After the pinion starts to rotate, quickly (within five seconds) turn OFF switch 2 to stop the pinion's rotation.

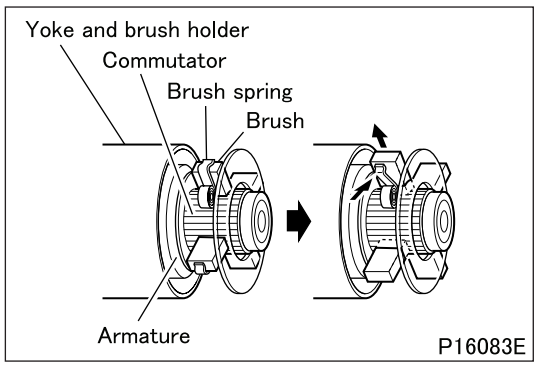
CAUTION ⚠

- **When switches 1 and 2 are turned ON, the pull-in coil P and holding coil H are both energized. The circuit is connected such that no voltage is applied to starter terminal B, so current flows to the pull-in coil while the pinion rotates. To prevent the pull-in coil from burning out, it is essential to turn OFF switch 2 quickly (within five seconds) after the pinion starts to rotate.**

- Apply a pipe-shaped implement to the pinion stopper.
- Using a hammer, lightly tap the pipe-shaped implement to remove the stopper ring from the ring groove of the pinion stopper.
- Remove the stopper ring and pinion.
- Turn OFF switch 1 to de-energize the starter.

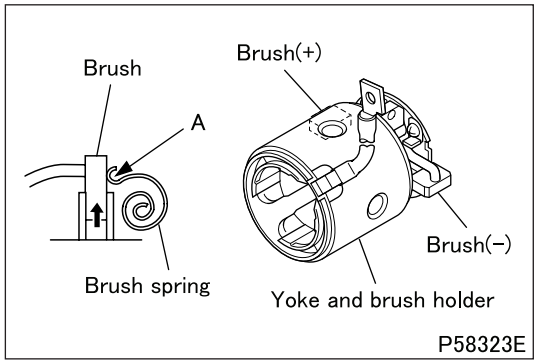
CAUTION ⚠

- **When the starter is de-energized, the mechanism will attempt to pull in the pinion. Thus, the stopper ring may slip back into the ring groove of the pinion stopper. If this happens, energize the starter and go through the pinion removal procedure again.**



■ **Disassembly: Yoke and brush holder**

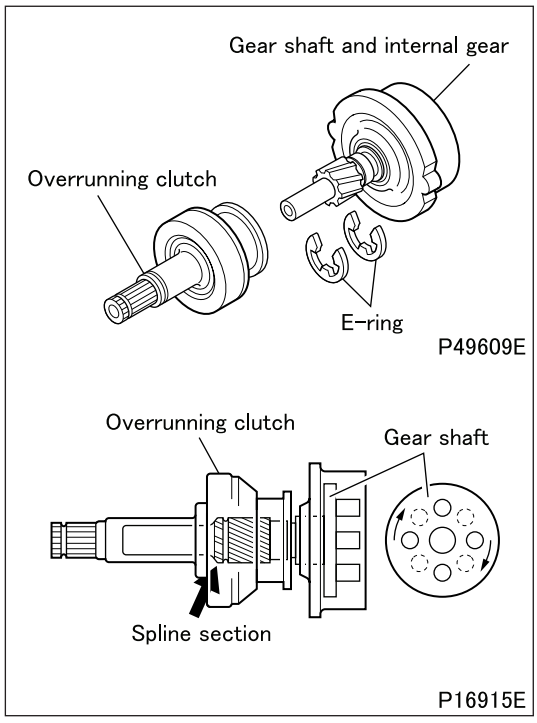
- Use the following method to remove the yoke and brush holder in order to prevent the commutator of the armature from being damaged by the brushes.
  - Lift the brushes away from the commutator and hold them lifted by applying the brush springs against the sides of the brush springs.



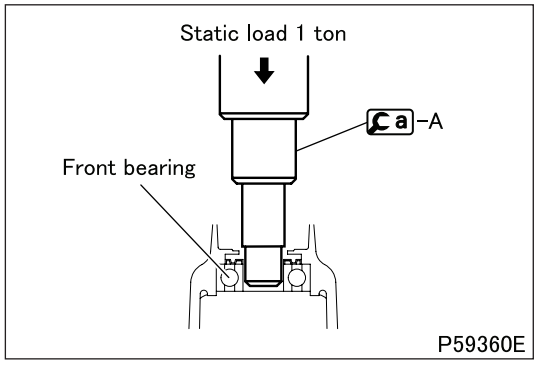
  - Pull part A of each brush spring and pull up the brushes.
  - Hold the brushes in position with the brush springs as illustrated.
  - Remove the yoke and brush holder.

■ **Disassembly: Gear shaft and internal gear**

- Remove the E-rings and then the gear shaft and internal gear from the overrunning clutch.
  Proceed as follows if the gear shaft cannot be removed due to interference of the splined section of gear shaft with internal parts of the overrunning clutch.
  - Press the gear shaft against the overrunning clutch.
  - Turn the gear shaft approx. 1/8 of a turn to change the position of splined section.



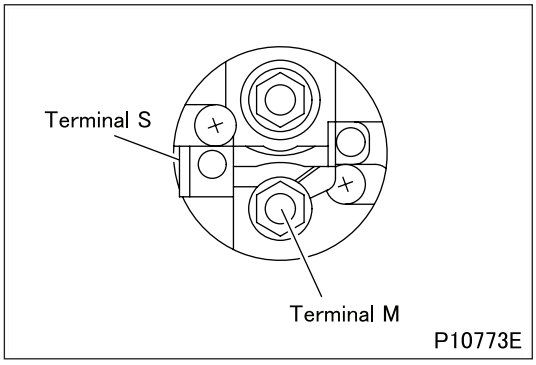
■ **Disassembly: Front bearing**



◆Inspection procedure◆

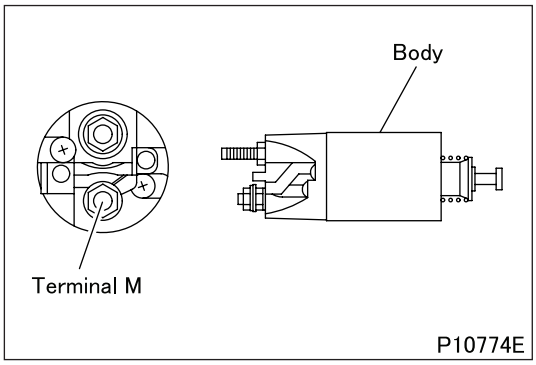
■ Inspection: Magnetic switch

- Perform the following inspections. If any abnormality is found, replace the switch.

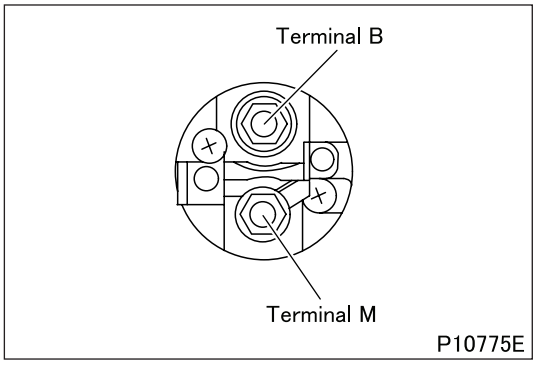


(1) Test for coil open circuit

- Check that continuity exists between terminals S and M.

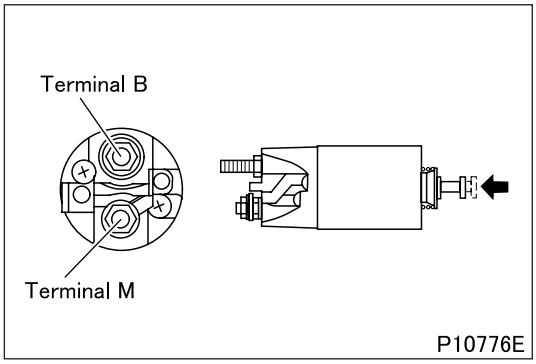


- Check that continuity exists between terminal M and the body.



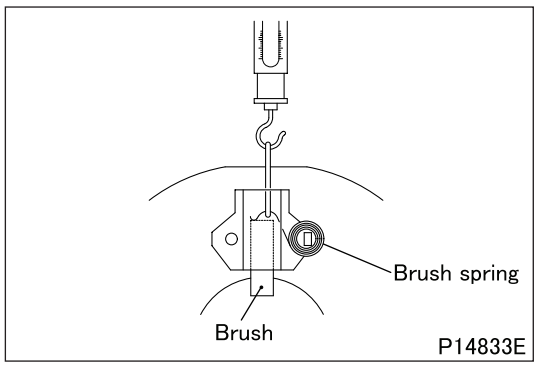
(2) Test for fused-together contacts

- Check that continuity does not exist between terminals B and M.



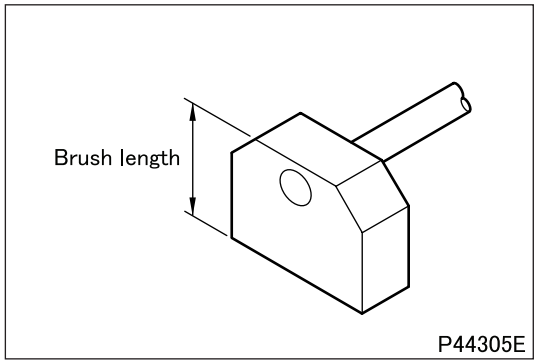
(3) Test for contact-to-contact continuity

- Push in the end of the magnetic switch to close the internal contacts. Then, check that continuity exists between terminals B and M.



■ **Inspection: Brush spring pressure**

- Using new brushes, measure the load required to separate each brush spring from its brush.
- If either measurement is lower than the specified limit, replace the brush springs.



■ **Inspection: Brush (–)**

(1) Brush length

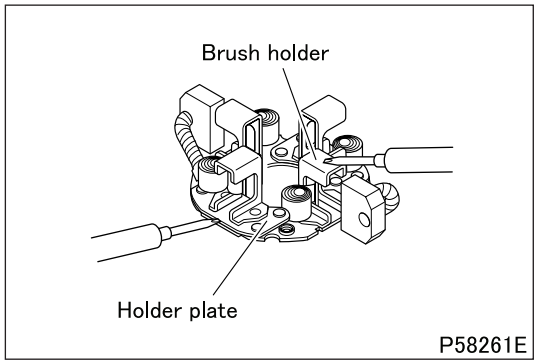
- If either brush (–) is shorter than the limit, it must be replaced.

CAUTION ⚠

- **The brush (–) and its brush holder should be replaced as a set.**

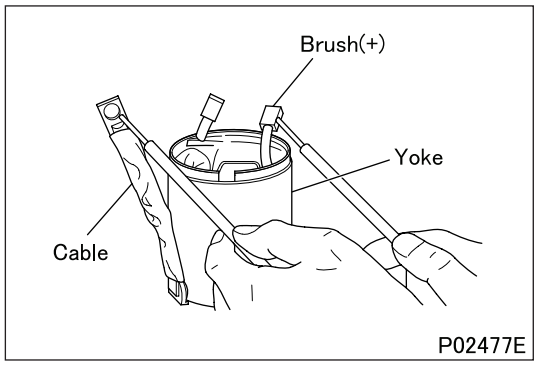
(2) Contact surface of armature's commutator and brush

- If the commutator contact surface of either brush is rough or unevenly worn, rectify it with emery paper (#300 to 500).



■ **Inspection: Brush holder**

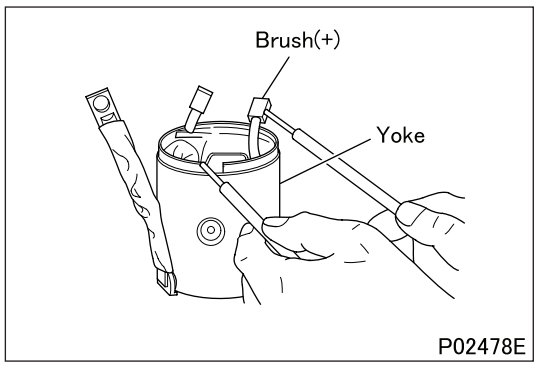
- Thoroughly clean the (+) brush holder and the (–) holder plate, then, check that continuity does not exist between them.
- If continuity exists, there is a short circuit and the brush holder must be replaced.



■ **Inspection: Yoke**

(1) Test for coil open circuit

- Check that continuity exists between the cable and the (+) brush.
- If there is no continuity, there is an open circuit and the yoke or (+) brush must be replaced.

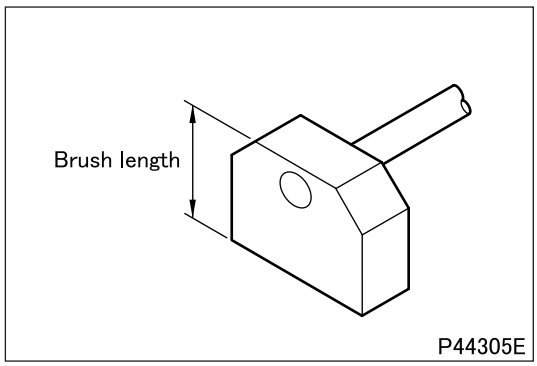


(2) Test for coil grounding

- Check that continuity does not exist between the yoke and the (+) brush.
- If continuity exists, the coil is grounded. Inspect the insulation, and replace the yoke and the (+) brush if the insulation cannot be rectified.

CAUTION ⚠

- **The coil may be grounded to the yoke due to the accumulation of worn-off metal particles from the brushes and/or armature.**



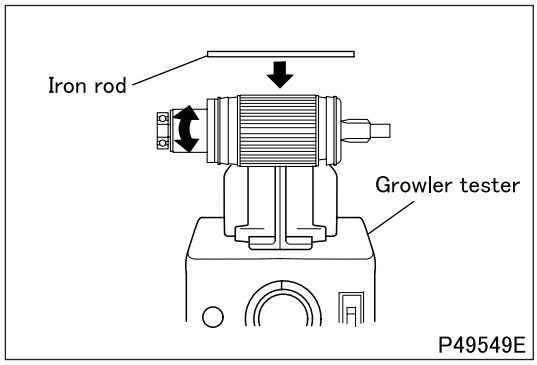
■ **Inspection: Brush (+)**

(1) Brush length

- If either brush (+) is shorter than the limit, it must be replaced.

(2) Contact surface of armature's commutator and brush

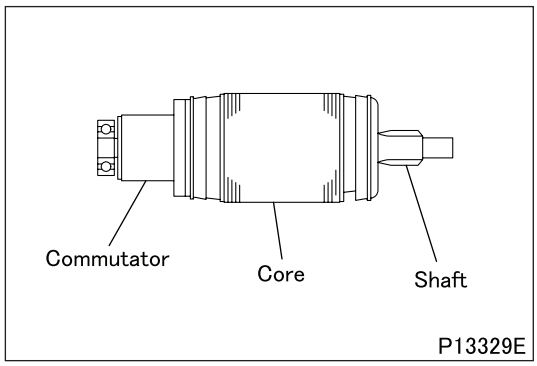
- If the commutator contact surface of either brush is rough or unevenly worn, rectify it with emery paper (#300 to 500).



■ **Inspection: Armature**

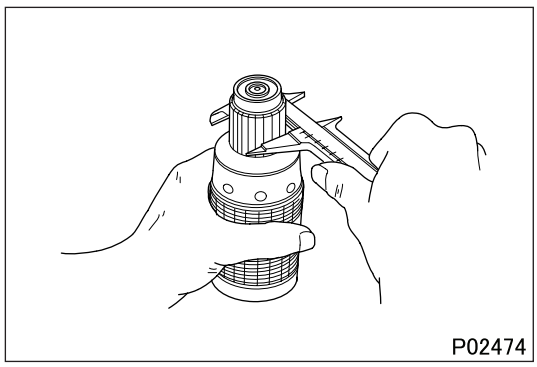
(1) Test for coil short circuit

- Hold an iron rod parallel with the armature.
- Slowly rotate the armature by hand.
- If the iron rod vibrates or is pulled toward the armature, the coil is short-circuited and the armature must be replaced.



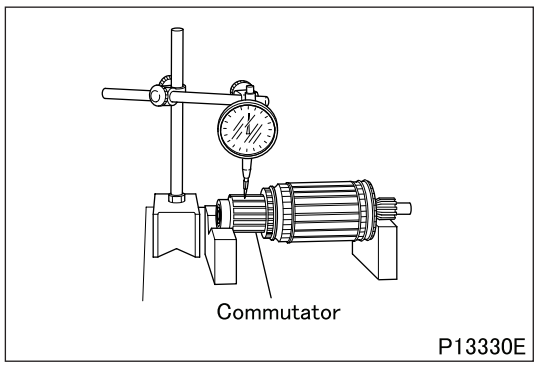
(2) Test for coil grounding

- Check that continuity does not exist between the commutator and the core (or shaft).
- If continuity exists, the coil is grounded and the armature must be replaced.



(3) Commutator outside diameter

- If the measurement is out of specification, replace the armature.

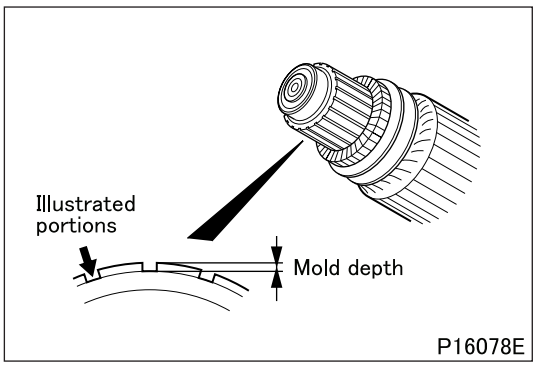


(4) Runout of commutator periphery

- If the reading exceeds the specified limit, rectify the commutator of the armature, making sure the outside diameter stays within specification.

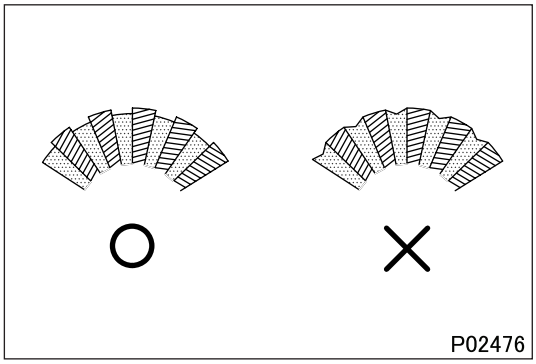
(5) Condition of commutator surface

- If the surface is rough or has stepped wear, rectify it with emery paper (#300 to 500).
- After rectifying the surface, check the extent of commutator runout.



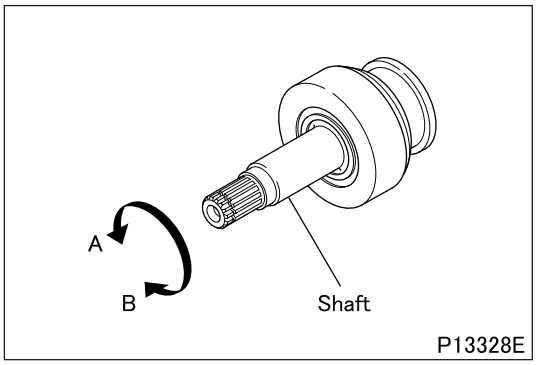
(6) Mold depth between segments

- If the measurement is lower than the specified limit, rectify or replace the armature.
- To rectify the armature, grind the illustrated portions.



- If the mold is worn as illustrated, rectify or replace the armature.

○: Acceptable
X : Unacceptable

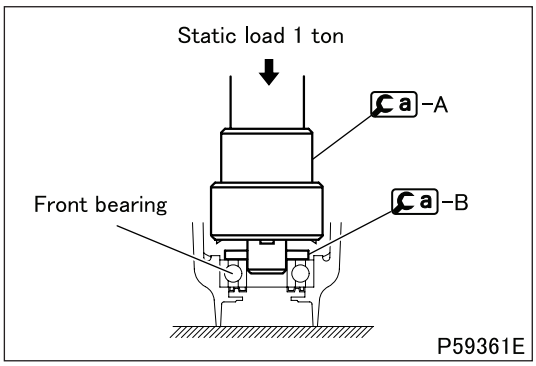


■ Inspection: Overrunning clutch

If the following inspections reveal any abnormality, replace the overrunning clutch.

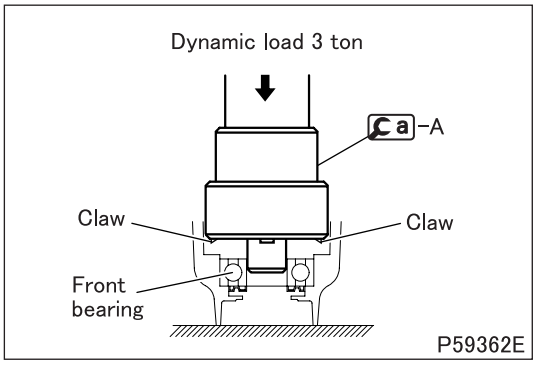
- Turn the shaft in direction B and check that it rotates smoothly.
- Turn the shaft in direction A and check that it locks.

◆Assembly procedure◆



■ Assembly: Front bearing

- Press-fit the front bearing using Ca–A and Ca–B.



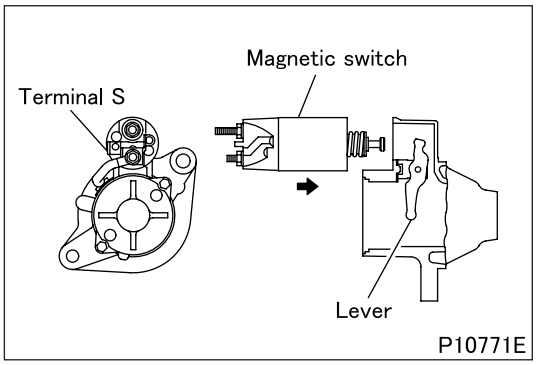
- After the press fitting, caulk the front bearing using the claws on Ca–A.

CAUTION ⚠

- **Avoid re-caulking previously caulked points.**

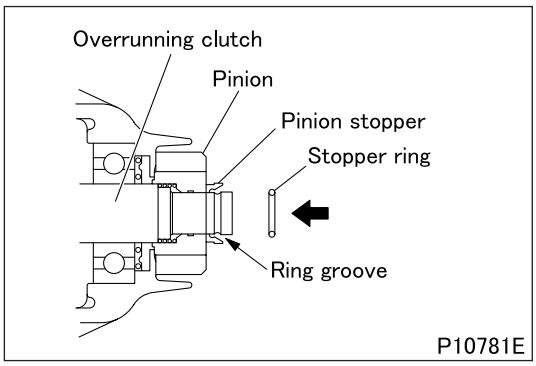
■ **Assembly: Yoke and brush holder**

- To install the yoke and brush holder, follow the removal sequence in reverse.
  (See "■ **Disassembly: Yoke and brush holder**")



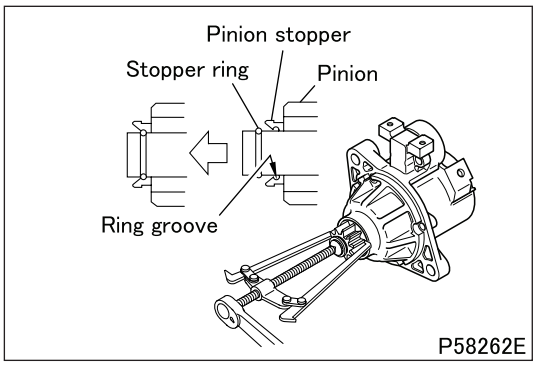
■ **Assembly: Magnetic switch**

- Fit the magnetic switch onto the lever with terminal S aligned as illustrated.



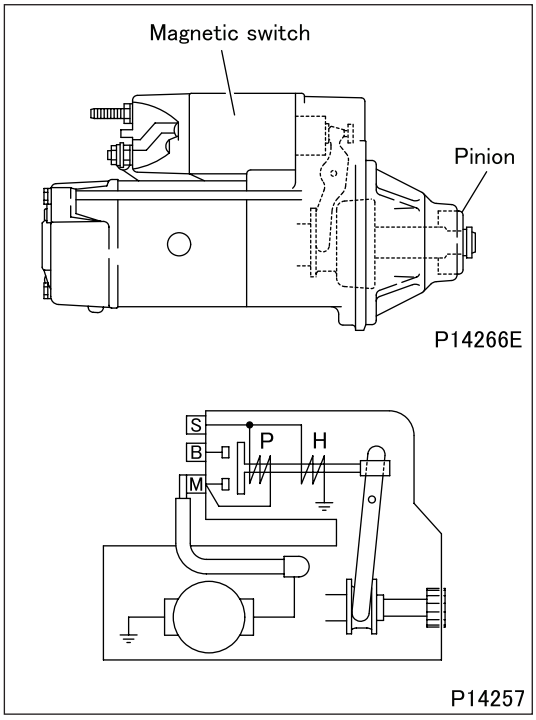
■ **Assembly: Pinion**

- For installation of the pinion, it is not necessary to supply current to the starter.
  - Fit the pinion stopper and pinion onto the overrunning clutch, making sure they are oriented as illustrated.
  - Fit the stopper ring into the ring groove of the overrunning clutch.



- Pull the pinion hard and securely fit the stopper ring into the ring groove of the pinion stopper.

◆Inspection after assembly◆



■ **Inspection: Performance and pinion gap**

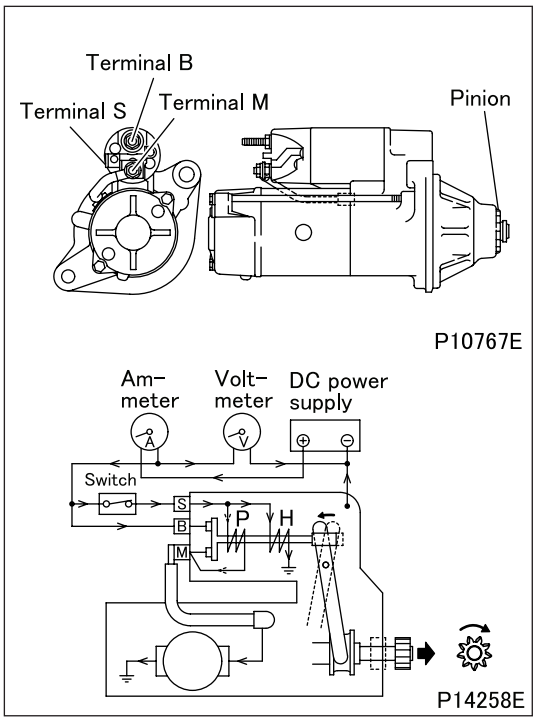
- After assembling the starter, perform inspections with current supplied to it.

WARNING ⚠

- **When the starter is energized, the pinion will spring out and rotate. Be careful not to touch it with your hands.**
- **The magnetic switch may become very hot during inspections. Be careful when touching it.**

CAUTION ⚠

- **Do not energize the pull-in coil P for longer than 10 seconds, and do not energize the holding coil H for longer than 30 seconds. If these periods are exceeded, the coils may overheat and burn out.**
- **When current is supplied to the starter, a large current (100 A or higher) will flow. For inspection purposes, booster cables or similarly thick cables must therefore be used. Also, it is important to ensure that all connections are secure.**



(1) Performance test

- Connect the starter as illustrated.
- Set the voltage to 23 Volts DC.

CAUTION ⚠

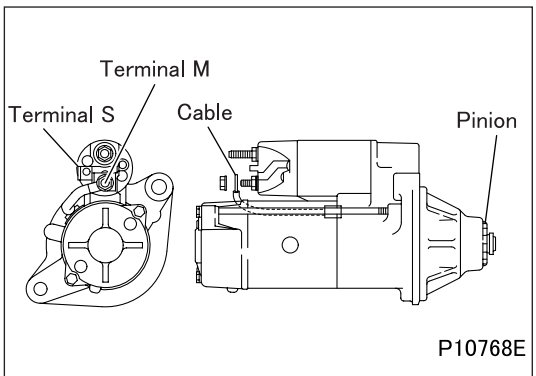
- **The voltage applied must not exceed 24 V.**

- The following operations are performed with current supplied to the starter. Thus, the entire test (consisting of measurement of the current flowing through the starter and measurement of the starter's rotational speed) must be completed within 30 seconds.
  - Turn ON the switch to supply current to the starter. The pinion will spring out and rotate.

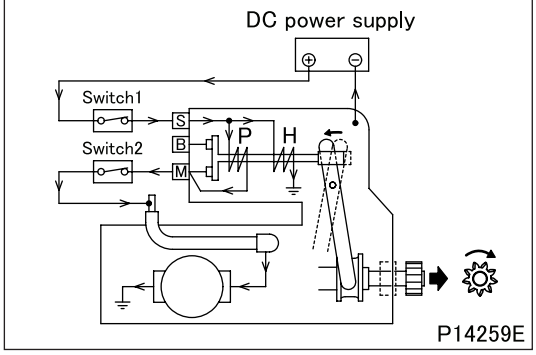
CAUTION ⚠

- **When the switch is turned ON, the pull-in coil P and holding coil H are both energized. When the large current from the DC power supply flows from terminal B to terminal M, the supply of current to the pull-in coil P is cut; only the holding coil H remains energized. To prevent the holding coil from burning out, it is essential to complete all operations within 30 seconds.**

  - Measure the current and the starter's rotational speed. To measure the rotational speed, shine a stroboscope on the pinion.
  - Turn OFF the switch to de-energize the starter.
- If either measurement is out of specification, disassemble and inspect the starter again.



P10768E

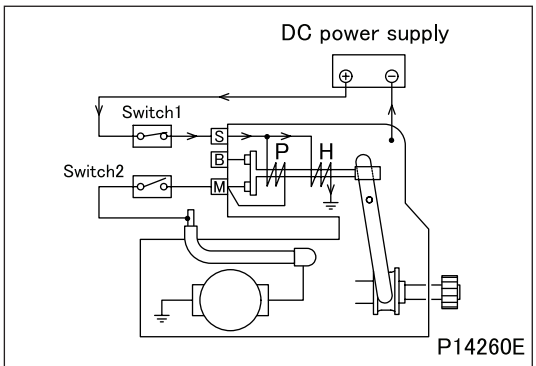


P14259E

(2) Pinion gap

- Connect the starter as illustrated.

- The following operations are performed with current supplied to the starter. Thus, the entire procedure for measurement of the pinion gap must be completed within 30 seconds.
  - Turn ON switches 1 and 2 to supply current to the starter. The pinion will spring out and rotate.

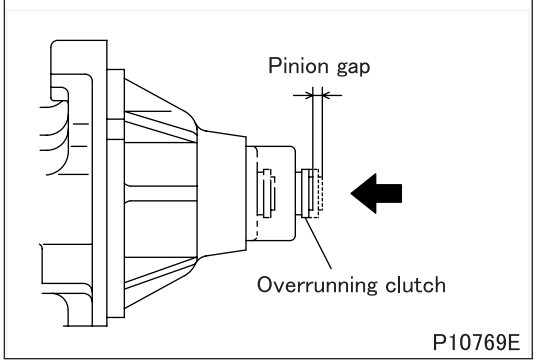


P14260E

  - After the pinion starts to rotate, quickly (within five seconds) turn OFF switch 2 to stop the pinion's rotation.

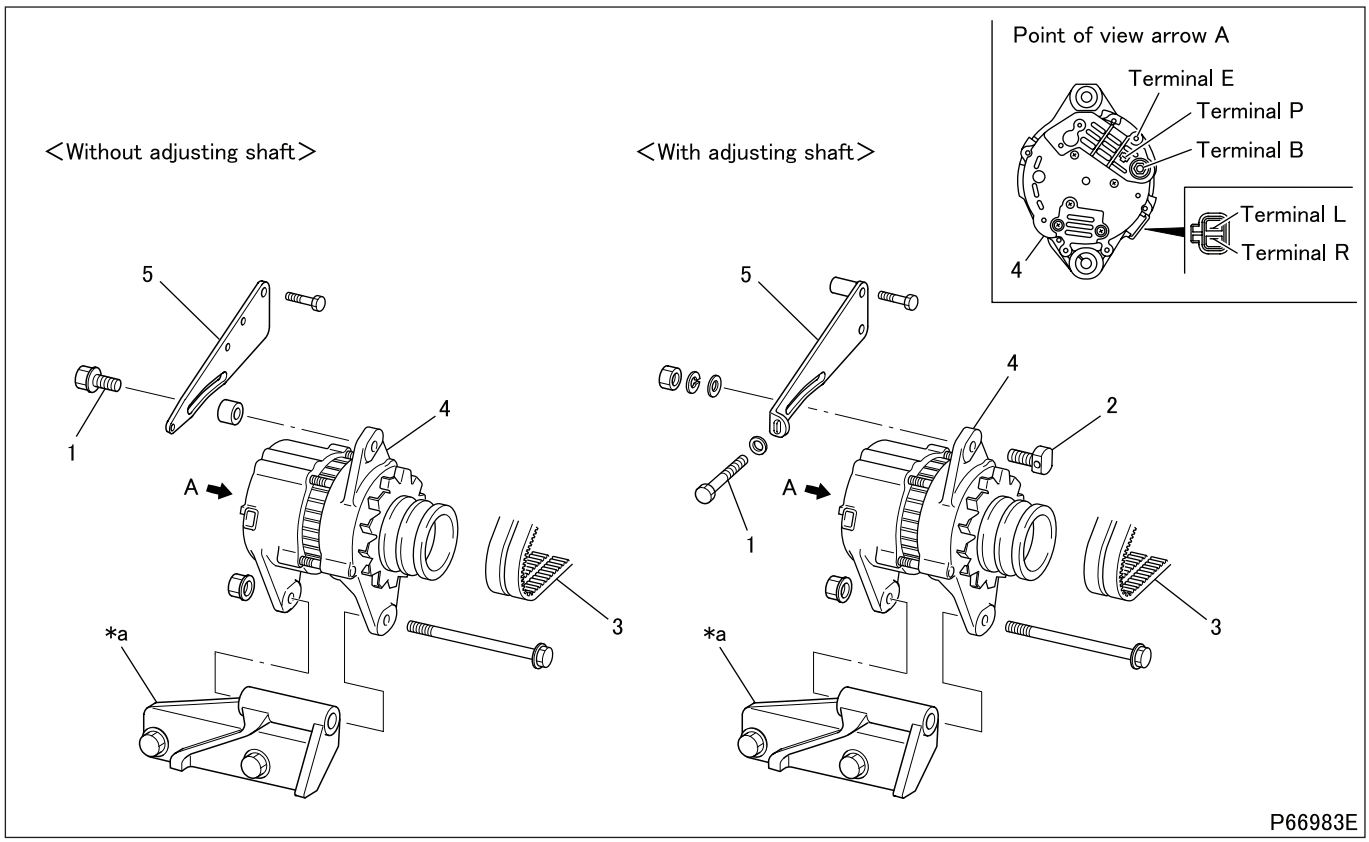
CAUTION ⚠

- **When switches 1 and 2 are turned ON, the pull-in coil P and holding coil H are both energized. The circuit is connected such that no voltage is applied to starter terminal B, so current flows to the pull-in coil while the pinion rotates. To prevent the pull-in coil from burning out, it is essential to turn OFF switch 2 quickly (within five seconds) after the pinion starts to rotate.**



P10769E

  - Pull out the end of the overrunning clutch and then lightly push in the end of the overrunning clutch and measure the amount of movement in the axial direction, i.e., the pinion gap.
  - Turn OFF switch 1 to de-energize the starter.
- If the measurement is out of specification, replace the lever.



● Removal sequence

1 Adjusting bolt
2 Adjusting shaft
<With adjusting shaft>
3 V-belt
4 Alternator
5 Adjusting plate

***a**: Alternator bracket

WARNING ⚠

- **Before removing the alternator, disconnect the (–) battery cable and insulate the cable and the (–) battery terminal with tape.**
- **It is dangerous to leave the (–) battery cable connected since the battery cable voltage is always present at terminal B.**

● Installation sequence

Follow the removal sequence in reverse.

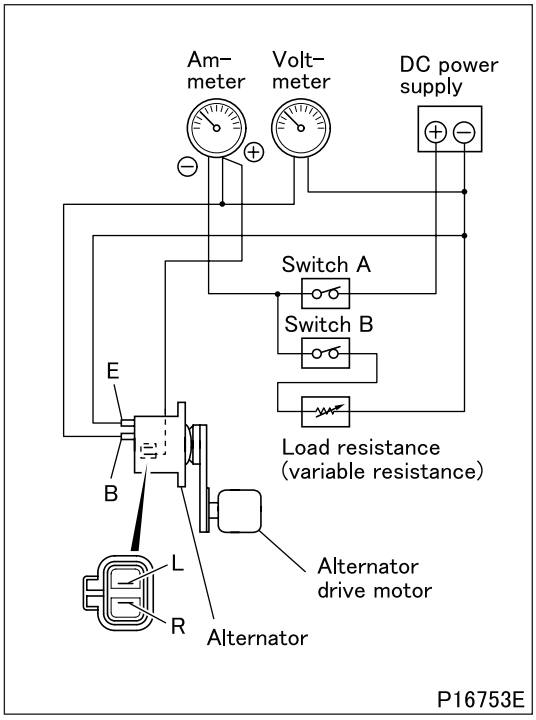
- For adjustment of V-belt tension (See Gr14).

Service standards

Location	Maintenance item		Standard value	Limit	Remedy
4	Alternator output current (* when alternator is hot and producing 27 V)	At 1500 rpm	24 A or more	–	Inspect
		At 2500 rpm	38 A or more	–	
		At 5000 rpm	45 A or more	–	
	Adjustment voltage of regulator (at 5000 rpm, 5 A is loaded)		28.5 ± 0.5 V	–	Replace

* The hot condition is that which occurs after the alternator has been running at normal ambient temperature at 5000 rpm and maximum output for 30 minutes.

◆Inspection procedure◆



■ Inspection: Alternator

(1) Alternator output current (bench test)

- Connect the alternator as illustrated.

CAUTION ⚠

- **Wires with sufficient thickness should be used for wiring and each connection should be securely fastened.**

B: Terminal B
E: Terminal E
L: Terminal L
R: Terminal R

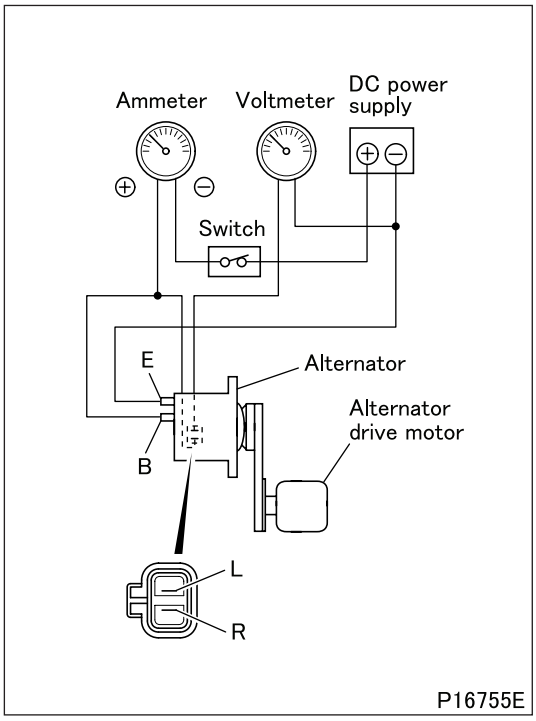
- Increase load resistance to the maximum (condition under which the load current hardly flows).
- Turn switch A and B ON.
- Run alternator at 5000 rpm for 30 minutes by adjusting load resistance so that electric current can conform to the following standard.
  Alternator nominal current

Current
Approx. 45 A

- Measure the current at each specified revolution of alternator.
- If the measured value deviates from the standard value, disassemble and check alternator.

(2) Adjustment voltage of regulator (bench test)

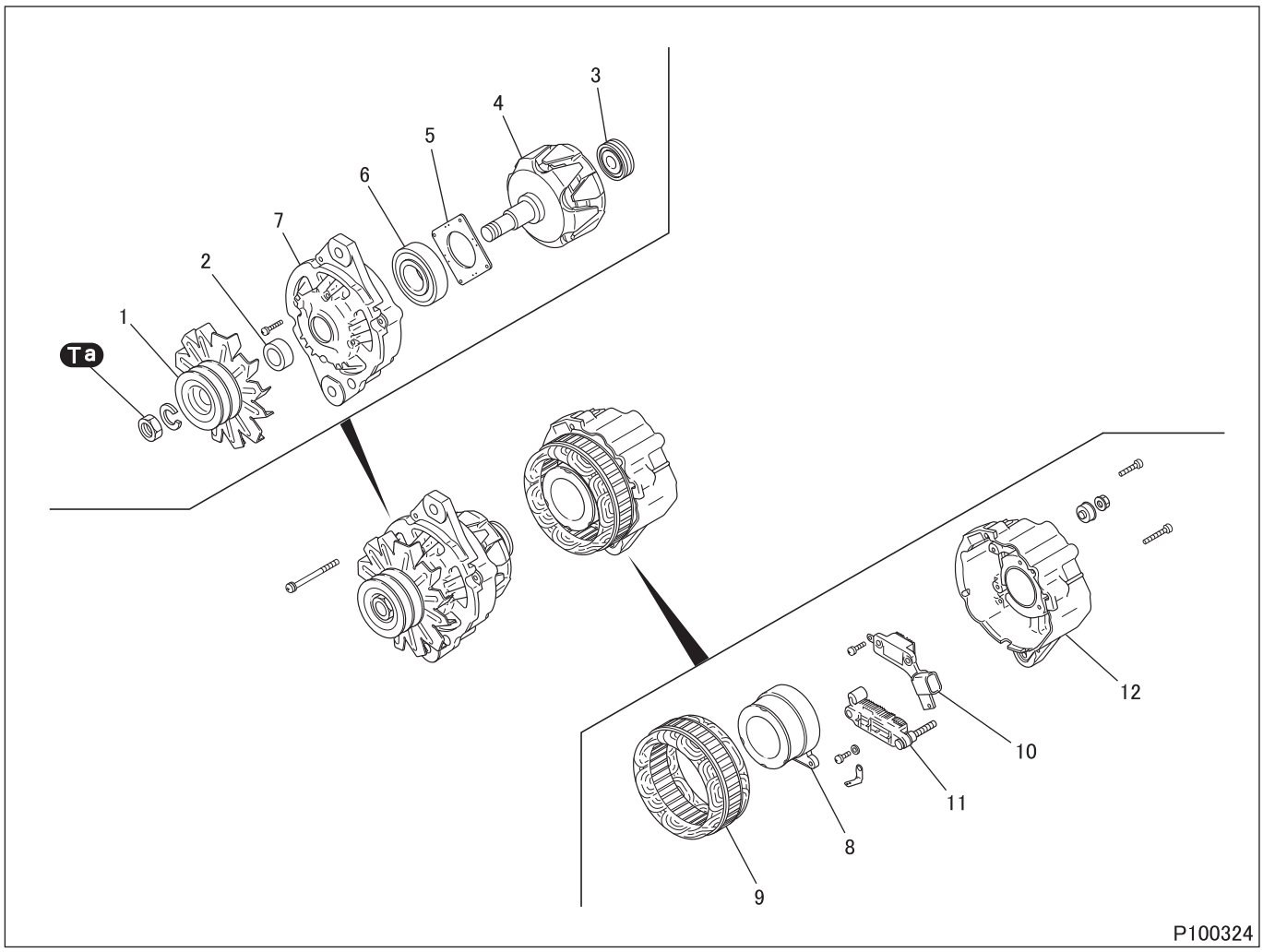
- Connect the alternator as illustrated.



B: Terminal B
E: Terminal E
L: Terminal L
R: Terminal R

- Turn switch ON.
- Run alternator at low speeds.
- Increase the speed of alternator to 5000 rpm and measure the voltage (adjustment voltage) at this speed. At the same time, make sure that the current is 5 amperes or less at 5000 rpm.
- If the measured value deviates from the standard value, do as follows:
  - If higher than the standard value: Replace the regulator.
  - If lower than the standard value: Inspect the alternator related parts before replacing the regulator.

#940 ALTERNATOR



● **Disassembly sequence**

1 Pulley & fan
2 Spacer
3 Rear bearing
4 Rotor
5 Cover
6 Front bearing
7 Front bracket
8 Field coil
9 Stator
10 Regulator
11 Rectifier
12 Rear bracket

- Do not remove the rear and front bearing, stator, or unless faulty.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

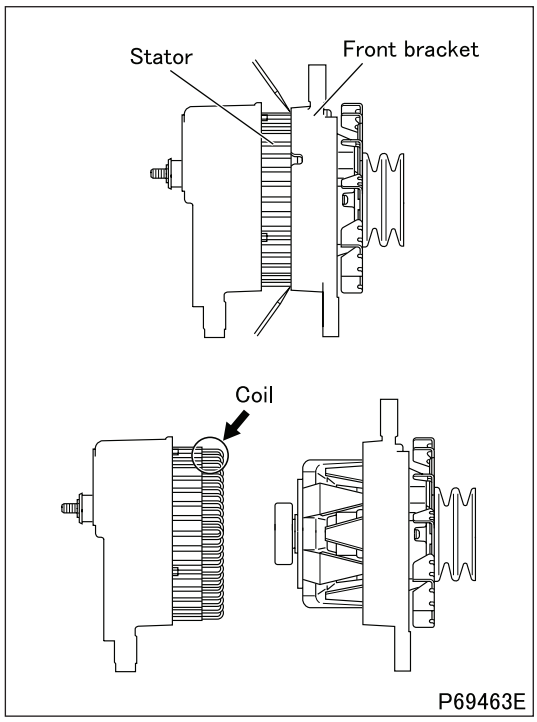
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
8	Field coil resistance (at 20°C)	6.1 to 7.1 Ω	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (pulley mounting)	143 to 181 {15 to 18}	–

◆Disassembly procedure◆

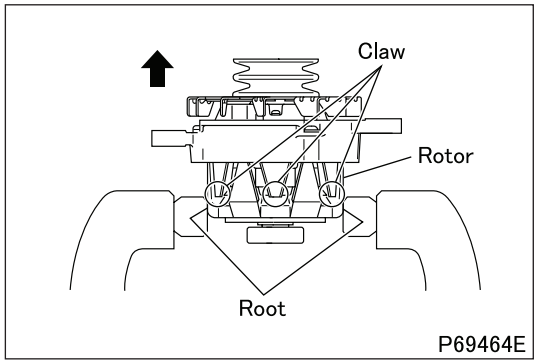


■ **Disassembly: Rotor and front bracket**

- Insert a screwdriver between front bracket and stator.
- Use the screwdriver to pry rotor and front bracket away from stator and rear bracket.

CAUTION ⚠

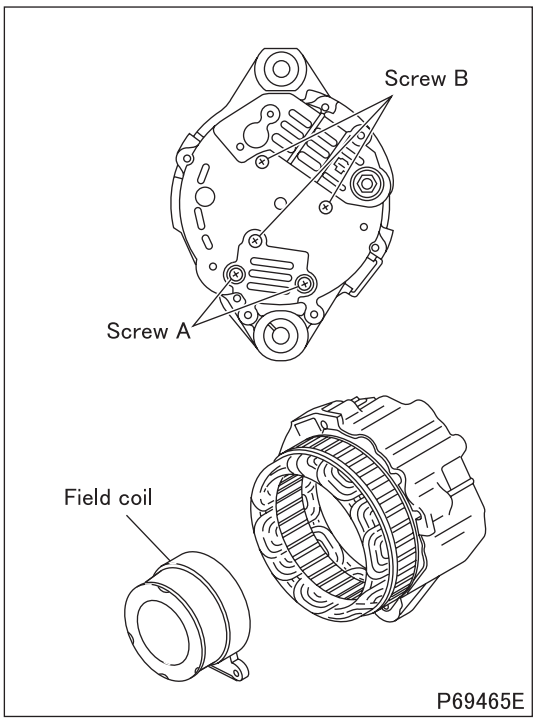
- **Be careful not to insert the screwdriver too deep or it will damage coil of stator and may cause a short-circuit.**



■ **Disassembly: Pulley**

CAUTION ⚠

- **Make sure to grip the root of the core claws when you hold the rotor in a vice. Gripping claws can damage them.**



■ **Disassembly: Field coil**

- Remove screw A (2 places).

CAUTION ⚠

- **If screws B are removed first, the weight of field coil may be placed on the joining portion with regulator which is fixed with screw A, causing break of the joining portion. To avoid this, remove screw A first.**

- Remove screw B (3 places).

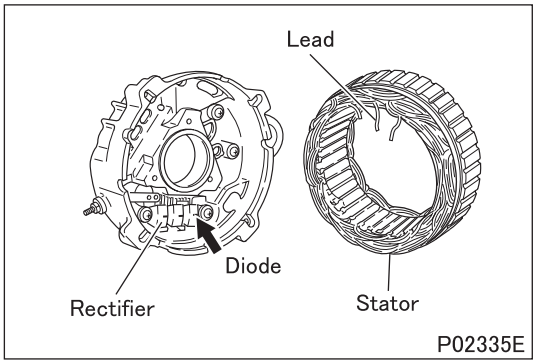
CAUTION ⚠

- **If screw B are removed, the field coil will fall under its own weight. Keep the field coil supported with your hand.**

- Remove field coil.

CAUTION ⚠

- **Do not remove the field coil forcibly. Otherwise the portion that joins with the regulator may be caught by the stator coil.**



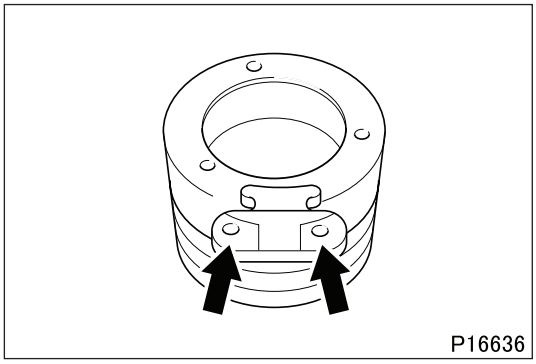
■ **Disassembly: Stator**

- Disconnect lead of stator from rectifier. The lead is soldered to the diode of the rectifier at 4 places.

CAUTION ⚠

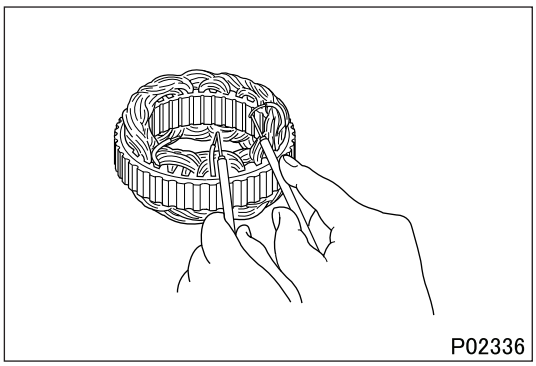
- **Unsolder within as short a time period as possible (within 5 seconds), otherwise diode can be easily damaged by heat.**

◆Inspection procedure◆



■ **Inspection: Field coil**

- Measure the resistance between the terminals of field coil.
- If the measured value deviates from the standard value, replace field coil.

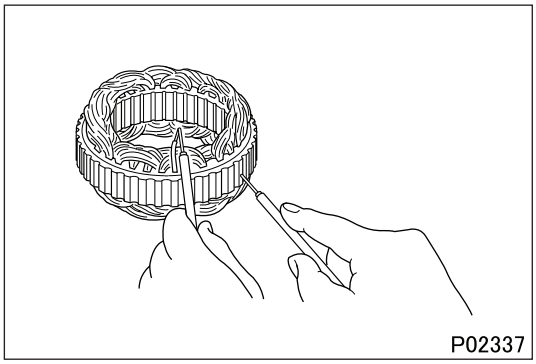

P02336

■ **Inspection: Stator**

- Perform the following inspections. If any abnormality is found, replace the stator.

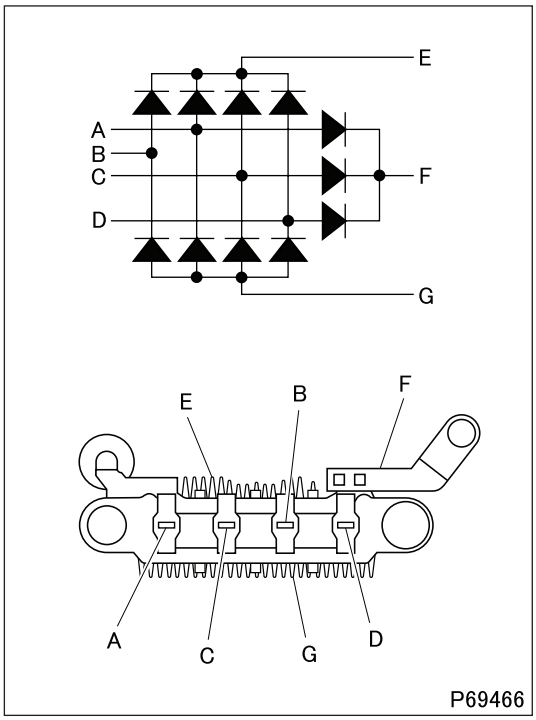
(1) Continuity between each lead wire

- Check that there is continuity between each stator lead.
- If there is no continuity, the lead has broken.


P02337

(2) Continuity between each lead wires and the core

- Check that there is no continuity between lead wires and the core.
- If there is continuity, the lead wire has short-circuited.



P69466

■ **Inspection: Rectifier**

- Check the function of diodes within rectifier properly. If any fault is found, replace the rectifier.

  If resistance is infinite in both cases, the diode has open.
  If resistance is close to 0 Ω in both cases, the diode has shorted.

  A, B, C, D: Lead connecting area of stator coil
  E, G: Heat sink area
  F: Regulator connecting area

- Inspection should be conducted twice, changing over the positive probe and the negative probe of the tester.

CAUTION ⚠

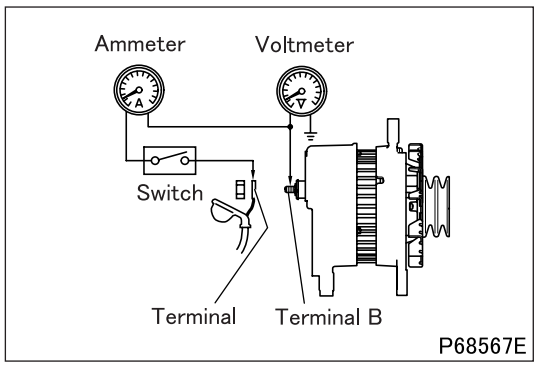
- **When inspecting using a tester, the current flowing through the rectifier is smaller than usual. Therefore, an incorrect resistance value may be indicated on the tester.**
  Additionally, incorrect indications become larger as the range of the tester gets smaller. Set the tester to the largest possible scale.

◆Assembly procedure◆

■ **Assembly: Stator**

- To install the stater, follow the disassembly sequence in reverse. (See "■ **Disassembly: Stator**".)

#950 INSPECTION OF ALTERNATOR



Performance test

- Connect the meters to the alternator as shown.

WARNING ⚠

- **To prevent possible injury, be sure to disconnect the negative terminal of the battery and insulate it with tape before working on the wiring. With the negative terminal (–) of the battery connected, battery voltage is always applied to terminal B.**
- **To connect to switch, use a lead wire with the same or larger diameter than that of the chassis harness connected to terminal B.**

- Turn on switch and make sure that voltmeter indicates battery voltage.
- Start the engine.
- Immediately turn on the switches for all lamps on the vehicle.
- Immediately accelerate the engine to the speed indicated below and measure the alternator's output current.
  Approx. 1400 rpm <A4T40399>
  Approx. 1900 rpm <A4T40379 (crankshaft pulley PCD 193mm)>
  Approx. 2100 rpm <A4TU7686>
  Approx. 2150 rpm <A4T40379 (crankshaft pulley PCD 168mm)>
  PCD: Pitch circle diameter
- The alternator is considered to be good if the measured value is 70% or more of the nominal output current.
  Alternator nominal output

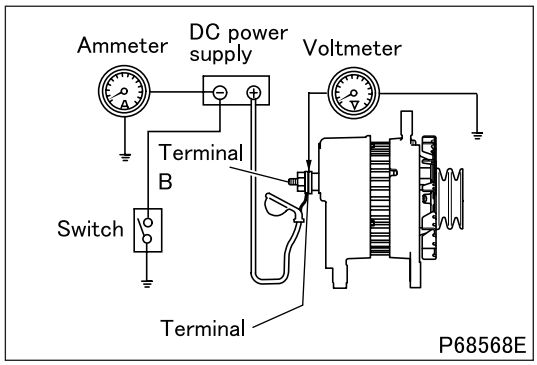
Alternator	Voltage	Output current
50 A	24 V	50 A

CAUTION ⚠

- **The general inspection is only a simplified check. Use a test bench for accurate checking.**

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
–	Adjusting voltage	28.5 ± 0.5 V	–	Replace



- Connect the meters to the alternator as shown.

WARNING ⚠

- **To prevent possible injury, be sure to disconnect the negative terminal of the battery and insulate it with tape before working on the wiring. With the negative terminal (–) of the battery connected, battery voltage is always applied to terminal B.**
- **To connect to switch, use a lead wire with the same or larger diameter than that of the chassis harness connected to terminal B.**

- Turn off the switches for lamps, heater, etc. so that electric loads may not be applied during the inspection.
- Turn on switch and then start the engine.
- If the output current is 5 amperes or less when the engine speed is raised to the appropriate speed indicated below, then measure the voltage at terminal B.
  Approx. 1400 rpm <A4T40399>
  Approx. 1900 rpm <A4T40379 (crankshaft pulley PCD 193mm)>
  Approx. 2100 rpm <A4TU7686>
  Approx. 2150 rpm <A4T40379 (crankshaft pulley PCD 168mm)>
  PCD: Pitch circle diameter

CAUTION ⚠

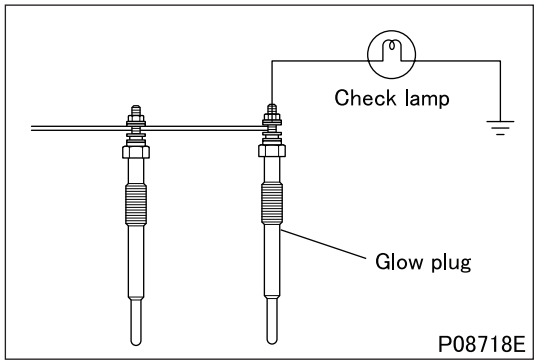
- **If the output current is in the range from 5 to 10 amperes, the measured value (regulated voltage) will be slightly lower.**
  28 V – 0.2 to 0.3 V

- If the output current is 5 amperes or more, do one of the following:
  - Run the engine for a while to charge the battery.
  - Replace the battery with a fully-charged one.
- If the measured value deviates from the standard value, conduct checking again on the test bench.

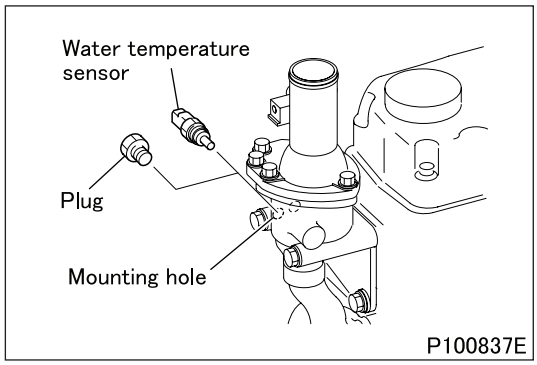
#955 INSPECTION OF PREHEATING SYSTEM

Service standards

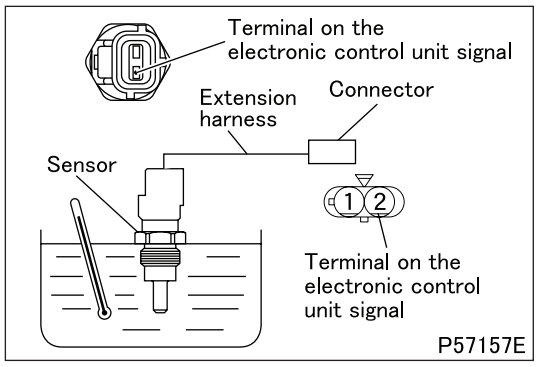
Location	Maintenance item			Standard value	Limit	Remedy
–	Coolant temperature	Pre-glow time	60°C or higher	No pre-glow operation	–	Inspect
			0 or 60°C	About 12 seconds	–	
			0°C or below	About 20 seconds	–	
		After-glow time	0°C or higher	No after-glow operation	–	
			0°C or below	About 168 seconds	–	



- Turn the starter switch to OFF.
- Connect a check lamp to the glow plug.



- Remove the water temperature sensor from the engine, and close the sensor mounting hole with the plug (M16 × 1.5 mm).



- Connect the extension harness between the water temperature sensor and connector.
- Place the water temperature sensor in a container of water.
- Conduct the following test while changing the temperature of water in the container. If anything abnormal is found, check relevant components.

(1) Pre-glow time checking

- Turn the starter switch to ON (without starting the engine) and confirm that the pre-glow time or check lamp ON time at each water temperature conform with standard values.

(2) After-glow time checking

- Start the engine and measure the check lamp ON time to ensure that the after-glow time conforms with the standard value.

GROUP 61 SPECIAL EQUIPMENT

SPECIFICATIONS

Air compressor

Item		Specifications	
Type		Water-cooled 1 cylinder	
Cylinder bore × stroke	mm	ϕ70 × 40	ϕ95 × 45
Cylinder displacement	cm^3 {mL}	154 {154}	319 {319}
Manufacturer		Sanwa Seiki	

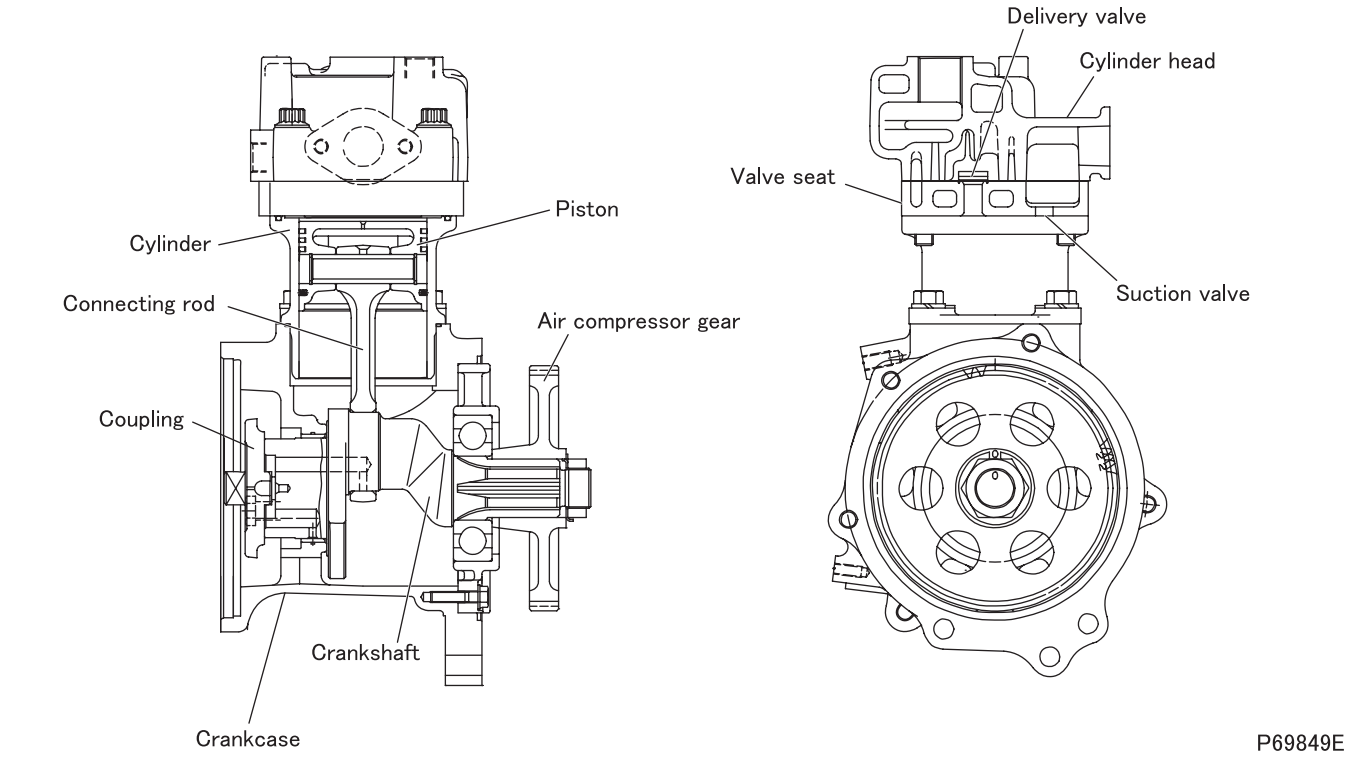
Air dryer

Item		Specifications
Model		DU-4
Heater capacity	V-W	24-70
Thermostat operating temperature °C	ON	4 ± 4
	OFF	16 ± 4
Purge chamber capacity	dm^3 {L}	1.0 {1.0}
Required time for recycling desiccant	sec.	30
Air pressure governor operating pressure kPa {kgf/cm^2}	Upper threshold pressure	$890\ ^{+29}_{-20}$ {$9.1\ ^{+0.3}_{-0.2}$}
	Lower threshold pressure	760 ± 15 {7.8 ± 0.15}
Manufacturer		Nabtesco

M E M O

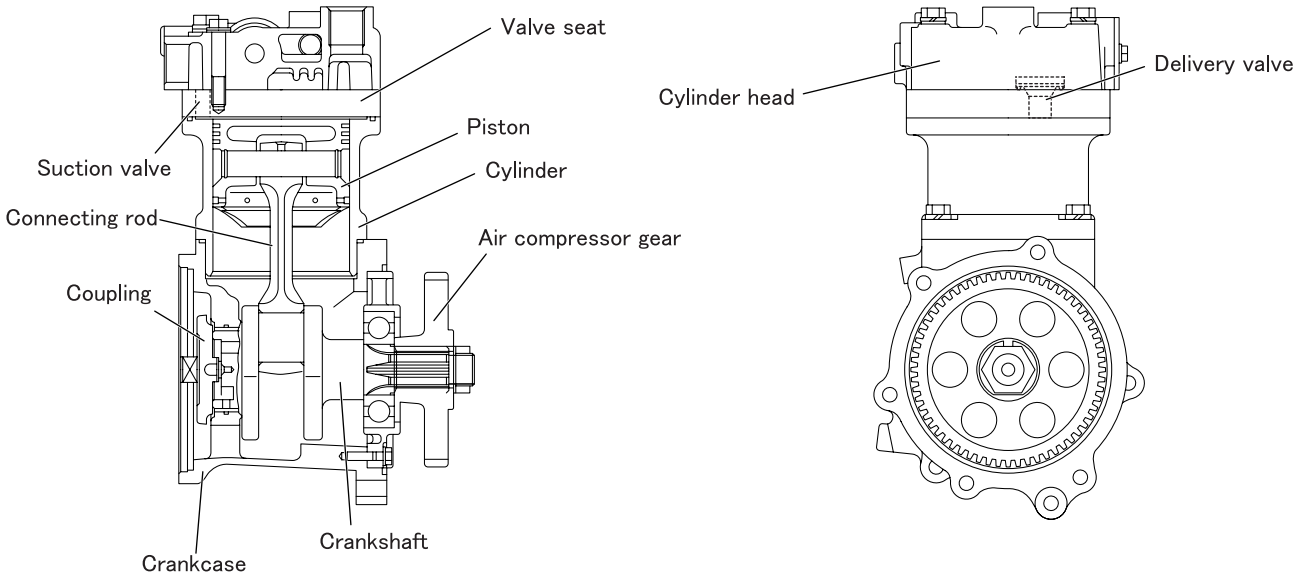
1. Air Compressor

＜154cm³{154mL}＞

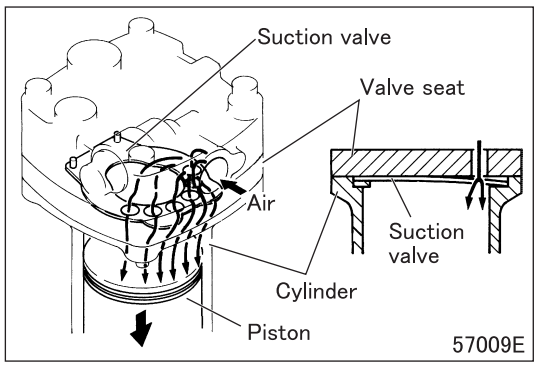


P69849E

＜319cm³{319mL}＞

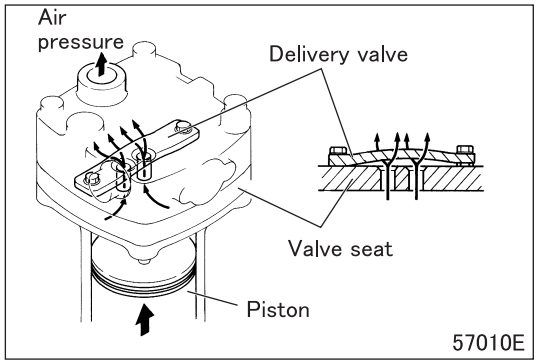


P69850E



1.1 During suction

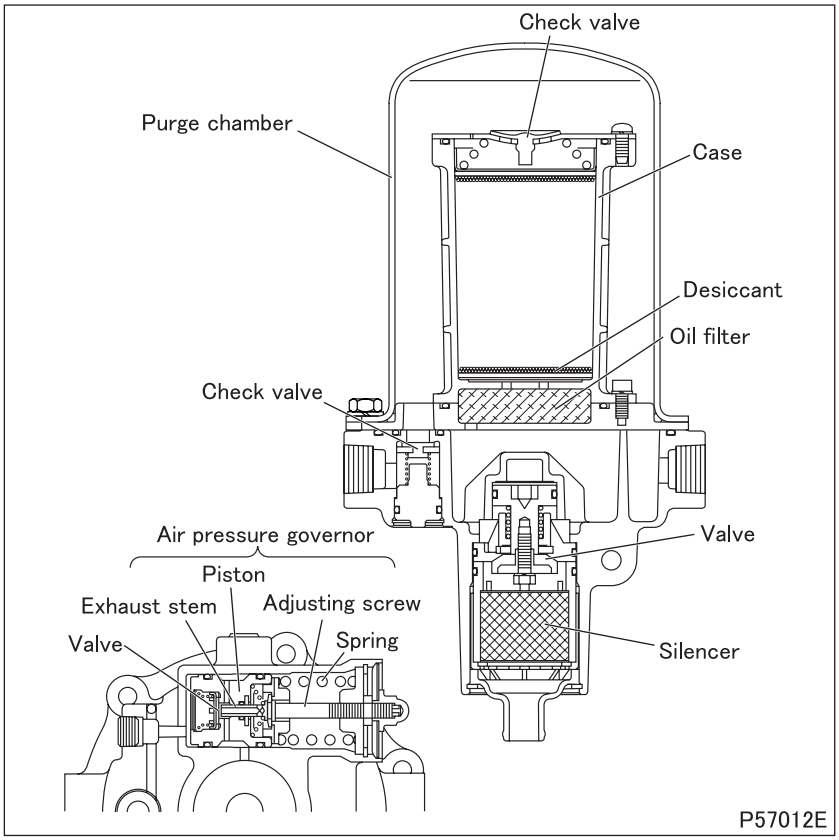
- When the piston goes down during the suction stroke cycle, the vacuum causes the suction valve to open, allowing air to be drawn into the cylinder.



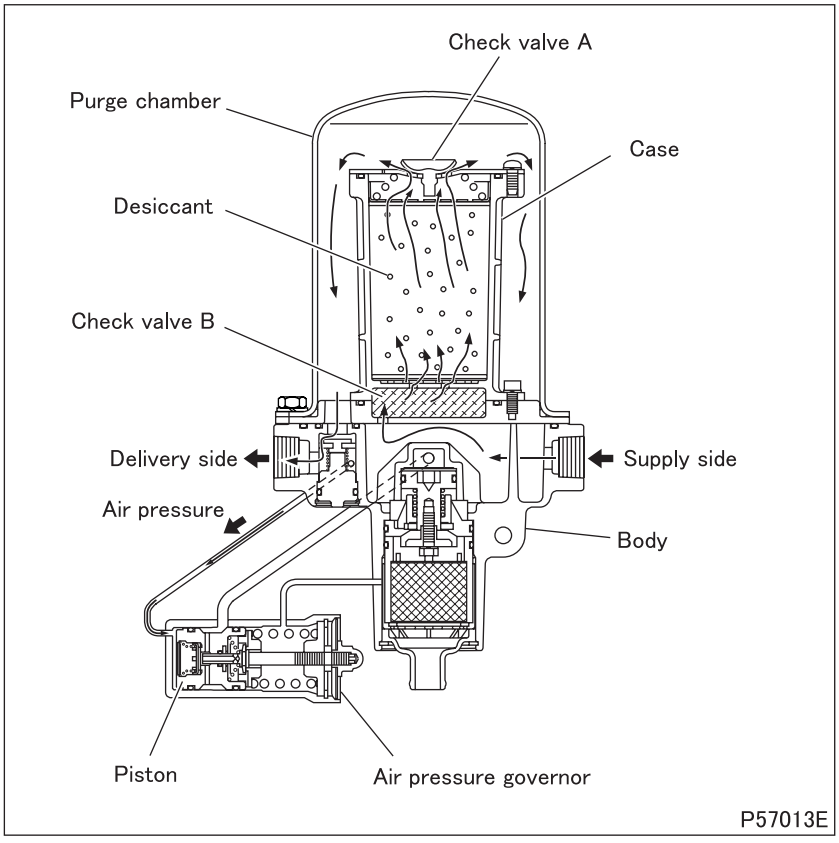
1.2 During compression and delivery

- When the piston goes up during the compression and delivery stroke cycle, the suction valve is closed by air pressure.
- Air pressure compressed by the piston forces open the delivery valve and makes its way to the air dryer and air tank.

2. Air Dryer

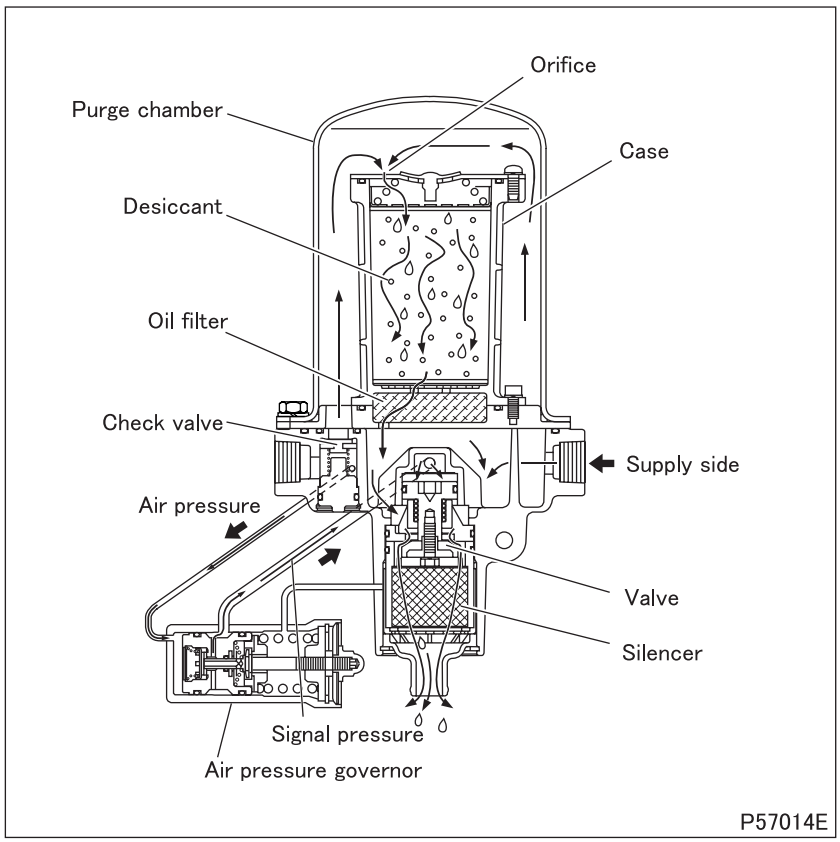


- The air dryer protects brake components by removing moisture and oil from air that has been compressed by the air compressor.
- The air dryer incorporates an air pressure governor, which keeps the pressure in the air tank constant by releasing air compressed by the air compressor to the atmosphere when the pressure in the air tank makes such operation necessary.



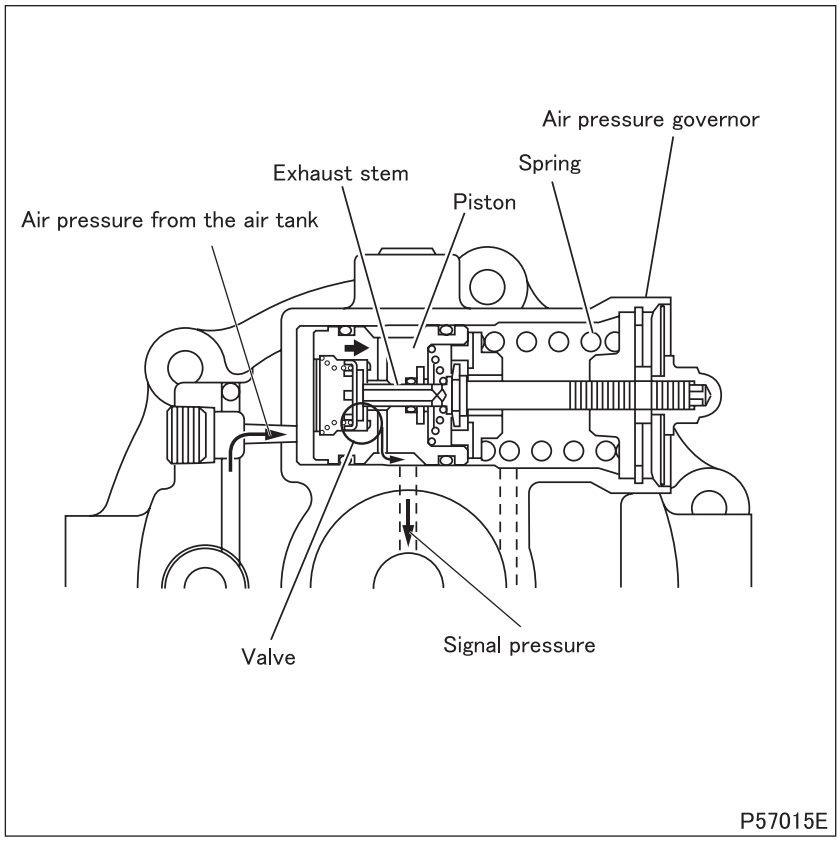
2.1 Drying action

- While the air tank is being charged, air from the air compressor enters the air dryer's supply side. Moisture and oil are separated from the air inside the body and collect in the bottom. The air then passes through the oil filter, which removes smaller oil droplets and particles of dust. The air then flows into the case, where the desiccant removes any remaining moisture.
- As the air flows upward in the case, it makes contact with increasingly dry desiccant and thus contains less and less moisture. When the air reaches the top of the case, it is dry. It flows through the check valve A, purge chamber, and check valve B, and it is then supplied from the delivery side to the air tank. Air pressure also acts upon the piston in the air pressure governor.



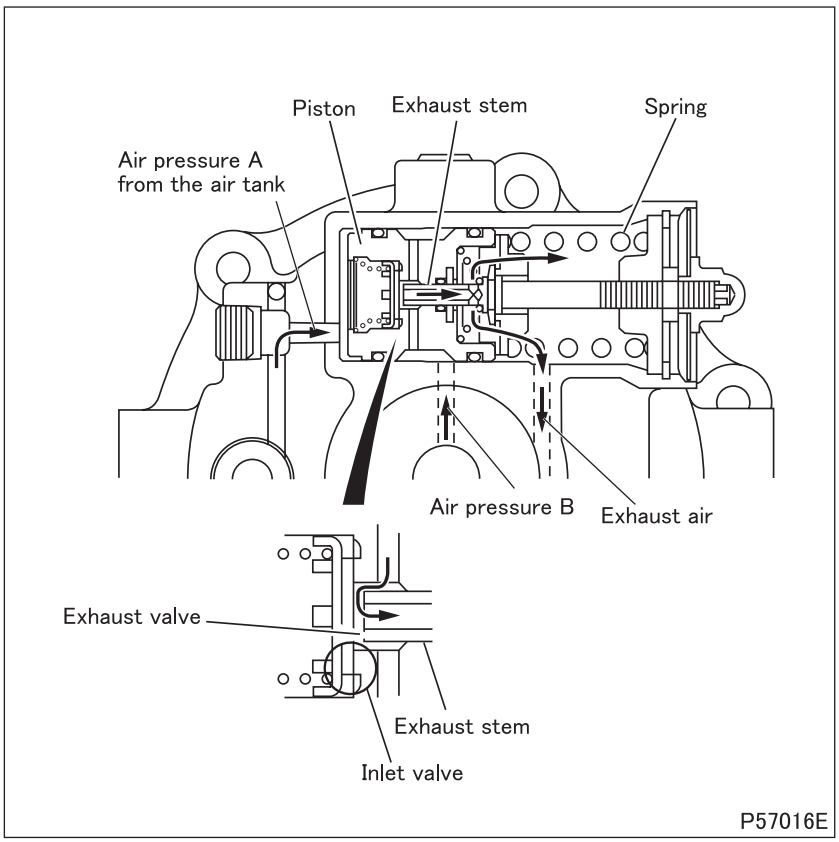
2.2 Regeneration of desiccant

- When the air pressure in the air tank reaches the upper threshold level, signal pressure from the air pressure governor causes the valve in the air dryer's control port to open. As a result, the pressure in the case cleans the oil filter and pushes the water and oil out into the atmosphere.
- Following the rapid drop in pressure, dry air in the purge chamber flows through the orifice, expands, and becomes super-dry. As this super-dry air flows backward through the case, it carries moisture from the desiccant out into the atmosphere, thereby completing the desiccant's regeneration.
- During the regeneration process, the check valve is closed. Thus, the signal pressure from the air pressure governor continues to act upon the control port and the valve remains open. Air from the air compressor thus flows through the valve, through the silencer, and out into the atmosphere.
- The regeneration process continues until air consumption causes the pressure in the air tank to decrease to the governor lower threshold level.



2.3 Operation when tank pressure reaches upper threshold level

- Air pressure from the air tank continuously acts upon the piston.
- When the tank pressure increases to such a level that it overcomes the spring, it pushes the piston upward such that the valve closes.
- When the tank pressure increases further and exceeds the upper threshold level, the piston is pushed upward further such that the exhaust stem opens the inlet valve. Air pressure from the air tank thus flows out of the air pressure governor as signal pressure, causing the valve to open. Regeneration of the air dryer's desiccant thus begins.



2.4 Operation when tank pressure reaches lower threshold level

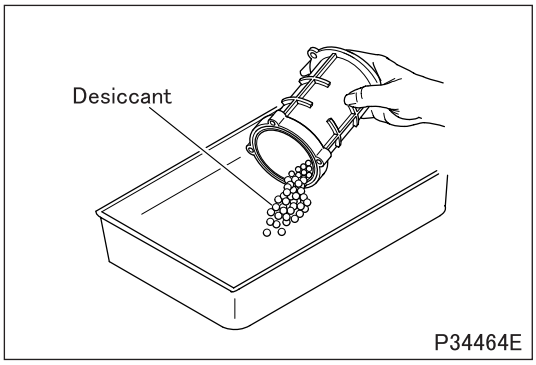
- When the air pressure A from the air tank drops below the lower threshold level, the piston is pushed downward by the spring such that the inlet valve closes and the exhaust valve opens. As a result, air pressure flows through the exhaust stem and escapes to the atmosphere.

Air dryer

Symptoms / Possible causes	Deposits come out of drain cock of air tank	No deposits come out of exhaust port	Freezing takes place within air dryer	Air pressure in air tank decreases markedly	Engine oil leaks from exhaust port	Reference Gr
Deterioration of desiccating agent	O					
Inoperative heater causing air dryer to freeze		O				
Malfunctioning of valve due to adherence of foreign particles		O				
Heater circuit open and therefore no heat retention			O			
Heater malfunction due to thermostat malfunction			O			
Extreme lowering of temperature of air dryer main body due to adherence of snow/ice			O			
Heater malfunction due to disconnection with thermostat			O			
Dry air in air tank flows out in reverse when check valve of air dryer fails to function as a non-return valve				O		
Rising of oil level in air compressor					O	

1. Maintenance and Inspection of Air Dryer

Perform maintenance and inspections at each of the indicated intervals or service time.

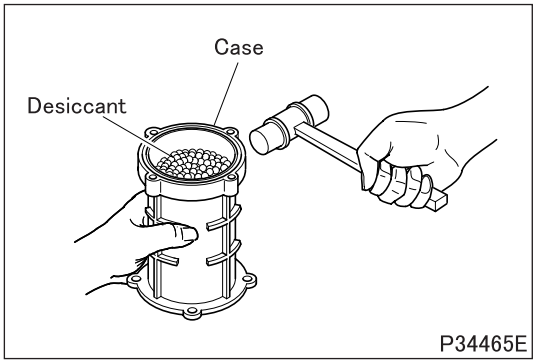


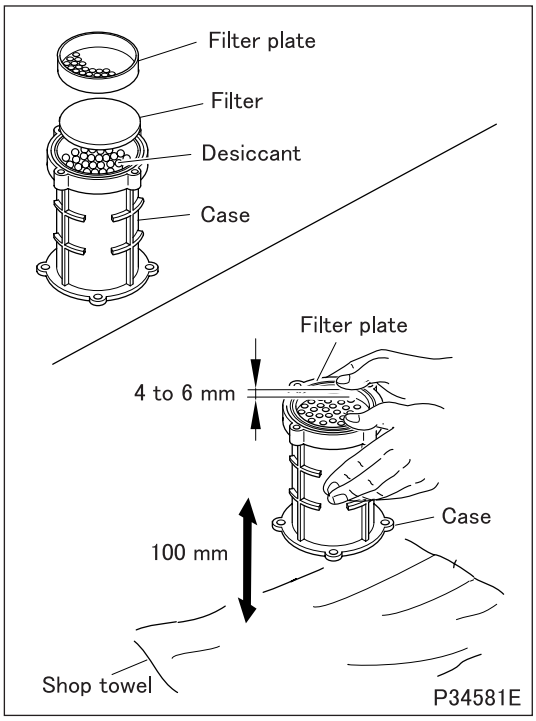
(1) Every three months or 500 hours

- Check whether the air dryer is functioning properly by opening the drain cock on the air tank and checking whether water flows out.
- If a small amount of water flows out, check whether the desiccant has changed color. If one fifth or more of the desiccant has changed in color from white to brown, replace the desiccant using repair kit B. (See “AIR DRYER”.)

NOTE

- **A small amount of moisture may collect whenever the temperature in the vicinity of the air tank drops by more than 16°C.**
- Place the desiccant in the case, then settle the desiccant by tapping gently and evenly around the case with a plastic hammer.





- Place the soft layer side of the filter on the desiccant, and place the filter plate on the case, then tap the desiccant down following the manners.
  - Before tapping the case against the work surface, lay two or three layers of shop towel on the work surface to protect the bottom of the case from scratches.
  - Holding down the filter plate with both hands, lift the case to a height of about 100 mm and tap it gently against the work surface.
  - Tap the case about 30 more times. Make sure the filter plate drops by 4 to 6 mm from its original position.

WARNING ⚠

- **Unless the tapping procedure is performed, particles of desiccant may escape and create blockages in brake lines, thus preventing normal brake operation.**

- Look carefully at the water that flows out of the air dryer’s exhaust port. If the water is contaminated with oil, inspect the air compressor. (See “AIR COMPRESSOR”.)

(2) Every year or 2000 hours

Disassemble the air dryer and replace the desiccant, oil filter, filter, and related rubber parts with the repair kit B. (See “AIR DRYER”.)

(3) Every two years or 4000 hours

Disassemble the air dryer and replace the desiccant, oil filter, and all rubber parts with repair kit A. (See “AIR DRYER”)

2. Inspection and Adjustment of Air Dryer's Air Pressure Governor

Service standards

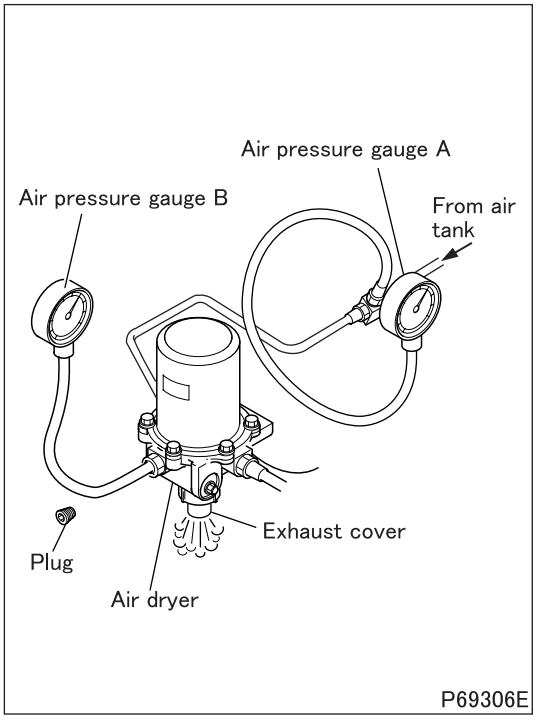
Location	Maintenance item		Standard value	Limit	Remedy
–	Threshold pressure	Upper threshold pressure	890 $^{+29}_{-20}$ kPa {9.1 $^{+0.3}_{-0.2}$ kgf/cm^2}	–	Adjust
		Lower threshold pressure	760 ± 15 kPa {7.8 ± 0.2 kgf/cm^2}	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Plug	14.7 to 24.5 {1.5 to 2.5}	–
–	Cap nut (seat and plate mounting)	4.9 to 5.9 {0.5 to 0.6}	–
–	Nut (for retention of adjusting screw)	6.9 to 7.8 {0.7 to 0.8}	–

Lubricant and/or sealant

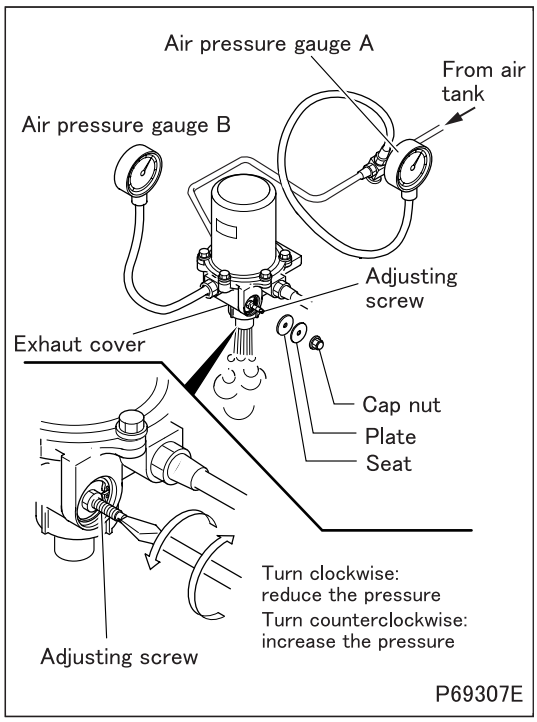
Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Plug thread	ThreeBond 1110B	As required

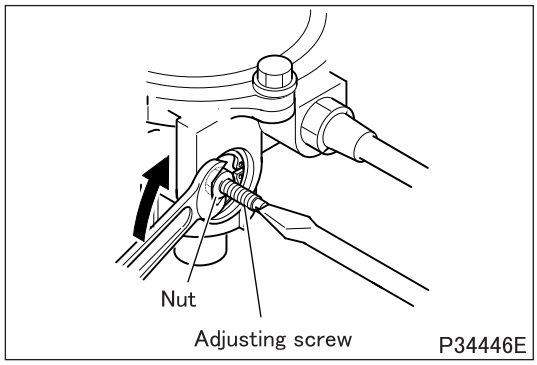


[Inspection]

(1) Air leak

- Install the air pressure gauge A between the air dryer and air tank (wet tank side).
- Remove the plug from the air dryer at the location shown in the drawing. Connect air pressure gauge B at that point.
- Start the engine to activate the air compressor such that the air pressure in the air tank gradually increases. Check that the pressures indicated by the pressure gauges **A**, **B** do not decrease when air is expelled from the exhaust cover.
- If the pressure indicated by either of the pressure gauges **A**, **B** decreases, air is leaking from the check valve and air pressure governor in the air dryer, causing continuous charging and purging. Carry out disassembly and inspection.





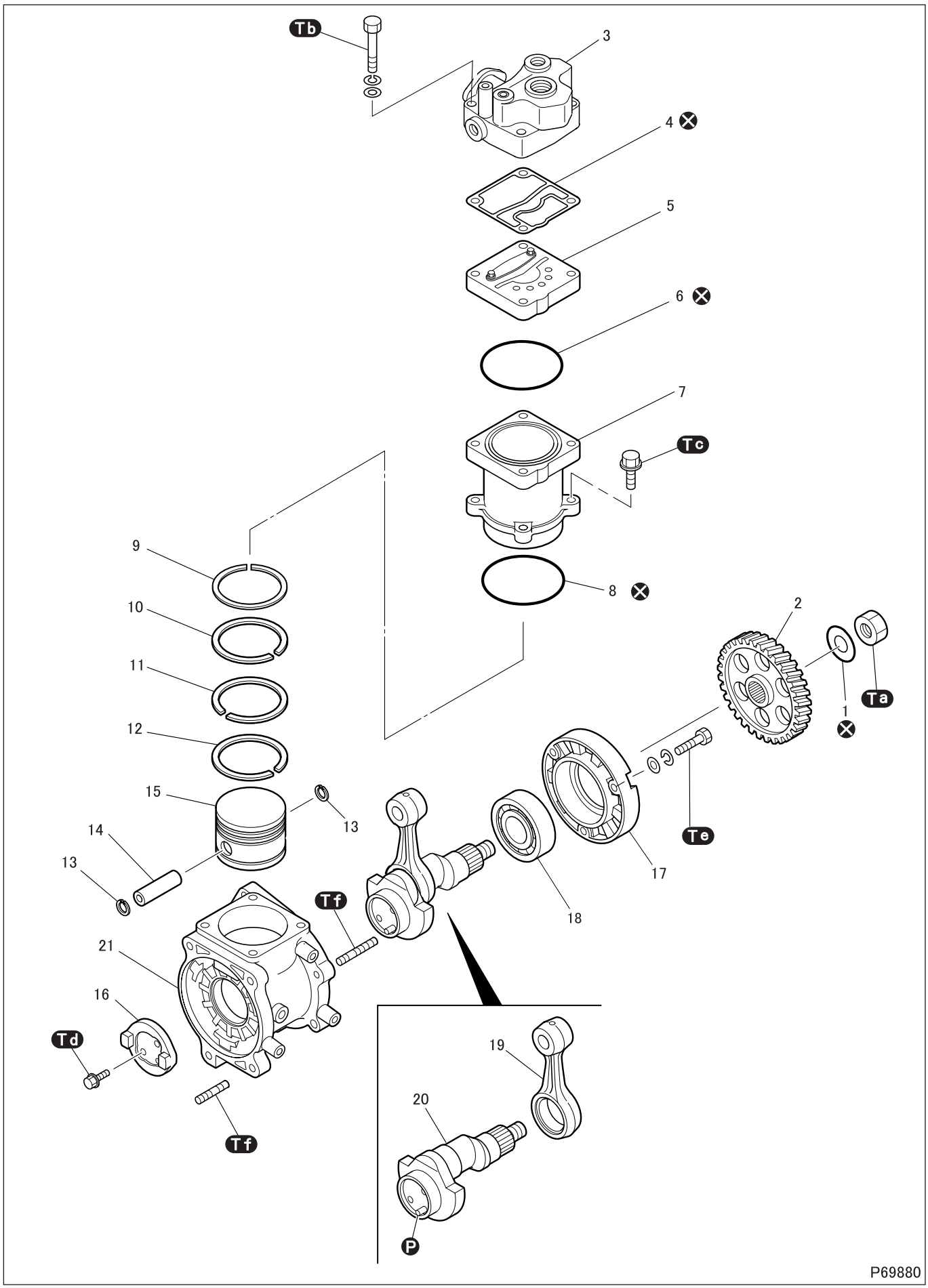
(2) Operating pressure of air pressure governor

- Remove the cap nut, plate, and seat.
- Start the engine and gradually increase the air pressure in the air tank.
- Turn the adjusting screw until the pressure indicated by air pressure gauge A when air is expelled from the exhaust cover is the standard value (the upper threshold pressure).
- Reduce the air pressure to the lower threshold pressure or lower, then gradually increase it again. Check whether the pressure indicated by the air pressure gauge A is the standard value (the upper threshold pressure). If the indicated pressure deviates from the standard value, make further adjustments.
- With the upper threshold pressure indicated, air from the air compressor is expelled from the exhaust cover continuously. With the equipment in this condition, open the drain cock to gradually reduce the air pressure. When air stops being expelled from the exhaust cover, check whether the pressure indicated by air pressure gauge B is the standard value (the lower threshold pressure). If the indicated pressure deviates from the standard value, replace relevant parts of the air compressor governor.

- Tighten the nut to hold the adjusting screw in position.

M E M O

AIR COMPRESSOR <154 cm^3 {154 mL}>



● Disassembly sequence

1 Lock washer
2 Compressor gear
3 Cylinder head
4 Gasket
5 Valve seat
6 O-ring
7 Cylinder liner
8 O-ring
9 1st compression ring
10 2nd compression ring
11 3rd compression ring
12 Oil ring
13 Snap ring
14 Piston pin
15 Piston
16 Coupling
17 Bearing cover
18 Bearing
19 Connecting rod
20 Crankshaft
21 Crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

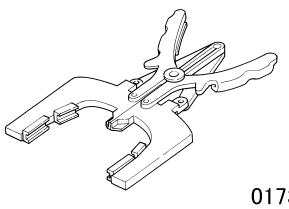
Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
7, 15	Clearance between cylinder liner and piston	Top	–	0.30	Replace
		Skirt	–	0.20	
9 to 12	Piston ring end gap (measured with ring placed in cylinder)	Compression ring	–	0.60	Replace
		Oil ring	–	0.65	
9 to 12, 15	Clearance between piston ring and piston groove	Compression ring	–	0.07	Replace
		Oil ring	–	0.075	
14, 15	Clearance between piston pin and piston		–	0.07	Replace
14, 19	Clearance between piston pin and connecting rod small end		–	0.07	Replace
19	End play of connecting rod		–	1.5	Replace
19, 20	Clearance between connecting rod big end and crankshaft		–	0.1	Replace
20	Crankshaft end play		–	0.7	Replace
20, 21	Clearance between crankshaft and crankcase bushing inside diameter		–	0.2	Replace

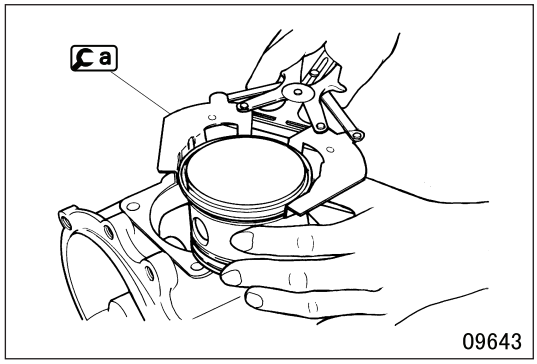
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (compressor gear mounting)	167 to 186 {17 to 19}	–
Tb	Bolt (cylinder head mounting)	29 to 34 {3.0 to 3.5}	–
Tc	Bolt (cylinder liner mounting)	25 to 29 {2.5 to 3.0}	–
Td	Bolt (coupling mounting)	53 to 65 {5.4 to 6.6}	–
Te	Nut (bearing cover mounting)	8.8 to 10.8 {0.9 to 1.1}	–
Tf	Stud bolt	5.9 to 12 {0.6 to 1.2}	–

Special tools

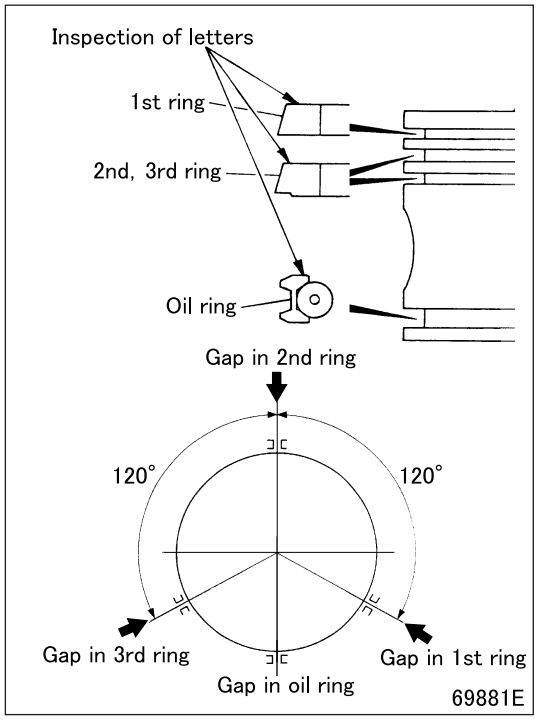
Mark	Tool name and shape	Part No.	Application
Ca	Piston ring tool  01732	MH060014	Removal and installation of compression rings

◆Removal procedure◆



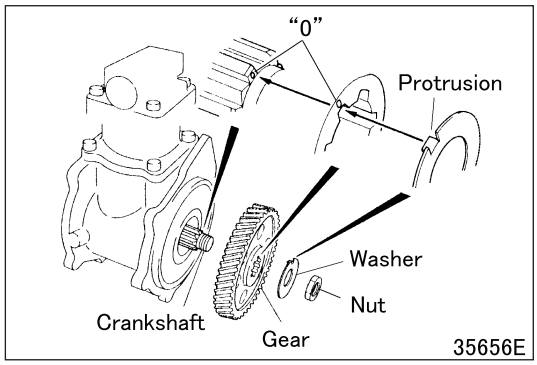
■ **Removal: Compression rings**

◆Installation procedure◆



■ **Installation: Compression rings**

- Install the compression rings, ensuring that their end gaps are located as shown in the illustration.
- Install the compression rings by following the removal sequence in reverse.
  (See "■ **Removal: Compression rings**".)

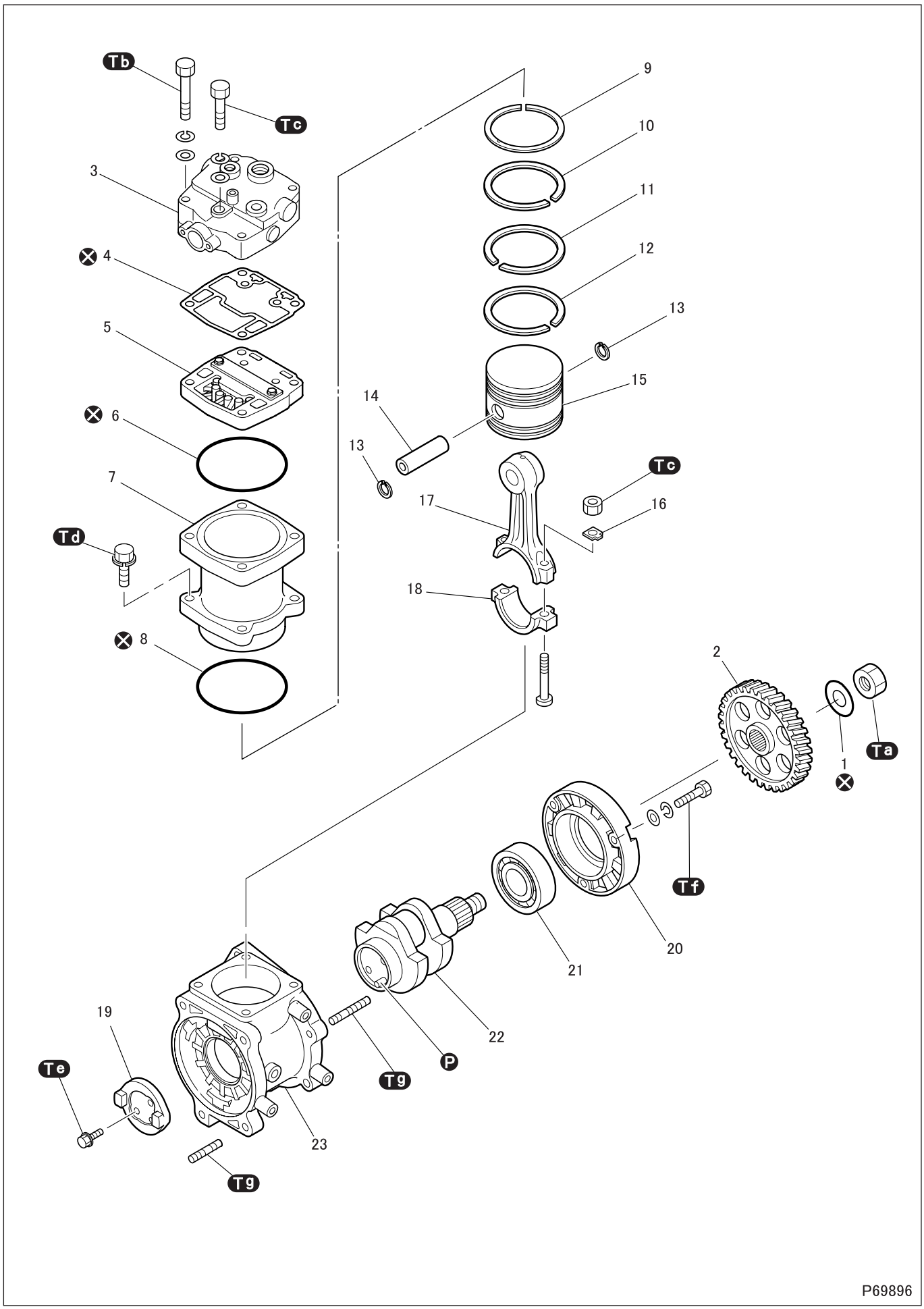


■ **Installation: Lock washer, compressor gear**

- Install the compressor gear onto the crankshaft, ensuring that "O" mark on the compressor gear is aligned with "O" mark on the crankshaft.
- Insert the protrusion of the lock washer such that the "O" mark on the compressor gear remains exposed.
- Tighten the nut to the specified torque. Bend one part at the bottom of the lock washer toward the nut to prevent the nut from loosening.

M E M O

AIR COMPRESSOR <319 cm^3 {319 mL}>



● Disassembly sequence

1 Lock washer
2 Compressor gear
3 Cylinder head
4 Gasket
5 Valve seat
6 O-ring
7 Cylinder liner
8 O-ring
9 1st compression ring
10 2nd compression ring
11 3rd compression ring
12 Oil ring
13 Snap ring
14 Piston pin
15 Piston
16 Lock washer
17 Connecting rod
18 Connecting rod cap
19 Coupling
20 Bearing cover
21 Bearing
22 Crankshaft
23 Crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

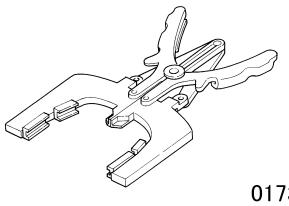
Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
7, 15	Clearance between cylinder liner and piston	Top	–	0.335	Replace
		Skirt	–	0.195	
9 to 12	Piston ring end gap (measured with ring placed in cylinder)	Compression ring	–	1.0	Replace
		Oil ring	–	0.8	
9 to 12, 15	Clearance between piston ring and piston groove	Compression ring	–	0.08	Replace
		Oil ring	–	0.07	
14, 15	Clearance between piston pin and piston		–	0.08	Replace
14, 17	Clearance between piston pin and connecting rod small end		–	0.07	Replace
17	End play of connecting rod		–	0.5	Replace
17, 18, 22	Clearance between connecting rod big end and crankshaft		–	0.1	Replace
22	Crankshaft end play		–	1.0	Replace
22, 23	Clearance between crankshaft and crankcase bushing inside diameter		–	0.12	Replace

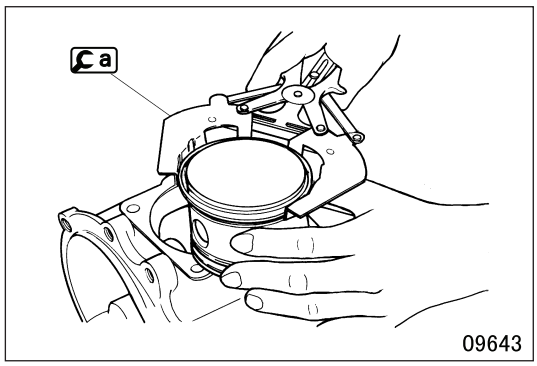
Tightening torque (Unit: N·m {ft.lbs, kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ⓣa	Nut (compressor gear mounting)	167 to 186 {17 to 19}	–
Ⓣb	Bolt (cylinder head mounting)	29 to 34 {3.0 to 3.5}	–
Ⓣc	Nut (connecting rod cap mounting)	23 to 25 {2.3 to 2.6}	–
	Bolt (valve seat mounting)		
Ⓣd	Nut (cylinder liner cap mounting)	25 to 29 {2.5 to 3.0}	–
Ⓣe	Bolt (coupling mounting)	53 to 65 {5.4 to 6.6}	–
Ⓣf	Nut (bearing cover mounting)	8.8 to 10.8 {0.9 to 1.1}	–
Ⓣg	Stud	5.9 to 12 {0.6 to 1.2}	–

Special tools

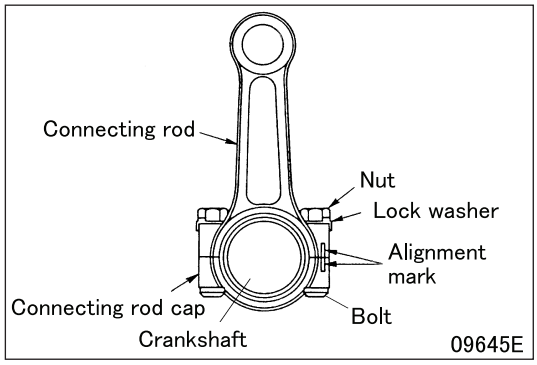
Mark	Tool name and shape	Part No.	Application
Ⓒa	Piston ring tool  01732	MH060014	Removal and installation of compression rings

◆Removal procedure◆



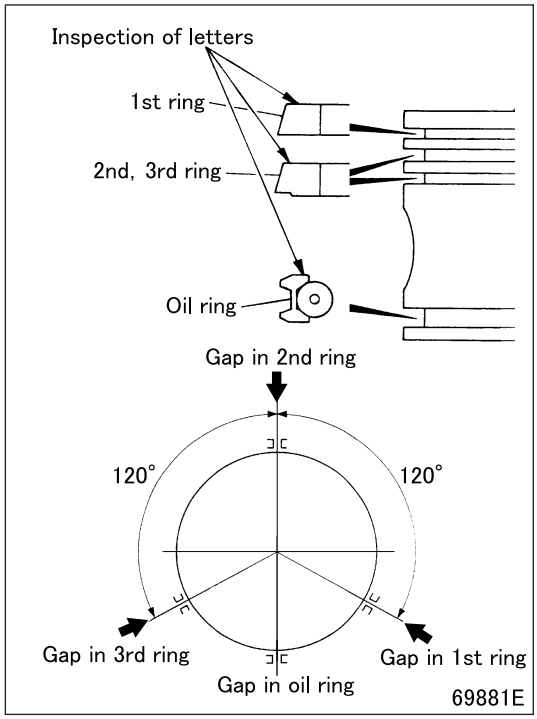
■ **Removal: Compression rings**

◆Installation procedure◆



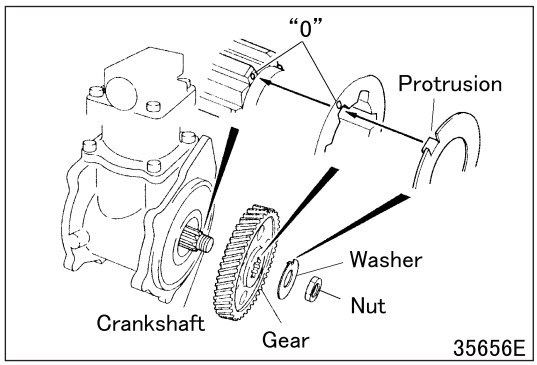
■ **Installation: Connecting rod cap and connecting rod**

- Assemble the connecting rod and cap while noting their alignment marks.
- Install bolts in such a way that the notches in the bolt heads are directed toward the inside of the connecting rod cap.



■ **Installation: Compression rings**

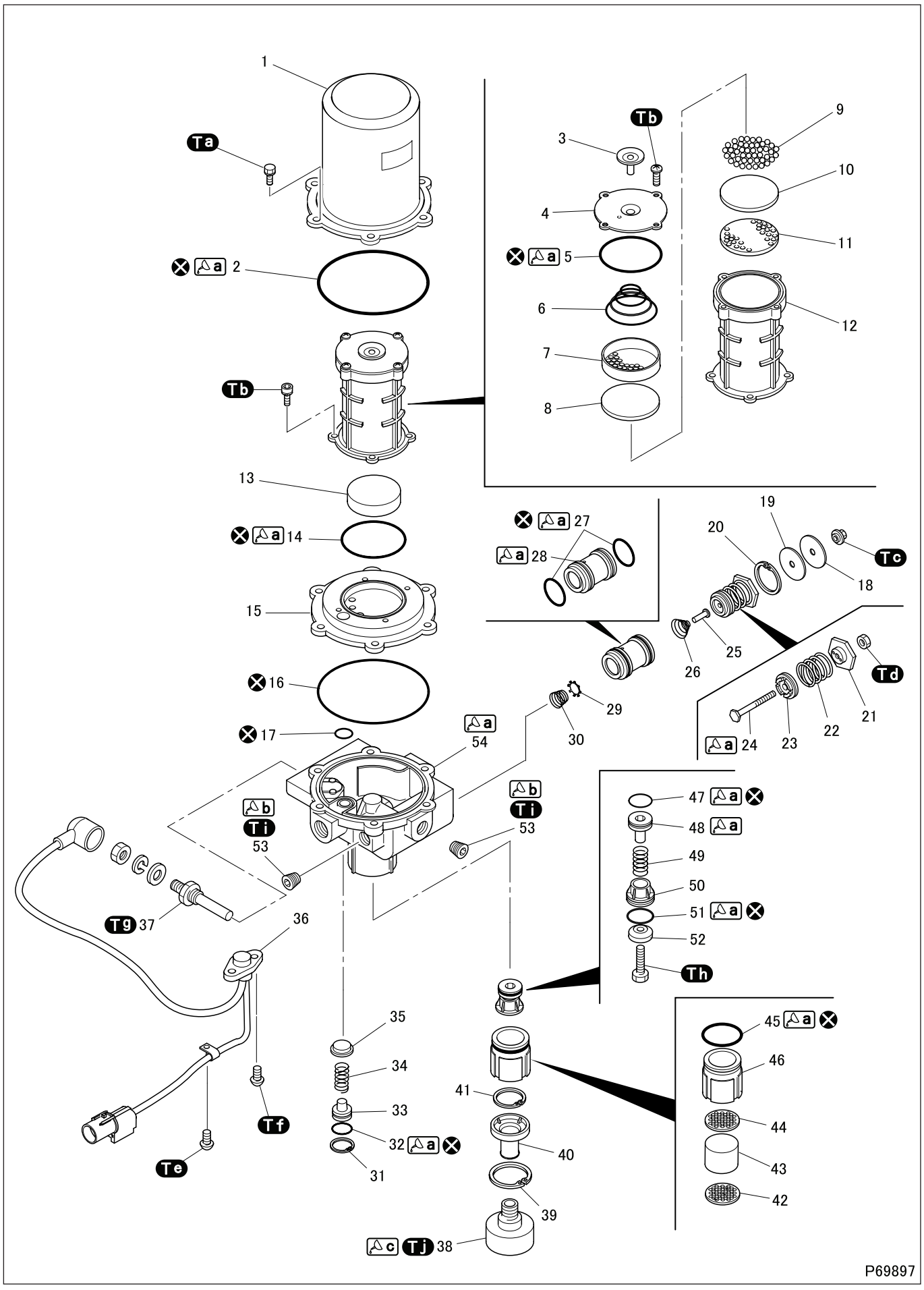
- Install the compression rings, ensuring that their end gaps are located as shown in the illustration.
- Install the compression rings by following the removal sequence in reverse.
  (See "■ **Removal: Compression rings**".)



■ **Installation: Lock washer, compressor gear**

- Install the compressor gear onto the crankshaft, ensuring that "O" mark on the compressor gear is aligned with "O" mark on the crankshaft.
- Insert the protrusion of the lock washer such that the "O" mark on the compressor gear remains exposed.
- Tighten the nut to the specified torque. Bend one part at the bottom of the lock washer toward the nut to prevent the nut from loosening.

M E M O


1
Ta
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Tb
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Tc
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Td
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Ti
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Tg
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Tf
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47
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Th
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Tj
38
P69897

● Disassembly sequence

1 Purge chamber
2 O-ring
3 Check valve
4 Case cover
5 O-ring
6 Set spring
7 Filter plate
8 Filter
9 Desiccant
10 Filter
11 Filter plate
12 Case
13 Oil filter
14 O-ring
15 Cover
16 Gasket ring
17 Gasket ring
18 Plate
19 Seat
20 Retaining ring
21 Upper spring seat
22 Spring
23 Lower spring seat
24 Adjusting screw
25 Exhaust stem
26 Exhaust stem spring
27 O-ring
28 Piston
29 Valve
30 Valve spring
31 Retaining ring
32 O-ring
33 Check valve guide
34 Check valve spring
35 Check valve
36 Thermostat
37 Heater
38 Silencer
39 Retaining ring
40 Exhaust cover
41 Retaining ring
42 Silencer plate
43 Silencer
44 Silencer plate
45 O-ring
46 Silencer case
47 O-ring
48 Piston
49 Valve spring
50 Valve body
51 O-ring
52 Valve
53 Plug
54 Body

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

- Check and adjust the air pressure governor after assembly. (See “GENERAL INSPECTION AND ADJUSTMENT”.)

Repair kit: Air dryer kit A, B

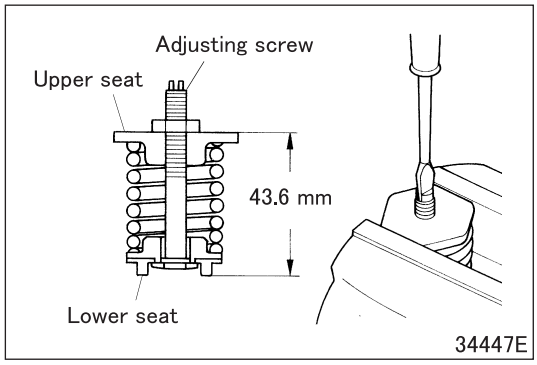
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (purge chamber, cover and body mounting)	17.7 to 27.5 {1.8 to 2.8}	–
Tb	Bolt (case mounting)	2.0 to 3.9 {0.2 to 0.4}	–
	Screw (case cover mounting)		
Tc	Cap nut (seat and plate mounting)	4.9 to 5.9 {0.5 to 0.6}	–
Td	Nut (adjusting screw retaining)	6.9 to 7.8 {0.7 to 0.8}	–
Te	Screw (clamp mounting)	1.0 to 1.5 {0.1 to 0.15}	–
Tf	Screw (thermostat mounting)	0.5 to 1.0 {0.05 to 0.10}	–
Tg	Heater	19.6 to 29.4 {2 to 3}	–
Th	Bolt (valve, piston and valve body mounting)	3.9 to 6.9 {0.4 to 0.7}	–
Ti	Plug	14.7 to 24.5 {1.5 to 2.5}	–
Tj	Silencer	29.4 to 39.2 {3.0 to 4.0}	–

Lubricant and/or sealant

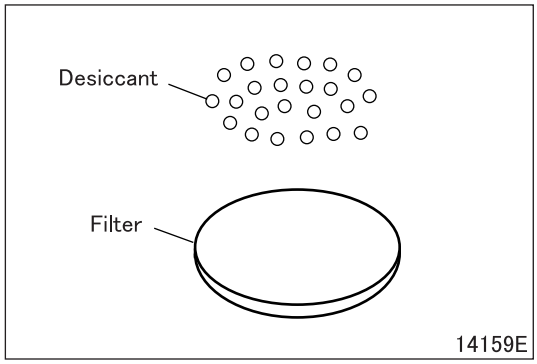
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Multipurpose grease [NLGI No. 2 (Li soap)]	As required
	Adjusting screw (entire surface except thread)		
	Outer periphery of piston and O-ring groove		
	Body (inside surface)		
b	Plug thread	ThreeBond 1110B	As required
c	Silencer thread	ThreeBond 1401B	Three threads from the end of thread

◆Installation procedure◆



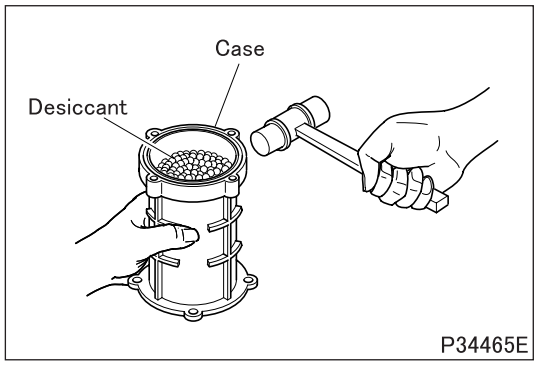
■ **Adjustment: Adjusting screw**

- Turn the adjusting screw to achieve the indicated dimension from the top of the upper spring seat to the bottom of the lower spring seat. Doing so will facilitate the threshold pressure adjustment to the specified value.

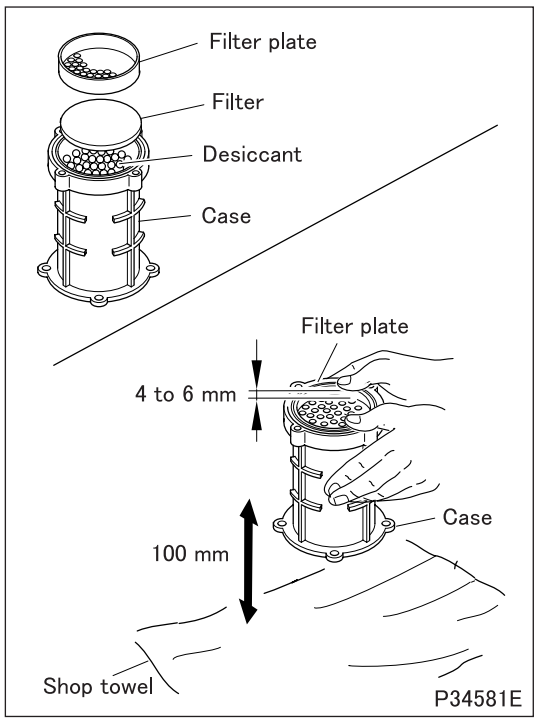


■ **Installation: Filters, desiccant, and filter plate**

- Install the filters with their soft layers facing the desiccant.



- Place the desiccant in the case, then settle the desiccant by tapping gently and evenly around the case with a plastic hammer.

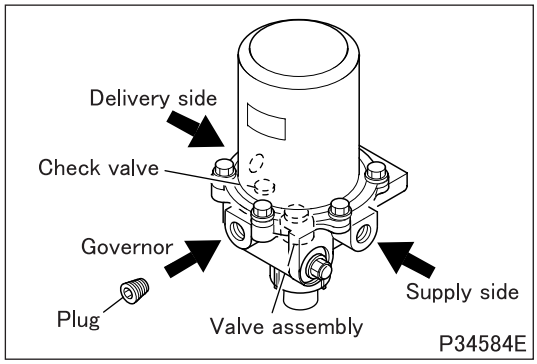


- Place the soft layer side of the filter on the desiccant, and place the filter plate on the case, then tap the desiccant down following the manners.
  - Before tapping the case against the work surface, lay two or three layers of shop towel on the work surface to protect the bottom of the case from scratches.
  - Holding down the filter plate with both hands, lift the case to a height of about 100 mm and tap it gently against the work surface.
  - Tap the case about 30 more times. Make sure the filter plate drops by 4 to 6 mm from its original position.

WARNING ⚠

- **Unless the tapping procedure is performed, particles of desiccant may escape and create blockages in brake lines, thus preventing normal brake operation.**

◆Inspection after installation◆



■ Inspection: Air leakage

- Completely plug the delivery side of the air dryer, then apply air pressure of 49 kPa {0.5 kgf/cm^2} or 780 kPa {8 kgf/cm^2} to the supply side and check that no air leaks from any joint.
  Leakage from the valve assembly must not exceed 20 cm^3 per minute.
- Increase the pressure applied to the supply side to 932 kPa {9.5 kgf/cm^2} to cause purging (regeneration). Check that no air leaks from the check valve and from the air pressure governor (with the plug removed).
- If there is air leakage from the air pressure governor or the check valves, charging (pressure filling) and purging (regeneration) will be performed continuously. Therefore, carry out the inspection of the air pressure governor and check valve.