4M4 ECO HYBRID

Pub.No.TWDE0911, NOVEMBER 2009

Shop Manual

diesel engine

FUSO

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MITSUBISHI FUSO TRUCK & BUS CORPORATION

4M4

ECO HYBRID

Shop Manual

diesel engine

FOREWORD

This Shop Manual is published for the information and guidance of personnel responsible for maintenance of Mitsubishi Fuso 4M4 series diesel engine, and includes procedures for adjustment and maintenance services.
We earnestly look forward to seeing that this manual is made full use of in order to perform correct services with no wastage.

For more details, please consult your nearest authorized Mitsubishi dealer or distributors.
Kindly note that the specifications and maintenance service figures are subject to change without prior notice in line with improvement which will be effected from time to time in the future.

NOVEMBER 2009

Applicable models
4M42T3

GROUP INDEX

This Shop Manual contains the information classified into the following groups.
If any system or equipment has two or more variations with significantly different construction, the variations are handled as different groups. These groups are identified by different alphabets preceded by the same number.

1. ENGINE volume

Group No.	Group subject
11	ENGINE
12	LUBRICATION
13	FUEL AND ENGINE CONTROL
14	COOLING
15	INTAKE AND EXHAUST
17	EMISSION CONTROL
18	HYBRID ELECTRIC VEHICLE SYSTEM

2. CHASSIS volume

Group No.	Group subject
21	CLUTCH
22	MANUAL TRANSMISSION
22E	INOMAT-II
25	PROPELLER SHAFT
26	FRONT AXLE
27	REAR AXLE
31	WHEEL, TIRE
33	FRONT SUSPENSION
34	REAR SUSPENSION
35	BRAKE
35EA	POWER ANTI-LOCK BRAKE SYSTEM
35EB	HILL START ASSIST SYSTEM
36	PARKING BRAKE
37	STEERING
41	BUMPER, FRAME
42	CAB MOUNTING, TILT
43	DOOR
51	EXTERIOR
52	INTERIOR
55	HEATER, AIR-CONDITIONER

3. ELECTRICAL volume

Group No.	Group subject
54	ELECTRICAL

GROUP 00 GENERAL

MODIFICATION SUMMARY

1. Characteristics of and Precautions for the ECO HYBRID Model

- The following are added to the characteristics of the CANTER ECO HYBRID.
  - The CANTER ECO HYBRID is equipped with a dedicated high voltage battery (350 V) for the hybrid electric vehicle system aside from the 24 V battery.
  - High voltage is cut off when the starter switch is OFF and the vehicle is stationary.
  - High voltage is generated in the high voltage circuit when the starter switch is ON or when the gear is engaged and the wheels are rotating.
  - High voltage in the high voltage circuit may be generated irrespective of the vehicle condition during the hybrid electric vehicle system abnormalities (the hybrid electric vehicle warning lamp illuminates).
  - Be sure to observe the regulations of your country or region regarding the qualifications or trainings required for servicing the high-voltage equipment.
- The following are added to the precautions concerning high voltage cable and high voltage devices.

DANGER ⚠

- **High voltage (350 V) may be generated in the high voltage circuit that consists of various high voltage devices (motor generator, motor electronic control unit and high voltage battery box) and cable (orange). Utmost care is required in handling these parts. When servicing, see Gr18 HYBRID ELECTRIC VEHICLE SYSTEM.**
- **Improper use of the high voltage battery may cause electric shock, overheating or fire though it is safe when properly handled. It may explode in the worst case.**

- The following are added to the remedies against vehicle damage by collision or the like.

WARNING ⚠

- **When the vehicle is on fire, use the ABC fire extinguisher to put out the fire. Since it is dangerous to fight a fire with a small quantity of water, spray a large amount of water from a fire hydrant or wait for the arrival of the fire brigade.**
- **When the vehicle is soaked in water, do not touch the high voltage devices and high voltage cable including the safety plug of the high voltage battery box to prevent electric shock. Work on the vehicle after pulling it out of water.**
- **Insulate any high voltage terminal that is exposed by damage with vinyl tape or the like to prevent electric shock.**

CAUTION ⚠

- **The electrolyte in the high voltage battery is as flammable as kerosene. If there is any fluid leakage near the high voltage box, wipe up the fluid while keeping fire away from it.**
- **Turn the starter switch to OFF to cut off the high voltage system. If it cannot be confirmed that the starter switch is OFF, disconnect the negative side battery cable from the 24 V battery. Then, remove the safety plug of the high voltage battery box with insulated gloves on while referring to Gr18 HYBRID ELECTRIC VEHICLE SYSTEM.**
- **In the case of the abnormality described above, replace the defective part referring to Gr18 HYBRID ELECTRIC VEHICLE SYSTEM.**

M E M O

VEHICLE MODEL CODING SYSTEM

<For Hong Kong and Singapore>

1	2	3	4	5	6	7	8	9	10	11
F	E	8	4	B	E	V	3	H	6	EX

1	Basic vehicle type	F	Cab-over engine truck
2	Load capacity, drive system	E	2 ton class and over, 4 × 2
3	Cab type	8	Wide cab
4	Suspension	4	Independent axle
5	Engine	B	4M42T
6	Wheelbase	E	3350 mm
7	Chassis arrangement for use	V	Van use
8	Rear tire arrangement, payload	3	Low deck/rear double Payload 3000 to 4000 kg
9	Vehicle specification	H	Hybrid
10	Engine output variation	6	4M42T3 (96 kW {130 PS})
11	Export specification	EX	

<For Australia and New Zealand>

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪
F	E	8	4	B	E	V	7	R	FA	H

1	Basic vehicle type	F	Cab-over engine truck
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3	Cab type	8	Wide cab
4	Suspension	4	Independent axle
5	Engine	B	4M42T
6	Wheelbase	E	3350 mm
7	Chassis arrangement for use	V	Van use
8	Rear tire arrangement, payload	7	Rear double Payload 3000 to 4000 kg
9	Steering position	R	Right-hand drive vehicle
10	Export specification	FA	
11	Vehicle specification	H	Hybrid

EQUIPMENT TYPE CODING SYSTEM

Component	Name plate marking	Code description
Engine		
4M42T3	4 | M | 4 | 2 | T | 3	Classification of turbocharger Turbocharged Order of development within same series Order of development among different series Diesel engine No. of cylinders (4)
Clutch		
C3W28	C | 3 | W | 28	Disc outside diameter Facing material (W: Woven) Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the clutch
Transmission		
M036S5	M | 036 | S | 5	Forward speeds Type of mesh (S: Synchromesh) Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the transmission
Propeller shaft		
P3	P | 3	Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the propeller shaft
Front axle		
F200T	F | 200 | T	Vehicle type (T: Truck) Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the front axle
Rear axle		
R033T	R | 03 | 3 | T	Vehicle type (T: Truck) Order of development within same series Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the rear axle
Reduction and differentioal		
D033H	D | 03 | 3 | H	Tooth profile (H: Hypoid gear) Order of development within same series Load carrying capacity of truck class (ton - nage) on which the clutch is primarily used Initial letter of the reduction & differentioal

Vehicle model	Engine	Clutch	Transmission	Propeller shaft	Rear axle	Reduction and differential
FE84BEV3H6EX	4M42T3	C3W28	M036S5	P3	R033T	D033H
FE84BEV7RFAH	4M42T3	C3W28	M036S5	P3	R033T	D033H

HOW TO READ THIS MANUAL

This manual consists of the following parts:
- Specifications
- Structure and Operation
- Troubleshooting
- On-vehicle Inspection and Adjustment
- Service procedures

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

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

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

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

DANGER ⚠	Precautions that should be taken in handling potentially dangerous substances such as battery fluid and coolant additives.
WARNING ⚠	Precautionary instructions, which, if not observed, could result in serious injury or death.
CAUTION ⚠	Precautionary instructions, which, if not observed, could result in damage to or destruction of equipment or parts.
NOTE	Suggestions or supplementary information for more efficient use of equipment or better understandings.

Terms and Units
- Front and rear
  The forward running direction of the vehicle is referred to as the front and the reverse running direction is referred to as the rear.

- Left and right
  Left hand side and right hand side, when facing the forward running direction of the vehicle, are respectively left and right.

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

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

Tightening torque

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

Units

- Tightening torques and other parameters are given in SI* units with metric units added in brackets { }.

***SI: Le Système International d’Unités**

Example: 390 N·m {40 kgf·m}

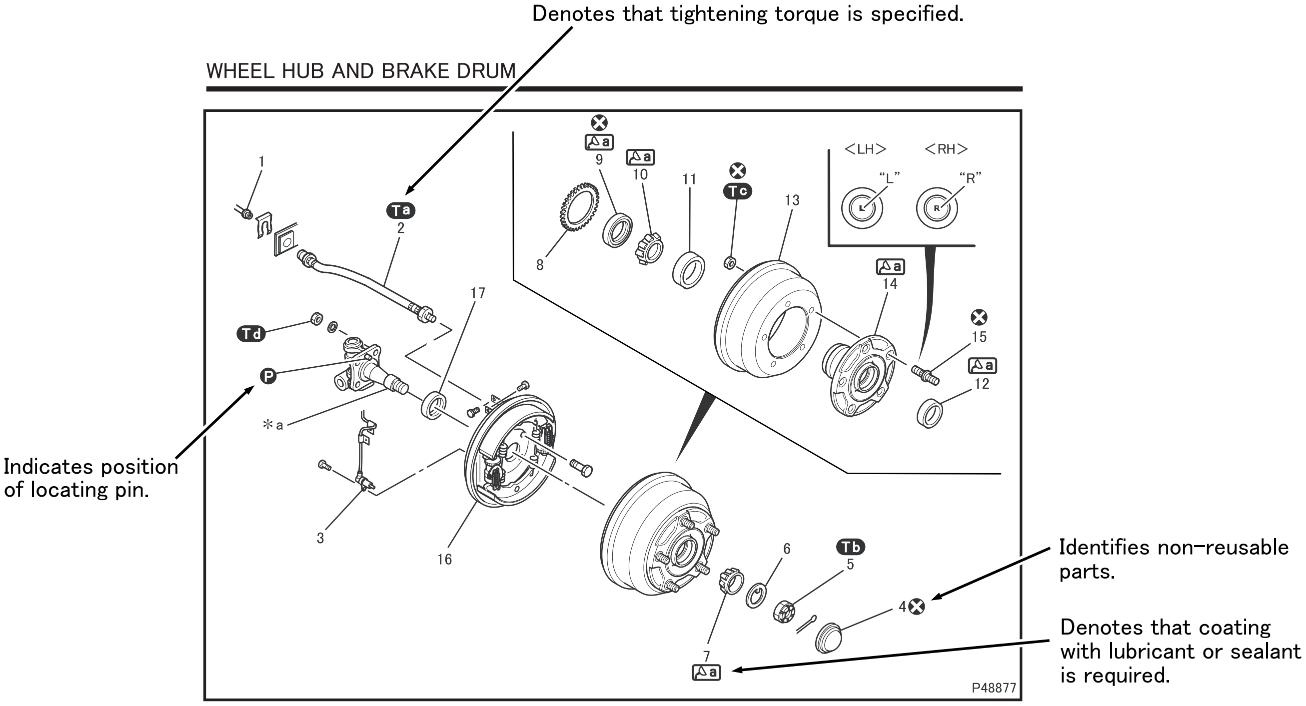
Metric unit
SI unit

Item		SI unit {metric unit}	Conversion factor
Force		N {kgf}	9.80665 N {1 kgf}
Moment of force		N·m {kgf·m}	9.80665 N·m {1 kgf·m}
Pressure	Positive pressure	kPa {kgf/cm^2}	98.0665 kPa {1 kgf/cm^2}
	Vacuum pressure	kPa {mmHg}	0.133322 kPa {1 mmHg}
		Pa {mmH_2O}	9.80665 Pa {1 mmH_2O}
Volume		dm^3 {L}	1 dm^3 {1 L}
Heat quantity		J {kcal}	4186.05 J {1 kcal}
Heat flow		W {kcal/h}	1.16279 W {1 kcal/h}
Power		kW {PS}	0.7355 kW {1 PS}

HOW TO READ THIS MANUAL

1. Illustrated Parts Breakdown and Service Procedures

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



● Disassembly sequence

1 Brake pipe
2 Brake hose
3 Wheel speed sensor
4 Hub cap
5 Lock nut
6 Lock washer
7 Outer bearing inner race
8 Anti-lock brake system rotor
9 Oil seal
10 Inner bearing inner race
11 Inner bearing outer race
12 Outer bearing outer race
13 Brake drum
14 Wheel hub
15 Hub bolt
16 Front drum brake (See Gr35A.)
17 Spacer

*a: Knuckle
P: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
7, 10, 11, 12	Starting torque of wheel hub bearing (tangential force at hub bolt position with oil seal fitted in)		1 to 3.5 N·m {0.10 to 0.35 kgf·m} (tangential force: 8.8 to 28.4 N {0.9 to 2.9 kgf})	–	Adjust or replace
14	Brake drum	Inside diameter	320	322	Repair or replace
		Cylindricality	0.05	0.20	

These location numbers correspond with disassembly sequence numbers.

P58289E

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

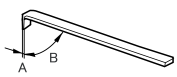
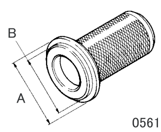
Tightening torque (unit: N·m{kgf·m})

Mark	Part to be tightened	Tightening torque	Remarks
Ta	Brake force tightening	13 to 17{1.3 to 1.7}	–
Tb	Lock nut	113 ± 15{11.5 ± 1.5}	Wet
Tc	Nut (brake drum and wheel hub mounting)	343 ± 39{35 ± 4}	–
Td	Nut (front drum brake mounting)	118 ± 20{12 ± 2}	–

Lubricant and/or sealant

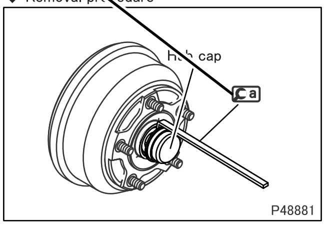
Mark	Point of application	Specified lubricant and/or sealant	Quantity
Aa	Between rolls of outer bearing inner race and inner bearing inner race	Mitsubishi wheel bearing grease	As required
	Inside wheel hub		395 ± 40 g

Special tools (unit: mm)

Mark	Tool name and shape	Part No.	Application
Ca	Hub Cap Wrench (A: 0.5°, B: 78°)  P49261	MB999108	Removal of hub cap
Cb	Oil Seal Installer (A: ϕ84, B: ϕ70)  05619	MB999097	Installation of oil seal

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

◆ Removal procedure



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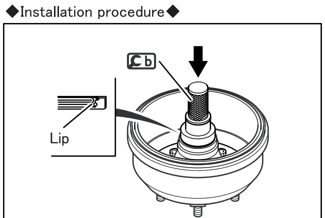
■Removal: Hub cap

◆Installation procedure◆



P48886

■Installation: Oil seal

Apply grease to the lip of the oil seal, then fit the oil seal onto the wheel hub in the illustrated direction.

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2. How to Use Diagnosis Codes <Electronic Control System>

There are the diagnosis code and message displayed on Multi-Use Tester.
Numerical values in parenthesis are added only when a diagnostic code indicated in the Multi-Use Tester display differs from the code indicated by the number of warning lamp flashes.

P0475: Exhaust Brake PWR (Open) (warning lamp flashes: 93)

Generation condition		Exhaust shutter 3-Way magnetic valve circuit is open
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (the warning lamp does not extinguish unless 3 consecutive valid signals are input).
Control effected by electronic control unit		・Control of auxiliary brake function is deactivated. ・White smoke reduction control is deactivated if idling condition is held for an extended period of time.
Inspection	Service data	C2: Auxiliary brake M/V1
	Actuator test	AA: Auxiliary brake M/V1
	Electronic control unit	17 : Exhaust shutter 3-Way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-Way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-Way magnetic valve circuit

Refer to
"Inspection of Electrical Equipment."

Refer to
"Electric Circuit Diagram."

Refer to
"Inspections Performed At Electronic Control Unit Connectors."

Refer to
"Actuator Tests Performed Using Multi-Use Tester."

Refer to
"Multi-Use Tester Service Data."

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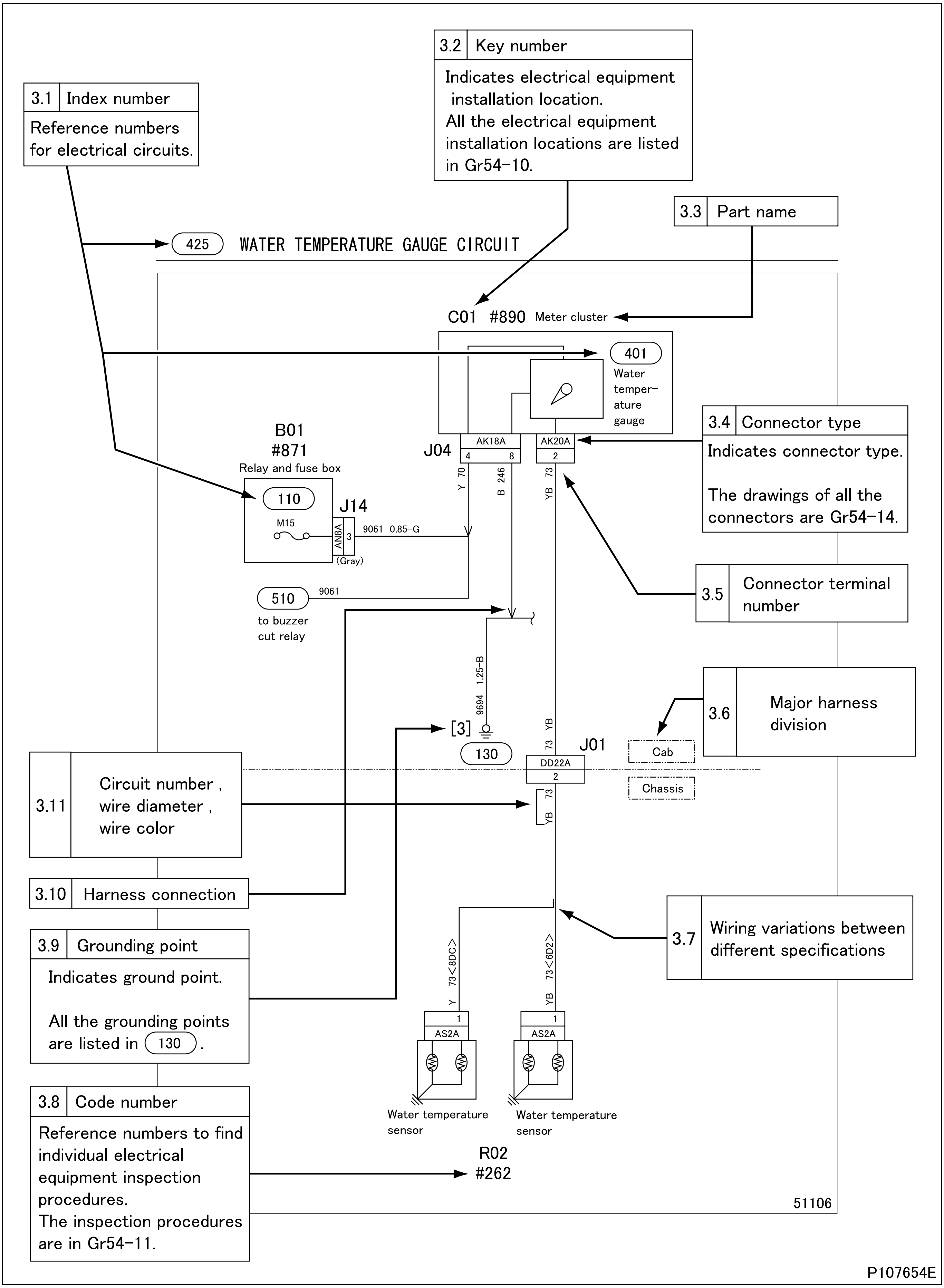
3. How to Read Circuits



3.1 Index number: (100) to (999)

- Index numbers are used as reference numbers for electrical circuits. Each electrical circuit has been assigned its own index number.

3.2 Key number: A01 to Z99

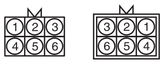
- Key numbers indicate electrical equipment installation locations. The installation location of a part can be easily found using its key number shown in a circuit diagram.
  All of the electrical equipment installation locations are listed in Gr54-10.

3.3 Part name

3.4 Connector type (type indication)

- A list of the connectors used is included in Gr54-14.

3.5 Connector terminal number



Female connector   Male connector

Connector terminal numbering starts with the upper left corner for female connectors and with the upper right corner for male connectors.

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3.6 Major harness division

- Major harness divisions are shown.

3.7 Wiring variations between different specifications

- Variations in wiring/circuit between different vehicle specifications are clearly indicated as shown.

3.8 Code number: #001 to #999

- Code numbers are reference numbers to find individual electrical equipment inspection procedures. The inspection procedure for a electrical equipment can be found using its code number shown in a circuit diagram.

3.9 Grounding point: [1] to [99]

- Locations where wires are grounded to the vehicle. All of the grounding points are listed in (130).

3.10 Harness connection

- The arrow in the wiring diagram indicates where harnesses are connected, and NOT the flow of electricity.

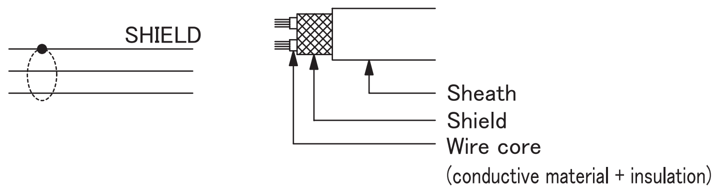
3.11 Circuit number, wire diameter, wire color

GL05   0.85 – BrY

Circuit number

Wire diameter

"Wire diameter" represents the cross section of the wire's conductive material. For example, "0.85" corresponds to 0.85 mm^2. On the circuit diagrams, the unit "mm^2" is omitted. Wires with a conductive cross section of 0.5 mm^2 are shown without the wire diameter or unit. As indicated below, shielding wires are marked with "SHIELD," and shielded wires are circled by a dotted line.



On the circuit drawings, twisted wires are indicated as shown below.

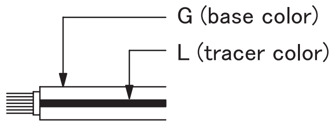
Wire color

Wire colors are represented by the first letter of the color.
Colors that all start with the letter "B" are indicated as follows.

- BLACK → B
- BLUE → L
- BROWN → Br

Wires that have both base and tracer colors are indicated by two letters.

RY (Yellow tracer on Red base)
GL (Blue tracer on Green base)



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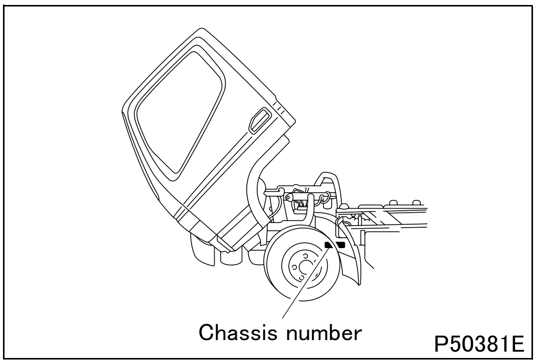
(1) Wire color

Wire color		Base color + tracer											
B	Black	BW	Black/ white	BY	Black/ yellow	BR	Black/red	BG	Black/ green	BL	Black/ blue		
Br	Brown	BrW	Brown/ white	BrB	Brown/ black	BrY	Brown/ yellow	BrR	Brown/ red	BrG	Brown/ green		
G	Green	GW	Green/ white	GR	Green/ red	GY	Green/ yellow	GB	Green/ black	GL	Green/ blue	GO	Green/ orange
Gr, Gy	Gray	GrL, GyL	Gray/ blue	GrR, GyR	Gray/ red								
L	Blue	LW	Blue/ white	LR	Blue/red	LY	Blue/ yellow	LB	Blue/ black	LO	Blue/ orange	LG	Blue/ green
Lg	Light green	LgR	Light green/ red	LgY	Light green/ yellow	LgB	Light green/ black	LgW	Light green/ white				
O	Orange	OL	Orange/ blue	OB	Orange/ black	OG	Orange/ green						
P	Pink	PB	Pink/ black	PG	Pink/ green	PL	Pink/ blue	PW	Pink/ white				
Pu	Purple												
R	Red	RW	Red/ white	RB	Red/ black	RY	Red/ yellow	RG	Red/ green	RL	Red/blue	RO	Red/ orange
Sb	Sky blue												
V	Violet	VY	Violet/ yellow	VW	Violet/ white	VR	Violet/red	VG	Violet/ green				
W	White	WR	White/ red	WB	White/ black	WL	White/ blue	WG	White/ green	WO	White/ orange		
Y	Yellow	YR	Yellow/ red	YB	Yellow/ black	YG	Yellow/ green	YL	Yellow/ blue	YW	Yellow/ white	YO	Yellow/ orange
		YP	Yellow/ pink	YV	Yellow/ violet								

CHASSIS NUMBER, ENGINE NUMBER, MOTOR NUMBER AND NAME PLATE

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



Chassis number

<Type 1>

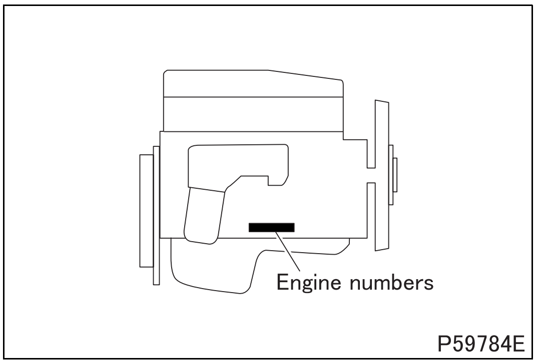
- The chassis number is indicated on the left frame, near the left front wheel.

Example: FE84BE – A□□□□□
Chassis number
Vehicle number

<Type 2>

- The chassis number is included in the vehicle identification number (V.I.N), which is stamped on the left-hand frame near the left front wheel.

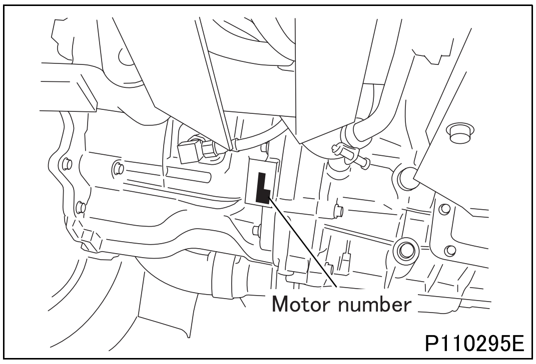
Example: JLF FE84BE0K J□□□□□
Chassis number
Vehicle number



Engine number

- The engine number is indicated on the right side of the crankcase.

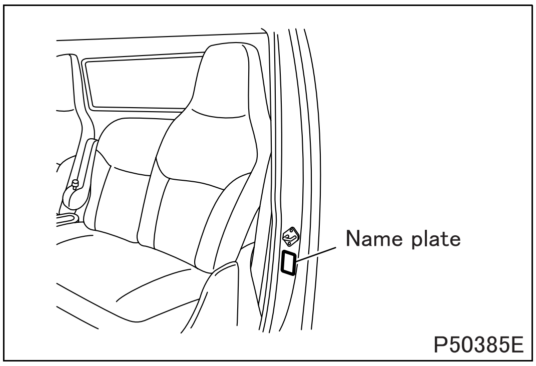
Example: 4M42 – □□□□□□
Engine number
Engine model



Motor number

- The motor number is indicated on the left below part of the clutch housing.

Example: S10B12345



Name plate

<Type 1>

- Name plate contains the following information.
  - MODEL
  - Chassis number
  - Engine number
  - Wheel base

<Type 2>

- Vehicle compliance and date plate are attached to the assistant driver's side door opening. The compliance plate certifies that your vehicle complied with Australian Design Rules at the time of manufacture. In all correspondence related to your vehicle the following information should be quoted.
  - The engine number.
  - The vehicle identification number (V.I.N.) – shown on compliance plate.
  - The S.O.A. No. (where applicable), option code, paint and trim codes located on date plate.

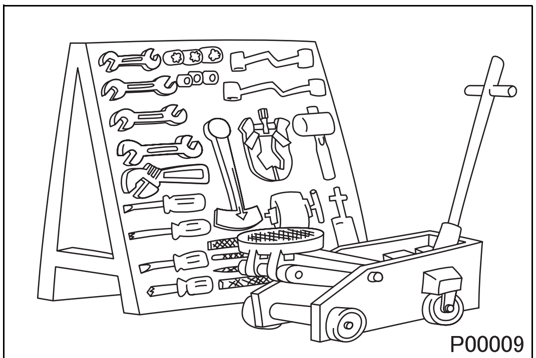
PRECAUTIONS FOR MAINTENANCE OPERATION

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

- Check the location of the fault, and identify its cause. Based on your findings, determine whether parts must be removed or disassembled. Then, follow the service procedure given in this manual.

P00008

- Perform service operations on a level surface. Before starting, take the following preparatory steps:
  - To prevent soiling and damage, place covers over the seats, trim and floor in the cab and over the paintwork of the body.

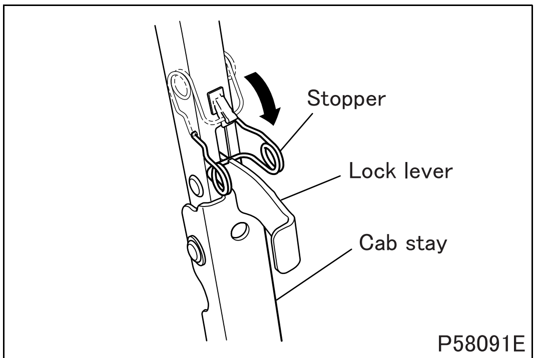


P00009

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

WARNING ⚠

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



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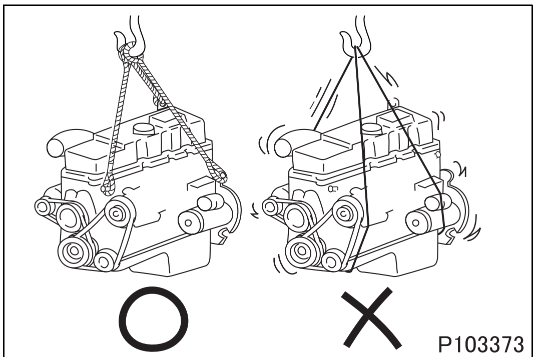
- After manually tilting the cab, be sure to engage the stopper with the lock lever to secure the cab stay in a rigid state.



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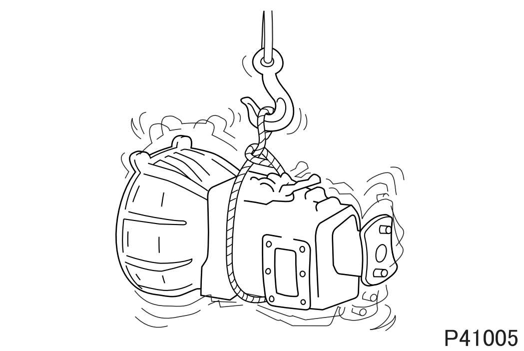
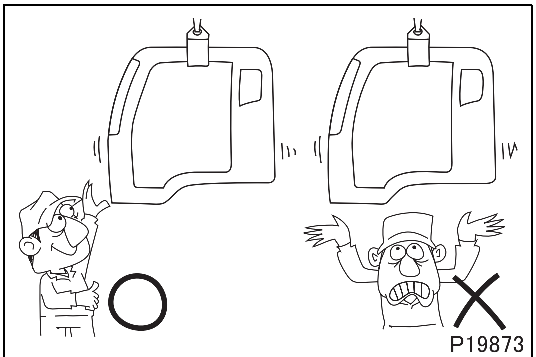
- Take extreme care when removing/installing heavy items such as engine, transmission and axle. When lifting heavy items using a cable etc., observe the following precautions.
  - Identify the mass of the item being lifted. Use a cable that is strong enough to support the mass.
  - When lifting the engine, always use the engine hanger.


P41005

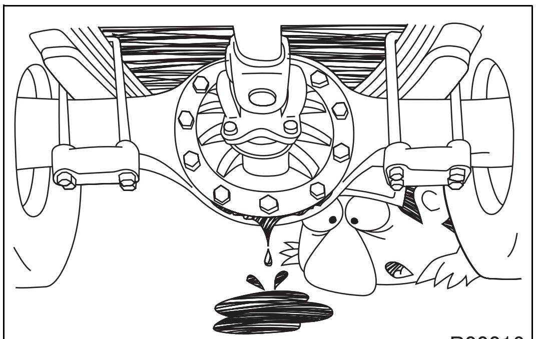
- If lifting eyes are not provided on the item being lifted, tie a cable around the item taking into account the item's center of gravity.


P19873

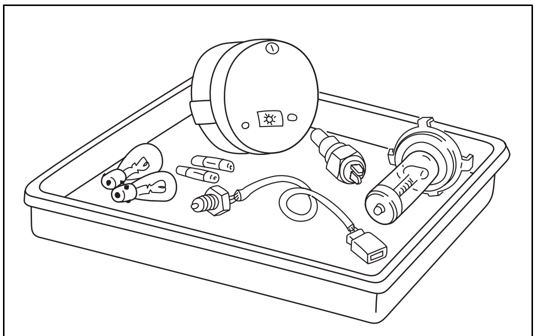
- Do not allow anyone to pass or stay under a lifted item that may fall.


P00012

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

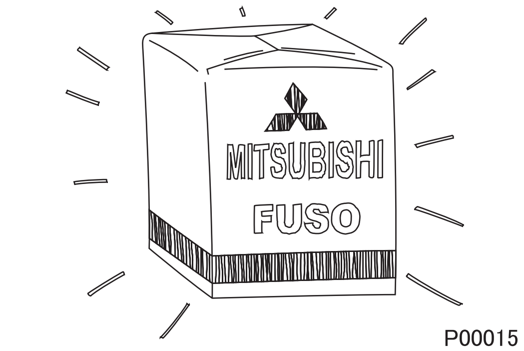

P00013

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


P20183

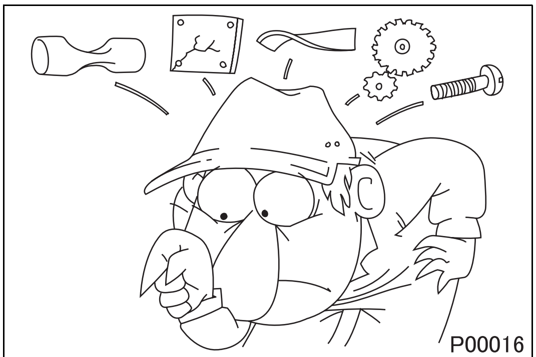
- Prepare replacement parts ready for installation.

PRECAUTIONS FOR MAINTENANCE OPERATION



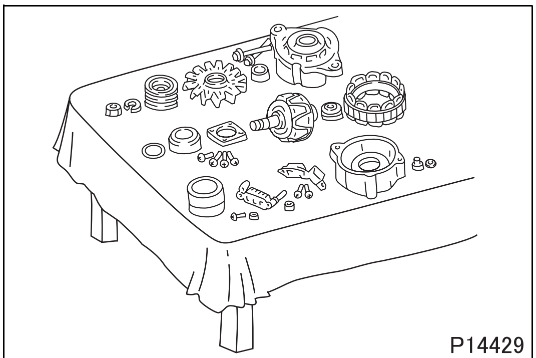
P00015

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



P00016

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

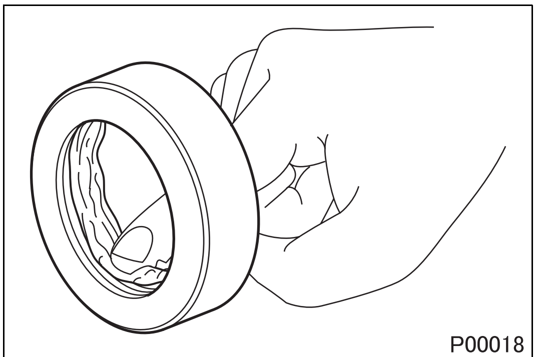


P14429

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

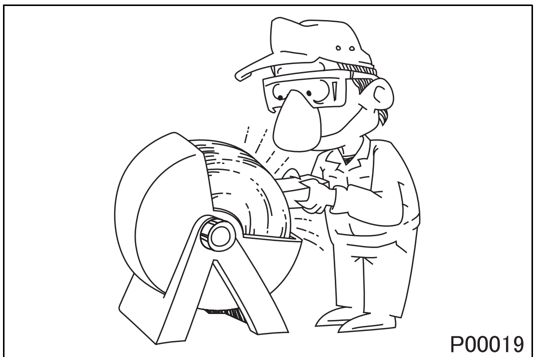
CAUTION ⚠

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



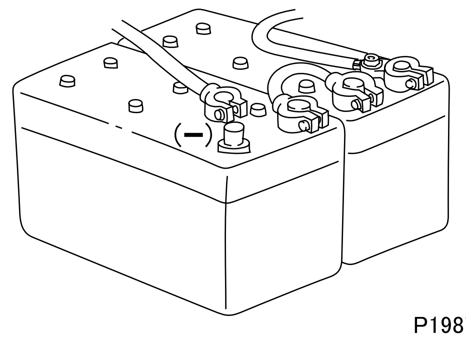
P00018

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



P00019

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

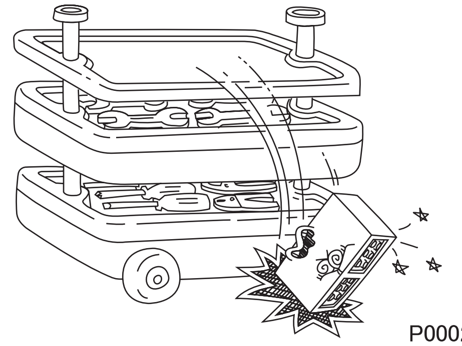


P19878

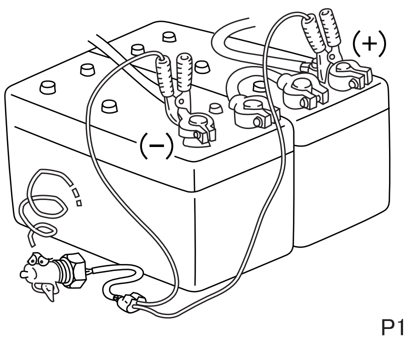
- Before working on the electrical system, disconnect the (–) battery cable to prevent short circuits.

CAUTION ⚠

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

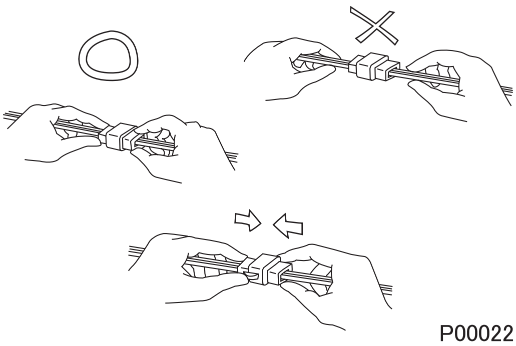

P00021

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

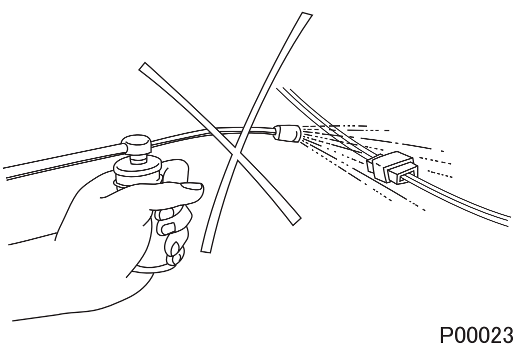


P19879

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

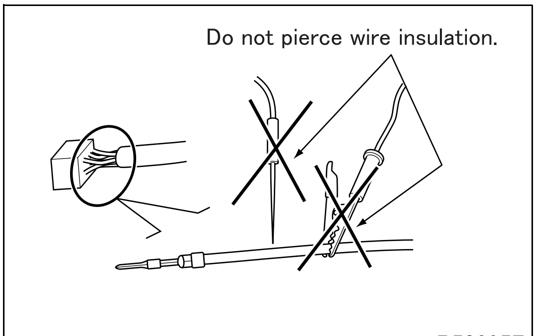

P00022

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


P00023

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

1. Handling Precautions for Electric Circuits

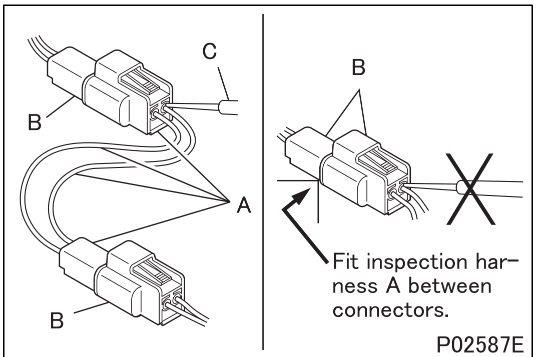


P50395E

CAUTION ⚠

- **Do not pierce wire insulation with test probes or alligator clips when performing electrical inspections. Doing so can, particularly with the chassis harness, hasten corrosion.**

1.1 Inspection of harnesses

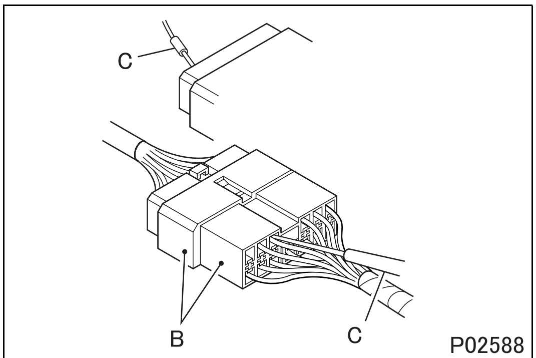


P02587E

(2) Inspections with connectors fitted together

(2.1) Waterproof connectors

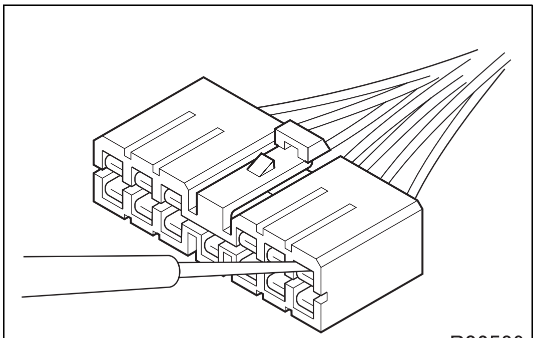
- Connect an inspection harness and connector A between the connectors B of the circuit to be inspected. Perform the inspection by applying a test probe C to the connectors of the inspection harness. Do not insert the test probe C into the wire-entry sides of the waterproof connectors since this would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



P02588

(2.2) Non-waterproof connectors

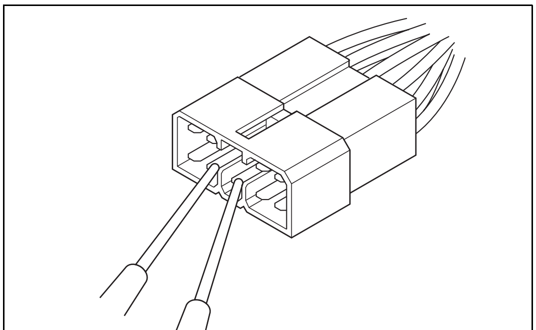
- Perform the inspection by inserting a test probe C into the wire-entry sides of the connectors. An extra-narrow probe is required for control unit connectors, which are smaller than other types of connector. Do not force a regular-size probe into control unit connectors since this would cause damage.


P02589

(3) Inspections with connectors separated

(3.1) Inspections on female terminals

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

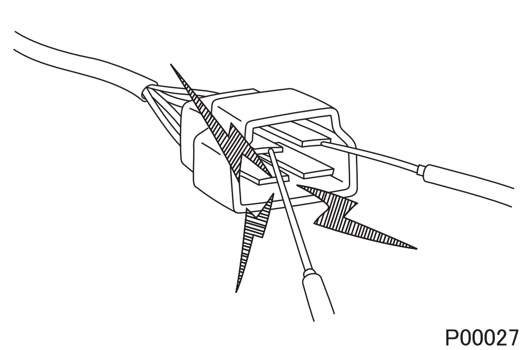

P02590

(3.2) Inspections on male terminals

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

CAUTION ⚠

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

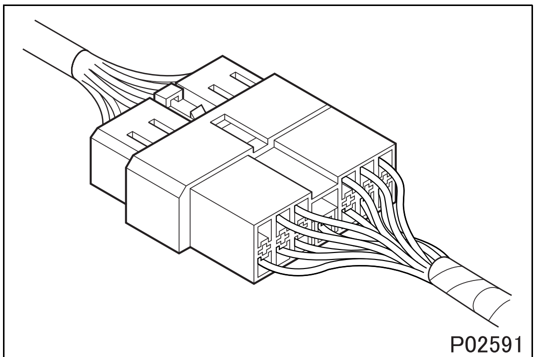


P00027

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

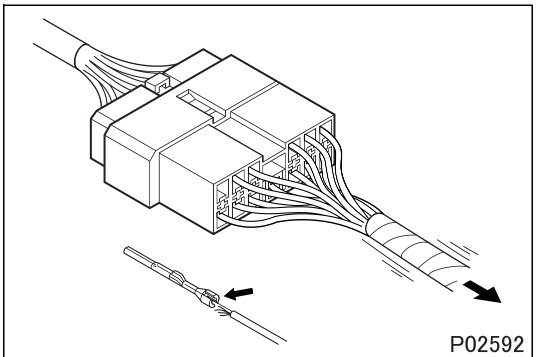
1.2 Inspection of connectors

(1) Visual inspection



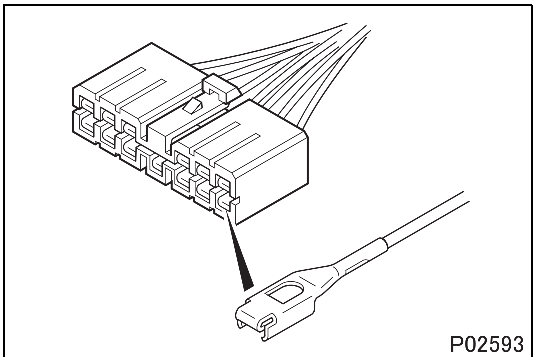
P02591

- Check that the connectors are fitted together securely.



P02592

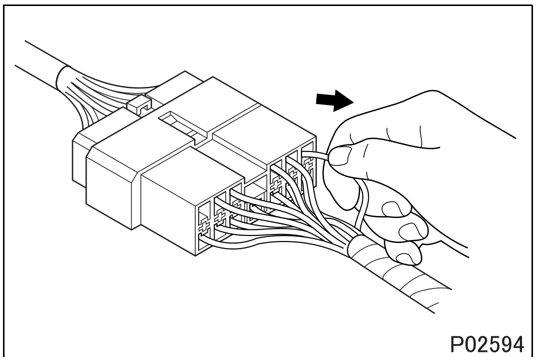
- Check whether wires have been separated from their terminals due to pulling of the harness.



P02593

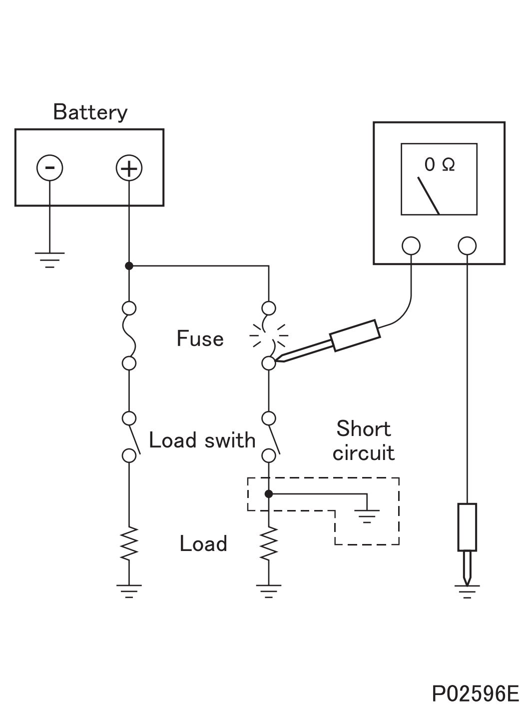
- Check that male and female terminals fit together tightly.
- Check for defective connections caused by loose terminals, by rust on terminals, or by contamination of terminals by foreign substances.

(2) Checking for loose terminals



P02594

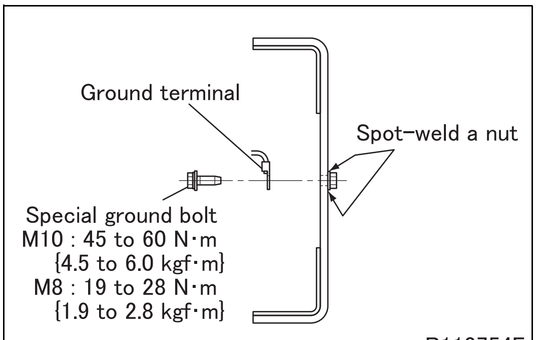
- If connector terminal retainers become damaged, male and female terminals may not mate with each other when the connector bodies are fitted together. To check for such terminals, gently pull each wire and see whether any terminals slip out of their connector housings.



P02596E

1.3 Inspections when a fuse blows

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

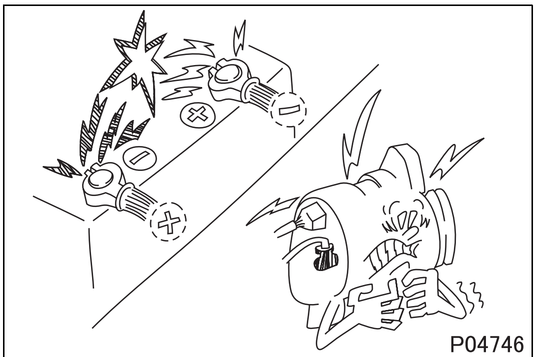


P110754E

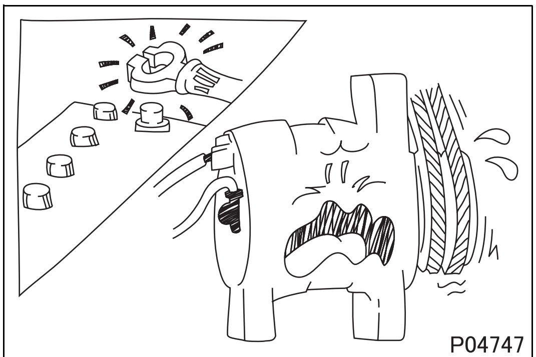
1.4 Inspection of chassis ground

- A special ground bolt is used to tighten a ground terminal. When servicing the ground point, be sure to follow the procedures described below:
  - When reinstalling the ground bolt
    Tighten the ground bolt to the specified torque.
  - When relocating the ground point
    A special ground bolt must be used. Spot-weld a nut to a frame and tighten the ground bolt to the specified torque. Be sure to apply touch-up paint to the welded point.

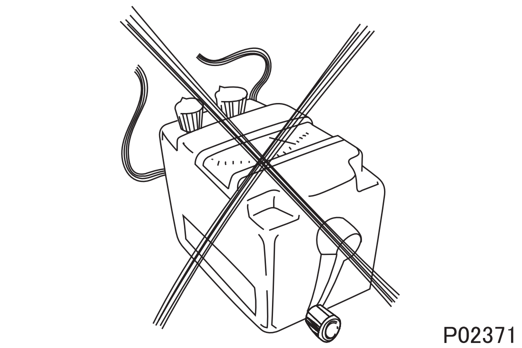
2. Service Precautions for Alternators


P04746

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


P04747

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

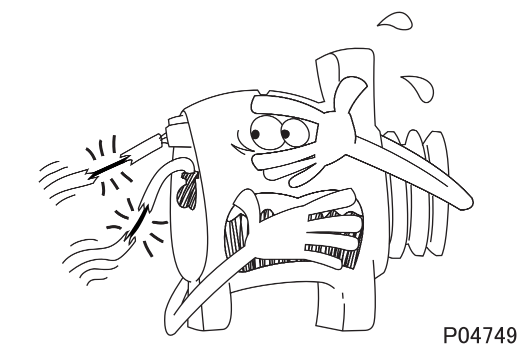


P02371

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

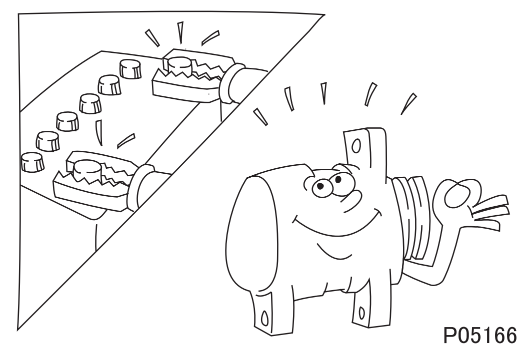
P05165

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



P04749

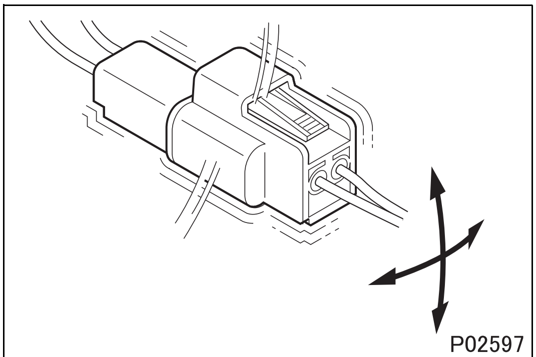
- Never operate an alternator with the B and L terminals short-circuited. Operation with the B and L terminals connected together would damage the diode trio.

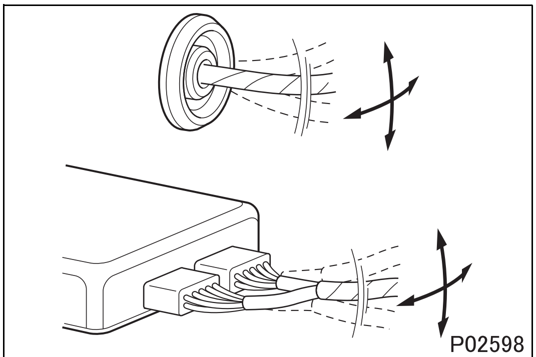


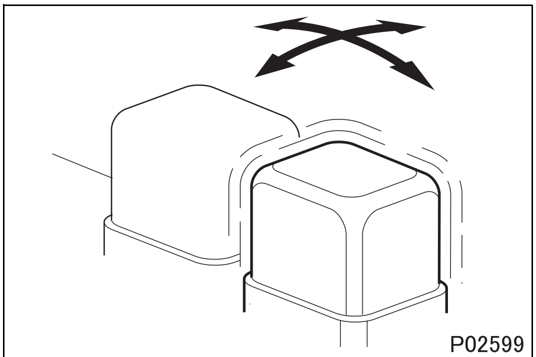
P05166

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

3. Intermittent Faults


P02597


P02598

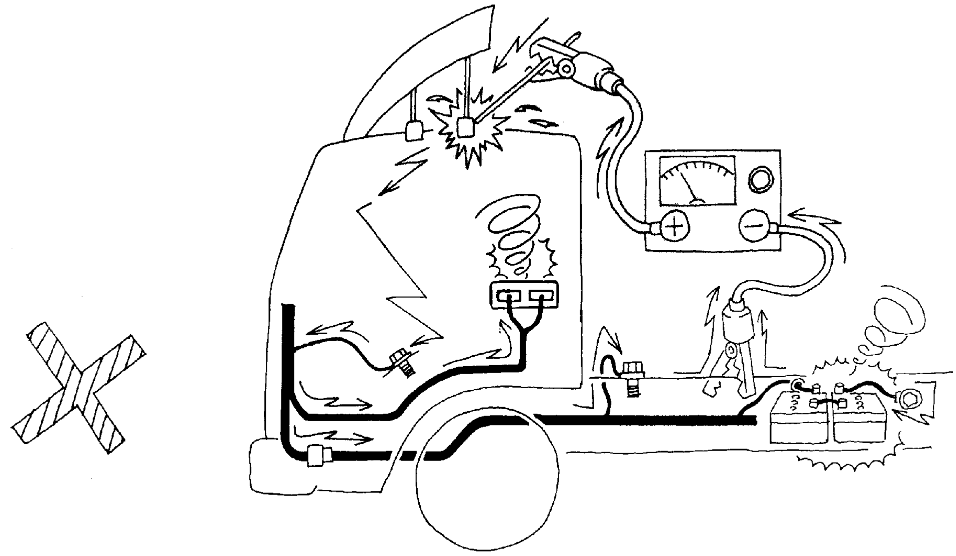

P02599

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

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

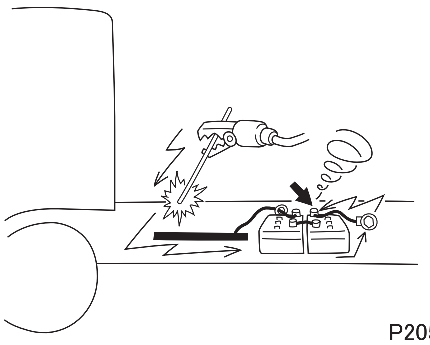
4. Precautions for Arc Welding

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



P27546

- Current flows backward as shown below.



P20516

4.1 From battery (–) cable

To prevent damage to the battery and to electrical devices that are connected directly to the battery, it is essential to disconnect the battery's (–) cable.

4.2 Procedure

- Turn the starter switch to the LOCK position.
- Disconnect the battery's (–) cable.
- Remove the safety plug of the high voltage battery box referring to Gr18 HYBRID ELECTRIC VEHICLE SYSTEM.
- Cover all parts of the vehicle that may be damaged by welding sparks.
- Connect the welder's (–) cable to the vehicle as close as possible to the area being welded. Do not connect the welder's (–) cable to the cab if the frame is being welded, and vice versa.
- Set the welding current in accordance with the part being welded.

5. Maintenance for Trucks with Airbags

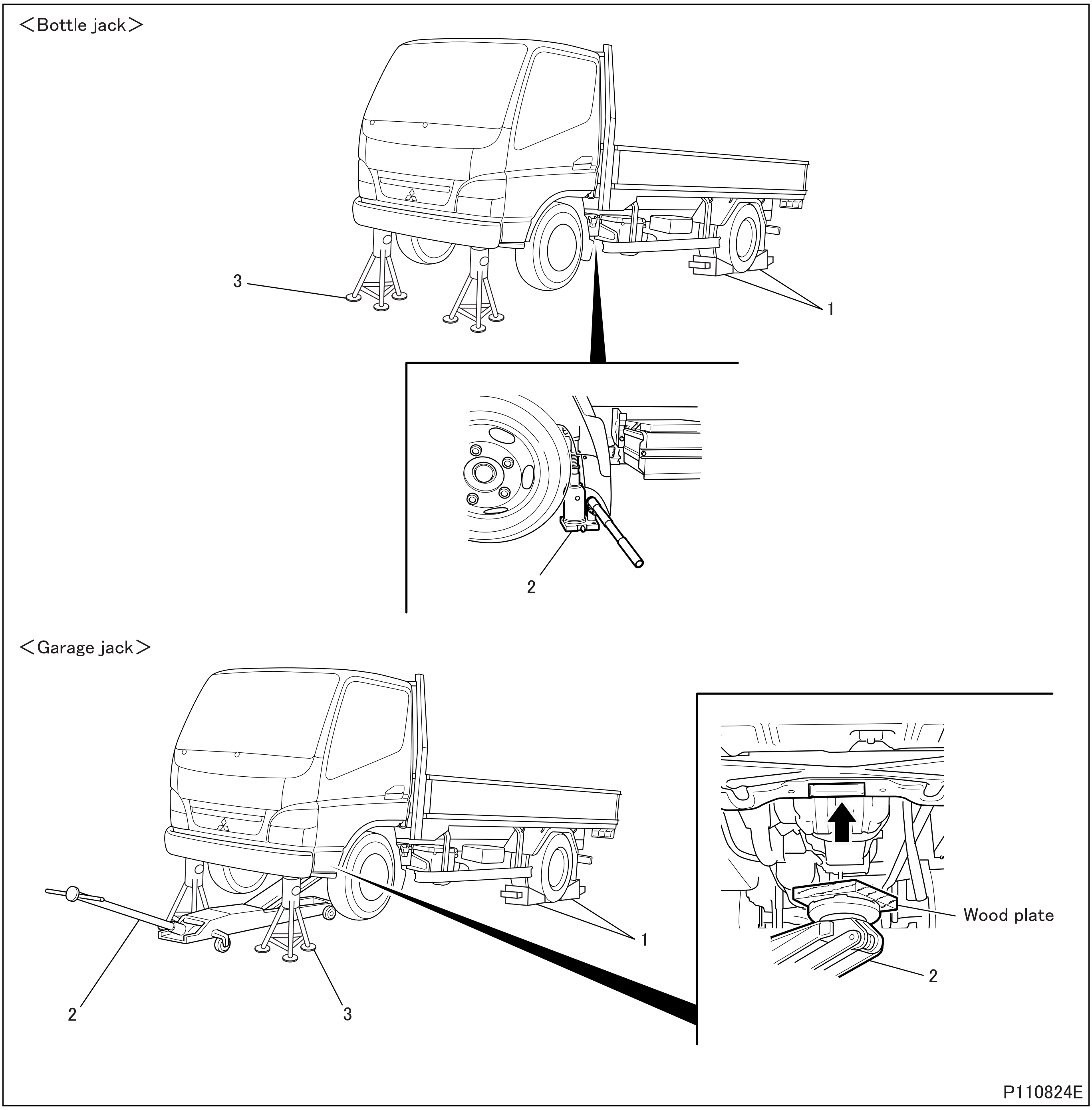
- For maintenance of SRS airbags and seat belts with pretensioners, work should be conducted safely by following the work procedure and precautions.

6. Precautions When Starting the Engine

- The engine warning lamp may illuminate if the starter switch is kept turned to the START position for a while with the gear engaged. (Diagnosis code P0016 "No SNSR Offset/Backup Mode" of the engine electronic control unit occurs.)
- If the engine warning lamp illuminated, place the transmission in neutral and turn the starter switch from OFF to ON four times to turn off the warning lamp.

JACKING UP THE VEHICLE

<Front of Vehicle>



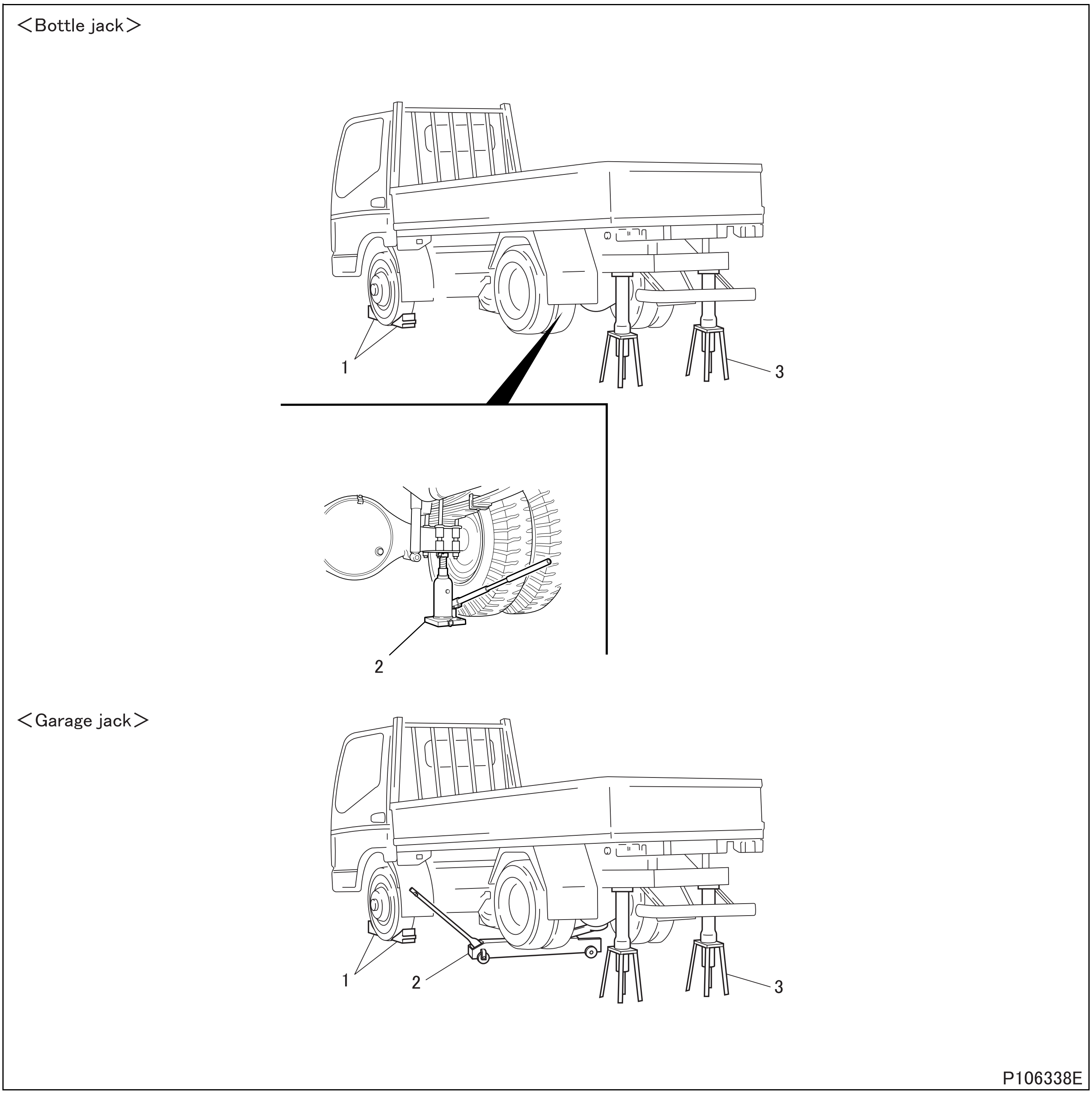
Jacking up procedure

1. Apply chocks to the rear wheels.
2. Raise the front of the vehicle using a bottle jack or garage jack.
3. Place rigid racks to support the frame on the front side of the vehicle.

WARNING ⚠

- **Apply chocks to the rear wheels to hold the vehicle in place.**
- **Do not remove the chocks until service operations are finished.**
- **It is extremely dangerous to support the vehicle with a bottle jack or garage jack alone. Use rigid racks additionally to support the frame on the front side of the vehicle.**
- **Leave the bottle jack or garage jack and rigid racks in place until all service operations are completed. Be sure not to remove them during work.**

<Rear of Vehicle>



Jacking up procedure

1 Apply chocks to the front wheels.

2 Raise the rear of the vehicle using a bottle jack or garage jack.

3 Place rigid racks to support the frame on both sides of the vehicle.

WARNING ⚠

- **Apply chocks to the front wheels to hold the vehicle in place.**
- **Do not remove the chocks until service operations are finished.**
- **It is extremely dangerous to support the vehicle with a bottle jack or garage jack alone. Use rigid racks additionally to support the frame on both sides of the vehicle.**
- **Leave the bottle jack or garage jack and rigid racks in place until all service operations are completed. Be sure not to remove them during work.**

1. Diagnosis Codes

- Diagnosis codes indicate the faulty sections of the vehicle.
- A fault can be repaired by reading out the diagnosis code(s) stored in the control unit and performing the remedy for that code(s).
- Diagnosis codes can be displayed in the following two methods. Select either of them according to the system to be diagnosed.
  - Using a Multi-Use Tester
  - Using flashing of a warning lamp on meter cluster
- The table below indicates the systems for which diagnosis codes can be displayed and the methods usable for individual systems.

1.1 Systems and diagnosis code displaying methods

<table>
<tr><th rowspan="2">Warning lamp</th><th rowspan="2">System</th><th colspan="2">Diagnosis codes displaying methods</th><th rowspan="2">Reference Gr</th></tr>
<tr><th>Multi-Use Tester</th><th>Flashing of warning lamp</th></tr>
<tr><td rowspan="6"></td><td>Common rail</td><td rowspan="6">O</td><td rowspan="6">O</td><td>13</td></tr>
<tr><td>Turbo charger</td><td rowspan="2">15</td></tr>
<tr><td>Diesel particulate filter</td></tr>
<tr><td>Exhaust gas recirculation</td><td>17</td></tr>
<tr><td>Starter continuous energizing preventing function</td><td rowspan="2">54</td></tr>
<tr><td>Pre-heat control</td></tr>
<tr><td>HEV</td><td>Hybrid electric vehicle system</td><td>O</td><td>O</td><td>18</td></tr>
<tr><td></td><td>INOMAT-II</td><td>O
(Gear shift indicator indication)</td><td>O</td><td>22E</td></tr>
<tr><td></td><td>Power anti-lock brake system</td><td>O</td><td>O</td><td>35EA</td></tr>
<tr><td>(ORANGE)</td><td>Hill start assist system</td><td>O</td><td>O</td><td>35EB</td></tr>
<tr><td></td><td>SRS airbag</td><td>O</td><td>–</td><td>52</td></tr>
</table>

1.2 Types of diagnosis codes

(1) Present diagnosis code

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

(2) Past diagnosis code

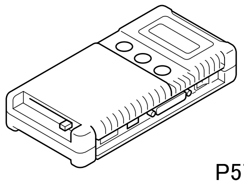
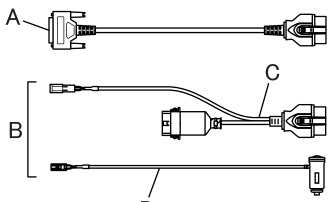
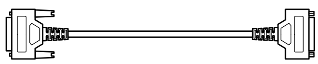
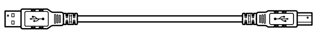
- Past fault developed in the vehicle is indicated by corresponding diagnosis code stored in the memory of the electronic control unit.
- With the vehicle restored to its normal condition or the starter switch turned from OFF to ON after inspection or repair against present diagnosis codes, the present diagnosis code is stored as past diagnosis codes in the memory of the electronic control unit.
- When reading out the past diagnosis codes, the warning lamp does not illuminate as such codes do not indicate the current fault.

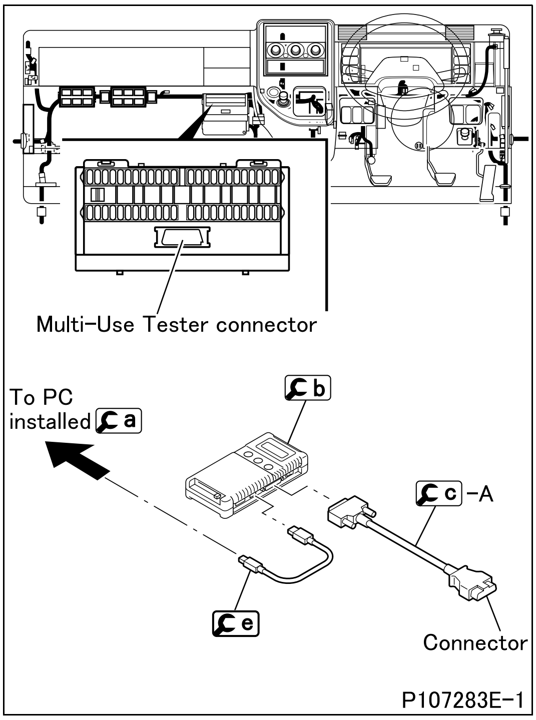
2. Reading and Erasing the Diagnosis Code

2.1 Using a Multi-Use Tester

(1) Connecting a Multi-Use Tester

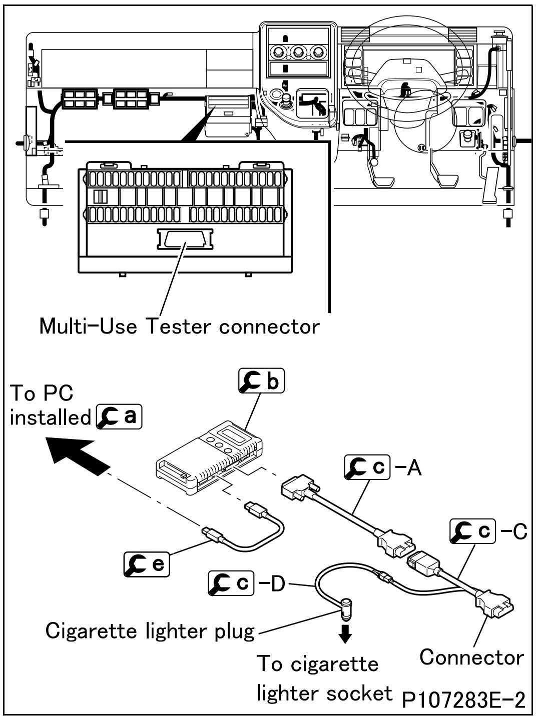
Special tools

Mark	Tool name and shape	Part No.	Application
a	Multi-Use Tester-III SOFTWARE DISC  P100236	FMS-E09-2* (Multi-Use Tester-III version)	*Installation of the Multi-Use Tester-III or version-up of the current version into Multi-Use Tester-III SOFTWARE DISC (Pub. No. SG0901A)
b	V.C.I.  P57296	MH062927	Data transmission between electronic control unit and PC
c	Multi-Use Tester test Harness E A: Harness for inspection and drive recorder B: Harness for drive recorder C: Drive recorder harness D: Cigarette lighter plug harness  P100753	MH063659 A: MH063661 B: MH063663 C: MH063665 D: MH063666	Power supply to V.C.I. and communication with electronic control unit
d	Multi-Use Tester test harness D (used for extension)  P57299	MH062951	Multi-Use Tester test harness B extension
e	USB cable  P57300	MH063668	Communication between V.C.I. and PC



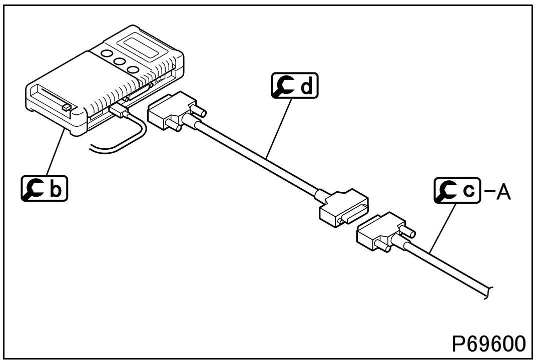
(1.1) To perform system inspection

- Move the starter switch to the LOCK position.
- Connect PC installed [a], [b], [c]-A and [e] as shown.
- Connect [c]-A connector to the Multi-Use Tester connector on the vehicle.



(1.2) To use drive recorder function

- Move the starter switch to the LOCK position.
- Connect PC installed [a], [b], [c]-A, [c]-C, [c]-D and [e] as shown.
- Connect [c]-C connector to the Multi-Use Tester connector on the vehicle.
- Connect the cigarette lighter plug of [c]-D to the cigarette lighter socket on the vehicle.



(1.3) To extend the Multi-Use Tester test harness

- Connect [d] to [c]-A to extend the test harness to use the Multi-Use Tester outside the vehicle.

(2) Access of diagnosis code

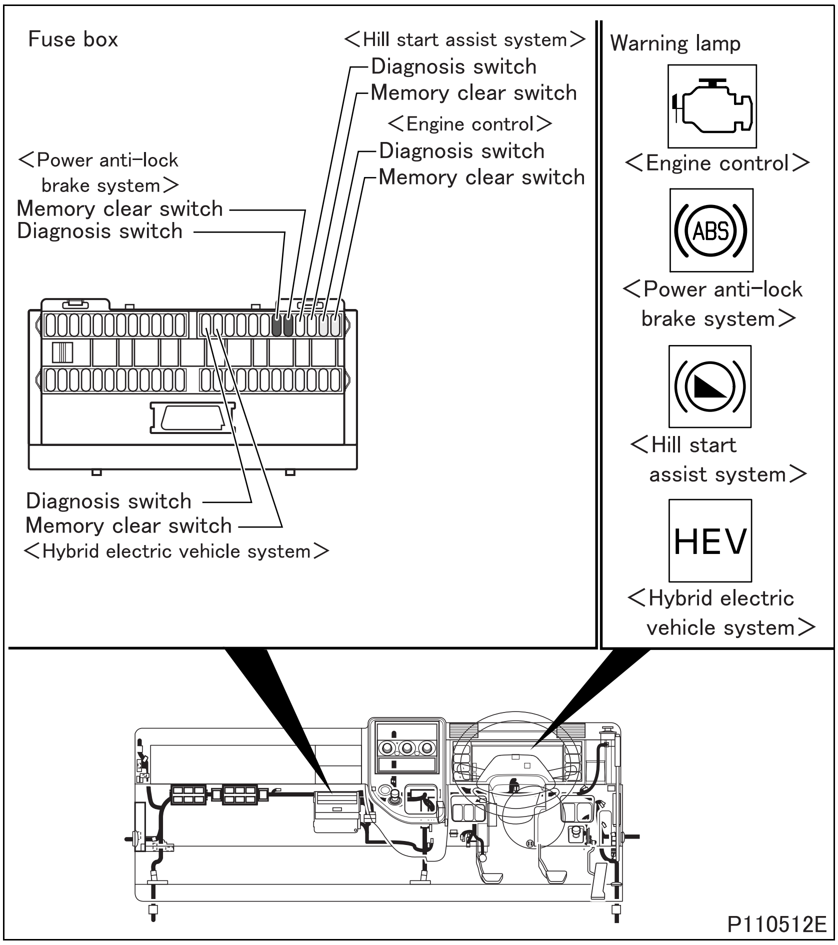
- Set the starter switch to ON.
- Operate the Multi-Use Tester for a display of necessary diagnosis code stored in the memory of the electronic control unit and identify the location of the fault.

(3) Clearing of diagnosis code

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

2.2 Using flashing of a warning lamp on meter cluster

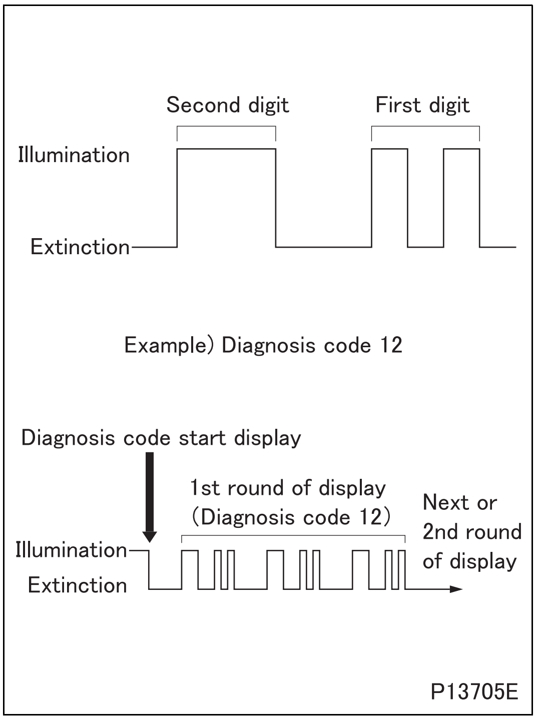
(1) Engine control, Power anti-lock brake system, Hill start assist system, Hybrid electric vehicle system



- Using the diagnosis and memory clear switches, display diagnosis codes.
- Diagnosis codes of the battery electronic control unit are sent to the motor electronic control unit and are displayed along with those of the motor electronic control unit by the diagnosis switch operation.
  However, some diagnosis codes (minor faults) can be checked only with the Multi-Use Tester.

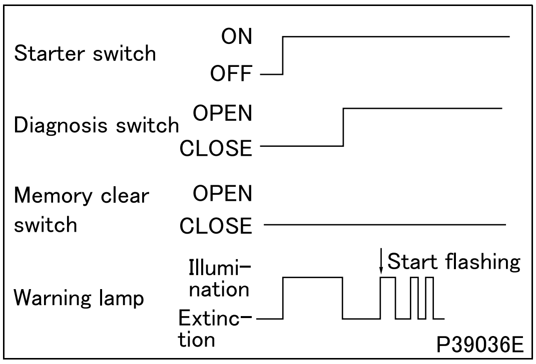
CAUTION ⚠

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



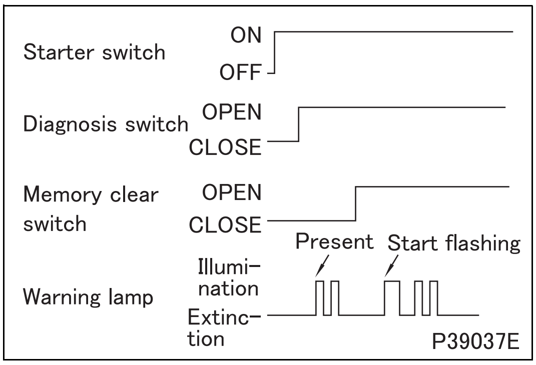
(1.1) Reading diagnosis codes

- To read a diagnosis code, observe how may times the warning lamp flashes and how long each illumination lasts.
- The duration of illumination differs between the first and second digits.
  - Second digit: 1.2 sec.
  - First digit: 0.4 sec.
- A diagnosis code consists of the flashing of second digit and the flashing of first digit in that order. If a diagnosis code has "0" in the second digit, only the first digit will be displayed.
- The diagnosis code 01 will be displayed if the system is normal.
- The same diagnosis code will be displayed 3 times in a row before moving to the display of the next code.
- After the last diagnosis code is displayed, the first code will be displayed again 3 times in a row and then the subsequent codes. This will be repeated.



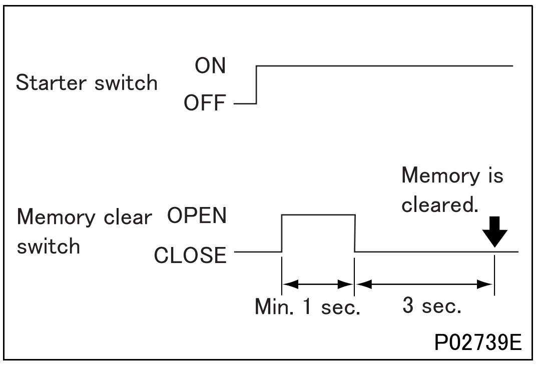
(1.2) Present diagnosis codes

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



(1.3) Present and past diagnosis codes

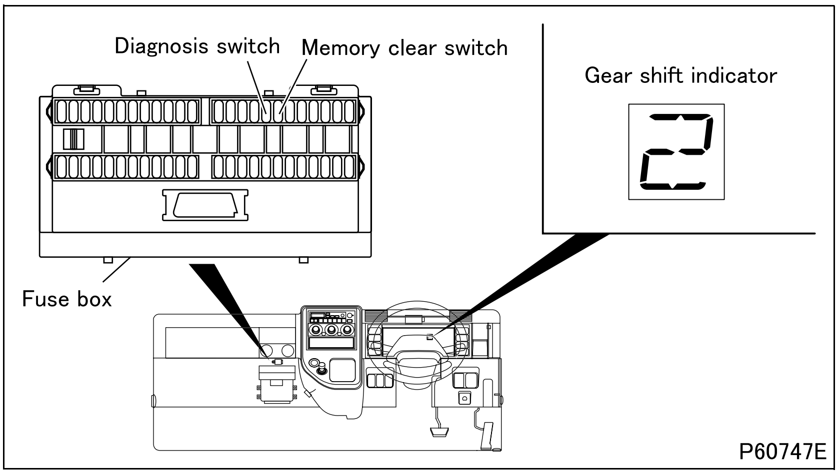
- Turn the starter switch to the ON position.
- Open the diagnosis switch.
- Present diagnosis codes will be displayed by flashing of the warning lamp.
- Open the memory clear switch.
- Present and past diagnosis codes will be displayed by flashing of the warning lamp.
- Turn the starter switch to the OFF position and connect the memory clear switch and diagnosis switch to terminate the diagnosis code displaying mode.



(1.4) Erasing diagnosis codes

- Turn the starter switch to the ON position (do not start the engine).
- Open the memory clear switch and reconnect it; all diagnosis codes stored in electronic control unit memory will be erased.
  To cancel diagnosis code erasure after opening the memory clear switch, turn the starter switch to the OFF position and then reconnect the memory clear switch.
- Erase the diagnosis codes stored in the battery electronic control unit using the Multi-Use Tester.

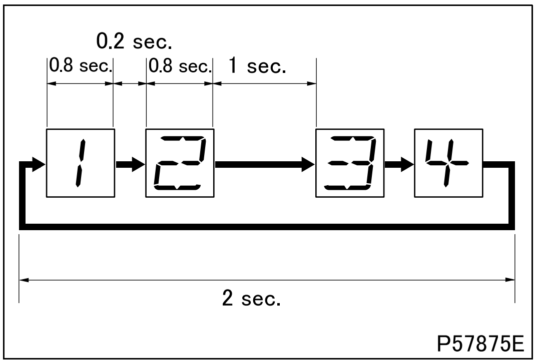
(2) INOMAT-II



- Display diagnosis codes using the diagnosis switch and memory clear switch.

NOTE

- **Diagnosis codes are erased by disconnecting and connecting operation of the memory clear switch. Fully understand the procedures before working.**



(2.1) Reading diagnosis codes

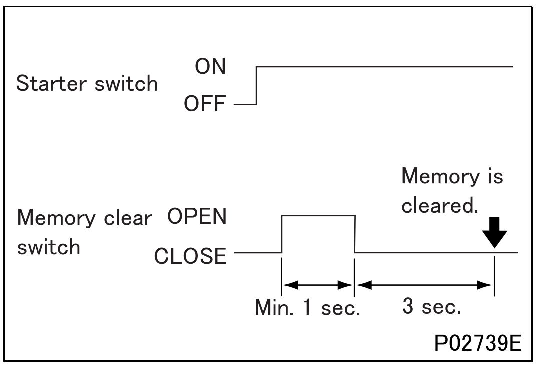
- To read a diagnosis code, check the indication of the gear shift indicator.
  Example: If the codes are 12 and 34, they will be displayed as shown in the drawing.
- If the system is normal, the diagnosis code 01 will be displayed.
- Diagnosis codes will be displayed each code once in the reverse chronological order.
- After the last diagnosis code is displayed, the first code will be displayed again and then the subsequent codes. This will be repeated.

(2.2) Present diagnosis codes

- Turn the starter switch to ON.
- Disconnect the diagnosis switch.
- The present diagnosis codes will be displayed on the gear shift indicator.
- When the diagnosis switch is connected, ECU will stop (terminate) displaying diagnosis codes.

(2.3) Present and past diagnosis codes

- Turn the starter switch to ON.
- Disconnect the diagnosis switch.
- The present diagnosis codes will be displayed on the gear shift indicator.
- Disconnect the memory clear switch.
- The present and past diagnosis codes will be displayed on the gear shift indicator.
- After the starter switch is turned to OFF, connect the memory clear switch and diagnosis switch to terminate the operation.



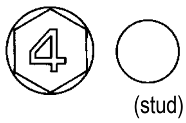
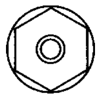
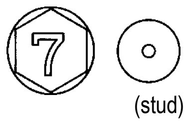
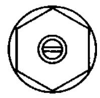
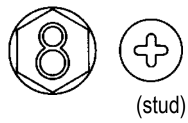
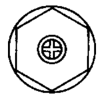
(2.4) Erasing diagnosis codes

- Turn the starter switch to ON. (Do not start the engine.)
- All diagnosis codes stored in the electronic control unit can be erased by disconnecting the memory clear switch and then connecting it again. If you discontinue the operation after the memory clear switch is disconnected, turn the starter switch to OFF and then connect the memory clear switch.

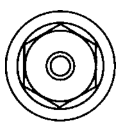
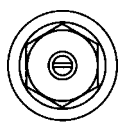
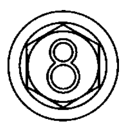
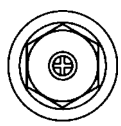
TABLE OF STANDARD TIGHTENING TORQUES

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

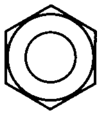
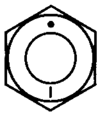
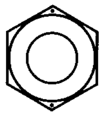
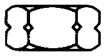
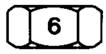
Hexagon Head Bolts and Stud Bolts (Unit: N·m {kgf·m})

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

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

Strength	4T		7T		8T	
Identification symbol / Nominal diameter						
M6	4 to 6 {0.4 to 0.6}	–	8 to 12 {0.8 to 1.2}	–	10 to 14 {1.0 to 1.4}	–
M8	10 to 15 {1.0 to 1.5}	–	19 to 28 {2.0 to 2.9}	–	22 to 33 {2.3 to 3.3}	–
M10	21 to 31 {2.1 to 3.1}	20 to 29 {2.0 to 3.0}	45 to 55 {4.5 to 5.5}	37 to 54 {3.8 to 5.6}	50 to 65 {5.0 to 6.5}	50 to 60 {5.0 to 6.0}
M12	38 to 56 {3.8 to 5.5}	35 to 51 {3.5 to 5.2}	80 to 105 {8.0 to 10.5}	70 to 95 {7.5 to 9.5}	90 to 120 {9 to 12}	85 to 110 {8.5 to 11}

Hexagon Nuts (Unit: N·m {kgf·m})

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

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

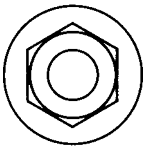
Strength	4T	
Identification symbol		
Nominal diameter	Standard screw thread	Coarse screw thread
M6	4 to 6 {0.4 to 0.6}	–
M8	10 to 15 {1.0 to 1.5}	–
M10	21 to 31 {2.1 to 3.1}	20 to 29 {2.0 to 3.0}
M12	38 to 56 {3.8 to 5.6}	35 to 51 {3.5 to 5.2}

TABLE OF STANDARD TIGHTENING TORQUES

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

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

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

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

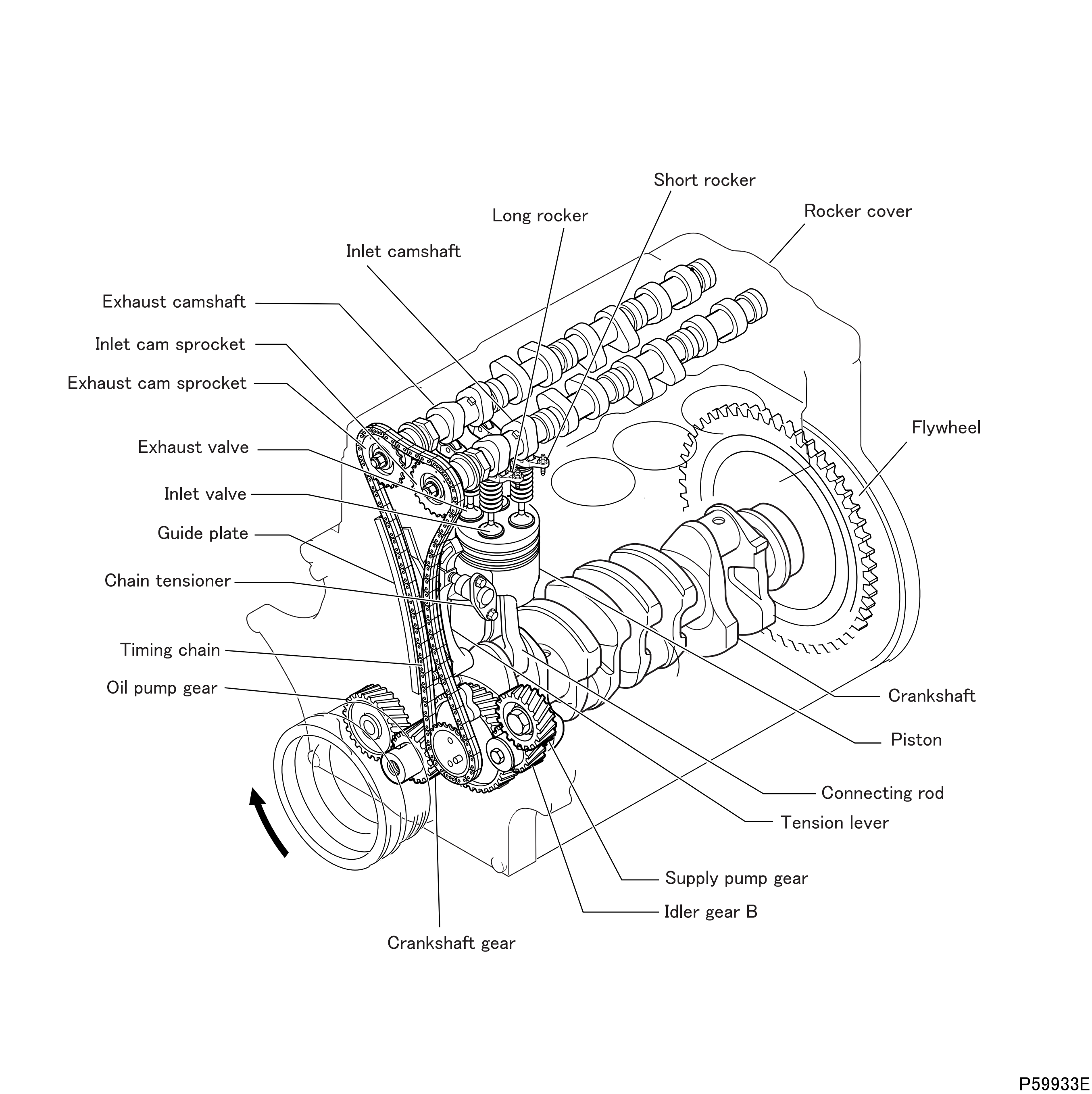
Tightening Torque for General-Purpose Air Piping Nylon Tube (SAE Type) (Unit: N·m {kgf·m})

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

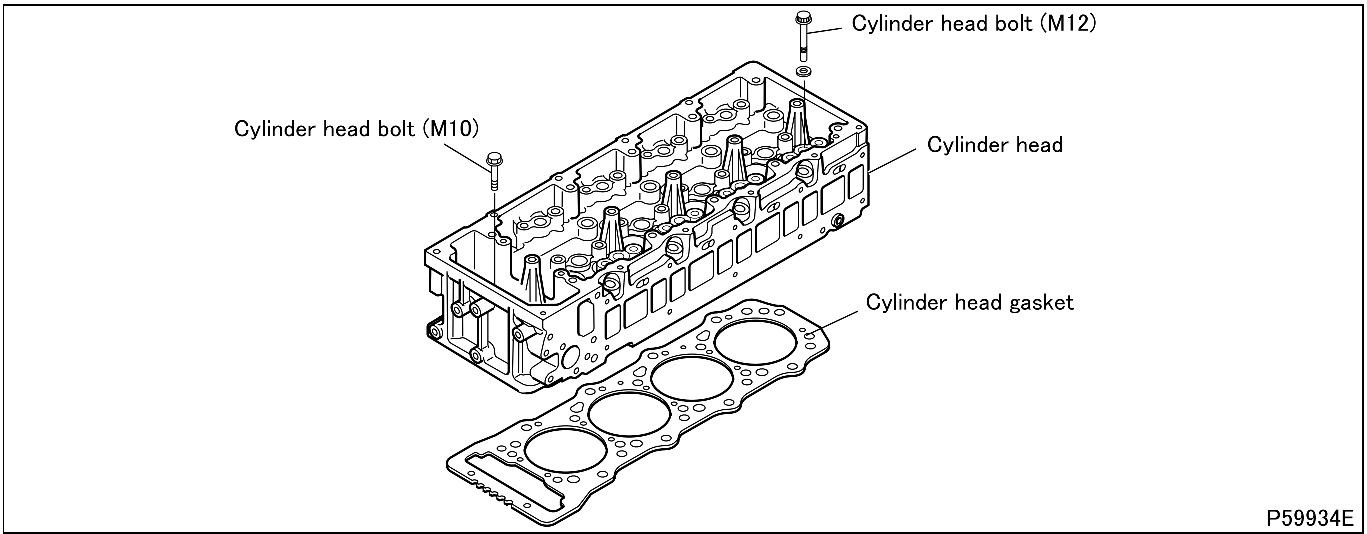
GROUP 11 ENGINE

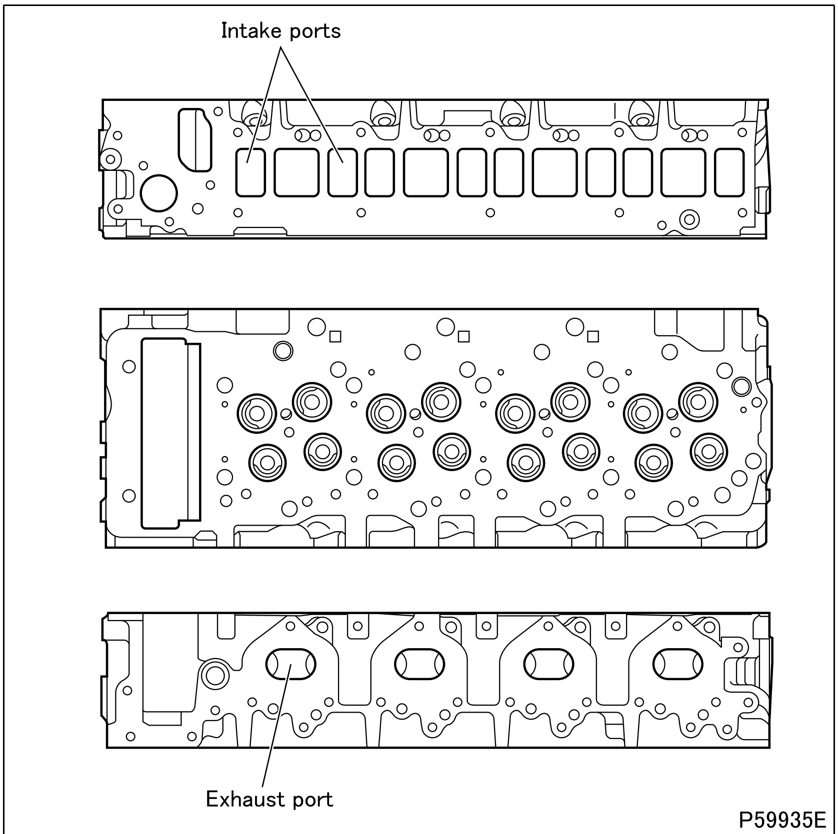
Item		Specifications
Engine model		4M42T3
Type		4-cylinder, in-line, water-cooled, 4-cycle diesel engine
Combustion chamber		Direction injection type
Valve mechanism		Double overhead camshaft (DOHC)
Maximum output	kW {PS} /rpm	96 {130} /3200
Maximum torque	N·m {kgf·m} /rpm	294 {30} /1700
Bore × stroke	mm	ϕ95 × 105
Total displacement	cm^3 {L}	2977 {2.977}
Compression ratio		17.0

1. Exploded View



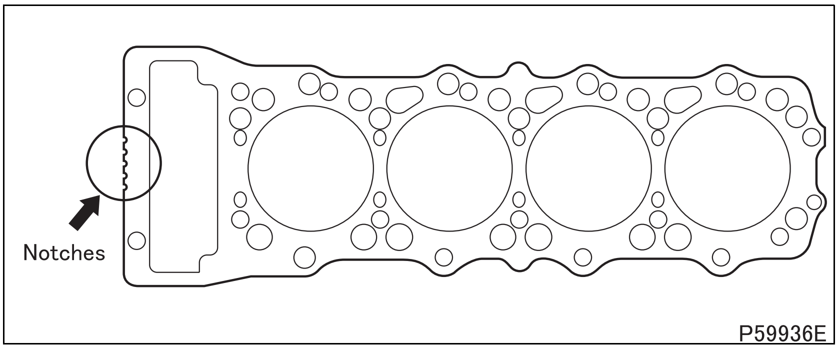
2. Cylinder Head and Cylinder Head Gasket





2.1 Cylinder head

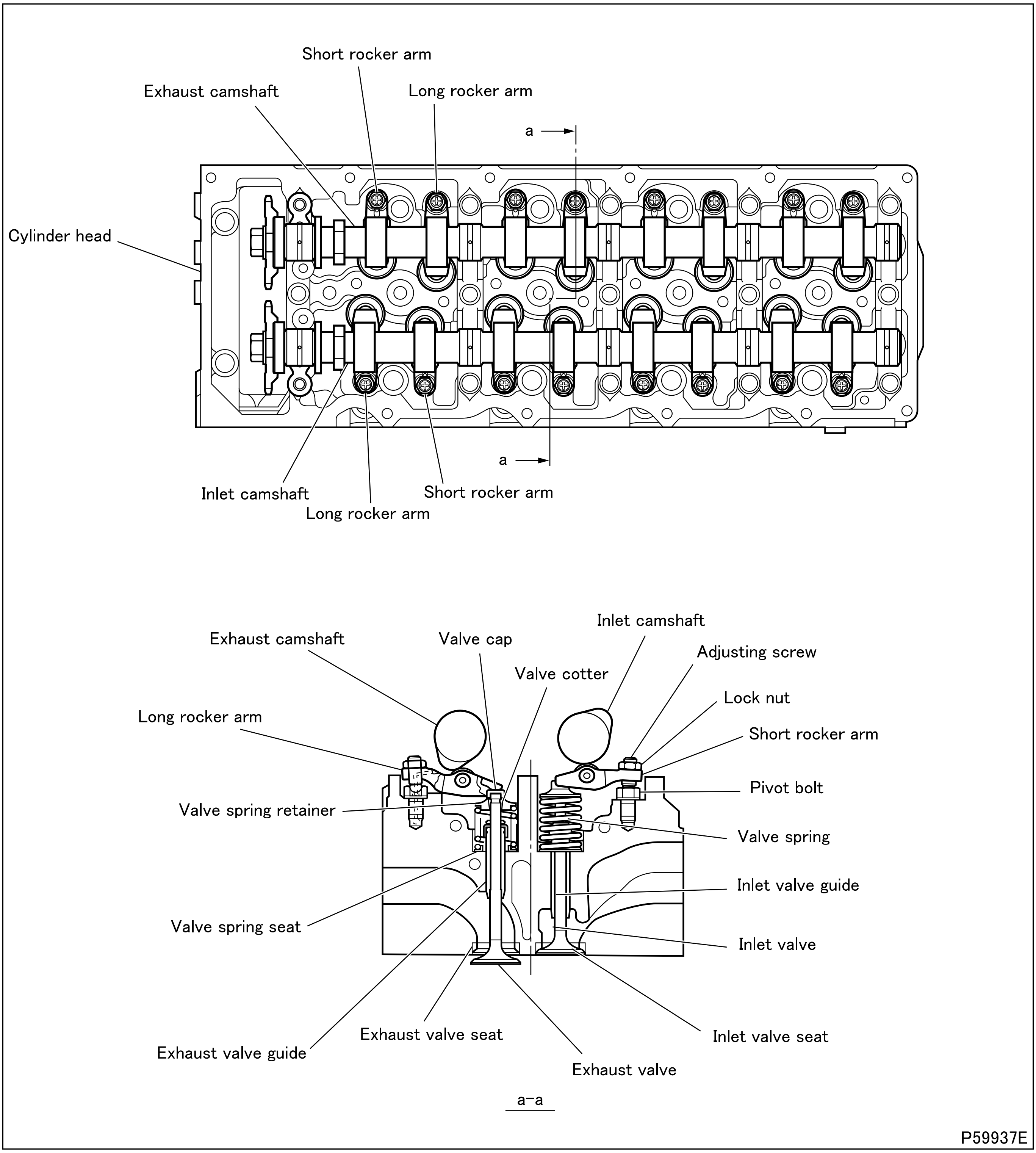
- The arrangement of the intake ports and exhaust ports is of a cross-flow type. The exhaust ports are provided on the right side and the intake ports are provided on the left side of the cylinder head.
- Cylinder head bolt (M12) is fastened to the upper crankcase and cylinder head bolt (M10) is fastened to the timing gear case.
- The cylinder head bolts must be tightened according to the specified procedure.



2.2 Cylinder head gasket

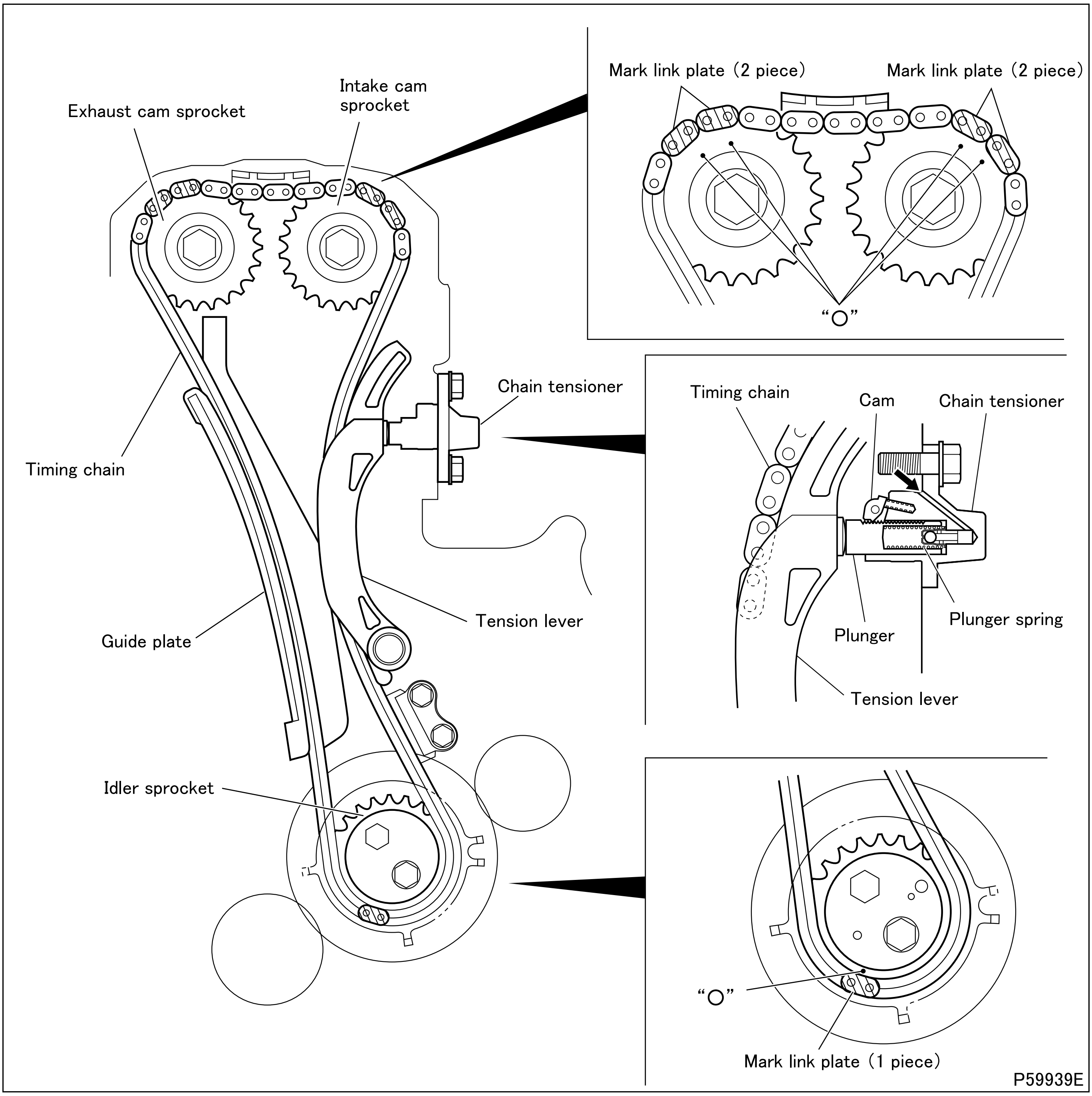
- Select and use a cylinder head gasket of a thickness that can accommodate the piston projection.
- The size (thickness) class of the gasket can be identified by the shape of the notches cut on the edge of each gasket.

3. Valve Mechanism



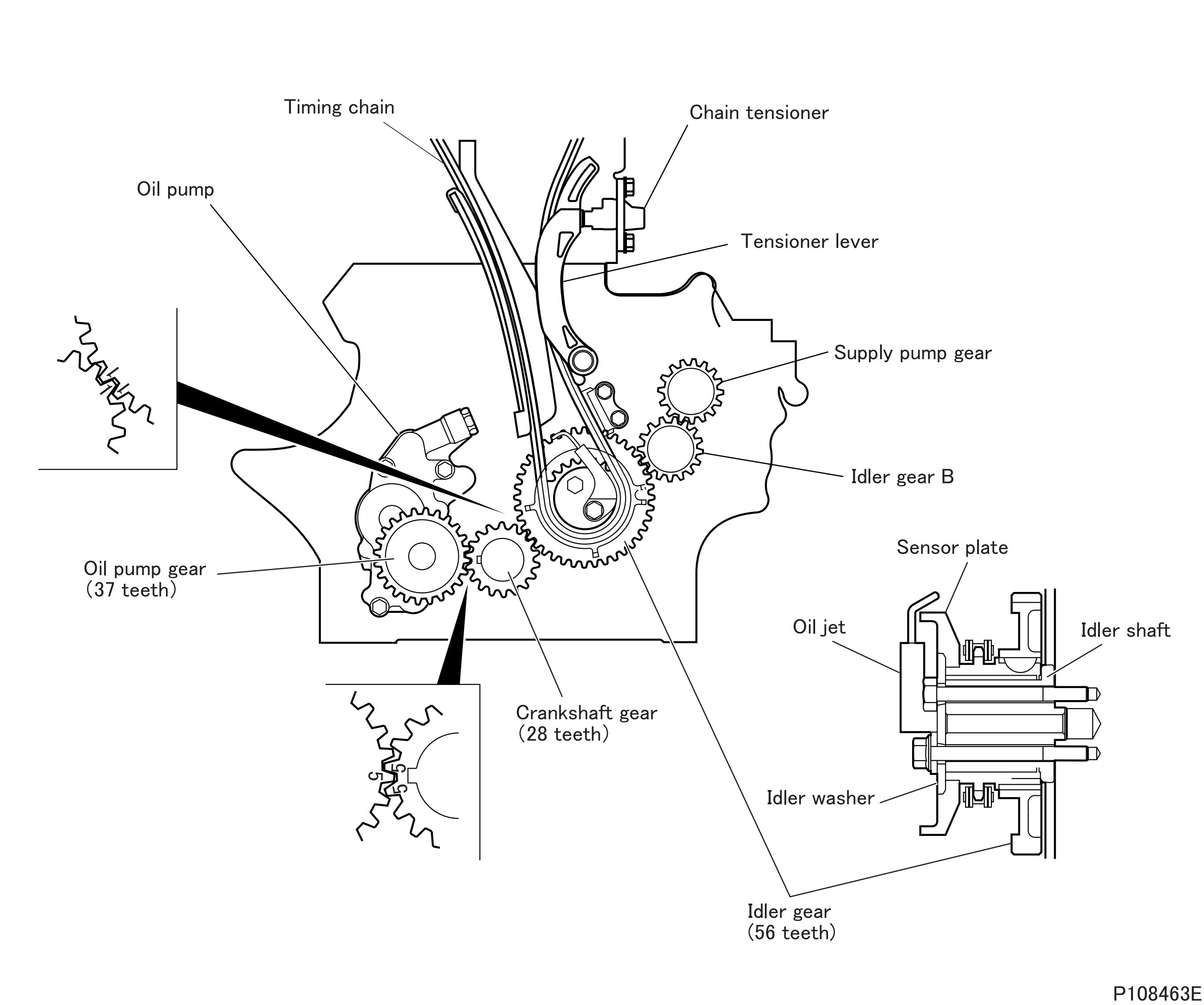
- The camshaft is driven by the timing chain. The exhaust camshaft and the intake camshaft are supported by camshaft holders at the journals and are retained by camshaft caps from above.
- There are two types of rocker arms: long rocker arm and short rocker arm. They are alternately provided by the valve position.

4. Timing Chain

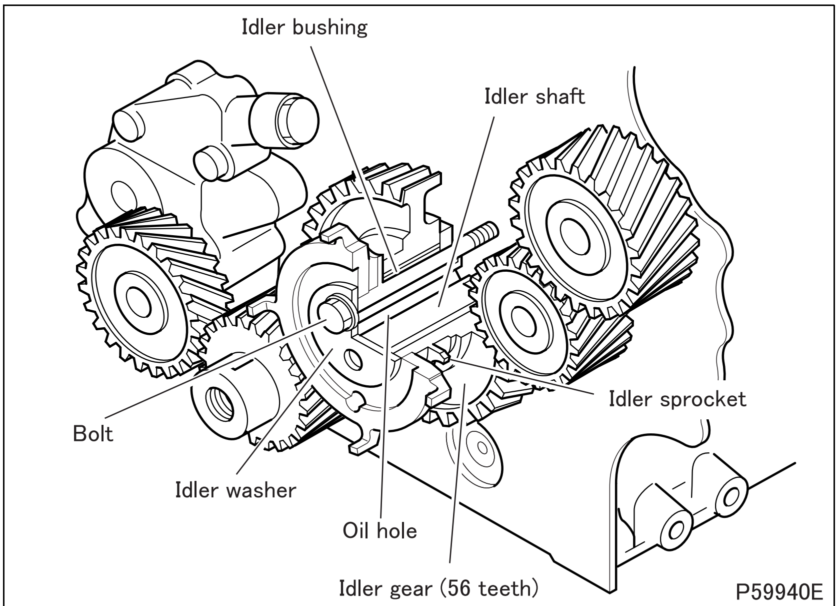


- The timing chain is an endless chain with 110 links that connects the exhaust cam sprocket, intake cam sprocket and the idler sprocket.
- The timing chain has mark link plates at three locations that indicate the position at which the crankshaft and the camshaft should take when the chain is installed. There are two plates at the first location and one plate at the second location. The first location (two-mark-link location) must be aligned with the mating mark "O" on the exhaust cam sprocket and the intake cam sprocket, and the second location (one-mark-link location) must be aligned with the mating mark "O" on the idler sprocket.
- The chain tensioner gives tension to the timing chain. The chain tensioner has a plunger with a built-in spring.
- When the chain tensioner is installed in position, the plunger directly pushes the tension lever, and the timing chain is tensioned automatically by a force determined by the tension of the plunger spring.
- After the plunger is installed, it is locked in place by a cam provided in the chain tensioner, which prevents accidental deflection of the timing chain while it is driven. Do not crank the engine in the reverse direction after installing the chain tensioner, as this will apply undue forces to the plunger and may cause such undesirable consequences as cam being over ridden by the plunger.

5. Timing Gears



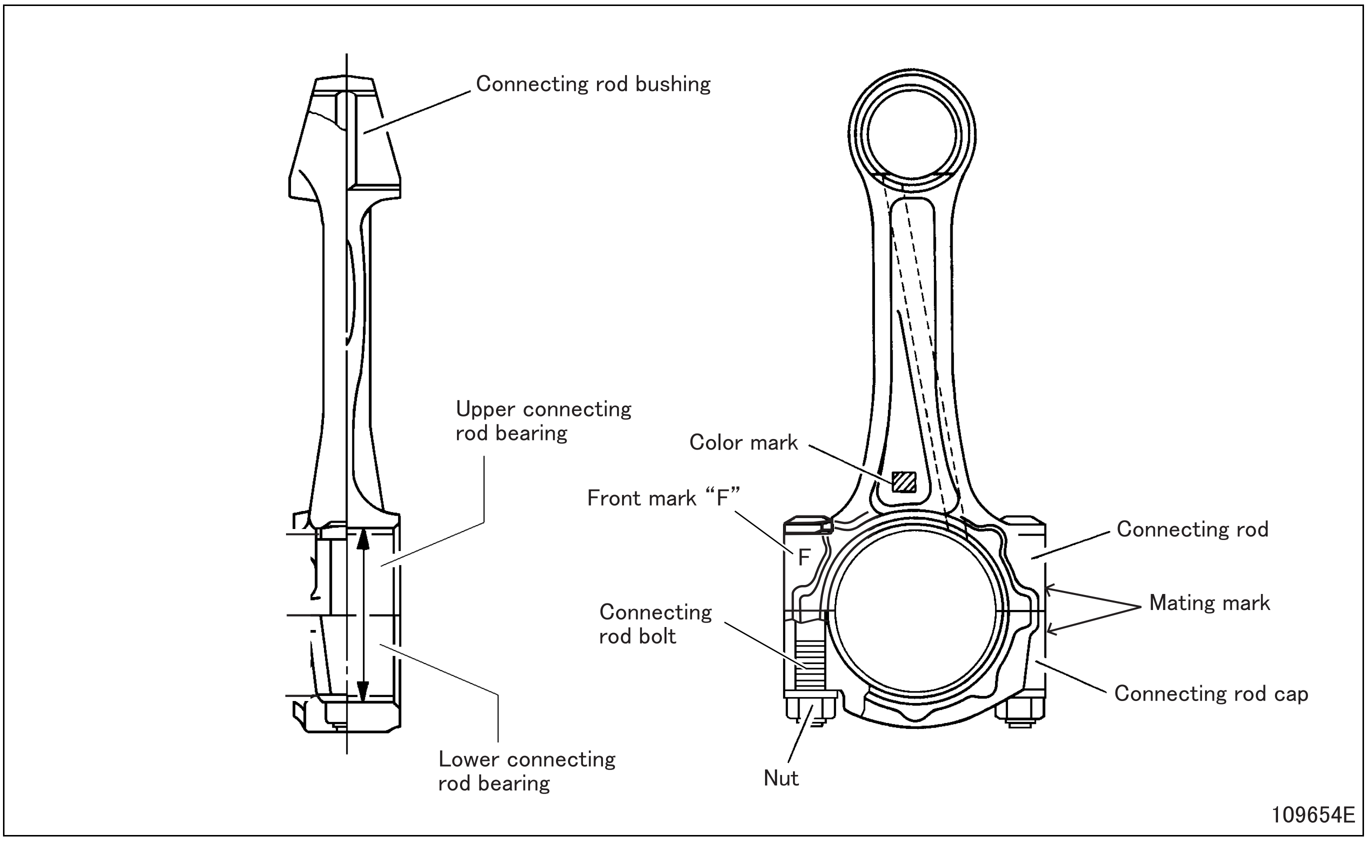
- Each timing gear has mating mark(s) "1" or "5" to ensure that it is engaged correctly with another gear during installation.



5.1 Idler gear

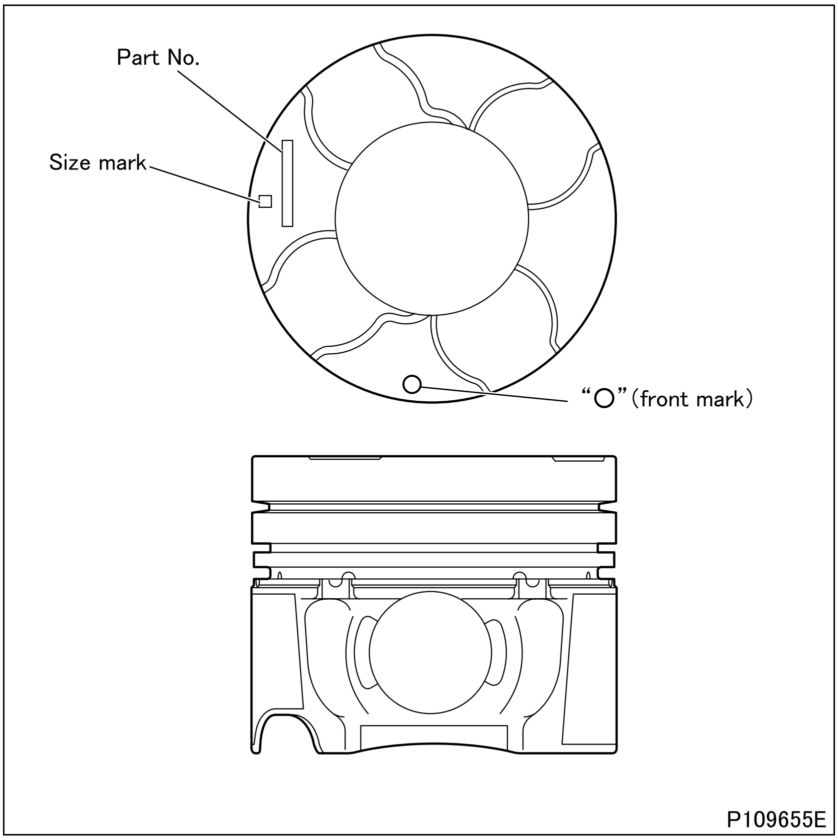
- The idler gear is press fitted into the idler sprocket, which drives the timing chain, and rotates on the idler shaft.
- The idler shaft is anchored to the crankcase using the idler washer and bolt.
  The idler sprocket is fitted with the idler bushing, which is lubricated by engine oil supplied through the oil holes drilled in the idler shaft.

6. Connecting Rod



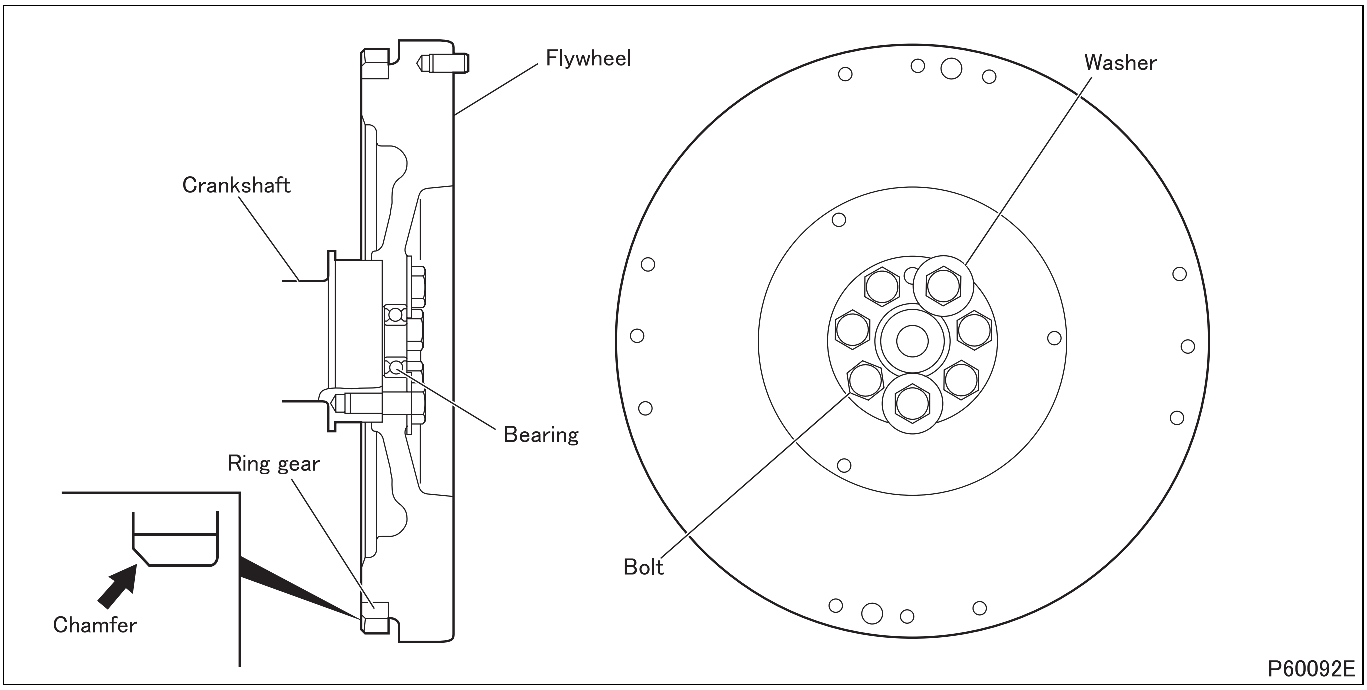
- The "F" mark indicates the assembly direction onto the piston and engine front side.
- The color mark indicates the diameter class of the large end.

7. Piston



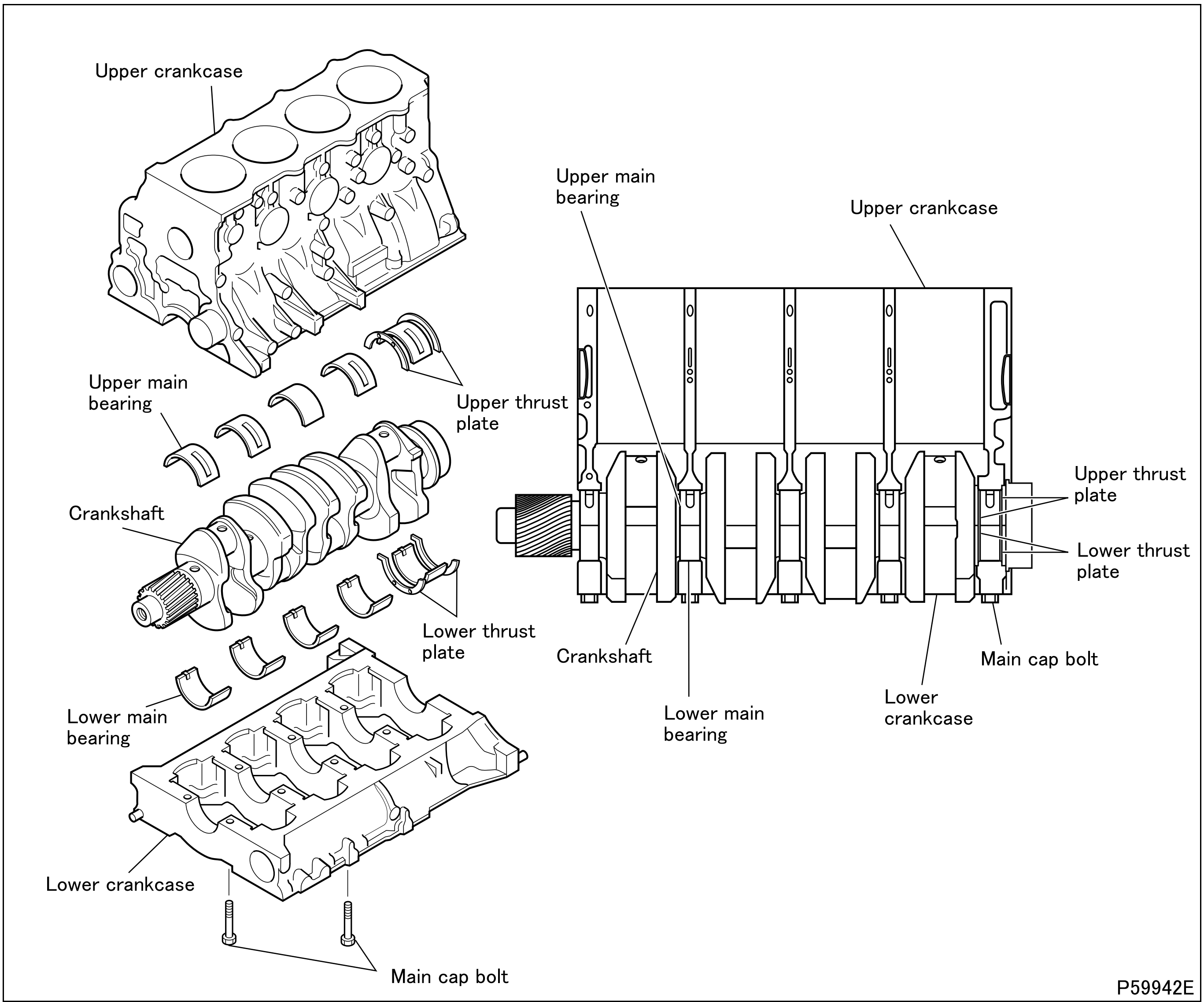
- For selective fit of the pistons with the upper crankcase, match corresponding size marks on the pistons and upper crankcase. The size marks of the pistons are "A" through "C" and the "C" marked piston has the largest outside diameter.
- Install the pistons with the front marks facing forward of the engine.

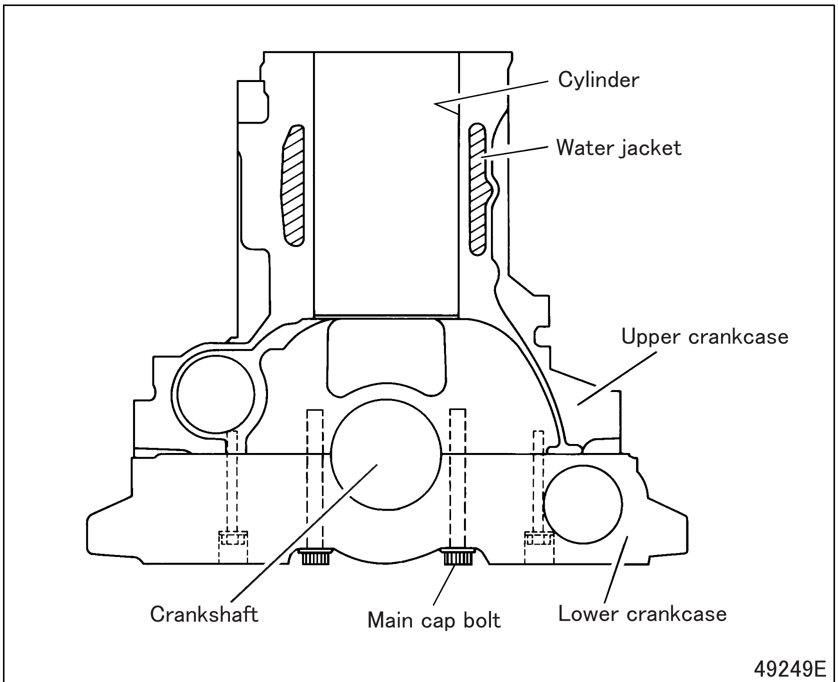
8. Flywheel



- The bearing is fitted into the flywheel and held in place by the washers.
- The peripheral edge on one side of the ring gear is chamfered for easy engagement of the gear with the starter pinion.

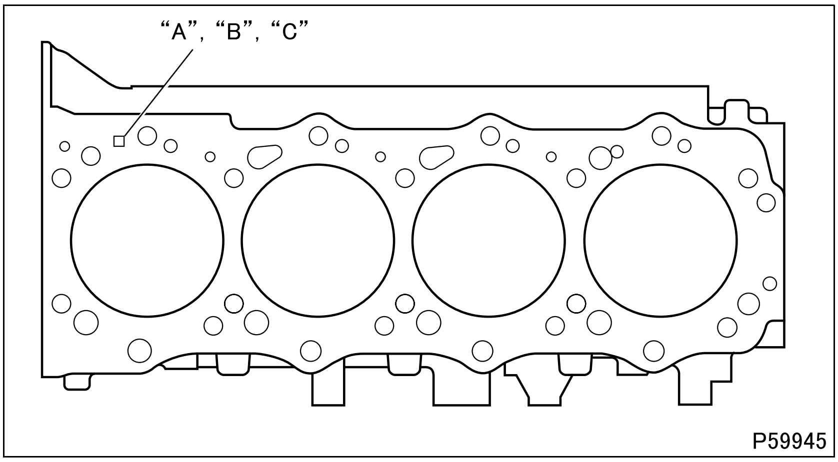
9. Crankcase, Crankshaft and Main Bearing



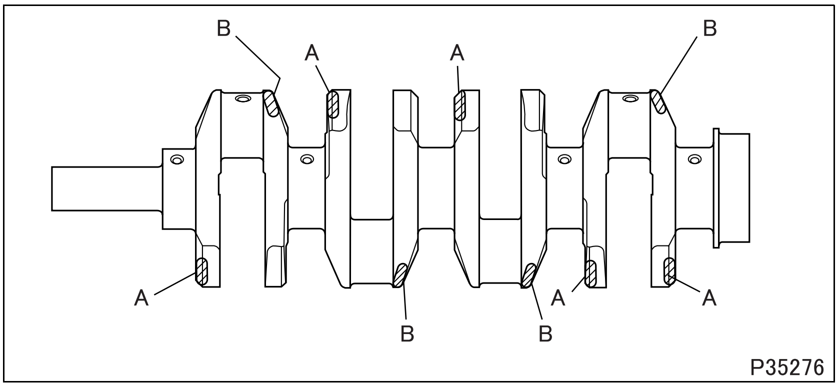


9.1 Crankcase

- The crankcase is a bi-block type consisting of an upper crankcase and a lower crankcase that are assembled to grip the crankshaft in between.
- The upper crankcase has cylinders whose surfaces are machined for direct contact with sliding pistons.
  The walls of the cylinders have water jackets for cooling the cylinders.
- The main cap bolts that hold the upper crankcase and the lower crankcase together must be tightened according to the specified procedure.

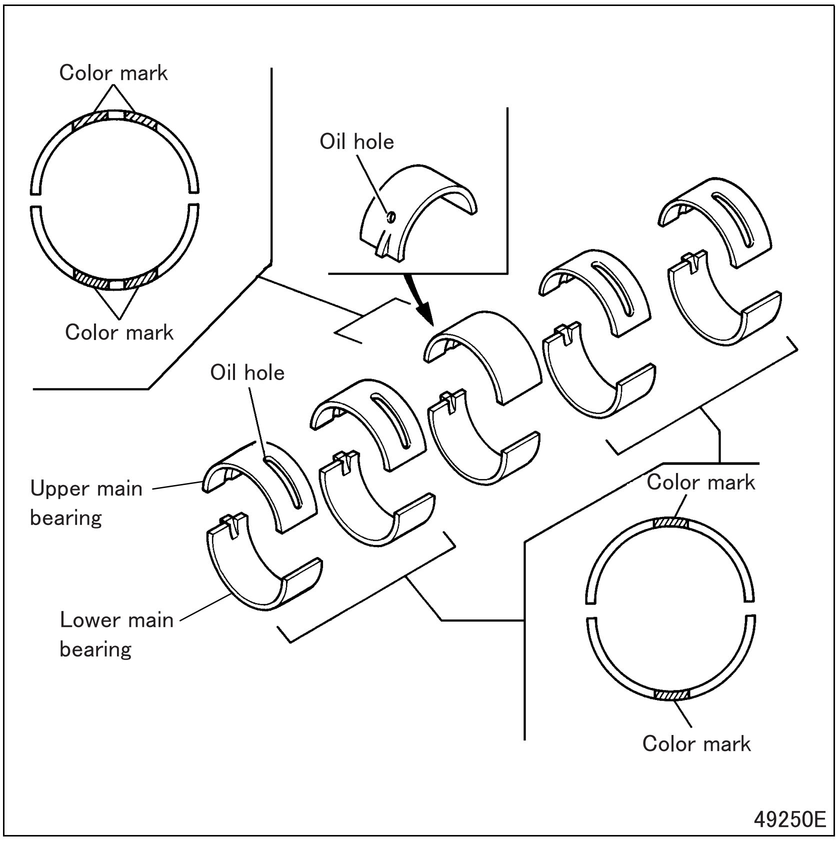


- The upper crankcase is provided with piston size marks "A", "B" and "C" stamped to help to select appropriate pistons.



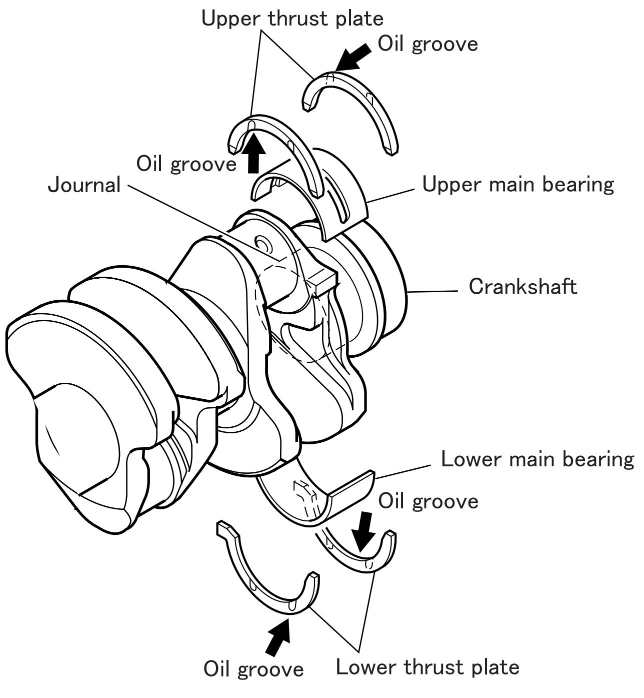
9.2 Crankshaft

- The crankshaft has two sets of color marks. Color mark A indicates the outside diameter of the journals (at five locations), and color mark B indicates the outside diameter of the pins (at four locations).



9.3 Main bearing

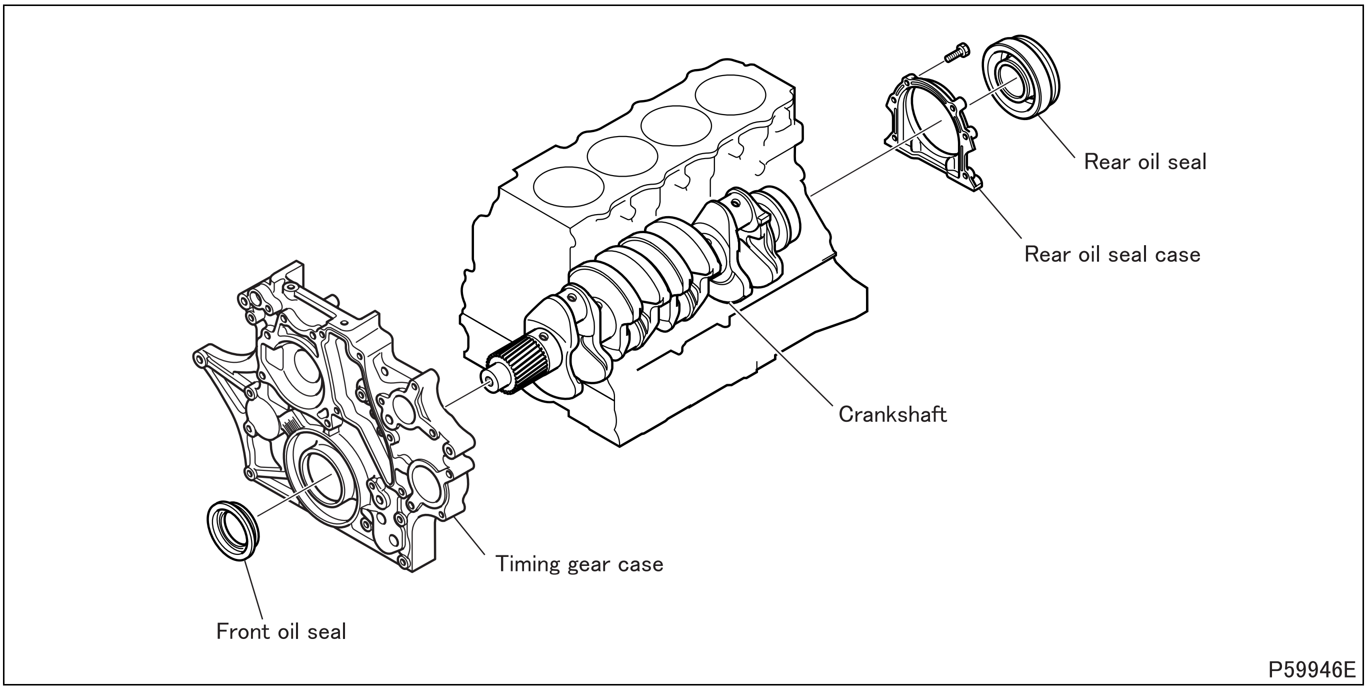
- Each upper main bearing has an oil hole, which provides a passage for engine oil to the corresponding crankshaft journal.
- Main bearings of different thickness are available so that the most appropriate ones can be selected to ensure proper clearance between them and journals.
  Bearing thickness classes are identified by color marks (red, blue and yellow) painted on the sides of the bearings.
- All the upper and lower main bearings are identical except for the No. 3 upper bearing and the No. 3 lower bearing.

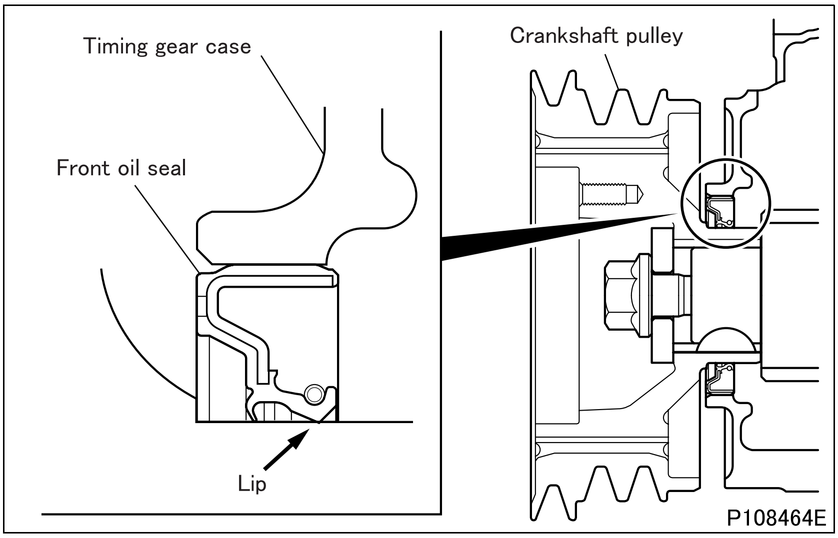


9.4 Thrust plates

- Two upper and lower thrust plate pairs are installed on both sides of the upper and lower main bearings at the rear most journal of the crankshaft.
- The thrust plates must be of a thickness that corresponds to the end play of the crankshaft.
  Each thrust plate has two oil grooves to ensure its minimum friction against the crankshaft journal.

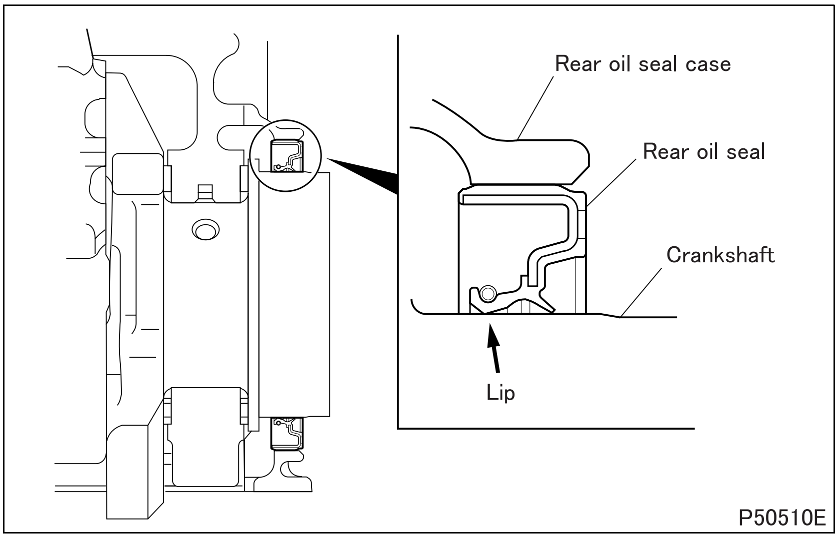
10. Oil Seal





10.1 Front oil seal

- The front oil seal is fitted in the timing gear case, and prevents oil from leaking by contact of its lip with the crankshaft pulley.



10.2 Rear oil seal

- The rear oil seal is fitted in the rear oil seal case, and prevents oil from leaking by contact of its lip with the crankshaft.

Possible causes \ Symptoms		Low power output	Abnormal engine noise	Reference Gr
Cylinder head and valve mechanism	Incorrect valve clearance	O	O	
	Defective cylinder head gasket	O	O	
	Worn valve and valve seat; carbon deposits	O	O	
	Weakened valve spring	O	O	
	Worn lifter shim		O	
Defective timing chain-related parts			O	
Timing gears	Incorrect backlash in timing gears		O	
	Poor lubrication of timing gears and idler shaft		O	
Camshaft	Excessive end play in camshaft		O	
	Worn camshaft		O	
Pistons and connecting rods	Worn/damaged piston ring groove(s)	O	O	
	Worn/damaged piston ring(s)	O	O	
	Worn piston pin and connecting rod small end		O	
Crankshaft	Excessive end play in crankshaft		O	
	Incorrectly fitted crankshaft		O	
	Worn/damaged crankshaft pins and connecting rod bearings		O	
	Worn/damaged crankshaft journals and main bearings		O	
Fuel system	Defective supply pump	O	O	Gr13
	Faulty fuel spray from injector	O	O	
	Air or water trapped in fuel system components	O		
	Irregular fuel (kerosene, heavy oil, bio-fuel, etc.) is used	O		
Cooling system	Malfunctioning cooling system	O		Gr14
	Loose/damaged belts		O	
Intake and exhaust system	Clogged air cleaner	O		Gr15
	Malfunctioning turbocharger	O	O	
	Clogged muffler	O		
Incorrect oil viscosity		O		
Incorrectly fitted piping and hoses			O	
Defective/incorrectly fitted alternator and other auxiliaries			O	

M E M O

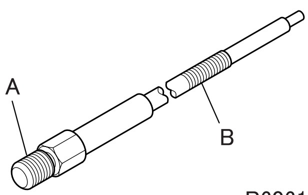
ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Measuring Compression Pressure

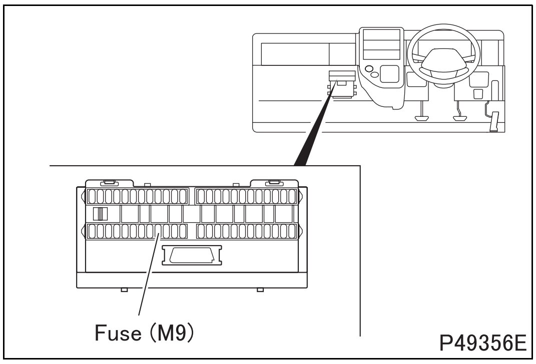
Service standards

Location	Maintenance item		Standard value	Limit	Remedy
–	Compression pressure	Each cylinder (at 220 rpm)	2840 kPa {29 kgf/cm^2}	2260 kPa {23 kgf/cm^2}	Inspect
		Cylinder-to-cylinder pressure difference	–	295 kPa {3 kgf/cm^2} or less	Inspect

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Compression gauge adaptor A: M16 × 1.5, B: M10 × 1.25 	MH063494	Measuring compression pressure

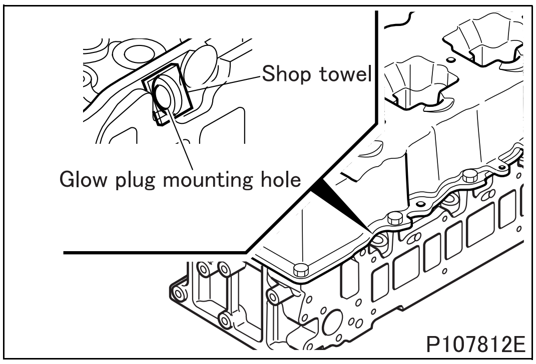
- For the hybrid electric vehicle system, there are two methods of cranking the engine, a conventional method using the starter and a method using the motor of the hybrid electric vehicle system.
- If the engine is cranked with the motor of the hybrid electric vehicle system, measurement of compression pressure may become inaccurate since the engine speed is slightly higher than when the starter is used for cranking. For this reason, engine cranking should be performed using the starter following the procedure below.
  - Turn the starter switch quickly up to the START position before the READY indicator lamp in the meter cluster illuminates. Though the indicator lamp illuminates in several seconds, the starter will keep running.
  - If the starter switch is turned to the START position after the READY indicator lamp in the meter cluster illuminates, the starter will not run and the engine is cranked with the motor of the hybrid electric vehicle system. In this case, turn the starter switch to OFF and try again.
- A drop in compression pressure can be used as a guide to determine when the engine should be overhauled.
- Measure the compression pressure at regular intervals. Keeping track of its transmission can provide a useful tool for troubleshooting. On new vehicles and vehicles with newly replaced parts, the compression pressure will be somewhat higher depending on the break-in condition of piston rings, valve seats, etc., but this will return to normal as the parts wear down.
- Before the compression measurement, check that the engine oil, starter, and battery are in normal condition.
- Place the vehicle in the following conditions.
  - Warm up the engine until the coolant temperature reaches approximately 80 to 90°C.
  - Turn off the lights and auxiliaries.
  - Place the transmission shift lever into the N position.
  - Place the steering wheel in the straight-ahead position.



- Remove the fuse (M9) to prevent fuel from being injected when the engine is cranked by the starter.

CAUTION ⚠

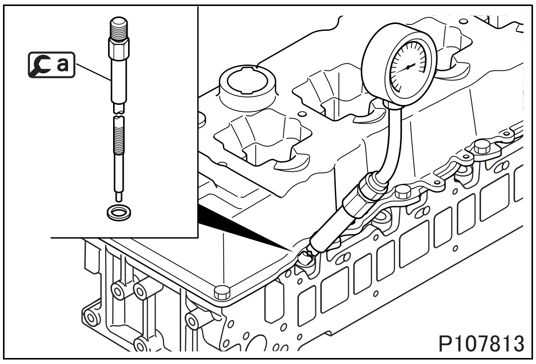
- **When cranking the engine, never shut off the power to the engine electronic control unit by disconnecting the engine electronic control unit connector or the like.**
  If the engine is cranked while shutting off the power to the engine electronic control unit, the electronic control unit cannot control the supply pump and this may cause failure to the pump.



- Remove all glow plugs.
- Cover the glow plug mounting holes with shop towels. After cranking the engine with the starter, check that no foreign substances are deposited on the shop towels.
- If there are deposits (such as engine oil or coolant) on the shop towels, the following may be the cause:
  - Deposits of engine oil alone can mean a defective piston ring seal; the piston rings must be inspected.
  - Deposits of both engine oil and coolant can mean cracks in the cylinders or cylinder head; the crankcase or cylinder head must be replaced.

WARNING ⚠

- **When coolant and engine oil deposits are evident, cranking the engine could be dangerous as these substances, heated to high temperatures, will blow out from the glow plug mounting holes. Make sure to stay away from the glow plug mounting holes when the engine is being cranked.**



- Attach a to one of the glow plug mounting holes and then attach a compression gauge.
- Crank the engine and measure the compression pressure for all the cylinders one after another. Determine the compression pressure difference between the cylinders.
- If the compression pressure and the cylinder-to-cylinder pressure difference are not within the limit, pour a small amount of engine oil into the corresponding glow plug mounting hole and remeasure the compression pressure.
  - If the compression pressure increases, the piston rings and cylinder surfaces may be badly worn or otherwise damaged.
  - If the compression pressure remains unchanged, there may be seizure in the valves, the valves may be incorrectly seated or the cylinder head gasket may be defective.
  - Install the glow plugs. (See later sections.)

2. Inspection and Adjustment of Valve Clearance

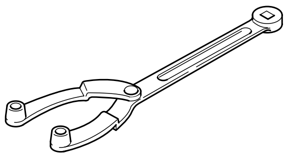
Service standards (Unit: mm)

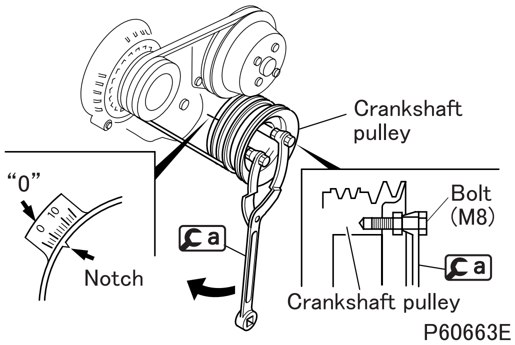
Location	Maintenance item		Standard value	Limit	Remedy
–	Valve clearance (when engine is cold)	Intake valve	0.1	–	Adjust
		Exhaust valve	0.15	–	Adjust

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Lock nut (adjusting screw mounting)	9 to 10 {0.9 to 1.1}	–

Special tools

Mark	Tool name and shape	Part No.	Application
a	Front hub and flange yoke holder  P07413	MB990767	For cranking the engine



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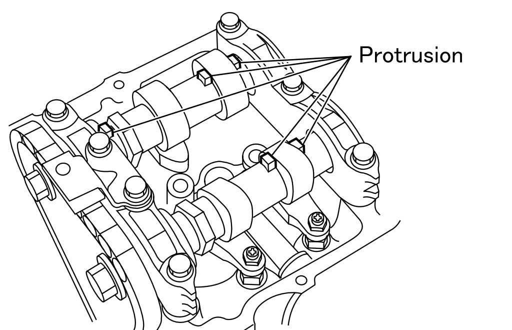


P59947E

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

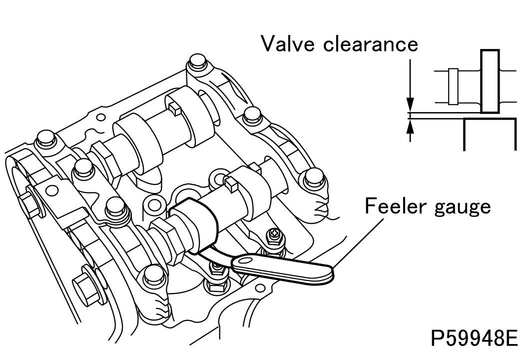
[Inspection]

- Remove the rocker cover.
- Bring the No. 1 or No. 4 cylinder piston to the top dead center (TDC) on the compression stroke according to the following procedure:
  - Rotate the crankshaft pulley in the illustrated direction so that the notch on the crankshaft pulley is aligned with the "0" mark on the timing gear case.

CAUTION ⚠

- **Do not turn the crankshaft pulley in the opposite direction to the illustrated one (counterclockwise), as this may cause damage to the tensioner that is adjusting the tension of the timing chain on the timing gear. If you turn the crankshaft pulley in the wrong direction by mistake, remove and reinstall the chain tensioner.**

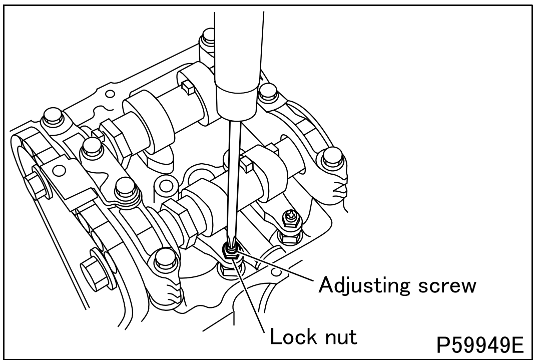
  - This will place either the No. 1 or No. 4 cylinder piston at TDC on the compression stroke. When the protrusion on the camshaft is facing upward the No.1 piston is at TDC. Rotate the engine by one full turn to switch the TDCs of the No. 1 and No. 4 cylinder pistons.



- With the No. 1 or No. 4 cylinder piston at TDC, measure the clearance of the valves marked with a circle in the table below.

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

- The feeler gauge must have a slight drag when taking measurements.
- If the feeler gauge can be moved without any resistance, the measurement will be incorrect.
- If the measurements are not within the standard value range, adjust the valve clearance via the following procedures.



[Adjustment]

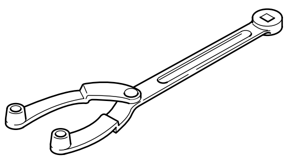
- For valve clearance adjustment, loosen the lock nut and turn the adjusting screw so that the feeler gauge moves with some resistance.
- After the adjustment, hold the adjusting screw in place with a screwdriver and tighten the lock nut to the specified torque. Inspect the valve clearance again with the feeler gauge.
- After the inspection, install the rocker cover and the gasket. (See later sections.)

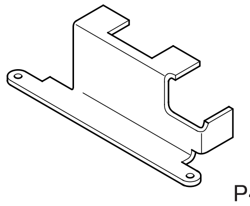
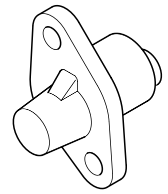
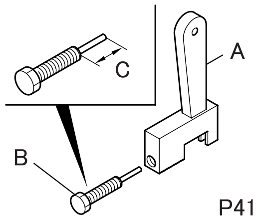
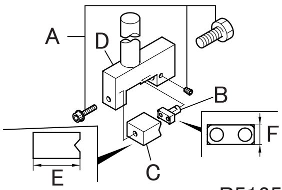
3. Inspection and Replacement of Timing Chain

Service standards (Unit: mm)

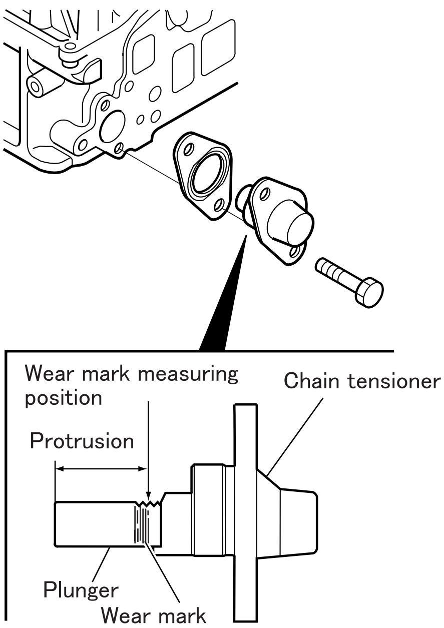
Location	Maintenance item	Standard value	Limit	Remedy
–	Protrusion of chain tensioner’s plunger	–	20	Replace timing chain

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Front hub and flange yoke holder  P07413	MB990767	Cranking the engine

Mark	Tool name and shape	Part No.	Application
b	Fixture tool  P41857	*MH063678	Replacement of timing chain
c	Dummy tensioner  P41858	*MH063554	
d	Chain disassembly tool A: Body B: Slider C: 13.5  P41859	*MH063555 A: MH063556 B: MH063558	
e	Riveting tool A: Set bolt B: Punch C: Die D: Holder E: 18, F: 9.6  P51355	*MH063559 A: MH063563 B: MH063565 C: MH063564 D: MH063560	

Tools marked with * are components of the timing chain tool set (MH063679).



P107555E

[Inspection]

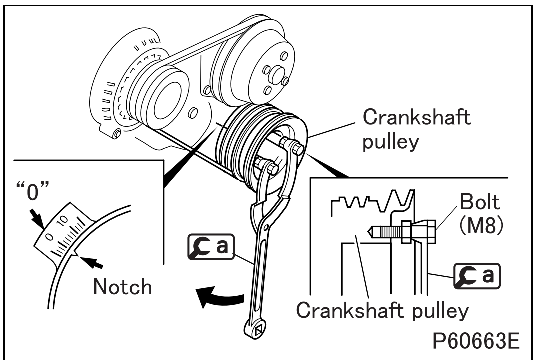
- Perform the following inspections. If there is any abnormality, replace the timing chain.

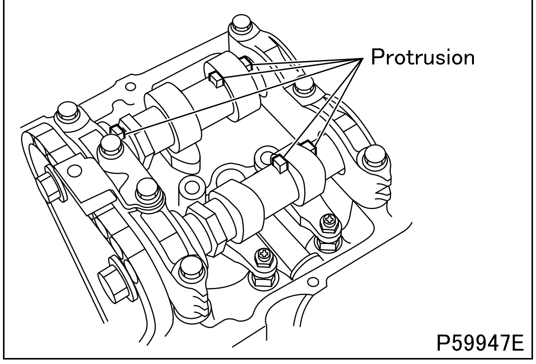
(1) Noise

- Run the engine and check for any abnormal noise caused by interference between piston and valve.
- If abnormal noise is heard, check the pistons and valves for possible interference. (See “CYLINDER HEAD AND MECHANISM” and “PISTON AND CONNECTING ROD”.)

(2) Protrusion of chain tensioner’s plunger

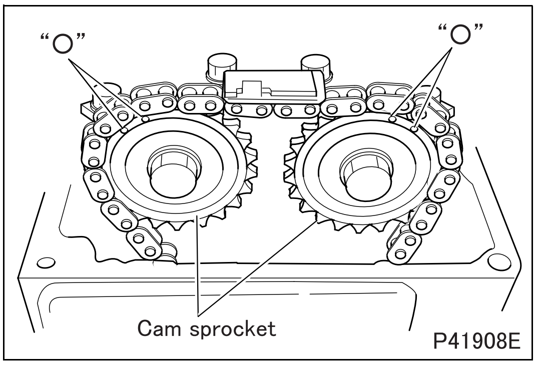
- Measure the protrusion of the chain tensioner’s plunger to determine the elongation of the timing chain.
- Remove the chain tensioner from the cylinder head. The plunger is bounced a little out of the chain tensioner by the spring inside. Prevent the plunger from falling.
- Measure the distance from the forward end of the plunger to the farthest wear mark. If the measured value exceeds the specified limit, replace the timing chain.



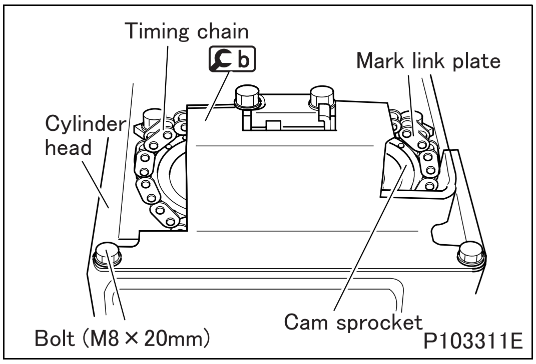


[Replacement]

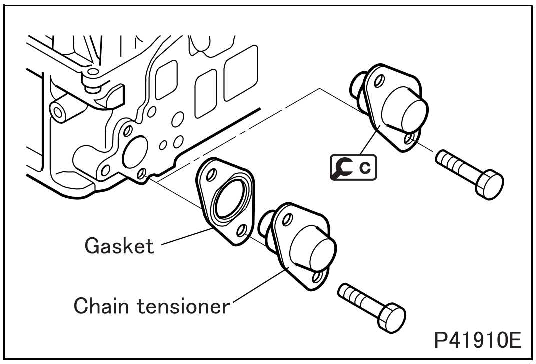
- Remove the fan coupling, front engine hanger and rocker cover.
- To check the timing position, rotate the crankshaft pulley clockwise with a and align the timing mark "0" on the timing gear case with the notch on the crankshaft pulley to bring the No. 1 cylinder piston to the top dead center (TDC) on the compression stroke. The No. 1 cylinder piston is at TDC if the protrusion on the camshaft is facing upward.



- With the No. 1 cylinder piston at TDC, check that the two mating marks " O " on the cam sprocket are at the illustrated positions.



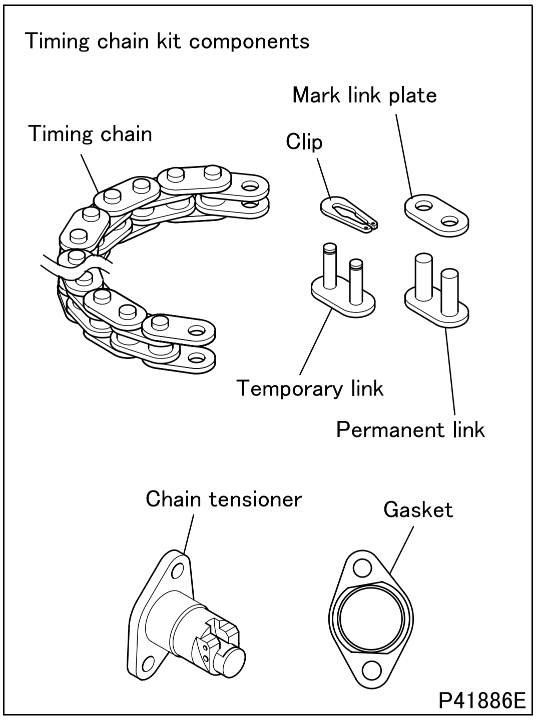
- Install b on the cylinder head and tighten the bolts (M8 × 20 mm) firmly.
- Crank the engine by hand and bring the mark link plate (one plate) of the timing chain to the illustrated position of the cam sprocket.

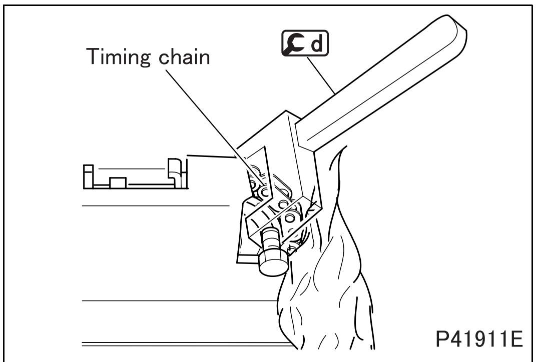


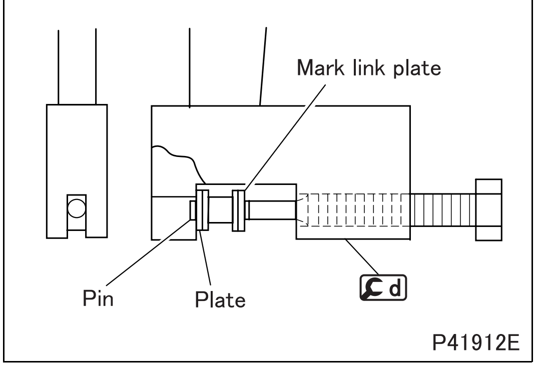
- Remove the chain tensioner and its gasket from the cylinder head.
- Install c on the cylinder head.

CAUTION ⚠

- **Fill the space around the timing chain with shop towels to prevent parts from falling into the timing gear case.**



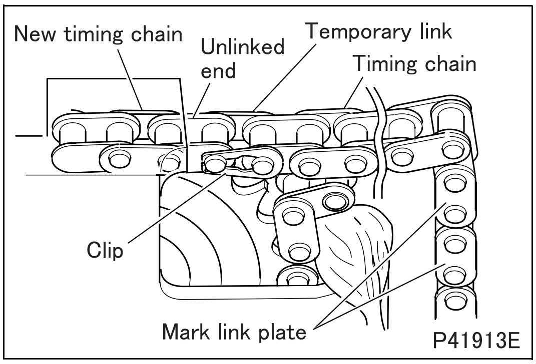




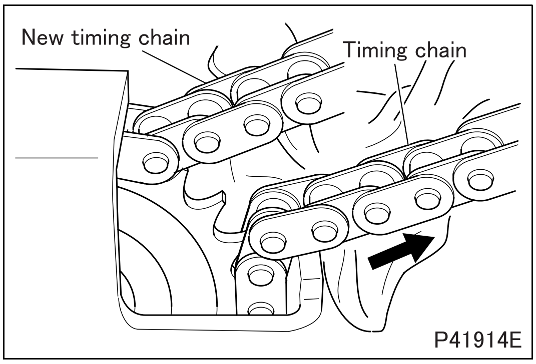
- Using d, remove the pins of the mark link plate (one plate) from the timing chain. Then, remove the mark link plate and the plate from the timing chain.
- If the pins are difficult to remove, press them out by inserting the temporary link of the timing chain kit into the pin holes from the front side of the engine.

CAUTION ⚠

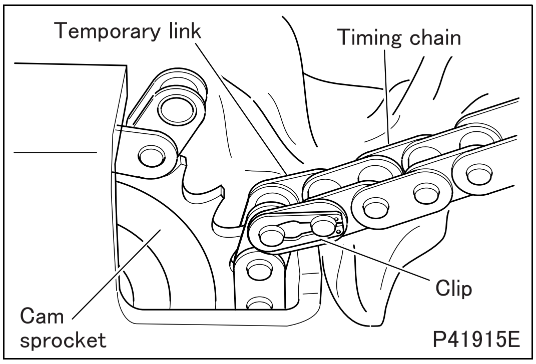
- **Do not mix up the mark link plate, pins and plates of the timing gear with those of the timing chain kit.**



- With the mark link plate (two plates) of the new timing chain facing the front of the engine, connect the new timing chain with the unlinked end of the old timing chain using a temporary link and clip.
- Remove the shop towels from the timing chain.



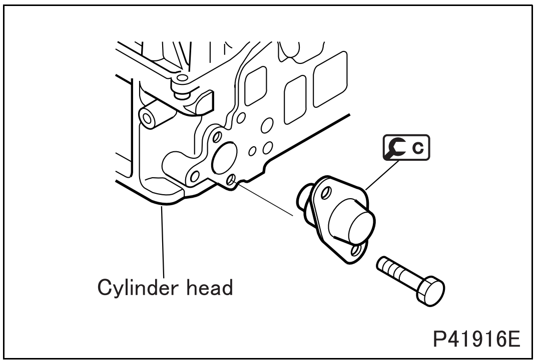
- Slowly crank the engine by hand in the normal direction to rotate the timing chain so that the new timing chain takes the place of the old one.



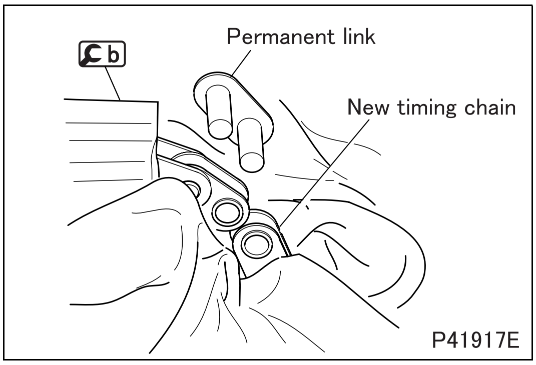
- Stop cranking when the old timing chain is completely delivered and the temporary link comes to the illustrated position of the cam sprocket.
- Fill the space around the timing chain with shop towels again. Remove the temporary link and the timing chain.

CAUTION ⚠

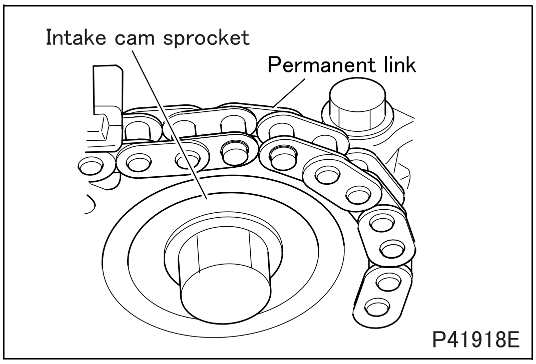
- **When the temporary link and clip are removed, discard them so as not to mix them with the timing chain kit.**



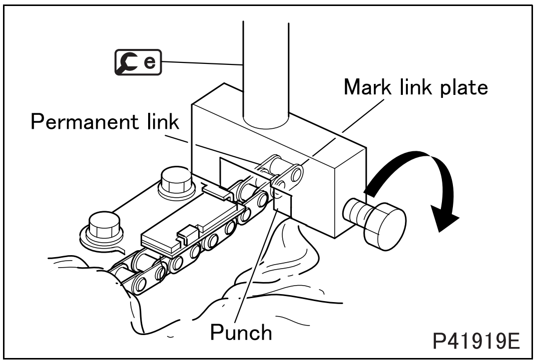
- Remove c from the cylinder head.



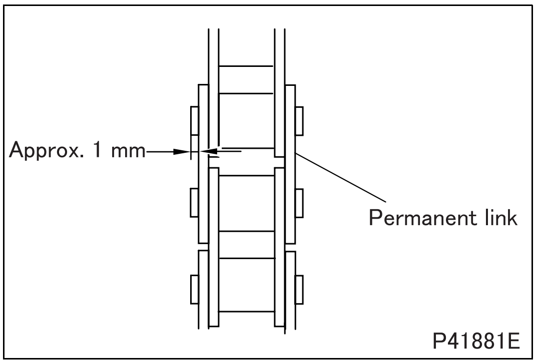
- Install a permanent link from the rear of the engine to connect the two ends of the new timing chain.
- Remove b.



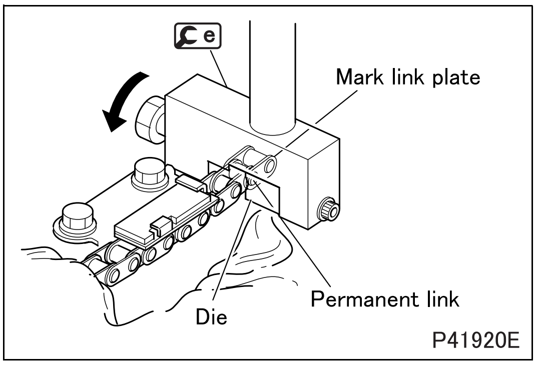
- Crank the engine by hand until the permanent link comes to the illustrated position of the intake cam sprocket.



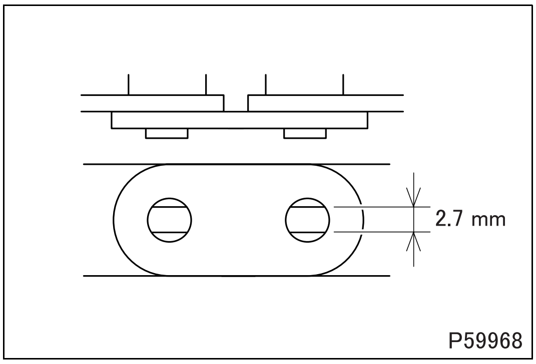
- Attach a mark link plate onto the punch of e.
- Align the pins of the permanent link with the holes on the mark link plate to set e.
- Tighten the bolt of e until it cannot be tightened any further.



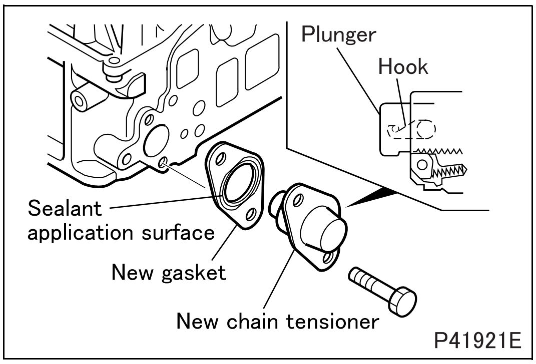
- Check that the pins of the permanent link project by the amount indicated in the illustration.



- Turn e around 180 degrees and mount it so that the die is aligned with the mark link plate.
- Tighten the bolt of e to approximately 64 N·m {6.5 kgf·m} and flatten the end of each pin of the permanent link.



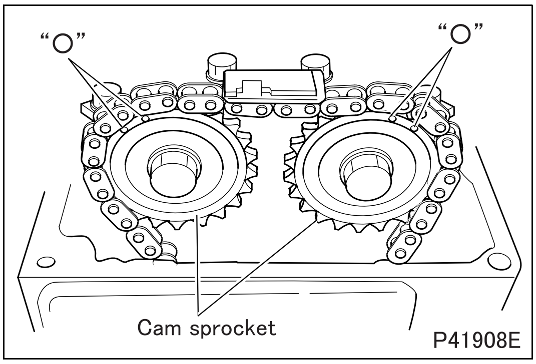
- Check that the pin ends are flattened to the width indicated in the illustration.
- Remove the shop towels from the timing chain.



- Check that the new chain tensioner's plunger is locked in place by the hook, then install it to the cylinder head with the new gasket. Make sure the sealant application surface of the gasket.
- Crank the engine in the normal direction (clockwise as viewed from the front of the engine). This unhooks the plunger, allowing the tension of the timing chain to be adjusted by the internal ratchet mechanism.

CAUTION ⚠

- **After the chain tension is installed, if the engine is reversed (counterclockwise as viewed from the front of the engine), an excessive thrust is imparted to the plunger, possibly causing damage to the cam. In case the engine is reversed, remove and check the chain tensioner. Reinstall it if there is no abnormality.**

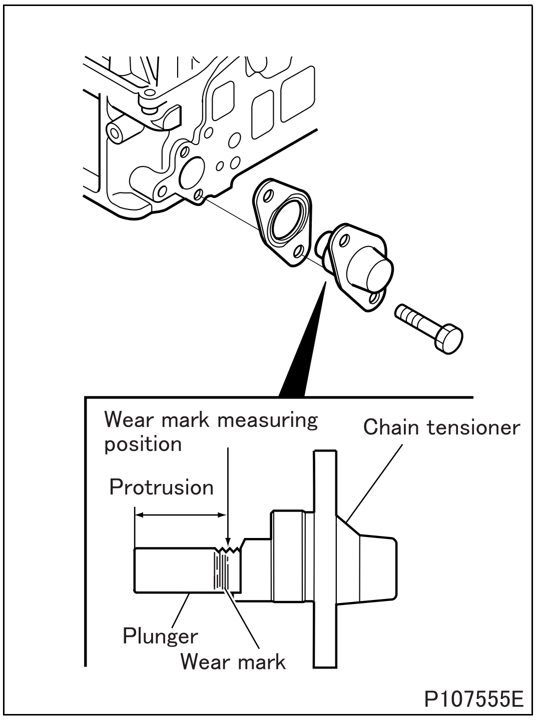


- With the No. 1 cylinder piston at TDC, check that the mating marks "○" on the cam sprocket are at the same place as before.
- Install the rocker cover and fan coupling.

4. Protrusion of Timing Chain Tensioner's Plunger

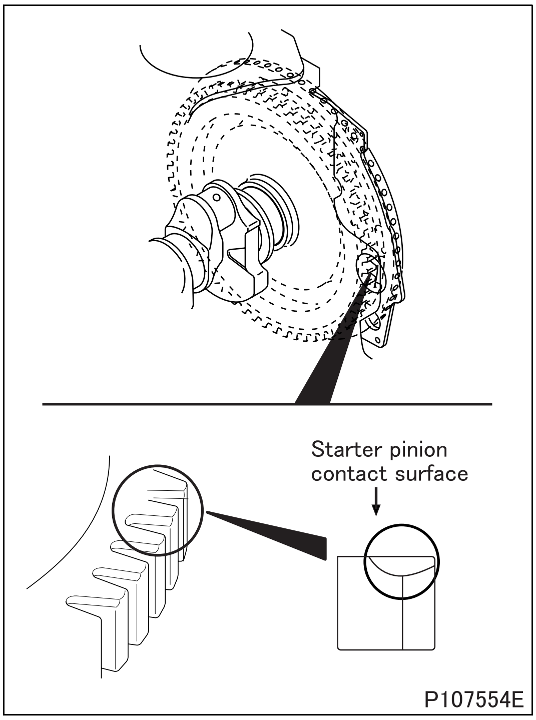
Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
–	Protrusion of timing chain tensioner's plunger	–	20	Replace



- Measure the protrusion of the chain tensioner's plunger to determine the elongation of the timing chain.
- Remove the chain tensioner from the cylinder head. The plunger is bounced a little out of the chain tensioner by the spring inside. Prevent the plunger from falling.
- Measure the distance from the forward end of the plunger to the farthest wear mark.
- If the measured value exceeds the specified limit, replace the timing chain. (See "ON-VEHICLE INSPECTION AND ADJUSTMENT", "3. Inspection and Replacement of Timing Chain".)

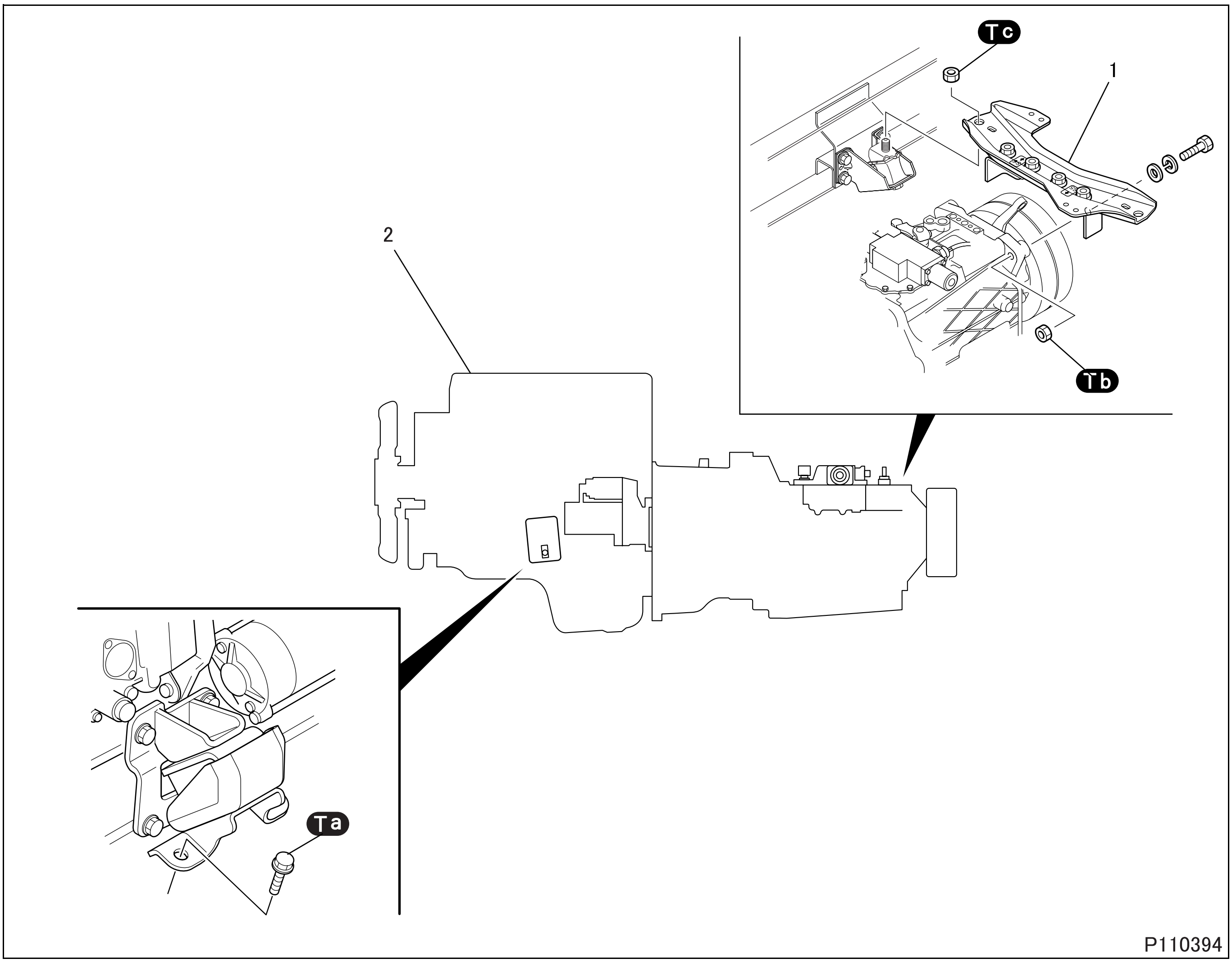
5. Damage to the Starter Pinion Contact Surface of Ring Gear



- Remove the starter from the engine. (See Gr54.)
- Visually examine the starter pinion contact surface of the ring gear for crack and other damage from the starter mounting hole.
- If there is any cracks or damages, replace the ring gear.
(See “FLYWHEEL”.)

M E M O

ENGINE REMOVAL AND INSTALLATION



CAUTION ⚠

- **Hoist the engine using care not to strike it against the cab and rear body.**
- **Only use hoisting equipment appropriate for the engine and transmission mass (approximately 510 kg).**

● Disassembly sequence

1 Transmission mounting support
2 Engine and transmission

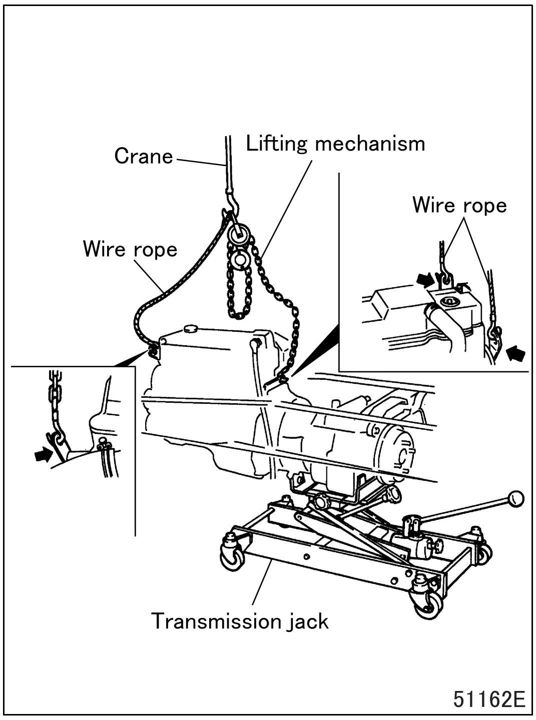
● Assembly sequence

Follow the disassembly sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

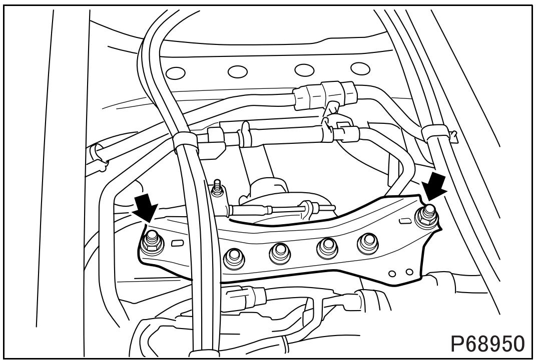
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (front mounting installation)	50 to 65 {5.1 to 6.6}	–
Tb	Nut (transmission mounting support installation)	130 to 170 {13 to 17}	–
Tc	Nut (transmission mounting support installation)	220 to 300 {22.4 to 30.6}	–

◆Removal procedure◆

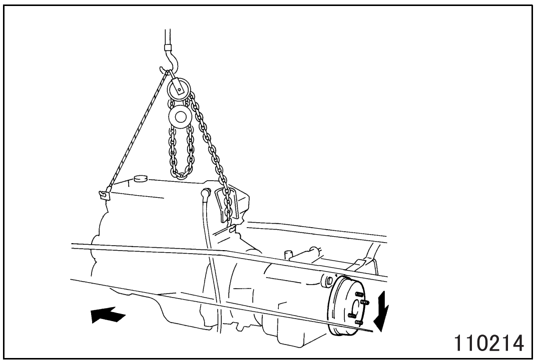


■ **Removal: Engine and transmission**

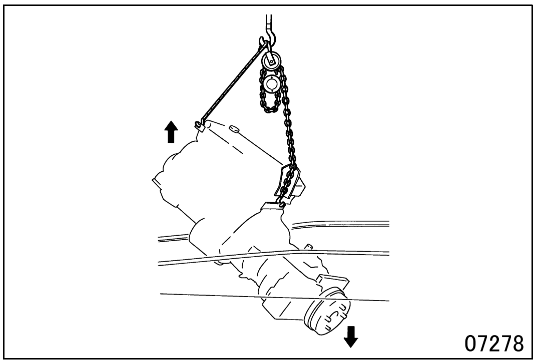
- Hook the wire rope and lifting mechanism each onto the three hangers on the engine and lift the engine with a crane until they are tight.
- Support the transmission with the transmission jack.
- Check that all wiring and piping have been disconnected from the engine.



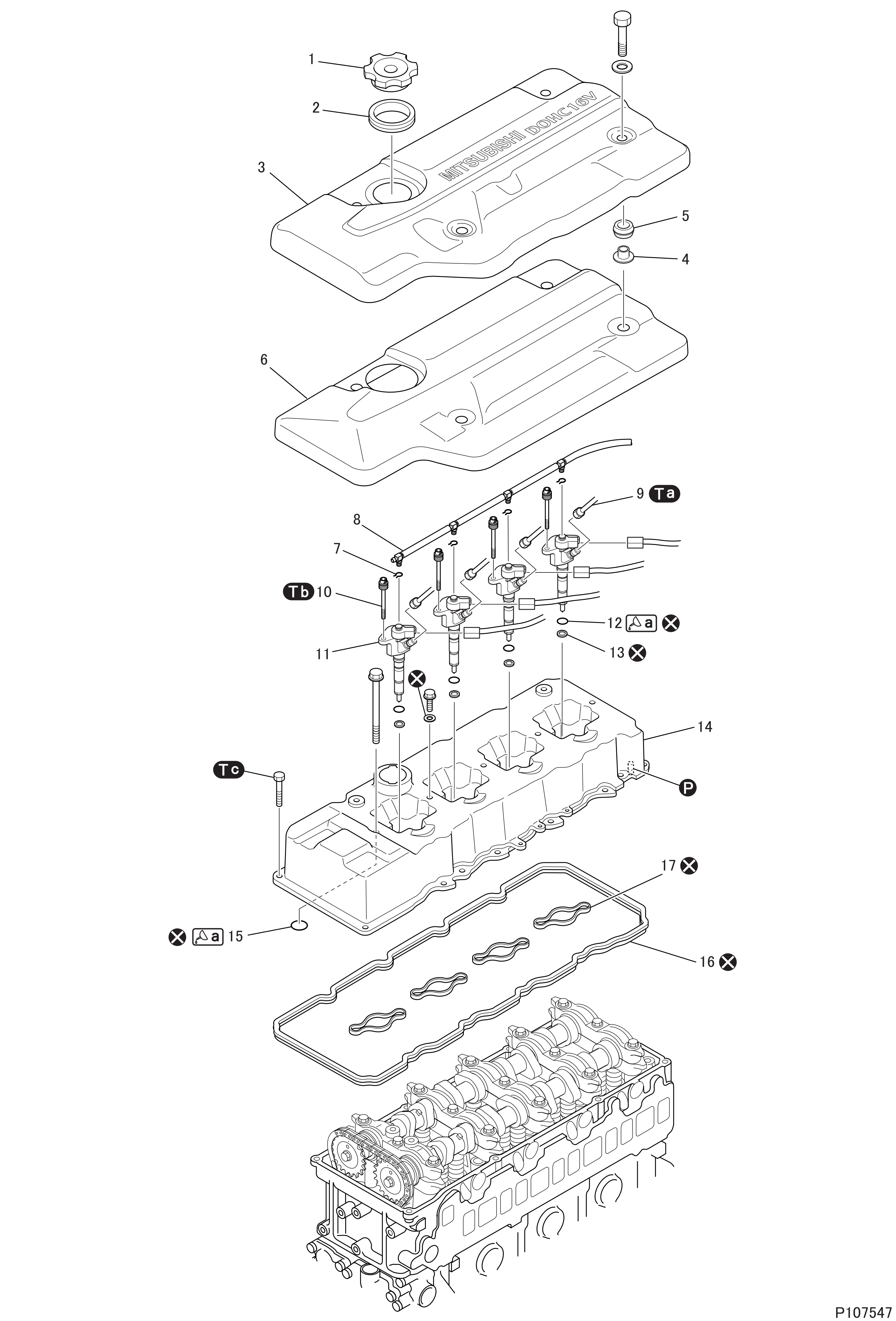
- Remove the engine rear support.



- Push down the transmission part of the assembly, and then move the engine and transmission assembly forward.



- Once the transmission is out of the front end of the rear body, turn the engine and transmission assembly 90 degrees to the right so as to prevent the assembly from hitting the frame and cab, and lower it to the right side of the vehicle. Make fine adjustments to the hoisting equipment as necessary.



1
2
3
MITSUBISHI DOHC16V
5
4
6
9 Ta
8
7
Tb 10
12 a
11
13
14
Tc
P
17
15 a
16
P107547

● Disassembly sequence

1 Oil filler cap
2 Grommet
3 Cover
4 Spacer
5 Insulator
6 Rocker cover rubber
7 Snap ring
8 Fuel return hose
9 Injection pipe (See Gr13.)
10 Bolt (with hexagonal hole)
11 Injector (See Gr13.)
12 O-ring
13 Tip gasket
14 Rocker cover
15 O-ring
16 Rocker cover gasket A
17 Rocker cover gasket B

P: Locating pin
⊗: Non-reusable parts

WARNING ⚠

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

CAUTION ⚠

- **When removing the injectors, be careful not to hit them with the tools etc.**
- **To help prevent fuel injection problems, keep the injector and injection pipe free from contamination.**

- Before removing the injectors, check that the injector mounting holes are clear of trapped water, oil and any other substances.

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Be sure to tighten the injector mounting bolts to the specified torque. Overtightening the bolts can deform the injectors, resulting in incorrect fuel injection.**

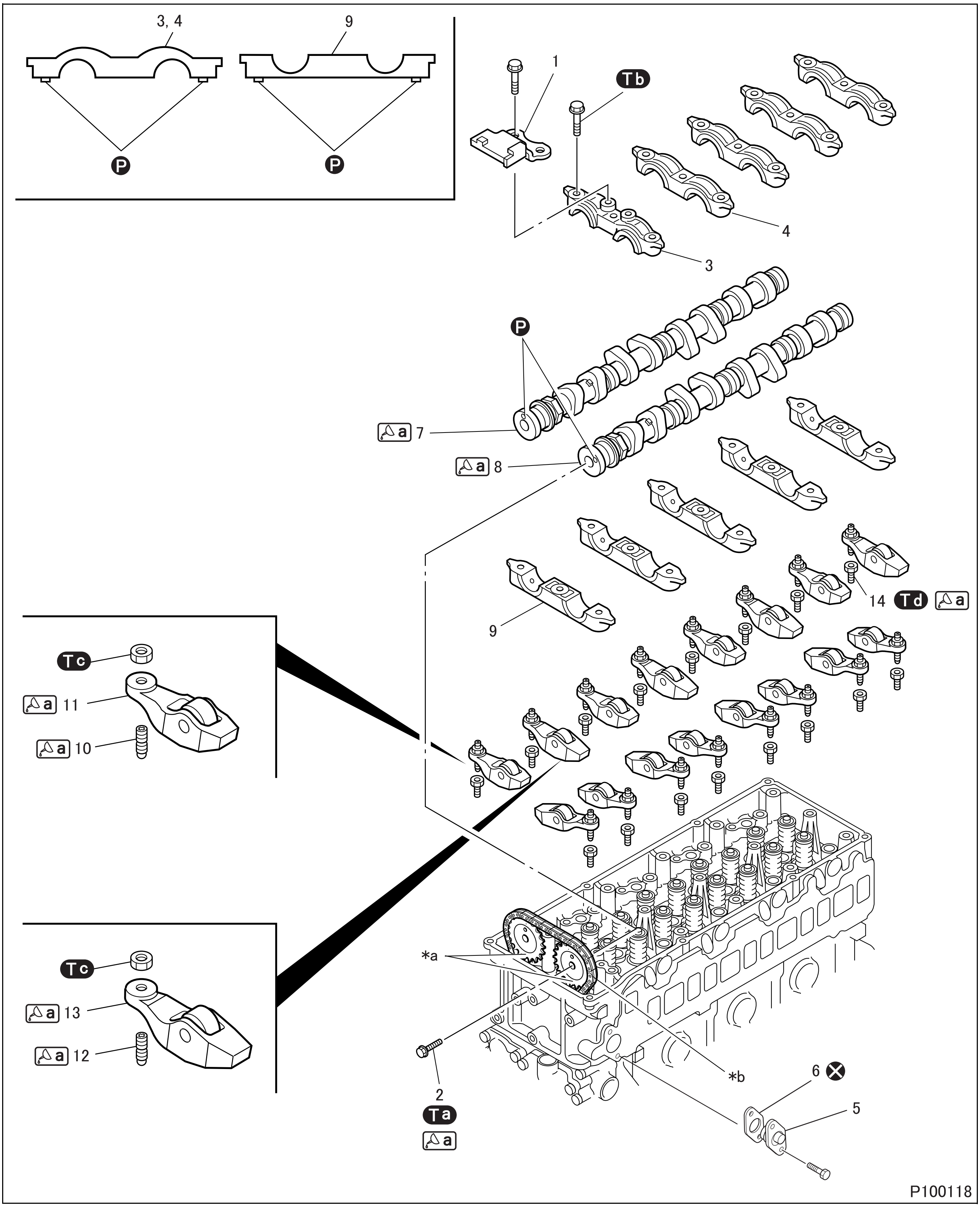
Tightening torques (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Injection pipe	30.4 to 35 {3.1 to 3.6}	–
Tb	Bolt (injector mounting)	5.2 to 7.2 {0.53 to 0.73}	–
Tc	Bolt (rocker cover mounting)	5 ± 1 {0.5 ± 0.1}	–

Lubricant and/or sealant

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

CAMSHAFT HOLDER AND CAMSHAFT



● Disassembly sequence

1	Upper guide plate	**8**	Intake camshaft	***a**:	Cam sprocket
2	Bolt	**9**	Camshaft holder	***b**:	Timing chain
3	No. 1 camshaft cap	**10**	Adjusting screw	Ⓟ:	Locating pin
4	Camshaft cap	**11**	Short rocker	⊗:	Non-reusable parts
5	Chain tensioner	**12**	Adjusting screw		
6	Gasket	**13**	Long rocker		
7	Exhaust camshaft	**14**	Pivot bolt		

CAUTION ⚠

- **Each camshaft cap and camshaft holder are processed as a pair. Do not replace only one of the two. Never change the combination.**

● Assembly sequence

Follow the disassembly sequence in reverse.

Service standards (Unit: mm)

<table>
<tr><th>Location</th><th colspan="4">Maintenance item</th><th>Standard value</th><th>Limit</th><th>Remedy</th></tr>
<tr><td>–</td><td colspan="4">End play of camshaft</td><td>0.10 to 0.18</td><td>0.3</td><td>Inspect</td></tr>
<tr><td rowspan="6">7</td><td rowspan="6">Exhaust camshaft</td><td rowspan="4">Difference between major axis and minor axis</td><td rowspan="2">Short rocker side</td><td>Major axis: 39.913</td><td rowspan="2">5.913</td><td rowspan="2">5.86</td><td rowspan="2">Replace</td></tr>
<tr><td>Minor axis: 34</td></tr>
<tr><td rowspan="2">Long rocker side</td><td>Major axis: 39.163</td><td rowspan="2">6.163</td><td rowspan="2">6.11</td><td rowspan="2">Replace</td></tr>
<tr><td>Minor axis: 33</td></tr>
<tr><td colspan="3">Bend</td><td>0.015</td><td>0.03</td><td>Replace</td></tr>
<tr><td colspan="3">Oil clearance at journals</td><td>0.05 to 0.086</td><td>0.15</td><td>Replace</td></tr>
<tr><td rowspan="6">8</td><td rowspan="6">Intake camshaft</td><td rowspan="4">Difference between major axis and minor axis</td><td rowspan="2">Long rocker side</td><td>Major axis: 40.160</td><td rowspan="2">6.160</td><td rowspan="2">6.11</td><td rowspan="2">Replace</td></tr>
<tr><td>Minor axis: 34</td></tr>
<tr><td rowspan="2">Short rocker side</td><td>Major axis: 39.102</td><td rowspan="2">6.102</td><td rowspan="2">6.05</td><td rowspan="2">Replace</td></tr>
<tr><td>Minor axis: 33</td></tr>
<tr><td colspan="3">Bend</td><td>0.015</td><td>0.03</td><td>Replace</td></tr>
<tr><td colspan="3">Oil clearance at journals</td><td>0.05 to 0.086</td><td>0.15</td><td>Replace</td></tr>
<tr><td>11, 13</td><td colspan="4">Clearance at rocker roller in radial direction</td><td>0.024 to 0.058</td><td>–</td><td>Replace</td></tr>
</table>

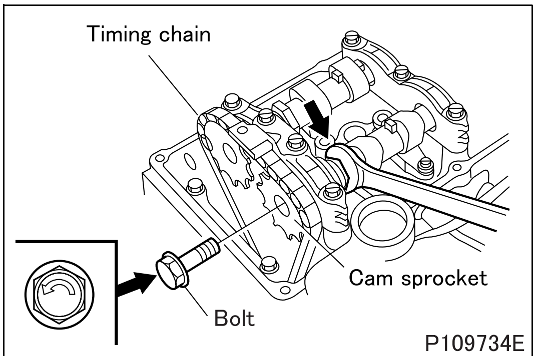
Tightening torques (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (cam sprocket mounting)	88 {9.0}	Wet (left hand thread)
Tb	Bolt (camshaft cap mounting)	18.6 to 20.6 {1.9 to 2.1}	–
Tc	Lock nut (adjusting screw mounting)	9 to 10 {0.9 to 1.1}	–
Td	Pivot bolt	30 to 46 {3.1 to 4.7}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Threads and seating surfaces of bolt (cam sprocket mounting)	Engine oil	As required
	Cam, journals and thrust surface of No. 1 journal of camshaft		
	Rocker roller		
	Sphere of adjusting screw		
	Concave of pivot bolt		

◆Removal procedure◆



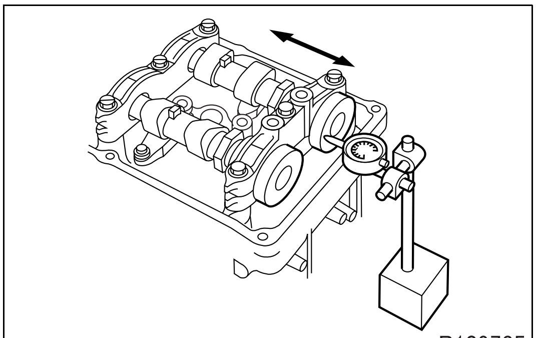
P109734E

■ Removal: Cam sprocket

- Bring the No. 1 cylinder piston to the top dead center (TDC) on the compression stroke. Make sure that the camshaft cam faces up in this position.
- After holding on the hexagonal portion of the camshaft to prevent it from turning, loosen the bolt to remove the cam sprocket.

CAUTION ⚠

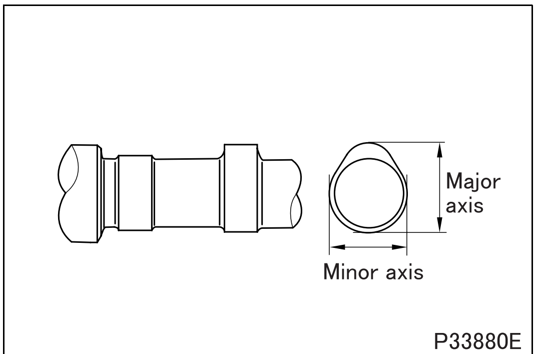
- **When removing the bolt, do not use the timing chain for the stopper.**
- **The bolt has a left-hand thread and has an arrow on its top that indicates the direction for tightening the bolt. To remove the bolt, turn it in the direction opposite to the arrow.**
- **The cam sprocket and the timing chain have the positional relation for installation. Keep the cam sprocket attached to the timing chain unless absolutely necessary.**


P109735

■ Inspection: End play of camshaft

- Attach a dial gauge to the rear of the engine and measure end play of the camshaft.
- If the measurement exceeds the limit, replace the defective part(s).

◆Inspection procedure◆

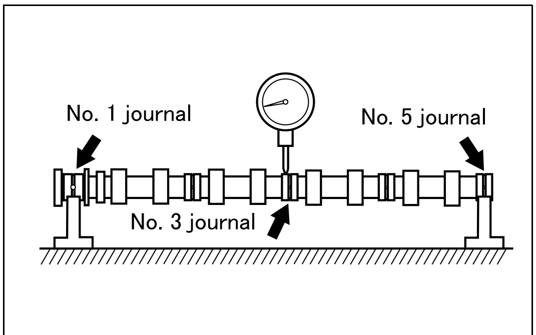


P33880E

■ Inspection: Camshaft

(1) Difference between major axis and minor axis

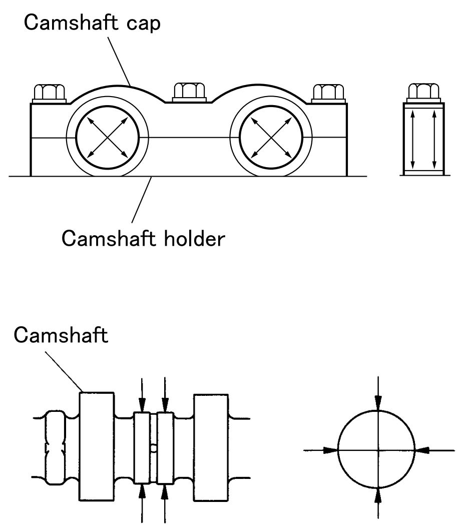
- If the measured value is below the specified limit, replace the camshaft.



P60534E

(2) Bend

- Support the camshaft at its No. 1 journal and No. 5 journal. Measure the extent of bend in the camshaft at the center of the No. 3 journal.
- Turn the camshaft through one revolution. One-half of the dial indicator reading represents the extent of bend.
- If the measurement exceeds the specified limit, replace the camshaft.



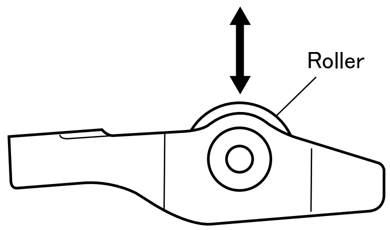
P60535E

(3) Oil clearance at the journals

- Measure the oil clearance, and if the measured value is higher than the limit, replace the faulty parts.

CAUTION ⚠

- **Each camshaft cap and camshaft holder are processed as a pair. Do not replace only one of the two. Never change the combination.**

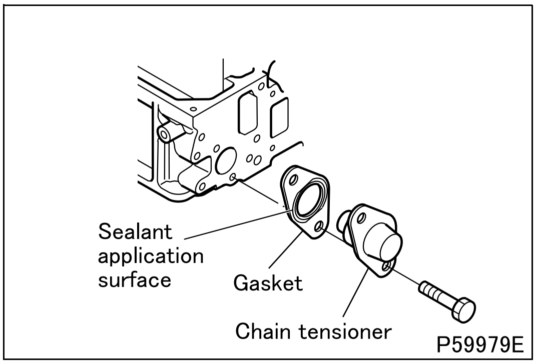


P60536E

■ Inspection: Clearance at the rocker (roller) in the radial direction

- If the measured value is not within the standard value range, replace the rocker.

◆Installation procedure◆

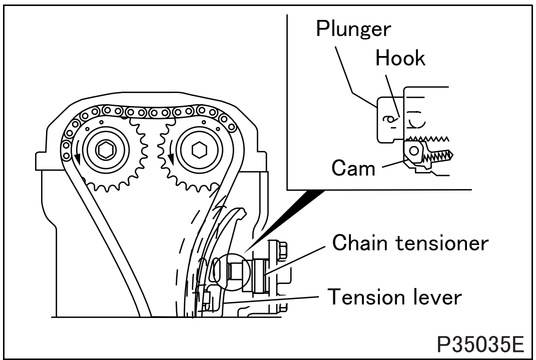


■ **Installation: Chain tensioner and gasket**

- Turn the cam of the chain tensioner, push in the plunger by hand and hold it in the retracted position with the hook.
- Install the gasket on the cylinder head so that the sealant will be on the chain tensioner side.

CAUTION ⚠

- **Installing the chain tensioner without holding the plunger in the retracted position will apply an excessive load on the timing chain and cause damage. Always push in the plunger and hold it in the retracted position before installing the tensioner.**



■ **Installation: Chain tensioner**

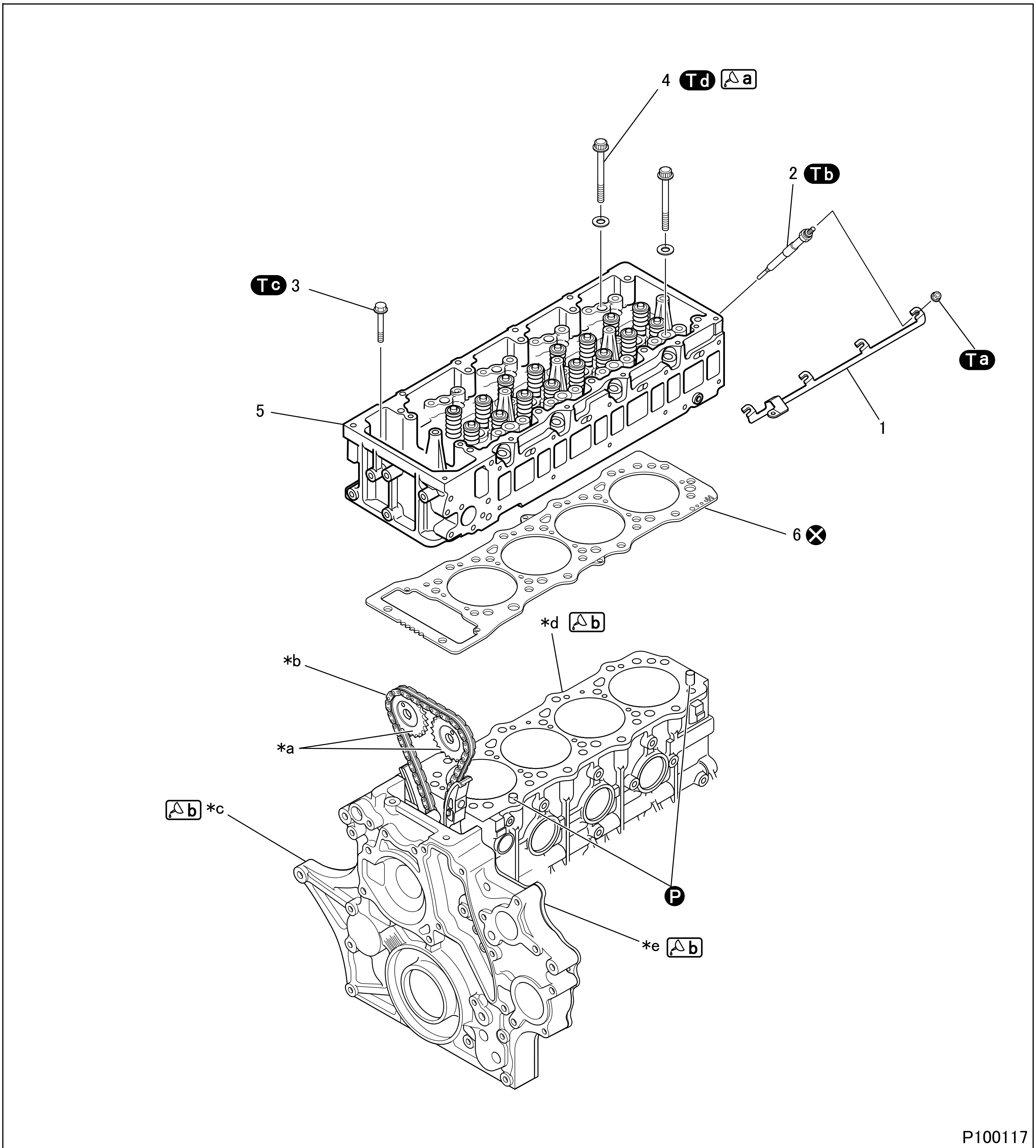
- Install the chain tensioner, then crank the engine in the normal direction (to clockwise as seen from the front of the engine). This will undo the hook, and the ratchet mechanism inside the chain tensioner will start adjusting the tension of the timing chain.

CAUTION ⚠

- **Do not crank the engine in the reverse direction (counterclockwise as seen from the front of the engine) after installing the chain tensioner, as this will apply an excessive load on the plunger and may cause damage to the cam.**
  If you crank the engine in the reverse direction by mistake, remove the chain tensioner and inspect it for damage. The tensioner may be reinstalled if it is intact.

M E M O

CYLINDER HEAD AND VALVE MECHANISM



● **Disassembly sequence**

1 Connecting plate
2 Glow plug
3 Cylinder head bolt (M10)
4 Cylinder head bolt (M12)
5 Cylinder head (See later sections.)
6 Cylinder head gasket

***a**: Cam sprocket
***b**: Timing chain
***c**: Timing gear case
***d**: Crankcase
***e**: Front plate
P: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **Glow plugs are fitted protruding from the bottom of the cylinder head. Therefore, when placing the cylinder head on the work bench without glow plugs removed, be careful not to have the glow plugs damaged.**

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **The cylinder head bolts (M12) are tightened using the torque-turn method. Any cylinder head bolt that has three marks indicating that the bolt has been tightened three times already must be replaced with a new one.**

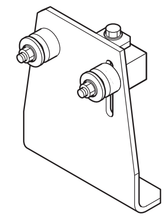
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (connecting plate mounting)	1.0 to 1.5 {0.1 to 0.15}	–
Tb	Glow plug	18 {1.8}	–
Tc	Cylinder head bolt (M10)	58 {5.8}	–
Td	Cylinder head bolt (M12)	49 {5} + 90°+ 90°	• Wet • Reusable up to three times

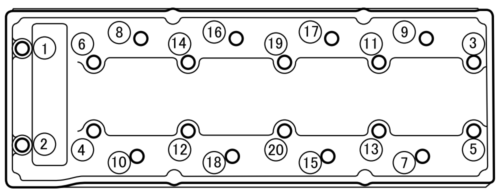
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
Aa	Cylinder head bolt threads and seating surfaces of their heads	Engine oil	As required
Ab	Top surfaces of areas where timing gear case, crankcase and front plate join together	ThreeBond 1217H	As required

Special tools

Mark	Tool name and shape	Part No.	Application
Ca	Cam sprocket holder kit  P34782	MH063490	Supporting the cam sprocket

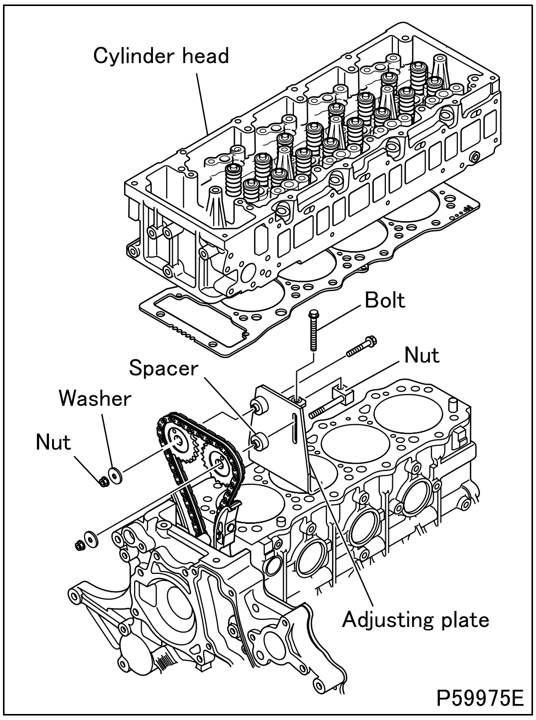
◆Removal procedure◆



P59974

■ Removal: Cylinder head

- Loosen the cylinder head bolts (M10: 1, 2), (M12: 3 to 20) by turns in the order indicated in the illustration before they are removed in the same order.



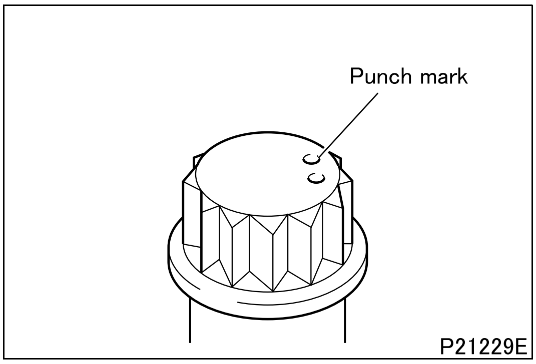
- With the timing chain kept attached to the cam sprocket, remove the cylinder head by lifting it straight up.
- After removing the cylinder head, hold the cam sprocket using a. Be careful not to drop the timing chain.

■ **Removal: Cylinder head gasket**

CAUTION ⚠

- **When removing the cylinder head gasket, be careful not to scratch the cylinder head, upper crankcase and the timing gear case.**

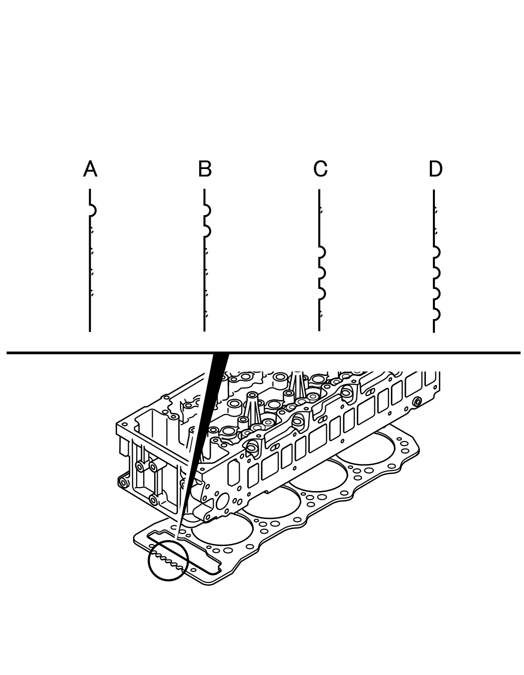
◆Installation procedure◆



■ **Installation: Cylinder head**

CAUTION ⚠

- **Before fitting the cylinder head bolts (M12), check the punch marks on each bolt's head. (Bolts with one or two punch marks can be reused.)**
- **The number of punch marks indicates the number of times the bolt has been tightened using the torque-turn method. Any bolt that has three marks (indicating that the bolt has been tightened three times already) must be replaced with a new one.**



P107828

- The cylinder head gasket is a selective use part. Choose the gasket according to the following procedure.
- Measure the amount of piston projection for every cylinder. (See the PISTON AND CONNECTING ROD section.)
- After the measurement, select a cylinder head gasket with the thickness appropriate for the average amount of piston projection from the following table.
- If any cylinder has a piston that has the amount of projection greater than the maximum value of the average piston projection amount by 0.05 mm or more, use a gasket a rank thicker (A→B, B→C, C→D).

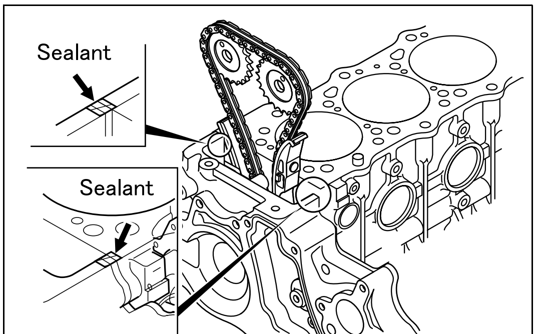
Unit: mm

Piston projection	Cylinder head gasket	
Average piston projection	Size ( ): Number of notches	Thickness when tightened
-0.209 to -0.149	A (1)	0.70 ± 0.04
-0.148 to -0.088	B (2)	0.75 ± 0.04
-0.087 to -0.027	C (3)	0.80 ± 0.04
-0.026 to 0.035	D (4)	0.85 ± 0.04

- The size class of the cylinder head gasket can be determined from the number of notches on the gasket edge.

CAUTION ⚠

- **If pistons, connecting rods or other relevant parts are replaced, measure to check the pistons for any change in protrusion.**



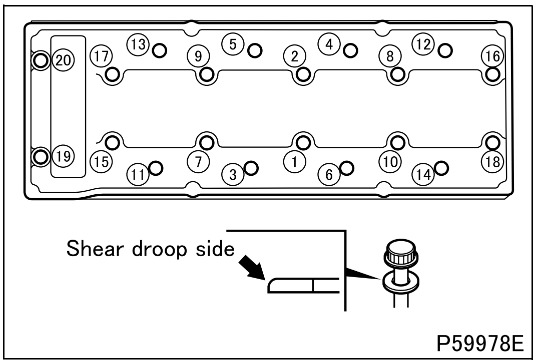
P59977E

- Clean the sealant application surfaces of each part.
- Apply sealant to the top surfaces of the areas where the timing gear case, the front plate and the upper crankcase join together (two locations).
- Install the cylinder head together with the cylinder head gasket on the crankcase within three minutes of applying the sealant, being careful not to dislodge the sealant.

CAUTION ⚠

- **Do not damage the cylinder head gasket. If damaged, abnormalities such as coolant or oil leakage, engine noise and output drop could be caused.**
- **Do not run the engine within one hour of installing the cylinder head. Reapply sealant to the surfaces indicated above if any cylinder head bolts are loosened or removed.**

- Tighten the cylinder head bolts by following different tightening procedures for bolts 1 to 18 (M12) and bolts 19 and 20 (M10). The bolts should be tightened in steps according to the following instructions.
- Install the cylinder head bolts with the shear droop (press punched edge) side of the washer on each of them facing in the indicated direction.



Tightening procedure for bolts 1 to 18

- Retighten the tightened cylinder head bolts (M12) to a torque of 49 N·m {5 kgf·m} in the order indicated in the illustration.
- After tightening, tighten the bolts further 90 degrees in the order indicated in the illustration.
- Then, tighten the bolts further another 90 degrees in the order indicated in the illustration.
- Finally, put a punch mark on the head of each bolt (M12) to indicate the number of times the bolt has been used.

CAUTION ⚠

- **Cylinder head bolts (M12) are tightened using the torque-turn method, and must never be additionally tightened after the final tightening.**

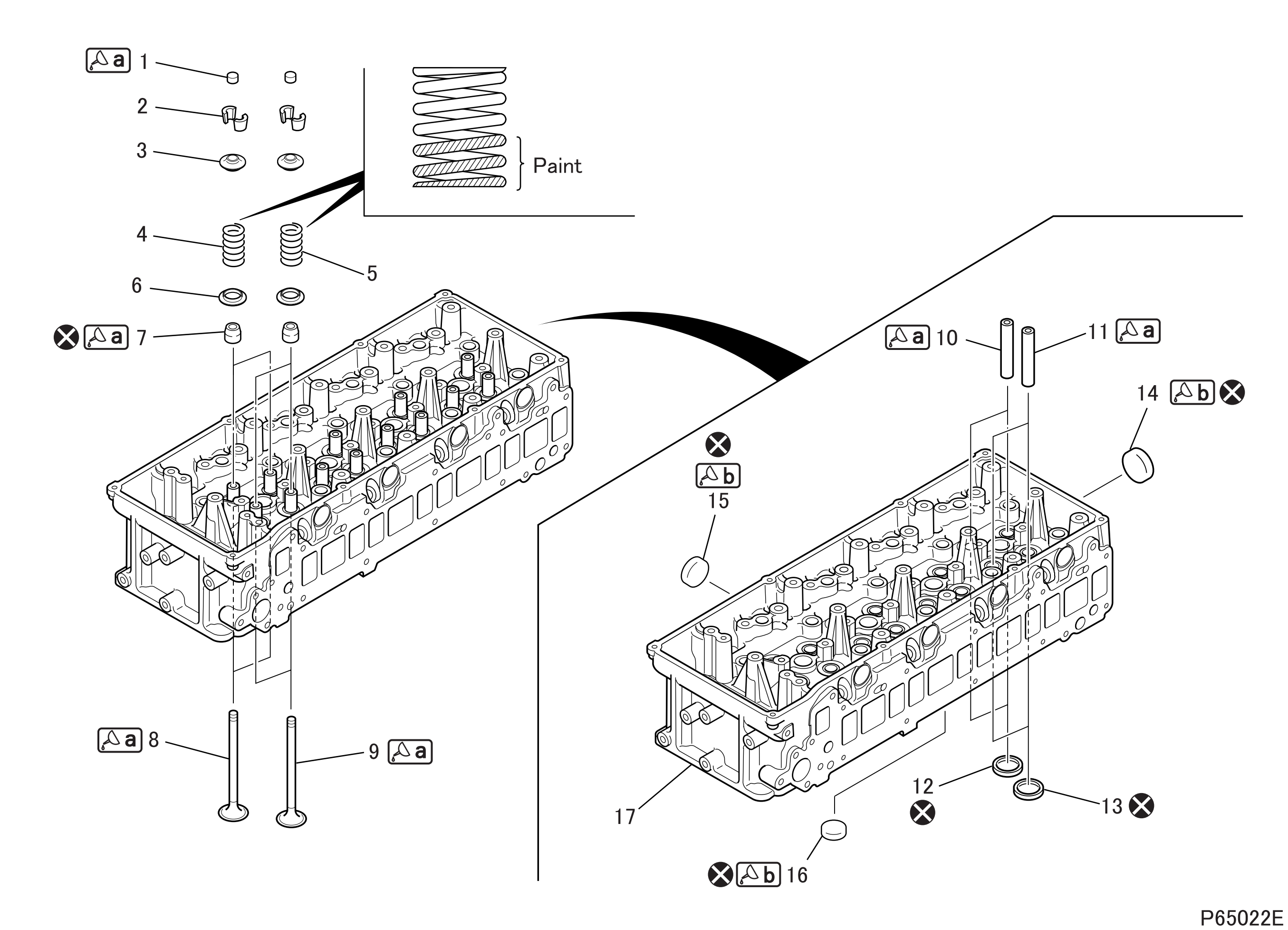
Tightening procedure for bolts 19 and 20

- After completing the tightening procedure for bolts 1 to 18 (M12), tighten bolts 19 and 20 (M10) to 58 N·m {5.8 kgf·m}.

M E M O

CYLINDER HEAD AND VALVE MECHANISM

Cylinder Head



● Disassembly sequence

1 Valve cap
2 Valve cotter
3 Valve spring retainer
4 Exhaust valve spring
5 Intake valve spring
6 Valve spring seat
7 Valve stem seal
8 Exhaust valve
9 Intake valve
10 Exhaust valve guide
11 Intake valve guide
12 Exhaust valve seat
13 Intake valve seat
14 Sealing cap (ϕ28 mm)
15 Sealing cap (ϕ22 mm)
16 Sealing cap (ϕ14 mm)
17 Cylinder head

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **When exhaust or intake valves are removed, their valve stem seals must be replaced.**

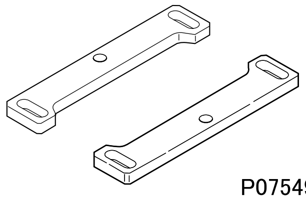
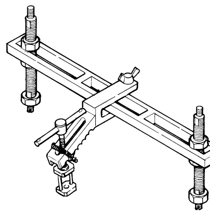
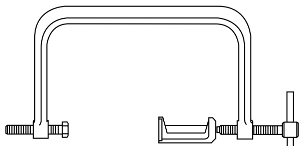
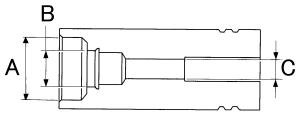
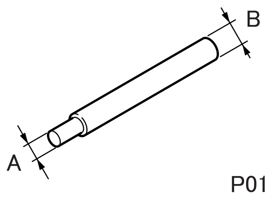
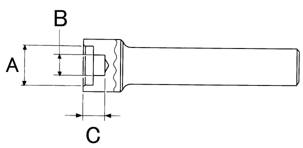
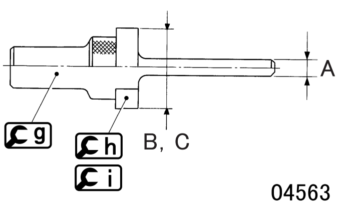
Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy
4	Exhaust valve spring	Free length		64.95	61.70	Replace
		Installed load (installed length: 39.5)		356.0 N ± 18 N {36.3 ± 1.8 kgf}	–	
		Tilt		–	2°	
5	Intake valve spring	Free length		49.61	47.13	Replace
		Installed load (installed length: 39.5)		243.2 N ± 12 N {24.8 ± 1.2 kgf}	–	
		Tilt		–	2°	
8	Exhaust valve	Stem diameter		$\phi 6.6^{-0.05}_{-0.07}$	$\phi 6.45$	Replace
		Valve seat angle		45° ± 15’	–	Reface
		Valve margin		1.0	0.8	Replace
		Sinkage from cylinder head bottom surface		0.3 ± 0.25	0.8	Replace
8, 10	Exhaust valve stem-to-exhaust valve guide clearance			0.05 to 0.09	0.15	Replace
9	Intake valve	Stem diameter		$\phi 6.6^{-0.025}_{-0.040}$	$\phi 6.45$	Replace
		Valve seat angle		45° ± 15’	–	Reface
		Valve margin		1.0	0.8	Replace
		Sinkage from cylinder head bottom surface		0.3 ± 0.25	0.8	Replace
9, 11	Intake valve stem-to-intake valve guide clearance			0.02 to 0.06	0.1	Replace
12	Exhaust valve seat width			2.2 ± 0.2	2.8	Replace
13	Intake valve seat width			2.2 ± 0.2	2.8	Replace
17	Cylinder head	Distortion of bottom surface		0.05	0.2	Replace
		Height from top to bottom		116 ± 0.2	115.8	Replace
		Valve seat hole diameters	Intake side	$\phi 31.5^{+0.025}_{0}$	–	Reface or replace
			Exhaust side	$\phi 29.5^{+0.021}_{0}$	–	

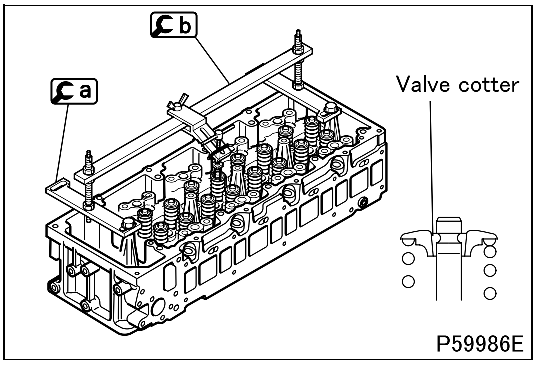
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Valve cap top surface	Engine oil	As required
	Valve stem seal lip		
	Valve stem and tip		
	Valve guide outer surface		
b	Sealing cap holes in cylinder head entire inner surfaces	ThreeBond 1386D or Loctite 962T	As required

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Valve spring compressor adapter plate  P07549	MD998784	
b	Valve spring compressor (use one of the types shown on the right)  07550	MD998772	Removal and installation of valve cotter
c	 P21300	MD999597	
d	Valve stem seal installer A: ϕ18, B: ϕ15.4, C: ϕ6.6  04560	MH063609	Installation of valve stem seal
e	Valve guide remover A: ϕ6.6, B: ϕ11.5  P01959	MD998665	Removal of valve guide
f	Valve guide installer A: ϕ24.5, B: ϕ12, C: 16.5  04562	MH063610	Installation of valve guide
g	Caulking tool, body A: ϕ6.6  04563	MH063613	
h	Caulking ring, intake valve guide B: ϕ31.5	MH062807	Installation of valve seat
i	Caulking ring, exhaust valve guide C: ϕ29.5	MH062808	

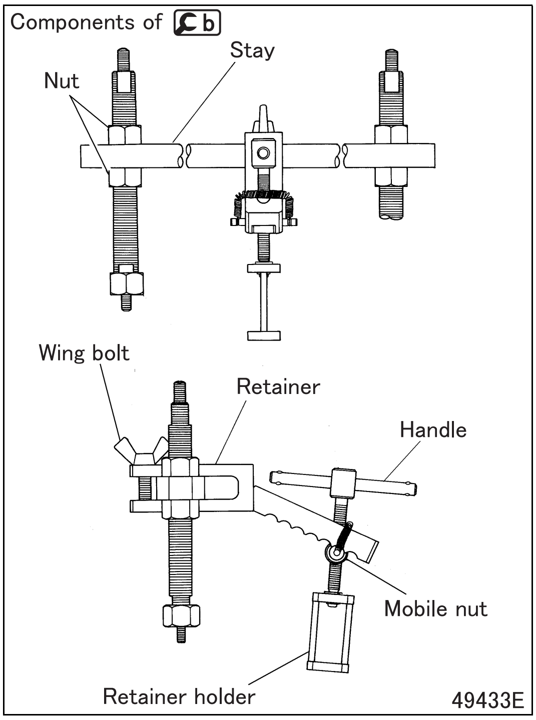
◆Removal procedure◆

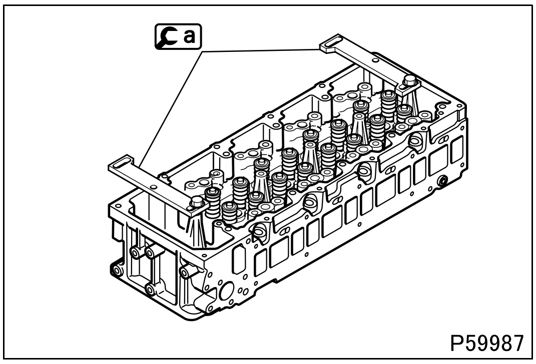


■ Removal: Valve cotter

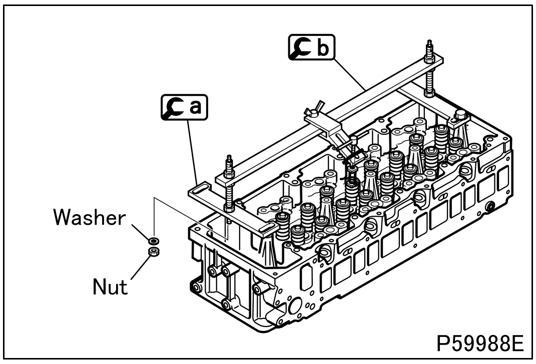
<Method 1>

- Using [a] and [b], remove and install the valve cotters according to the following procedure.

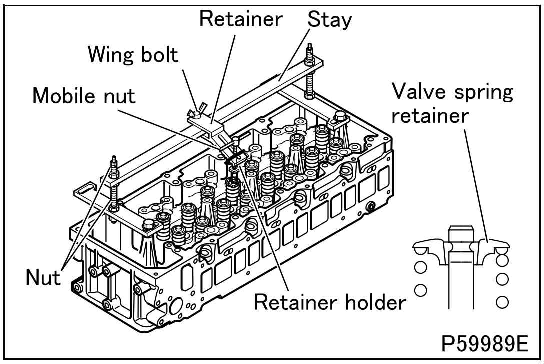




- Install [a] on the cylinder head using any bolts (M8 × 1.25 mm).

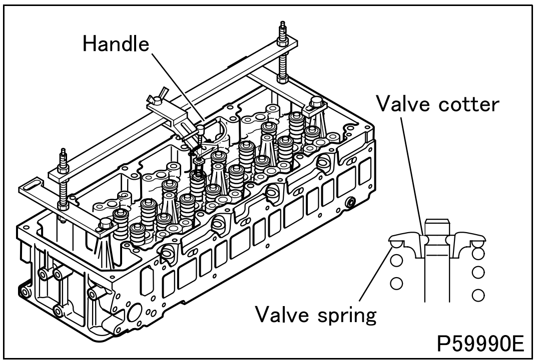


- Install [b] on [a] using any washers and nuts (M6 × 1.0 mm).



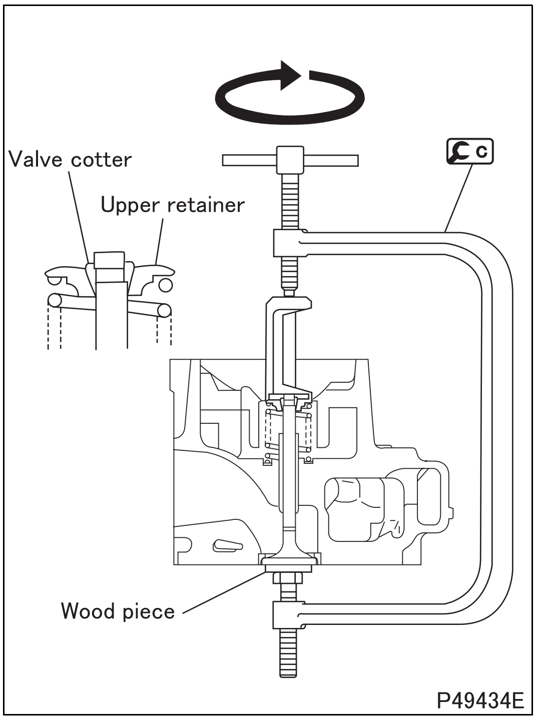
P59989E

- Set the stay to a level position.
- Adjust the retainer and the mobile nut so that the retainer holder presses down on the valve spring retainer from directly above, and fix them in place with the wing bolt.
  Adjust the vertical position of the retainer holder by raising or lowering the stay using the nuts.



P59990E

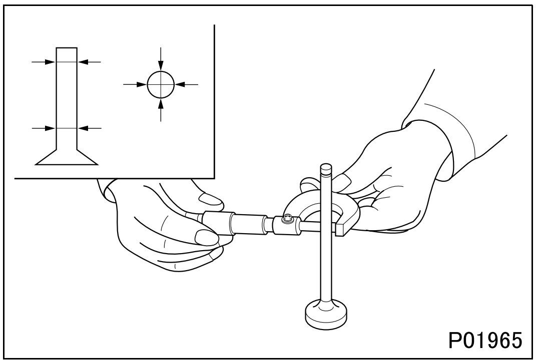
- Turn the handle clockwise to press down on the valve spring retainer, thus removing the valve cotter.



P49434E

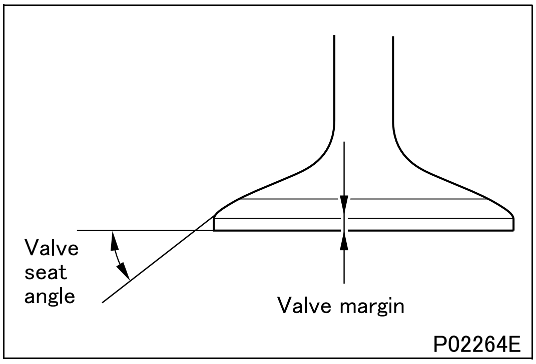
<Method 2>
- Place a wood piece between the valve and Cc to protect the valve from damage.
- Using Cc, press down on the upper retainer to remove the valve cotter.

◆Inspection procedure◆


P01965

■ Inspection: Valve
- If the valve is replaced after performing the following inspection, make sure to lap the valve and valve seat.

(1) Stem outside diameter
- Replace the valve if the measured value is below the limit or is severely worn.



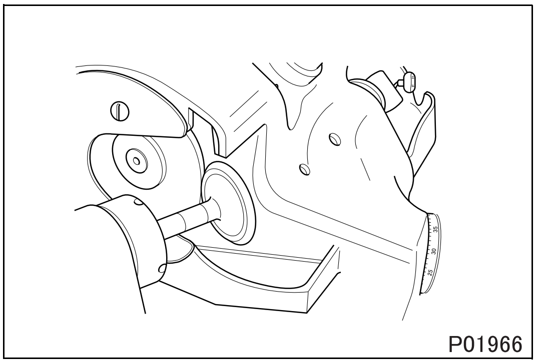
P02264E

(2) Valve seat angle

- Reface the valve if the measured value is not within the standard value range.

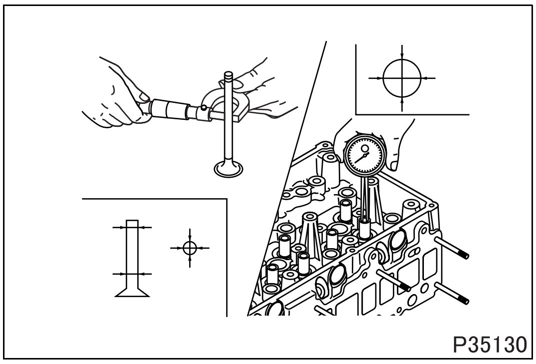
(3) Valve margin

- Reface or replace the valve if the measured value is below the limit.


P01966

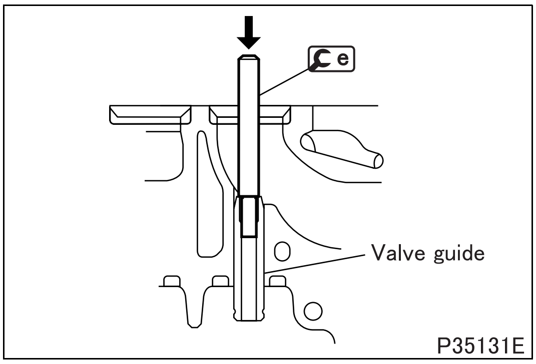
Refacing of valve

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


P35130

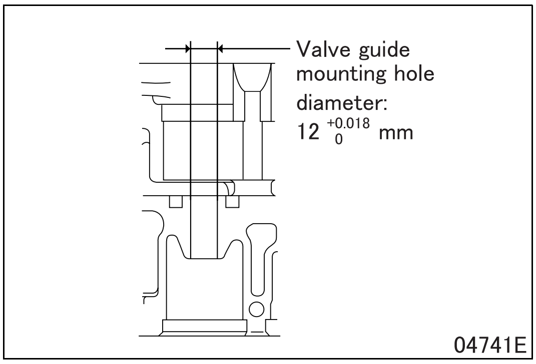
■ Inspection: Valve stem-to-valve guide clearance

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



P35131E

Replacement of valve guide
[Removal]



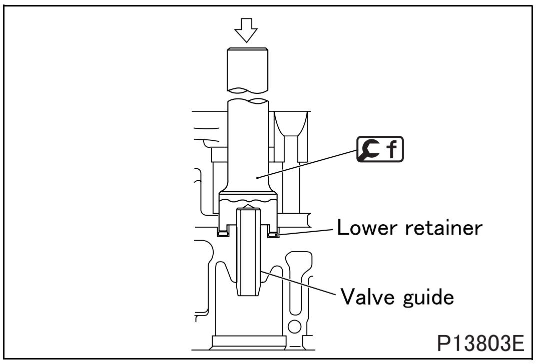
04741E

[Installation]

- Measure the diameter of the valve guide mounting hole in the cylinder head.
- If the measurement exceeds the specified value, select an oversized valve guide from the table below.
- Recondition the valve guide mounting hole to the diameter corresponding to the diameter of the selected oversized valve guide.

Unit: mm

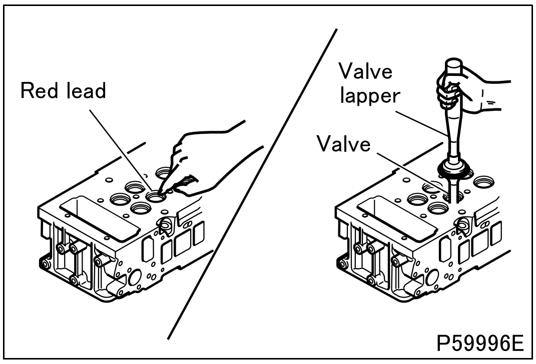
Available oversize	0.05	0.25	0.50
Valve guide inside diameter	$\phi 12.05^{+0.018}_{0}$	$\phi 12.25^{+0.018}_{0}$	$\phi 12.50^{+0.018}_{0}$



- Temporarily place the lower retainer on the cylinder head. Then, install the valve guide until Cf contacts the lower retainer closely.

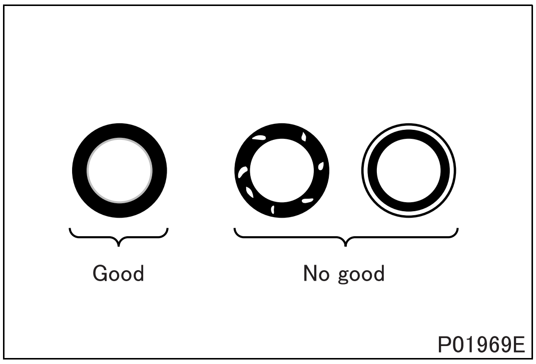
CAUTION ⚠

- **The valve guides have a specified amount of depth. Make sure to use Cf to achieve the specified depth.**
- **Intake valve guides are longer than exhaust valve guides. Make sure to install the correct type of guide in each location.**



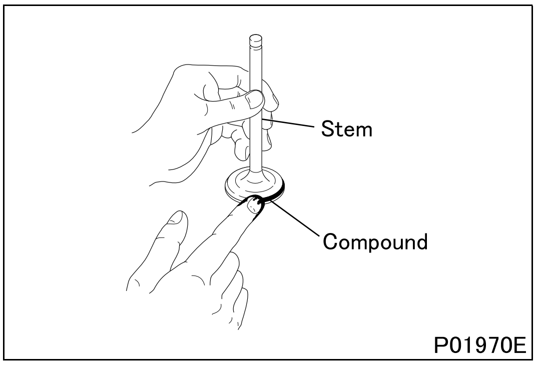
■ Inspection: Contact between valve and valve seat

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



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

Contact	Corrective action
Minor defect	Lapping
Serious defect	Refacing or replacement of valve and valve seat

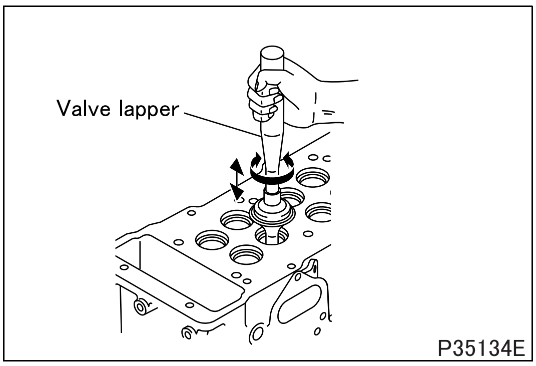


Lapping

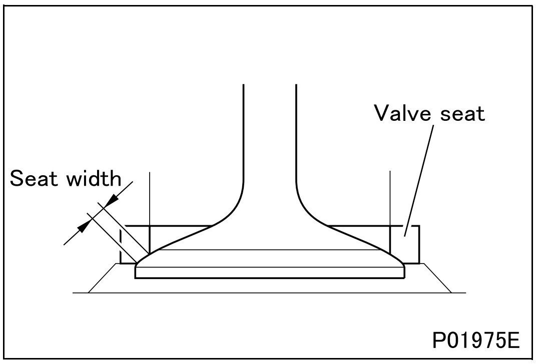
- Perform lapping according to the following procedure.
- Apply a thin coat of lapping compound to the valve seat contact surface of the valve.
- Adding a small amount of engine oil to the lapping compound can facilitate even application.
- Start with an intermediate-grit compound (120 to 150 grit) and finish with a fine-grit compound (200 grit or more).

CAUTION ⚠

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



- Strike the valve several times against the valve seat while rotating the valve a little at a time.
- Wash away the compound with diesel fuel.
- Apply engine oil to the valve contact surface of the valve seat and rub in the valve and valve seat well.
- Inspect the contact pattern of the valve and valve seat again.
- If the contact pattern is still defective, replace the valve seat.

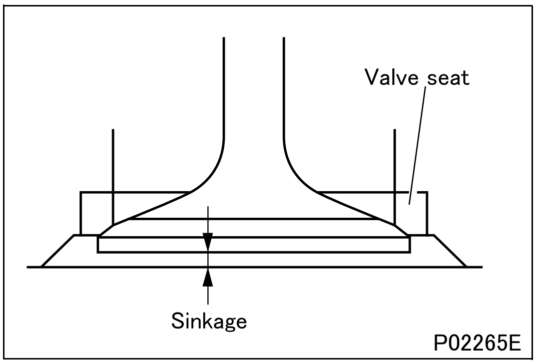


■ Inspection: Valve seats

- If a valve is corrected or replaced with a new one as a result of the following inspection, make sure to lap the valve and valve seat.

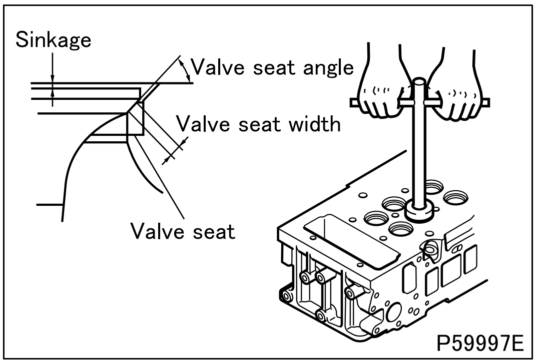
(1) Valve seat width

- If the measurement exceeds the limit, reface or replace the valve seat.



(2) Valve sinkage from cylinder head bottom surface

- Measure the sinkage with the valve seat in intimate contact.
- If the measurement exceeds the limit, adjust or replace the defective part(s).



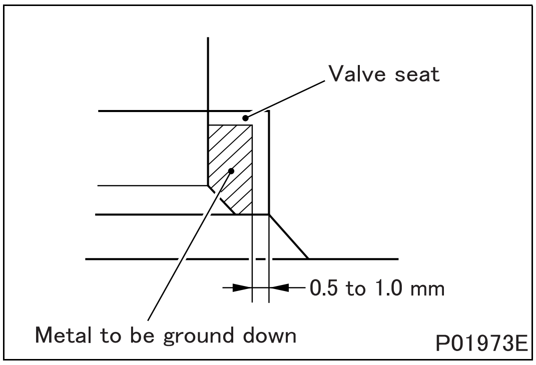
Refacing the valve seat

- Grind the valve seat using a valve seat cutter or valve seat grinder.
- After grinding, place a piece of sandpaper approximately #400 between the cutter and valve seat and grind the valve seat lightly.
- Use a 15° or 75° cutter to cut the valve seat to a width within the standard range. If the valve seat cannot be refaced, replace the valve seat.

CAUTION ⚠

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

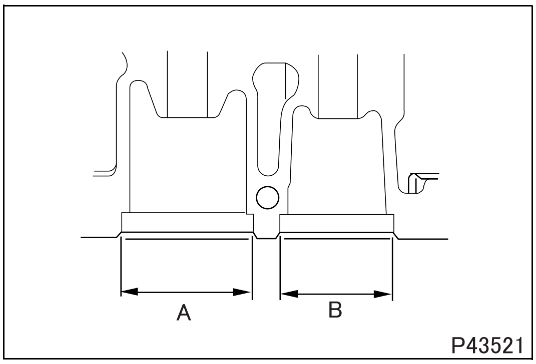
- After refacing, lap the valve and valve seat.



Replacement of valve seat

[Removal]

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



P43521

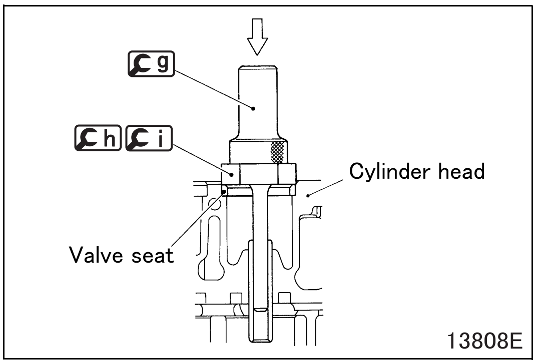
[Installation]

- Measure the inside diameters of the intake and exhaust valve seat holes A and B in the cylinder head.
- If the measurement exceeds the specified value, select an oversized valve seat from the table below.
- Reface valve seats A and B to the inside diameters of the selected oversizes.

Unit: mm

Available oversize		0.30	0.60
Intake valve seat mounting hole	Diameter: A	$\phi 31.8^{+0.025}_{0}$	$\phi 32.1^{+0.025}_{0}$
Exhaust valve seat mounting hole	Diameter: B	$\phi 29.8^{+0.021}_{0}$	$\phi 30.1^{+0.021}_{0}$

- Replace the cylinder head if defects are evident.
- Chill the valve seats thoroughly by immersing them in liquid nitrogen.
- Install the valve seat until it contacts the cylinder head closely using g and h (for intake valve seat) or i (for exhaust valve seat).
- After installing the valve seat, lap the valve seat and valve.



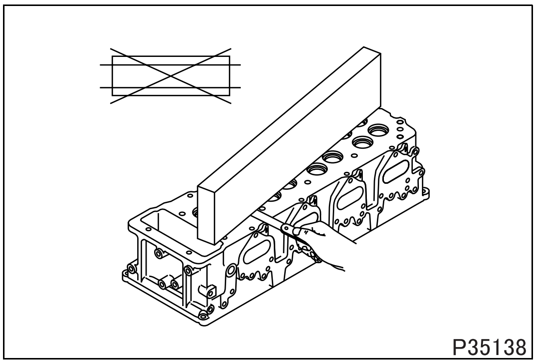
13808E

■ **Inspection: Distortion of cylinder head bottom surface**

- If the distortion exceeds the specified limit, replace the cylinder head.

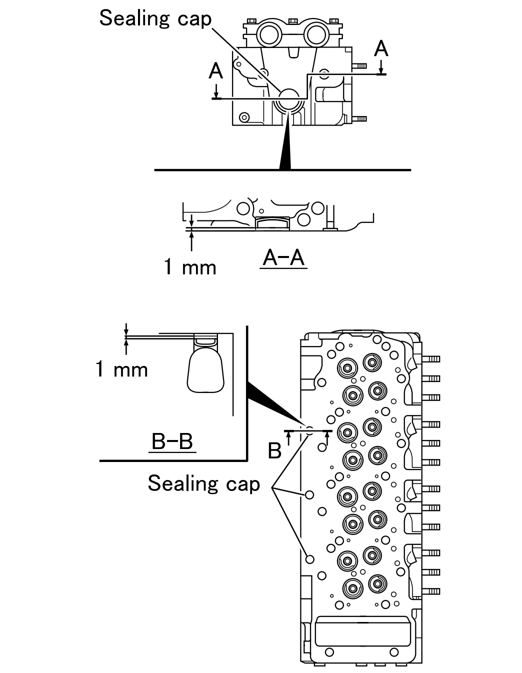
CAUTION ⚠

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



P35138

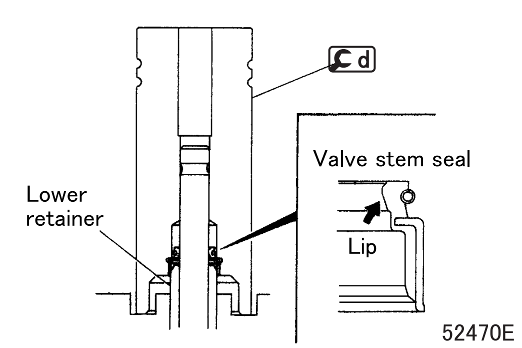
◆Installation procedure◆



P60001E

■ Installation: Sealing cap

- Apply sealant to the press fitting hole in the cylinder head.
- Install sealing caps and press them in to the depths respectively specified.



52470E

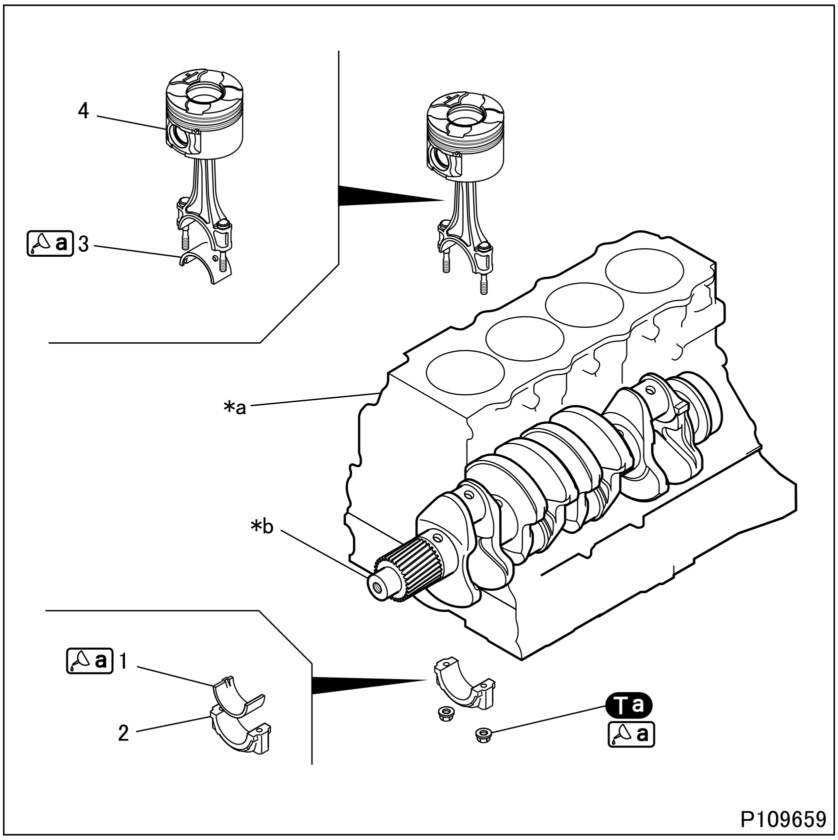
■ Installation: Valve stem seal

- Apply engine oil to the valve stem seal lip.
- Install the valve stem seal until it contacts the lower retainer closely using Cd.
- After installing the valve stem seal, check that the spring of the valve stem seal is deformed or broken.

■ Installation: Valve cotter

- Install the valve cotter in the same manner as in removal. (See "■ **Removal: Valve cotter**".)

PISTON AND CONNECTING ROD



● Disassembly sequence

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

***a**: Upper crankcase
***b**: Crankshaft

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **The connecting rod bolts are tightened using the torque-turn method. Any connecting rod bolt that has three marks indicating that it has been tightened three times already must be replaced with a new bolt together with its nut.**

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
–	Piston projection from upper crankcase top surface (average value)		-0.209 to 0.035	–	Inspect
–	Connecting rod end play		0.15 to 0.45	0.5	Replace
1, 3	Connecting rod bearing span when free		–	58.5	Replace
1, 3, *b	Connecting rod bearing-to-crankshaft oil clearance		0.022 to 0.055	0.1	Replace
4, *a	Piston-to-crankcase cylinder clearance		0.105 to 0.125	–	Correct or replace
***a**	Cylinder (upper crankcase)	Bore diameter	ϕ95 to 95.03	ϕ95.25	Replace
		Out-of-roundness	0.005 or less	–	Correct or replace
		Taper	0.015 or less	–	

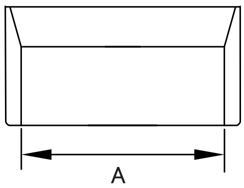
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (connecting rod cap installation)	49 {5.0} + 90°	• Wet • Reusable up to three times

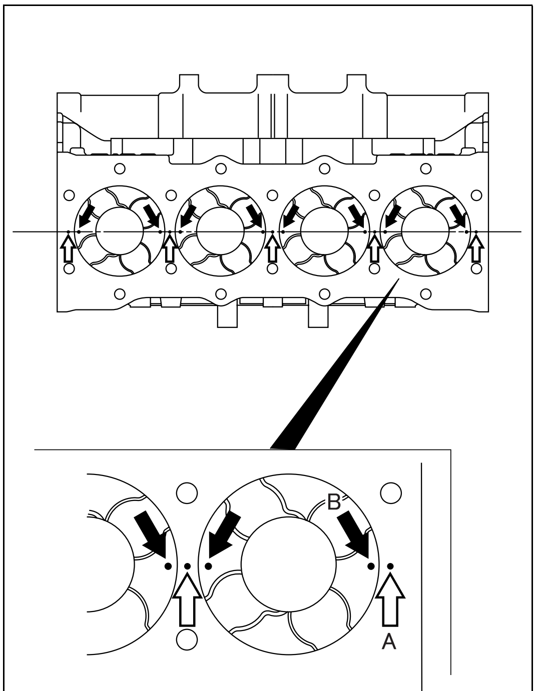
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Nut threads	Engine oil	As required
	Connecting rod bearing inside surface		

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Piston guide A ϕ95  P62500	MH062226	Installation of piston and connecting rod

◆Inspection before removal◆



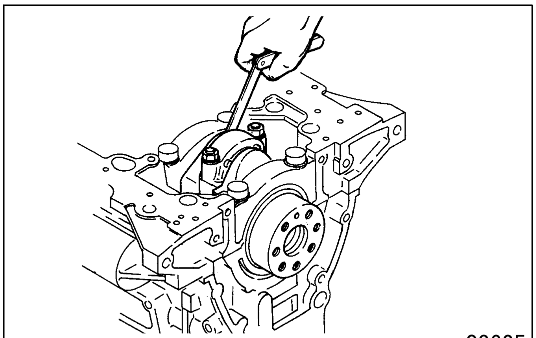
P60003

■ Inspection: Piston projection from upper crankcase top surface

CAUTION ⚠

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

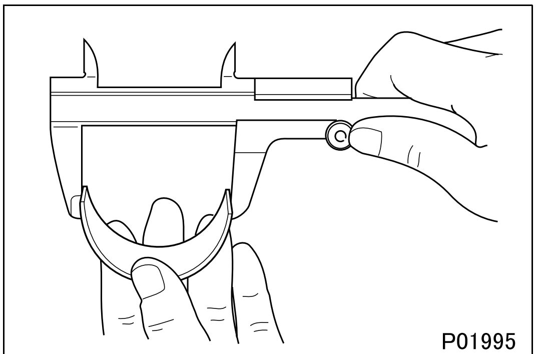
- Set the piston at the top dead center.
- Mark reference points A (five points in total) on the top surface of the upper crankcase as shown in the illustration. Using each of the marks as a zero point, measure the amount of piston projection relative to the zero point (height of measurement point B - height of reference point A).
- Make the measurements at the two measurement points B for each cylinder (eight points in total) using the reference point A nearest to each measurement point, and calculate the average value of all the measurements.
- If the average value is out of the standard value range, check the clearance between all relevant parts.
- Select and use a cylinder head gasket that can accommodate the average piston projection (average value of the eight measurements). (See the CYLINDER HEAD AND VALVE MECHANISM section.)


03625

■ Inspection: Connecting rod end play

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

◆Inspection procedure◆

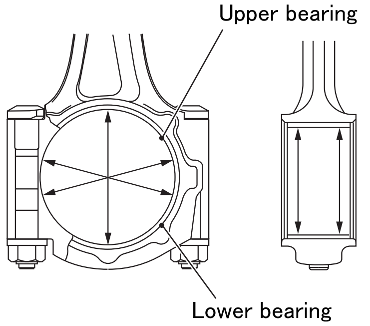

P01995

■ Inspection: Connecting rod bearing span when free

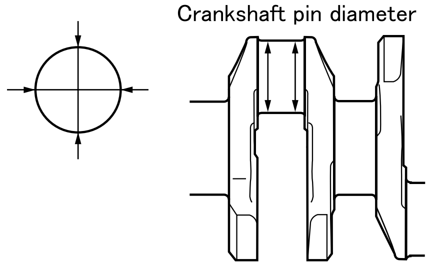
CAUTION ⚠

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

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



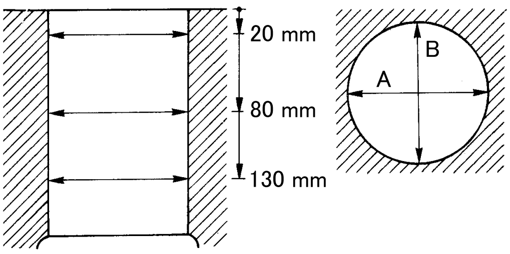
P60004E



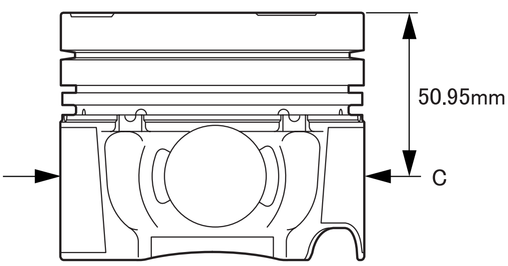
P60005E

■ **Inspection: Connecting rod bearing-to-crankshaft oil clearance**

- Fit the lower bearing to the connecting rod cap and the upper bearing to the connecting rod, then tighten the nut to a torque of 49 N·m {5.0 kgf·m}.
- Measure the inside diameter of the bearing and the diameter of the crankshaft pin.
- If the clearance exceeds the limit, replace the defective part(s).
- If a bearing has to be replaced with an undersized one, machine the crankshaft pin to the specified undersize diameter. (See the CRANKSHAFT AND CRANKCASE section.)



05158



P109660

■ **Inspection: Piston-to-crankcase cylinder clearance**

- If the measurement is not within the standard value range, perform one of the steps below according to the condition.
  - A: Measure on cylinder bore in crankcase (in direction of crankshaft axis)
  - B: Measure on cylinder bore in crankcase (in direction perpendicular to crankshaft axis)
  - C: Measure on piston (in direction perpendicular to piston pin hole)
- If the crankcase cylinder bore diameter exceeds the specified limit, rebore all the cylinders to an oversize diameter and replace the pistons and piston rings with the corresponding oversized ones.

CAUTION ⚠

- **If any one cylinder is found to be defective and must be rebored, all the other cylinders must also be rebored to the same oversize.**

- If the cylinder bore diameter is within the standard value range, replace the piston and piston rings.

Selection of oversized piston

- Available oversizes: 0.50 mm and 1.00 mm (two sizes)
- Measure the bore diameter of each cylinder. Select the appropriate oversized piston based on the largest of the measurements.
- Measure the outside diameter of the chosen oversized piston.
- Rebore each cylinder to a diameter at which the piston-to-cylinder clearance will be within the standard value range.

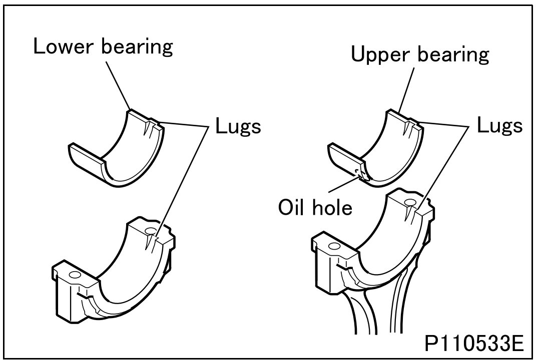
CAUTION ⚠

- **Rebore the cylinder in the following order to prevent the generated heat from causing distortion in the crankcase.**
  No. 2→No. 4→No. 1→No. 3

Reboring diameter (tolerance ± 0.005) =
Oversized piston diameter (measured value) +
Piston-to-cylinder clearance (median of service standard value range) – 0.02 mm (honing margin)

- After boring the cylinders, hone them to the finish dimension (tolerance ± 0.005).
  Finish dimension (tolerance ± 0.005) =
  Oversized piston diameter (measured value) +
  Piston-to-cylinder clearance (median of service standard value range)
- Honing finish surface roughness: 1.2 to 3.5 μm
- Honing cross hatch angle: 20° ± 5° (semi angle)
- Cylinder bore out-of-squareness: 0.05 mm
- Measure the piston-to-cylinder clearance.

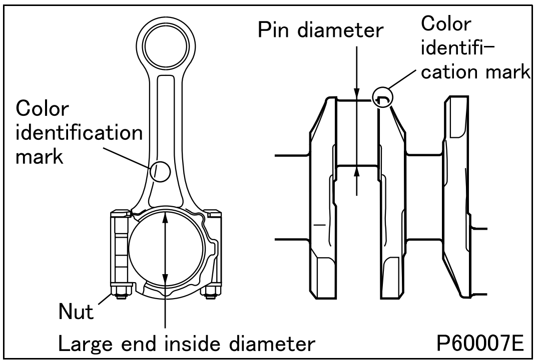
◆Installation procedure◆



■ Installation: Connecting rod bearings

CAUTION ⚠

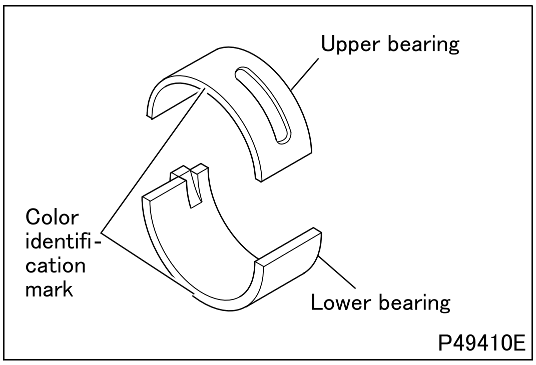
- **Do not reverse the positions of the lower bearing and the upper bearing (with oil hole) when installing, as this may cause seizure in the engine.**



- Select and use a bearing set of a thickness that can accommodate the inside diameter of the connecting rod's large end and the diameter of the crankshaft pin. Use either of the following methods for the selection.

(1) Measurement based selection

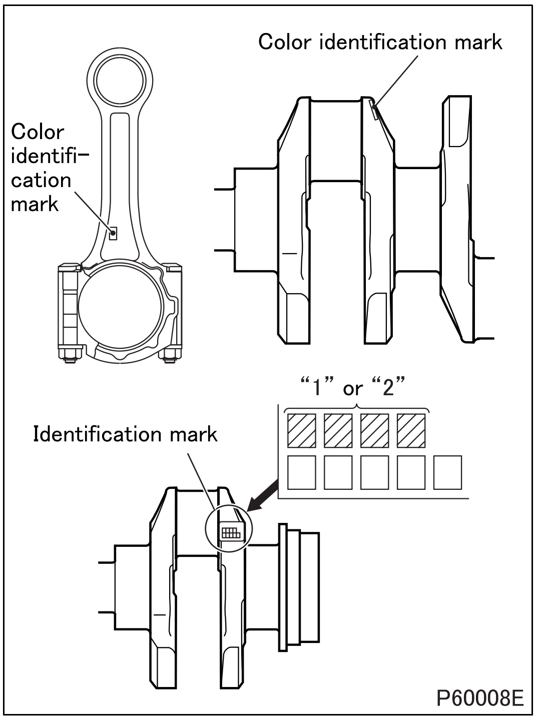
- Install the connecting rod cap on the piston and connecting rod assembly without fitting the lower and upper bearings.
- Tighten the nut to 49 N·m {5.0 kgf·m}.
- Measure the inside diameter of the connecting rod's large end (vertically from one point), and the outside diameter of the crankshaft pin (vertically or horizontally from one point).



- Select a bearing set that matches the measurements from the table below.
  If the color identification mark is indiscernible, measure the thickness of the bearing walls and use the measurements in its place.

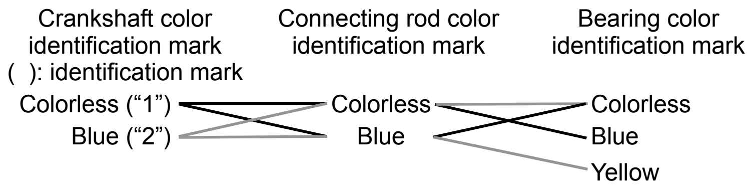
Unit: mm

Diameter of crankshaft pin	Inside diameter of connecting rod large end	Bearing	
		Color identification mark	Thickness
$\phi 54^{-0.012}_{-0.020}$	$\phi 58^{+0.019}_{+0.010}$	Colorless	$2^{-0.001}_{-0.005}$
	$\phi 58^{+0.010}_{0}$	Blue	$2^{-0.005}_{-0.009}$
$\phi 54^{-0.020}_{-0.029}$	$\phi 58^{+0.019}_{+0.010}$	Yellow	$2^{+0.003}_{-0.001}$
	$\phi 58^{+0.010}_{0}$	Colorless	$2^{-0.001}_{-0.005}$

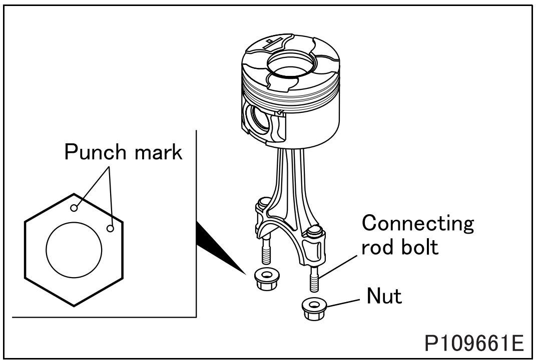


(2) **Color identification mark based method**

- Use selection by identification color for new parts.
- The connecting rods, crankshafts, and bearings can be appropriately combined in the following ways according to their color identification marks:



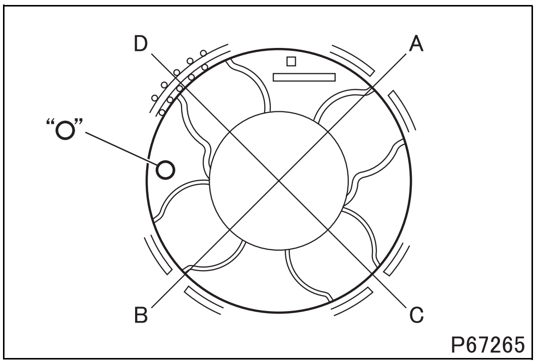
Each crankshaft also has an identification mark ("1" or "2") indicating the diameter of each pin.



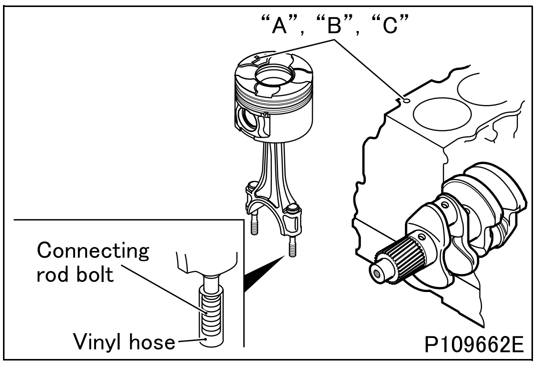
■ **Installation: Piston and connecting rod**

CAUTION ⚠

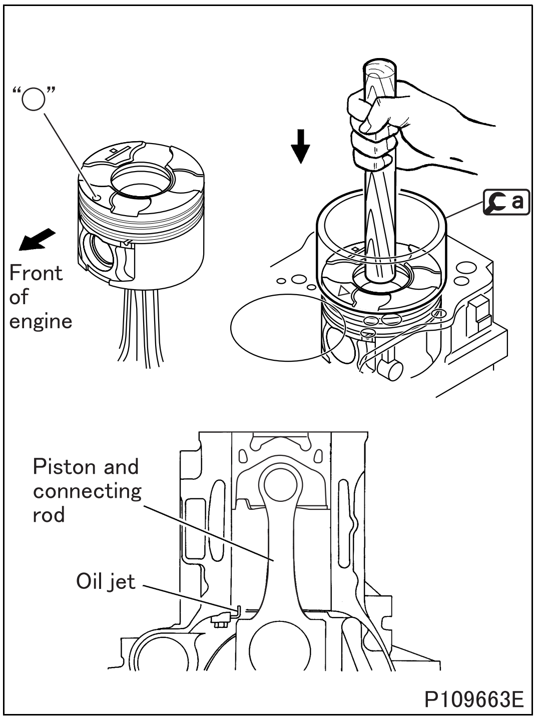
- **Before installing the piston and connecting rod, check the punch marks on each nut's top surface. The nut and its bolt can be reused if there are two or less punch marks.**
- **The punch marks indicate the number of times each bolt has been tightened using the torque-turn tightening method. Any connecting rod bolt and nut that already has three punch marks must be replaced.**



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



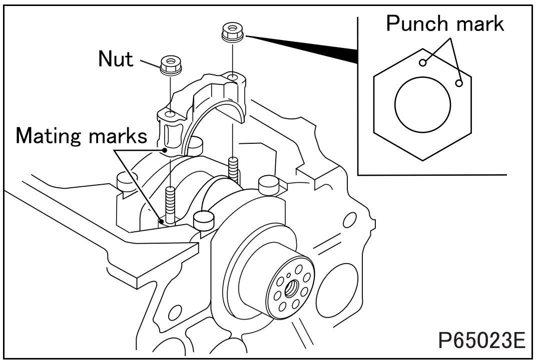
- If the cylinder has not been machined to an oversize, check that the size marks ("A", "B" or "C") on the piston and the upper crankcase are the same.
- Cover the connecting rod bolts with vinyl hoses to prevent them from scratching the wall surface of the cylinder in the upper crankcase and the crankshaft pin.



- Face the front mark “ ○ ” of the piston toward the front of the engine and install the piston.

CAUTION ⚠

- **Make sure that the piston and connecting rod do not hit the oil jet during installation.**



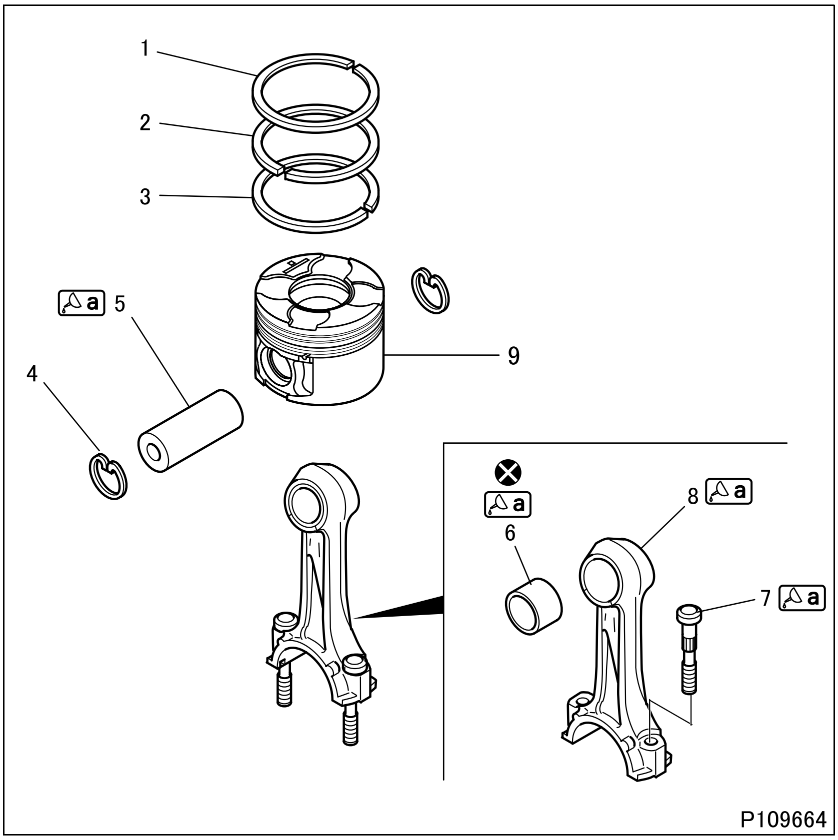
- After installing the piston and connecting rod assembly, align the mating marks on the connecting rod and connecting rod cap and tighten the nuts alternately in the following manner.
  - Tighten the nut to a torque of 49 N·m {5.0 kgf·m}.
  - After tightening, tighten the nut further by 90 degrees to the right. Put a punch mark on the nut’s top surface to indicate the number of times it has been used.

CAUTION ⚠

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

PISTON AND CONNECTING ROD

Piston and Connecting Rod



● Disassembly sequence

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

⊗: Non-reusable parts

CAUTION ⚠

- **Do not remove the connecting rod bolt unless defects are evident.**

● Assembly sequence

Follow the disassembly sequence in reverse.

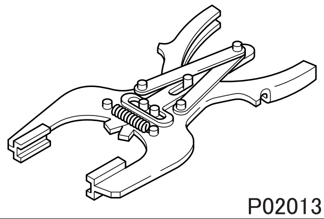
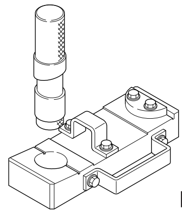
Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
1 to 3	Piston ring end gap	1st compression ring	$0.4^{+0.05}_{-0.1}$	1.5	Replace
		2nd compression ring	$0.5^{+0.05}_{-0.1}$		
		Oil ring	0.4 ± 0.1		
1 to 3, 9	Piston ring side clearance in piston groove	1st compression ring	0.11 to 0.16	0.2	Replace
		2nd compression ring	0.065 to 0.105	0.15	
		Oil ring	0.025 to 0.065		
5, 6	Piston pin-to-connecting rod bushing clearance		0.028 to 0.049	0.1	Replace
5, 9	Piston pin-to-piston clearance		0.007 to 0.021	0.05	Replace
8	Connecting rod	Bend	–	0.05	Replace
		Twist	–	0.1	

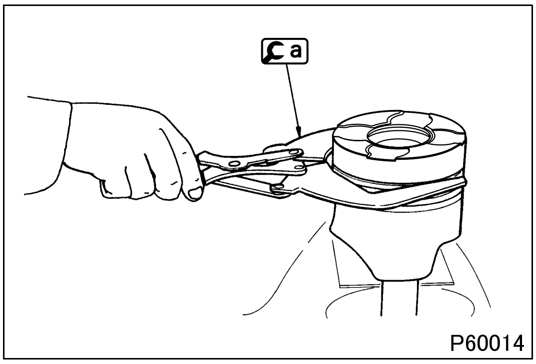
Lubricant and/or sealant

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

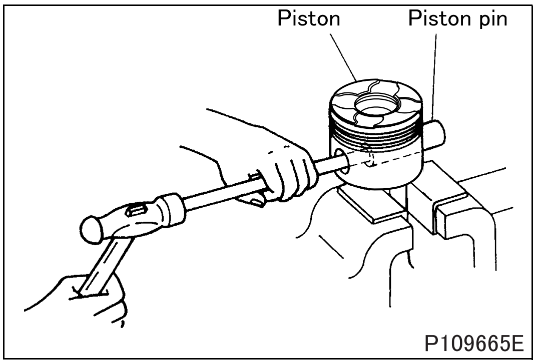
Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Piston ring tool  P02013	MH060014	Removal and installation of piston rings
b	Connecting rod bushing puller kit  P02015	MH062575	Removal and installation of connecting rod bushings

◆Removal procedure◆



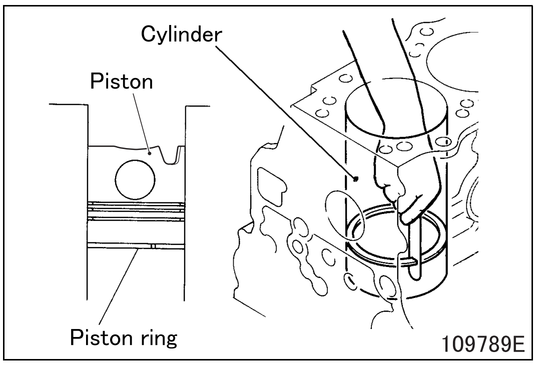
■ **Removal: Piston ring**



■ **Removal: Piston pin**

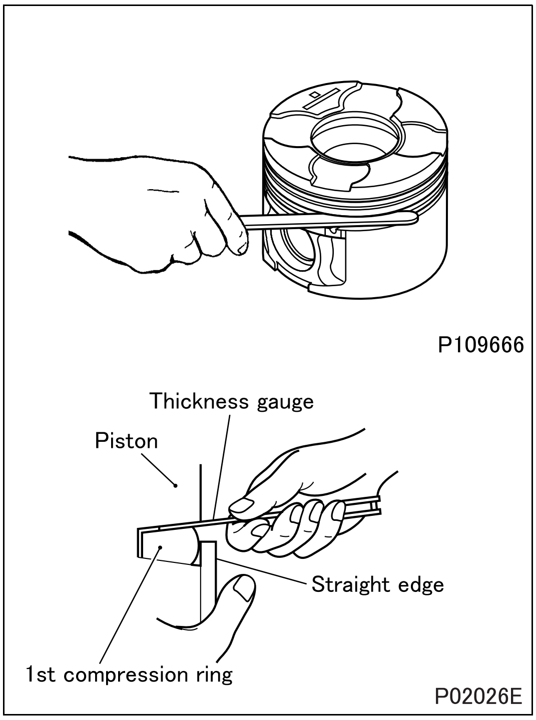
- Remove the piston pin by striking it with a rod and hammer.
- If the piston pin is difficult to remove, first heat the piston in hot water or with a piston heater.

◆Inspection procedure◆



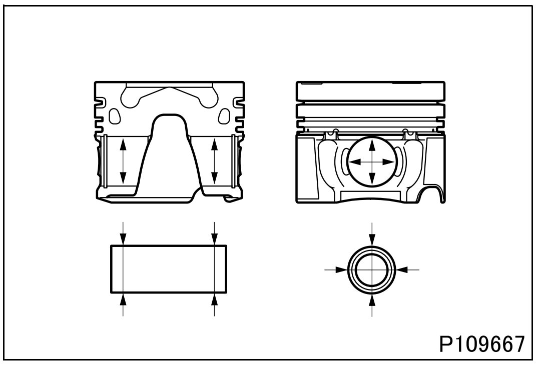
■ **Inspection: Piston ring end gap**

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



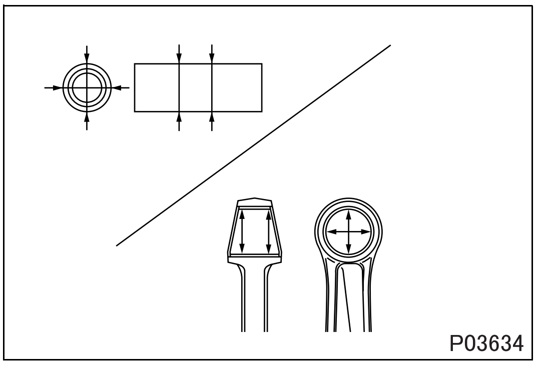
■ **Inspection: Piston ring side clearance in piston groove**

- Remove any carbon deposits from the ring groove in the piston before measurement.
- Measure the side clearance of each ring around the piston's entire periphery.
- The 1st compression ring is a full-keystone type. Measure the side clearance for this compression ring with a feeler gauge while pressing the ring against the piston with a straight edge.
- If any of the measurements exceeds the specified limit, replace the defective part(s). If any of the piston rings is defective, replace all the rings on the piston as a set.



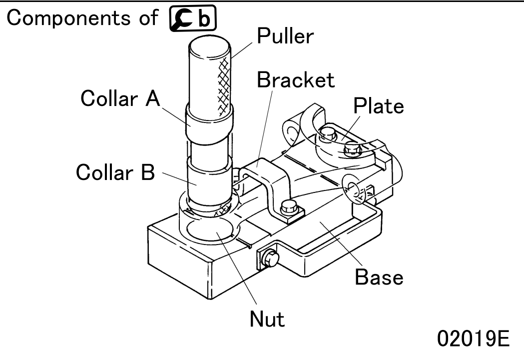
■ **Inspection: Piston pin-to-piston clearance**

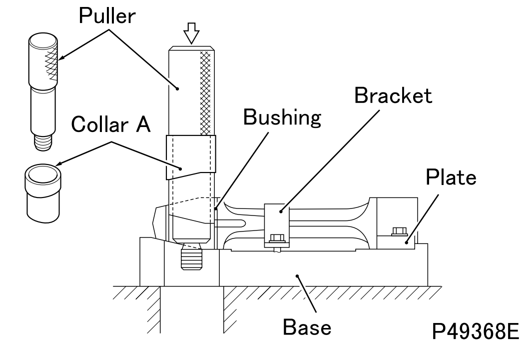
- If any of the measurements exceeds the specified limit, replace the defective part(s).



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

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



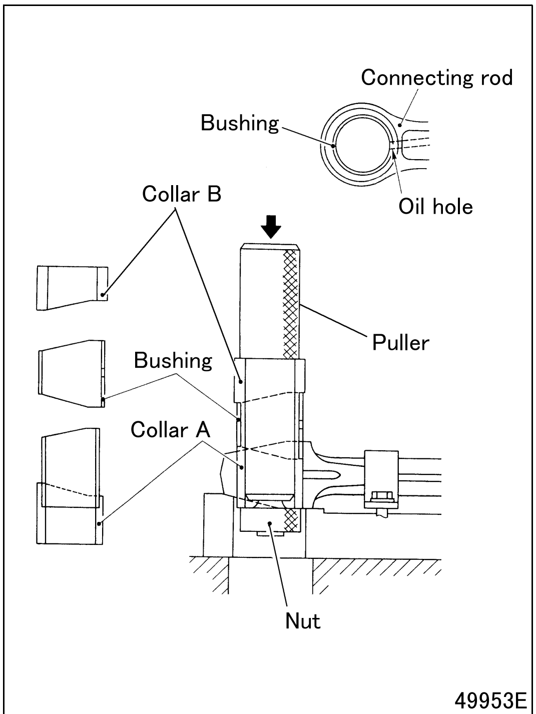


Replacement of connecting rod bushing

- Replace the connecting rod bushing using Cb.

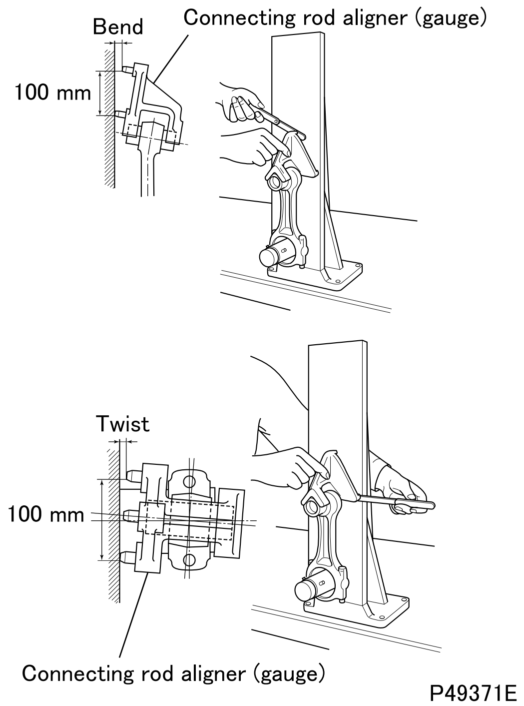
[Removal]

- Remove the upper rod bearing (if fitted) from the large end of the connecting rod.
- Mount the connecting rod on the base and lock it in position with the bracket and plate.
- Fit collar A over the puller with its ends facing in the illustrated directions. Then, slowly apply a pressure of approximately 49 kN {5000 kgf} to the puller with a press to force out the connecting rod bushing.



[Installation]

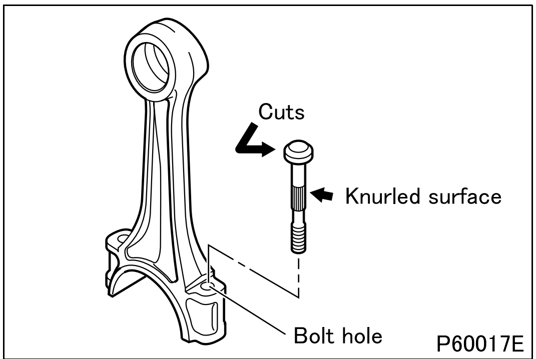
- Apply engine oil to the outside surface of the connecting rod bushing and the bushing fitting surface of the connecting rod.
- Fit collar B, the bushing, and collar A over the puller in the illustrated directions and lock this arrangement together with the nut.
- Align the oil holes in the connecting rod bushing and the connecting rod. Then, use a press to slowly apply a pressure of approximately 49 kN {5000 kgf} to the puller until the bushing is forced into place.
- After press-fitting the connecting rod bushing, measure the clearance between the piston pin and connecting rod bushing.
- If the measurement is less than the standard clearance range, ream the bushing.



■Inspection: Connecting rod bend and twist

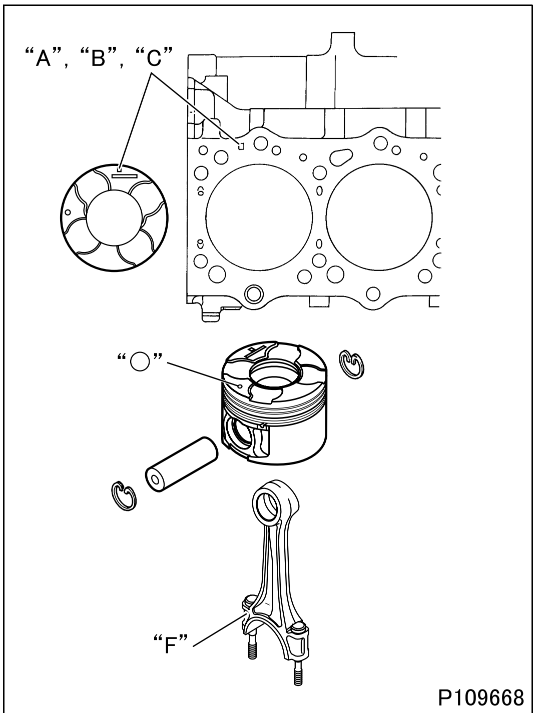
- Mount the connecting rod on the connecting rod aligner. Also mount the connecting rod bearings, piston pin, and connecting rod cap to create the same conditions as are expected when the connecting rod is mounted on a crankshaft. Tighten the nuts of the connecting rod bearing cap to a torque of 49 N·m {5 kgf·m}.
- Measure the extent of bend and twist in the connecting rod.
- If either measurement exceeds the specified limit, replace the connecting rod.

◆Installation procedure◆



■ Installation: Connecting rod bolts

- Check that there are no burrs or other defects on the surface of the connecting rod bolt holes. Replace the connecting rod if defects are evident.
- Apply engine oil to the knurled surface of the connecting rod bolt. Then, install the bolt by using a press to apply a pressure of approximately 4.9 kN {500 kgf} at the maximum with the cuts of the bolt head facing in the illustrated direction.



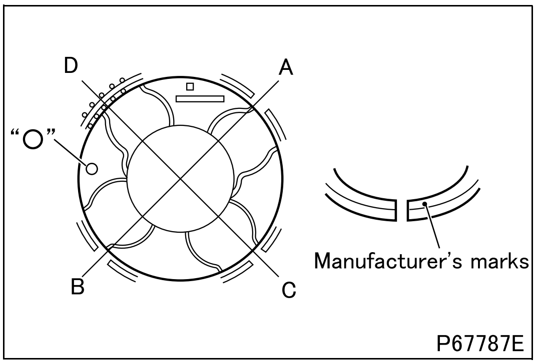
■ Installation: Piston and connecting rod

- Install pistons and connecting rods as follows when replacing them.
  - All the cylinders used in the same engine must be the same in weight.
- If the cylinder has not been machined to an oversize, check that the size marks of piston and upper crankcase (“A”, “B” or “C”) are the same. The piston size for each cylinder is shown on the upper crankcase.

CAUTION ⚠

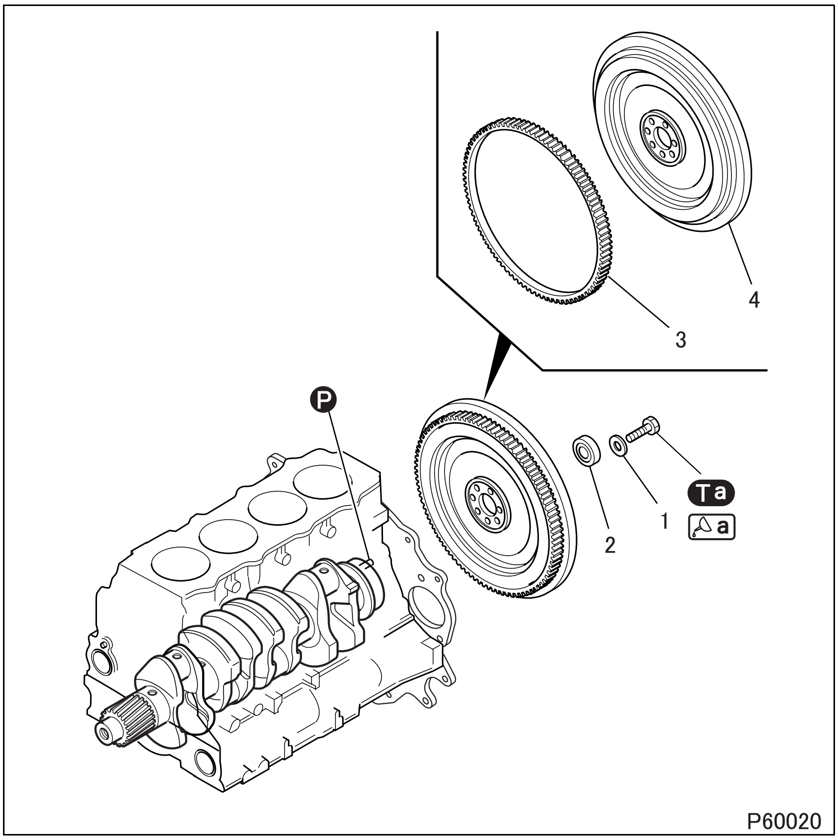
- **If the size of installed piston is different from the piston size shown on the upper crankcase, the engine is caused to seize up.**

- Apply engine oil to the piston pin, and assemble the piston and connecting rod with their marks facing in the illustrated directions.
- If the piston is difficult to insert, heat the piston in hot water or with a piston heater.



■ **Installation: Piston rings**

- With the manufacturer's mark (found near the piston ring end gaps) facing up, install the piston rings so that the end gap of each ring is positioned as illustrated.
  A: 1st compression ring end gap
  B: 2nd compression ring end gap
  C: Oil ring end gap
  D: Oil ring's expander spring end gap
  "O": Front mark on piston
  The manufacturer's marks are present only on the 1st and 2nd compression rings.



● **Disassembly sequence**

1 Washer
2 Pilot bearing
3 Ring gear
4 Flywheel

P: Locating pin

- Do not remove the pilot bearing and ring gear unless defects are evident.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

- Make sure that there are no foreign substances, oil and other harmful flaws on the flywheel mounting surface.

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
3	Wear of the ring gear		–	1.0	Replace
4	Flywheel	Friction surface runout (when fitted)	0.05	0.2	Rectify or replace
		Friction surface height	22.8	21.8	Replace
		Friction surface distortion	0.05 or less	0.2	Rectify or replace
		Friction surface parallelism	0.1	–	Rectify or replace

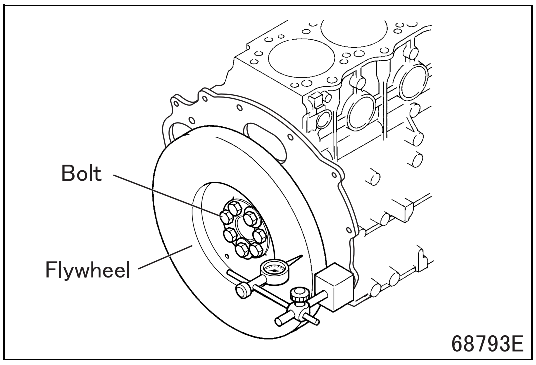
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (flywheel installation)	39 {4.0} + 30°	• Wet • Reusable up to three times

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Bolt threads	Engine oil	As required

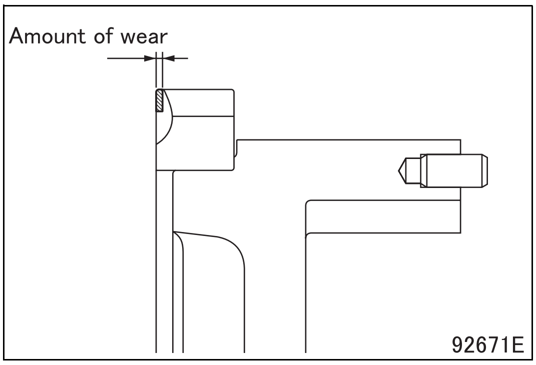
◆Inspection before removal◆



■ **Inspection: Flywheel friction surface runout**

- If the runout exceeds the specified limit, check that the bolts are tightened correctly and that there are no abnormalities on the crankshaft mounting surface, then rectify or replace the flywheel.

◆Inspection procedure◆



■ **Inspection: Wear of the ring gear**

[Inspection]

- If the measurement exceeds the limit, replace the ring gear.

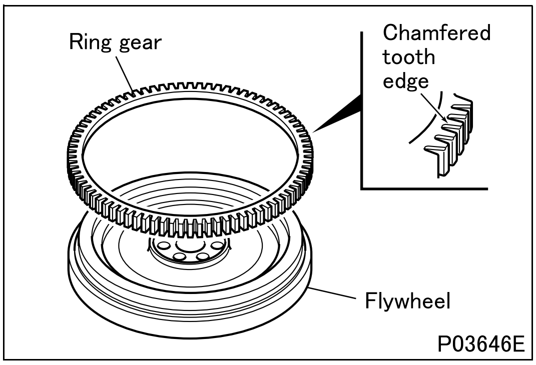
Replacement of the ring gear

[Removal]

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

WARNING ⚠

- **Never touch the heated ring gear, otherwise you may burn yourself.**



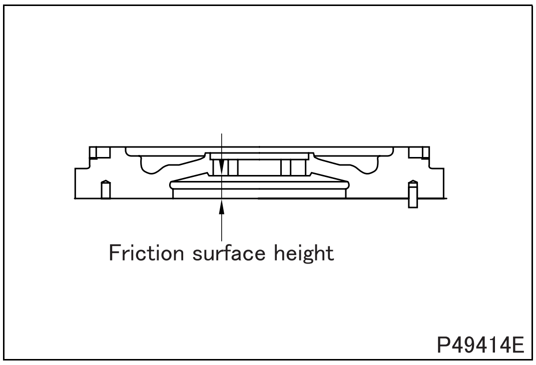
[Installation]

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

WARNING ⚠

- **Never touch the heated ring gear, otherwise you may burn yourself.**

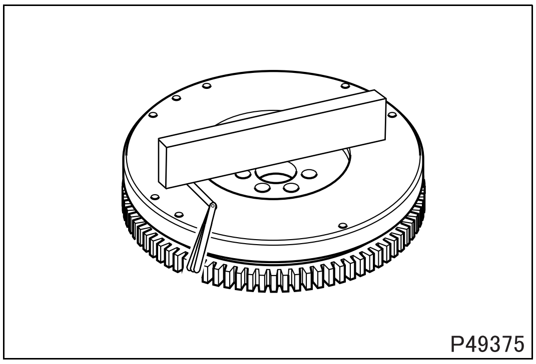
- Fit the ring gear with the side having non-chamfered tooth edge toward the flywheel.



■ **Inspection: Flywheel**

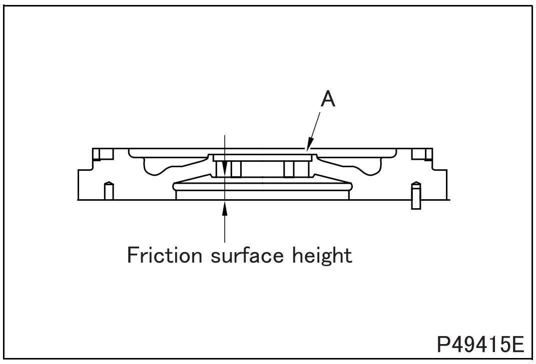
(1) Friction surface height

- If the height is below the specified limit, replace the flywheel.



(2) Friction surface distortion

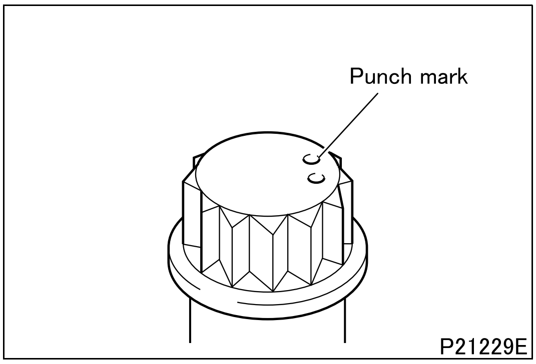
- If the measured amount is above the specified limit, rectify or replace the flywheel.



Rectification of flywheel

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

◆Installation procedure◆



■ Installation: Flywheel

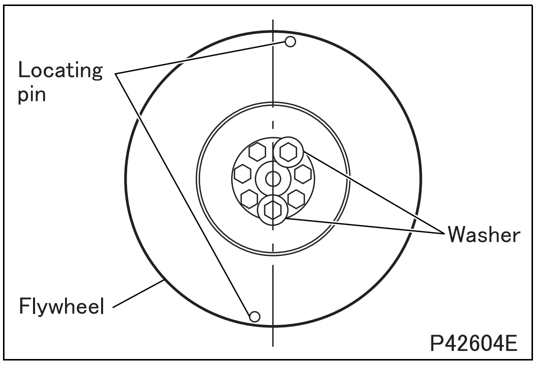
CAUTION ⚠

- **Before fitting the flywheel mounting bolts, check the punch marks on each bolt's head. (Bolts with one or two punch marks can be used.)**
- **The number of punch marks indicates the number of times the flywheel mounting bolt has been tightened using the torque-turn method. Any bolt that has three marks (indicating that the bolt has been tightened three times already) must be replaced with a new one.**

- Tighten the flywheel mounting bolts to a torque of 39 N·m {4.0 kgf·m}.
- After installing, give the bolts a further 30° turn clockwise to tighten up, then provide a punch mark on the head of each bolt to indicate the number of times of its use.

CAUTION ⚠

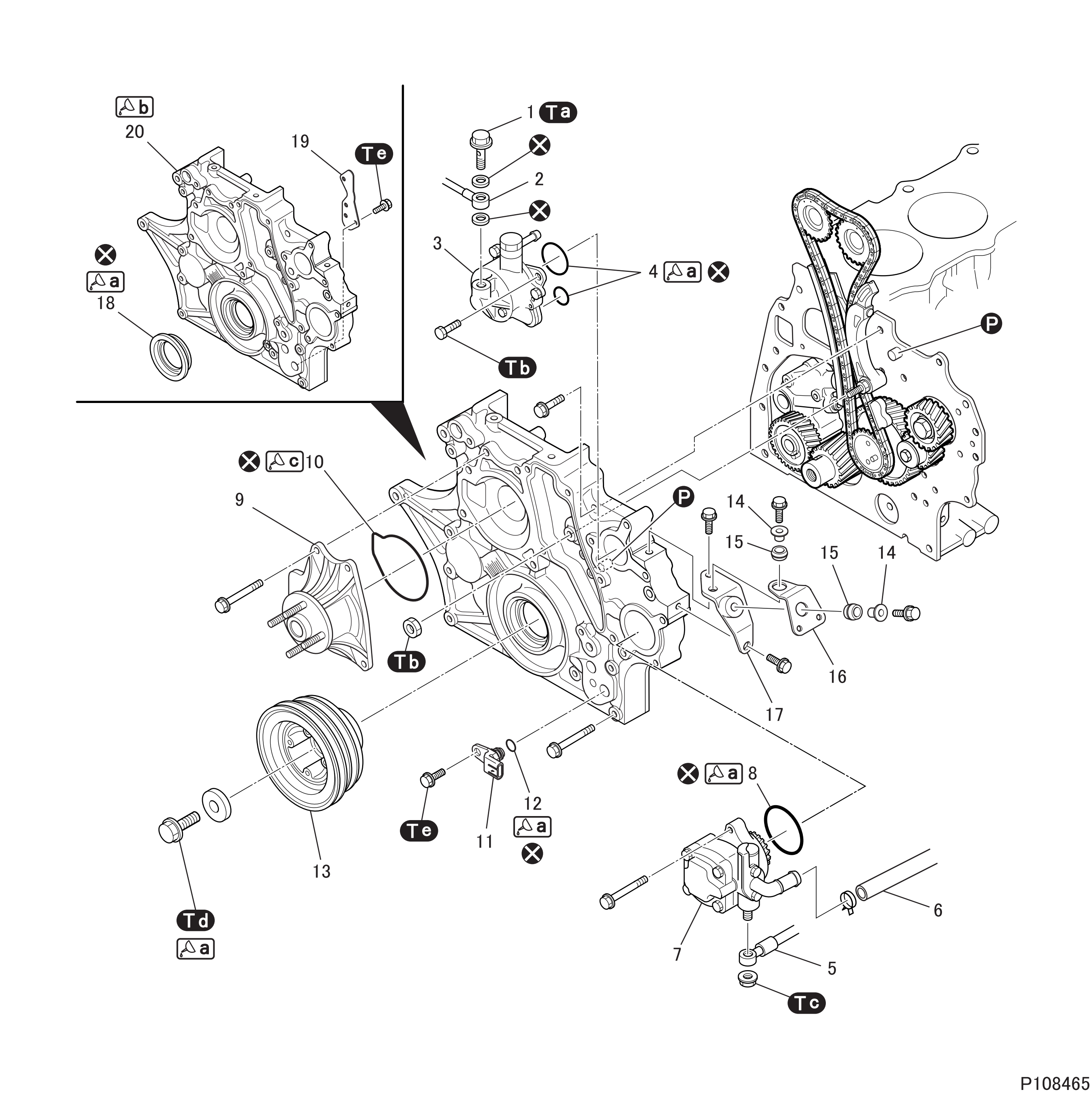
- **The bolts should be tightened within the plastic region. Never tighten them further than the specified angle.**



■ Installation: Washer

- Install the washer in the illustrated position.

M E M O



● **Disassembly sequence**

- **1** Eyebolt
- **2** Oil pipe
- **3** Vacuum pump (See Gr35.)
- **4** O-ring
- **5** Power steering pipe
- **6** Hose
- **7** Power steering oil pump (See Gr37.)
- **8** O-ring
- **9** Water pump
- **10** O-ring
- **11** Cylinder recognition sensor
- **12** O-ring
- **13** Crankshaft pulley
- **14** Spacer
- **15** Insulator
- **16** Bracket B
- **17** Bracket A
- **18** Front oil seal
- **19** Plate
- **20** Timing gear case

P: Locating pin
⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

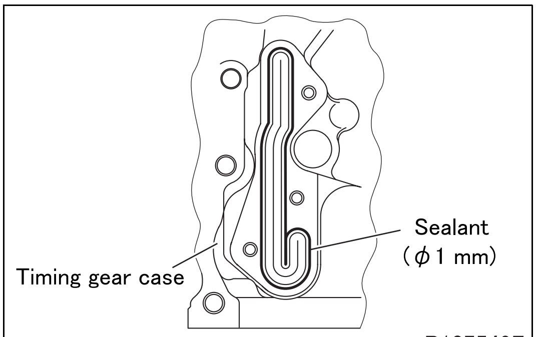
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Eyebolt (oil pipe mounting)	20 {2.0}	–
Tb	Bolt (vacuum pump mounting)	23 {2.4}	–
	Nut (timing gear case mounting)		
Tc	Nut (power steering pipe mounting)	29.4 to 39.2 {3 to 4}	–
Td	Bolt (crankshaft pulley mounting)	323 {33.0}	Wet
Te	Bolt (cylinder recognition sensor mounting)	8 {0.8}	–
	Bolt (plate mounting)		

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required
	Front oil seal lip		
	Bolt threads		
b	Timing gear case mounting surface	ThreeBond 1207C	As required
	Plate mounting surface of timing gear case		
c	O-ring	Soapy water	As required

◆Installation procedure◆



P107549E

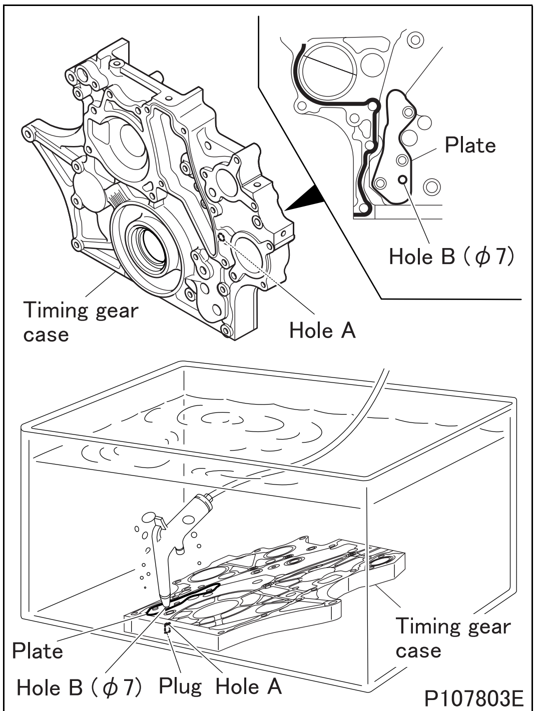
■ Installation:

[Installation]

- Clean the sealant application surface of the plate and timing gear case.
- Apply a bead of sealant to the plate mounting surface of the timing gear case evenly and without any breaks.
- Install the plate within 15 minutes of applying the sealant, being careful not to dislodge the sealant.

CAUTION ⚠

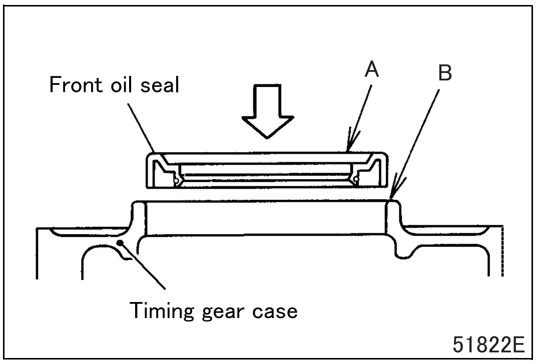
- **If the plate mounting bolts are subsequently loosened or removed, be sure to apply sealant again upon reassembly.**



P107803E

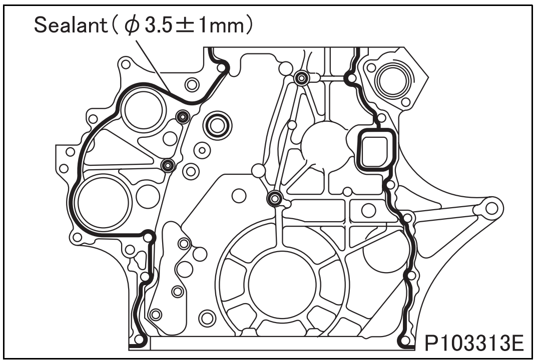
[Inspection]

- Perform the inspection one hour after the timing gear case is installed to the timing gear case.
- Plug the hole A in the timing gear case.
- Apply the nozzle of an air gun to the hole B in the plate, then immerse the timing gear case in a container of water while applying an air pressure of 15 kPa {0.2 kgf/cm^2} into it.
- If air bubbles come out from the plate fitting surface, reinstall the plate.
- After the inspection, unplug the hole A and drain water, if trapped, from the timing gear case.



■ **Installation: Front oil seal**

- Install the front oil seal with its ends facing as illustrated so that end surface A of the oil seal is flush with end surface B of the timing gear case.



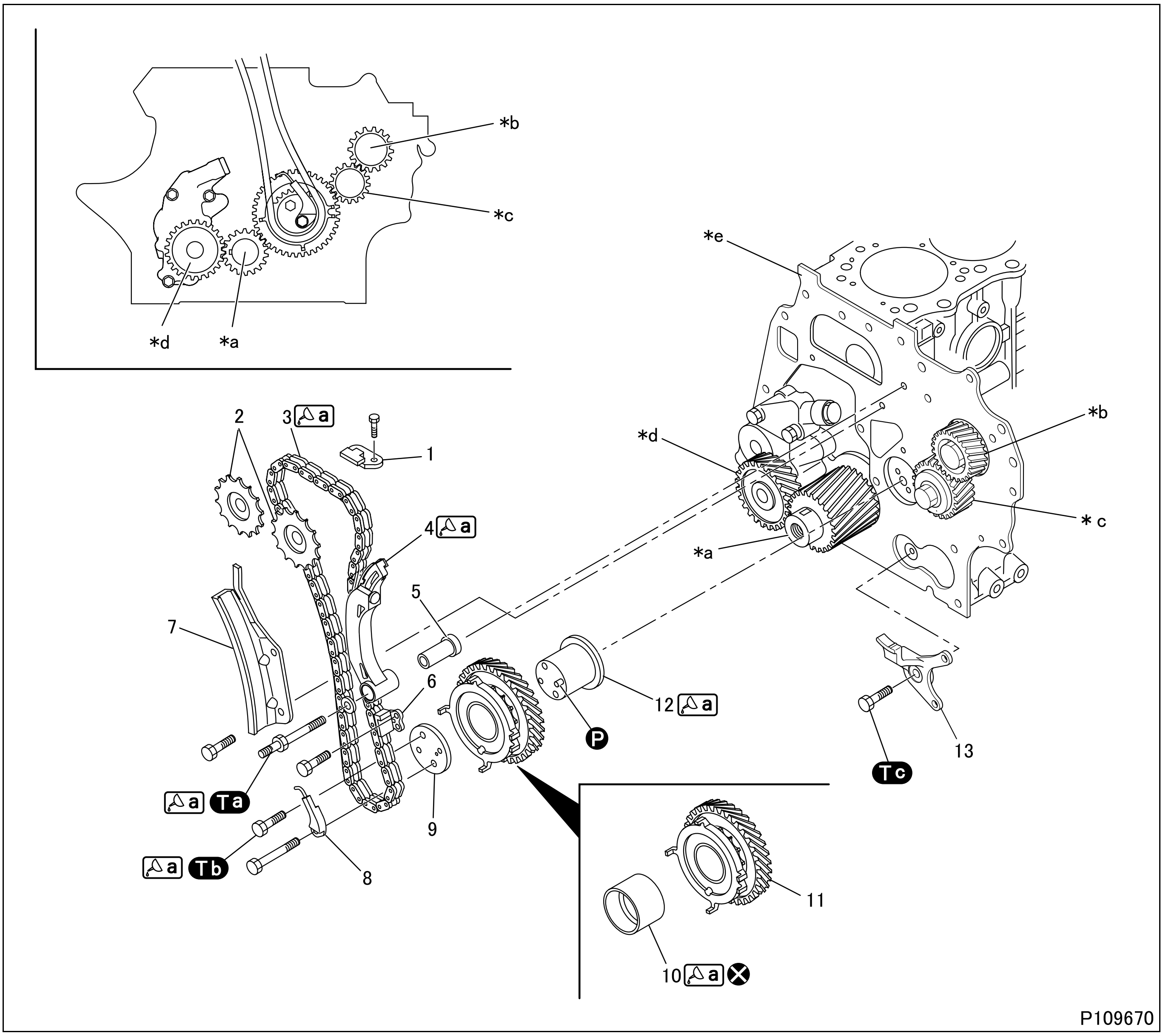
■ **Installation: Timing gear case**

- Clean the sealant application surface of each part.
- Apply a bead of sealant to the front plate mounting surface of the timing gear case evenly and without any breaks.
- Install the timing gear case within 15 minutes of applying the sealant, being careful not to dislodge the sealant.

CAUTION ⚠

- **Do not run the engine within one hour of mounting the timing gear case.**
- **If the timing gear case mounting nuts or bolts are loosened or removed, be sure to reapply sealant.**

M E M O



● Disassembly sequence

- **1** Upper guide plate
- **2** Cam sprocket
- **3** Timing chain
- **4** Tension lever
- **5** Tension lever shaft
- **6** Lower guide plate
- **7** Guide plate
- **8** Oil jet
- **9** Idler washer
- **10** Idler sprocket bushing
- **11** Idler gear and sprocket
- **12** Idler shaft
- **13** Chain support

- ***a**: Crankshaft gear
- ***b**: Supply pump gear
- ***c**: Idler gear B
- ***d**: Oil pump gear
- ***e**: Front plate

- P: Locating pin
- ⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

- After tightening the tension lever shaft mounting bolt, check that the tension lever moves smoothly.
- The idler shaft also serves as a locating component for the front plate.

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
–	Backlash between gears	Oil pump gear and crankshaft gear	0.098 to 0.158	0.3	Replace
		Crankshaft gear and idler gear and sprocket	0.082 to 0.142	0.3	
		Idler gear and sprocket and idler gear B	0.096 to 0.156	0.4	
–	Idler gear and sprocket end play		0.05 to 0.20	0.3	Replace
3	Elongation of timing chain (clearance between chains with tension lever pressed)		16.5	9	Replace
4, 5	Tension lever-to-tension lever shaft clearance		0.06 to 0.18	0.3	Replace
10, 12	Idler sprocket bushing-to-idler shaft clearance		0.02 to 0.06	0.1	Replace

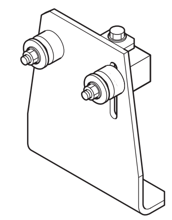
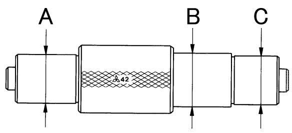
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (tension lever shaft mounting)	40 {4.1}	Wet
Tb	Bolt (idler shaft mounting)	44 {4.4}	Wet
Tc	Bolt (chain support mounting)	45 to 55 {4.6 to 5.6}	–

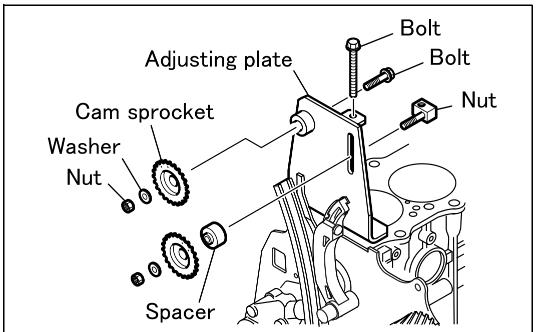
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Timing chain sliding surfaces	Engine oil	As required
	Bolt threads		
	Tension lever shaft mounting surface of tension lever		
	Idler sprocket bushing inner surface		
	Idler shaft outer surface		

Special tools (Unit: mm)

<table>
<tr><th>Mark</th><th>Tool name and shape</th><th>Part No.</th><th>Application</th></tr>
<tr><td>a</td><td>Cam sprocket holder kit

P34782</td><td>MH063490</td><td>Supporting the cam sprocket</td></tr>
<tr><td>b</td><td>Idler sprocket bushing puller
<table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>ϕ41.5</td><td>ϕ46</td><td>ϕ42</td></tr></table>
04569</td><td>MH062462</td><td>Removal and installation of idler sprocket bushing</td></tr>
</table>

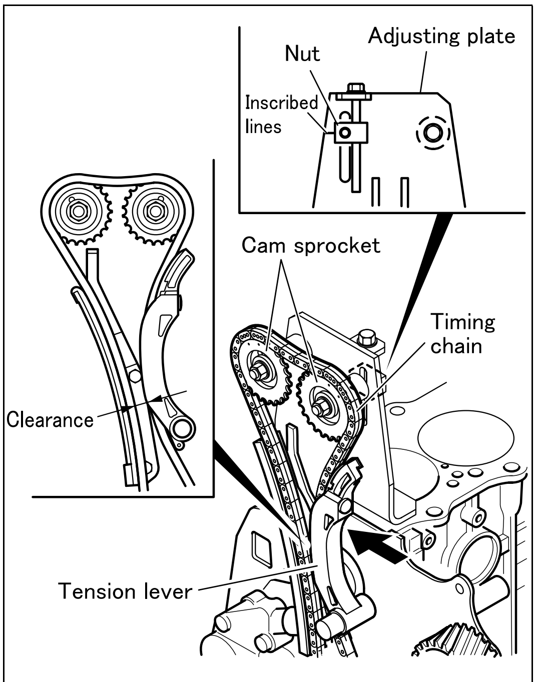
◆Inspection before removal◆



P60025E

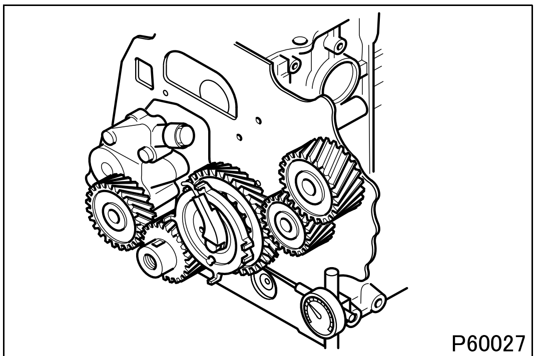
■ **Inspection: Timing chain elongation**

- Support the cam sprocket with [Ca].



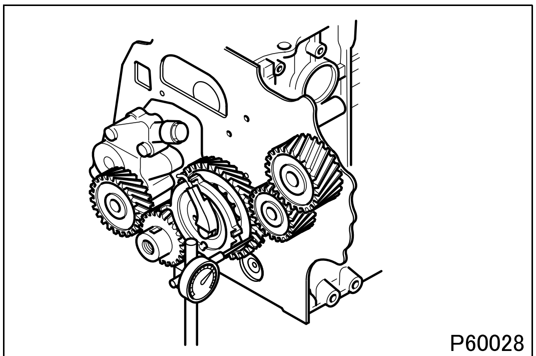
P60026E

- Align the inscribed lines on the adjusting plate and the nut to adjust the exhaust cam sprocket and the intake cam sprocket positions to their normal installed positions.
- Push the tension lever by hand to make the timing chain taut.
- Measure the amount of elongation of the timing chain (smallest distance between the two chain portions).
- Replace the timing chain if the measured distance is below the specified limit.


P60027

■ **Inspection: Backlash between gears**

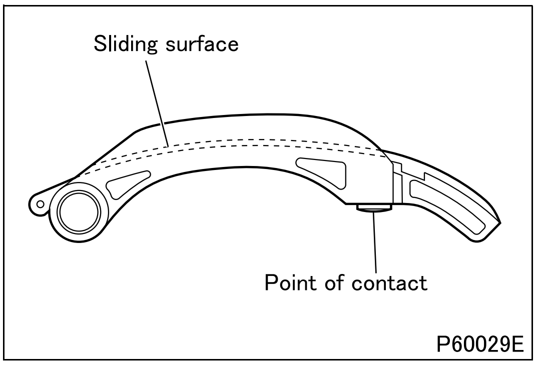
- For each pair of gears, measure the backlash for at least three teeth.
- If any of the measurements exceeds the specified limit, replace the defective part(s).


P60028

■ **Inspection: Idler gear and sprocket assembly end play**

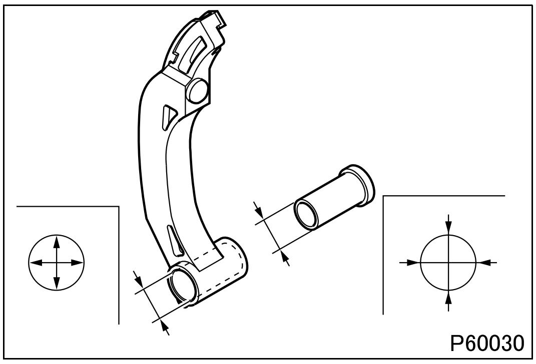
- If the measurement exceeds the specified limit, replace the defective part(s).

◆Inspection procedure◆



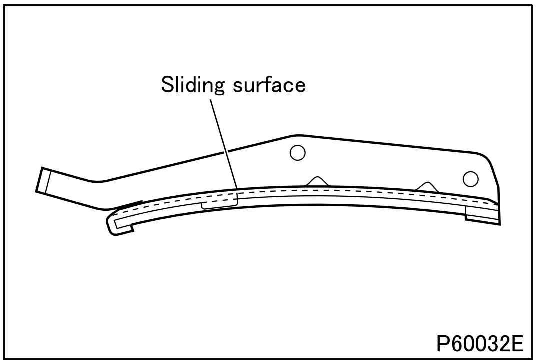
■ Inspection: Tension lever

- Check the timing chain sliding surface and point of contact of the tension lever for cracking or flaking.
- Replace the tension lever if defects are evident.



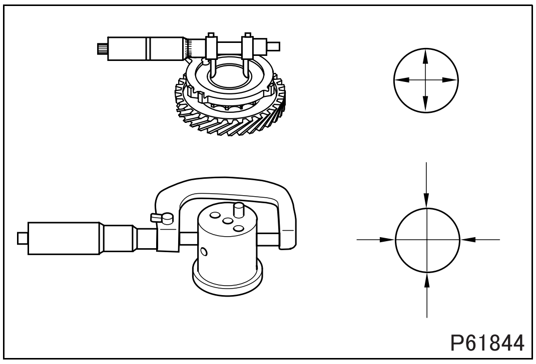
■ Inspection: Tension lever-to-tension lever shaft clearance

- Replace the defective part(s) if the clearance exceeds the specified limit.



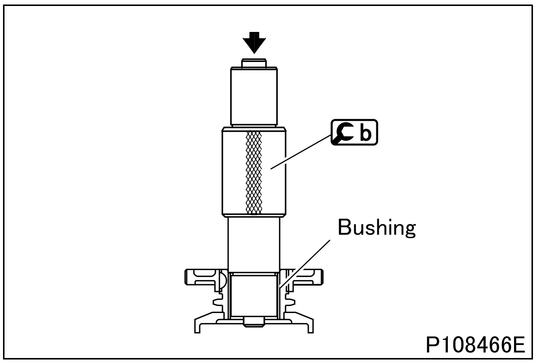
■ Inspection: Guide plate

- Check the timing chain sliding surface of the guide plate for cracking or flaking.
- Replace the guide plate if defects are evident.

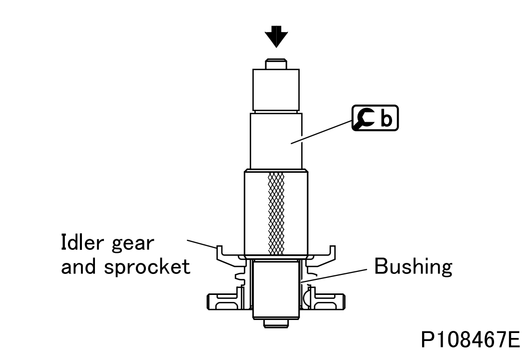


■ Inspection: Idler sprocket bushing-to-idler shaft clearance

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



Replacement of idler sprocket bushing
[Removal]

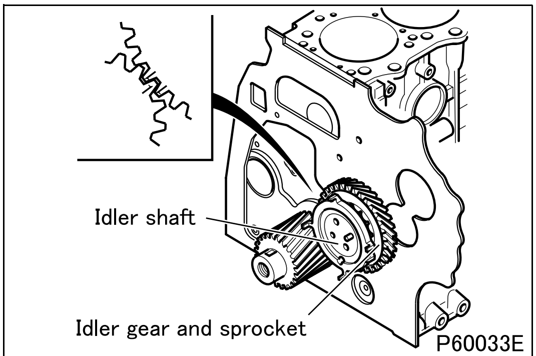


P108467E

[Installation]

- Place the idler gear and sprocket with its ends facing as illustrated.
- Install the bushing until b sits on the chamfered end of the idler gear and sprocket.
- After installation, measure the clearance again.
- If the measurement is below the specified limit, ream the bushing.

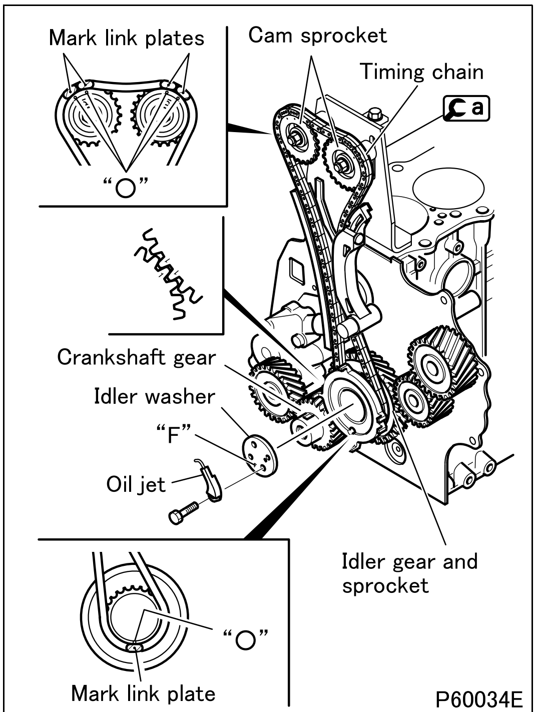
◆Installation procedure◆



P60033E

■ Installation: Idler gear and sprocket

- Install the idler gear and sprocket on the idler shaft while aligning the marks "1" on its teeth with the corresponding mark on one of the crankshaft gear teeth.



P60034E

■ Installation: Timing chain

- Support the cam sprocket with a.
- Check that the idler gear and sprocket and the crankshaft gear are engaged at the "1" marked teeth.
- Align the " O " mark on the idler gear and sprocket with the mark link plate (one plate) on the timing chain.

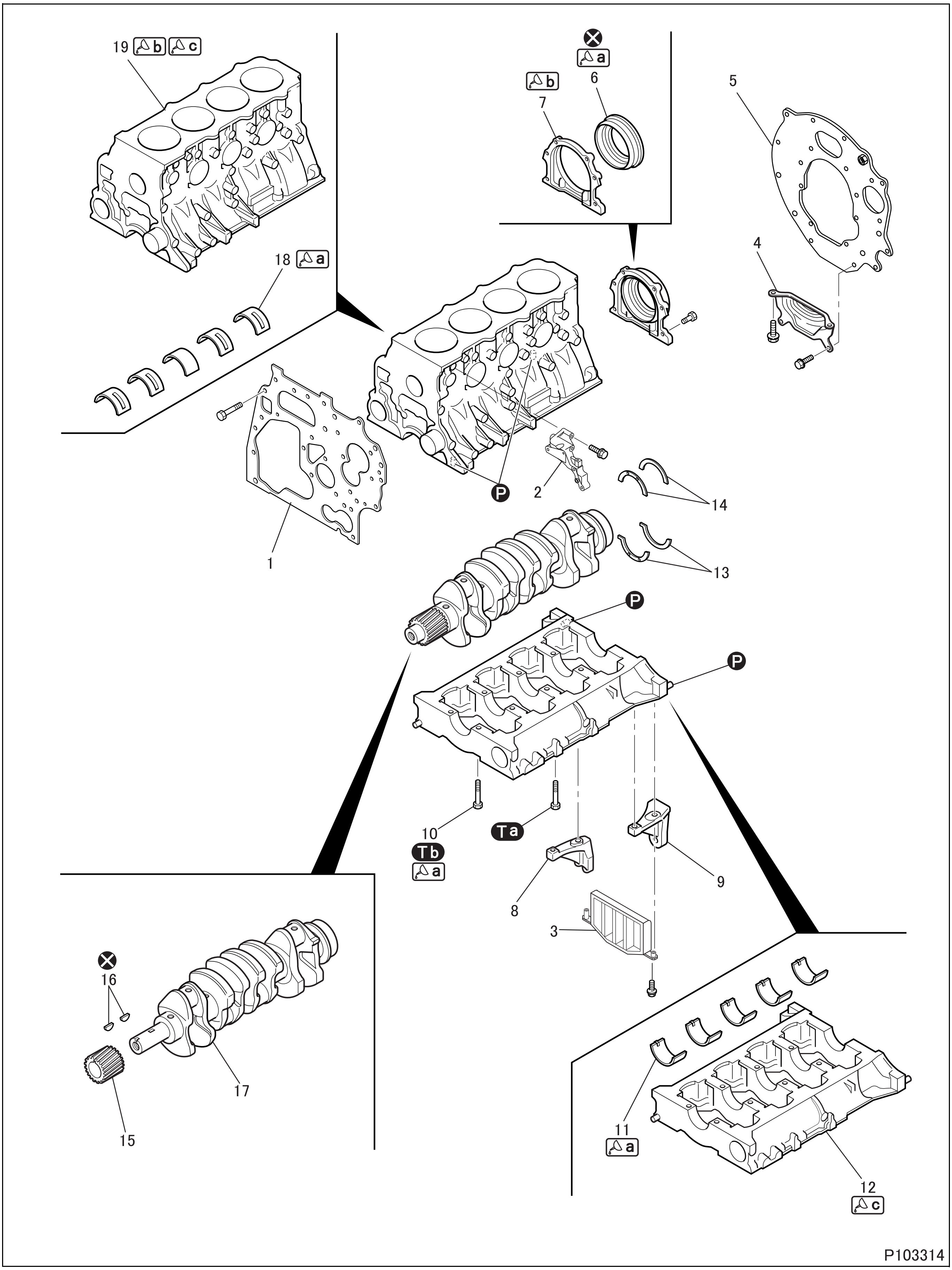
CAUTION ⚠

- **The timing chain has mark link plates in two locations (one with one mark link plate and the other with two mark link plates). Do not confuse the two locations when carrying out this procedure.**

- Install the timing chain with the mark link plates (two plates) aligned with the " O " marks on the exhaust cam sprocket and intake cam sprocket.
- After installing the timing chain, install the idler washer so that the front mark "F" is facing forward.

MEMO

CRANKSHAFT AND CRANKCASE



● Disassembly sequence

1 Front plate
2 Stiffener
3 Rubber spacer
4 Dust cover
5 Rear plate
6 Rear oil seal
7 Rear oil seal case
8 Stiffener RH
9 Stiffener LH
10 Main cap bolt
11 Lower main bearing
12 Lower crankcase
13 Lower thrust plate
14 Upper thrust plate
15 Crankshaft gear
16 Key
17 Crankshaft
18 Upper main bearing
19 Upper crankcase

Ⓟ: Locating pin
⊗: Non-reusable parts

CAUTION ⚠

- **The lower crankcase and upper crankcase are manufactured as paired parts, and therefore must always be replaced as a set.**

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **The main cap bolts are tightened using the torque-turn tightening method. Any bolt that has three punch marks must be replaced with a new one.**

Service standards (Unit: mm)

Location	Maintenance item			Standard value	Limit	Remedy
–	Crankshaft end play			0.10 to 0.28	0.4	Adjust
11, 17, 18	Main bearing-to-crankshaft oil clearance		All except No. 3	0.032 to 0.06	0.15	Replace
			No. 3	0.072 to 0.1		
11, 18	Main bearing span when free			–	73.16	Replace
17	Crankshaft	Bend		0.02 or less	0.05	Replace
		Pins and journals	Out-of-roundness	0.01 or less	–	Rectify or replace
			Taper	0.006 or less	–	
		Center-to-center distance between journal and pin		52.05 ± 0.05	–	
		Journal width	No. 1	27.5	–	
			No. 2 to 4	30	–	
			No. 5	$30^{+0.039}_{0}$	–	
		Pin width		$35^{+0.2}_{0}$	–	
		Fillet		R3.5	–	
19	Upper crank-case	Top surface distortion		0.01	0.07	Rectify or replace
		Cylinder	Out-of-roundness	0.005 or less	–	Replace
			Taper	0.015 or less	–	

Tightening torque (Unit: N·m {kgf·m})

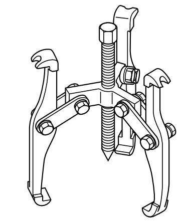
Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (lower crankcase mounting)	25 {2.5}	–
Tb	Main cap bolt (lower crankcase mounting)	20 {2.0} + 90° + 90°	• Wet • Reusable up to three times

CRANKSHAFT AND CRANKCASE

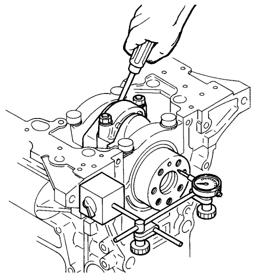
Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Rear oil seal lip	Engine oil	As required
	Main cap bolt threads and seating surfaces		
	Main bearing inside surface		
b	Lower crankcase mounting surface of upper crankcase	ThreeBond 1217H	As required
	Upper and lower crankcase mounting surfaces of rear oil seal case		
c	Front plate mounting surfaces of upper crankcase and lower crankcase	ThreeBond 1207C	As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Gear puller  P02065	MH062469	Removal of crankshaft gear

◆Inspection before removal◆

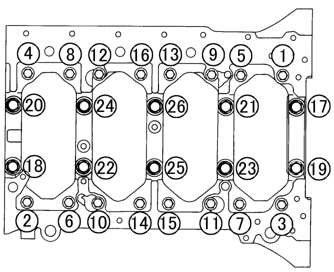


03739

■ **Inspection: Crankshaft end play**

- If the measurement exceeds the specified limit, replace the thrust plates with oversized ones.
  Available oversizes:
  +0.15 mm, +0.30 mm, +0.45 mm
- Replace the crankshaft if the end play is too large to adjust using oversized thrust plates.

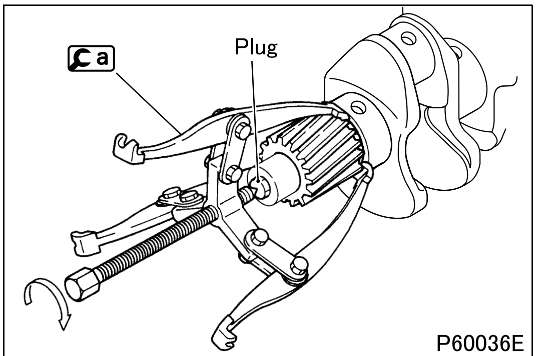
◆Removal procedure◆



49927

■ **Removal: Lower crankcase**

- Loosen the bolts in several passes in the order indicated in the illustration (1 to 16).
- After loosening the bolts, loosen the main cap bolts in several passes in the order indicated in the illustration (17 to 26), then remove the main cap bolts.



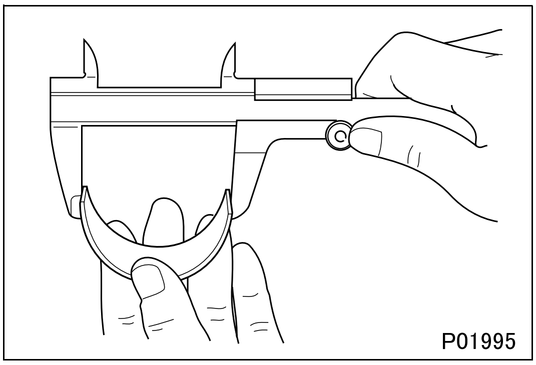
P60036E

■ **Removal: Crankshaft gear**

CAUTION ⚠

- **Attach a plug (M16 × 1.5 mm, length 30 mm) on the end of the crankshaft to prevent any damage by a.**
- **Do not tap off the crankshaft gear as this can damage it.**

◆Inspection procedure◆

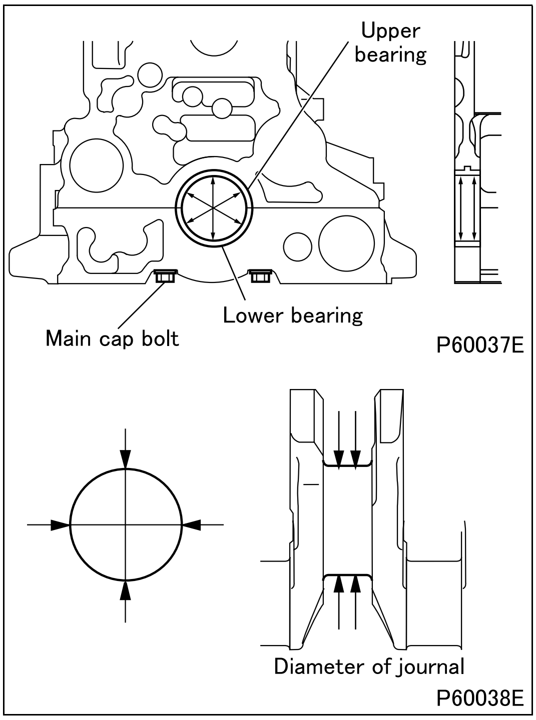


■ **Inspection: Main bearing span when free**

CAUTION ⚠

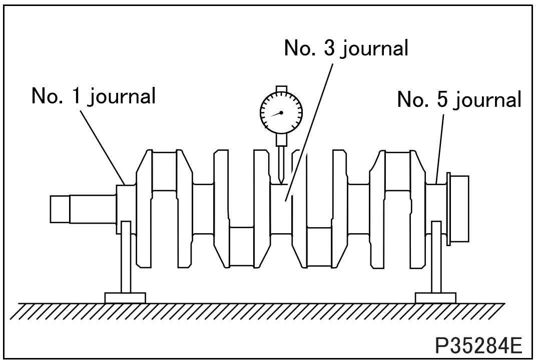
- **Do not attempt to manually expand the bearings.**

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



■ **Inspection: Main bearing-to-crankshaft oil clearance**

- Fit the upper bearing into the upper crankcase and the lower bearing into the lower crankcase.
- Tighten the main cap bolts to a torque of 20 N·m {2.0 kgf·m}.
- Measure the inside diameter of the main bearing and the diameter of the corresponding crankshaft journal.
- If the difference between the measurements exceeds the specified limit, machine the crankshaft journal to one of the specified undersized dimensions.

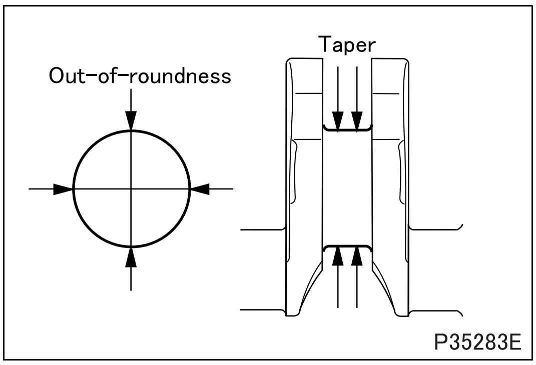


■ **Inspection: Crankshaft**

[Inspection]

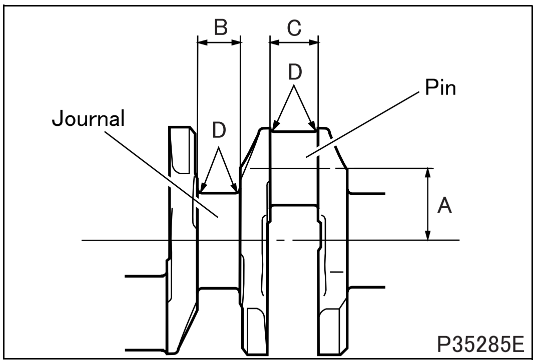
(1) Bend

- Support the crankshaft at its No. 1 journal and No. 5 journal. Measure the extent of bending in the crankshaft at the center of the No. 3 journal. A half of the dial gauge reading obtained as the crankshaft is rotated by a full turn represents the bend of the crankshaft.
- If the measurement exceeds the specified limit, replace the crankshaft.



(2) Out-of-roundness and taper of crankshaft journals and pins

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



Grinding of crankshaft

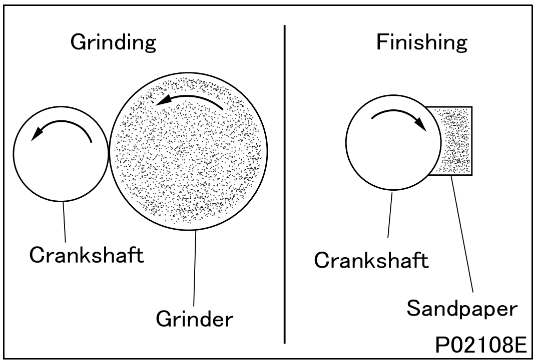
CAUTION ⚠

- **If the crankshaft is ground to an undersize, the main bearings must be replaced with the undersized ones of the corresponding undersize.**

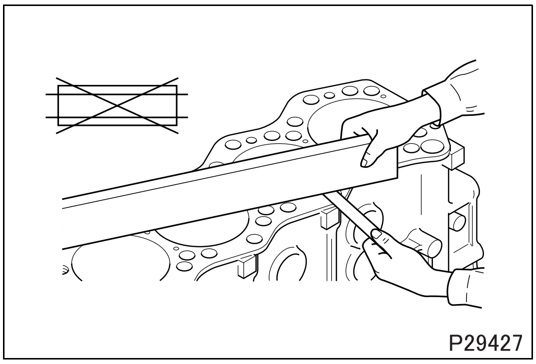
- Make sure of necessary undersize dimensions in the maintenance standard table and carry out grinding work in accordance with the following procedure.
- Do not change the center-to-center distance A between the journal and pin.
- Do not change the journal width B and the pin width C.
- Finish the fillets D smoothly.
- Carry out a magnetic inspection to check for cracks possibly caused by grinding. Also, check that the hardness of the surface has not dropped below Shore hardness number (Hs) 75.
- Replace the crankshaft if defects are evident.

Crankshaft undersize dimensions (Unit: mm)

	Undersizes			
	0.25	0.50	0.75	1.00
Finished journal diameter	67.711 to 67.728	67.461 to 67.478	67.211 to 67.228	66.961 to 66.978
Finished pin diameter	53.721 to 53.738	53.471 to 53.488	53.221 to 53.238	52.971 to 52.988
Out-of-roundness	0.01 or less			
Taper	0.006 or less			



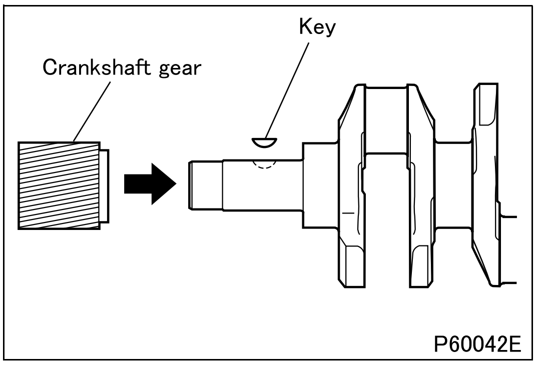
- When grinding, turn both the crankshaft and the grinder counterclockwise as viewed from the crankshaft front end.
- When finishing the crankshaft with whetstone or sandpaper, rotate the crankshaft clockwise.



■ **Inspection: Distortion of upper crankcase top surface**

- If the measurement exceeds the specified limit, grind the crankcase top surface with a surface grinder.
- Limit the amount of removed metal to make sure that the amount of piston projection above the crankcase top surface stays within the standard value range. (See the PISTON AND CONNECTING ROD section.)

◆**Installation procedure**◆



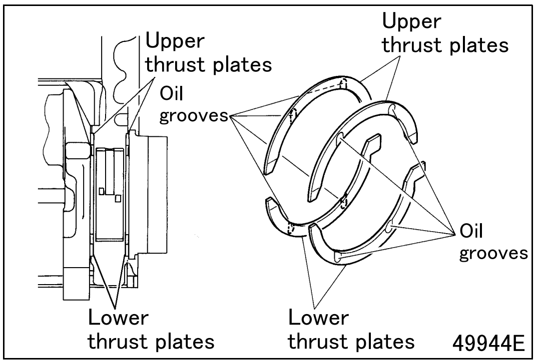
■ **Installation: Crankshaft gear**

- Heat the crankshaft gear to approximately 170 ± 10°C with a gas burner or the like.

WARNING ⚠

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

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



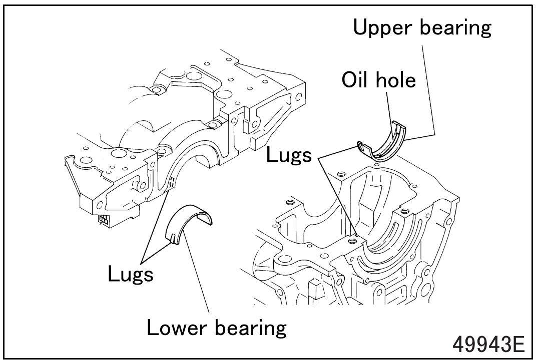
■ **Installation: Thrust plates**

- Install the thrust plates on the rearmost main bearings with the oil grooves on the inner plates facing inward and those on the outer plates outward as shown in the illustration.

CAUTION ⚠

- **Be sure to orient the oil grooves of the thrust plates as indicated above, otherwise seizures may occur in the engine.**

- Use oversized thrust plates when adjusting the crankshaft end play. The upper and lower thrust plates on the same side must be of the same size. The thrust plates on one side may differ in size from those on the other side.

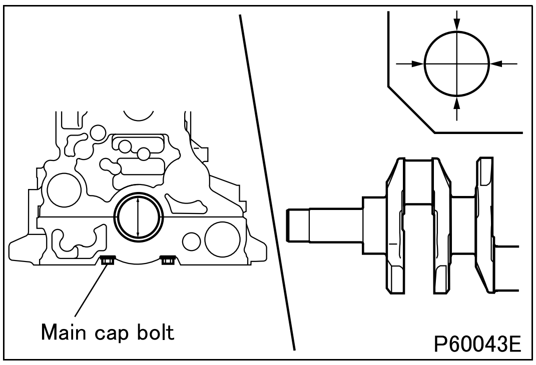


■ **Installation: Main bearings**

CAUTION ⚠

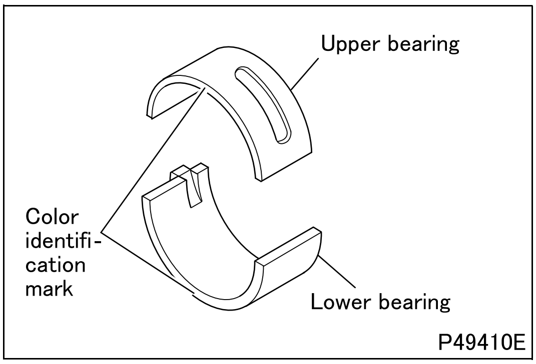
- **The upper main bearing has an oil hole while the lower main bearing does not. Do not confuse the two, as incorrect installation can cause seizures in the engine.**

- Select and use a main bearing set of a thickness that can accommodate the inside diameter of each main bearing fitting hole between the upper crankcase and lower crankcase and the diameter of the corresponding crankshaft journal.
  Select the appropriate main bearing set by one of the following two methods.



(1) Measurement based selection

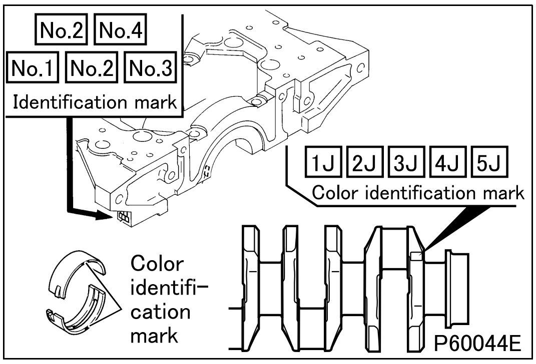
- Mount the lower crankcase on the upper crankcase without fitting main bearings.
- Tighten the main cap bolts to 20 N·m {2.0 kgf·m}.
- Measure the inside diameter of the main bearing fitting hole between the upper crankcase and lower crankcase (vertically from one point), and the diameter of the crankshaft journal (vertically or horizontally from two points).



- Select a main bearing set that matches the measurements from the table below.
  If the color identification mark is indiscernible, measure the thickness of the bearing walls and use the measurements in its place.

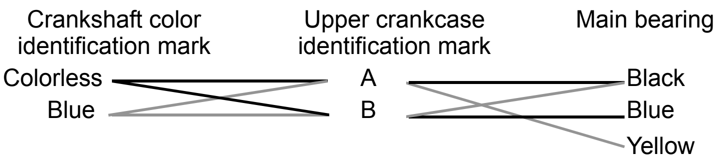
(Unit: mm)

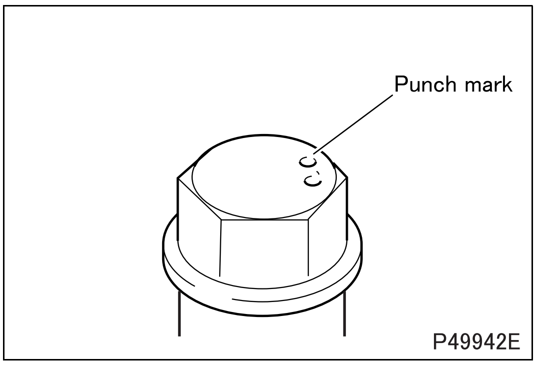
Crankshaft	Upper crankcase and lower crankcase	Main bearing		
Diameter of journal	Inside diameter of main bearing fitting hole	Color identification mark	Journal No.	Thickness
$68^{-0.022}_{-0.030}$	$72^{+0.019}_{+0.010}$	Black	No. 1, 2, 4, 5	$2^{-0.001}_{-0.005}$
			No. 3	$2^{-0.021}_{-0.025}$
	$72^{+0.010}_{0}$	Blue	No. 1, 2, 4, 5	$2^{-0.005}_{-0.009}$
			No. 3	$2^{-0.025}_{-0.029}$
$68^{-0.030}_{-0.039}$	$72^{+0.019}_{+0.010}$	Yellow	No. 1, 2, 4, 5	$2^{+0.003}_{-0.001}$
			No. 3	$2^{-0.017}_{-0.021}$
	$72^{+0.010}_{0}$	Black	No. 1, 2, 4, 5	$2^{-0.001}_{-0.005}$
			No. 3	$2^{-0.021}_{-0.025}$



(2) Color identification mark based selection

- Use selection by identification color for new parts.
- The crankshaft, upper crankcase, and main bearing can be appropriately combined in the following ways according to their color identification marks:
  - 1J: Position of color identification mark on No. 1 journal
  - 2J: Position of color identification mark on No. 2 journal
  - 3J: Position of color identification mark on No. 3 journal
  - 4J: Position of color identification mark on No. 4 journal
  - 5J: Position of color identification mark on No. 5 journal

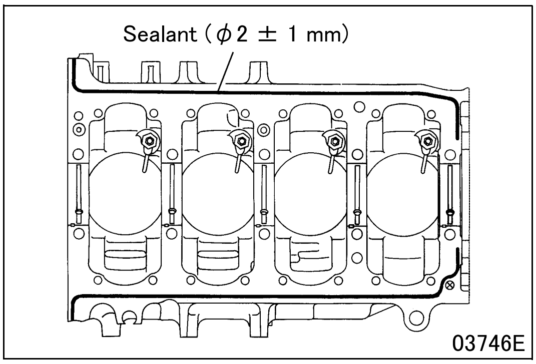




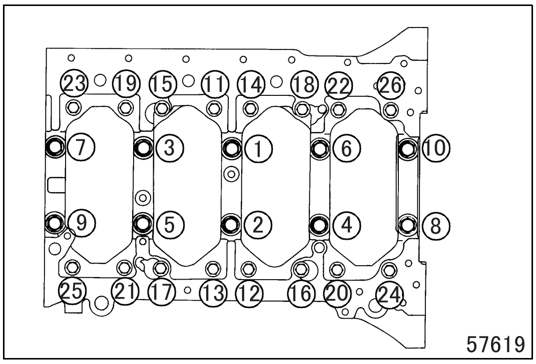
■ **Installation: Lower crankcase**

CAUTION ⚠

- **Before installing the main cap bolt, check the punch marks on each bolt's head. (Bolts with one or two punch marks can be reused.)**
- **The punch marks indicate the number of times each main cap bolt has been tightened using the torque-turn tightening method. Any main cap bolt that already has three punch marks (the bolt has already been tightened three times) must be replaced.**



- Clean the sealant application surfaces of each part.
- Apply a bead of sealant to the upper crankcase evenly and without any breaks as shown in the illustration.
- Install the lower crankcase within three minutes of applying the sealant to the upper crankcase, being careful not to dislodge the sealant.



- Apply engine oil to the threads and seating surface under the head of each of the main cap bolts, and tighten the bolts to a torque of 20 N·m {2.0 kgf·m} in the order indicated in the illustration (1 to 10).
- Then, tighten the main cap bolts further by 90° in the same order.
- Tighten them by another 90° in the same order.
- After completing tightening of the main cap bolts, tighten the bolts (11 to 26) to the specified torque in the order indicated in the illustration.

CAUTION ⚠

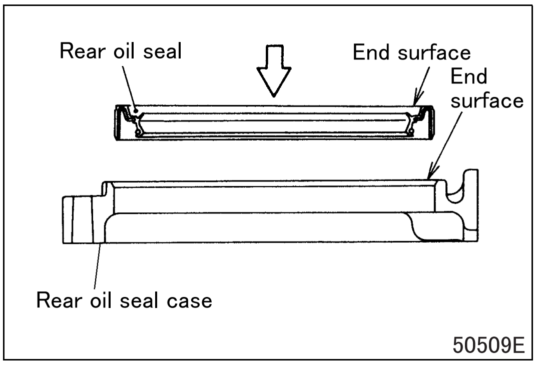
- **Do not run the engine within one hour after installing the bolts.**
- **Reapply sealant to the upper crankcase if the bolts or main cap bolts are loosened or removed.**

- After tightening the main cap bolts using the torque-turn tightening method, make a punch mark on the head of each main cap bolt to indicate the number of times it has been used.

CAUTION ⚠

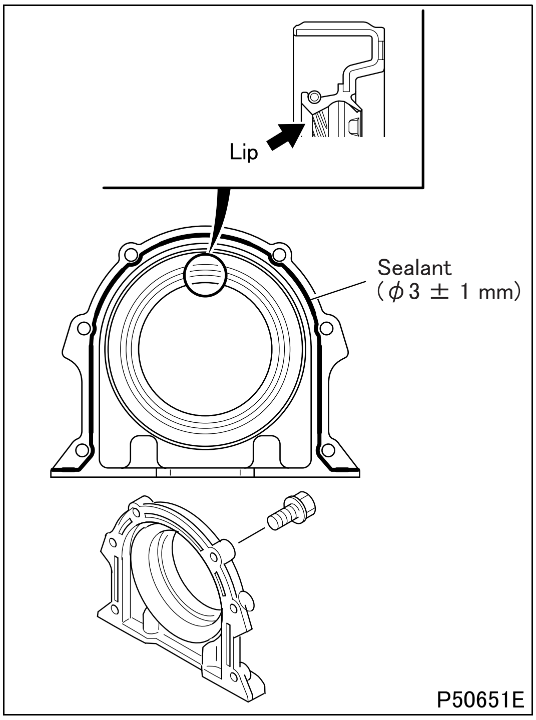
- **The main cap bolts are tightened using the torque-turn tightening method and must never be additionally tightened after the final angular tightening.**

- After installing the lower crankcase, check that the crankshaft can be rotated lightly by hand. Inspect the main bearing cap fitting holes if the crankshaft does not rotate smoothly.



■ Installation: Rear oil seal

- Install the rear oil seal in the rear oil seal case in the illustrated direction until the end surface of the oil seal is flush with the end surface of the rear oil seal case.

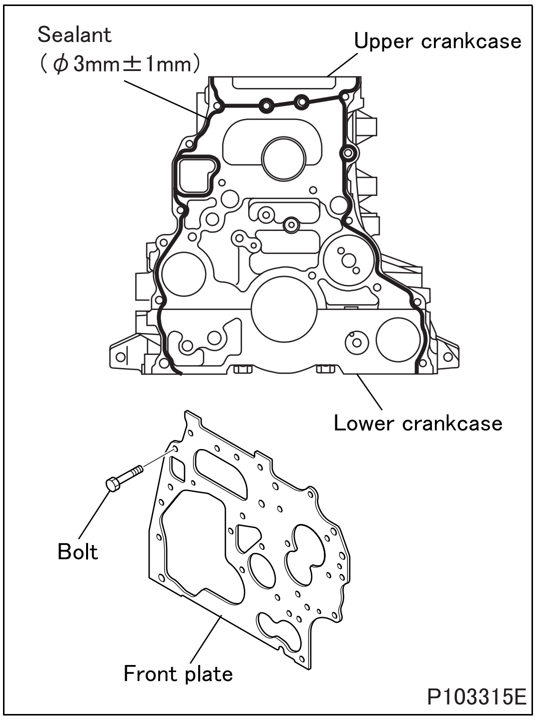


■ **Installation: Rear oil seal case**

- Apply engine oil to the rear oil seal lip.
- Clean the sealant application surface.
- Apply a bead of sealant to the rear oil seal case evenly and without any breaks as shown in the illustration.
- Install the rear oil seal case on the crankcase assembly within three minutes of applying the sealant, being careful not to dislodge the sealant.

CAUTION ⚠

- **Do not run the engine within one hour after installing the rear oil seal case.**
- **Reapply sealant to the rear oil seal case if any of the bolts is loosened or removed.**



■ **Installation: Front plate**

- Clean the sealant application surfaces of each part.
- Apply a bead of sealant to the upper crankcase and lower crankcase evenly and without any breaks as shown in the illustration.
- Install the front plate within three minutes of applying the sealant, being careful not to dislodge the sealant.

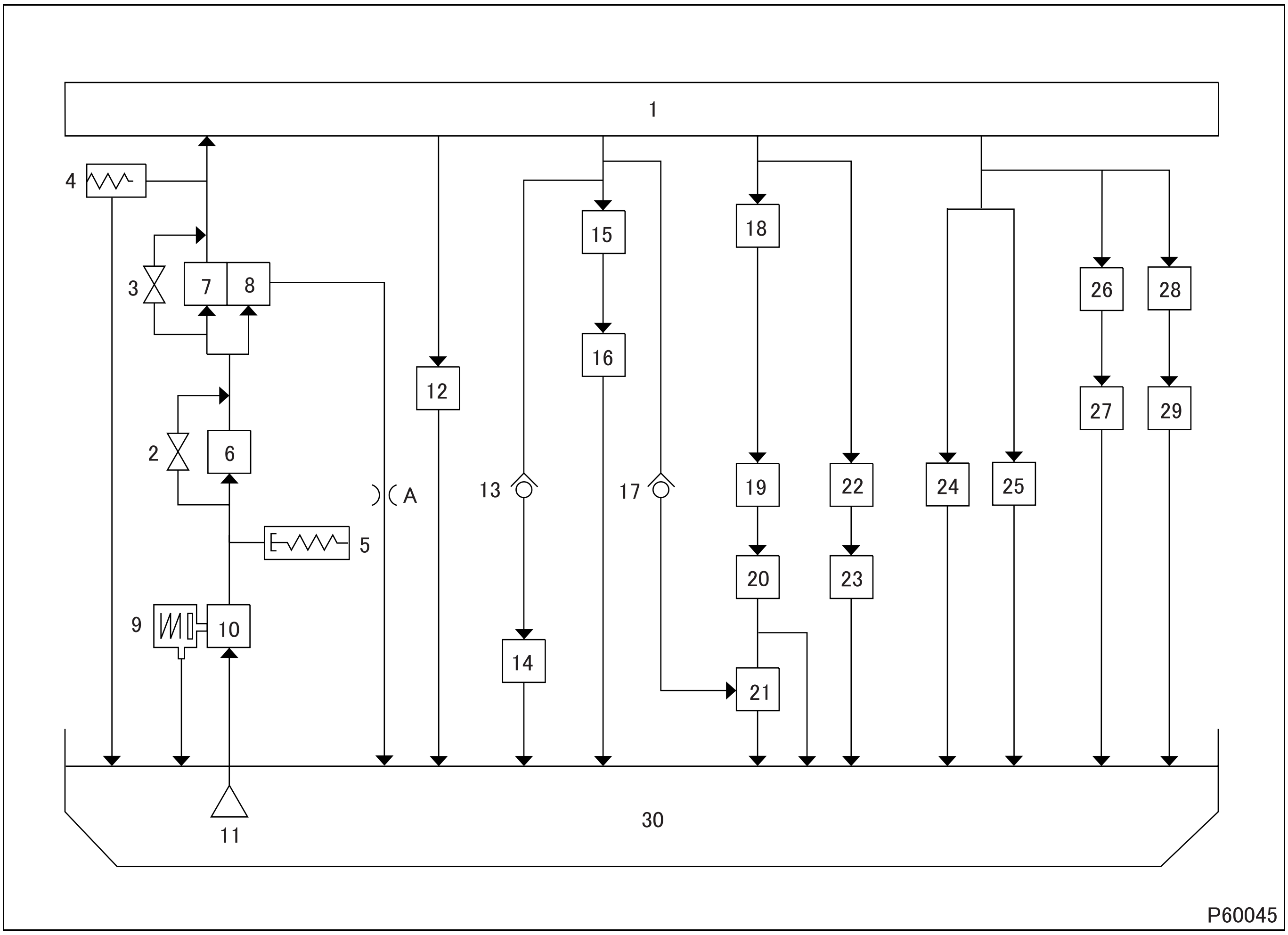
CAUTION ⚠

- **Do not run the engine within one hour after installing the front plate.**
- **Reapply sealant to the upper crankcase and lower crankcase if any of the bolts is loosened or removed. All the bolts except the bolt shown in the illustration are for fastening both the front plate and timing gear case. Use any suitable bolts in place of these bolts to keep the front plate temporarily in place until the timing gear case is installed.**

GROUP 12 LUBRICATION

Item			Specifications
Method of lubrication			Forced lubrication by oil pump
Oil filter			Spin-on filter paper type
Oil cooler			Shell and plate type (multiple-plate type)
Engine oil	Grade		API classification CJ-4, JASO classification DH-2 or ACEA classification E6
	Viscosity (application/SAE viscosity number)	Below 0°C	10W-30
		Above –15°C	15W-40
		Above 30°C	40
	Quantity dm^3 {L}	Oil pan	6.5 {6.5}
		Oil filter	1 {1}
Regulator valve opening pressure kPa {kgf/cm^2}			620 ± 30 {6.3 ± 0.3}
Bypass valve opening pressure kPa {kgf/cm^2}			490 ± 30 {5 ± 0.3}
Relief valve opening pressure kPa {kgf/cm^2}			883 ± 98 {9 ± 1}

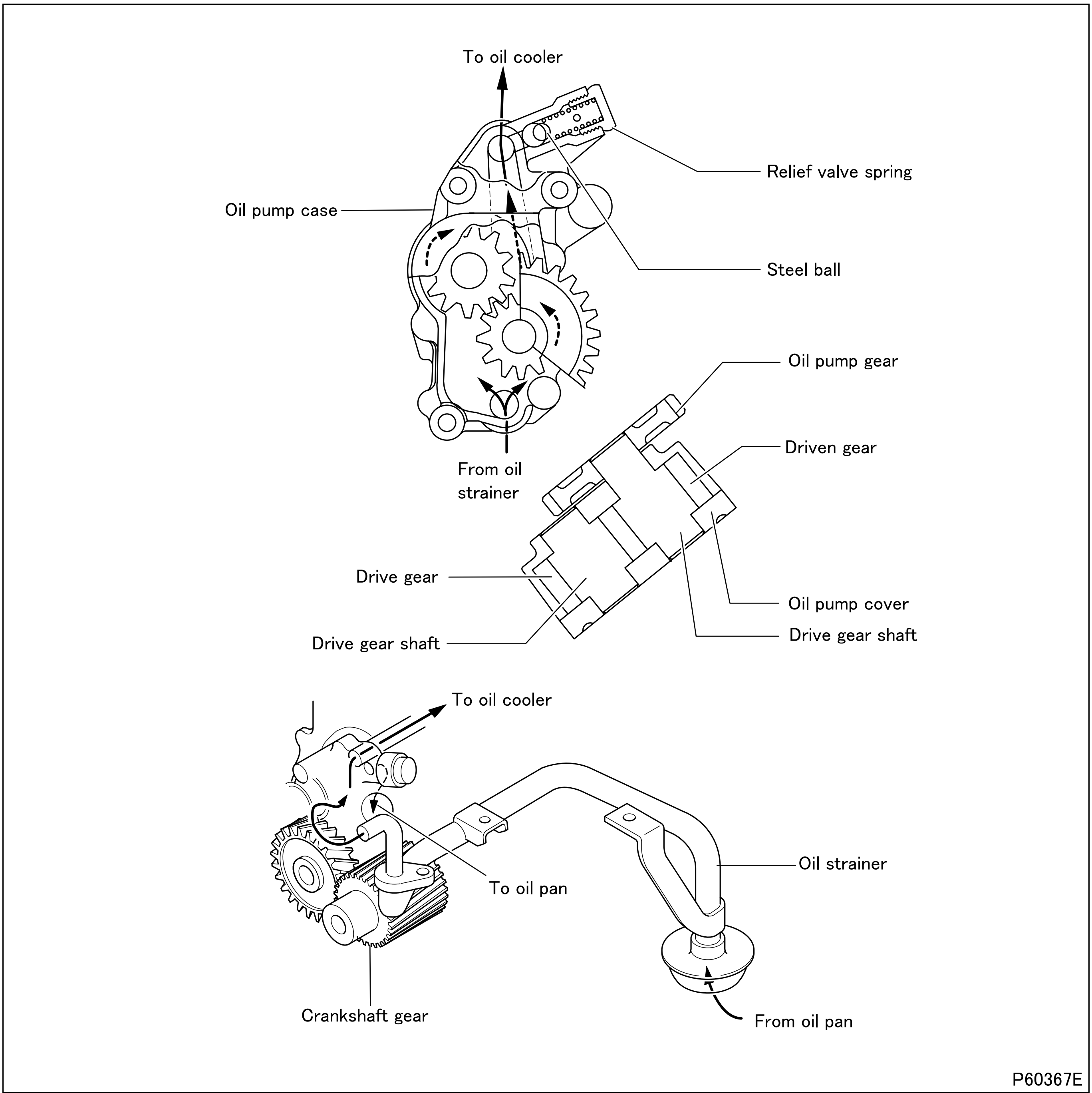
1. Lubrication System



1 Main oil gallery
2 Bypass valve
3 Bypass valve
4 Regulator valve
5 Engine oil pressure switch
6 Oil cooler
7 Full-flow filter element
8 Bypass filter element
9 Relief valve
10 Oil pump
11 Oil strainer
12 Turbocharger
13 Oil jet
14 Timing chain
15 Idler bushing
16 Timing gear
17 Oil jet
18 Crankshaft main bearing
19 Connecting rod bearing
20 Connecting rod bushing
21 Piston
22 Supply pump idler gear bushing
23 Supply pump idler gear shaft
24 Vacuum pump
25 Chain tensioner
26 Camshaft journal (No. 1)
27 Camshaft journal (No. 2 to No. 5)
28 Pivot bolt
29 Valve mechanism
30 Oil pan

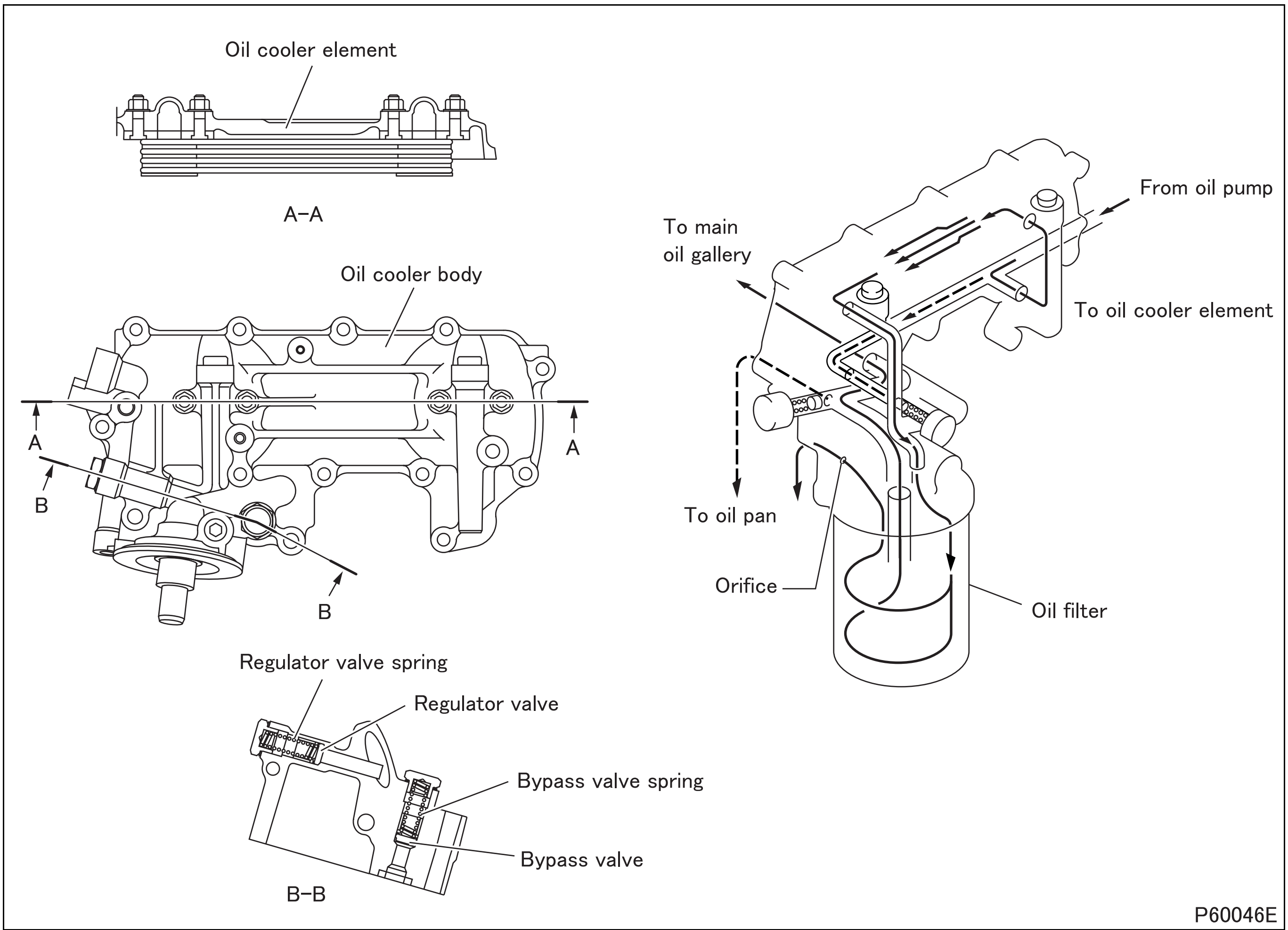
A: Orifice

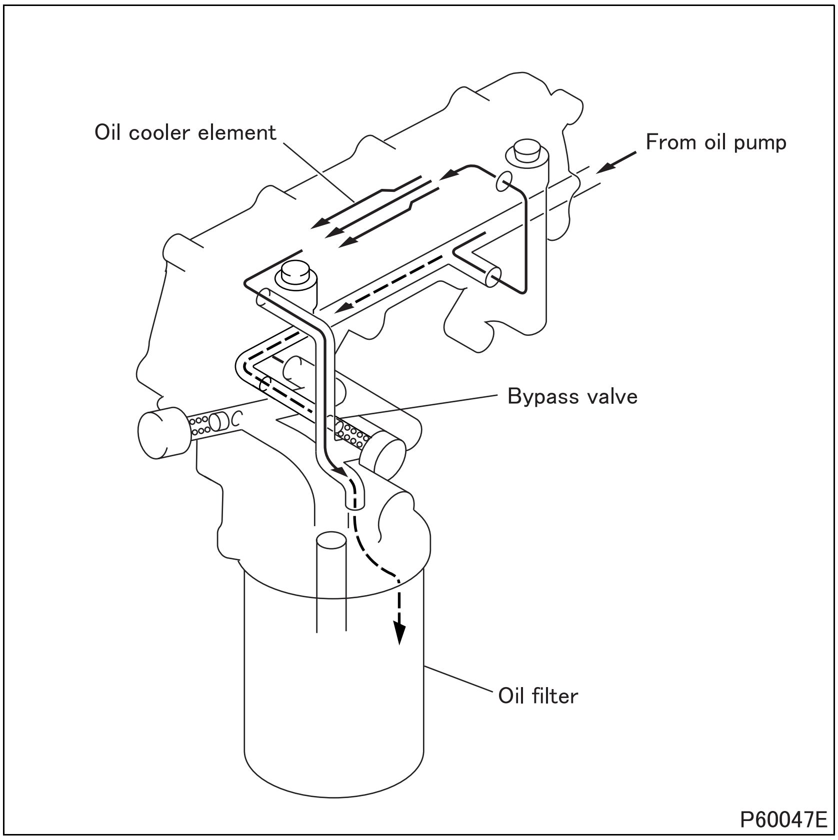
2. Oil Pump



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

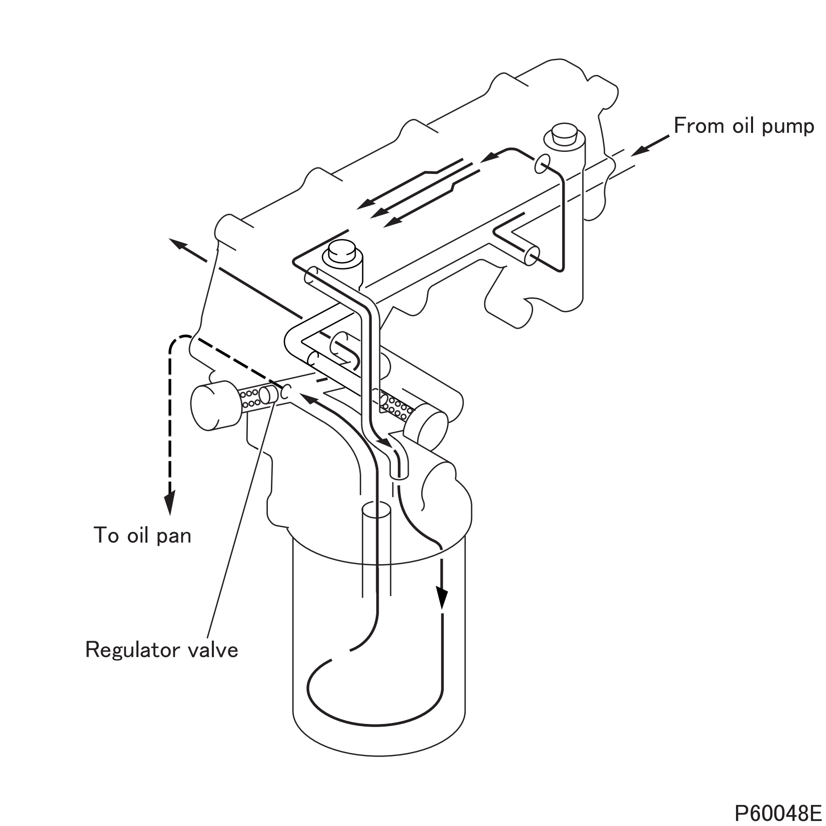
3. Oil Cooler and Oil Filter





3.1 Bypass valve

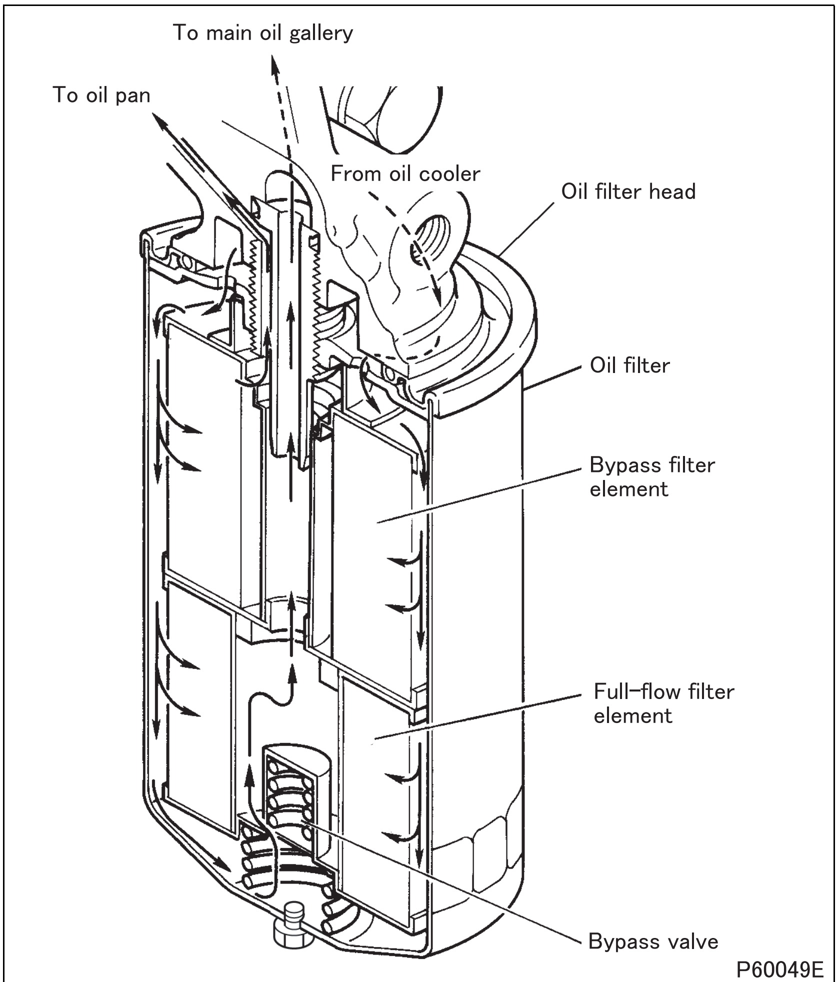
- When the engine oil is cool and its viscosity is high, or when the oil cooler element becomes clogged and restricts the flow of the engine oil, the bypass valve opens to let the engine oil bypass the oil cooler and flow directly to the oil filter.



3.2 Regulator valve

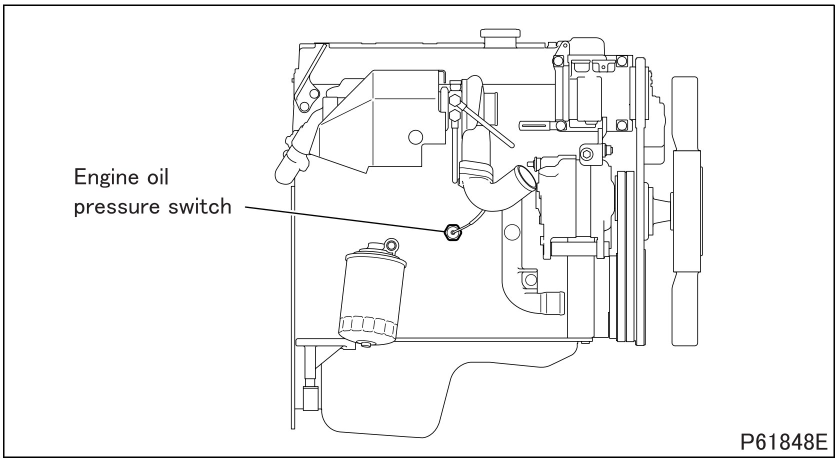
- When the oil pressure in the main oil gallery exceeds the specified level, the regulator valve opens to adjust the oil pressure by allowing part of the engine oil to escape to the oil pan.

4. Oil Filter



- This oil filter is a spin-on paper-filter type that incorporates both a bypass filter and a full-flow filter.
- A bypass valve is installed in the lower part of the oil filter. When the filter elements are clogged, this valve opens to let the engine oil bypass the filter elements and flow directly to the main oil gallery, thereby preventing seizures in the engine.

5. Engine Oil Pressure Switch

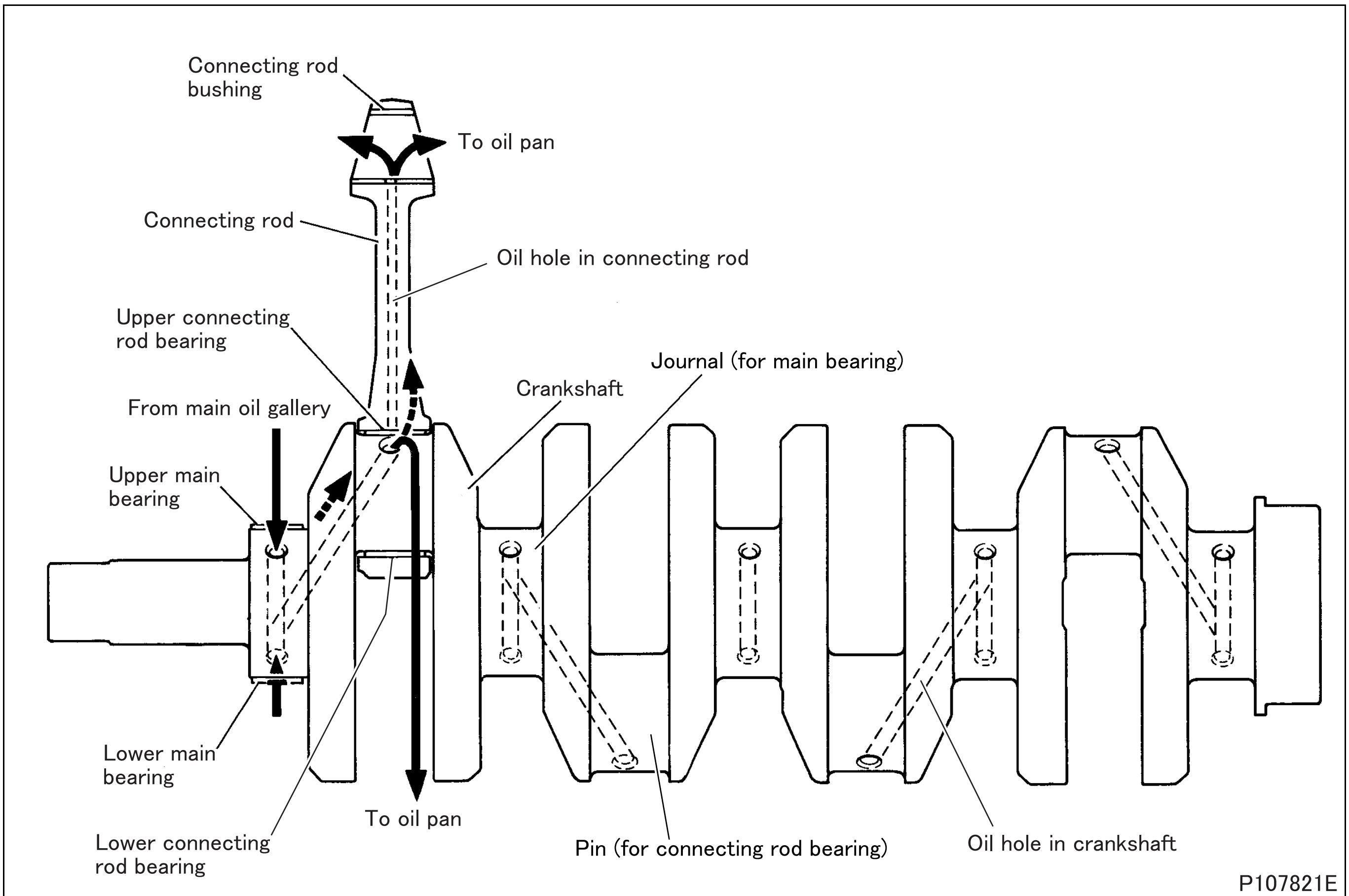


- When the pressure of the engine oil to the main oil gallery drops below the specified level, an electrical contact inside the engine oil pressure switch closes.
- This causes a warning lamp on the meter cluster to illuminate and notify the operator of the excessive pressure drop.

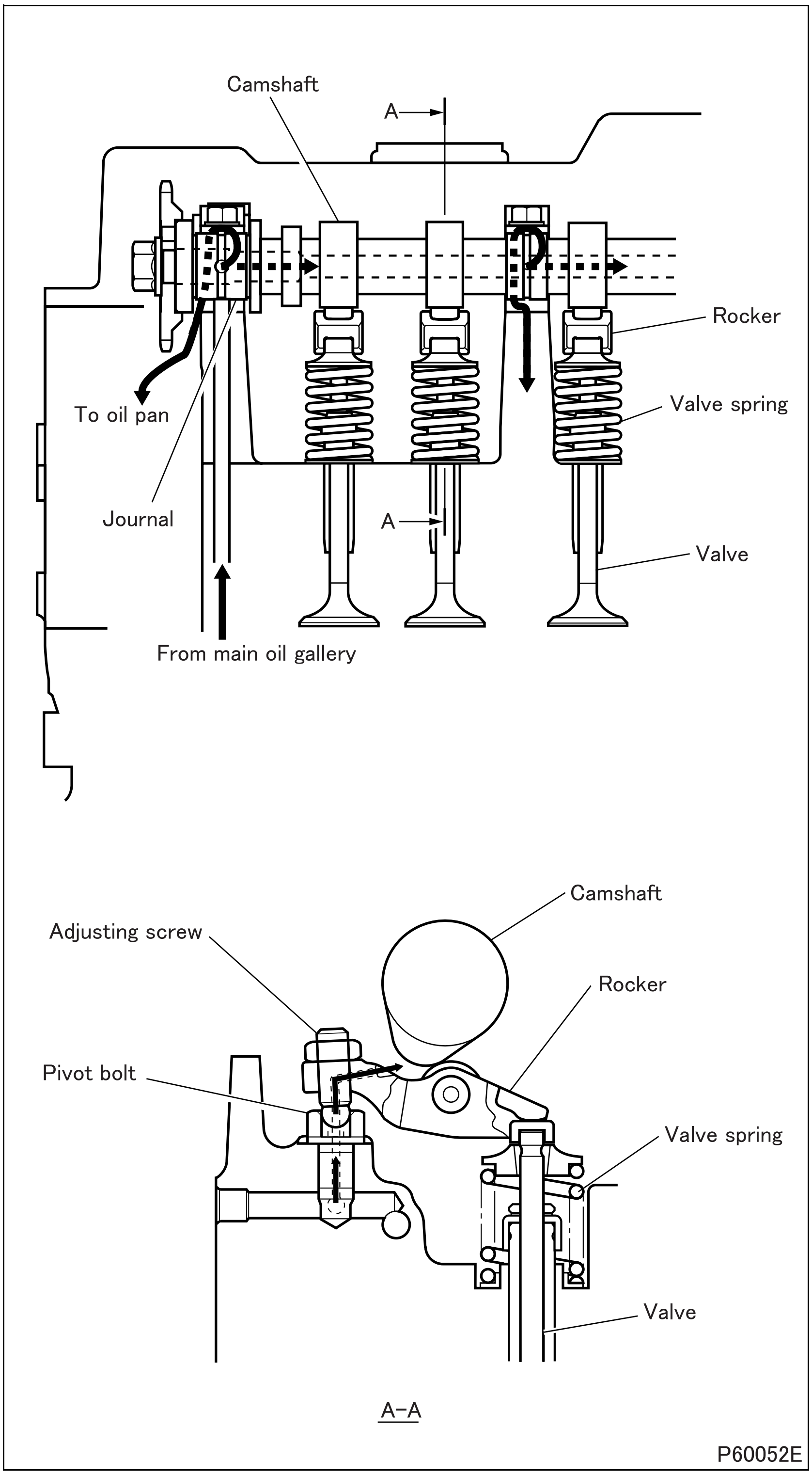
6. Lubrication of Engine Components

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

6.1 Main bearing and connecting rod bearing

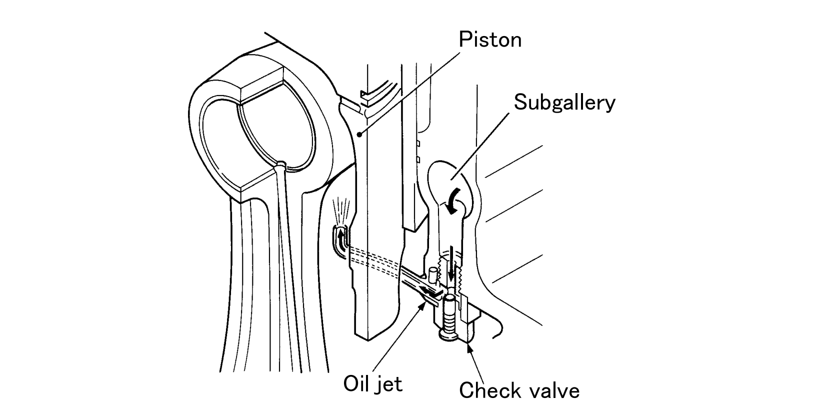


- Engine oil supplied through an oil passage in the crankshaft lubricates the large end (connecting rod bearing) of each connecting rod. Simultaneously, engine oil supplied through an oil passage in the connecting rod lubricates the connecting rod’s small end.



6.2 Valve mechanism

- The engine oil flows from the main oil gallery to the oil passages in the cylinder head to lubricate every journal on the camshaft, and then returns to the oil pan.
- Engine oil flows from the cylinder head to the oil passages in the pivot bolt and the adjusting screw to lubricate the rocker arms and camshaft.



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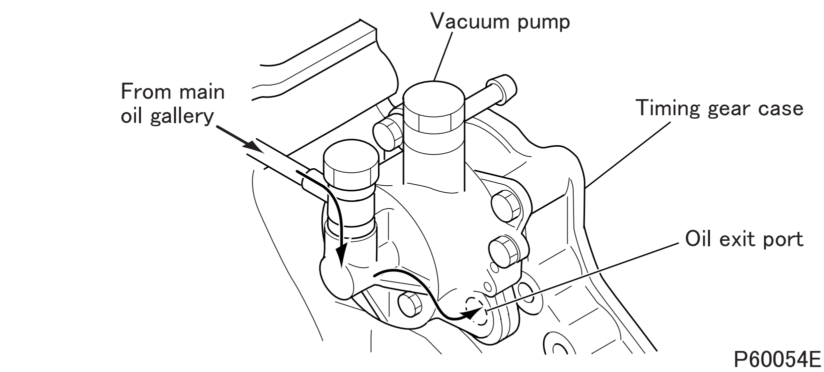
6.3 Check valves and oil jets

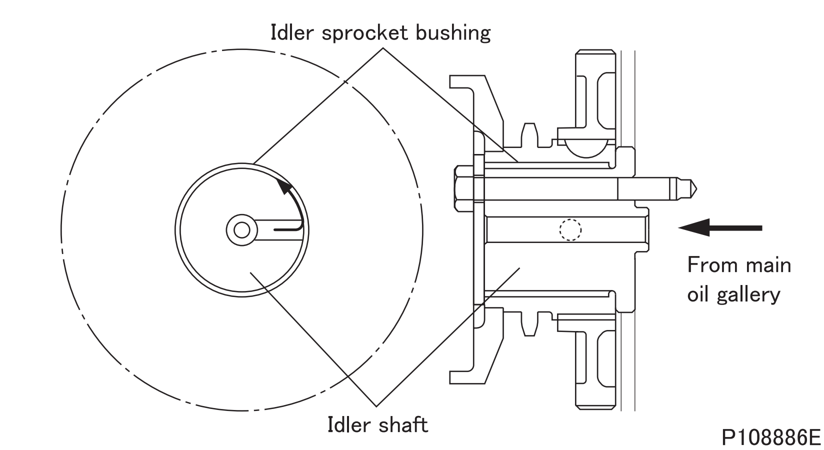
- An oil jet is fitted in the lower part of the subgallery for each cylinder.
- Engine oil is sprayed out of the oil jet into the piston to cool the piston.
- Each oil jet is fitted with a check valve that opens and closes at predetermined oil pressure levels. At low engine speeds, the check valve closes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



P60054E

6.4 Vacuum pump

- Engine oil flows to the vacuum pump through the oil pipe to lubricate the pump vanes.
- The used engine oil is discharged from the oil outlet port and returns to the oil pan.



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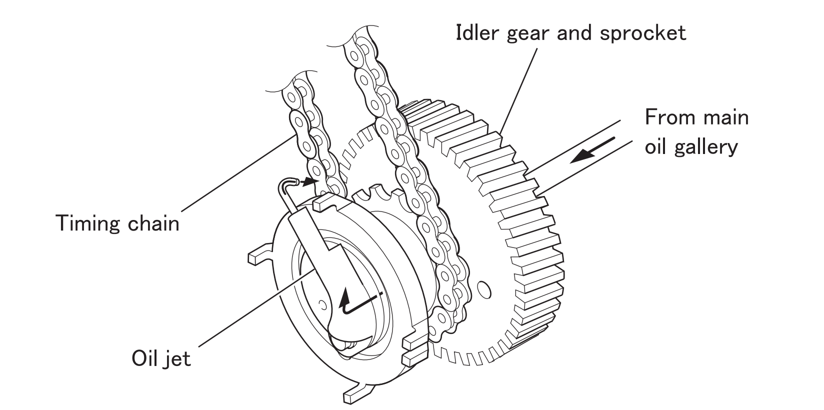
6.5 Idler shaft

- The idler sprocket bushing is lubricated by the engine oil fed through the oil passage in the idler shaft.



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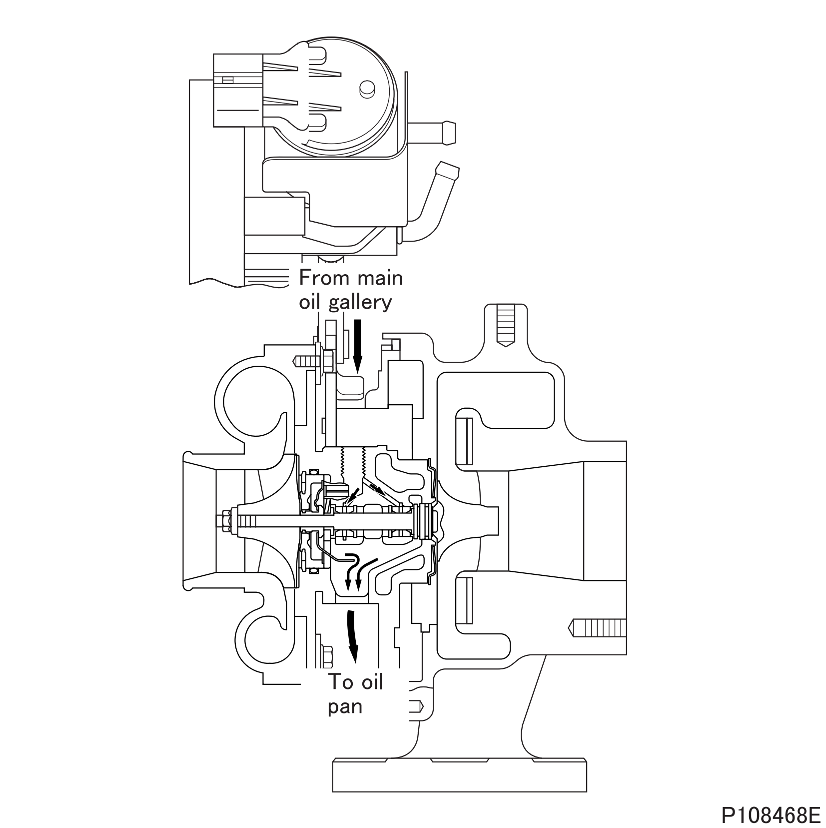
6.6 Timing chain

- The timing chain is lubricated by the engine oil spouted from the oil injection hole of the oil jet fitted to the idler shaft.



6.7 Turbocharger

- Engine oil is fed to the bearing housing from the main oil gallery through the oil pipe to lubricate the inside of the turbocharger.
- The piston rings, which are installed on both sides of the turbine wheel shaft, serve as oil seals.

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

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Oil Filter Replacement

WARNING ⚠

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

CAUTION ⚠

- **Always use specified engine oil. Use of unspecified engine oil can cause the diesel particulate filter to be clogged prematurely.**
- **Make sure not to put any engine oil on the belt when working on the oil filter. Belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**

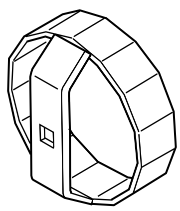
Tightening torque (Unit: N·m {kgf·m})

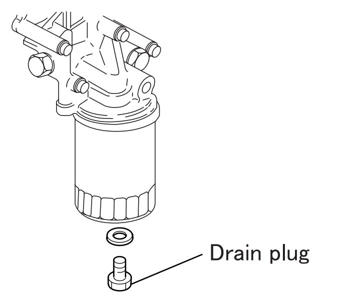
Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain plug (oil filter)	11.8 ± 1.9 {1.2 ± 0.2}	–

Lubricant and/or sealant

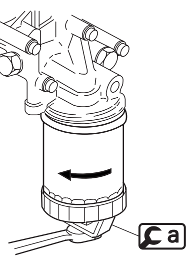
Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Oil filter	Engine oil (API classification CJ-4, JASO classification DH-2 or ACEA classification E6 SAE 40, 15W-40, 10W-30)	Approx.1 dm^3 {1L}
–	Oil filter gasket		As required

Special tools

Mark	Tool name and shape	Part No.	Application
a	Oil filter wrench  P04735	MH061590	Removal of oil filter



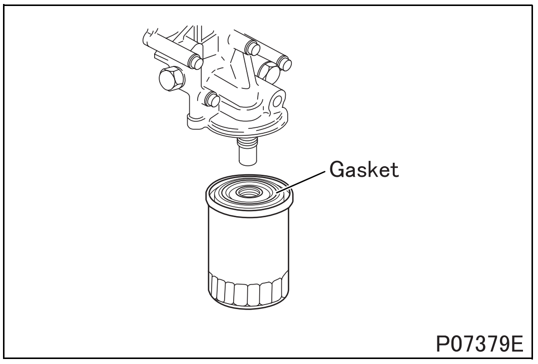
P49632E



P07378

[Removal]

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



[Installation]

- Clean the oil filter mounting surfaces of the oil cooler.
- Apply a thin coat of engine oil on the oil filter gasket.
- Screw in the oil filter by hand until the gasket touches the oil cooler. Then, tighten the filter by turning it further by five eighths (5/8) of a turn.
- After installing the oil filter, start the engine and check that there are no oil leaks.
- Remove and reinstall the oil filter if it is leaky.
- Pour a specified amount of engine oil.
- Run the engine for 1 minute or more to fill the oil filter with the engine oil.
- Stop the engine and check the engine oil level. (See later section.)

2. Engine Oil Replacement

WARNING ⚠

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

CAUTION ⚠

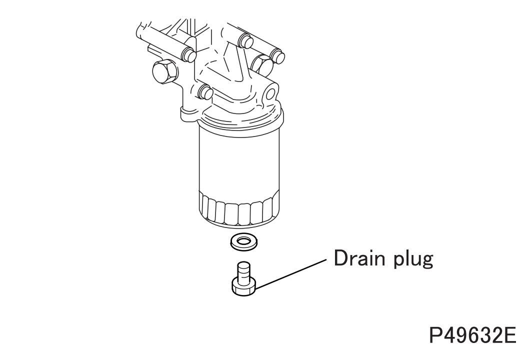
- **Always use specified engine oil. Use of unspecified engine oil can cause the diesel particulate filter to be clogged prematurely.**
- **Make sure not to put any engine oil on the belt during engine oil replacement. Belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**

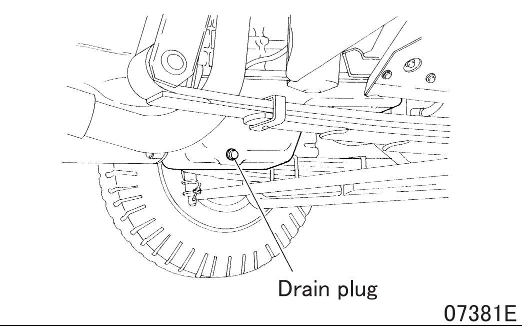
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain plug (oil filter)	11.8 ± 1.9 {1.2 ± 0.2}	–
–	Drain plug (oil pan)	39 {4.0}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Oil filter	Engine oil (API classification CJ-4, JASO classification DH-2 or ACEA classification E6 SAE 40, 15W-40, 10W-30)	Approx. 1 dm^3 {1 L}
	Oil pan		Approx. 6.5 dm^3 {6.5 L}





[Draining]

- Before draining the engine oil, warm up the engine until the water temperature gauge begins to move.
- Remove the filler cap.
- Remove the drain plugs of the oil filter and oil pan to drain out the engine oil.

[Refilling]

- Tighten the drain plugs to the specified torque, then pour a specified amount of new engine oil into the engine.
- Run the engine for 1 minute or more to fill the oil filter with the engine oil.
- Stop the engine and check the engine oil level.

CAUTION ⚠

- **If the specified quantity is exceeded as a result of addition of oil, increased oil consumption and/or deteriorated crankcase emission control system function may result.**

3. Oil Pressure Measurement

Service standards

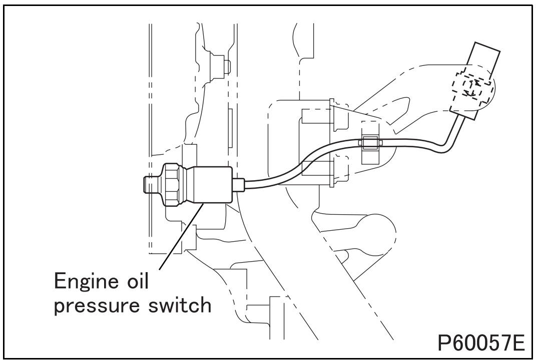
Location	Maintenance item		Standard value	Limit	Remedy
–	Oil pressure (oil temperature at 70 to 90°C)	No-load minimum speed	145 kPa {1.5 kgf/cm^2}	49 kPa {0.5 kgf/cm^2}	Inspect
		No-load maximum speed	295 to 490 kPa {3 to 5 kgf/cm^2}	195 kPa {2 kgf/cm^2}	

Tightening torque (Unit: N·m {kgf·m})

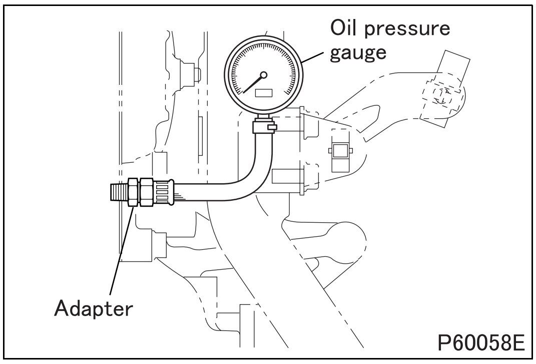
Mark	Parts to be tightened	Tightening torque	Remarks
–	Engine oil pressure switch	12 {1.2}	• Sealant • With cold engine

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Engine oil pressure switch threads	ThreeBond 1211	As required



- Remove the engine oil pressure switch.

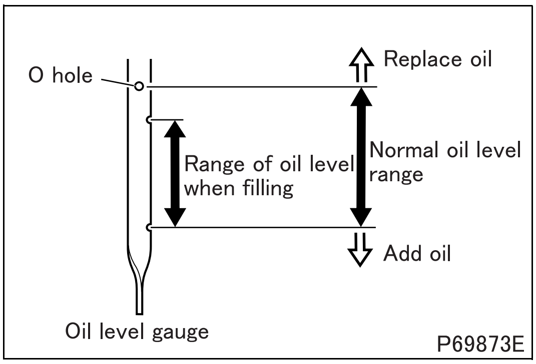


- Using an adapter, connect an oil pressure gauge to the engine oil pressure switch mounting hole.
- Warm up the engine until the oil temperature reaches 70 to 90 °C.
- Measure the oil pressure while running the engine at a minimum speed and then at maximum speed, both under no load.
- If the measurements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

CAUTION ⚠

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

4. Engine Oil Level Inspection



- Perform the inspection on a flat surface.
- Warm up the engine until the water temperature gauge points to the median.
- Check the oil level 30 minutes after the engine was stopped. If the oil level is checked about 10 minutes after engine stop, if appears 2 to 5 mm lower than the actual level.
- If the oil level is beyond the O hole, it is an indication that a portion of fuel injected during diesel particulate filter regeneration was mixed into the engine oil to raise the oil level. In such a case, replace the engine oil.

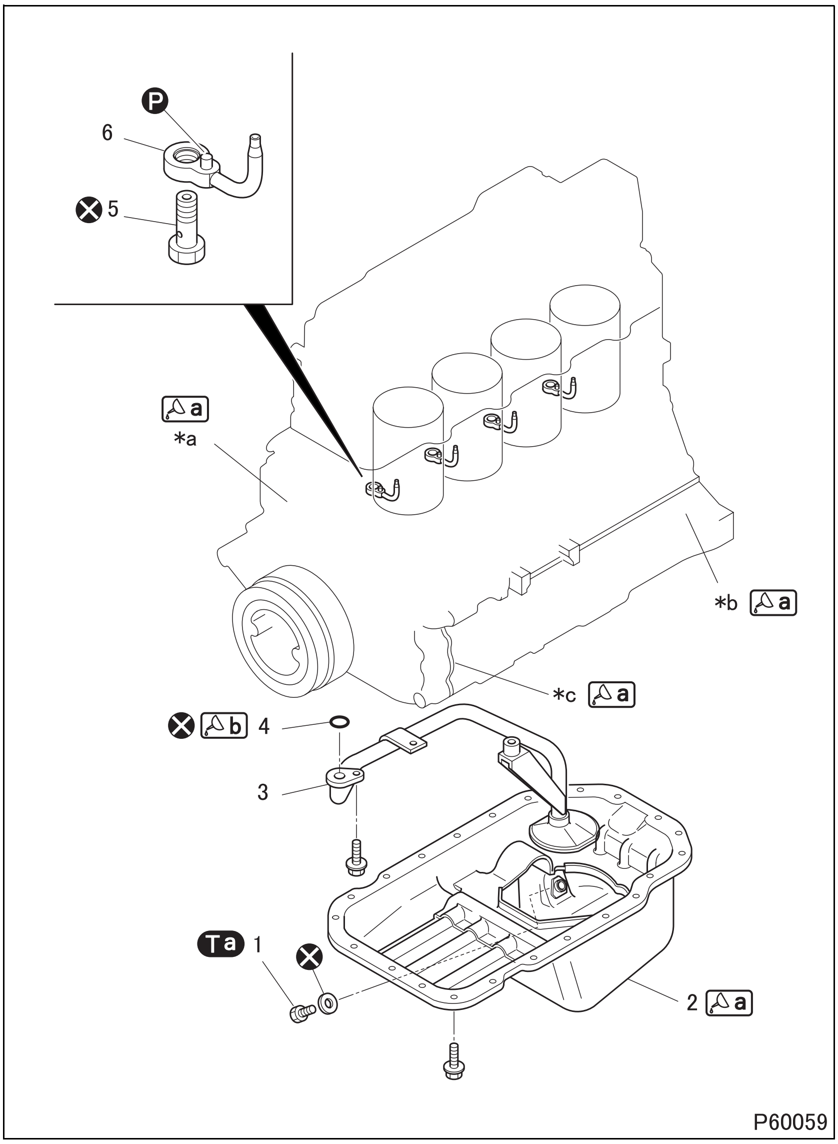
CAUTION ⚠

- **If the engine oil is over the O hole of the level gauge, it has been deteriorated and can cause an engine trouble. A sudden rise in engine speed can occur in other case.**

- If the oil level is lower than it should be, supply additional oil up to the replenishment limit.
- If the measured oil level is within normal range but daily check finds oil decrease excessive, check for possible abnormalities below.
  - Piston ring is stuck to piston.
  - Excessive clearance between the piston and the crankcase cylinder

MEMO

OIL PAN, OIL STRAINER AND OIL JET



● Disassembly sequence

1 Drain plug
2 Oil pan
3 Oil strainer
4 O-ring
5 Check valve
6 Oil jet

*a: Timing gear case
*b: Lower crankcase
*c: Front plate
Ⓟ: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

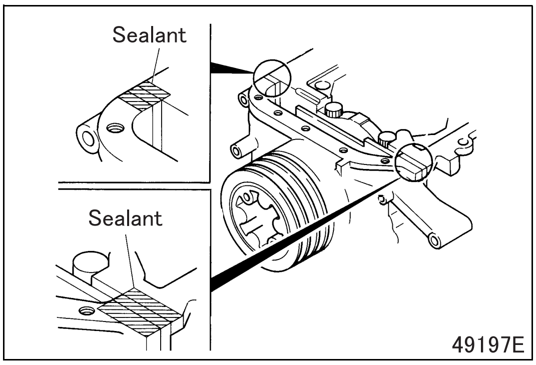
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain plug	39 {4.0}	–

Lubricant and/or sealant

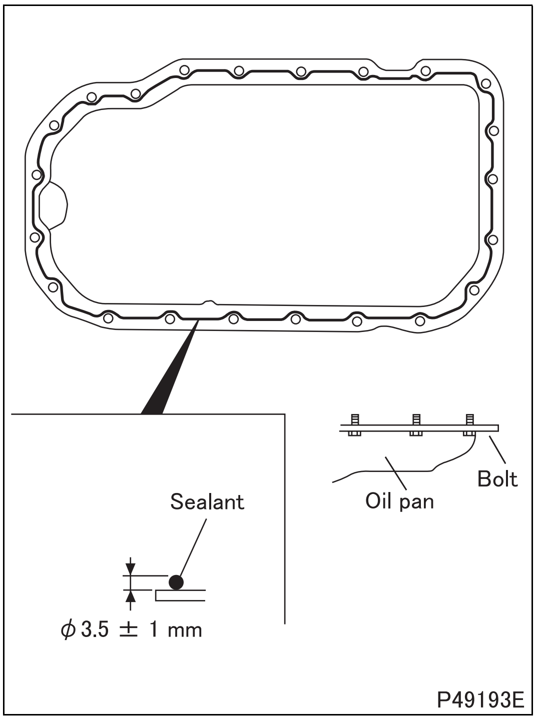
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Lower crankcase mounting surface of oil pan	ThreeBond 1217H	As required
	Timing gear case, lower crank case and front plate mounting surfaces of oil pan		
b	O-ring	Engine oil	As required

◆Installation procedure◆



■ Installation: Oil pan

- Clean the sealant application surfaces of each part.
- Apply a bead of sealant to each of the mating surfaces of the timing gear case, lower crankcase and front plate (at the two locations indicated in the illustration).

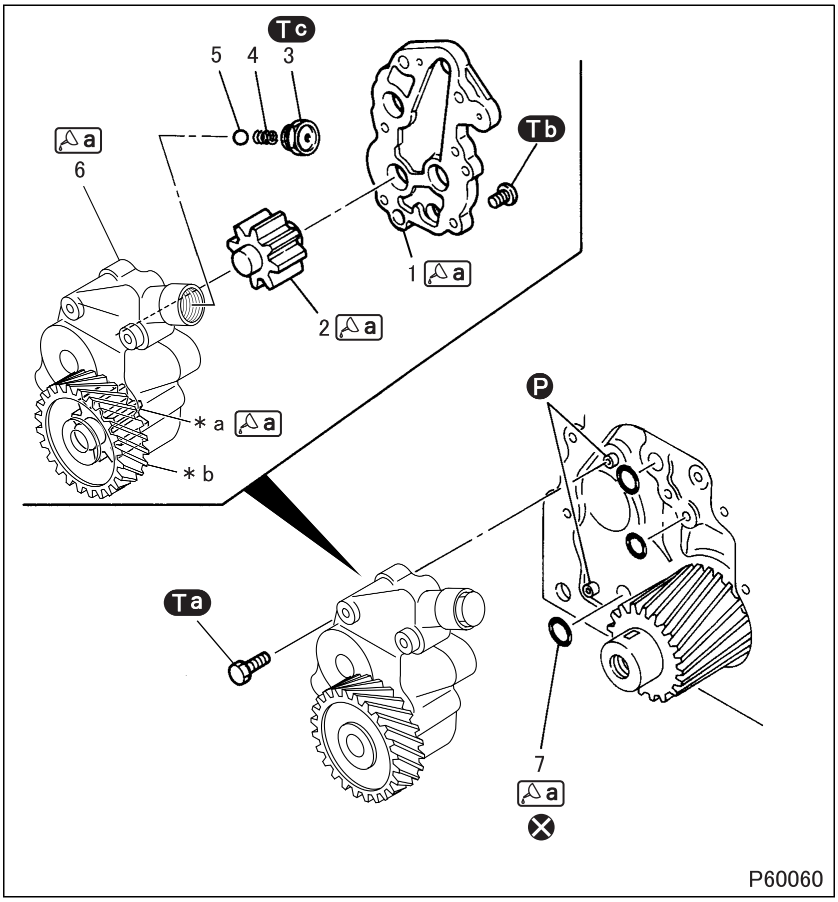


- Clean the mating surfaces of each part.
- Apply a bead of sealant to the mating surface of the oil pan evenly and without any breaks.
- Mount the oil pan within three minutes of applying the sealant. Make sure that the sealant stays in place.

CAUTION ⚠

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

OIL PUMP



● Disassembly sequence

1 Oil pump cover
2 Driven gear
3 Plug
4 Relief valve spring
5 Steel ball
6 Gear and case
7 O-ring

***a**: Drive gear
***b**: Oil pump gear
P: Locating pin
⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly procedure in reverse.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
1, 2	Oil pump cover-to-driven gear shaft clearance	0.03 to 0.05	0.15	Replace
1, 6	Oil pump cover-to-gear and case shaft clearance	0.03 to 0.05	0.15	Replace
2, 6	Gear and case-to-driven gear shaft clearance	0.03 to 0.05	0.15	Replace
2, 6, *a	Sinkage of each gear from gear and case end surface	0.05 to 0.10	0.15	Replace
	Gear and case-to-tooth tip clearance for each gear	0.15 to 0.26	0.27	Replace
4	Load of installed relief valve spring (installed length: 30.9)	70 ± 8.8 N {7.1 ± 0.9 kgf}	–	Replace

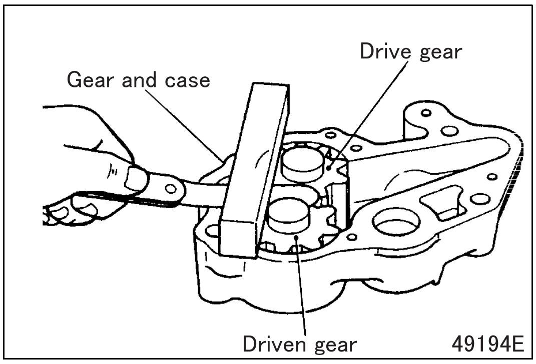
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (oil pump mounting)	23.8 {2.4}	–
Tb	Screw (oil pump cover mounting)	7.8 to 11.8 {0.8 to 1.2}	–
Tc	Plug (relief valve spring mounting)	39.2 to 49.0 {4.0 to 5.0}	–

Lubricant and/or sealant

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

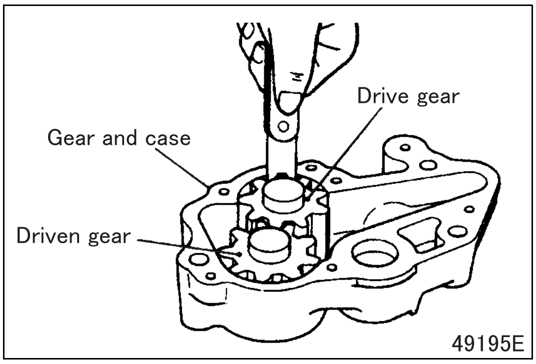
◆Inspection procedure◆



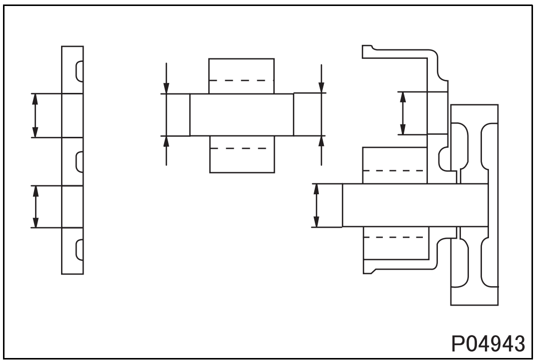
■ **Inspection: Driven gear, drive gear and gear and case**

- Carry out the following inspection. Replace the oil pump if any defects are found.

(1) Sinkage of each gear from gear and case end surface



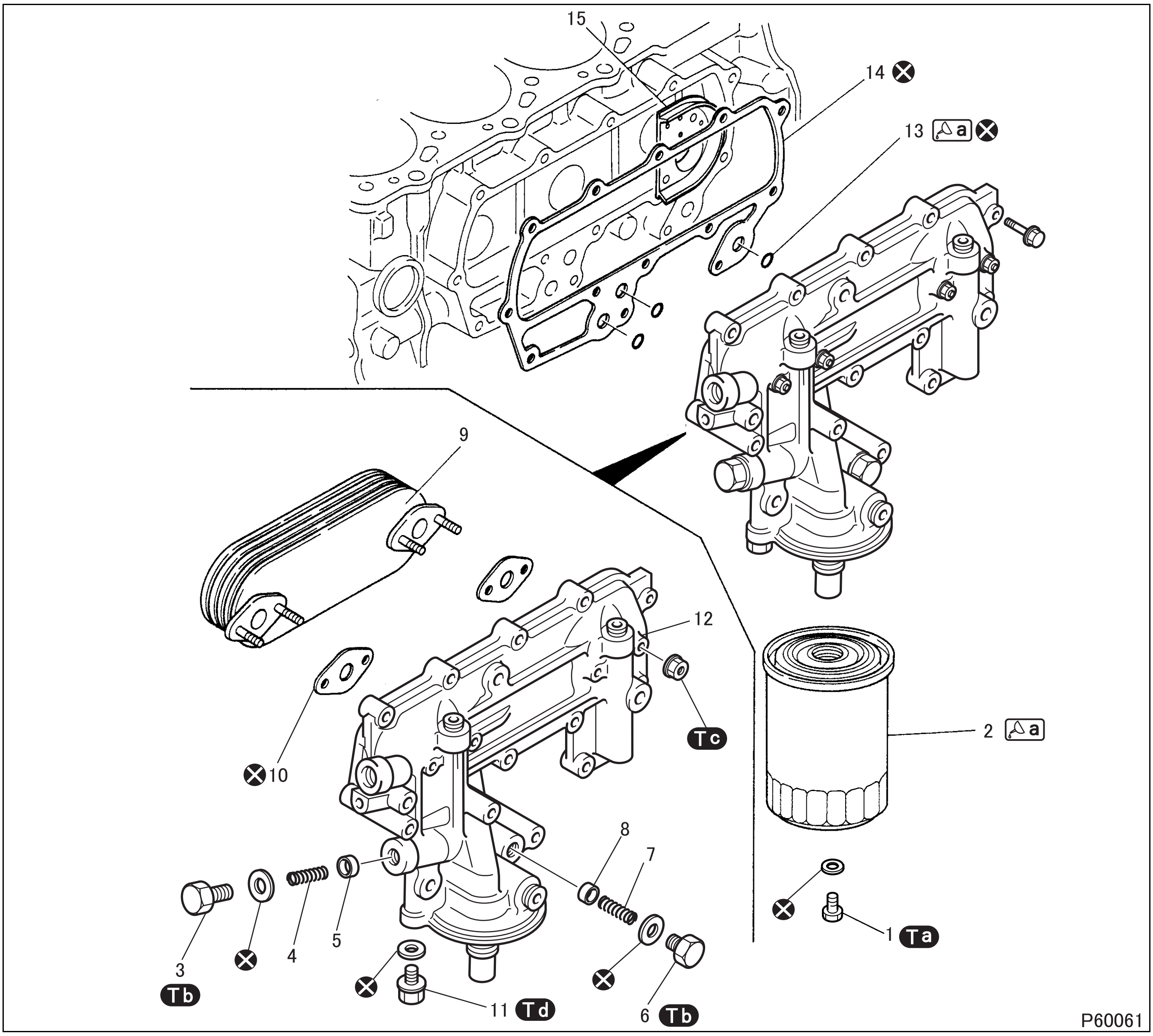
(2) Gear and case-to-tooth tip clearance for each gear



■ **Inspection: Oil pump cover, driven gear, and gear and case**

- Measure the clearance between each gear's shaft and the oil pump cover, as well as between each gear's shaft and the gear and case.
- If the measurements are not within the standard value range, replace the defective part(s).

OIL COOLER AND OIL FILTER



● Removal sequence

- **1** Drain plug
- **2** Oil filter
- **3** Plug
- **4** Regulator valve spring
- **5** Regulator valve
- **6** Plug
- **7** Bypass valve spring
- **8** Bypass valve
- **9** Oil cooler element
- **10** Gasket
- **11** Water drain plug
- **12** Oil cooler body
- **13** O-ring
- **14** Gasket
- **15** Water separate lip

⊗: Non-reusable parts

WARNING ⚠

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

CAUTION ⚠

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

● Installation sequence

Follow the removal sequence in reverse.

- Do not reuse the oil filter elements by washing.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
4	Load of installed regulator valve spring (installed length: 39.8)	66 ± 5.9 N {6.7 ± 0.6 kgf}	–	Replace
7	Load of bypass valve spring (installed length: 42)	40 ± 5.9 N {4.1 ± 0.6 kgf}	–	Replace
9	Air leakage from oil cooler element (air pressure: 1.47 MPa {15 kgf/cm^2} for 15 seconds)	0 cm^3 {0 mL}	–	Replace

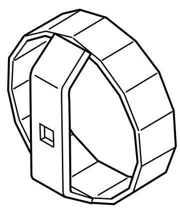
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain plug	11.8 ± 1.9 {1.2 ± 0.2}	–
Tb	Plug (regulator valve spring mounting)	44.1 ± 4.8 {4.5 ± 0.5}	–
	Plug (bypass valve spring mounting)		
Tc	Nut (oil cooler element mounting)	19.6 ± 4.8 {2.0 ± 0.5}	–
Td	Water drain plug	29 {3}	–

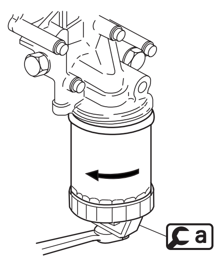
Lubricant and/or sealant

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

Special tools

Mark	Tool name and shape	Part No.	Application
a	Oil filter wrench  P04735	MH061590	Removal of oil filter

◆ Removal procedure ◆

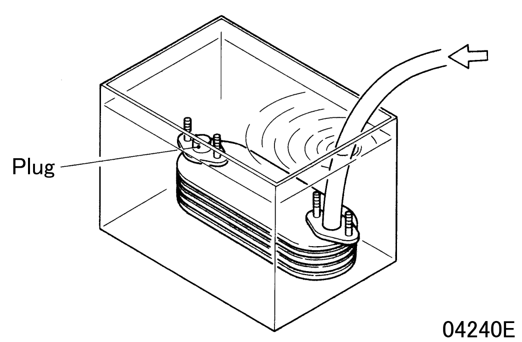


P07378

■ Removal: Oil filter

OIL COOLER AND OIL FILTER

◆Inspection procedure◆

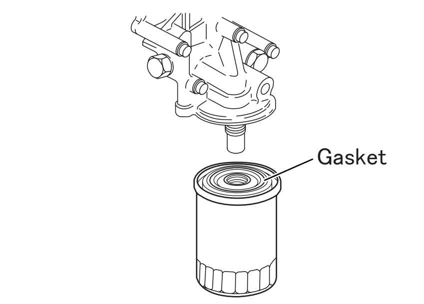


04240E

■ Inspection: Oil cooler element

- Plug the outlet of the oil cooler element and connect a hose to the engine oil inlet port. Then, immerse the oil cooler element in a tank of water.
- Apply an air pressure of 1.47 MPa {15 kgf/cm^2} for 15 seconds through the hose, and check for any air leaks.
- Replace the element if it leaks air.

◆Installation procedure◆



P07379E

■ Installation: Oil cooler

- Clean the oil filter mounting surface of the oil cooler.
- Apply a thin coat of engine oil on the oil filter gasket.
- Screw in the oil filter by hand until the gasket touches the oil cooler. Then, tighten the filter by turning further by five eighths (5/8) of a turn.
- After installing the oil filter, start the engine and check that there are no oil leaks.
- Remove and reinstall the oil filter if it is leaky.
- Stop the engine and check the engine oil level.
- Add engine oil if necessary.

GROUP 13
FUEL AND ENGINE CONTROL

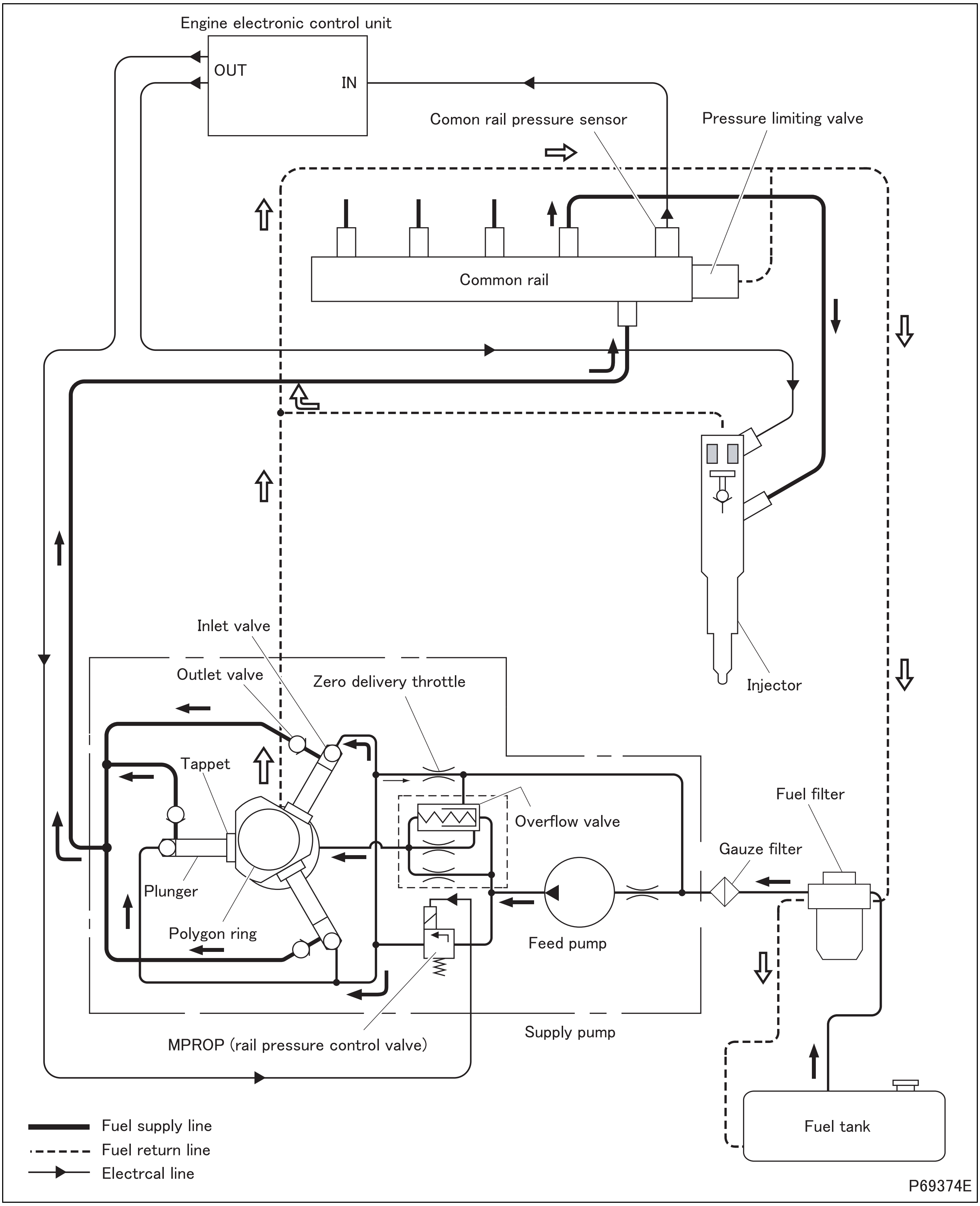
Item			Specifications
Supply pump	Manufacturer		Bosch
	Supply pump type		CP3.3 NH
	Control system		Electronically-controlled pump
	Model		Radial, 3-cylinder
	Feed pump type		External gear type
	MPROP (rail pressure control valve)	Model	MPROP
		Rated voltage V	24
	Max. common rail pressure MPa {kgf/cm^2}		180 {1840}
Common rail	Manufacturer		Bosch
	Common rail capacity cm^3 {ml}		18.7 {18.7}
	Pressure limiting valve opening pressure MPa {kgf/cm^2}		210 to 220 {2141 to 2243}
	Common rail pressure sensor supply voltage V		5
Injectors	Manufacturer		Bosch
	Control system		Electrical
	Max. operating pressure MPa {kgf/cm^2}		180 {1840}
	Min. operating pressure MPa {kgf/cm^2}		25 {255}
Engine electronic control unit	Manufacturer		Bosch
	Rated voltage V		24

M E M O

1. Common Rail System

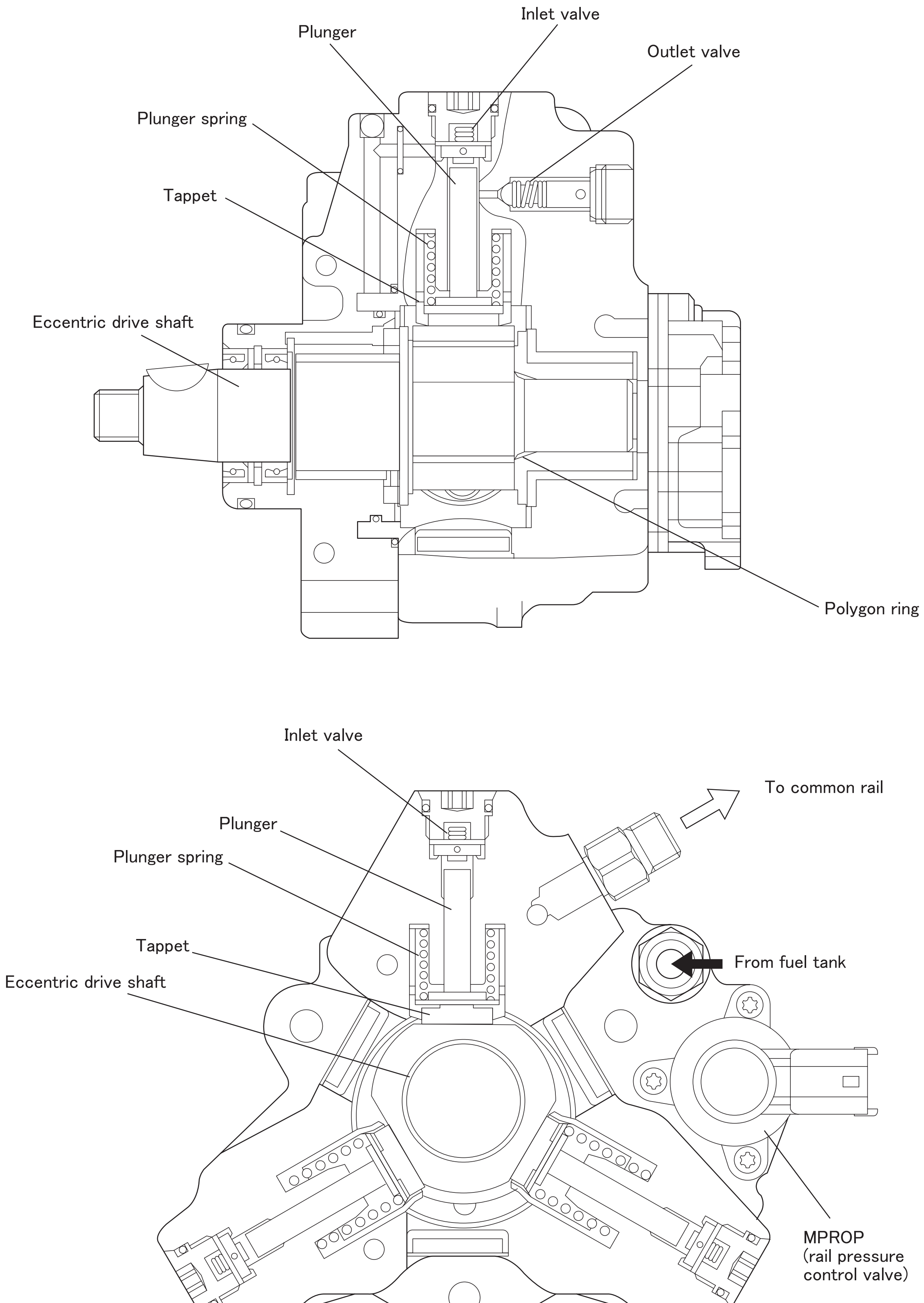
1.1 Overview

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


Engine electronic control unit
OUT
IN
Comon rail pressure sensor
Pressure limiting valve
Common rail
Inlet valve
Outlet valve
Zero delivery throttle
Injector
Tappet
Overflow valve
Fuel filter
Gauze filter
Plunger
Polygon ring
Feed pump
MPROP (rail pressure control valve)
Supply pump
Fuel supply line
Fuel return line
Electrcal line
Fuel tank
P69374E

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

1.2 Supply pump



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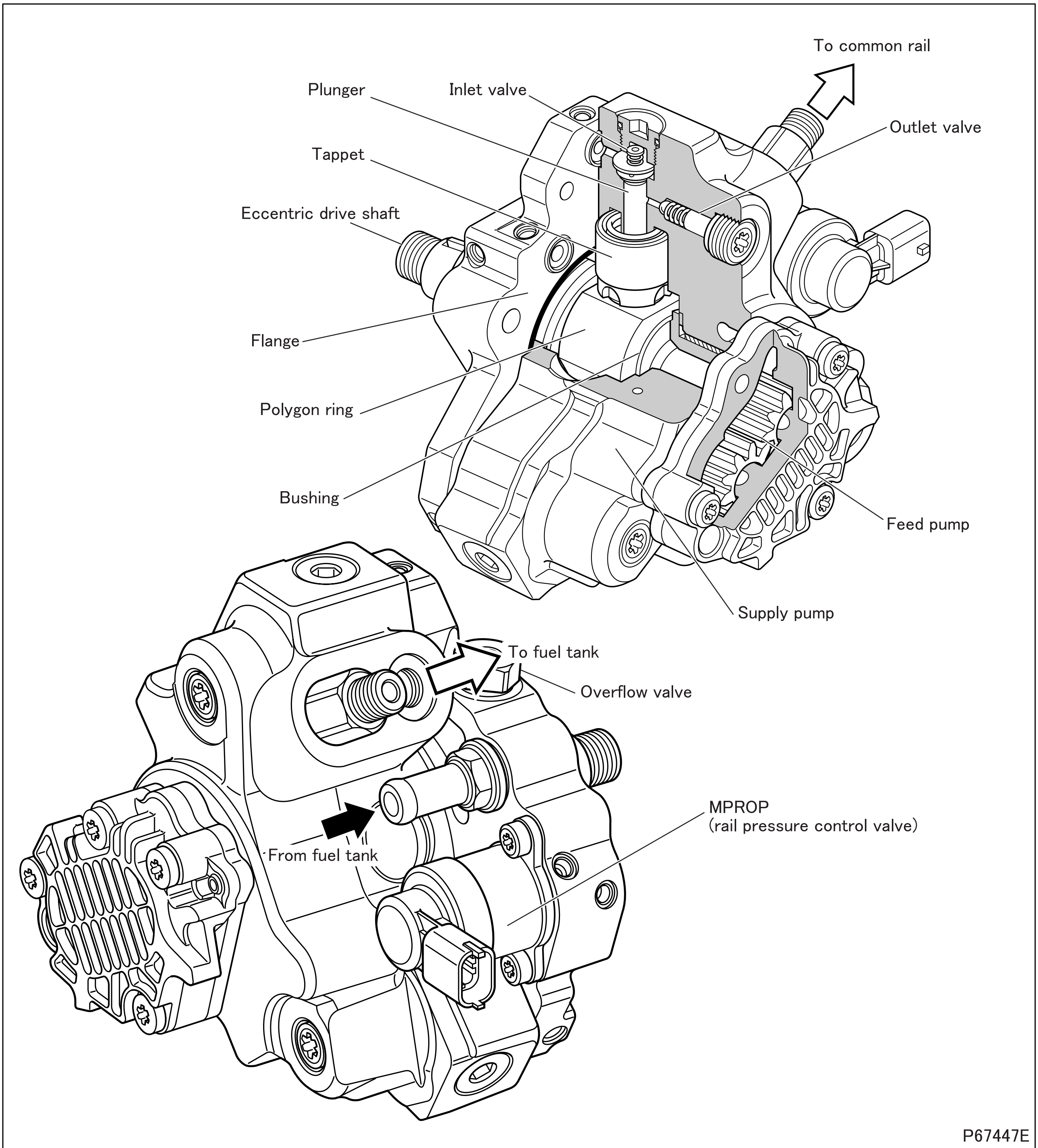
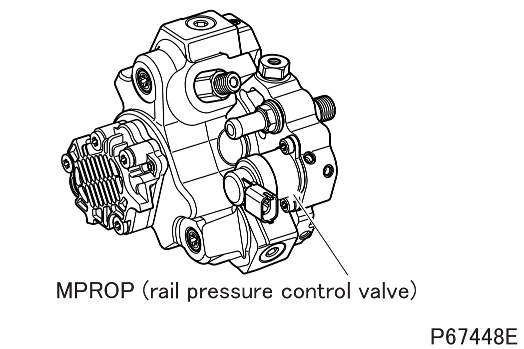


- The supply pump pressurizes fuel and supplies it in a highly pressurized state.
- Fuel drawn from the fuel tank by the feed pump is not supplied directly to the plungers. It is supplied first to the MPROP (rail pressure control valve), which controls the amount of fuel reaching the plungers.
- If the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



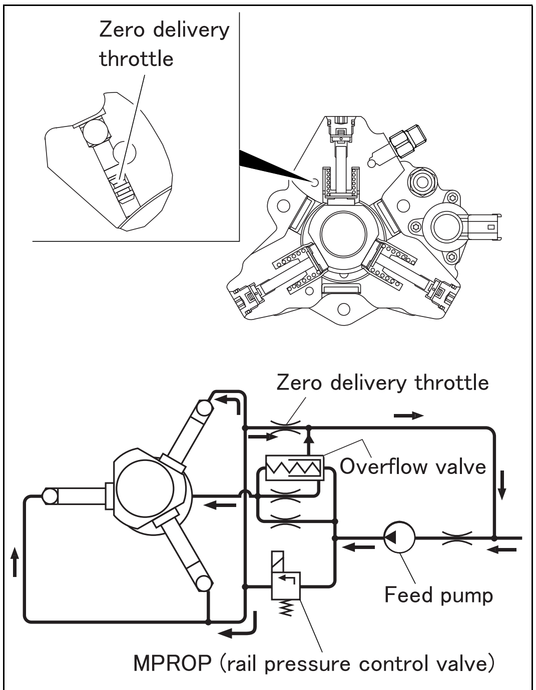
P67448E

(1) MPROP (rail pressure control valve)

CAUTION ⚠

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

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



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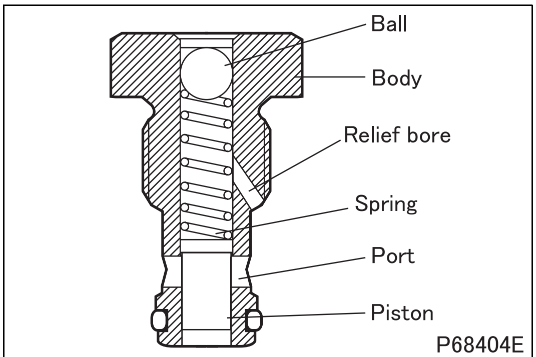
(2) Zero delivery throttle

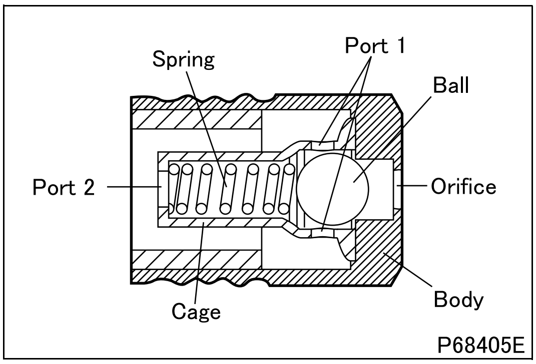
- A small amount of fuel can flow through the MPROP (rail pressure control valve) to the plunger even when the MPROP reduces fuel flow to the fullest extent. To stop the fuel feed to the plunger, the zero delivery throttle is opened to return fuel to the feed pump, causing the fuel flow for the plunger to reach zero.



P68404E

(3) Overflow valve

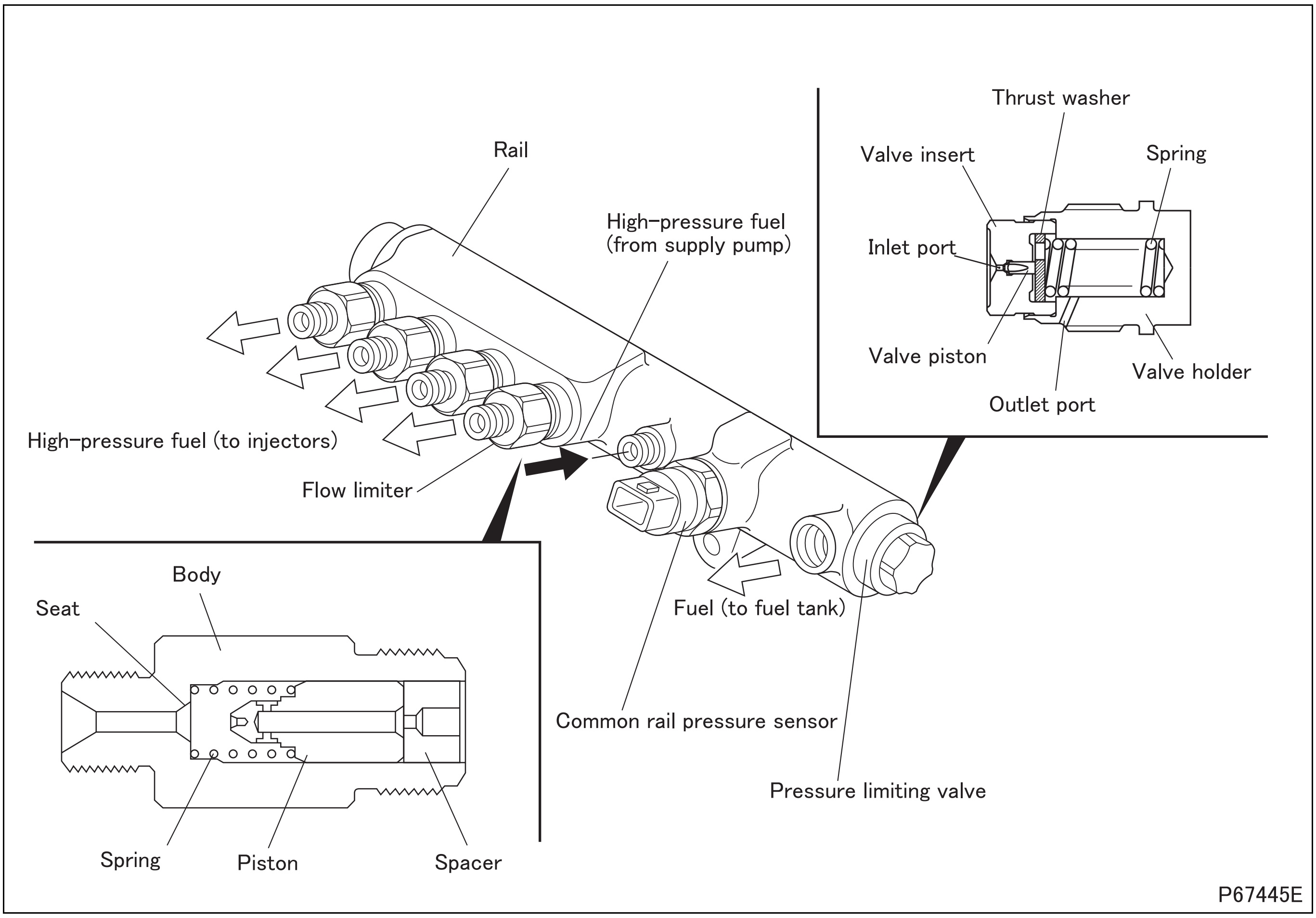
- The overflow valve opens when the pressure of the fuel sent from the feed pump exceeds the predetermined level to return the excess fuel to the inlet side of the feed pump. The fuel which has overflowed enters into the eccentric drive shaft chamber to lubricate the parts in the chamber.



(4) Flow control valve

- The flow control valve diverts the excess of fuel sent from the feed pump into the eccentric drive shaft chamber for the part lubrication.

1.3 Common rail

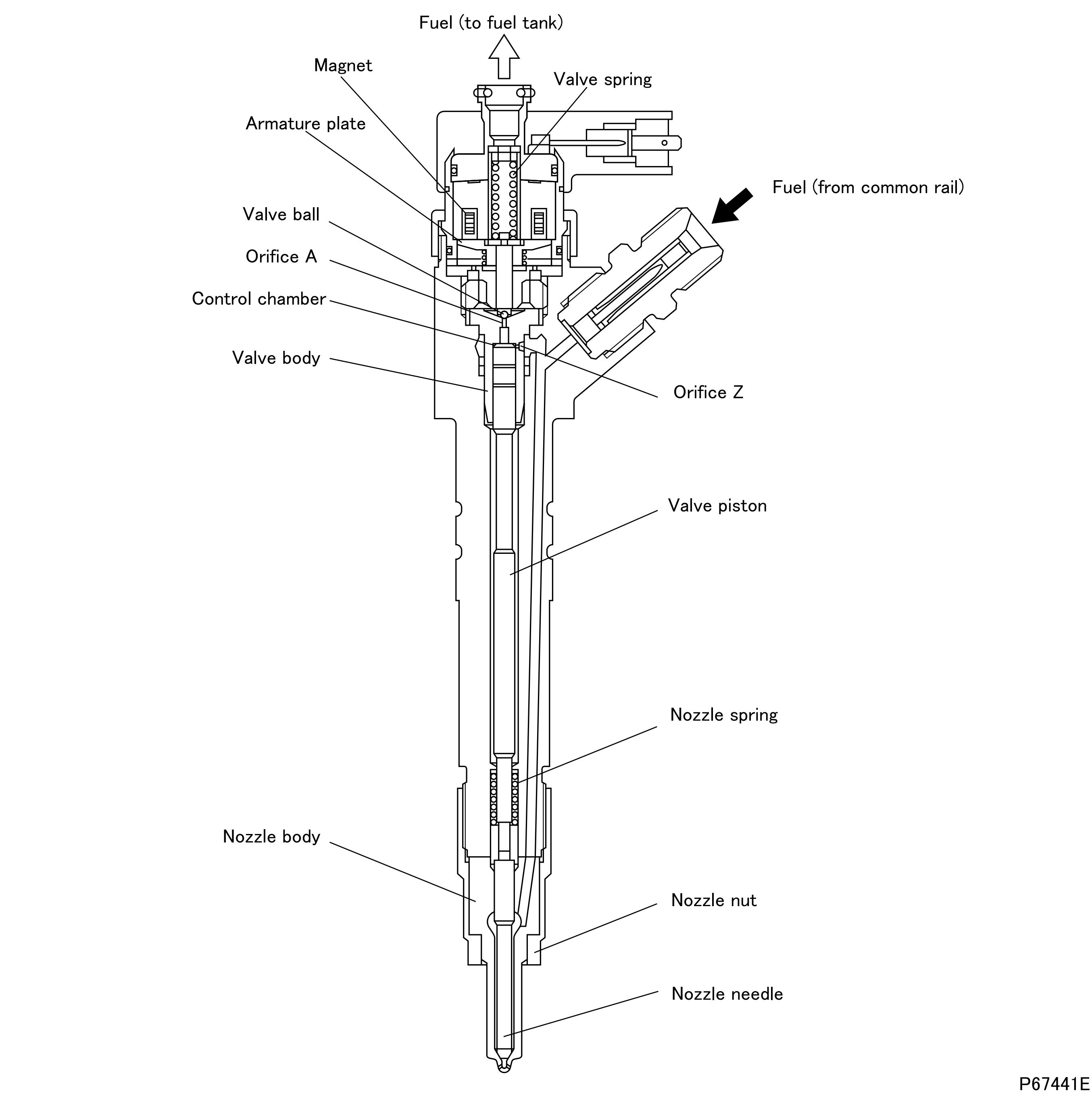


- The common rail distributes to the injectors high-pressure fuel that has been fed from the supply pump.
- Each flow limiter prevents an abnormal outflow of fuel. It does so by blocking the fuel passage in the event of fuel leakage from the injection pipe or excessive injection of fuel from the injector.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

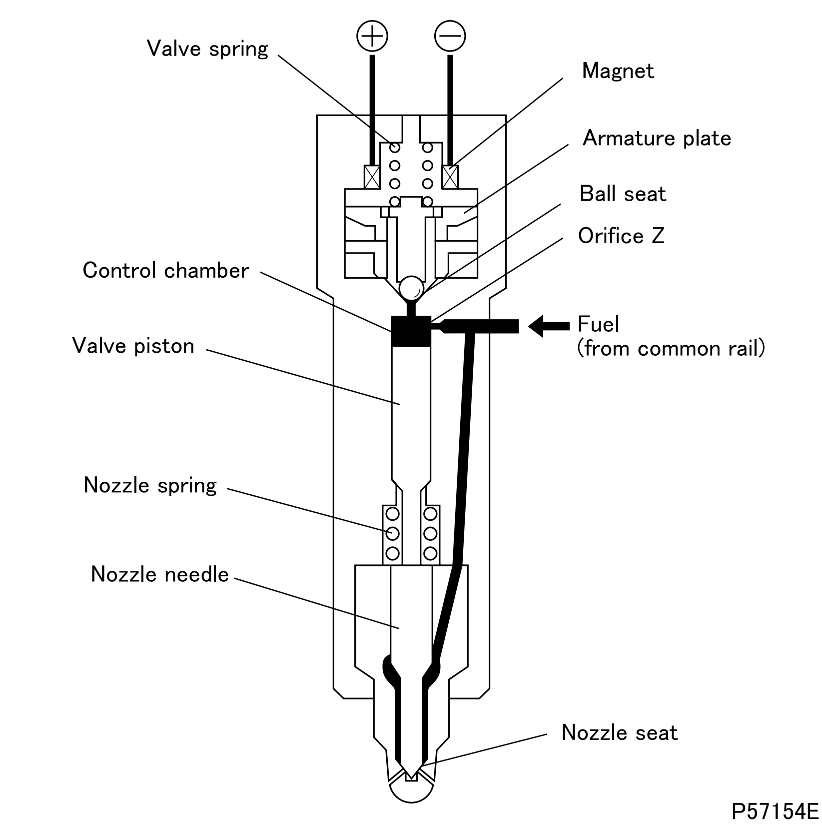
Flow limiter

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

1.4 Injector



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

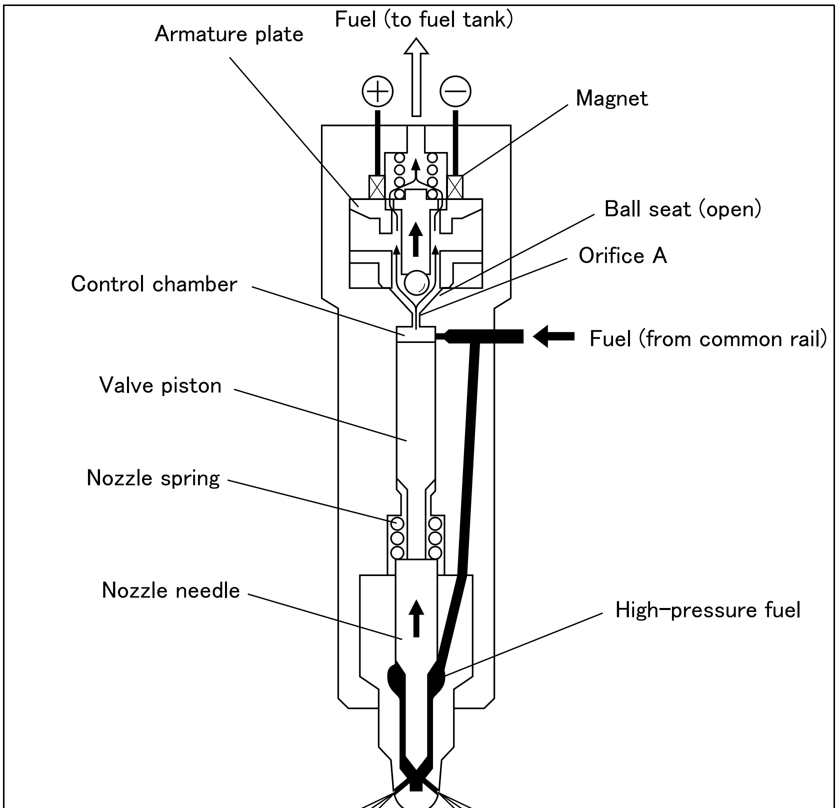


P57154E

(1) Operation

(1.1) Injection not taking place

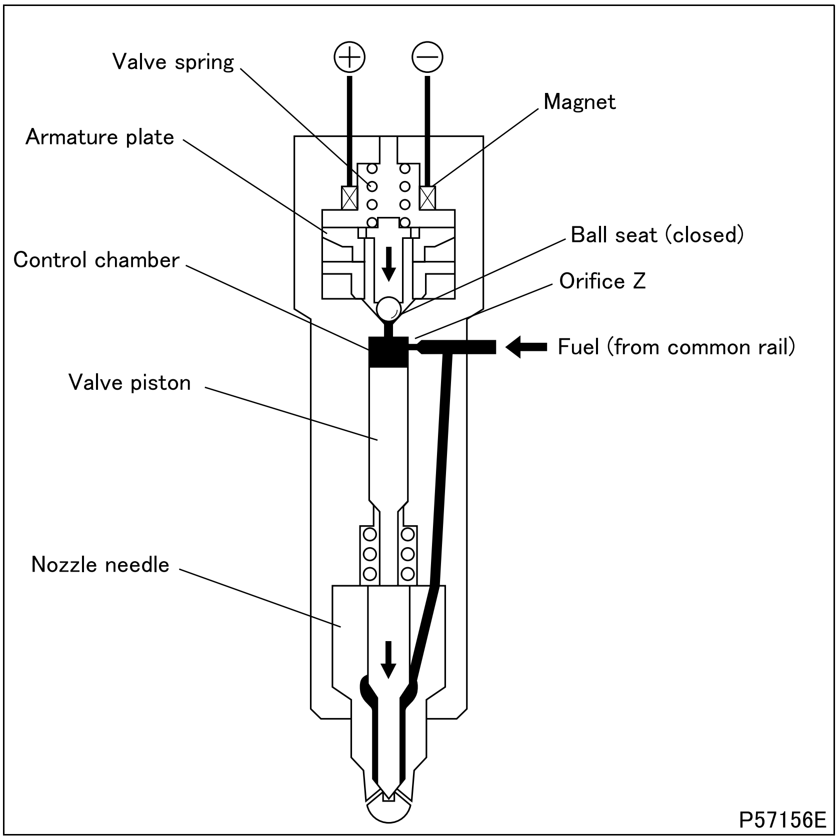
- With the magnet not energized, the armature plate is pushed up by the valve spring such that the ball seat is closed.
- The high-pressure fuel acts upon the control chamber via orifice Z. The same pressure acts upon the nozzle needle.
- The fuel pressure acting on the nozzle needle cannot overcome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



P57155E

(1.2) Start of injection

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



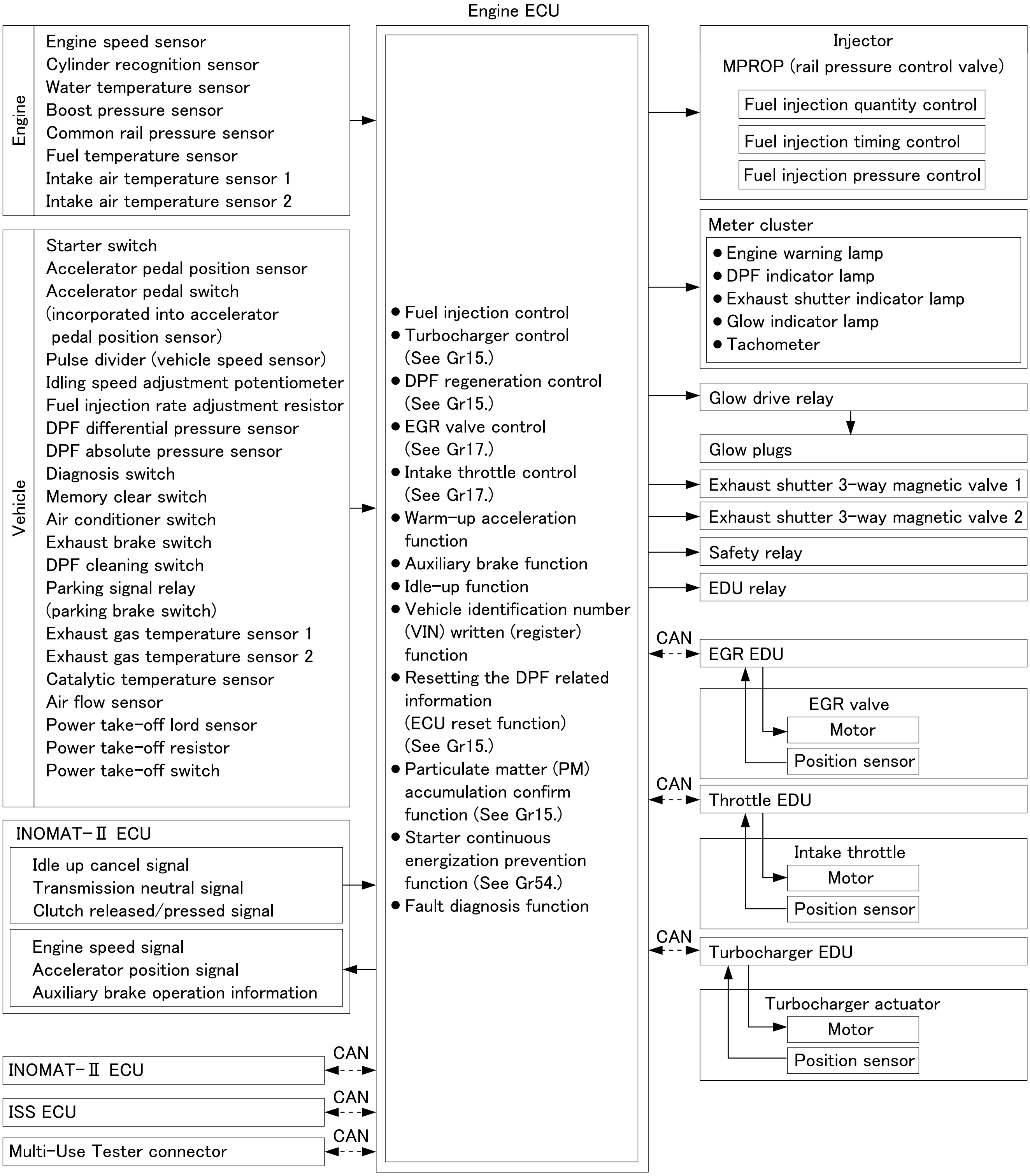
(1.3) End of injection

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

2. Engine Electronic Control Unit

- According to output information signals from the sensors and switches of the controllers to ensure normal operation of the common rail system, regeneration control type diesel particulate filter system and exhaust gas recirculation system, the engine and vehicle, characteristic and correction data stored in the ROM (a kind of memory) are read into the CPU (central processor unit) and arithmetically processed to thereby control the various systems.

2.1 System block diagram



CAN: Controller area network
DPF: Diesel Particulate Filter
ECU: Electronic control unit
EDU: Electronic drive unit
EGR: Exhaust gas recirculation
INOMAT-II: Intelligent and innovative mechanical automatic transmission-II
ISS: Idling-stop and start system

P110525E

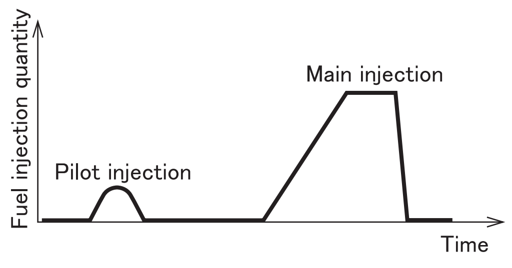
Part		Main function/operation
Engine speed sensor		Sensing of engine speed
Cylinder recognition sensor		Cylinder recognition
Water temperature sensor		Sensing of coolant temperature
Boost pressure sensor		Sensing of boost pressure
Common rail pressure sensor		Sensing of common rail pressure
Fuel temperature sensor		Sensing of fuel temperature
Intake air temperature sensor 1		Sensing of intake air temperature
Intake air temperature sensor 2		Sensing of boost air temperature
Starter switch		Senses that the engine is in starting condition with the starter switch in START position.
Accelerator pedal position sensor		Sensing of extent of accelerator pedal depression
Accelerator pedal switch (incorporated into accelerator pedal position sensor)		Sensing of released/pressed condition of accelerator pedal (ON with pedal released)
Pulse divider (vehicle speed sensor)		Sensing of vehicle speed
Idling speed adjustment potentiometer		Acceleration of warm-up
Fuel injection rate adjustment resistor		Correction of fuel injection rate
DPF absolute pressure sensor		Sensing of DPF absolute pressure
DPF differential pressure sensor		Sensing of DPF filter differential pressure
Diagnosis switch		Output of diagnosis codes
Memory clear switch		Deletion of diagnosis codes; output of past diagnosis codes
Air conditioner switch		ON when air conditioner is operating
Exhaust brake switch		Exhaust brake ON/OFF control
DPF cleaning switch		ON/OFF changeover of DPF parked regeneration
Parking signal relay (parking brake switch)		Detection of parking condition (turns ON when the parking brake is applied)
Exhaust gas temperature sensor 1		Detection of ceramic filter inlet temperature
Exhaust gas temperature sensor 2		Detection of ceramic filter outlet temperature
Catalytic temperature sensor		Detection of front oxidation catalytic inlet temperature
Air flow sensor		Sensing of intake air flow rate
Power take-off load sensor		Sensing of extent of accelerator pedal depression
Power take-off resistor		Selection of power take-off map
Power take-off switch		Operation of power take-off
Injector		Control of fuel injection quantity, fuel injection timing, and fuel injection pressure
MPROP (rail pressure control valve)		Control of fuel injection pressure
Engine warning lamp		Indication of system abnormalities
DPF indicator lamp		Illuminates when the particulate matter accumulates in the DPF ceramic filter
Exhaust shutter indicator lamp		ON when auxiliary brake is operating
Glow indicator lamp		ON when preheating system is started
Tachometer		Indication of engine speed (in meter cluster)
Glow drive relay		ON/OFF control of glow plugs
Exhaust shutter 3-way magnetic valve 1, 2		ON/OFF control of exhaust shutter valve
Safety relay		Control of starter continuous energization prevention function
EDU relay		Switching ON/OFF supply of power to exhaust gas recirculation electronic drive unit, throttle and turbocharger electronic drive unit
INOMAT-II ECU	Idle-up cancel signal	Releasing the idle-up except N range
	Transmission neutral signal	Sensing of Transmission neutral (N range)
	Clutch released/pressed signal	Sensing of clutch released/pressed
	Engine speed signal	Output of engine speed for INOMAT-II control
	Accelerator pedal position signal	Output of extent of accelerator pedal for INOMAT-II control

Part	Main function/operation
CAN communication (EGR EDU, Throttle EDU, Turbocharger EDU)	Engine data recognized by the engine electronic control unit are outputted to the CAN bus to enable systems to obtain data that they need for control. Each electronic drive unit issues signals to the engine electronic control unit via the CAN bus to enable it to effect engine control appropriate for each type of system control.
CAN communication (INOMAT-II ECU, ISS ECU)	Engine data recognized by the engine ECU are outputted to the CAN bus to enable systems to obtain data that they need for control. The INOMAT-II ECU and ISS ECU issue signals to the engine ECU to enable it to effect engine control appropriate to control of the system. (See Gr22E for INOMAT-II ECU.) (See Gr54 for ISS ECU.)
CAN communication (Multi-Use Tester)	Allowing the service personnel to read or erase diagnosis codes and obtain the electronic control unit and vehicle data using a scan tool.

ABS: Anti-lock brake system
CAN: Controller area network
DPF: Diesel particulate filter
ECU: Electronic control unit
EDU: Electronic drive unit
ISS: Idling stop and start system
INOMAT-II: Intelligent and innovative mechanical automatic transmission-II

2.2 Fuel injection control

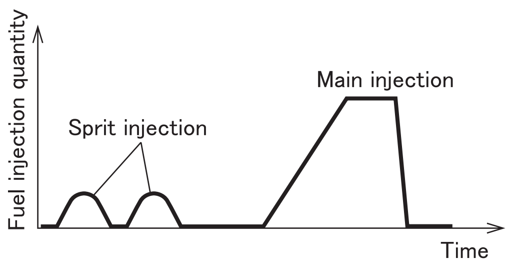
(1) Pilot injection



90708E

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

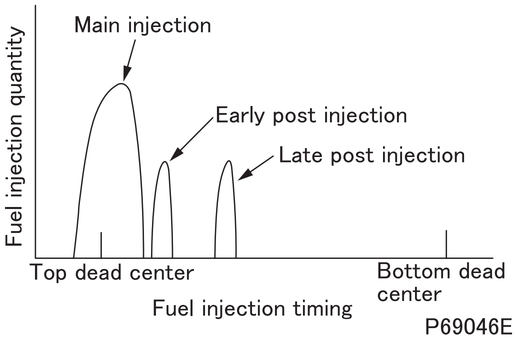
(2) Split injection control



P90709E

- Split injection entails the injection of an extremely small amount of fuel two or more times ahead of the main injection.
- This improves the ignitability of fuel and realizes better startability at cold engine and reduction of HC at low-load operation.

(3) Post injection

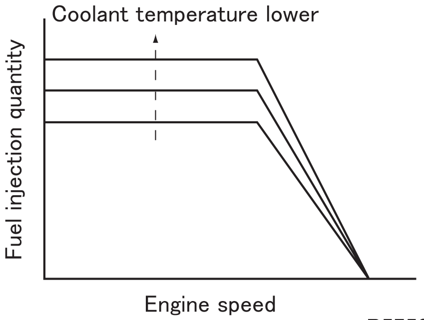


P69046E

- Fuel injection control for diesel particular filter regeneration is performed in such a way, with early post injection and late post injection added after conventional fuel injection (main injection), exhaust gas temperature is increased to burn out particulate matter (PM) collected in the DPF.

2.3 Fuel injection quantity control

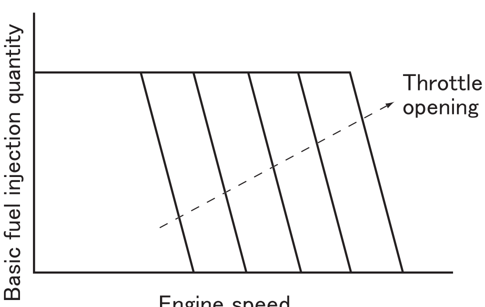
(1) Fuel injection quantity during engine startup



P57507E

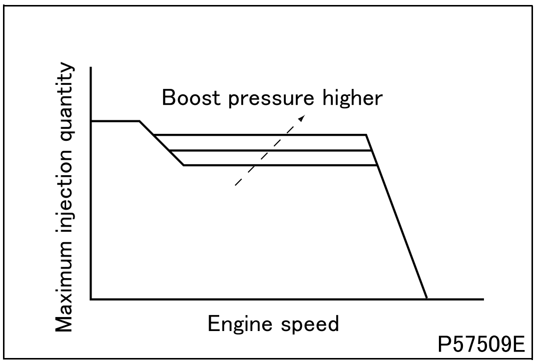
- During engine startup, the fuel injection quantity is determined in accordance with the engine speed and coolant temperature.

(2) Basic fuel injection quantity



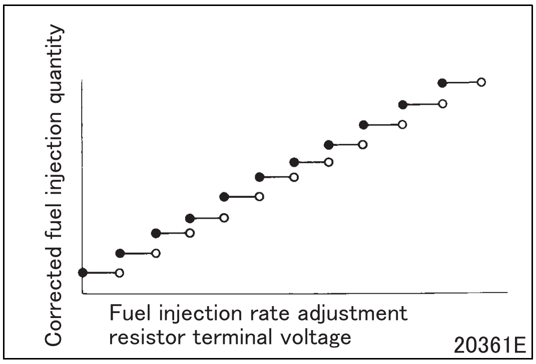
P57508E

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



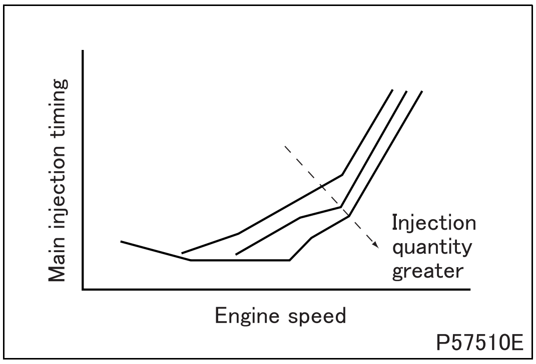
(3) Maximum injection quantity

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



(4) Fuel injection rate adjustment resistor correction amount

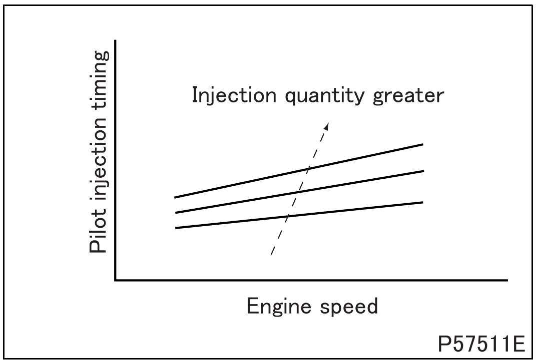
- To limit inconsistency in the injection quantity, the injection quantity is corrected by the fuel injection rate adjustment resistor.



2.4 Fuel injection timing control

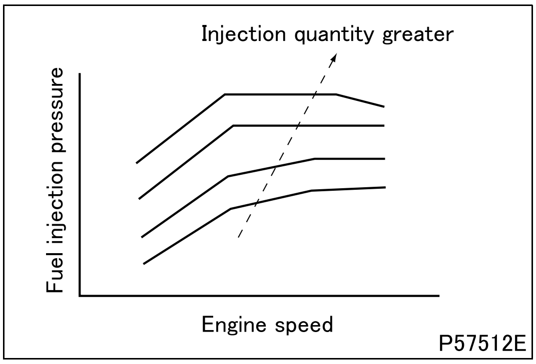
(1) Main injection timing

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



(2) Pilot injection timing (pilot interval)

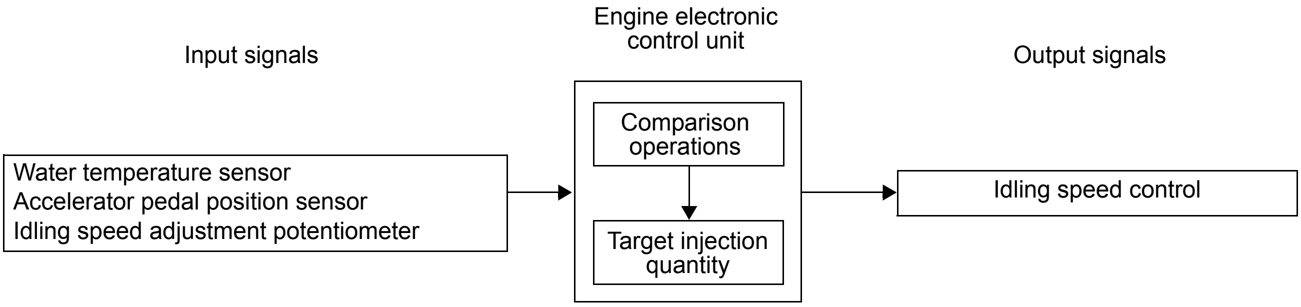
- The pilot injection timing is calculated from the fuel injection quantity and engine speed.



2.5 Fuel injection pressure control

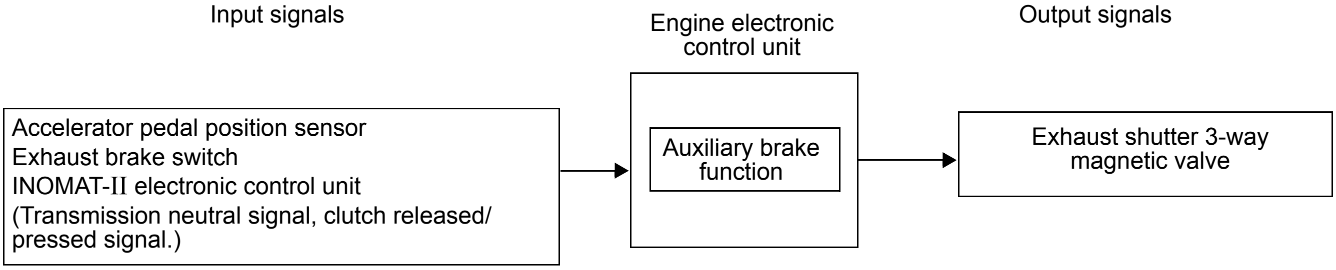
- The fuel injection pressure is calculated from the fuel injection quantity and engine speed.

2.6 Warm-up acceleration function



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

2.7 Auxiliary brake function



INOMAT-II: Intelligent and innovative mechanical automatic transmission-II

- The auxiliary brake function activates or deactivates the exhaust shutter 3-way magnetic valve according to the vehicle condition to control the exhaust brake.

2.8 Idle-up function

- The idle-up function increases the engine idling speed when a load is applied to the engine by other system (such as air conditioner) or when the warm-up acceleration function are activated.
  Also, in the case of variable geometry turbocharger-equipped vehicles, idling speed can be increased with the lighting switch turned on as well.

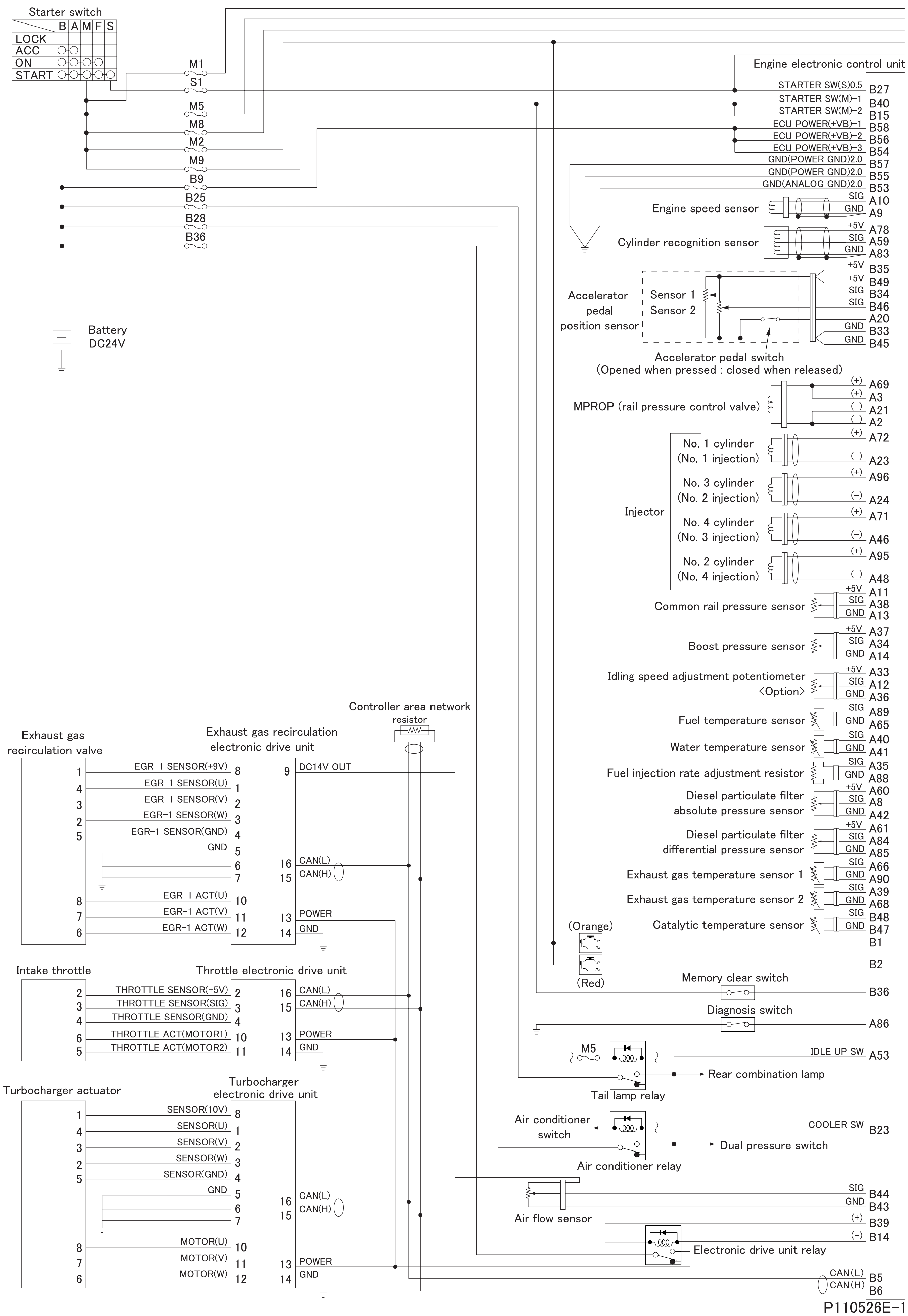
2.9 Vehicle identification number (VIN) written (register) function

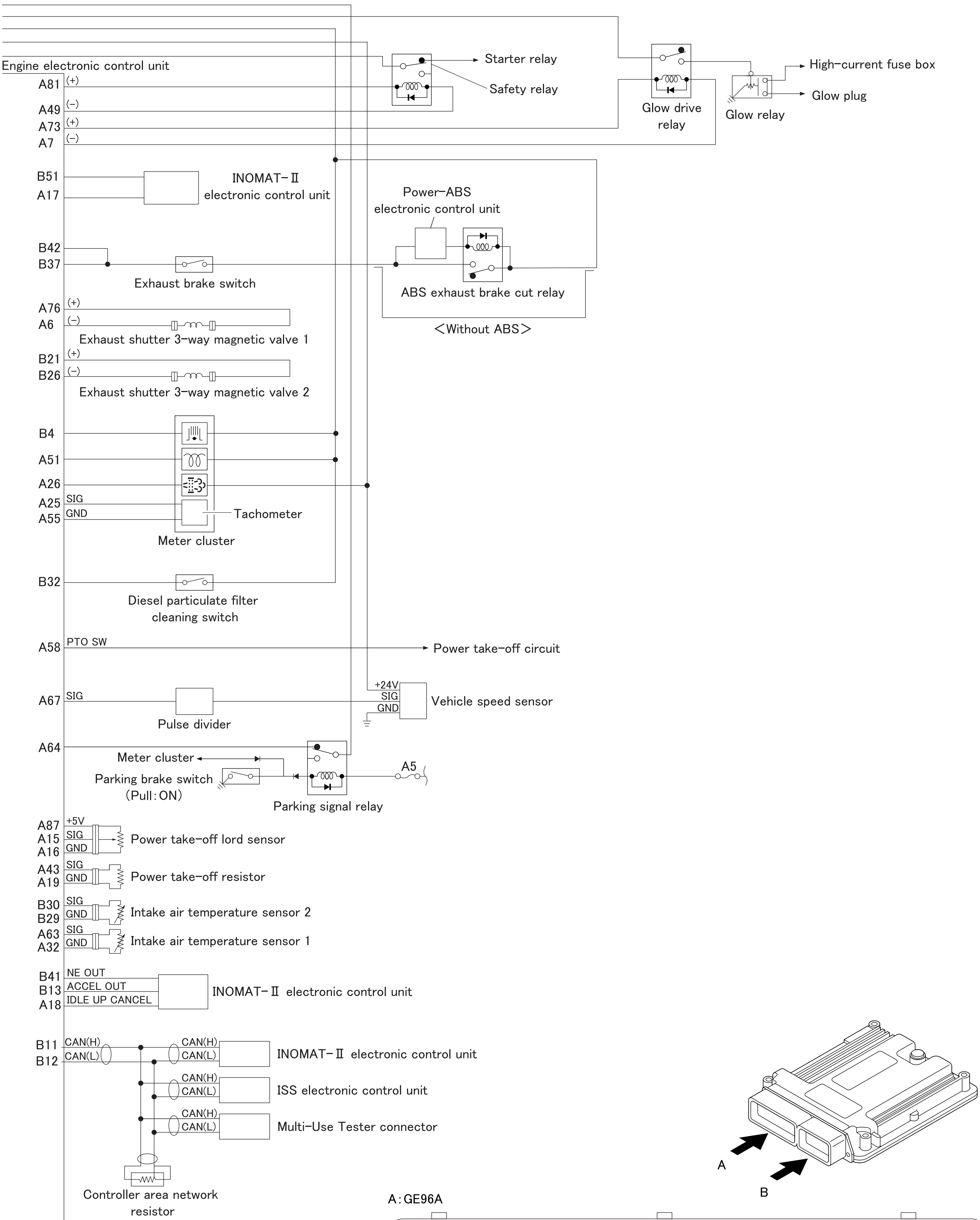
- The vehicle identification number (VIN) registration function is used to have the VIN of the vehicle registered when a new engine electronic control unit is installed or the existing one is replaced.
  (For the VIN registration method, see "ON-VEHICLE INSPECTION AND ADJUSTMENT".)

2.10 Fault diagnosis function

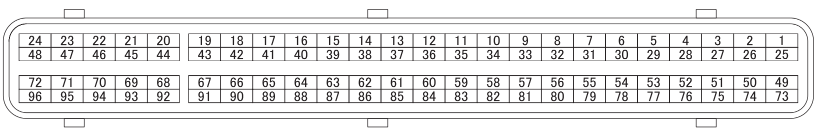
- The sensors and other components are continuously monitored for faults. In the event that a component is found faulty, an indication is made in the meter cluster to alert the driver, the fault location is memorized in the form of a diagnosis code, and the control during fault is initiated.
- While the control during fault is taking place, the system's functionality is limited to ensure vehicle and driver safety. It is possible to read the memorized diagnosis code using a Multi-Use Tester or from flashing of the warning lamp.

2.11 Electronic Control Unit Connection Diagram

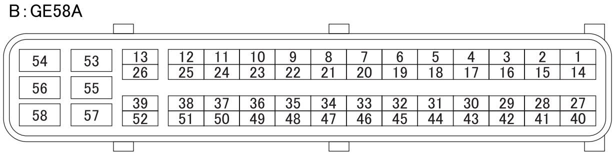




A: GE96A



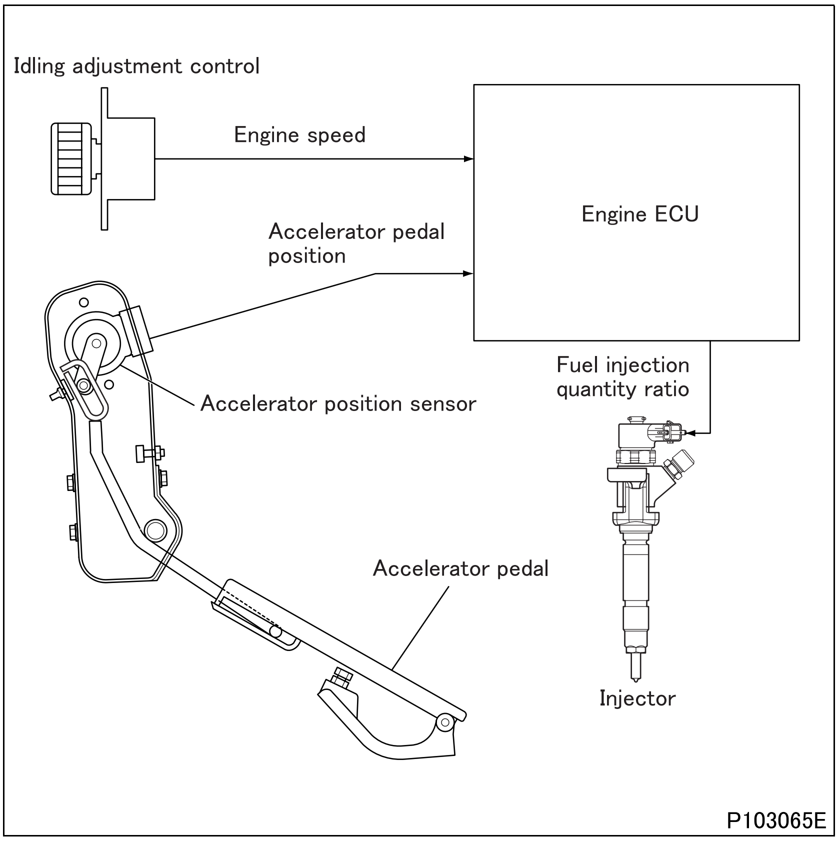
B: GE58A



ABS: Anti-lock brake system
ISS: Idling stop & start system
INOMAT-II: Intelligent and innovative mechanical automatic transmission-II

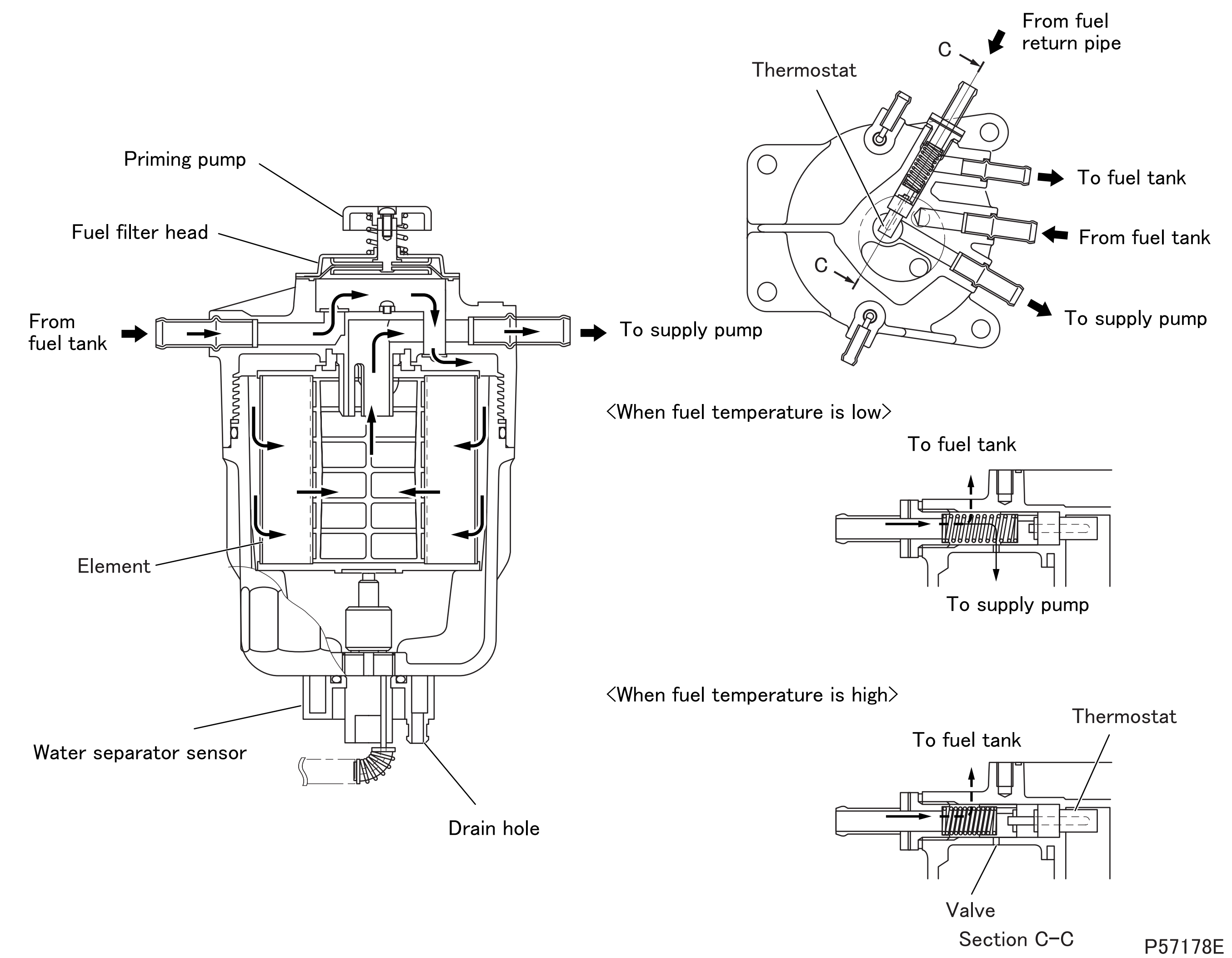
P110526E-2

3. Accel Control



- The engine is electronically controlled by the engine electronic control unit (ECU).
- By processing accelerator pedal position data from the accelerator position sensor, the engine electronic control unit controls the injectors for optimum fuel injection.

4. Fuel Filter



- The fuel filter, which also serves as a water separator, removes impurities in the fuel through the filter element and also separates water from fuel.
- The water that has been separated from the fuel collects at the bottom of the fuel filter. A water separator sensor is installed in the fuel filter, which activates the warning lamp on the meter cluster when the water reaches a certain level.
- The water can be drained through the drain hole by loosening the water separator sensor.
- A priming pump is provided at the fuel filter head. The priming pump is used for air-bleeding the fuel system.
- When the fuel temperature rises, the thermostat swells and the valve of the fuel filter head is closed. The high-temperature fuel entirely returns to the fuel tank through the fuel return pipe.
- When the fuel temperature lowers, the thermostat does not swell and the valve to the fuel filter remains open. The high-temperature fuel returning through the fuel return pipe is let through the valve to mix into the fuel around the element. The fuel around the element is warmed as a result and wax in it (precipitated when the fuel temperature is low) is dissolved to prevent clogging of the element.

TROUBLESHOOTING <FUEL SYSTEM>

Possible causes \ Symptoms		Engine refuses to start	Engine is difficult to start	Engine knocks	Engine output is unstable	Engine output is insufficient	Engine maximum speed is too high	Engine is idling unstably	Engine stops soon after starting	Engine does not reach maximum speed	Engine does not stop	Fuel supply is insufficient	warning lamp illuminates	Reference Gr
Common rail system faulty													O	
Supply pump	Defective feed pump		O			O			O		O			*a
	Defective sealing supply pump overflow valve		O			O			O		O			*a
	Defective MPROP (rail pressure control valve)		O			O			O		O		O	*a
	Defective supply pump		O			O			O		O			*a
Common rail	Malfunction of common rail pressure sensor	O	O		O	O			O				O	*b
	Operation of flow limiter			O		O							O	*b
	Pressure limiting valve malfunction			O									O	*b
Incorrect injector fuel injection	Open or short circuit failure, poor contact of injector magnetic valve		O	O		O					O		O	*b
	Defective injector, defective injector magnetic valve, defective injection nozzle		O	O		O					O			*b
Clogged fuel filter		O			O			O	O					
No fuel in fuel tank		O												
Clogged fuel pipe and/or leaky pipe joints		O												
Air or water in fuel system		O			O			O	O					
Fuel other than low-sulfur diesel oil used (high-sulfur diesel oil, kerosene, heavy oil, biofuel, etc.)			O	O		O		O						
Fuel leakage from high pressure joint			O	O	O	O					O			
Engine control	Poorly adjusted accelerator pedal stopper bolt					O				O				
	Defective accelerator position sensor						O			O			O	
Cracked fuel pipe and/or hose												O		

*a: Contact a Bosch service station for repair.

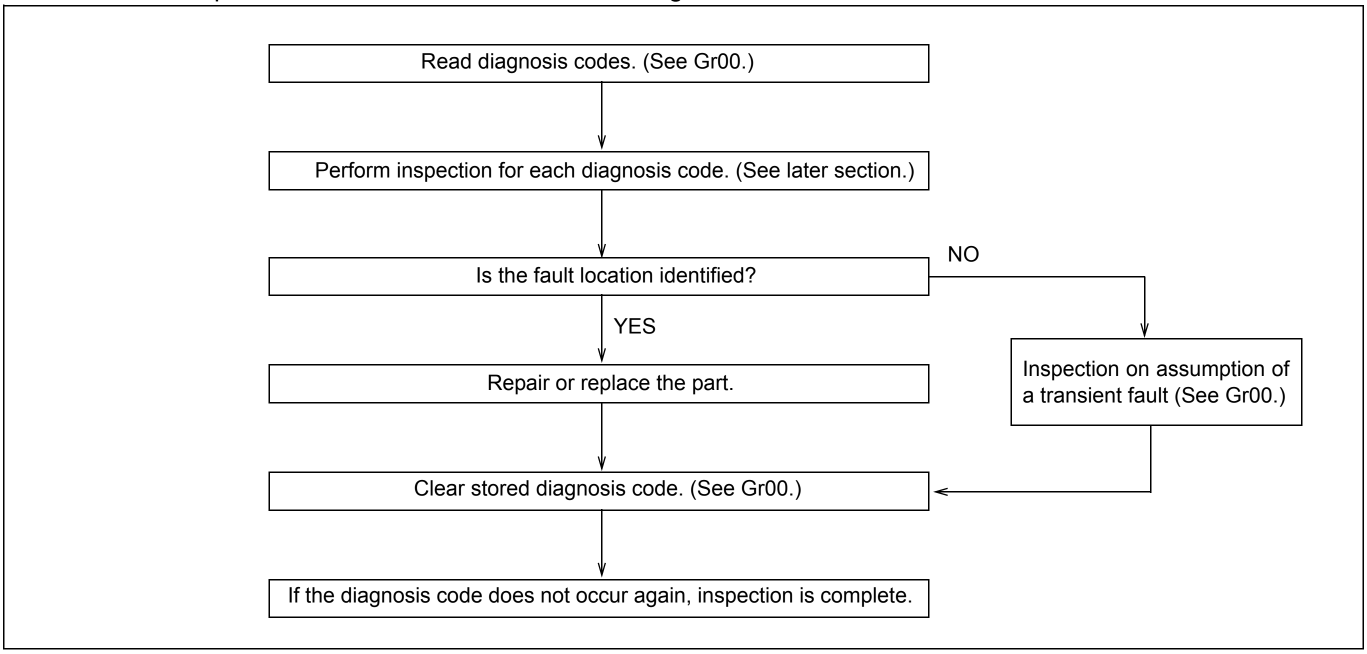
*b: Replace common rail or injector

Possible causes \ Symptoms	Engine refuses to start	Engine is difficult to start	Engine knocks	Engine output is unstable	Engine output is insufficient	Engine maximum speed is too high	Engine is idling unstably	Engine stops soon after starting	Engine does not reach maximum speed	Engine does not stop	Fuel supply is insufficient	warning lamp illuminates	Reference Gr
Oil viscosity unsuitable		O					O						Gr12
Valve clearance incorrect		O					O						Gr11
Defective cylinder head gasket		O					O						
Wear of and/or carbon deposits on valve and valve seat		O					O						
Distorted valve springs		O					O						
Worn or damaged piston rings		O					O						
Worn or damaged piston ring groove		O											
Worn piston and/or cylinder liner		O					O						
Poorly functioning cooling system		O					O						Gr14
Defective starter switch	O	O											Gr54
Defective glow plug		O											
Open-circuited, short-circuited or poorly connected engine speed sensor and/or cylinder recognition sensor	O	O										O	
Open-circuited, short-circuited or poorly connected boost pressure sensor			O	O	O				O			O	
Open-circuited, short-circuited or poorly connected coolant temperature sensor	O	O										O	
Poorly connected injection rate adjusting resistor			O		O							O	
Open-circuited, short-circuited or poorly connected idling adjustment control			O				O					O	
Blown fuse	O	O						O				O	Gr54

TROUBLESHOOTING <DIAGNOSIS USING Multi-Use Tester>

1. Diagnosis Procedure

- Perform the inspection in accordance with the following flowchart.



2. Diagnostic Precautions

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

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.

Multi-Use Tester indication		Warning lamp indication			Remarks
Code	Message	Flashes	Orange	Red	
P0002	Fuel system	63	O	–	
P0004	Fuel system (High)	63	O	–	
P0016	Ne SNSR Offset/Backup Mode	14	O	O	
P0045	VGT Actuator (Open)	51	O	–	Gr15
P0046	VGT Actuator (Performance)	51	O	–	Gr15
P0047	VGT Actuator (Low)	51	O	–	Gr15
P0087	CRS (Too Low)	36	O	–	
P0088	CRS (Too High)	23	O	O	
P0089	MPROP (Over Load)	63	O	–	
P0090	MPROP (Open Circuit)	63	O	–	
P0091	MPROP (Low)	63	O	–	
P0092	MPROP (High)	63	O	–	
P0093	CRS (Fuel Leak)	22	O	O	
P0097	INT Air Temp Sensor 2 (Low)	9	O	–	Gr17
P0098	INT Air Temp Sensor 2 (High)	9	O	–	Gr17
P0102	Airflow Sensor (Low)	17	O	–	Gr17
P0103	Airflow Sensor (High)	17	O	–	Gr17
P0112	INT Air Temp SNSR (Low)	44	O	–	
P0113	INT Air Temp SNSR (High)	44	O	–	
P0117	Water Temp SNSR (Low)	21	O	–	
P0118	Water Temp SNSR (High)	21	O	–	
P0122	Accel Pedal Sensor 1	24	O	–	
P0123	Accel Pedal Sensor 1	24	O	–	
P0148	CRS (Fuel Delivery)	22	–	O	
P0182	Fuel Temp Sensor (inlet) Low	41	–	–	
P0183	Fuel Temp Sensor (inlet) High	41	–	–	
P0192	CRS Pressure SNSR (Low)	11	O	–	
P0193	CRS Pressure SNSR (High)	11	O	–	
P0201	Injector M/V-Cylinder 1 (Load)	37	O	–	
P0202	Injector M/V-Cylinder 2 (Load)	38	O	–	
P0203	Injector M/V-Cylinder 3 (Load)	39	O	–	
P0204	Injector M/V-Cylinder 4 (Load)	8	O	–	
P0219	Engine Overrunning	7	–	O	
P0222	Accel Pedal Sensor 2	16	O	–	
P0223	Accel Pedal Sensor 2	16	O	–	
P0226	Throttle Valve Position	28	O	–	Gr17
P0234	Over Boost	54	O	–	Gr15
P0237	Boost Press SNSR (Low)	32	O	–	Gr15
P0238	Boost Press SNSR (High)	32	O	–	Gr15
P0251	Common Rail Pressure Defect	36	O	–	
P0253	Common Rail Pressure Defect	22	–	O	
P0254	Common Rail Pressure Defect	23	–	O	
P0335	Engine Revolution SNSR	15	O	–	
P0339	Engine Revolution SNSR (Plausi)	15	O	O	
P0340	Camshaft Position SNSR	12	O	–	

Multi-Use Tester indication		Warning lamp indication			Remarks
Code	Message	Flashes	Orange	Red	
P0344	Camshaft Position SNSR (Plausi)	12	O	–	
P0380	Relay for Glow Relay	26	–	–	Gr54
P0381	Glow Lamp	89	–	–	
P0383	Relay for Glow Relay	26	–	–	
P0384	Relay for Glow Relay	26	–	–	
P0403	EGR1 (Actuator Circuit)	2	O	–	Gr17
P0404	EGR System	67	O	–	
P0409	EGR1 (Position Sensor)	67	O	–	
P0472	DPF Press SNSR (LOW)	98	O	–	Gr15
P0473	DPF Press SNSR (HIGH)	98	O	–	
P0489	EGR Power Supply	67	O	–	Gr17
P0490	EGR Power Supply	67	O	–	
P0500	Vehicle Speed Sensor	25	O	–	
P0506	Idle Volume	52	O	–	
P0507	Idle Volume	52	O	–	
P0510	Accel SW	65	–	–	
P0545	DPF Temp SNSR (upstream) Low	87	O	–	Gr15
P0546	DPF Temp SNSR (upstream) High	87	O	–	
P0562	Power Supply Voltage (Low)	33	O	–	
P0563	Power Supply Voltage (High)	33	O	–	
P0605	ECU System (Hardware)	33	O	–	
P0607	ECU System	33	O	O	
P060B	A/D Converter	33	O	–	
P0615	Starter Safety Relay (Over Load)	48	–	O	Gr54
P0616	Starter Safety Relay (Low)	48	–	O	
P0617	Starter Safety Relay (High)	48	–	O	
P061B	ECU Performance (Calc)	33	O	–	
P061C	ECU Performance (Ne)	33	O	–	
P062D	Injector Bank 1	82	O	–	
P062E	Injector Bank 2	82	O	–	
P0642	Sensor Supply Voltage 1 (Low)	81	O	–	
P0643	Sensor Supply Voltage 1 (High)	81	O	–	
P0652	Sensor Supply Voltage 2 (Low)	81	O	–	
P0653	Sensor Supply Voltage 2 (High)	81	O	–	
P0657	M/V Voltage (Low)	79	O	–	
P0685	EDU Relay (Open)	84	O	–	Gr15, 17
P0686	EDU Relay (Low)	84	O	–	
P0687	EDU Relay (High)	84	O	–	
P0688	EDU Relay (Over Load)	84	O	–	
P0698	Sensor Supply Voltage 3 (Low)	81	O	–	
P0699	Sensor Supply Voltage 3 (High)	81	O	–	
P1171	Q Adjustment Resistor (Low)	34	O	–	
P1172	Q Adjustment Resistor (High)	34	O	–	

Multi-Use Tester indication		Warning lamp indication			Remarks
Code	Message	Flashes	Orange	Red	
P1410	Exhaust Absolute Pressure (High)	92	O	–	
P1411	Excessive exhaust Temperature	88	–	O	
P1412	DPF Temp Abnormal 1 (Auto) (Low)	92	–	–	Gr15
P1413	DPF Temp Abnormal 2 (Auto) (Low)	92	–	–	
P1414	DPF Temp Abnormal 3 (Auto) (High)	92	–	–	
P1415	DPF Interval Abnormal (Auto)	92	–	–	
P1416	DPF Temp Abnormal 1 (Manual) (Low)	92	O	–	
P1417	DPF Temp Abnormal 2 (Manual) (Low)	92	O	–	
P1418	DPF Temp Abnormal 3 (Manual) (High)	92	O	–	
P1419	DPF Interval Abnormal (Manual)	92	O	–	
P1421	PM accumulation amount level 1	92	O	–	
P1422	PM accumulation amount level 2	92	O	–	Gr15
P1430	DPF Regeneration switch	78	O	–	
P1435	Exhaust Relative Pressure (Low)	92	O	–	
P1440	DPF Temp Abnormal 4 (Auto)	92	–	–	
P1441	DPF Temp Abnormal 4 (Manual)	92	–	–	
P1447	Catalyst Temp Sensor (Low)	13	O	–	
P1448	Catalyst Temp Sensor (High)	13	O	–	
P1466	Auxiliary Brake M/V 2 (Plausi)	94	O	–	
P1467	Auxiliary Brake M/V 2 (Low)	94	O	–	
P1468	Auxiliary Brake M/V 2 (High)	94	O	–	
P1577	Segment Sensor Supply Voltage	81	–	–	
P1578	Segment Sensor Supply Voltage	81	–	–	
P1632	CAN (EGR Time out)	95	O	–	Gr17
P1635	CAN (Intake Throttle)	96	O	–	
P1645	CAN Communication (VGT)	76	O	–	
P1660	DPF Lamp Control Circuit (Low)	29	O	–	Gr15
P2032	Exhaust Gas Temp (Low)	88	O	–	
P2033	Exhaust Gas Temp (High)	88	O	–	
P2100	TVA (Open)	28	O	–	
P2101	TVA (System)	28	O	–	
P2102	TVA (Short)	28	O	–	Gr17
P2108	TVA (Controller)	28	O	–	
P2135	TVA SNSR (Voltage)	28	O	–	
P2146	Injector Bank 1 (Plausibility)	82	O	–	
P2147	Injector Bank 1 (Low)	82	O	–	
P2148	Injector Bank 1 (High)	82	O	–	
P2149	Injector Bank 2 (Plausibility)	82	O	–	
P2150	Injector Bank 2 (Low)	82	O	–	
P2151	Injector Bank 2 (High)	82	O	–	
P2169	Exhaust Valve Act (Open)	93	O	–	
P2170	Exhaust Valve Act (Gnd)	93	O	–	
P2171	Exhaust Valve Act (Batt)	93	O	–	
P2228	Atm Press SNSR (Low)	19	O	–	
P2229	Atm Press SNSR (High)	19	O	–	
P2263	VGT System	51	O	–	Gr15

Multi-Use Tester indication		Warning lamp indication			Remarks
Code	Message	Flashes	Orange	Red	
P2413	EGR System	67	O	–	Gr17
P2453	DPF Diff SNSR (Plausi) & MFF	97	O	–	Gr15
P2454	DPF Diff SNSR (Low) & MFF	97	O	–	
P2455	DPF Diff SNSR (High) & MFF	97	O	–	
P253C	PTO Acc (Low)	61	O	–	
P253D	PTO Acc (High)	61	O	–	
P254C	PTO Ne (Low)	62	–	–	
P254D	PTO Ne (High)	62	–	–	
P2562	VGT Position Sensor	51	O	–	Gr15
P2670	MPROP Voltage (Low)	36	O	–	
U0001	CAN No Data Received	95	O	–	
U0073	CAN Communication Bus Off	95	O	–	

3.2 Diagnosis code generation conditions and inspection items

P0002: Fuel system (warning lamp flashes: 63)

Generation condition		Internal trouble of engine electronic control unit (malfunction of MPROP (rail pressure control valve control circuit is detected)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0004: Fuel system (High) (warning lamp flashes: 63)

Generation condition		Internal trouble of engine electronic control unit (malfunction of MPROP (rail pressure control valve drive circuit is detected)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0016: Ne SNSR Offset/Backup Mode (warning lamp flashes: 14)

Generation condition		Either of the following occurs. (1) Slippage of the camshaft and crankshaft in angle recognition is detected. (Diagnosis switch flashes warning lamp (red): 12 times) (2) Despite input of starter switch signal (S signal), output signals from engine speed sensor and cylinder detection sensor remain off for 7.2 seconds. (Diagnosis switch flashes warning lamp (red): 14 times) (3) When backup mode is established (controlled by cylinder recognition sensor) due to malfunction of the engine speed sensor unit. (Diagnosis switch flashes warning lamp (red): 15 times)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		[In the case of above problem (1)] • Effects no special control. [In the case of above problem (2)] • Normal control (engine restart not enabled) [In the case of above problem (3)] • Control is carried out using cylinder recognition sensors.
Inspection	Service data	01: Engine Revolution, 71: Starter SW (S)
	Electronic control unit connector	05 : Engine speed sensor, 06 : Cylinder recognition sensor
	Electrical equipment	#263: Engine speed sensor, #320: Cylinder recognition sensor
	Electric circuit diagram	Engine speed sensor, cylinder recognition sensor and starter switch (S) system

P0087: CRS (Too Low) (warning lamp flashes: 36)

Generation condition		Actual common rail pressure is lower than target common rail pressure (the difference is 16.7 % or more) or remains in that state for more for 60 seconds (actual common rail pressure is still below target level).
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped.
Inspection	Service data	03: Reference Common Rail Pressure, 04: Actual Common Rail Pressure, 05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Electrical equipment	#582: Injector
	Other	• Check the fuel pipe • Fuel filter • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.) • Injector (Have work performed by Bosch service station.)

P0088: CRS (Too High) (warning lamp flashes: 23)

Generation condition		Either of the following occurs. (1) Although the discharge rate of MPROP (rail pressure control valve) is lower than the specified limit, actual common rail pressure remains higher than the target common rail pressure (the difference is 16.7 % or more) for 10 seconds (a state in which little fuel is delivered from MPROP (rail pressure control valve) but common rail internal pressure exceeds target common rail pressure) (2) Actual common rail pressure remains over 105.6 % for 5 seconds (actual common rail pressure is excessive).
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped.
Inspection	Service data	03: Reference Common Rail Pressure, 04: Actual Common Rail Pressure, 05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Electrical equipment	#582: Injector
	Other	• MPROP (rail pressure control valve) (Have work performed by Bosch service station.) • Supply pump (Have work performed by Bosch service station.) • Injector (Have work performed by Bosch service station.)

P0089: MPROP (Over Load) (warning lamp flashes: 63)

Generation condition		Current flowing in MPROP (rail pressure control valve) circuit remains in excess of the specified limit for 0.3 second.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped.
Inspection	Electronic control unit connector	11 : MPROP (rail pressure control valve)
	Electrical equipment	#574: MPROP (rail pressure control valve)
	Electric circuit diagram	MPROP (rail pressure control valve) system
	Other	MPROP (rail pressure control valve) (Have work performed by Bosch service station.)

P0090: MPROP (Open Circuit) (warning lamp flashes: 63)

Generation condition		MPROP (rail pressure control valve) circuit open-circuited for 0.3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Electronic control unit connector	11 : MPROP (rail pressure control valve)
	Electrical equipment	#574: MPROP (rail pressure control valve)
	Electric circuit diagram	MPROP (rail pressure control valve) system
	Other	MPROP (rail pressure control valve) (Have work performed by Bosch service station.)

P0091: MPROP (Low) (warning lamp flashes: 63)

Generation condition		MPROP (rail pressure control valve) circuit shorted to ground for 0.3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Electronic control unit connector	11 : MPROP (rail pressure control valve)
	Electrical equipment	#574: MPROP (rail pressure control valve)
	Electric circuit diagram	MPROP (rail pressure control valve) system
	Other	MPROP (rail pressure control valve) (Have work performed by Bosch service station.)

P0092: MPROP (High) (warning lamp flashes: 63)

Generation condition		MPROP (rail pressure control valve) circuit shorted to power supply for 0.3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Electronic control unit connector	11 : MPROP (rail pressure control valve)
	Electrical equipment	#574: MPROP (rail pressure control valve)
	Electric circuit diagram	MPROP (rail pressure control valve) system
	Other	MPROP (rail pressure control valve) (Have work performed by Bosch service station.)

P0093: CRS (Fuel Leak) (warning lamp flashes: 22)

Generation condition		After diagnosis code P0087 occurs, the discharge rate of MPROP (rail pressure control valve) is above the specified limit but actual common rail pressure is lower than target common rail pressure (the difference is 16.7 % or more) or remains in that state for more for 60 seconds (a state in which more fuel than specified quantity is delivered from MPROP (rail pressure control valve) but common rail internal pressure is below target common rail pressure).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Engine stops.
Inspection	Other	• Fuel system piping • Fuel filter • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.)

P0112: INT Air Temp SNSR (Low) (warning lamp flashes: 44)

Generation condition		Intake air temperature sensor 1 voltage remains less than 0.15 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Backup value (25°C) is used.
Inspection	Service data	0D: Intake Air Temperature 1, 28: Intake Air Temp SNSR1 Voltage
	Electronic control unit connector	13 : Intake air temperature sensor 1
	Electrical equipment	#305: Intake air temperature sensor
	Electric circuit diagram	Intake air temperature sensor 1 system

P0113: INT Air Temp SNSR (High) (warning lamp flashes: 44)

Generation condition		Intake air temperature sensor 1 voltage remains higher than 4.87 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Backup value (25°C) is used.
Inspection	Service data	0D: Intake Air Temperature 1, 28: Intake Air Temp SNSR1 Voltage
	Electronic control unit connector	13 : Intake air temperature sensor 1
	Electrical equipment	#305: Intake air temperature sensor
	Electric circuit diagram	Intake air temperature sensor 1 system

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

Generation condition		Water temperature sensor voltage remains less than 0.2 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (80°C) is used. • DPF regeneration control is stopped. • Exhaust gas recirculation control is stopped. • Throttle control is stopped.
Inspection	Service data	13: Water Temperature, 25: Water Temp SNSR Voltage
	Electronic control unit connector	01 : Water temperature sensor
	Electrical equipment	#262: Water temperature sensor
	Electric circuit diagram	Water temperature sensor system

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

Generation condition		Water temperature sensor voltage remains higher than 4.85 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (80°C) is used. • DPF regeneration control is stopped. • Exhaust gas recirculation control is stopped. • Throttle control is stopped.
Inspection	Service data	13: Water Temperature, 25: Water Temp SNSR Voltage
	Electronic control unit connector	01 : Water temperature sensor
	Electrical equipment	#262: Water temperature sensor
	Electric circuit diagram	Water temperature sensor system

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

Generation condition		Accelerator pedal position sensor 1 voltage remains less than 0.5 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		[When sensor 1 (incorporated in accelerator pedal position sensor) only malfunctions] • Control by sensor 2 (incorporated in accelerator pedal position) [When both sensors 1 and 2 (incorporated in accelerator pedal position sensor) malfunction] • Accelerator switch ON: Accelerator pedal depressed 30 % of stroke Accelerator switch OFF: Controlled with recognition that accelerator pedal is not pressed. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Intake throttle control is stopped.
Inspection	Service data	40: Accel Pedal Sensor Voltage 1, 42: Accel Pedal Position (unfiltered), 43: Accel Pedal Position (filtered)
	Electronic control unit connector	02 : Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor system

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

Generation condition		Accelerator pedal position sensor 1 voltage remains higher than 4.7 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		[When sensor 1 (incorporated in accelerator pedal position sensor) only malfunctions] • Control by sensor 2 (incorporated in accelerator pedal position) [When both sensors 1 and 2 (incorporated in accelerator pedal position sensor) malfunction] • Accelerator switch ON: Accelerator pedal depressed 30% of stroke Accelerator switch OFF: Controlled with recognition that accelerator pedal is not pressed. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Intake throttle control is stopped.
Inspection	Service data	40: Accel Pedal Sensor Voltage 1, 42: Accel Pedal Position (unfiltered), 43: Accel Pedal Position (filtered)
	Electronic control unit connector	02 : Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor system

P0148: CRS (Fuel Delivery) (warning lamp flashes: 22)

Generation condition		Actual common rail pressure remains less than 5.6 % for 30 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 5 second.
Control effected by electronic control unit		Engine stops.
Inspection	Service data	03: Reference Common Rail Pressure, 04: Actual Common Rail Pressure, 05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Other	• Check the fuel pipe • Fuel filter • Injector (Have work performed by Bosch service station.) • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.)

P0182: Fuel Temp Sensor (inlet) (Low) (warning lamp flashes: 41)

Generation condition		Fuel temperature sensor voltage remains less than 0.15 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Engine is controlled using backup value (40°C).
Inspection	Service data	14: Fuel Temperature (inlet), 26: Fuel Temp SNSR Voltage
	Electronic control unit connector	03 : Fuel temperature sensor
	Electrical equipment	#323: Fuel temperature sensor
	Electric circuit diagram	Fuel temperature sensor system

P0183: Fuel Temp Sensor (inlet) (High) (warning lamp flashes: 41)

Generation condition		Fuel temperature sensor voltage remains higher than 4.8 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Engine is controlled using backup value (40°C).
Inspection	Service data	14: Fuel Temperature (inlet), 26: Fuel Temp SNSR Voltage
	Electronic control unit connector	03 : Fuel temperature sensor
	Electrical equipment	#323: Fuel temperature sensor
	Electric circuit diagram	Fuel temperature sensor system

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

Generation condition		Common rail pressure sensor voltage remains less than 0.2 V for 0.25 second.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Common rail pressure open loop control is effected. • Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “B4 to B7: Injector Test” are stopped. • Turbocharger control is stopped.
Inspection	Service data	2A: Common Rail Press SNSR Voltage
	Electrical equipment	#319: Common rail pressure sensor
	Electric circuit diagram	Common rail pressure sensor system
	Other	Common rail pressure sensor (Have work performed by Bosch service station.)

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

Generation condition		Common rail pressure sensor voltage remains higher than 4.8 V for 0.25 second.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Common rail pressure open loop control is effected. • Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “B4 to B7: Injector Test” are stopped. • Turbocharger control is stopped.
Inspection	Service data	2A: Common Rail Press SNSR Voltage
	Electrical equipment	#319: Common rail pressure sensor
	Electric circuit diagram	Common rail pressure sensor system
	Other	Common rail pressure sensor (Have work performed by Bosch service station.)

P0201: Injector M/V-Cylinder 1 (Load) (warning lamp flashes: 37)

Generation condition		Injector magnetic valve (No. 1 cylinder) circuit shorted, open-circuited or overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Actuator test	B4: Injector Test 1
	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Other	Injector (No. 1 cylinder) (Have work performed by Bosch service station.)

P0202: Injector M/V-Cylinder 2 (Load) (warning lamp flashes: 38)

Generation condition		Injector magnetic valve (No. 2 cylinder) circuit shorted, open-circuited or overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Actuator test	B6: Injector Test 3
	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Other	Injector (No. 2 cylinder) (Have work performed by Bosch service station.)

P0203: Injector M/V-Cylinder 3 (Load) (warning lamp flashes: 39)

Generation condition		Injector magnetic valve (No. 3 cylinder) circuit shorted, open-circuited or overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Actuator test	B7: Injector Test 4
	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Other	Injector (No. 3 cylinder) (Have work performed by Bosch service station.)

P0204: Injector M/V-Cylinder 4 (Load) (warning lamp flashes: 8)

Generation condition		Injector magnetic valve (No. 4 cylinder) circuit shorted, open-circuited or overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Actuator test	B5: Injector Test 2
	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Other	Injector (No. 4 cylinder) (Have work performed by Bosch service station.)

P0219: Engine Overrunning (warning lamp flashes: 7)

Generation condition		Engine speed is higher than specification (4,300 rpm).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Engine is stopped.
Inspection	Electrical equipment	• Check for occurrences of diagnosis code “P0335: Engine Revolution SNSR”. • If the diagnosis code is redisplayed with the pointer of the tachometer not reaching the red zone, replace the engine electronic control unit. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

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

Generation condition		Accelerator pedal position sensor 2 voltage remains less than 0.5 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		[When sensor 2 (incorporated in accelerator pedal position sensor) only malfunctions] • Control by sensor 1 (incorporated in accelerator pedal position) [When both sensors 1 and 2 (incorporated in accelerator pedal position sensor) malfunction] • Accelerator switch ON: Accelerator pedal depressed 30 % of stroke Accelerator switch OFF: Controlled with recognition that accelerator pedal is not pressed. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Intake throttle control is stopped.
Inspection	Service data	41: Accel Pedal Sensor Voltage 2, 42: Accel Pedal Position (unfiltered), 43: Accel Pedal Position (filtered)
	Electronic control unit connector	02 : Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor system

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

Generation condition		Accelerator pedal position sensor 2 voltage remains higher than 4.7 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		[When sensor 2 (incorporated in accelerator pedal position sensor) only malfunctions] • Control by sensor 1 (incorporated in accelerator pedal position) [When both sensors 1 and 2 (incorporated in accelerator pedal position sensor) malfunction] • Accelerator switch ON: Accelerator pedal depressed 30 % of stroke Accelerator switch OFF: Controlled with recognition that accelerator pedal is not pressed. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Intake throttle control is stopped.
Inspection	Service data	41: Accel Pedal Sensor Voltage 2, 42: Accel Pedal Position (unfiltered), 43: Accel Pedal Position (filtered)
	Electronic control unit connector	02 : Accelerator pedal position sensor
	Electrical equipment	#324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor system

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

Generation condition		Abnormal rise in common rail pressure occurs and common rail pressure limiting valve is caused to open.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration valve control is stopped. • Throttle control is stopped.
Inspection	Service data	05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Electrical equipment	#587: MPROP (rail pressure control valve), #582: Injector
	Other	• Air-bleeding of fuel system (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.) • Inspection of fuel piping • Fuel filter • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.) • Injectors (Have work performed by Bosch service station.)

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

Generation condition		Abnormal fall in common rail pressure occurs when common rail pressure limiting valve is open (diagnosis code P0251 occurs).
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Engine is stopped.
Inspection	Service data	05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Electrical equipment	#582: Injector
	Other	• Air-bleeding of fuel system (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.) • Inspection of fuel piping • Fuel filter • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.) • Injectors (Have work performed by Bosch service station.)

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

Generation condition		Abnormal rise in common rail pressure occurs when common rail pressure limiting valve is open (diagnosis code P0251 occurs).
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Engine is stopped.
Inspection	Service data	05: Difference Common Rail Pressure
	Actuator test	B3: Fuel Leak Check
	Other	• Inspection of fuel piping • Fuel filter • Supply pump (Have work performed by Bosch service station.) • Pressure limiting valve (Have work performed by Bosch service station.) • Injectors (Have work performed by Bosch service station.)

P0335: Engine Revolution SNSR (warning lamp flashes: 15)

Generation condition		No engine speed sensor signals are received.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is carried out using cylinder recognition sensors.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	05 : Engine speed sensor
	Electrical equipment	#263: Engine speed sensor
	Electric circuit diagram	Engine speed sensor system

P0339: Engine Revolution SNSR (Plausi) (warning lamp flashes: 15)

Generation condition		Engine speed sensor signal indicates too high speeds (6,000 rpm or higher).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is carried out using cylinder recognition sensors.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	05 : Engine speed sensor
	Electrical equipment	#263: Engine speed sensor
	Electric circuit diagram	Engine speed sensor system

P0340: Camshaft Position SNSR (warning lamp flashes: 12)

Generation condition		No cylinder recognition sensor signals are received.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is carried out using engine speed sensors.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	06 : Cylinder recognition sensor
	Electrical equipment	#320: Cylinder recognition sensor
	Electric circuit diagram	Cylinder recognition sensor system

P0344: Camshaft Position SNSR (Plausi) (warning lamp flashes: 12)

Generation condition		Cylinder recognition sensor signals are irregular (due to too large inconsistency in angular recognition between camshaft and crankshaft).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Control is carried out using engine speed sensors.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	06 : Cylinder recognition sensor
	Electrical equipment	#320: Cylinder recognition sensor
	Electric circuit diagram	Cylinder recognition sensor system

P0500: Vehicle Speed Sensor (warning lamp flashes: 25)

Generation condition		When all the conditions below are applicable. • Engine speed: 1000 rpm or more • Clutch signal OFF • Gears engaged despite transmission neutral signal • Vehicle speed remains less than 2 km/h for 60 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	18: Vehicle Speed
	Electronic control unit connector	07 : Vehicle speed sensor
	Electrical equipment	#265: Vehicle speed sensor
	Electric circuit diagram	Vehicle speed sensor system

P0506: Idle Volume (warning lamp flashes: 52)

Generation condition		Idling speed adjustment potentiometer voltage remains less than 0.7 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.

Control effected by electronic control unit		• When power take-off switch is ON
		  • Accelerator pedal position decided by idling speed adjustment potentiometer is 0 %.
		• When power take-off switch is OFF
		  • Control is effected with auto idle permanently selected.

Inspection	Service data	17: Idle Volume Voltage
	Electronic control unit connector	08 : Idling speed adjustment potentiometer
	Electrical equipment	#157: Idling speed adjustment potentiometer
	Electric circuit diagram	Idling speed adjustment potentiometer system

P0507: Idle Volume (warning lamp flashes: 52)

Generation condition		Idling speed adjustment potentiometer voltage remains higher than 4.6 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.

Control effected by electronic control unit		• When power take-off switch is ON
		  • Accelerator pedal position decided by idling speed adjustment potentiometer is 0 %.
		• When power take-off switch is OFF
		  • Control is effected with auto idle permanently selected.

Inspection	Service data	17: Idle Volume Voltage
	Electronic control unit connector	08 : Idling speed adjustment potentiometer
	Electrical equipment	#157: Idling speed adjustment potentiometer
	Electric circuit diagram	Idling speed adjustment potentiometer system

P0510: Accel SW (warning lamp flashes: 65)

Generation condition		When all the conditions below are applicable. • Multi-Use Tester Service Data “09: Accel Pedal Position (filtered)” exceeds 30 % (Sensor 1 (incorporated in accelerator pedal position sensor) is abnormal). • Accelerator pedal switch input remains ON (accelerator pedal released) for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	09: Accel Pedal Position (filtered), 73: Accel SW
	Electronic control unit connector	09 : Accelerator pedal switch
	Electrical equipment	#324: Accelerator pedal switch (incorporated in accelerator pedal position sensor)
	Electric circuit diagram	Accelerator pedal switch system

P0562: Power Supply Voltage (Low) (warning lamp flashes: 33)

Generation condition		Power voltage of actuator in the electronic control unit remains below the specified limit for 3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Control of engine is stopped.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0563: Power Supply Voltage (High) (warning lamp flashes: 33)

Generation condition		Power voltage of actuator in the electronic control unit remains over the specified limit for 3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Control of engine is stopped.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0605: ECU System (Hardware) (warning lamp flashes: 33)

Generation condition		Some error has occurred in reading or writing process.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		No particular control takes place.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0607: ECU system (warning lamp flashes: 33)

Generation condition		Diagnosis code is generated under either of the following conditions. • Power supply to injector driving IC in the electronic control unit is abnormal. • Injector driving IC or timer IC in the electronic control unit is abnormal. • Power voltage monitoring circuit in the electronic control unit malfunctions.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Engine is stopped.
Inspection	Other	Replace engine electronic unit (See “ON-VEHICLE INSPECTION AND ADJUST-MENT”.)

P060B: A/D Converter (warning lamp flashes: 33)

Generation condition		Unit (A/D converter) in electronic control unit is abnormal.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Engine is stopped.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P061B: ECU Performance (Calc) (warning lamp flashes: 33)

Generation condition		Abnormal condition has occurred in arithmetic processing inside engine electronic control unit.
Recoverability		System recovers if any valid signal is input with starter switch in ON position.
Control effected by electronic control unit		No particular control takes place.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P061C: ECU Performance (Ne) (warning lamp flashes: 33)

Generation condition		Abnormal condition has occurred in engine speed processing inside engine electronic control unit.
Recoverability		System recovers if any valid signal is input with starter switch in ON position.
Control effected by electronic control unit		No particular control takes place.
Inspection	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P062D: Injector Bank 1 (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 1 and No. 4 cylinders) has stopped functioning temporarily.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 1 and No. 4 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B4 to B7: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (for No. 1 cylinder) or (for cylinder No. 4)
	Other	Injector (Have work performed by Bosch service station.)

P062E: Injector Bank 2 (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 2 and No. 3 cylinders) has stopped functioning temporarily.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 2 and No. 3 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B4 to B7: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (for No. 2 cylinder) or (for cylinder No. 3)
	Other	Injector (Have work performed by Bosch service station.)

P0642: Sensor Supply Voltage 1 (Low) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 1) is lower than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	0A: Accel Pedal Sensor Voltage 1, 17: Idle Volume Voltage
	Electronic control unit connector	02 : Accelerator pedal position sensor, 08 : Idling speed adjustment potentiometer
	Electrical equipment	#157: Idling speed adjustment potentiometer, #324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor (sensor 1), Idling speed adjustment potentiometer system
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0643: Sensor Supply Voltage 1 (High) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 1) is higher than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	0A: Accel Pedal Sensor Voltage 1, 17: Idle Volume Voltage.
	Electronic control unit connector	02 : Accelerator pedal position sensor, 08 : Idling speed adjustment potentiometer
	Electrical equipment	#157: Idling speed adjustment potentiometer, #324: Accelerator pedal position sensor
	Electric circuit diagram	Accelerator pedal position sensor (sensor 1), Idling speed adjustment potentiometer system
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0652: Sensor Supply Voltage 2 (Low) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 2) is lower than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	0B: Accel Pedal Sensor Voltage 2, 24: Boost Press SNSR Voltage, 2B: Exhaust gas pressure
	Electronic control unit connector	02 : Accelerator pedal position sensor, 18 : Diesel particulate filter absolute pressure sensor
	Electrical equipment	#318: Boost pressure sensor, #324: Accelerator pedal position sensor, #334: Diesel particulate filter absolute pressure sensor
	Electric circuit diagram	Boost pressure sensor, Accelerator pedal position sensor (sensor 2), Diesel particulate filter absolute pressure sensor system
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0653: Sensor Supply Voltage 2 (High) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 2) is higher than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	0B: Accel pedal Sensor Voltage 2, 24: Boost Press SNSR Voltage, 2B: Exhaust gas pressure
	Electronic control unit connector	02 : Accelerator pedal position sensor, 18 : Diesel particulate filter absolute pressure sensor
	Electrical equipment	#318: Boost pressure sensor, #324: Accelerator pedal position sensor, #334: Diesel particulate filter absolute pressure sensor
	Electric circuit diagram	Boost pressure sensor, Accelerator pedal position sensor (sensor 2), Diesel particulate filter absolute pressure sensor system
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0657: M/V Voltage (Low) (warning lamp flashes: 79)

Generation condition		Magnetic valve power supply remains low for 0.5 second.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		No specific control is effected (Failure occurs owing to abnormality of injector circuit).
Inspection	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector system

P0698: Sensor Supply Voltage 3 (Low) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 3) is lower than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	05: Difference Common Rail Pressure, 1B: PTO Accel Sensor Voltage, 2A: Common Rail Press SNSR Voltage
	Electronic control unit connector	15 : Power take-off load sensor, 17 : Diesel particulate filter differential pressure sensor
	Electrical equipment	#317: Power take-off load sensor, #319: Common rail pressure sensor, #334: Diesel particulate filter differential pressure sensor
	Electric circuit diagram	Power take-off load sensor, Common rail pressure sensor, Diesel particulate filter differential pressure sensor system.
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P0699: Sensor Supply Voltage 3 (High) (warning lamp flashes: 81)

Generation condition		Engine electronic control unit internal voltage (sensor supply voltage 3) is higher than specification.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	05: Difference Common Rail Pressure, 1B: PTO Accel Sensor Voltage, 2A: Common Rail Press SNSR Voltage
	Electronic control unit connector	15 : Power take-off load sensor, 17 : Diesel particulate filter differential pressure sensor
	Electrical equipment	#317: Power take-off load sensor, #319: Common rail pressure sensor, #334: Diesel particulate filter differential pressure sensor
	Electric circuit diagram	Power take-off load sensor, Common rail pressure sensor, Diesel particulate filter differential pressure sensor system.
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

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

Generation condition		Voltage of fuel injection rate adjustment resistor remains less than 0.2 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Control is made using a backup value (No. 1).
Inspection	Service data	19: Q Adjustment Resistor No.
	Electronic control unit connector	10 : Fuel injection rate adjustment resistor
	Electrical equipment	#828: Fuel injection rate adjustment resistor
	Electric circuit diagram	Fuel injection rate adjustment resistor system

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

Generation condition		Voltage of fuel injection rate adjustment resistor remains higher than 4.8 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Control is made using a backup value (No. 1).
Inspection	Service data	19: Q Adjustment Resistor No.
	Electronic control unit connector	10 : Fuel injection rate adjustment resistor
	Electrical equipment	#828: Fuel injection rate adjustment resistor
	Electric circuit diagram	Fuel injection rate adjustment resistor system

P1466: Auxiliary Brake M/V 2 (Plausi) (warning lamp flashes: 94)

Generation condition		Exhaust shutter 3-way magnetic valve 2 is abnormal. (Errors unrecognizable by engine-electronic control unit are detected.)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	84: Exhaust Brake M/V 2
	Actuator test	A7: Auxiliary Brake M/V 2
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 2 system

P1467: Auxiliary Brake M/V 2 (Low) (warning lamp flashes: 94)

Generation condition		Exhaust shutter 3-way magnetic valve 2 circuit is shorted to ground.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	84: Exhaust Brake M/V 2
	Actuator test	A7: Auxiliary Brake M/V 2
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 2 system

P1468: Auxiliary Brake M/V 2 (High) (warning lamp flashes: 94)

Generation condition		Exhaust shutter 3-way magnetic valve 2 circuit is shorted to power supply.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	84: Exhaust Brake M/V 2
	Actuator test	A7: Auxiliary Brake M/V 2
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 2 system

P1577: Segment Sensor Supply Voltage (warning lamp flashes: 81)

Generation condition		Cylinder recognition sensor voltage remains less than 0 V for 20 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	06 : Cylinder recognition sensor
	Electrical equipment	Cylinder recognition sensor
	Electric circuit diagram	Cylinder recognition sensor system

P1578: Segment Sensor Supply Voltage (warning lamp flashes: 81)

Generation condition		Cylinder recognition sensor voltage remains higher than 5 V for 20 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	01: Engine Revolution
	Electronic control unit connector	06 : Cylinder recognition sensor
	Electrical equipment	Cylinder recognition sensor
	Electric circuit diagram	Cylinder recognition sensor system

P2146: Injector Bank 1 (Plausibility) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 1 and No. 4 cylinder) circuit open-circuited.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 1 and No. 4 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 1 cylinder) or (No. 4 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2147: Injector Bank 1 (Low) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 1 and No. 4 cylinder) circuit shorted to ground.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 1 and No. 4 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 1 cylinder) or (No. 4 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2148: Injector Bank 1 (High) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 1 and No. 4 cylinder) circuit shorted to power supply.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 1 and No. 4 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 1 cylinder) or (No. 4 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2149: Injector Bank 2 (Plausibility) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 2 and No. 3 cylinder) circuit open-circuited.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 2 and No. 3 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 2 cylinder) or (No. 3 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2150: Injector Bank 2 (Low) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 2 and No. 3 cylinder) circuit shorted to ground.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 2 and No. 3 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 2 cylinder) or (No. 3 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2151: Injector Bank 2 (High) (warning lamp flashes: 82)

Generation condition		Injector magnetic valve (for No. 2 and No. 3 cylinder) circuit shorted to power supply.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injector (for No. 2 and No. 3 cylinders) is stopped. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A5: VGT” is stopped. • Actuator tests “B3 to B6: Injector Test” are stopped.
Inspection	Electronic control unit connector	04 : Injector
	Electrical equipment	#582: Injector
	Electric circuit diagram	Injector (No. 2 cylinder) or (No. 3 cylinder) system
	Other	Injector (Have work performed by Bosch service station.)

P2169: Exhaust Valve Act (Open) (warning lamp flashes: 93)

Generation condition		Exhaust shutter 3-way magnetic valve 1 circuit is opened or overloaded.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	83: Exhaust Brake M/V 1
	Actuator test	A6: Auxiliary Brake M/V 1
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 1 system

P2170: Exhaust Valve Act (Gnd) (warning lamp flashes: 93)

Generation condition		Exhaust shutter 3-way magnetic valve 1 circuit is shorted to ground.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	83: Exhaust Brake M/V 1
	Actuator test	A6: Auxiliary Brake M/V 1
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 1 system

P2171: Exhaust Valve Act (Batt) (warning lamp flashes: 93)

Generation condition		Exhaust shutter 3-way magnetic valve 1 circuit is shorted to power supply.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Control of auxiliary brake is deactivated. • DPF regeneration control is stopped.
Inspection	Service data	83: Exhaust Brake M/V 1
	Actuator test	A6: Auxiliary Brake M/V 1
	Electronic control unit connector	12 : Exhaust shutter 3-way magnetic valve
	Electrical equipment	#565: Exhaust shutter 3-way magnetic valve
	Electric circuit diagram	Exhaust shutter 3-way magnetic valve 1 system

P2228: Atm Press SNSR (Low) (warning lamp flashes: 19)

Generation condition		Voltage of atmospheric pressure sensor (inside engine electronic control unit) remains less than 2 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (101.3 kPa) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	15: Atmospheric Pressure
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P2229: Atm Press SNSR (High) (warning lamp flashes: 19)

Generation condition		Voltage of atmospheric pressure sensor (inside engine electronic control unit) remains higher than 4.7 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (101.3 kPa) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	15: Atmospheric Pressure
	Other	Replace engine electronic control unit (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

P253C: PTO Acc (Low) (warning lamp flashes: 61)

Generation condition		When all the conditions below are applicable. • Power take-off switch: ON • Power take-off load sensor voltage remains less than 0.5 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Lever position during power take-off operation is fixed at 0 %.
Inspection	Service data	1A: PTO Accel Position, 1B: PTO Accel Sensor Voltage
	Electronic control unit connector	15 : Power take-off load sensor
	Electrical equipment	#317: Power take-off load sensor
	Electric circuit diagram	Power take-off load sensor system

P253D: PTO Acc (High) (warning lamp flashes: 61)

Generation condition		When all the conditions below are applicable. • Power take-off switch: ON • Power take-off load sensor voltage remains higher than 3.5 V for 1 second.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Lever position during power take-off operation is fixed at 0 %.
Inspection	Service data	1A: PTO Accel Position, 1B: PTO Accel Sensor Voltage
	Electronic control unit connector	15 : Power take-off load sensor
	Electrical equipment	#317: Power take-off load sensor
	Electric circuit diagram	Power take-off load sensor system

P254C: PTO Ne (Low) (warning lamp flashes: 62)

Generation condition		When all the conditions below are applicable. • Power take-off switch: ON • Power take-off resistor voltage remains less than 0.2 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Resistance of power take-off resistor is fixed at 0 Ω
Inspection	Service data	1C: PTO Adjustment Resistor No.
	Electronic control unit connector	16 : Power take-off resistor
	Electrical equipment	#828: Power take-off resistor
	Electric circuit diagram	Power take-off resistor system

P254D: PTO Ne (High) (warning lamp flashes: 62)

Generation condition		When all the conditions below are applicable. • Power take-off switch: ON • Power take-off resistor voltage remains higher than 4.8 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Resistance of power take-off resistor is fixed at 0 Ω
Inspection	Service data	1C: PTO Adjustment Resistor No.
	Electronic control unit connector	16 : Power take-off resistor
	Electrical equipment	#828: Power take-off resistor
	Electric circuit diagram	Power take-off resistor system

P2670: MPROP Voltage (Low) (warning lamp flashes: 36)

Generation condition		MPROP (rail pressure control valve) power supply is low.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration control is stopped. • Throttle control is stopped.
Inspection	Electronic control unit connector	12 : MPROP (rail pressure control valve)
	Electrical equipment	#574: MPROP (rail pressure control valve)
	Electric circuit diagram	MPROP (rail pressure control valve) system
	Other	• MPROP (rail pressure control valve) (Have work performed by Bosch service station.) • Supply pump (Have work performed by Bosch service station.)

U0001: CAN No Data Received (warning lamp flashes: 95)

Generation condition		Transmission of controller area network signal from engine-electronic control unit is faulty (abnormality in controller area network communication)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Electronic control unit connector	14 : Controller area network resistor
	Electrical equipment	#828: Controller area network resistor (Turbocharger electronic drive unit connection side)
	Electric circuit diagram	Controller area network resistor system (Turbocharger electronic drive unit connection side)

U0073: CAN Communication Bus Off (warning lamp flashes: 95)

Generation condition		Engine-electronic control unit detects abnormality in controller area network communication (Controller area network signal transmission or reception fail more than specified times) ※ Diagnosis code P1632, P1635 or P1645 may occur simultaneously (if these diagnosis codes occur at the same time, possibility is high that harness somewhere near engine electronic control unit is faulty)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Transmission of controller area network signal stopped • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Electronic control unit connector	14 : Controller area network resistor
	Electrical equipment	#828: Controller area network resistor (Turbocharger electronic drive unit connection side)
	Electric circuit diagram	Controller area network resistor system (Turbocharger electronic drive unit connection side)

4. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
01	Engine Revolution	■■■■.rpm	Racing (engine running)	Value corresponds to tachometer indication.
02	Reference Injection Quantity	■■■.■ %	Engine is stopped. (Starter switch in ON position)	Fuel injection quantity necessary for engine start is indicated (variable according to coolant temperature)
03	Reference Common Rail Pressure	■■■. ■ %	Engine is stopped (Starter switch in ON position)	Target common rail pressure necessary for engine start is indicated
04	Actual Common Rail Pressure	■■■. ■ %	Engine is stopped (Starter switch in ON position)	Common rail pressure necessary for engine start is indicated
05	Difference Common Rail Pressure	■■■. ■ %	Idling	0 %
06	EGR Position	■■■.■ %	See Gr17.	–
07	Intake Throttle Position	■■■.■ %	See Gr17.	–
08	Accel Pedal Position (unfiltered)	■■■.■ %	Accelerator pedal not pressed	0 %
			Accelerator pedal gradually pressed	Value gradually increases.
			Accelerator pedal fully pressed	100 %
09	Accel Pedal Position (filtered)	■■■.■ %	Accelerator pedal not pressed	0 %
			Accelerator pedal gradually pressed	Value gradually increases.
			Accelerator pedal fully pressed	100 %
0A	Accel Pedal Sensor Voltage 1	■.■■■ V	Accelerator pedal gradually pressed from released position	0.85 to 4.15 V
0B	Accel Pedal Sensor Voltage 2	■.■■■ V	Accelerator pedal gradually pressed from released position	0.85 to 4.15 V
0C	Boost Pressure	■■■.■ kPa	See Gr15.	–
0D	Intake Air Temperature 1	■■■.■ °C	When vehicle is running	Equal to ambient temperature or ambient temperature + 50°C
0E	Intake Air Temperature 2	■■■.■ °C	See Gr17.	–
0F	Exhaust gas temperature 1	■■■■.°C	See Gr15.	–
10	Exhaust gas temperature 2	■■■■.°C	See Gr15.	–
11	Difference pressure across DPF	■■■. ■kPa	See Gr15.	–
12	Exhaust gas pressure	■■■. ■kPa	See Gr15.	–
13	Water Temperature	■■■.■ °C	Engine cold	Value corresponds to ambient temperature.
			Engine in process of warming up	Value gradually increases.
			Engine stopped after warming up	Value gradually decreases.
14	Fuel Temperature (inlet)	■■■.■ °C	Engine cold	Value corresponds to ambient temperature.
			Engine in process of warming up	Value gradually increases.
			Engine stopped after warming up	Value gradually decreases.
15	Atmospheric Pressure	■■■.■ kPa	Altitude: 0 m	101 kPa
			Altitude: 600 m	95 kPa
16	Air mass flow	■■■.■ g/s	See Gr17.	–
17	Idle Volume Voltage	■.■■■ V	AUTO (0°)	4.0 ± 0.1 V
			SLOW (30°)	3.0 ± 0.2 V
			FAST (300°)	1.0 ± 0.1 V
			Without idle speed adjustment potentiometer	4.0 ± 0.1 V
18	Vehicle Speed	■■■■.km/h	Vehicle in motion	Value corresponds to speedometer indication.

No.	Item	Data	Inspection condition	Requirement
19	Q Adjustment Resistor No. (Part name: Fuel injection rate adjustment resistor)	1/2/3/4/5/6/7/8/9/10/ 11/NON	–	Number matches number marked on fuel injection rate adjustment resistor.
1A	PTO Accel Position	■■■. ■ %	Power take-off is operated (MIN-MAX)	0 to 100 %
1B	PTO Accel Sensor Voltage	■. ■■■V	Power take-off is operated (MIN-MAX)	1.0 to 3.0 V
1C	PTO Adjustment Resistor No.	1/2/3/4/5/6/7/8/9/10/ 11/NON	–	Number matches number maked on power take-off resistor.
1D	Power Supply Voltage	■■.■■ V	Starter switch ON	Value matches battery voltage.
1E	Exhaust Gas Flow	■■■■.m³/h	See Gr15.	–
21	Catalyst Temp SNSR	■■■■.°C	See Gr15.	–
22	VGT Position	■■■.■ %	See Gr15.	–
23	Atmospheric Press SNSR Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply.	approx. 5000 mV
			Sensor circuit shorted to ground.	approx. 0 mV
24	Boost Press SNSR Voltage	■■■. ■mV	See Gr15.	–
25	Water Temp SNSR Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	approx. 5000 mV
			Sensor circuit shorted to ground	approx. 0 mV
26	Fuel Temp SNSR Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	approx. 5000 mV
			Sensor circuit shorted to ground	approx. 0 mV
27	Intake Air Temp SNSR2 Voltage	■■■. ■mV	See Gr17.	–
28	Intake Air Temp SNSR1 Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	approx. 5000 mV
			Sensor circuit shorted to ground	approx. 0 mV
29	Catalyst Temp SNSR Voltage	■■■. ■mV	See Gr15.	–
2A	Common Rail Press SNSR Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	approx. 5000 mV
			Sensor circuit shorted to ground	approx. 0 mV
2B	Exhaust gas pressure	■■■. ■mV	See Gr15.	–
2C	Exhaust gas temp SNSR1 Voltage	■■■. ■mV	See Gr15.	–
2D	Exhaust gas temp SNSR2 Voltage	■■■. ■mV	See Gr15.	–
71	Starter SW (S)	ON/OFF	Engine cranked by means of starter switch.	ON
			Starter switch in position except START	OFF
72	Starter SW (M)	ON/OFF	Starter switch in ON position	ON
			Starter switch in position except ON	OFF
73	Accel SW	ON/OFF	Accelerator pedal not pressed	ON
			Accelerator pedal pressed	OFF
74	DPF SW	ON/OFF	See Gr15.	–
75	Auxiliary Brake SW (Part name: Exhaust brake switch)	ON/OFF	Combination switch ON	ON
			Combination switch OFF	OFF
77	Clutch SW (INOMAT)	ON/OFF	Clutch pedal not pressed	ON
			Clutch pedal pressed	OFF
78	Neutral SW	ON/OFF	Gear shift lever in position except N	ON
			Gear shift lever in N position	OFF
79	Idle Up Cancel SW	ON/OFF	Gear shift lever in position except N	ON
			Gear shift lever in N position	OFF
7A	Air conditioner SW 1	ON/OFF	Air conditioner compressor running	ON
			Air conditioner compressor not running	OFF
			[Actuator test] B0: Air Conditioner SW	

No.	Item	Data	Inspection condition	Requirement
7B	Idle Up Signal	ON/OFF	Lighting switch ON	ON
			Lighting switch OFF	OFF
7E	PTO SW	ON/OFF	Switch ON	ON
			Switch OFF	OFF
7F	Diagnosis SW	ON/OFF	Diagnosis switch ON (fuse fitted)	ON
			Diagnosis switch OFF (fuse removed)	OFF
80	Memory Clear	ON/OFF	Memory clear switch ON (fuse fitted)	ON
			Memory clear switch OFF (fuse removed)	OFF
81	Parking Break SW	ON/OFF	Vehicle parked	ON
			Vehicle in motion	OFF
83	Exhaust Brake M/V 1	ON/OFF	Exhaust shutter 3-way magnetic valve ON	ON
			Exhaust shutter 3-way magnetic valve OFF	OFF
			[Actuator test] A6: Auxiliary Brake M/V 1	
84	Exhaust Brake M/V 2	ON/OFF	Exhaust shutter 3-way magnetic valve 2 ON	ON
			Exhaust shutter 3-way magnetic valve 2 OFF	OFF
			[Actuator test] A7: Auxiliary Brake M/V 2	
85	Auxiliary Brake Indicator Lamp	ON/OFF	Exhaust shutter 3-way magnetic valve ON	ON
			Exhaust shutter 3-way magnetic valve OFF	OFF
			[Actuator test] A8: Auxiliary Brake Indicator Lamp	
86	Glow Relay	ON/OFF	See Gr54.	–
87	Glow Relay Indicator Lamp	ON/OFF	See Gr54.	–
88	Starter Safety Relay	ON/OFF	See Gr54.	–
89	EDU Power Relay	ON/OFF	See Gr15, 17.	–
8A	MIL Lamp	ON/OFF	Starter switch ON (engine not started)	ON
			No error after engine startup	OFF
			[Actuator test] AD: MIL Lamp	
8B	Diagnosis Lamp	ON/OFF	Starter switch ON (engine not started)	ON
			No error after engine startup	OFF
			[Actuator test] AE: Diagnosis Lamp	
8C	DPF Indicator Lamp	ON/OFF	See Gr15.	–

5. Actuator Tests Performed Using Multi-Use Tester

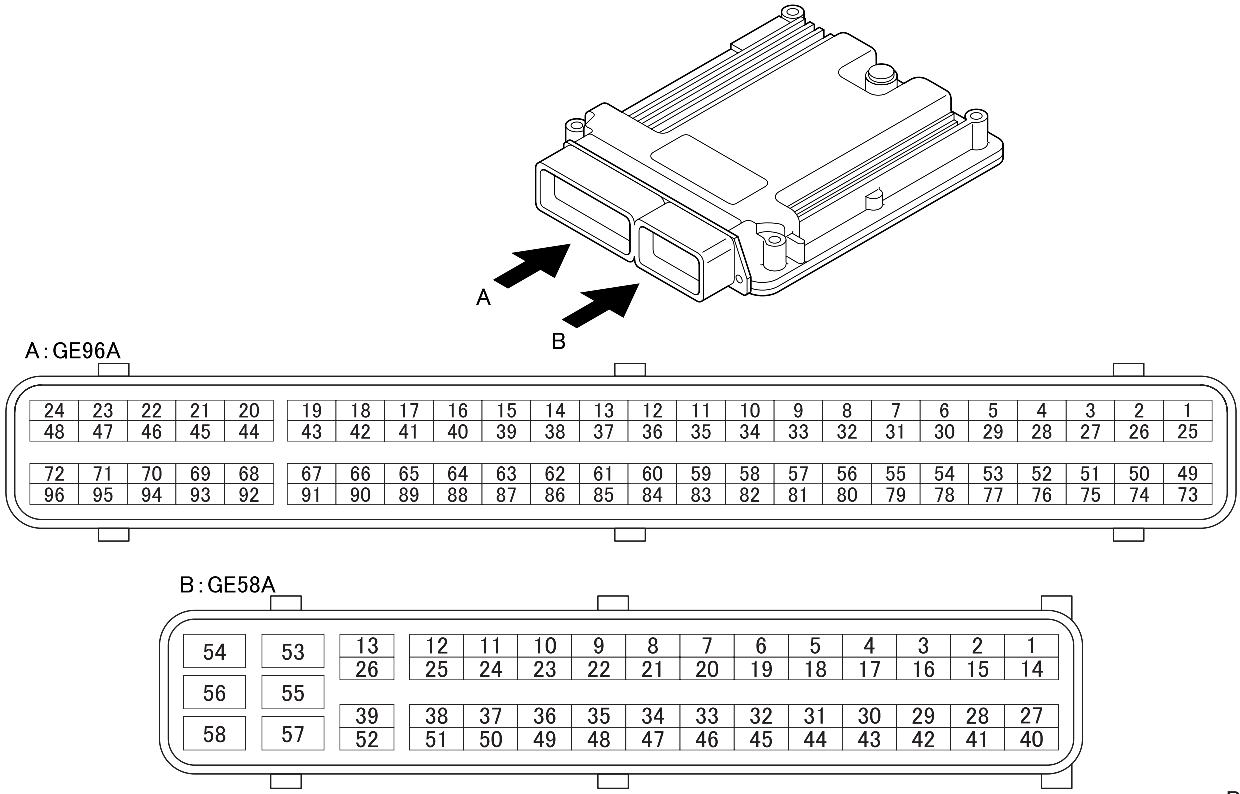
- It is possible to see service data and actuator tests simultaneously.

No.	Item	Explanation	Confirmation method
A1	EGR	See Gr17.	–
A2	DPF Regeneration	See Gr15.	–
A4	Intake Throttle 1	See Gr17.	–
A5	VGT	See Gr15.	–
A6	Auxiliary Brake M/V 1 (Part name: Exhaust shutter 3-way magnetic valve)	Exhaust shutter 3-way magnetic valve 1 drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON • Engine: stopped	Operating sound of magnetic valve [Service data] 83: Exhaust Brake M/V 1
A7	Auxiliary Brake M/V 2 (Part name: Exhaust shutter 3-way magnetic valve)	Exhaust shutter 3-way magnetic valve 2 drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON • Engine: stopped	Operating sound of magnetic valve [Service data] 84: Exhaust Brake M/V 2
A8	Auxiliary Brake Indicator Lamp	Exhaust brake indicator lamp drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON • Engine: stopped	ON/OFF condition of indicator lamp [Service data] 85: Auxiliary Brake Indicator Lamp
A9	Relay for Glow Relay	See Gr54.	–
AA	Glow Indicator Lamp	See Gr54.	–
AB	Starter Safety Relay	See Gr54.	–
AC	EDU Relay	See Gr15, 17.	–
AD	MIL Lamp	Engine warning lamp (orange) drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Transmission: Neutral • Engine: stopped	ON/OFF condition of warning lamp (orange) [Service data] 8A: MIL Lamp
AE	Diagnosis Lamp	Engine warning lamp (red) drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Transmission: Neutral • Engine: stopped	ON/OFF condition of warning lamp (red) [Service data] 8B: Diagnosis Lamp
AF	DPF Indicator Lamp	See Gr15.	–
B0	Air Conditioner SW	Air Conditioner drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON • Engine: Idling	ON/OFF condition of air conditioner [Service data] 7A: Air Conditioner SW
B1	Idle Up Cancel SW	Idle up cancel drive signal [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON • Engine: stopped	ON/OFF condition of idle up cancel signal [Service data] 79: Idle Up Cancel SW
B2	Fuel Leak Check	Rail pressure increased on a constant slope (for 6 seconds) [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Transmission: Neutral • Diagnosis switch: OFF (with fuse removed)	Check that no fuel leaks from fuel system.
B3	Injector Test 1	Selected injector magnetic valve forcibly deactivated [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Engine speed: Below 1500 rpm • Transmission: Neutral • No active diagnosis code generated	Check that injector magnet valve for No. 1 cylinder stops operating.
B4	Injector Test 2		Check that injector magnet valve for No. 4 cylinder stops operating.
B5	Injector Test 3		Check that injector magnet valve for No. 2 cylinder stops operating.
B6	Injector Test 4		Check that injector magnet valve for No. 3 cylinder stops operating.

6. Inspections Performed at Electronic Control Unit Connectors

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

6.1 Electronic control unit connector terminal layout



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6.2 Inspection instructions

- Some inspections are performed with the connectors removed. Others are performed with the connectors fitted.

CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

Check item	Measurement method
01 Resistance of water temperature sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A40-A41 • 20°C: 2.45 ± 0.14 kΩ • 80°C: 0.32 kΩ (reference value) • 110°C: 141.7 ± 2 Ω
02 Output voltage of accelerator pedal position sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–) B34-B33 and B45 (accelerator pedal position sensor 1) B46-B33 and B45 (accelerator pedal position sensor 2) • With accelerator pedal not pressed: 0.85 ± 0.1 V • With accelerator pedal pressed: 4.15 ± 0.1 V
03 Resistance of fuel temperature sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A89-A65 • 20°C: $2.45^{+0.14}_{-0.13}$ kΩ • 80°C: 0.318 ± 0.008 kΩ • 110°C: 0.1417 ± 0.0018 kΩ
04 Resistance of injector magnetic valve	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A72-A23 (injector magnetic valve: No. 1 cylinder) A96-A24 (injector magnetic valve: No. 2 cylinder) A71-A46 (injector magnetic valve: No. 3 cylinder) A95-A48 (injector magnetic valve: No. 4 cylinder) • 0.255 ± 0.04 Ω
05 Resistance of engine speed sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A10-A9 • 860 ± 86 Ω (20°C)
06 Resistance of cylinder recognition sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A78-A83 (+5 V to GND) • 200 to 1,800 Ω
07 Output voltage of vehicle speed sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) • Turn wheels slowly using chassis dynamometer. [Requirements] Terminals (+)-(–): A67-chassis ground • High pulse voltage: Approx. 8 ± 1 V • Low pulse voltage: 0.5 V or lower
08 Output voltage of idling speed adjustment potentiometer	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): A12-A36 • AUTO position: 4.0 ± 0.1 V • SLOW position: 3.0 ± 0.1 V • FAST position: 1.0 ± 0.1 V

Check item	Measurement method
09 Operating voltage of accelerator pedal switch	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): A20-B33 and B45 • With accelerator pedal pressed: 0 V • With accelerator pedal not pressed: 5 V
10 Resistance of fuel injection rate adjustment resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A35-A88 • No. 1 resistor: 270 ± 13.5 Ω • No. 2 resistor: 510 ± 25.5 Ω • No. 3 resistor: 820 ± 41 Ω • No. 4 resistor: 1,300 ± 65 Ω • No. 5 resistor: 2,000 ± 100 Ω • No. 6 resistor: 3,300 ± 165 Ω • No. 7 resistor: 5,600 ± 280 Ω • No. 8 resistor: 15,000 ± 750 Ω • No. 9 resistor: 390 ± 19.5 Ω • No. 10 resistor: 4,300 ± 215 Ω • No. 11 resistor: 9,100 ± 455 Ω
11 Resistance of MPROP (rail pressure control valve)	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A69-A21, A69-A2, A3-A21, A3-A2 • 2.6 to 3.15 Ω
12 Voltage of exhaust shutter 3-way magnetic valve	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): exhaust shutter 3-way magnetic valve 1 (A76-A6) exhaust shutter 3-way magnetic valve 2 (B21-B26) • With exhaust brake operating: Corresponding to battery voltage • With exhaust brake not operating: 0 V
13 Resistance of intake air temperature sensor 1	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A63-A32 • 0°C: $15^{+3.78}_{-2.94}$ kΩ • 20°C: $6.514^{+1.437}_{-1.147}$ kΩ • 80°C: $0.874^{+0.136}_{-0.115}$ kΩ
14 Resistance of controller area network resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B5-B6 • 120 ± 6 Ω
15 Output voltage of power take-off load sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): A15-A16 • Idling: 0.85 ± 0.1 V • Full load: 3.0 ± 0.1 V

16 Resistance of power take-off resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A35-A88 • No. 1 resistor: 270 ± 13.5 Ω • No. 2 resistor: 510 ± 25.5 Ω • No. 3 resistor: 820 ± 41 Ω • No. 4 resistor: 1,300 ± 65 Ω • No. 5 resistor: 2,000 ± 100 Ω • No. 6 resistor: 3,300 ± 165 Ω • No. 7 resistor: 5,600 ± 280 Ω • No. 8 resistor: 15,000 ± 750 Ω • No. 9 resistor: 390 ± 19.5 Ω • No. 10 resistor: 4,300 ± 215 Ω • No. 11 resistor: 9,100 ± 455 Ω
17 Voltage of diesel particulate filter differential pressure sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] <Power supply voltage> Terminals (+)-(–): A61-A85 • 5 V <Output voltage> Terminals (+)-(–): A84-A85 • 1 to 4.5 V
18 Voltage of diesel particulate filter absolute pressure sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] <Power supply voltage> Terminals (+)-(–): A60-A42 • 5 V <Output voltage> Terminals (+)-(–): A8-A42 • 1.875 to 4.5 V

1. Inspecting and Adjusting No-load Minimum and Maximum Speeds

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
–	Minimum no-load speed (idling speed)	600 ± 25 rpm	–	Inspect
–	Maximum no-load speed	3700 rpm	–	Inspect

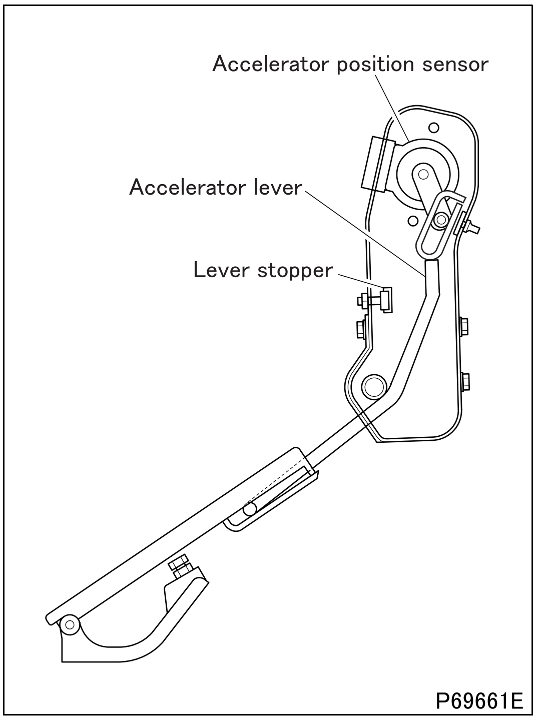
[Work before inspection]

- Before starting the inspection and adjustment, carry out the following preparatory steps:
- Warm up the engine until the engine coolant temperature is approximately 80 to 95°C; (Check by Multi-Use Tester service data “13: Water temperature”.)
- Turn off all lamps and accessories;
- Place the transmission shift lever into the N position;
- Set the steering wheel at the straight-ahead position; and
- Attach a tachometer.

[Inspection]

(1) No-load minimum speed

- Without pressing the accelerator pedal, measure the engine speed.
- If the measurement is not within the standard value range, inspect the accelerator position sensor. (See “ENGINE CONTROL”.)
- If no defects are evident during the above inspection, check diagnosis code from engine-electronic control unit or fuel system.



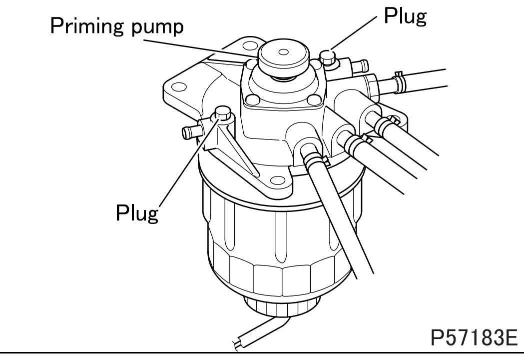
(2) No-load maximum speed

- Press the accelerator pedal as far as it will go.
- With the accelerator pedal touching the lever stopper, measure the engine speed.
- If the measurement is not within the standard value range, inspect the accelerator position sensor. (See “ACCELERATOR PEDAL”.)
- If no defects are evident during the above inspection, check diagnosis code from engine-electronic control unit or fuel system.

2. Air-bleeding of Fuel System

Tightening torque (Unit: N·m {kgf·m})

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



- Loosen one of the air vent plugs on the fuel filter.
- Move the priming pump up and down to pump out the fuel.
- Continue operating the priming pump until the fuel flowing out of the plug is free of air bubbles.
- When no more air bubbles are evident, tighten the air vent plug to the specified torque.
- Feed the fuel some more by operating the priming pump further until a strong resistance is felt.
- When the fuel temperature is low, you may not feel the resistance. Be sure to operate the priming pump several times even in such a case.
- Wipe up any spilled fuel and start the engine.
- Check that there is no fuel leakage.

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **To avoid risk of fire, wipe up any spilled fuel.**

3. Fuel Filter Replacement

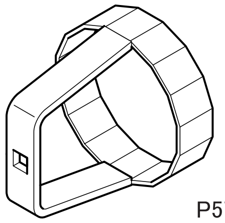
Tightening torque (Unit: N·m {kgf·m})

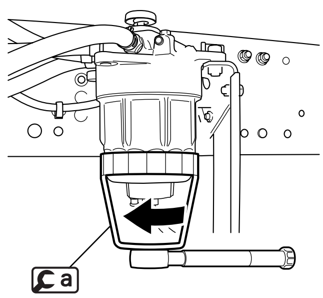
Mark	Parts to be tightened	Tightening torque	Remarks
–	Water separator sensor	5 ± 1 {0.5 ± 0.1}	–
–	Case	30 ± 2 {3.1 ± 0.2}	–

Lubricant and/or sealant

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

Special tools

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



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[Removal]

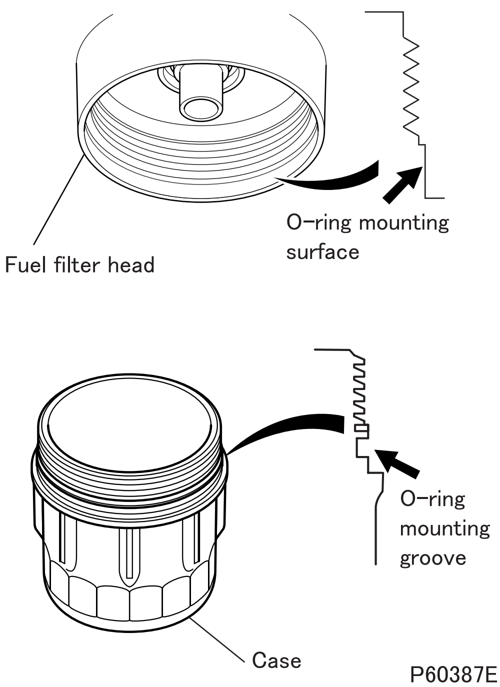
- Loosen the water separator sensor and drain fuel from the case.
- Remove the case using a.

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **To avoid risk of fire, wipe up any spilled fuel.**

CAUTION ⚠

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



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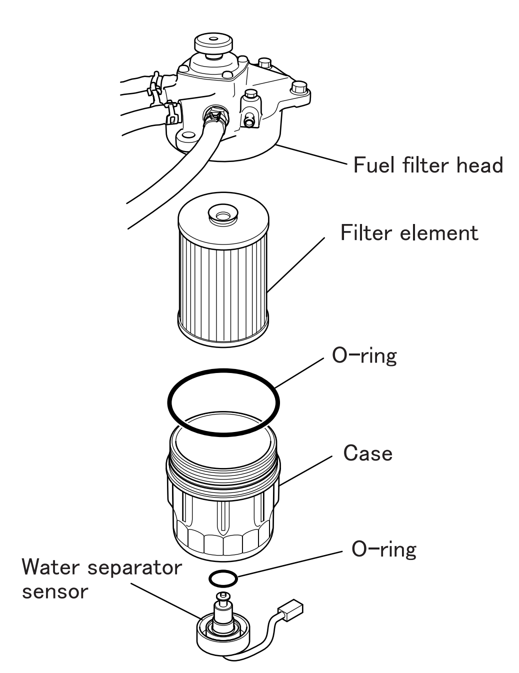
[Installation]

- Clean the O-ring mounting surface of the fuel filter head and the O-ring groove of the case.

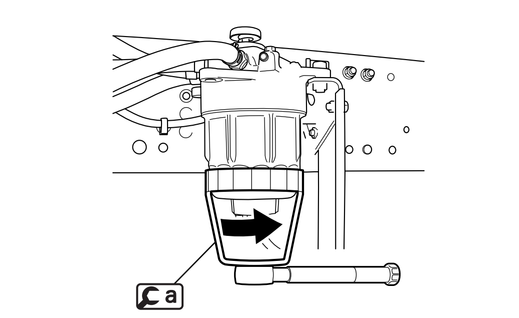


P57199E

- Replace the filter element and O-ring with new one.
- Apply a thin coat of engine oil to the O-ring, and install it on the case and water separator sensor.

CAUTION ⚠

- **Be sure to use only genuine MITSUBISHI filter elements. The use of non-genuine fuel filters can cause engine failure.**
- **Prevent fine dust particles from entering the fuel filter and fuel hose, as they can cause problems such as faulty fuel injection.**

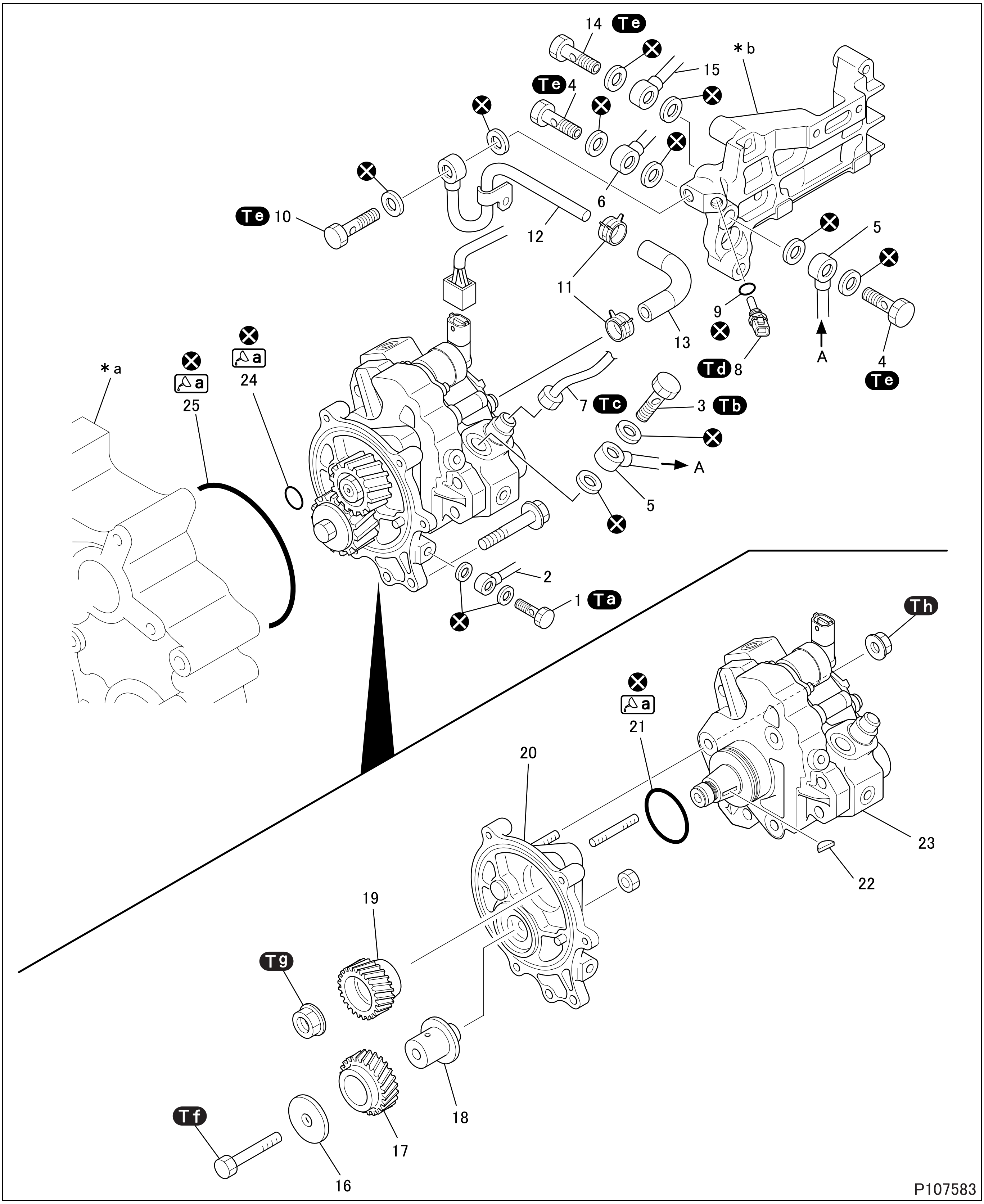


P57200

- Use a to tighten the case to the specified torque.
- Install the water separator sensor, and then air-bleed the fuel system.
- Start the engine, and check that there is no fuel leakage.
- Reinstall the fuel filter if there is any leakage.

4. Registration of Vehicle Identification Number (VIN)

- A vehicle identification number (VIN) must be written (registered) to the engine electronic control unit after:
  - The current engine electronic control unit is replaced with a new one.
  - The current engine electronic control unit is replaced with one that has been used on another vehicle.
- For the details of the replace work, consult your nearest MITSUBISHI FUSO distributor or dealer.



14 Te
*b
15
Te 4
6
Te 10
12
11
13
9
Td 8
5
4
Te
A
*a
25
a
24
a
7 Tc
3 Tb
A
5
2
1 Ta
Th
21
a
20
23
22
19
Tg
18
Tf
17
16
P107583

● Removal sequence

1 Eyebolt
2 Oil pipe
3 Eyebolt
4 Eyebolt
5 Fuel return pipe A
6 Fuel return pipe B
7 Fuel pipe
8 Fuel temperature sensor
9 O-ring
10 Eyebolt
11 Clamp
12 Fuel suction pipe
13 Fuel hose
14 Eyebolt
15 Fuel suction pipe
16 Idler washer A
17 Idler gear B
18 Idler shaft A
19 Supply pump gear
20 Flange plate
21 O-ring
22 Key
23 Supply pump
24 O-ring
25 O-ring

***a**: Timing gear case
***b**: EGR cooler bracket
⊗: Non-reusable parts
EGR: Exhaust gas recirculation

WARNING ⚠

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

CAUTION ⚠

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

- For servicing the supply pump assembly, contact a Bosch service station.

● Installation sequence

Follow the removal sequence in reverse.

CAUTION ⚠

- **Make sure that the connector of MPROP (rail pressure control valve) is connected to the harness at engine side before starting the engine. If the engine is started without connecting the MPROP connector, the engine electronic control unit cannot control the supply pump and the fault of the engine may result.**

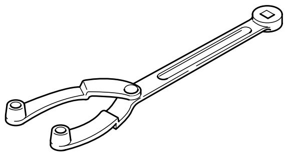
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Eyebolt (oil pipe mounting)	20 {2.0}	–
Tb	Eyebolt (fuel return pipe A mounting)	38.2 {3.9}	–
Tc	Fuel pipe	25 {2.6}	–
Td	Fuel temperature sensor	19.6 {2.0}	–
Te	Eyebolt (fuel return pipe B mounting)	39 {4.0}	–
	Eyebolt (fuel suction pipe mounting)		
Tf	Bolt (idler gear B mounting)	37 to 53 {3.8 to 5.4}	–
Tg	Nut (supply pump gear mounting)	100 to 110 {10.2 to 11.2}	–
Th	Nut (supply pump mounting)	25 to 28 {2.5 to 2.9}	–

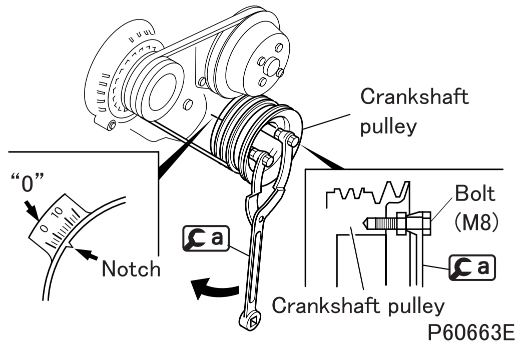
Lubricant and/or sealant

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

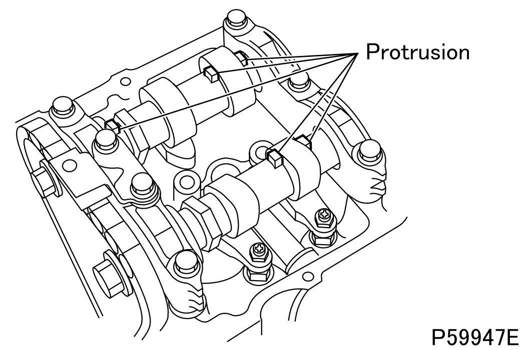
Special tools

Mark	Tool name and shape	Part No.	Application
a	Front hub and flange yoke holder  P07413	MB990767	Rotate crankshaft pulley

◆Installation procedure◆



P60663E



P59947E

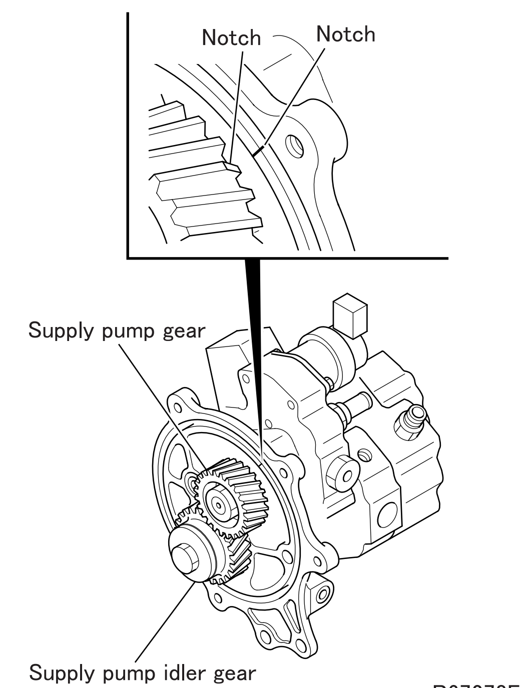
■ Installation: Supply pump

- Remove the oil filler cap.
- Bring the No. 1 cylinder piston to the top dead center (TDC) on the compression stroke according to the following procedure:
  - Rotate the crankshaft pulley in the direction of the arrow shown in the illustration until its notch aligns with the "0" scale mark on the timing gear case.

CAUTION ⚠

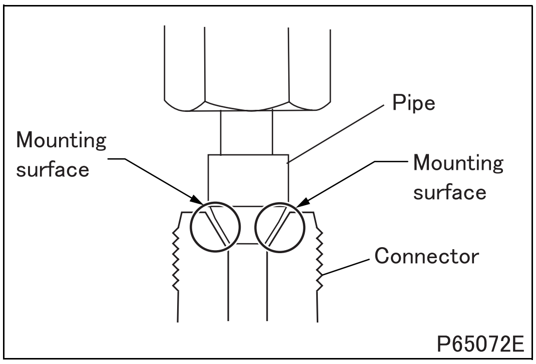
- **Do not rotate the crankshaft pulley in the direction reverse to the direction indicated in the illustration; doing so could cause damage to the timing chain tensioner at the timing gear train. Should the crankshaft pulley be rotated in the reverse direction, remove the tensioner and reinstall it correctly.**

- This will place either the No. 1 or No. 4 cylinder piston at TDC on the compression stroke.
  The No. 1 cylinder piston is at TDC if the camshaft projections visible through the oil filler cap mounting hole are facing upward. Rotate the engine by one full turn to switch the TDCs of the No. 1 and No. 4 cylinder pistons.



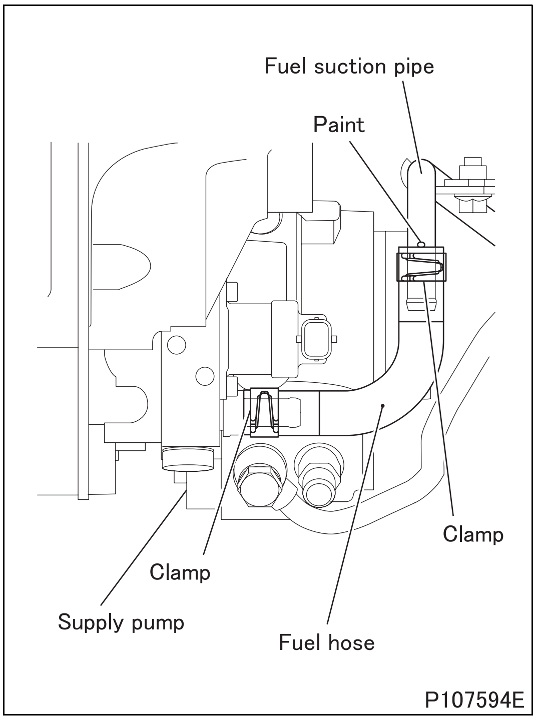
P67278E

- Align the notch on the flange plate with the notch on the supply pump gear.
- Check that the notch on the flange plate and the notch on the supply pump gear are correctly aligned, and then push the supply pump.



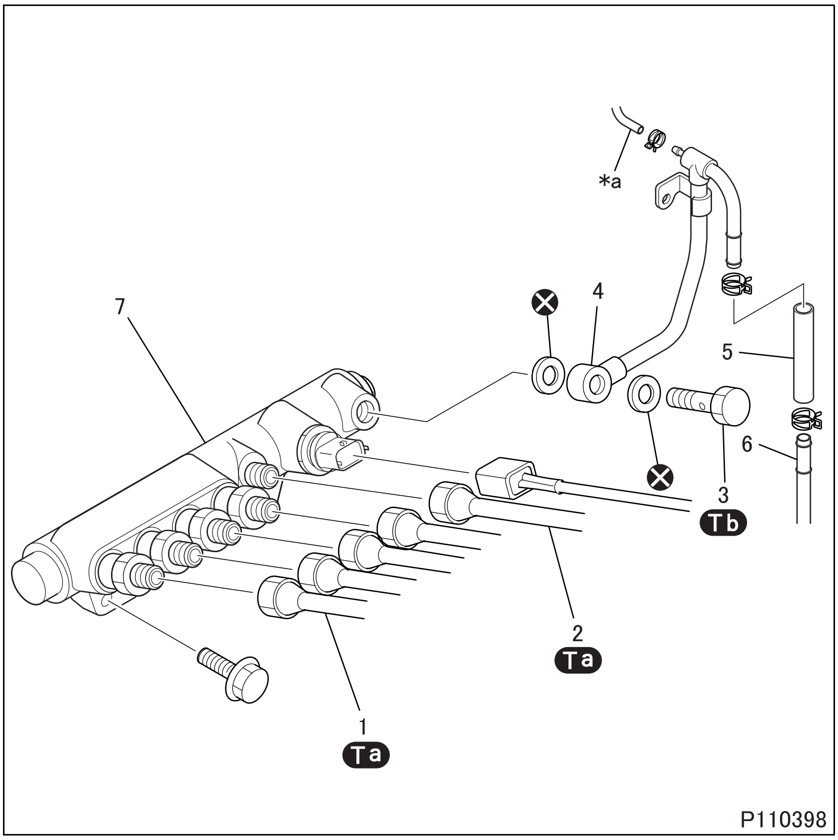
■ **Installation: Fuel pipe**

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



■ **Installation: Fuel hose and clamp**

- Connect the fuel hose with the supply pump side of it installed all the way to the supply pump. As to the fuel suction pipe side, install it in the illustrated position. Fasten clamps in the illustrated direction.



● **Disassembly sequence**

1 Injection pipe
2 Fuel pipe
3 Eyebolt
4 Fuel return pipe C
5 Hose
6 Fuel return pipe B
7 Common rail

***a**: Fuel return hose
⊗: Non-reusable parts

WARNING ⚠

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

CAUTION ⚠

- **If dust enters the common rail, the engine performance will be greatly affected. To prevent it, be sure to cover up openings left after pipes and other parts are removed. Also, wash eyebolts, gaskets, etc. in light oil to clear of dirt.**

- If any abnormality of the common rail is found, replace it.

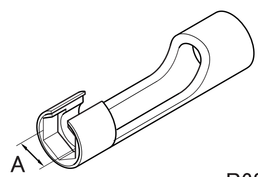
● **Assembly sequence**

Follow the disassembly sequence in reverse.

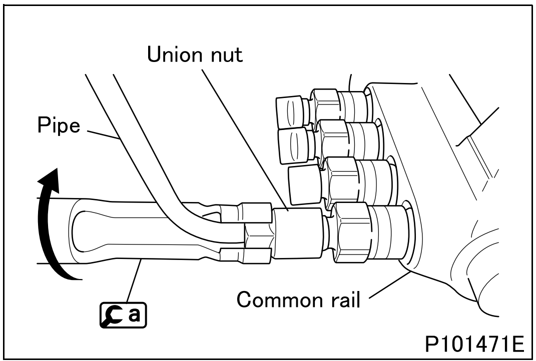
Tightening torque (Unit: N·m {kgf·m})

Location	Parts to be tightened	Tightening torque	Remarks
Ta	Injection pipe	30.4 to 35 {3.1 to 3.6}	–
	Fuel pipe		
Tb	Eyebolt (fuel return pipe mounting)	39 {4.0}	–

Special tools (Unit: mm)

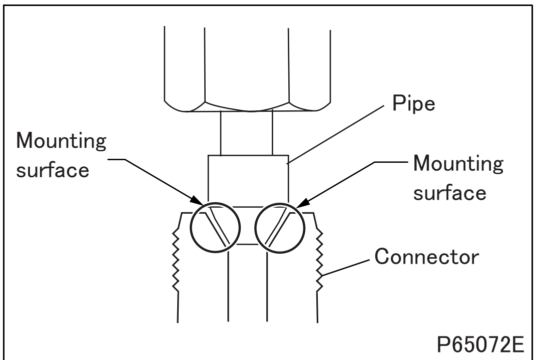
Mark	Tool name and shape	Part No.	Application
a	Socket wrench A: 19  A P68771	MH063074	Removal and installation of injection pipe and fuel pipe

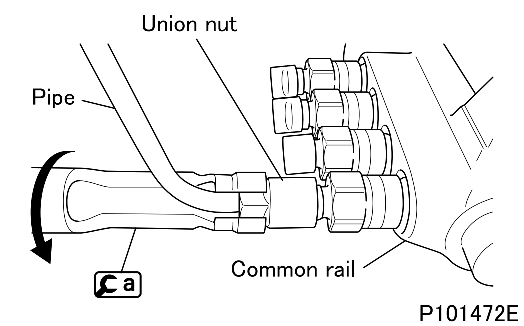
◆Removal procedure◆



■ Removal: Injection pipe and fuel pipe

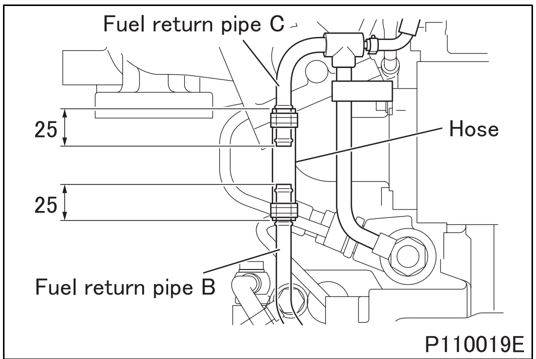
◆Installation procedure◆





■ Installation: Injection pipe and fuel pipe

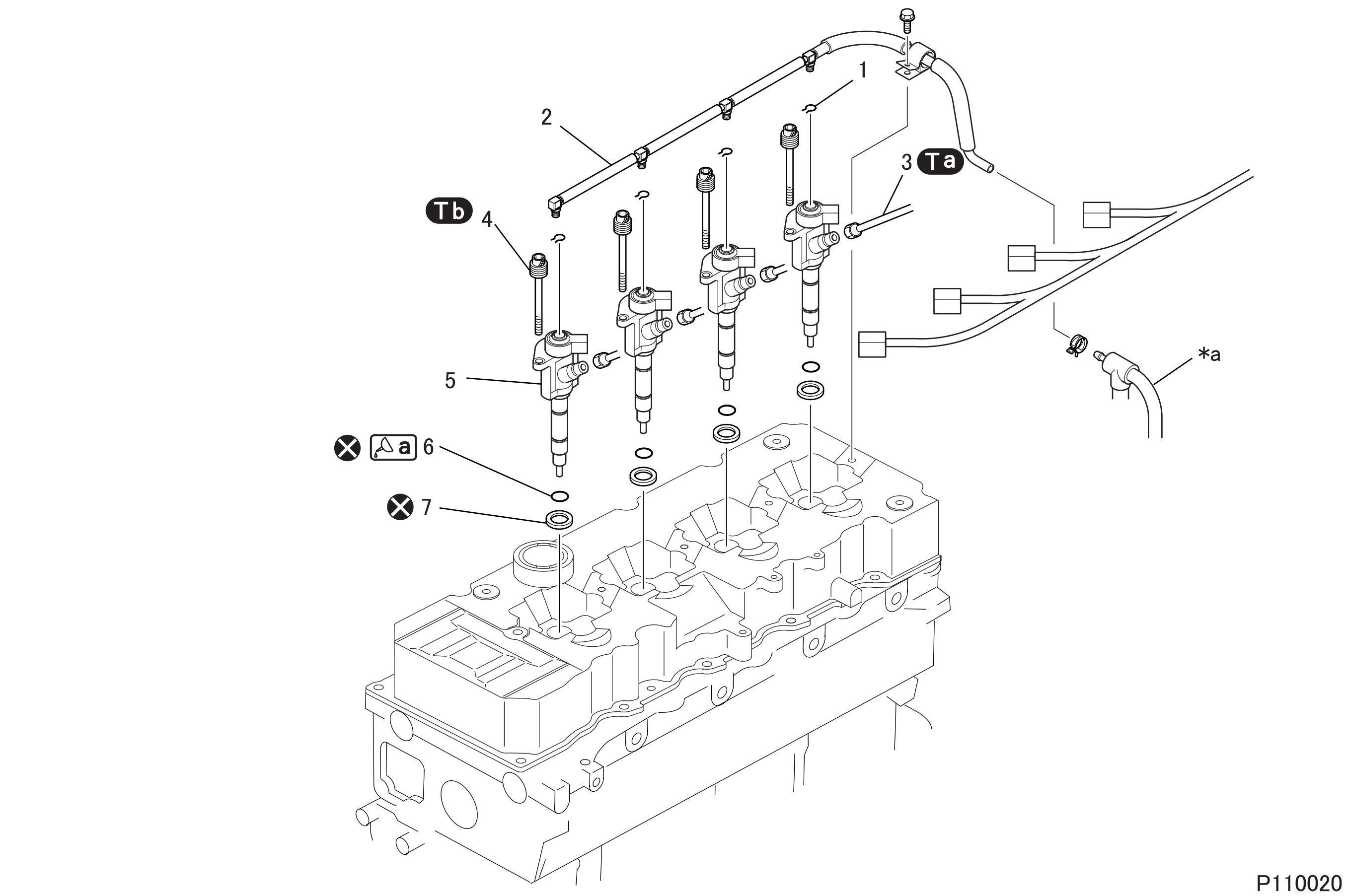
- Ensure that the pipe and mounting surfaces of the connector are flat and free from damage.
- Bring the pipe into intimate contact with mounting surfaces of the connector evenly, and temporarily tighten it without applying an excessive force.
- After temporary tightening, position the torque wrench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



■ Installation: Hose

- Install the hose to the fuel return pipe B and fuel return pipe C to the illustrated dimensions.

INJECTOR



● **Disassembly sequence**

1	Snap ring	**6**	O-ring
2	Fuel return hose	**7**	Nozzle tip gasket
3	Injection pipe		
4	Bolt (with hexagonal hole)	***a**:	Fuel return pipe C
5	Injector	⊗:	Non-reusable parts

WARNING ⚠

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

CAUTION ⚠

- **When removing the injectors, take care not to strike them with the tool, etc.**
- **To eliminate fuel injection and other problems, protect the injectors and pipes, that have been removed, from the ingress of contaminants.**

- Before removing the injectors, check injector mounting holes for trapped water and oil.
- If any abnormality of the injector is found, replace it.

● **Assembly sequence**

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Do not use any wire brush or the similar tools to clean the injection holes of the injectors, or the holes could be crushed.**
- **The injector mounting bolts must always be tightened to the specified torque. Overtightening them could result in a deformed injector and consequently defective fuel injection.**

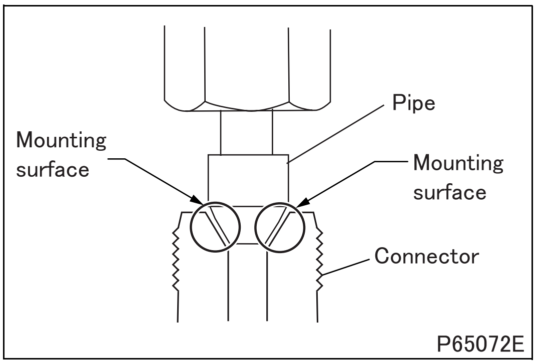
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Injection pipe	30.4 to 35 {3.1 to 3.6}	–
Tb	Bolt (injector mounting)	5.2 to 7.2 {0.53 to 0.73}	–

Lubricant and/or sealant

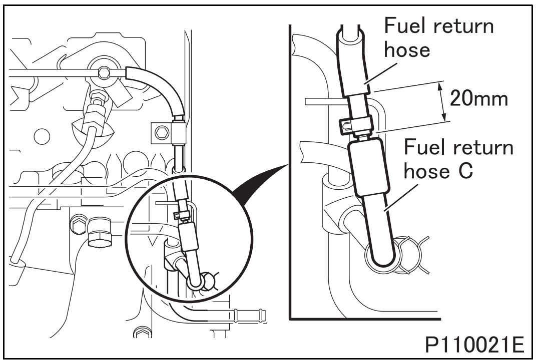
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	As required

◆Installation procedure◆



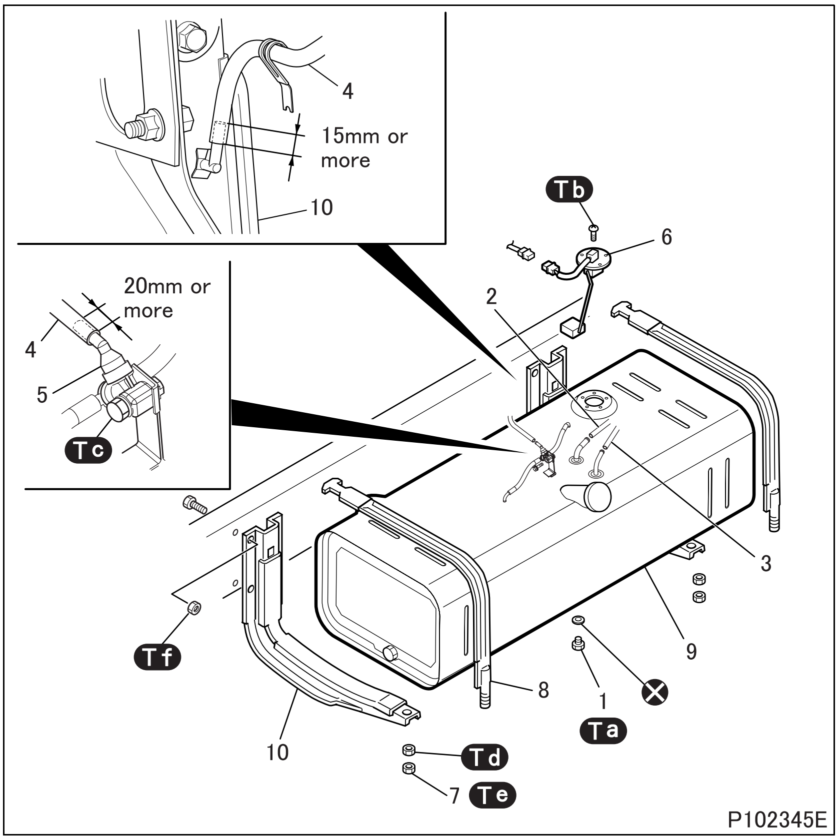
■ Installation: Injection pipe

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



■ Installation: Fuel return hose

- Install the fuel return hose to the fuel return hose C to the illustrated dimension.



● Removal sequence

1 Drain plug
2 Suction hose
3 Return hose
4 Air vent tube
5 Fuel check valve
6 Fuel level sensor
7 Lock nut
8 Fuel tank band
9 Fuel tank
10 Fuel tank bracket

⊗: Non-reusable parts

● Installation sequence

Follow the removal sequence in reverse.

DANGER ⚠

- **Do not allow any flames or sources of heat near the fuel tank, as it may explode.**

WARNING ⚠

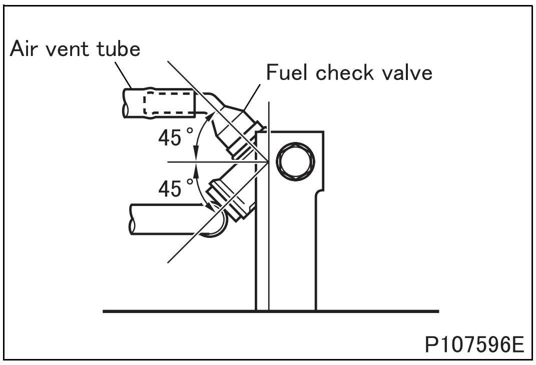
- **To avoid risk of fire, wipe up any spilled fuel.**

- Insert the air vent tube into fuel tank bracket, while taking care not to pinch or crush with the fuel tank band.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Drain plug	19.6 ± 4.9 {2.0 ± 0.5}	–
Tb	Screw (fuel level sensor mounting)	0.98 to 1.47 {0.10 to 0.15}	–
Tc	Bolt (fuel check valve mounting)	4.9 to 8.8 {0.5 to 0.9}	–
Td	Nut (fuel tank band mounting)	3.9 to 7.8 {0.4 to 0.8}	–
Te	Lock nut (fuel tank band mounting)	8.8 to 13.7 {0.9 to 1.4}	–
Tf	Nut (fuel tank bracket mounting)	70 to 90 {7.1 to 9.1}	–

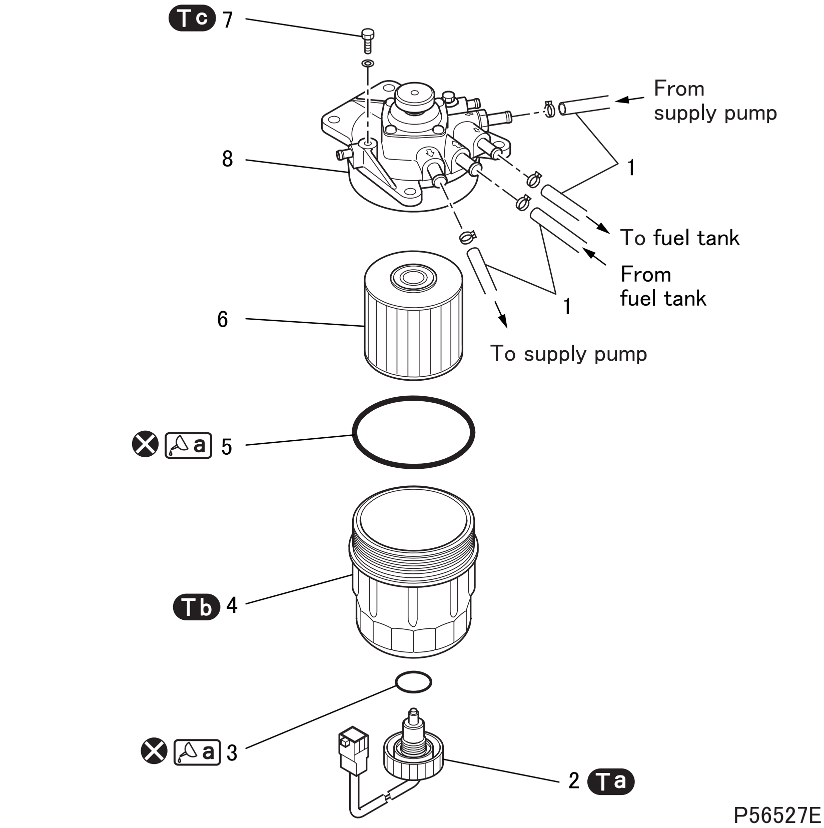
◆Installation procedure◆



■ Installation: Fuel check valve

- Install the fuel check valve at the illustrated angle.

FUEL FILTER



● Disassembly sequence

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

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

WARNING ⚠

- **Fuel is highly flammable. Keep it away from flames and sources of heat.**
- **To avoid risk of fire, wipe up any spilled fuel.**

CAUTION ⚠

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

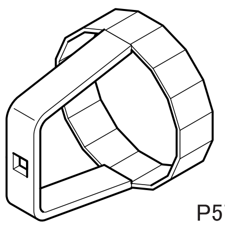
Tightening torque (Unit: N·m {kgf·m})

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

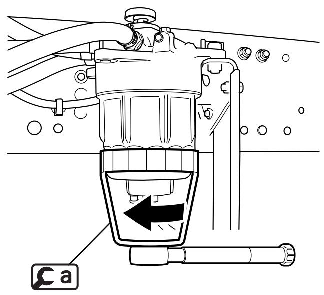
Lubricant and/or sealant

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

Special tools

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

◆Removal procedure◆

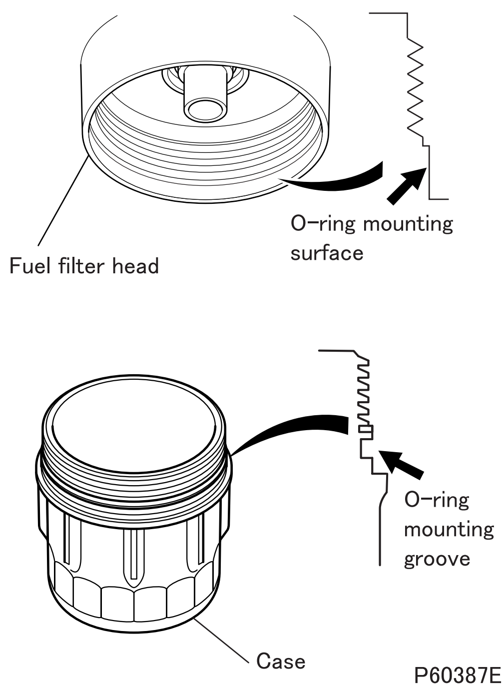


P57197

■ Removal: Case

- Loosen the water separator sensor and drain fuel from the case.
- Remove the case using a.

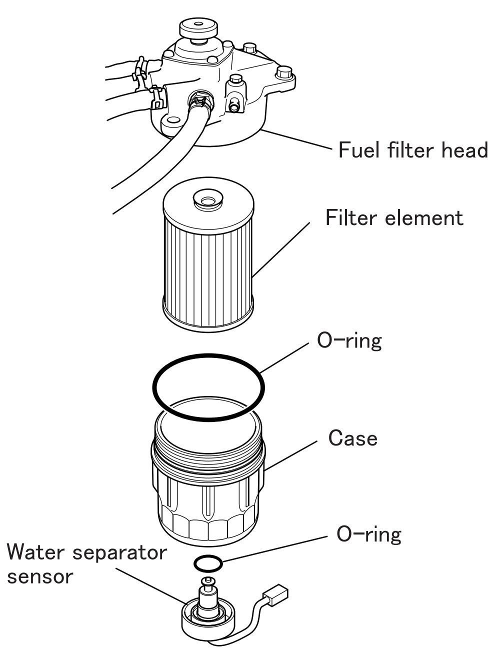
◆Installation procedure◆



P60387E

■ Installation: Case

- Clean the O-ring mounting surface of the fuel filter head and the O-ring groove of the case.

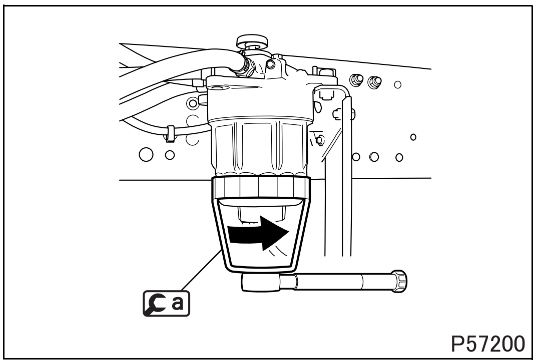


P57199E

- Replace the filter element and O-ring with new one.
- Apply a thin coat of engine oil to the O-ring, and install it on the case and water separator sensor.

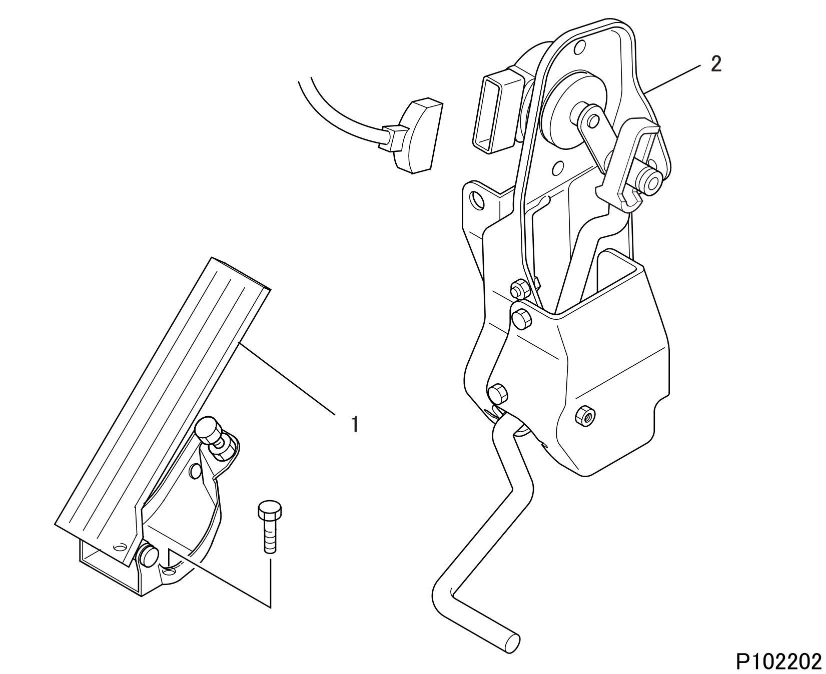
CAUTION ⚠

- **Be sure to use only genuine MITSUBISHI FUSO filter elements. The use of non-genuine fuel filters can cause engine failure.**
- **Prevent fine dust particles from entering the fuel filter and fuel pipe, as they can cause problems such as faulty fuel injection.**



- Use a to tighten the case to the specified torque.
- Install the water separator sensor, and then air-bleed the fuel system.
- Start the engine, and check that there is no fuel leakage.
- Reinstall the fuel filter if there is any leakage.

M E M O



P102202

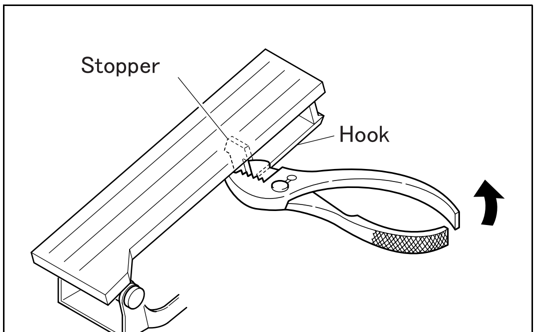
● **Removal sequence**

1 Accelerator pedal (See later sections.)
2 Accelerator link (See later sections.)

● **Installation sequence**

Follow the removal sequence in reverse.

◆Removal procedure◆



P65878E

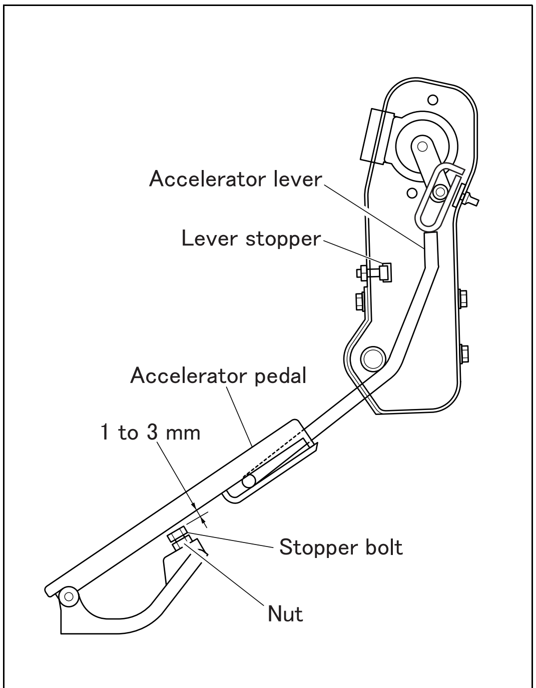
■ **Removal: Accelerator pedal**

- Using pliers, pinch the hook of the stopper on the accelerator pedal. Separate the stopper from the pedal while turning the hook by about 15 degrees.

CAUTION ⚠

- **Do not yank on the stopper, as this may damage it.**

◆Installation procedure◆

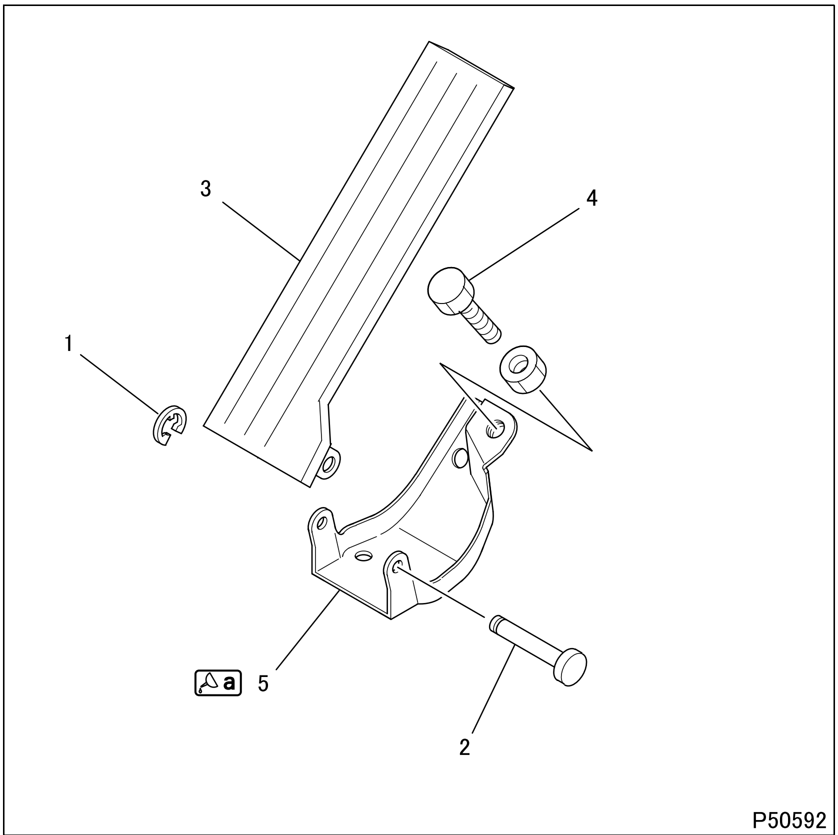


P69663E

■ **Installation: Accelerator pedal**

- Press the accelerator pedal until the accelerator lever touches the accelerator link lever stopper.
- Check that the clearance between the stopper and the stopper bolt contact surface of the pedal is as indicated in the illustration.
- If the clearance is not within the indicated value range, adjust the stopper bolt and lock it with the nut.

Accelerator Pedal



● Disassembly sequence

1 E-ring
2 Clevis pin
3 Accelerator pedal
4 Stopper bolt
5 Accelerator pedal bracket

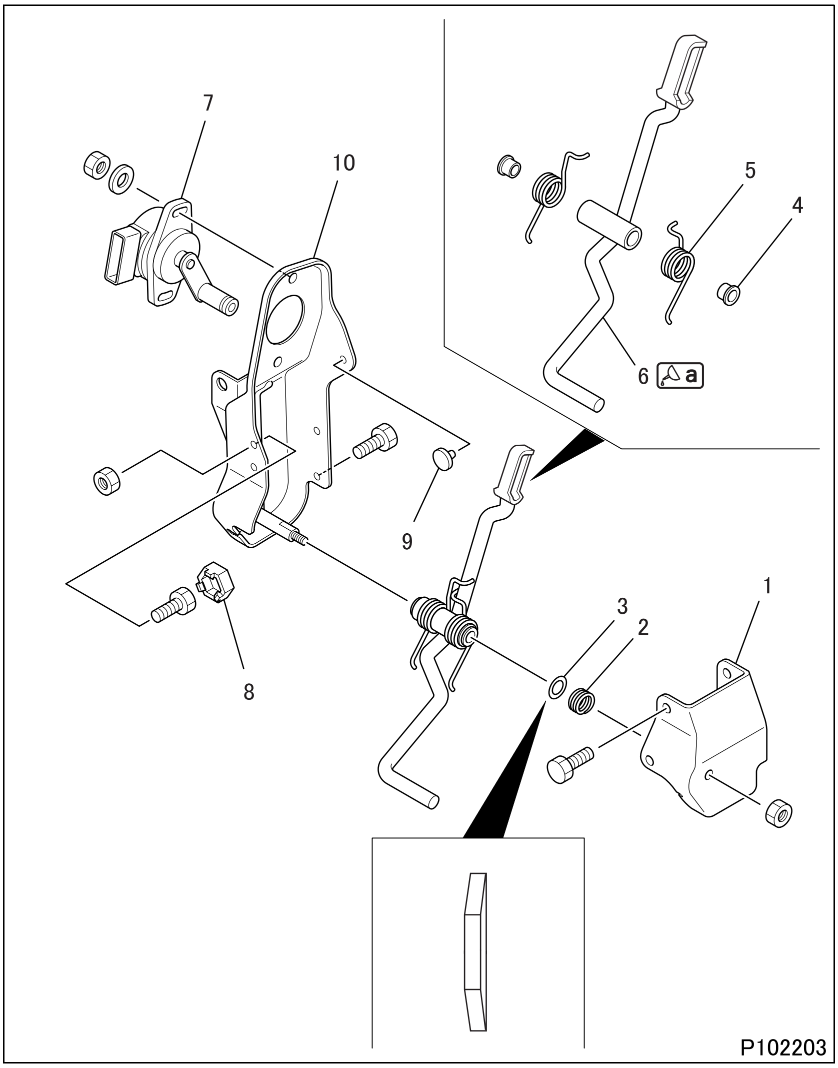
● Assembly sequence

Follow the disassembly sequence in reverse.

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Accelerator pedal and bracket contact surfaces	Chassis grease [NLGI No. 1 (Li soap)]	As required

Accelerator Linkage



● Disassembly sequence

1 Cover
2 Spring
3 Washer
4 Bushing
5 Return spring
6 Accelerator lever
7 Accelerator position sensor and accelerator switch assembly
8 Lever stopper
9 Rubber stopper
10 Accelerator link bracket

● Assembly sequence

Follow the disassembly sequence in reverse.

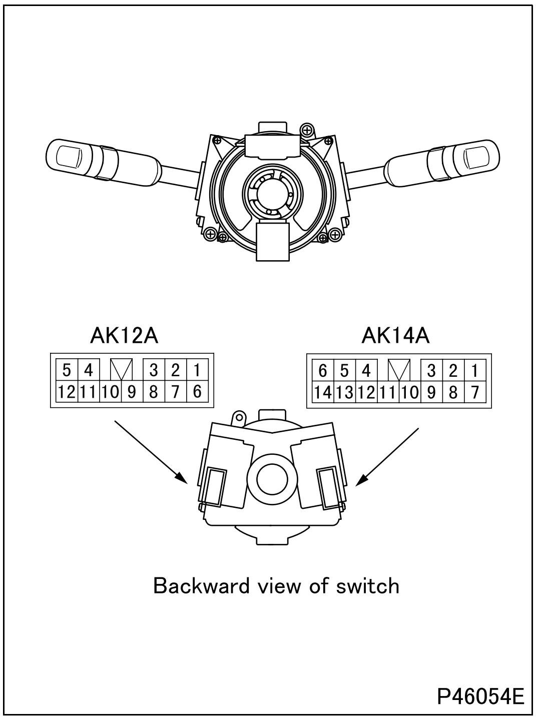
NOTE

- **Perform the inspection and adjustment of the accelerator position sensor. (See “INSPECTION OF ELECTRICAL EQUIPMENT”.)**

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Accelerator lever and return spring sliding surface	Chassis grease [NLGI No. 1 (Li soap)]	As required

M E M O

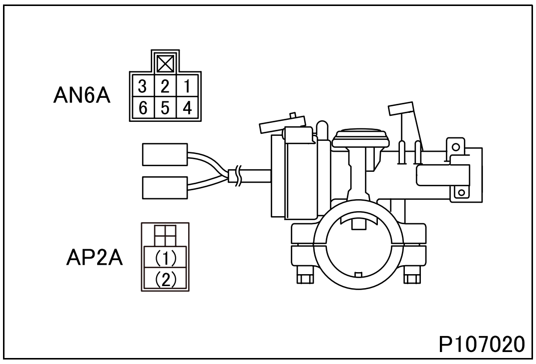


#001 Inspection of combination switch

AK14A connector connection table

Switch position		Terminals with continuity
Exhaust brake switch	OFF	–
	ON	12 - 13

- For other inspections than shown above, see Gr54.
- If there is any abnormality, replace the switch. (See Gr37.)

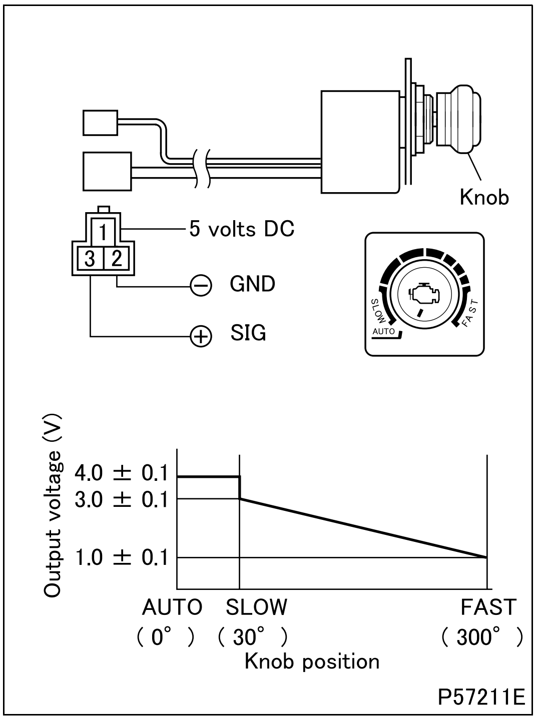


#002 Inspection of starter switch

AP2A, AN6A connector connection table

Switch position		Continuity terminal
LOCK	Without key	–
	With key	5–6
ACC		(2)–3, 5–6
ON		(1)–(2)–3, 5–6
START		(1)–(2)–2–3, 5–6

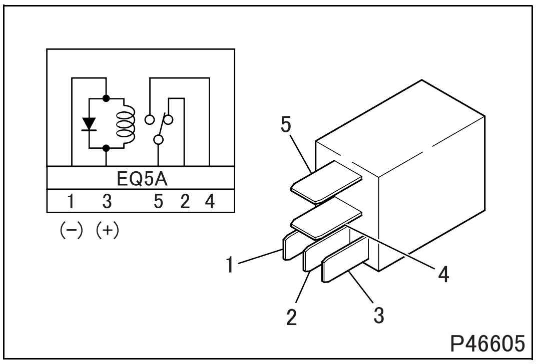
- Terminal numbers within parentheses ( ) show terminals of AP2A.
- If any fault is found, replace the switch. (See Gr37.)



#157 Inspection of idling speed adjustment potentiometer

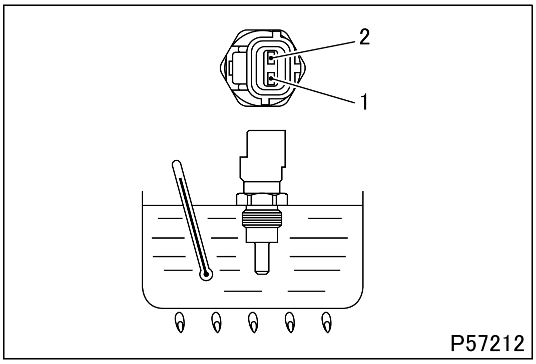
- Apply 5 volts DC to terminals 1 and 2 of the idling speed adjustment potentiometer.
- Turn the knob fully counterclockwise. Then, measure the output voltage across terminals 2 and 3 (see the diagrams on the left) while slowly turning the knob clockwise.
- If any measurement is out of specification, replace the idling speed adjustment potentiometer.

	Knob position	Output voltage
Standard value	AUTO (0°)	4.0 ± 0.1 V
	SLOW (30°)	3.0 ± 0.1 V
	FAST (300°)	1.0 ± 0.1 V



#201 Inspection of relay (normally open type 5 pin)

- Perform continuity check and operation check, and if any fault is found, replace the relay.

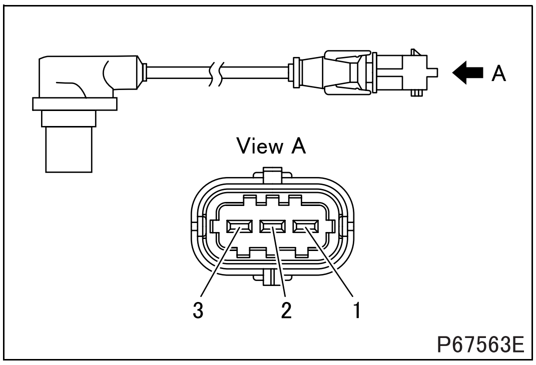


#262 Inspection of water temperature sensor

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

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

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

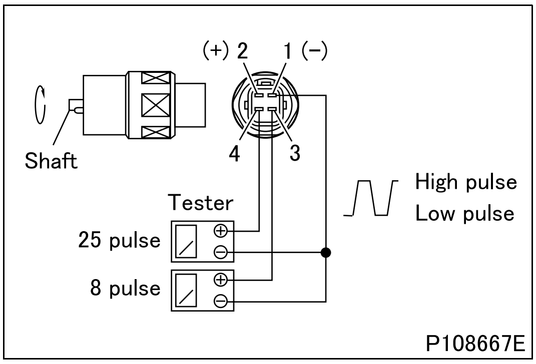


#263 Inspection of engine speed sensor

- Measure the resistance between terminals 1 and 2.

Standard value (at 20°C)	860 ± 86 Ω

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

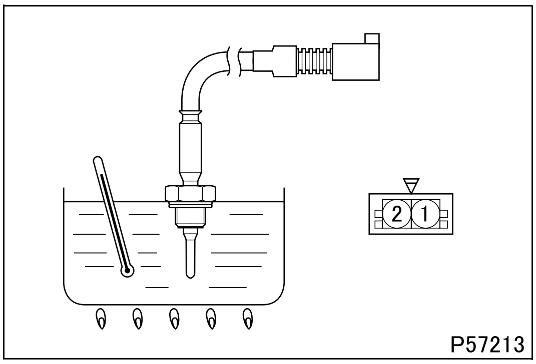


#265 Inspection of vehicle speed sensor

- With the 24 volts DC applied to terminals to 1 and 2, slowly turn the shaft of the vehicle speed sensor.
- Measure the maximum voltage (high pulse voltage) and minimum voltage (low pulse voltage) occurring at each specified pair of terminals.

Terminals	Inspection condition	Standard value
8 pulse output terminals 1(–) to 3(+)	Low pulse voltage	1.5 V or lower
	High pulse voltage	23.5 V or more
25 pulse output terminals 1(–) to 4(+)	Low pulse voltage	0.5 V or lower
	High pulse voltage	8 ± 1 V

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

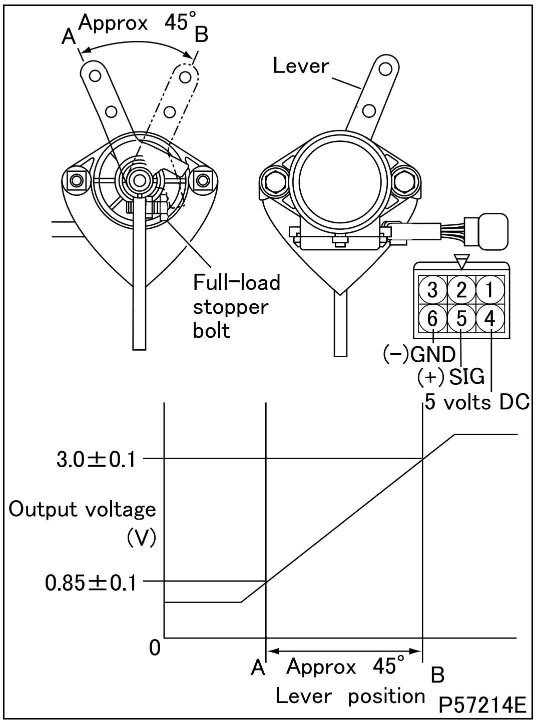


#305 Inspection of intake air temperature sensor 1

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

Standard value	0°C	$15^{+3.78}_{-2.94}$ kΩ
	20°C	$6.514^{+1.437}_{-1.147}$ kΩ
	80°C	$0.874^{+0.136}_{-0.115}$ kΩ

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

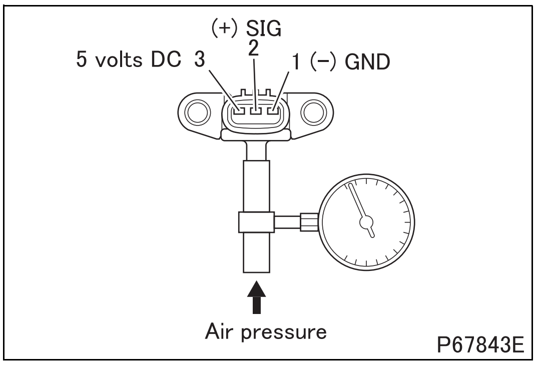


#317 Inspection of power take-off load sensor

- Apply 5 volts DC to terminals 4 and 6.
- Measure the output voltage across terminals 5 and 6 with the lever at idling position A and at full-load position B.

	Lever position	Output voltage
Standard value	Idling position A	0.85 ± 0.1 V
	Full-load position B	3.0 ± 0.1 V

- If measurement of full-load position B deviates from standard value, adjust with full load stopper bolt.
- If measurement of idling position A deviates from standard value, replace the sensor.



#318 Inspection of boost pressure sensor

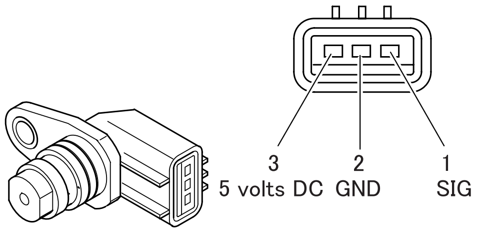
- Apply 5 volts DC to terminals 3 and 1.
- Apply air pressure. Gradually increase it and, while doing so, measure the output voltage occurring at terminals 2 and 1.

	Air pressure (gauge pressure)	Voltage
Standard value	99 kPa {1.0 kgf/cm^2}	Approx. 2.5 V
	232.3 kPa {2.3 kgf/cm^2}	Approx. 4.5 V

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

#319 Inspection of common rail pressure sensor

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



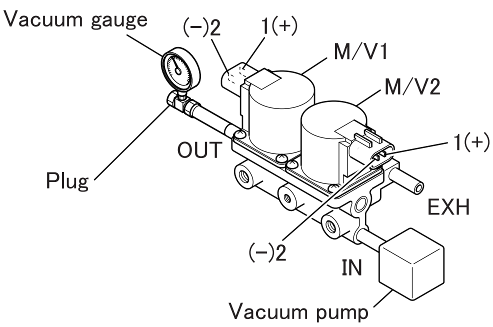
P56466

#320 Inspection of cylinder recognition sensor

- Measure the resistance between terminals 2 and 3.

Standard value	200 to 1,800 Ω

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



M/V1	M/V2	IN	OUT	EXH
OFF	OFF		○—	—○
ON	OFF	○—	—○	
OFF	ON	○—	—○····	····○

○—○ : Pneumatic continuity

········ : Pneumatic continues via a reducing valve

P110575E

#565 Inspection of exhaust shutter 3-way magnetic valve

- Perform the following checks. If there is any abnormality, replace the exhaust shutter 3-way magnetic valve.

(1) Check of operation

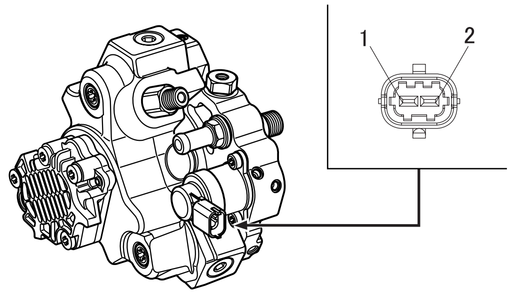
- Gradually increase from zero the voltage applied to terminals 1 and 2.
- Observe the voltage when the exhaust shutter 3-way magnetic valve operates.
  (Determine the magnet valve's OFF-ON operation from the operating sound.)

Standard value (min. operating voltage)	22 V or lower

(2) Inspection of air circuit for continuity, air-tightness and reducing valve activation

- Pipe the air circuit as shown, and check that when a negative pressure of 93 kPa {700 mmHg} is applied to the IN port to activate M/V1, the vacuum gauge reads 93 kPa {700 mmHg}. Also, check that atmospheric pressure is not let in from the EXH side port.
- Check that when M/V2 is activated with a negative pressure of 93 kPa {700 mmHg} applied to the IN port, the vacuum gauge reading is within the specified limit.

Standard value	Negative pressure: 53.3 ± 1.3 kPa {430 ± 9.8 mmHg}



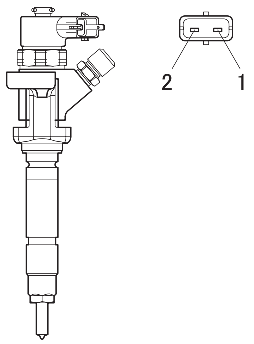
P67794

#574 Inspection of MPROP (rail pressure control valve)

- Measure the resistance between terminals 1 and 2.

Standard value	2.6 to 3.15 Ω

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



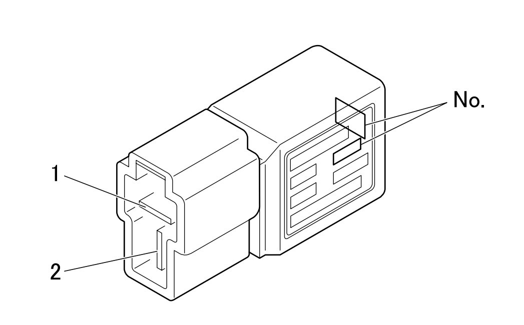
P67440

#582 Inspection of injector magnetic valve

- Measure the resistance between terminals 1 and 2.

Standard value (at 20°C)	0.255 ± 0.04 Ω

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



P64425

#828 Inspection of fuel injection rate adjustment resistor, power take-off resistor and controller area network resistor

- Measure the resistance of the resistor number marked on the fuel injection rate adjustment resistor, power take-off resistor and controller area network resistor.

Standard value (at 20°C)	Resistor No.	1	270 ± 13.5 Ω
		2	510 ± 25.5 Ω
		3	820 ± 41 Ω
		4	1,300 ± 65 Ω
		5	2,000 ± 100 Ω
		6	3,300 ± 165 Ω
		7	5,600 ± 280 Ω
		8	15,000 ± 750 Ω
		9	390 ± 19.5 Ω
		10	4,300 ± 215 Ω
		11	9,100 ± 455 Ω
		12	120 ± 6 Ω (for CAN resistor)

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

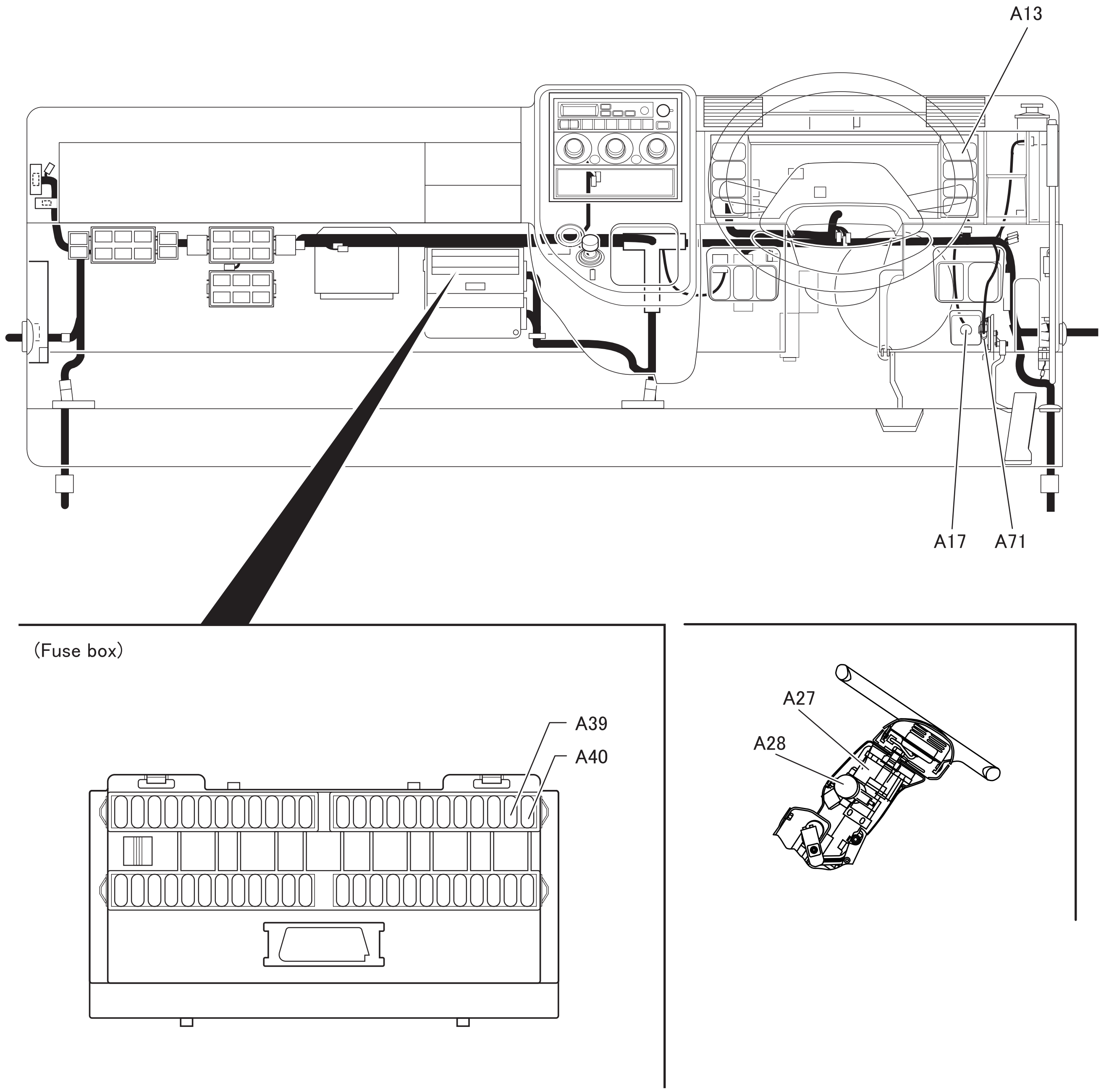
CAUTION ⚠

- **The fuel injection rate adjustment resistor, power take-off resistor and controller area network resistor are matched to the engine. If you replace them, be sure to replace them with ones that have the same resistor number.**

M E M O

INSTALLED LOCATIONS OF PARTS

A13–71

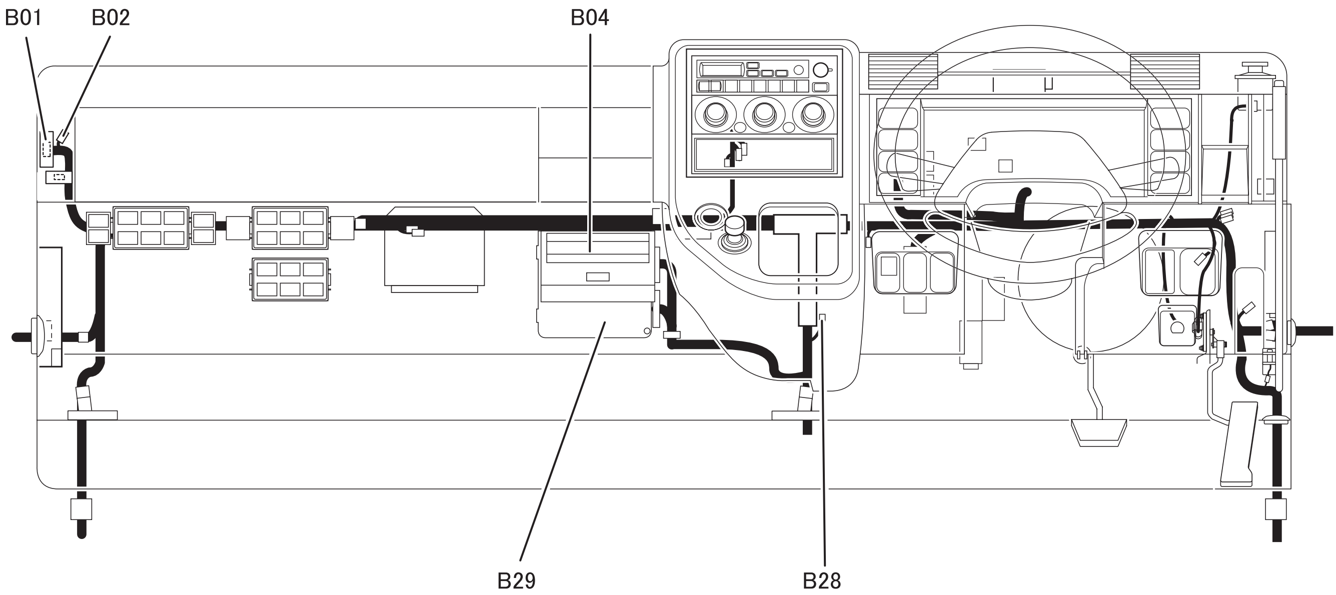


A13 DPF cleaning switch
A17 Idling speed adjustment potentiometer
A27 Combination switch
A28 Starter switch
A39 Diagnosis switch
A40 Memory clear switch
A71 Accelerator pedal position sensor

DPF : Diesel particulate filter
ECU : Electronic control unit

13–L04634

B01–29

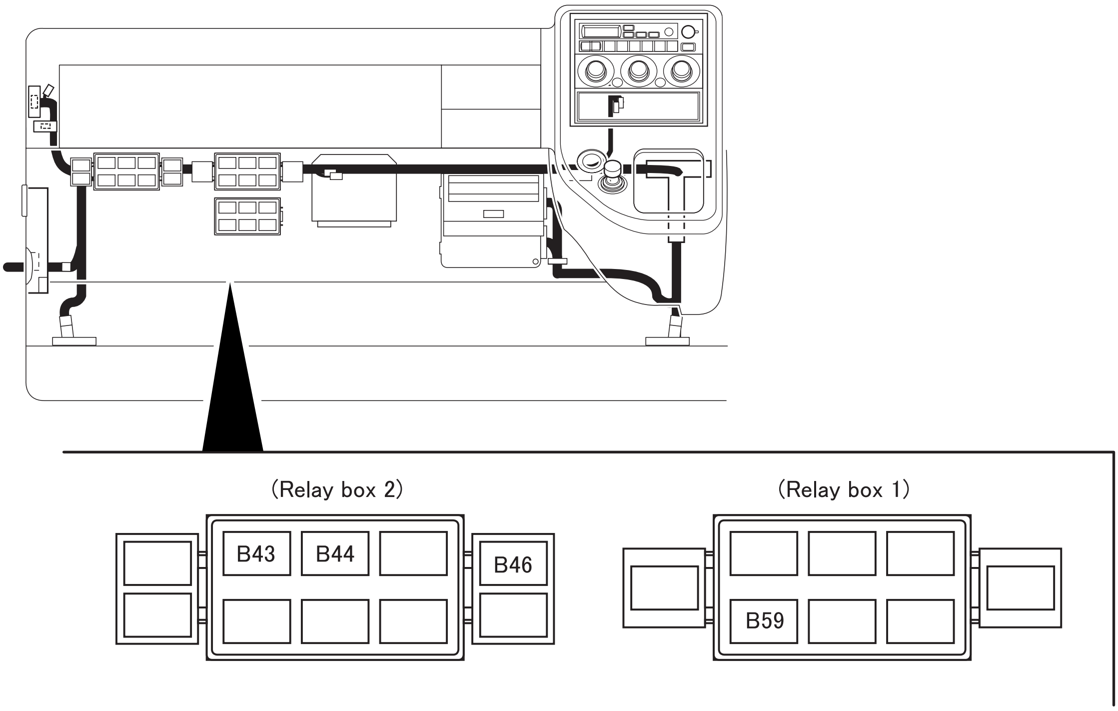


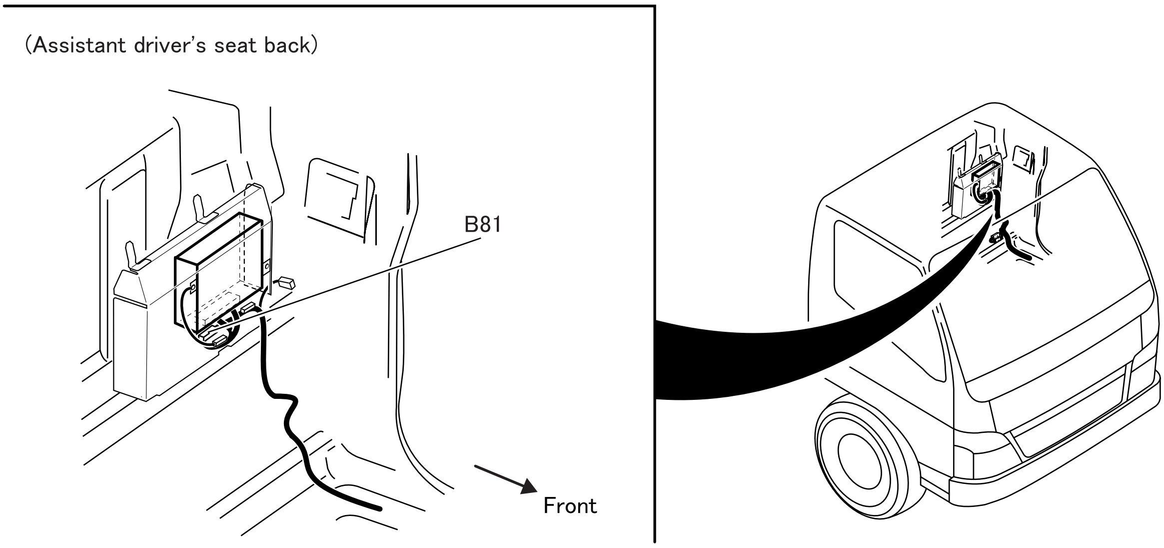
B01 VG turbocharger EDU
B02 CAN resistor
B04 Fuse box
B28 Diode
B29 Engine ECU

ECU : Electronic control unit
EDU : Electronic drive unit
VG : Variable geometry
CAN : Control area network

13–L04635

B43−81



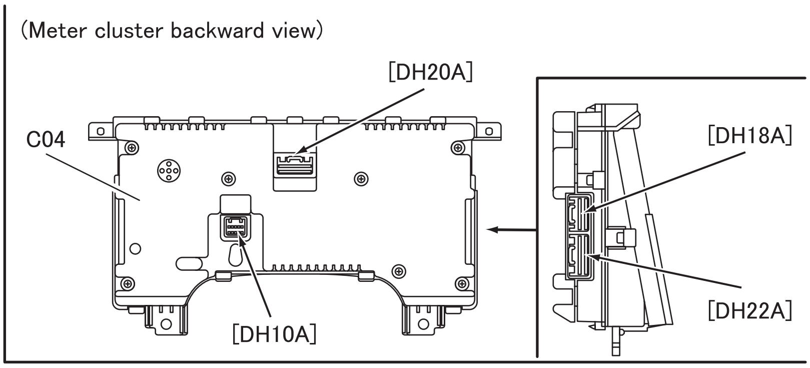


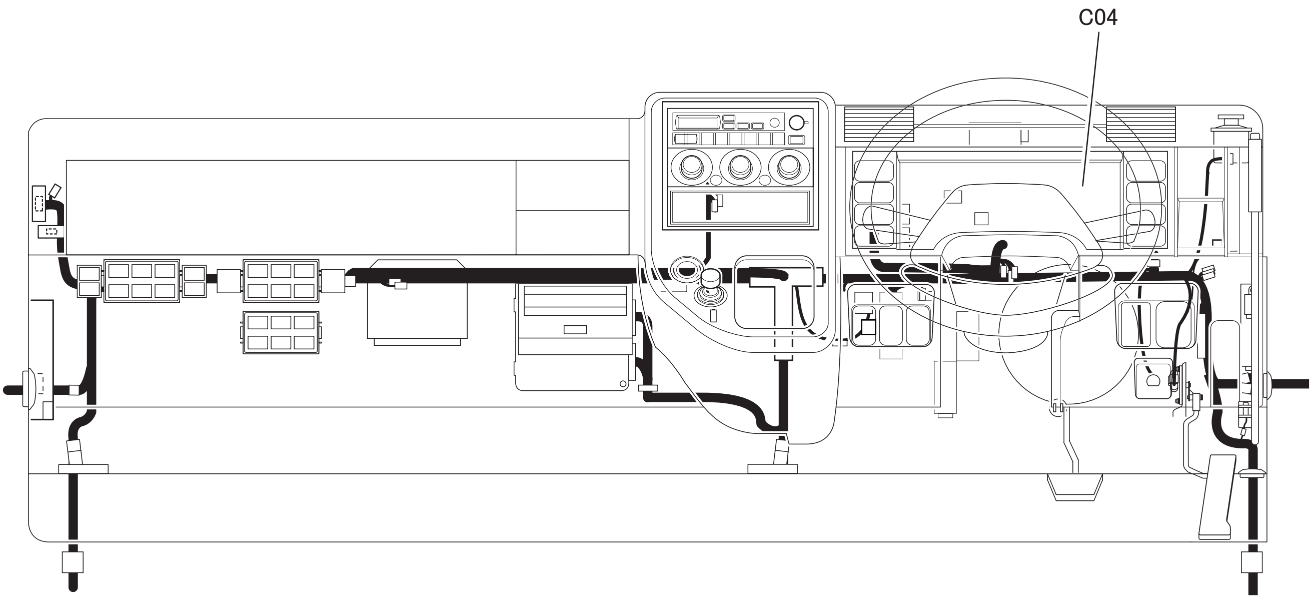
B43	ABS exhaust brake cut relay
B44	Glow drive relay
B46	Starter power supply cut relay
B59	Safety relay
B81	CAN resistor

ABS : Anti−lock brake system
CAN : Control area network

13−L04636

C04

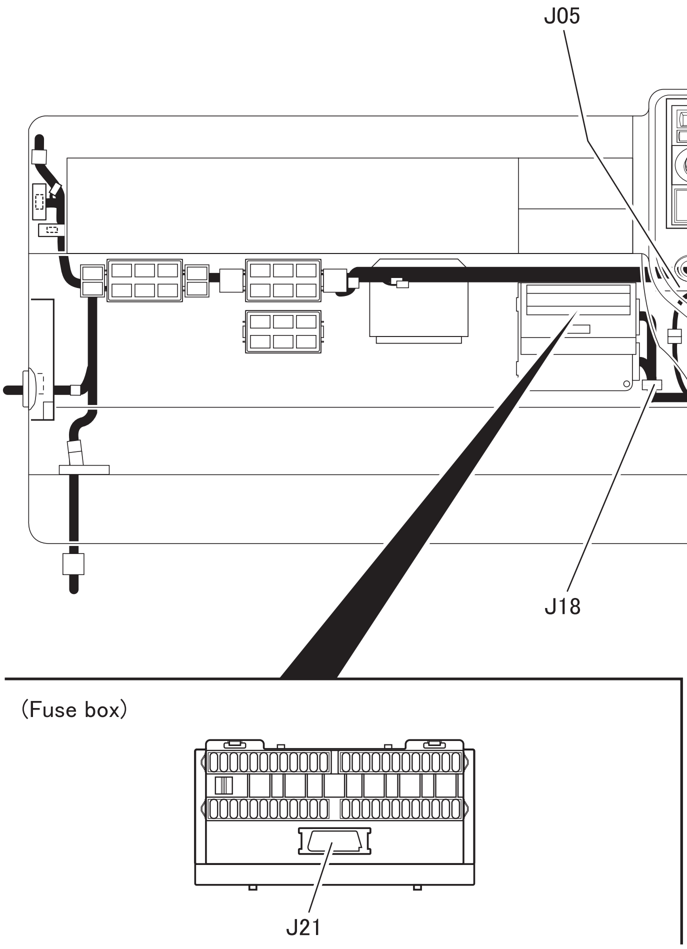




C04 Meter cluster

Indicate by connector type [ ].

J05–21

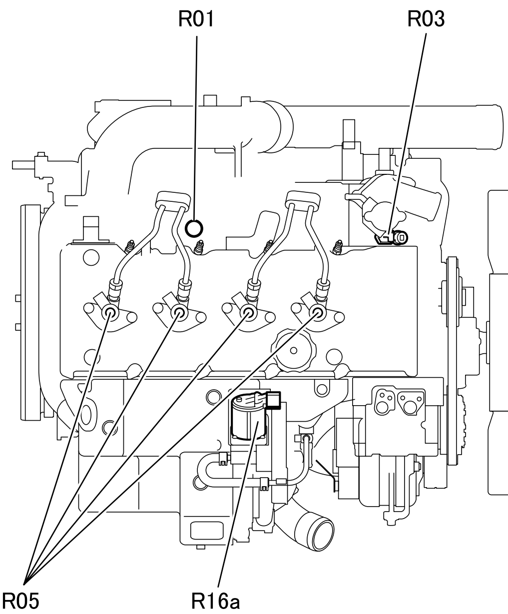


J05 Joint connector (J/C–1, 3)
J15 Joint connector (J/C–M1)
J18 Joint connector (J/C–2)
J21 Multi–Use Tester connector

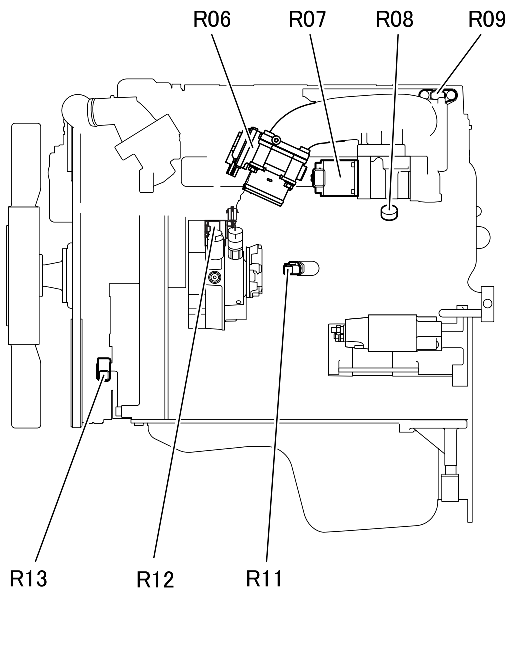
13–L04638

R01-16

(Upper view)



(Left side view)



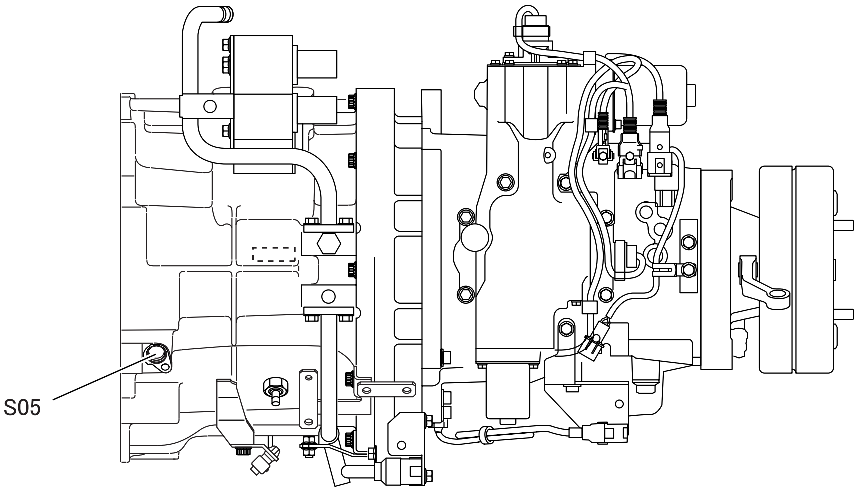
R01 Boost air temperature sensor
R03 Water temperature sensor
R05 Injector
R06 Throttle actuator
R07 EGR valve
R08 Common rail pressure sensor
R09 Boost pressure sensor
R11 Fuel temperature sensor
R12 MPROP (rail pressure control valve)
R13 Cylinder recognition sensor
R16a VG turbocharger actuator

EGR : Exhaust gas recirculation
VG : Variable geometry

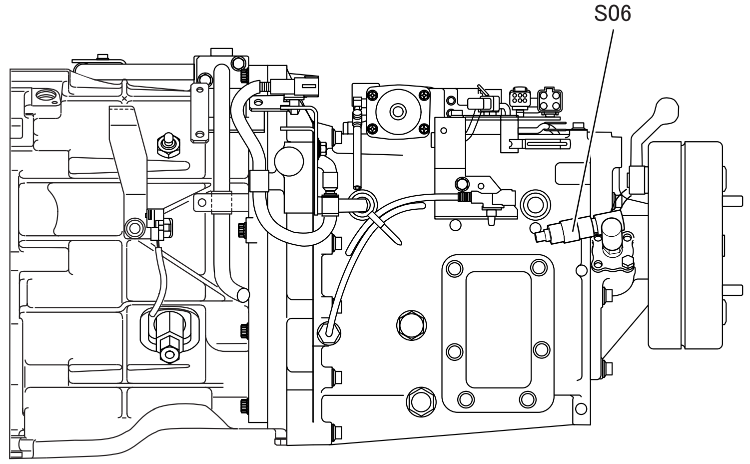
13-L04639

S05–06

(Upper view)



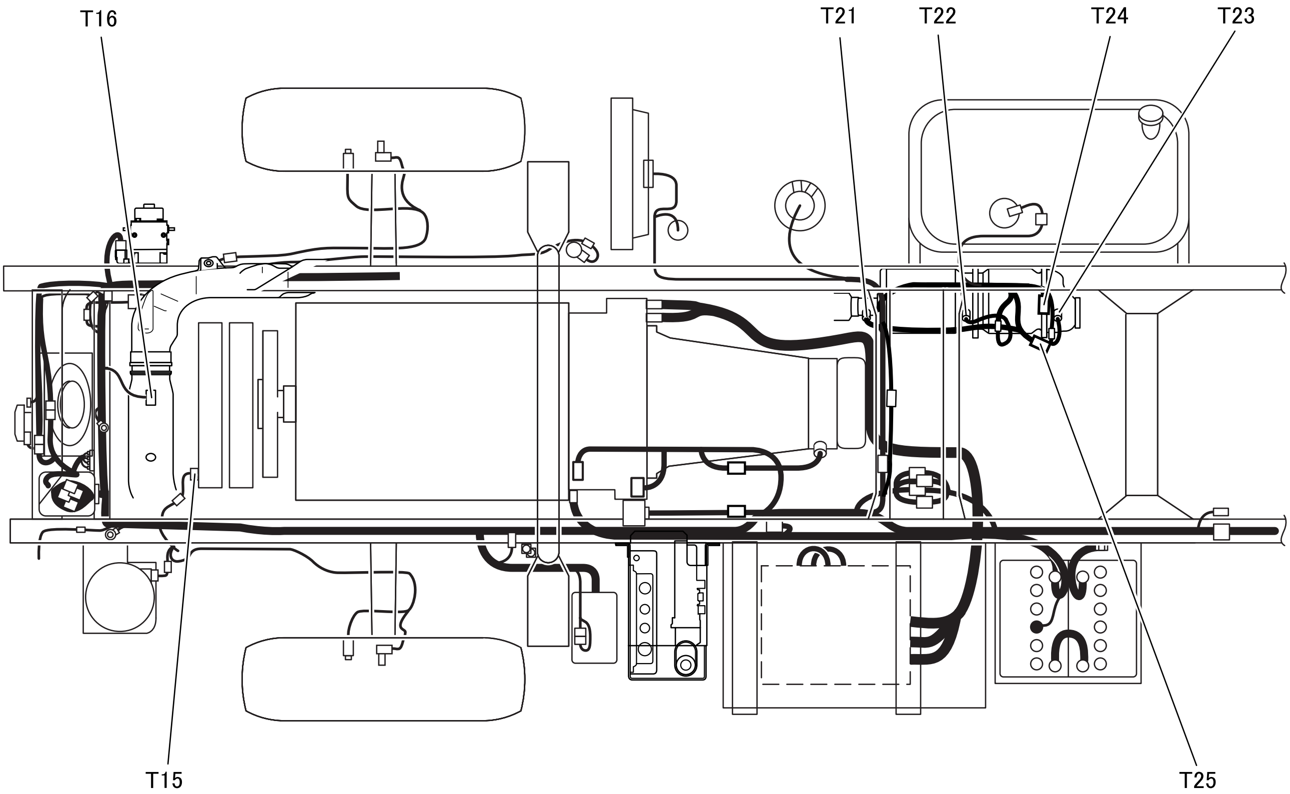
(Left side view)



S05 Engine speed sensor
S06 Vehicle speed sensor

13–L04640

T15–25 (Sensor)



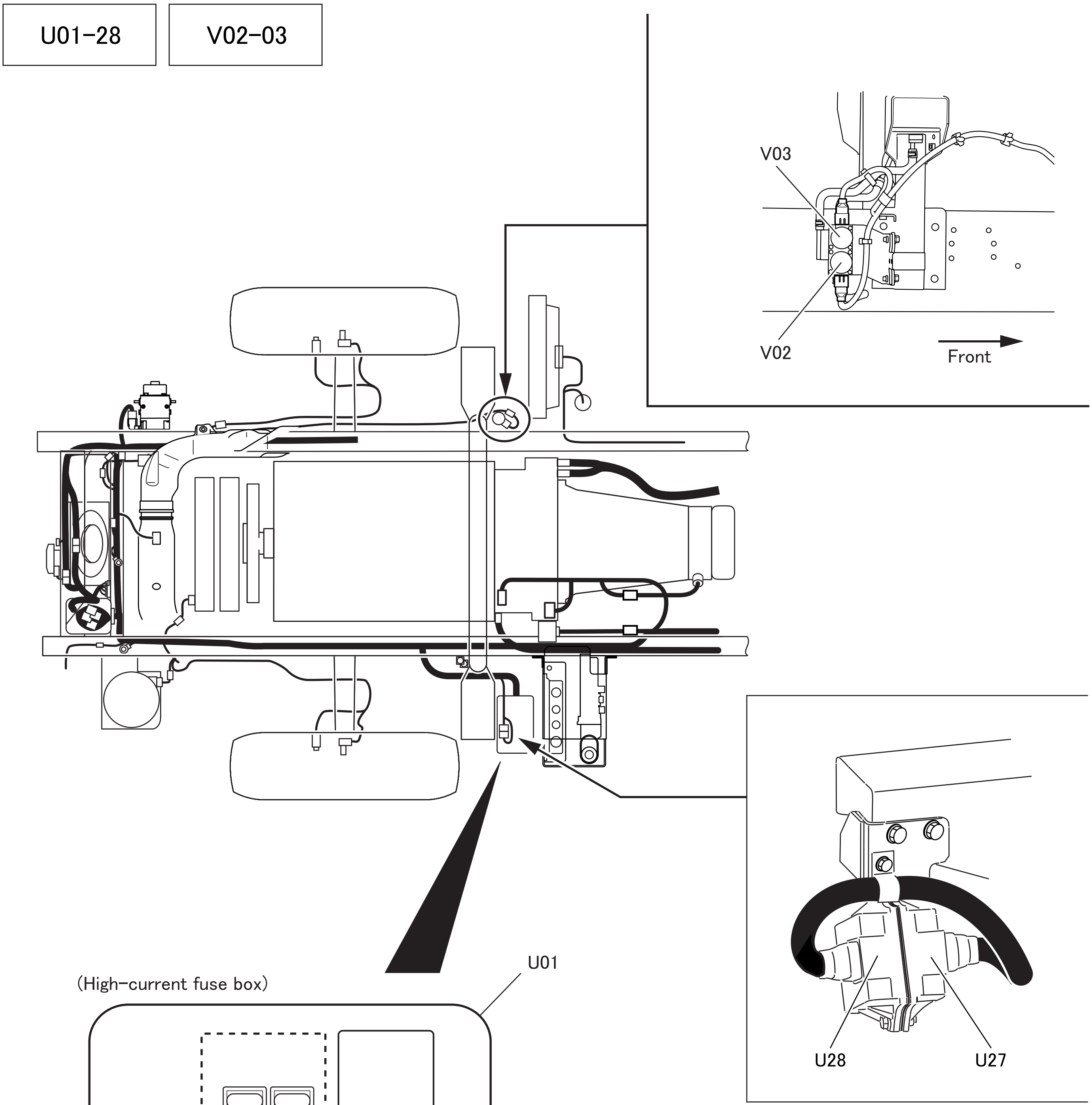
T15 Intake air temperature sensor 1
T16 Air flow sensor
T21 Catalytic temperature sensor
T22 Exhaust gas temperature sensor 1
T23 Exhaust gas temperature sensor 2
T24 DPF absolute pressure sensor
T25 DPF differential pressure sensor

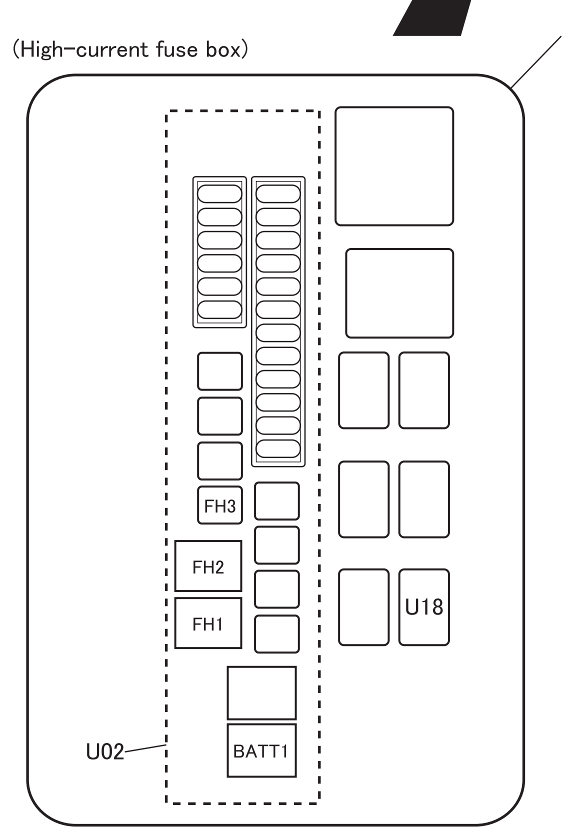
DPF : Diesel particulate filter

13–L04641

INSTALLED LOCATIONS OF PARTS

U01–28	V02–03





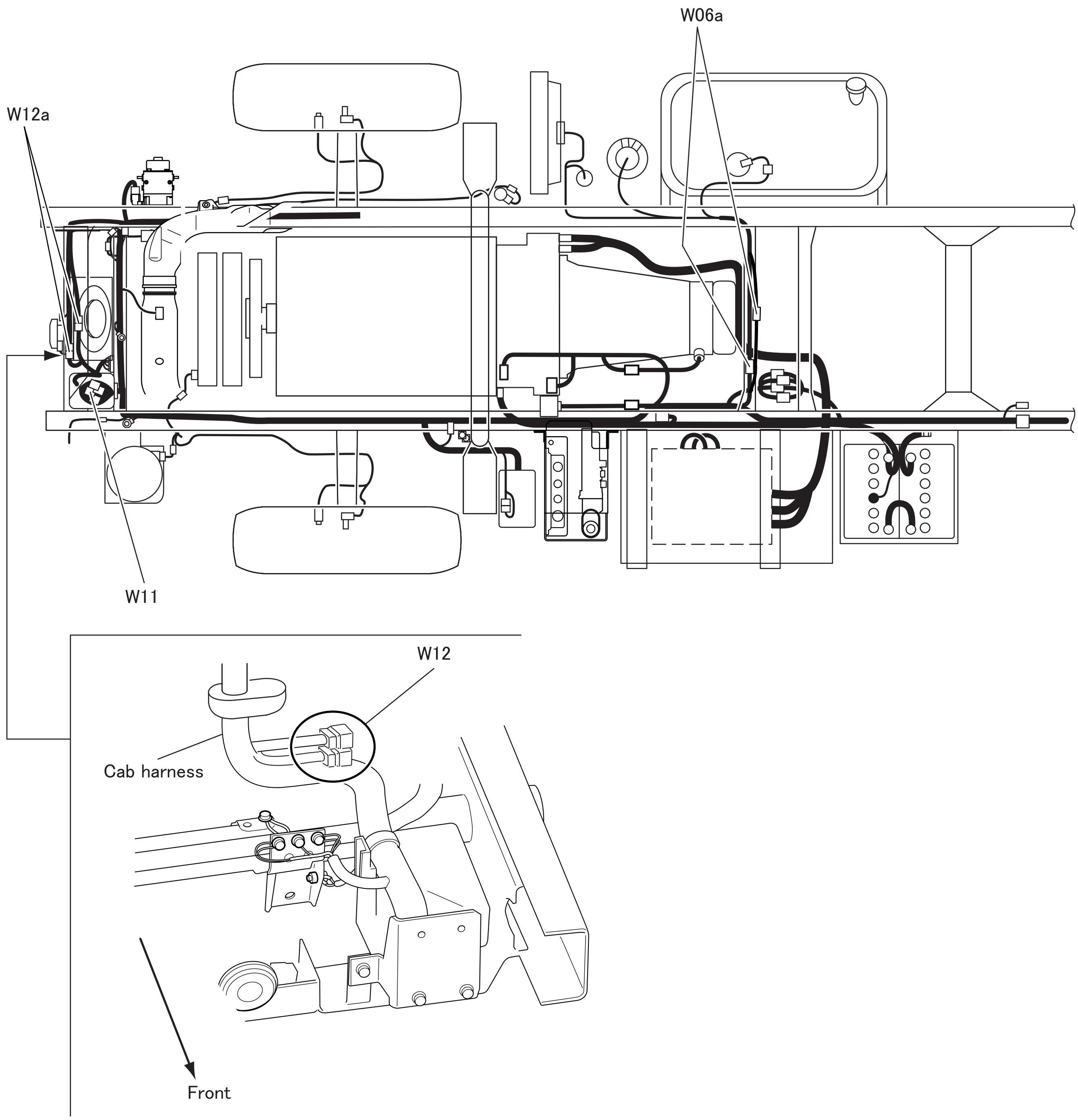
U01 High–current fuse box
U02 High–current fuse, fuse
U18 EDU reray
U27 EGR EDU
U28 Throttle EDU

V02 Exhaust shutter 3–way magnetic valve 1
V03 Exhaust shutter 3–way magnetic valve 2

EDU : Electronic drive unit
EGR : Exhaust gas recirculation

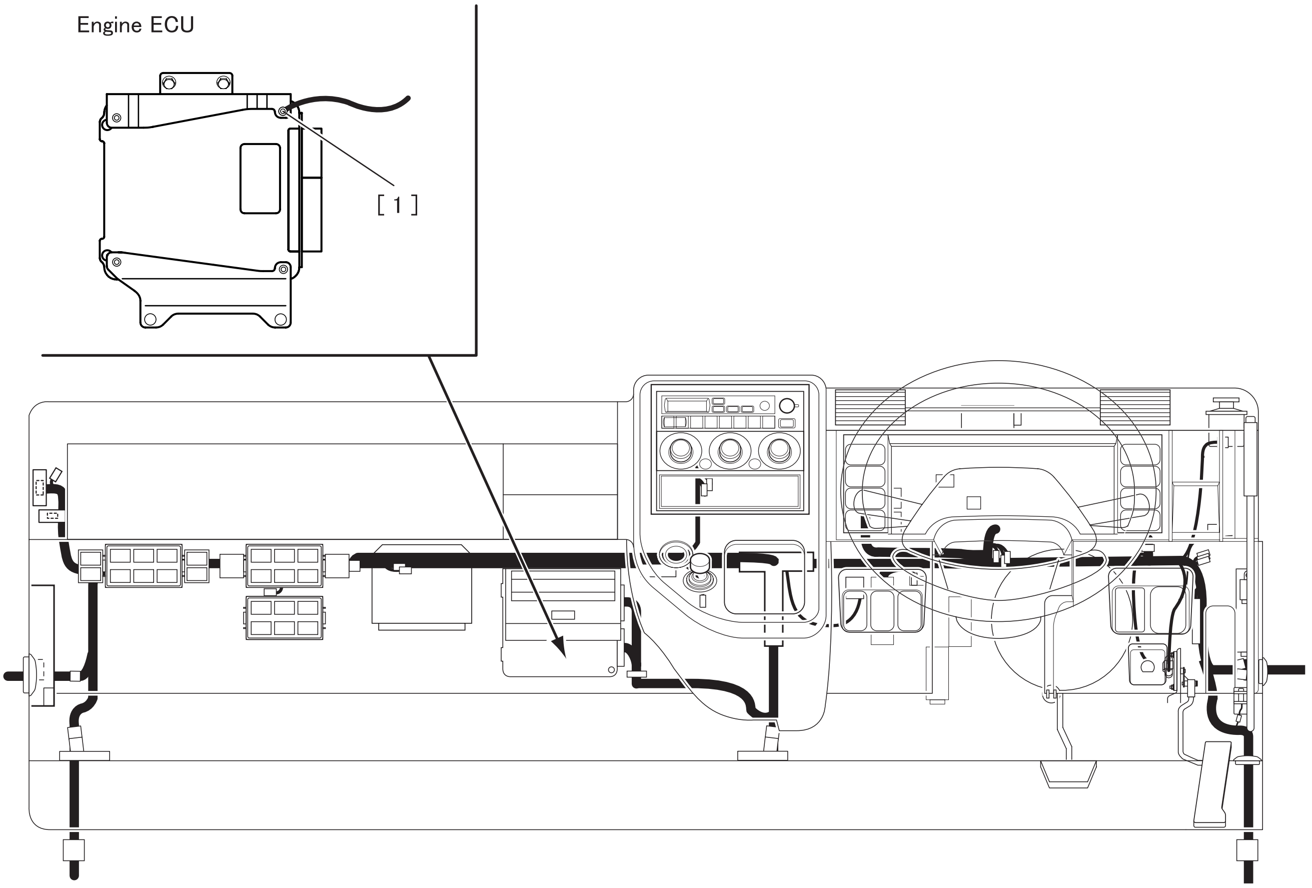
13–L04642

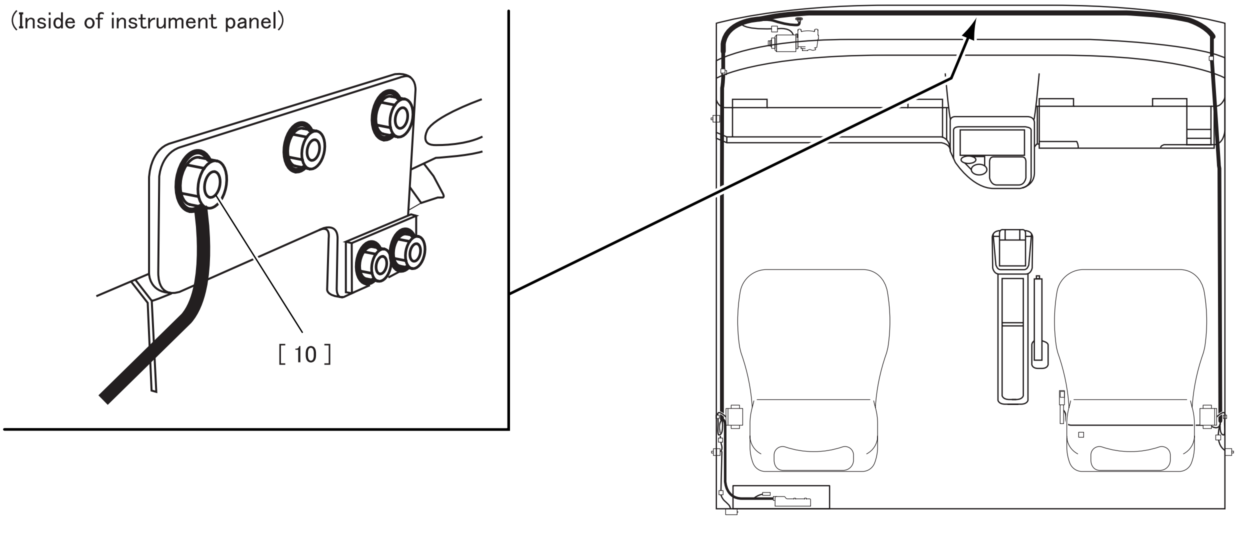
W06-12



W06a Connection of chassis harness and chassis (sub) harness
W11 Connection of cab harness and chassis harness (in connector box)
W12 Connection of cab harness and engine harness
W12a Connection of cab harness and chassis harness

[1]–[10]	Cab ground



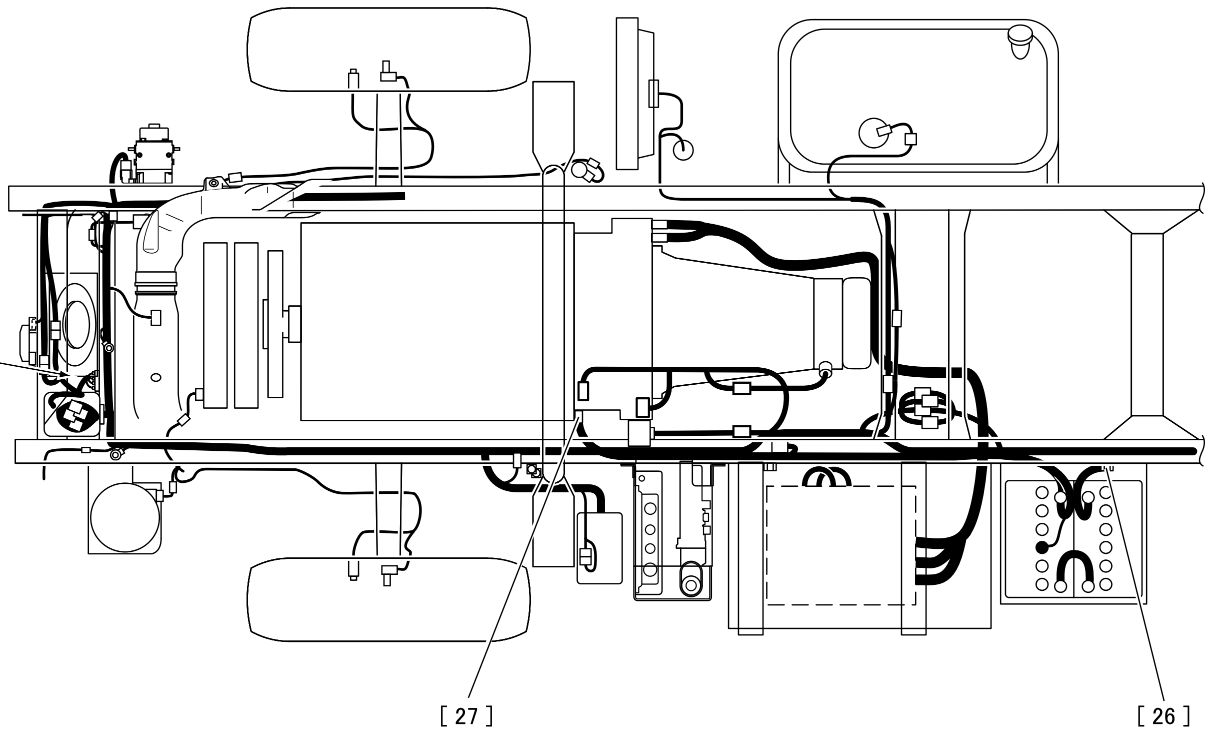


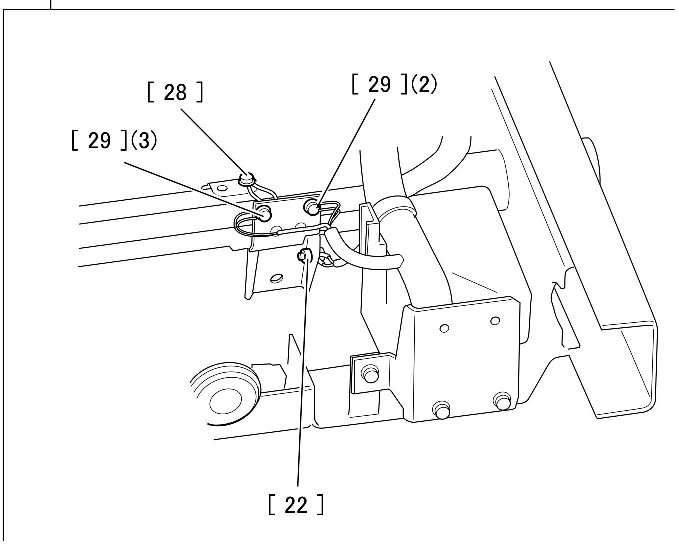
[1]　Ground
[10]　Ground

ECU : Electronic control unit

13–L04647

[22]-[29] Chassis ground

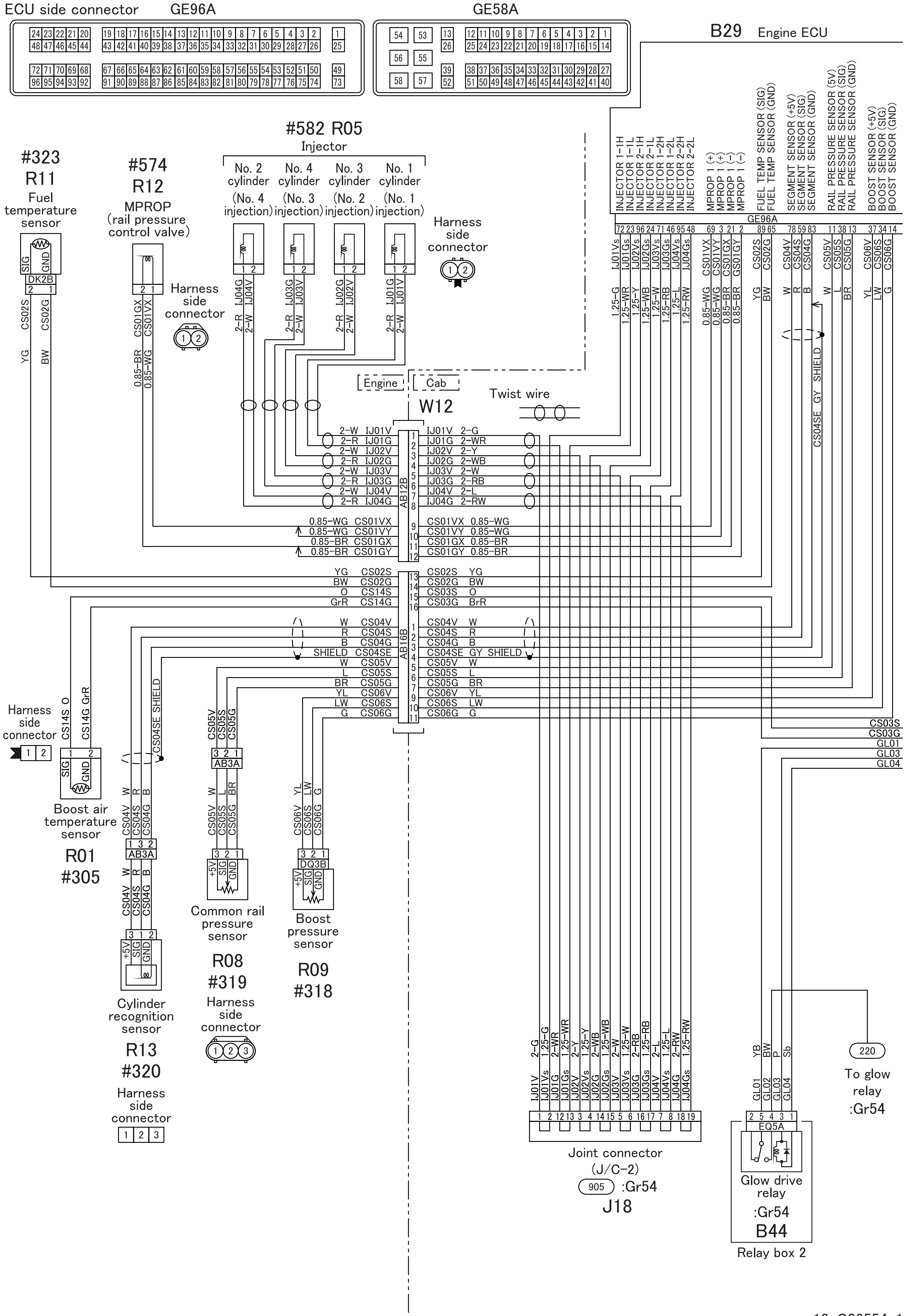


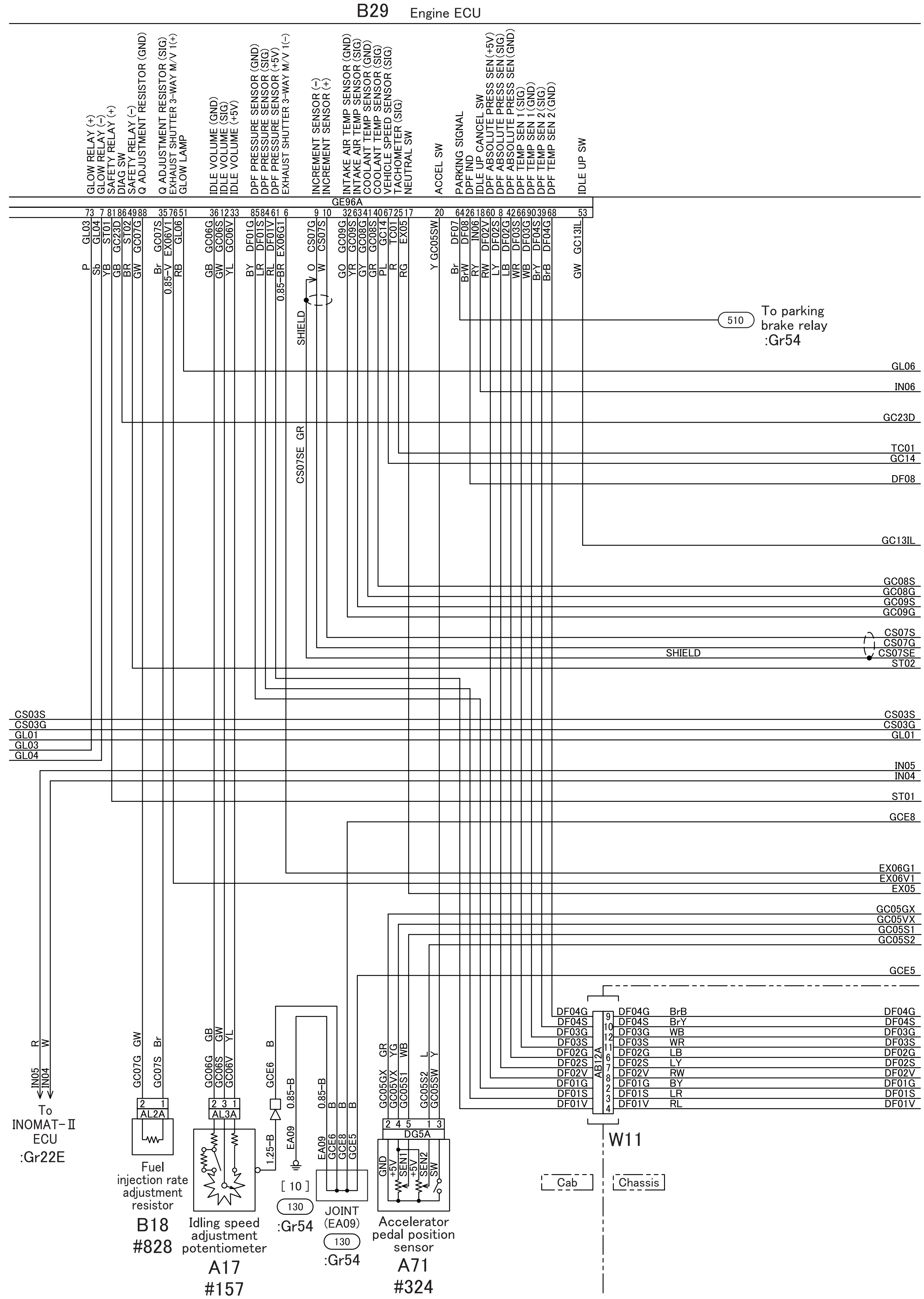


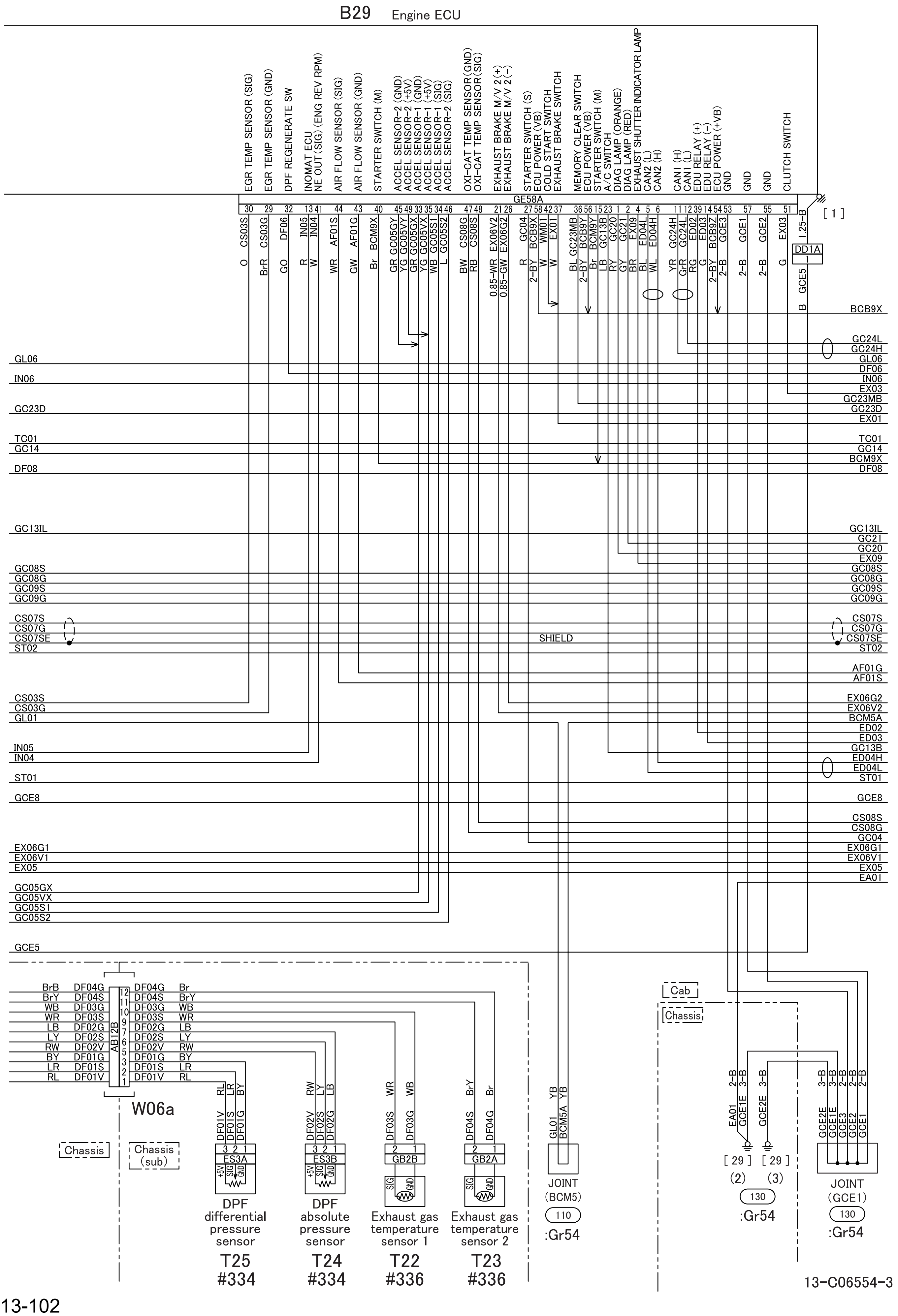
[22] Ground
[26] Ground
[27] Ground
[28] Ground
[29](2) Ground
[29](3) Ground

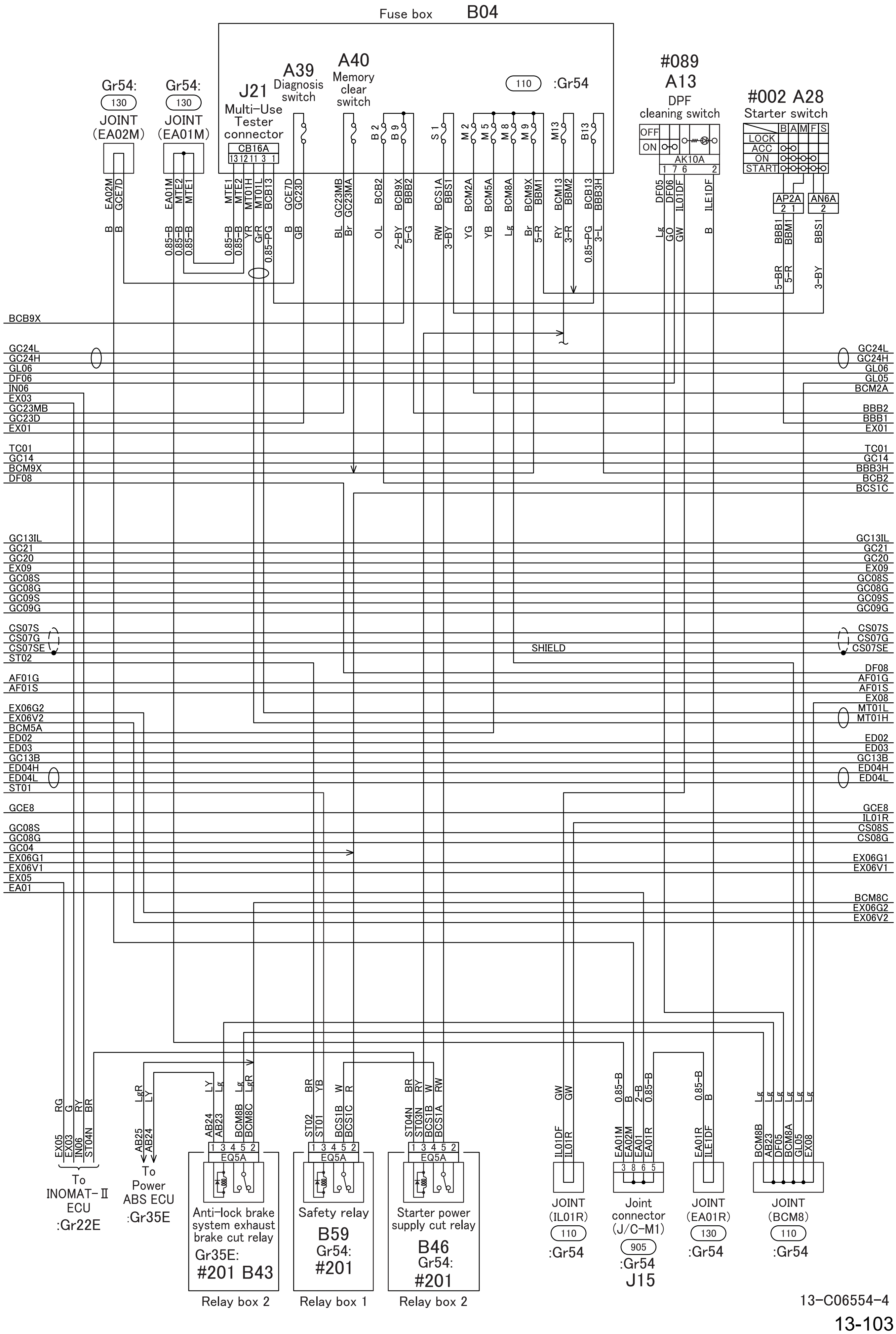
13-L04648

ELECTRIC CIRCUIT DIAGRAM

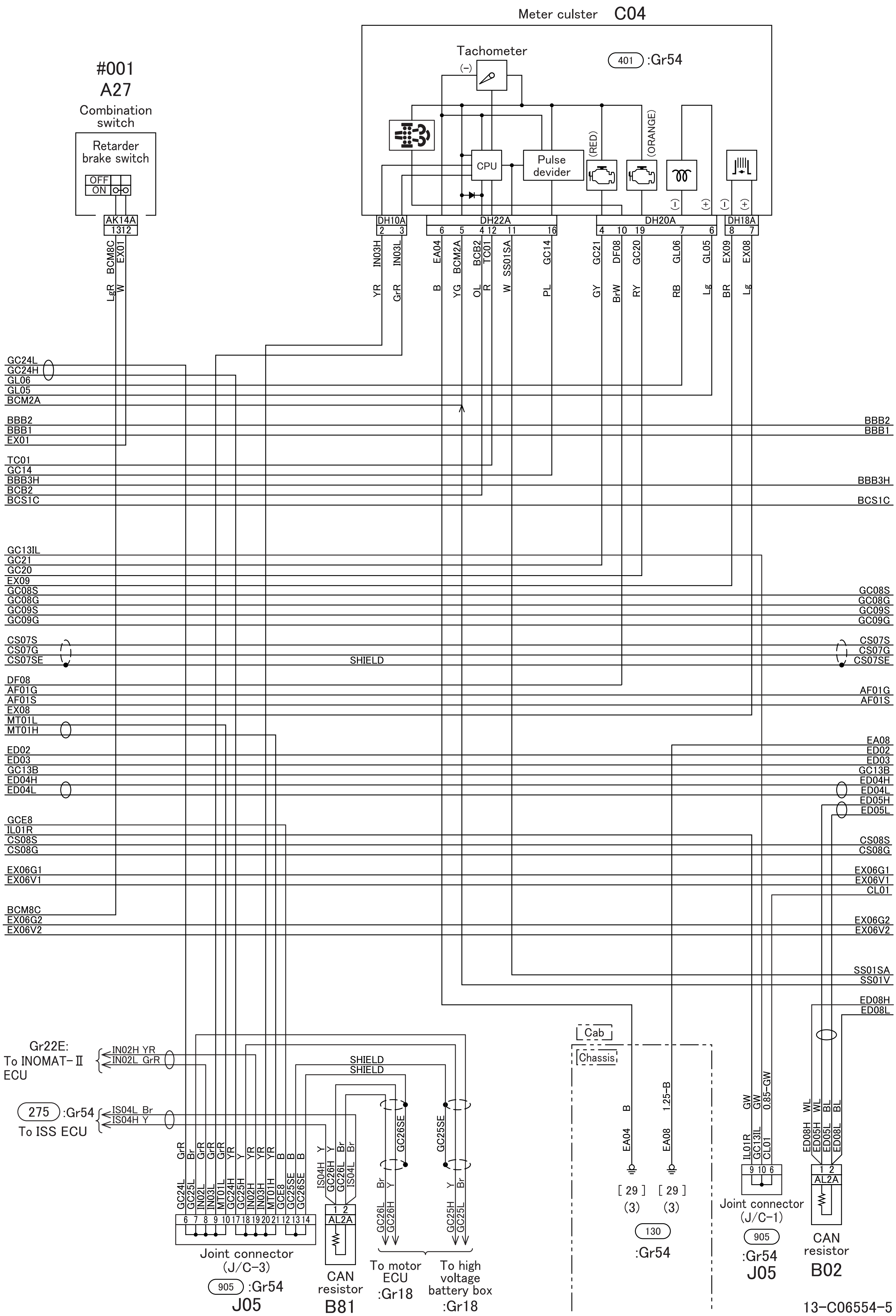


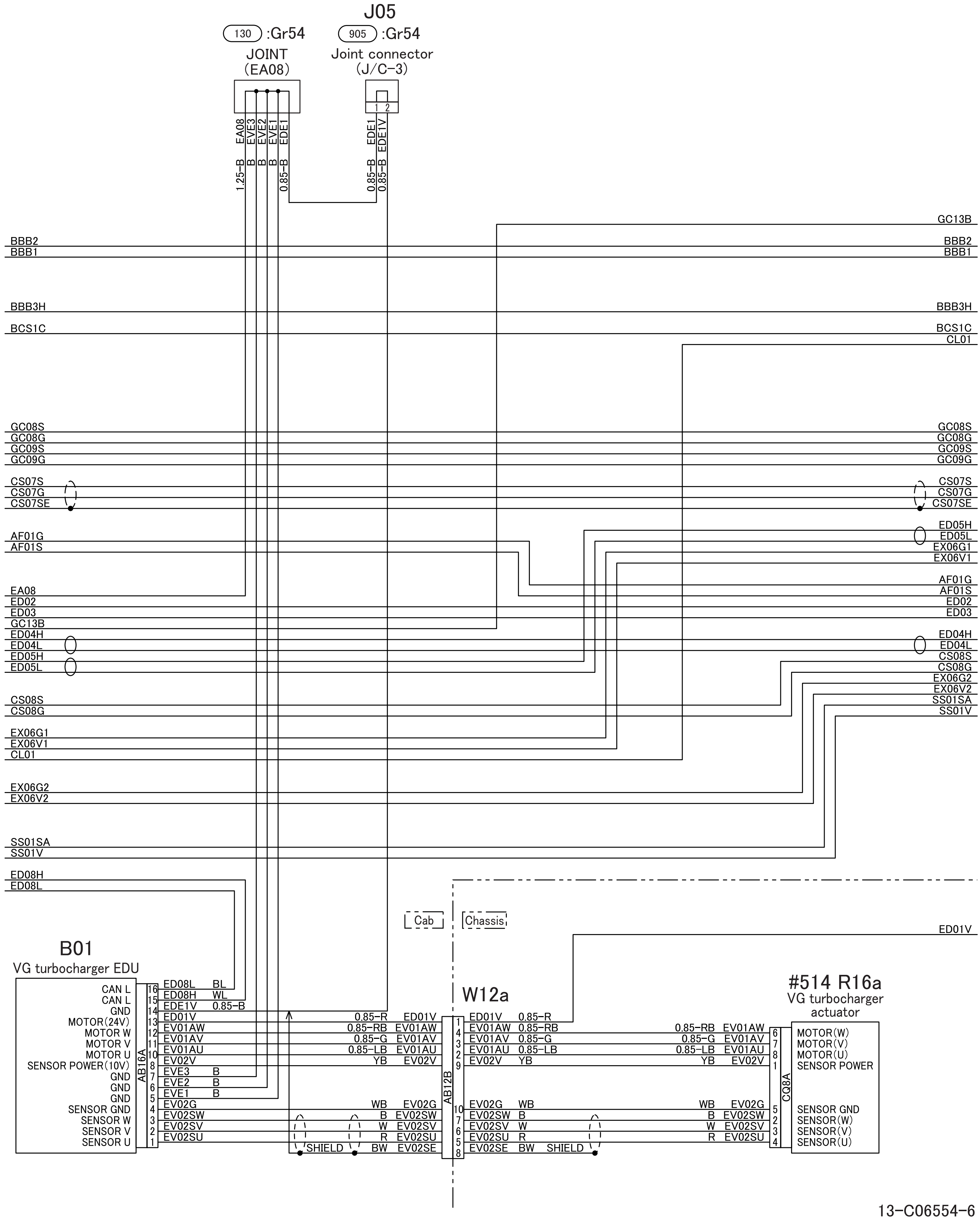

B29 Engine ECU
GLOW RELAY (+)
GLOW RELAY (−)
SAFETY RELAY (+)
DIAG SW
SAFETY RELAY (−)
Q ADJUSTMENT RESISTOR (GND)
Q ADJUSTMENT RESISTOR (SIG)
EXHAUST SHUTTER 3-WAY M/V 1(+)
GLOW LAMP
IDLE VOLUME (GND)
IDLE VOLUME (SIG)
IDLE VOLUME (+5V)
DPF PRESSURE SENSOR (GND)
DPF PRESSURE SENSOR (SIG)
DPF PRESSURE SENSOR (+5V)
EXHAUST SHUTTER 3-WAY M/V 1(−)
INCREMENT SENSOR (−)
INCREMENT SENSOR (+)
INTAKE AIR TEMP SENSOR (GND)
INTAKE AIR TEMP SENSOR (SIG)
COOLANT TEMP SENSOR (GND)
COOLANT TEMP SENSOR (SIG)
VEHICLE SPEED SENSOR (SIG)
TACHOMETER (SIG)
NEUTRAL SW
ACCEL SW
PARKING SIGNAL
DPF IND
IDLE UP CANCEL SW
DPF ABSOLUTE PRESS SEN(+5V)
DPF ABSOLUTE PRESS SEN(SIG)
DPF ABSOLUTE PRESS SEN(GND)
DPF TEMP SEN 1(SIG)
DPF TEMP SEN 1(GND)
DPF TEMP SEN 2(SIG)
DPF TEMP SEN 2(GND)
IDLE UP SW
GE96A
SHIELD
To parking brake relay :Gr54
510
GL06
IN06
GC23D
TC01
GC14
DF08
GC13IL
GC08S
GC08G
GC09S
GC09G
CS07S
CS07G
CS07SE
ST02
CS03S
CS03G
GL01
GL03
GL04
IN05
IN04
ST01
GCE8
EX06G1
EX06V1
EX05
GC05GX
GC05VX
GC05S1
GC05S2
GCE5
To INOMAT-Ⅱ ECU :Gr22E
AL2A
AL3A
Fuel injection rate adjustment resistor
B18
#828
Idling speed adjustment potentiometer
A17
#157
[10]
130
:Gr54
JOINT (EA09)
DG5A
Accelerator pedal position sensor
A71
#324
AB12A
W11
Cab
Chassis


B29 Engine ECU
EGR TEMP SENSOR (SIG)
EGR TEMP SENSOR (GND)
DPF REGENERATE SW
INOMAT ECU
NE OUT (SIG) (ENG REV RPM)
AIR FLOW SENSOR (SIG)
AIR FLOW SENSOR (GND)
STARTER SWITCH (M)
ACCEL SENSOR-2 (GND)
ACCEL SENSOR-2 (+5V)
ACCEL SENSOR-1 (GND)
ACCEL SENSOR-1 (+5V)
ACCEL SENSOR-1 (SIG)
ACCEL SENSOR-2 (SIG)
OXI-CAT TEMP SENSOR (GND)
OXI-CAT TEMP SENSOR (SIG)
EXHAUST BRAKE M/V 2 (+)
EXHAUST BRAKE M/V 2 (−)
STARTER SWITCH (S)
ECU POWER (VB)
COLD START SWITCH
EXHAUST BRAKE SWITCH
MEMORY CLEAR SWITCH
ECU POWER (VB)
STARTER SWITCH (M)
A/C SWITCH
DIAG LAMP (ORANGE)
DIAG LAMP (RED)
EXHAUST SHUTTER INDICATOR LAMP
CAN2 (L)
CAN2 (H)
CAN1 (H)
CAN1 (L)
EDU RELAY (+)
EDU RELAY (−)
ECU POWER (+VB)
GND
GND
GND
CLUTCH SWITCH
GE58A
[1]
DD1A
SHIELD
W06a
AB12B
Cab
Chassis
Chassis (sub)
ES3A
ES3B
GB2B
GB2A
DPF differential pressure sensor
T25 #334
DPF absolute pressure sensor
T24 #334
Exhaust gas temperature sensor 1
T22 #336
Exhaust gas temperature sensor 2
T23 #336
JOINT (BCM5)
110
:Gr54
[29] [29]
(2) (3)
130
:Gr54
JOINT (GCE1)
130
:Gr54
13-C06554-3

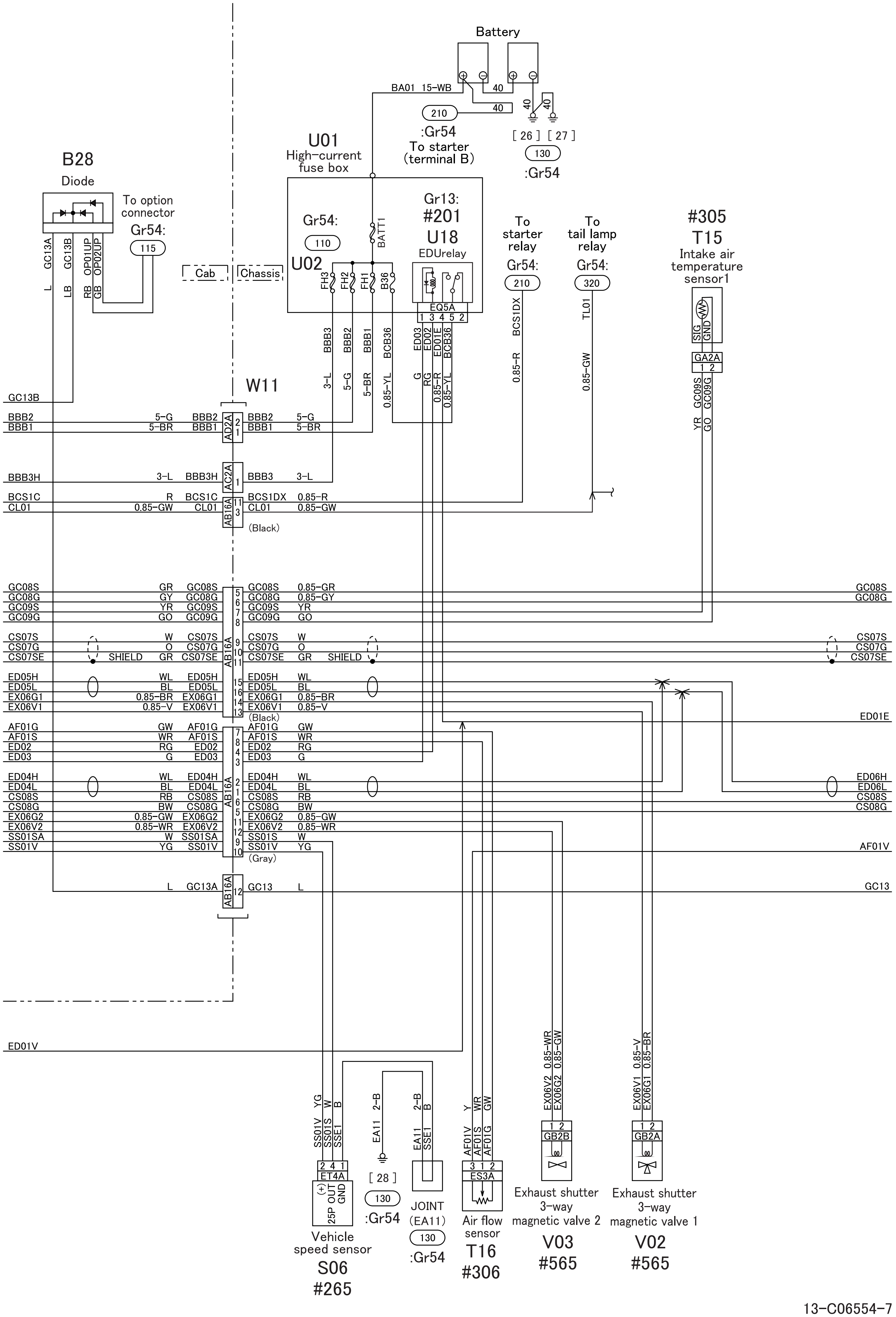

Fuse box B04
A39 Diagnosis switch
A40 Memory clear switch
J21 Multi-Use Tester connector
Gr54: 130 JOINT (EA02M)
Gr54: 130 JOINT (EA01M)
110 :Gr54
#089 A13 DPF cleaning switch
#002 A28 Starter switch
SHIELD
To INOMAT-II ECU :Gr22E
To Power ABS ECU :Gr35E
Anti-lock brake system exhaust brake cut relay
Gr35E: #201 B43
Relay box 2
Safety relay
B59 Gr54: #201
Relay box 1
Starter power supply cut relay
B46 Gr54: #201
Relay box 2
JOINT (IL01R) 110 :Gr54
Joint connector (J/C-M1) 905 :Gr54 J15
JOINT (EA01R) 130 :Gr54
JOINT (BCM8) 110 :Gr54
13-C06554-4

ELECTRIC CIRCUIT DIAGRAM

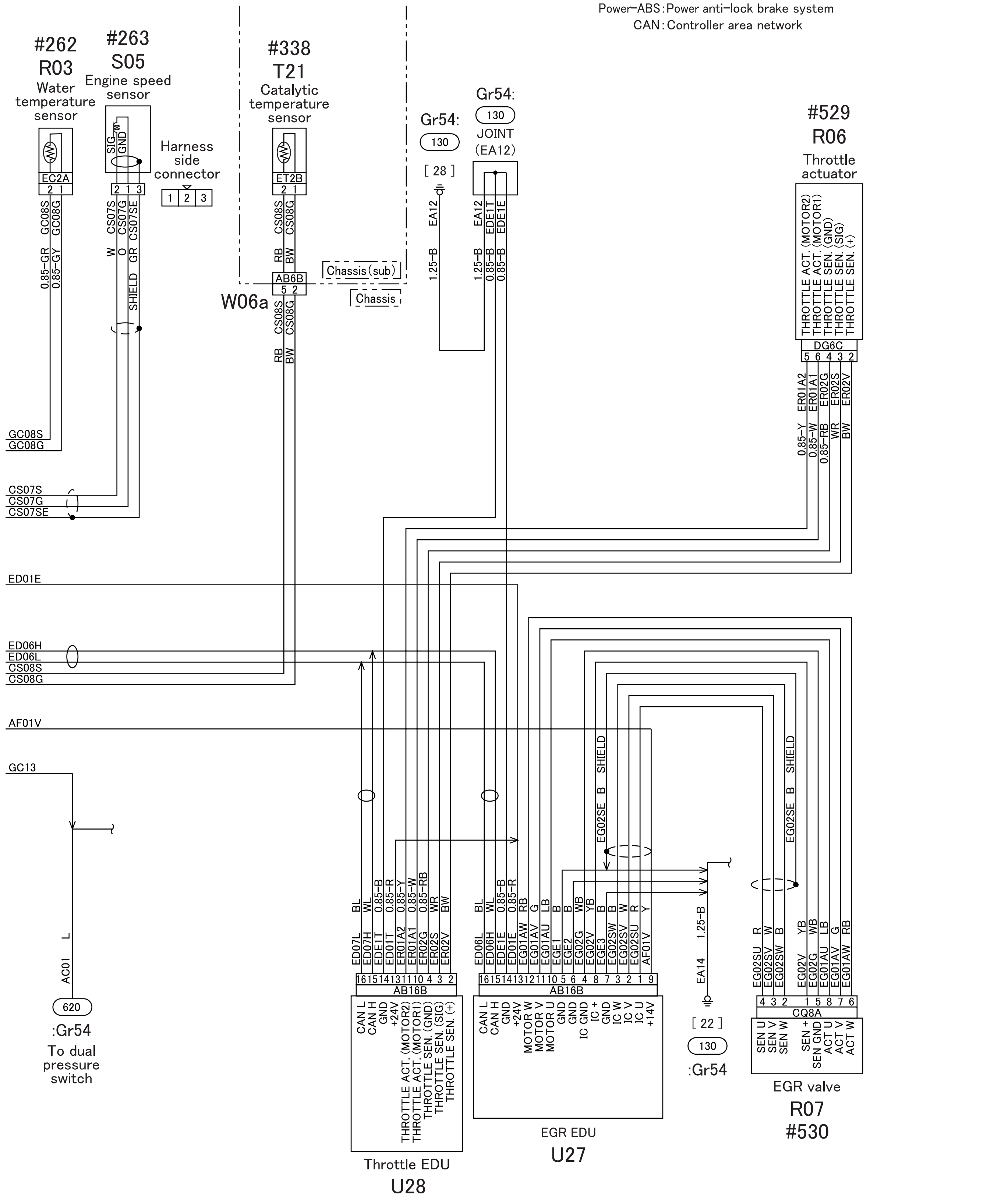



J05
130 :Gr54
JOINT
(EA08)
905 :Gr54
Joint connector
(J/C-3)
EA08 EVE3 EVE2 EVE1 EDE1
1.25-B B B B 0.85-B
EDE1 EDE1V
0.85-B 0.85-B
GC13B
BBB2
BBB1
BBB3H
BCS1C
CL01
GC08S
GC08G
GC09S
GC09G
CS07S
CS07G
CS07SE
AF01G
AF01S
ED05H
ED05L
EX06G1
EX06V1
EA08
ED02
ED03
GC13B
ED04H
ED04L
ED05H
ED05L
CS08S
CS08G
EX06G2
EX06V2
SS01SA
SS01V
EX06G1
EX06V1
CL01
EX06G2
EX06V2
SS01SA
SS01V
ED08H
ED08L
Cab
Chassis
ED01V
B01
VG turbocharger EDU
CAN L
CAN L
GND
MOTOR(24V)
MOTOR W
MOTOR V
MOTOR U
SENSOR POWER(10V)
GND
GND
GND
SENSOR GND
SENSOR W
SENSOR V
SENSOR U
AB16A
ED08L BL
ED08H WL
EDE1V 0.85-B
ED01V
EV01AW
EV01AV
EV01AU
EV02V
EVE3 B
EVE2 B
EVE1 B
EV02G
EV02SW
EV02SV
EV02SU
SHIELD
W12a
AB12B
0.85-R ED01V
0.85-RB EV01AW
0.85-G EV01AV
0.85-LB EV01AU
YB EV02V
WB EV02G
B EV02SW
W EV02SV
R EV02SU
BW EV02SE
ED01V 0.85-R
EV01AW 0.85-RB
EV01AV 0.85-G
EV01AU 0.85-LB
EV02V YB
EV02G WB
EV02SW B
EV02SV W
EV02SU R
EV02SE BW SHIELD
#514 R16a
VG turbocharger
actuator
CQ8A
0.85-RB EV01AW
0.85-G EV01AV
0.85-LB EV01AU
YB EV02V
WB EV02G
B EV02SW
W EV02SV
R EV02SU
MOTOR(W)
MOTOR(V)
MOTOR(U)
SENSOR POWER
SENSOR GND
SENSOR(W)
SENSOR(V)
SENSOR(U)
13-C06554-6

ELECTRIC CIRCUIT DIAGRAM



ECU: Electronic control unit
EDU: Electronic drive unit
DPF: Diesel particulate filter
EGR: Exhaust gas recirculation
VG: Variable geometry
INOMAT-Ⅱ: Intelligent and innovative mechanical automatic transmission-Ⅱ
ISS: Idling stop and start system
Power-ABS: Power anti-lock brake system
CAN: Controller area network

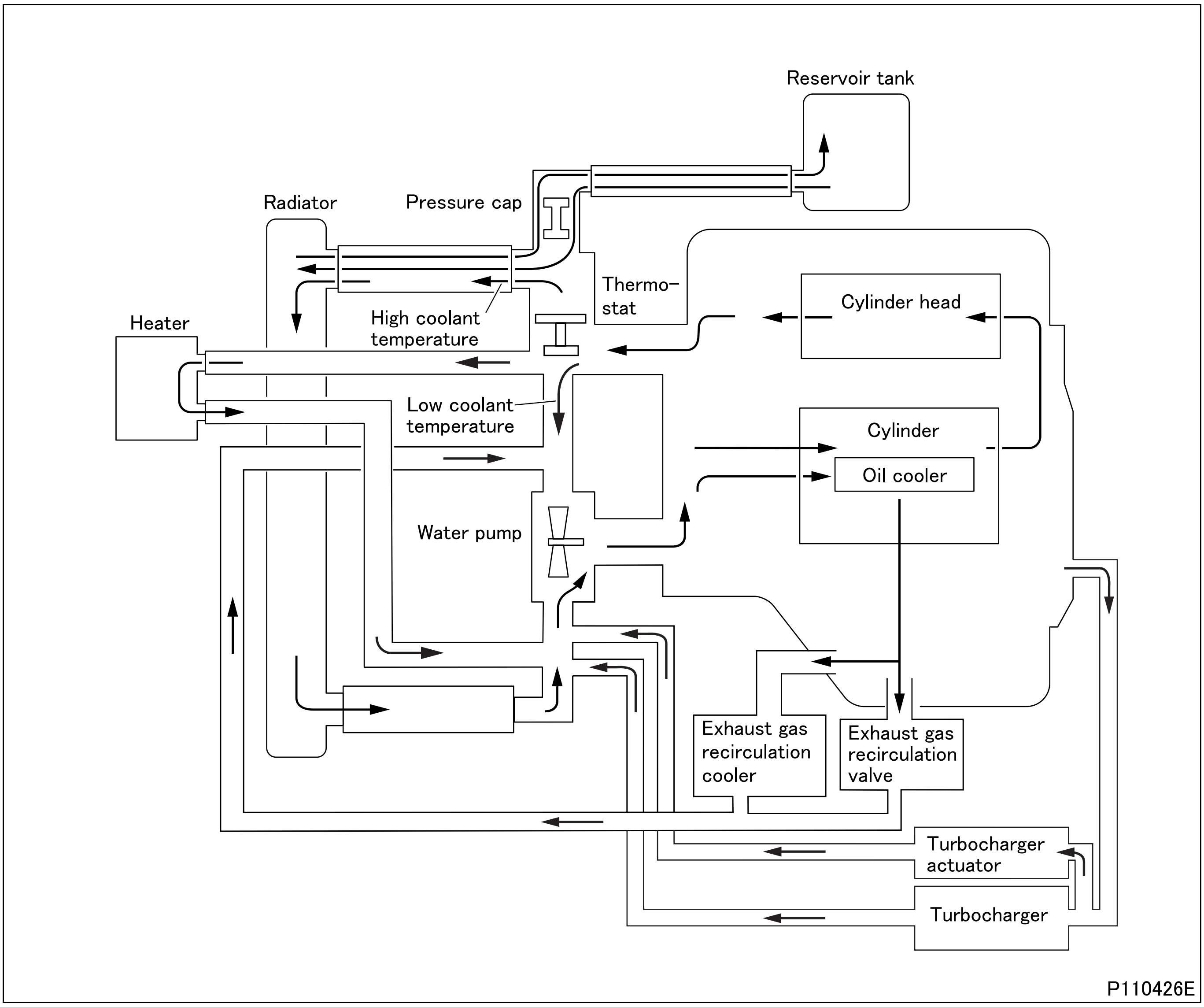


GROUP 14 COOLING

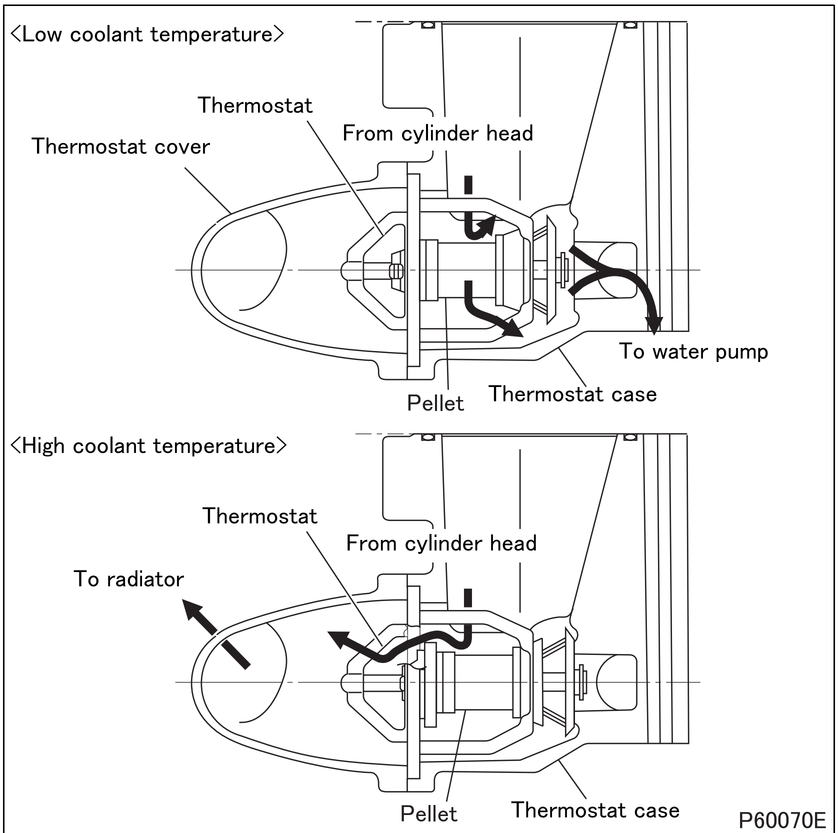
SPECIFICATIONS

Item		Specifications
Cooling system		Forced water circulation system
Water pump		Belt-driven involute type
Thermostat		Wax pellet, bottom bypass type (with jiggle valve)
Automatic cooling fan coupling		Continuous control type
Radiator		Tube and corrugated fin type
Coolant capacity	dm^3 {L}	11.2 {11.2}

1. Cooling System (Flow of Coolant)



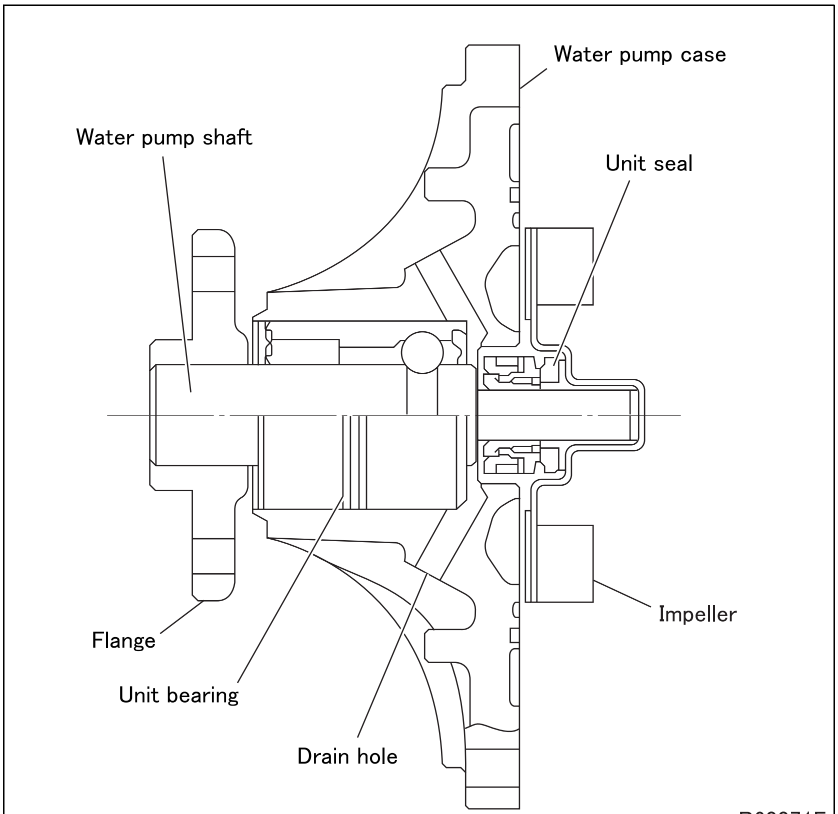
2. Thermostat



P60070E

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

3. Water Pump



P60071E

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

Possible causes		Overheating (poor cooling)	Overcooling	Abnormal noise	Excessive coolant loss	Reference Gr
Belt	Loose or damaged	O		O		
	Excessive tension			O		
	Oil on belt	O				
Water pump	Incorrectly mounted water pump	O			O	
	Defective gasket	O			O	
	Defective unit bearing	O		O		
	Defective impeller	O				
	Defective unit seal	O			O	
	Fit of unit bearing on flange and impeller too loose	O		O		
Thermostat	Incorrectly mounted case	O			O	
	Defective gasket	O			O	
	Valve opening temperature too high (valve remains closed)	O				
	Valve opening temperature too low (valve remains open)		O			
	Leakage from coolant temperature sensor	O			O	
Radiator	Clogged core	O				
	Cracked core and/or separation in welds	O			O	
	Cracks in upper tank and/or lower tank	O			O	
	Defective caulking of upper tank and/or lower tank	O			O	
	Defective packing of upper tank and/or lower tank	O			O	
Automatic cooling fan coupling	Defective bearing	O		O		
	Damaged bimetal	O				
	Contaminated bimetal	O	O			
	Silicon oil leakage	O		O		
Cylinder head	Incorrectly mounted cylinder head	O			O	Gr11
	Defective gasket	O			O	
Oil cooler	Incorrectly mounted oil cooler	O			O	Gr12
	Defective gasket	O			O	
EGR-related items	Incorrectly mounted EGR cooler bracket	O			O	Gr17
	Incorrectly mounted EGR cooler	O			O	
	Incorrectly mounted connector	O			O	
	Incorrectly mounted adapter	O			O	
	Damaged O-ring	O			O	
Poorly airtight pressure cap		O				
Insufficient coolant amount, contaminated coolant		O				
Clogged or scaled coolant passage		O				
Incorrectly connected hoses		O			O	
Incorrectly connected pipes		O			O	
Excessively low exterior temperature			O			

*EGR: Exhaust gas recirculation

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Inspection and Adjustment of Belt Tension

CAUTION ⚠

- **Make sure that there is no oil or grease on the belts. Belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**

Service standards (Unit: mm)

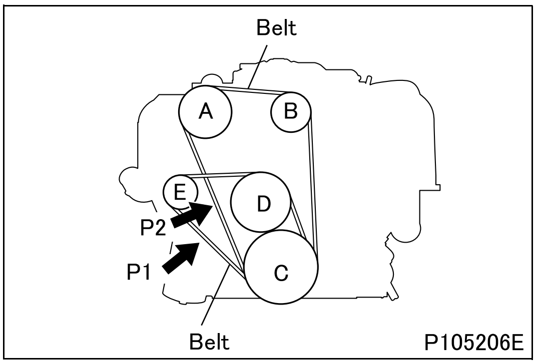
Location	Maintenance item		Standard value	Limit	Remedy
–	Belt tension <For fan>	When new	14.5 to 16	–	Adjust
		When reused	17 to 19		
	Belt tension <For air conditioner>	When new	18 to 21.5	–	Adjust
		When reused	23 to 26		

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Nut (tension pulley mounting)	42.2 {4.3}	–

Special tools

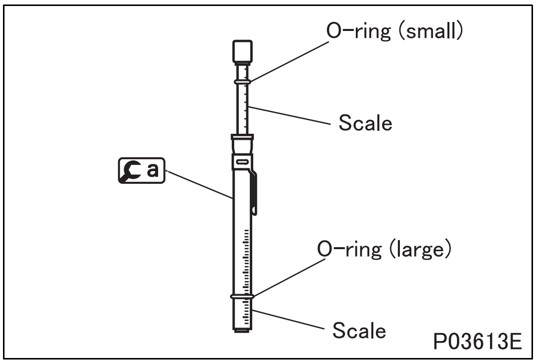
Mark	Tool name and shape	Part No.	Application
a	Belt tension gauge  P03612	MH062345	Measurement of tension of belt



P105206E

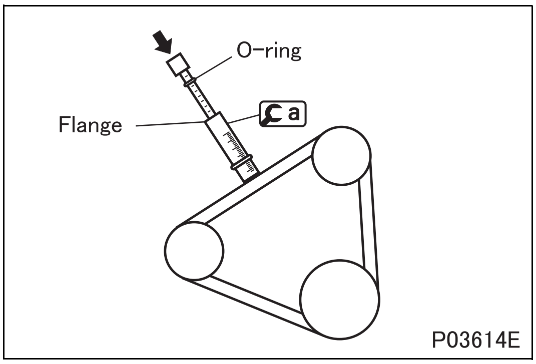
[Inspection]

- Press each belt at a central portion between pulleys with a force of approximately 98 N {10 kgf} as shown in the illustration and measure the amount of deflection of the belt.
  - A: Cooler compressor pulley (for air conditioner)
  - B: Tension pulley (for air conditioner)
  - C: Crankshaft pulley
  - D: Water pump pulley
  - E: Alternator pulley
  - P1, P2: Belt measuring part

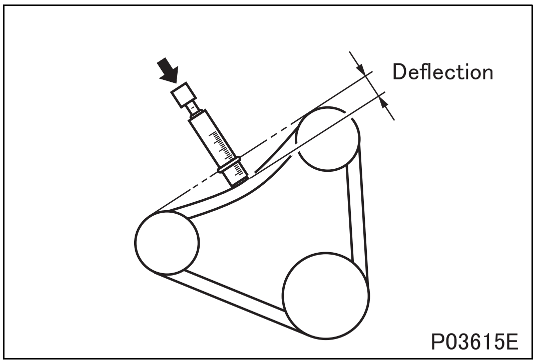


P03613E

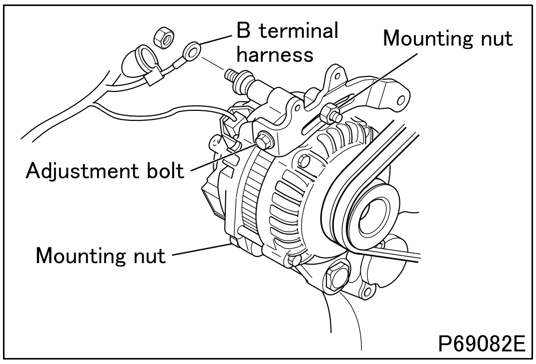
- Place the small O-ring on a at the scale mark corresponding to 98 N {10 kgf} (press force).
- Place the large O-ring on a at the scale mark corresponding to the maximum permissible deflection value specified for the belt.



- Place [a] at a central portion between pulleys of the belt and push the handle (indicated by the arrow in the illustration) until the O-ring touches the flange.



- Measure the amount of deflection of the belt.
- If the measured value deviates from the standard value range, adjust the tension of the belt as follows.



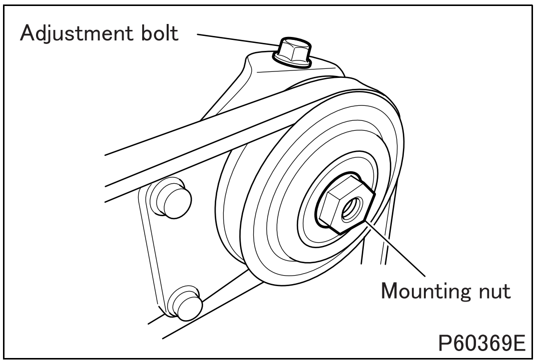
[Adjustment]

(1) Belt for fan

- Disconnect the negative battery cable from the battery.
- Disconnect the alternator B terminal harness from the alternator.
- Loosen the alternator mounting bolt, and adjust the tension of the belt by moving the alternator as required.
- After the adjustment is completed, retighten the mounting nuts firmly.

CAUTION ⚠

- **Do not adjust the belt with the alternator B terminal harness connected, or the harness will be damaged.**
- **Excessive tension in the belt may damage not only the belt itself but also the bearings of the related components.**
- **When the B terminal harness is connected to the alternator, ensure that it will not interfere with its neighboring equipment.**



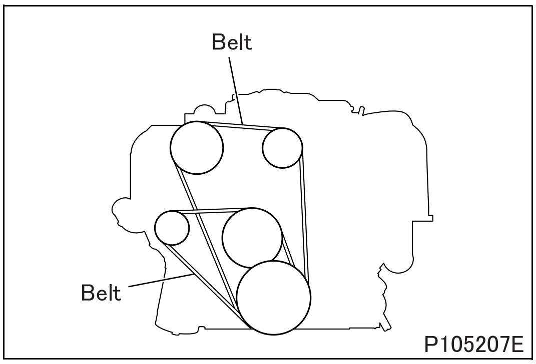
(2) Belt for air conditioner

- Loosen the tension pulley mounting nut and adjust the belt tension by turning the adjustment bolt.
- After the adjustment is completed, tighten the mounting bolt to the specified torque.

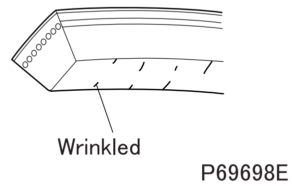
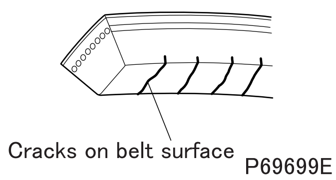
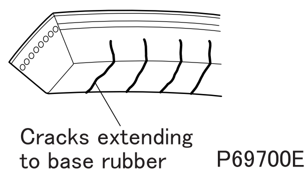
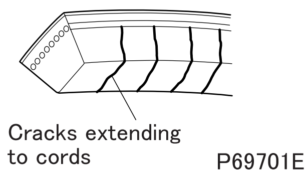
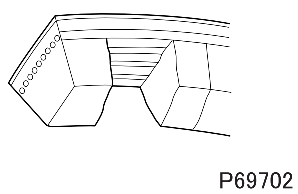
CAUTION ⚠

- **Excessive tension in the belt may damage not only belt itself but also the bearings of the related components.**

2. Inspection of Cracks or Damage of the Belt



- Visually check the belts for possible cracks and damage.
- If any faults are found, replace the belts.

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

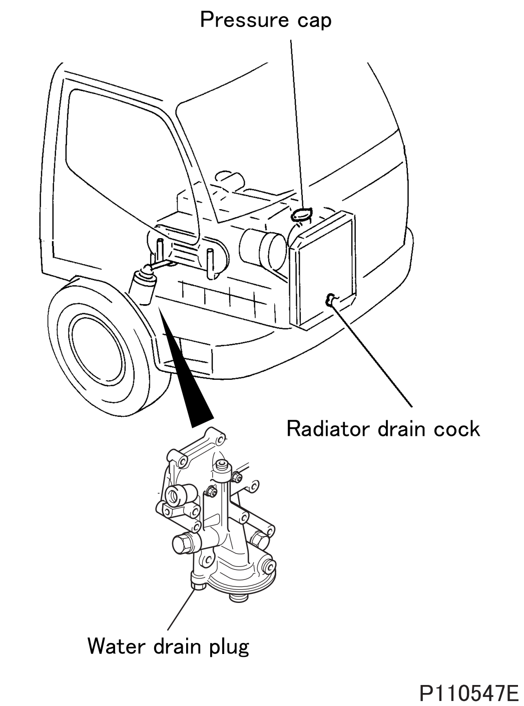
3. Coolant Replacement and Cleaning of Cooling System

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Radiator drain cock	1.5 ± 0.3 {0.15 ± 0.03}	–
–	Water drain plug	29 {3}	–

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

3.1 Draining of coolant



- Before draining the radiator, slowly loosen the pressure cap covered with a shop towel or the like and lower pressure in the cooling system while coolant is cool enough. Remember to drain the coolant out of the reservoir tank as well.

WARNING ⚠

- **Opening the pressure cap while the coolant temperature is still high can cause hot coolant to spray out. Cover the pressure cap with a cloth, and loosen it slowly to let the pressure out before opening it fully.**

3.2 Cleaning procedure

CAUTION ⚠

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

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

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

- Ordinary condition

Flushing with water.

- Coolant extremely dirty
- Radiator clogged

Cleaning using FUSO RADIATOR CLEANER (RADIPET-7).

Drain out coolant.

Make water solution of FUSO RADIATOR CLEANER (RADIPET-7) at 5 to 10 % concentration in volume.

Remove the pressure cap and pour solution into thermostat cover.

Let the engine idle for 30 minutes with the solution at approximately 90°C.

CAUTION ⚠

- **Limit the engine idling period to one hour. Operating an engine containing the cleaning solution for longer time may lead to damage of the cooling system.**

Drain out coolant/cleaning solution.

Remove the pressure cap and pour tap water (preferably hot) into the thermostat cover.

Let the engine idle for 10 minutes with water at approximately 90°C.

Drain out water.

Cleaning is complete if drained water is clear.
Repeat procedure if drained water is not clear.

CAUTION ⚠

- **After cleaning the cooling system using cleaning solution, fill it with coolant containing the specified additive as soon as possible.**
- **To prevent freezing of the coolant and corrosion of the cooling system, use the coolant with the specified ratio of FUSO DIESEL LONGLIFE COOLANT. (See the Owner's Handbook for instructions on the use of the additive.)**

DANGER ⚠

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

WARNING ⚠

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

4. Air Bleeding of Cooling System

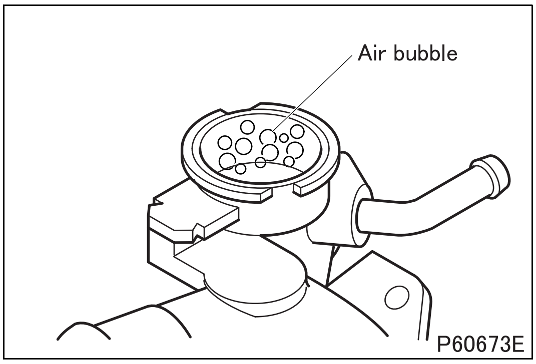
- With the pressure cap removed and the coolant temperature at 90°C, let the engine idle in order to bleed air completely out of the cooling system.
- After air bleeding is completed, refill the reservoir tank with coolant as needed.

5. Air/Gas Leakage Test

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

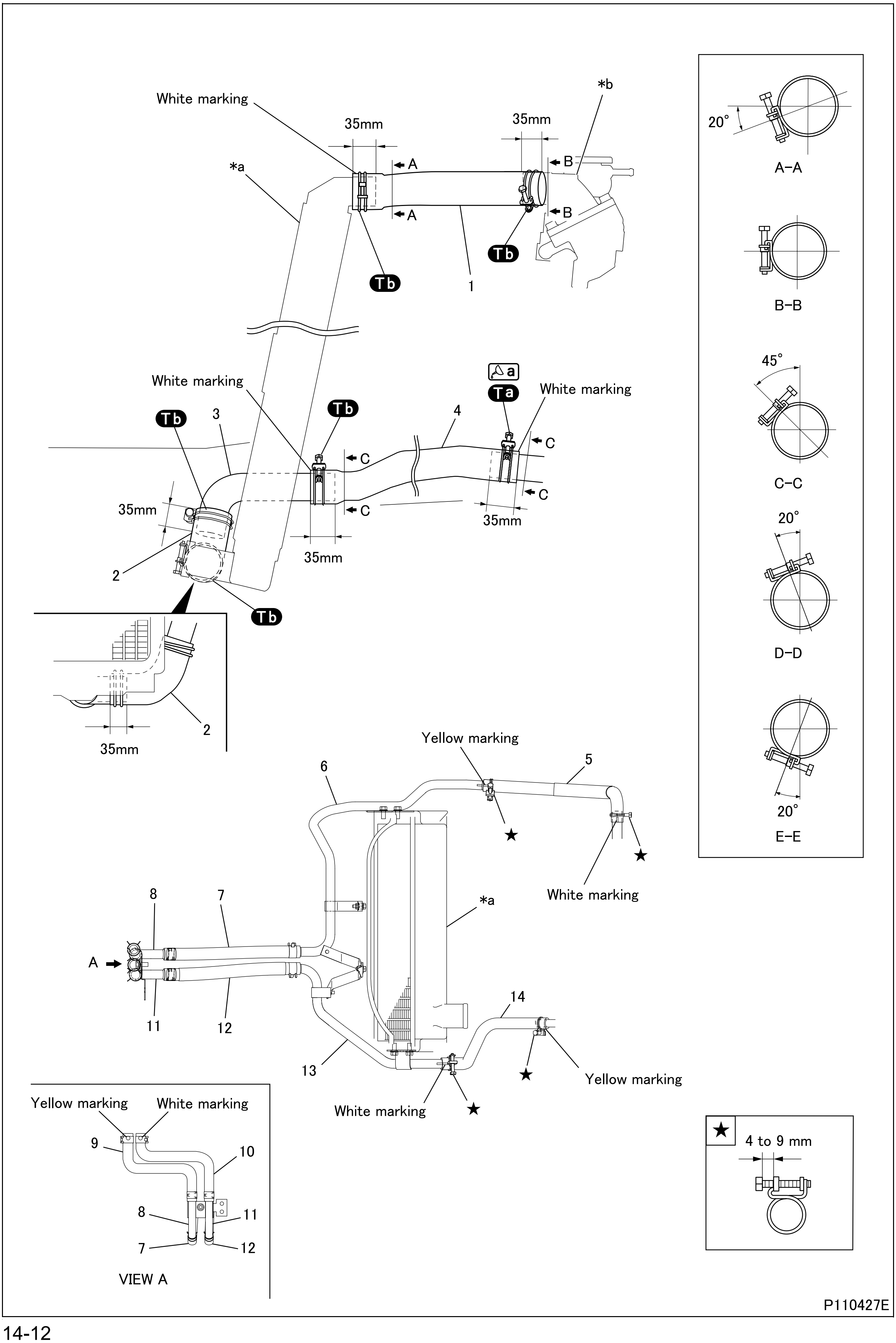
WARNING ⚠

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

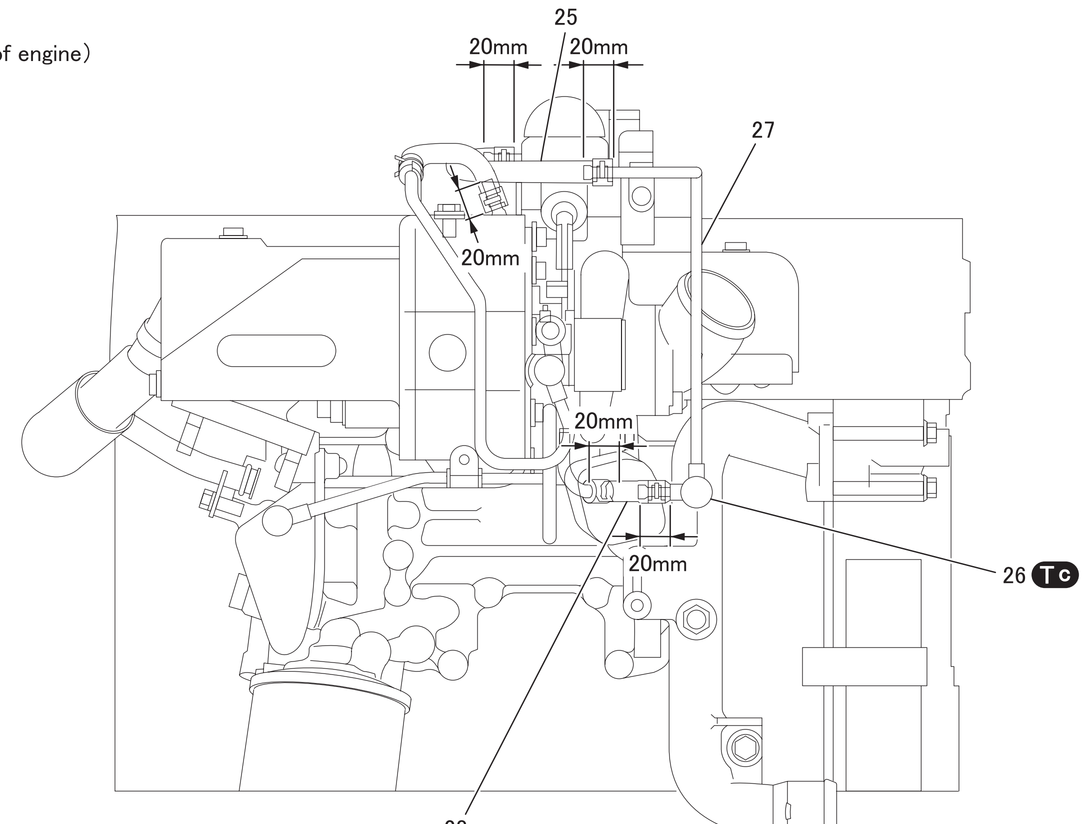


- Run the engine until the coolant temperature rises to approximately 90°C.
- If air bubbles appear continuously through the filler port, there is air or exhaust gas penetrating into the cooling system.
- Presence of air in coolant can be an indication of loose cylinder head bolts, loose water pump mounting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

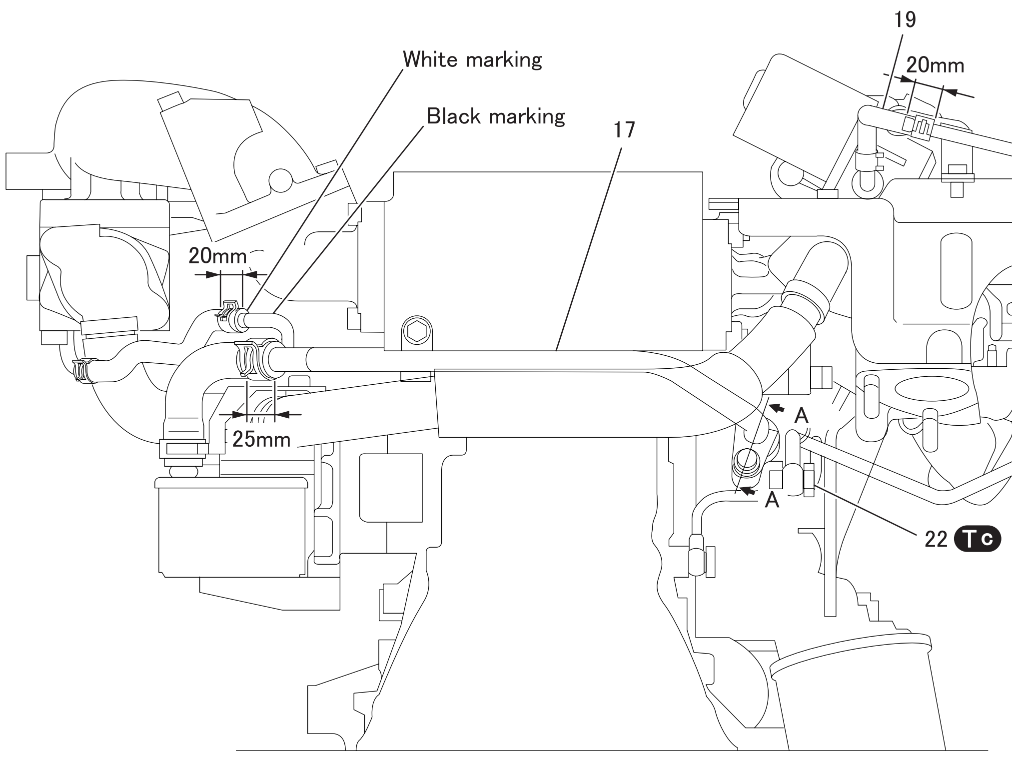
DISCONNECTION AND CONNECTION OF HOSES AND PIPES

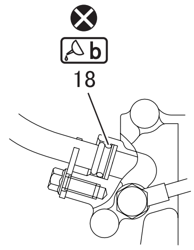


(Right side of engine)



(Rear view of engine)





Cross section A－A

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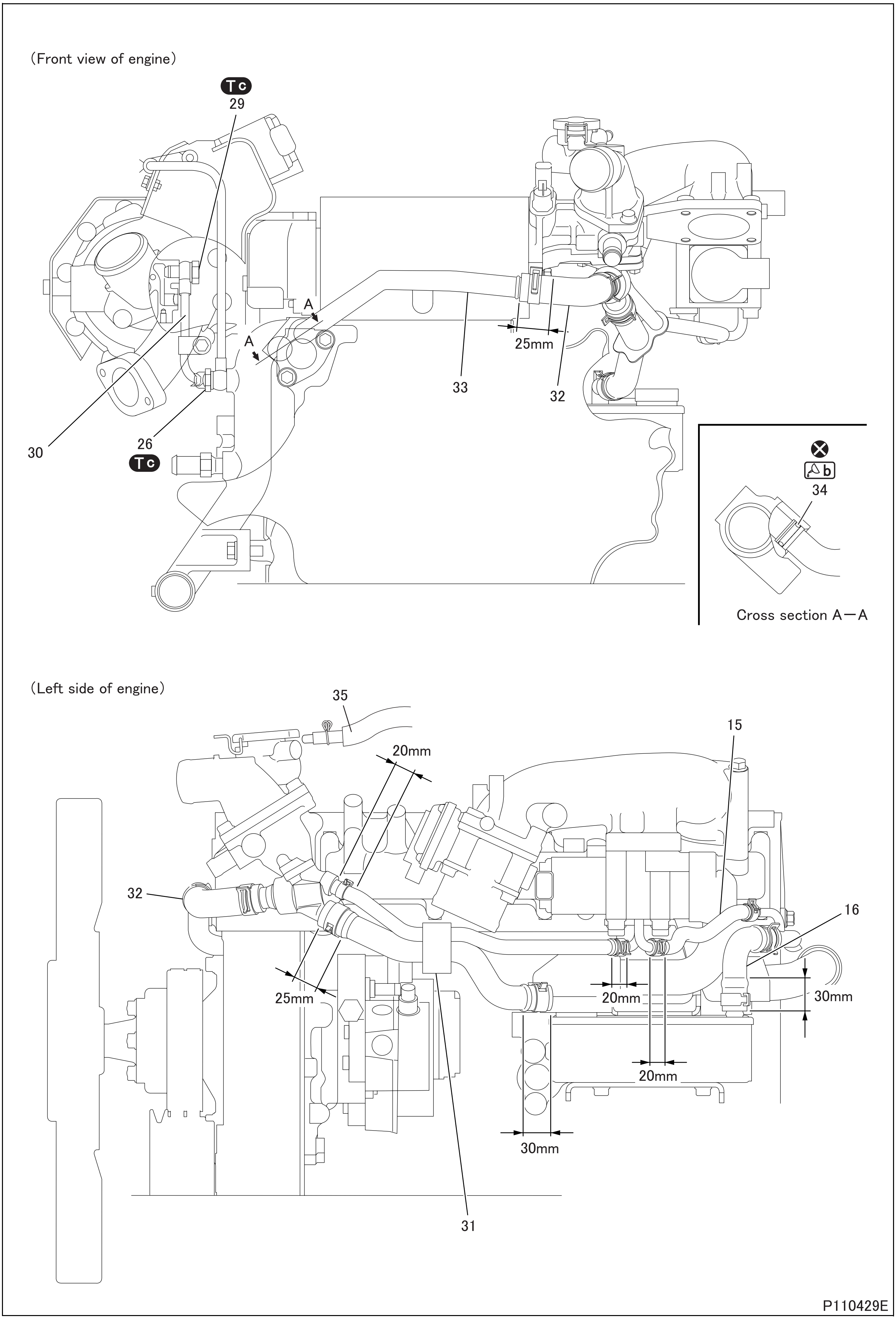
DISCONNECTION AND CONNECTION OF HOSES AND PIPES



● Removal sequence

1 Upper radiator hose
2 Lower radiator hose
3 Radiator pipe
4 Lower radiator hose
5 Heater hose
6 Heater pipe
7 Heater hose
8 Heater pipe
9 Heater hose
10 Heater hose
11 Heater pipe
12 Heater hose
13 Heater pipe
14 Water hose
15 Water hose
16 Water hose
17 Water pipe
18 O-ring
19 Water hose
20 Eyebolt
21 Water pipe
22 Eyebolt
23 Connector
24 Water pipe
25 Water hose
26 Eyebolt
27 Water pipe
28 Water hose
29 Eyebolt
30 Water pipe
31 Water hose
32 Water hose
33 Water pipe
34 O-ring
35 Water hose

*a: Radiator
*b: Thermostat cover

⊗: Non-reusable parts

● Installation sequence

Follow the removal sequence in reverse.

CAUTION ⚠

- **Keep the O-ring free of engine oil. Engine oil will make the O-ring swell, which may cause leakage.**

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

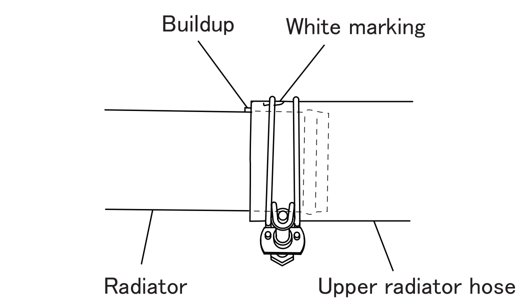
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	1.5 to 2.0 {0.15 to 0.2}	Wet
Tb	Clamp	3.0 to 4.5 {0.3 to 0.5}	–
Tc	Eyebolt	25 {2.6}	–
Td	Connector	93 {9.3}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Clamp screw threads	Engine oil	As required
b	O-ring	Soapy water	As required

◆Installation procedure◆



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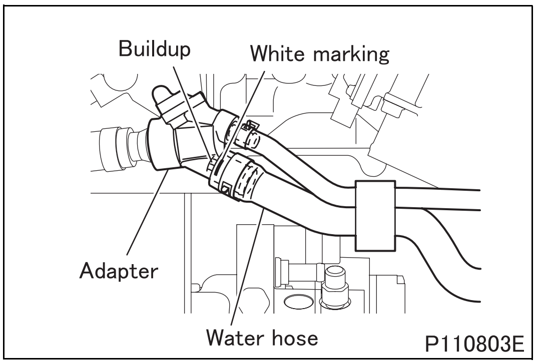
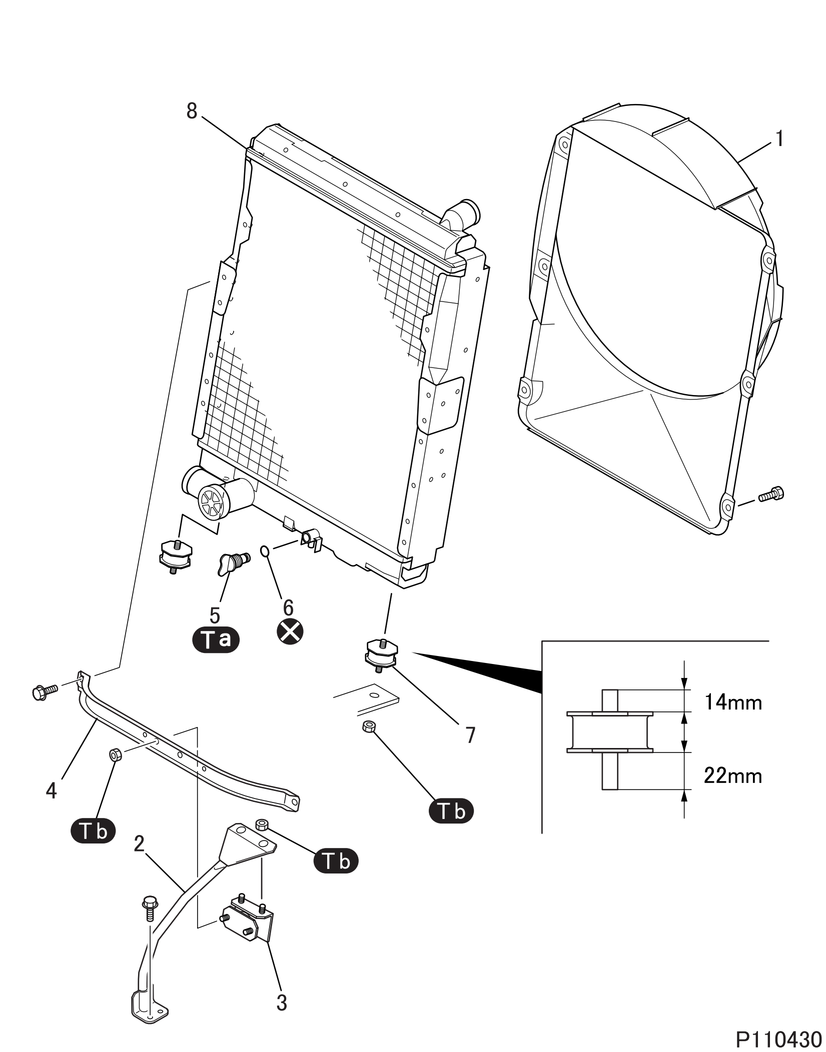
■ Installation: Upper radiator hose

- Connect the upper radiator hose with its marking opposed to the buildup of the radiator.



■ **Installation: Water hose**

- Connect the water hose with its marking opposed to the buildup of the adapter.



● **Removal sequence**

1 Shroud
2 Support rod
3 Support cushion
4 Upper support
5 Radiator drain cock
6 O-ring
7 Support cushion
8 Radiator (See later section.)

⊗: Non-reusable parts

● **Installation sequence**

Follow the removal sequence in reverse.

- See the previous section "DISCONNECTING AND CONNECTION OF HOSES AND PIPES" for the correct insertion depth of radiator as well as the correct tightening torque of clamps.

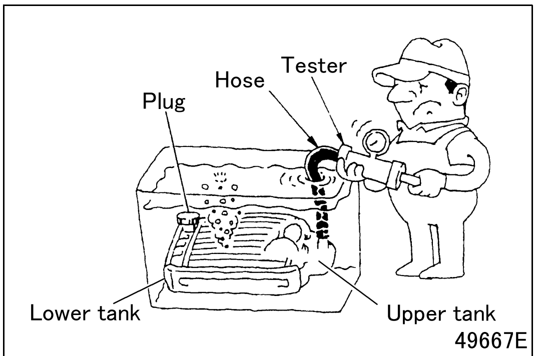
Service standards

Location	Maintenance item	Standard value	Limit	Remedy
–	Air leakage from radiator (air pressure 147 kPa {1.47 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Radiator drain cock	1.5 ± 0.3 {0.15 ± 0.03}	–
Tb	Nut (support cushion mounting)	12 to 15 {1.2 to 1.5}	–

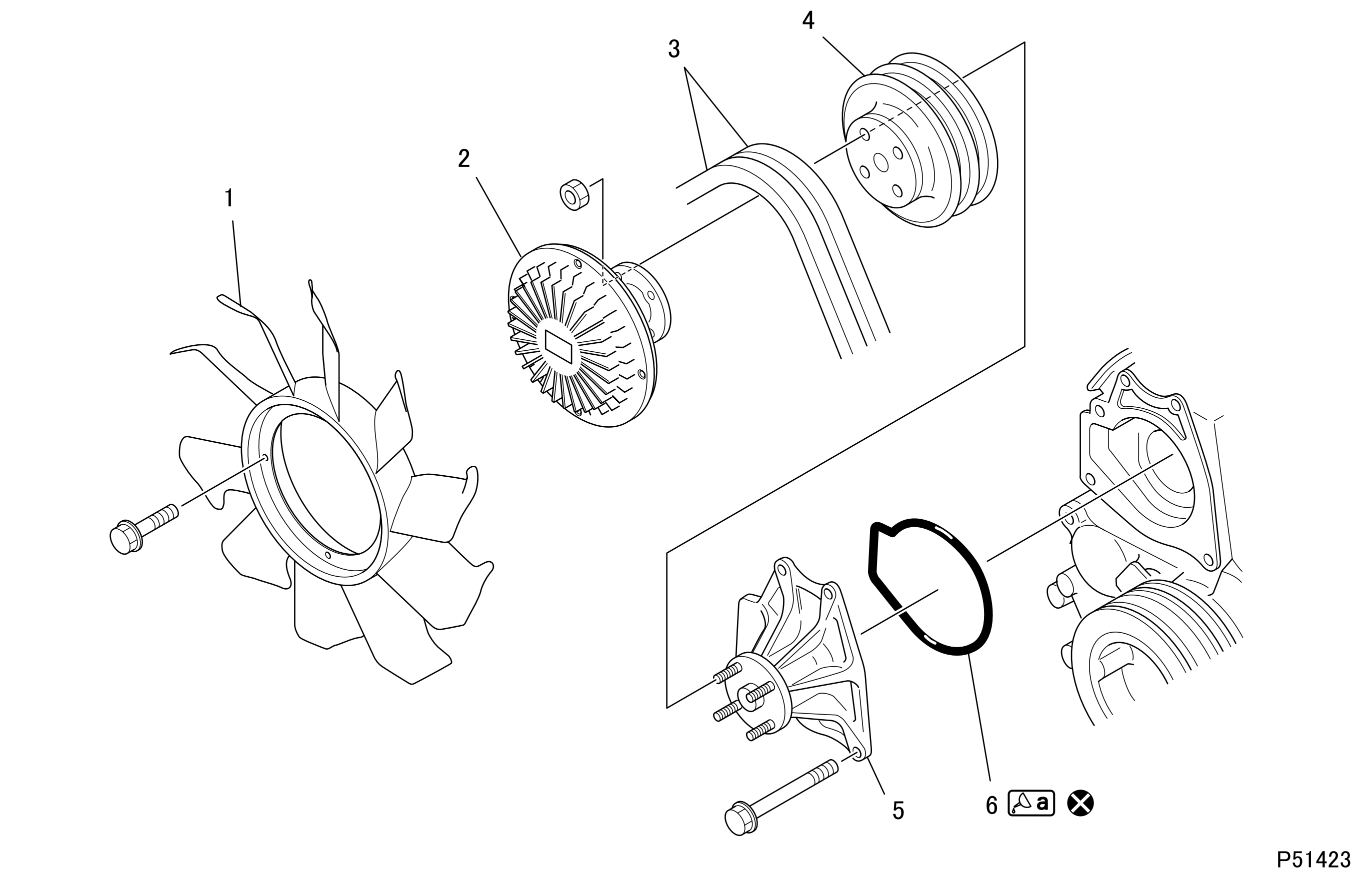
◆Inspection procedure◆



■ **Inspection: Air leakage from radiator**

- Connect a hose and radiator cap tester to the upper tank.
- Plug the lower tank and put the entire radiator into a tank filled with water.
- Apply a specified air pressure using radiator cap tester, and check for any air leakage.
- If air leakage is found, replace the radiator.

COOLING FAN, BELT AND WATER PUMP



● Removal sequence

1 Cooling fan
2 Automatic cooling fan coupling
3 Belt
4 Water pump pulley
5 Water pump
6 O-ring

⊗: Non-reusable parts

- The automatic cooling fan coupling and the water pump cannot be disassembled. It must be replaced if defective.

● Installation sequence

Follow the removal sequence in reverse.

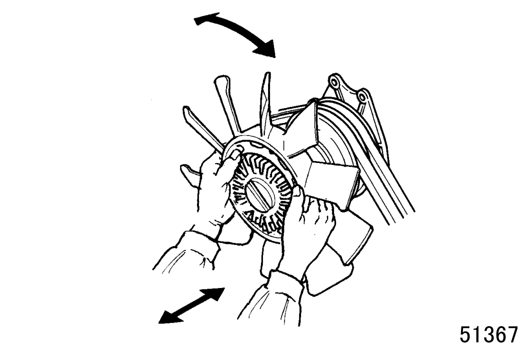
CAUTION ⚠

- **The water pump pulley is driven by two belts. Always replace the two belts simultaneously to ensure that both belts have the same tension.**
- **Make sure that there is no oil or grease on the belts. Belts soiled with oil or grease may easily slip, resulting in deteriorated performance of the cooling system.**
- **Keep the O-ring free from engine oil. Engine oil will make the O-ring swell, which may cause leakage.**

Lubricant and/or sealant

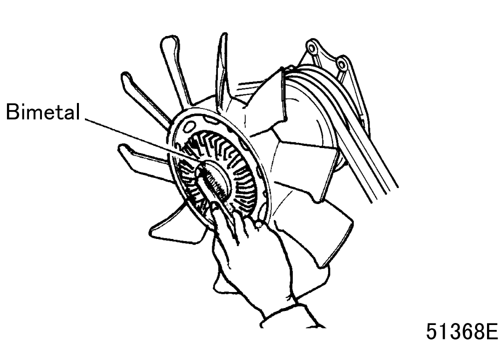
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Soapy water	As required

◆Inspection and cleaning procedure◆


51367

■ **Inspection: Automatic cooling fan coupling**

- Make an inspection of the following points. Replace the automatic cooling fan coupling if defective.
  Check that:
  - the hydraulic oil sealed inside the coupling is not leaking;
  - the coupling does not make any abnormal noise or rotate unevenly due to defects in the inside bearing when rotated manually; and
  - the automatic cooling fan coupling does not move too much when pushed and pulled in the axial directions when the engine is cold.



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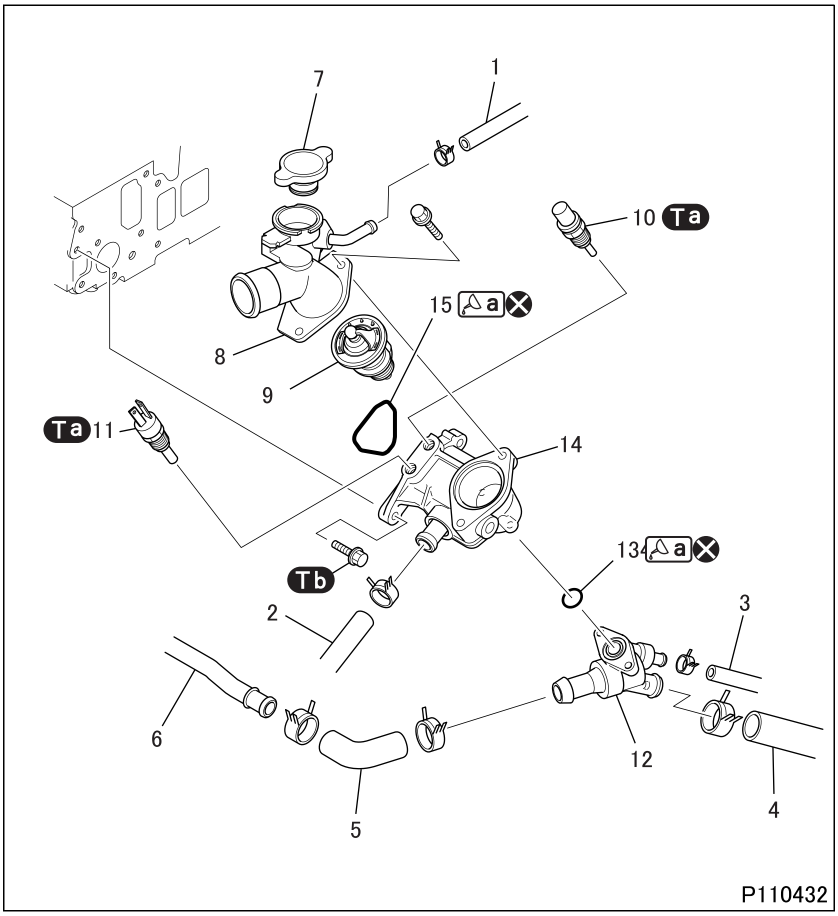
■ **Cleaning: Automatic cooling fan coupling**

- When removing foreign matter from the bimetal, be careful not to press too hard against the bimetal.

PRESSURE CAP, THERMOSTAT



● Disassembly sequence

1 Water hose
2 Water hose
3 Water hose
4 Water hose
5 Water hose
6 Water bypass pipe
7 Pressure cap
8 Thermostat cover
9 Thermostat
10 Water temperature sensor (for engine control)
11 Water temperature sensor (for thermometer)
12 Adapter
13 O-ring
14 Thermostat case
15 O-ring

⊗: Non-reusable parts

● Assembly sequence

Follow the disassembly sequence in reverse.

CAUTION ⚠

- **Keep the O-ring free of engine oil. Engine oil will make the O-ring swell, which may cause leakage.**

Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
7	Pressure cap valve opening pressure		110 ± 15 kPa {1.1 ± 0.15 kgf/cm^2}	–	Replace
9	Thermostat	Valve opening temperature	82.0 ± 2°C	–	Replace
		Valve lift / temperature	8.5 or more / 95°C	–	

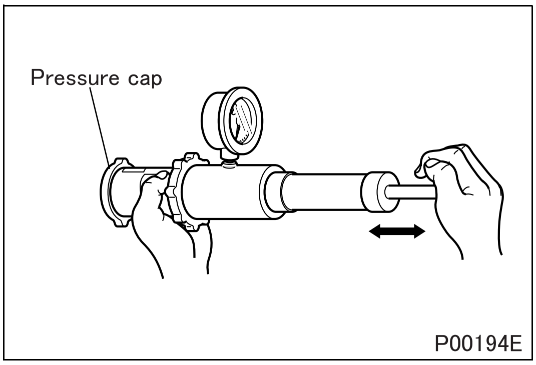
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Water temperature sensor (for engine control)	40 {4.1}	–
	Water temperature sensor (for thermometer)		
Tb	Bolt (thermostat case installation)	19 to 28 {2.0 to 2.9}	–

Lubricant and/or sealant

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

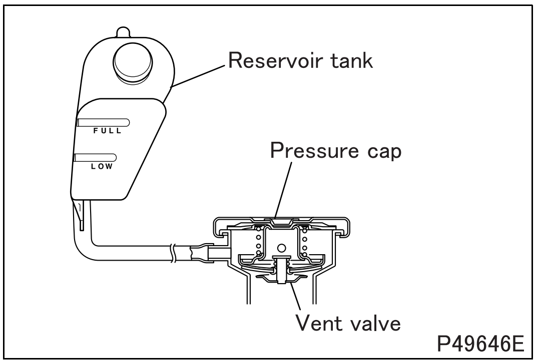
◆Inspection procedure◆



■ Inspection: Pressure cap

(1) Pressure cap valve opening pressure

- Replace the pressure cap if the measured value deviates from the standard value range.

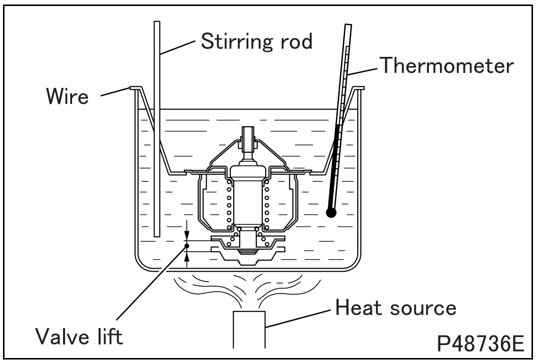


(2) Inspection of vent valve

- Before starting the inspection, check the level of coolant in the reservoir tank.
- Run the engine at full speed. Stop the engine when the level of coolant in the reservoir tank noticeably rises.
- Wait until the coolant temperature drop to the ambient temperature. Then, check if the coolant in the reservoir tank has returned to the same level as that confirmed before the engine was started.
- If the coolant has failed to return to its original level, the vent valve is defective. In this case, replace the pressure cap.

CAUTION ⚠

- **Be aware of that removing the pressure cap before the coolant cools down to the ambient temperature will result in loss of vacuum in the radiator, which prevents the coolant from being returned to the reservoir tank.**



■ Inspection: Thermostat

- Stir the water using a stirring rod to maintain an even water temperature in the container, then conduct the tests indicated below.
- If the measured values deviate from the standard value ranges, replace the thermostat.

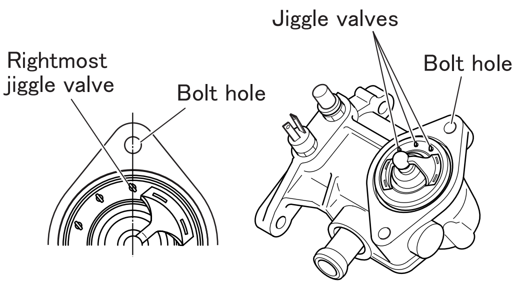
(1) Valve opening temperature

- Hold the thermostat with wire to keep it away from the heat source.
- Heat the water gradually to the valve opening temperature.
- Maintain this temperature for five minutes and make sure that the valve is completely open.
- Make sure that the valve closes completely when the water temperature drops below 65°C.

(2) Valve lift/temperature

- Heat the water to 95°C with the valve completely open. Maintain this temperature in this state for five minutes and measure the valve lift.

◆Installation procedure◆



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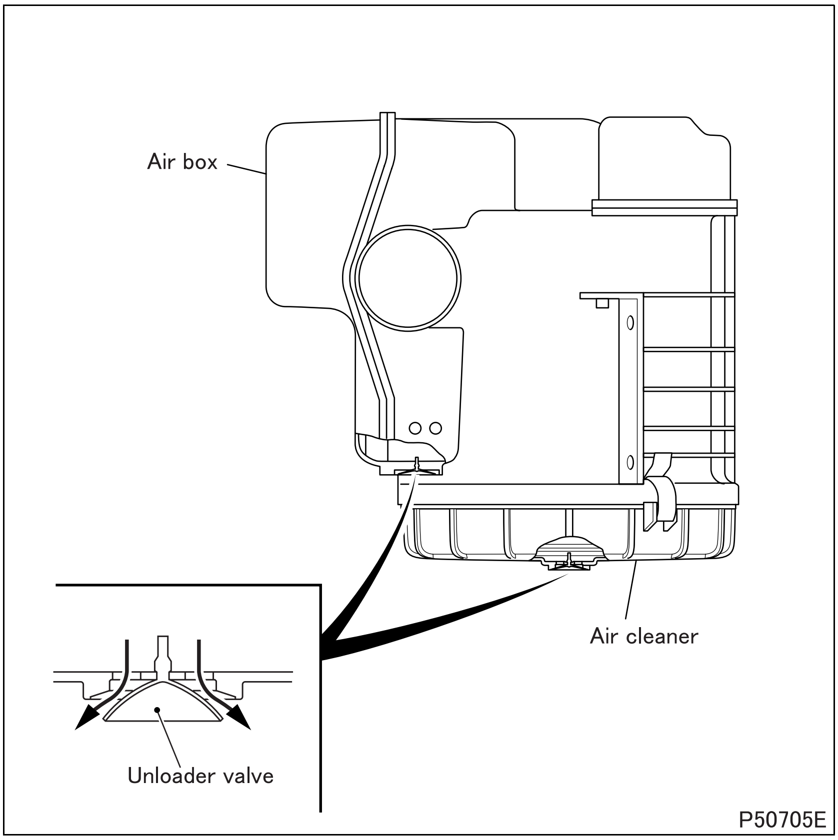
■ **Installation: Thermostat**

- Install the thermostat while aligning the rightmost jiggle valve with the bolt hole in the thermostat case as shown in the illustration.

GROUP 15 INTAKE AND EXHAUST

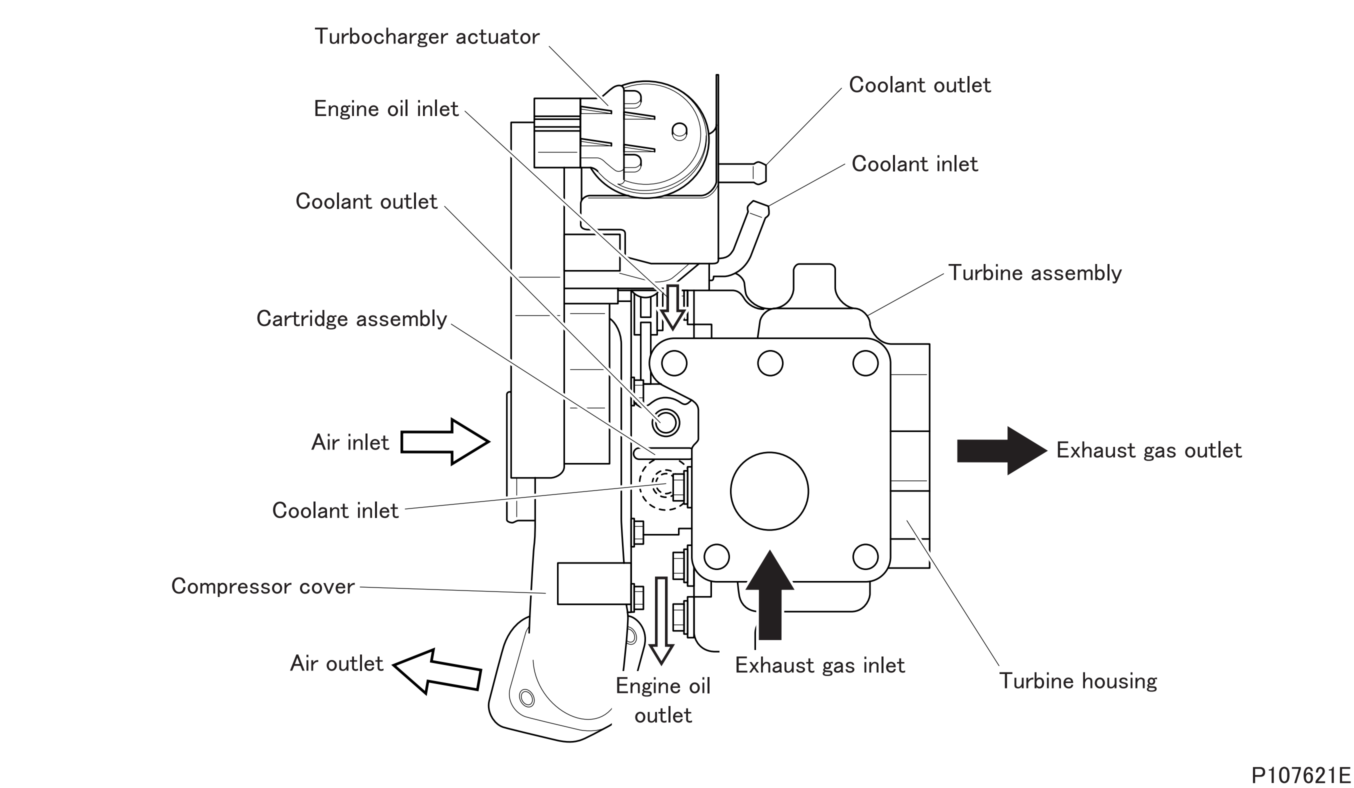
Item		Specifications
Air cleaner element type		Filter paper type
Turbocharger	Model	TD 04
	Manufacturer	MITSUBISHI HEAVY INDUSTRIES
	Cooling system	Water-cooled
Intercooler type		Tube and corrugated fin air cooled type
Diesel Particulate Filter type		Regeneration control type diesel particulate filter system

1. Air Cleaner



- The air cleaner is a single element type.
- When the engine slows down below the predetermined speed, the level of vacuum in the air cleaner changes and causes the unloader valve to vibrate. Vibration of the unloader valve allows the air cleaner to automatically discharge any water and dust that has accumulated inside.

2. Turbocharger

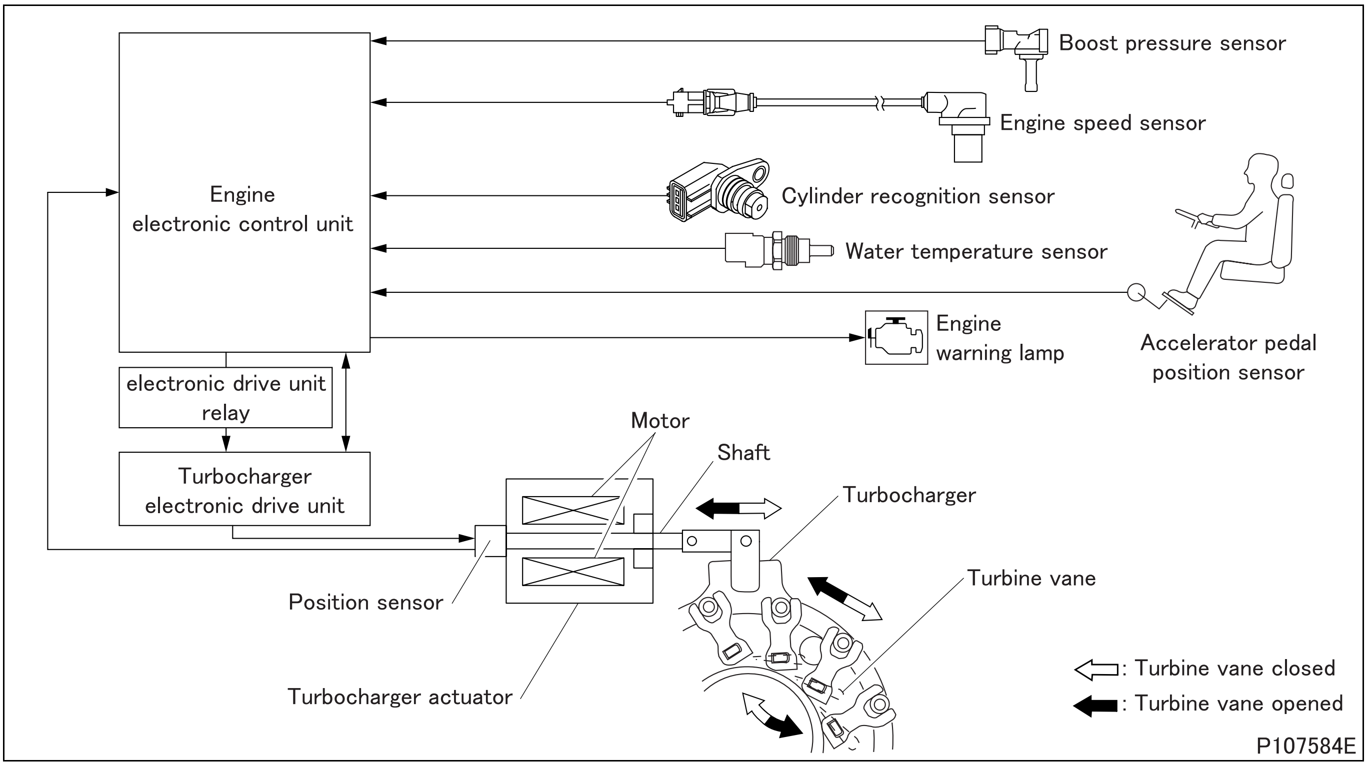


- TD04 model is equipped with turbocharger, which is a variable nozzle vane type turbocharger with adjustable, heat-resistive alloy turbine vanes provided at the turbine exhaust gas inlet port.

3. Turbocharger Control System

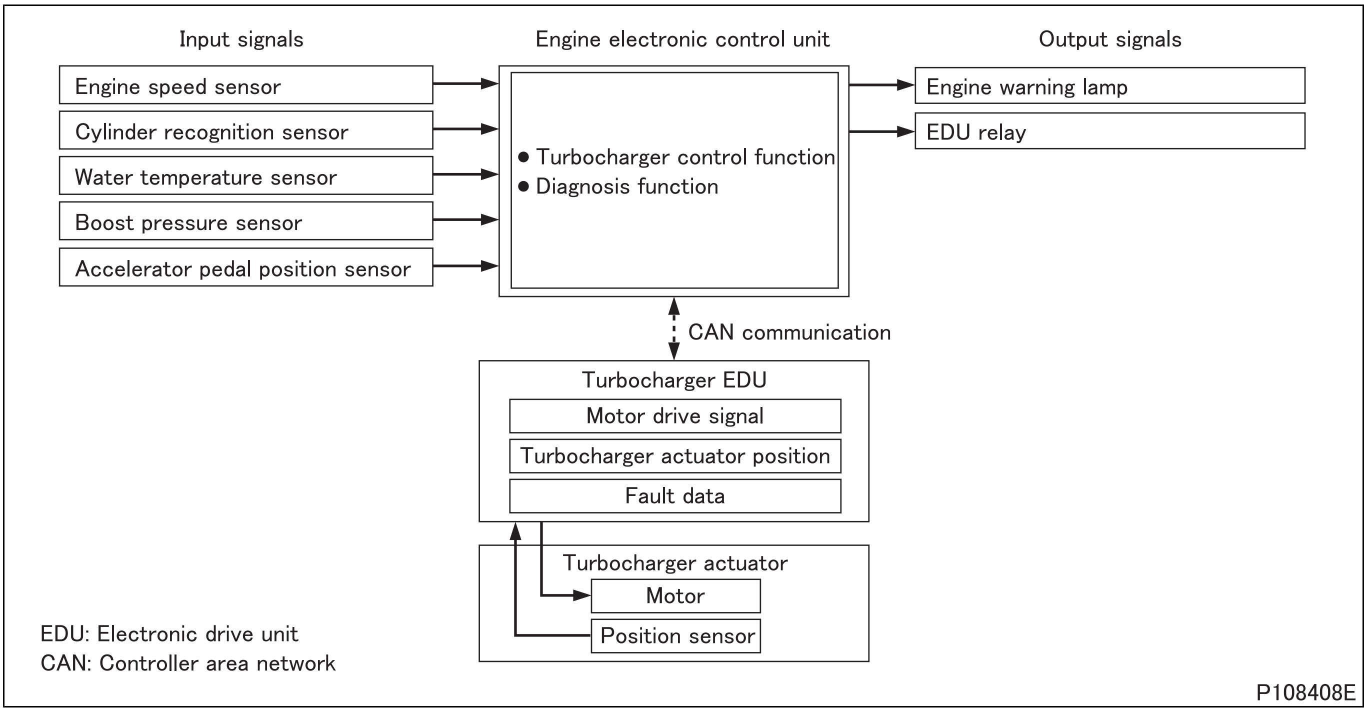
3.1 General description

- In the turbocharger control system, various engine-related information (engine speed, coolant temperature, accelerator position) and driving status are collected by the relevant sensors and are sent to the engine electronic control unit and turbocharger electronic drive unit which then control the engine based on the information received.
- The turbocharger actuator controls the opening of turbine vanes according to control signals to ensure low fuel consumption and high torque operation over the entire speed range.



3.2 Electronic control system

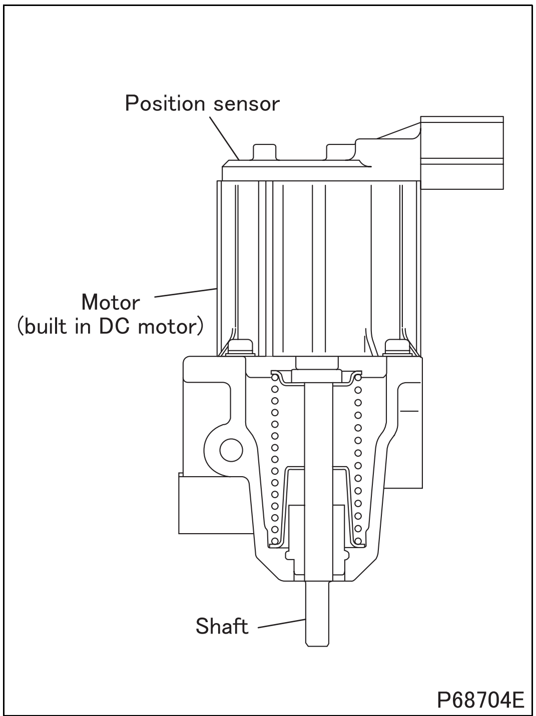
(1) System block diagram



Part	Main function/operation
Engine speed sensor	Sensing of engine speed
Cylinder recognition sensor	Cylinder recognition
Water temperature sensor	Sensing of coolant temperature
Boost pressure sensor	Sensing of boost pressure
Accelerator pedal position sensor	Sensing of extent of accelerator pedal depression
Engine warning lamp	Indication of system abnormalities
EDU relay	Switching ON/OFF supply of power to exhaust gas recirculation electronic drive unit, throttle and turbocharger electronic drive unit
CAN communication (Turbocharger EDU)	Engine data recognized by the engine electronic control unit are outputted to the CAN bus to turbocharger systems to obtain data that they need for control. Turbocharger electronic drive unit issues signals to the engine electronic control unit via the CAN bus to enable it to effect engine control appropriate for each type of system control.

(2) Turbocharger control function

- In response to output data from various sensors, the engine electronic control unit determines the opening of turbine vanes as required by the engine operating status and sends necessary control signals to the turbocharger electronic drive unit. (Target opening of turbine vanes.)
- The turbocharger electronic drive unit activates the turbocharger actuator motor to detect the amount of resultant shaft position by means of the position sensor and sends it to the engine electronic control unit. (Actual opening of turbine vanes.)
  Thus, the target opening of turbine vanes can be accurately maintained as commanded by the engine electronic control unit.



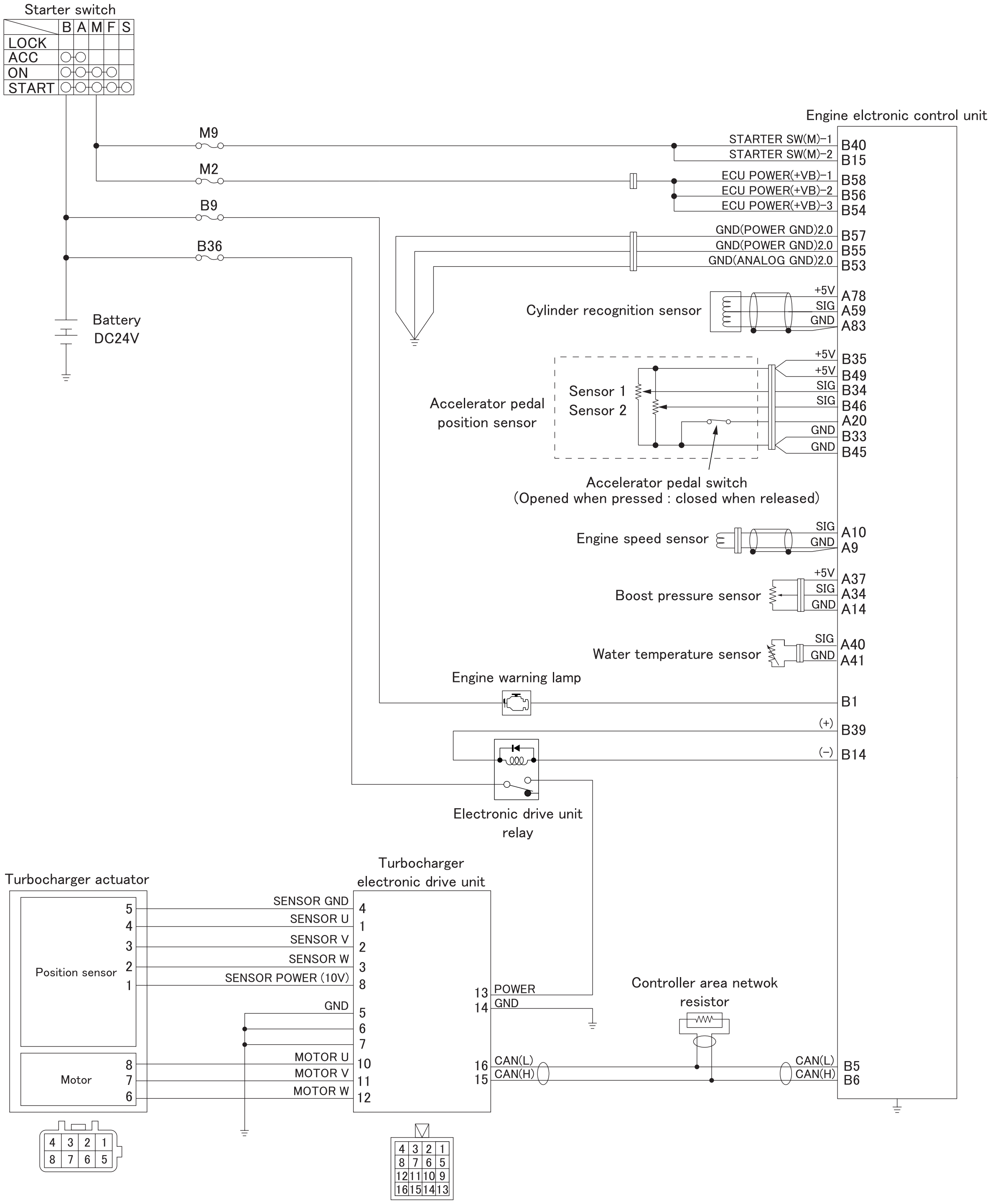
(2.1) Turbocharger actuator

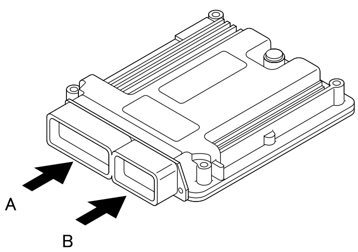
- In response to command signals from the turbocharger electronic drive unit, the turbocharger actuator moves the shaft up and down by means of its DC motor to open and close the turbine vanes.

(3) Fault diagnosis function

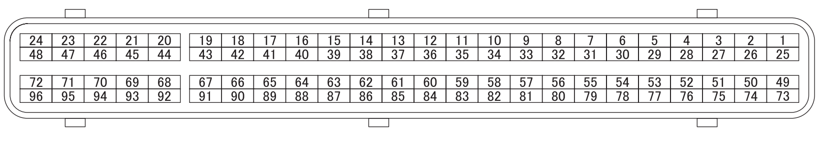
- The engine electronic control unit continuously monitors the electronic drive units and sensors for faults. In the event that the engine electronic control unit finds a component faulty, it causes an indication to be made in the meter cluster to alert the driver. At the same time, it memorizes the fault location in the form of a diagnosis code and starts a control during fault.
- While the engine is running, the turbocharger electronic drive unit continuously monitor communication with the position sensor and motor of the turbocharger actuator communication with the engine electronic control unit. In the event that they identify a fault, they send fault data to the engine electronic control unit.
- While control necessitated by a fault is taking place, the system’s functionality is limited to ensure vehicle and driver safety. It is possible to read the memorized diagnosis code using a Multi-Use Tester or from flashing of the warning lamp.
- The control during fault recovers by servicing the faults. However, for some diagnosis codes, the warning lamp stays illuminated until the normal signals are input for several times.
- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- The Multi-Use Tester is capable of showing more detailed diagnosis codes.

3.3 Electronic control unit wiring diagram

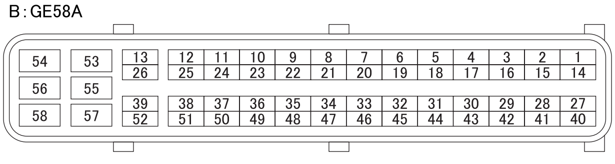




A: GE96A



B: GE58A



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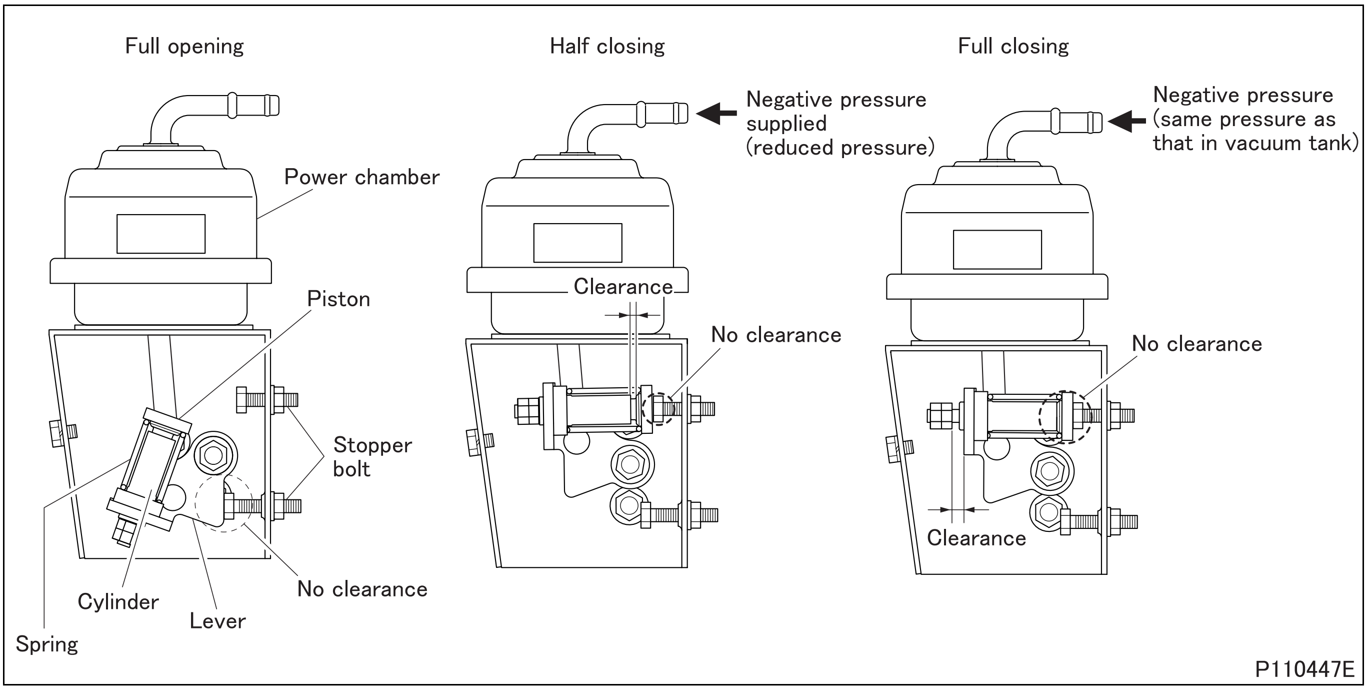
4. Exhaust Shutter

4.1 Overview

- The exhaust shutter is used for controlling the diesel particulate filter regeneration and facilitating the warming up of the exhaust brake.

4.2 Operation



- The butterfly valve operates in interlocking with the lever movement.

(1) When the butterfly valve is fully opened (exhaust shutter is not operating)

- The spring in the power chamber is acting in the direction where the butterfly valve is forced open since no negative pressure is supplied from the vacuum tank.

(2) When the butterfly valve is half closed

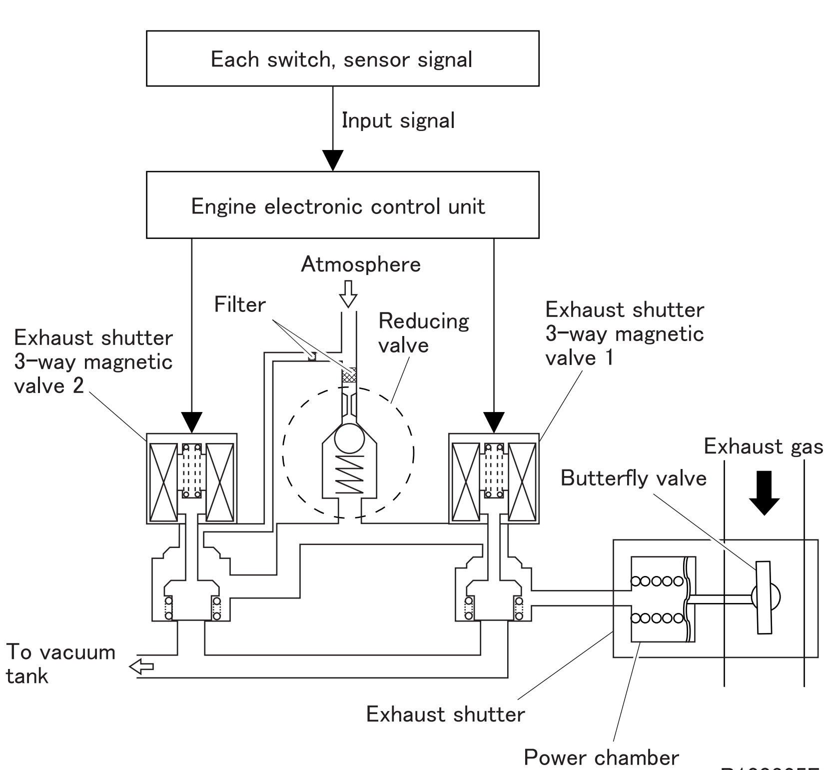
- The negative pressure having passed through the pressure reducing valve compresses the spring in the power chamber, which causes the butterfly valve to move in the closing direction and the piston end to be pressed against the stopper bolt. At this time, however, the butterfly valve is not brought in its fully closed position because the force of the spring attached to the lever exceeds the reduced negative pressure.

(3) When the butterfly valve is fully closed

- The negative pressure is directly applied to the power chamber and compresses the spring in the power chamber, which causes the butterfly valve to move in the closing direction and the piston end to be pressed against the stopper bolt. At this time, the negative pressure is higher and therefore compresses the spring attached to the lever farther, which allows the butterfly valve to move to the fully closed position.

4.3 Control

- The exhaust shutter opens/closes the butterfly valve by the signal from the engine electronic control unit.



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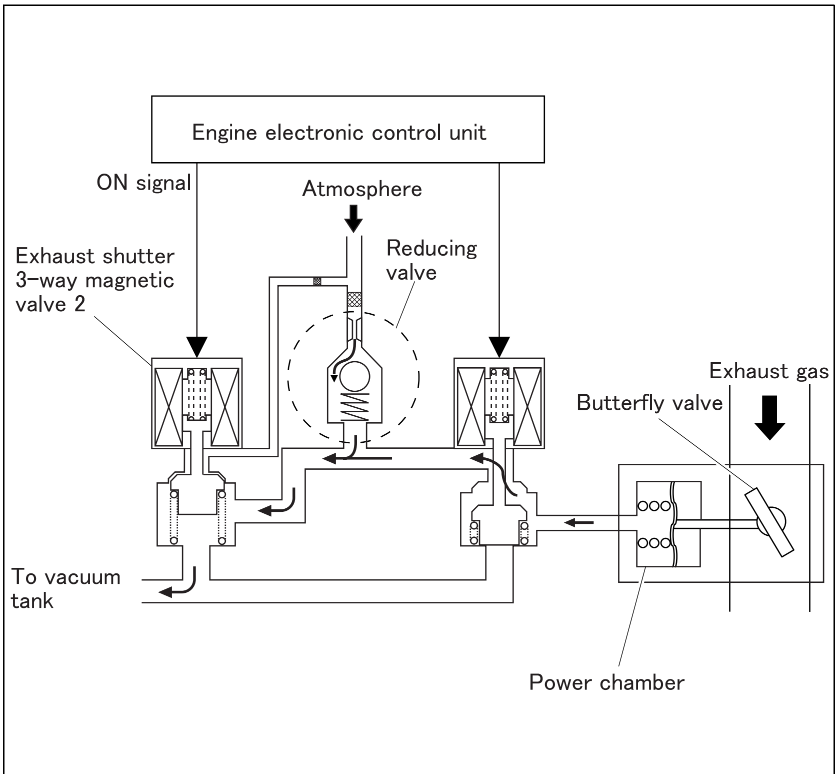
(1) Operation

(1.1) When the butterfly valve is fully opened (exhaust shutter is not operating)

- As there is no signal from the engine electronic control unit, the exhaust shutter 3-way magnetic valve 1 and 2 are not activated and the butterfly valve is kept open.



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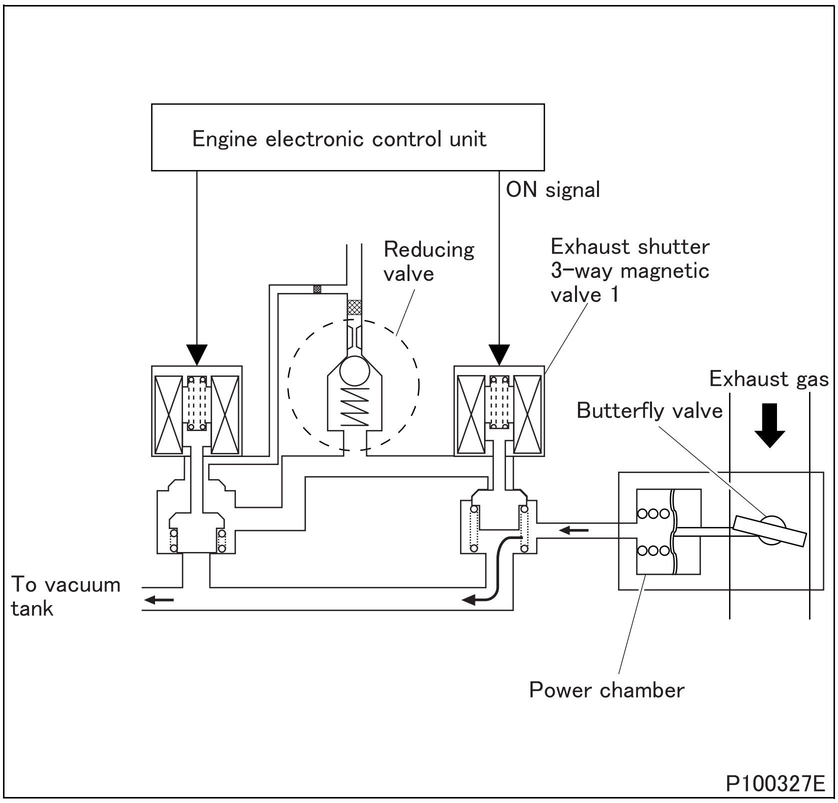
(1.2) When the butterfly valve is half closed

- By the ON signal from the engine electronic control unit, the exhaust shutter 3-way magnetic valve 2 is activated.
- The negative pressure from the vacuum tank is reduced by the pressure reducing valve, and the reduced pressure is applied to the power chamber. Therefore, the butterfly valve is half closed.



(1.3) When the butterfly valve is fully closed

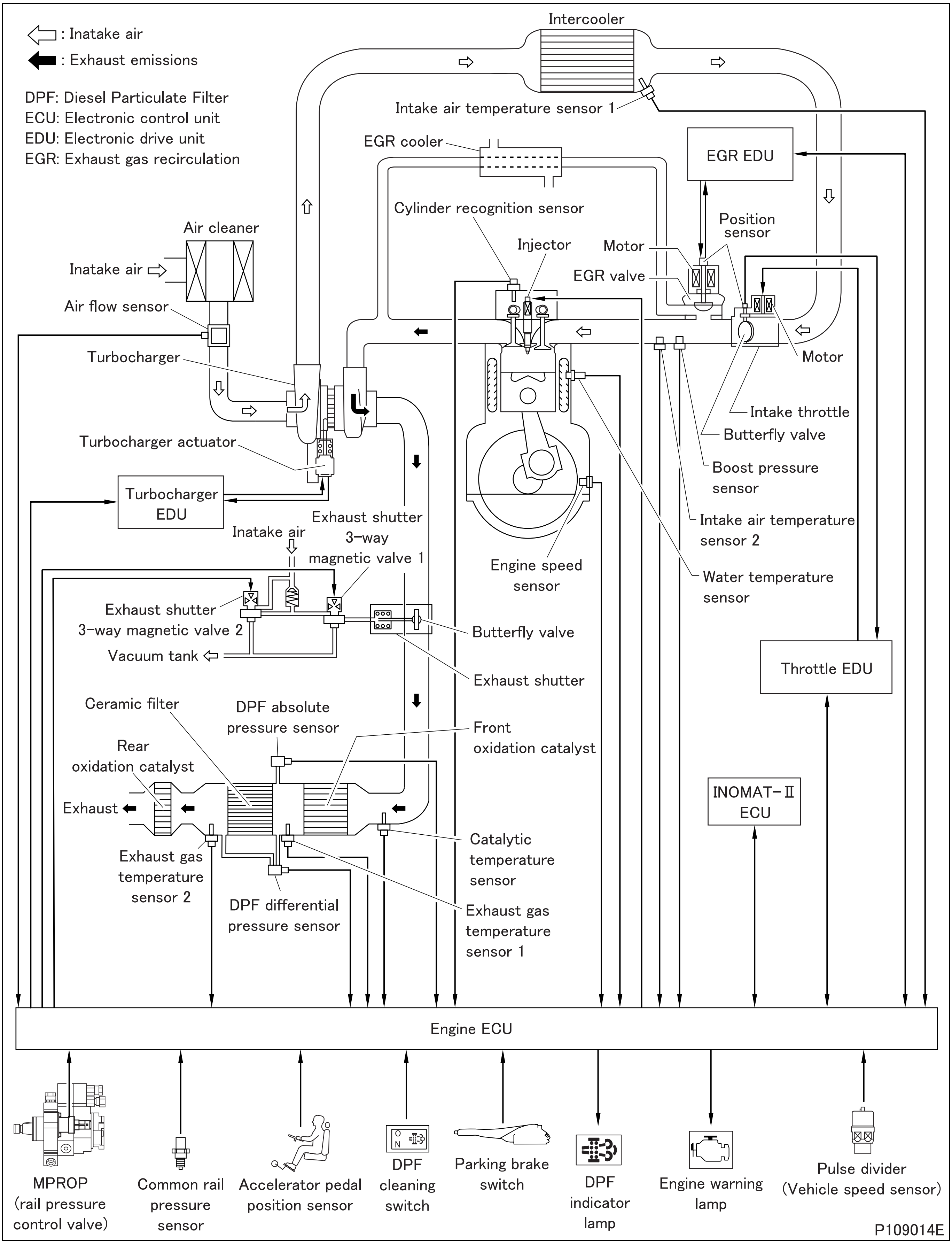
- By the ON signal from the engine electronic control unit, the exhaust shutter 3-way magnetic valve 1 is activated.
- The negative pressure from the vacuum tank is applied to the power chamber and the butterfly valve is fully closed.

5. Diesel Particulate Filter Regeneration Control System

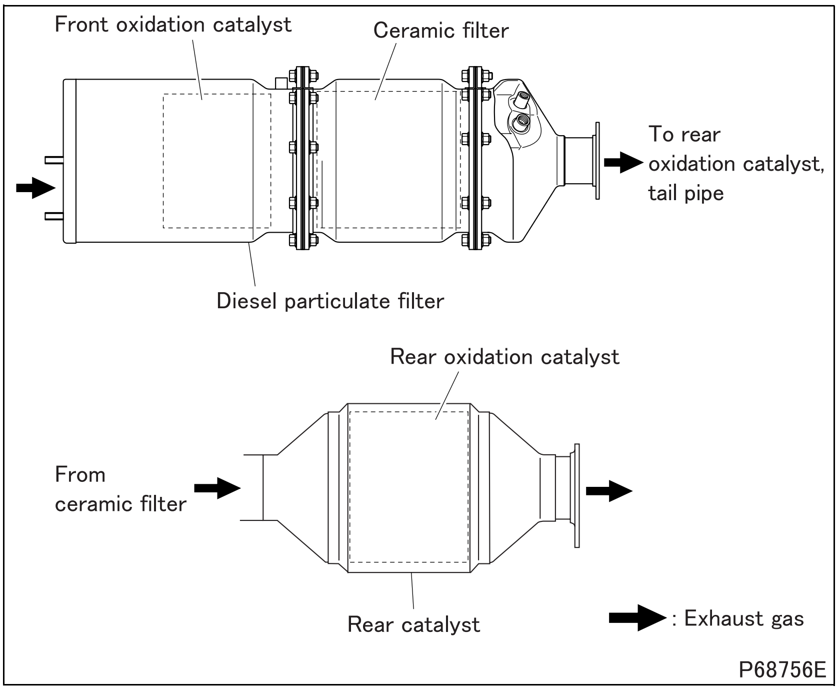
5.1 Overview

- The diesel particulate filter regeneration control system burns and removes the particulate matter (PM) in the ceramic filter using high temperature exhaust gas to prevent excessive accumulation of particulate matter in the ceramic filter. Thus the diesel particulate filter is regenerated.
- The regeneration is divided into two types. One is the continuous regeneration utilizing high temperature exhaust gas during high-speed or high-load operations. The other is the automatic or parked regeneration which uses high temperature exhaust gas created by the regeneration control by the engine electronic control unit.
- For automatic or parked regeneration, the engine electronic control unit estimates the accumulated amount of particulate matter from the vehicle operating hours, driving distance and the engine condition during driving, and the regeneration is performed by controlling the fuel injection (amount and timing), turbocharger, exhaust shutter and intake throttle to make high temperature exhaust gas.

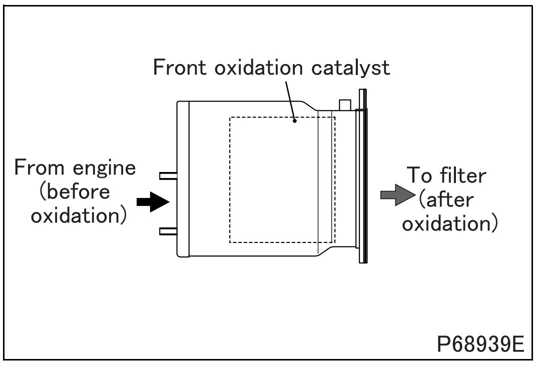
5.2 Structure



5.3 Diesel particulate filter, rear oxidation catalyst

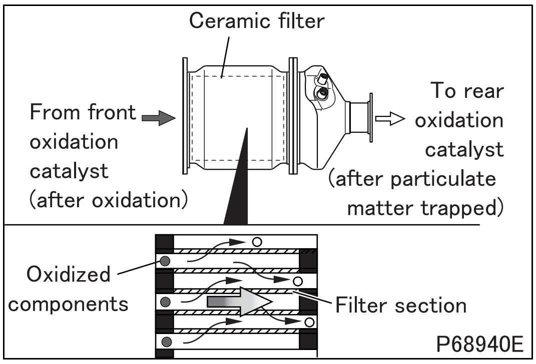


- Diesel particulate filter unit consists of the front oxidation catalyst, ceramic filter, and rear oxidation catalyst attached at the rear end.



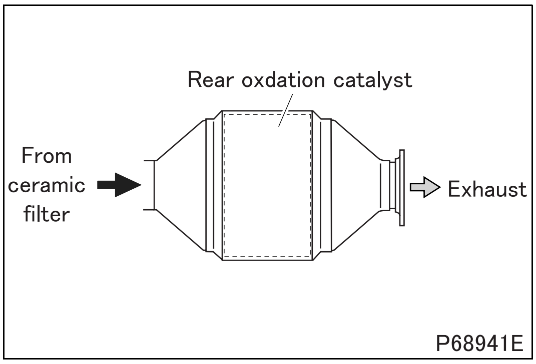
(1) Front oxidation catalyst

- In normal driving condition, unburnt fuel and part of the particulate matter in the exhaust gas from the engine is purified by this catalyst.
- During filter regeneration, the unburnt fuel supplied by the post injection is oxidized by the front oxidation catalyst, and the oxidation heat raises exhaust gas temperature.



(2) Ceramic filter

- The ceramic filter is an aggregate of thin tubes, and these tubes are closed at either end alternatively. During normal operation, particulate matter is trapped when the exhaust gas enters a tube and passes through the wall of the tube (filter section) to the adjacent tube.
- During regeneration, the particulate matter accumulated in the filter is cleared by burning at high temperature. This, however, cannot remove the calcium (ash) contained in the engine oil and the ash will accumulate in the filter. The excessively accumulated ash may cause early clogging of the ceramic filter. Therefore, the ceramic filter must be cleaned periodically.

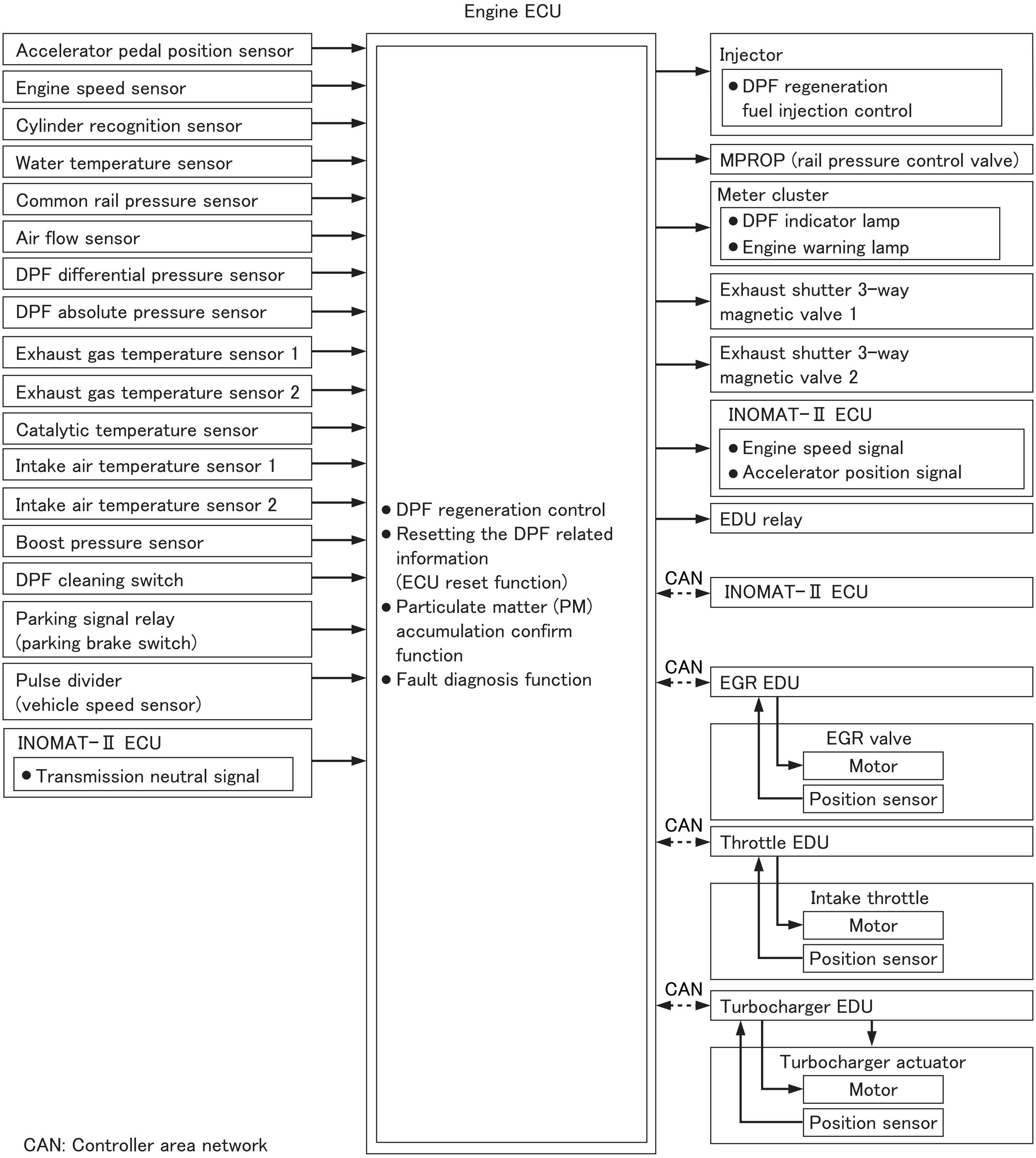


(3) Rear oxidation catalyst

- The rear oxidation catalyst oxidize and remove the components (HC and CO) which remain untreated through the diesel particulate filter.

5.4 Electronic control system

(1) System block diagram



CAN: Controller area network
DPF: Diesel Particulate Filter
ECU: Electronic control unit
EDU: Electronic drive unit
EGR: Exhaust gas recirculation

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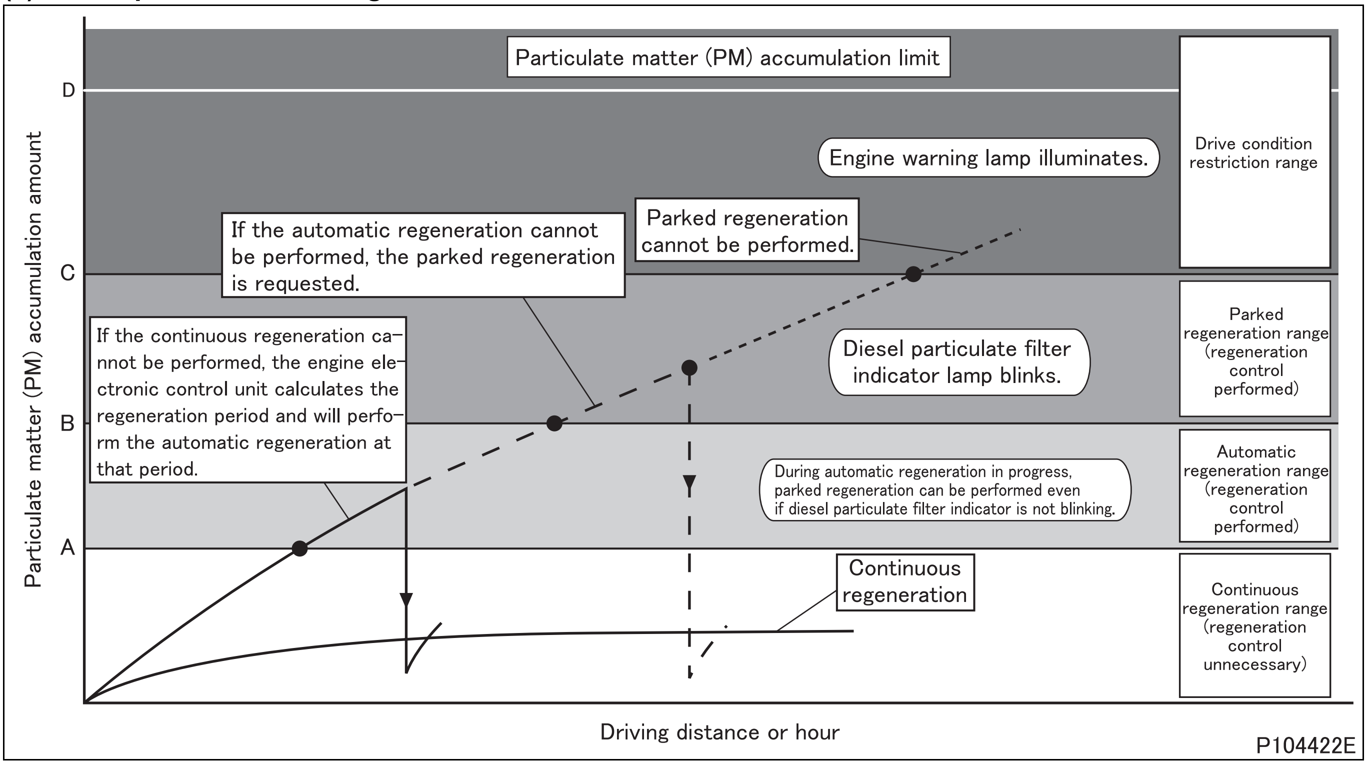
Part		Main function/operation
Accelerator pedal position sensor		Detection of extent of accelerator pedal depression
Engine speed sensor		Detection of engine speed
Cylinder recognition sensor		Cylinder recognition
Water temperature sensor		Detection of coolant temperature
Common rail pressure sensor		Sensing of common rail pressure
Air flow sensor		Sensing of intake air flow rate
DPF absolute pressure sensor		Detection of DPF absolute pressure
DPF differential pressure sensor		Detection of DPF filter differential pressure
Exhaust gas temperature sensor 1		Detection of ceramic filter inlet temperature
Exhaust gas temperature sensor 2		Detection of ceramic filter outlet temperature
Catalytic temperature sensor		Detection of front catalyst inlet temperature
Intake air temperature sensor 1		Detection of upper stream side intake air temperature (in the intercooler)
Intake air temperature sensor 2		Detection of downstream side intake air temperature (after joining the exhaust gas recirculation)
Boost pressure sensor		Sensing of boost pressure
DPF cleaning switch		ON/OFF changeover of DPF parked regeneration
Parking signal relay (parking brake switch)		Detection of parking condition (turns ON when the parking brake is applied)
Vehicle speed sensor		Sensing of vehicle speed
Injector		DPF regeneration fuel injection control
MPROP (rail pressure control valve)		Control of fuel injection pressure
DPF indicator lamp		Illuminates when the particulate matter accumulation in the DPF exceeds a certain value.
Engine warning lamp		Indication of system abnormalities Illuminates when the particulate matter accumulation in the DPF ceramic filter.
Exhaust shutter 3-way magnetic valve 1, 2		ON/OFF control of exhaust shutter valve
EDU relay		Switching ON/OFF supply of power to EGR EDU, turbocharger EDU and throttle EDU
INOMAT-II ECU	Transmission neutral signal	Sensing of transmission neutral (N range)
	Engine speed signal	Output of engine speed for INOMAT-II electronic control unit
	Accelerator position signal	Output of extent of accelerator pedal for INOMAT-II electronic control unit
Controller area network communication (INOMAT-II electronic control unit)		• Engine data recognized by the engine electronic control unit are outputted to the controller area network bus to system to obtain data that they need for control. • INOMAT-II electronic control unit issues signals to the engine electronic control unit to enable it to effect engine control appropriate to control of the system.
Controller area network communication (turbocharger EDU, throttle EDU and EGR EDU)		• Engine data recognized by the engine electronic control unit are outputted to the controller area network bus to enable systems to obtain data that they need for control. • Each EDU opens/closes the valves to increase exhaust gas temperature for DPF regeneration.

DPF: Diesel particulate filter
EDU: Electronic drive unit
EGR: Exhaust gas recirculation
ECU: Electronic control unit
INOMAT-II: Intelligent and innovative mechanical automatic transmission-II

(2) Diesel particulate filter regeneration control



- The above diagram shows the relations between the driving distance or hours and the particulate matter accumulation amount, and the range of each diesel particulate filter regeneration operation.
- The particulate matter accumulation amount increases as the driving distance or hours increase. However, by conducting the regeneration operation that matches the vehicle operating condition and the particulate matter accumulation amount, the particulate matter accumulation amount is reduced to keep the performance of the diesel particulate filter.
- The regeneration is divided into two types – the continuous regeneration utilizing exhaust gas during normal driving operation and the automatic or parked regeneration which uses exhaust gas created by the regeneration control.

(2.1) Continuous regeneration

- When exhaust gas temperature is high during high-speed or high-load operation, NO_2 created by the action of the front oxidation catalyst continuously burns the particulate matter accumulated in the ceramic filter.

(2.2) Regeneration control

● Automatic regeneration

- When the particulate matter accumulation level is between A and B on the diagram, the engine electronic control unit decides the regeneration period and the automatic regeneration will be performed at an appropriate period. During regeneration, the unburnt fuel (HC) supplied by the post injection is oxidized by the front oxidation catalyst, and the oxidation heat from that reaction burns the particulate matter accumulated in the ceramic filter.

● Parked regeneration

- If the particulate matter (PM) deposit exceeds the level B, it becomes impossible to cease the combustion removal of particulate matters by means of automatic regeneration. The diesel particulate filter indicator lamp will blink if such a condition is encountered to alert the driver of the need to perform the parked regeneration. The parked regeneration is performed when the diesel particulate filter cleaning switch is turned on with all of the following requirements satisfied.
  - Engine has warmed up (coolant temperature: 70°C or higher)
    On vehicles with idling speed adjusting potentiometer, its knob must be set to “AUTO” position.
  - Accelerator pedal released (accelerator pedal position sensor: 0%)
  - Parking brake applied (parking brake switch: ON)
  - Gearshift lever placed in N position.
  - Power take-off inactive (power take-off switch: OFF)
- During regeneration, the diesel particulate filter indicator lamp blinks in two intervals (slow and fast) in accordance with the particulate matter accumulation amount.
- The exhaust gas temperature increase procedure and the particulate matter burning procedure are the same as that for the automatic regeneration.

● Restriction on drive conditions

- When the particulate matter accumulation level exceeds C on the diagram, the engine warning lamp illuminates and some restrictions are applied to the driving conditions.
- Under this restriction, parked regeneration will not take place even if the diesel particulate filter cleaning switch is turned on.

(3) Resetting the DPF-related information (ECU reset function)

- Resetting the DPF-related information is performed to make the particulate matter (PM) deposit recognized by the engine electronic control unit coincide with the actual particulate matter (PM) deposit accumulated in diesel particulate filter after replacing or cleaning diesel particulate filter.
- The DPF-related information is memorized by the engine electronic control unit as historical records for alerting the driver of the need to make the diesel particulate filter regeneration. (For the method for resetting the DPF-related information, see “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

(4) Particulate matter (PM) deposit verification function

- The particulate matter (PM) deposit verification function allows the driver to recognize the current particulate matter (PM) deposit through the number of flashing times of diesel particulate filter indicator. This function is activated while the diesel particulate filter cleaning switch is kept pressed with the starter switch placed in the “ON” position (without starting the engine).
- Periodical use of this function will give the operator a yardstick for the parked regeneration of the diesel particulate filter, which is helpful for preventing system failures caused by clogged or broken diesel particulate filter resulting from excessive particulate matter (PM) deposit.
- The relationship between the diesel particulate filter indicator flashing pattern and the particulate matter (PM) deposit is as shown below:

<table>
<tr><th>DPF indicator flashing pattern</th><th>Particulate matter (PM) deposit</th><th>Availability of DPF regeneration</th><th>Remarks</th></tr>
<tr><td>Flashing once</td><td>Very small</td><td rowspan="2">• DPF parked regeneration not allowed</td><td>–</td></tr>
<tr><td>Flashing twice</td><td>Small</td><td>DPF automatic regeneration soon started</td></tr>
<tr><td>Flashing 3 times</td><td>Medium</td><td>• DPF automatic regeneration performed
• DPF parked regeneration allowed</td><td>–</td></tr>
<tr><td>Flashing 4 times</td><td>Large</td><td>• DPF automatic regeneration not performed
• DPF parked regeneration allowed</td><td rowspan="2">DPF indicator blinking during driving</td></tr>
<tr><td>Illumination ※</td><td>Very large</td><td>• DPF regeneration prohibited (regeneration by Multi-Use Tester allowed)</td></tr>
</table>

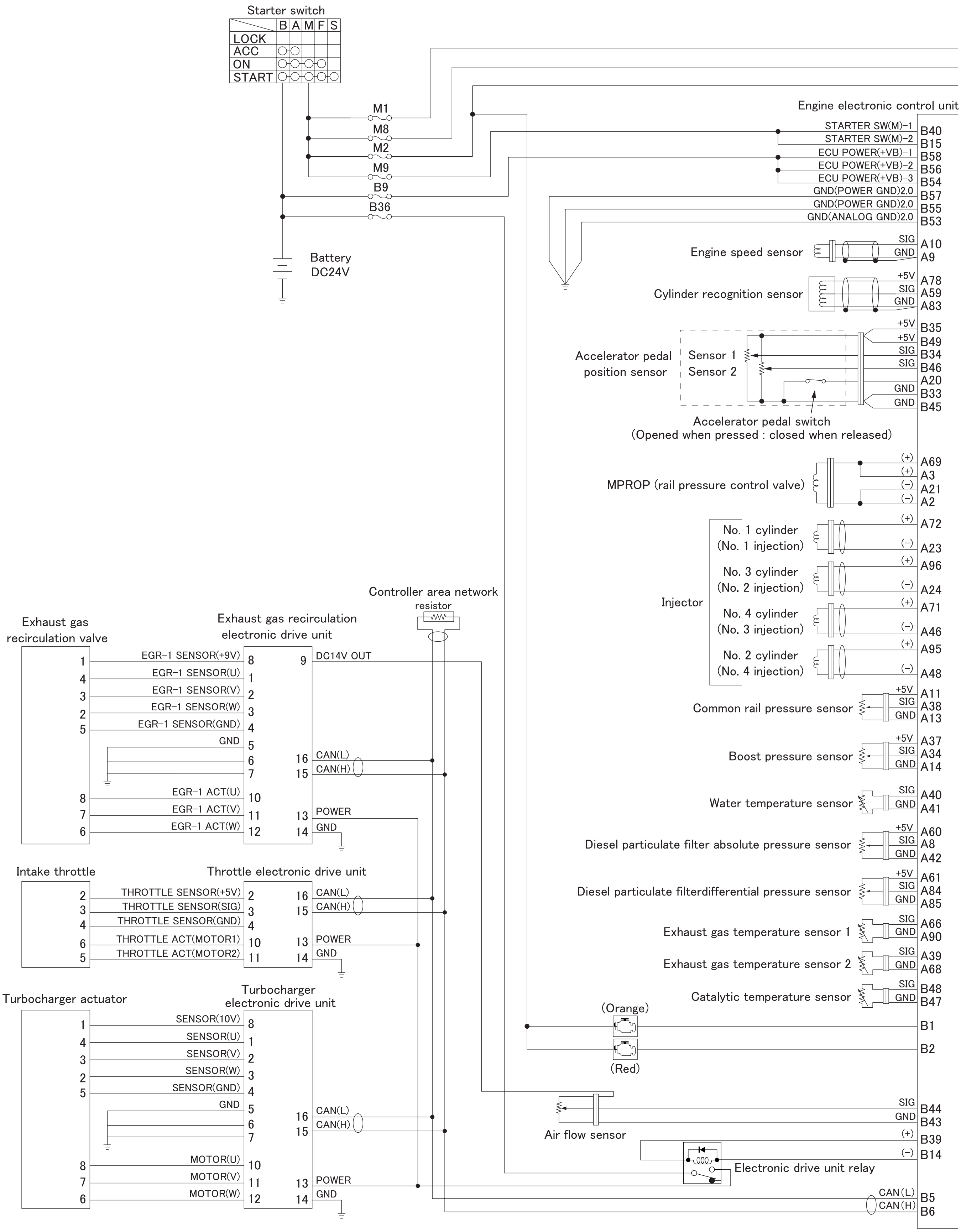
※ While DPF cleaning switch is being pressed

(5) Fault diagnosis function

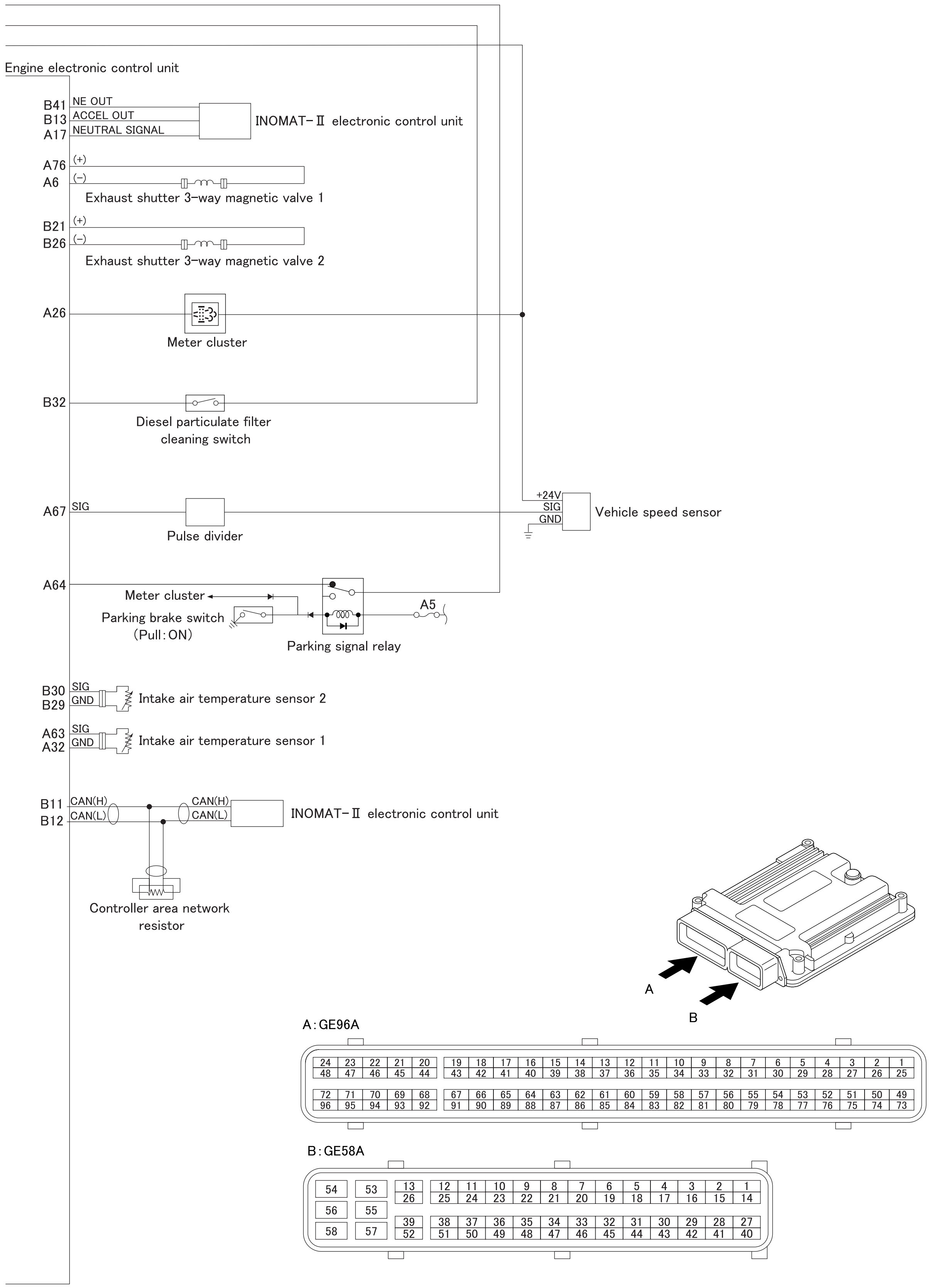
- The engine electronic control unit continuously monitors the electronic drive units and sensors for faults. In the event that the engine electronic control unit finds a component faulty, it causes an indication to be made in the meter cluster to alert the driver. At the same time, it memorizes the fault location in the form of a diagnosis code and starts a control during fault.
- While control necessitated by a fault is taking place, the system’s functionality is limited to ensure vehicle and driver safety. It is possible to read the memorized diagnosis code using a Multi-Use Tester or from flashing of the warning lamp.

ECU: Electronic control unit
DPF: Diesel particulate filter

5.5 Electronic control unit wiring diagram



P110556E


Engine electronic control unit
B41 NE OUT
B13 ACCEL OUT
A17 NEUTRAL SIGNAL
INOMAT-Ⅱ electronic control unit
A76 (+)
A6 (−)
Exhaust shutter 3-way magnetic valve 1
B21 (+)
B26 (−)
Exhaust shutter 3-way magnetic valve 2
A26
Meter cluster
B32
Diesel particulate filter cleaning switch
A67 SIG
Pulse divider
+24V
SIG
GND
Vehicle speed sensor
A64
Meter cluster
Parking brake switch (Pull：ON)
A5
Parking signal relay
B30 SIG
B29 GND
Intake air temperature sensor 2
A63 SIG
A32 GND
Intake air temperature sensor 1
B11 CAN(H)
B12 CAN(L)
CAN(H)
CAN(L)
INOMAT-Ⅱ electronic control unit
Controller area network resistor
A
B
A：GE96A
B：GE58A

P110556E-2

Possible causes			Engine hard to start	Black exhaust gas	White exhaust gas	Poor engine power	Excess oil consumption	Abnormal noise or vibration in intake/exhaust system	Exhaust brake does not work	Exhaust brake not released	Engine output inconsistent	Conditions for diesel particulate filter regeneration not met	Reference Gr
Air cleaner		Clogged air cleaner element	O	O		O							
Turbocharger	Cartridge assembly	Defective bearing		O		O		O					
		Carbon deposits on shaft and turbine wheel		O		O							
		Interference between shaft and turbine wheel and turbine housing		O		O		O					
		Shaft and turbine wheel bend		O		O		O					
		Shaft and turbine wheel broken		O		O		O					
		Interference between compressor wheel and compressor cover		O		O		O					
		Compressor wheel broken		O		O		O					
		Faulty sliding inside each part due to clogged lubricating oil pipe and eyebolt		O		O							
	Compressor cover improperly mounted			O		O	O	O					
	Turbine housing improperly mounted					O		O					
	Turbocharger actuator malfunctioning										O	O	
Intercooler		Foreign substances deposited on intercooler front core				O							
Throttle actuator		Butterfly valve does not open		O	O	O							Gr17
		Butterfly valve malfunction		O	O	O							
Front pipe/tail pipe deformed								O					
Front pipe/tail pipe fitted poorly								O					
Diesel particulate filter	Ceramic filter clogged		O			O							
	Diesel particulate filter broken			O				O					
Exhaust shutter	Vacuum system	Insufficient vacuum							O			O	
		Piping crushed and restricted							O			O	
	Electric system	3-way magnetic valve faulty							O	O		O	Gr13
	Defective butterfly valve								O	O	O	O	
	Stuck valve shaft								O	O		O	
	Defective power chamber								O		O	O	
Incorrect valve clearances				O									Gr11
Head gasket defective				O									
Wear/carbon deposits on valves and valve seats				O									
Valve spring weakened				O									
Piston rings worn/damaged					O		O						
Piston ring grooves worn/damaged					O		O						
Cooling system malfunctioning				O									Gr14
Engine oil quantity excessive					O								Gr12
Major moving parts seized				O									Gr11
Uneven or excessive fuel injection				O									Gr13
Exhaust gas temperature sensor open-circuited or intermittent connection												O	

ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Measurement and Adjustment of Turbocharger Boost Pressure

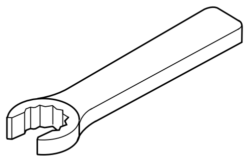
CAUTION ⚠

- **If boost pressure exceeds the standard value, the engine may malfunction or break down. Boost pressure must be within the specified range.**

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
–	Boost pressure	120 ± 2 kPa	–	Inspect or adjust

Special tools

Mark	Tool name and shape	Part No.	Application
a	Spanner  P68859	MH063019	Removal and installation of lock nut

1.1 Preparation

- Remove the safety plug from the high voltage battery box while referring to Gr18 HEV System.
  (Be sure to observe the regulations of your country or region regarding the qualifications or trainings required for servicing the high-voltage equipment.)
- Shift the transmission to neutral.
- Hold the steering wheel in neutral position.
- Turn off lamps and accessory devices not to increase the engine speed.
- Connect the Multi-Use Tester. (See Gr00.)
- If any fault exists (corresponding diagnosis code is issued), rectify it.

1.2 Measurement and correction of boost pressure

- Warm up the engine until the engine coolant has been heated to more than 70°C. (Determine coolant temperature from service data [13: Water temperature].)
- Check that the non-load minimum speed (idling speed) is as specified. (See Gr13.)
- Select [A5: VGT1] in [Actuator Test] of the Multi-Use Tester. Set [Target Value] to 70% and execute.
- When [A5: VGT1] is executed, the engine speed should be automatically increased to 2000 rpm.
- Maintain the state of [Target Value] having been executed (10 minutes or more) until boost pressure is stabilized.
- Measure the following items from among [Service Data].
  0C: Boost pressure (measured boost pressure)
  15: Atmospheric pressure (measured atmospheric pressure)
- Measure the intake air temperature (ambient temperature around the vehicle) using a thermometer.
- Obtain boost pressure correction value respectively by calculating above Service Data.

[Calculation of intake air temperature correction value]

- Intake air temperature correction value = –0.12 (Measured boost temperature –25)

[Calculation of atmospheric pressure correction value]

- Atmospheric pressure correction value = Measured atmospheric pressure –100

[Calculation of boost pressure correction value]

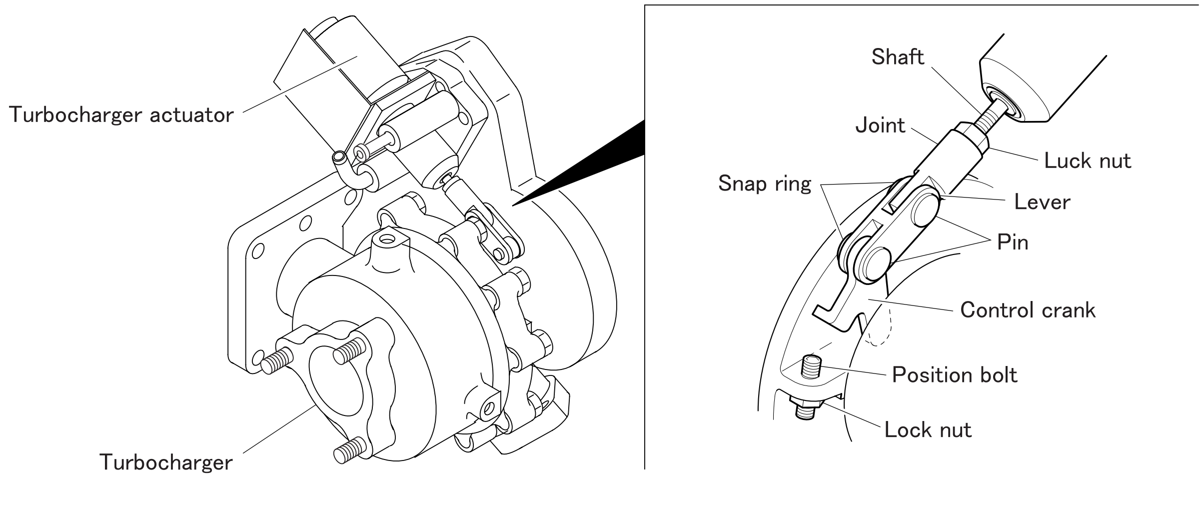
- Boost pressure correction value = Measured boost pressure – intake air temperature correction value – atmospheric pressure correction value
- If boost pressure correction value deviates from the standard value, adjust the turbocharger.

WARNING ⚠

- **The turbocharger is hot for a while after the engine is stopped. Take care not to burn yourself during adjustment work.**

1.3 Turbocharger adjustment

- Adjust the turbocharger using the flowchart shown below.



P107835E

Check of whether control crank and position bolt are in contact

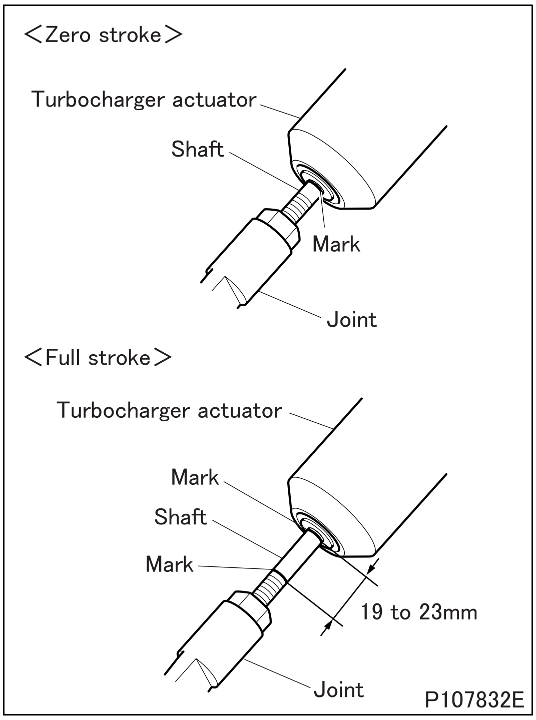
(1) When control crank and position bolt are in contact (normal condition)

- (1.1) Adjustment of position bolt length
- ※ (1.2) Adjustment of turbocharger actuator shaft length
- (1.3) Measurement of boost pressure
  - OK → Adjustment complete
  - NG → (1.4) Replacement of turbocharger → Adjustment complete

(2) When control crank and position bolt are not in contact

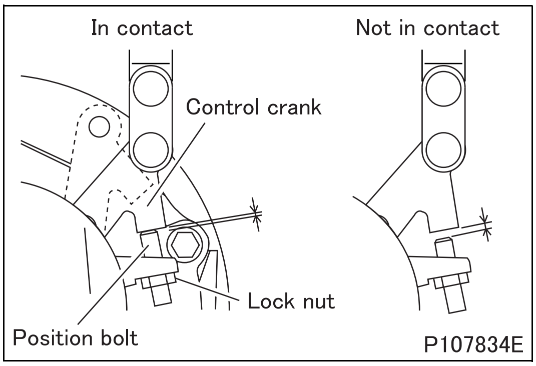
- (2.1) Adjustment of turbocharger actuator shaft length
- (2.2) Measurement of boost pressure
  - OK → Adjustment complete
  - NG → (2.3) Adjustment of position bolt length
    - ※ (2.4) Adjustment of turbocharger actuator shaft length
    - (2.5) Measurement of boost pressure
      - OK → Adjustment complete
      - NG → (2.6) Replacement of turbocharger

※ Adjustment must be performed only when diagnosis code P2263 is generated or when the control crank does not contact the position bolt.



[Inspection]

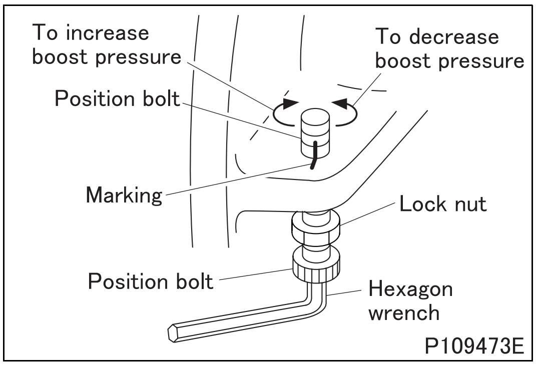
- Check whether the control crank comes into contact with the position bolt in accordance with the procedure described below.
  - Place the starter switch in the “ON” position, and check to confirm that the turbocharger actuator shaft moves once to the full stroke position. At this time, put a thin paper between the control crank and position bolt to check for contact condition between them.
- If they are in contact, make adjustments in accordance with the procedures described in (1) below. If not, make adjustments in accordance with the procedures described in (2) below.



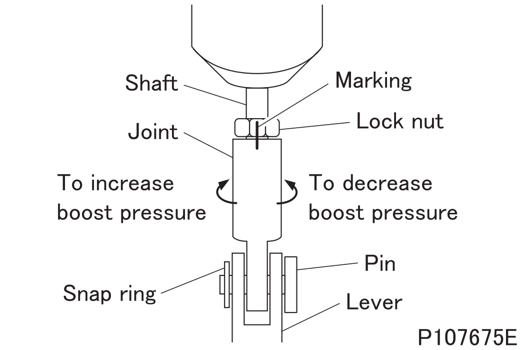
[Adjustment]

(1) When control crank and position bolt are in contact (normal condition)

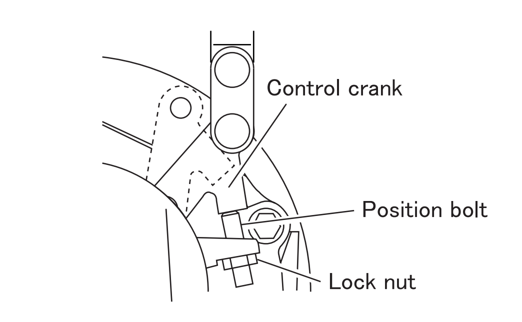
(1.1) Adjustment of position bolt length



- Place the starter switch in the “LOCK” position or remove the starter key.
- Loosen the lock nut at a.
- Provide alignment markings on the position bolt and turbocharger actuator unit with a pen or the like as shown in the illustration.
- Insert a hex wrench into the position bolt as shown and turn the bolt with it to adjust the boost pressure to the standard value.
  - To increase boost pressure: Turn the position bolt clockwise (loosening direction).
  - To decrease boost pressure: Turn the position bolt counterclockwise (tightening direction).
  - Change in pressure: An increase of approximately 3 kPa per turn of the position bolt (with the measurement of boost pressure)
- After adjustment, tighten the lock nut of position bolt.



P107675E



P107837E

(1.2) Adjustment of turbocharger actuator shaft length

- This adjustment must be performed only when diagnosis code P2263 is generated or when the control crank does not contact the position bolt.
- Place the starter switch in the “LOCK” position or remove the starter key.
- Provide alignment markings on the lock nut of turbocharger actuator and joint with a pen or the like as shown in the illustration.
- Remove the snap ring and pin from the turbocharger actuator.
- Loosen the lock nut and turn the joint to extend the shaft.
- Guide to adjustment:

  The shaft length must be changed only by the same amount as the position bolt adjustment made in the paragraph “(1.1) Adjustment of position bolt length”. (The amount of the turbocharger actuator stroke must not be changed.) The shaft length will change 1 mm by each one turn of the joint.
- The shaft length shall be considered normal if diagnosis code P2263 is not generated and the contact between the control crank and position bolt is observed even if it has not been adjusted by the same amount as for the position bolt.
- After adjustment, fit the snap ring and pin onto the turbocharger actuator, and tighten the lock nut.

CAUTION ⚠

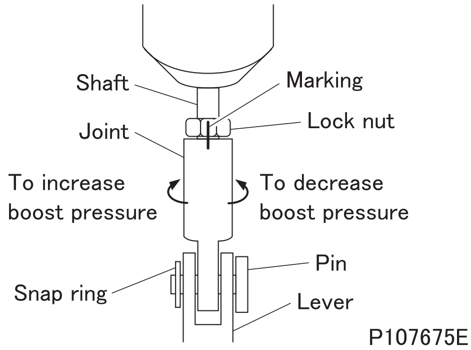
- **If the shaft of the turbocharger actuator deviates from the standard stroke range (19 to 23 mm), the engine electronic control unit judges the condition as an adjustment error, generating the diagnosis code “P2263: VGT System” and displaying the engine warning (amber). If such indications are given, adjust the shaft length such that the shaft is shortened by the length equivalent to half a turn of the shaft. If the stroke is still out of the standard value range, check the turbocharger.**

(1.3) Measurement of boost pressure

- For measurement of the boost pressure, see “1.2 Measurement and correction of boost pressure.”

(1.4) Replacement of turbocharger

- For replacement of the turbocharger, see “TURBOCHARGER.”



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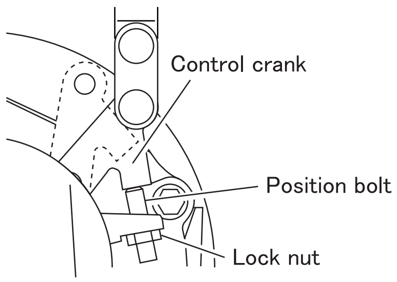


P107837E

(2) When the control crank does not come into contact with the position bolt

(2.1) Adjustment of turbocharger actuator shaft length

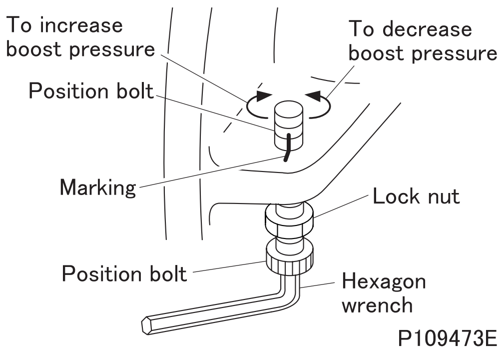
- Place the starter switch in the “LOCK” position or remove the starter key.
- Put an alignment mark on the lock nut and the joint of the turbocharger actuator with a pen or the like as shown in the illustration.
- Remove the snap ring and the pin on the turbocharger actuator side.
- Loosen the lock nut and turn the joint section. Place the starter switch in the “ON” position. Pull out the turbocharger actuator shaft to the length in which the control crank will contact the position bolt when the shaft is extended temporarily to its full stroke position.
  Guide to adjustment:
  The shaft length will change 1 mm by each one turn of the joint.
- Replace the lever and pin with new ones if the correct contact is not achieved even when the shaft is pulled out to the limit.
- Upon completing the shaft adjustment, install the snap ring and the pin on the turbocharger actuator side and tighten the lock nut.

CAUTION ⚠

- **If the amount of the stroke of the turbocharger actuator shaft is out of the standard value range (19 to 23 mm), the engine electronic control unit judges the condition as an adjustment error, generating the diagnosis code “P2263: VGT system error” and displaying the engine warning (amber). If the stroke deviates from the standard value, inspect the turbocharger.**

(2.2) Measurement of boost pressure

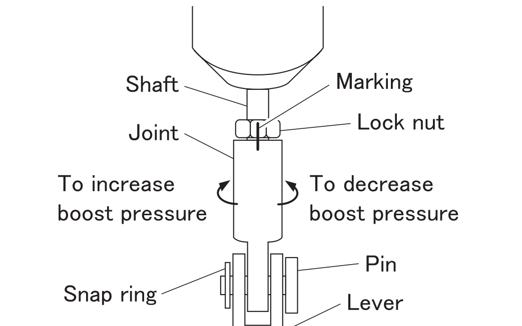
- For measurement and of boost pressure, see “1.2 Measurement and correction of boost pressure”.



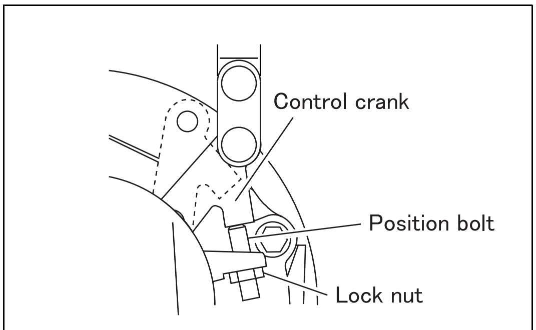
P109473E

(2.3) Adjustment of the position bolt length

- This adjustment should be performed only when the boost pressure is not within the standard value range.
- Put an alignment mark on the position bolt and the turbocharger actuator body using a pen or the like as shown in the illustration.
- Loosen the lock nut of the position bolt using a.
- Fit a hex wrench onto the position bolt as shown in the illustration and turn the bolt such that the measured boost pressure meets the standard value.
  - To increase the boost pressure:
    Turn the position bolt clockwise as shown in the illustration.
  - To decrease the boost pressure:
    Turn the position bolt counterclockwise as shown in the illustration.
  - Guide to adjustment:
    The boost pressure will change approximately 3 kPa each time the position bolt is turned one turn (when taking measurements of boost pressure).
- After adjustment, secure the lock nut with a.



P107675E



P107837E

(2.4) Adjustment of turbocharger actuator shaft length

- This adjustment must be performed only when diagnosis code P2263 is generated or when the control crank does not contact the position bolt.
- Place the starter switch in the “LOCK” position or remove the starter key.
- Provide alignment markings on the lock nut of turbocharger actuator and joint with a pen or the like as shown in the illustration.
- Remove the snap ring and pin from the turbocharger actuator.
- Loosen the lock nut and turn the joint to extend the shaft.
- Guide to adjustment:

  The shaft length must be changed only by the same amount as the position bolt adjustment made in the paragraph “(1.1) Adjustment of position bolt length”. (The amount of the turbocharger actuator stroke must not be changed.) The shaft length will change 1 mm by each one turn of the joint.
- The shaft length shall be considered normal if diagnosis code P2263 is not generated and the contact between the control crank and position bolt is observed even if it has not been adjusted by the same amount as for the position bolt.
- After adjustment, fit the snap ring and pin onto the turbocharger actuator, and tighten the lock nut.

CAUTION ⚠

- **If the shaft of the turbocharger actuator deviates from the standard stroke range (19 to 23 mm), the engine electronic control unit judges the condition as an adjustment error, generating the diagnosis code “P2263: VGT System” and displaying the engine warning (amber). If such indications are given, adjust the shaft length such that the shaft is shortened by the length equivalent to half a turn of the shaft. If the stroke is still out of the standard value range, check the turbocharger.**

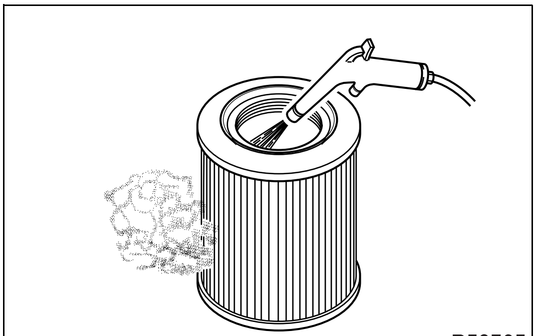
(2.5) Measurement of boost pressure

- For measurement of the boost pressure, see “1.2 Measurement and correction of boost pressure.”

(2.6) Replacement of turbocharger

- For replacement of the turbocharger, see “TURBOCHARGER.”

2. Cleaning and Inspection of Air Cleaner Element



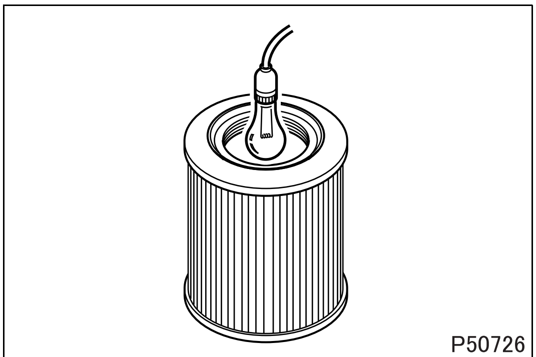
P50725

[Cleaning]

- Blow a jet of compressed air at a pressure not higher than 685 kPa {7 kgf/cm^2} against the inside surfaces of the element.
- Move the compressed air jet up and down along all pleats of the filter paper element.

CAUTION ⚠

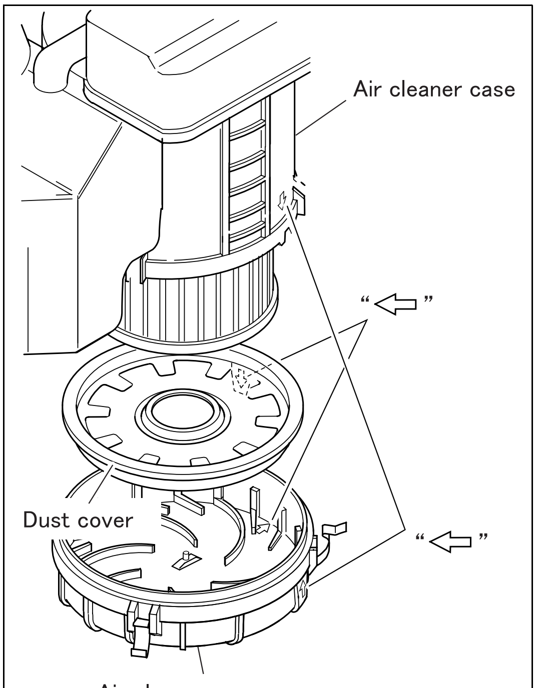
- **For the frequency and timing of cleaning, see the relevant instruction manual. More frequent cleaning than necessary may damage the element, causing dust and foreign matter to be sucked into the engine.**
- **Do not strike the element or hit it against another object to remove dust.**
- **Do not blow compressed air against outside surfaces of the element.**



P50726

[Inspection]

- Shine some electric light inside the element.
- Replace the element if thin spots or broken parts are evident in the filter paper, or if the packing at the top of the element is damaged.
  Also replace the element if the dust on the element is damp with oily smoke or soot, regardless of the replacement schedule.



P61831E

[Installation]

- Install the covers while aligning their respective “⇦” marks with each other as shown in the illustration.

3. Check for Looseness in Intake Manifold Mounting Bolts and Nuts

- Check for looseness in the intake manifold and air inlet pipe mounting bolts and nuts. If there is looseness, tighten the bolts and nuts to the specified torque. (See “INTAKE MANIFOLD”.)

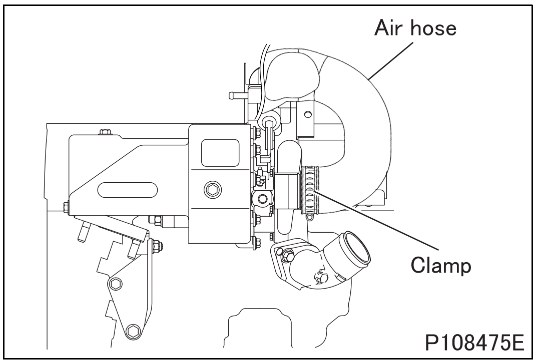
4. Check for Cracks and Gas Leakage in Exhaust Manifold

- Inspect the exhaust manifold visually. If there is any trace of gas leakage or cracks, replace the exhaust manifold. (See “EXHAUST MANIFOLD”.)
- Check for looseness in the exhaust manifold mounting nuts. If there is looseness, tighten the nuts to the specified torque. (See “EXHAUST MANIFOLD”.)

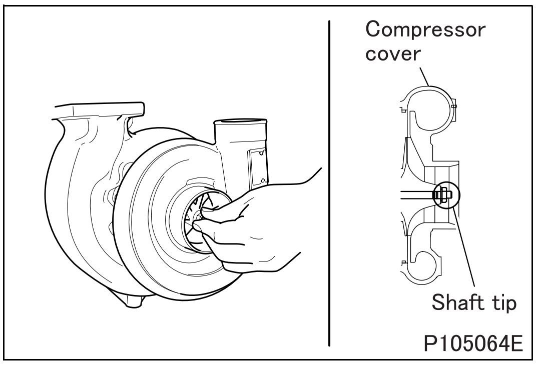
5. Check for Cracks and Gas Leakage in Turbocharger

- Inspect the turbocharger visually. If there is any trace of gas leakage or cracks, replace the turbocharger. (See “TURBOCHARGER”.)
- Check for looseness in the turbocharger mounting bolts and nuts. If there is looseness, tighten the bolts and nuts to the specified torque. (See “TURBOCHARGER”.)

6. Loose Turbocharger



- Remove the bolts, loosen the clamp securing the air hose and turbocharger and remove the air hose.



- Turn the compressor wheel by turning the shaft tip with fingers. Check that the compressor wheel rotate smoothly without touching the compressor.
- If any abnormality is found, disassemble and inspect the turbocharger. (See “TURBOCHARGER”.)

7. Inspection of Diesel Particulate Filter Unit for Clogging and Cleaning of the Diesel Particulate Filter Unit

- These works should be performed at 12-month intervals as follows:

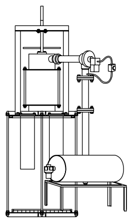
CAUTION ⚠

- **Diesel particulate filter has become very hot after the operation of engine. Cool down the diesel particulate filter sufficiently so as not to get burnt.**
- **The ceramic filter must be cleaned every 3 years or every 150,000 km running after installing (replacement with) a new filter. Sustained use without cleaning can cause ashes to accumulate, possibly resulting in broken ceramic filter.**

Service standards

Location	Maintenance item	Standard value	Limit	Remedy
–	Diesel particulate filter differential pressure (between before and after regeneration, cleaning, no-load operation at maximum speed)	Less than 7.5 kPa	7.5 kPa or more	Replace

Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Diesel particulate filter cleaning equipment  P101729	MH063817	Cleaning of ceramic filter

7.1 Preparation

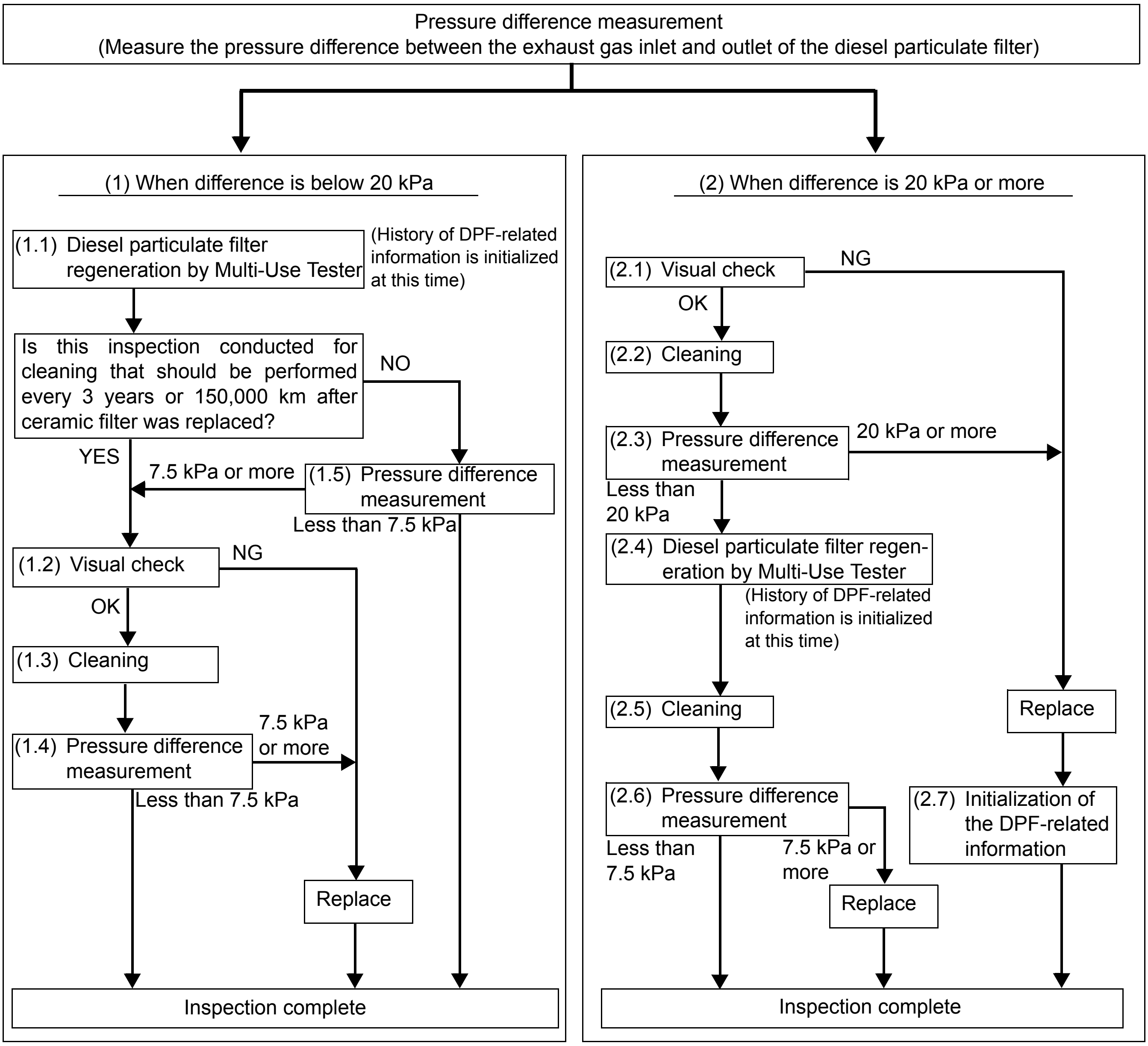
- Place the transmission in neutral.
- Turn the steering wheel in neutral position and securely apply the parking brake.
- Turn off lamps and accessory devices not to increase the engine speed.
- Connect the Multi-Use Tester. (See Gr00.)
- Check diagnosis code of each electronic control system. If any fault exists, rectify it.
- Warm up the engine until the engine coolant has been heated to more than 70°C.
  (Check by Multi-Use Tester service data “13: Water Temperature”.)

7.2 Inspection procedure

- Perform inspection following the flowchart shown below.

CAUTION ⚠

- **The pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter may exceed 20 kPa due to clogging of the ceramic filter or other reasons. If diesel particulate filter regeneration is conducted using the actuator test “DPF Regeneration” of the Multi-Use Tester in this condition, soot in the filter would burn abnormally, heating and possibly damaging the filter. Be sure to measure the pressures to make sure that the difference is smaller than 20 kPa before conducting diesel particulate filter regeneration.**
- **Follow this flowchart until the end. Otherwise, particulate matter that has been accumulated in the ceramic filter could not be removed completely, generating a gap between the amount of accumulated particulate matter recognized by the engine electronic control unit and the actual amount. In this case, diagnosis codes related to the diesel particulate filter would be issued.**



DPF: Diesel particulate filter

- Measure the pressure difference following the procedure shown below.
  - Check that the exhaust gas temperature is 150°C to 300°C. (Check by Multi-Use Tester service data “0F: Exhaust gas temperature 1”.)
  - Fully press the accelerator pedal (no-load maximum speed).
  - Measure the pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter.
    (Measure by Multi-Use Tester service data “11: Difference pressure across DPF”.)
- If the pressure difference is below 20 kPa, follow the procedure (1) shown below. If the pressure difference is 20 kPa or more, follow the procedure (2).

(1) When pressure difference between exhaust gas inlet and outlet of diesel particulate filter is below 20 kPa

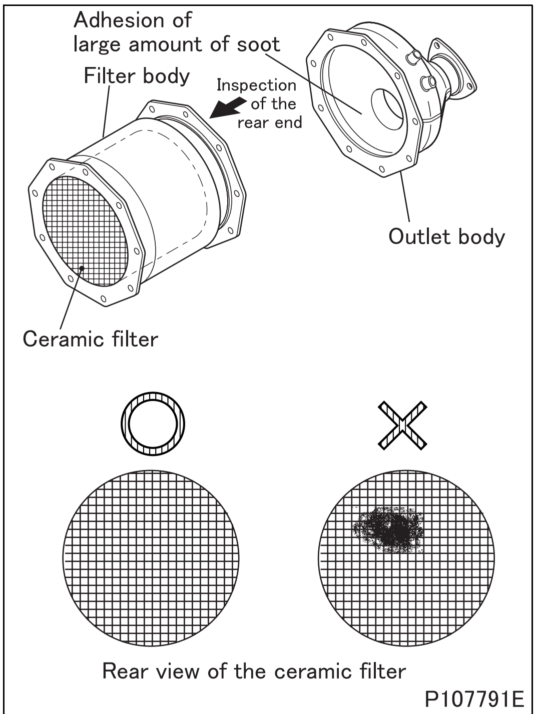
(1.1) Regeneration by Multi-Use Tester

- In this regeneration, the temperature of the ceramic filter is raised to burn the particulate matter collected in it. When burning the particulate matter, the ceramic filter may emit a burning odor, which is not abnormal.
- Idle the engine (no-load minimum speed).
- Apply the parking brake securely.
- Conduct the regeneration of the diesel particulate filter using the Multi-Use Tester. (Perform actuator test by Multi-Use Tester “A2: DPF Regeneration”.)

CAUTION ⚠

- **Do not perform the regeneration near flammable objects because exhaust gas becomes very hot.**

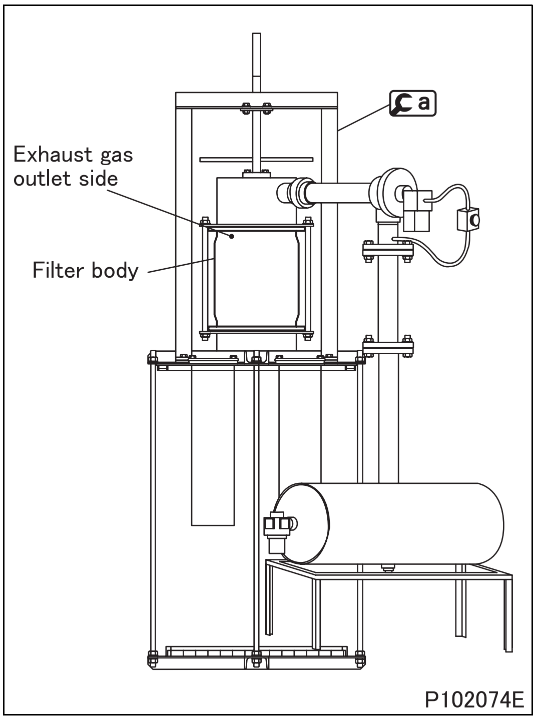
- During regeneration, the engine speed increases.



(1.2) Visual check

- Disassemble the diesel particulate filter and check for the following items.
  - Adhesion of a large amount of soot to the inside of the outlet body
  - Damage to the rear end of the ceramic filter
- If a large amount of soot is adhered to the inside of the outlet body, check the exhaust gas because engine-related parts may be abnormal. (See later section.)

DPF: Diesel particulate filter



(1.3) Cleaning

- The purpose of the cleaning made after regeneration is to remove the ashes produced from the combustion of particulate matters (PM).
- Set the filter body in a with the exhaust gas outlet side facing upward. (Outlet body side)
- Adjust the air tank pressure of a to 0.6 MPa {6.1 kgf/cm^2} and press and hold the operation switch for more than 3 seconds.
- Repeat the above operation 5 times.
- a shall be operated in accordance with the operation manual.

(1.4) Pressure difference measurement

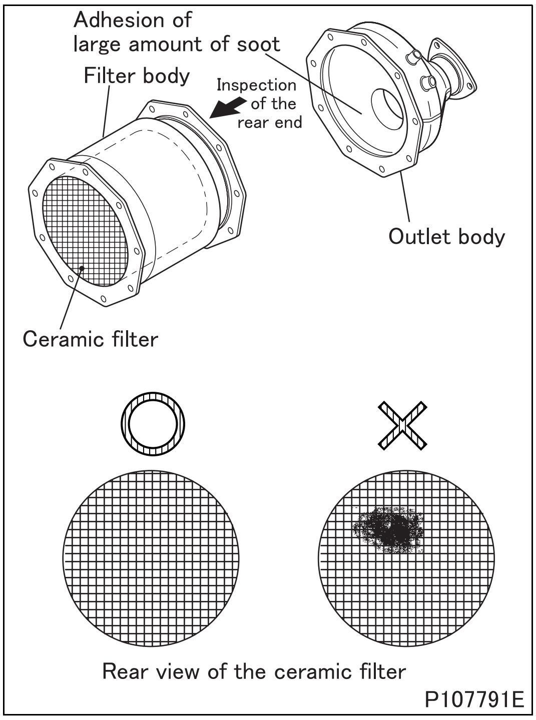
- The purpose of the differential pressure measurements taken after the cleaning is to verify that the inside of the diesel particulate filter is cleaned up sufficiently.
- Check that the exhaust gas temperature is 150°C to 300°C. (Check by Multi-Use Tester service data “0F: Exhaust gas temperature 1”.)
- Fully press the accelerator pedal (no-load maximum speed).
- Measure the pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter. (Measure by Multi-Use Tester service data “11: Difference pressure across DPF”.)

(1.5) Pressure difference measurement

- The purpose of the differential pressure measurements taken after the cleanings which are not performed at an interval of 3 years or 150,000 km running is to check if the Particulate matter (PM) deposit affects the regeneration control of the diesel particulate filter.
- Check that the exhaust gas temperature is 150°C to 300°C. (Check by Multi-Use Tester service data “0F: Exhaust gas temperature 1”.)
- Fully press the accelerator pedal (no-load maximum speed).
- Measure the pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter. (Measure by Multi-Use Tester service data “11: Difference pressure across DPF”.)

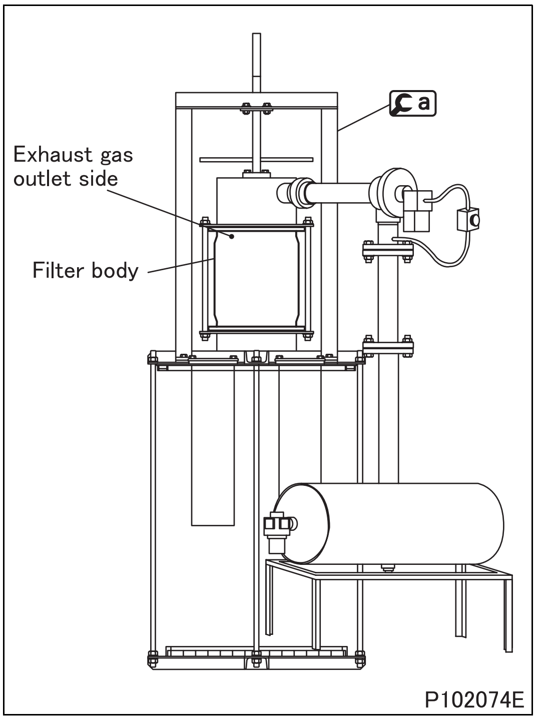
DPF: Diesel particulate filter

(2) When pressure difference between exhaust gas inlet and outlet of diesel particulate filter is 20 kPa or more



(2.1) Visual check

- Disassemble the diesel particulate filter and check for the following items.
  - Adhesion of a large amount of soot to the inside of the outlet body
  - Damage to the rear end of the ceramic filter
- If a large amount of soot is adhered to the inside of the outlet body, check the exhaust gas because engine-related parts may be abnormal. (See later section.)



(2.2) Cleaning

- The purpose of the cleaning made before regeneration is to remove the excessive ashes beforehand because the regeneration (combustion) with a large amount of ashes accumulated on the ceramic filter can cause the filter section to break.
- Set the filter body in a with the exhaust gas outlet side facing upward. (outlet body side)
- Adjust the air tank pressure of a to 0.6 MPa {6.1 kgf/cm^2} and press and hold the operation switch for more than 3 seconds.
- Repeat the above operation 5 times.
- a shall be operated in accordance with the operation manual.

(2.3) Pressure difference measurement

- The purpose of the differential pressure measurements taken after the cleaning is to verify that the inside of the diesel particulate filter is cleaned up sufficiently.
- Check that the exhaust gas temperature is 150°C to 300°C. (Check by Multi-Use Tester service data “0F: Exhaust gas temperature 1”.)
- Fully press the accelerator pedal (no-load maximum speed).
- Measure the pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter. (Measure by Multi-Use Tester service data “11: Difference pressure across DPF”.)

DPF: Diesel particulate filter

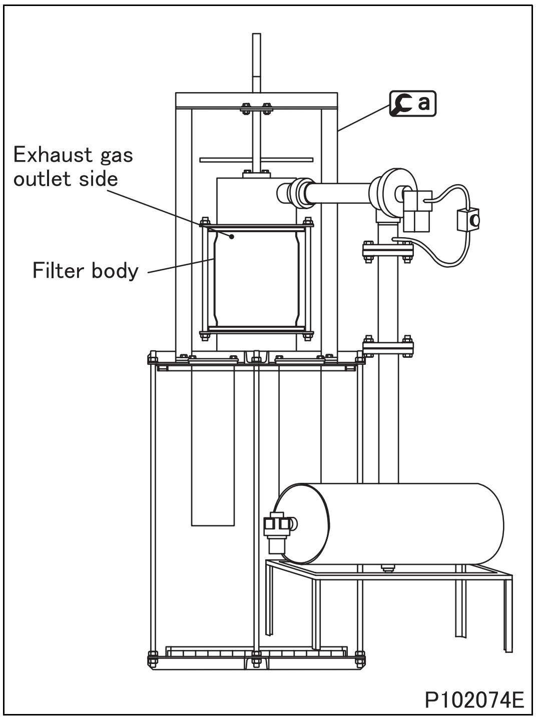
(2.4) Regeneration by Multi-Use Tester

- In this regeneration, the temperature of the ceramic filter is raised to burn the particulate matter collected in it.
  When burning the particulate matter, the ceramic filter may emit a burning odor, which is not abnormal.
- Idle the engine (no-load minimum speed).
- Apply the parking brake securely.
- Conduct the regeneration of the diesel particulate filter using the Multi-Use Tester. (Perform actuator test by Multi-Use Tester “A2: DPF Regeneration”.)

CAUTION ⚠

- **Do not perform the regeneration near flammable objects because exhaust gas becomes very hot.**

- During regeneration, the engine speed increases.



(2.5) Cleaning

- The purpose of the cleaning made before regeneration is to remove the ashes produced from the combustion of particulate matters (PM).
- Set the filter body in a with the exhaust gas outlet side facing upward. (outlet body side)
- Adjust the air tank pressure of a to 0.6 MPa {6.1 kgf/cm^2} and press and hold the operation switch for more than 3 seconds.
- Repeat the above operation 5 times.
- a shall be operated in accordance with the operation manual.

(2.6) Pressure difference measurement

- The purpose of the differential pressure measurements taken after twice the cleaning is to verify that the inside of the diesel particulate filter is cleaned up sufficiently.
- Check that the exhaust gas temperature is 150°C to 300°C.
  (Check by Multi-Use Tester service data “0F: Exhaust gas temperature 1”.)
- Fully press the accelerator pedal (no-load maximum speed).
- Measure the pressure difference between the exhaust gas inlet and outlet of the diesel particulate filter.
  (Measure by Multi-Use Tester service data “11: Difference pressure across DPF”.)

(2.7) Initialization of the DPF-related information

- Initialize the historical records of DPF-related information using Multi-Use Tester.
  (See “**9. Initialization of the DPF-Related Information**”.)

DPF: Diesel particulate filter

8. Inspection of Exhaust Gas

- If the diesel particulate filter clogs early, or if a large amount of soot adheres inside the diesel particulate filter outlet body, check whether it is caused by the engine-related (engine, common rail system, exhaust gas recirculation system, etc.) fault or not as follows.

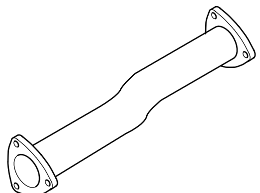
CAUTION ⚠

- **Diesel particulate filter has become very hot after the operation of engine. Cool down the diesel particulate filter sufficiently so as not to get burnt.**

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
–	Nut (diesel particulate filter mounting)	26 to 33 {2.7 to 3.4}	–
	Nut (tail pipe mounting)		

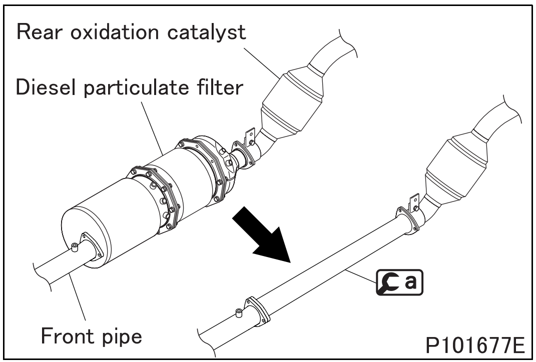
Special tools (Unit: mm)

Mark	Tool name and shape	Part No.	Application
a	Dummy pipe  P101728	MH063819	Inspection of exhaust gas

8.1 Preparation

- Place the transmission in neutral.
- Turn the steering wheel in neutral position and securely apply the parking brake.
- Connect the Multi-Use Tester. (See Gr00.)
- Check diagnosis code of each electronic control system. If any fault exists, rectify it.
- Warm up the engine until the engine coolant has been heated to more than 70°C.
  (Check by Multi-Use Tester service data “13: Water temperature”.)

8.2 Inspection procedure



P101677E

- Remove diesel particulate filter, each sensor, pipe and hose and install a between front pipe and tail pipe. (See “DIESEL PARTICULATE FILTER”.)
- Race the engine with the tool attached and check to see if the exhaust gas is white or black. If any apparently white or black smoke is emitted, check the following and repair the faulty components as necessary.
  - Common rail system (See Gr13.)
  - Exhaust gas recirculation system (See Gr17.)
  - Exhaust shutter
  - Air cleaner
  - Turbocharger
  - Boost pressure
  - Compression pressure (See Gr11.)
- After inspection, remove a and install diesel particulate filter between front pipe and tail pipe. Then reinstall the removed sensors, pipes and hoses. (See “DIESEL PARTICULATE FILTER”.)
- Be sure to erase diagnosis codes after the end of inspection as engine warning lamp may illuminate by diagnostic function when sensors installed on diesel particulate filter are removed.

DPF: Diesel particulate filter

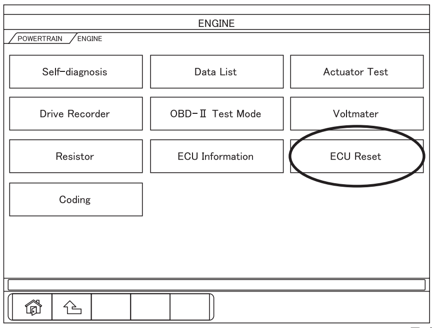
9. Initialization of the DPF-Related Information

- The engine electronic control unit stores the DPF-related information as historical records to facilitate the regeneration of the diesel particulate filter.
- The initialization of the DPF-related information is performed to make the particulate matter (PM) deposit recognized by the engine electronic control unit coincide with the actual particulate matter (PM) deposit accumulated in diesel particulate filter after replacing or cleaning diesel particulate filter.
- The initialization of the DPF-related information should be performed using a Multi-Use Tester as follows:

9.1 Preparation

- This operation should be performed under the following conditions.
  - Starter switch: ON (but do not start engine)
  - Vehicle stationary
  - Diagnosis switch: ON (fuse connected)
  - T/M: Place the gearshift lever in the neutral position.

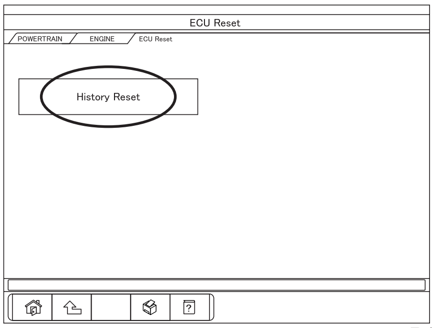
9.2 Initialization of the DPF-related information



P101911E

(1) System selection

- Select "Engine/Transmission" from the system selection menu. Then select "Engine control" from the menu. After a short while, the menu for the engine control will be displayed.
- Select the "ECU Reset".

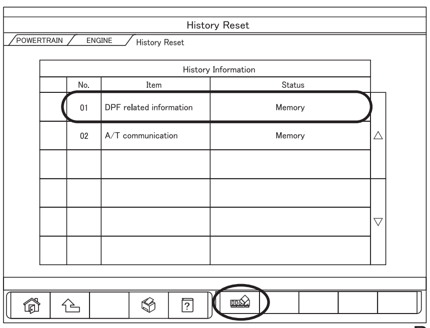


P101912E

(2) ECU reset function selection

Screen for selecting [ECU Reset] functions

- Select the "History reset".



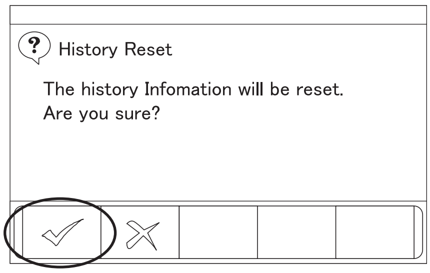
P101913E

(3) History reset

Screen for selecting [History Reset] functions

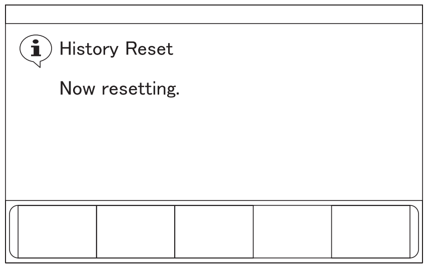
- Select No. 01 "DPF-related information".
- Click "Reset" button.
  If "No memory" is displayed in the "Status", this work sequence is ended because of absence of any history necessary to be reset.

ECU: Electronic control unit
DPF: Diesel particulate filter



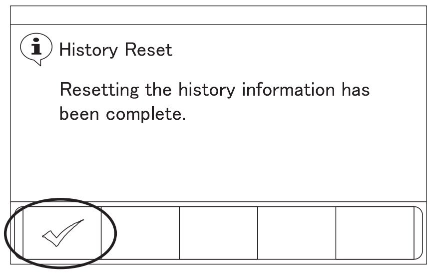
P102065E

[History reset confirmation] screen
- Click “OK” button.



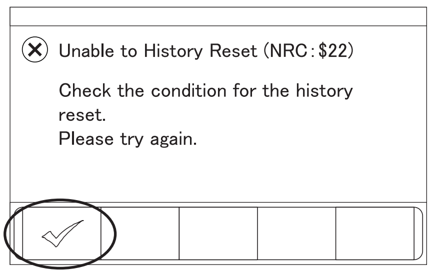
P102066E

[History resetting] screen
- During resetting, do nothing and wait for a while.



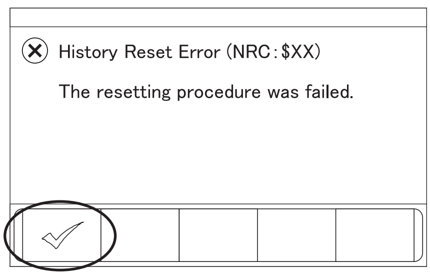
P102067E

[History reset completed] screen
- The screen shown at left will be displayed when the resetting is completed. Press “OK” button, and the [History reset] screen is restored.
- Following screen will appear if abnormality occurred during resetting.



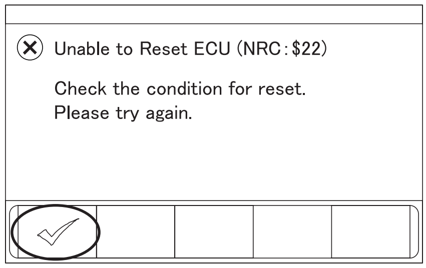
P102068E

[History reset condition error] screen
- This screen will appear when a execution failure signal is sent from the engine electronic control unit to the Multi-Use Tester during resetting.
- In this case, check if the conditions for the execution of the procedure are satisfied and retry from the beginning.
- Click “OK” to return to the [History reset] screen.



P102069E

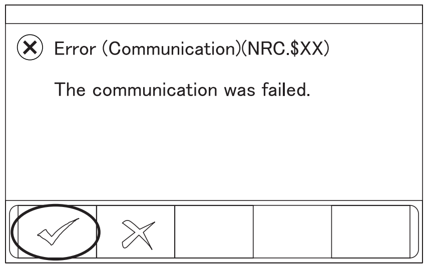
[History reset failed] screen
- This screen will appear when the communication error between Multi-Use Tester and the engine electronic control unit or the resetting error occurs.
- In this case, check if the Multi-Use Tester and the vehicle (engine electronic control unit) is connected correctly and if the conditions for the execution of this procedure are satisfied. Retry from the beginning.
- Click “OK” to return to the [History reset] screen.



P102070E

[ECU reset condition error] screen

- This screen will appear when a execution failure signal is sent from the engine electronic control unit to the Multi-Use Tester during resetting.
- In this case, check if the conditions for the execution of the procedure are satisfied and retry from the beginning.
- Click “OK” to return to the [History reset] screen.



P101986E

Error while operating the Multi-Use Tester
[Communication error] screen

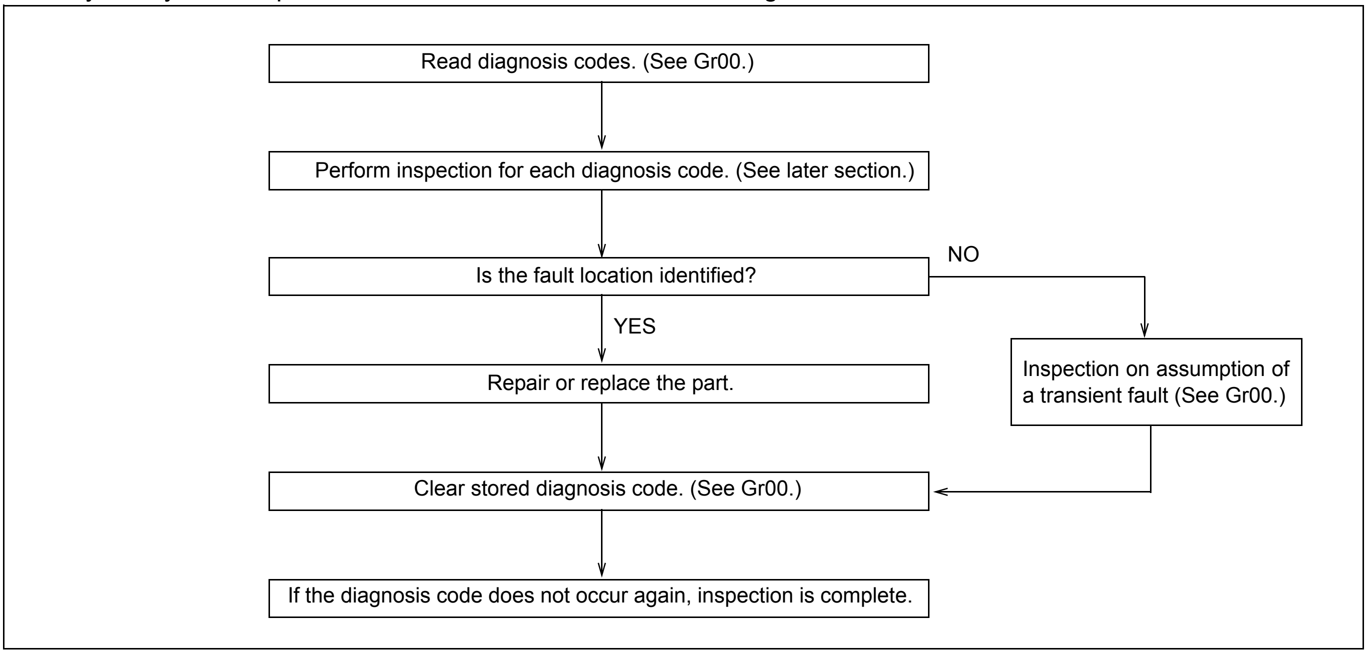
- The screen shown at left will be displayed when the communication between the engine electronic control unit and Multi-Use Tester is disabled during some operation being executed.
- In this case, check if the conditions for the execution of the procedure are satisfied and retry from the beginning.
- Click “OK” button.

ECU: Electronic control unit

TURBOCHARGER CONTROL SYSTEM

1. Diagnosis Procedure

- Carry out system inspection in accordance with the flow chart given below.



2. Diagnostic Precautions

- Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
- Before disconnecting battery cables, harnesses and connectors, set the starter switch to LOCK or OFF, then allow at least 20 seconds.
- To avoid having electrical parts damaged, set the starter switch and lighting switch to LOCK or OFF before reconnecting battery cables, harnesses and connectors.
- When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and car body.
- Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C) as the measuring condition.
- To start the engine, be sure to connect the connector of the MPROP (rail pressure control valve) to the engine harness. If the engine is started without connecting the MPROP connector, the engine electronic control unit cannot control the supply pump and the fault of the engine may result.
- If the electronic control unit is replaced with a new one, some data must be registered in the new electronic control unit for proper engine control. This also applied to the case when replacing the electronic control unit with the one that has been used in other vehicle. (See Gr13.)

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- The Multi-Use Tester is capable of showing more detailed diagnosis codes.
- The control during fault recovers by servicing the faults. However, for some diagnosis codes, the warning lamp stays illuminated until the normal signals are input for several times.

Code	Message	Warning lamp indication		
		Flashes	Orange	Red
P0045	VGT Actuator (Open)	51	O	–
P0046	VGT Actuator (Performance)	51	O	–
P0047	VGT Actuator (Low)	51	O	–
P0234	Over Boost	54	O	–
P0237	Boost Press SNSR (Low)	32	O	–
P0238	Boost Press SNSR (High)	32	O	–
P0685	EDU Relay (Open)	84	O	–
P0686	EDU Relay (Low)	84	O	–
P0687	EDU Relay (High)	84	O	–
P0688	EDU Relay (Over Load)	84	O	–
P1645	CAN Communication (VGT)	76	O	–
P2263	VGT System	51	O	–
P2562	VGT Position Sensor	51	O	–

3.2 Diagnosis code generation conditions and inspection items

P0045: VGT Actuator (Open) (warning lamp flashes: 51)

Generation condition		Open turbocharger actuator circuit
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Electrical equipment	#514: Turbocharger actuator
	Electric circuit diagram	Turbocharger actuator system

P0046: VGT Actuator (Performance) (warning lamp flashes: 51)

Generation condition		Turbocharger actuator circuit is overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Electrical equipment	#514: Turbocharger actuator
	Electric circuit diagram	Turbocharger actuator system

P0047: VGT Actuator (Low) (warning lamp flashes: 51)

Generation condition		Turbocharger actuator circuit is shorted.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Turbocharger control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Electrical equipment	#514: Turbocharger actuator
	Electric circuit diagram	Turbocharger actuator system

P0234: Over Boost (warning lamp flashes: 54)

Generation condition		The boost pressure is kept higher than the upper limit for 10 seconds. (The boost pressure varies depending on not only the engine speed but the barometric pressure.) ※ The warning lamp (orange) is lit when the faulty condition is sustained for 10 seconds after this diagnosis code is generated.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Injection quantity is limited.
Inspection	Service data	0C: Boost Pressure
	Actuator test	A5: VGT
	Other	Turbocharger

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

Generation condition		Boost pressure sensor voltage remains less than 0.3 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (101.3 kPa) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	24: Boost Press SNSR Voltage
	Electronic control unit connector	03: Boost pressure sensor
	Electrical equipment	#318: Boost pressure sensor
	Electric circuit diagram	Boost pressure sensor system

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

Generation condition		Boost pressure sensor voltage remains higher than 4.9 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Backup value (101.3 kPa) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	24: Boost Press SNSR Voltage
	Electronic control unit connector	03: Boost pressure sensor
	Electrical equipment	#318: Boost pressure sensor
	Electric circuit diagram	Boost pressure sensor system

P0685: EDU Relay (Open) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay is open-circuited.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02: Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0686: EDU Relay (Low) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay circuit is shorted to ground.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02: Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0687: EDU Relay (High) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay circuit is shorted to power supply side.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02: Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0688: EDU Relay (Over Load) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay circuit is over loaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02: Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

DPF: Diesel particulate filter

P1645: CAN Communication (VGT) (warning lamp flashes: 76)

Generation condition		The controller area network signals from the turbocharger electronic drive unit cannot be received within the specified time duration. ※ Diagnosis code P1632, P1635 or U0073 may occur simultaneously (if these diagnosis codes occur at the same time, possibility is high that harness somewhere near engine electronic control unit is faulty)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Turbocharger control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Service data	22: VGT Position
	Actuator test	AD: EDU Relay
	Electronic control unit connector	01: Controller area network resistor, 02: Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay, #828: Controller area network resistor
	Electric circuit diagram	Controller area network communication between engine electronic control unit and turbocharger electronic drive unit, turbocharger electronic drive unit power system

P2263: VGT System (warning lamp flashes: 51)

Generation condition		The turbocharger actuator fails to operate in accordance with the commands from the turbocharger electronic drive unit even in the operable range or is forced to come out of the operable range.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Fuel injection rate is limited. • Exhaust gas recirculation valve control is stopped. • Turbocharger control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Electrical equipment	#514: Turbocharger actuator
	Electric circuit diagram	Turbocharger actuator system

P2562: VGT Position Sensor (warning lamp flashes: 51)

Generation condition		Turbocharger electronic drive unit determines the turbocharger position sensor to be faulty.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Fuel injection rate is limited. • Exhaust gas recirculation valve control is stopped. • Turbocharger control is stopped. • DPF regeneration control is stopped. • Intake throttle control is stopped. • Actuator tests “A5: VGT” is stopped.
Inspection	Electrical equipment	#514: Turbocharger actuator
	Electric circuit diagram	Turbocharger actuator system

DPF: Diesel particulate filter

4. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
0C	Boost Pressure	■■■. ■ kPa	Engine speed: 3700 rpm	120 ± 2 kPa
22	VGT Position	■■■. ■%	When engine is stationary	100%
			When vehicle is running	10 to 85%
24	Boost Press SNSR Voltage	■■■. ■mV	Sensor circuit open circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
89	EDU Power Relay	ON/OFF	Starter switch ON	ON
			Starter switch OFF	OFF
		[Actuator test] AC: EDU Relay		

5. Actuator Tests Performed Using Multi-Use Tester

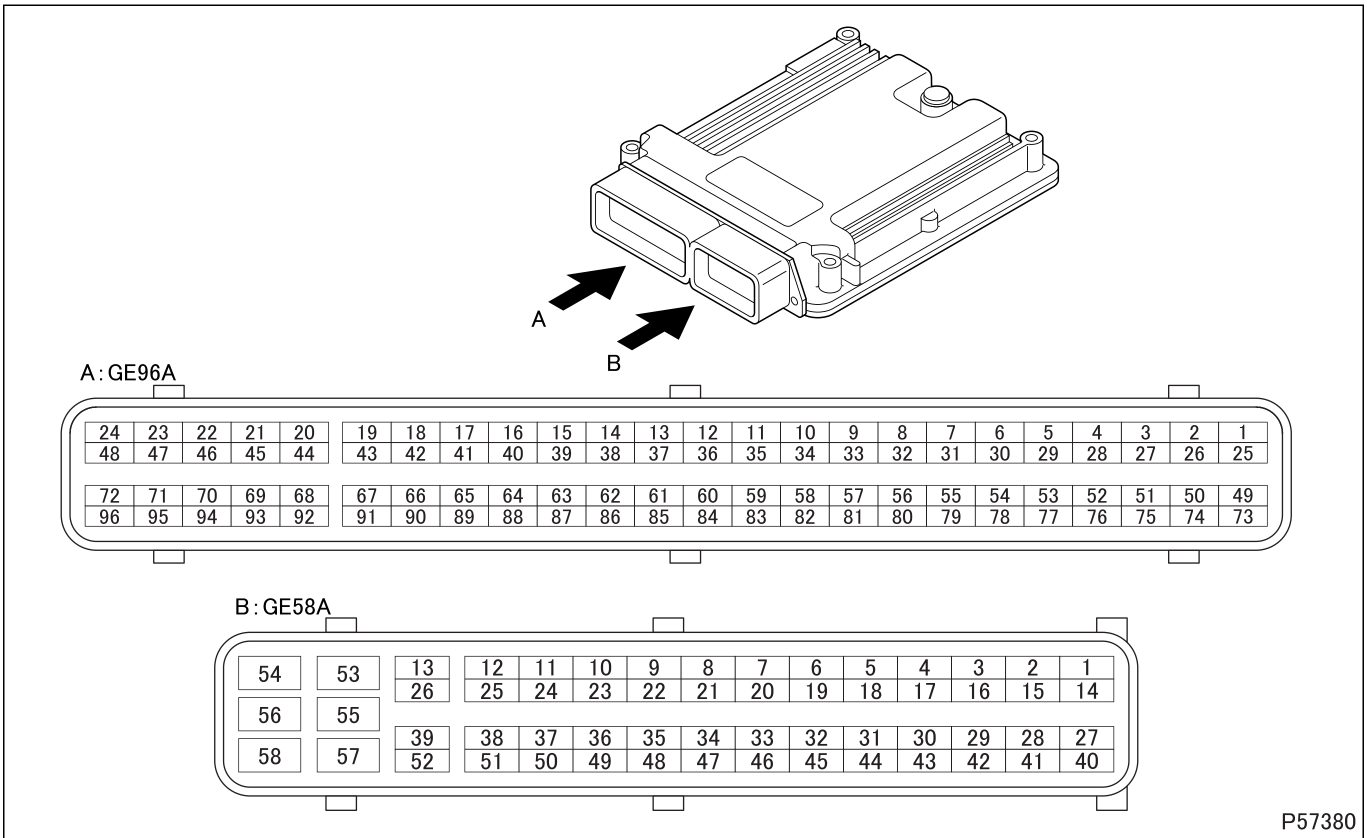
- It is possible to see service data and actuator tests simultaneously.

No.	Item	Explanation	Confirmation method
A5	VGT	Maintain turbocharger throttle opening indicated by Multi-Use Tester during engine operation. [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON (engine started) • Transmission: neutral • Diagnosis switch: OFF (with fuse removed) **NOTE** • **Adjust turbocharger throttle opening within the range from 15% to 80%.**	See “Measurement and Adjustment of Turbocharger Boost Pressure”. [Service data] 22: VGT Position
AC	EDU Relay	Electronic drive unit relay drive signal (Errors related to exhaust gas recirculation and to the intake throttle can be detected when this actuator test is executed.)	Operating sound of relay [Service data] 89: EDU Power Relay

6. Inspections Performed at Electronic Control Unit Connectors

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

6.1 Electronic control unit connector terminal layout



6.2 Inspection instructions

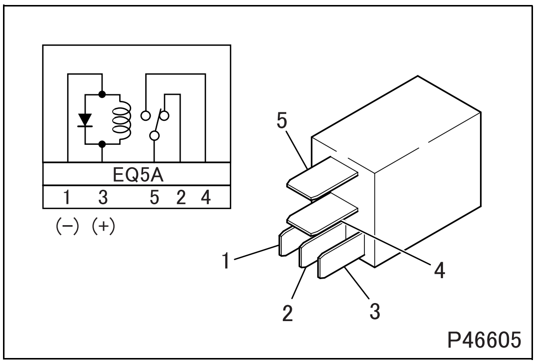
- Some inspections are performed with the connectors removed. Others are performed with the connectors fitted.

CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

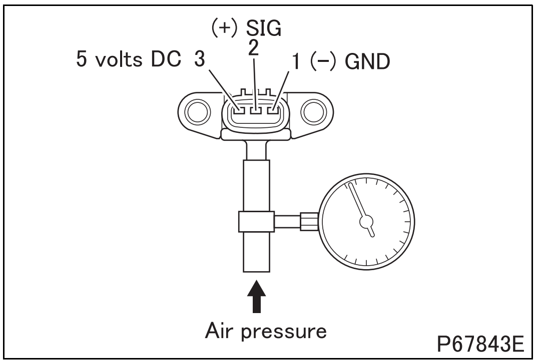
Check item	Measurement
01 Resistance of controller area network resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B5-B6 • 120 ± 6
02 Voltage of electronic drive unit relay	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): B39-B14 • With relay operating: Corresponding to battery voltage • With relay not operating: 0 V
03 Voltage of boost pressure sensor	[Conditions] • Starter switch ON • Engine: idling • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): A34-A14 • Higher than 0.3 V and lower than 4.9 V (no continuity between each terminal and chassis ground and between terminals)

7. Inspection of Electrical Equipment



#201 Inspection of relay (normally open, 5 pins)

- Perform a continuity check and an operation check. If there is any abnormality, replace the relay.

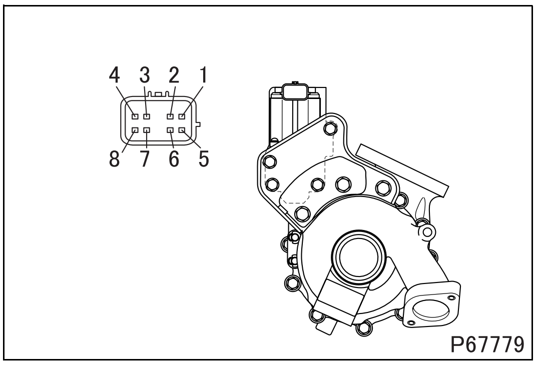


#318 Inspection of boost pressure sensor

- Apply 5 volts DC to terminals 3 and 1.
- Apply air pressure. Gradually increase it and, while doing so, measure the output voltage occurring at terminals 2 and 1.

Standard value	Air pressure (gauge pressure)	Voltage
	99 kPa {1.0 kgf/cm^2}	Approx. 2.5 V
	232.3 kPa {2.3 kgf/cm^2}	Approx. 4.5 V

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



#514 Inspection of turbocharger actuator

- Perform the following checks. If there is any abnormality, replace the turbocharger actuator.

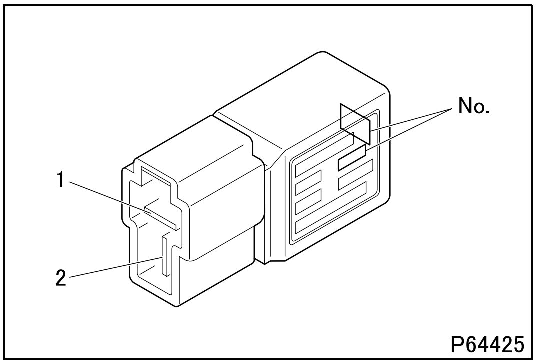
(1) Coil resistance of motor

- Measure the resistance between terminals 8 and 7, the resistance between terminals 8 and 6, and the resistance between terminals 7 and 6.

Standard value	2.1 ± 0.3 Ω

(2) Position sensor

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



#828 Inspection of controller area network resistor

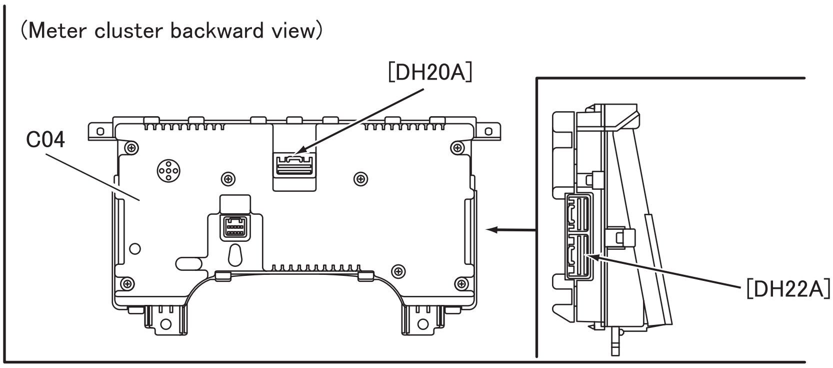
- Measure the resistance between terminals 1 and 2.

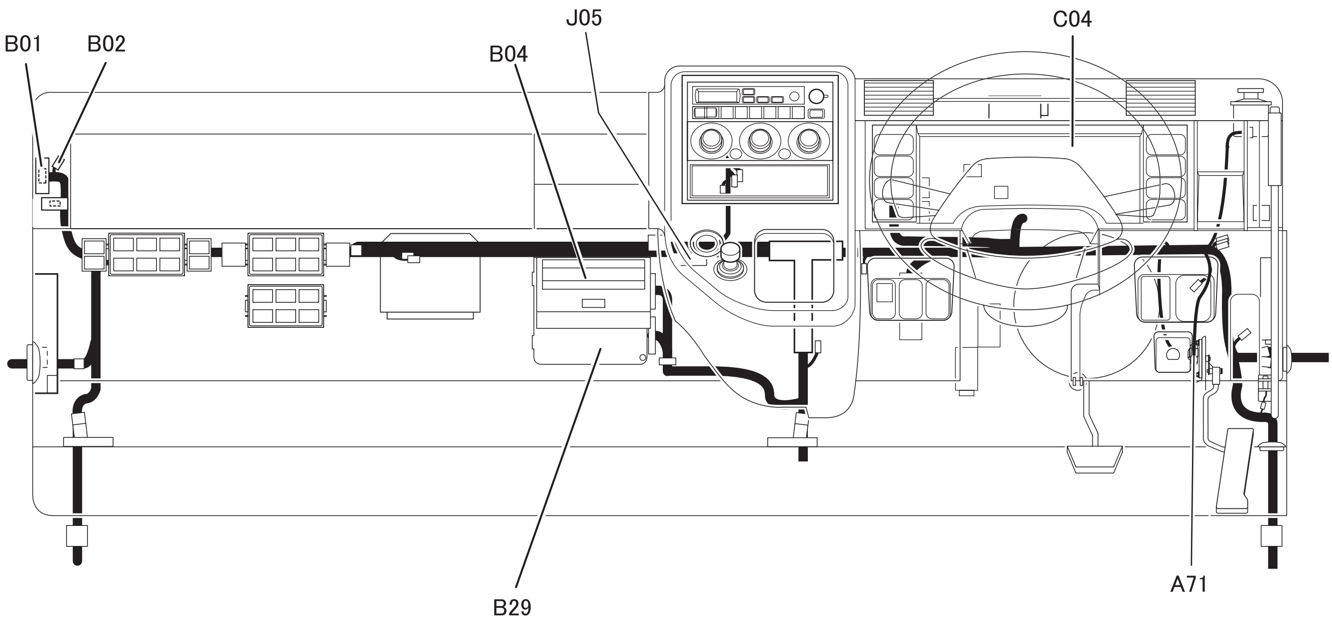
Standard value (at 20°C)	120 ± 6 Ω

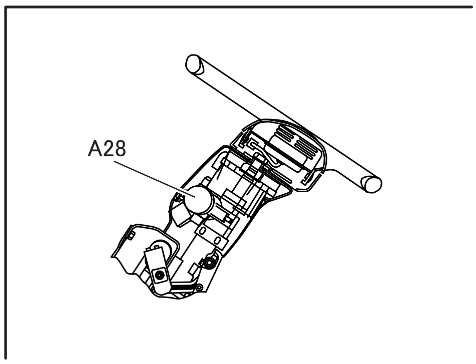
- If the measurement is out of specification, replace the controller area network resistor.

8. Installed Locations of Parts

A28–71	B01–29	C04	J05







A28 Starter switch
A71 Accelerator pedal position sensor

B01 VG turbocharger EDU
B02 CAN resistor
B04 Fuse box
B29 Engine ECU

C04 Meter cluster

J05 Joint connector (J/C–3)

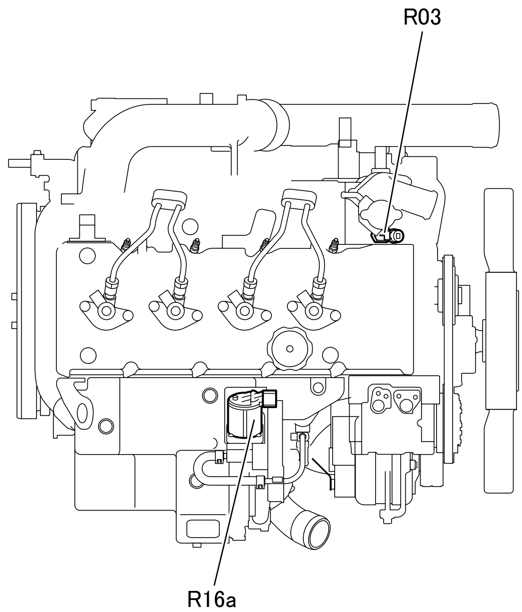
ECU : Electronic control unit
EDU : Electronic drive unit
VG : Variable geometry
CAN : Control area network

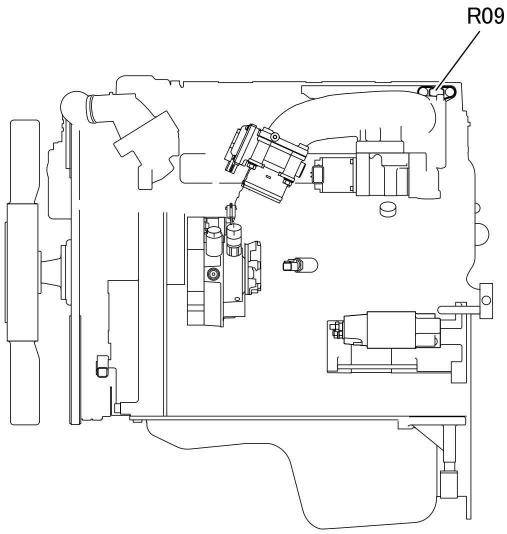
15–L04650

R03-16 | S05

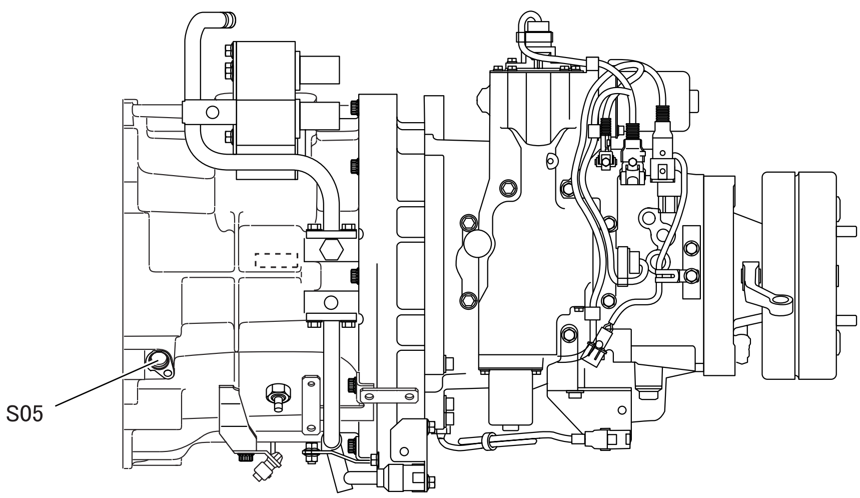
(Upper view)

(Left side view)





(Upper view)



R03 Water temperature sensor
(connects to engine electronic control unit)
R09 Boost pressure sensor
R16a VG turbocharger actuator

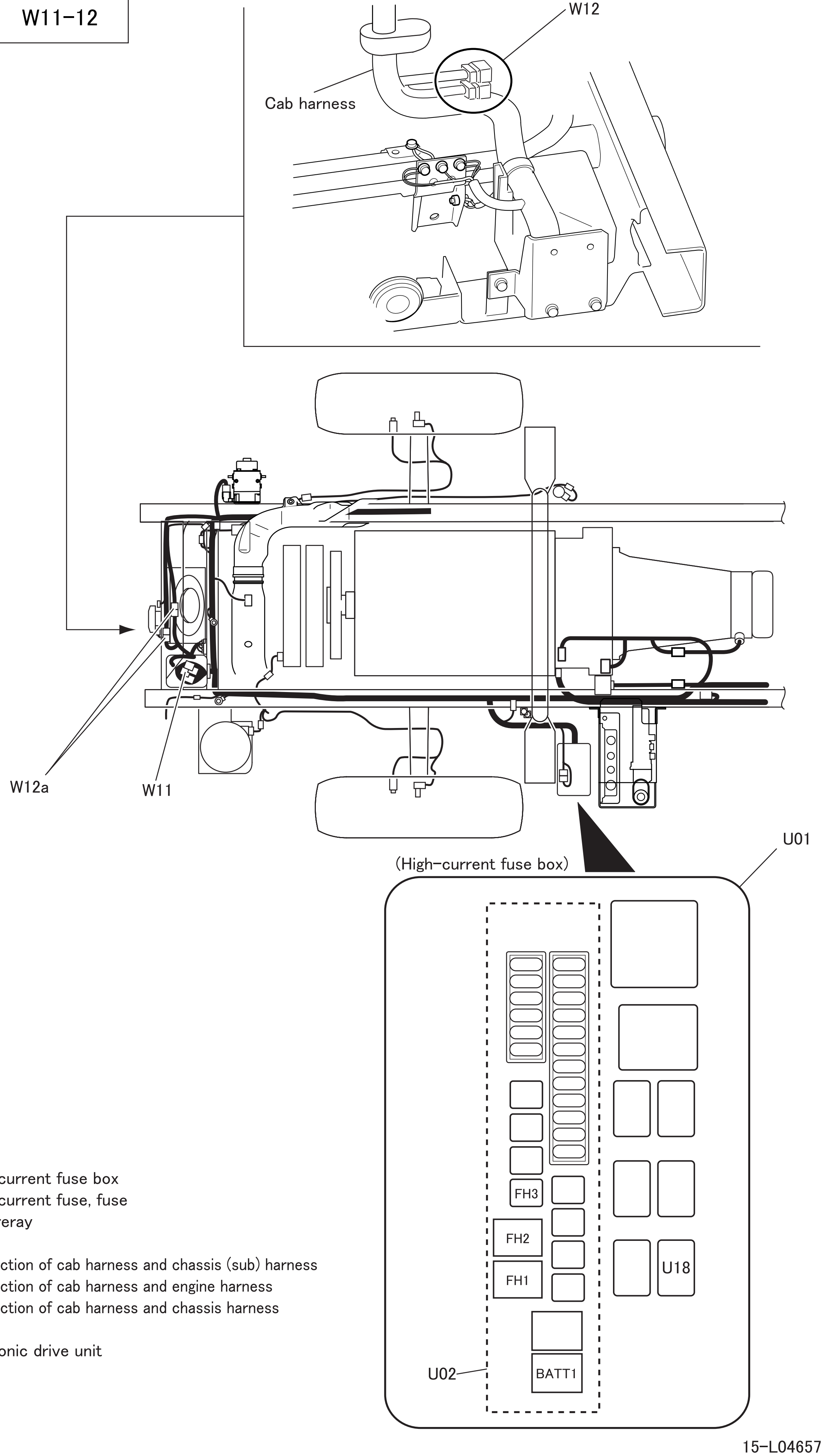
S05 Engine speed sensor

VG : Variable geometry

15–L04653

TURBOCHARGER CONTROL SYSTEM

U01–18 | W11–12

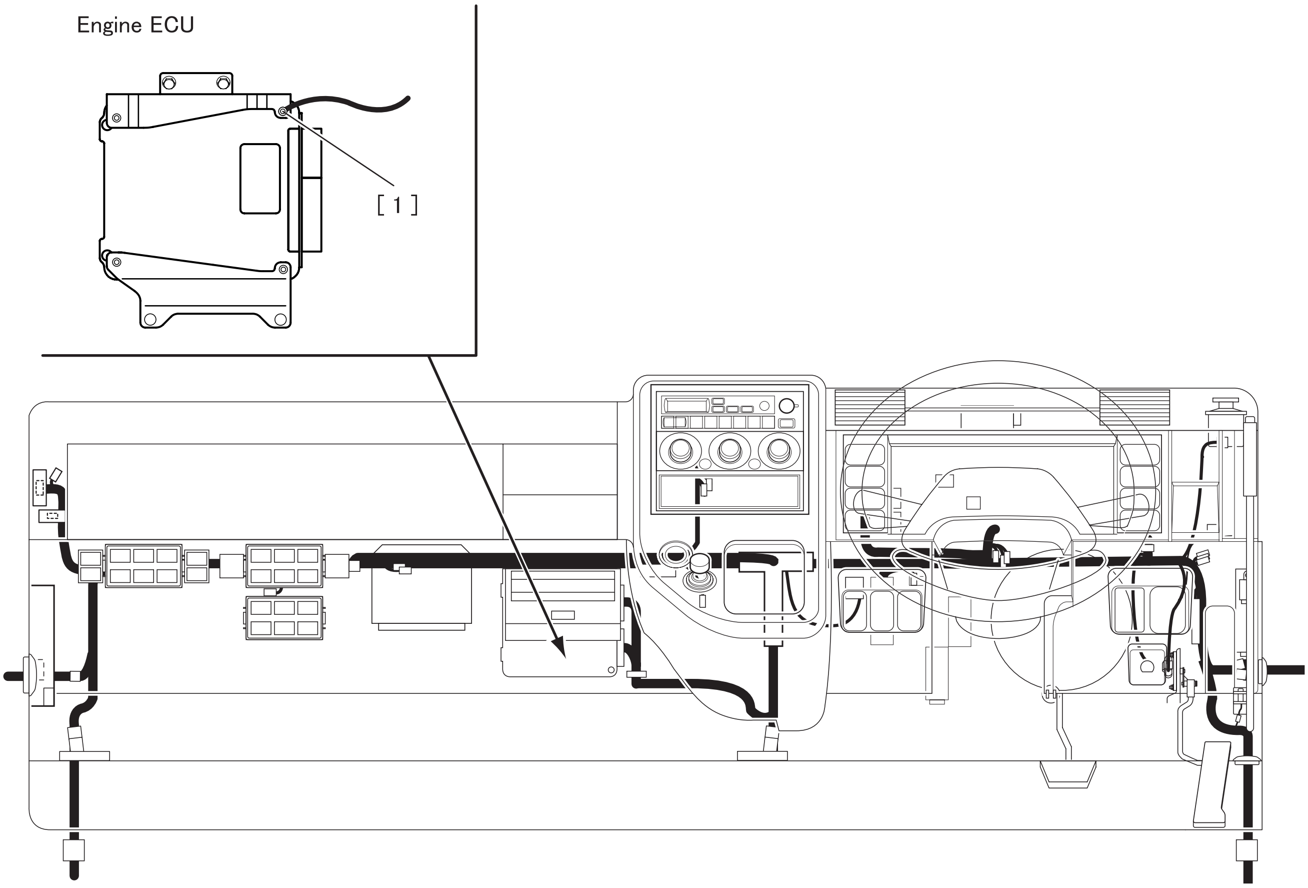


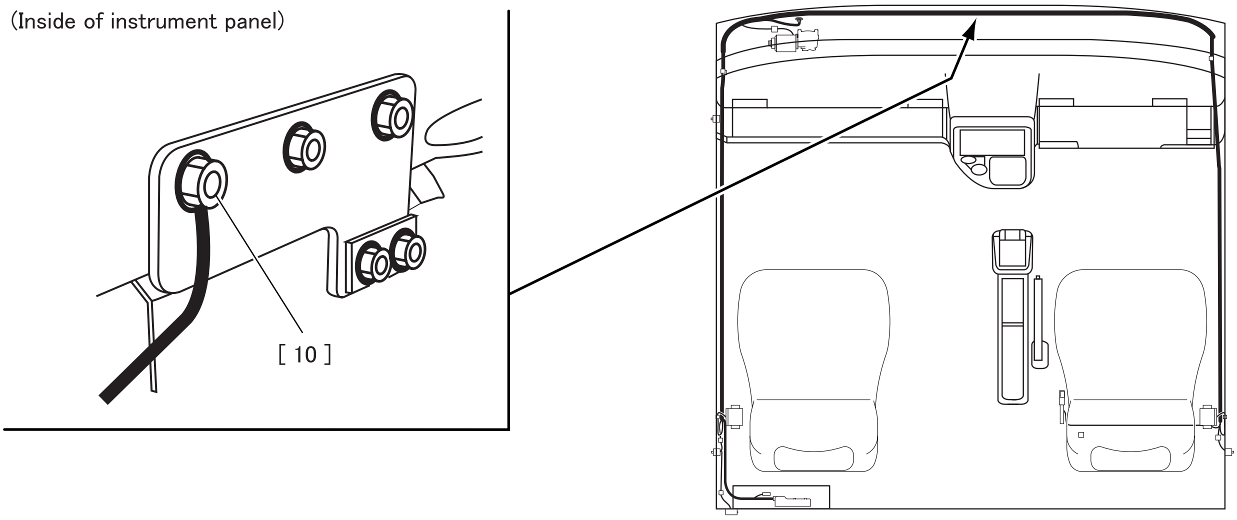
U01 High–current fuse box
U02 High–current fuse, fuse
U18 EDU reray

W11 Connection of cab harness and chassis (sub) harness
W12 Connection of cab harness and engine harness
W12a Connection of cab harness and chassis harness

EDU : Electronic drive unit

[1]–[10]	Cab ground





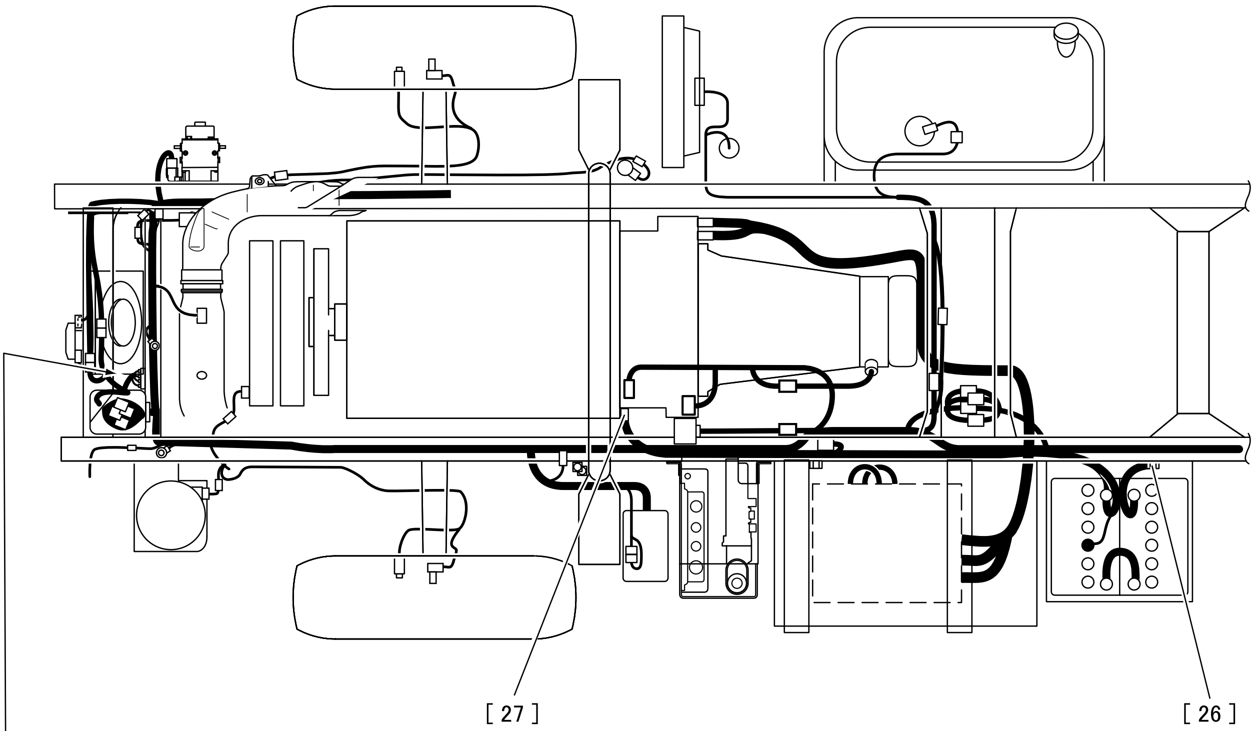
[1] Ground
[10] Ground

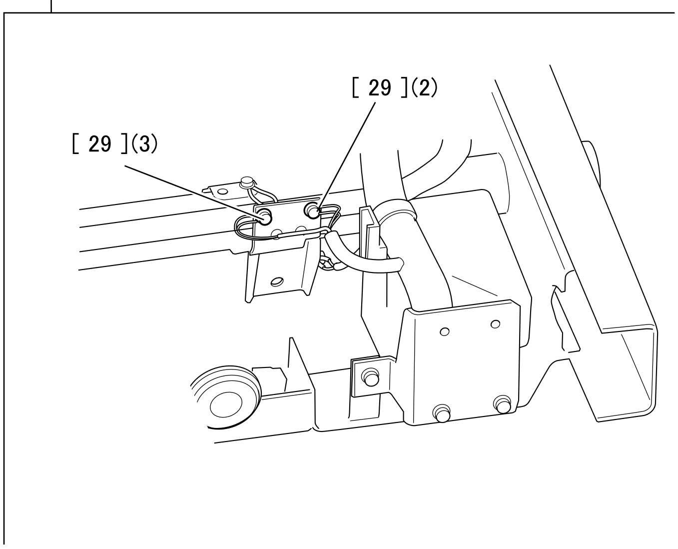
ECU : Electronic control unit

15–L04658

TURBOCHARGER CONTROL SYSTEM

[26]-[29]	Chassis ground

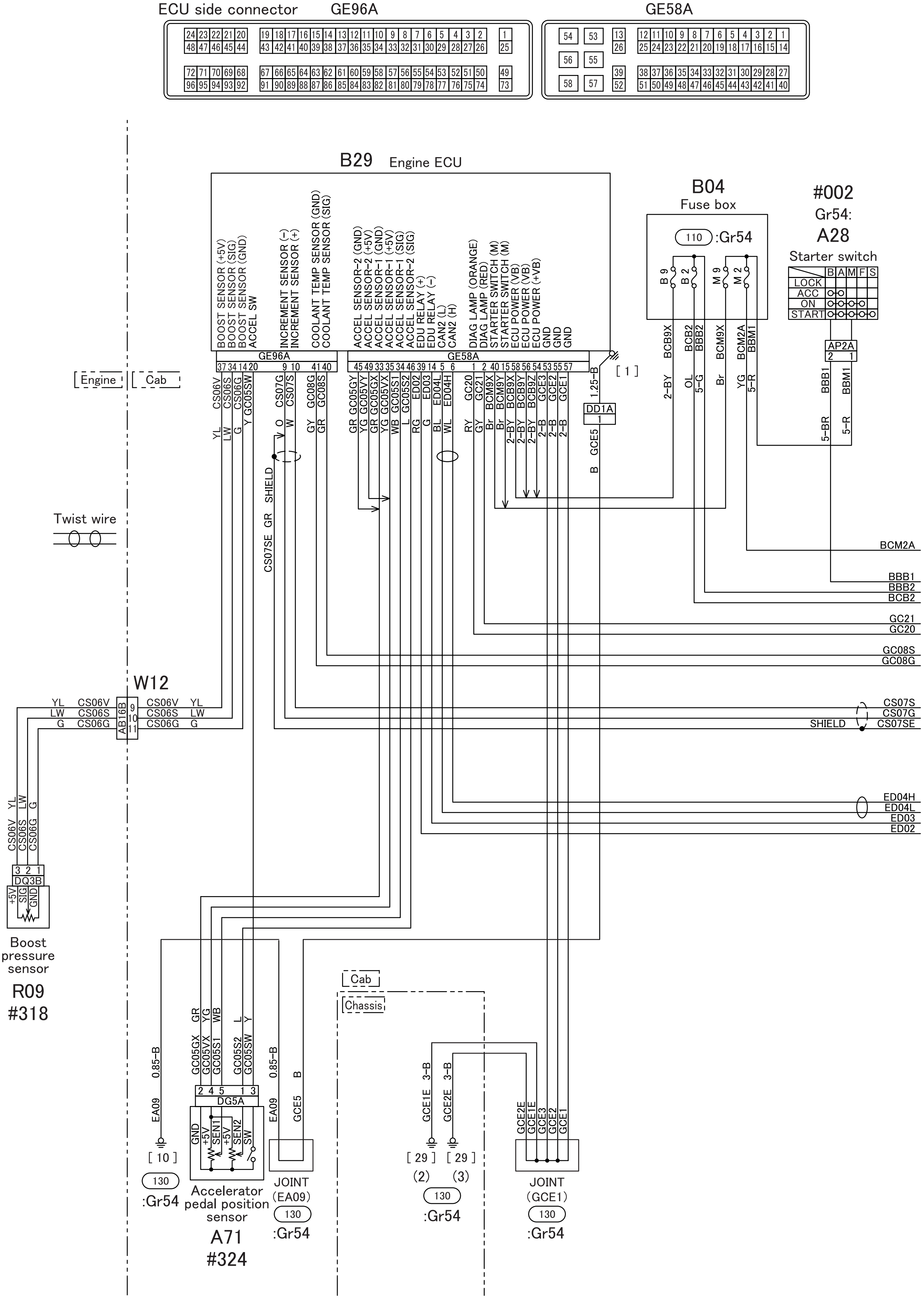




[26] Ground
[27] Ground
[29](2) Ground
[29](3) Ground

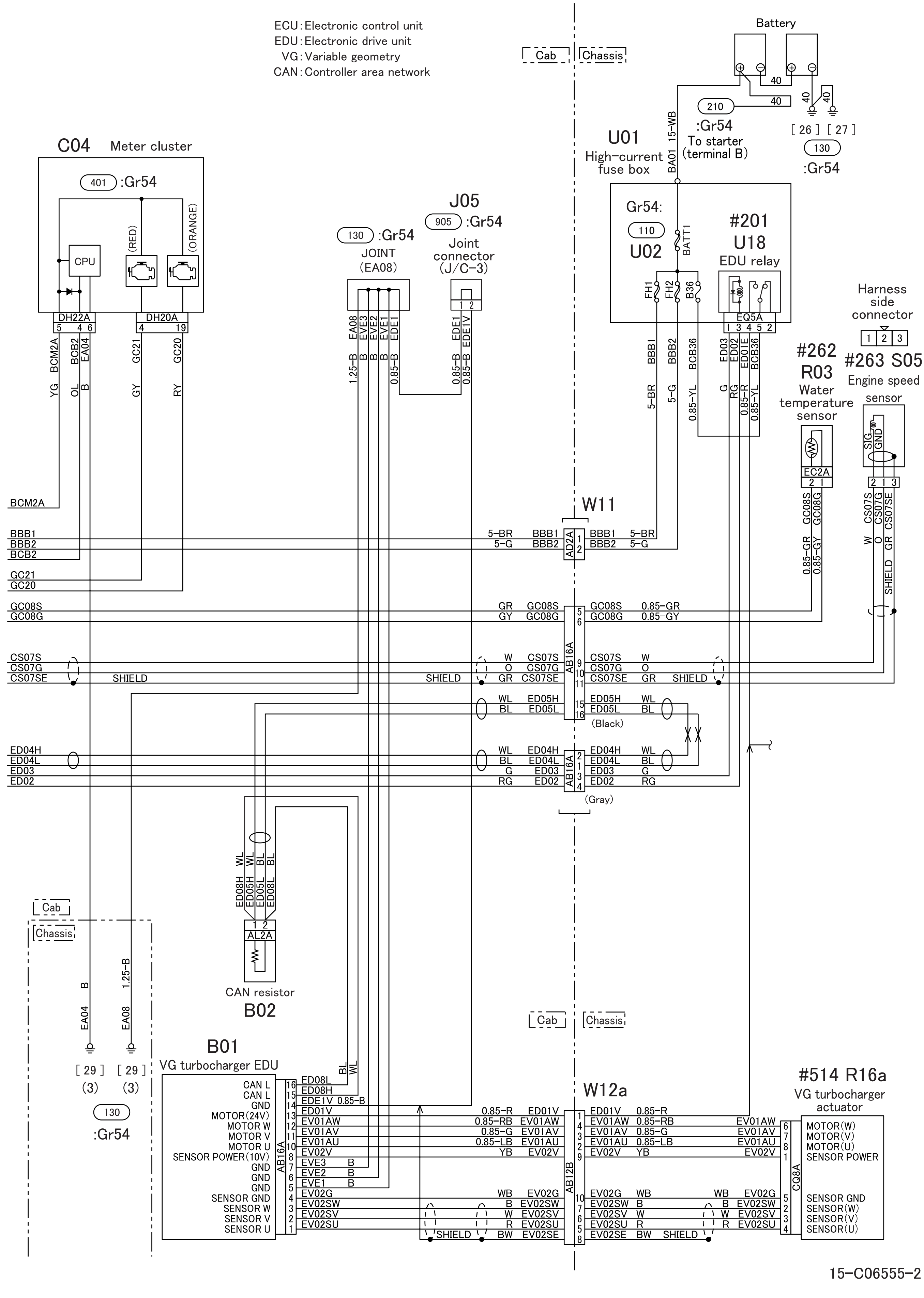
15-L04659

9. Electric Circuit Diagram



15−C06555−1

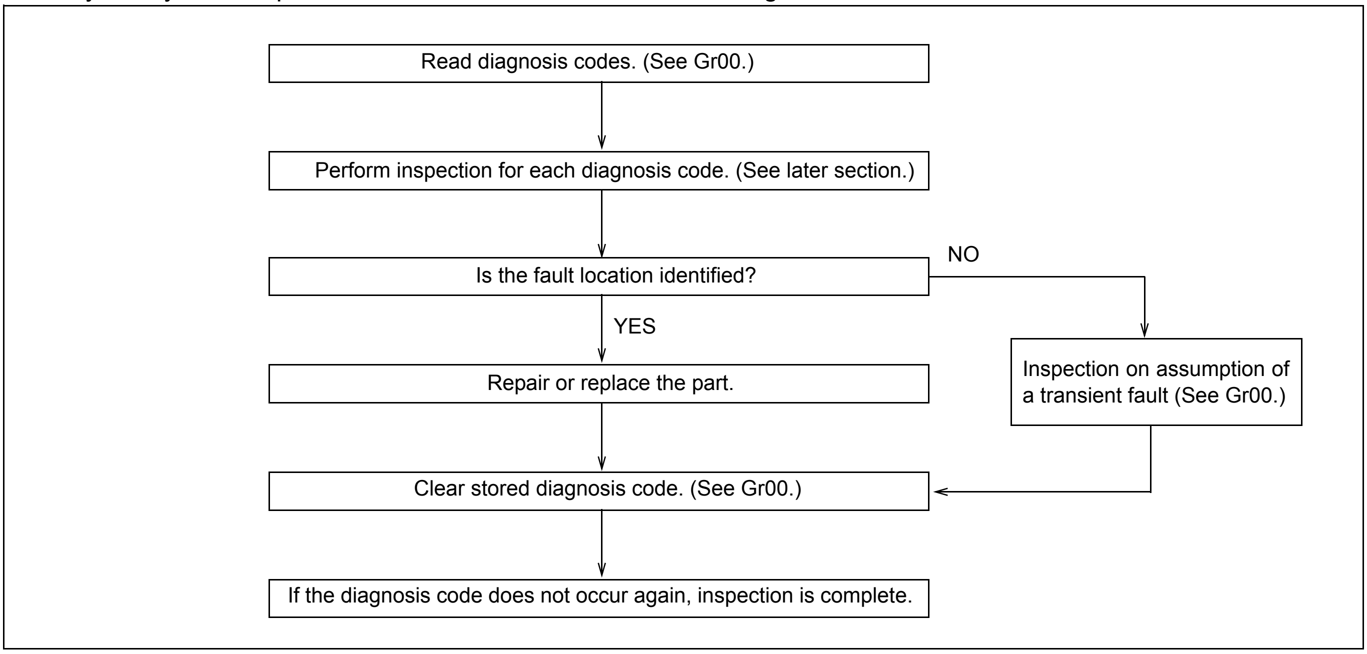
TURBOCHARGER CONTROL SYSTEM



M E M O

1. Diagnosis Procedure

- Carry out system inspection in accordance with the flow chart given below.



2. Diagnostic Precautions

- Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
- Before disconnecting battery cables, harnesses and connectors, set the starter switch to LOCK or OFF, then allow at least 20 seconds.
- To avoid having electrical parts damaged, set the starter switch and lighting switch to LOCK or OFF before reconnecting battery cables, harnesses and connectors.
- When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and car body.
- Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C) as the measuring condition.
- To start the engine, be sure to connect the connector of the MPROP (rail pressure control valve) to the engine harness. If the engine is started without connecting the MPROP connector, the engine electronic control unit cannot control the supply pump and the fault of the engine may result.
- If the electronic control unit is replaced with a new one, some data must be registered in the new electronic control unit for proper engine control. This also applied to the case when replacing the electronic control unit with the one that has been used in other vehicle. (See Gr13.)

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- The Multi-Use Tester is capable of showing more detailed diagnosis codes.
- The control during fault recovers by servicing the faults. However, for some diagnosis codes, the warning lamp stays illuminated until the normal signals are input for several times.

Code	Message	Warning lamp indication		
		Flashes	Orange	Red
P0472	DPF Press SNSR (Low)	98	O	–
P0473	DPF Press SNSR (High)	98	O	–
P0545	DPF Temp SNSR (upstream) Low	87	O	–
P0546	DPF Temp SNSR (upstream) High	87	O	–
P1410	Exhaust Absolute Pressure (High)	92	O	–
P1411	Excessive exhaust Temperature	92	–	–
P1412	DPF Temp Abnormal 1 (Auto) (Low)	92	–	–
P1413	DPF Temp Abnormal 2 (Auto) (Low)	92	–	–
P1414	DPF Temp Abnormal 3 (Auto) (High)	92	–	–
P1415	DPF Interval Abnormal (Auto)	92	–	–
P1416	DPF Temp Abnormal 1 (Manual) (Low)	92	O	–
P1417	DPF Temp Abnormal 2 (Manual) (Low)	92	O	–
P1418	DPF Temp Abnormal 3 (Manual) (High)	92	O	–
P1419	DPF Interval Abnormal (Manual)	92	O	–
P1421	PM accumulation amount level 1	92	O	–
P1422	PM accumulation amount level 2	92	O	–
P1430	DPF Regeneration Switch	7B	O	–
P1435	Exhaust Relative Pressure (Low)	92	O	–
P1440	DPF Temp Abnormal 4 (Auto)	92	–	–
P1441	DPF Temp Abnormal 4 (Manual)	92	–	–
P1447	Catalyst Temp Sensor (Low)	13	O	–
P1448	Catalyst Temp Sensor (High)	13	O	–
P1660	DPF Lamp Control Circuit (Low)	29	O	–
P2032	Exhaust Gas Temp (Low)	88	O	–
P2033	Exhaust Gas Temp (High)	88	O	–
P2453	DPF Diff SNSR (Plausi) & MFF	97	O	–
P2454	DPF Diff SNSR (Low) & MFF	97	O	–
P2455	DPF Diff SNSR (High) & MFF	97	O	–

3.2 Diagnosis code generation conditions and inspection items

P0472: DPF Press SNSR (Low) (warning lamp flashes: 98)

Generation condition		Diesel particulate filter absolute pressure sensor voltage is at or below the specified value (0.38 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust pressure measurement is disabled (operations are continued with exhaust pressure in diesel particulate filter fixed at 101.3 kPa (barometric pressure).)
Inspection	Service data	12: Exhaust gas pressure, 2B: Exhaust gas pressure
	Electronic control unit connector	02 : Diesel particulate filter absolute pressure sensor
	Electrical equipment	#334: Diesel particulate filter absolute pressure sensor
	Electric circuit diagram	Diesel particulate filter absolute pressure sensor system

DPF: Diesel particulate filter

P0473: DPF Press SNSR (High) (warning lamp flashes: 98)

Generation condition		Diesel particulate filter absolute pressure sensor voltage is at or above the specified value (4.87 V).
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust pressure measurement is disabled (operations are continued with exhaust pressure in diesel particulate filter fixed at 101.3 kPa (barometric pressure).)
Inspection	Service data	12: Exhaust gas pressure, 2B: Exhaust gas pressure
	Electronic control unit connector	02 : Diesel particulate filter absolute pressure sensor
	Electrical equipment	#334: Diesel particulate filter absolute pressure sensor
	Electric circuit diagram	Diesel particulate filter absolute pressure sensor system

P0545: DPF Temp SNSR (upstream) Low (warning lamp flashes: 87)

Generation condition		The voltage of exhaust gas temperature sensor 1 is lower than 0.35 V for 3 seconds while all of the following conditions are met. • Water temperature: 70°C or more • Engine speed: 2000 rpm or more • Target injection quantity is within the specified value
Recoverability		System recovers if any normal signal is received with all of the following conditions met. • Water temperature: 70°C or more • Engine speed: 2000 rpm or more • Target injection quantity is within the specified value
Control effected by electronic control unit		• Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature before ceramic filter fixed at 20°C.) • DPF regeneration control is stopped.
Inspection	Service data	2C: Exhaust gas temp SNSR1 Voltage
	Electronic control unit connector	03 : Exhaust gas temperature sensor 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

DPF: Diesel particulate filter

P0546: DPF Temp SNSR (upstream) High (warning lamp flashes: 87)

Generation condition		Either of the following occurs. (1) The voltage of exhaust gas temperature sensor 1 is higher than 4.8 V for 2 minutes while all of the following diagnosis conditions are met. (The exhaust gas temperature does not rise irrespective of a certain amount of load being applied.) • Water temperature: 70°C or more • Engine speed: 2000 rpm or more • Target injection quantity is within the specified value (2) The voltage of exhaust gas temperature sensor 1 is higher than 4.8 V for 20 seconds while all of the following diagnosis conditions are met. • More than 20 minutes passed after the engine was started. • The catalyst temperature sensor is in a normal condition and the measured temperature is higher than 125°C. (These are confirmed from the Service Data “21: Catalyst Temp SNSR”.) • The temperature measured by exhaust gas temperature sensor 1 is not varied since the engine is started. (This is confirmed from the Service Data “0F: Exhaust gas temperature 1”.)
Recoverability		[In the case of above problem (1)] • System recovers if any normal signals are received while all of the conditions mentioned in Generation condition (1) are met. [In the case of above problem (2)] • System recovers when the diagnosis code is erased after all faulty parts are remedied. (System recovery by turning starter switch to OFF and then ON does not take place because the detection of generation conditions is very difficult.)
Control effected by electronic control unit		• Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature before ceramic filter fixed at 20°C.) • Function for calculating the particulate matter (PM) deposit based on exhaust gas temperature at diesel particulate filter inlet is disabled. • DPF regeneration control is stopped.
Inspection	Service data	2C: Exhaust gas temp SNSR1 Voltage
	Electronic control unit connector	03 : Exhaust gas temperature sensor 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

P1410: Exhaust Absolute Pressure (High) (warning lamp flashes: 92)

Generation condition		Diesel particulate filter absolute pressure sensor measurement value remains over 146.3 kPa for 3 seconds.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • Function for calculating the particulate matter (PM) deposit is disabled. • DPF regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Intake throttle control is stopped.
Inspection	Service data	12: Exhaust gas pressure 1
	Electrical equipment	#334: Diesel particulate filter absolute pressure sensor
	Electric circuit diagram	Diesel particulate filter absolute pressure sensor system
	Other	• The inside of ceramic filter is clogged by excessively accumulated particulate matters (PM) and ashes. • Turbocharger • Injector (Have work performed by Bosch.) • Diesel particulate filter absolute pressure sensor • Poor combustion due to use of incorrect fuel • Poor combustion due to use of incorrect engine oil

DPF: Diesel particulate filter

P1411: Excessive exhaust Temperature (warning lamp flashes: 92)

Generation condition		Exhaust gas temperature sensor 2 measurement value remains over 750°C for 30 seconds. (Excessively high temperature of ceramic filter.)
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Idling stop & start system control is stopped.
Inspection	Service data	10: Exhaust gas temperature 2
	Electrical equipment	#336: Exhaust gas temperature sensor 2
	Other	• Discrepancy between target fuel injection rate calculated by electronic control unit and actual fuel injection rate • Engine and injection quantity adjustment resistor number unmatched • Poor combustion due to use of incorrect fuel • Poor combustion due to use of incorrect engine oil • Damage of ceramic filter

P1412: DPF Temp Abnormal 1 (Auto) (Low) (warning lamp flashes: 92)

Generation condition		During temperature rise control for diesel particulate filter automatic regeneration in progress is encountered 3 times the situation where any measurements by exhaust gas temperature sensor 1 do not reach the temperature necessary for the temperature rise control even after driving over 5 km or for more than 5 minutes. (Insufficient temperature rise of front oxidation catalyst during diesel particulate filter automatic regeneration control.) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.) ※ Where this diagnosis code is issued, diagnosis code P1440 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is completed.
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Insufficient temperature rise of front oxidation catalyst during diesel particulate filter automatic regeneration control
		  • Driving style which hardly subjects the vehicle to heavy loads is used or the vehicle is driven in severe operating conditions
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Exhaust gas temperature sensor 1
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

DPF: Diesel particulate filter

P1413: DPF Temp Abnormal 2 (Auto) (Low) (warning lamp flashes: 92)

Generation condition		After particulate matter (PM) combustion control of diesel particulate filter automatic regeneration is started, is encountered once the situation where more than 15 minutes passed without any measurements by exhaust gas temperature sensor 1 not reaching the temperature required for enabling regeneration of ceramic filter. (Poor ceramic filter temperature control during diesel particulate filter automatic regeneration control.) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.) ※ Where this diagnosis code is issued, diagnosis code P1440 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is completed.
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Insufficient temperature rise of ceramic filter during diesel particulate filter automatic regeneration control
		  • Driving style which hardly subjects the vehicle to heavy loads is used or the vehicle is driven in severe operating conditions
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Exhaust gas temperature sensor 1
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

P1414: DPF Temp Abnormal 3 (Auto) (High) (warning lamp flashes: 92)

Generation condition		After particulate matter (PM) combustion control of diesel particulate filter automatic regeneration is started, is encountered 3 times the situation where more than 10 minutes passed with any measurements by exhaust gas temperature sensor 1 exceeding the upper temperature limit for regeneration of ceramic filter. (Poor ceramic filter temperature control during diesel particulate filter automatic regeneration control.) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.) ※ Where this diagnosis code is issued, diagnosis code P1440 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is completed.
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Abnormal combustion due to clogged ceramic filter inside
		  • Abnormal temperature rise of ceramic filter during diesel particulate filter automatic regeneration control
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil
		  • Exhaust gas temperature sensor 1

DPF: Diesel particulate filter

P1415: DPF Interval Abnormal (Auto) (warning lamp flashes: 92)

Generation condition		Diesel particulate filter automatic regeneration is conducted for abnormally longer time (more than 35 minutes). (Diesel particulate filter automatic regeneration is not completed due to poor diesel particulate filter temperature control.) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.) ※ Where this diagnosis code is issued, diagnosis code P1440 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is completed.
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Prolonged diesel particulate filter automatic regeneration time due to use of driving style which hardly subjects the vehicle to heavy loads or due to driving in severe operating conditions.
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Dirty sensing section of exhaust gas temperature sensor
		  • Air flow sensor
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

P1416: DPF Temp Abnormal 1 (Manual) (Low) (warning lamp flashes: 92)

Generation condition		During temperature rise control for diesel particulate filter parked regeneration in progress, any measurements by exhaust gas temperature sensor 1 do not reach the temperature necessary for the temperature rise control even after elapse of 5 minutes. (Insufficient temperature rise of front oxidation catalyst during diesel particulate filter parked regeneration control.) ※ Where this diagnosis code is issued, diagnosis code P1441 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration is performed using diesel particulate filter cleaning switch after initializing DPF-related information is completed.
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Insufficient temperature rise of front oxidation catalyst during diesel particulate filter parked regeneration control
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Dirty sensing section of exhaust gas temperature sensor
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

DPF: Diesel particulate filter

P1417: DPF Temp Abnormal 2 (Manual) (Low) (warning lamp flashes: 92)

Generation condition		After particulate matter (PM) combustion control of diesel particulate filter parked regeneration is started, more than 30 minutes have passed without any measurements by exhaust gas temperature sensor 1 not reaching the temperature required for enabling regeneration of ceramic filter. (Poor ceramic filter temperature control during diesel particulate filter parked regeneration control.) ※ Where this diagnosis code is issued, diagnosis code P1441 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration is performed using diesel particulate filter cleaning switch after initializing DPF-related information is completed.
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Insufficient temperature rise of ceramic filter during diesel particulate filter parked regeneration control
		  • Driving style which hardly subjects the vehicle to heavy loads is used or the vehicle is driven in severe operating conditions
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Dirty sensing section of exhaust gas temperature sensor
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

P1418: DPF Temp Abnormal 3 (Manual) (High) (warning lamp flashes: 92)

Generation condition		After particulate matter (PM) combustion control of diesel particulate filter parked regeneration is started, more than 10 minutes have passed with any measurements by exhaust gas temperature sensor 1 exceeding the upper temperature limit for regeneration of ceramic filter. (Poor ceramic filter temperature control during diesel particulate filter parked regeneration control.) ※ Where this diagnosis code is issued, diagnosis code P1441 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration is performed using diesel particulate filter cleaning switch after initializing DPF-related information is completed.
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped.
Inspection	Service data	0F: Exhaust gas temperature 1
	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Abnormal combustion due to clogged ceramic filter inside
		  • Abnormal temperature rise of ceramic filter during diesel particulate filter automatic regeneration control
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

DPF: Diesel particulate filter

P1419: DPF Interval Abnormal (Manual) (warning lamp flashes: 92)

Generation condition		Diesel particulate filter parked regeneration is conducted for abnormally longer time (more than 60 minutes). (Diesel particulate filter parked regeneration is not completed due to poor diesel particulate filter temperature control.) ※ Where this diagnosis code is issued, diagnosis code P1441 is left in the record of past diagnosis codes.
Recoverability		System recovers when diesel particulate filter parked regeneration is performed using diesel particulate filter cleaning switch after initializing DPF-related information is completed.
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped.
Inspection	Electrical equipment	#336: Exhaust gas temperature sensor 1
	Electric circuit diagram	Exhaust gas temperature sensor 1 system

	Other	• Prolonged diesel particulate filter parked regeneration time due to defective parts associated with diesel particulate filter regeneration control
		  • Exhaust shutter
		  • Intake throttle
		  • Injector (Have work performed by Bosch.)
		  • Dirty sensing section of exhaust gas temperature sensor
		  • Air flow sensor
		  • Deterioration of front oxidation catalyst (incorporated in inlet body)
		  • Poor combustion due to use of incorrect fuel
		  • Poor combustion due to use of incorrect engine oil

P1421: PM accumulation amount level 1 (warning lamp flashes: 92)

Generation condition		If the vehicle is continued to be driven even after diesel particulate filter parked regeneration request is issued (diesel particulate filter indicator blinks rapidly) and the particulate matter (PM) deposit estimated by engine electronic control unit becomes larger than the specified value (clogging level: low) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.)
Recoverability		System recovers when diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is completed.
Control effected by electronic control unit		• Injection quantity is limited. • Idling stop & start system control is stopped.

Inspection	Other	Check the following items which can cause this diagnosis code to be generated.
		1. Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is not performed yet.
		2. Parked regeneration is disabled because the following parts are faulty.
		  • DPF indicator (meter cluster)
		  • DPF cleaning switch
		  • Parking brake switch
		  • A5 fuse
		  • M1 fuse
		  • INOMAT-II electronic control unit

P1422: PM accumulation amount level 2 (warning lamp flashes: 92)

Generation condition		If the vehicle is continued to be driven even after diesel particulate filter parked regeneration request is issued (diesel particulate filter indicator blinks rapidly) and the particulate matter (PM) deposit estimated by engine electronic control unit becomes larger than the specified value (clogging level: high)
Recoverability		System recovers when diesel particulate filter parked regeneration is performed using diesel particulate filter cleaning switch after initializing DPF-related information is completed.
Control effected by electronic control unit		• Injection quantity is limited. • DPF regeneration control is stopped. • Idling stop & start system control is stopped.
Inspection	Other	If “P1421: PM accumulation amount level 1” is recorded in the “Past diagnosis codes”, check the diesel particulate filter body for clogging. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

DPF: Diesel particulate filter

P1430: DPF Regeneration Switch (warning lamp flashes: 7B)

Generation condition		When diesel particulate filter cleaning switch ON input is received continuously for 60 seconds during driving
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	74: DPF SW
	Electronic control unit connector	06 : Diesel particulate filter cleaning switch
	Electrical equipment	#089: Diesel particulate filter cleaning switch
	Electric circuit diagram	Diesel particulate filter cleaning switch system

P1435: Exhaust Relative Pressure (Low) (warning lamp flashes: 92)

Generation condition		When all the conditions below are applicable. • Exhaust gas flow rate exceeds 600 m^3/h. • Vehicle speed: 1 km/h or higher • Power take-off switch: OFF (Power take-off not activated.) • Measurements of less than 1.0 kPa are output continuously for 10 seconds from diesel particulate filter pressure sensor (for filter differential pressure detection). (Pressure difference between before and after ceramic filter is too small.)
Recoverability		System recovers when normal signals are received with all of the following conditions met. • Exhaust gas flow rate exceeds 600 m^3/h. • Vehicle speed: 1 km/h or higher • Power take-off switch: OFF (Power take-off not activated.)
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Other	• Slipped off, cracked, clogged or incorrectly connected pressure hose of diesel particulate filter differential pressure sensor • Slipped off, cracked or clogged pressure pipe of diesel particulate filter differential pressure sensor • Damage of ceramic filter

P1440: DPF Temp Abnormal 4 (Auto) (warning lamp flashes: 92)

Generation condition		This diagnosis code is registered in the past diagnosis code log when the generation condition for any one of P1412 to P1415 diagnosis codes is met once. (This is not generated as a current diagnosis code.) (This diagnosis code does not indicate that there is a trouble in diesel particulate filter or associated parts. This is logged to show that the system has failed in diesel particulate filter automatic regeneration control.) (Diesel particulate filter parked regeneration by using diesel particulate filter cleaning switch is possible.)
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Other	Refer to description for diagnosis codes which were generated simultaneously.

P1441: DPF Temp Abnormal 4 (Manual) (warning lamp flashes: 92)

Generation condition		When any one of P1416 to P1419 diagnosis codes is generated
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		DPF regeneration control is stopped.
Inspection	Other	Refer to description for diagnosis codes which were generated simultaneously.

DPF: Diesel particulate filter

P1447: Catalyst Temp Sensor (Low) (warning lamp flashes: 13)

Generation condition		Catalytic temperature sensor voltage remains less than 351.9 mV for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature before front oxidation catalyst fixed at 20°C). • DPF regeneration control is stopped.
Inspection	Service data	21: Catalyst Temp SNSR, 29: Catalyst Temp SNSR Voltage
	Electronic control unit connector	05 : Catalytic temperature sensor
	Electrical equipment	#338: Catalytic temperature sensor
	Electric circuit diagram	Catalytic temperature sensor system

P1448: Catalyst Temp Sensor (High) (warning lamp flashes: 13)

Generation condition		Either of the following occurs. (1) The voltage of catalytic temperature sensor is higher than 4.8 V for 20 seconds while all of the following diagnosis conditions are met. • Water temperature: 70°C or more • Engine speed: 2000 rpm or more • Target injection quantity is within the specified value (2) The voltage of catalytic temperature sensor is higher than approximately 1.8 V for 20 seconds while all of the following diagnosis conditions are met. • Exhaust gas temperature sensor is in a normal condition • More than 20 minutes passed after engine was started • Measurements by catalyst temperature sensor have been kept at an identical level since engine has started. • The temperature measured by exhaust gas temperature sensor is higher than 115°C (This is confirmed in Service Data “0F: Exhaust gas temperature 1”.)
Recoverability		[In the case of above problem (1)] • System recovers if any normal signals are received while all of the conditions mentioned in Generation condition (1) are met. [In the case of above problem (2)] • System recovers when the diagnosis code is erased after all faulty parts are remedied. (System recovery by turning starter switch to OFF and then ON does not take place because the detection of generation conditions is very difficult.)
Control effected by electronic control unit		• Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature before front oxidation catalyst fixed at 20°C). • DPF regeneration control is stopped.
Inspection	Service data	21: Catalyst Temp SNSR, 29: Catalyst Temp SNSR Voltage
	Electronic control unit connector	05 : Catalytic temperature sensor
	Electrical equipment	#338: Catalytic temperature sensor
	Electric circuit diagram	Catalytic temperature sensor system

P1660: DPF Lamp Control Circuit (Low) (warning lamp flashes: 29)

Generation condition		Diesel particulate filter indicator lamp circuit is opened or shorted.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Effects no special control.
Inspection	Service data	8C: DPF Indicator Lamp
	Electronic control unit connector	B0: DPF Indicator Lamp
	Electric circuit diagram	Diesel particulate filter indicator lamp system

DPF: Diesel particulate filter

P2032: Exhaust Gas Temp (Low) (warning lamp flashes: 88)

Generation condition		Exhaust gas temperature sensor 2 voltage remains less than 351.9 mV.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature after ceramic filter fixed at 20°C).
Inspection	Service data	10: Exhaust gas temperature 2, 2D: Exhaust gas temp SNSR2 Voltage
	Electronic control unit connector	04 : Exhaust gas temperature sensor 2
	Electrical equipment	#337: Exhaust gas temperature sensor 2
	Electric circuit diagram	Exhaust gas temperature sensor 2 system

P2033: Exhaust Gas Temp (High) (warning lamp flashes: 88)

Generation condition		Either of the following occurs. (1) The voltage of exhaust gas temperature sensor 2 is higher than 4.8 V for 2 minutes while all of the following diagnosis conditions are met. • Water temperature: 70°C or more • Engine speed: 2000 rpm or more • Target injection quantity is within the specified value (2) The voltage of exhaust gas temperature sensor 2 is higher than approximately 4,800 mV for 20 seconds while all of the following diagnosis conditions are met. • There are no faults in catalyst temperature sensor and exhaust gas temperature sensor 1. • More than 2 minutes passed after engine was started. • Measurements by exhaust gas temperature sensor 2 have been kept at an identical level since engine has started. • The temperature measured by exhaust gas temperature sensor 1 is higher than 150°C.
Recoverability		[In the case of above problem (1)] • System recovers if any normal signals are received while all of the conditions mentioned in Generation condition (1) are met. [In the case of above problem (2)] • System recovers when the diagnosis code is erased after all faulty parts are remedied. (System recovery by turning starter switch to OFF and then ON does not take place because the detection of generation conditions is very difficult.)
Control effected by electronic control unit		Exhaust gas temperature measurement is disabled (operations are continued with exhaust gas temperature after ceramic filter fixed at 20°C).
Inspection	Service data	10: Exhaust gas temperature 2, 2D: Exhaust gas temp SNSR2 Voltage
	Electronic control unit connector	04 : Exhaust gas temperature sensor 2
	Electrical equipment	#337: Exhaust gas temperature sensor 2
	Electric circuit diagram	Exhaust gas temperature sensor 2 system

P2453: DPF Diff SNSR (Plausi) & MFF (warning lamp flashes: 97)

Generation condition		The condition where pressure difference between before and after ceramic filter in diesel particulate filter exceeds the limit value to the negative side is continued for one minute. (Diesel particulate filter pressure difference exceeds the specified value to the negative side.) (The specified value for diesel particulate filter pressure difference is very small and it is very difficult to determine the variation of the value on Multi-Use Tester service data. Therefore, it may be possible that the diagnosis code is generated even if no value variations occurred actually.)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Function for calculating the particulate matter (PM) deposit based on exhaust gas pressure is disabled. • DPF regeneration control is stopped.
Inspection	Electrical equipment	#334: Diesel particulate filter differential pressure sensor
	Other	• Pressure pipe and pressure hose clogged • Diesel particulate filter differential pressure sensor

DPF: Diesel particulate filter

P2454: DPF Diff SNSR (Low) & MFF (warning lamp flashes: 97)

Generation condition		Diesel particulate filter differential pressure sensor voltage is at or below the specified value (0.38 V). (Diesel particulate filter pressure difference exceeds the specified value to the negative side.)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Diesel particulate filter pressure difference measurement is disabled (operations are continued with pressure difference between before and after ceramic filter in diesel particulate filter fixed at 0 kPa). • Function for calculating the particulate matter (PM) deposit based on exhaust gas pressure is disabled.
Inspection	Service data	11: Difference pressure across DPF
	Electronic control unit connector	01 : Diesel particulate filter differential pressure sensor
	Electrical equipment	#334: Diesel particulate filter differential pressure sensor
	Electric circuit diagram	Diesel particulate filter differential pressure sensor system

P2455: DPF Diff SNSR (High) & MFF (warning lamp flashes: 97)

Generation condition		Diesel particulate filter differential pressure sensor voltage is at or above the specified value (4.87 V). (Diesel particulate filter pressure difference exceeds the specified value to the positive side.)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Diesel particulate filter pressure difference measurement is disabled (operations are continued with pressure difference between before and after ceramic filter in diesel particulate filter fixed at 0 kPa). • Function for calculating the particulate matter (PM) deposit based on exhaust gas pressure is disabled.
Inspection	Service data	11: Difference pressure across DPF
	Electronic control unit connector	01 : Diesel particulate filter differential pressure sensor
	Electrical equipment	#334: Diesel particulate filter differential pressure sensor
	Electric circuit diagram	Diesel particulate filter differential pressure sensor system

DPF: Diesel particulate filter

4. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
0F	Exhaust gas temperature 1	■■■■°C	During warm-up	Gradually increased
10	Exhaust gas temperature 2	■■■■°C	During warm-up	Gradually increased
11	Difference pressure across DPF	■■■. ■kPa	No-load running at maximum speed after diesel particulate filter regeneration is completed	7.5 kPa or lower
12	Exhaust gas pressure	■■■. ■kPa	No-load running at maximum speed after diesel particulate filter regeneration is completed	107.5 kPa or lower
21	Catalyst Temp SNSR	■■■■°C	During warm-up	Gradually increased
29	Catalyst Temp SNSR Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
2B	Exhaust gas pressure	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
2C	Exhaust gas temp SNSR1 Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
2D	Exhaust gas temp SNSR2 Voltage	■■■. ■mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
74	DPF SW	ON/OFF	Diesel particulate filter cleaning switch ON	ON
			Diesel particulate filter cleaning switch OFF	OFF
			[Actuator test] A2: DPF Regeneration	
8C	DPF Indicator Lamp	ON/OFF	During diesel particulate filter parked regeneration	ON
			Except above	OFF
			[Actuator test] AF: DPF Indicator Lamp	

5. Actuator Tests Performed Using Multi-Use Tester

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

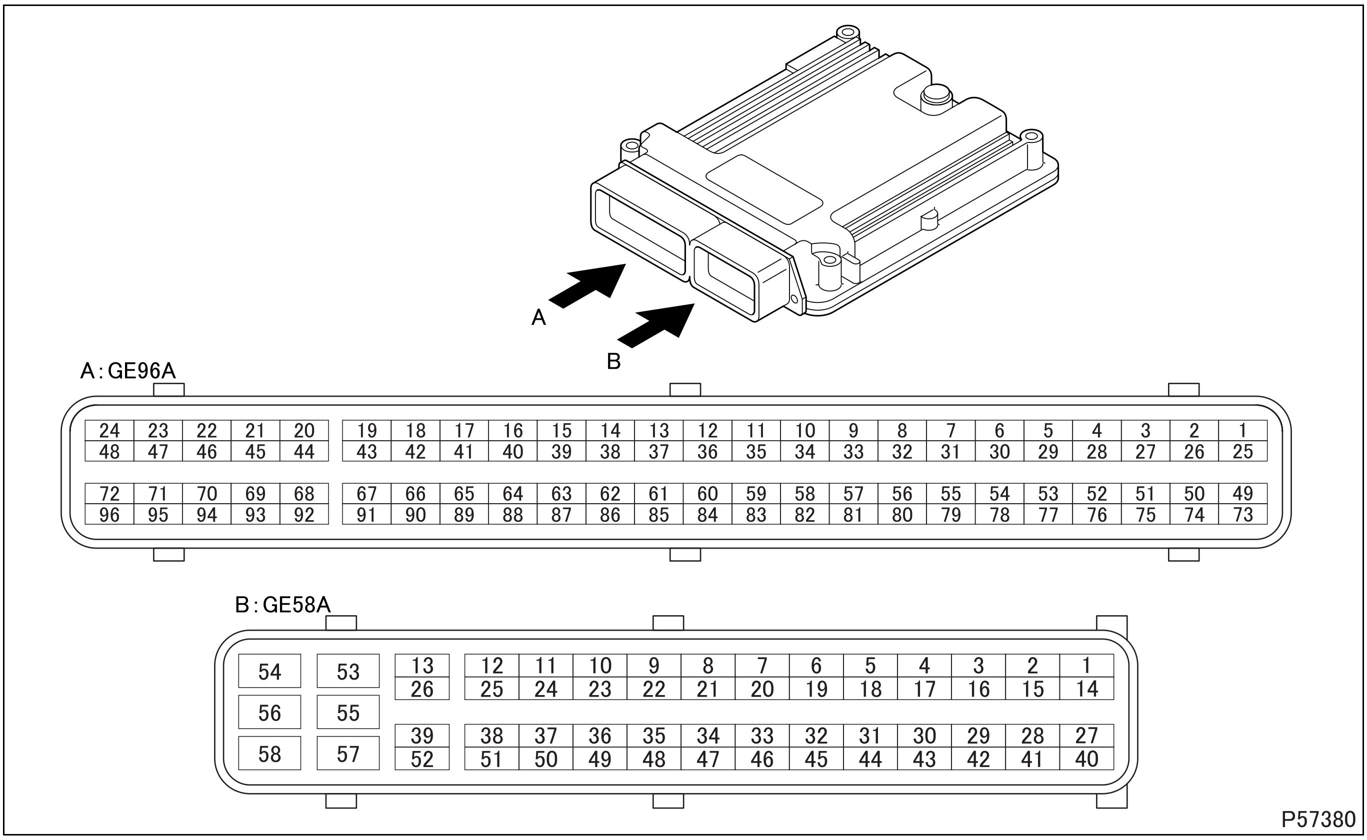
No.	Item	Description	Check method
A2	DPF Regeneration	Request is output for diesel particulate filter parked regeneration [Can be executed under following conditions] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON (engine started) • Engine: Idling • Parking brake: Vehicle parked (parking brake switch: ON) • After engine warm-up	• Check that diesel particulate filter indicator lamp flickers • Diesel particulate filter parked regeneration started with diesel particulate filter cleaning switch ON and engine speed increased. [Service data] 74: DPF SW
AF	DPF Indicator Lamp	Diesel particulate filter indicator lamp turned ON/OFF [Can be executed under following conditions] • Vehicle: stationary (vehicle speed 0 km/h {0 MPH}) • Starter switch: ON • Engine: Idling • Transmission: neutral or P range	Check that indicator lamp is turned on and off [Service data] 8C: DPF Indicator Lamp

DPF: Diesel particulate filter

6. Inspections Performed at Electronic Control Unit Connectors

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

6.1 Electronic control unit connector terminal layout



6.2 Inspection instructions

- Some inspections are performed with the connectors removed. Others are performed with the connectors fitted.

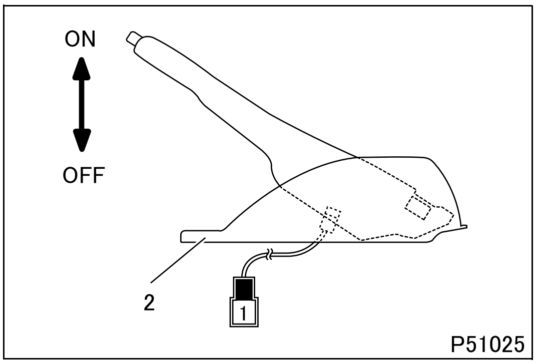
CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

Check item	Measurement method
01 Voltage of diesel particulate filter differential pressure sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] <Power supply voltage> Terminals (+)-(–): A61-A85 • 5 V <Output voltage> Terminals (+)-(–): A84-A85 • 1 to 4.5 V
02 Voltage of diesel particulate filter absolute pressure sensor	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] <Power supply voltage> Terminals (+)-(–): A60-A42 • 5 V <Output voltage> Terminals (+)-(–): A8-A42 • 1.875 to 4.5 V

Check item	Measurement method
03 Resistance of exhaust gas temperature sensor 1	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A66-A90 • 20°C: 241.8 kΩ • 50°C: $106.2^{+74.3}_{-41.8}$ kΩ • 100°C: $33.56^{+17.60}_{-10.60}$ kΩ • 150°C: $13.90^{+5.36}_{-3.60}$ kΩ • 200°C: $6.896^{+2.064}_{-1.252}$ kΩ
04 Resistance of exhaust gas temperature sensor 2	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A39-A68 • 20°C: 241.8 kΩ • 50°C: $106.2^{+74.3}_{-41.8}$ kΩ • 100°C: $33.56^{+17.60}_{-10.60}$ kΩ • 150°C: $13.90^{+5.36}_{-3.60}$ kΩ • 200°C: $6.896^{+2.064}_{-1.252}$ kΩ
05 Resistance of catalytic temperature sensor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B48-B47 • 20°C: 241.8 kΩ • 50°C: $106.2^{+74.3}_{-41.8}$ kΩ • 100°C: $33.56^{+17.60}_{-10.60}$ kΩ • 150°C: $13.90^{+5.36}_{-3.60}$ kΩ • 200°C: $6.896^{+2.064}_{-1.252}$ kΩ
06 Voltage of diesel particulate filter cleaning switch	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] • With diesel particulate filter cleaning switch ON (during switch being pressed): Corresponding to battery voltage • With diesel particulate filter cleaning switch not pressed: 0 V

7. Inspection of Electrical Equipment

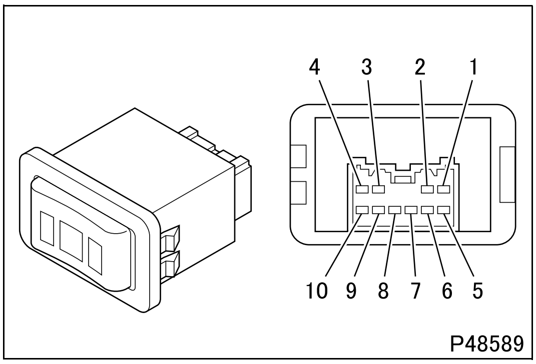


#038 Inspection of parking brake switch

- Measure continuity between terminals 1 and 2 (body) ground.

Pull the parking brake lever	Continuity exists
Release the parking brake lever	Continuity does not exist

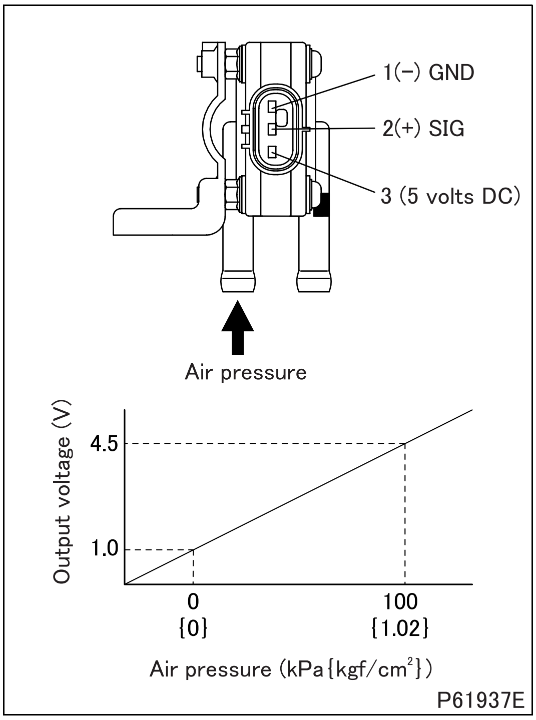
- If any fault is found, replace the switch. (See Gr36.)



#089 Inspection of diesel particulate filter cleaning switch

Switch position	Terminals with continuity	Night illumination
–	1-8	(+) 6-2 (–)
ON	1-7	

- If there is any abnormality, replace the switch.



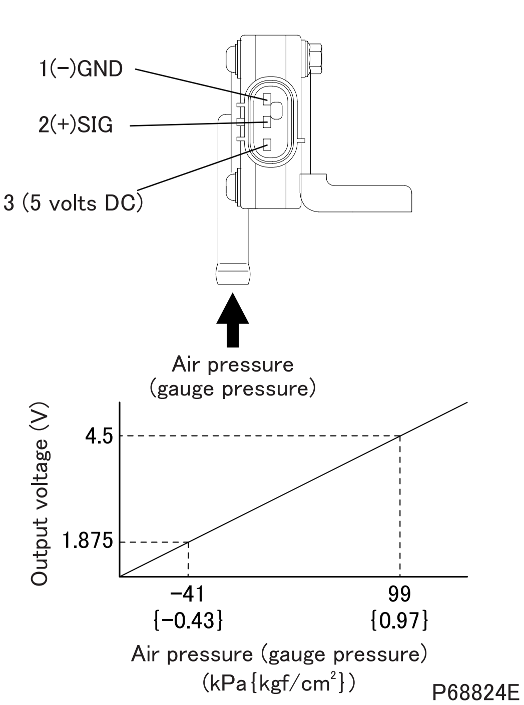
#334 Inspection of diesel particulate filter pressure sensor

<Diesel particulate filter differential pressure sensor>

- Apply a 5 volts DC voltage between terminals 1 and 3 of the diesel particulate filter differential pressure sensor.
- Apply air pressures to the sensor and measure the sensor output voltage between terminals 1 and 2 (see illustration).

Standard value	0 ± 3.5 kPa {0 ± 0.04 kgf/cm^2}	1 V
	100 ± 3.5 kPa {1.020 ± 0.04 kgf/cm^2}	4.5 V

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

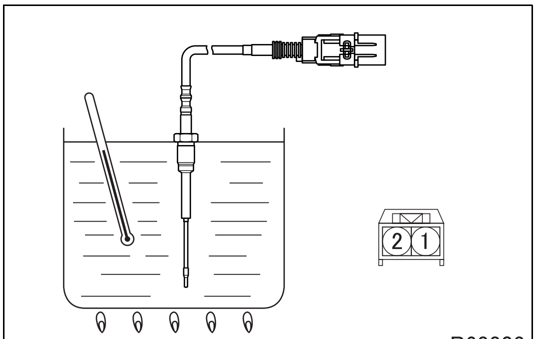


P68824E

<Diesel particulate filter absolute pressure sensor>
- Apply a 5 volts DC voltage between terminals 1 and 3 of the diesel particulate filter absolute pressure sensor.
- Apply air pressures to the sensor and measure the sensor output voltage between terminals 1 and 2 (see illustration).

Standard value	–41 ± 3.2 kPa {–0.42 ± 0.03 kgf/cm^2}	1.875 V
	99 ± 3.2 kPa {1.01 ± 0.03 kgf/cm^2}	4.5 V

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



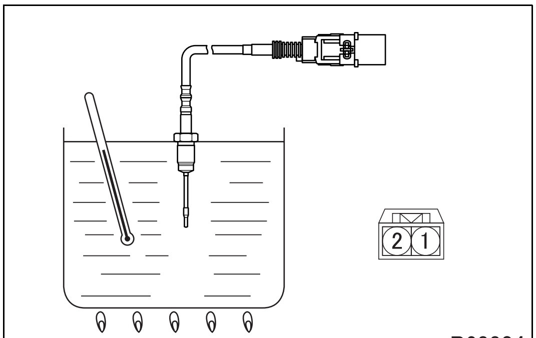
P68803

#336 Inspection of exhaust gas temperature sensor

<Exhaust gas temperature sensor 1>
- The exhaust gas temperature sensor 1 may output false signals if its tip is contaminated. Clean it if necessary.
- Place the sensor in a container filled with engine oil.
- Heat the oil to each of the specified temperatures. Stir the oil well while doing so.
- Measure the resistance between terminals 1 and 2.

Standard value	20°C	241.8 kΩ
	50°C	$106.2^{+74.3}_{-41.8}$ kΩ
	100°C	$33.56^{+17.60}_{-10.60}$ kΩ
	150°C	$13.90^{+5.36}_{-3.60}$ kΩ
	200°C	$6.896^{+2.064}_{-1.252}$ kΩ

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

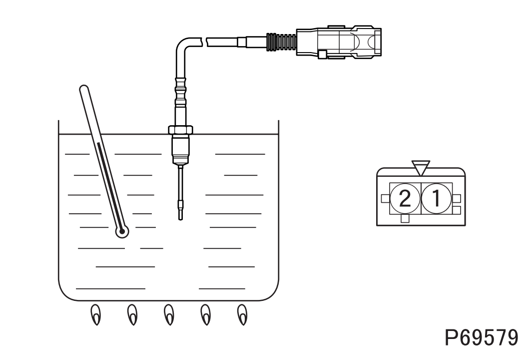


P68804

<Exhaust gas temperature sensor 2>
- The exhaust gas temperature sensor 2 may output false signals if its tip is contaminated. Clean it if necessary.
- Place the sensor in a container filled with engine oil.
- Heat the oil to each of the specified temperatures. Stir the oil well while doing so.
- Measure the resistance between terminals 1 and 2.

Standard value	20°C	241.8 kΩ
	50°C	$106.2^{+74.3}_{-41.8}$ kΩ
	100°C	$33.56^{+17.60}_{-10.60}$ kΩ
	150°C	$13.90^{+5.36}_{-3.60}$ kΩ
	200°C	$6.896^{+2.064}_{-1.252}$ kΩ

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



P69579

#338 Inspection of catalytic temperature sensor

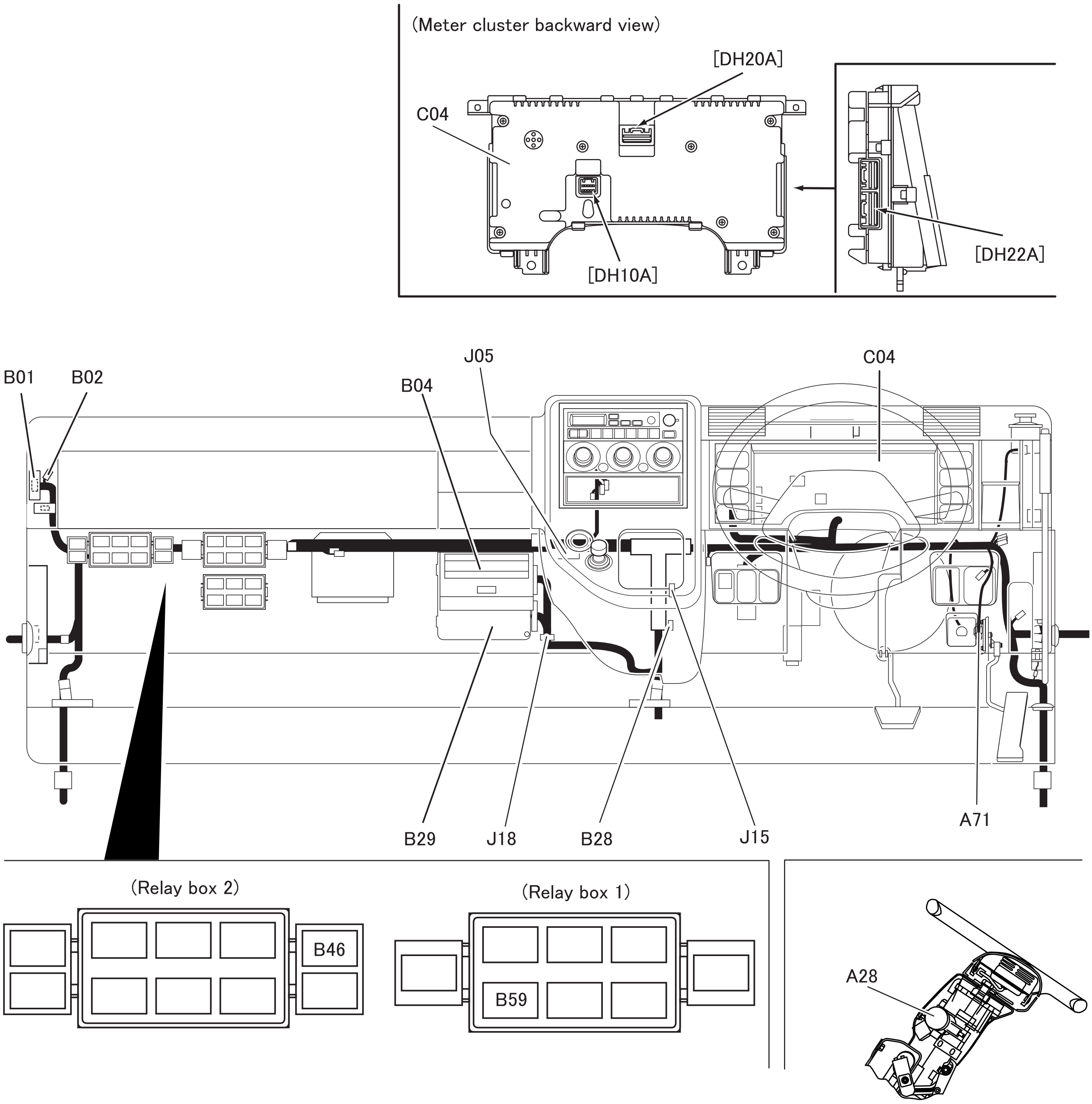
- The catalytic temperature sensor may output false signals if its tip is contaminated. Clean it if necessary.
- Place the sensor in a container filled with engine oil.
- Heat the oil to each of the specified temperatures. Stir the oil well while doing so.
- Measure the resistance between terminals 1 and 2.

Standard value	20°C	241.8 kΩ
	50°C	$106.2^{+74.3}_{-41.8}$ kΩ
	100°C	$33.56^{+17.60}_{-10.60}$ kΩ
	150°C	$13.90^{+5.36}_{-3.60}$ kΩ
	200°C	$6.896^{+2.064}_{-1.252}$ kΩ

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

8. Installed Locations of Parts

A28–71	B01–59	C04	J05–18



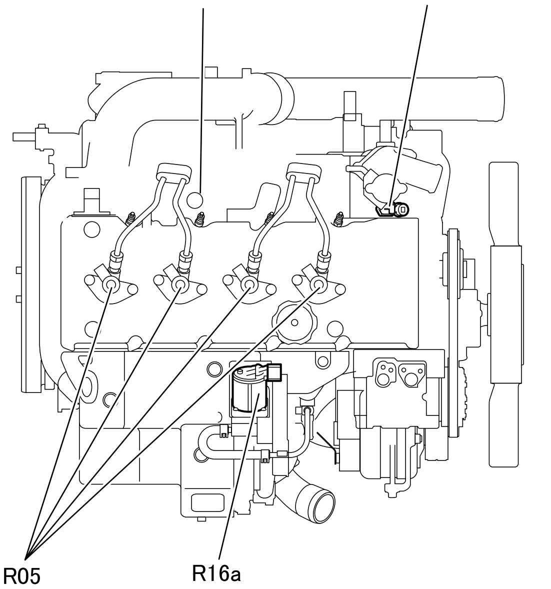
A28	Starter switch	C04	Meter cluster
A71	Accelerator pedal position sensor		
		J05	Joint connector (J/C–3)
B01	VG turbocharger EDU	J15	Joint connector (J/C–M1)
B02	CAN resistor	J18	Joint connector (J/C–2)
B04	Fuse box		
B28	Diode	ECU : Electronic control unit	
B29	Engine ECU	EDU : Electronic drive unit	
B46	Starter power supply relay	VG : Variable geometry	
B59	Safety relay	CAN : Control area network	

15–L04660

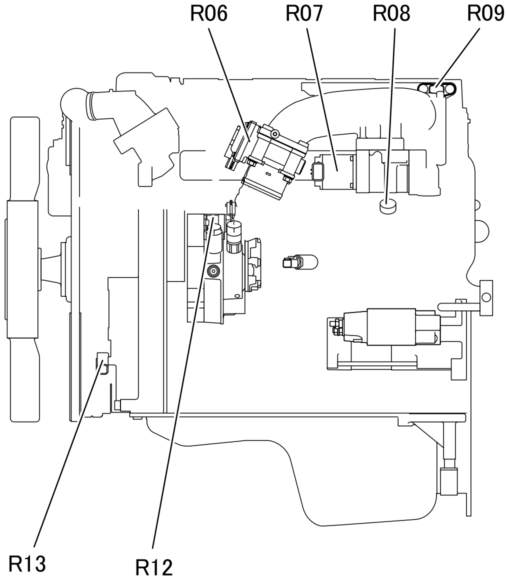
DIESEL PARTICULATE FILTER REGENERATION SYSTEM

R01–16	S05–06

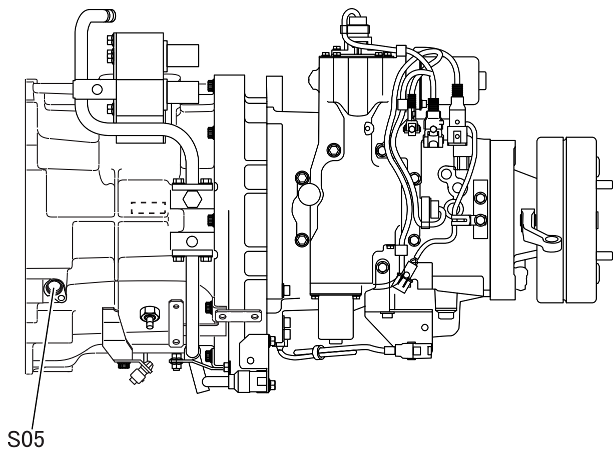
(Upper view)



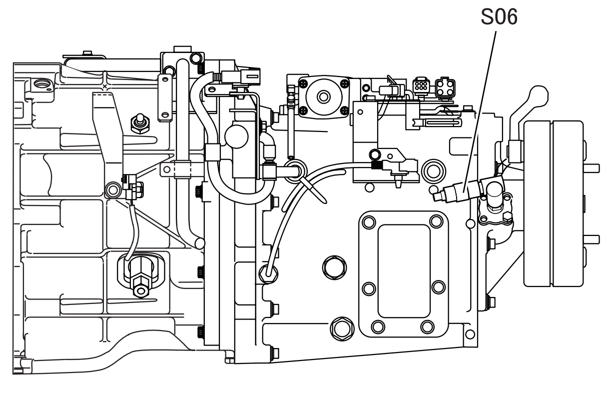
(Left side view)



(Upper view)



(Left side view)



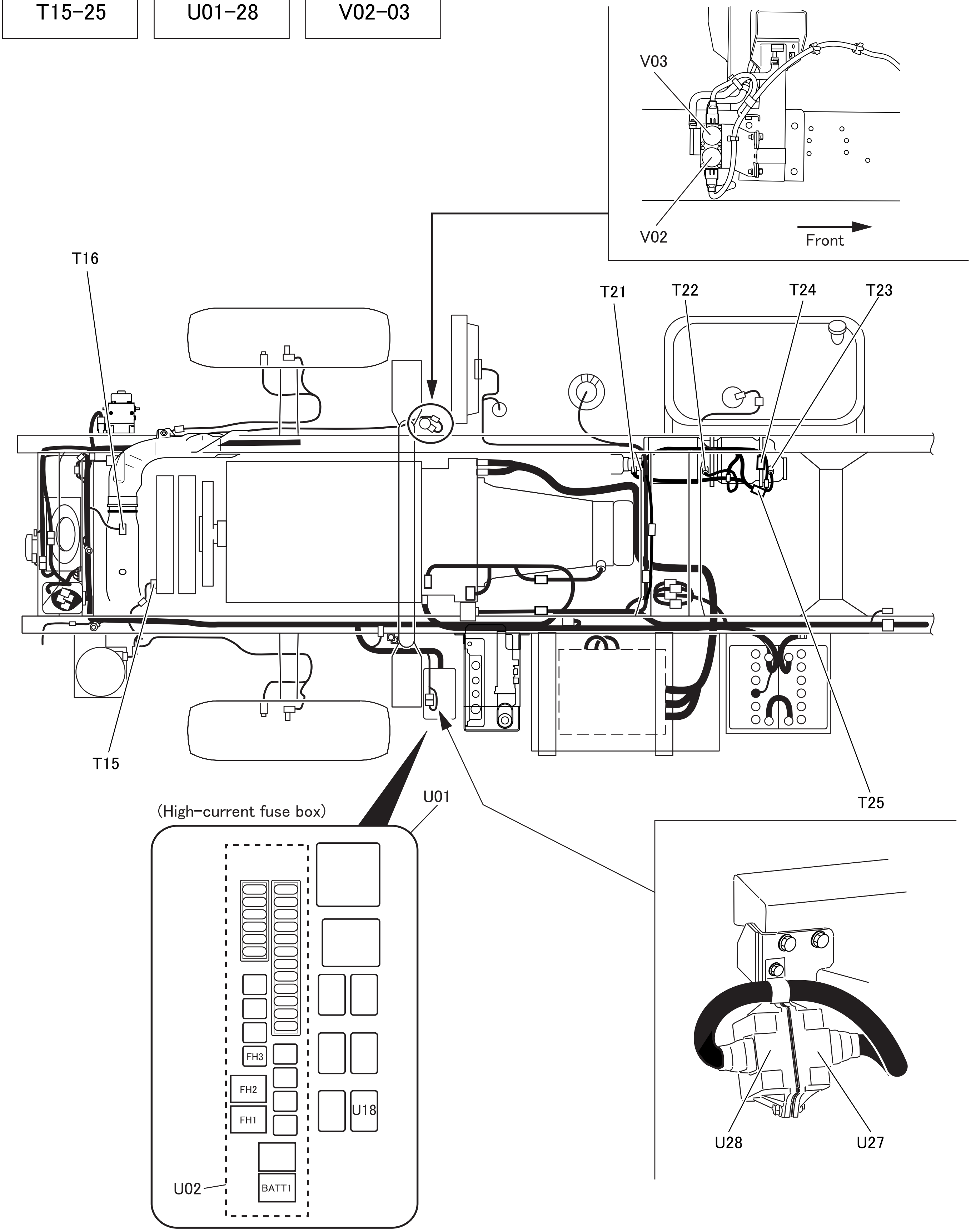
R01 Boost air temperature sensor
R03 Water temperature sensor
R05 Injector
R06 Throttle actuator
R07 EGR valve
R08 Common rail pressure sensor
R09 Boost pressure sensor
R12 MPROP (rail pressure control valve)
R13 Cylinder recognition sensor
R16a VG turbocharger actuator

S05 Engine speed sensor
S06 Vehicle speed sensor

EGR : Exhaust gas recirculation
VG : Variable geometry

15–L04661

T15-25	U01-28	V02-03

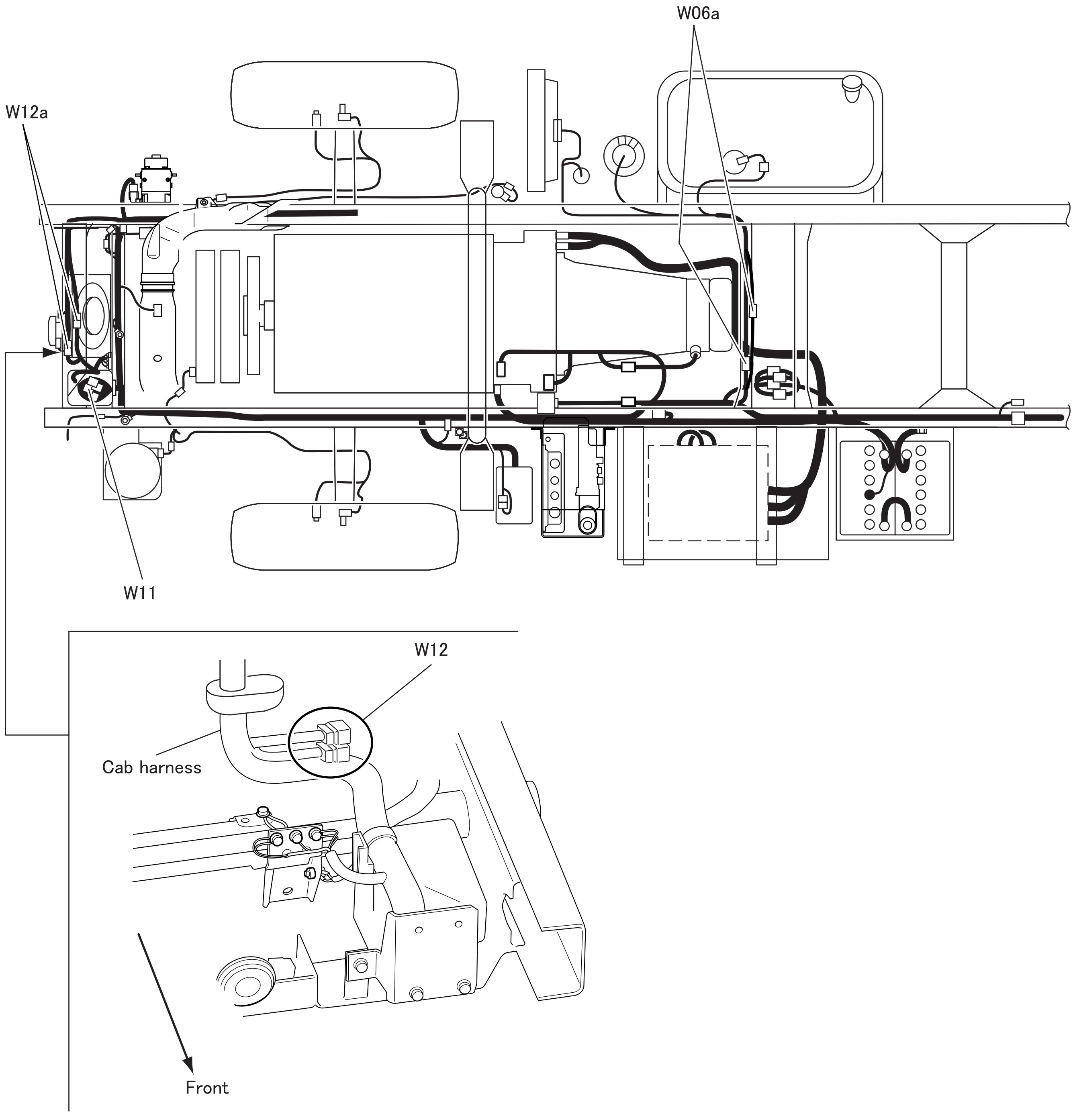


T15	Intake air temperature sensor 1	U01	High-current fuse box	V02	Exhaust shutter 3-way magnetic valve 1
T16	Air flow sensor	U02	High-current fuse, fuse	V03	Exhaust shutter 3-way magnetic valve 2
T21	Catalytic temperature sensor	U18	EDU relay		
T22	Exhaust gas temperature sensor 1	U27	EGR EDU		
T23	Exhaust gas temperature sensor 2	U28	Throttle EDU		
T24	DPF absolute pressure sensor				
T25	DPF differential pressure sensor				

DPF : Diesel particulate filter
EDU : Electronic drive unit
EGR : Exhaust gas recirculation

15-L04662

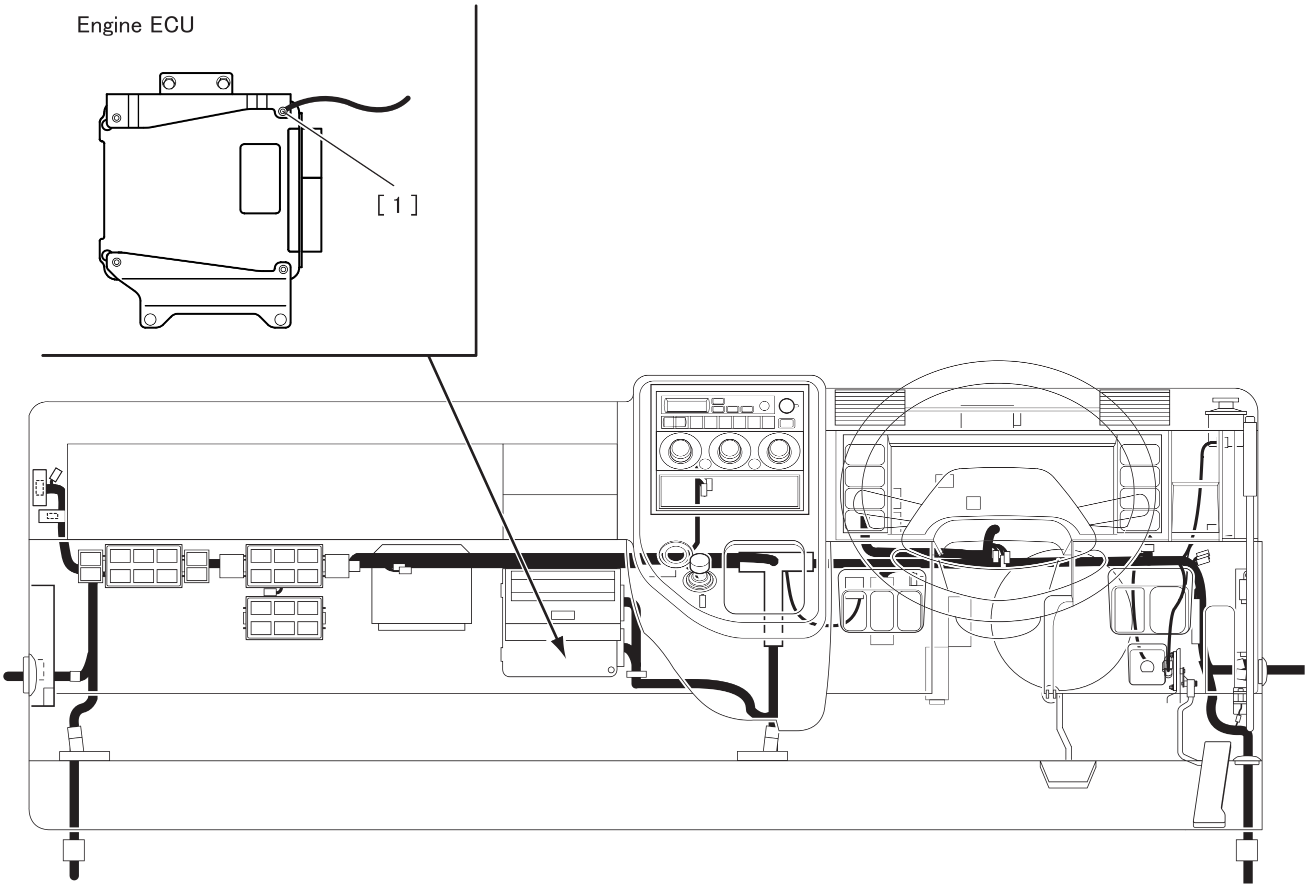
W06–12

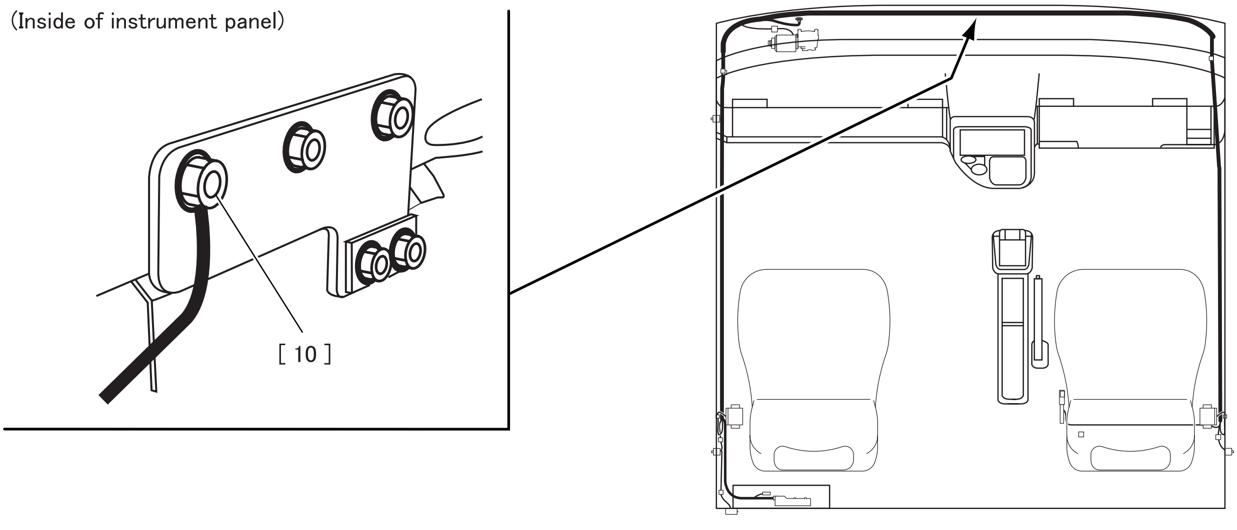


W06a Connection of chassis harness and chassis (sub) harness
W11 Connection of cab harness and chassis harness (in connector box)
W12 Connection of cab harness and engine harness
W12a Connection of cab harness and chassis harness

15–L04663

[1]–[10] Cab ground





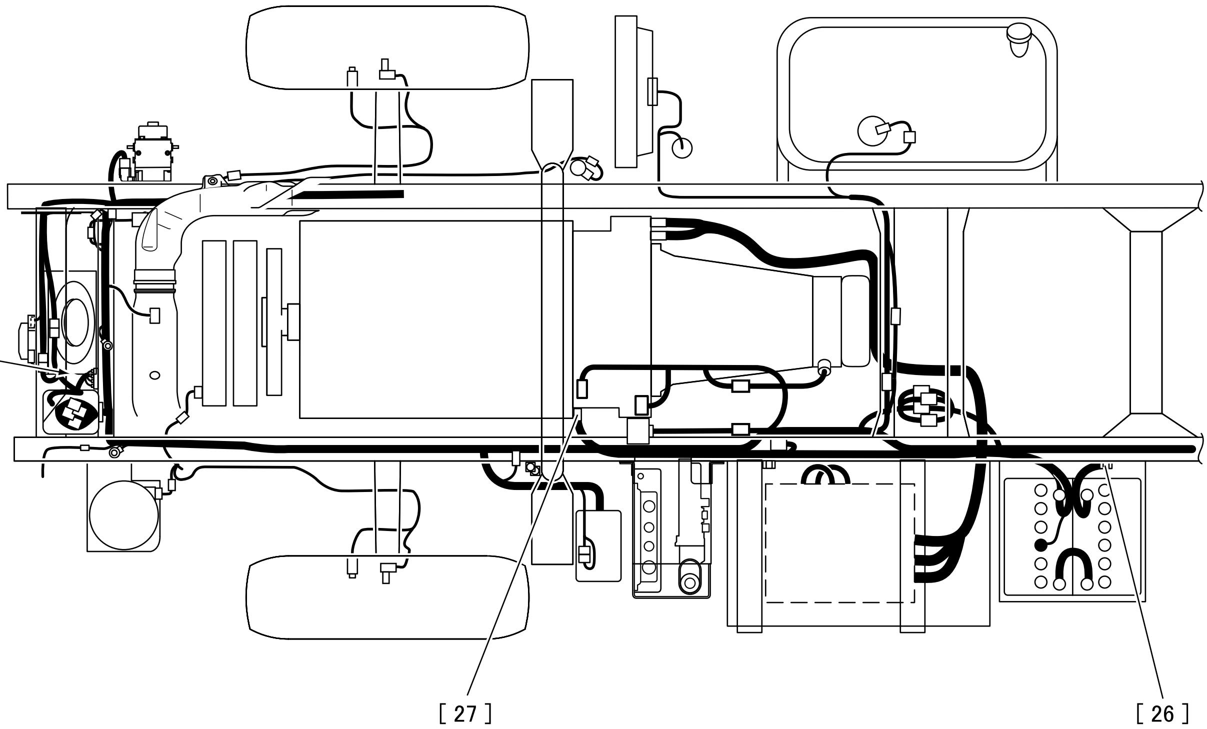
[1] Ground
[10] Ground

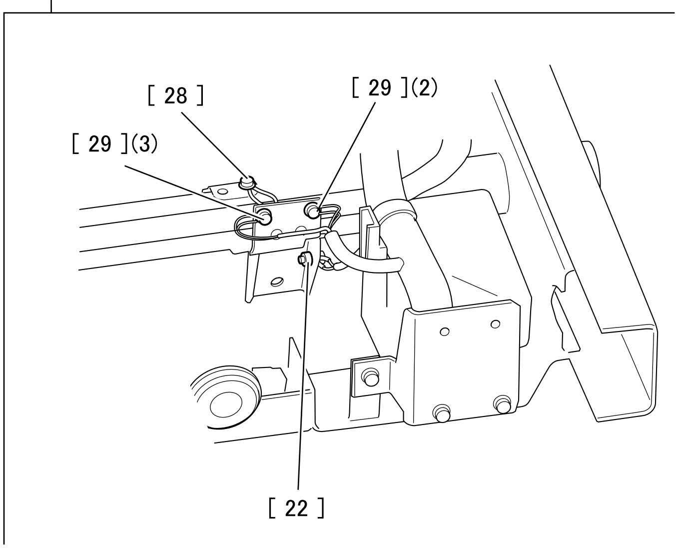
ECU : Electronic control unit

15–L04664

DIESEL PARTICULATE FILTER REGENERATION SYSTEM

[22]–[29]	Chassis ground

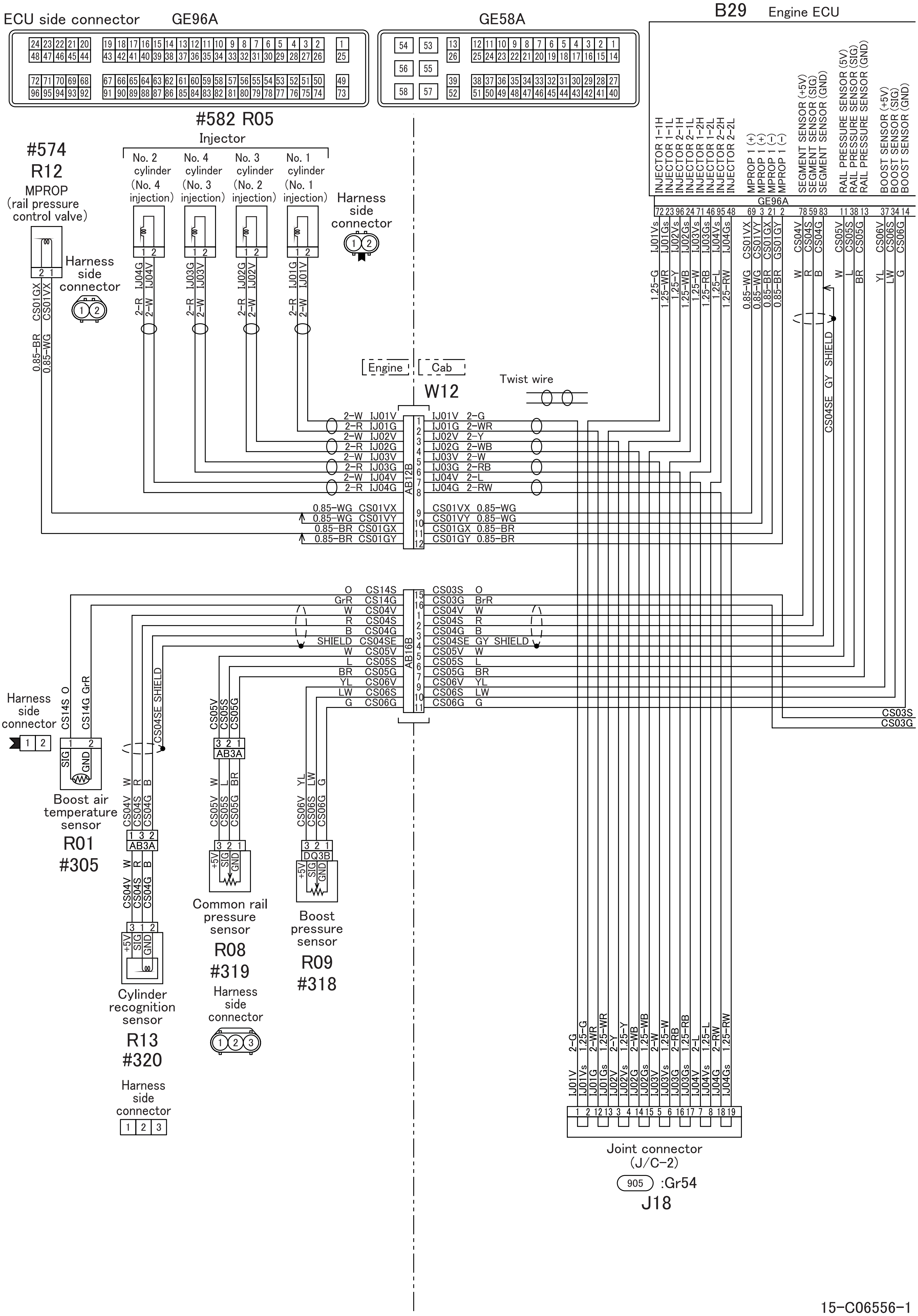




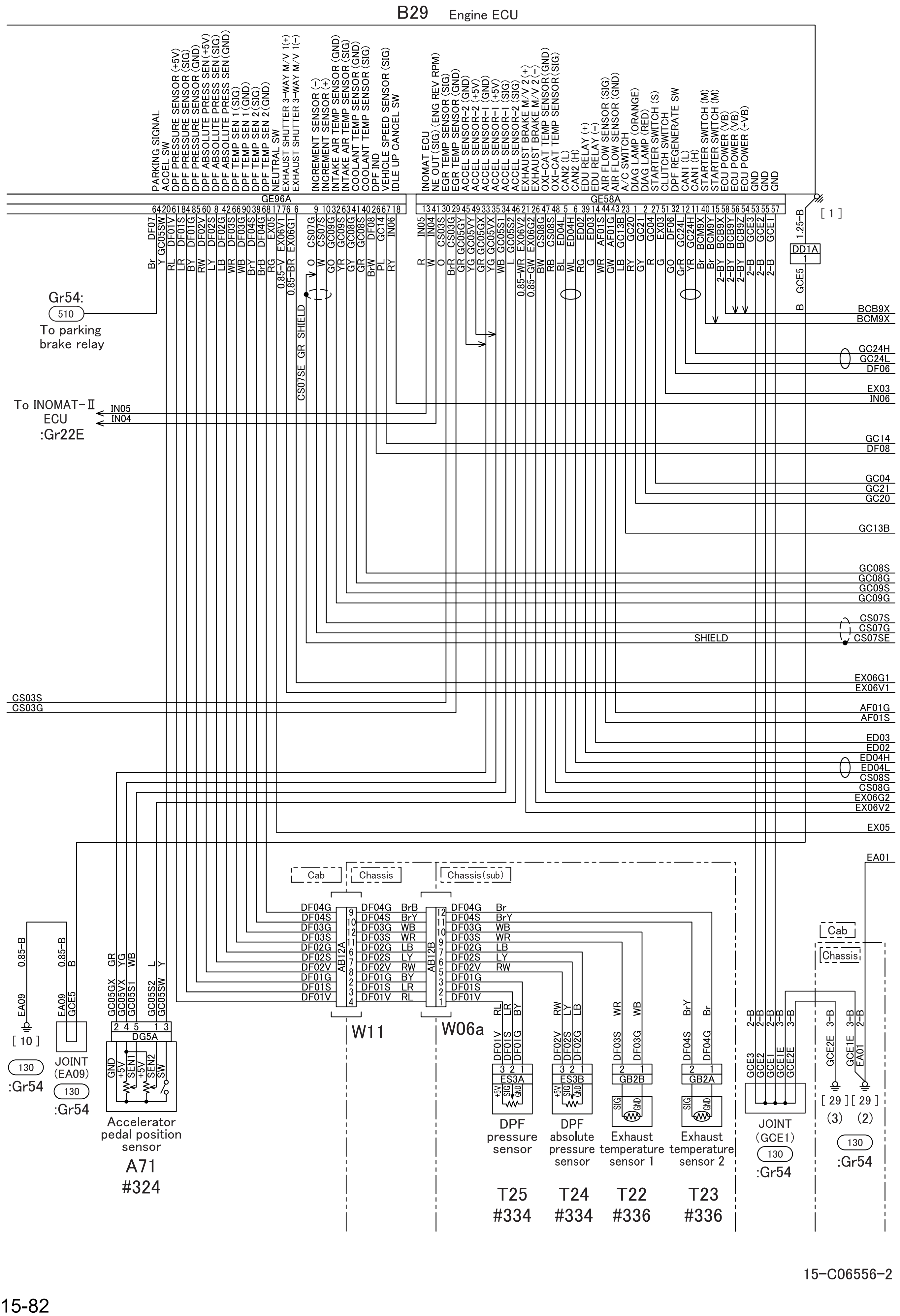
[22] Ground
[26] Ground
[27] Ground
[28] Ground
[29](2) Ground
[29](3) Ground

15–L04665

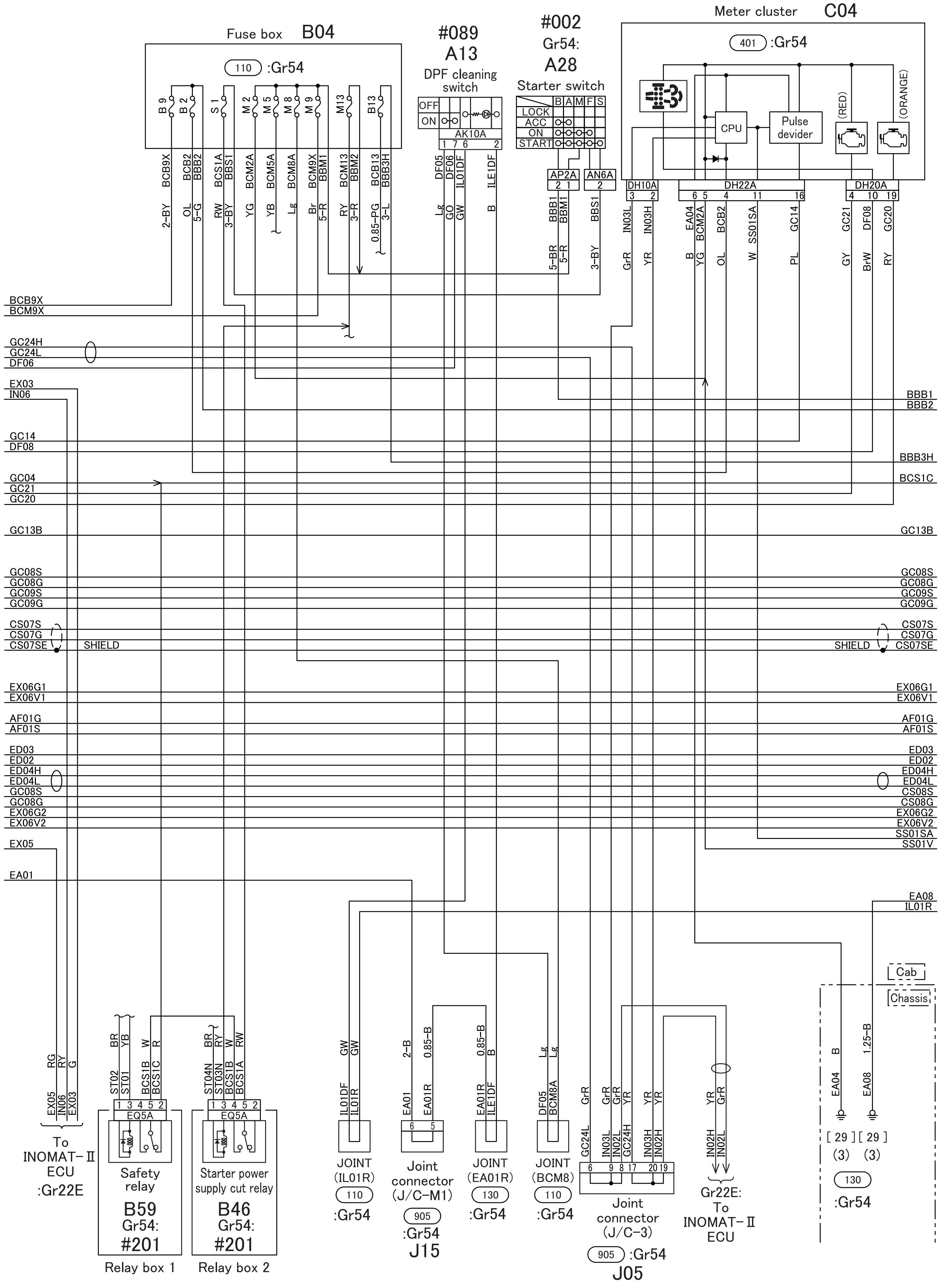
9. Electric Circuit Diagram



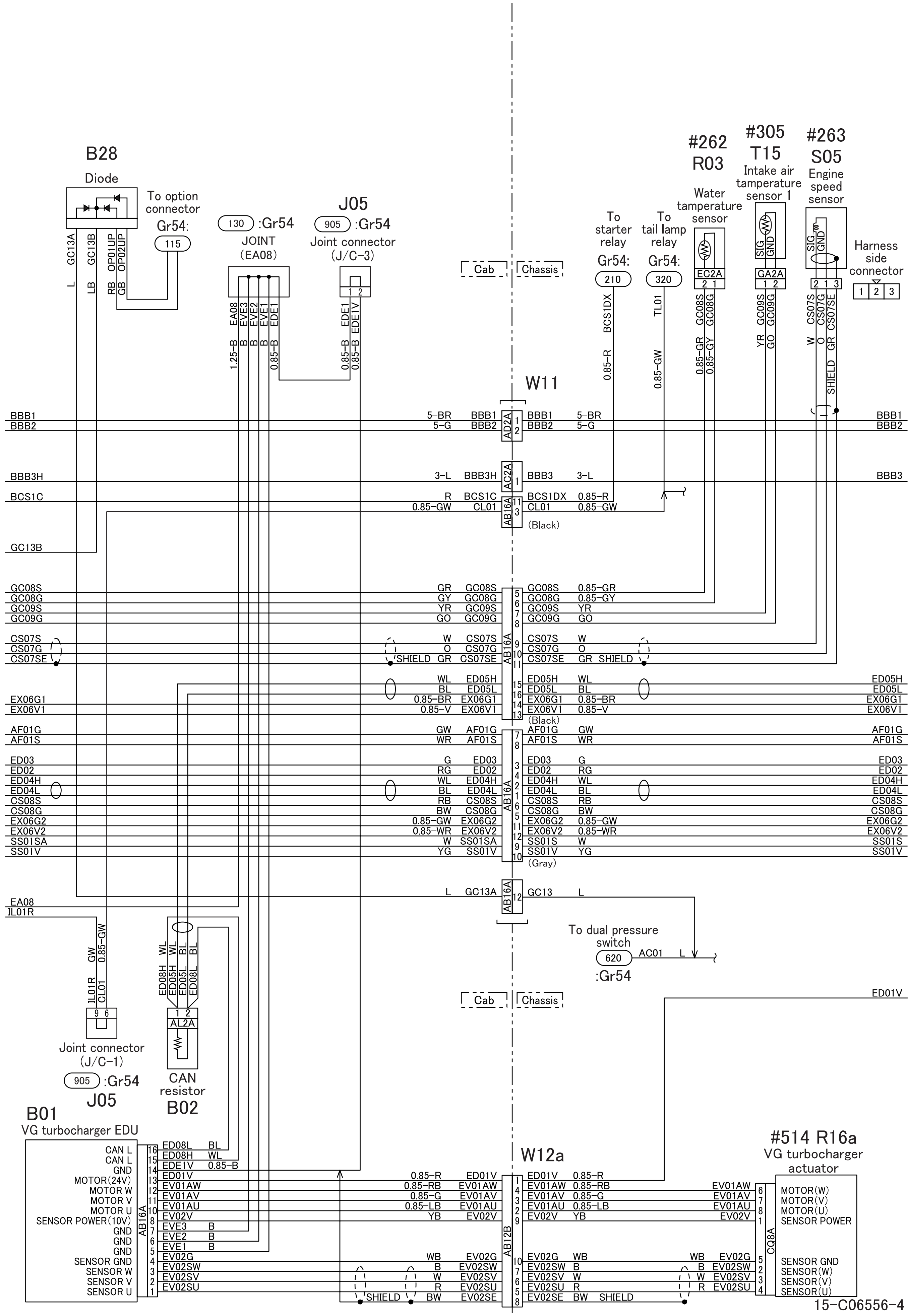
DIESEL PARTICULATE FILTER REGENERATION SYSTEM



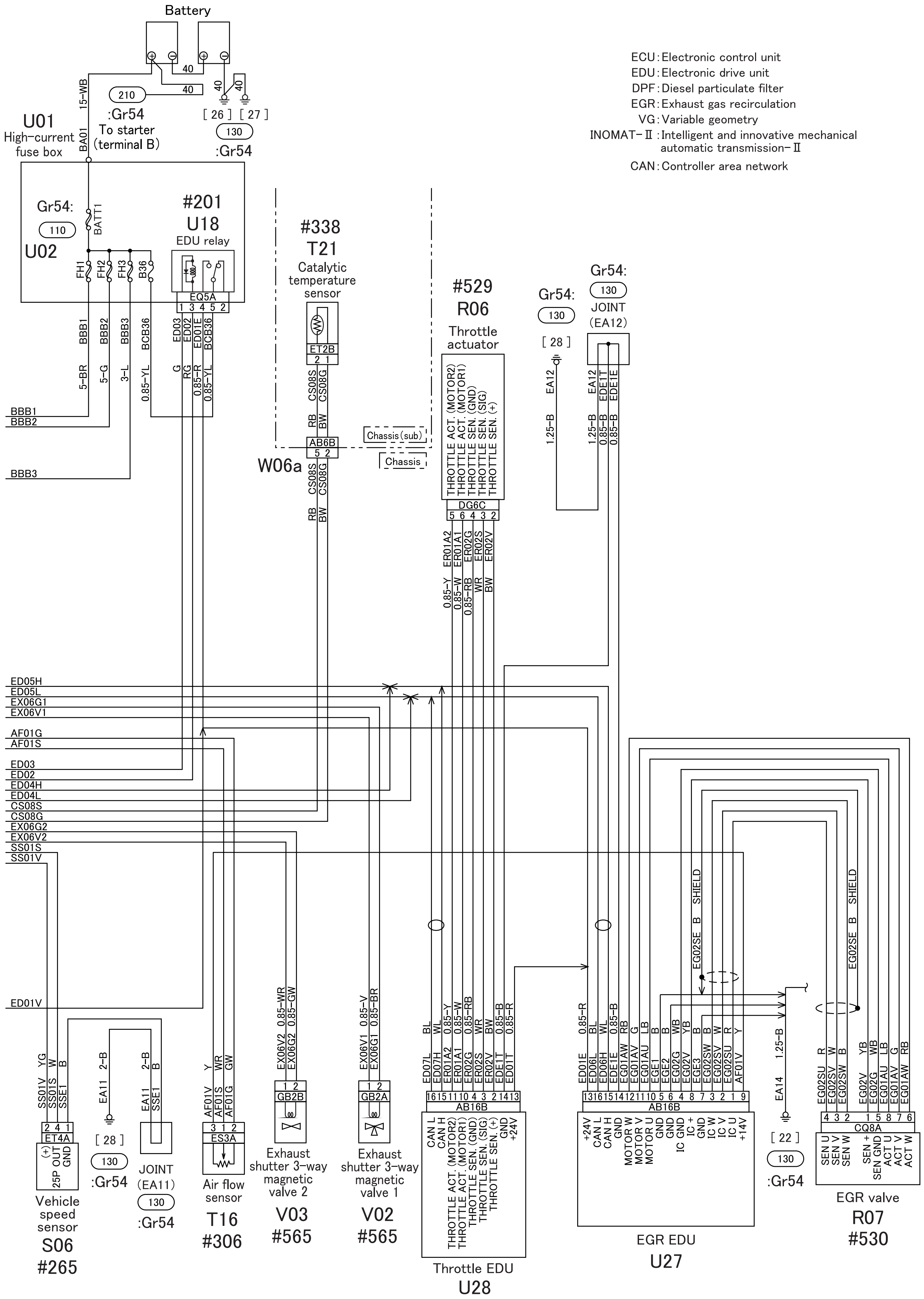
15-C06556-2


Fuse box B04
110 :Gr54
#089 A13 DPF cleaning switch
#002 Gr54: A28 Starter switch
Meter cluster C04
401 :Gr54
CPU
Pulse devider
(RED)
(ORANGE)
To INOMAT−Ⅱ ECU :Gr22E
Safety relay B59 Gr54: #201
Starter power supply cut relay B46 Gr54: #201
Relay box 1
Relay box 2
JOINT (IL01R) 110 :Gr54
Joint connector (J/C−M1) 905 :Gr54 J15
JOINT (EA01R) 130 :Gr54
JOINT (BCM8) 110 :Gr54
Joint connector (J/C−3) 905 :Gr54 J05
Gr22E: To INOMAT−Ⅱ ECU
Cab
Chassis
[29] [29] (3) (3)
130 :Gr54
SHIELD

15−C06556−3

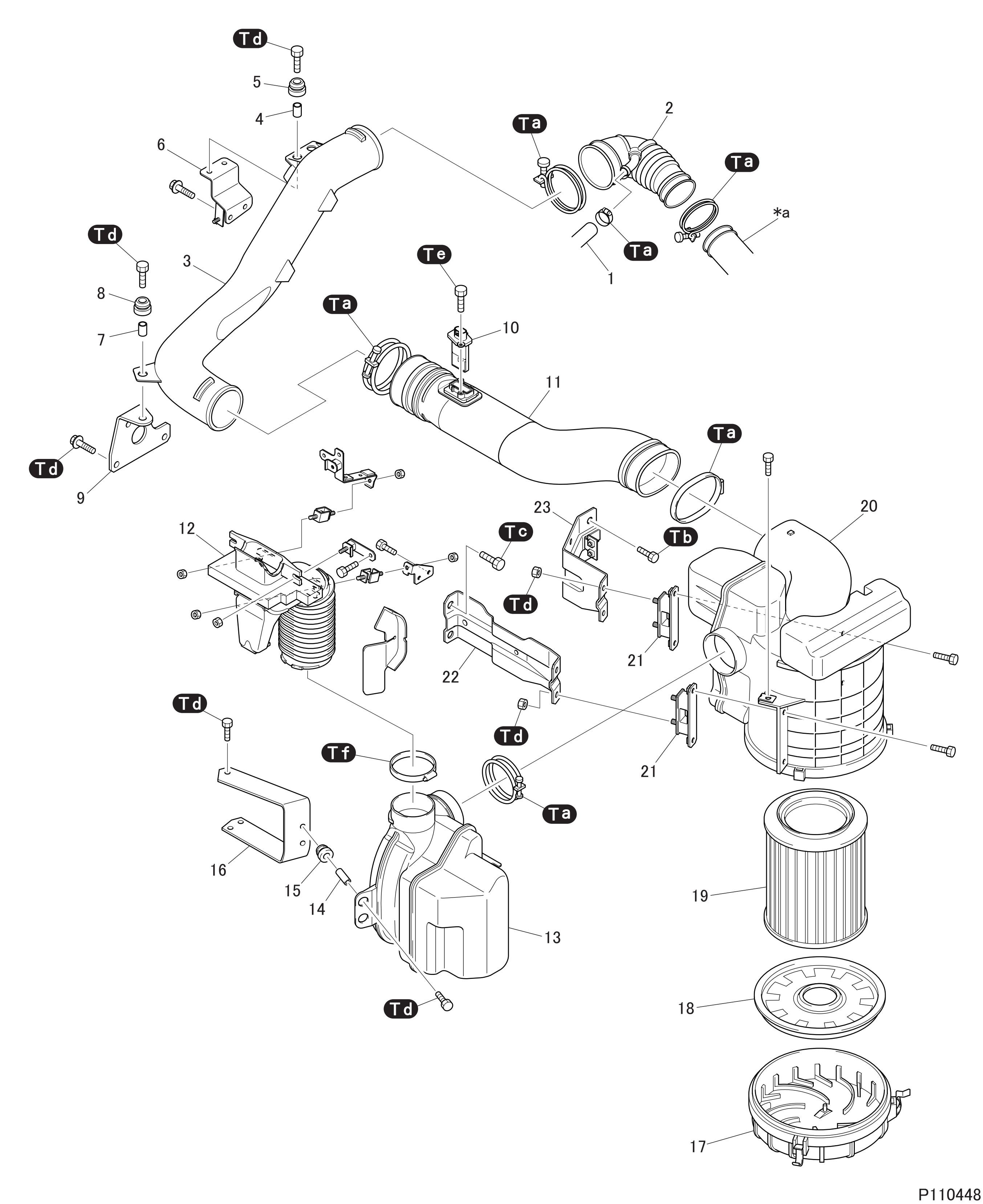

B28
Diode
To option connector
Gr54: 115
130 :Gr54
JOINT (EA08)
J05
905 :Gr54
Joint connector (J/C-3)
To starter relay
Gr54: 210
To tail lamp relay
Gr54: 320
#262 R03
Water tamperature sensor
#305 T15
Intake air tamperature sensor 1
#263 S05
Engine speed sensor
Harness side connector
Cab
Chassis
W11
To dual pressure switch
620 :Gr54
Joint connector (J/C-1)
905 :Gr54
J05
CAN resistor
B02
B01
VG turbocharger EDU
CAN L
CAN L
GND
MOTOR(24V)
MOTOR W
MOTOR V
MOTOR U
SENSOR POWER(10V)
GND
GND
GND
SENSOR GND
SENSOR W
SENSOR V
SENSOR U
W12a
#514 R16a
VG turbocharger actuator
MOTOR(W)
MOTOR(V)
MOTOR(U)
SENSOR POWER
SENSOR GND
SENSOR(W)
SENSOR(V)
SENSOR(U)
SHIELD
15-C06556-4

ECU: Electronic control unit
EDU: Electronic drive unit
DPF: Diesel particulate filter
EGR: Exhaust gas recirculation
VG: Variable geometry
INOMAT-Ⅱ: Intelligent and innovative mechanical automatic transmission-Ⅱ
CAN: Controller area network



15-C06556-5

AIR DUCT AND AIR CLEANER



● **Disassembly sequence**

1 Breather hose
2 Air hose
3 Air duct
4 Insulator collar
5 Insulator
6 Air duct bracket A
7 Insulator collar
8 Insulator
9 Air duct bracket B
10 Air flow sensor
11 Air duct
12 Air inlet duct A
13 Air inlet duct B
14 Insulator collar
15 Insulator
16 Air inlet duct bracket
17 Air cleaner cover
18 Dust cover
19 Element
20 Air cleaner case
21 Air cleaner support cushion
22 Air cleaner bracket A
23 Air cleaner bracket B

***a**: Air inlet coupler

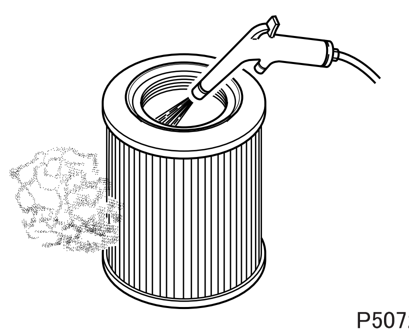
● Assembly sequence

Follow the disassembly sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	3.0 to 3.4 {0.3 to 0.35}	–
Tb	Bolt (air cleaner bracket B mounting)	25 to 30 {2.5 to 3.0}	–
Tc	Bolt (air cleaner bracket A mounting)	90 to 110 {9.2 to 11.2}	–
Td	Bolt (air duct mounting)	12 to 15 {1.2 to 1.5}	–
	Bolt (air duct bracket A and B mounting)		
	Nut (air cleaner support cushion mounting)		
	Bolt (air inlet duct B mounting)		
	Bolt (air inlet duct bracket mounting)		
Te	Bolt (air flow sensor mounting)	1.2 to 1.8 {0.12 to 0.18}	–
Tf	Clamp	3.0 to 3.5 {0.3 to 0.36}	–

◆Cleaning, inspection procedure◆



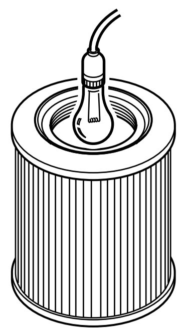
P50725

■ Cleaning: Element

- Blow a jet of compressed air at a pressure not higher than 685 kPa {7 kgf/cm^2} against the inside surfaces of the element.
- Move the compressed air jet up and down along all pleats of the filter paper element.

CAUTION ⚠

- **For the frequency and timing of cleaning, see the relevant instruction manual. More frequent cleaning than necessary could damage the element or cause dust and foreign matter to be sucked into the engine.**
- **Do not strike the element or hit it against another object to remove dust.**
- **Do not blow compressed air against outside surfaces of the element.**

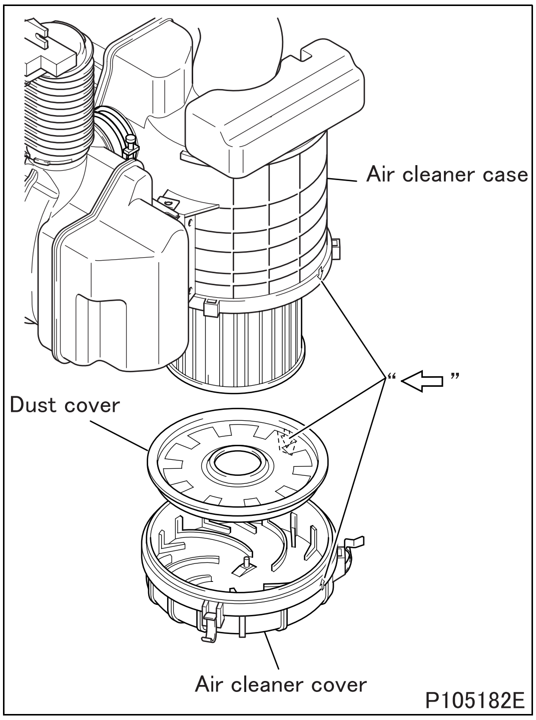


P50726

■ Inspection: Element

- Shine some electric light inside the element.
- Replace the element if thin spots or broken parts are evident in the filter paper, or if the packing at the top of the element is damaged.
  Also replace the element if the dust on the element is damp with oily smoke or soot, regardless of the replacement schedule.

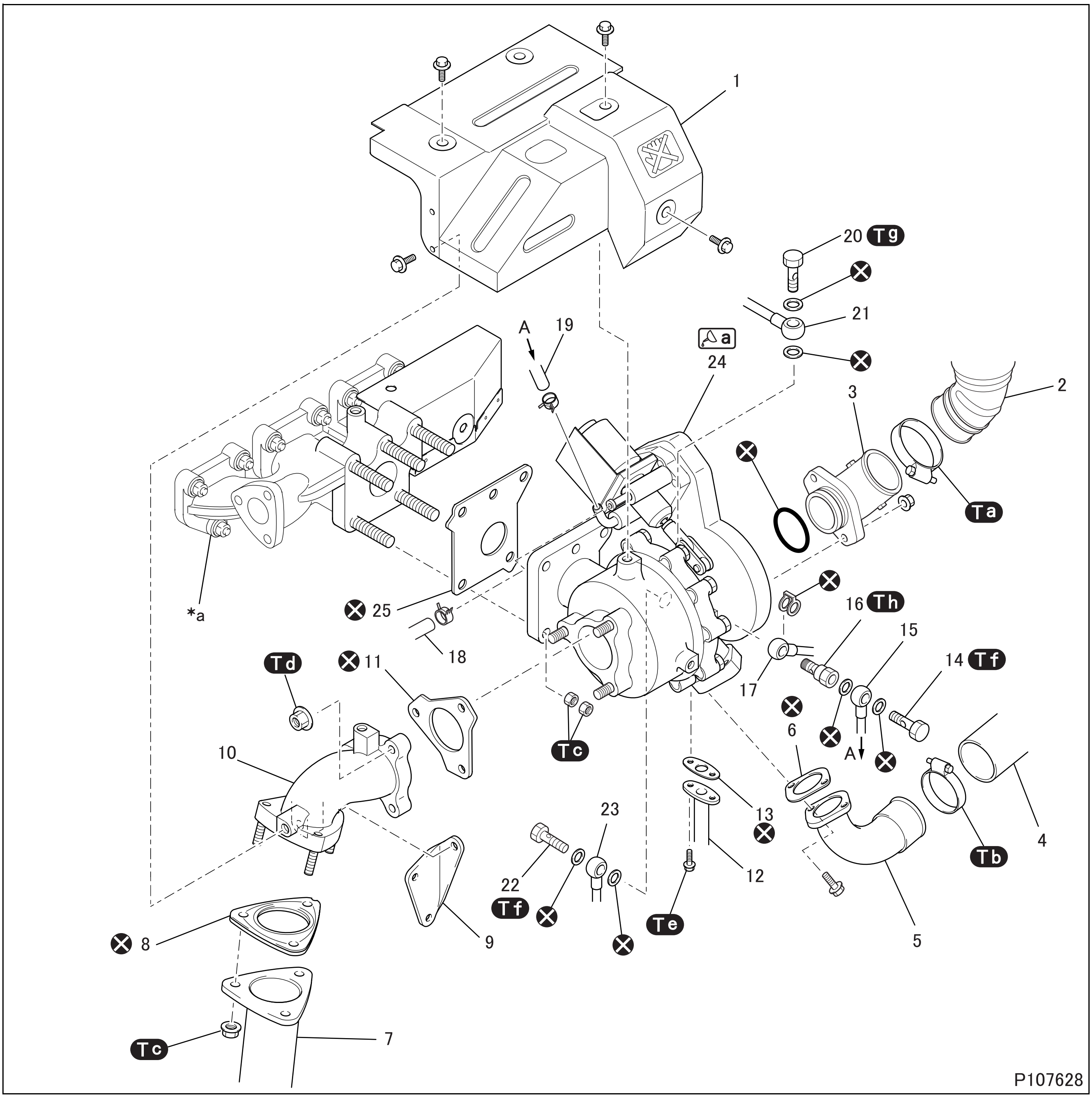
◆Installation procedure◆



■ Installation: Dust cover and air cleaner cover

- Install the covers while aligning their respective “⇦” marks with each other as shown in the illustration.

M E M O



● Removal sequence

1 Turbocharger insulator
2 Air hose
3 Air inlet coupler
4 Air inlet hose
5 Air outlet fitting
6 Gasket
7 Front pipe
8 Gasket
9 Turbocharger coupler bracket
10 Turbocharger coupler
11 Gasket
12 Oil return pipe
13 Gasket
14 Eyebolt
15 Water pipe
16 Connector
17 Water pipe
18 Water hose
19 Water hose
20 Eyebolt
21 Oil pipe
22 Eyebolt
23 Water pipe
24 Turbocharger (See later section.)
25 Gasket

*a: Exhaust manifold
⊗: Non-reusable parts

● Installation sequence

Follow the removal sequence in reverse.

- After installation, measure and adjust the boost pressure. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

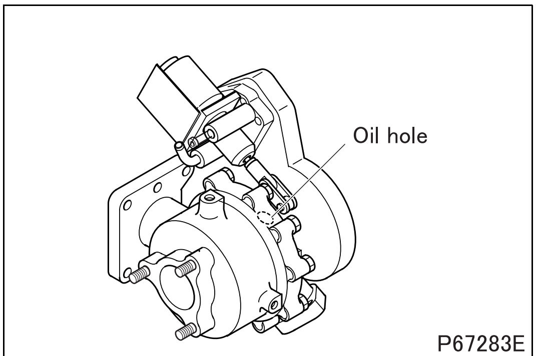
Tighening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	3 to 3.4 {0.3 to 0.35}	–
Tb	Clamp	3.9 to 4.9 {0.4 to 0.5}	–
Tc	Nut (front pipe mounting)	45 to 60 {4.6 to 6.1}	–
	Nut (turbocharger mounting)		
Td	Nut (turbocharger coupler mounting)	49 {5.0}	–
Te	Bolt (oil pipe mounting)	8 {0.82}	–
Tf	Eyebolt (water pipe mounting)	25 {2.6}	–
Tg	Eyebolt (oil pipe mounting)	20 {2.0}	–
Th	Connector (water pipe mounting)	93 {9.3}	–

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Pouring into turbocharger	Engine oil	As required

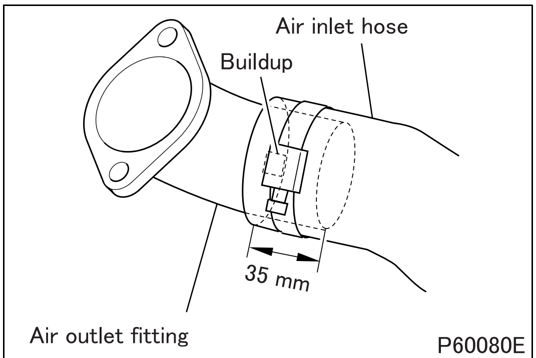
◆ Installation procedure ◆



P67283E

■ Installation: Turbocharger

- Before installing the turbocharger assembly, pour engine oil into the oil hole to ensure smooth operation of the internal parts.

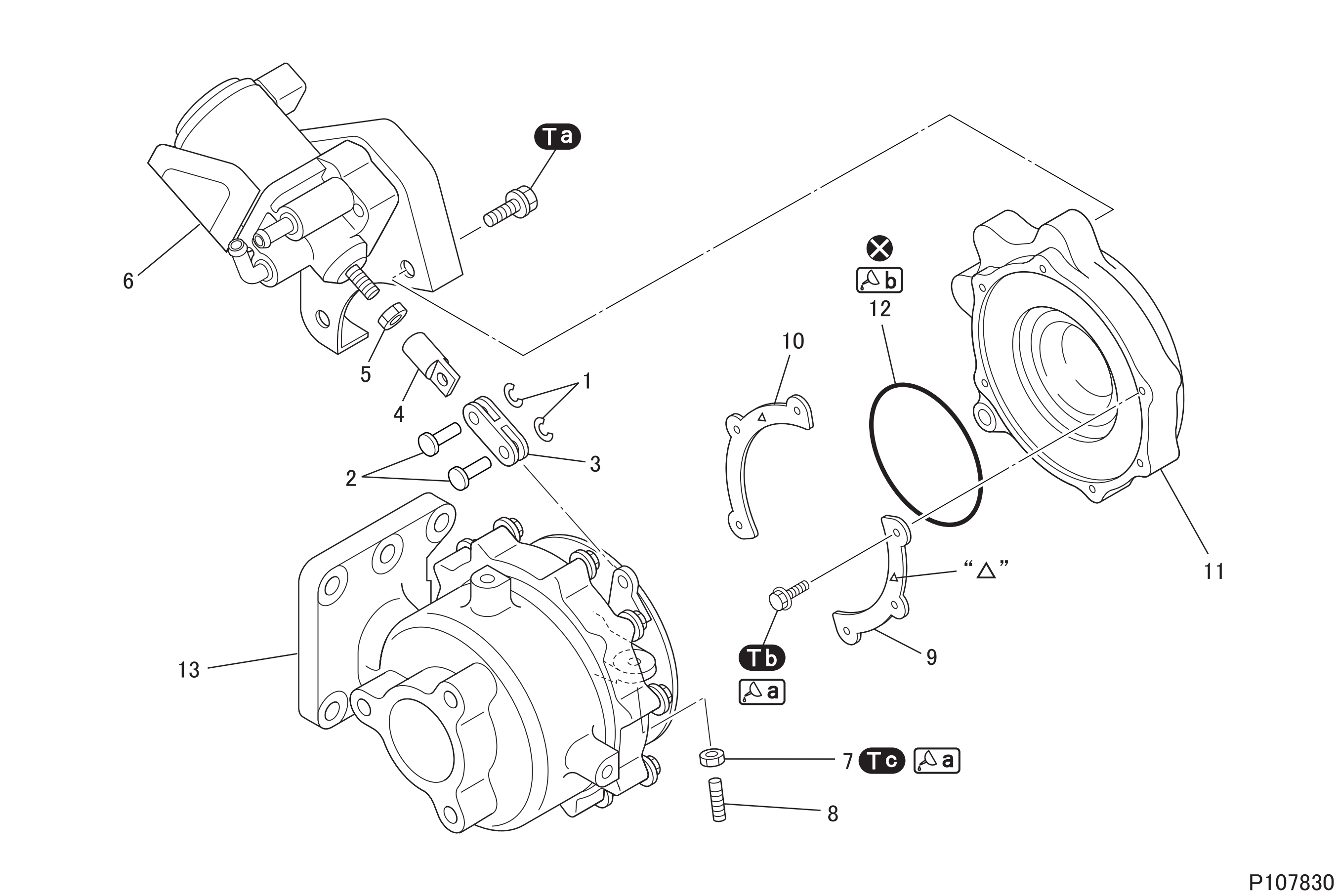


P60080E

■ Installation: Air inlet hose

- Fit the air inlet hose over the air outlet fitting as deep as its end touches the buildup on the fitting.

Turbocharger



● Removal sequence

- **1** Snap ring
- **2** Pin
- **3** Lever
- **4** Joint
- **5** Lock nut
- **6** Turbocharger actuator
- **7** Lock nut
- **8** Position bolt
- **9** Lock plate B
- **10** Lock plate A
- **11** Compressor cover
- **12** O-ring
- **13** Turbine assembly

⊗: Non-reusable parts

CAUTION ⚠

- **The blades on the turbine assembly are easily bent. Make sure that they do not strike the compressor cover.**
- **The turbine assembly is a non-disassemble component. When it becomes unsmooth in rotation or has a damaged compressor wheel, replace the turbocharger.**

NOTE

- **Do not remove the joint and position bolt from the turbocharger actuator and turbine assembly unless they are defective.**

● Installation sequence

Follow the removal sequence in reverse.

Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
2	Pin outer diameter	ϕ8	ϕ7.5	Replace
3	Lever inner diameter	ϕ8	ϕ8.5	Replace
4	Joint inner diameter	ϕ8	ϕ8.5	Replace
6	Turbocharger actuator shaft stroke	19 to 23	18.4	Replace
13	Play in shaft axis direction of turbine assembly	0.55 to 0.66	0.72	Replace

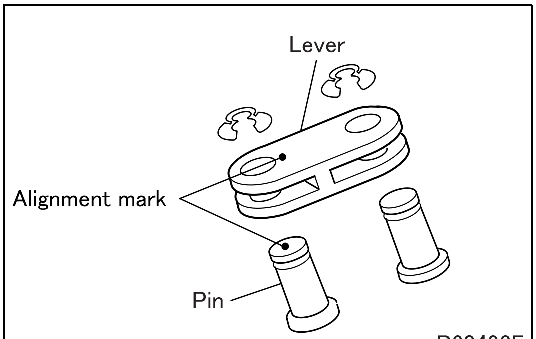
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (turbocharger actuator mounting)	21.6 to 23.5 {2.2 to 2.4}	–
Tb	Bolt (lock plate A and B mounting)	2.9 to 4.9 {0.3 to 0.5}	Wet
Tc	Lock nut	4.9 to 9.8 {0.5 to 1.0}	Wet

Lubricant and/or sealant

Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	Thread area of bolts	Seizure preventive compound (FEL-PRO CA-5)	As required
	Thread area of nuts		
b	O-ring	Engine oil	As required

◆Work before removal◆



P60493E

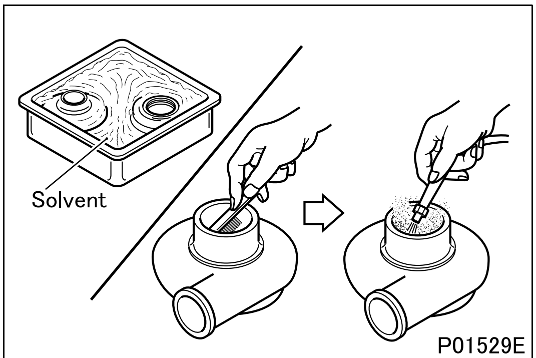
■ **Alignment mark**

- Put alignment marks on the pin and lever.

CAUTION ⚠

- **Be sure to provide alignment marks on the lever and pin to ensure installation of the pins in right places when reused. Pins in wrong position would change boost pressure to result in a malfunctioning or damaged engine.**

◆Work after disassembly◆



P01529E

■ **Cleaning**

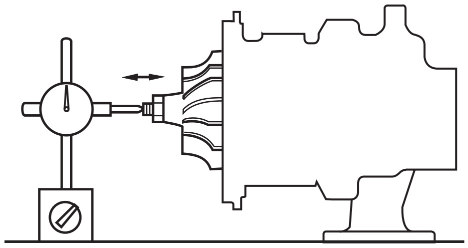
- Before cleaning, visually check the disassembled parts for scorches, abrasion and other marks that may be difficult to see after cleaning. Replace any part that appears defective.
- Immerse the disassembled parts in a non-flammable solvent (a 5 to 10 aqueous solution of Oil Clean from New Hope Co., Ltd.). Take out the parts and blow them dry with compressed air. Remove any hard deposits with a stiff brush or plastic scraper.

CAUTION ⚠

- **Do not immerse the cartridge assembly in the solvent. Doing so will cause the O-ring inside the cartridge assembly to sell up, which may adversely affect turbocharger operation.**

- Again, immerse the parts in the solvent.
- Blow them dry using compressed air.

◆Inspection procedure◆


P107831

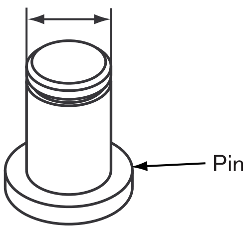
■ Inspection: Turbine assembly

(1) Visual check

- Replace the turbocharger if the compressor cover is damaged or if smooth rotation is not ensured.

(2) Play in shaft axial direction

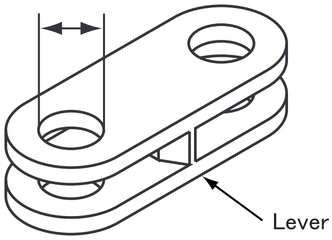
- Install the turbine assembly on a flat board with its flanged section pressed against the board. Then, measure the runout using a dial gauge.
- If the measurement exceeds the limit, replace the turbine assembly.



P68657E

■ Inspection: Pin outer diameter

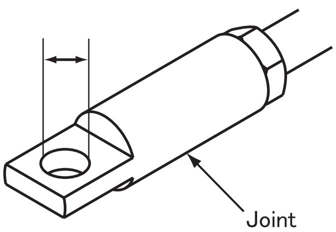
- If the measurement is less than the limit, replace the pin.



P68658E

■ Inspection: Lever inner diameter

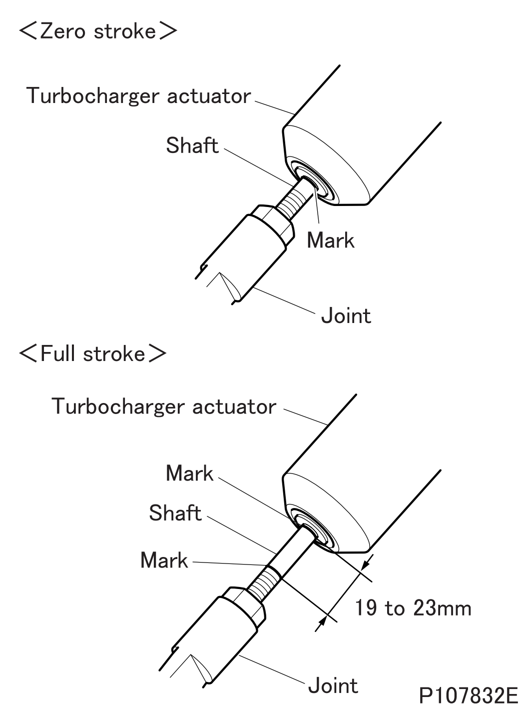
- If the measurement exceeds the limit, replace the lever.



P60888E

■ Inspection: Joint inner diameter

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

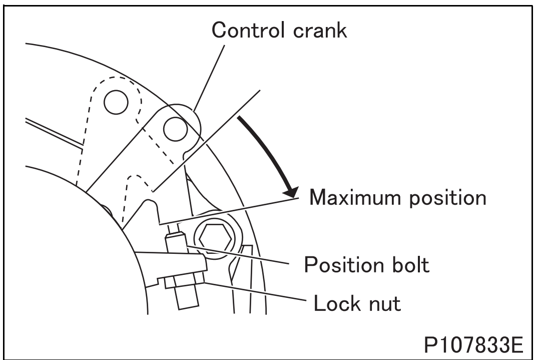


P107832E

■ **Inspection: Turbocharger actuator shaft stroke**

- Conduct the turbocharger actuator check with the turbocharger electronic drive unit mounted on the vehicle.
- Mark the turbocharger actuator shaft at the zero stroke point.
- Select [A5: VGT] from [Actuator Test] on the Multi-Use Tester screen and execute it. The turbocharger actuator shaft will be brought into a full stroke state.
- Measure the amount of stroke from the full stroke point to the marked point.
- If the measurement is out of specified standard value, replace the turbocharger actuator.

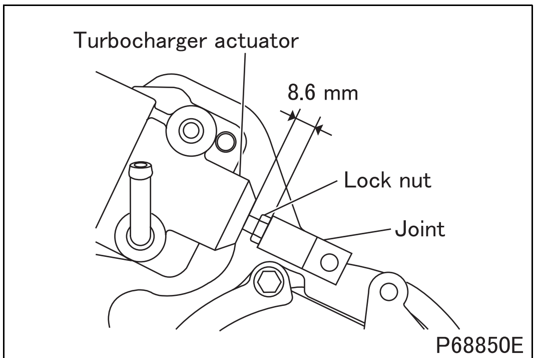
◆Installation procedure◆



P107833E

■ **Installation: Position bolt**

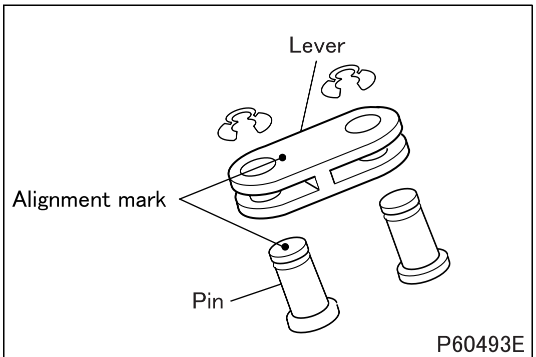
- Move the control crank to the maximum position, and install the position bolt to the turbine assembly.
  Make sure that the position bolt is in contact with the control crank.
- In this state, give the position bolt two and half turns, then tighten the lock nut to secure the position bolt.



P68850E

■ **Installation: Joint**

- With the actuator shaft in a zero stroke state, adjust the distance between the end faces of the actuator and joint to the illustrated value.
  Adjusting guide: 1 mm with one full turn of joint
- After the adjustment, tighten the lock nut.



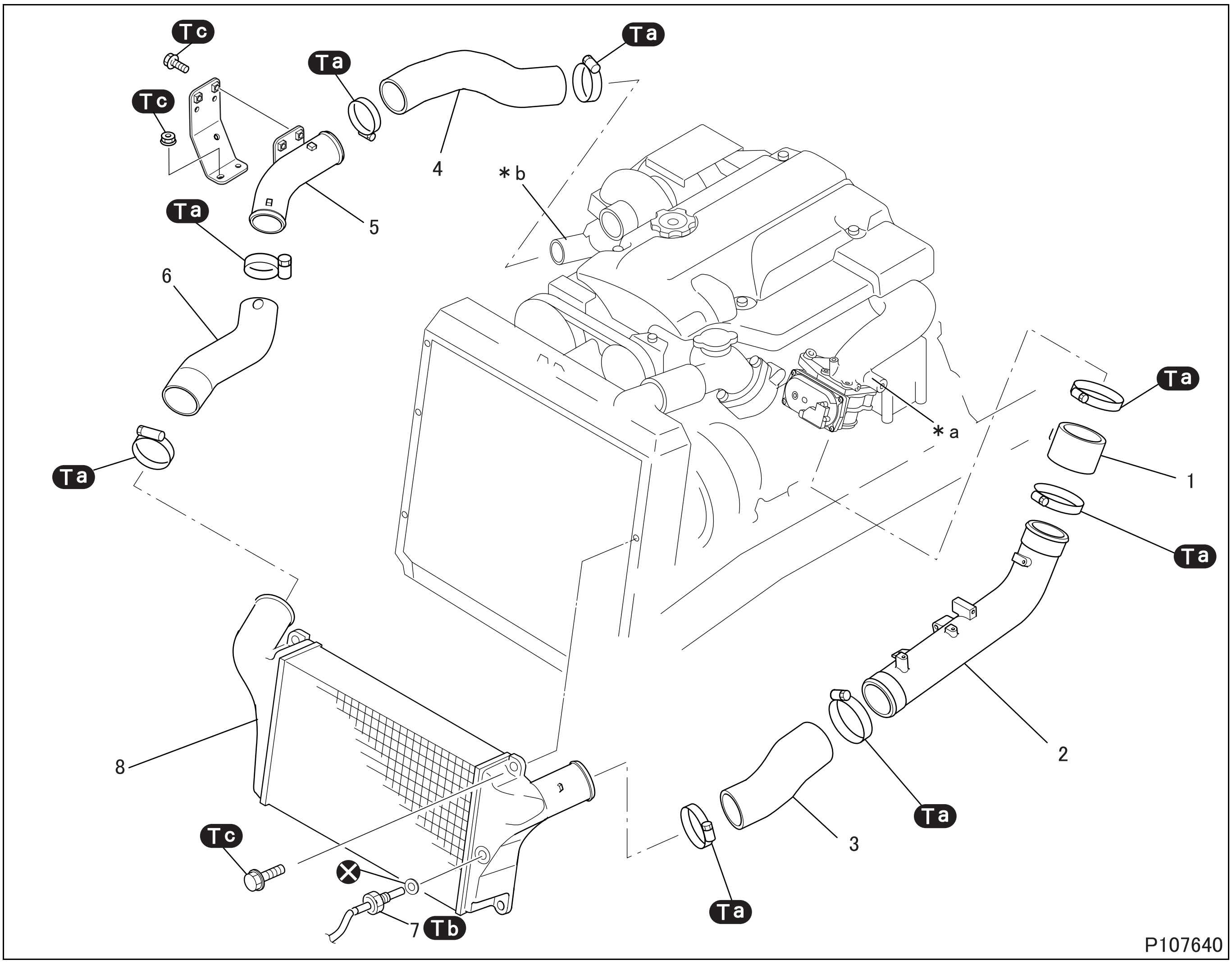
P60493E

■ **Installation: Pin**

- Install the pins in the lever according to alignment marks.

CAUTION ⚠

- **Be sure to match the alignment marks to ensure installation of the pins in right places when reused. Pins in wrong position would change the boost pressure to result in a malfunctioning or damaged engine.**



● Disassembly sequence

1 Air inlet hose
2 Air inlet pipe LH
3 Air inlet hose
4 Air inlet hose
5 Air inlet pipe RH
6 Air inlet hose
7 Intake air temperature sensor 1
8 Intercooler

＊a: Air inlet pipe
＊b: Air outlet fitting
⊗: Non-reusable parts

CAUTION ⚠

- **When removing the air inlet hose, do not try to pry it off with strong force using a screwdriver or other similar tools. Doing that can damage the fluoro-layer on the inner surface of the hose, possibly compromising the oil resistance of the hose.**

● Assembly sequence

Follow the disassembly sequence in reverse.

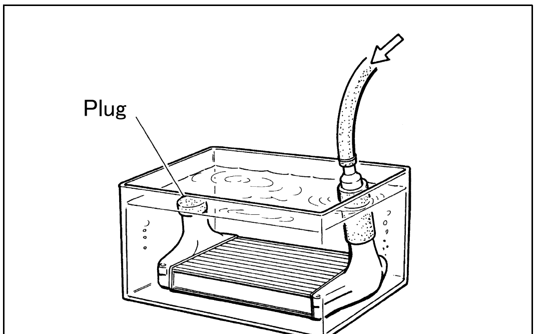
Service standards (Unit: mm)

Location	Maintenance item	Standard value	Limit	Remedy
8	Intercooler air leakage (air pressure: 200 kPa {2.0 kgf/cm^2} maintained for 30 seconds)	0 cm^3 {0 mL}	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Clamp	3.9 to 4.9 {0.4 to 0.5}	–
Tb	Intake air temperature sensor 1	14.7 to 24.5 {1.5 to 2.5}	–
Tc	Bolt (intercooler mounting)	12 to 15 {1.2 to 1.5}	–
	Bolt (bracket mounting)		
	Nut (bracket mounting)		

◆Inspection procedure◆

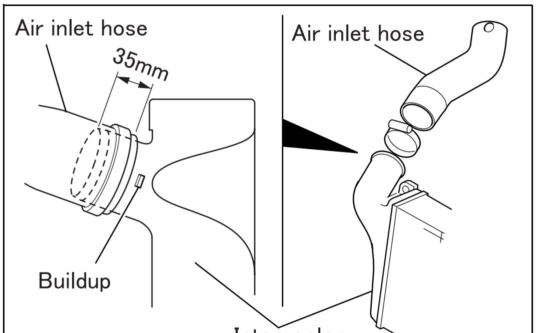


01552E

■ Inspection: Air leakage from intercooler

- Plug one of the air ports of the intercooler and immerse it in a tank of water. Apply the specified air pressure to the intercooler through the other air port and retain pressure for 30 seconds.
- Replace the intercooler if any air leakage is evident.

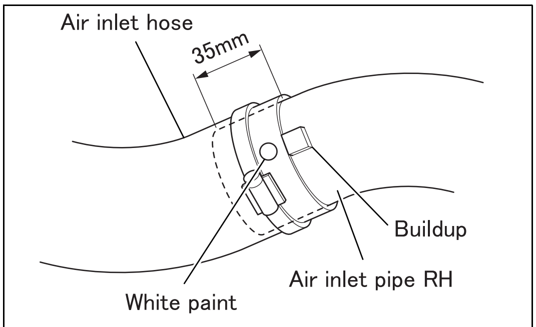
◆Installation procedure◆



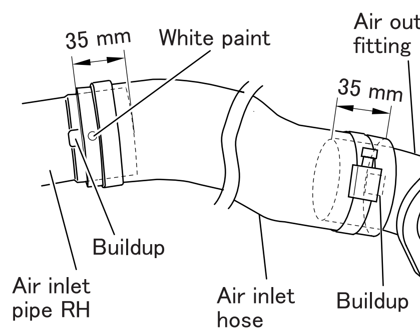
P107267E

■ Installation: Air inlet hose

- When connecting the hose to the intercooler, note that the over-lap length shown in the illustration must be assured.



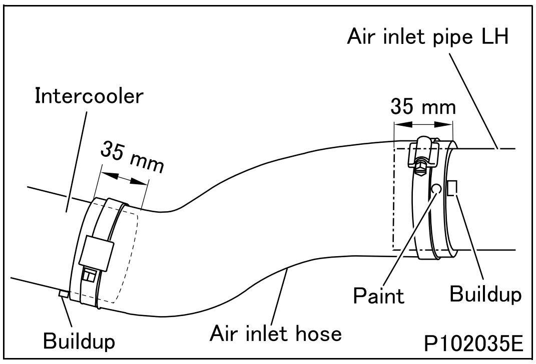
P107268E



P60084E

■Installation: Air inlet hose

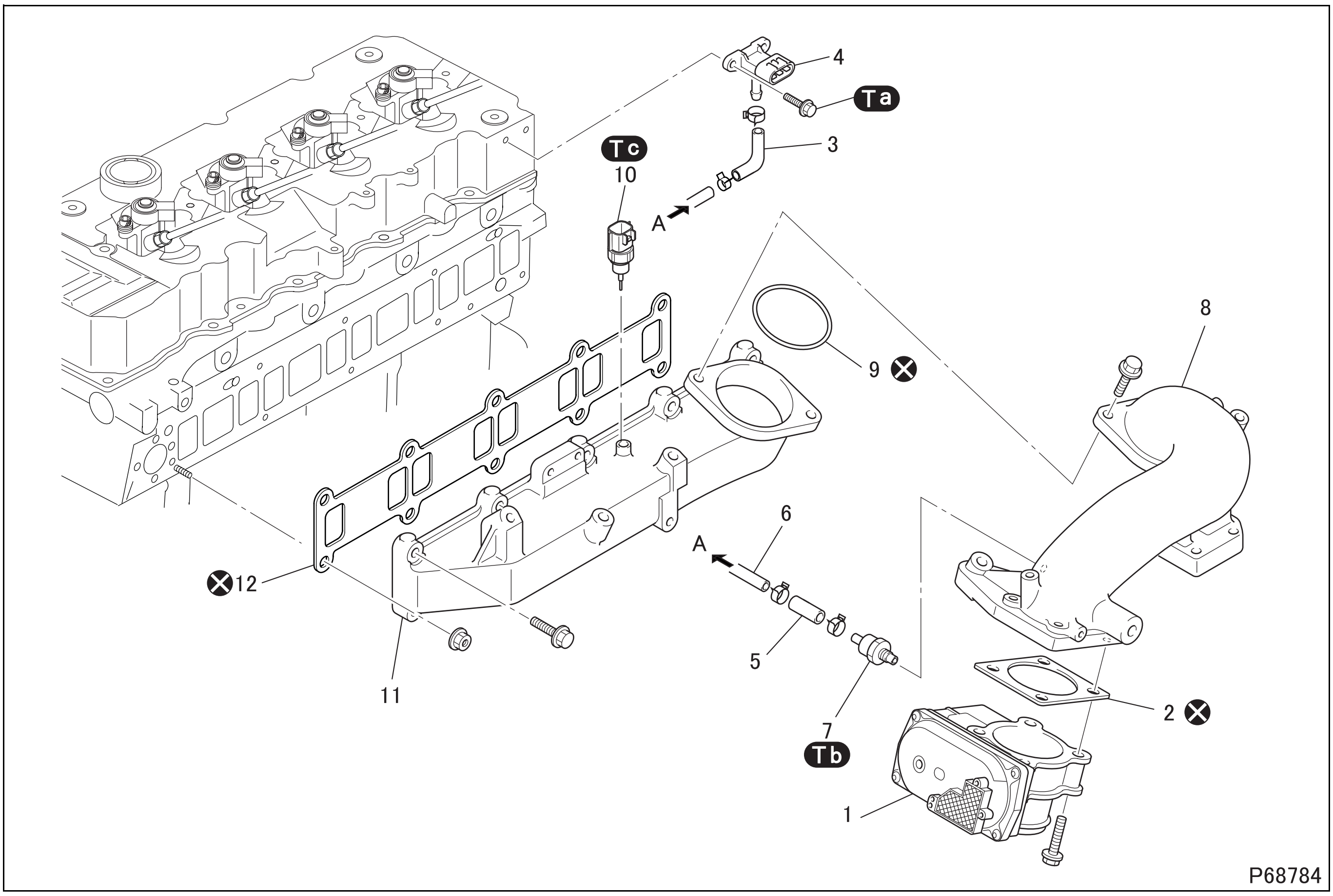
- Install the air inlet hose so that its paint faces the buildup of the air inlet pipe RH.
- Install the air inlet hose to the intercooler, air inlet pipe RH and air outlet fitting to the illustrated dimensions.



- Install the air inlet hose to the air inlet pipe LH with the paint on the hose aligned with the buildup on the pipe.
- Install the air inlet hoses to the intercooler and air inlet pipe LH to the illustrated dimensions.

MEMO

INTAKE MANIFOLD



● Disassembly sequence

1 Intake throttle
2 Gasket
3 Vacuum hose
4 Boost pressure sensor
5 Vacuum hose
6 Vacuum pipe
7 Gas filter
8 Air inlet pipe
9 O-ring
10 Intake air temperature sensor 2
11 Intake manifold
12 Gasket

⊗: Non-reusable parts

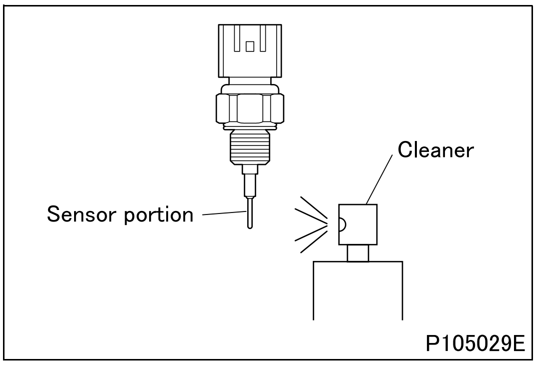
● Assembly sequence

Follow the disassembly sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (boost pressure sensor mounting)	4 to 6 {0.4 to 0.6}	–
Tb	Gas filter	14.7 to 19.6 {1.5 to 2.0}	–
Tc	Intake air temperature sensor 2	25 ± 5 {2.5 ± 0.5}	–

◆Inspection procedure◆



■ **Inspection: Intake air temperature sensor 2**

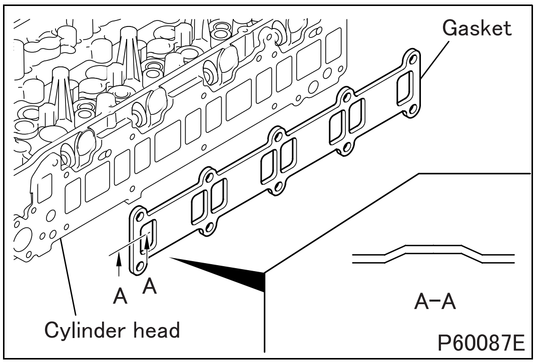
- Check that the sensor portion is free of soot, oily substance, etc.
- If necessary, clean the sensor portion as follows.
- Spray a cleaner on the sensor portion from 2 to 3 cm away.
  Recommended cleaners: Nonchlorinated solvent.
- In 20 to 30 seconds after spraying, wipe the sensor portion clear of the sprayed cleaner using a soft waste cloth or the like.

CAUTION ⚠

- **Be sure to wait for 20 to 30 seconds before wiping. It takes the cleaner that long to dissolve foreign matter.**

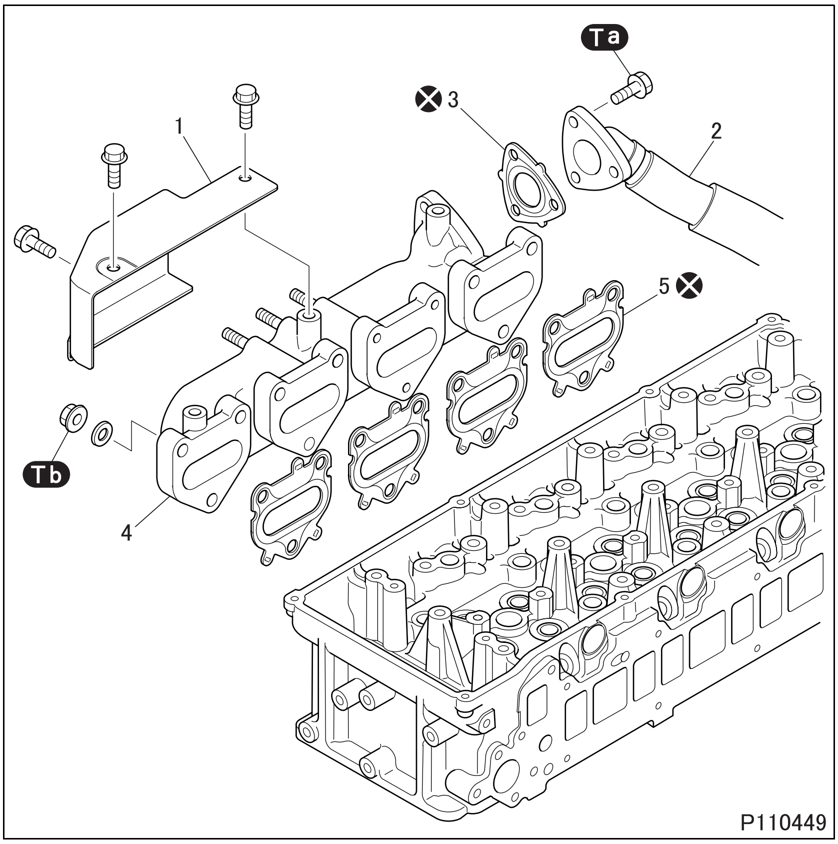
- If the sensor portion is fouled excessively, the positive crankcase ventilation (PCV) may be faulty. Inspect the PCV valve and breather to locate the cause and remove it. (See Gr17.)

◆Installation procedure◆



■ **Installation: Gasket**

- Install the gasket on the cylinder head in the illustrated direction.



● **Disassembly sequence**

1 Exhaust insulator
2 Exhaust gas recirculation pipe
3 Gasket
4 Exhaust manifold
5 Gasket

⊗: Non-reusable parts

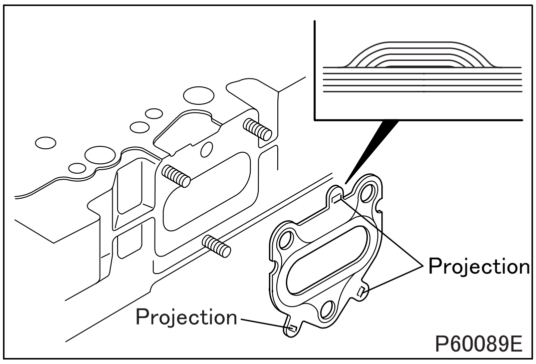
● **Assembly sequence**

Follow the disassembly sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (exhaust gas recirculation pipe mounting)	23.8 {2.4}	–
Tb	Nut (exhaust manifold mounting)	30 {3.1}	–

◆Installation procedure◆

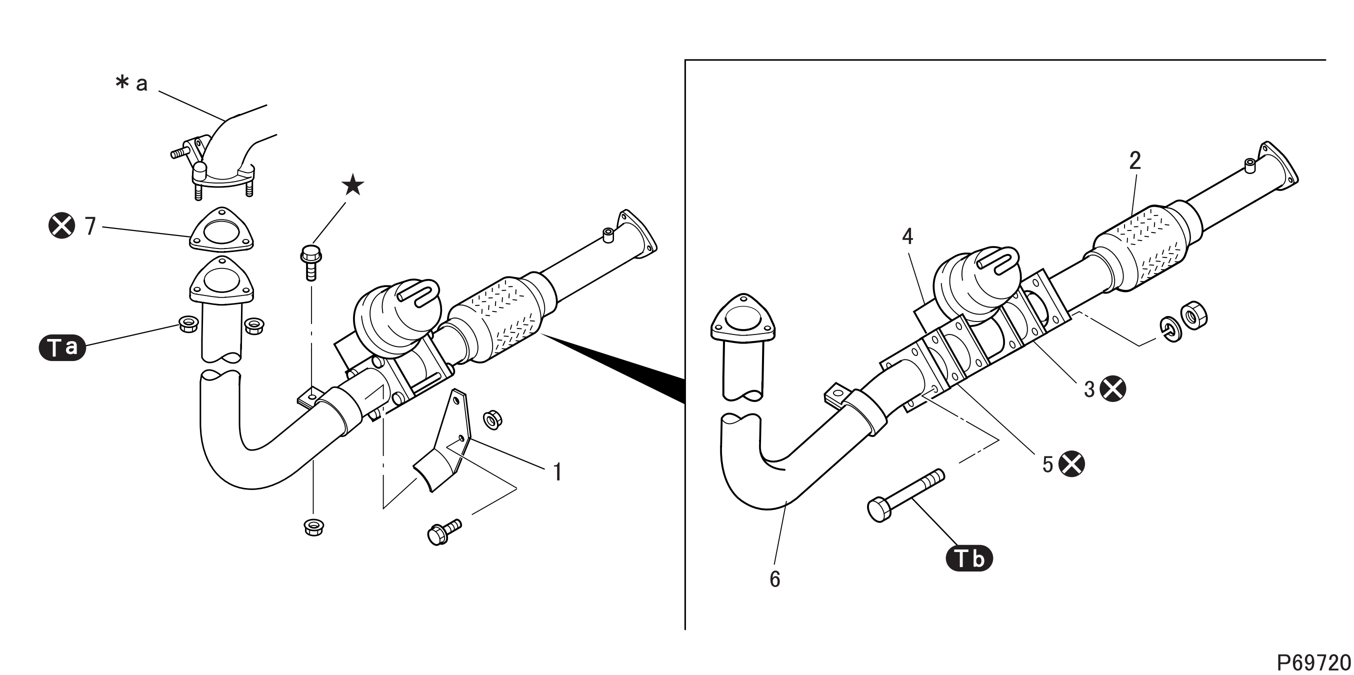


■**Installation: Gasket**

- Install the gasket on the cylinder head in the illustrated direction.

M E M O

EXHAUST PIPE



● **Removal sequence**

1 Brace bracket
2 Front pipe
3 Gasket
4 Exhaust shutter (See later section.)
5 Gasket
6 Front pipe
7 Gasket

***a**: Turbocharger coupler
⊗: Non-reusable parts

CAUTION ⚠

- **Loosen the ★ marked bolt first to prevent undue forces from being applied to the front pipe.**

● **Installation sequence**

Follow the removal sequence in reverse.

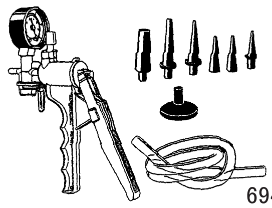
CAUTION ⚠

- **Tighten the ★ marked bolt last to prevent undue forces from being applied to the front pipe.**

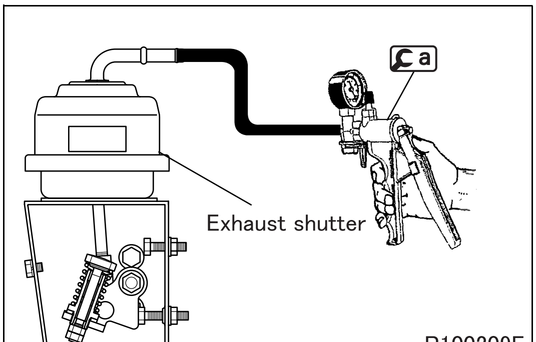
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (front pipe mounting)	45 to 60 {4.6 to 6.1}	–
Tb	Bolt (exhaust shutter mounting)	25 to 28 {2.5 to 2.9}	–
Tc	Bolt (brace bracket clamp mounting)	21 to 31 {2.1 to 3.1}	–

Special tools

Mark	Tool name and shape	Part No.	Application
a	Vacuum pump kit  69431	MH063724	Removal and installation of exhaust shutter

◆Removal procedure◆

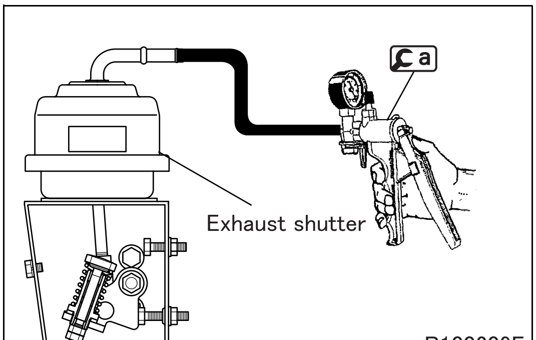


P100209E

■Removal: Exhaust shutter

- Attach a to the power chamber of the exhaust shutter.
- Apply some load to the exhaust shutter using a to remove the shutter.

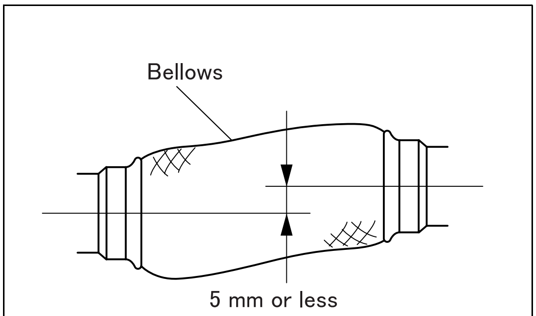
◆Installation procedure◆



P100209E

■Installation: Exhaust shutter

- Attach a to the power chamber of the exhaust shutter.
- Apply some load to the exhaust shutter using a to install the shutter.



P64278E

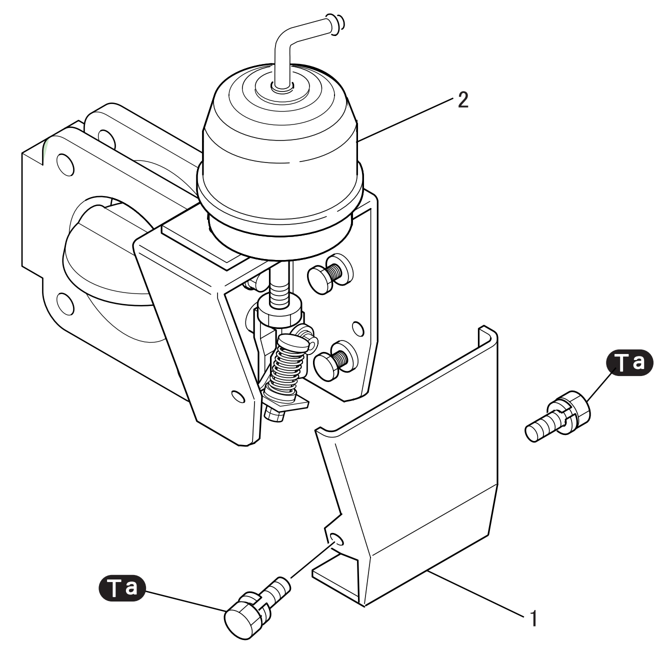
■Installation: Front pipe

- Install the front pipe so that the amounts of offset in both vertical and horizontal directions between the pipes in front of and behind the bellows are within the specified value.

CAUTION ⚠

- **The function of the bellows on the front pipe is to reduce the vehicle noise level. It is not intended for compensating for misalignment that may result from improper installation of the front pipe. Install the front pipe properly to avoid excessive tension or other stress on the bellows.**

Exhaust Shutter



● Disassembly sequence

1 Cover
2 Exhaust shutter

- The exhaust shutter cannot be disassembled. Replace the exhaust shutter as a unit if any damage is found on the power chamber or other component parts.

● Assembly sequence

Follow the disassembly sequence in reverse.

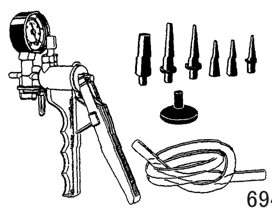
Service standards (Unit: mm)

Location	Maintenance item		Standard value	Limit	Remedy
–	Clearance between butterfly valve and body (average clearance between top and bottom)	When butterfly valve is fully closed (negative pressure for inspection: at least 87 to 93 kPa {650 to 700 mmHg})	0.10 to 0.25	–	Replace
		When butterfly valve is half closed (negative pressure for inspection: 51 kPa {380 mmHg} and 55 kPa {410 mmHg})	0.60 to 0.75	–	Replace
–	Air-tightness of power chamber (at 15 sec. after vacuum of 93 kPa {698 mmHg} is achieved in chamber)		Negative pressure: 90 kPa {675 mmHg} or above	–	Replace

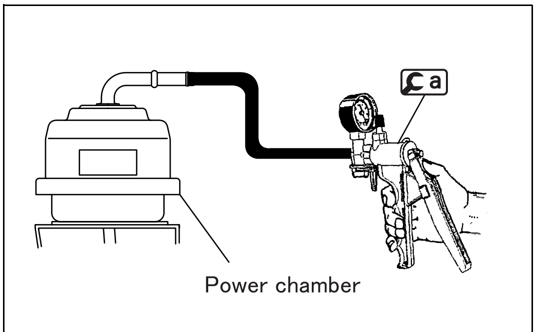
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (cover mounting)	4.9 to 6.9 {0.5 to 0.7}	–

Special tools

Mark	Tool name and shape	Part No.	Application
a	Vacuum pump kit  69431	MH063724	Inspection of power chamber

◆Inspection procedure◆

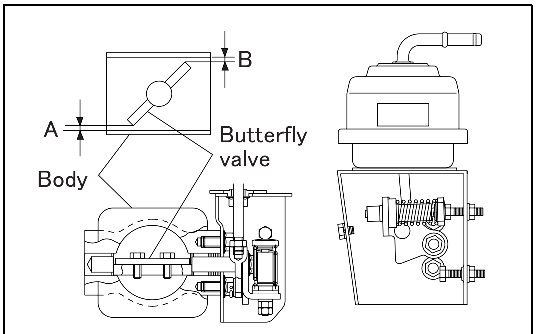


P102550E

■ Inspection: Exhaust shutter

(1) Air tightness of power chamber

- Apply the negative pressure for inspection to the power chamber using a.
- After elapse of 15 seconds, check that the vacuum gauge reading meets with the specified value.
- If the measurement deviates from the standard value, replace the exhaust shutter.



P100211E

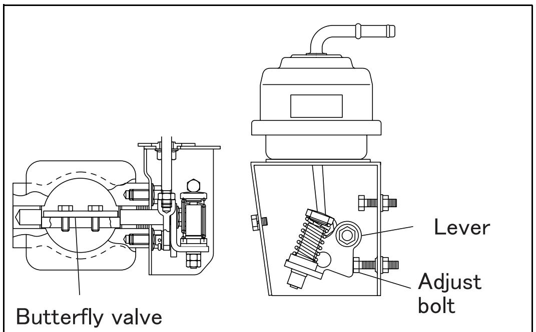
(2) Clearance between butterfly valve and body (average clearance between top and bottom)

(2.1) When the butterfly valve is fully closed

- Apply the negative pressure for inspection to the power chamber. Measure the clearance between the butterfly valve and body at the top A and that at the bottom B with the butterfly valve fully closed. Calculate the average clearance.

$$\text{Clearance} = \frac{(A + B)}{2}$$

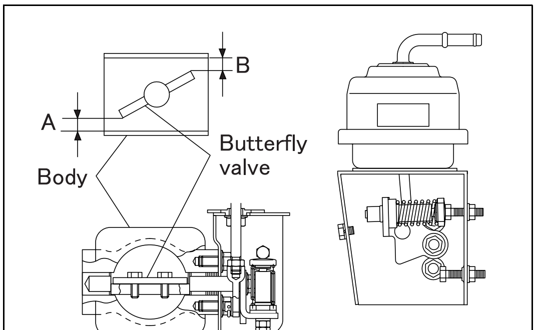
- If the measurement deviates from the standard value, replace the exhaust shutter.



P100212E

(2.2) When the butterfly valve is fully opened

- Check to ensure that there is no clearance between the lever and adjusting bolt and that the butterfly valve is kept fully open.
- If there is any abnormality, replace the exhaust shutter.



P100213E

(2.3) When the butterfly valve is half closed

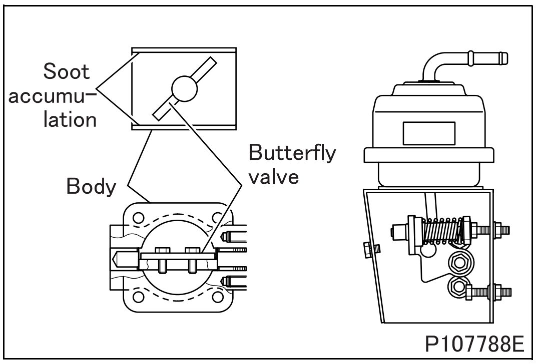
- Apply the negative pressure for inspection to the power chamber. Measure the clearance between the butterfly valve and body at the top A and that at the bottom B with the butterfly valve half closed. Calculate the average clearance.

$$\text{Clearance} = \frac{(A + B)}{2}$$

CAUTION ⚠

- **Be sure to take measurements after the butterfly valve is brought once in fully open position and then placed in half closed position. Never take measurements on butterfly valve which is brought in half closed position from the fully closed position.**

- If the measurement deviates from the standard value, replace the exhaust shutter.

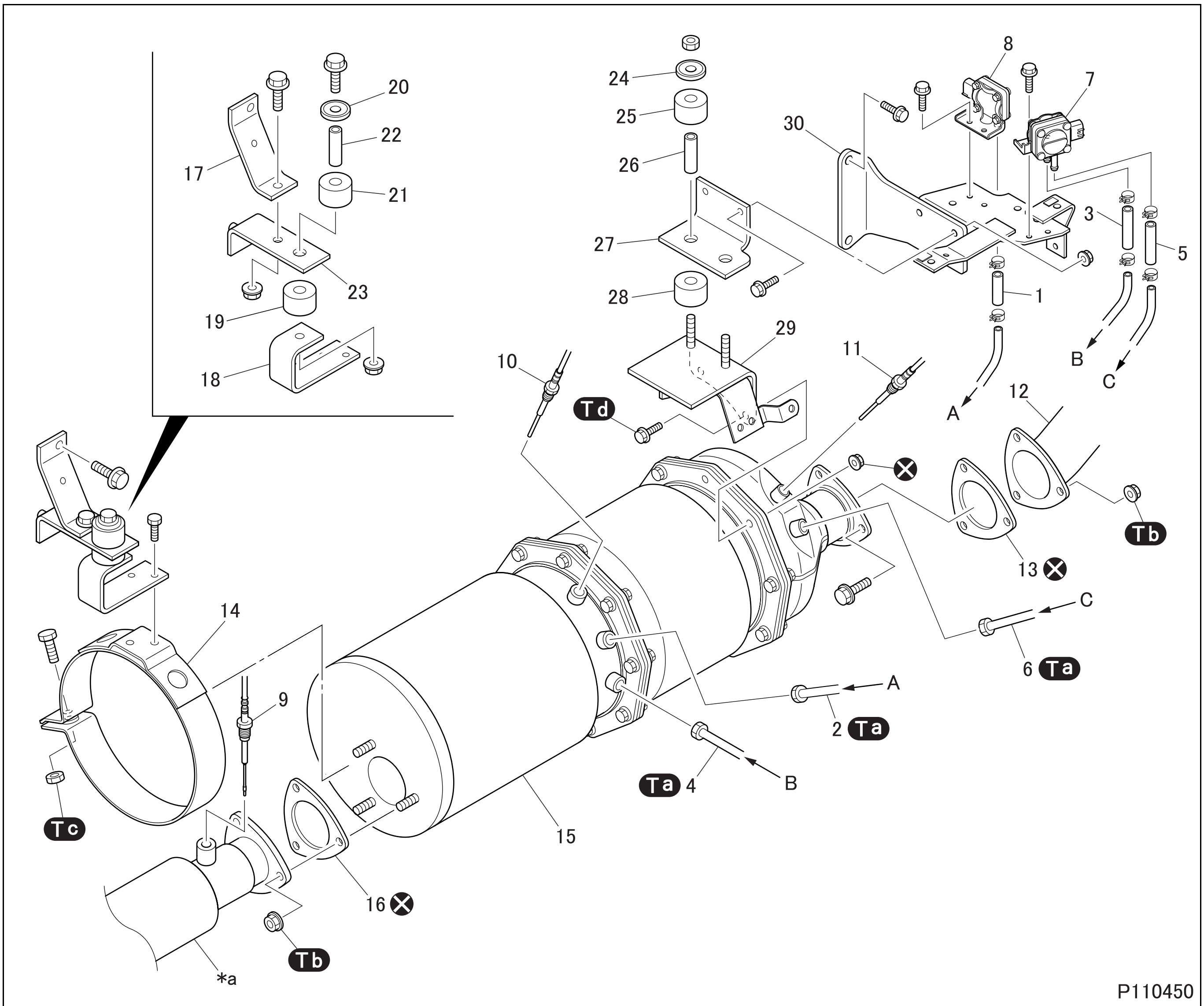


(3) Inspection of body inside

- Check that the body inside is not sooted.
- Clean the body if any soot accumulation is found.

MEMO

DIESEL PARTICULATE FILTER



● Removal sequence

1 Pressure hose
2 Pressure pipe
3 Pressure hose
4 Pressure pipe
5 Pressure hose
6 Pressure pipe
7 DPF differential pressure sensor
8 DPF absolute pressure sensor
9 Exhaust gas temperature sensor 1
10 Catalytic temperature sensor
11 Exhaust gas temperature sensor 2
12 Rear oxidation catalyst (See later section.)
13 Gasket
14 DPF band
15 DPF (See later section.)
16 Gasket
17 Bracket
18 Stay
19 Cushion rubber
20 Cap
21 Cushion rubber
22 Collar
23 Bracket
24 Cap
25 Cushion rubber
26 Collar
27 Bracket
28 Cushion rubber
29 Bracket
30 Bracket

*a: Front pipe
⊗: Non-reusable parts
DPF: Diesel Particulate Filter

NOTE

- **The color of the diesel particulate filter surface may turn brown. This discoloration is due to the inherent characteristics of stainless steel and does not indicate rusting or any other abnormality.**

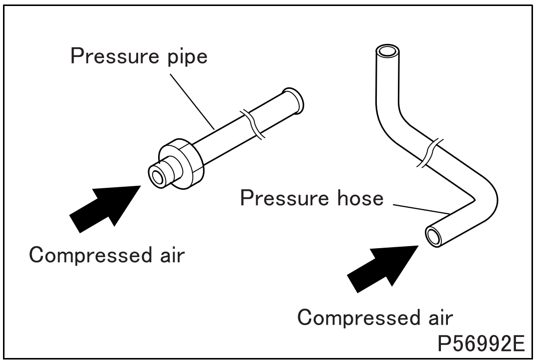
● Installation sequence

Follow the removal sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Pressure pipe	40 {4.0}	–
Tb	Nut (rear oxidation catalyst mounting)	26 to 33 {2.7 to 3.2}	–
	Nut (front pipe mounting)		
Tc	Nut (diesel particulate filter band mounting)	45 to 55 {4.5 to 5.6}	–
Td	Bolt (bracket mounting)	49 to 63.7 {5.0 to 6.4}	–

◆ Inspection procedure ◆

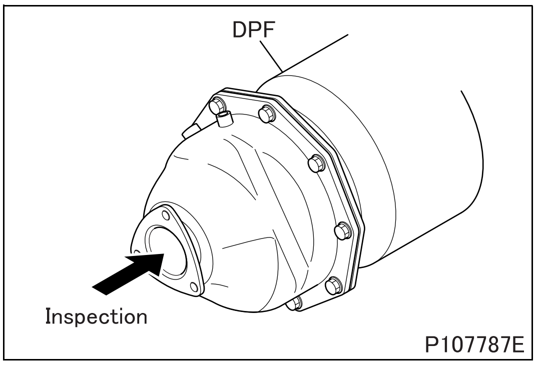


■ Inspection: Pressure pipe and pressure hose

- Check the pressure pipe and hose for clogging by blowing compressed air into the pipe and hose.

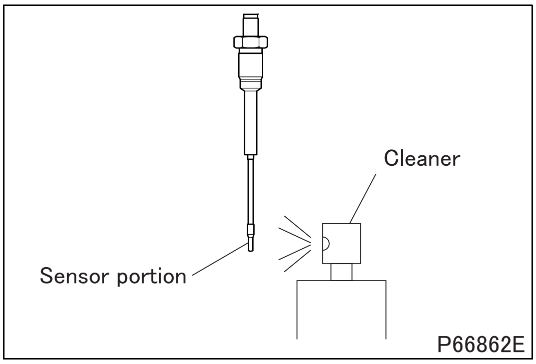
CAUTION ⚠

- **Inspection must be performed on an individual pressure pipe or hose.**
- **If compressed air is blown into the pressure pipe or hose with diesel particulate filter sensor still installed, the sensor may become damaged.**



■ Inspection: Diesel particulate filter

- Check the exhaust passage inside the diesel particulate filter for adhesion of soot in large quantity.
- If large amounts of soot are found, replace the diesel particulate filter because broken ceramic filter is suspected.



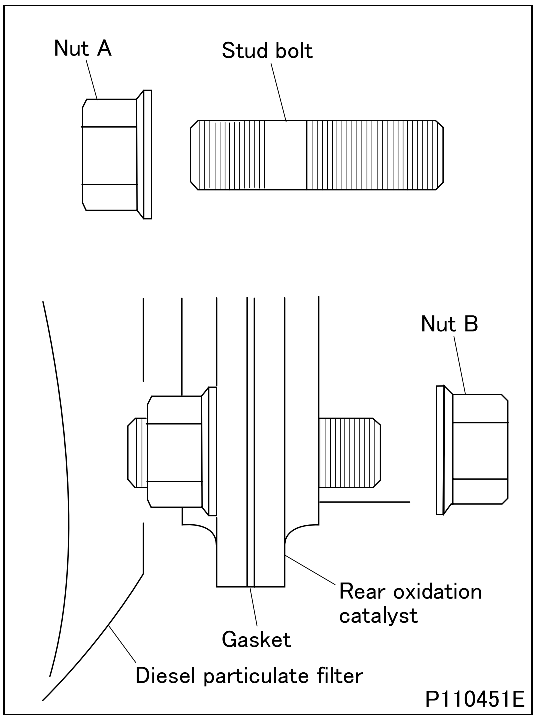
■ Inspection: Catalytic temperature sensor, exhaust gas temperature sensor

- Check that the sensor portion is free of soot, oily substance, etc.
- If necessary, clean the sensor portion as follows.
- Spray a cleaner on the sensor portion from 2 to 3 cm away. Recommended cleaners: Nonchlorinated solvent.
- In 20 to 30 seconds after spraying, wipe the sensor portion clear of the sprayed cleaner using a soft waste cloth or the like.

CAUTION ⚠

- **Be sure to wait for 20 to 30 seconds before wiping. It takes the cleaner that long to dissolve foreign matter.**

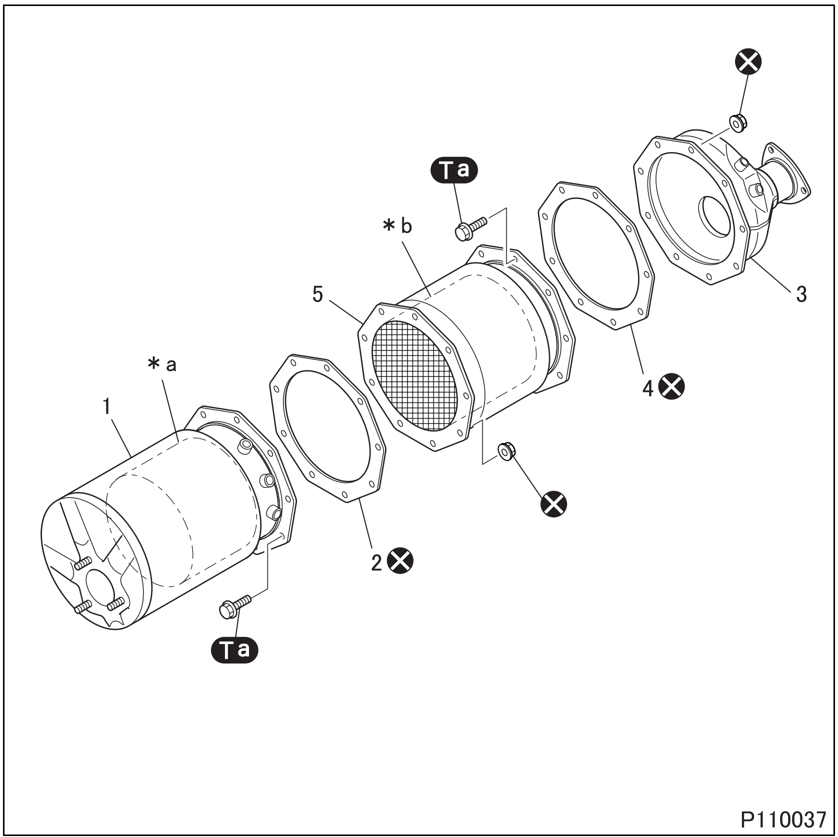
◆Installation procedure◆



■ Installation: Rear oxidation catalyst

- Screw the nut A onto the shorter threaded side of the stud bolt until it cannot be turned any more.
- Insert the stud bolt with nut A attached into position from the diesel particulate filter side. Fit the gasket and the rear catalyst and tighten the nut B to the specified torque.

Diesel Particulate Filter



● **Disassembly sequence**

1 Inlet body
2 Gasket
3 Outlet body
4 Gasket
5 Filter body

***a**: Front oxidation catalyst
***b**: Ceramic filter
⊗: Non-reusable parts

● **Assembly sequence**

Follow the disassembly sequence in reverse.

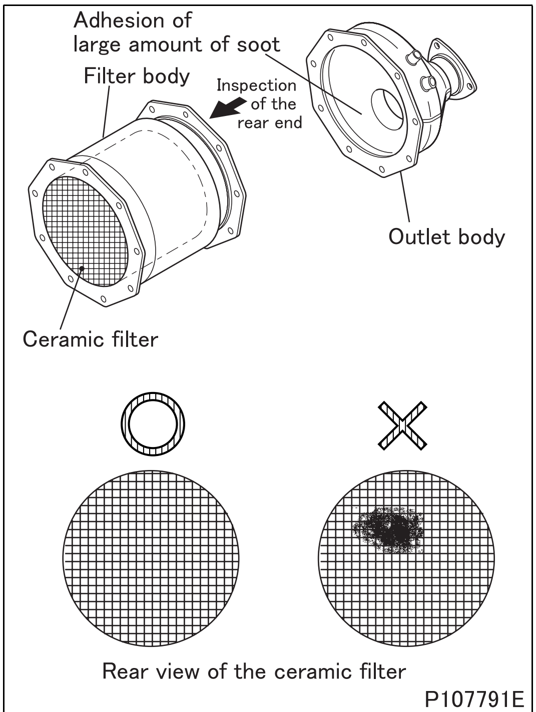
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (inlet body mounting)	49 to 63.7 {5.0 to 6.4}	–
	Bolt (outlet body mounting)		

◆Inspection procedure◆

■**Inspection: Inlet body**

- Inspect the front oxidation catalyst of inlet body visually.
- Replace the inlet body if any abnormalities such as break are found.



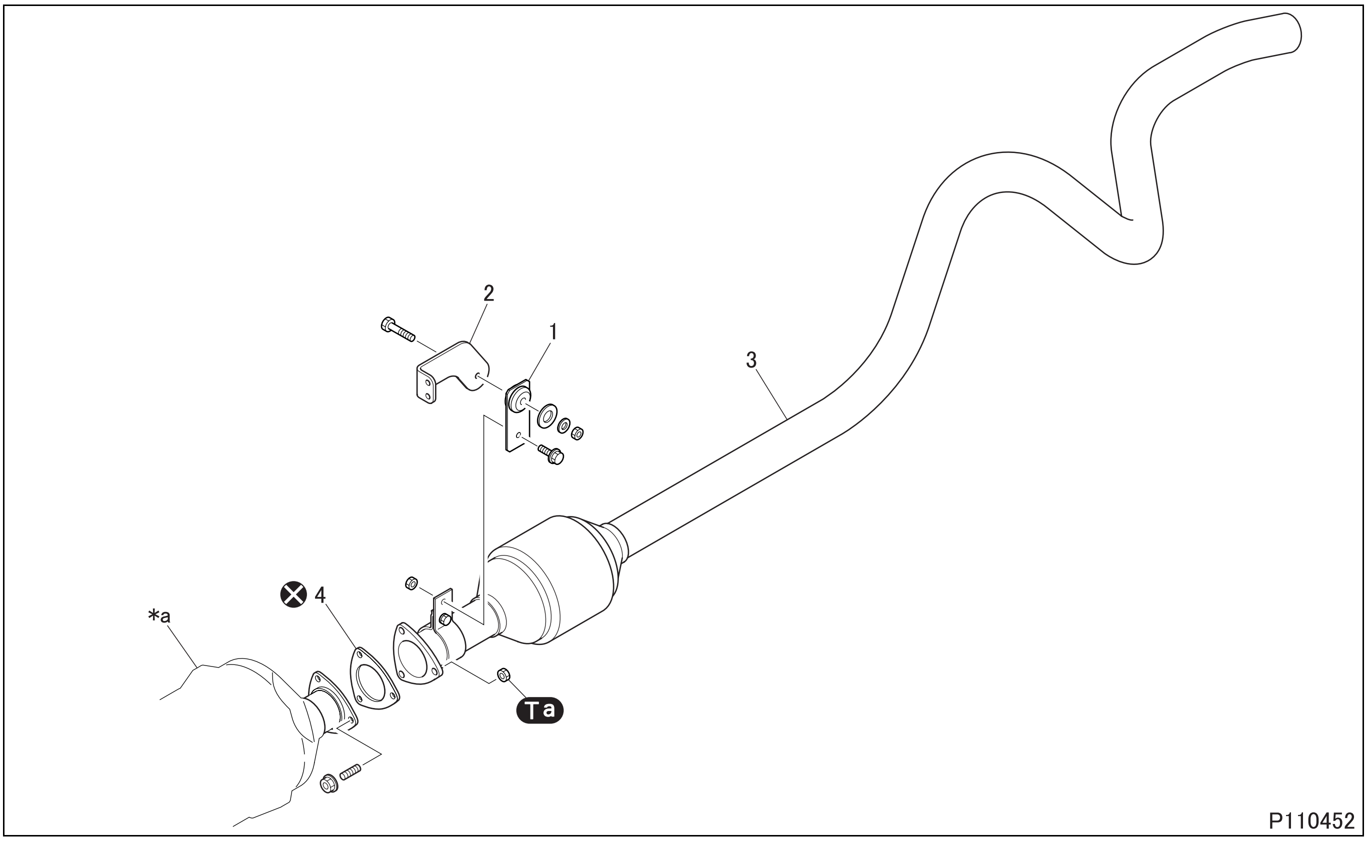
■**Inspection: Outlet body**

- Check the inside the outlet body for adhesion of soot in large quantity.
- If a large amount of soot accumulation is found, perform exhaust gas checks because faulty engine parts are suspected. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

■**Inspection: Filter body**

- Check the ceramic filter for damage from the rear of the filter body.
- If any fault is found, replace the filter body.
- Clean the filter body if the ceramic filter is dirty even if no abnormalities are found. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

REAR OXIDATION CATALYST



● **Removal sequence**

1 Suspender
2 Exhaust hanger
3 Rear oxidation catalyst
4 Gasket

***a**: Diesel particulate filter
***b**: Rear oxidation catalyst
⊗: Non-reusable parts

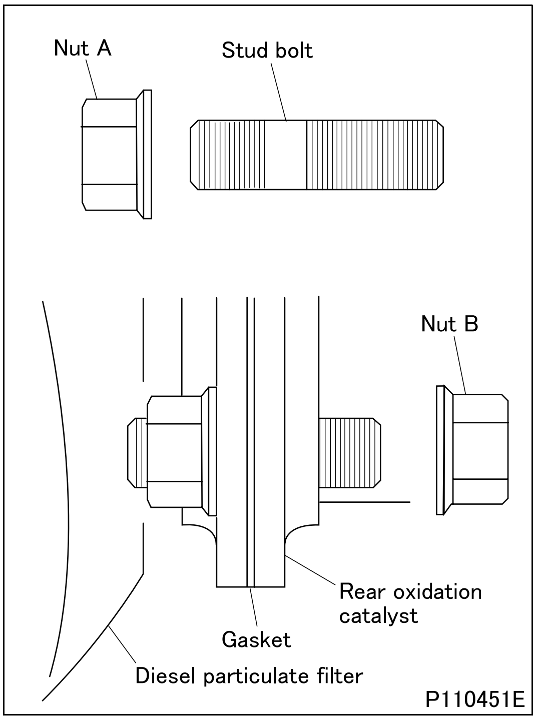
● **Installation sequence**

Follow the removal sequence in reverse.

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Nut (rear oxidation catalyst mounting)	26 to 33 {2.7 to 3.4}	–

◆Installation procedure◆



■ Installation: Rear oxidation catalyst

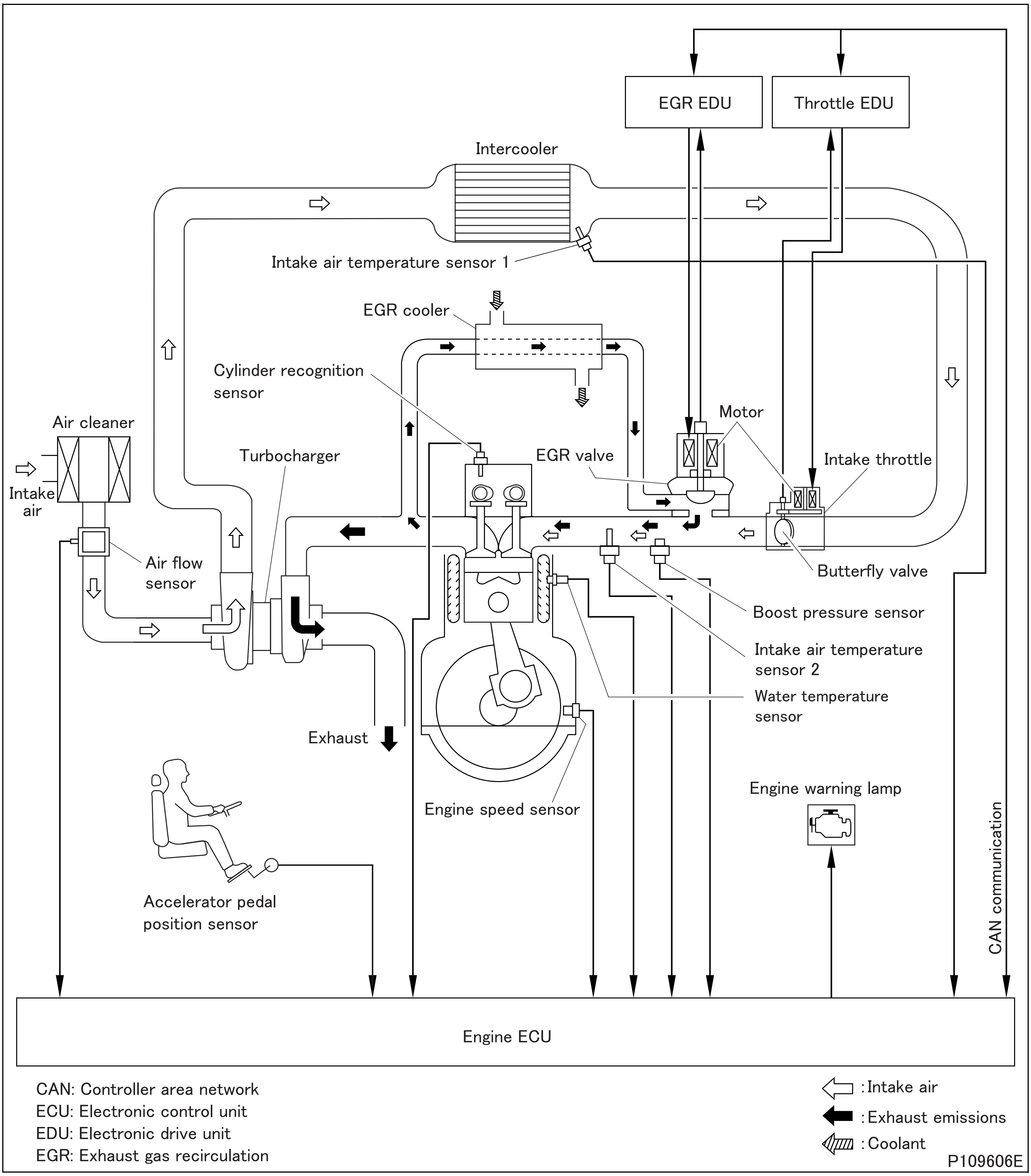
- Screw the nut A onto the shorter threaded side of the stud bolt until it cannot be turned any more.
- Insert the stud bolt with nut A attached into position from the diesel particulate filter side. Fit the gasket and the rear catalyst and tighten the nut B to the specified torque.

GROUP 17 EMISSION CONTROL

1. Exhaust Gas Recirculation System

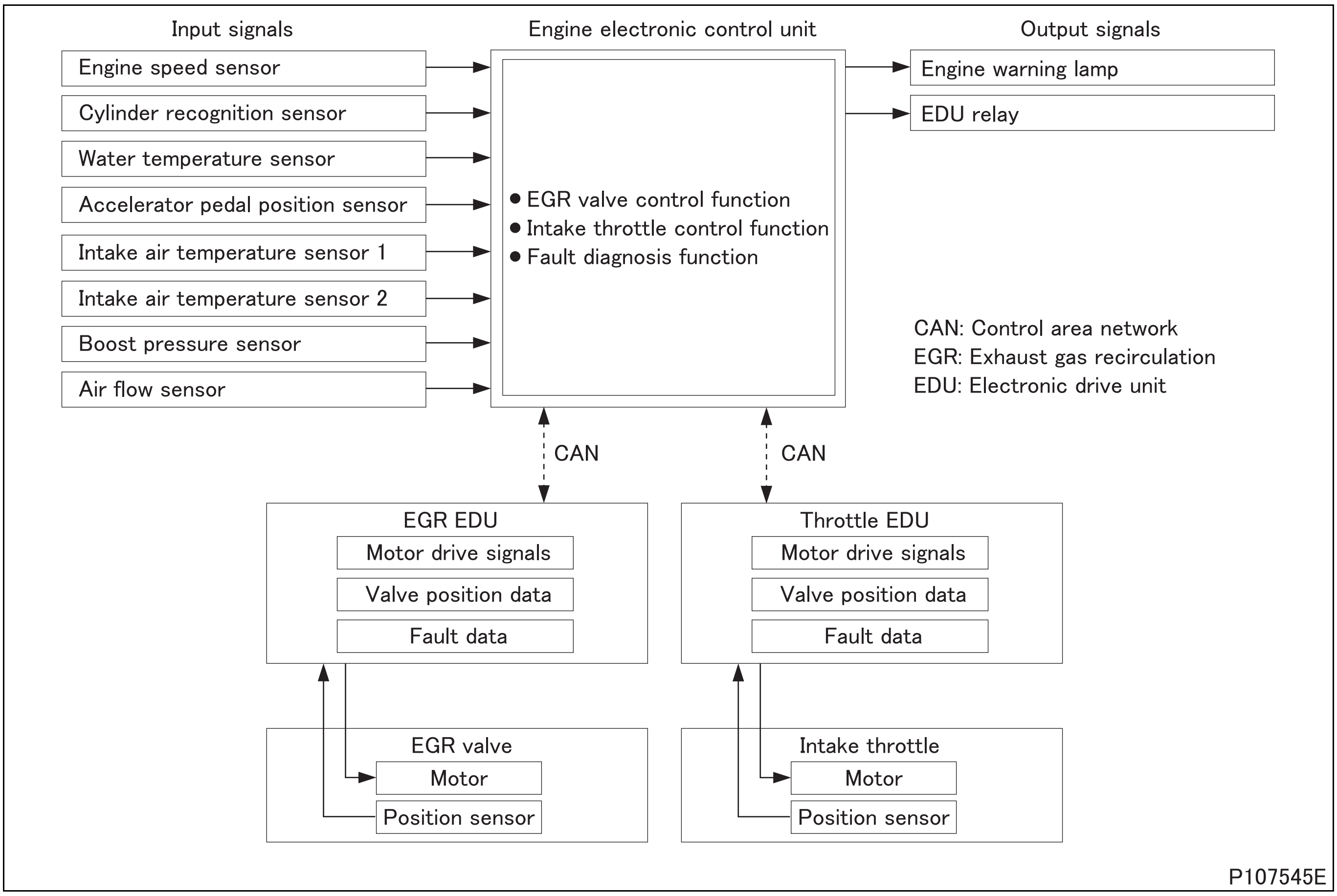
1.1 Overview

- In the exhaust gas recirculation system, the engine electronic control unit and multiple electronic drive units control the exhaust gas recirculation valve and intake throttle in accordance with information from sensors on various aspects of the engine (engine speed, intake air quantity, coolant temperature, throttle opening, etc.).
- Exhaust gas recirculation involves the introduction of inert gases in the post-combustion exhaust emissions into the intake manifold. By reducing the combustion temperature, it reduces the amount of nitrogen oxides (NOx), which are harmful, in the exhaust emissions.
  Further, an exhaust gas recirculation cooler cools the recirculated exhaust emissions, thereby reducing the peak combustion temperature.
- The intake air quantity is adjusted by means of intake throttle control such that the effectiveness of exhaust gas recirculation is maximized.



1.2 Electronic control system

(1) System block diagram

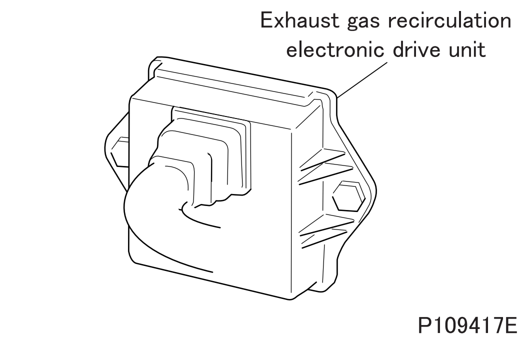


Part	Main function/operation
Engine speed sensor	Sensing of engine speed
Cylinder recognition sensor	Cylinder recognition
Water temperature sensor	Sensing of coolant temperature
Accelerator pedal position sensor	Sensing of extent of accelerator pedal depression
Intake air temperature sensor 1	Sensing of intake air temperature
Intake air temperature sensor 2	Sensing of boost air temperature
Boost pressure sensor	Sensing of boost pressure
Air flow sensor	Sensing of intake air flow rate
Engine warning lamp	Indication of system abnormalities
EDU relay	Switching ON/OFF supply of power to exhaust gas recirculation electronic drive unit, throttle and turbocharger electronic drive unit
CAN communication (EGR EDU, Throttle EDU)	Engine data recognized by the engine electronic control unit are outputted to the CAN bus to enable systems to obtain data that they need for control. Each electronic drive unit issues signals to the engine electronic control unit via the CAN bus to enable it to effect engine control appropriate for each type of system control.

CAN: Controller area network
EGR: Exhaust gas recirculation
EDU: Electronic drive unit

(2) Exhaust gas recirculation valve control function

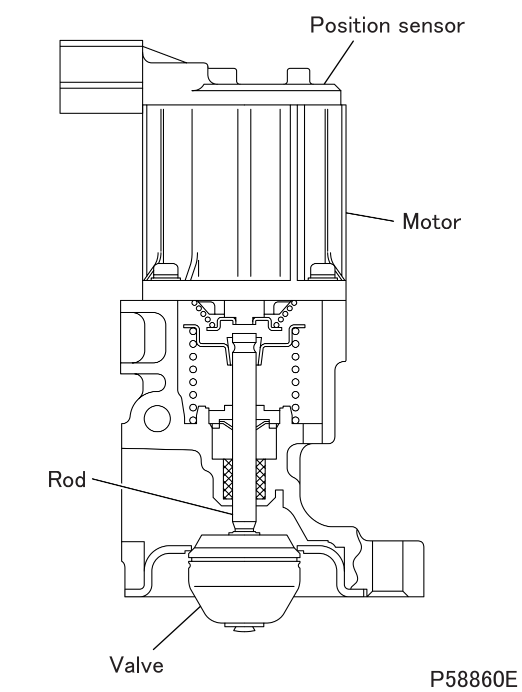
- In accordance with data from sensors, the engine electronic control unit determines the exhaust gas recirculation valve opening that suits the operating condition and sends a control signal (this indicates the target exhaust gas recirculation valve opening) to the exhaust gas recirculation electronic drive unit.
  When necessary to prevent black smoke emissions and engine speed instability (for example, when the engine is heavily loaded, when the engine is lightly loaded, and when the exhaust brake is operating), the engine electronic control unit stops exhaust gas recirculation valve control.



P109417E

(2.1) Exhaust gas recirculation electronic drive unit

- The exhaust gas recirculation electronic drive unit activates the exhaust gas recirculation valve motor. At the same time, it monitors the extent of valve lift using a position sensor and sends this information (this indicates the actual exhaust gas recirculation valve opening) to the engine electronic control unit.
  This operation makes it possible for the target exhaust gas recirculation valve opening indicated by the engine electronic control unit to be precisely maintained.



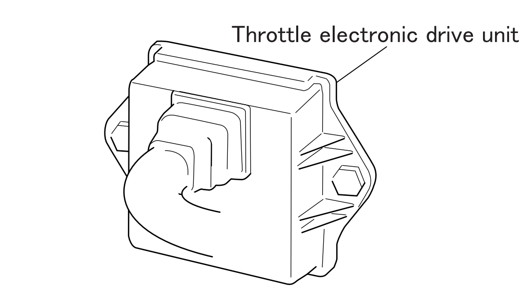
P58860E

(2.2) Exhaust gas recirculation valve

- Exhaust gas recirculation valve is used to mix exhaust gas flowing in the exhaust manifold into intake air flowing in the intake manifold.
- Exhaust gas recirculation valve incorporates a motor to open and close the valve and a position sensor to detect the lift amount of the valve.
- DC motor in the exhaust gas recirculation valve is driven by control signals from the exhaust gas recirculation electronic drive unit. Via a rod, the motor's operation opens and closes the valve.

(3) Intake throttle control function

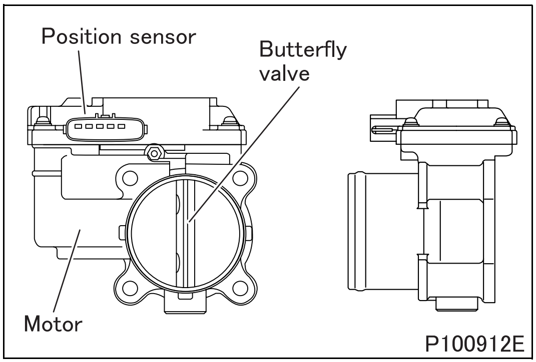
- When the engine electronic control unit determines from sensor data on the engine speed and engine loading that the vacuum pressure in the intake manifold is low, it increases the amount of exhaust emissions introduced into the intake manifold by determining an appropriate butterfly valve opening and by sending corresponding control signals (these indicate the target throttle opening) to the throttle electronic drive unit.



P109418E

(3.1) Throttle electronic drive unit

- The throttle electronic drive unit activates the valve motor. At the same time, it monitors the valve opening using a position sensor and sends this information (this indicates the actual throttle opening) to the engine electronic control unit.
  This operation makes it possible for the target throttle opening indicated by the engine electronic control unit to be precisely maintained.



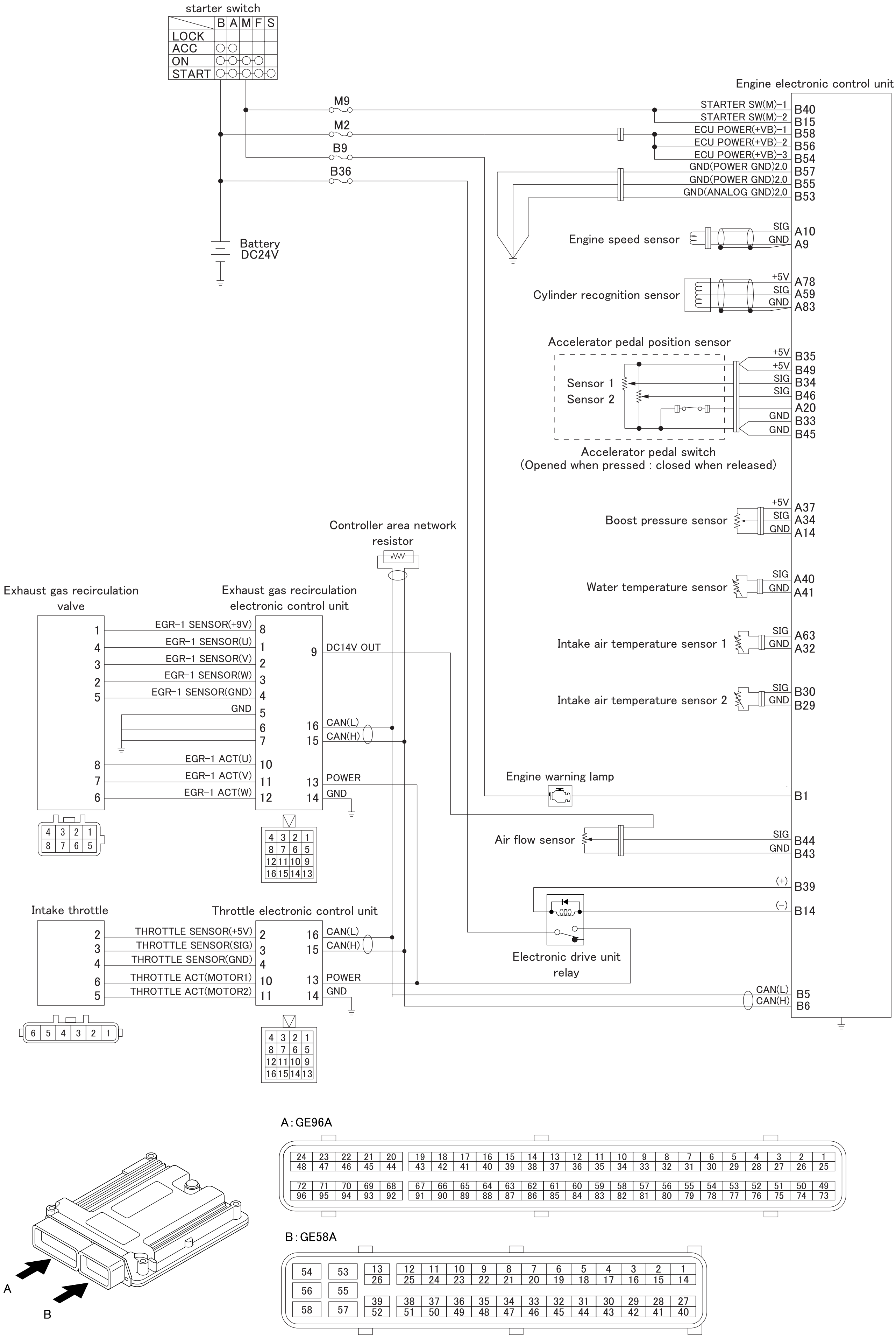
(3.2) Intake throttle

- In accordance with signals from the throttle electronic drive unit, the motor opens and closes the butterfly valve, thereby adjusting the intake air amount such that the effectiveness of exhaust gas recirculation is maximized.

(4) Fault diagnosis function

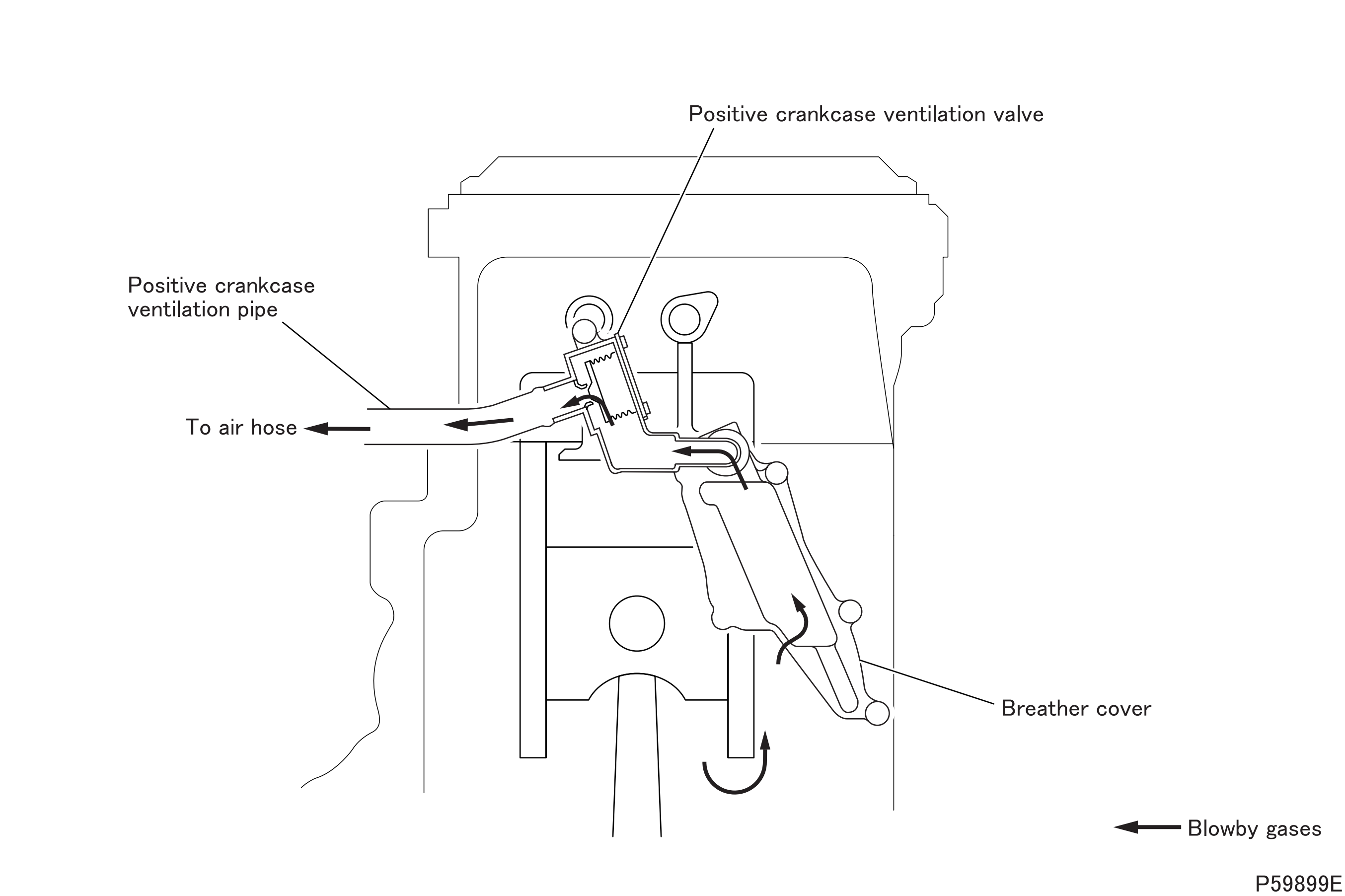
- The engine electronic control unit continuously monitors the electronic drive units and sensors for faults. In the event that the engine electronic control unit finds a component faulty, it causes an indication to be made in the meter cluster to alert the driver. At the same time, it memorizes the fault location in the form of a diagnosis code and starts a control during fault.
- While the engine is running, the exhaust gas recirculation electronic drive unit and throttle electronic drive unit continuously monitor communication with the position sensor and motor of the exhaust gas recirculation valve, communication with the position sensor and motor of the throttle actuator, and communication with the engine electronic control unit. In the event that they identify a fault, they send fault data to the engine electronic control unit.
- While control necessitated by a fault is taking place, the system’s functionality is limited to ensure vehicle and driver safety. It is possible to read the memorized diagnosis code using a Multi-Use Tester or from flashing of the warning lamp. (See Gr00.)

1.3 Electronic control unit connection diagram



P107625E

2. Blowby Gas Return System



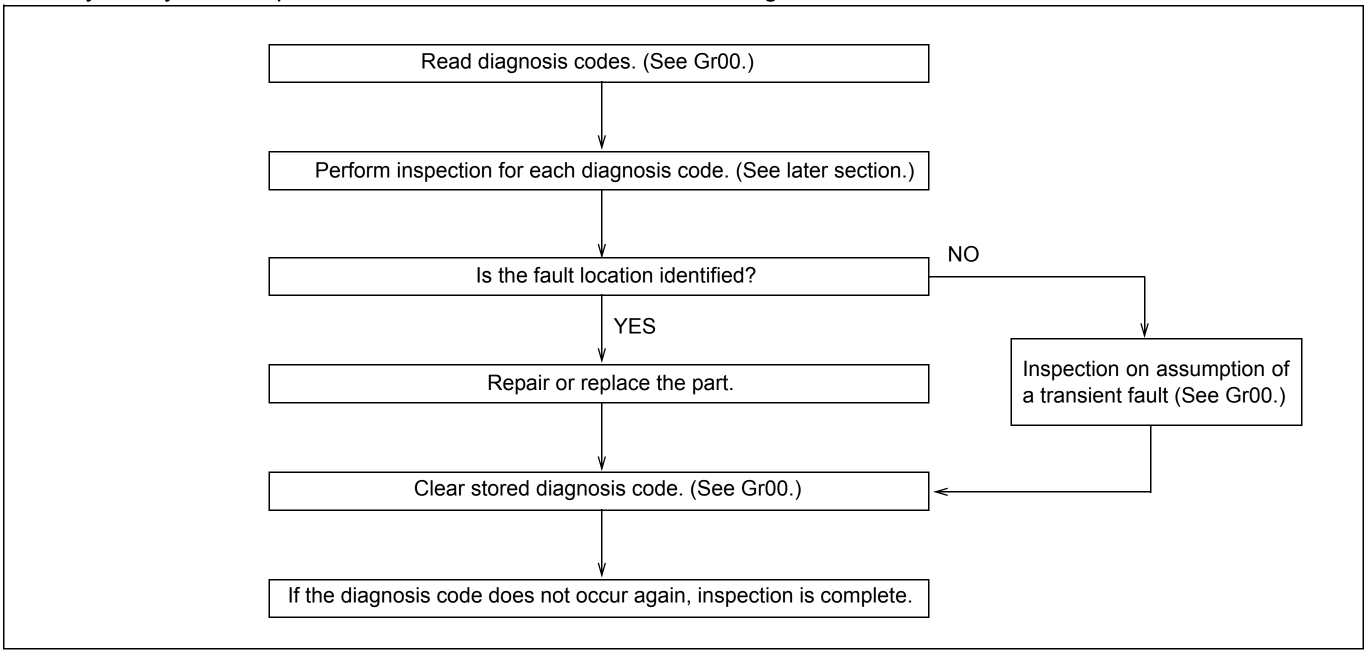
- The crankcase emission control system returns blowby gases to an air hose to prevent them from being released to the outside air.
- The positive crankcase ventilation valve keeps constant the pressure inside the crankcase.

Possible causes \ Symptoms		Excessive black smoke	Excessive white smoke	Abnormal noise or vibration of exhaust system	Overheating (poor cooling)	Exhaust gas recirculation system is abnormal	Reference Gr
Engine output is limited due to faulty exhaust gas recirculation system						O	
Exhaust gas recirculation valve	Exhaust gas recirculation valve improperly mounted			O			
	Exhaust gas recirculation valve malfunction	O				O	
Exhaust gas recirculation cooler	Exhaust gas recirculation cooler improperly mounted			O			
	Defective gasket			O			
	Leakage from exhaust gas recirculation cooler				O		
Exhaust gas recirculation pipe	Exhaust gas recirculation pipe improperly mounted			O			
	Exhaust gas recirculation pipe broken			O			
	Defective gasket			O			
Defective positive crankcase ventilation valve			O				
Leakage from positive crankcase ventilation hose				O			

M E M O

1. Diagnosis Procedure

- Carry out system inspection in accordance with the flow chart given below.



2. Diagnostic Precautions

- Before measuring voltage, check the battery for charged condition and specific gravity. If system inspection is performed with the battery uncharged or reduced in specific gravity, accurate measurements cannot be achieved.
- Before disconnecting battery cables, harnesses and connectors, set the starter switch to LOCK or OFF, then allow at least 20 seconds.
- To avoid having electrical parts damaged, set the starter switch and lighting switch to LOCK or OFF before reconnecting battery cables, harnesses and connectors.
- When performing measurement with the tester, handle the test bar carefully so that it does not damage internal circuit and other electrical parts of the electronic control unit to result in a short-circuit failure between terminals in connector or between connector and car body.
- Resistance is affected by temperature. Determine the necessity of resistance measurement following given temperature specification as a guide. Otherwise, use normal temperature (10 to 35°C) as the measuring condition.
- To start the engine, be sure to connect the connector of the MPROP (rail pressure control valve) to the engine harness. If the engine is started without connecting the MPROP connector, the engine electronic control unit cannot control the supply pump and the fault of the engine may result.
- If the electronic control unit is replaced with a new one, some data must be registered in the new electronic control unit for proper engine control. This also applied to the case when replacing the electronic control unit with the one that has been used in other vehicle. (See Gr13.)

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- The Multi-Use Tester is capable of showing more detailed diagnosis codes.
- The control during fault recovers by servicing the faults. However, for some diagnosis codes, the warning lamp stays illuminated until the normal signals are input for several times.

Code	Message	Warning lamp indication		
		Flashes	Orange	Red
P0097	INT Air Temp Sensor 2 (Low)	9	O	–
P0098	INT Air Temp Sensor 2 (High)	9	O	–
P0102	Airflow Sensor (Low)	17	O	–
P0103	Airflow Sensor (High)	17	O	–
P0112	INT Air Temp SNSR (Low)	44	O	–
P0113	INT Air Temp SNSR (High)	44	O	–
P0226	Throttle Valve Position	28	O	–
P0403	EGR1 (Actuator Circuit)	2	O	–
P0404	EGR System	67	O	–
P0409	EGR1 (Position Sensor)	67	O	–
P0489	EGR Power Supply	67	O	–
P0490	EGR Power Supply	67	O	–
P0685	EDU Relay (Open)	84	O	–
P0686	EDU Relay (Low)	84	O	–
P0687	EDU Relay (High)	84	O	–
P0688	EDU Relay (Over Load)	84	O	–
P1632	CAN (EGR Time Out)	95	O	–
P1635	CAN (Intake Throttle)	96	O	–
P2100	TVA (Open)	28	O	–
P2101	TVA (System)	28	O	–
P2102	TVA (Short)	28	O	–
P2108	TVA (Controller)	96	O	–
P2135	TVA SNSR (Voltage)	28	O	–
P2413	EGR System	67	O	–

3.2 Diagnosis code generation conditions and inspection items

P0097: INT Air Temp Sensor 2 (Low) (warning lamp flashes: 9)

Generation condition		Intake air temperature sensor 2 voltage remains less than 0.15 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Backup value (25°C) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	27: Intake Air Temp SNSR 2 Voltage
	Electronic control unit connector	04 : Intake air temperature sensor 2
	Electrical equipment	#304: Intake air temperature sensor 2
	Electric circuit diagram	Intake air temperature sensor 2 system

P0098: INT Air Temp Sensor 2 (High) (warning lamp flashes: 9)

Generation condition		Intake air temperature sensor 2 voltage remains higher than 4.8 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Backup value (25°C) is used. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	27: Intake Air Temp SNSR 2 Voltage
	Electronic control unit connector	04 : Intake air temperature sensor 2
	Electrical equipment	#304: Intake air temperature sensor 2
	Electric circuit diagram	Intake air temperature sensor 2 system

P0102: Airflow Sensor (Low) (warning lamp flashes: 17)

Generation condition		Airflow sensor voltage remains less than 1.1 V (intake air flow rate: 1.4 g/s) for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Carries out control using a backup value (Fix the intake air flow rate at 8.3 g/s.). • Diesel particulate filter regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	16: Air mass flow
	Electrical equipment	#306: Air flow sensor
	Electric circuit diagram	Air flow sensor system

P0103: Airflow Sensor (High) (warning lamp flashes: 17)

Generation condition		Airflow sensor voltage remains higher than 4.7 V (intake air flow rate: 269.4 g/s) for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Carries out control using a backup value (Fix the intake air flow rate at 8.3 g/s.). • Diesel particulate filter regeneration control is stopped. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	16: Air mass flow
	Electrical equipment	#306: Air flow sensor
	Electric circuit diagram	Air flow sensor system

P0112: INT Air Temp SNSR (Low) (warning lamp flashes: 44)

Generation condition		Intake air temperature sensor 1 voltage remains less than 0.15 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Backup value (25°C) is used.
Inspection	Service data	0D: Intake Air Temperature 1, 28: Intake Air Temp SNSR1 Voltage
	Electronic control unit connector	03 : Intake air temperature sensor 1
	Electrical equipment	#305: Intake air temperature sensor
	Electric circuit diagram	Intake air temperature sensor 1 system

P0113: INT Air Temp SNSR (High) (warning lamp flashes: 44)

Generation condition		Intake air temperature sensor 1 voltage remains higher than 4.87 V for 3 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		Backup value (25°C) is used.
Inspection	Service data	0D: Intake Air Temperature 1, 28: Intake Air Temp SNSR1 Voltage
	Electronic control unit connector	03 : Intake air temperature sensor 1
	Electrical equipment	#305: Intake air temperature sensor
	Electric circuit diagram	Intake air temperature sensor 1 system

P0226: Throttle Valve Position (warning lamp flashes: 28)

Generation condition		Throttle electronic control unit detects abnormality in intake throttle position sensor voltage or in target degree of throttle opening.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Electrical equipment	#306: Air flow sensor
	Electric circuit diagram	Intake throttle system

P0403: EGR 1 (Actuator Circuit) (warning lamp flashes: 2)

Generation condition		Exhaust gas recirculation electronic drive unit has judged that exhaust gas recirculation valve motor was faulty.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	06: EGR Position
	Actuator test	A1: EGR
	Electrical equipment	#530: Exhaust gas recirculation valve
	Electric circuit diagram	Exhaust gas recirculation system

P0404: EGR System (warning lamp flashes: 67)

Generation condition		Exhaust gas recirculation electronic control unit fails in initialization of exhaust gas recirculation valve (initialization takes place each time the engine is started).
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Diesel particulate filter regeneration control is stopped.
Inspection	Service data	06: EGR Position
	Actuator test	A1: EGR
	Electrical equipment	#530: Exhaust gas recirculation valve
	Electric circuit diagram	Exhaust gas recirculation system

P0409: EGR 1 (Position Sensor) (warning lamp flashes: 67)

Generation condition		Exhaust gas recirculation electronic drive unit judges exhaust gas recirculation position sensor faulty.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Exhaust gas recirculation valve control is stopped.
Inspection	Service data	06: EGR Position
	Actuator test	A1: EGR
	Electrical equipment	#530: Exhaust gas recirculation valve
	Electric circuit diagram	Exhaust gas recirculation system

P0489: EGR Power Supply (warning lamp flashes: 67)

Generation condition		Exhaust gas recirculation valve power supply voltage remains less than 13 V for 2 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	1D: Power Supply Voltage
	Electrical equipment	#530: Exhaust gas recirculation valve, #860: Battery
	Electric circuit diagram	Exhaust gas recirculation relay and battery system

P0490: EGR Power Supply (warning lamp flashes: 67)

Generation condition		Exhaust gas recirculation valve power supply voltage remains higher than 35 V for 2 seconds.
Recoverability		System recovers if signal becomes normal with starter switch in ON position for 1 second.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	1D: Power Supply Voltage
	Electrical equipment	#530: Exhaust gas recirculation valve
	Other	Alternator (See Gr54.)

P0685: EDU Relay (Open) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay open-circuited.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Diesel particulate filter regeneration control is stopped. • Throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0686: EDU Relay (Low) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay circuit shorted to ground.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Diesel particulate filter regeneration control is stopped. • Throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0687: EDU Relay (High) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay circuit shorted to power source.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Diesel particulate filter regeneration control is stopped. • Throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P0688: EDU Relay (Over Load) (warning lamp flashes: 84)

Generation condition		Electronic drive unit relay over loaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Diesel particulate filter regeneration control is stopped. • Throttle control is stopped.
Inspection	Service data	89: EDU Power Relay
	Actuator test	AD: EDU Relay
	Electronic control unit connector	02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay
	Electric circuit diagram	Electronic drive unit relay system

P1632: CAN (EGR Time out) (warning lamp flashes: 95)

Generation condition		No controller area network signal from exhaust gas recirculation electronic drive unit is received for 1 second. ※ Diagnosis code P1635, P1645 or U0073 may occur simultaneously (if these diagnosis codes occur at the same time, possibility is high that harness somewhere near engine electronic control unit is faulty)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	06: EGR Position
	Actuator test	A1: EGR, AD: EDU Relay
	Electronic control unit connector	01 : Controller area network resistor, 02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay, #828: Controller area network resistor
	Electric circuit diagram	Controller area network communication between engine electronic control unit and exhaust gas recirculation electronic drive unit, exhaust gas recirculation electronic drive unit power system

P1635: CAN (Intake Throttle) (warning lamp flashes: 96)

Generation condition		No controller area network signals from throttle electronic drive unit are received for 1 second. ※ Diagnosis code P1632, P1645 or U0073 may occur simultaneously (if these diagnosis codes occur at the same time, possibility is high that harness somewhere near engine electronic control unit is faulty)
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Diesel particulate filter regeneration control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Service data	07: Intake Throttle Position
	Actuator test	AD: EDU Relay
	Electronic control unit connector	01 : Controller area network resistor, 02 : Electronic drive unit relay
	Electrical equipment	#201: Electronic drive unit relay, #828: Controller area network resistor
	Electric circuit diagram	Controller area network communication between engine electronic control unit and throttle electronic drive unit, throttle electronic drive unit power system

P2100: TVA (Open) (warning lamp flashes: 28)

Generation condition		When throttle electronic drive unit detects either of the following signals • Throttle electronic drive unit circuit shorted to ground. • Motor coil (inside intake throttle) shorted to ground.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Service data	07: Intake Throttle Position
	Actuator test	A4: Intake Throttle 1
	Electrical equipment	#529: Intake throttle
	Electric circuit diagram	Intake throttle system

P2101: TVA (System) (warning lamp flashes: 28)

Generation condition		When throttle electronic drive unit detects either of the following signals • Intake throttle circuit open-circuited. • Motor coil (inside intake throttle) open-circuited or overloaded.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Service data	07: Intake Throttle Position
	Actuator test	A4: Intake Throttle 1
	Electrical equipment	#529: Intake throttle
	Electric circuit diagram	Intake throttle system

P2102: TVA (Short) (warning lamp flashes: 28)

Generation condition		When throttle electronic drive unit detects either of the following signals • Intake throttle circuit shorted to power supply. • Motor coil (inside intake throttle) shorted.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Service data	07: Intake Throttle Position
	Actuator test	A4: Intake Throttle 1
	Electrical equipment	#529: Intake throttle
	Electric circuit diagram	Intake throttle system

P2108: TVA (Controller) (warning lamp flashes: 96)

Generation condition		When throttle electronic drive unit detects either of the following signals • Intake throttle circuit shorted to power supply. • Motor coil (inside intake throttle) shorted.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control is stopped. • Actuator tests “A4: Intake Throttle 1” is stopped.
Inspection	Service data	07: Intake Throttle Position
	Electrical equipment	#529: Intake throttle
	Electric circuit diagram	Intake throttle system

P2135: TVA SNSR (Voltage) (warning lamp flashes: 28)

Generation condition		Throttle electronic drive unit judges throttle position sensor power abnormal.
Recoverability		System recovers if any valid signal is input when starter switch is turned from OFF to ON (the warning lamp does not go out unless 3 consecutive valid signals are input).
Control effected by electronic control unit		• Injection quantity is limited. • Exhaust gas recirculation valve control is stopped. • Throttle control is stopped.
Inspection	Service data	07: Intake Throttle Position
	Actuator test	A4: Intake Throttle 1
	Electrical equipment	#529: Intake throttle
	Electric circuit diagram	Intake throttle system

P2413: EGR System (warning lamp flashes: 67)

Generation condition		When either of the following signals is received from exhaust gas recirculation electronic drive unit for 2 seconds • Target exhaust gas recirculation valve opening calculated by engine electronic control unit deviates from the specified limit. • No target valve opening signal is sent from engine electronic control unit.
Recoverability		System recovers if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		• Exhaust gas recirculation valve control is stopped. • Throttle control valve is stopped.
Inspection	Service data	06: EGR Position
	Actuator test	A1: EGR
	Electrical equipment	#530: Exhaust gas recirculation valve
	Electric circuit diagram	Exhaust gas recirculation system

4. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
06	EGR Position	■■■.■ %	Idling	0%
07	Intake Throttle Position	■■■.■ %	Idling	90%
0D	Intake Air Temperature 1	■■■.■ °C	On a cold engine	Equal to ambient temperature
0E	Intake Air Temperature 2	■■■.■ °C	On a cold engine	Equal to ambient temperature
16	Air mass flow	■■■.■ g/s	Accelerator pedal is pressed gradually.	Flow rate to be increased accordingly
1D	Power Supply Voltage	■■.■■ V	Starter switch ON	Value matches battery voltage
27	Intake Air Temp SNSR2 Voltage	■■■.■ mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
28	Intake Air Temp SNSR1 Voltage	■■■.■ mV	Sensor circuit open-circuited or shorted to power supply	Approx. 5000 mV
			Sensor circuit shorted to ground	Approx. 0 mV
89	EDU Power Relay	ON/OFF	Starter switch ON	ON
			Starter switch OFF	OFF
		[Actuator test] Ac: EDU relay		

5. Actuator Tests Performed Using Multi-Use Tester

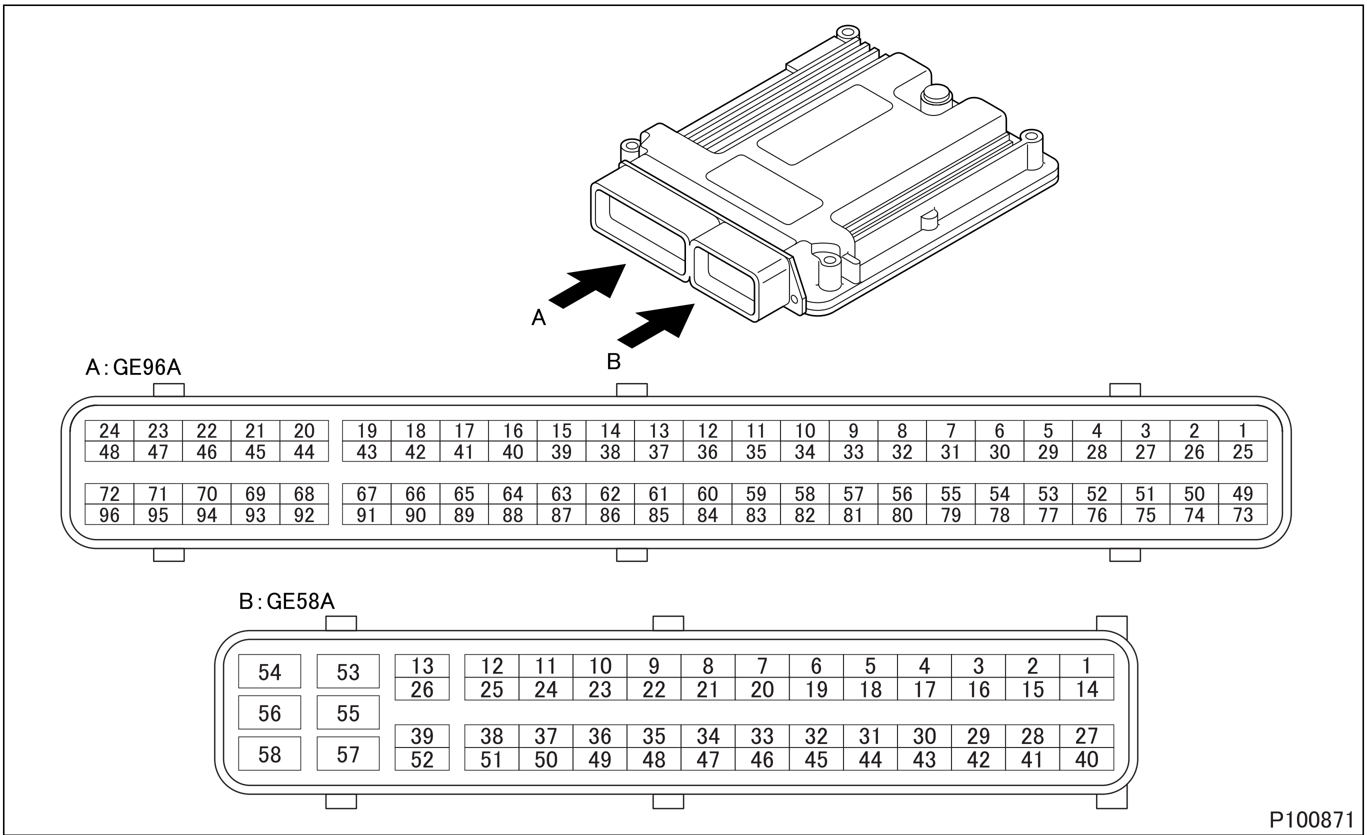
- It is possible to see service data and actuator tests simultaneously.

No.	Item	Explanation	Confirmation method
A1	EGR	Maintain exhaust gas recirculation valve opening indicated by Multi-Use Tester during engine operation. [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON (engine started) • Transmission: neutral • Diagnosis switch: OFF (with fuse removed)	Check that the EGR valve opening is changed.
A4	Intake Throttle 1	Maintain intake throttle opening indicated by Multi-Use Tester during engine operation. [Can be executed when the following conditions are satisfied] • Vehicle: stationary (vehicle speed 0 km/h) • Starter switch: ON (engine started) • Transmission: neutral • Diagnosis switch: OFF (with fuse removed)	Check that the throttle opening is changed.
Ac	EDU Relay	Electronic drive unit relay drive signal (Errors related to exhaust gas recirculation and to the intake throttle can be detected when this actuator test is executed.)	Operating sound of relay [Service data] 89: EDU Power Relay

6. Inspections Performed at Electronic Control Unit Connectors

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

6.1 Electronic control unit connector terminal layout



6.2 Inspection instructions

- Some inspections are performed with the connectors removed. Others are performed with the connectors fitted.

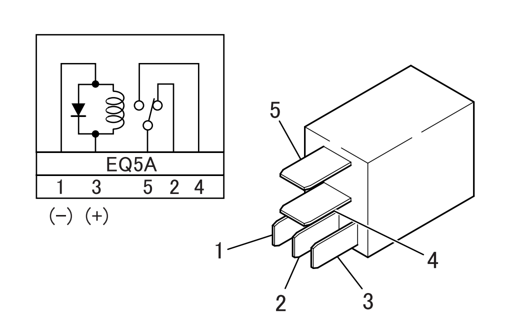
CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

Check item	Measurement method
01 Resistance of controller area network resistor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B5-B6 • 120 ± 6 Ω
02 Voltage of electronic drive unit relay	[Conditions] • Starter switch ON • Vehicle-side harness connected (Perform inspection on back of connector.) [Requirements] Terminals (+)-(–): B39-B14 • With relay operating: Corresponding to battery voltage • With relay not operating: 0 V

03 Resistance of intake air temperature sensor 1	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: A63-A32 • 0°C: $15^{+3.78}_{-2.94}$ kΩ • 20°C: $6.514^{+1.437}_{-1.147}$ kΩ • 80°C: $0.874^{+0.136}_{-0.115}$ kΩ
04 Resistance of intake air temperature sensor 2	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals: B29-B30 • 0°C: $162.3^{+48.8}_{-36.5}$ kΩ • 20°C: $61.47^{+15.99}_{-12.35}$ kΩ • 80°C: $6.120^{+1.095}_{-0.907}$ kΩ

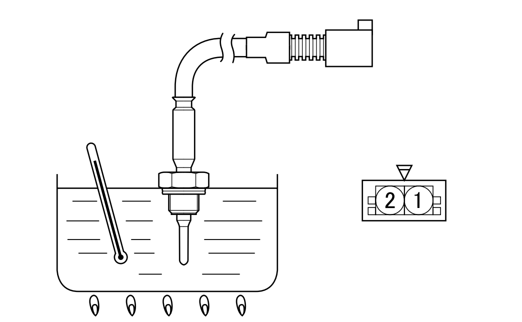
7. Inspection of Electrical Equipment



P46605

#201 Inspection of relay (normally open, 5 pins)

- Perform a continuity check and an operation check. If there is any abnormality, replace the relay.



P57213

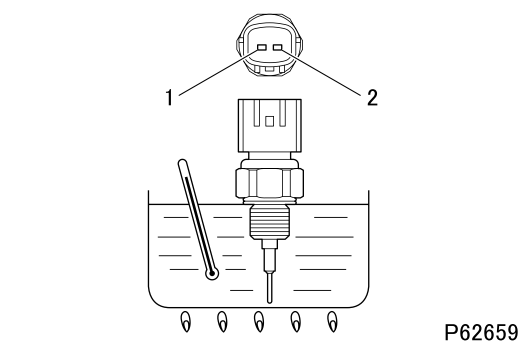
#305 Inspection of air temperature sensor

<Intake air temperature sensor 1>

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

Standard value	0°C	$15^{+3.78}_{-2.94}$ kΩ
	20°C	$6.514^{+1.437}_{-1.147}$ kΩ
	80°C	$0.874^{+0.136}_{-0.115}$ kΩ

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



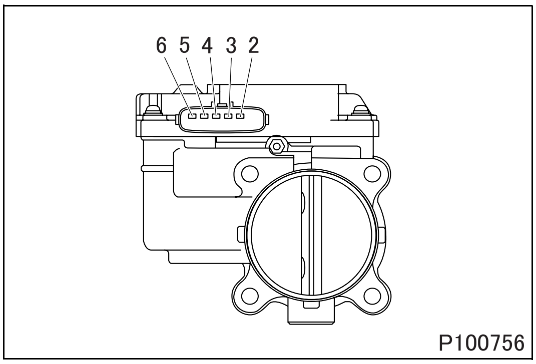
P62659

<Intake air temperature sensor 2>

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

Standard value	0°C	$162.3^{+48.5}_{-36.5}$ kΩ
	20°C	$61.47^{+15.99}_{-12.35}$ kΩ
	80°C	$6.120^{+1.095}_{-0.907}$ kΩ

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



#529 Inspection of intake throttle

- Perform the following checks. If there is any abnormality, replace the intake throttle.

(1) Coil resistance of motor

- Measure the resistance between terminals 5 and 6.

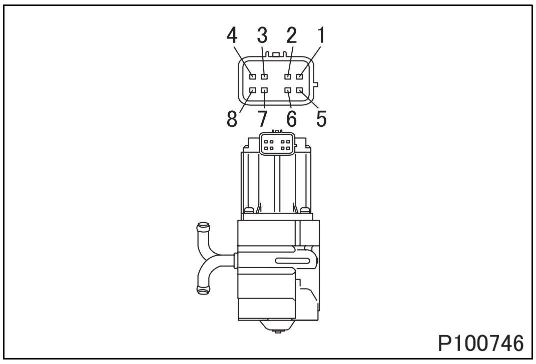
Standard value	0.3 to 80 Ω

NOTE

- **If the measurement deviates from the standard value, measure the resistance again after manually opening and closing the butterfly valve 5 times.**

(2) Position sensor

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



#530 Inspection of exhaust gas recirculation valve

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

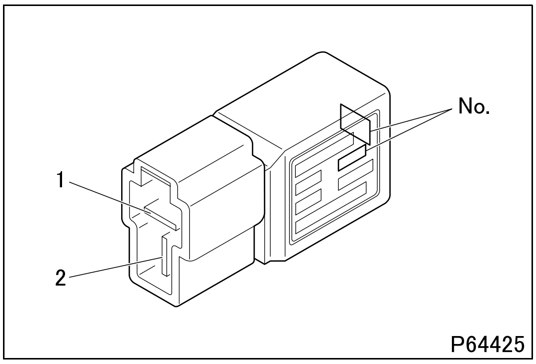
(1) Coil resistance of motor

- Measure the resistance between terminals 8 and 7, the resistance between terminals 8 and 6, and the resistance between terminals 7 and 6.

Standard value	11.3 ± 1.5 Ω

(2) Position sensor

- The sensor cannot easily be inspected in isolation, so you must evaluate it indirectly by inspection of system harness and related parts.
- If there is no abnormality in any related part but the system is abnormal, replace the exhaust gas recirculation valve.



#828 Inspection of controller area network resistor

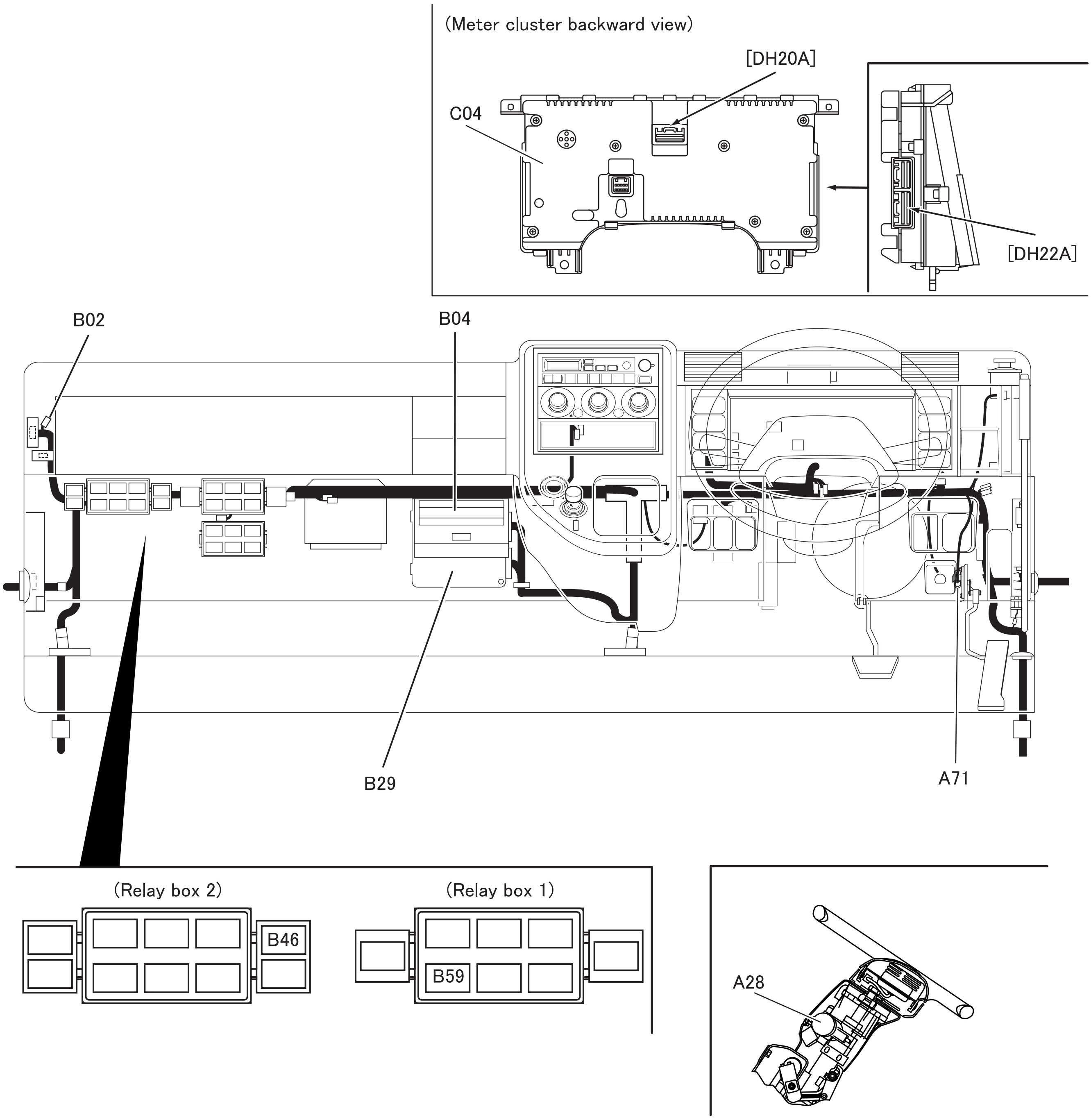
- Measure the resistance between terminals 1 and 2.

Standard value (at 20°C)	120 ± 6 Ω

- If the measurement is out of specification, replace the controller area network resistor.

8. Installed Locations of Parts

A28–71	B02–59	C04



A28	Starter switch	
A71	Accelerator pedal position sensor	
B02	CAN resistor	
B04	Fuse box	
B29	Engine ECU	
B46	Starter power supply cut relay	
B59	Safety relay	
C04	Meter cluster	

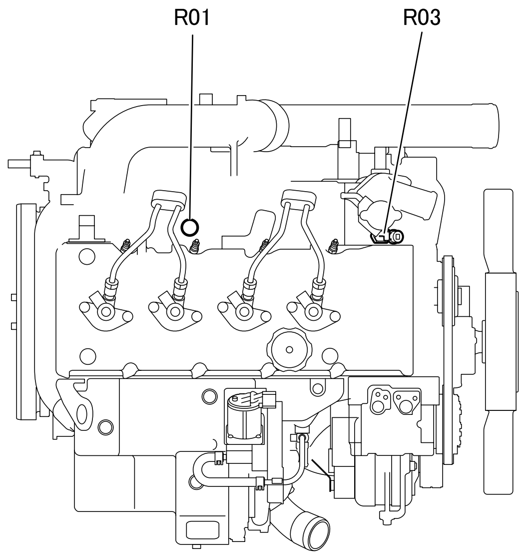
ECU : Electronic control unit
EDU : Electronic drive unit
CAN : Control area network

Indicate by connector type [ ].

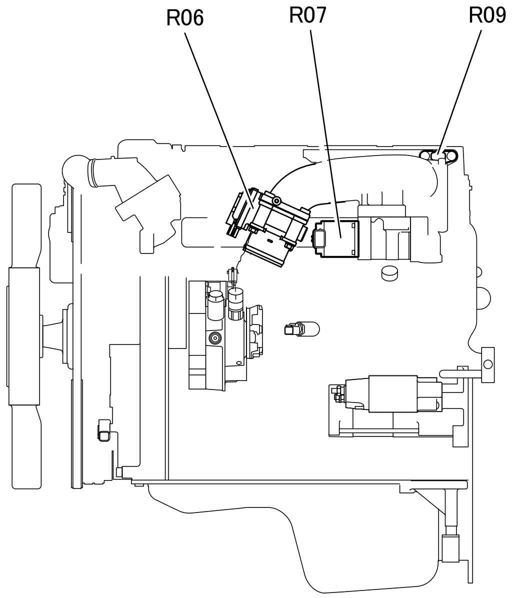
17–L04675

R01–09	S05

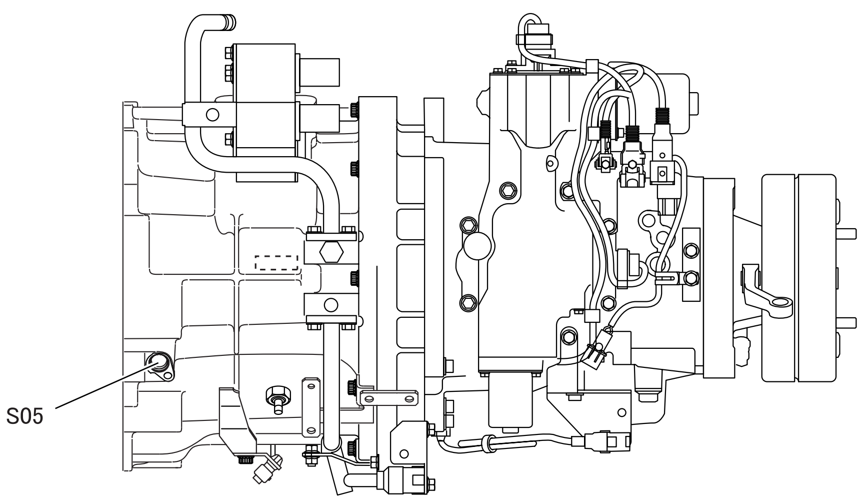
(Upper view)



(Left side view)



(Upper view)



R01 Boost air temperature sensor
R03 Water temperature sensor
R06 Throttle actuator
R07 EGR valve
R09 Boost pressure sensor

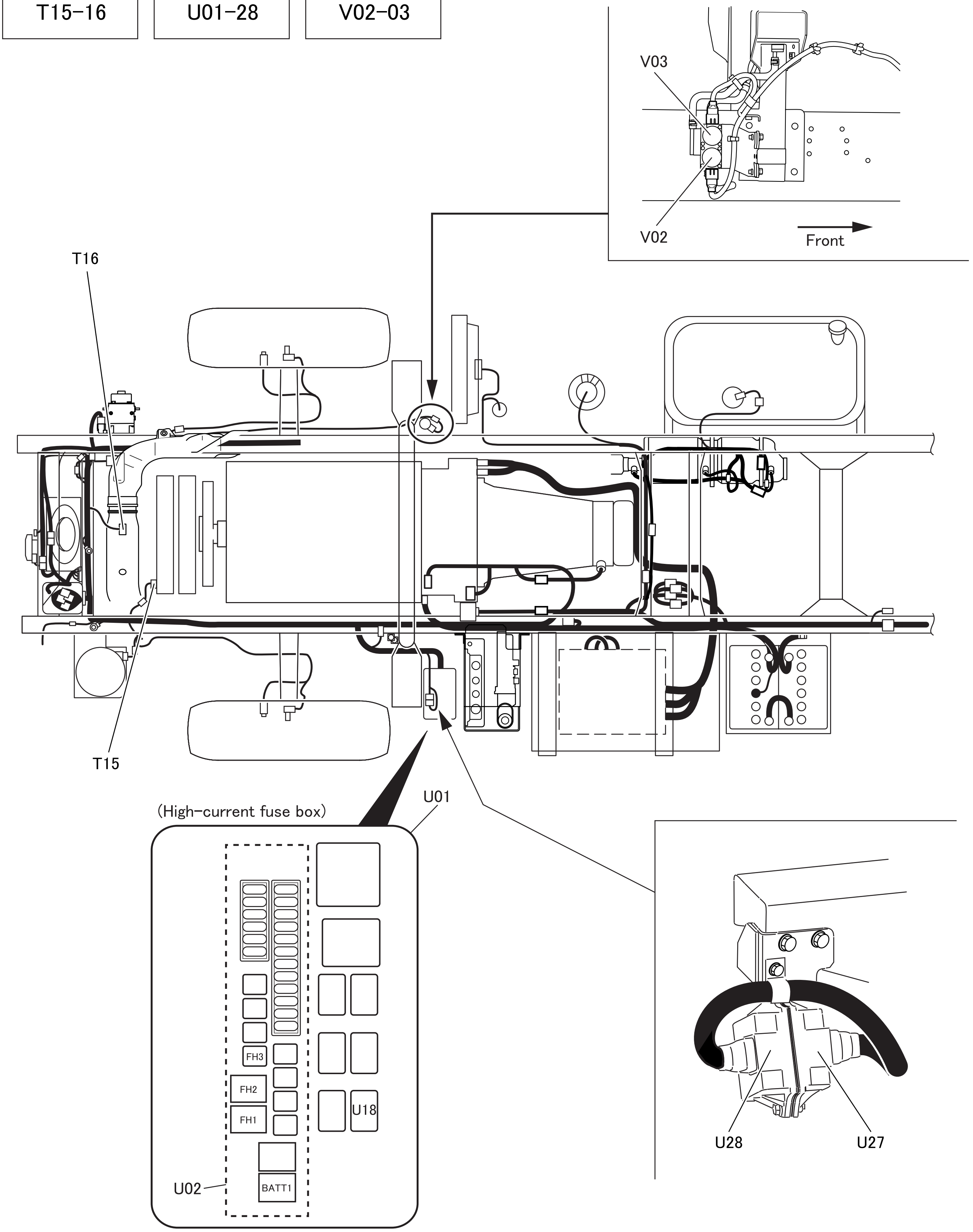
S05 Engine speed sensor

EGR : Exhaust gas recirculation

17–L04676

EXHAUST GAS RECIRCULATION SYSTEM

T15–16	U01–28	V02–03

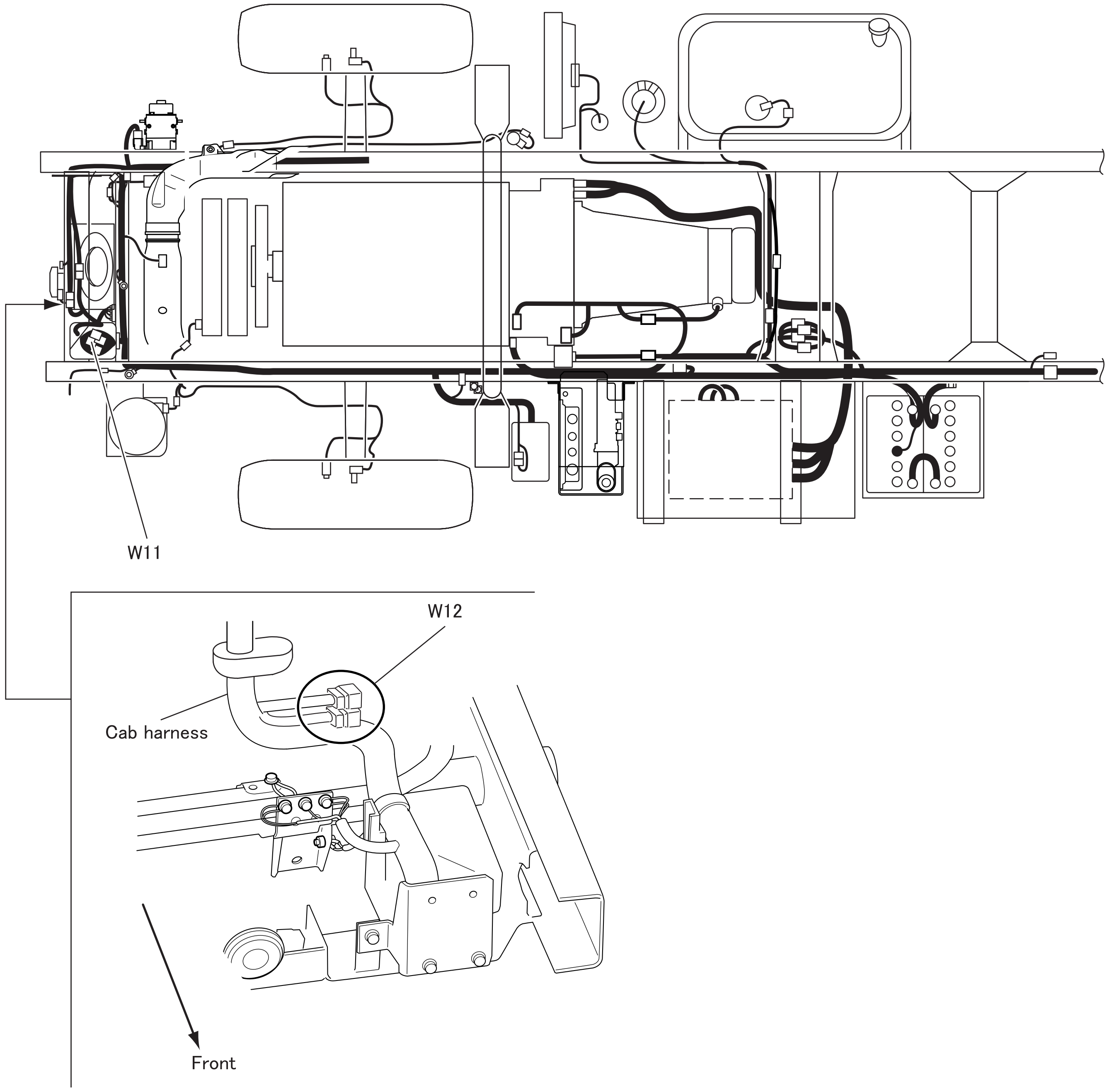


T15	Intake air temperature sensor 1	U01	High-current fuse box	V02	Exhaust shutter 3-way magnetic valve 1
T16	Air flow sensor	U02	High-current fuse, fuse	V03	Exhaust shutter 3-way magnetic valve 2
		U18	EDU reray		
		U27	EGR EDU		
		U28	Throttle EDU		

EDU : Electronic drive unit
EGR : Exhaust gas recirculation

17–L04677

W11-12

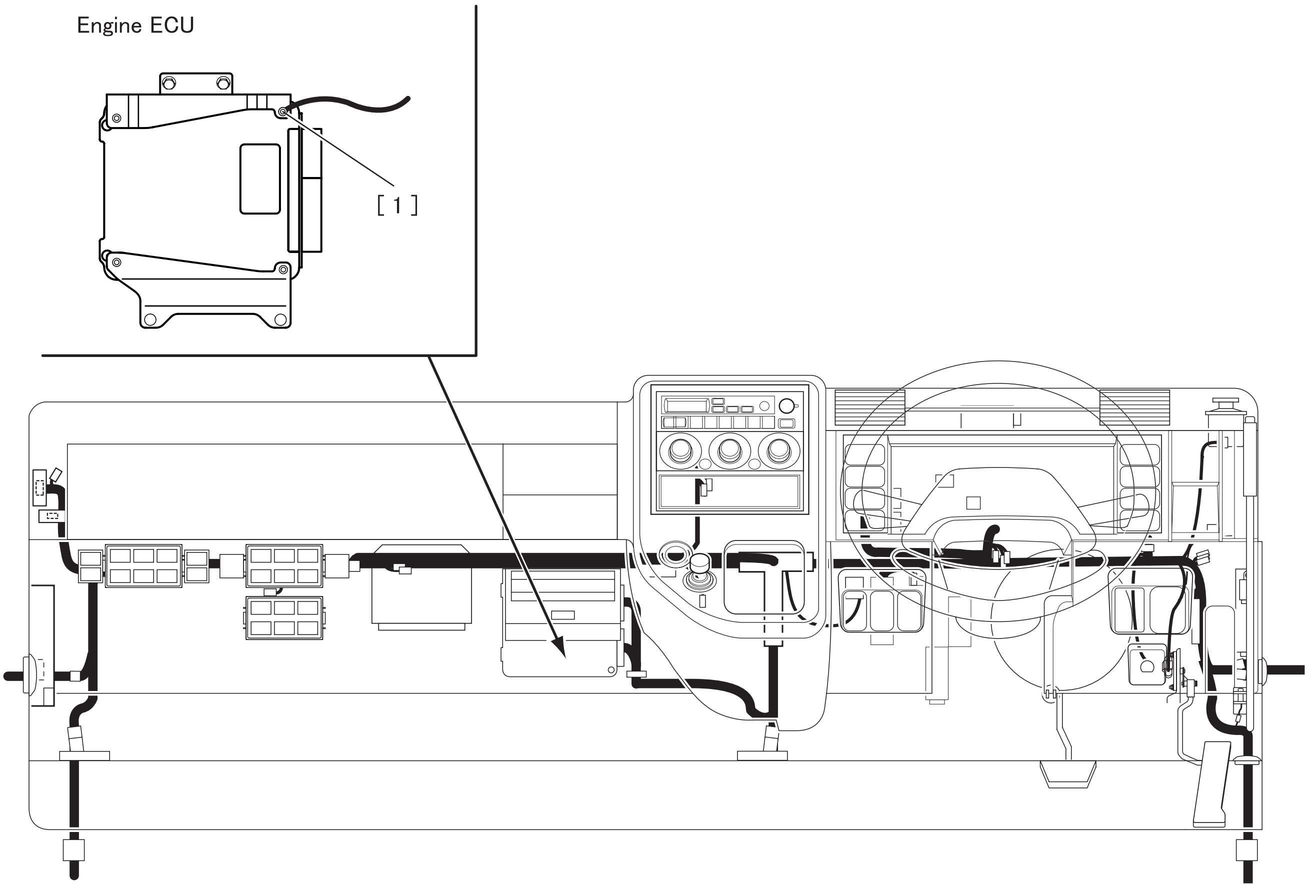


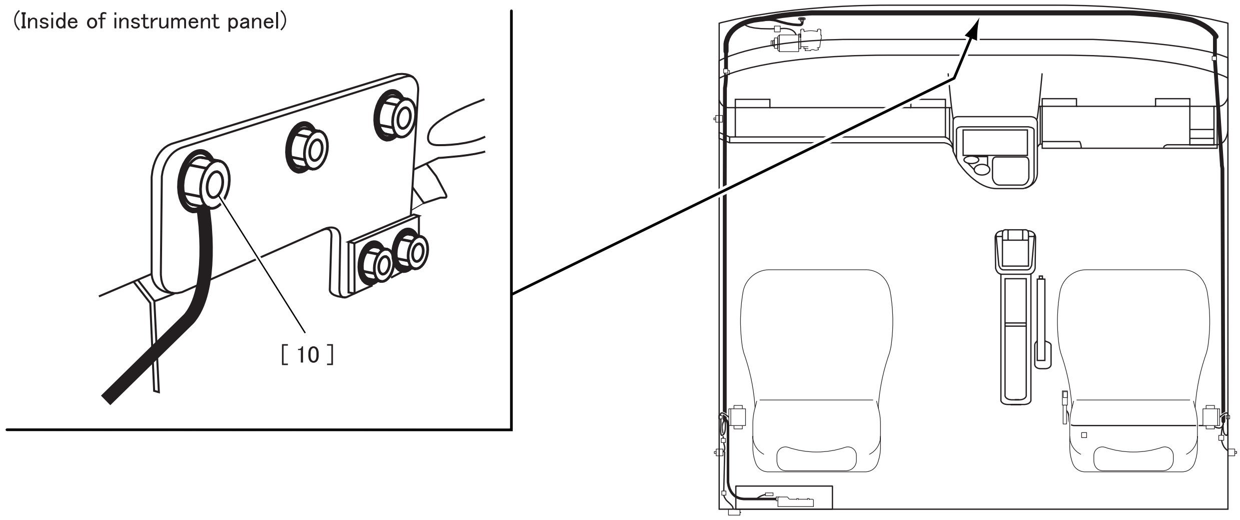
W11 Connection of cab harness and chassis harness (in connector box)
W12 Connection of cab harness and engine harness

17-L04678

EXHAUST GAS RECIRCULATION SYSTEM

[1]–[10]	Cab ground



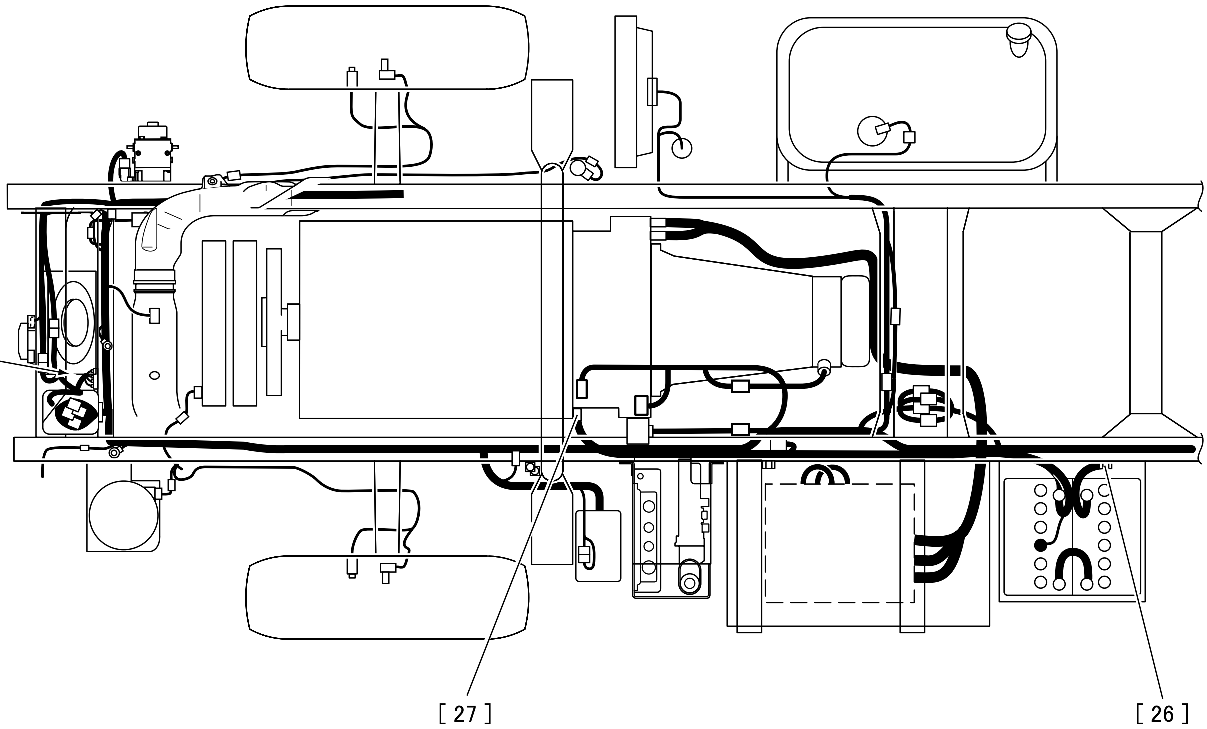


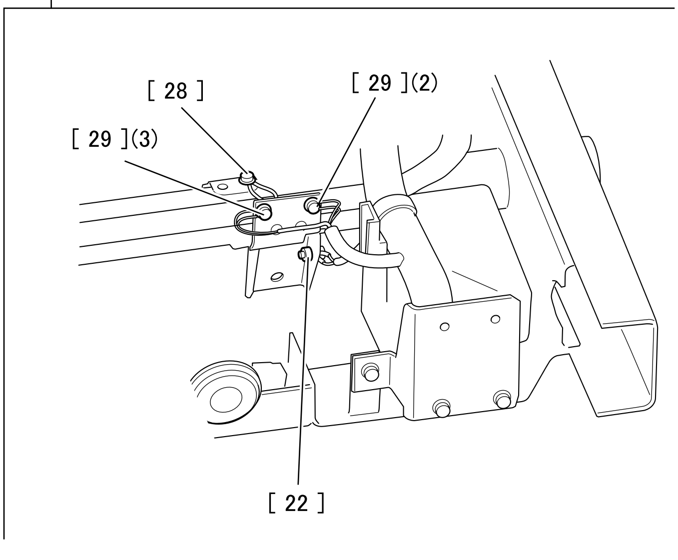
[1] Ground
[10] Ground

ECU : Electronic control unit

17–L04679

[22]–[29] Chassis ground

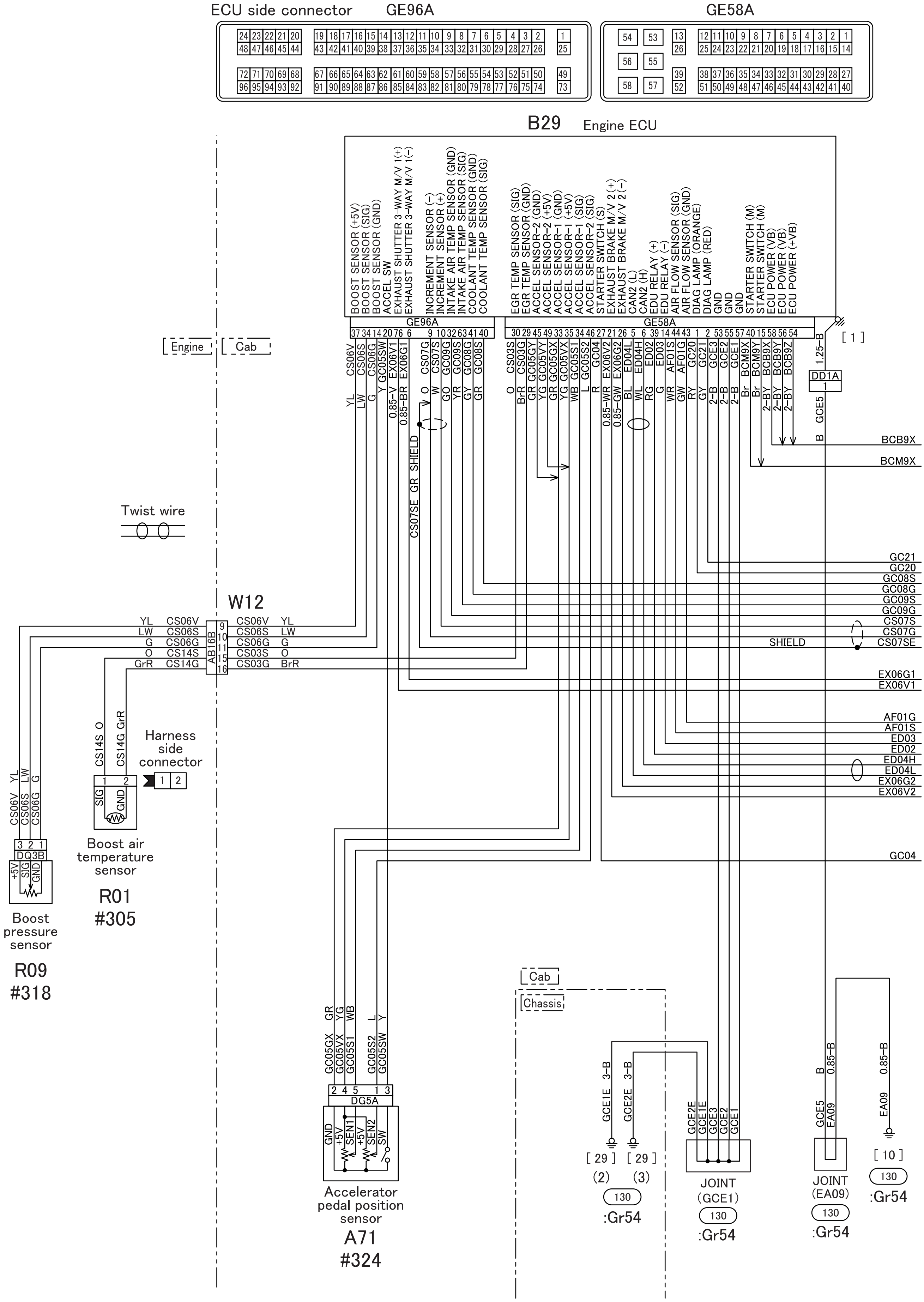




[22] Ground
[26] Ground
[27] Ground
[28] Ground
[29](2) Ground
[29](3) Ground

17–L04680

9. Electric Circuit Diagram



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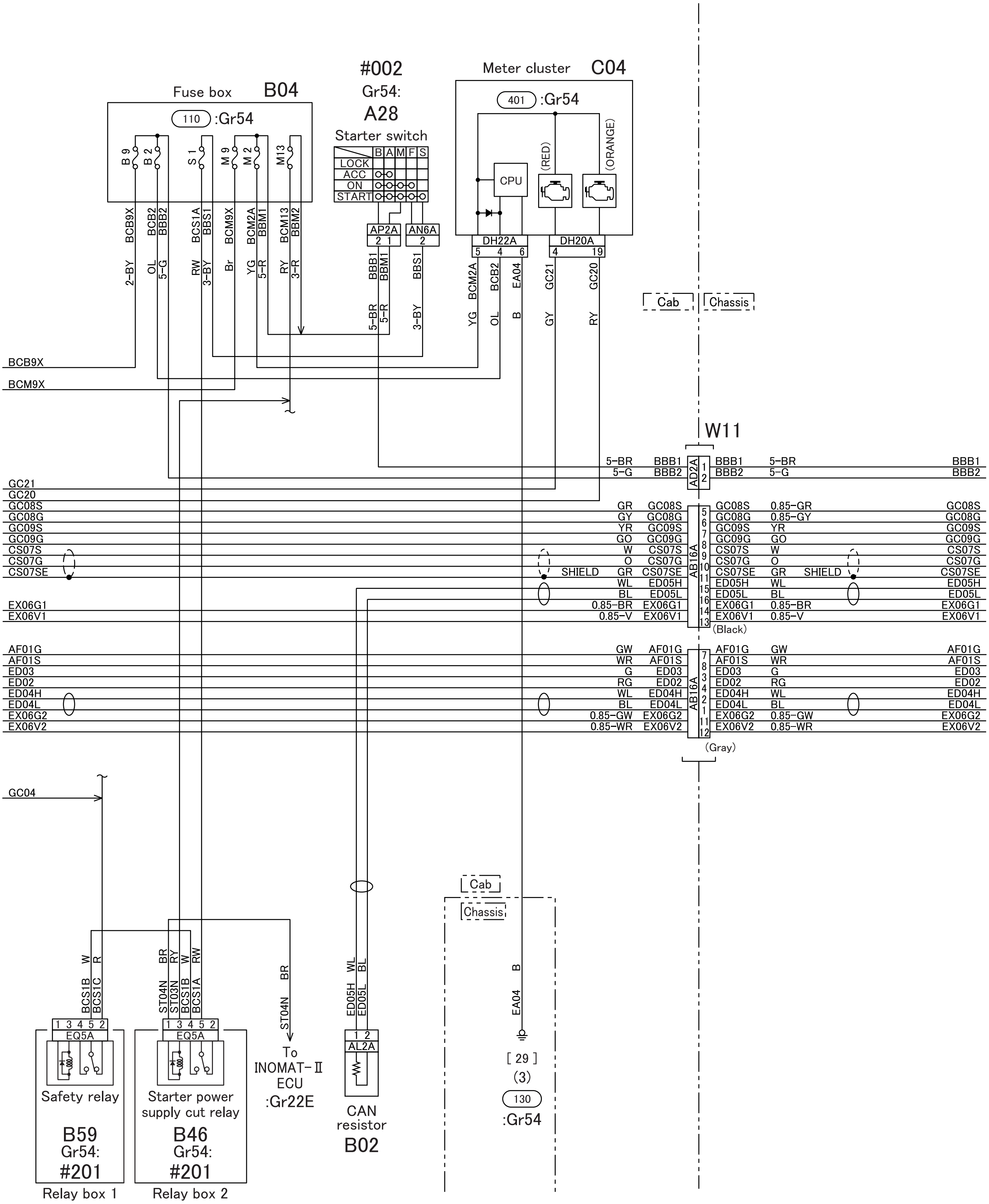
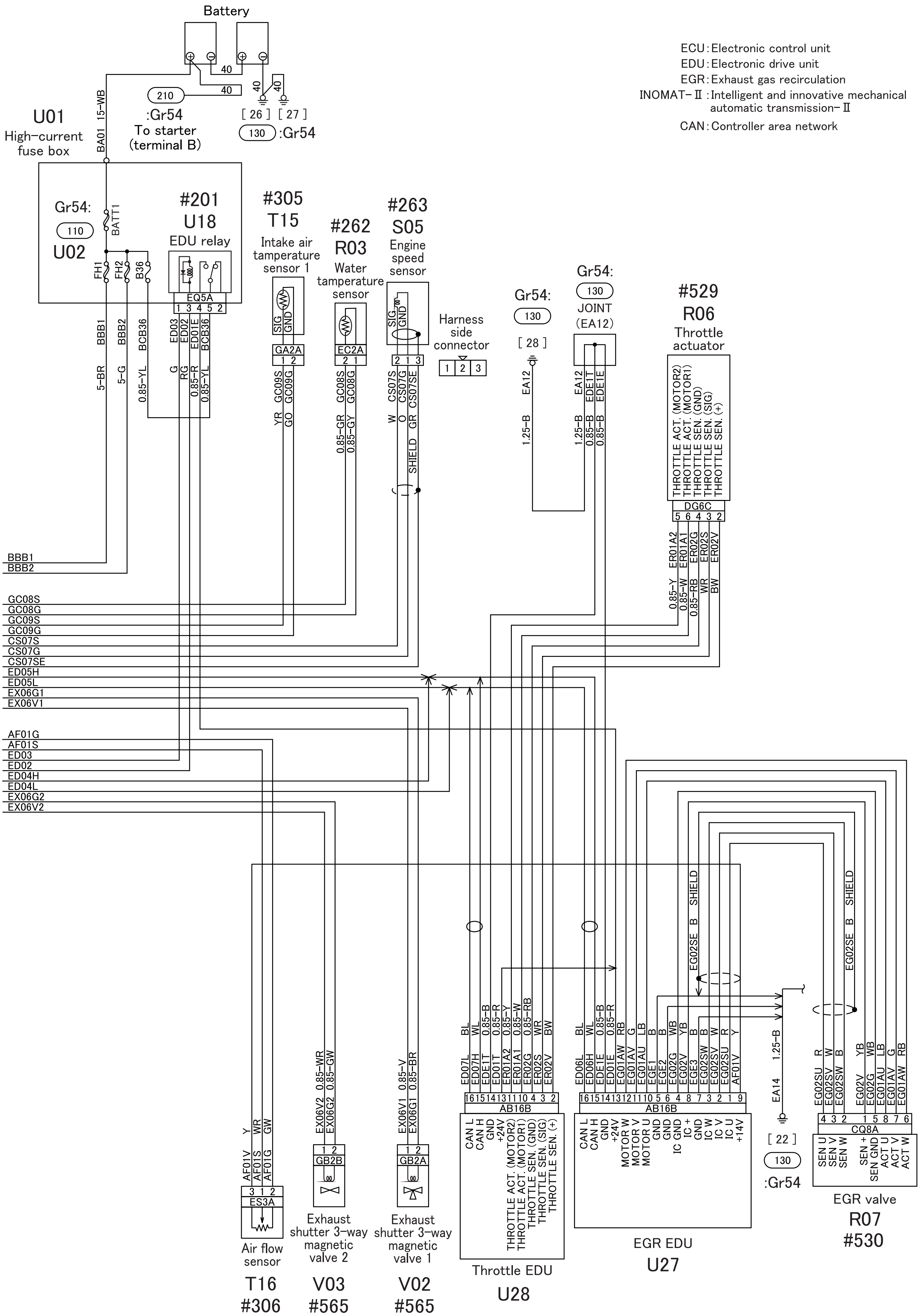

Fuse box B04
110 :Gr54
B 9
B 2
S 1
M 9
M 2
M13
BCB9X
BCB2
BBB2
BCS1A
BBS1
BCM9X
BCM2A
BBM1
BCM13
BBM2
2-BY
OL
5-G
RW
3-BY
Br
YG
5-R
RY
3-R
#002
Gr54:
A28
Starter switch
B A M F S
LOCK
ACC
ON
START
AP2A
2 1
AN6A
2
BBB1
BBM1
BBS1
5-BR
5-R
3-BY
Meter cluster C04
401 :Gr54
CPU
(RED)
(ORANGE)
DH22A
5 4 6
DH20A
4 19
BCM2A
BCB2
EA04
GC21
GC20
YG
OL
B
GY
RY
Cab
Chassis
BCB9X
BCM9X
W11
5-BR BBB1 AD2A 1 BBB1 5-BR BBB1
5-G BBB2 2 BBB2 5-G BBB2
GC21
GC20
GC08S
GC08G
GC09S
GC09G
CS07S
CS07G
CS07SE
EX06G1
EX06V1
GR GC08S 5 GC08S 0.85-GR GC08S
GY GC08G 6 GC08G 0.85-GY GC08G
YR GC09S 7 GC09S YR GC09S
GO GC09G 8 GC09G GO GC09G
W CS07S 9 CS07S W CS07S
O CS07G 10 CS07G O CS07G
SHIELD GR CS07SE 11 CS07SE GR SHIELD CS07SE
WL ED05H 15 ED05H WL ED05H
BL ED05L 16 ED05L BL ED05L
0.85-BR EX06G1 14 EX06G1 0.85-BR EX06G1
0.85-V EX06V1 13 EX06V1 0.85-V EX06V1
AB16A
(Black)
AF01G
AF01S
ED03
ED02
ED04H
ED04L
EX06G2
EX06V2
GW AF01G 7 AF01G GW AF01G
WR AF01S 8 AF01S WR AF01S
G ED03 3 ED03 G ED03
RG ED02 4 ED02 RG ED02
WL ED04H 2 ED04H WL ED04H
BL ED04L 1 ED04L BL ED04L
0.85-GW EX06G2 11 EX06G2 0.85-GW EX06G2
0.85-WR EX06V2 12 EX06V2 0.85-WR EX06V2
AB16A
(Gray)
GC04
W R
BCS1B BCS1C
1 3 4 5 2
EQ5A
Safety relay
B59
Gr54:
#201
Relay box 1
BR RY W RW
ST04N ST03N BCS1B BCS1A
1 3 4 5 2
EQ5A
Starter power supply cut relay
B46
Gr54:
#201
Relay box 2
BR
ST04N
To INOMAT-Ⅱ ECU :Gr22E
WL BL
ED05H ED05L
1 2
AL2A
CAN resistor
B02
Cab
Chassis
B
EA04
[29]
(3)
130
:Gr54

EXHAUST GAS RECIRCULATION SYSTEM

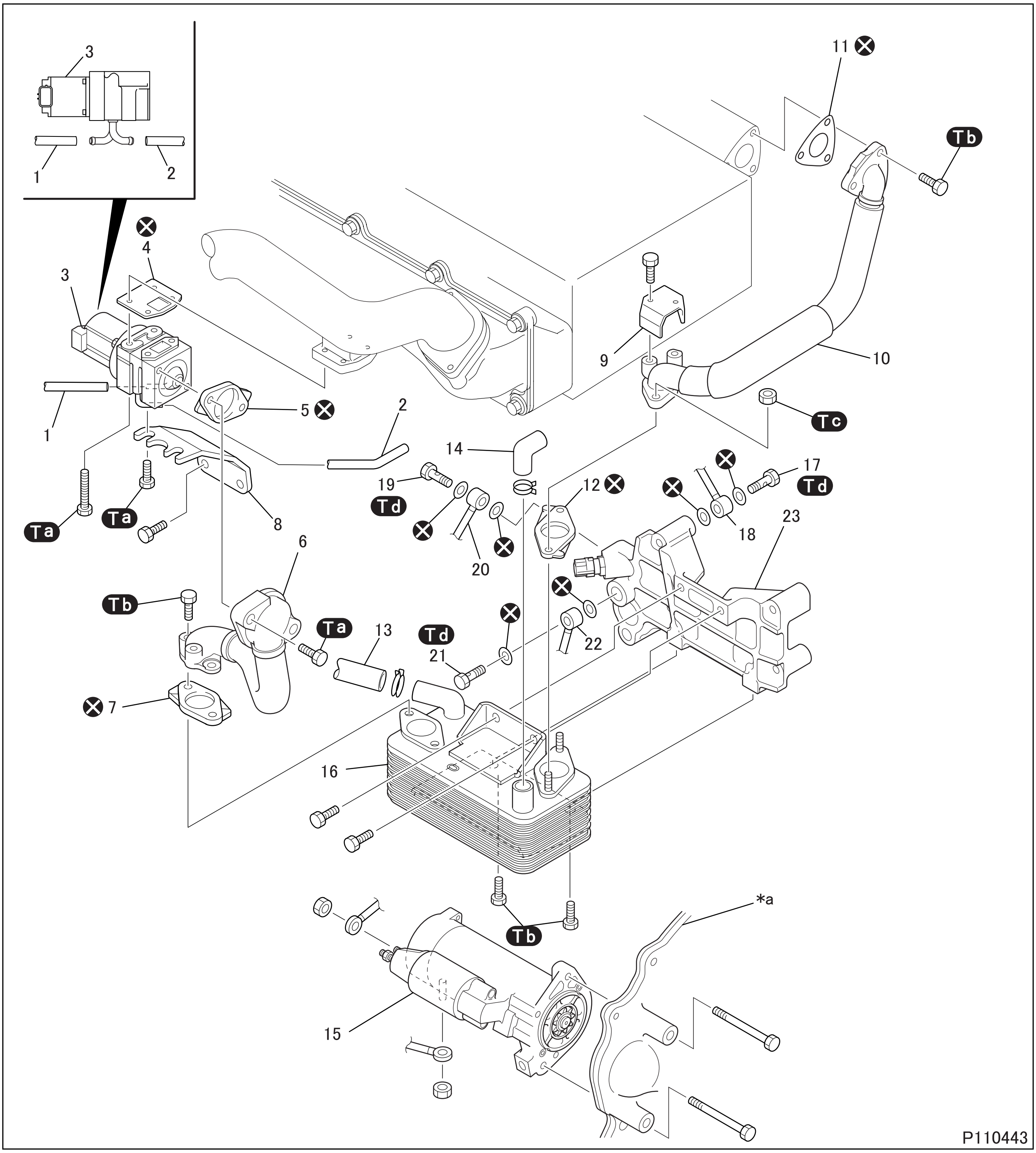


ECU: Electronic control unit
EDU: Electronic drive unit
EGR: Exhaust gas recirculation
INOMAT-Ⅱ: Intelligent and innovative mechanical automatic transmission-Ⅱ
CAN: Controller area network

17-C06557-3

M E M O

EXHAUST GAS RECIRCULATION VALVE, PIPE AND COOLER



● **Removal sequence**

1 Water hose
2 Water hose
3 EGR valve
4 EGR valve gasket B
5 EGR valve gasket A
6 EGR pipe B
7 EGR gasket
8 EGR valve bracket
9 EGR pipe insulator A
10 EGR pipe A
11 EGR pipe gasket
12 EGR gasket
13 Water hose
14 Water hose
15 Starter
16 EGR cooler
17 Eyebolt
18 Fuel pipe
19 Eyebolt
20 Fuel pipe
21 Eyebolt
22 Fuel return pipe
23 EGR cooler bracket

***a**: Clutch housing
⊗: Non-reusable parts
EGR: Exhaust gas recirculation

- Even when all coolant in the crankcase has been drained out, approximately 0.5 dm^3 {0.5 L} of coolant remains in the EGR cooler. Before removing the EGR cooler, make ready a container to catch the coolant.

● Installation sequence

Follow the removal sequence in reverse.

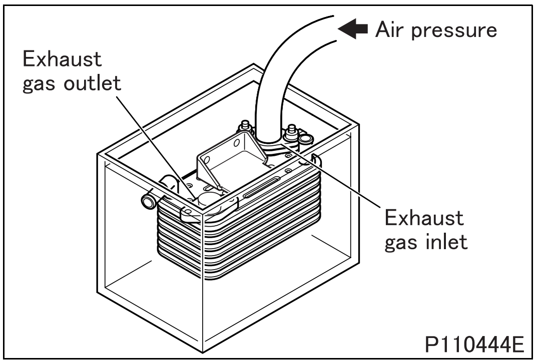
Service standards

Location	Maintenance item		Standard value	Limit	Remedy
16	Air leakage of EGR cooler	Exhaust gas passage side (air pressure: 294 kPa {3 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace
		Water passage side (air pressure: 196 kPa {2 kgf/cm^2})	0 cm^3 {0 mL}	–	Replace

Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (mounting of EGR valve)	47.5 {4.8}	–
	Bolt (mounting of EGR valve bracket)		
	Bolt (mounting of EGR pipe B)		
Tb	Bolt (mounting of EGR pipe A)	23.2 {2.4}	–
	Bolt (mounting of EGR 2)		
	Bolt (mounting of EGR pipe B)		
Tc	Nut (mounting of EGR pipe A)	14 to 19 {1.4 to 1.9}	–
Td	Eyebolt (mounting of fuel pipe)	39 {4.0}	–
	Eyebolt (mounting of suction pipe)		

◆Inspection procedure◆



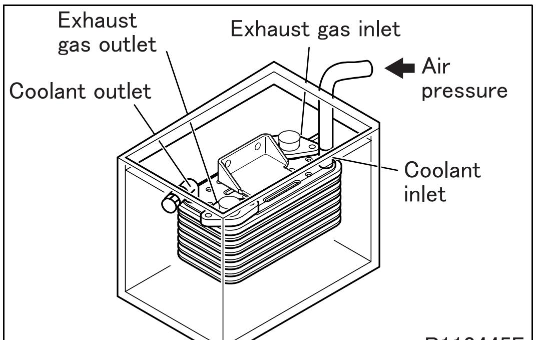
P110444E

■ Inspection: Air leakage of EGR cooler

- Perform the following inspection. If any abnormality is found, replace the exhaust gas recirculation cooler.

(1) Exhaust gas passage side

- Fit a cover over the exhaust gas outlet of the exhaust gas recirculation cooler, and connect a hose to the exhaust gas inlet. Then, submerge the exhaust gas recirculation cooler in a container of water. Make sure the coolant passage is full of water.
- Apply specified air pressure through the hose. Check that air does not leak from any part of the exhaust gas recirculation cooler.

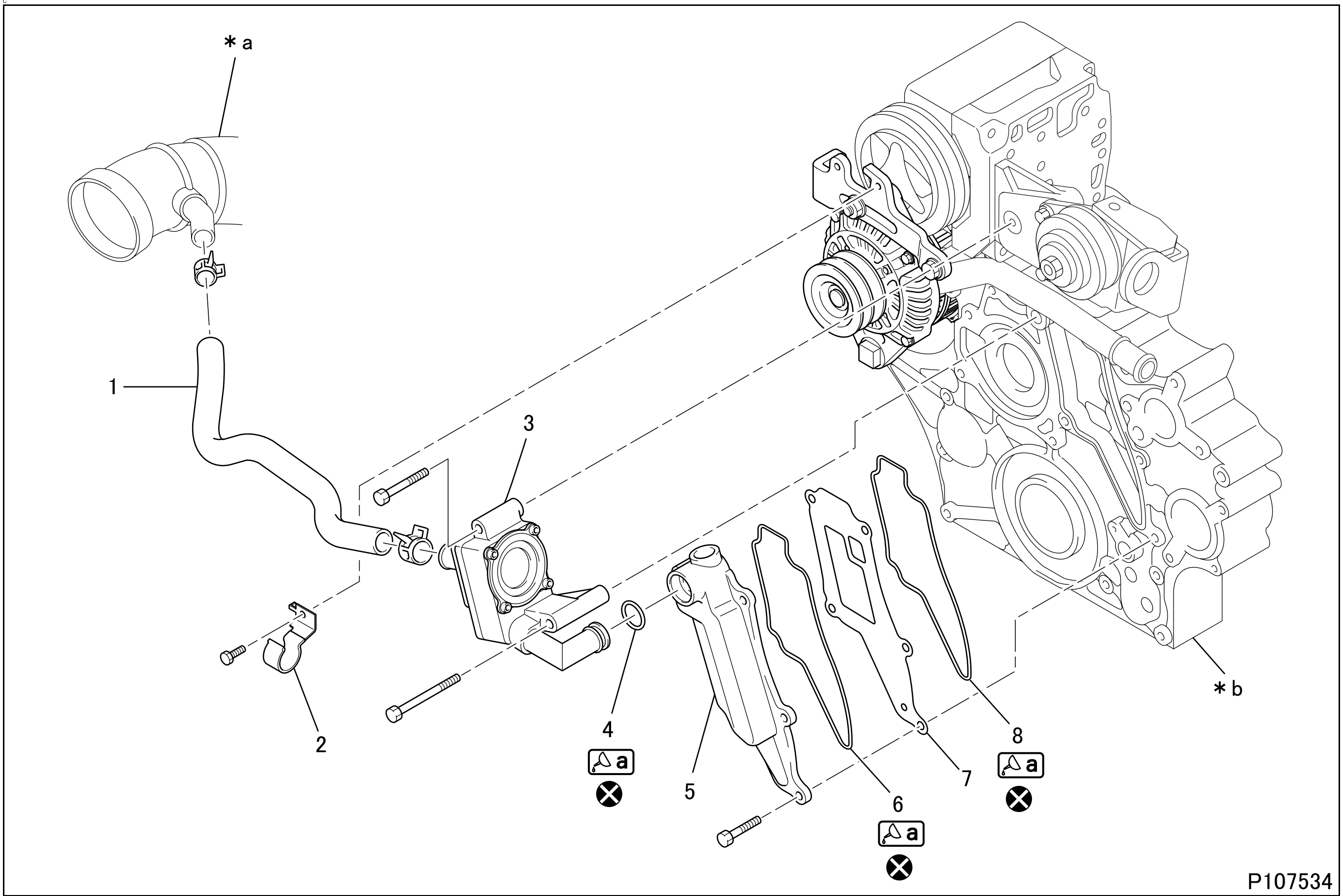


P110445E

(2) Coolant passage side

- Fit covers over the exhaust gas recirculation cooler's exhaust gas inlet, exhaust gas outlet, and coolant outlet, and connect a hose to the coolant inlet. Then, submerge the exhaust gas recirculation cooler in a container of water.
- Apply specified air pressure through the hose. Check that air does not leak from any part of the exhaust gas recirculation cooler.

BLOWBY GAS RETURN SYSTEM



● Removal sequence

1 Breather hose
2 Hose clip
3 PCV valve
4 O-ring
5 Breather cover
6 O-ring
7 Breather
8 O-ring

***a**: Air hose
***b**: Timing gear case
⊗: Non-reusable parts
PCV: Positive crankcase ventilation

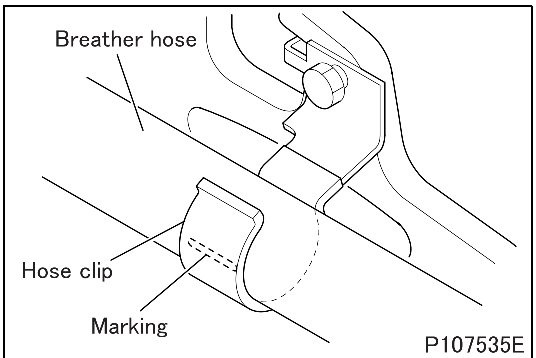
● Installation sequence

Follow the removal sequence in reverse.

Lubricant and/or sealant

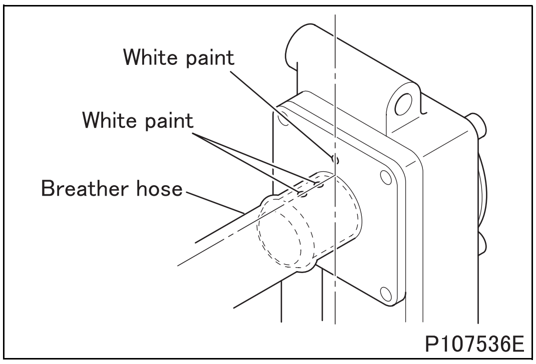
Mark	Points of application	Specified lubricant and/or sealant	Quantity
a	O-ring	Engine oil	–

◆Installation procedure◆



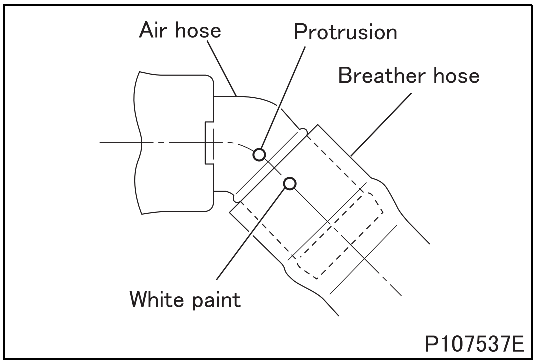
■ Installation: Hose clip

- Install hose clips to the markings on the breather hose.



■ **Installation: Breather hose**

- Insert the breather hose so that its white paint mark becomes vertical to paint mark on positive crankcase ventilation valve, then connect the hose firmly all the way into the valve.



- Insert the breather hose with its white paint mark opposed to the projection of the air hose, then connect the hose firmly all the way to the spool.

GROUP 18
HYBRID ELECTRIC VEHICLE SYSTEM

Motor Generator

Item		Specification
Manufacturer		MITSUBISHI HEAVY INDUSTRIES
Type		Permanent magnet synchronous
Cooling system		Water cooling
Rated voltage	V	DC350
Maximum output	kW {PS}	35 {48}
Maximum torque	N·m {kgf·m}	200 {20}
Mass	kg	67

High Voltage Battery Box (Battery Electronic Control Unit and High Voltage Battery)

Item		Specification
Manufacturer		HITACHI VEHICLE ENERGY
Type		Lithium ion
Number of cells		96 (48 × 2)
Capacity	Ah	5.5
Rated voltage	V	DC350 (for motor generator operation) and DC24 (for electronic control unit operation)
Mass	kg	89

Motor Electronic Control Unit

Item		Specification
Manufacturer		MITSUBISHI HEAVY INDUSTRIES
Rated output current	A	58
Maximum output current	A	175
Rated voltage	V	DC350 (for motor generator operation) and DC24 (for electronic control unit operation)

Blower Motor

Item			Specification
Manufacturer			DENSO
Model			ϕ250 × 60F modified
Motor specification	Type		DC ferrite
	Rated voltage	V	DC24
Fan specification	Type		Axial flow fan

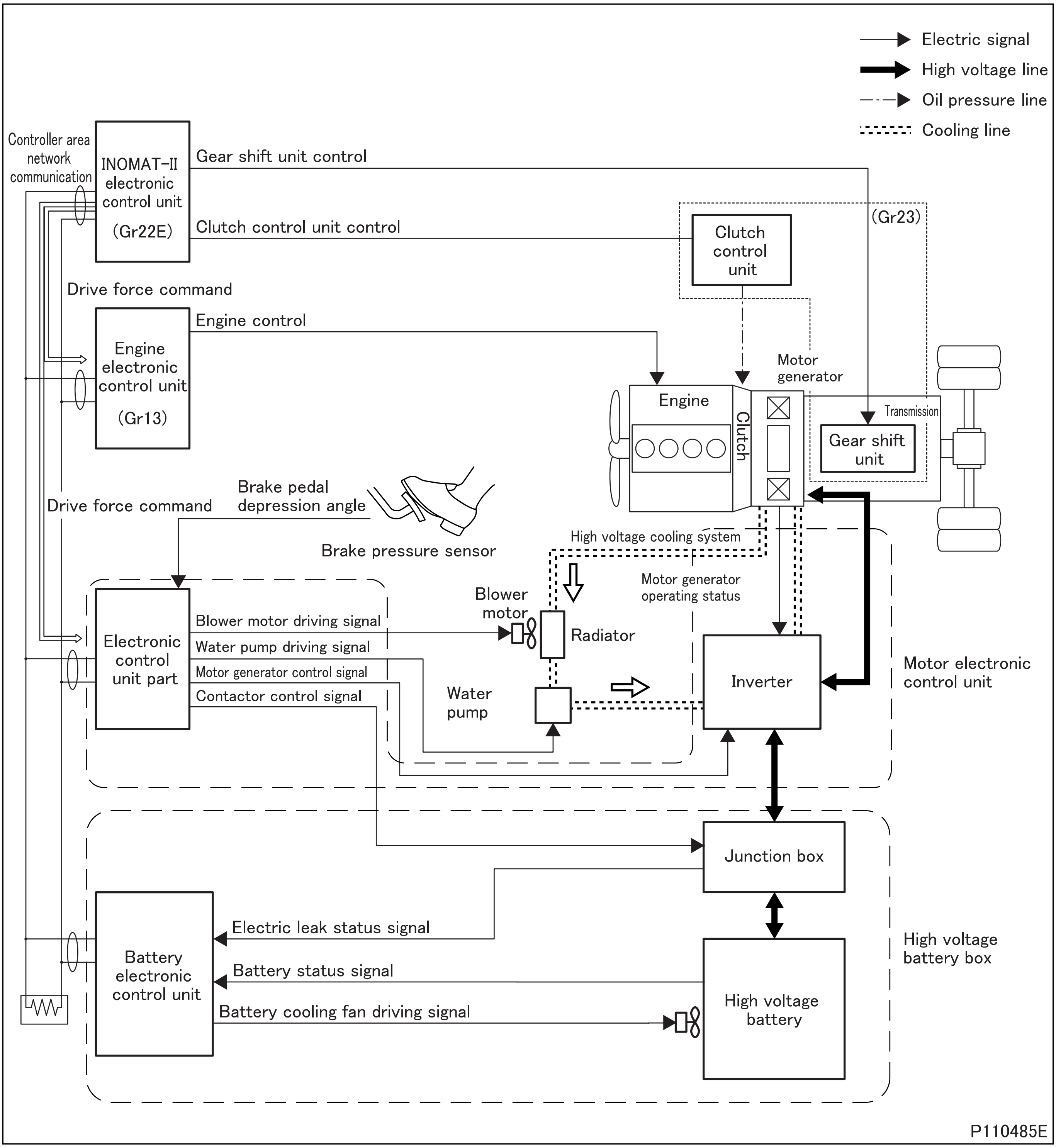
Water Pump

Item		Specification
Manufacturer		MIKUNI CORPORATION
Model		CP21A11-01
Rated voltage	V	DC24
Operating voltage	A	1 or less
Quantity of water supply	dm^3 {L} /min	Approx. 15.8 {15.8} or more (at 20 kPa {0.2 kgf/cm^2})

M E M O

1. Outline

1.1 Hybrid electric vehicle system

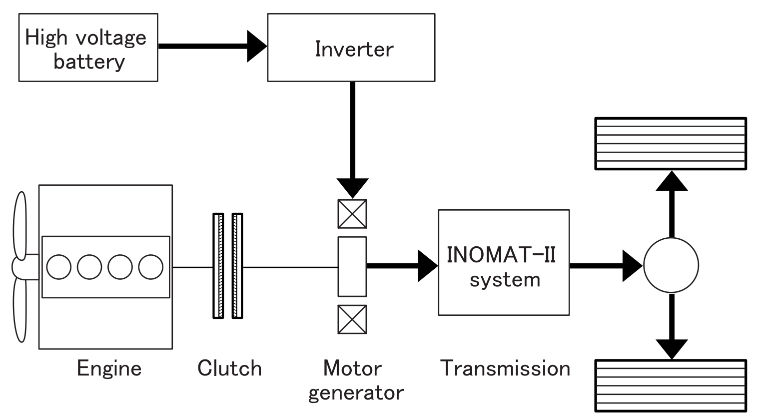


- CANTER ECO HYBRID is a parallel type hybrid electric vehicle system designed to economize fuel consumption and reduce exhaust gas emission by selective or combined use of engine and motor generator according to the running condition of the vehicle.
- The motor generator, located in the back of the clutch housing, not only generates motive power but also serves as a dynamo under the control of the motor electronic control unit.
- Heated motor generator and the inverter in the motor electronic control unit are cooled with the high voltage cooling system.
- The high voltage battery is managed and controlled by the battery electronic control unit.
- Torque (drive force) generated by the engine and motor generator is distributed by the INOMAT-II electronic control unit.

- Respective electronic control units, which constantly send and receive input and output data through controller area network communication, take their shares of control to ensure the normal operation of the hybrid electric vehicle system.

1.2 Driving

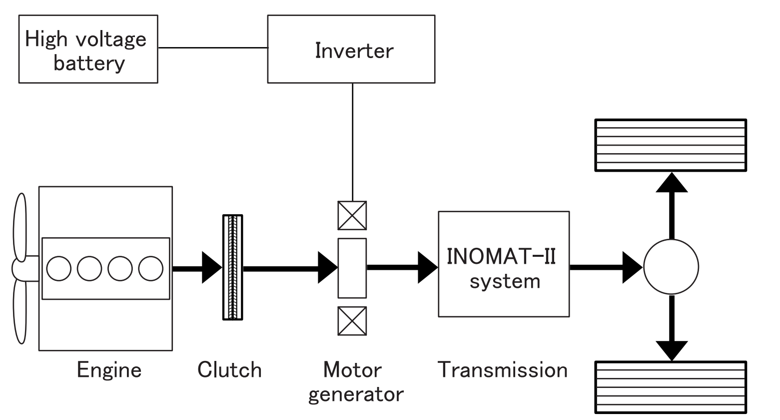
- The engine and motor generator are operated, independently or combined, by the torque (drive force) distribution command of the INOMAT-II electronic control unit in accordance with the vehicle running condition and high voltage battery state of charge.



P68512E

(1) When starting

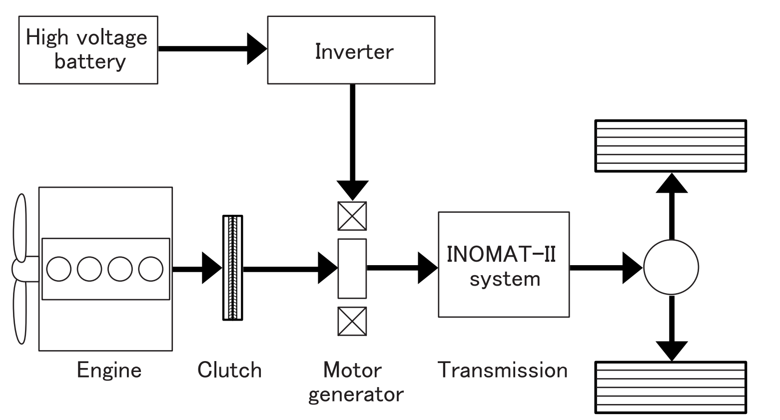
- The motor generator is used to start the vehicle.



P68513E

(2) When running (high voltage battery state of charge: Normal)

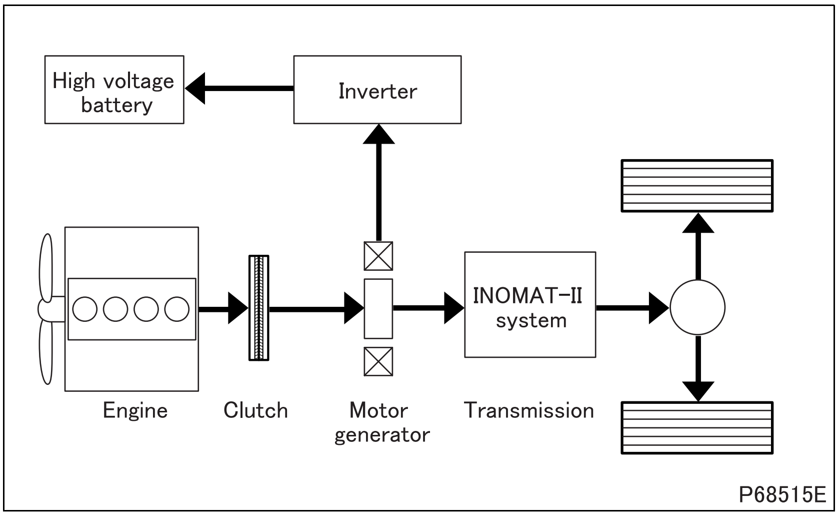
- With the clutch engaged, the vehicle runs using the engine only.



P68514E

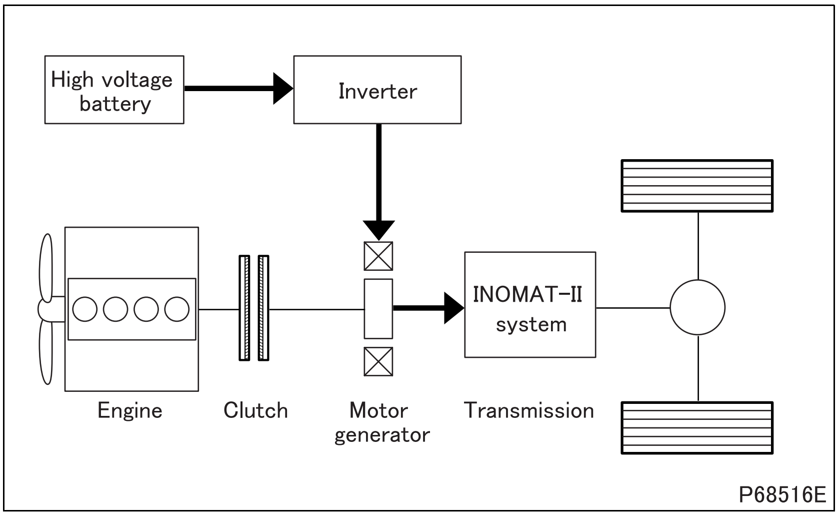
(3) When running (high voltage battery state of charge: High)

- The engine is assisted by the motor generator.



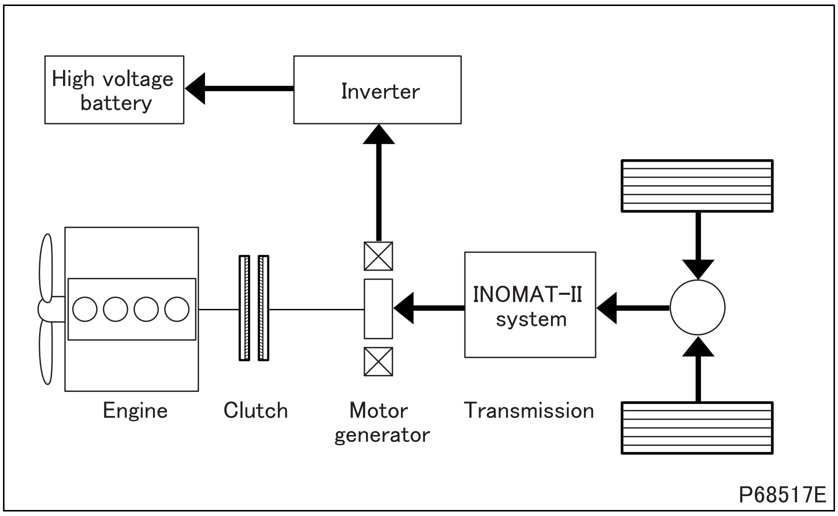
(4) When running (high voltage battery state of charge: Low)

- The motor generator is operated as a dynamo by the engine.



(5) When running (during gear shifting)

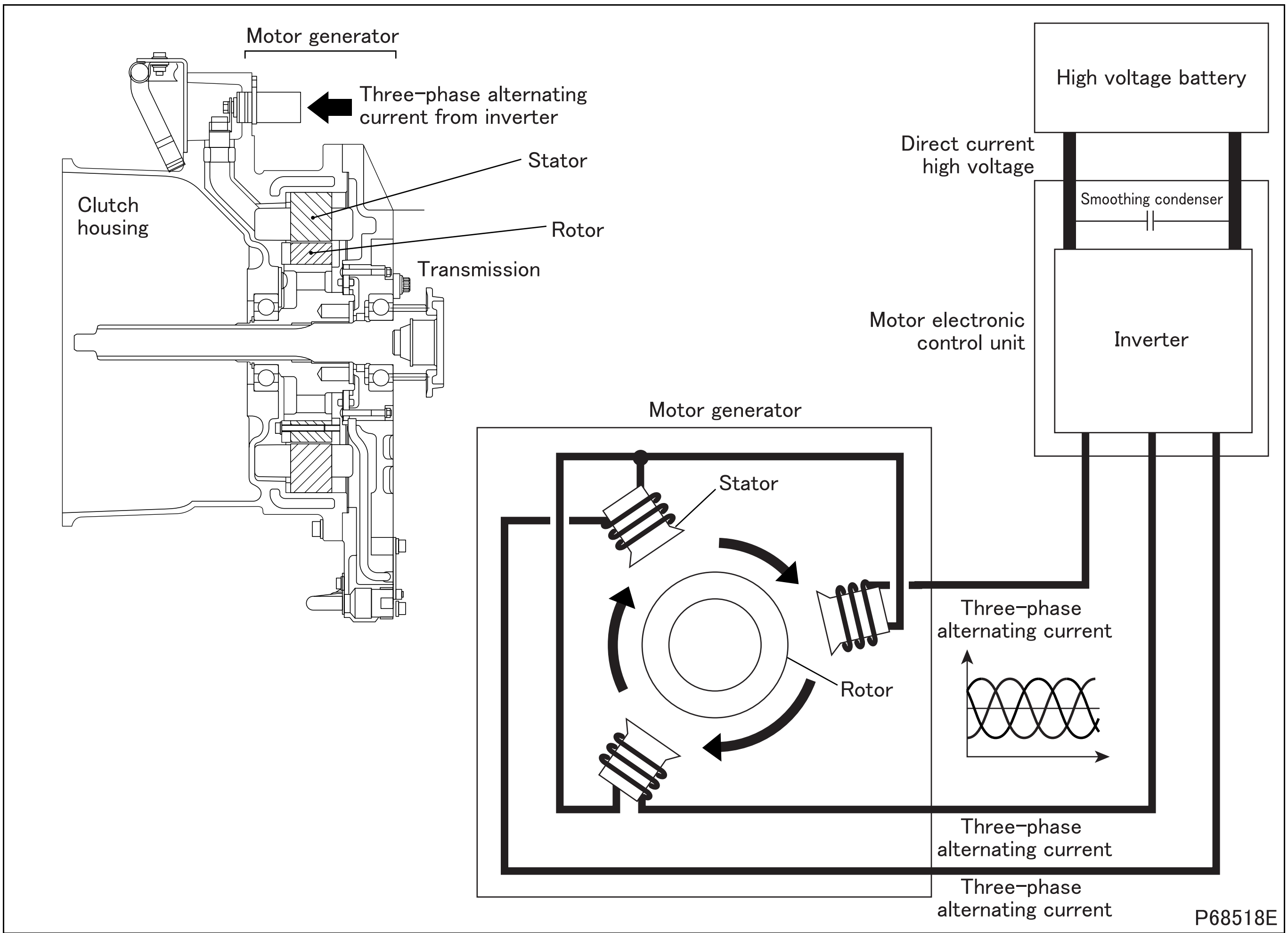
- The motor generator is used to facilitate the synchronized gear shifting.



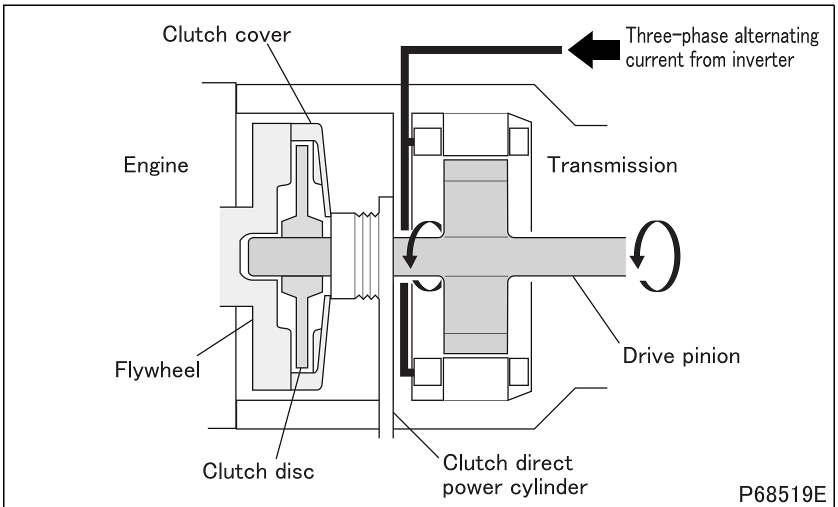
(6) When braking

- The motor generator is operated as a dynamo to charge the high voltage battery with braking energy regenerated. At the same time, braking force equal to that of engine brake is generated.
- When large braking force is required, engine or exhaust braking is activated with the clutch engaged.

1.3 Motor generator and drive line



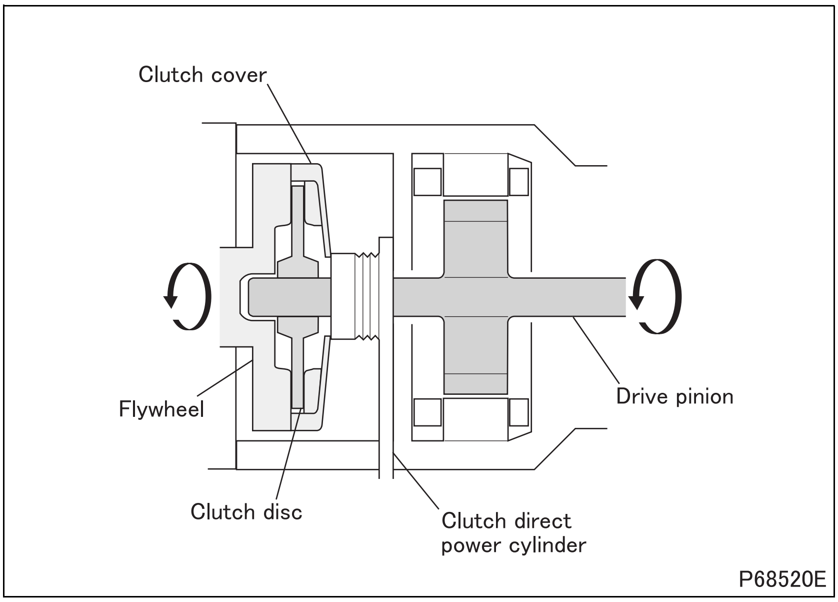
- The motor generator is located in the back of the clutch housing.
- By the command of the motor electronic control unit, direct current high voltage output from the high voltage battery is converted to a three-phase alternating current through the inverter and flows into the stator assembly to produce a magnetic field in it. As a result, the rotor is turned to send the torque (drive force) to the transmission.
- During braking, the motor generator operates as a dynamo. The rotor is turned to produce three-phase alternating current in the stator assembly. Three-phase alternating current is converted to direct current high voltage through the inverter to charge the high voltage battery.
- The smoothing capacitor in the motor electronic control unit stabilizes direct current high voltage.



(1) Drive line (when motor generator operates alone)

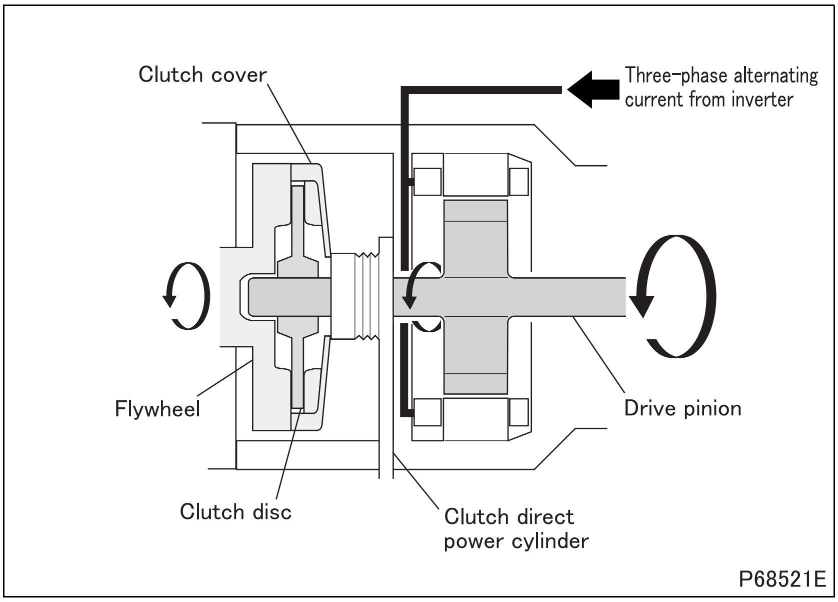
- The engine is in the idling state with the clutch disengaged.
- The motor generator operation drives the drive pinion to run the vehicle.

* The illustration at the left outlines the structure and operation of the drive line. For the actual clutch-related operation, see Gr21.



(2) Drive line (when engine operates alone)

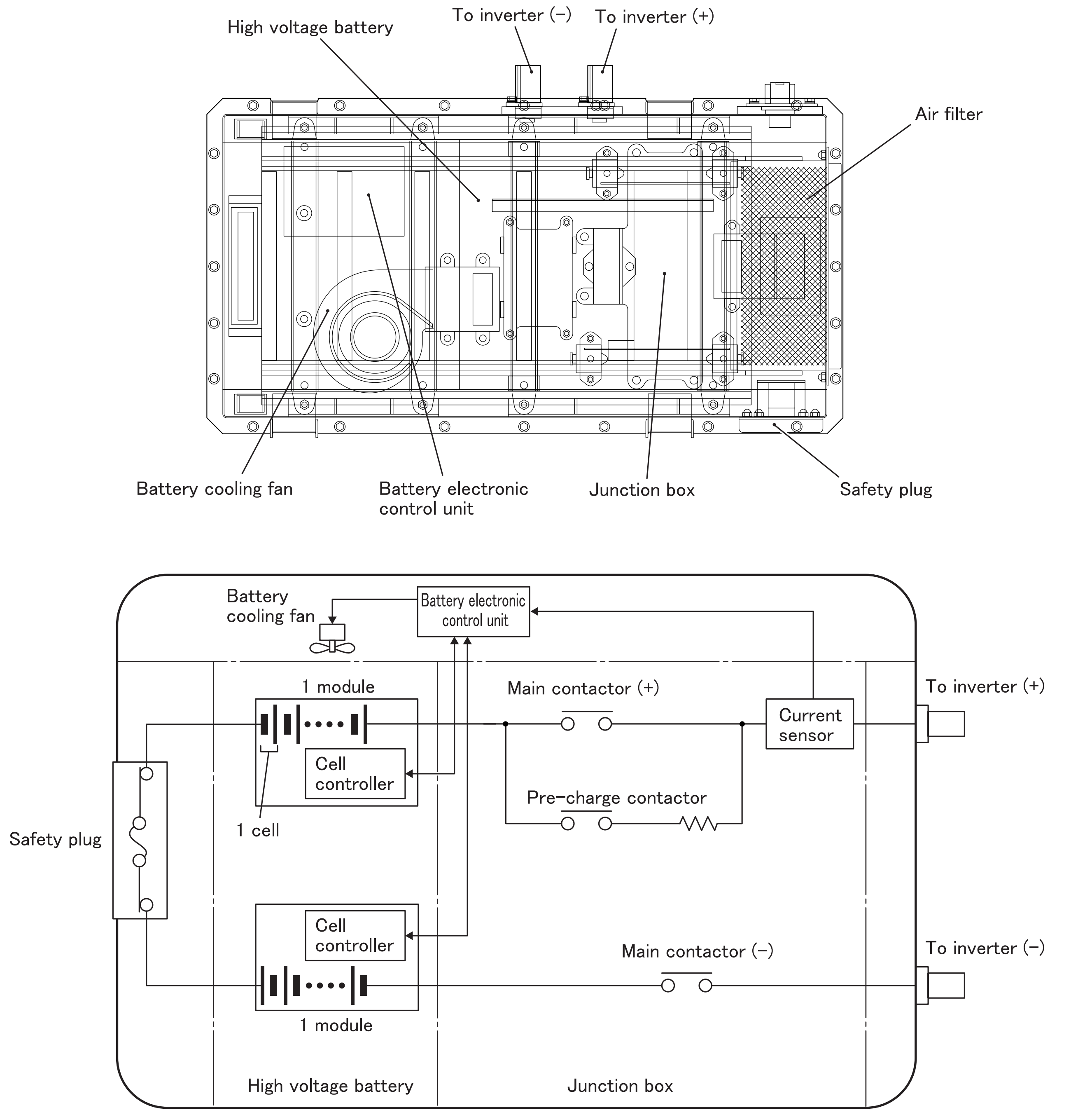
- The clutch is engaged and engine output torque (drive force) is directly transmitted to the drive pinion.



(3) Drive line (when engine and motor generator operate)

- The clutch is engaged and engine output torque (drive force) is transmitted to the drive pinion along with motor generator output torque (drive force).

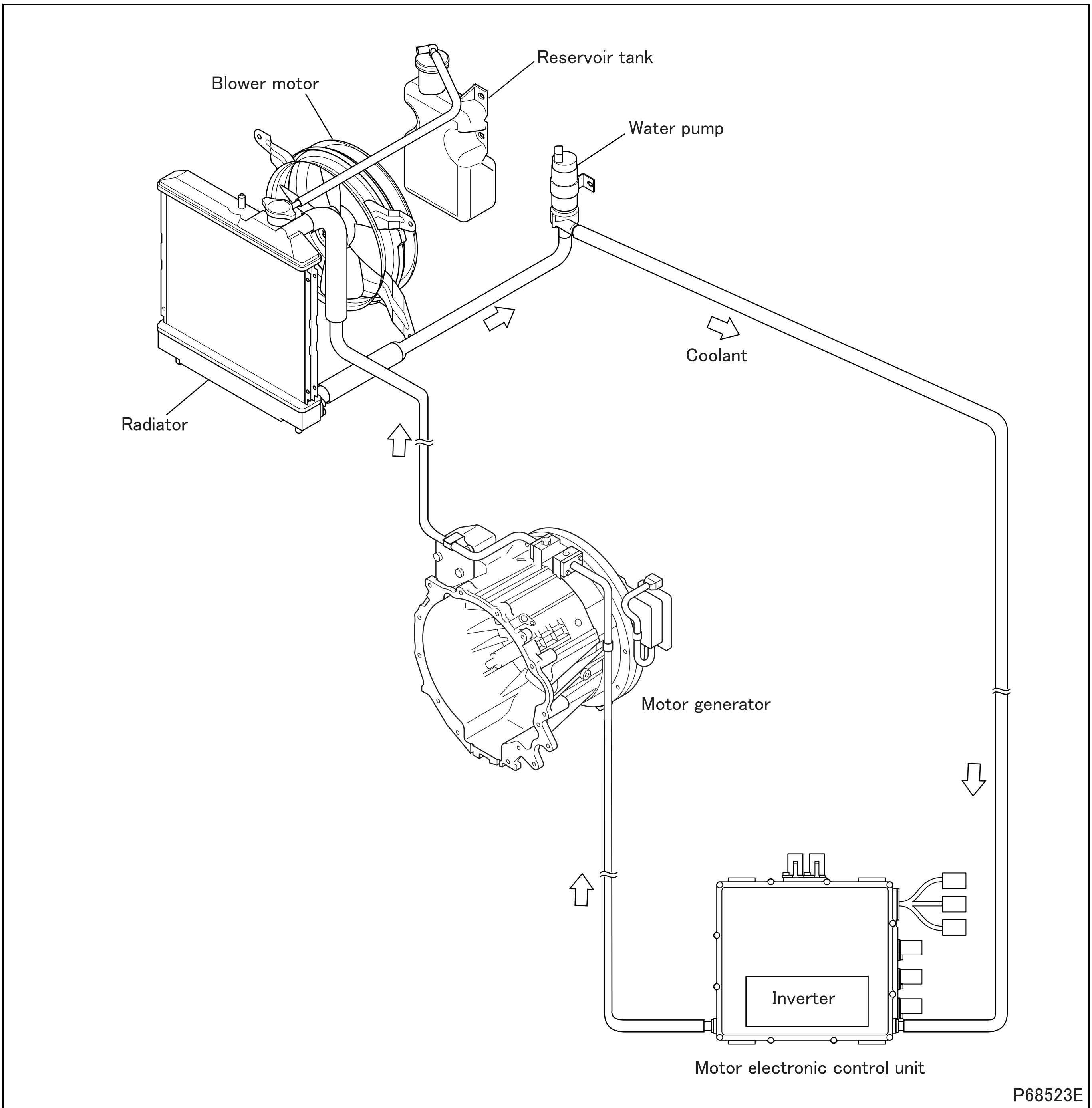
1.4 High voltage battery box



P68522E

- The high voltage battery box consists of a high voltage battery, a battery electronic control unit, a junction box, a safety plug, a battery cooling fan and an air filter.
- The high voltage battery is composed of two series-connected modules, each module being made up of 48 series-connected cells.
- Each module is provided with a cell controller, through which data of each cell is sent to the battery electronic control unit.
- The relay for high voltage located in the junction box (with the main contactor (+) and (–)) is energized by the command of the motor electronic control unit to supply electric power to the inverter in the motor electronic control unit.
- When the safety plug is disconnected, electric power is cut off. (High voltage still remains in the circuit.)
- The battery cooling fan is operated by the command of the battery electronic control unit to discharge heat generated by the high voltage battery to the outside of the high voltage battery box using air taken in through the air filter.

1.5 High voltage cooling system

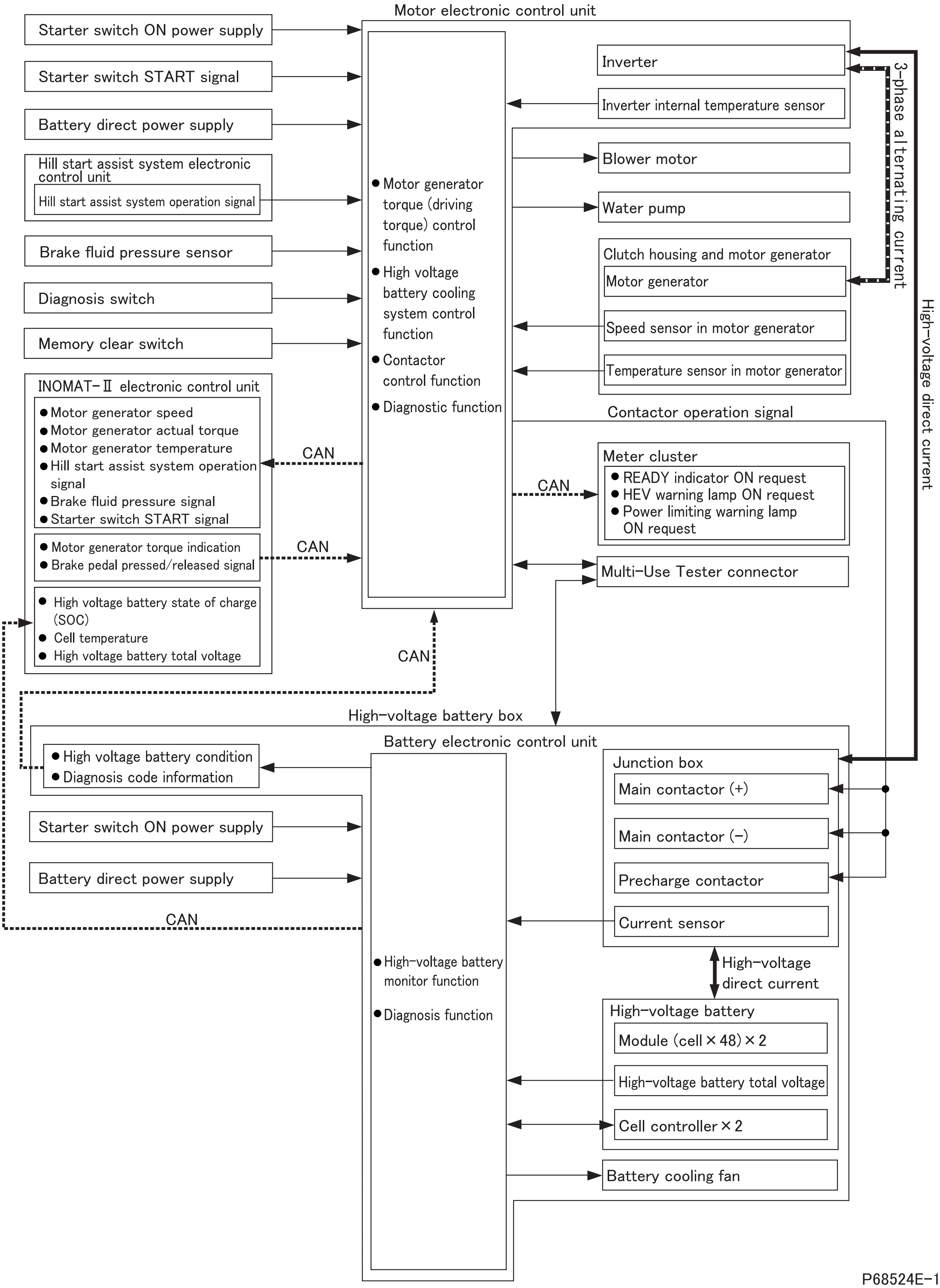


- Each high voltage device in the hybrid electric vehicle system is provided with dedicated cooling lines independent from those of the engine.
- The high voltage cooling system cools the inverters in the motor generator and motor electronic control unit heated through their operation under high voltage.
- The blower motor and water pump are so controlled by the motor electronic control unit that high voltage devices are cooled to the optimal temperature.

MEMO

2. Electronic Control System

2.1 System block diagram



P68524E−1

(1) Motor electronic control unit

Part name	Main function or operation
Starter switch ON power supply	Supplies electronic control unit power supply (with starter switch ON)
Starter switch START signal	Detection of cranking (used for engine start function by motor generator, sent to INOMAT-II electronic control unit)
Battery direct power supply	Supplies electronic control unit power supply (continuous)
Hill start assist system operation signal	Hill start assist system operation signal (used for idling stop and start control by INOMAT-II electronic control unit)
Brake fluid pressure sensor	Detection of brake pedal position
Diagnosis switch	Display of diagnosis code
Memory clear switch	Display (past) or erasure of diagnosis code
Inverter	• Converts direct current high voltage from high voltage battery to three-phase alternating current • Converts three-phase alternating current to direct current high voltage
Temperature sensor in inverter	Detection of inverter temperature (measures at three points, i.e., U, V and W phase)
Blower motor	Cools radiator in high voltage cooling system
Water pump	Circulates coolant in high voltage cooling system
Motor generator	• Activated on reception of three-phase alternating current to output torque (drive force) • Operates as a dynamo to generate regenerated force during braking or similar situations
Revolution sensor in motor generator	Detection of motor generator speed
Temperature sensor in motor generator	Detection of motor generator temperature
Multi-Use Tester connector	Communication with Multi-Use Tester

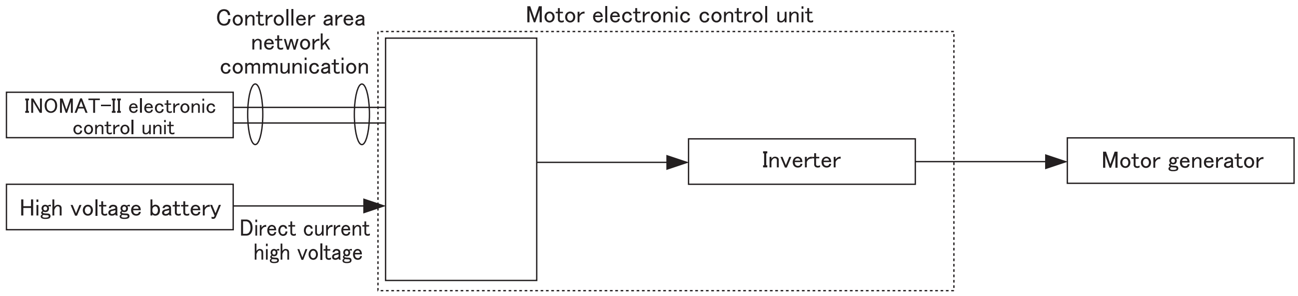
(2) High voltage battery box

Part name	Main function or operation
Starter switch ON power supply	Supplies electronic control unit power supply (with starter switch ON)
Battery direct power supply	Supplies electronic control unit power supply (continuous)
Main contactor (+)	Connection/Disconnection between high voltage battery and inverter (positive side)
Main contactor (–)	Connection/Disconnection between high voltage battery and inverter (negative side)
Pre-charge contactor	Connects during charging
Current sensor	Detection of current in high voltage battery box
Module	Consists of 48 series-connected cells, 2 modules are high voltage batteries
High voltage battery total voltage	Battery electronic control unit detects high voltage battery total voltage
Cell controller	Provides battery electronic control unit with each cell information
Battery cooling fan	Discharges heat generated from high voltage battery into outside of high voltage battery box
Multi-Use Tester connector	Communication with Multi-Use Tester

2.2 Motor electronic control unit

- See Gr22E since main control related to the hybrid electric vehicle system is executed by INOMAT-II electronic control unit.

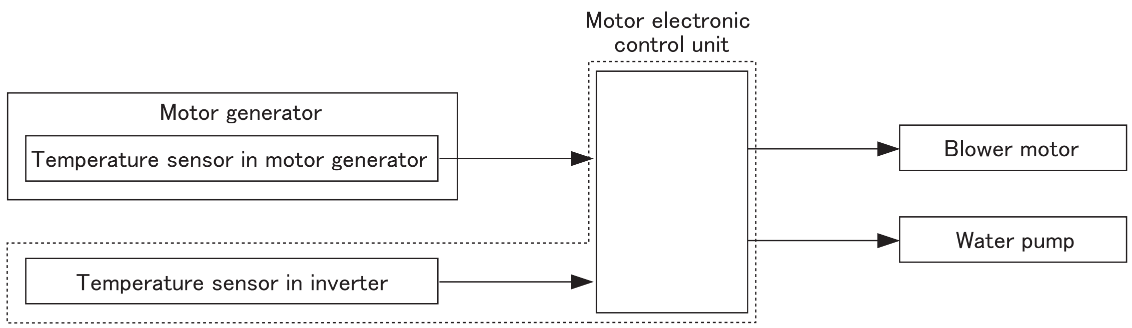
(1) Motor generator torque (drive force) control function



P68525E

- When the INOMAT-II electronic control unit commands the motor electronic control unit to generate torque (drive force), the motor electronic control unit outputs a signal to the inverter to activate the motor generator.
- When the motor generator or inverter is overheated or in other abnormal conditions, the motor electronic control unit operates the motor generator restricting its torque (drive force and regenerated force).

(2) High voltage cooling system control function



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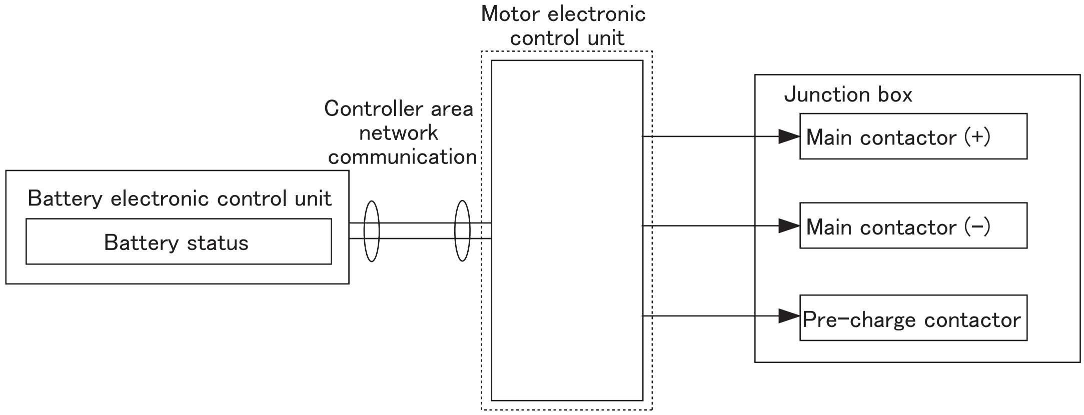
- The motor electronic control unit operates the blower motor and water pump according to the motor generator and inverter temperatures.

(3) Contactor control function



P68527E

- Contactors, housed in the junction box of the high voltage battery box, serve as relays to open and close the high voltage circuit between the high voltage battery and inverter.
- To activate the hybrid electric vehicle system, the motor electronic control unit commands the main contactor (+) and (–) to close. This can cause electric power to be sent to the inverter to activate the motor generator.
- To charge the high voltage battery, the motor electronic control unit commands the pre-charge contactor to close.

(4) Diagnostic function

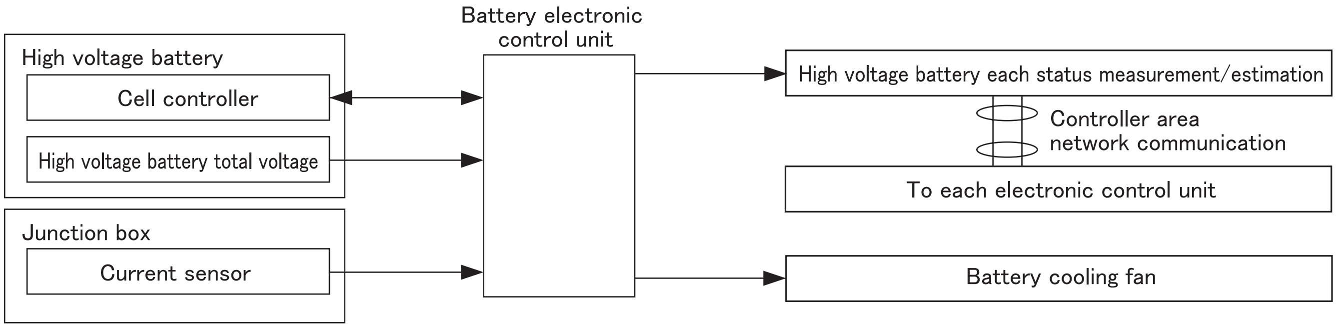
- The motor electronic control unit constantly monitors the operating condition of respective sensors for failure during the starter switch ON. If any sensor is faulty, fault information is indicated on the meter cluster to inform the driver. At the same time, the fault location is stored as a diagnosis code and control-during-fault is started.
- During control-during-fault, the motor electronic control unit restricts the system function to ensure safety of the vehicle and driver. The stored diagnosis code can be retrieved on Multi-Use Tester or through the warning lamp illumination.
- Control-during-fault can be categorized as in the following table.

Control-during-fault	Major cause	Lamp illumination status
Normal	–	READY
Hybrid electric vehicle system operation inhibited	Major fault	HEV
Hybrid electric vehicle system operates with partial decline in function	Minor fault	HEV READY

- Diagnosis code differs between Multi-Use Tester and warning lamp indication.

2.3 Battery electronic control unit

(1) High voltage battery monitoring function



P68528E

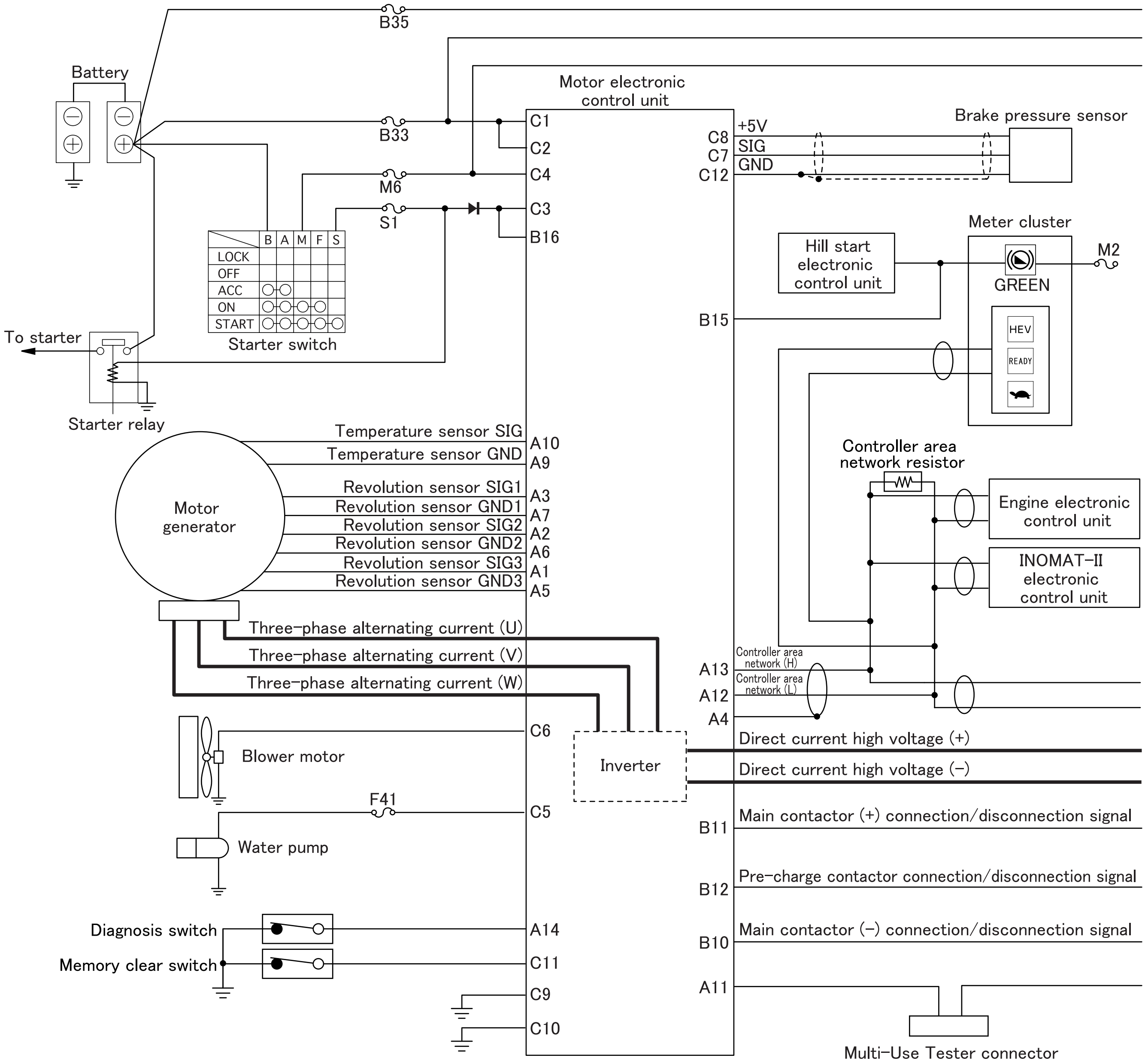
- The battery electronic control unit performs such functions as measurement of the total voltage of the high voltage battery and estimation of high voltage battery state of charge, and monitors the high voltage battery to ensure the secure power supply.
- The cell controller equalizes the voltages of all the cells.
- The battery electronic control unit controls the battery cooling fan in accordance with cell temperature data received from the cell controllers to cool the high voltage battery.

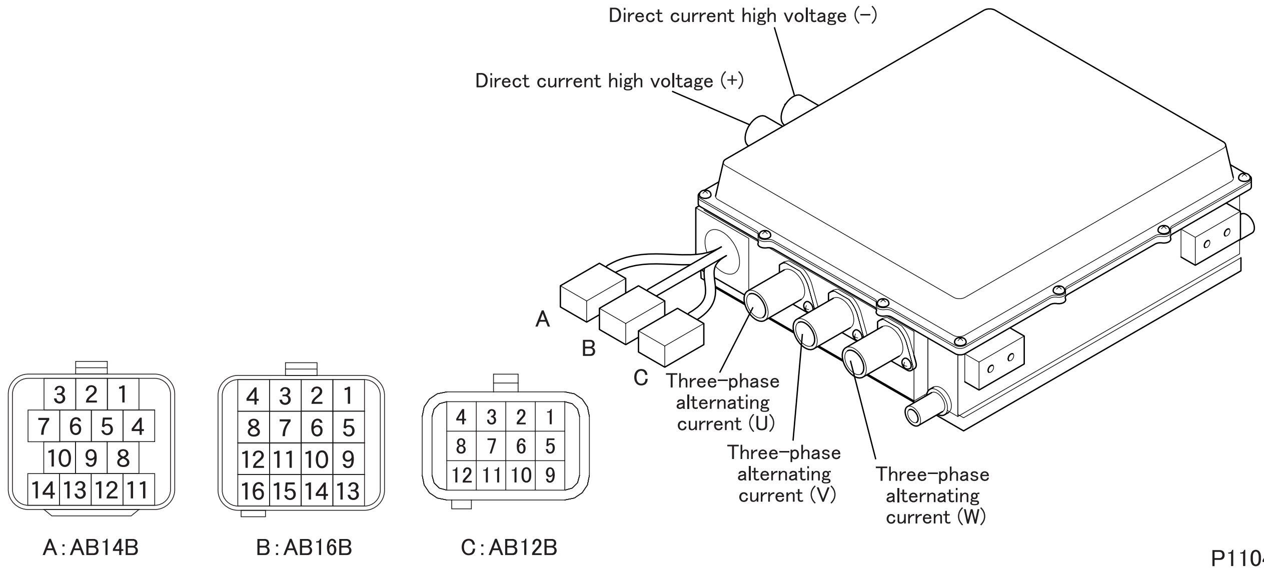
(2) Diagnostic function

- The battery electronic control unit has the same diagnostic functions as the motor electronic control unit does; however, some diagnosis codes (minor faults) can be accessed on Multi-Use Tester only.

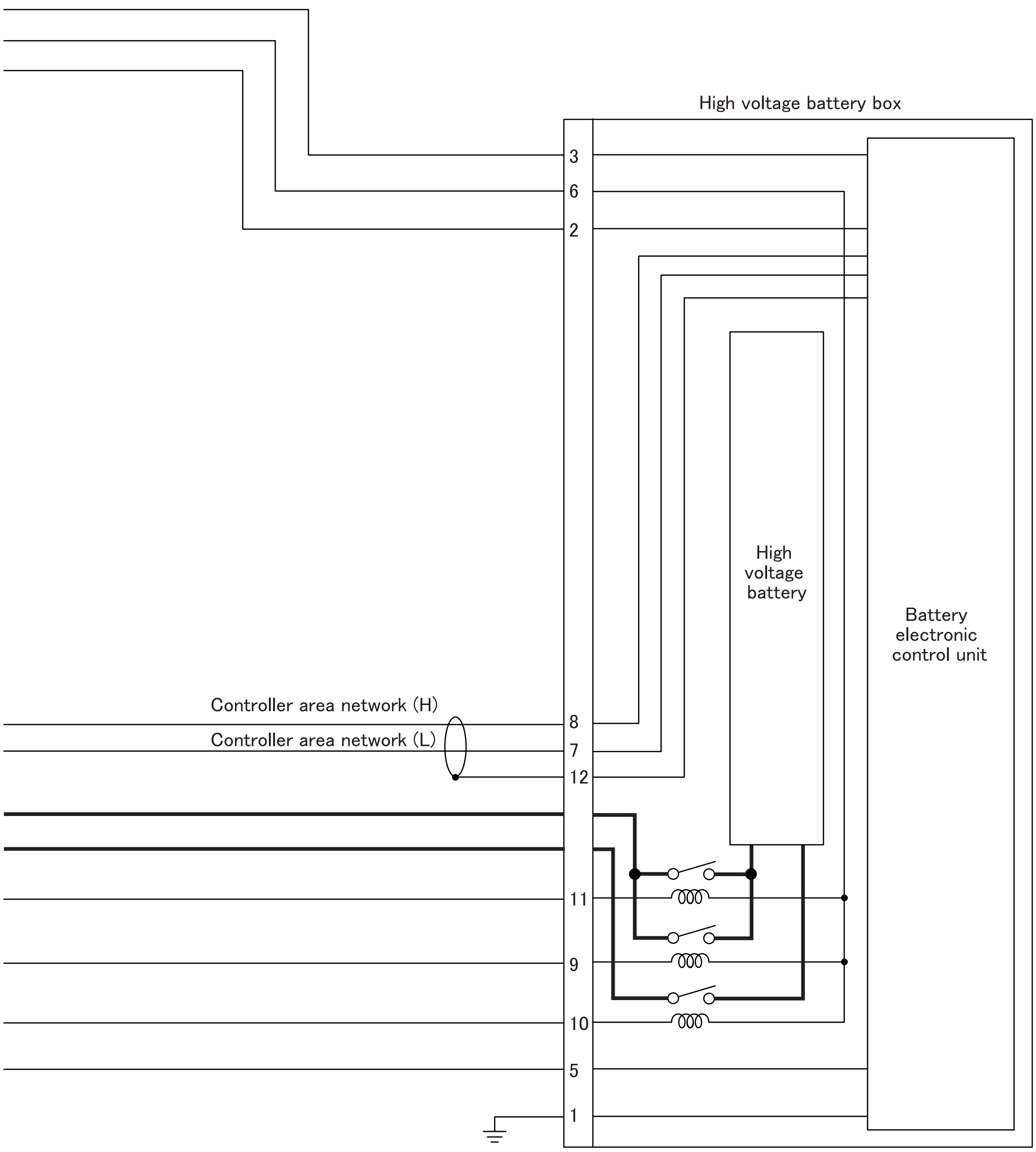
M E M O

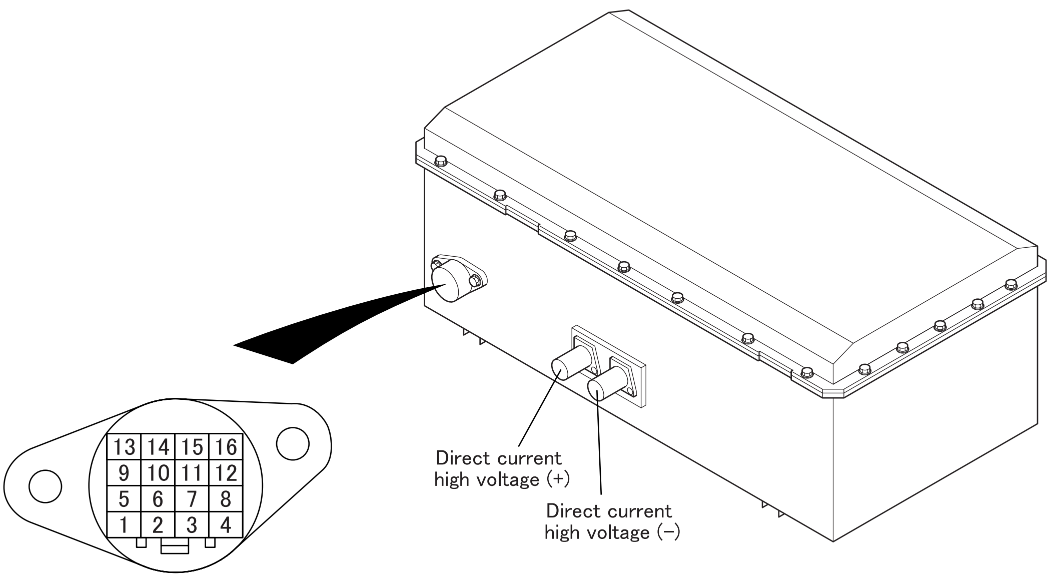
3. Electronic Control Unit Connection Diagram





P110486E


High voltage battery box
3
6
2
High
voltage
battery
Battery
electronic
control unit
Controller area network (H)
Controller area network (L)
8
7
12
11
9
10
5
1

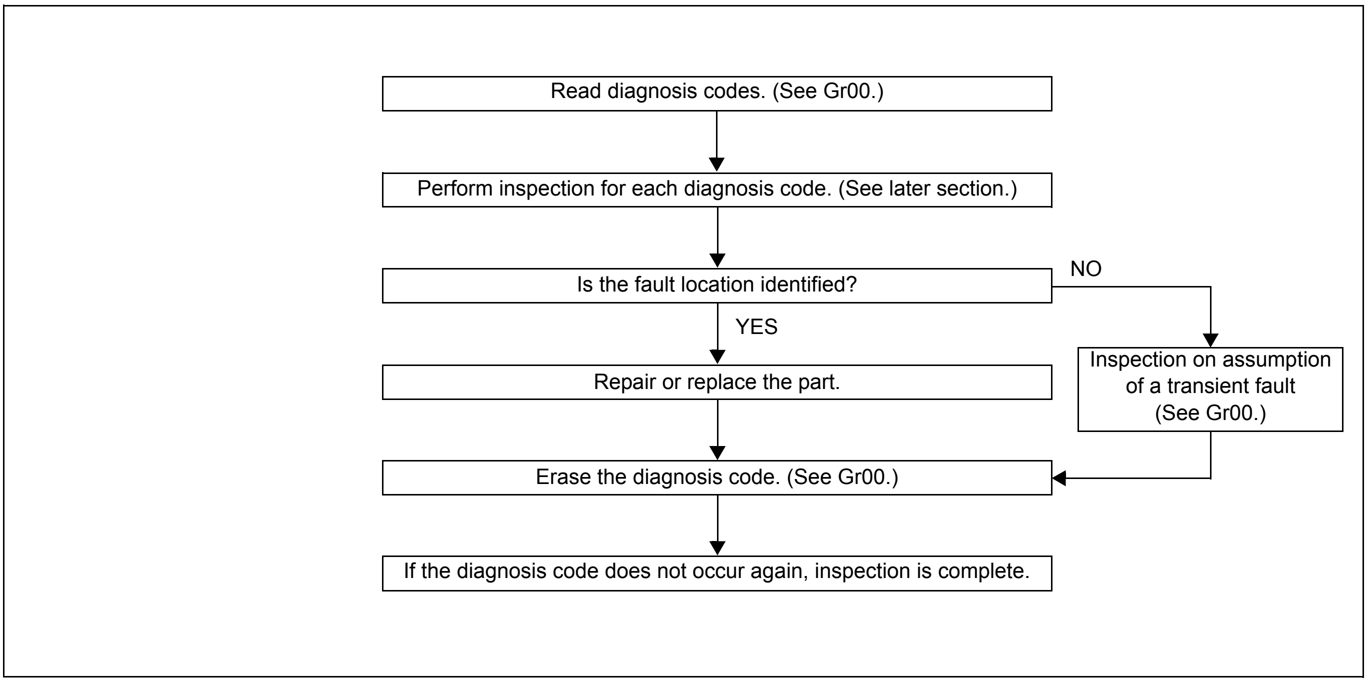

13 14 15 16
9 10 11 12
5 6 7 8
1 2 3 4
Direct current
high voltage (+)
Direct current
high voltage (−)

P68530E

TROUBLESHOOTING <MOTOR ELECTRONIC CONTROL UNIT>

1. Diagnosis Procedure

- Perform the inspection in accordance with the following flowchart.



2. Diagnostic Precautions

WARNING ⚠

- **When removing the high voltage cable (orange), see “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT” and perform maintenance in an appropriate manner.**

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

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- Diagnosis codes for the battery electronic control unit (except minor faults) are sent to meter cluster via motor electronic control unit.

Code	Message	Flashes	Warning lamp indication
P0A05	Water Pump Driver Failure	10	O
P0A1B	CPU Failure	28	O
P0A2B	Motor Temp Sensor Failure	18	O
P0A2F	Motor Coil Over Temp	16	O
P0A3C	IPM Over Temp	17	O
P0A3F	Resolver Failure Flug	26	O
P0A44	Resolver Over Value	27	O
P0A5E	UVW Disconnect	15	O
P0A5F	UVW Over Current	12	O
P0A78	IPM Failure	13	O
P0A7E	★BCU Over Temperature	53	O
P0A90	Motor Torque Unmatch	32	O
P0AA1	Main Contactor P&N Welded	09	O
P0AA6	★BCU Leak	65	O
P0AC2	★BCU Over Current	52	O
P0AC3	★BCU Current Sensor Failure	60	O
P0AD9	Main Contactor Driver Failure	08	O
P0AE2	Precharge Contactor Welded	37	O
P0AE3	Smooth Capacitor Charge Shortage	05	O
P0AED	IPM Temp Sensor Failure	22	O
P0AFA	★BCU Over Discharge	55	O
P0AFB	★BCU Over Charge	58	O
P1A00	Smooth Capacitor Low Voltage	02	O
P1A01	Smooth Capacitor Over Voltage	03	O
P1A02	BCU Battery Low Voltage	04	O
P1A03	24V Battery Low Voltage	06	O
P1A04	Smooth Capacitor Discharge Fail	07	O
P1A05	Radiator Fan Driver Failure	11	O
P1A06	IPU Time Out	14	O

Code	Message	Flashes	Warning lamp indication
P1A07	IPM U Temp Sensor Failure	19	O
P1A08	IPM V Temp Sensor Failure	20	O
P1A09	IPM W Temp Sensor Failure	21	O
P1A0A	CAN NG Data Received	23	O
P1A0B	Motor Locked	25	O
P1A0C	Memory Failure	29	O
P1A0D	Brake Pressure Sensor Failure	34	O
P1A0E	Hill Start Input Failure	35	O
P1A0F	STS CAN Failure	39	O
P1A10	P1A04 happens	40	O
P1A13	Motor Over Speed	43	O
P1A51	★BCU Cell Over Discharge	54	O
P1A52	★BCU Cell Over Charge Signal	56	O
P1A53	★BCU Cell Over Charge	57	O
P1A54	★BCU Current/Voltage Unmatch	61	O
P1A55	★BCU Initial Voltage Failure	62	O
P1A56	★BCU CC Communication Failure	63	O
P1A57	★BCU CAN Receive Failure	66	O
P1A58	★BCU CAN Transmit Failure	67	O
P1A59	★BCU CAN Bus Off	68	O
P1A60	★BCU CAN Initialize Failure	69	O
P1A62	★BCU CC Balancing SW Failure	71	O
P1A63	★BCU CC Sensing Line Failure	72	O
P1A65	★BCU Temp Sensor Failure	74	O
P1A66	★BCU Voltage Sensor Failure	75	O
P1A67	★BCU CC IC Number Unmatch	76	O
P1A68	★BCU Cell Voltage Unbalance	77	O
U0001	CAN No Data Received	24	O
U3010	S Input Failure	33	O

★: Diagnosis code of battery electronic control unit (See “TROUBLESHOOTING <BATTERY ELECTRONIC CONTROL UNIT>”.)

3.2 Diagnosis code generation conditions and inspection items

P0A05: Water Pump Driver Failure (warning lamp flashes: 10)

Generation condition		Inconsistency between water pump operation command and detected monitor signal
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	73: Water Pump ON/OFF Monitor 98: Water Pump Relay ON/OFF
	Service data	A7: P1A53 happens
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P0A1B: CPU Failure (warning lamp flashes: 28)

Generation condition		Abnormality of inverter in motor electronic control unit is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P0A2B: Motor Temp Sensor Failure (warning lamp flashes: 18)

Generation condition		Abnormality of motor generator temperature (open-circuit or short is detected)
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	06: Motor Stator Temperature
	Electronic control unit connector	01: Motor generator (temperature sensor)
	Electrical equipment	#437: Motor generator (temperature sensor)
	Electric circuit diagram	Circuit between motor electronic control unit and motor generator
	Other	Replacement of motor electronic control unit (inverter software abnormality)

P0A2F: Motor Coil Over Temp (warning lamp flashes: 16)

Generation condition		Motor generator temperature is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Freeze frame data	06: Motor Stator Temperature
	Electronic control unit connector	01: Motor generator (temperature sensor)
	Electrical equipment	#437: Motor generator (temperature sensor)
	Other	• Inspection of trapped air and coolant leakage in high voltage cooling system • Replacement of motor electronic control unit (inverter software abnormality)

P0A3C: IPM Over Temp (warning lamp flashes: 17)

Generation condition		Inverter temperature is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Freeze frame data	07: Inverter U Temperature 08: Inverter V Temperature 09: Inverter W Temperature
	Other	• Inspection of trapped air and coolant leakage in high voltage cooling system • Replacement of motor electronic control unit (inverter software abnormality)

P0A3F: Resolver Failure Flug (warning lamp flashes: 26)

Generation condition		Abnormality of revolution sensor in motor generator is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Freeze frame data	79: P0A3F happens
	Electronic control unit connector	01: Motor generator (revolution sensor)
	Electrical equipment	#437: Motor generator (revolution sensor)
	Electric circuit diagram	Circuit between motor electronic control unit and motor generator
	Other	Replacement of motor electronic control unit (inverter software abnormality)

P0A44: Resolver Over Value (warning lamp flashes: 27)

Generation condition		Revolution sensor in motor generator is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Electronic control unit connector	01: Motor generator (revolution sensor)
	Electrical equipment	#437: Motor generator (revolution sensor)
	Electric circuit diagram	Circuit between motor electronic control unit and motor generator
	Other	Replacement of motor electronic control unit (inverter software abnormality)

P0A5E: UVW Disconnect (warning lamp flashes: 15)

Generation condition		Open-circuit of three-phase alternating current circuit is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Electronic control unit connector	01: Motor generator (alternating current power supply system)
	Electrical equipment	#437: Motor generator (alternating current power supply system)
	Electric circuit diagram	Three-phase alternating current system (circuit between motor generator and motor electronic control unit)
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P0A5F: UVW Over Current (warning lamp flashes: 12)

Generation condition		Three-phase alternating current is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	0B: U Current 0C: V Current 0D: W Current
	Electric circuit diagram	Three-phase alternating current system (circuit between motor generator and motor electronic control unit)
	Other	• Short-circuit in AC power supply system in motor electronic control unit or motor generator • Replacement of motor electronic control unit (inverter software abnormality)

P0A78: IPM Failure (warning lamp flashes: 13)

Generation condition		Abnormality in inverter
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	C1: IPU F0 Error C5: IPU Over Voltage C6: IPU Over Temp
	Other	• Inspection of trapped air and coolant leakage in high voltage cooling system • Replacement of motor electronic control unit (inverter software abnormality)

P0A90: Motor Torque Unmatch (warning lamp flashes: 32)

Generation condition		Difference between required motor generator torque (drive force) and actual motor generator torque (drive force) is at or above the specified value during motor generator control.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	04: Motor Actual Torque 11: Motor Demand Torque (Normal if they are the same.)
	Electric circuit diagram	Three-phase alternating current system (circuit between motor generator and motor electronic control unit)
	Other	Inspection of insulation resistance of motor electronic control unit, high voltage cable and motor generator (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.)

P0AA1: Main Contactor P&N Welded (warning lamp flashes: 09)

Generation condition		Adhesion of main contactor (+) is detected. (Seizure in ON condition)
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Service data	92: Main Contactor N ON/OFF 96: Main Contactor P ON/OFF
	Actuator test	A3: P0A7E happens A4: P1A51 happens
	Electronic control unit connector	04: Contactor signal (insulation resistance)
	Electric circuit diagram	Contactor system (circuit between motor electronic control unit and high voltage battery box)
	Other	• Replacement of high voltage battery box <When contactor is faulty> • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P0AD9: Main Contactor Driver Failure (warning lamp flashes: 08)

Generation condition		Inconsistency between main contactor (+) operation command and detected monitor signal
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Conduct the following inspection after performing troubleshooting of battery electronic control unit.	
	Service data	92: Main Contactor N ON/OFF 96: Main Contactor P ON/OFF
	Actuator test	A3: P0A7E happens A4: P1A51 happens
	Electronic control unit connector	02: High voltage battery box (power supply voltage of electronic control unit) 03: High voltage battery box (continuity of contactor) (See “TROUBLESHOOTING <BATTERY ELECTRONIC CONTROL UNIT>”.)
	Electric circuit diagram	Contactor system (circuit between motor electronic control unit and high voltage battery box)
	Other	• Replacement of high voltage battery box <When contactor is faulty> • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P0AE2: Precharge Contactor Welded (warning lamp flashes: 37)

Generation condition		When READY indicator lamp is on, smoothing capacitor voltage rises above the specified value during standby for pre-charge contactor to turn ON after main contactor ON.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Freeze frame data	03: Motor Speed
	Service data	97: Precharge Contactor ON/OFF
	Actuator test	A5: P0AFA happens
	Electronic control unit connector	04: Contactor signal (insulation resistance)
	Electric circuit diagram	Pre-charge contactor system (circuit between motor electronic control unit and high voltage battery box)
	Other	• Replacement of high voltage battery box <When contactor operation is faulty> • Replacement of motor electronic control unit (inverter software abnormality)

P0AE3: Smooth Capacitor Charge Shortage (warning lamp flashes: 05)

Generation condition		Voltage across smoothing capacitor is below the target charging voltage after pre-charge contactor ON.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor and pre-charge contactor OFF (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	92: Main Contactor N ON/OFF 97: Precharge Contactor ON/OFF (If they are both ON, abnormality of direct current high voltage system. If not, contactor abnormality.)

<Inspection of direct current high voltage system>

Inspection	Other	Perform troubleshooting of battery electronic control unit.
	Electric circuit diagram	Direct current high voltage system (circuit between high voltage battery box and motor electronic control unit)
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty)

<Inspection of contactor>

Inspection	Service data	92: Main Contactor N ON/OFF 97: Precharge Contactor ON/OFF
	Actuator test	A4: P1A51 happens A5: P0AFA happens
	Electronic control unit connector	03: High voltage battery box (continuity of contactor) (See “TROUBLESHOOTING <BATTERY ELECTRONIC CONTROL UNIT>”.)
	Electric circuit diagram	Contactor system (circuit between high voltage battery box and motor electronic control unit)
	Other	• Replacement of high voltage battery box <When contactor continuity is abnormal> • Replacement of motor electronic control unit (inverter internal circuit faulty)

P0AED: IPM Temp Sensor Failure (warning lamp flashes: 22)

Generation condition		Abnormality of temperature sensor in inverter
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	07: Inverter U Temperature 08: Inverter V Temperature 09: Inverter W Temperature
	Other	Replacement of motor electronic control unit (abnormality of temperature sensor in inverter or software)

P1A00: Smooth Capacitor Low Voltage (warning lamp flashes: 02)

Generation condition		Voltage across smoothing capacitor is below the specified value after main contactor (+) ON.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Conduct the following inspection after performing troubleshooting of battery electronic control unit.	
	Freeze frame data	02: Voltage
	Electric circuit diagram	Direct current high voltage system (circuit between high voltage battery box and motor electronic control unit)
	Other	• Replacement of high voltage battery box (high voltage battery voltage faulty) <Service data 02: Voltage> • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A01: Smooth Capacitor Over Voltage (warning lamp flashes: 03)

Generation condition		Voltage across smoothing capacitor is above the specified value after main contactor (+) ON.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator control immediately terminated. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	02: Voltage
	Other	• Perform troubleshooting of battery electronic control unit. • Replacement of high voltage battery box (high voltage battery voltage faulty) <Service data 02: Voltage> • Replacement of motor electronic control unit (inverter software abnormality)

P1A02: BCU Battery Low Voltage (warning lamp flashes: 04)

Generation condition		High voltage battery total voltage (via controller area network communication) is at or below the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	02: Voltage
	Other	• Perform troubleshooting of battery electronic control unit. • Replacement of high voltage battery box (high voltage battery box voltage faulty or battery electronic control unit faulty) <Service data 02: Voltage> • Replacement of motor electronic control unit (inverter software abnormality)

P1A03: 24V Battery Low Voltage (warning lamp flashes: 06)

Generation condition		Abnormality of battery direct power supply voltage
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	7A: P1A03 happens
	Electronic control unit connector	05: Power supply voltage of electronic control unit (battery direct power supply)
	Electric circuit diagram	Circuit between motor electronic control unit and battery
	Other	• Inspection of battery and alternator (See Gr54.) • Replacement of motor electronic control unit (inverter software abnormality)

P1A04: Smooth Capacitor Discharge Fail (warning lamp flashes: 07)

Generation condition		After discharge command, voltage across smoothing capacitor is above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Electric discharge command stopped. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	When another diagnosis code is issued, perform its troubleshooting.
	Freeze frame data	03: Motor Speed
		92: Main Contactor N ON/OFF 96: Main Contactor P ON/OFF (If they are both OFF, replace motor electronic control unit (internal circuit abnormality).)
	Service data	92: Main Contactor N ON/OFF 96: Main Contactor P ON/OFF
	Actuator test	A3: P0A7E happens A4: P1A51 happens
	Electronic control unit connector	04: Contactor signal (insulation resistance) 03: High voltage battery box (insulation resistance) (See “TROUBLESHOOTING <BATTERY ELECTRONIC CONTROL UNIT>”.)
	Electric circuit diagram	Contactor system (circuit between high voltage battery box and motor electronic control unit)
	Other	• Replacement of high voltage battery box (internal circuit faulty) <When insulation resistance of contactor signal is abnormal> • Replacement of motor electronic control unit (internal circuit faulty)

P1A05: Radiator Fan Driver Failure (warning lamp flashes: 11)

Generation condition		Inconsistency between blower motor operation command and detected monitor signal
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	74: Radiator Fan ON/OFF Monitor 89: Radiator Fan Relay ON/OFF
	Actuator test	A6: P1A52 happens
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A06: IPU Time Out (warning lamp flashes: 14)

Generation condition		Abnormality in battery electronic control unit
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of motor electronic control unit (inverter software abnormality)

P1A07: IPM U Temp Sensor Failure (warning lamp flashes: 19)

Generation condition		Abnormality of temperature sensor in inverter
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	07: Inverter U Temperature
	Other	Replacement of motor electronic control unit (abnormality of temperature sensor in inverter or software)

P1A08: IPM V Temp Sensor Failure (warning lamp flashes: 20)

Generation condition		Abnormality of temperature sensor in inverter
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	08: Inverter V Temperature
	Other	Replacement of motor electronic control unit (abnormality of temperature sensor in inverter or software)

P1A09: IPM W Temp Sensor Failure (warning lamp flashes: 21)

Generation condition		Abnormality of temperature sensor in inverter
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	09: Inverter W Temperature
	Other	Replacement of motor electronic control unit (abnormality of temperature sensor in inverter or software)

P1A0A: CAN NG Data Received (warning lamp flashes: 23)

Generation condition		Controller area network communication data reception is abnormal. (bus off status at transmission or reception; data out of range)
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Electronic control unit connector	02: Controller area network resistor
	Electrical equipment	#828: Controller area network resister
	Electric circuit diagram	Controller area network resistor system
	Other	• Inspection of controller area network transmission status of other electronic control units • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A0B: Motor Locked (warning lamp flashes: 25)

Generation condition		Inhibited value of torque (drive force) is beyond the specified value and motor speed is below the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Standby with 0% torque (drive force) command for motor generator. (Motor generator assist torque drops.)
Inspection	Freeze frame data	03: Motor Speed
	Electronic control unit connector	01: Motor generator (revolution sensor)
	Electrical equipment	#437: Motor generator (revolution sensor)
	Electric circuit diagram	Circuit between motor electronic control unit and motor generator
	Other	• Replacement of clutch housing and motor generator (motor generator broken) (See Gr22.) • Replacement of motor electronic control unit (inverter software abnormality)

P1A0C: Memory Failure (warning lamp flashes: 29)

Generation condition		Abnormality of inverter in motor electronic control unit is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A0D: Brake Pressure Sensor Failure (warning lamp flashes: 34)

Generation condition		Brake fluid pressure sensor voltage deviates from the specified value or is inconsistent with stop lamp signal (controller area network communication) during operation control.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		None
Inspection	Freeze frame data	1B: Brake Pressure Sensor Value
	Electrical equipment	#302: Brake fluid pressure sensor
	Electric circuit diagram	Circuit between motor electronic control unit and brake fluid pressure sensor
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A0E: Hill Start Input Failure (warning lamp flashes: 35)

Generation condition		Either of the following: • Abnormal motor requiring torque (power) while hill start assist system is operating • Operation of hill start assist system continues for a specified duration
Recoverability		Recovered if hill start assist system indicator lamp goes out.
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) Backup mode as: Brake pedal pressed: Hill start assist system operating; brake pedal released: Hill start assist system not operating. (Vehicle can run with hybrid electric system operation despite partial decline in function.)
Inspection	Freeze frame data	88: Hill start lamp ON/OFF
	Electronic control unit connector	06: Hill start assist system operation signal
	Electric circuit diagram	Circuit between motor electronic control unit and hill start assist system electronic control unit
	Other	• Hill start assist system (See Gr35EB.) • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A0F: STS CAN Failure (warning lamp flashes: 39)

Generation condition		Motor generator speed is at or above 1500 rpm and stop lamp switch information (controller area network communication) is abnormal.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication), amount of brake pedal depression fixed to 0. (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Freeze frame data	9B: Brake SW Input (CAN)
	Electrical equipment	#042: Stop lamp switch
	Electric circuit diagram	Circuit among motor electronic control unit, controller area network communication line, INOMAT-II electronic control unit and stop lamp switch
	Other	• When a diagnosis code related to controller area network communication is issued, perform its troubleshooting. • Inspection of controller area network transmission status of INOMAT-II electronic control unit and presence of diagnosis code related to stop lamp switch. (See Gr22E.) • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A10: P1A04 happens (warning lamp flashes: 40)

Generation condition		System was restarted after it is once terminated while diagnosis code P1A04: [Smooth Capacitor Discharge Fail (flashes: 07)] occurs.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Other	• When another diagnosis code is issued, perform its troubleshooting. • Check that this diagnosis code is not issued by turning the starter switch from OFF to ON. • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

P1A13: Motor Over Speed (warning lamp flashes: 43)

Generation condition		Motor generator speed is at or above the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Motor generator torque (drive force and regenerated force) is inhibited. (Vehicle can run with hybrid electric vehicle system operation.)
Inspection	Freeze frame data	03: Motor Speed
	Electrical equipment	#437: Motor generator (revolution sensor)
	Other	Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

U0001: CAN No Data Received (warning lamp flashes: 24)

Generation condition		No data received with controller area network communication
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Main contactor OFF after motor generator speed decreased. (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	17: INOMAT CAN Receive Time 18: BCU CAN Receive Time
	Electronic control unit connector	02: Controller area network resistor
	Electric circuit diagram	Controller area network resistor system
	Other	• Inspection of controller area network transmission status of other electronic control units • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

U3010: S Input Failure (warning lamp flashes: 33)

Generation condition		Abnormality of starter switch start signal is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication), engine started from starter. (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Freeze frame data	7B: S Input SW2 ON/OFF 86: S Input SW1 ON/OFF
	Electronic control unit connector	03: Starter switch start signal
	Electric circuit diagram	Starter switch start signal system (among motor electronic control unit, starter switch and battery)
	Other	• Inspection of starter switch (See Gr54.) • Replacement of motor electronic control unit (inverter internal circuit faulty or software abnormality)

4. Freeze Frame Data of Multi-Use Tester

- Freeze frame data is the value of service data at the generation of a diagnosis code.
- Multiple freeze frame data related to the generated diagnosis code can be accessed on Multi-Use Tester.
- For diagnostic criteria, see the table of service data.

5. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
01	Smooth Capacitor Voltage	■■■■. V	READY indicator lamp illuminates	235 to 430 V
02	Voltage	■■■■. V	READY indicator lamp illuminates	240 to 418 V
03	Motor Speed	■■■■. rpm	Vehicle stationary with shift lever in N position	Synchronous with tachometer
			Vehicle stationary with shift lever in D position	0 rpm
			Vehicle in motion	Synchronous with tachometer
04	Motor Actual Torque	■■■■. Nm	READY indicator lamp illuminates	Approximately consistent with required motor torque
05	Final Torque Instruction	■■■. ■ %	READY indicator lamp illuminates	–100 to 100%
06	Motor Stator Temperature	■■■. ■ °C	READY indicator lamp illuminates	Normal temperature to 140°C
07	Inverter U Temperature	■■■. ■ °C	READY indicator lamp illuminates	Normal temperature to 100°C
08	Inverter V Temperature	■■■. ■ °C	READY indicator lamp illuminates	Normal temperature to 100°C
09	Inverter W Temperature	■■■. ■ °C	READY indicator lamp illuminates	Normal temperature to 100°C
0A	Current Effect Value	■■■. ■ %	READY indicator lamp illuminates	0 to 130%
0B	U Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
0C	V Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
0D	W Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
0E	Resolver Input Value	■■■■.	–	–
0F	Last Resolver Input Value	■■■■.	–	–
10	Mode Sequence No.	■■■■. digit	–	–
11	Motor Demand Torque	■■■■. Nm	READY indicator lamp illuminates	Approximately consistent with actual motor torque
12	SOC *1	■■■. ■ %	READY indicator lamp illuminates	20 to 70%
13	Maximum Drive Torque	■■■■. Nm	–	–
14	Maximum Regenerate Torque	■■■■. Nm	–	–
15	Present Time	■■■■. ms	Displays time elapsed after power is supplied to motor electronic control unit	0 to 4080 ms
16	IPU Receive Time	■■■■. ms	Displays time elapsed after receiving data from inverter	0 to 4080 ms
17	INOMAT CAN Receive Time	■■■■. ms	Displays time elapsed after receiving data from INOMAT-II electronic control unit	0 to 4080 ms (normal if value increases)
18	BCU CAN Receive Time	■■■■. ms	Displays time elapsed after receiving data from battery electronic control unit	0 to 4080 ms (normal if value increases)
1A	Stator Temperature Input Value	■. ■■■ V	READY indicator lamp illuminates	0.9 V (140°C) to 4.6 V (10°C)
1B	Brake Pressure Sensor Value	■. ■■■ V	Brake pedal firmly pressed	Above 1.1 V
			Brake pedal released	Approx. 0.5 V

*1: High voltage battery state of charge

No.	Item	Data	Inspection condition	Requirement
1F	INOMAT CAN Over Range Time	■■■■. digit	INOMAT-II system normal	0 digit *
20	BCU CAN Over Range Time	■■■■. digit	Battery electronic control unit normal	0 digit *
21	CAN Bus Off Time	■■■■. digit	Controller area network communication normal	0 digit *
24	Shut Down Voltage	■■■■. V	–	–
25	Inverter U Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
26	Inverter V Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
27	Inverter W Current	■■■. ■ %	READY indicator lamp illuminates	–130 to 130%
28	Memory Trouble	■■■■.	–	–
72	Main Contactor ON/OFF Monitor	ON/OFF	READY indicator lamp illuminates	ON
			READY indicator lamp extinguished	OFF
73	Water Pump ON/OFF Monitor	ON/OFF	Motor generator temperature above 50°C	ON
			Cold	OFF
			[Actuator test] A7: Water Pump ON	
74	Radiator Fan ON/OFF Monitor	ON/OFF	Motor generator temperature above 80°C	ON
			Cold	OFF
			[Actuator test] A6: Radiator Fan ON	
75	Memory Clear SW ON/OFF	ON/OFF	Memory clear switch connected	ON
			Memory clear switch released	OFF
76	Diag SW ON/OFF	ON/OFF	Memory clear switch connected	ON
			Memory clear switch released	OFF
79	P0A3F happens	ON/OFF	Revolution sensor in motor generator abnormal	ON
			Revolution sensor in motor generator normal	OFF
7A	P1A03 happens	ON/OFF	Battery direct power supply abnormal	ON
			Battery direct power supply normal	OFF
7B	S Input SW2 ON/OFF	ON/OFF	Starter switch in START position	ON
			Other cases	OFF
86	S Input SW1 ON/OFF	ON/OFF	Starter switch in START position	ON
			Other cases	OFF
87	M Input SW ON/OFF	ON/OFF	Starter switch in ON position	ON
			Other cases	OFF
88	Hill Start Lamp ON/OFF	ON/OFF	Hill start indicator lamp illuminates	ON
			Hill start indicator lamp extinguished	OFF
89	Radiator Fan Relay ON/OFF	ON/OFF	Motor generator temperature above 80°C	ON
			Cold	OFF
			[Actuator test] A6: Radiator Fan ON	
92	Main Contactor N ON/OFF	ON/OFF	READY indicator lamp illuminates	ON
			READY indicator lamp extinguished (Hybrid electric vehicle system operation inhibited)	OFF
			[Actuator test] A4: Main Contactor N ON	
93	Capacitor Discharge FET ON/OFF	ON/OFF	–	–
96	Main Contactor P ON/OFF	ON/OFF	READY indicator lamp illuminates	ON
			READY indicator lamp extinguished (Hybrid electric vehicle system operation inhibited)	OFF
			[Actuator test] A3: Main Contactor P ON	

*digit: number of times

No.	Item	Data	Inspection condition	Requirement
97	Precharge Contactor ON/OFF	ON/OFF	Immediately after starter switch ON (approx. 1 second)	ON
			Other cases	OFF
			[Actuator test] A5: Precharge Contactor ON	
98	Water Pump Relay ON/OFF	ON/OFF	Motor generator temperature above 50°C	ON
			Cold	OFF
			[Actuator test] A7: Water Pump ON	
99	BCU OK Flug ON/OFF	ON/OFF	READY indicator lamp illuminates	ON
			READY indicator lamp extinguished (diagnosis code related to high voltage battery abnormality issued)	OFF
9A	BCU NG Flug ON/OFF	ON/OFF	READY indicator lamp extinguished (diagnosis code related to high voltage battery abnormality issued)	ON
			READY indicator lamp illuminates	OFF
9B	Brake SW Input (CAN)	ON/OFF	Brake pedal pressed	ON
			Brake pedal not pressed	OFF
9C	S Input History	ON/OFF	Starter switch placed in START position more than once after starter switch ON	ON
			Other cases	OFF
A2	P0AC2 happens	ON/OFF	Diagnosis code P0AC2 (52) issued	ON
			Other cases	OFF
A3	P0A7E happens	ON/OFF	Diagnosis code P0A7E (53) issued	ON
			Other cases	OFF
A4	P1A51 happens	ON/OFF	Diagnosis code P0A51 (54) issued	ON
			Other cases	OFF
A5	P0AFA happens	ON/OFF	Diagnosis code P0AFA (55) issued	ON
			Other cases	OFF
A6	P1A52 happens	ON/OFF	Diagnosis code P1A52 (56) issued	ON
			Other cases	OFF
A7	P1A53 happens	ON/OFF	Diagnosis code P1A53 (57) issued	ON
			Other cases	OFF
A8	P0AFB happens	ON/OFF	Diagnosis code P0AFB (58) issued	ON
			Other cases	OFF
AA	P0AC3 happens	ON/OFF	Diagnosis code P0AC3 (60) issued	ON
			Other cases	OFF
AB	P1A54 happens	ON/OFF	Diagnosis code P1A54 (61) issued	ON
			Other cases	OFF
AC	P1A55 happens	ON/OFF	Diagnosis code P1A55 (62) issued	ON
			Other cases	OFF
AD	P1A56 happens	ON/OFF	Diagnosis code P1A56 (63) issued	ON
			Other cases	OFF
AF	P0AA6 happens	ON/OFF	Diagnosis code P0AA6 (65) issued	ON
			Other cases	OFF
B0	P1A57 happens	ON/OFF	Diagnosis code P1A57 (66) issued	ON
			Other cases	OFF
B1	P1A58 happens	ON/OFF	Diagnosis code P1A58 (67) issued	ON
			Other cases	OFF
B2	P1A59 happens	ON/OFF	Diagnosis code P1A59 (68) issued	ON
			Other cases	OFF
B3	P1A60 happens	ON/OFF	Diagnosis code P1A60 (69) issued	ON
			Other cases	OFF
B5	P1A62 happens	ON/OFF	Diagnosis code P1A62 (71) issued	ON
			Other cases	OFF

No.	Item	Data	Inspection condition	Requirement
B6	P1A63 happens	ON/OFF	Diagnosis code P1A63 (72) issued	ON
			Other cases	OFF
B8	P1A65 happens	ON/OFF	Diagnosis code P1A65 (74) issued	ON
			Other cases	OFF
B9	P1A66 happens	ON/OFF	Diagnosis code P1A66 (75) issued	ON
			Other cases	OFF
BA	P1A67 happens	ON/OFF	Diagnosis code P1A67 (76) issued	ON
			Other cases	OFF
BB	P1A68 happens	ON/OFF	Diagnosis code P1A68 (77) issued	ON
			Other cases	OFF
C1	IPU FO Error	ON/OFF	Any one of them possibly ON when diagnosis code P0A1B (28) “CPU Failure” issued	ON
				OFF
C2	IPU Temp Sensor W Error	ON/OFF		ON
				OFF
C3	IPU Temp Sensor V Error	ON/OFF		ON
				OFF
C4	IPU Temp Sensor U Error	ON/OFF		ON
				OFF
C5	IPU Over Voltage	ON/OFF		ON
				OFF
C6	IPU Over Temp	ON/OFF		ON
				OFF
CD	Torque Reduction (No.1–2)	ON/OFF	Any one of them possibly ON when output limitation warning lamp illuminates	ON
				OFF
CE	Torque Reduction (No.3–4)	ON/OFF		ON
				OFF
CF	Torque Reduction (No.5)	ON/OFF		ON
				OFF
D0	Torque Reduction (No.6–10)	ON/OFF		ON
				OFF
D1	Torque Reduction (No.11)	ON/OFF		ON
				OFF
E1	d Output Torque Reduction	ON/OFF		ON
				OFF
E2	d Integration Torque Reduction	ON/OFF		ON
				OFF
E3	q Output Torque Reduction	ON/OFF		ON
				OFF
E4	q Integration Torque Reduction	ON/OFF		ON
				OFF
E6	U Duty Torque Reduction	ON/OFF		ON
				OFF
E7	V Duty Torque Reduction	ON/OFF		ON
				OFF
E8	W Duty Torque Reduction	ON/OFF		ON
				OFF

6. Actuator Tests Performed Using Multi-Use Tester

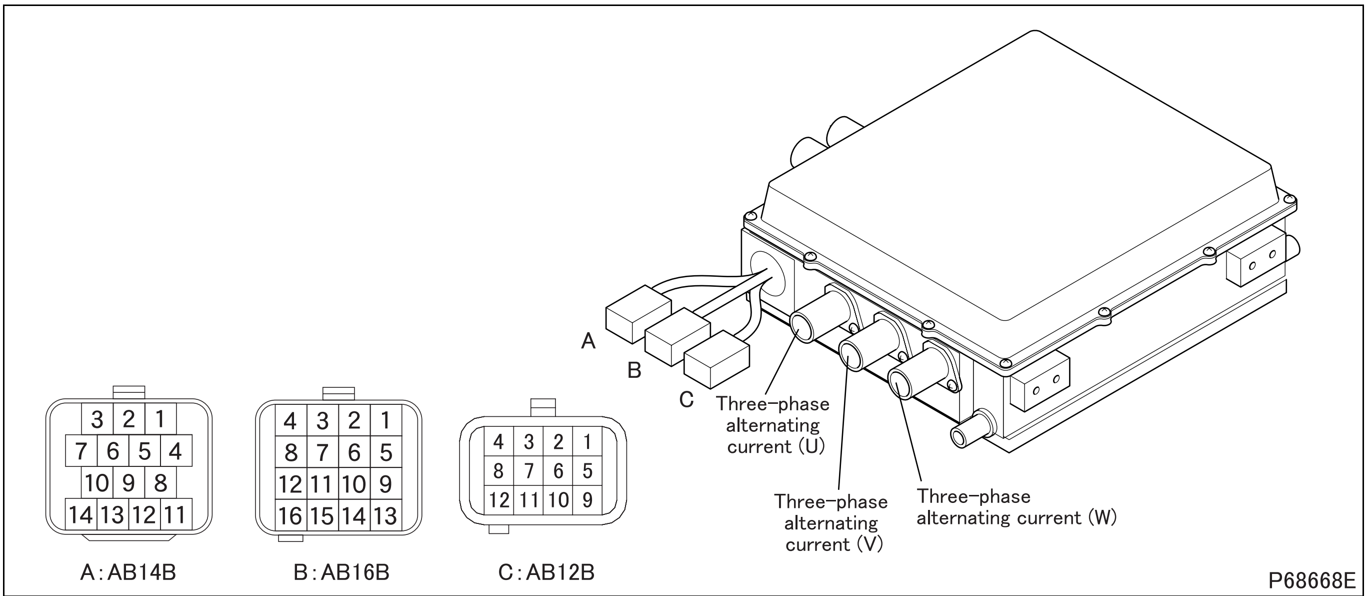
- It is possible to see service data and actuator tests simultaneously.

No.	Item	Explanation	Confirmation method
A1	Motor Drive	Motor generator activated (automatically stopped when high voltage battery state of charge reaches 30%) [Can be executed when the following conditions are satisfied] • READY indicator lamp illuminates • Engine idling (motor generator speed 500 to 1000 rpm) • 20 seconds after shift lever placed in N position • Actuator test No. A1 and A2 not activated simultaneously	Check that engine and motor generator speed increases. [Service data] 03: Motor Speed
A2	Motor Regenerate	Charging from driven motor generator (automatically stopped when high voltage battery state of charge reaches 60%) [Can be executed when the following conditions are satisfied] • READY indicator lamp illuminates • Engine idling (motor generator speed 500 to 1000 rpm) • 20 seconds after shift lever placed in N position • Actuator test No. A1 and A2 not activated simultaneously	Check that the following service data value increases (high voltage battery state of charge). [Service data] 12: SOC
A3	Main Contactor P ON	Main contactor (+) connected (automatic reset after 6 seconds) [Can be executed when the following conditions are satisfied] • Safety plug disconnected (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.) • Two or more of actuator tests No. A3, A4 and A5 not activated simultaneously	Check that operation sound of main contactor (+) in high voltage battery box is noted. [Service data] 96: Main Contactor P ON/OFF
A4	Main Contactor N ON	Main contactor (–) connected (automatic reset after 6 seconds) [Can be executed when the following conditions are satisfied] • Safety plug disconnected (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.) • Two or more of actuator tests No. A3, A4 and A5 not activated simultaneously	Check that operation sound of main contactor (–) in high voltage battery box is noted. [Service data] 92: Main Contactor N ON/OFF
A5	Precharge Contactor ON	Pre-charge contactor connected (automatic reset after 6 seconds) [Can be executed when the following conditions are satisfied] • Safety plug disconnected (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.) • Two or more of actuator tests No. A3, A4 and A5 not activated simultaneously	Check that operation sound of pre-charge contactor in high voltage battery box is noted. [Service data] 97: Precharge Contactor ON/OFF
A6	Radiator Fan ON	Blower motor activated (automatic reset after 6 seconds)	Check visually or with operation sound that blower motor operates. [Service data] 89: Radiator Fan Relay ON/OFF
A7	Water Pump ON	Water pump activated (automatic reset after 10 minutes)	• Check with operation sound that water pump operates. • Used for air bleeding of high voltage cooling system. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.) [Service data] 98: Water Pump Relay ON/OFF

7. Inspections Performed at Electronic Control Unit Connectors

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

7.1 Electronic control unit connector terminal layout



7.2 Inspection instructions

- Inspections are performed with the connector removed because of the water and dust-proof connector.

CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

Check item	Measurement method
01 Resistance of motor generator	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] <Temperature sensor in motor generator> Terminals: A9-A10 • 0°C: 144.0 to 182.5 kΩ • 5°C: 112.3 to 140.8 kΩ • 10°C: 88.2 to 109.5 kΩ • 15°C: 69.8 to 85.8 kΩ • 20°C: 55.7 to 67.8 kΩ • 25°C: 44.7 to 53.9 kΩ • 30°C: 36.1 to 43.2 kΩ <Revolution sensor in motor generator> Terminals: A3-A7: 30.2 ± 6.0 Ω A2-A6: 33.8 ± 6.8 Ω A1-A5: 12.3 ± 2.5 Ω <Motor generator alternating power supply system (U, V and W)> * Regarding disconnection of high voltage cable, see “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”. Terminals: U-V, V-W and W-U: 0.028 ± 0.003 Ω (at 20°C)

Check item	Measurement method
02 Resistance of controller area network resistor	[Conditions] • Starter switch OFF • Disconnect engine electronic control unit from motor electronic control unit at connector and check at vehicle side harness. [Requirements] Terminals: A12-A13: 120 ± 6 Ω
03 Voltage of starter switch start signal	[Conditions] • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals (+)-(–): C3 or B16-C9 • Starter switch START position: Approx. 24 V • Starter switch except START position: 0 V
04 Insulation resistance of contactor signal	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on electronic control unit-side connector. [Requirements] Terminals (+)-(–): B10, B11 or B12-chassis ground: There is no continuity.
05 Power supply voltage of electronic control unit	[Conditions] • Disconnect connector. Perform inspection on vehicle-side connector. [Requirements] Terminals (+)-(–): C1 or C2-C9: Approx. 24 V
06 Voltage of hill start assist system operation signal	[Conditions] • Starter switch ON • Disconnect harness from electronic control unit. Perform inspection on vehicle-side connector. [Requirements] Terminals (+) - (–): B15-C9 • Hill start assist system operating: 0 V • Hill start assist system not operating: Approx. 24 V

8. Possible Causes of Symptoms

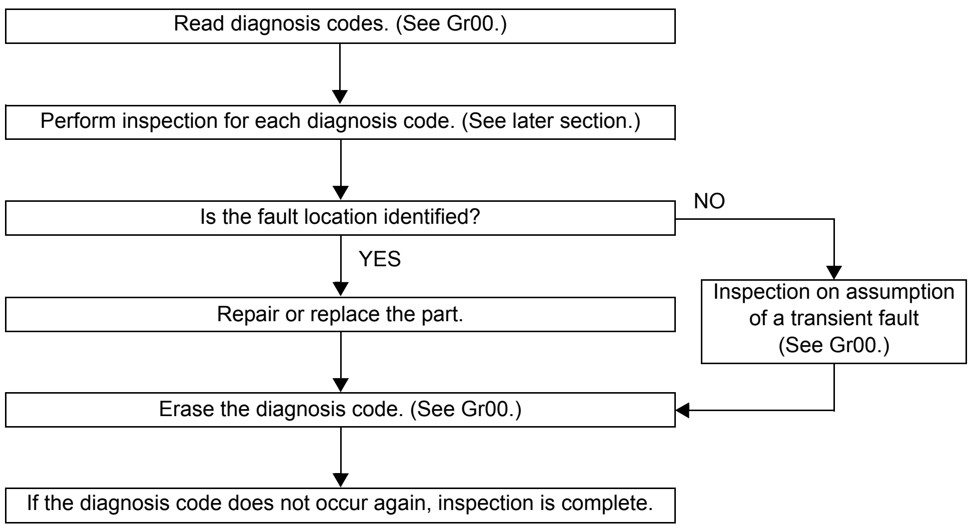
Warning lamp lights frequently during output limiting condition	

Possible causes	• High-voltage system cooling system
	  • Insufficient air bleeding
	  • Insufficient coolant
	  • Faulty water pump
	  • Faulty blower motor
	  • Clogged radiator
	• High-voltage battery box
	  • Clogged air filter
	  • Faulty battery cooling fan
	  • Clogged air outlet of high-voltage battery box
	  • Battery in high-voltage battery box expired (if service data No. 16: 59-1 is 300% or higher)

TROUBLESHOOTING <BATTERY ELECTRONIC CONTROL UNIT>

1. Diagnosis Procedure

- Perform the inspection in accordance with the following flowchart.



2. Diagnostic Precautions

WARNING ⚠

- **When removing the high voltage cable (orange), see “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT” and perform maintenance in an appropriate manner.**

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

3. Inspections Based on Diagnosis Codes

3.1 Diagnosis code list

- Diagnosis codes shown by the Multi-Use Tester and those indicated by flashing of the warning lamp are different.
- Diagnosis codes for the battery electronic control unit (except minor faults (codes with ☆ or ★)) are sent to the meter cluster via the motor electronic control unit. These codes are checked with diagnosis switch operation of the motor electronic control unit or Multi-Use Tester.
- Some diagnosis codes (minor faults (codes with ☆ or ★)) do not cause the warning lamp to illuminate when they occurs. In addition, they cannot be checked with the diagnosis switch operation of the motor electronic control unit. Use Multi-Use Tester to check them.
- Some diagnosis codes (codes with ★) detect minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

Code	Message	Flashes	Warning lamp indication
P0A7E	Over Temp	53	O
P0AA6	Leak	65	O
P0AC2	Over Current	52	O
P0AC3	Current Sensor Failure	60	O
P0AFA	Over Discharge	55	O
P0AFB	Over Charge	58	O
P1A51	Cell Over Discharge	54	O
P1A52	Cell Over Charge Signal	56	O
P1A53	Cell Over Charge	57	O
P1A54	Current/Voltage Unmatch	61	O
P1A55	Initial Voltage Failure	62	O
P1A56	CC Communication Failure	63	O
P1A57	CAN Receive Failure	66	O
P1A58	CAN Transmit Failure	67	O
P1A59	CAN Bus Off	68	O
P1A60	CAN Initialize Failure	69	O

Code	Message	Flashes	Warning lamp indication
P1A62	CC Balancing SW Failure	71	O
P1A63	CC Sensing Line Failure	72	O
P1A65	Temp Sensor Failure	74	O
P1A66	Voltage Sensor Failure	75	O
P1A67	CC IC Number Unmatch	76	O
P1A68	Cell Voltage Unbalance	77	O
P1A69	☆Leak Sensor Failure	–	O
P1A70	☆12V Low Voltage	–	–
P1A71	☆12V Over Voltage	–	–
P1A72	Cooling Fan Failure	–	O
P1A73	★Over Temp Warning	–	–
P1A74	★Cell Low Voltage Warning	–	–
P1A75	★Low Voltage Warning	–	–
P1A76	★Cell Over Voltage Warning	–	–
P1A77	★Over Voltage Warning	–	–
P1A78	EEPROM Failure	–	O

3.2 Diagnosis code generation conditions and inspection items

P0A7E Over Temp (warning lamp flashes: 53)

Generation condition		High voltage battery temperature is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with IN-OMAT-II.)
Inspection	Freeze frame data	03: Battery Highest Temp
	Other	• Inspection of air filter in high voltage battery box (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.) • Replacement of high voltage battery box (internal circuit faulty) <Service data 03: Battery Highest Temp>

P0AA6: Leak (warning lamp flashes: 65)

Generation condition		Battery electronic control unit detects high voltage battery current leakage in direct current high voltage system or three-phase alternating current system.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Electric circuit diagram	• Three-phase alternating current system (circuit between motor generator and motor electronic control unit) • Direct current high voltage system (circuit between high voltage battery box and motor electronic control unit)
	Other	• Inspection of insulation resistance of motor electronic control unit, high voltage cable and motor generator (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.) • Replace high voltage battery box if insulation resistance of motor electronic control unit, high voltage cable and motor generator is normal.

P0AC2: Over Current (warning lamp flashes: 52)

Generation condition		Detected value of current sensor is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	02: Battery Current
	Other	Replace high voltage battery box (internal circuit faulty). If the fault still remains, replace motor electronic control unit.

P0AC3: Current Sensor Failure (warning lamp flashes: 60)

Generation condition		Abnormality of current sensor is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P0AFA: Over Discharge (warning lamp flashes: 55)

Generation condition		High voltage battery total voltage is at or below the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	01: Battery Full Voltage 05: SOC
	Other	• Replace clutch housing and motor generator (See Gr22.) when service data 05: SOC decreases during engine idling. If the fault still remains, replace motor electronic control unit. • Replacement of high voltage battery box (internal circuit faulty)

P0AFB: Over Charge (warning lamp flashes: 58)

Generation condition		High voltage battery total voltage is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	01: Battery Full Voltage 05: SOC
	Other	• Replace clutch housing and motor generator (See Gr22.) when service data 05: SOC decreases during engine idling. If the fault still remains, replace motor electronic control unit. • Replacement of high voltage battery box (internal circuit faulty)

P1A51: Cell Over Discharge (warning lamp flashes: 54)

Generation condition		Over discharge of cell voltage (via cell controller) is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	05: SOC
	Other	• Replace clutch housing and motor generator (See Gr22.) when service data 05: SOC decreases during engine idling. If the fault still remains, replace motor electronic control unit. • Replacement of high voltage battery box (internal circuit faulty)

P1A52: Cell Over Charge Signal (warning lamp flashes: 56)

Generation condition		Maximum cell voltage (via overvoltage detection line) is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	05: SOC
	Other	• Replace clutch housing and motor generator (See Gr22.) when service data 05: SOC decreases during engine idling. If the fault still remains, replace motor electronic control unit. • Replacement of high voltage battery box (internal circuit faulty)

P1A53: Cell Over Charge (warning lamp flashes: 57)

Generation condition		Maximum cell voltage (via cell controller) is at or above the specified value.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Freeze frame data	05: SOC
	Other	• Replace clutch housing and motor generator (See Gr22.) when service data 05: SOC decreases during engine idling. If the fault still remains, replace motor electronic control unit. • Replacement of high voltage battery box (internal circuit faulty)

P1A54: Current/Voltage Unmatch (warning lamp flashes: 61)

Generation condition		High voltage battery total voltage remains unchanged when high voltage battery current value has changed.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A55: Initial Voltage Failure (warning lamp flashes: 62)

Generation condition		Abnormality of continuity in overvoltage detection line in cell controller is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A56: CC Communication Failure (warning lamp flashes: 63)

Generation condition		Abnormality of cell controller communication is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A57: CAN Receive Failure (warning lamp flashes: 66)

Generation condition		Reception abnormality of controller area network communication with motor electronic control unit
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Electronic control unit connector	01: Controller area network resistor
	Electric circuit diagram	Controller area network resistor system
	Other	• Inspection of controller area network transmission status of motor electronic control unit (if abnormal, replacement of motor electronic control unit) • Replacement of high voltage battery box (internal circuit faulty)

P1A58: CAN Transmit Failure (warning lamp flashes: 67)

Generation condition		Transmission abnormality of controller area network communication
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A59: CAN Bus Off (warning lamp flashes: 68)

Generation condition		Abnormality of controller area network communication circuit in battery electronic control unit
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A60: CAN Initialize Failure (warning lamp flashes: 69)

Generation condition		Abnormality of controller area network communication circuit in battery electronic control unit
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A62: CC Balancing SW Failure (warning lamp flashes: 71)

Generation condition		Abnormality of cell controller is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A63: CC Sensing Line Failure (warning lamp flashes: 72)

Generation condition		Abnormality of cell controller is detected when power is supplied.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A65: Temp Sensor Failure (warning lamp flashes: 74)

Generation condition		Abnormality of cell controller is detected.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A66: Voltage Sensor Failure (warning lamp flashes: 75)

Generation condition		Inconsistency between high voltage battery total voltage (detected by battery electronic control unit) and the sum of cell voltages (via cell controller)
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	• Check safety plug for mounting condition. • Replacement of high voltage battery box (internal circuit faulty)

P1A67: CC IC Number Unmatch (warning lamp flashes: 76)

Generation condition		Abnormality of cell controller is detected when power is supplied.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A68: Cell Voltage Unbalance (warning lamp flashes: 77)

Generation condition		Difference between state of charge of each cell and its average value is at or above the specified value when power is supplied.
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Charge and discharge inhibited (Hybrid electric vehicle system operation inhibited, vehicle can run only with INOMAT-II.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A69: Leak Sensor Failure

Generation condition		Abnormality in battery electronic control unit
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A70: 12V Low Voltage

Generation condition		Battery electronic control unit power supply voltage (24 V system, stepped down to 12 V in high voltage battery box) is at or below the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Electronic control unit connector	02: Electronic control unit power supply voltage
	Electric circuit diagram	Circuit between high voltage battery box and battery
	Other	• Inspection of battery and alternator (See Gr54.) • Replacement of high voltage battery box (internal circuit faulty)

P1A71: 12V Over Voltage

Generation condition		Battery electronic control unit power supply voltage (24 V system, stepped down to 12 V in high voltage battery box) is at or above the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Electronic control unit connector	02: Electronic control unit power supply voltage
	Electric circuit diagram	Circuit between high voltage battery box and battery
	Other	• Inspection of battery and alternator (See Gr54.) • Replacement of high voltage battery box (internal circuit faulty)

P1A72: Cooling Fan Failure

Generation condition		Inconsistency between battery cooling fan operating signal and monitor signal
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

P1A73: Over Temp Warning

Generation condition		High voltage battery temperature is at or above the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Other	This diagnosis code detects minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

P1A74: Cell Low Voltage Warning

Generation condition		Minimum cell voltage (via cell controller) is at or below the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Other	This diagnosis code detects minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

P1A75: Low Voltage Warning

Generation condition		High voltage battery total voltage is at or below the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Other	This diagnosis code detects minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

P1A76: Cell Over Voltage Warning

Generation condition		Cell voltage (via cell controller) is at or above the specified value or abnormal.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Other	This diagnosis code detects minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

P1A77: Over Voltage Warning

Generation condition		High voltage battery total voltage is at or above the specified value.
Recoverability		Recovered if signal becomes normal with starter switch in ON position.
Control effected by electronic control unit		Charge and discharge temporarily inhibited (Upon recovery, hybrid electric vehicle system operation resumed)
Inspection	Other	This diagnosis code detects minor changes in condition. Inspection is not required since the condition returns to normal after some driving.

P1A78: EEPROM Failure

Generation condition		Abnormality in battery electronic control unit
Recoverability		Recovered if signal becomes normal when starter switch is turned OFF to ON (power supply resumed to electronic control unit).
Control effected by electronic control unit		Transmission to each electronic control unit (controller area network communication) (Vehicle can run with hybrid electric vehicle system operation despite partial decline in function.)
Inspection	Other	Replacement of high voltage battery box (internal circuit faulty)

4. Freeze Frame Data of Multi-Use Tester

- Freeze frame data is the value of service data at the generation of a diagnosis code.
- Multiple freeze frame data related to the generated diagnosis code can be accessed on Multi-Use Tester.
- For diagnostic criteria, see the table of service data.

5. Multi-Use Tester Service Data

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

No.	Item	Data	Inspection condition	Requirement
01	Battery Full Voltage	■■■■. V	READY indicator lamp illuminates	240 to 418 V
02	Battery Current	■■■■. A	Engine stopped	0 A
			READY indicator lamp illuminates	–130 to 130 A
03	Battery Highest Temp	■■■■. °C	READY indicator lamp illuminates	Normal temperature to 65°C
04	Battery Lowest Temp	■■■■. °C	READY indicator lamp illuminates	Normal temperature to 65°C
05	SOC	■■■. ■ %	READY indicator lamp illuminates	20 to 70%
06	SOH	■■■■. %	READY indicator lamp illuminates	100 to 300%
07	Battery Discharge Enable Power	■■■. ■ kW	–	–
08	Battery Charge Enable Power	■■■. ■ kW	–	–
09	Cell Average Voltage	■■■■. mV	READY indicator lamp illuminates	2700 to 4100 mV
0A	Cell Highest Voltage	■■■■. mV	READY indicator lamp illuminates	2500 to 4250 mV
0B	Highest Voltage Cell No.	■■■■.	–	1 to 96
0C	Cell Lowest Voltage	■■■■. mV	READY indicator lamp illuminates	2500 to 4250 mV
0D	Lowest Voltage Cell No.	■■■■.	–	1 to 96

*1: High voltage battery state of charge
*2: High voltage battery state of health

6. Actuator Tests Performed Using Multi-Use Tester

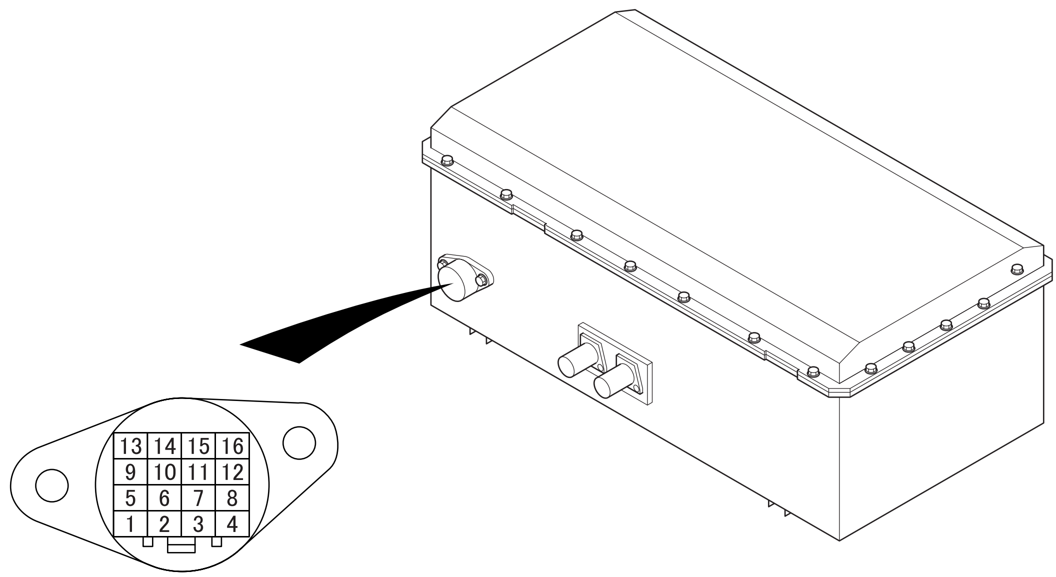
- It is possible to see service data and actuator tests simultaneously.

No.	Item	Explanation	Confirmation method
A1	Cooling Fan Active	Battery cooling fan activated (automatic reset after 10 seconds)	Check with operation sound that cooling fan operates.

7. Inspections Performed at Electronic Control Unit Connectors

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

7.1 Electronic control unit connector terminal layout



7.2 Inspection instructions

- Inspections are performed with the connector removed because of the water and dust-proof connector.
- Battery electronic control unit is checked at the connector of high voltage battery box.

CAUTION ⚠

- **Do not touch any terminal except those specified for the inspection. Be particularly careful not to cause short circuits between terminals using the tester probes.**

Check item	Measurement method
01 Resistance of controller area network resistor	[Conditions] • Starter switch OFF • Disconnect engine electronic control unit from high voltage battery box at connector and check at vehicle side harness of high voltage battery box. [Requirements] Terminals: 7-8: 120 ± 6 Ω
02 Power supply voltage of electronic control unit	[Conditions] • Disconnect connector. Perform inspection on vehicle-side connector of high voltage battery box. [Requirements] <Battery direct power supply> Terminals: 3-1 and 6-1: Approx. 24 V <Starter switch ON power supply> Terminals: 2-1 • Starter switch ON: Approx. 24 V • Starter switch OFF: 0 V
03 Continuity and insulation resistance of contactor	[Conditions] • Starter switch OFF • Disconnect connector. Perform inspection on vehicle-side connector of high voltage battery box. [Requirements] <Continuity> Terminals: 9, 10 or 11-6: There is continuity. <Insulation resistance> Terminals: 9, 10 or 11-chassis ground: There is no continuity.

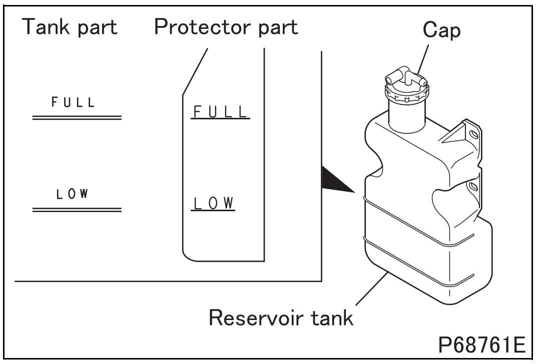
8. Possible Causes of Symptoms

Warning lamp lights frequently during output limiting condition	

Possible causes	• High-voltage system cooling system
	  • Insufficient air bleeding
	  • Insufficient coolant
	  • Faulty water pump
	  • Faulty blower motor
	  • Clogged radiator
	• High-voltage battery box
	  • Clogged air filter
	  • Faulty battery cooling fan
	  • Clogged air outlet of high-voltage battery box
	  • Battery in high-voltage battery box expired (if service data No. 16: 59-1 is 300% or higher)

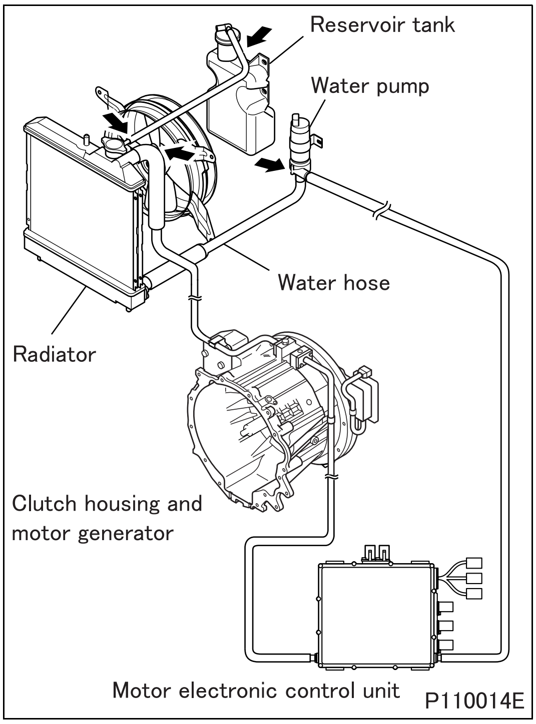
ON-VEHICLE INSPECTION AND ADJUSTMENT

1. Inspection of Coolant Level



- Inspection should be performed before starting the engine when the coolant is cold.
- Check that the coolant level in the reservoir tank is between “FULL” and “LOW” lines.
- If the coolant level is below “LOW” line, check the cooling system for leakage. If no leakage is found, add coolant up to “FULL” line.
  Be sure to use the mixture of FUSO DIESEL LONG LIFE COOLANT and water in appropriate concentration to prevent freezing of the coolant and corrosion of the cooling system. (For details, see Owner’s Handbook.)
- If the coolant level is extremely low or it lowers instantly after refilling, check the cooling system for leakage.

2. Inspection of Coolant Leakage



- After driving, check the radiator, reservoir tank, water pump, water hose, motor electronic control unit, etc. for coolant leakage with the engine idling.
- If any leakage is found, check the related parts for installation condition. If any loose part is found, tighten to the specified torque. If any cracked or damaged part is found, replace the part. (See the following.)

3. Coolant Replacement of High Voltage Cooling System

Tightening torque (Unit: N·m {kgf·m})

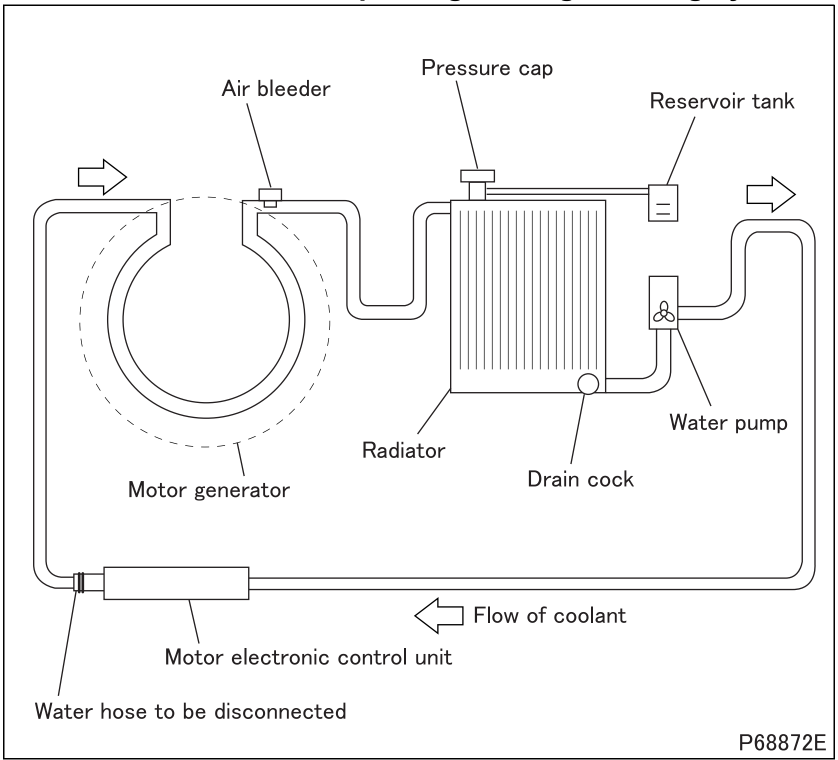
Mark	Parts to be tightened	Tightening torque	Remarks
–	Drain cock	1.0 ± 0.5 {0.1 ± 0.05}	–
	Air bleeder	34.3 ± 4.9 {3.5 ± 0.5}	–

Lubricant and/or sealant

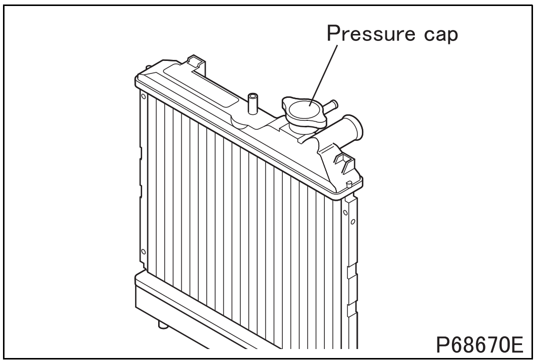
Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Cap fitting port in radiator	Engine coolant	★ 5.3 dm^3 {5.3 L}
–	Thread area of air bleeder	ThreeBond 1105	As required

★: Reference value (Actually, coolant cannot be drained off completely.)

3.1 Positional relationship of high voltage cooling system



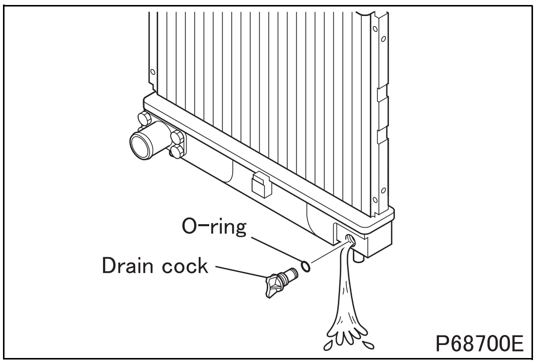
3.2 Draining



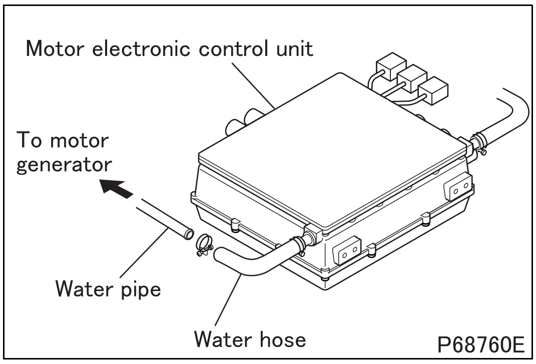
- Remove the pressure cap of the radiator.

CAUTION ⚠

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



- Open the radiator drain cock to drain coolant around the radiator.



- Disconnect the water hose (between the motor electronic control unit and the motor generator) of the motor electronic control unit.
- Coolant around the motor electronic control unit is drained.
- To drain coolant in the motor generator, apply air pressure to the water pipe on the motor generator side.

3.3 Cleaning

CAUTION ⚠

- **Do not use hard water as it causes scaling and rust.**

Required properties of soft water

Total hardness	300 ppm or less
Sulfate SO_4^{-}	100 ppm or less
Chloride Cl^{-}	100 ppm or less
Total dissolved solids	500 ppm or less
pH	6 to 8

- Using the radiator for extended periods of time without cleaning can increase chance of rust and scale formation, which may cause poor cooling. The cooling system must be cleaned periodically.
- In cases where a great amount of rust has accumulated it is common for the radiator to leak as a result of cleaning. Conduct a through check for leakage after cleaning.
- Reinstall the drain cock and water pipe removed in Section 3.2.
- Connect Multi-Use Tester. (See Gr00.)
- Select an appropriate cleaning method according to the condition of the cooling system as shown below.

- Ordinary condition

Flushing with water.

- Coolant extremely dirty
- Radiator clogged

Cleaning using FUSO RADIATOR CLEANER (RADIPET-7).

Make water solution of FUSO RADIATOR CLEANER (RADIPET-7) at 5 to 10% concentration in volume.

Pour solution into the radiator from the pressure cap fitting port.

Perform actuator test No. A7 “Water Pump ON” (automatically terminated in 10 minutes) once.

CAUTION ⚠

- **Limit the engine idling period to one hour. Operating an engine containing the cleaning solution for longer time may lead to damage of the cooling system.**

Drain out coolant. (See section 3.2.)

Pour tap water into the radiator from the pressure cap fitting port.

Perform actuator test No. A7 “Water Pump ON” (automatically terminated in 10 minutes) once.

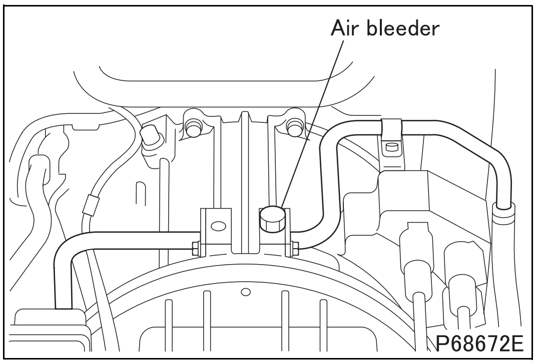
Drain out water. (See section 3.2.)

Cleaning is complete if drained water is clear.
Repeat procedure if drained water is not clear.

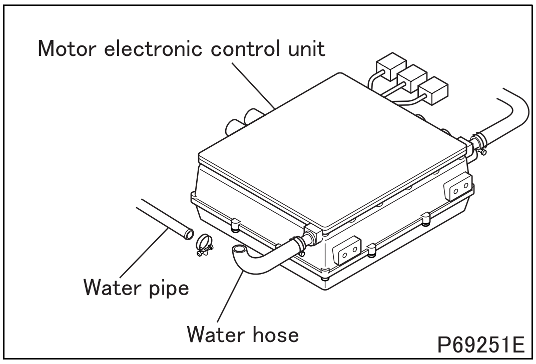
CAUTION ⚠

- **After cleaning the cooling system using cleaning solution, fill it with coolant as soon as possible.**

3.4 Filling and air bleeding



- After draining the coolant (or tap water if used for cleaning), fit the drain cock.
- Disconnect the water hose and remove the air bleeder on top of the motor generator.



- Turn up the end of the water hose.
- Pour coolant from the pressure cap port while performing actuator test No. A7 “Water pump ON” (automatically terminated in 10 minutes).

CAUTION ⚠

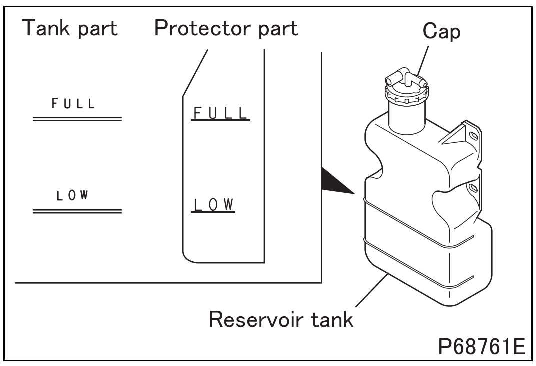
- **To prevent freezing of the coolant and corrosion of the cooling system, be sure to use the mixture of FUSO DIESEL LONG LIFE COOLANT and water with appropriate concentration. (See Owner’s Handbook for details.)**

- When coolant comes out from the water hose, connect the water hose to the water pipe.

CAUTION ⚠

- **If the end of the water hose is not turned up, a large amount of air may be trapped in the motor electronic control unit.**

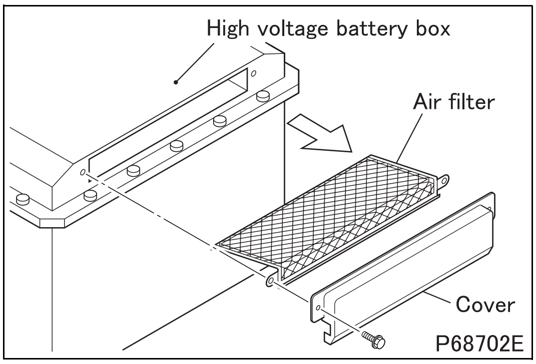
- When coolant comes out from the air bleeder port, fit the air bleeder.
- Pour the coolant up to the pressure cap port.
- Perform actuator test No. A7 “Water Pump ON” (automatically terminated in 10 minutes) twice so that coolant circulates through the cooling system for a total of 20 minutes for air bleeding.
- If the coolant level at the pressure cap port lowers, pour the additional coolant until the radiator is filled with coolant up to the brim of the pressure cap port. Then, fit the pressure cap.
- Remove the cap from the reservoir tank and pour coolant into it up to the “FULL” line.



4. Inspection of Air Filter in High Voltage Battery Box

Lubricant and/or sealant

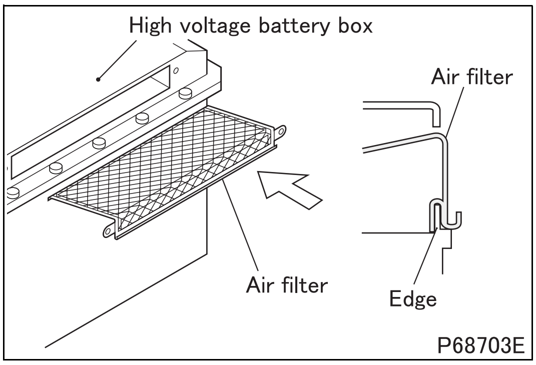
Mark	Points of application	Specified lubricant and/or sealant	Quantity
–	Cover contact surface with high voltage battery box	Shinetsu Silicones KE45T or Service Kit B (Part No. MK443503)	As required



[Removal]
- Remove the cover.
- Remove the air filter by pulling it out while lifting it.

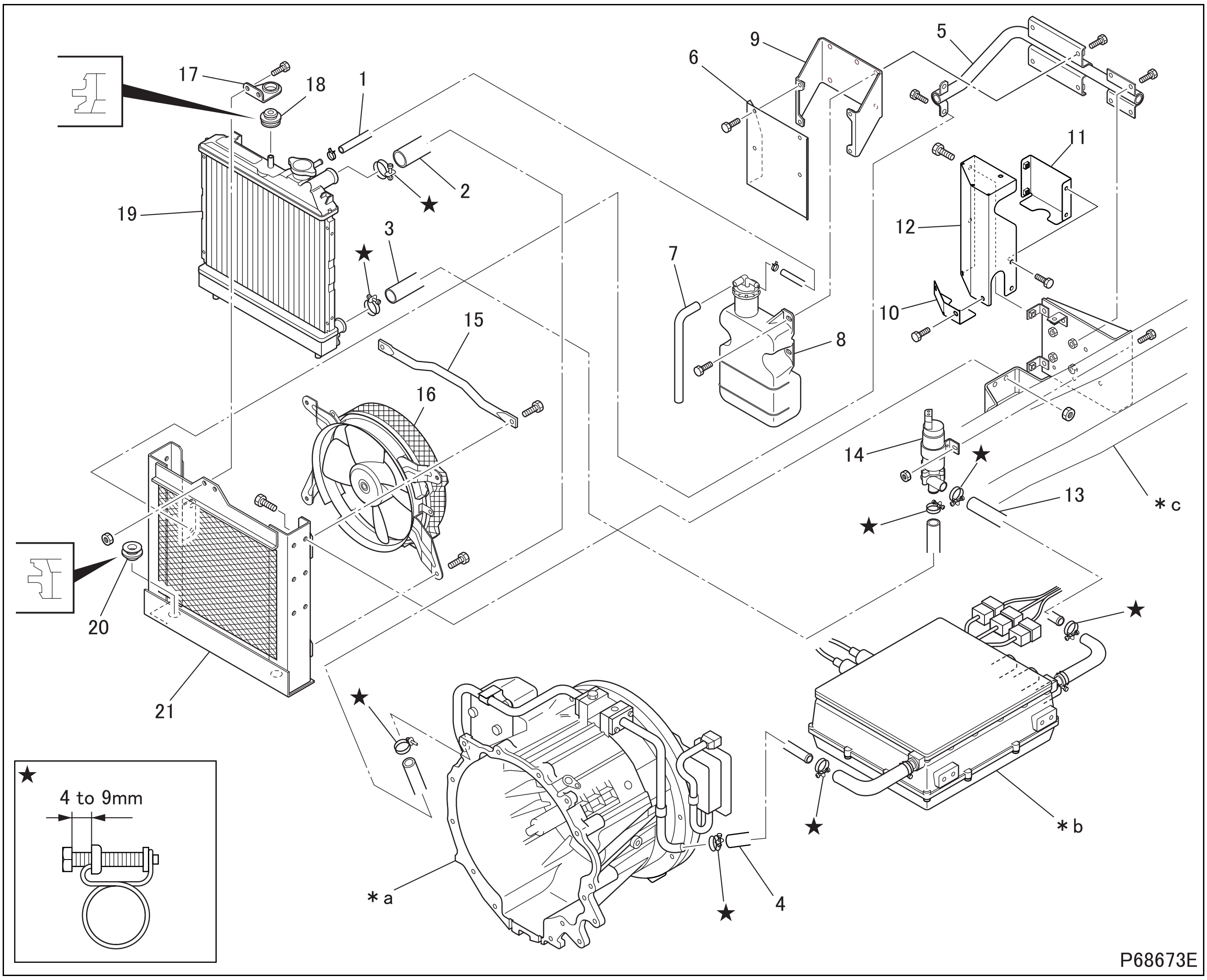
[Inspection]
- Check the air filter and clean it if it is dirty.

[Cleaning]
- Clean with water.
- If dirt cannot be removed with water, replace the air filter.



[Installing]
- Insert the air filter horizontally.
- Fit the air filter into the edge of the high voltage battery box to install it.
- Apply sealant to the contact surface of the cover with the high voltage battery box and install the cover.

HIGH VOLTAGE COOLING SYSTEM



● **Removal sequence**

1 Water hose
2 Water hose
3 Water hose
4 Water hose
5 Stay
6 Protector
7 Water hose
8 Reservoir tank
9 Tank bracket
10 Pump cover (bottom)
11 Pump cover (rear)
12 Pump cover (middle)
13 Water hose
14 Water pump
15 Rod
16 Blower motor
17 Radiator support
18 Bush
19 Radiator
20 Bush
21 Radiator holder

***a**: Clutch housing & motor generator
***b**: Motor electronic control unit
***c**: Frame

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

WARNING ⚠

- **Do not spill coolant on any high voltage device or the high voltage cable. If spilt, wipe it off securely.**

● **Installation sequence**

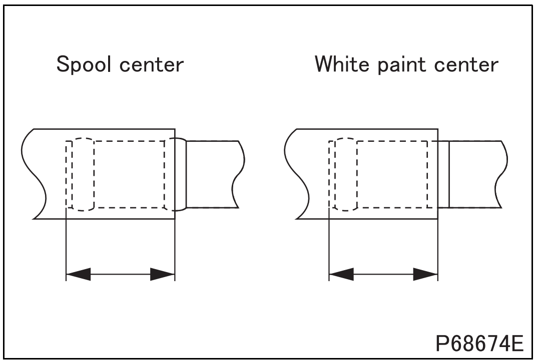
Follow the removal sequence in reverse.

◆Work before installation◆

■ Draining of coolant

- Perform draining of coolant in the high voltage cooling system. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

◆Installation procedure◆



■ Installation: Water hose

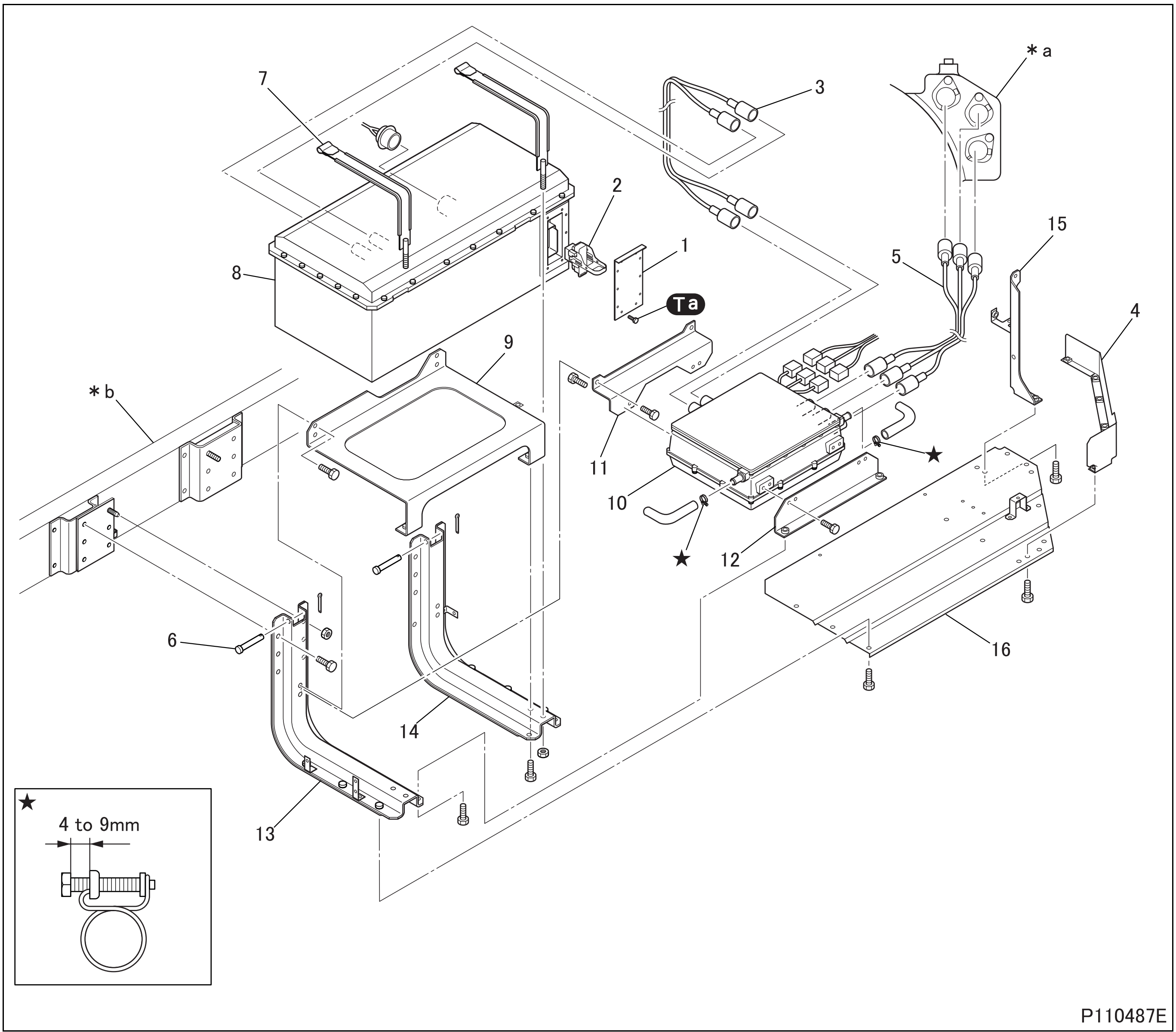
- Connect the water hose with the pipe fixing the hose end at the spool center or white paint center. (If the hose is properly connected, the measurement indicated in the illustration is 30 ± 3 mm.)
- If the pipe has no white paint, install the water hose so that the measurement indicated in the illustration becomes 30 ± 3 mm.

◆Work after installation◆

■ Refilling of coolant

- After installing the devices and pipes of the high voltage cooling system, refill coolant. (See “ON-VEHICLE INSPECTION AND ADJUSTMENT”.)

HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT



● Removal sequence

1 Safety plug cover & packing
2 Safety plug
3 High voltage cable (between high voltage battery box and motor electronic control unit)
4 Connector cover
5 High voltage cable (between motor electronic control unit and motor generator)
6 Clevis pin
7 Strap & packing
8 High voltage battery box
9 Box bracket (middle)
10 Motor electronic control unit
11 Motor electronic control unit support (upper)
12 Motor electronic control unit support (lower)
13 Box bracket (front)
14 Box bracket (rear)
15 Cable bracket
16 Base bracket

*a: Clutch housing & Motor generator
*b: Frame

WARNING ⚠

- **Make sure that the insulated gloves are not cracked, ripped, broken or damaged and not wet before use.**
- **High voltage devices have magnetic parts. Do not carry metal parts in your pockets that can induce short circuit if dropped. Do not work wearing what can be affected by magnetism, such as magnetic card and wrist watch.**
- **A mechanic who has a pacemaker or any other electronic medical devices can work on the hybrid electric vehicle without being affected. (Magnetic force is almost equal to that of ordinary vehicles.)**
- **Before inspection and maintenance involving the high voltage circuit, put up a sign “Do Not Touch. High Voltage Work In Progress” or the like at the working place and the driver’s seat to warn other workers.**
- **To avoid the risk of failure, do not disassemble high voltage devices (except removal of the high voltage battery box safety plug and air filter).**

● Installation sequence

Follow the removal sequence in reverse.

Repair kit: Service Kit A (Part No.: MK443502), Service kit C (Part No.: MK443504)

Service standards

<table>
<tr><th>Location</th><th colspan="2">Maintenance item</th><th>Standard value</th><th>Limit</th><th>Remedy</th></tr>
<tr><td>3, 5</td><td rowspan="4">Insulation resistance</td><td>Between high voltage cable and inner peripheral aluminum part</td><td rowspan="4">Above 10 MΩ
(at DC 500 V)</td><td rowspan="4">–</td><td rowspan="4">Replace</td></tr>
<tr><td rowspan="2">10</td><td>Between motor electronic control unit (+ and –) and chassis ground or case</td></tr>
<tr><td>Between motor electronic control unit (U, V and W) and chassis ground or case</td></tr>
<tr><td>*a</td><td>Between motor generator (U, V and W) and chassis ground or case</td></tr>
</table>

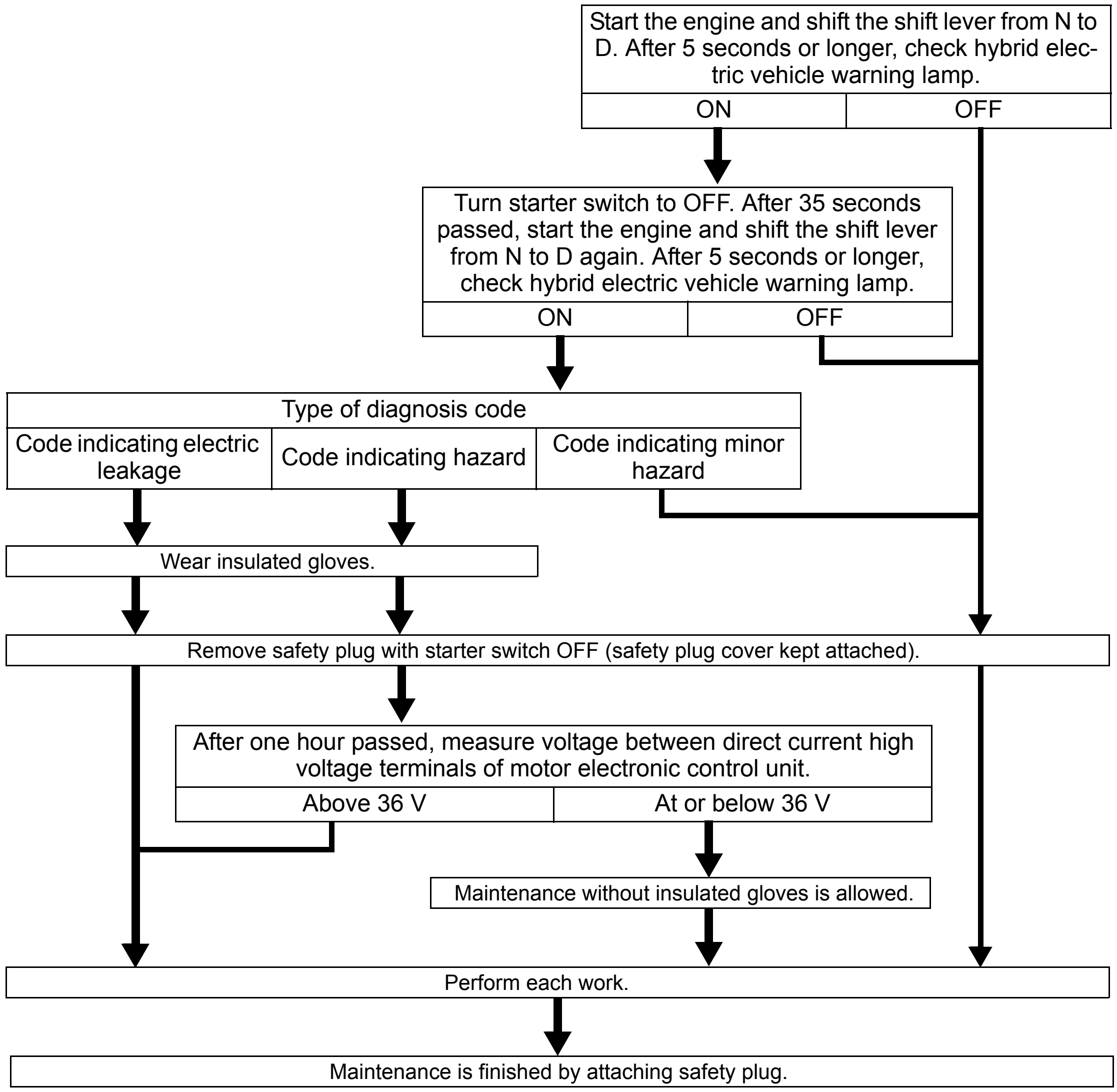
Tightening torque (Unit: N·m {kgf·m})

Mark	Parts to be tightened	Tightening torque	Remarks
Ta	Bolt (installation of safety plug cover & packing)	6.2 ± 0.5 {0.6 ± 0.05}	–

◆Work before removal◆

■ Maintenance workflow

- The way to handle high voltage devices differs depending on presence/absence of diagnosis codes and, if issued, on the type of the diagnosis code. Before working, see the following chart to grasp a general idea of handling procedures.



■ Removal: High voltage cooling system

- Remove the water hose in high voltage cooling system. (See “HIGH VOLTAGE COOLING SYSTEM”.)

WARNING ⚠

- **Do not spill coolant on any high voltage device or the high voltage cable. If spilt, wipe it off securely.**

■ Preparation

- Apply chocks to the front and rear wheels to prevent the vehicle from moving.
- Start the engine and shift the shift lever from N to D. After 5 seconds or longer, check that the hybrid electric vehicle warning lamp is off (the hybrid electric vehicle system is normal).

<When hybrid electric vehicle warning lamp is off>
- Turn the starter switch to OFF.

<When hybrid electric vehicle warning lamp is on>
- Turn the starter switch to OFF. After 35 seconds passed, start the engine and shift the shift lever from N to D.
- After 5 seconds or longer, check the hybrid electric vehicle warning lamp for its on/off status. If it is ON, refer to the corresponding diagnosis code. (See Gr00.)
- Turn the starter switch to OFF.

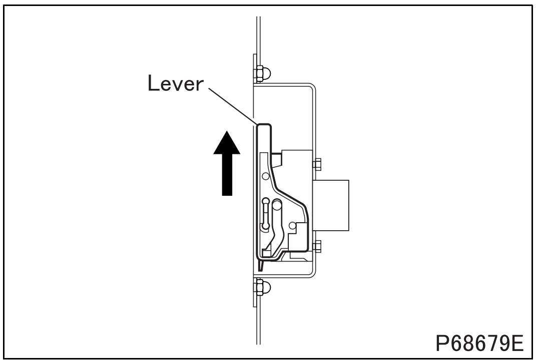
- After turning the starter switch to OFF, pull out the key and keep it to prevent other workers from carelessly turning the starter switch to ON.

DANGER ⚠

- **When the diagnosis codes listed below occur, work with insulated gloves since high voltage may still remain.**

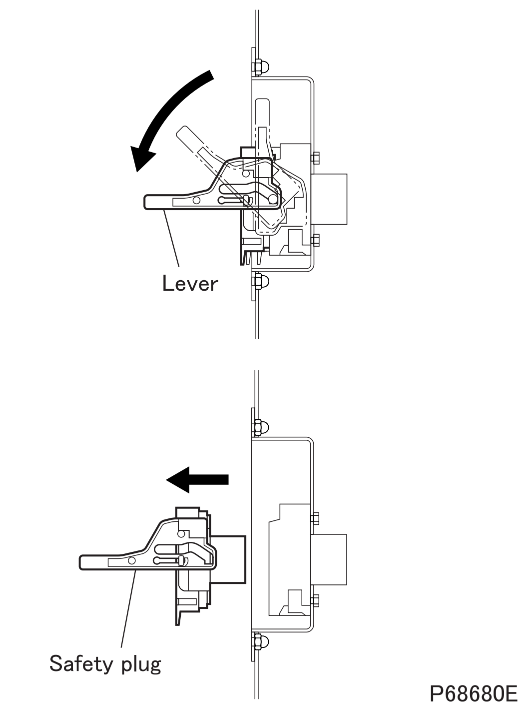
Code	Message	Flashes
P0A1B	CPU Failure	28
P0AA1	Main Contactor P&N Welded	09
P0AA6	Leak	65
P0AD9	Main Contactor Driver Failure	08
P0AE2	Precharge Contactor Welded	37
P1A04	Smooth Capacitor Discharge Fail	07
P1A10	P1A04 happens	40

◆Removal procedure◆



■ Removal: Safety plug

- Slide the lever of the safety plug upward.

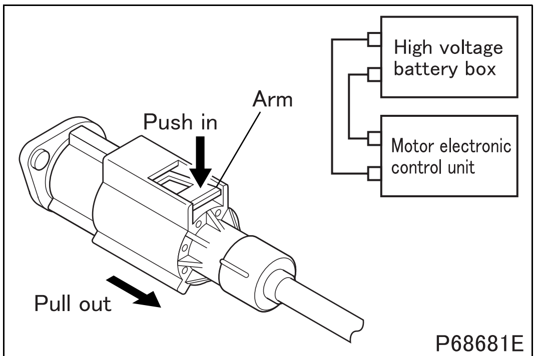


P68680E

- Pull the lever of the safety plug and rotate it 90 degrees.
- Remove the safety plug from the high voltage battery box by pulling it out.
- Install the safety plug cover & packing to prevent foreign substances and water from mixing.
- Keep the safety plug to prevent other workers from carelessly installing it.
- During preparation, if a diagnosis code that indicates possible remaining of high voltage (except P0AA6 (65): Leak) occurs, wait for an hour and resume the work.

WARNING ⚠

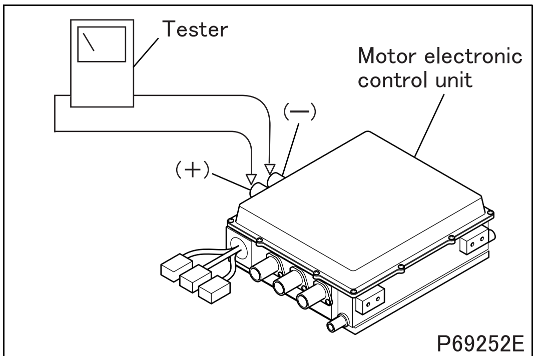
- **If the diagnosis code P0AA6 (65): Leak occurs, residual voltage will remain in the high voltage circuit and motor electronic control unit even after an hour passed. In this case, work with insulated gloves on without waiting for an hour.**



P68681E

■ Removal: High voltage cable (between high voltage battery box and motor electronic control unit)

- While pushing in the arm, remove the high voltage cable by pulling out the female connector.
- Make the device side and high voltage cable side terminals watertight and dust-tight with tape.

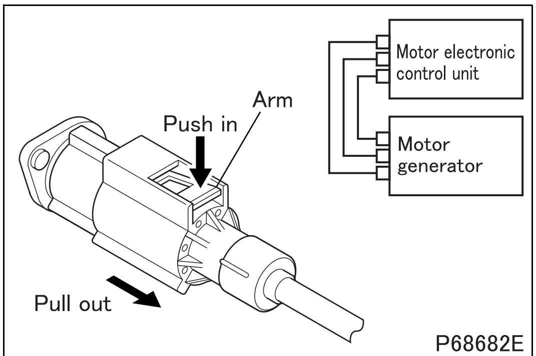


P69252E

- During preparation, if a diagnosis code that indicates possible remaining of high voltage (except P0AA6 (65): Leak) occurs, measure voltage between the direct current high voltage terminals of the motor electronic control unit and make sure that the voltage is below 36 V. If this is the case, you can proceed with the work without wearing insulated gloves.

WARNING ⚠

- **If the diagnosis code P0AA6 (65): Leak occurs, residual voltage remains in the high voltage circuit and motor electronic control unit. In this case, do all the work with insulated gloves on without measuring voltage.**

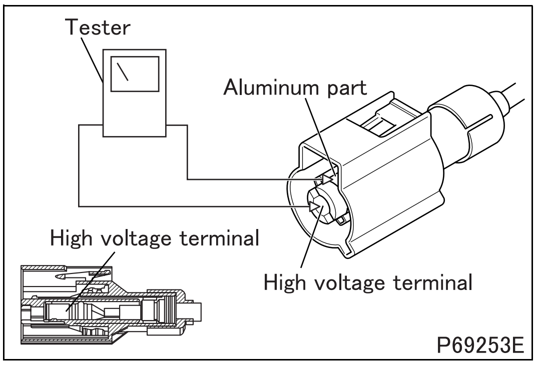


P68682E

■ Removal: High voltage cable (between motor electronic control unit and motor generator)

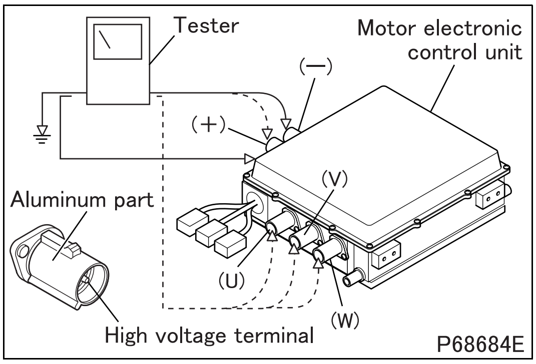
- While pushing in the arm, remove the high voltage cable by pulling out the female connector.
- Make the device side and high voltage cable side terminals watertight and dust-tight with tape.

◆Inspection procedure◆



■ **Inspection: Insulation resistance**

- Measure insulation resistance between the high voltage terminal and inner peripheral aluminum part inside each high voltage cable. Use an insulation tester whose range is wider than 1000 V.
- If the measured value deviates from the standard value, replace the high voltage cable.

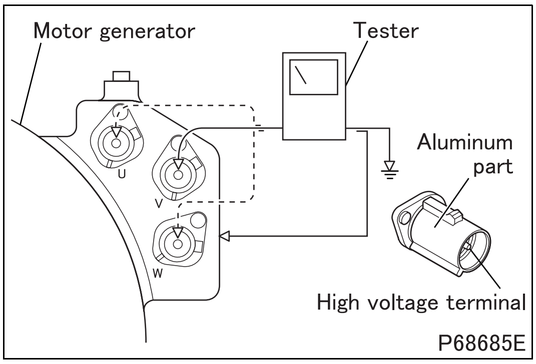


- Measure insulation resistance between each high voltage terminal of the motor electronic control unit and the chassis ground (if provided on the vehicle). Use an insulation tester whose range is wider than 1000 V.
- The outside surface (aluminum part) of the connector on the motor electronic control unit side is for shielding. The inner connector is the high voltage terminal.

WARNING ⚠

- **Be sure to remove the high voltage cable before inspection.**

- If the measured value deviates from the standard value, replace the motor electronic control unit.



- Measure insulation resistance between each high voltage terminal of the motor generator and the chassis ground (if provided on the vehicle). Use an insulation tester whose range is wider than 1000 V.
- The outside surface (aluminum part) of the connector on the motor generator side is for shielding. The inner connector is the high voltage terminal.

WARNING ⚠

- **Be sure to remove the high voltage cable before inspection.**

- If the measured value deviates from the standard value, replace the clutch housing & motor generator. (See Gr22.)

◆Replacement procedure◆

■ **Replacement: High voltage battery box**

- If the high voltage battery box is replaced for failure, leave the safety plug of the abnormal high voltage battery box removed and perform insulating treatment to the high voltage terminals to avoid accidents such as electric shock.

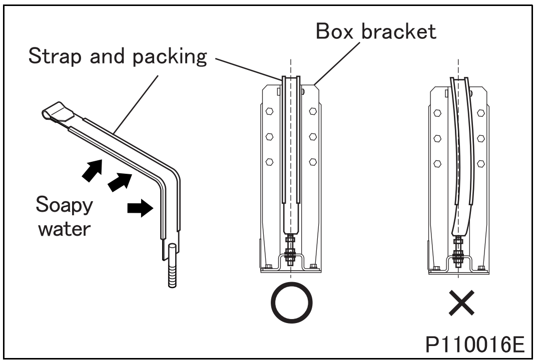
DANGER ⚠

- **Since high voltage is not discharged even if the box is left as it is for a long time, it is possible to receive an electric shock if someone touches the high voltage terminals by mistake.**

WARNING ⚠

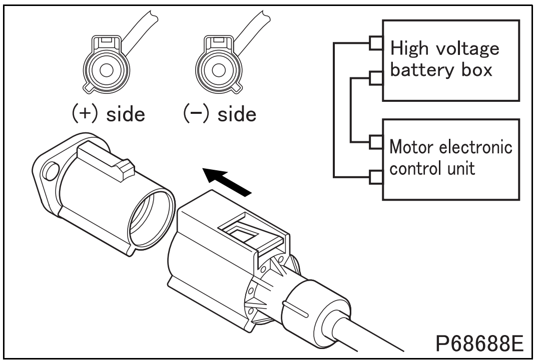
- **Do not disassemble the high voltage battery box.**
- **Leave the safety plug cover & packing installed so that the safety plug connecting terminals are not exposed.**

◆Installation procedure◆



■ **Installation: Strap and packing**

- Apply soapy water on the rubber section of each strap and packing where it contacts with the battery box. Then install each strap and packing by aligning it with the center of the box bracket.



■ **Installation: High voltage cable (between high voltage battery box and motor electronic control unit)**

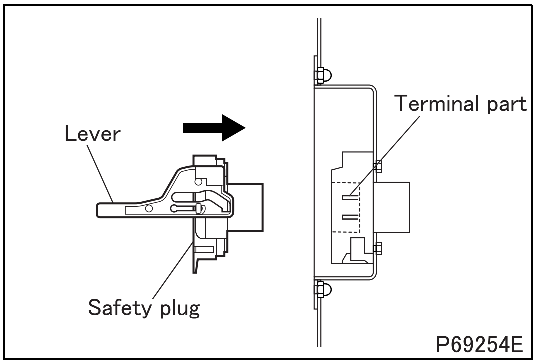
- Insert the high voltage cable until a click is heard.
- Check that the cable is installed securely by lightly pulling the female connector.

■ **Installation: Safety plug**

- Check that the starter switch is OFF and all the high voltage devices, high voltage cables and 24 V wiring are correctly connected.

WARNING ⚠

- **Make sure that no other workers are performing maintenance on high voltage devices.**



- Insert the safety plug into the terminal part securely. Then, push in the lever and rotate it 90 degrees.

CAUTION ⚠

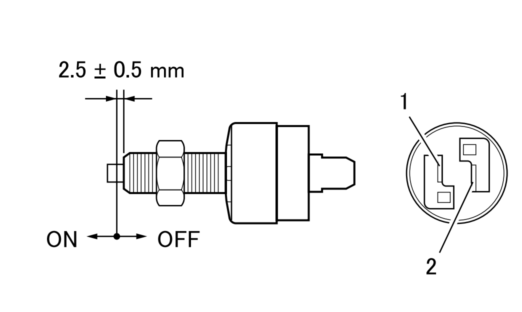
- **If the lever is forcibly rotated before adequately inserted, it can be broken.**

- Slide the lever of the safety plug downward until it locks.

◆Work after installation◆

■ Hybrid electric vehicle system activation

- Turn the starter switch to ON and check that the READY indicator lamp on the meter cluster illuminates.
- If the READY indicator lamp does not illuminate, the hybrid electric vehicle system is faulty. Perform troubleshooting to deal with the fault. In addition, if diagnosis code P1A66 (75): “Voltage Sensor Failure” occurs, the safety plug may not be properly installed. Reinstall the safety plug.

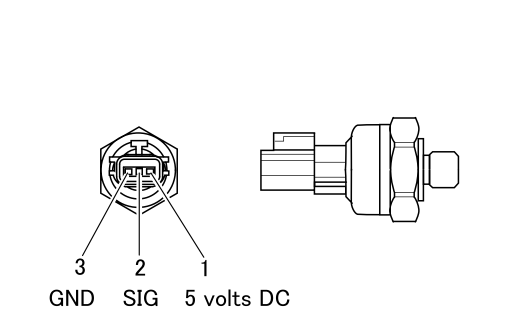


P07071

#042 Inspection of stop lamp switch

Switch position	Continuity terminal
OFF	–
ON	1–2

- If any fault is found, replace the switch.



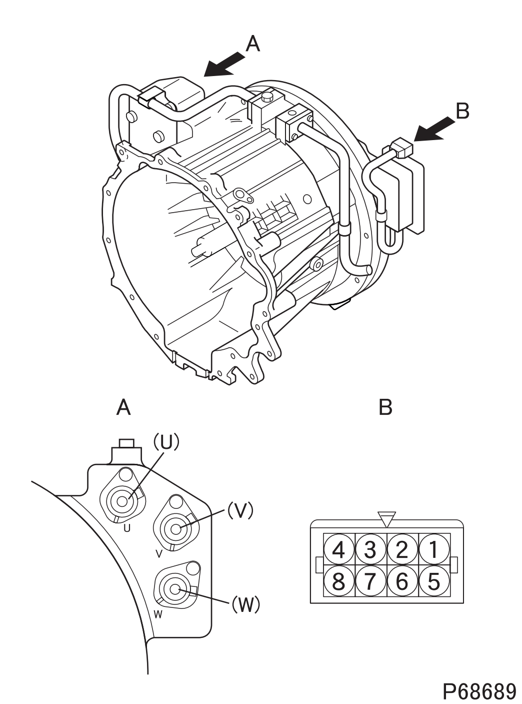
P59291E

#302 Inspection of brake fluid pressure sensor

- Apply voltage 5 volts DC between terminals 1 and 3.
- Measure the output voltage generated between terminals 2 and 3.

Standard value	0.5 V

- If the measurement is not within the range of the standard value, replace the sensor.



P68689

#437 Inspection of motor generator

- Remove the high voltage cable. (See “HIGH VOLTAGE CABLE, HIGH VOLTAGE BATTERY BOX AND MOTOR ELECTRONIC CONTROL UNIT”.)

<Revolution sensor and alternating current power supply>

- Measure values of resistance between the following terminals.

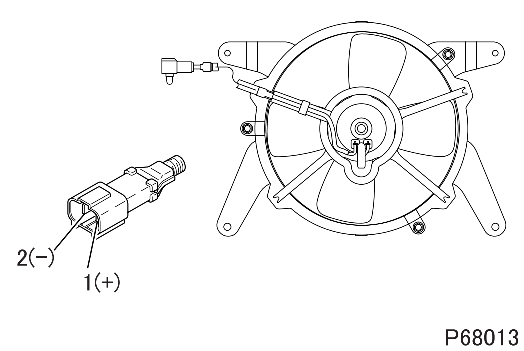
Standard value (20°C)	Revolution sensor	1–4	30.2 ± 6.0 Ω
		3–8	33.8 ± 6.8 Ω
		2–7	12.3 ± 2.5 Ω
	Alternating current power supply system (U–V)	U–V	0.028 ± 0.003 Ω
	Alternating current power supply system (V–W)	V–W	
	Alternating current power supply system (W–U)	W–U	

<Temperature sensor>

- Measure value of resistance between terminals 5 and 6.

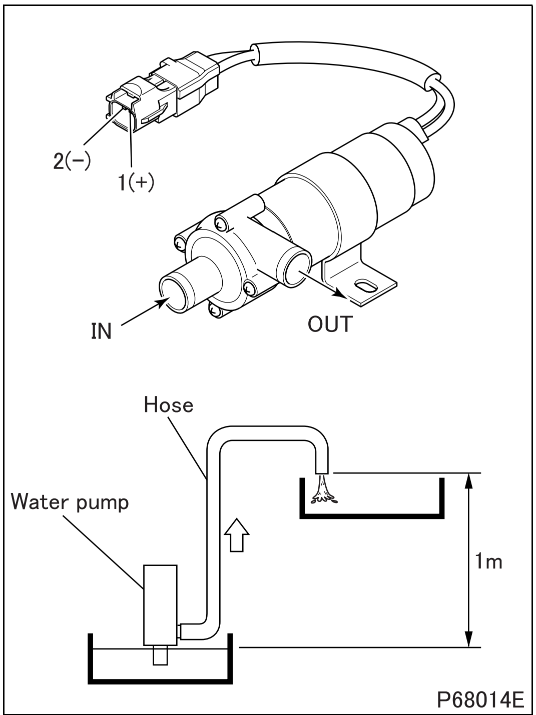
Standard value	0°C	144.0 to 182.5 kΩ
	5°C	112.3 to 140.8 kΩ
	10°C	88.2 to 109.5 kΩ
	15°C	69.8 to 85.8 kΩ
	20°C	55.7 to 67.8 kΩ
	25°C	44.7 to 53.9 kΩ
	30°C	36.1 to 43.2 kΩ

- If the measured value deviates from the standard value, replace the clutch housing & motor generator. (See Gr22.)



#495 Inspection of blower motor

- Make sure that the fan operates when 24 volts DC is applied between terminals 1 and 2.
- If any fault is found, replace the motor.



#768 Inspection of water pump

- Perform the following checks, and if any fault is found, replace the water pump.

<Detailed inspection>

- Connect the hose to the OUT port. Put the IN side in a water-filled container and the OUT side in an empty container.
- Apply voltage 24 volts DC between terminals 1 and 2.
- Measure the quantity of water discharged from the OUT side.

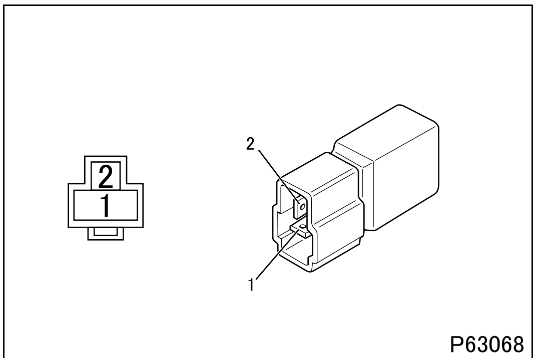
Standard value (at 10 kPa {0.1 kgf/cm^2} (1 m))	Above approx. 20 dm^3 {20 L}/min.

<Simple inspection>

- Put the IN side in a water-filled container.
- Apply voltage 24 volts DC between terminals 1 and 2 and check that the operating sound is heard.

CAUTION ⚠

- **Do not operate the water pump without water being circulated to avoid malfunction.**



#828 Inspection of controller area network resistor

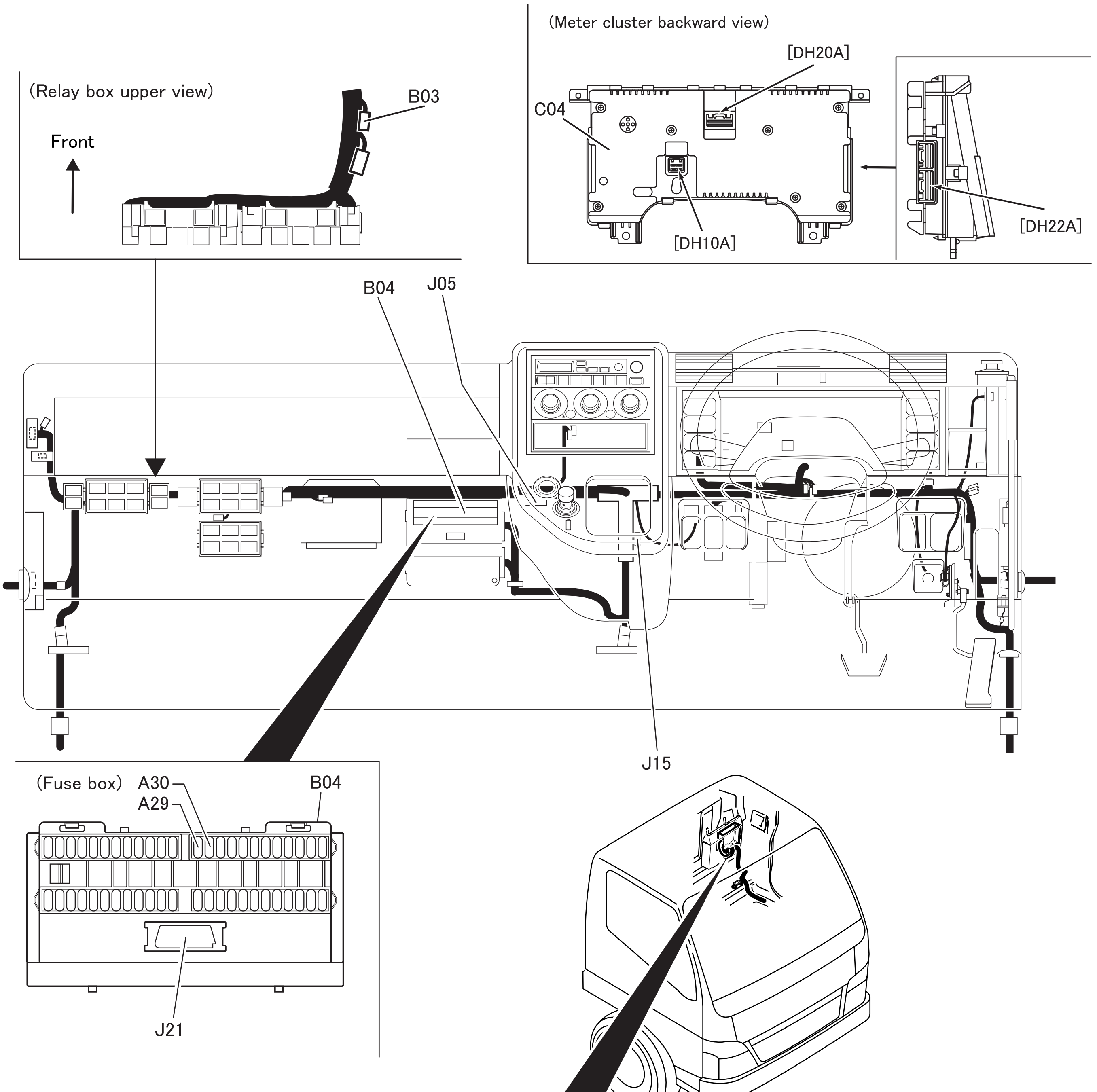
- Measure the resistance between terminals 1 and 2.

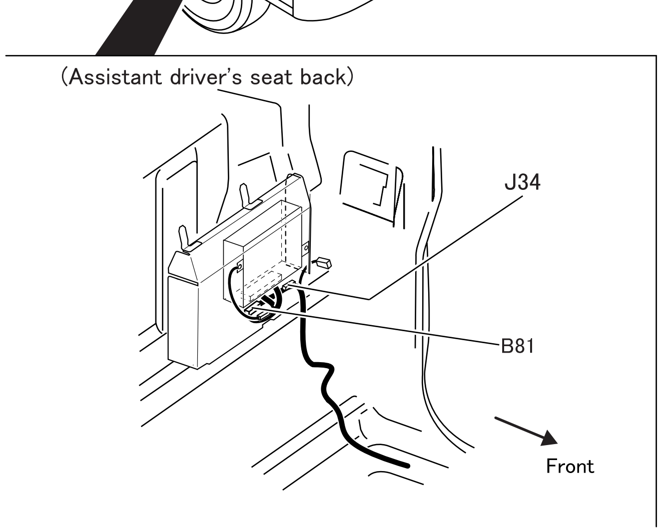
Standard value (at 20°C)	120 ± 6 Ω

- If the measured value is out of the standard value, replace the resistor.

INSTALLED LOCATIONS OF PARTS

A29–30	B03–81	C04	J05–34





A29 Diagnosis switch
A30 Memory clear switch

B03 Diode
B04 Fuse box
B81 CAN resistor

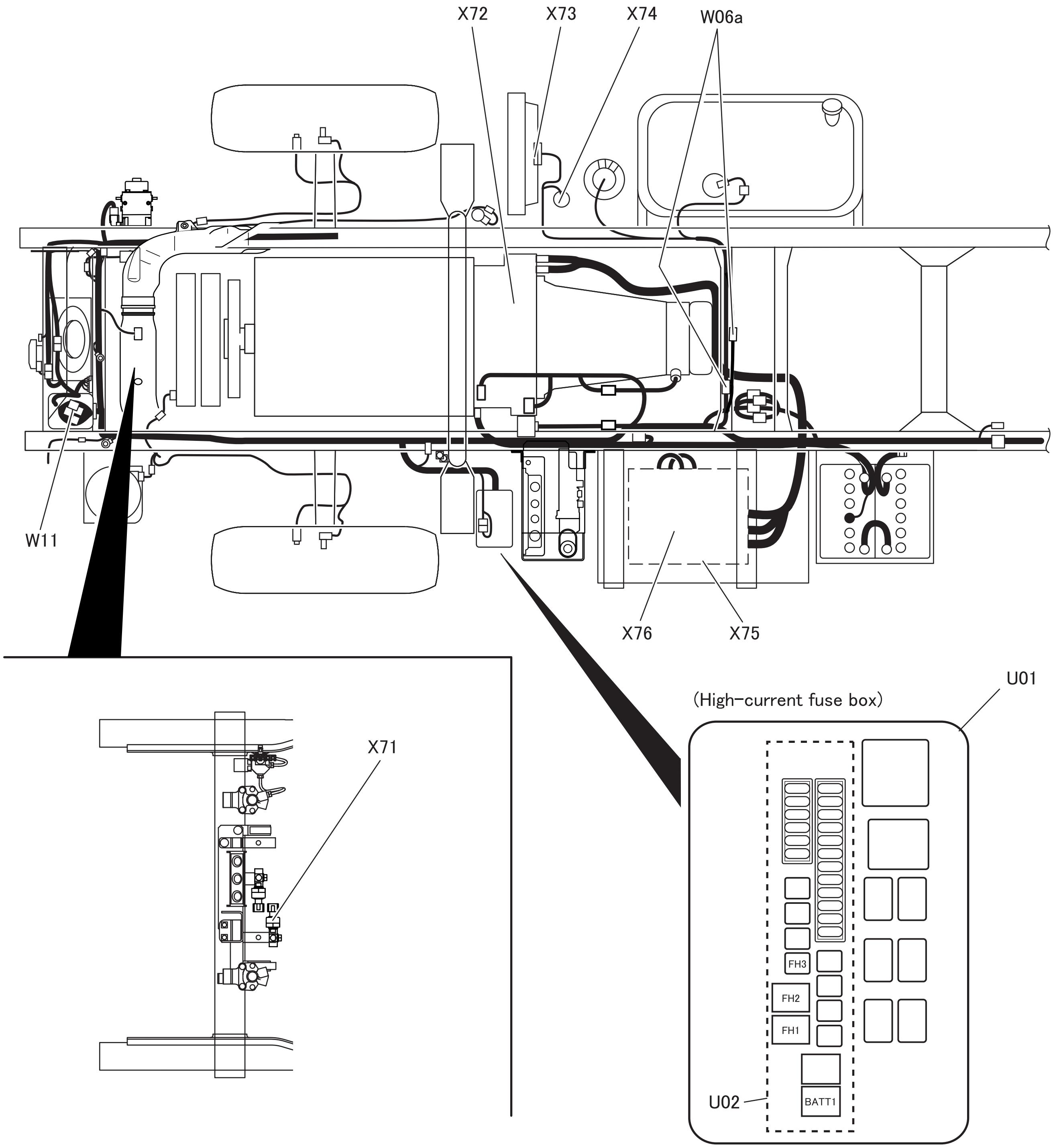
C04 Meter cluster

J05 Joint connector (J/C–1, 3)
J15 Joint connector (J/C–M1)
J21 Multi–Use Tester connector
J34 Connector

ECU : Electronic control unit
CAN : Control area network
Indicate by connector type [ ].

18–L04695

U01-02	W06-11	X71-76



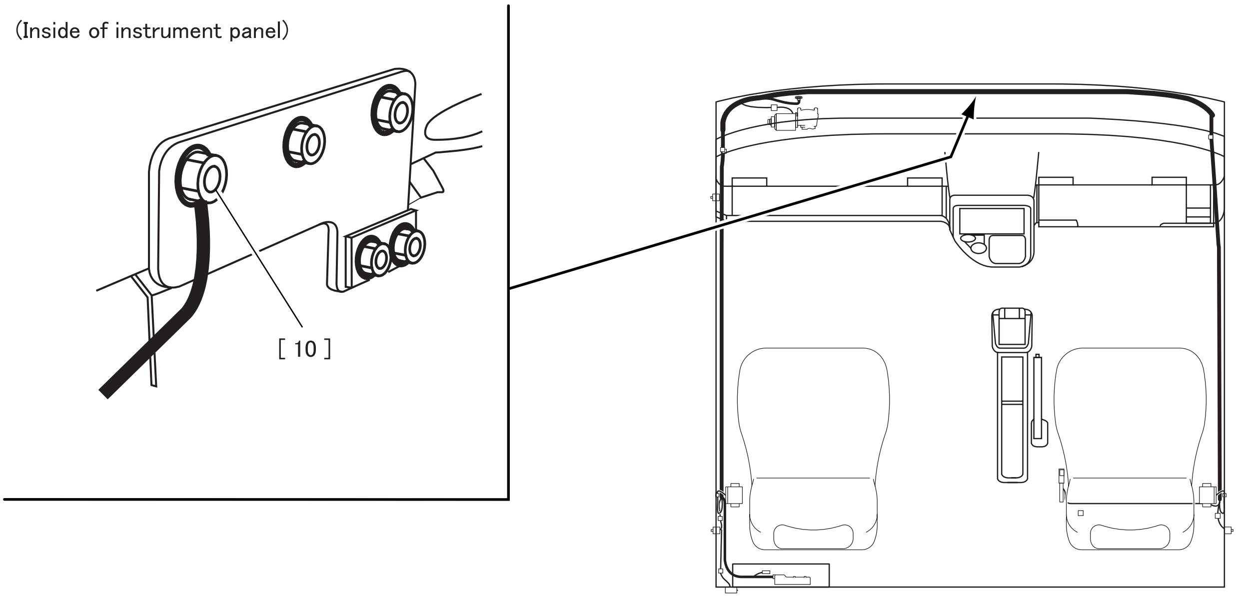
U01 High-current fuse box
U02 High-current fuse, fuse

W06a Connection of chassis harness and chassis (sub) harness
W11 Connection of cab harness and chassis (sub) harness

X71 Master pressure sensor
X72 Motor generator
X73 Blower motor
X74 Water pump
X75 High voltage battery box
X76 Motor electronic control unit

18-L04696

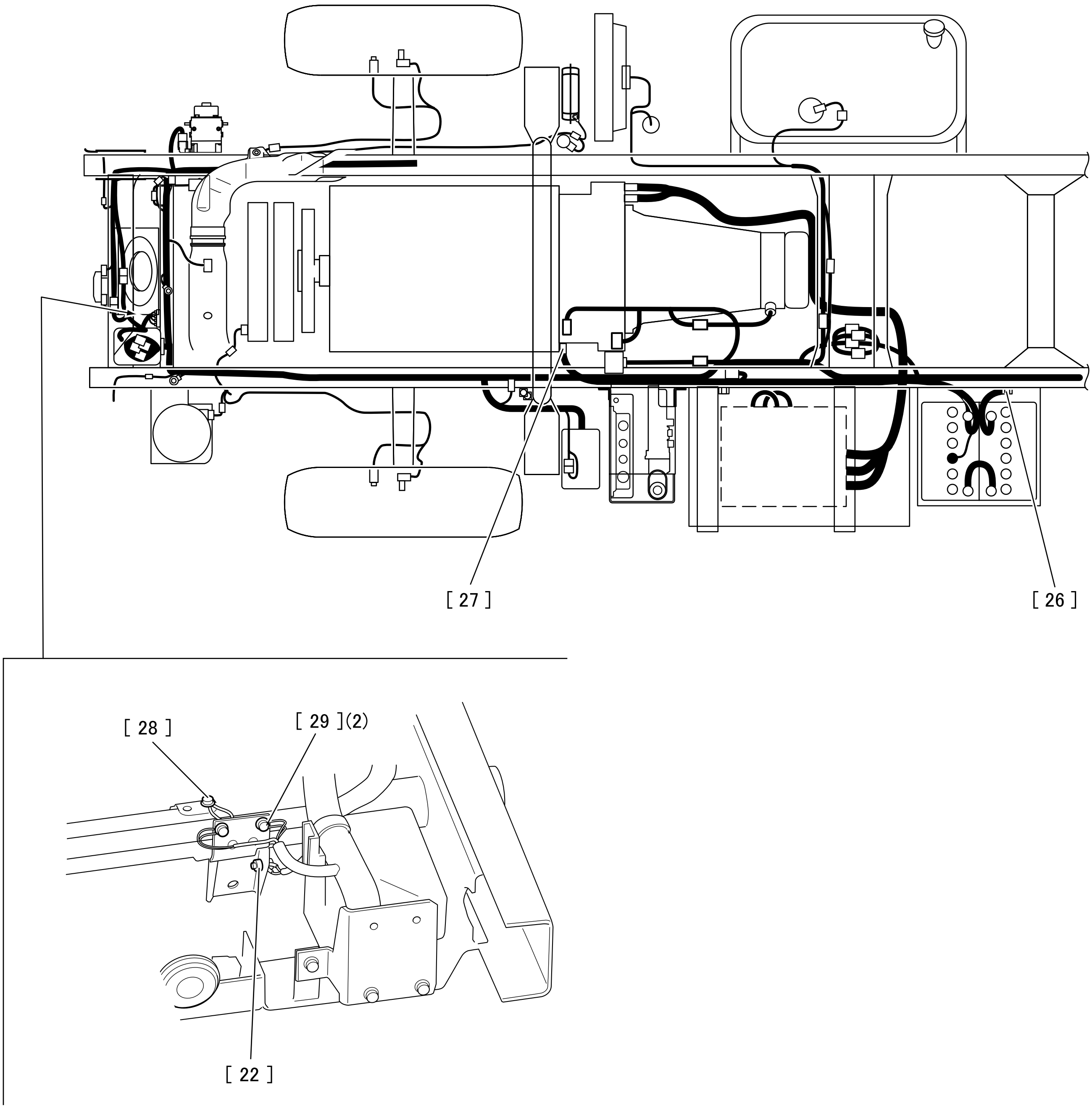
[10]	Cab ground



[10] Ground

18–L04697

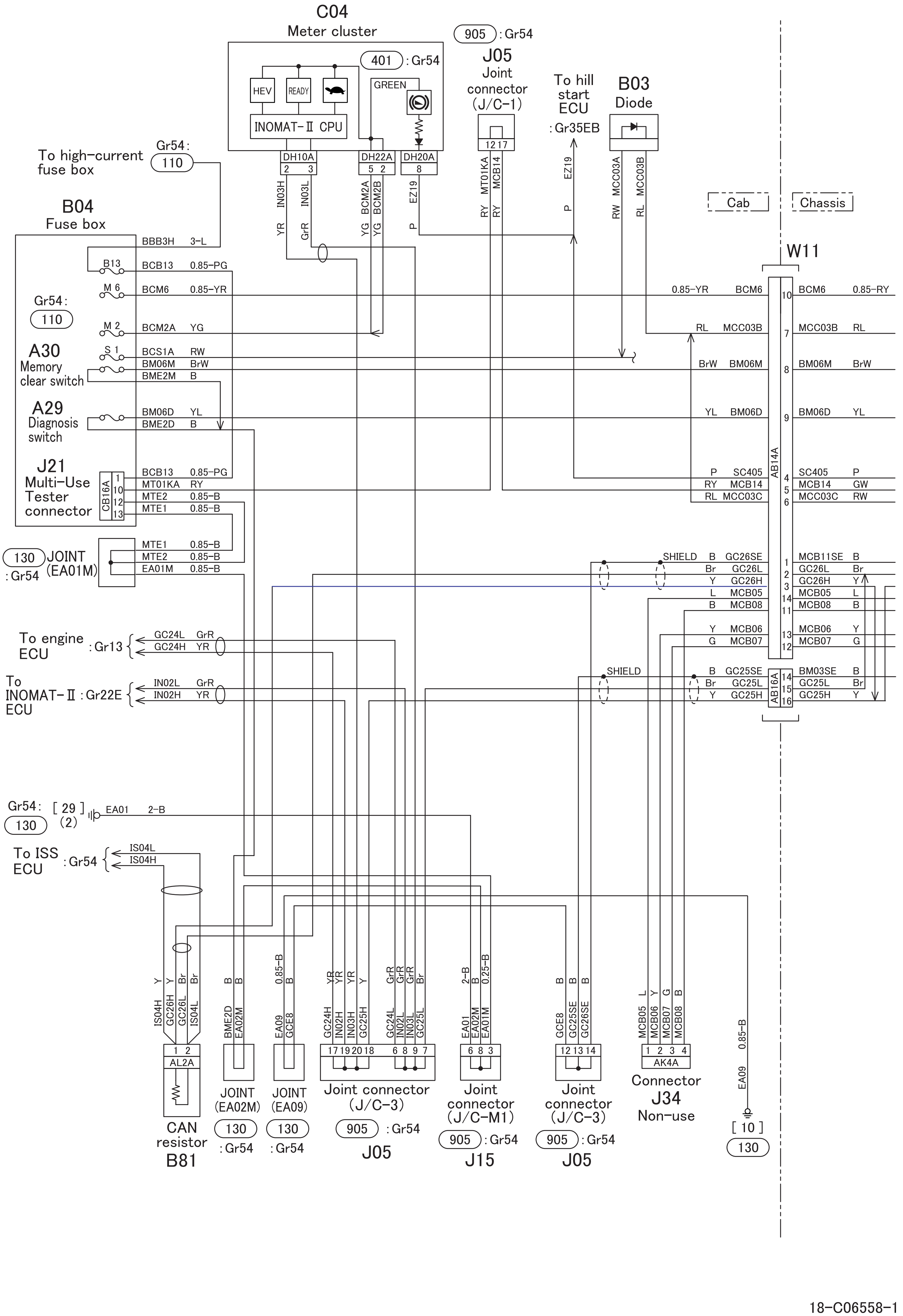
[22]-[29] Chassis ground

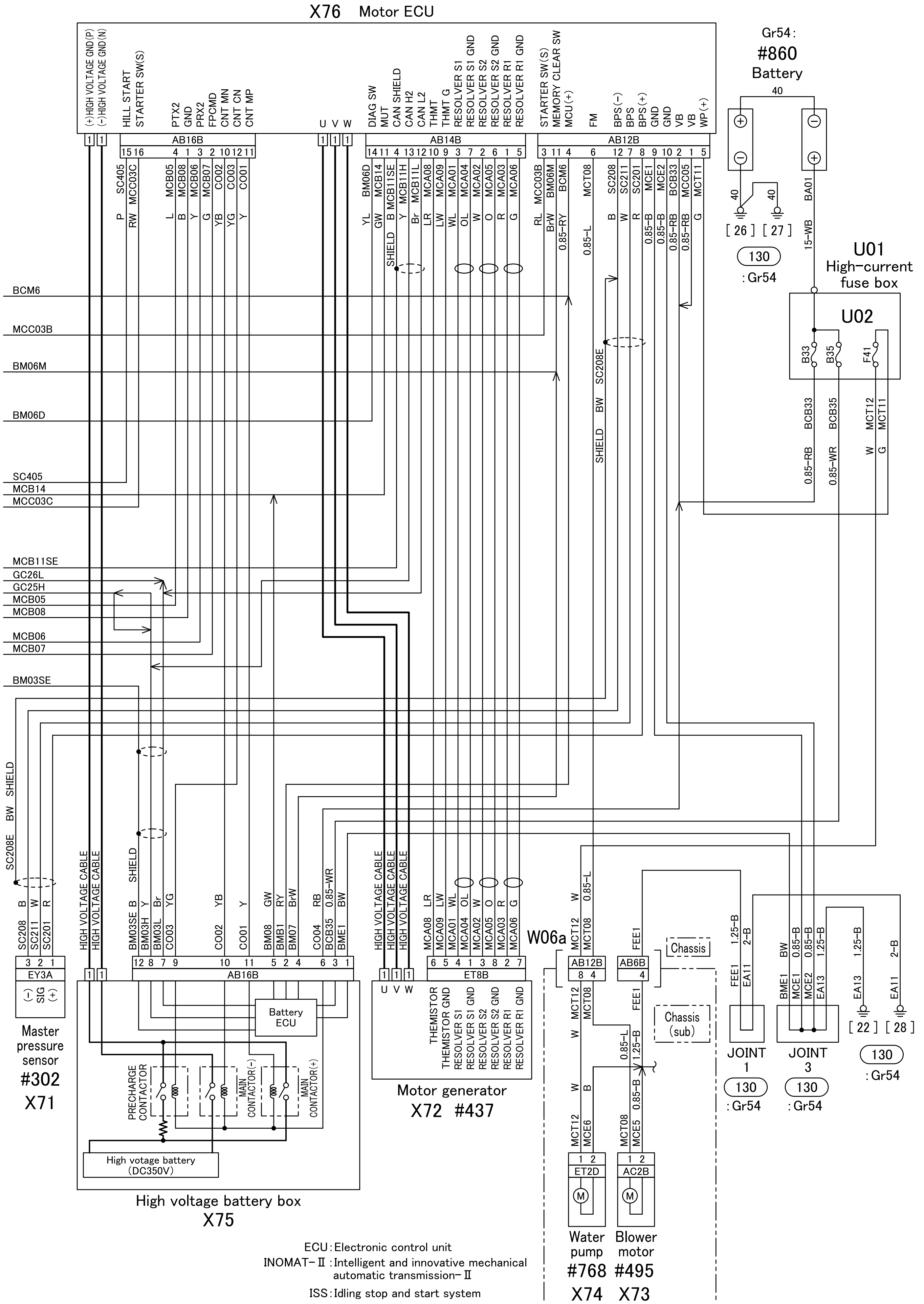


[22] Ground
[26] Ground
[27] Ground
[28] Ground
[29](2) Ground

18-L04698

ELECTRIC CIRCUIT DIAGRAM





ECU: Electronic control unit
INOMAT-Ⅱ: Intelligent and innovative mechanical automatic transmission-Ⅱ
ISS: Idling stop and start system
CAN: Controller area network

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4M4

ECO HYBRID

Shop Manual

diesel engine

MITSUBISHI FUSO TRUCK & BUS CORP.

NOVEMBER 2009

512 (H)