HINO DIESEL ENGINE WORKSHOP MANUAL

J05E-TH

(HS ENGINE for 25t)

KSS-SMJ5-E111E

2007.6

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For your information:

This documentation does not contain any descriptions in regard to the hatched part

"6. Emission Control".
"15. Air Compressors".

1 GENERAL

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Warning

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Observe the following precautions to work safely and to prevent damage to customers' vehicles.

This manual is prepared for qualified service engineers who are recognized as technical expert. Those who are not qualified, who are not appropriately trained, who performs service without appropriate tool or equipment, or who perform service with the way not specified in this manual may not only damage the vehicle, but also put service engineers and surrounding people in danger.

- Appropriate service and repair are essential to ensure safety of service engineers and safety and reliability of vehicles. Be sure to use Hino genuine parts for replacement of parts. Do not use deteriorated parts in quality.
- Items described in this manual are the procedures to be observed in service and repair. For service and repair according to this procedure, be sure to use the special tools designed for each purpose.
- If a method or a tool not recommended is used, safety of service engineers, and safety and reliability of vehicles may be impaired. Never use a method or tool not recommended.
- This manual shows “Warning” and “Caution” for items that need to be observed so that accidents may not occur during service or repair, or that damage to vehicle due to improper method may not impair safety and reliability of vehicles. These instructions cannot give warning for all possible hazards. Note that items with “Warning” or “Caution” are not absolute for safety.

How to read this manual

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1. Scope of repair work

(1) Repair work is classified into three large categories of "Diagnosis", "Mounting/removal, replacement, assembly·disassembly and inspection·adjustment" and "Final inspection".

(2) This manual describes "Diagnosis" in the first process and "Mounting/removal, replacement, assembly·disassembly and inspection·adjustment" in the second process. Explanation of "Final inspection" in the third process is omitted here.

(3) Although the following work is not described in this manual, it should be performed in actual work.

a. Jacking and lifting
b. Cleaning and washing of removed parts as required
c. Visual inspection

2. Standard value

(1) Standard value, limit, action and tightening torque described in the text are summarized in tables.

3. Items to be prepared

(1) Items to be prepared before work are SST, tools, gauges and lubricant, etc. These are listed in the list section of items to be prepared. Items such as general tools, jack, rigid rack, etc. that are usually equipped in general service shop are omitted.

4. How to read sections and titles

(1) Sections are classified according to J2008, SAE standard.

(2) For areas that show system names like "Engine control system", "Inspection", "Adjustment", "Replacement", "Overhaul", etc. of components are described.

(3) For areas that show part names like "Injection pump", "Mounting/removal and disassembly" is described.

(4) Illustrations of the parts catalog are shown for part layout. (Part codes in the parts catalog are described in the illustration. Major names and tightening torque are listed in the table.)

⚠ **CAUTION** **The part layouts in this manual are inserted based on illustrations and part numbers of the parts catalog CD-ROM issued in April, 2007. (Some areas do not show exploded view. They will be additionally issued when the parts catalog CD is revised.) Be sure to use the parts catalog for confirmation of illustrations and part numbers and for ordering parts.**

5. How to read troubleshooting

(1) Failure diagnosis in this manual describes Step 2 and Step 3 below :

(1) Question	**"Step 1"**	**Hear from customers for conditions and environments of failures and check the fact.**
(2) Pre-inspection **(3) Reproduction method**	**"Step 2"**	**Perform diagnosis inspection, status inspection, function inspection and basic inspection. Check the failure status. If it is difficult to reproduce the problem with status inspection, use the reproduction method.**
(4) Troubleshooting for each diagnosis code **(5) Troubleshooting for each failure status**	**"Step 3"**	**Summarize inspection results obtained from Step 2. Perform inspection systematically according to troubleshooting procedures for each diagnosis code or failure status.**
(6) Confirmation test	**"Step 4"**	**Check if failure occurs again after repair. If it is difficult to reproduce a failure, perform the confirmation test under the conditions and environment of the failure.**

(2) Pre-inspection

Pre-inspection	• **Pre-inspection is performed in the following steps :** **Diagnosis inspection→Diagnosis deletion→Failure status check (Use the reproduction method if not reproduced.)→Diagnosis reconfirmation** • **Estimate the failure system before the reproduction test. Attach a tester and evaluate estimated failure together with failure status. Refer to the troubleshooting chart for estimated cause of a failure.** • **An error code is displayed if a failure occurs instantaneously. If any specific failure is not found, perform troubleshooting using the reproduction method.** • **Failure status check** **If failure is reproduced, perform Step 2 → Step 3 → Step 4.** **If failure is not reproduced, use the reproduction method (simulation of external conditions or check of each wire harness and connector, etc.)**

6. How to read explanation details

(1) Part layout

Example

ENGINE MECHANICAL [J08E] 9–17

Timing Gear Cover and Flywheel Housing

Part layout

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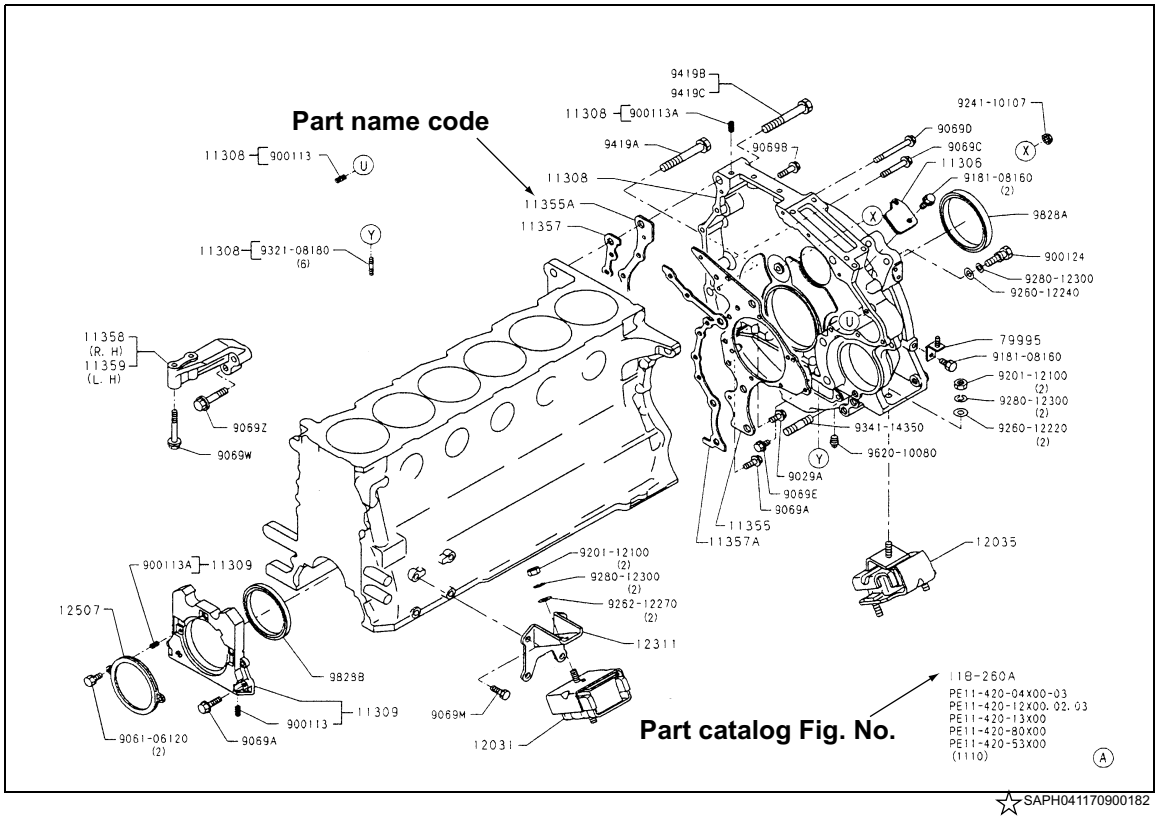

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11308	Flywheel housing	11390	End plate
11309	Oil seal retainer	9828A	Front oil seal*
11357	Gasket*	9828B	Rear oil seal*
11357A	Gasket*		

Description of part name code

*Parts not to be reused.

Left: Part name code (nut)

Tightening torque

9069H	M14 : 171.5N m{1, 750kgf cm}	9419A	M16 : 196N m{2, 000kgf cm}
9069J	M12 : 97N m{990kgf cm}	9419B	M16 : 196N m{2, 000kgf cm}

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☆:It is the ID number for parts to prepare electronic data. It is not required for repair work.

7. Definition of terms

Terms in this manual are defined as follows :

(1) Direction

a. Individual unit

Front/back direction

The power input side is front and the output side is back.

Rotating direction

When viewed from the rear, the clockwise direction is right rotation and the counterclockwise direction is left rotation.

Vertical direction

With a unit mounted on the vehicle (chassis), the upward direction is upper and the downward direction is lower.

Left/right direction

When viewed from the rear, the left direction is left and the right direction is right.

(2) Standard value ·····Basic dimension excluding tolerance and clearance generated by tolerances when two parts are joined

(3) Repair limit···It is the value requiring repair. Symbol of + or - with the value means increase or decrease to the standard value.

(4) Service limit···It is the value requiring replacement. Symbol of + or - with the value means increase or decrease to the standard value.

(5) Warning·····It is an item that may result in risk of human life or serious injury by incorrect handling.

(6) Caution·····It is an item that should not be performed including inhibited work or an item that require attention in working procedures.

(7) Reference·····It is supplementary explanation in work.

8. Unit

(1) SI unit is used in this manual. SI unit is the international unit to unify the conventional different international units into one unit per quantity and to promote smooth technical communications.

(2) This manual shows both the SI unit and conventional units. The conventional units are shown in { }.

	SI unit	Conventional unit	Conversion value[*1] (1[Conventional unit] = X [SI unit])		SI unit	Conventional unit	Conversion value[*1] (1[Conventional unit] = X [SI unit])
Force	N	kgf	1kgf=9.80665N	Spring constant	N/mm	kgf/mm	1kgf/mm=980665N/mm
Torque[*2]	N·m	kgf·cm	1kgf·cm=0.0980665 N·m	Volume	L	cc	1cc=1mL
Pressure	Pa	kgf/cm^2	1kgf/ cm^2=98.0665kPa =0.0980665MPa	Efficiency	W	PS	1PS=0.735499kW
		mmHg	1mmHg=0.133322kPa	Calorific value	W·h	cal	1kcal=1.163W·h
Rotational speed	r/min	rpm	1rpm=1r/min	Fuel consumption rate	g/W·h	g/PS·h	1g/PS·h=1.3596g/kW·h
	min^{-1}		1rpm=1min^{-1}				

[*1] : X means the value when 1 [Conventional unit] is converted to the SI unit. It is used as the conversion factor from the conventional unit to the SI unit.

[*2] : The conversion value of the torque may vary depending on the unit. Observe the standard values described for each unit.

Precautions for work

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1. General precautions

To ensure safety in work and to prevent accidents, observe the following items :

(1) Appearance
   a. Wear safety goggles.
   b. Do not wear watch, necktie, ring, bracelet, necklace, etc. to prevent accident before work.
   c. Bind long hair at the back.
   d. Be sure to wear a cap and safety shoes.

(2) Safety work
   a. Do not touch radiator, muffler, exhaust pipe, tail pipe, etc. after stop of the engine to prevent burn.
   b. Do not put your clothes or tools near the rotating part (in particular, cooling fan or V–belt) during operation of the engine.
   c. Remove the starter key when the engine is not started.
   d. Start the engine at a well ventilated place so that carbon monoxide may not be filled.
   e. Since gas from the fuel or the battery is flammable, do not spark a fire or smoke a cigarette near the area.
   f. Since the battery fluid is poisonous and corrosive, be careful for handling.
   g. Do not short-circuit the cable of the battery or starter. Otherwise, the cable may be burned or burn may occur.
   h. If a tool or rag is left in the engine compartment, it may be bounced with a rotating part of the engine, resulting in injury.
   i. To tow a failure machine, refer to "Towing" in the "Operation manual" of the machine.

2. Precautions for service work

Pay attention to the following points before service work

(1) Preparation before disassembly
   a. Prepare general tools, special tools and gauges before work.
   b. To disassemble a complicated area, put a stamp or match mark on the location not functionally affected to ease assembly. To repair the electric system, disconnect the cable from the minus terminal of the battery before work.
   c. Perform inspection according to the procedure in the text before disassembly.

(2) Inspection during disassembly
   Every time parts are removed, check the area where the parts are assembled and check for deformation, damage, wear or scratch.

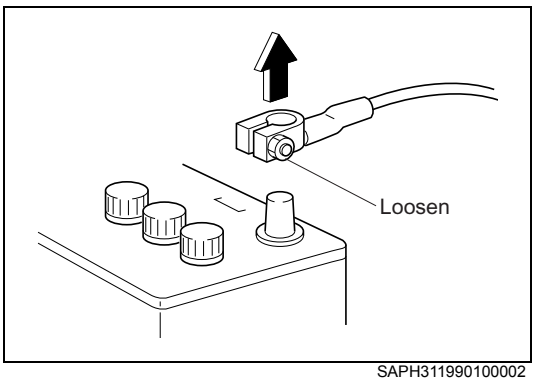
(3) Arrangement of disassembled parts
   Place removed parts neatly in order. Separate parts to be replaced from parts to be reused.

(4) Washing of disassembled parts
   Clean and wash parts to be reused well.

(5) Inspection and measurement
   Inspect and measure parts to be reused as required.

(6) Assembly
   a. Keep the specified standard values (tightening torque, adjusting values, etc.) and assemble correct parts in the correct order.
   b. Be sure to use genuine parts for parts to be replaced.
   c. Use new packing, gasket, O–ring and cotter pin.
   d. Use seal gaskets for some areas where gaskets are used. Apply specified oil or grease to sliding areas where application of oil is required, and apply specified grease to the oil seal lip before assembly.

(7) Check of adjustment
   Make adjustments to the service standard values using a gauge or tester.



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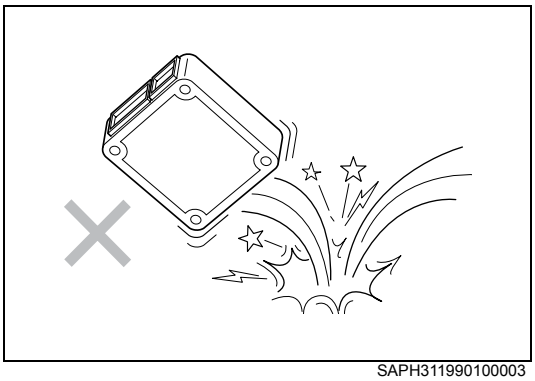
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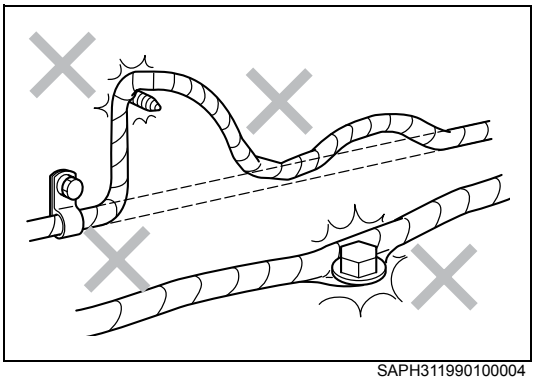
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3. Precautions for electric system

(1) Removal of battery cable

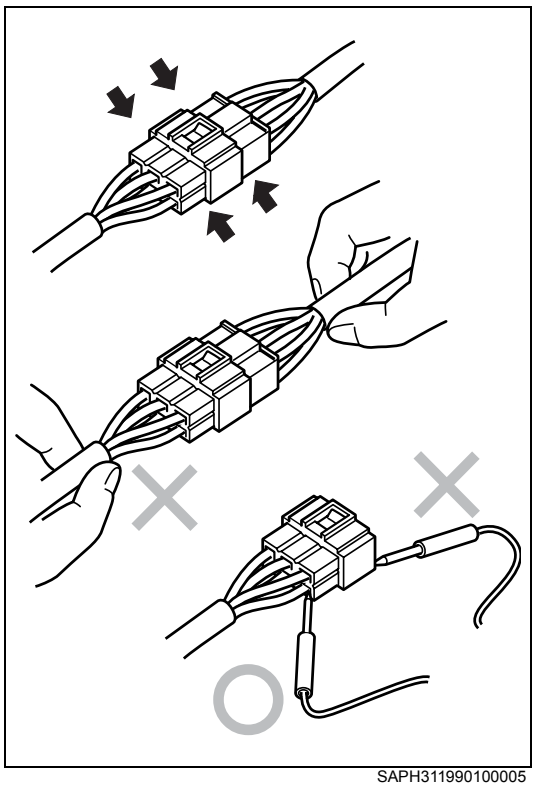
a. In an electric system, remove the cable from the battery minus (-) terminal to prevent burnout due to short-circuit.
b. When the battery cable is removed, the battery terminal may be damaged. Loosen the nut completely and never pry it for removal.

(2) Handling of electronic parts

a. Do not give impact on electronic parts such as computer and relay.
b. Do not place electronic parts at a high temperature and humidity area.
c. Do not expose electronic parts to water in washing of a vehicle.

(3) Handling of wire harness

a. Mark clamps and clips to prevent interference of a wire harness with body edge, sharp edge and bolts. Be sure to reassemble it to the original position.
b. When parts are assembled, be careful not to pinch a wire harness.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(4) Handling of connector

a. When a connector is removed, hold the connector (as shown by the arrow in the left) and pull it out. Do not pull the wire harness.
b. Unlock the locking connector before pulling.
c. Insert the locking connector completely until it clicks.
d. To insert a test lead into the connector, insert it from the back of the connector.
e. If it is difficult to insert a test lead from the back of the connector, prepare a harness for inspection.

4. Precautions for electric welding

Inadvertent electric welding on a cab or chassis may cause reverse welding current from the grounding circuit, resulting in damage to electric and electronic parts. Observe the following items for electric welding.

(1) Turn "OFF" the starter switch.
(2) Make sure that switches are "OFF".
(3) Disconnect the minus (-) terminal of the battery according to the removal procedure of the battery cable.
(4) Disconnect connectors of each computer.
(5) Remove all fuses. (For locations of fuses, refer to "Electrical System Chapter".)
(6) Be sure to connect grounding of the electric welding machine near the welding area.
Connect grounding from a bolt (plated bolt) or a frame near the welding area.
Remove paint of the frame for connection of grounding from the frame.
(7) Other precautions
a. Put a cover on rubber hoses, wire harnesses, pipes, tires, etc. around the welding area so that they may not be exposed to spatter.
b. Perform welding under appropriate conditions and minimize heat effect in the peripheral area. Also maintain welding quality.
(8) After welding, connect and assemble in the order of the fuse and the minus terminal of the battery disassembled. When paint is removed from a frame or cab, apply rust preventive coating with the same color.
(9) After reassembly, check the function if it operates correctly.

Tightening of engine bolts and nuts

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1. Tightening torque of general standard bolts

(1) For bolts with seatings

Unit : N·m{kgf·cm}

Screw diameter x Pitch	7T	9T
M8 x 1.25 (Coarse thread)	28.5{290}	36{370}
M10 x 1.25 (Fine thread)	60{610}	74.5{760}
M10 x 1.5 (Coarse thread)	55{560}	68.5{700}
M12 x 1.25 (Fine thread)	108{1, 100}	136{1, 390}
M12 x 1.75 (Coarse thread)	97{990}	125{1, 280}
M14 x 1.5 (Fine thread)	171.5{1, 750}	216{2, 210}
M14 x 2 (Coarse thread)	154{1, 570}	199{2, 030}
Remark	Bolt with number “7” on the head	Bolt with number “9” on the head

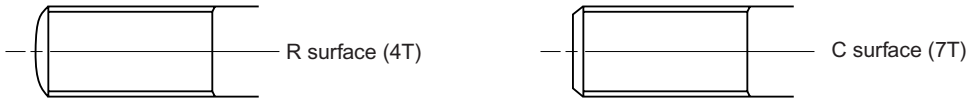
⚠ **CAUTION** • **8T bolt is in accordance with 7T bolt.**

(2) For bolts with washers

Unit : N·m{kgf·cm}

Screw diameter x Pitch	4T	7T	9T
M6 x 1 (Coarse thread)	6{60}	10{100}	13{130}
M8 x 1.25 (Coarse thread)	14{140}	25{250}	31{320}
M10 x 1.25 (Fine thread)	29{300}	51{520}	64{650}
M10 x 1.5 (Coarse thread)	26{270}	47{480}	59{600}
M12 x 1.25 (Fine thread)	54{550}	93{950}	118{1, 200}
M12 x 1.75 (Coarse thread)	49{500}	83{850}	108{1, 100}
M14 x 1.5 (Fine thread)	83{850}	147{1, 500}	186{1, 900}
M14 x 2 (Coarse thread)	74{750}	132{1, 350}	172{1, 750}
Remark	Bolt with number “4”on the head Projection bolt Stud with R surface at free end	Bolt with number“7”on the head Stud with C surface at free end	Bolt with number “9”on the head

⚠ **CAUTION** • **8T bolt is in accordance with 7T bolt.**



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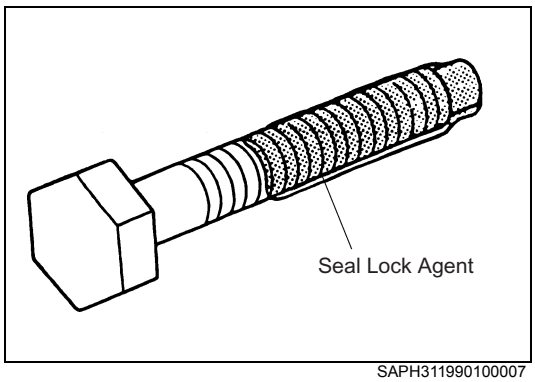

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2. Precoated bolt

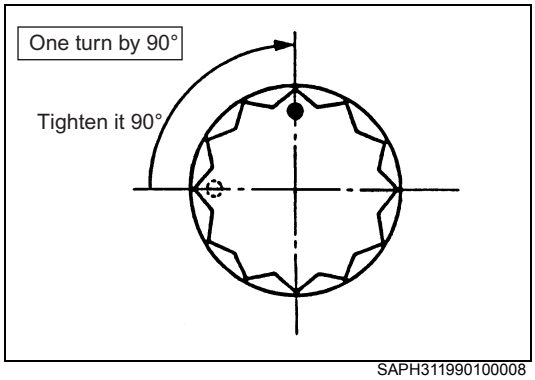
Precoated bolt is the bolt with an application of a seal lock agent at the thread.

(1) When re-application of lock agent is required
   a. When precoated bolts are removed
   b. When precoated bolts are moved due to tightening check (for loosening or tightening)

NOTICE

- **Check torque with the lower limit of the tightening torque allowable value. If movement is found, tighten the bolt according to the procedure below.**

(2) Re-use method of precoated bolt lock
   a. Clean bolt and screw holes. (Clean screw holes for replacement.)
   b. Dry completely by blowing air.
   c. Apply the specified seal lock agent to the thread of the bolt.



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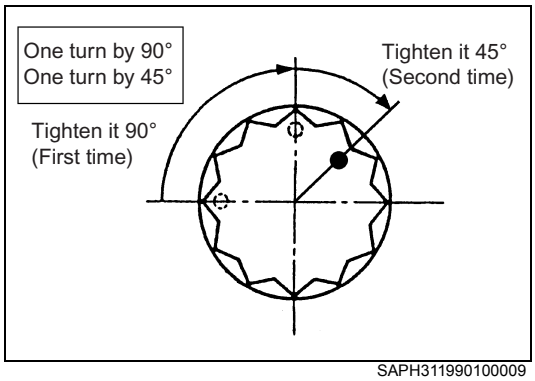
3. Plastic region tightening method (angle method)

(1) Precautions

Some engines are tightened with the plastic region tightening method.

Since it is different from the conventional method, tighten it according to the instruction in the text.



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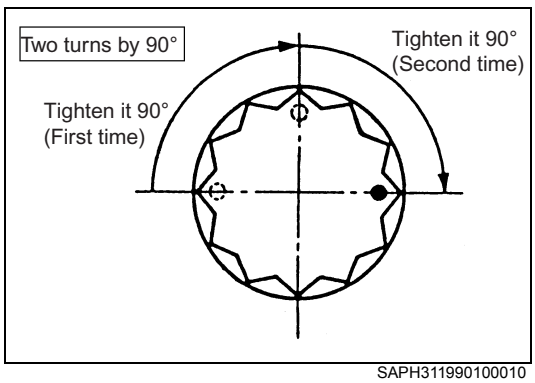
(2) Parts tightened

Cylinder head bolt, crankshaft main bearing cap bolt, connecting rod bearing cap bolt, etc.

⚠ CAUTION

- **Measure the overall length of the bolt before assembly and replace the bolt if the length exceeds the service limit.**
  Apply engine oil to bolt seating and bolt thread in assembly.



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(3) Tightening method after tightening to seating torque

Tightening of 90 °, 135 °(90 °once and 45 °once) and 180 °(90 °twice) is available.

Tightening of chassis bolts and nuts

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1. Tightening torque of general standard bolts and nuts

(1) Selection method of tightening torque

a. Find the applicable strength zone from the table below and select the bolt tightening torque from the table described later.

b. Select the nut tightening torque from the mating bolt as described above.

(2) Identification method of bolt strength zone

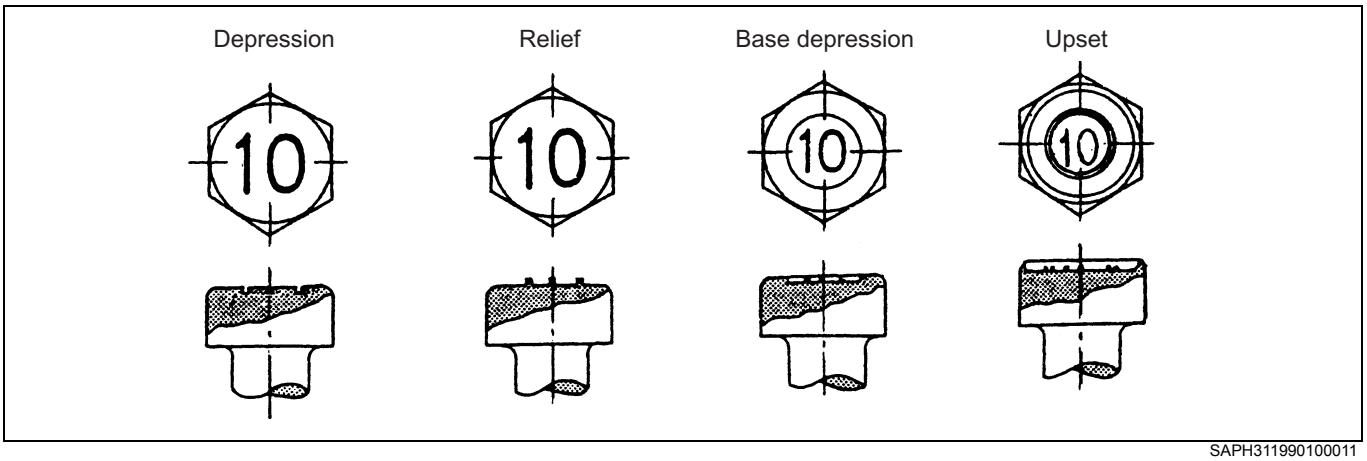
a. Identification method with product

Hexagonal bolt

Strength zone of hexagonal bolts is, in principle, indicated with recession, relief, surface depression and upset on the head with the symbol in the table.

Strength zone	6T	7T	8T	9T	10T	11T	12T
Identification symbol for part	6	7	8	q*1	10	11	12

(*1) : 9 may be misread with 6. It is expressed in q.



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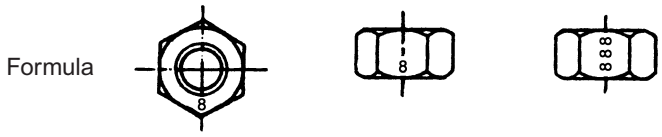
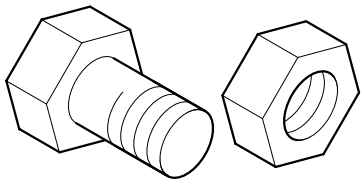
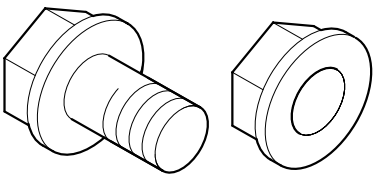
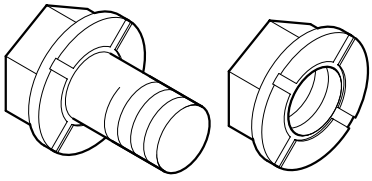
Hexagonal nut

Symbol example for identification of the strength zone of the hexagonal nut is shown in the table below :



(3) Types of general standard bolts and nuts

Standard seating	Seating A with flange	Seating B with flange
		

(4) Standard tightening torque table of general standard bolts and nuts
(Representative standard seating is described)

Unit : N·m{kgf·cm}

Strength zone / Bolt diameter (mm)	4T	7T	9T
M6	4.5±1.8{50±20} (Cab) 5.5±1.1{60±10} (Chassis)	9.0±1.8{90±20}	11.5±2.0{117±23}
M8	14.0±3.5{140±40} (Cab) 17.0±3.0{170±30} (Chassis)	22.0±4.0{220±40} *2	29.0±5.5{300±60} *2
M10	27.0±5.0{276±55}	43.0±8.5{440±90} *2 (Cab) 51.5±10.0{530±100} (Chassis)	57.0±11.0{580±110} *2 (Cab) 68.5±13.5{700±140} (Chassis)
M12	48.0±9.5{490±98}	76.0±15.0{776±150} *2 (Cab) 91.0±18.0{930±180} (Chassis)	100.0±20.0{1, 020±200} *2 (Cab) 120.0±24.0{1, 220±240} (Chassis)
M14	77.0±15.0{786±157}	120.0±24.0{1, 220±240}	160.0±32.0{1, 630±326}
M16	120.0±24.0{1, 220±244}	190.0±38.0{1, 940±390}	250.0±50.0{2, 550±510}
M18	165.0±33.0{1, 680±336}	260.0±52.0{2, 650±530}	345.0±69.0{3, 520±704}
M20	235.0±47.0{2, 400±480}	370.0±74.0{3, 770±750}	490.0±98.0{5, 000±1, 000}
M22	320.0±64.0{3, 270±654}	505.0±100.0{5, 150±1, 030}	670.0±130.0{6, 840±1, 370}
M24	405.0±81.0{4, 130±826}	640.0±125.0{6, 530±1, 310}	845.0±165.0{8, 620±1, 720}

⚠ **CAUTION**

- **Use the tightening torque value for seating A with flange except for *2 in the table larger by 10% than the tightening torque value in the table.**
- **Use the tightening torque value for seating B with flange of *2 in the table larger by 20% than the tightening torque value in the table.**
  The tightening torque value of M8 for seating B with flange remaines unchanged.
- **Seating B with flange of *2 in the table is interchangeable with the standard seating in pairs. Use the standard seating for the tightening torque value.**

Tightening of flare nuts and hoses

JP31199010102005

1. Tightening torque of pipe flare nut

Unit : N·m{kgf·cm}

Pipe outer diameter / Material	ϕ4.76	ϕ6.35	ϕ8	ϕ10	ϕ12	ϕ15
Steel pipe	15±5{150±50}	25±5{250±50}	36±5{370±50}	52±7{530±70}	67±7{680±70}	88±8{900±80}

2. Tightening torque of hoses

Unit : N·m{kgf·cm}

	Hose outer diameter ϕ10.5 fitting	Hose outer diameter ϕ13, ϕ20, ϕ22, fitting at packing	Hose outer diameter PF3/8 fitting
Air hose	21.5±1.5{215±15}	41.5±2.5{425±25}	—
	Only meter gauge 10{100}		
Brake hose	Packing 51.5±7.5{525±75}	—	—

3. Lock nut tightening torque of brass joint

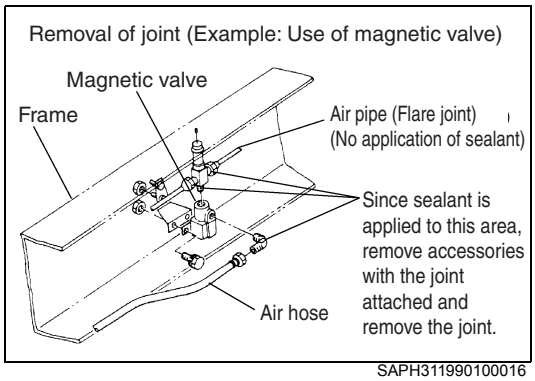
Unit : N·m{kgf·cm}

Screw nominal size	M12	M16	M20	M27
Tightening torque	15±2{150±20}	66±6{670±60}	97±9{990±90}	209±19{2130±190}

Taper thread sealant for piping

JP31199010102006

The taper thread of the air pipe joint has application of sealant [Loctite # 575 (by Japan Loctite)]. Follow the procedures below for connection or disconnection of pipes.

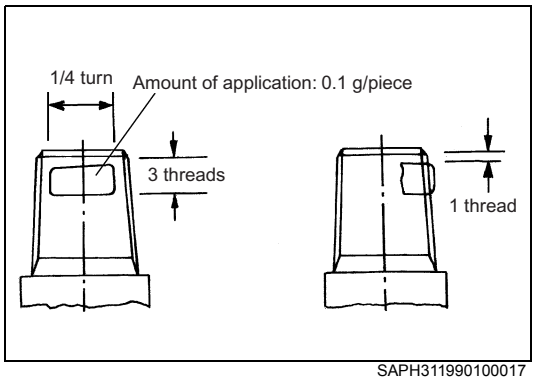


SAPH311990100016

1. For disconnection

(1) The sealant (# Loctite 575) has strong sealing feature. The return torque of the taper joint is increased about 1.5 times the initial tightening torque. When the joint is disconnected, use a long wrench for disconnection.

(2) When a joint at a poorly accessible area is replaced, remove accessories first and disconnect the joint.



SAPH311990100017

2. For connection

(1) For application of sealant (# Loctite 575), wipe the sealing area completely with a rag or thinner. Apply sealant directly to about three ridges for quarter round with offset of one ridge from the end. Tighten it according to the tightening torque in the table below.
Remove dirt completely from the mating part (female) before tightening.

⚠ **CAUTION** • **If your eye or skin comes in contact with sealant, wash it off immediately with water.**

Tightening torque of taper joint Unit : N·m{kgf·cm}

Screw diameter / Material	1/4	3/8	1/2
Steel	49±10{500±100}	64±15{650±150}	
Aluminum, brass	25±5{250±50}	34±5{350±50}	44±5{450±50}

(2) When a sealing tape is replaced with sealant, remove the tape completely first as in (1).

⚠ **CAUTION** • **Be careful to prevent entry of dirt or foreign matter in the pipe.**

(3) If air leak is found after assembly with application of sealant, air leak cannot be stopped with additional tightening. Assemble the part again according to (1) and (2).

Assembly of joints and gaskets for piping

JP31199010102007

1. Tightening torque of joints

Unit : N·m{kgf·cm}

Sealing method / Tightening screw size	Gasket sealing method (Aluminum + Rubber or Copper)	Metal sealing method (Flare pipe type, nipple connector type)	
		Type A	Type B
M8	13{130}		
M10	20{200}		11{110}
M12	25{250}	20{200}	
M14	25{250}	31{320}	
M16	29{300}	39{400}	
M18	39{400}	59{600}	
M20	*39{400}	64{650}	20{200}
M24	69{700}		
M28	*127{1300}		

2. Joint assembly procedure and subsequent inspection

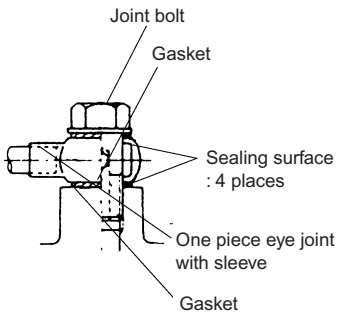
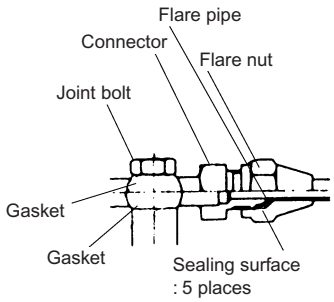
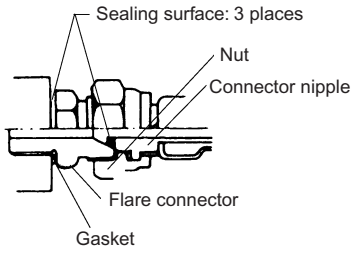
(1) Before assembly, make sure that there is no dirt or burr on the seating surface (mating part, pipe joint, gasket, etc.).

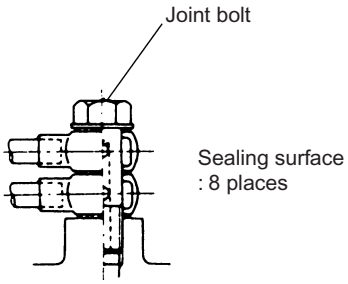
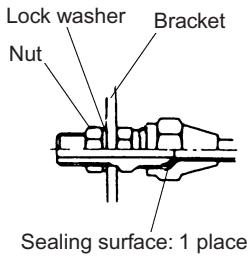
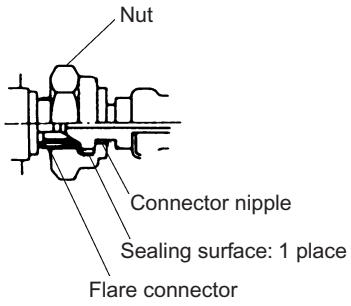
(2) Since pipes have some degrees of freedom for assembly, the seating surface tends to incline. Tighten pipes finally after temporary tightening to prevent leak.

(3) After tightening, apply the specified pressure to each pipe joint to ensure that there is no leak.

(4) Observe the values above for each tightening torque.
*When assembled soft washer # 4840FR-N (aluminum and rubber carbon pressure bonding) is loosened or removed, be sure to replace it with a new part. This is not necessary for normal retightening.

3. Examples of joint methods in various pipes

<table>
<tr><th rowspan="2">Gasket sealing method</th><th colspan="2">Metal sealing method</th></tr>
<tr><th>Type A
(Flare pipe type)</th><th>Type B
(Nipple connector type)</th></tr>
<tr><td> 
</td><td> 
</td><td> 

Sealing surface: 5 places</td></tr>
<tr><td> 
</td><td> 
</td><td> 
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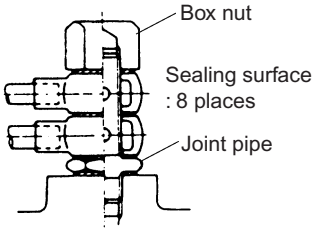
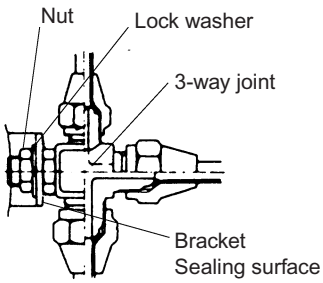
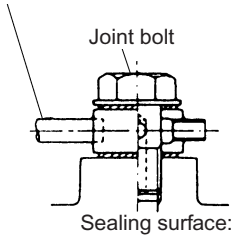
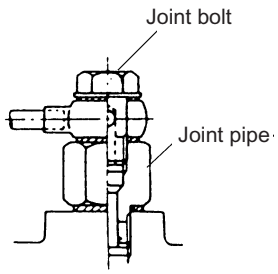
<tr><td> 
</td><td> 
</td><td></td></tr>
<tr><td>One piece eye joint without sleeve
 

Sealing surface: 4 places</td><td></td><td></td></tr>
<tr><td> 

Sealing surface: 6 places</td><td></td><td></td></tr>
</table>

Handling of liquid gasket

JP31199010102008

1. Application of liquid gasket and part assembly procedure

(1) Remove old liquid gasket on each part and mating part completely. Clean the parts with a rag to prevent deposit of oil, moisture, dirt, etc.
Be sure to overap parts at the beginning and at the end of application.

(2) Be careful for offset with the mating part when a part applied with liquid gasket is assembled. Apply the liquid gasket again if offset occurs.

(3) Assemble parts within 20 minutes after application of the liquid gasket.
If 20 minutes has passed, remove the liquid gasket and apply it again.

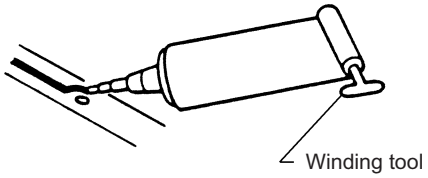
(4) Start the engine at least 15 minutes or more after assembly of parts.

2. Removal of parts

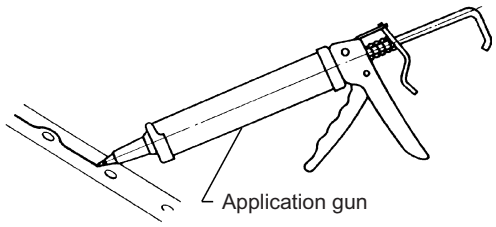
(1) When parts are removed, do not pry one place only. Remove parts by prying each other using collar or clearance on the flange. When gasket is removed, be careful to prevent entry of gasket offal into the engine.

3. Others

(1) When the liquid gasket is contained in a tube, use the accompanying winding tool. When it is contained in a cartridge, use the application gun.

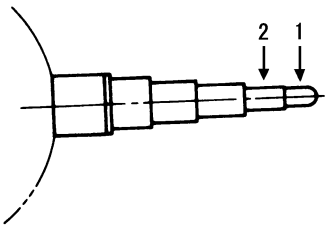


Tube: 150 g



Cartridge type: 300 g

For a tube, desired application width may be obtained from the cut position at the nozzle end.



Nozzle of tube

1 : Approx. 2 mm at the 1st section cut
2 : Approx. 5 mm at the 2nd section cut

Failure diagnosis table for each problem

JP31199010301001

Engine mechanical

Causes and actions are described for each item.

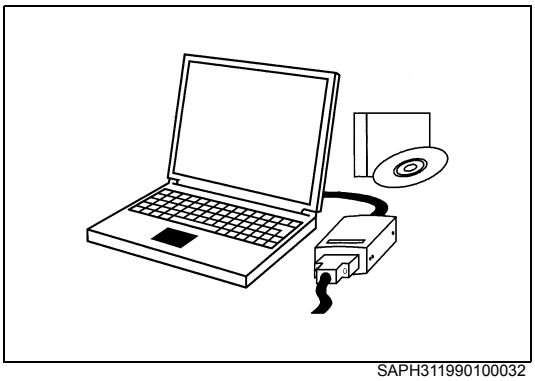
JP03Z01020601001

Status	Cause	Action
Engine overheat (coolant)	Insufficient coolant	Replenish coolant
	Faulty thermostat	Replace thermostat
	Water leak from cooling system	Correction
	Faulty coolant pump	Repair or replace
	Faulty head gasket	Replace head gasket
Engine overheat (radiator)	Clogging of radiator	Cleaning of radiator
	Corrosion of cooling system	Clean and repair cooling system
	Clogging of radiator core front part	Clean radiator
	Faulty radiator cap	Replace radiator cap
Engine overheat (compression pressure)	Non-synchronous injection timing	Adjust injection timing.
	Faulty fuel injection pressure	Adjust injection pressure
	Faulty fuel	Replace with correct fuel
	Faulty injector	Replace injector
Engine overheat (lubrication unit)	Deterioration of engine oil	Replace engine oil
	Faulty oil pump	Replace oil pump
	Insufficient engine oil	Replenish engine oil
Large engine oil consumption (piston, cylinder liner and piston ring)	Wear of piston ring and cylinder liner	Replace piston ring and cylinder liner
	Damage to piston ring	Replace piston ring and cylinder liner
	Faulty fixing of piston ring	Replace piston ring and cylinder liner
	Faulty assembly of piston ring	Replace piston ring and cylinder liner
	Faulty engine oil	Replace engine oil
	Faulty piston ring joint	Reassemble piston ring
Large engine oil consumption (valve and valve guide)	Wear of valve stem	Replace valve and valve guide
	Wear of valve guide	Replace valve guide
	Faulty assembly of valve stem seal	Replace stem seal
	Excessive oil lubrication to rocker arm	Inspection of clearance between rocker arm and rocker arm shaft
Large engine oil consumption (others)	Faulty oil level gauge	Replace with correct level gauge
	Excessive filling of engine oil	Fill with appropriate amount of oil.
	Leak of engine oil	Repair or replace the part of oil leak.
Piston seizure (in operation)	Sudden stop of engine	Perform warm-up before stop of engine
Piston seizure (lubrication unit)	Insufficient engine oil	Replenish engine oil
	Deterioration of engine oil	Replace engine oil
	Incorrect engine oil	Replace with correct engine oil.
	Low oil pressure	Inspection of lubrication unit
	Faulty oil pump	Replace oil pump
Piston seizure	Abnormal combustion	Refer to overheat section.
Piston seizure	Cooling unit	Refer to overheat section.

SAPH311990100031

Failure diagnosis using HinoDX

JP31199010301002



SAPH311990100032

⚠ **CAUTION** • **HinoDX is used for inspection and adjustment of the system in addition to failure diagnosis.**

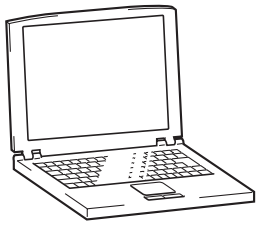
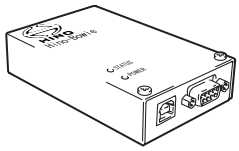
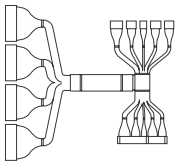
1. HinoDX

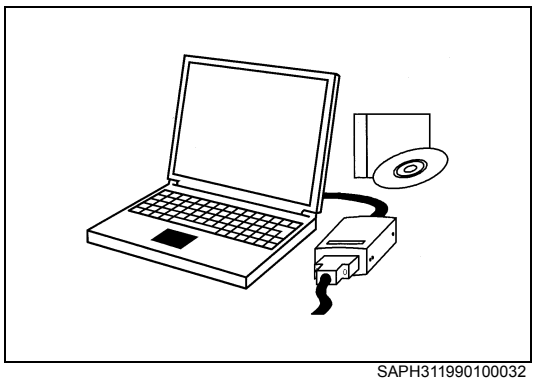
(1) With HinoDX, failure of the common rail fuel injection system can be diagnosed. The interface box (Hino-Bowie) and the special cable are required for connection to the vehicle.

Special tool : 09121-1040 Hino-Bowie
09042-1220 Cable between vehicle and Hino-Bowie
CD-ROM HinoDX

⚠ **CAUTION** • **Install the software of the Hino Diagnostic eXplorer (HinoDX) in the PC. For the installation method, refer to the instruction manual accompanying the CD.**

2. List of failure diagnosis tools

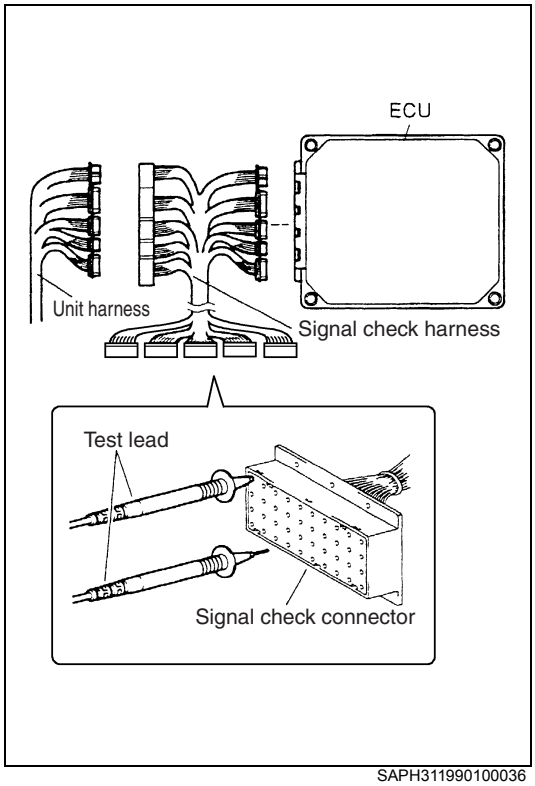
Part name	Part No.	External shape	General description and function
PC (DOS/V standard)	—		• Operating system (OS) : Windows95, Windows98(IE5.0 or later), Windows2000(SP3, IE5.0 or later), WindowsXP(SP1a, IE6.0 or later) • CPU and memory : Conditions that assure operation of the above operating system • Display : 800 x 600, 256 colors or more
Hino-Bowie (Interface box)	09121 - 1040 Cable between vehicle and Hino-Bowie (09042 - 1220)		• PC interface
Signal check harness	09049 - 1080 (for common rail fuel injection system)		Interrupting installation between vehicle harness and ECU allows inspection with a tester rod while the power is supplied.



SAPH311990100032

3. Deletion of past failures

(1) To delete past failures of the engine ECU, use HinoDX on the PC. (Refer to "HinoDX operation manual".)



SAPH311990100036

4. Connection of signal check harness

(1) To prevent damage to the ECU connector and to improve accessibility, connect the signal check harness and put a testing rod on the signal check connector of the signal check harness for meaurement.

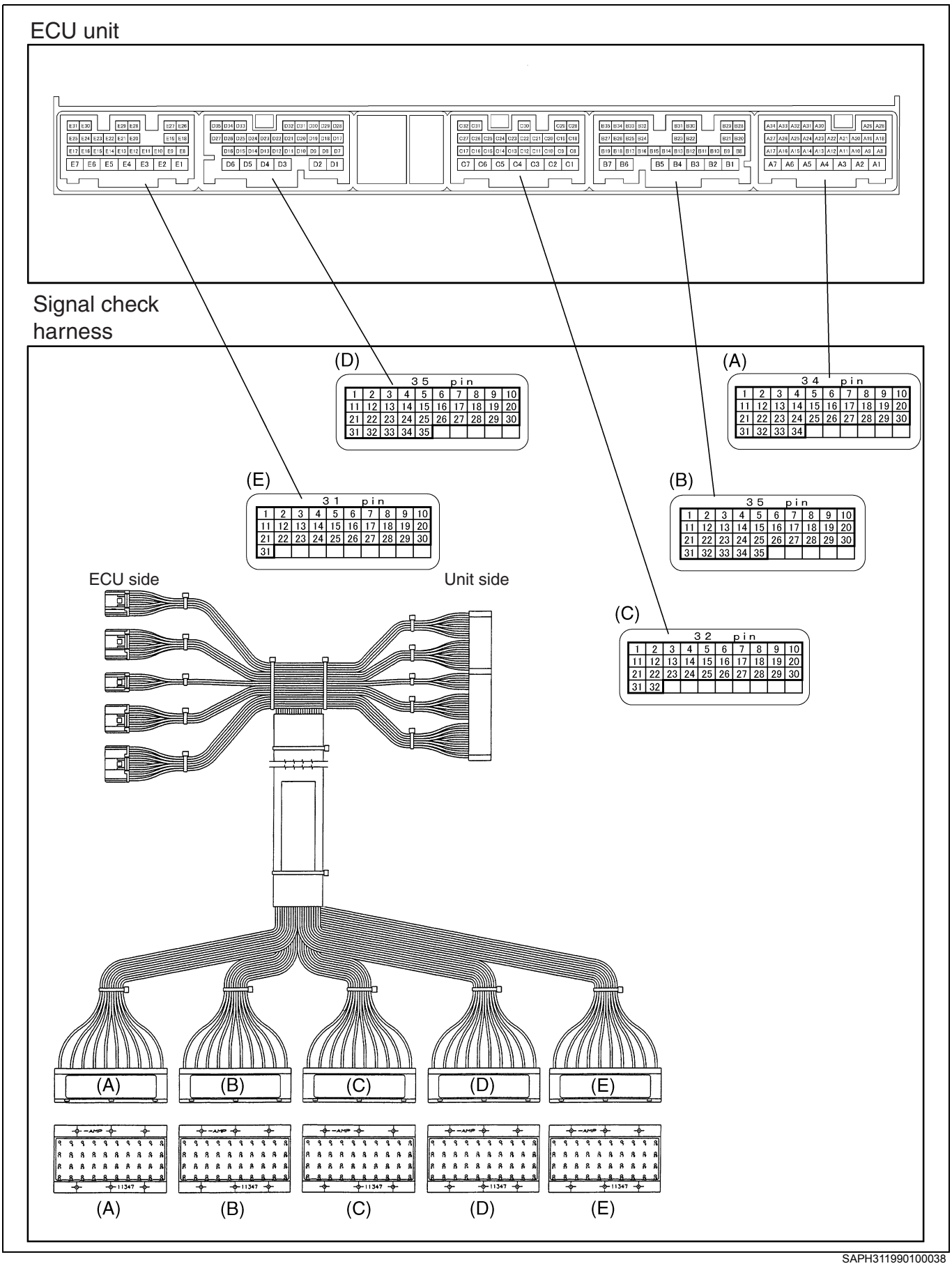
a. Disconnect the connector from the ECU.

⚠ **CAUTION** • **Do not break the locking tab of the connector.**

b. Connect the signal check harness to the machine harness and the ECU.
Signal check harness
(for common rail fuel injection system)
Part No.
09049-1080

(2) Terminal No.

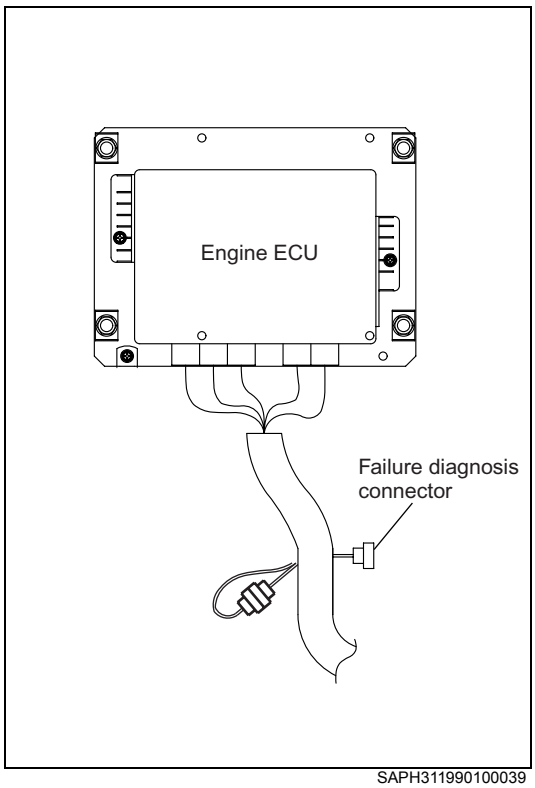
For the signal check harness connector, the ECU terminal number in the text is treated as follows :



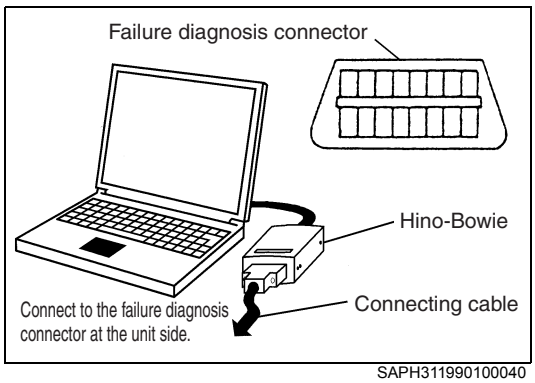
SAPH311990100038

Connection method of HinoDX

JP31199010301003



SAPH311990100039



SAPH311990100040

1. Connection of HinoDX

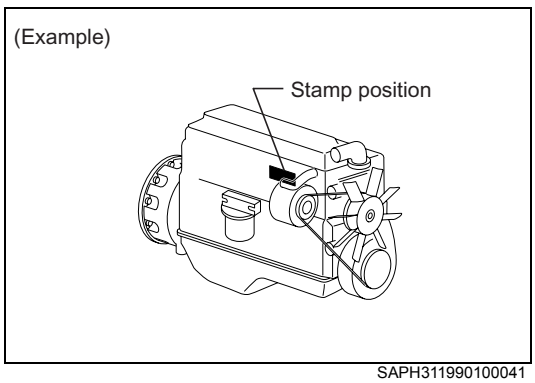
(1) Remove the left side cover at the rear of the driver's seat and connect the failure diagnosis connector with a PC which installed HinoDX through the interface box.

Special tool : 09121-1040 Hino-Bowie (Interface box)
09042-1220 Connecting cable
CD-ROM HinoDX

(2) Set the starter key to "ON" and start HinoDX.

Chassis number and engine number

JP31199010401001



SAPH311990100041

1. Engine type and engine number

(1) Engine type and engine number are stamped at the left cylinder block when viewed from the cooling fan. For order of parts, information of this number will facilitate procedures smoothly.

Ex. J05E TA10101

2 STANDARD VALUE

Engine Body 2-2
Standard value 2-2
Tightening torque 2-2
Fuel System 2-2
Tightening torque 2-2
Electrical 2-3
Standard value 2-3
Tightening torque 2-3
Intake 2-3
Tightening torque 2-3
Engine Mechanical 2-4
Standard value 2-4
Tightening torque 2-11
Exhaust 2-12
Tightening torque 2-12
Cooling 2-12
Standard value 2-12
Lubrication 2-12
Standard value 2-12
Tightening torque 2-14
Starting and Charging 2-14
Standard value (Alternator 50A) 2-14
Tightening torque (Alternator 50A) 2-15
Standard value (starter) 2-15
Tightening torque (starter) 2-16
Turbocharger 2-16
Standard value 2-16
Tightening torque 2-16

Engine Body

Standard value

JP31199020205001

MPa {kgf/cm^2, lbf/in.^{2}}

Inspection item	Standard value	Repair limit	Service limit	Action
Compression pressure (Engine revolution per cylinder: 150 r/min)	3.4-3.7 {35-38, 493-237}	—	2.7 {28, 392}	

Tightening torque

JP31199020205002

Unit:N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Starter B terminal	7.8 - 8.8 {80 - 110, 5.8 - 6.5}	
Alternator B terminal	3.3 - 4.4 {33 - 45, 2.4 - 3.2}	
Oil pan drain cock	41 {420, 30}	
Radiator hose band	4.5 - 5.0 {45 - 50, 3.3 - 3.7}	

Fuel System

Tightening torque

JP31199020205003

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Injector clamp	25 {250, 18}	
Supply pump - Bearing holder case	28.5 {290, 21}	
Bearing holder case - Pump drive	28.5 {290, 21}	
Supply pump coupling flange mounting nut	63.7 {650, 47}	
Injector harness	2.2 {22, 1.6}	
Fuel filter air bleeding bolt	1.7 - 2.6 {17.3 - 23, 1.2 - 1.9}	

Electrical

Standard value

JP31199020205018

Inspection item	item	item	Standard value	Remark
V-belt tension adjustment	When installing a new belt	Deflection	8 - 10mm {0.3152 - 0.394in.} (Reference push force 98N {10kgf, 22lbf})	Compression gauge (09444-1210) is used.
		Tension	490 - 570 N {50 - 58 kgf, 110 - 128 lbf}	Belt tension gauge (95506-00090 Denso part No.) is used.
	At the time of inspection	Deflection	10 - 12mm {0.394 - 0.472in.} (Reference push force 98N {10kgf, 22lbf})	Compression gauge (09444-1210) is used.
		Tension	320 - 400 N {33 - 41 kgf, 72 - 90 lbf}	Belt tension gauge (95506-00090 Denso part No.) is used.

Tightening torque

JP31199020205019

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Starter mounting bolt	154 {1,570, 114}	
Starter mounting nut	171.5 {1,750, 126}	
Battery cable mounting nut	16 - 22 {165 - 225, 11 - 16}	
Alternator through bolt	83 {850, 61}	
E terminal bolt	3.2 - 4.4{33 - 45, 2 - 3}	
Fixing bolt at brace	51{520, 38}	
Outside B terminal mounting nut	3.2 - 4.4{33 - 45, 2 - 3}	
Through bolt	7.8 - 9.8{80 - 99, 6 - 7}	

Intake

Tightening torque

JP31199020205005

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Intake manifold mounting bolt	28.5 {290, 21}	

Engine Mechanical

Standard value

JP31199020205006

Unit : mm {in.}

Inspection item		Standard value	Repair limit	Service limit	Action
Valve clearance (cold)	IN	0.30 {0.0118}	—	—	
	EX	0.45 {0.0177}	—	—	
Cylinder liner protrusion		0.01 - 0.08 {0.003 - 0.003}	—	—	
Cylinder liner flange width		8 {0.314}	—	—	
Cylinder block flange width		8 {0.314}	—	—	
Cylinder block inner diameter	A	117 - 117.008 {4.6063 - 4.6066}	—	—	
	B	117.008 - 117.014 {4.6066 - 4.6068}	—	—	
	C	117.014 - 117.022 {4.6068 - 4.6072}	—	—	
Cylinder liner outer diameter	A	116.982 - 116.99 {4.6056 - 4.6059}	—	—	
	B	116.99 - 116.996 {4.6059 - 4.6061}	—	—	
	C	116.996 - 117.004 {4.6061 - 4.6064}	—	—	
Clearance between cylinder liner and cylinder block		0.01 - 0.026 {0.0003 - 0.0010}	—	—	
Cylinder liner inner diameter		112 {4.4094}	—	112.15 {4.4154}	Cylinder Replace liner
Piston outer diameter (Pin hole 23mm{0.9 in.} above the lower end of the skirt Square direction)		111.9±0.006 {4.4089±0.0002}	—	—	
Piston clearance		0.088 - 0.112 {0.0034 - 0.0044}	—	—	Cylinder Liner Replace piston

Inspection item			Standard value	Repair limit	Service limit	Action
Piston ring	Free joint clearance	Top	Approx. 11.5 {0.4527}	—	—	
		Second	Approx. 14 {0.5512}	—	—	
	Gap between ends of piston ring	Top	0.3 - 0.40 {0.0118 - 0.0157}	—	1.5 {0.0591}	Replace piston ring
		Second	0.75 - 0.9 {0.0295 - 0.0354}	—	1.2 {0.0472}	
		Oil	0.15 - 0.3 {0.0059 - 0.0118}	—	1.2 {0.0472}	
	Ring width B dimension	Top	2.5 {0.0984}	—	–0.1 {–0.0039}	Replace piston ring
		Second	2 {0.0787}	—	–0.1 {–0.0039}	
		Oil	4 {0.1574}	—	–0.1 {–0.0039}	
Piston	Piston ring groove	Top	2.5 {0.0984}	—	+0.2 {+0.0079}	Replace piston
		Second	2 {0.0787}	—	+0.2 {+0.0079}	
		Oil	4 {0.1574}	—	+0.1 {+0.0039}	
	Clearance between piston ring and piston ring groove	Top	0.09 - 0.13 {0.0035 - 0.0051}	—	—	Replace piston ring or piston.
		Second	0.04 - 0.08 {0.00016 - 0.0031}	—	—	
		Oil	0.02 - 0.06 {0.0008 - 0.0024}	—	—	
	Piston pin outer diameter		37 {1.4567}	—	–0.04 {–0.0015}	Replace piston pin
	Piston boss inner diameter		37 {1.4567}	—	+0.05 {+0.0020}	Replace piston
	Clearance between piston pin and piston boss		–0.002T - 0.025L {0.0000 - 0.0010} (T : Tightening allowance, L : Clearance)	—	0.05 {0.0020}	Replace piston pin or piston
Connecting rod bushing inner diameter			37 {1.4567}	—	+0.1 {0.0039}	Replace connecting rod bushing

Inspection item		Standard value	Repair limit	Service limit	Action
Connecting rod bushing oil clearance		0.015 - 0.036 {0.0006 - 0.0014}	—	0.08 {0.0031}	Replace piston pin or connecting rod bushing
Crank shaft	Crank pin outer diameter	65 {2.5590}	—	63.8 {2.5118}	Replace the crankshaft. (Note 1)
	Thickness of connecting rod bearing	2.0 {0.0787}	—	—	
	Connecting rod oil clearance	0.031 - 0.082 {0.0012 - 0.0032}	0.2 {0.0079}	—	Replace bearing for clearance of 0.3 or more (Note 2)
	Crank journal outer diameter	80{3.1496}	—	78.8 {3.1024}	Crank Replace shaft (Note 1)
	Thickness of main bearing	2.5 {0.2342}	—	—	
	Crankshaft oil clearance	0.051 - 0.102 {0.0020 - 0.0040}	0.2 {0.0079}	—	Replace bearing (Note 2)
	Center journal width	36 {1.4173}	—	+1.00 {+0.039}	Replace crankshaft.
	Thickness of thrust bearing	2.5 {0.2342}	—	—	
	Crankshaft end play	0.050 - 0.219 {0.0020 - 0.0086}	0.50 {0.0020}	1.219 {0.0480}	Replace thrust bearing or crankshaft
	Crankshaft runout	—	0.15 {0.0059}	—	Ground to under-size
	Crank pin width	34 {13.386}	—	+0.8 {+0.0315}	Replace crankshaft
Note 1 : Correction with re-grinding for eccentric wear of 0.10 or more. Re-grinding for wear of 0.20 or more. Replace crankshaft for wear of 1.20 or more. Note 2 : Under-size bearing values are 0.25, 0.50, 0.75 and 1.00.					
Connecting rod large end width		34 {1.3386}	—	–0.8 {–0.0315}	Replace connecting rod

Inspection item			Standard value	Repair limit	Service limit	Action
Connecting rod end play			0.20 - 0.52 {0.0079 - 0.0205}	—	1.0 {0.0394}	Replace connecting rod or crankshaft
Cam shaft	Camshaft journal outer diameter		40 {1.5748}	—	–0.15 {–0.0059}	Replace camshaft
	Camshaft bearing inner diameter		40 {1.5748}	—	+0.15 {+0.059}	Bearing Replacement
	Camshaft bearing oil Clearance		0.020 - 0.063 {0.0008 - 0.0025}	—	—	Replace camshaft or bearing
	Cam height	IN	50.067 {1.9711}	—	–0.08 {–0.0031}	Replace camshaft
		EX	52.104 {2.0513}	—		
	Cam lift	IN	8.067 {0.3175}	—	–0.08 {–0.0031}	Replace camshaft
		EX	10.104 {0.3978}	—		
	Camshaft journal width (Rear journal)		33 {1.2992}	—	—	
	Camshaft end play		0.100 - 0.178 {0.0039 - 0.0070}	—	—	Replace camshaft
	Camshaft runout		0.04 {0.0016}	—	0.1 {0.039}	Replace camshaft
Rocker shaft outer diameter			22 {0.8661}	—	–0.08 {–0.0031}	Replace rocker shaft
Rocker arm bushing inner diameter			22 {0.8661}	—	+0.08 {+0.0031}	Replace rocker arm bushing
Rocker arm oil clearance			0.030 - 0.101 {0.00012 - 0.0040}	—	0.15 {0.0059}	
Valve stem outer diameter		IN	7 {0.2756}	—	—	Replace valve
		EX	7 {0.2756}	—	—	
Valve guide inner diameter		IN	7 {0.2756}	—	—	Replace valve guide
		EX	7 {0.2756}	—	—	
Oil clearance between valve guide and valve stem		IN	0.023 - 0.058 {0.0009 - 0.0020}	—	—	Replace valve or valve guide
		EX	0.050 - 0.083 {0.0020 - 0.0033}	—	—	
Valve sink		IN	0.55 - 0.85 {0.0217 - 0.0335}	—	1.1 {0.0433}	Replace valve and valve seat
		EX	1.15 - 1.45 {0.0453 - 0.0571}	—	1.7 {0.0669}	

Inspection item				Standard value	Repair limit	Service limit	Action
Valve seat angle			IN	30°	Allowable angle 30° - 30°35'		Correction
			EX	45°	Allowable angle 45° - 30°30'		
Valve face angle			IN	30°	Allowable angle 29°30 - 45°		
			EX	45°	Allowable angle 44°30 - 45°		
Valve spring	Inner	Set length		44.8 {1.764}	—	—	
		Set load		129N {13.1kgf, 29lbf}	—	—	
		Free length		64.6 {2.5433}	—	–3.0 {–0.3543}	Replace spring
		Squareness		—	—	2.0 {0.0787}	Replace spring
	Outer	Set length		46.8 {1.8252}	—	—	
		Set load		314N {32.0kgf, 70lbf}	—	—	
		Free length		75.7 {2.9803}	—	–3.0 {–0.3543}	Replace spring
		Squareness		—	—	2.0 {0.0787}	Replace spring

Inspection item			Standard value	Repair limit	Service limit	Action
Timing gear	Backlash	Crank - Main idle	0.030 - 0.167 {0.0012 - 0.0066}	—	0.30 {0.0012}	Gear replacement
		Main idle - Pump drive idle	0.032 - 0.096 {0.0013 - 0.0038}	—	0.10 {0.00393}	
		Pump drive idle - Pump drive	0.020 - 0.083 {0.0008 - 0.0033}	—	0.10 {0.00393}	
		Main idle - Sub-idle	0.030 - 0.113 {0.0012 - 0.0044}	—	0.30 {0.0012}	
		Sub-idle - Oil pump	0.030 - 0.113 {0.0012 - 0.0044}	—	0.30 {0.0012}	
		Sub-idle - Cam idle	0.050 - 0.218 {0.0020 - 0.0086}	—	0.30 {0.0012}	
		Cam idle - Cam	0.030 - 0.253 {0.0012 - 0.0100}	—	0.30 {0.0012}	
	Main idle	Shaft outer diameter	57 {2.2441}	—	—	
		Bushing inner diameter	57 {2.2441}	—	—	
		Clearance between shaft and bushing	0.030 - 0.090 {0.0012 - 0.0084}	—	0.20 {0.0079}	Replace shaft or bushing
		Gear width	44 {1.7322}	—	—	
		Shaft length	44 {1.7322}	—	—	
		End play	0.114 - 0.160 {0.0045 - 0.0063}	—	0.30 {0.0012}	Replace shaft or gear
	Sub-idle	Shaft outer diameter	50 {1.9685}	—	—	
		Bushing inner diameter	50 {1.9685}	—	—	
		Clearance between shaft and bushing	0.025 - 0.075 {0.0010 - 0.0030}	—	0.20 {0.0079}	Replace shaft or bushing
		Gear width	22 {0.8661}	—	—	
		Shaft length	22 {0.8661}	—	—	
		End play	0.040 - 0.120 {0.0016 - 0.0047}	—	0.30 {0.0012}	Replace shaft or gear

Inspection item			Standard value	Repair limit	Service limit	Action
Timing gear	Cam idle	Shaft outer diameter	34 {1.3386}	—	—	
		Bushing inner diameter	34 {1.3386}	—	—	
		Clearance between shaft and bushing	0.025 - 0.075 {0.0002 - 0.0030}	—	0.20 {0.0079}	Replace shaft or bushing
		Gear width	22 {8.6614}	—	—	
		Shaft length	22 {8.6614}	—	—	
		End play	0.040 - 0.120 {0.0016 - 0.0047}	—	0.30 {0.0012}	Replace thrust plate or gear
	Pump drive idle	Shaft outer diameter	34 {1.3386}	—	—	
		Bushing inner diameter	34 {1.3386}	—	—	
		Clearance between shaft and bushing	0.025 - 0.075 {0.0002 - 0.0030}	—	0.10 {0.0039}	Replace shaft or bushing
		Gear width	28.5 {1.1220}	—	—	
		Shaft length	28.5 {1.1220}	—	—	
		End play	0.016 - 0.22 {0.0006 - 0.0087}	—	—	
Flatness under cylinder head Flatness above cylinder block			Longitudinal direction 0.06 {0.0024} Square direction 0.03 {0.0012}	—	0.20 {0.0079}	Grinding is inhibited because backlash between cam idle – sub-idle gears is changed.
Surface runout of flywheel			—	0.15 {0.0060}	—	
Camshaft gear mounting bolt			—	—	31 {1.2205}	Replacement
Bearing cap bolt (Crankshaft mounting)			—	—	108 {4.2520}	Replacement
Connecting rod bolt			—	—	68.0 {2.6772}	Replacement
Head bolt		long	—	—	187.5 {7.3819}	Replacement
		middle	—	—	156.5 {6.1614}	Replacement
		short	—	—	126.5 {4.9803}	Replacement

Valve timing

Exhaust valve open (before BDC)	**54°**
Exhaust valve close (after TDC)	**13°**
Intake valve open (before TDC)	**14°**
Intake valve close (after BDC)	**30°**

Tightening torque

JP31199020205007

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Crankshaft pulley mounting bolt	**118 {1,203, 87}**	
Head cover mounting bolt	**28.5 {290, 21}**	
Camshaft bearing cap mounting bolt	**28.5 {290, 21}**	
Union bolt of leakage pipe	**13.5 {135, 10}**	
Injector harness mounting nut	**28 {290, 21}**	
Camshaft gear mounting bolt	**59 {600, 44}+90°**	
Rocker arm and crosshead adjusting screw lock nut	**25 {250, 18}**	
Rocker arm support bolt	**59 {600, 44}**	
Head bolt	**59 {600, 44}+90°+90°**	
Cam idle gear shaft mounting bolt	**108 {1,100, 80}**	
Main bearing cap mounting bolt	**69 {700, 51}+90°+45°**	**Refer to the main text.**
Connecting rod cap mounting bolt	**69 {700, 51}+90°+45°**	
Oil check valve	**22 {220, 16}**	
Sub-idle gear shaft mounting bolt	**108 {1,100, 80}**	
Main idle gear shaft mounting bolt	**172 {1,750, 127}**	
Flywheel mounting bolt	**186 {1,900, 137}**	
Flywheel housing mounting bolt	**196 {2,000, 145}**	**M16**
	55 {560, 41}	**M10**
	36 {370, 27}	**M8**
Flywheel housing stay - Flywheel housing	**171.5 {1, 750}**	**M14**
Rear end plate torx bolt	**55 {560, 41}**	
Supply pump bearing case mounting bolt	**28.5 {290, 21}**	
Air compressor idle gear shaft mounting bolt	**108 {1,100, 80}**	

Exhaust

Tightening torque

JP31199020205008

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Exhaust manifold mounting stud bolt	30 {300, 22}	
Exhaust manifold mounting nut	53 {540, 40}	

Cooling

Standard value

JP31199020205009

Inspection item	Standard value	Repair limit	Service limit	Action
Thermostat valve open temperature	74.5 - 78.5°C {166.1 - 173.3°F}	—	—	Replacement
Thermostat valve lift (Set temperature 95 °C)	10mm {0.3937 in.} or more	—	—	Replacement

Lubrication

Standard value

JP31199020205010

Unit : mm {in.}

Inspection item	Standard value	Repair limit	Service limit	Action
Hydraulic alarm switch operation pressure	39kPa {0.4kgf/cm^2, 5.66lbf/in.^{2}}	—	—	

Inspection item		Standard value	Repair limit	Service limit	Action
Oil pump	Outer diameter of drive gear	54 {2.1260}	—	—	
	Cylinder block side Oil pump chamber inner diameter	54 {2.1260}	—	—	
	Clearance between drive gear and cylinder block	0.100 - 0.202 {0.0039 - 0.0080}	—	0.30 {0.0118}	Replace drive gear or oil pump
	Drive gear width	28.5 {1.1220}	—	—	
	Cylinder block side Depth of oil pump chamber	28.5 {1.1220}	—	—	
	Drive gear end play	0.049 - 0.113 {0.00193 - 0.0044}	—	0.15 {0.059}	Replace drive gear or oil pump
	Outer diameter of driven gear shaft	18 {0.7087}	—	—	
	Cylinder block hole diameter	18 {0.7087}	—	—	
	Clearance between drive gear shaft outer diameter and bushing inner diameter at cylinder block side	0.040 - 0.099 {0.0016 - 0.0039}	—	—	Replace drive gear or bushing
	Outer diameter of driven gear shaft	18 {0.7087}	—	—	
	Cylinder block hole diameter	18 {0.7087}	—	—	
	Clearance between driven gear shaft outer diameter and cylinder block hole diameter	0.030 - 0.075 {0.0012 - 0.0030}	—	—	Replace oil pump
	Outer diameter of driven gear shaft	18 {0.7087}	—	—	
	Inner diameter of driven gear bushing	18 {0.7087}	—	—	
	Clearance between driven gear shaft outer diameter and gear bushing inner diameter	0.040 - 0.083 {0.016 - 0.0033}	—	0.15 {0.059}	Replace oil pump or bushing
	Backlash between drive gear and driven gear	0.072 - 0.277 {0.0028 - 0.0109}	—	0.30 {0.0118}	Replace oil pump

Tightening torque

JP31199020205011

Unit : N·m{kgf·cm, lbf·ft}

Tightening area			Tightening torque	Remark
Oil pan mounting bolt			30 {300, 22}	
Oil strainer			31 {320, 23}	
Oil pan drain cock			41 {420, 30}	
Oil pump mounting bolt			28.5 {290, 21}	
Oil cooler	Oil circuit spring plug	M14	24.5±4.9 {250±50, 18±4}	
		M20	24.5±4.9 {250±50, 18±4}	
		M22	29.4±4.9 {300±50, 22±4}	
		M24	34.3±4.9 {350±50, 25±4}	
	Coolant drain plug		44.1±4.9 {450±50, 33±4}	
Oil cooler case assembly mounting bolt			24.5±4.9 {250±50, 18±4}	

Starting and Charging

Standard value (Alternator 50A)

JP31199020205012

Inspection item		Standard value	Repair limit	Service limit	Action
Resistance between stator coil terminals (for 2 phases)		0.22 - 0.26Ω	—	—	Replacement
Resistance between stator coil core and coil		1MΩor more	—	—	Replacement
Resistance of feed coil		5.6 - 6.8Ω	—	—	Replacement
Resistance between feed coil core and coil		1MΩor more	—	—	Replacement
Shaft outer diameter of rotor assembly	Front	25mm {0.9843 in.}	—	24.98mm {0.9835 in.}	Replacement
	Rear	17mm {0.6693 in.}	—	16.98mm {0.6685 in.}	
Resistance between diode and rectifier holder	Forward resistance value	Approx. 10Ω	—	—	Replacement
	Reverse resistance value	Infinite	—	—	
Resistance between regulator terminals F — E	Forward resistance value	Approx. 10Ω	—	—	Replacement
	Reverse resistance value	Infinite	—	—	

Tightening torque (Alternator 50A)

JP31199020205013

Unit : N·m{kgf·cm, lbf·ft}

Tightening area	Tightening torque	Remark
Bearing cover mounting bolt	1.9 - 2.5 {20 - 25, 1 - 2}	
Pulley mounting nut	127 - 157 {1, 300 - 1, 600, 94 - 116}	
Feed coil - Rear bracket	2.9 - 3.9 {30 - 39, 2 - 3}	
Heat sink mounting bolt	1.9 - 2.5 {20 - 25, 1 - 2}	Screw lock is used
Regulator mounting bolt	1.9 - 2.5 {20 - 25, 1 - 2}	
Inside B terminal mounting nut	4.9 - 5.9 {50 - 60, 4 - 4}	
Front side - Rear side mounting bolt	7.8 - 9.8 {80 - 99, 6 - 7}	
Coupler holder mounting bolt	1.9 - 2.5 {20 - 25, 1 - 2}	
Cover mounting bolt	3.3 - 4.4 {34 - 44, 2 - 3}	

Standard value (starter)

JP31199020205014

Unit : mm {in.}

Inspection item		Standard value	Service limit	Action
Yoke assembly	Resistance between coil lead wire and yoke	—	1kΩor less	Replace yoke assembly
	Brush length	18 {0.7087}	13 {0.5118} or less	Replace brush
Armature assembly	Resistance between commutator and core	1MΩor more	1kΩor less	Replace armature assembly
	Commutator outer diameter	36{1.4173}	34 {1.1458} or less	
	Shaft outer diameter A	12 {0.4724}	11.98 {0.4717} or less	
	Shaft outer diameter B	9 {0.3643}	8.98 {0.3535} or less	
	Undercut depth	0.5 - 0.8 {0.0197}	0.2{0.0079} or less	Correction
Holder assembly	Resistance between holder and plate	—	1kΩor less	Replace holder assembly
	Brush length	18 {0.7087}	13 {0.5118} or less	Replace brush
Shaft assembly outer diameter	A	26 {1.0236}	25.90 {1.0197} or less	Replace shaft assembly
	B	12.1 {0.4764}	12.04 {4.7401} or less	
Clutch assembly inner sleeve outer diameter		25 {0.9843}	24.90 {0.9803} or more	Replacement
Metal bushing inner diameter of pinion case		25 {0.9843}	25.2 {0.9921} or more	Replace brush
Metal bushing inner diameter of center bracket		26 {1.02362}	26.2 {1.0315}	Replace center bracket

Inspection item		Standard value	Service limit	Action
Metal bushing inner diameter of shaft assembly		9 {0.3543}	9.2 {0.3622}	Replace shaft assembly
Bearing housing inner diameter of rear bracket		28 {1.1024}	28.1 {1.1063} or more	Replace commutator end frame
Start magnet switch assembly	Between C terminal and M terminal (P coil)	0.12 - 0.15Ω	—	Replace start magnet switch assembly
	Between C terminal and body (H coil)	1.13 - 1.25Ω	—	

Tightening torque (starter)

JP31199020205015

Unit : N·m{kgf·cm, lbf·tt}

Tightening area	Tightening torque	Remark
C lead wire mounting bolt	2 - 3 {19 - 25, 1 - 2}	
M lead wire mounting nut	12.3 - 15.2 {126 - 154, 9 - 11}	
Commutator end frame mounting through bolt	15.7 - 17.6 {160 - 179, 12 - 13}	
Brush holder set bolts of commutator end frame	3.6 - 4.9 {37 - 49, 3 - 4}	
Start magnet switch assembly mounting bolt at pinion case	3.6 - 4.9 {37 - 49, 3 - 4}	
Pinion case switch set bolts	14 - 16 {140 - 160, 10 - 12}	

Turbocharger

Standard value

JP31199020205016

Unit : mm {in.}

Inspection item		Standard value	Repair limit	Service limit	Action
Turbine shaft play	Axial direction	0.1 {0.0039}	—	—	
	Diameter direction	1.0 {0.0397}	—	—	

Tightening torque

JP31199020205017

Unit : N·m{kgf·cm, lbf·tt}

Tightening area	Tightening torque	Remark
Turbocharger mounting nut	56 {570, 41}	

3 PARTS TO BE PREPARED

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Special tool 3-2
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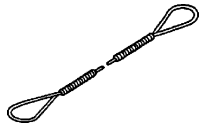
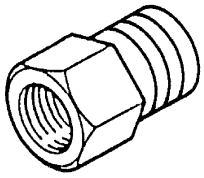
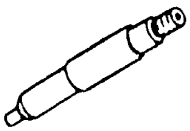
Engine Body

Special tool

JP31199030901001

Shape	Part No.	Description	Remark
	09491–1010	Wire rope	For engine lifting
	09552–1030	Compression gauge adapter	
	09552–1060	Compression gauge adapter	
	09552–1110	Compression gauge adapter	

Fuel System

Lubricant, etc.

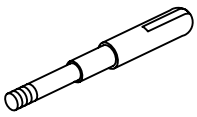
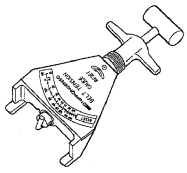
JP31199030901002

Name	Remark
Guide pin (SZ105-08067)	For supply pump positioning

Electrical

Special tool

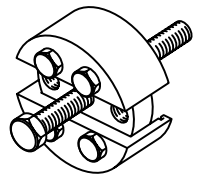
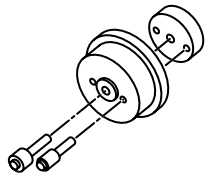
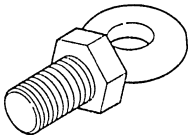
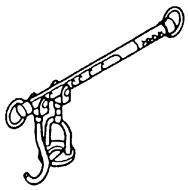
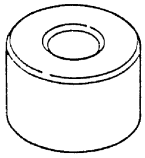
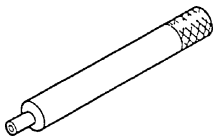
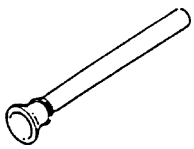
JP31199030901003

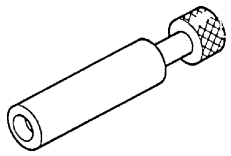
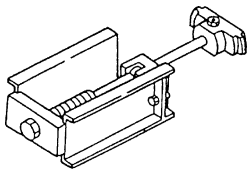
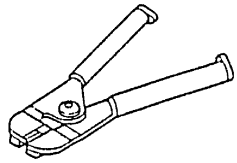
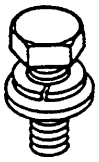
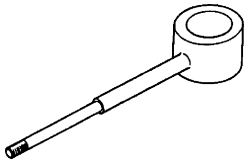
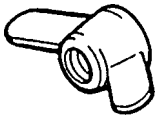
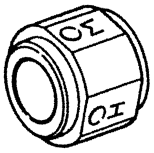
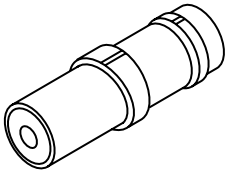
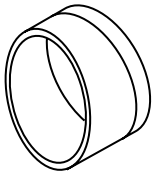
Shape	Part No.	Name	Remark
	09444–1210	Compression gauge	For V–belt tension adjustment
	95506–00090 (Denso part No.)	Belt tension gauge	For V–belt tension adjustment

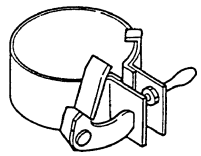
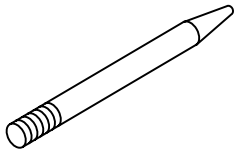
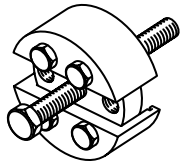
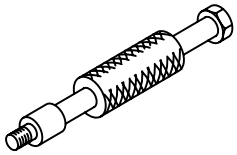
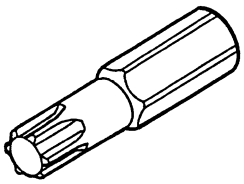
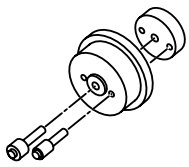
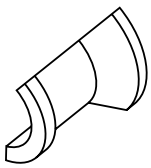
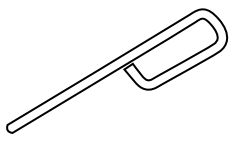
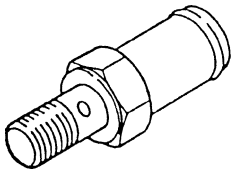
Engine Mechanical

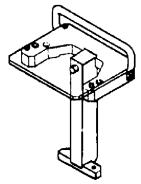
Special tool

JP31199030901004

Shape	Part No.	Name	Remark
	09420–1731	Oil seal puller	For crankshaft front oil seal removal
	09407–1030	Oil seal press	For crankshaft front oil seal press-fit
	09433–1070	Eye bolt	For assembly/disassembly of cylinder head
	09470–1170	Valve spring press	For assembly/disassembly of valve spring retainer
	09471–1520	Guide	For valve guide press-fit
	09472–1210	Bar	For nozzle seat clamping
	9800–06100	Steel ball	For nozzle seat clamping (together with 09472–1210)
	09431–1020	Valve lapping tool	For valve adjustment

Shape	Part No.	Name	Remark
	09472–2100	Bar	For valve stem seal mounting
	09420–2100	Cylinder liner puller	For removal and inspection of cylinder liner
	09442–1011	Piston ring expander	For assembly/disassembly of piston ring
	9191–08252	Bolt	For mounting of connecting rod small end bushing (together with 09402–1480 or 09402–1540)
	09402–1530	Press sub-assembly	For assembly/disassembly of connecting rod small end bushing
	9233–10360	Wing nut	For assembly/disassembly of connecting rod small end bushing (together with 09402–1530)
	09481–1130	Guide	For assembly/disassembly of connecting rod small end bushing (together with 09402–1530)
	09402–1540	Spindle	For assembly/disassembly of connecting rod small end bushing
	09481–1540	Guide	For mounting of connecting rod small end bushing (together with 09402–1540)

Shape	Part No.	Name	Remark
	09441–1370	Piston ring holder	For piston mounting
	09481–1340	Guide	For assembly/disassembly of flywheel
	09420–1742	Oil seal puller	For crankshaft rear oil seal removal
	09420–1100 09420–1442	Sliding hammer	For main/sub idle gear assembly and cam idle gear shaft removal
	09411–1300	Socket wrench	For assembly/disassembly of Torx bolt
	09407–1040	Oil seal press	For crankshaft rear oil seal press-fit
	09471–1490	Guide	For insertion of cylinder liner
	09472–1620	Tool	For cooling jet repair
	9001–24262	Check bolt	For cooling jet inspection and adjustment

Shape	Part No.	Name	Remark
	09470–1280	Tool assembly	For cooling jet inspection and adjustment

Instruments

JP31199030901005

Name	Remark
Micrometer	For measurement of part outer diameter
Cylinder gauge	For measurement of part inner diameter
Thickness gauge	For measurement of each clearance
Dial gauge	For measurement of parts

Lubricant, etc.

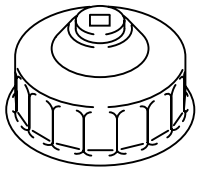
JP31199030901006

Name	Remark
Liquid gasket (Threebond TB1207B or equivalent : Black)	For sealing of parts
Liquid gasket (Threebond TB1207D or equivalent : Silver)	For sealing of parts
Liquid gasket (Threebond TB1211 or equivalent : White)	For sealing of parts
Red lead	Valve adjustment
Dye penetrant	For inspection of crack

Lubrication

Special tool

JP31199030901007

Shape	Part No.	Name	Remark
	09503–1110	Oil filter wrench	

Lubricant, etc.

JP31199030901008

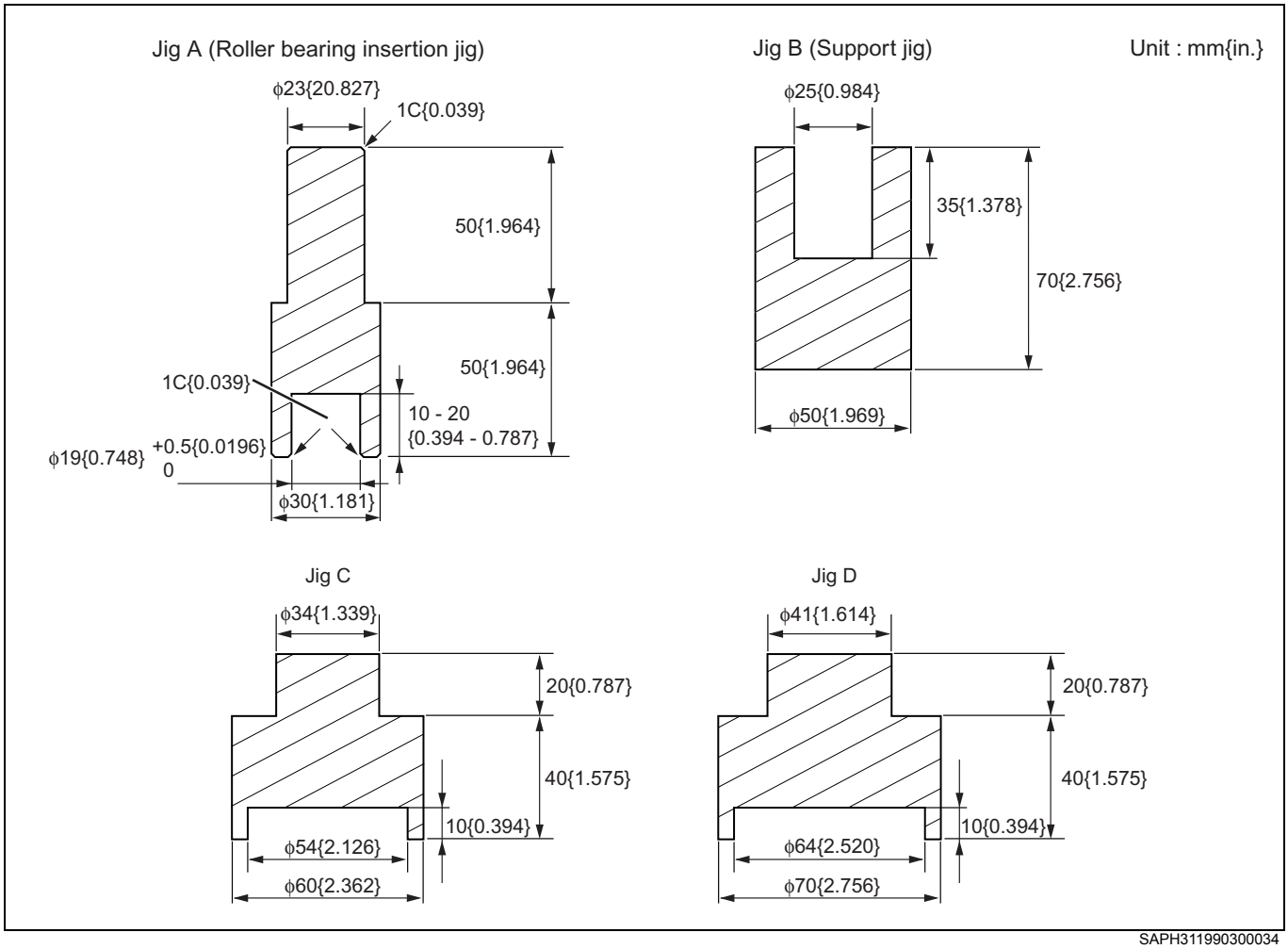
Name	Remark
Liquid gasket (Threebond TB1207D or equivalent : Silver)	For sealing of parts
Liquid gasket (Threebond TB1211 or equivalent : White)	For sealing of parts

Starting and Charging

Jig (reference dimensional drawing for manufacture)

JP31199030901009

This is used for assembly of bearing. Reference dimensions are shown in the figures below:



SAPH311990300034

Instruments

JP31199030901010

Alternator

Name	Remark
Circuit tester	For measurement of parts
Micrometer	For measurement of parts
Regulator checker (G&M Machinery ICD-101D or equivalent)	For inspection of regulator

Starter

Name	Remark
Circuit tester	For measurement of parts
Micrometer	For measurement of part outer diameter
Growler tester	For inspection of armature
Cylinder gauge	For measurement of part inner diameter

Lubricant, etc.

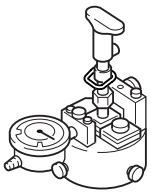
JP31199030901011

Name	Remark
Kyodo Yushi Multemp AC-N	For lubrication of parts
Nisseki Mitsubishi Pyroknock #2	For lubrication of parts

Turbocharger

Special tool

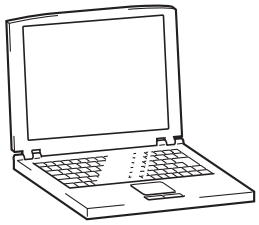
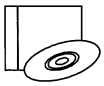
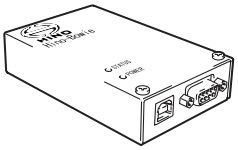
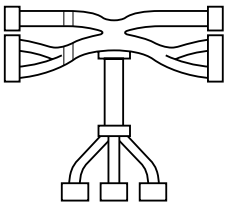
JP31199030901012

Shape	Part No.	Name	Remark
	09444-1800	Tool assembly	

Engine Failure Diagnosis

Special tool

JP311990309010 16

Shape	Part No.	Name	Remark
	–	Personal computer (DOS-V)	• Operating system(OS):Windows95, Windows98(IE5.0 or later), Windows2000(SP3, IE5.0 or later), WindowsXP(SP1a, IE6.0 or later) • CPU and memory: Conditions that assure operation of the above operating system • Display: 800 x 600, 256 colors or more
		HinoDX	Failure diagnosis software (CD-ROM)
	09121–1040	Hino-Bowie (Interface box)	Used together with the cable between the vehicle and Hino-Bowie (09042-1220)
	09049–1080	Signal check harness	This is installed as interruption between vehicle harness and the ECU. Tester inspection is allowed in energized status.

4 ENGINE ASSEMBLY/DISASSEMBLY

Inspection Before Service 4-2
Measurement of compression pressure 4-2
Engine Body..... 4-4
Removal..... 4-4
Installation..... 4-6
Work after installation 4-6

Inspection Before Service

Measurement of compression pressure

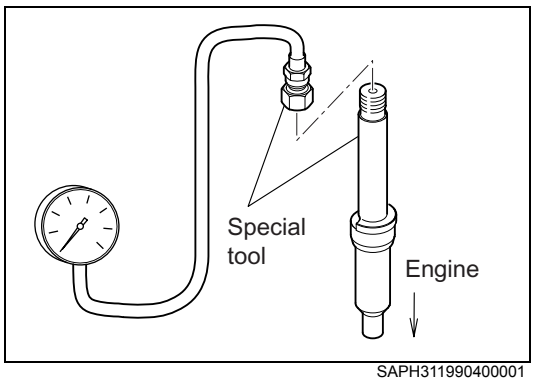
JP31199040702001

NOTICE

- **Measure the compression pressure before disassembly of the engine and record the result. Regular measurement of the compression pressure can tell the engine status.**

1. Preparation before measurement

(1) Charge the battery completely.
(2) Check the valve clearance and adjust it when exceeding the standard value.
(3) Warm the engine and set the water temperature to 80 °C{176°F}.
(4) Remove the air cleaner.
(5) Remove the head cover.
(6) Remove all injectors.
(7) To prevent spread of engine oil, attach a jig which cuts a head cover in half. (Cut it so that the camshaft may be covered.



SAPH311990400001

2. Measurement

(1) Attach a special tool to the nozzle sheet of the cylinder where the compression pressure is measured with nozzle clamp and clamp fixing bolts.

Special tool : Compression gauge adapter

Part No.	Parts tightened
09952-1110	**Insert in the injector mounting area**
09552-1030 (3/4-16 UNF)	**Adjusting to screw size of air gauge, the adapter which it selects**
09552-1060 (W16 ridges 18)	

(2) Turn the starter and measure the compression pressure.

⚠ CAUTION

- **Do not operate the starter for 15 seconds or more.**
- **Since the air cleaner is removed, prevent entry of dirt.**

(3) Measure the compression pressure of each cylinder continuously.

Engine revolution 150r/min {rpm}

	Compression pressure: Unit MPa {kgf/cm^2,lbf/in.^{2}}
Standard value	**3.4 - 3.7 {35 - 38 ,493 - 537}**
Service limit	**2.7 {28, 392}**
Difference between cylinders	**0.3{3, 44} or less**

(4) If the compression pressure is the service limit or less or if the difference between cylinders is over the standard value, overhaul the engine.

(5) After measurement, reassemble the removed parts.

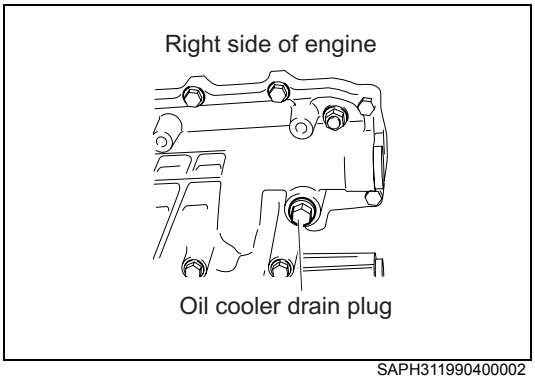
Engine Body

Removal

JP31199040702002

1. Preliminary work before removal of engine

(1) Place the vehicle on a level ground.
(2) Block tires with scotch.
(3) Remove the battery cable from the battery minus terminal.



SAPH311990400002

2. Drain of coolant and engine oil

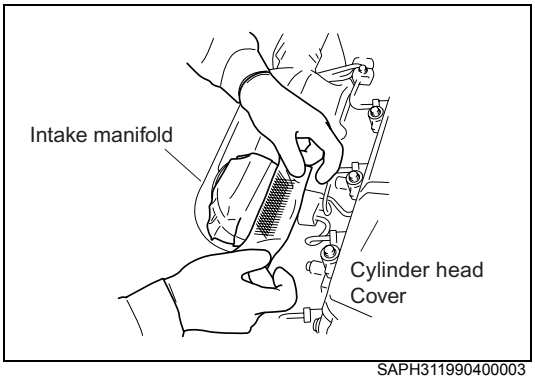
(1) Drain coolant from the radiator drain cock and the oil cooler drain plug.

NOTICE
- **Removal of the filler cap facilitates quick drain.**
- **Connection of an appropriate hose to the oil cooler drain pipe facilitates drain of coolant without spread.**

⚠ CAUTION
- **To prevent burn, drain coolant after the temperature is sufficiently low.**
- **To dispose coolant, observe the specified method (waste disposal) or the method with attention to environment.**

(2) Drain engine oil from the oil pan drain plug as required.

⚠ CAUTION
- **To prevent burn, drain coolant after the temperature is sufficiently low.**
- **Dispose coolant according to the specified method (waste treatment) or with a method considering the environment.**

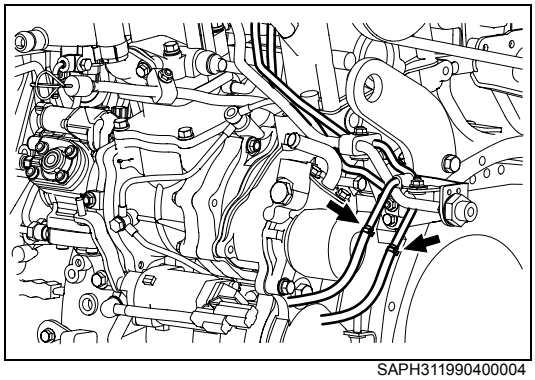


SAPH311990400003

3. Removal of intake hose, intercooler hose and exhaust pipe

(1) Loosen the clamp and remove the intake hose.
(2) Remove nuts and remove the exhaust pipe.

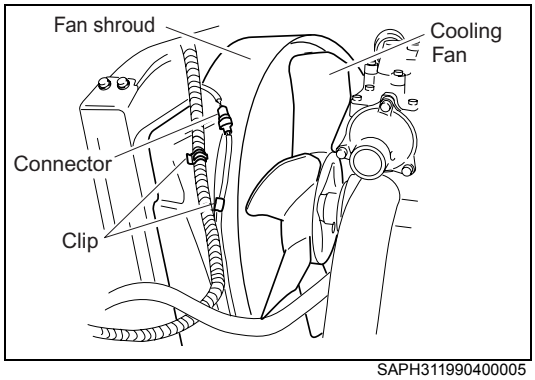
⚠ CAUTION
- **Close the opening of the intake manifold with a packing tape to prevent entry of dirt inside the engine.**


SAPH311990400004

4. Disconnection of fuel hose

(1) Remove the fuel hoses (feed side and return side). Wrap the removed hose with a plastic sheet with its end facing upward to prevent spill of fuel.

⚠ **CAUTION** • **Wipe spilled fuel with a rag.**

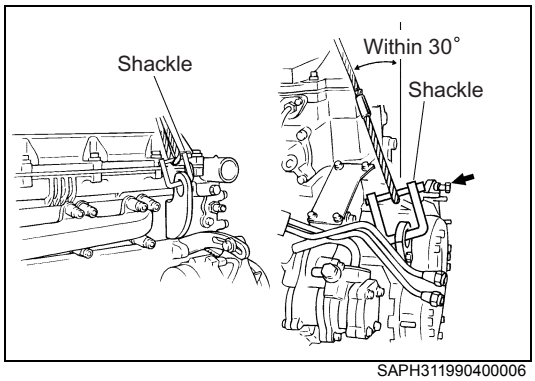


SAPH311990400005

5. Disconnection of water, engine oil pipes, etc.

(1) Disconnect the hose between the radiator and the engine.
(2) Disconnect the car heater pipe.
(3) Disconnect the oil filter hose.
(4) Disconnect the fuel filter hose.

⚠ **CAUTION** • **Wipe off spilled water and engine oil with waste.**



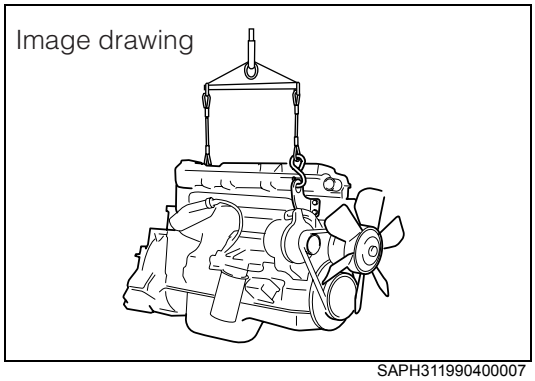
SAPH311990400006

6. Engine lifting (Lifting the engine single unit)

(1) Place a commercially available shackle and a special tool wire rope with the engine hanger.
Special tool : 09491–1010 Wire rope

(2) Keep a little slack of the wire rope.

⚠ **CAUTION** • **Keep the wire inclination 30° from the vertical line.**



SAPH311990400007

(3) When the wire is completely tense, make sure that the wire is firmly engaged with the engine hanger. Then, lift the engine slowly.

⚠ **CAUTION** • **Work carefully so that the engine may not come in contact with the frame and others.**

Installation

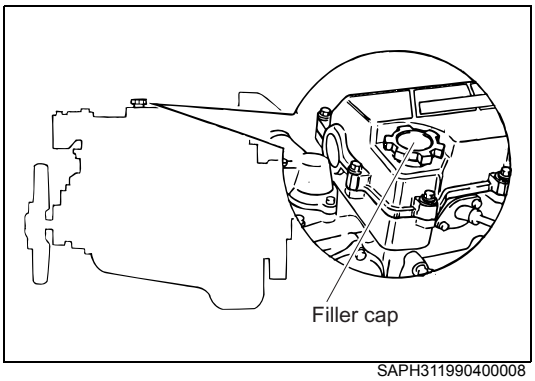
JP31199040702003

1. Connection of fuel hose

(1) Insert a fuel hose and fix it with a hose band.

Work after installation

JP31199040702004



SAPH311990400008

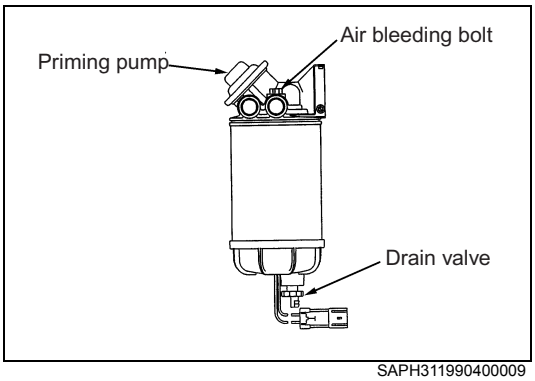
1. Inspection of engine oil

(1) Make sure that the drain cock is closed.
(2) Pour engine oil.
(3) Check the amount of oil with an oil level gauge.
Engine oil amount (L{us gal})

Oil pan	Oil filter and etc
Approx. 18{4.76}	Approx. 2.5{0.66}

⚠ CAUTION • **Please use Hino genuine engine oil**

Multi grade	**SAE #10W-30**
Single grade	**SAE #30**



SAPH311990400009

2. Air bleeding of fuel system

(1) Prepare a rag to receive fuel at the end of the drain valve.
(2) Loosen the air bleeding plug of the fuel filter.
(3) The priming pump is moved front and back.
(4) Move the pump until fuel without bubble comes out from the drain valve.
(5) Tighten the air bleeding bolt.
Tightening torque :
1.7 - 2.6 N·m {17.3 - 23 kgf·cm, 1.2 - 1.9 lbf·ft}
(6) Move the priming pump again until it becomes heavy.

⚠ CAUTION • **After work, wipe off spilled fuel. After start of the engine, make sure that there is no fuel leak.**

5 FUEL SYSTEM

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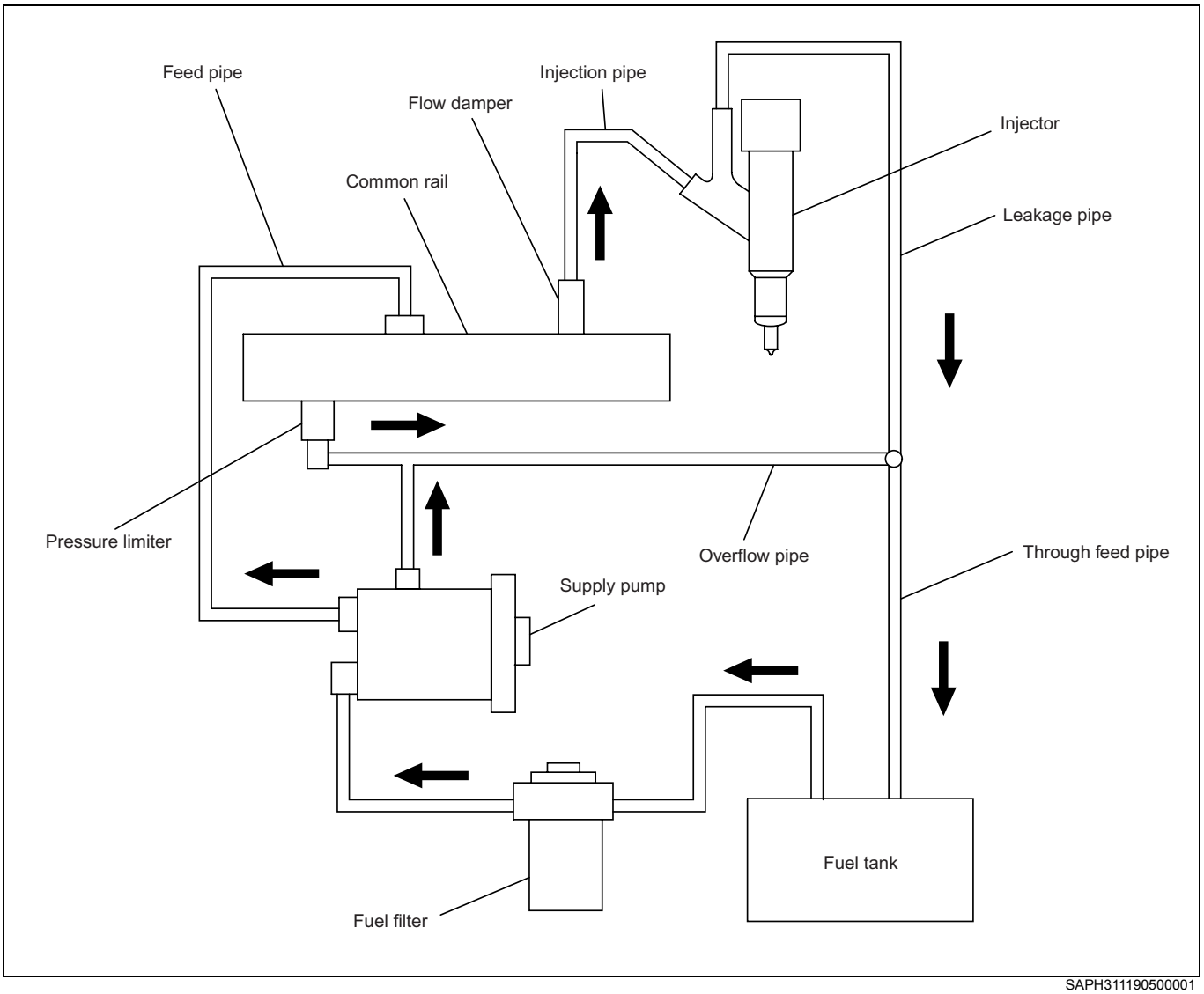
Fuel System

Fuel system diagram

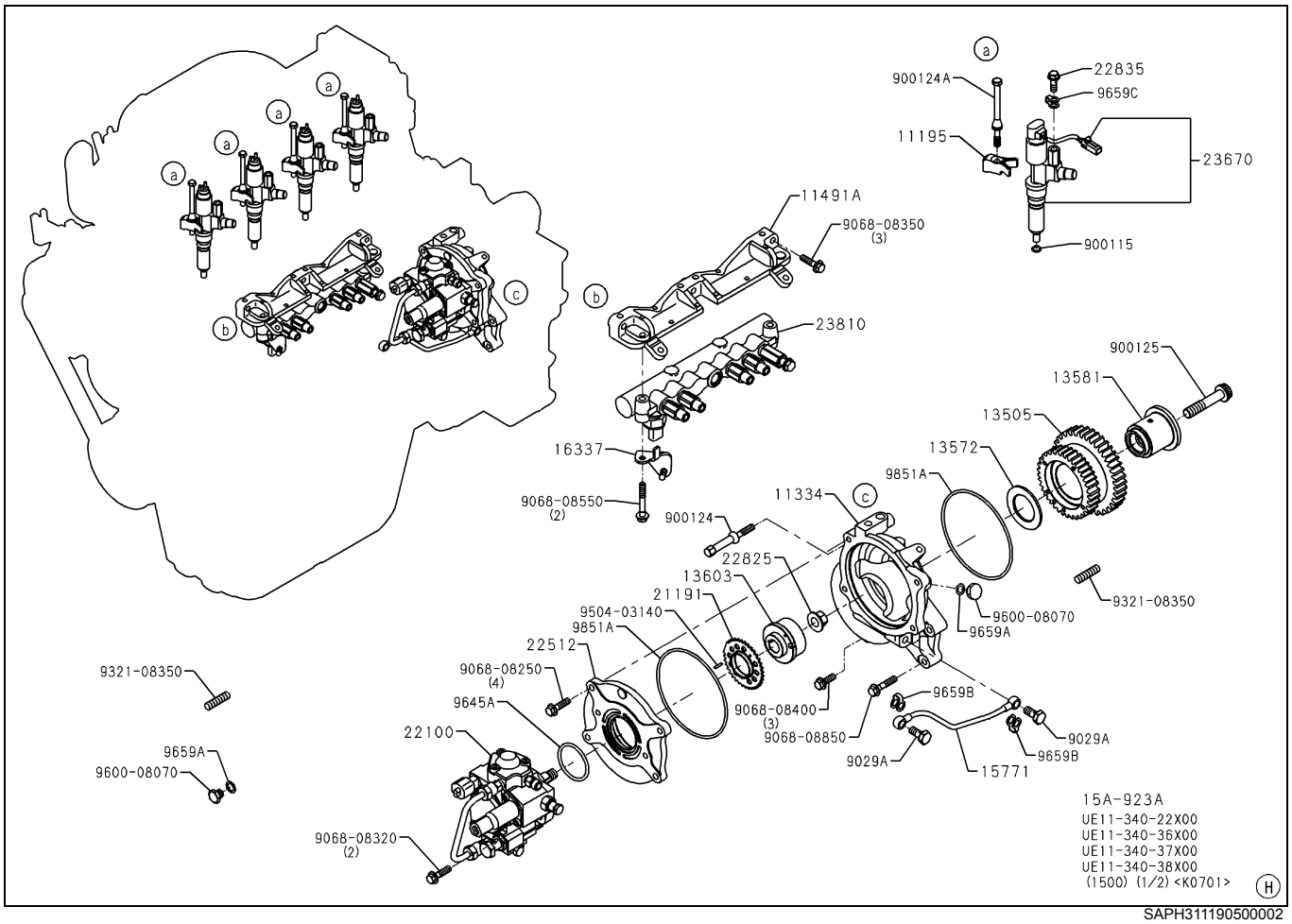
JP31199050402001



SAPH311190500001

Part layout

JP311990504020003



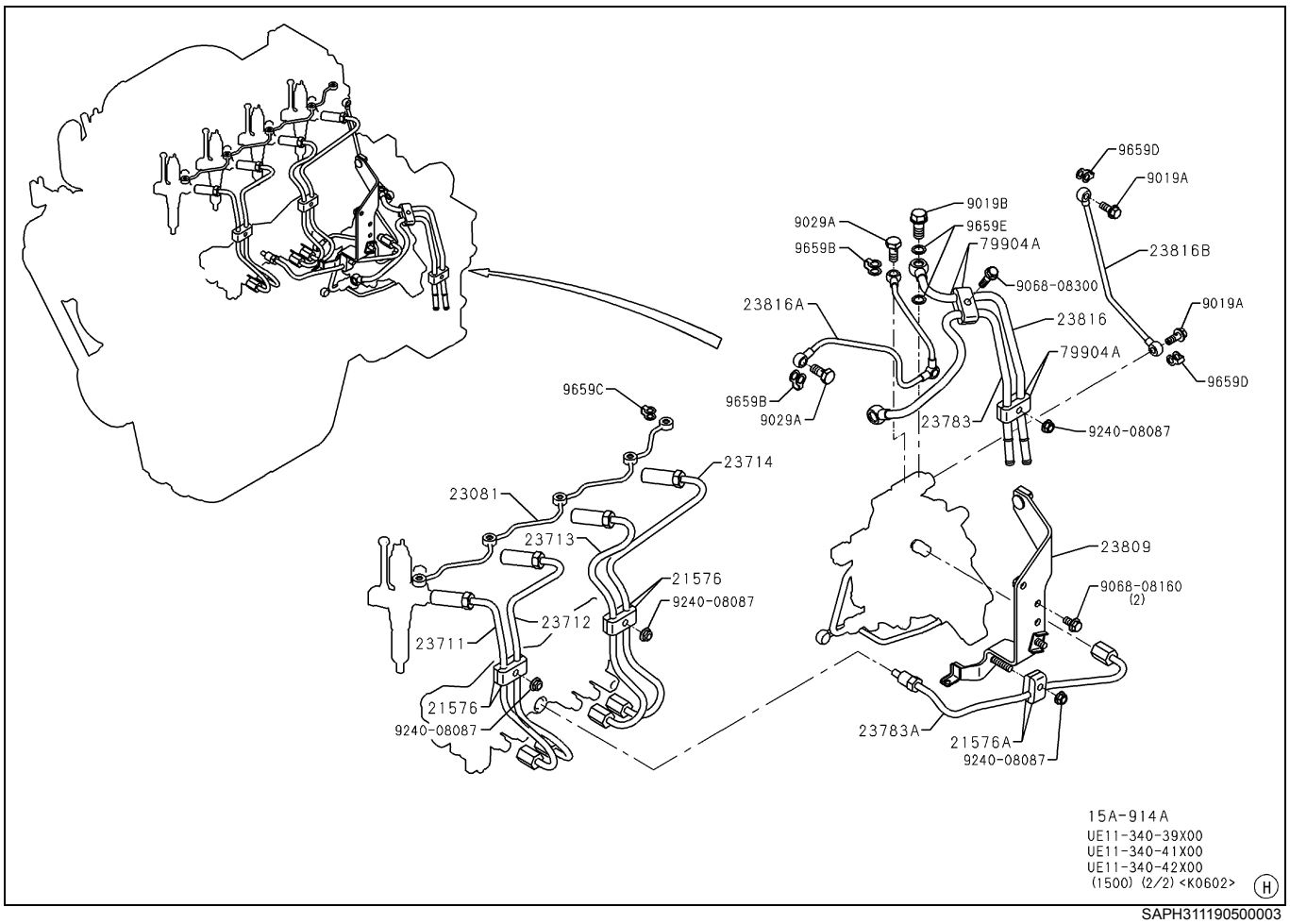
SAPH311190500002

11195	Nozzle clamp holder	23670	Injector
11334	Bearing holder case	23810	Common rail assembly
11491A	Common rail bracket	9645A	O–ring*
22100	Supply pump	9851A	O–ring*

*Parts not to be reused.

Tightening torque

22825	63.7N·m {650 kgf·cm, 47lbf·ft}	9068-08320	28.5N·m {290kgf·cm, 21lbf·ft}
900124	108N·m {1,100 kgf·cm, 80lbf·ft}	9068-08400	28.5N·m {290kgf·cm, 21lbf·ft}
900124A	25N·m {250 kgf·cm, 18lbf·ft}	9068-08850	28.5N·m {290kgf·cm, 21lbf·ft}
9068-08250	28.5N·m {290kgf·cm, 21lbf·ft}		



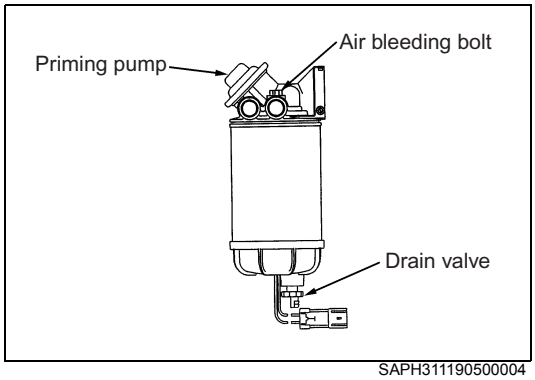
SAPH311190500003

23081	Leakage pipe	23816A	Through feed pipe
23711	Injection pipe	23816B	Through feed pipe
23712	Injection pipe	9659B	Gasket*
23713	Injection pipe	9659C	Gasket*
23714	Injection pipe	9659D	Gasket*
23783A	Fuel pipe	9659E	Gasket*
23816	Through feed pipe		

*Parts not to be reused.

Fuel filter drain (on machine main unit)

JP31199050704001



SAPH311190500004

1. **Prepare a water container under the drain pipe.**

2. **Loosen the fuel filter air bleeding bolt and the drain valve. Discharge water at the bottom of the fuel filter case.**

⚠ **CAUTION**
- **Since discharged water contains fuel, observe the local disposal procedure for disposal.**

3. **Close the drain valve.**

4. **Start the priming pump and bleed air from the system.**

⚠ **CAUTION**
- **Make sure that the fuel filter air bleeding bolt is loose.**

5. **Tighten the fuel filter air bleeding bolt.**
   Tightening torque :
   1.7 - 2.6 N·m {17.3 - 23 kgf·cm, 1.2 - 1.9 lbf·ft}

⚠ **CAUTION**
- **After work, wipe off spilled water or fuel. After start of the engine, make sure that there is no fuel leak.**

Replacement of fuel filter element (on machine main unit)

JP31002050704002

⚠ **CAUTION**
- **The frequency for water draining and replacement of the fuel filter element differs according to the fuel situation in the use region.**
  Replace the fuel filter element every 500 hours or when the engine output decreases, whichever occurs first.
- **Inspection of the fuel filter element and draining of water should be performed before each start of operation.**
- **Always use an original fuel filter element.**

1. Removal of water cup

(1) Refer to "Drain of the fuel filter" and discharge water from the fuel filter.

(2) Remove the water cup of the fuel filter.

⚠ **CAUTION**
- **Completely remove any dust around the water cup.**

2. Removal of fuel filter element

(1) Remove the fuel filter element.

⚠ **CAUTION**
- **Completely remove any dust around the fuel filter head and especially around the air vent bolt.**
- **Since the filter contains diesel oil, prepare a tray.**

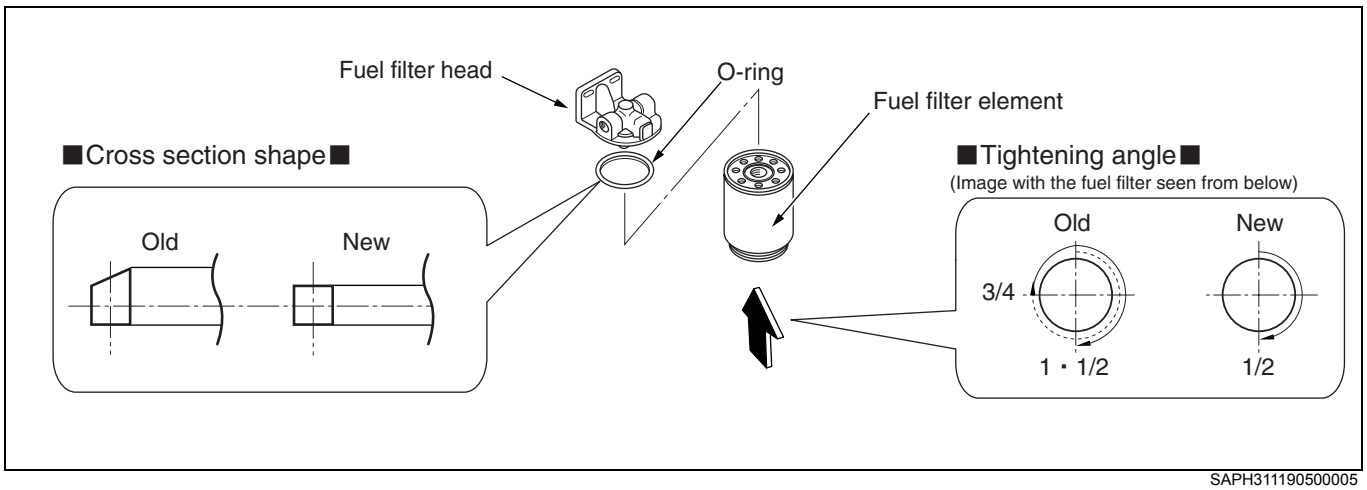
3. Installation of fuel filter element

⚠ **CAUTION** • **Fuel filter element is not reused.**

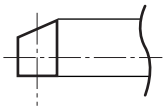
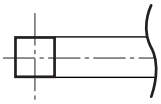
(1) The soiling and the foreign material of the clamp face are removed.
(2) Install the fuel filter element with according to tightening angle in the table below of a turn after the O-ring of the fuel filter element comes into contact with the fuel filter head.

NOTICE • **The cross-section shape of the O-ring on the side of the fuel filter element has been changed.**

⚠ **CAUTION** • **Tighten after confirming whether the O-ring is a new or an old one.**
• **As the O-ring is included in the element kit, do not use an O-ring again after it has been removed once.**
• **Install the O-ring after applying fuel to the surface of the O-ring.**
• **Do not use a tool, but tighten by hand.**

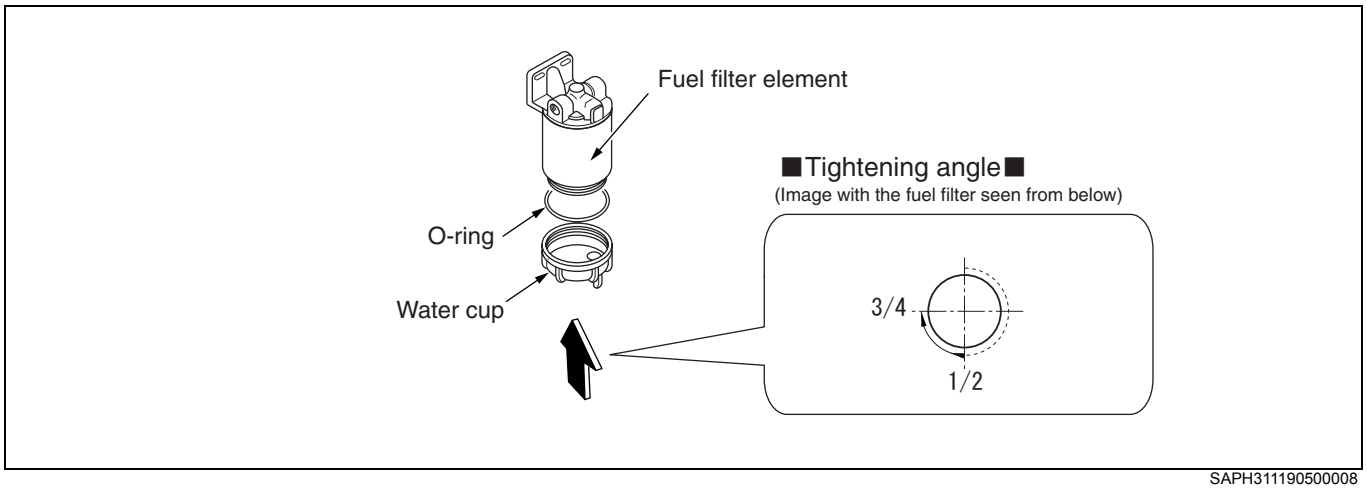


SAPH311190500005

New/Old	Cross section shape	Tightening angle
Old supply part		**3/4 to 1.5 turns**
New supply part		**1/2 turn**

4. Installation of water cup

⚠ **CAUTION**
- **Fuel filter element is not reused.**
- **Install the O-ring after applying fuel to the surface of the O-ring.**
- **Do not use a tool, but tighten by hand.**



SAPH311190500008

(1) Install the fuel filter element with 1/2 to 3/4 of a turn after the O-ring of the water cup comes into contact with the fuel filter element.
(2) Tighten the fuel filter drain valve.

5. Bleeding air from the fuel system

(1) Start the priming pump and bleed air from the system.

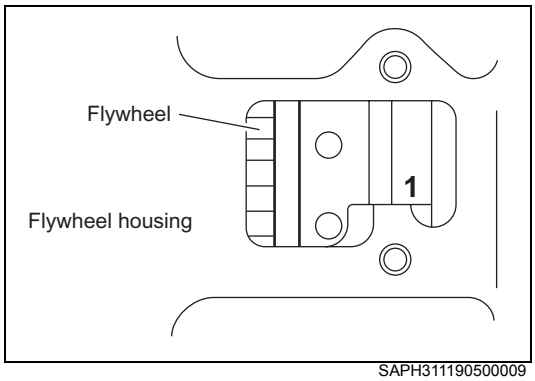
⚠ **CAUTION**
- **Make sure that the fuel filter air bleeding bolt is loose.**

(2) Tighten the fuel filter air bleeding bolt.
Tightening torque :
1.7 - 2.6 N·m {17.3 - 23 kgf·cm, 1.2 - 1.9 lbf·ft}

⚠ **CAUTION**
- **After work, wipe off spilled fuel. After start of the engine, make sure that there is no fuel leak.**

Replacement of supply pump

JP31199050704003



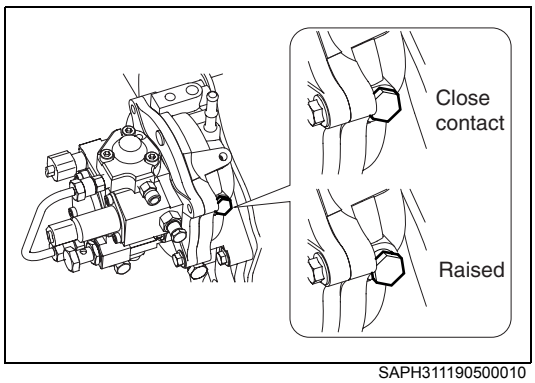
SAPH311190500009

1. Compression upper dead center setting of No.1 cylinder

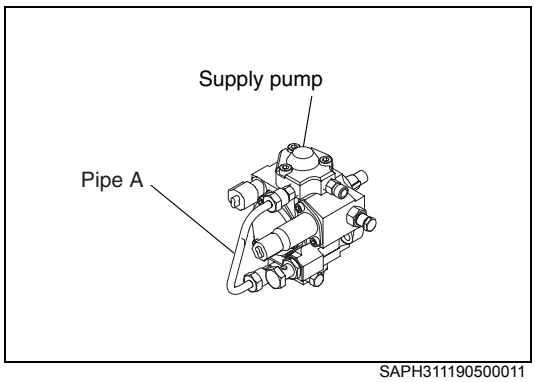
(1) Turn the crankshaft counterclockwise when viewed from the flywheel. Set the timing mark in the flywheel housing inspection window to "1".

(2) Remove the inspection window plug in the bearing holder case of the supply pump. Tighten the guide pin (SZ105-08067) very gently and make sure that the bolt seating comes in close contact with the bearing holder.

⚠ **CAUTION** • **If it is raised, there must be contact other than the stopper key for the coupling flange. Do not tighten hard.**



SAPH311190500010



SAPH311190500011

2. Removal of supply pump

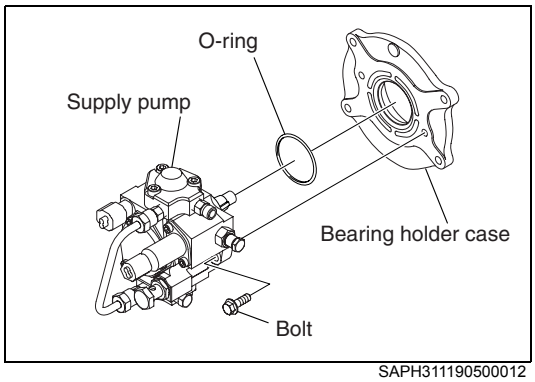
(1) Remove the fuel pipe connected to the supply pump.

⚠ **CAUTION** • **Do not remove pipes A.**

(2) Remove the supply pump at the bearing holder case.

(3) Remove the drive gear using the special tool designed for that purpose.

Special tool : 09650-1101 Bearing puller

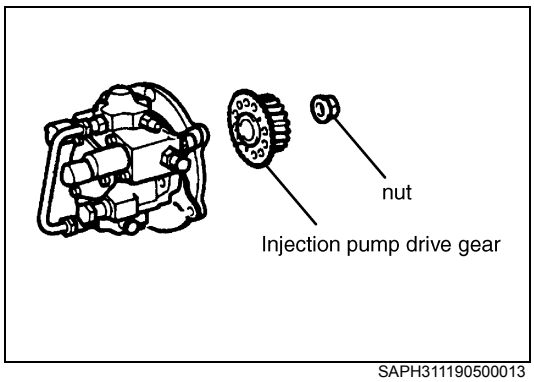


SAPH311190500012

3. Assembly of supply pump and bearing holder case

(1) Fit a new O-ring to the supply pump and install the bearing holder case.

Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

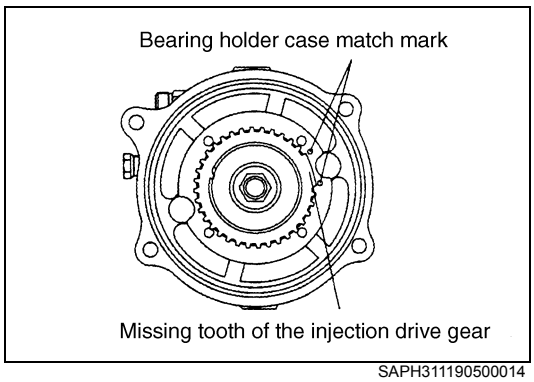


SAPH311190500013

(2) Secure the supply pump, install the injection pump drive gear on the shaft, and use a vice or similar to prevent turning while tightening the nut.

Tightening torque : 63.7 N·m {650 kgf·cm, 47 lbf·ft}

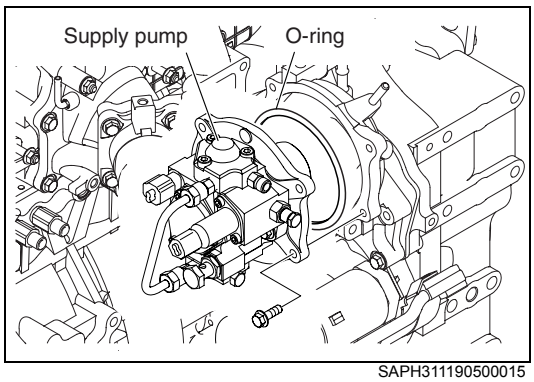
⚠ **CAUTION**
- **Do not use the guide bolt for stopper key of the shaft.**



SAPH311190500014

4. Installation of supply pump

(1) Match the match mark of the bearing holder case with the missing tooth of the injection pump drive gear.



SAPH311190500015

(2) Install a new O-ring and mount the air compressor and supply pump assembly on the flywheel housing.

Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

⚠ **CAUTION**
- **Adjust the gear so that the compression top dead center alignment of the No.1 cylinder may not be changed.**
- **Be sure to remove the guide bolt in cranking the engine.**
- **After assembly, be sure to remove the guide bolt and install the inspection window plug.**

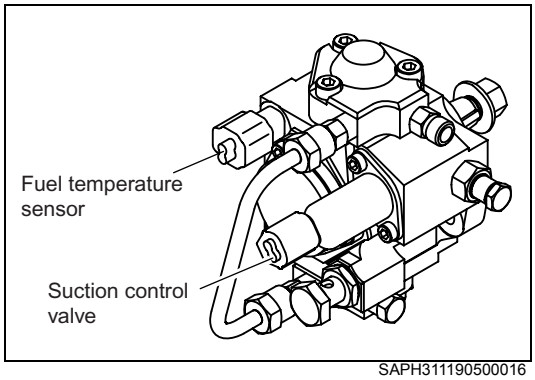
5. Update of supply pump learning value

(1) When the supply pump is replaced, update the learning value memorized in the engine ECU with the failure diagnosis tool (HinoDX) using PC. (Refer to "HinoDX operation manual".)

⚠ **CAUTION**
- **If learning value is not updated, correct common rail pressure is not controlled, resulting in engine stall or high common rail pressure. Therefore, when the supply pump is replaced, be sure to update the learning value.**

Inspection of supply pump

JP31199050704004



SAPH311190500016

1. Inspection of suction control valve and fuel temperature sensor

(1) Measure the resistance of the suction control valve terminals and the fuel temperature sensor terminals using a circuit tester. If it is beyond the standard, remove the supply pump assembly and request for replacement at the Denso service shop.

	Between suction control valve terminals
Standard value	**7.65 - 8.15Ω(at 20°C {68°F})**

	Terminals between fuel temperature sensors
Standard value	**13.5 - 16.5kΩ(at -20°C{68°F})**
	2.2 - 2.7kΩ(at 20°C{68°F})
	0.29 - 0.35kΩ(at 80°C{176°F})

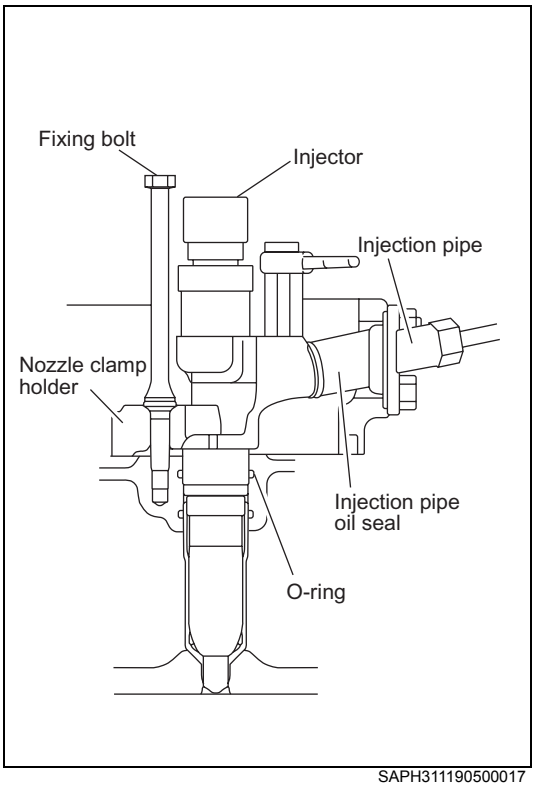
Replacement of injector

JP31199050704005

1. Removal of injector

(1) Remove the fixing bolt and remove the plate and the injection pipe oil seal.

(2) Remove the nozzle clamp holder and remove the injector.



SAPH311190500017

2. Installation of injector

(1) Attach a new O-ring to the groove of the cylinder head and insert the injector.

⚠ CAUTION
- **Apply engine oil to the O-ring and be careful to prevent pinching of the O-ring.**

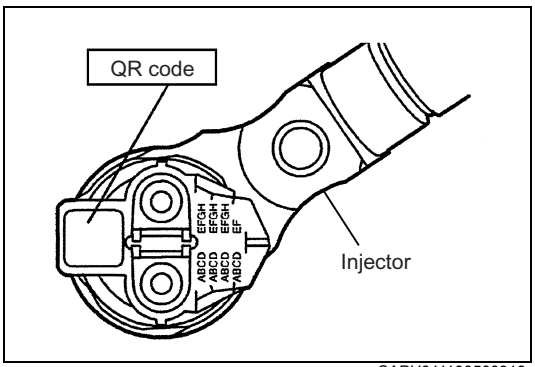
(2) Install the nozzle clamp holder and tack weld the injector temporarily.

⚠ CAUTION
- **Do not fix the nozzle holder until the injection pipe is tack welded.**

(3) Put a new injection pipe oil seal on the injector and install the plate.

⚠ CAUTION
- **Install the injection pipe oil seal to prevent undue force to the injection nozzle. (Offset position between the injection pipe oil seal and the injection nozzle may cause oil leak or poor assembly of the injection pipe.)**

(4) Assemble the injection pipe temporarily and tighten the fixing bolt of the nozzle clamp holder.
Tightening torque : 25 N·m {250 kgf·cm, 1.8 lbf·ft}



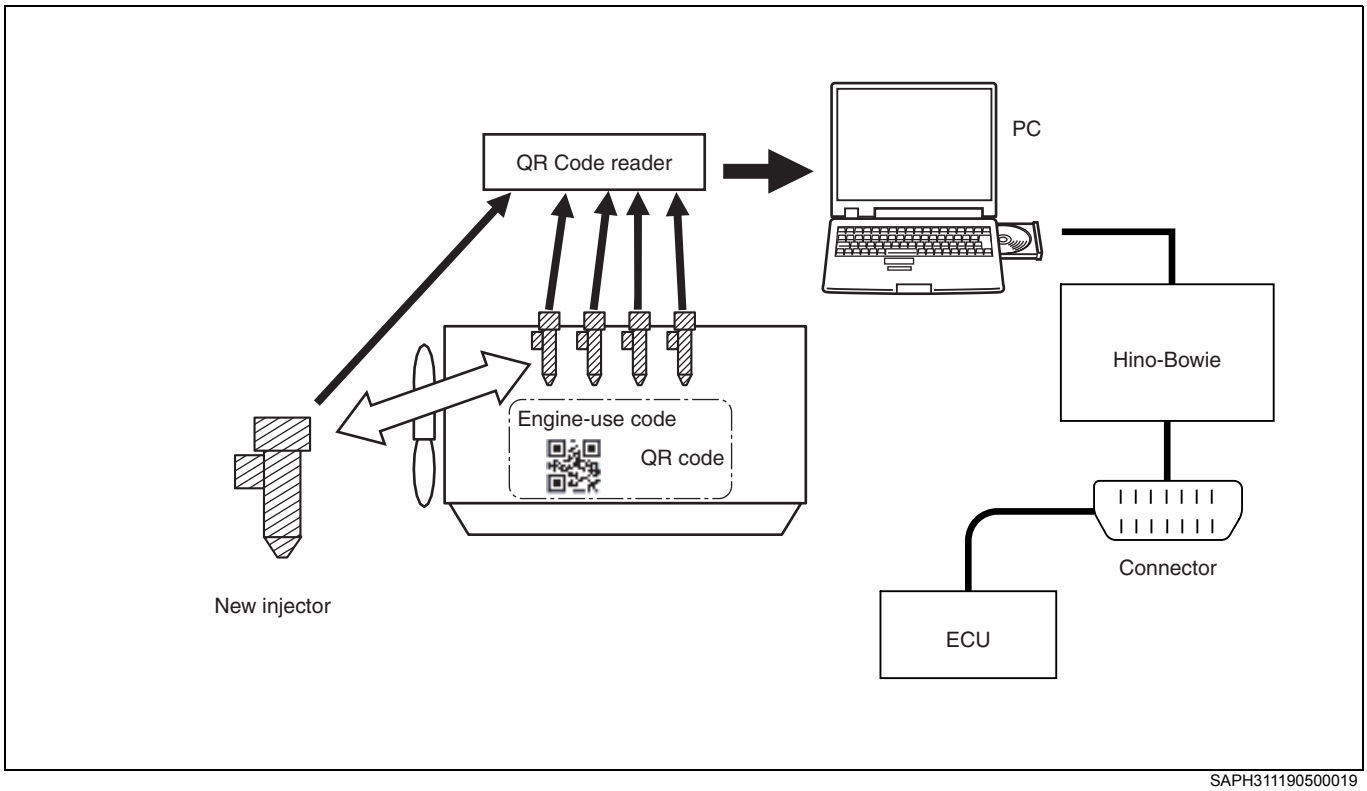
SAPH311190500018

3. Entry of injector correction value to the engine ECU (entry using HinoDX and QR code reader)

⚠ CAUTION
- **When the injector is replaced, it is necessary to enter the injector correction value (QR code) described on the new injector to the engine ECU. Incorrect entry of the correction value may result in faulty engine.**

NOTICE
- **Available entry methods of the injector correction value are the PC tool and the QR code reader.**
- **The flow of work is described in the following. If you want details regarding any procedure, however, refer to the PC Tools instruction manual.**

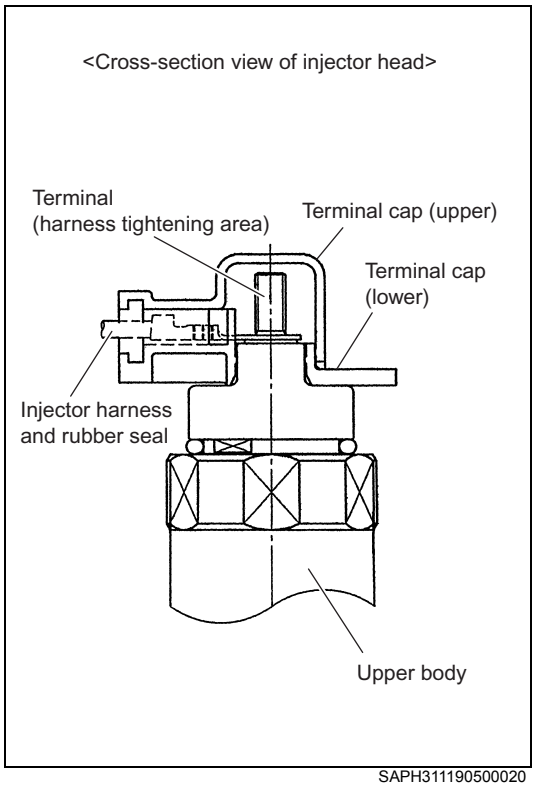
(1) Read the injector QR code with the scanner of the QR code reader and prepare the correction data file.
(2) Enter the injector correction value directly from the PC tools to the engine ECU.



SAPH311190500019

Inspection of injector

JP31199050704006



SAPH311190500020

1. Inspection of injector insulation

(1) Remove the injector plastic terminal cap (upper).
(2) Measure the insulation resistance between the injector upper body and one terminal (no polarity) of two terminals for the injector harness.

Standard value (normal temperature)	**1000MΩor more**

(3) Measure the resistance value between two terminals above.

Standard value (at 20°C)	**0.45Ω±0.1**

(4) If the resistance value in (2) and (3) exceeds the standard value, replace the injector assembly.

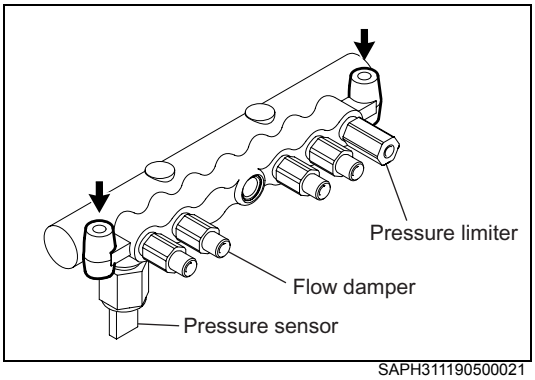
2. Cleaning of injector

(1) Remove sludge at or around the terminal, if any.

⚠ **CAUTION** • **In removing sludge, do not use a cleaning agent. Wipe it off with a rag. Use of a cleaning agent may result in electric failure due to penetration of the agent.**

Replacement of common rail

JP31199050704007

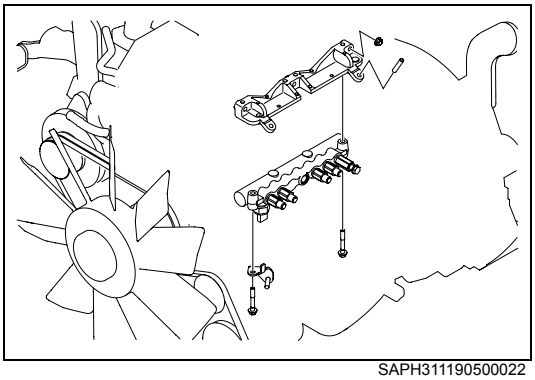


SAPH311190500021

1. Removal of common rail

(1) Remove the common rail together with the flow damper, pressure sensor and pressure limiter from the intake manifold.

⚠ **CAUTION**
- **Remove dirt around parts before removing the common rail**

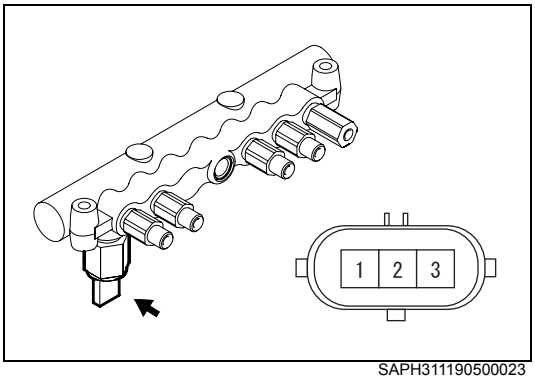

SAPH311190500022

2. Installation of common rail

(1) Install the common rail on the intake manifold.

Inspection of common rail

JP31199050704008



SAPH311190500023

1. Inspection of common rail pressure sensor

(1) Measure the resistance value between terminals using a circuit tester. If it exceeds the standard value, replace the common rail assembly

	Between 1 and 2	Between 2 and 3
Standard value (kΩ) At stop of engine	0.5 - 3.0	6.5 - 18.5

7 ELECTRICAL

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Inspection of components 7-8
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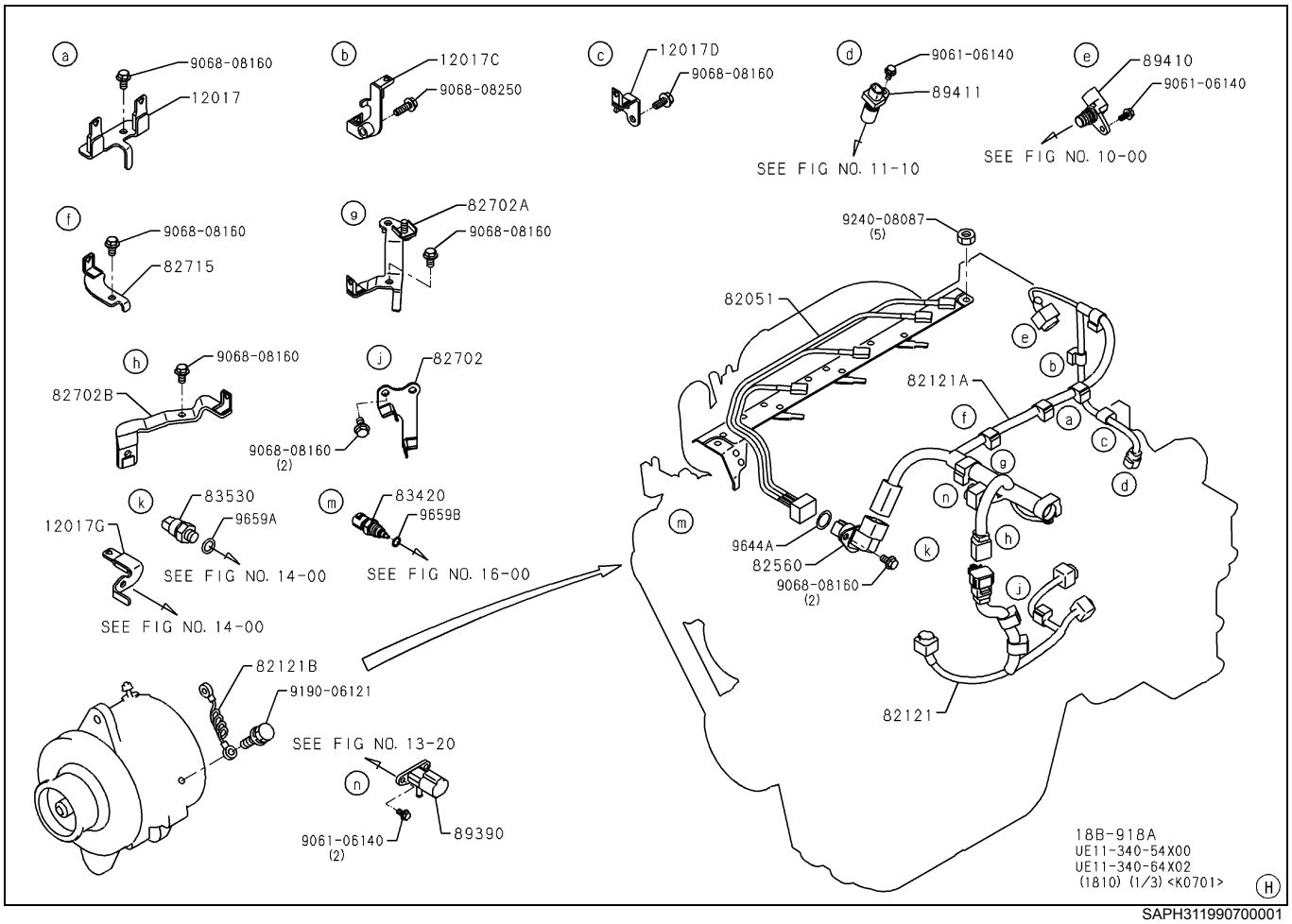
Installation of starter 7-10
Installation of alternator 7-11

Electrical System

Part layout

JP311990704020001

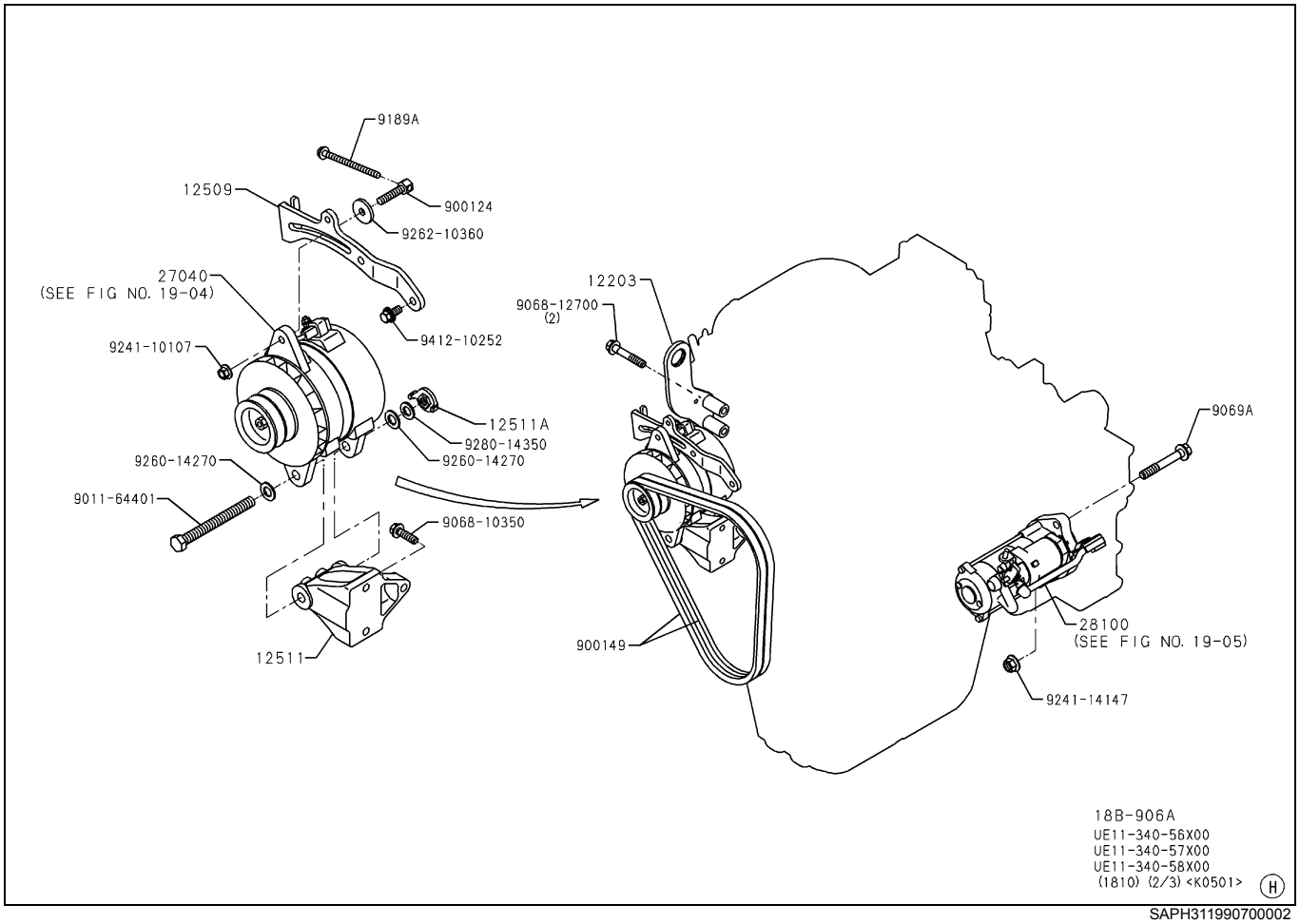


SAPH311990700001

82051	Injector harness	89390	Boost pressure sensor
83420	Water temperature sender gauge	89410	Engine sub revolution sensor
83530	Oil pressure warning switch	89411	Engine main revolution sensor

Tightening torque

9190-06121	4N·m{40kgf·cm, 3lbf·ft}	

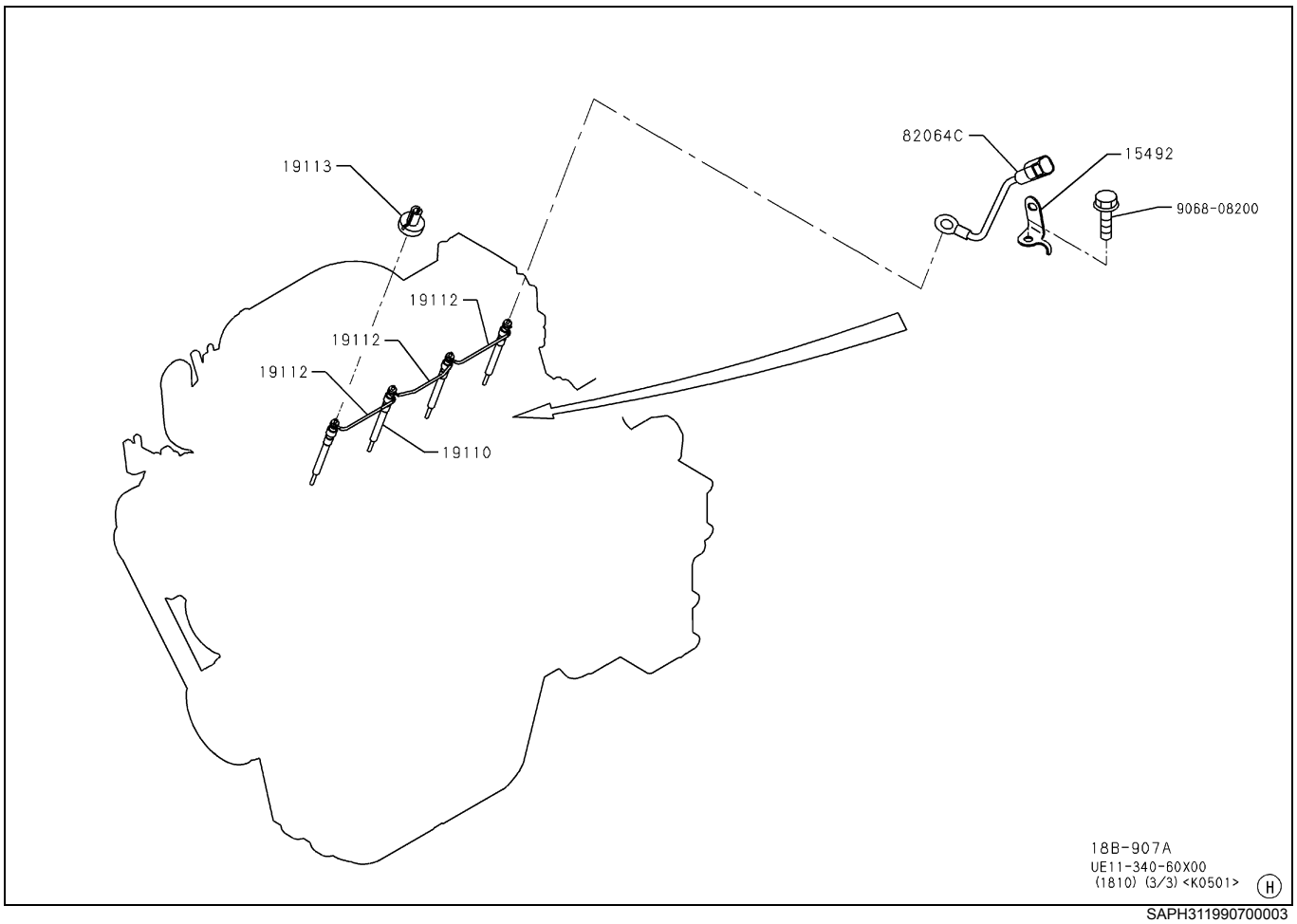


SAPH311990700002

12509	Alternator brace	9011-64410	Through bolt
12511	Alternator bracket	9241-10107	Fixing bolt at brace
27040	Alternator assembly	9189A	Adjusting bolt
28100	Starter assembly		

Tightening torque

9069A	154N·m{1,570kgf·cm, 114lbf·ft}	9241-10107	51N·m{520kgf·cm, 38lbf·ft}
9011-64401	83N·m{850kgf·cm, 61lbf·ft}	9241-14147	154N·m{1,570kgf·cm, 114lbf·ft}
9189A	5.9N·m{60kgf·cm, 4lbf·ft}		

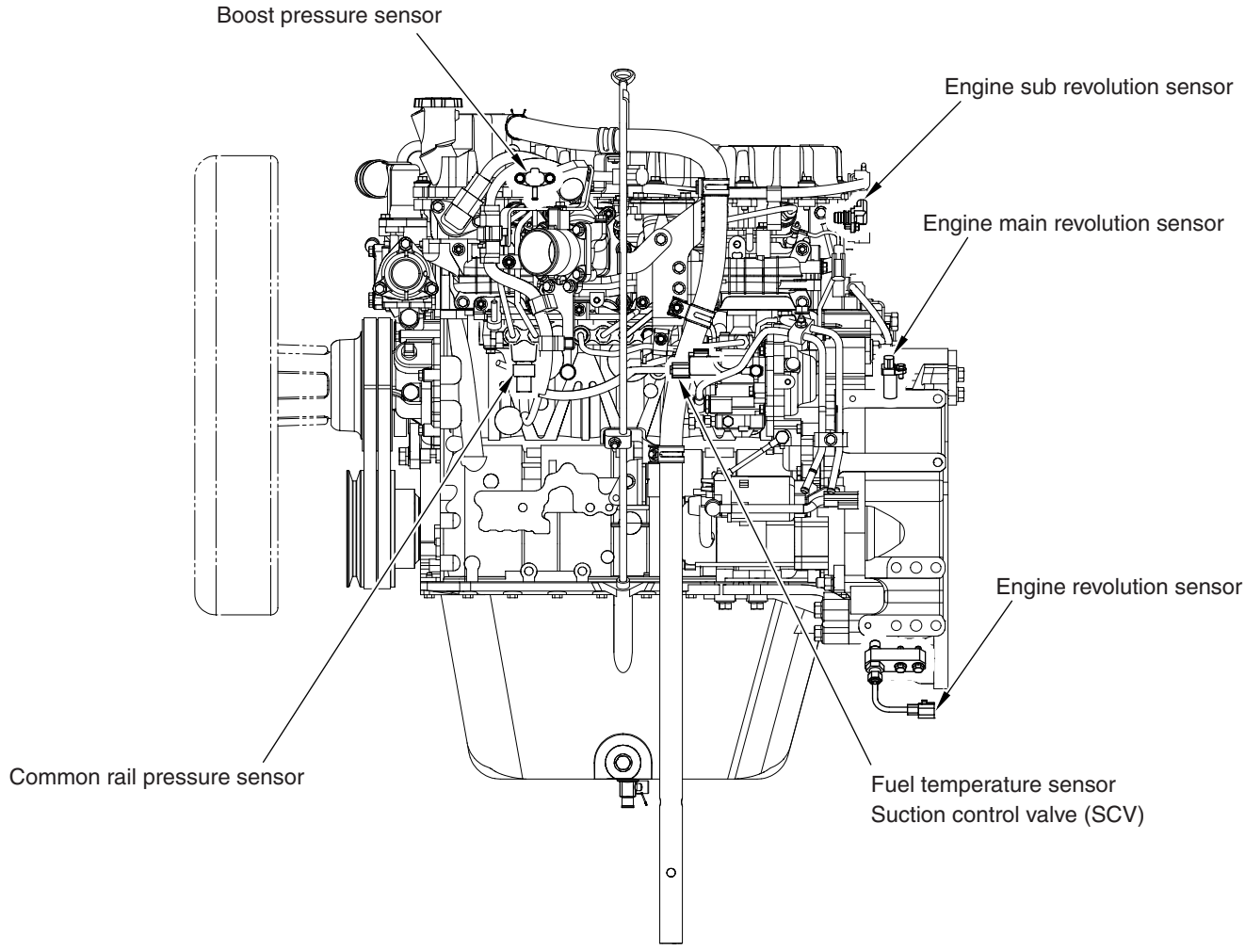


SAPH311990700003

19110	Glow plug	

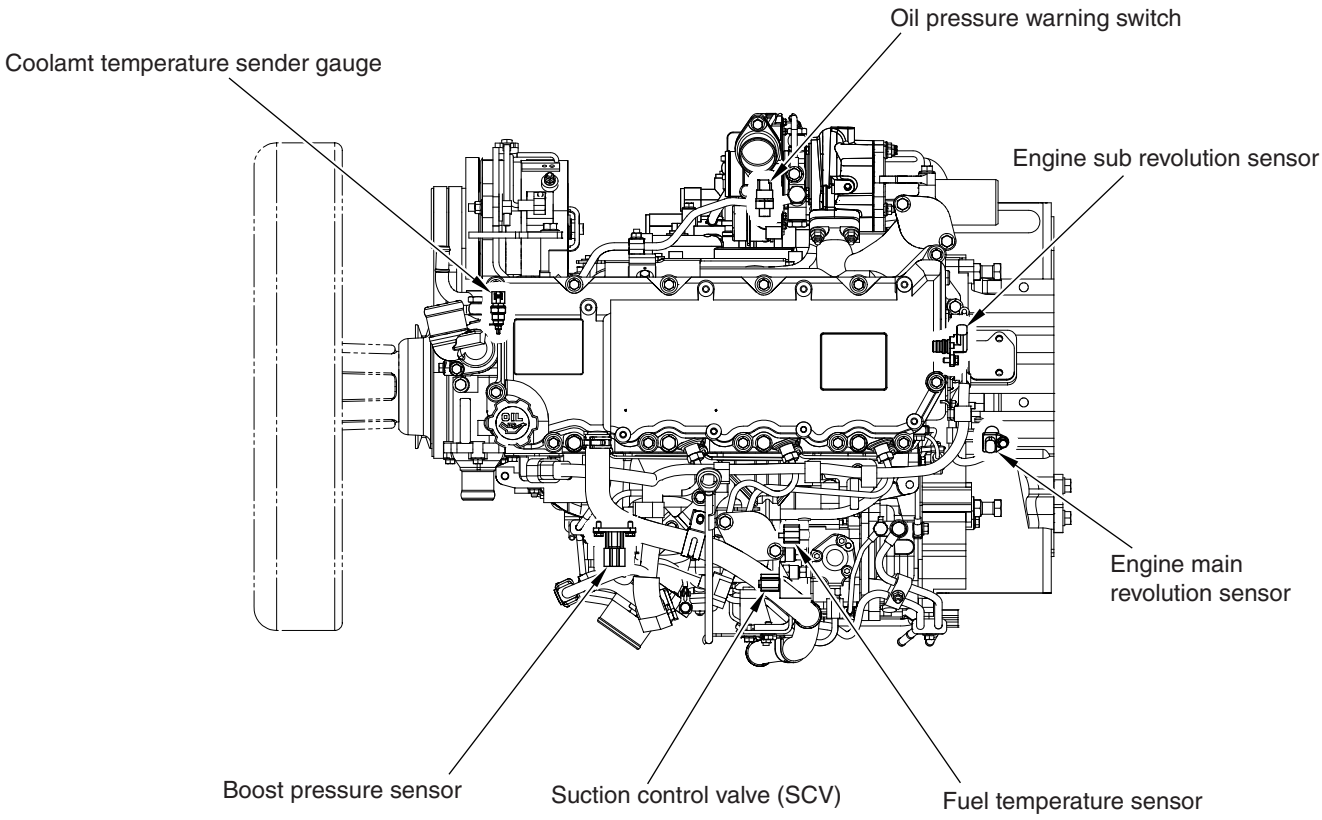
Layout of components

JP31199070402003



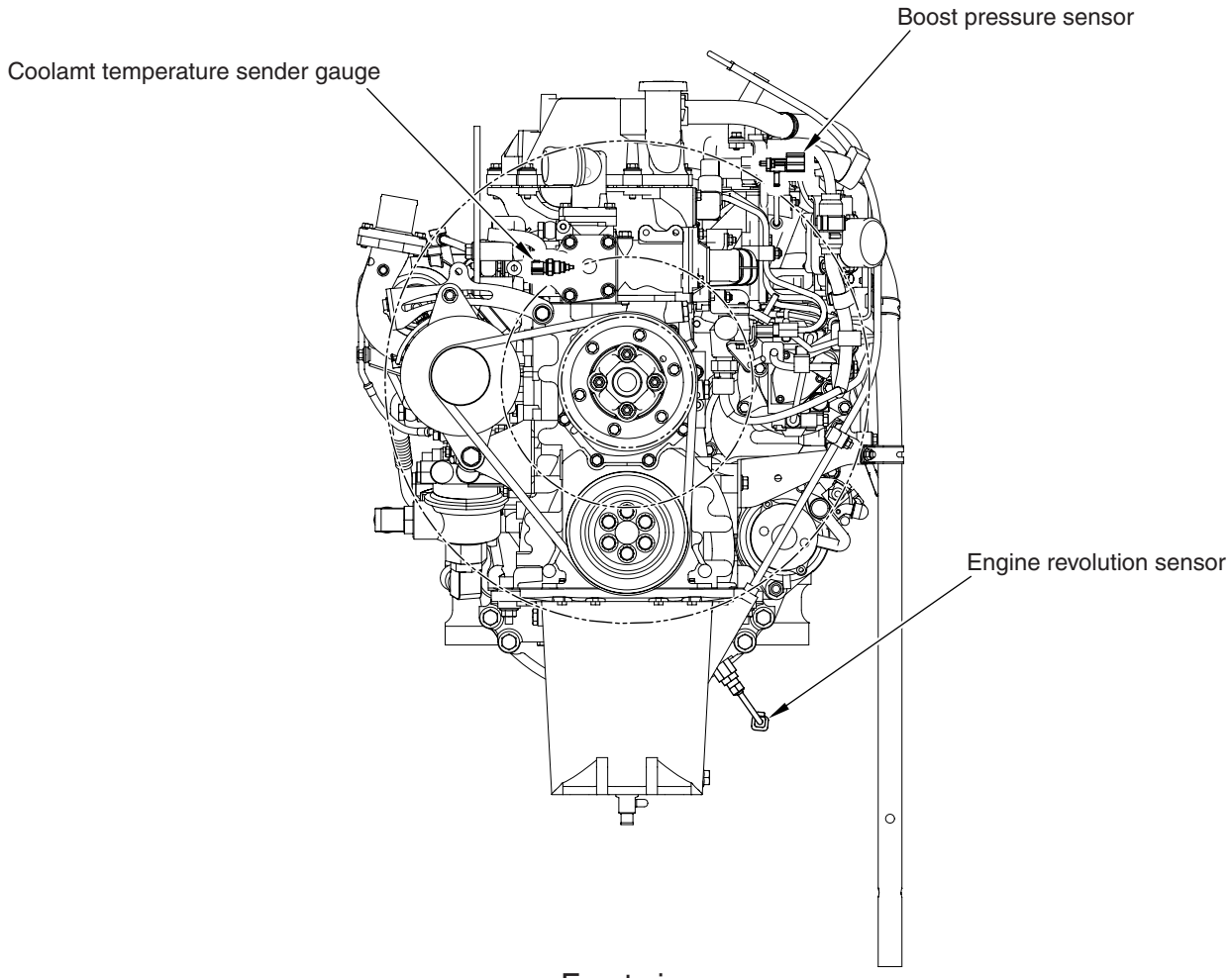
Left side view

SAPH311990700004



Upper view

SAPH311990700005

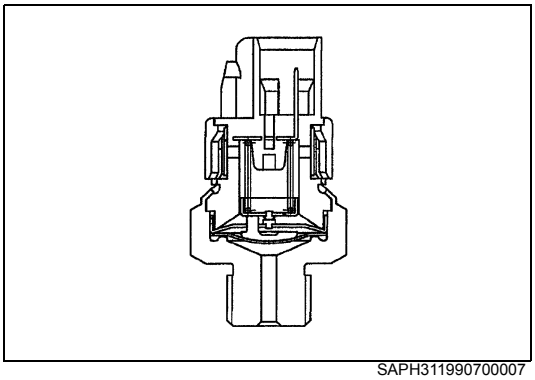


Front view

SAPH311990700006

Inspection of components

JP31199070702001

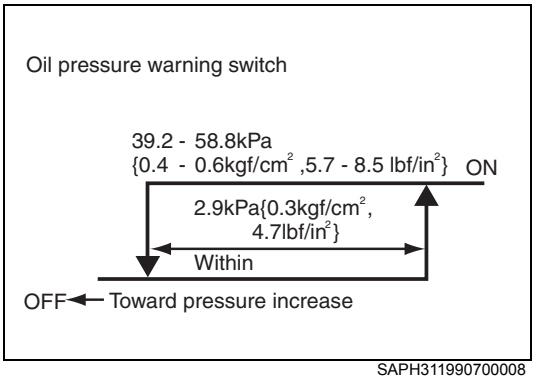


SAPH311990700007

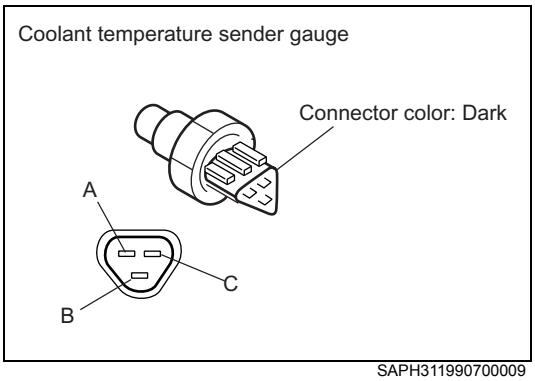
1. Inspection of oil pressure warning switch (Laid out on the oil filter)

(1) Apply pressure with air or oil and check continuity between terminals using a circuit tester. If it is faulty, replace it.

At no load or less than 39kPa {0.4kgf/cm^2 ,5.6565lbf/in.^{2}}	**With continuity**
At 39kPa {0.4kgf/cm^2 ,5.6565lbf/in.^{2}}	**Without continuity**



SAPH311990700008



SAPH311990700009

2. Inspection of coolant temperature sender gauge (Installation on thermostat case)

(1) Heat the coolant temperature sender gauge using hot water.

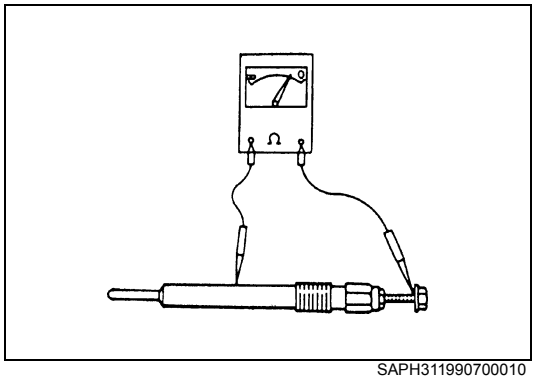
(2) Measure the resistance between terminals using a circuit tester. If it is faulty, replace the gauge.

Between A and C

Temperature (°C{°F})	**-20 {-68}**	**20 {68}**	**80 {176}**	**110 {230}**
Resistance value (Ω)	**13.84 - 16.33**	**2.32 - 2.59**	**0.31 - 0.326**	**0.1399 - 0.1435**

Between B and body

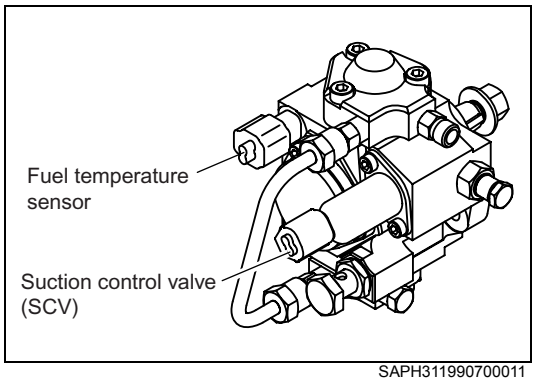
Temperature (°C,°F)	**75 {167}**	**100 {212}**
Resistance value (Ω)	**79 - 92**	**35.5 - 42.5**


SAPH311990700010

3. Inspection of glow plug

(1) Measure continuity between the body and the terminal using a circuit tester. If it is faulty, replace the glow plug.

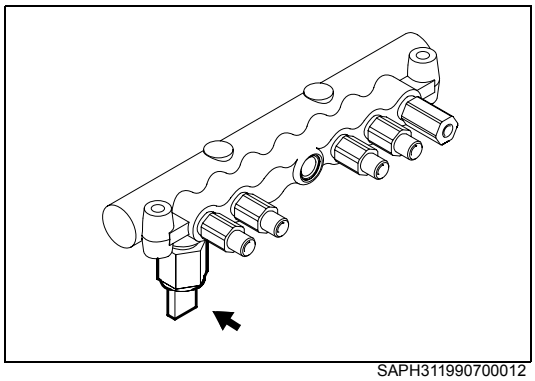
Standard value	
Resistance value : Ω(Normal temperature 20°C{68°F})	**2.59 - 3.29**



SAPH311990700011

4. Inspection of suction control valve SCV and fuel temperature sensor

(1) For inspection and replacement of the suction control valve (SCV) and the fuel temperature sensor, refer to the chapter of "J05E FUEL SYSTEM ".


SAPH311990700012

5. Inspection of common rail pressure sensor

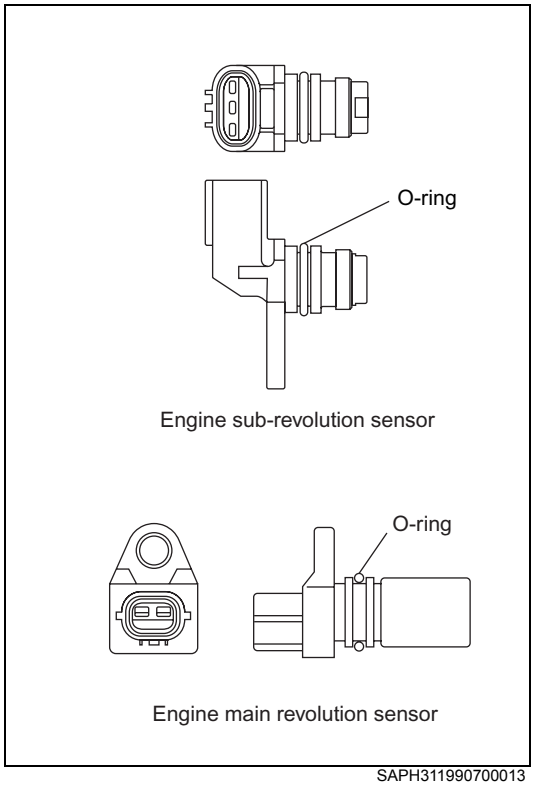
(1) For inspection and replacement of the common rail pressure sensor, refer to the chapter of "J05E FUEL SYSTEM".

6. Inspection of injector

(1) For inspection and replacement of the injector, refer to the chapter of "J05E FUEL SYSTEM".

Installation of component

JP31199070702002



SAPH311990700013

1. Installation of engine revolution sensor

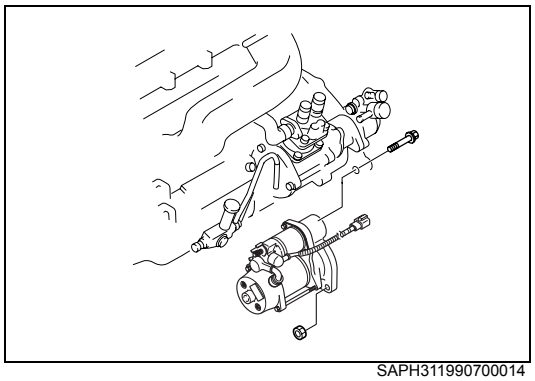
(1) Confirm that there are O-rings on the sensors and then mount one sensor on top of the flywheel housing and one on the cam housing.

NOTICE

- **Since this sensor is a flange type, gap does not have to be adjusted.**

Installation of starter

JP31199070702003



SAPH311990700014

1. Install the starter with bolts and nuts.

Tightening torque : 154 N·m {1,570 kgf·cm, 114 lbf·ft}

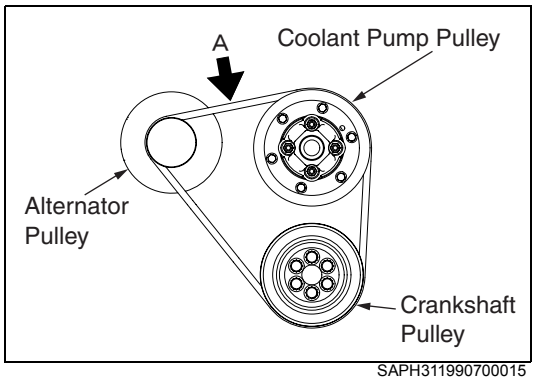
Installation of alternator

JP31199070702004

1. Installation of alternator

(1) Tighten the alternator temporarily using through bolts and nuts.

(2) Tighten the adjusting bolts and fixing bolts temporarily.



SAPH311990700015

2. V–belt tension adjustment

Item	When installing a new belt	At the time of inspection
Deflection	8 - 10mm {0.3152 - 0.394in.}	10 - 12mm {0.394 - 0.472in.}
Tension	490 - 570 N {50 - 58 kgf, 110 - 128 lbf}	320 - 400 N {33 - 41 kgf, 72 - 90 lbf}

Special tool : 09444-1210 Compression gauge (used at the time of measuring the deflection amount) [Reference push force 98N {10kgf, 22lbf}]
95506-00090 (Denso part No.) Belt tension gauge (used at the time of measuring the tension force)

⚠ CAUTION
- **If the V-belt is replaced with a new one, it becomes loose due to initial fitting. Run the engine for three to five minutes and adjust the tension of the belt again.**

NOTICE
- **At the time of inspection, the new V-belt has reached the value after complete initial stretching. A new V-belt completes initial stretching after running the engine for approximately two hours.**

(1) Tighten the through bolt of the commutator end frame.
Tightening torque : Through bolt
83 N·m {850 kgf·cm, 61 lbf·ft}

(2) Tighten the lock nut on the brace side.
Tightening torque : Adjusting bolt
51 N·m {520 kgf·cm, 38 lbf·ft}

(3) Tighten the adjusting bolt and make sure the bolt is locked.
Tightening torque : Adjusting bolt
5.9 N·m {60 kgf·cm, 4 lbf·ft}

(4) Securely connect the ground wire terminal for the alternator.
Tightening torque : Adjusting bolt
4 N·m {40 kgf·cm, 3 lbf·ft}

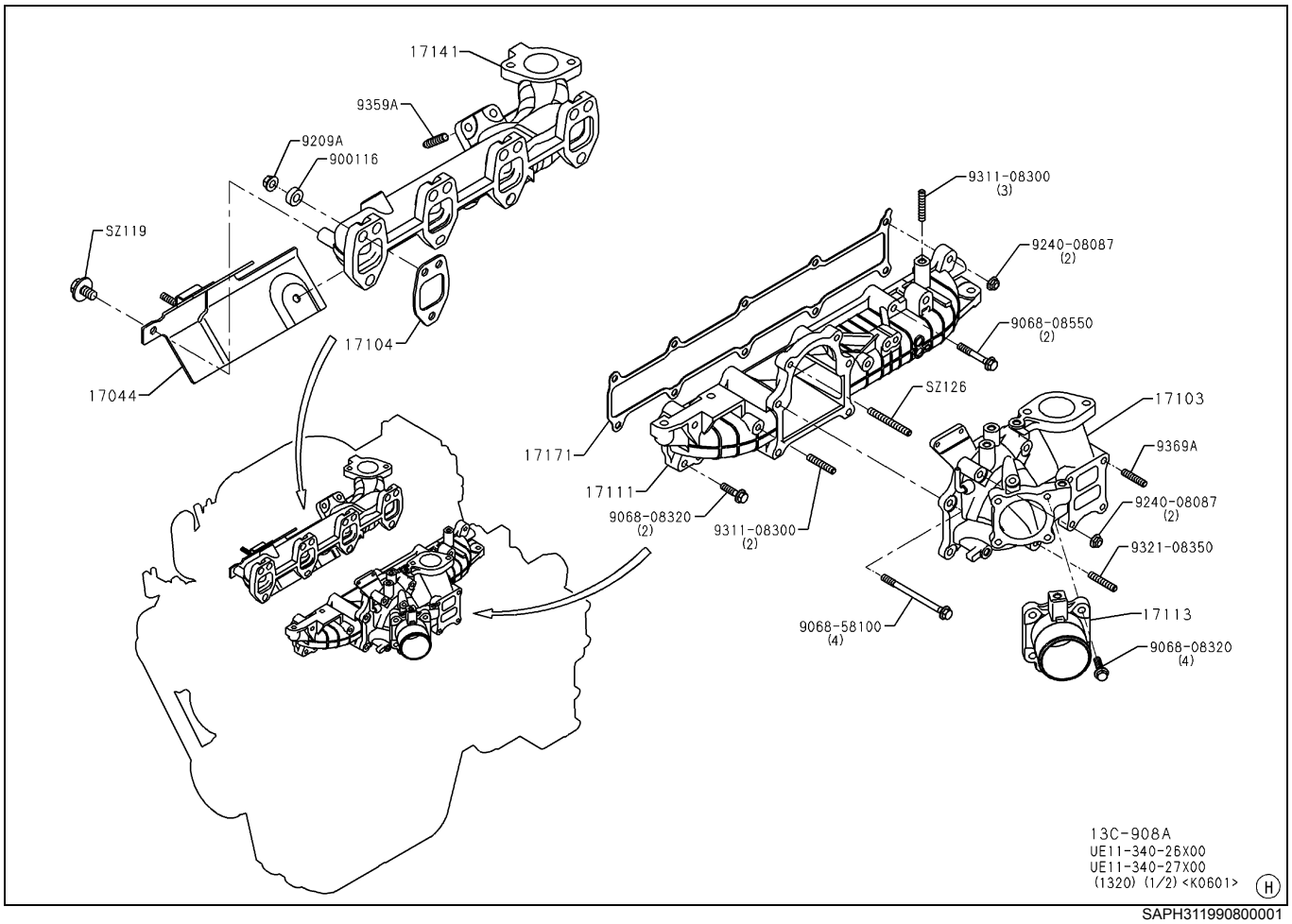
8 INTAKE

Intake Manifold 8-2
Part layout 8-2
Replacement 8-4

Intake Manifold

Part layout

JP311990804020001



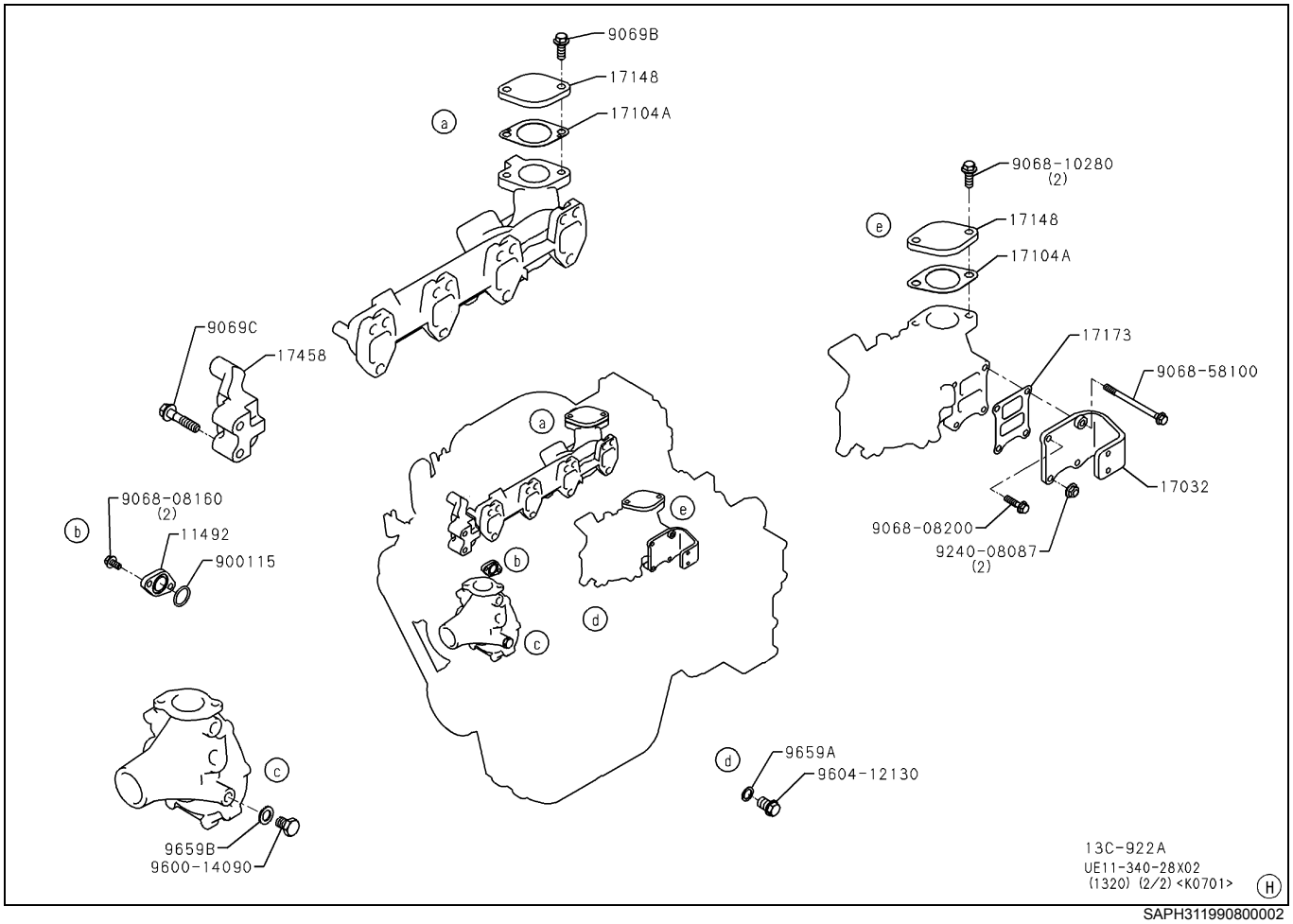
SAPH311990800001

17103	Intake pipe	17113	Intake pipe
17111	Intake manifold	17171	Gasket*

*Parts not to be reused.

Tightening torque

9068-08320	28.5 N·m {290 kgf·cm, 21lbf·ft}	9240-08087	28.5 N·m {290 kgf·cm, 21lbf·ft}
9068-08550	28.5 N·m {290 kgf·cm, 21lbf·ft}		



SAPH311990800002

17104A	Gasket*	17148	Plate

*Parts not to be reused.

Replacement

JP31199080704001

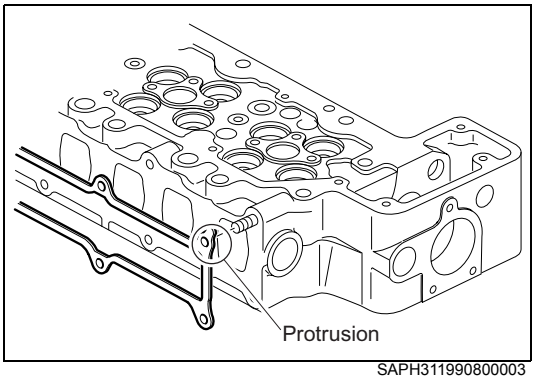
1. Removal of intake manifold

(1) Remove bolts and nuts and remove the intake manifold.

2. Installation of intake manifold

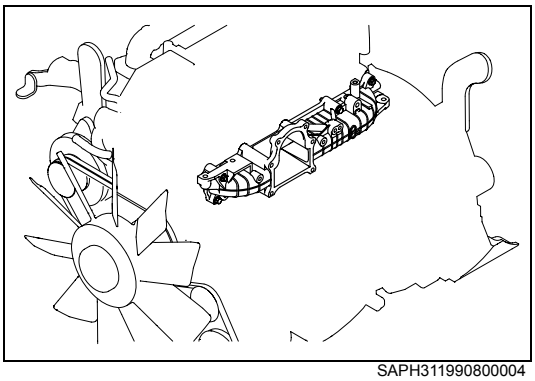
(1) Clean inside of the intake manifold and the cylinder head.

(2) Assemble a new gasket.



SAPH311990800003

⚠ **CAUTION**
- **Install the gasket so that the protrusion may come at the rear end stud bolt of the cylinder head.**


SAPH311990800004

(3) Install the intake manifold and tighten it with bolts and nuts.

Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

3. Installation of intake pipe

(1) After removing contamination on the contact surface, apply liquid gasket [Threebond TB1207B(black) or equivalent] to the circumference of the contact surface.

⚠ **CAUTION**
- **Apply it continuously.**
- **Apply the liquid gasket at the width of 1.5 to 2.5 mm {0.0591 to 0.09843 in.}**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**

(2) Install the intake pipe with bolts and nuts.

9 ENGINE MECHANICAL

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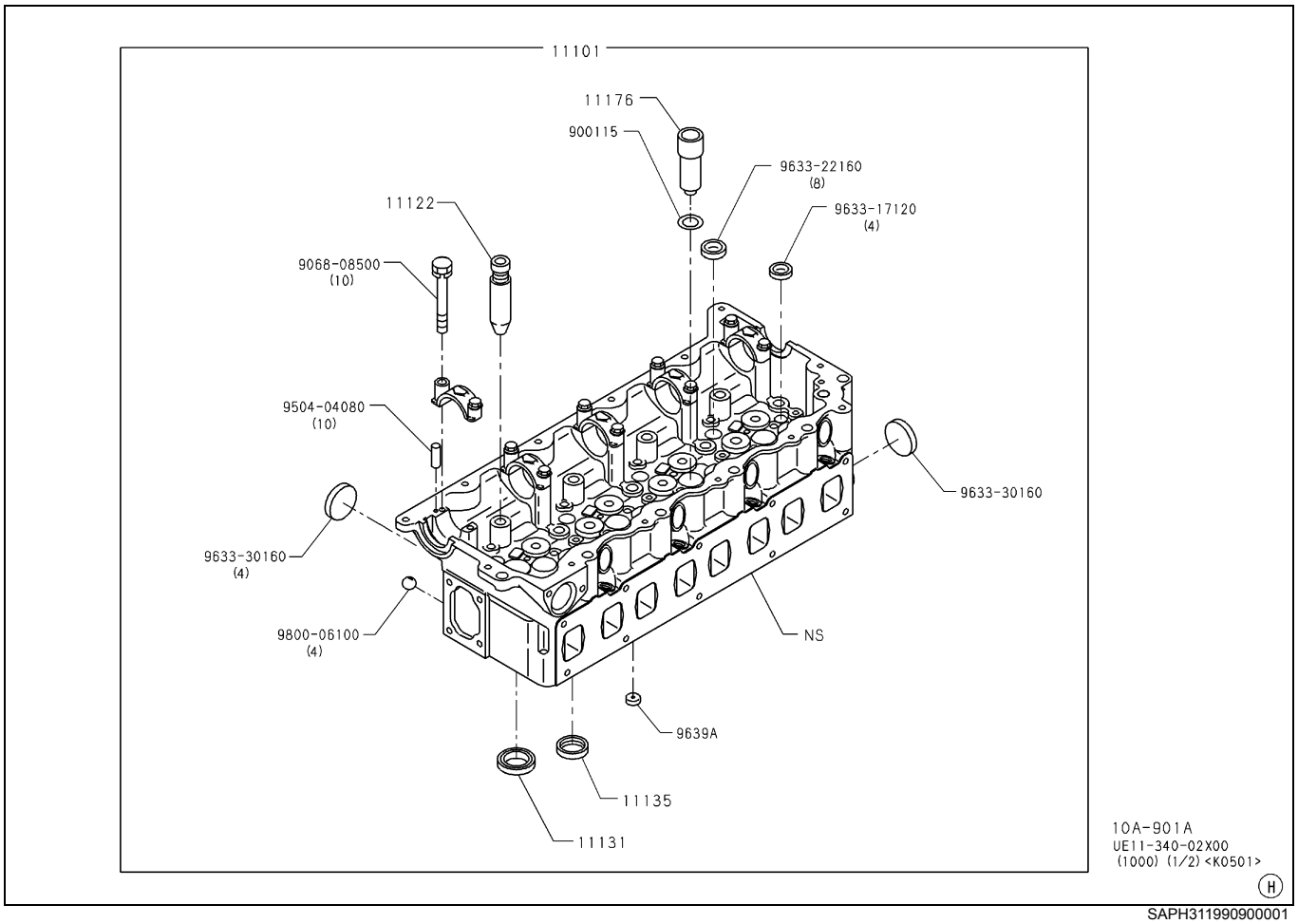
Cylinder Head

Part layout

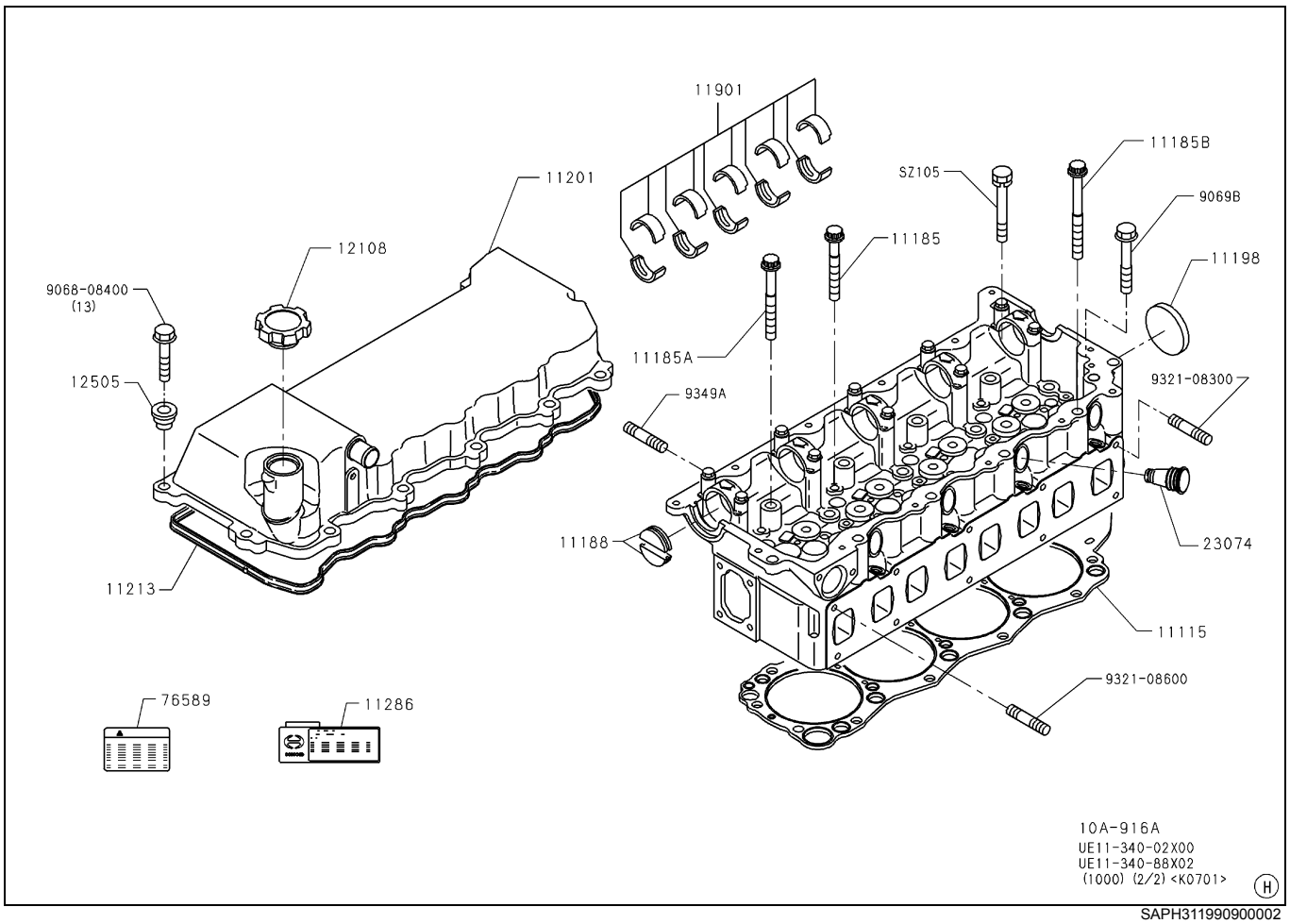
JP31199090402001



SAPH311990900001

11101	Cylinder head assembly	11135	Exhaust valve seat
11122	Valve guide	11176	Nozzle seat
11131	Intake valve seat	900115	O-ring*

*Parts not to be reused.



SAPH311990900002

11115	Cylinder head gasket	12108	Oil filler cap
11188	Semicircular plug	12505	Silent block
11201	Cylinder head cover	23074	Injection pipe oil seal*
11213	Head cover gasket		

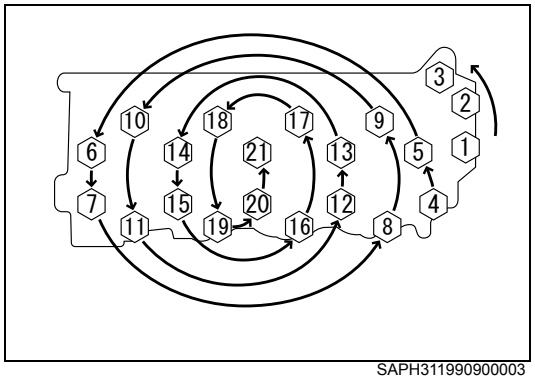
*Parts not to be reused.

Tightening torque

11185	59N·m{600kgf·cm, 44lbf·ft}+90°+90°	9069B	59N·m{600kgf·cm, 44lbf·ft}
11185A	59N·m{600kgf·cm, 44lbf·ft}+90°+135°	9349A	30N·m{300kgf·cm, 22lbf·ft}
11185B	59N·m{600kgf·cm, 44lbf·ft}+90°+180°	SZ105	59N·m{600kgf·cm, 44lbf·ft}
9068-08400	28.5N·m{290kgf·cm, 21lbf·ft}		

Replacement of cylinder head

JP31199090704001

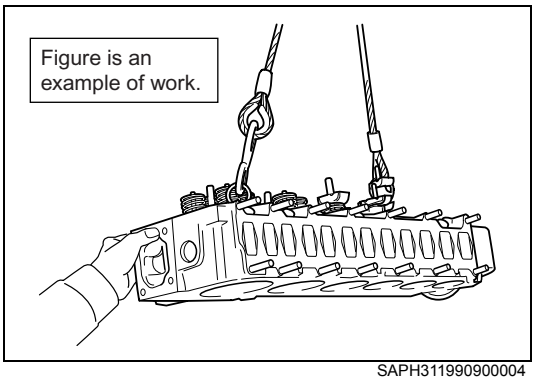


SAPH311990900003

1. Removal of cylinder head and head gasket

(1) First remove the head bolts 1 to 3.

(2) Then gradually loosen the head bolts 4 to 21 from the outside to the inside (approx. 1/4 turn each time) and remove them.



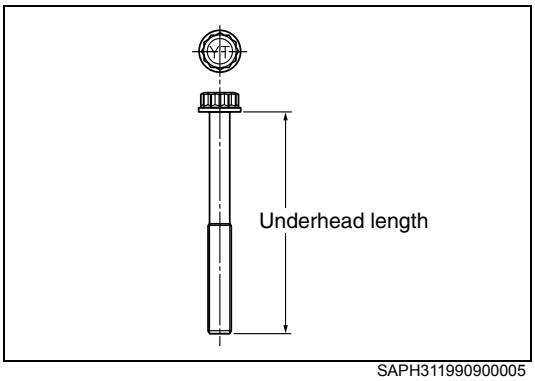
SAPH311990900004

(3) Remove the cylinder head using a special tool and hoist.

Special tool : 09433–1070 Eye bolt

NOTICE

- **If it is difficult to remove the cylinder head, insert a chisel between the cylinder head and the cylinder block, and move the chisel vertically so that the contact surface may not be damaged. Then, separate the cylinder head.**

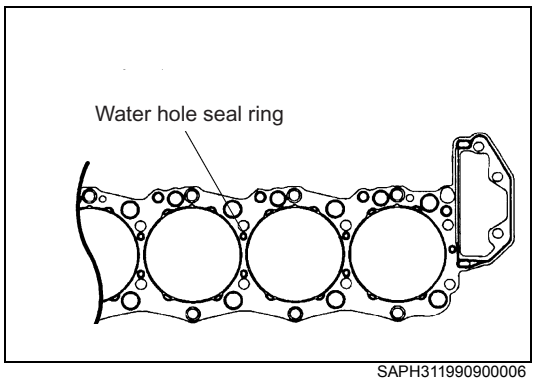


SAPH311990900005

2. Inspection of head bolt length

(1) Measure the underhead length of the head bolt (M12 only) using vernier calipers. If it is beyond the service limit, replace it with a new one.

Service limit (mm{in.})	**126.5{4.9803 in.}**



SAPH311990900006

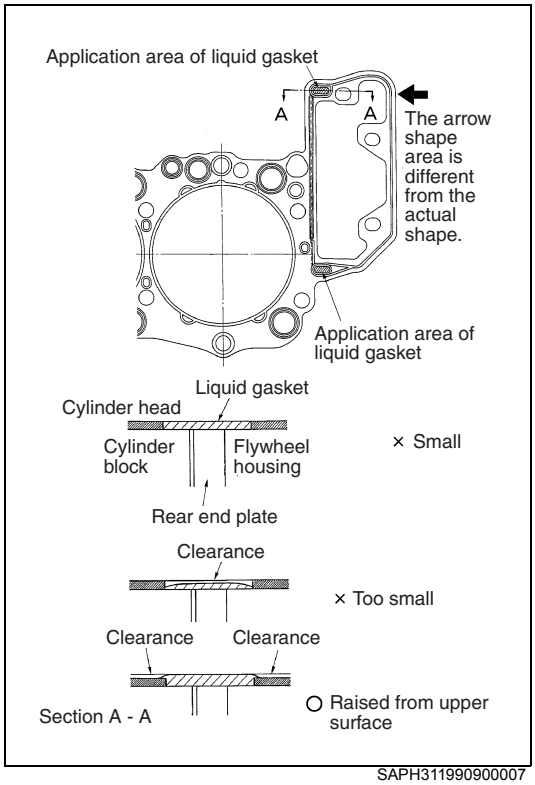
3. Installation of cylinder head gasket and liquid gasket application procedure

(1) Cut the rear end plate gasket to be flush with the surface of the cylinder block upper surface using a scraper.

(2) Install the cylinder head gasket on the cylinder block and the flywheel housing.

⚠ CAUTION

- **Remove dirt, water or oil from the mounting surfaces of the cylinder head and the cylinder block before work.**
- **Never reuse the gasket. Otherwise, it may damage the engine.**
- **The water hole seal ring of the cylinder head gasket is susceptible to damage. Avoid contact with hand or object.**
- **Before installation of the cylinder head gasket, make sure that there is no fall of or damage to the seal ring.**



SAPH311990900007

(3) Apply appropriate amount of liquid gasket [Threebond TB1211 (white) or equivalent] to the cylinder head gasket hole at the joint surface between the cylinder block and the flywheel housing.

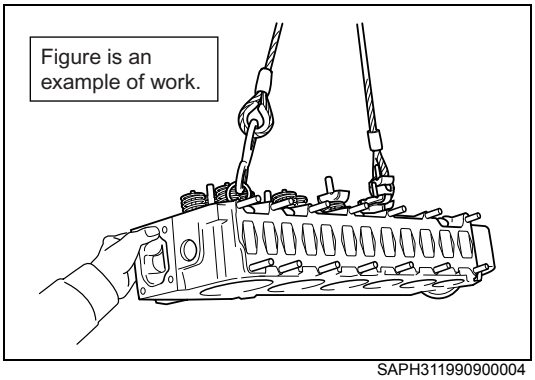
⚠ CAUTION

- **Apply the liquid gasket so that the surface of the liquid gasket may be raised on the cylinder head gasket.**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**

4. Installation of cylinder head

(1) Clean the head bolt seat at the cylinder head upper surface and the cylinder head lower surface.

(2) Apply engine oil to the head bolt seat and the bolt thread.



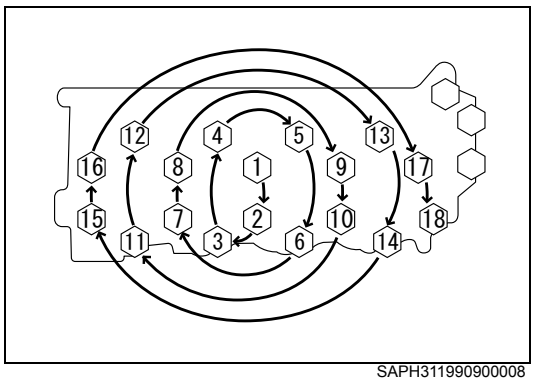
SAPH311990900004

(3) Align the dowel pins of the cylinder block using a special tool and hoist and mount the cylinder head.

Special tool : 09433–1070 Eye bolt

⚠ CAUTION
- **Before mounting the cylinder head, make sure that there is no foreign matter in the cylinder.**
- **When the cylinder head is mounted, be careful for engagement between the cam idle gear and the sub-idle gear. (Contact of gear teeth with undue force may cause impact mark or chipping, resulting in abnormal noise or missing tooth.)**

NOTICE
- **Mounting of the cylinder head with guide bolt can prevent displacement of the liquid gasket.**



SAPH311990900008

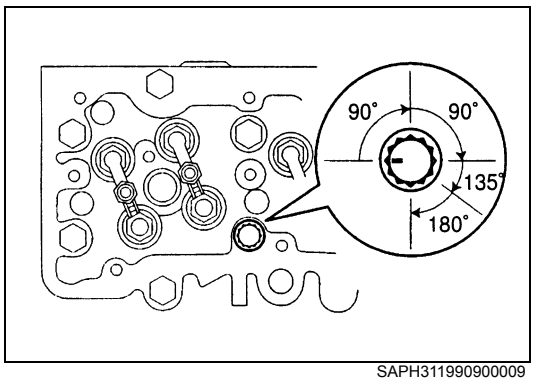
(4) Sequentially tighten head bolts (M12) 1 to 18 from the center to the outside in the order shown in the figure.
Tightening torque : 59 N·m {600 kgf·cm, 44 lbf·ft}

(5) After tightening, tighten head bolts 1 to 18 again from the center to the outside.
Tightening torque : 59 N·m {600 kgf·cm, 44 lbf·ft}

(6) Mark the head parts of head bolts (M12) 1 to 18 with paint in the same direction.

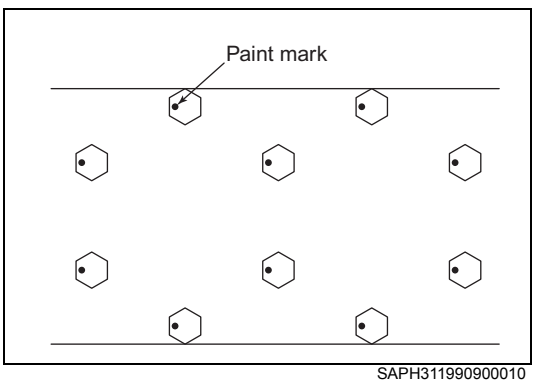
(7) Tighten head bolts (M12) 1 to 18 in tightening order for another 90°. (First time)

(8) Tighten head bolts (M12) 1 to 18 according to the same procedure by the angles shown in the table. (Second time)



SAPH311990900009

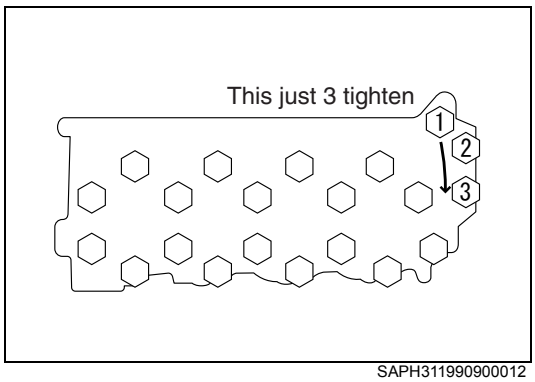
Tightening angle	Head bolts No.
90°	1,2,7,8,9,10,15,16,17
135°	4,5,12,13
180°	3,6,11,14,18



SAPH311990900010

(9) Make sure the head bolts that have the same tightening angle markings have the same orientation.

⚠ CAUTION
- **If a bolt is turned excessively in retightening, do not loosen it.**



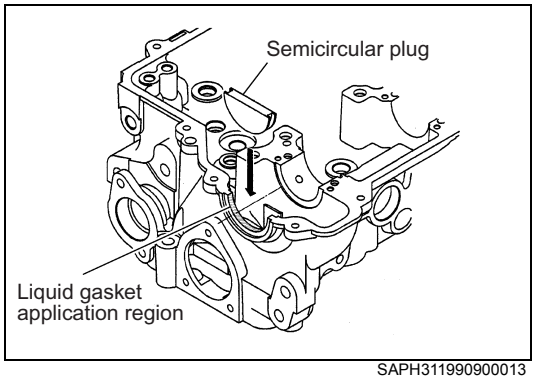
SAPH311990900012

(10) Tighten the remaining bolts (M10) 1 to 3 in the order shown in the figure.

Tightening torque : 59 N·m {600 kgf·cm, 44 lbf·ft}

Liquid gasket application procedure for semicircular plug (only when semicircular plug is removed)

JP31199090704002



SAPH311990900013

1. Remove liquid gasket from the cylinder plug and the camshaft housing.

2. Coat the semicircular plugs at the front and rear of the cylinder head with liquid gasket (Three Bond TB 1207B-Black or equivalent), and install the semicircular plugs.

3. Temporarily install the cylinder head cover with the gasket attached, and execute a parallel adjustment of the semicircular plugs.

⚠ **CAUTION** • **Be sure to wipe protruding liquid gasket.**

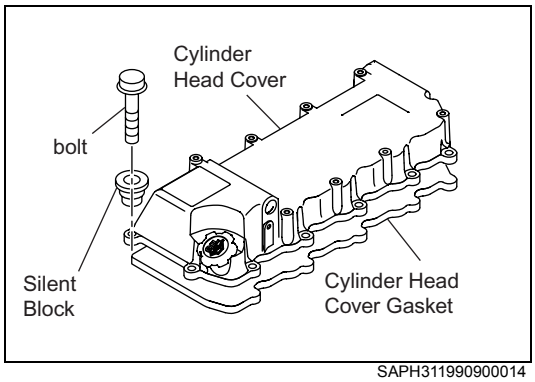
Replacement of head cover

JP31199090704003

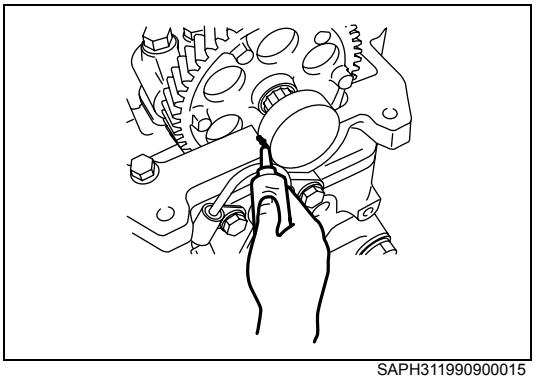
1. Installation of head cover

(1) Wipe off the liquid gasket stuck to the sides of the semicircular plugs on the front and rear ends of the cylinder head.

(2) Wipe dirt (including liquid gasket) and oil on the joint surfaces of the cylinder head cover and the camshaft housing. Install a new head cover gasket on the cylinder head cover.

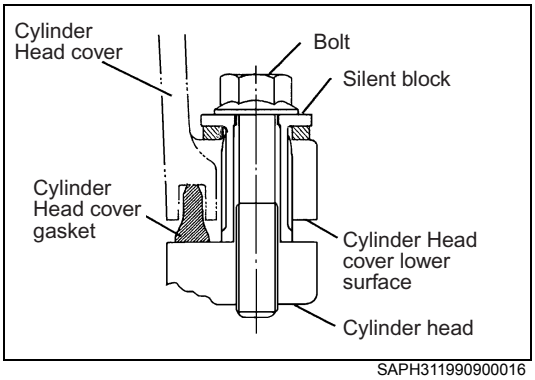


SAPH311990900014


SAPH311990900015

(3) Coat the semicircular plugs with liquid gasket (Three Bond TB 1207B-Black or equivalent) just before you install the cylinder head cover.

⚠ **CAUTION**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**



SAPH311990900016

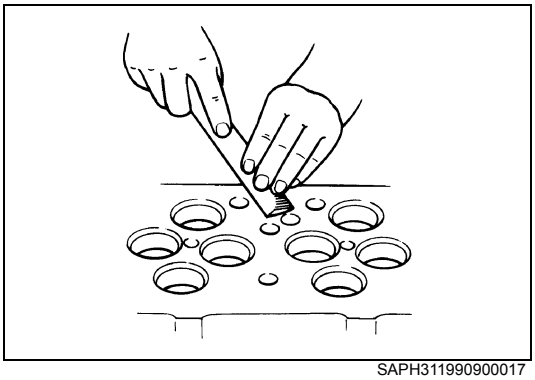
(4) Put the cylinder head cover on the cylinder head and tighten bolts.

Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

NOTICE
- **Silent block the rubber is attached to the spacer**

Overhaul of cylinder head

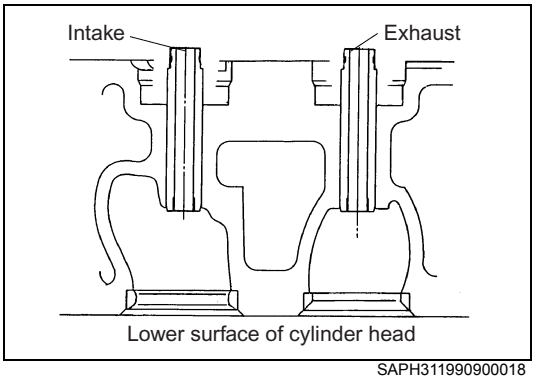
JP311990907020001


SAPH311990900017

1. Cleaning of cylinder head

(1) Remove carbon or other deposit using a scraper.
(2) Clean the cylinder head.

⚠ **CAUTION**
- **To remove carbon or other deposit, do not damage the lower surface of the cylinder head.**

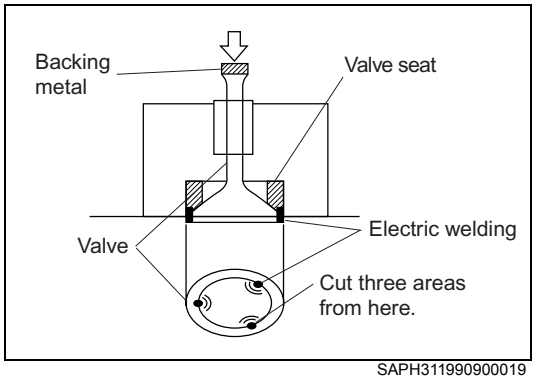


SAPH311990900018

2. Replacement of valve guide

(1) Remove the valve stem seal.
(2) Remove the valve guide using a brass bar or press.
(3) When a new valve guide is assembled, do not pry the end in assembly and press fit using a special tool.
Special tool : 09471–1520 Guide

⚠ **CAUTION**
- **In press fit, be careful not to damage the valve stem at the upper/lower ends of the guide.**
- **In press fit, be sure to apply engine oil to the circumference of the valve guide.**



SAPH311990900019

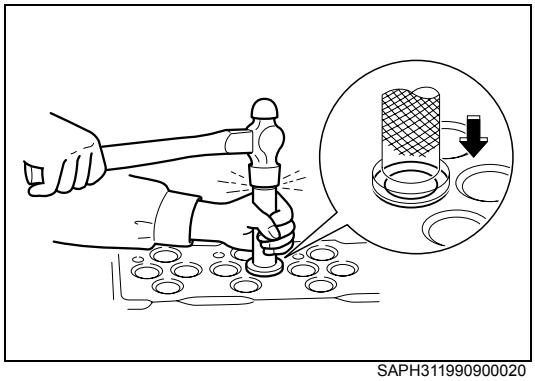
3. Replacement of valve seat

⚠ **CAUTION** • **The valve seat replacement procedure below may damage the cylinder head depending on the case. It is recommended that a request for replacement be made to a machining vendor.**

(1) If the valve seat is replaced, use an out-of-use valve. After cutting three pieces from the valve circumference, weld them to the valve seat.

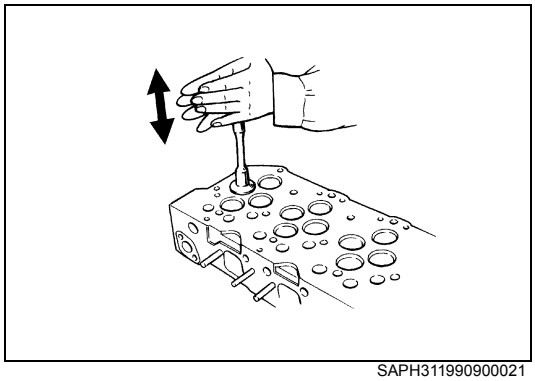
⚠ **CAUTION** • **Apply grease to protect the cylinder head lower surface from welding spatter before work.**

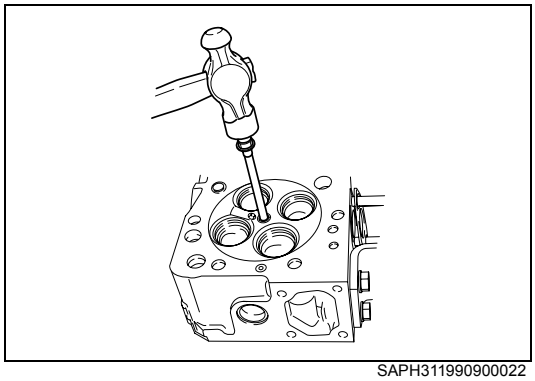
(2) Put a backup metal (e.g. brass bar) at the valve stem head and pull out the valve seat using a press.
(3) Remove welding spatter or dirt on the valve seat surface.
(4) Heat the cylinder head to approx. 80 to 100 °C and strike the cooled valve seat into the mounting area of the cylinder head.


SAPH311990900020

(5) Apply small amount of lapping compound to the contact surface between the valve and the valve seat.

(6) Strike gently while turning the valve using a special tool for adjustment.
Special tool : 09431–1020 Valve lapping tool

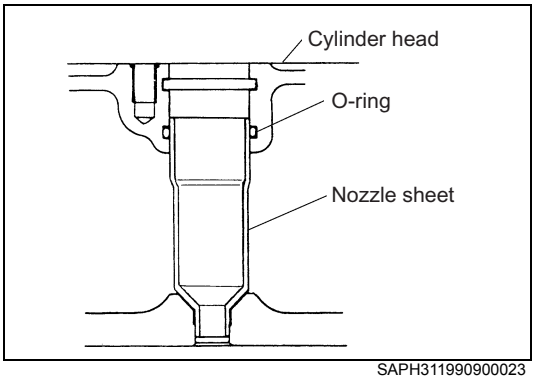

SAPH311990900021


SAPH311990900022

4. Replacement of nozzle seat

(1) Tap the nozzle seat from the cylinder head lower part. Then, put an appropriate bolt inside.
(2) Hit the bolt head using a hammer and pull out the nozzle seat toward the the cylinder head upper part.
(3) Remove the O-ring from the cylinder head.

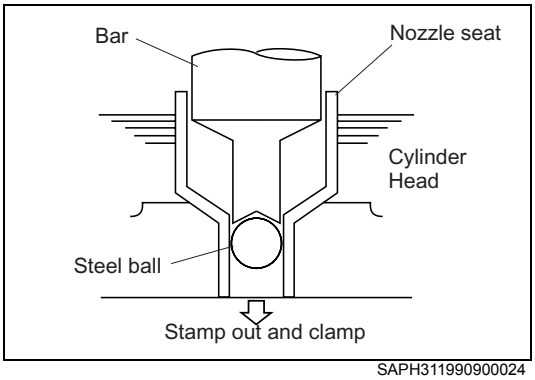
⚠ **CAUTION** • **After pulling out the nozzle seat, be sure to remove deposit such as remaining liquid gasket or dirt.**



SAPH311990900023

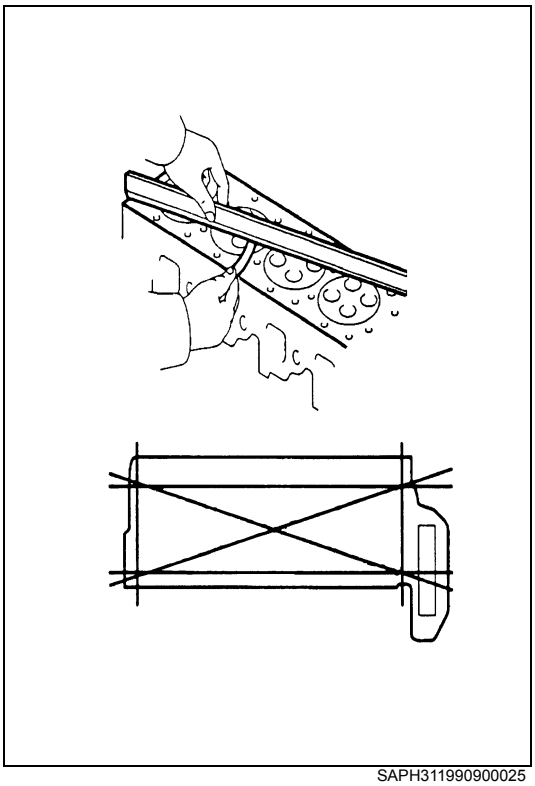
(4) After attaching a new O-ring into the nozzle seat hole of the cylinder head, apply the liquid gasket [Threebond TB1211 (white) or equivalent] at the lower part of a new nozzle seat and assemble it on the cylinder head.

⚠ **CAUTION** • **Be sure to replace the O-ring with a new part. Reuse may cause water leak or gas leak, resulting in overheat or crack of the cylinder head.**



SAPH311990900024

(5) Clamp the nozzle seat using a special tool.
Special tool : 09472–1210 Bar
9800–06100 Steel ball


SAPH311990900025

5. Inspection of cylinder head

(1) Inspection of cylinder head distortion
a. Measure distortion of the cylinder head lower surface and the manifold mounting surface using a ruler.

Standard value (mm{in.})	Service limit (mm{in.})
Longitudinal direction 0.06{0.0024} Square direction 0.03{0.0012}	**0.2{0.0079}**

b. If the measurement value is beyond the service limit, replace it.

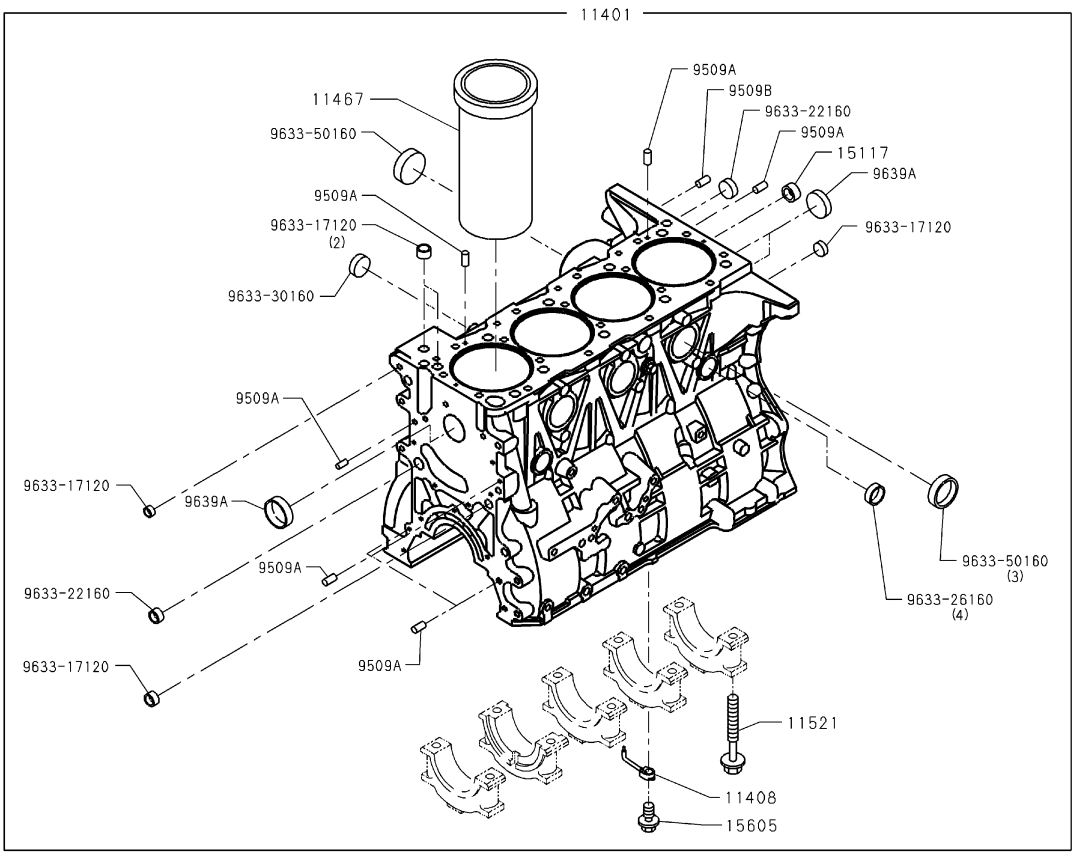
⚠ **CAUTION** • **Repair of the lower surface by grinding can change backlash of the timing gear. Do not grind it.**

(2) Inspection of cylinder head crack
a. With dye penetrant test method (red check), make sure that there is no crack or damage in the cylinder head.

Cylinder Block

Part layout

JP31199090402002



SAPH311990900026

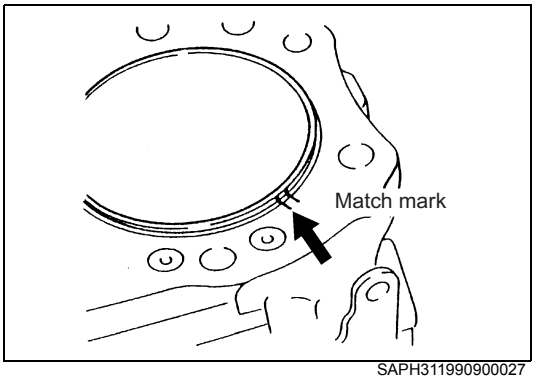
11401	Cylinder block assembly	11467	Cylinder liner
11408	Cooling jet		

Tightening torque

11521	69N·m{700kgf·cm, 51lbf·ft}+90°+45°	15605	22N ·m{220kgf·cm, 16lbf·ft}

Overhaul

JP31199090702002

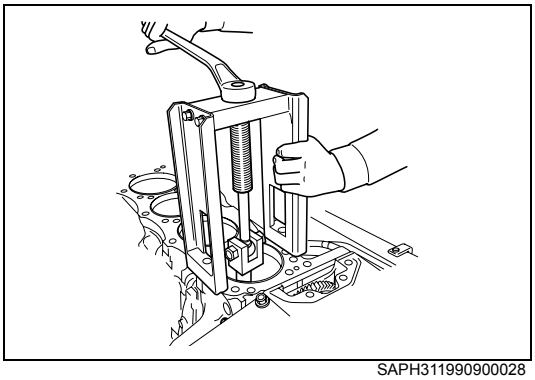


SAPH311990900027

1. Replacement of cylinder liner

(1) Put match marks on the flange surfaces of the cylinder block and the cylinder liner using a oil based marker.

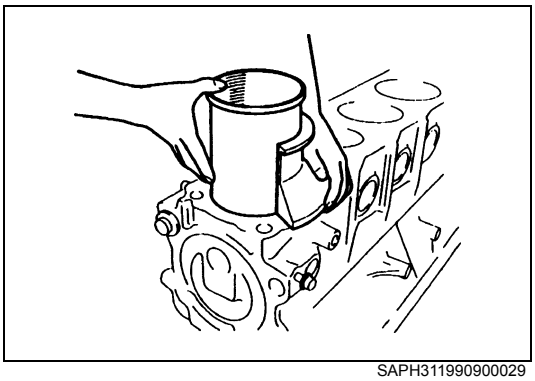
⚠ **CAUTION**
- **Store removed cylinder liners for each cylinder number.**
- **Never provide match marks with a punch.**


SAPH311990900028

(2) Pull out the cylinder liner toward the cylinder block upper part using a special tool.

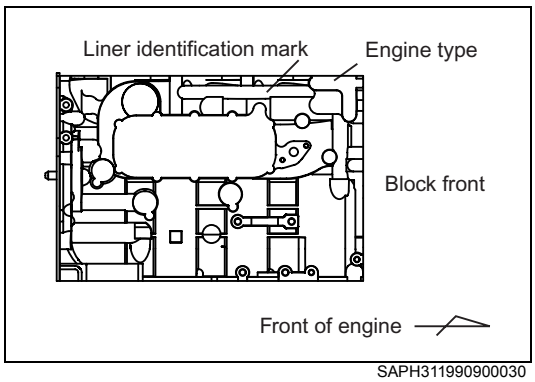
Special tool : 09420-2100 Cylinder liner puller

⚠ **CAUTION**
- **Be careful for handling of the cylinder liner. Do not reuse the cylinder liner which has been dropped.**
- **Do not touch the cooling jet during work.**

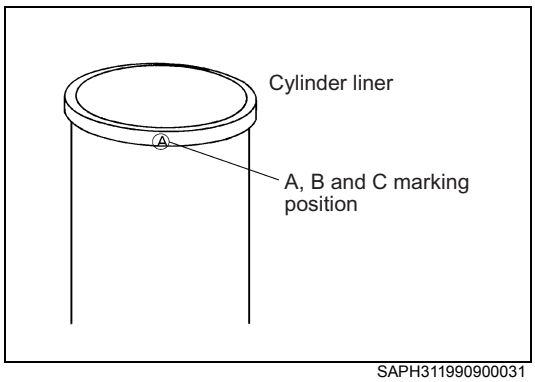

SAPH311990900029

(3) Apply engine oil to the inner bore of the cylinder block.

(4) Align the match mark of the cylinder liner with that of the cylinder block. Install the cylinder liner using a special tool.
Special tool : 09471–1490 Guide

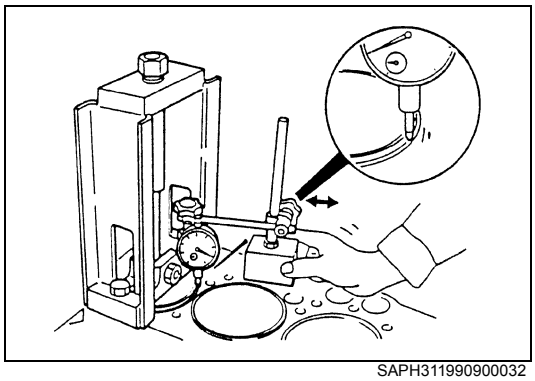


SAPH311990900030



SAPH311990900031

⚠ **CAUTION** • **When a new cylinder liner is installed, install the cylinder liner with the same identification mark (A, B, C) stamped on the cylinder block.**

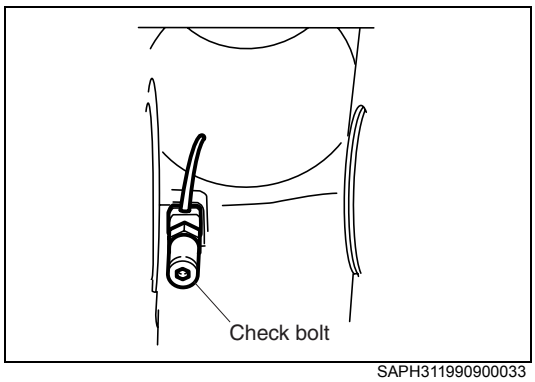

SAPH311990900032

2. Inspection of protrusion at cylinder liner flange

(1) Fix the cylinder liner using a special tool.
Tightening torque : 9.8 N·m {100 kgf·cm, 7 lbf·ft}
Special tool : 09420–2100 Cylinder liner puller

(2) Measure protrusion of the flange using a dial gauge.

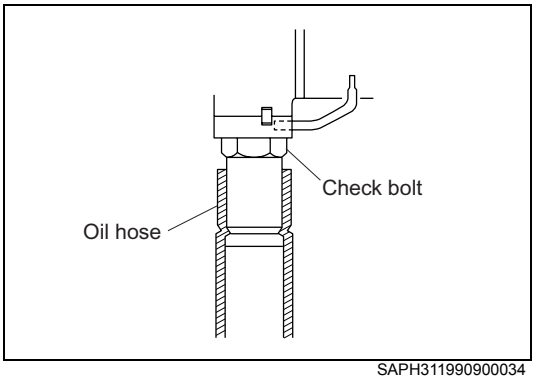
Standard value (mm{in.})	**0.01 - 0.08 {0.0004 - 0.0031}**



SAPH311990900033

3. Inspection and adjustment of cooling jet

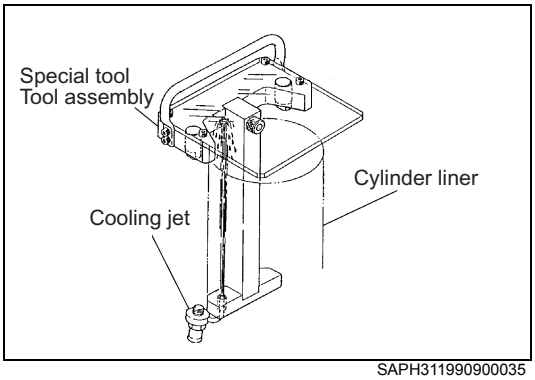
(1) Remove the standard oil check valve and install the cooling jet on the cylinder block using a special tool.
Special tool : 9001–24262 Check bolt



SAPH311990900034

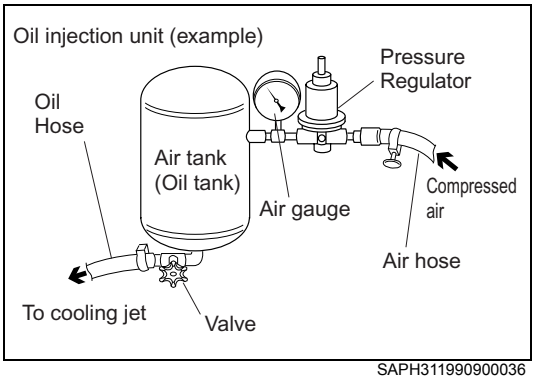
(2) Connect the injection test oil hose from the lower part of the cylinder block to the special tool check bolt.

⚠ **CAUTION**
- **Use new engine oil for injection of oil.**



SAPH311990900035

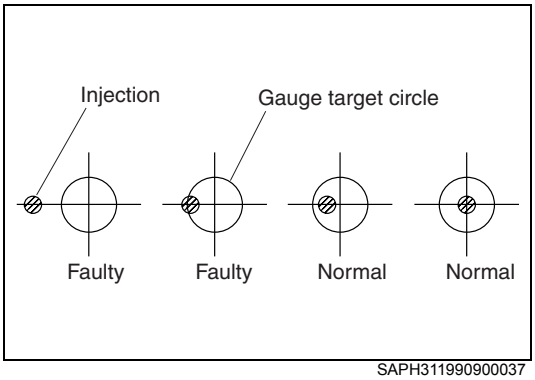
(3) Set a special tool on the cylinder block.
Special tool : 09470–1280 Tool assembly



SAPH311990900036

(4) Inject oil from the nozzle of the cooling jet at the hydraulic pressure of 196kPa{2kgf/cm^2, 28lbf/in.^{2}}.

NOTICE
- **Refer to the drawing for the oil injection unit.**

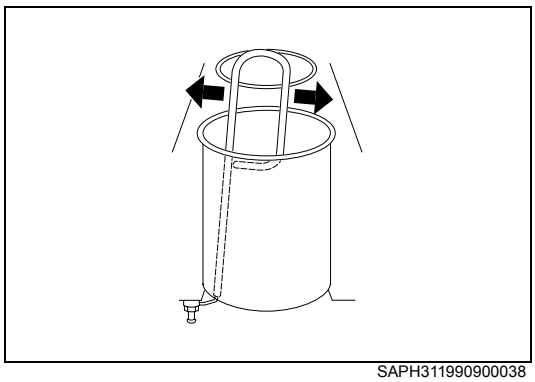


SAPH311990900037

(5) When the injection center hits within the specified line of the gauge, it is considered normal.

⚠ **CAUTION**
- **Oil is susceptible to combustion due to spread. Do not use fire near around.**
- **Work at well ventilated place.**

(6) Make sure that the jet position check gauge hole at the tool assembly end may not interfere with the cooling jet pipe.



SAPH311990900038

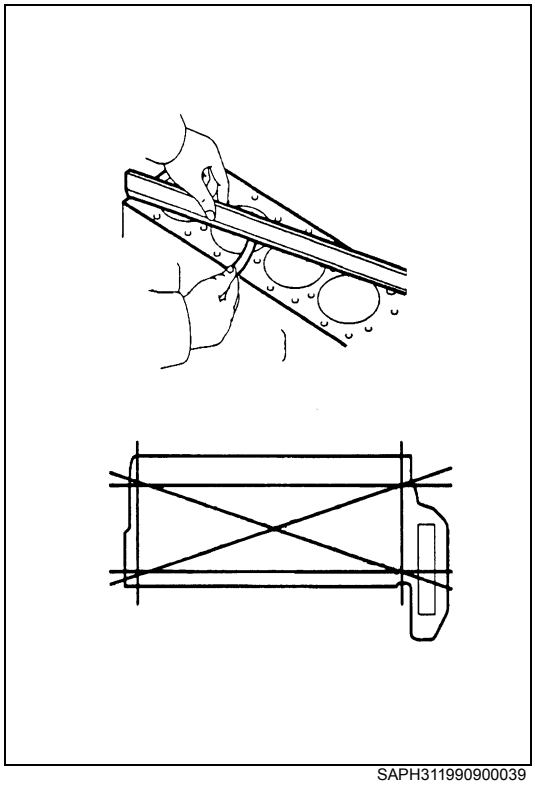
(7) If injection does not hit the target circle, correct it with a special tool.

Special tool : 09472–1620 Tool

(8) If it cannot be corrected, install a new cooling jet for reinspection.

(9) Remove the check bolt and install the cooling jet on the cylinder block using the genuine oil check valve.
Tightening torque : 22 N·m {220 kgf·cm, 16 lbf·ft}

(10) After assembly of the piston, make sure that the cooling jet does not interfere with the piston at the piston bottom dead center.



SAPH311990900039

4. Inspection of cylinder block

(1) Inspection of cylinder block distortion

a. Measure distortion on the cylinder block using a ruler.

Standard value (mm{in.})	Service limit (mm{in.})
Longitudinal direction 0.06{0.0024} Square direction 0.03{0.0012}	**0.2{0.0079}**

b. If the measurement value is beyond the service limit, replace it.

⚠ **CAUTION** • **Repair of the upper surface by grinding can change backlash of the timing gear. Do not grind it.**

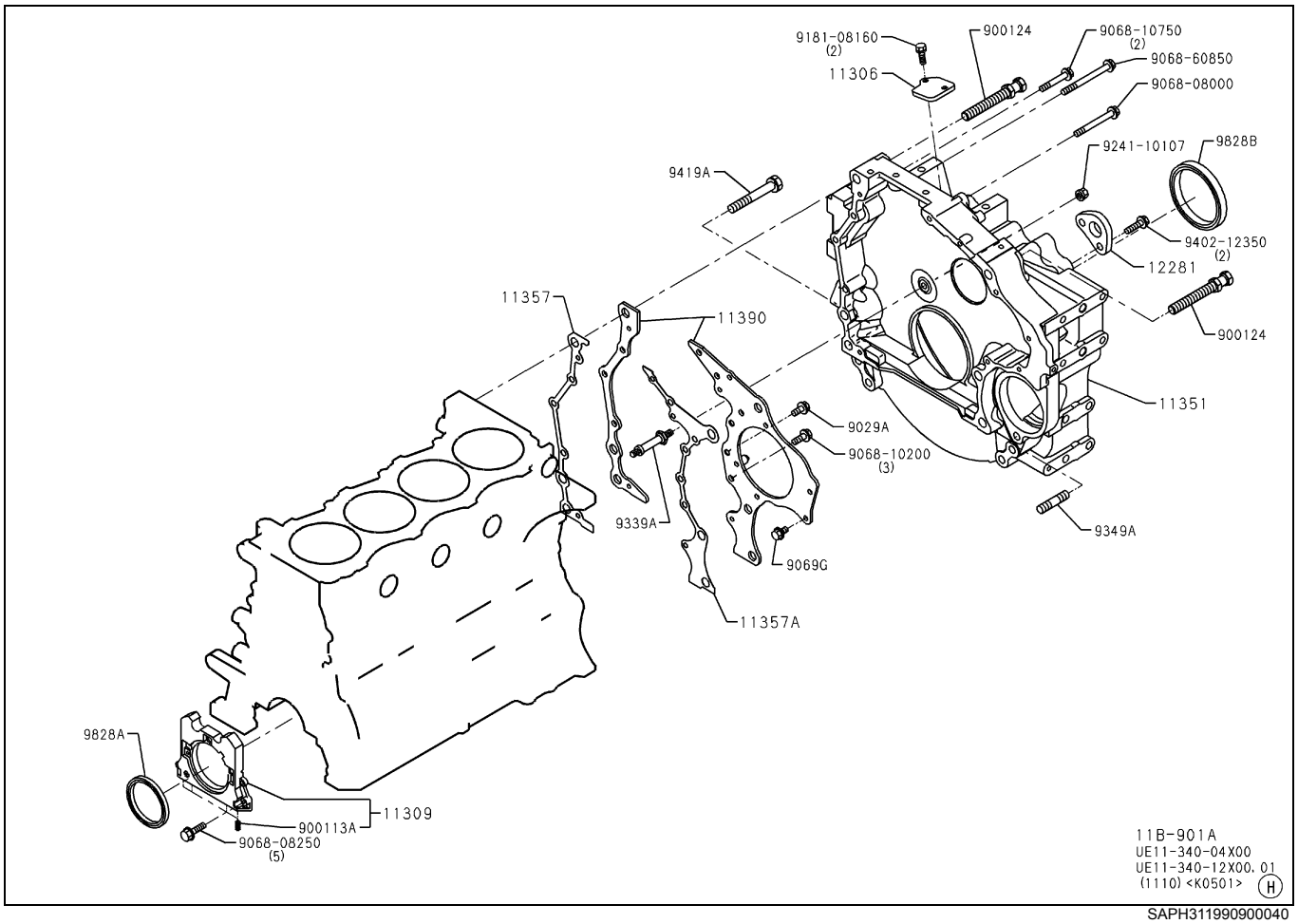
(2) Inspection of cylinder block crack

a. With dye penetrant test method (red check), make sure that there is no crack or damage in the cylinder block.

Timing Gear Cover and Flywheel Housing

Part layout

JP31199090402003



SAPH311990900040

11309	Front oil seal retainer	11390	End plate
11351	Flywheel housing	9828A	Front oil seal*
11357	Gasket*	9828B	Rear oil seal*
11357A	Gasket*		

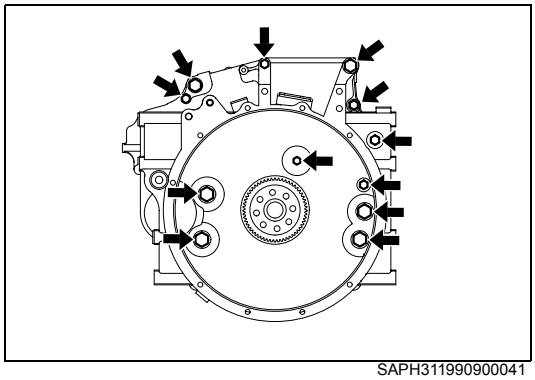
*Parts not to be reused.

Tightening torque

9068-08000	36N·m{370kgf·cm, 27lbf·ft}	90124A	196N·m{2,000kgf·cm, 145lbf·ft}
9068-10750	55N·m{560kgf·cm, 41lbf·ft}	9241-10107	55N·m{560kgf·cm, 41lbf·ft}
9068-60850	55N·m{560kgf·cm, 41lbf·ft}	9339A	55N·m{560kgf·cm, 41lbf·ft}
90124	196N·m{2,000kgf·cm, 145lbf·ft}	9419A	196N·m{2,000kgf·cm, 145lbf·ft}

Replacement of flywheel housing

JP31199090702003

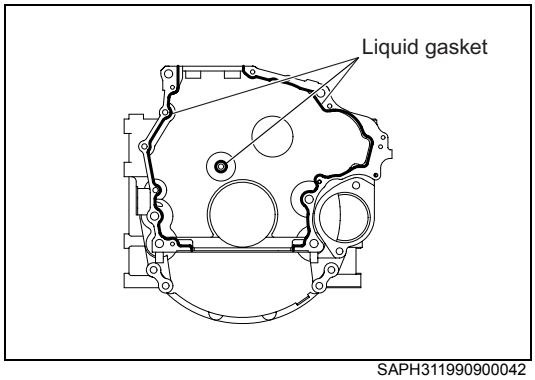


SAPH311990900041

1. Removal of flywheel housing

(1) Remove bolts and remove the flywheel housing.

⚠ **CAUTION**
- **Remove bolts fixing the flywheel housing from the cylinder block.**



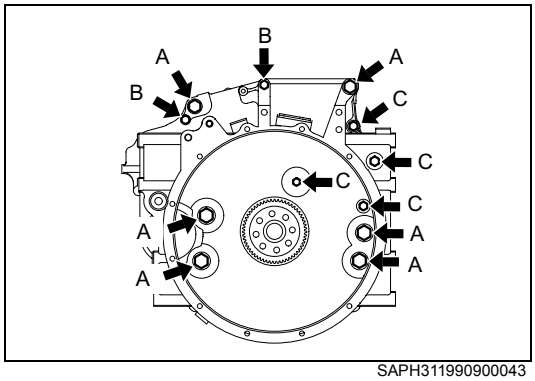
SAPH311990900042

2. Installation of flywheel housing

(1) Remove contamination from the joint surfaces of the flywheel housing and the end plate using a scraper.

(2) Apply the liquid gasket [Threebond TB1207D (silver) or equivalent] to the flywheel housing as shown in the figure.

⚠ **CAUTION**
- **Apply it continuously.**
- **Apply the liquid gasket at the width of 1.5 to 2.5 mm{0.0591 to 0.0984 in.}.**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**



SAPH311990900043

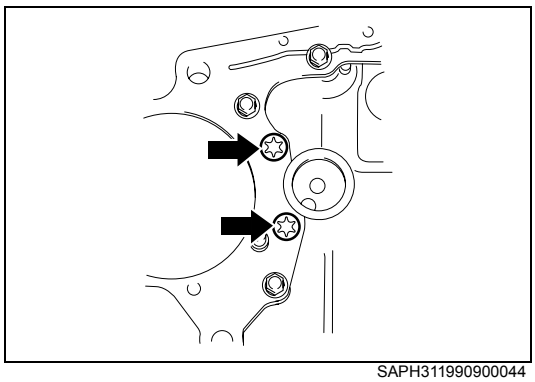
(3) Install the flywheel housing on the cylinder block with bolts.

Tightening torque :
196 N·m {2,000 kgf·cm, 145 lbf·ft} (Area A)
36 N·m {370 kgf·cm, 27 lbf·ft} (Area B)
55 N·m {560 kgf·cm, 41 lbf·ft} (Area C)

⚠ **CAUTION**
- **Tighten bolts fixing the flywheel housing from the cylinder block.**

Replacement of end plate

JP31199090702004

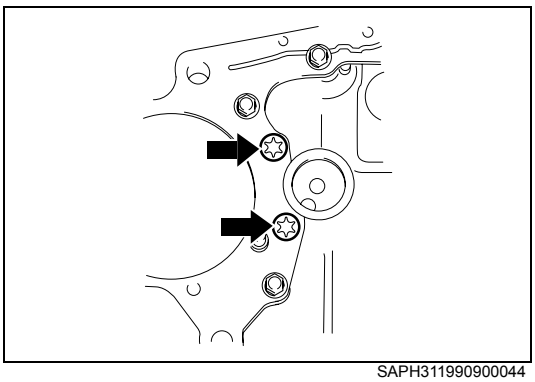


SAPH311990900044

1. Removal of end plate

(1) Remove bolts.

(2) Remove the Torx bolt and remove the end plate using a special tool.
Special tool : 09411–1300 Socket wrench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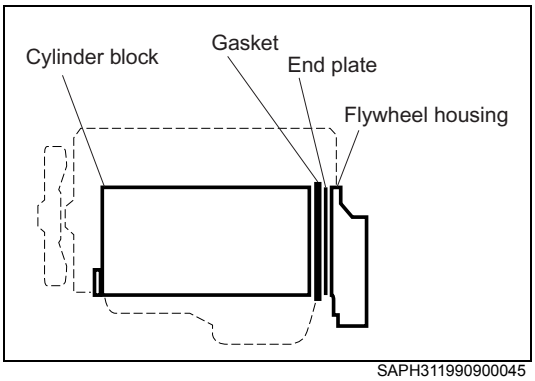


SAPH311990900045

2. Installation of end plate

(1) Install the end plate and a new gasket with bolts.

⚠ **CAUTION**
- **Make sure that there is no dirt or foreign matter on the installation surface of the cylinder block and the screw holes.**

(2) Apply sealant (Super 5M or equivalent) to the thread of the Torx bolt.

(3) Install the Torx bolt using a special tool.
Special tool : 09411–1300 Socket wrench

Tightening torque : 55 N·m {560 kgf·cm, 41 lbf·ft}

(4) Cut the gasket with a scraper to be flush to the upper/ lower surfaces of the cylinder block.

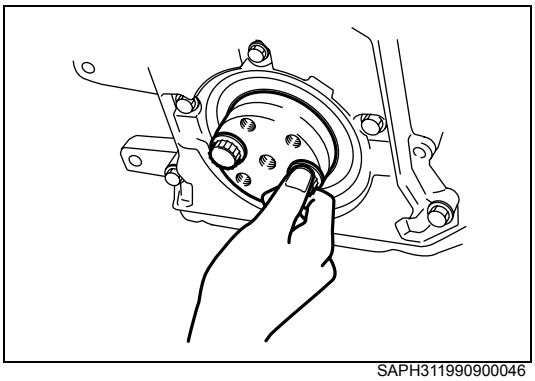
Replacement of crankshaft front oil seal

JP31199090704004

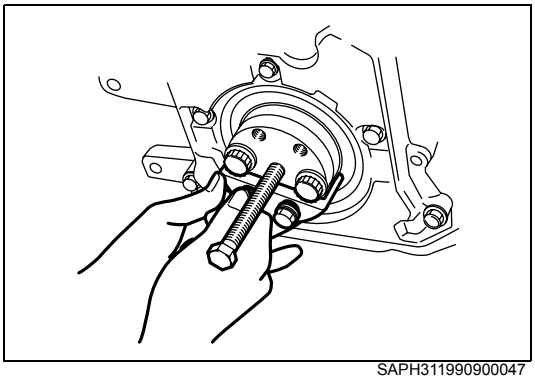
1. Removal of front oil seal

(1) Install the plate of the special tool oil seal puller on the crankshaft using two crankshaft damper mounting bolts.

Special tool : 09420–1731 Oil seal puller


SAPH311990900046

(2) Hook the special tool oil seal puller with the tab of the front oil seal and install the hook on the plate of the special tool oil seal puller with accompanying bolts.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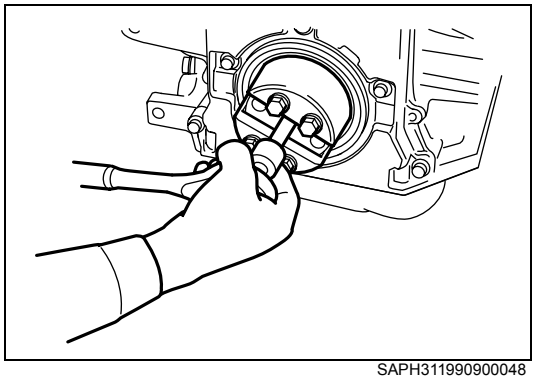
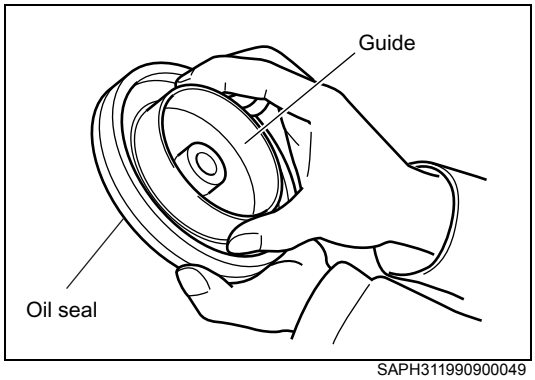

SAPH311990900048

(3) Remove two bolts which installed the plate of the special tool oil seal puller on the crankshaft.

(4) Attach the accompanying center bolt to the special tool oil seal puller and tighten it. Pull out the front oil seal.

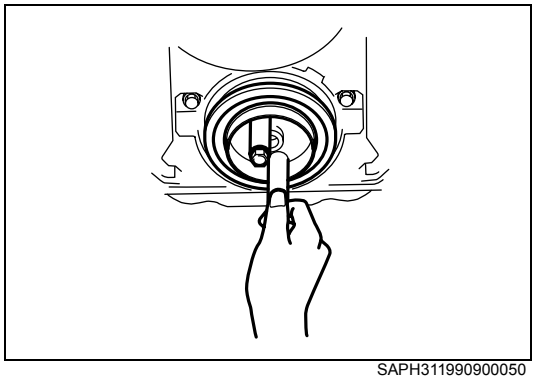


SAPH311990900049

2. Installation of front oil seal

(1) Insert a new oil seal into the guide of the oil seal press.
Special tool : 09407–1030 Oil seal press

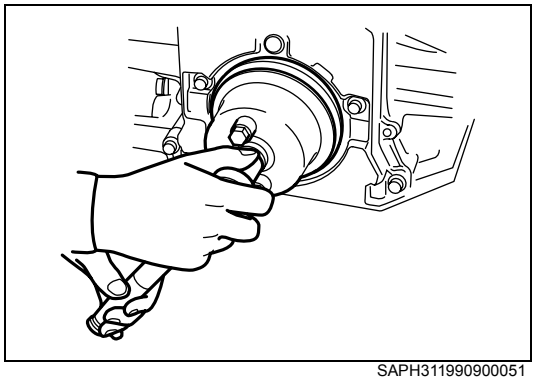
⚠ **CAUTION** • **Be careful for front/rear directions of the front oil seal. (The felt surface is at the crankshaft damper side.)**


SAPH311990900050

(2) Remove contamination from the joint surface of the front oil seal and the cylinder block.

(3) Apply small amount of engine oil to the seal area of the front oil seal.

(4) Install the oil seal press guide inserting a new front oil seal with accompanying guide bolts on the crankshaft.

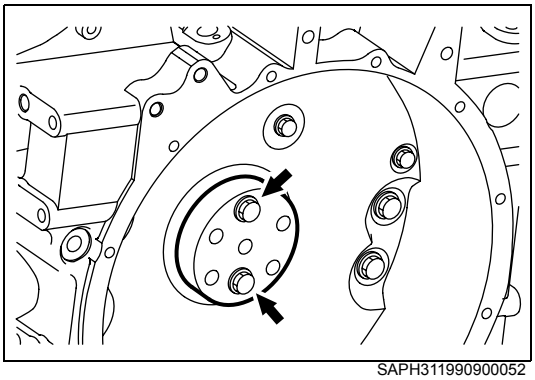

SAPH311990900051

(5) Align the oil seal press hole to the guide bolt and insert the oil seal press.

(6) Attach the accompanying center bolt to the oil seal press and tighten it until stop. Press fit the front oil seal.

Replacement of crankshaft rear oil seal

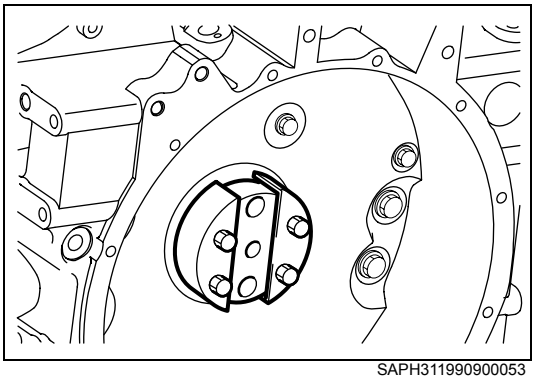
JP31199090704005


SAPH311990900052

1. Removal of rear oil seal

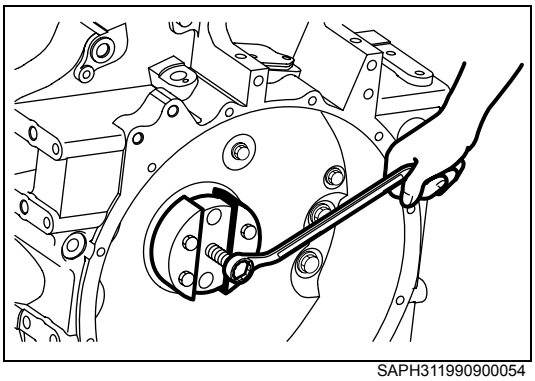
(1) Install the plate of the special tool oil seal puller on the crankshaft using two flywheel assembly mounting bolts.
Special tool : 09420–1742 Oil seal puller

⚠ **CAUTION** • **Align the large hole of the plate with the collar dowel of the crankshaft.**

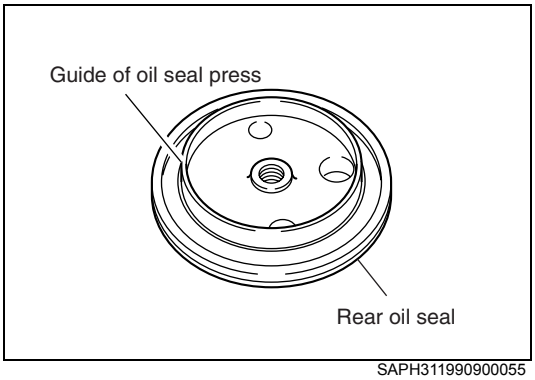

SAPH311990900053

(2) Hook the oil seal puller with the tab of the rear oil seal and install the hook on the plate of the oil seal puller with accompanying bolts.

(3) Remove two bolts which installed the plate of the oil seal puller on the crankshaft.


SAPH311990900054

(4) Attach the accompanying center bolt to the oil seal puller and tighten it. Pull out the rear oil seal.

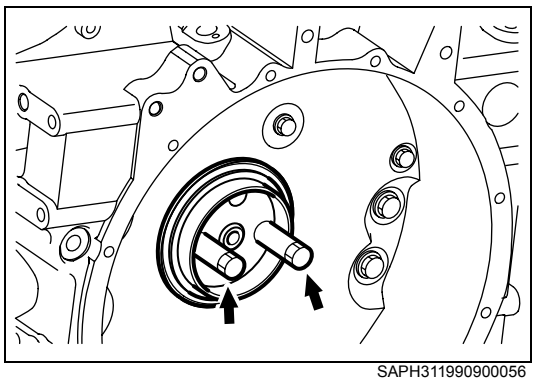


SAPH311990900055

2. Installation of rear oil seal

(1) Insert a new rear oil seal into the guide of the oil seal press.
Special tool : 09407–1040 Oil seal press

⚠ **CAUTION** • **Be careful for front/rear directions of the rear oil seal. (The felt surface is at the flywheel side.)**

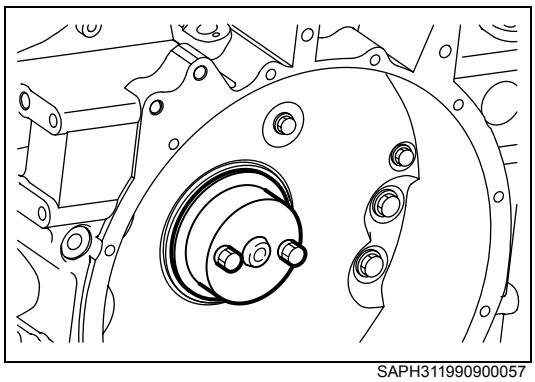

SAPH311990900056

(2) Remove contamination from the joint surface of the rear oil seal and the flywheel housing

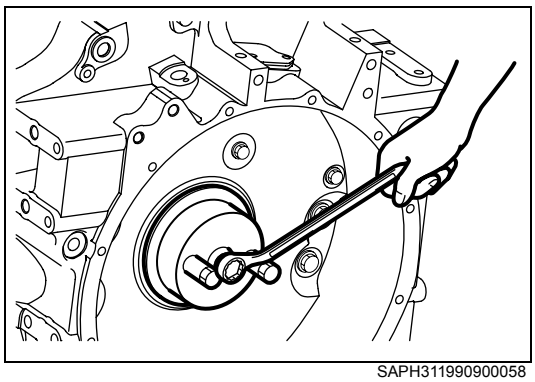
(3) Apply small amount of engine oil to the seal area of the rear oil seal.

(4) Install the oil seal press guide inserting a new rear oil seal with accompanying guide bolts on the crankshaft.

⚠ **CAUTION** • **Align the large hole of the guide with the collar dowel of the crankshaft.**


SAPH311990900057

(5) Align the oil seal press hole to the guide bolt and insert the oil seal press.

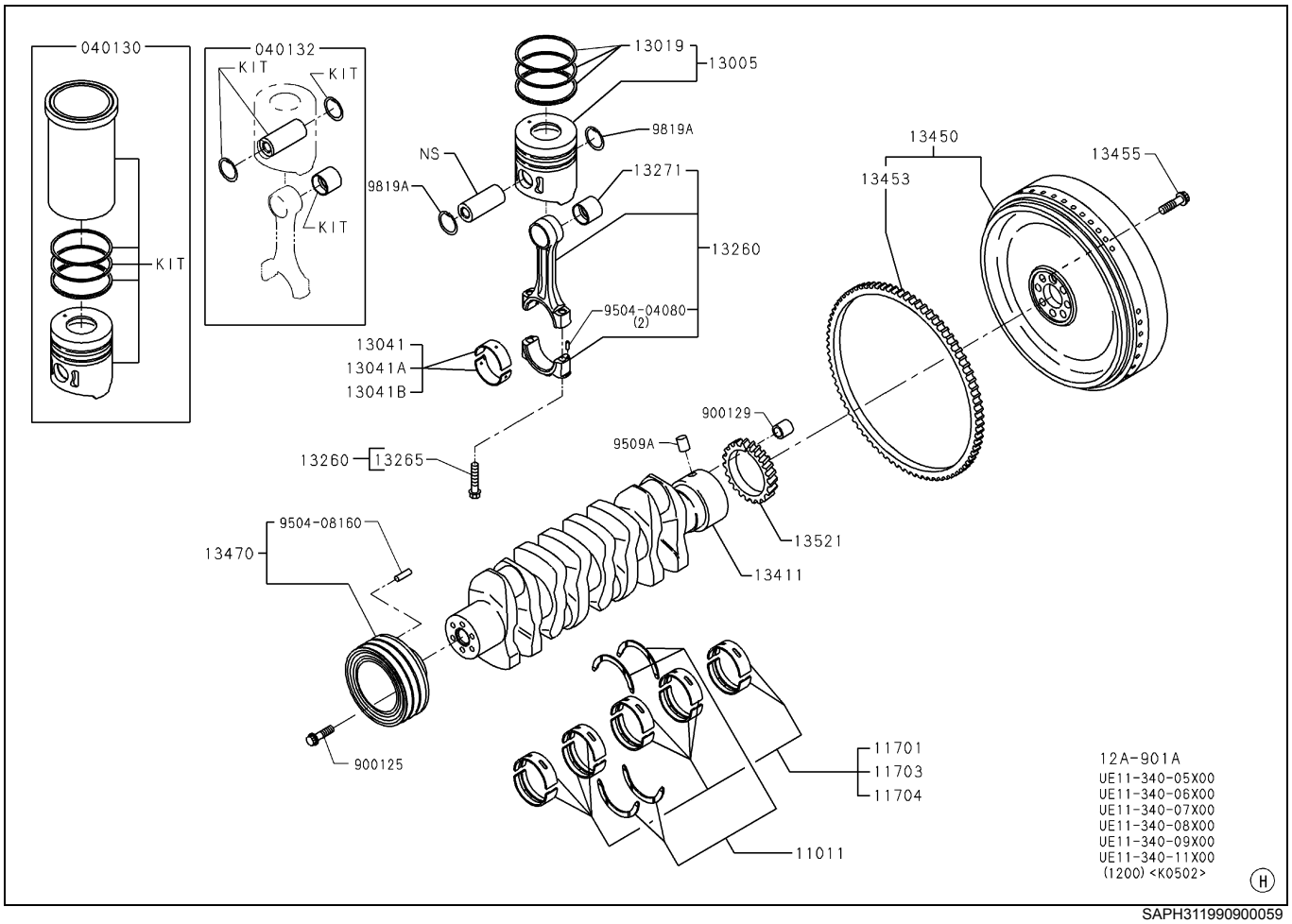

SAPH311990900058

(6) Attach the accompanying center bolt to the oil seal press and tighten it until stop. Press fit the rear oil seal.

Main Moving Parts

Part layout

JP31199090402004



SAPH311990900059

11011	Thrust bearing	13260	Connecting rod assembly
11701	Main bearing	13271	Connecting rod bush
11703	Main bearing US 0.25	13411	Crankshaft
11704	Main bearing US 0.50	13450	Flywheel assembly
13005	Piston, Piston ring set	13453	Ring gear
13041	Connecting rod bearing	13470	Crankshaft pulley
13041A	Connecting rod bearing	13521	Crankshaft gear
13041B	Connecting rod bearing	9819A	Retainer ring*

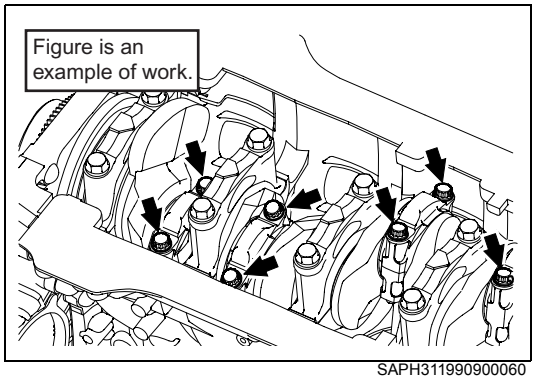
*Parts not to be reused.

Tightening torque

13265	69N·m{700kgf·cm, 51lbf·ft}+90°+45°	900125	118N·m {1, 200 kgf·cm, 87lbf·ft}
13455	186N·m {1, 900 kgf·cm, 137lbf·ft}		

Replacement of piston and connecting rod

JP31199090702005

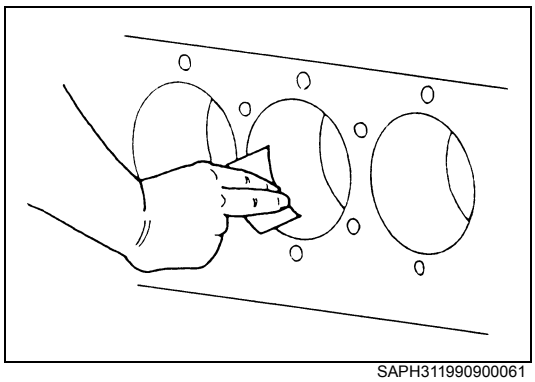


SAPH311990900060

1. Removal of piston

(1) Remove bolts and remove the connecting rod cap.

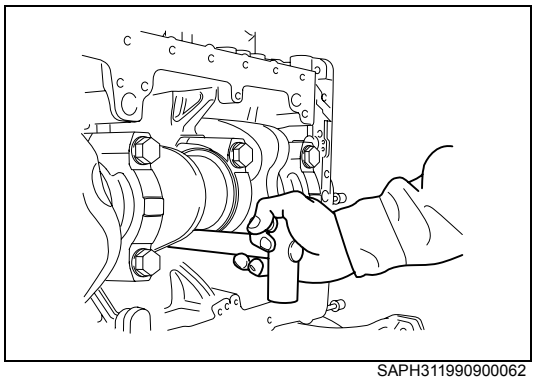
⚠ **CAUTION**
- **Insert a large flat tip screwdriver into the flywheel gear from the flywheel housing inspection hole to prevent turning of the crankshaft.**
- **Store removed connecting rod cap for each cylinder number so that combinations of the connecting rod and the connecting rod cap may not be changed.**


SAPH311990900061

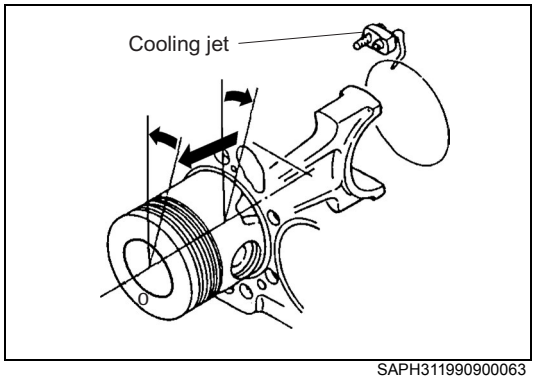
(2) Remove carbon on the cylinder liner inner surface with a scraper or a sand paper (No. 150 or so) in the circumferential direction.

⚠ **CAUTION**
- **Do not damage parts lower than the carbon deposit area.**

(3) Fix the cylinder liner with bolts and a plate.


SAPH311990900062

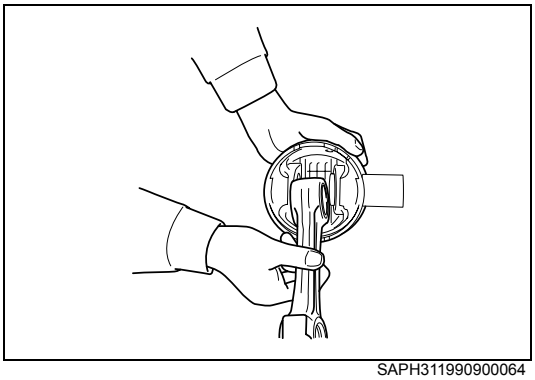
(4) Hit the connecting rod from underneath the engine using a handle of a hammer. Remove the piston together with the connecting rod.



SAPH311990900063

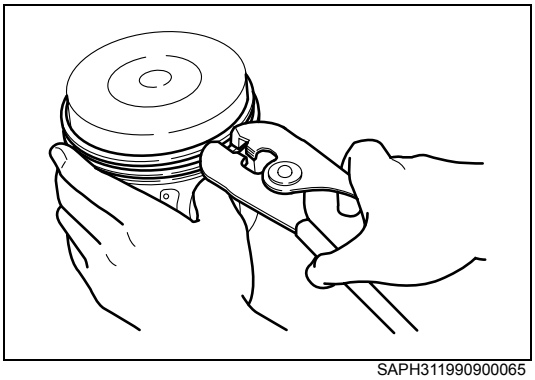
NOTICE
- **In removing the piston, rotate the connecting rod as shown in the figure. Do not bend the cooling jet.**

⚠ **CAUTION**
- **Store removed pistons and connecting rods for each cylinder number.**
- **Be careful not to touch the cooling jet.**


SAPH311990900064

2. Disassembly of piston and connecting rod

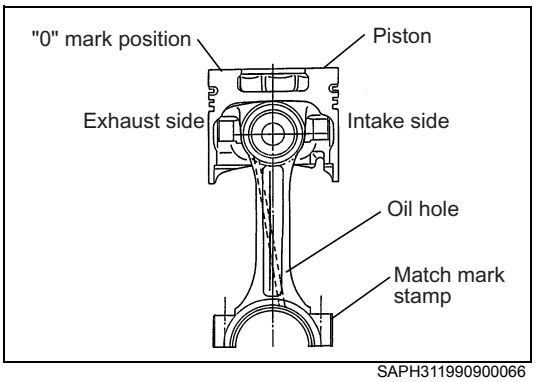
(1) Remove the retainer ring using snap ring pliers.
(2) Remove the piston pin using the brass bar and disconnect the piston from the connecting rod.


SAPH311990900065

(3) Remove the piston ring using a special tool.

Special tool : 09442–1011 Piston ring expander

⚠ **CAUTION**
- **Since the piston ring is susceptible to damage, be careful for handling.**
- **Store piston rings for each cylinder number.**
- **Store the piston rings so that the upper and lower surfaces may be identified.**

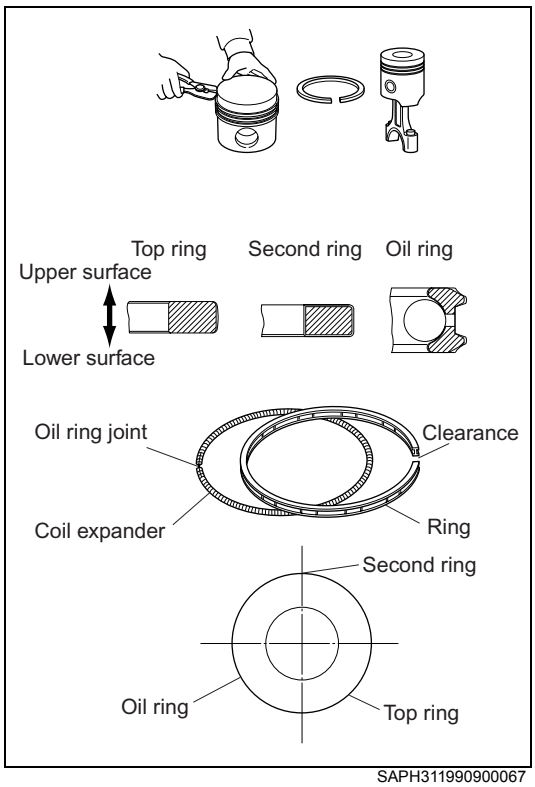


SAPH311990900066

3. Assembly of piston and connecting rod

(1) Install the piston on the connecting rod so that the "0" mark on the piston may be opposite to the match mark stamp on the connecting rod
(2) Install a new retainer ring using a snap ring pliers.

⚠ **CAUTION**
- **Make sure that there is no backlash in the retainer ring.**



SAPH311990900067

(3) Face the side with the piston ring identification print upward and install in the order of the oil ring, second ring and top ring using a special tool.

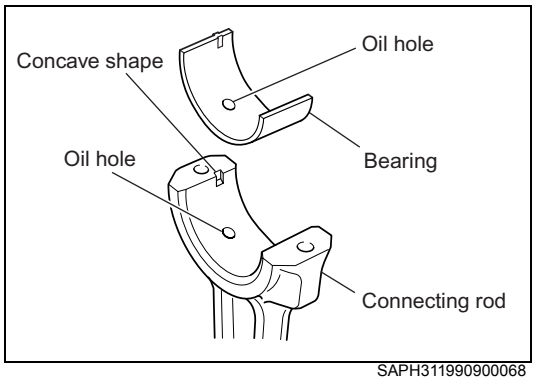
NOTICE

- **The identification print is present only on the secondary ring and the top and bottom of the top ring and the oil ring are not identified.**

Special tool : 09442–1011 Piston ring expander

(4) Connect the joint of the coil expander and fit the oil ring inside the ring. Offset the coil expander joint with the ring joint by 180 deg for installation.

(5) Allocate the joints of the piston ring with uniform intervals as shown in the figure.



SAPH311990900068

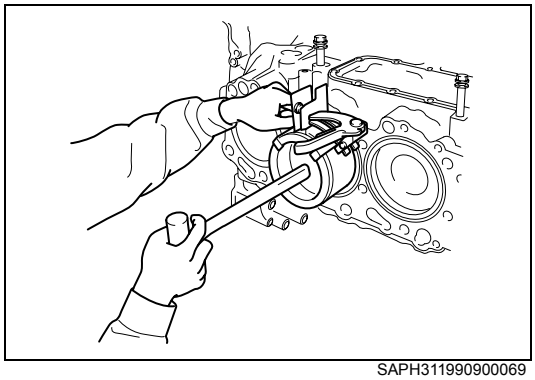
4. Installation of piston and connecting rod

(1) Allocate the joints of the piston ring with uniform intervals as shown in the figure.

(2) Install the connecting rod bearing to suit concave shape of the connecting rod.

⚠ CAUTION

- **Make sure that the oil hole of the connecting rod bearing is aligned with the oil hole of the connecting rod.**

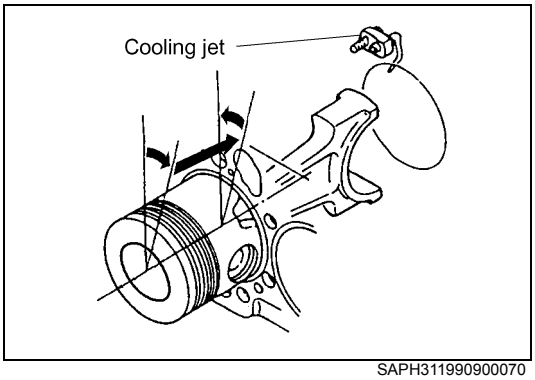

SAPH311990900069

(3) Apply engine oil to the piston, cylinder liner and connecting rod bearing and compress the piston ring using a special tool.

Special tool : 09441–1370 Piston ring holder

⚠ CAUTION

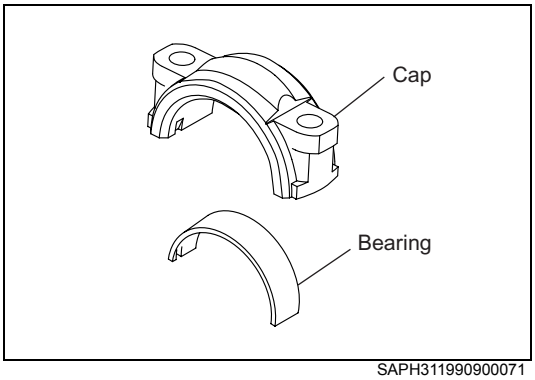
- **Make sure that there is no deformation or damage to the special tool piston ring holder.**



SAPH311990900070

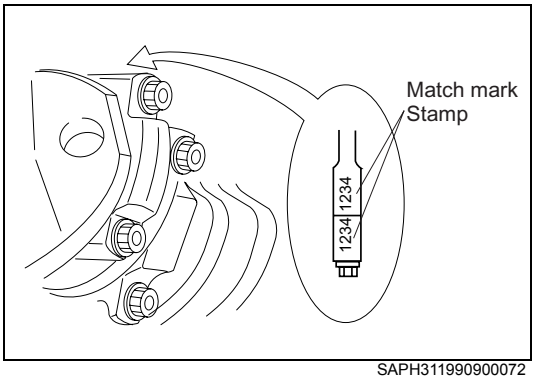
(4) Insert the piston carefully so that the connecting rod may not come in contact with the cooling jet.

⚠ **CAUTION**
- **Face the "0" mark on the piston toward the exhaust side for insertion.**
- **Set the crankshaft of the cylinder as the top dead center for assembly.**
- **Do not damage the cylinder liner, crankshaft and cooling jet during work.**



SAPH311990900071

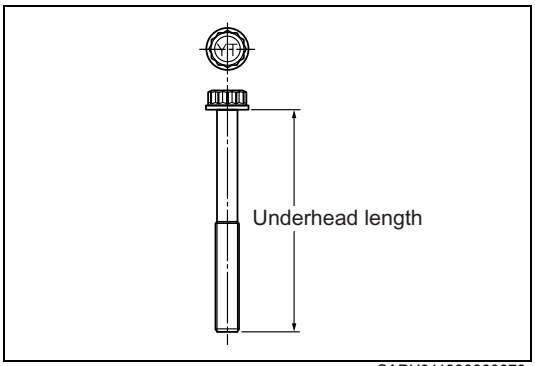
(5) Install the connecting rod bearing to suit concave shape of the connecting rod cap.



SAPH311990900072

(6) Align the match mark of the connecting rod cap with that of the connecting rod and fix it with a dowel pin.

⚠ **CAUTION**
- **Do not change the combination between the connecting rod and the connecting rod cap.**

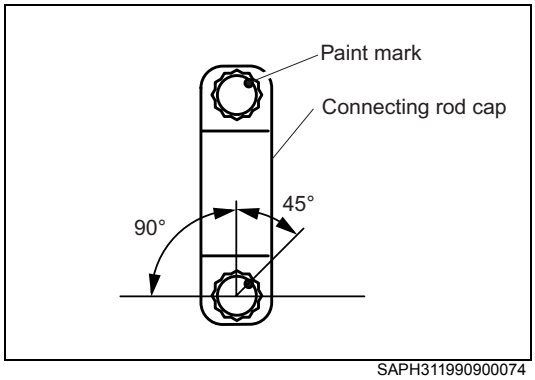


SAPH311990900073

(7) Measure the underhead length of the connecting rod bolt using a vernier calipers. If it is out of the service limit, replace it with a new one.

Service limit (mm{in.})	**68.0{2.6772} or less**

(8) Apply engine oil to the connecting rod bolt thread and the seat and install it on the connecting rod.



SAPH311990900074

(9) Tighten the connecting rod bolt and mark the bolt head in the same direction with paint.

Tightening torque : 69 N·m {700 kgf·cm, 51 lbf·ft}

(10) Retighten the connecting rod bolt 90 °.

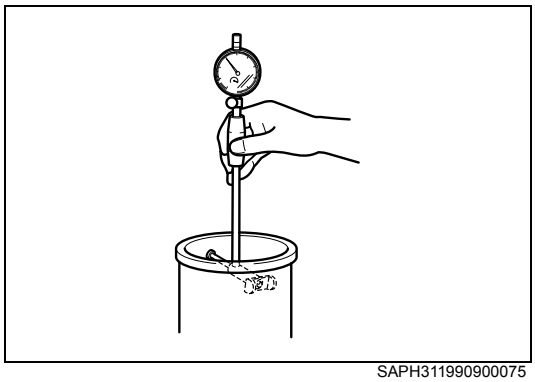
(11) Retighten the connecting rod bolt further 45 °.

(12) Make sure that all marks are in the same direction.

⚠ **CAUTION** • **If a bolt is turned excessively in retightening, do not loosen it.**

Inspection of piston and connecting rod

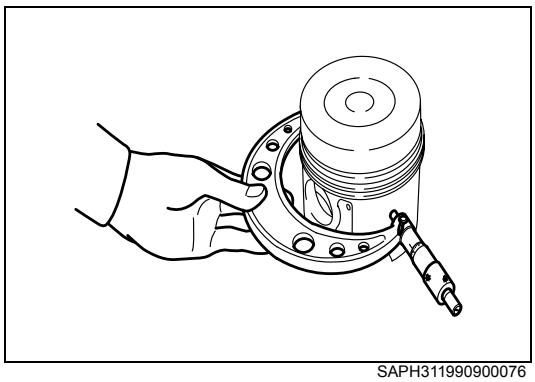
JP31199090703001


SAPH311990900075

1. Inspection of piston clearance

(1) Measure the inner diameter of the cylinder liner sliding surface using a cylinder gauge.

Standard value (mm{in.})	Service limit (mm{in.})
112{4.4095}	112.15{4.4153}


SAPH311990900076

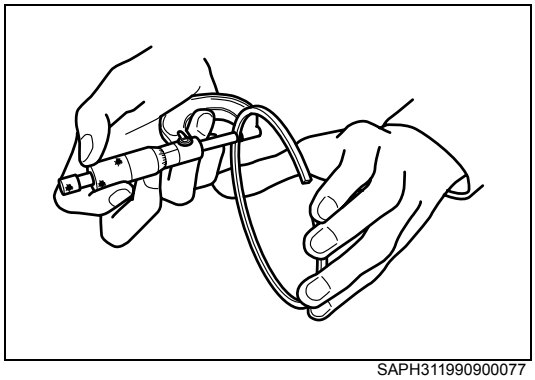
(2) Measure the piston outer diameter using a micrometer.

⚠ **CAUTION** • **The measuring position is 23 mm{0.9055 in.} above the piston lower end and square to the pin hole.**

Standard value (mm{in.})	111.9±0.006{4.4055±0.0002}

(3) Calculate the difference between the inner diameter of the cylinder liner and the outer diameter of the piston. If it is beyond the standard value, replace the cylinder liner and the piston.

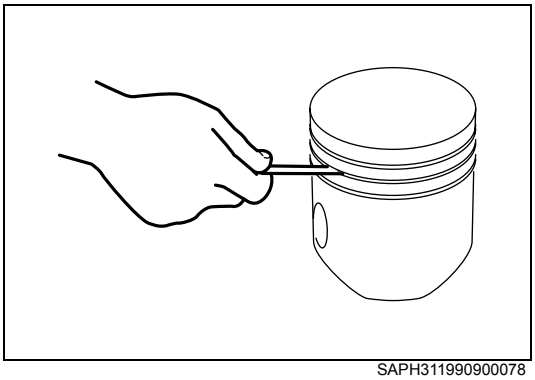
Standard value (mm{in.})	0.088 - 0.112{0.0035 - 0.0044}}


SAPH311990900077

2. Inspection of clearance between piston ring and ring groove

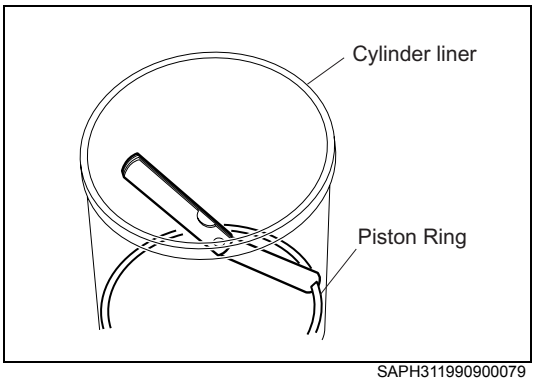
(1) Measure the piston ring width using a micrometer. If it is beyond the service limit, replace the piston ring.

	Standard value (mm{in.})	Service limit (mm{in.})
Top ring	2.5{0.0984}	2.40{0.0945}
Second ring	2{0.0787}	1.90{0.0748}
Oil ring	4{0.1575}	3.90{0.1535}


SAPH311990900078

(2) Measure the piston ring groove using a thickness gauge. If it is out of the service limit, replace the piston.

	Standard value (mm{in.})	Service limit (mm{in.})
Top ring groove	2.5{0.0984}	2.70{0.1063}
Second ring groove	2{0.0787}	2.20{0.0866}
Oil ring groove	4{0.1575}	4.10{0.1614}



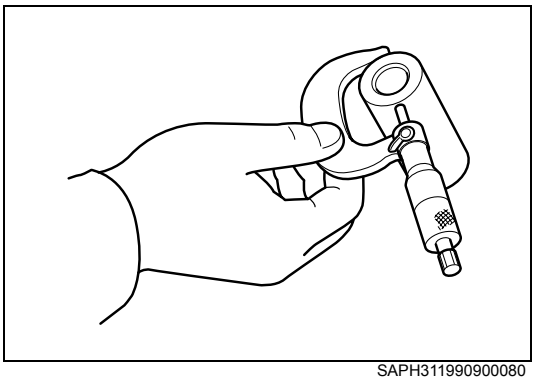
SAPH311990900079

3. Inspection of piston ring joint clearance

(1) Insert the piston ring into the cylinder liner by 80 mm horizontally using piston.

(2) Measure the piston ring joint clearance using a thickness gauge. If it is out of the service limit, replace the piston ring.

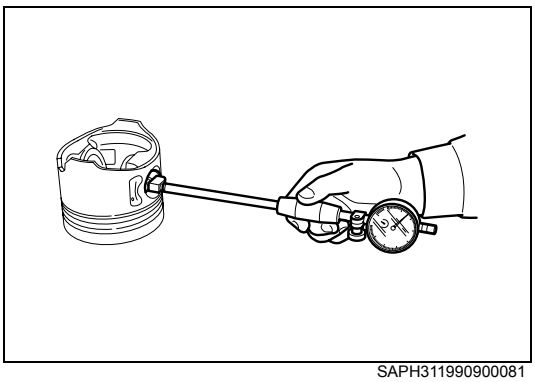
	Standard value (mm{in.})	Service limit (mm{in.})
Top ring	0.3 - 0.40 {0.0118 - 0.0157}	1.5{0.0591}
Second ring	0.75 - 0.9 {0.0295 - 0.0354}	1.2{0.0472}
Oil ring	0.15 - 0.3 {0.0059 - 0.1181}	1.2{0.0472}


SAPH311990900080

4. Inspection of piston pin

(1) Measure the outer diameter of the contact area of the piston pin with the piston boss using a micrometer.

Standard value (mm{in.})	Service limit (mm{in.})
37 {1.4567}	36.96{1.4551}


SAPH311990900081

(2) Measure the piston boss inner diameter using a cylinder gauge.

Standard value (mm{in.})	Service limit (mm{in.})
37 {1.4567}	37.05{1.4587}

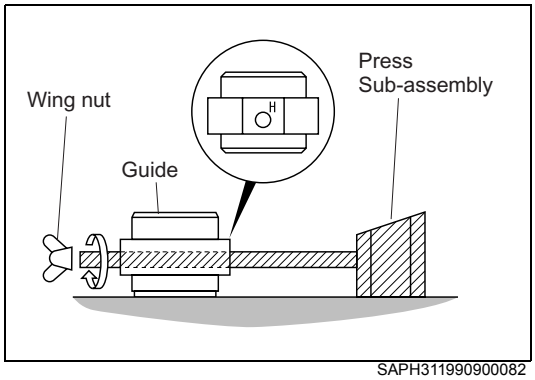
(3) Calculate the difference between the outer diameter of the piston pin contact area with the piston boss and the inner diameter of the piston boss. If it is out of the service limit, replace the piston pin or piston.

Standard value (mm)	Service limit (mm{in.})
–0.002T-0.025L	0.05{0.0020}

T : Tightening allowance, L : Clearance

Replacement of connecting rod bushing

JP31199090704006



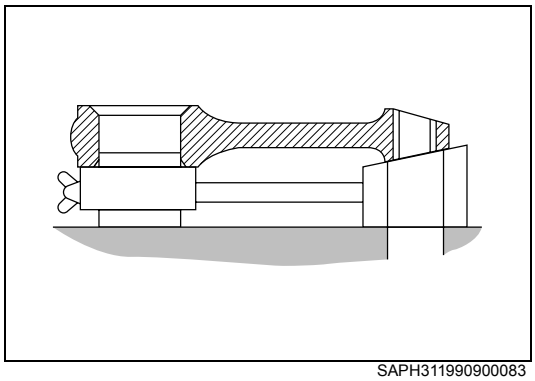
SAPH311990900082

1. Removal of connecting rod bushing

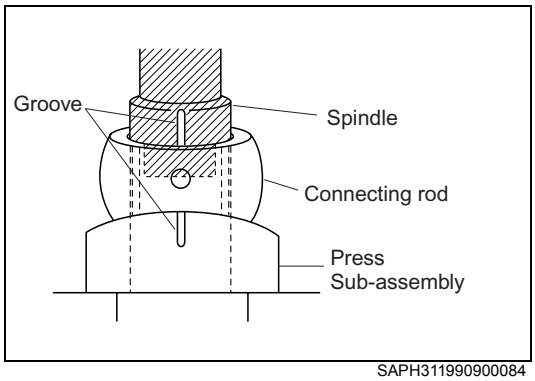
(1) Put the special tool press sub-assembly together with the special tool guide nut and fix them using the special tool wing nut.

Special tool : 09481–1130 Guide
09402–1530 Press sub-assembly
9233–10360 Wing nut

⚠ **CAUTION**
- **Face "H" mark of the guide upward for assembly.**
- **Assemble it on a level table and make sure that the lower end of the guide and the press sub-assembly is flat.**


SAPH311990900083

(2) With the large end bearing removed, assemble the connecting rod and put it on the assembled special tool.

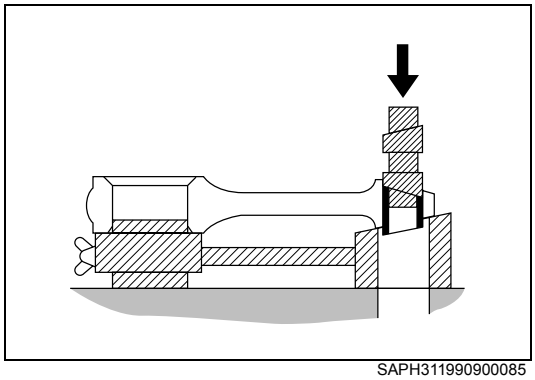


SAPH311990900084

(3) Install the special tool spindle on the bushing of the connecting rod.

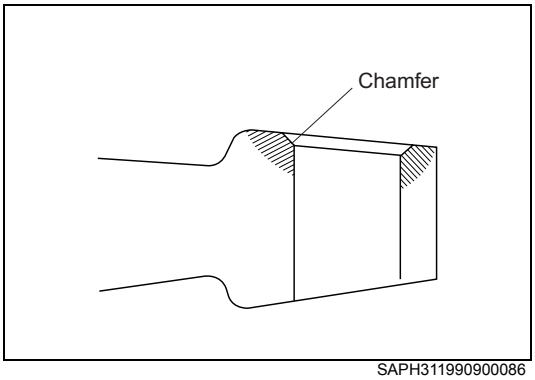
Special tool : 09402–1540 Spindle

⚠ **CAUTION**
- **Align the press sub-assembly groove with the special tool spindle groove for installation.**


SAPH311990900085

(4) Remove the bushing of the connecting rod using a press.

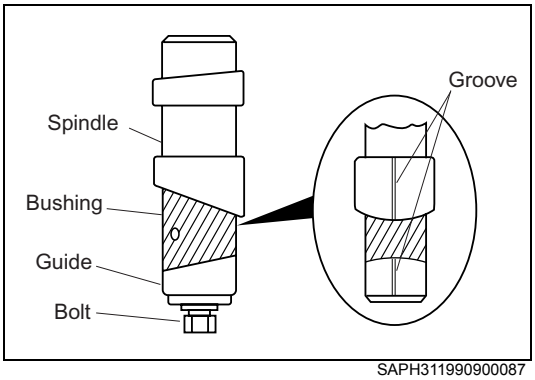
⚠ **CAUTION**
- **Move the press slowly.**



SAPH311990900086

(5) Chamfer one side of the connecting rod small end uniformly according to the figure.

⚠ **CAUTION**
- **Remove burr completely.**
- **After chamfering, remove dirt from the inner surface at the small end and from the oil hole.**



SAPH311990900087

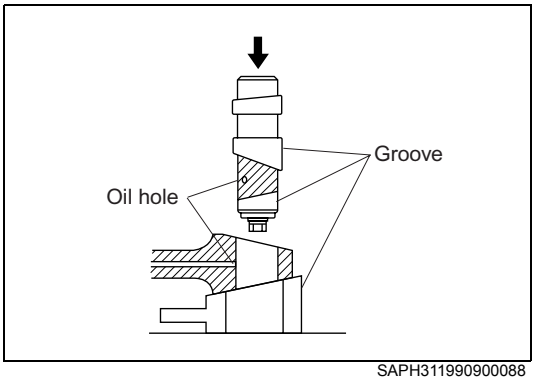
2. Installation of connecting rod bushing

(1) Install a new bushing on the special tool spindle and install the special tool guide and the special tool bolt.

Special tool : 09402–1540 Spindle
09481–1540 Guide
9191–08252 Bolt

Tightening torque :
5 - 6 N·m {50 - 70 kgf·cm, 3.5 - 4 lbf·ft}

⚠ **CAUTION**
- **Align grooves of the special tool guide and the special tool spindle for installation.**
- **Make sure that the edge of the special tool spindle and the special tool guide is in close contact.**



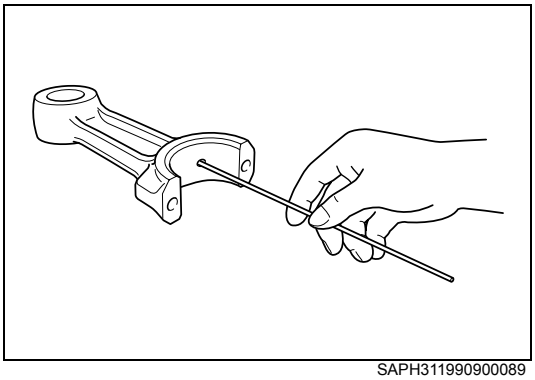
SAPH311990900088

(2) Align the connecting rod oil hole with the bushing oil hole assembled on the special tool. Make sure that the groove of the special tool spindle is in alignment with the groove of the special tool press sub-assembly.

⚠ **CAUTION**
- **Place the connecting rod so that the chamfer side of the connecting rod small end inner diameter may be the bushing side**
- **Apply engine oil to the inner diameter surface of the connecting rod.**

(3) Install the bushing on the connecting rod using a press.

(4) Insert a rod with the diameter of 6 mm from the oil hole at the connecting rod large end and make sure that it goes through the oil hole at the small end.

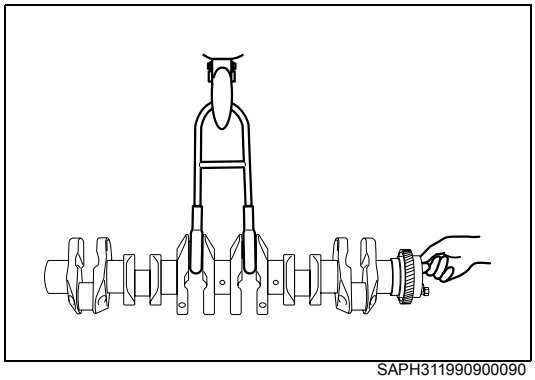

SAPH311990900089

NOTICE
- **Displacement of oil holes may cause insufficient lubrication, resulting in seizure.**

(5) Insert a new piston pin and check if there is no drag or backlash.

Replacement of crankshaft

JP31199090704007

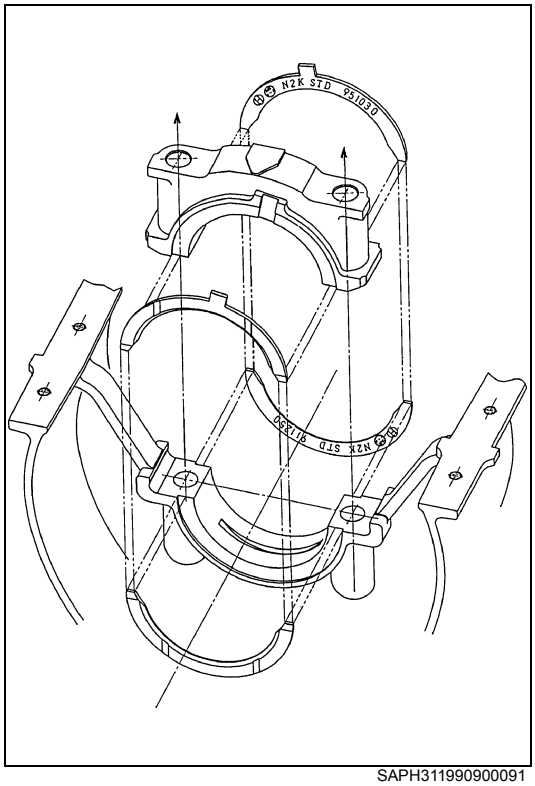


SAPH311990900090

1. Removal of crankshaft

(1) Remove the main bearing cap and the main shaft bearing. Remove the crankshaft using a hoist.

⚠ **CAUTION**
- **Since the part is heavy, be careful for handling.**
- **Store removed main bearing caps and main bearings for each cylinder number.**



SAPH311990900091

2. Installation of crankshaft

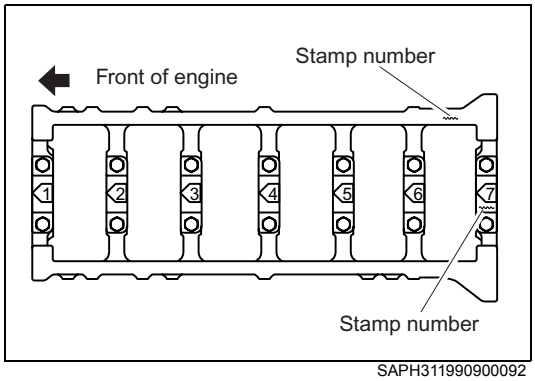
(1) Face the groove side (front) of the thrust bearing toward the crankarm and the part number side (back) toward the main bearing cap or the cylinder block. Install it on the cylinder block and the main bearing cap.

⚠ **CAUTION**
- **To prevent falling in assembly, apply engine oil or grease to the back of the thrust bearing.**

(2) Install the main bearing on the cylinder block and each bearing cap.

⚠ **CAUTION**
- **Assemble the bearing with oil hole on the cylinder block and assemble the bearing without oil hole on the cap.**
- **Apply new engine oil to the sliding surfaces of each bearing.**

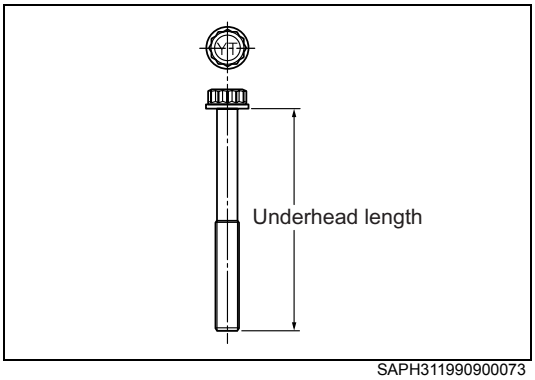
(3) Align the crankshaft with the cylinder block.



SAPH311990900092

(4) Align the main bearing cap which has the thrust bearing and the main bearing with the cylinder block.

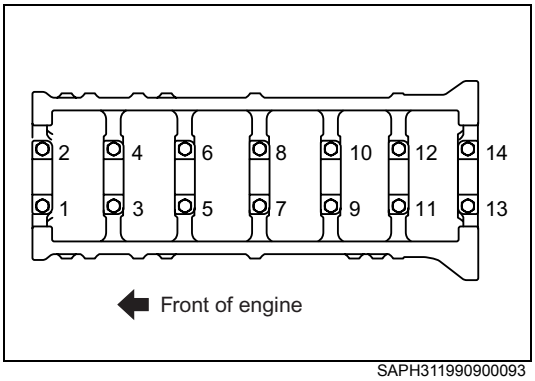
⚠ **CAUTION**
- **The pentagon mark on the main bearing cap should face the front of the vehicle. Align in the order of 1, 2, 3, 4, 5, 6 and 7 from the front.**
- **Check the stamp number of each main bearing cap with the stamp number of the cylinder block.**



SAPH311990900073

(5) Measure the underhead length of the bearing cap bolt using a vernier calipers. If it is out of the service limit, replace it with a new one.

Service limit (mm{in.})	108{4.252}



SAPH311990900093

(6) Apply engine oil to the bolt seat and the bolt thread of the bearing cap bolt.

(7) Tighten the bearing cap bolt according to the sequence in the figure.
Tightening torque : 69 N·m {700 kgf·cm, 51 lbf·ft}

(8) Loosen the bearing cap fixing the thrust bearing and hit the crankshaft gently at the front/rear end using a plastic hammer.

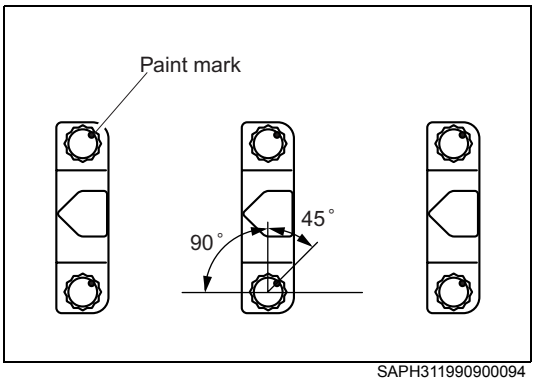
(9) Loosen all bearing cap bolts.

(10) Tighten the bearing cap bolt as in (7).
Tightening torque : 69 N·m {700 kgf·cm, 51 lbf·ft}

(11) Mark bearing cap bolt heads in the same direction with paint.

(12) Tighten 90 deg (1/4 turn) with the same order as in (7).

(13) Retighten 45 deg (1/8 turn) as in (7).



SAPH311990900094

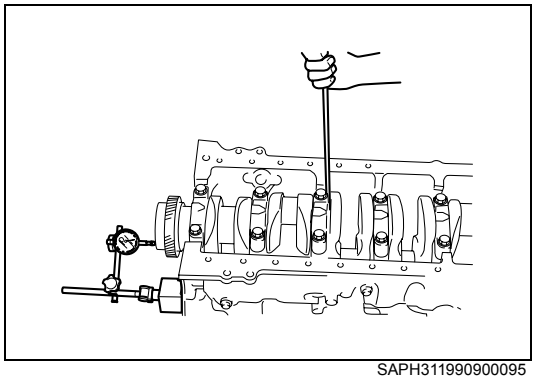
(14) Make sure that all paint marks are in the same direction.

⚠ **CAUTION**
- **If it is excessively retightened, do not loosen it.**

(15) After tightening, hit the front/rear ends of the crankshaft gently with a plastic hammer for initial fit.

⚠ **CAUTION**
- **Make sure that the crankshaft turns smoothly.**
- **Measure the end play of the crankshaft and make sure that it is within the standard value.**

Standard value (mm{in.})	Repair limit (mm{in.})	Service limit (mm{in.})
0.050 - 0.219 {0.0020 - 0.0086}}	0.50{0.0197}	1.219{0.0480}


SAPH311990900095

Inspection of crankshaft

JP31199090703002

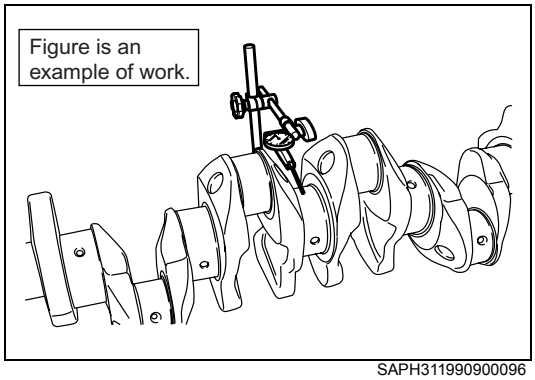
1. Inspection of end play

(1) Measure the end play of the crankshaft using a dial gauge. If it is beyond the repair limit, replace the thrust bearing. If it is beyond the service limit, replace the crankshaft.

Standard value (mm{in.})	Repair limit (mm{in.})	Service limit (mm{in.})
0.050 - 0.219 {0.020 - 0.0086}	0.50{0.0197}	1.219{0.0480}

NOTICE

- **Standard width of thrust bearing2.5mm{0.0984in.}**

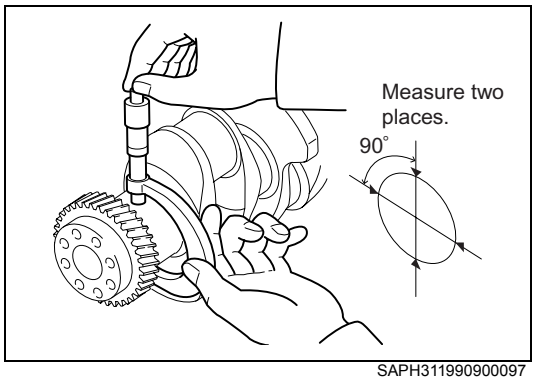


SAPH311990900096

2. Inspection of rotation runout

(1) Measure the crankshaft rotation runout using a dial gauge. If it is beyond the repair limit, grind the crankshaft and use the undersize bearing.

Repair limit (mm{in.})	0.15{0.0060}



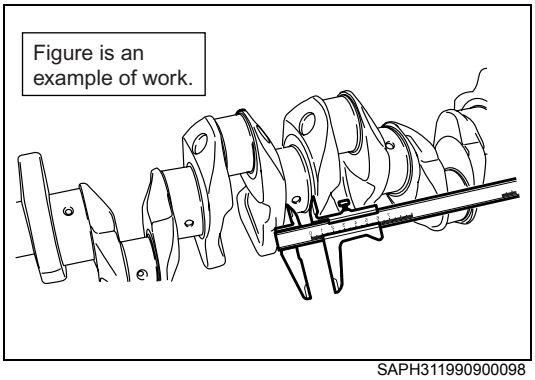
SAPH311990900097

3. Inspection of journal wear

(1) Measure the outer diameter of the crankshaft journal using a micrometer. If it is faulty, grind or replace the crankshaft. When the crankshaft is ground, use the undersize bearing.

Journal standard value (mm{in.})	80{3.1496}

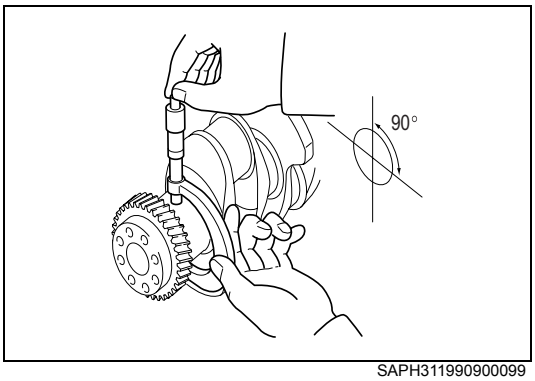
Wear value (mm{in.})	Action
Eccentric wear 0.10{0.0039}	Regrind for correction.
Wear of 0.20{0.0079} or more	Regrind
Wear of 1.20{0.0472}	Replace the crankshaft.



SAPH311990900098

(2) Measure the crankshaft center journal width using a vernier calipers. If it is out of the service limit, replace the crankshaft.

Standard value (mm{in.})	Service limit (mm{in.})
36{1.4173}	37.0{1.4567}

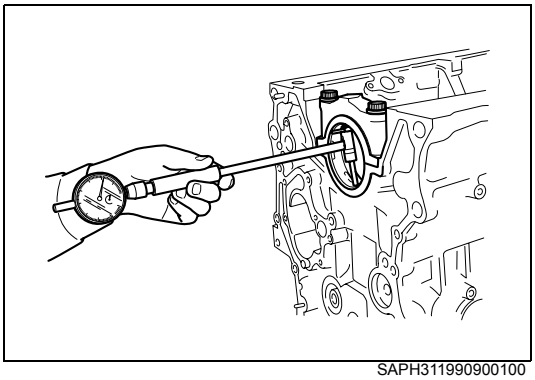


SAPH311990900099

4. Inspection of crankshaft oil clearance

(1) Measure the outer diameter of the crankshaft journal using a micrometer.

Standard value (mm{in.})	Service limit (mm{in.})
80{3.1496}	78.8{3.1024}


SAPH311990900100

(2) Do not install the crankshaft. Install the crankshaft bearing and the main bearing cap on the cylinder block.

(3) Measure the crankshaft bearing inner diameter using a cylinder gauge.

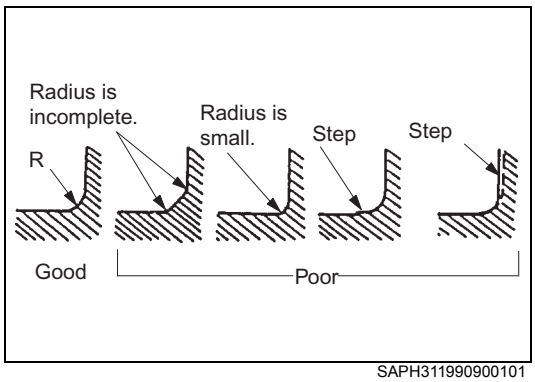
(4) Calculate the difference between the outer diameter of the crankshaft journal and the inner diameter of the crankshaft bearing. If it is beyond the repair limit, grind the crankshaft and use the undersize bearing.

Standard value (mm{in.})	Repair limit (mm{in.})
0.051 - 0.102 {0.0020 - 0.0040}	0.2{0.0079}

NOTICE

- **Standard bearing thickness : 2.5mm**
- **Undersize bearing value : 0.25, 0.50, 0.75, 1.00**

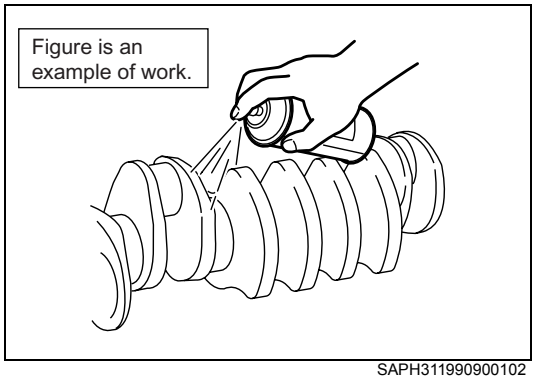
Bearing size	Journal outer diameter (mm{in.})
Standard	79.940 - 79.960 {3.1472 - 3.1480}
0.25.00US	79.690 - 79.710 {3.1374 - 3.1382}
0.50US	79.440 - 79.460 {3.1276 - 3.1283}
0.75US	79.190 - 79.210 {3.1177 - 3.1185}
1.00US	78.940 - 78.960 {3.1079 - 3.1087}



SAPH311990900101

(5) Dimension of fillet "R"

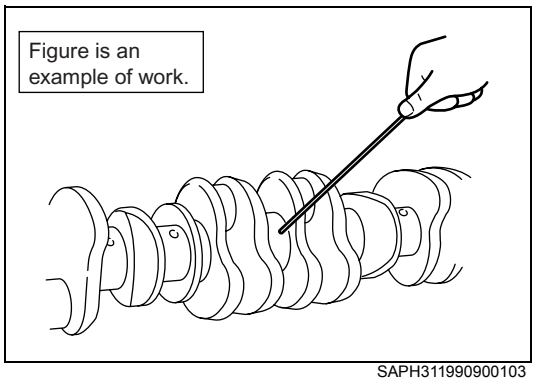
Crank pin
2.5 to 3.0mm {0.0984 to 0.1181 in.}
Journal
2.5 to 3.0mm {0.0984 to 0.1181 in.}



SAPH311990900102

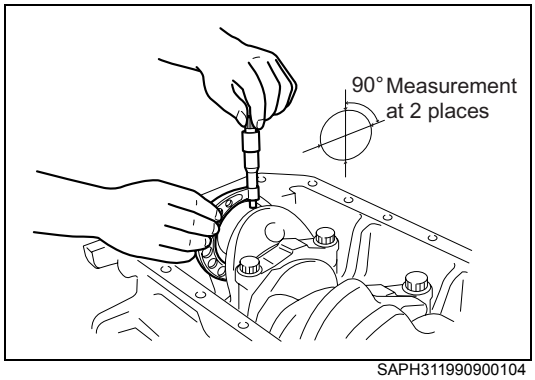
5. Inspection of crack and damage on crankshaft and of oil hole

(1) Check for crack or damage using dye penetrant. If a faulty condition is found, replace the crankshaft.



SAPH311990900103

(2) Check for clogging of the crankshaft oil hole. If faulty condition is found, replace the crankshaft.



SAPH311990900104

6. Inspection of pin wear

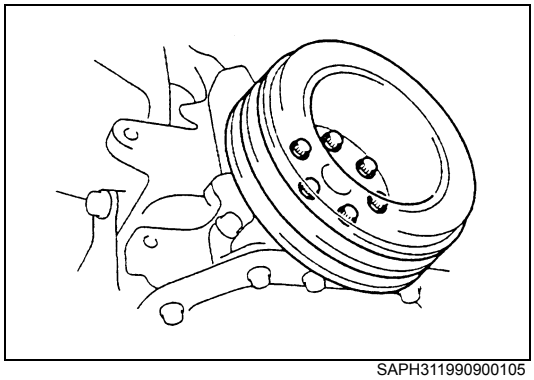
(1) Measure the outer diameter of the crankshaft crank pin using a micrometer. If it is faulty, grind or replace the crankshaft.
When the crankshaft is ground, use the undersize bearing.

Crank pin standard value	65

Wear value (mm{in.})	Action
Eccentric wear 0.10{0.0039}	Regrind for correction.
Wear of 0.20{0.0079} or more	Regrind
Wear of 1.20{0.0472}	Replace the crankshaft.

Replacement of crankshaft pulley

JP31199090704008



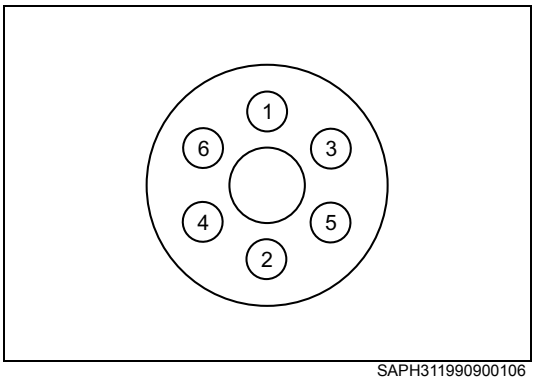
SAPH311990900105

1. Removal of crankshaft pulley

(1) Remove bolts and remove the crankshaft pulley.

NOTICE

- **Insert a large flat tip screwdriver into the flywheel gear from the flywheel housing inspection hole to prevent turning of the crankshaft.**



SAPH311990900106

2. Installation of crankshaft pulley

(1) Apply engine oil to the bolt seat and the bolt thread of the crankshaft pulley mounting bolt.

(2) Install the crankshaft pulley on the crankshaft and tighten it according to the figure.

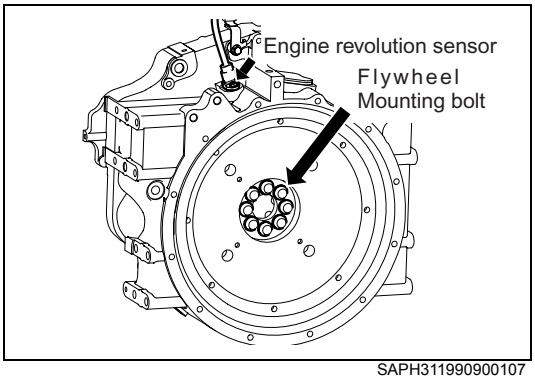
Tightening torque : 118 N·m {1,200 kgf·cm, 87 lbf·ft}

NOTICE

- **Insert a large flat tip screwdriver into the flywheel gear from the flywheel housing inspection hole to prevent turning of the crankshaft.**

Replacement of flywheel

JP31199090704009



SAPH311990900107

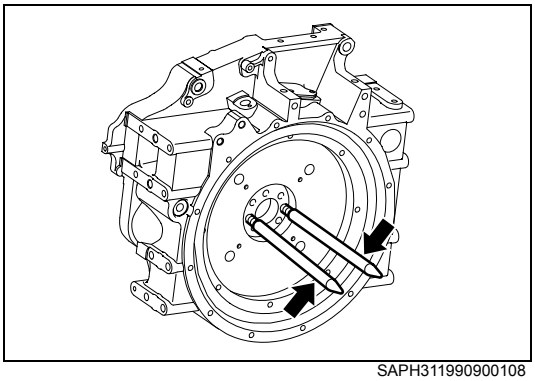
1. Removal of flywheel

(1) Remove the engine revolution sensor.

(2) Remove bolts fixing the flywheel.

NOTICE

- **Insert a large flat tip screwdriver into the flywheel gear from the flywheel housing inspection hole to prevent turning of the crankshaft.**



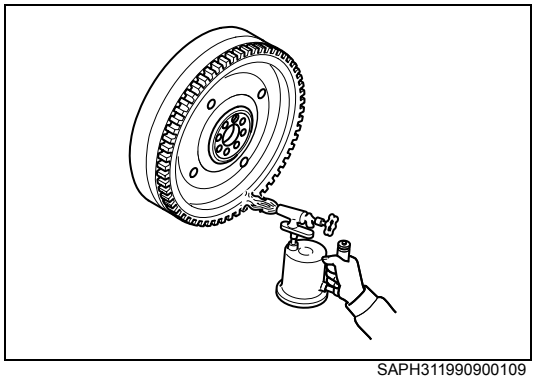
SAPH311990900108

(3) Install a special tool into the bolt hole of the crankshaft to remove the flywheel.

Special tool : 09481–1340 Guide

⚠ CAUTION

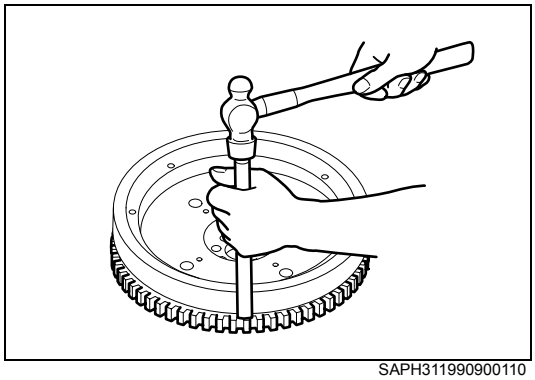
- **Since the flywheel is heavy, be careful for handling.**
- **Do not give impact to the special tool during work.**


SAPH311990900109

2. Removal of ring gear

(1) Heat the entire ring gear circumference with a burner until it is about 200 °C(392°F).

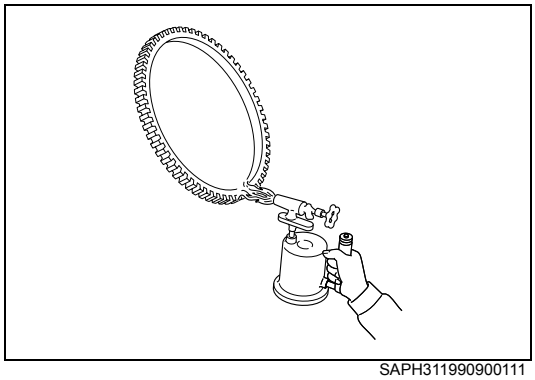
⚠ **CAUTION** • **Do not touch the ring gear and the flywheel with bare hand while they are hot.**


SAPH311990900110

(2) Hit the circumference of the ring gear gently using a backing rod to remove the ring gear from the flywheel.

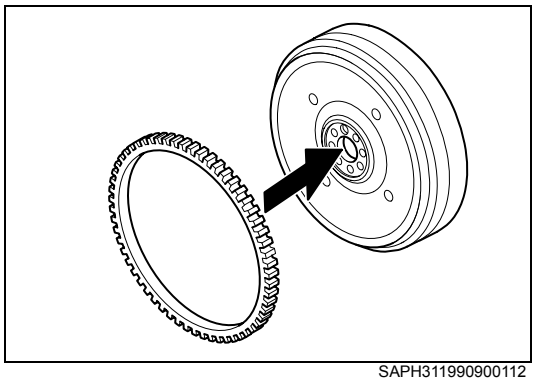
⚠ **CAUTION** • **Do not touch the ring gear and the flywheel with bare hand while they are hot.**

3. Installation of ring gear


SAPH311990900111

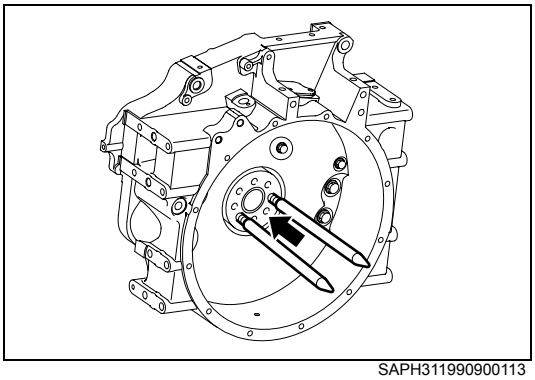
(1) Heat the entire ring gear circumference with a burner until it is about 200 °C(392°F).

⚠ **CAUTION** • **Do not touch the ring gear and the flywheel with bare hand while they are hot.**


SAPH311990900112

(2) Face the chamfered side toward the flywheel and install it on the flywheel quickly.

⚠ **CAUTION** • **Do not touch the ring gear and the flywheel with bare hand while they are hot.**


SAPH311990900113

4. Installation of flywheel

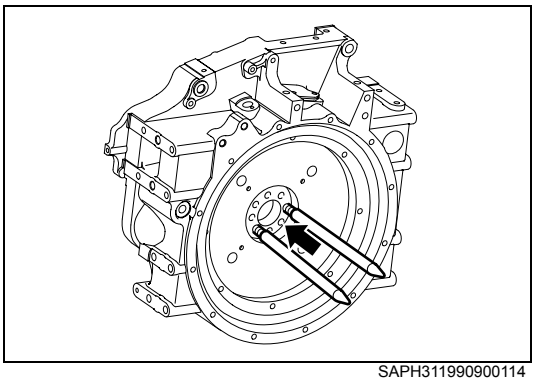
(1) Make sure that there is no burr or dirt on the joint surface of the crankshaft and the flywheel and the screw hole.

(2) Install the special tool into the bolt hole of the crankshaft.
Special tool : 09481–1340 Guide

NOTICE
- **Install one special tool on the collar dowel and the other at the opposite side of the collar dowel.**

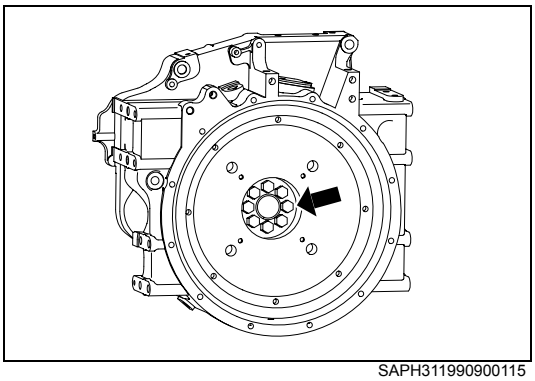
(3) Insert the flywheel until it comes in contact with the collar dowel of the crankshaft and adjust the position.

⚠ CAUTION
- **Since the flywheel is heavy, be careful for handling.**
- **Do not give impact to the special tool during work.**


SAPH311990900114

(4) Insert the flywheel until it comes in contact with the crankshaft.

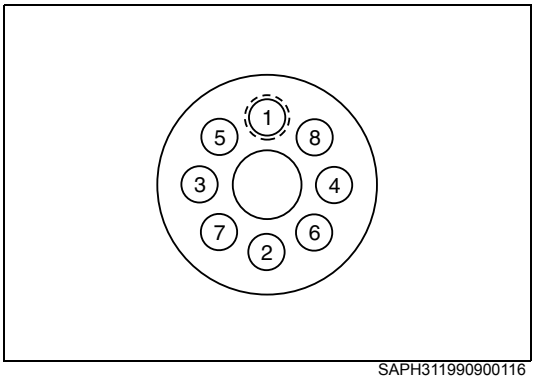
(5) Apply engine oil to the bolt seat and the bolt thread of the flywheel mounting bolt.


SAPH311990900115

(6) Tighten 6 bolts by 2 to 3 threads temporarily with hand in the bolt holes without installation of the special tool.

(7) Tighten 6 bolts gradually and tighten temporarily.

(8) Remove the special tool and tighten remaining two bolts temporarily as in (6) and (7).



SAPH311990900116

(9) Tighten the flywheel according to the order in the figure.

Tightening torque : 186 N·m {1,900 kgf·cm, 137 lbf·ft}

NOTICE
- **Insert a large flat tip screwdriver into the flywheel gear from the flywheel housing inspection hole to prevent turning of the crankshaft.**

(10) Loosen all bolts.

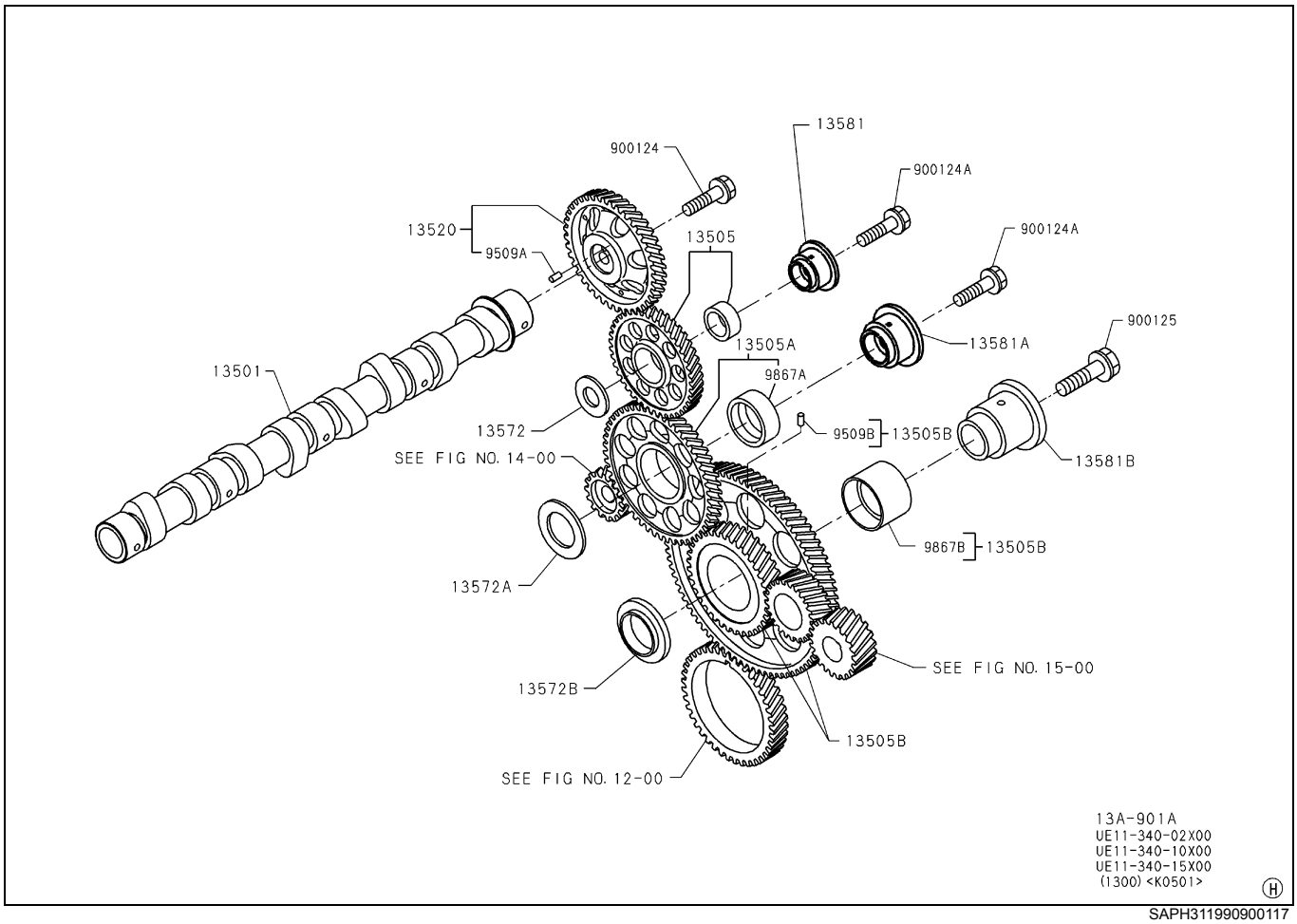
(11) Tighten the bolts again.
Tightening torque : 186 N·m {1,900 kgf·cm, 137 lbf·ft}

(12) Install the engine revolution sensor.

Camshaft and Idle Gear

Part layout

JP31199090402005



SAPH311990900117

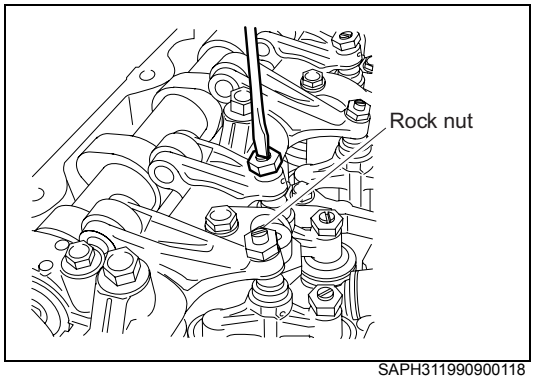
13501	Camshaft assembly	13572B	Idle gear thrust plate
13505	Cam idle gear	13581	Idle gear shaft
13505A	Sub-idle gear	13581A	Idle gear shaft
13505B	Main idle gear	13581B	Idle gear shaft
13520	Camshaft gear	9867A	Idle gear bush
13572	Idle gear thrust plate	9867B	Idle gear bush
13572A	Idle gear thrust plate		

Tightening torque

900124	59N·m{600kgf·cm, 44lbf·ft}+90°	900125	172N·m {1, 750 kgf·cm, 127lbf·ft}
900124A	108N·m {1, 100 kgf·cm, 80lbf·ft}		

Removal of camshaft

JP31199090702006

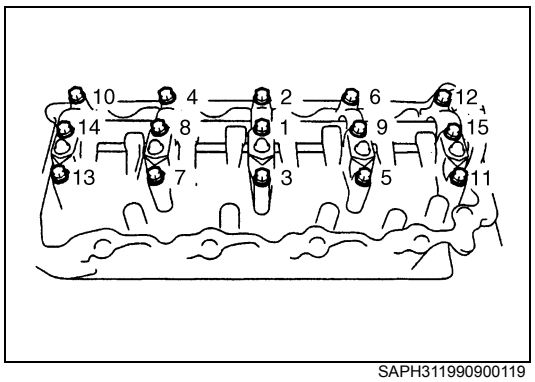


SAPH311990900118

1. Removal of rocker arm and camshaft assembly

(1) Loosen the lock nut and turn the adjusting screw completely.

⚠ CAUTION
- **Removal without turning the adjusting screw may bend the rocker shaft.**

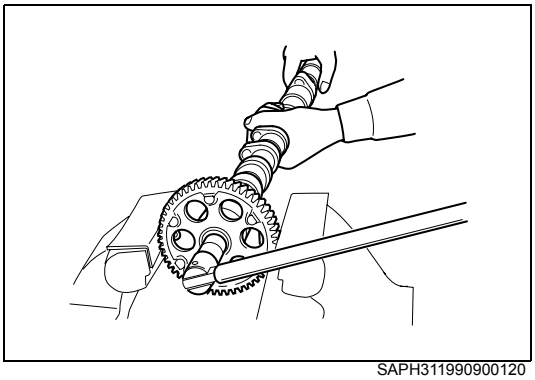


SAPH311990900119

(2) Loosen the rocker arm support bolts gradually from the center and remove the rocker arm and the rocker arm shaft.

Disassembly of camshaft

JP31199090702007


SAPH311990900120

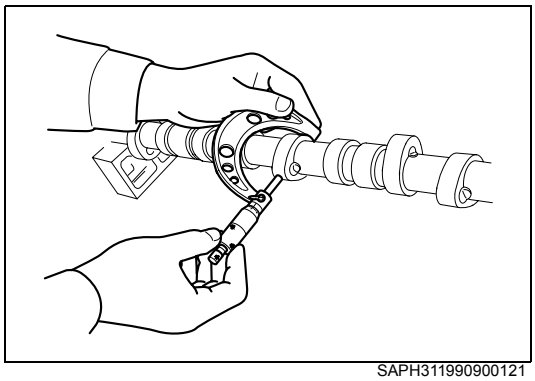
1. Disassembly of camshaft

(1) Fix the camshaft gear using a vice to disassemble the camshaft.

⚠ CAUTION
- **Prevent faulty conditions on the gear such as deformation, impact, scratch, etc.**

Inspection of camshaft and camshaft bearing

JP31199090702008

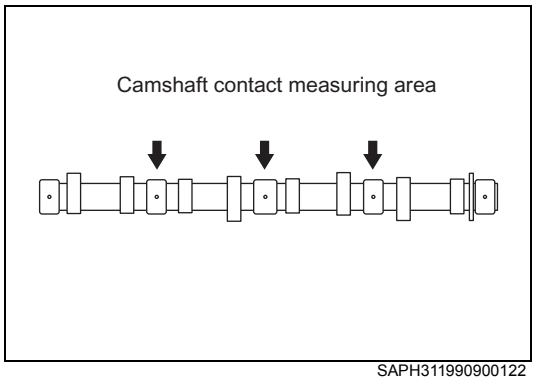


SAPH311990900121

1. Inspection of cam height on camshaft

(1) Measure the cam height using a micrometer. If it is beyond the service limit, replace the camshaft.

		Standard value (mm{in.})	Service limit (mm{in.})
Cam height	IN	50.067{1.9711}	49.987{1.9680}
	EX	52.104{2.0513}	52.024{2.0482}
Cam lift	IN	8.067{0.3176}	(7.987{0.3144})
	EX	10.104{0.3978}	(10.024{0.3946})



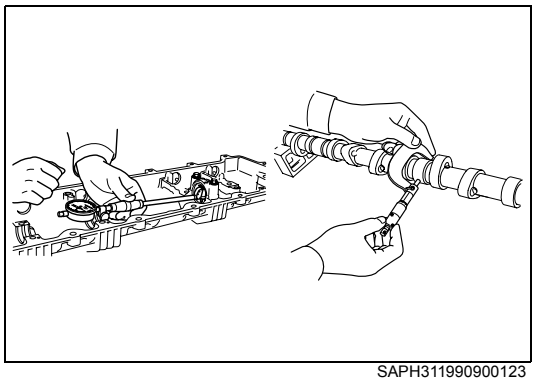
SAPH311990900122

2. Inspection of camshaft runout

(1) Put the journal at both ends of the camshaft on the V block.

(2) Put a dial gauge to each journal of the camshaft and measure runout of the camshaft. If it is beyond the service limit, replace the camshaft.

Standard value (mm{in.})	Service limit (mm{in.})
0.04{0.0016}	0.1{0.0039}



SAPH311990900123

3. Inspection of camshaft bearing oil clearance

(1) Measure the outer diameter of the camshaft journal using a micrometer.

Standard value (mm{in.})	Service limit (mm{in.})
40{1.5748}	39.85{1.5689}

(2) Measure the camshaft bearing inner diameter using a cylinder gauge.

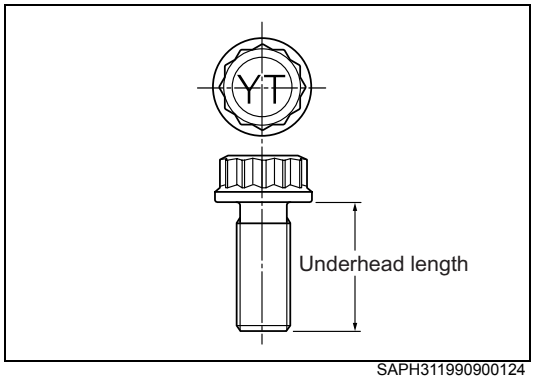
Standard value (mm{in.})	Service limit (mm{in.})
40{1.5748}	40.15{1.5807}

(3) Calculate the difference of the camshaft journal bearing inner diameter. If it is beyond the standard value, replace the camshaft or the camshaft bearing.

Standard value (mm{in.})	0.020 - 0.063 {0.0008 - 0.0025}

Assembly of camshaft

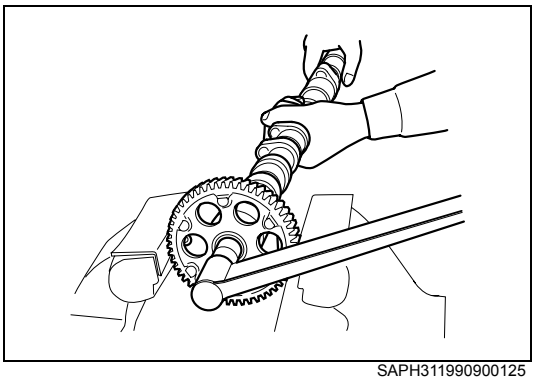
JP31199090702009



SAPH311990900124

1. **Measure the camshaft mounting bolt using a vernier calipers. If it is out of the service limit, replace it with a new one.**

Service limit (mm{in.})	**31{1.2205}**


SAPH311990900125

2. **Fix the camshaft gear using a vice. Apply engine oil to the seat and the bolt thread of the camshaft gear mounting bolt.**

3. **Set the dowel pin to the camshaft and the camshaft gear and tighten the camshaft gear mounting bolt.**
   Tightening torque : 59 N·m {600 kgf·cm, 44 lbf·ft}

4. **Retighten 90 deg (1/4 turn).**

⚠ **CAUTION**
- **If it is excessively retightened, do not loosen it.**
- **Prevent faulty conditions on the gear such as deformation, impact, scratch, etc.**

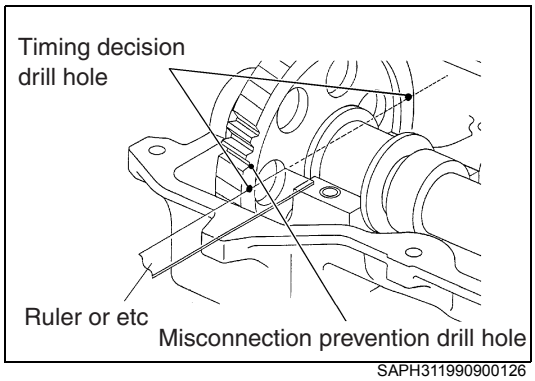
Installation of camshaft

JP31199090702010

1. Align the No. 1 cylinder to the compression top dead center.

2. Installation of camshaft and rocker arm.

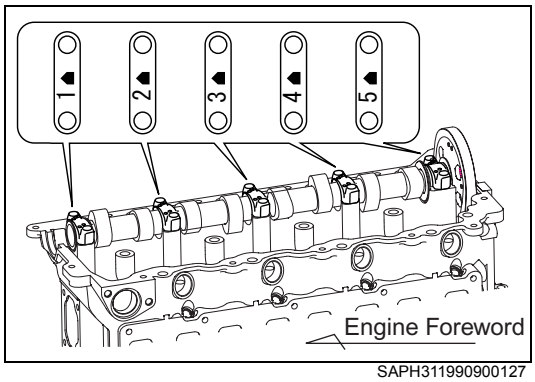
(1) Place the camshaft so that two holes at 180 degrees from the three drilled holes of the camshaft gear may be horizontal to the upper surface of the camshaft housing.



SAPH311990900126

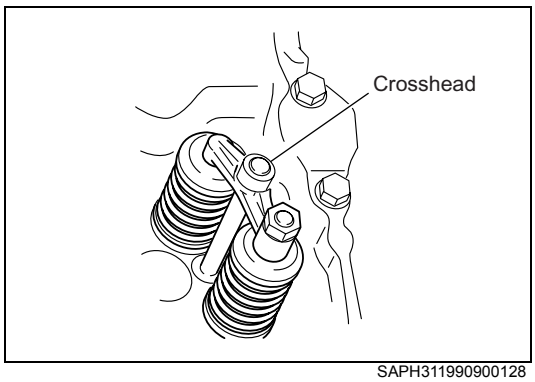
⚠ CAUTION
- **Place a transparent plastic ruler or an edged ruler on the upper surface of the camshaft housing and the side of the camshaft gear. Make sure that the position of the foolproof drilled hole is above the ruler.**

(2) Coat the bearing parts with engine oil and then install the camshaft bearing caps in numerical order 1-2-3-4-5 from the front of the engine, making sure the five-sided mark on the cap points forward.



SAPH311990900127

(3) Make sure the crosshead is correctly laid across each valve.



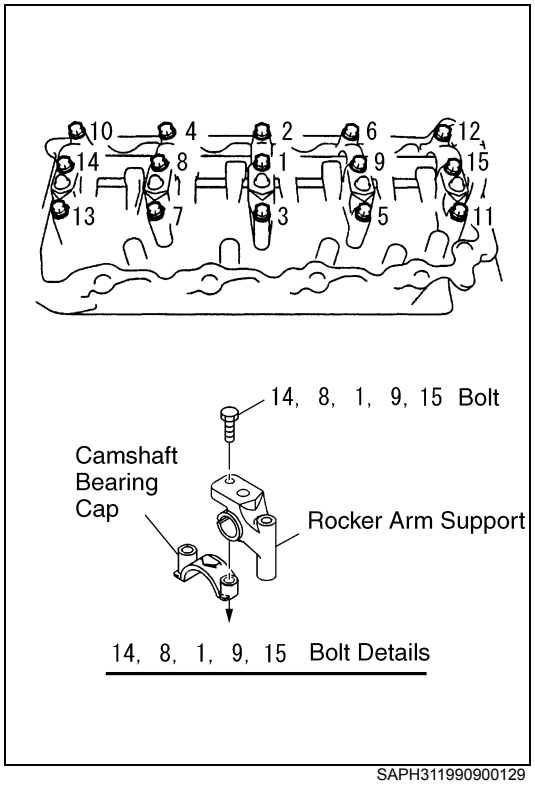
SAPH311990900128

⚠ CAUTION
- **To make sure the crosshead is correctly in place, move it to the left and right by hand and make sure it clicks against the valves.**
- **If the crosshead is not sitting properly on the valves, it will push the upper seat and cause the valve to drop out.**

(4) Make sure the rocker arm is correctly assembled on the rocker arm shaft.

(5) Fully unscrew the adjust screw on the end of the rocker arm.

NOTICE
- **Securing the rocker arm and nozzle clamp together with a string will facilitate installation work.**



SAPH311990900129

(6) Apply engine oil to the cam threads and set the rocker arm in position, making sure it is correctly laid on the crosshead. Then, tighten the bolts in the sequence shown in the figure, making several passes and gradually tightening them each time.

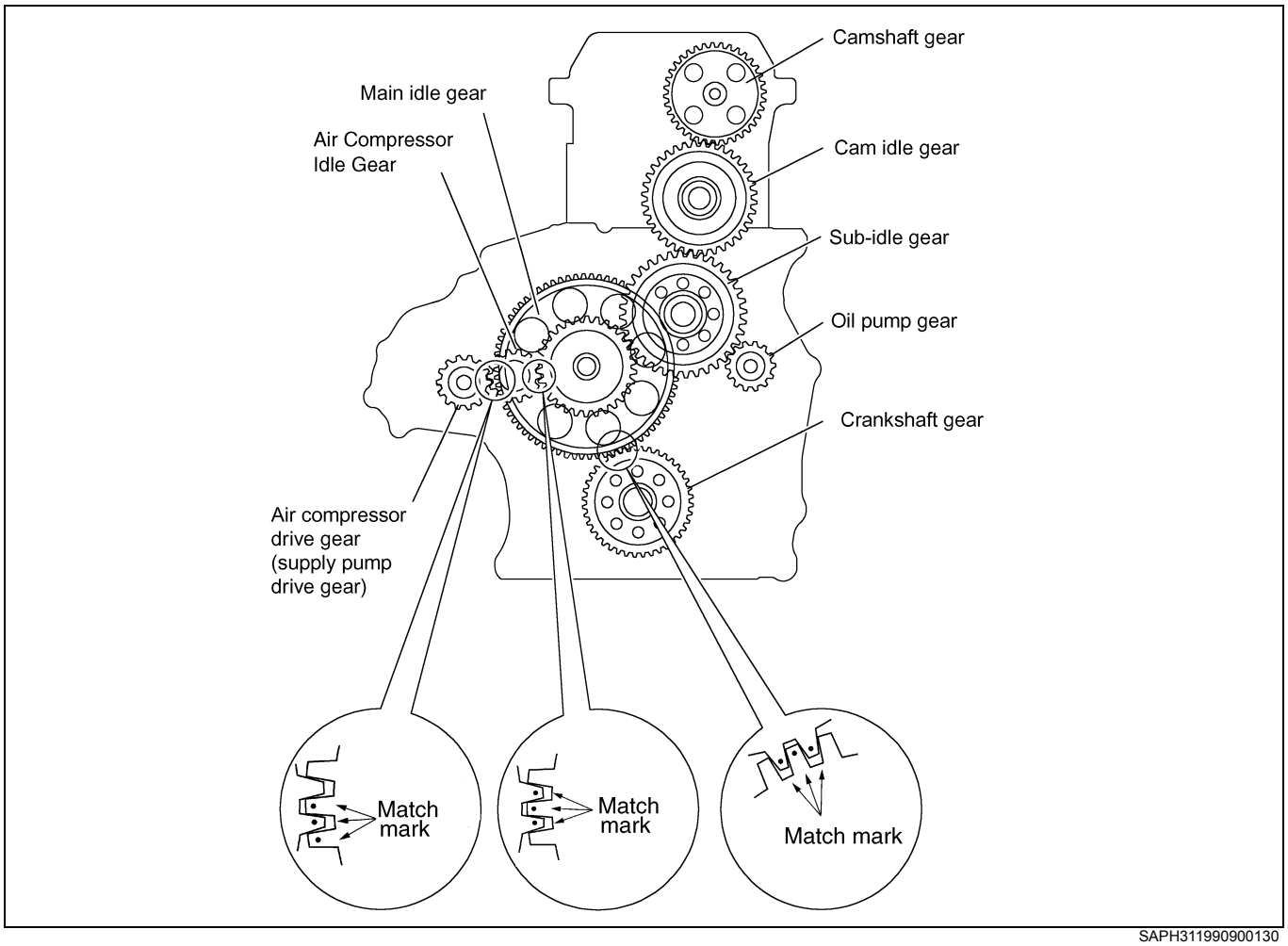
Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

⚠ **CAUTION**

- **After the bolts are tightened, make sure the rocker arm moves smoothly.**

Gear train layout

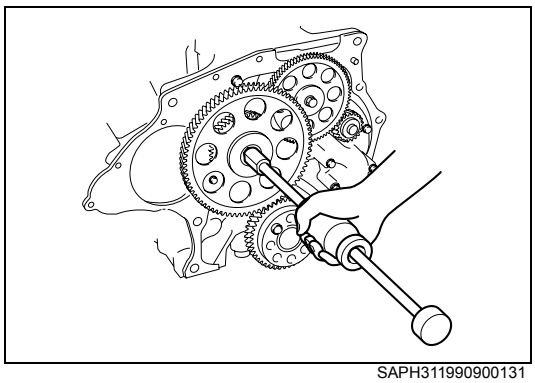
JP31199090402006



SAPH311990900130

Removal of timing gear

JP31199090702011



SAPH311990900131

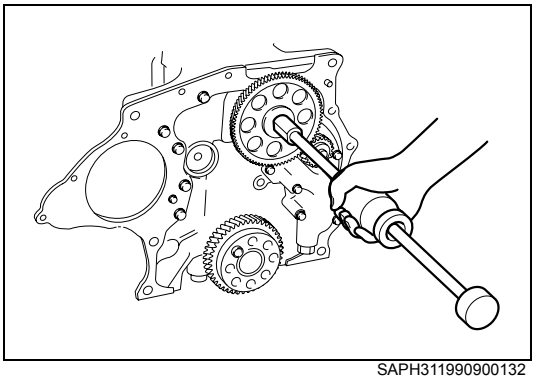
1. Removal of main idle gear

(1) Remove the idle gear shaft mounting bolt and pull out the main idle gear assembly using a special tool.

Special tool : 09420–1100 Sliding hammer
09420–1442 Sliding hammer

(2) Remove the idle gear thrust plate.

(3) Remove the idle gear shaft from the main idle gear.


SAPH311990900132

2. Removal of sub-idle gear

(1) Remove the idle gear shaft mounting bolt and the idle gear thrust plate and pull out the sub-idle gear assembly using a special tool.

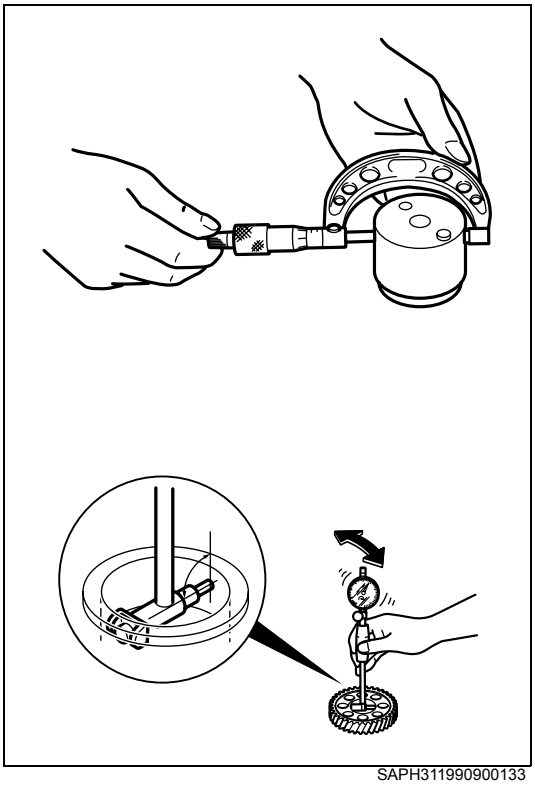
Special tool : 09420–1100 Sliding hammer
09420–1442 Sliding hammer

(2) Remove the idle gear thrust plate.

(3) Remove the idle gear shaft from the sub-idle gear.

Inspection of timing gear components

JP31199090702012


SAPH311990900133

1. Inspection of clearance between idle gear shaft and idle gear bushing

(1) Measure the idle gear shaft outer diameter using a micrometer and the idle gear bushing inner diameter using a cylinder gauge.

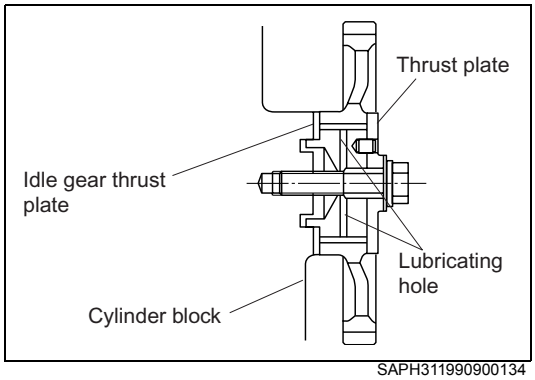
		Standard value (mm{in.})
Main idle gear shaft	Shaft outer diameter	57{2.2441}
	Bushing inner diameter	57{2.2441}
Sub-idle gear shaft	Shaft outer diameter	50{1.9685}
	Bushing inner diameter	50{1.9685}

(2) Calculate the difference between the idle gear bushing inner diameter and the idle gear shaft outer diameter. If it is beyond the service limit, replace the idle gear shaft and the idle gear bushing.

	Standard value (mm{in.})	Service limit (mm{in.})
Main idle gear shaft	0.030 - 0.090 {0.0012 - 0.0035}	0.20{0.0079}
Sub-idle gear shaft	0.025 - 0.075 {0.0010 - 0.030}	0.20{0.0079}

Installation of timing gear

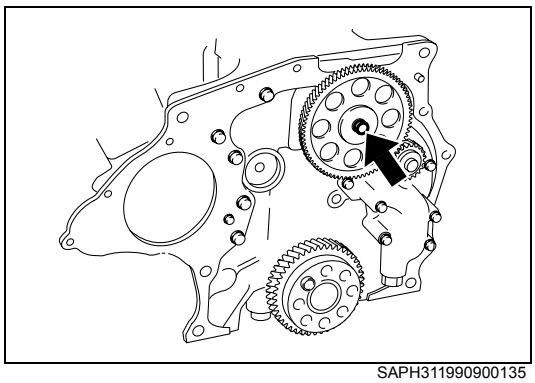
JP31199090702013



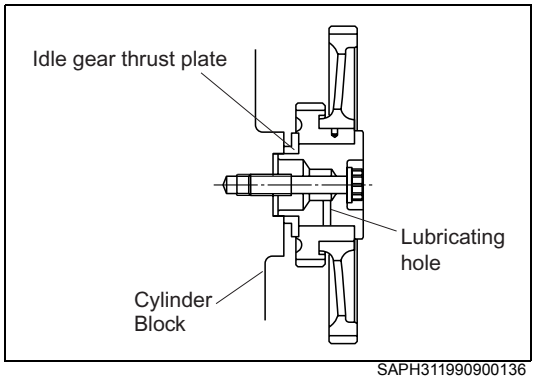
SAPH311990900134

1. Installation of sub-idle gear

(1) Install the idle gear shaft on the sub-idle gear.
(2) Install the idle gear thrust plate.
(3) Provide the lubricating hole of the idle gear shaft in the vertical direction.
(4) Install the idle gear thrust plate on the idle gear shaft.
(5) Apply engine oil to the bolt seat and the bolt thread of the idle gear shaft mounting bolt.


SAPH311990900135

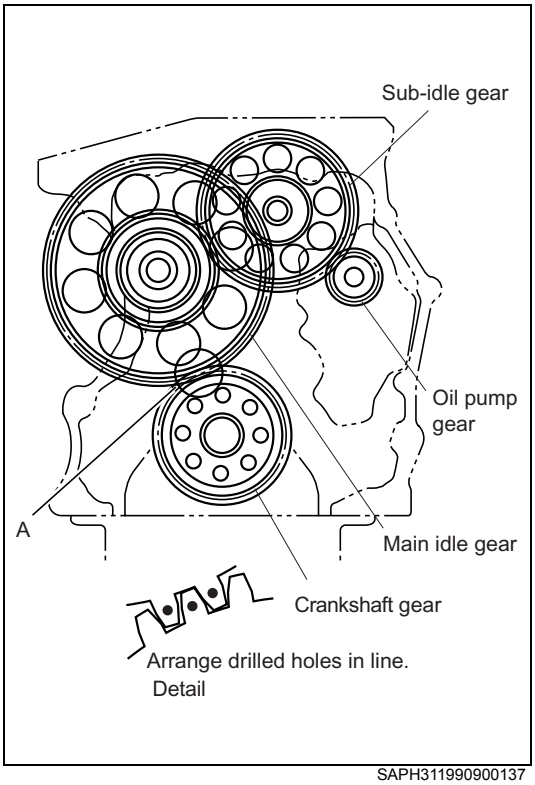
(6) Install the idle gear shaft mounting bolt.
Tightening torque : 108 N·m {1,100 kgf·cm, 80 lbf·ft}



SAPH311990900136

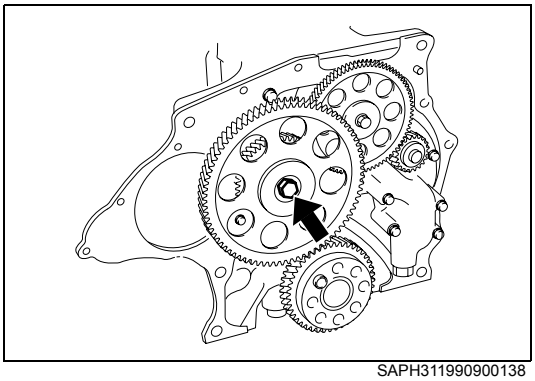
2. Installation of main idle gear

(1) Install the idle gear shaft on the main idle gear.
(2) Install the idle gear thrust plate.



SAPH311990900137

(3) Face the lubricating hole of the idle gear shaft toward the oil pan (downward). Install A in the figure by adjusting the timing of the crankshaft gear and the main idle gear as in the detailed drawing.


SAPH311990900138

(4) Apply engine oil to the bolt seat and the bolt thread of the idle gear shaft mounting bolt.

(5) Install the idle gear shaft mounting bolt.
Tightening torque : 172 N·m {1,750 kgf·cm, 127 lbf·ft}

(6) Measure backlash and end play of each idle gear. Make sure that it is within the standard value.

Overhaul of sub-idle gear (bearing case side)

JP31199090702014

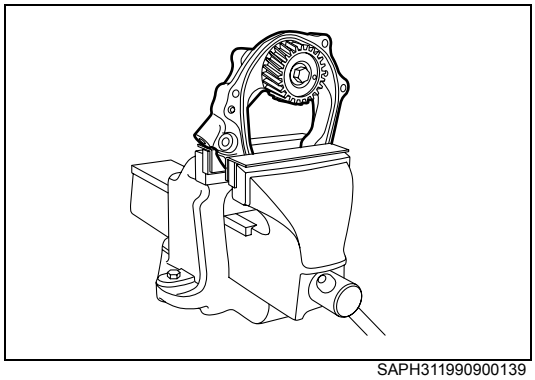
1. Removal of bearing case assembly

(1) Remove the supply pump.
"Reference : Replacement, Supply pump".

(2) Disconnect the bearing case assembly.

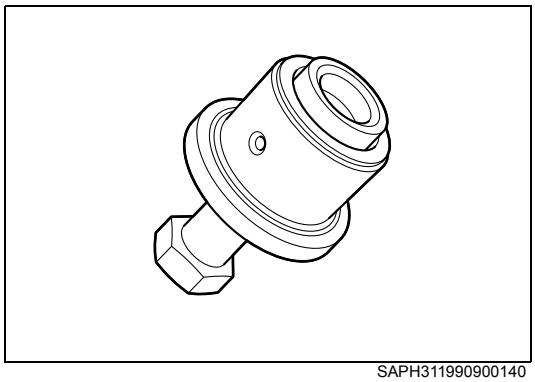
⚠ **CAUTION** • **One bolt is tightened from the timing gear case.**

(3) Fix the bearing case with a vice.



SAPH311990900139

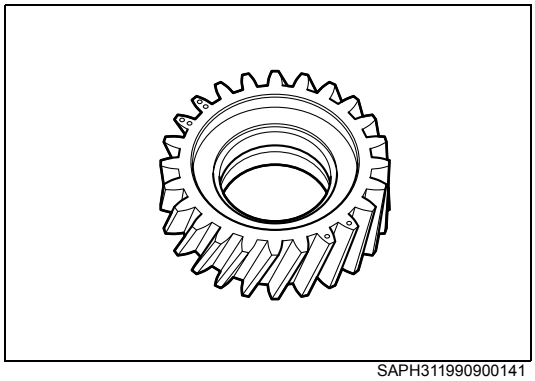
(4) Remove the sub-idle gear shaft mounting bolt and pull out the idle gear shaft using a sliding hammer.



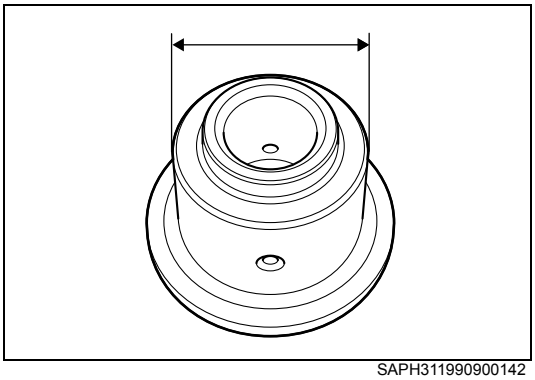
SAPH311990900140

(5) Remove the sub-idle gear.

(6) Remove the idle gear thrust plate.

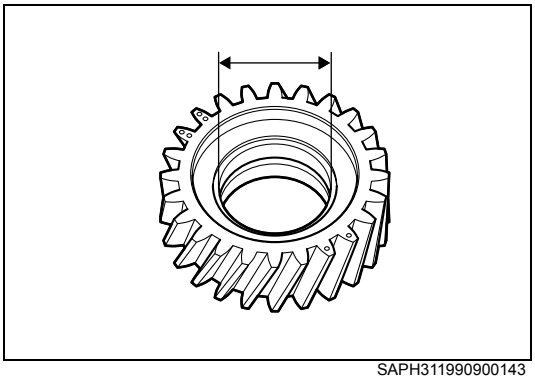


SAPH311990900141


SAPH311990900142

2. Inspection of clearance between sub-idle gear shaft and sub-idle gear bushing

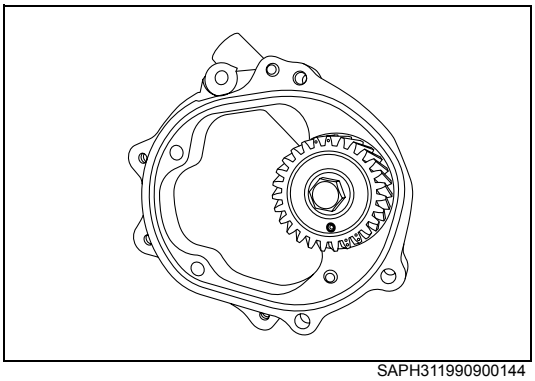
(1) Measure the outer diameter of the idle gear shaft.


SAPH311990900143

(2) Measure the inner diameter of the sub-idle gear.

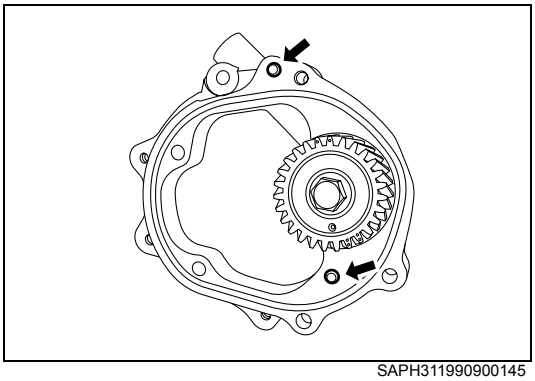
(3) Calculate the clearance. If it is beyond the standard value, replace the shaft and the bushing.

Standard value (mm{in.})	**0.025 - 0.075 {0.0010 - 0.030}**


SAPH311990900144

3. Installation of bearing case assembly

(1) Install the idle gear thrust plate.
(2) Install the gear shaft on the sub-idle gear.
(3) Face the lubricating hole of the gear shaft downward and install it on the bearing case.
(4) Install the sub-idle gear shaft mounting bolt.
Tightening torque : 108 N·m {1,100 kgf·cm, 80 lbf·ft}


SAPH311990900145

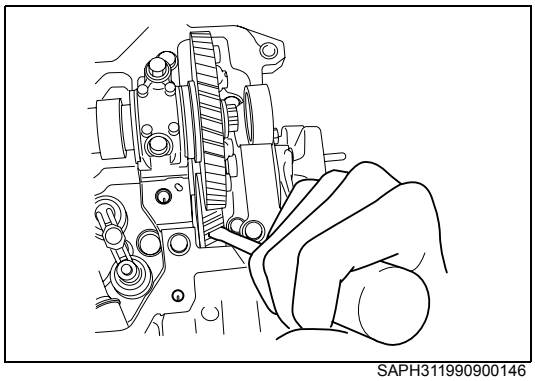
(5) Assemble the supply pump and bearing case.

Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

⚠ **CAUTION** • **Be careful for fall of the O-ring**

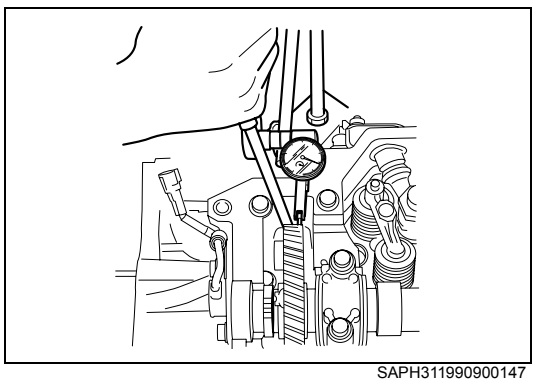
Inspection of installation status for each gear

JP31199090703003


SAPH311990900146

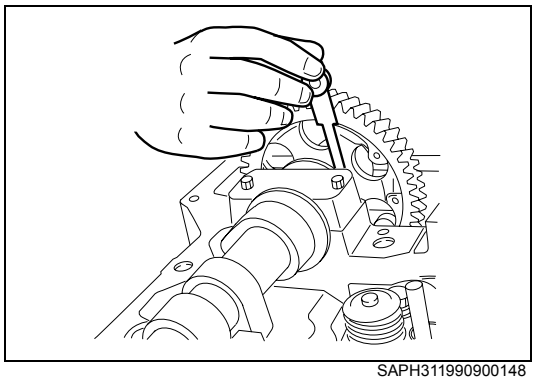
1. Inspection of backlash between camshaft gear and cam idle gear

(1) Insert a large flat tip screwdriver into the cam idle gear from the side of the camshaft gear of the camshaft housing to prevent turning of the cam idle gear.


SAPH311990900147

(2) Measure backlash between the camshaft gear and the cam idle gear using a dial gauge. If it is beyond the service limit, replace each gear.

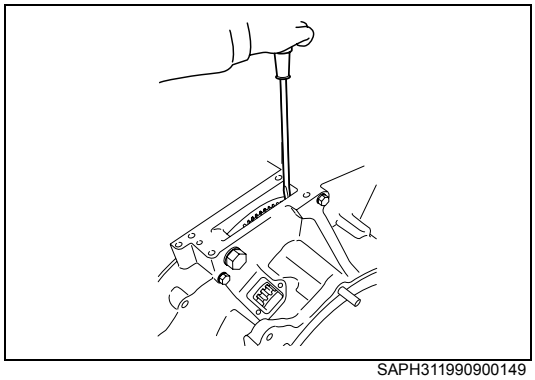
Standard value (mm{in.})	Service limit (mm{in.})
0.030 - 0.253 {0.0012 - 0.0100}	0.30{0.0118}


SAPH311990900148

2. Inspection of camshaft end play

(1) Measure the end play of the camshaft using a thickness gauge. If it is beyond the standard value, replace the camshaft.

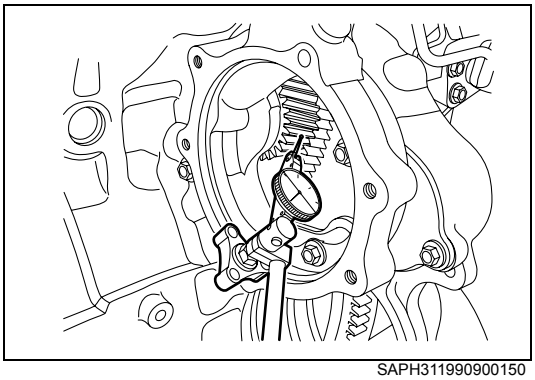
Standard value (mm)	0.100 - 0.178 {0.0039 - 0.0070}


SAPH311990900149

3. Inspection of backlash between main idle gear and air compressor idle gear

(1) Remove the supply pump drive at the bearing case. "Reference : Replacement, Supply pump".

(2) Insert a large flat tip screwdriver into the main idle gear from the timing gear dust cover of the flywheel housing to prevent turning of the main idle gear.


SAPH311990900150

(3) Measure backlash between the main idle gear and the air compressor idle gear using a dial gauge and a magnet stand. If it is beyond the service limit, replace each gear.

NOTICE

- **If the magnet stand is not stable, provide a steel plate for measurement using bolt holes of the cylinder block.**

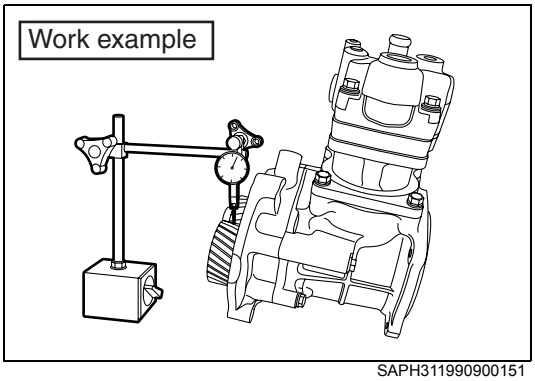
Standard value (mm{in.})	Service limit (mm{in.})
0.032 - 0.096 {0.0013 - 0.0038}	0.10{0.0039}

4. Inspection of backlash between idle gear at bearing case and supply pump drive gear

(1) Remove the supply pump drive.
"Reference : Replacement, Supply pump"

(2) Remove the bearing case assembly.

(3) Fix the supply pump drive with a vice and install the bearing case assembly.



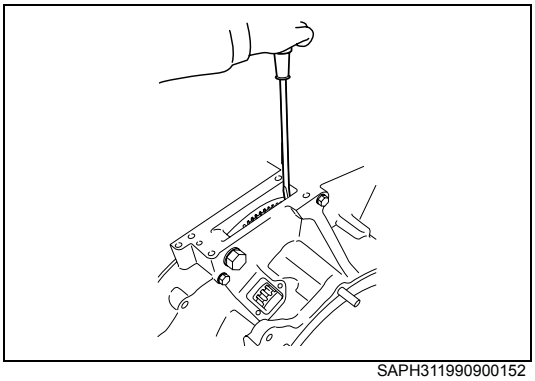
SAPH311990900151

(4) Measure backlash between the idle gear and the supply pump drive gear using a dial gauge and a magnet stand. If it is beyond the service limit, replace each gear.

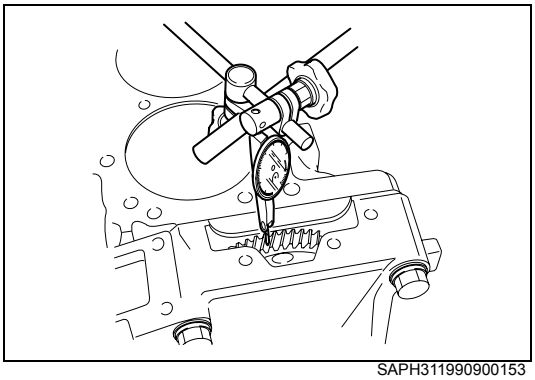
Standard value (mm{in.})	Service limit (mm{in.})
0.020 - 0.083 {0.0008 - 0.0033}	0.10{0.0039}

5. Inspection of backlash between main idle gear and sub-idle gear

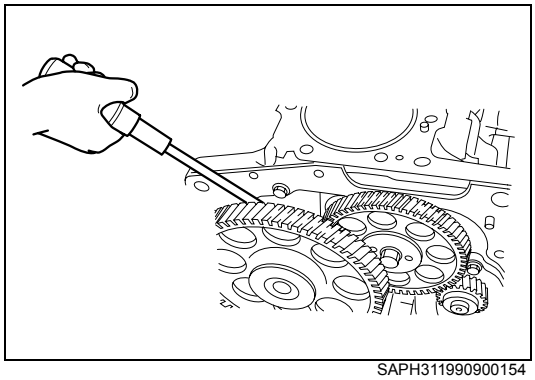
(1) Insert a large flat tip screwdriver into the main idle gear from the timing gear dust cover of the flywheel housing to prevent turning of the main idle gear.


SAPH311990900152

(2) Measure backlash between the main idle gear and the sub-idle gear using a dial gauge and a magnet stand. If it is beyond the service limit, replace each gear.

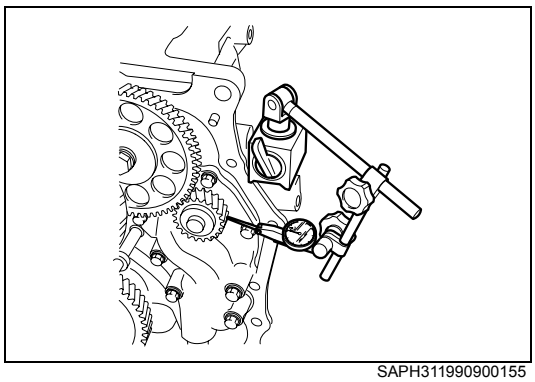

SAPH311990900153

Standard value (mm{in.})	Service limit (mm{in.})
0.030 - 0.113 {0.0012 - 0.0044}	0.30{0.0118}


SAPH311990900154

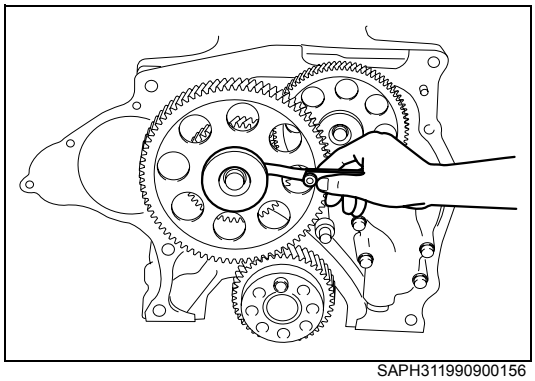
6. Inspection of backlash between sub-idle gear at cam idle gear and oil pump gear

(1) Insert a large flat tip screwdriver into the sub-idle gear to prevent turning of the sub-idle gear.


SAPH311990900155

(2) Measure backlash between the sub-idle gear and the oil pump gear using a dial gauge and a magnet stand. If it is beyond the service limit, replace each gear.

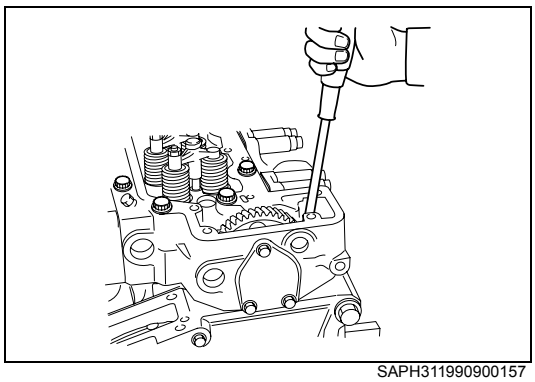
Standard value (mm{in.})	Service limit (mm{in.})
0.030 - 0.131 {0.0012 - 0.0005}	0.30{0.0118}


SAPH311990900156

7. Inspection of idle gear end play

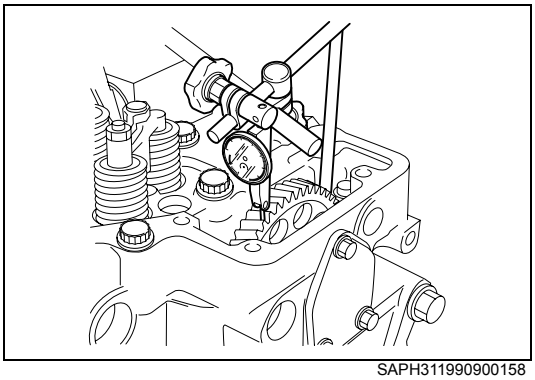
(1) Measure the end play of each gear using a thickness gauge. If it is beyond the service limit, replace each gear or shaft.

	Standard value (mm{in.})	Service limit (mm{in.})
Main idle gear	0.114 - 0.160 {0.0045 - 0.0063}	0.30{0.0118}
Sub-idle gear	0.040 - 0.095 {0.0016 - 0.0037}	0.30{0.0118}


SAPH311990900157

8. Inspection of backlash between cam idle gear and sub-idle gear

(1) Insert a large flat tip screwdriver into the sub-idle gear from the side of the cam idle gear of the cylinder head to prevent turning of the sub-idle gear.


SAPH311990900158

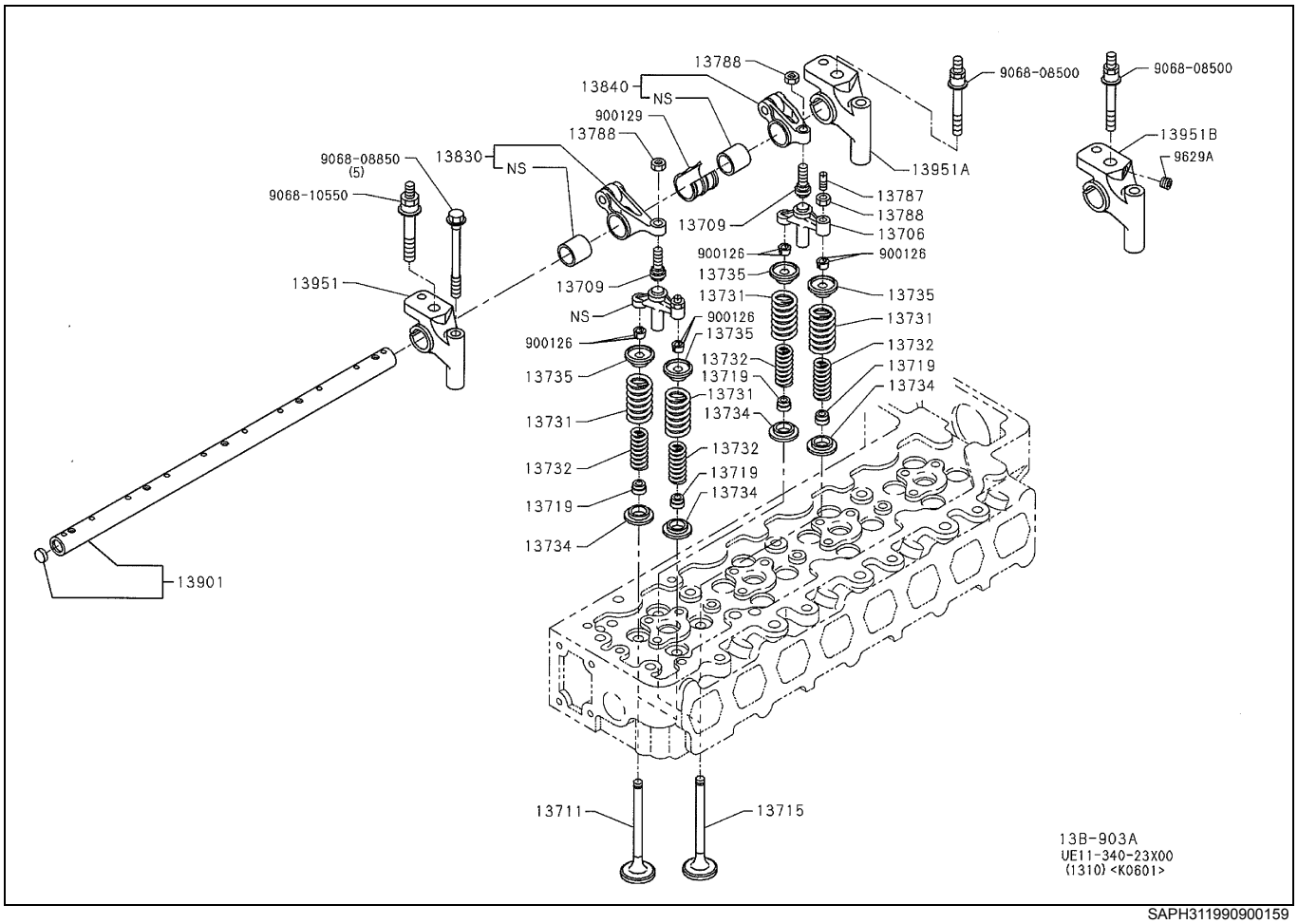
(2) Measure backlash between the cam idle gear and the sub-idle gear using a dial gauge. If it is beyond the service limit, replace each gear.

Standard value (mm{in.})	Service limit (mm{in.})
0.050 - 0.218 {0.0020 - 0.0086}	**0.30{0.0118}**

Valve System

Part layout

JP31199090402007



SAPH311990900159

13706	Crosshead assembly	13735	Valve spring upper seat
13709	Adjusting screw (rocker arm)	13787	Adjusting screw (cross head)
13711	Intake valve	13830	Rocker arm intake
13715	Exhaust valve	13840	Rocker arm (exhaust)
13719	Valve stem seal*	13901	Rocker shaft
13731	Outer valve spring	13951	Rocker arm support
13732	Inner valve spring	900126	Valve spring retainer
13734	Valve spring lower seat		

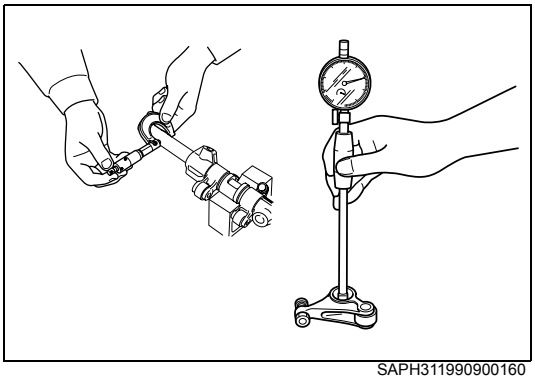
*Parts not to be reused.

Tightening torque

13788	25N·m {250 kgf·cm, 18lbf·ft}	9069B	28.5N·m{290kgf·cm, 21lbf·ft}
9069A	28.5N·m{290kgf·cm, 21lbf·ft}	9069C	28.5N·m{290kgf·cm, 21lbf·ft}

Overhaul of valve system

JP31199090702015



SAPH311990900160

1. Inspection of rocker arm oil clearance

(1) Measure the outer diameter of the rocker shaft using a micrometer.

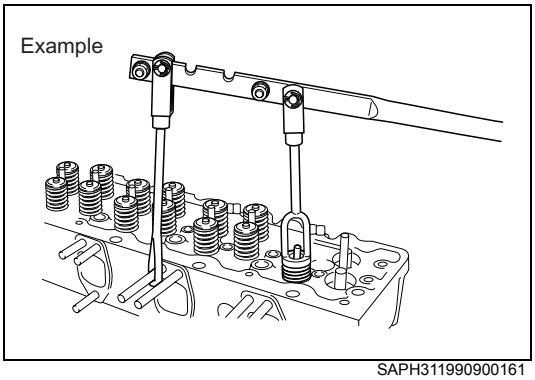
Standard value (mm{in.})	Service limit (mm{in.})
22{0.8661}	21.92{0.8630}

(2) Measure the rocker arm bushing inner diameter using a cylinder gauge.

Standard value (mm{in.})	Service limit (mm{in.})
22{0.8661}	20.08{0.7905}

(3) Calculate the difference between the outer diameter of the rocker shaft and the inner diameter of the rocker arm bushing. If it is beyond the standard value, replace the rocker shaft or the rocker arm bushing.

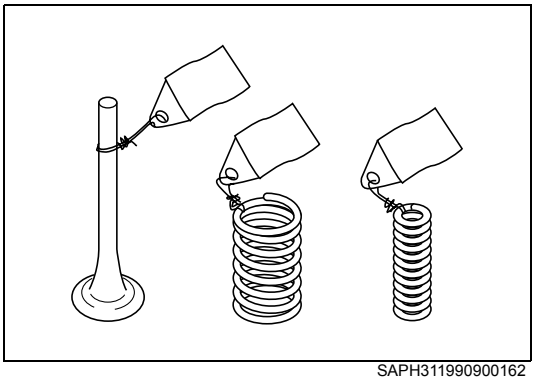
Standard value (mm{in.})	Service limit (mm{in.})
0.03 - 0.101 {0.0012 - 0.0039}	0.15{0.0059}



SAPH311990900161

2. Removal of valve spring

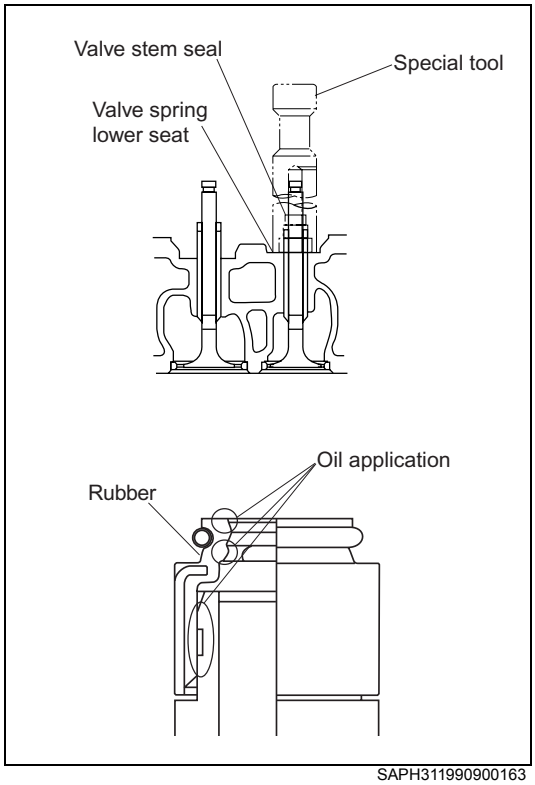
(1) Compress the valve spring using a special tool and remove the valve spring retainer.
Special tool : 09470–1170 Valve spring press



SAPH311990900162

(2) Remove the intake and exhaust valves.

⚠ **CAUTION**
- **Attach a tag with the applicable cylinder number to the valve so that combinations of the valve and the cylinder head may not be mixed.**

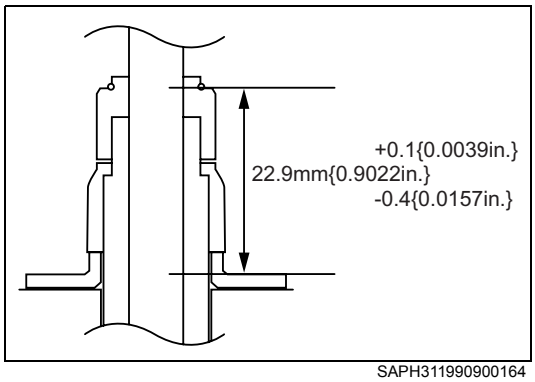


SAPH311990900163

3. Replacement of valve stem seal

(1) After removing the valve stem seal, assemble the valve spring lower seat. Apply engine oil to the lip and the inner surface of the valve stem seal. Strike the valve guide using a special tool until the special tool comes in contact with the valve spring lower sea
Special tool : 09472–2100 Bar

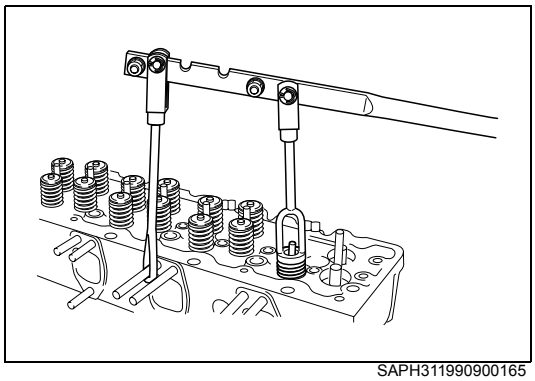
⚠ **CAUTION**
- **After assembly of the valve stem seal, make sure that there is no deformation, crack or inclination of the rubber.**



SAPH311990900164

(2) After striking, check the height.

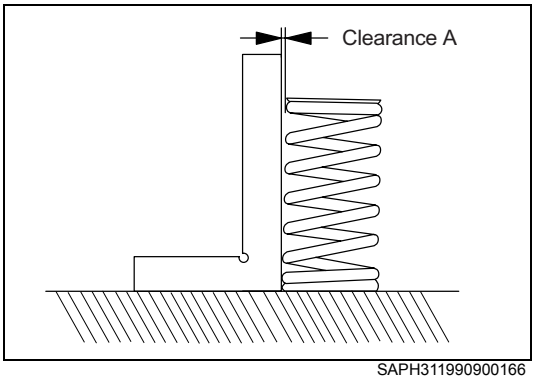
Standard value (mm{in.})	**22.5 - 23.0 {0.8858 - 0.9055}**


SAPH311990900165

4. Installation of valve spring

(1) Install the valve spring upper seat on the valve spring.
(2) Compress the valve spring using a special tool and install the valve spring retainer.
Special tool : 09470–1170 Valve spring press

⚠ **CAUTION**
- **Apply engine oil to the contact surface of each part before assembly.**
- **Be sure to assemble each valve at the original cylinder position.**
- **When the valve spring is compressed, avoid contact of the valve spring upper seat with the valve stem seal.**
- **Since the valve spring has equal spacing, vertical direction is not specified for assembly.**
- **Check for scratch on the valve stem seal when the valve is reused.**

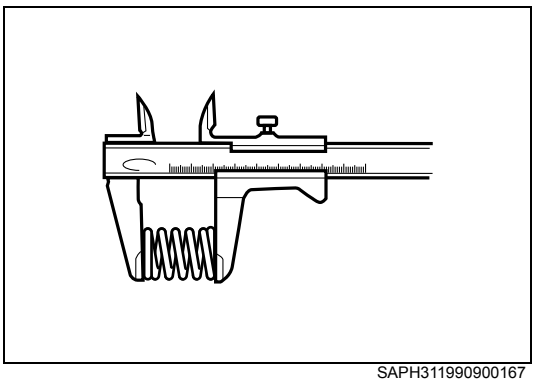


SAPH311990900166

5. Inspection of valve spring

(1) Measure squareness of the valve spring using a square or a thickness gauge. If it is beyond the service limit (clearance A), replace the valve spring.

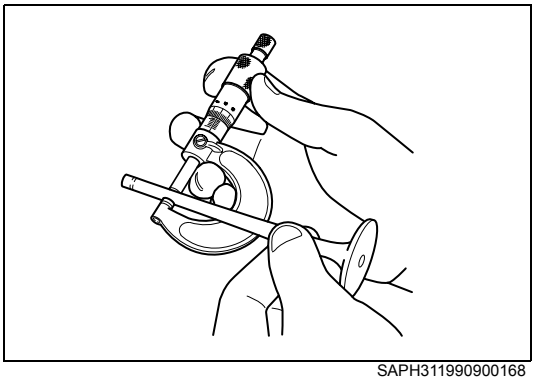
Clearance A (mm{in.})	2.0{0.0787}


SAPH311990900167

(2) Measure the free length of the valve spring using a vernier calipers. If it is out of the service limit, replace the valve spring.

Measuring item	Standard value (mm{in.})	Service limit (mm{in.})
Inner valve spring	(64.6[2.5433])	61.6[2.4252]
Outer valve spring	(75.7[2.9803])	72.7[2.8622]

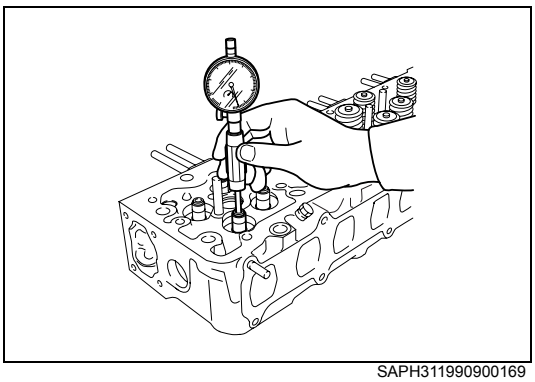
The value in [ ] is the reference value.


SAPH311990900168

6. Inspection of oil clearance between valve guide and valve stem

(1) Measure the outer diameter of the valve stem using a micrometer.

Measuring item	Standard value (mm{in.})
Intake valve stem	7{0.2756}
Exhaust valve stem	7{0.2756}


SAPH311990900169

(2) Measure the valve guide inner diameter using a cylinder gauge.

Measuring item	Standard value (mm{in.})
Intake valve guide	7{0.2756}
Exhaust valve guide	7{0.2756}

(3) Calculate the difference between the valve stem outer diameter and the valve guide inner diameter. If it is beyond the standard value, replace the valve or the valve guide.

Measuring item	Standard value (mm{in.})
Intake valve oil clearance	0.023 - 0.058 {0.0009 - 0.0023}
Exhaust valve oil clearance	0.050 - 0.083 {0.0020 - 0.0033}

Adjustment of valve clearance

JP31199090706001

1. Precautions before adjustment

⚠ **CAUTION** • **Before adjustment, make sure that bolts of the cylinder head, rocker arm support, nozzle clamp, camshaft housing and camshaft bearing cap are tightened to the specified torque.**

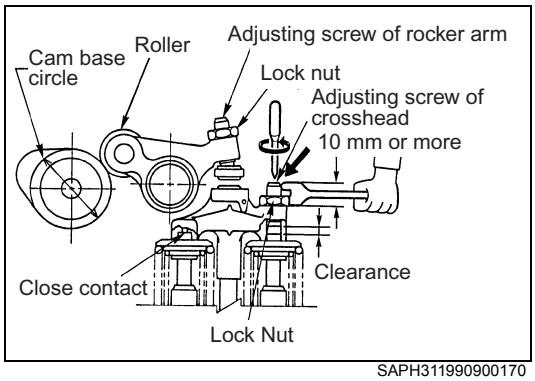
2. Adjustment of valve clearance

(1) Make sure that there is no dirt between the crosshead and the valve stem

(2) Turn the crankshaft in the forward direction and adjust the cylinder to the compression top dead center.

⚠ **CAUTION** • **Make sure that there is a roller on the cam base circle.**

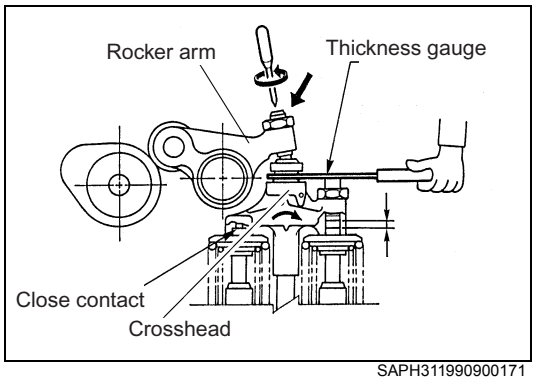
(3) Loosen the adjusting screw and the lock nut of the crosshead completely.



SAPH311990900170

⚠ **CAUTION** • **Provide the adjusting screw protrusion of 10 mm or more from the top surface of the crosshead. If the adjusting screw is not completely separated from the valve stem, correct adjustment is not allowed.**

(4) Insert a thickness gauge between the rocker arm and the crosshead and adjust the clearance with the adjusting screw of the rocker arm. Tighten the lock nut.



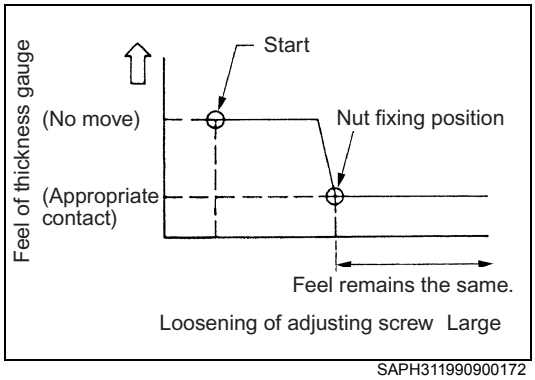
SAPH311990900171

Standard value (cold engine)	**IN**	**0.30mm{0.0118 in.}**
	EX	**0.45mm{0.0177 in.}**

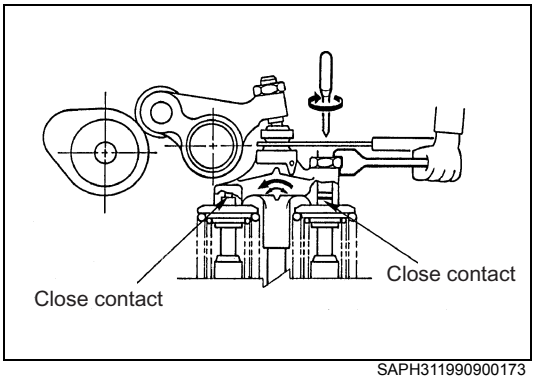
Tightening torque : 25 N·m {250 kgf·cm, 18 lbf·ft}

(5) Loosen the adjusting screw of the crosshead with the thickness gauge inserted. Make sure that feel on the thickness gauge is not lighter.

⚠ **CAUTION** • **If it becomes lighter, make adjustments again from the beginning.**

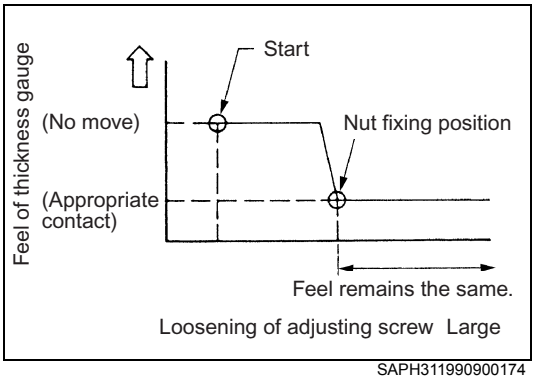


SAPH311990900172



SAPH311990900173

(6) Tighten the adjusting screw of the crosshead until the thickness gauge does not move.



SAPH311990900174

(7) While loosening the adjusting screw of the crosshead gradually, tighten the lock nut of the crosshead at the position where feel on the thickness gauge is appropriate.

Tightening torque : 25 N·m {250 kgf·cm, 18 lbf·ft}

⚠ **CAUTION**

- **Do not over-loosen the adjusting screw. Over-loosening of the adjusting screw reproduces the original status. Although feel on the thickness gauge is appropriate, there is clearance between the adjusting screw and the valve of the crosshead. Correct adjustment is not allowed.**

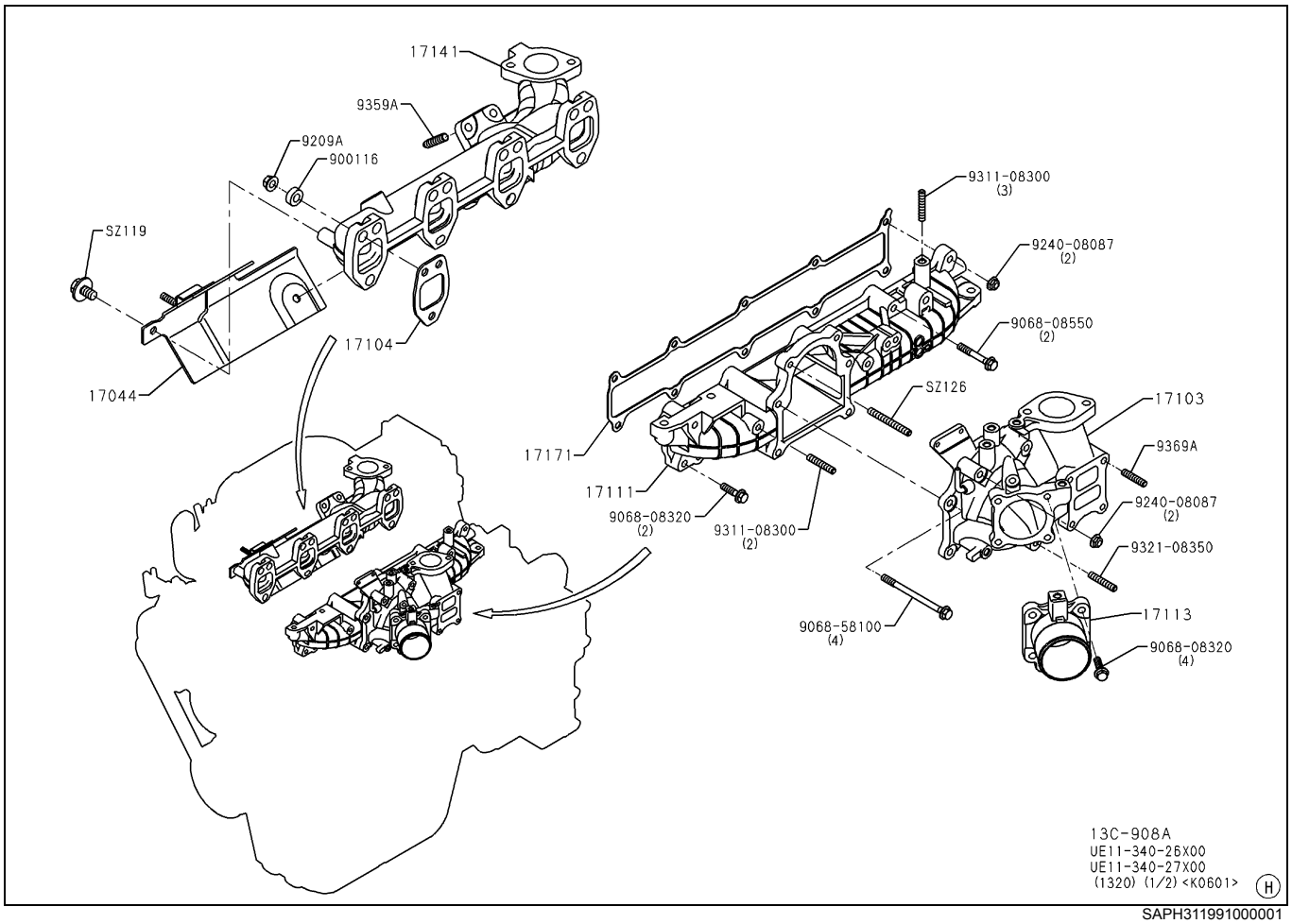
10 EXHAUST

Exhaust Manifold 10-2
Part layout 10-2
Replacement 10-4

Exhaust Manifold

Part layout

JP31199100402001



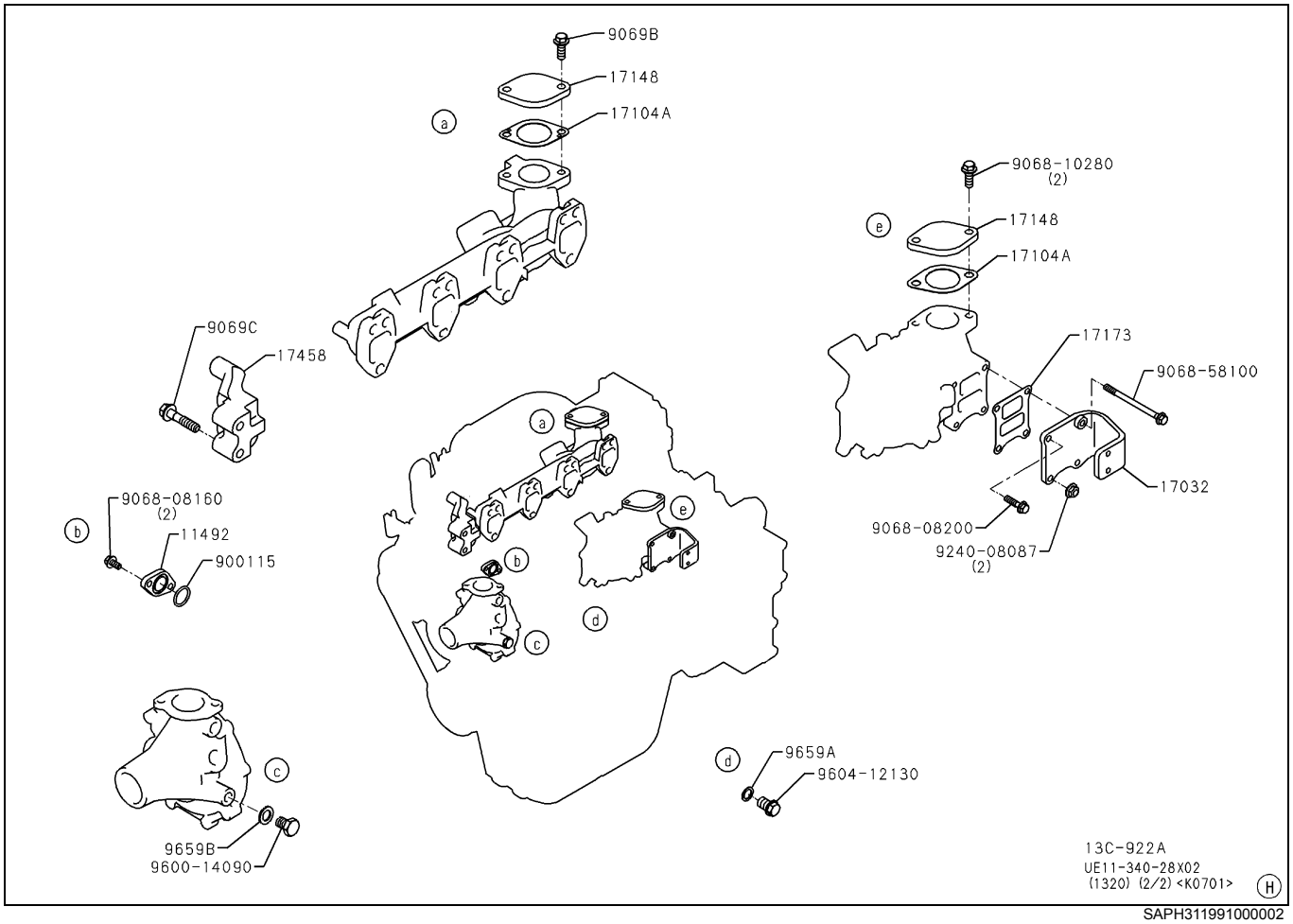
SAPH311991000001

17104	Gasket*	17141	Exhaust manifold

*Parts not to be reused.

Tightening torque

9209A	53 N·m {540 kgf·cm, 40lbf·ft}	



SAPH311991000002

17104A	Gasket*	17148	Plate

*Parts not to be reused.

Replacement

JP31199100704001

1. Removal of exhaust manifold

(1) Remove nuts and remove the exhaust manifold.

2. Replacement of stud bolt

(1) Remove dirt (e.g. sealant) at the female thread of the cylinder head and clean the thread again with tap (M10 x 1.5).

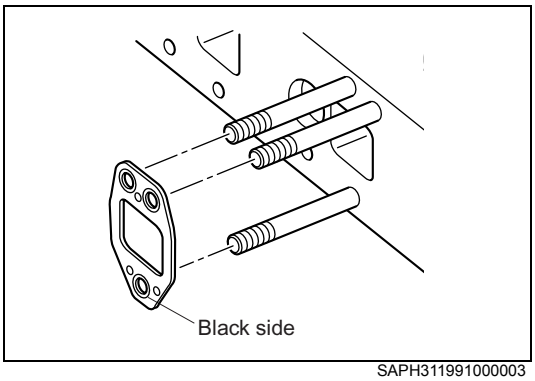
(2) Use the Torx wrench to tighten a new stud bolt.
Tightening torque : 30 N·m {300 kgf·cm, 22 lbf·ft}

⚠ **CAUTION**
- **Excessive tightening with over torque may cause crack in the cylinder head.**

3. Installation of exhaust manifold

(1) Assemble a new gasket.

⚠ **CAUTION**
- **Since a gasket has front and back, install the black side on the exhaust manifold.**

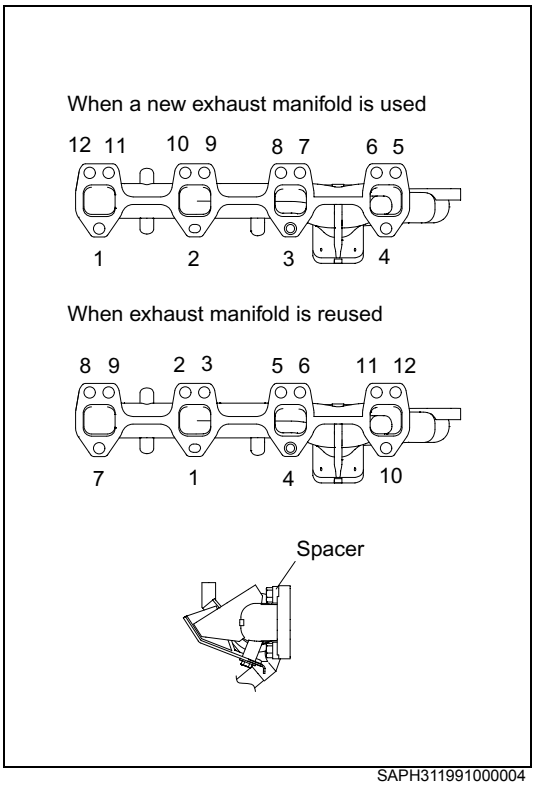


SAPH311991000003

(2) Tighten the mounting nut of the exhaust manifold according to the order in the figure.

Tightening torque : 53 N·m {540 kgf·cm, 40 lbf·ft}

⚠ **CAUTION**
- **When nuts are tightened, prevent each spacer from riding on the counterbore area of the manifold flange.**
- **The tightening sequence of the exhaust manifold varies between use of a new part and reuse.**



SAPH311991000004

(3) Tighten the same nuts again according to the order in the figure.
Tightening torque : 53 N·m {540 kgf·cm, 40 lbf·ft}

⚠ **CAUTION**
- **Be sure to retighten it.**

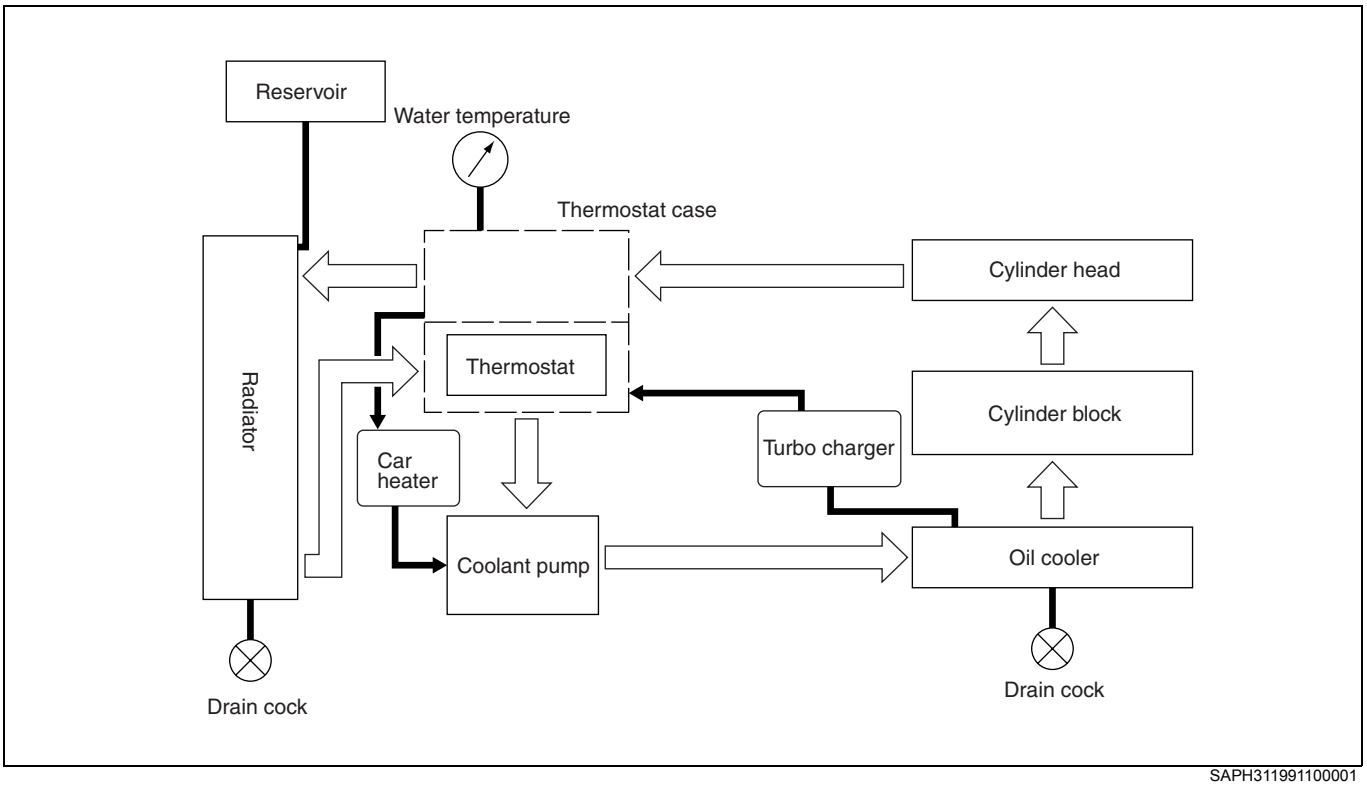
11 COOLING

Cooling System 11-2
Cooling system drawing 11-2
Part layout 11-3
Replacement of thermostat case 11-4
Inspection of thermostat 11-5
Replacement of coolant pump 11-6

Cooling System

Cooling system drawing

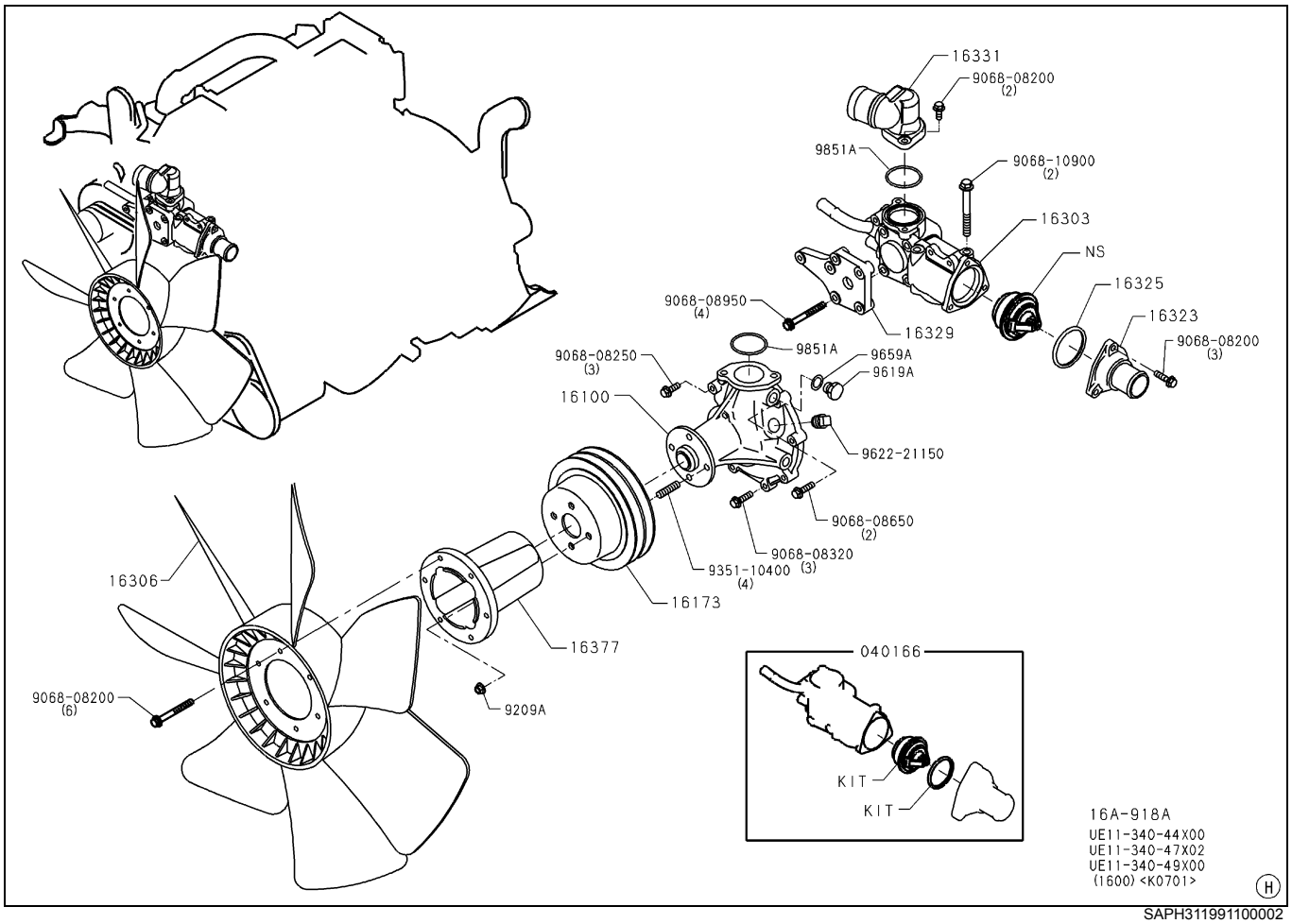
JP31199110803001



SAPH311991100001

Part layout

JP311991104020002



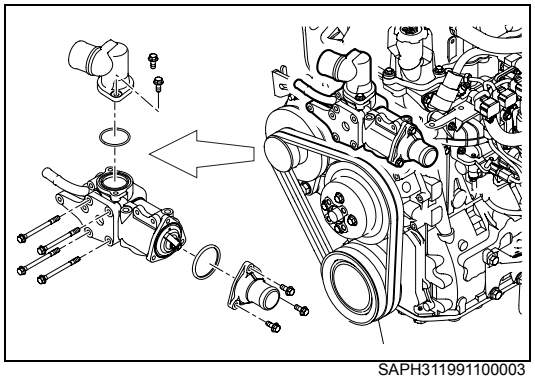
SAPH311991100002

16100	Coolant pump assembly	16325	Gasket*
16173	Coolant pump pulley	16331	Thermostat case cover
16303	Thermostat case	16377	Fan spacer
16306	Cooling fan	9851A	O–ring*
16323	Thermostat case cover		

*Parts not to be reused.

Replacement of thermostat case

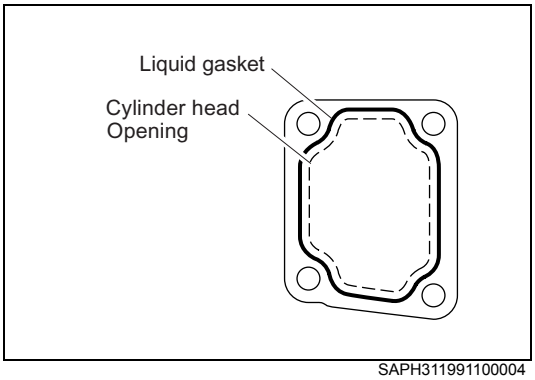
JP31199110704001


SAPH311991100003

1. Removal of thermostat case

(1) Remove bolts and remove the thermostat case.

(2) Remove the O-ring from the groove on the coolant pump.



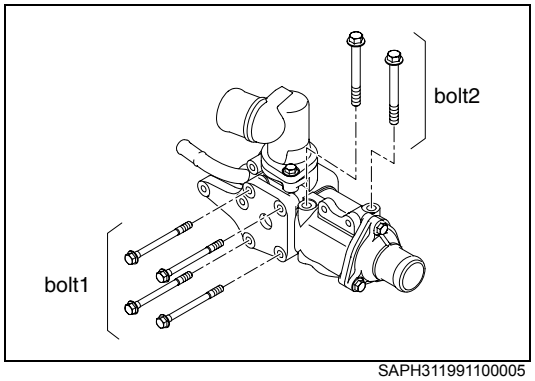
SAPH311991100004

2. Installation of thermostat case

(1) Remove contamination on the joint between the thermostat case and the cylinder head using a scraper.

(2) Apply liquid gasket [Threebond TB1207B(black) or equivalent] to the thermostat case as shown in the figure.

⚠ **CAUTION**
- **Apply it continuously.**
- **Apply the liquid gasket at the width of 1.5 to 2.5 mm{0.0591 to 0.0984 in.}.**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**



SAPH311991100005

(3) Install the new O-ring on the groove of the coolant pump.

(4) Put the thermostat case mounting bolt through the thermostat case in advance.

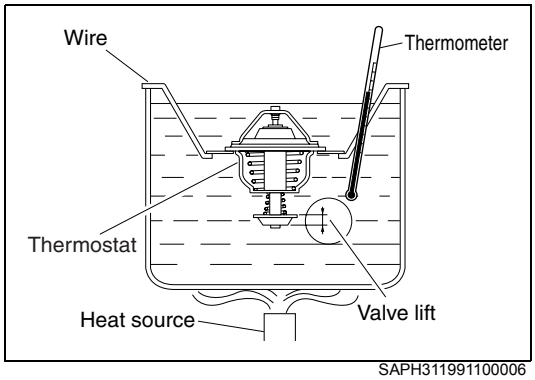
(5) Align the thermostat case at the mounting position and tighten mounting bolt 1 temporarily to the cylinder head.

(6) Tighten mounting bolt 2 temporarily to the coolant pump.

(7) Tighten bolts in the order mounting bolt 1 to the cylinder head and mounting bolt 2 to the coolant pump.

Inspection of thermostat

JP31199110703001



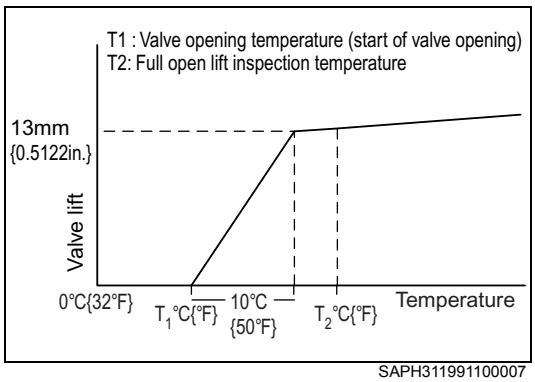
SAPH311991100006

1. Individual inspection of thermostat

(1) Put the thermostat in water as shown in the figure and heat it.

⚠ CAUTION

- **Support the thermostat in the center to prevent approach to the heat source.**
- **Stir the water well so that water temperature in the container may be uniform.**



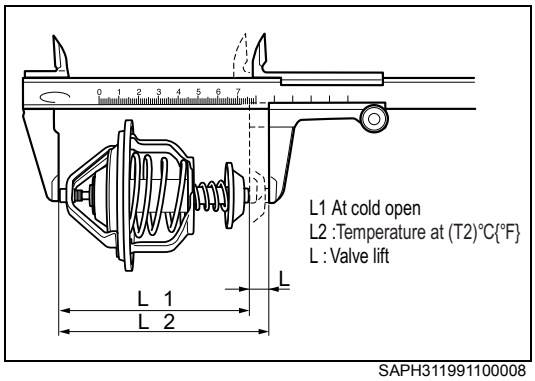
SAPH311991100007

(2) Measure the temperature (valve opening temperature) that opens the thermostat valve.

Thermostat valve opening temperature standard value : T1(°C{°F})	**74.5 - 78.5 {166.1 - 173.3}**

NOTICE

- **The thermostat valve opening temperature (T1) is stamped on the thermostat seat.**



SAPH311991100008

(3) Increase the water temperature to 95 °C{203°F} and measure the lift of the thermostat valve.

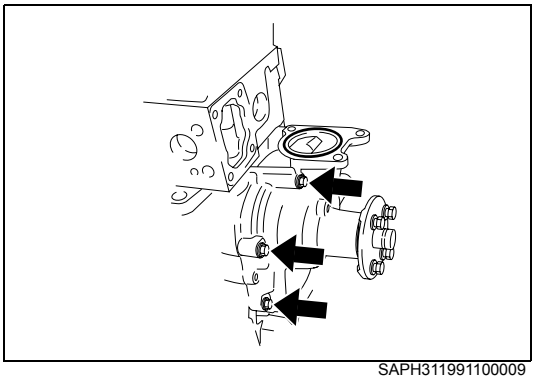
Thermostat valve full open lift inspection temperature : T2 (°C{°F})	Valve lift : L (mm{in.})
95{203}	**10{0.3937} or more**

(4) Put the full open thermostat valve in water at normal temperature. Make sure that the thermostat valve closes completely within 5 minutes.

(5) If faulty item is found with the inspection above, replace the thermostat.

Replacement of coolant pump

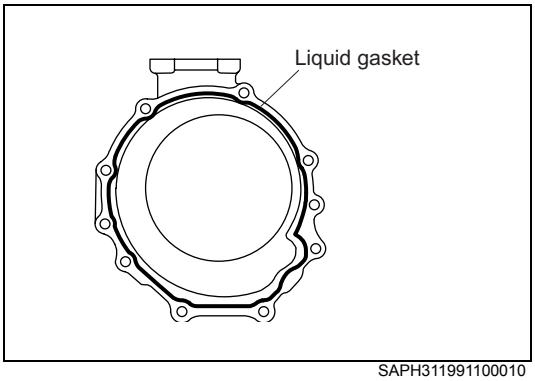
JP31199110704002



SAPH311991100009

1. Removal of coolant pump

(1) Remove bolts and remove the coolant pump.



SAPH311991100010

2. Installation of coolant pump

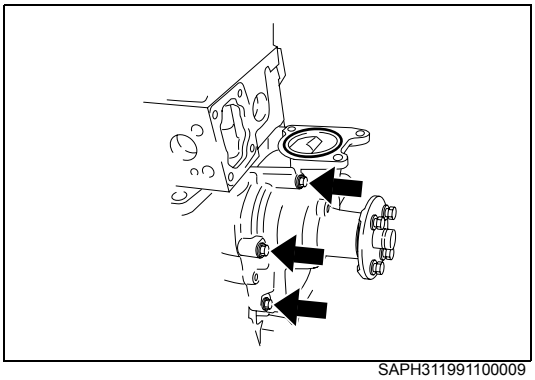
(1) Remove contamination on the joint surface between the coolant pump and the cylinder block using a scraper and degrease the surface.

(2) Apply the liquid gasket [Threebond TB1207B (black) or equivalent] to the coolant pump as shown in the figure.

⚠ CAUTION

- **Apply it continuously.**
- **Apply the liquid gasket at the width of 2 to 3mm{0.0787 to 0.1181in.}.**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**
- **Fill the groove on the water pump flange with the liquid gasket.**

(3) Install the coolant pump to the dowel pin of the cylinder block.



SAPH311991100009

NOTICE

- **When the coolant pump is installed using a guide bolt, displacement of the liquid gasket does not occur.**

12 LUBRICATION

Oil Cooler, Oil Filter and Oil Pump 12-2
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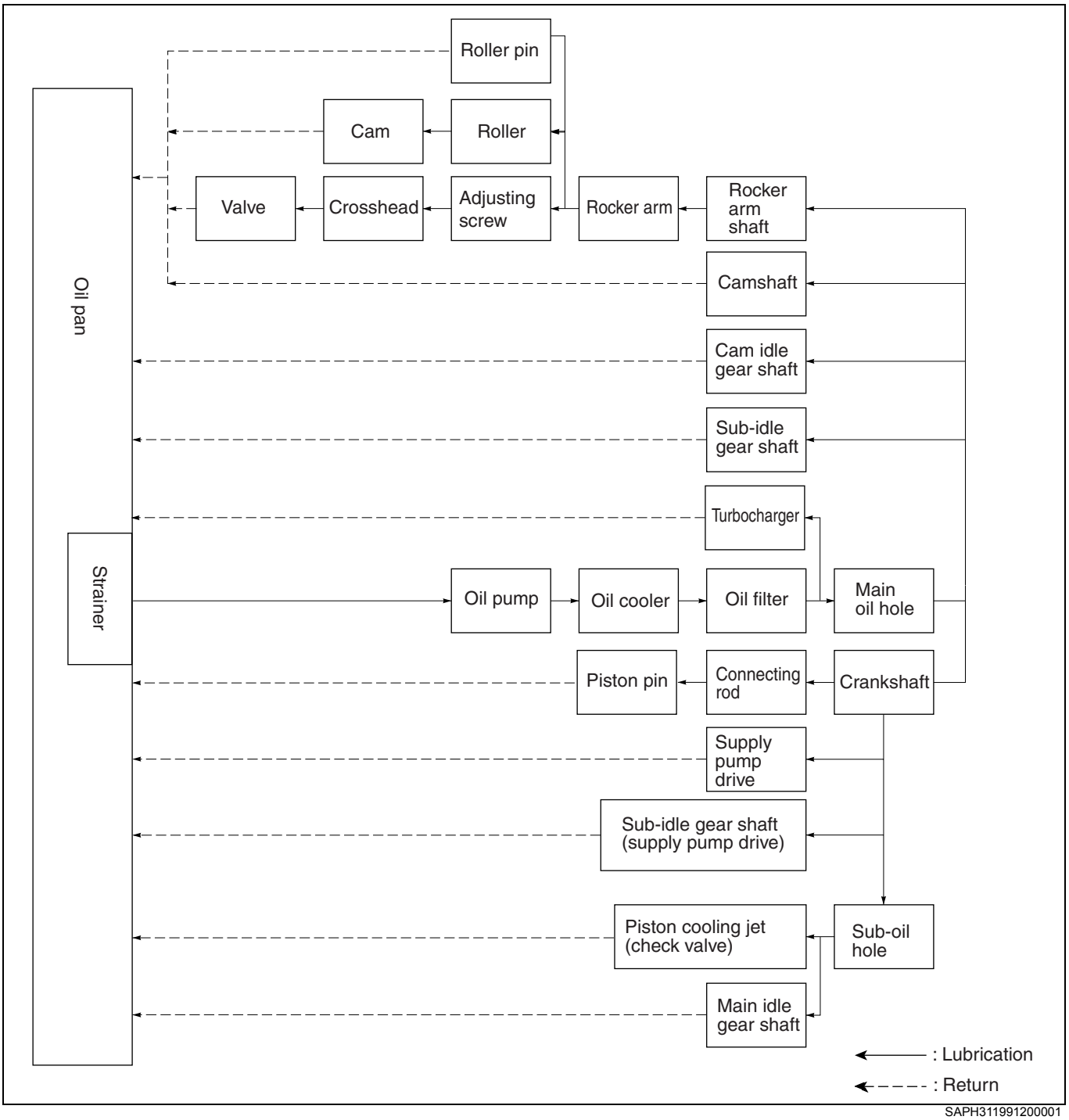
Oil Cooler, Oil Filter and Oil Pump

System drawing

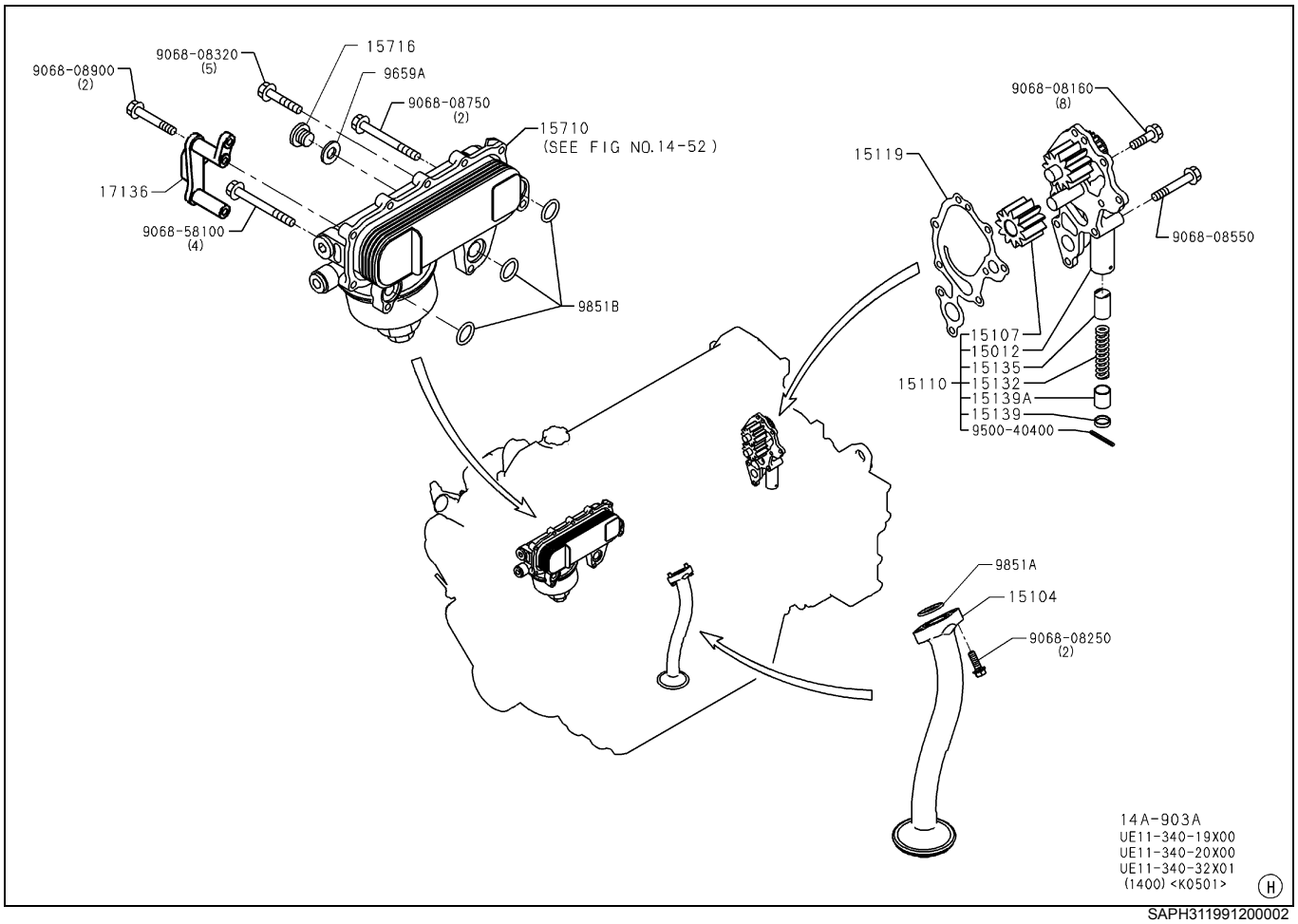
JP31199120805001



SAPH311991200001

Part layout

JP311991204020001



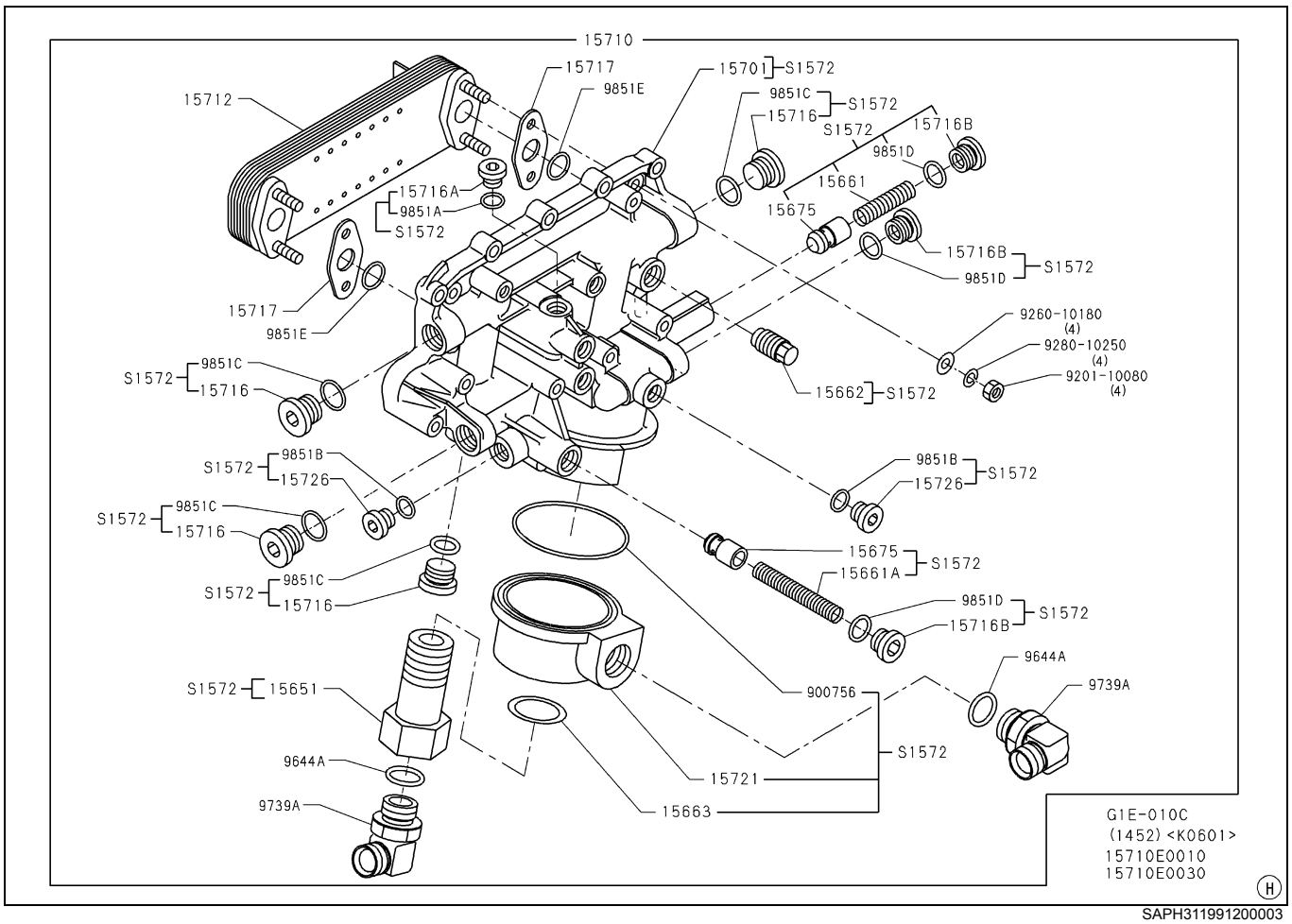
SAPH311991200002

15012	Oil pump cover assembly	15710	Oil cooler
15104	Oil strainer	9500-40400	Cotter pin*
15107	Driven gear	9851A	O–ring*
15110	Oil pump assembly	9851B	D–ring*
15119	Gasket*	15139	Seat2
15132	Relief valve spring	15139A	Seat1
15135	Safety valve		

*Parts not to be reused.

Tightening torque

9068-08160	28.5N·m {290kgf·cm, 21lbf·ft}	9068-08750	24.5±4.9N·m {250±50kgf·cm, 18±4llbf·ft}
9068-08250	31N·m {320kgf·cm, 23lbf·ft}	9068-08900	24.5±4.9N·m {250±50kgf·cm, 18±4lbf·ft}
9068-08320	24.5±4.9N·m {250±50kgf·cm, 18±4lbf·ft}	9068-58100	24.5±4.9N·m {250±50kgf·cm, 18±4llbf·ft}
9068-08550	28.5N·m {290kgf·cm, 21lbf·ft}		



SAPH311991200003

15662	Drain plug	9644A	O–ring*
15675	Safety valve	9739A	Elbow
15701	Oil cooler case	9851A	O–ring*
15710	Oil cooler assembly	9851B	O–ring*
15712	Oil cooler element	9851C	O–ring*
15717	Gasket*	9851D	O–ring*
15720	Oil cooler case assembly	9851E	O–ring*

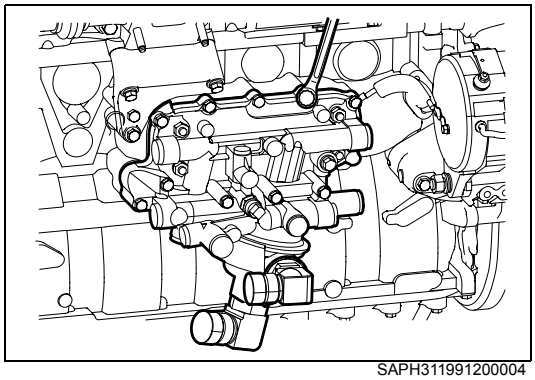
*Parts not to be reused.

Tightening torque

15662	44.1±4.9 N·m {450±50 kgf·cm, 33±4lbf·ft}	9201-10080	24.5±4.9 N·m {250±50 kgf·cm, 18±4lbf·ft}

Replacement of oil cooler

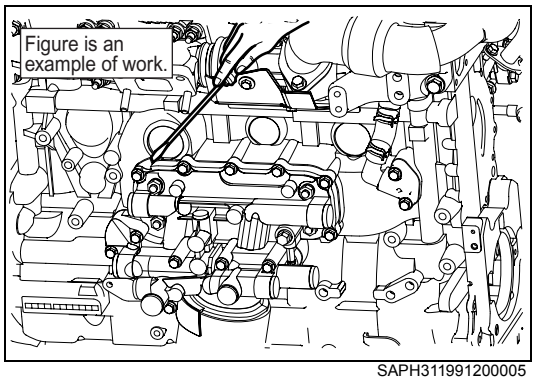
JP31199120704001



SAPH311991200004

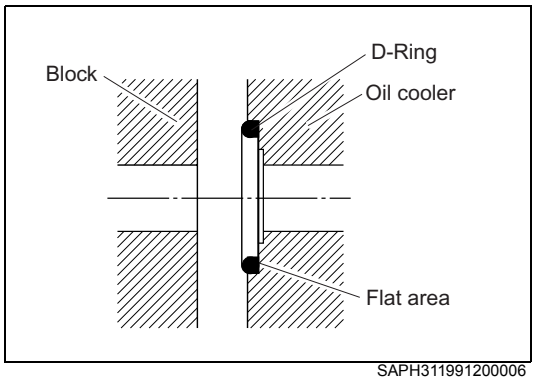
1. Removal of oil cooler

(1) Remove bolts and hose joint, and remove the oil cooler.



SAPH311991200005

(2) If it is difficult to remove the oil cooler due to liquid gasket sticking to the cylinder block, put a flat tip screwdriver at the protrusion in the figure for removal.

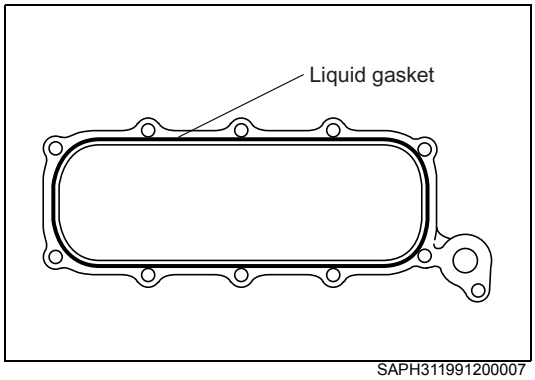


SAPH311991200006

2. Installation of oil cooler

(1) Assemble the new D-ring into the D-ring groove of the oil cooler.

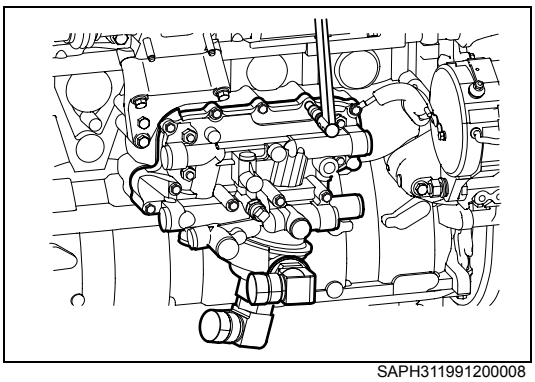
⚠ **CAUTION** • **Face the D-ring flat area toward the oil cooler.**



SAPH311991200007

(2) Remove contamination on the joint surface between the oil cooler and the cylinder block using a scraper. Apply the liquid gasket [Threebond TB1207 (silver) or equivalent] to the oil cooler as shown in the figure.

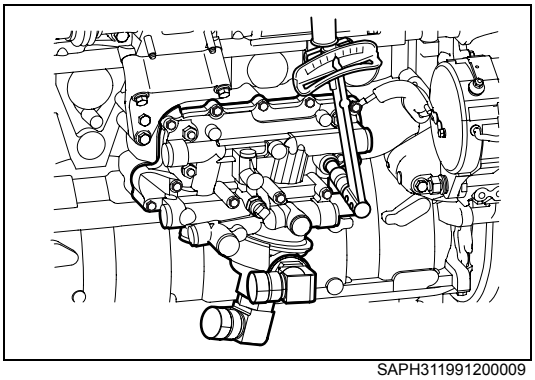
⚠ **CAUTION**
- **Apply it continuously.**
- **Apply the liquid gasket at the width of 1.5 to 2.5 mm{0.0590 to 0.0984 in.}.**
- **Install the oil cooler within 20 minutes after application of the liquid gasket.**


SAPH311991200008

(3) Insert the positioning stud into the screw hole of the cylinder block and install the oil cooler.

(4) After temporary tightening with bolts, remove the positioning stud and tighten bolts.
Tightening torque :
24.5±4.9 N·m {250±50 kgf·cm, 18±4 lbf·ft}

⚠ **CAUTION**
- **Tighten together with the alternator ground.**
- **Be sure to connect the turbocharger lubricating oil hose.**


SAPH311991200009

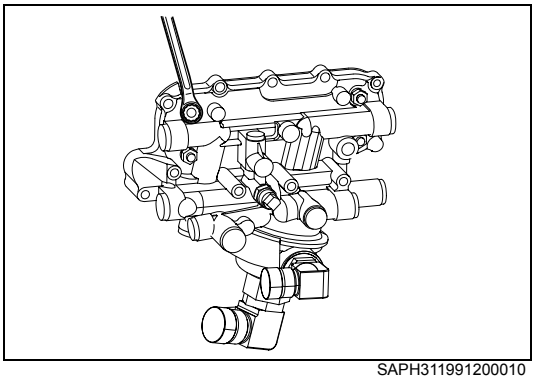
(5) Install the drain plug.

Tightening torque :
44.1±4.9 N·m {450±50 kgf·cm, 33±4 lbf·ft}

⚠ **CAUTION**
- **If a new part is used, tighten it to 58.8±4.9N·m {600±50kgf·cm, 43±4lbf·ft} and loosen it. Then, tighten it again to the torque above.**

Overhaul of oil cooler

JP311991207020001


SAPH311991200010

1. Removal of oil cooler element

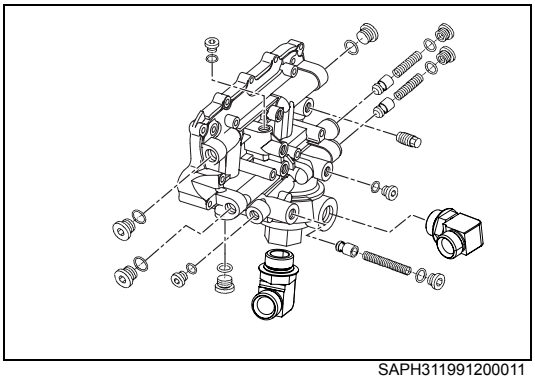
(1) Remove nuts and remove the oil cooler element.

2. Inspection of oil cooler element

(1) Wash water and oil channels with kerosene oil or washing fluid.

(2) Check for crack or deformation on the stud bolt mounting area and element visually.

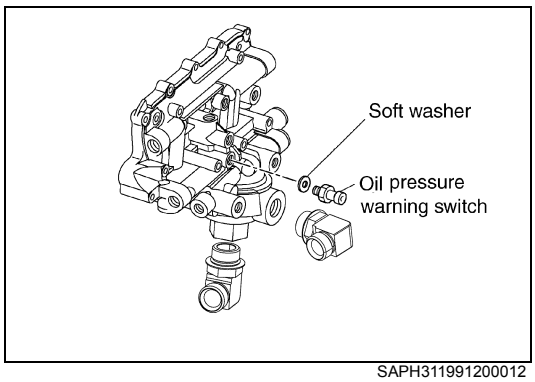
(3) Blow air of approx. 0.5kgf/cm^2 into the oil channel to check for leak from parts. If crack, leak or deformation is found, replace it with a new part.


SAPH311991200011

3. Disassembly of oil cooler case

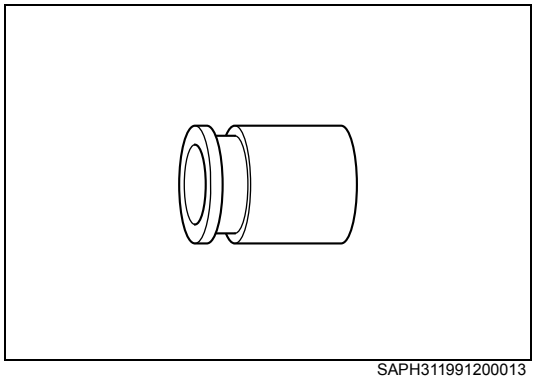
⚠ **CAUTION**
- **Disassembly immediately after stop of the engine may cause blowout of engine oil.**

(1) Remove valve spring plugs and safety valves using a hexagonal wrench.



SAPH311991200012

(2) Remove the oil pressure warning switch.

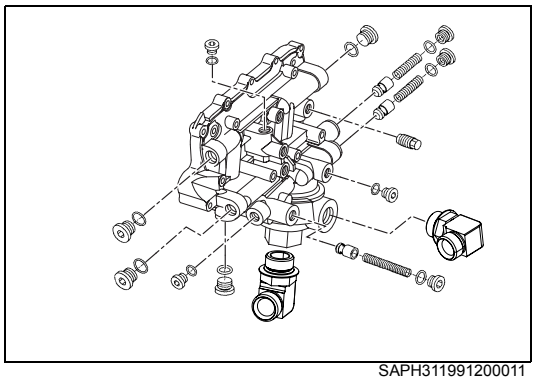

SAPH311991200013

4. Inspection of safety valve wear and damage

(1) If wear or damage is found, replace it.

5. Inspection of oil pressure warning switch

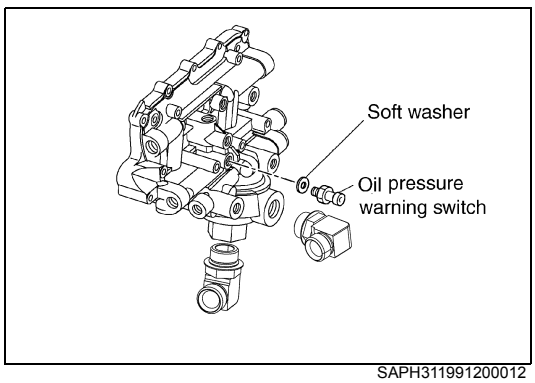
(1) For inspection of oil pressure warning switch, refer to "Inspection of components"- "Electrical".


SAPH311991200011

6. Assembly of oil cooler case

(1) Install a new O-ring and install valve spring plugs and safety valves using a hexagonal wrench.

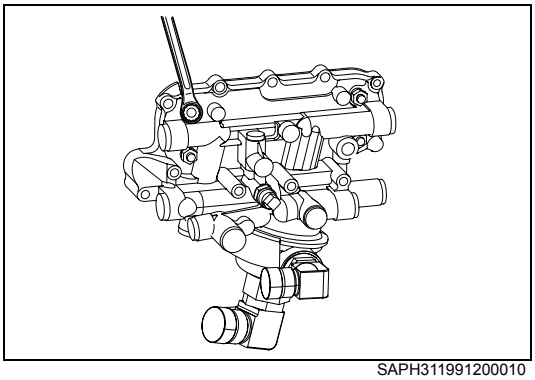
Tightening torque :
24.5±4.9 N·m {250±50 kgf·cm, 18±4 lbf·ft} (M14, M20)
29.4±4.9 N·m {300±50 kgf·cm, 22±4 lbf·ft} (M22)
34.3±4.9 N·m {350±50 kgf·cm, 25±4 lbf·ft} (M24)



SAPH311991200012

(2) Apply the liquid gasket [Threebond TB1211 (white) or equivalent] to the sealing surface of a new soft washer.

(3) Install the soft washer in (2) and the oil pressure warning switch.



SAPH311991200010

7. Installation of oil cooler element

(1) Assemble new gasket and new O-ring and assemble the oil cooler element with nuts.

Tightening torque :
24.5±4.9 N·m {250±50 kgf·cm, 18±4 lbf·ft}

⚠ **CAUTION**

- **In handling the oil cooler element, be careful not to give damage to it.**

Replacement of oil pump

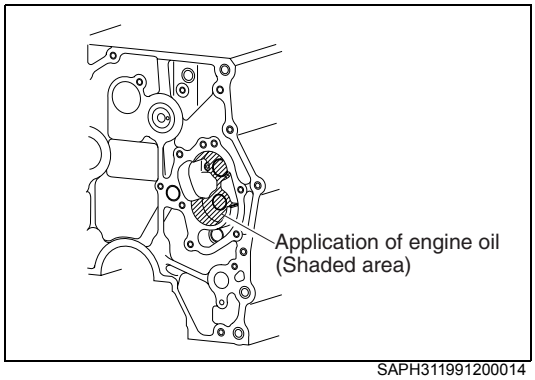
JP31199120704002

1. Removal of oil pump

(1) Dismount the engine from the machine.
(2) Remove the flywheel.
(3) Remove the flywheel housing.
(4) Remove the timing gear.
(5) Remove the oil pump.

2. Installation of oil pump

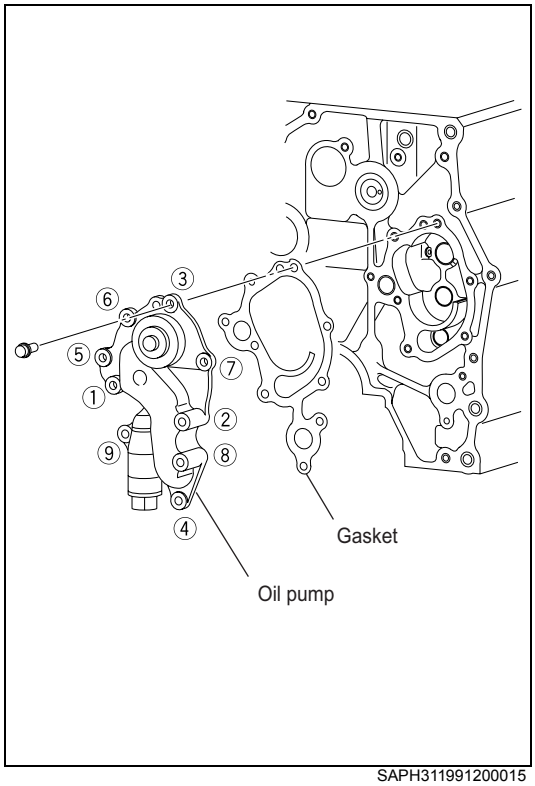
(1) Apply engine oil to the pump case and the bearing (shaded area) of the cylinder block.



SAPH311991200014

⚠ CAUTION
- **Without application of engine oil, poor oil suction may occur at the initial start, resulting in seizure or abnormal wear.**

(2) To prevent bolt hole offset of the new gasket, apply engine oil to the cylinder block in advance and place and fix the gasket.



SAPH311991200015

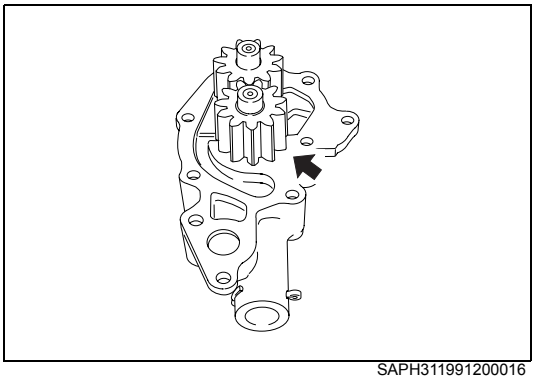
⚠ CAUTION
- **Assembly with offset gasket may cause faulty sealing. Oil in the oil pump may be completely discharged when the engine stops. Faulty sealing may cause insufficient suction of oil at initial revolution of engine restart, resulting in seizure or abnormal wear.**

(3) Tighten the oil pump according to the order in the figure.
Tightening torque : 28.5 N·m {290 kgf·cm, 21 lbf·ft}

⚠ CAUTION
- **If the tightening order is not observed, the oil pump may be damaged.**
- **After tightening, make sure that the gear can be turned with hand.**

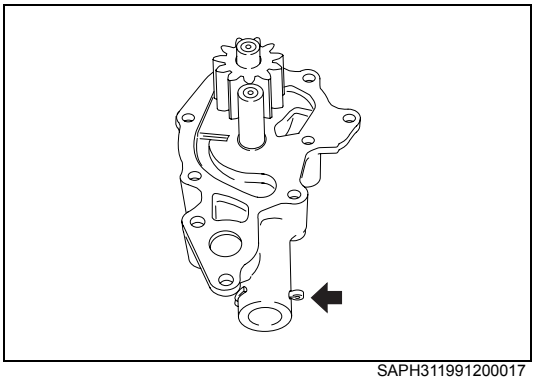
Overhaul of oil pump

JP31199120702002



SAPH311991200016

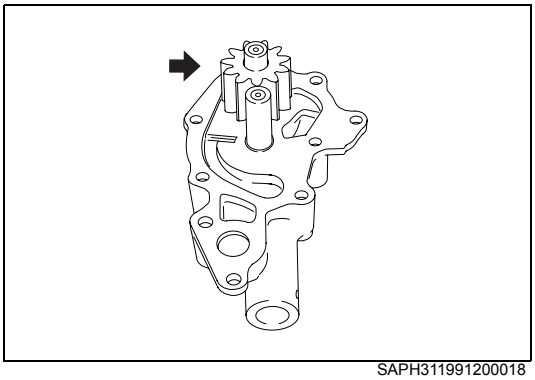
1. Remove the driven gear.



SAPH311991200017

2. Remove the cotter pin and remove seat 2, seat 1, relief valve spring and safety valve.

⚠ CAUTION
- **When the cotter pin is removed, seat 2 and the relief valve spring may eject out.**

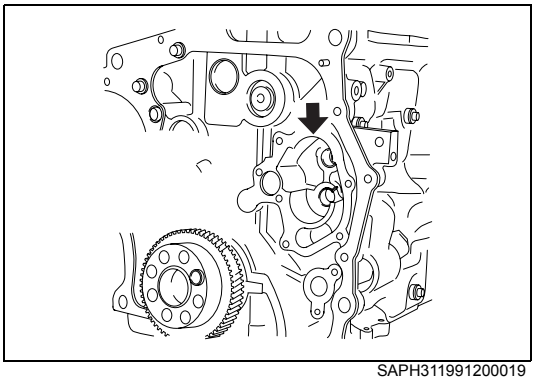


SAPH311991200018

3. Inspection of clearance between drive gear and cylinder block

(1) Measure the outer diameter of the drive gear and the inner diameter of the pump chamber at cylinder block.

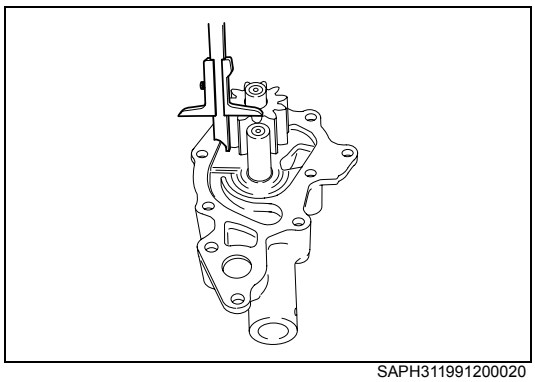
Measuring area	Standard value (mm{in.})
Outer diameter of drive gear	54{2.1260}
Inner diameter of pump chamber at cylinder block	54{2.1260}



SAPH311991200019

(2) Calculate the difference between the outer diameter of the drive gear and the inner diameter of the pump chamber at the cylinder block. If it is beyond the service limit, replace the oil pump assembly.

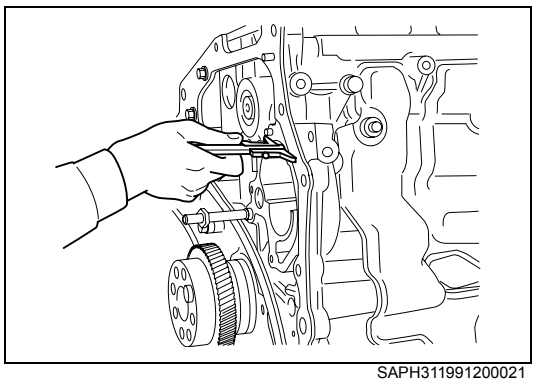
Standard value (mm{in.})	Service limit (mm{in.})
0.100 - 0.202{0.0039 - 0.0080} (reference)	0.30{0.0118}


SAPH311991200020

4. End play inspection between drive gear and cylinder block

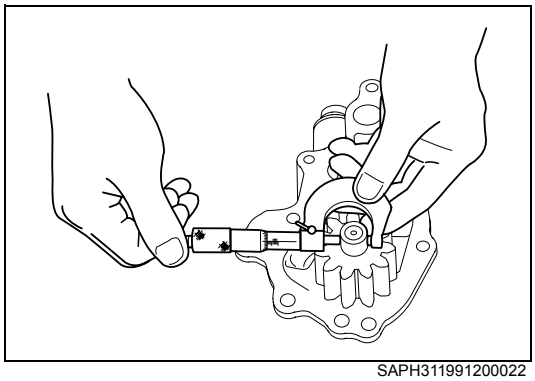
(1) Measure the drive gear width and the pump chamber depth at the cylinder block using a depth gauge.

Measuring area	Standard value (mm{in.})
Width of drive gear	28.5{1.1220}
Depth of pump chamber at cylinder block	28.5{1.1220}


SAPH311991200021

(2) Calculate the difference between the depth of the drive gear and the pump chamber depth at the cylinder block. If it is beyond the service limit, replace the oil pump assembly.

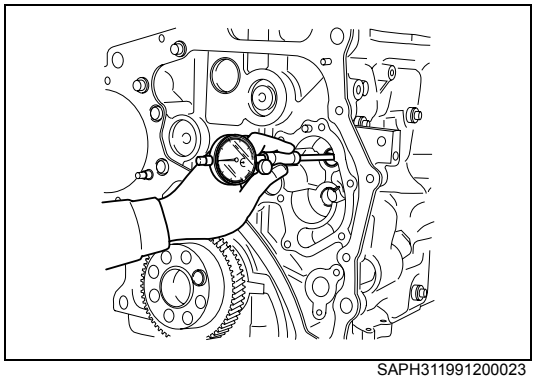
Standard value (mm{in.})	Service limit (mm{in.})
0.049 - 0.113{0.0020 - 0.0044} (reference)	0.15{0.0060}


SAPH311991200022

5. Inspection of clearance between outer diameter of driven gear shaft and cylinder block hole diameter

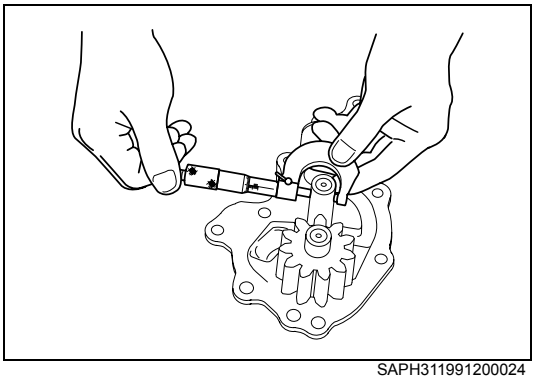
(1) Measure the outer diameter of the driven gear shaft using a micrometer and measure the cylinder block hole diameter using a cylinder gauge.

Measuring area	Standard value (mm{in.})
Outer diameter of driven gear shaft	18{0.7087}
Cylinder block hole diameter	18{0.7087}


SAPH311991200023

(2) Calculate the difference between the outer diameter of the driven gear and the cylinder block hole diameter. If it is beyond the service limit, replace the oil pump assembly.

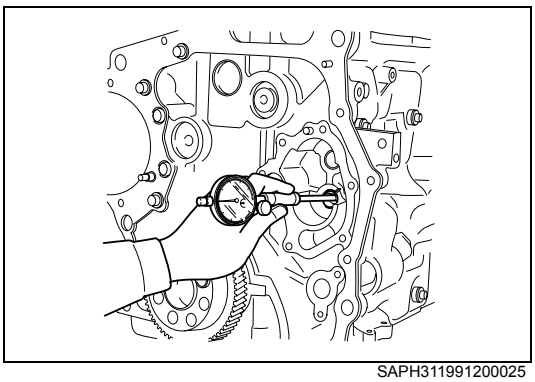
Standard value (mm{in.})	0.040 - 0.099 {0.0016 - 0.0039}


SAPH311991200024

6. Inspection of clearance betweeen outer diameter of driven gear shaft and inner diameter of driven gear bushing

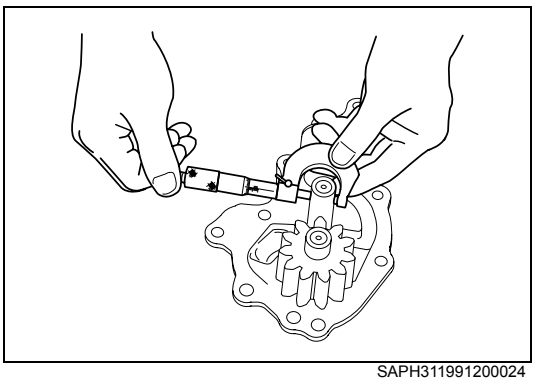
(1) Measure the outer diameter of the driven gear shaft using a micrometer and measure the inner diameter of the driven gear bushing using a cylinder gauge.

Measuring area	Standard value (mm{in.})
Outer diameter of driven gear shaft	18{0.7087}
Cylinder block hole diameter	18{0.7087}


SAPH311991200025

(2) Calculate the difference between the outer diameter of the driven gear and the cylinder block hole diameter. If it is beyond the service limit, replace the oil pump assembly.

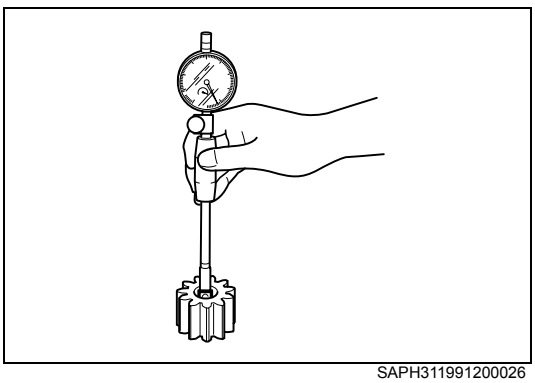
Standard value (mm{in.})	0.030 - 0.075 {0.0012 - 0.0030}


SAPH311991200024

7. Inspection of clearance betweeen outer diameter of driven gear shaft and inner diameter of driven gear bushing

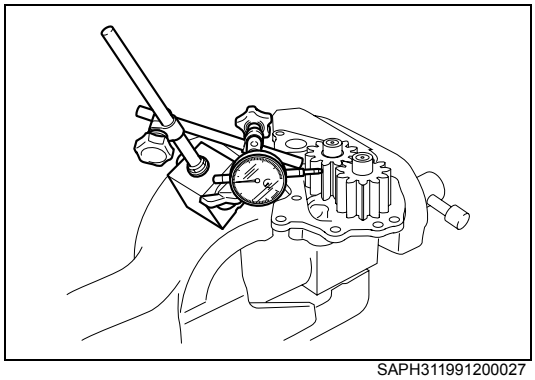
(1) Measure the outer diameter of the driven gear shaft using a micrometer and measure the inner diameter of the driven gear bushing using a cylinder gauge.

Measuring area	Standard value (mm{in.})
Outer diameter of driven gear shaft	18{0.7087}
Inner diameter of driven gear bushing	18{0.7087}


SAPH311991200026

(2) Calculate the difference between the outer diameter of the driven gear shaft and the inner diameter of the driven gear bushing. If it is beyond the service limit, replace the oil pump assembly or the driven gear bushing.

Standard value (mm{in.})	Service limit (mm{in.})
0.040 - 0.083 {0.0016 - 0.0033}	0.15{0.00059}

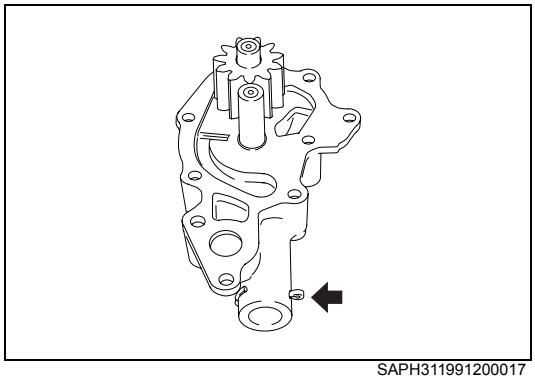

SAPH311991200027

8. Inspection of drive gear backlash

(1) Fix the oil pump assembly with a vice.

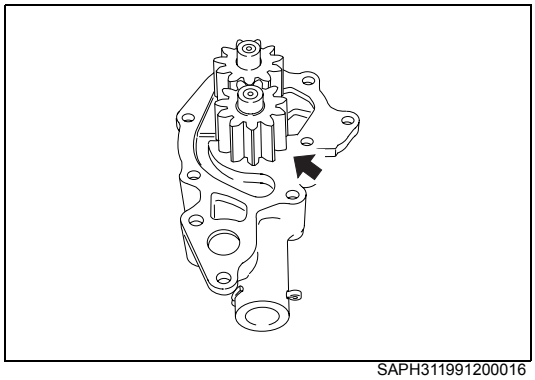
(2) Measure backlash between the drive gear and the driven gear using a dial gauge. If it is beyond the service limit, replace the oil pump assembly.

Standard value (mm{in.})	Service limit (mm{in.})
0.072 - 0.277 {0.0028 - 0.0109}	0.30{0.0118}


SAPH311991200017

9. Assembly of oil pump

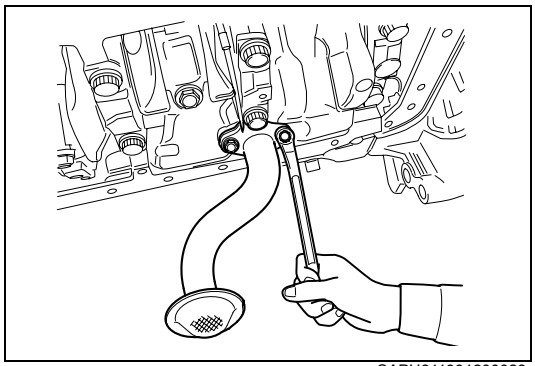
(1) Install the safety valve, relief valve, seat 1 and seat 2 on the oil pump cover assembly with new cotter pins.


SAPH311991200016

(2) Install the driven gear.

Replacement of oil strainer

JP31199120704003


SAPH311991200028

1. Removal of oil strainer

(1) Remove bolts and remove the oil strainer.

2. Installation of oil strainer

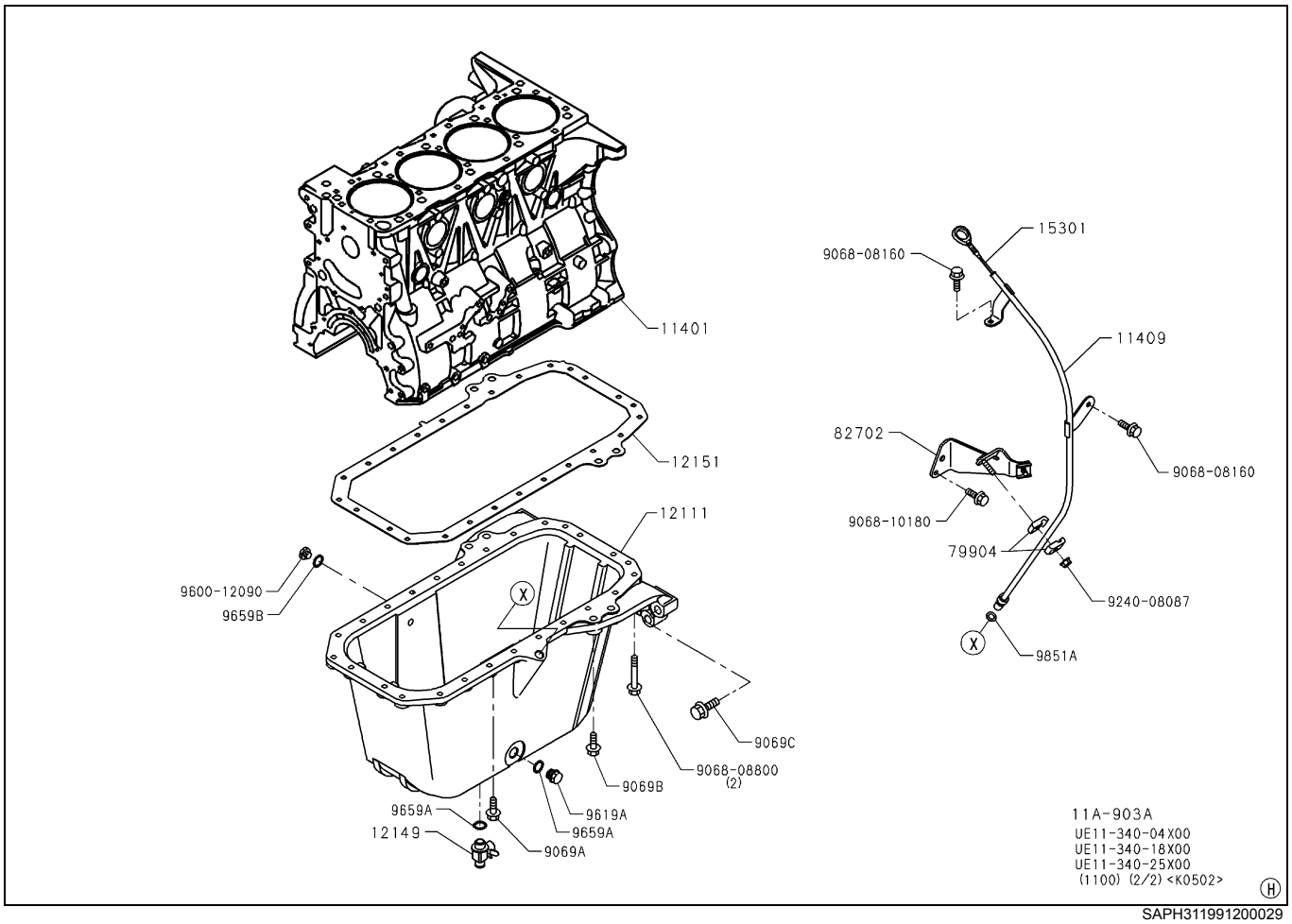
(1) Replace the O-ring with new ones and install the oil strainer.

Tightening torque : 31 N·m {320 kgf·cm, 23 lbf·ft}

Oil Pan

Part layout

JP31199120402003



SAPH311991200029

12111	Oil pan assembly	12149	Drain plug
12151	Oil pan gasket*	9659A	Gasket*

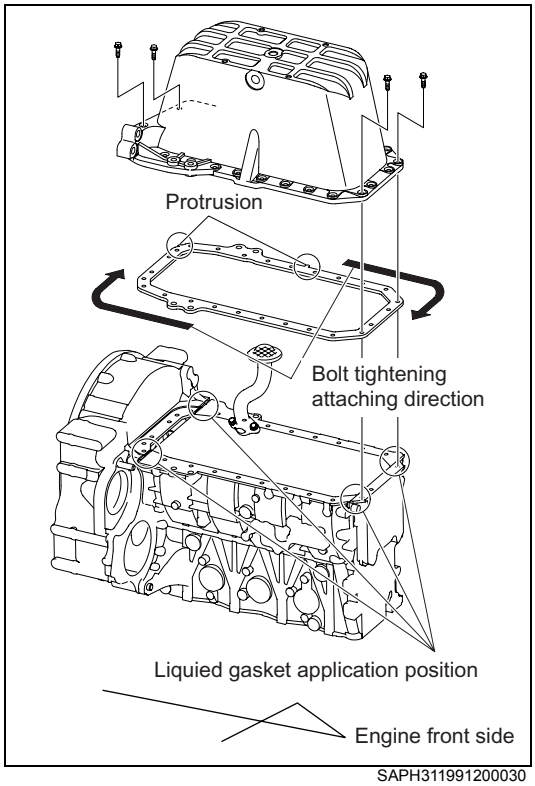
*Parts not to be reused.

Tightening torque

12149	30 N·m {300 kgf·cm, 22lbf·ft}	9068-08800	30 N·m {300 kgf·cm, 22lbf·ft}

Replacement

JP31199120704004



SAPH311991200030

1. Installation of oil pan

(1) Cut the gasket of the rear end plate to be flush to the cylinder block lower surface using a scraper.

(2) Make sure that there is no deformation, dirt or oil on the joint surface between the cylinder block and the oil pan. Apply liquid gasket [Threebond TB1207D (silver) or equivalent] to the front rear end of the cylinder block lower surface.

(3) Insert several stud bolts (70 mm{2.7559 in.} or larger) for positioning into the cylinder block screw hole.

(4) Position the oil pan gasket protrusion at the intake side and the flywheel housing (printed seal surface at cylinder block). Align the new oil pan gasket and oil pan to the cylinder block lower surface and tighten bolts in the arrow order of the figure.
Tightening torque :
19.6 - 24.5 N·m {200 - 250 kgf·cm, 14 - 18 lbf·ft}

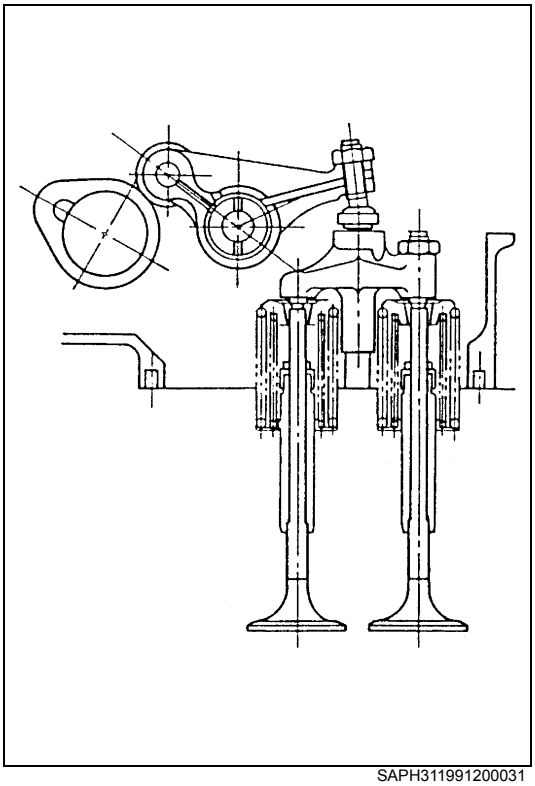
(5) Remove positioning stud bolts and install the correct bolts.

(6) Tighten bolts in the arrow order of the figure.
Tightening torque : 30 N·m {300 kgf·cm, 22 lbf·ft}

⚠ **CAUTION**
- **Check if the washer is not riding on the flange.**
- **Make sure that the printed seal is not peeled or damaged before installation of the oil pan gasket.**

Inspection of lubrication status

JP31199120703001



SAPH311991200031

1. Inspection of valve system

⚠ **CAUTION**
- **Perform inspection with the water temperature at 60 °C{140°F}.**

(1) Remove the head cover.

⚠ **CAUTION**
- **To prevent spread of engine oil, attach a jig which cuts a head cover in half. Cut it to the degree that the camshaft is covered.**

(2) Adjust the engine revolution to the standard idling revolution [1,000/min{rpm}].

(3) After start of the engine, make sure that oil is supplied to the areas below of all rocker arms within about 10 seconds.
- Roller and cam surface
- Cross head and spring upper seat surface through adjusting screw

⚠ **CAUTION**
- **If time until lubrication is long or if lubrication is not performed, the oil pressure may be low or the oil channel may be clogged. Seizure, abnormal wear or abnormal noise may occur due to insufficient lubrication.**

13 STARTING AND CHARGING

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Disassembly 13-3
Inspection of components 13-9
Assembly 13-14

Alternator (50A) 13-21
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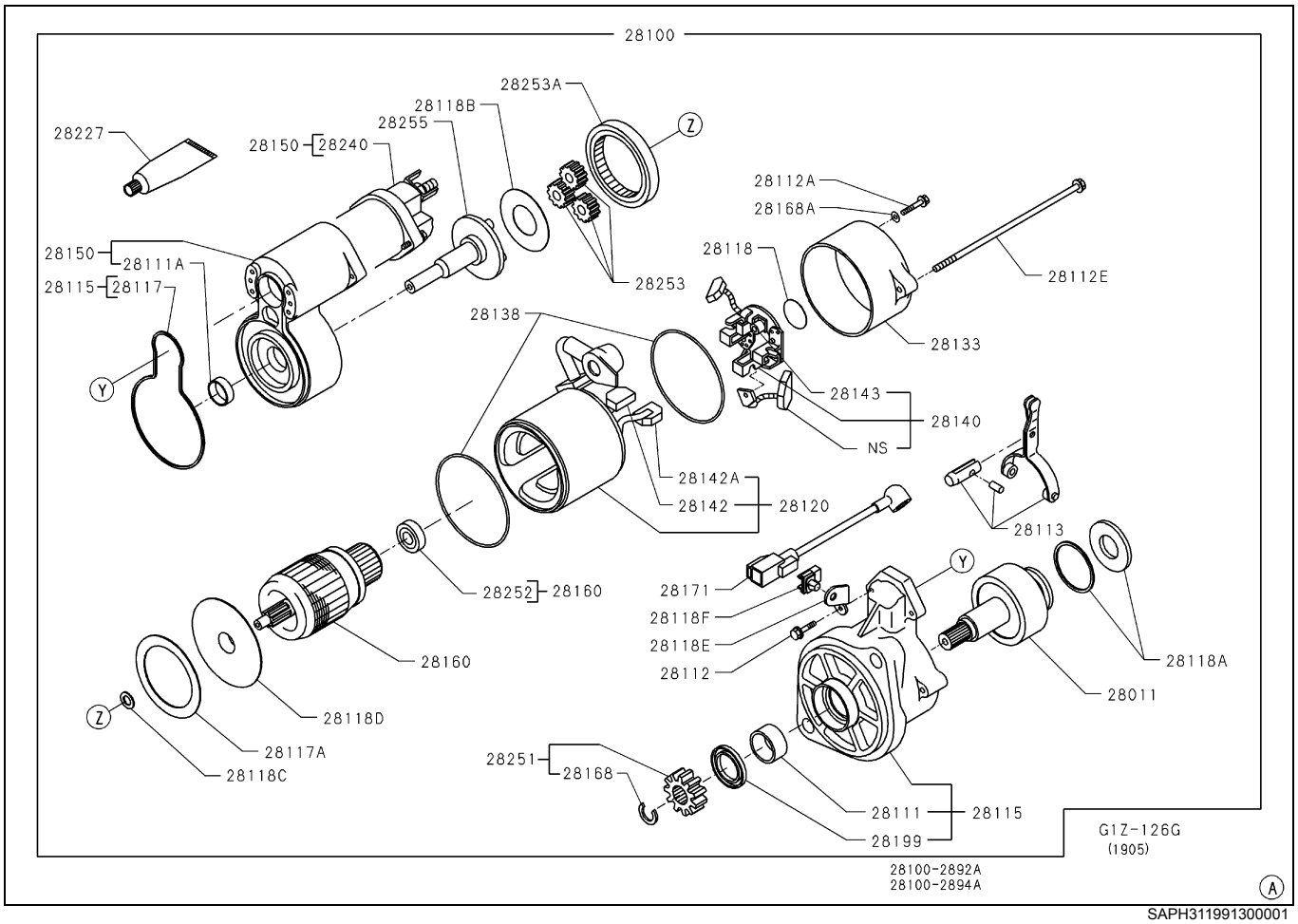
Circuit drawing (50A) 13-22
Disassembly 13-23
Inspection of components 13-26
Assembly 13-29
Inspection after assembly 13-33

Starter

Part layout (typical example)

JP31199130402001



SAPH311991300001

28011	Clutch assembly	28138	Packing*
28100	Starter	28140	Brush holder assembly
28111	Bushing	28142	Brush
28111A	Bushing	28142A	Brush
28113	Lever assembly	28143	Spring
28115	Start drive housing	28150	Center bracket
28117	Packing*	28160	Armature assembly
28117A	Packing*	28168	Retainer clip*
28118	Plate	28199	Dust protector
28118A	Brake plate	28240	Start magnet switch
28118B	Plate	28251	Pinion
28118C	Sim	28252	Rear side bearing*
28118D	Cover	28255	Shaft assembly
28120	Yoke assembly	28253	Planetary gear
28133	Commutator end frame	28253A	Internal gear

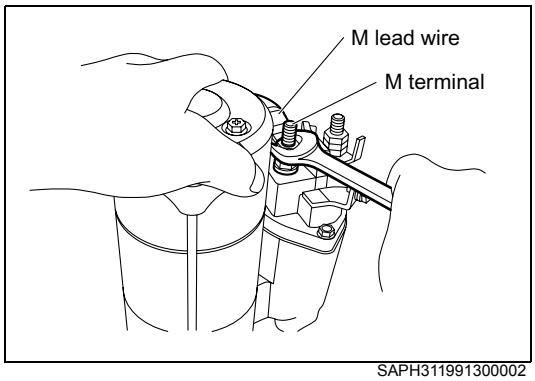
*Parts not to be reused.

Tightening torque

28112	14-16 N·m{140-160kgf·cm, 10-12lbf·ft}	28112E	15.7-17.6 N·m{160-179kgf·cm, 12-13lbf·ft}
28112A	3.6-4.9 N·m{37-49kgf·cm, 3-4lbf·ft}		

Disassembly

JP31199130702001



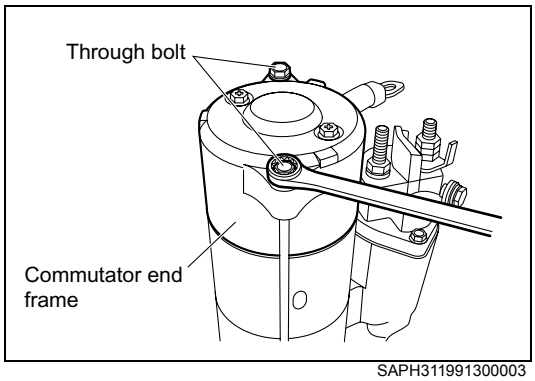
SAPH311991300002

NOTICE • **Fix the starter on the working table to ease accessibility.**

1. MRemoval of lead wire

(1) Remove the cap of the M terminal.

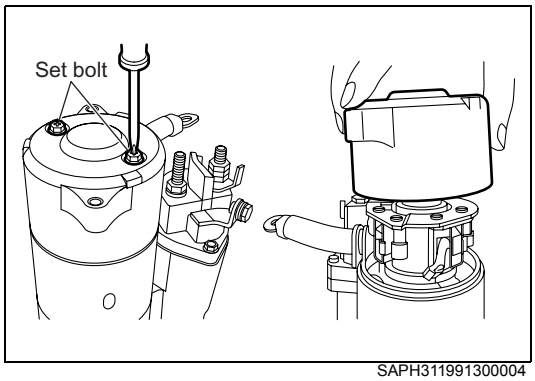
(2) Remove nuts and remove the M lead wire.



SAPH311991300003

2. Removal of commutator end frame

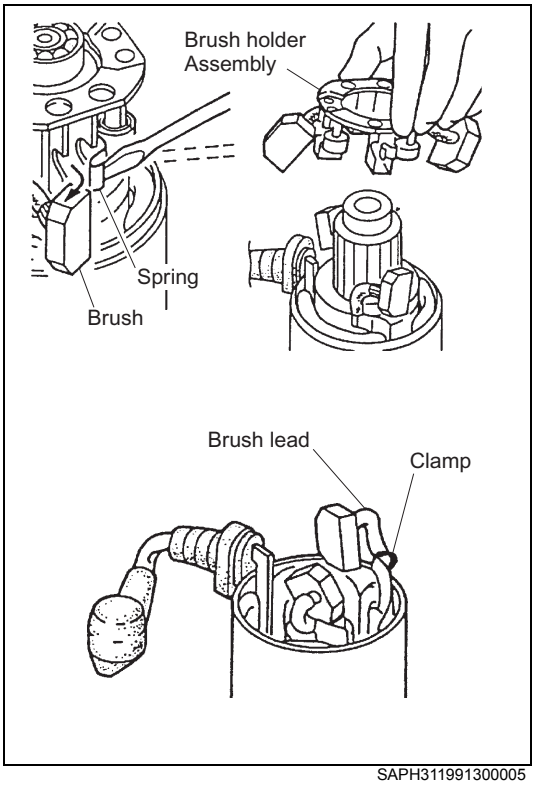
(1) Loosen and remove two through bolts.



SAPH311991300004

(2) Remove two set bolts and remove the commutator end frame.

⚠ **CAUTION** • **Hold the M lead wire and remove the commutator end frame by lifting.**



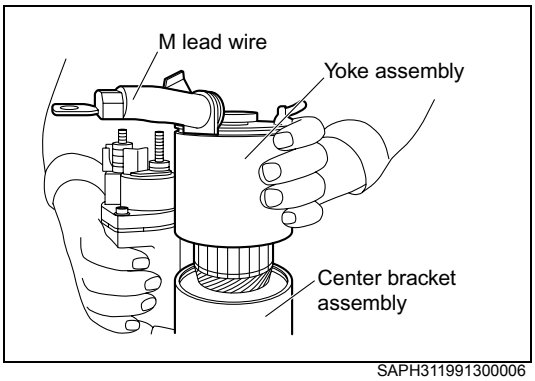
SAPH311991300005

3. Removal of brush holder assembly

(1) Lift the spring using a flat tip screwdriver or pliers. Remove four brushes from the brush holder assembly.

⚠ **CAUTION** • **Do not cut the brush lead fixing clamp.**

(2) Remove the brush holder assembly from the armature assembly.

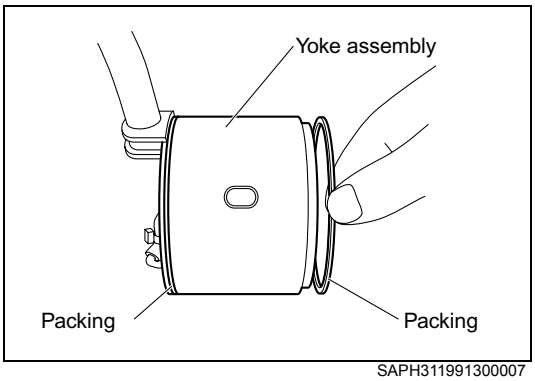


SAPH311991300006

4. Removal of yoke assembly

(1) Remove the yoke assembly from the center bracket assembly.

⚠ **CAUTION** • **Do not hold the M lead wire and hold the yoke assembly outer diameter for removal.**

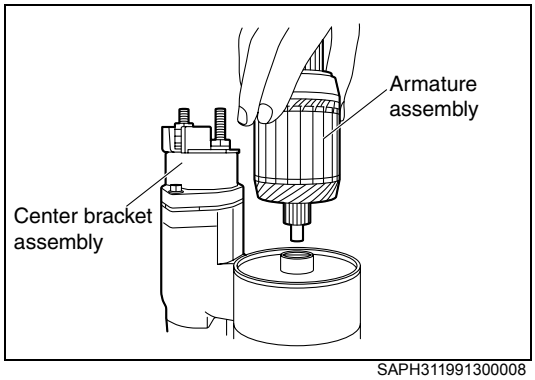


SAPH311991300007

5. Removal of packing

(1) Remove the packing from the centering parts at both ends of the yoke assembly.

⚠ **CAUTION** • **Damaged packing must not be resued. Replace it with a new part.**

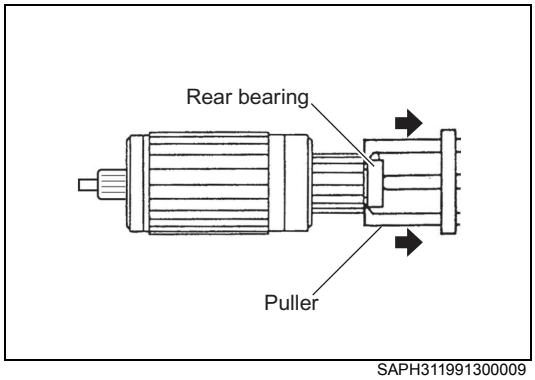


SAPH311991300008

6. Removal of armature assembly

(1) Remove the armature assembly by lifting.

⚠ **CAUTION** • **When the armature assembly is removed, the washer at the end of the gear may be dropped and lost. Be careful for handling.**

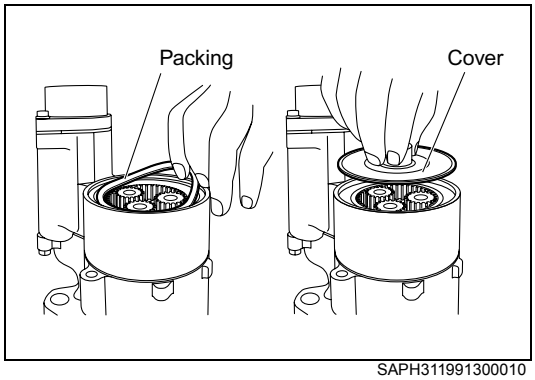


SAPH311991300009

7. Removal of rear bearing

(1) Pull out the bearing of the armature assembly using a puller or press.

⚠ **CAUTION** • **Removed bearing must not be reused. Replace it with a new one.**



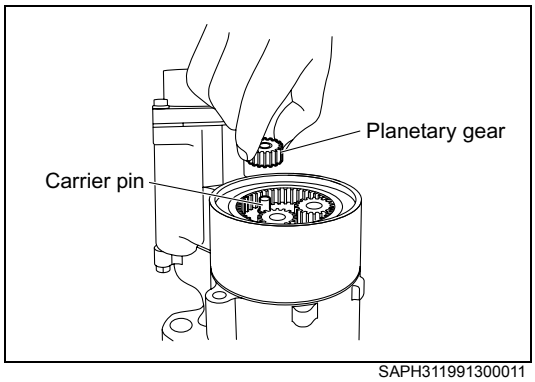
SAPH311991300010

8. Removal of cover

(1) Remove the cover from the center bracket assembly.

(2) Remove the packing.

⚠ **CAUTION** • **Damaged packing must not be resued. Replace it with a new part.**

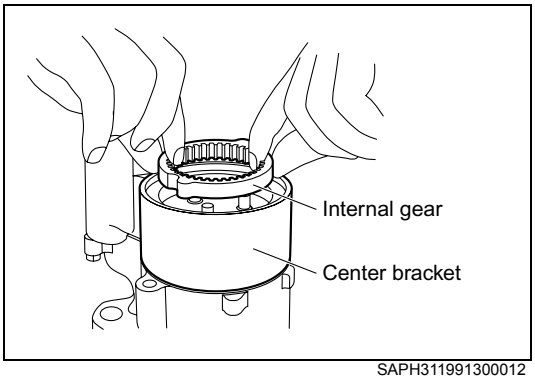


SAPH311991300011

9. Removal of planetary gear

(1) Remove the planetary gear from the carrier pin.

⚠ **CAUTION** • **Make sure that the gear is not damaged or chipped.**

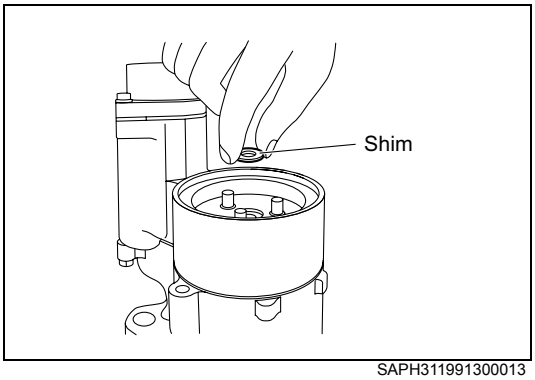


SAPH311991300012

10. Removal of internal gear

(1) Remove the internal gear from the center bracket.

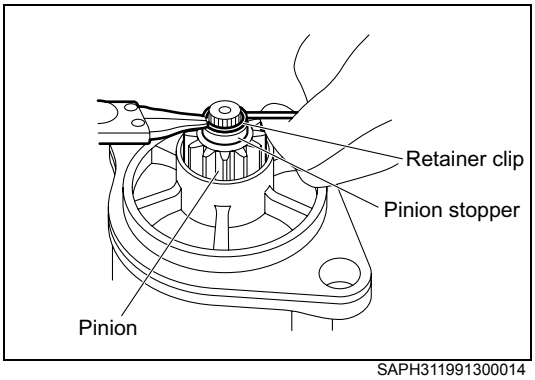
⚠ CAUTION
- **Make sure that the gear is not damaged or chipped.**



SAPH311991300013

11. Removal of shim washer

(1) Remove the shim washer from the center bracket.



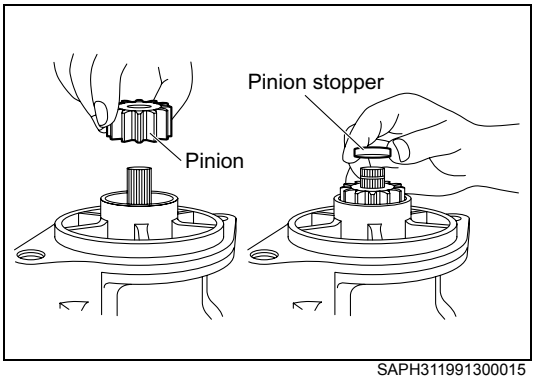
SAPH311991300014

12. Removal of pinion

(1) Remove the retainer clip using a tool such as snap ring pliers.

⚠ CAUTION
- **Retainer clip must not be reused. Replace it with a new one.**

NOTICE
- **Push upward or pull out the chipped part of the clip mouth.**

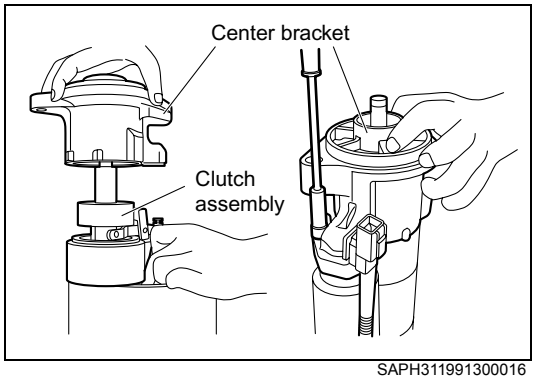


SAPH311991300015

(2) Remove the pinion stopper.

(3) Remove the pinion.

⚠ CAUTION
- **Make sure that the gear is not damaged or chipped.**

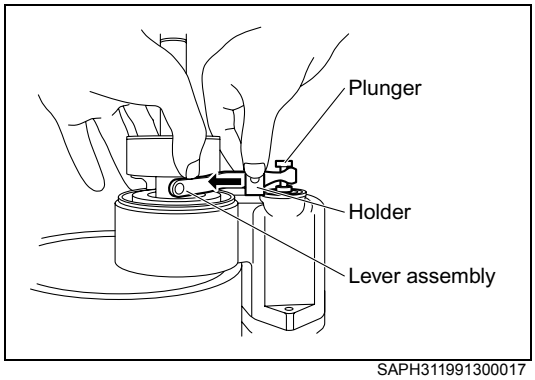


SAPH311991300016

13. Removal of center bracket

(1) Remove two set bolts at the switch using a box screwdriver or offset wrench.

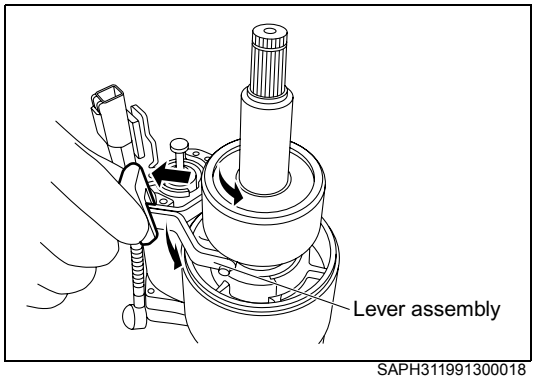
(2) Lift and remove the center bracket.



SAPH311991300017

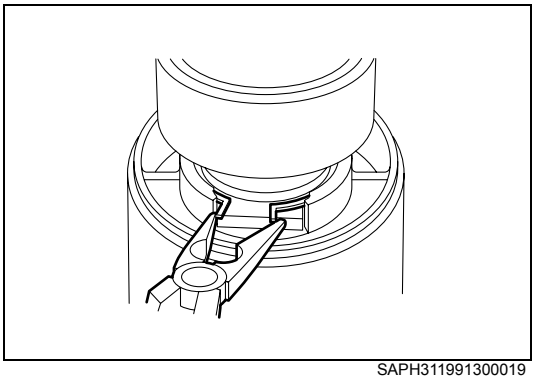
14. Removal of lever

(1) Hold the lever holder and press the entire lever to the clutch. Remove the link with the plunger.



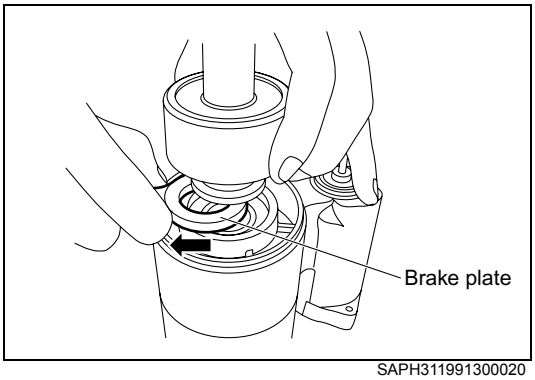
SAPH311991300018

(2) Turn and pull out the lever assembly using the clutch as the axis.


SAPH311991300019

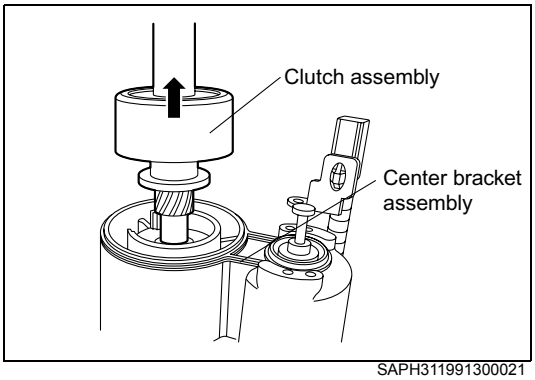
15. Removal of brake plate

(1) Hold the clutch case outer diameter and slide the clutch assembly upward. Pinch the clip end fixing the brake plate and remove it by bending.



SAPH311991300020

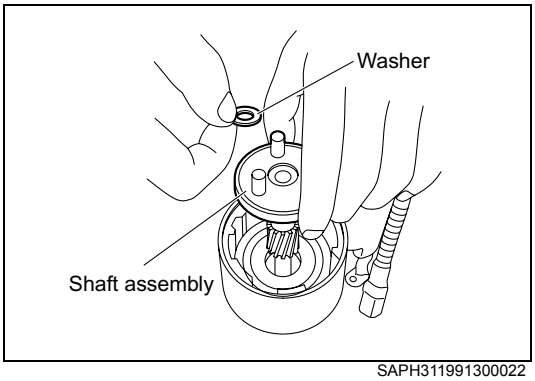
(2) Remove the brake plate.



SAPH311991300021

16. Removal of clutch assembly

(1) While pressing the clutch assembly to the center bracket assembly, offset the helical spline by one tooth.
Pull out the clutch assembly upward from the offset position and remove it.

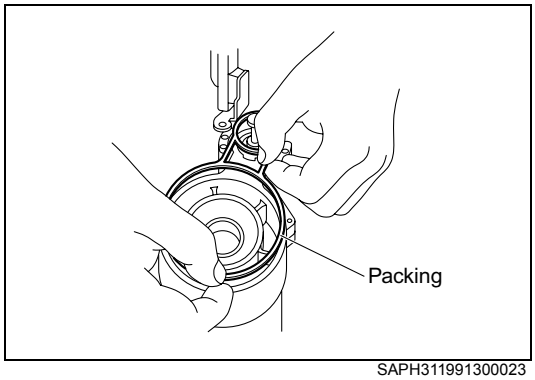


SAPH311991300022

17. Removal of shaft assembly

(1) Turn the center bracket assembly upside down. Hold the carrier plate and pull out the shaft assembly.

⚠ **CAUTION**
- **Washers are available at the upper and lower parts of the carrier plate. Be careful for loss of the washers.**



SAPH311991300023

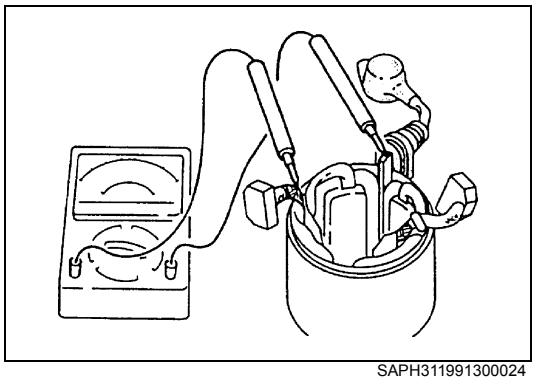
18. Removal of packing

(1) Turn the center bracket upside down again and remove the packing.

⚠ **CAUTION** • **Packing must not be reused.**

Inspection of components

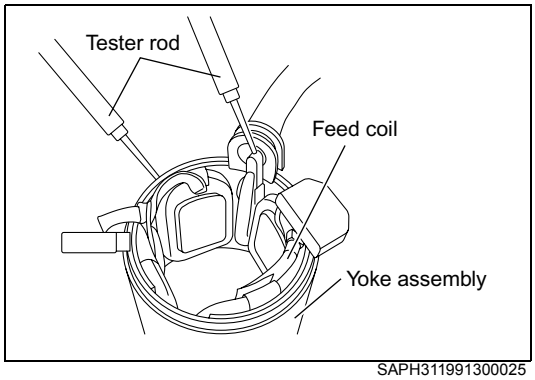
JP31199130703001


SAPH311991300024

1. Inspection of yoke assembly

(1) Make sure that the coil lead wire has electric continuity using a circuit tester.

(2) Make sure that there is no discoloration at the coil.

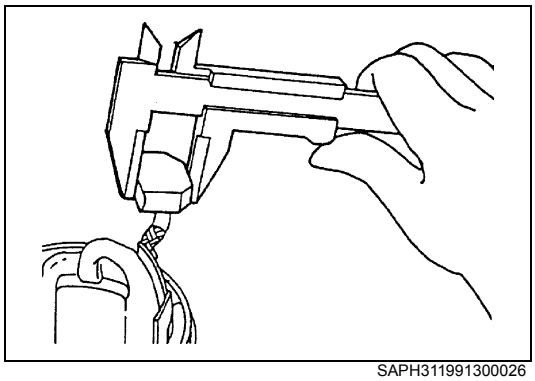


SAPH311991300025

(3) Measure the resistance between the coil lead wire and the yoke with a circuit tester and check insulation.
When the value is below the service limit, replace it.

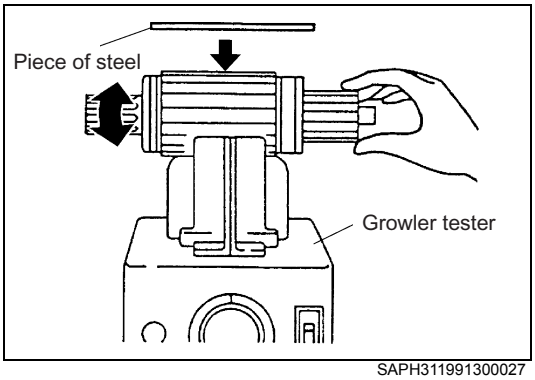
Service limit	1kΩor less

⚠ **CAUTION** • **After cleaning and drying, take measurements.**


SAPH311991300026

(4) Measure the brush length using vernier calipers.
When the value is below the service limit, replace it.

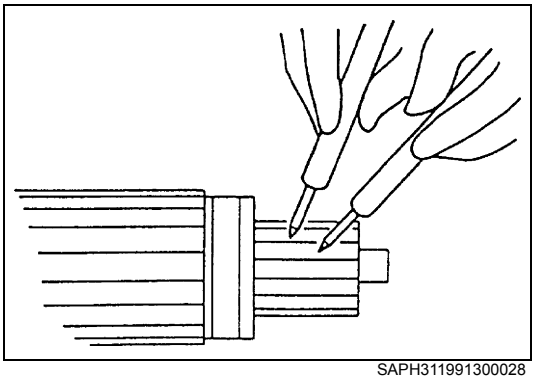
Standard value (mm{in.})	Service limit (mm{in.})
18{0.7087}	13{0.5118} or less



SAPH311991300027

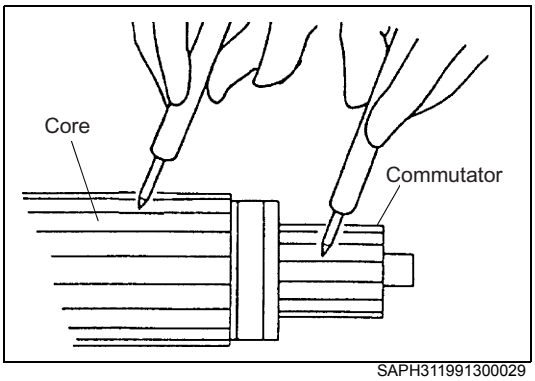
2. Inspection of armature assembly

(1) Turn the armature assembly using a commercially available growler tester and put a piece of steel on the armature assembly. Make sure that the steel piece is not vibrating on the core circumference.


SAPH311991300028

(2) Make sure that adjacent segments of the commutator have electric continuity using a circuit tester.

(3) Make sure that there is no discoloration at the coil.

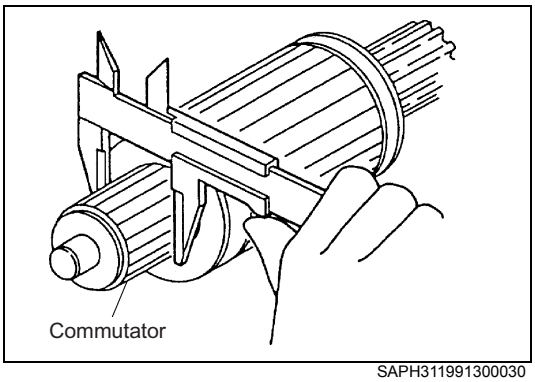


SAPH311991300029

(4) Measure the resistance between the commutator and the core using a circuit tester and check insulation.
When the value is below the service limit, replace it.

Standard value	Service limit
1MΩor more	1kΩor less

⚠ **CAUTION** • **After cleaning and drying, take measurements.**



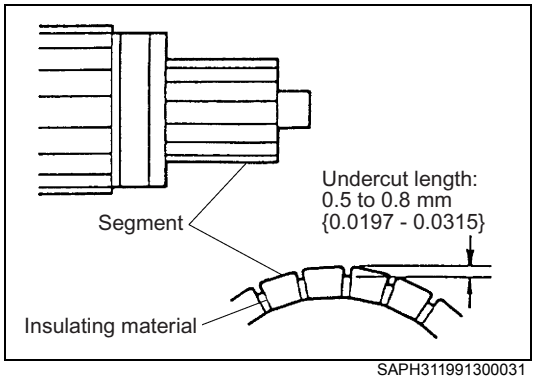
SAPH311991300030

(5) Measure the commutator outer diameter using vernier calipers.
When the value is below the service limit, replace it.

⚠ **CAUTION** • **After removing roughness on the surface (after polishing), take measurements.**

Commutator outer diameter

Standard value (mm{in.})	Service limit (mm{in.})
36{1.4173}	34{1.3386} or less

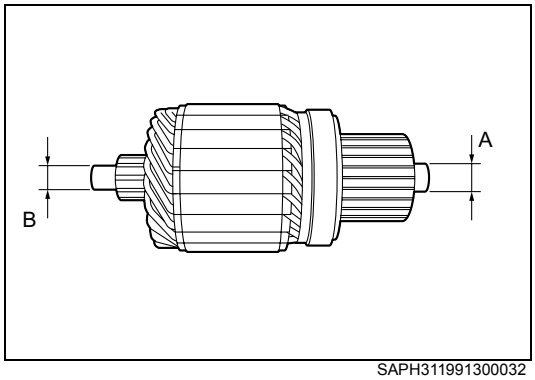


SAPH311991300031

(6) Measure the undercut depth between segments. If the undercut depth is beyond the service limit, repair it.

Standard value (mm{in.})	Service limit (mm{in.})
0.5 - 0.8{0.0197 - 0.0315}	0.2{0.0079} or less

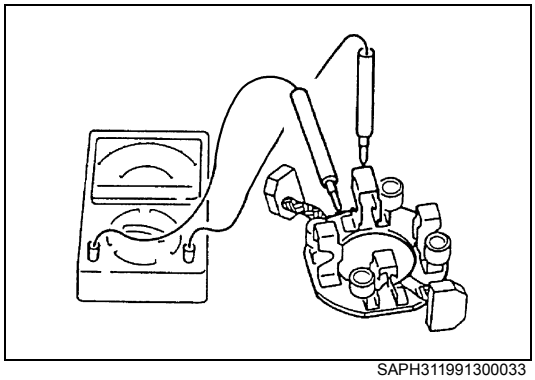
⚠ **CAUTION** • **In repair, do not leave insulation material at the end of the segment.**



SAPH311991300032

(7) Measure the shaft outer diameter using a micrometer. If it is beyond the service limit, replace the shaft.

Measuring area	Standard value (mm{in.})	Service limit (mm{in.})
Area	12{0.4724}	11.98{0.4717} or less
Area	9{0.3543}	8.98{0.3535} or less

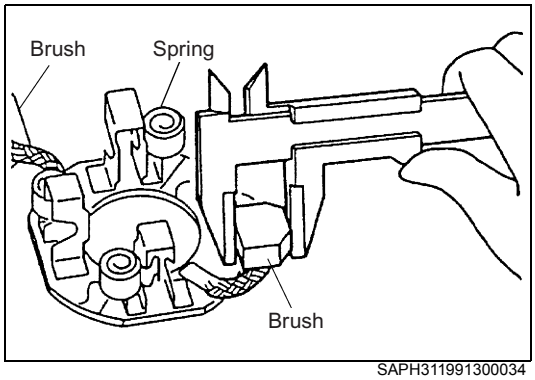

SAPH311991300033

3. Inspection of brush holder assembly

(1) Measure the resistance between the holder (plus) and the plate using a circuit tester and check insulation.
When the value is below the service limit, replace it.

Service limit	1kΩor less

⚠ **CAUTION** • **After cleaning and drying, take measurements.**

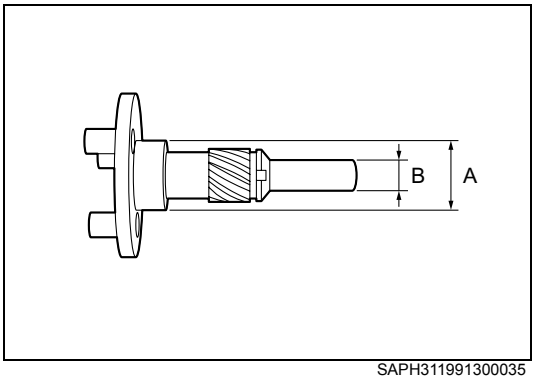


SAPH311991300034

(2) Measure the brush length using vernier calipers.
When the value is below the service limit, replace it.

Standard value (mm{in.})	Service limit (mm{in.})
18{0.7087}	13{0.5118} or less

(3) Make sure that the spring has pressure.

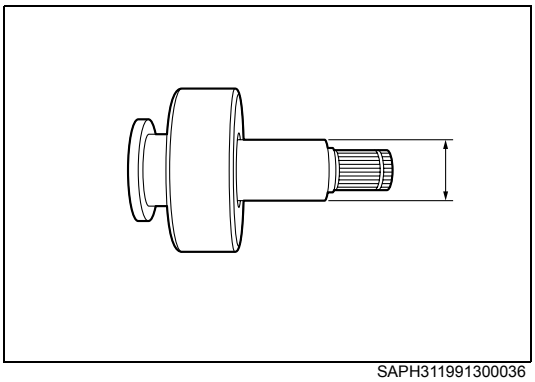


SAPH311991300035

4. Inspection of shaft assembly

(1) Measure the outer diameter of the shaft using a micrometer
If it is beyond the service limit, replace the shaft.

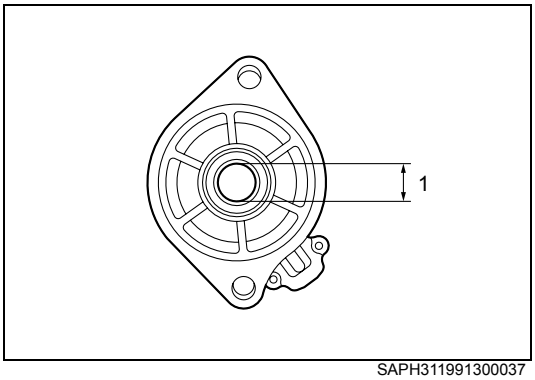
Measuring area	Standard value (mm{in.})	Service limit (mm{in.})
Area	26{1.0236}	25.90{1.0197} or less
Area	12.1{0.4764}	12.04{0.4740} or less


SAPH311991300036

5. Inspection of clutch assembly

(1) Measure the outer diameter of the inner sleeve using a micrometer.
If it is beyond the service limit, replace the clutch assembly.

Standard value (mm{in.})	Service limit (mm{in.})
25{0.9843}	24.90{0.9803} or less

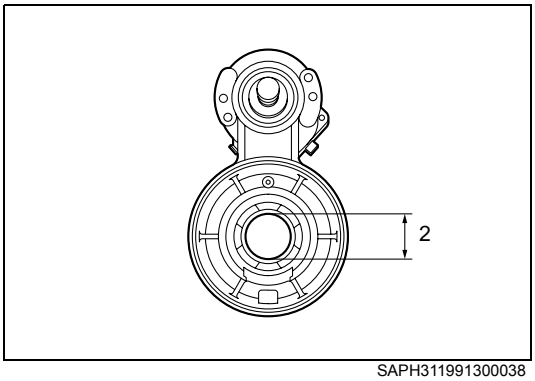


SAPH311991300037

6. Inspection of bearing

(1) Measure the bearing metal inner diameter (1 in the figure) of the pinion case using a cylinder gauge. If it is beyond the service limit, replace the bushing.

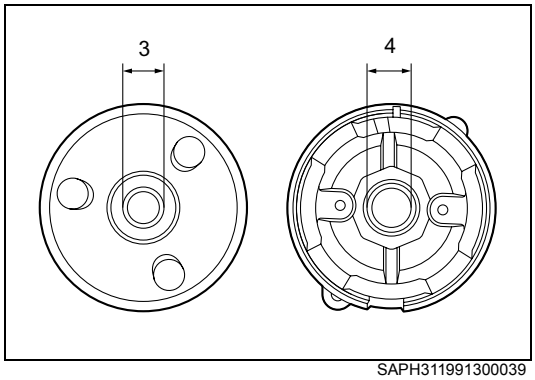
Standard value (mm{in.})	Service limit (mm{in.})
25{0.9843}	25.2{0.9921} or more



SAPH311991300038

(2) Measure the bearing metal inner diameter (2 in the figure) of the center bracket using a cylinder gauge. If it is beyond the service limit, replace the center bracket.

Standard value (mm{in.})	Service limit (mm{in.})
26{1.0236}	26.2{1.0315}



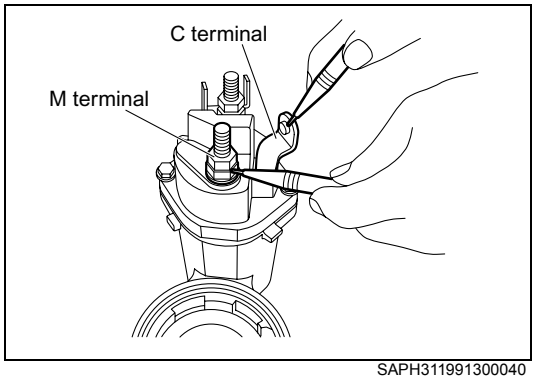
SAPH311991300039

(3) Measure the bearing metal inner diameter (3 in the figure) of the shaft assembly using a cylinder gauge. If it is beyond the service limit, replace the shaft assembly.

Standard value (mm{in.})	Service limit (mm{in.})
9{0.3543}	9.2{3.6220}

(4) Measure the bearing housing inner diameter (4 in the figure) of the commutator end frame using a cylinder gauge. If it is beyond the service limit, replace the commutator end frame.

Standard value (mm{in.})	Service limit (mm{in.})
28{1.1024}	28.1{1.1063} or more

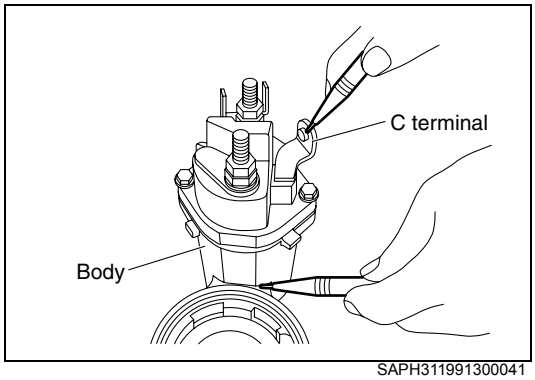


SAPH311991300040

7. Inspection of start magnet switch assembly (resistance of P coil)

(1) Measure the P coil resistance between the C terminal and the M terminal using a circuit tester.
If it is beyond the service limit, replace the start magnet switch.

Standard value (Ω)	0.12 - 0.14

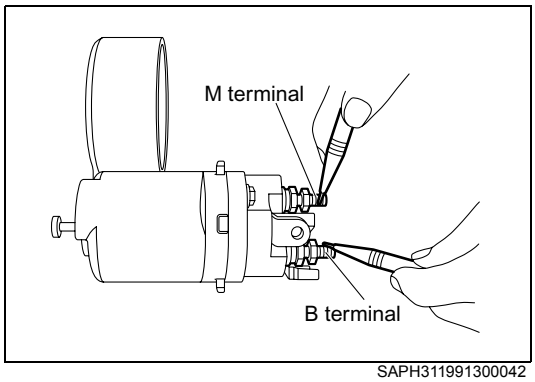


SAPH311991300041

8. Inspection of start magnet switch assembly (resistance of H coil)

(1) Measure the H coil resistance between the C terminal and the body using a circuit tester.
If it is beyond the service limit, replace the start magnet switch.

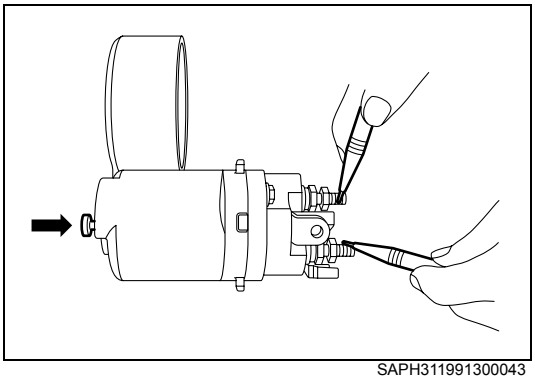
Standard value(Ω)	1.13 - 1.25



SAPH311991300042

9. Inspection of start magnet switch assembly (electric continuity inspection)

(1) Check electric continuity between the B terminal and the M terminal using a circuit tester, and make sure that there is no electric continuity.


SAPH311991300043

(2) Push the end of the start magnet switch assembly (close the internal contact) and make sure that there is electric continuity between the B terminal and the M terminal using a circuit tester.

Assembly

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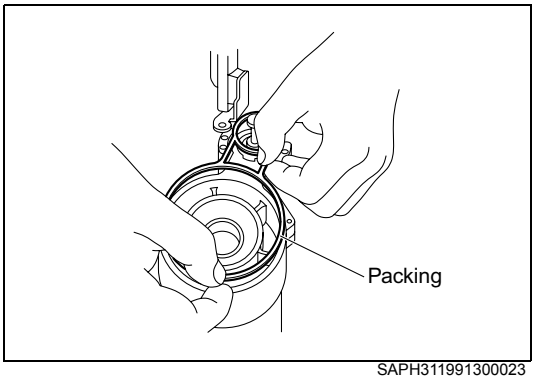
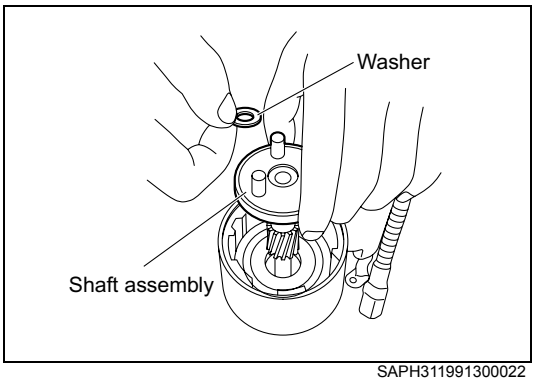


SAPH311991300023

1. Installation of packing

(1) Install a new packing on the center bracket assembly.

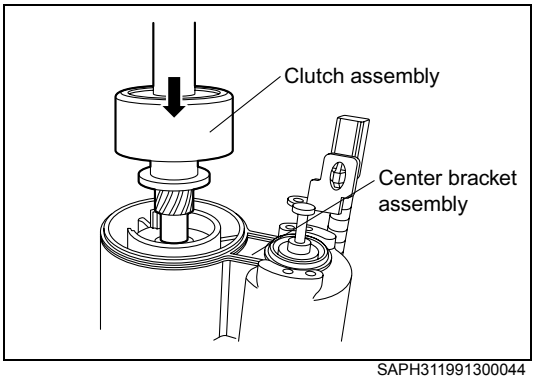


SAPH311991300022

2. Installation of shaft assembly

(1) Turn the center bracket assembly upside down and hold the carrier plate. Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the shaft assembly.

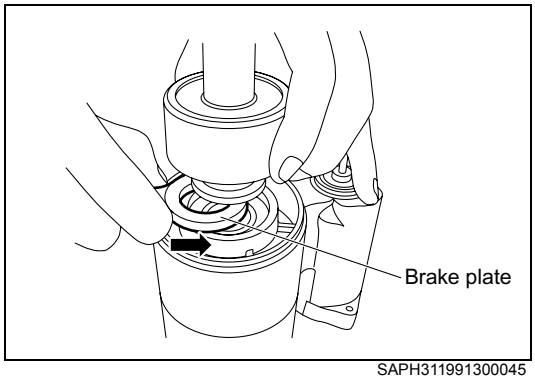
⚠ **CAUTION**
- **Washers are available at the upper and lower parts of the carrier plate. Be careful for loss of the washers.**



SAPH311991300044

3. Installation of clutch assembly

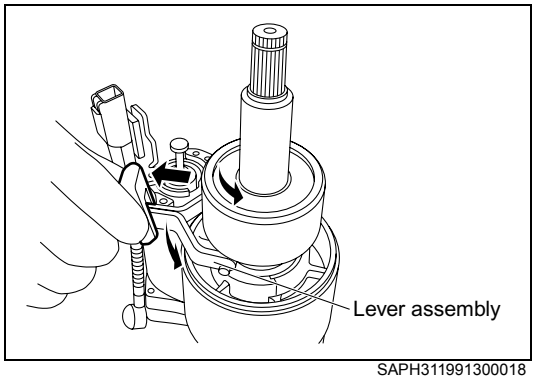
(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and insert the clutch assembly into the center bracket assembly.



SAPH311991300045

4. Installation of brake plate

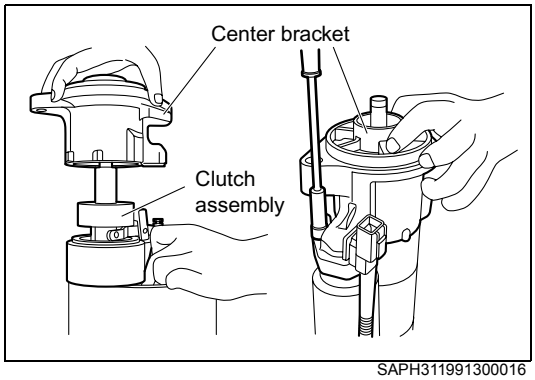
(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the brake plate.



SAPH311991300018

5. Installation of lever

(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list). Turn and install the lever assembly using the clutch as the axis.



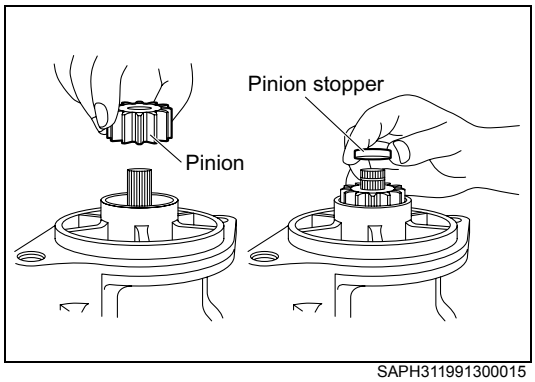
SAPH311991300016

6. Installation of pinion case

(1) Install two set bolts at the switch using a box screwdriver or offset wrench.

Tightening torque :

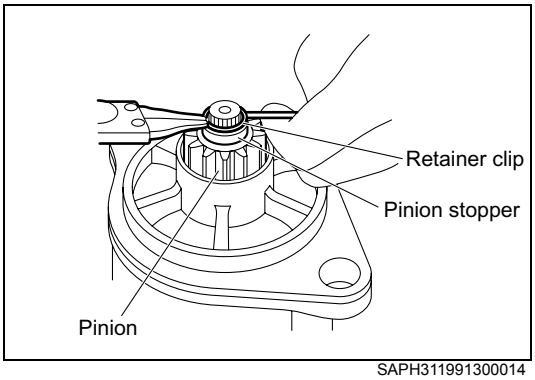
14 - 16 N·m {140 - 160 kgf·cm, 10 - 12 lbf·ft}



SAPH311991300015

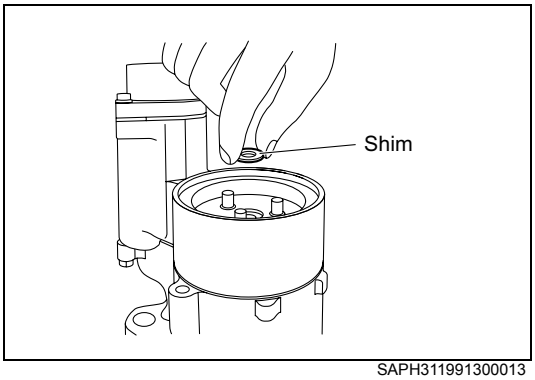
7. Installation of pinion

(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the pinion and the pinion stopper.



SAPH311991300014

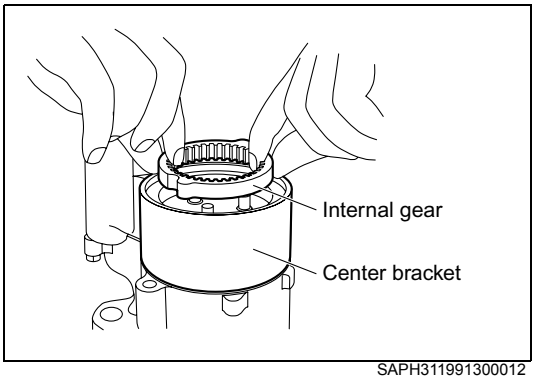
(2) Install the retainer clip using a tool such as snap ring pliers.



SAPH311991300013

8. Installation of shim washer

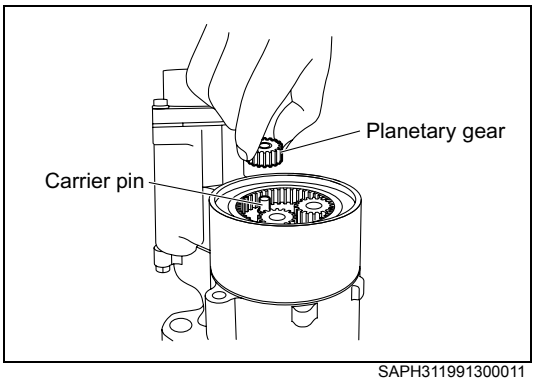
(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the shim washer on the center bracket.



SAPH311991300012

9. Removal of internal gear

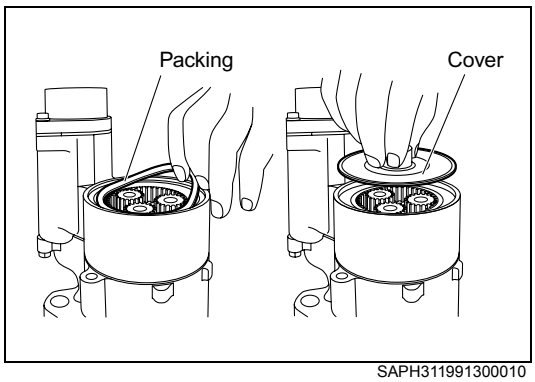
(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the internal gear on the center bracket.



SAPH311991300011

10. Installation of planetary gear

(1) Lubricate parts (refer to the lubrication point drawing and the lubrication list) and install the planetary gear on the carrier pin.



SAPH311991300010

11. Installation of cover

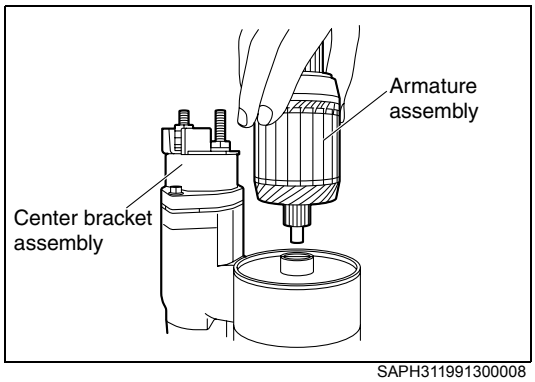
(1) Install a new packing.

(2) Install the cover on the center bracket assembly.

12. Installation of rear bearing

(1) Install the bearing on the armature assembly using a press.

⚠ **CAUTION** • **When the bearing is removed, replace it with a new one.**

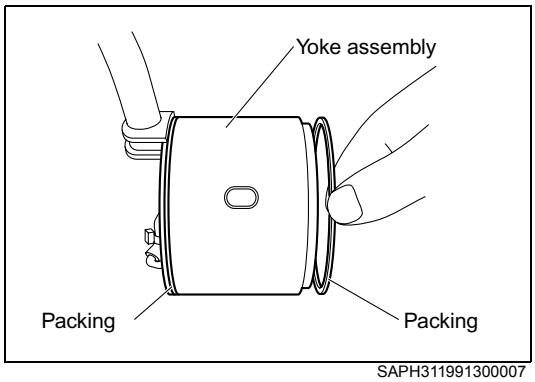


SAPH311991300008

13. Installation of armature assembly

(1) Install the armature assembly.

⚠ **CAUTION** • **When the armature assembly is installed, the washer at the end of the gear may be dropped and lost. Be careful for handling.**

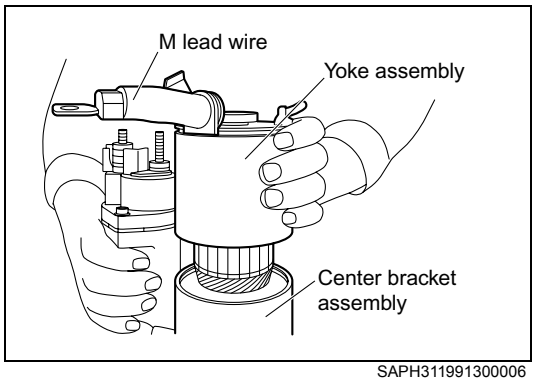


SAPH311991300007

14. Installation of packing

(1) Install a new packing on the centering location at both ends of the yoke assembly.

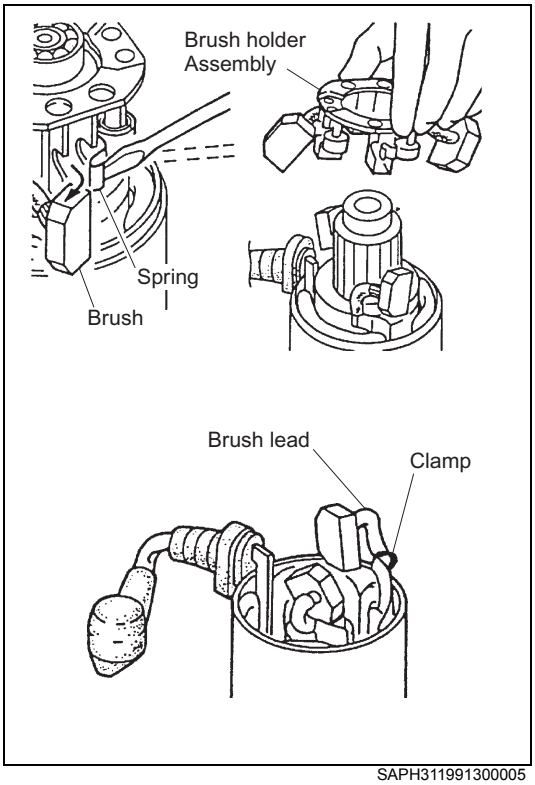
⚠ **CAUTION** • **Damaged packing must not be resued. Replace it with a new part.**



SAPH311991300006

15. Installation of yoke assembly

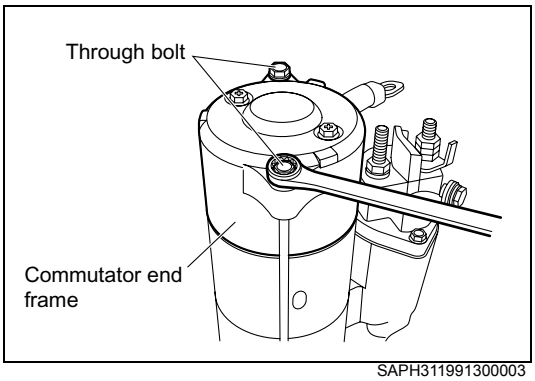
(1) Install the yoke assembly on the center bracket assembly.



SAPH311991300005

16. Installation of brush holder assembly

(1) Lift the spring using a flat tip screwdriver, long-nose pliers or pliers. Install four brushes on the brush holder assembly.

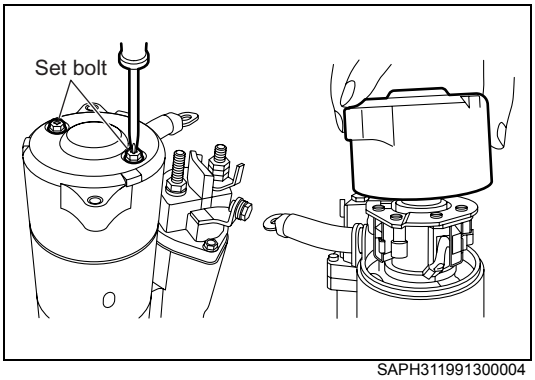


SAPH311991300003

17. Installation of commutator end frame

(1) Tighten the through bolt of the commutator end frame.

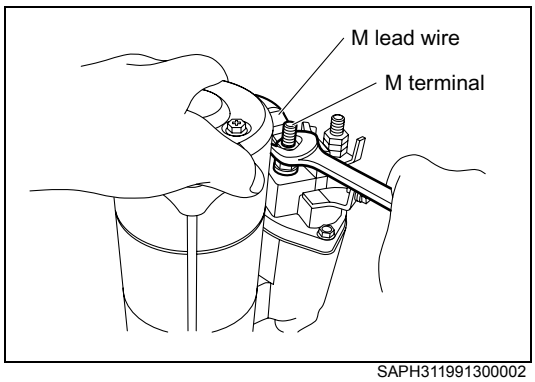
Tightening torque :
15.7 - 17.6 N·m {160 - 179 kgf·cm, 12 - 13 lbf·ft}



SAPH311991300004

(2) Tighten two set bolts.
Tightening torque :
3.6 - 4.9 N·m {37 - 49 kgf·cm, 3 - 4 lbf·ft}

⚠ **CAUTION**
- **Hold the M lead wire and remove the commutator end frame by lifting.**



SAPH311991300002

18. Installation of lead wire

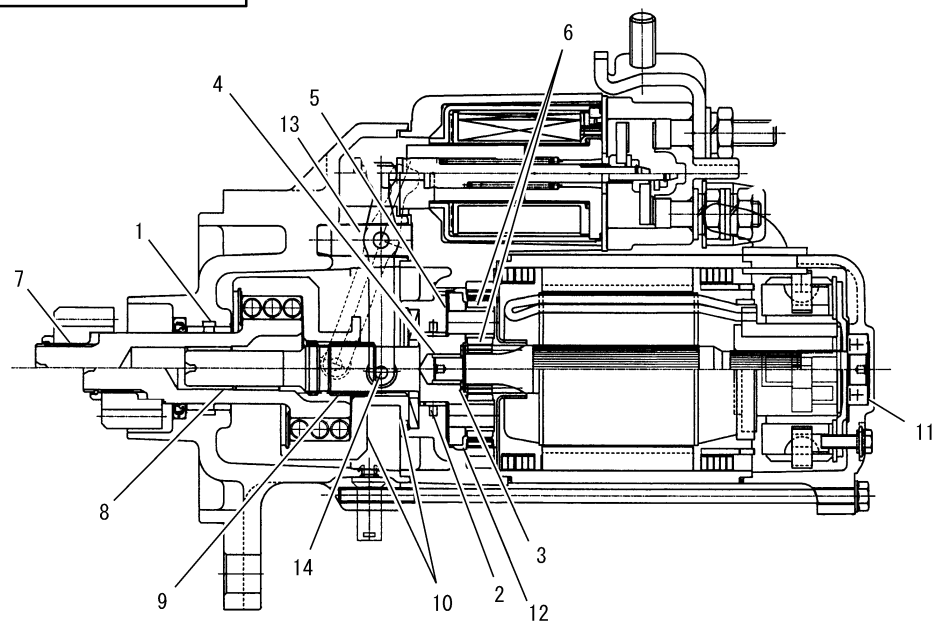
(1) Install the M lead wire.

19. Lubrication

Refer to the following figure and table for lubricant to be applied.

⚠ **CAUTION** • **There shall be no lubricant on the commutator surface, brush and contact.**

Figure of lubricating locations



SAPH311991300046

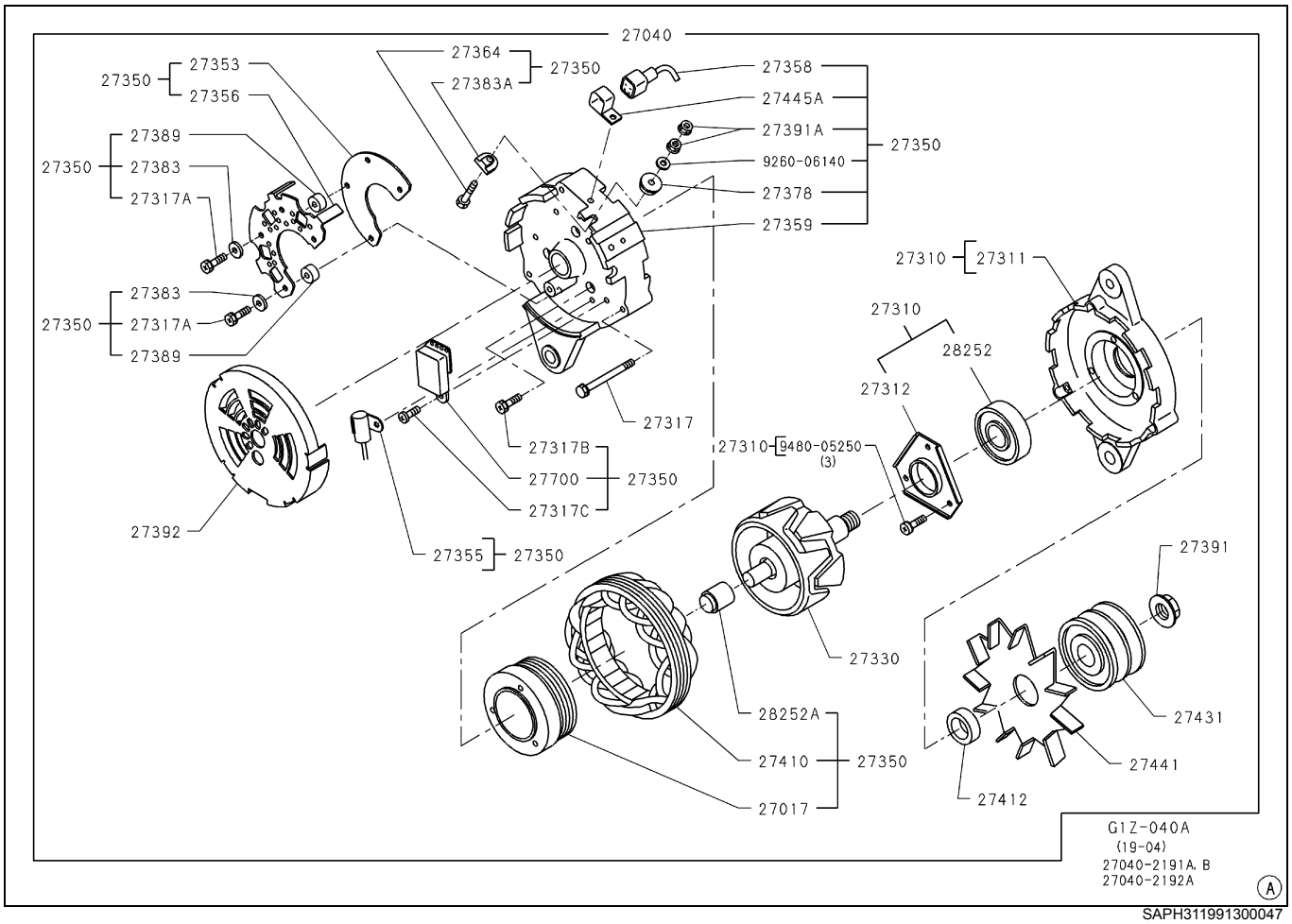
Table of lubricant

Code	Lubricating point	Lubricant used	Amount (g{oz})	Remark	Lubricant manufacturer
1	Pinion case metal and grease reservoir	Multemp AC-N	0.8 - 1.5 {0.03 - 0.05}		Kyodo Yushi
2	Bracket center metal and grease reservoir	Multemp AC-N	0.5 - 1.5 {0.03 - 0.05}		Kyodo Yushi
3	Shim washer	Multemp AC-N	0.2 - 0.5 {0.01 - 0.02}	Applied to both sides of washer.	Kyodo Yushi
4	Armature front metal	Multemp AC-N	0.5 - 1 {0.02 - 0.04}		Kyodo Yushi
5	Shim washer	Multemp AC-N	0.2 - 0.5 {0.01 - 0.02}	Applied to both sides of washer.	Kyodo Yushi
6	Internal gear Armature gear Planetary gear	Multemp AC-N	7 -11 {0.25 - 0.39}		Kyodo Yushi
7	Pinion straight Spline	Multemp AC-N	0.5 - 1 {0.02 - 0.04}		Kyodo Yushi
8	Inner sleeve metal	Multemp AC-N	0.3 - 0.6 {0.01 - 0.02}		Kyodo Yushi
9	Helical spline	Multemp AC-N	0.5 - 1 {0.02 - 0.04}		Kyodo Yushi
10	Clutch case lever shifter	Pyroknock No.2	1 - 2 {0.04 - 0.07}		Nippon Oil Corporation
11	Bracket rear bearing housing	Pyroknock No.2	0.2 - 0.5 {0.01 - 0.02}		Nippon Oil Corporation
12	Planetary gear metal	Multemp AC-N	1 - 2 {0.04 - 0.07}		Kyodo Yushi
13	Lever holder	Multemp AC-N	0.4 - 0.8 {0.01 - 0.03}		Kyodo Yushi
14	Lever roller rod	Pyroknock No.2	0.2 - 0.5 {0.01 - 0.02}	Assemble the roller after application of grease to prevent fall of the roller in assembly.	Nippon Oil Corporation

Alternator (50A)

Part layout (typical example of 50A)

JP311991304020002



SAPH311991300047

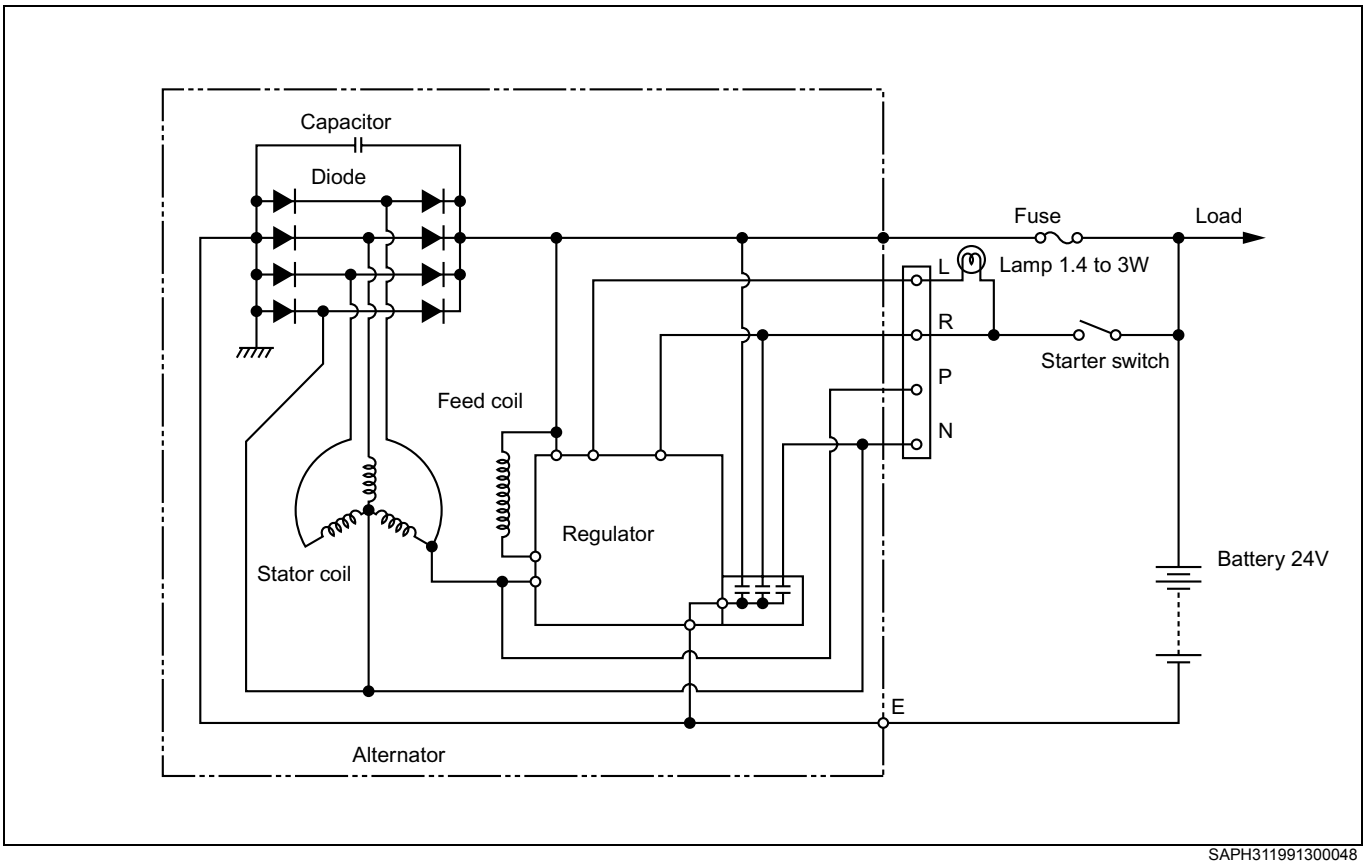
27017	Feed coil	27383A	Insulator
27040	Alternator	27389	Insulator
27310	Drive end frame assembly	27392	Cover
27311	Drive end frame	27410	Stator coil
27312	Bearing cover	27412	Collar
27330	Rotor assembly	27431	Pulley
27350	End frame assembly	27441	Fan
27353	Rectifier minus	27445A	Coupler holder
27356	Rectifier plus	27700	Regulator
27359	End frame	28252	Front bearing
27383	Insulator	28252A	Rear bearing

Tightening torque

27317	7.8-9.8 N m{80-99 kgf·cm, 6-7lbf·ft}	27317C	1.9-2.5 N·m{20-25 kgf·cm, 1-2lbf·ft}
27317A	1.9-2.5 N·m{20-25 kgf·cm, 1-2lbf·ft}	27391	127 - 157 N·m{1, 300 - 1, 600 kgf·cm, 94-116lbf·ft}
27317B	2.9 - 3.9 N·m{30 - 39 kgf·cm, 2-3lbf·ft}	27391A	Internal nut : 4.9-5.9 N m{50-60 kgf·cm, 3.6-4.3lbf·ft}

Circuit drawing (50A)

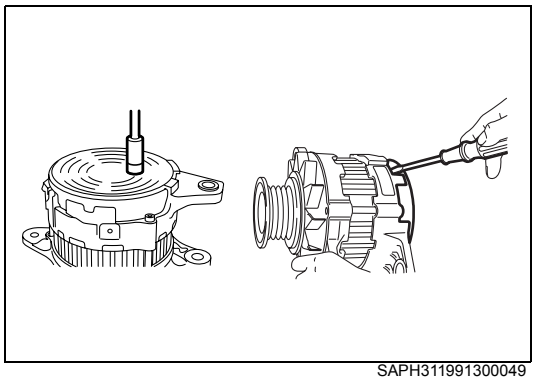
JP31199130803001



SAPH311991300048

Disassembly

JP31199130702003



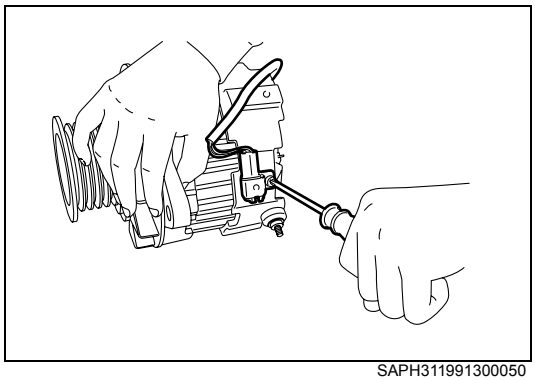
SAPH311991300049

⚠ **CAUTION** • **Place a rubber mat and perform work on the mat.**

1. Disconnection of front from rear

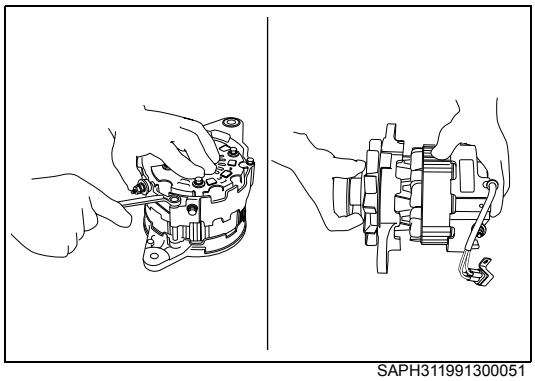
(1) Remove fixing bolts and remove the cover.

⚠ **CAUTION** • **Press the tabs of the cover for removal. Be careful not to break the tab with excessive force.**



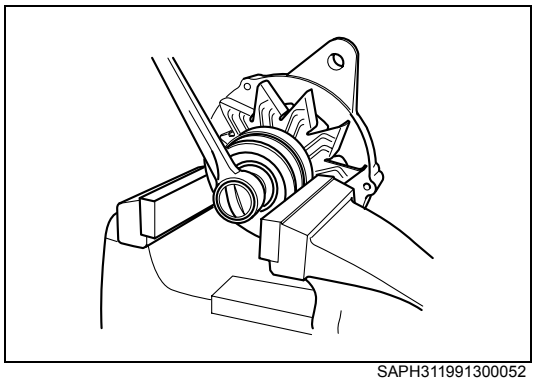
SAPH311991300050

(2) Remove bolts with a screwdriver and remove the coupler holder.



SAPH311991300051

(3) Remove three through bolts and disconnect the front from the rear.

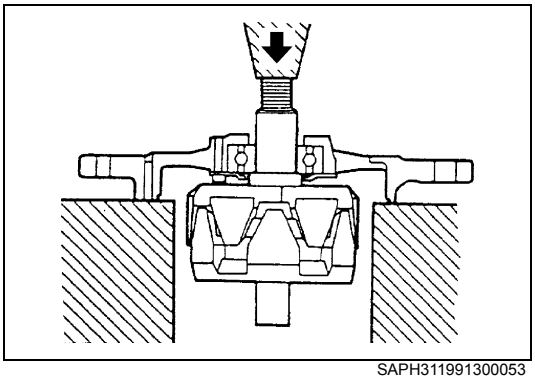


SAPH311991300052

2. Disassembly of front

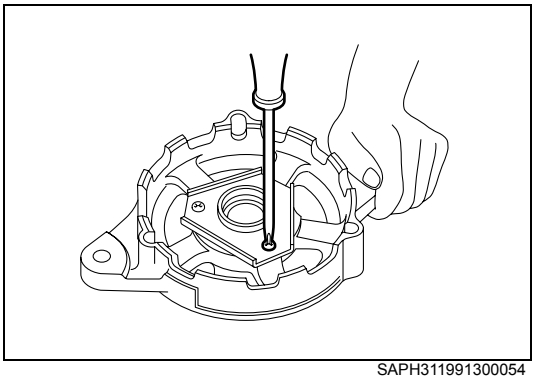
(1) Remove nuts and remove the pulley, fan and collar.

⚠ **CAUTION** • **Tie around a general V –belt in the pulley groove and fix the pulley with a vice.**

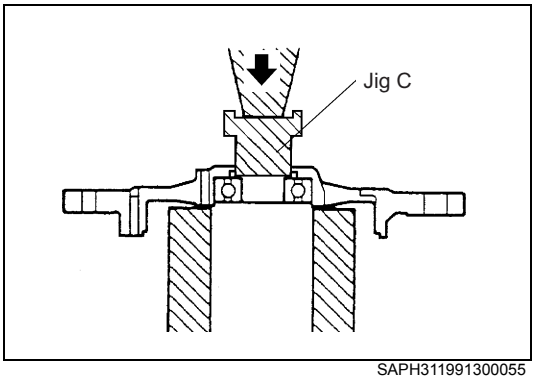

SAPH311991300053

(2) Remove the rotor assembly using a press.

⚠ **CAUTION**
- **Do not damage the end of the thread.**
- **Support the rotor assembly to prevent fall of the rotor assembly.**


SAPH311991300054

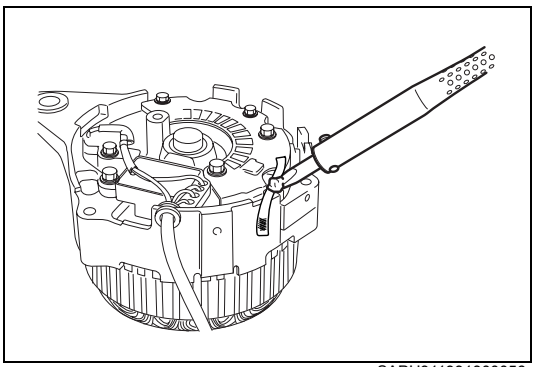
(3) Remove three bolts with a screwdriver and remove the bearing cover.



SAPH311991300055

(4) Remove the ball bearing from the front bracket using a press or jig C.

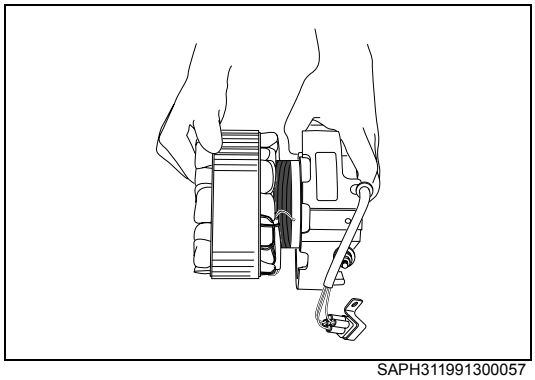
⚠ **CAUTION**
- **Place jig C at the inner race of the front bearing.**
- **Removed bearing must not be reused.**


SAPH311991300056

3. Disassembly of rear

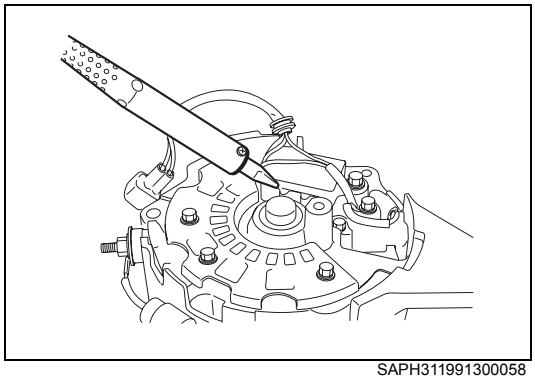
(1) Remove solder of the lead wire connecting the stator coil and the diode using a soldering bit and suction line or a solder suction device

⚠ **CAUTION**
- **At solder of the stator coil and the diode, the end of the diode is clamped. Do not damage the diode by prying. Deformed diode must not be reused.**
- **Perform soldering in a short time (within 5 seconds).**


SAPH311991300057

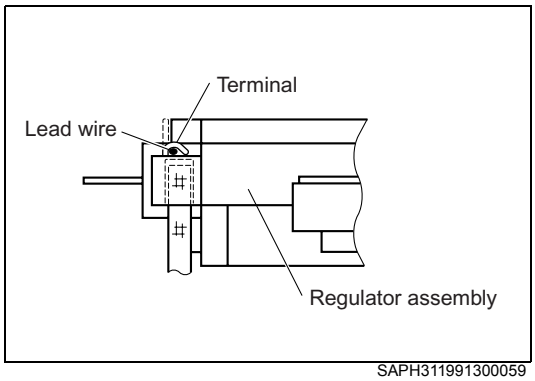
(2) Remove the stator coil from the rear bracket.

⚠ **CAUTION**
- **Do not damage the stator coil.**


SAPH311991300058

(3) Remove solder of the lead wire connecting the regulator and the field coil using a soldering bit.

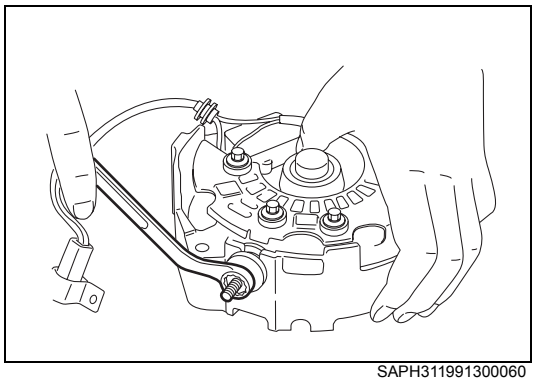
⚠ **CAUTION**
- **Remove the lead wire of the field coil by raising the terminal of the regulator.**
- **Perform soldering in a short time (within 5 seconds).**

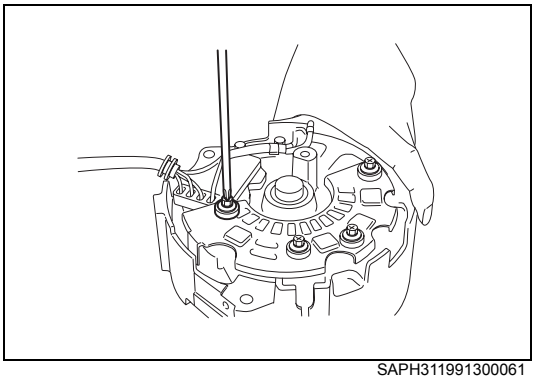


SAPH311991300059

(4) Loosen the nut at the B terminal.

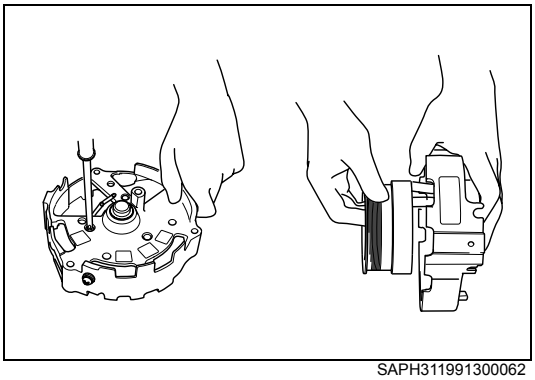
⚠ **CAUTION**
- **Loosen the nut to some extent and do not remove it from the B terminal.**


SAPH311991300060

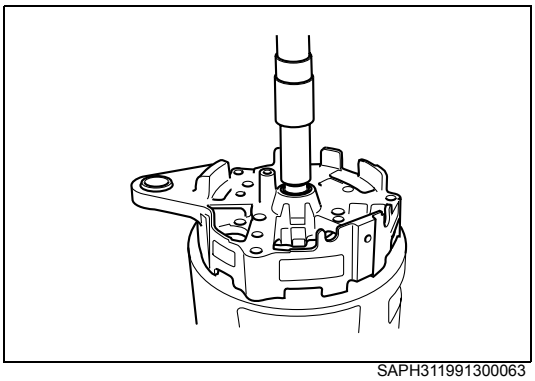

SAPH311991300061

(5) Remove five bolts using a screwdriver and remove the heat sink assembly (plus), heat sink assembly (minus) and regulator all together.

⚠ **CAUTION**
- **Screw lock is used. Since torque is high until bolt is removed, be careful not to damage the groove of the bolt head.**
- **When the rear bracket is reused, clean the screw hole.**


SAPH311991300062

(6) Remove the capacitor.
(7) Remove three bolts with a screwdriver and remove the field coil from the rear bracket.

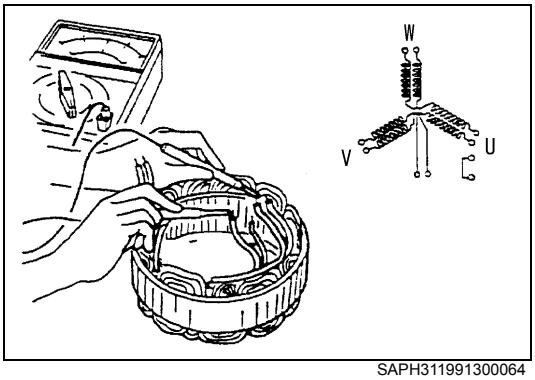

SAPH311991300063

(8) Remove the roller bearing from the rear bracket using a press, jig A and jig B.

⚠ **CAUTION**
- **Removed bearing must not be reused.**

Inspection of components

JP31199130703002



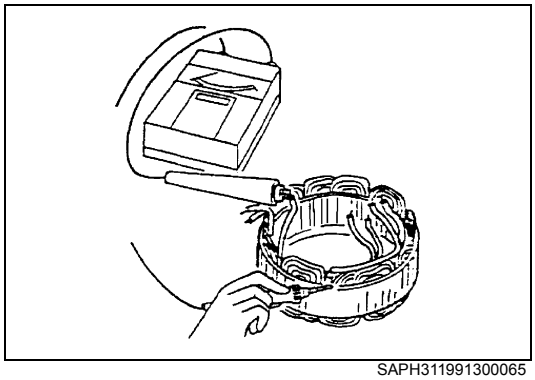
SAPH311991300064

⚠ **CAUTION**
- **Place a rubber mat and perform work on the mat.**

1. Inspection of stator coil and field coil

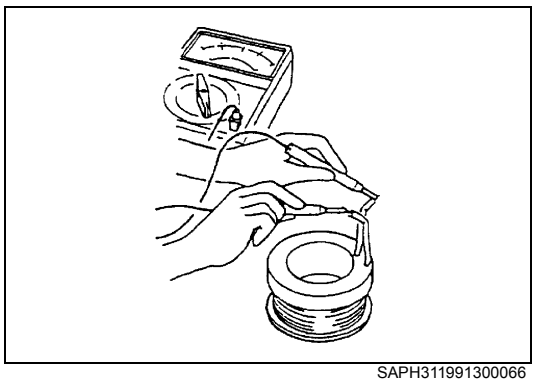
(1) Measure the resistance between U-V, V-W and W-U terminals of the stator coil using a circuit tester.

Standard value (Ω)	**0.15 - 0.17**


SAPH311991300065

(2) Measure the resistance between the stator coil core and each terminal using a megger tester.

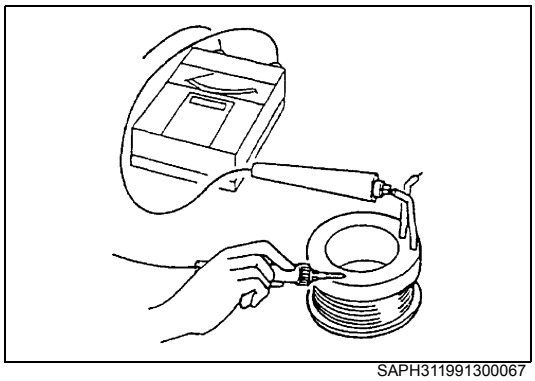
Standard value (MΩ)	1 or more


SAPH311991300066

(3) Measure the resistance of the field coil using a circuit tester.

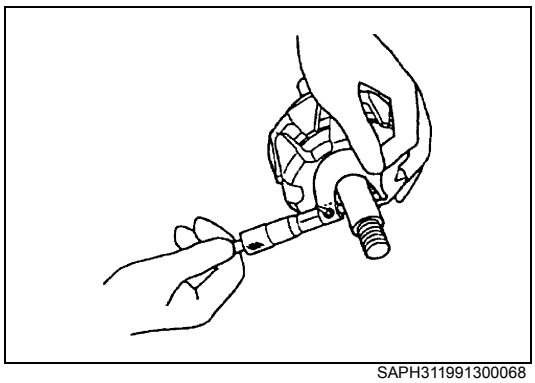
Standard value (Ω)	6.4 - 7.0

⚠ **CAUTION**
- **Do not damage the circumferential surface of the coil.**
- **Damaged coil circumference must not be reused.**


SAPH311991300067

(4) Measure the resistance between the core and the coil using a megger tester.

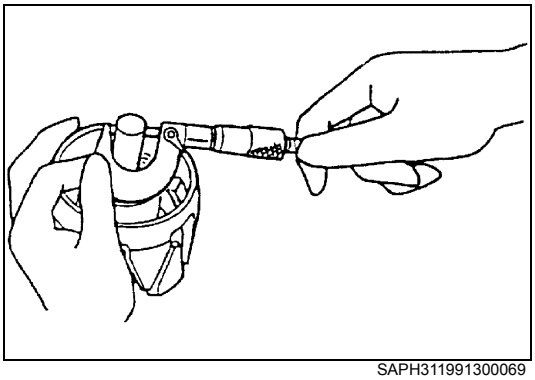
Standard value (MΩ)	1 or more


SAPH311991300068

2. Inspection of rotor assembly

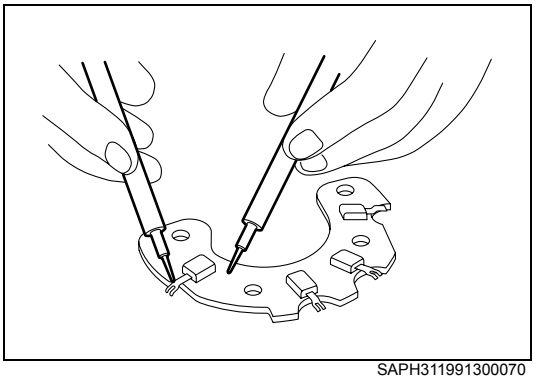
(1) Measure the outer diameter of the shaft at the ball bearing insertion area of the rotor assembly using a micrometer.

Standard value (mm{in.})	25{0.9843}
Service limit (mm{in.})	24.98{0.9835}


SAPH311991300069

(2) Measure the outer diameter of the shaft at the roller bearing insertion area of the rotor assembly using a micrometer.

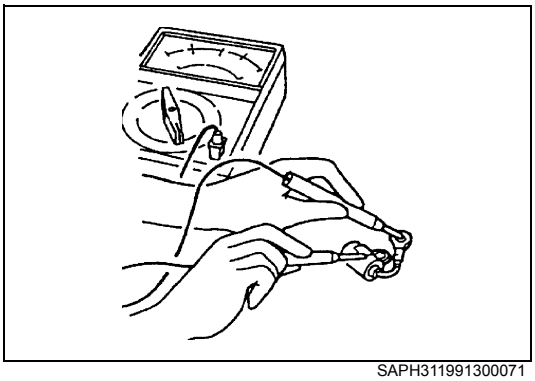
Standard value (mm{in.})	**17{0.6693}**
Service limit (mm{in.})	**16.98{0.6685}**


SAPH311991300070

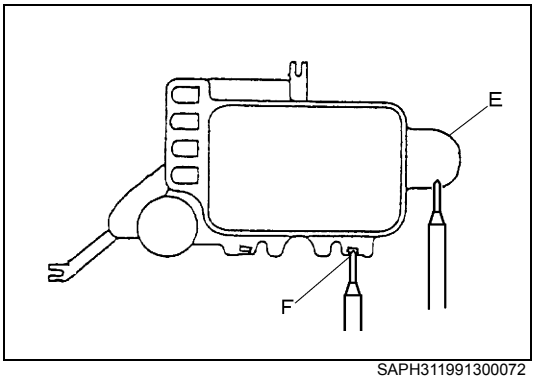
3. Inspection of diode, capacitor and regulator

(1) Measure the resistance of the holder between the minus diode and the heat sink holder using a circuit tester.

	Standard value
Forward resistance value	**Approx. 10 Ω**
Reverse resistance value	**Infinite**


SAPH311991300071

(2) Measure the resistance between the capacitor terminal and the body using a circuit tester. Make sure that it indicates 800 kΩ and then immediately indicates infinite value.



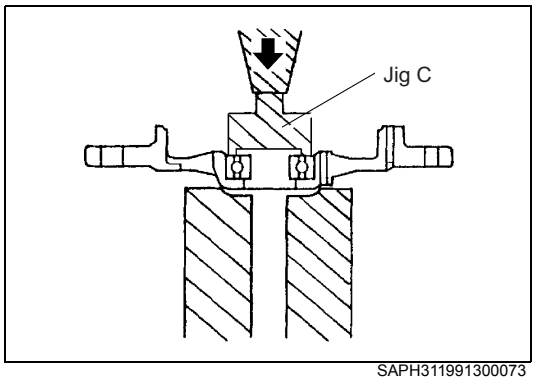
SAPH311991300072

(3) Inspection of regulator
Measure the resistance between regulator terminals F and E using a circuit tester.

	Standard value
Forward resistance value	**Approx. 10 Ω**
Reverse resistance value	**Infinite**

Assembly

JP31199130702004



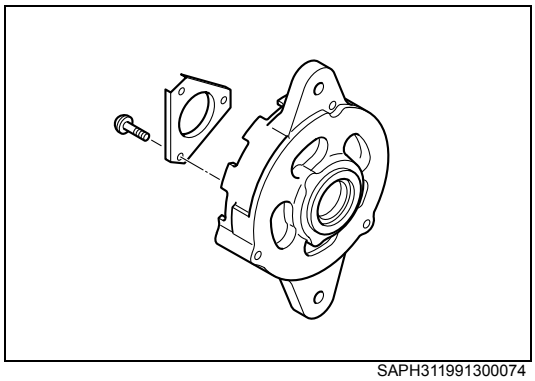
SAPH311991300073

⚠ **CAUTION**
- **Place a rubber mat and perform work on the mat.**

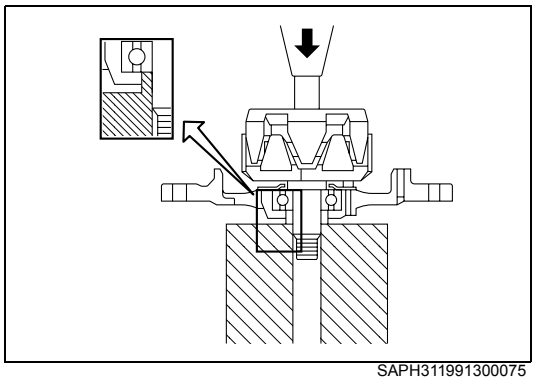
1. Assembly of front

(1) Press fit a new ball bearing into the front bracket using a press and jig C.

⚠ **CAUTION**
- **Place jig C at the outer race of the ball bearing.**
- **Removed bearing must not be reused.**

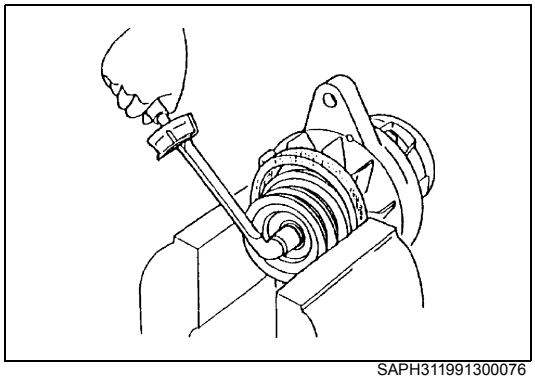

SAPH311991300074

(2) Install the bearing cover with bolts.
Tightening torque :
1.9 - 2.5 N·m {20 - 25 kgf·cm, 1 - 2 lbf·ft}


SAPH311991300075

(3) Install the rotor assembly using a press.

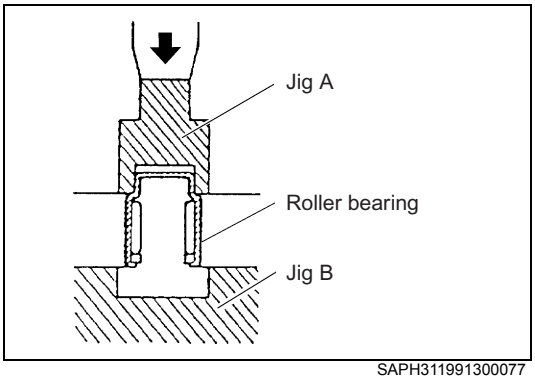
⚠ **CAUTION**
- **Be sure to support the inner race of the bearing for press fit of the rotor.**
- **Do not damage the shaft.**


SAPH311991300076

(4) Install the space collar, fan and pulley on the shaft of the rotor assembly.

Tightening torque :
127 - 157 N·m {1,300 - 1,600 kgf·cm, 94 - 116 lbf·ft}

⚠ **CAUTION**
- **Tie around a general V –belt in the pulley groove and fix the pulley with a vice.**

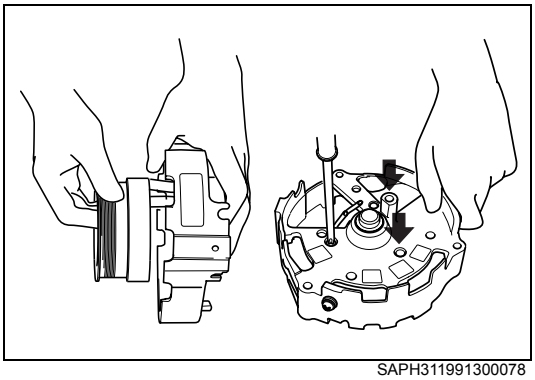


SAPH311991300077

2. Assembly of rear

(1) Press fit a new roller bearing into the rear bracket using a press, jig A and jig B.

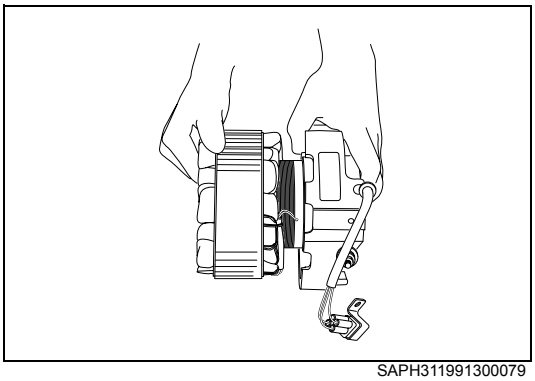
⚠ **CAUTION** • **Press fit until jig A comes in contact with the rear bracket.**


SAPH311991300078

(2) Install the field coil on the rear bracket.

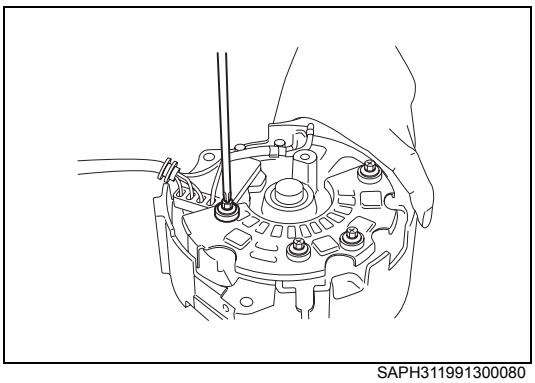
Tightening torque :
2.9 - 3.9 N·m {30 - 39 kgf·cm, 2 - 3 lbf·ft}

⚠ **CAUTION** • **Tighten bolts finally after temporary tightening. Tighten them evenly.**


SAPH311991300079

(3) Assemble the stator coil on the rear bracket temporarily.

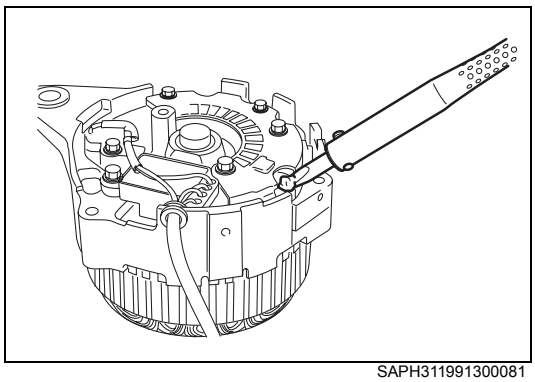
⚠ **CAUTION** • **Do not damage the stator coil.**


SAPH311991300080

(4) Install parts referring to the part layout.

Tightening torque :
1.9 - 2.5 N·m {20 - 25 kgf·cm, 1 - 2 lbf·ft}

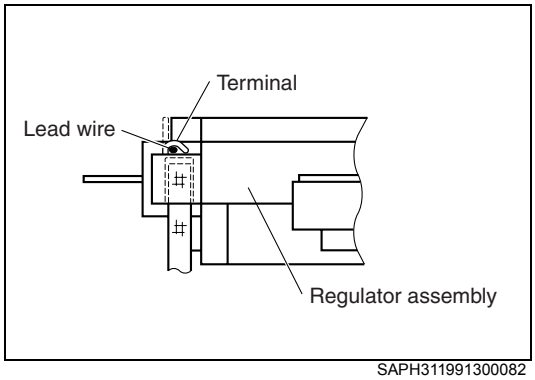
⚠ **CAUTION** • **Apply screw lock to the ends of the heat sink mounting bolt and the regulator mounting bolt.**



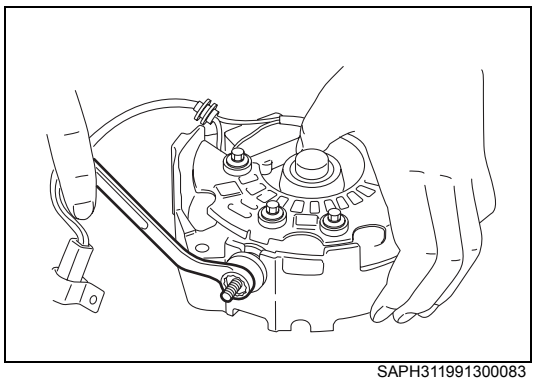
SAPH311991300081

(5) Solder the lead wire connecting the regulator and the field coil, and connecting the stator coil and the diode using a soldering bit.

⚠ **CAUTION**
- **Perform soldering after tightening of bolts.**
- **Bend and fix the regulator terminal before soldering the lead wire of the field coil.**
- **Clamp the end of the diode of the stator coil before soldering.**
- **Perform soldering in a short time (within 5 seconds).**



SAPH311991300082

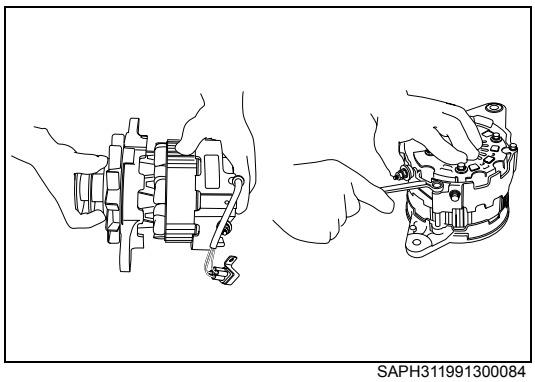


SAPH311991300083

(6) Tighten the nut inside the B terminal.

Tightening torque :
4.9 - 5.9 N·m {50 - 60 kgf·cm, 3.6 - 4.3 lbf·ft}

NOTICE
- **After installation of the alternator, connect the wire and tighten the outside nut**



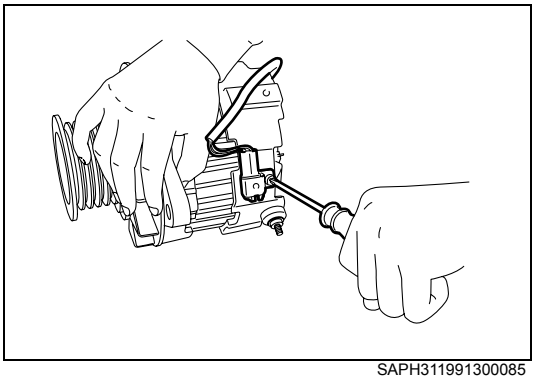
SAPH311991300084

3. Joint of front and rear

(1) Joint the front with the rear with bolts.

Tightening torque :
7.8 - 9.8 N·m {80 - 99 kgf·cm, 6 - 7 lbf·ft}

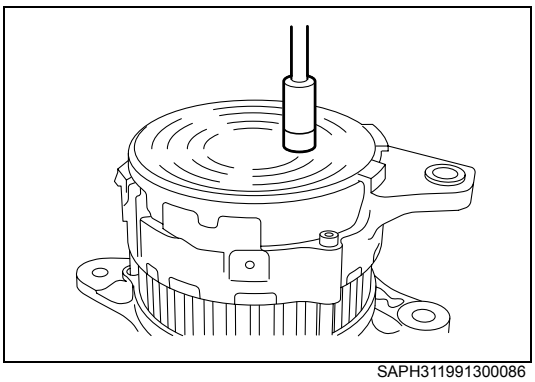
⚠ **CAUTION**
- **Tighten bolts evenly.**



SAPH311991300085

(2) Install the coupler holder and tighten bolts.

Tightening torque :
1.9 - 2.5 N·m {20 - 25 kgf·cm, 1 - 2 lbf·ft}



SAPH311991300086

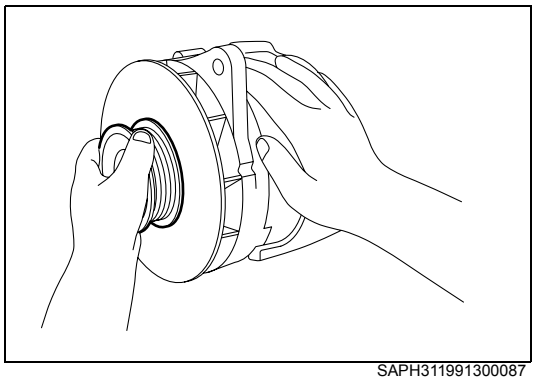
(3) Align the tab and install the cover. Fix it with bolts.

Tightening torque :
3.3 - 4.4 N·m {34 - 44 kgf·cm, 2 - 3 lbf·ft}

⚠ **CAUTION**
- **Do not hit the cover because the tab may be broken.**

Inspection after assembly

JP31199130703003

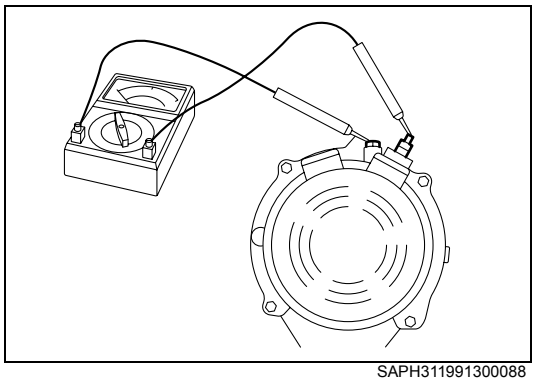


SAPH311991300087

⚠ **CAUTION** • **Place a rubber mat and perform work on the mat.**

1. Inspection of rotation

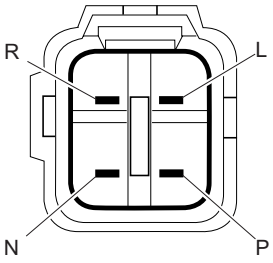
(1) Turn the pulley with hand to check if there is no interference with internal parts and if rotation is smooth.



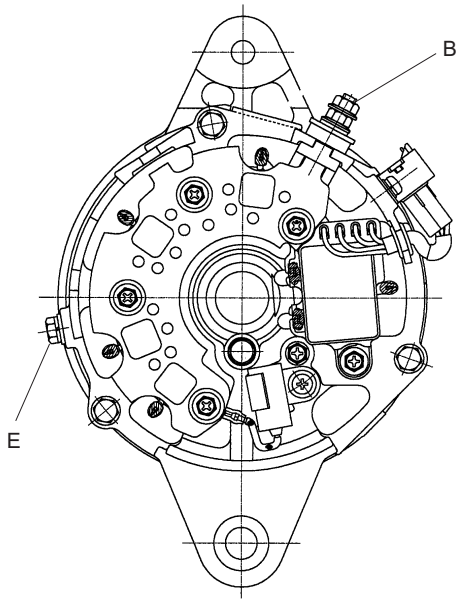
SAPH311991300088

(2) Measure the resistance between B and E terminals and between P and E terminals using a circuit tester. If it is beyond the standard value (e.g. 0 Ω), disassemble it again and reassemble the unit correctly.

Circuit tester lead		Standard value
(+)	(–)	
B	E	Approx. 20 Ω
E	B	Infinite
P	E	Approx.7 Ω
E	P	Infinite



Connector details



SAPH311991300089

14 TURBOCHARGER

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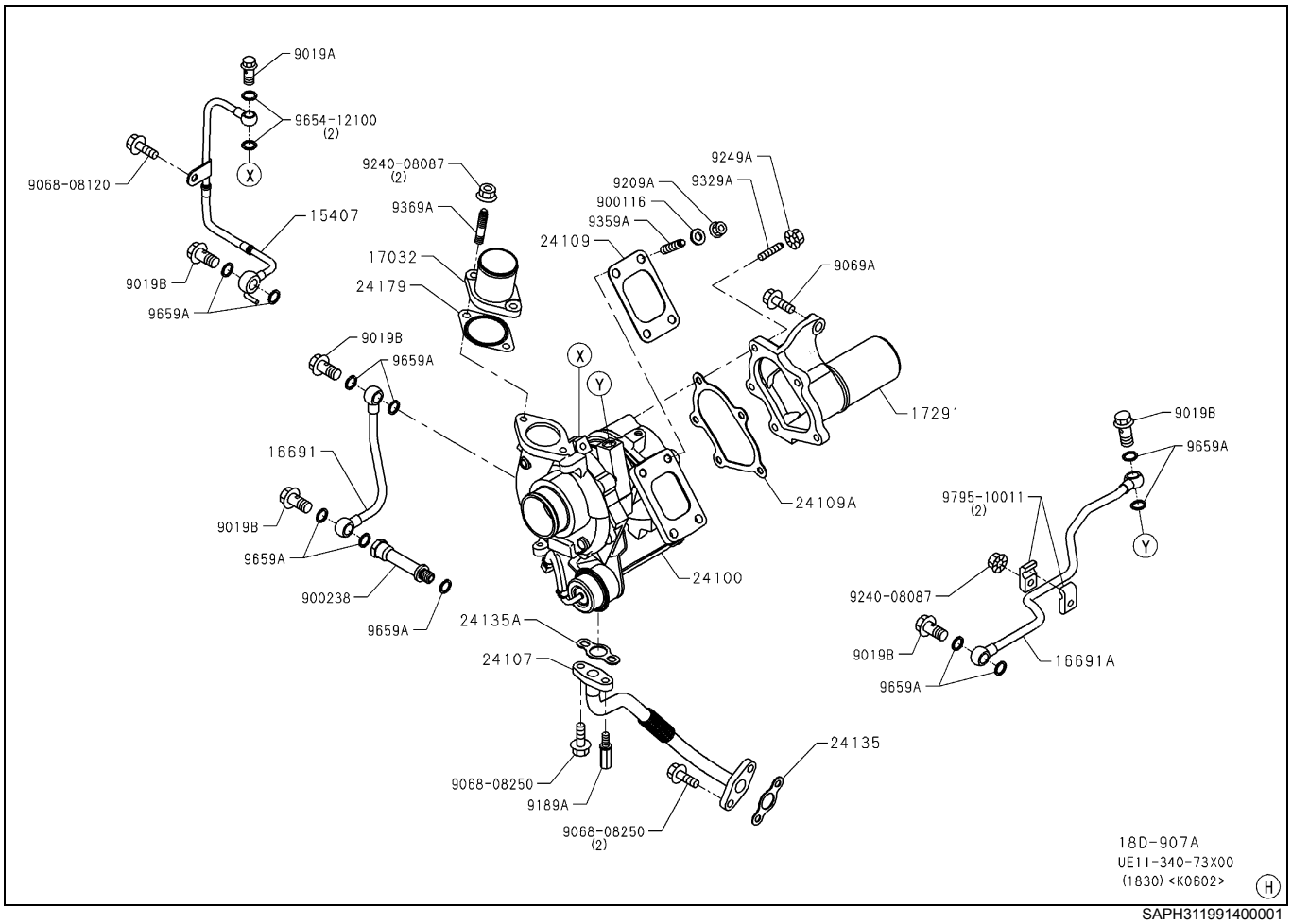
Turbocharger Assembly

Part layout

JP311991404020001



SAPH311991400001

15407	Oil inlet pipe	24109	Gasket*
16691	Coolant pipe	24109A	Gasket*
16691A	Coolant pipe	24135	Gasket*
17291	Exhaust manifold connector	24135A	Gasket*
24100	Turbocharger assembly	9654-12100	Gasket*
24107	Oil outlet pipe	9659A	Gasket*

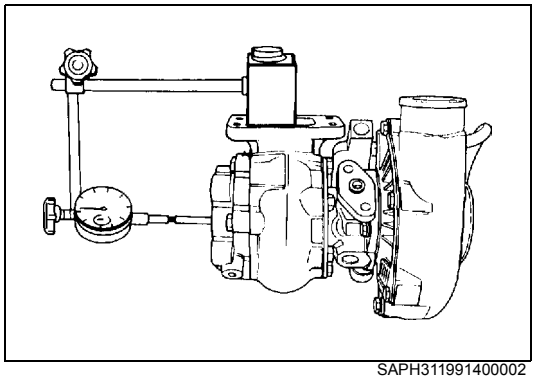
*Parts not to be reused.

Tightening torque

9209A	56 N·m {570 kgf·cm, 41lbf·ft}	

Inspection

JP31199140501001



SAPH311991400002

1. Inspection of turbine shaft axial play

(1) Inspect play of the turbine shaft at the exhaust side using a special tool.

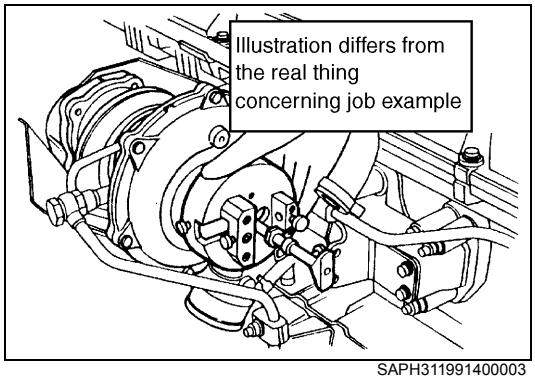
Special tool : 09444-1800 Tool assembly

(2) If the measurement value is beyond the standard value, ask the manufacturer to overhaul the unit.

Standard value (mm{in.})	**Axial direction**	**0.1 {0.0039}**
	Radial direction	**1.0 {0.0393}**

NOTICE

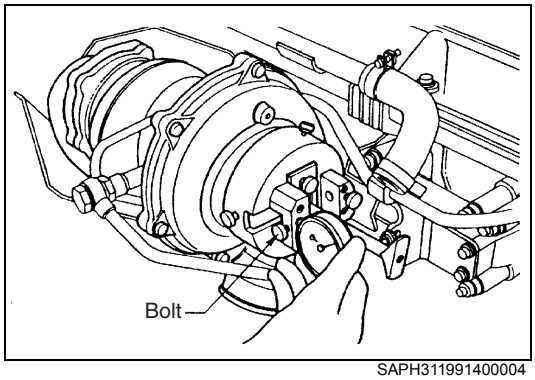
- **Since the assembly is replaced, disassembly and inspection are not allowed.**



SAPH311991400003

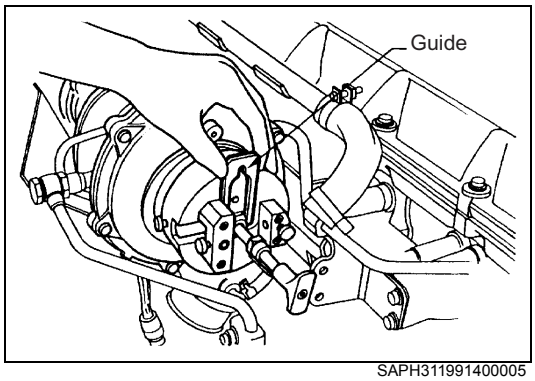
2. Inspection procedure with special tool

(1) Remove dial gauge (key No. 1), loosen the bolt (key No. 13) of the guide (key No. 13) and turn the guide (key No. 2) 90°. Put the dial gauge into the plate (key No. 8) which is inspected for axial play, and tighten the bolt (key No. 19) for fixing.

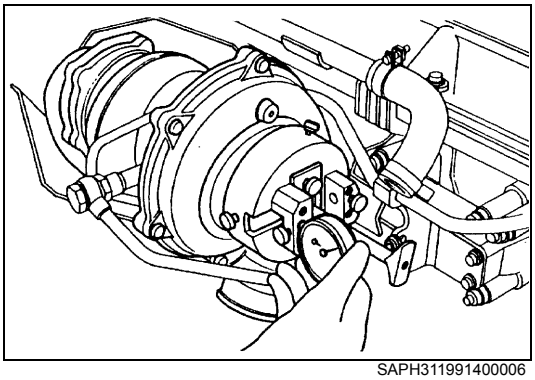


SAPH311991400004

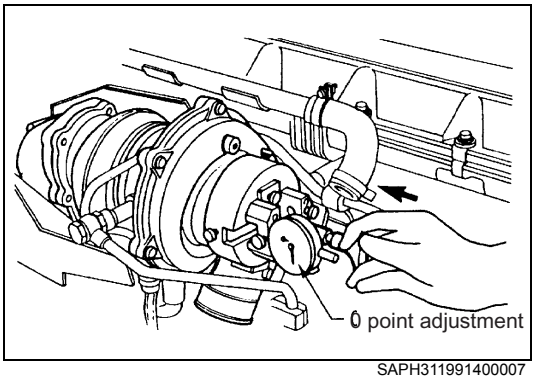
(2) Insert the guide (key No. 9) to preventment horizontal movement of the measuring instrument.



SAPH311991400005

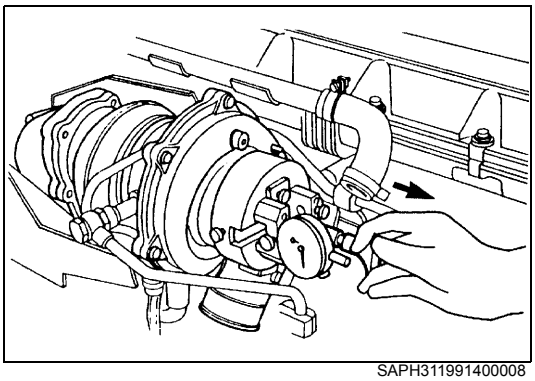

SAPH311991400006

(3) When the guide (key No. 9) is fixed, move the bar (key No. 4) vertically and fix the guide (key No. 9) with the stopper (key No. 10) so that the needle of the dial gauge may come at the center.



SAPH311991400007

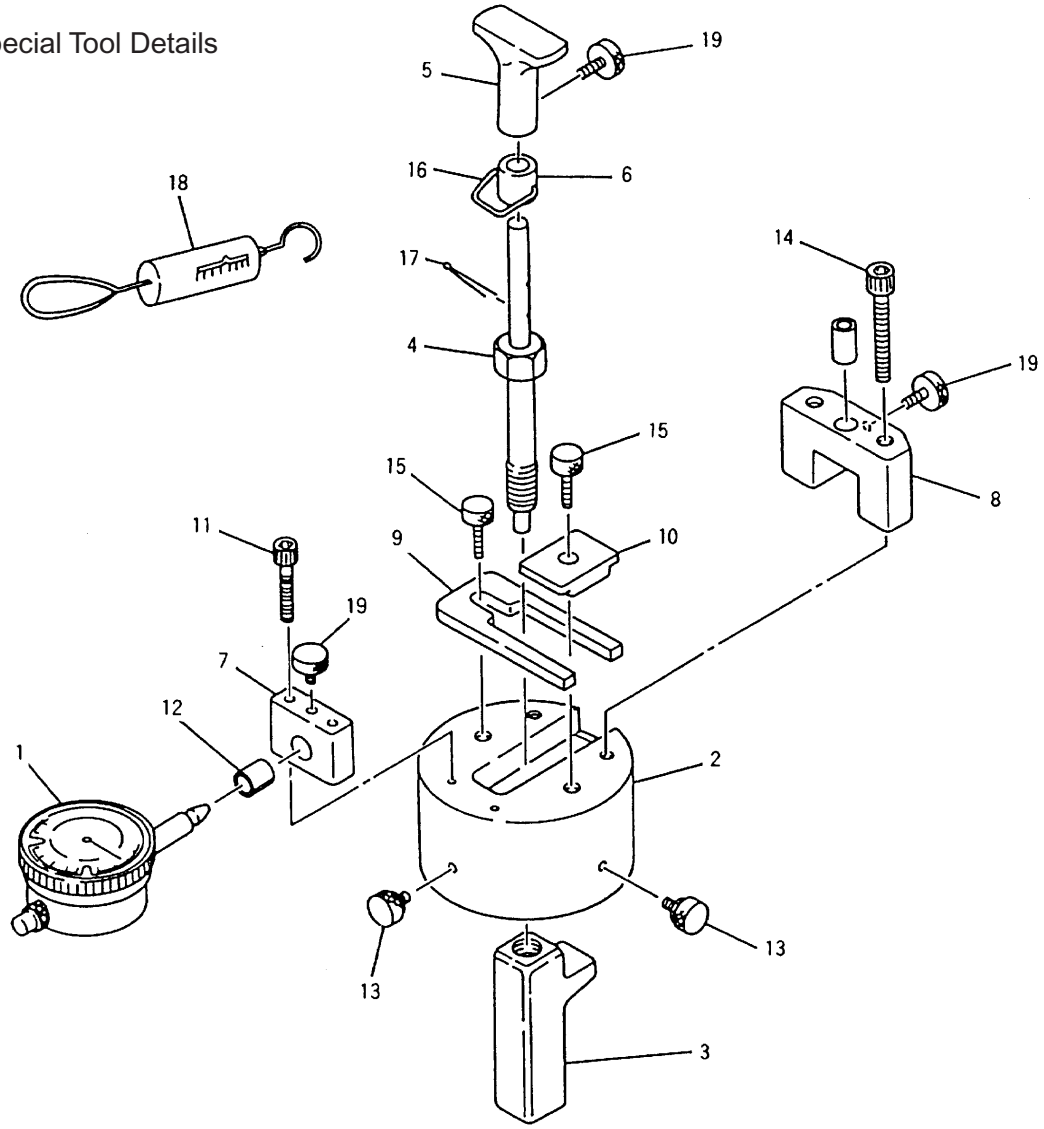
(4) Hold the puller (key No. 5) and press it toward the turbine in the axial direction. Set the dial gauge reading to 0.


SAPH311991400008

(5) Pull it to the opposite side and measure movement in the axial direction.

(6) Take three measurements and use the average value as the measurement value.

Special Tool Details



Key No.	Part name	Key No.	Part name
Assembly	Tool assembly	10	Stopper
1	Gauge (dial gauge)	11	Bolt
2	Guide	12	Sleeve
3	Stopper	13	Bolt
4	Bar	14	Bolt
5	Puller	15	Bolt
6	Sleeve	16	Hook
7	Plate	17	Snap ring (cotter pin)
8	Plate	18	Bar (spring)
9	Guide	19	Bolt

SAPH311991400009

Replacement

JP31199140704001

1. Removal

(1) Remove the boost pipe and U-turn pipe.

(2) Disconnect all pipes connected to the turbocharger.

⚠ **CAUTION**
- **Loosen union bolt of the coolant pipe, drain coolant and remove the pipe. Disconnect the lower pipe similarly and remove the oil pipe.**
- **After removing pipes, be sure to seal oil holes, water holes and cylinder block holes to prevent entry of dirt.**

(3) Remove the bolts fixing the exhaust pipe and the turbocharger and remove the turbocharger.

⚠ **CAUTION**
- **After removal, seal holes both at the exhaust manifold and the exhaust pipe to prevent entry of foreign matter.**
- **If a stud bolt is sticking, remove and replace the stud bolt using a commercially available stud remover.**

2. Installation

(1) Install the turbocharger in the reverse order of disassembly. When the turbocharger is installed on the engine or after installation, observe the following precautions for work. Pay special attention to entry of foreign matter inside the turbocharger.
Tightening torque :
56 N·m {570 kgf·cm, 41 lbf·ft}
(Turbocharger to exhaust manifold)

(2) Lubrication and cooling system

a. Before installation on the engine, pour new engine oil from the oil inlet and turn the turbocharger with hand to lubricate the journal bearing and the thrust bearing.

b. Clean the oil pipe, oil hose, coolant pipe and hose. Check for pipe deformation, hose crack or dirt or foreign matter in the pipe or hose.

c. Do not use sealant at the installation surface of the oil pipe and the coolant pipe or joint between the coolant hose and the coolant pipe to prevent failures such as damage due to clogging or loosening of tightened areas.

d. Be sure to use new soft washers, O-rings and gaskets.

e. Be sure to install the oil pipe, oil hose, coolant pipe and coolant hose correctly to prevent leak of oil or water from connections.

(3) Air intake system
   a. Make sure that there is no dirt or foreign matter in the air intake system.
   b. Do not use sealant at the inlet/outlet of air to prevent failures such as damage due to clogging or loosening of tightened areas.
   c. Be sure to install the air feed pipe and the air hose correctly to prevent air leak from connections.

(4) Exhaust system
   a. Make sure that there is no dirt or foreign matter in the exhaust piping system.
   b. Since heat resistant steel is used for bolts and nuts, do not mix them with normal bolts for installation.

16 FAILURE DIAGNOSIS FOR EACH ENGINE STATUS

FAILURE DIAGNOSIS FOR EACH ENGINE STATUS
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Starter 16-6
Turbocharger 16-7

FAILURE DIAGNOSIS FOR EACH ENGINE STATUS

Engine mechanical

JP31199160601001

Status	Cause	Action
Engine overheat (coolant)	Insufficient coolant	Replenish coolant
	Faulty thermostat	Replace thermostat
	Water leak from cooling system	Correction
	Faulty coolant pump	Repair or replace
	Faulty head gasket	Replace head gasket
Engine overheat (radiator)	Clogging of radiator	Cleaning of radiator
	Corrosion of cooling system	Clean and repair cooling system
	Clogging of radiator core front part	Clean radiator
	Faulty radiator cap	Replace radiator cap
Engine overheat (compression pressure)	Non-synchronous injection timing	Injection timing inspection
	Faulty fuel injection pressure	Injection pressure inspection
	Faulty fuel	Replace with correct fuel
	Faulty injector	Replace injector
Engine overheat (lubrication unit)	Deterioration of engine oil	Replace engine oil
	Faulty oil pump	Replace oil pump
	Insufficient engine oil	Replenish engine oil
Large engine oil consumption (piston, cylinder liner and piston ring)	Wear of piston ring and cylinder liner	Replace piston ring and cylinder liner
	Damage to piston ring	Replace piston ring and cylinder liner
	Faulty fixing of piston ring	Replace piston ring and cylinder liner
	Faulty assembly of piston ring	Replace piston ring and cylinder liner
	Faulty engine oil	Replace engine oil
	Faulty piston ring joint	Reassemble piston ring
Large engine oil consumption (valve and valve guide)	Wear of valve stem	Replace valve and valve guide
	Wear of valve guide	Replace valve guide
	Faulty assembly of valve stem seal	Replace stem seal
	Excessive oil lubrication to rocker arm	Inspection of clearance between rocker arm and rocker arm shaft
Large engine oil consumption (others)	Faulty oil level gauge	Replace with correct level gauge
	Excessive filling of engine oil	Fill with appropriate amount of oil.
	Leak of engine oil	Repair or replace the part of oil leak.
Piston seizure (in operation)	Sudden stop of engine	Perform warm-up before stop of engine
Piston seizure (lubrication unit)	Insufficient engine oil	Replenish engine oil
	Deterioration of engine oil	Replace engine oil
	Incorrect engine oil	Replace with correct engine oil.
	Low oil pressure	Inspection of lubrication unit
	Faulty oil pump	Replace oil pump

Status	Cause	Action
Piston seizure	Abnormal combustion	Refer to overheat section.
Piston seizure	Cooling unit	Refer to overheat section.
Insufficient engine power (air cleaner)	Clogging of air cleaner element	Clean or replace air cleaner element
Insufficient engine power	Overheat	Refer to overheat section.
Insufficient engine power (fuel unit)	Faulty injection of injector	Replace injector
	Faulty injector due to deposit of carbon	Replace injector
	Entry of air into fuel system	Air bleeding of fuel system
	Faulty fuel filter	Replace element
	Faulty fuel	Replace with correct fuel
Insufficient engine power	Abnormal compression pressure	Refer to overheat section.
Insufficient engine power	Piston, cylinder liner and piston ring	Refer to overheat section.
Faulty engine start (electric unit)	Faulty battery	Check battery
	Faulty wiring of starter	Replace starter wiring
	Loose battery cable	Tighten battery terminal connection or replace cable
	Faulty operation of starter	Replace starter assembly
	Faulty start assist unit	Replace start assist unit
Faulty engine start (air cleaner)	Clogging of air cleaner element	Clean or replace air cleaner element
Faulty engine start (fuel unit)	Insufficient fuel	Replenish fuel and bleed air from fuel system
	Clogging of fuel system	Clean fuel system.
	Air intake from connection of fuel system	Tighten connections
	Clogging of fuel filter	Replace fuel filter
	Loose connection of injection pipe	Tighten connecting nut of injection pump
Faulty engine start (injector)	Injector seizure	Replace injector
Faulty engine start (lubrication unit)	Excessive viscosity of engine oil	Replace with engine oil with correct viscosity
Faulty engine start (others)	Piston seizure	Replace piston, piston ring and cylinder liner
	Bearing seizure	Replace bearing and crankshaft
	Low compression pressure	Overhaul engine
	Damage to ring gear	Replace ring gear and replace starter pinion gear.
Faulty idling (injector)	Faulty injection pressure	Injection pressure inspection
	Faulty injection status	Adjust or replace injector.

Status	Cause	Action
Faulty idling (nozzle)	Faulty injection pressure	Injection pressure inspection
	Faulty spray status	Adjust or replace nozzle
	Carbon deposit at nozzle end	Remove carbon
	Seizure of needle valve	Replace nozzle
Faulty idling (engine)	Faulty valve clearance	Adjustment of valve clearance
	Faulty contact of valve seat	Adjust or replace valve and valve seat.
	Low coolant temperature	Perform warm-up.
	Large variation of compression pressure between cylinders	Overhaul engine Training of engine difference not performed after exchange of the engine ECU
	Training of engine difference not performed after exchange of the engine ECU	Perform training of engine difference after exchange of the engine ECU
Gas leak (head gasket)	Reuse	Replace gasket.
	Damage	Replace gasket.
	Replace gasket.	Replace gasket.
Gas leak (head bolt)	Loose head bolt	Tighten bolt.
	Incorrect tightening sequence or incorrect tightening torque	Tighten bolt to correct torque according to the correct tightening sequence.
	Extension of head bolt	Replace bolt.
Gas leak (cylinder block)	Crack	Replace cylinder block.
	Distortion of cylinder block upper surface	Repair or replace cylinder block.
	Depression of cylinder liner insertion (insufficient protrusion of cylinder liner)	Replace cylinder liner or block.
Gas leak (cylinder head)	Crack of cylinder head	Replace cylinder head.
	Distortion of cylinder head lower surface	Repair or replace cylinder head.
Gas leak (cylinder liner)	Crack of cylinder liner	Replace cylinder liner.
	Corrosion of cylinder liner	Replace cylinder liner.
	Insufficient protrusion of cylinder liner	Replace cylinder liner or block.
Gas leak (others)	Incorrect injection timing	Injection timing inspection

Alternator

JP31199160601002

Status	Cause	Action
Lamp is ON.→Charge current does not run (alternator).	Faulty regulator (open PTr)	Replace regulator.
	Faulty stator coil (disconnection, rare shorting)	Replace stator coil.
	Fault feed coil (disconnection, rare shorting)	Replace feed coil.
	Faulty diode (open, shorting)	Replace rectifier.
	Disconnection or poor contact of lead wire (plate, support, etc.)	Repair or replace lead wire.
Lamp is ON.→Charge current does not run (wiring).	Disconnection of wire (fuse)	Replace wire (fuse).
Lamp is ON.→Voltmeter indicates 29V or more (alternator).	Faulty regulator (shorting of PTr)	Replace regulator.
	Faulty tightening of voltage detection circuit (e.g. support)	Repair, replace voltage detection circuit or replace regulator.
Lamp is ON.→Charge current is correctly running (alternator).	Faulty regulator (open Tr)	Replace regulator.
Lamp is OFF.→Charge current is always limited.→Battery goes flat (alternator).	Faulty stator coil (disconnection of 1 phase, rare shorting)	Replace stator coil.
	Faulty diode (open, shorting)	Replace rectifier.
	Disconnection or poor contact of lead wire (plate, support, etc.)	Repair or replace lead wire.
Lamp is OFF.→Charge current is always limited.→Battery goes flat (operation load).	Operation load is large (Load balance is poor).	Reduce load
Lamp is OFF.→Charge current is always large.→Battery fluid runs short in a short period of time (alternator).	Faulty regulator (shorting of PTr)	Replace regulator.
	Faulty tightening of voltage detection circuit (e.g. support)	Repair or replace voltage detection circuit.
Lamp is OFF.→Charge current is always large.→Battery fluid runs short in a short period of time (battery).	Battery is close to the service life.	Replace battery.
Others→Abnormal noise (alternator)	Faulty stator coil (rare shorting, grounding)	Replace stator coil.
	Contact of inner surface (faulty bearing, wear of bracket)	Repair or replace bearing.
Others→Abnormal noise (V belt)	Faulty tension of V belt (belt slip)	Correction

Starter

JP31199160601003

Status	Cause	Action
Starter does not turn. Turning is low.	Faulty connection of starter key	Repair connecting area.
	Flat battery	Charge or replace.
	Disconnection, loosening or corrosion of battery terminal	After cleaning, tighten.
	Grounding wire is disconnected.	Be sure to connect it.
	Use of incorrect engine oil	Replace with correct oil.
	Faulty contact of start magnet switch assembly.	Replace start magnet switch assembly
	Faulty contact or failure of starter relay	Replace starter relay.
	Wear of starter brush	Replace brush
	Seizure of commutator	Repair commutator.
	Wear of commutator	Undercut
	Shorting of armature	Replace armature assembly
	Insufficient tension of brush spring	Replace brush spring.
	Faulty operation of clutch	Clean or replace.

Turbocharger

JP31199160601004

Status	Cause	Action
Exhaust smoke is black (insufficient intake air).	Clogging of air cleaner element	Clean or replace air cleaner element.
	Air intake inlet is closed.	Recover normal status.
	Leak from connection of air intake system	Check and repair.
	Revolution of blower impeller and turbine shaft is heavy	Disassembly and repair.
Exhaust smoke is black (Turbocharger is not operating).	Oil impurities are deposited at the sealing part of the turbine and revolution of the turbine shaft is heavy.	Replace engine oil and disassemble the turbocharger for cleaning.
	Seizure of bearing	Replace turbocharger.
	Seizure of bearing (insufficient lubrication or clogging of oil pipe)	Check the oil system of the engine and repair faulty areas. Also, replace engine oil.
	Seizure of bearing (Oil temperature is too high.)	Check the oil system of the engine and repair faulty areas. Also, replace engine oil.
	Seizure of bearing (Balance of revolving body is poor.)	Replace or clean revolving part.
	Seizure of bearing (insufficient warm-up or sudden stop from loaded operation: Unloaded operation)	Observe the precautions strictly in the operation manual.
	Contact of or damage to turbine shaft and blower impeller (excessive operation)	Check and repair engine parts.
	Contact of or damage to turbine shaft and blower impeller (excessive increase of exhaust gas temperature)	Check and repair engine parts.
	Contact of or damage to turbine shaft and blower impeller (entry of foreign matter)	Disassemble the engine to remove foreign matter completely. Check and repair the air cleaner and engine parts.
	Contact of or damage to turbine shaft and blower impeller (wear of bearing)	Replace turbocharger.
	Contact of or damage to turbine shaft and blower impeller (faulty assembly)	Reassemble or replace.
Exhaust smoke is black (due to exhaust gas resistance).	Exhaust gas is leaking before the turbocharger. Revolution is not increased.	Check and repair mounting area.
	Since pipe of the exhaust system is deformed or clogged, revolution of the turbocharger is not increased.	Recover normal status.

Status	Cause	Action
Exhaust smoke is white.	Engine oil runs out to the blower or the turbine due to clogging or deformation of the oil return pipe.	Repair or replace pipe.
	Negative pressure at the back of the blower impeller is increased and engine oil runs out to the blower.	Check and replace the pipe. Replace or clean the air cleaner element.
	Seal ring is excessively worn or damaged due to excessive wear of the bearing.	Disassemble and repair turbocharger.
	Entry of water into the cylinder	Exchange or repair of the parts where water has entered
Oil is quickly reduced.	Seal ring is excessively worn or damaged due to excessive wear of the bearing.	Disassemble and repair turbocharger.
	Engine oil enters into exhaust gas before the turbocharger.	Check and service engine parts.
Low engine output	Gas leak from exhaust system parts	Check and repair faulty areas.
	Air leak from blower outlet	Check and repair faulty areas.
	Clogging of air cleaner element	Clean or replace air cleaner element
	Contamination of or damage to turbocharger	Replace turbocharger.
Acceleration (follow-up of turbocharger) is poor (slow).	Carbon deposit at the turbine (disc sealing area) makes revolution of the turbine heavy.	Replace engine oil and clean turbocharger.
	Air and gas leak from intake/ exhaust system parts	Check and repair faulty areas.
	Combustion is faulty.	Check the engine fuel system and recover correct combustion status.
Abnormal noise	If the gas passage is extremely narrowed due to clogging at the turbine case nozzle or if acceleration is performed, reverse flow (usually called surging) occurs due to clogging of blower discharge air.	Replace turbocharger.
	Revolving part is in contact.	Replace turbocharger.
	Air and gas leak from intake/ exhaust system parts	Check and repair faulty areas.

Status	Cause	Action
Vibration	Loosening between turbocharger and intake/exhaust pipe and between oil pipe and mounting area	Check the turbocharger mounting status and repair faulty areas.
	Failure of metal, contact between revolving part and peripheral parts, or damage to the blower impeller of the turbine rotor due to entry of foreign matter is found.	Replace turbocharger. Remove foreign matter completely, if any.
	Balance of revolving body is poor.	Replace revolving body.

17 ENGINE DIAGNOSIS CODE

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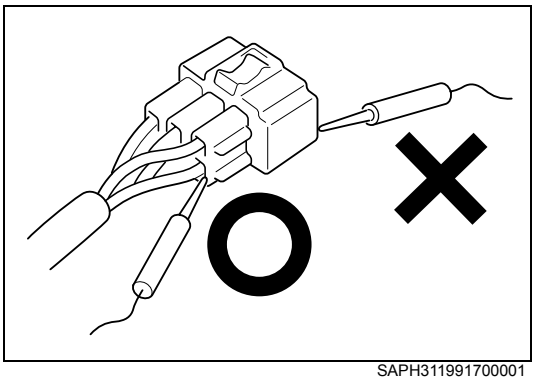
Engine ECU

Precautions

JP31199170102001

⚠ CAUTION

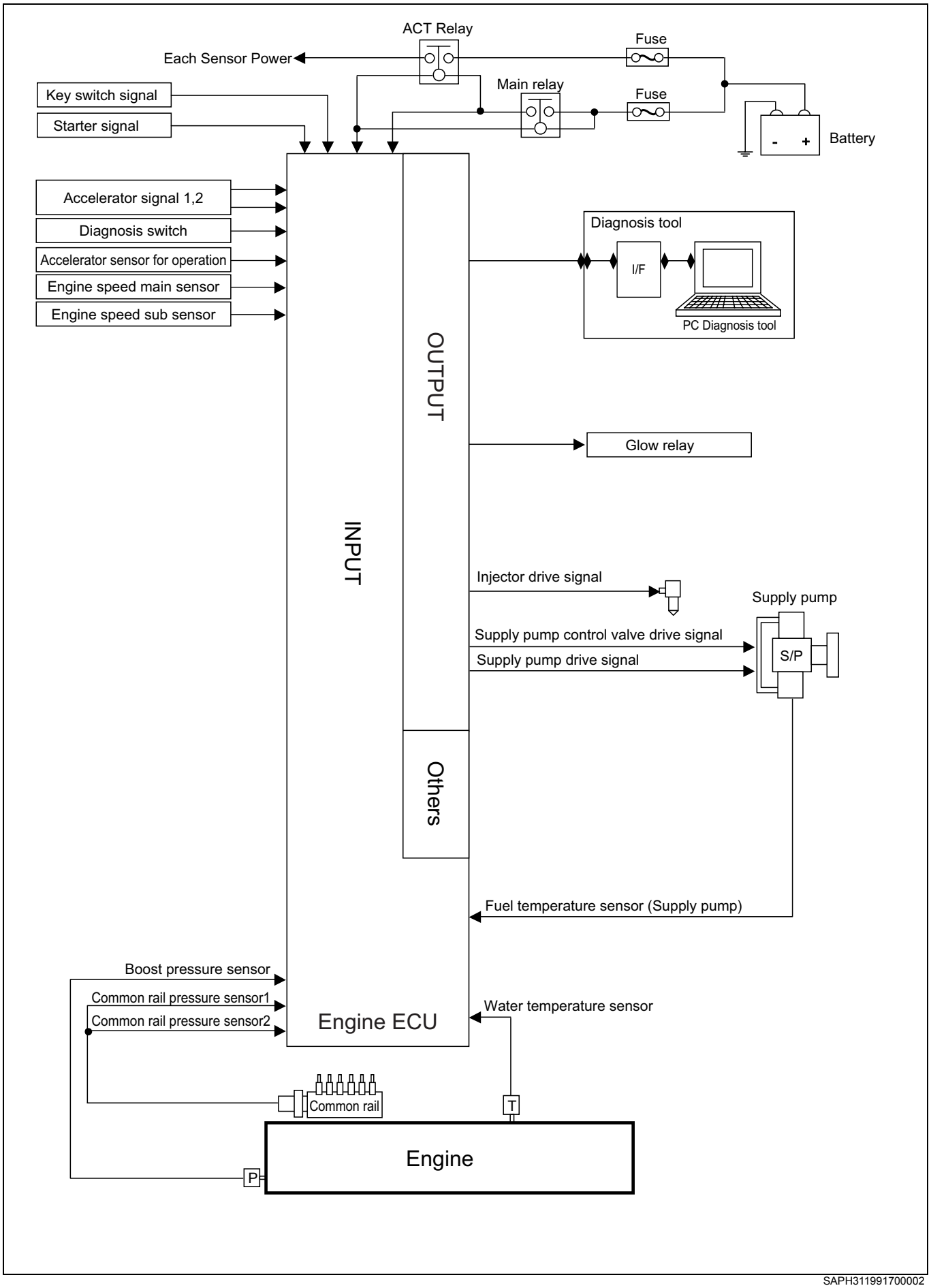
- **Make sure that each connector is connected before inspection.**
- **Do not place a tester rod on the connecting surface of the connector. Otherwise, terminals are damaged or short-circuited.**
- **Delete the past failure memory after recording. Perform failure diagnosis again to check current failure.**
- **After failure analysis, delete the past failure memory. If the past failure memory is not deleted, the failure indicator lamp remains ON.**
- **All connector drawings are viewed from the connecting surface. Place the tester rod from the back.**



SAPH311991700001

System block diagram

JP31199170803001



SAPH311991700002

Inspection

JP31199170703001

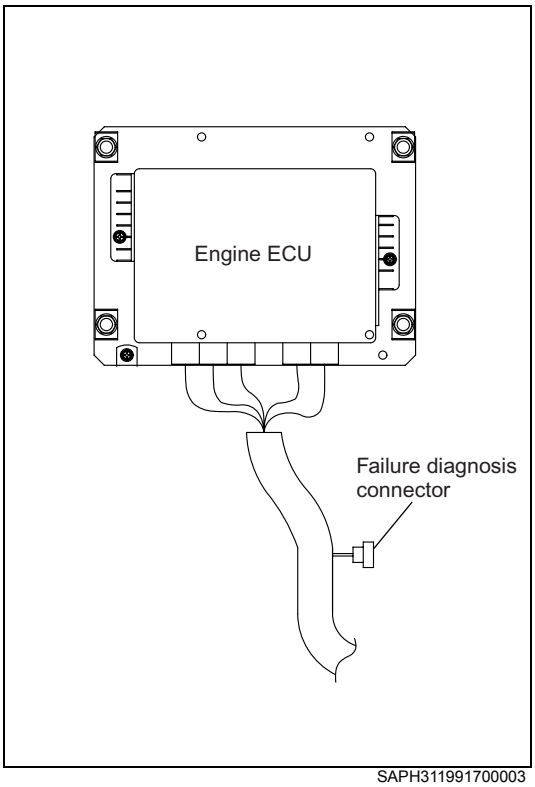
1. Pre-inspection

(1) If an error occurs on the system, The DTC code is indicated in the console panel.

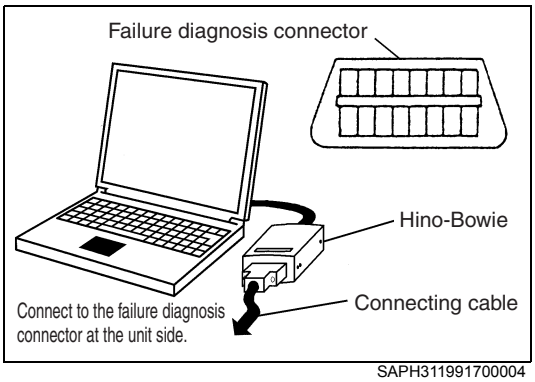
(2) Reading of failure code

a. Connection of HinoDX

1. Remove the left side cover at the rear of the driver's seat and connect the failure diagnosis connector with a PC which installed HinoDX through the interface box.

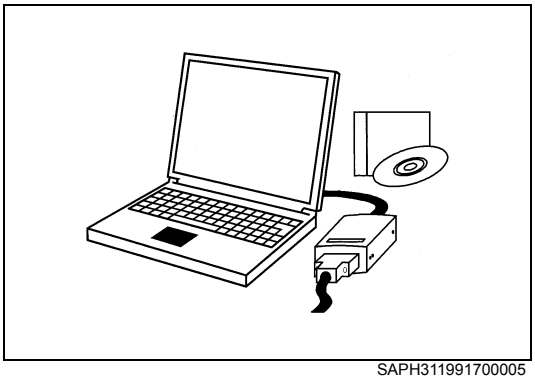


SAPH311991700003



SAPH311991700004

Special tool : 09121-1040 Hino-Bowie (Interface box)
09042-1220 Connecting cable
CD-ROM HinoDX



SAPH311991700005

2. Deletion method of past failure

(1) To delete past failures of the engine ECU, use HinoDX on the PC. (Refer to "HinoDX operation manual".)

Table of failure code

JP31199170601001

NOTICE • **For the system status by indication of DTC code in the table, refer to "1. Pre-inspection, Inspection, Engine ECU".**
"Reference : Inspection, Engine ECU, Engine diagnosis code"

[a] Failure diagnosis and [b] Alarm display (alarm status)	DTC code	Estimated failure cause	Page
a. Engine does not start Engine stopped. b. DTC code indication.	P0335	Engine speed main sensor circuit malfunction	17-12
	P0606	CPU malfunction (Hard detection)	17-47
	P0629	Supply pump SCV malfunction (Power source line short)	17-43
a. Low output b. DTC code indication.	P0200	ECU charge circuit high input	17-48
	P0611	ECU charge circuit low input	17-48
a. Low output (LOW idle 800rpm fixing) b. DTC code indication.	P2120	Accelerator sensor 1 and 2 malfunction	17-30
a. Low output b. DTC code indication.	P0217	Engine overheat	17-17
a. Difficult to start engine. b. DTC code indication.	P0540	Preheat circuit malfunction	17-46
a. Low output b. DTC code indication.	P0234	Turbocharger over boost	17-21
	P0088	Excessive common rail pressure	17-21
	P0088	Excessive common rail pressure, supply pump excess forced feed	17-22
	P0108	Boost pressure sensor circuit high input	17-19
	P0117	Coolant temperature sensor circuit low input	17-16
	P0118	Coolant temperature sensor circuit high input	17-16
	P0191	Common rail pressure sensor malfunction	17-23
	P0192	Common rail pressure sensor circuit low input	17-24
	P0193	Common rail pressure sensor circuit high input	17-24
	P0201	Injector circuit malfunction -cylinder 1	17-38
	P0202	Injector circuit malfunction -cylinder 2	17-38

[a] Failure diagnosis and [b] Alarm display (alarm status)	DTC code	Estimated failure cause	Page
a. Low output b. DTC code indication.	P0203	Injector circuit malfunction -cylinder 3	17-38
	P0204	Injector circuit malfunction -cylinder 4	17-38
	P0237	Boost pressure sensor circuit low input	17-19
	P0605	Flash ROM error	17-47
	P0607	Monitoring IC malfunction in CPU	17-47
	P0628	Supply pump SCV malfunction (Full discharge mode)	17-43
	P1211	Injector common 1 ground short	17-34
	P1212	Injector common 1 power source line short	17-36
	P1212	Injector common 1 open circuit	17-36
	P1214	Injector common 2 ground short	17-34
	P1215	Injector common 2 power source line short	17-36
	P1215	Injector common 2 open circuit	17-36
	P1601	Injector correction data conformity error	17-47
	P2228	Atmospheric pressure sensor circuit low input	17-33
	P2229	Atmospheric pressure sensor circuit high input	17-33
	P2635	Supply pump SCV sticking	17-45
	P2635	Supply pump malfunction	17-45
a. Other problems b. DTC code indication.	P0182	Fuel temperature sensor circuit low input	17-18
	P0183	Fuel temperature sensor circuit high input	17-18
	P0340	Engine speed sub sensor circuit malfunction	17-14
	P0686	Main relay malfunction	17-49
	P2122	Accelerator sensor circuit 1 low voltage	17-26
	P2123	Accelerator sensor circuit 1 high voltage	17-26
	P2127	Accelerator sensor circuit 2 low voltage	17-28
	P2128	Accelerator sensor circuit 2 high voltage	17-28
	P1133	Emergency accelerator sensor malfunction high input	17-31

[a] Failure diagnosis and [b] Alarm display (alarm status)	DTC code	Estimated failure cause	Page
a. Other problems	P0219	Engine overrun	17-17
	P0263	Cylinder 1 contribution/balance fault	17-41
b. No indication	P0266	Cylinder 2 contribution/balance fault	17-41
	P0269	Cylinder 3 contribution/balance fault	17-41
	P0272	Cylinder 4 contribution/balance fault	17-41
	P0617	Starter signal malfunction	17-49
	P2635	Supply pump abnormal pressure record	17-45
	U1001	Interruption of CAN communication (unit)	-

Signal check harness

JP31199170301001

1. Signal check harness

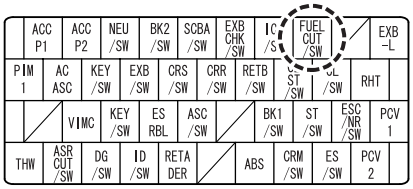
⚠ CAUTION

- **When measuring terminal of the engine ECU, connect the signal check harness to prevent damage to the connector. Place the tester rod on the contact box of the signal check harness for measurement.**

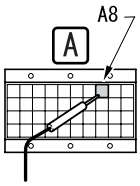
NOTICE

- **Terminal numbers in the text and the illustrations correspond as shown below in the "Computer pin arrangement".**

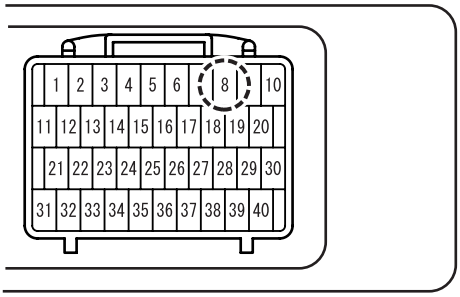
ECU terminal name



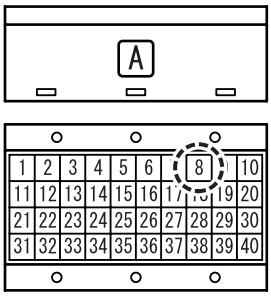
[Example] For A8 terminal



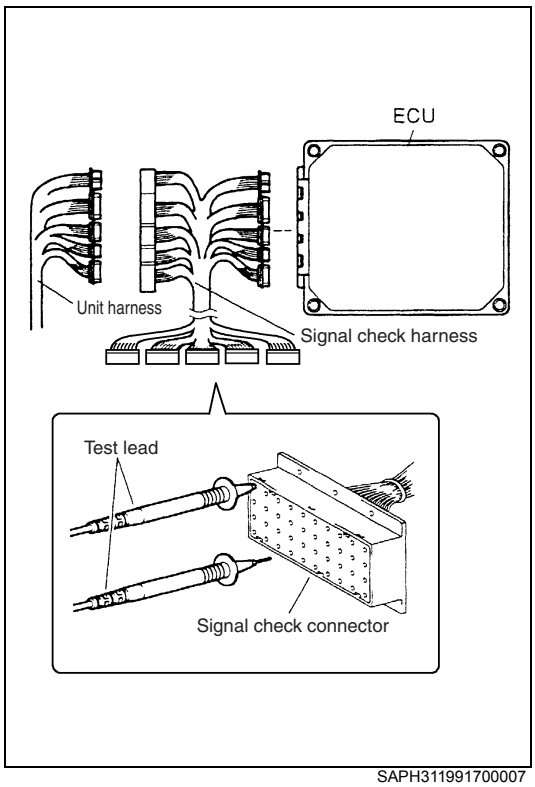
ECU terminal number



Signal check harness (contact box)



SAPH311991700006



SAPH311991700007

2. Connection of signal check harness

(1) Set the starter key to "OFF" and disconnect the connector from the engine ECU.

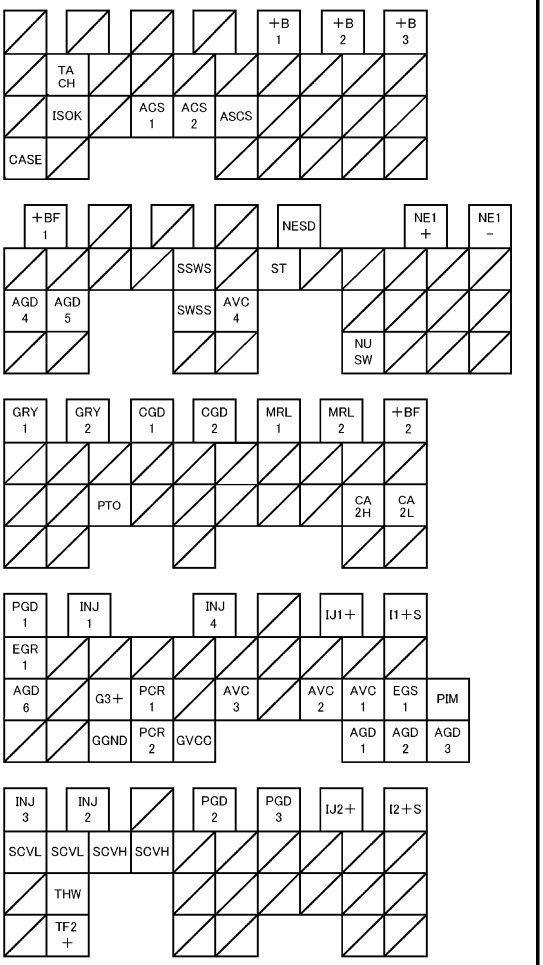
(2) Connect the signal check harness to the engine ECU and the unit harness.

Special tool : Signal check harness (09049-1080)

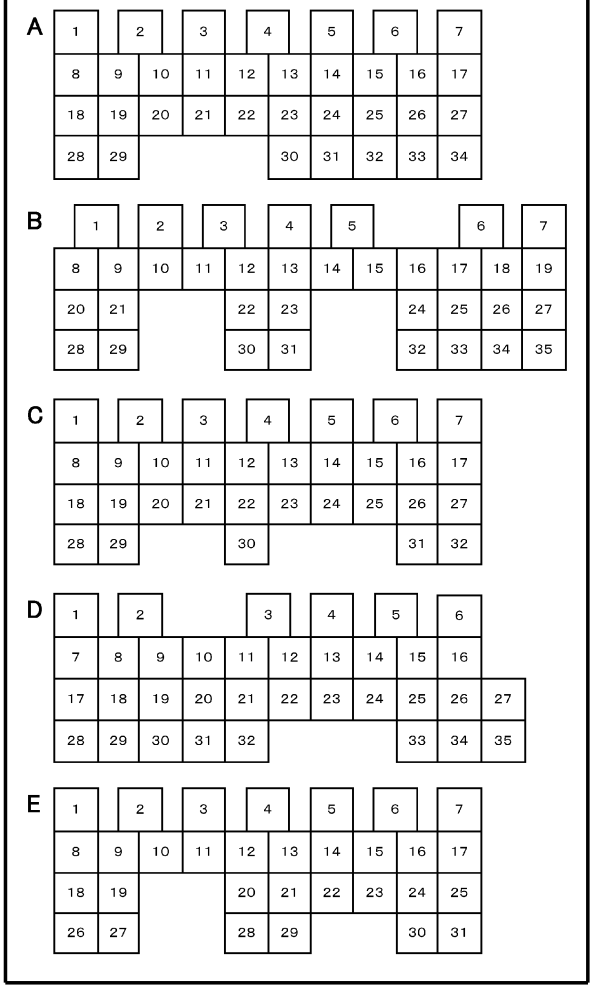
Computer pin arrangement

JP31199170201001

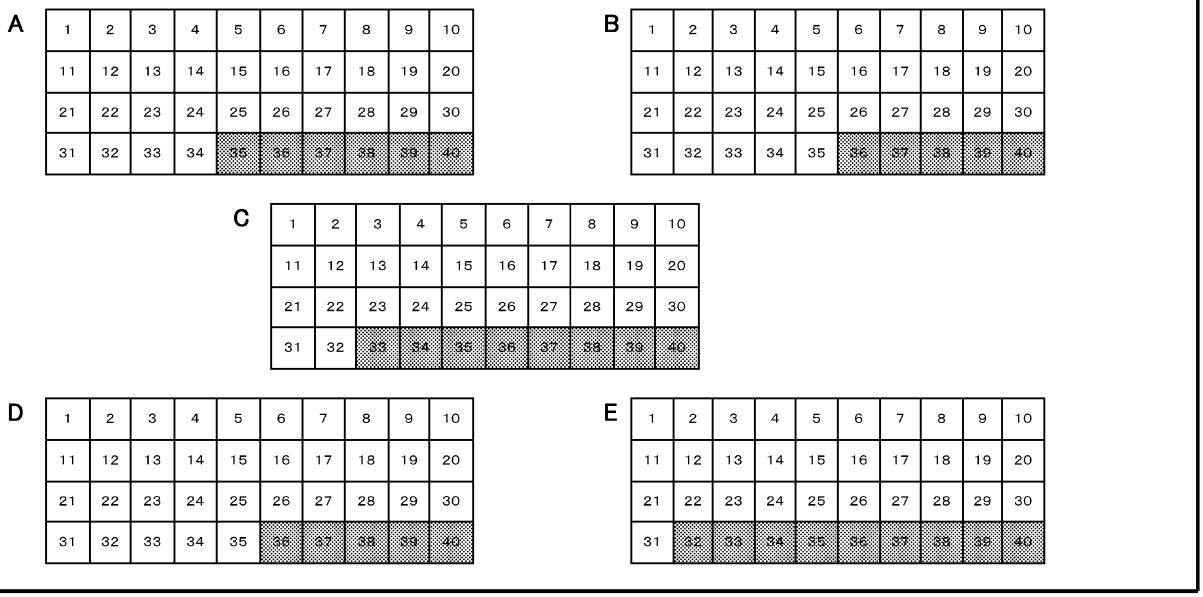
ECU terminal name



ECU terminal number



Signal check harness (contact box)

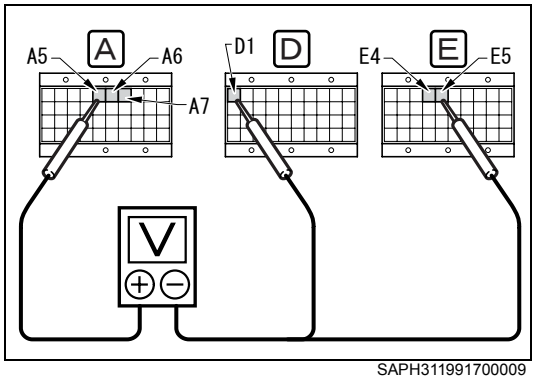


SAPH3119917000008

Check the ECU power supply voltage

JP31199170601002

1	Measurement of voltage between terminals



SAPH311991700009

1. Set the starter key to "OFF" and connect the signal check harness.
2. Turn the starter key "ON" and measure voltage between terminals A5, A6, A7 and terminals D1, E4, E5.
   Standard value : 20 V or more

NG

- 0 V : Blown fuse, harness failure, ground failure, etc.
- 20 V or less : Battery deterioration, ground failure, etc.

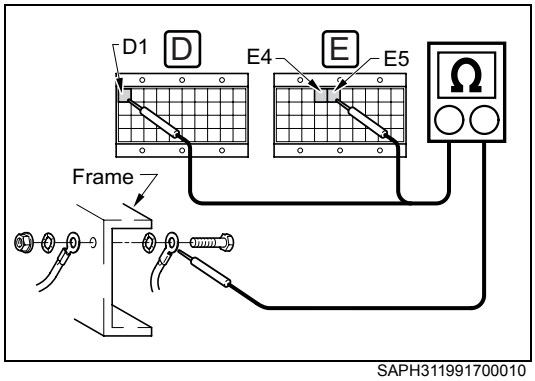
OK

Normal

Check the ground

JP31199170601003

1	Measurement of resistance between terminals



SAPH311991700010

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminals D1, E4, E5 and the terminal (-) of the battery.
   Standard value : 1 Ω or less

NG

Disconnection of ground harness, contact failure, etc.

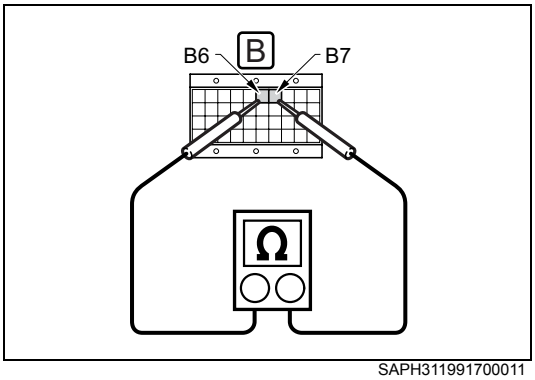
OK

Normal

Engine speed main sensor circuit malfunction (DTC code P0335)

JP31199170601004

1	Measurement of resistance between terminals



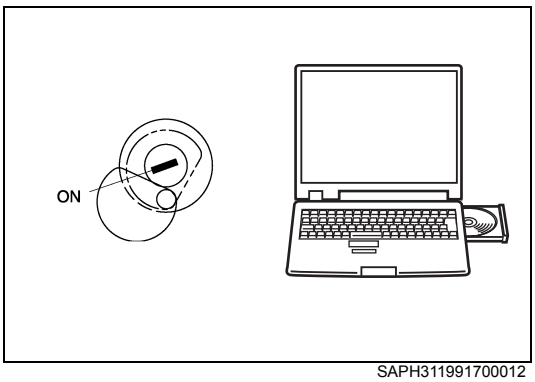
SAPH311991700011

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminal B6 and terminal B7.
   Standard value : Approx. 125.5 ± 17 Ω (20 °C{68 °F})

NG → [3] Go to measurement of resistance between sensor terminals.

OK

2	Check of diagnosis code



SAPH311991700012

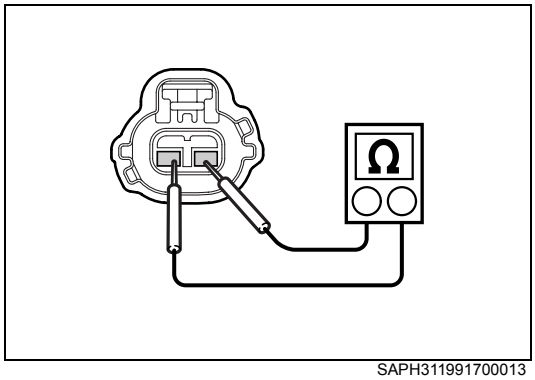
1. Connect the ECU side connector of the signal check harness. After deleting the past failure, Start the engine and confirm that no diagnostic code is put out.
   Standard : No diagnostic code

NG → Contact failure of ECU connector, ECU failure, short-circuit of harness

OK

Normal

3	Measurement of resistance between terminals



SAPH311991700013

1. Disconnect the connector of the main engine speed sensor and measure the resistance between No. 1 and No. 2 terminals at the sensor.

Standard value : Approx. 125.5 ± 17 Ω (20 °C{68 °F})

NG → Failure of main engine speed sensor

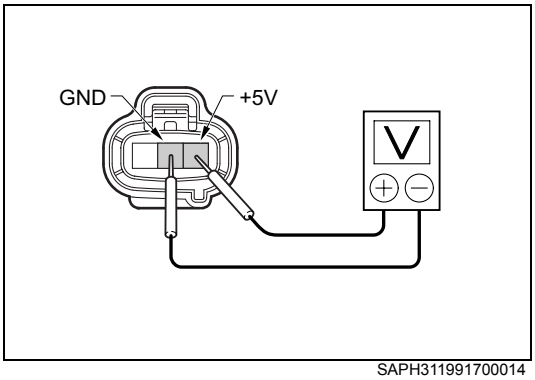
OK

Harness disconnection or connector failure

Engine speed sub sensor circuit malfunction (DTC code P0340)

JP31199170601005

1	Measurement of voltage between sensor terminals



SAPH311991700014

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the connector of the sub-speed sensor.
3. Set the starter key to "ON" and measure voltage between the +5V terminal and the GND terminal of the sub-speed sensor connector (at unit harness side).

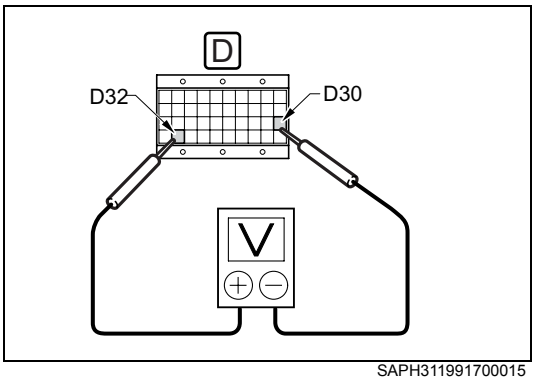
Standard value : 5.0 ± 0.5 V

NG → [2] Go to measurement of voltage between terminals.

OK

[3] Go to measurement of voltage between terminals.

2	Measurement of voltage between terminals



SAPH311991700015

1. Measure voltage between terminal D32 and terminal D30 of the signal check harness.

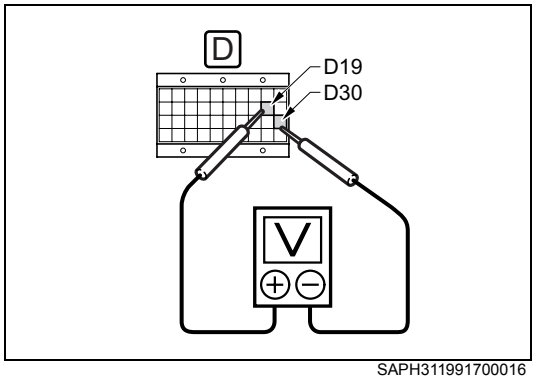
Standard value : 5.0 ± 0.5V

NG → Engine ECU failure, connector failure

OK

Harness failure

3	Measurement of voltage between terminals



SAPH311991700016

1. Set the starter key to "OFF" and connect the connector of the sub-speed sensor.
2. Start the engine and keep idling status.
3. Measure voltage between terminal D19 and terminal D30 of the signal check harness.
4. After measurement, stop the engine.

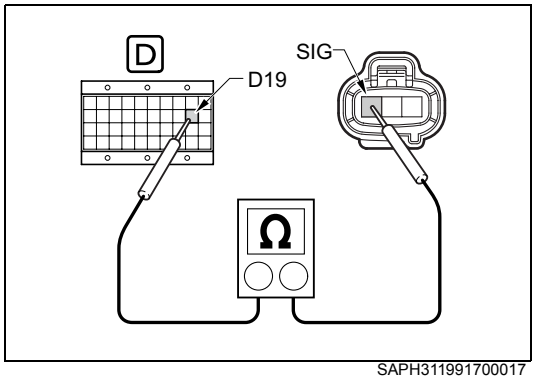
Standard : Pulse waveform of 0 ↔ 5 V

NG → [4] Go to measurement of resistance between terminals.

OK

Engine ECU failure, ECU connector failure

4	Measurement of resistance between terminals



SAPH311991700017

1. Leave the connector of the sub-speed sensor connected.
2. Measure resistance between the No. 1 terminal at the unit harness of the sub-speed sensor connector and terminal D19 of the signal check harness.

⚠ **CAUTION** • **The connector of the sub-speed sensor in the figure is viewed from the fitting surface.**

Standard value : 2 Ω or less

NG → Harness failure

OK

Failure of sub-speed sensor

Engine speed main and sub sensor circuit malfunction (DTC code P0335)

JP31199170601006

1. Inspection item

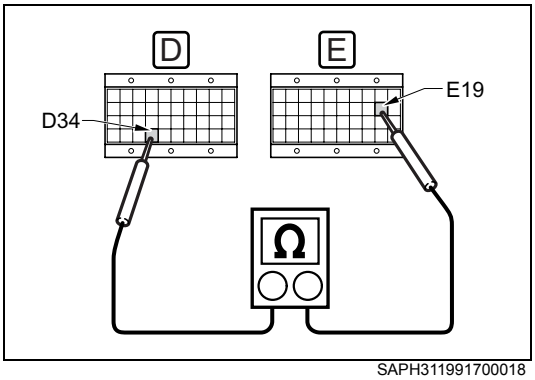
(1) Take actions of (DTC code P0335) and (DTC code P0340).
"Reference : Engine speed main sensor circuit malfunction (DTC code P0335), Engine ECU, Engine diagnosis code"
"Reference : Engine speed sub sensor circuit malfunction (DTC code P0340), Engine ECU, Engine diagnosis code"

Coolant temperature sensor malfunction (DTC code P0117, P0118)

JP31199170601007

DTC	P0117	Coolant temperature sensor circuit low input
DTC	P0118	Coolant temperature sensor circuit high input

1	Measurement of resistance between terminals



SAPH311991700018

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminal E19 and terminal D34.

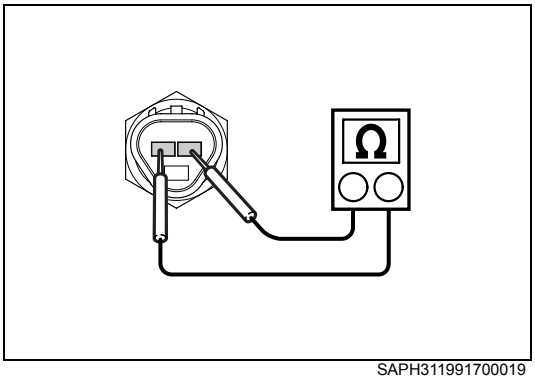
Standard value (Measure either one point of the following.)
: 2.45 kΩ (Coolant temperature at 20 °C{68 °F})
: 1.15 kΩ (Coolant temperature at 40 °C{104 °F})
: 584 Ω (Coolant temperature at 60 °C{140 °F})
: 318 Ω (Coolant temperature at 80 °C{176 °F})

NG → [2] Go to measurement of resistance between sensor terminals.

OK

Engine ECU failure, ECU connector failure, harness short-circuit

2	Measurement of resistance between terminals



SAPH311991700019

1. Disconnect the connector of the coolant temperature sensor and measure the resistance between No. 1 and No. 2 terminals at the sensor.

Standard value (Measure either one point of the following.)
: 2.45 kΩ (Coolant temperature at 20 °C{68 °F})
: 1.15 kΩ (Coolant temperature at 40 °C{104 °F})
: 584 Ω (Coolant temperature at 60 °C{140 °F})
: 318 Ω (Coolant temperature at 80 °C{176 °F})

NG → Failure of coolant temperature sensor

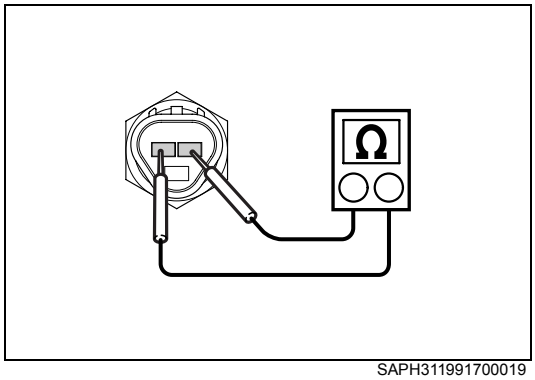
OK

Harness disconnection, connector failure

Engine overheat (DTC code P0217)

JP31199170601008

1	Measurement of resistance between terminals



SAPH311991700019

1. Set the starter key to "OFF", disconnect the connector of the coolant temperature sensor and measure the resistance between No. 1 and No. 2 terminals at the sensor.

   Standard value (Measure either one point of the following.)
   : 2.45kΩ (Coolant temperature at 20 °C{68 °F})
   : 1.15kΩ (Coolant temperature at 40 °C{104 °F})
   : 584Ω (Coolant temperature at 60 °C{140 °F})
   : 318Ω (Coolant temperature at 80 °C{176 °F})

NOTICE

- **This code is displayed when the coolant temperature sensor is normal and the coolant temperature is 115 °C{221 °F} or more.**
- **While this failure code is detected, the maximum injection volume is restricted. When the coolant temperature is 80 °C{176°F} or less, normal control is resumed.**

NG → Failure of coolant temperature sensor
Take actions of (DTC code P0117,P0118)

OK

Failure of engine cooling system

Engine overrun (DTC code P0219)

JP31199170601009

1. This failure code is displayed when the engine speed of 2,600 r/min or more is detected. While this failure code is detected, fuel injection is stopped. When the engine speed is lower than 2,500 r/min., fuel injection is resumed.

NOTICE

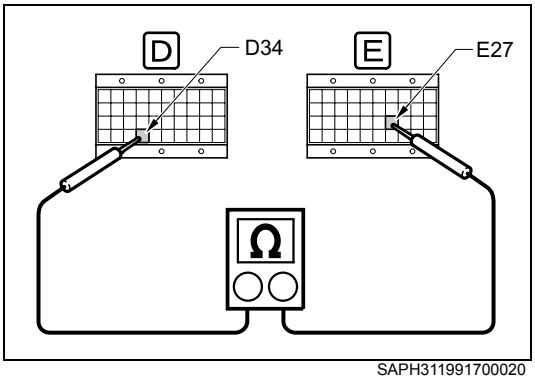
- **The objective of this failure code is not to detect overrun due to failure of this system, but to memorize high revolution of the engine.**
- **Engine speed may be incorrectly recognized with noise on the speed sensor signal due to harness failure or modification, resulting in detection of overrun.**

Fuel temperature sensor malfunction (DTC code P0182, P0183)

JP31199170601010

DTC	P0182	Fuel temperature sensor circuit low input
DTC	P0183	Fuel temperature sensor circuit high input

1	Measurement of resistance between terminals



SAPH311991700020

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminal E27 and terminal D34.

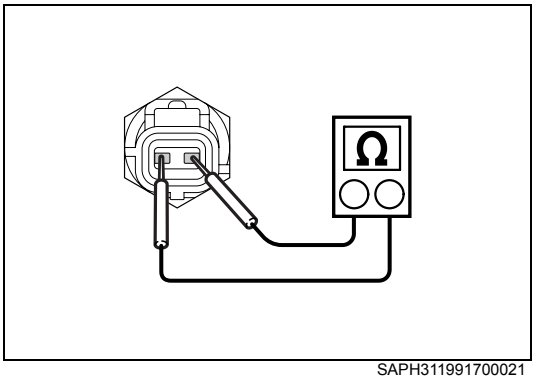
Standard value (Measure either one point of the following.)
: 2.45 kΩ (Fuel temperature at 20 °C{68 °F})
: 1.15 kΩ (Fuel temperature at 40 °C{104 °F})
: 584 Ω (Fuel temperature at 60 °C{140 °F})
: 318 Ω (Fuel temperature at 80 °C{176 °F})

NG → [2] Go to measurement of resistance between terminals.

OK

Engine ECU failure, ECU connector failure, harness short-circuit

2	Measurement of sensor resistance



SAPH311991700021

1. Disconnect the connector of the fuel temperature sensor and measure the resistance between No. 1 and No. 2 terminals at the sensor.

Standard value (Measure either one point of the following.)
: 2.45 kΩ (Fuel temperature at 20 °C{68 °F})
: 1.15 kΩ (Fuel temperature at 40 °C{104 °F})
: 584 Ω (Fuel temperature at 60 °C{140 °F})
: 318 Ω (Fuel temperature at 80 °C{176 °F})

NG → Failure of fuel temperature sensor

OK

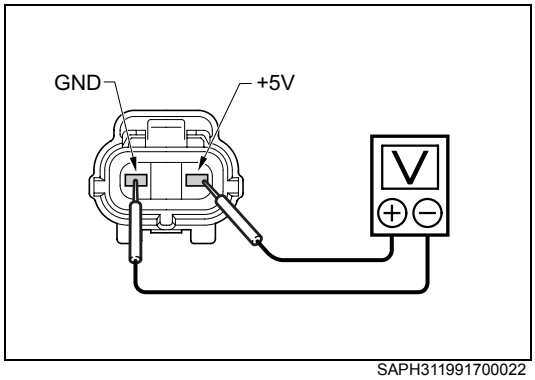
Harness disconnection, connector failure

Boost pressure sensor malfunction (DTC code P0108, P0237)

JP31199170601011

DTC	P0108	Boost pressure sensor circuit high input
DTC	P0237	Boost pressure sensor circuit low input

1	Measurement of voltage between sensor terminals



SAPH311991700022

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the connector of the boost pressure sensor.
3. Set the starter key to "ON" and measure voltage between the +5V terminal and the GND terminal of the boost pressure sensor connector (at unit harness side).

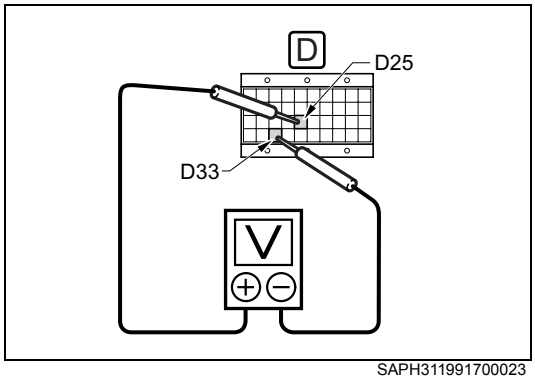
Standard value : 5 ± 0.5 V

NG → [2] Go to measurement of voltage between terminals.

OK

[3] Go to measurement of voltage between terminals.

2	Measurement of voltage between terminals



SAPH311991700023

1. Measure the voltage between terminal D25 and terminal D33 of the signal check harness.

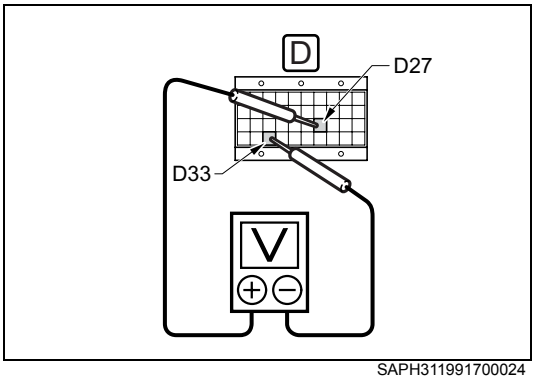
Standard value : 5 ± 0.5 V

NG → Engine ECU failure, ECU connector failure

OK

Harness failure

3	Measurement of voltage between terminals



SAPH311991700024

1. Set the starter key to "OFF" and connect the connector of the boost pressure sensor.
2. Set the starter key to "ON" and measure the voltage between terminal D27 and terminal D33 of the signal check harness.

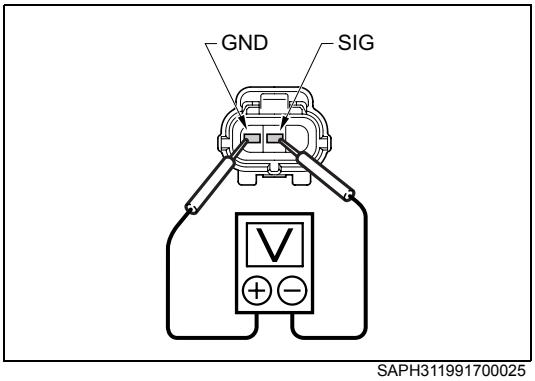
Standard value : 0.2 to 4.8 V

NG → [4] Go to measurement of voltage between terminals.

OK

Engine ECU failure, ECU connector failure

4	Measurement of voltage between sensor terminals



SAPH311991700025

1. Leave the connector of the boost pressure sensor connected.
2. Measure the voltage between the SIG terminal and the GND terminal of the boost pressure sensor connector (at unit harness side).

Standard value : 0.2 to 4.8 V

NG → Boost pressure sensor failure

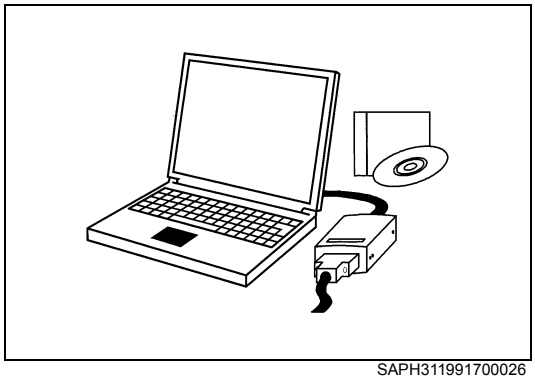
OK

Harness failure

Turbocharger over boost (DTC code P0234)

JP31199170601012

1	Inspection with failure diagnosis tool



SAPH311991700026

1. After failure, perform failure diagnosis with a failure diagnosis tool (HinoDX) using PC.
2. Connect the failure diagnosis tool (HinoDX) using PC and set the starter key to "ON".

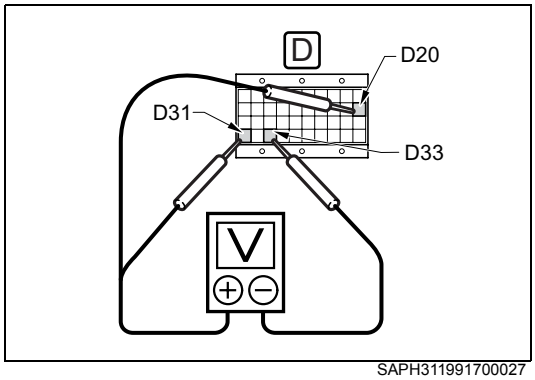
OK

Perform diagnosis of the boost pressure sensor (DTC code P0108, P0237).

Excessive common rail pressure (DTC code P0088)

JP31199170601013

1	Measurement of voltage between terminals



SAPH311991700027

1. Set the starter key to "OFF" and connect the signal check harness.
2. Set the starter key to "ON" and measure the voltage between terminals D20/D31 and terminal D33 of the signal check harness.

Standard value : 3.6 to 4.7 V

NG → Engine ECU failure or harness/connector contact failure

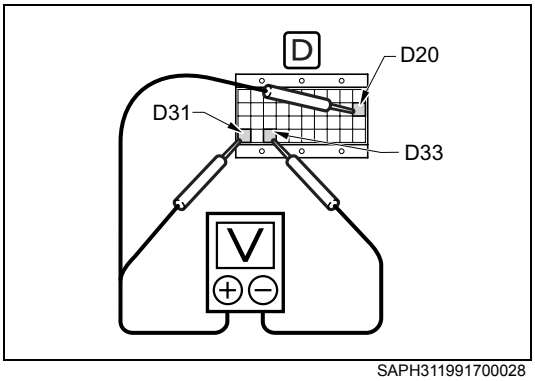
OK

Failure of common rail pressure sensor

Excessive common rail pressure, supply pump excess forced feed (DTC code P0088)

JP31199170601014

1	Measurement of voltage between terminals



SAPH311991700028

1. Set the starter key to "OFF" and connect the signal check harness.
2. Start and warm-up the engine until the coolant temperature gauge moves.
3. Set the engine speed to idling. PFIN = Approx. 30 MPa (approx. 1.5V)
4. Measure the voltage between terminal D20/D31 and terminal D33 of the signal check harness.

Standard value : 1.56 V or less

NG → Failure of common rail pressure sensor

OK

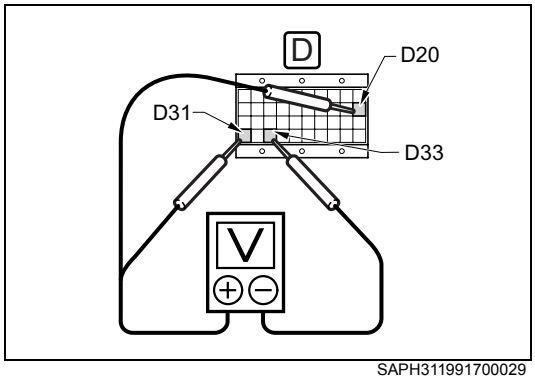
2	Check of failure code

1. Make sure that other failure code is not output.
   If other failure code is output, repair the failure code and make sure again that DTC code P0088 is output. In particular, if a failure code of the main and sub-engine speed sensor systems is output, make necessary repairs to prevent output of the code.
2. Check the fuel injection timing of the supply pump. If the timing is not set 0° for the top dead center, set it correctly.
3. When there is no error after the check above, delete the past failure using the PC diagnosis tool and start the engine.
   If the same code is output again, possible failures are the supply pump, common rail pressure sensor system and engine ECU. Perform more detailed diagnosis with failure diagnosis tool (HinoDX) using PC.

Common rail pressure sensor malfunction (DTC code P0191)

JP31199170601015

1	Measurement of voltage between terminals



SAPH311991700029

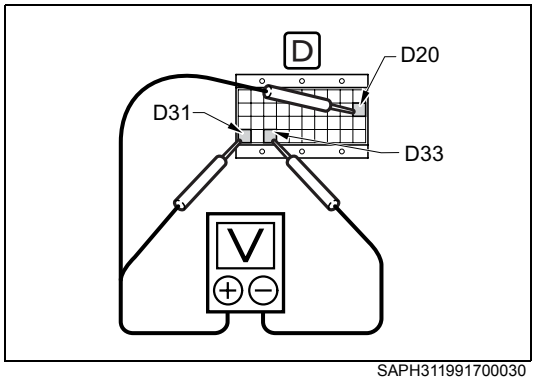
1. Set the starter key to "OFF" and connect the signal check harness.
2. Set the starter key to "ON" and measure the voltage between terminals D20/D31 and terminal D33.

Standard value : 0.9 to 1.1 V

NG → Engine ECU failure or harness/connector contact failure

OK

2	Measurement of voltage between terminals



SAPH311991700030

1. Start the engine.
2. While measuring the voltage between terminals D20/D31 and terminal D33 of the signal check harness, repeat full opening/closing of the accelerator.

Standard : Voltage must change. (1.0 to 3.2 V)

NG → Common rail pressure sensor failure or harness/connector contact failure

OK

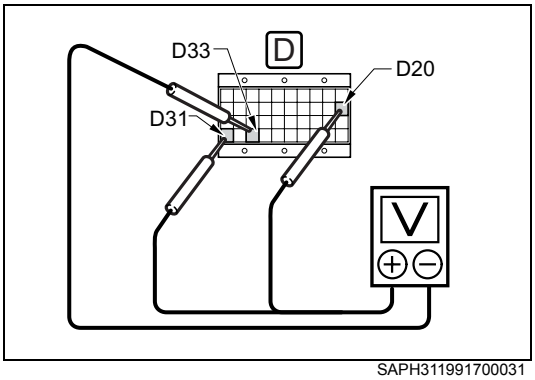
Engine ECU failure, connector contact failure

Common rail pressure sensor malfunction (DTC code P0192, P0193)

JP31199170601016

DTC	P0192	Common rail pressure sensor circuit low input
DTC	P0193	Common rail pressure sensor circuit high input

1	Measurement of voltage between terminals



SAPH311991700031

1. Set the starter key to "OFF" and connect the signal check harness.
2. Set the starter key to "ON" and measure the voltage between terminals D20/D31 and terminal D33 of the signal check harness.

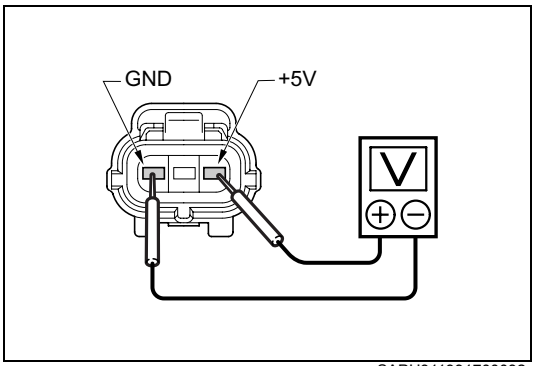
Standard value : 0.7 to 4.7 V

NG → [2] Go to measurement of voltage between terminals.

OK

Engine ECU failure, ECU connector failure

2	Measurement of voltage between sensor terminals



SAPH311991700032

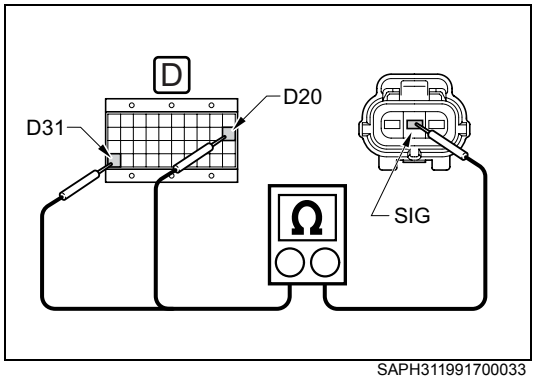
1. Set the starter key to "OFF" and disconnect the connector of the common rail pressure sensor.
2. Set the starter key to "ON" and measure voltage between the +5V terminal and the GND terminal of the common rail pressure sensor connector (at unit harness side).

Standard value : 5 ± 0.5 V

NG → [4] Go to measurement of resistance between terminals.

OK

3	Measurement of resistance between terminals



SAPH311991700033

1. Set the starter key to "OFF" and disconnect the ECU side connector of the signal check harness.
2. Measure the resistance between terminals D20/D31 of the signal check harness and the SIG terminal of the common rail pressure sensor connector (at unit harness side).

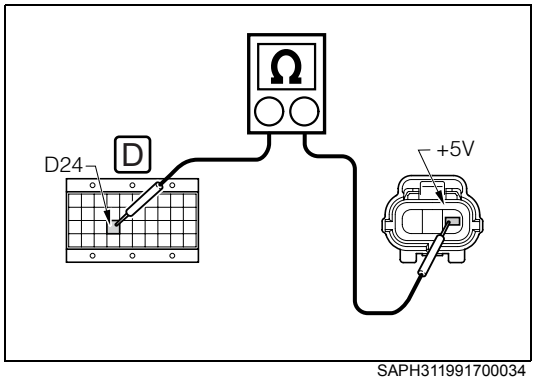
Standard value : 2 Ω or less

NG → Harness failure

OK

Connector contact failure

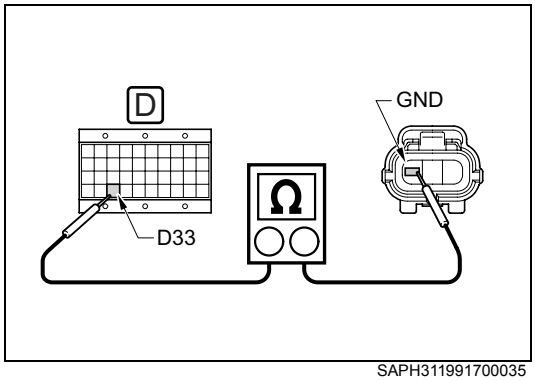
4	Measurement of resistance between terminals



SAPH311991700034

1. Set the starter key to "OFF" and disconnect the ECU side connector of the signal check harness.
2. Measure the resistance between terminals D24 of the signal check harness and the +5 V terminal of the common rail pressure sensor connector (at unit harness side).

Standard value : 2 Ω or less



SAPH311991700035

3. Measure the resistance between terminal D33 of the signal check harness and the GND terminal of the common rail pressure sensor connector (at unit harness side).

Standard value : 2 Ω or less

NG → Harness failure

OK

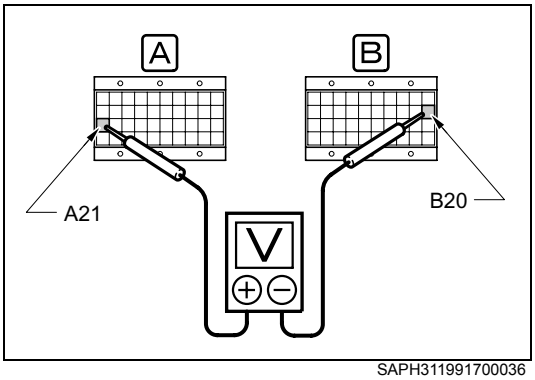
Engine ECU failure, ECU connector failure

Accelerator sensor 1 malfunction (DTC code P2122, P2123)

JP31199170601017

DTC	P2122	Accelerator sensor circuit 1 low voltage
DTC	P2123	Accelerator sensor circuit 1 high voltage

1	Measurement of voltage between terminals



SAPH311991700036

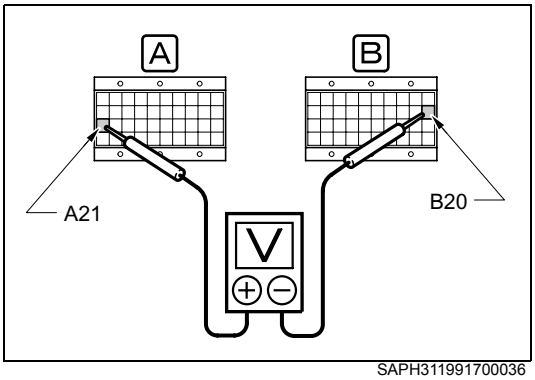
1. Set the starter key to "OFF" and connect the signal check harness.
2. Set the starter key to "ON" and measure the voltage between terminal A21 and terminal B20 of the signal check harness.

Standard value : 0.7 - 1.5V (idle status)

NG → [3] Voltage measuring at the output port of the mechatronic controller

OK

2	Measurement of voltage between terminals



SAPH311991700036

1. While increasing the throttle, measure the voltage between terminal A21 and terminal B20 of the signal check harness.

Standard value

Measuring item	Engine revolution (r/min)	Voltage(V)
Low idle	**1,000**	**Approx.1.4**
High idle	**2,100**	**Approx.3.5**

NG → Defective mechatronic controller

OK

Harness failure

3	Voltage measuring at the output port of the mechatronic controller

1. With the starter key set to "ON", do not open the slot and measure the voltage between pin 25 of the pin connector 28 of the mechatronics controller and B21 of the signal check harness.
   When an abnormal value is detected, the mechatronics controller becomes defective.
   Abnormal value
   : 0.3 V or less
   : 4.85 V or more

NG → Engine ECU failure, ECU connector failure or disconnection of harness, short-circuit of harness

OK

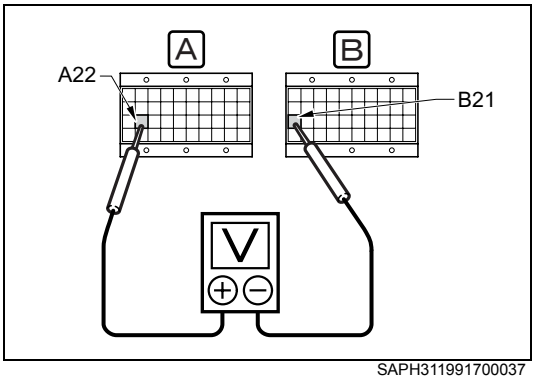
Defective mechatronic controller

Accelerator sensor 1 malfunction (DTC code P2127, P2128)

JP31199170601018

DTC	P2127	Accelerator sensor circuit 2 low voltage
DTC	P2128	Accelerator sensor circuit 2 high voltage

1	Measurement of voltage between terminals



SAPH311991700037

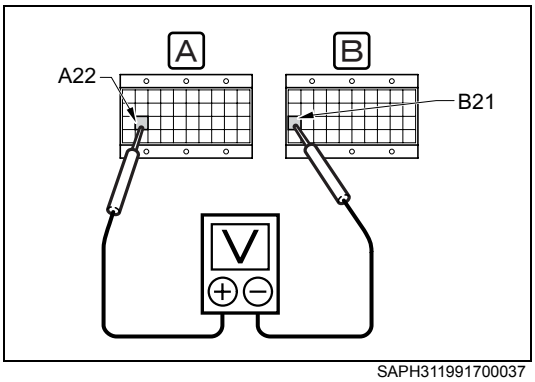
1. Set the starter key to "OFF" and connect the signal check harness.
2. Set the starter key to "ON" and measure the voltage between terminal A22 and terminal B21 of the signal check harness.

Standard value : 0.7 - 1.5V (idle status)

NG → [3] Voltage measuring at the output port of the mechatronic controller

OK

2	Measurement of voltage between terminals



SAPH311991700037

1. While increasing the throttle, measure the voltage between terminal A22 and terminal B21 of the signal check harness.

Standard value

Measuring item	Engine revolution (r/min)	Voltage(V)
Low idle	**1,000**	**Approx.1.4**
High idle	**2,100**	**Approx.3.5**

NG → Defective mechatronic controller

OK

Harness failure

3	Voltage measuring at the output port of the mechatronic controller

1. With the starter key set to "ON", do not open the slot and measure the voltage between pin 25 of the pin connector 28 of the mechatronics controller and B21 of the signal check harness.
   When an abnormal value is detected, the mechatronics controller becomes defective.
   Abnormal value
   : 0.3 V or less
   : 4.85 V or more

NG → Engine ECU failure, ECU connector failure or disconnection of harness, short-circuit of harness

OK

Defective mechatronic controller

Accelerator sensor 1 and 2 malfunction (DTC code P2120)

JP31199170601019

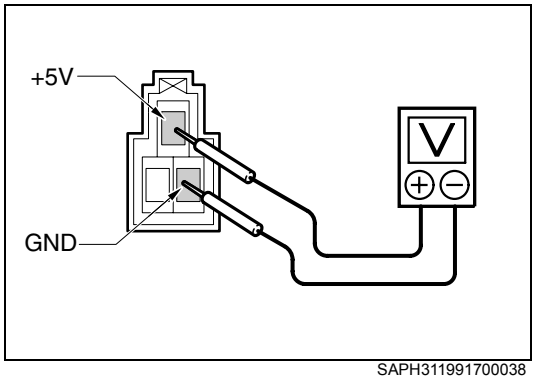
1	Inspection item

1. Take action of DTC code P2120.
   "Reference : Accelerator sensor 1 malfunction (DTC code P2122, P2123), Engine ECU, Engine diagnosis code"
   "Reference : Accelerator sensor 2 malfunction (DTC code P2126), Engine ECU, Engine diagnosis code"

Emergency accelerator sensor malfunction (DTC code P1133)

JP03Z01030703026

1	Power supply voltage measuring



SAPH311991700038

1. With the ECU connector connected, disconnect the sensor connector and measure the voltage between the power terminal (+5 V) and the GND terminal.

⚠ **CAUTION** • **The connector in the figure is seen from the fitting surface.**

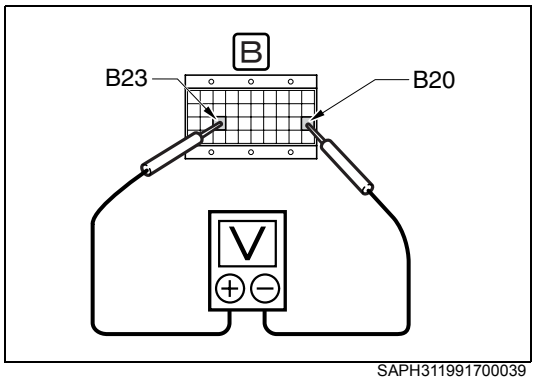
Standard value : 5.0 ± 0.5 V

NG → [2] Go to measurement of voltage between terminals.

OK

[3] Go to measurement of voltage between terminals.

2	Measurement of voltage between terminals



SAPH311991700039

1. Measure the voltage between terminals B20 and B23 of the signal check harness.

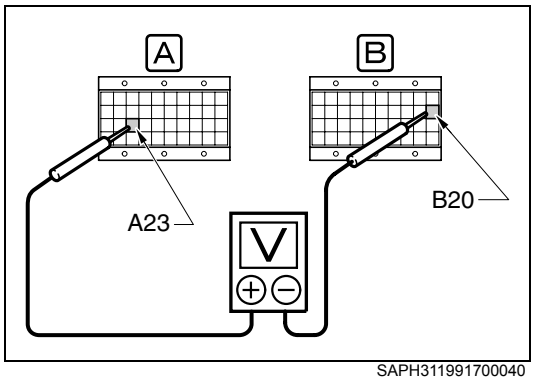
Standard value : 5.0 ± 0.5 V

NG → Engine ECU, engine ECU connector failure

OK

Harness failure

3	Measurement of voltage between terminals



SAPH311991700040

1. Connect the sensor connector and measure the voltage between terminals A23 and B20 of the signal check harness.

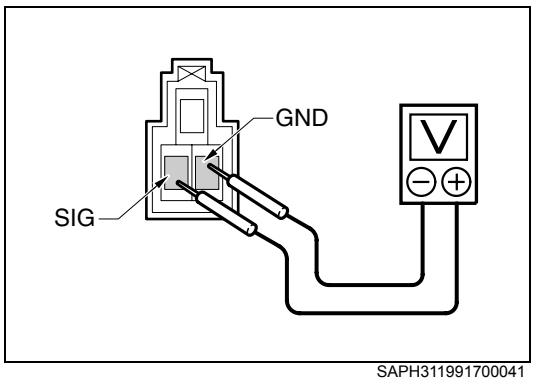
Standard value : Approx. 0.0 to 3.2 V (idle to full throttle)

NG → [4] Go to measurement of voltage between terminals.

OK

Engine ECU failure, engine ECU connector failure

4	Measurement of voltage between sensor terminals



SAPH311991700041

1. Leave the emergency accelerator sensor connected.
2. Connect the sensor connector and measure the voltage between the terminals SIG and GND of the sensor.

⚠ **CAUTION**
- **The connector in the figure is seen from the fitting surface.**

Standard value : Approx. 0.0 to 3.2 V (idle to full throttle)

NG → Emergency accelerator sensor failure

OK

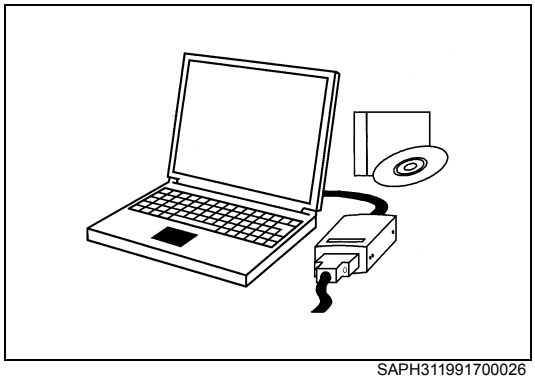
Harness failure

Atmospheric pressure sensor malfunction (DTC code P2228, P2229)

JP31199170601020

DTC	P2228	Atmospheric pressure sensor circuit low input
DTC	P2229	Atmospheric pressure sensor circuit high input

1	Check of diagnosis code



SAPH311991700026

1. After deleting the past failures with the failure diagnosis tool (HinoDX) using PC, check again if the same code (DTC code P2228, P2229) is output.

Standard : Normal

NG → Engine ECU failure

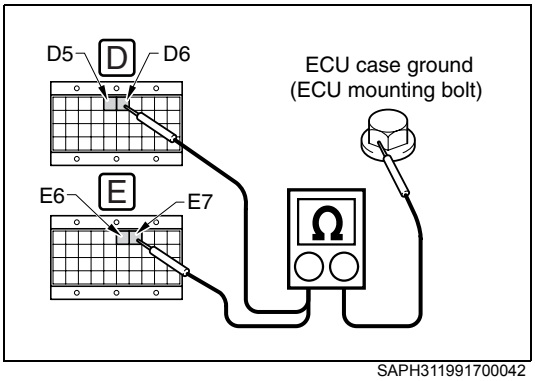
OK

Since it may be a temporary malfunction due to radio interference, it is acceptable when the system recovers normal operation.

Injector common 1 ground short (DTC code P1211), Injector common 2 ground short (DTC code P1214)

JP31199170601021

1	Measurement of resistance between terminals



SAPH311991700042

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness.
3. Measure the resistance between each terminal of the signal check harness and the ECU case ground.

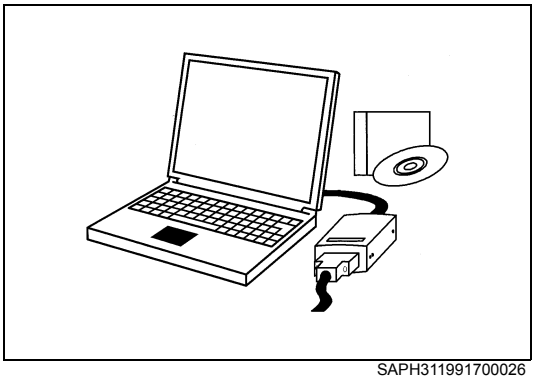
DTC code	Terminal to measure resistance	
P1211	D5, D6	ECU case ground
P1214	E6, E7	ECU case ground

Standard value : ∞ Ω

NG → [3] Go to measurement of resistance between injector terminals.

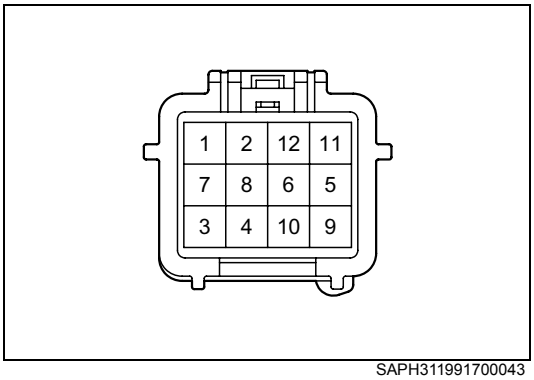
OK

2	Check of diagnosis code


SAPH311991700026

1. Set the starter key to "OFF" and connect the ECU side connector of the signal check harness.
2. Start the engine and delete the past failures with the failure diagnosis tool (HinoDX) using PC.
3. If the same failure code is output again, replace the engine ECU. If the normal code is output, it is considered that a temporary error has occurred.

3	Measurement of resistance between injector terminals



SAPH311991700043

1. Set the starter key to "OFF".
2. The injector clustered connector at the front side of the engine shall be disconnected.
3. Measure the resistance between terminals of the injector clustered connector (at unit harness side).

DTC code	Terminal to measure resistance	
	+ side	– side
P1211	5, 6, 10, 12	ECU case ground
P1214	2, 4, 7, 8	ECU case ground

Standard value : $\infty\ \Omega$

NG → Harness failure (failure including pinching of harness which has not satisfied the standard value)

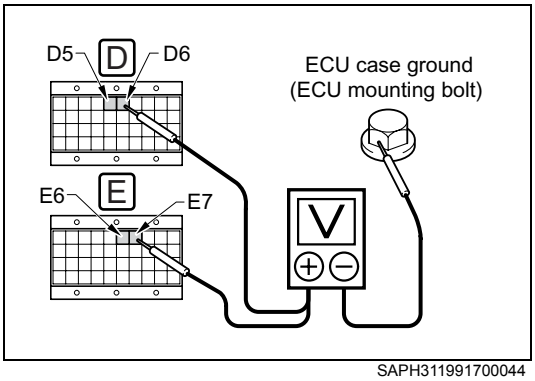
OK

Inspection of harness inside head cover (Short-circuit of the harness inside the head cover to the ground line may have occurred.)

Injector common 1 power source line short (DTC code P1212), Injector common 2 power source line short (DTC code P1215)

JP31199170601022

1	Measurement of voltage between terminals



SAPH311991700044

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and set the starter key to "ON".
3. Measure the voltage between each terminal of the signal check harness and the ECU case ground.

⚠ **CAUTION** • **Never start the engine because it may cause failure of the unit or electric shock.**

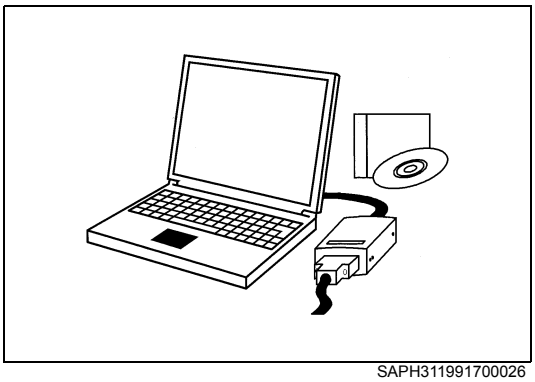
DTC code	Terminal to measure voltage	
	+ side	– side
P1212	D5, D6	ECU case ground
P1215	E6, E7	ECU case ground

Standard value : 14 V or less

NG → [3] Go to measurement of voltage between injector terminals.

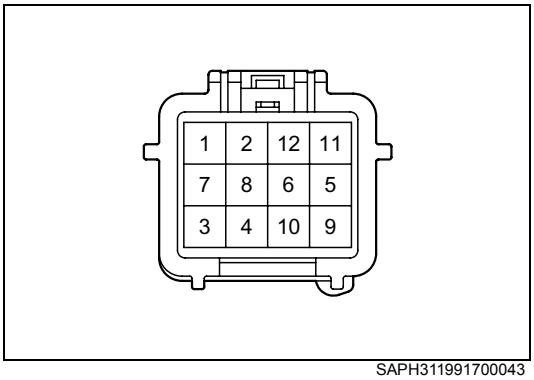
OK

2	Check of diagnosis code


SAPH311991700026

1. Set the starter key to "OFF" and connect the ECU side connector of the signal check harness.
2. Start the engine and delete the past failures with the failure diagnosis tool (HinoDX) using PC.
3. If the same failure code is output again, replace the common rail ECU. If the normal code is output, it is considered that a temporary error has occurred.

3	Measurement of voltage between injector terminals



SAPH311991700043

1. Set the starter key to "OFF".
2. The injector clustered connector at the front side of the engine shall be disconnected and set the starter key to "ON".
3. Measure the voltage between terminals of the injector clustered connector (at unit harness side).

⚠ **CAUTION** • **Never start the engine because it may cause failure of the unit or electric shock.**

DTC code	Terminal to measure voltage	
	+ side	– side
1212	5, 6	ECU case ground
1215	7, 8	ECU case ground

Standard value : 14 V or less

NG → Harness failure (harness failure of terminal that has not satisfied the standard value)

OK

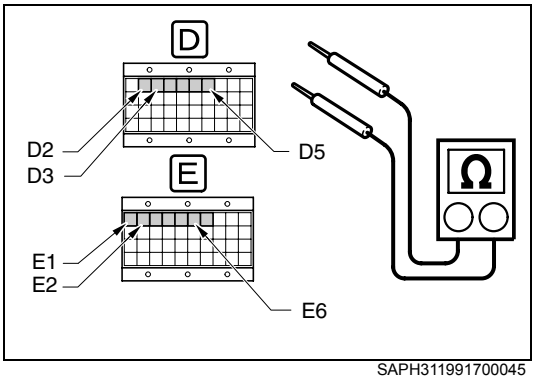
Inspection of harness inside head cover (Short-circuit of the harness inside the head cover to the power line may have occurred.)

Injector circuit malfunction (DTC code P0201 to P0204)

JP31199170601023

DTC	P0201	Injector circuit malfunction -cylinder 1
DTC	P0202	Injector circuit malfunction -cylinder 2
DTC	P0203	Injector circuit malfunction -cylinder 3
DTC	P0204	Injector circuit malfunction -cylinder 4

1	Measurement of resistance between terminals



SAPH311991700045

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminals.

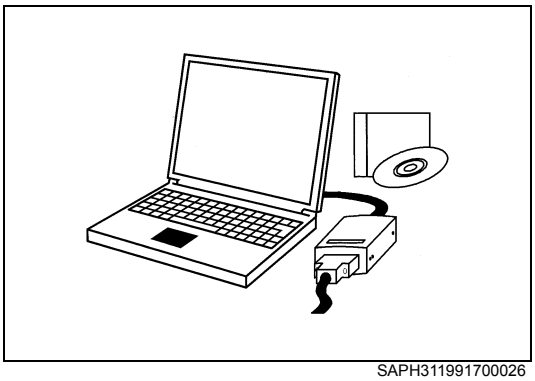
DTC code	Failure area (injector)	Terminal to measure resistance
P0201	**# 1**	**D2 ↔ D5**
P0202	**# 2**	**E2 ↔ E6**
P0203	**# 3**	**E1 ↔ E7**
P0204	**# 4**	**D3 ↔ D6**

Standard value : 2 Ω or less

NG → [3] Go to measurement of resistance between injector terminals.

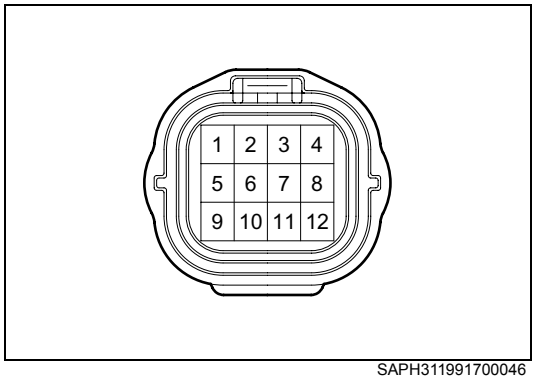
OK

2	Check of diagnosis code


SAPH311991700026

1. Set the starter key to "OFF" and connect the ECU side connector of the signal check harness.
2. Start the engine and delete the past failures with the failure diagnosis tool (HinoDX) using PC.
3. If the same failure code is output again, replace the common rail ECU. If the normal code is output, it is considered that a temporary error has occurred.

3	Measurement of resistance between injector terminals



SAPH311991700046

1. The injector clustered connector at the front side of the engine shall be disconnected.
2. Measure the resistance between terminals of the injector clustered connector (male) at the cam housing.

DTC code	Terminal to measure resistance
P0201	**5 ↔ 10**
P0202	**7 ↔ 11**
P0203	**3 ↔ 8**
P0204	**2 ↔ 6**

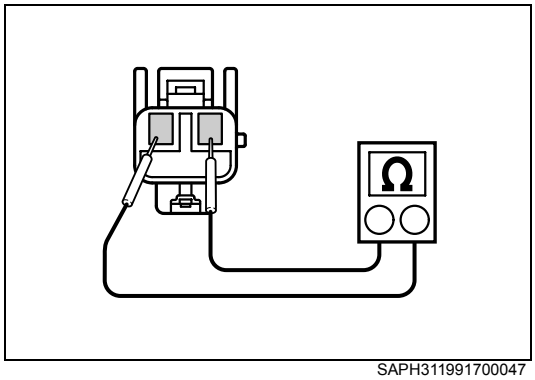
Standard value : 2 Ω or less

NG → [4] Go to measurement of resistance between injector terminals.

OK

unit harness disconnection (Check the harness between the ECU and the injector clustered connector.)

4	Measurement of resistance between injector terminals



SAPH311991700047

1. Remove the head cover and disconnect the injector connector (injector side) of the cylinder indicated by the failure code. Measure the resistance between the No. 1 terminal and the No. 2 terminal.

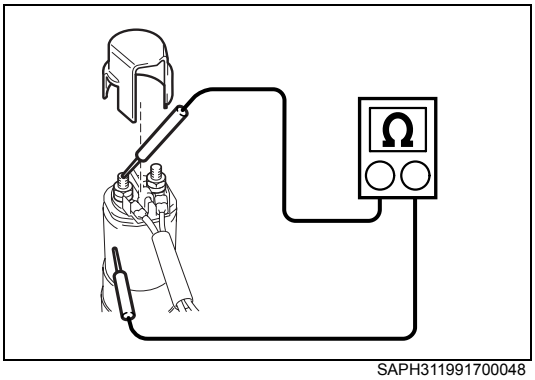
Standard value : 0.45 ± 0.05 Ω

NG → [5] Go to measurement of resistance between injector terminals.

OK

Contact failure of harness or connector inside the head cover

5	Measurement of resistance between injector terminals



SAPH311991700048

1. Remove the terminal cap of the injector of the cylinder indicated by the failure code and measure the insulation resistance between the terminal and the upper body.

Standard value : 1, 000 MΩ or more

NG → Injector TWV coil disconnection (Replace the injector assembly.)

OK

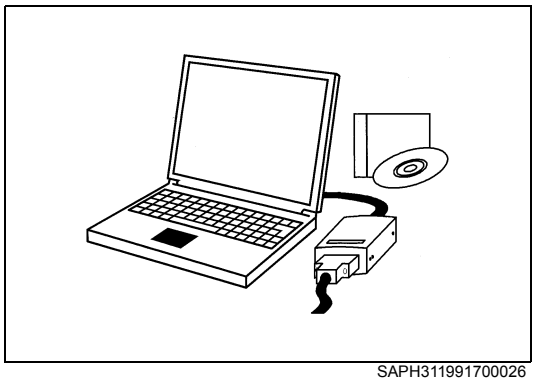
Injector harness disconnection (Replace the injector harness.)

Cylinder contribution/balance fault (DTC codes P0263, P0266, P0269, P0272)

JP31199170601024

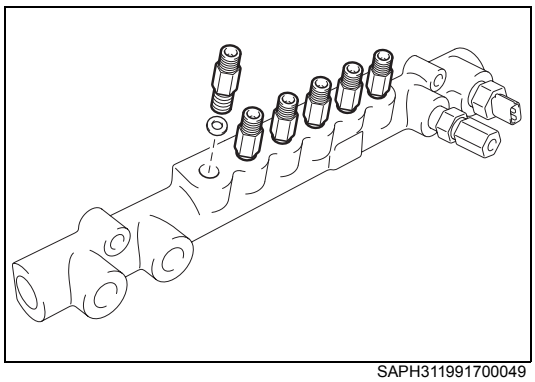
DTC	P0263	Cylinder 1 contribution/balance fault
DTC	P0266	Cylinder 2 contribution/balance fault
DTC	P0269	Cylinder 3 contribution/balance fault
DTC	P0272	Cylinder 4 contribution/balance fault

1	Inspection of flow damper 1



SAPH311991700026

1. Set the starter key to "OFF" and stop the engine.
2. Wait for approx. 30 seconds and start the engine.
3. Warm-up the engine until coolant temperature is 60 °C{140 °F} or more, delete the past failure with a failure diagnosis tool (HinoDX) using PC.

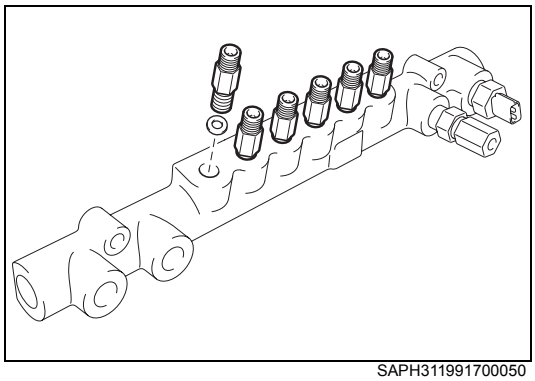


SAPH311991700049

4. If the same failure code is displayed as the current failure after deleting the past failure, check the flow damper of the cylinder indicated by the failure code.

DTC code	Failure area (Flow damper)
P0263	**# 1**
P0266	**# 2**
P0269	**# 3**
P0272	**# 4**

2	Inspection of flow damper 2



SAPH311991700050

1. Remove the flow damper from the common rail and run air from one side of the flow damper. Check if the damper is not blocked by release of air to the opposite side.

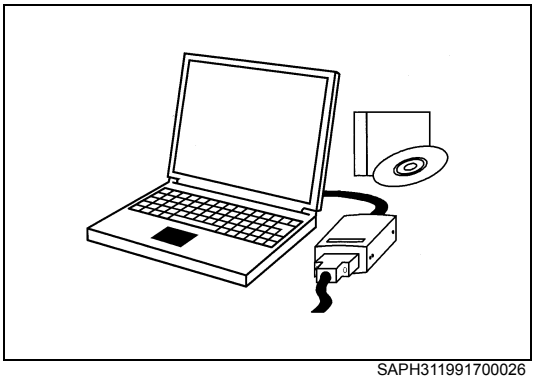
⚠ **CAUTION** • **When air is run, be careful so that dirt, water, etc. may not enter the flow damper.**

Standard value : Air must flow. (Flow damper is normal.)

NG → Replace the flow damper (if air is not run)

OK

3	Check of failure code


SAPH311991700026

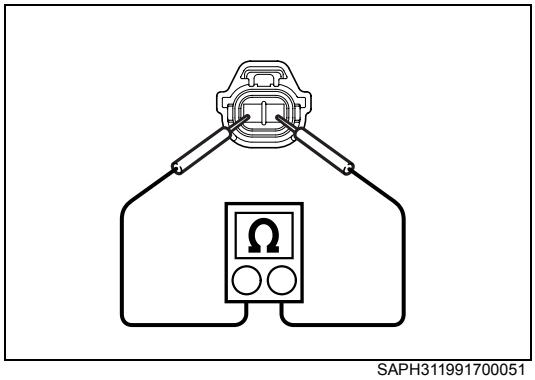
1. Make sure that other failure code is not output.
   If other failure code is output, repair the failure first and delete the past failure with the failure diagnosis tool (HinoDX) using PC.
   Then, if this failure code is output again, the following failures may be estimated.
   - Excessive fuel flow due to leak from broken pipe, crack in pipe or pipe connection between the flow damper and the injector pipe
     → Check for leak
   - Too large or too small fuel flow due to increase of leak inside inside the injector
     → Check for leak on the individual injector with a nozzle tester
   - Excessive fuel flow due to failure of injection nozzle and seat
     → Check for seat failure on the individual injector with a nozzle tester
   - Too large or too small fuel flow due to malfunction of the injector
     → Check with replacement of injector
   - Too small fuel flow due to clogging in the fuel supply system
     → Inspection of fuel filter
2. To specify a failure location above, check the compensation between cylinders with the failure diagnosis tool (HinoDX) using PC and stop an injector. Then, perform diagnosis while viewing the engine data.

Supply pump SCV malfunction (DTC code P0628, P0629)

JP31199170601025

DTC	P0628	Supply pump SCV malfunction (Full discharge mode)
DTC	P0629	Supply pump SCV malfunction (Power source line short)

1	Measurement of resistance between solenoid terminals



SAPH311991700051

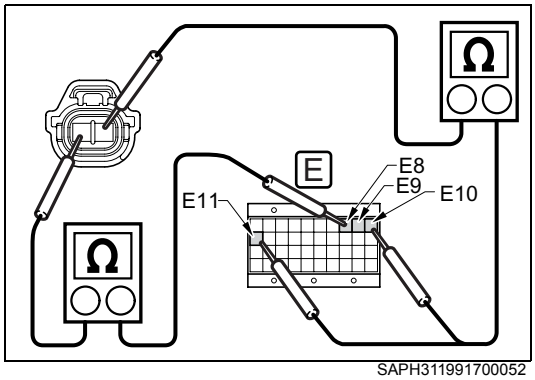
1. Set the starter key to "OFF", disconnect the connector of the supply pump solenoid valve and measure the resistance between No. 1 and No. 2 terminals at the supply pump solenoid valve.

Standard value : 7.9 ± 0.5 Ω (20 °C{68 °F})

NG → Failure of supply pump solenoid valve

OK

2	Measurement of resistance between terminals



SAPH311991700052

1. Set the starter key to "OFF", connect the signal check harness and disconnect the ECU side connector.

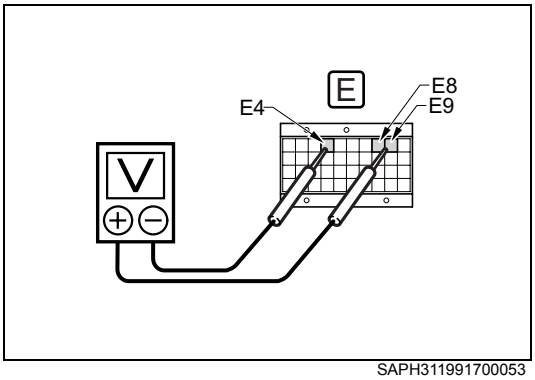
2. Measure the resistance between terminals E10/E11 of the signal check harness and the No. 1 terminal of the supply pump solenoid valve (at unit harness side).
In a similar manner, measure the resistance of terminals E8/E9 of the signal check harness and the No. 2 terminal of the supply pump solenoid valve connector (at unit harness side).

Standard value : 1 Ω or less

NG → Harness disconnection, connector failure

OK

3	Measurement of voltage between terminals



SAPH311991700053

1. Turn "ON" the starter key.
2. Measure voltage between terminal E4 and terminals E8/E9 of the signal check harness.
   Standard value : Pulse waveform at 24V ↔ 0V

NG → Failure of ECU connector

OK →

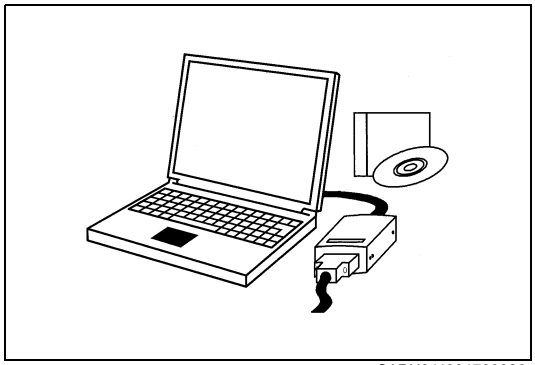
Engine ECU failure

⚠ **CAUTION** • **After turning "ON" the starter key, take measurements within 40 seconds.**

Supply pump SCV sticking (DTC code P2635), Supply pump malfunction (DTC code P2635), Supply pump abnormal pressure record (DTC code P2635)

JP31199170601026

1	Inspection of supply pump



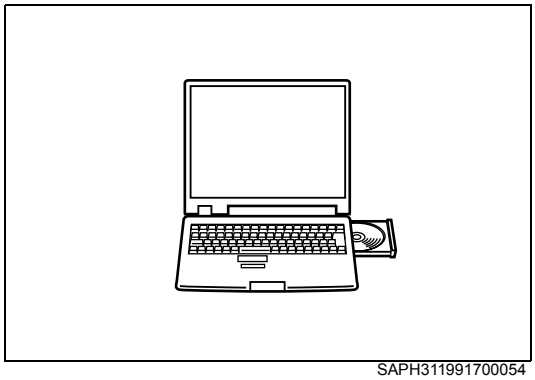
SAPH311991700026

1. Set the starter key to "OFF" and stop the engine.
2. Wait for approx. 30 seconds and start the engine.
3. Warm-up the engine until coolant temperature is 60 °C{140 °F} or more, and delete the past failure with the failure diagnosis tool (HinoDX) using PC.
4. Run the engine at no load up to HI idle. Or repeat no-load operation from LOW idle to HI idle two or three times and confirm that the same fault code is displayed again.

NG → Replace supply pump.

OK

2	Check of failure code



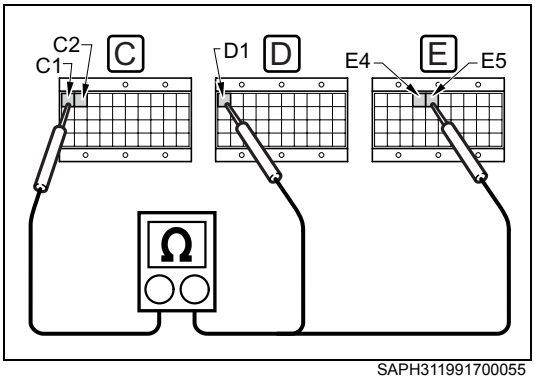
SAPH311991700054

1. Make sure that other failure code is not output.
   If other failure code is output, repair the failure code and make sure again that DTC code P2635 is output.
2. When there is no error after the check above, delete the past failure and operate the engine.
   If the same code is output again, possible failures are the supply pump and engine ECU. Perform more detailed diagnosis with failure diagnosis tool (HinoDX) - HinoDX [Inspection Menu], using PC.

Preheat circuit malfunction (DTC code P0540)

JP31199170601030

1	Measurement of resistance between terminals



SAPH311991700055

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and measure the resistance between terminals C1, C2 and terminals D1, E4, E5.

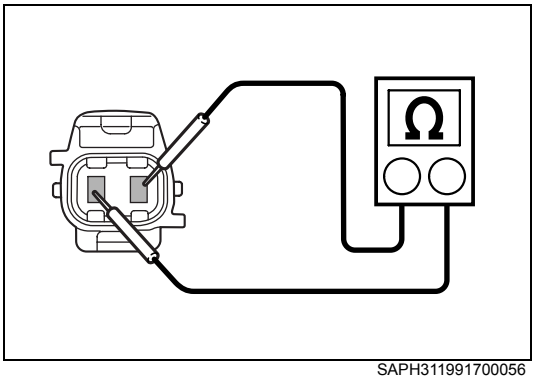
Standard value : 25 ± 2.5 Ω

NG → [2] Go to measurement of resistance between terminals.

OK

Engine ECU failure, ECU connector failure

2	Measurement of relay resistance



SAPH311991700056

1. Remove the heater relay and measure the resistance between terminals.

Standard value : 24.8 ± 0.5 Ω

NG → Heater relay failure

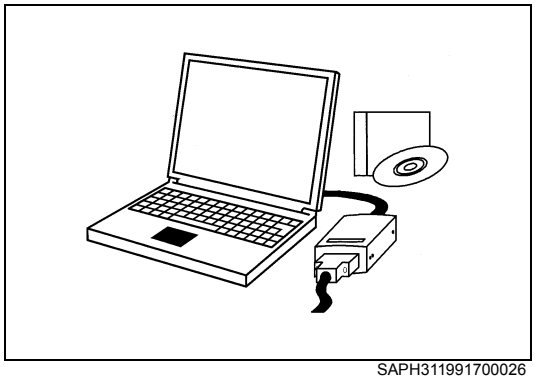
OK

Harness failure, connector failure

Injector correction data conformity error (DTC code P1601)

JP31199170601031

1	Inspection of QR code



SAPH311991700026

1. Read the QR code data with the failure diagnosis tool (HinoDX) using PC.

   Reference value: This shall coincide with the QR code managed by the unit manufacturer.

NG → Write the QR code again.

OK

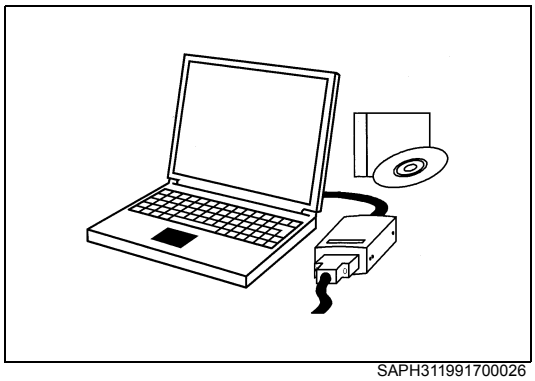
Replace engine ECU.

ECU internal error (DTC code P0605, P0606, P0607)

JP31199170601032

DTC	P0605	Flash ROM error
DTC	P0606	CPU malfunction (Hard detection)
DTC	P0607	Monitoring IC malfunction in CPU

1	Check of diagnosis code



SAPH311991700026

1. Set the starter key to "OFF" and set it to "ON" again.
2. After deleting the past failure, check if the same code (DTC code P0605, P0606, P0607) is output again.

   Standard : Normal

NG → Engine ECU failure

OK

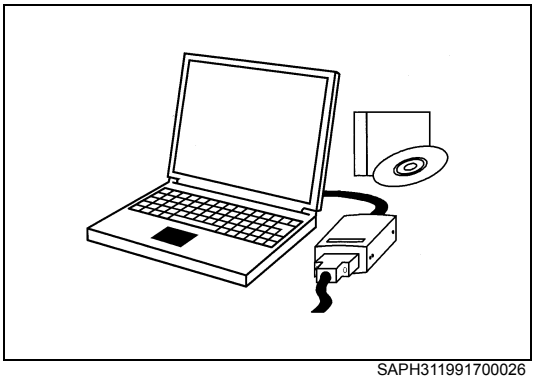
Since it may be a temporary malfunction due to radio interference, it is acceptable when the system recovers normal operation.

ECU charge circuit malfunction (DTC code P0200, P0611)

JP31199170601033

DTC	P0200	ECU charge circuit high input
DTC	P0611	ECU charge circuit malfunction

1	Check of ECU



SAPH311991700026

1. Set the starter key to "OFF" and set it to "ON" again.
2. After deleting the past failure, check if the same code (DTC code P0611, P0200) is output again.

Standard : Normal

NG → Engine ECU failure

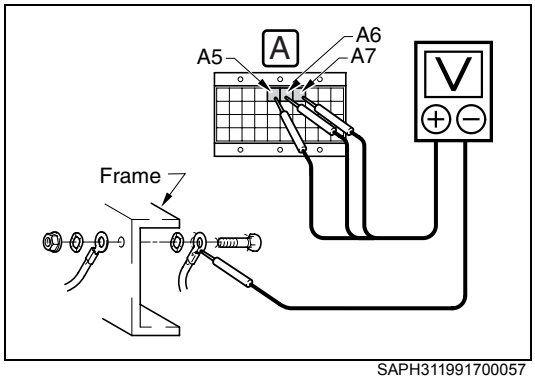
OK

Since it may be a temporary malfunction due to radio interference, it is acceptable when the system recovers normal operation.

Main relay malfunction (DTC code P0686)

JP31199170601034

1	Measurement of voltage between terminals



SAPH311991700057

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and set the starter key to "ON". Measure the voltage between terminals A5, A6, A7 and the chassis GND.

Standard value : 0 V

NG → Defective harness

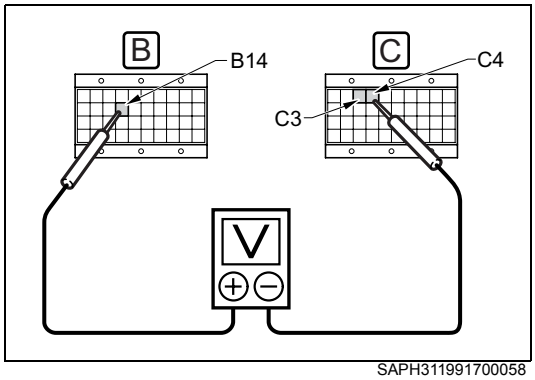
OK

Engine ECU failure, engine ECU connector failure

Starter signal malfunction (DTC code P0617)

JP31199170601035

1	Measurement of voltage between terminals



SAPH311991700058

1. Set the starter key to "OFF" and connect the signal check harness.
2. Disconnect the ECU side connector of the signal check harness and set the starter key to "ON".
3. Measure voltage between terminal B14 and terminals C3/C4.

⚠ **CAUTION** • **Measuring shall be done in an environment where the engine may be started.**

Standard value
: 0 V (when starter key is at "OFF")
: 24 V (when starter key is at "START")

NG → Harness failure

OK

Engine ECU failure, ECU connector failure