SEBM023407

SHOP MANUAL

KOMATSU

170-3 SERIES

DIESEL ENGINE

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The affected pages are indicated by the use of the following marks. It is requested that necessary actions be taken to these pages according to the table below.

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SAFETY

SAFETY NOTICE

IMPORTANT SAFETY NOTICE

Proper service and repair is extremely important for safe machine operation. The service and repair techniques recommended by Komatsu and described in this manual are both effective and safe. Some of these techniques require the use of tools specially designed by Komatsu for the specific purpose.

To prevent injury to workers, the symbol ⚠ is used to mark safety precautions in this manual. The cautions accompanying these symbols should always be followed carefully. If any dangerous situation arises or may possibly arise, first consider safety, and take the necessary actions to deal with the situation.

GENERAL PRECAUTIONS

Mistakes in operation are extremely dangerous. Read the Operation and Maintenance Manual carefully BEFORE operating the machine.

1. Before carrying out any greasing or repairs, read all the precautions given on the decals which are fixed to the machine.
2. When carrying out any operation, always wear safety shoes and helmet. Do not wear loose work clothes, or clothes with buttons missing.
   - Always wear safety glasses when hitting parts with a hammer.
   - Always wear safety glasses when grinding parts with a grinder, etc.
3. If welding repairs are needed, always have a trained, experienced welder carry out the work. When carrying out welding work, always wear welding gloves, apron, hand shield, cap and other clothes suited for welding work.
4. When carrying out any operation with two or more workers, always agree on the operating procedure before starting. Always inform your fellow workers before starting any step of the operation. Before starting work, hang UNDER REPAIR signs on the controls in the operator's compartment.
5. Keep all tools in good condition and learn the correct way to use them.
6. Decide a place in the repair workshop to keep tools and removed parts. Always keep the tools and parts in their correct places. Always keep the work area clean and make sure that there is no dirt or oil on the floor. Smoke only in the areas provided for smoking. Never smoke while working.

PREPARATIONS FOR WORK

7. Before adding oil or making any repairs, park the machine on hard, level ground, and block the wheels or tracks to prevent the machine from moving.
8. Before starting work, lower blade, ripper, bucket or any other work equipment to the ground. If this is not possible, insert the safety pin or use blocks to prevent the work equipment from falling. In addition, be sure to lock all the control levers and hang warning signs on them.
9. When disassembling or assembling, support the machine with blocks, jacks or stands before starting work.
10. Remove all mud and oil from the steps or other places used to get on and off the machine. Always use the handrails, ladders or steps when getting on or off the machine. Never jump on or off the machine. If it is impossible to use the handrails, ladders or steps, use a stand to provide safe footing.

PRECAUTIONS DURING WORK

11. When removing the oil filler cap, drain plug or hydraulic pressure measuring plugs, loosen them slowly to prevent the oil from spurting out.
    Before disconnecting or removing components of the oil, water or air circuits, first remove the pressure completely from the circuit.
12. The water and oil in the circuits are hot when the engine is stopped, so be careful not to get burned.
    Wait for the oil and water to cool before carrying out any work on the oil or water circuits.
13. Before starting work, remove the leads from the battery. Always remove the lead from the negative (–) terminal first.
14. When raising heavy components, use a hoist or crane.
    Check that the wire rope, chains and hooks are free from damage.
    Always use lifting equipment which has ample capacity.
    Install the lifting equipment at the correct places. Use a hoist or crane and operate slowly to prevent the component from hitting any other part. Do not work with any part still raised by the hoist or crane.
15. When removing covers which are under internal pressure or under pressure from a spring, always leave two bolts in position on opposite sides. Slowly release the pressure, then slowly loosen the bolts to remove.
16. When removing components, be careful not to break or damage the wiring. Damaged wiring may cause electrical fires.
17. When removing piping, stop the fuel or oil from spilling out. If any fuel or oil drips onto the floor, wipe it up immediately. Fuel or oil on the floor can cause you to slip, or can even start fires.
18. As a general rule, do not use gasoline to wash parts. In particular, use only the minimum of gasoline when washing electrical parts.
19. Be sure to assemble all parts again in their original places.
    Replace any damaged parts with new parts.
    - When installing hoses and wires, be sure that they will not be damaged by contact with other parts when the machine is being operated.
20. When installing high pressure hoses, make sure that they are not twisted. Damaged tubes are dangerous, so be extremely careful when installing tubes for high pressure circuits. Also, check that connecting parts are correctly installed.
21. When assembling or installing parts, always use the specified tightening torques. When installing protective parts such as guards, or parts which vibrate violently or rotate at high speed, be particularly careful to check that they are installed correctly.
22. When aligning two holes, never insert your fingers or hand. Be careful not to get your fingers caught in a hole.
23. When measuring hydraulic pressure, check that the measuring tool is correctly assembled before taking any measurements.
24. Take care when removing or installing the tracks of track-type machines.
    When removing the track, the track separates suddenly, so never let anyone stand at either end of the track.

FOREWORD

GENERAL

This shop manual has been prepared as an aid to improve the quality of repairs by giving the serviceman an accurate understanding of the product and by showing him the correct way to perform repairs and make judgements. Make sure you understand the contents of this manual and use it to full effect at every opportunity.

This shop manual mainly contains the necessary technical information for operations performed in a service workshop. For ease of understanding, the manual is divided into the following chapters; these chapters are further divided into the each main group of components.

STRUCTURE AND FUNCTION

This section explains the structure and function of each component. It serves not only to give an understanding of the structure, but also serves as reference material for troubleshooting.
In addition, this section may contain hydraulic circuit diagrams, electric circuit diagrams, and maintenance standards.

TESTING AND ADJUSTING

This section explains checks to be made before and after performing repairs, as well as adjustments to be made at completion of the checks and repairs.
Troubleshooting charts correlating "Problems" with "Causes" are also included in this section.

DISASSEMBLY AND ASSEMBLY

This section explains the procedures for removing, installing, disassembling and assembling each component, as well as precautions for them.

MAINTENANCE STANDARD

This section gives the judgment standards for inspection of disassembled parts.
The contents of this section may be described in STRUCTURE AND FUNCTION.

OTHERS

This section mainly gives hydraulic circuit diagrams and electric circuit diagrams.
In addition, this section may give the specifications of attachments and options together.

NOTICE

The specifications contained in this shop manual are subject to change at any time and without any advance notice. Use the specifications given in the book with the latest date.

HOW TO READ THE SHOP MANUAL

VOLUMES

Shop manuals are issued as a guide to carrying out repairs. They are divided as follows:

Chassis volume: Issued for every machine model
Engine volume: Issued for each engine series
Electrical volume:
Attachments volume: } Each issued as one volume to cover all models

These various volumes are designed to avoid duplicating the same information. Therefore, to deal with all repairs for any model , it is necessary that chassis, engine, electrical and attachment volumes be available.

DISTRIBUTION AND UPDATING

Any additions, amendments or other changes will be sent to KOMATSU distributors. Get the most up-to-date information before you start any work.

FILING METHOD

1. See the page number on the bottom of the page. File the pages in correct order.
2. Following examples show how to read the page number.
   Example 1 (Chassis volume):

   10 - 3
   Item number (10. Structure and Function)
   Consecutive page number for each item.

   Example 2 (Engine volume):

   12 - 5
   Unit number (1. Engine)
   Item number (2. Testing and Adjusting)
   Consecutive page number for each item.

3. Additional pages: Additional pages are indicated by a hyphen (-) and number after the page number. File as in the example.
   Example:

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REVISED EDITION MARK

When a manual is revised, an edition mark (①②③....) is recorded on the bottom of the pages.

REVISIONS

Revised pages are shown in the LIST OF REVISED PAGES next to the CONTENTS page.

SYMBOLS

So that the shop manual can be of ample practical use, important safety and quality portions are marked with the following symbols.

Symbol	Item	Remarks
⚠	Safety	Special safety precautions are necessary when performing the work.
★	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing the work.
kg	Weight	Weight of parts of systems. Caution necessary when selecting hoisting wire, or when working posture is important, etc.
🔧	Tightening torque	Places that require special attention for the tightening torque during assembly.
🖌	Coat	Places to be coated with adhesives and lubricants, etc.
⛽	Oil, water	Places where oil, water or fuel must be added, and the capacity.
💧	Drain	Places where oil or water must be drained, and quantity to be drained.

HOISTING INSTRUCTIONS

HOISTING

Heavy parts (25 kg or more) must be lifted with a hoist, etc. In the **DISASSEMBLY AND ASSEMBLY** section, every part weighing 25 kg or more is indicated clearly with the symbol kg

- If a part cannot be smoothly removed from the machine by hoisting, the following checks should be made:
  1) Check for removal of all bolts fastening the part to the relative parts.
  2) Check for existence of another part causing interference with the part to be removed.

WIRE ROPES

1) Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

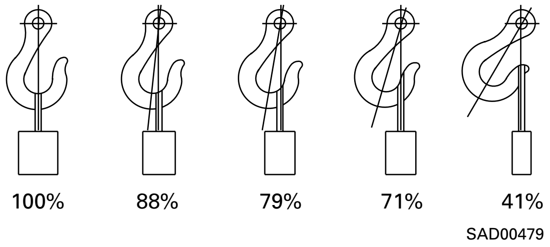
Wire ropes
(Standard "Z" or "S" twist ropes
without galvanizing)

Rope diameter	Allowable load	
mm	kN	tons
10	9.8	1.0
11.5	13.7	1.4
12.5	15.7	1.6
14	21.6	2.2
16	27.5	2.8
18	35.3	3.6
20	43.1	4.4
22.4	54.9	5.6
30	98.1	10.0
40	176.5	18.0
50	274.6	28.0
60	392.2	40.0

★ The allowable load value is estimated to be one-sixth or one-seventh of the breaking strength of the rope used.

2) Sling wire ropes from the middle portion of the hook.

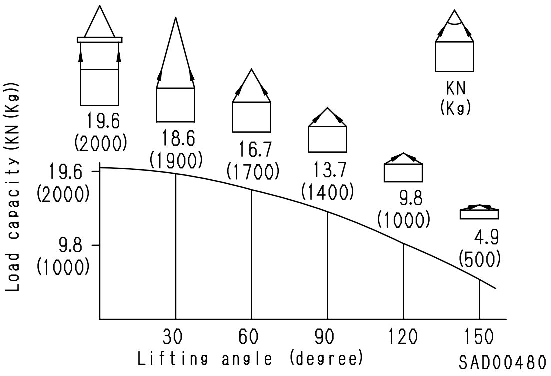
Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



3) Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound onto the load.

Slinging with one rope may cause turning of the load during hoisting, untwisting of the rope, or slipping of the rope from its original winding position on the load, which can result in a dangerous accident.

4) Do not sling a heavy load with ropes forming a wide hanging angle from the hook.
When hoisting a load with two or more ropes, the force subjected to each rope will increase with the hanging angles. The table below shows the variation of allowable load kN {kg} when hoisting is made with two ropes, each of which is allowed to sling up to 9.8 kN {1000 kg} vertically, at various hanging angles.
When two ropes sling a load vertically, up to 19.6 kN {2000 kg} of total weight can be suspended. This weight becomes 9.8 kN {1000 kg} when two ropes make a 120° hanging angle. On the other hand, two ropes are subjected to an excessive force as large as 39.2 kN {4000 kg} if they sling a 19.6 kN {2000 kg} load at a lifting angle of 150°.



METHOD OF DISASSEMBLING, CONNECTING PUSH-PULL TYPE COUPLER

Before carrying out the following work, release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.

Even if the residual pressure is released from the hydraulic tank, some hydraulic oil flows out when the hose is disconnected. Accordingly, prepare an oil receiving container.

Disconnection

1) Release the residual pressure from the hydraulic tank. For details, see TESTING AND ADJUSTING, Releasing residual pressure from hydraulic tank.

2) Hold adapter (1) and push hose joint (2) into mating adapter (3). (See Fig. 1)
   ★ The adapter can be pushed in about 3.5 mm.
   ★ Do not hold rubber cap portion (4).

3) After hose joint (2) is pushed into adapter (3), press rubber cap portion (4) against (3) until it clicks. (See Fig. 2)

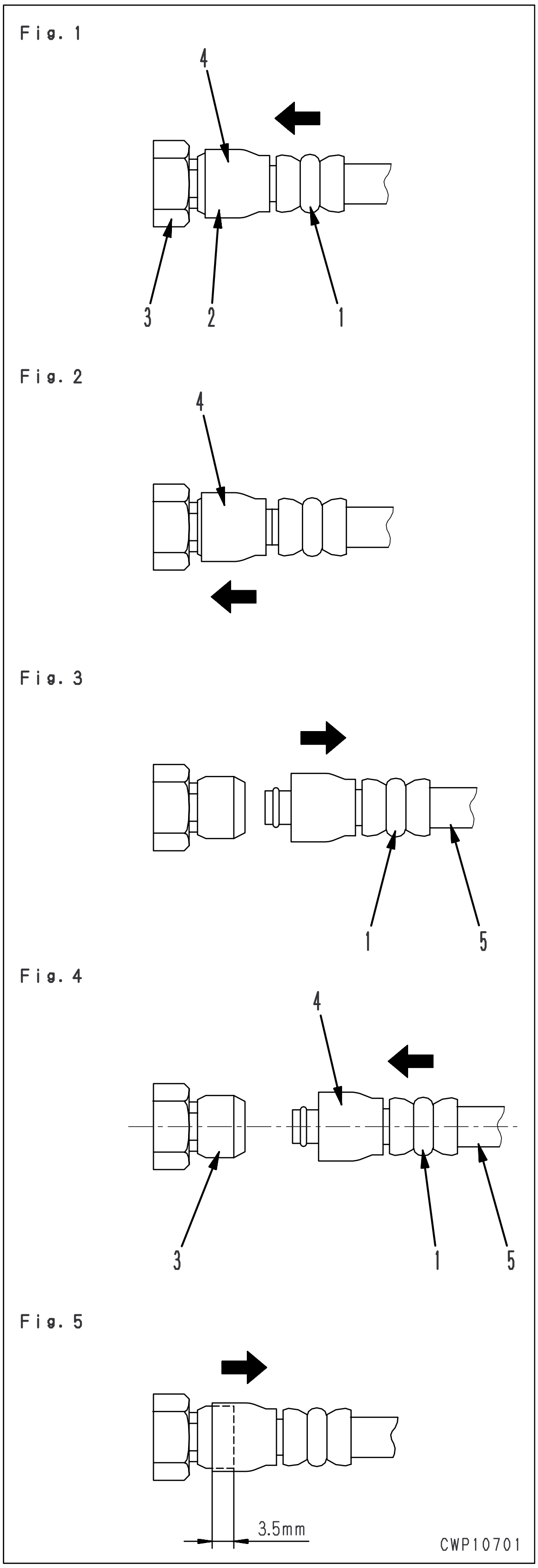
4) Hold hose adapter (1) or hose (5) and pull it out. (See Fig. 3)
   ★ Since some hydraulic oil flows out, prepare an oil receiving container.

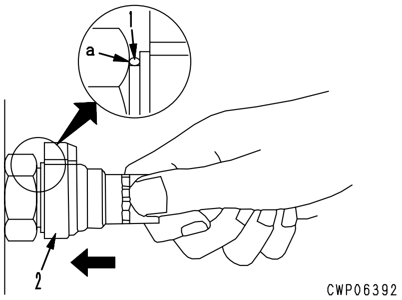
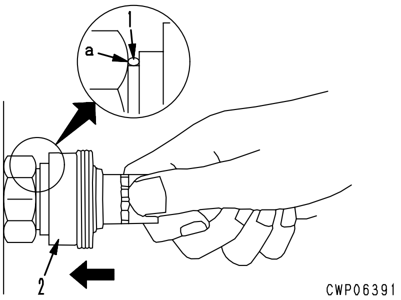
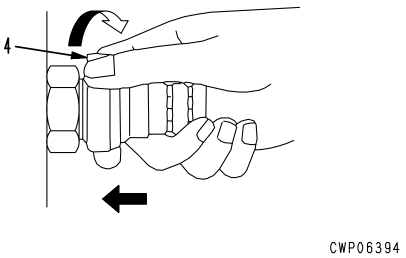
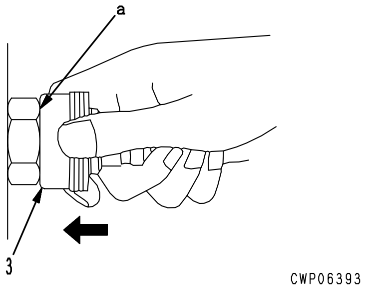
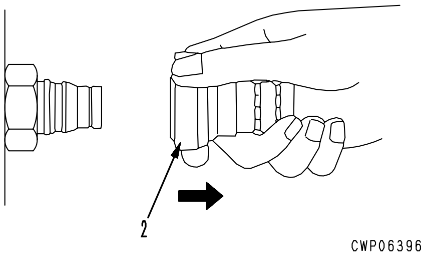
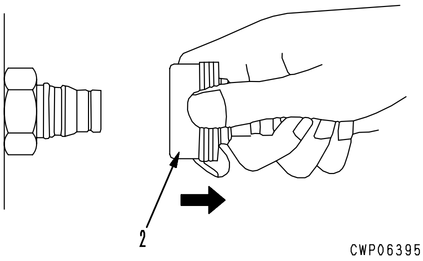
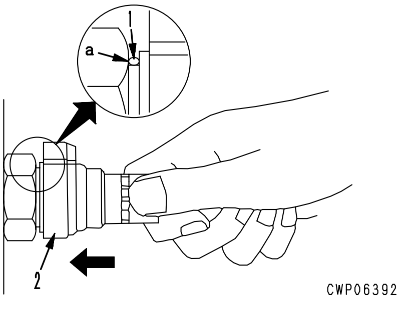
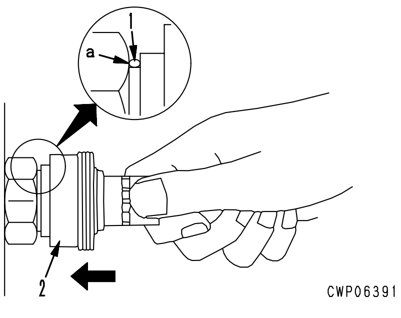
Connection

1) Hold hose adapter (1) or hose (5) and insert it in mating adapter (3), aligning them with each other. (See Fig. 4)
   ★ Do not hold rubber cap portion (4).

2) After inserting the hose in the mating adapter perfectly, pull it back to check its connecting condition. (See Fig. 5)
   ★ When the hose is pulled back, the rubber cap portion moves toward the hose about 3.5 mm. This does not indicate abnormality, however.

Type 1



	Type 2	Type 3
Disassembly	1) Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface **a** of the hexagonal portion at the male end.  	1) Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface **a** of the hexagonal portion at the male end. 
	2) Hold in the condition in Step 1), and turn lever (4) to the right (clockwise).  	2) Hold in the condition in Step 1), and push until cover (3) contacts contact surface **a** of the hexagonal portion at the male end. 
	3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it.  	3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it. 
Connection	• Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface **a** of the hexagonal portion at the male end to connect it.  	• Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface **a** of the hexagonal portion at the male end to connect it. 

COATING MATERIALS

★ The recommended coating materials such as adhesives, gasket sealants and greases used for disassembly and assembly are listed below.
★ For coating materials not listed below, use the equivalent of products shown in this list.

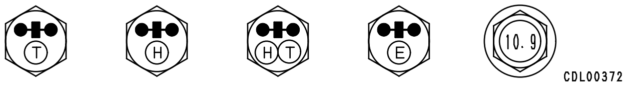
Category	Komatsu code	Part No.	Q'ty	Container	Main applications, featuresr
Adhesives	LT-1A	790-129-9030	150 g	Tube	• Used to prevent rubber gaskets, rubber cushions, and cock plug from coming out.
	LT-1B	790-129-9050	20 g (2 pcs.)	Polyethylene container	• Used in places requiring an immediately effective, strong adhesive. Used for plastics (except polyethylene, polyprophylene, tetrafluoroethlene and vinyl chloride), rubber, metal and non-metal.
	LT-2	09940-00030	50 g	Polyethylene container	• Features: Resistance to heat and chemicals • Used for anti-loosening and sealant purpose for bolts and plugs.
	LT-3	790-129-9060 (Set of adhesive and hardening agent)	Adhesive: 1 kg Hardening agent: 500 g	Can	• Used as adhesive or sealant for metal, glass and plastic.
	LT-4	790-129-9040	250 g	Polyethylene container	• Used as sealant for machined holes.
	Holtz MH 705	790-126-9120	75 g	Tube	• Used as heat-resisting sealant for repairing engine.
	Three bond 1735	790-129-9140	50 g	Polyethylene container	• Quick hardening type adhesive • Cure time: within 5 sec. to 3 min. • Used mainly for adhesion of metals, rubbers, plastics and woods.
	Aron-alpha 201	790-129-9130	2 g	Polyethylene container	• Quick hardening type adhesive • Quick cure type (max. strength after 30 minutes) • Used mainly for adhesion of rubbers, plastics and metals.
	Loctite 648-50	79A-129-9110	50 cc	Polyethylene container	• Resistance to heat, chemicals • Used at joint portions subject to high temperatures.
Gasket sealant	LG-1	790-129-9010	200 g	Tube	• Used as adhesive or sealant for gaskets and packing of power train case, etc.
	LG-5	790-129-9070	1 kg	Can	• Used as sealant for various threads, pipe joints, flanges. • Used as sealant for tapered plugs, elbows, nipples of hydraulic piping.
	LG-6	790-129-9020	200 g	Tube	• Features: Silicon based, resistance to heat, cold • Used as sealant for flange surface, tread. • mab Used as sealant for oil pan, final drive case, etc.

Category	Komatsu code	Part No.	Q'ty	Container	Main applications, featuresr
Adhesives	LG-7	790-129-9070	1 g	Tube	• Ftures: Silicon based, quick hardening type • Used as sealant for flywheel housing, intake manifold, oil an, thermostat housing, etc.
	Three bond 1211	790-129-9090	100 g	Tube	• Used as heat-resisting sealant for repairing engine.
Molybdenum disulphide lubricant	LM-G	09940-00051	60 g	Can	• Used as lubricant for sliding portion (to prevent from squeaking).
	LM-P	09940-00040	200 g	Tube	• Used to prevent seizure or scuffling of the thread when press fitting or shrink fitting. • Used as lubricant for linkage, bearings, etc.
Grease	G2-LI	SYG2-400LI SYG2-350LI SYG2-400LI-A SYG2-160LI SYGA-160CNLI	Various	Various	• General purpose type
	G2-CA	SYG2-400CA SYG2-350CA SYG2-400CA-A SYG2-160CA SYGA-160CNCA	Various	Various	• Used for normal temperature, light load bearing at places in contact with water or steam.
	Molybdenum disulphide lubricant	SYG2-400M	400 g (10 per case)	Belows type	• Used for places with heavy load

STANDARD TIGHTENING TORQUE

STANDARD TIGHTENING TORQUE TABLE (WHEN USING TORQUE WRENCH)

★ In the case of metric nuts and bolts for which there is no special instruction, tighten to the torque given in the table below.

Thread diameter of bolt	Width across flats		
mm	mm	Nm	kgm
6	10	13.2 ± 1.4	1.35 ± 0.15
8	13	31 ± 3	3.2 ± 0.3
10	17	66 ± 7	6.7 ± 0.7
12	19	113 ± 10	11.5 ± 1
14	22	177 ± 19	18 ± 2
16	24	279 ± 30	28.5 ± 3
18	27	382 ± 39	39 ± 4
20	30	549 ± 59	56 ± 6
22	32	745 ± 83	76 ± 8.5
24	36	927 ± 103	94.5 ± 10.5
27	41	1320 ± 140	135 ± 15
30	46	1720 ± 190	175 ± 20
33	50	2210 ± 240	225 ± 25
36	55	2750 ± 290	280 ± 30
39	60	3290 ± 340	335 ± 35

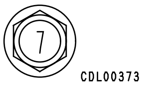
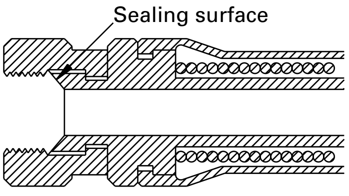
Thread diameter of bolt	Width across flats		
mm	mm	Nm	kgm
6	10	7.85 ± 1.95	0.8 ± 0.2
8	13	18.6 ± 4.9	1.9 ± 0.5
10	14	40.2 ± 5.9	4.1 ± 0.6
12	27	82.35 ± 7.85	8.4 ± 0.8

TABLE OF TIGHTENING TORQUES FOR FLARED NUTS

★ In the case of flared nuts for which there is no special instruction, tighten to the torque given in the table below.



Thread diameter	Width across flat	Tightening torque	
mm	mm	Nm	kgm
14	19	24.5 ± 4.9	2.5 ± 0.5
18	24	49 ± 19.6	5 ± 2
22	27	78.5 ± 19.6	8 ± 2
24	32	137.3 ± 29.4	14 ± 3
30	36	176.5 ± 29.4	18 ± 3
33	41	196.1 ± 49	20 ± 5
36	46	245.2 ± 49	25 ± 5
42	55	294.2 ± 49	30 ± 5

TABLE OF TIGHTENING TORQUES FOR SPLIT FLANGE BOLTS

★ In the case of split flange bolts for which there is no special instruction, tighten to the torque given in the table below.

Thread diameter	Width across flat	Tightening torque	
mm	mm	Nm	kgm
10 12 16	14 17 22	65.7 ± 6.8 112 ± 9.8 279 ± 29	6.7 ± 0.7 11.5 ± 1 28.5 ± 3

TABLE OF TIGHTENING TORQUES FOR O-RING BOSS PIPING JOINTS

★ Unless there are special instructions, tighten the O-ring boss piping joints to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque	
	mm	mm	Nm	kgm
02 03, 04 05, 06 10, 12 14	14 20 24 33 42	Varies depending on type of connector.	34.3 ± 4.9 93.1 ± 9.8 142.1 ± 19.6 421.4 ± 58.8 877.1 ± 132.3	3.5 ± 0.5 9.5 ± 1 14.5 ± 2 43 ± 6 89.5 ± 13.5

TABLE OF TIGHTENING TORQUES FOR O-RING BOSS PLUGS

★ Unless there are special instructions, tighten the O-ring boss plugs to the torque below.

Norminal No.	Thread diameter	Width across flat	Tightening torque	
	mm	mm	Nm	kgm
08	08	14	7.35 ± 1.47	0.75 ± 0.15
10	10	17	11.27 ± 1.47	1.15 ± 0.15
12	12	19	17.64 ± 1.96	1.8 ± 0.2
14	14	22	22.54 ± 1.96	2.3 ± 0.2
16	16	24	29.4 ± 4.9	3 ± 0.5
18	18	27	39.2 ± 4.9	4 ± 0.5
20	20	30	49 ± 4.9	5 ± 0.5
24	24	32	68.6 ± 9.8	7 ± 1
30	30	32	107.8 ± 14.7	11 ± 1.5
33	33	n	127.4 ± 19.6	13 ± 2
36	36	36	151.9 ± 24.5	15.5 ± 2.5
42	42	n	210.7 ± 29.4	21.5 ± 3
52	52	n	323.4 ± 44.1	33 ± 4.5

TIGHTENING TORQUE FOR 102 ENGINE SERIES

1) BOLT AND NUTS

Use these torques for bolts and nuts (unit: mm) of Cummins Engine.

Thread diameter	Tightening torque	
mm	Nm	kgm
6	10 ± 2	1.02 ± 0.20
8	24 ± 4	2.45 ± 0.41
10	43 ± 6	4.38 ± 0.61
12	77 ± 12	7.85 ± 1.22

2) EYE JOINTS

Use these torques for eye joints (unit: mm) of Cummins Engine.

Thread diameter	Tightening torque	
mm	Nm	kgm
6	8 ± 2	0.81 ± 0.20
8	10 ± 2	1.02 ± 0.20
10	12 ± 2	1.22 ± 0.20
12	24 ± 4	2.45 ± 0.41
14	36 ± 5	3.67 ± 0.51

3) TAPERED SCREWS

Use these torques for tapered screws (unit: inch) of Cummins Engine.

Thread diameter	Tightening torque	
inch	Nm	kgm
1 / 16	3 ± 1	0.31 ± 0.10
1 / 8	8 ± 2	0.81 ± 0.20
1 / 4	12 ± 2	1.22 ± 0.20
3 / 8	15 ± 2	1.53 ± 0.41
1 / 2	24 ± 4	2.45 ± 0.41
3 / 4	36 ± 5	3.67 ± 0.51
1	60 ± 9	6.12 ± 0.92

TIGHTENING TORQUE TABLE FOR HOSES (TAPER SEAL TYPE AND FACE SEAL TYPE)

★ Tighten the hoses (taper seal type and face seal type) to the following torque, unless otherwise specified.

★ Apply the following torque when the threads are coated (wet) with engine oil.

Nominal size of hose	Width across flats	Tightening torque (Nm {kgm})		Taper seal type	Face seal type	
		Range	Target	Thread size (mm)	Nominal thread size - Threads per inch, Thread series	Root diameter (mm) (Reference)
02	19	35 - 63 {3.5 - 6.5}	44 {4.5}	14	$\frac{9}{16}$ - 18UNF	14.3
03	22	54 - 93 {5.5 - 9.5}	74 {4.5}	–	$\frac{11}{16}$ - 16UN	17.5
	24	59 - 98 {6.0 - 10.0}	78 {8.0}	18	–	–
04	27	84 - 132 {8.5 - 13.5}	103 {10.5}	22	$\frac{13}{16}$ - 16UN	20.7
05	32	128 - 186 {13.0 - 19.0}	157 {16.0}	24	1 - 14UNS	25.4
06	36	177 - 245 {18.0 - 25.0}	216 {22.0}	30	$1\frac{3}{16}$ - 12UNF	30.3
(10)	41	177 - 245 {18.0 - 25.0}	216 {22.0}	33	–	–
(12)	46	197 - 294 {20.0 - 30.0}	245 {25.0}	36	–	–
(14)	55	246 - 343 {25.0 - 35.0}	294 {30.0}	42	–	–

ELECTRIC WIRE CODE

In the wiring diagrams, various colors and symbols are employed to indicate the thickness of wires.
This wire code table will help you understand WIRING DIAGRAMS.
Example: 5WB indicates a cable having a nominal number 5 and white coating with black stripe.

CLASSIFICATION BY THICKNESS

Norminal number	Copper wire			Cable O.D. (mm)	Current rating (A)	Applicable circuit
	Number of strands	Dia. of strands (mm^2)	Cross section (mm^2)			
0.85	11	0.32	0.88	2.4	12	Starting, lighting, signal etc.
2	26	0.32	2.09	3.1	20	Lighting, signal etc.
5	65	0.32	5.23	4.6	37	Charging and signal
15	84	0.45	13.36	7.0	59	Starting (Glow plug)
40	85	0.80	42.73	11.4	135	Starting
60	127	0.80	63.84	13.6	178	Starting
100	217	0.80	109.1	17.6	230	Starting

CLASSIFICATION BY COLOR AND CODE

Priori-ty	Circuits Classi-fication		Charging	Ground	Starting	Lighting	Instrument	Signal	Other
1	Pri-mary	Code	W	B	B	R	Y	G	L
		Color	White	Black	Black	Red	Yellow	Green	Blue
2	Auxi-liary	Code	WR	—	BW	RW	YR	GW	LW
		Color	White & Red	—	White & Black	Red & White	Rellow & Red	Green & White	Blue & White
3		Code	WB	—	BY	RB	YB	GR	LR
		Color	White & Black	—	Black & Yellow	Red & Black	Yellow & Black	Green & Red	Blue & Yellow
4		Code	WL	—	BR	RY	YG	GY	LY
		Color	White & Blue	—	Black & Red	Red & Yellow	Yellow & Green	Green & Yellow	Blue & Yellow
5		Code	WG	—	—	RG	YL	GB	LB
		Color	White & Green	—	—	Red & Green	Yellow & Blue	Green & Black	Blue & Black
6		Code	—	—	—	RL	YW	GL	—
		Color	—	—	—	Red & Blue	Yellow & White	Green & Blue	—

CONVERSION TABLE

METHOD OF USING THE CONVERSION TABLE

The Conversion Table in this section is provided to enable simple conversion of figures. For details of the method of using the Conversion Table, see the example given below.

EXAMPLE

- Method of using the Conversion Table to convert from millimeters to inches

1. Convert 55 mm into inches.
   (1) Locate the number 50 in the vertical column at the left side, take this as Ⓐ, then draw a horizontal line from Ⓐ.
   (2) Locate the number 5 in the row across the top, take this as Ⓑ, then draw a perpendicular line down from Ⓑ.
   (3) Take the point where the two lines cross as Ⓒ. This point Ⓒ gives the value when converting from millimeters to inches. Therefore, 55 mm = 2.165 inches.
2. Convert 550 mm into inches.
   (1) The number 550 does not appear in the table, so divide by 10 (move the decimal point one place to the left) to convert it to 55 mm.
   (2) Carry out the same procedure as above to convert 55 mm to 2.165 inches.
   (3) The original value (550 mm) was divided by 10, so multiply 2.165 inches by 10 (move the decimal point one place to the right) to return to the original value. This gives 550 mm = 21.65 inches.

Ⓑ

Millimeters to inches

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
Ⓐ 50	1.969	2.008	2.047	2.087	2.126	Ⓒ 2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to Inches

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to Pound

1 kg = 2.2046 lb

	0	1	2	3	4	5	6	7	8	9
0	0	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liter to U.S. Gallon

1ℓ = 0.2642 U.S. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.361	25.625	25.889	26.153

Liter to U.K. Gallon

1ℓ = 0.21997 U.K. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.969	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgm to ft. lb

1 kgm = 7.233 ft. lb

	0	1	2	3	4	5	6	7	8	9
0	0	7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	296.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	1005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kg/cm^2 to lb/in^2

1kg/cm^2 = 14.2233 lb/in^2

	0	1	2	3	4	5	6	7	8	9
0	0	14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1010	1024	1038	1053	1067	1081	1095	1109	1124
80	1138	1152	1166	1181	1195	1209	1223	1237	1252	1266
90	1280	1294	1309	1323	1337	1351	1365	1380	1394	1408
100	1422	1437	1451	1465	1479	1493	1508	1522	1536	1550
110	1565	1579	1593	1607	1621	1636	1650	1664	1678	1693
120	1707	1721	1735	1749	1764	1778	1792	1806	1821	1835
130	1849	1863	1877	1892	1906	1920	1934	1949	1963	1977
140	1991	2005	2020	2034	2048	2062	2077	2091	2105	2119
150	2134	2148	2162	2176	2190	2205	2219	2233	2247	2262
160	2276	2290	2304	2318	2333	2347	2361	2375	2389	2404
170	2418	2432	2446	2460	2475	2489	2503	2518	2532	2546
180	2560	2574	2589	2603	2617	2631	2646	2660	2674	2688
190	2702	2717	2731	2745	2759	2773	2788	2802	2816	2830
200	2845	2859	2873	2887	2901	2916	2930	2944	2958	2973
210	2987	3001	3015	3030	3044	3058	3072	3086	3101	3115
220	3129	3143	3158	3172	3186	3200	3214	3229	3243	3257
230	3271	3286	3300	3314	3328	3343	3357	3371	3385	3399
240	3414	3428	3442	3456	3470	3485	3499	3513	3527	3542

Temperature

Fahrenheit-Centigrade Conversion ; a simple way to convert a Fahrenheit temperature reading into a Centigrade temperature reading or vice versa is to enter the accompanying table in the center or boldface column of figures.

These figures refer to the temperature in either Fahrenheit or Centigrade degrees.

If it is desired to convert from Fahrenheit to Centigrade degrees, consider the center column as a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left.

If it is desired to convert from Centigrade to Fahrenheit degrees, consider the center column as a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

1°C = 33.8°F

°C		°F	°C		°F	°C		°F	°C		°F
–40.4	**–40**	–40.0	–11.7	**11**	51.8	7.8	**46**	114.8	27.2	**81**	117.8
–37.2	**–35**	–31.0	–11.1	**12**	53.6	8.3	**47**	116.6	27.8	**82**	179.6
–34.4	**–30**	–22.0	–10.6	**13**	55.4	8.9	**48**	118.4	28.3	**83**	181.4
–31.7	**–25**	–13.0	–10.0	**14**	57.2	9.4	**49**	120.2	28.9	**84**	183.2
–28.9	**–20**	–4.0	–9.4	**15**	59.0	10.0	**50**	122.0	29.4	**85**	185.0
–28.3	**–19**	–2.2	–8.9	**16**	60.8	10.6	**51**	123.8	30.0	**86**	186.8
–27.8	**–18**	–0.4	–8.3	**17**	62.6	11.1	**52**	125.6	30.6	**87**	188.6
–27.2	**–17**	1.4	–7.8	**18**	64.4	11.7	**53**	127.4	31.1	**88**	190.4
–26.7	**–16**	3.2	–7.2	**19**	66.2	12.2	**54**	129.2	31.7	**89**	192.2
–26.1	**–15**	5.0	–6.7	**20**	68.0	12.8	**55**	131.0	32.2	**90**	194.0
–25.6	**–14**	6.8	–6.1	**21**	69.8	13.3	**56**	132.8	32.8	**91**	195.8
–25.0	**–13**	8.6	–5.6	**22**	71.6	13.9	**57**	134.6	33.3	**92**	197.6
–24.4	**–12**	10.4	–5.0	**23**	73.4	14.4	**58**	136.4	33.9	**93**	199.4
–23.9	**–11**	12.2	–4.4	**24**	75.2	15.0	**59**	138.2	34.4	**94**	201.2
–23.3	**–10**	14.0	–3.9	**25**	77.0	15.6	**0**	140.0	35.0	**95**	203.0
–22.8	**–9**	15.8	–3.3	**26**	78.8	16.1	**61**	141.8	35.6	**96**	204.8
–22.2	**–8**	17.6	–2.8	**27**	80.6	16.7	**62**	143.6	36.1	**97**	206.6
–21.7	**–7**	19.4	–2.2	**28**	82.4	17.2	**63**	145.4	36.7	**98**	208.4
–21.1	**–6**	21.2	–1.7	**29**	84.2	17.8	**64**	147.2	37.2	**99**	210.2
–20.6	**–5**	23.0	–1.1	**30**	86.0	18.3	**65**	149.0	37.8	**100**	212.0
–20.0	**–4**	24.8	–0.6	**31**	87.8	18.9	**66**	150.8	40.6	**105**	221.0
–19.4	**–3**	26.6	0	**32**	89.6	19.4	**67**	152.6	43.3	**110**	230.0
–18.9	**–2**	28.4	0.6	**33**	91.4	20.0	**68**	154.4	46.1	**115**	239.0
–18.3	**–1**	30.2	1.1	**34**	93.2	20.6	**69**	156.2	48.9	**120**	248.0
–17.8	**0**	32.0	1.7	**35**	95.0	21.1	**70**	158.0	51.7	**125**	257.0
–17.2	**1**	33.8	2.2	**36**	96.8	21.7	**71**	159.8	54.4	**130**	266.0
–16.7	**2**	35.6	2.8	**37**	98.6	22.2	**72**	161.6	57.2	**135**	275.0
–16.1	**3**	37.4	3.3	**38**	100.4	22.8	**73**	163.4	60.0	**140**	284.0
–15.6	**4**	39.2	3.9	**39**	102.2	23.3	**74**	165.2	62.7	**145**	293.0
–15.0	**5**	41.0	4.4	**40**	104.0	23.9	**75**	167.0	65.6	**150**	302.0
–14.4	**6**	42.8	5.0	**41**	105.8	24.4	**76**	168.8	68.3	**155**	311.0
–13.9	**7**	44.6	5.6	**42**	107.6	25.0	**77**	170.6	71.1	**160**	320.0
–13.3	**8**	46.4	6.1	**43**	109.4	25.6	**78**	172.4	73.9	**165**	329.0
–12.8	**9**	48.2	6.7	**44**	111.2	26.1	**79**	174.2	76.7	**170**	338.0
–12.2	**10**	50.0	7.2	**45**	113.0	26.7	**80**	176.0	79.4	**175**	347.0

UNITS

In this manual, the measuring units are indicated with Internatinal System of units (SI).
As for reference, conventionally used Gravitational System of units are indicated in parentheses { }.

Example:

N {kg}
Nm {kgm}
MPa {kg/cm^2}
kPa {mmH$_2$O}
kPa {mmHg}
kW/rpm {HP/rpm}
g/kWh {g/HPh}

01 GENERAL

APPPLICABLE MACHINE

Engine	Engine Serial No.	Applicable machine	
SA6D170E-3		D375A-5	Bulldozer
SAA6D170E-3		PC1250-7	Hydraulic excavator
		WA600-3	Wheel loader
		WD600-3	Wheel dozer
		HD465-7	Dump truck
		HD605-7	Dump truck
		Generator	Generator

SPECIFICATIONS

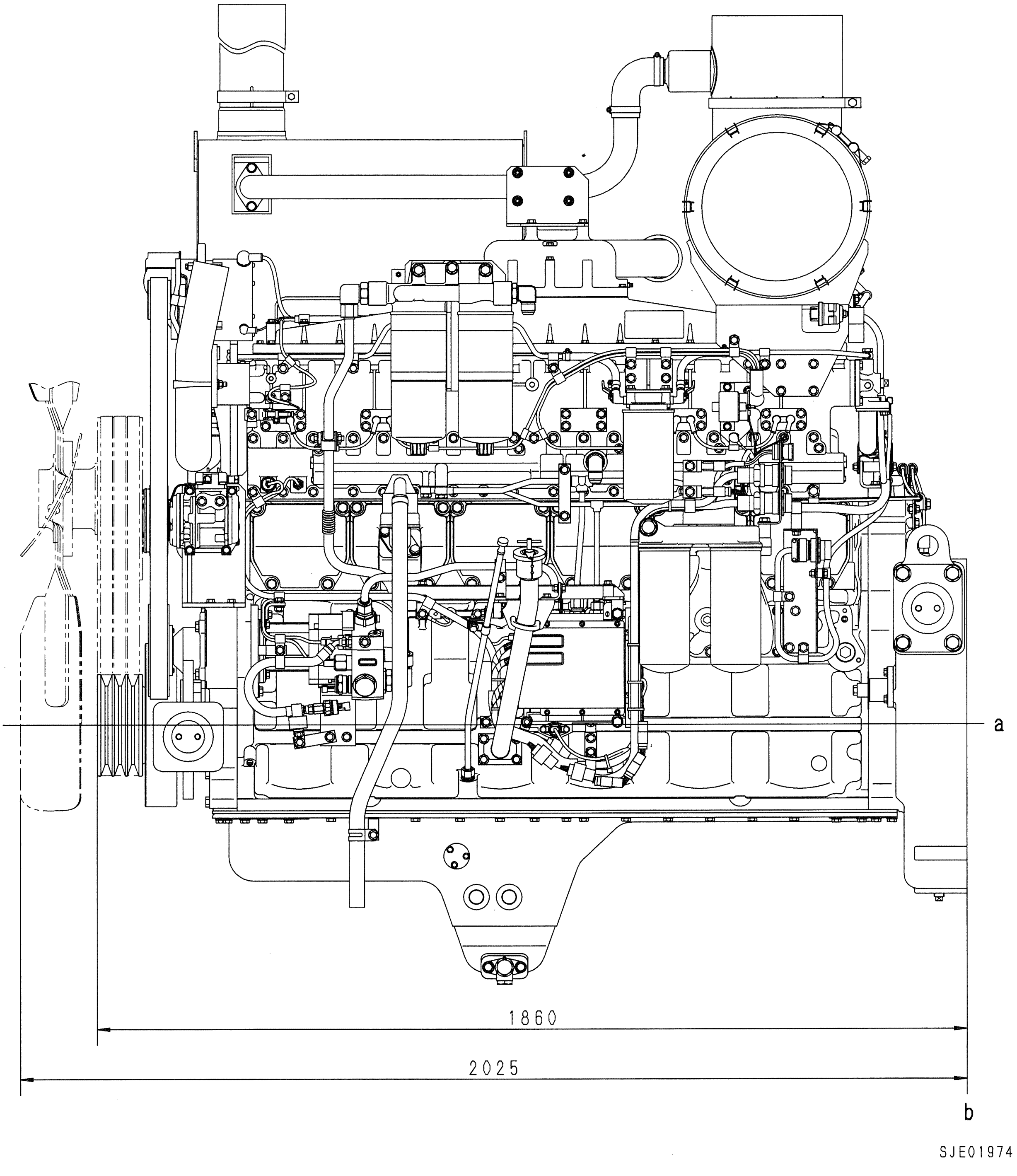
Engine model			SA6D170E-3	SAA6D170E-3
Applicable machine			D375A-5	WA600-3
	Number of cylinder – Bore x Stroke	mm	6 – 170 x 170	
	Piston displacement	ℓ {cc}	23.2 {23,150}	
	Firing order		1 – 5 – 3 – 6 – 2 – 4	
Dimensions	Overall length	mm	1,860	2,244
	Overall width	mm	1,240	885
	Overall height (excluding exhaust pipe)	mm	2,093	1,920
	Overall height (including exhaust pipe)	mm	—	—
Performance	Flyweel horsepower	kW {HP}/rpm	391{524}/1,800 (Net)	337 {452}/2,000 (Net)
	Maximum torque	Nm {kgm}/rpm	2,650 {270}/1,300 (Net)	2,120 {216}/1,400 (Net)
	High idling speed	rpm	2,000± 40	2,170 ± 30
	Low idling speed	rpm	750 ± 50	700 ± 25
	Minimum fuel consumption ratio	g/kW•h{g/HP•h}	224 {167}	221 {165}
	Dry weight	kg	2,740	2,900
	Fuel pump		Trochoid gear pump (KOMATSU HPI system)	
	Governor		Electronic control type	
	Lubricating oil amount (refill capacity)	ℓ	67 (56)	64 (60)
	Coolant amount	ℓ	(Engine side: 47)	(Engine side: 47)
	Alternator		24V, 75A	24V, 75A
	Starting motor		24V, 7.5kW x 2	24V, 7.5kW x 2
	Battery		12V, 200Ahc x 2	12V, 200Ahc x 2
	Turbocharger		KOMATSU KTR110L	KOMATSU KTR110L
	Air compressor		—	—
	Others		With aftercooler	With air cooled after cooler

SAA6D170E-3			
WD600-3	PC1250-7	HD465-7 HD605-7	Generator
6 - 170 x 170			
23.2 {23,150}			
1 – 5 – 3 – 6 – 2 – 4			
2,244	2,235	2,057	2,638
1,138	1,235	1,250	1,073
1,940	1,936	1,644	1,815
—	—	—	—
370{497}/2,000 (Net)	485 {651}/1,800 (Net)	533 {715}/2,000 (Net)	548 {735}/1,500 (50Hz) (Net)
2,391 {244}/1,400 (Net)	2,913 {297}/1,300 (Net)	3,207 {327}/1,400 (Net)	548 {735}/1,800 (60Hz) (Net)
—	—	—	—
2,190 ± 30	2,000 ± 40	2,270 ± 50	Max. 1,575 (50Hz) Max. 1,890 (60Hz)
700 ± 25	900 ± 25	750 ± 50	800 ± 50
222 {163}	218 {160}	211 {155}	(Rated output) 203 {151} (50Hz) 212 {158} (60Hz)
2,900	2,870	2,740	2,565
Trochoid gear pump			
(KOMATSU HPI system) Electronic control type			
64 (60)	67 (56)	67 (56)	196 (190)
	137 (Engine side: 47)	137 (Engine side: 47)	137 (Engine side: 47)
24V, 75A	24V, 150A	24V, 50A	—
24V, 7.5kW x 2	24V, 11kW x 2	24V, 7.5kW x 2	24V, 11kW
12V, 200Ah x 2	12V, 200Ah x 2	12V, 200Ah x 2	12V, 200Ah x 2
KOMATSU KTR110L	SCHWITZER S500		SCHWITZER S500
—	Recipro type, single cylinder		—
With air cooled aftercooler	With air cooled aftercooler		With air cooled aftercooler

OVERALL DRAWING

SA6D170E-3 VIEW FROM LEFT SIDE (D375A-5)

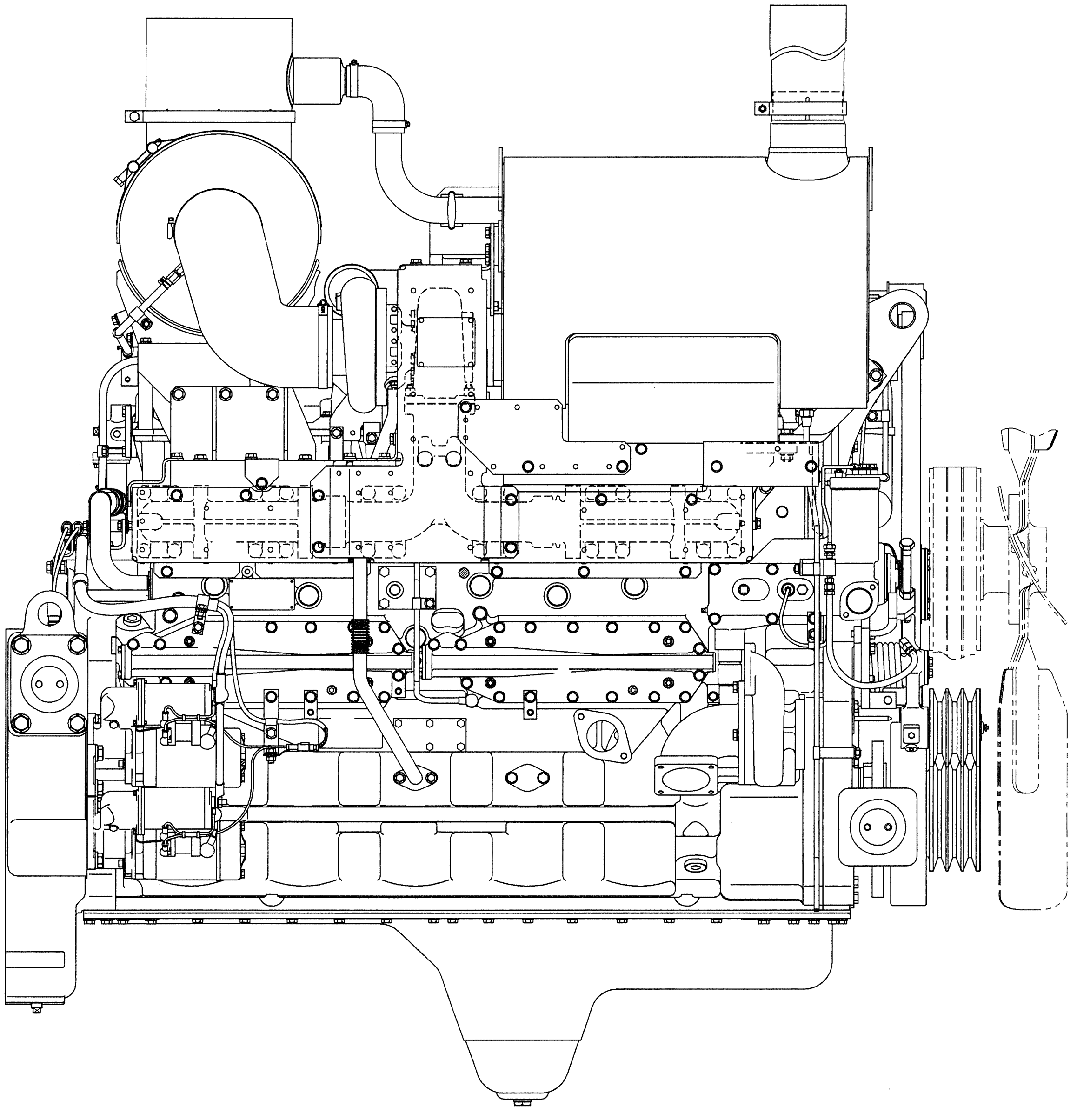
★ The actual engine may be different because of modifications.



a. Center of crankshaft
b. Rear face of flywheel housing

SA6D170E-3 VIEW FROM RIGHT SIDE (D375A-5)

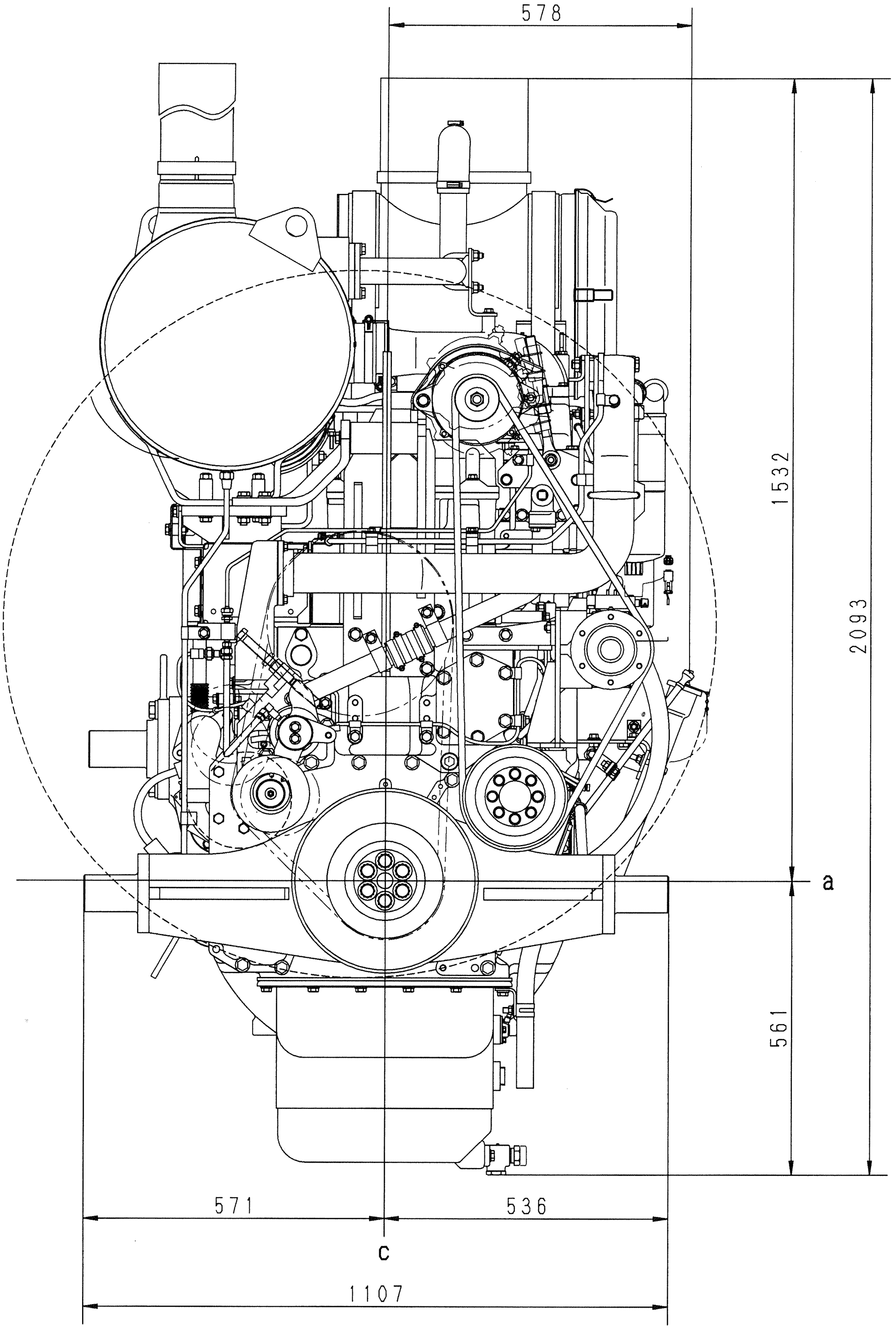
★ The actual engine may be different because of modifications.



SJE01975

SA6D170E-3 VIEW FROM FRONT (D375A-5)

★ The actual engine may be different because of modifications.

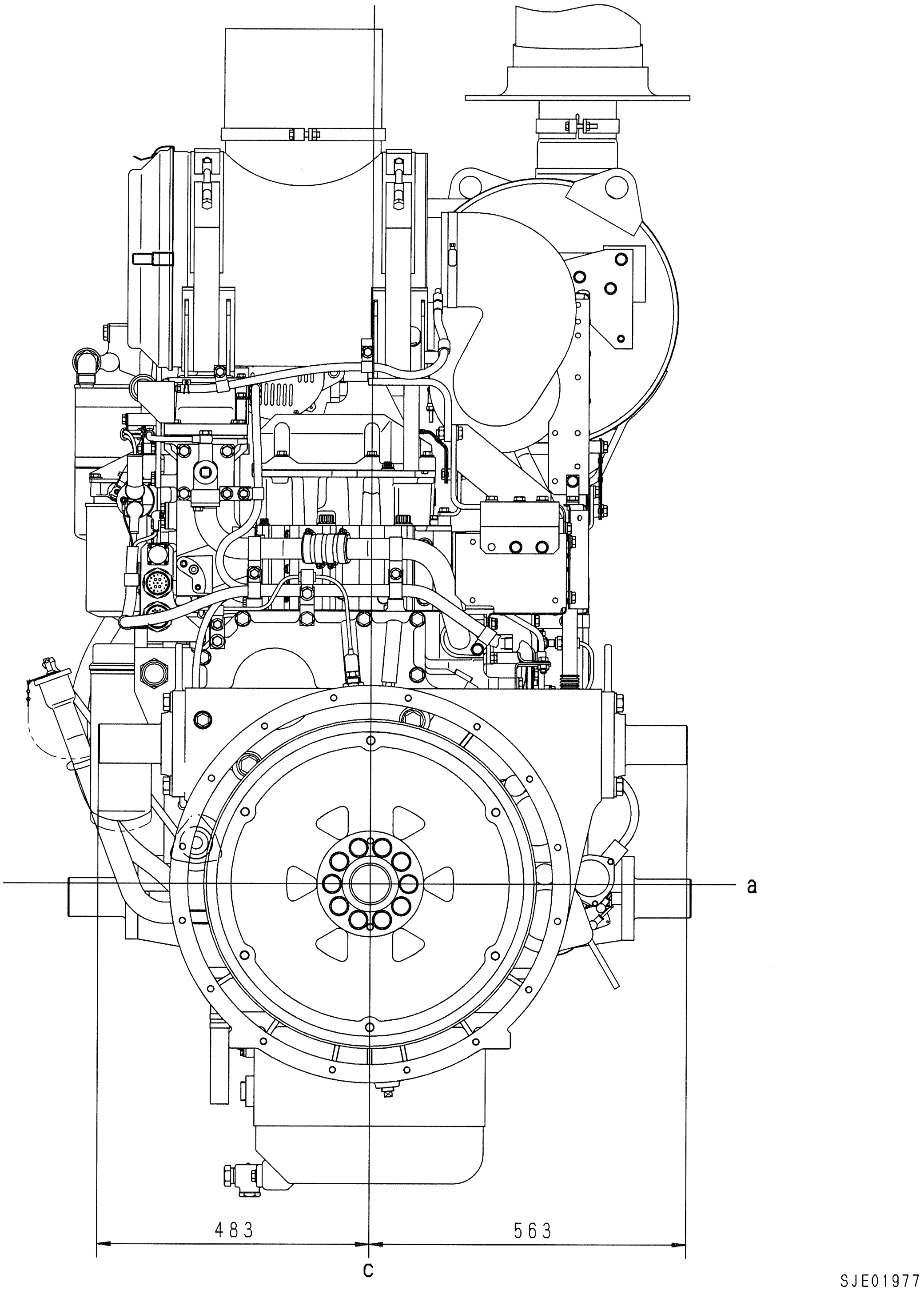


SJE01976

a. Center of crankshaft
c. Center of cylinder liner

SA6D170E-3 VIEW FROM REAR (D375A-5)

★ The actual engine may be different because of modifications.

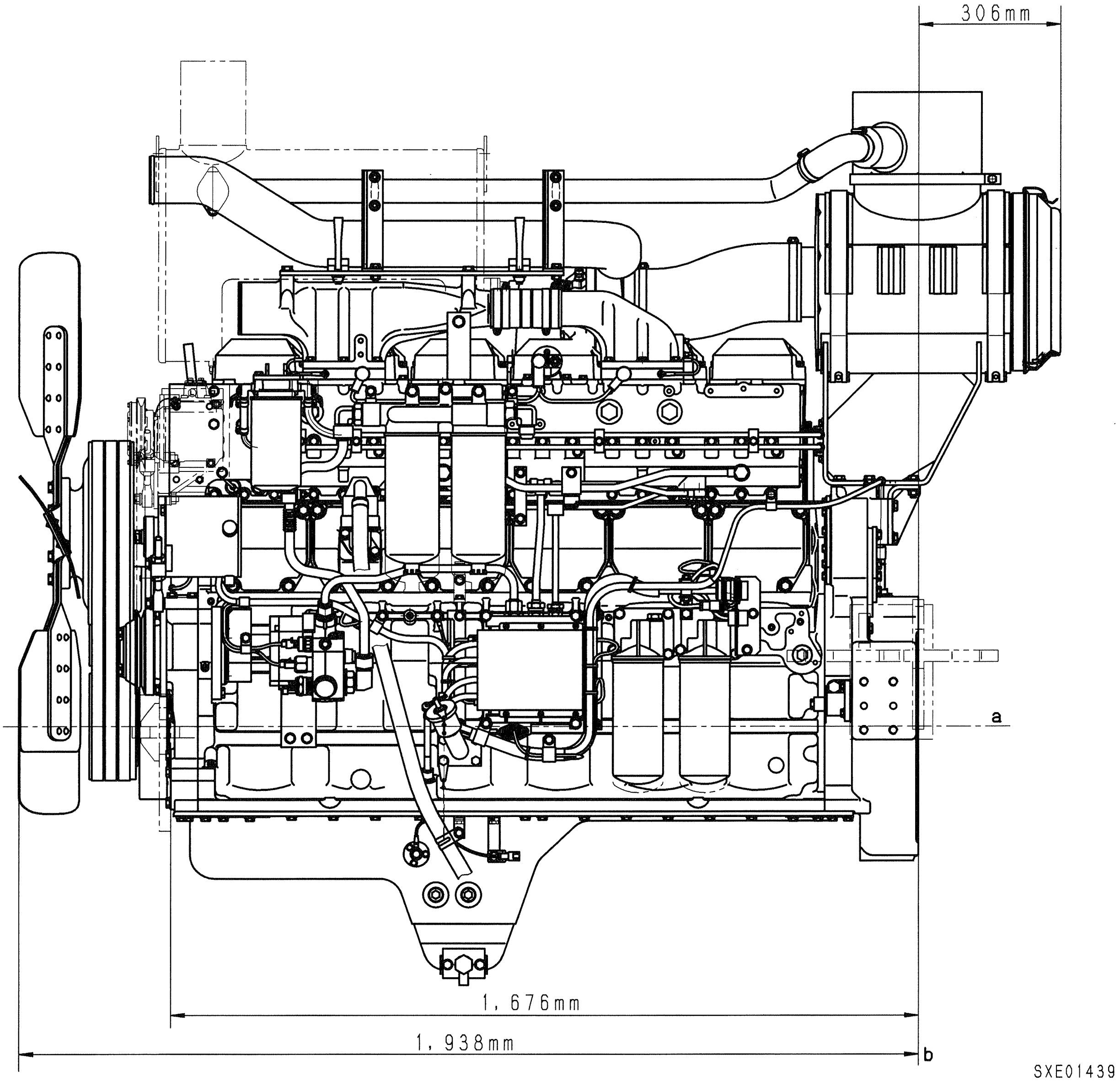


a. Center of crankshaft
c Center of cylinder liner

OVERALL DRAWING

SAA6D170E-3 VIEW FROM LEFT SIDE (WA600-3)

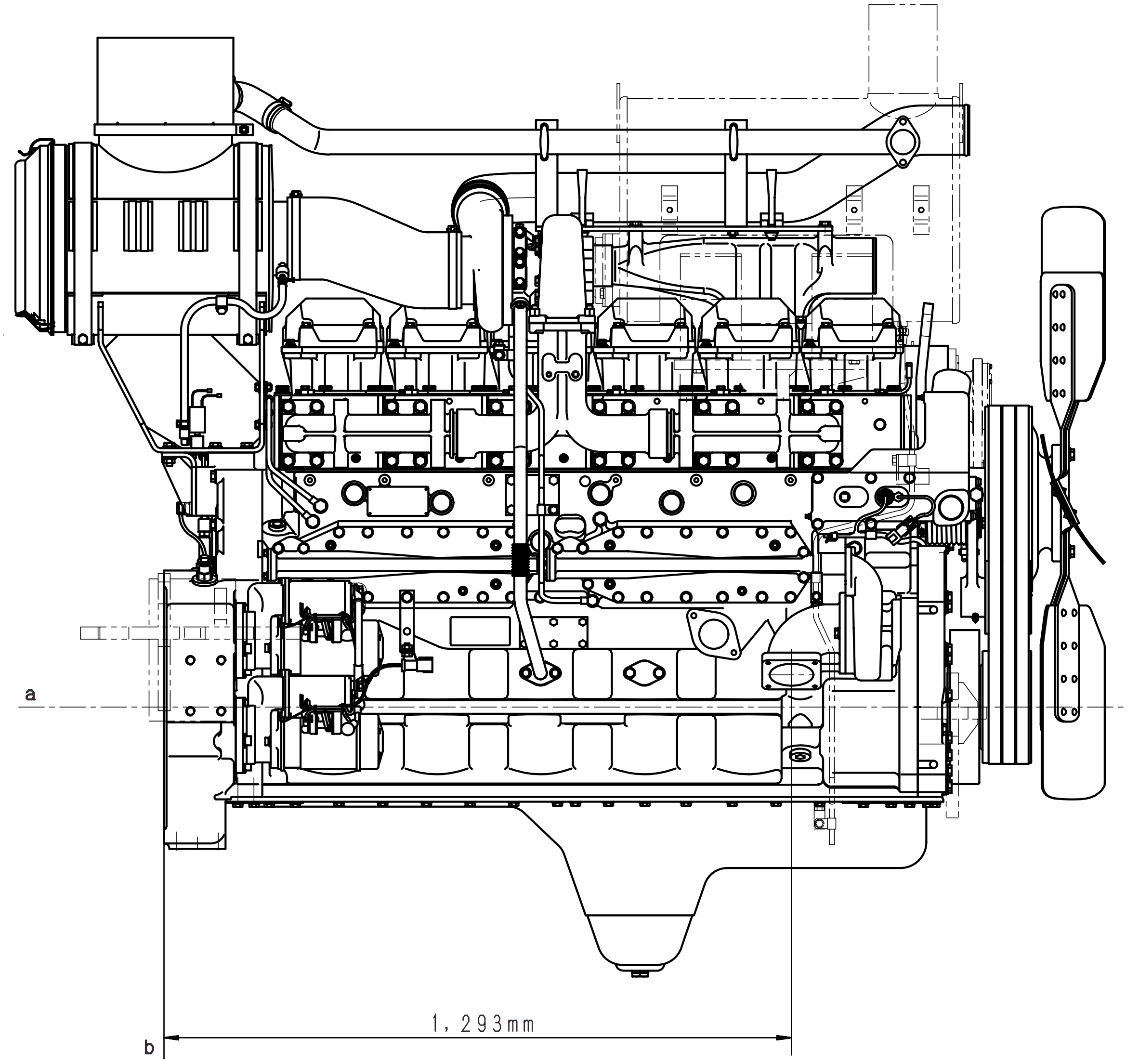
★ The actual engine may be different because of modifications.



a. Center of crankshaft
b. Rear face of flywheel housing

SAA6D170E-3 VIEW FROM RIGHT SIDE

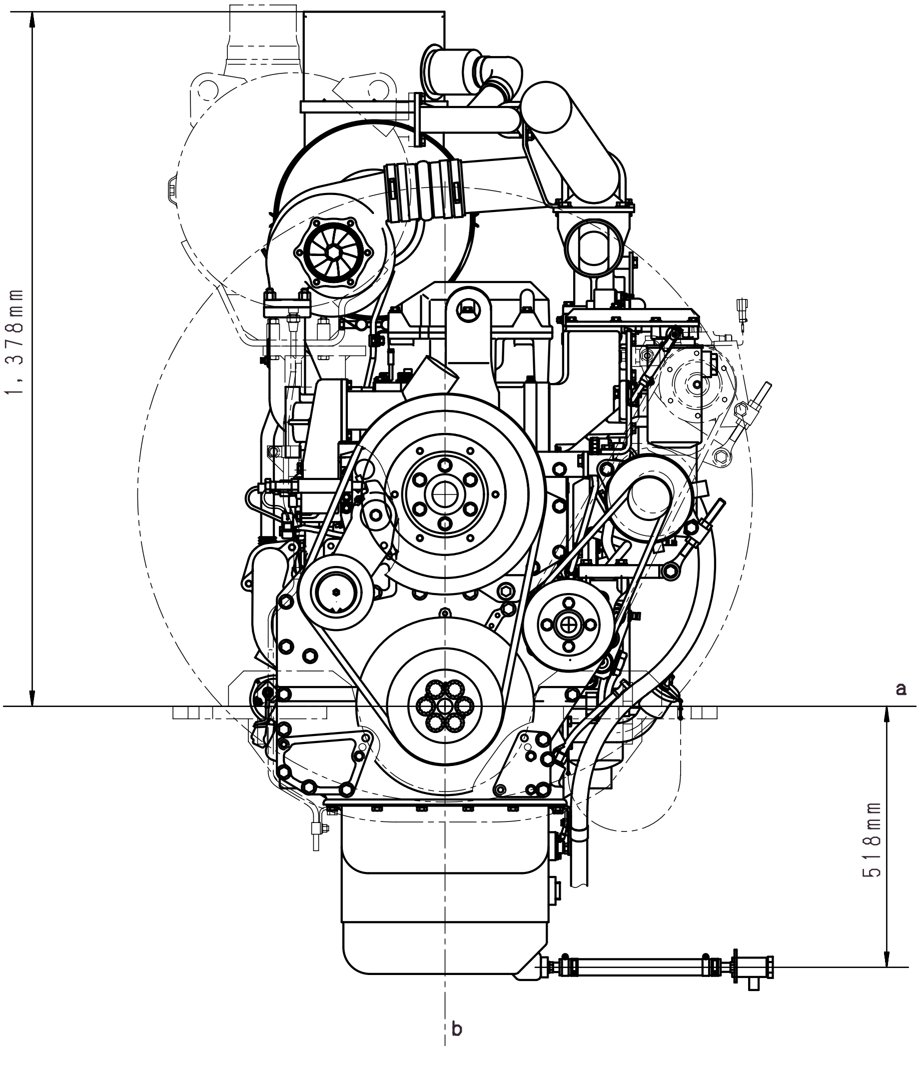
★ The illustration shows the engine for the WA600-3.
The actual engine may be different because of modifications.



a. Center of crankshaft
b. Rear face of flywheel housing

SAA6D170E-3 VIEW FROM FRONT

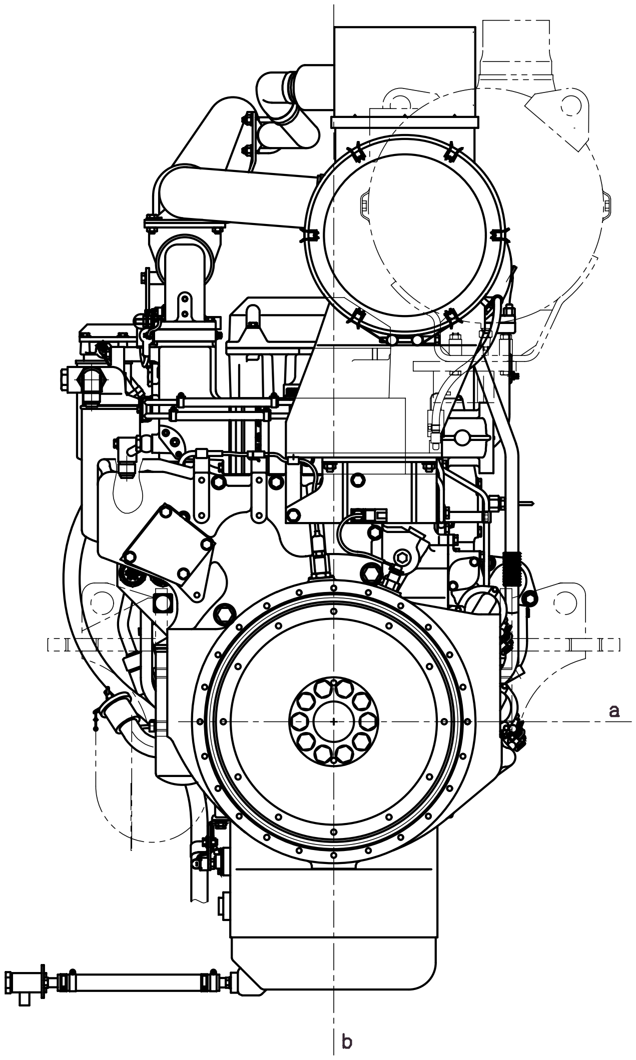
★ The illustration shows the engine for the WA600-3.
The actual engine may be different because of modifications.



a. Center of crankshaft
b. Center of cylinder liner

SAA6D170E-3 VIEW FROM REAR

★ The illustration shows the engine for the WA600-3.
The actual engine may be different because of modifications.

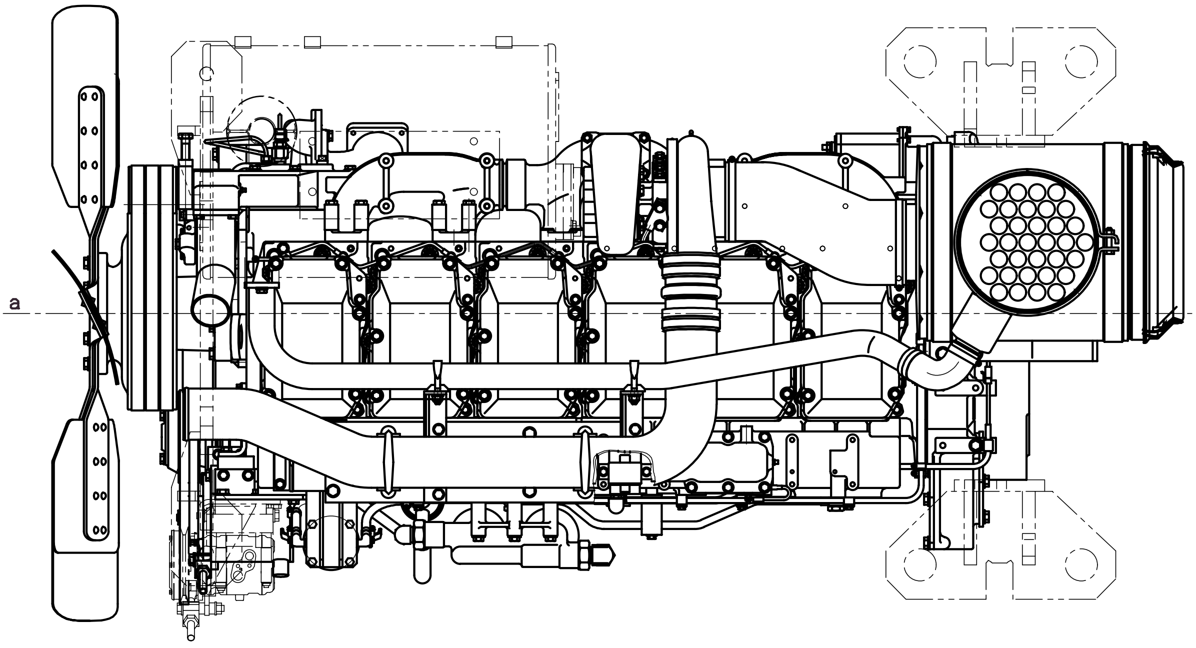


SXE01442

a. Center of crankshaft
b. Center of cylinder liner

SAA6D170E-3 VIEW FROM TOP

★ The illustration shows the engine for the WA600-3.
The actual engine may be different because of modifications.

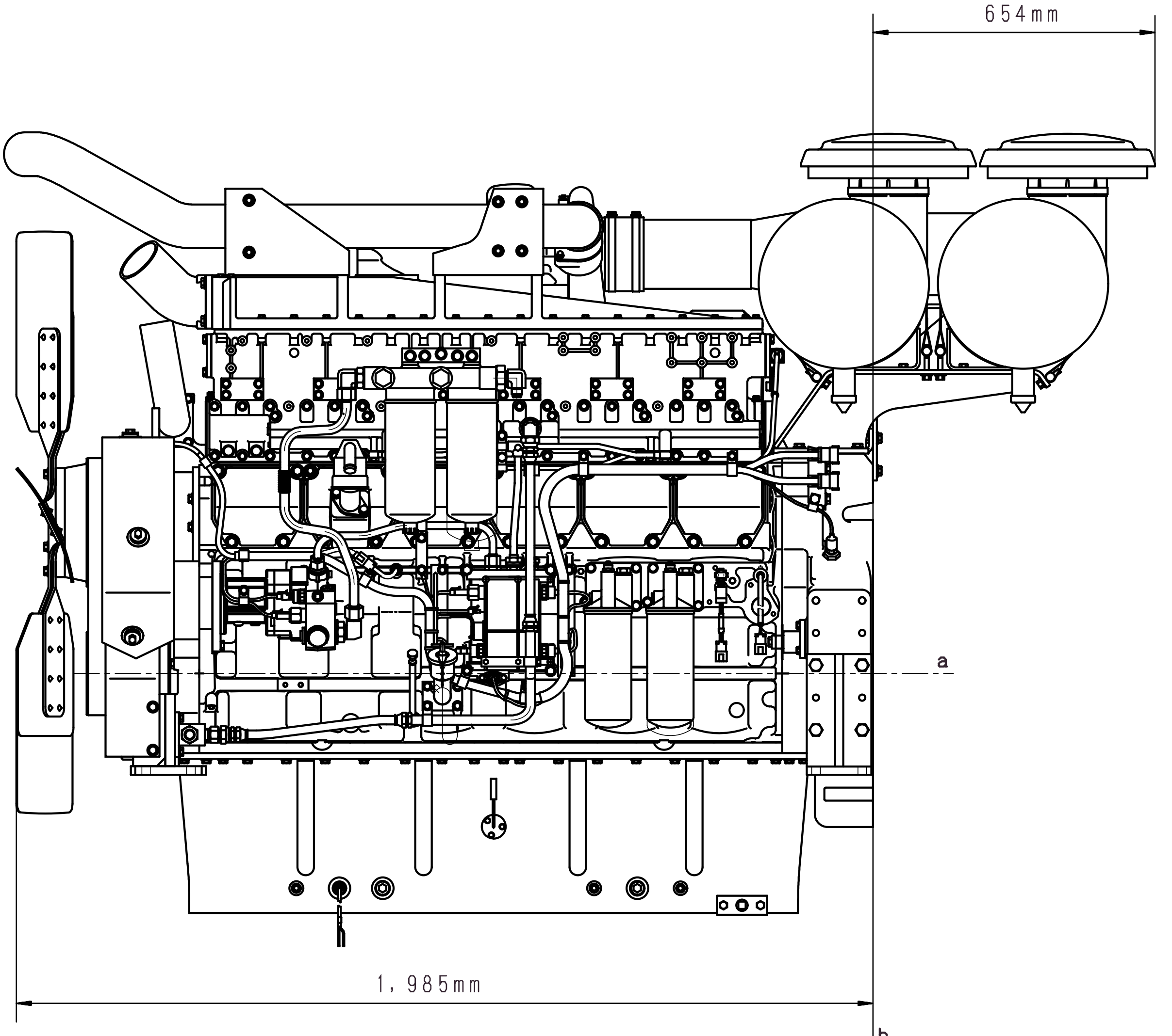


SXE01443

a. Center of cylinder liner

SAA6D170E-3 VIEW FROM LEFT SIDE

★ The illustration shows the engine for the normal generator.
The actual engine may be different because of modifications.

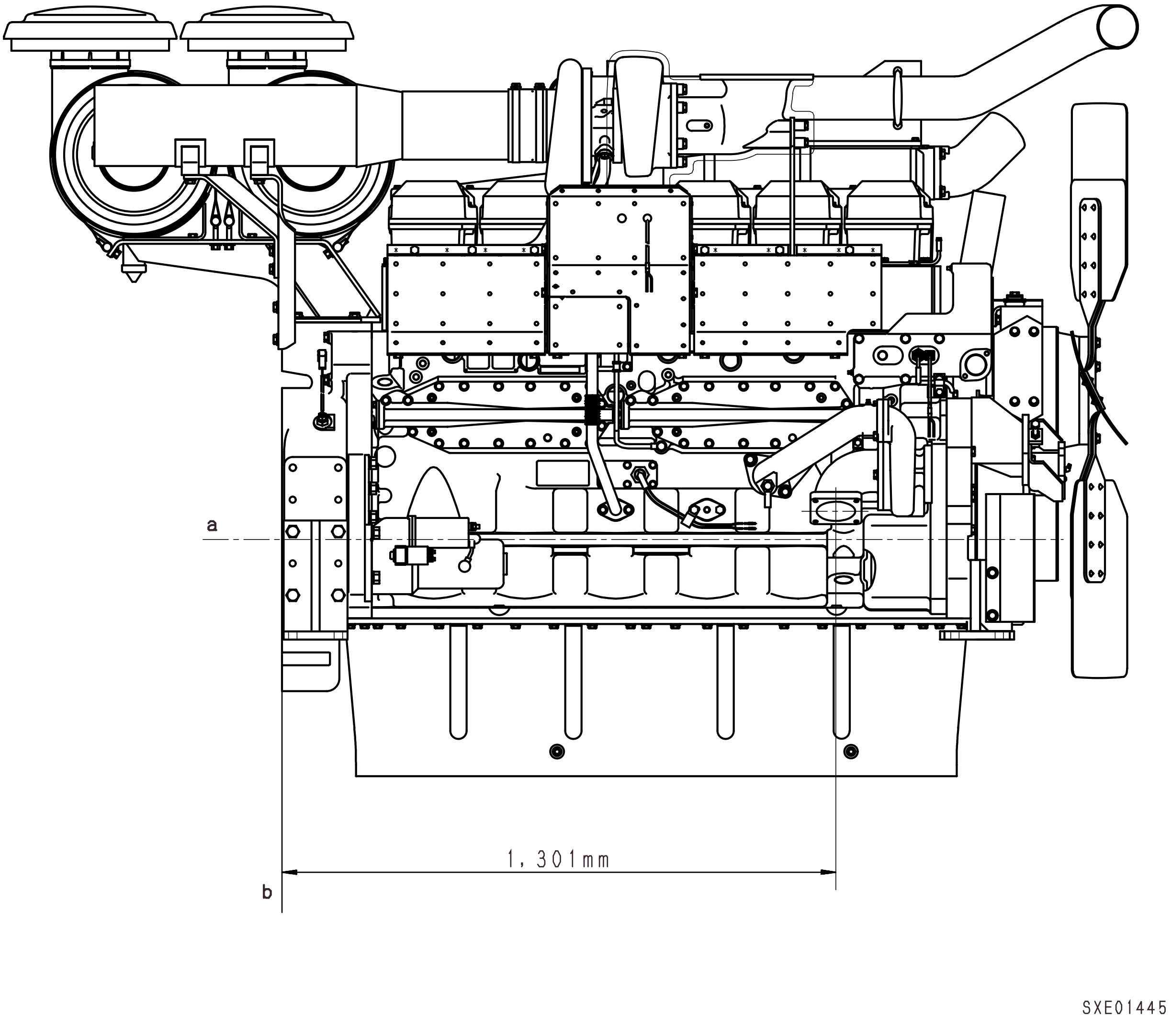


SXE01444

a. Center of crankshaft
b. Rear face of flywheel housing

SAA6D170E-3 VIEW FROM RIGHT SIDE

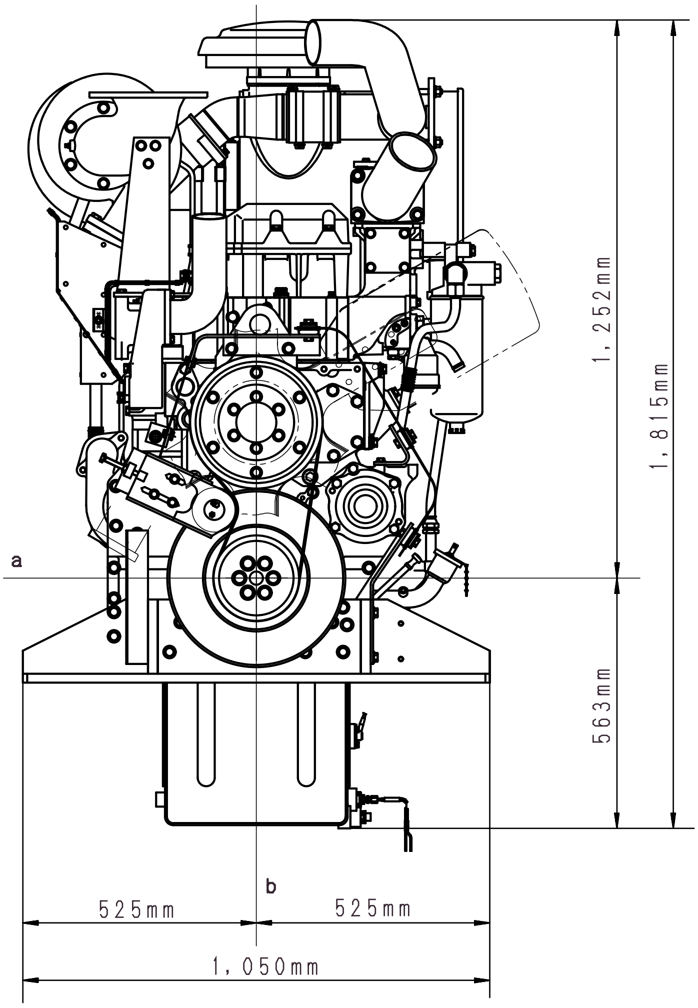
★ The illustration shows the engine for the normal generator.
The actual engine may be different because of modifications.



a. Center of crankshaft
b. Rear face of flywheel housing

SAA6D170E-3 VIEW FROM FRONT

★ The illustration shows the engine for the normal generator.
The actual engine may be different because of modifications.

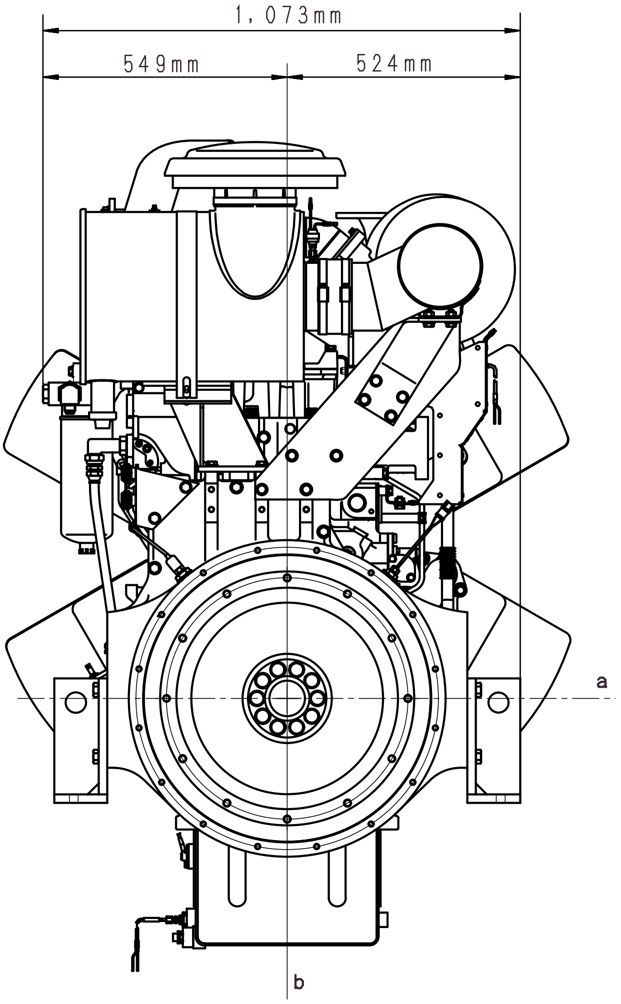


SXE01446

a. Center of crankshaft
b. Center of cylinder liner

SAA6D170E-3 VIEW FROM REAR

★ The illustration shows the engine for the normal generator.
The actual engine may be different because of modifications.

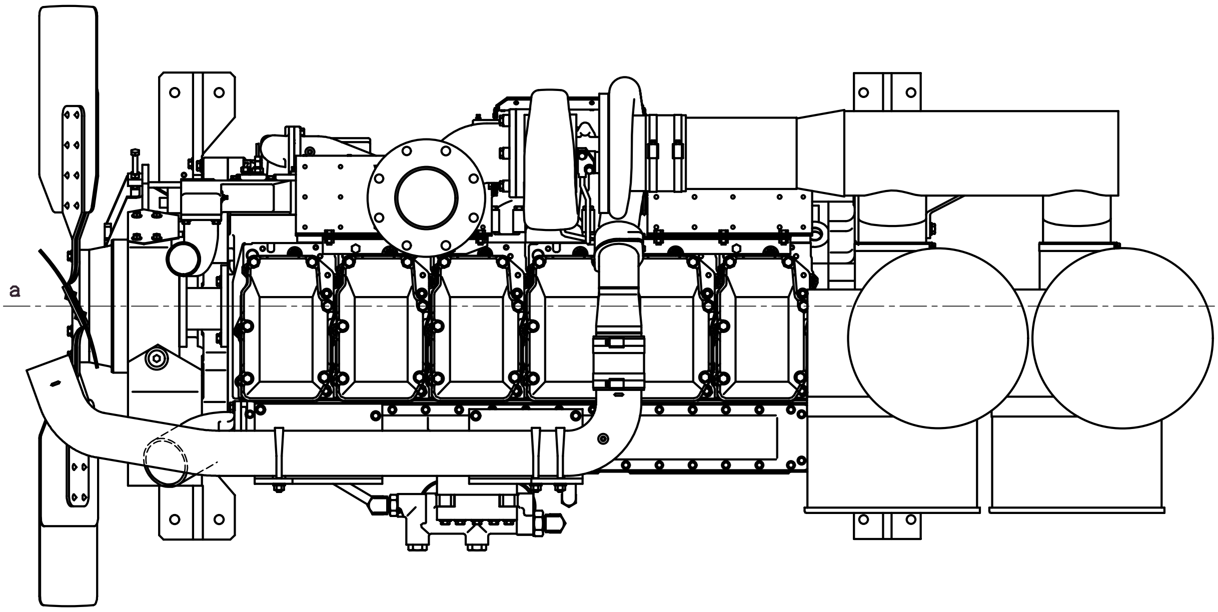


SXE01447

a. Center of crankshaft
b. Center of cylinder liner

SAA6D170E-3 VIEW FROM TOP

★ The illustration shows the engine for the normal generator.
The actual engine may be different because of modifications.



SXE01448

a. Center of cylinder liner

WEIGHT TABLE

Unit: kg

No.	Iteml	Component	SA6D170E-3	SAA6D170E-3	
1	Turbocharger	KTR110L	25	25	
		SCHWITZER S500	—	51 (Generator)	
2	Cylinder head assembly	Cylinder head, valve and valve spring	44	44	
3	Cylinder block assembly	Cylinder block, main bearing cap and cylinder liner	810	810	
4	Gear case cover	—	42	42	
5	Oil pan	—	45	45	
6	Flywheel assembly	Flywheel Ring gear	—	34 (WA600-3)	
7	Flywheel housing	—	—	93 (WA600-3)	
8	Crankshaft assembly	Crankshaft, crank gear (2 pcs.)	264	264	
9	Camshaft assembly	Camshaft, cam gear and thrust plate	70	70	
10	piston and connecting rod assembly	Piston, piston ring, piston pin and connecting rod	21	21	
11	Oil pump	—	10	10	
12	Fuel pump	—	20	20	
13	Water pump	—	16	16	
14	Alternetor	—	11 (60A) 12.5 (75A)	11 (60A) 12.5 (75A)	
15	Starting motor	—	18 x 2	18 x 2	
16	After cooler	—	—	40	
17	Air compressor	—	—	15	

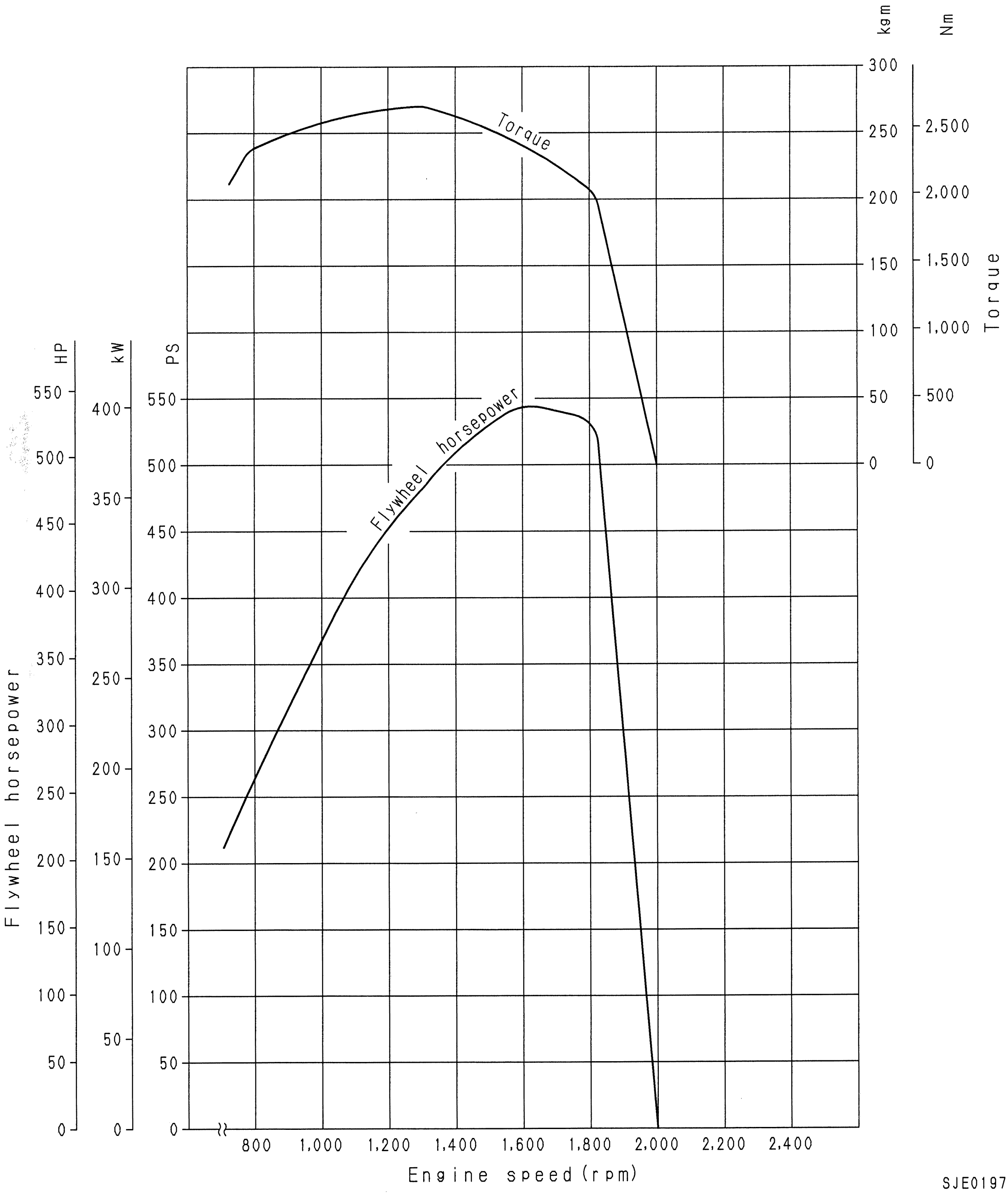
ENGINE PERFORMANCE CURVE

Engine	Engine serial No.	Applicable machine	Page
SA6D170E-3		D375A-5	01 – 18
SAA6D170E-3		WA600-3	01 – 19
		WD600-3	01 – 22
		PC1250-7	01 – 20
		HD465-7 HD605-7	01 – 21

SA6D170E-3 (D375A-5)

Flywheel horsepower: 391 kW {524 HP} /1,800 rpm (Net)

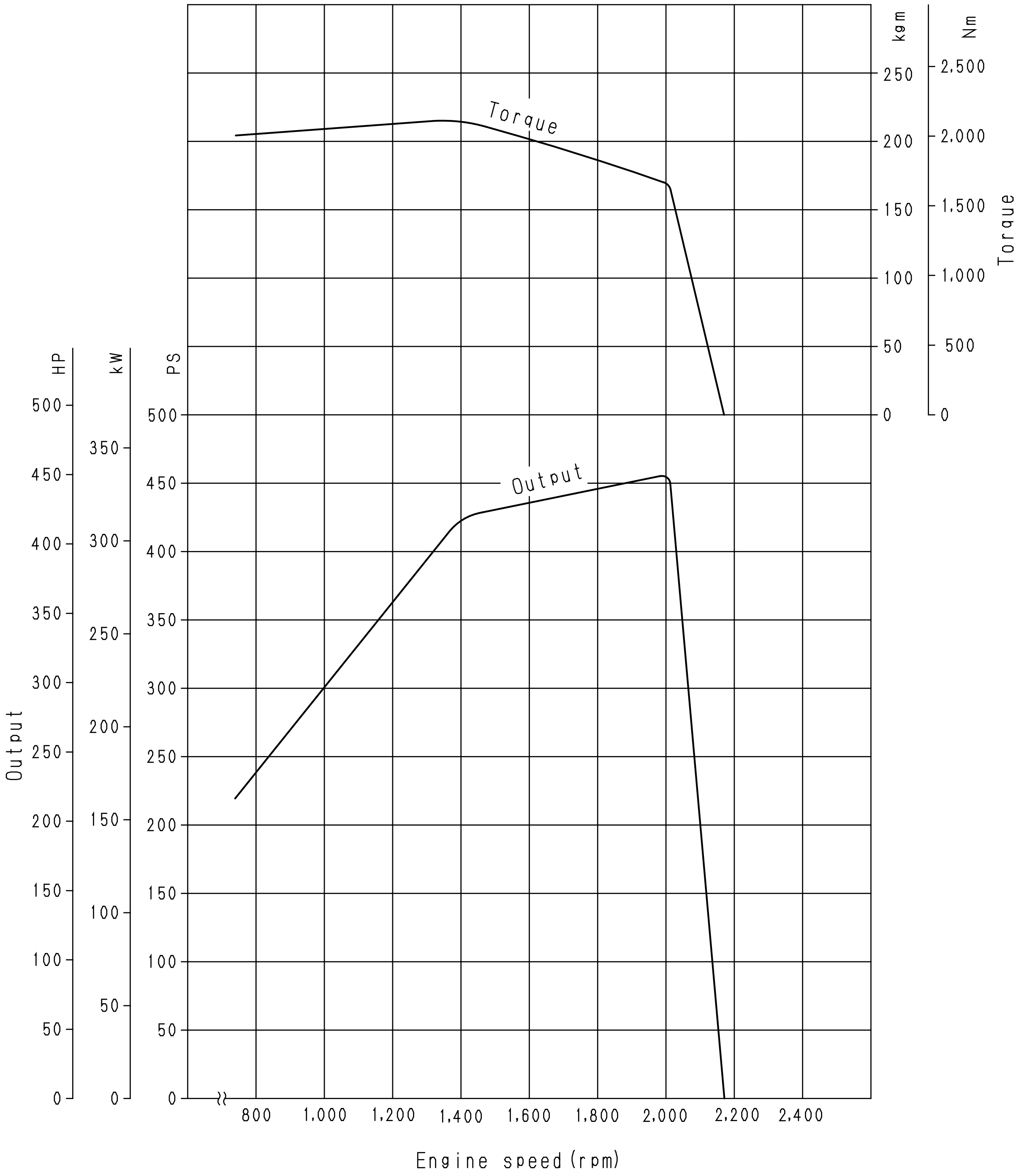
Maximum torque : 2,650 Nm {270 kgm} /1,300 rpm (Net)



SAA6D170E-3 (WA600-3)

Flywheel horsepower: 337 kW {452 HP} /2,000 rpm (Net)

Maximum torque : 2,120 Nm {216 kgm} /1,400 rpm (Net)

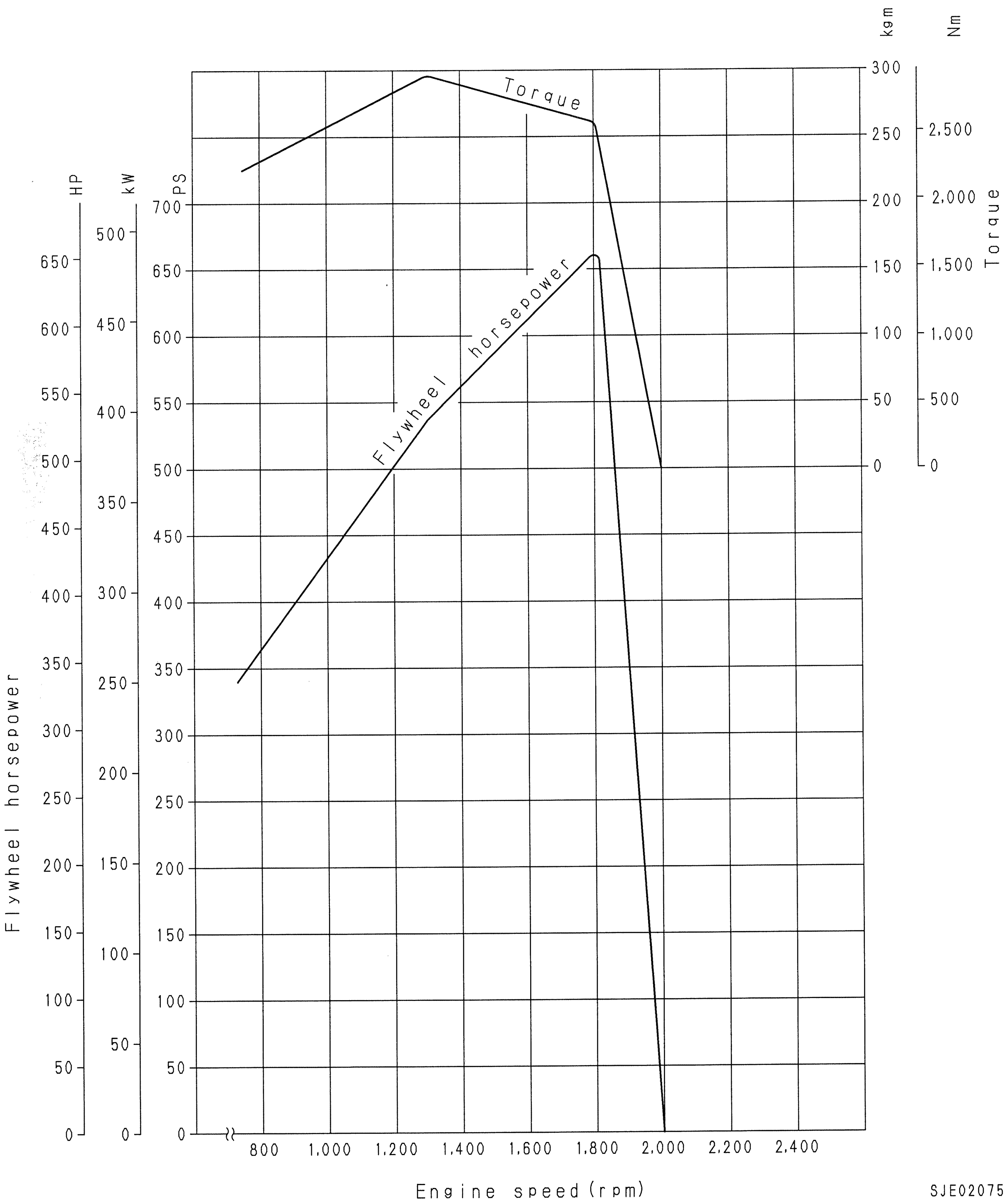


SXE01668

SAA6D170E-3 (PC1250-7)

Flywheel horsepower: 485 kW {651 HP} /1,800 rpm (Net)

Maximum torque : 2,913 Nm {297 kgm} /1,300 rpm (Net)

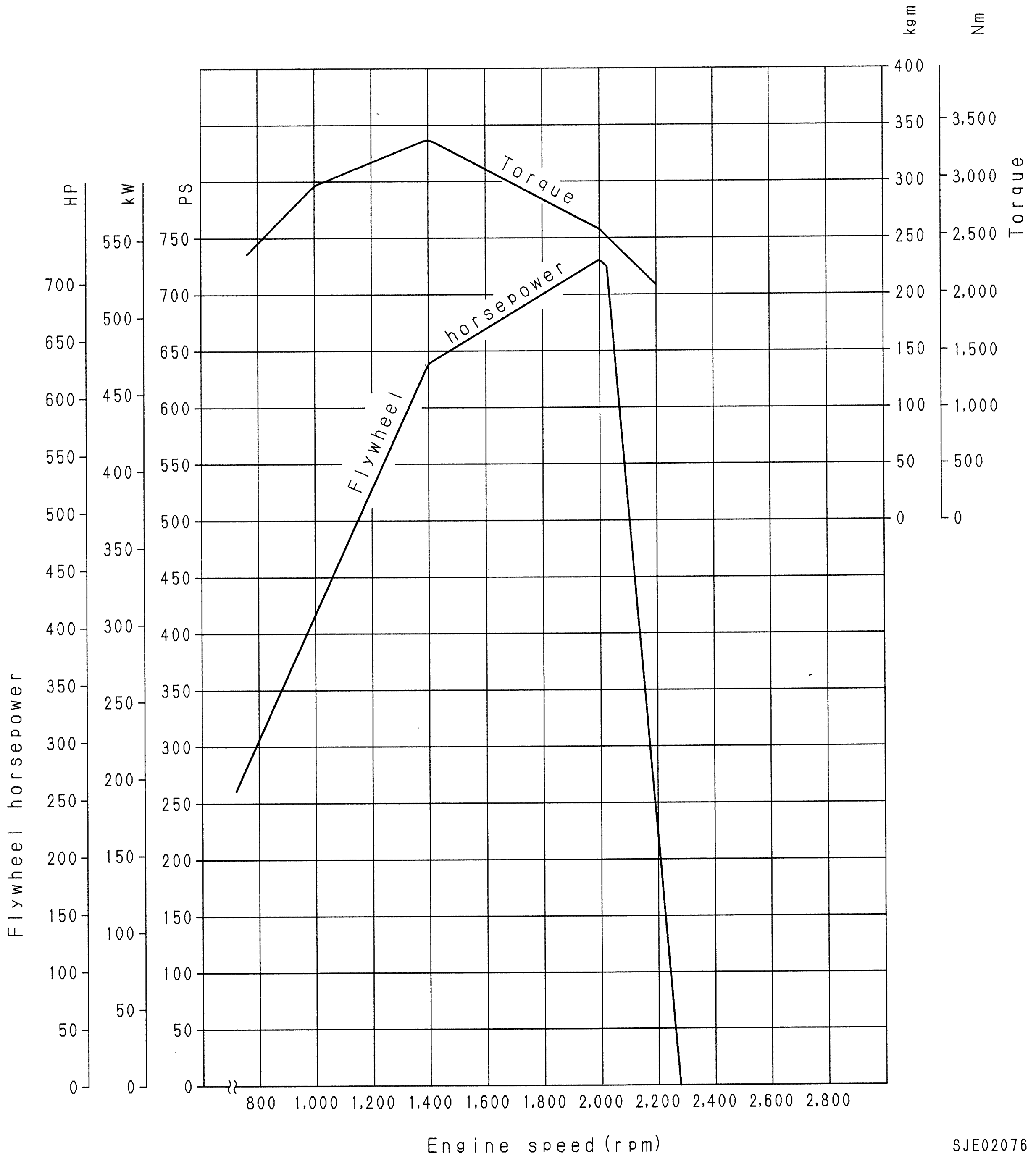


SJE02075

SAA6D170E-3 (HD465-7, HD605-7)

Flywheel horsepower: 533 kW {715 HP} /2,000 rpm (Net)

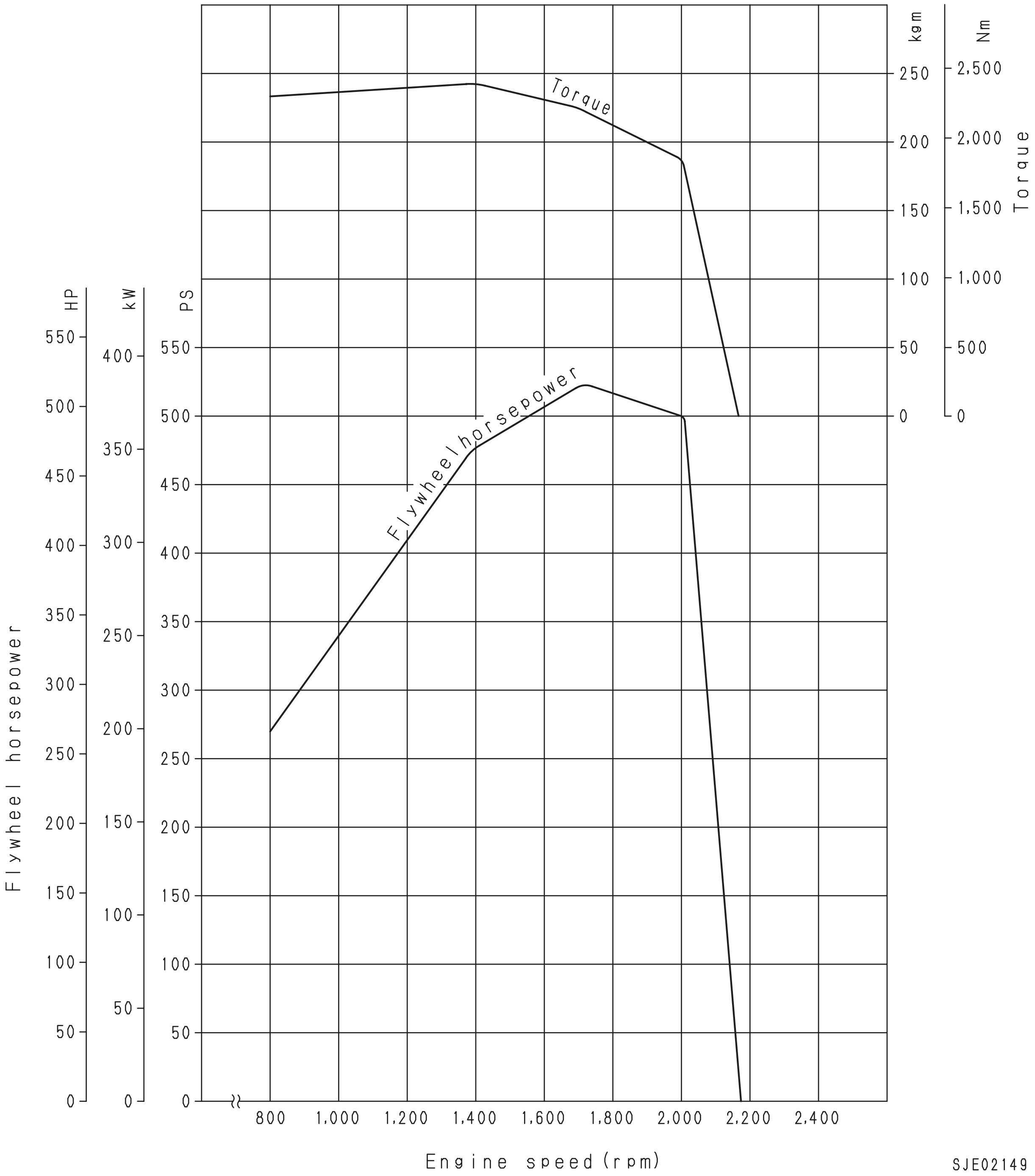
Maximum torque : 3,207 Nm {327 kgm} /1,400 rpm (Net)



SAA6D170E-3 (WD600-3)

Flywheel horsepower: 370 kW {497 HP} /2,000 rpm (Net)

Maximum torque : 2,391 Nm {244 kgm} /1,400 rpm (Net)

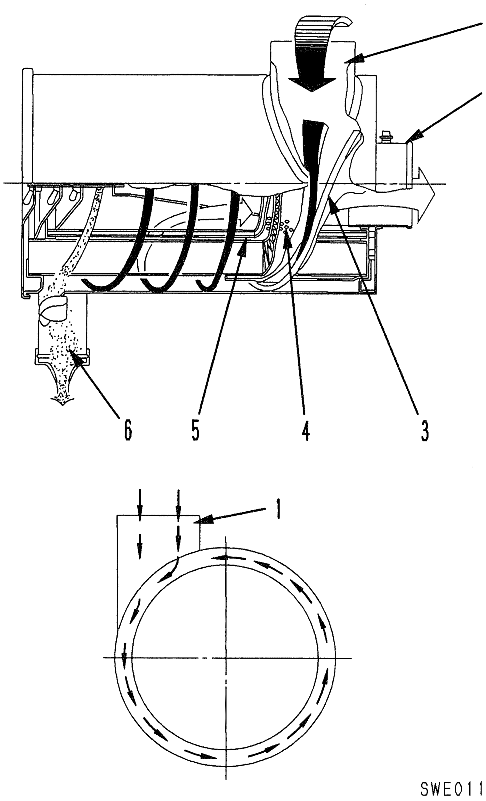


11 STRUCTURE AND FUNCTION

★ The illustration given in STRUCTURE AND FUNCTION are representative illustration. Depending on the machine model, the actual, component may be different from the illustration.

AIR CLEANER

FTG TYPE (Generator)



1. Inlet
2. Outlet
3. Guide valve
4. Primary element
5. Safety element
6. Vacuator

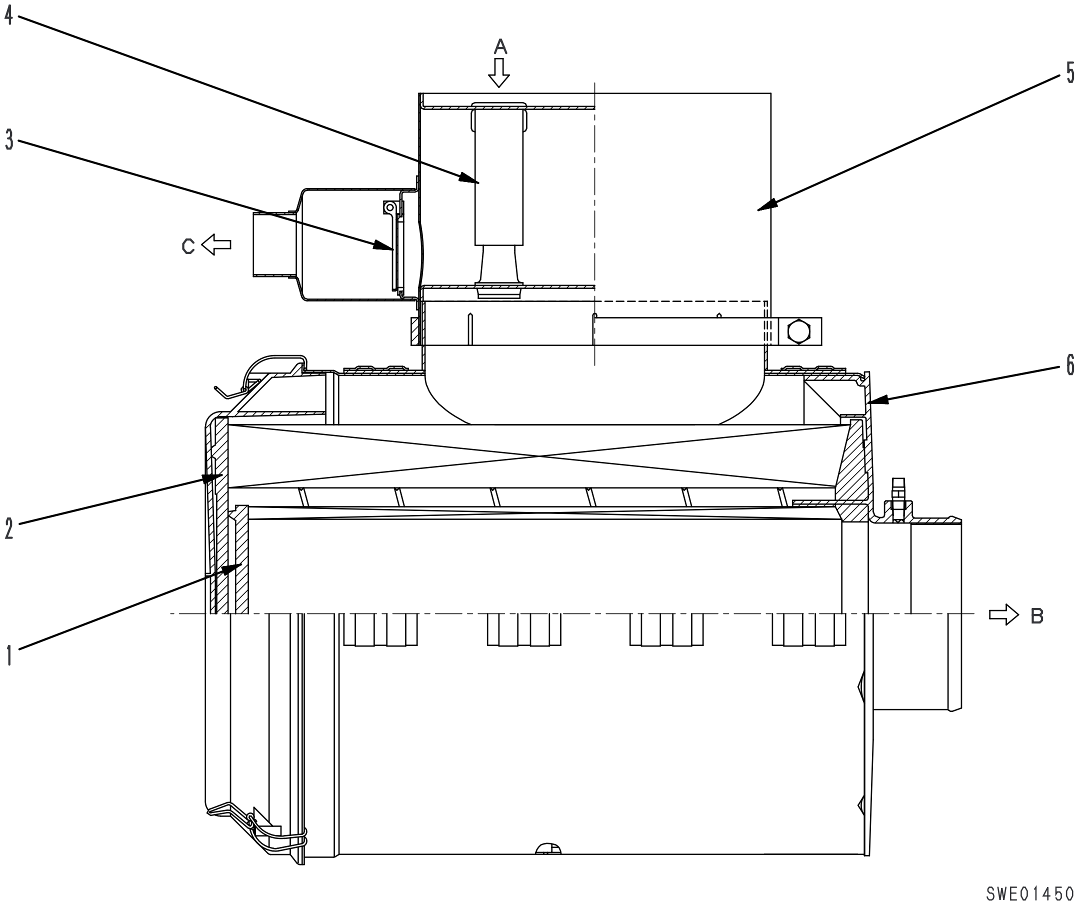
STRUCTURE

- Air containing dust is sucked in from inlet (1) at a tangent, and the dust is separated by the centrifugal force of guide vane (3). More than 99.9% of the remaining dust is removed by primary element (4), and the cleaned air then passes through safety element (5) and outlet (2), and is sucked into the engine.
  The dust and moisture that is separated by the guide vane (3) rotates around the inside wall of body, and goes inside vacuator valve (6), where it is discharged automatically to the outside.

EGB TYPE (D375A-5, WA600-3, WD600-3, PC1250-7) (KOMA-CLONE MULTICYCLONE TYPE)

★ The actual engine may be different because of modifications.

★ The specifications may be different from the following figure, depending on the type of machine.

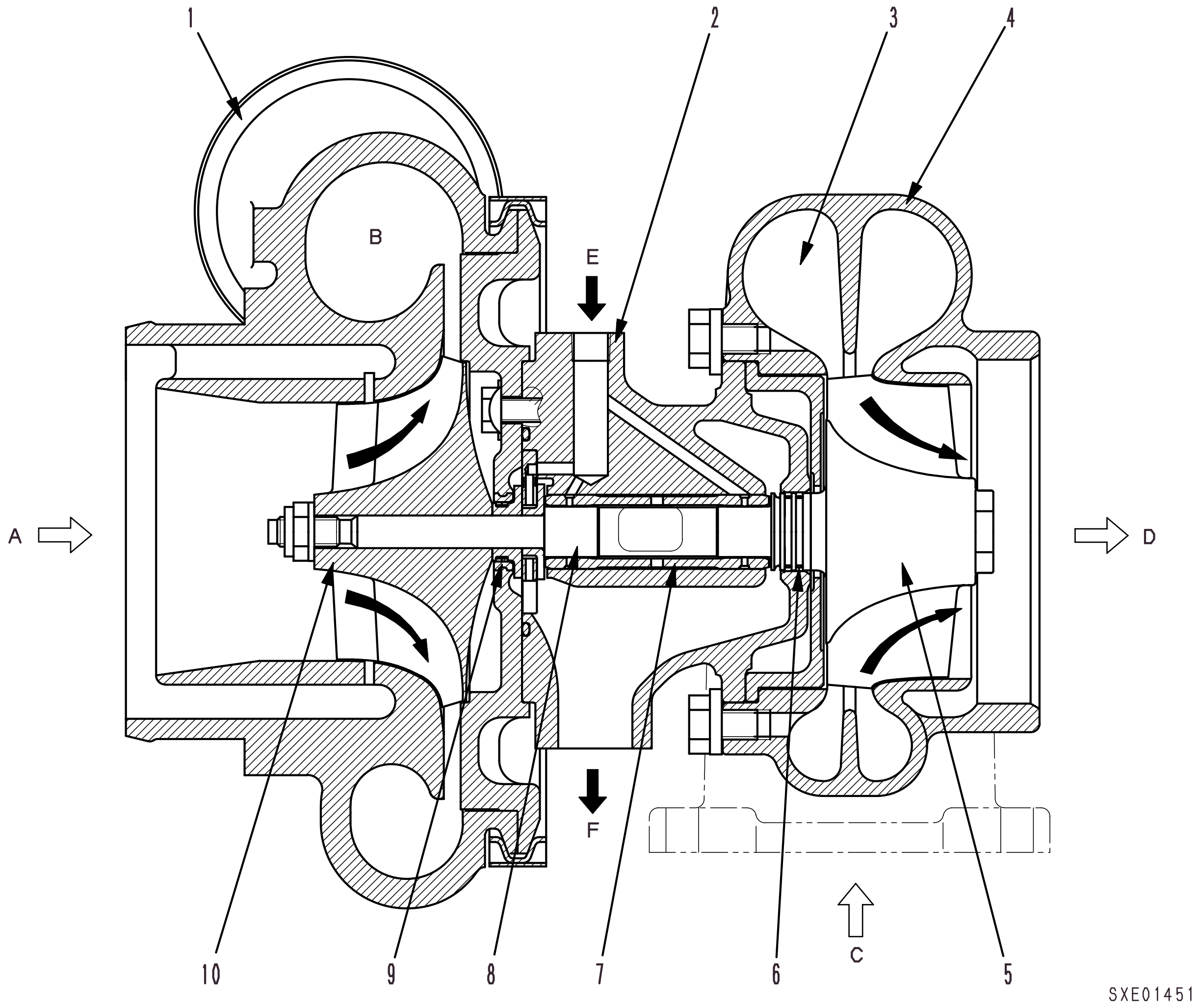


1. Inner element
2. Outer element
3. Check valve
4. Tube (34 pcs.)
5. Precleaner
6. Body of air cleaner

A. Air inlet
B. To turbocharger (sucked air)
C. To muffler (dust)

TURBOCHARGER

KTR110L (oil cooled type)



1. Blower housing
2. Center housing
3. Thrust nozzle
4. Turbine housing
5. Turbine impeller
6. Seal ring
7. Journal bearing
8. Turbing shaft
9. Thrust bearing
10. Blower impeller

A. Air intake
B. Air output
C. Exhaust (inlet port)
D. Exhaust (outlet port)
E. Oil (inlet port)
F. Oil (outlet port)

SPECIFICATIONS
Type: Komatsu KTR110L
(oil cooled type)
Overall length: 308 mm
Overall width: 305 mm
Overall height: 287 mm
Weight: 25 kg

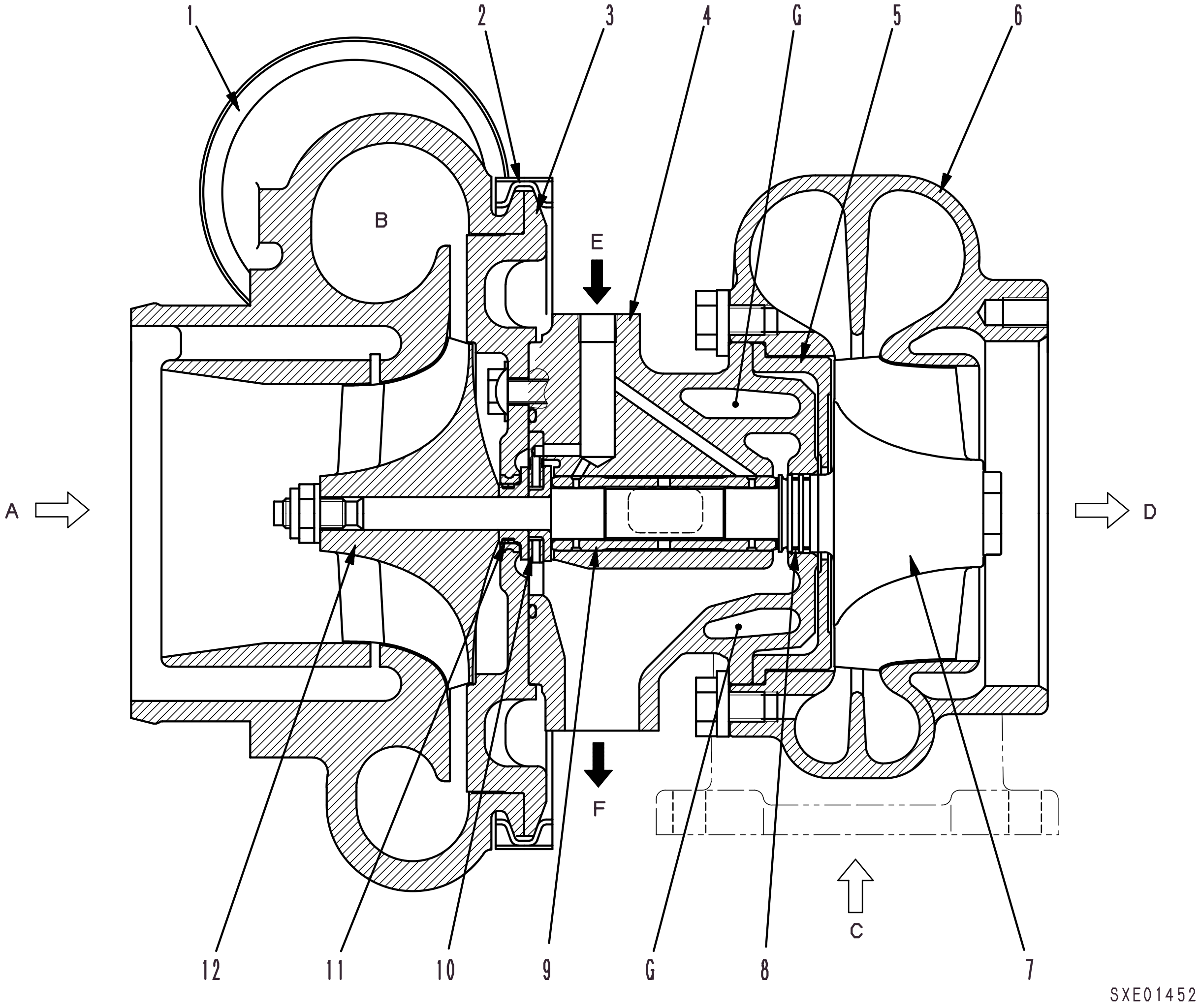
Structure and function of turbocharger

- Inside the turbocharger there is turbine impeller (5), which is rotated by the high-speed exhaust gas. Blower impeller (10), which is on the same shaft as the turbine impeller rotates and sends supercharged intake air to the engine.
- Shaft (8), which connects the turbine impeller and blower impeller, forms one unit with the turbine impeller. The blower impeller is secured with a nut to the tip of the shaft at the opposite end from the turbine impeller.
- The shaft rotates at the exceptionally high speed of 50,000 to 100,000 rpm, and also receives thrust load from the intake air applied to the impeller.
- For this reason, the shaft is supported by cylindrical floating type journal bearing (7) and thrust bearing (9).
- Center housing (2) holds the bearing and has oil that lubricates the floating part of the shaft.
- The sealing at the lubricating portion and the exhaust and intake air ends is performed by seal ring (6).
- Turbine housing (4) contains the turbine impeller, and also leads the exhaust gas from the exhaust manifold to the turbine impeller portion. The action of nozzle (3) rotates the impeller at high speed and exhausts the gas to the outside of the engine.
- Blower housing (1) contains the blower impeller, and leads the intake air to the blower impeller portion. The intake air compressed by the blower impeller is charged to the engine.

Lubrication of turbocharger

- Engine oil is supplied from hole **E** at the top of center housing, lubricates the bearings and the lubricating portion, then returns to the engine oil pan from the hole **F** at the bottom of the center housing.

KTR110L (water cooled type)



1. Blower housing
2. V-band
3. Defuser plate
4. Center housing
   (water-cooled center housing is option)
5. Shroud
6. Turbine housing
7. Turbine impeller
8. Seal ring
9. Metal
10. Thrust metal
11. Seal ring
12. Blower impeller

A. Intake inlet
B. Intake outlet
C. Exhaust inlet
D. Exhaust outlet
E. Oil inlet
F. Oil outlet
G. Cooling water

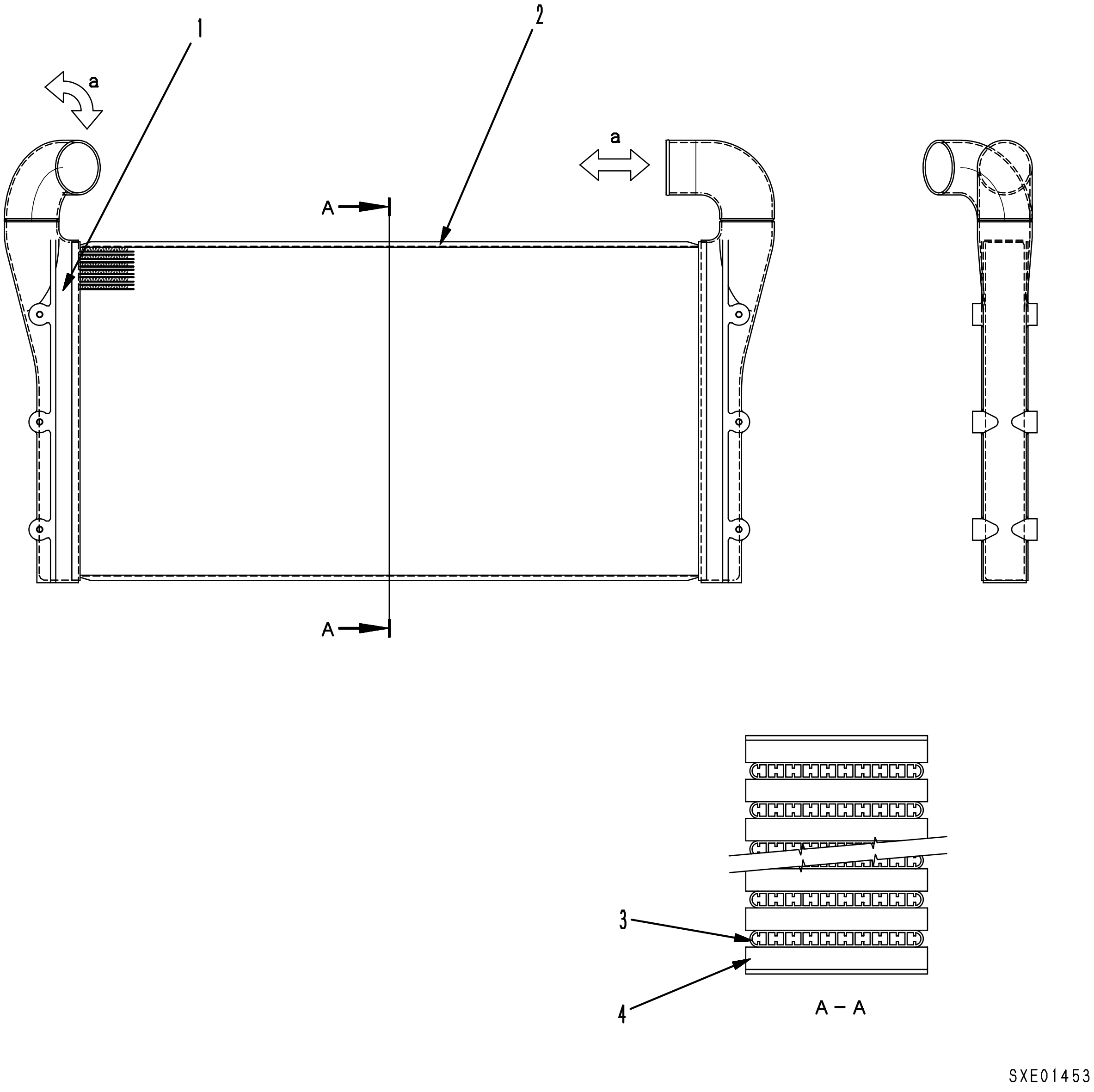
SPECIFICATIONS
Type: Komatsu KTR110L
(water cooled type)
Overall length: 308 mm
Overall width: 305 mm
Overall height: 287 mm
Weight: 22.5 kg

AFTERCOOLER

AIR-COOLED TYPE

SAA6D170E-3 (WA600-3)

★ The specifications are subject to change according to modification etc.



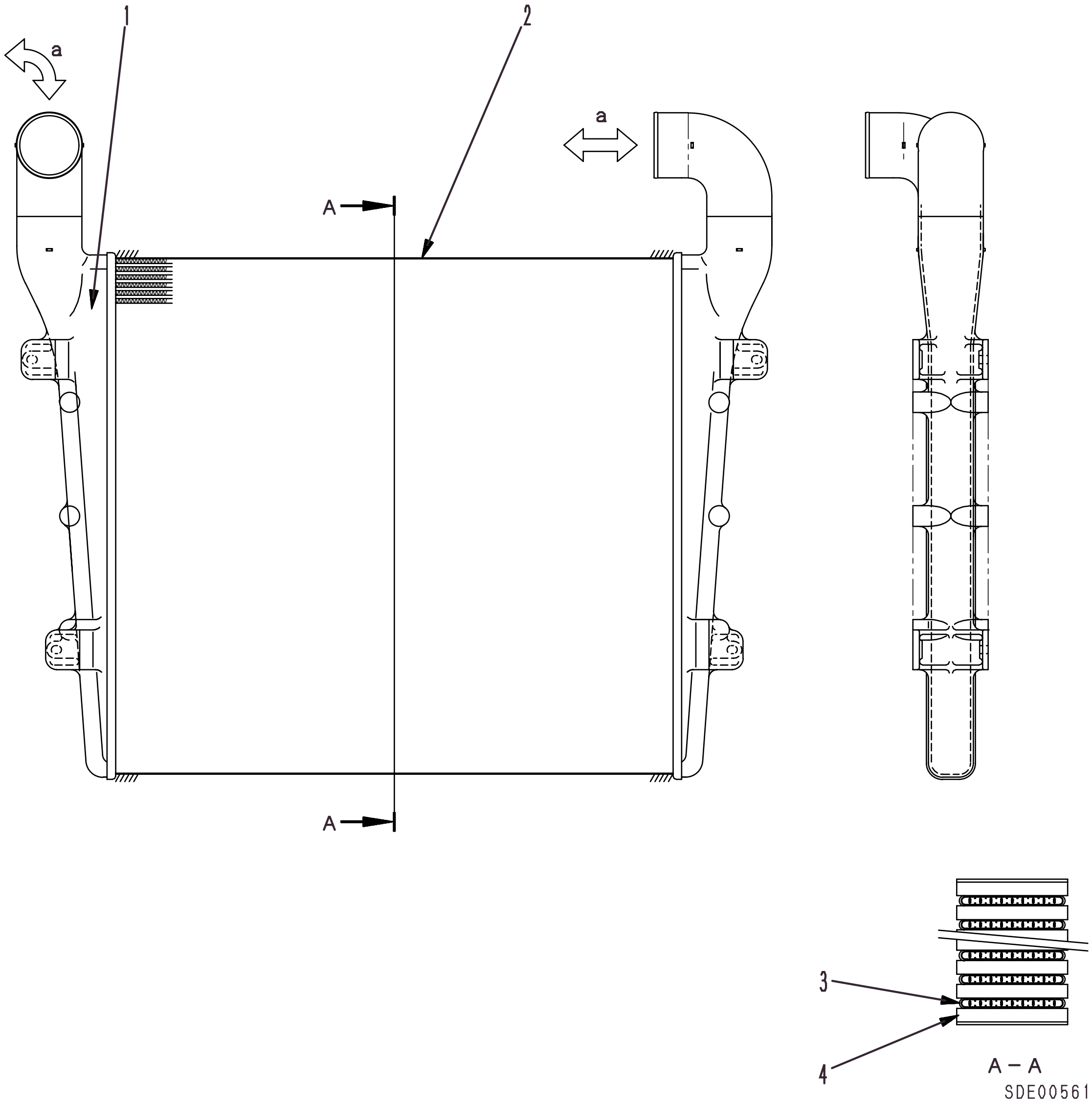
1. Tank
2. Side support
3. Tube
4. Fin

A. Intake air port
(Turbocharger ↔ Intake manifold)

AIR-COOLED TYPE

SAA6D170E-3 (Generator)

★ The specifications are subject to change according to modification etc.

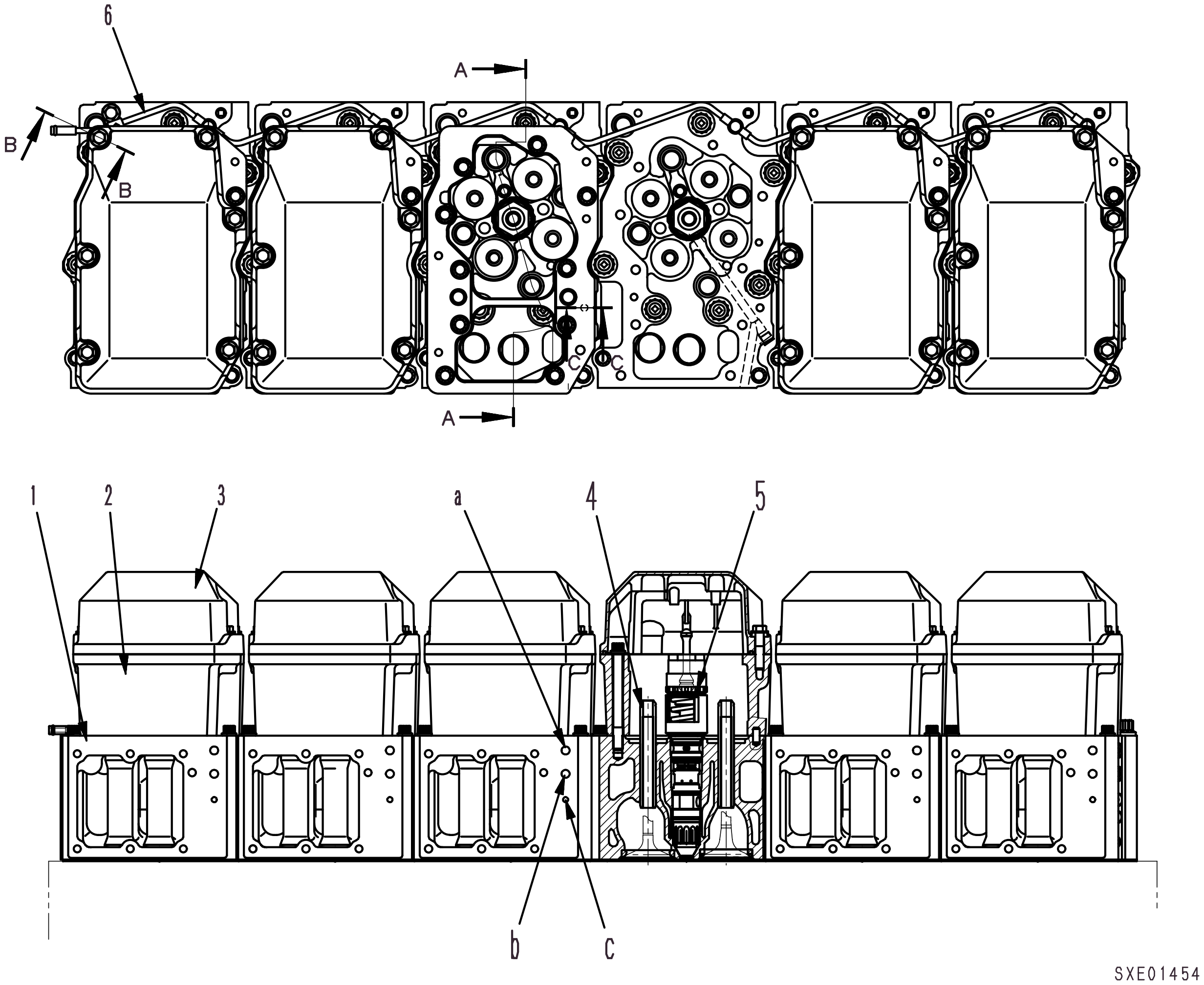


1. Tank
2. Side support
3. Tube
4. Fin

a. Intake air port
(Turbocharger ↔ Intake manifold)

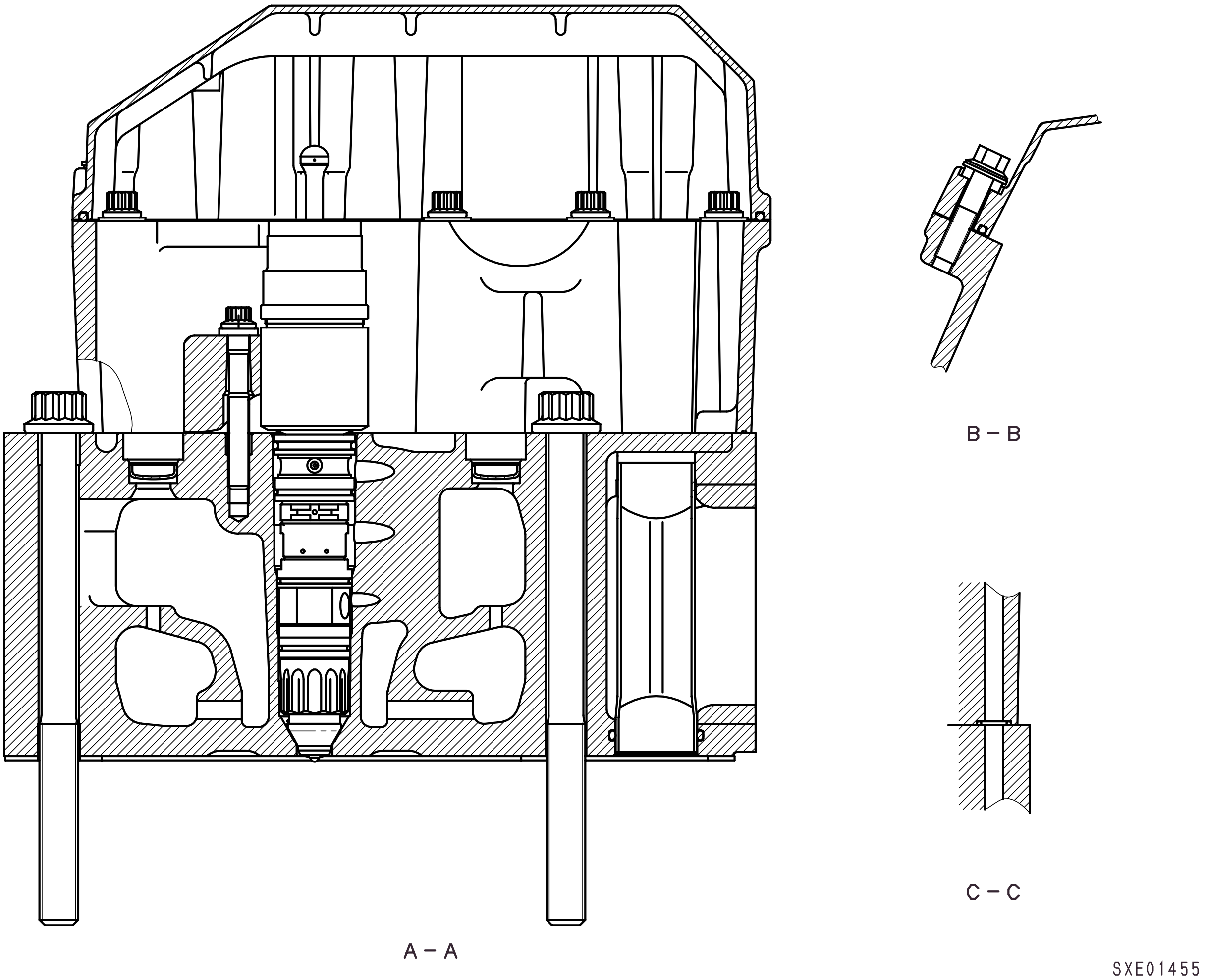
CYLINDER HEAD

★ The specifications may be different from the following figure, depending on the type of machine.



1. Cylinder head
2. Rocker arm housing
3. Cylinder head cover
4. Valve guide
5. Injector
6. Air vent tube (for cooling water)

a. Fuel inlet (for fuel timing)
b. Fuel returrn
C. Fuel inlet (for fuel supply)



SPECIFICATIONS

Cylinder head

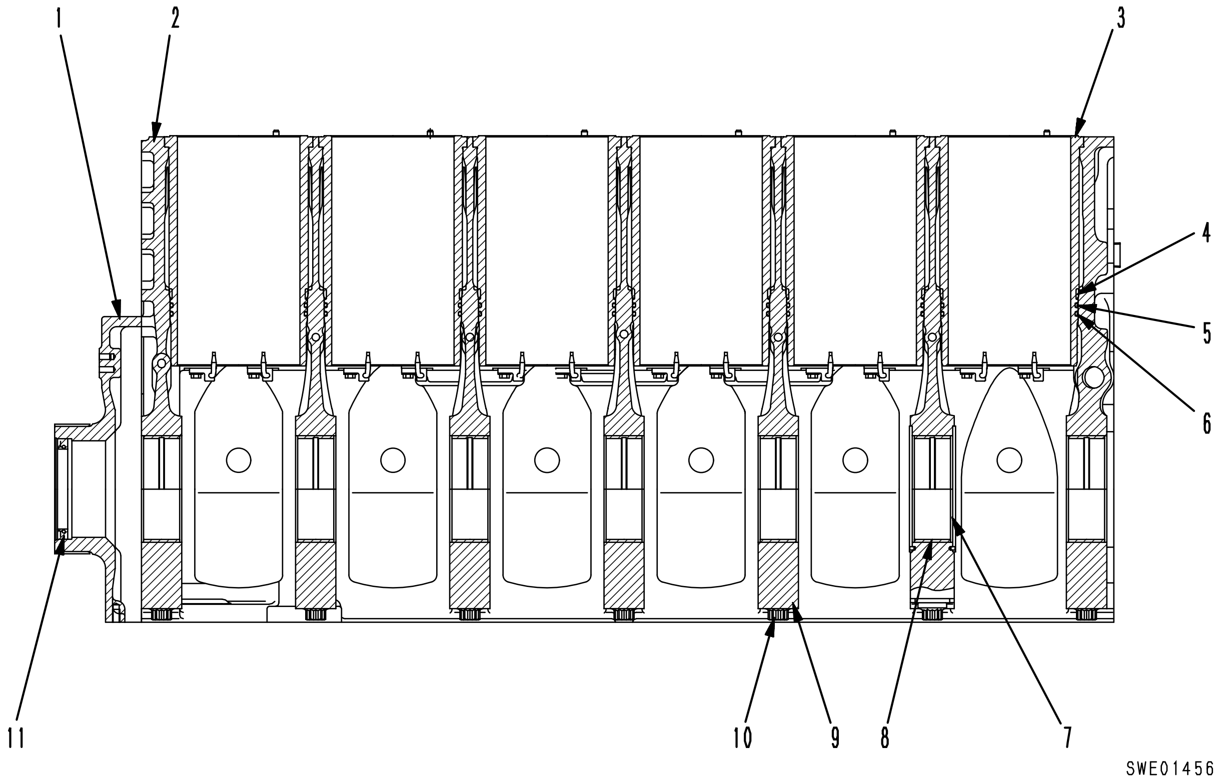
- Direct fuel injection type, 4 valves
- Split type (1 cylinder, 1 head)

Valve seat insert

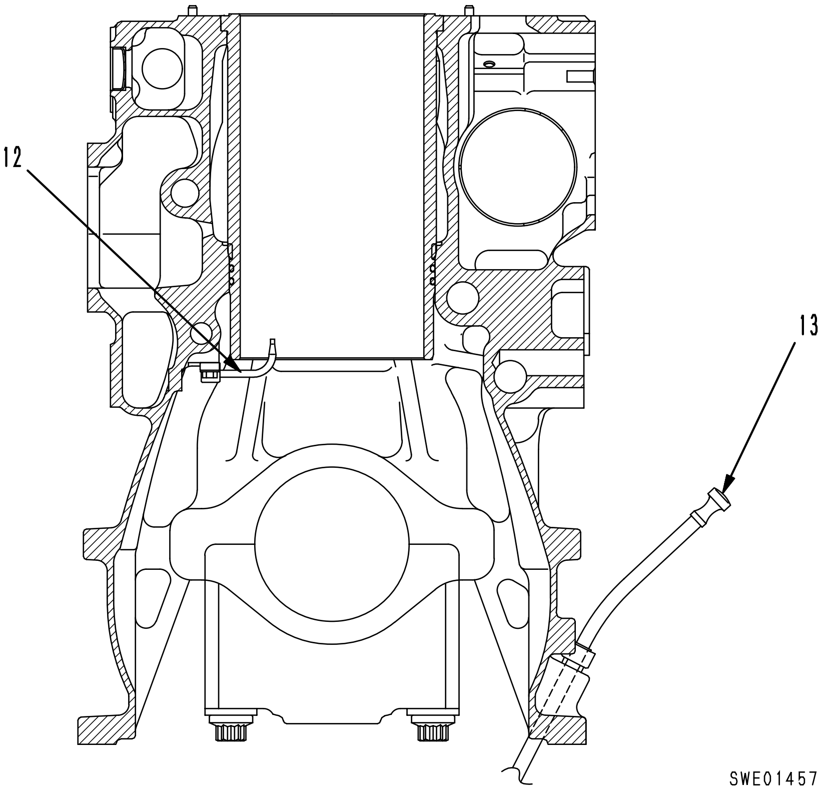
- Intake valve insert
- Exhaust valve insert

} Both press fitted to seat

CYLINDER BLOCK



1. Front cover
2. Cylinder block
3. Cylinder liner
4. Crevice seal
5. Liner O-ring
6. Liner O-ring
7. Thrust metal
8. Main metal
9. Main metal cap
10. Main metal cap bolt
11. Front oil seal
12. Piston cooling nozzle
13. Oil level gauge



SPECIFICATIONS

Cylinder block

- Crankshaft: 7 bearings
- Camshaft: High cam type, 7 bearings
- Main cap mounting bolt: Plastic-area tightening

Front oil seal

- Single lip with dust seal (Lay-down seal)

Piston cooling

- With cooling nozzle
  (2 for each cylinder, with sub nozzle at rear)

Cylinder liner

- Wet type
- Machining of inside wall: Plateau honing, tufftriding

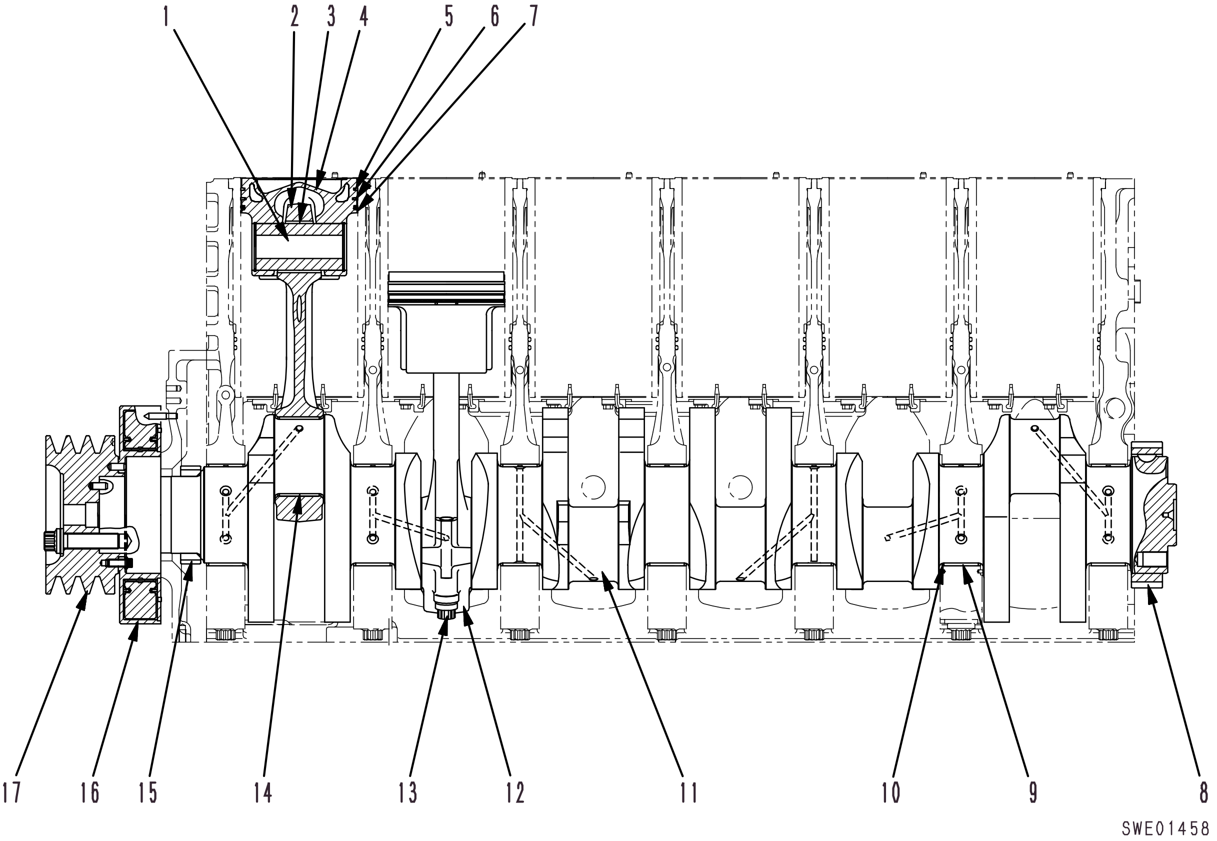
Liner seal

- Top : Crevice seal
- Middle : O-ring (Ethylene propylene rubber)
- Bottom: O-ring (Silicon rubber)

MAIN CIRCULATION SYSTEM

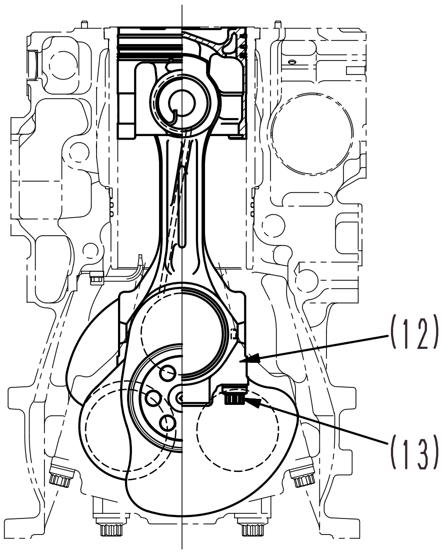
★ The specifications may be different from the following figure, depending on the type of machine.

★ The numbers in ( ) are used when indicating other parts of the same type or when explaining the same part when seen from a different angle.



1. Piston pin
2. Connecting rod
3. Connecting rod bushing
4. Piston (FCD piston)
5. Top ring
6. Second ring
7. Oil ring
8. Camshaft drive gear (No. of teeth: 63)
9. Main metal
10. Thrust metal
11. Crankshaft
12. Connecting rod cap
13. Connecting rod cap mounting bolt
14. Connecting rod metal
15. Crankshaft gear (No.of teeth: 36)
16. Vibration damper
17. Crankshaft pulley

FCD PISTON TYPE



SXE01459

SPECIFICATIONS

Crankshaft

- Special alloy steel forging, 7 bearings
- Journal surface: Induction hardening

Main bearing, connecting rod bearing

- 3-layer kelmet
- Upper main bearing: With oil groove

Connecting rod

- Alloy steel forging

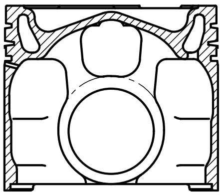
Crankshaft

- Closed die forging
- Journal portion fillet portion: Induction hardening

Piston

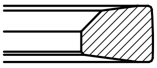
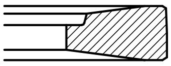
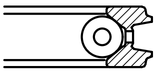
Type	Shaker type

- Ductile casting
- Forced lubricating oil cooling by piston cooling nozzle (2 nozzles per cylinder)



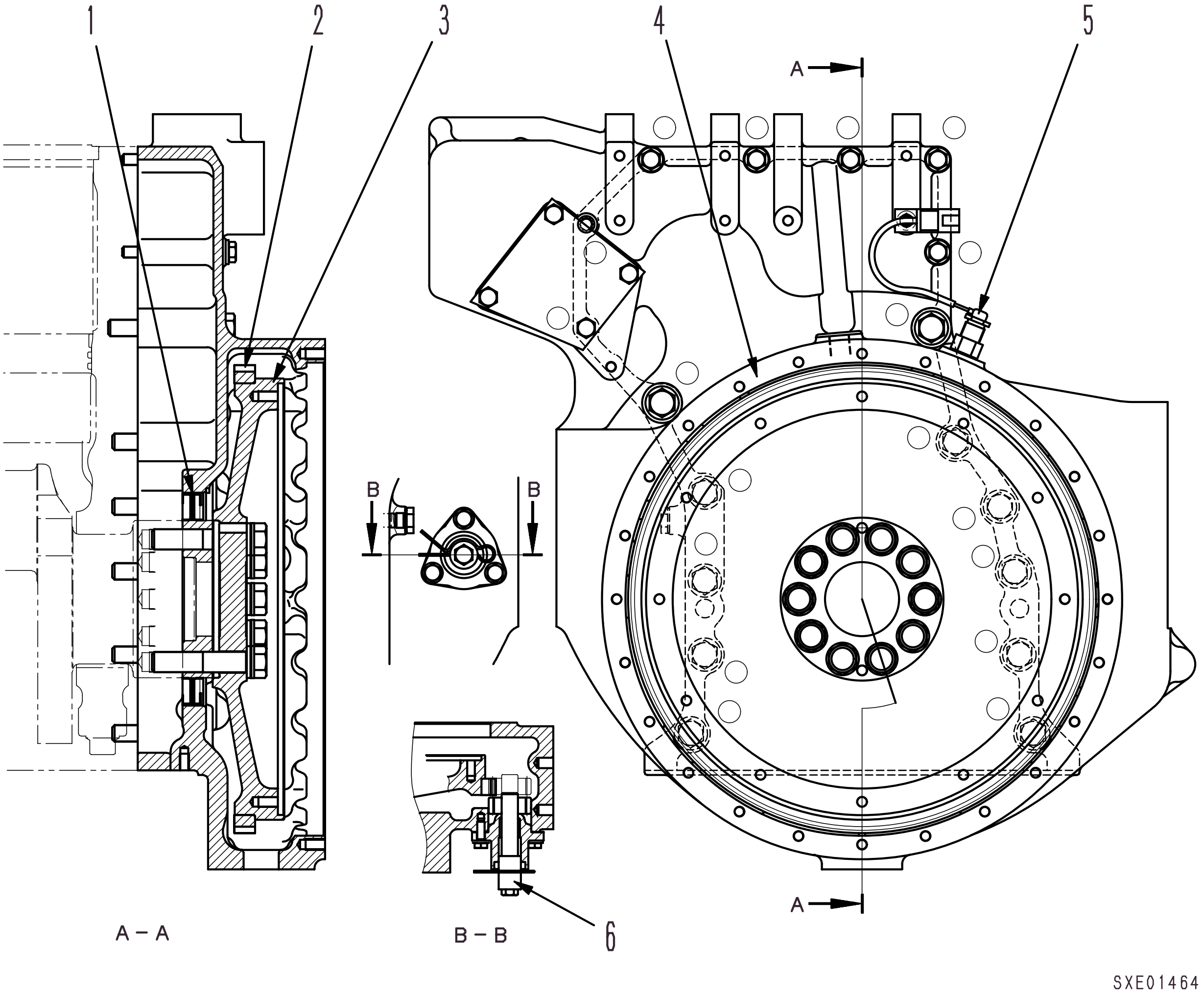
SXE01460

Piston ring

Engine	TOP ring (with inner cut)	2nd ring	Oil ring
SA6D170E-3 SAA6D170E-3	Barrel face, inner cut, hard chrome plating  SXE01461	Inner cut, taper face, hard chrome plating  SXE01462	Bevel cutter, surface nitriding  SXE01463

FLYWHEEL AND FLYWHEEL HOUSING

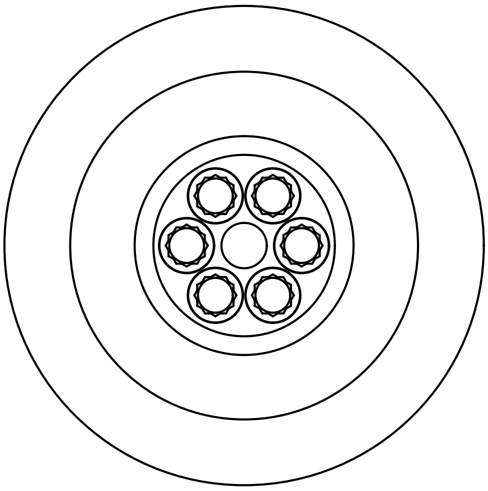
★ The specifications may be different from the following figure, depending on the type of machine.

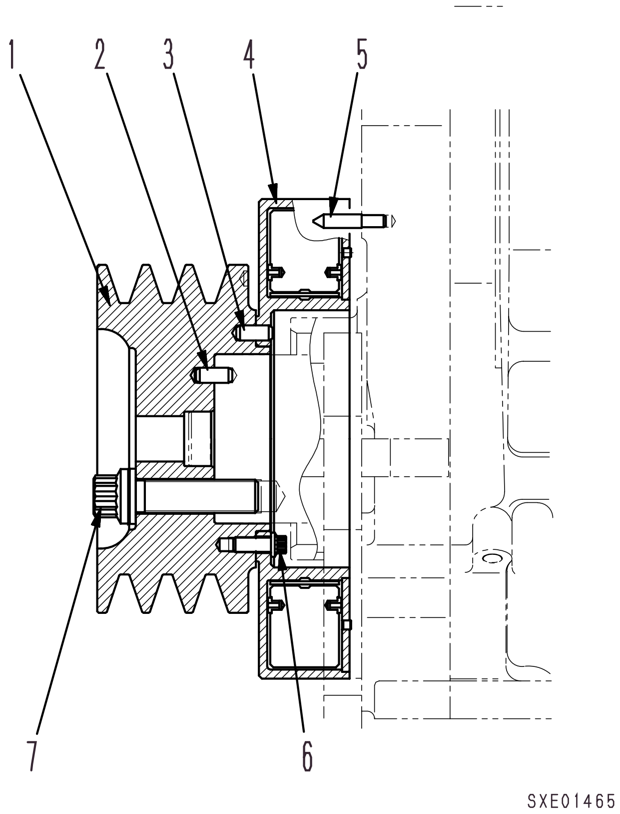


1. Rear seal
2. Ring gear (No. of teeth: 118)
3. Flywheel
4. Flywheel housing
5. Engine rotating sensor
6. Barring device (service tool)

VIBRATION DAMPER

★ The specifications may be different from the following figure, depending on the type of machine.

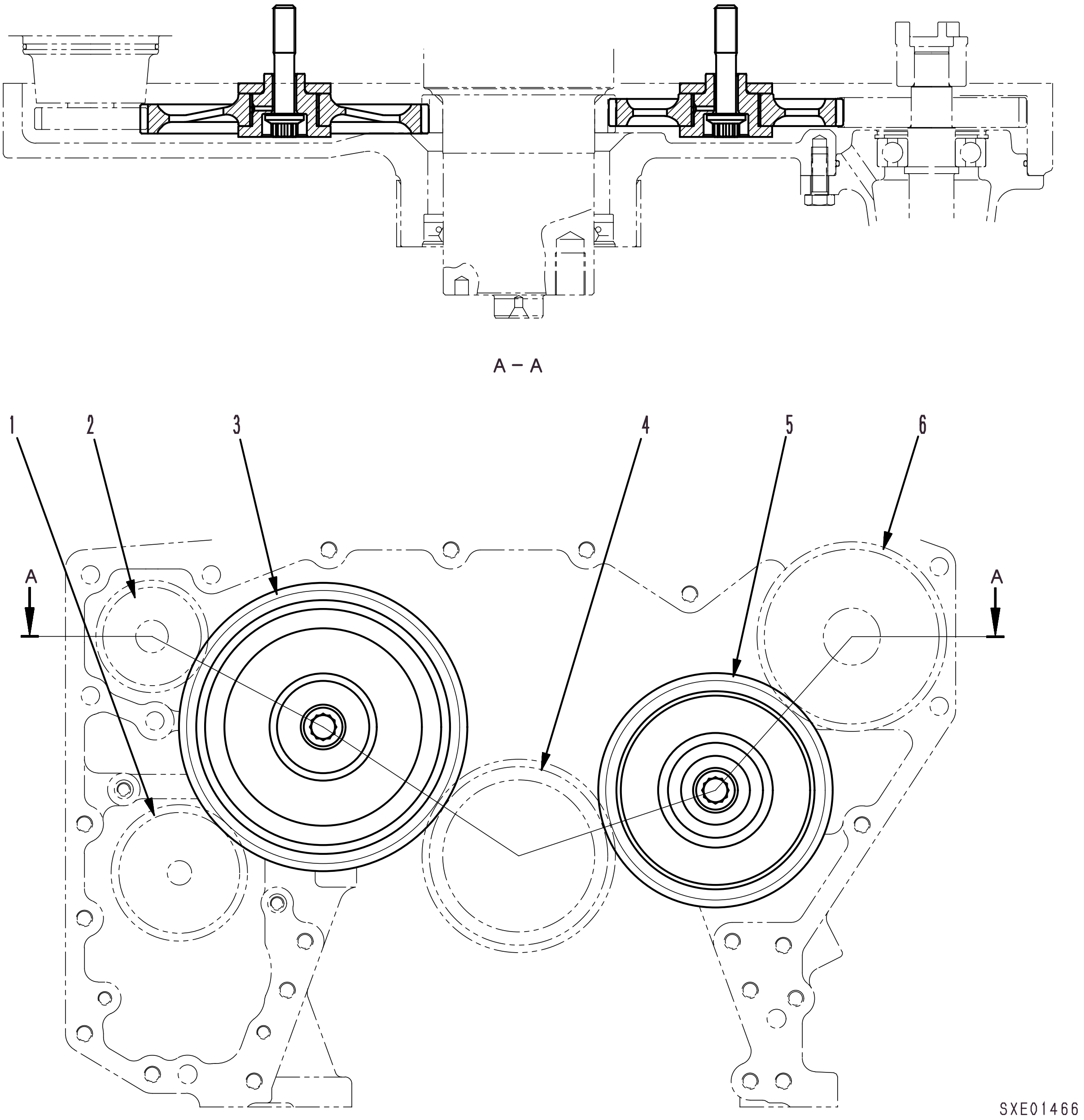




1. Crankshaft pulley
2. Pin (crankshaft – crankshaft pulley)
3. Pin (crankshaft – vibration damper)
4. Vibration damper
5. Pointer
6. Bolt (crankshaft – vibration damper)
7. Bolt (crankshaft – crankshaft pulley)

GEAR TRAIN

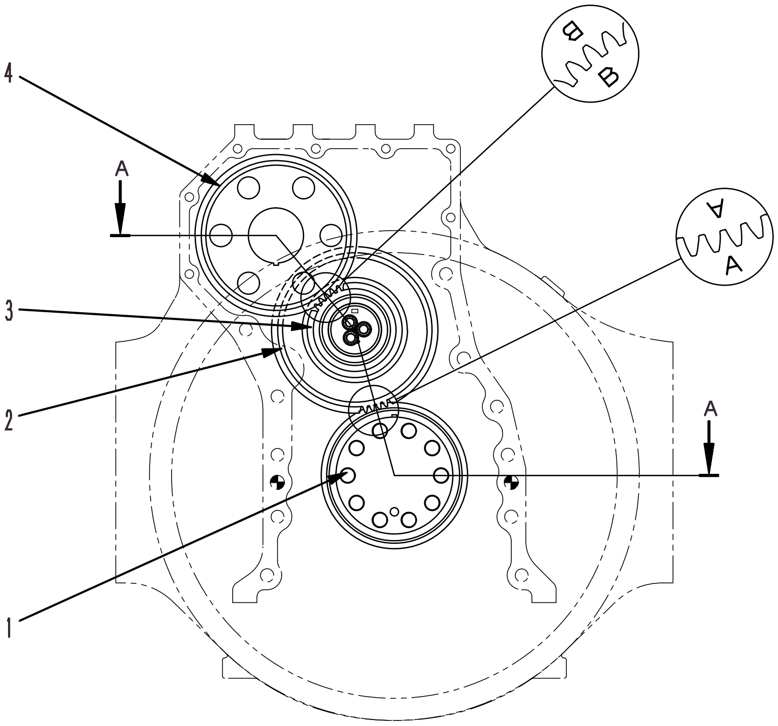
FRONT SIDE (for driving auxiliary equipment)

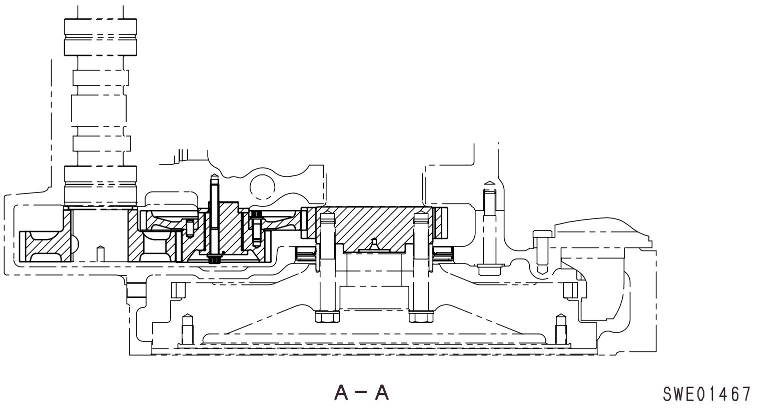


1. Oil pump drive gear (No. of teeth: 38)
2. Water pump drive gear (No. of teeth: 31)
3. Idler gear (No. of teeth: 84)
4. Crankshaft gear (No. of teeth: 55)
5. Idler gear (No. of teeth: 67)
6. Alternator, fuel pump drive gear (No. of teeth: 55)

TIMING GEAR

REAR SIDE (for driving camshaft)



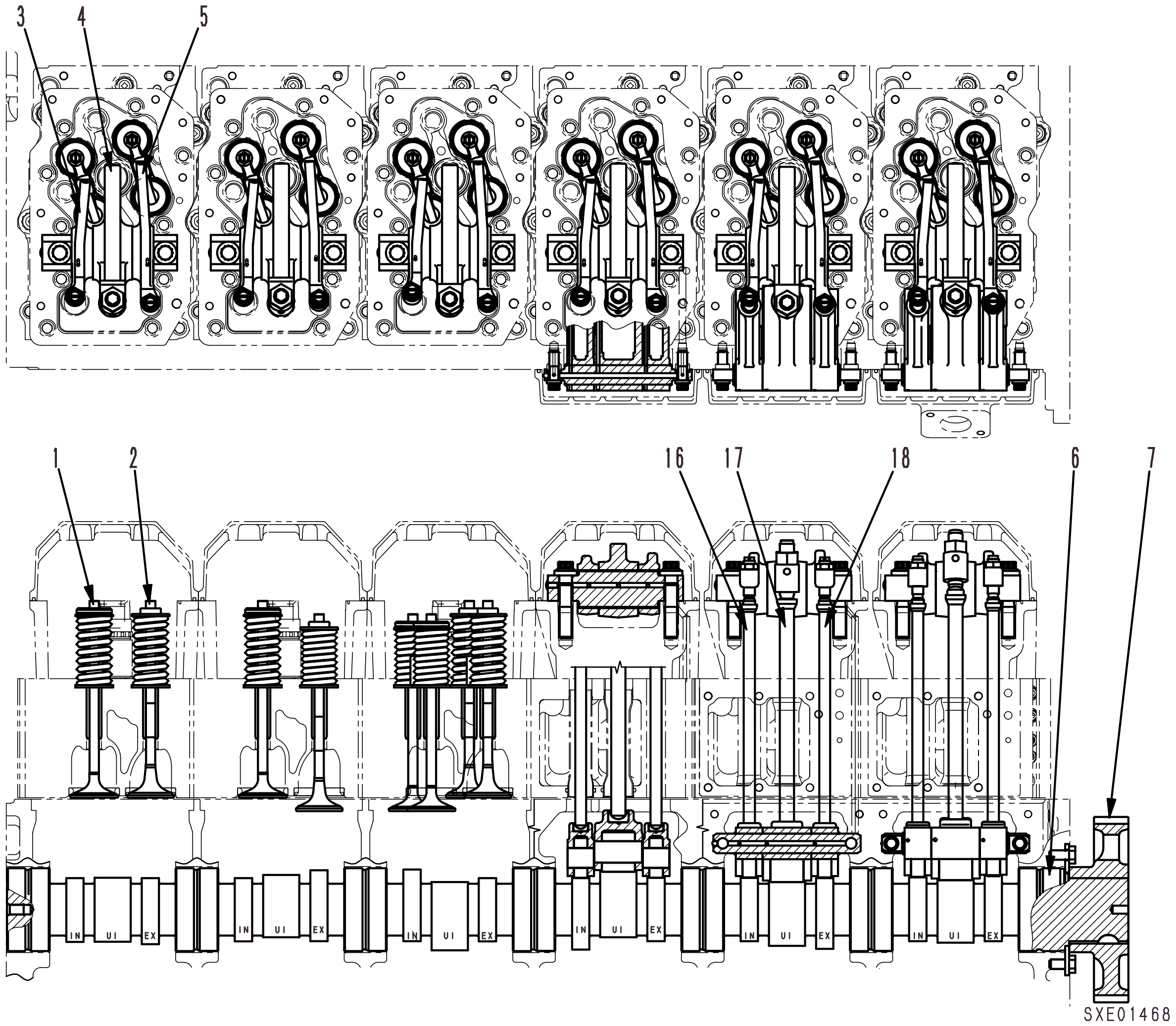


1. Crankshaft gear (No. of teeth: 63)
2. Idler gear (No. of teeth: 72)
3. Idler gear (No. of teeth: 40)
4. Camshaft gear (No. of teeth: 70)

A. Timing mark
   (between crankshaft gear and idler gear)
B. Timing mark
   (between idler gear and camshaft gear)

VALVE SYSTEM

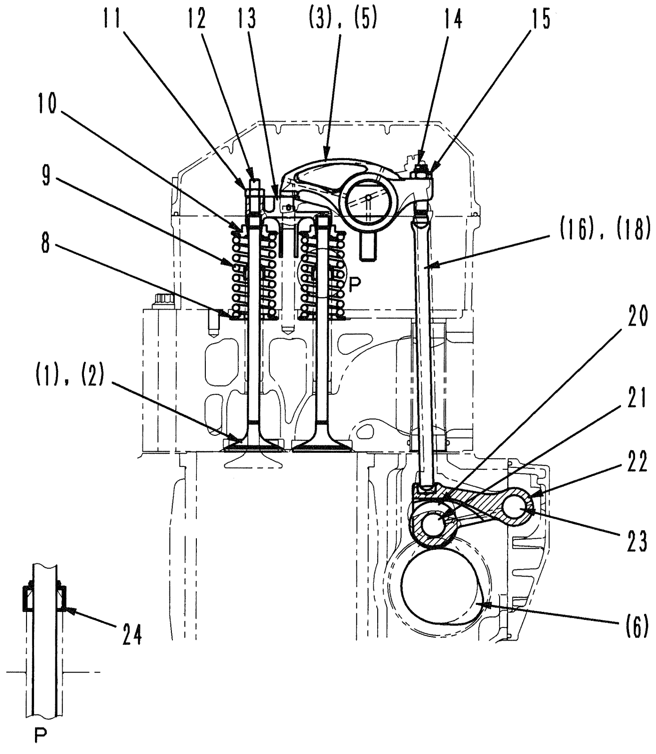
★ The numbers in ( ) are used when indicating other parts of the same type or when explaining the same part when seen from a different angle.



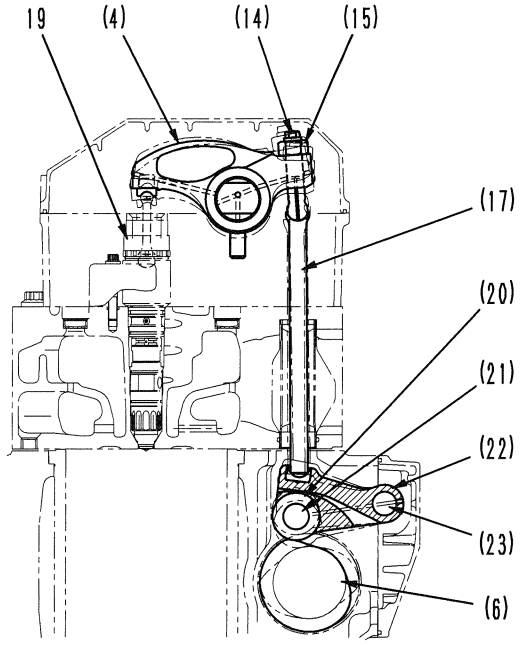
1. Intake valve
2. Exhaust valve
3. Rocker arm (for intake)
4. Rocker arm (for UI)
5. Rocker arm (for exhaust)
6. Camshaft
7. Camshaft gear
   (No. of teeth: 70)
8. Lower spring seat
9. Spring
10. Upper spring seat
11. Locknut (for crosshead)
12. Adjustment screw
    (for crosshead)
13. Crosshead
14. Adjustment screw
15. Locknut
16. Push rod (for intake)
17. Push rod (for UI)
18. Push rod (for exhaust)
19. Injector
20. Cam roller
21. Cam follower pin
22. Cam follower
23. Cam follower shaft
24. Oil seal
    (for intake and exhaust)

★ UI is the affreviation for Unit Injector.

No. 1 cylinder intake, exhaust side



No. 1 cylinder injector



SXE01470

SPECIFICATIONS

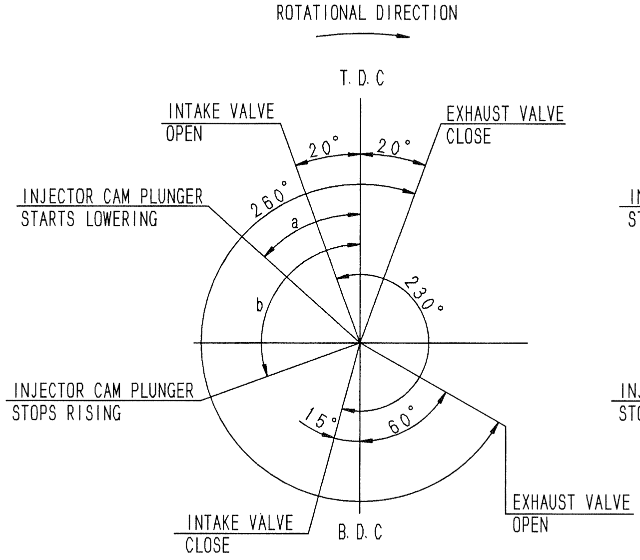
Camshaft

- Special alloy steel forging, 7 bearings
- Journal surface, cam surface: Induction hardening

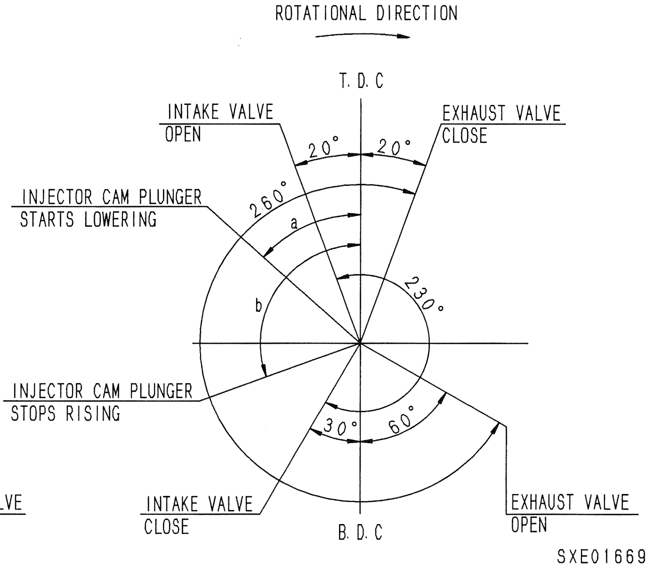
Injector plunger timing

Camshaft part No.	Plunger lowering start angle **a**	Plunger rise completion angle **b**
6240-41-1210	BTDC53°	BTDC109°

Valve timing (WA600-3)



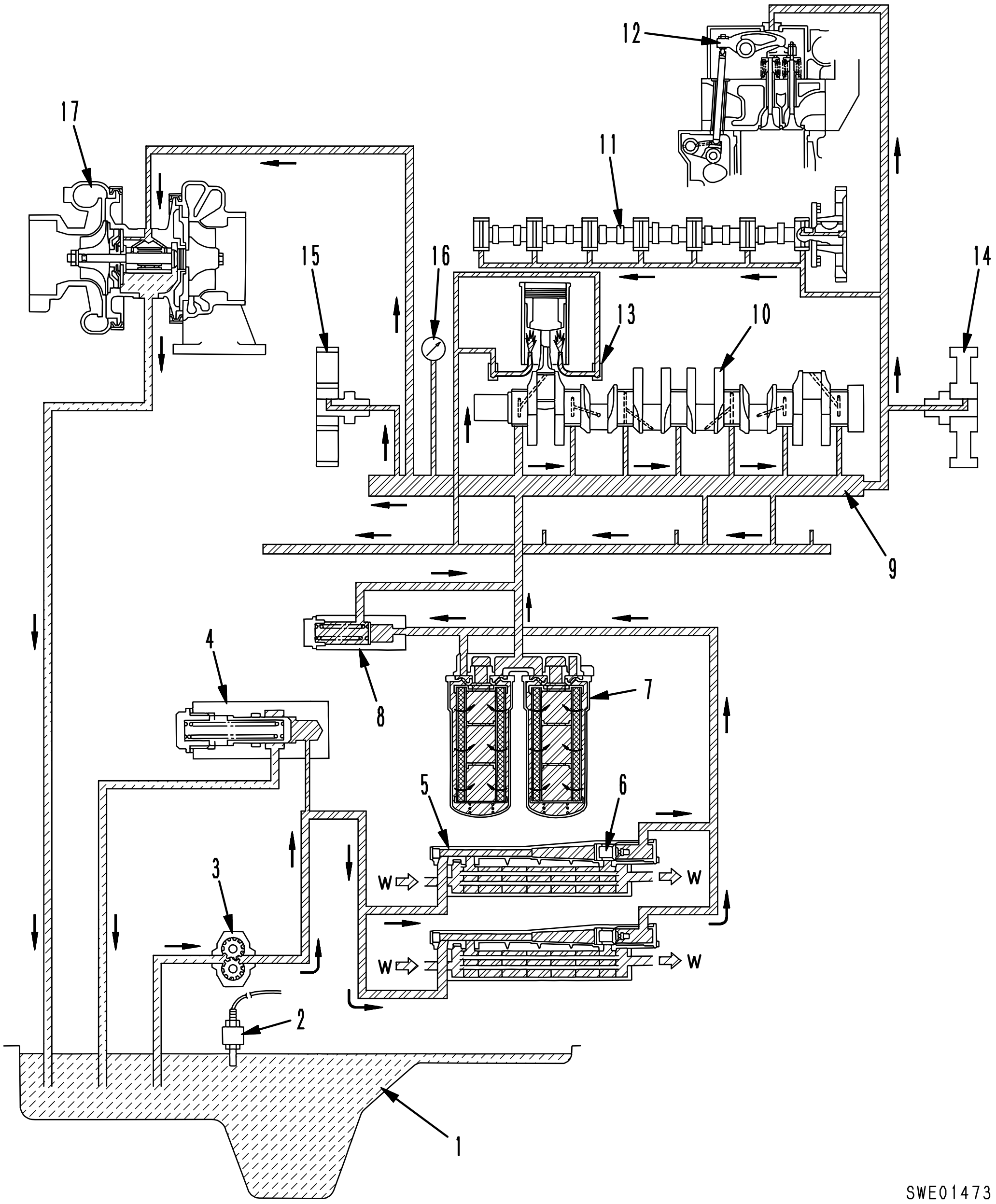
- **Valve timing (HD375A-5, generator)**



SXE01669

LUBRICATION SYSTEM DIAGRAM

★ The actual engine may be different because of modifications.

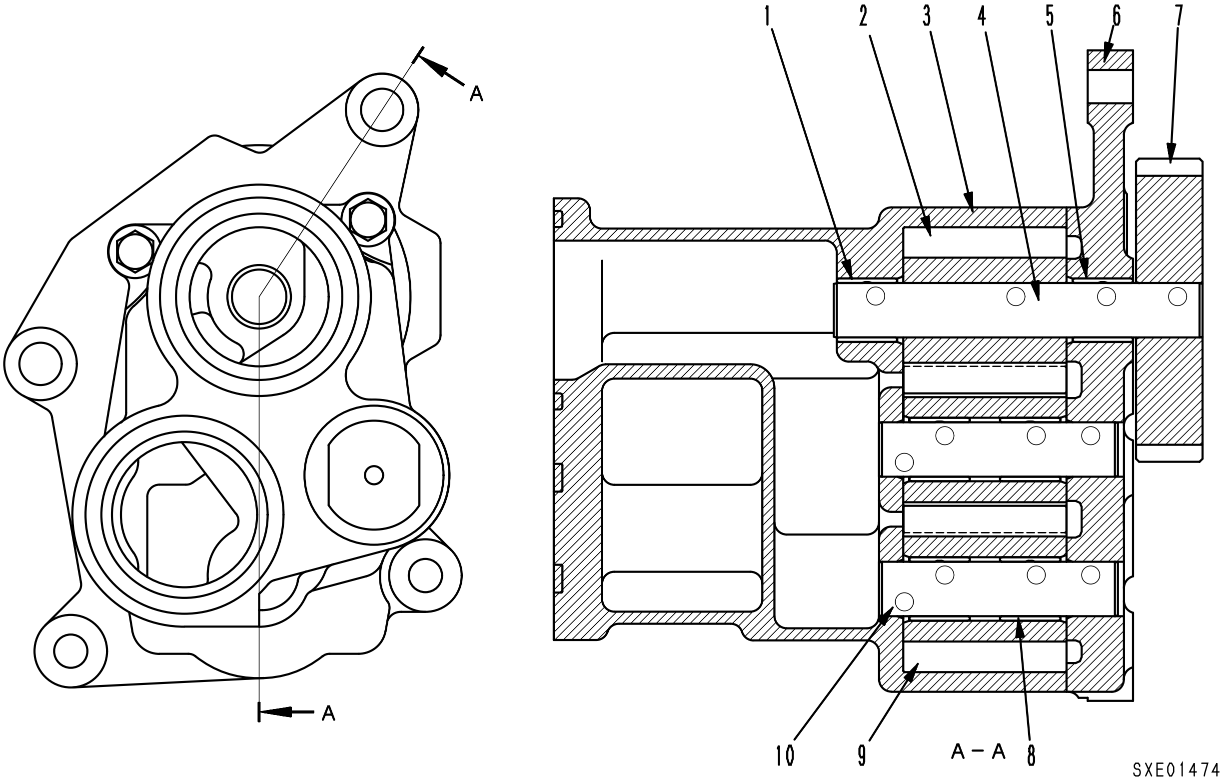


1. Oil pan
2. Oil level sensor
3. Oil pump
4. Regulator valve
5. Oil cooler
6. Thermo valve
7. Oil filter
8. Safety valve
9. Main gallery
10. Crankshaft
11. Camshaft
12. Rocker arm
13. Piston cooling nozzle
14. Timing gear (rear side)
15. Auxiliary equipment drive gear (front side)
16. Oil pressure gauge
17. Turbocharger

W. Cooling water

OIL PUMP

★ The actual engine may be different because of modifications.

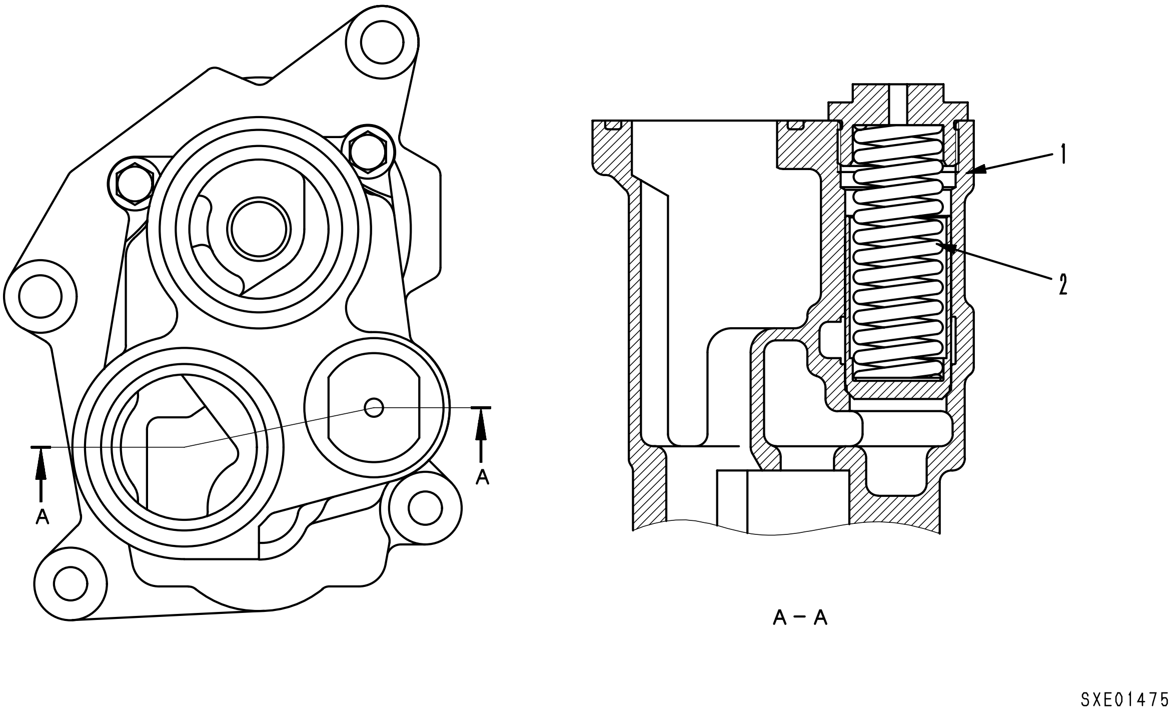


1. Bushing
2. Drive gear (No. of teeth: 10)
3. Oil pump body
4. Drive shaft
5. Bushing
6. Pump cover
7. Oil pump drive gear (No. of teeth: 38)
8. Bushing
9. Driven gear (No. of teeth: 10)
10. Driven shaft

SPECIFICATIONS

- Gear pump
- Rotating speed: Engine speed x 1.45

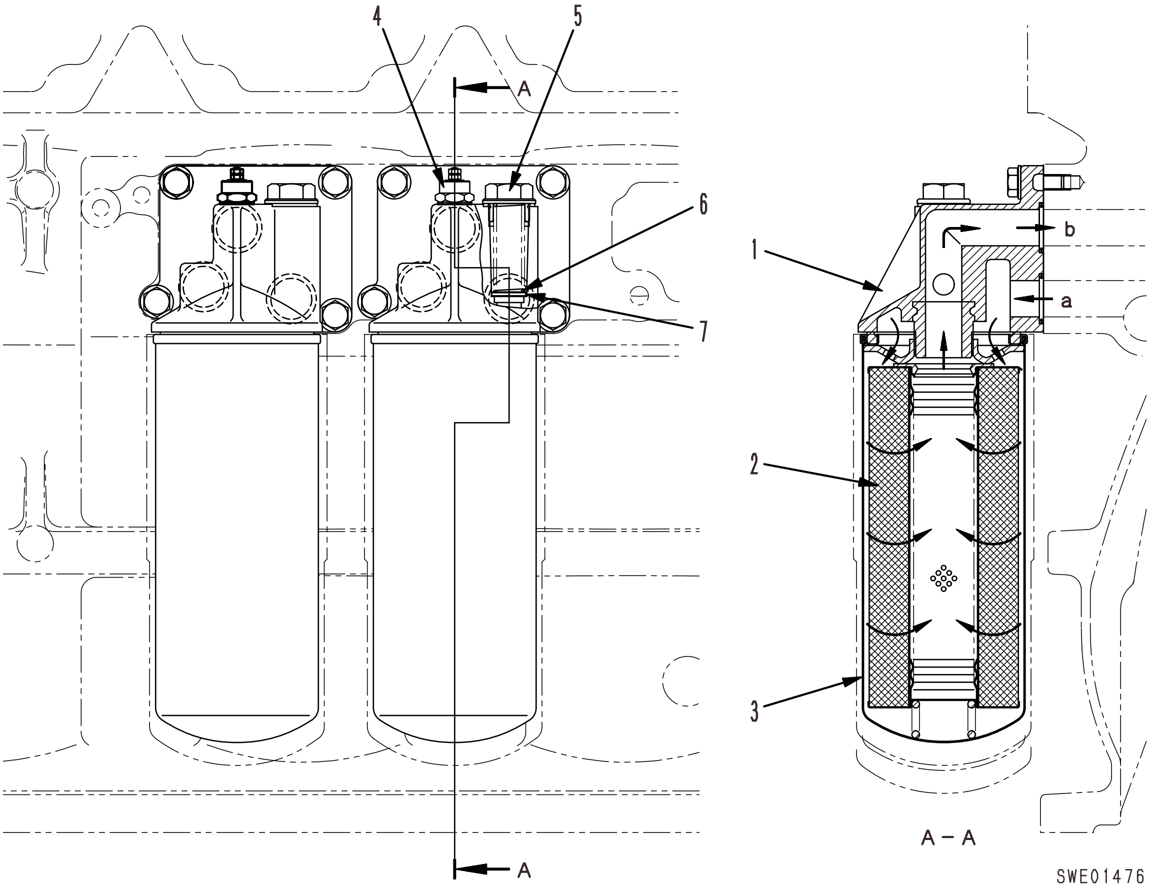
OIL PUMP RELIEF VALVE



1. Valve
2. Spring

OIL FILTER, SAFETY VALVE

★ The actual engine may be different because of modifications.



Oil filter

1. Filter bracket
2. Filter element } Cartridge
3. Filter case } Cartridge

Safety valve

4. Oil pressure switch (for filter clogging)
5. Safety valve cap
6. Valve spring
7. Safety valve

a. From oil pump
b. To all parts of engine

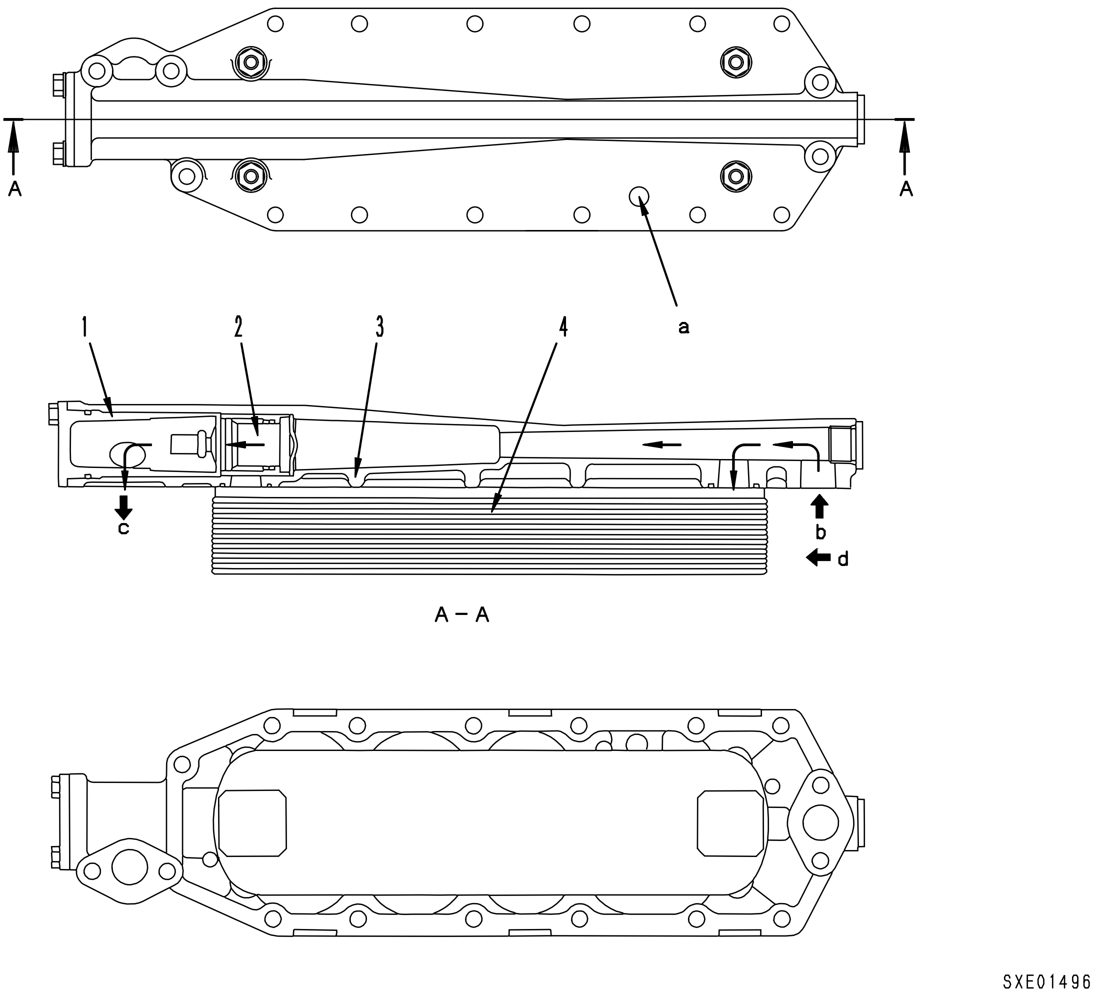
SPECIFICATIONS
Oil filter

- Filtering area: 0.9 m^2 x 2

Safety valve

- . Actuating pressure (differential pressure):
  245 ± 19.6 kPa {2.5 ± 0.2 kg/cm^2}

OIL COOLER



1. Thermostat cover
2. Thermostat (thermo valve)
3. Cooler cover
4. Cooler element

a. Water drain
b. Oil inlet
c. To all parts of engine (oil)
d. Water inlet

SPECIFICATIONS

Oil cooler thermo valve

- Cracking temperature: 85 ± 15°C
- Fully open temperature: 100°C
- Fully open lift: Min. 8 mm

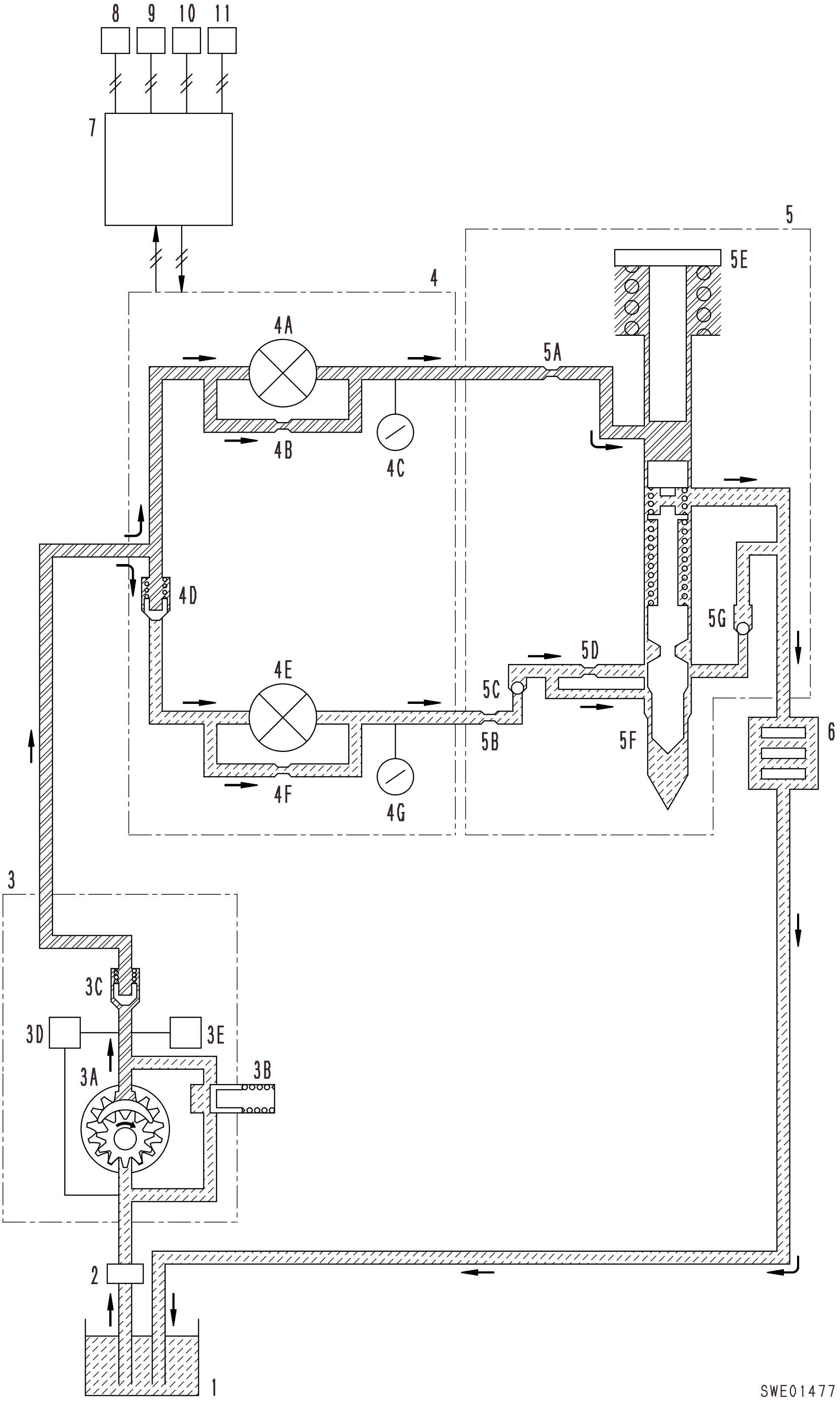
Oil cooler

- Oil cooler: 2 units installed
- Heat exchange: Min. 60,000 kcal/h
- Oil flow: 280 ℓ /min
- Water flow: 890 ℓ /min
- No. of stages of cooler element: 9
- Heat transfer area : 0.65 m^2 x 2

FUEL SYSTEM DIAGRAM

HPI SYSTEM

★ HPI is the abbreviation for High-Pressure Injection.



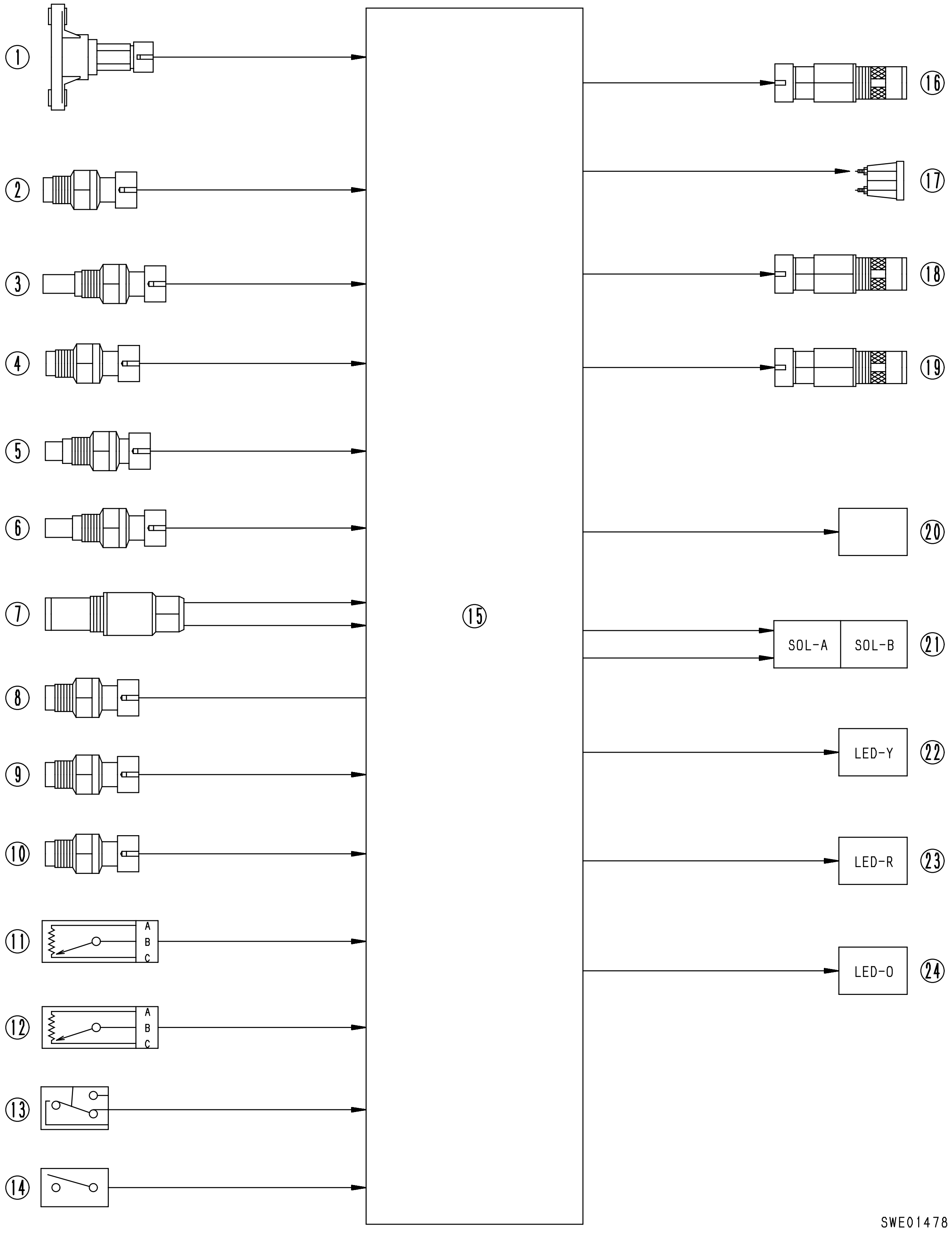
1. Fuel tank
2. Fuel filter
3. Fuel pump assembly
   - 3A. Gear pump
   - 3B. Pump regulator
   - 3C. Check valve
   - 3D. Fuel pump actuator
   - 3E. Fuel pump pressure sensor
4. Control valve assembly
   - 4A. Timing rail actuator valve
   - 4B. Fuel leak throttle (220 cc/min)
   - 4C. Timing rail pressure sensor
   - 4D. Shut-off valve
   - 4E. Fuel rail actuator valve
   - 4F. Fuel leak throttle (110 cc/min)
   - 4G. Fuel rail pressure sensor
5. Injector assembly
   - 5A. Timing orifice
   - 5B. Fuel orifice
   - 5C. Gravity check valve
   - 5D. Bypass orifice
   - 5E. Injector
   - 5F. Plunger
   - 5G. Gravity check valve
6. Fuel cooler
7. ECM controller
8. Engine speed sensor
9. Atmospheric pressure sensor
10. Boost pressure sensor
11. Boost temperature sensor

OUTLINE OF HPI SYSTEM

- The HPI system consists of injector assembly (5), control valve assembly (4), and fuel pump assembly (3).
- Injector assembly (5) controls the amount of fuel injection and the injection timing by controlling the amount of fuel passing through fuel orifice (5B). In order to control the fuel flow, it is necessary to control the fuel rail pressure and timing rail pressure. To control these pressures, control valve assembly (4) has 2 pressure sensors and 2 actuator valves built in. These carry out control so that the fuel rail pressure and timing rail pressure become the target value. Shut-off valve (4D), used to stop the engine, is installed in the fuel rail line.
- Fuel pump assembly controls the basic pressure of the fuel. The fuel supplied from fuel tank (1) passes through fuel filter (2), is then sucked up by gear pump (3A), and is supplied to control valve assembly (4). The discharge pressure of the fuel pump is controlled to a suitable level by adjusting the opening angle of fuel pump actuator (3D).

ENGINE CONTROLLER CONTROL SYSTEM

FUNCTION



With the control system using the engine controller, the signals detected by the sensors are input and the engine controller calculates these. It then outputs the signal for the results to the actuators to control the fuel injection amount and the fuel injection timing.

★ This section contains only the information about the equipment mounted on the engine or the related equipment.

★ In some cases, the mounted equipment is also related to the machine, so for details of that portion, see the manual for the machine.

① Atmospheric pressure sensor
The atmospheric pressure sensor is installed to the control valve unit. It detects the atmospheric pressure and inputs an analog signal to the controller.

② Boost pressure sensor
The boost pressure sensor is installed to the intake manifold. It detects the turbocharger boost pressure (intake pressure) and inputs an analog signal to the controller.

③ Intake air temperature sensor
The intake air temperature sensor is installed to the intake manifold. It detects the intake air temperature and inputs an analog signal to the controller.

④ Oil pressure sensor
The oil pressure sensor is installed to the cylinder block lubricating system. It detects the oil pressure in the lubricating circuit and inputs an analog signal to the controller.

⑤ Fuel temperature sensor
The fuel temperature sensor is installed to the control valve unit. It detects the pressure of the fuel supplied from the fuel pump and inputs an analog signal to the controller.

⑥ Cooling water temperature sensor
The cooling water temperature sensor is installed to the thermostat housing. It detects the temperature of the cooling water and inputs an analog signal to the controller.

⑦ Engine speed sensor
The engine speed sensor is installed to the flywheel housing. It detects the speed of the flywheel and inputs an analog signal to the controller.
There is one engine speed sensor. It holds the signal circuit for two systems.

⑧ Fuel pump pressure sensor
The fuel pump pressure sensor is installed to the fuel pump. It detects the discharge pressure of the fuel pump and inputs an analog signal to the controller.

⑨ Fuel rail pressure sensor
The fuel rail pressure sensor is installed to the control valve unit. It detects the pressure of the fuel rail (fuel injection amount circuit) and inputs an analog signal to the controller.

⑩ Timing rail pressure sensor
The timing rail pressure sensor is installed to the control valve unit. It detects the pressure of the timing rail (fuel injection timing circuit) and inputs an analog signal to the controller.

⑪ Throttle sensor (installed to machine)
The throttle sensor is installed to the machine (or to the outside of the engine). It detects the angle of the accelerator on the machine (or outside) and inputs an analog signal to the controller.

⑫ Remote throttle sensor (installed to machine)
The remote throttle sensor is installed to the machine (or to the outside of the engine). It detects the angle of the accelerator on the machine (or outside) and inputs an analog signal to the controller.

⑬ Idling validation switch (installed to machine)
The idling validation switch is installed to the machine (or to the outside of the engine). It detects the idling setting and inputs an ON/OFF signal to the controller.

⑭ Troubleshooting switch (installed to machine)
The troubleshooting switch is installed to the machine (or to the outside of the engine). When it confirms an error code shown by the LED, it inputs an ON/OFF signal to the controller.

⑮ Engine controller
The engine controller is installed to the control valve unit. It controls the overall system.

⑯ Fuel pump actuator
The fuel pump actuator is installed to the fuel pump. It receives the output signal from the controller and controls the output pressure of the fuel pump to a constant value.

⑰ Fuel shut-off valve
The fuel shut-off valve is installed to the control valve unit. It receives the output signal from the controller and controls the opening (operation) or shutting off (stop) of the fuel supply circuit from the fuel pump.

⑱ Fuel rail actuator
The fuel rail actuator is installed to the control valve unit. It receives the output signal from the controller and adjusts the pressure of the fuel rail (fuel injection amount circuit) to control the fuel injection amount.

⑲ Timing rail actuator
The timing rail actuator is installed to the control valve unit. It receives the output signal from the controller and adjusts the pressure of the timing rail (fuel injection timing circuit) to control the fuel injection timing.

⑳ Electric heater (installed to machine)
The electric heater is installed to the machine (or the outside of the engine). It receives the output signal from the controller and drives the electric heater or the starting aid.

㉑ Dual output solenoid (installed to machine)
The dual output solenoid is installed to the machine (or the outside of the engine). It receives the output signal from the controller and drives the applicable device.

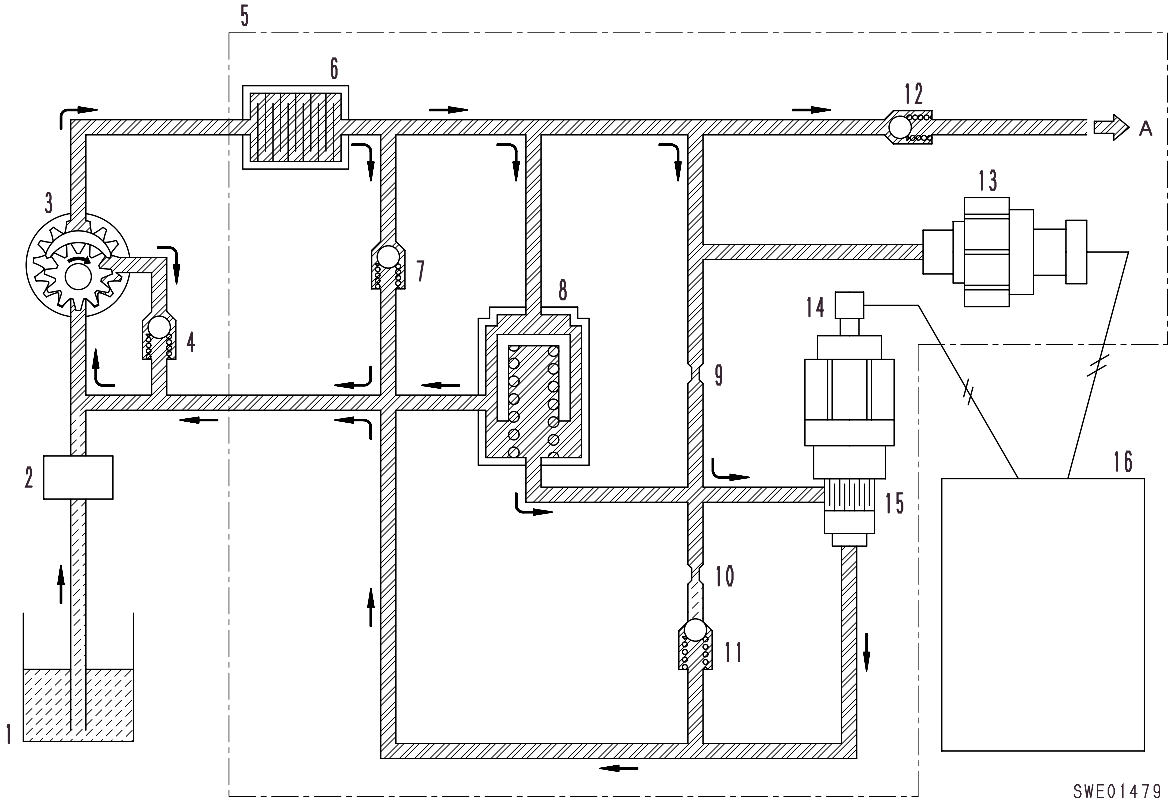
㉒ Warning (yellow) LED (installed to machine)
The warning (yellow) LED is installed to the machine (or the outside of the engine). It receives the output signal from the controller and when an abnormality occurs or when an error code is given, it displays the condition by lighting up, flashing, or going out.

㉓ Stop (red) LED (installed to machine)
The stop (red) LED is installed to the machine (or the outside of the engine). It receives the output signal from the controller and when an abnormality occurs or when an error code is given, it displays the condition by lighting up, flashing, or going out.

㉔ Check (orange) LED (installed to machine)
The check (orange) LED is installed to the machine (or the outside of the engine). It receives the output signal from the controller and when an abnormality occurs or when an error code is given, it displays the condition by lighting up, flashing, or going out.

★ The devices installed to the machine differ according to the machine mounting the engine, so see the Operation and Maintenance Manual for the machine model.

FUEL PUMP PRESSURE CONTROL CIRCUIT

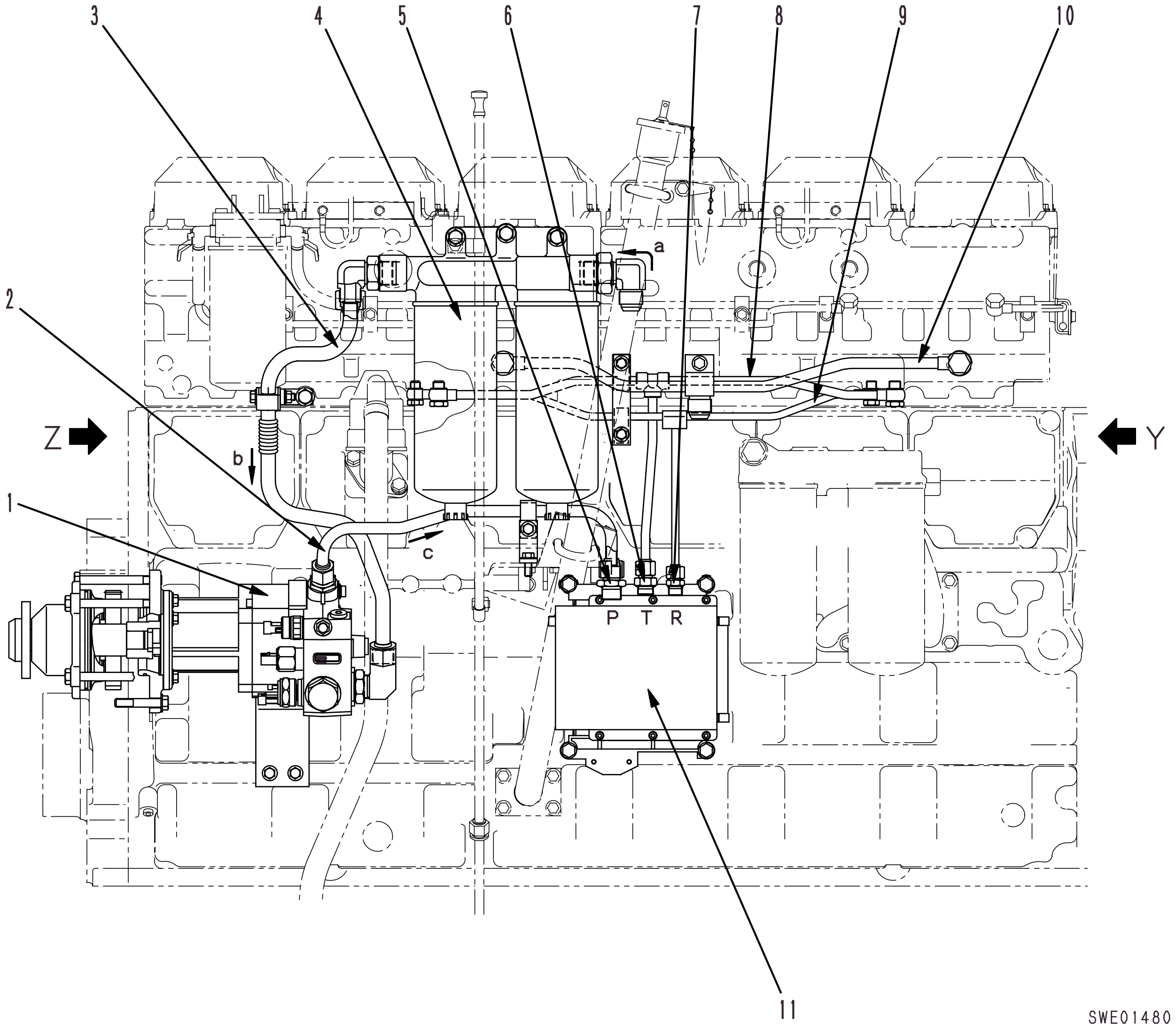


1. Fuel tank
2. Fuel filter
3. Fuel pump
4. Relief valve
5. Regulator housing
6. Screen (36 micron)
7. Regulator valve
8. Bypass valve
9. Control orifice
10. Relief orifice
11. Relief valve
12. Discharge check valve
13. Pressure sensor
14. Actuator
15. Screen (105 micron)
16. ECM controller

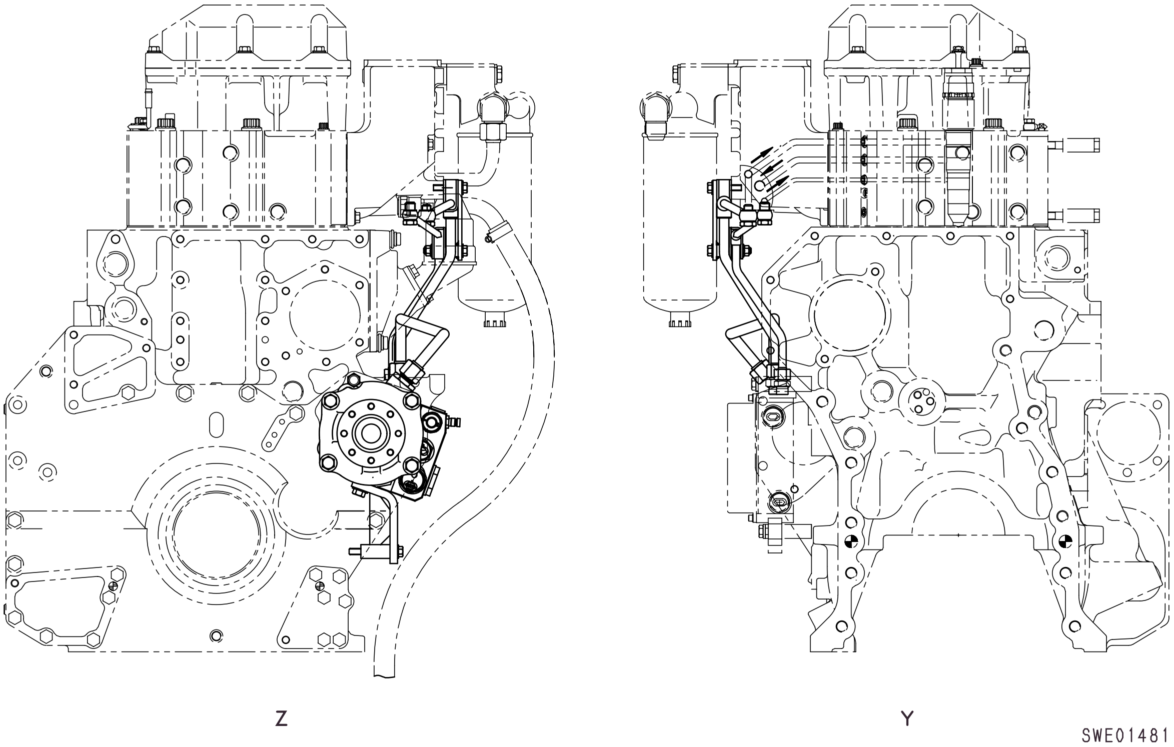
A. To injector

FUEL PUMP

PIPING



1. Fuel pump
2. Fuel pipe (from pump to ECVA)
3. Fuel pipe (from filter to pump)
4. Fuel filter
5. Fuel inlet
6. Fuel timing
7. Fuel rail
8. Fuel pipe (for fuel timing)
9. Fuel pipe (for fuel rail)
10. Fuel pipe (return)
11. ECVA (ECM controller)



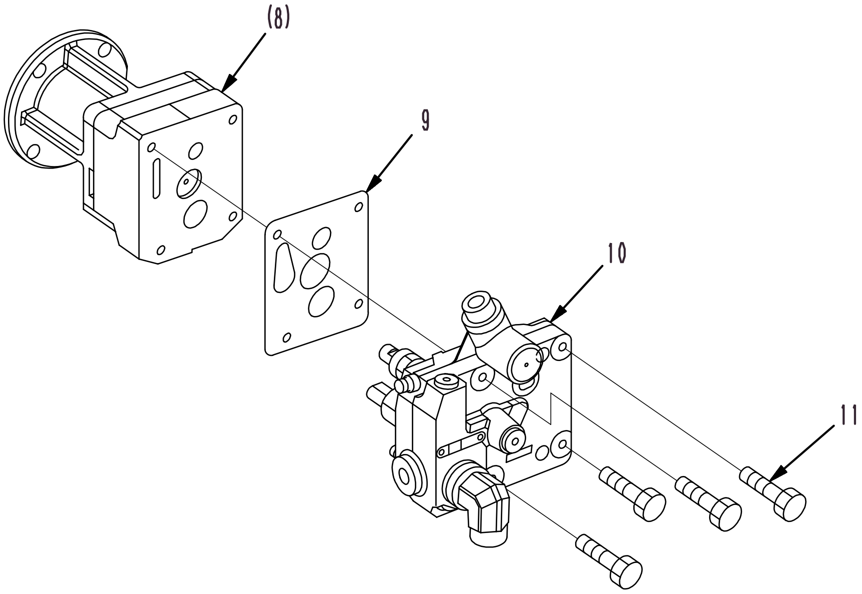
a. To fuel filter
b. To fuel pump
c. To fuel inlet

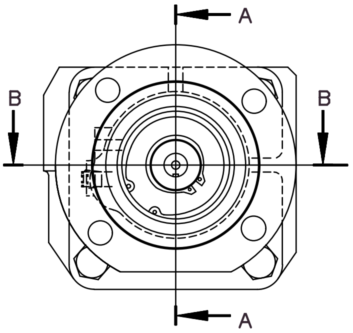
SPECIFICATIONS

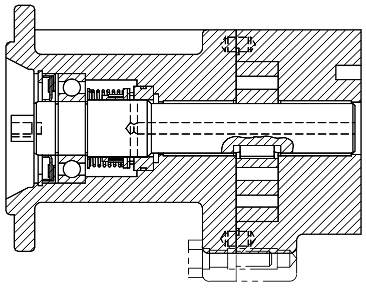
Type : HPI method
Lubricating method : Lubrication by fuel

FUEL PUMP

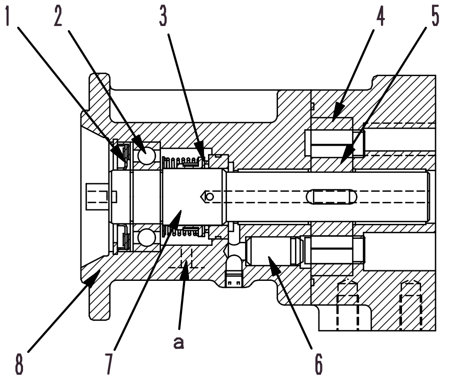
★ The numbers in ( ) are used when indicating other parts of the same type or when explaining the same part when seen from a different angle.







A – A

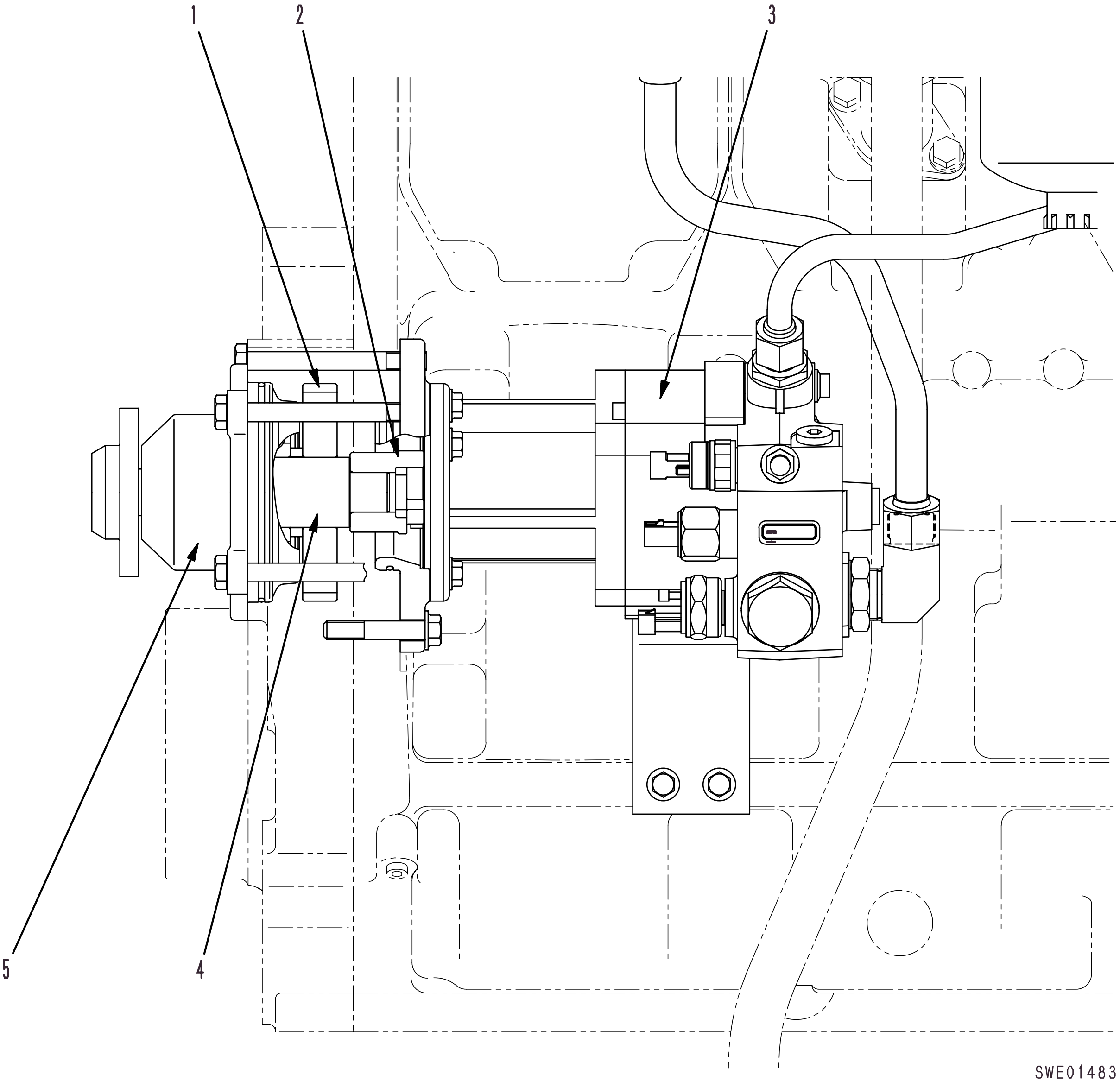


B – B SWE01482

1. Oil seal
2. Bearing
3. Mechanical fuel seal
4. Gear (outer)
5. Gear (inner)
6. Check valve (for adjusting fuel pressure)
7. Drive shaft
8. Pump housing
9. Gasket
10. Regulator valve housing
11. Mounting bolt

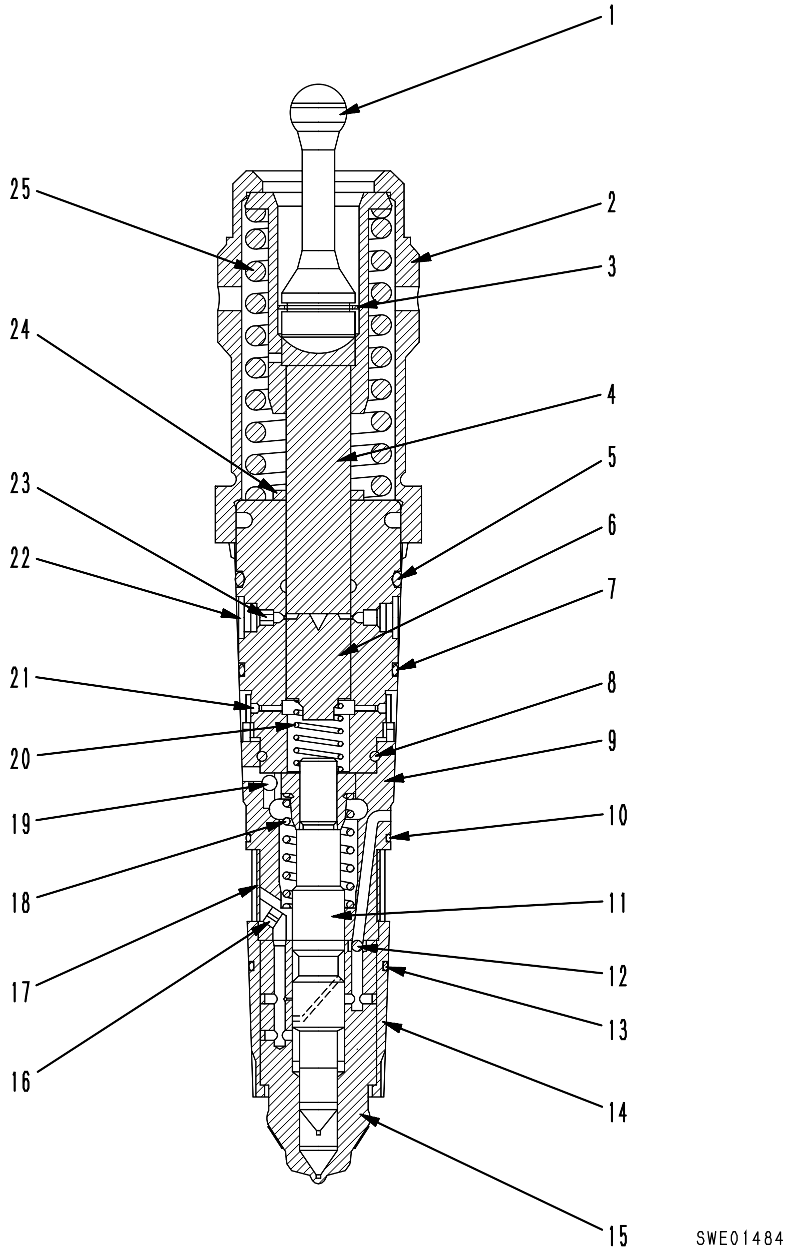
a. Breather (for fuel, oil drain)

FUEL PUMP DRIVE



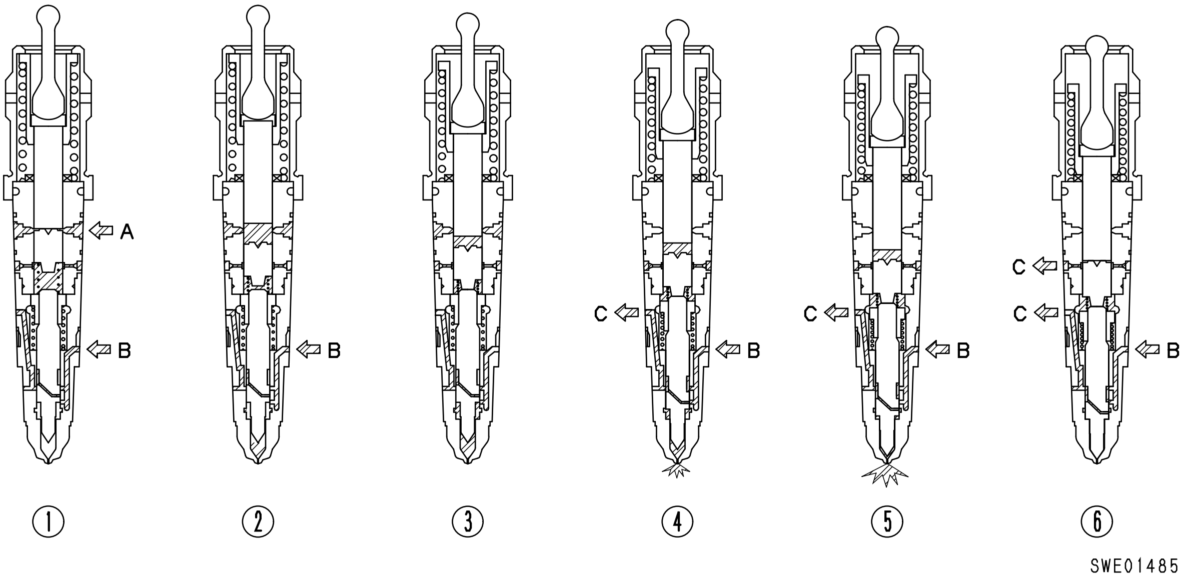
1. Drive gear (No. of teeth: 55)
2. Coupling
3. Fuel pump
4. Fuel pump drive shaft
5. Bearing housing

INJECTOR



1. Link
2. Top stop housing
3. Link retainer
4. Upper plunger
5. O-ring
6. Intermediate plunger
   (for adjusting fuel injection timing)
7. O-ring
8. Pin
9. Spring housing
10. O-ring
11. Lower plunger
12. Check ball
13. O-ring
14. Nozzle retainer
15. Nozzle
16. Rail orifice
17. Screen (for rail)
18. Lower spring
19. Check ball
20. Bias spring
21. Ring valve (for spill pressure control)
22. Screen (for timing)
23. Timing orifice
24. Oil seal
25. Return spring

HPI FUEL INJECTION SYSTEM



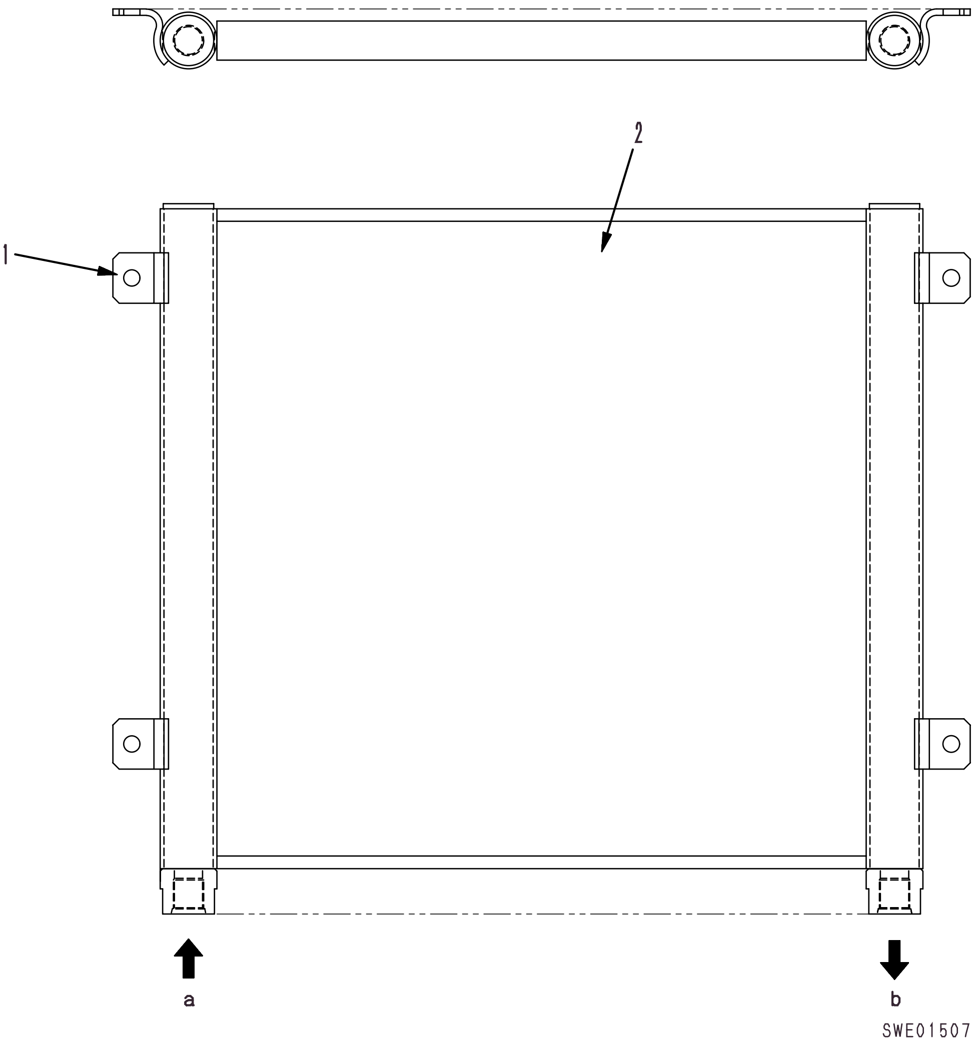
A. To timing chamber
B. To metering chamber
C. Return (to fuel cooler)

Fuel injection stroke

① Start of metering
② Completion of timing chamber metering
③ Completion of injection metering
④ Start of injection
⑤ Completion of injection
⑥ Completion of timing chamber spill

FUEL COOLER

★ The actual engine may be different because of modifications.



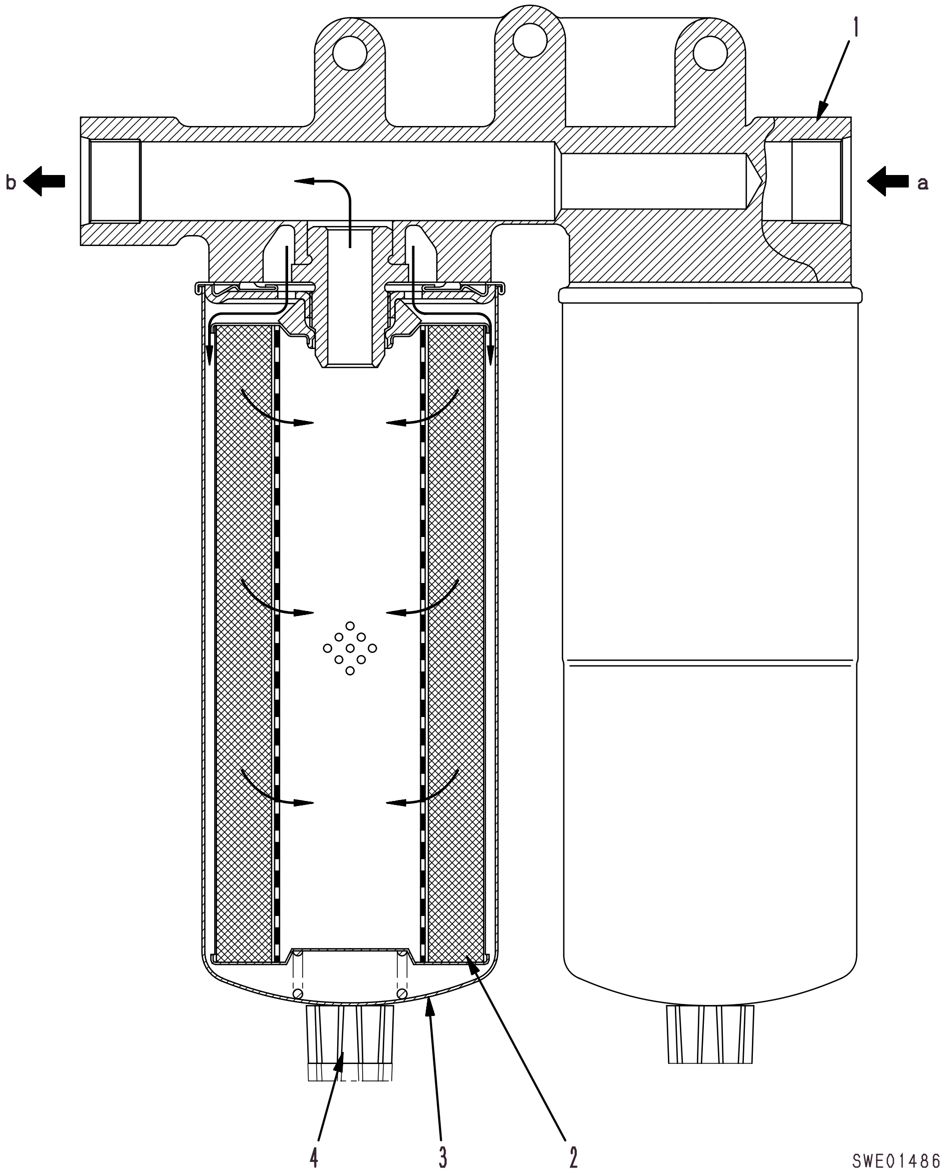
1. Mount bracket
2. Core

a. From injector
b. To fuel tank

SPECIFICATIONS

Cooling method: Air cooled
Core type: CF40, (4.5/2P)
Heat dissipation surface: 6.45 m^2
Heat dissipation amount: 11.63 kW {10,000 kcal}/h
Fuel pressure: Max. 5.88 kPa {0.06 kg/cm^2}
(When fuel temperature at cooler inlet port is 100°C)

FUEL FILTER



1. Filter bracket
2. Filter element } Cartridge
3. Filter case } Cartridge
4. Drain plug

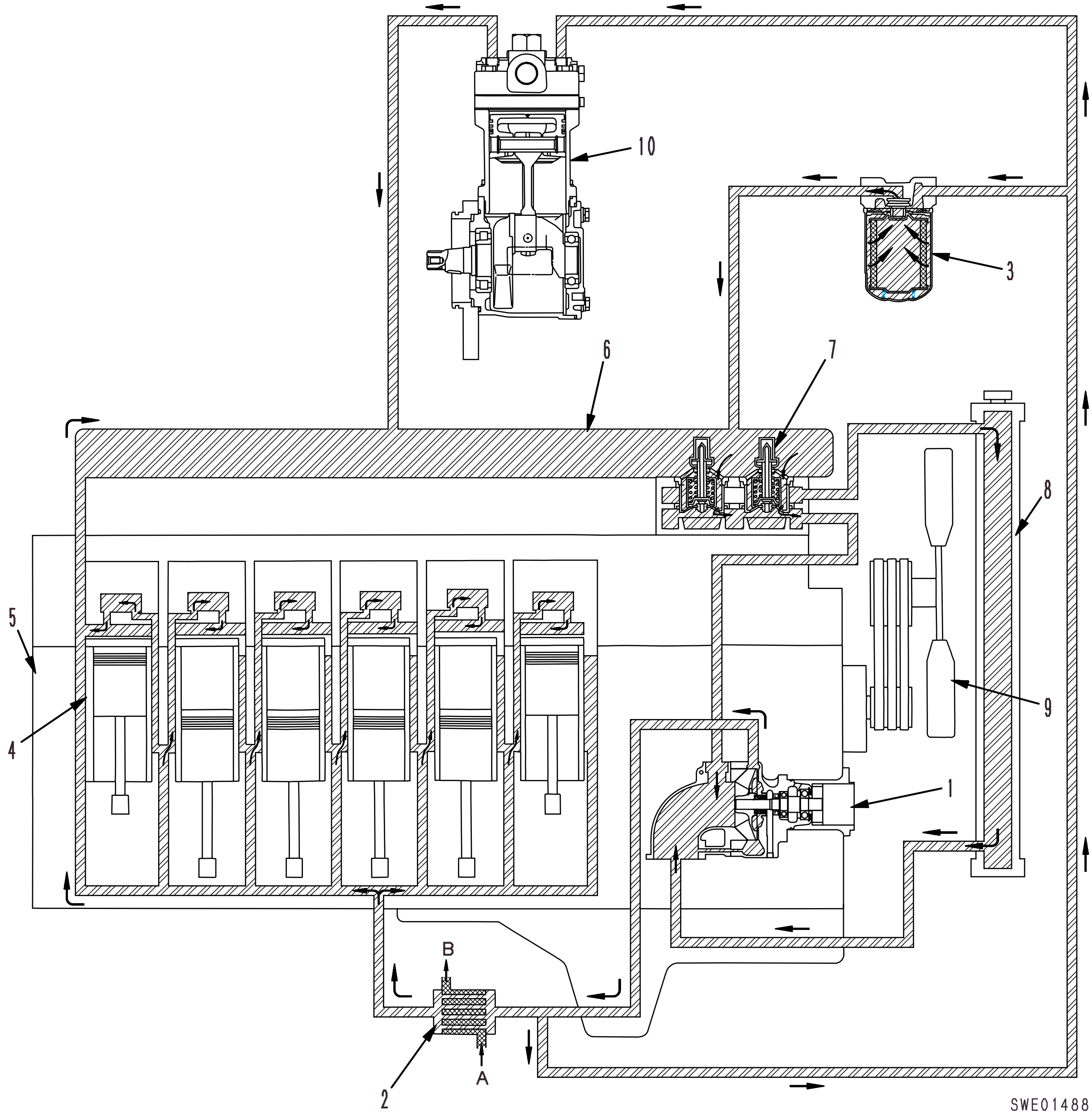
a. From fuel tank
b. To fuel pump

SPECIFICATIONS

Filtering area: 1 m^2 x 2

COOLING SYSTEM DIAGRAM

★ The actual engine may be different because of modifications.

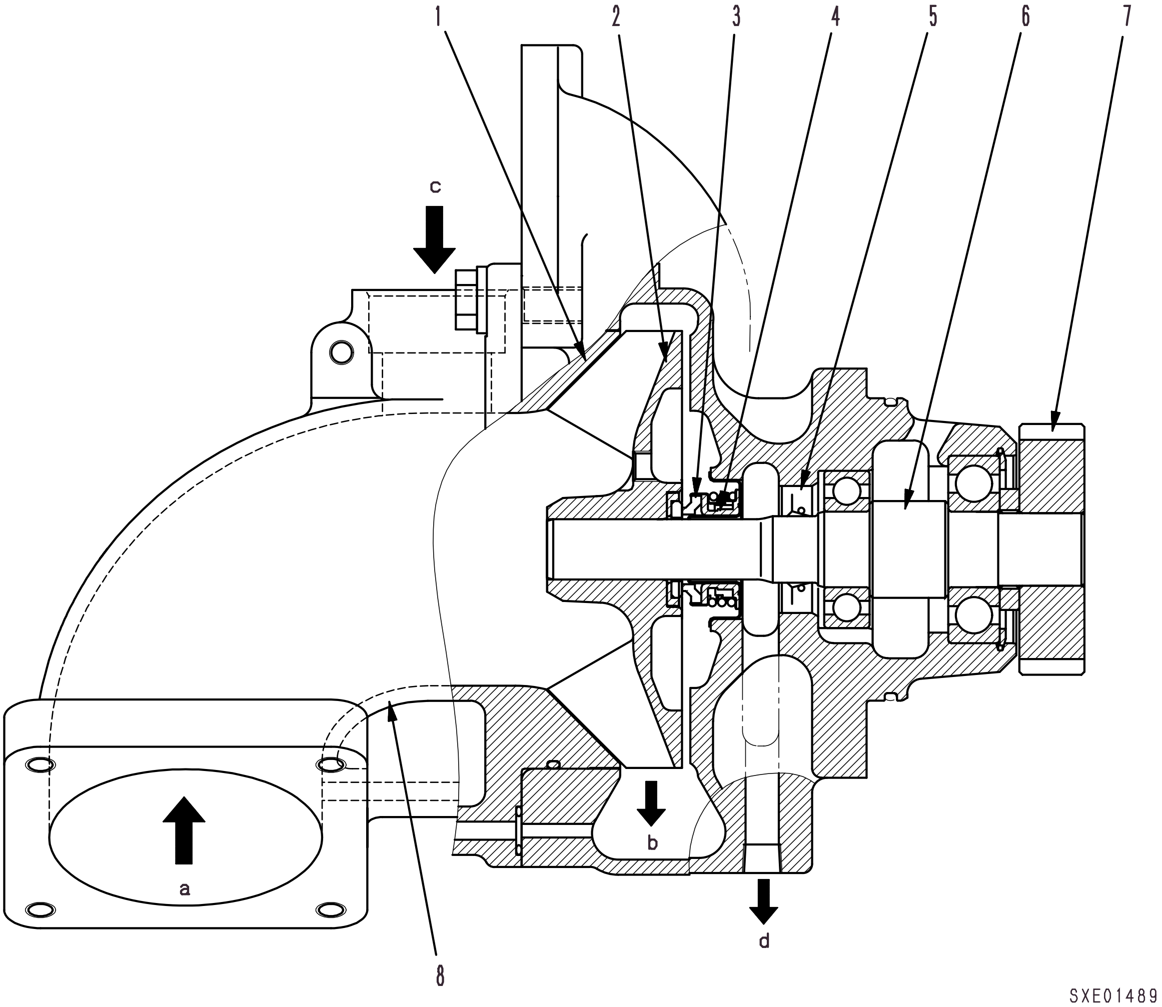


1. Water pump
2. Oil cooler
3. Corrosion resistor
4. Cylinder liner
5. Cylinder block
6. Water manifold (inside cylinder block)
7. Thermostat
8. Radiator
9. Fan
10. Air compressor

A. From oil pump (oil)
B. To all parts of engine (oil)

WATER PUMP

★ The actual engine may be different because of modifications.



1. Pump body
2. Impeller
3. Floating seal
4. Water seal
5. Oil seal
6. Pump shaft
7. Water pump drive gear (No. of teeth: 31)
8. Inlet housing

a. From radiator
b. To oil cooler
c. From thermostat
d. Breather (for water drain)

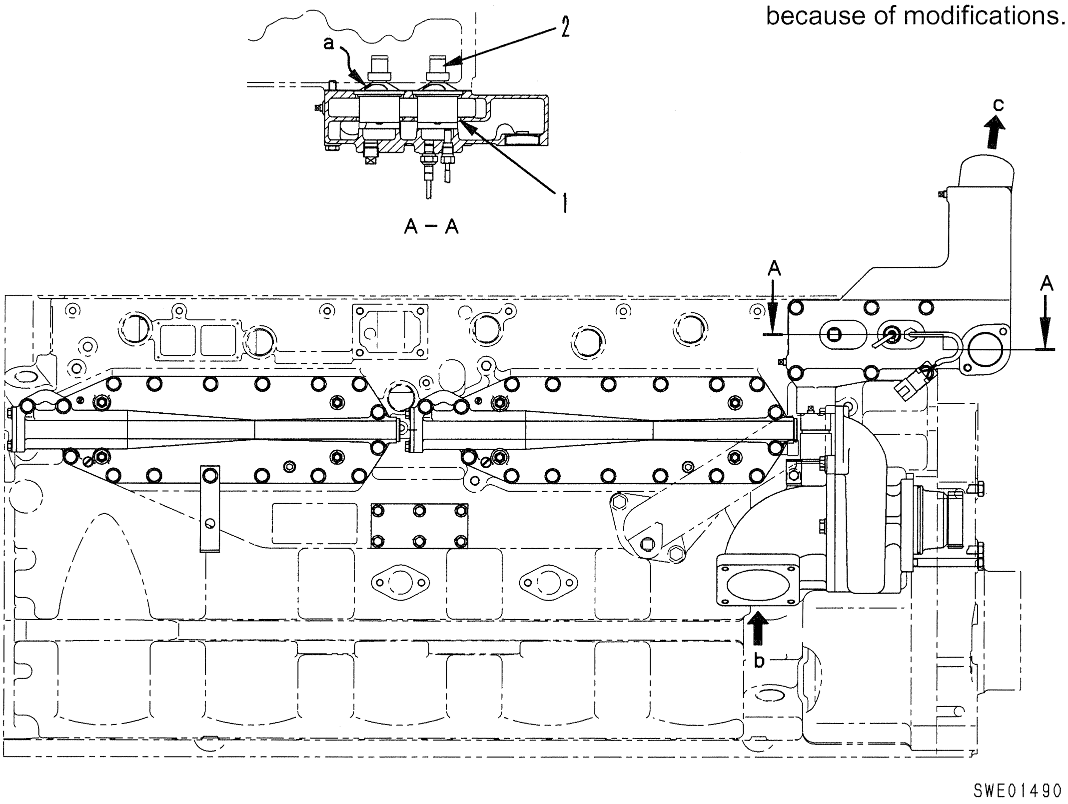
SPECIFICATIONS

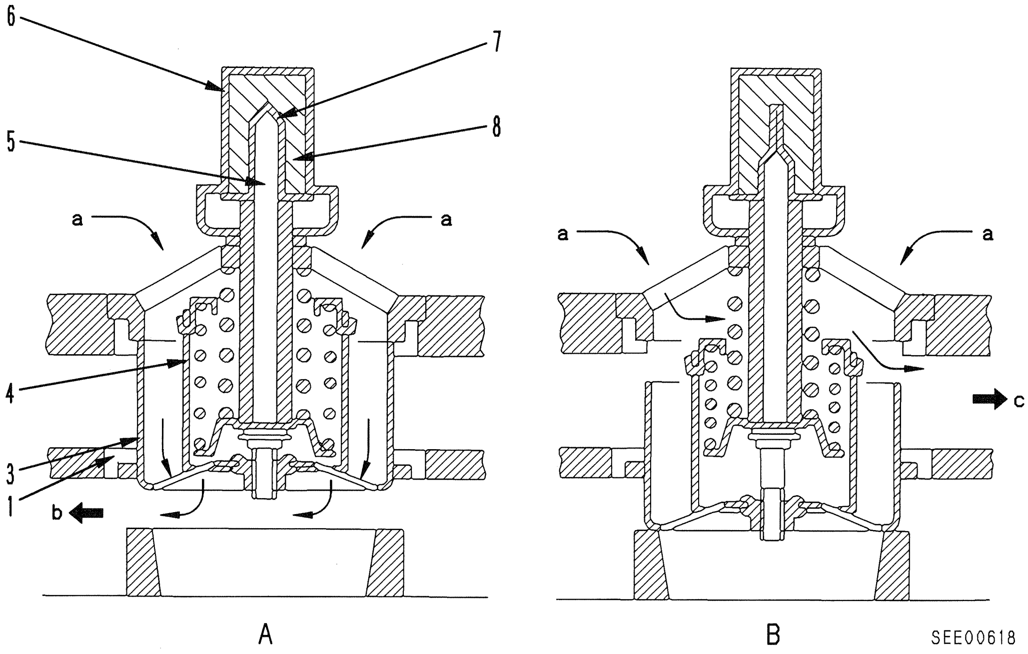
Rotating speed: Engine speed x 1.77

Water flow: 800 ℓ /min (at 3,730 rpm)

THERMOSTAT

★ The actual engine may be different because of modifications.





1. Seal
2. Thermostat
3. Valve
4. Body
5. Piston
6. Heat sensing portion
7. Sleeve
8. Inflation agent

A. When cold (close)
B. When hot (fully open)
a. From all parts of engine
b. To water pump
c. To radiator

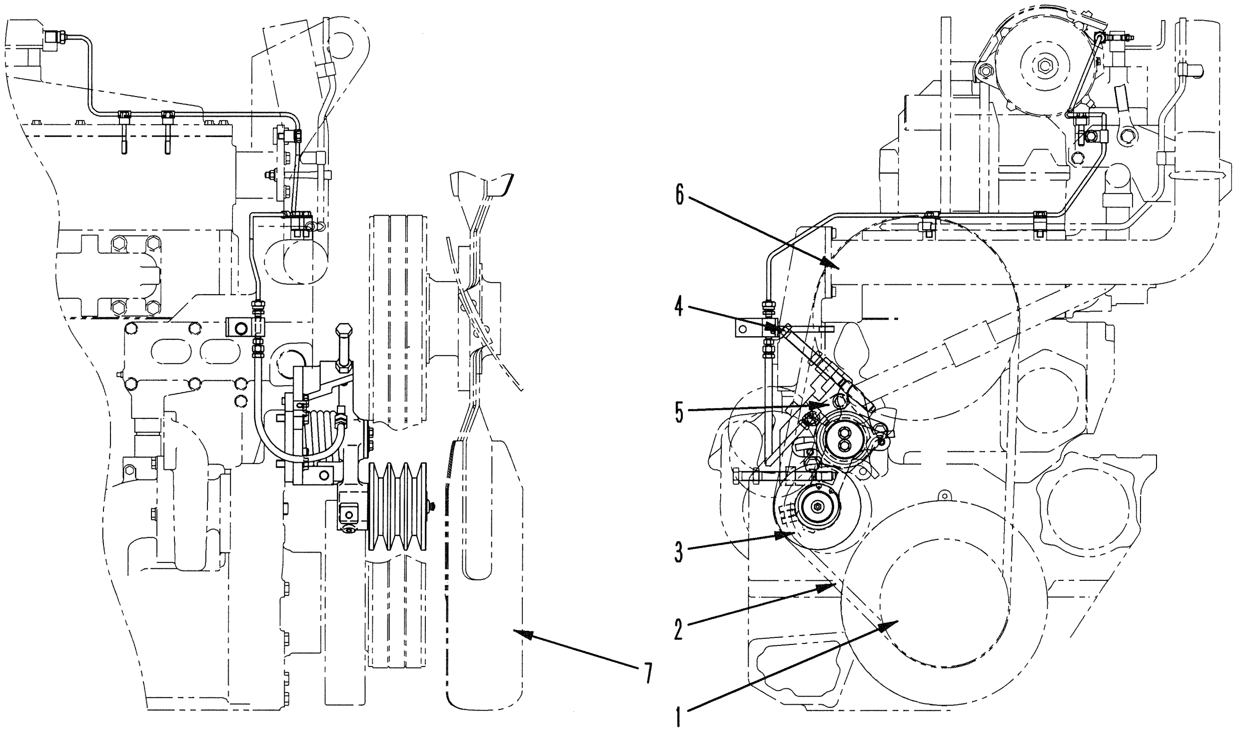
SPECIFICATIONS (as individual part)

Cracking temperature: 76.5 ± 2°C
Full open temperature: 90°C
Valve lift: Min. 9 mm

FAN, TENSION PULLEY

FAN DRIVE (D375A-5)

★ The actual engine may be different because of modifications.



SJE01979

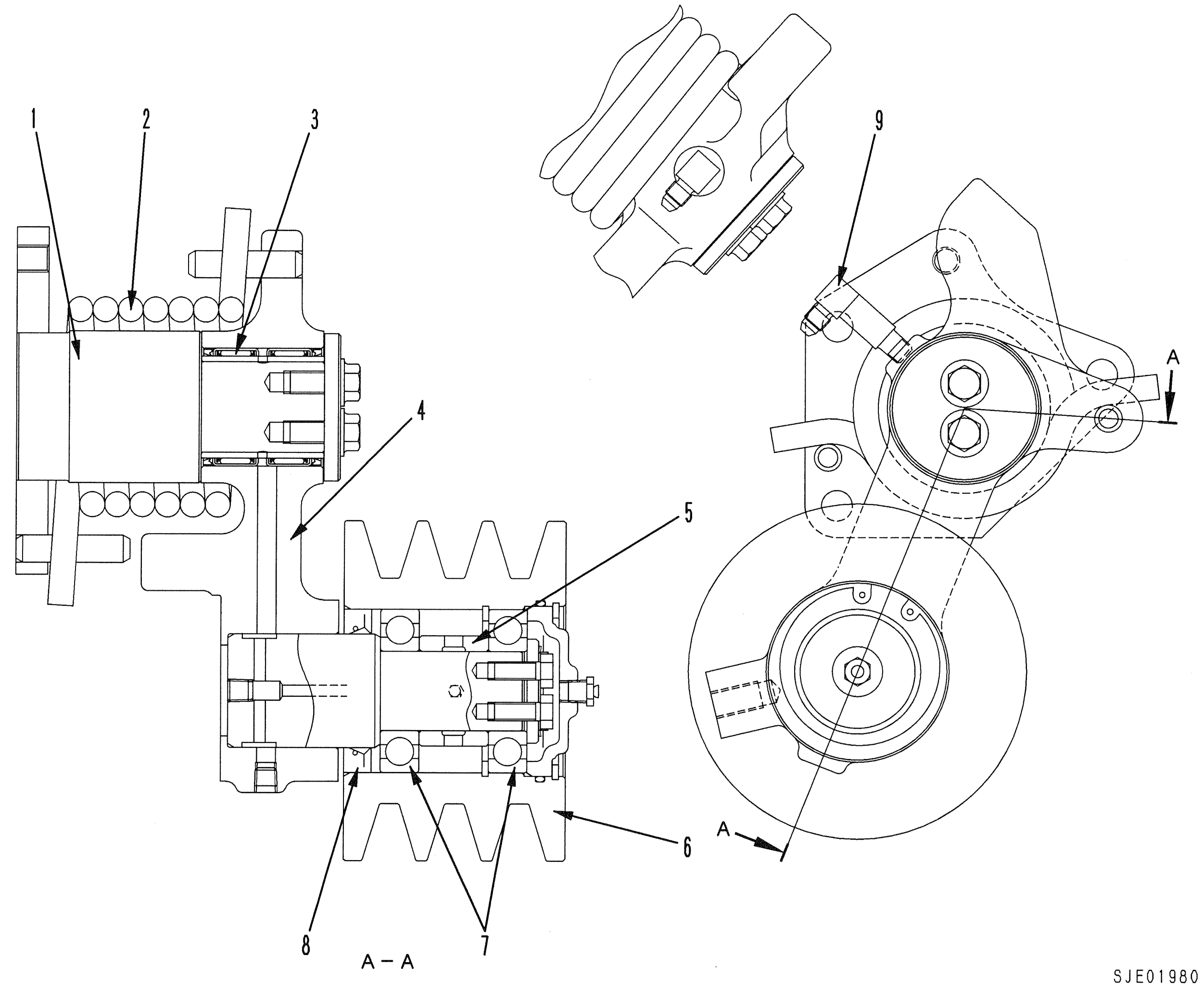
1. Crankshaft pulley
2. Fan belt
3. Tension pulley
4. Adjustment bolt
5. Tension pulley bracket
6. Fan pulley
7. Fan

Pulley outside diameter Unit: mm

Model	Fan pulley	Crankshaft pulley	Tension pulley	Direction of wind from fan
D375A-5	351	220	150	Blows out

TENSION PULLEY (D375A-5)

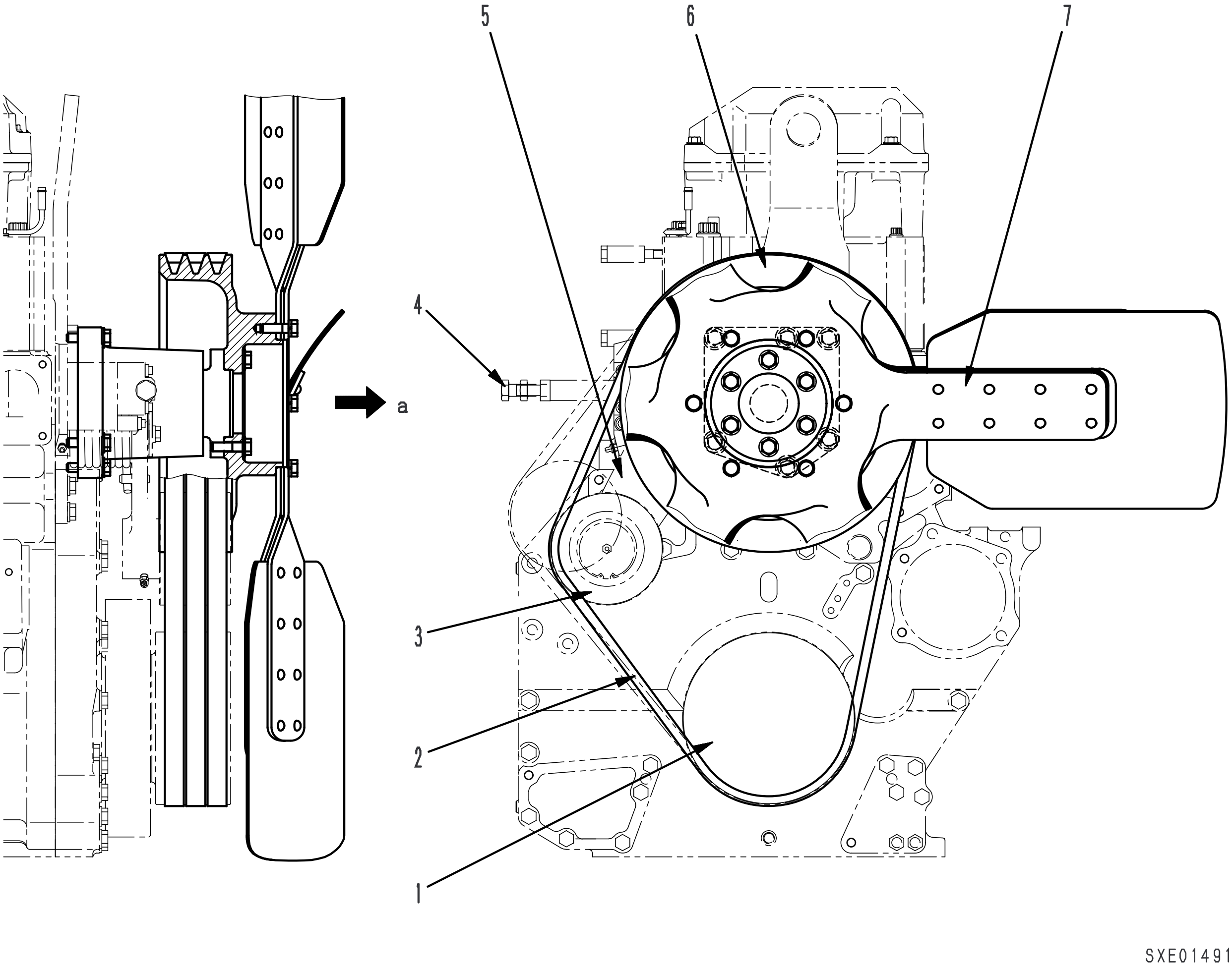
★ The actual engine may be different because of modifications.



1. Tension shaft
2. Spring
3. Roller bearing
4. Tension bracket
5. Spacer
6. Tension pulley (outside diameter: 150 mm)
7. Ball bearing
8. Oil seal
9. Grease nipple

FAN DRIVE (WA600-3, WD600-3)

★ The actual engine may be different because of modifications.



1. Crankshaft pulley
2. Fan belt
3. Tension pulley
4. Adjustment bolt
5. Tension pulley bracket
6. Fan pulley
7. Fan

a. Direction of wind

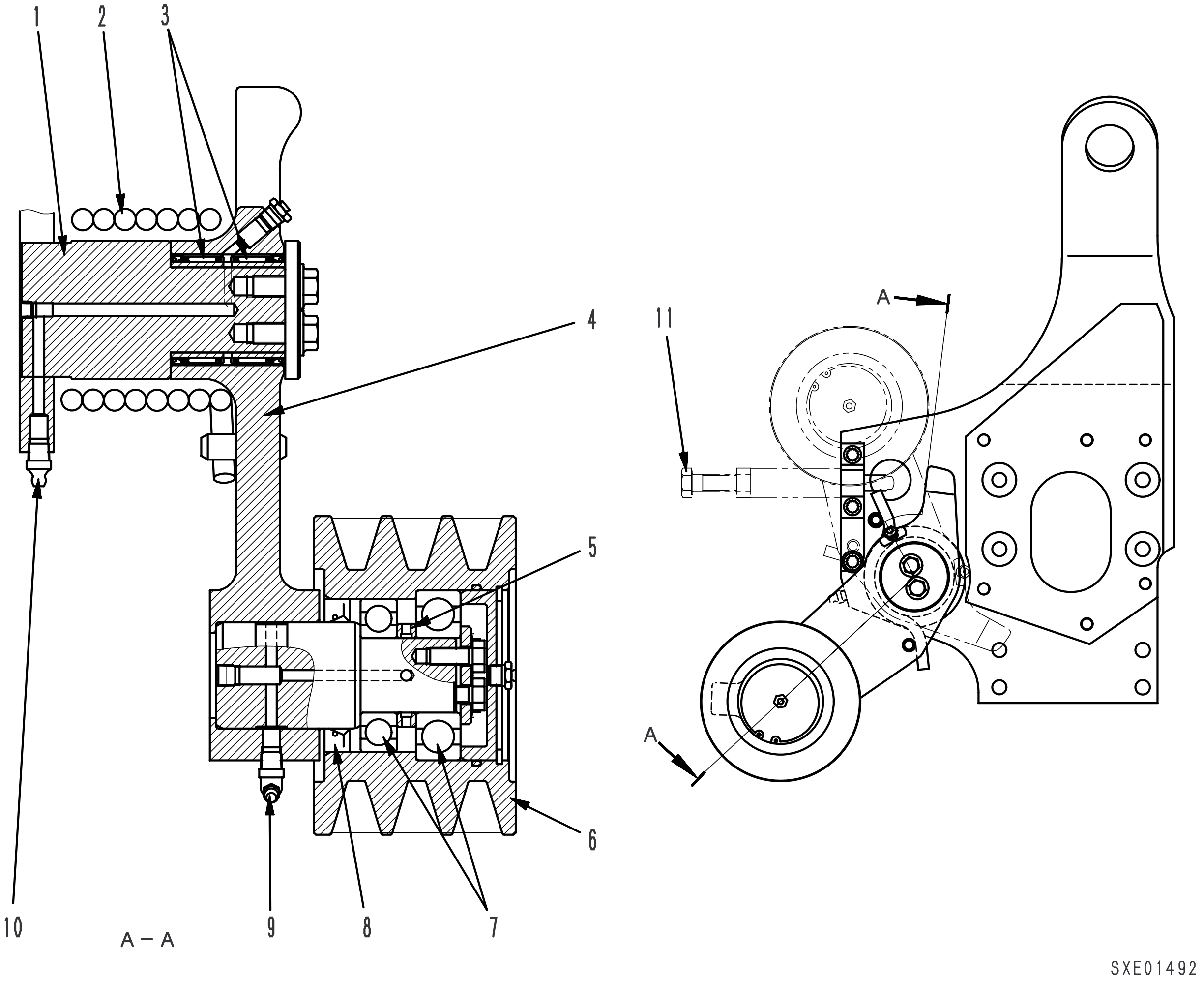
Pulley outside diameter Unit: mm

Model	Fan pulley	Crankshaft pulley	Tension pulley	Direction of wind from fan
WA600-3 WD600-3	397	230	150	Blows out

TENSION PULLEY (WA600-3, WD600-3, PC1250-7, HD465-7, HD605-7)

★ The actual engine may be different because of modifications.

★ The specifications may be different from the following figure, depending on the type of machine.

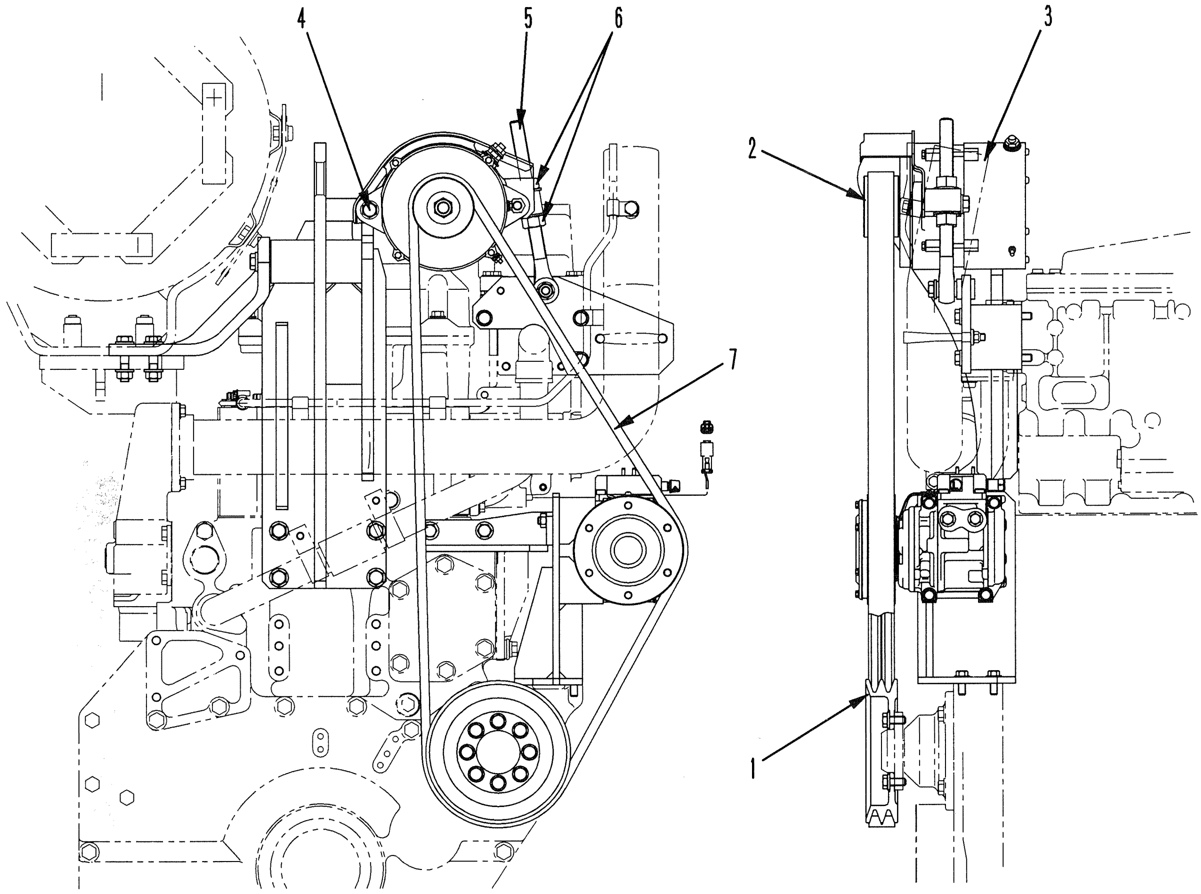


1. Tension shaft
2. Spring
3. Roller bearing
4. Tension bracket
5. Spacer
6. Tension pulley (outside diameter: 150 mm)
7. Ball bearing
8. Oil seal
9. Grease nipple
10. Grease nipple
11. Adjustment bolt

ALTERNATOR

ALTERNATOR MOUNTING (D375A-5)

★ The actual engine may be different because of modifications.



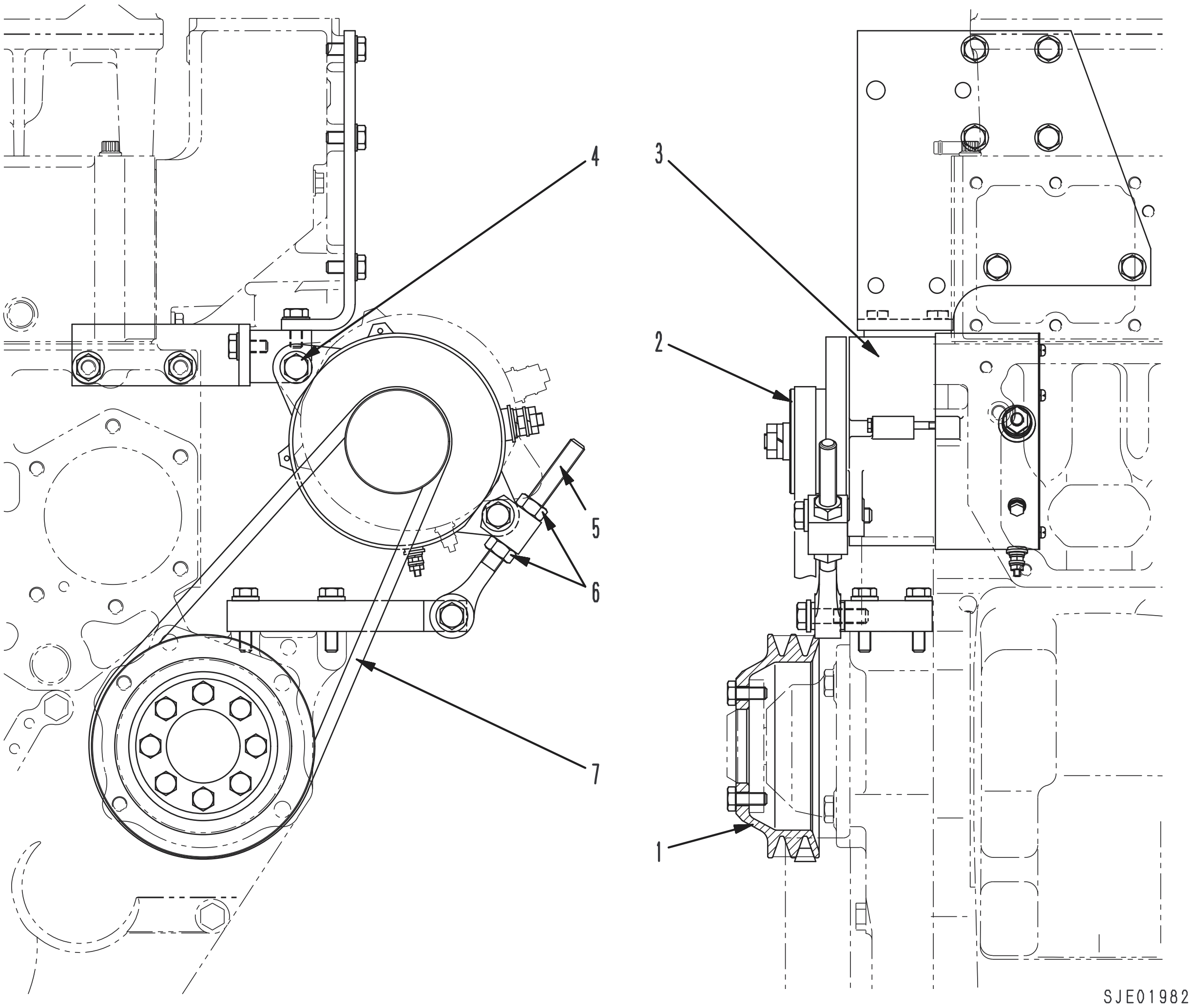
SJE01981

1. Drive pulley (pulley outside diameter: 200 mm)
2. Alternator pulley (pulley outside diameter: 85 mm)
3. Alternator
4. Alternator mounting bolt
5. Adjustment bolt
6. Locknut
7. V-belt

ALTERNATOR MOUNTING (WA600-3, WD600-3, PC1250-7, HD465-7, HD605-7)

★ The actual engine may be different because of modifications.

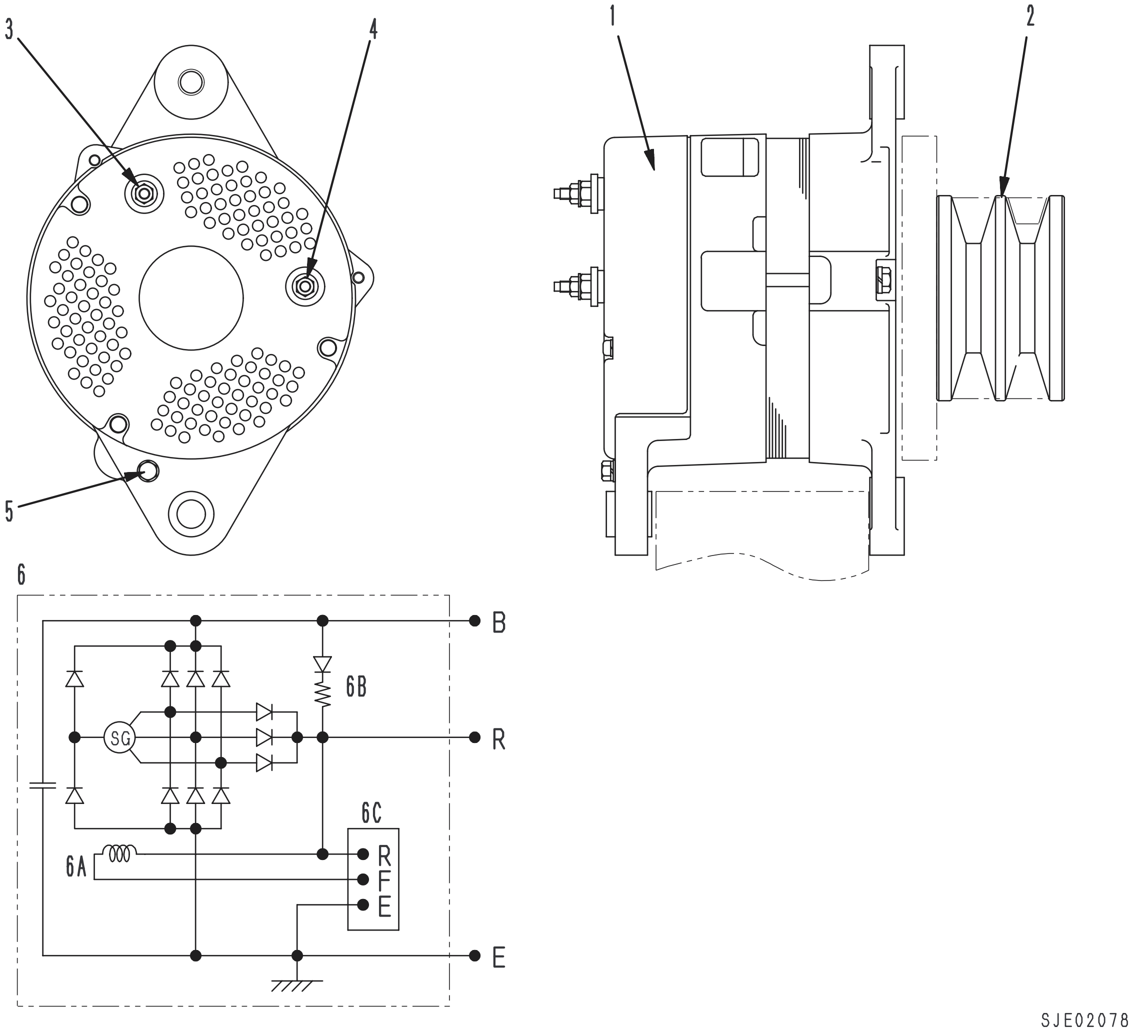
★ The specifications may be different from the following figure, depending on the type of machine.



1. Drive pulley (pulley outside diameter: 182 mm)
2. Alternator pulley (pulley outside diameter: 85 mm)
3. Alternator
4. Alternator mounting bolt
5. Adjustment bolt
6. Locknut
7. V-belt

ALTERNATOR WITH BUILT-IN REGULATOR (OPEN TYPE, 60A)

★ The actual engine may be different because of modifications.

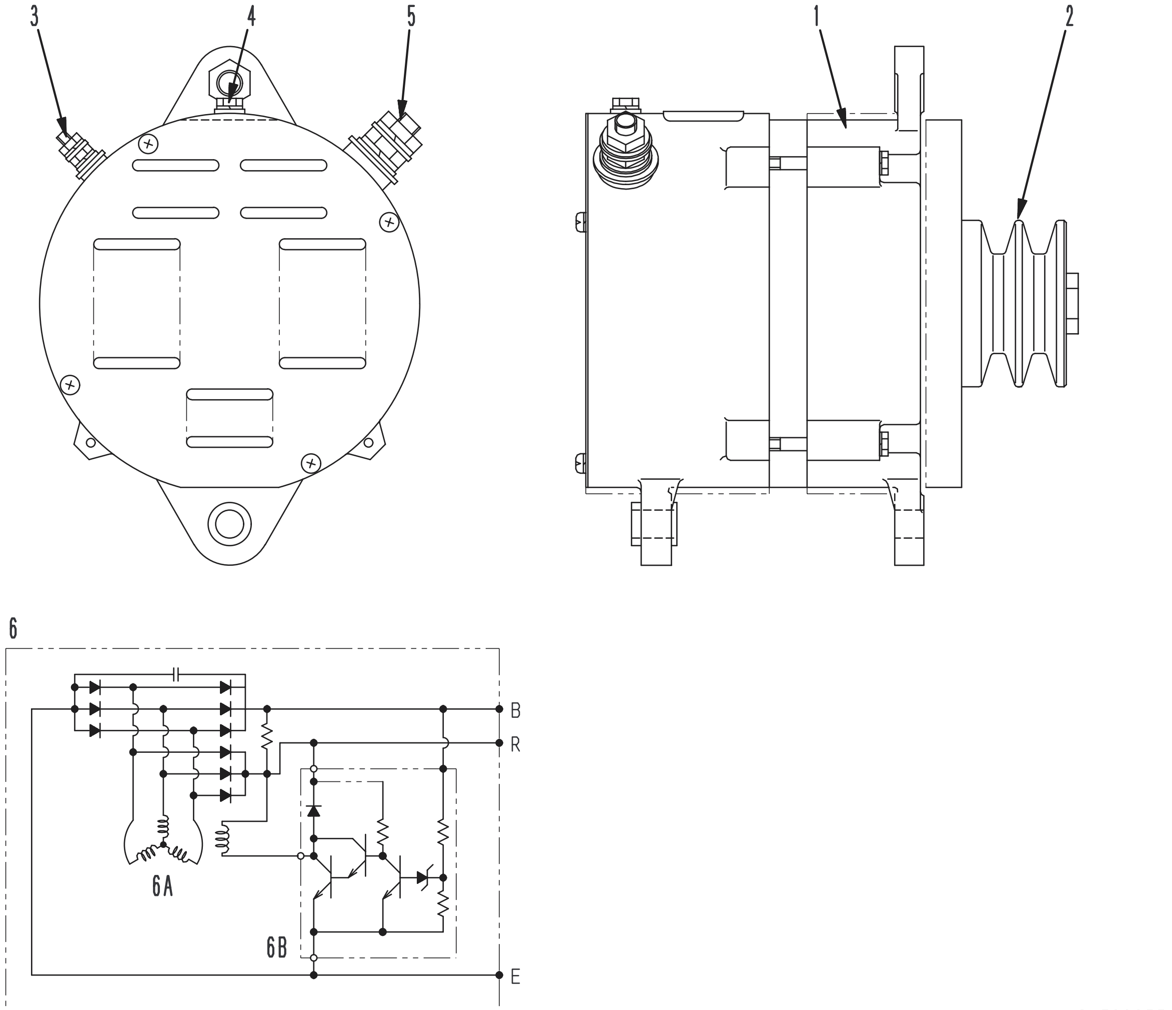


1. Alternator
2. Alternator pulley
3. Terminal B
4. Terminal R
5. Terminal E
6. Internal electric circuit diagram
   - 6A. Field coil
   - 6B. Primary energized resistance
   - 6C. Regulator

Engine	Machine model	Type	Specification	Pulley diameter (mm)	Weight (kg)
SA6D170E-3	D375A-5 (If equipped)	Sawafuji Denki, open type	24V, 60A	85	11

ALTERNATOR WITH BUILT-IN REGULATOR (OPEN TYPE, 75A)

★ The actual engine may be different because of modifications.



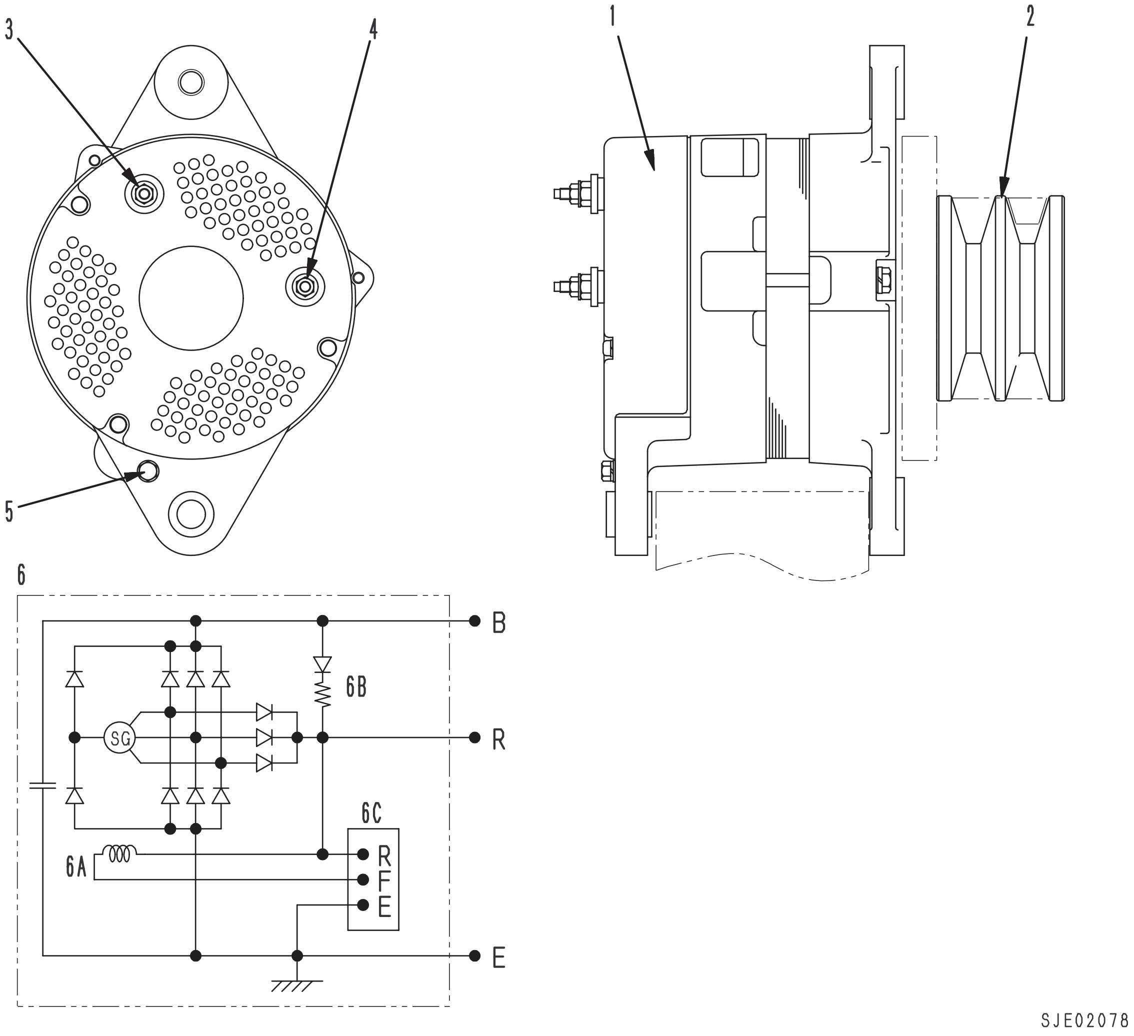
1. Alternator
2. Alternator pulley
3. Terminal B
4. Terminal E
5. Terminal R
6. Internal electric circuit diagram
   6A. Alternator
   6B. Regulator

Unit: mm

Engine	Machine model	Type	Specification	Pulley diameter (mm)	Weight (kg)
SA6D170E-3	D375A-5 (If equipped)	Sawafuji Denki, open type	24V, 75A	85	12.5
SAA6D170E-3	WA600-3 WD600-3	Sawafuji Denki, open type	24V, 75A	85	12.5

ALTERNATOR WITH BUILT-IN REGULATOR (OPEN TYPE, 50)

★ The shape may differ according to the machine model.



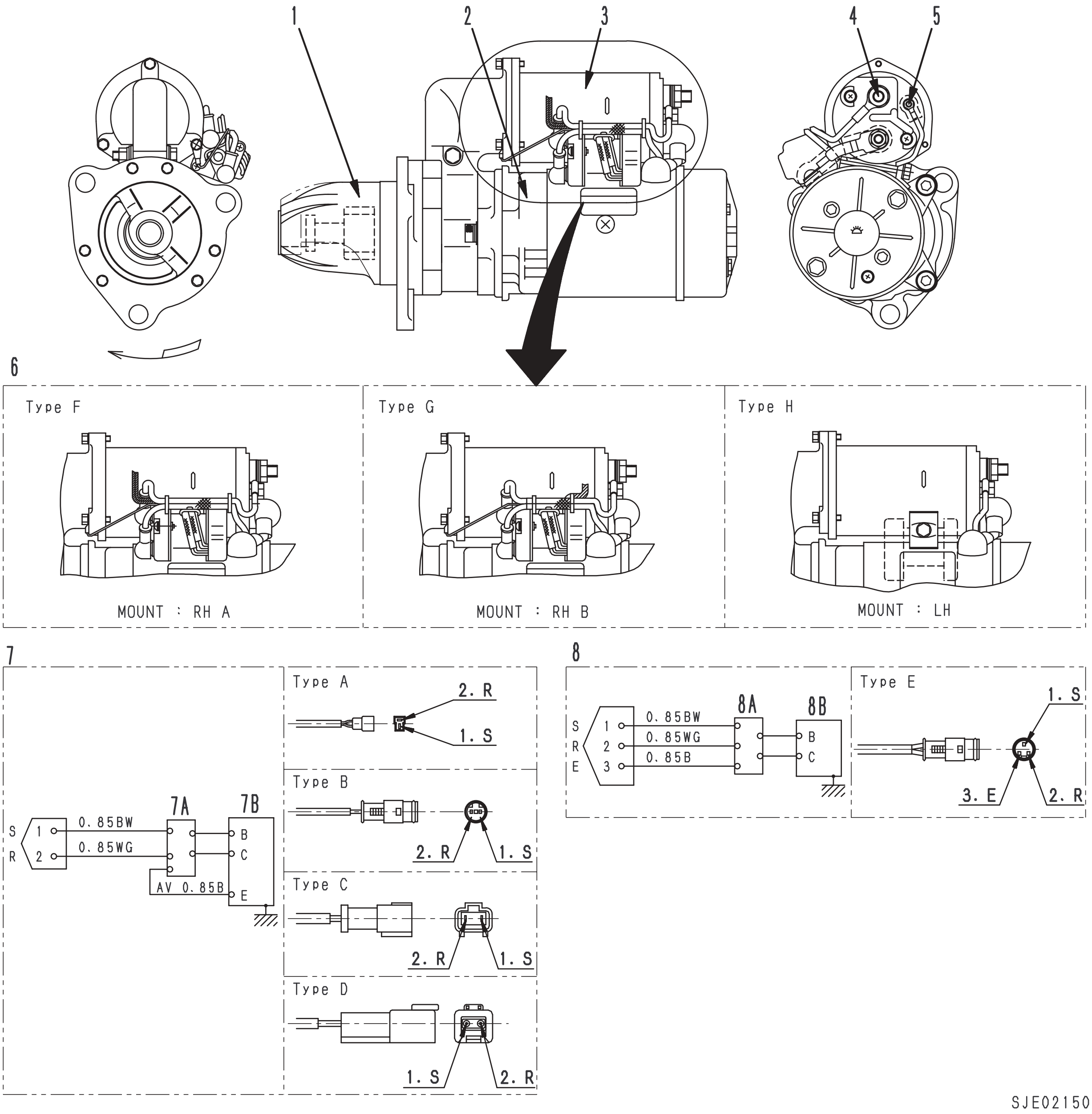
1. Alternator
2. Alternator pulley
3. Terminal B
4. Terminal R
5. Terminal E
6. Internal electric circuit diagram
    6A. Field coil
    6B. Primary energized resistance
    6C. Regulator

Engine	Machine model	Type	Specification	Pulley diameter (mm)	Weight (kg)
SAA6D170E-3	PC1250-7	Nikko Denki Open type (brushless)	24V, 50A	85	11
	HD465-7	Nikko Denki Open type (brushless)	24V, 50A	85	11
	HD605-7	Nikko Denki Open type (brushless)	24V, 50A	85	11

STARTING MOTOR

For 7.5 kW

★ The actual engine may be different because of modifications.



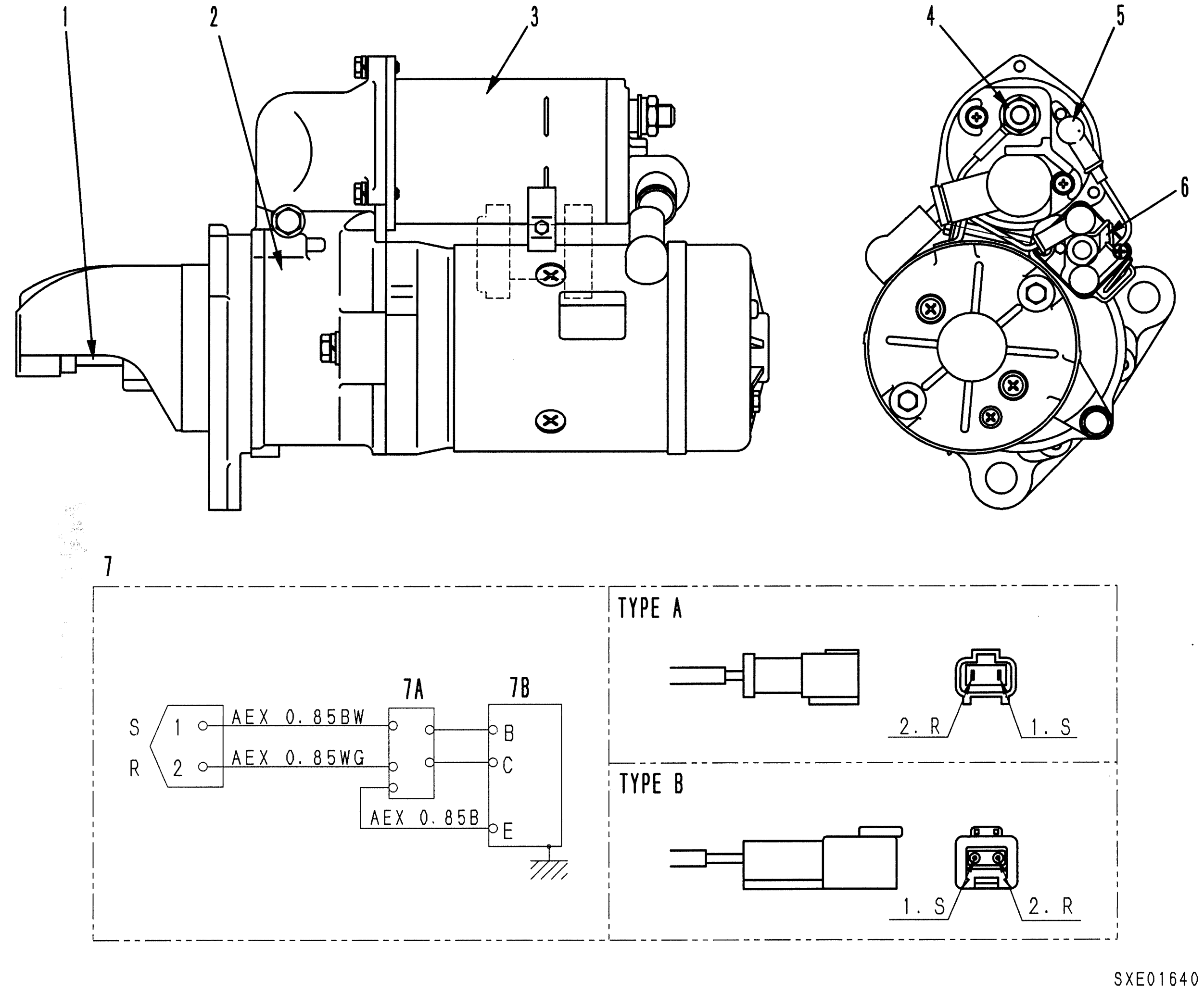
1. Pinion gear
2. Starting motor assembly
3. Magnetic switch
4. Terminal B
5. Terminal C
6. Safety relay
7. External wiring diagram (2-pin connector type)
   - 7A. Safety relay portion
   - 7B. Starting motor portion
8. Extermal wiring diagram (3-pin connector type)
   - 8A. Safety relay portion
   - 8B. Starting motor portion

S. To starting switch terminal C
R. To alternator terminal R
E. To ground

Engine	Machine model	Type	Specification	No. of pinion teeth	Weight (kg)	Safety relay mounting type	Connector type
SA6D170E-3	D375A-5	Nikko Denki (water-proof, oil-proof type)	27V, 7.5kWx2	11	18	G	E
SAA6D170E-3	WA600-3 WD600-3 HD465-7 HD605-7	Nikko Denki (water-proof, oil-proof type)	27V, 7.5kWx2	11	18	G	C

For 11kW

★ The shape may differ according to the machine model.



1. Pinion gear
2. Starting motor assembly
3. Magnetic switch
4. Terminal B
5. Terminal C
6. Safety relay
7. External wiring diagram (2-pin connector type)
   - 7A. Safety relay portion
   - 7B. Starting motor portion

S. To starting switch terminal C
R. To alternator terminal R
E. To ground

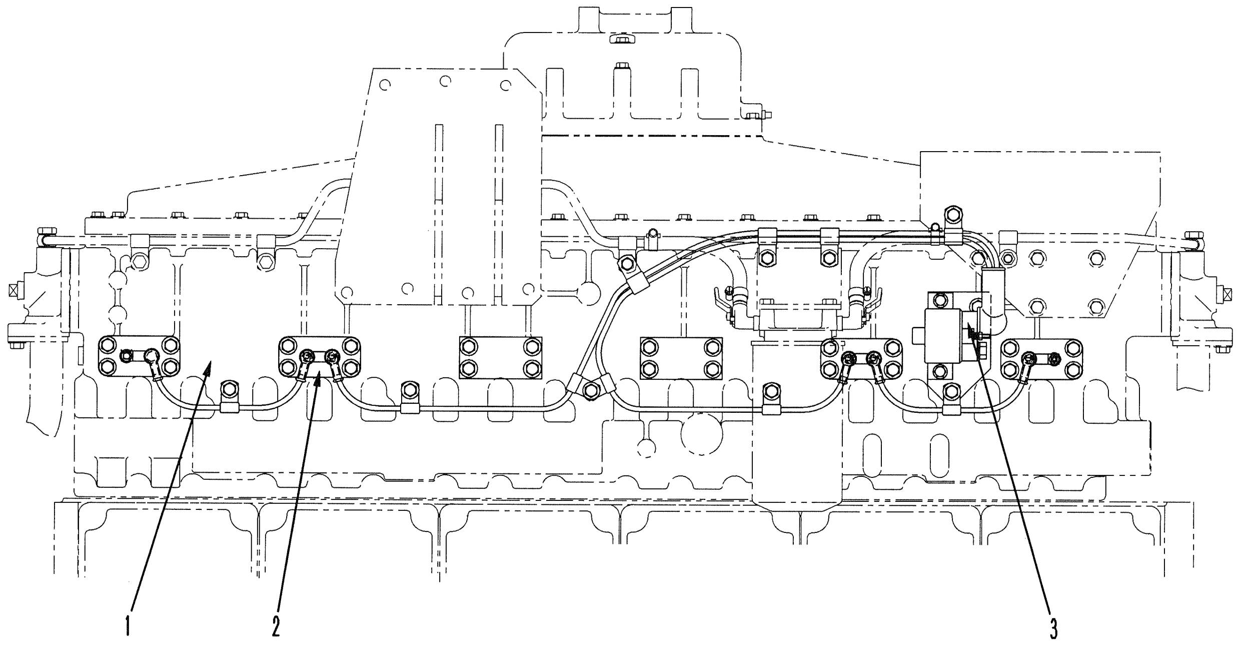
Engine	Machine model	Type	Specifica-tion	No. of pinion teeth	Weight (kg)	Connector type
SAA6D170E-3	PC1250-7	Nikko Denki (water-proof, oil-proof type)	24V, 11kW	11	18	B

STARTING AID

SA6D170E-3

ELECTRICAL HEATER MOUNTING

★ The actual engine may be different because of modifications.



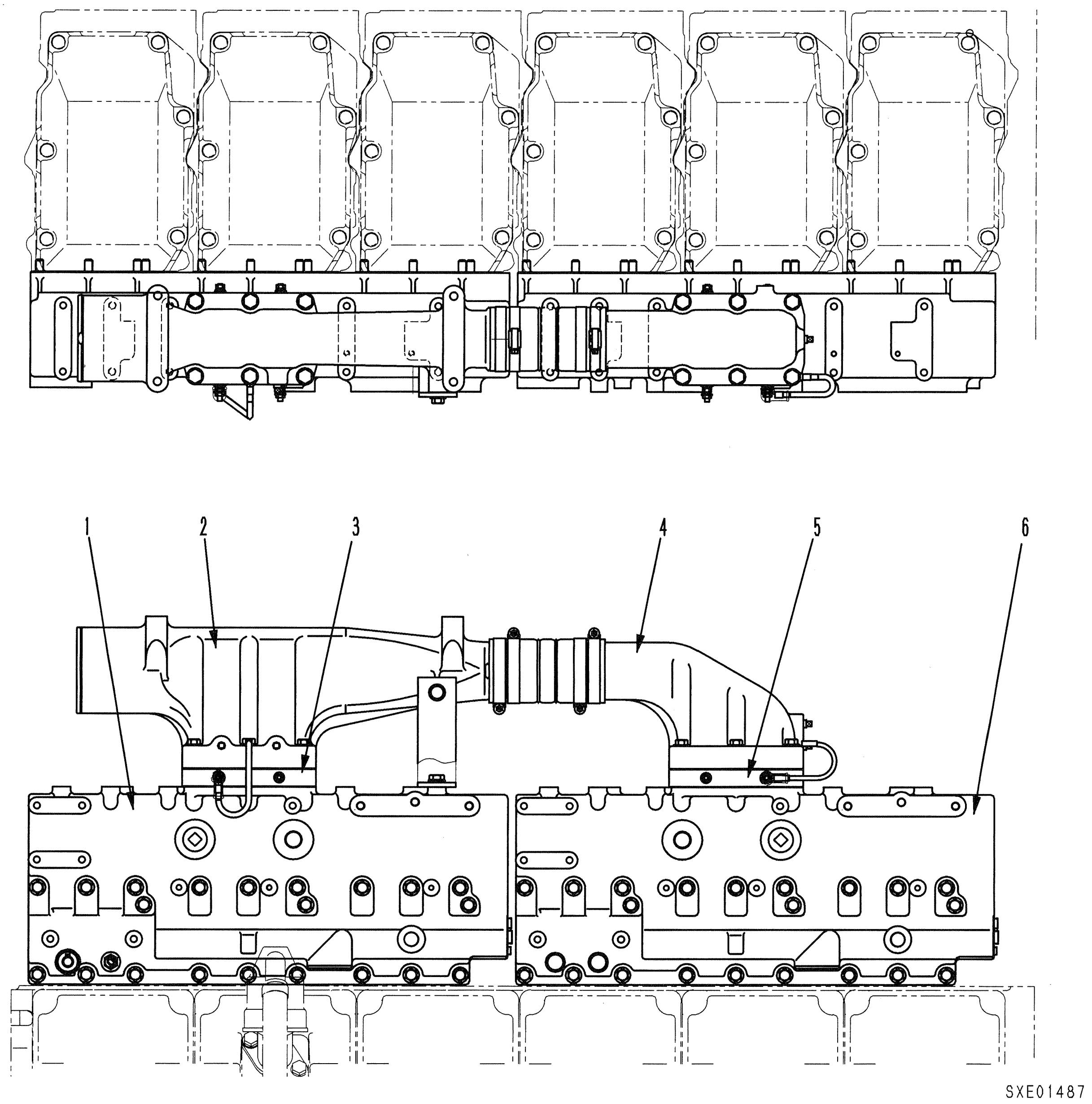
SJE01985

1. Intake manifold (Aftercooler)
2. Coil heater
3. Relay

SAA6D170E-3

ELECTRICAL HEATER MOUNTING

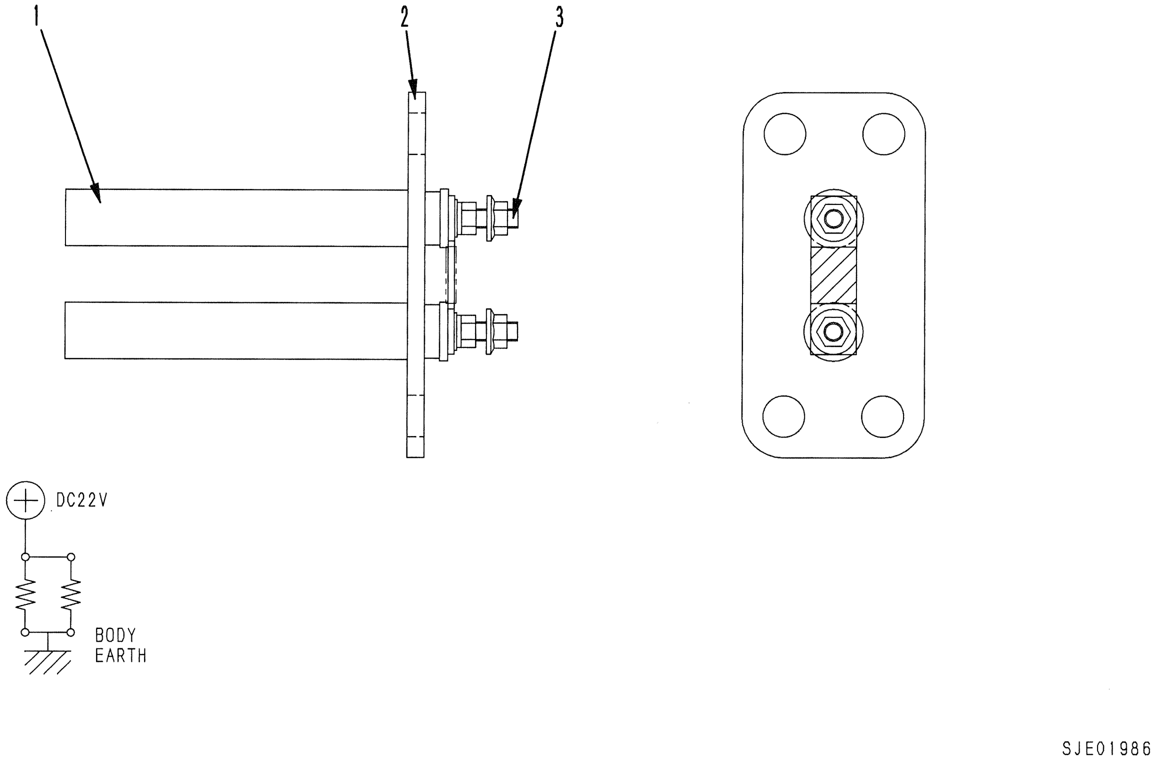
★ The actual engine may be different because of modifications.



1. Intake manifold (front)
2. Connector (front)
3. Electrical intake air heater (front)
4. Connector (rear)
5. Electrical intake air heater (rear)
6. Intake manifold (rear)

ELECTRICAL HEATER (SA6D170E-3)

★ The actual engine may be different because of modifications.



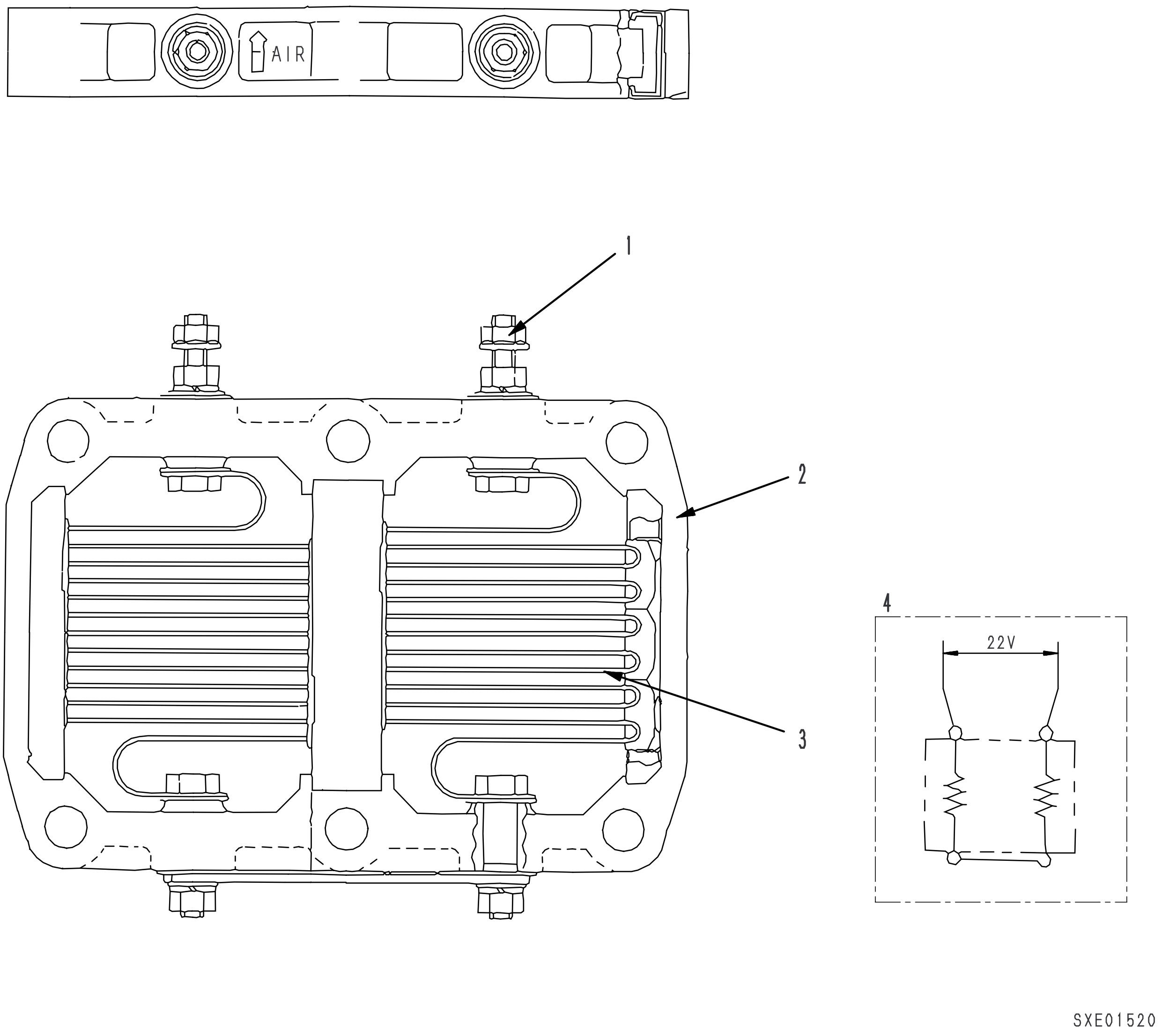
1. Heater assembly
2. Body
3. Terrminal

SPECIFICATIONS

Heater type: Coil heater
Rated voltage: 22V (DC)
Rated current: 36 A

ELECTRICAL HEATER (SAA6D170E-3)

★ The actual engine may be different because of modifications.



1. Terminal
2. Body
3. Heater coil
4. Connection diagram

SPECIFICATIONS

Heater type: Electrical intake air heater
Rated voltage: 22V (DC)
Rated current: 111 A

12 TESTING AND ADJUSTING

STANDARD VALUE TABLE FOR TROUBLESHOOTING

Engine				SAA6D170E-3	
Model				D375A-5	
Cate-gory	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Perfor-mance	Engine speed	High idling Low idling	rpm rpm	2,000±40 750^{+50}_{0}	
	Speed needed to start	0°C (without starting aid) -20°C (with starting aid)	rpm rpm	Min. 130 Min. 100	— —
Intake, exhaust system	Intake resistance	Whole speed range	kPa{mmH$_2$O}	Max. 3 {Max. 300}	7.5 {762}
	Air supply pressure	At rated output	kPa{mmH$_2$O}	Min. 126.7 {Min.950}	113.3 {850}
	Exhaust pressure	At rated output	kPa{mmH$_2$O}	Min. 106.7 {Min. 800}	96.0 {720}
	Exhaust temperature	Whole speed range (20°C)	°C	Min 650	700
	Exhaust gas color	At sudden acceleration (low idling → high idling) At rated output	Bosch index	Max. 4.5 Max. 1.0 Max. 0.5	5.5 2.0 1.5
	Valve clearance	Intake valve Exhaust valve	mm mm	0.32 0.62	— —
Engine proper	Compression pressure	Oil temperature: 40 – 60°C (engine speed: 210 – 250 rpm)	MPa{kg/cm^2}	Min. 2.9 {Min. 30}	2.1 {21}
	Blow-by pressure	At rated output (water temperature: Min. 70°C)	kPa{kg/cm^2}	Max. 3.9 {Max. 400}	7.9 {800}
Lubrication system	Oil pressure (oil temperature: Min. 80°C)	At rated output SAE30 or SAE15W-40	MPa{kg/cm^2}	0.39 – 0.54 {4.0 – 5.5}	0.21 {2.1}
		SAE10W	MPa{kg/cm^2}	0.34 – 0.49 {3.5 – 5.0}	0.18 {1.8}
		At low idling SAE30 or SAE15W-40	MPa{kg/cm^2}	Min. 0.12 {Min. 1.2}	0.07 {0.7}
		SAE10W	MPa{kg/cm^2}	Min. 0.10 {Min. 1.0}	0.7 {0.7}
	Oil temperature	Whole speed range (inside oil pan)	°C	90 – 110	120
	Oil consumption	Ratio to fuel consumption at continuous rated output	%	Max. 0.5	1.0
Cooling system	Radiator pressure valve function	Cracking pressure (differential pressure)	kPa{kg/cm^2}	—	—
	Fan speed	At rated speed	rpm	1,125±35	1,125±35
	Fan belt tension	Deflection when pressed with finger force of approx. 58.8 N {6 kg}	mm	— Auto-tension	—
	Alternator belt tension	Deflection when pressed with finger force of approx. 98 N {10 kg}	mm	10 – 15	

★ This STANDARD VALUE TABLE does not give the standard values for adjusting the engine output.

★ Do not use the values in this table to change the adjusting the ECVA or injector.

SAA6D170E-3					
WA600-3		Generator (50HZ specification)		Generator (60HZ specification)	
Standard value for new machine	Service limit value	Standard value for new machine	Service limit value	Standard value for new machine	Service limit value
2,170±30	2,170±30	Max. 1,575	Max. 1,575	Max. 1,890	Max. 1,890
700±25	700±25	700±25	700±25	700±25	700±25
Min. 130	Min. 130	Min. 130	Min. 130	Min. 130	Min. 130
Min. 100	Min. 100	Min. 100	Min. 100	Min. 100	Min. 100
Max. 3	7.5	Max. 3	7.5	Max. 3	7.5
{Max. 300}	{762}	{Max. 300}	{762}	{Max. 300}	{762}
Min. 126.7	113.3	Min. 126.7	113.3	Min. 126.7	113.3
{Min.950}	{850}	{Min.950}	{850}	{Min.950}	{850}
Min. 106.7	96.0	Min. 106.7	96.0	Min. 106.7	96.0
{Min. 800}	{720}	{Min. 800}	{720}	{Min. 800}	{720}
Min 650	700	Min 650	700	Min 650	700
Max. 4.5	5.5	—	—	—	—
Max. 1.0	2.0	Max. 1.0	2.0	Max. 1.0	2.0
Max. 0.5	1.5	Max. 0.8	2.0	Max. 0.8	2.0
0.32	—	0.32	—	0.32	—
0.62	—	0.62	—	0.62	—
Min. 2.9	2.1	Min. 2.9	2.1	Min. 2.9	2.1
{Min. 30}	{21}	{Min. 30}	{21}	{Min. 30}	{21}
Max. 3.9	7.9	Max. 3.9	7.9	Max. 3.9	7.9
{Max. 400}	{800}	{Max. 400}	{800}	{Max. 400}	{800}
0.39 – 0.54	0.21	0.39 – 0.54	0.21	0.39 – 0.54	0.21
{4.0 – 5.5}	{2.1}	{4.0 – 5.5}	{2.1}	{4.0 – 5.5}	{2.1}
0.34 – 0.49	0.18	0.34 – 0.49	0.18	0.34 – 0.49	0.18
{3.5 – 5.0}	{1.8}	{3.5 – 5.0}	{1.8}	{3.5 – 5.0}	{1.8}
Min. 0.12	0.08	Min. 0.12	0.08	Min. 0.12	0.08
{Min. 1.2}	{0.8}	{Min. 1.2}	{0.8}	{Min. 1.2}	{0.8}
Min. 0.10	0.07	Min. 0.10	0.07	Min. 0.10	0.07
{Min. 1.0}	{0.7}	{Min. 1.0}	{0.7}	{Min. 1.0}	{0.7}
90 – 110	120	90 – 110	120	90 – 110	120
Max. 0.5	1.0	Max. 0.4	1.0	Max. 0.4	1.0
—	—	70{0.7}	—	70{0.7}	—
1,150±35	1,150±35	960±30	960±30	1,150±35	1,150±35
Semi auto-tension	—	3	3	3	3
10 – 15	10 – 15	—	—	—	—

Engine				SAA6D170E-3	
Model				WD600-3	
Category	Item	Measurement conditions	Unit	Standard value for new machine	Service limit value
Performance	Engine speed	High idling Low idling	rpm rpm	2,190±30 700±25	2,190±30 700±25
	Speed needed to start	0°C (without starting aid) -20°C (with starting aid)	rpm rpm	Min. 130 Min. 100	Min. 130 Min. 100
Intake, exhaust system	Intake resistance	Whole speed range	kPa{mmH_2O}	Max. 3 {Max. 300}	7.5 {762}
	Air supply pressure	At rated output	kPa{mmH_2O}	Min. 126.7 {Min.950}	113.3 {850}
	Exhaust pressure	At rated output	kPa{mmH_2O}	Min. 106.7 {Min. 800}	96.0 {720}
	Exhaust temperature	Whole speed range (20°C)	°C	Min 650	700
	Exhaust gas color	At sudden acceleration (low idling → high idling) At rated output	Bosch index	Max. 4.5 Max. 1.0 Max. 0.5	5.5 2.0 1.5
	Valve clearance	Intake valve Exhaust valve	mm mm	0.32 0.62	— —
Engine proper	Compression pressure	Oil temperature: 40 – 60°C (engine speed: 210 – 250 rpm)	MPa{kg/cm^2}	Min. 2.9 {Min. 30}	2.1 {21}
	Blow-by pressure	At rated output (water temperature: Min. 70°C)	kPa{kg/cm^2}	Max. 3.9 {Max. 400}	7.9 {800}
Lubrication system	Oil pressure (oil temperature: Min. 80°C)	At rated output SAE30 or SAE15W-40	MPa{kg/cm^2}	0.39 – 0.54 {4.0 – 5.5}	0.21 {2.1}
		SAE10W	MPa{kg/cm^2}	0.34 – 0.49 {3.5 – 5.0}	0.18 {1.8}
		At low idling SAE30 or SAE15W-40	MPa{kg/cm^2}	Min. 0.12 {Min. 1.2}	0.08 {0.8}
		SAE10W	MPa{kg/cm^2}	Min. 0.10 {Min. 1.0}	0.07 {0.7}
	Oil temperature	Whole speed range (inside oil pan)	°C	90 – 110	120
	Oil consumption	Ratio to fuel consumption at continuous rated output	%	Max. 0.5	1.0
Cooling system	Radiator pressure valve function	Cracking pressure (differential pressure)	kPa{kg/cm^2}	—	—
	Fan speed	At rated speed	rpm	1,080±35	1,080±35
	Fan belt tension	Deflection when pressed with finger force of approx. 58.8 N {6 kg}	mm	Semi auto-tension	—
	Alternator belt tension	Deflection when pressed with finger force of approx. 98 N {10 kg}	mm	10 – 15	10 – 15

★ This STANDARD VALUE TABLE does not give the standard values for adjusting the engine output.

★ Do not use the values in this table to change the adjusting the ECVA or injector.

STANDARD VALUE TABLE FOR ELECTRICAL PARTS

<table>
<tr><th>Component Name</th><th>Connector No.</th><th>Inspection Method</th><th>Criteria</th><th>Measurement conditions</th></tr>
<tr><td>Atmospheric pressure sensor</td><td>AAPS/
AAPR</td><td>Measurement of voltage</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Height</th><th>Atmospheric pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="5">Between (C) – (B)</td><td>0 m</td><td>101.0 kPa {760 mmHg}</td><td>4.42 ± 0.12 V</td></tr>
<tr><td>1,000 m</td><td>89.9 kPa {674 mmHg}</td><td>3.97 ± 0.12 V</td></tr>
<tr><td>2,000 m</td><td>79.5 kPa {596 mmHg}</td><td>3.57 ± 0.12 V</td></tr>
<tr><td>3,000 m</td><td>70.1 kPa {526 mmHg}</td><td>3.21 ± 0.12 V</td></tr>
<tr><td>4,000 m</td><td>61.6 kPa {462 mmHg}</td><td>2.88 ± 0.12 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
<tr><td>Boost pressure sensor</td><td>IMPR</td><td>Measurement of voltage</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Boost pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="2">Between (C) – (B)</td><td>0 kPa {0 mmHg}</td><td>0.5 ± 0.03 V</td></tr>
<tr><td>345 kPa {2,590 mmHg}</td><td>4.5 ± 0.08 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
<tr><td>Intake manifold temperature sensor</td><td>IMTS</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Intake manifold temperature</th><th>Resistance</th></tr>
<tr><td rowspan="5">Between (A) – (B)</td><td>0°C</td><td>30k – 36kΩ</td></tr>
<tr><td>25°C</td><td>9k – 11kΩ</td></tr>
<tr><td>50°C</td><td>3k – 4kΩ</td></tr>
<tr><td>75°C</td><td>1,350 – 1,500Ω</td></tr>
<tr><td>100°C</td><td>600 – 675Ω</td></tr>
<tr><td>Between (A), (B) – ground</td><td>—</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Oil pressure sensor</td><td>OPS</td><td>Measurement of voltage</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Oil pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="2">Between (C) – (B)</td><td>0 kPa {0 mmHg}</td><td>0.5 ± 0.08 V</td></tr>
<tr><td>689 kPa {7.03 mmHg}</td><td>4.5 ± 0.08 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
</table>

<table>
<tr><th>Component Name</th><th>Connector No.</th><th>Inspection Method</th><th>Criteria</th><th>Measurement conditions</th></tr>
<tr><td>Fuel temperature sensor</td><td>FTS/
FLTP</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Intake manifold temperature</th><th>Resistance</th></tr>
<tr><td rowspan="5">Between (A) – (B)</td><td>0°C</td><td>30k – 36kΩ</td></tr>
<tr><td>25°C</td><td>9k – 11kΩ</td></tr>
<tr><td>50°C</td><td>3k – 4kΩ</td></tr>
<tr><td>75°C</td><td>1,350 – 1,500Ω</td></tr>
<tr><td>100°C</td><td>600 – 675Ω</td></tr>
<tr><td>Between (A), (B) – ground</td><td>—</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Water temperature sensor</td><td>CTS/
CLTP</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Water temperature</th><th>Resistance</th></tr>
<tr><td rowspan="5">Between (A) – (B)</td><td>0°C</td><td>30k – 36kΩ</td></tr>
<tr><td>25°C</td><td>9k – 11kΩ</td></tr>
<tr><td>50°C</td><td>3k – 4kΩ</td></tr>
<tr><td>75°C</td><td>1,350 – 1,500Ω</td></tr>
<tr><td>100°C</td><td>600 – 675Ω</td></tr>
<tr><td>Between (A), (B) – ground</td><td>—</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Engine speed sensor</td><td>SP1•SP2</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Resistance</th></tr>
<tr><td>Between (A) – (B)</td><td>1,000 – 2,000 Ω</td></tr>
<tr><td>Between (A), (B) – ground</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Fuel pump pressure sensor</td><td>PMPR</td><td>Measurement of voltage</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Fuel pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="2">Between (C) – (B)</td><td>0 kPa {0 kg/cm^2}</td><td>0.5 ± 0.04 V</td></tr>
<tr><td>2,582 kPa {26.33 kg/cm^2}</td><td>4.5 ± 0.06 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
<tr><td>Fuel rail pressure sensor</td><td>RPR</td><td>Measurement of voltage</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Fuel pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="2">Between (C) – (B)</td><td>103 kPa {10.5 kg/cm^2}</td><td>0.5 ± 0.04 V</td></tr>
<tr><td>1,722 kPa {17.56 kg/cm^2}</td><td>4.5 ± 0.06 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
</table>

<table>
<tr><th>Component Name</th><th>Connector No.</th><th>Inspection Method</th><th>Criteria</th><th>Measurement conditions</th></tr>
<tr><td>Timing rail pressure sensor</td><td>TPR</td><td>Measurement of voltagee</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Fuel pressure</th><th>Voltage</th></tr>
<tr><td>Between (A) – (B)</td><td>—</td><td>4.75 – 5.25 V</td></tr>
<tr><td rowspan="2">Between (C) – (B)</td><td>0 kPa
{0 kg/cm²}</td><td>0.5 ± 0.04 V</td></tr>
<tr><td>2,582 kPa
{26.33 kg/cm²}</td><td>4.5 ± 0.06 V</td></tr>
</table></td><td>1) Connect T-adapter to connector.
2) Turn starting switch ON.</td></tr>
<tr><td>Fuel pump actuator</td><td>FTS/
FLTP</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Resistance</th></tr>
<tr><td>Between (A) – (C)</td><td>7 – 9 Ω</td></tr>
<tr><td>Between (A), (C) – ground</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Fuel shut-off valve</td><td>FSO+•
FSO-</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Resistance</th></tr>
<tr><td>Between FSO+ – FSO-</td><td>23 – 40 Ω</td></tr>
<tr><td>Between FSO+, FSO- – ground</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Fuel rail actuator</td><td>RAIL</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Resistance</th></tr>
<tr><td>Between (A) – (C)</td><td>7 – 9 Ω</td></tr>
<tr><td>Between (A), (C) – ground</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
<tr><td>Timing rail actuator</td><td>TIMG</td><td>Measurement of resistance</td><td>If the condition is within the range shown in the table below, it is normal.
<table>
<tr><th>Pin</th><th>Resistance</th></tr>
<tr><td>Between (A) – (C)</td><td>7 – 9 Ω</td></tr>
<tr><td>Between (A), (C) – ground</td><td>Min. 1 MΩ</td></tr>
</table></td><td>1) Turn starting switch OFF.
2) Disconnect connector.</td></tr>
</table>

TOOLS FOR TESTING, ADJUSTING, AND TROUBLESHOOTING

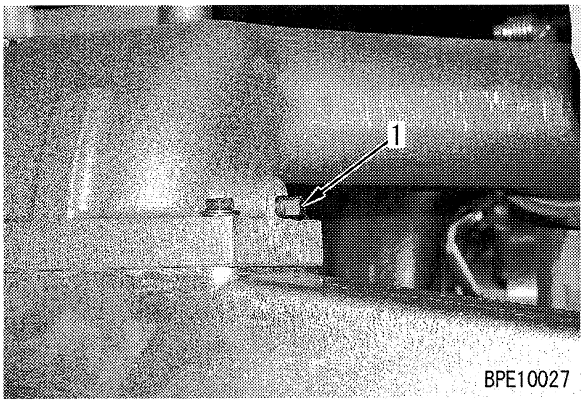
Check, measurement item	Sym-bol		Troubleshooting tool	Part Number	Remarks
Intake resistance	A		Pressure test kit	799-203-2002	- 9.8 – 0 kPa{- 1,000 – 0 mmH$_2$O}
Intake pressure					0 – 200 kPa{0 – 1,500 mmH$_2$O}
Exhaust pressure					0 – 200 kPa{0 – 1,500 mmH$_2$O}
Blow-by pressure					0 – 9.8 kPa{0 – 1,000 mmH$_2$O}
Lubricant pressure					0 – 1.0 MPa{0 – 10 kg/cm^2}
Fuel pressure	B	1	Adapter	795-799-5550	For measuring fuel pressure
		2	Hose	799-101-5150	
		3	Oil pressure gauge	795-799-5560	-0.1 – 0 MPa{-1.0 – 0 kg/cm^2}
		4	Oil pressure gauge	799-101-5140	2.5 MPa{25 kg/cm^2}
Intake temperature, exhaust temperature	C		Digital temperature gauge	799-101-1502	-99.9 – 1,299°C
Oil temperature, water temperature					
Troubleshooting for injector	D		Heat gun (surface temperature gauge)	795-799-5510	For carry out troubleshooting of injector
Exhaust color	E		Handy smoke tester	799-201-9000	
			Smoke meter	Commercially available	
Compression pressure	F	1	Gauge assembly	795-502-1590	6.9 MPa{70kg/cm^2}
		2	Adapter	795-611-1210	For 170-3 engine
			O-ring	6560-11-8410	
			O-ring	6560-11-8310	
			O-ring	6560-11-8210	
			O-ring	6560-11-8510	
			Gasket	6560-11-7310	
Valve clearance	G		Barring device	6162-23-4500	
			Feeler gauge	Commercially available	Intake: 0.32 mm, Exhaust: 0.62 mm
Specific gravity of battery electrolyte	H		Battery, coolant tester	795-501-1001	Temperature: –5 to – 50°C
Coolant freezing temperature				799-202-9001	Specific gravity: 1,100 – 1,300
Pressure valve function	J		Radiator cap tester	799-202-9001	0 – 0.2 MPa{0 – 2 kg/cm^2}
Leakage from cooling system					
Quality of coolant	K		Water tester	799-202-7002	PH, nitrous acid ion density

Check, measurement item	Sym-bol		Troubleshooting tool	Part Number	Remarks
Electrical components, wiring harnesses	L	1	Wiring harness checker	799-601-9000	T-adapter for HD30 and DT, box
		2	Socket (S)	795-799-5520	For speed sensor
		3	Socket (C)	795-799-5530	For intake air temperature sensor For coolant temperature sensor
		4	Socket (A)	795-799-5540	For fuel temperature sensor
		5	Cable	795-799-5540 (cummins No. 3824774)	Atmospheric pressure Fuel rail pressure sensor Timing rail pressure sensor Fuel pump actuator Fuel rail actuator Timing rail actuator Engine oil pressure sensor Boost pressure sensor Fuel pump pressure sensor
		6	Cable	795-799-5470 (cummins No. 3824775)	
		7	Cable	795-799-5480 (cummins No. 3824776)	

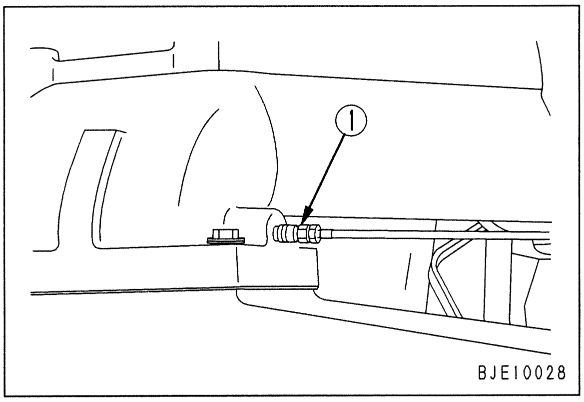
MEASURING INTAKE AIR PRESSURE (BOOST PRESSURE)

⚠ When installing or removing the measuring equipment, be careful not to touch high-temperature parts.

1. Remove air intake pressure measurement plug (1).



2. Install the nipple and hose ① of pressure test kit **A** and connect the hose to pressure test kit **A**.



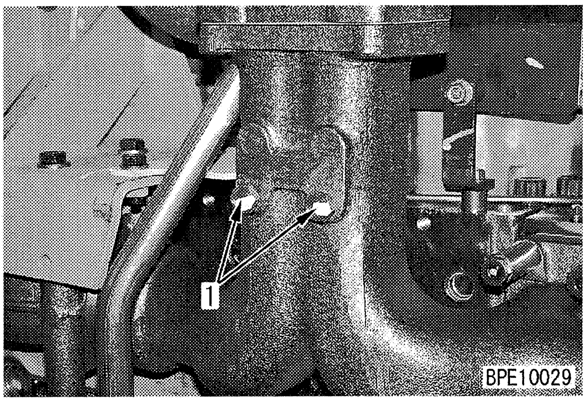
3. Start the engine and measure the intake air pressure (boost pressure) when the engine is running at rated horsepower.
   ★ When measuring with the engine mounted on the machine, measure according to the conditions given in the shop manual for the machine.

4. After completing the measurement, remove the measurement equipment and set to the original condition.

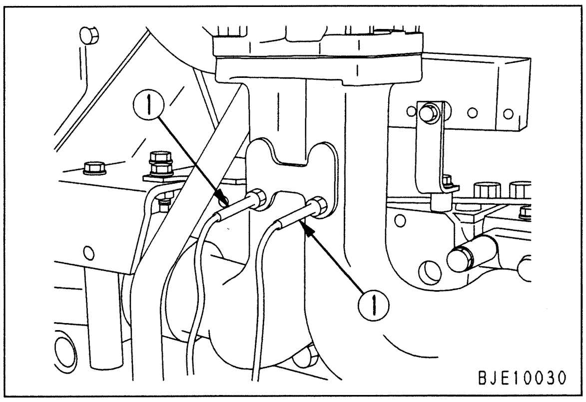
MEASURING EXHAUST TEMPERATURE (OVERALL ENGINE)

⚠ Wait for the exhaust manifold temperature to go down before removing or installing the measuring equipment.

1. Remove exhaust temperature measurement plug (1).
   ★ Since the exhaust manifolds of cylinders No. 1 – 3 and those of cylinders No. 4 – 6 are independent from each other, measure the exhaust temperature at both plugs.



2. Fit the sensor ① of digital temperature gauge **C**, then connect to the digital temperature gauge **B**.



3. Start the engine and measure the intake air pressure (boost pressure) when the engine is running at rated horsepower.
   ★ When measuring with the engine mounted on the machine, measure according to the conditions given in the shop manual for the machine.

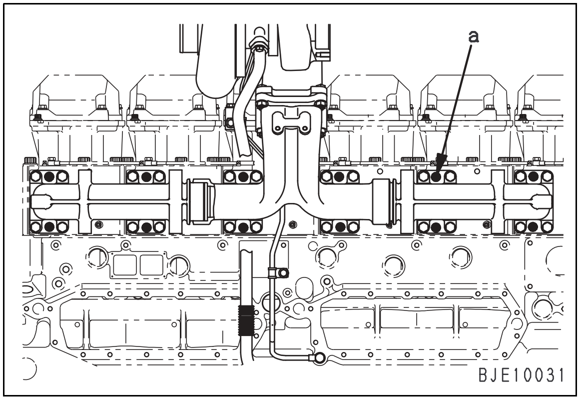
4. After completing the measurement, remove the measurement equipment and set to the original condition.

TROUBLESHOOTING FOR INJECTOR

★ If the torque converter stall speed or the hydraulic pump relief speed is low and bad combustion seems to be caused by defective fuel injection, perform troubleshooting for the injector according to the following procedure.

1. Stop the engine and wait for it to cool down.
   ★ A guideline for judging if the engine has cooled down is that the temperature of the exhaust manifold is less than 20°C above the ambient temperature.

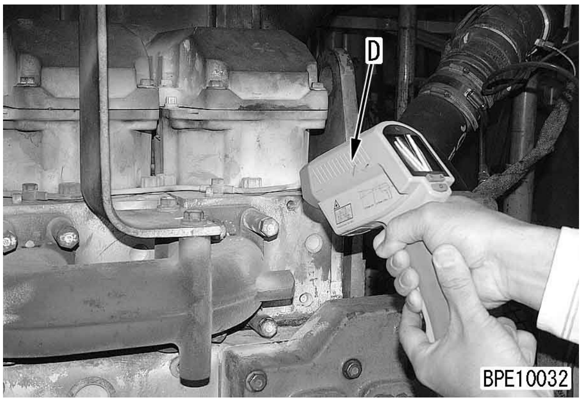
2. Make measurement marks **a** to the exhaust manifold outlets of the all cylinders.
   ★ Make the marks at the same points of the tops or bottoms of the exhaust manifolds of the all cylinders.



3. Using heat gun **D**, measure the temperature at the exhaust manifold outlet port of each cylinder before starting the engine.
   ★ Apply the measurement light (center) of the heat gun to mark **a** of each cylinder to prevent dispersion of the measurement results caused by difference of the measuring points.

4. Run the engine at low idling speed.

5. Using heat gun **D**, measure the temperature at the exhaust manifold outlet port of each cylinder 3 minutes, 6 minutes, 9 minutes, and 12 minutes after starting the engine.
   ★ Apply the measurement light (center) of the heat gun to mark **a** of each cylinder to prevent dispersion of the measurement results caused by difference of the measuring points.



6. Compensate the measured value for each cylinder 12 minutes after starting the engine and judge if there is any cylinder with a problem.
   ★ Compensation value

Unit:°C

Cylinder	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Compensation value	+20	+5	0	0	+5	+20

★ Method of judgement
After compensating, add up the values for the exhaust gas temperature and calculate the average value. Any cylinder that is more than 20ºC lower than the average value can be considered abnormal.

★ Measurement and judgement example 1
No. 2 cylinder is more than 20°C lower than the average value, so judge it as abnormal.

Unit:°C

Cylinder	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Measured value	85	62	79	112	89	82
Compensated value	105	67	79	112	94	102
Average value	93					

★ Measurement and judgement example 2
No. 3 cylinder is more than 20°C lower than the average value, so judge it as abnormal.

Unit:°C

Cylinder	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Measured value	86	96	73	91	94	103
Compensated value	106	101	73	91	99	123
Average value	99					

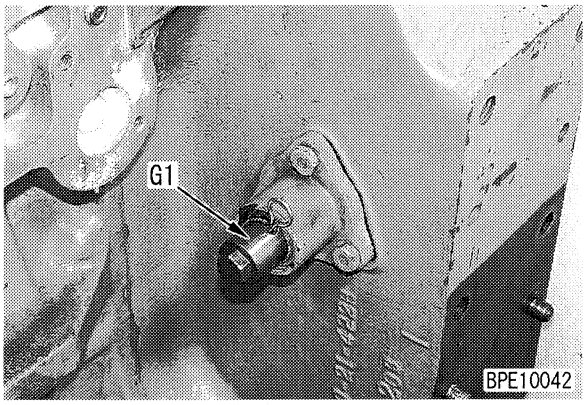
★ Measurement and judgement example 3
No cylinder is more than 20°C lower than the average value, so judge all cylinders as normal.

Unit:°C

Cylinder	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Measured value	70	88	88	93	86	72
Compensated value	90	93	88	93	91	92
Average value	91					

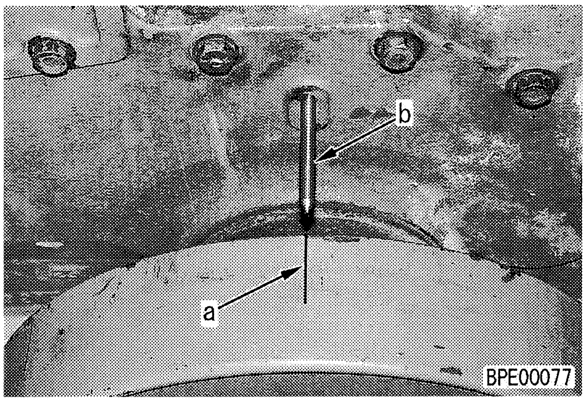
ADJUSTING VALVE CLEARANCE

1. Remove the cover of the flywheel housing, then install barring device **G1**.



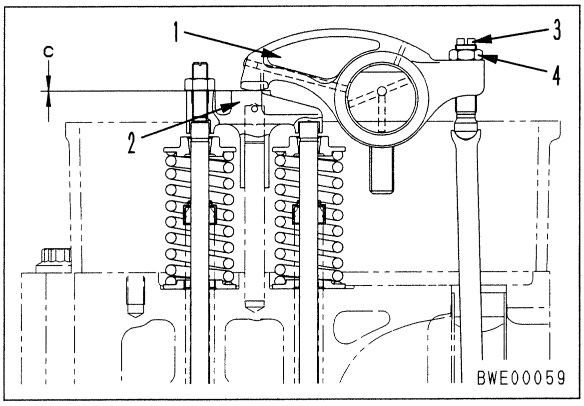
2. Remove the cylinder head cover.

3. Using barring device **G1**, rotate the crankshaft in the normal direction to set No. 1 cylinder at compression top dead center, and align pointer **b** with the [1.6TOP] line **a** on the crankshaft pulley.
   ★ At compression top dead center, the valve rocker arm can be moved by hand by the amount of the valve clearance. If the rocker arm does not move, the crankshaft is not at compression dead center, so rotate it one more turn.



4. To adjust the valve clearance, insert feeler gauge **G2** into clearance c between rocker arm (1) and crosshead (2), and adjust the valve clearance with adjustment screw (3).
   ★ Insert the feeler gauge and turn the adjustment screw until the clearance is a sliding fit.
   ★ Valve clearance
   Intake valve: 0.32 mm
   Exhaust valve: 0.62 mm

5. Tighten locknut (4) to hold adjustment screw (3) in position.
   Locknut :
   57.8 – 77.4 Nm {5.9 – 7.9 kgm}
   ★ After tightening the locknut, check the clearance again.

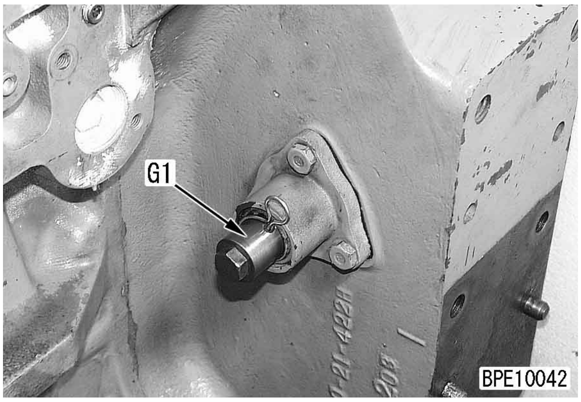


6. Turn the crankshaft 120° each time in the normal direction and repeat the procedure in Steps 3 to 5 to adjust the valves of each cylinder according to the firing order.
   ★ Firing order : 1 – 5 – 3 – 6 – 2 – 4

7. After completing the measurement, set to the original condition.
   Cylinder head cover mounting bolt:
   9.8 ± 1.0 Nm {1 ± 0.1 kgm}

ADJUSTING INJECTOR SET LOAD

1. Remove the cover of the flywheel housing, then install barring device **G1**.



2. Remove the cylinder head cover.

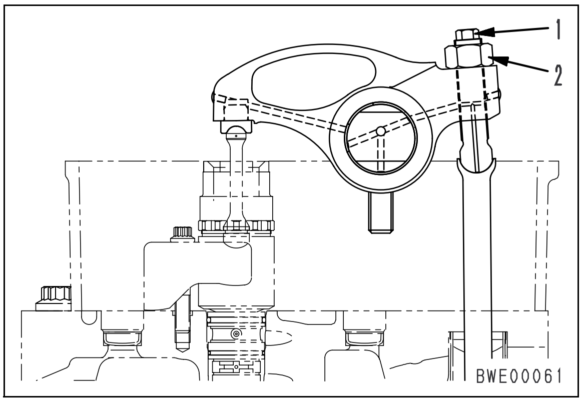
3. Using barring device **G1**, rotate the crankshaft in the normal direction to set No. 1 cylinder at compression top dead center, and align pointer **b** with the [1.6TOP] line **a** on the crankshaft pulley.
   - ★ Watch the movement of the rocker arm and check that the No. 1 cylinder is at the compression stroke. (If the rocker arms for both the intake and exhaust sides move only the amount of the valve clearance, the cylinder is at the compression stroke.)
   - ★ The cylinder where at compression top is different from the cylinder where the injector is being adjusted, so check the table below when carrying out the operation.
   - ★ Cylinder at compression top and cylinder for adjustment of injector:

Compression top	1	5	3	6	2	4
Injector to adjust	2	4	1	5	3	6

4. Loosen lock nut (2), then fully loosen adjustment screw (1) of the injector to be adjusted, then tighten it by hand.
   - ★ Check that the socket at the tip of the rocker arm and the ball of the push rod are both fitted securely into the injector and push rod, respectively.

5. Tighten adjustment screw (1), repeat the loosening operation, then tighten finally.
   Adjustment screw:
   1st time : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}
   2nd time : Loosen fully
   3rd time : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}
   4th time : Loosen fully
   5th time : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}

6. Hold adjustment screw (1) in position, then tighten locknut (2).
   Locknut: **205.8 – 245 Nm {21 – 25 kgm}**



7. After completing the adjustment, set to the original position.
   Cylinder head mounting bolt :
   9.8 ± 1.0 Nm {1 ± 0.1 kgm}

MEASURING COMPRESSION PRESSURE

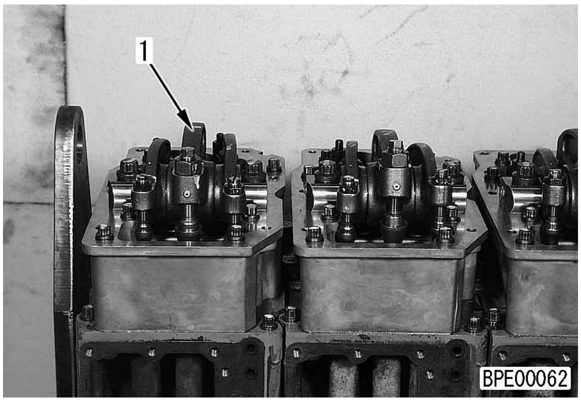
⚠ When measuring the compression pressure, be careful not to touch the exhaust manifold or muffler, or to get caught in rotating parts.

★ Measure the compression pressure with the engine warmed up.
(Oil temperature: 40 – 60°C)

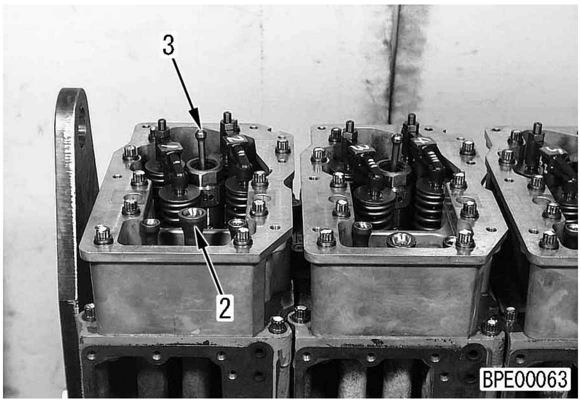
★ Since adapter assemblies **F2** of the all cylinders should be removed and installed simultaneously for efficiency, prepare 6 sets of them.

1. Remove the cylinder head cover.

2. Remove rocker arm assemblies (1) of the all cylinder.



3. Remove injector push rods (2) and injectors (3) of the all cylinders.
   ★ Use a special tool to remove the injector (see DISASSEMBLY AND ASSEMBLY).



4. Install adapter assemblies **F2** to the all cylinders and secure them with the holders.
   ★ Install each adapter assembly with the hole for taking out the injector on the opposite side of the holder.
   ★ Hold the adapter in position with an injector holder.

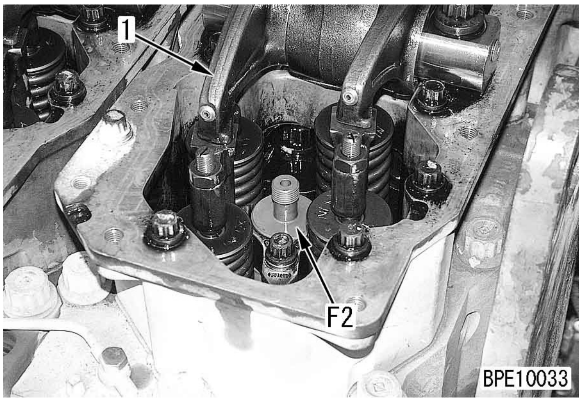
   Mounting bolt:
   24.5 – 34.3 Nm {2.5 – 3.5 kgm}

5. Install rocker arm assembly (1), then adjust the valve clearance.

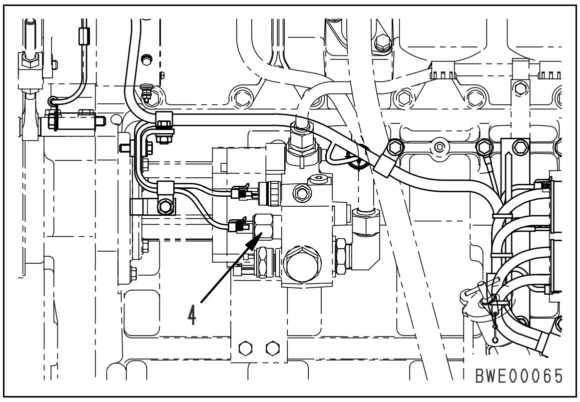
   Mounting bolt thread, seat:
   Engine oil (E030CD)

   Mounting bolt:
   235.2 – 254.8 Nm {24 – 26 kgm}

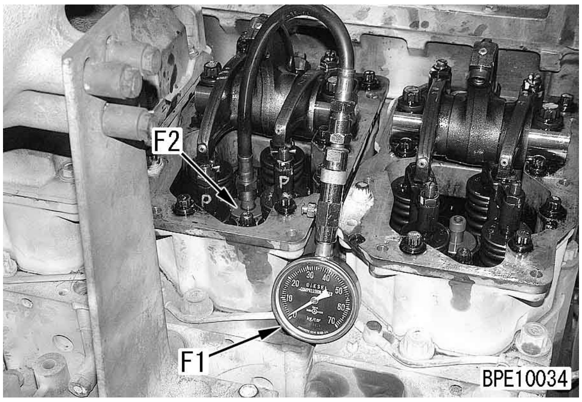
   ★ For details, see ADJUSTING VALVE CLEARANCE.



6. Disconnect 2 large-sized intermediate connectors (4) of the engine.
   ★ This sets so that no fuel is supplied from the fuel pump to the injector.



7. Connect compression gauge **F1** to adapter assembly **F2** of the cylinder to be measured.



8. Measure the compression pressure when the engine is cranked with the starting motor.
   ★ Measure the compression pressure when the gauge indicator is stable.

9. After completing the measurement, remove the measurement equipment and set to the original condition.
   ★ Check the length under the head of the mounting bolt of the injector holder. If it is more than 80 mm, replace the bolt with a new part.

   Injector holder mounting bolt thread, seat:
   Engine oil (E030CD)

   Injector holder mounting bolt:
   1st time : 24.5 – 34.3 Nm (2.5 – 3.5 kgm)
   2nd time : Tighten 90 – 120°

   Rocker arm mounting bolt thread, seat:
   Engine oil (E030CD)

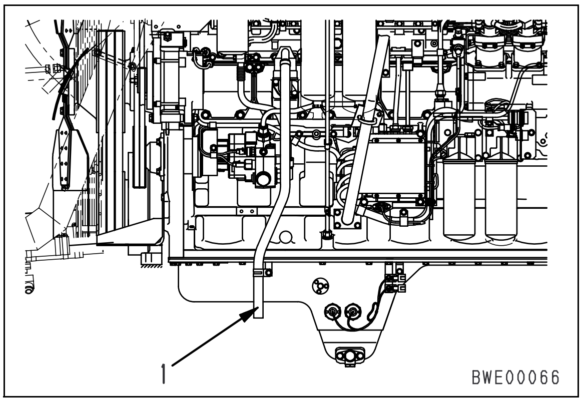
   Rocker arm assembly mounting bolt:
   235.2 – 254.8 Nm {24 – 26 kgm}

   ★ Adjust the valve clearance. For details, see ADJUSTING VALVE CLEARANCE.
   ★ Adjust the injector. For details, see TESTING AND ADJUSTING INJECTOR LIFT.

   Cylinder head cover mounting bolt:
   9.8 ± 1.0 Nm {1.0 ± 0.1 kgm}

MEASURING BLOW-BY PRESSURE

1. Install the nozzle of pressure test kit **A** to blow-by hose (1), then connect to the pressure test kit.

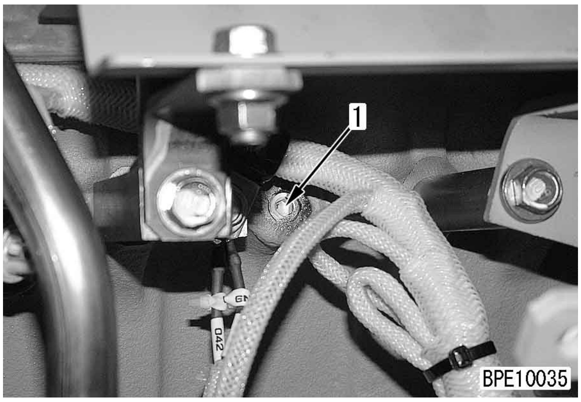


2. Measure the blow-by pressure when the engine is running at rated horsepower.
   ★ When measuring with the engine mounted on the machine, measure using the conditions given in the shop manual for the machine.

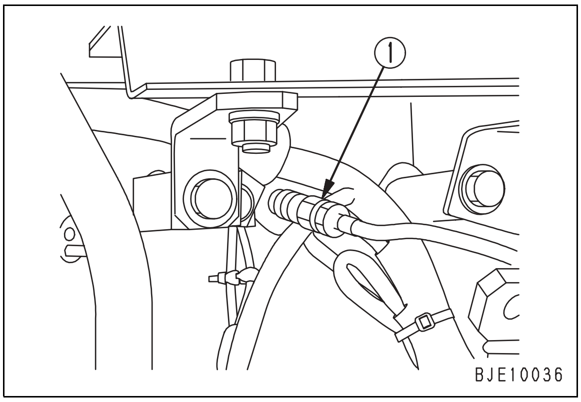
3. After completing the measurement, remove the measuring equipment and set to the original condition.

MEASURING OIL PRESSURE

1. Remove oil pressure measurement plug (1).



2. Install the nipple and hose ① of pressure test kit **A** and connect the hose to pressure test kit **A**.



3. Start the engine and measure the oil pressure when the engine is running at low idling and high idling.

4. After completing the measurement, remove the measuring equipment and set to the original condition.

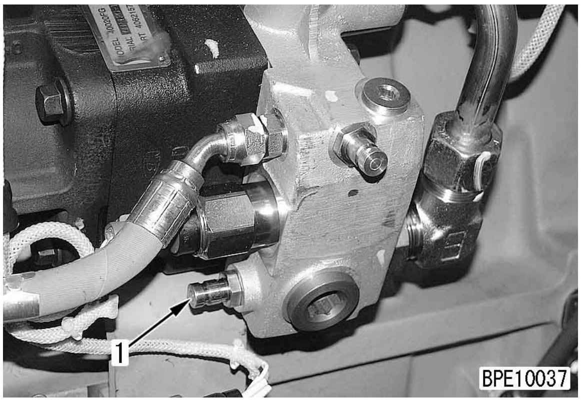
HANDLING EQUIPMENT IN FUEL CIRCUIT

★ Precautions when carrying out inspection and maintenance of fuel system.
With the HPI type fuel injection system, more precise equipment is used than on the conventional fuel injection pump and nozzle. Problems may occur if dirt or dust get in, so always be careful of the following points.
When carrying out inspection or maintenance of the fuel line, pay more attention than usual to prevent dirt or dust from getting in. If there is any dirt stuck to any part, use clean fuel to wash it off completely.

★ Precautions when replacing fuel filter cartridge
Always use a genuine Komatsu part for the fuel filter cartridge.
With the HPI type fuel injection system, more precise equipment is used than on the conventional fuel injection pump and nozzle. Problems may occur if dirt or dust get in, so a special filter with highly efficient filtering performance is used. For this reason, do not use imitation filters. If they are used, there is danger of problems occurring in the fuel line.

MEASURING FUEL CIRCUIT PRESSURE

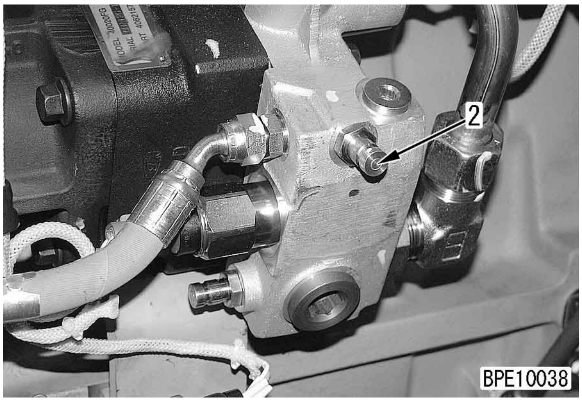
1. **Measuring fuel pump inlet pressure (with oil pressure gauge)**
   1) Connect adapter **B1**, hose **B2**, and oil pressure gauge **B3** to inlet pressure measuring coupler (1).



   2) Start the engine and measure the fuel pump inlet pressure at high idling.
      - ★ Check that the fuel pump inlet pressure is in the following ranges.
      - ★ Fuel pump inlet pressure (Negative pressure):

Engine speed	Fuel pump inlet pressure (kPa{mmHg})	Condition
High idling	Max. –13.6 {Max. –102}	When new filter is used
	Max. –27.1 {Max. –203}	Normal condition

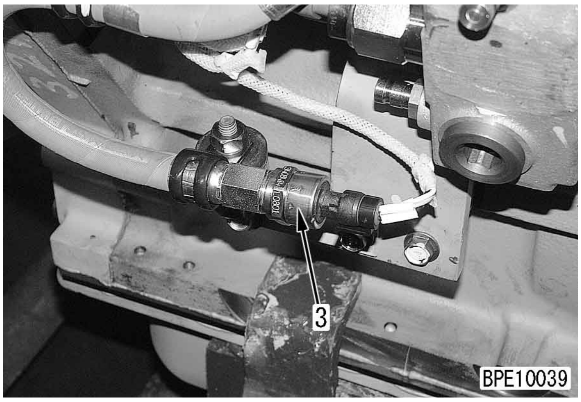
2. **Measuring fuel pump outlet pressure (with oil pressure gauge)**
   1) Connect adapter **B1**, hose **B2**, and pressure gauge **B4** to outlet pressure measuring coupler (2).



   2) Start the engine and measure the fuel pump outlet pressure at each engine speed.
      - ★ Check that the fuel pump outlet pressure is in the following ranges.
      - ★ Fuel pump outlet pressure:

Engine speed (rpm)	Fuel pump outlet pressure (MPa{kg/cm^2})	Sensor voltage (Reference) (V)
600	0.83 ± 0.14 {8.45 ± 1.41}	1.78 ± 0.21
700	0.93 ± 0.14 MPa {9.50 ± 1.41}	1.94 ± 0.21
800	1.03 ± 0.14 MPa {10.53 ± 1.41}	2.10 ± 0.21
900	1.14 ± 0.14 MPa {11.60 ± 1.41}	2.26 ± 0.21
1,000	1.25 ± 0.14 MPa {12.70 ± 1.41}	2.42 ± 0.21
1,100	1.34 ± 0.14 MPa {13.70 ± 1.41}	2.59 ± 0.21
1,200	1.46 ± 0.14 MPa {14.90 ± 1.41}	2.76 ± 0.21

3. **Measuring fuel pump outlet pressure (with sensor)**
   1) Insert cable **N7** in the connector of fuel pump pressure sensor (3).



   2) Start the engine and measure the power source voltage of the fuel pump pressure sensor.
      ★ Check that the power source voltage is within the following range.
      ★ Sensor power source voltage (between (A) and (B)): 4.75 – 5.25 V

   3) Run the engine at each speed and measure the signal voltage of the fuel pump pressure sensor.
      ★ Check that the power source voltage is within the following range.
      ★ Sensor power source voltage (between (C) and (B)):

Engine speed (rpm)	Signal voltage (V)	Fuel pump outlet port pressure (reference) (MPa{kg/cm^2})
600	1.78±0.21	0.83±0.14 {8.45±1.41}
700	1.94±0.21	0.93±0.1 {9.50±1.41}
800	2.10±0.21	1.03±0.14 {10.53±1.41}
900	2.26±0.21	1.14±0.14 {11.60±1.41}
1,000	2.42±0.21	1.25±0.14 {12.70±1.41}
1,100	2.59±0.21	1.34±0.14 {13.70±1.41}
1,200	2.76±0.21	1.46±0.14 {14.90±1.41}

VISUAL INSPECTION OF RETURN FUEL

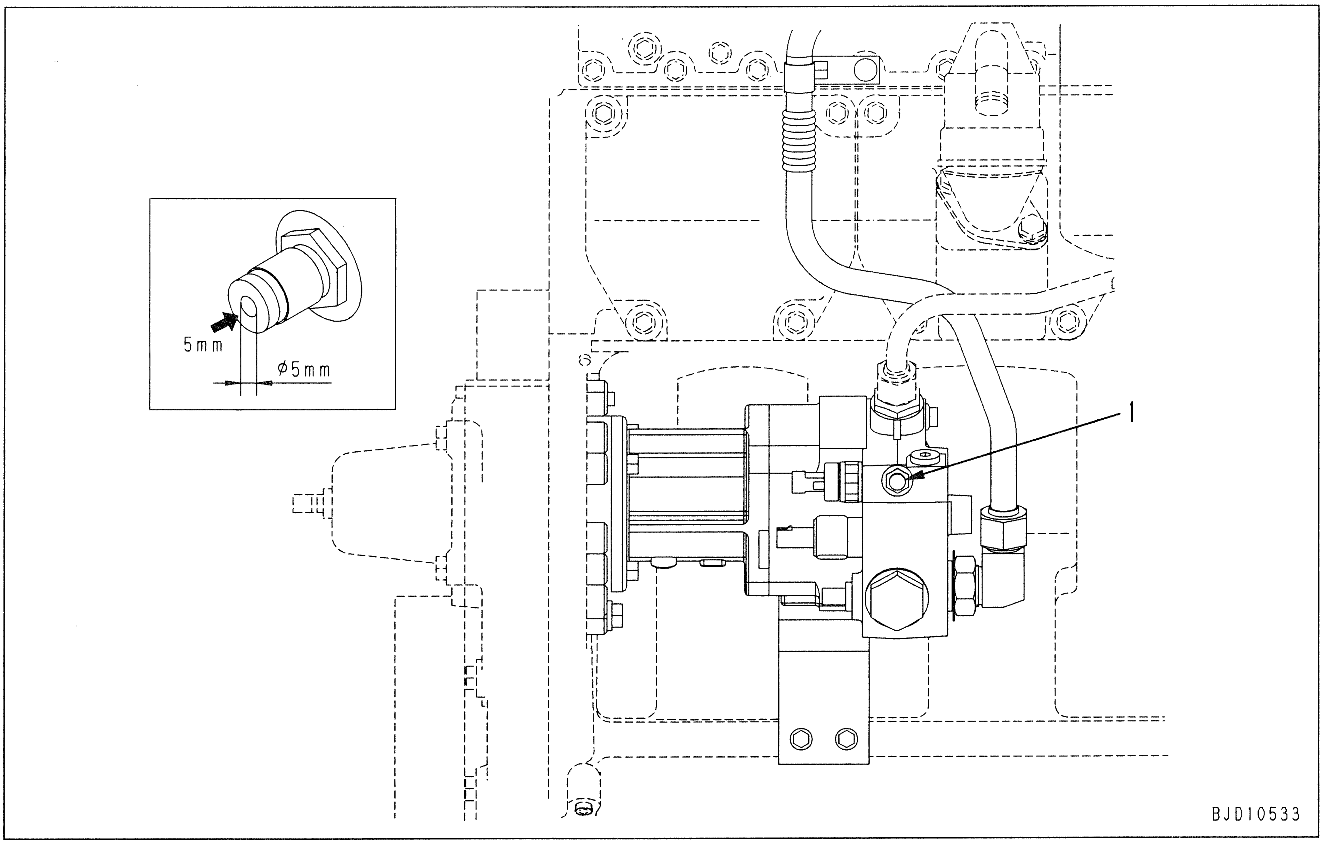
★ The fuel used for control of the timing rail in the fuel circuit and the excessive fuel that is not used injected in the fuel rail are returned from the injector through the fuel cooler to the fuel tank.

★ If the engine does not revolve normally or fuel consumption is abnormally high, inspect the return fuel according to the following procedure.

1. Disconnect the fuel return hose before the fuel tank.
   ★ Plug the hole of the fuel tank.
   ★ Keep the return hose open and receive the fuel with an oil pan, etc.

2. Start the engine and check that the fuel flows out of the fuel return hose smoothly.
   ★ Fuel spillage (Reference)
   At low idling: 4 – 6 ℓ/min
   At high idling: 10 – 12 ℓ/min
   ★ If the fuel spillage is extremely low, check the return piping and fuel cooler for clogging.

BLEEDING AIR FROM FUEL CIRCUIT



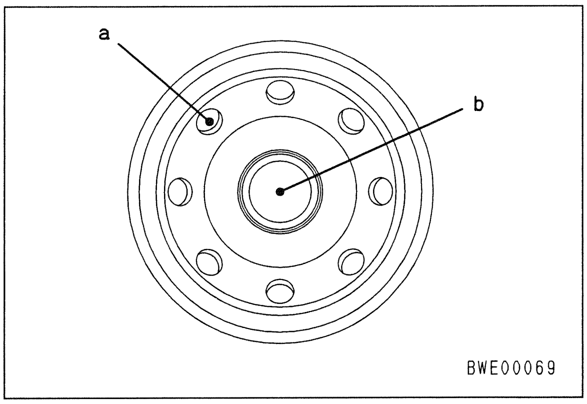
★ Bleed the air from the fuel circuit as follows if the engine does not start or is difficult to start after the following operations.

- When starting the engine for the first time
- When the fuel filter has been replaced
- When the fuel tank has been cleaned
- When fuel has been added after the engine stopped

1. Open the valves at the supply side and return side of the fuel tank.
   ★ At the same time, check that there is ample fuel in the tank.

2. Fill the fuel filter with fuel.
   ★ Do this only after the fuel filter has been replaced.
   ★ If the fuel filter has not been replaced, there is danger of dirt or dust getting in, so do not remove the fuel filter.

★ Fill with fuel through the 8 inlet port portions a of the filter. Portion **b** is the outlet port (clean side) after filtering, so fuel must not be added from here.



★ There is no problem with starting if a small amount of air gets in, so if fuel flows out, the operation is completed.

3. Crank the engine with the starting motor, push air bleed valve (2) at the discharge side, and bleed the air from the discharge circuit.
   ★ There is no problem with starting if a small amount of air gets in, so if fuel flows out, the operation is completed.

4. Start the engine and run at low idling.
   ★ The injector forms an open circuit, so when the engine is operated, the air remaining in the circuit escapes from the injector to the inside of the cylinder or the fuel tank.
   ★ After starting the engine, there is a small amount of variation in the engine speed until the air is completely removed, so continue to run the engine at low idling until the speed becomes stable.

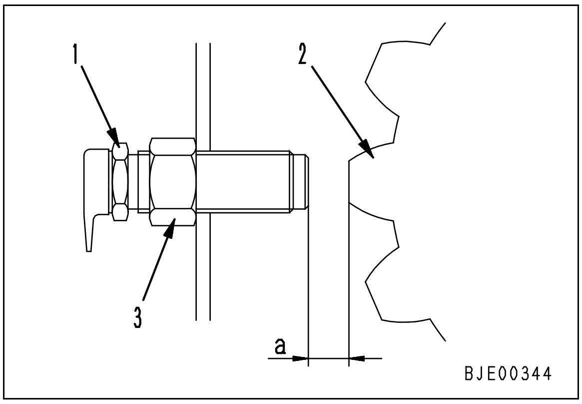
ADJUSTING SPEED SENSOR

★ If the engine speed sensor or flywheel has been removed or replaced, adjust as follows.

1. Screw in sensor (1) until the tip contacts the tip of the tooth of flywheel ring gear (2).
   Thread: Loctite gasket
   (Hydraulic sealant No. 21028)

2. After the sensor contacts the tip of the tooth, turn it back 1/2 – 3/4 turns.
   ★ This makes **a** clearance of 1.25 mm between the tip of the sensor and the tip of the gear tooth.

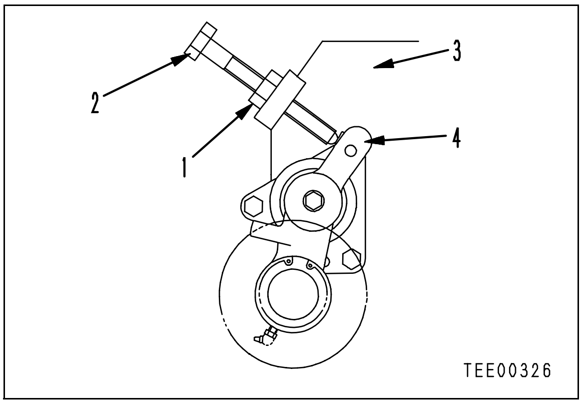
3. Hold sensor (1) in position, then tighten locknut (3).
   kgm Locknut:
   33.9 – 47.5 Nm {3.5 – 4.8 kgm}

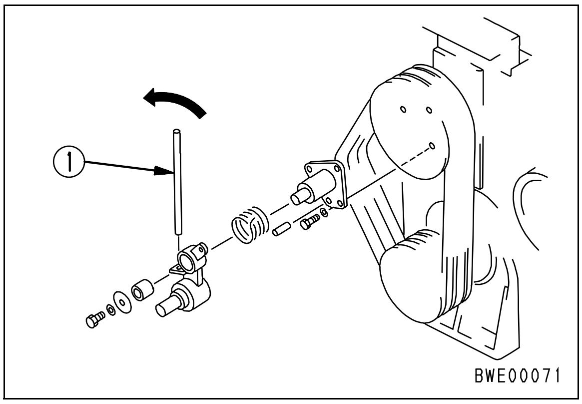


REPLACING AND ADJUSTING FAN BELT

SPRING TYPE

1. **Replacing**
   1) Loosen locknut (1), then return adjustment screw (2) fully until it reaches bracket (3).
   2) Insert a 50 cm bar ① into the hole (∅18 mm) of the tension pulley lever, then pull strongly and hold in position.
   3) Remove the old belt and replace it with a new belt.

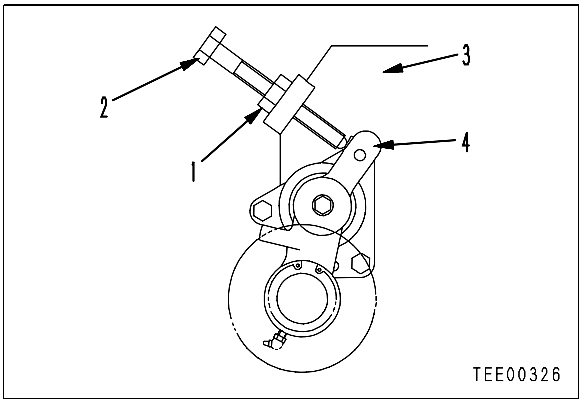




2. **Adjusting**
   1) Screw in until the tip of adjustment screw (2) contacts tension pulley lever (4).
   2) Screw in a further 3 turns, then secure in position with locknut (1).

      kgm Locknut :

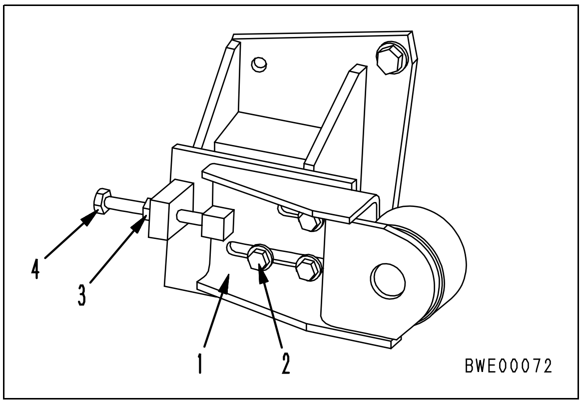
      289 ± 20 Nm {29.5 ± 2 kgm}



★ If the fan belt starts to whine during operation, or if a clearance is formed between the tension pulley lever and the adjustment screw, adjust in the same way as above.

RIGID TYPE

1. **Replacing**
   1) Loosen 3 mounting bolts (2) of tension pulley (1).
   2) Loosen locknut (3), then loosen adjustment screw (4).
   3) Remove the old belt and replace it with a new belt.



2. Adjusting

1) Use adjustment screw (4) to move tension pulley (1) and adjust the tension of the fan belt.

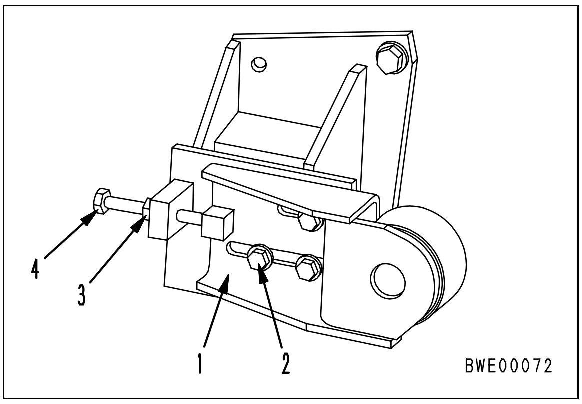
★ Pushing force when adjusting:
Approx. 58.8 N {approx. 6 kg}

★ Deflection between crankshaft pulley and fan pulley: 3 mm

2) Hold adjustment screw (4) in position, then tighten locknut (3).

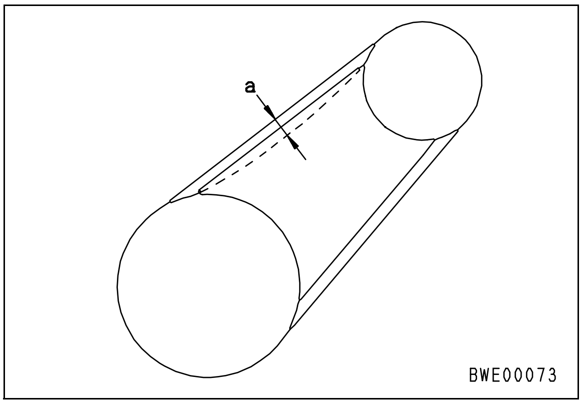
3) Tighten 3 mounting bolts (2) to hold tension pulley (1) in position.

kgm Mounting bolt :
58.8 – 73.5 Nm {6.0 – 7.5 kgm}



TESTING AND ADJUSTING ALTERNATOR BELT TENSION

1. **Inspecting**
   Measure deflection **a** when the belt is pressed with a finger at a point midway between the alternator pulley and drive pulley.
   - ★ Pushing force when measuring:
     Approx. 98 Nm {approx. 10 kg}
   - ★ Deflection: 10 – 15 mm



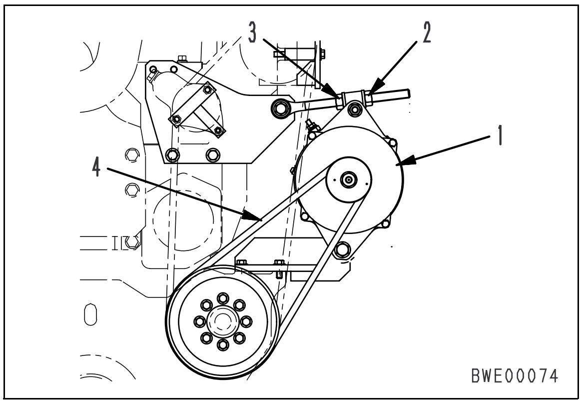
2. **Adjusting**
   - ★ If the deflection is not within the specified range, adjust as follows.

   1) Loosen 2 mounting bolts of alternator (1) and the lock bolt of the bar.
   2) Loosen locknut (2), move alternator (1) with adjustment nut (3), and adjust the tension of belt (4).
      - ★ Deflection: 10 – 15 mm
   3) Tighten locknut (2).

      kgm Locknut :
      147 – 245 Nm {15 – 25 kgm}
   4) Tighten 2 mounting bolts of alternator (1) and the lock bolt of the bar.

      kgm Top mounting bolt :
      65 – 85 Nm {6.7 – 8.7 kgm}

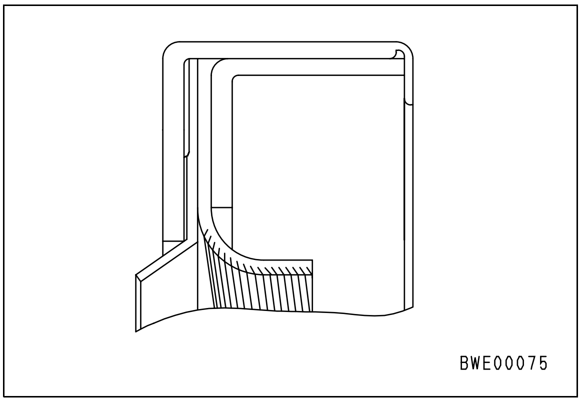
      kgm Bottom mounting bolt :
      108 – 132 Nm {11 – 13.5 kgm}



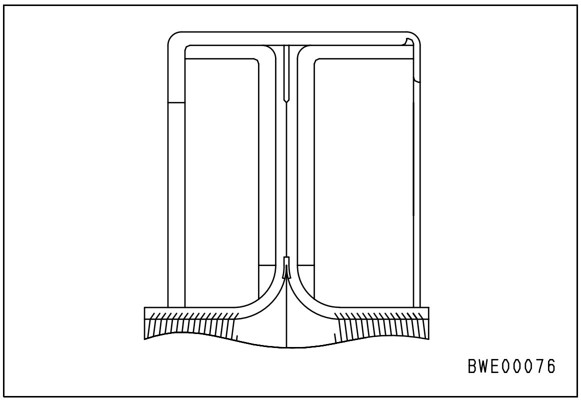
PRECAUTIONS WHEN OPERATING ENGINE AS AN INDIVIDUAL PART

★ When operating the engine as an individual part on a bench, the lubricating conditions are different from the condition when the engine is mounted on the machine, so be careful to use the correct rear oil seal.

1. **When operating as an individual part on a bench**
   When operating the engine as an individual part, use the single-lip type oil seal shown in the diagram below as a test consumable part.
   ★ Seal Part No. 6162-25-4251
   ★ When using a double-lip type, the lubricating conditions are different, so there is danger of damaging the seal lip.

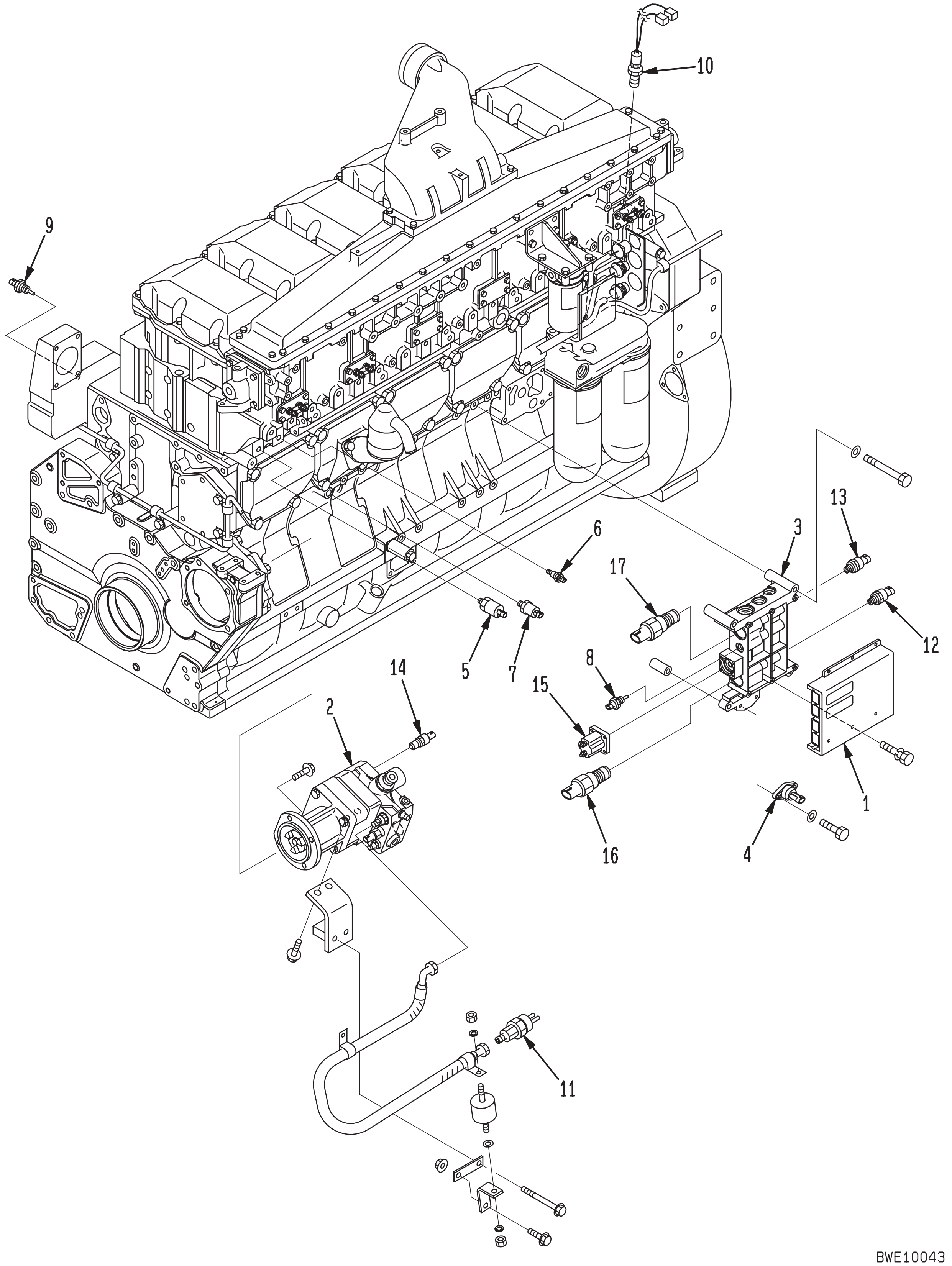


2. **When installing engine on machine after completing operation as an individual part**
   When installing the engine to the machine, replace the oil seal with the double-lip type shown in the diagram below.
   ★ Seal Part No.: 6240-21-4250
   ★ Install the engine, taking care not to damage it.
   ★ For details, see DISASSEMBLY AND ASSEMBLY.



ARRANGEMENT OF CONTROL DEVICES AND ELECTRIC CIRCUIT DIAGRAM FOR HPI

Arrangement of control devices (for troubleshooting)



Controller pump valve

1. Engine controller
   ★ The engine controller of the generator specification is installed on the engine side and that of the construction machine specification is installed on the machine side.
2. Fuel pump assembly
3. Control valve assembly

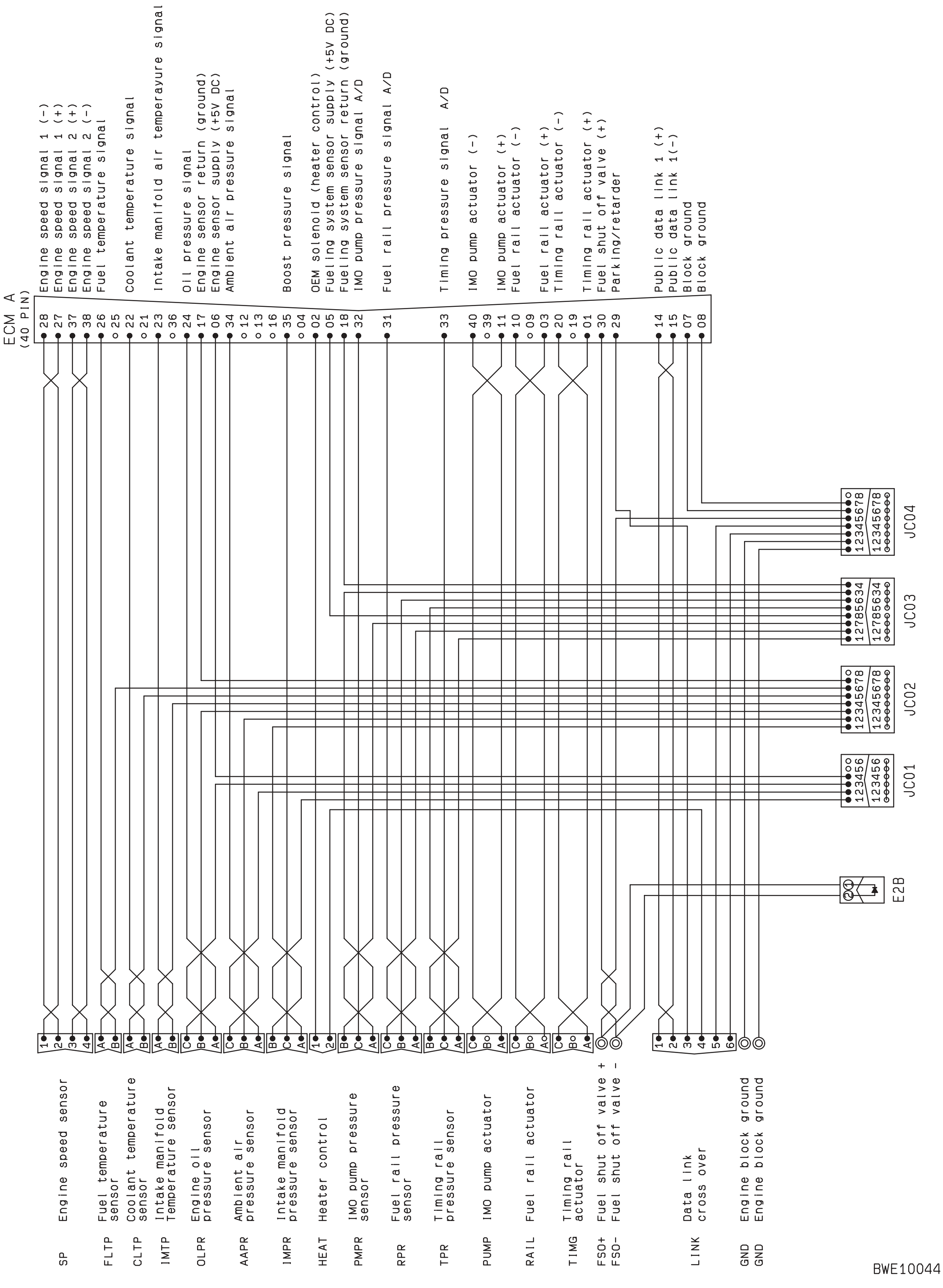
Sensors

4. Atmospheric pressure sensor (AAPR)
5. Boost pressure sensor (IMPR)
6. Intake air temperature sensor (IMTS)
7. Oil pressure sensor (OPS)
8. Fuel temperature sensor (FLTP)
9. Water temperature sensor (CLTP)
10. Speed sensor (SP)
11. Fuel pump pressure sensor (PMPR)
12. Fuel rail pressure sensor (RPR)
13. Timing rail pressure sensor (TPR)

Actuator

14. Fuel pump actuator (FLTP)
15. Fuel shut-off valve (FSO+, FSO–)
16. Fuel rail actuator (RAIL)
17. Timing rail actuator (TIMG)

Electric circuit diagram (For troubles shooting)



BWE10044

RUN-IN STANDARD

Engine	Machine model	Item		Item					
				1	2	3	4	5	6
SA6D170E-3	D375A-5	Operating time	min	3	6	3	3	10	5
		Engine speed	rpm	750	1,000	1,200	1,200	1,500	1,800
		Dynamometer load	N {kg}	0 {0}	310 {32}	690 {70}	1,470 {150}	2,190 {223}	2,890 {295}
		Output	kW {HP}	0 {0}	24 {32}	62 {83}	132 {177}	246 {330}	391 {525}
SAA6D170E-3	WA600-3	Operating time	min	3	6	3	3	10	5
		Engine speed	rpm	700	1,000	1,200	1,200	1,500	2,000
		Dynamometer load	N {kg}	0 {0}	295 {30}	590 {60}	1,180 {120}	1,765 {180}	2,355 {240}
		Output	kW {HP}	0 {0}	22 {30}	53 {71}	106 {142}	199 {266}	353 {473}
	WD600-3	Operating time	min						
		Engine speed	rpm						
		Dynamometer load	N {kg}						
		Output	kW {HP}						
	PC1250-7	Operating time	min	2	8	2	3	5	
		Engine speed	rpm	900	1,000	1,200	1,500	1,800	
		Dynamometer load	N {kg}	0 {0}	680 {69}	1,750 {178}	2,810 {287}	3,600 {367}	
		Output	kW {HP}	0 {0}	51 {68}	164 {211}	316 {424}	485 {651}	
	HD465-7 HD605-7	Operating time	min	2	8	2	3	5	
		Engine speed	rpm	750	1,000	1,200	1,500	2,000	
		Dynamometer load	N {kg}	0 {0}	710 {72}	1,800 {184}	2,870 {293}	3,560 {363}	
		Output	kW {HP}	0 {0}	53 {71}	163 {218}	324 {434}	533 {715}	
	Generator	Operating time	min	3	6	3	3	10	5
		Engine speed	rpm	800	1,000	1,200	1,200	1,500	1,800
		Dynamometer load	N {kg}	0 {0}	540 {55}	1,080 {110}	2,160 {220}	3,240 {330}	4,310 {440}
		Output	kW {HP}	0 {0}	40 {54}	97 {130}	194 {260}	364 {488}	583 {781}
		Operating time	min						
		Engine speed	rpm						
		Dynamometer load	N {kg}						
		Output	kW {HP}						
		Operating time	min						
		Engine speed	rpm						
		Dynamometer load	N {kg}						
		Output	kW {HP}						

PERFORMANCE TEST STANDARDS

Engine	Machine model	Test item	Specification value (net)	Speed (rpm)	Dynamometer load (N{kg})
SA6D170E-3	D375A-5	Rated horsepower	391kW{524HP}/ 1,800 rpm	1,800 ± 5	—
		Max. torque	2,650Nm{270kg}/ 1,300 rpm	1,300 ± 100	—
		High idling speed	2,100 ± 40 rpm	2,100 ± 40	—
		Low idling speed	750^{+50}_{0} rpm	750^{+50}_{0}	—
SAA6D170E-3	WA600-3	Rated horsepower	337kW{452HP}/ 2,000 rpm	2,000 ± 5	—
		Max. torque (net)	2,120Nm{216kg}/ 1,400 rpm	1,400 ± 100	—
		High idling speed	2,170 ± 30 rpm	2,170 ± 30	—
		Low idling speed	700 ± 25 rpm	700 ± 25 rpm	—
	WD600-3	Rated horsepower	370kW/2,000 rpm {497HP/2,000 rpm}	2,000 ± 5	—
		Max. torque (net)	2,391Nm/1,400 rpm {244 kgm/1,400 rpm}	1,400 ± 100	—
		High idling speed	2,190 ± 30 rpm	2,190 ± 30	—
		Low idling speed	700 ± 25 rpm	700 ± 25 rpm	—
	PC1250-7	Rated horsepower	485kW{651HP}/ 1,800 rpm	1,800 ± 5	—
		Max. torque (net)	2,913Nm{297kg}/ 1,300 rpm	1,300 ± 5	—
		High idling speed	2,000 ± 40 rpm	2,000 ± 40 rpm	—
		Low idling speed	900 ± 25 rpm	900 ± 25 rpm	—
	HD465-7 HD605-7	Rated horsepower	533kW{715HP}/ 2,000 rpm	2,000 ± 5	—
		Max. torque (net)	3,207Nm{327kg}/ 1,400 rpm	1,400 ± 5	—
		High idling speed	2,270 ± 50 rpm	2,270 ± 50 rpm	—
		Low idling speed	750 ± 50 rpm	750 ± 50 rpm	—
	Generator (50HZ specification)	Rated horsepower	570kW/1,500 rpm {764 HP/1,500 rpm}	1,500 ± 5	4,920 – 5,220 {502 – 532}
		Max. torque (net)	—	—	—
		High idling speed	Max. 1570 rpm	Max. 1570 rpm	—
		Low idling speed	800 ± 50 rpm	800 ± 50 rpm	—
	Generator (60HZ specification)	Rated horsepower	585kW/1,800 rpm {784 HP/1,800 rpm}	1,800 ± 5	4,210 – 4,450 {429 – 454}
		Max. torque (net)	—	—	—
		High idling speed	Max. 1,890 rpm	Max. 1,890 rpm	—
		Low idling speed	800 ± 50 rpm	800 ± 50 rpm	—

★ This table shows the standard values using the JIS correction factor.

★ The output and torque values in the table are the standard values with the fan removed, so they are different from the specification values.

★ The table shows the standard values with an air cleaner installed, muffler installed, alternator under no load, and air compressor open (when installed).

★ The dynamometer load shows the value for an arm length of 716 mm.

Output (gross) (kW{HP})	Torque (gross) (Nm{kgm})	Fuel consumption (sec/500cc)	Cooling water temperature (°C)	Lubricating oil temperature (°C)	Lubricating oil pressure (kPa{kg/cm^2})	Exhaust temperature (°C)
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
552 – 585 {741 – 787}	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—
566 – 600 {761 – 807}	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	Max. 650
—	—	—	70 – 90	90 – 110	343 – 539 {3.5 – 5.5}	—
—	—	—	70 – 90	80 – 110	Min. 118 {Min. 1.2}	—

★ Use JIS No. 2 diesel oil as the fuel.
★ Use SAE15W-40 or SAE30 as the lubricating oil.

TROUBLESHOOTING OF MECHANICAL SYSTEM (S MODE)

POINTS TO REMEMBER WHEN TROUBLESHOOTING

⚠ Stop the machine in a level place, and check that the safety pins and blocks are securely fitted, and the parking brake is securely applied.

⚠ When carrying out the operation with two or more workers, keep strictly to the agreed signals, and do not allow any unauthorized person to come near.

⚠ If the radiator cap is removed when the engine is still hot, boiling water may spurt out and cause serious burns. Always wait for the water temperature to go down before removing the radiator cap.

⚠ Be extremely careful not to touch any hot parts or to get caught in any rotating parts.

⚠ When disconnecting wiring, always disconnect the negative (–) terminal of the battery first.

⚠ When removing a plug or cap from a location which is under pressure from oil, water, or air, always release the internal pressure first. When installing measuring equipment, be sure to connect it properly.

The aim of troubleshooting is to pinpoint the basic cause of the failure, to carry out repairs swiftly, and to prevent reoccurrence of the failure. When carrying out troubleshooting, and important point is of course to understand the structure and function. However, a short cut to effective troubleshooting is to ask the operator various questions to form some idea of possible causes of the failure that would produce the reported symptoms.

1. **When carrying out troubleshooting, do not hurry to disassemble the components**

   If components are disassembled immediately any failure occurs:
   - Parts that have no connection with the failure or other unnecessary parts will be disassembled
   - It will become impossible to find the cause of the failure.

   It will also cause a waste of man-hours, parts, or oil or grease, and at the same time, will also lose the confidence of the user or operator.

   For this reason, when carrying out troubleshooting, it is necessary to carry out thorough prior investigation and to carry out troubleshooting in accordance with the fixed procedure.

2. **Points to ask user or operator**
   1) Have any other problems occurred apart from the problem that has been reported?
   2) Was there anything strange about the machine before the failure occurred?
   3) Did the failure occur suddenly, or were there problems with the machine condition before this?
   4) Under what conditions did the failure occur?
   5) Had any repairs been carried out before the failure? When were these repairs carried out?
   6) Has the same kind of failure occurred before?

3. **Checks before troubleshooting**
   1) Is there any sign of abnormality in the machine or engine?
   2) Always carry out the Checks before starting.
   3) Carry out other checks if necessary.
   4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
   5) Check for any error display on the controller.

4. **Confirming failure**

   Confirm the extent of the failure yourself, and judge whether to handle it as a real failure or as a problem with the method of operation, etc.

   ★ When operating the machine to re-enact the troubleshooting symptoms, do not carry out any investigation or measurement that may make the problem worse.

5. **Troubleshooting**

   Use the results of the investigation and inspection in Items 2 – 4 to narrow down the causes of failure, then use the troubleshooting matrix or flowchart to locate the position of the failure exactly.

   ★ The basic procedure for troubleshooting is as follows.
   1) Start from the simple points.
   2) Start from the most likely points.
   3) Investigate other related parts or information.

6. **Measures to remove root cause of failure**

   Even if the failure is repaired, if the root cause of the failure is not repaired, the same failure will occur again.

   To prevent this, always investigate why the problem occurred. Then, remove the root cause.

METHOD OF USING TROUBLESHOOTING CHARTS

This troubleshooting chart is divided into three sections: **questions, check items, and troubleshooting**. The questions and check items are used to pinpoint high probability causes that can be located from the failure symptoms or simple inspeciton without using troubleshooting tools.
Next, troubleshooting tools or direct inspection are used to check the high probability causes to make final confirmation.

[Questions]

Sections Ⓐ + Ⓑ in the chart on the right corresponds to the items where answers can be obtained from the user. The items in Ⓑ are items that can be obtained from the user, depending on the user's level.

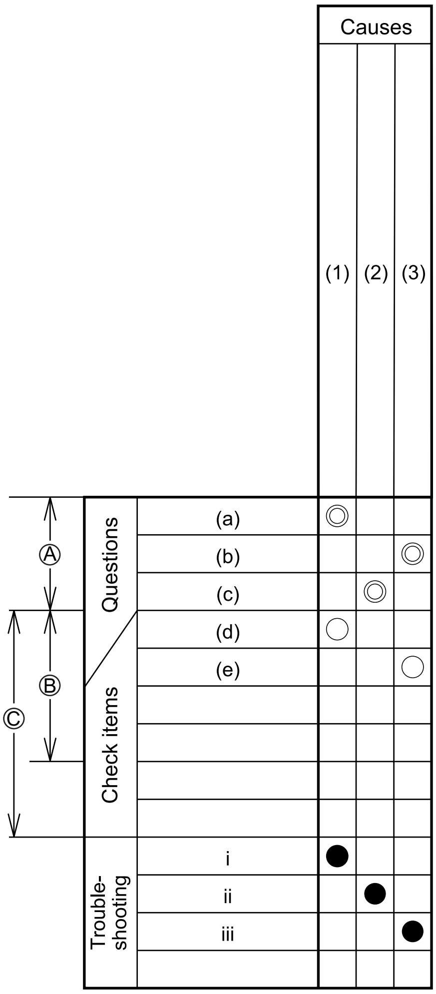
[Check items]

The serviceman carries out simple inspection to narrow down the causes. The items under Ⓒ in the chart on the right correspond to this.
The serviceman narrows down the causes from information Ⓐ that he has obtained from the user and the results of Ⓒ that he has obtained from his own inspection.

[Troubleshooting]

Troubleshooting is carried out in the order of probability, starting with the causes that have been marked as having the highest probability from information gained from **[Questions]** and **[Check items]**.

The basic method of using the troubleshooting chart is as follows.
Items listed for **[Questions]** and **[Check items]** that have a relationship with the Cause items are marked with ○, and of these, causes that have a high probability are marked with ◎.
Check each of the **[Questions]** and **[Check items]** in turn, and marked the ○ or ◎ in the chart for items where the problem appeared. The vertical column (Causes) that has the highest number of points is the most probable cause, so start troubleshooting for that item to make final confirmation of the cause.
As a rule, do not use it when calculating the points for locating the cause, but it can be included if necessary to determine the order for troubleshooting.
Use the △ in the Cause column as reference for **[Degree of use (Operated for long period)]** in the **[Questions]** section as reference.



- **Example of troubleshooting when exhaust gas is black**
  Let us assume that [Clogged air cleaner] is taken to be the cause of black exhaust gas. Three symptoms have causal relationship with this problem: [Exhaust gas slowly became black], [Power slowly became weaker], and [Dust indicator is red].
  If we look from these three symptoms to find the causes, we find that there is a relationship with five causes. Let us explain here the method of using this causal relationship to pinpoint the most probable cause.

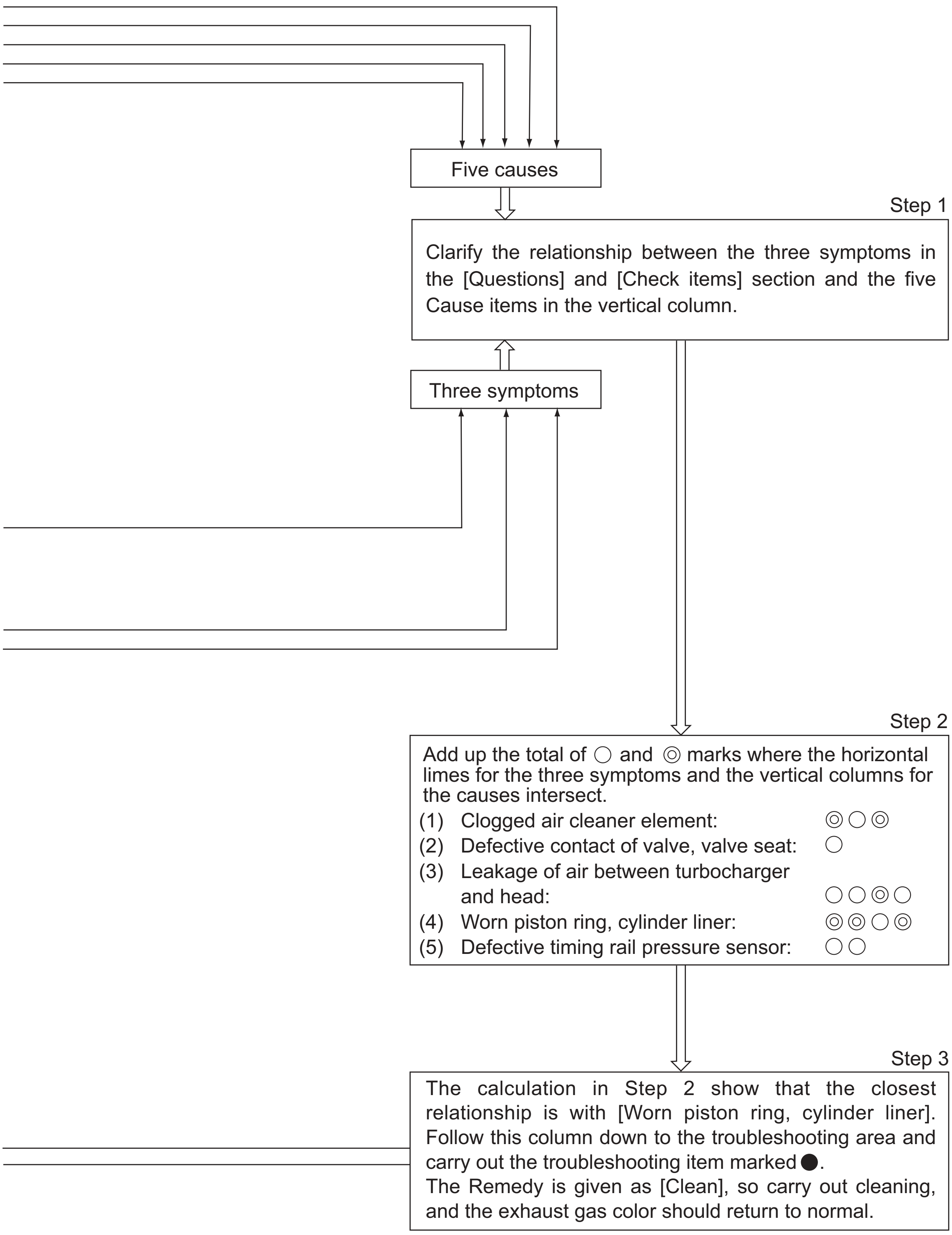
S-7 Exhaust smoke is black (incomplete combustion)

General causes why exhaust smoke is black

- Insufficient intake of air
- Defective condition of fuel injection
- Excessive injection of fuel

Legend
○ : Possible causes (judging from Questions and Check items)
◎ : Most probable causes (judging from Questions and Check items)
△ : Possible causes due to length of use (used for a long period)
● : Items to confirm the cause.

			Causes											
			Clogged air cleaner element	Seized turbocharger, interference	Defective contact of valve and valve seat	Improper adjustment of valve clearance	Leakage of air between turbocharger and cylinder head	Crushed, clogged muffler	Worn piston ring, cylinder liner	Defective fuel pump	Defective injector	Cut, worn injector O-ring	Failure timing rail pressure sensor	Defective timing rail actuator (Marked ★)
Questions	Confirm recent repair history													
	Degree of use of machine	Operated for long period	△						△					
	Color of exhaust gas	Suddenly became black		◎							◎	○	○	○
		Gradually became black	◎				○						○	○
		Blue under light load							◎	○		○	○	○
	Non-specified fuel is being used													
	Engine oil must be added more frequently								◎					
	Power was lost	Suddenly		◎				○			◎			
		Gradually	○		○		○		○					
Check items	Dust indicator is red		◎											
	Muffler is crushed							◎						
	Leakage of air between turbocharger and head, loose clamp						◎							
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low										◎			
	Noise of interference is heard from around turbocharger			◎										
	Clanging sound is heard from around cylinder head					◎								
	Exhaust noise is abnormal			○				◎						
	Engine pickup is poor and combustion is irregular			○		○	○	○		○	○	○		
	Blow-by gas is excessive								◎					
Troubleshooting	Inspect air cleaner directly		●											
	When turbocharger is rotated by hand, it is found to be heavy			●										
	When compression pressure is measured, it is found to be low				●				●					
	Inspect valve clearance directly					●								
	When muffler is removed, exhaust sound improves							●						
	Inspect between turbocharger and cylinder head directly						●							
	When pressure at outlet port of fuel pump is measured, it is found to be low									●		●		
	When temperature of injector of each cylinder is measured, there are some cylinders that are low										●			
	Abnormality in timing rail pressure sensor system is indicated (※1)									●		●	●	
	Inspect sensor directly (Output voltage)												●	
	Inspect actuator directly (Resistance and filter for clogging)													●
		Remedy	Clean	Replace	Replace	Adjust	Correct	Replace	Replace	Replace	Replace	Replace	Replace	Replace



Step 1

Clarify the relationship between the three symptoms in the [Questions] and [Check items] section and the five Cause items in the vertical column.

Step 2

Add up the total of ○ and ◎ marks where the horizontal limes for the three symptoms and the vertical columns for the causes intersect.

(1) Clogged air cleaner element: ◎ ○ ◎
(2) Defective contact of valve, valve seat: ○
(3) Leakage of air between turbocharger and head: ○ ○ ◎ ○
(4) Worn piston ring, cylinder liner: ◎ ◎ ○ ◎
(5) Defective timing rail pressure sensor: ○ ○

Step 3

The calculation in Step 2 show that the closest relationship is with [Worn piston ring, cylinder liner]. Follow this column down to the troubleshooting area and carry out the troubleshooting item marked ●.
The Remedy is given as [Clean], so carry out cleaning, and the exhaust gas color should return to normal.

S-1 Starting performance is poor (starting always takes time)

General causes why starting performance is poor
- Defective electrical system
- Insufficient supply of fuel
- Insufficient intake of air
- Improper selection of fuel
- Defective HPI sensor
- Defective HPI actuator

			Causes															
			Clogged air cleaner element	Defective contact of valve, valve seat	Worn piston ring, cylinder liner	Clogged fuel tank cap	Clogged fuel filter, strainer	Loose piping, fuel filter, entry of air	Defective fuel pump	Defective shut-off valve	Clogged timing rail actuator screen	Defective injector	Defective injector check ball	Cut, worn injector O-ring	Defective or deteriorated battery	Defective preheating circuit (when starting in low temperatures)	Defective alternator	Defective alternator regulator
Questions	Confirm recent repair history																	
	Degree of use of machine	Operated for long period	△				△									△		
	Starting performance became worse gradually		○	◎	◎		○											
	Engine starts easily when warm										◎					◎	◎	
	Non-specified fuel is being used						○				○	○						
	Replacement of filters has not been carried out according to Operation Manual		◎				◎					○						
	Engine oil must be added more frequently				◎													
	Charge caution lamp lights up																◎	◎
	When preheating, preheating indicator lamp does not light up															◎		
Check items	Dust indicator is red		◎															
	Air breather hole in fuel tank cap is clogged					◎												
	Starting motor cranks engine slowly														◎			
	When engine is cranked with starting motor,	Little fuel comes out even when injection pump sleeve nut is loosened					◎											
		Little fuel comes out even when fuel filter air bleed plug is loosened				◎		◎										
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low											◎						
	Engine does not pick up smoothly, and combustion is irregular			○	○							◎						
	There is hunting from engine (rotation is irregular)						○	○	○			○	○	○				
	Blow-by gas is excessive				◎													
	Difficult to stop engine									◎			◎					
Troubleshooting	Inspect air cleaner element directly		●															
	When compression pressure is measured, it is found to be low			●	●													
	Inspect fuel filter, strainer directly						●											
	When negative pressure at inlet port of fuel pump is measured, it is found to be high						●											
	When pressure at outlet port of fuel pump is measured, it is found to vary							●										
	When pressure at outlet port of fuel pump is measured, it is found to be low								●					●				
	Inspect fuel pump directly								●									
	Inspect fuel shut-off valve directly									●								
	Inspect timing rail actuator screen directly										●							
	When temperature of exhaust gas of each cylinder is measured, there are some cylinders that are low											●		●				
	Inspect injector directly											●	●	●				
	When specific gravity of electrolyte and voltage of battery are measured, one of them is low														●			
	When starting switch is turned to HEAT, heater mount does not become warm															●		
	Is voltage 26 - 30V between alternator terminal B and terminal E with engine at low idling?	Yes																●
		No															●	
	Inspect sensor directly (Output voltage and resistance)																	
	Inspect actuator directly (Resistance and filter for clogging)																	
		Remedy	Clean	Correct	Replace	Correct	Clean	Clean	Replace	Replace	Clean	Replace	Replace	Replace	Replace	Replace	Replace	Replace

Causes									
Defective atmospheric pressure sensor	Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective water temperature sensor	Defective intake manifold temperature sensor	Defective fuel rail actuator (Marked ∗1)	Defective timing rail actuator (Marked ∗1)	Defective fuel pump actuator (Marked ∗1)
○	○	○	○	○			△	△	△
					○	○			

●	●	●	●	●	●	●			
							●	●	●
Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace

∗1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

S-2 Engine does not start

a) Engine does not turn

General causes why engine does not turn
- Internal parts of engine seized
  - ★ See Troubleshooting S-4.
- Defective electrical system
- Problem in power train (troubleshooting for machine)
  - ★ See the manual for the machine.

			Causes							
			Broken flywheel ring gear	Defective or deteriorated battery	Defective battery terminal connection	Defective starting circuit wiring	Defective starting switch	Defective battery relay	Defective starting motor	Defective safety relay or safety switch
Questions	Confirm recent repair history									
	Degree of use of machine	Operated for long period	△	△						
	Condition of horn when starting switch is turned ON	Horn does not sound			○	◎	○			
		Horn volume is low		◎						
Check items	Battery electrolyte is low					◎				
	Battery terminal is loose				◎					
	When starting switch is turned to ON, there is no clicking sound from battery relay			○				◎		
	When starting switch is turned to START, starting pinion does not move out			○		◎	○			
	When starting switch is turned to START, starting pinion moves out, but	Speed of rotation is low		◎						
		Makes grating noise	◎						◎	
		Soon disengages again								◎
		Makes rattling noise and does not turn		○					○	○
Troubleshooting	Inspect flywheel ring gear directly		●			＊1.				
	When specific gravity of electrolyte and voltage of battery are measured, one of them is low			●						
	Turn starting switch OFF, connect cord, and carry out troubleshooting at ON	When terminal B and terminal C of starting switch are connected, engine starts					●			
		There is no 24V between battery relay terminal B and terminal E						●		
		When terminal B and terminal C of starting motor are connected, engine starts							●	
		When terminal B and terminal C of safety relay are connected, engine starts								●
		When terminal of safety switch and terminal B of starting motor are connected, engine starts								●
		Remedy	Replace	Replace	Correct	—	Replace	Replace	Replace	Replace

＊1. Carry out troubleshooting of machine

b) Engine turns but no exhaust smoke comes out (fuel is not being injected)

General causes why engine turns but no exhaust smoke comes out
- Fuel is not being supplied
- Supply of fuel is extremely small
- Improper selection of fuel (particularly in winter)
- Defective HPI sensor
- Defective HPI actuator

			Causes								
			Insufficient fuel in tank	Clogged fuel tank cap	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Broken fuel pump drive shaft	Defective fuel shut-off valve	Defective fuel shut-off valve wiring	Clogged timing actuator screen	Defective atmospheric pressure sensor
Questions	Confirm recent repair history										
	Degree of use of machine	Operated for long period		△		△					
	Exhaust smoke suddenly stopped coming out (when starting again)						◎				
	Starting performance became worse gradually										○
	Starts when engine is warm									◎	
	Starts when engine is cold										
	Replacement of filters has not been carried out according to Operation Manual					◎					
Check items	When fuel tank is inspected, it is found to be empty		◎								
	Air breather hole in fuel tank cap is clogged			◎							
	Rust and water are found when fuel tank is drained					○					
	When fuel filter is drained, fuel does not come out			◎	◎	◎					
	There is leakage from fuel piping				◎						
	Wiring of fuel shut-off valve is loose								◎		
	Cylinder block ground wiring is loose								◎		
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out				◎	◎				
		Fuel pump outlet port coupler is pushed, air comes out together with fuel		◎	◎						
Troubleshooting	When negative pressure at inlet port of fuel pump is measured, it is found to be high				●	●					
	Inspect fuel filter, strainer directly					●					
	Inspect fuel pump drive shaft directly						●				
	Inspect fuel shut-off valve directly							●			
	When starting switch is turned to START, voltage [24V] is not generated between fuel shut-off valve connector pins								●		
	Inspect timing rail actuator screen directly									●	
	Inspect sensor directly (Output voltage and resistance)										●
	Inspect actuator directly (Resistance and filter for clogging)										
		Remedy	Add	Correct	Clean	Clean	Replace	Replace	Replace	Replace	Replace

Causes								
Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective water temperature sensor	Defective intake manifold temperature sensor	Defective fuel rail actuator (Marked*1)	Defective timing rail actuator (Marked*1)	Defective fuel pump actuator (Marked*1)
○	○	○	○			△	△	△
				○	○			

●	●	●	●	●	●			
						●	●	●
Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace

*1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

c) Exhaust smoke comes out but engine does not start (fuel is being injected)

General causes why exhaust smoke comes out but engine does not start

- Lack of rotating force due to defective electrical system
- Insufficient supply of fuel
- Insufficient intake of air
- Improper selection of fuel and oil
- Defective HPI sensor
- Defective HPI actuator

			Causes										
			Clogged air cleaner element	Defective dynamic valve system (valve, rocker arm, etc.)	Worn piston ring, cylinder liner	Clogged fuel tank cap	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Defective fuel pump	Clogged timing actuator screen	Defective injector	Defective or deteriorated battery	Defective preheating heater circuit
Questions	Confirm recent repair history												
	Degree of use of machine	Operated for long period			△							△	
	Suddenly failed to start			◎					◎				
	Starting performance became worse gradually												
	Starts when engine is warm									◎		○	◎
	Starts when engine is cold												
	Non-specified fuel is being used							◎	○	◎	○		
	Replacement of filters has not been carried out according to Operation Manual					◎	◎	◎					
	Engine oil must be added more frequently				◎								
Check items	When preheating, preheating indicator lamp does not light up												◎
	Dust indicator is red		◎										
	Air breather hole in fuel tank cap is clogged						◎						
	Rust and water are found when fuel tank is drained						◎	◎					
	When fuel filter is drained, no fuel comes out					◎	◎	◎					
	There is leakage from fuel piping						◎						
	Starting motor cranks engine slowly											◎	
	When engine is cranked, abnormal noise is generated around cylinder head			◎									
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out						◎	◎				
		Fuel pump outlet port coupler is pushed, air comes out together with fuel				◎	◎						
Troubleshooting	Inspect air cleaner element directly		●										
	Inspect dynamic valve system directly			●									
	When compression pressure is measured, it is found to be low				●								
	When negative pressure at inlet port of fuel pump is measured, it is found to be high					●	●	●					
	When fuel filter, strainer directly							●					
	Inspect fuel pump directly								●				
	Inspect timing rail actuator screen directly									●			
	When temperature of exhaust gas of each cylinder is measured, there are some cylinders that are low										●		
	When specific gravity of electrolyte and voltage of battery are measured, one of them is low											●	
	When starting switch is at HEAT, heater mount does not become warm												●
	Inspect sensor directly (Output voltage and resistance)												
	Inspect actuator directly (Resistance and filter for clogging)												
	Inspect fuel rail actuator directly												
		Remedy	Clean	Replace	Replace	Clean	Clean	Clean	Replace	Replace	Replace	Replace	Correct

Causes										
Defective atmospheric pressure sensor	Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective water temperature sensor	Defective intake manifold temperature sensor	Defective fuel rail actuator (Marked ∗1)	Defective timing rail actuator (Marked ∗1)	Defective fuel pump actuator (Marked ∗1)	Clogged fuel rail actuator
○	○	○	○	○			△	△	△	
					○	○				

●	●	●	●	●	●	●				
							●	●	●	
										●
Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace

∗1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)

[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

S-3 Engine does not pick up smoothly (follow-up is poor)

General causes why engine does not pick up smoothly

- Insufficient intake of air
- Insufficient supply of fuel
- Defective condition of fuel spray
- Improper fuel used
- Abnormality in fuel control system
- Defective HPI sensor
- Defective HPI actuator
- Normal output is not applied
  → See Troubleshooting S-6

			Causes										
			Clogged air cleaner element	Seized turbocharger	Defective contact of valve and valve seat	Improper valve clearance	Worn piston ring, cylinder liner	Clogged fuel tank cap	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Defective fuel pump	Defective injector	Failure boost pressure sensor
Questions	Confirm recent repair history												
	Degree of use of machine	Operated for long period	△							△			
	Engine pick-up suddenly became worse			◎	○			○	◎			○	
	Non-specified fuel is being used									◎	◎	◎	
	Replacement of filters has not been carried out according to Operation Manual		◎							◎		○	
	Engine oil must be added more frequently						◎						
Check items	Dust indicator is red		◎										
	Air breather hole in fuel tank cap is clogged							◎					
	Rust and water are found when fuel is drained									◎	◎		
	There is leakage from fuel piping								◎				
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out								◎	◎		
		Fuel pump outlet port coupler is pushed, air comes out together with fuel						◎	◎				
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low											◎	◎
	Color of exhaust gas	Blue under light load					◎						
		Black	◎	◎	○								
	Clanging sound is heard from around cylinder head					◎							
	Noise of interference is heard from around turbocharger			◎									
	High idling speed under no load is normal, but speed suddenly drops when load is applied									◎	◎		◎
	There is hunting from engine (rotation is irregular)									○	◎	○	
	Blow-by gas is excessive						◎						
Troubleshooting	Inspect air cleaner element directly		●										
	When turbocharger is rotated by hand, it is found to be heavy			●									
	When compression pressure is measured, it is found to be low				●		●						
	Inspect valve clearance directly					●							
	When pressure at outlet port of fuel pump is measured, it is found to vary							●	●				
	Inspect fuel filter, strainer directly									●			
	When negative pressure at inlet port of fuel pump is measured, it is found to be high									●			
	When pressure at outlet port of fuel pump is measured, it is found to be low										●		
	When temperature of injector of each cylinder is measured, there are some cylinders that are low											●	
	When intake air pressure (boost pressure) is measured, it is found to be normal												●
	Inspect actuator directly (Resistance and filter for clogging)												
	Inspect sensor directly (Output voltage and resistance)												
	Inspect for air leakage												
		Remedy	Clean	Correct	Replace	Correct	Replace	Correct	Clean	Clean	Replace	Replace	Replace

Causes				
Defective fuel rail actuator (Marked ∗1)	Defective timing rail actuator (Marked ∗1)	Defective fuel pump actuator (Marked ∗1)	Defective atmospheric pressure sensor	Air leakage from piping between turbocharger and cylinder head
●	●	●		
			●	
				●
Replace	Replace	Replace	Replace	Replace

∗1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

S-4 Engine stops during operations

General causes why engine stops during operations

- Seized parts inside engine
- There is overheating
  - ★ See Troubleshooting S-14.
- Problem in power train (troubleshooting for machine)
  - ★ See the manual for the machine.
- Defective HPI sensor
- Defective HPI actuator

			Causes												
			Broken dynamic valve system (valve, rocker arm, etc.)	Broken, seized piston, connecting rod	Broken, seized main bearing, connecting rod bearing	Broken, seized gear train	Insufficient fuel in tank	Clogged fuel tank cap	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Broken fuel pump drive shaft	Defective injector	Broken auxiliary equipment (pump, compressor, etc.)	Failure in power train (troubleshooting for machine)	Defective atmospheric pressure sensor
Questions	Confirm recent repair history														
	Degree of use of machine	Operated for long period								△					
	Condition when engine stopped	Abnormal noise was heard and engine stopped suddenly	◎	◎	◎	◎					◎		◎	◎	○
		Engine overheated and stopped		◎	○								○		
		Engine stopped slowly					◎			○					○
		There was hunting and engine stopped					◎	○		○					○
	Non-specified fuel is being used														
	Replacement of filters has not been carried out according to Operation Manual									○		◎			
Check items	Fuel level caution lamp lights up						◎								
	When fuel tank is inspected, it is found to be empty						◎								
	Air breather hole in fuel tank cap is clogged													◎	
	Rust and water are found when fuel tank is drained				◎					◎					
	Metal particles are found when oil is drained									○					
	When it is attempted to turn by hand using barring tool	Does not turn at all		◎	◎										
		Turns in opposite direction	◎												
		Moves amount of gear backlash				◎									
		Fuel pump shaft does not turn									◎				
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out					◎			◎	◎				
		Fuel pump outlet port coupler is pushed, air comes out together with fuel						◎	◎						
	Engine turns, but stops when load is applied to machine														
Troubleshooting	Inspect dynamic valve system directly		●											Carry out troubleshooting of machine	
	Inspect piston, connecting rod directly			●											
	Inspect main bearing, connecting rod directly				●										
	Inspect gear train directly					●									
	When pressure at outlet port of fuel pump is measured, it is found to vary							●	●						
	Inspect fuel filter, strainer directly									●					
	When negative pressure at inlet port of fuel pump is measured, it is found to be high									●					
	When pressure at outlet port of fuel pump is measured, it is found to be low									●	●				
	When temperature of injector of each cylinder is measured, there are some cylinders that are low														
	Engine rotates when pump auxiliary equipment (pump, compressor, etc.) is removed											●			
	Inspect sensor directly (Output voltage and resistance)												●		
	Inspect actuator directly (Resistance and filter for clogging)														●
		Remedy	Replace	Replace	Replace	Replace	Add	Correct	Correct	Clean	Replace	Replace	Replace	—	Replace

Causes								
Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective fuel rail actuator (Marked *)	Defective timing rail actuator (Marked *)	Defective fuel pump actuator (Marked *)	Defective fuel shut-off valve	Clogged fuel inlet circuit
○	○	○	○	○	○	○		
○	○	○	○	○	○	○		
○	○	○	○	○	○	○		

								●
	●	●	●					
●				●	●	●	●	
Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Clean

*1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)

[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

S-5 Engine does not rotate smoothly (hunting)

General causes why engine does not rotate smoothly

- Air in fuel system
- Defective governor mechanism
- Defective HPI sensor
- Defective HPI actuator
- Normal output is not applied
  → See Troubleshooting S-6

			Causes									
			Insufficient fuel in tank	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Defective fuel pump	Defective actuation of fuel rail actuator	Defective actuation of timing rail actuator	Defective injector	Defective injector check ball	Cut, worn injector O-ring	High resistance, clogged fuel return circuit
Questions	Confirm recent repair history											
	Degree of use of machine	Operated for long period			△							△
	Condition of hunting	Occurs at a certain speed range					○	○				
		Occurs at low idling	◎	◎	◎	◎				◎	◎	◎
		Occurs even when speed is raised	○	○	○	○				○	○	○
		Occurs on slopes	◎				◎	◎		◎		
	When fuel tank is inspected, it is found to be empty		◎									
	Rust, water are found when fuel tank is drained			○	○		○	○				○
Check items	Leakage from fuel piping			◎								
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out			◎							
		Fuel pump outlet port coupler is pushed, air comes out together with fuel	◎	◎								
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low									◎		
	Engine speed sometimes rises too far							○	○		◎	
	Engine is difficult to stop										◎	
Troubleshooting	Inspect fuel filter, strainer directly			●	●							
	When negative pressure at inlet port of fuel pump is measured, it is found to be high			●	●							
	When pressure at outlet port of fuel pump is measured, it is found to vary			●								
	When pressure at outlet port of fuel pump is measured, it is found to be low				●	●					●	
	When temperature of injector of each cylinder is measured, there are some cylinders that are low								●			
	When flow of spill fuel is checked visually, it is found to be low											●
	Inspect sensor directly (Output voltage and resistance)											
	Inspect actuator directly (Resistance and filter for clogging)						●	●				
	Inspect fuel rail actuator screen directly											
	Inspect timing rail actuator screen directly											
		Remedy	Replace	Clean	Clean	Replace	Replace	Replace	Replace	Replace	Replace	Clean

Causes									
Defective atmospheric pressure sensor	Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective fuel pump actuator (Marked *1)	Defective in throttle sensor	Defective in speed sensor	Clogged fuel rail actuator screen	Clogged timing rail actuator screen
○	○	○	○	○	○	○	○	○	○
○	○	○	○	○	○	○	○	○	○
○	○	○	○	○	○	○	○	○	○
●	●	●	●	●			●		
					●				
								●	
									●
Replace	Replace	Replace	Replace	Replace	Replace	—	Replace	Replace	Replace

*1. If the following error code is displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If it is not displayed, it is not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[318] [E-93]: Abnormality in fuel pump actuator

S-6 Engine lacks output (or lacks power)

★ Measure the engine speed and judge if the problem is in the engine or on the machine.

General causes why engine lacks output

- Insufficient intake of air
- Insufficient supply of fuel
- Improper fuel used
  (if non-specified fuel is used, output drops)
- There is overheating
  ★ See Troubleshooting **S-14**.
- Defective HPI sensor
- Defective HPI actuator

			Causes											
			Clogged air cleaner element	Seized turbocharger, interference	Defective contact of valve and valve seat	Improper adjustment of valve clearance	Worn piston ring, cylinder liner	Clogged fuel tank cap	Loose piping, fuel filter, entry of air	Clogged fuel filter, strainer	Defective fuel pump	Defective injector	Cut, worn injector O-ring	Defective atmospheric pressure sensor
Questions	Confirm recent repair history													
	Degree of use of machine	Operated for long period	△		△		△			△				
	Power was lost	Suddenly		◎									○	
		Gradually	○		○		○			○		○		○
	Non-specified fuel is being used									◎		◎		
	Replacement of filters has not been carried out according to Operation Manual		◎							◎				
	Engine oil must be added more frequently						◎							
Check items	Dust indicator lamp is red		◎											
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out												
		Fuel pump outlet port coupler is pushed, air comes out together with fuel						◎	◎					
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low											◎		
	Color of exhaust gas	Black	◎	◎										
		Blue under light load					◎				○		○	
	Clanging sound is heard from around cylinder head					◎								
	Noise of interference is heard from around turbocharger			◎										
	Engine pickup is poor and combustion is irregular			◎				○	○		○	○	○	
	There is hunting from engine (rotation is irregular)							○	○	○	○		○	
	High idling speed of engine is low											○		
	Blow-by gas is excessive						◎							
Troubleshooting	Inspect air cleaner element directly		●											
	When turbocharger is rotated by hand, it is found to be heavy			●										
	When compression pressure is measured, it is found to be low				●		●							
	Inspect valve clearance directly					●								
	When pressure at outlet port of fuel pump is measured, it is found to vary								●					
	Inspect fuel filter, strainer directly									●				
	When negative pressure at inlet port of fuel pump is measured, it is found to be high									●				
	When pressure at outlet port of fuel pump is measured, it is found to be low									●	●		●	
	When temperature of injector of each cylinder is measured, there are some cylinders that are low											●		
	Inspect sensor directly (Output voltage and resistance)													●
	Inspect actuator directly (Resistance and filter for clogging)													
	Check part No. of controller calibration data													
		Remedy	Clean	Replace	Replace	Adjust	Replace	Correct	Clean	Clean	Replace	Replace	Replace	Replace

Causes									
Defective boost pressure sensor	Defective fuel rail pressure sensor	Defective timing rail pressure sensor	Defective fuel pump pressure sensor	Defective fuel rail actuator (Marked *1)	Defective timing rail actuator (Marked *1)	Defective fuel pump actuator (Marked *1)	High resistance or clogged fuel circuit	Defective throttle sensor	Defective controller calibration data
								○	
○	○	○	○	○	○	○	○	○	
○	○	○	○	○	○	○			
							●		
●	●	●							
			●						
				●	●	●			●
Replace	Replace	Replace	Replace	Replace	Replace	Replace	Clean	—	—

*1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[514] [E-73]: Abnormality in fuel rail actuator
[112] [E-83]: Abnormality in timing rail actuator
[318] [E-93]: Abnormality in fuel pump actuator

S-7 Exhaust smoke is black (incomplete combustion)

General causes why exhaust smoke is black
- Insufficient intake of air
- Defective condition of fuel injection
- Excessive injection of fuel
- Defective HPI sensor
- Defective HPI actuator
- Normal output is not applied
  → See Troubleshooting S-6

			Causes											
			Clogged air cleaner element	Seized turbocharger, interference	Defective contact of valve and valve seat	Improper adjustment of valve clearance	Leakage of air between turbocharger and cylinder head	Crushed, clogged muffler	Worn piston ring, cylinder liner	Defective fuel pump	Defective injector	Cut, worn injector O-ring	Failure timing rail pressure sensor	Defective timing rail actuator (Marked ∗1)
Questions	Confirm recent repair history													
	Degree of use of machine	Operated for long period	△						△					
	Color of exhaust gas	Suddenly became black		◎							◎	○	○	○
		Gradually became black	◎				○						○	○
		Blue under light load							◎	○		○	○	○
	Non-specified fuel is being used													
	Engine oil must be added more frequently								◎					
	Power was lost	Suddenly		◎				○			◎			
		Gradually	○		○		○		○					
Check items	Dust indicator is red		◎											
	Muffler is crushed							◎						
	Leakage of air between turbocharger and head, loose clamp						◎							
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low										◎			
	Noise of interference is heard from around turbocharger			◎										
	Clanging sound is heard from around cylinder head					◎								
	Exhaust noise is abnormal			○				◎						
	Engine pickup is poor and combustion is irregular			○		○	○	○		○	○	○		
	Blow-by gas is excessive								◎					
Troubleshooting	Inspect air cleaner directly		●											
	When turbocharger is rotated by hand, it is found to be heavy			●										
	When compression pressure is measured, it is found to be low				●				●					
	Inspect valve clearance directly					●								
	When muffler is removed, exhaust sound improves							●						
	Inspect between turbocharger and cylinder head directly						●							
	When pressure at outlet port of fuel pump is measured, it is found to be low									●		●		
	When temperature of injector of each cylinder is measured, there are some cylinders that are low										●			
	Abnormality in timing rail pressure sensor system is indicated (∗2)									●		●	●	
	Inspect sensor directly (Output voltage)												●	
	Inspect actuator directly (Resistance and filter for clogging)													●
		Remedy	Clean	Replace	Replace	Adjust	Correct	Replace	Replace	Replace	Replace	Replace	Replace	Replace

∗1. If the following error codes are displayed, carry out the troubleshooting in "EA mode" or "EB mode". (If any of the following error codes is not displayed, they are not probably the cause of the trouble. In this case, inspect the other devices for the cause.)
[112] [E-83]: Abnormality in timing rail actuator

∗2. If an error code of the timing rail pressure sensor system is displayed, carry out the troubleshooting in "EA mode" or "EB mode".

S-8 Oil consumption is excessive (or exhaust smoke is blue)

★ To prevent the oil from leaking up or down in the turbocharger, do not run the engine at idling for more than 20 minutes continuously (both low and high idling).

General causes why oil consumption is excessive

- Abnormal combustion of oil
- External leakage of oil
- Wear of parts in lubrication system

			Causes													
			Dust sucked in from intake system	Turbocharger		Worn, damaged valve (stem, guide, seal)	Worn piston ring, cylinder liner	Broken piston ring	Clogged breather or breather hose	Worn, broken rear oil seal	Too much engine oil added	Leakage from oil drain plug	Broken oil cooler	Leakage from oil filter or oil cooler	Leakage from oil piping	Leakage from oil pan or cylinder head
				Worn seal at turbine end	Worn seal at blower end											
Questions	Confirm recent repair history															
	Degree of use of machine	Operated for long period		△	△	△	△									
	Oil consumption suddenly increased							◎			◎		○			
	Engine oil must be added more frequently						◎						○			
Check items	Engine oil becomes contaminated quickly						◎	○	○							
	Oil level is above H level on gauge										◎					
	Outside of engine is dirty with oil											◎		◎	◎	◎
	There are loose piping clamps in intake system		◎													
	Inside of turbocharger intake pipe is dirty with oil				◎	○										
	Inside of exhaust pipe is dirty with oil			◎												
	There is oil in engine cooling water												◎			
	Oil level in clutch chamber or damper chamber rises									◎						
	Exhaust smoke is blue under light load						◎	◎								
	Amount of blow-by gas	Excessive			○	○	◎	◎								
		None							◎							
Troubleshooting	When intake manifold is removed, dust is found inside		●													
	Excessive play of turbocharger shaft			●	●											
	When intake manifold is removed, inside is found to be dirty with oil					●										
	When compression pressure is measured, it is found to be low						●	●								
	Inspect breather element directly								●							
	Inspect rear oil seal directly									●						
	There is external leakage of oil from engine											●		●	●	●
	Pressure-tightness test of oil cooler shows there is leakage												●			
		Remedy	Correct	Replace	Replace	Correct	Replace	Replace	Clean	Correct	Correct	Correct	Replace	Correct	Correct	Correct

S-9 Oil becomes contaminated quickly

General causes why oil becomes contaminated quickly

- Entry of exhaust gas into oil due to internal wear
- Clogging of lubrication passage
- Defective combustion
- Improper fuel used
- Operation under excessive load
- Oil change interval is too long

			Causes									
			Clogged turbocharger lubrication drain tube	Defective seal at turbocharger turbine end	Worn valve (stem, guide, seal)	Worn piston ring, cylinder liner	Clogged breather, breather tube	Too much engine oil added	Clogged oil cooler	Clogged oil filter	Defective oil filter safety valve	Exhaust smoke is black
Questions	Confirm recent repair history											
	Degree of use of machine	Operated for long period		△	△	△						
	Non-specified oil is being used									○		
	Engine oil must be added more frequently					◎		○				
Check items	Oil level is above H level on gauge							◎				
	When oil filter is inspected, metal particles are found				○	○				◎		
	When exhaust pipe is removed, inside is found to be dirty with oil				◎							
	Even when engine oil temperature rises, oil filter caution lamp lights up (machines equipped with caution lamp)									◎	○	
	Engine oil temperature rises quickly							◎	◎			
	Color of exhaust gas	Blue under light load				◎						
		Black										◎
	Amount of blow-by gas	Excessive	○	○	○	◎						
		None					◎					
Troubleshooting	Inspect turbocharger lubrication drain tube directly		●									Carry out Troubleshooting S-7
	Excessive play of turbocharger shaft			●								
	When compression pressure is measured, it is found to be low				●	●						
	Inspect breather element directly						●					
	Inspect oil cooler directly								●			
	Inspect oil filter directly									●		
	Inspect safety valve directly										●	
		Remedy	Clean	Replace	Replace	Replace	Clean	Correct	Clean	Replace	eplace	—

S-10 Fuel consumption is excessive

General causes why fuel consumption is excessive
- Leakage of fuel
- Defective condition of fuel injection
- Excessive injection of fuel
- Defective HPI sensor

			Causes									
			Leakage of fuel inside head cover	Clogged fuel filter, strainer	Defective fuel pump	Defective injector	Cut, worn injector O-ring	Failure fuel rail pressure sensor	Failure timing rail pressure sensor	High resistance, clogged fuel return circuit	Defective atmospheric pressure sensor	Defective boost pressure sensor
Questions	Confirm recent repair history											
	Degree of use of machine	Operated for long period				△				△		
	Condition of fuel consumption	More than for other machines of same model										
		Gradually increased								◎		
		Suddenly increased	○			◎						
	There is external leakage of fuel from engine		◎									
Check items	Engine oil level rises and smells of diesel fuel											
	When engine is cranked with starting motor, and	Fuel pump outlet port coupler is pushed, almost no fuel comes out										
		Fuel pump outlet port coupler is pushed, air comes out together with fuel										
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low					◎						
	Exhaust smoke color	Black				◎	◎		◎			
		White	○									
Troubleshooting	Inspect inside of head cover directly		●									
	When negative pressure at inlet port of fuel pump is measured, it is found to be high			●								
	Inspect fuel pump directly				●							
	When temperature of injector of each cylinder is measured, there are some cylinders that are low					●						
	When pressure at outlet port of fuel pump is measured, it is found to be low						●					
	Abnormality in fuel rail pressure sensor system is indicated (∗1)							●				
	Abnormality in timing rail pressure sensor system is indicated (∗1)								●			
	When flow of return fuel is checked visually, it is found to be low									●		
	Inspect sensor directly (Output voltage)							●	●		●	●
	Remedy		Correct	Clean	Replace	Replace	Replace	Replace	Replace	Clean	Replace	Replace

∗ 1. If an error code of the fuel rail pressure sensor system or timing rail pressure sensor system is displayed, carry out the troubleshooting in "EA mode" or "EB mode".

S-11 Oil is in cooling water, or water spurts back, or water level goes down

General causes why oil is in cooling water
- Internal leakage in lubrication system
- Internal leakage in cooling system

			Causes						
			Broken cylinder head, head gasket	Internal cracks in cylinder block	Insufficient protrusion of cylinder liner	Damaged cylinder liner O-ring, holes caused by pitting	Broken oil cooler core, O-ring	Broken water pump seal	Broken power train oil cooler (troubleshooting for machine)
Questions	Confirm recent repair history								
	Degree of use of machine	Operated for long period				△	△		
	Oil level	Suddenly increased	○				○		○
		Gradually increased		○		○			
	Hard water is being used as cooling water (or corrosion resistor valve is closed)					○	○		
Check items	Excessive air bubbles inside radiator, spurts back		◎		◎				
	Engine oil level has risen, oil is cloudy white			○		○	◎	○	
	Hydraulic oil, transmission oil on machine side is cloudy white								◎
	When hydraulic oil, transmission oil on machine side is drained, water is found								◎
Troubleshooting	Carry out pressure-tightness test of cylinder head		●						
	Inspect cylinder block, liner directly			●		●			
	Inspect cylinder liner directly				●				
	Carry out pressure-tightness test of oil cooler						●		●
	Inspect water pump directly							●	
		Remedy	Replace	Replace	Replace	Replace	Replace	Replace	Replace

S-12 Oil pressure caution lamp lights up (drop in oil pressure)

General causes why oil pressure caution lamp lights up
- Leakage, clogging, wear of lubricating system
- Defective oil pressure control
- Improper selection of fuel (insufficient viscosity)
- Deterioration of oil due to overheating

			Causes												
			Worn crankshaft journal	Lack of oil in oil pan	Clogged oil pan suction strainer	Clogged, broken oil pump suction pipe	Broken oil pump suction pipe brazing	Defective oil pump	Defective oil pump relief valve	Clogged oil cooler	Clogged oil filter	Leaking, crushed hydraulic piping	Water, fuel in oil	Defective oil level sensor	Defective oil pressure sensor
Questions	Confirm recent repair history														
	Degree of use of machine	Operated for long period	△								△				
	Non-specified oil is being used		○								○				
	Replacement of filters has not been carried out according to Operation Manual										◎				
	Engine oil pressure caution lamp lights up								○		◎				
Check items	Condition when oil pressure lamp lights up	Lights up at low idling	◎						◎						
		Lights up at low, high idling		○	◎	◎	◎	◎	○	○					
		Lights up on slopes		◎											
		Sometimes lights up							◎					○	○
	Oil level caution lamp lights up (machines equipped with caution lamp)			◎										◎	
	There is crushing, external leakage from hydraulic piping											◎			
	Oil level in oil pan is low			◎											
	Oil is cloudy white or smells of diesel oil												◎		
	When oil is drained, metal particles are found		◎												
	When oil filter is inspected, metal particles are found		◎					○							
Troubleshooting	Inspect oil filter directly		●								●		Carry out Troubleshooting S-13		
	Inspect suction strainer, pipe directly				●	●	●								
	Oil pump rotation is heavy, there is play							●							
	Inspect relief valve, regulator valve directly								●						
	Inspect oil filter directly									●					
	When engine oil level sensor is replaced, oil pressure lamp goes out (machines equipped with oil level sensor)													●	
	When oil pressure is measured, it is found to be normal														●
		Remedy	Clean	Add	Clean	Clean	Correct	Replace	Adjust	Replace	Clean	Correct	—	Replace	Replace

S-13 Oil level rises

★ If there is oil in the cooling water, carry out Troubleshooting S-11.

General causes why oil level rises

- Cooling water in oil (milky white)
- Fuel in oil (diluted, and smells of diesel fuel)
- Entry of water or oil from other component

			Causes											
			Broken aftercooler core	Broken cylinder head, head gasket	Defective cylinder head injector sleeve	Cracks inside cylinder block	Damaged cylinder liner O-ring, holes caused by pitting	Broken, broken rear oil seal face	Broken oil cooler core, O-ring	Clogged water pump drain hole (breather hole), defective seal	Defective thermostat seal	Worn fuel pump seal	Cut, worn injector O-ring	Defective auxiliary equipment (pump, compressor) seal
Questions	Confirm recent repair history													
	Degree of use of machine	Operated for long period			△		△	△		△				△
	Fuel must be added more frequently										◎	◎	◎	
	Engine oil smells of diesel fuel										◎	◎	◎	
Check items	There is oil in cooling water			○	○	○	○		◎					
	When engine is first started, drops of water come from muffler				◎									
	When radiator cap is removed and engine is run at low idling, an abnormal number of bubbles appear, or water spurts back			◎										
	Exhaust smoke is white		○		◎						○		○	
	Water pump drain hole (breather hole) is clogged									◎				
	When water pump drain hole (breather hole) is cleaned, water comes out									◎				
	Oil level goes down in clutch or damper chamber							◎						
	Oil level goes down in hydraulic tank													◎
Troubleshooting	Carry out pressure-tightness test of aftercooler		●											
	When compression pressure is measured, it is found to be low			●										
	Carry out pressure-tightness test of cylinder head				●									
	Inspect cylinder block, liner directly					●	●							
	Inspect rear oil seal directly							●						
	Carry out pressure-tightness test of oil cooler								●					
	Inspect water pump directly									●				
	Inspect thermostat directly										●			
	Inspect fuel pump directly											●		
	Inspect injector directly												●	
	Inspect pump auxiliary equipment (pump, compressor) directly													●
		Remedy	Replace	Replace	Replace	Replace	Replace	Correct	Replace	Replace	Correct	Replace	Correct	Replace

S-14 Water temperature becomes too high (overheating)

General causes why water temperature becomes too high
- Lack of cooling air (deformation, damage of fan)
- Drop in heat dissipation efficiency
- Rise in oil temperature in power train (troubleshooting for machine)
  - ★ See the manual for the machine.

			Causes												
			Broken cylinder head, head gasket	Cracks inside cylinder block	Damaged cylinder liner O-ring, holes caused by pitting	Clogged, broken oil cooler	Lack of cooling water	Clogged radiator core	Clogged, crushed radiator fins	Defective radiator cap (pressure valve)	Fan belt slipping, worn fan pulley	Broken water pump	Defective operation of thermostat	Defective water temperature gauge	Rise in power train oil temperature (troubleshooting for machine)
Questions	Confirm recent repair history														
	Degree of use of machine	Operated for long period	△		△			△	△						
	Condition of overheating	Suddenly overheated					○				○	◎			
		Always tends to overheat						◎	◎		○		○		
	Water temperature gauge	Rises quickly											◎		
		Does not go down from red range												◎	
	Radiator water level caution lamp lights up (machines equipped with caution lamp)						◎								
Check items	Engine oil level has risen, oil is cloudy white			◎	◎	○									
	Cloudy white oil is floating on cooling water					◎									
	Excessive air bubbles inside radiator, water spurts back		◎												
	When light bulb is held behind radiator, no light passes through								◎						
	Radiator shroud, inside of underguard are clogged with dirt or mud								◎		◎				
	Water is leaking because of cracks in hose or loose clamps						◎								
	When belt tension is inspected, it is found to be loose										◎				
	Fan belt whines under sudden load										◎				
	Cooling water flows out from overflow hose									◎					
	Power train oil temperature enters red range faster than engine water temperature														◎
Troubleshooting	When compression pressure is measured, it is found to be low		●												Carry out troubleshooting of machine
	Carry out pressure-tightness test of cylinder head		●												
	Inspect cylinder block, liner directly			●	●										
	Inspect oil cooler directly					●									
	Inspect radiator core directly							●							
	When temperature difference between top and bottom radiator tanks is measured, it is found to be slight								●						
	Carry out function test on radiator cap (cracking pressure)									●					
	When temperature difference between top and bottom radiator tanks is measured, it is found to be excessive											●			
	Carry out function test on thermostat (cracking temperature)												●		
	When water temperature is measured, it is found to be normal													●	
		Remedy	Replace	Replace	Replace	Replace	Add	Correct	Correct	Replace	Correct	Replace	Replace	Replace	—

S-15 Abnormal noise is made

★ Judge if the noise is an internal noise or an external noise.

General causes why abnormal noise is made

- Abnormality due to defective parts
- Abnormal combustion noise
- Air sucked in from intake system

			Causes											
			Seized turbocharger, internal interference	Leakage of air between turbocharger and head	Broken dynamic valve system (valve, rocker arm, etc.)	Defective adjustment of valve clearance	Defect inside muffler (dividing board out of position)	Excessive wear of piston ring, cylinder liner	Seized crankshaft bearing	Missing, seized gear bushing	Improper gear train backlash	Deformed cooling fan, fan belt interference	Defective injector	Air leakage from auxiliary equipment (pump, compressor)
Questions	Confirm recent repair history													
	Degree of use of machine	Operated for long period						△						
	Condition of abnormal noise	Gradually occurred						○				○		
		Suddenly occurred	○		○					○				
	Non-specified fuel is being used												○	
	Engine oil must be added more frequently							◎						
	Seal on injection pump has come off													
	Metal particles are found in oil filter							◎	◎	◎				
Check items	Leakage of air between turbocharger and head, loose clamp			◎										
	Noise of interference is heard from around turbocharger		◎											
	Clanging sound is heard from around cylinder head				◎	◎								
	Vibrating noise is heard from around muffler						◎							
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low												◎	
	Color of exhaust gas	Blue under light load						◎						
		Black	◎	○		○								
	Engine pickup is poor and combustion is abnormal												◎	
	Abnormal noise is loud when accelerating engine					○					○	○	○	○
	Blow-by gas is excessive							◎						
Troubleshooting	When turbocharger is rotated by hand, it is found to be heavy		●											
	Inspect dynamic valve system directly				●									
	Inspect valve clearance directly					●								
	When muffler is removed, abnormal noise disappears						●							
	When compression pressure is measured, it is found to be low							●						
	Inspect crankshaft bearing directly								●					
	Inspect front gear and rear gear directly									●	●			
	Inspect cooling fan, belt directly											●		
	When temperature of exhaust gas of each cylinder is measured, there are some cylinders that are low												●	
	Inspect piping of pump auxiliary equipment (pump, compressor, etc.) directly													●
		Remedy	Replace	Correct	Replace	Adjust	Replace	Replace	Replace	Replace	Correct	Correct	Replace	Replace

S-16 Vibration is excessive

★ If there is abnormal noise together with the vibration, carry out Troubleshooting **S-15** also.

General causes why vibration is excessive
- Defective parts (abnormal wear, breakage)
- Improper alignment between engine and chassis
- Abnormal combustion

			Causes									
			Defective dynamic valve system (valve, rocker arm, etc. stuck)	Worn main bearing, connecting rod	Worn cam bushing	Improper gear train backlash	Defective vibration damper	Defective fuel rail pressure sensor	Clogged injector	Worn front support spigot joint portion	Loose engine mounting bolts, broken cushion	Internal damage in clutch chamber or damper chamber (troubleshooting for machine)
Questions	Confirm recent repair history											
	Degree of use of machine	Operated for long period		△	△					△	△	
	Condition of vibration	Suddenly increased	○				○					○
		Gradually increased		○	○				○	○	○	
	Non-specified fuel is being used			○	○							
Check items	Seal on injection pump has come off							◎				
	Metal particles are found in oil filter			◎	◎							
	Metal particles are found when oil is drained			◎	◎							
	Oil pressure is low at low idling			○	○							
	Vibration occurs at mid-range speed										○	○
	Vibration follows engine speed					○	○			○	○	○
	Exhaust smoke is black		◎					○	○			
Troubleshooting	Inspect dynamic valve system directly		●						●			
	Inspect main bearing, connecting rod directly			●								
	Inspect cam bushing directly				●							
	Inspect front gear train and rear gear train directly					●						
	Inspect vibration damper directly						●					
	Injection pump test shows that injection amount is incorrect							●				
	Inspect front support spigot joint directly									●		
	Inspect engine mounting bolts, cushions directly										●	
	Inspect clutch chamber or damper chamber directly (troubleshooting for machine)											●
		Remedy	Replace	Replace	Replace	Correct	Replace	Adjust	Replace	Replace	Replace	Replace

TROUBLESHOOTING OF CONTROLLER SYSTEM OF ENGINE FOR CONSTRUCTION EQUIPMENT (EA MODE)

★ This section gives an outline of the troubleshooting procedures for the electrical systems related to the engine proper and the engine controller (for construction equipment).
When carrying out troubleshooting of the electrical system with the engine mounted on the machine, use this section and the shop manual for the machine.

POINTS TO REMEMBER WHEN TROUBLESHOOTING

⚠ When carrying out troubleshooting, stop the machine in a level place, and check that the safety pin, blocks, and parking brake are securely applied.

⚠ When carrying out the operation with two or more workers, keep strictly to the agreed signals, and do not allow any unauthorized person to come near.

⚠ If the radiator cap is removed when the engine is still hot, boiling water may spurt out and cause burns. Always wait for the temperature to go down before starting the operation.

⚠ Be extremely careful not to touch any hot parts or to get caught in any rotating parts.

⚠ When disconnecting wiring, always disconnect the negative (–) terminal of the battery first.

⚠ When removing the plug from a location which is under pressure from oil, water, or air, always release the internal pressure first. When installing measuring equipment, be sure to connect it properly.

The aim of troubleshooting is to pinpoint the basic cause of the failure, to carry out repairs swiftly, and to prevent reoccurrence of the failure. When carrying out troubleshooting, an important point is of course to understand the structure and function. However, a short cut to effective troubleshooting is to ask the operator various questions to form some idea of possible causes of the failure that would produce the reported symptoms.

1. **When carrying out troubleshooting, do not hurry to disassemble the components**
   If components are disassembled immediately any failure occurs:
   - Parts that have no connection with the failure or other unnecessary parts will be disassembled
   - It will become impossible to find the cause of the failure.

   It will also cause a waste of man-hours, parts, or oil or grease, and at the same time, will also lose the confidence of the user or operator.

For this reason, when carrying out troubleshooting, it is necessary to carry out thorough prior investigation and to carry out troubleshooting in accordance with the fixed procedure.

2. **Points to ask user or operator**
   1) Are there signs of any abnormality on the machine or engine?
   2) Always carry out the checks before starting.
   3) Always carry out any other necessary checks.
   4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
   5) Check if there is any error code display for the controller.
   6) Has the same kind of failure occurred before?

3. **Checks before troubleshooting**
   1) Are there signs of any abnormality on the machine or engine?
   2) Always carry out the checks before starting.
   3) Always carry out any other necessary checks.
   4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
   5) Check if there is any error code display for the controller.

4. **Confirming failure**
   Confirm the extent of the failure yourself, and judge whether to handle it as a real failure or as a problem with the method of operation, etc.
   ★ When operating the machine to re-enact the troubleshooting symptoms, do not carry out any investigation or measurement that may make the problem worse.

5. Troubleshooting

Use the results of the investigation and inspection in Items 2 – 4 to narrow down the causes of failure, then use the troubleshooting matrix or flowchart to locate the position of the failure more precisely.

★ The basic procedure for troubleshooting is as follows.

1) Start from the simple points.
2) Start from the most likely points.
3) Investigate other related information.

6. Measures to remove root cause of failure

Even if the failure is repaired, if the root cause of the failure is not repaired, the same failure will occur again.

To prevent this, always investigate why the problem occurred. Then, remove the root cause.

METHOD OF USING TROUBLESHOOTING CHARTS

Method of using troubleshooting flowchart

① **Troubleshooting code number and problem**
The title at the top of the troubleshooting flowchart gives the troubleshooting code number and the problem with the machine.

② **General precautions**
When carrying out troubleshooting for the problem, precautions that apply to all items are given at the top of the page under the title and marked with ★.

★ The common precautions marked ★ at the top of the page are not given in the ⬚ (box formed by a broken line) on the left, but must always be followed when carrying out the check given in the □ (box formed by a solid line) on the right.

★

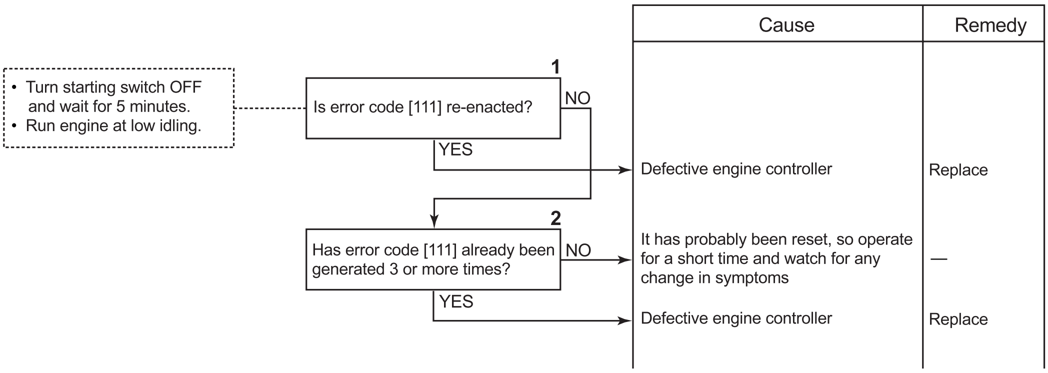
③ **Distinguishing conditions**
Even with the same problem, the method of troubleshooting may differ according to the model, component, or problem. In such cases, the failure mode is further divided into sections marked with small letters (for example, **a**), **b**)).
If the failure mode is divided into sections, go to the appropriate section to carry out troubleshooting.
If the troubleshooting table is not divided into sections, start troubleshooting from the first check item in the flowchart.

④ **Method of following troubleshooting chart**
Note: The number written at the top right corner of the □ is an index number; it does not indicate the order to follow.)

- To the left of the □ there is ⬚ (box formed by a broken line). This contains the procedure and conditions needed for inspection and measurement of the item in the □. Before starting inspection or measurement, always read the instructions for the procedure carefully, and make sure that you understand them.
- Check or measure the item inside □, and judge if the result is YES or NO. If the judgement values in the □ are correct or the answer to the question inside the □ is YES, follow the YES line; if the judgement value is not correct, or the answer to the question is NO, follow the NO line. Continue the troubleshooting for the next item in the same way.
  Following the YES or NO lines according to the results of the inspection or measurement will lead finally to the Cause and Remedy block. Check the cause and take the action given as the remedy.

⑤ **Troubleshooting tools**
Details of the tools needed for troubleshooting are given separately in the table of TOOLS FOR TESTING, ADJUSTING, AND TROUBLESHOOTING.

<Example of troubleshooting>



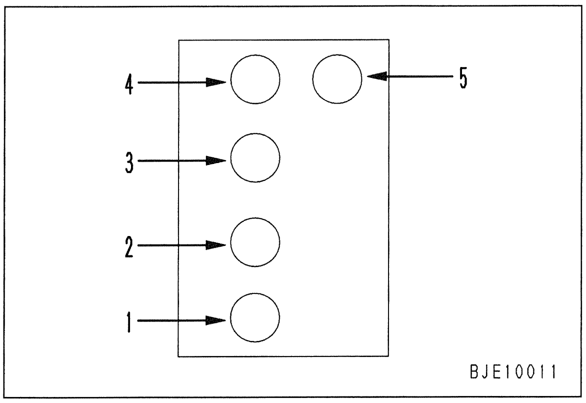
ERROR CODE DISPLAY AND POINTS TO REMEMBER WHEN TROUBLESHOOTING

1. Error code display

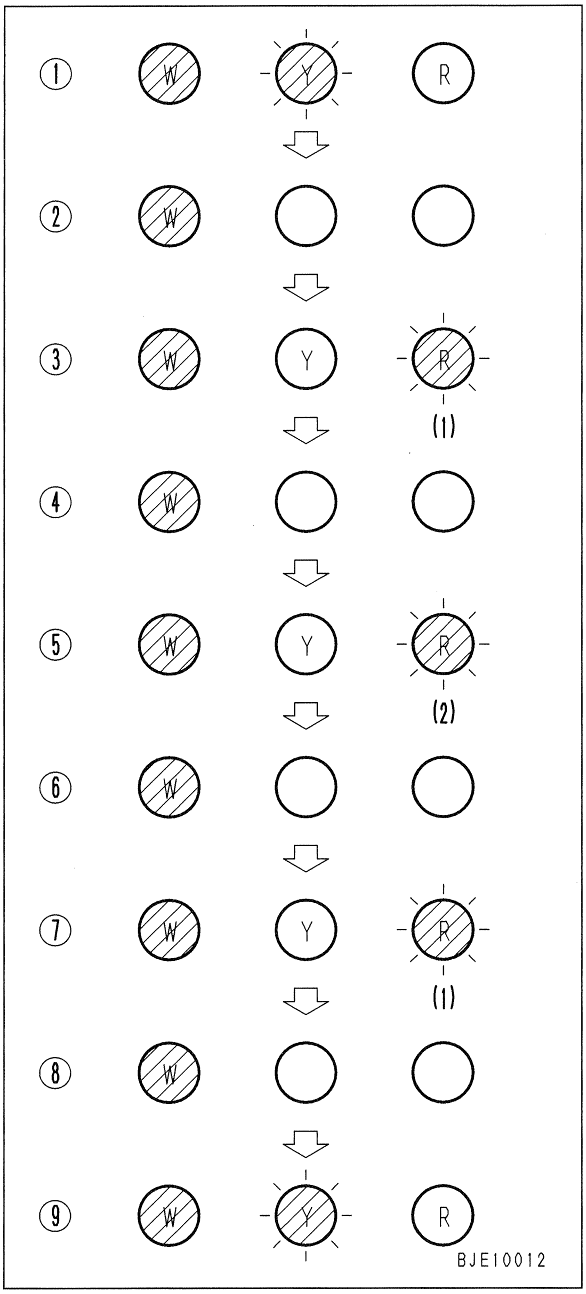
Lamp display type

★ The position of installation of the switches and lamps differs according to the machine.

- When an abnormality occurs, the engine controller displays the applicable error code and level of the problem by a combination of ON, OFF, and flashing of orange lamp (1), yellow lamp (2), and red lamp (3).
- Display of level of problem
  The engine controller lights up the orange, yellow, and red lamps according to the level of the problem that has occurred in the system.
  1) When orange lamp (1) lights up:
     This indicates that the engine controller has recorded the abnormality.
     Depending on the type of abnormality, the output is automatically limited.
  2) When yellow lamp (2) lights up:
     This indicates that an abnormality has occurred, but the engine can still be operated.
  3) When red lamp (3) lights up:
     This indicates that a serious abnormality has occurred and that the engine must be stopped immediately.
- Method of checking error code:
  Turn the starting switch OFF, turn troubleshooting switch (5) ON, then turn the starting switch ON again to display the error code by the combination of lamps as follows.
  ★ The number of times the red lamp flashes displays the number of the error code starting from the left.
  (The orange lamp keeps lighting while the error code is displayed.)
  (1) The yellow lamp (Y) flashes once (Start of display).
  (2) The yellow lamp (Y) is turned off for about 1 second.
  (3) The red lamp (R) flashes to display the number for the first digit.
  (4) The red lamp (R) is turned off for about 1 second.
  (5) The red lamp (R) flashes to display the number for the second digit
  (6) The red lamp (R) is turned off for about 1 second.
  (7) The red lamp (R) flashes to display the number for the third digit.
  (8) The red lamp (R) is turned off for about 1 second.
  (9) The yellow lamp (Y) flashes once (End of display)



Example of display: When displaying error code [121]



★ Displays (2) to (9) display the error code repeatedly until selector switch (4) is used to switch the display code.

★ To switch the error code that is being displayed, operate selector switch (4) to the (+) side to show the next error code or to the (-) side to show the previous error code.

★ When the problem is removed, the error code in memory is automatically deleted from the engine controller.

★ If there is no error code in memory, all three lamp light up.
(Disconnection check of lamps.)

Monitor panel communication type

- The engine controller communicates the error code to the machine monitor panel and displays it as a service code on the monitor panel.

★ For details, see the shop manual for the machine.

2. Table of error codes (lamp display type)

Error code	System with abnormality
111	Abnormality in controller memory
112	Abnormality in timing rail actuator
113	Abnormality with electric current in timing rail actuator system
115	Abnormality in engine speed sensor 2 system
116	Abnormality in timing rail pressure sensor system high level
117	Abnormality in timing rail pressure sensor system low level
118	Abnormality in fuel pump pressure sensor system high level
119	Abnormality in fuel pump pressure sensor system low level
121	Abnormality in engine speed sensor 1 system
122	Abnormality in boost pressure sensor system high level
123	Abnormality in boost pressure sensor system low level
131	Abnormality in throttle sensor system high level
132	Abnormality in throttle sensor system low level
133	Abnormality in remote throttle sensor system high level
134	Abnormality in remote throttle sensor system low level
135	Abnormality in oil pressure sensor system high level
141	Abnormality in oil pressure sensor system low level
143	Abnormal drop in oil pressure (level 1)
144	Abnormality in water temperature sensor system high level
145	Abnormality in water temperature sensor system low level
151	Abnormal rise in water temperature
153	Abnormality in temperature sensor system high level
154	Abnormality in intake air temperature sensor system low level
221	Abnormality in atmospheric pressure sensor system high level
222	Abnormality in atmospheric pressure sensor system low level
234	Overspeed
254	Abnormality in fuel shut-off valve system voltage
259	Abnormality in fuel shut-off valve
261	Abnormal rise in fuel temperature
263	Abnormality in fuel temperature sensor system high level
265	Abnormality in fuel temperature sensor system low level
316	Abnormality in fuel pump actuator system current
318	Abnormality in fuel pump actuator
343	Abnormality in controller internal communication
346	Abnormality in controller power down
384	Abnormality in preheating heater control system
415	Abnormal drop in oil pressure (level 2)
423	423 Abnormality in timing rail pressure sensor system in range
431	Abnormality 1 in idling validation switch system
432	Idling validation process error
441	Abnormality in battery voltage low level
442	Abnormality in battery voltage high level
451	Abnormality in fuel rail pressure sensor system high level
452	Abnormality in fuel rail pressure sensor system low level
455	Abnormality in fuel rail actuator system current
467	Abnormality in timing rail actuator control
468	Abnormality in fuel rail actuator control
514	Abnormality in fuel rail actuator
527	Abnormality in dual output solenoid A system
529	Abnormality in dual output solenoid B system
551	Abnormality 2 in idling validation switch system
554	Abnormality in fuel rail pressure sensor in range

3. Points to remember when troubleshooting

1) Points to remember if abnormality returns to normal by itself:

   If the connector is disconnected and the T-adapter is inserted, or if the T-adapter is removed and the connector is returned to its original position when carrying out troubleshooting, and the error code is no longer displayed, the abnormality has proba-bly returned to normal by itself.

   However, there is a high probability that the same problem will occur again, so it is desirable to follow up this problem carefully.

2) Handling connectors:
   - ★ Before carrying out troubleshooting, check that all the connectors related to the error code are properly inserted.
   - ★ Always connect any disconnected connectors before going on the next step and when finishing the troubleshooting operation.

ACTION TAKEN BY CONTROLLER AND CONDITION OF MACHINE WHEN ERROR CODE IS DISPLAYED

User code	System with abnormality	Nature of abnormality	Condition when normal
111	Abnormality in controller memory	Failure of memory hardware inside controller or communications failure in internal processor	—
112	Abnormality in timing rail actuator	• Abnormality in timing rail Excessive difference between timing rail command fuel value and actual timing fuel Judgment value (reference): Difference more than 400 mm^3/st or less than –750 mm^3/st (when coolant temperature is 0°C or above)	—
113	Abnormality with electric current in timing rail actuator system	• Abnormality has occurred in timing rail actuator circuit Between ECMA (1) and (20) (reference value): Detected outside range of 0.40±0.35A (engine stopped)	• Resistance of timing rail actuator Between TIMG (A) and (C): 7 – 9 Ω
115	Abnormality in engine speed sensor 2 system	• No signal is input from engine speed sensor circuit system 2 ECMA (27), (28): Signal 1 ECMA (37), (38): Signal 2	• Resistance of engine speed sensor Between SP2 (A) and (B) (signal 1):1 – 2 kΩ Between SP1 (A) and (B) (signal 2):1 – 2 kΩ
116	Abnormality in timing rail pressure sensor system high level	• Abnormality has occurred in timing rail pressure sensor circuit ECMA (33): 4.78 V or more detected	• Voltage of timing rail pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (33) and (18) (signal): 0.42 – 0.58 V (engine stopped)
117	Abnormality in timing rail pressure sensor system low level	• Abnormality has occurred in timing rail pressure sensor circuit ECMA (33): 0.30 V or less detected	• Voltage of timing rail pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (33) and (18) (signal): 0.42 – 0.58 V (engine stopped)
118	Abnormality in fuel pump pressure sensor system high level	• Abnormality has occurred in fuel pump pressure sensor circuit ECMA (32): 4.78 V or more detected	• Voltage of fuel pump pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (32) and (18) (signal): 0.42 – 0.58 V (engine stopped)
119	Abnormality in fuel pump pressure sensor system low level	• Abnormality has occurred in fuel pump pressure sensor circuit ECMA (32): 0.30 V or less detected	• Voltage of fuel pump pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (32) and (18) (signal): 0.42 – 0.58 V (engine stopped)
121	Abnormality in engine speed sensor 1 system	• 15. No signal is input from engine speed sensor circuit system 2 to one of following ECMA (27), (28): Signal 1 ECMA (37), (38): Signal 2	• Resistance of engine speed sensor Between SP2 (A) and (B) (signal 1): 1 – 2 kΩ Between SP1 (A) and (B) (signal 2): 1 – 2 kΩ
122	Abnormality in boost pressure sensor system high level	• Abnormality has occurred in boost pressure sensor circuit ECMA (35): 4.72 V or more detected	• Voltage of boost pressure sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (35) and (17) (signal): 0.42 – 0.58 V (engine stopped)
123	Abnormality in boost pressure sensor system low level	• Abnormality has occurred in boost pressure sensor circuit ECMA (35): 0.30 V or less detected	• Voltage of boost pressure sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (35) and (17) (signal): 0.42 – 0.58 V (engine stopped)

Action by controller	Problem that appears on machine	Probable cause
• Red lamp lights up	• Engine cannot be started	• Defective engine controller
• Red lamp lights up • Limits engine speed to 1500 rpm	• Engine speed goes down	• Excessive negative pressure at inlet port of fuel pump • Defective timing rail actuator or clogged screen • Broken injector O-ring • Defective engine controller
• Yellow lamp lights up	• Engine output goes down • Engine emits white smoke	• Defective timing rail actuator • Defective wiring harness and connector of timing rail actuator circuit • Defective engine controller
• Red lamp lights up • Outputs speed signal 0 rpm	• Engine stops	• Defective engine speed sensor • Defective wiring harness and connector of engine speed sensor circuit • Defective engine controller
• Red lamp lights up • Carries out open control of timing rail • Limits engine speed to 1500 rpm	• Engine makes abnormal explosion sound or emits white smoke, then engine speed becomes 1500 rpm	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller
• Red lamp lights up • Carries out open control of timing rail • Limits engine speed to 1500 rpm	• Engine makes abnormal explosion sound or emits white smoke, then engine speed becomes 1500 rpm1	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller
• Yellow lamp lights up • Carries out open control of fuel pump	—	• Defective fuel pump pressure sensor • Defective wiring harness and connector of fuel pump pressure sensor circuit • Defective engine controller
• Yellow lamp lights up • Carries out open control of fuel pump	—	• Defective fuel pump pressure sensor • Defective wiring harness and connector of fuel pump pressure sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective engine speed sensor • Defective wiring harness and connector of engine speed sensor circuit • Defective engine controller
• No lamps light up	• Exhaust gas color is poor when accelerating • Engine output increases	• Defective boost pressure sensor • Defective wiring harness and connector of boost pressure sensor circuit • Defective engine controller
• No lamps light up	• Engine output goes down	• Defective boost pressure sensor • Defective wiring harness and connector of boost pressure sensor circuit • Defective engine controller

User code	System with abnormality	Nature of abnormality	Condition when normal
131	Abnormality in throttle sensor system high level	• Abnormality has occurred in throttle sensor circuit ECMB (29): 4.80 V or more detected	• Resistance of throttle sensor Between TPS (C) and (A) (power source): 2,000 – 3,000 Ω Between TPS (B) and (A) (signal): 200 – 3,000 Ω
132	Abnormality in throttle sensor system low level	• Abnormality has occurred in throttle sensor circuit ECMB (29): 0.30 V or less detected	• Resistance of throttle sensor Between TPS (C) and (A) (power source): 2,000 – 3,000 Ω Between TPS (B) and (A) (signal): 200 – 3,000 Ω
133	Abnormality in remote throttle sensor system high level	• Abnormality has occurred in remote throttle sensor circuit ECMB (30): 4.80 V or more detecte	• Resistance of remote throttle sensor Between RTPS (C) and (A) (power source): 2,000 – 3,000 Ω Between RTPS (B) and (A) (signal): 200 – 3000 Ω
134	Abnormality in remote throttle sensor system low level	• Abnormality has occurred in remote throttle sensor circuit ECMB (30): 0.30 V or less detected	• Resistance of remote throttle sensor Between RTPS (C) and (A) (power source): 2,000 – 3,000 Ω Between RTPS (B) and (A) (signal): 200 – 3,000 Ω
135	Abnormality in oil pressure sensor system high level	• Abnormality has occurred in oil pressure sensor circuit ECMB (24): 4.88 V or more detected	• Voltage of oil pressure sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (24) and (17) (signal): 0.42 – 0.58 V (engine stopped)
141	Abnormality in oil pressure sensor system low level	• Abnormality has occurred in oil pressure sensor circuit ECMA (24): 0.31 V or less detected	• 14. Voltage of oil pressure sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (24) and (17) (signal): 0.42 – 0.58 V (engine stopped)
143	Abnormal drop in oil pressure (level 1)	• Oil pressure sensor detected pressure lower than set oil pressure (level 1) Level 1 judgment value (reference) At 600 rpm Max. 0.05 MPa { 0.5 kg/cm^2} At 1000 rpm Max. 0.09 MPa { 0.9 kg/cm^2} At 1500 rpm Max. 0.15 MPa { 1.5 kg/cm^2} At 1800 rpm Max. 0.18 MPa {1.85 kg/cm^2} At 2000 rpm Max. 0.21 MPa { 21 kg/cm^2}	—
144	Abnormality in water temperature sensor system high level	• Abnormality has occurred in water temperature sensor circuit ECMA (22): 4.95 V or more detected	• Resistance of water temperature sensor Between CTS (A) and (B): 600 – 36k Ω
145	Abnormality in water temperature sensor system low level	• Abnormality has occurred in water temperature sensor circuit ECMA (22): 0.21 V or less detected	• Resistance of water temperature sensor Between CTS (A) and (B): 600 – 36k Ω
151	Abnormal rise in water temperature	• Water temperature sensor has detected temperature higher than set temperature Judgment value (reference): Min. 105°C	
153	Abnormality in intake air temperature sensor system high level	• Abnormality has occurred in intake air temperature sensor circuit ECMA (23): 4.88 V or less detected	• Resistance of intake air temperature sensor Between IMTS (A) and (B): 36 – 600 Ω
154	Abnormality in intake air temperature sensor system low level	• Abnormality has occurred in intake air temperature sensor circuit ECMA (23): 0.08 V or more detected	• Resistance of intake air temperature sensor Between IMTS (A) and (B): 36 – 600 Ω
221	Abnormality in atmospheric pressure sensor system high level	• Abnormality has occurred in atmospheric pressure sensor circuit ECMA (34): 4.78 V or more detected	• Voltage of atmospheric temperature sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (34) and (17) (signal): 0.42 – 0.58 V (engine stopped)

Action by controller	Problem that appears on machine	Probable cause
• Red lamp lights up • Holds engine at constant speed	• Engine output and speed suddenly go down	• Defective throttle sensor • Defective wiring harness and connector of throttle sensor circuit • Defective engine controller
• Red lamp lights up • Holds engine at constant speed	• Engine output and speed suddenly go up	• Defective throttle sensor • Defective wiring harness and connector of throttle sensor circuit • Defective engine controller
• Red lamp lights up • Holds engine at constant speed	• Engine speed suddenly goes down	• Defective remote throttle sensor • Defective wiring harness and connector of remote throttle sensor circuit • Defective engine controller
• Red lamp lights up • Holds engine at constant speed	• Engine speed suddenly goes down	• Defective remote throttle sensor • Defective wiring harness and connector of remote throttle sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective oil pressure sensor • Defective wiring harness and connector of oil pressure sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective oil pressure sensor • Defective wiring harness and connector of oil pressure sensor circuit • Defective engine controller
• Orange lamp lights up • After 10 seconds limits injection amount to 50%	—	• Defective engine • Defective oil pressure sensor
• Yellow lamp lights up	—	• Defective water temperature sensor • Defective wiring harness and connector of water temperature sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective water temperature sensor • Defective wiring harness and connector of water temperature sensor circuit • Defective engine controller
• Orange lamp lights up • After 10 seconds limits injection amount to 50%	—	• Defective engine • Defective water temperature sensor
• Yellow lamp lights up	—	• Defective intake air temperature sensor • Defective wiring harness and connector of intake air temperature sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective intake air temperature sensor • Defective wiring harness and connector of intake air temperature sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective atmospheric pressure sensor • Defective wiring harness and connector of atmospheric pressure sensor circuit • Defective engine controller

User code	System with abnormality	Nature of abnormality	Condition when normal
222	Abnormality in atmospheric pressure sensor system low level	• Abnormality has occurred in atmospheric pressure sensor circuit ECMA (34): 0.20 V or less detected	• Voltage of atmospheric pressure sensor Between ECMA (6) and (17) (power source): 4.75 – 5.25 V Between ECMA (34) and (17) (signal): 0.42 – 0.58 V (engine stopped)
234	Overspeed	• Engine speed sensor has detected speed higher than set speed Judgment value (reference): D375A :2,400 rpm or more WA600 :2,500 rpm or more PC1100 :2,400 rpm or more Morita :2,550 rpm or more	—
254	Abnormality in fuel shut-off valve system voltage	• Abnormality has occurred in fuel shut-off valve circuit Between ECMA (30) and (8): Voltage of 6.0 V or less or resistance of 20 Ω or less detected	• Resistance of fuel shut-off valve Between FSO (+) and (-): 23 – 40 Ω
259	Abnormality in fuel shut-off valve	• Fuel shut-off valve remains open and does not close (even when electric power is turned off, engine does not stop)	—
261	Abnormal rise in fuel temperature	• Fuel temperature sensor has detected temperature higher than set temperature Judgment value (reference): 76°C or more	—
263	Abnormality in fuel temperature sensor system high level	• Abnormality has occurred in fuel temperature sensor circuit ECMA (26): 4.95 V or more detected	• Resistance of fuel temperature sensor Between FTS (A) and (B): 600 – 36k Ω
265	Abnormality in fuel temperature sensor system low level	• Abnormality has occurred in fuel temperature sensor circuit ECMA (26): 0.21 V or less detected	• Resistance of fuel temperature sensor Between FTS (A) and (B): 600 – 36k Ω
316	Abnormality in fuel pump actuator system current	• Abnormality has occurred in fuel pump actuator circuit Between ECMA (11) and (40) (reference value): Detected value outside range of 0.40±0.35A (engine stopped)	• Resistance of fuel pump actuator Between PUMP (A) and (C): 7 – 9 Ω
318	Abnormality in fuel pump actuator	• Excessive difference between fuel pump command pressure value and actual pressure Judgment value (reference): Difference more than ±2.11 MPa {2.1 kg/cm^2} (when coolant temperature is 38°C or above)	—
343	Abnormality in controller internal communication	• Microprocessor error inside controller	—
346	Abnormality in controller power down	• Error in data recorded in power-down internal memory of controller	—
384	Abnormality in preheating heater control system	• Abnormality has occurred in preheating heater control circuit ECMB (2): Circuit open or short circuit in circuit detected	• Resistance of heater relay Between relay coils: 000 – 000 Ω
415	Abnormal drop in oil pressure (level 2)	• Oil pressure sensor detected pressure lower than set oil pressure (level 2) Level 1 judgment value (reference) At 600 rpm Max. 0.04 MPa {0.4 kg/cm^2} At 1,000 rpm Max. 0.08 MPa {0.8 kg/cm^2} At 1,500 rpm Max. 0.13 MPa {1.3 kg/cm^2} At 1,800 rpm Max. 0.16 MPa {1.6 kg/cm^2} At 2,000 rpm Max. 0.18 MPa {1.8 kg/cm^2}	—

Action by controller	Problem that appears on machine	Probable cause
• Yellow lamp lights up	—	• Defective atmospheric pressure sensor • Defective wiring harness and connector of atmospheric pressure sensor circuit • Defective engine controller
• Red lamp lights up • Shuts off power supply to fuel shut-off valve Closes fuel rail actuator fully (to shut off fuel).	—	• Defective engine • Defective engine speed sensor • Defect on machine
• No lamps light up • Shuts off power supply to fuel shut-off valve	• Engine stops	• Defective fuel shut-off valve • Defective wiring harness and connector of fuel shut-off valve circuit • Defective engine controller
• Red lamp lights up • Shuts off power supply to fuel shut-off valve	• Engine cannot stop	• Defective fuel shut-off valve • Defective injector • Defective engine controller
• Orange lamp lights up • After 30 seconds limits engine speed to 800 rpm	—	• Defective engine • Defective fuel temperature sensor • Defect on machine
• Yellow lamp lights up	—	• Defective fuel temperature sensor • Defective wiring harness and connector of fuel temperature sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective fuel temperature sensor • Defective wiring harness and connector of fuel temperature sensor circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective fuel pump actuator • Defective wiring harness and connector of fuel pump actuator circuit • Defective engine controller
• Yellow lamp lights up	• Engine speed becomes unstable	• Defective fuel pump actuator • Excessive negative pressure at inlet port of fuel pump • Defective fuel temperature sensor • Defective injector • Defective engine controller
• Yellow lamp lights up	—	• Defective controller
• Yellow lamp lights up	• Loss of power-down data (maintenance data, present controller data, engine operating time, etc.)	• Defective battery • Blown fuse • Defective wiring harness and connector of controller power source circuit • Defective engine controller
• Yellow lamp lights up	—	• Defective heater relay • Defective wiring harness and connector of heater relay circuit • Defective engine controller
• Orange lamp lights up • After 10 seconds limits injection amount to 50%	—	• Defective engine • Defective oil pressure sensor

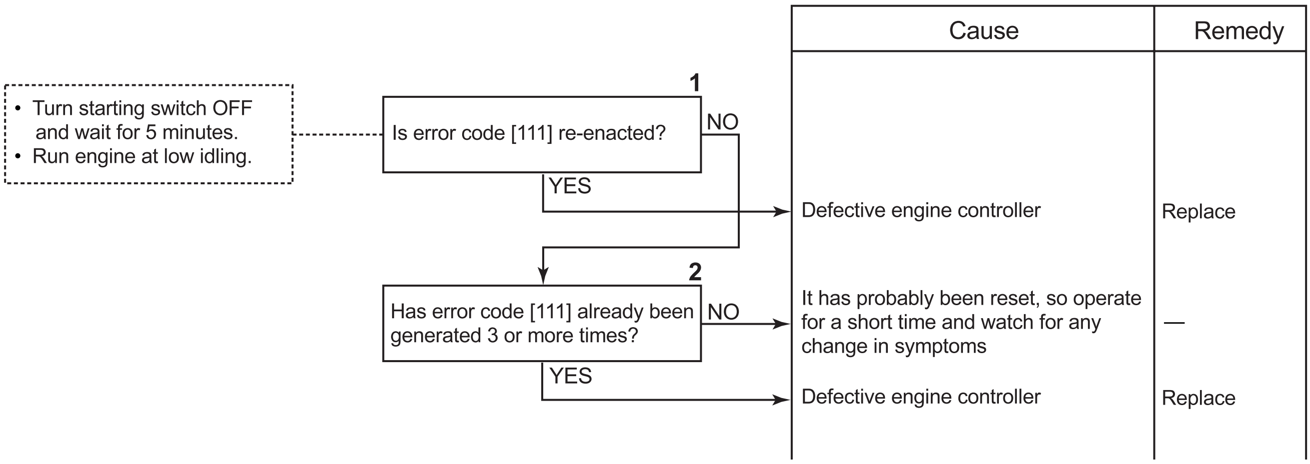
User code	System with abnormality	Nature of abnormality	Condition when normal
423	Abnormality in timing rail pressure sensor system in range	• Timing rail pressure sensor detected abnormal pressure Judgment value (reference) when starting switch is ON: 2.42 MPa {24.65 kg/cm^2} or more	—
431	Abnormality 1 in idling validation switch system	• Simultaneous detection of voltage from both ON signal and OFF signal of idling validation switch ECMB (12): Idling OFF signal ECMB (13): Idling ON signal	• Resistance of idling switch Between IVS (A) and (B): Max. 125 Ω (pedal released) Between IVS (A) and (C): Max. 125 Ω (pedal depressed)
432	Idling validation process error	• Throttle sensor signal and idling validation ON signal, OFF signal do not match ECMB (12): Idling OFF signal ECMB (13): Idling ON signal	• Resistance of idling switch Between IVS (A) and (B): Max. 125 Ω (pedal released) Between IVS (A) and (C): Max. 125 Ω (pedal depressed)
441	Abnormality in battery voltage low level	• Abnormality has occurred in controller power source circuit ECMB (3)(4)(5): 12 V or less detected	• Voltage of controller power source Between ECMB (3)(4)(5) and ECMA (7)(8): 17.3 – 34.7 V (When starting switch is OFF)
442	Abnormality in battery voltage high level	• Abnormality has occurred in controller power source circuit ECMB (3)(4)(5): 38 V or less detected	• Voltage of controller power source Between ECMB (3)(4)(5) and ECMA (7)(8): 17.3 – 34.7 V (When starting switch is OFF)
451	Abnormality in fuel rail pressure sensor system high level	• Abnormality has occurred in fuel rail pressure sensor circuit ECMA (31): 4.78 V or more detected	• Voltage of fuel rail pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (31) and (18) (signal): 0.42 – 0.58 V (engine stopped)
452	Abnormality in fuel rail pressure sensor system low level	• Abnormality has occurred in fuel rail pressure sensor circuit ECMA (31): 0.15 V or less detected	• Voltage of fuel rail pressure sensor Between ECMA (5) and (18) (power source): 4.75 – 5.25 V Between ECMA (31) and (18) (signal): 0.42 – 0.58 V (engine stopped)
455	Abnormality in fuel rail actuator system current	• Abnormality has occurred in fuel rail actuator circuit Between ECMA (1) and (20) (reference value): 0.40 ± 0.35 A (engine stopped)	• Resistance of fuel rail actuator Between RAIL (A) and (C): 7 – 9 Ω
467	Abnormality in timing rail actuator control	• Excessive difference between timing rail command fuel value and actual timing fuel, does not reach target value	—
468	Abnormality in fuel rail actuator control	• Excessive difference between fuel rail command injection amount value and actual injection amount, does not reach target value	—
514	Abnormality in fuel rail actuator	• Excessive difference between fuel rail command injection amount value and actual injection amount Fuel rail judgment value (reference): Difference ±600 mm^3/st or more for ±50 msec or difference ±250 mm^3/st or more for ± 200 msec	—
527	Abnormality in dual output solenoid A system	• Abnormality has occurred in dual output solenoid A circuit ECMB (1): Circuit open or short circuit detected	• Resistance of dual output solenoid A Between solenoid pins: 28 – 32 Ω

Action by controller	Problem that appears on machine	Probable cause
• Yellow lamp lights up • Limits high idling speed to 1,500 rpm	—	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller • Excessive suction resistance of fuel filter
• Red lamp lights up	—	• Defective idling validation switch • Defective wiring harness and connector of idling validation switch • Defective engine controller
• Red lamp lights up • Recognizes throttle signal as 0%	—	• Defective idling validation switch • Defective wiring harness and connector of idling validation switch • Defective engine controller
—	—	• Defective battery • Blown fuse • Defective wiring harness and connector of controller power source circuit • Defective engine controller
—	—	• Defective battery • Blown fuse • Defective wiring harness and connector of controller power source circuit • Defective engine controller
• Red lamp lights up • Carries out open control of fuel rail	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller
• Red lamp lights up • Carries out open control of fuel rail	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller
• Red lamp lights up • Sets current to fuel rail actuator to 0 A	—	• Defective fuel rail actuator • Defective wiring harness and connector of fuel rail actuator circuit • Defective engine controller
• Yellow lamp lights up • Limits engine speed to 1500 rpm	—	• Excessive negative pressure at inlet port of fuel pump • Defective timing rail actuator or clogged screen • Broken injector O-ring • Defective engine controller
• Yellow lamp lights up • Limits maximum injection amount to 217 mm^3/st	—	• Excessive negative pressure at inlet port of fuel pump • Defective fuel rail actuator or clogged screen • Broken injector O-ring • Defective engine controller
• Yellow lamp lights up • Limits maximum injection amount to 217 mm^3/st	—	• Excessive negative pressure at inlet port of fuel pump • Defective fuel rail actuator or clogged screen • Broken injector O-ring • Defective engine controller
• Yellow lamp lights up	—	• Defective dual output solenoid A • Defective wiring harness and connector of dual output solenoid A circuit • Defective engine controller

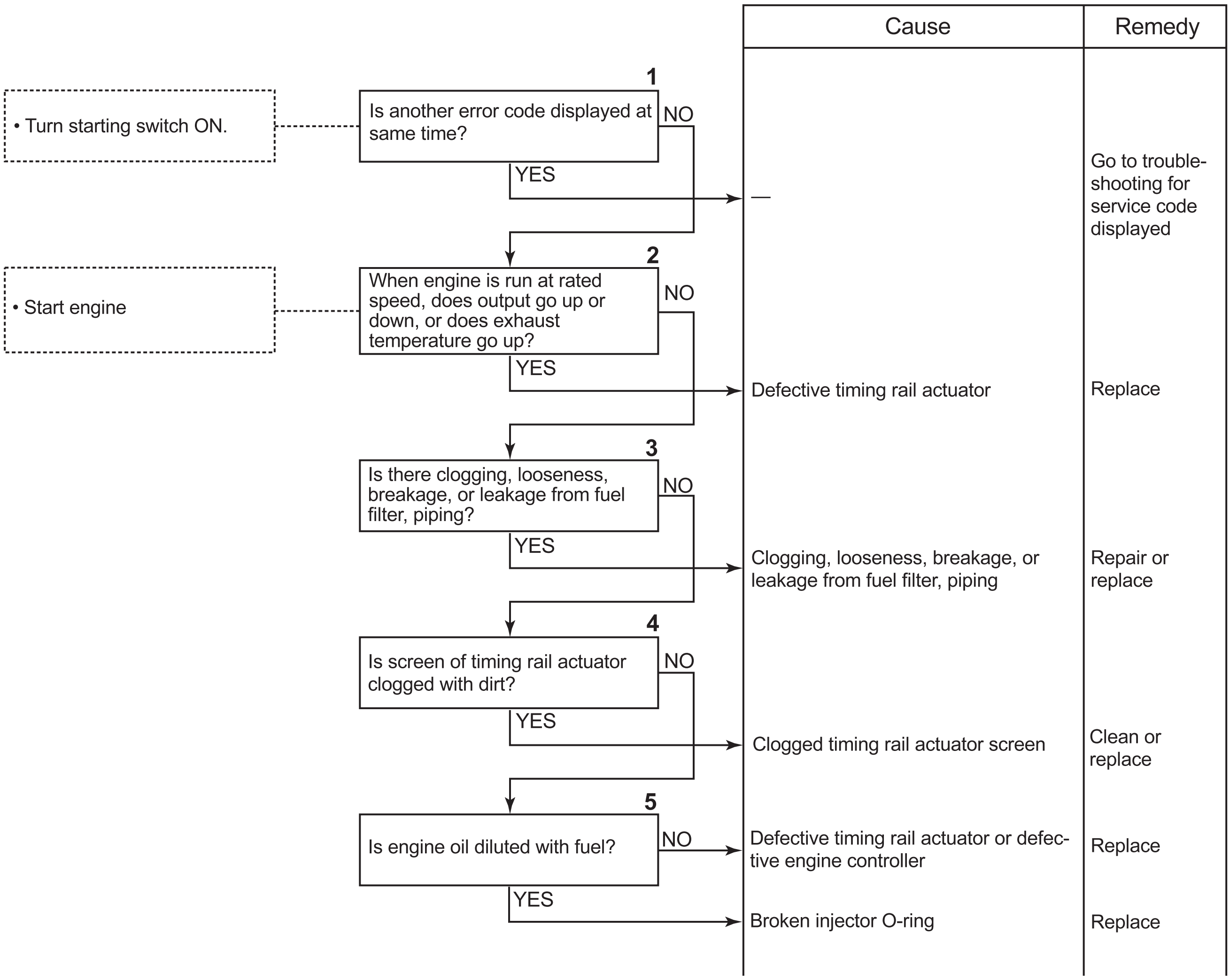
User code	System with abnormality	Nature of abnormality	Condition when normal
529	Abnormality in dual output solenoid B system	• Abnormality has occurred in dual output solenoid B circuit ECMB (9): Circuit open or short circuit detected	• Resistance of dual output solenoid B Between solenoid pins: 28 – 32 Ω
551	Abnormality 2 in idling validation switch system	• Simultaneous detection of no voltage from both ON signal and OFF signal of idling validation switch ECMB (12): Idling OFF signal ECMB (13): Idling ON signal	• Resistance of idling switch Between IVS (A) and (B): Max. 125 Ω (pedal released) Between IVS (A) and (C): Max. 125 Ω (pedal depressed)
554	Abnormality in fuel rail pressure sensor in range	• Fuel rail pressure sensor detected abnormal pressure Judgment value (reference): When starting switch is ON: 0.17 MPa {1.76 kg/cm^2} or more	—

Action by controller	Problem that appears on machine	Probable cause
• Yellow lamp lights up	—	• Defective dual output solenoid B • Defective wiring harness and connector of dual output solenoid B circuit • Defective engine controller
• Red lamp lights up • Recognizes throttle signal as 0%	—	• Defective idling validation switch • Defective wiring harness and connector of idling validation switch circuit • Defective engine controller
• Yellow lamp lights up • Limits maximum injection amount to 270 mm^3/st	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller • Excessive suction resistance of fuel filter

EA-1 Error code [111] (Abnormality in controller memory)



EA-2 Error code [112] (Abnormality in timing rail actuator



EA-3 Error code [113] (Abnormality with electric current in timing rail actuator system)

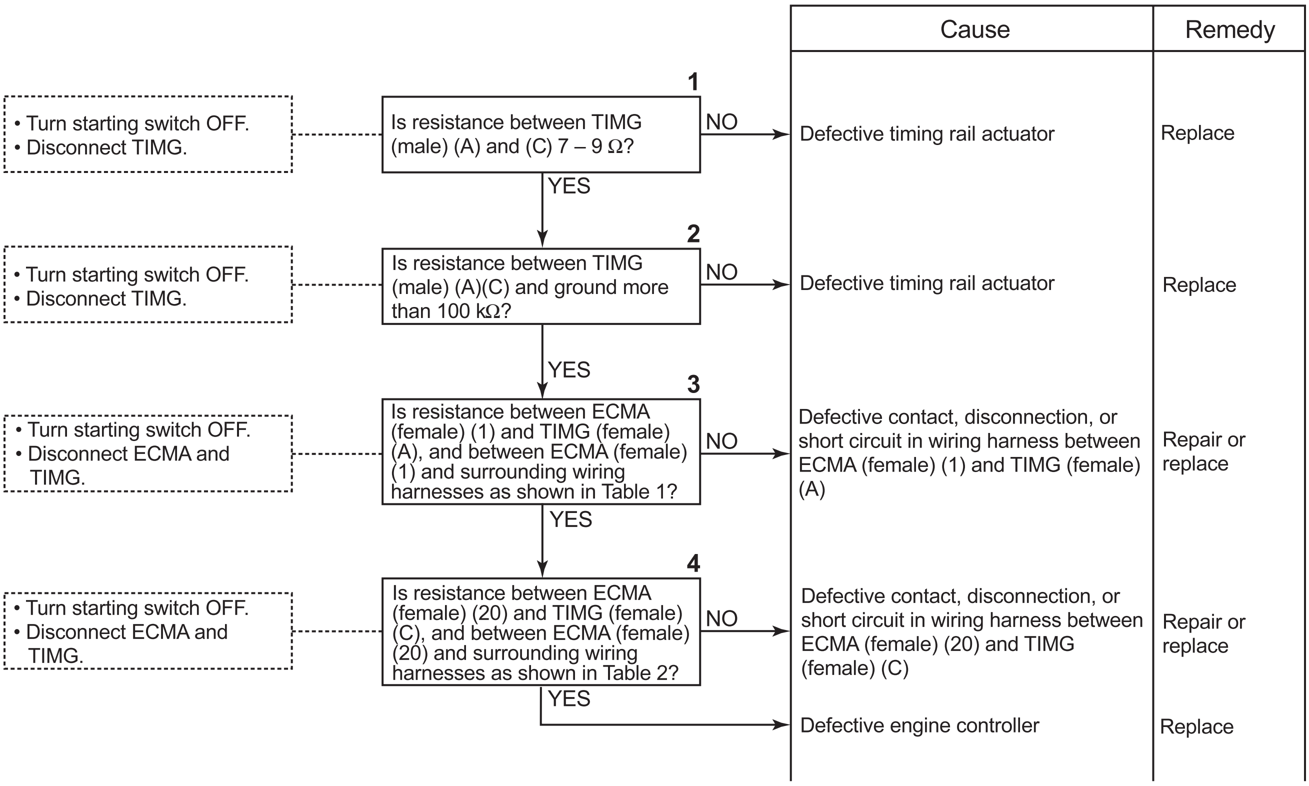


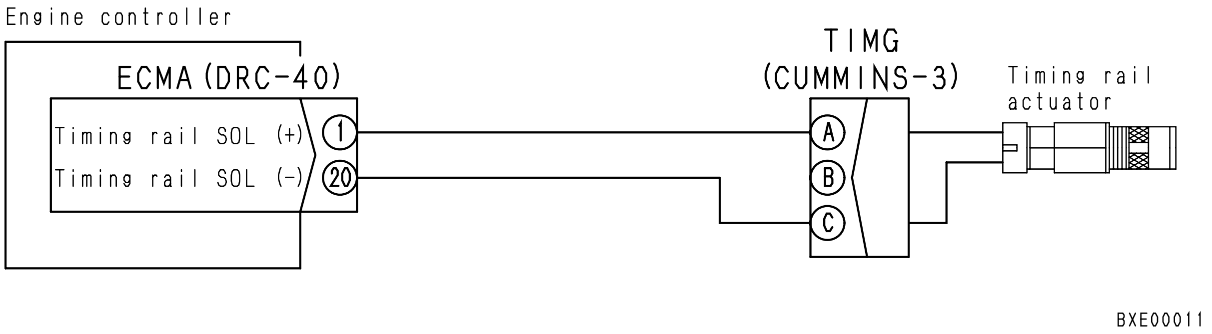
Table 1

ECMA (female), TIMG (female)	Resistance value
Between ECMA (1) and TIMG (A)	Max. 10Ω
Between ECMA (1) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), TIMG (female)	Resistance value
Between ECMA (20) and TIMG (C)	Max. 10Ω
Between ECMA (20) and surrounding wiring harnesses	Min. 1 MΩ

EA-3 Related electrical circuit diagram



EA-4 Error code [115] (Abnormality in engine speed sensor 2 system)

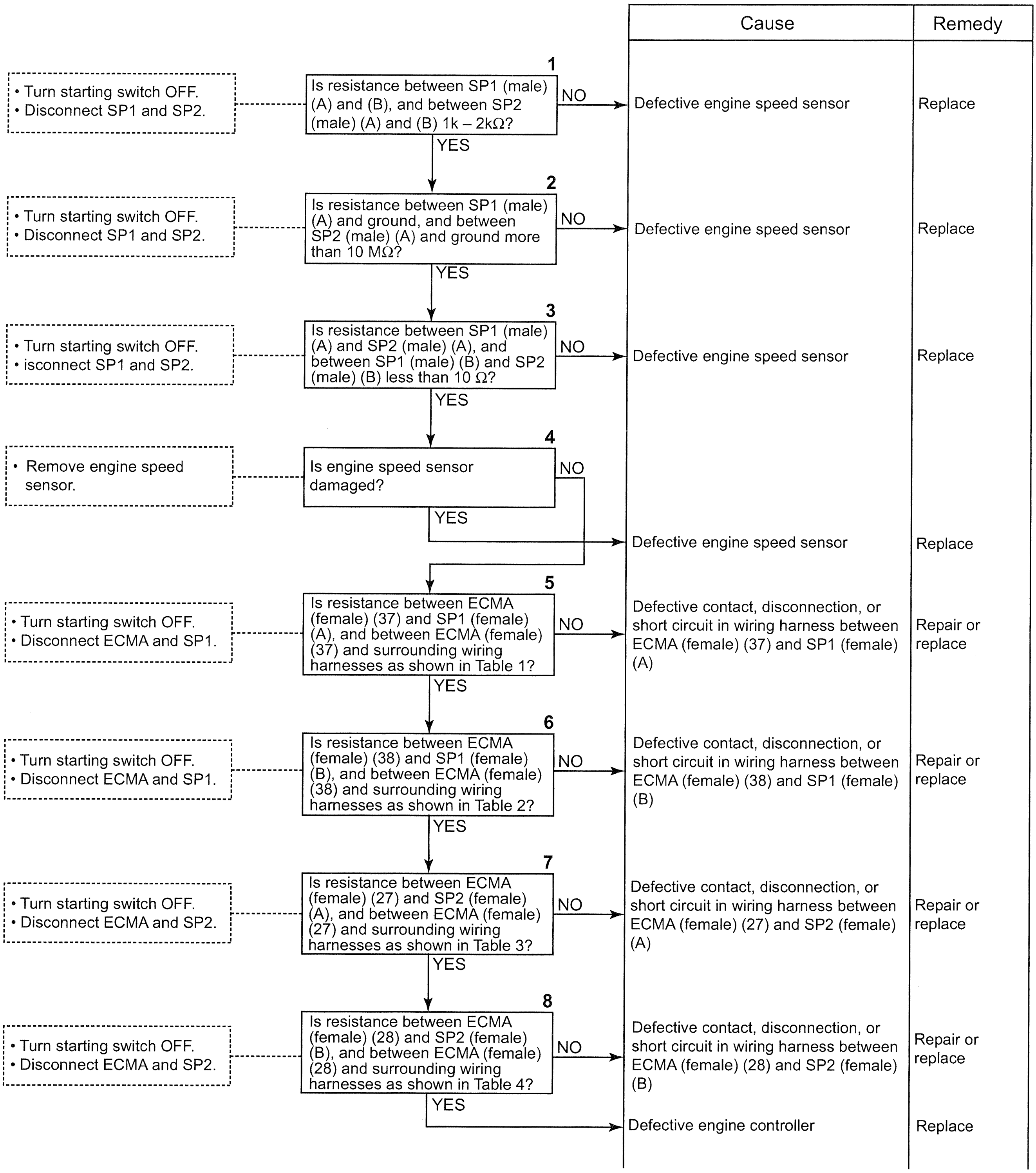


Table 1

ECMA (female), SP1 (female)	Resistance value
Between ECMA (37) and SP1 (A)	Max. 10Ω
Between ECMA (37) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), SP1 (female)	Resistance value
Between ECMA (38) and SP1 (B)	Max. 10Ω
Between ECMA (38) and surrounding wiring harnesses	Min. 1 MΩ

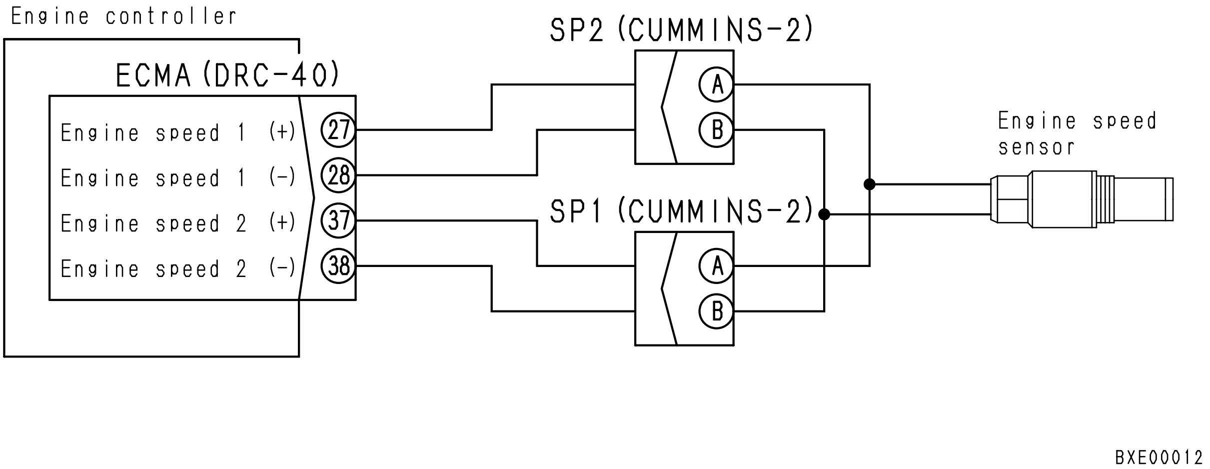
Table 3

ECMA (female), SP2 (female)	Resistance value
Between ECMA (27) and SP2 (A)	Max. 10Ω
Between ECMA (27) and surrounding wiring harnesses	Min. 1 MΩ

Table 3

ECMA (female), SP2 (female)	Resistance value
Between ECMA (28) and SP2 (B)	Max. 10Ω
Between ECMA (28) and surrounding wiring harnesses	Min. 1 MΩ

EA-4 Related electrical circuit diagram



EA-5 Error code [116] (Abnormality in timing rail pressure sensor system high level)

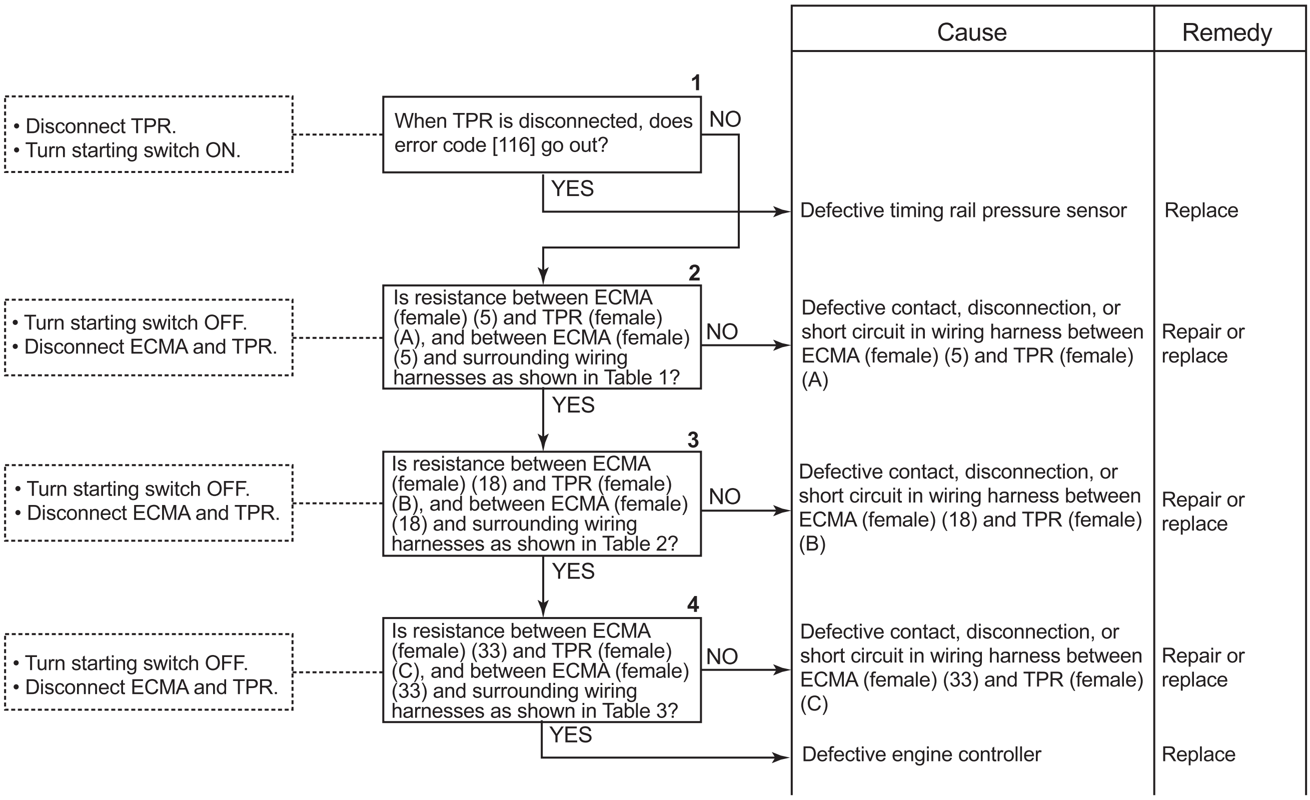


Table 1

ECMA (female), TPR (female)	Resistance value
Between ECMA (5) and TPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

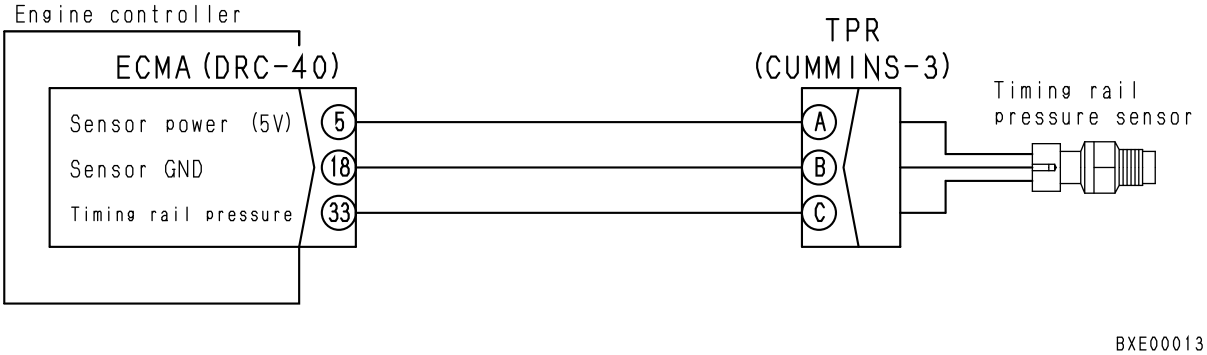
Table 2

ECMA (female), SP1 (female)	Resistance value
Between ECMA (18) and TPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

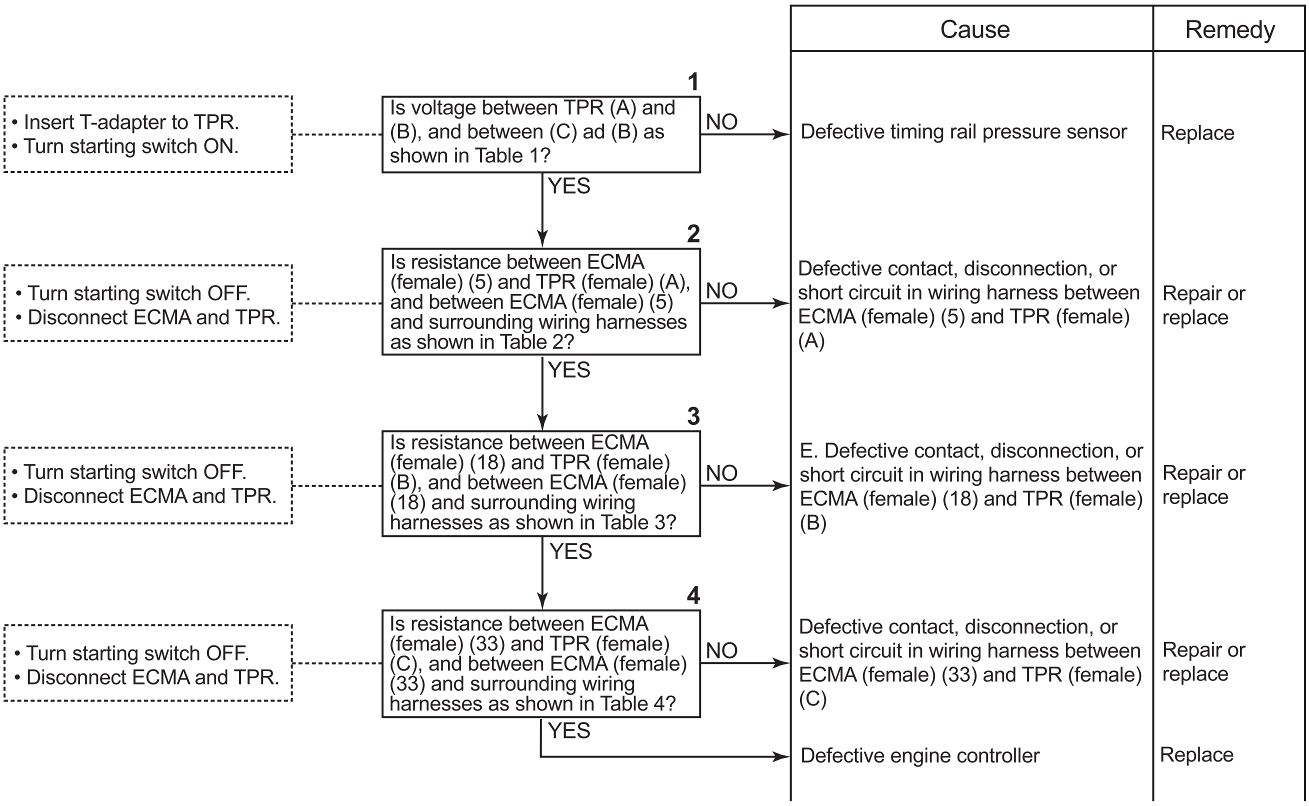
Table 3

ECMA (female), TPR (female)	Resistance value
Between ECMA (33) and TPR (C)	Max. 10Ω
Between ECMA (33) and surrounding wiring harnesses	Min. 1 MΩ

EA-5 Related electrical circuit diagram



EA-6 Error code [117] (abnormality in timing rail pressure sensor system low level)



1

- Insert T-adapter to TPR.
- Turn starting switch ON.

Is voltage between TPR (A) and (B), and between (C) ad (B) as shown in Table 1?

NO → Cause: Defective timing rail pressure sensor — Remedy: Replace

YES ↓

2

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

Is resistance between ECMA (female) (5) and TPR (female) (A), and between ECMA (female) (5) and surrounding wiring harnesses as shown in Table 2?

NO → Cause: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (5) and TPR (female) (A) — Remedy: Repair or replace

YES ↓

3

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

Is resistance between ECMA (female) (18) and TPR (female) (B), and between ECMA (female) (18) and surrounding wiring harnesses as shown in Table 3?

NO → Cause: E. Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (18) and TPR (female) (B) — Remedy: Repair or replace

YES ↓

4

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

Is resistance between ECMA (female) (33) and TPR (female) (C), and between ECMA (female) (33) and surrounding wiring harnesses as shown in Table 4?

NO → Cause: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (33) and TPR (female) (C) — Remedy: Repair or replace

YES → Cause: Defective engine controller — Remedy: Replace

Table 1

TPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), TPR (female)	Resistance value
Between ECMA (5) and TPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

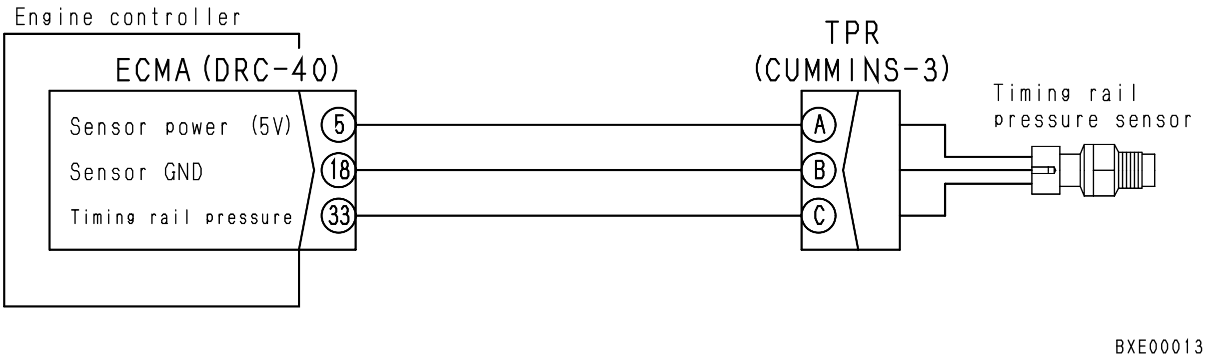
Table 3

ECMA (female), TPR (female)	Resistance value
Between ECMA (18) and TPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

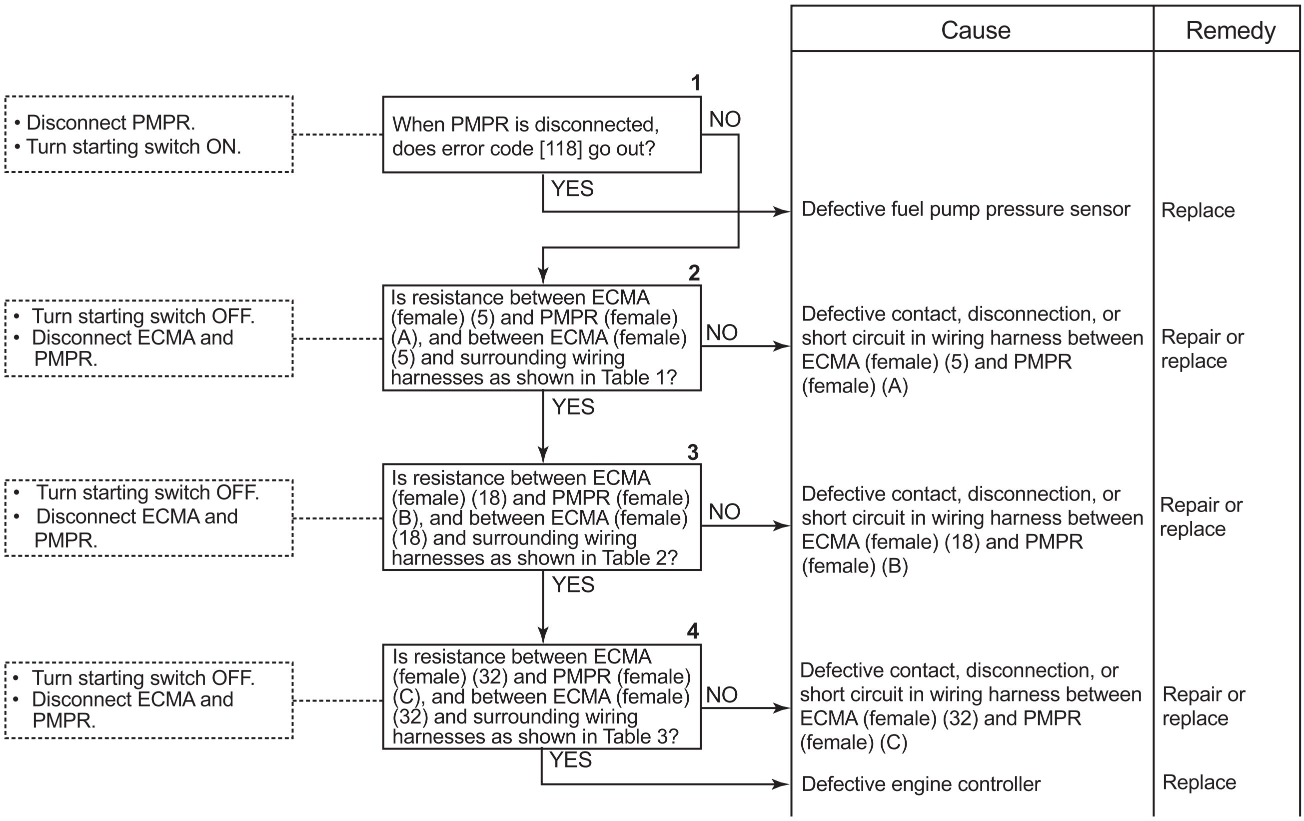
Table 4

ECMA (female), TPR (female)	Resistance value
Between ECMA (33) and TPR (C)	Max. 10Ω
Between ECMA (33) and surrounding wiring harnesses	Min. 1 MΩ

EA-6 Related electrical circuit diagram



EA-7 Error code [118] (Abnormality in fuel pump pressure sensor system high level)



Step	Preparation	Check	NO	YES
1	• Disconnect PMPR. • Turn starting switch ON.	When PMPR is disconnected, does error code [118] go out?	Go to 2	Cause: Defective fuel pump pressure sensor — Remedy: Replace
2	• Turn starting switch OFF. • Disconnect ECMA and PMPR.	Is resistance between ECMA (female) (5) and PMPR (female) (A), and between ECMA (female) (5) and surrounding wiring harnesses as shown in Table 1?	Cause: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (5) and PMPR (female) (A) — Remedy: Repair or replace	Go to 3
3	• Turn starting switch OFF. • Disconnect ECMA and PMPR.	Is resistance between ECMA (female) (18) and PMPR (female) (B), and between ECMA (female) (18) and surrounding wiring harnesses as shown in Table 2?	Cause: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (18) and PMPR (female) (B) — Remedy: Repair or replace	Go to 4
4	• Turn starting switch OFF. • Disconnect ECMA and PMPR.	Is resistance between ECMA (female) (32) and PMPR (female) (C), and between ECMA (female) (32) and surrounding wiring harnesses as shown in Table 3?	Cause: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (32) and PMPR (female) (C) — Remedy: Repair or replace	Cause: Defective engine controller — Remedy: Replace

Table 1

ECMA (female), PMPR (female)	Resistance value
Between ECMA (5) and PMPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

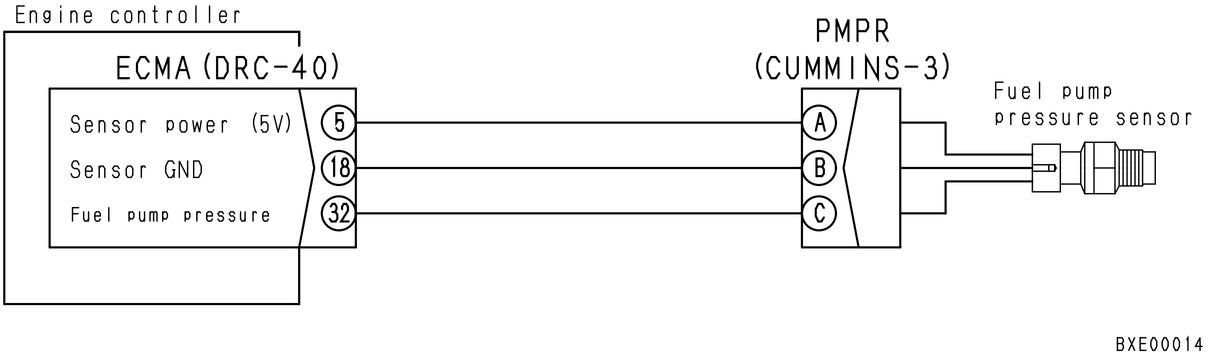
Table 2

ECMA (female), PMPR (female)	Resistance value
Between ECMA (18) and PMPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

Table 3

ECMA (female), PMPR (female)	Resistance value
Between ECMA (32) and PMPR (C)	Max. 10Ω
Between ECMA (32) and surrounding wiring harnesses	Min. 1 MΩ

EA-7 Related electrical circuit diagram



EA-8 Error code [119] (Abnormality in fuel pump pressure sensor system low level)

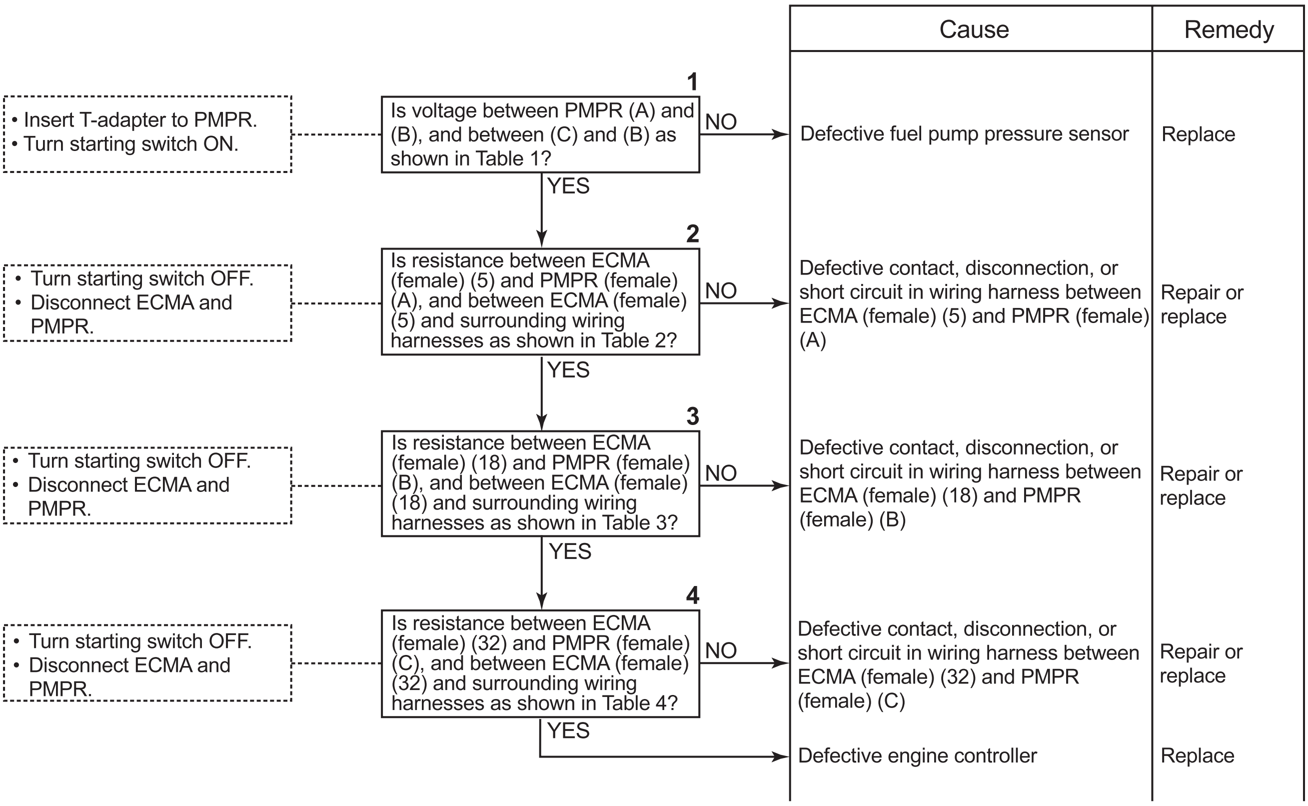


Table 1

PMPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), PMPR (female)	Resistance value
Between ECMA (5) and PMPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

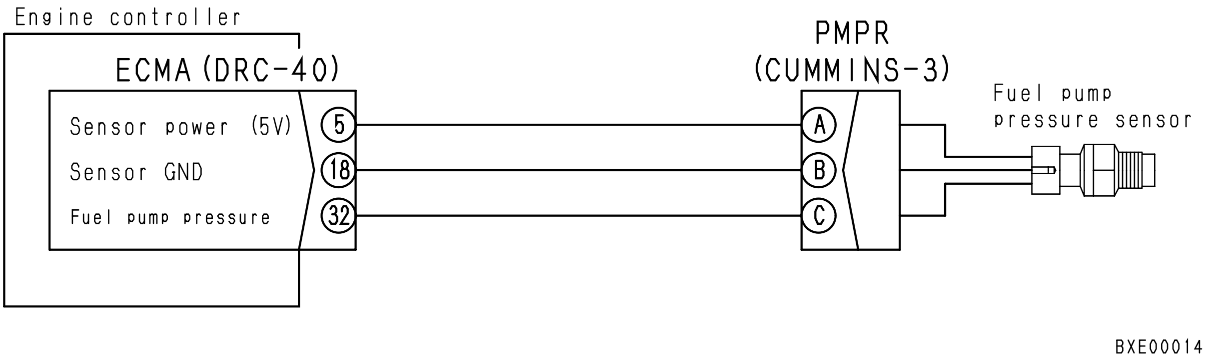
Table 3

ECMA (female), PMPR (female)	Resistance value
Between ECMA (18) and PMPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

ECMA (female), PMPR (female)	Resistance value
Between ECMA (32) and PMPR (C)	Max. 10Ω
Between ECMA (32) and surrounding wiring harnesses	Min. 1 MΩ

EA-8 Related electrical circuit diagram



EA-9 Error code [121] (Abnormality in engine speed sensor 1 system)

★ Carry out troubleshooting for error code [115].

EA-10 Error code [122] (Abnormality in boost pressure sensor system high level)

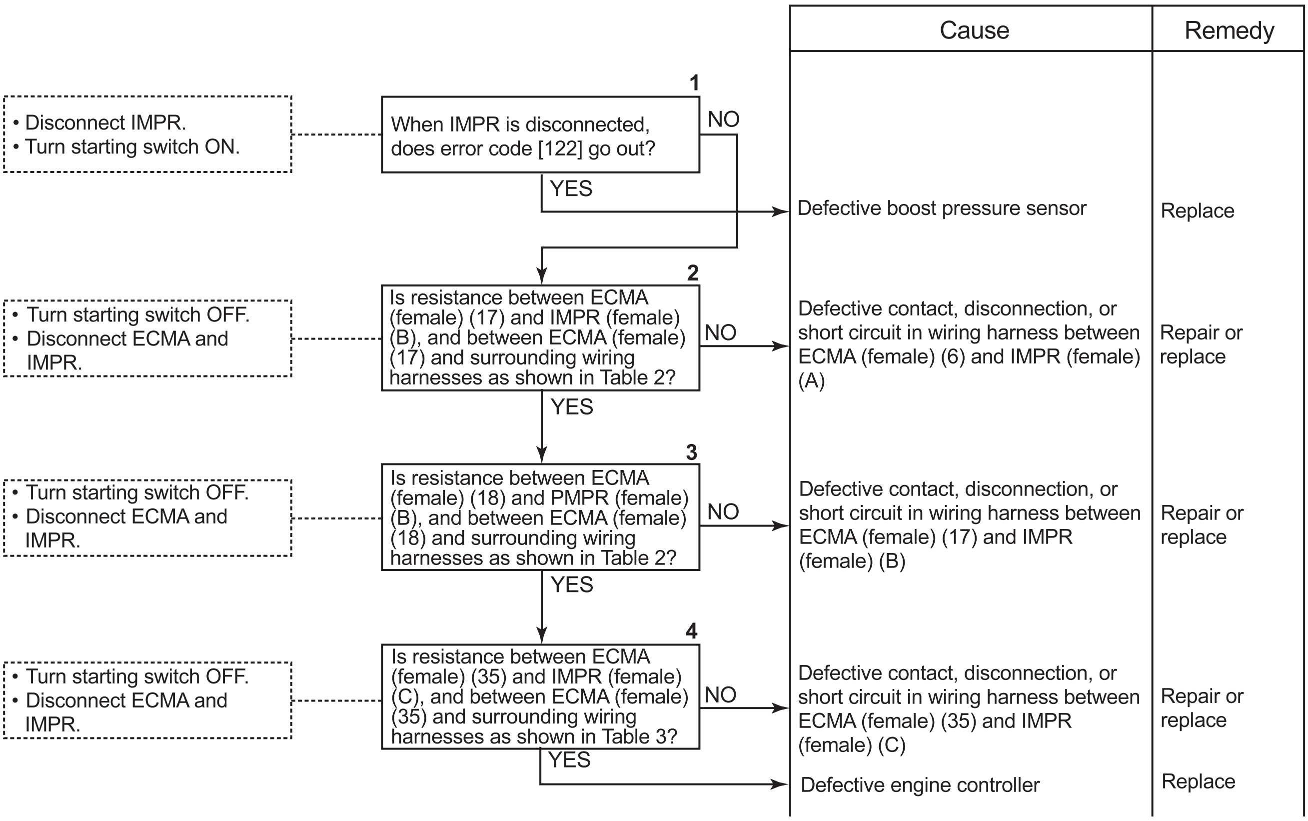


Table 1

ECMA (female), IMPR (female)	Resistance value
Between ECMA (6) and IMPR (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

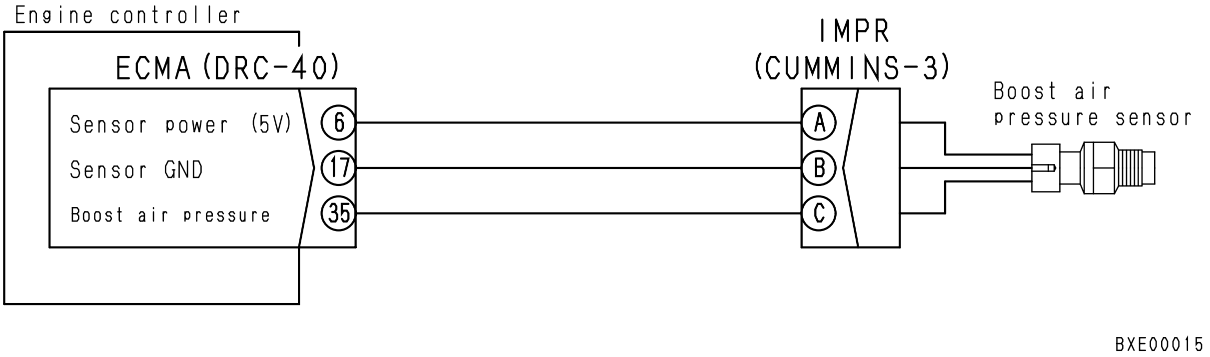
Table 2

ECMA (female), IMPR (female)	Resistance value
Between ECMA (17) and IMPR (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

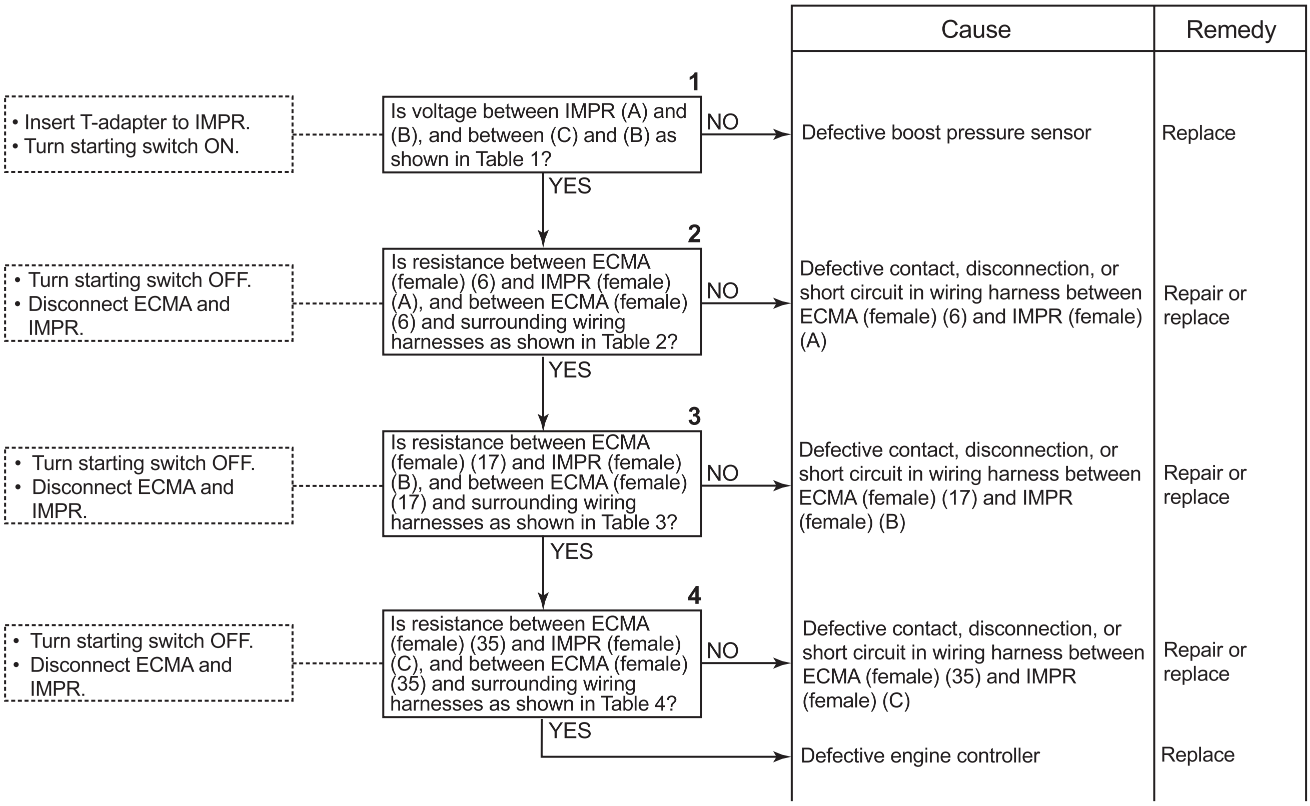
Table 3

ECMA (female), IMPR (female)	Resistance value
Between ECMA (35) and IMPR (C)	Max. 10Ω
Between ECMA (35) and surrounding wiring harnesses	Min. 1 MΩ

EA-10 Related electrical circuit diagram



EA-11 Error code [123] (Abnormality in boost pressure sensor system low level)



Step	Preparation	Check	Cause	Remedy
1	• Insert T-adapter to IMPR. • Turn starting switch ON.	Is voltage between IMPR (A) and (B), and between (C) and (B) as shown in Table 1? NO →	Defective boost pressure sensor	Replace
2	• Turn starting switch OFF. • Disconnect ECMA and IMPR.	YES → Is resistance between ECMA (female) (6) and IMPR (female) (A), and between ECMA (female) (6) and surrounding wiring harnesses as shown in Table 2? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (6) and IMPR (female) (A)	Repair or replace
3	• Turn starting switch OFF. • Disconnect ECMA and IMPR.	YES → Is resistance between ECMA (female) (17) and IMPR (female) (B), and between ECMA (female) (17) and surrounding wiring harnesses as shown in Table 3? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (17) and IMPR (female) (B)	Repair or replace
4	• Turn starting switch OFF. • Disconnect ECMA and IMPR.	YES → Is resistance between ECMA (female) (35) and IMPR (female) (C), and between ECMA (female) (35) and surrounding wiring harnesses as shown in Table 4? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (35) and IMPR (female) (C)	Repair or replace
		YES →	Defective engine controller	Replace

Table 1

IMPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), IMPR (female)	Resistance value
Between ECMA (6) and IMPR (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

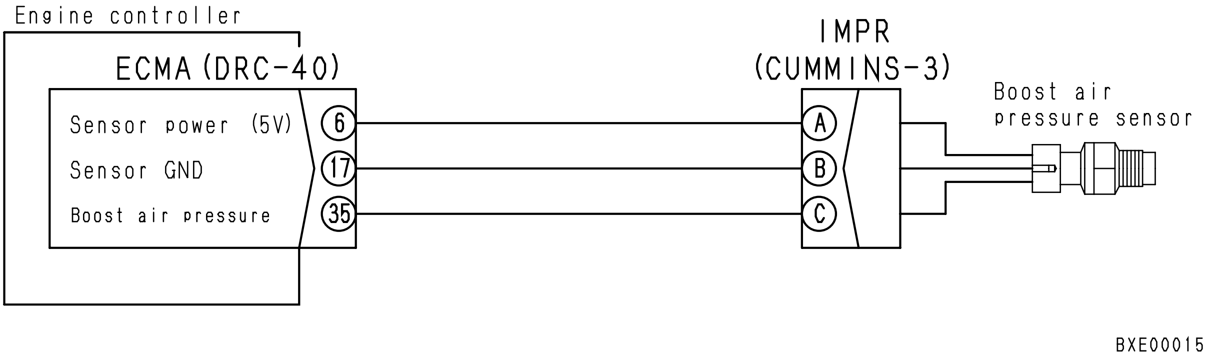
Table 3

ECMA (female), IMPR (female)	Resistance value
Between ECMA (17) and IMPR (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

ECMA (female), IMPR (female)	Resistance value
Between ECMA (35) and IMPR (C)	Max. 10Ω
Between ECMA (35) and surrounding wiring harnesses	Min. 1 MΩ

EA-11 Related electrical circuit diagram



BXE00015

EA-12 Error code [131] (Abnormality in throttle sensor system high level)

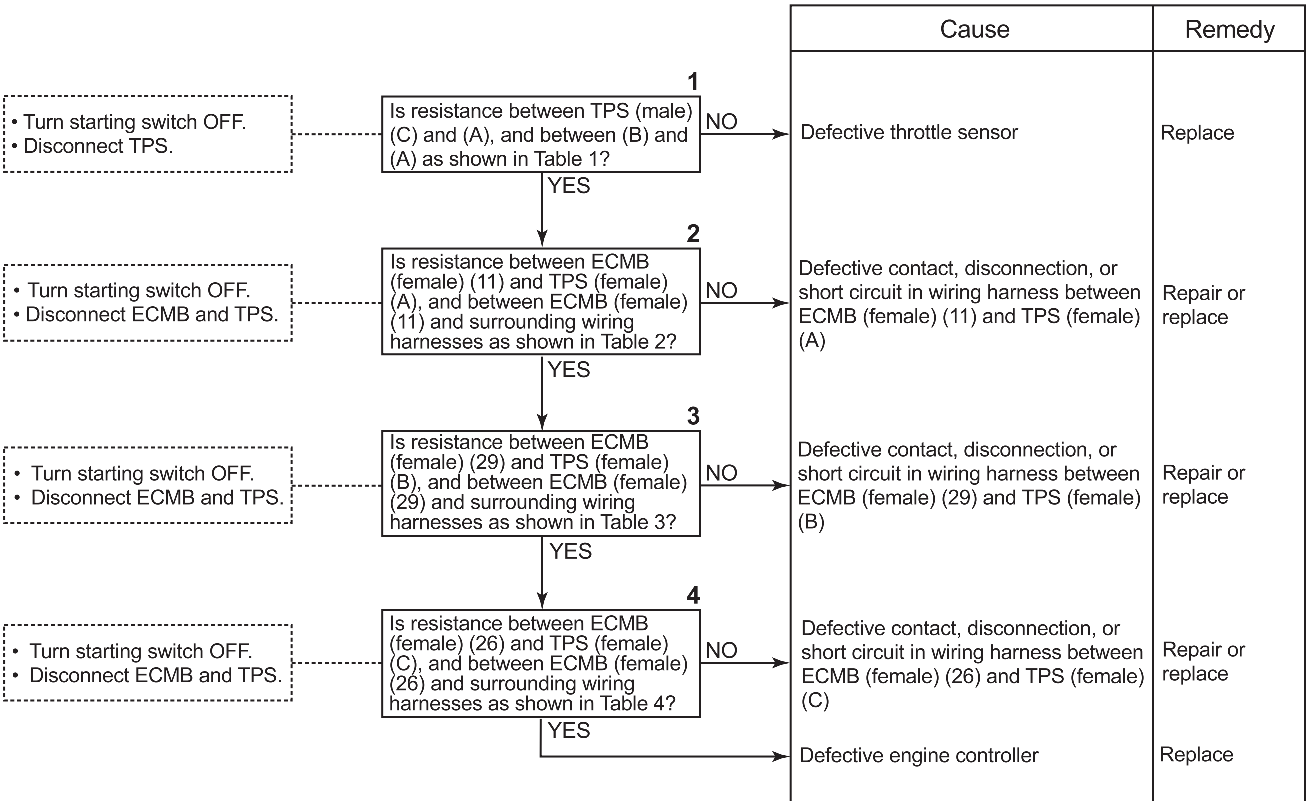


Table 1

TPS (male)	Resistance value
Between (C) and (A)	2,000 – 3,000 Ω
Between (B) and (A)	200 – 3,000 Ω

Table 2

ECMB (female), TPS (female)	Resistance value
Between ECMA (11) and TPS (A)	Max. 10 Ω
Between ECMB (11) and surrounding wiring harnesses	Min. 1 MΩ

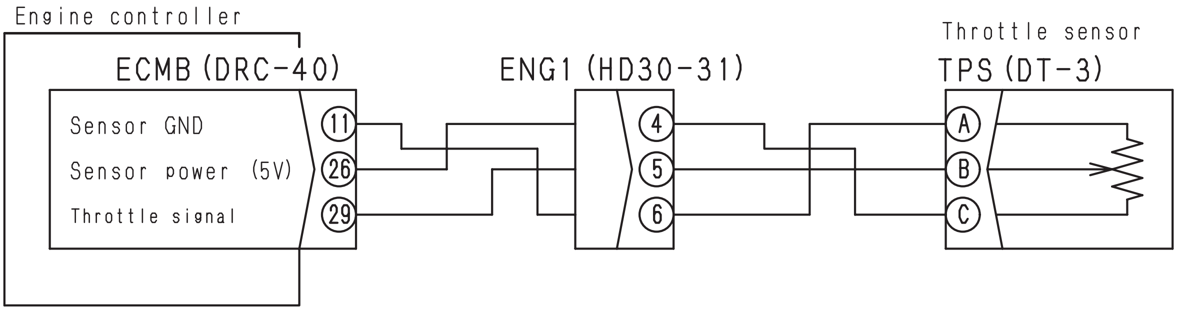
Table 3

ECMB (female), TPS (female)	Resistance value
Between ECMB (29) and TPS (B)	Max. 10 Ω
Between ECMB (29) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

ECMB (female), TPS (female)	Resistance value
Between ECMB (26) and TPS (C)	Max. 10 Ω
Between ECMB (26) and surrounding wiring harnesses	Min. 1 MΩ

EA-12 Related electrical circuit diagram



BXE00016

EA-13 Error code [132] (Abnormality in throttle sensor system low level)

★ Carry out troubleshooting for error code [131].

EA-14 Error code [133] (Abnormality in remote throttle sensor system high level)

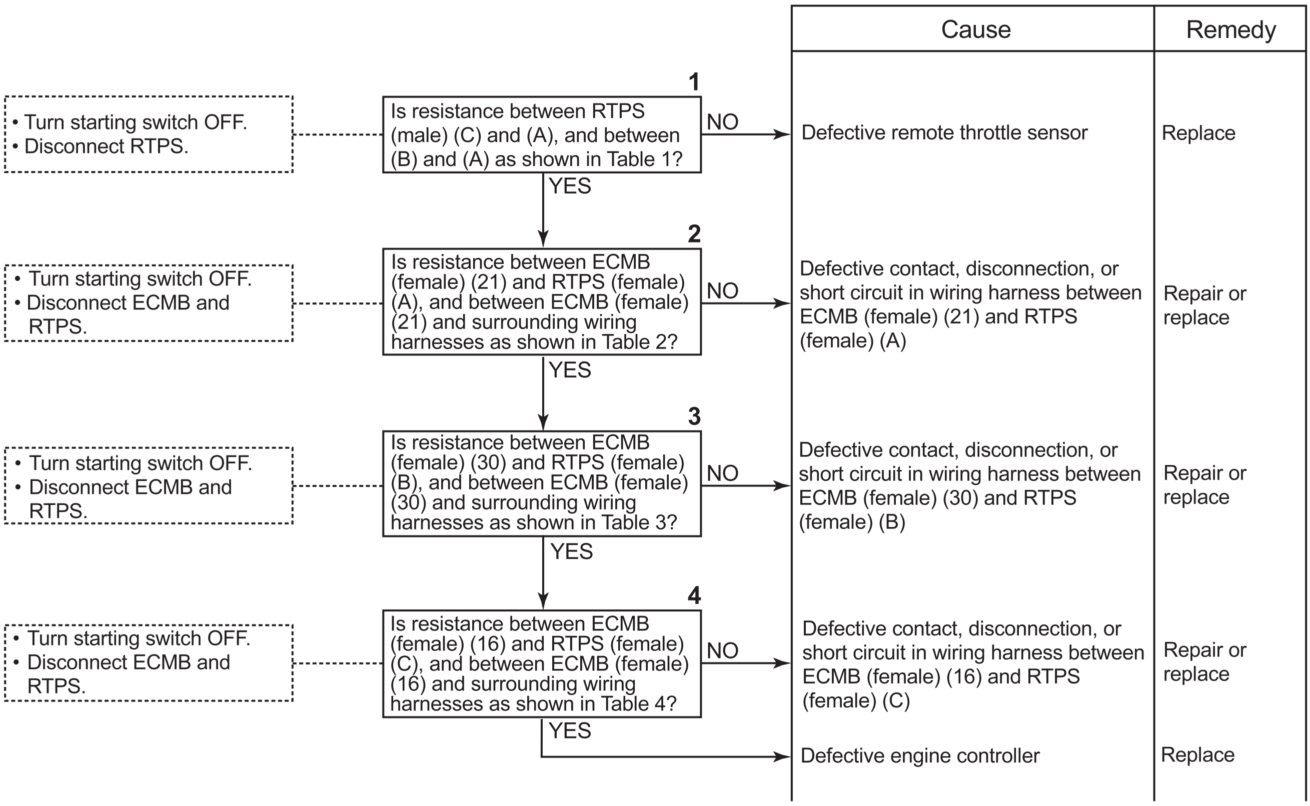


Table 1

RTPS (male)	Resistance value
Between (C) and (A)	2,000 – 3,000 Ω
Between (B) and (A)	200 – 3,000 Ω

Table 2

ECMB (female), RTPS (female)	Resistance value
Between ECMA (21) and RTPS (A)	Max. 10 Ω
Between ECMB (21) and surrounding wiring harnesses	Min. 1 MΩ

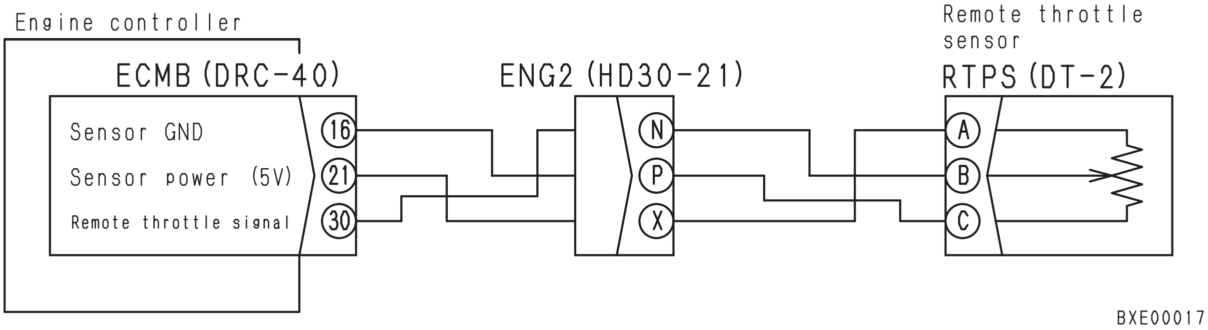
Table 3

ECMB (female), RTPS (female)	Resistance value
Between ECMB (30) and RTPS (B)	Max. 10 Ω
Between ECMB (30) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

ECMB (female), RTPS (female)	Resistance value
Between ECMB (16) and RTPS (C)	Max. 10 Ω
Between ECMB (16) and surrounding wiring harnesses	Min. 1 MΩ

EA-14 Related electrical circuit diagram



EA-15 Error code [134] (Abnormality in remote throttle sensor system low level)

★ Carry out troubleshooting for error code [133].

EA-16 Error code [135] (Abnormality in oil pressure sensor system high level)

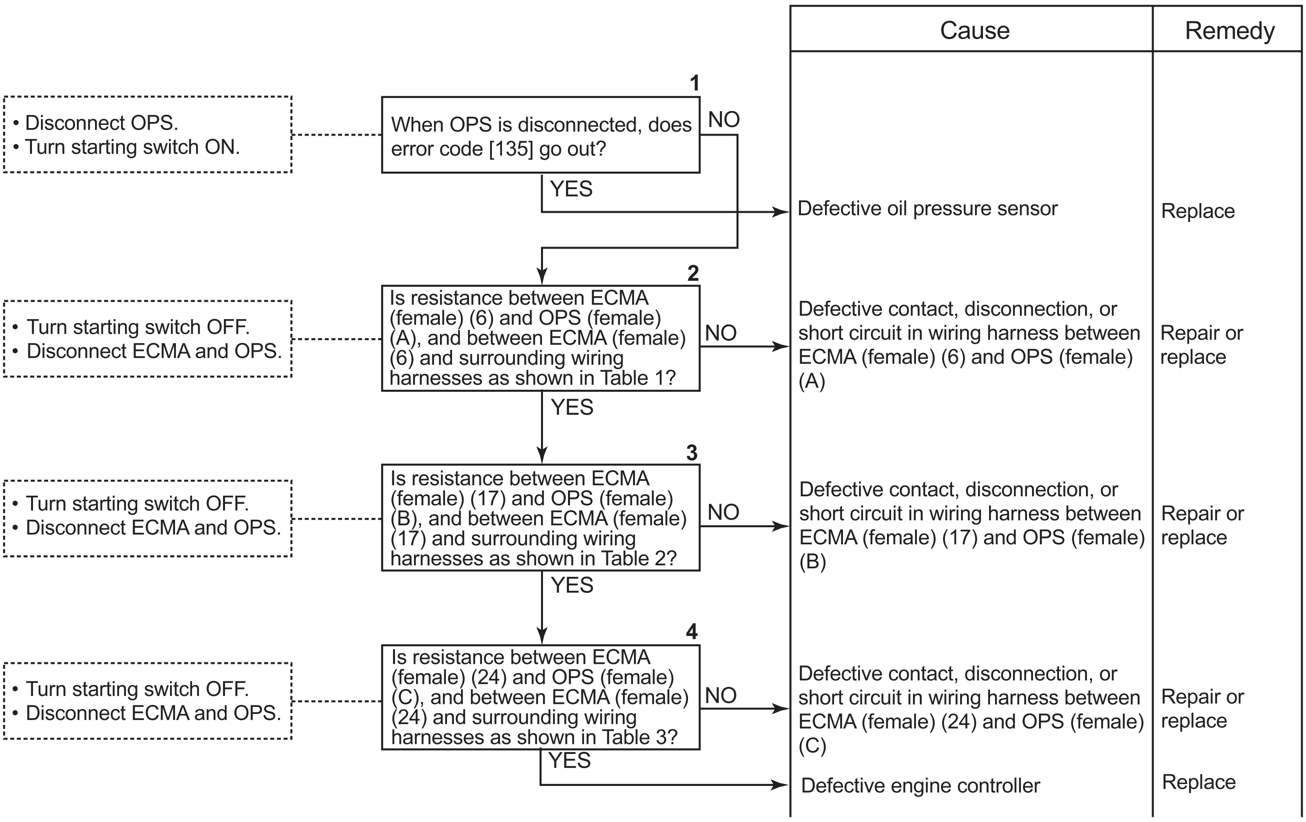


Table 1

ECMA (female), OPS (female)	Resistance value
Between ECMA (6) and OPS (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

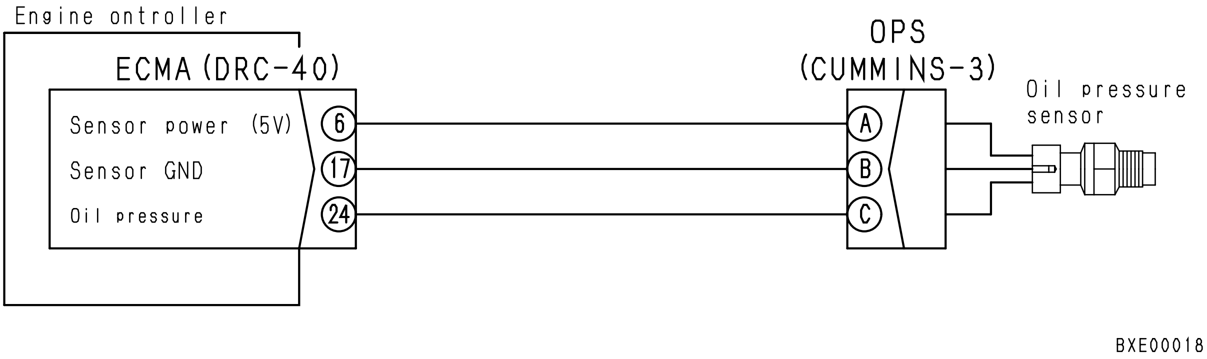
Table 2

ECMA (female), OPS (female)	Resistance value
Between ECMA (17) and OPS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

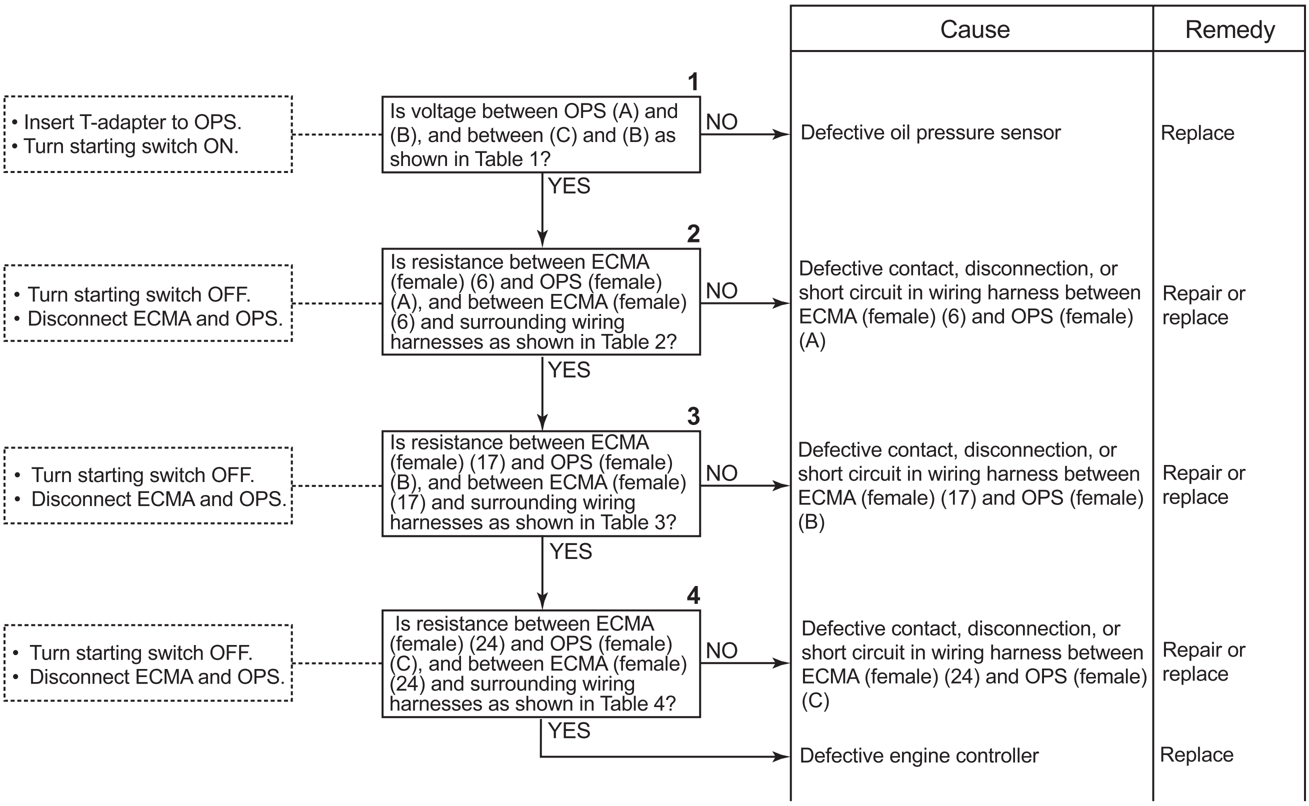
Table 3

ECMA (female), OPS (female)	Resistance value
Between ECMA (24) and OPS (C)	Max. 10Ω
Between ECMA (24) and surrounding wiring harnesses	Min. 1 MΩ

EA-16 Related electrical circuit diagram



EA-17 Error code [141] (Abnormality in oil pressure sensor system low level)



1. • Insert T-adapter to OPS. • Turn starting switch ON.
Is voltage between OPS (A) and (B), and between (C) and (B) as shown in Table 1?
NO → Defective oil pressure sensor — Replace
YES → 2

2. • Turn starting switch OFF. • Disconnect ECMA and OPS.
Is resistance between ECMA (female) (6) and OPS (female) (A), and between ECMA (female) (6) and surrounding wiring harnesses as shown in Table 2?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (6) and OPS (female) (A) — Repair or replace
YES → 3

3. • Turn starting switch OFF. • Disconnect ECMA and OPS.
Is resistance between ECMA (female) (17) and OPS (female) (B), and between ECMA (female) (17) and surrounding wiring harnesses as shown in Table 3?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (17) and OPS (female) (B) — Repair or replace
YES → 4

4. • Turn starting switch OFF. • Disconnect ECMA and OPS.
Is resistance between ECMA (female) (24) and OPS (female) (C), and between ECMA (female) (24) and surrounding wiring harnesses as shown in Table 4?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (24) and OPS (female) (C) — Repair or replace
YES → Defective engine controller — Replace

Table 1

OPS	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), OPS (female)	Resistance value
Between ECMA (6) and OPS (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

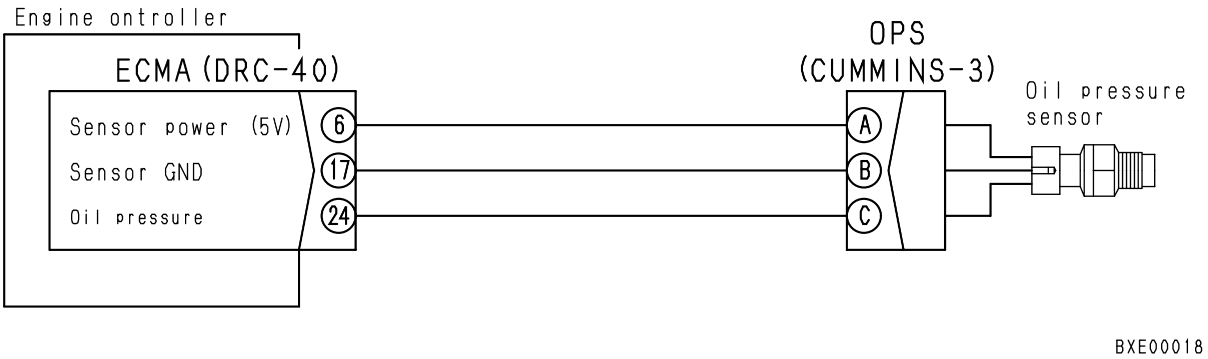
Table 3

ECMA (female), OPS (female)	Resistance value
Between ECMA (17) and OPS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

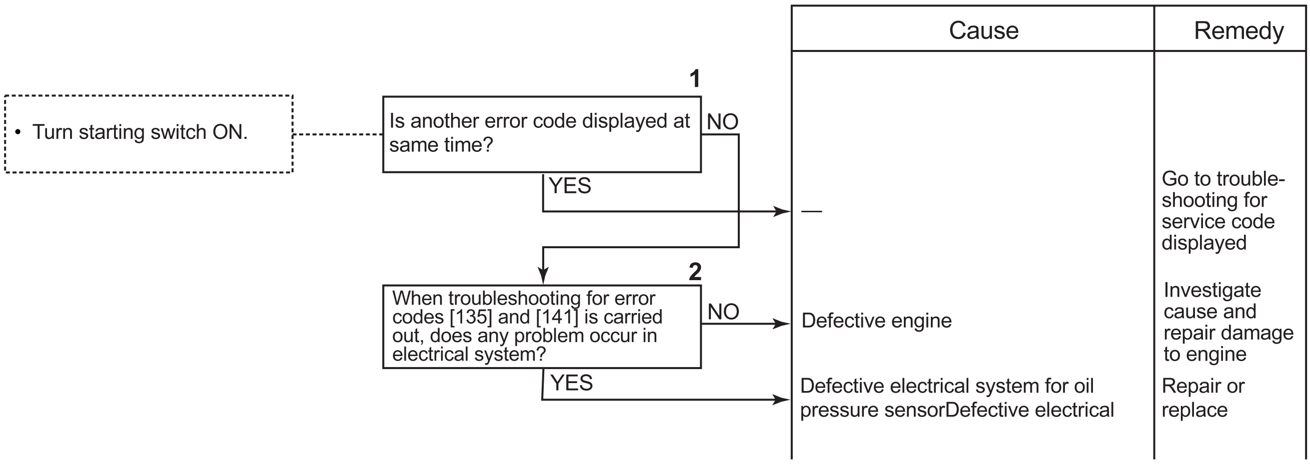
Table 4

ECMA (female), OPS (female)	Resistance value
Between ECMA (24) and OPS (C)	Max. 10Ω
Between ECMA (24) and surrounding wiring harnesses	Min. 1 MΩ

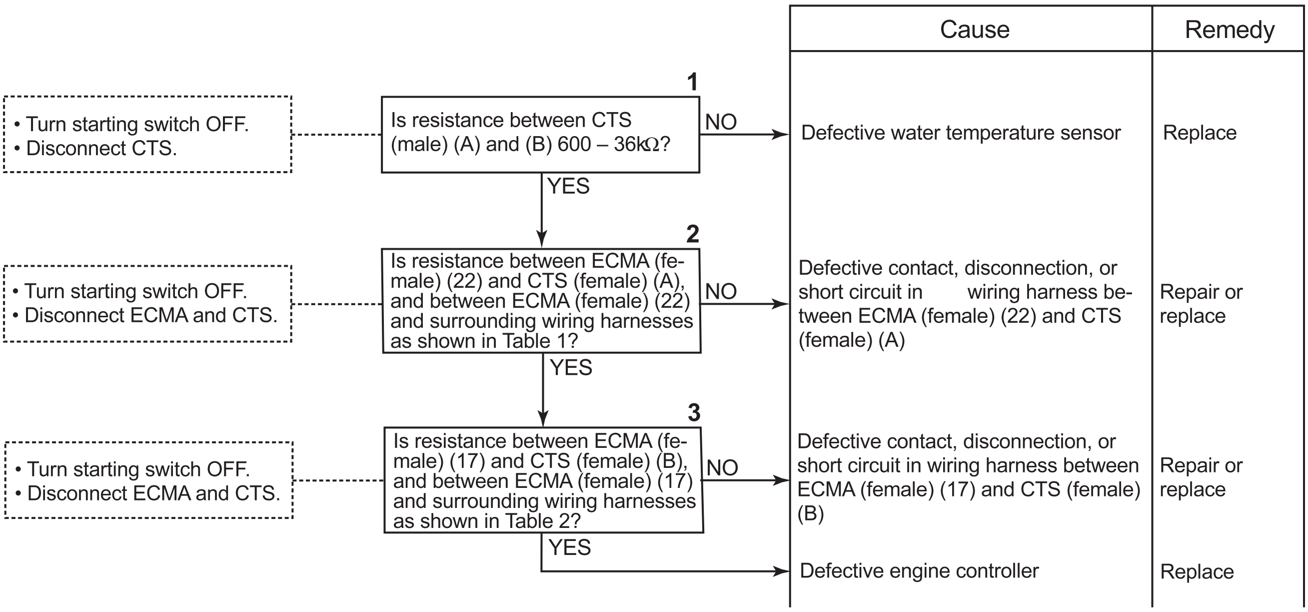
EA-17 Related electrical circuit diagram



EA-18 Error code [143] (Abnormal drop in oil pressure (level 1))



EA-19 Error code [144] (Abnormality in water temperature sensor system high level)



			Cause	Remedy
1	• Turn starting switch OFF. • Disconnect CTS.	Is resistance between CTS (male) (A) and (B) 600 – 36kΩ? NO →	Defective water temperature sensor	Replace
2	• Turn starting switch OFF. • Disconnect ECMA and CTS.	Is resistance between ECMA (female) (22) and CTS (female) (A), and between ECMA (female) (22) and surrounding wiring harnesses as shown in Table 1? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (22) and CTS (female) (A)	Repair or replace
3	• Turn starting switch OFF. • Disconnect ECMA and CTS.	Is resistance between ECMA (female) (17) and CTS (female) (B), and between ECMA (female) (17) and surrounding wiring harnesses as shown in Table 2? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (17) and CTS (female) (B)	Repair or replace
		YES →	Defective engine controller	Replace

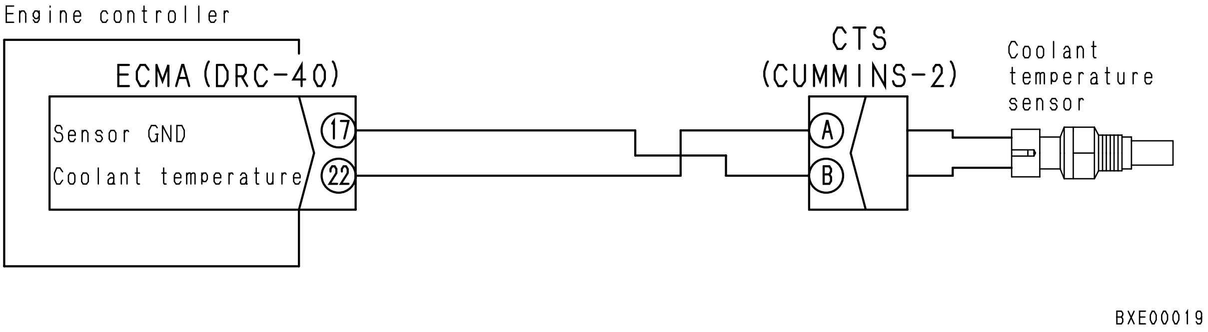
Table 1

ECMA (female), CTS (female)	Resistance value
Between ECMA (22) and CTS (A)	Max. 10Ω
Between ECMA (22) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), CTS (female)	Resistance value
Between ECMA (17) and CTS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

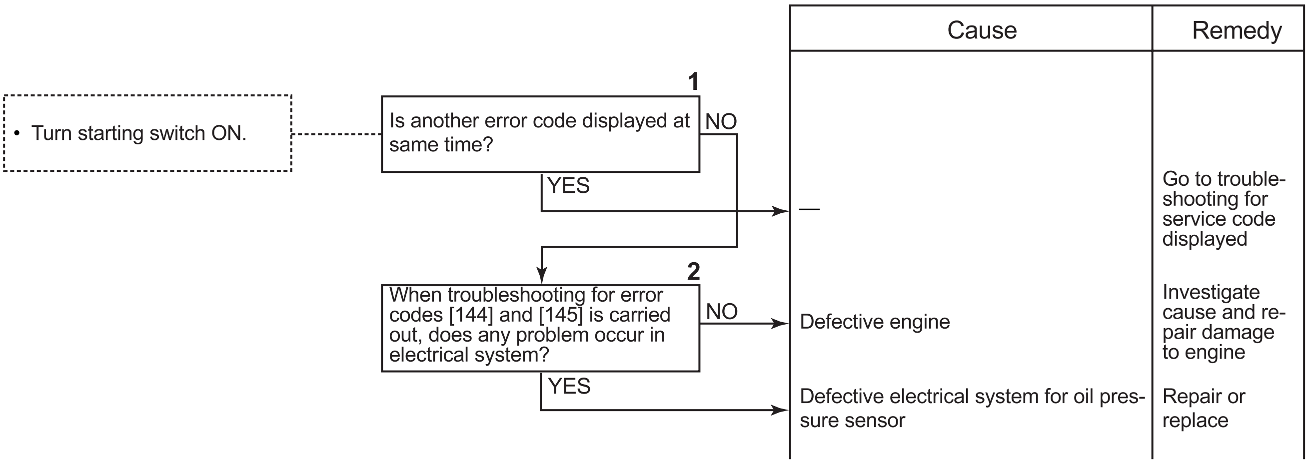
EA-19 Related electrical circuit diagram



EA-20 Error code [145] (Abnormality in water temperature sensor system low level)

★ Carry out troubleshooting for error code [144].

EA-21 Error code [151] (Abnormal rise in water temperature)



EA-22 Error code [153] (Abnormality in intake air temperature sensor system high level)

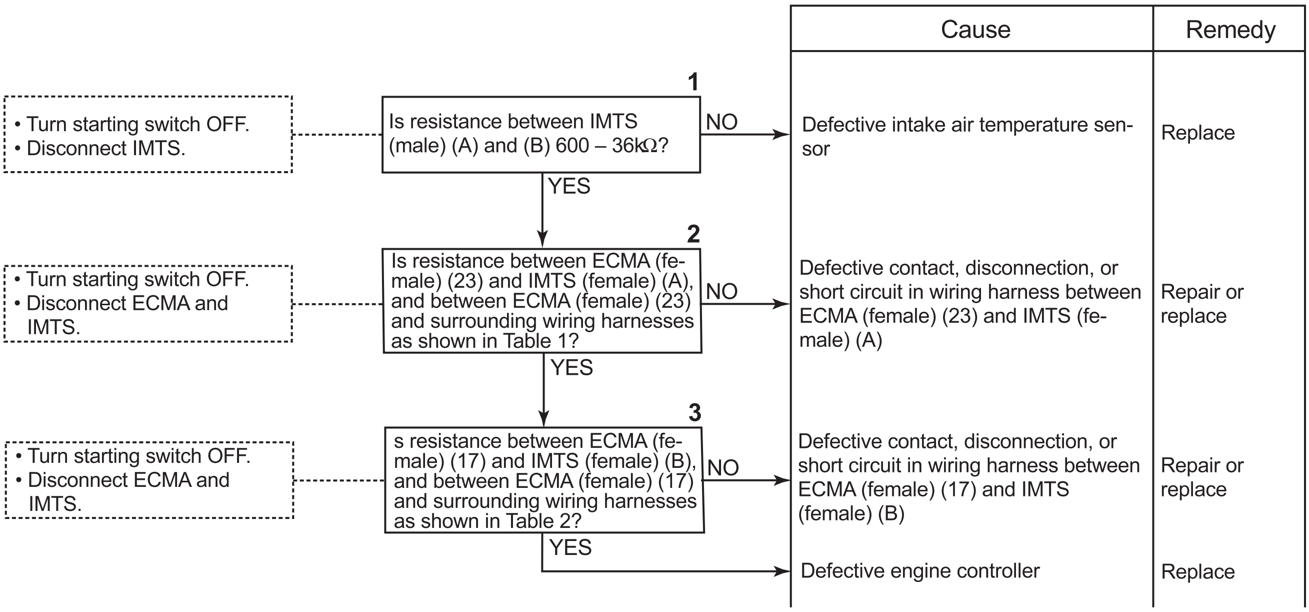


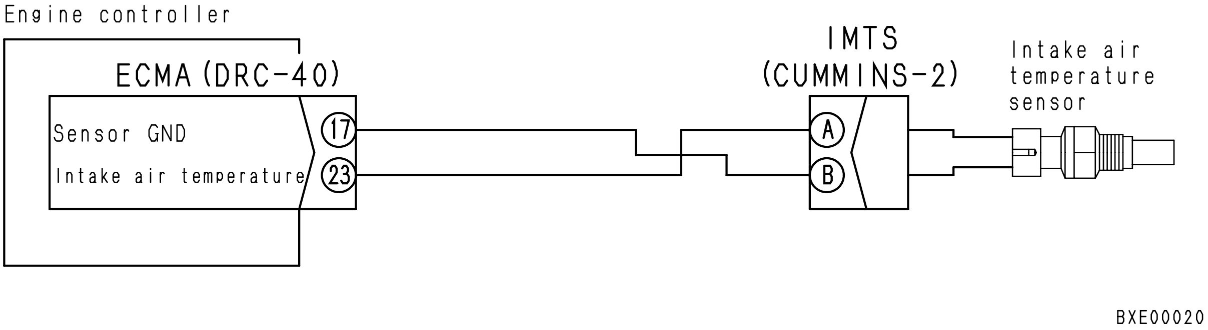
Table 1

ECMA (female), IMTS (female)	Resistance value
Between ECMA (23) and IMTS (A)	Max. 10Ω
Between ECMA (23) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), IMTS (female)	Resistance value
Between ECMA (17) and IMTS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

EA-22 Related electrical circuit diagram



EA-23 Error code [154] (Abnormality in intake air temperature sensor system low level)

★ Carry out troubleshooting for error code [153].

EA-24 Error code [221] (Abnormality in atmospheric pressure sensor system high level)

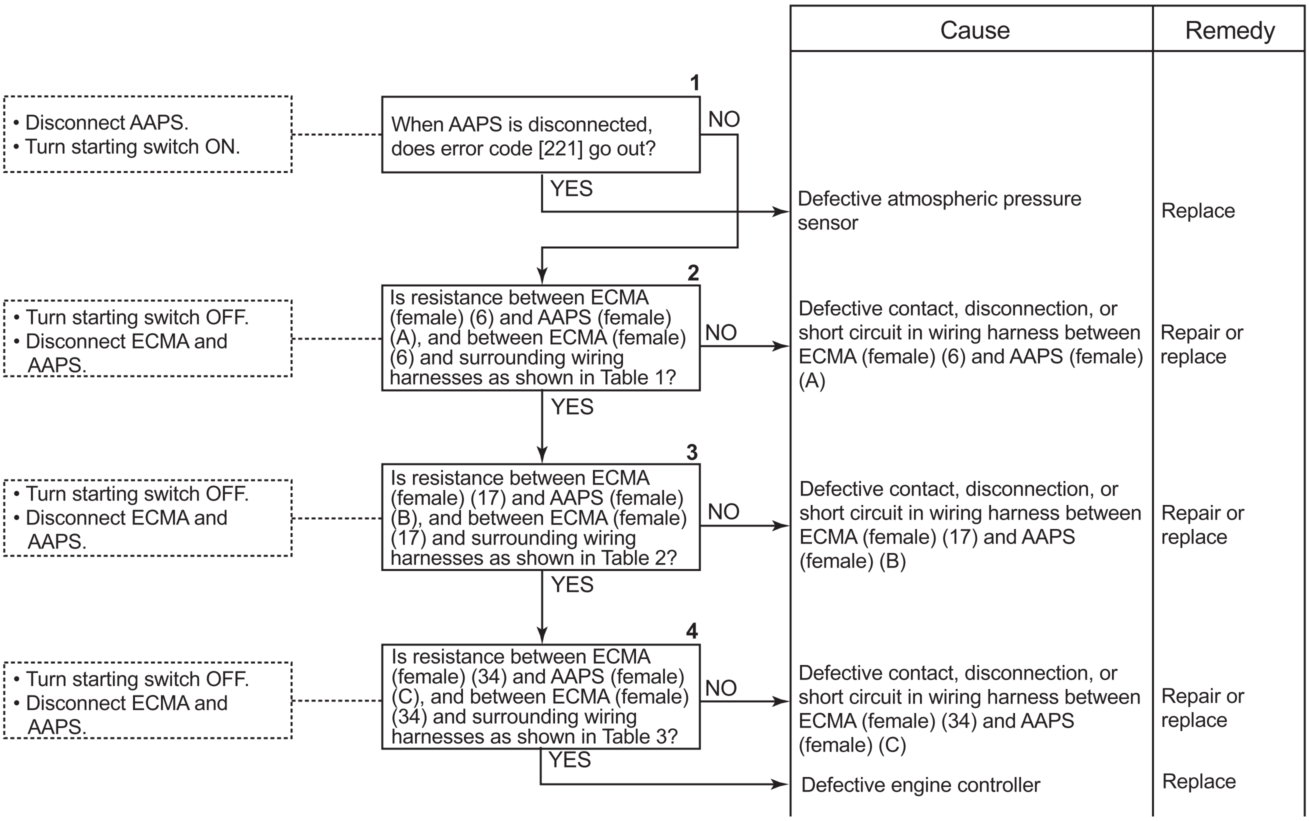


Table 1

ECMA (female), AAPS (female)	Resistance value
Between ECMA (6) and AAPS (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

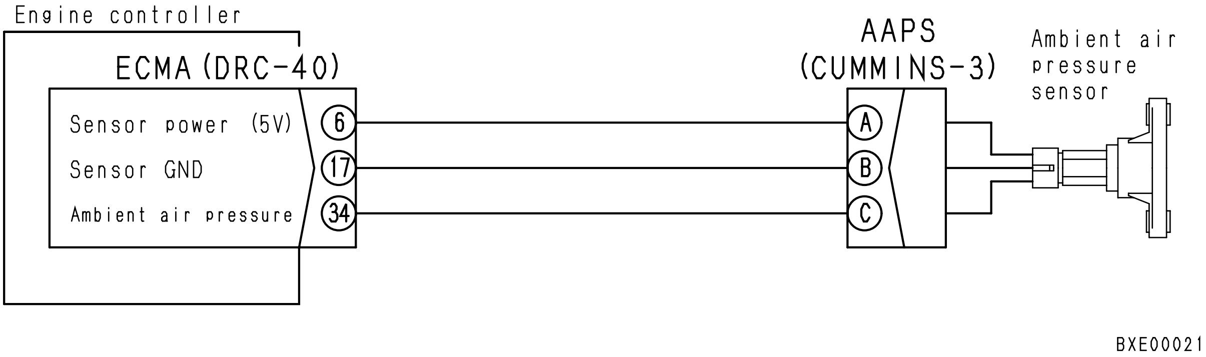
Table 2

ECMA (female), AAPS (female)	Resistance value
Between ECMA (17) and AAPS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

Table 3

ECMA (female), AAPS (female)	Resistance value
Between ECMA (34) and AAPS (C)	Max. 10Ω
Between ECMA (34) and surrounding wiring harnesses	Min. 1 MΩ

EA-24 Related electrical circuit diagram



EA-25 Error code [222] (Abnormality in atmospheric pressure sensor system low)

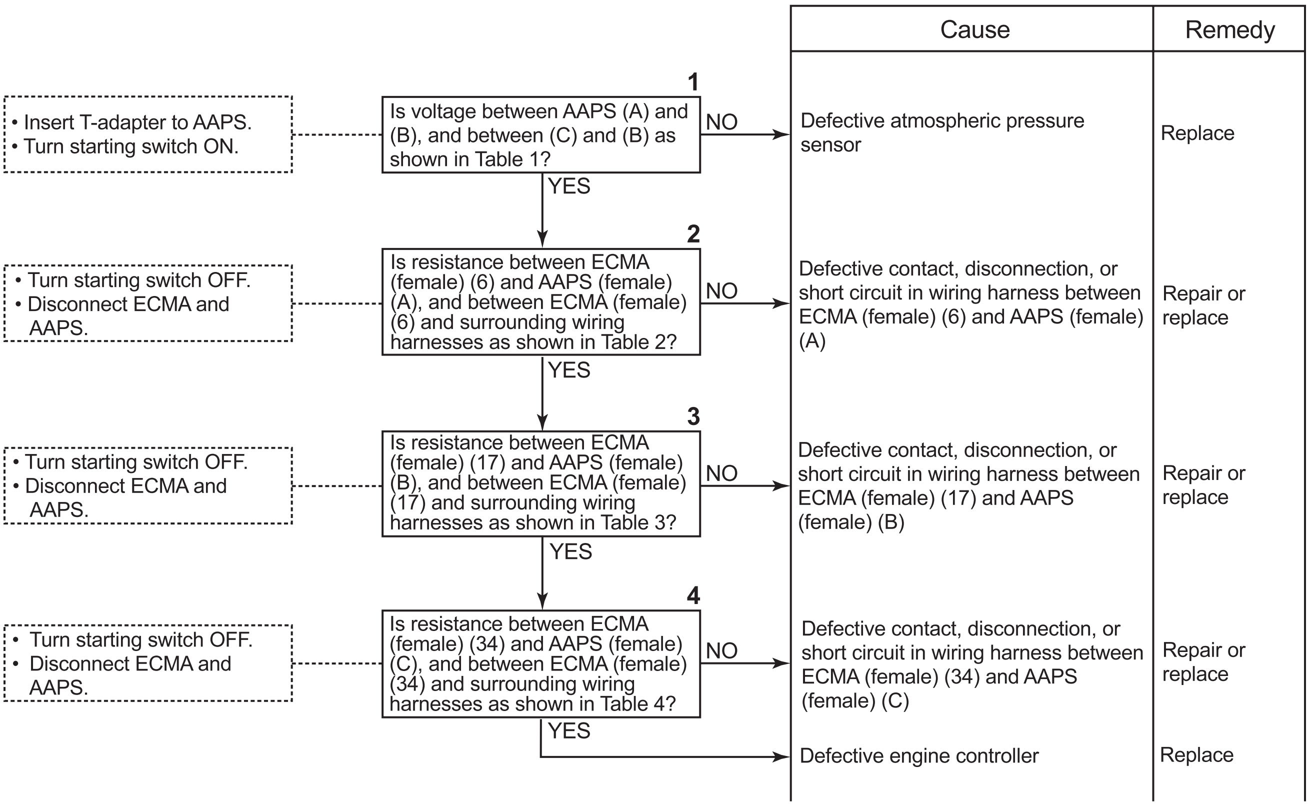


Table 1

AAPS	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), AAPS (female)	Resistance value
Between ECMA (6) and AAPS (A)	Max. 10Ω
Between ECMA (6) and surrounding wiring harnesses	Min. 1 MΩ

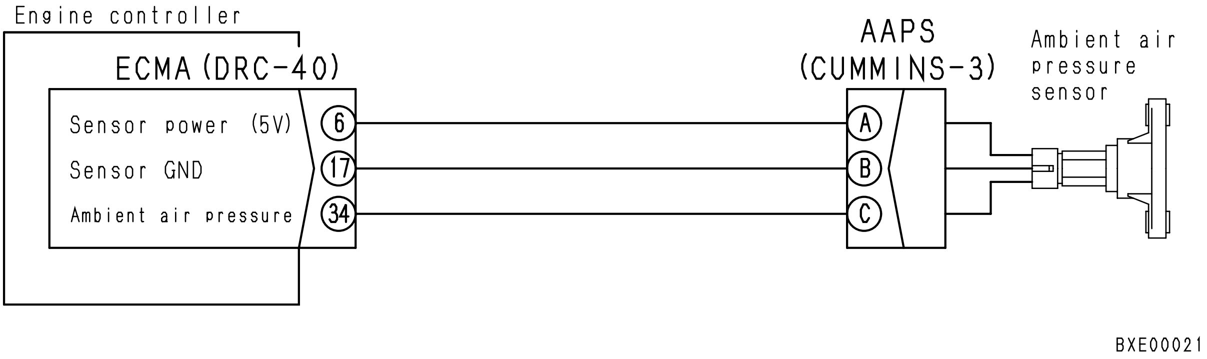
Table 3

ECMA (female), AAPS (female)	Resistance value
Between ECMA (17) and AAPS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

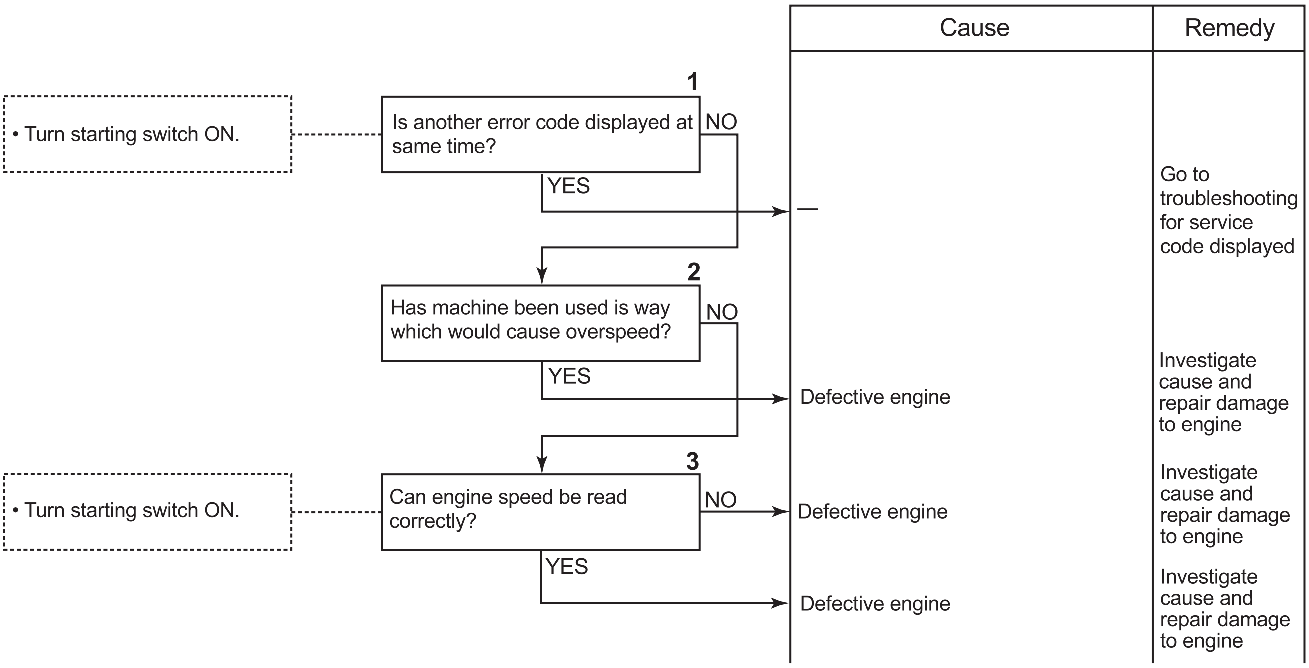
Table 4

ECMA (female), AAPS (female)	Resistance value
Between ECMA (34) and AAPS (C)	Max. 10Ω
Between ECMA (34) and surrounding wiring harnesses	Min. 1 MΩ

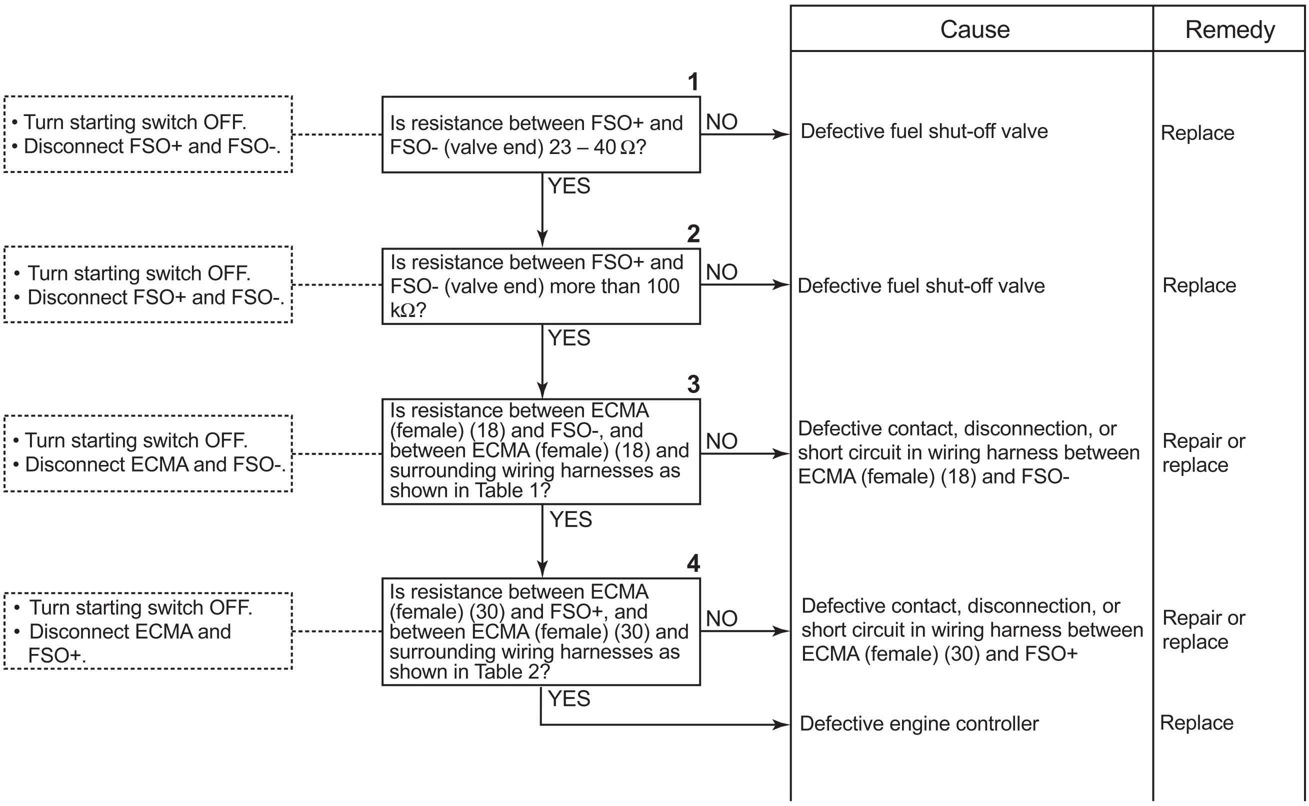
EA-25 Related electrical circuit diagram



EA-26 Error code [234] (Overspeed)



EA-27 Error code [254] (Abnormality in fuel shut-off valve system voltage)



1
- Turn starting switch OFF.
- Disconnect FSO+ and FSO-.

Is resistance between FSO+ and FSO- (valve end) 23 – 40 Ω?

NO: Defective fuel shut-off valve — Replace

2
- Turn starting switch OFF.
- Disconnect FSO+ and FSO-.

Is resistance between FSO+ and FSO- (valve end) more than 100 kΩ?

NO: Defective fuel shut-off valve — Replace

3
- Turn starting switch OFF.
- Disconnect ECMA and FSO-.

Is resistance between ECMA (female) (18) and FSO-, and between ECMA (female) (18) and surrounding wiring harnesses as shown in Table 1?

NO: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (18) and FSO- — Repair or replace

4
- Turn starting switch OFF.
- Disconnect ECMA and FSO+.

Is resistance between ECMA (female) (30) and FSO+, and between ECMA (female) (30) and surrounding wiring harnesses as shown in Table 2?

NO: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (30) and FSO+ — Repair or replace

YES: Defective engine controller — Replace

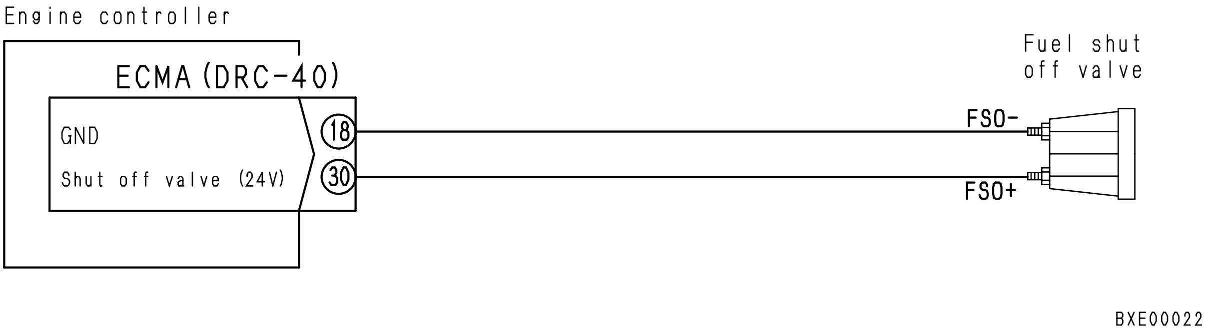
Table 1

ECMA (female), FSO-	Resistance value
Between ECMA (18) and FSO-	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

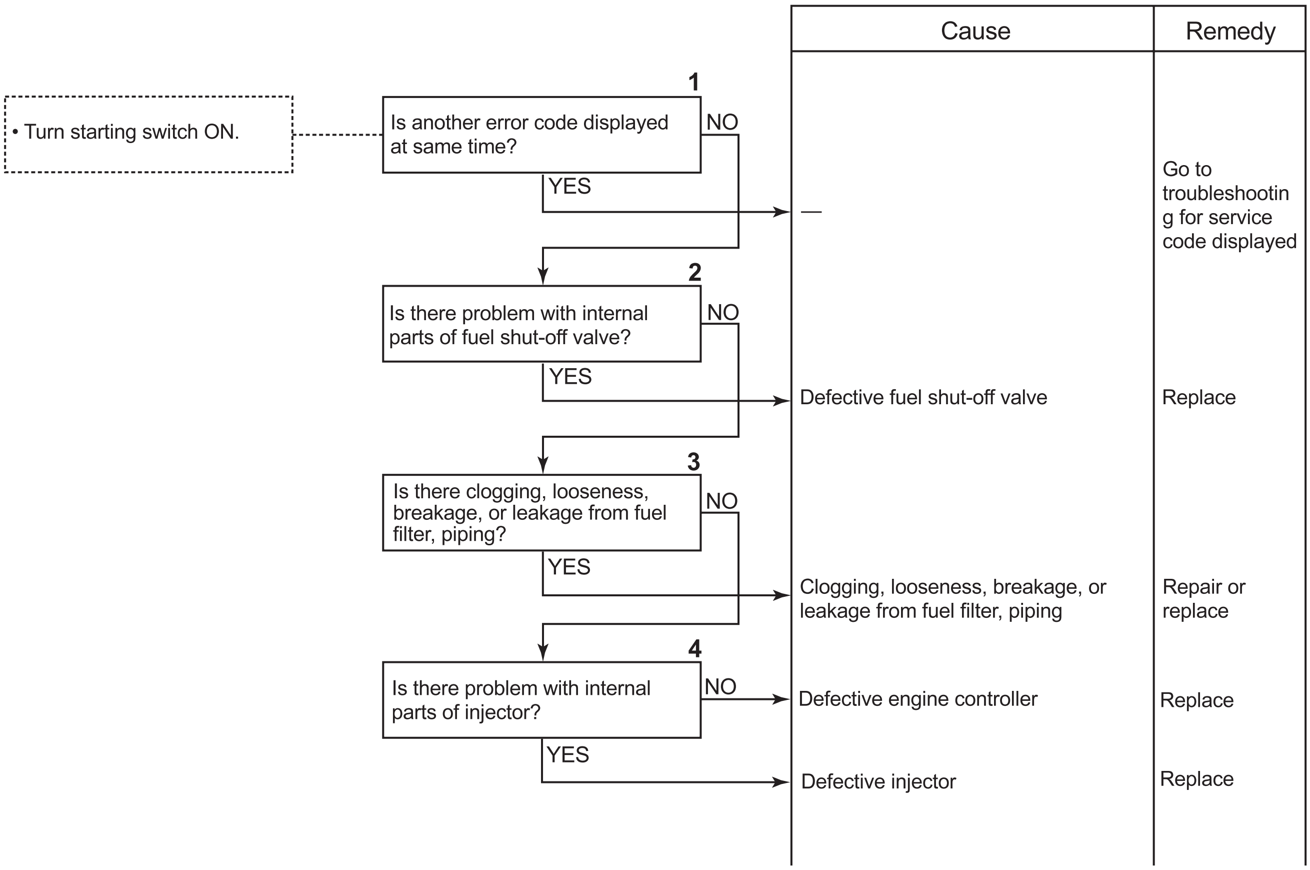
Table 2

ECMA (female), FSO+	Resistance value
Between ECMA (30) and FSO+	Max. 10Ω
Between ECMA (30) and surrounding wiring harnesses	Min. 1 MΩ

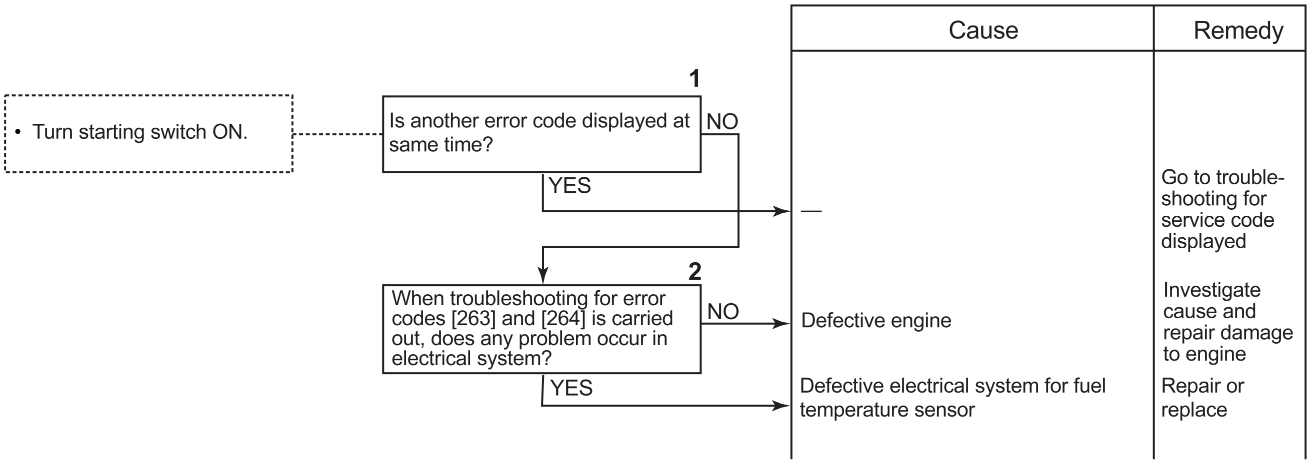
EA-27 Related electrical circuit diagram



EA-28 Error code [259] (Abnormality in fuel shut-off valve)



EA-29 Error code [261] (Abnormal rise in fuel temperature)



EA-30 Error code [263] (Abnormality in fuel temperature sensor system high level)

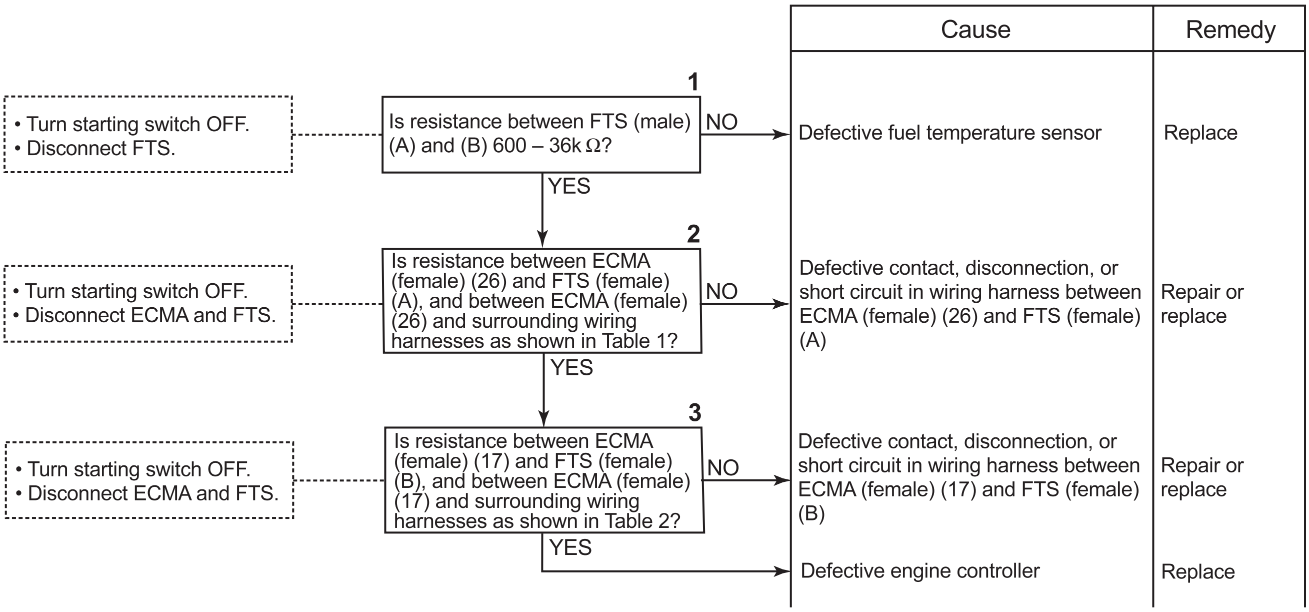


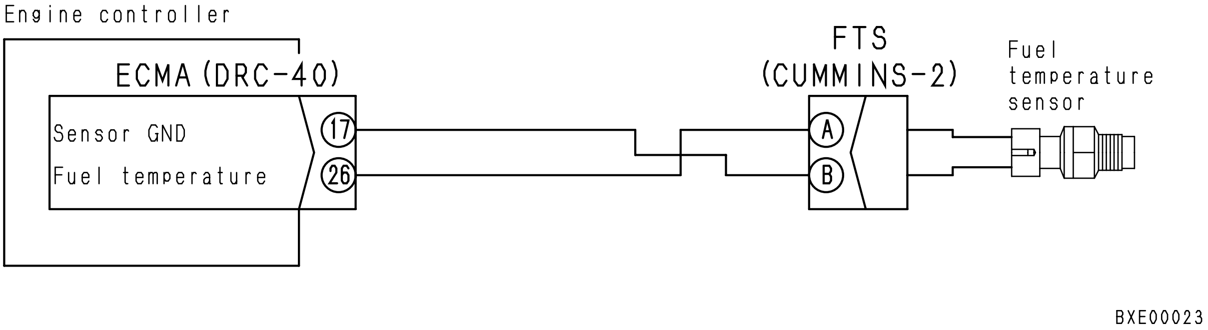
Table 1

ECMA (female), FTS (female)	Resistance value
Between ECMA (26) and FTS (A)	Max. 10Ω
Between ECMA (26) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), FTS (female)	Resistance value
Between ECMA (17) and FTS (B)	Max. 10Ω
Between ECMA (17) and surrounding wiring harnesses	Min. 1 MΩ

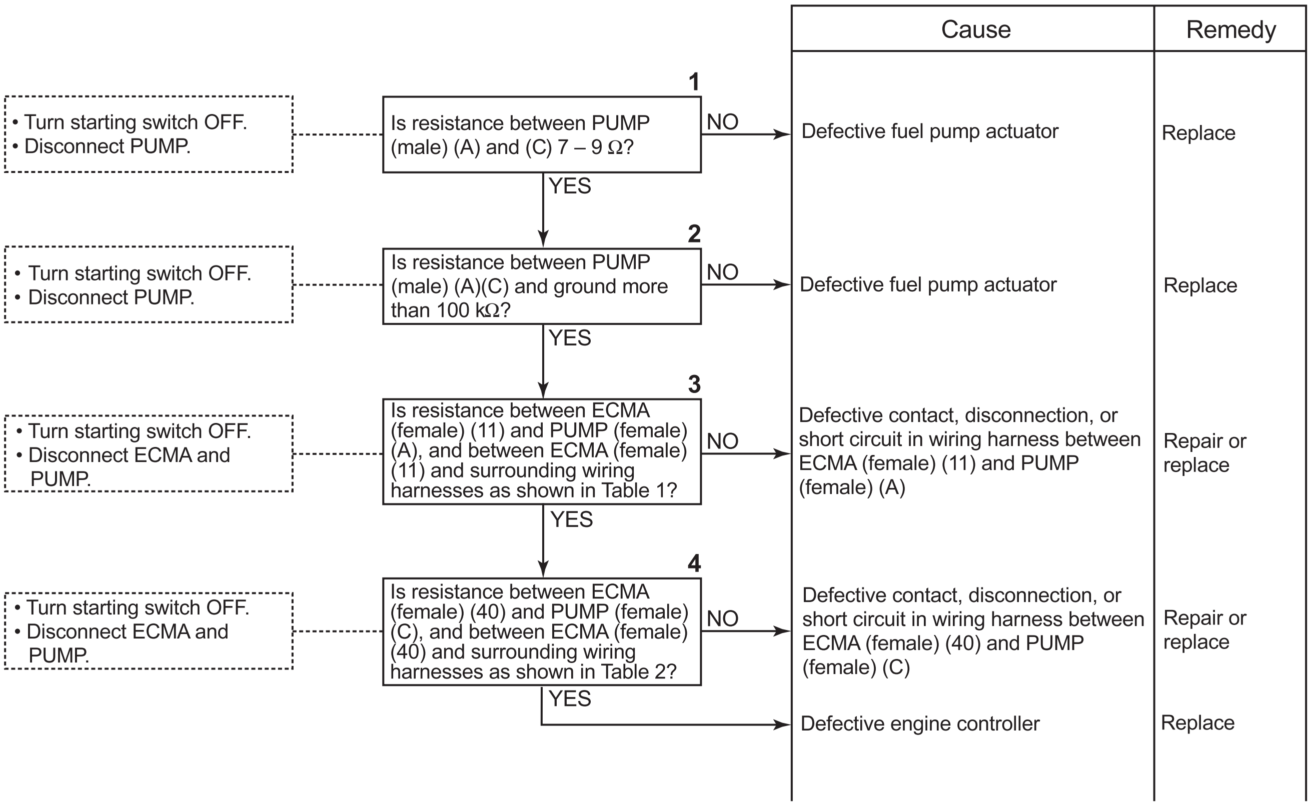
EA-30 Related electrical circuit diagram



EA-31 Error code [265] (Abnormality in fuel temperature sensor system low level)

★ Carry out troubleshooting for error code [263].

EA-32 Error code [316] (Abnormality in fuel pump actuator system current)



Cause | Remedy

1
- Turn starting switch OFF.
- Disconnect PUMP.

Is resistance between PUMP (male) (A) and (C) 7 – 9 Ω?
NO → Defective fuel pump actuator — Replace
YES ↓

2
- Turn starting switch OFF.
- Disconnect PUMP.

Is resistance between PUMP (male) (A)(C) and ground more than 100 kΩ?
NO → Defective fuel pump actuator — Replace
YES ↓

3
- Turn starting switch OFF.
- Disconnect ECMA and PUMP.

Is resistance between ECMA (female) (11) and PUMP (female) (A), and between ECMA (female) (11) and surrounding wiring harnesses as shown in Table 1?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (11) and PUMP (female) (A) — Repair or replace
YES ↓

4
- Turn starting switch OFF.
- Disconnect ECMA and PUMP.

Is resistance between ECMA (female) (40) and PUMP (female) (C), and between ECMA (female) (40) and surrounding wiring harnesses as shown in Table 2?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (40) and PUMP (female) (C) — Repair or replace
YES → Defective engine controller — Replace

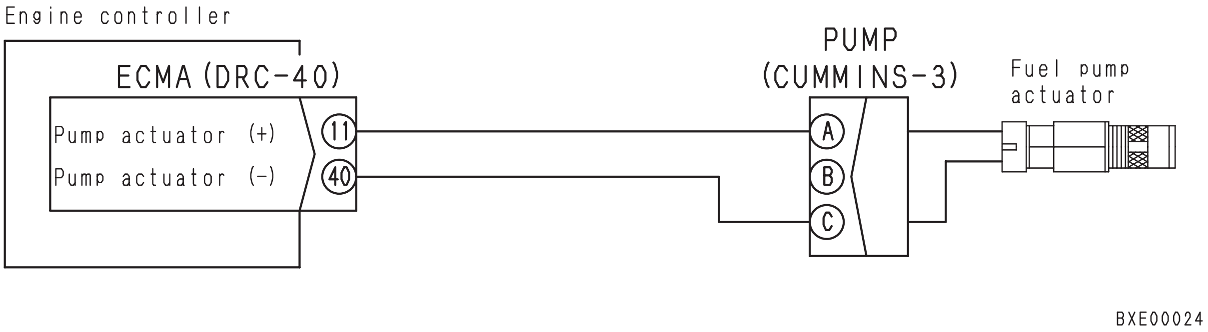
Table 1

ECMA (female), PUMP (female)	Resistance value
Between ECMA (11) and PUMP (A)	Max. 10Ω
Between ECMA (11) and surrounding wiring harnesses	Min. 1 MΩ

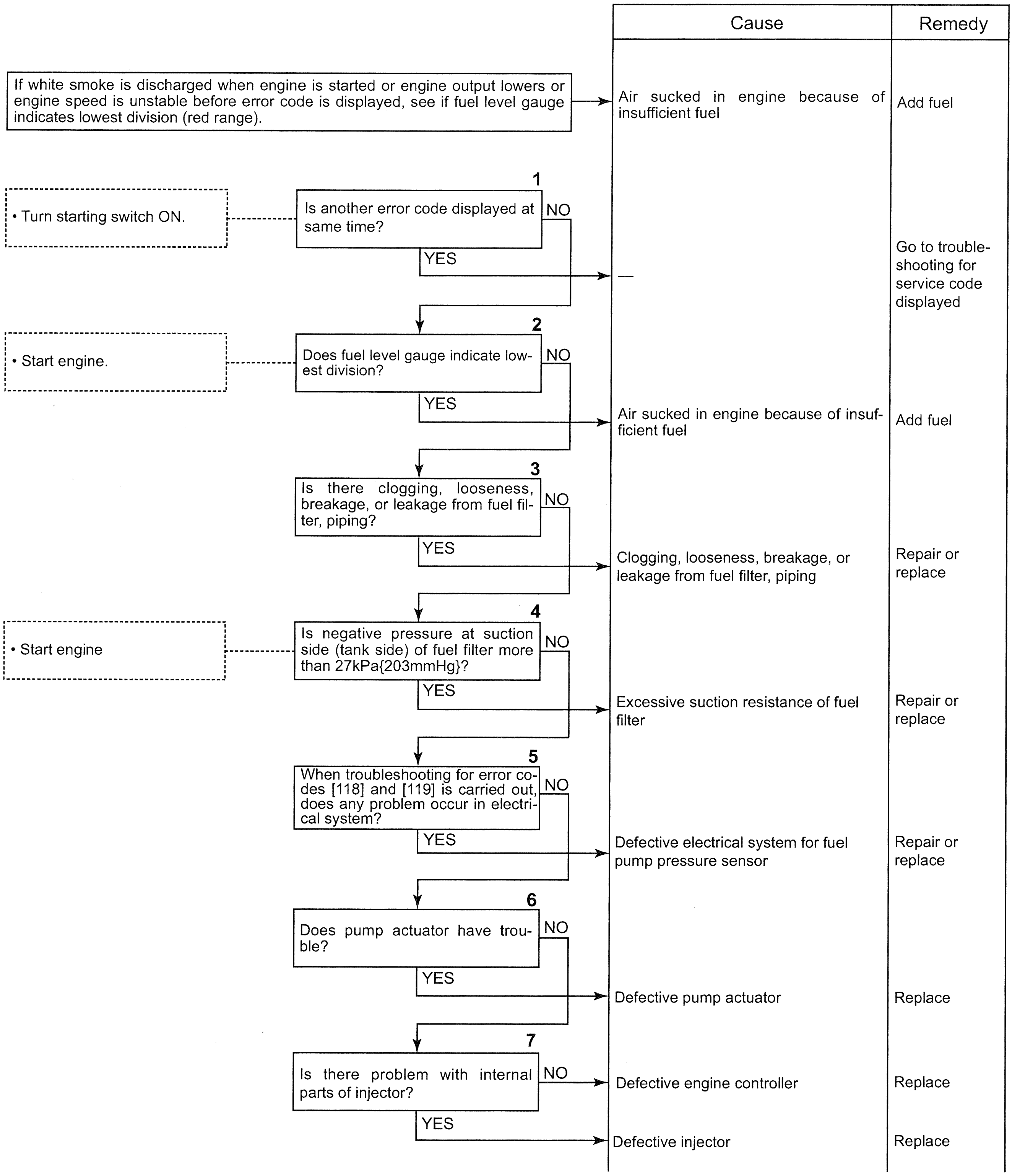
Table 2

ECMA (female), PUMP (female)	Resistance value
Between ECMA (40) and PUMP (C)	Max. 10Ω
Between ECMA (40) and surrounding wiring harnesses	Min. 1 MΩ

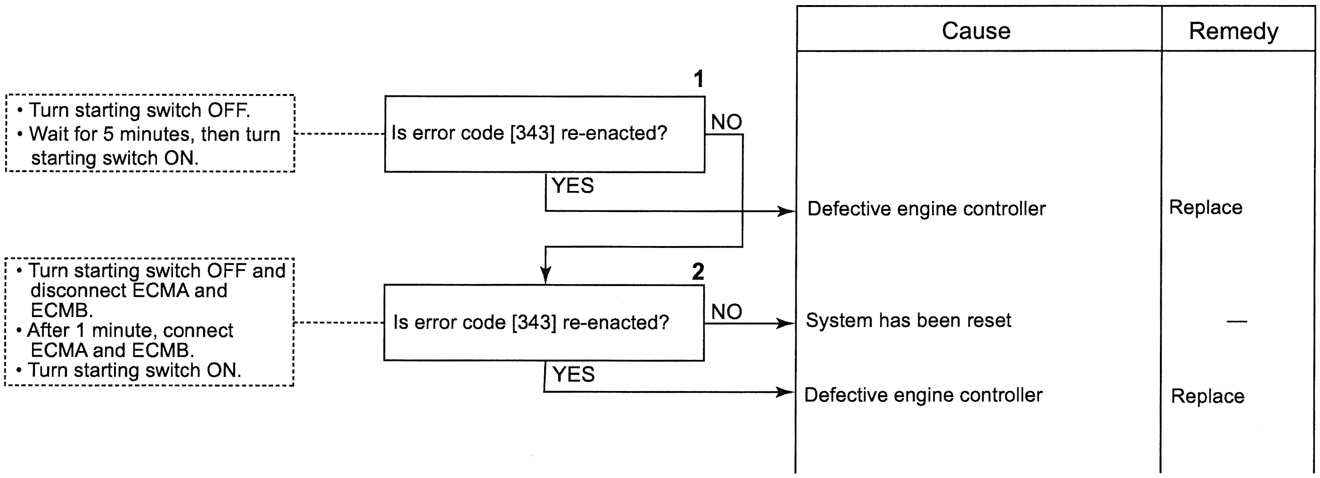
EA-32 Related electrical circuit diagram



EA-33 Error code [318] (Abnormality in fuel pump actuator)



EA-34 Error code [343] (Abnormality in controller internal communication)



EA-35 Error code [346] (Abnormality in controller power down)

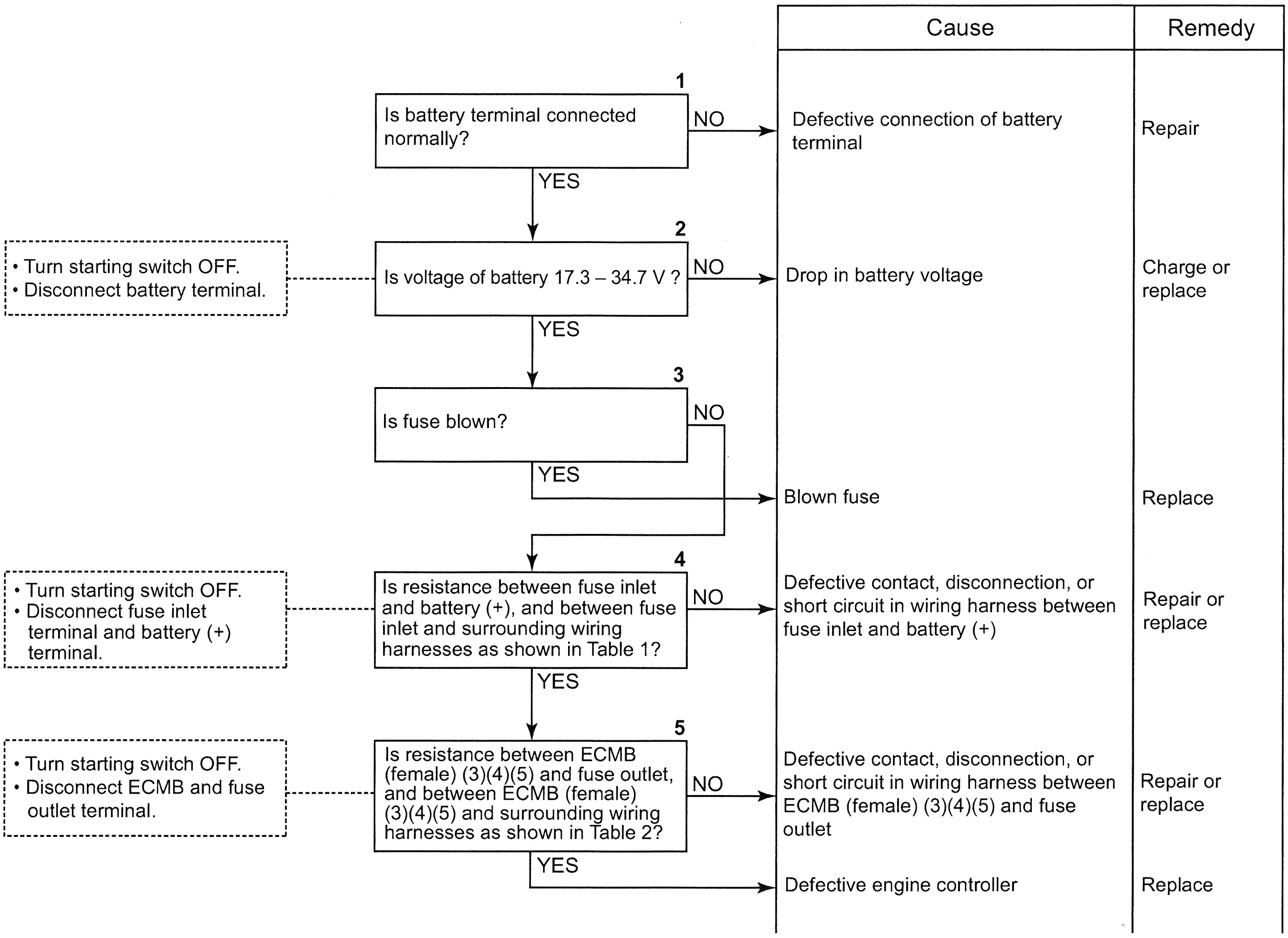


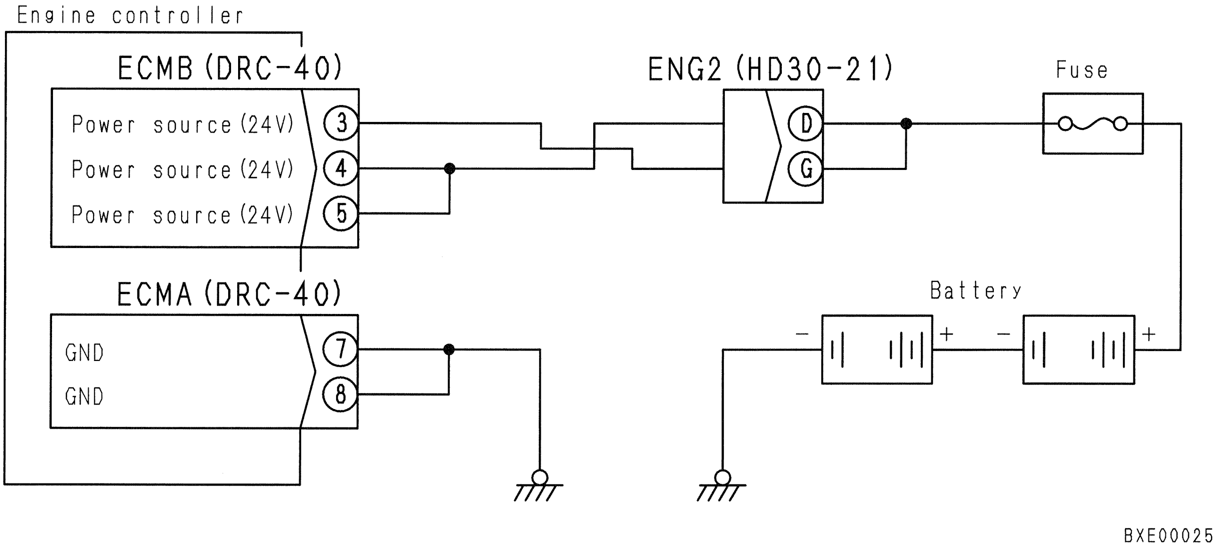
Table 1

Fuse inlet, battery (+)	Resistance value
Between fuse inlet and battry (+)	Max. 10 Ω
Between fuse inlet and surrounding wiring harness	Min. 1 MΩ

Table 2

ECMB (female), fuse outlet	Resistance value
Between ECMB (3)(4)(5) and fuse outlet	Max. 10 Ω
Between ECMB (3)(4)(5) and surrounding wiring harness	Min. 1 MΩ

EA-35 Related electrical circuit diagram



EA-36 Error code [384] (Abnormality in preheating heater control system)

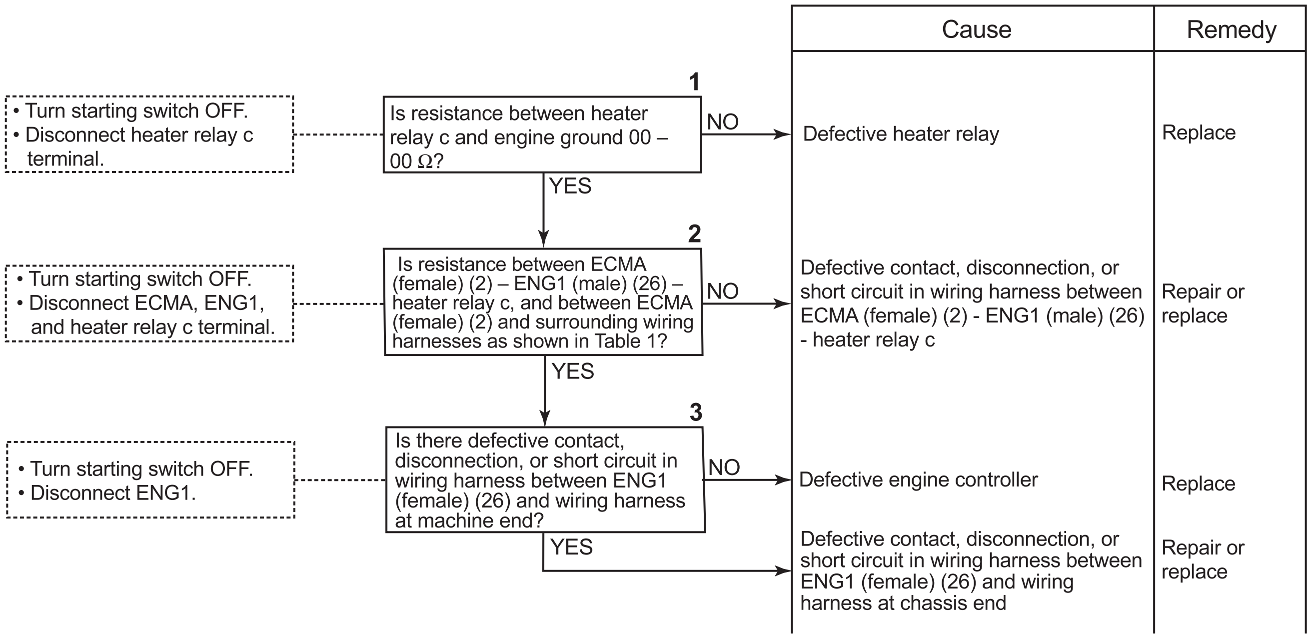
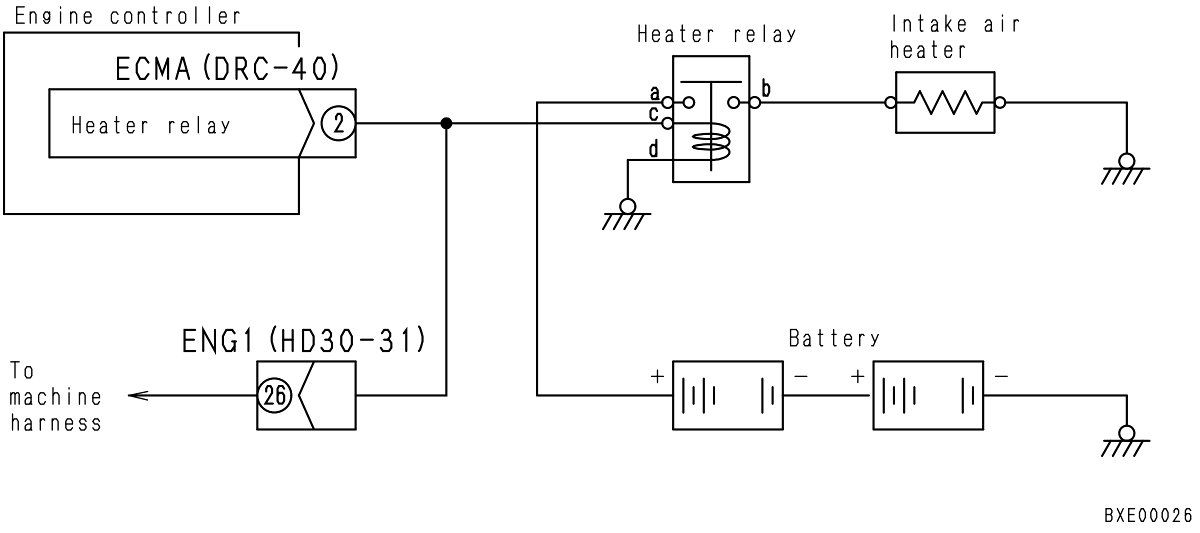


Table 1

ECMA (female), ENG1 (male), heater relay c	Resistance value
Between ECMA (2) - ENG1 (26) – heater relay c	Max. 10Ω
Between ECMA (2) and surrounding wiring harnesses	Min. 1 MΩ

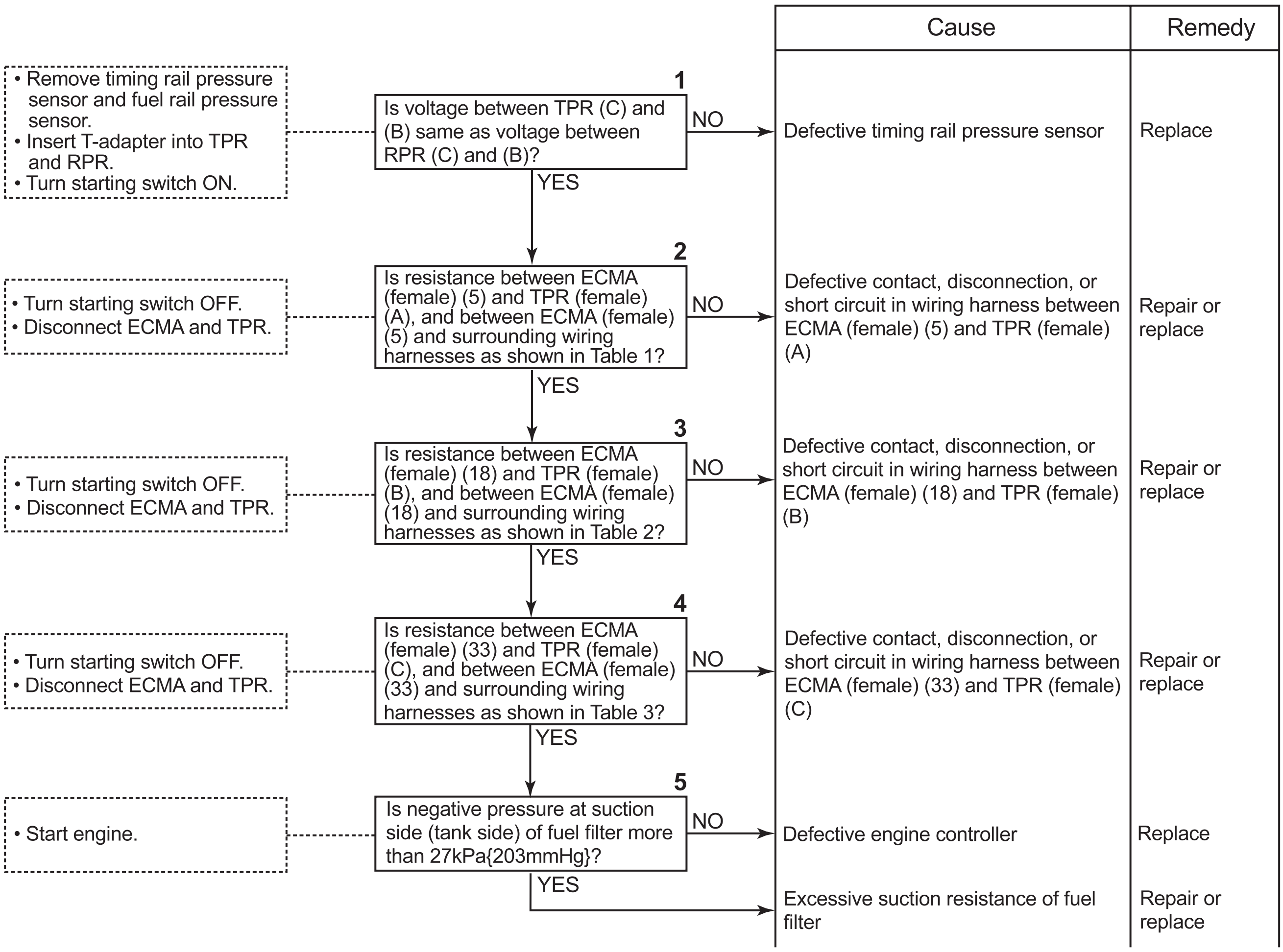
EA-36 Related electrical circuit diagram



EA-37 Error code [415] (Abnormal drop in oil pressure (level 2))

★ Carry out troubleshooting for error code [143].

EA-38 Error code [423] (Abnormality in timing rail pressure sensor system in range)



- Remove timing rail pressure sensor and fuel rail pressure sensor.
- Insert T-adapter into TPR and RPR.
- Turn starting switch ON.

1 Is voltage between TPR (C) and (B) same as voltage between RPR (C) and (B)?

NO: Defective timing rail pressure sensor — Replace

YES: go to 2

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

2 Is resistance between ECMA (female) (5) and TPR (female) (A), and between ECMA (female) (5) and surrounding wiring harnesses as shown in Table 1?

NO: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (5) and TPR (female) (A) — Repair or replace

YES: go to 3

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

3 Is resistance between ECMA (female) (18) and TPR (female) (B), and between ECMA (female) (18) and surrounding wiring harnesses as shown in Table 2?

NO: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (18) and TPR (female) (B) — Repair or replace

YES: go to 4

- Turn starting switch OFF.
- Disconnect ECMA and TPR.

4 Is resistance between ECMA (female) (33) and TPR (female) (C), and between ECMA (female) (33) and surrounding wiring harnesses as shown in Table 3?

NO: Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (33) and TPR (female) (C) — Repair or replace

YES: go to 5

- Start engine.

5 Is negative pressure at suction side (tank side) of fuel filter more than 27kPa{203mmHg}?

NO: Defective engine controller — Replace

YES: Excessive suction resistance of fuel filter — Repair or replace

Table 1

ECMA (female), TPR (female)	Resistance value
Between ECMA (5) and TPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

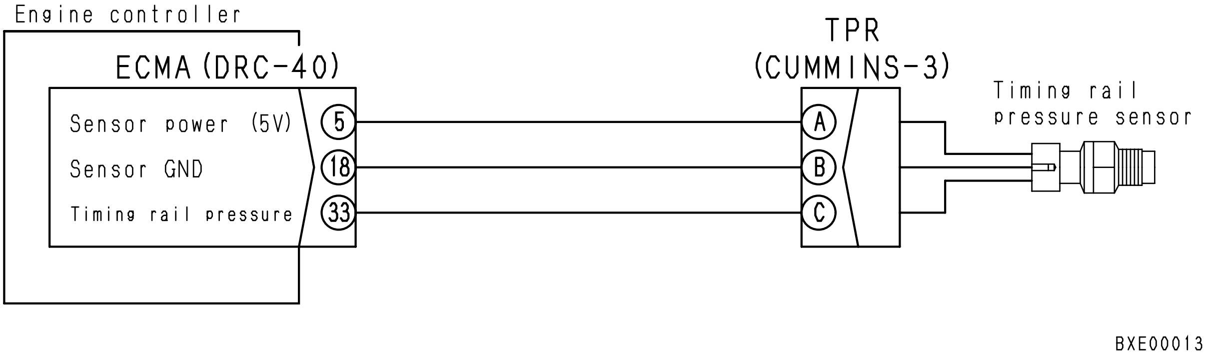
Table 2

ECMA (female), TPR (female)	Resistance value
Between ECMA (18) and TPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

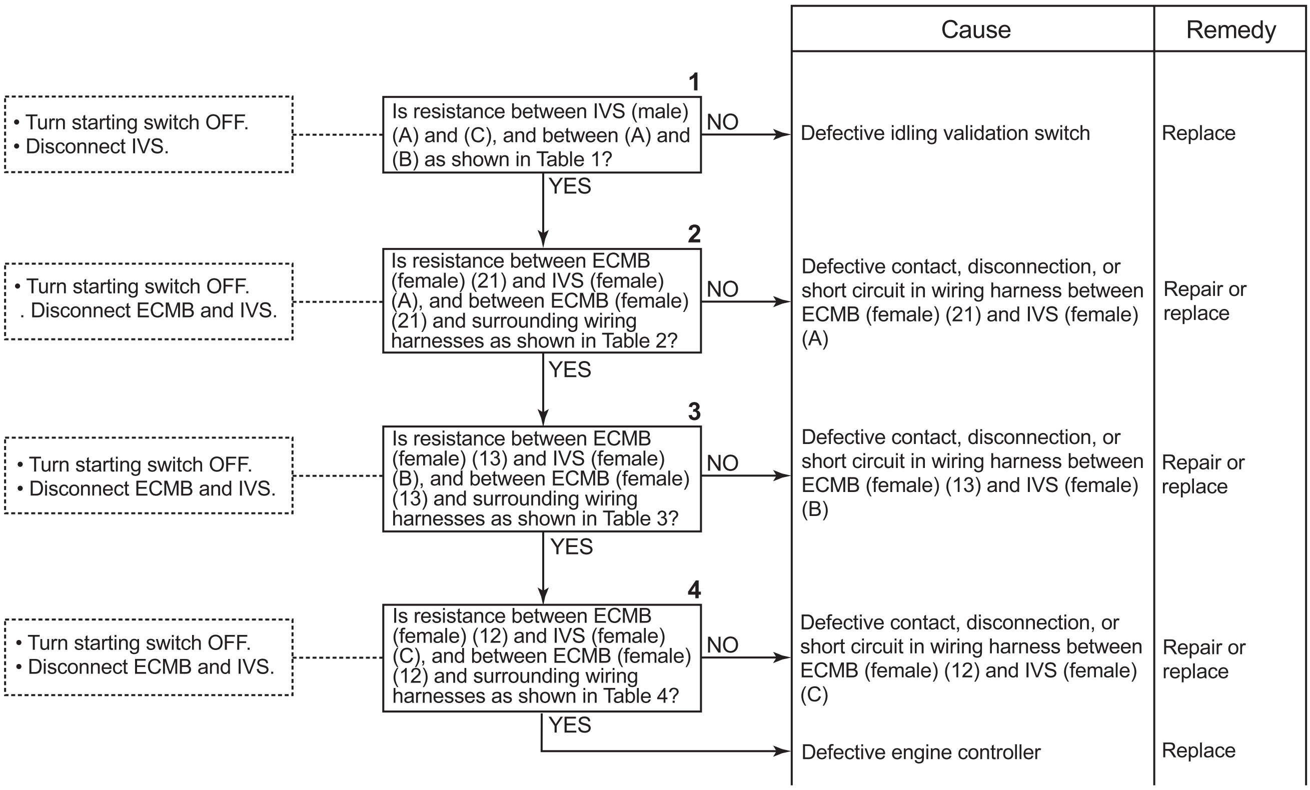
Table 3

Between ECMA (33) and TPR (C)	Resistance value
Between ECMA (33) and TPR (C)	Max. 10Ω
Between ECMA (33) and surrounding wiring harnesses	Min. 1 MΩ

EA-38 Related electrical circuit diagram



EA-39 Error code [431] (Abnormality 1 in idling validation switch system)



	Cause	Remedy
1 • Turn starting switch OFF. • Disconnect IVS. Is resistance between IVS (male) (A) and (C), and between (A) and (B) as shown in Table 1? NO →	Defective idling validation switch	Replace
YES ↓ **2** • Turn starting switch OFF. . Disconnect ECMB and IVS. Is resistance between ECMB (female) (21) and IVS (female) (A), and between ECMB (female) (21) and surrounding wiring harnesses as shown in Table 2? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (21) and IVS (female) (A)	Repair or replace
YES ↓ **3** • Turn starting switch OFF. • Disconnect ECMB and IVS. Is resistance between ECMB (female) (13) and IVS (female) (B), and between ECMB (female) (13) and surrounding wiring harnesses as shown in Table 3? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (13) and IVS (female) (B)	Repair or replace
YES ↓ **4** • Turn starting switch OFF. • Disconnect ECMB and IVS. Is resistance between ECMB (female) (12) and IVS (female) (C), and between ECMB (female) (12) and surrounding wiring harnesses as shown in Table 4? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (12) and IVS (female) (C)	Repair or replace
YES →	Defective engine controller	Replace

Table 1

IVS (male)	Pedal	Resistance value
Between (A) and (B)	Released (idling ON)	Max. 125Ω
Between (A) and (C)	Depressed (idling OFF)	Max. 125Ω

Table 2

ECMB (female), IVS (female)	Resistance value
Between ECMA (21) and IVS (A)	Max. 10Ω
Between ECMB (21) and surrounding wiring harnesses	Min. 1 MΩ

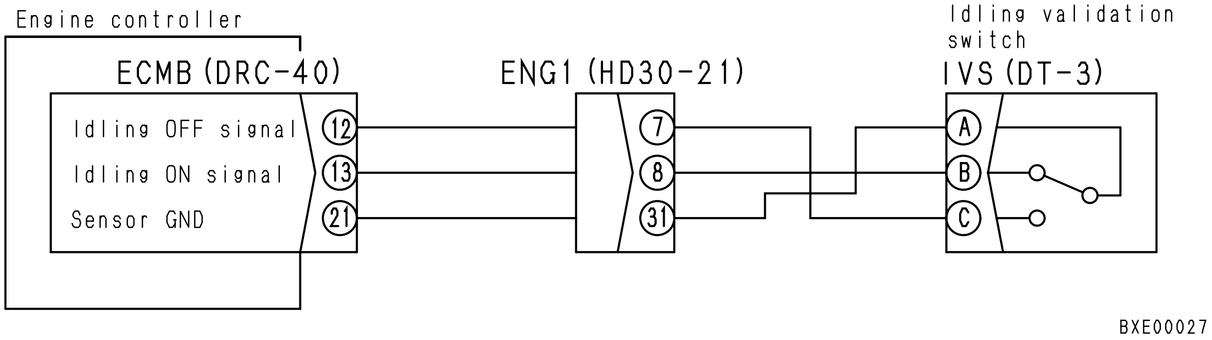
Table 3

ECMB (female), IVS (female)	Resistance value
Between ECMB (13) and IVS (B)	Max. 10Ω
Between ECMB (13) and surrounding wiring harnesses	Min. 1 MΩ

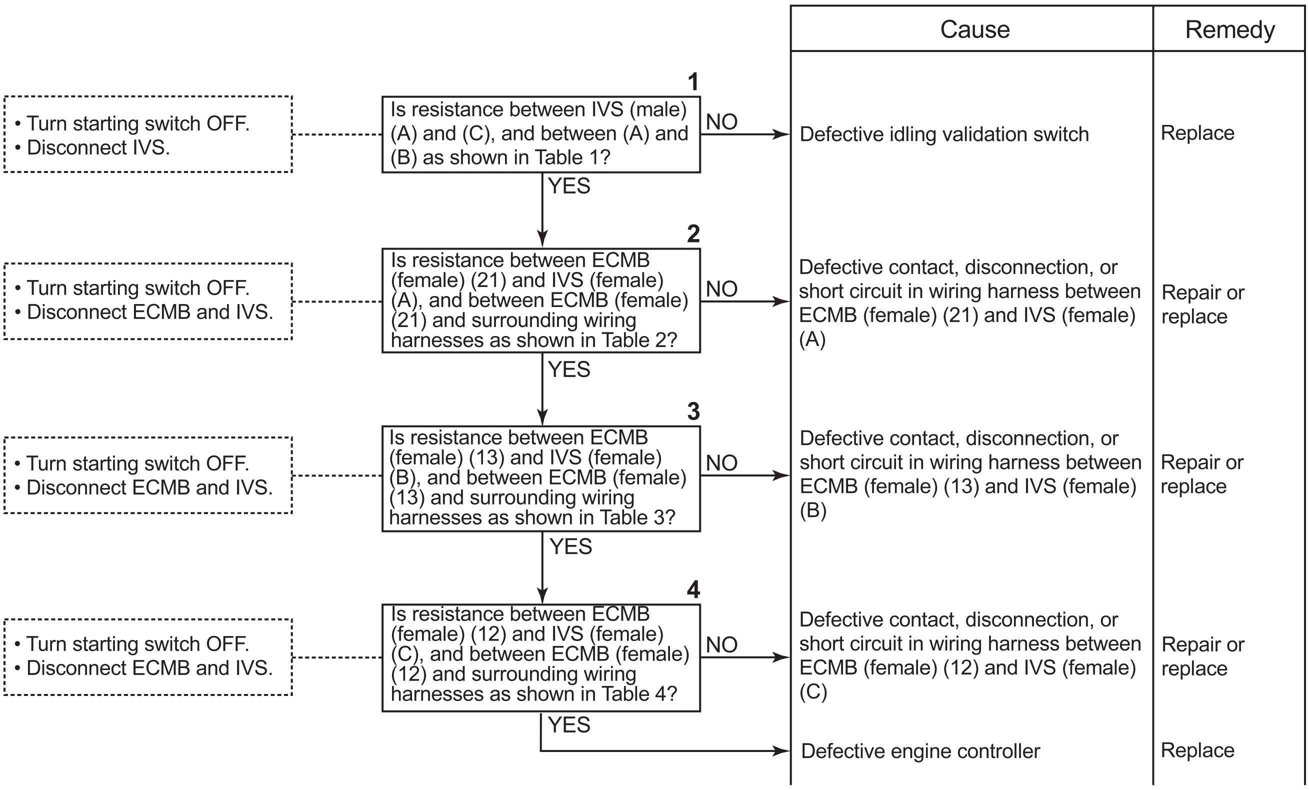
Table 4

ECMB (female), IVS (female)	Resistance value
Between ECMB (12) and IVS (C)	Max. 10Ω
Between ECMB (12) and surrounding wiring harnesses	Min. 1 MΩ

EA-39 Related electrical circuit diagram



EA-40 Error code [432] (Idling validation process error)



Cause	Remedy

1. • Turn starting switch OFF. • Disconnect IVS.
   Is resistance between IVS (male) (A) and (C), and between (A) and (B) as shown in Table 1?
   NO → Defective idling validation switch — Replace
   YES ↓

2. • Turn starting switch OFF. • Disconnect ECMB and IVS.
   Is resistance between ECMB (female) (21) and IVS (female) (A), and between ECMB (female) (21) and surrounding wiring harnesses as shown in Table 2?
   NO → Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (21) and IVS (female) (A) — Repair or replace
   YES ↓

3. • Turn starting switch OFF. • Disconnect ECMB and IVS.
   Is resistance between ECMB (female) (13) and IVS (female) (B), and between ECMB (female) (13) and surrounding wiring harnesses as shown in Table 3?
   NO → Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (13) and IVS (female) (B) — Repair or replace
   YES ↓

4. • Turn starting switch OFF. • Disconnect ECMB and IVS.
   Is resistance between ECMB (female) (12) and IVS (female) (C), and between ECMB (female) (12) and surrounding wiring harnesses as shown in Table 4?
   NO → Defective contact, disconnection, or short circuit in wiring harness between ECMB (female) (12) and IVS (female) (C) — Repair or replace
   YES → Defective engine controller — Replace

Table 1

IVS (male)	Pedal	Resistance value
Between (A) and (C)	Released or depressed	2,000 – 3,000Ω
Between (B) and (C)	Released (idling ON)	1,500 – 3,000Ω
	Depressed (idling OFF)	200 – 1,500 Ω

Table 2

ECMB (female), IVS (female)	Resistance value
Between ECMA (21) and IVS (A)	Max. 10Ω
Between ECMB (21) and surrounding wiring harnesses	Min. 1 MΩ

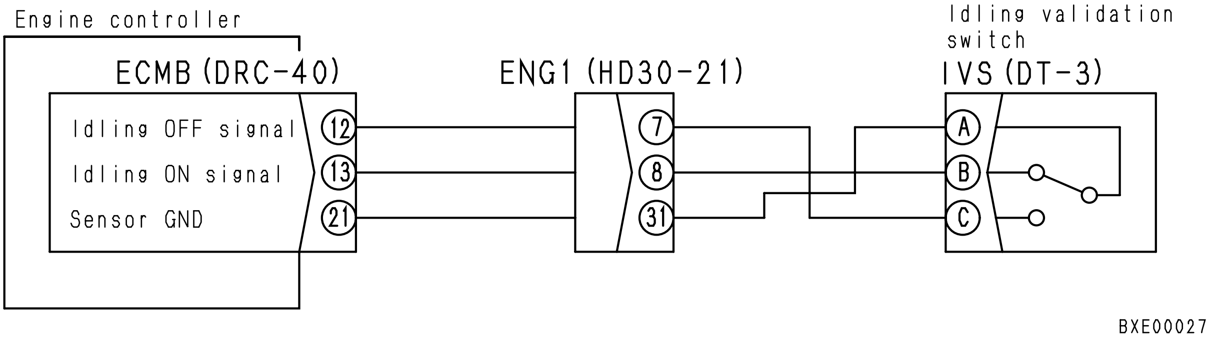
Table 3

ECMB (female), IVS (female)	Resistance value
Between ECMB (13) and IVS (B)	Max. 10Ω
Between ECMB (13) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

ECMB (female), IVS (female)	Resistance value
Between ECMB (12) and IVS (C)	Max. 10Ω
Between ECMB (12) and surrounding wiring harnesses	Min. 1 MΩ

EA-40 Related electrical circuit diagram



EA-41 Error code [441] (Abnormality in battery voltage low level)

★ Carry out troubleshooting for error code [346].

EA-42 Error code [442] (Abnormality in battery voltage high level)

★ Carry out troubleshooting for error code [346].

EA-43 Error code [451] (Abnormality in fuel rail pressure sensor system high level)

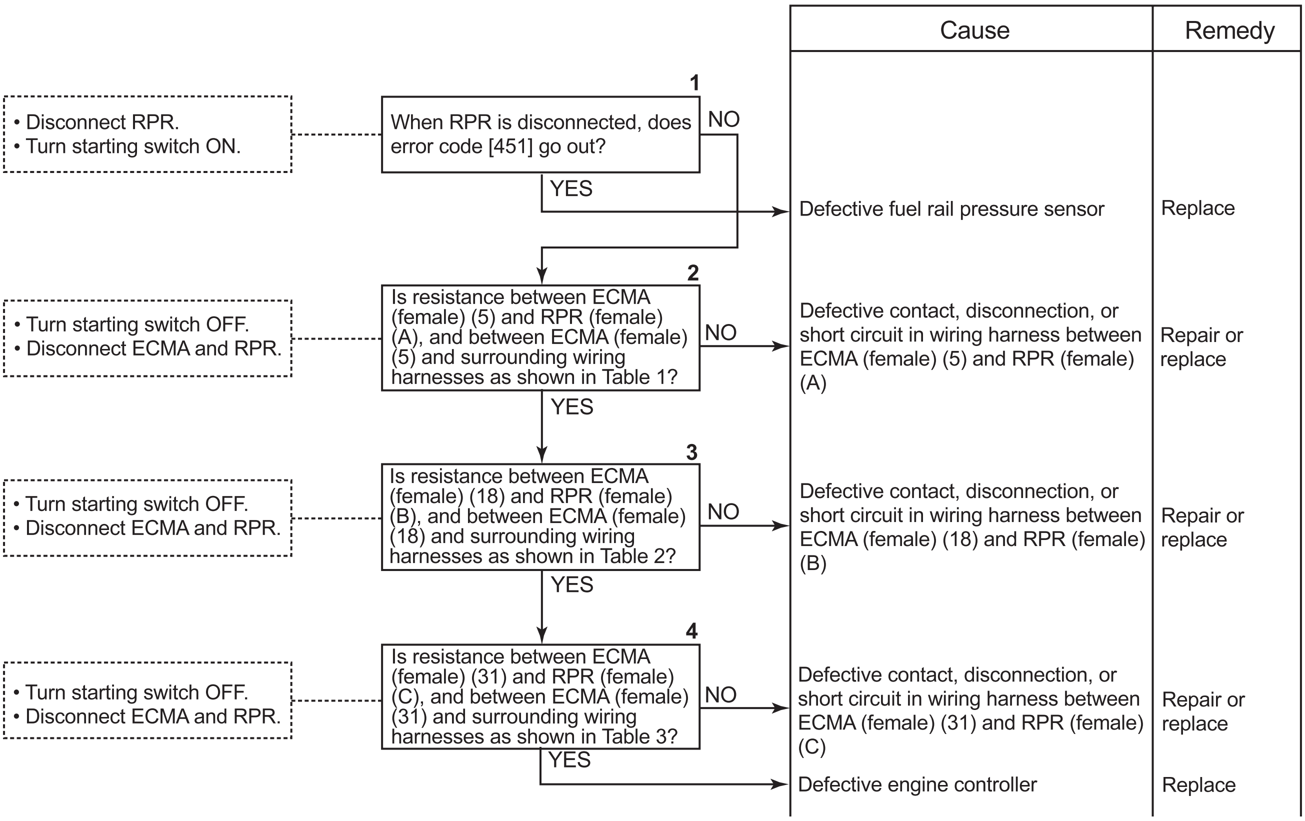


Table 1

ECMA (female), RPR (female)	Resistance value
Between ECMA (5) and RPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

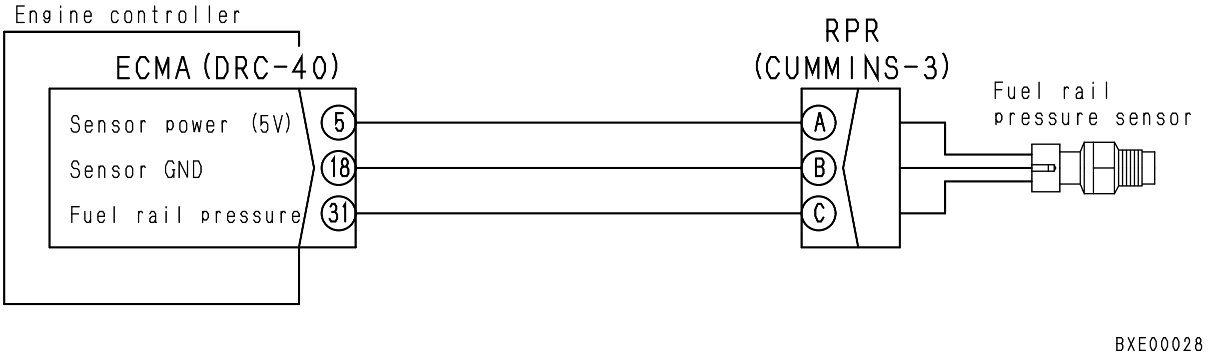
Table 2

ECMA (female), RPR (female)	Resistance value
Between ECMA (18) and RPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

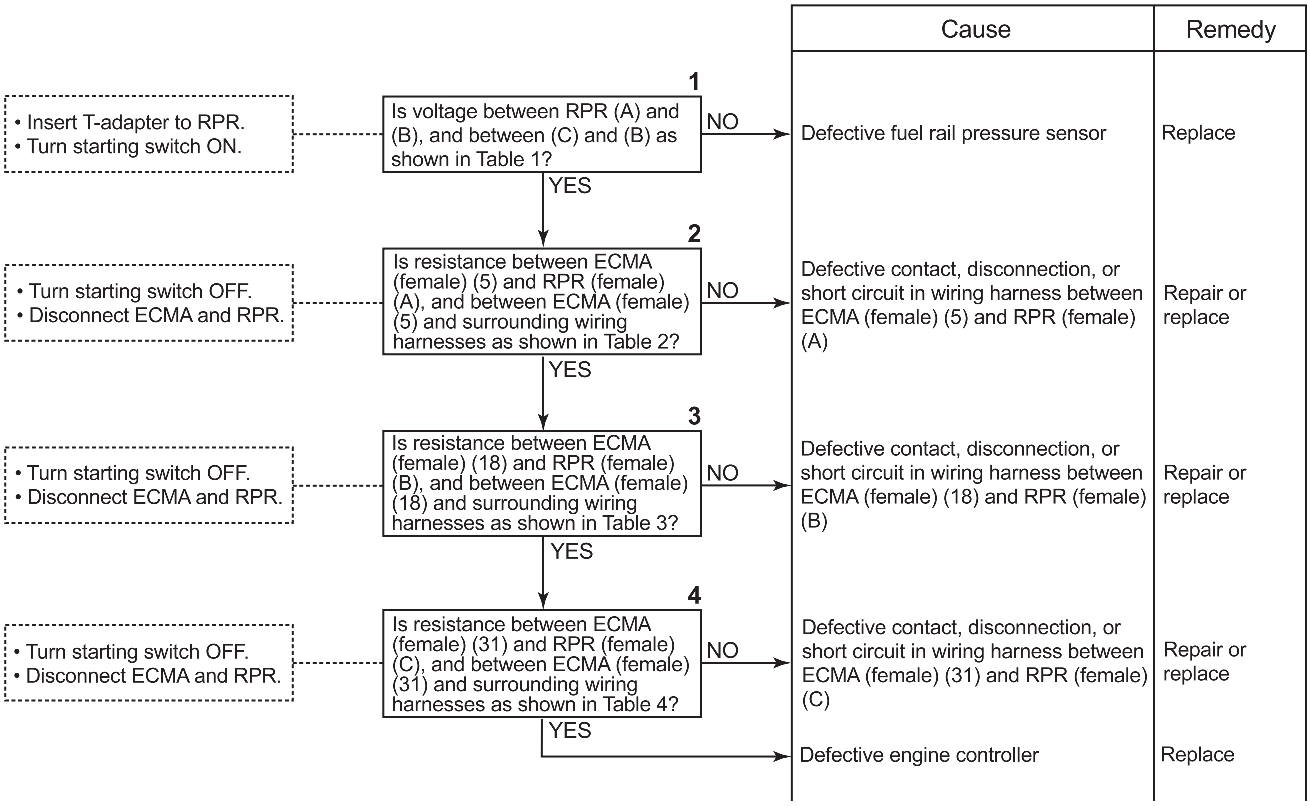
Table 3

ECMA (female), RPR (female)	Resistance value
Between ECMA (31) and RPR (C)	Max. 10Ω
Between ECMA (31) and surrounding wiring harnesses	Min. 1 MΩ

EA-43 Related electrical circuit diagram



EA-44 Error code [452] (Abnormality in fuel rail pressure sensor system low level)



Cause	Remedy

1
- Insert T-adapter to RPR.
- Turn starting switch ON.

Is voltage between RPR (A) and (B), and between (C) and (B) as shown in Table 1?
NO → Defective fuel rail pressure sensor — Replace
YES → 2

2
- Turn starting switch OFF.
- Disconnect ECMA and RPR.

Is resistance between ECMA (female) (5) and RPR (female) (A), and between ECMA (female) (5) and surrounding wiring harnesses as shown in Table 2?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (5) and RPR (female) (A) — Repair or replace
YES → 3

3
- Turn starting switch OFF.
- Disconnect ECMA and RPR.

Is resistance between ECMA (female) (18) and RPR (female) (B), and between ECMA (female) (18) and surrounding wiring harnesses as shown in Table 3?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (18) and RPR (female) (B) — Repair or replace
YES → 4

4
- Turn starting switch OFF.
- Disconnect ECMA and RPR.

Is resistance between ECMA (female) (31) and RPR (female) (C), and between ECMA (female) (31) and surrounding wiring harnesses as shown in Table 4?
NO → Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (31) and RPR (female) (C) — Repair or replace
YES → Defective engine controller — Replace

Table 1

RPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

ECMA (female), RPR (female)	Resistance value
Between ECMA (5) and RPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

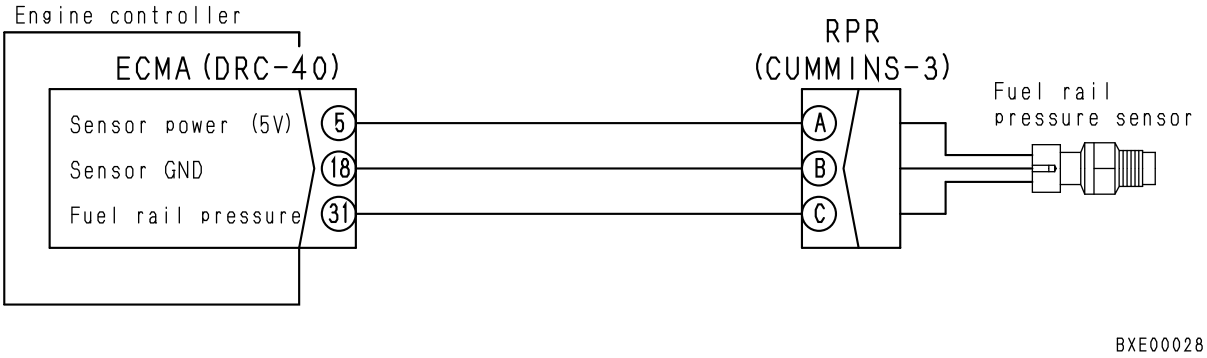
Table 3

ECMA (female), RPR (female)	Resistance value
Between ECMA (18) and RPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

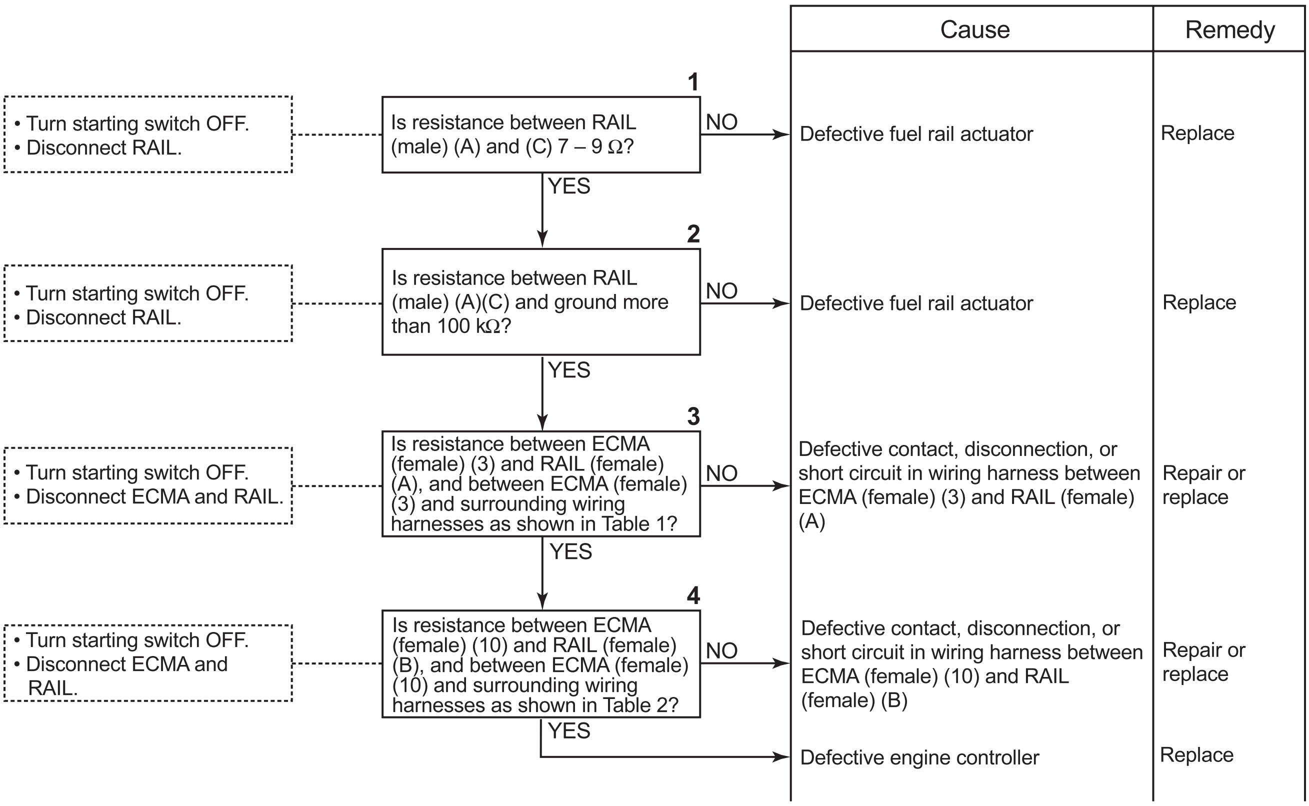
Table 4

ECMA (female), RPR (female)	Resistance value
Between ECMA (31) and RPR (C)	Max. 10Ω
Between ECMA (31) and surrounding wiring harnesses	Min. 1 MΩ

EA-44 Related electrical circuit diagram



EA-45 Error code [455] (Abnormality in fuel rail actuator system current)



	Cause	Remedy
1 • Turn starting switch OFF. • Disconnect RAIL. — Is resistance between RAIL (male) (A) and (C) 7 – 9 Ω? NO →	Defective fuel rail actuator	Replace
YES → **2** • Turn starting switch OFF. • Disconnect RAIL. — Is resistance between RAIL (male) (A)(C) and ground more than 100 kΩ? NO →	Defective fuel rail actuator	Replace
YES → **3** • Turn starting switch OFF. • Disconnect ECMA and RAIL. — Is resistance between ECMA (female) (3) and RAIL (female) (A), and between ECMA (female) (3) and surrounding wiring harnesses as shown in Table 1? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (3) and RAIL (female) (A)	Repair or replace
YES → **4** • Turn starting switch OFF. • Disconnect ECMA and RAIL. — Is resistance between ECMA (female) (10) and RAIL (female) (B), and between ECMA (female) (10) and surrounding wiring harnesses as shown in Table 2? NO →	Defective contact, disconnection, or short circuit in wiring harness between ECMA (female) (10) and RAIL (female) (B)	Repair or replace
YES →	Defective engine controller	Replace

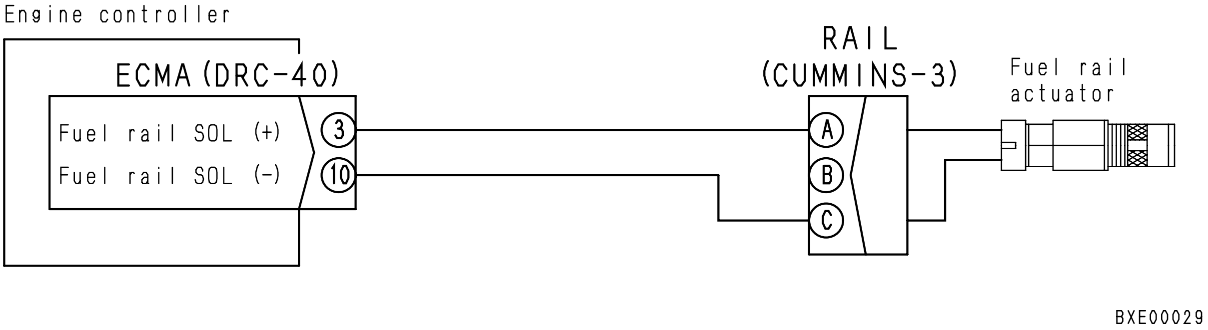
Table 1

ECMA (female), RAIL (female)	Resistance value
Between ECMA (3) and RAIL (A)	Max. 10Ω
Between ECMA (3) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

ECMA (female), RAIL (female)	Resistance value
Between ECMA (10) and RAIL	Max. 10Ω
Between ECMA (10) and surrounding wiring harnesses	Min. 1 MΩ

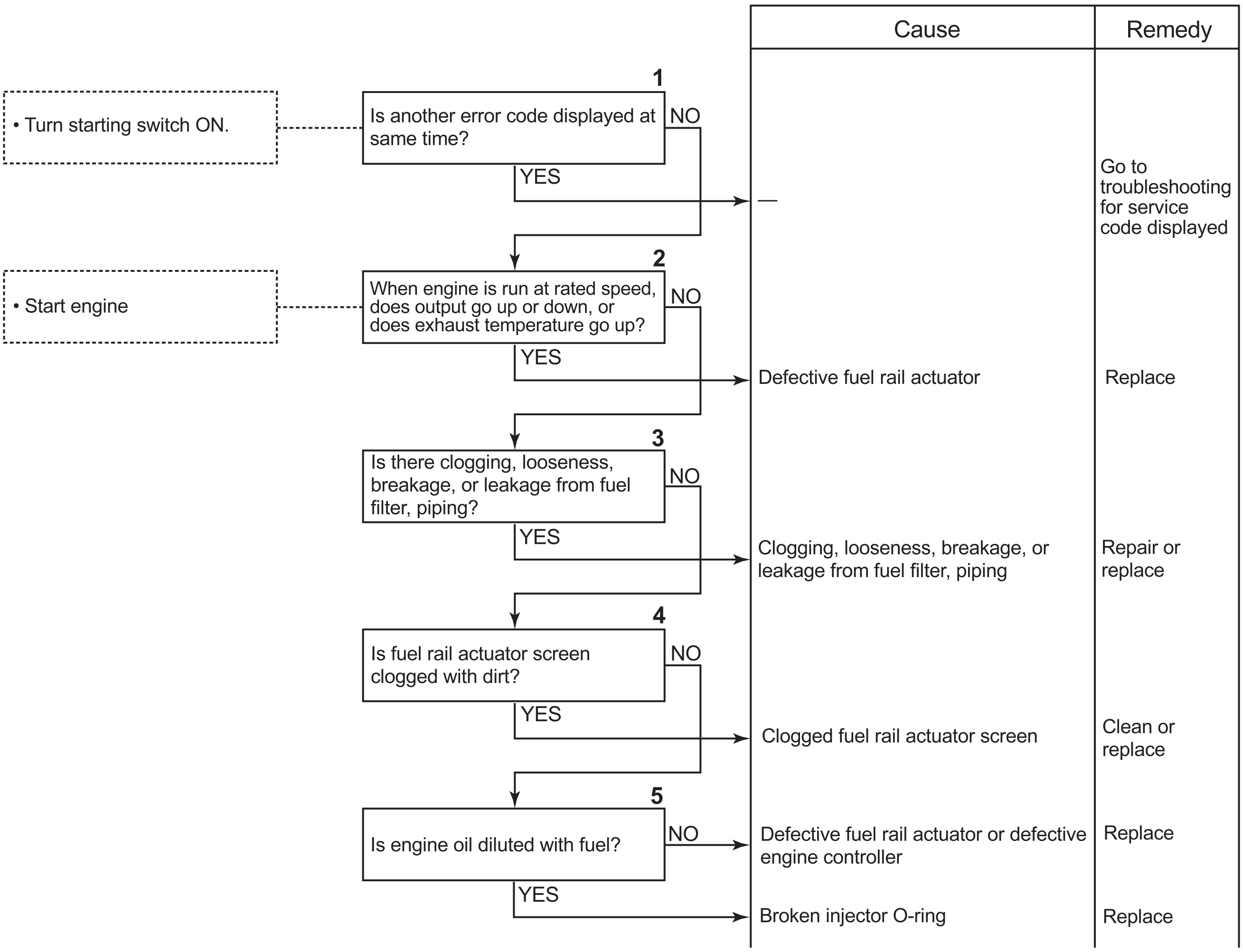
EA-45 Related electrical circuit diagram



EA-46 Error code [467] (Abnormality in timing rail actuator control)

★ Carry out troubleshooting for error code [112].

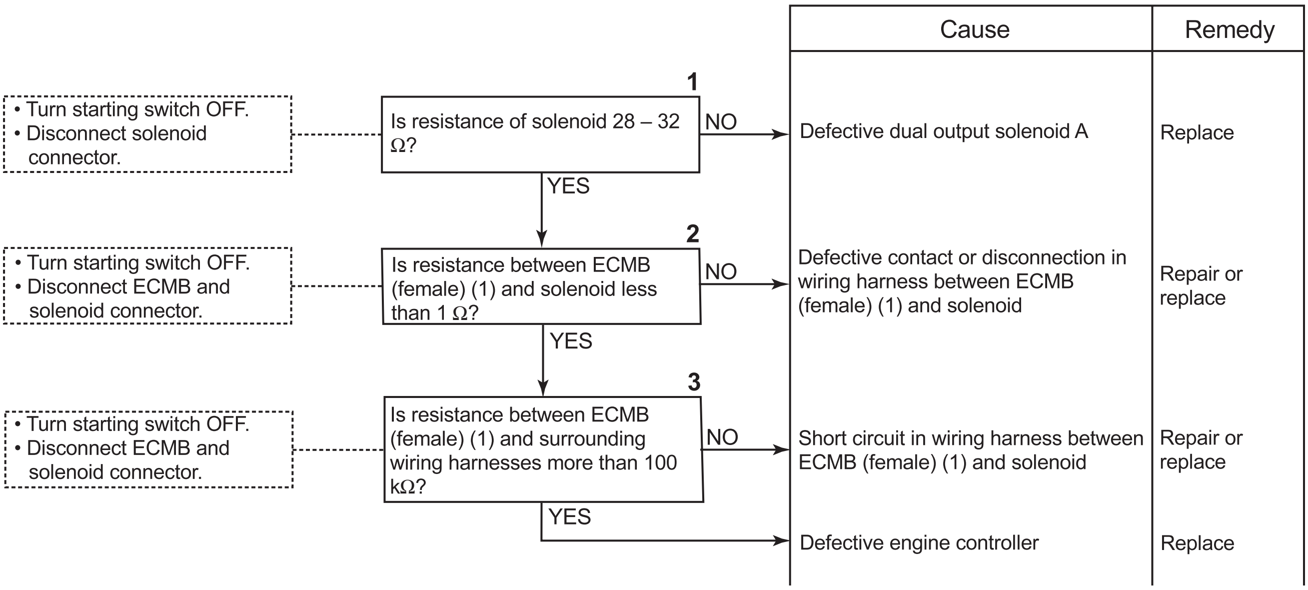
EA-47 Error code [468] (Abnormality in fuel rail actuator control)



EA-48 Error code [514] (Abnormality in fuel rail actuator)

★ Carry out troubleshooting for error code [468].

EA-49 Error code [527] (Abnormality in dual output solenoid A system)



1

- Turn starting switch OFF.
- Disconnect solenoid connector.

Is resistance of solenoid 28 – 32 Ω?

2

- Turn starting switch OFF.
- Disconnect ECMB and solenoid connector.

Is resistance between ECMB (female) (1) and solenoid less than 1 Ω?

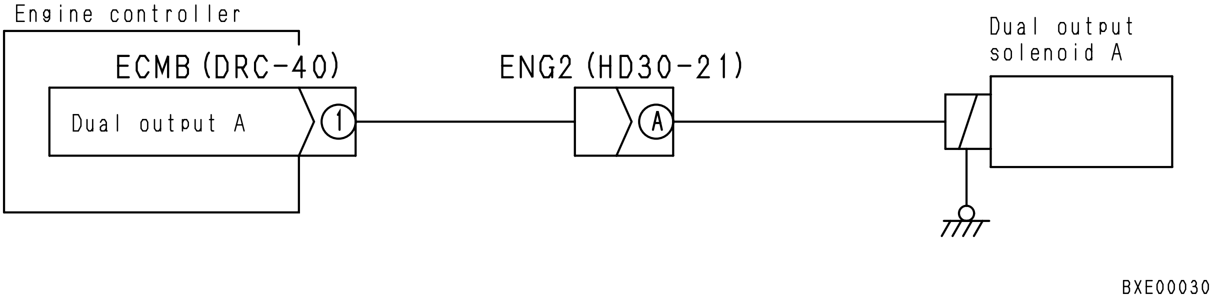
3

- Turn starting switch OFF.
- Disconnect ECMB and solenoid connector.

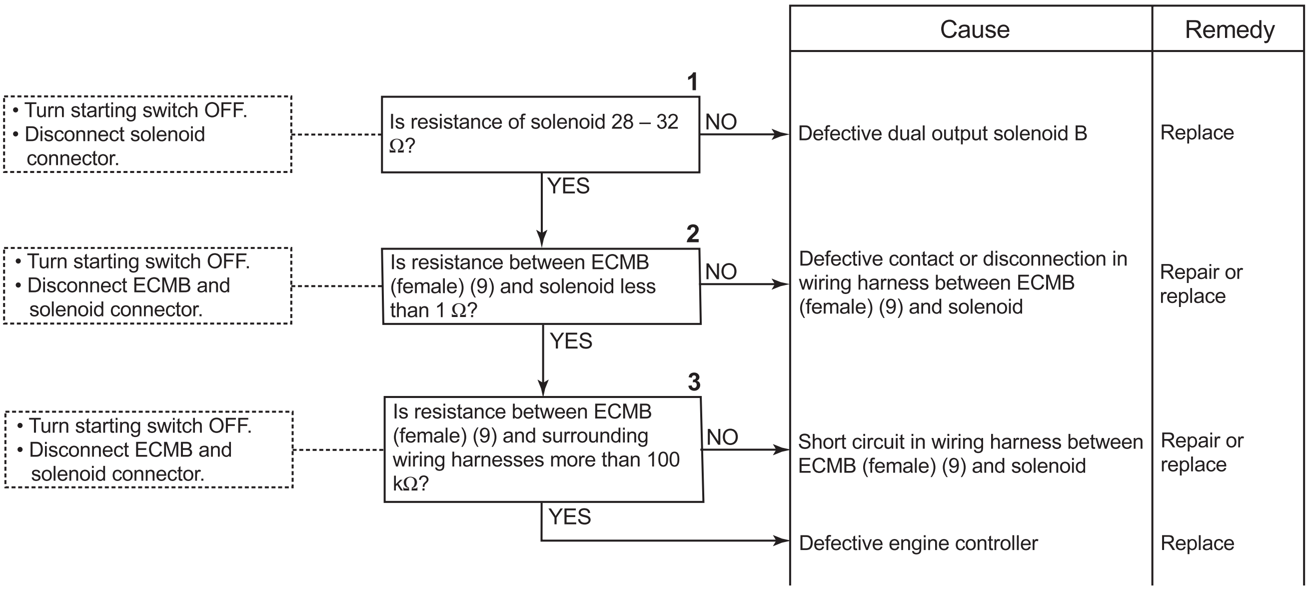
Is resistance between ECMB (female) (1) and surrounding wiring harnesses more than 100 kΩ?

	Cause	Remedy
1 NO	Defective dual output solenoid A	Replace
2 NO	Defective contact or disconnection in wiring harness between ECMB (female) (1) and solenoid	Repair or replace
3 NO	Short circuit in wiring harness between ECMB (female) (1) and solenoid	Repair or replace
3 YES	Defective engine controller	Replace

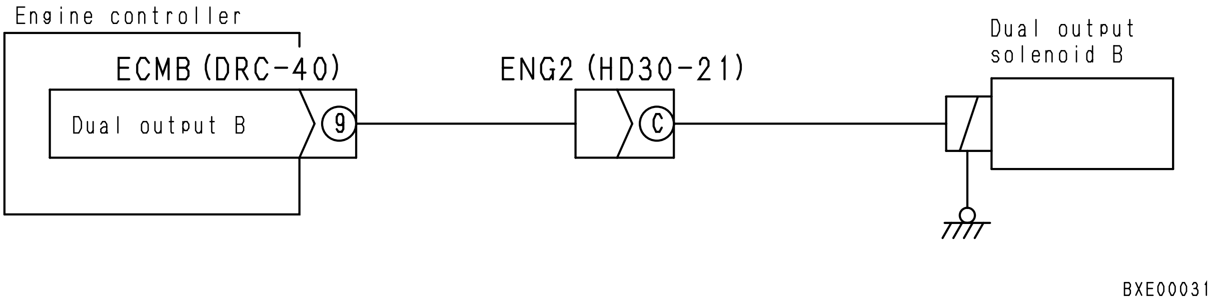
EA-49 Related electrical circuit diagram



EA-50 Error code [529] (Abnormality in dual output solenoid B system)



EA-50 Related electrical circuit diagram



EA-51 Error code [551] (Abnormality 2 in idling validation switch system)

★ Carry out troubleshooting for error code [431].

EA-52 Error code [554] (Abnormality in fuel rail pressure sensor in range)

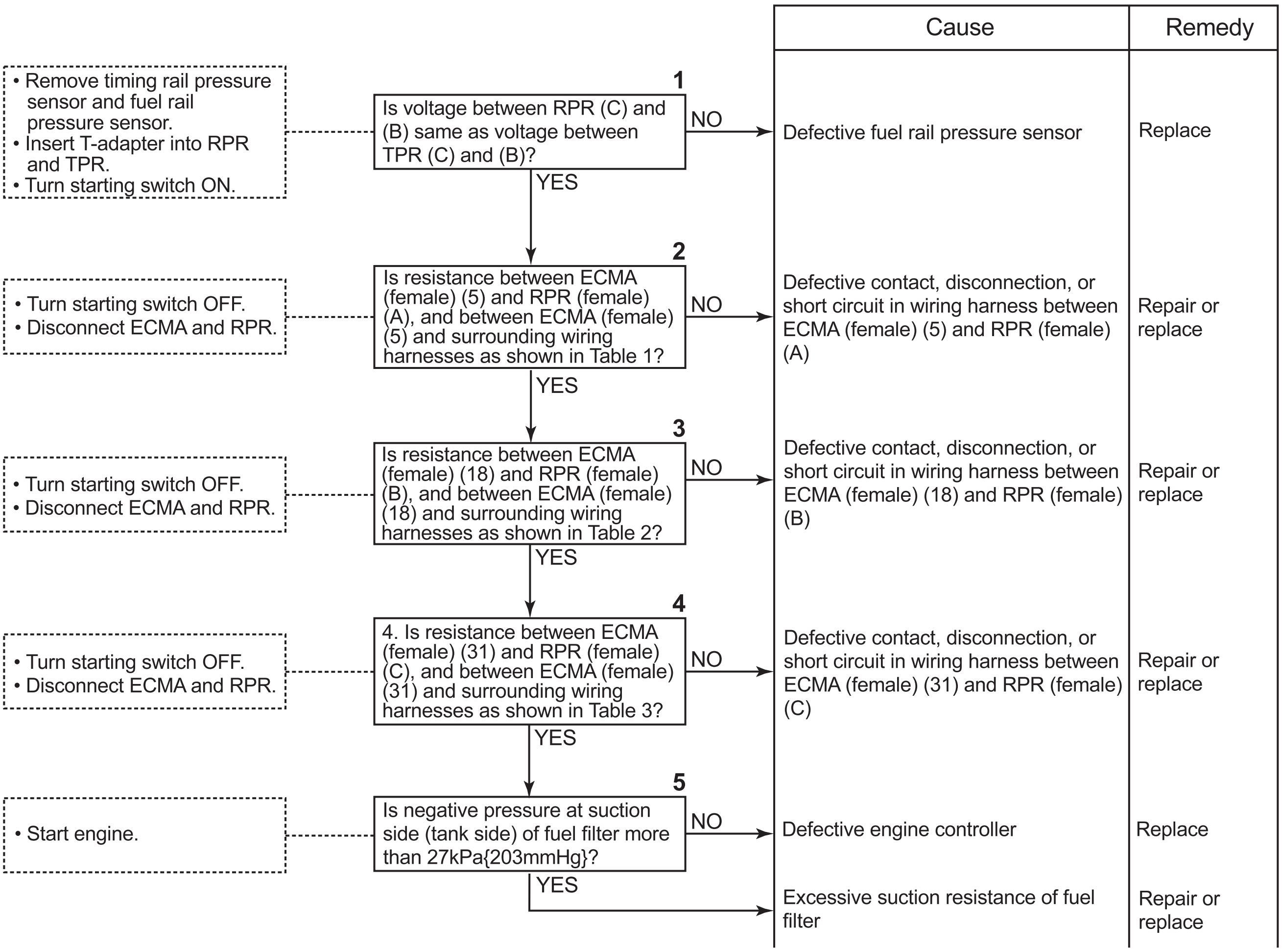


Table 1

ECMA (female), RPR (female)	Resistance value
Between ECMA (5) and RPR (A)	Max. 10Ω
Between ECMA (5) and surrounding wiring harnesses	Min. 1 MΩ

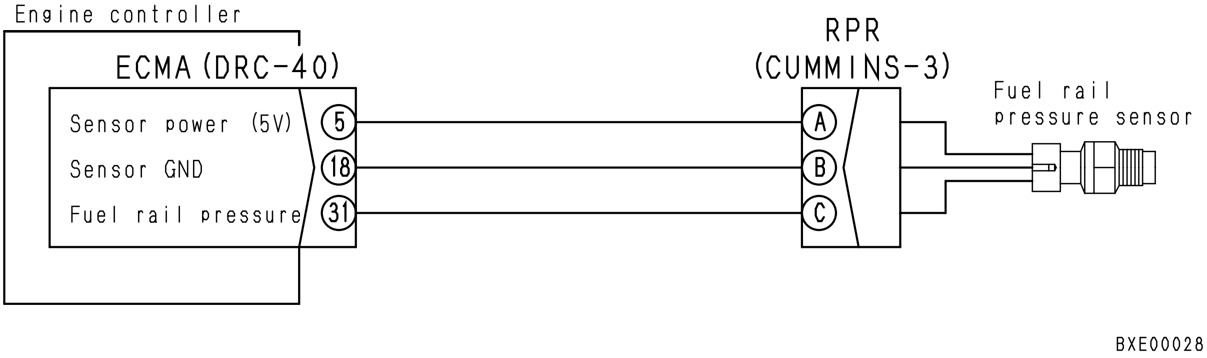
Table 2

ECMA (female), RPR (female)	Resistance value
Between ECMA (18) and RPR (B)	Max. 10Ω
Between ECMA (18) and surrounding wiring harnesses	Min. 1 MΩ

Table 3

ECMA (female), RPR (female)	Resistance value
Between ECMA (31) and RPR (C)	Max. 10Ω
Between ECMA (33) and surrounding wiring harnesses	Min. 1 MΩ

EA-52 Related electrical circuit diagram



TROUBLESHOOTING OF CONTROLLER SYSTEM OF ENGINE FOR GENERATOR EQUIPMENT (EB MODE)

★ This section gives an outline of the troubleshooting procedures for the electrical systems related to the engine proper and the engine controller (for construction equipment).
When carrying out troubleshooting of the electrical system with the engine mounted on the machine, use this section and the shop manual for the machine.

POINTS TO REMEMBER WHEN TROUBLESHOOTING

⚠ When carrying out troubleshooting, stop the machine in a level place, and check that the safety pin, blocks, and parking brake are securely applied.

⚠ When carrying out the operation with two or more workers, keep strictly to the agreed signals, and do not allow any unauthorized person to come near.

⚠ If the radiator cap is removed when the engine is still hot, boiling water may spurt out and cause burns. Always wait for the temperature to go down before starting the operation.

⚠ Be extremely careful not to touch any hot parts or to get caught in any rotating parts.

⚠ When disconnecting wiring, always disconnect the negative (–) terminal of the battery first.

⚠ When removing the plug from a location which is under pressure from oil, water, or air, always release the internal pressure first. When installing measuring equipment, be sure to connect it properly.

The aim of troubleshooting is to pinpoint the basic cause of the failure, to carry out repairs swiftly, and to prevent reoccurrence of the failure. When carrying out troubleshooting, an important point is of course to understand the structure and function. However, a short cut to effective troubleshooting is to ask the operator various questions to form some idea of possible causes of the failure that would produce the reported symptoms.

1. **When carrying out troubleshooting, do not hurry to disassemble the components**

   If components are disassembled immediately any failure occurs:
   - Parts that have no connection with the failure or other unnecessary parts will be disassembled
   - It will become impossible to find the cause of the failure.

   It will also cause a waste of man-hours, parts, or oil or grease, and at the same time, will also lose the confidence of the user or operator.

For this reason, when carrying out troubleshooting, it is necessary to carry out thorough prior investigation and to carry out troubleshooting in accordance with the fixed procedure.

2. **Points to ask user or operator**
   1) Are there signs of any abnormality on the machine or engine?
   2) Always carry out the checks before starting.
   3) Always carry out any other necessary checks.
   4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
   5) Check if there is any error code display for the controller.
   6) Has the same kind of failure occurred before?

3. **Checks before troubleshooting**
   1) Are there signs of any abnormality on the machine or engine?
   2) Always carry out the checks before starting.
   3) Always carry out any other necessary checks.
   4) Other maintenance items can be checked externally, so check any item that is considered to be necessary.
   5) Check if there is any error code display for the controller.

4. **Confirming failure**

   Confirm the extent of the failure yourself, and judge whether to handle it as a real failure or as a problem with the method of operation, etc.

   ★ When operating the machine to re-enact the troubleshooting symptoms, do not carry out any investigation or measurement that may make the problem worse.

5. **Troubleshooting**
   Use the results of the investigation and inspection in Items 2 – 4 to narrow down the causes of failure, then use the troubleshooting matrix or flowchart to locate the position of the failure more precisely.
   ★ The basic procedure for troubleshooting is as follows.
      1) Start from the simple points.
      2) Start from the most likely points.
      3) Investigate other related information.

6. **Measures to remove root cause of failure**
   Even if the failure is repaired, if the root cause of the failure is not repaired, the same failure will occur again.
   To prevent this, always investigate why the problem occurred. Then, remove the root cause.

METHOD OF USING TROUBLESHOOTING CHARTS

Method of using troubleshooting flowchart

① **Troubleshooting code number and problem**
The title at the top of the troubleshooting flowchart gives the troubleshooting code number and the problem with the machine.

② **General precautions**
When carrying out troubleshooting for the problem, precautions that apply to all items are given at the top of the page under the title and marked with ★.

★ The common precautions marked ★ at the top of the page are not given in the ⬚ (box formed by a broken line) on the left, but must always be followed when carrying out the check given in the ☐ (box formed by a solid line) on the right.

★

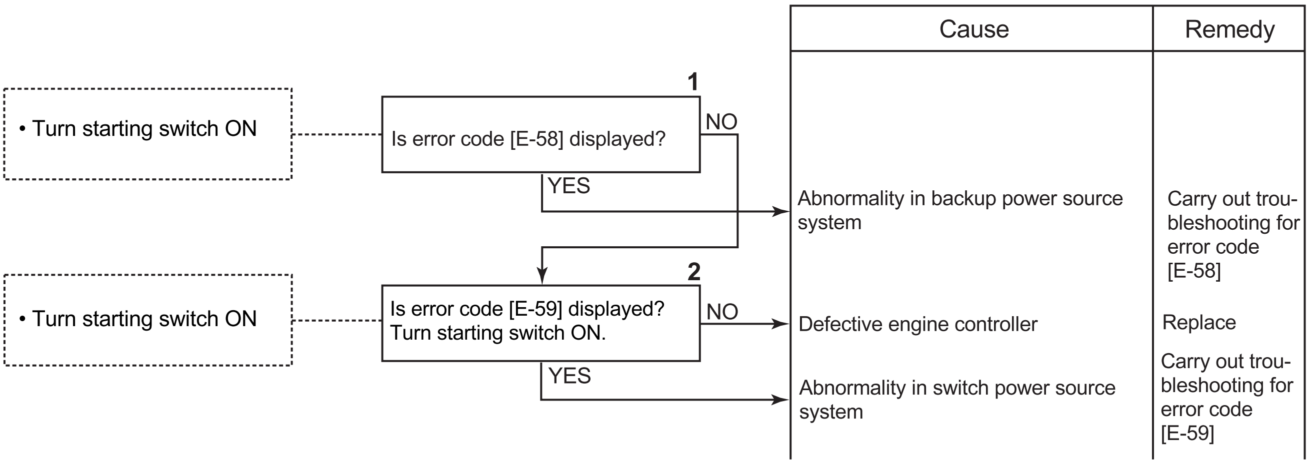
③ **Distinguishing conditions**
Even with the same problem, the method of troubleshooting may differ according to the model, component, or problem. In such cases, the failure mode is further divided into sections marked with small letters (for example, **a**), **b**)).
If the failure mode is divided into sections, go to the appropriate section to carry out troubleshooting.
If the troubleshooting table is not divided into sections, start troubleshooting from the first check item in the flowchart.

④ **Method of following troubleshooting chart**
Note: The number written at the top right corner of the ☐ is an index number; it does not indicate the order to follow.)

- To the left of the ☐ there is ⬚ (box formed by a broken line). This contains the procedure and conditions needed for inspection and measurement of the item in the ☐. Before starting inspection or measurement, always read the instructions for the procedure carefully, and make sure that you understand them.
- Check or measure the item inside ☐, and judge if the result is YES or NO. If the judgement values in the ☐ are correct or the answer to the question inside the ☐ is YES, follow the YES line; if the judgement value is not correct, or the answer to the question is NO, follow the NO line. Continue the troubleshooting for the next item in the same way.
  Following the YES or NO lines according to the results of the inspection or measurement will lead finally to the Cause and Remedy block. Check the cause and take the action given as the remedy.

⑤ **Troubleshooting tools**
Details of the tools needed for troubleshooting are given separately in the table of TOOLS FOR TESTING, ADJUSTING, AND TROUBLESHOOTING.

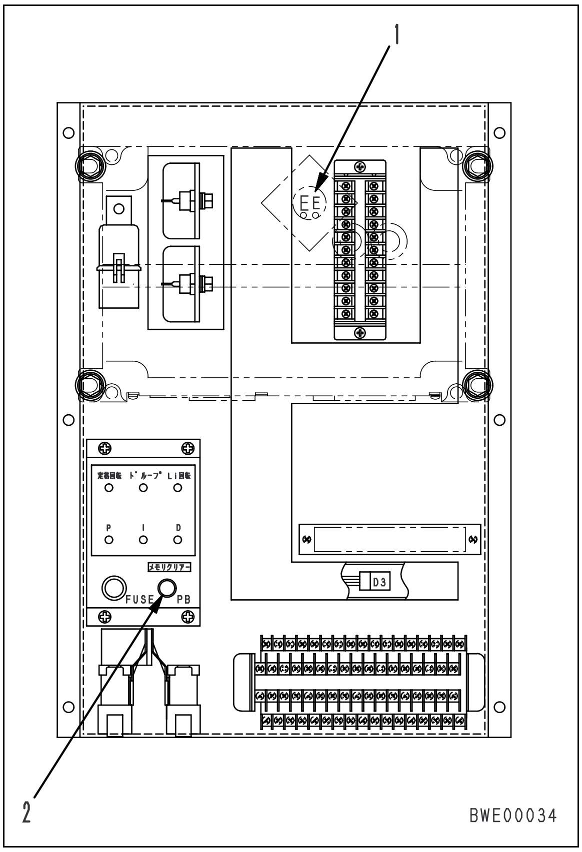
<Example of troubleshooting>

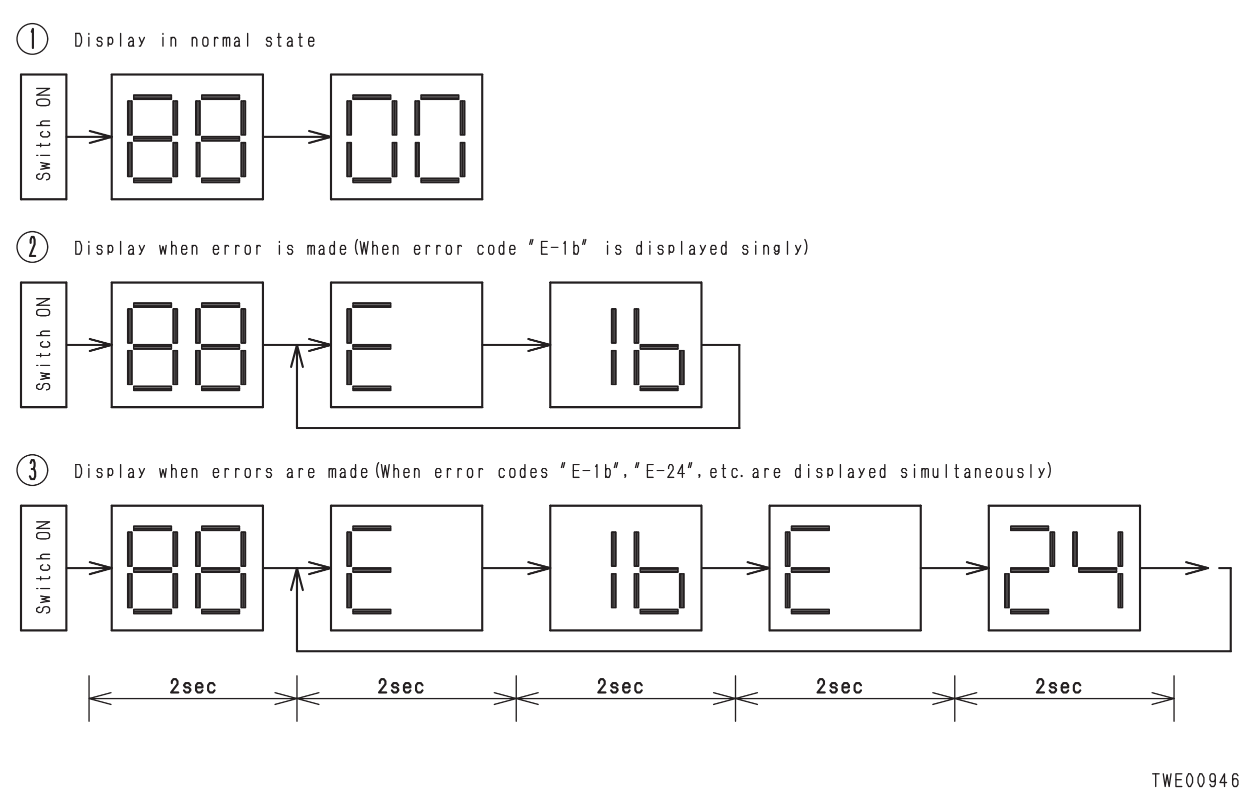


ERROR CODE DISPLAY AND POINTS TO REMEMBER WHEN TROUBLESHOOTING

1. Error code display

- When an abnormality occurs, the engine controller displays the appropriate error code for the abnormality in display window (1) of the controller using seven segments with two alphanumeric digits.
- When the starting switch is turned ON, the display check displays [**88**], then displays [**E**] to show the occurrence of an error and a 2-digit code repeatedly.
  If there are multiple error codes in memory, the display returns to the first display after completing all the displays.
- To prevent mistakes when reading, the numerals and letters are displayed as follows.
  Numerals: 0 • 1 • 2 • 3 • 4 • 5 • 6 • 7 • 8 • 9
  Alphabet: A • b • C • d • E
- When re-enacting an abnormality or after completion of repair of an abnormality, keep the starting switch at the ON position and the error codes are deleted from memory.





2. Table of error codes

Error code	System with abnormality
E-10	Abnormality in power source voltage system
E-16	Abnormality in fuel shut-off valve system
E-1b	Abnormality in engine speed sensor A system
E-1C	Abnormality in engine speed sensor B system
E-21	Mistaken connection of wiring harness connector
E-22	Overrun
E-23	Overheat
E-24	Abnormal drop in oil pressure
E-34	Abnormality in coolant temperature sensor system
E-56	Abnormality in solenoid power source 1 system
E-57	Abnormality in solenoid power source 2 system
E-58	Abnormality in backup power source system
E-59	Abnormality in switch power source system
E-70	Abnormality in fuel rail pressure sensor system high level
E-71	Abnormality in fuel rail pressure sensor system low level
E-72	X Abnormality in fuel rail pressure sensor system in range
E-73	Abnormality in fuel rail actuator
E-75	Abnormality with electric current in fuel rail actuator system
E-80	Abnormality in timing rail pressure sensor system high level
E-81	Abnormality in timing rail pressure sensor system low level
E-82	Abnormality in timing rail pressure sensor system in range
E-83	Abnormality in timing rail actuator
E-85	Abnormality with electric current in timing rail actuator system in range
E-90	Abnormality in fuel pump pressure sensor system high level
E-91	Abnormality in fuel pump pressure sensor system low level
E-93	Abnormality in fuel pump actuator
E-95	Abnormality with electric current in fuel pump actuator system
E-A0	Abnormality in shut-off valve
E-A1	Abnormality in starting switch ON signal system
E-A2	Abnormality in power source self-retention relay system
E-A3	Abnormality in emergency stop signal input
E-b0	Abnormality in atmospheric pressure sensor system high level
E-b1	Abnormality in atmospheric pressure sensor system low level
E-b2	Abnormality in boost air pressure sensor system high level
E-b3	Abnormality in boost air pressure sensor system low level
E-b4	Abnormality in boost air pressure sensor system in range
E-b6	Abnormality in droop adjustment volume system
E-b7	Abnormality in rated speed adjustment volume system
E-b8	Abnormality in Li speed adjustment volume system
E-b9	Abnormality in lamp time adjustment volume system
E-bA	Abnormality in P constant adjustment volume system
E-bb	Abnormality in I constant adjustment volume system
E-bC	Abnormality in D constant adjustment volume system
E-bd	Abnormality in fuel temperature sensor system
E-bE	Abnormal rise in fuel temperature

3. Points to remember when troubleshooting

1) Points to remember if abnormality returns to normal by itself:

   If the connector is disconnected and the T-adapter is inserted, or if the T-adapter is removed and the connector is returned to its original position when carrying out troubleshooting, and the error code is no longer displayed, the abnormality has proba-bly returned to normal by itself.

   However, there is a high probability that the same problem will occur again, so it is desirable to follow up this problem carefully.

2) Handling error codes:

   When displaying the error code and carrying out troubleshooting, note down the displayed codes, then erase the display. After trying to re-enact the problem, carry out troubleshooting according to the error codes that are displayed.

   ★ There are cases where mistaken operation or abnormalities that occur when the connector is disconnected are recorded in memory. Erasing the data and then re-enacting the problem saves any wasted work.

3) Handling connectors:

   ★ Before carrying out troubleshooting, check that all the connectors related to the error code are properly inserted.

   ★ Always connect any disconnected connectors before going on the next step and when finishing the troubleshooting operation.

ACTION TAKEN BY CONTROLLER AND CONDITION OF MACHINE WHEN ERROR CODE IS DISPLAYED

User code	System with abnormality	Nature of abnormality	Condition when normal
E-10	Abnormality in power source voltage system	• Abnormality has occurred in controller power source system (error code E-58 or E-59 is displayed at same time)	—
E-16	Abnormality in fuel shut-off valve system	• Abnormality has occurred in fuel shut-off valve circuit Between CN1 (1) and (13): Voltage 6.0 V or less or resistance 20 Ω or less detected	• Resistance of fuel shut-off valve Between FSO+ and FSO-: 23 – 40 Ω
E-1b	Abnormality in engine speed sensor A system	• Abnormality has occurred in engine speed sensor A system CN3-1 (2): Speed sensor A signal	• Resistance of engine speed sensor A Between SP1 (A) and (B): 1000 – 2,000 Ω
E-1C	Abnormality in engine speed sensor B system	• Abnormality has occurred in engine speed sensor B system CN3-1 (3): Speed sensor B signal	• Resistance of engine speed sensor B Between SP2 (A) and (B): 1000 – 2,000 Ω
E-21	Mistaken connection of wiring harness connector	• Mistaken connection of controller connector CN3-1 and CN5-1 detected • Abnormality has occurred in connector check circuit CN5-1 (1): Connector check signal	• Resistance of controller wiring harness Between CN5-1 (1) and CN3-1 (14): Max. 10 Ω
E-22	Overrun	• Engine speed sensor has detected speed higher than set speed	—
E-23	Overheat	• Water temperature sensor has detected temperature higher than set temperature Judgment value (reference): Min. 105°C	—
E-24	Abnormal drop in oil pressure	• Oil pressure sensor has detected pressure lower than set pressure	—
E-34	Abnormality in coolant temperature sensor system	• Abnormality has occurred in coolant temperature sensor circuit CN3-2 (9): 0.3 V or less or 4.7 or more detected	• Resistance of coolant temperature sensor Between CLTP (A) and (B): 600 – 36k Ω
E-56	Abnormality in solenoid power source 1 system	• Abnormality has occurred in solenoid power source 1 system	—
E-57	Abnormality in solenoid power source 2 system	• Abnormality has occurred in solenoid power source 2 system	—
E-58	Abnormality in backup power source system	• Abnormality has occurred in backup power source (permanent power source) circuit	—
E-59	Abnormality in switch power source system	• Abnormality has occurred in switch power source (starting switch ON power source) circuit	—
E-70	Abnormality in fuel rail pressure sensor system high level	• Abnormality has occurred in fuel rail pressure sensor circuit CN3-1 (10): 4.78 V or more detected	• Voltage of fuel rail pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 - 5.25 V Between CM3-1 (10) and (14) (signal): 0.42 - 0.58 V (engine stopped)

Action by controller	Problem that appears on machine	Probable cause
• Stops engine • Outputs alarm	—	—
• Shuts off power supply to fuel shut-off valve • Outputs alarm.	• Engine stops • Engine cannot be started	• Defective fuel shut-off valve • Defective wiring harness and connector of fuel shut-off valve circuit • Defective engine controller
• B system is normal, continues control with B system signal	• Engine speed is not stable • Engine stops	• Defective engine speed sensor • Defective wiring harness and connector of engine speed sensor A circuit • Defective engine controller
• If A system is normal, continues control with A system signal	• Engine speed is not stable • Engine stops	• Defective engine speed sensor • Defective wiring harness and connector of engine speed sensor B circuit • Defective engine controller
• Outputs alarm	• Engine speed is not stable • Engine stops	• Mistaken connection of connector • Defective connector wiring harness • Defective engine controller
• Shuts off power supply to fuel shut-off valve • Outputs alarm	• Engine stops	• Defective engine • Defective engine speed sensor • Defective engine controller • Defect on machine
• Outputs alarm	• Engine stops	• Defective engine • Defective coolant temperature sensor • Defective engine controller
• Outputs alarm	• Engine stops	• Defective engine • Defective oil pressure sensor • Defective engine controller
• Controls water temperature at constant level (85°C)	—	• Defective coolant temperature sensor • Disconnection in wiring harness of defective circuit of coolant temperature • Defective engine controller
• If system 2 is normal, continues control with system 2 power supply • Stops engine if both systems are abnormal • Outputs alarm	• Engine speed is not stable • Engine stops	• Defective engine external wiring • Defective wiring harness and connector of solenoid power source 1 circuit • Defective engine controller
• If system 1 is normal, continues control with system 1 power supply • Stops engine if both systems are abnormal • Outputs alarm	• Engine speed is not stable • Engine stops	• Defective engine external wiring • Defective wiring harness and connector of solenoid power source 2 circuit • Defective engine controller
• If switch power source is normal, continues control with switch power supply • Outputs alarm	• Controller cannot save error code	• Defective engine external wiring • Defective wiring harness and connector of backup power source circuit • Defective engine controller
• If backup power source is normal, continues control with backup power supply • Outputs alarm	—	• Defective engine external wiring • Defective wiring harness and connector of switch power source circuit • Defective engine controller
• Controls injection rate open	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller

User code	System with abnormality	Nature of abnormality	Condition when normal
E-71	Abnormality in fuel rail pressure sensor system low level	• Abnormality has occurred in fuel rail pressure sensor circuit CN3-1 (10): 0.15 V or less detected	• Voltage of fuel rail pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 - 5.25 V Between CM3-1 (10) and (14) (signal): 0.42 - 0.58 V (engine stopped)
E-72	Abnormality in fuel rail pressure sensor system in range	• Timing rail pressure sensor detected abnormal pressure :	—
E-73	Abnormality in fuel rail actuator	• Excessive difference between fuel rail command injection amount value and actual injection amount	—
E-75	Abnormality with electric current in fuel rail actuator system	• Abnormality has occurred in fuel rail actuator circuit	• Resistance of fuel rail actuator Between RAIL (A) and (C): 7 – 9 Ω
E-80	Abnormality in timing rail pressure sensor system high level	• Abnormality has occurred in timing rail pressure sensor circuit	• Voltage of timing rail pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 - 5.25 V Between CN3-2 (14) and CN3-1 (14) (signal): 0.42 - 0.58 V (engine stopped)
E-81	Abnormality in timing rail pressure sensor system low level	• Abnormality has occurred in timing rail pressure sensor circuit CN3-2 (14): 0.15 V or less detected	• Voltage of timing rail pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 - 5.25 V Between CN3-2 (14) and CN3-1 (14) (signal): 0.42 - 0.58 V (engine stopped)
E-82	Abnormality in timing rail pressure sensor system in range	• Timing rail pressure sensor detected abnormal pressure	—
E-83	Abnormality in timing rail actuator	• Excessive difference between timing rail command fuel value and actual timing fuel	—
E-85	Abnormality in timing rail actuator sensor system in range	• Abnormality has occurred in timing rail actuator circuit	• Resistance of timing rail actuator Between TIMG (A) and (C): 7 – 9 Ω
E-90	Abnormality in fuel pump pressure sensor system high level	• Abnormality has occurred in fuel pump pressure sensor circuit CN3-1 (9): 4.78 V or more detected	• Voltage of fuel pump pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 – 5.25 V Between CN3-1 (9) and (14) (signal): 0.42 – 0.58 V (engine stopped)
E-91	Abnormality in fuel pump pressure sensor system low level	• Abnormality has occurred in fuel pump pressure sensor circuit CN3-1 (9): 0.15 V or less detected	• Voltage of fuel pump pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 – 5.25 V Between CN3-1 (9) and (14) (signal): 0.42 – 0.58 V (engine stopped)

Action by controller	Problem that appears on machine	Probable cause
• Controls injection rate open	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller
• Controls injection rate open	—	• Defective fuel rail pressure sensor • Defective wiring harness and connector of fuel rail pressure sensor circuit • Defective engine controller
• Controls injection rate open	—	• Defective engine • Leakage of fuel, clogging • Defective fuel rail actuator or clogged screen • Defective injector O-ring • Defective engine controller
• Stops engine • Outputs alarm	—	• Defective fuel rail actuator • Defective wiring harness and connector of fuel rail actuator circuit • Defective engine controller
• Controls injection rate open	—	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller
• Controls injection rate open	—	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller
• Controls injection rate open	—	• Defective timing rail pressure sensor • Defective wiring harness and connector of timing rail pressure sensor circuit • Defective engine controller
• Controls injection rate open	• Abnormal combustion sound or white smoke is produced	• Leakage of fuel, clogging • Defective timing rail actuator or clogged screen • Defective injector O-ring • Defective engine controller
• Stops engine • Outputs alarm	—	• Defective timing rail actuator • Defective wiring harness and connector of timing rail actuator circuit • Defective engine controller
• Carries out open control of fuel pump	—	• Defective fuel pump pressure sensor • Defective wiring harness and connector of fuel pump pressure sensor circuit • Defective engine controller
• Carries out open control of fuel pump	—	• Defective fuel pump pressure sensor • Defective wiring harness and connector of fuel pump pressure sensor circuit • Defective engine controller

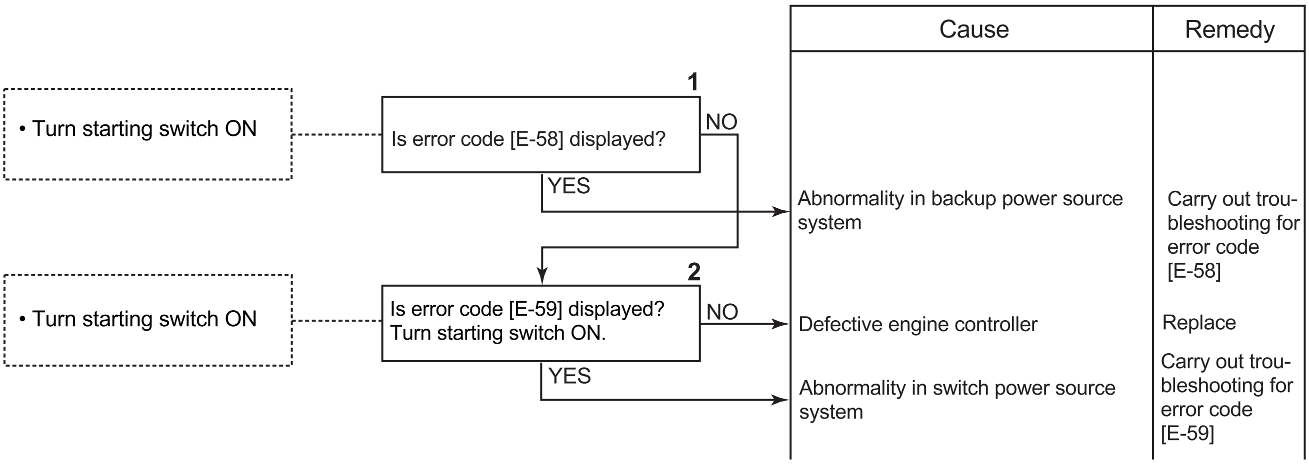
User code	System with abnormality	Nature of abnormality	Condition when normal
E-93	Abnormality in fuel pump actuator	• Excessive difference between fuel pump command pressure value and actual pressure	—
E-95	Abnormality with electric current in fuel pump actuator system	• Abnormality has occurred in fuel pump actuator circuit	• Resistance of fuel pump actuator Between PUMP (A) and (C): 7 – 9 Ω
E-A0	Abnormality in shut-off valve	• Fuel shut-off valve remains open and does not close (even when electric power is shut off, engine does not stop)	—
E-A1	Abnormality in starting switch ON signal system	• Abnormality has occurred in starting switch ON signal circuit	—
E-A2	Abnormality in power source self-retention relay system	• Abnormality has occurred in power source self-retention relay circuit	• Resistance of timing rail actuator Between relay (1) and (2): 200 – 400 Ω
E-A3	Abnormality in emergency stop signal input	• Emergency stop signal input from outside engine • Abnormality has occurred in emergency stop circuit	—
E-b0	Abnormality in atmospheric pressure sensor system high level	• Abnormality has occurred in atmospheric pressure sensor circuit CN3-1 (20): 4.78 V or more detected	• Voltage of atmospheric pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 – 5.25 V Between CN3-1 (20) and (14) (signal): 0.42 – 0.58 V (engine stopped)
E-b1	Abnormality in atmospheric pressure sensor system low level	• Abnormality has occurred in atmospheric pressure sensor circuit CN3-1 (20): 0.15 V or less detected	• Voltage of atmospheric pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 – 5.25 V Between CN3-1 (20) and (14) (signal): 0.42 – 0.58 V (engine stopped)
E-b2	Abnormality in boost air pressure sensor system high level	• Abnormality has occurred in boost air pressure sensor circuit CN3-2 (13): 4.78 V or more detected	• Voltage of boost air pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 – 5.25 V Between CN3-2 (13) and CN3-1 (14) (signal): 0.42 – 0.58 V (engine stopped)
E-b3	Abnormality in boost air pressure sensor system low level	• Abnormality has occurred in atmospheric pressure sensor circuit CN3-2 (13): 0.30 V or less detected	• Voltage of atmospheric pressure sensor Between CN3-1 (6) and (14) (power source): 4.75 - 5.25 V Between CN3-2 (13) and CN3-1 (14) (signal): 0.42 – 0.58 V (engine stopped)
E-b4	Abnormality in boost air pressure sensor system in range	• Boost air pressure sensor has detected abnormal pressure	—
E-b6	Abnormality in droop adjustment volume system	• Abnormality has occurred in droop adjustment volume circuit	• Resistance of droop adjustment volume Between CN3-2 (1) and CN3-1 (14): Fully closed: Max. 1.1 kW Fully open: 1.8 – 2.0 kΩ

Action by controller	Problem that appears on machine	Probable cause
—	• Engine speed becomes unstable	• Leakage of fuel, clogging • Defective fuel pump actuator or clogged screen • Defective injector O-ring • Defective engine controller
• Outputs alarm	—	• Defective fuel pump actuator • Defective wiring harness and connector of fuel pump actuator circuit • Defective engine controller
• Shuts off power supply to fuel shut-off valve • Stops engine forcibly	• Engine cannot stop • Engine a long time stop	• Defective fuel shut-off valve • Clogged fuel drain circuit • Defective injector • Defective engine controller
• Stops engine • Outputs alarm	• Engine does not start	• Defective external equipment of engine, wiring harness • Defective wiring harness and connector of starting switch ON signal circuit • Defective engine controller
• Stops engine • Outputs alarm	• Engine does not start	• Defective power source self-retention relay • Defective engine external wiring harness • Defective wiring harness and connector of power source self-retention relay circuit • Defective engine controller
• Stops engine • Outputs alarm	—	• Defective external equipment of engine, wiring harness • Defective wiring harness and connector of emergency stop signal circuit • Defective engine controller
• Controls at standard atmospheric pressure	—	• Defective atmospheric pressure sensor • Defective wiring harness and connector of atmospheric pressure sensor circuit • Defective engine controller
• Controls at standard atmospheric pressure	—	• Defective atmospheric pressure sensor • Defective wiring harness and connector of atmospheric pressure sensor circuit • Defective engine controller
• Controls by calculating boost pressure from r.p.m. and injection rate	—	• Defective boost air pressure sensor • Defective wiring harness and connector of boost air pressure sensor circuit • Defective engine controller
• Controls by calculating boost pressure from r.p.m. and injection rate	—	• Defective boost air pressure sensor • Defective wiring harness and connector of boost air pressure sensor circuit • Defective engine controller
—	—	• Defective boost air pressure sensor • Defective wiring harness and connector of boost air pressure sensor circuit • Defective engine controller
—	—	• Defective panel • Defective wiring harness of droop adjustment volume circuit • Defective engine controller

User code	System with abnormality	Nature of abnormality	Condition when normal
E-b7	Abnormality in rated speed adjustment volume system	• Abnormality has occurred in rated speed adjustment volume circuit	Resistance of rated speed adjustment volume Between CN3-2 (11) and CN3-1 (14): Fully closed: Max. 1.1 kΩ Fully open: 1.8 – 2.0 kΩ
E-b8	Abnormality in Li speed adjustment volume system	• Abnormality has occurred in Li speed adjustment volume circuit	• Resistance of Li speed adjustment volume Between CN3-2 (10) and CN3-1 (14): Fully closed: Max. 1.1 kχ Fully open: 1.8 – 2.0 kΩ
E-b9	Abnormality in lamp time adjustment volume system	• Abnormality has occurred in lamp time adjustment volume circuit	• Lamp time adjustment volume resistance Between CN3-1 (6) - (14): Fully closed: Max. 1.1 kΩ Fully opened: 1.8 - 2.0 kΩ
E-bA	Abnormality in P constant adjustment volume system	• Abnormality has occurred in P constant adjustment volume circuit	• Resistance of P constant adjustment volume Between CN3-2 (5) and CN3-1 (14): Fully closed: Max. 1.1 kΩ Fully open: 1.8 – 2.0 kΩ
E-bb	Abnormality in I constant adjustment volume system	• Abnormality has occurred in I constant adjustment volume circuit	• Resistance of I constant adjustment volume Between CN3-2 (6) and CN3-1 (14): Fully closed: Max. 1.1 kΩ Fully open: 1.8 – 2.0 kΩ
E-bC	Abnormality in D constant adjustment volume system	• Abnormality has occurred in D constant adjustment volume circuit	• Resistance of D constant adjustment volume Between CN3-2 (7) and CN3-1 (14): Fully closed: Max. 1.1 kΩ Fully open: 1.8 – 2.0 kΩ
E-bd	Abnormality in fuel temperature sensor system	• Abnormality has occurred in fuel temperature sensor circuit CN3-2 (8): 0.3 V or less or 4.7 V or more detected	• Resistance of fuel temperature sensor Between FLTP (A) and (B): 600 – 36k Ω
E-bE	Abnormal rise in fuel temperature	• Fuel temperature sensor has detected temperature higher than set temperature Judgment value (reference): 76°C or more	—

Action by controller	Problem that appears on machine	Probable cause
—	—	• Defective panel • Defective wiring harness of rated speed adjustment volume circuit • Defective engine controller
—	—	• Defective panel • Defective wiring harness of Li speed adjustment volume circuit • Defective engine controller
—	—	• Defective panel • Defective wiring harness of lamp time adjustment volume circuit at machine end • Defective engine controller
—	—	• Defective panel • Defective wiring harness of P constant adjustment volume circuit • Defective engine controller
—	—	• Defective panel • Defective wiring harness of I constant adjustment volume circuit • Defective engine controller
—	—	• Defective panel • Defective wiring harness of I constant adjustment volume circuit • Defective engine controller
—	—	• Defective fuel temperature sensor • Defective wiring harness and connector of fuel temperature sensor circuit • Defective engine controller
—	—	• Leakage of fuel, clogging • Defective fuel cooler at machine end • Defective fuel temperature sensor • Defective engine controller

EB-1 Error code [E-10] (Abnormality in power source voltage system)



EB-2 Error code [E-16] (Abnormality in fuel shut-off valve system voltage)

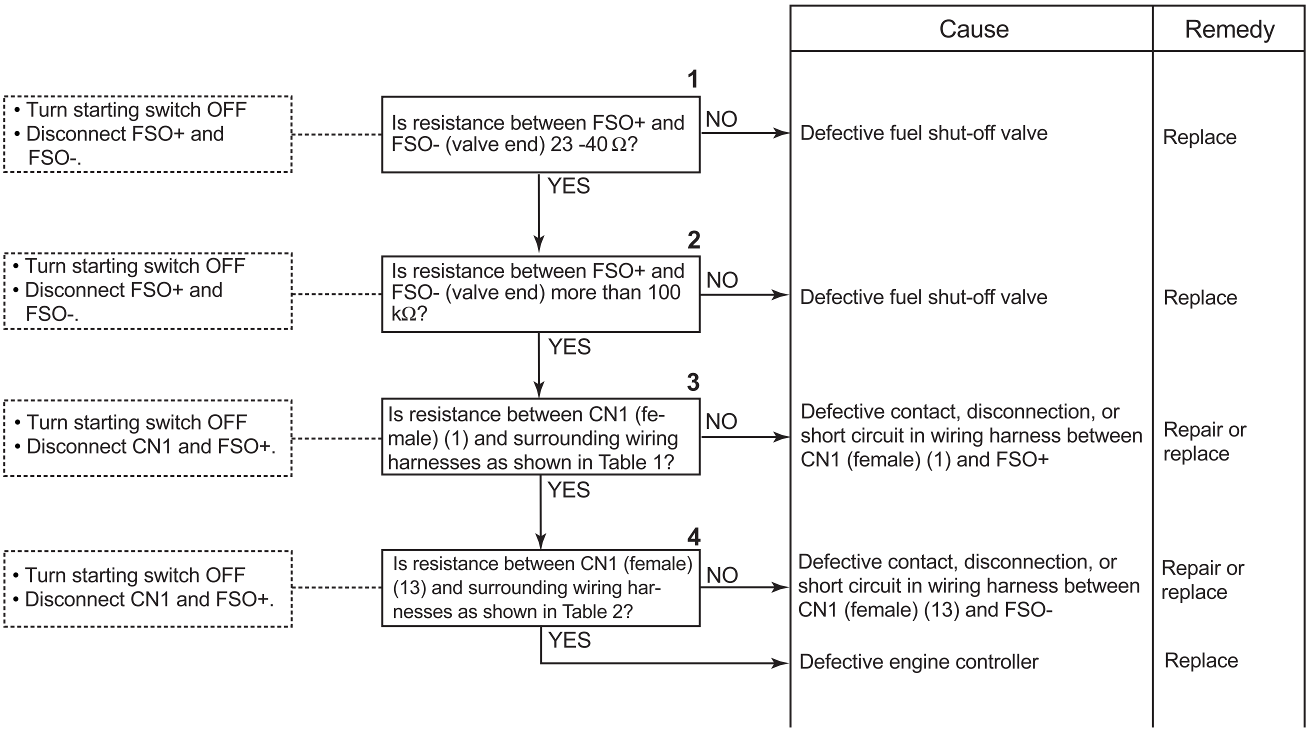


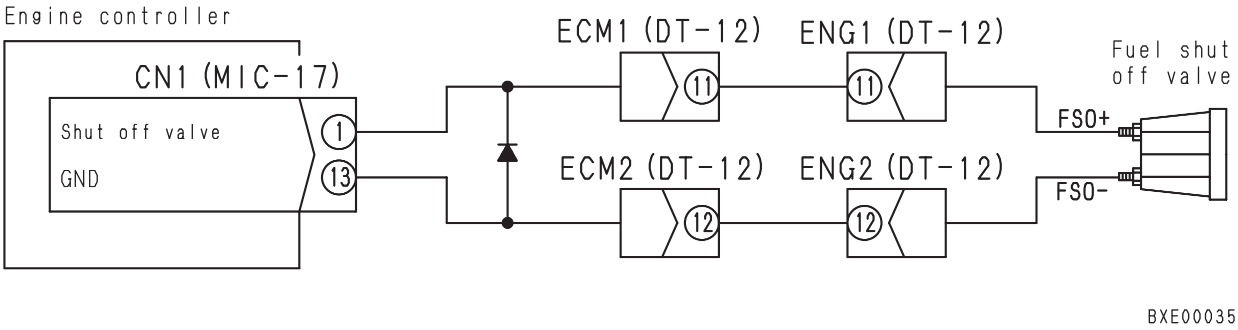
Table 1

CN1 (female), FSO+	Resistance value
Between CN1 (1) and FSO+	Max. 10 Ω
Between CN1 (1) and surrounding wiring harnesses	Min. 1 MΩ

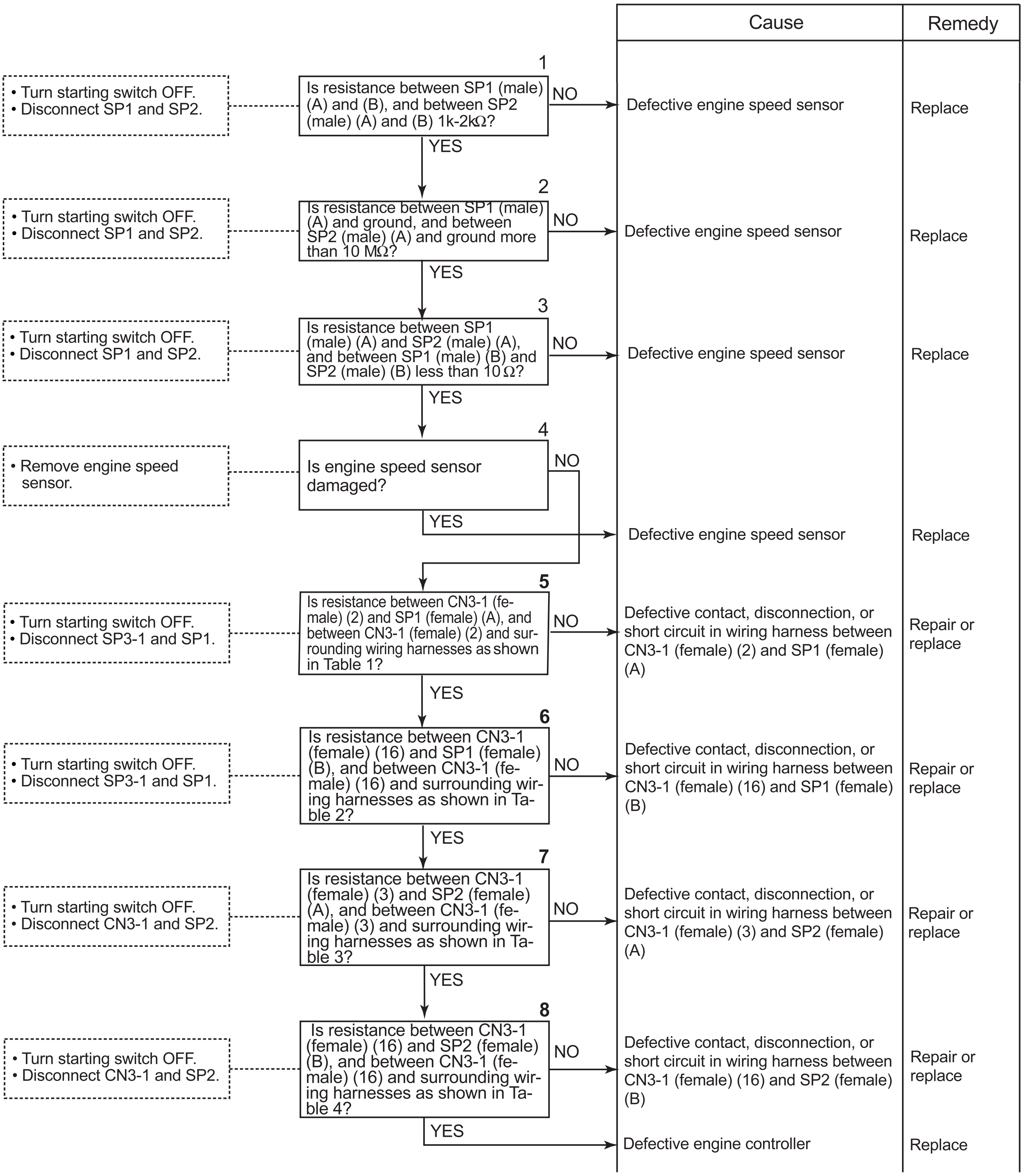
Table 2

CN1 (female), FSO-	Resistance value
Between CN1 (13) and FSO-	Max. 10 Ω
Between ECMA (30) and surrounding wiring harnesses	Min. 1 MΩ

EB-2 Related electrical circuit diagram



EB-3 Error code [E-1b] (Abnormality in engine speed sensor A system)



- Turn starting switch OFF.
- Disconnect SP1 and SP2.

1 Is resistance between SP1 (male) (A) and (B), and between SP2 (male) (A) and (B) 1k-2kΩ?

NO: Defective engine speed sensor — Replace

- Turn starting switch OFF.
- Disconnect SP1 and SP2.

2 Is resistance between SP1 (male) (A) and ground, and between SP2 (male) (A) and ground more than 10 MΩ?

NO: Defective engine speed sensor — Replace

- Turn starting switch OFF.
- Disconnect SP1 and SP2.

3 Is resistance between SP1 (male) (A) and SP2 (male) (A), and between SP1 (male) (B) and SP2 (male) (B) less than 10 Ω?

NO: Defective engine speed sensor — Replace

- Remove engine speed sensor.

4 Is engine speed sensor damaged?

YES: Defective engine speed sensor — Replace

- Turn starting switch OFF.
- Disconnect SP3-1 and SP1.

5 Is resistance between CN3-1 (female) (2) and SP1 (female) (A), and between CN3-1 (female) (2) and surrounding wiring harnesses as shown in Table 1?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (2) and SP1 (female) (A) — Repair or replace

- Turn starting switch OFF.
- Disconnect SP3-1 and SP1.

6 Is resistance between CN3-1 (female) (16) and SP1 (female) (B), and between CN3-1 (female) (16) and surrounding wiring harnesses as shown in Table 2?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (16) and SP1 (female) (B) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and SP2.

7 Is resistance between CN3-1 (female) (3) and SP2 (female) (A), and between CN3-1 (female) (3) and surrounding wiring harnesses as shown in Table 3?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (3) and SP2 (female) (A) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and SP2.

8 Is resistance between CN3-1 (female) (16) and SP2 (female) (B), and between CN3-1 (female) (16) and surrounding wiring harnesses as shown in Table 4?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (16) and SP2 (female) (B) — Repair or replace

YES: Defective engine controller — Replace

Table 1

CN3-1 (female) and SP1 (female)	Resistance value
Between CN3-1 (2) and SP1 (A)	Max. 10Ω
Between CN3-1 (2) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

CN3-1 (female), SP1 (female)	Resistance value
Between CN3-1 (16) and SP1 (B)	Max. 10Ω
Between CN3-1 (16) and surrounding wiring harnesses	Min. 1 MΩ

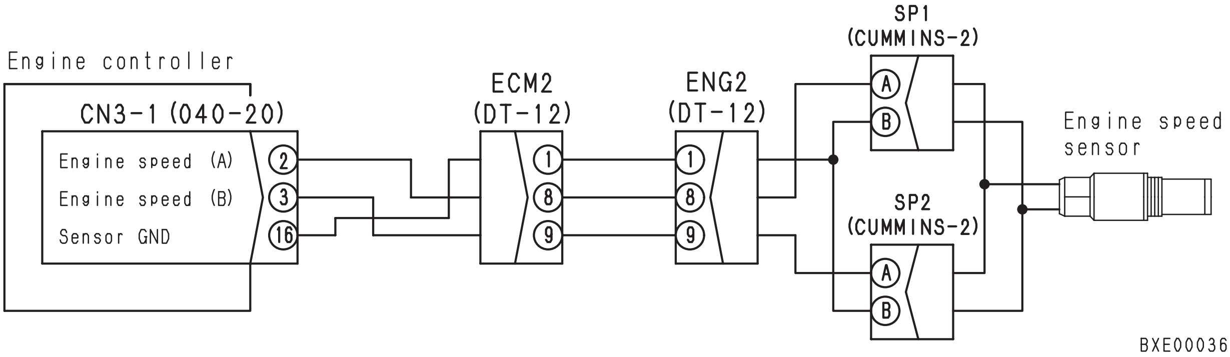
Table 3

CN3-1 (female), SP2 (female)	Resistance value
Between CN3-1 (3) and SP2 (A)	Max. 10Ω
Between CN3-1 (3) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

CN3-1 (female), SP2 (female)	Resistance value
Between CN3-1 (16) and SP2 (B)	Max. 10Ω
Between CN3-1 (16) and surrounding wiring harnesses	Min. 1 MΩ

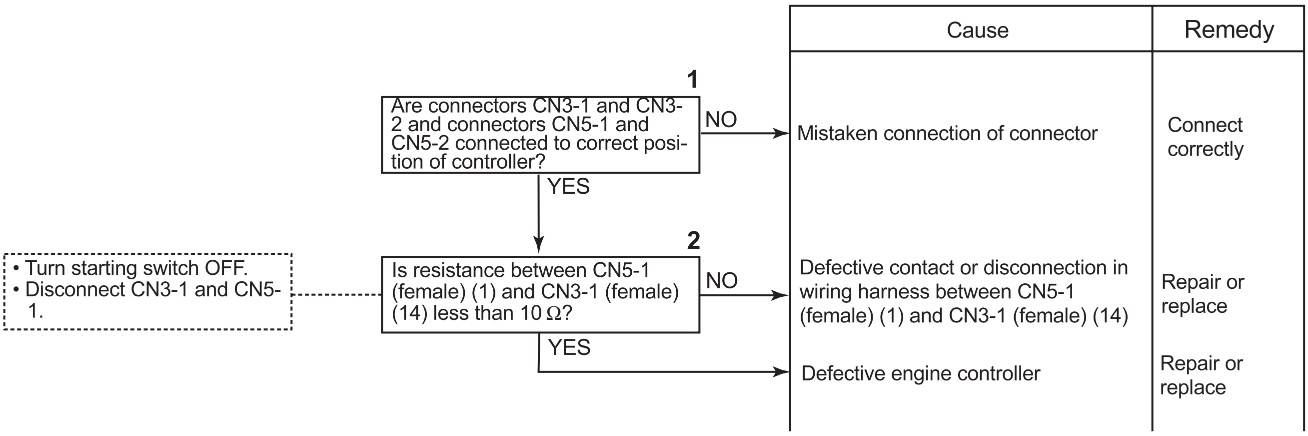
EB-3 Related electrical circuit diagram



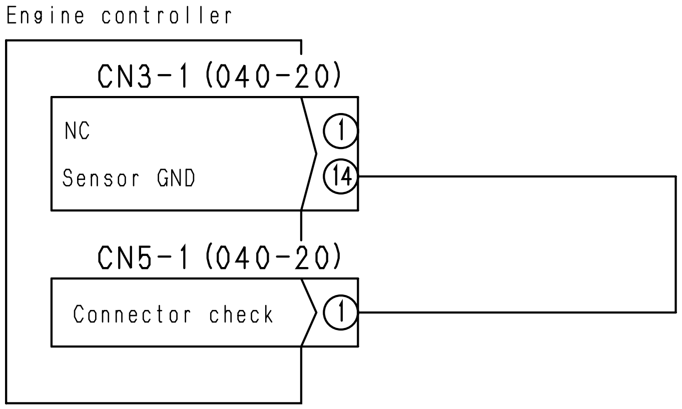
EB-4 Error code [E-1C] (Abnormality in engine speed sensor B system)

★ Carry out troubleshooting for error code [E-1b].

EB-5 Error code [E-21] (Mistaken of connection of wiring harness connector)

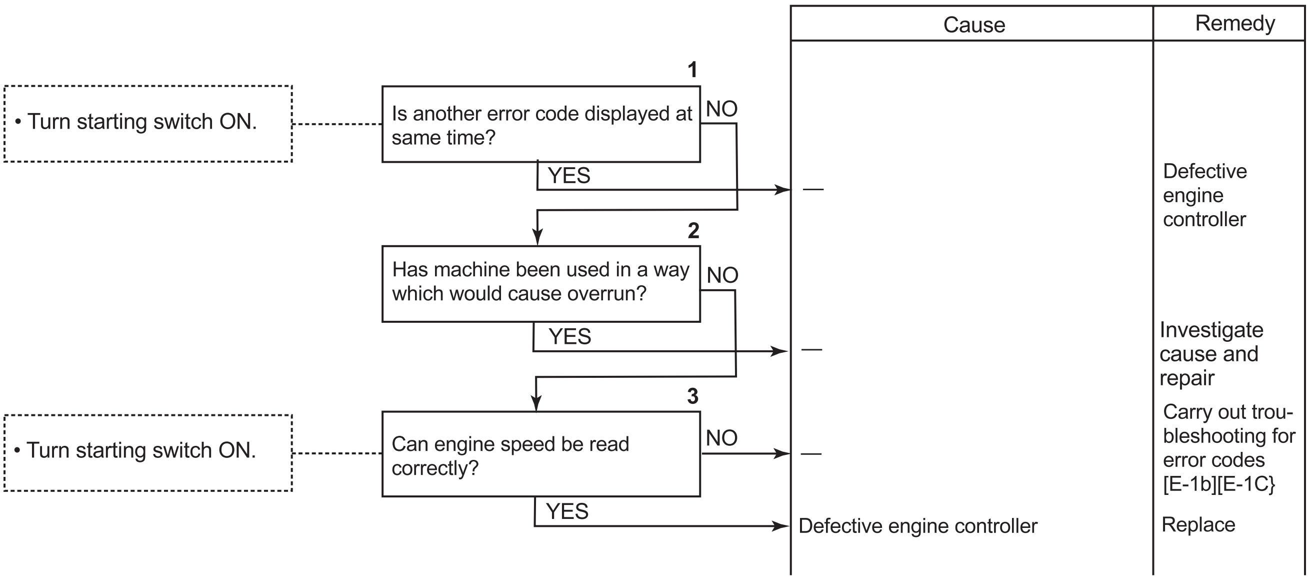


EB-5 Related electrical circuit diagram

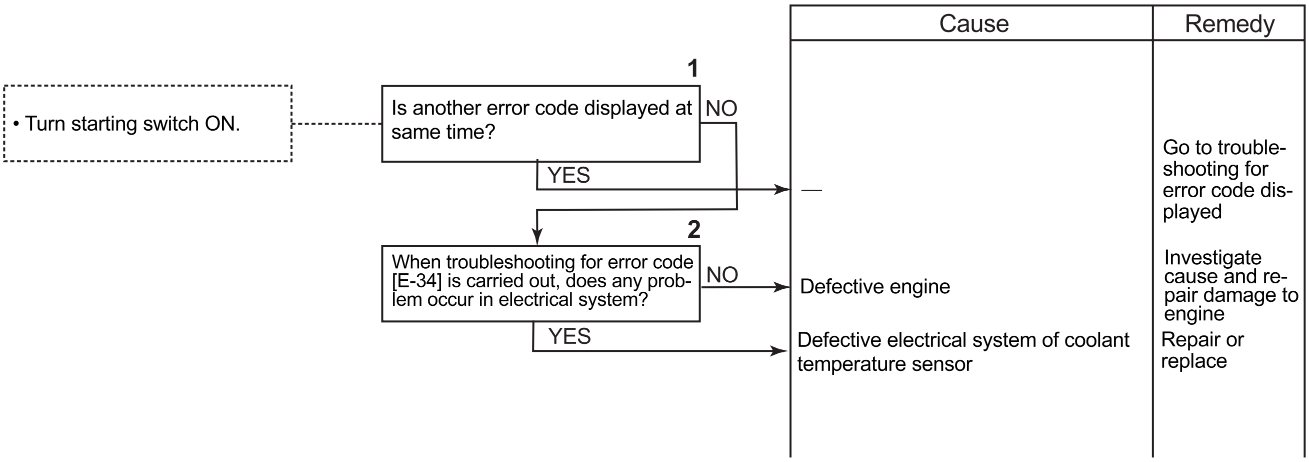


BXE00037

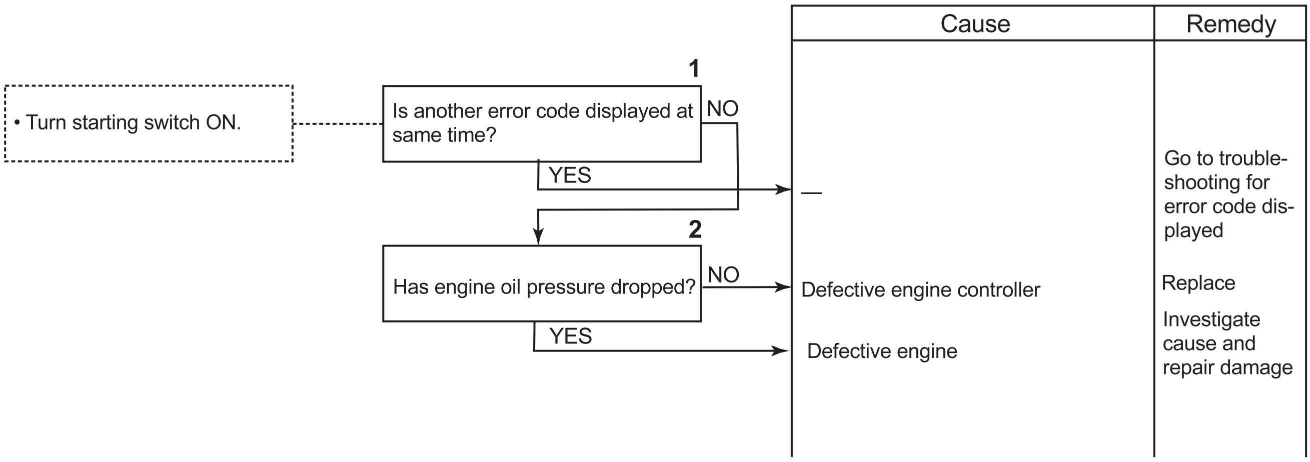
EB-6 Error code [E-22] (Overrun)



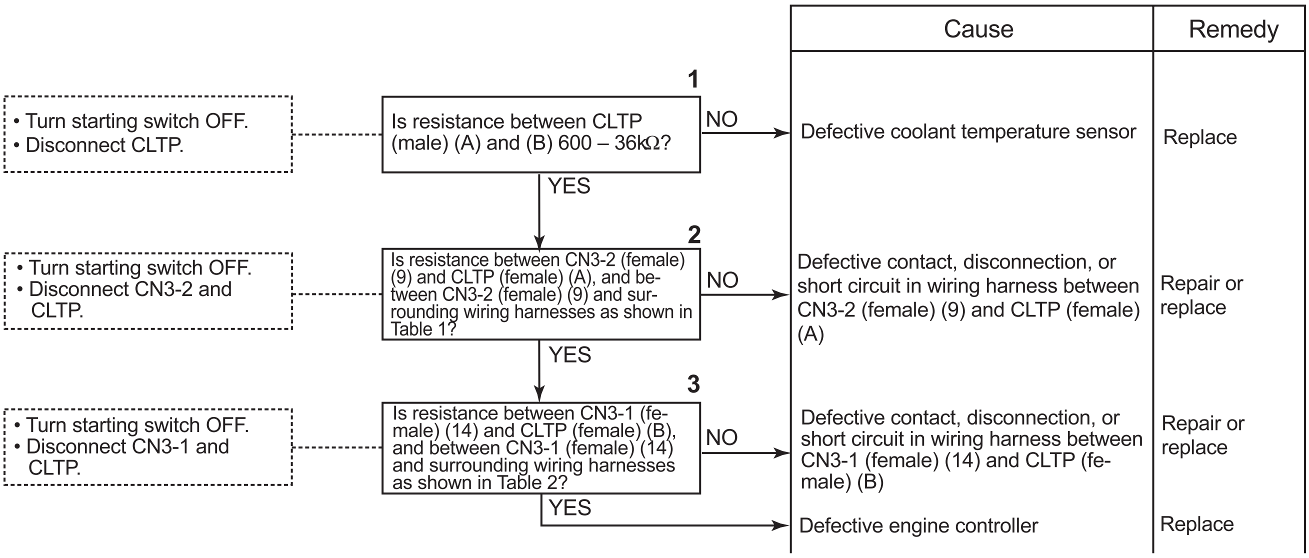
EB-7 Error code [E-23] (Overheat)



EB-8 Error code [E-24] (Abnormal drop in oil pressure)



EB-9 Error code [E-34] (Abnormality in coolant temperature sensor system)



Cause | Remedy

1

- Turn starting switch OFF.
- Disconnect CLTP.

Is resistance between CLTP (male) (A) and (B) 600 – 36kΩ?

NO → Defective coolant temperature sensor — Replace

YES ↓

2

- Turn starting switch OFF.
- Disconnect CN3-2 and CLTP.

Is resistance between CN3-2 (female) (9) and CLTP (female) (A), and between CN3-2 (female) (9) and surrounding wiring harnesses as shown in Table 1?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-2 (female) (9) and CLTP (female) (A) — Repair or replace

YES ↓

3

- Turn starting switch OFF.
- Disconnect CN3-1 and CLTP.

Is resistance between CN3-1 (female) (14) and CLTP (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 2?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and CLTP (female) (B) — Repair or replace

YES → Defective engine controller — Replace

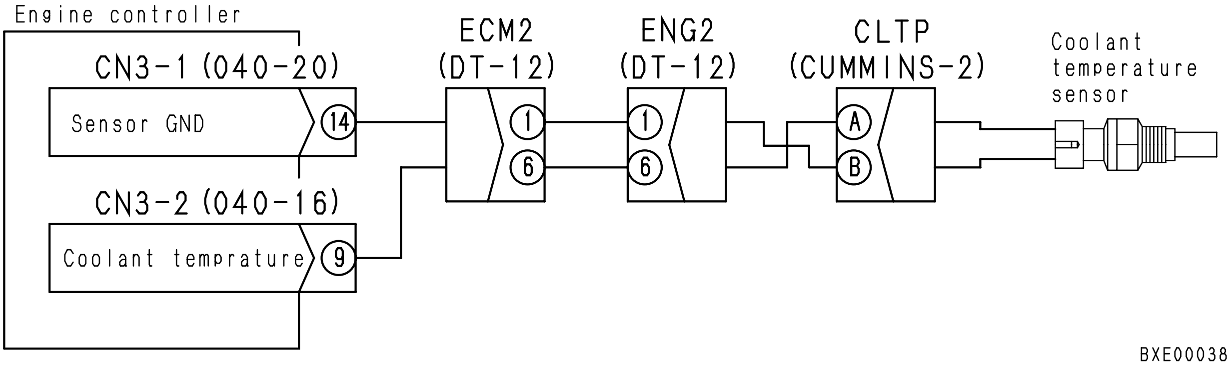
Table 1

CN3-2 (female), CLTP (female)	Resistance value
Between CN3-2 (9) and CLTP (A)	Max. 10Ω
Between CN3-2 (9) and surrounding wiring harnesses	Min. 1 MΩ

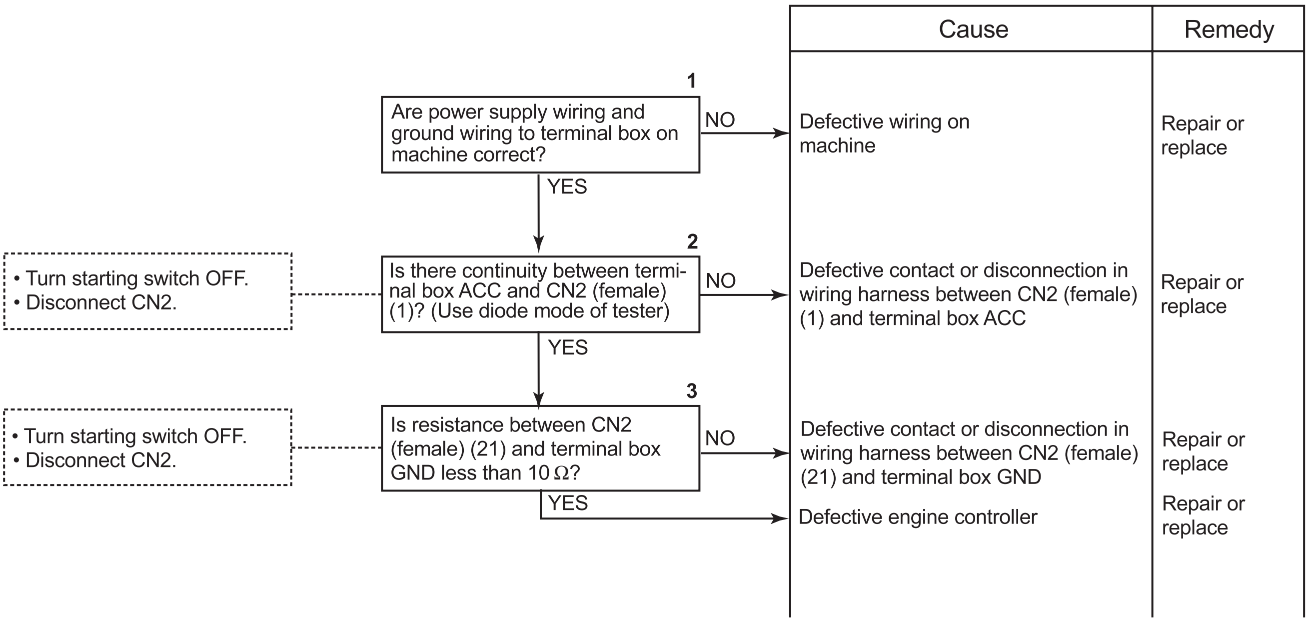
Table 2

CN3-1 (female), CLTP (female)	Resistance value
Between CN3-1 (14) and CLTP (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

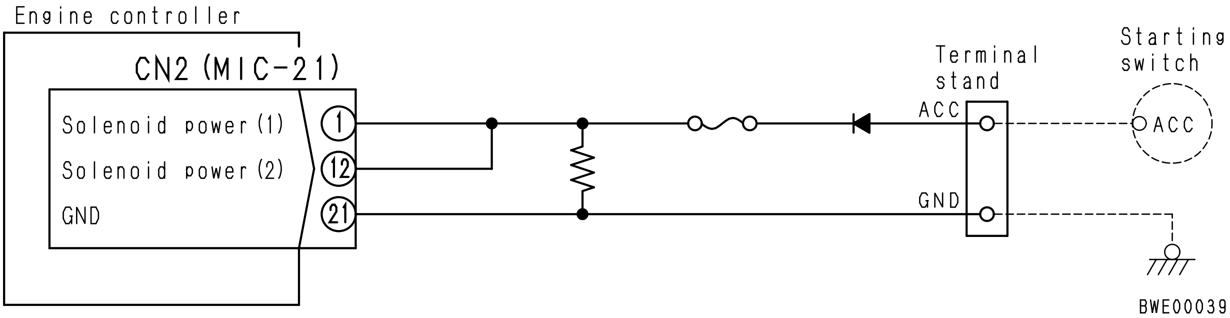
EB-9 Related electrical circuit diagram



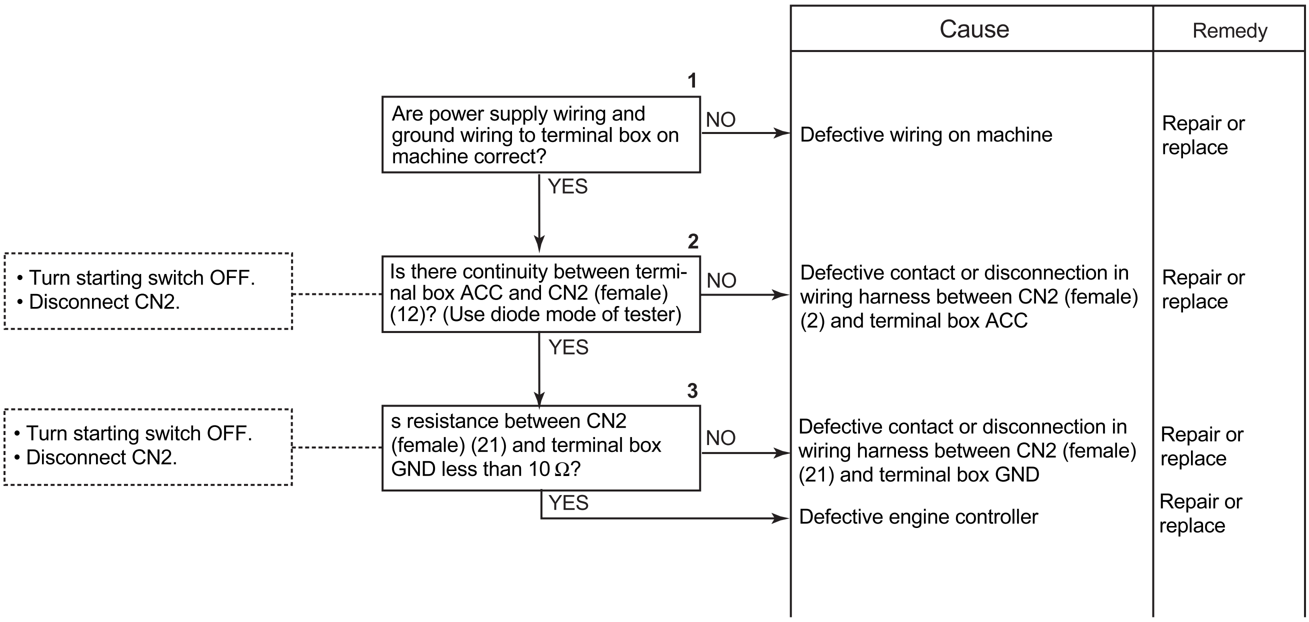
EB-10 Error code [E-56] (Abnormality in solenoid power source 1 system)



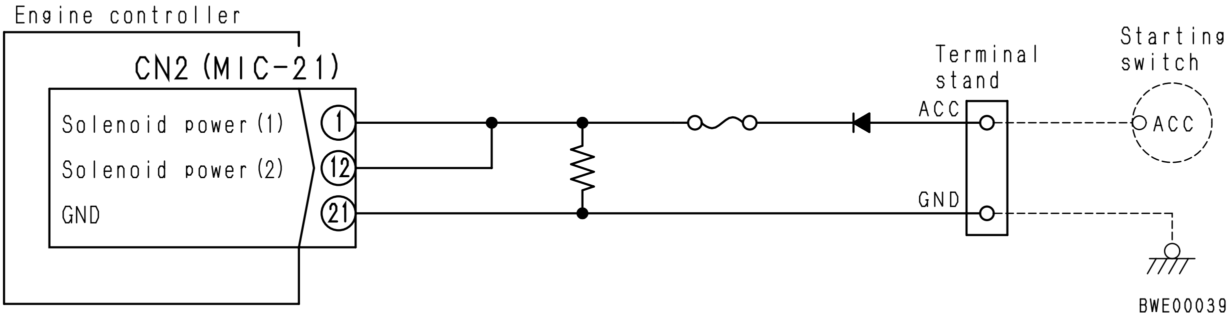
EB-10 Related electrical circuit diagram



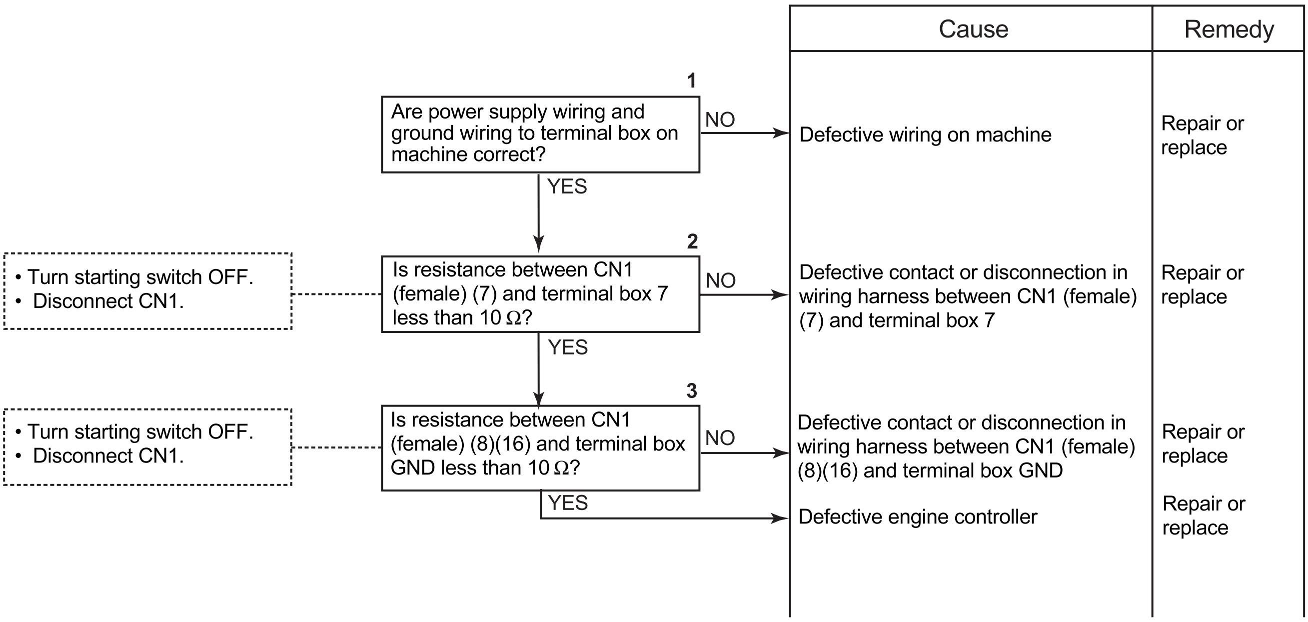
EB-11 Error code [E-57] (Abnormality in solenoid power source 2 system)



EB-11 Related electrical circuit diagram



EB-12 Error code [E-58] (Abnormality in backup power source system)



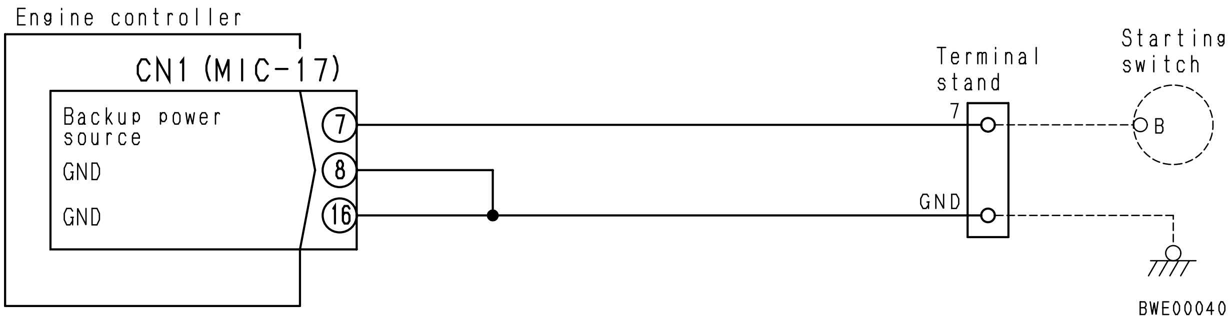
1 Are power supply wiring and ground wiring to terminal box on machine correct?
- NO → Defective wiring on machine — Repair or replace
- YES → 2

2 Is resistance between CN1 (female) (7) and terminal box 7 less than 10 Ω?
- • Turn starting switch OFF.
- • Disconnect CN1.
- NO → Defective contact or disconnection in wiring harness between CN1 (female) (7) and terminal box 7 — Repair or replace
- YES → 3

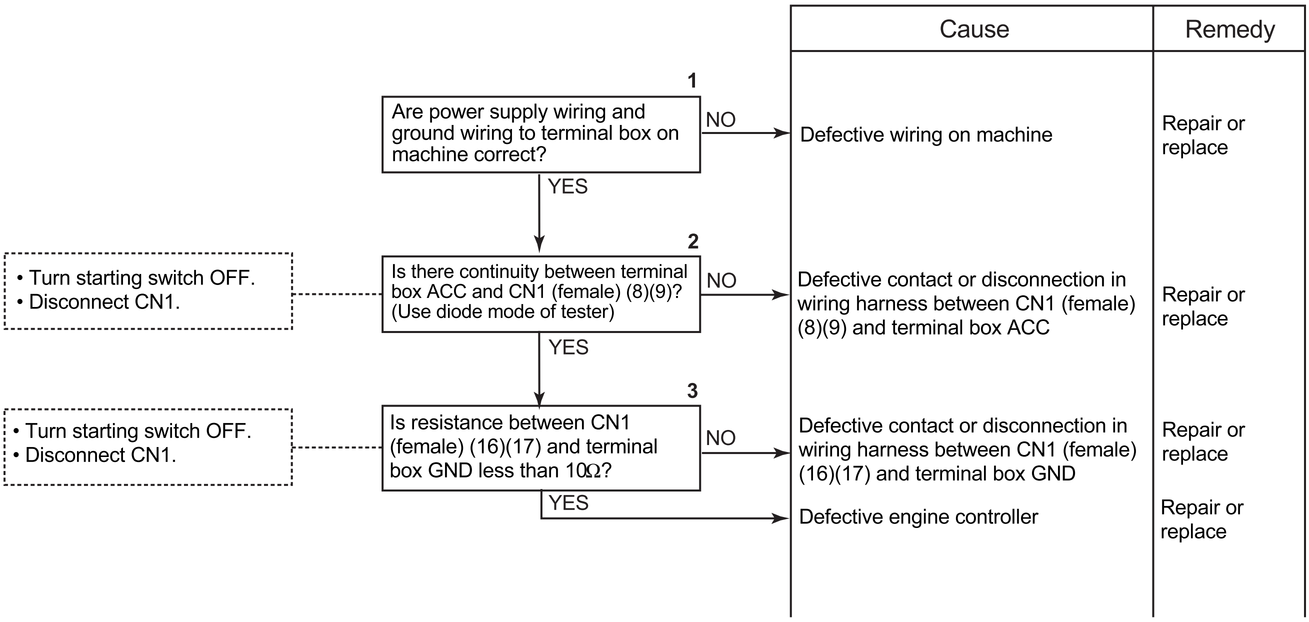
3 Is resistance between CN1 (female) (8)(16) and terminal box GND less than 10 Ω?
- • Turn starting switch OFF.
- • Disconnect CN1.
- NO → Defective contact or disconnection in wiring harness between CN1 (female) (8)(16) and terminal box GND — Repair or replace
- YES → Defective engine controller — Repair or replace

Cause	Remedy
Defective wiring on machine	Repair or replace
Defective contact or disconnection in wiring harness between CN1 (female) (7) and terminal box 7	Repair or replace
Defective contact or disconnection in wiring harness between CN1 (female) (8)(16) and terminal box GND	Repair or replace
Defective engine controller	Repair or replace

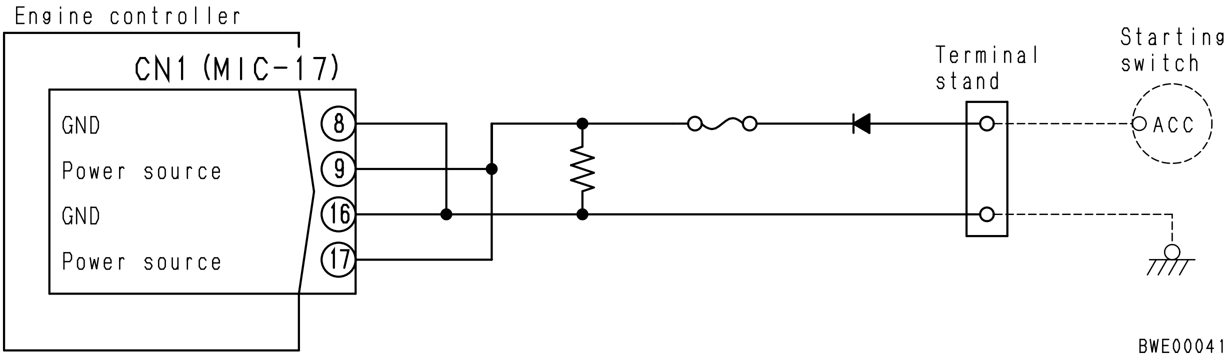
EB-12 Related electrical circuit diagram



EB-13 Error code [E-59] (Abnormality in switch power source system)



EB-13 Related electrical circuit diagram



EB-14 Error code [E-70] (Abnormality in fuel rail pressure sensor system high level)

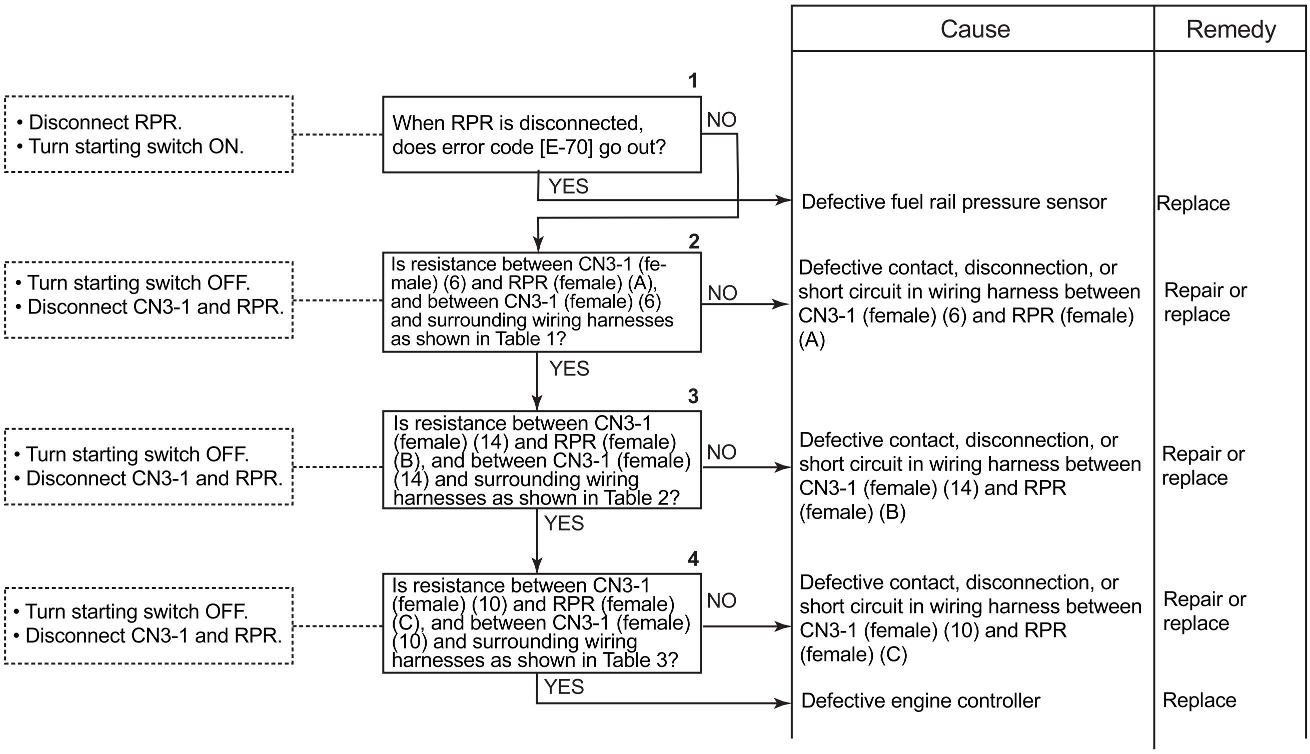


Table 1

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (6) and RPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

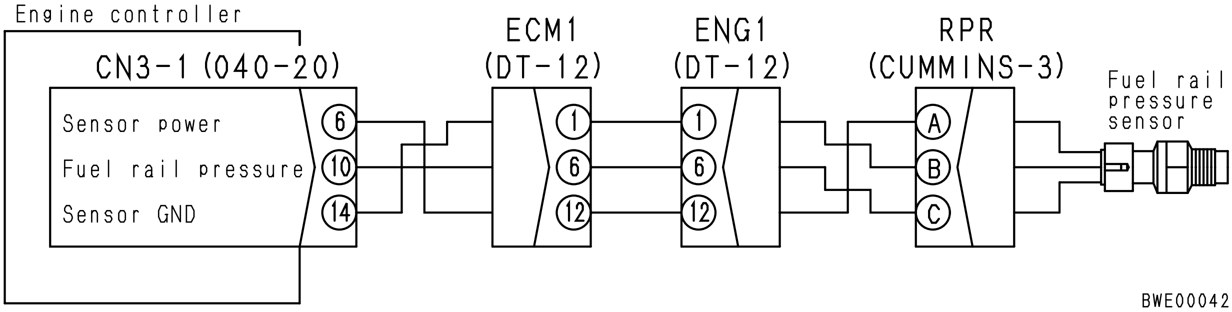
Table 2

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (14) and RPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

Table 3

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (10) and RPR (C)	Max. 10Ω
Between CN3-1 (10) and surrounding wiring harnesses	Min. 1 MΩ

EB-14 Related electrical circuit diagram



EB-15 Error code [E-71] (Abnormality in fuel rail pressure sensor system low level)

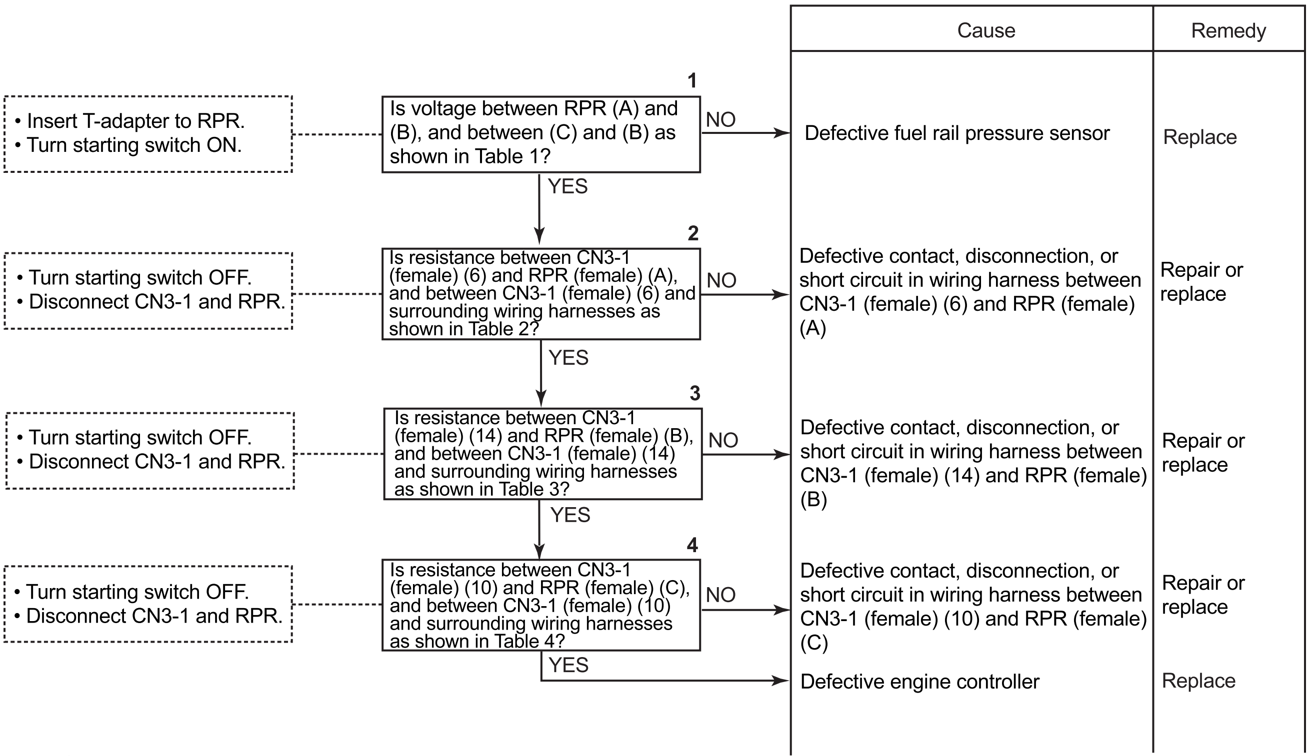


Table 1

RRR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (6) and RPR (A)	Max. 10 Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

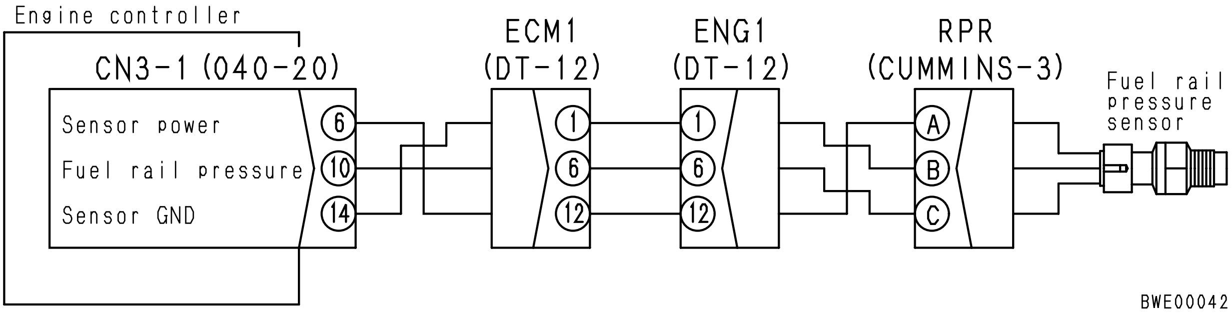
Table 3

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (14) and RPR (B)	Max. 10 Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

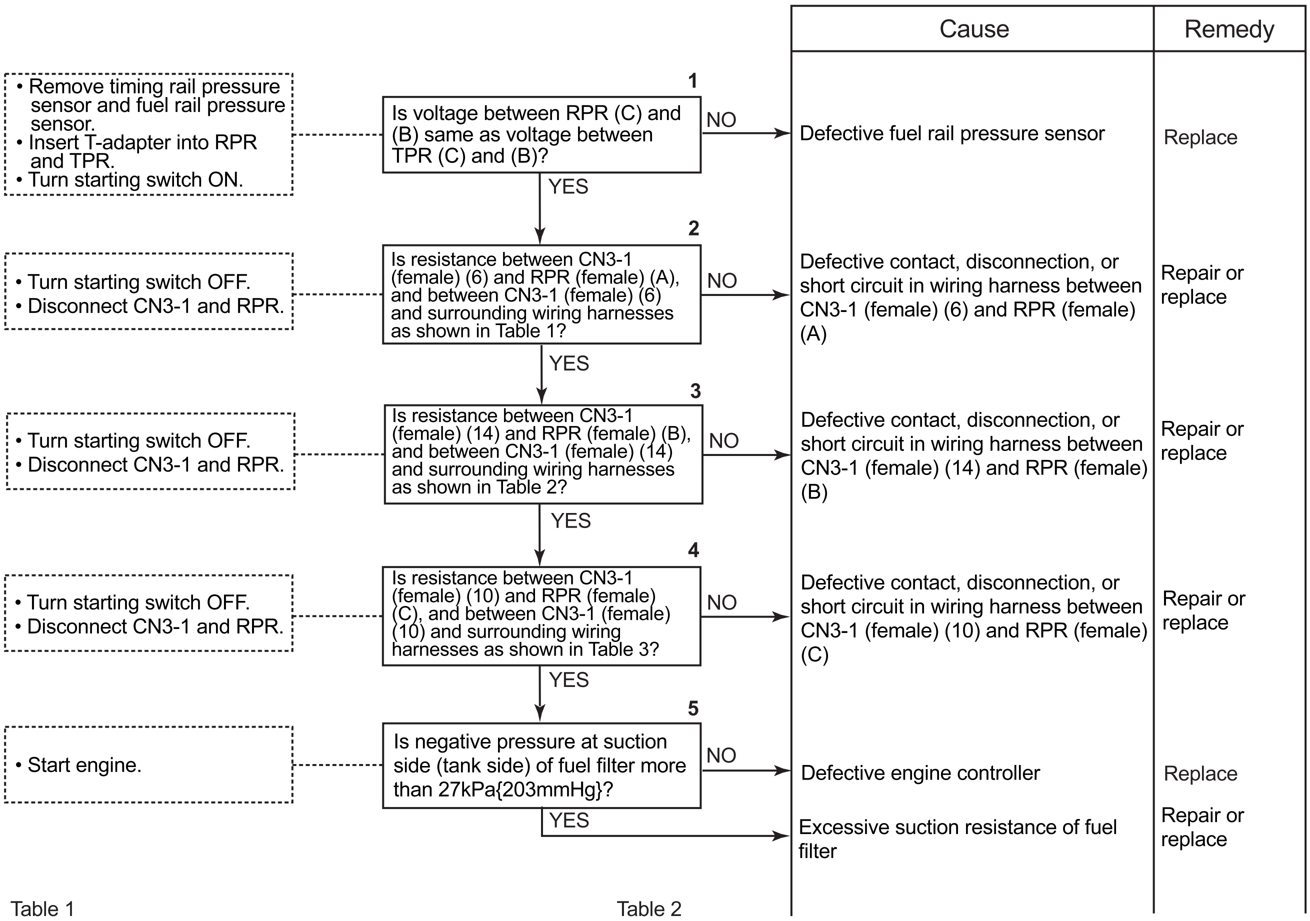
Table 4

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (10) and RPR (C)	Max. 10 Ω
Between CN3-1 (10) and surrounding wiring harnesses	Min. 1 MΩ

EB-15 Related electrical circuit diagram



EB-16 Error code [E-72] (Abnormality in fuel rail pressure sensor system in range)



1 (• Remove timing rail pressure sensor and fuel rail pressure sensor. • Insert T-adapter into RPR and TPR. • Turn starting switch ON.)
Is voltage between RPR (C) and (B) same as voltage between TPR (C) and (B)?
- NO: Defective fuel rail pressure sensor — Replace
- YES: go to 2

2 (• Turn starting switch OFF. • Disconnect CN3-1 and RPR.)
Is resistance between CN3-1 (female) (6) and RPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 1?
- NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and RPR (female) (A) — Repair or replace
- YES: go to 3

3 (• Turn starting switch OFF. • Disconnect CN3-1 and RPR.)
Is resistance between CN3-1 (female) (14) and RPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 2?
- NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and RPR (female) (B) — Repair or replace
- YES: go to 4

4 (• Turn starting switch OFF. • Disconnect CN3-1 and RPR.)
Is resistance between CN3-1 (female) (10) and RPR (female) (C), and between CN3-1 (female) (10) and surrounding wiring harnesses as shown in Table 3?
- NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (10) and RPR (female) (C) — Repair or replace
- YES: go to 5

5 (• Start engine.)
Is negative pressure at suction side (tank side) of fuel filter more than 27kPa{203mmHg}?
- NO: Defective engine controller — Replace
- YES: Excessive suction resistance of fuel filter — Repair or replace

Table 1

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (6) and RPR (A)	Max. 10 Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

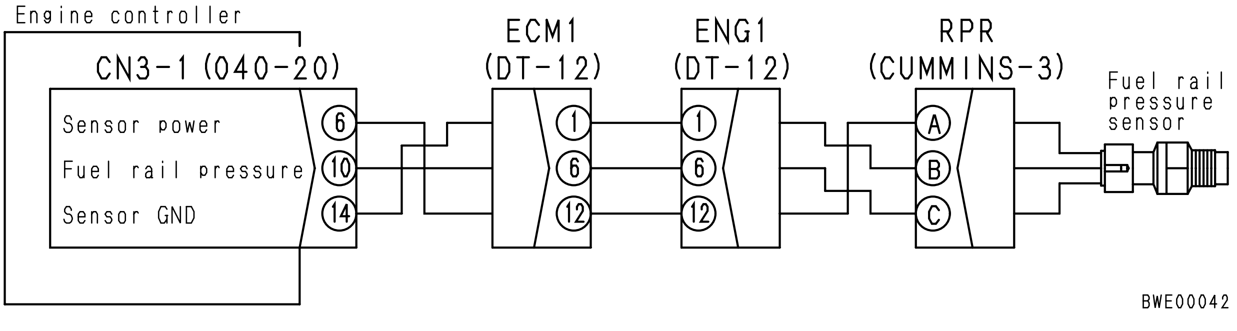
Table 2

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (14) and RPR (B)	Max. 10 Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

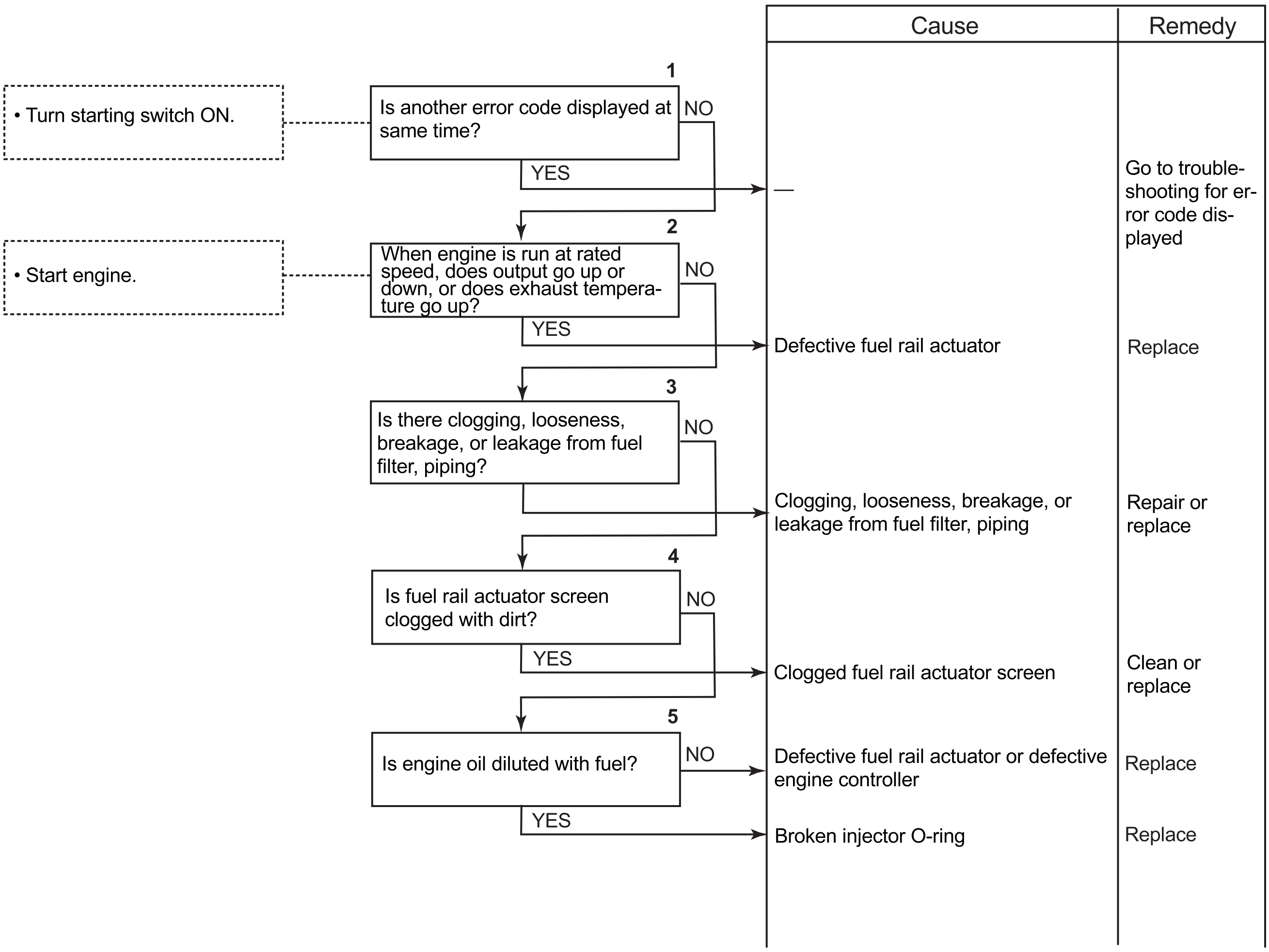
Table 3

CN3-1 (female), RPR (female)	Resistance value
Between CN3-1 (10) and RPR (C)	Max. 10 Ω
Between CN3-1 (10) and surrounding wiring harnesses	Min. 1 MΩ

EB-16 Related electrical circuit diagram



EB-17 Error code [E-73] (Abnormality in fuel rail actuator)



EB-18 Error code [E-75] (Abnormality with electric current in fuel rail actuator system)

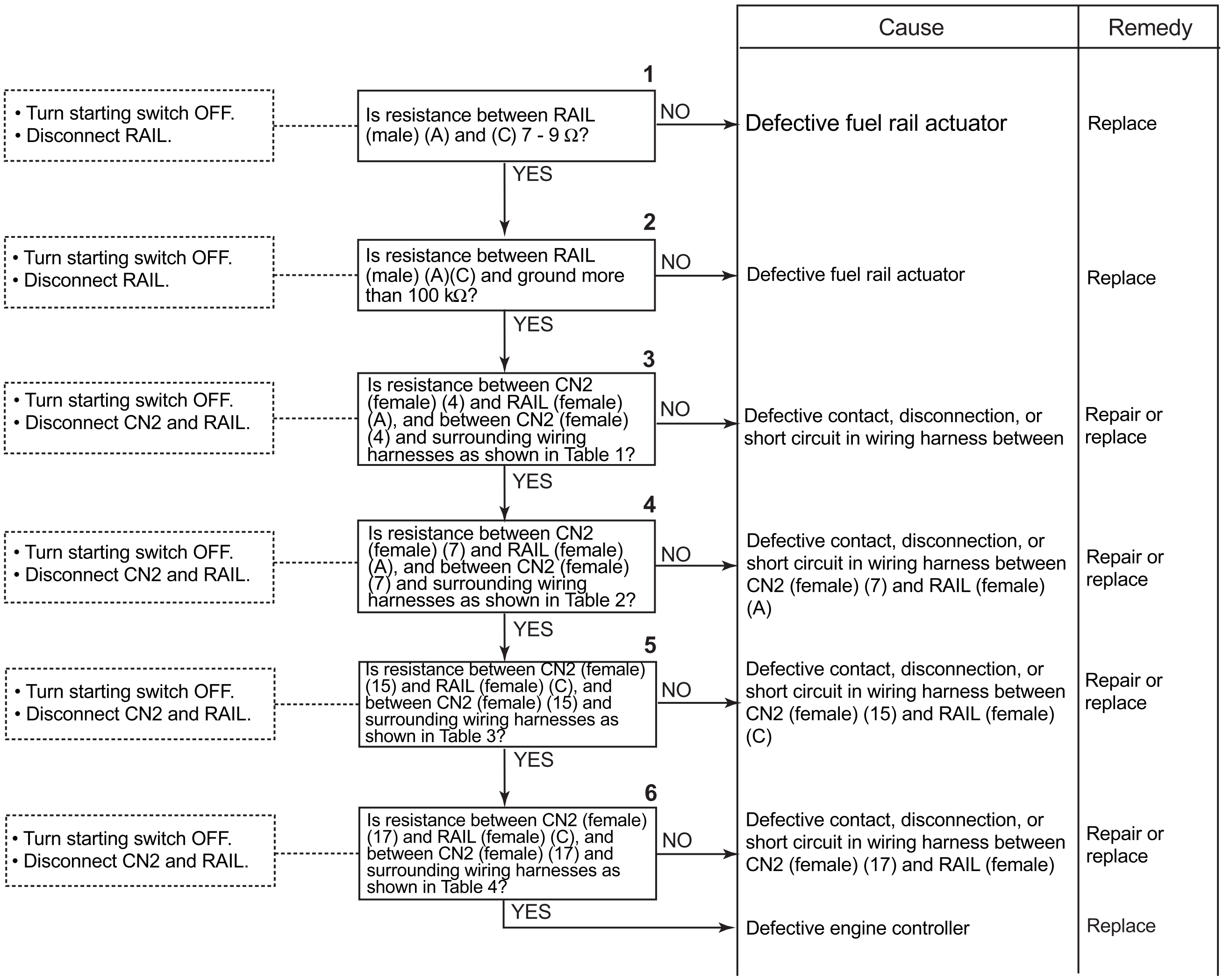


Table 1

CN2 (female), RAIL (female)	Resistance value
Between CN2 (4) and RAIL (A)	Max. 10Ω
Between CN2 (4) and surrounding wiring harnesses	Min. 1 MΩ

Table 2

CN2 (female), RAIL (female)	Resistance value
Between CN2 (7) and RAIL (A)	Max. 10Ω
Between CM2 (7) and surrounding wiring harnesses	Min. 1 MΩ

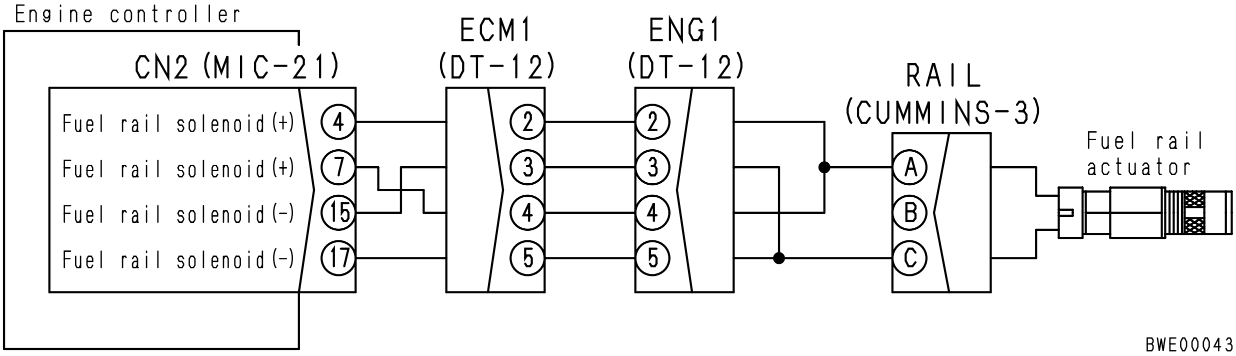
Table 3

CN2 (female), RAIL (female)	Resistance value
Between CN2 (15) and RAIL (C)	Max. 10Ω
Between CN2 (15) and surrounding wiring harnesses	Min. 1 MΩ

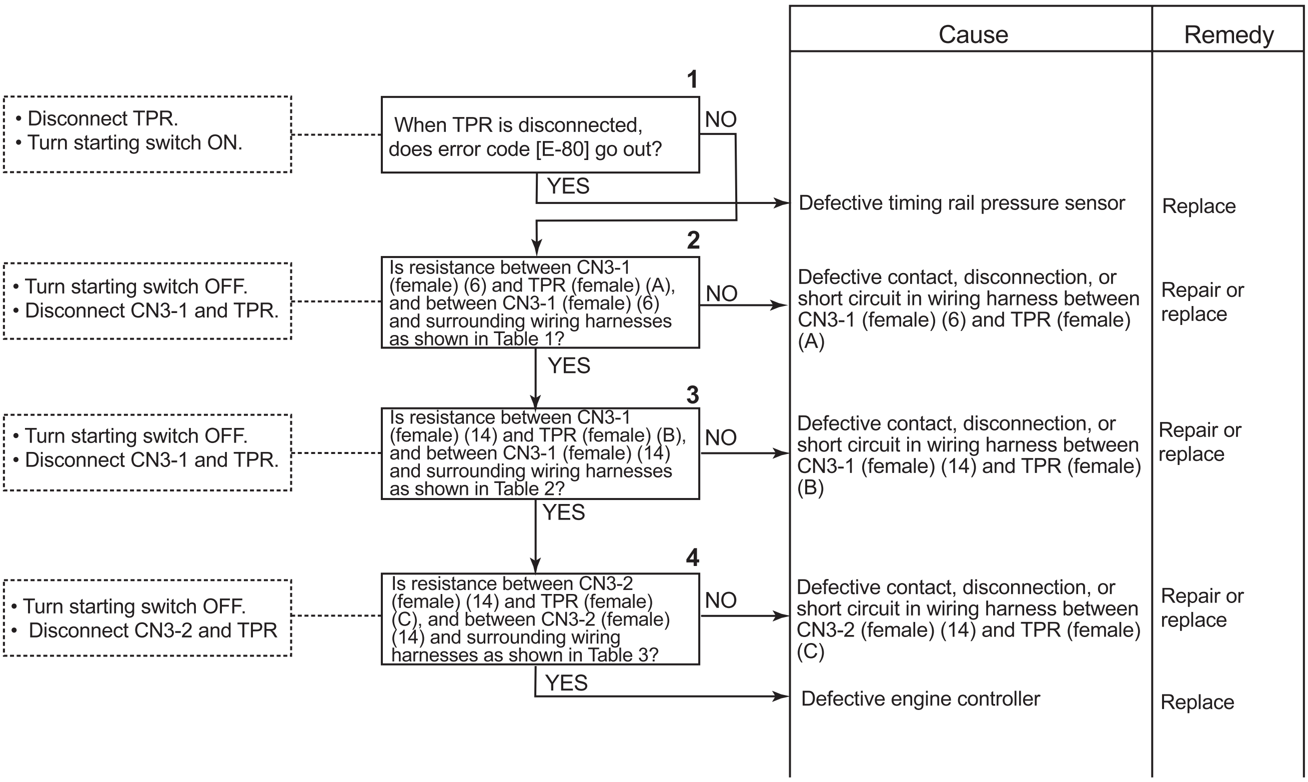
Table 3

CN2 (female), RAIL (female)	Resistance value
Between CN2 (17) and RAIL (C)	Max. 10Ω
Between CM2 (17) and surrounding wiring harnesses	Min. 1 MΩ

EB-18 Related electrical circuit diagram



EB-19 Error code [E-80] (Abnormality in timing rail pressure sensor system high level)



Cause

Remedy

1

- Disconnect TPR.
- Turn starting switch ON.

When TPR is disconnected, does error code [E-80] go out?

YES → Defective timing rail pressure sensor — Replace

NO → 2

- Turn starting switch OFF.
- Disconnect CN3-1 and TPR.

Is resistance between CN3-1 (female) (6) and TPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 1?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and TPR (female) (A) — Repair or replace

YES → 3

- Turn starting switch OFF.
- Disconnect CN3-1 and TPR.

Is resistance between CN3-1 (female) (14) and TPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 2?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and TPR (female) (B) — Repair or replace

YES → 4

- Turn starting switch OFF.
- Disconnect CN3-2 and TPR

Is resistance between CN3-2 (female) (14) and TPR (female) (C), and between CN3-2 (female) (14) and surrounding wiring harnesses as shown in Table 3?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-2 (female) (14) and TPR (female) (C) — Repair or replace

YES → Defective engine controller — Replace

Table 1

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (6) and TPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

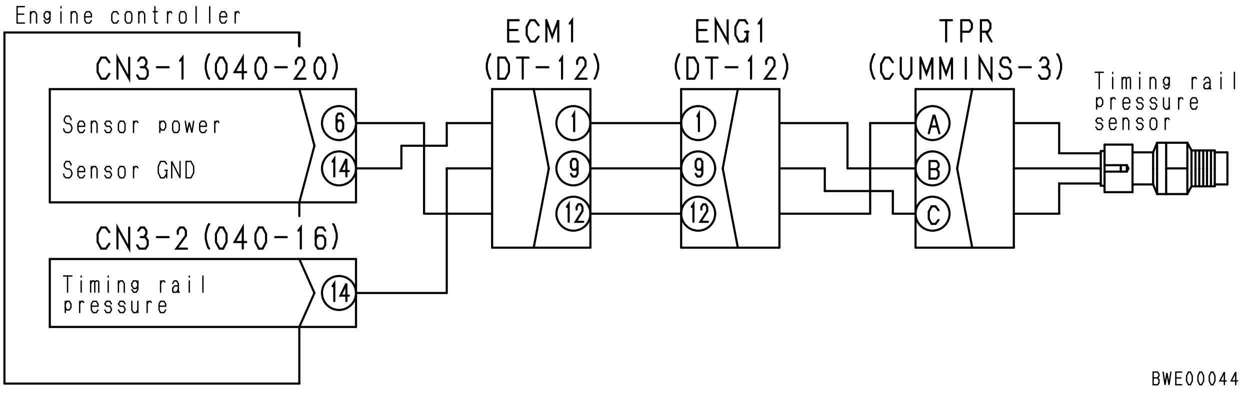
Table 2

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (14) and TPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

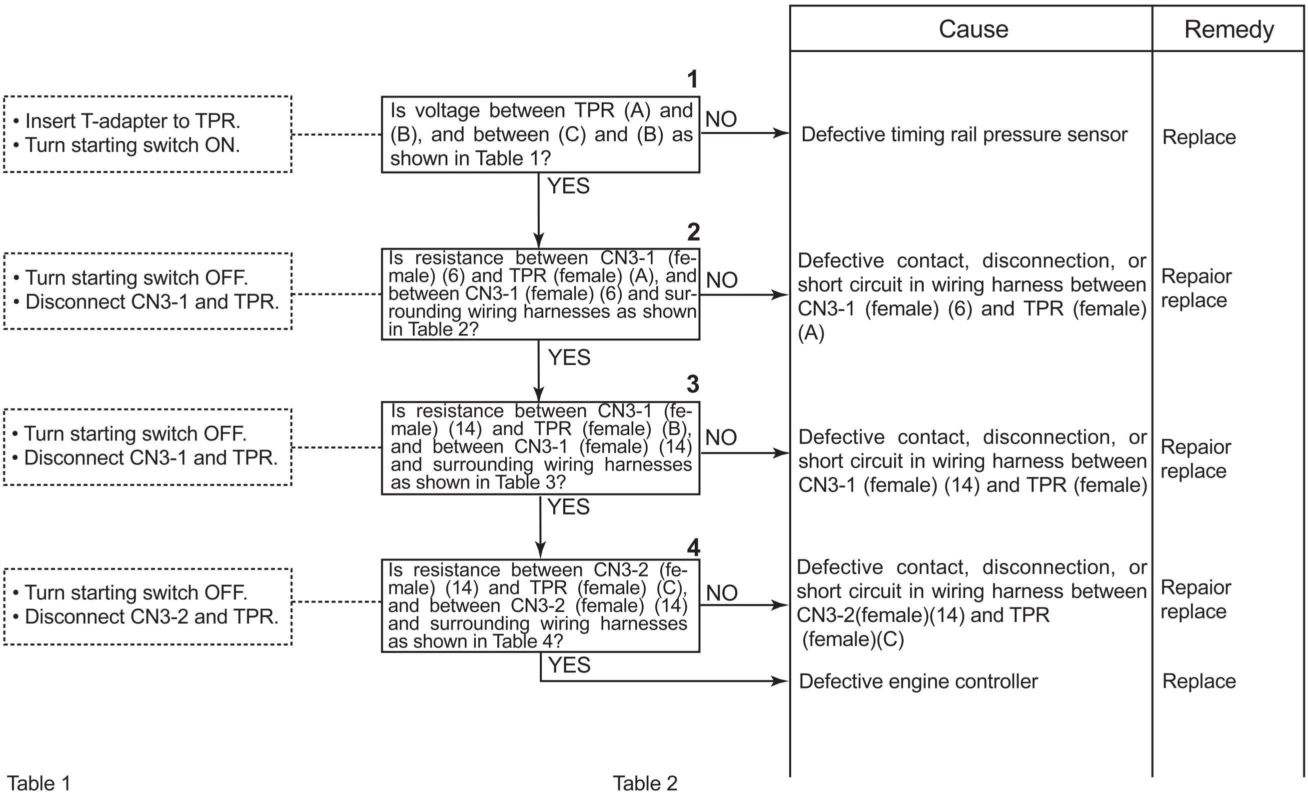
Table 3

CN3-2 (female), TPR (female)	Resistance value
Between CN3-2 (14) and TPR (C)	Max. 10Ω
Between CN3-2 (14) and surrounding wiring harnesses	Min. 1 MΩ

EB-19 Related electrical circuit diagram



EB-20 Error code [E-81] (Abnormality in timing rail pressure sensor system low level)



Cause	Remedy

1
- Insert T-adapter to TPR.
- Turn starting switch ON.

Is voltage between TPR (A) and (B), and between (C) and (B) as shown in Table 1?

NO → Defective timing rail pressure sensor — Replace

YES ↓

2
- Turn starting switch OFF.
- Disconnect CN3-1 and TPR.

Is resistance between CN3-1 (female) (6) and TPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 2?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and TPR (female) (A) — Repaior replace

YES ↓

3
- Turn starting switch OFF.
- Disconnect CN3-1 and TPR.

Is resistance between CN3-1 (female) (14) and TPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 3?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and TPR (female) — Repaior replace

YES ↓

4
- Turn starting switch OFF.
- Disconnect CN3-2 and TPR.

Is resistance between CN3-2 (female) (14) and TPR (female) (C), and between CN3-2 (female) (14) and surrounding wiring harnesses as shown in Table 4?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-2(female)(14) and TPR (female)(C) — Repaior replace

YES → Defective engine controller — Replace

Table 1

TRR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (6) and TPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

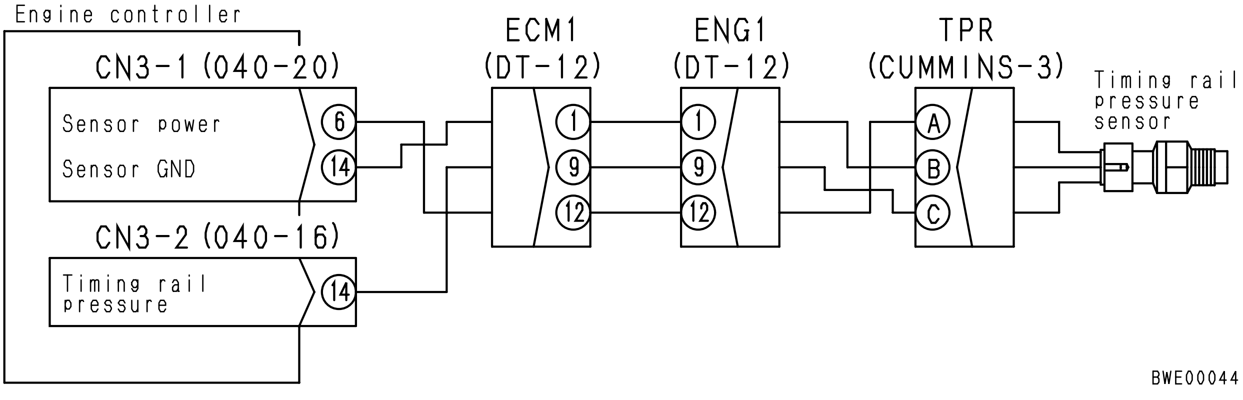
Table 3

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (14) and TPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

CN3-2 (female), TPR (female)	Resistance value
Between CN3-2 (14) and TPR (C)	Max. 10Ω
Between CN3-2 (14) and surrounding wiring harnesses	Min. 1 MΩ

EB-20 Related electrical circuit diagram



EB-21 Error code [E-82] (Abnormality in timing rail pressure sensor system in range)

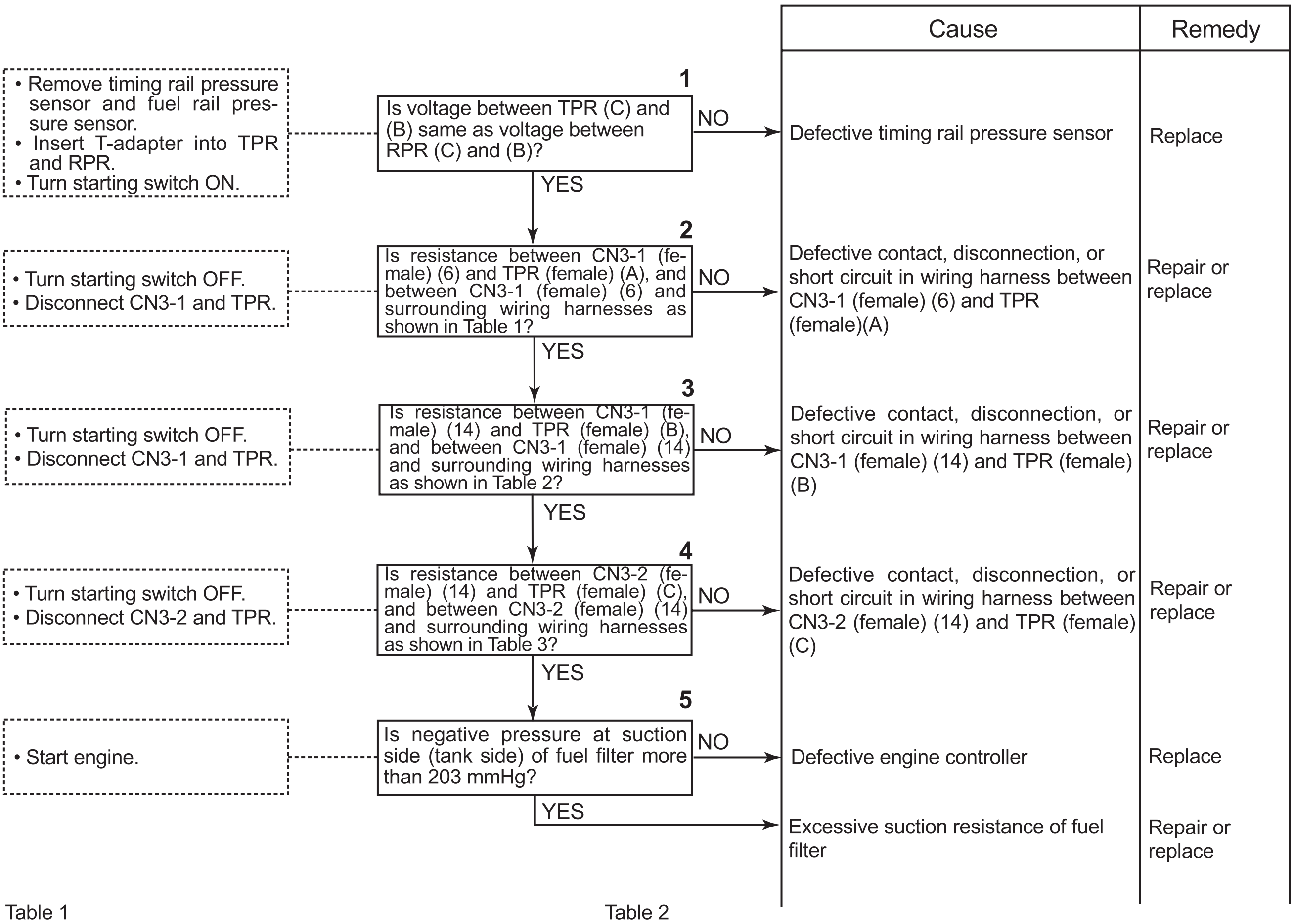


Table 1

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (6) and TPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

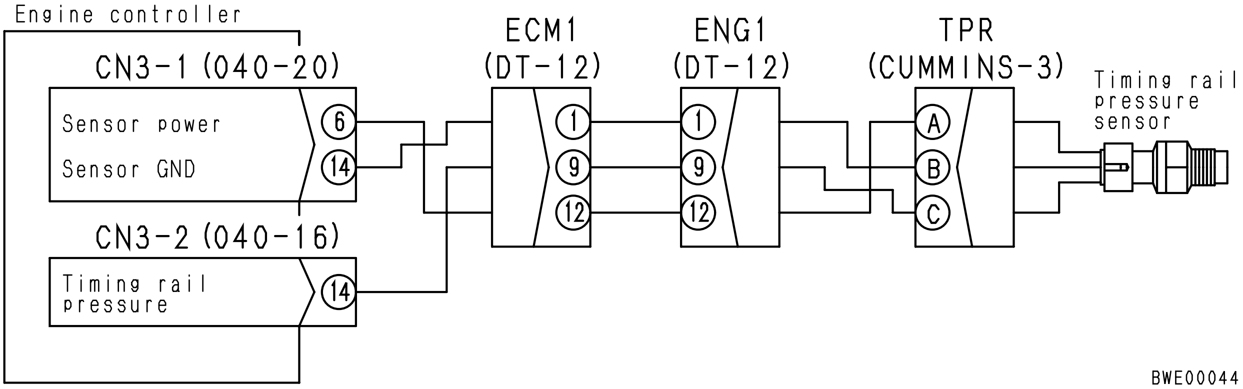
Table 2

CN3-1 (female), TPR (female)	Resistance value
Between CN3-1 (14) and TPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

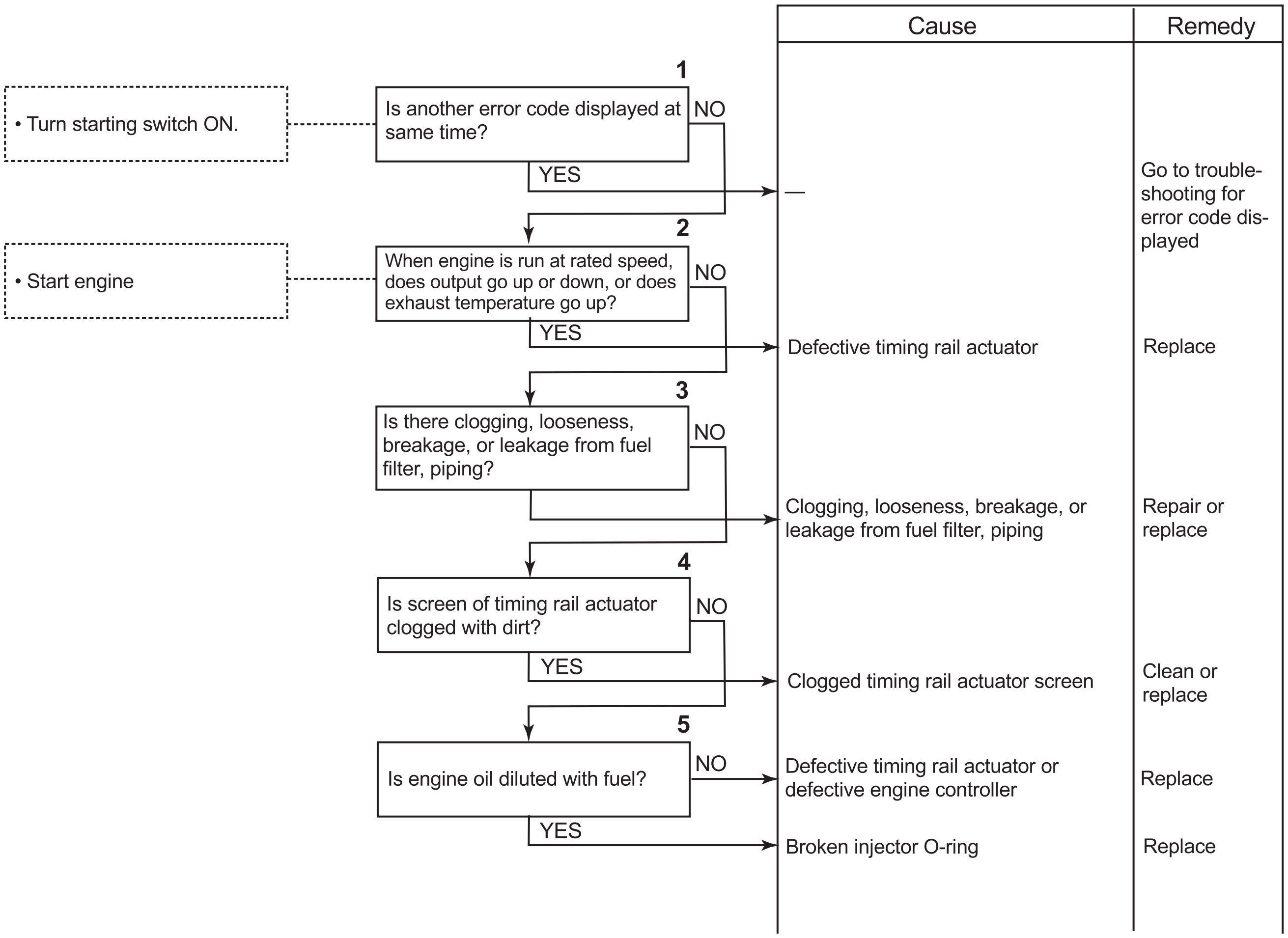
Table 3

CN3-2 (female), TPR (female)	Resistance value
Between CN3-2 (14) and TPR (C)	Max. 10Ω
Between CN3-2 (14) and surrounding wiring harnesses	Min. 1 MΩ

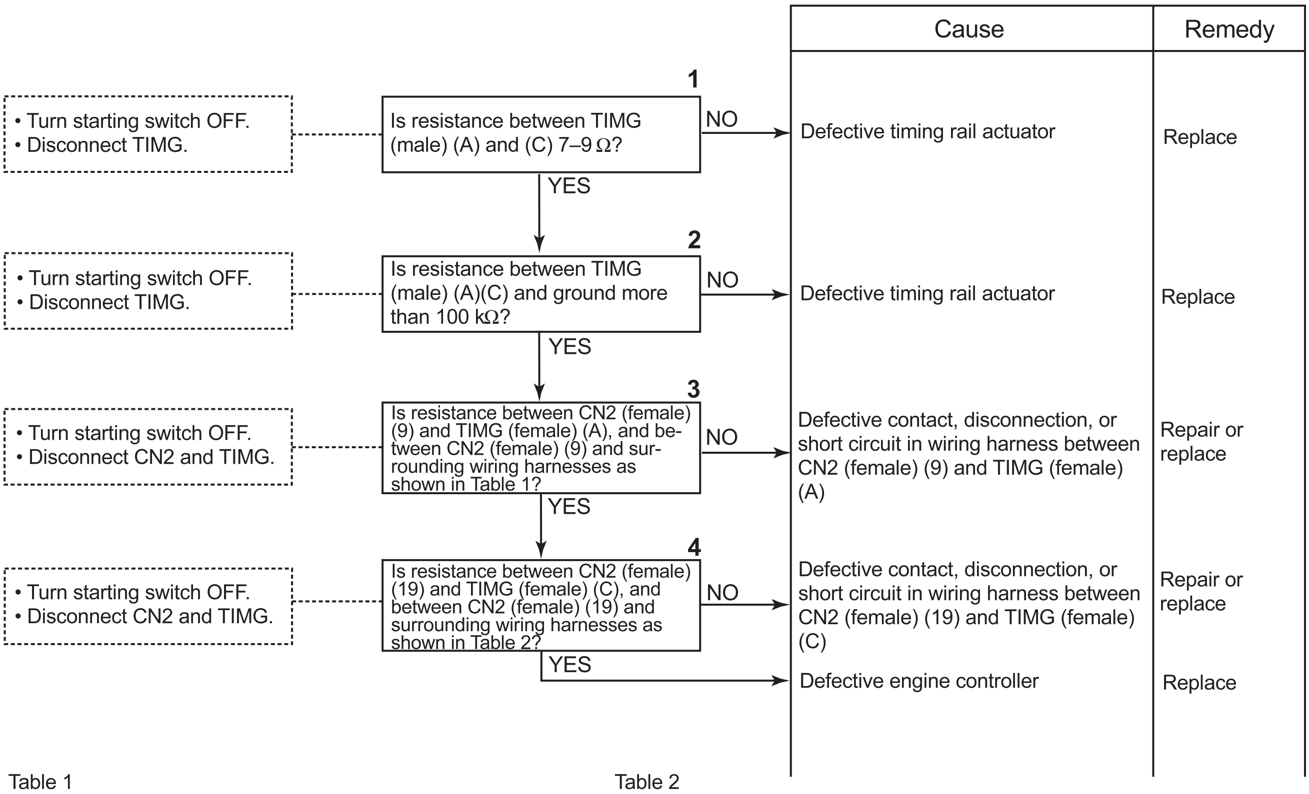
EB-21 Related electrical circuit diagram



EB-22 Error code [E-83] (Abnormality in timing rail actuator)



EB-23 Error code [E-85] (Abnormality with electric current in timing rail actuator system)



	Cause	Remedy

1

- Turn starting switch OFF.
- Disconnect TIMG.

Is resistance between TIMG (male) (A) and (C) 7–9 Ω?

NO → Defective timing rail actuator — Replace

YES ↓

2

- Turn starting switch OFF.
- Disconnect TIMG.

Is resistance between TIMG (male) (A)(C) and ground more than 100 kΩ?

NO → Defective timing rail actuator — Replace

YES ↓

3

- Turn starting switch OFF.
- Disconnect CN2 and TIMG.

Is resistance between CN2 (female) (9) and TIMG (female) (A), and between CN2 (female) (9) and surrounding wiring harnesses as shown in Table 1?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN2 (female) (9) and TIMG (female) (A) — Repair or replace

YES ↓

4

- Turn starting switch OFF.
- Disconnect CN2 and TIMG.

Is resistance between CN2 (female) (19) and TIMG (female) (C), and between CN2 (female) (19) and surrounding wiring harnesses as shown in Table 2?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN2 (female) (19) and TIMG (female) (C) — Repair or replace

YES → Defective engine controller — Replace

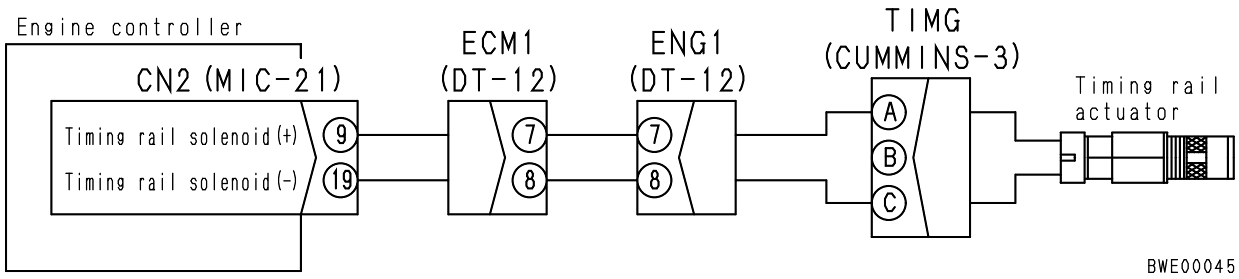
Table 1

CN2 (female), TIMG (female)	Resistance value
Between CN2 (9) and TIMG (A)	Max. 10 Ω
Between CN2 (9) and surrounding wiring harnesses	Min. 1 MΩ

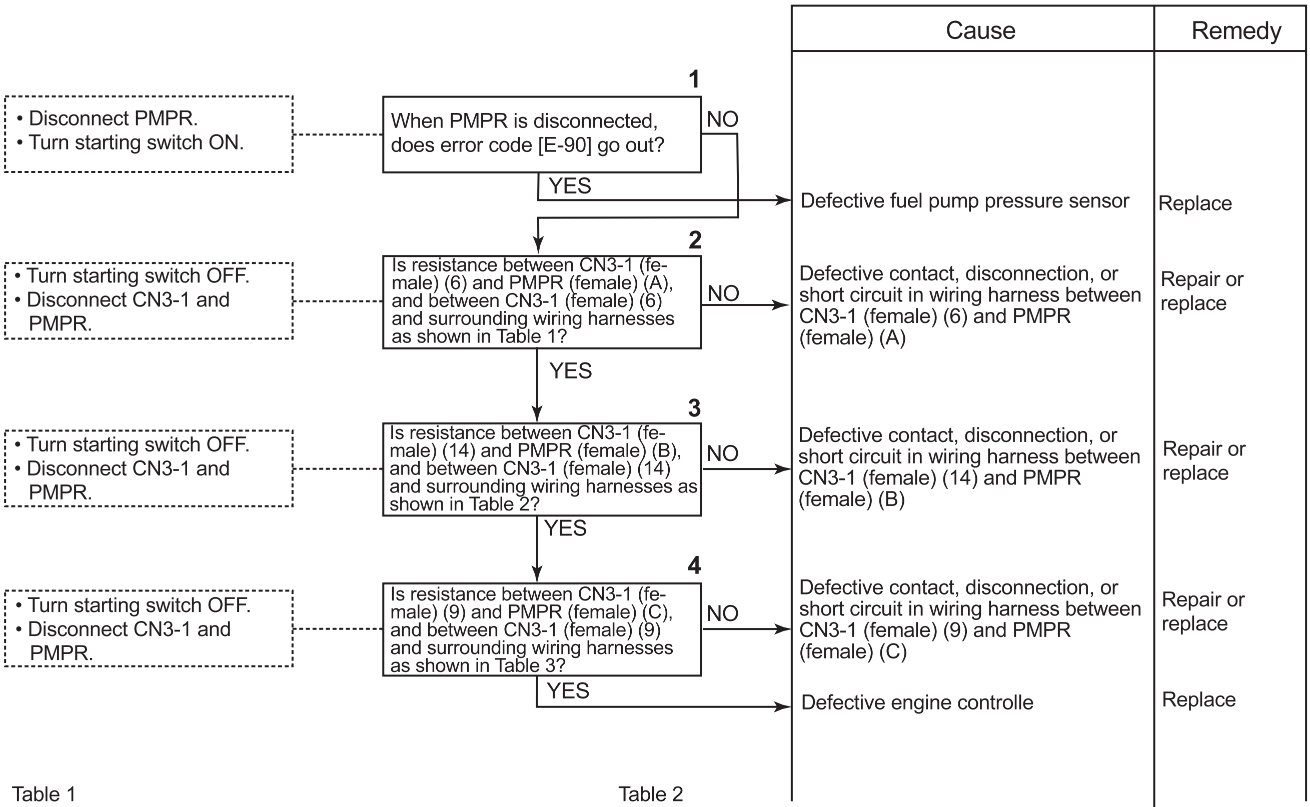
Table 2

CN2 (female), TIMG (female)	Resistance value
Between CN2 (19) and TIMG (C)	Max. 10 Ω
Between CN2 (19) and surrounding wiring harnesses	Min. 1 MΩ

EB-23 Related electrical circuit diagram



EB-24 Error code [E-90] (Abnormality in fuel pump pressure sensor system high level)



- Disconnect PMPR.
- Turn starting switch ON.

1 When PMPR is disconnected, does error code [E-90] go out?

YES: Defective fuel pump pressure sensor — Replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

2 Is resistance between CN3-1 (female) (6) and PMPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 1?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and PMPR (female) (A) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

3 Is resistance between CN3-1 (female) (14) and PMPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 2?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and PMPR (female) (B) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

4 Is resistance between CN3-1 (female) (9) and PMPR (female) (C), and between CN3-1 (female) (9) and surrounding wiring harnesses as shown in Table 3?

NO: Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (9) and PMPR (female) (C) — Repair or replace

YES: Defective engine controlle — Replace

Table 1

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1 (6) and PMPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

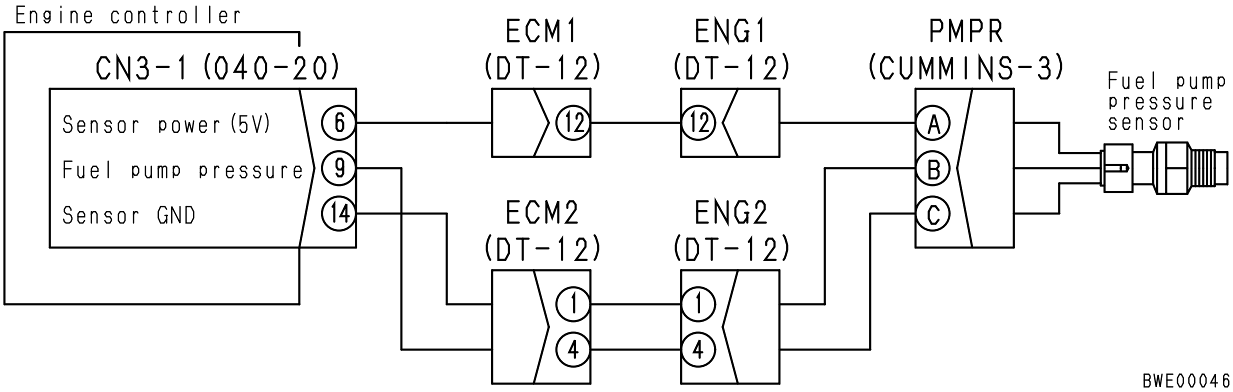
Table 2

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1 (14) and PMPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

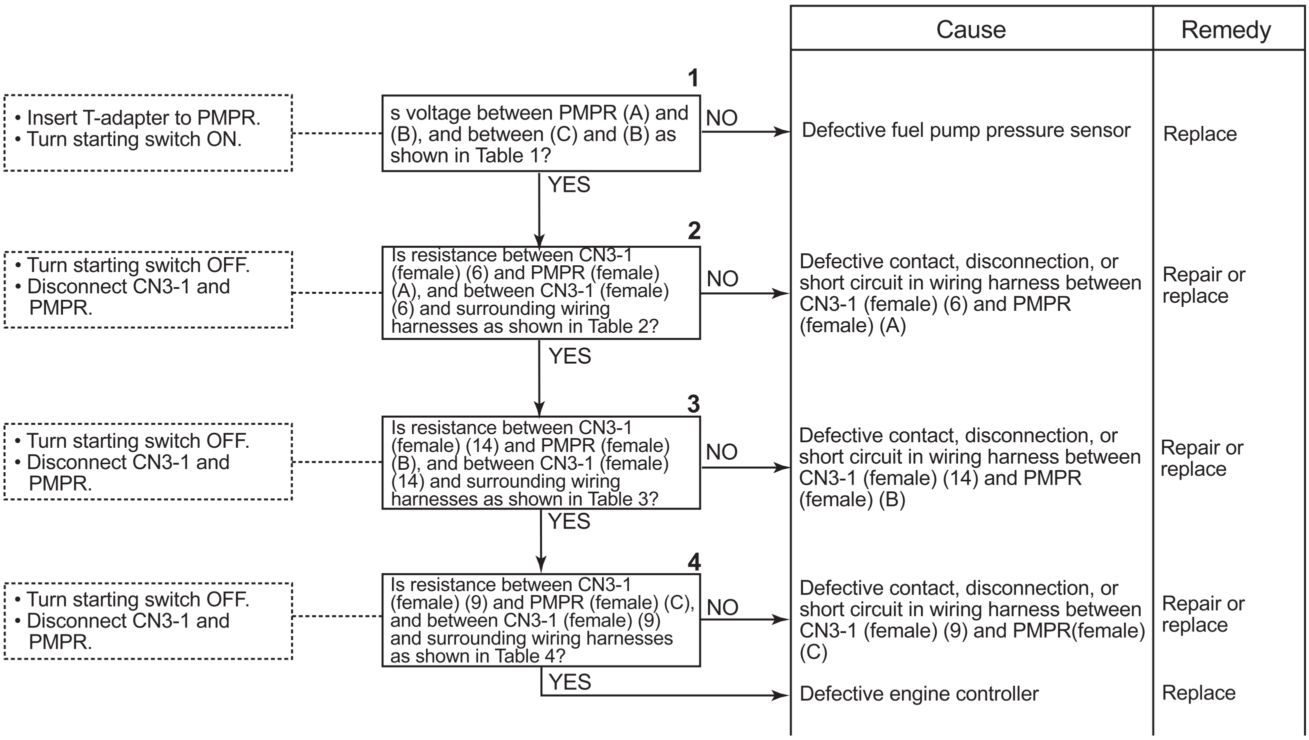
Table 3

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1 (9) and PMPR (C)	Max. 10Ω
Between CN3-1 (9) and surrounding wiring harnesses	Min. 1 MΩ

EB-24 Related electrical circuit diagram



EB-25 Error code [E-91] (Abnormality in fuel pump pressure sensor system low level)



- Insert T-adapter to PMPR.
- Turn starting switch ON.

1 s voltage between PMPR (A) and (B), and between (C) and (B) as shown in Table 1?

NO → Defective fuel pump pressure sensor — Replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

2 Is resistance between CN3-1 (female) (6) and PMPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 2?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and PMPR (female) (A) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

3 Is resistance between CN3-1 (female) (14) and PMPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 3?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and PMPR (female) (B) — Repair or replace

- Turn starting switch OFF.
- Disconnect CN3-1 and PMPR.

4 Is resistance between CN3-1 (female) (9) and PMPR (female) (C), and between CN3-1 (female) (9) and surrounding wiring harnesses as shown in Table 4?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (9) and PMPR(female) (C) — Repair or replace

YES → Defective engine controller — Replace

Table 1

PMPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1 (6) and PMPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

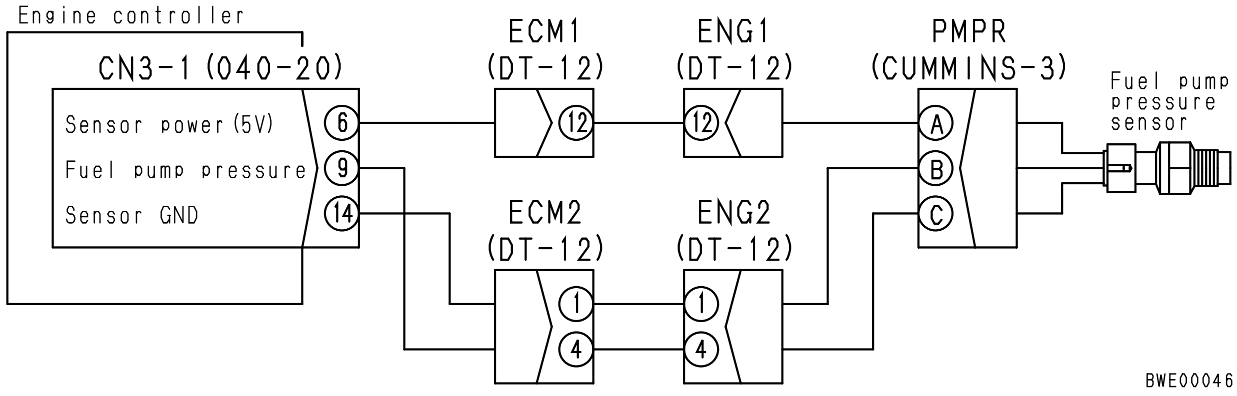
Table 3

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1(14) and PMPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

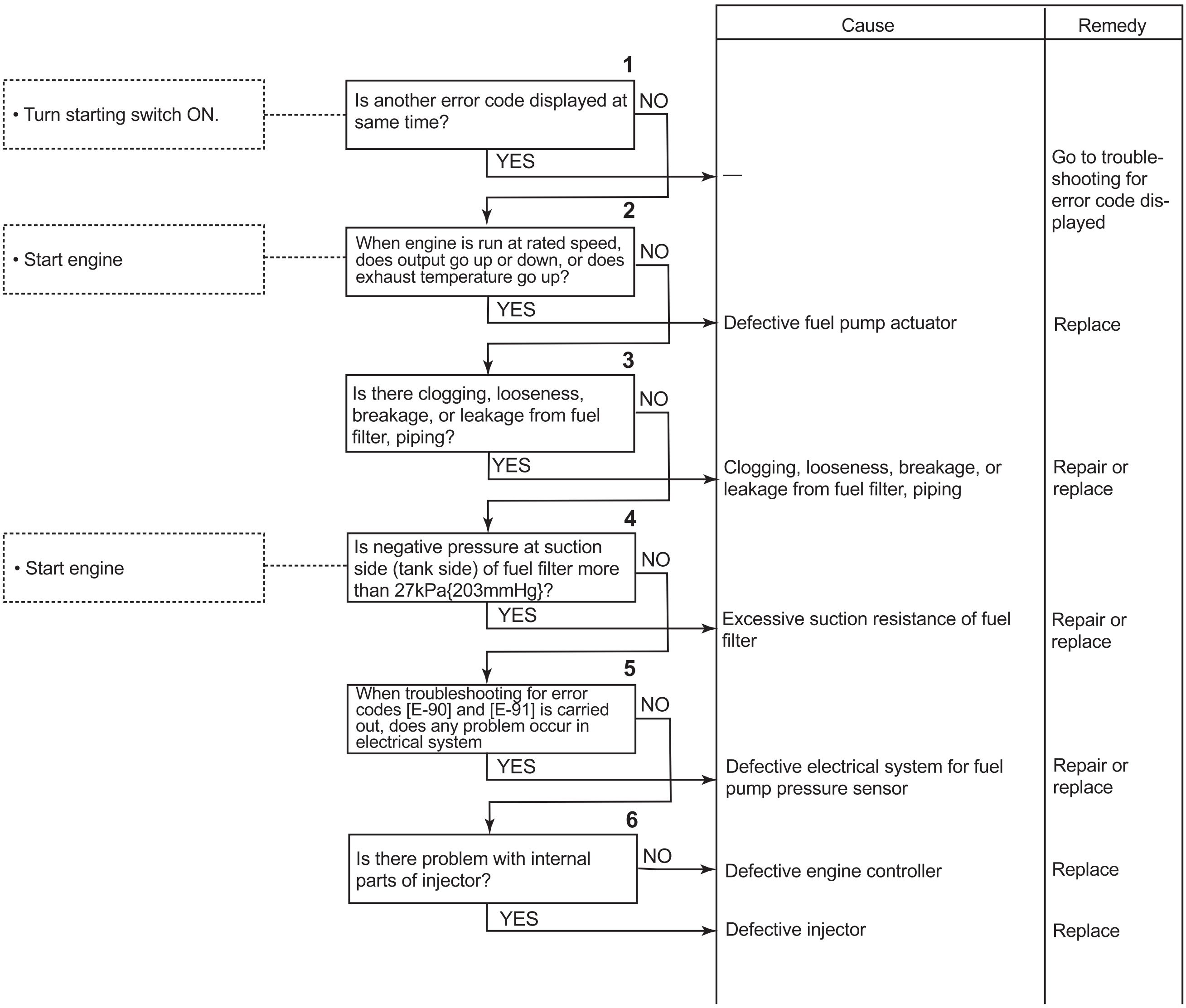
Table 4

CN3-1 (female), PMPR (female)	Resistance value
Between CN3-1 (9) and PMPR (C)	Max. 10Ω
Between CN3-1 (9) and surrounding wiring harnesses	Min. 1 MΩ

EB-25 Related electrical circuit diagram



EB-26 Error code [E-93] (Abnormality in fuel pump actuator)



EB-27 Error code [E-95] (Abnormality with electric current in fuel pump actuator system)

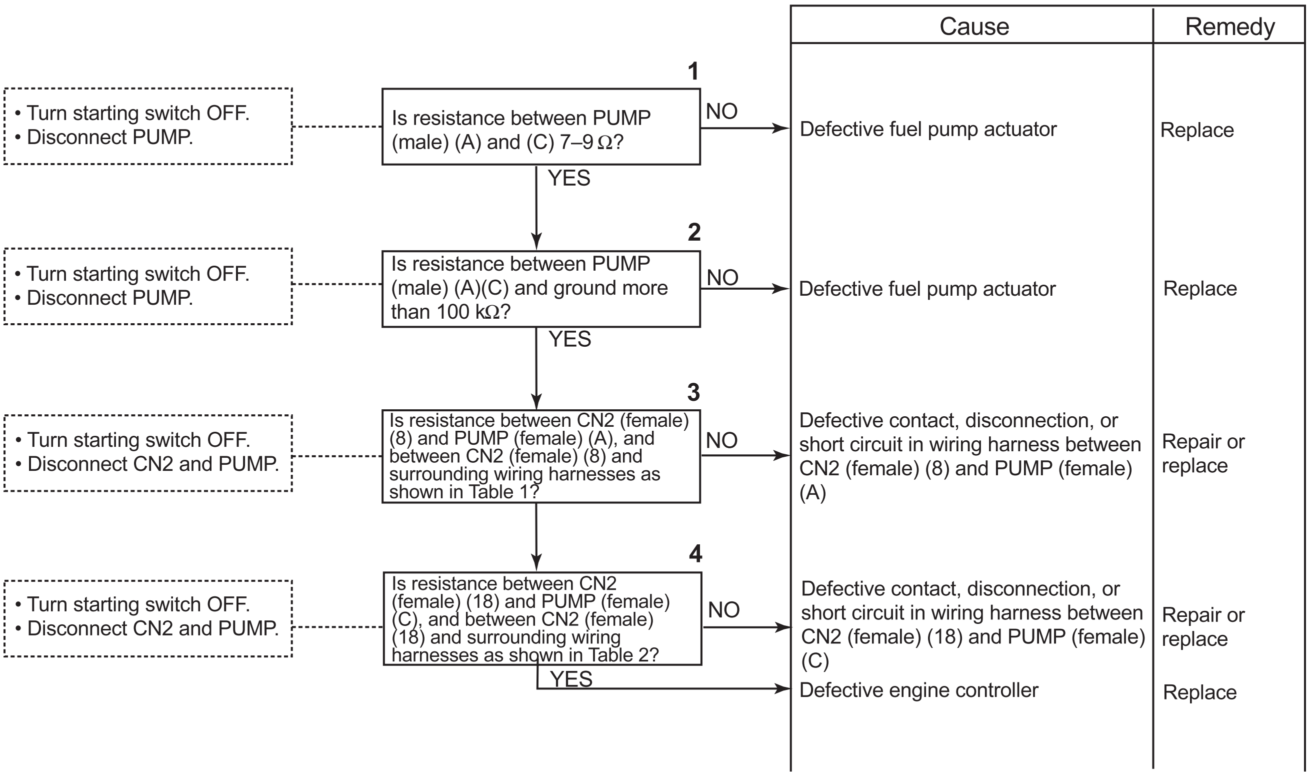


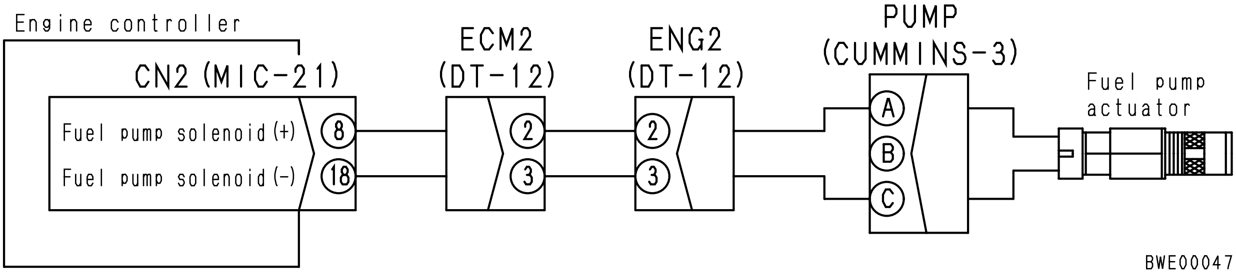
Table 1

CN2 (female), PUMP (female)	Resistance value
Between CN2 (8) and PUMP (A)	Max. 10Ω
Between CN2 (8) and surrounding wiring harnesses	Min. 1 MΩ

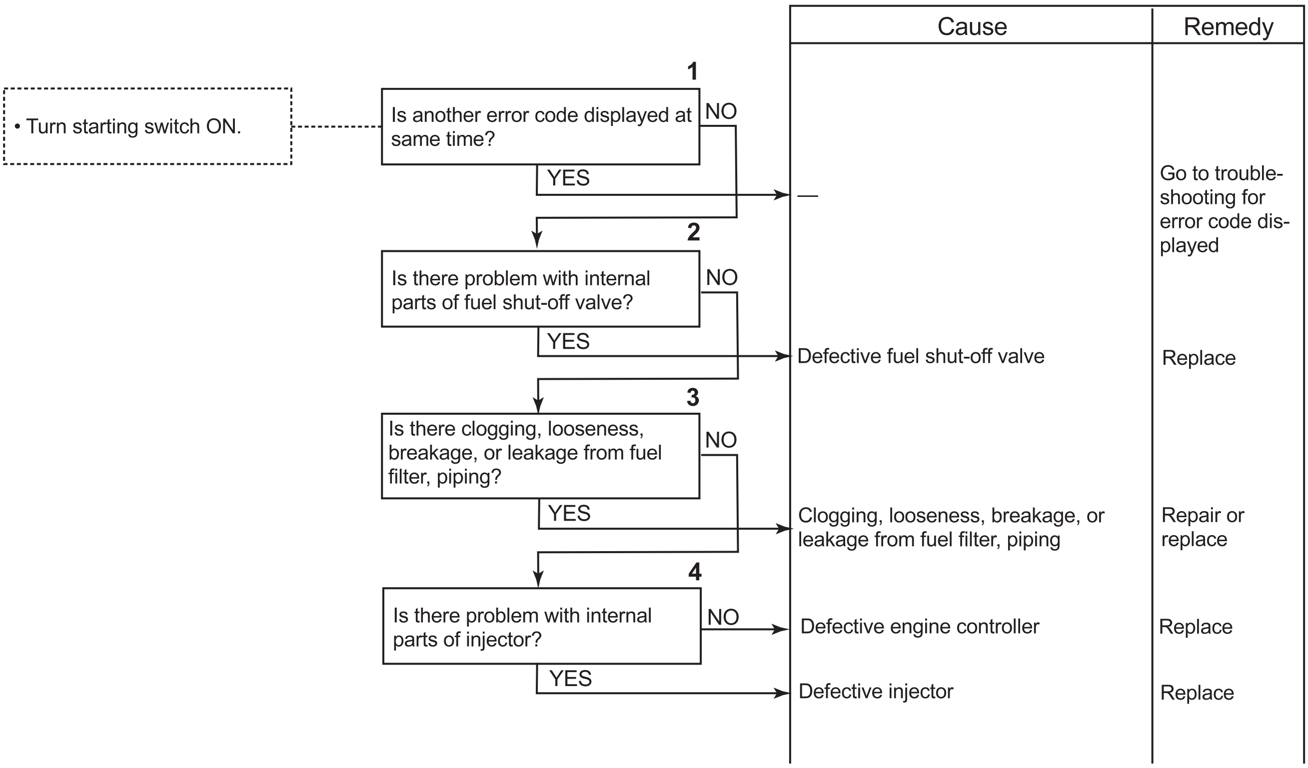
Table 2

CN2 (female), PUMP (female)	Resistance value
Between CN2 (18) and PUMP (B)	Max. 10Ω
Between CN2 (18) and surrounding wiring harnesses	Min. 1 MΩ

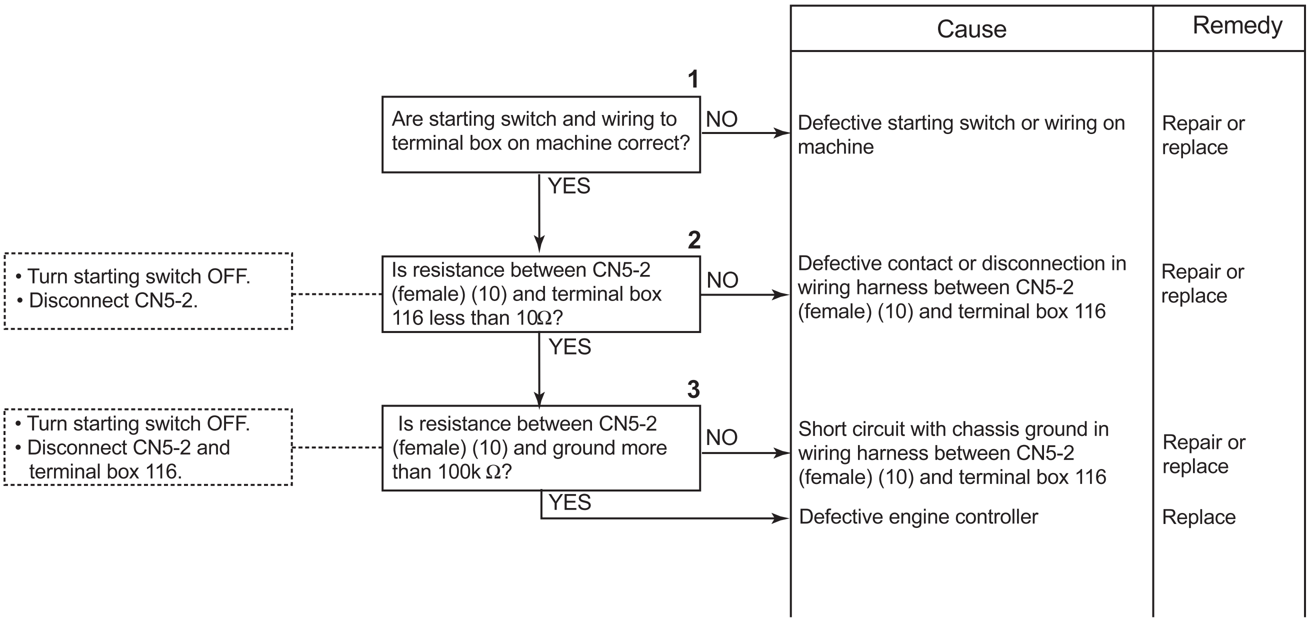
EB-27 Related electrical circuit diagram



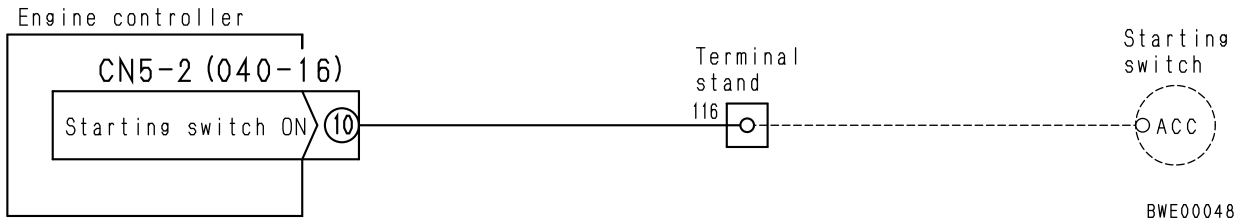
EB-28 Error code [E-A0] ([Abnormality in fuel shut-off valve)



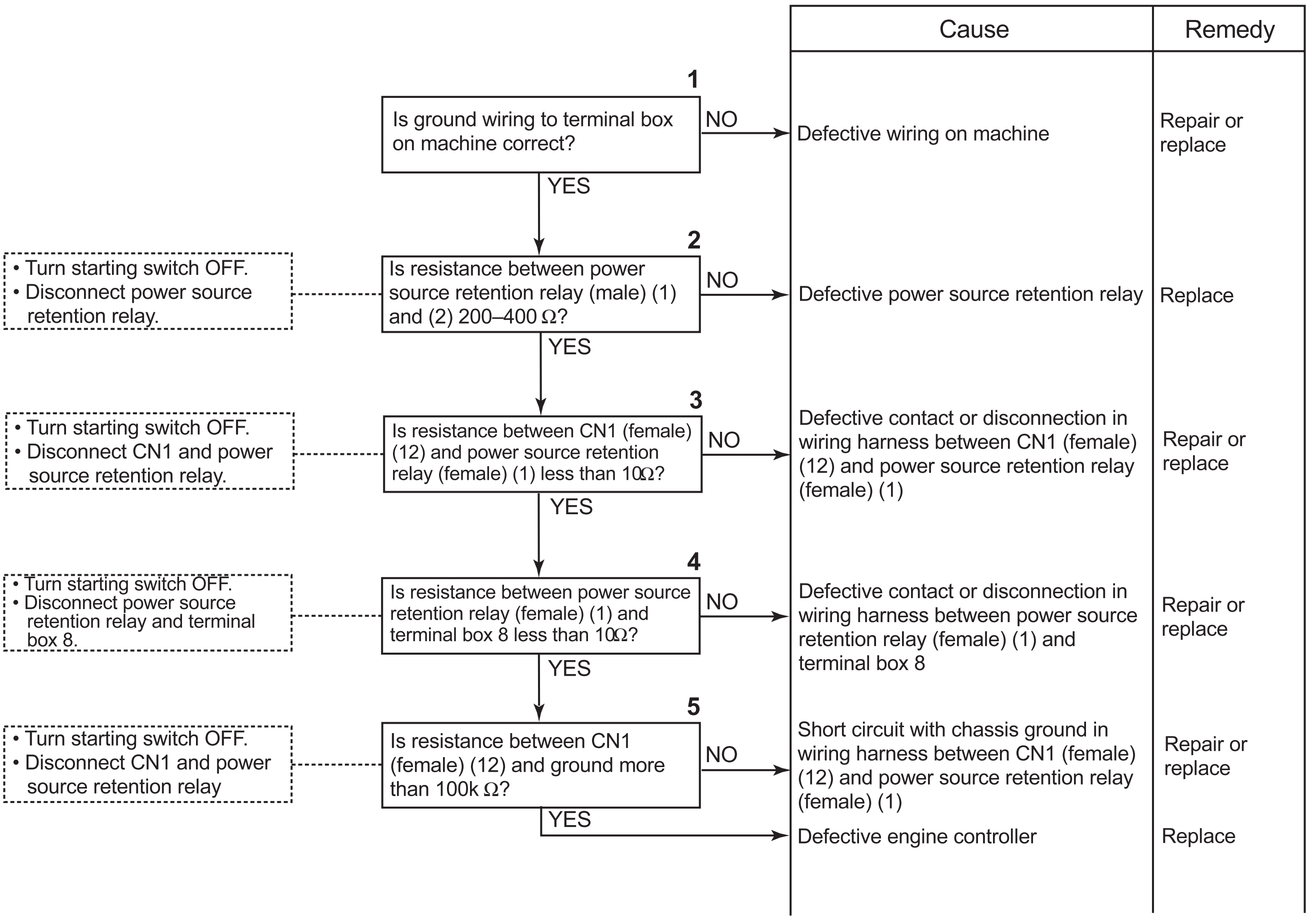
EB-29 Error code [E-A1] (Abnormality in starting switch ON signal system)



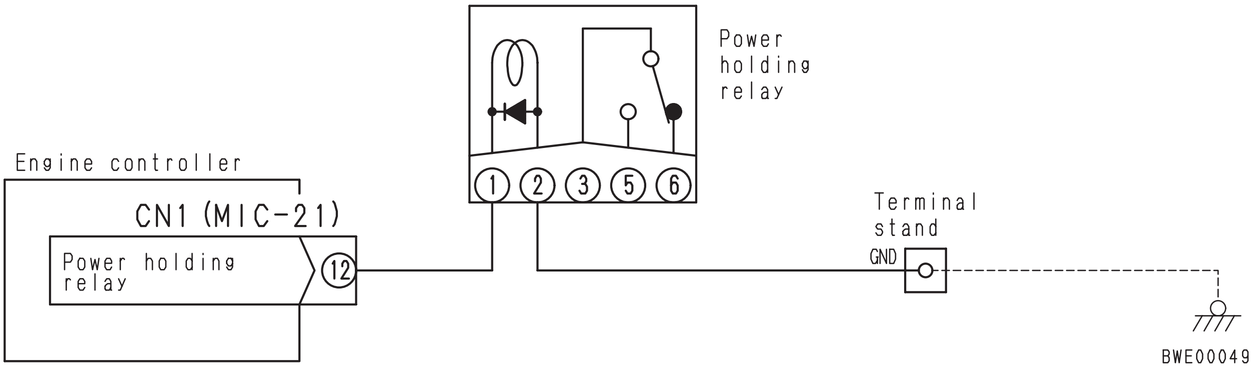
EB-29 Related electrical circuit diagram



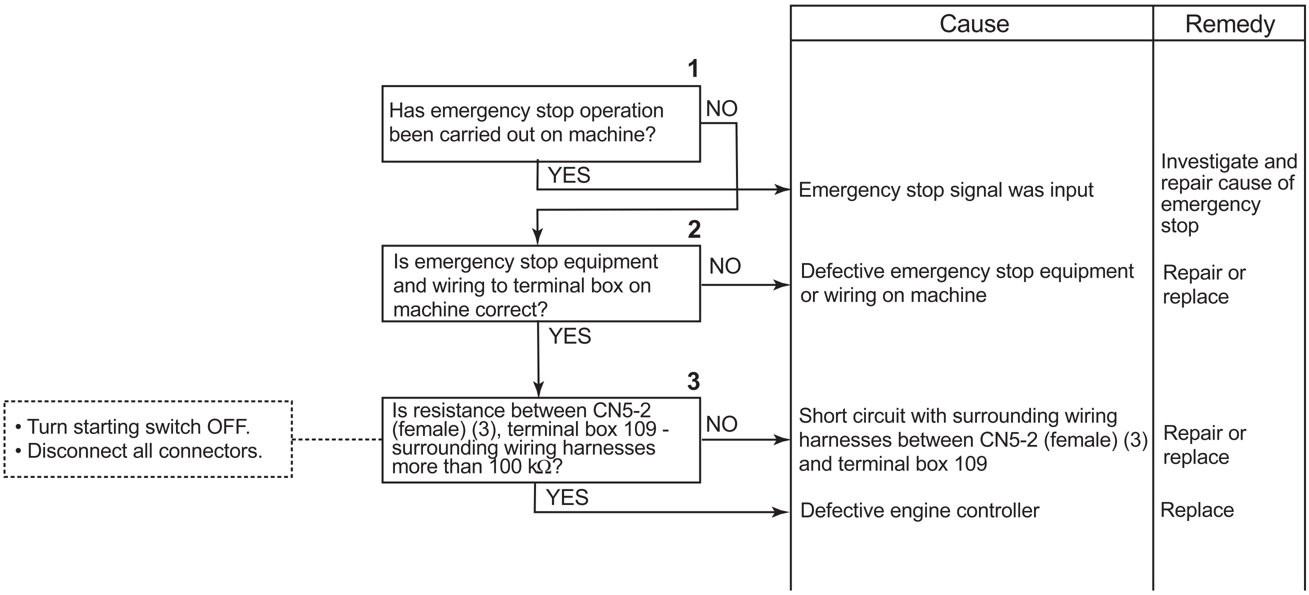
EB-30 Error code [E-A2] (Abnormality in power source retention relay system)



EB-30 Related electrical circuit diagram



EB-31 Error code [E-A3] (Abnormality in emergency stop signal input)



Has emergency stop operation been carried out on machine?

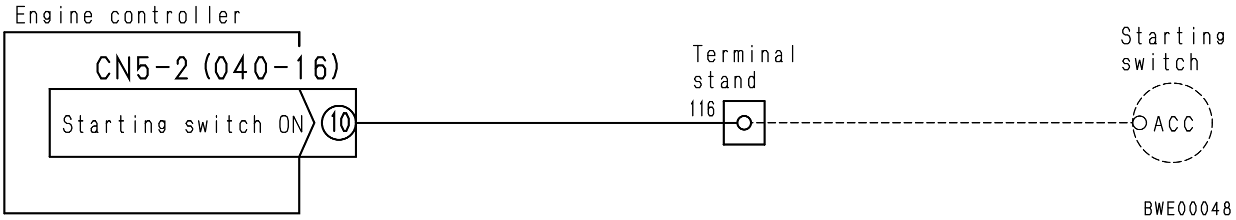
Is emergency stop equipment and wiring to terminal box on machine correct?

Is resistance between CN5-2 (female) (3), terminal box 109 - surrounding wiring harnesses more than 100 kΩ?

- Turn starting switch OFF.
- Disconnect all connectors.

Cause	Remedy
Emergency stop signal was input	Investigate and repair cause of emergency stop
Defective emergency stop equipment or wiring on machine	Repair or replace
Short circuit with surrounding wiring harnesses between CN5-2 (female) (3) and terminal box 109	Repair or replace
Defective engine controller	Replace

EB-31 Related electrical circuit diagram



EB-32 Error code [E-b0] (Abnormality in atmospheric pressure sensor system high level)

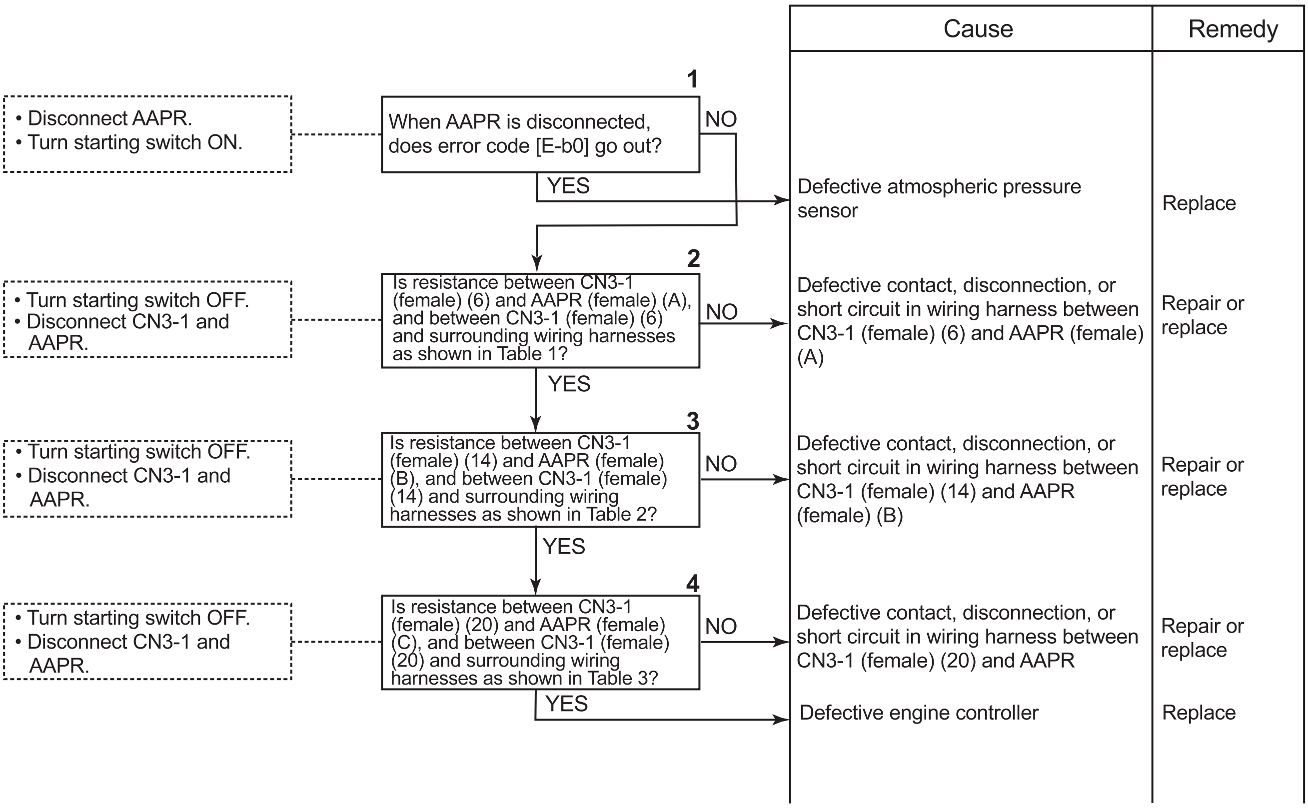


Table 1

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (6) and AAPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

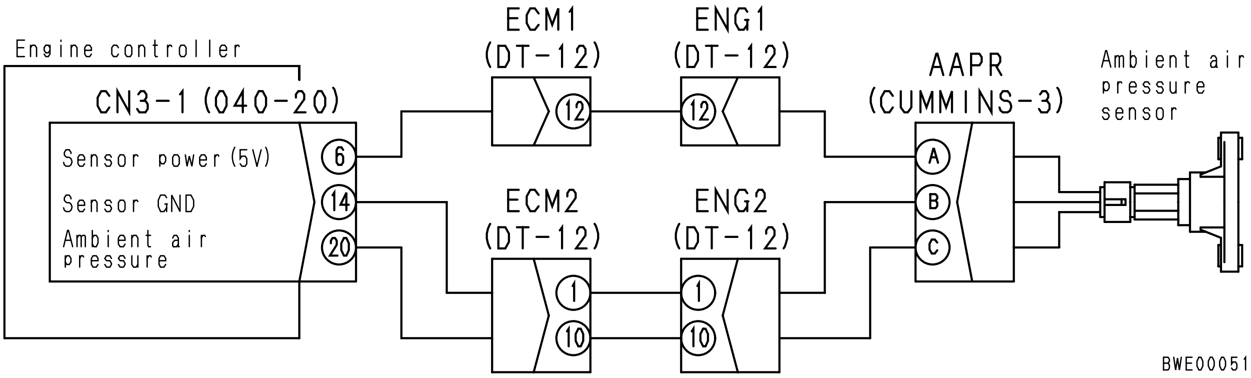
Table 2

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (14) and AAPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

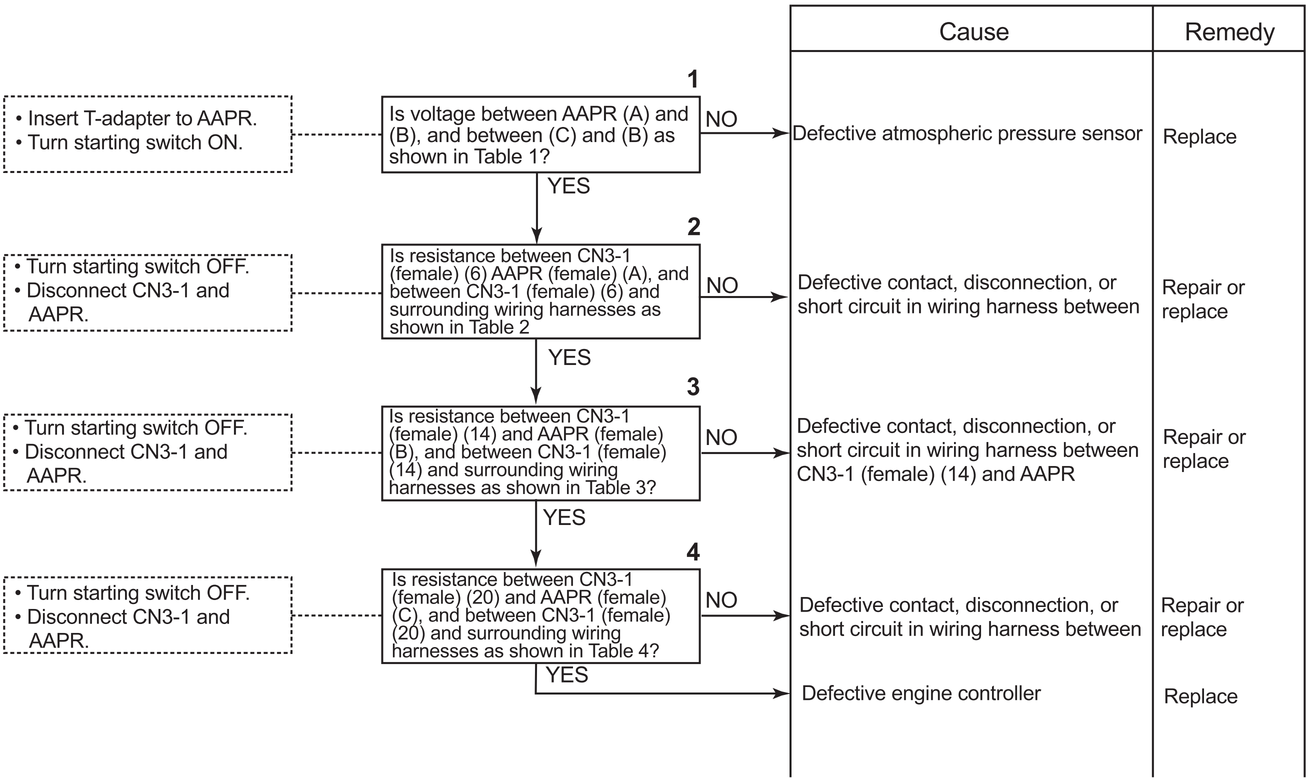
Table 3

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (20) and AAPR (C)	Max. 10Ω
Between CN3-1 (20) and surrounding wiring harnesses	Min. 1 MΩ

EB-32 Related electrical circuit diagram



EB-33 Error code [E-b1] (Abnormality in atmospheric pressure sensor system low level)



Cause | Remedy

1

- Insert T-adapter to AAPR.
- Turn starting switch ON.

Is voltage between AAPR (A) and (B), and between (C) and (B) as shown in Table 1?

NO → Defective atmospheric pressure sensor — Replace

YES ↓

2

- Turn starting switch OFF.
- Disconnect CN3-1 and AAPR.

Is resistance between CN3-1 (female) (6) AAPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 2

NO → Defective contact, disconnection, or short circuit in wiring harness between — Repair or replace

YES ↓

3

- Turn starting switch OFF.
- Disconnect CN3-1 and AAPR.

Is resistance between CN3-1 (female) (14) and AAPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 3?

NO → Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and AAPR — Repair or replace

YES ↓

4

- Turn starting switch OFF.
- Disconnect CN3-1 and AAPR.

Is resistance between CN3-1 (female) (20) and AAPR (female) (C), and between CN3-1 (female) (20) and surrounding wiring harnesses as shown in Table 4?

NO → Defective contact, disconnection, or short circuit in wiring harness between — Repair or replace

YES → Defective engine controller — Replace

Table 1

AAPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (6) and AAPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

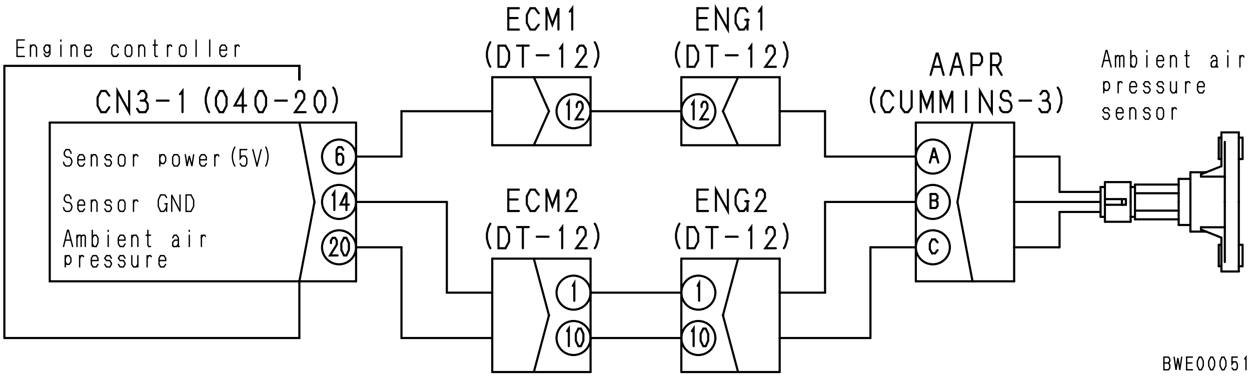
Table 3

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (14) and AAPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

CN3-1 (female), AAPR (female)	Resistance value
Between CN3-1 (20) and AAPR (C)	Max. 10Ω
Between CN3-1 (20) and surrounding wiring harnesses	Min. 1 MΩ

EB-33 Related electrical circuit diagram



EB-34 Error code [E-b2] (Abnormality in boost air pressure sensor system high level)

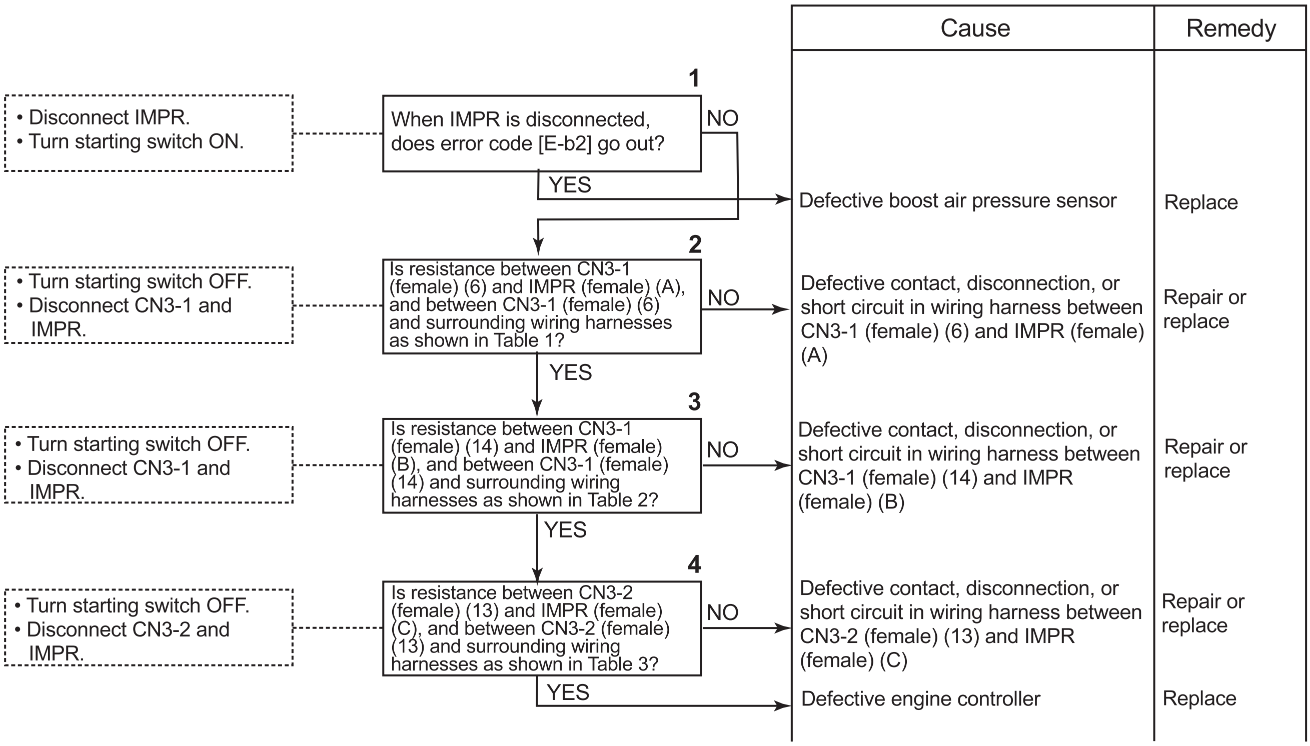


Table 1

CN3-1 (female), IMPR (female)	Resistance value
Between CN3-1 (6) and IMPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

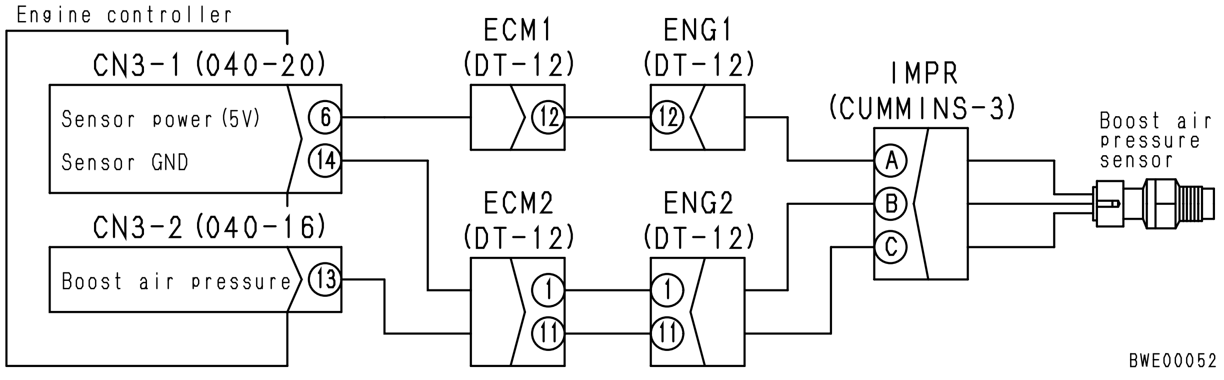
Table 2

CN3-1 (female), IMPR (female)	Resistance value
Between CN3-1 (14) and IMPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

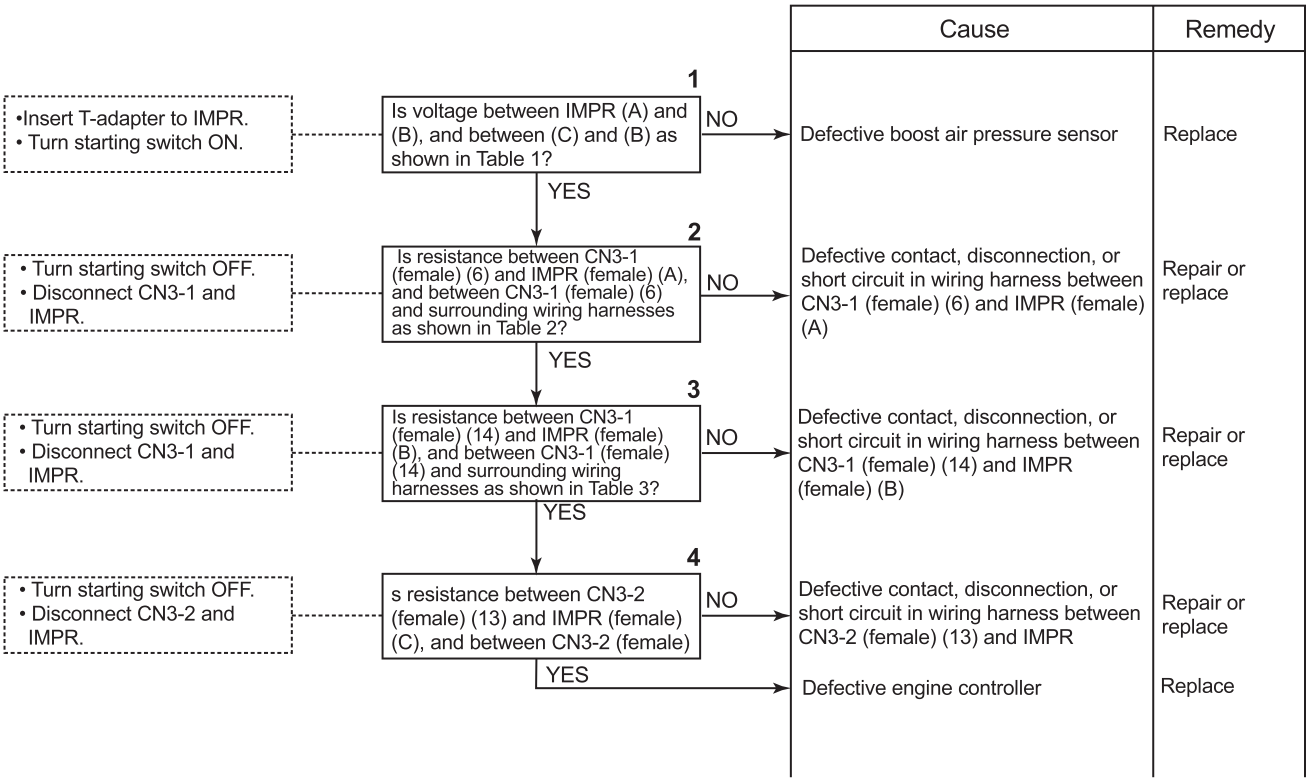
Table 3

CN3-2 (female), IMPR (female)	Resistance value
Between CN3-2 (13) and IMPR (B)	Max. 10Ω
Between CN3-2 (13) and surrounding wiring harnesses	Min. 1 MΩ

EB-34 Related electrical circuit diagram



EB-35 Error code [E-b3] (Abnormality in boost air pressure sensor system low level)



Step	Preparation	Check	Result	Cause	Remedy
1	•Insert T-adapter to IMPR. • Turn starting switch ON.	Is voltage between IMPR (A) and (B), and between (C) and (B) as shown in Table 1?	NO	Defective boost air pressure sensor	Replace
2	• Turn starting switch OFF. • Disconnect CN3-1 and IMPR.	Is resistance between CN3-1 (female) (6) and IMPR (female) (A), and between CN3-1 (female) (6) and surrounding wiring harnesses as shown in Table 2?	NO	Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (6) and IMPR (female) (A)	Repair or replace
3	• Turn starting switch OFF. • Disconnect CN3-1 and IMPR.	Is resistance between CN3-1 (female) (14) and IMPR (female) (B), and between CN3-1 (female) (14) and surrounding wiring harnesses as shown in Table 3?	NO	Defective contact, disconnection, or short circuit in wiring harness between CN3-1 (female) (14) and IMPR (female) (B)	Repair or replace
4	• Turn starting switch OFF. • Disconnect CN3-2 and IMPR.	s resistance between CN3-2 (female) (13) and IMPR (female) (C), and between CN3-2 (female)	NO	Defective contact, disconnection, or short circuit in wiring harness between CN3-2 (female) (13) and IMPR	Repair or replace
4			YES	Defective engine controller	Replace

Table 1

IMPR	Voltage
Between (A) and (B)	4.75 – 5.25 V
Between (C) and (B)	0.42 – 0.58 V

Table 2

CN3-1 (female), IMPR (female)	Resistance value
Between CN3-1 (6) and IMPR (A)	Max. 10Ω
Between CN3-1 (6) and surrounding wiring harnesses	Min. 1 MΩ

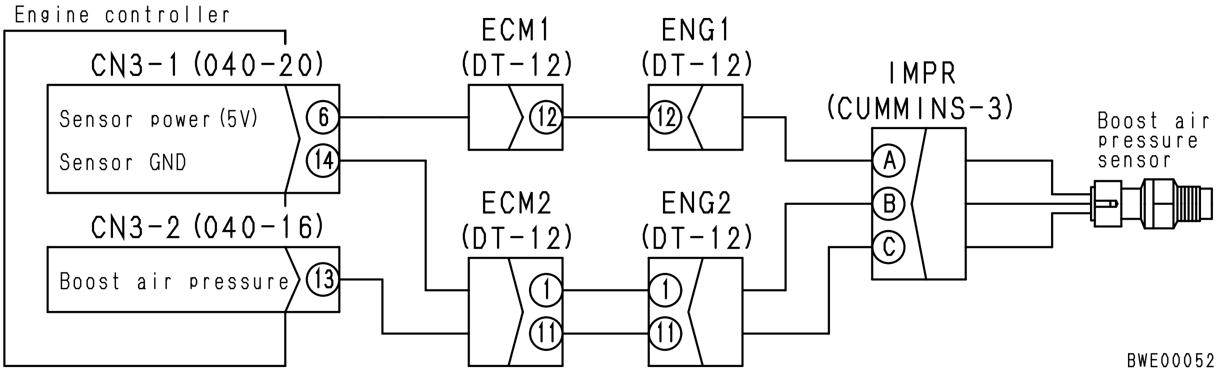
Table 3

CN3-1 (female), IMPR (female)	Resistance value
Between CN3-1 (14) and IMPR (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

Table 4

CN3-2 (female), IMPR (female)	Resistance value
Between CN3-2 (13) and IMPR (C)	Max. 10Ω
Between CN3-2 (13) and surrounding wiring harnesses	Min. 1 MΩ

EB-35 Related electrical circuit diagram



EB-36 Error code [E-b4] (Abnormality in boost air pressure sensor system in range)

★ Carry out troubleshooting for error code [E-b3].

EB-37 Error code [E-b6] (Abnormality in droop adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and

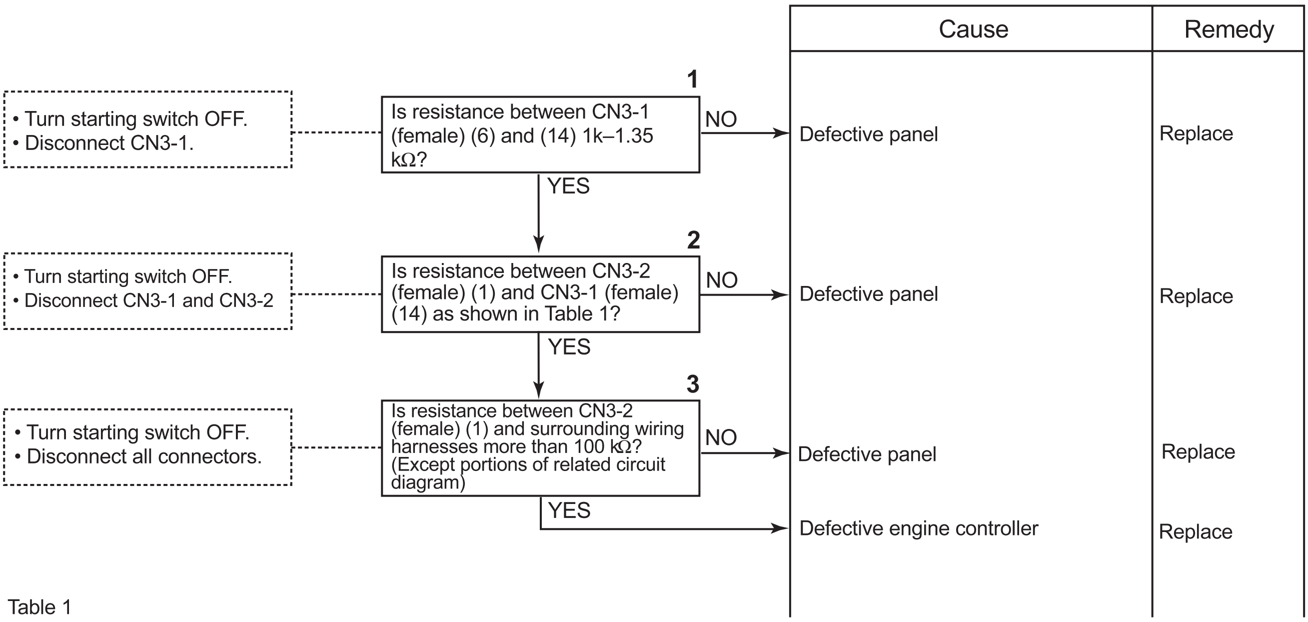
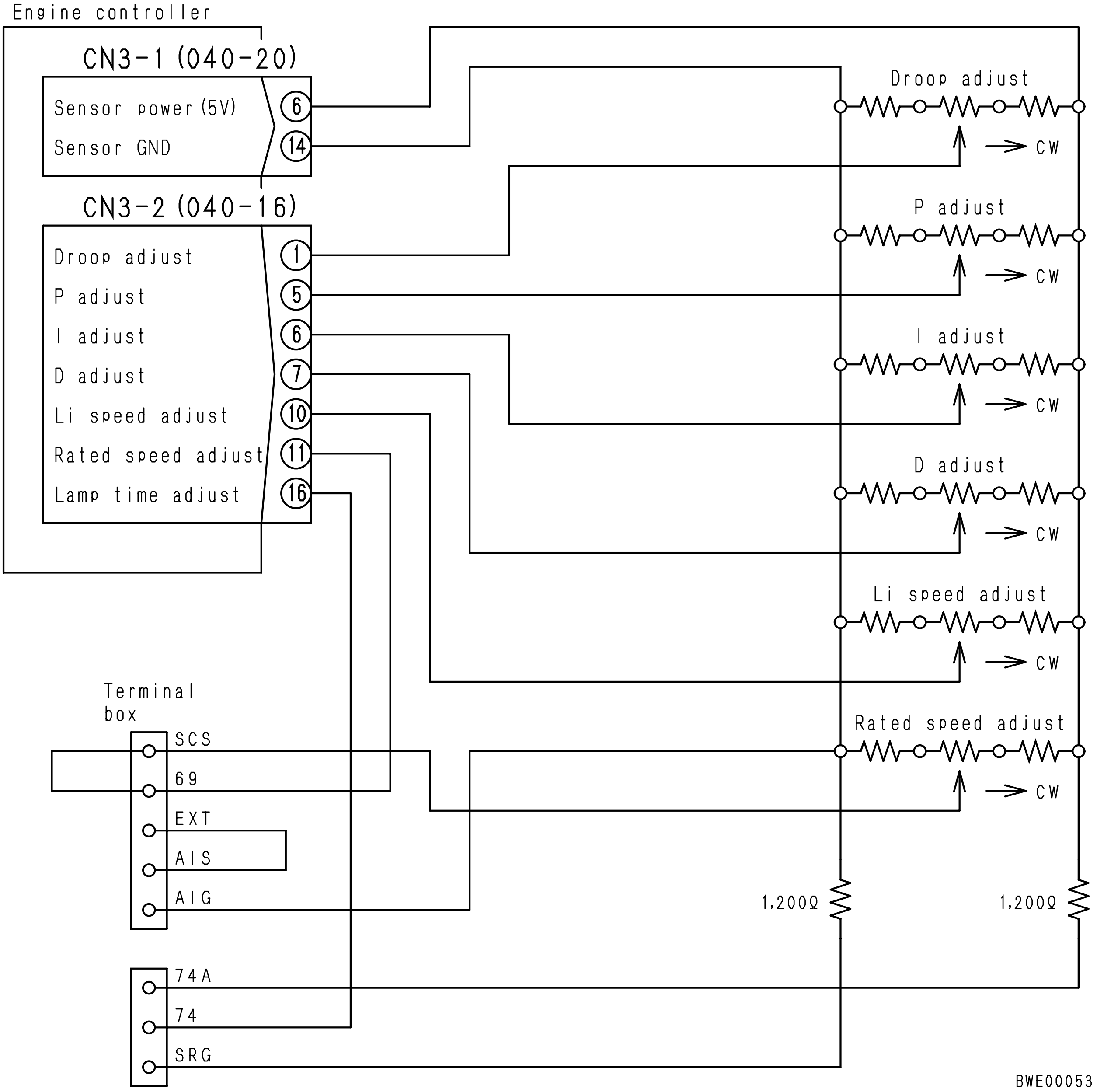


Table 1

CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (1) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Depressed (idling OFF)	1.8 – 2.0 kΩ

EB-37 Related electrical circuit diagram



EB-38 Error code [E-b7] (Abnormality in rated speed adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].

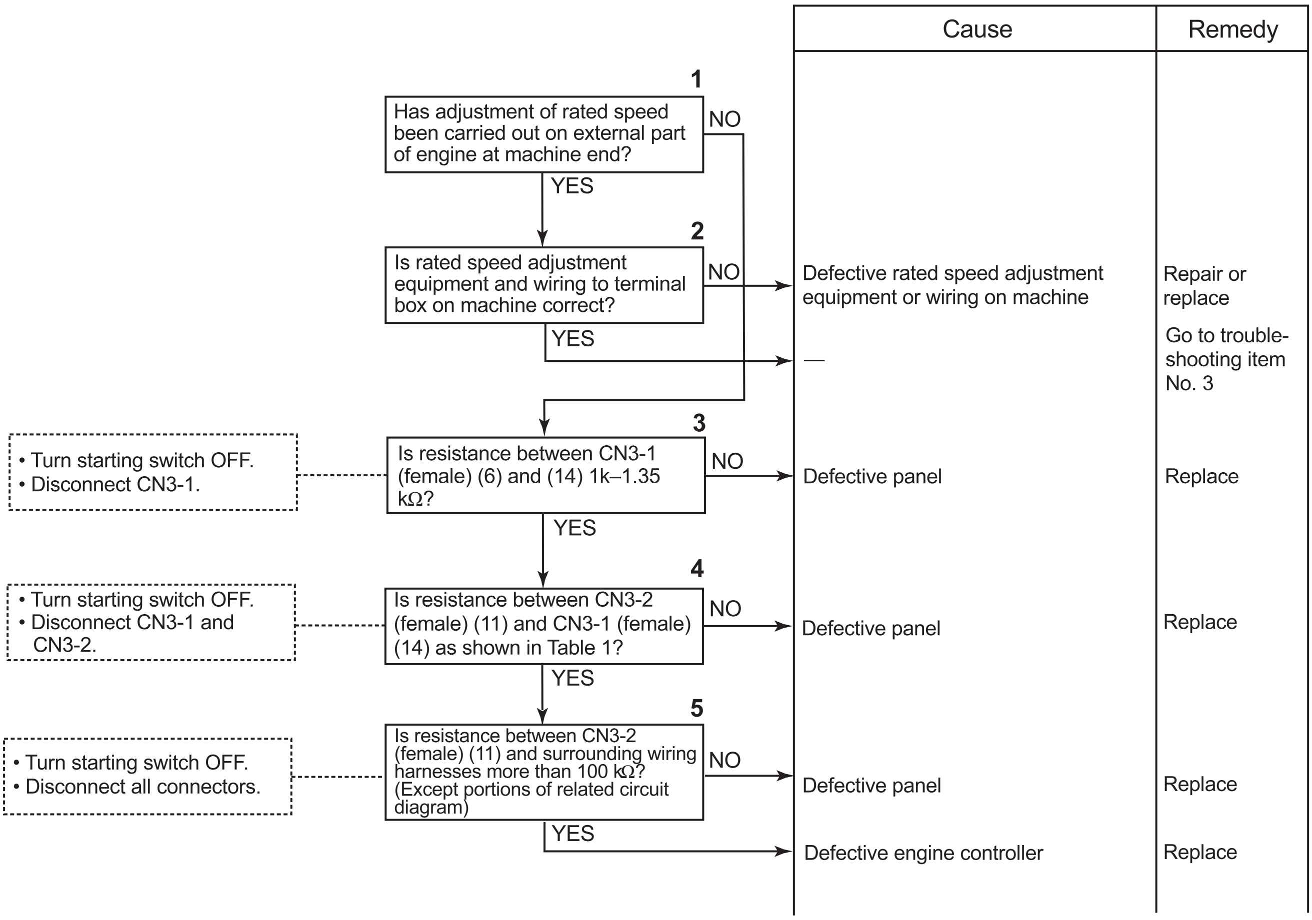
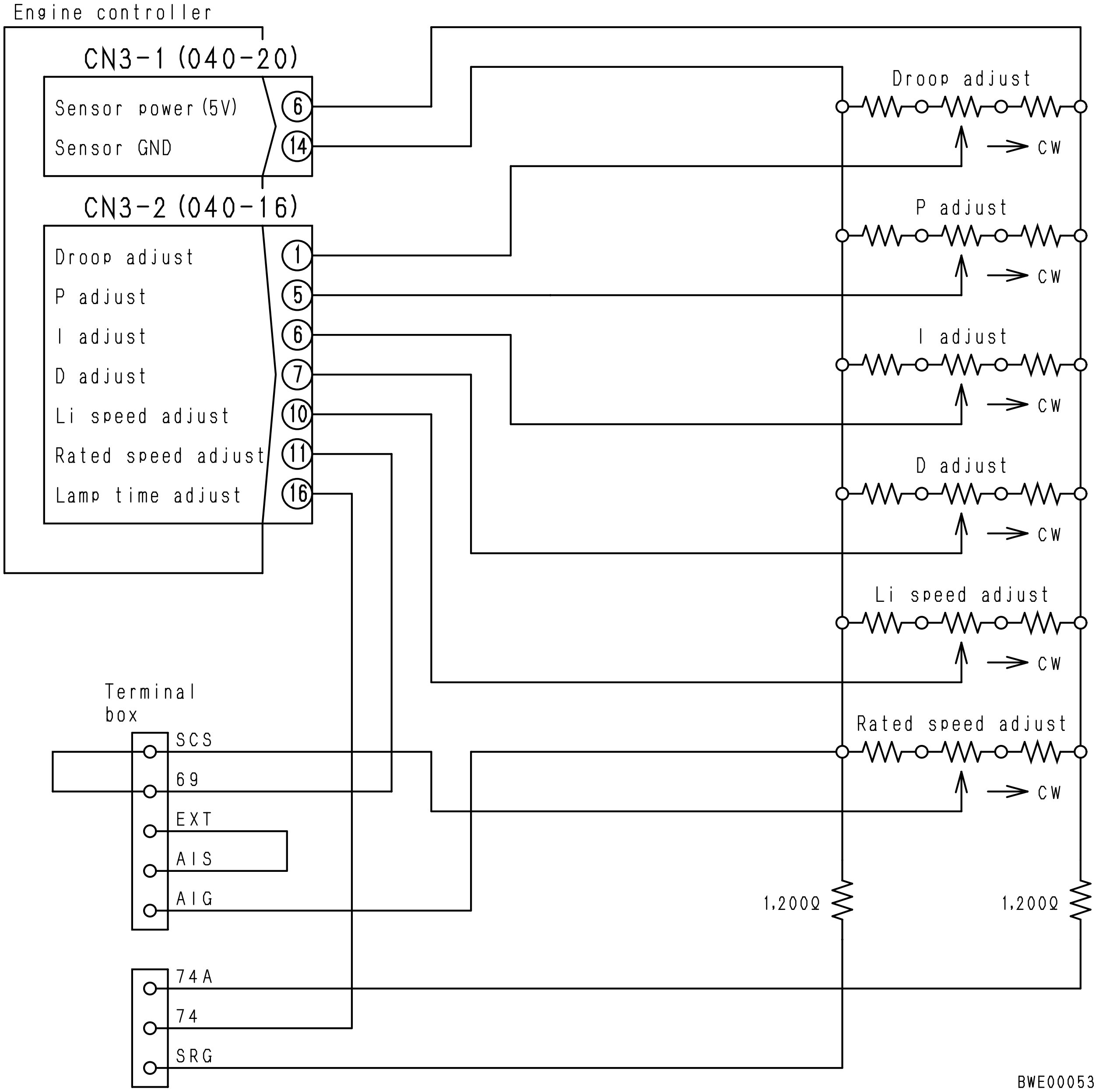


Table 1

CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (1) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Full open (full right)	1.8 – 2.0 kΩ

EB-38 Related electrical circuit diagram



EB-39 Error code [E-b8] (Abnormality in Li speed adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].

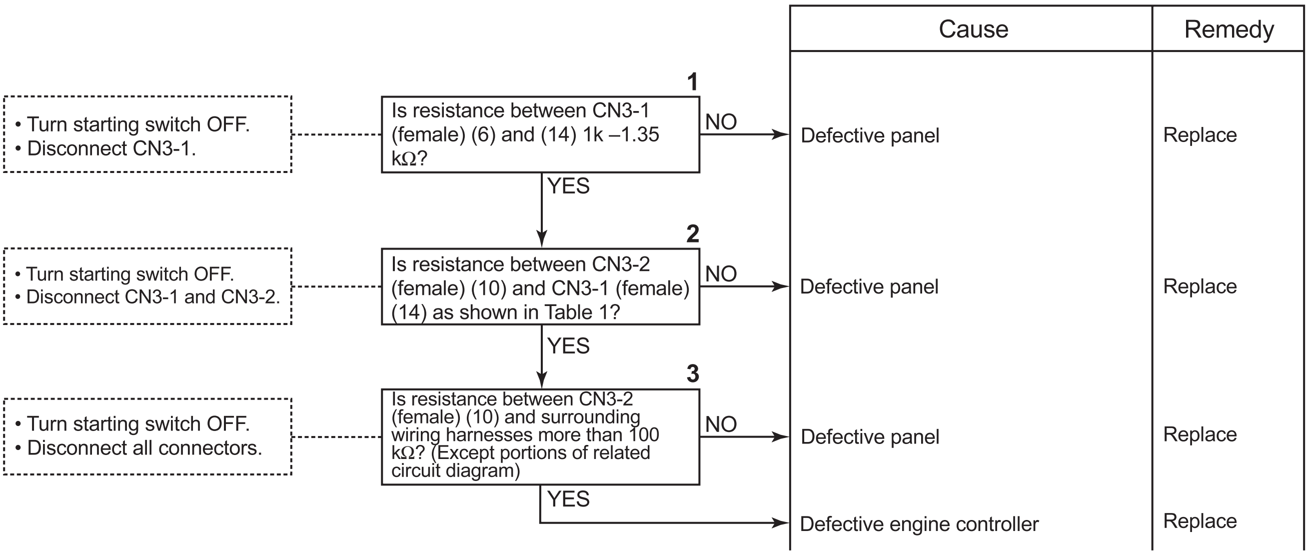
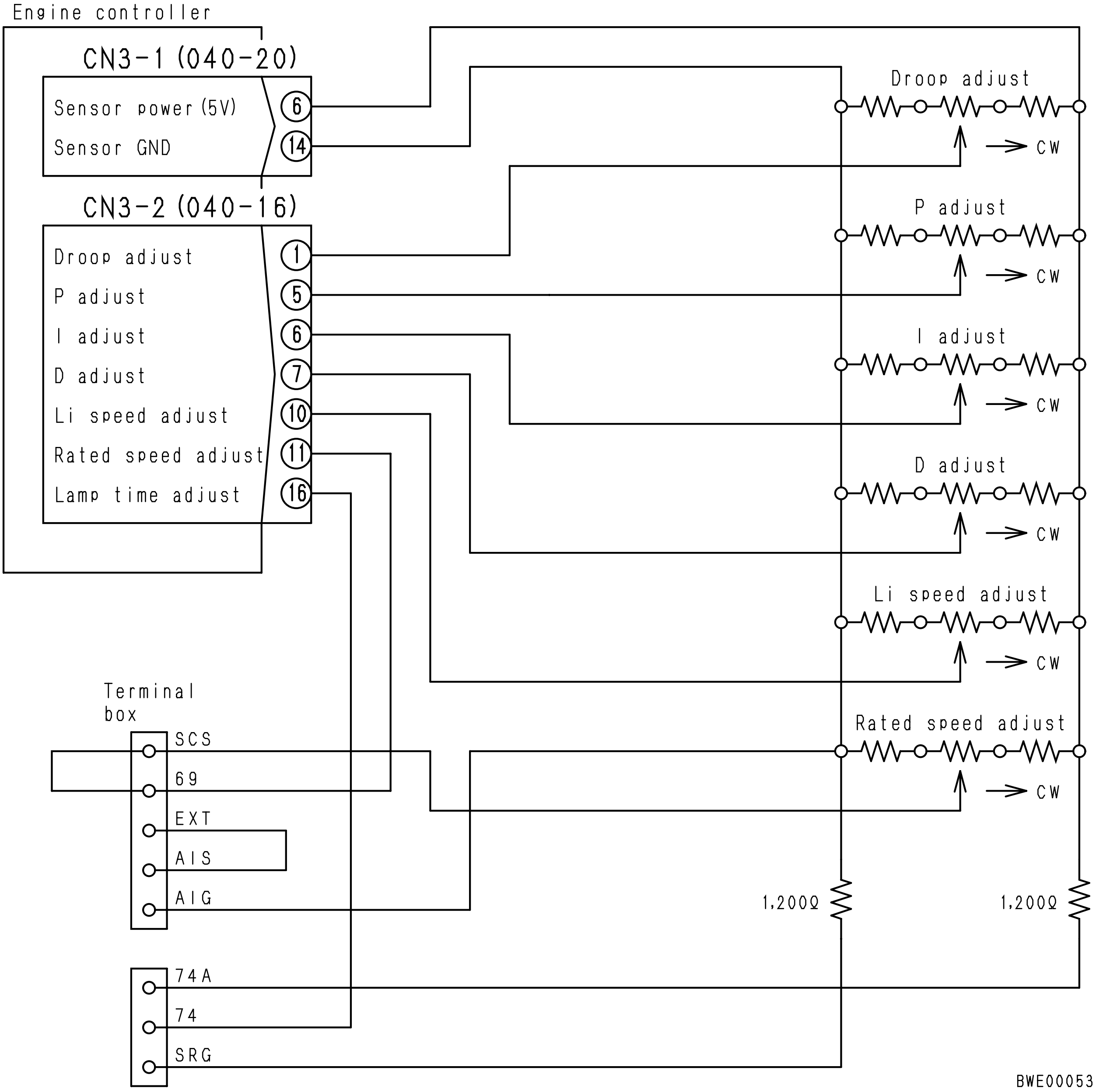


Table 1

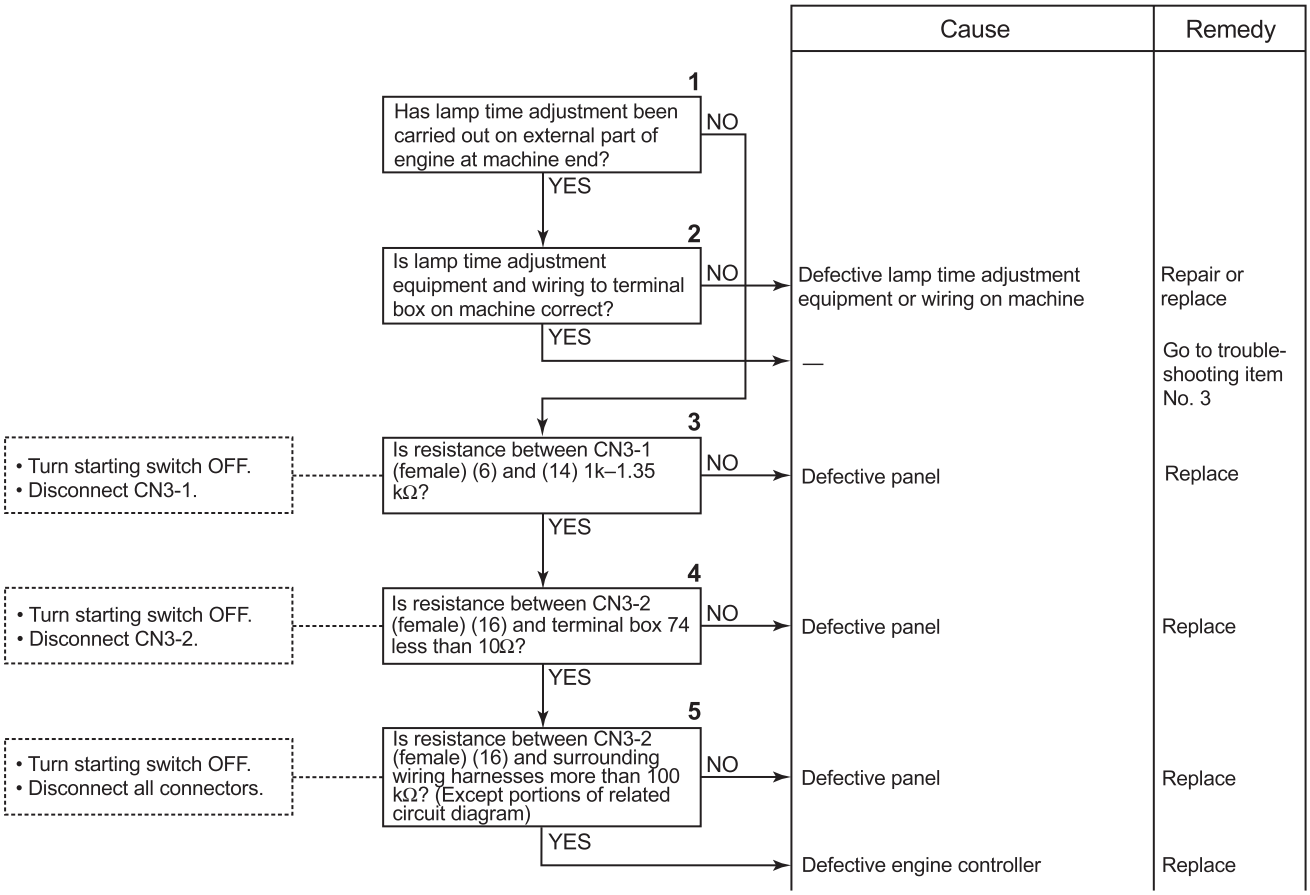
CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (10) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Fully open (full right)	1.8 – 2.0 kΩ

EB-39 Related electrical circuit diagram

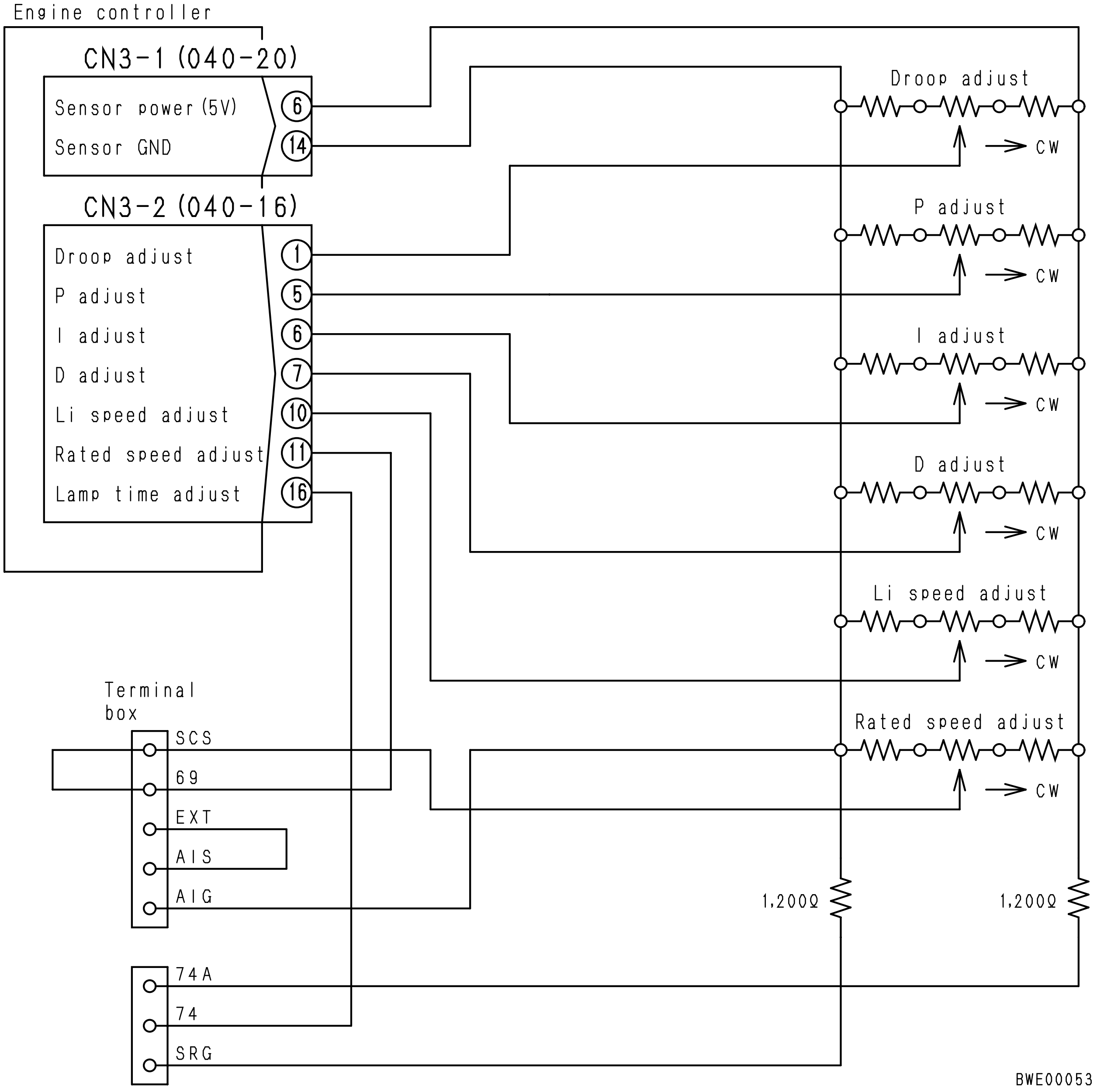


EB-40 Error code [E-b9] (Abnormality in lamp time adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].



EB-40 Related electrical circuit diagram



EB-41 Error code [E-bA] (Abnormality in P constant adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].

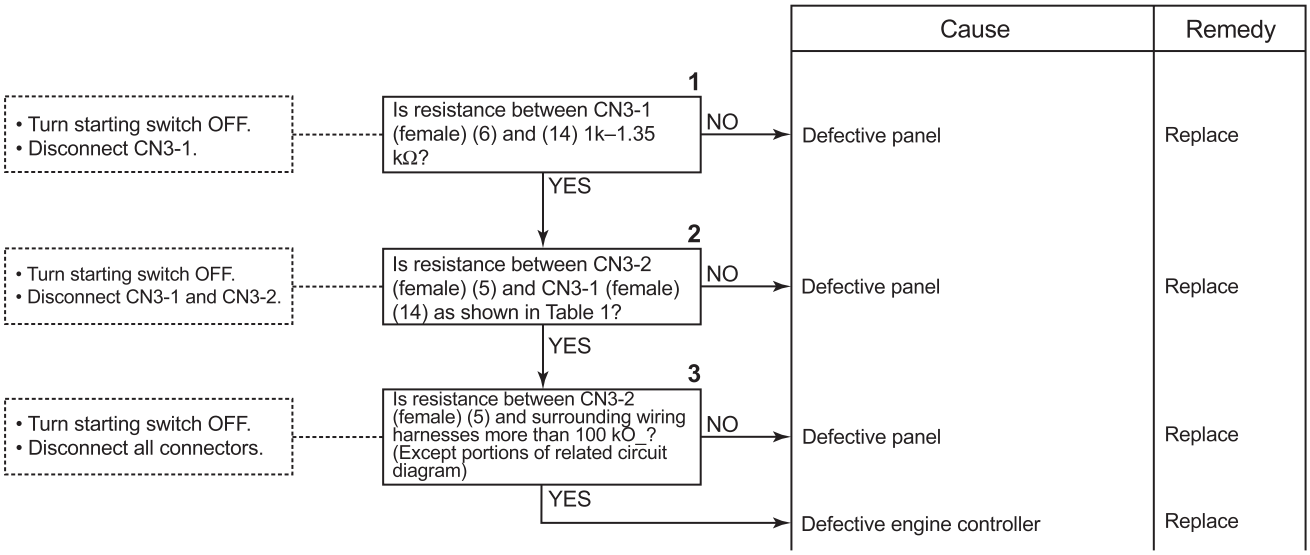
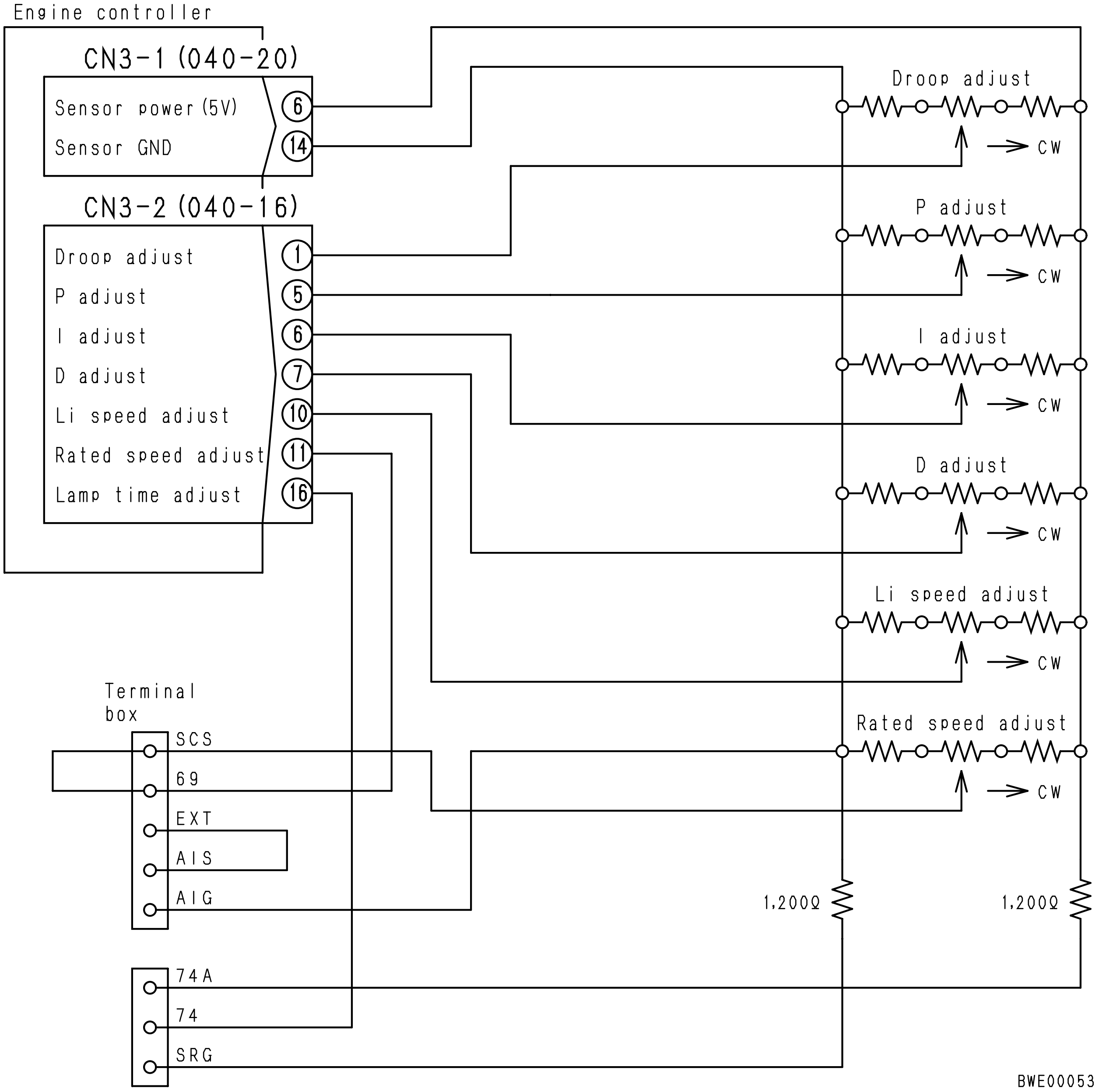


Table 1

CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (5) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Fully open (full right)	1.8 – 2.0 kΩ

EB-41 Related electrical circuit diagram



EB-42 Error code [E-bb] (Abnormality I constant adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].

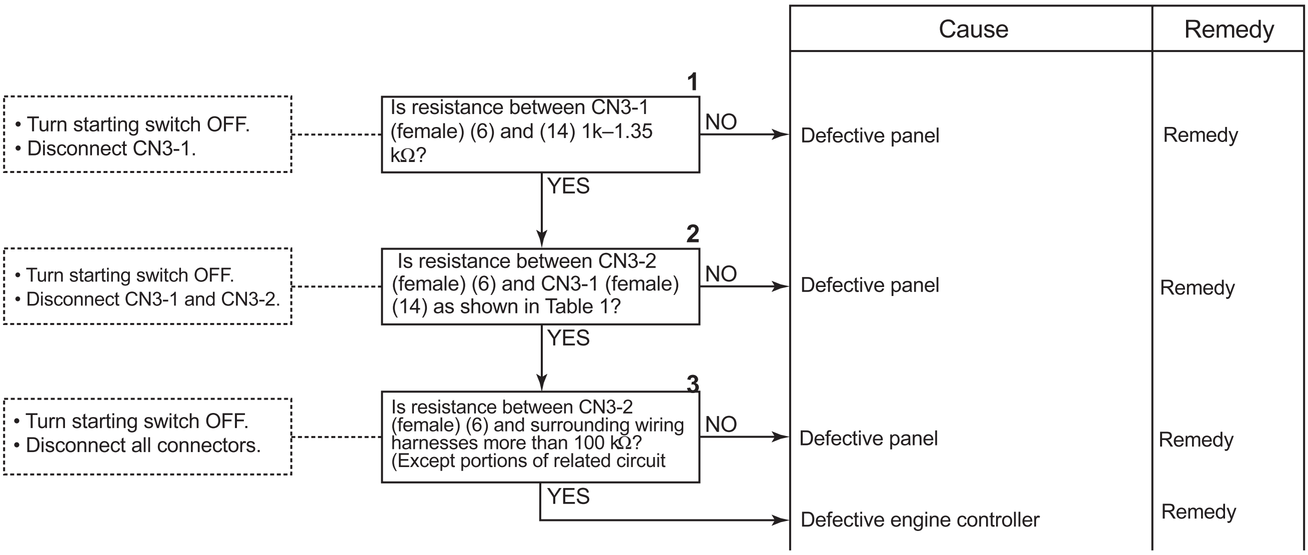
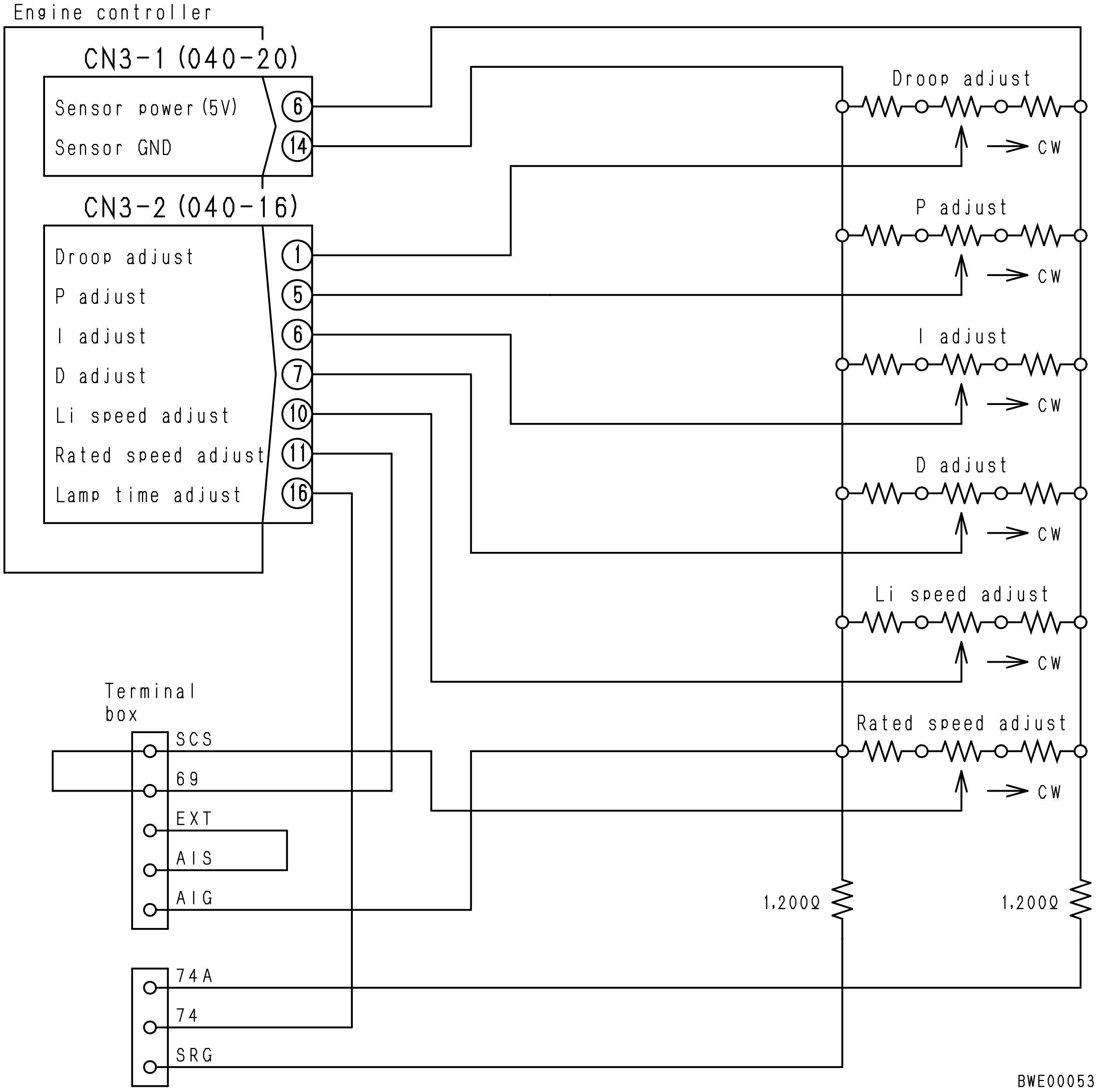


Table 1

CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (6) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Fully open (full right)	1.8 – 2.0 kΩ

EB-42 Related electrical circuit diagram



EB-43 Error code [E-bC] (Abnormality in D constant adjustment volume system)

★ Before carrying out troubleshooting, connect terminal box [SCS] and [69], and open all of [EXIT], [AIS], [AIG], [74A], [74], and [SRG].

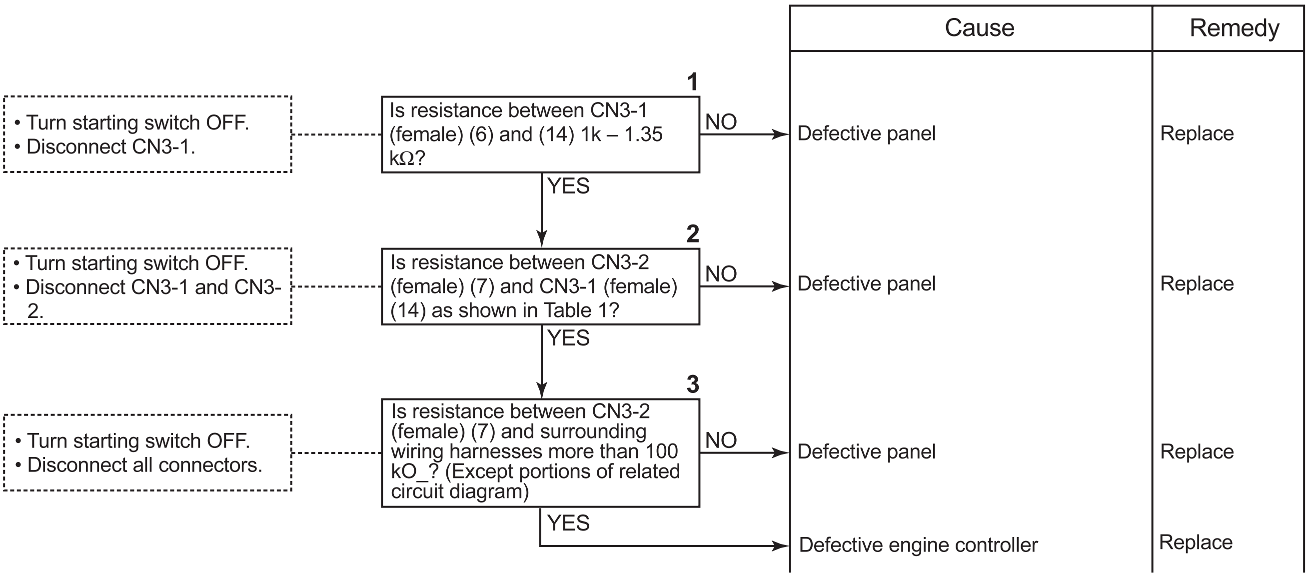
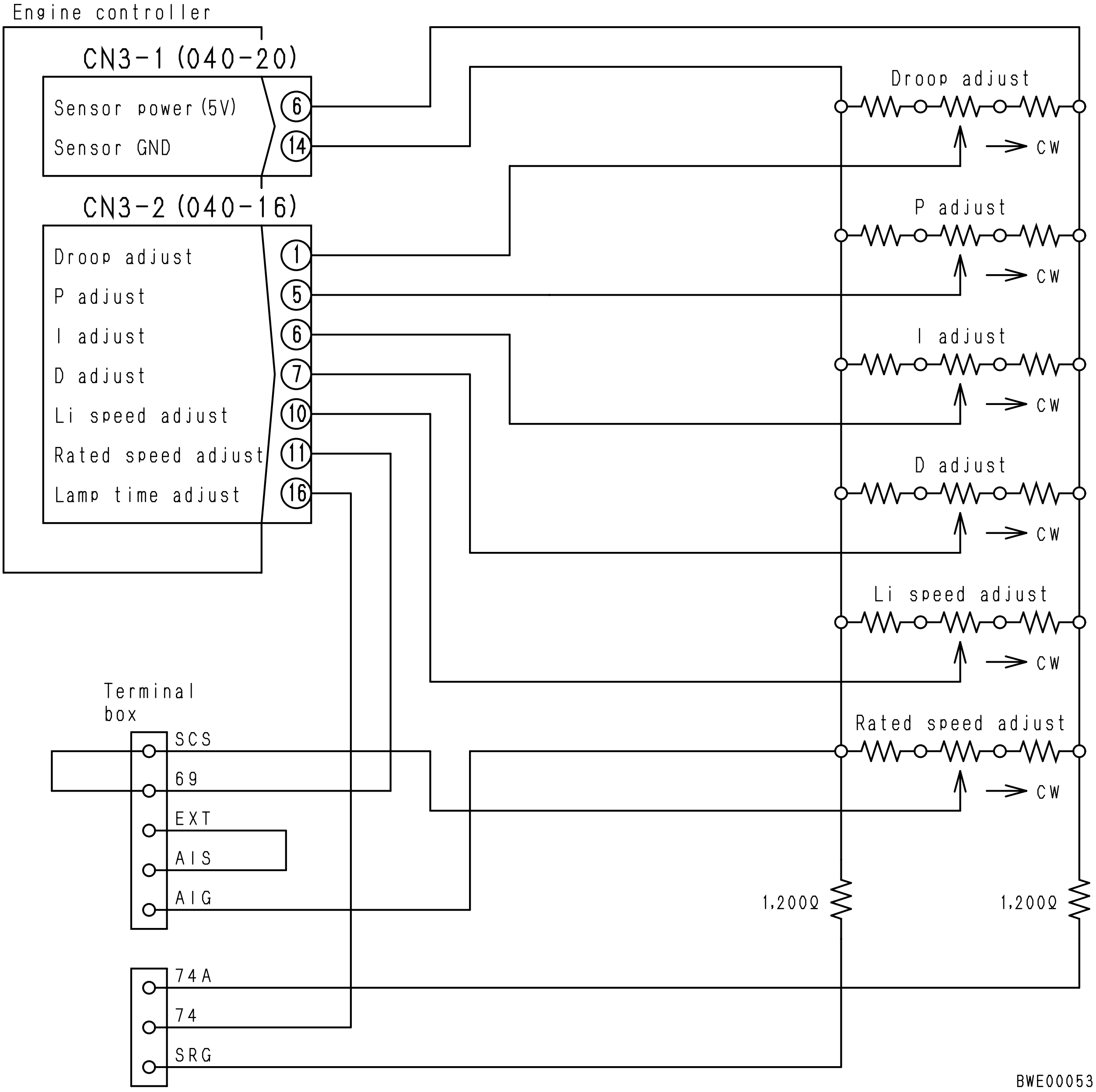


Table 1

CN3-2 (female), CN3-1 (female)	Volume	Resistance value
Between CN3-2 (7) and CN3-1 (14)	Fully closed (full left)	Max. 1.1 kΩ
	Fully open (full right)	1.8 – 2.0 kΩ

EB-43 Related electrical circuit diagram



EB-44 Error code [E-bd] (Abnormality in fuel temperature sensor system)

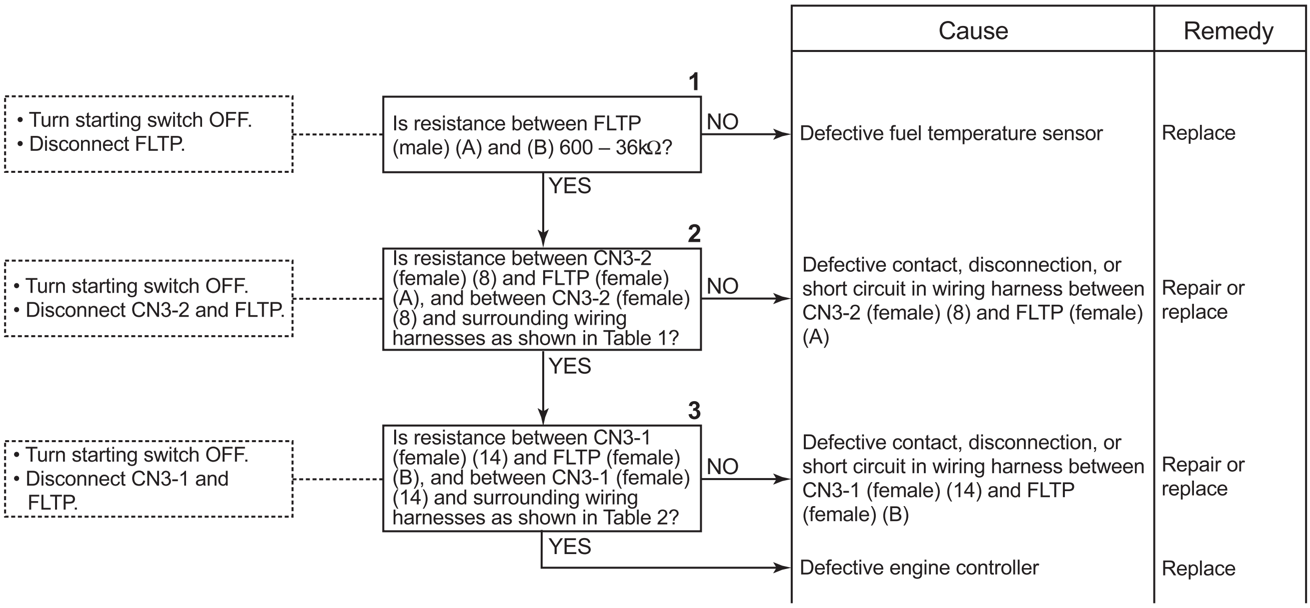


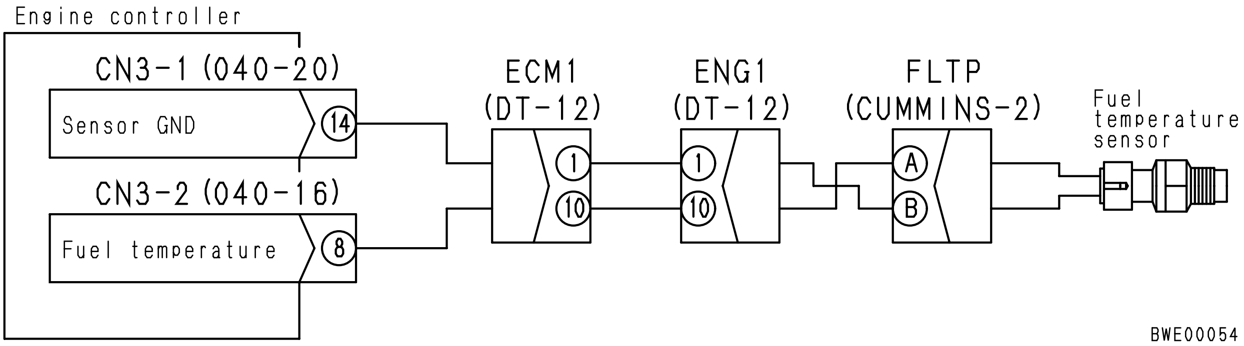
Table 1

CN3-2 (female), FLTP (female)	Resistance value
Between CN3-2 (8) and FLTP (A)	Max. 10Ω
Between CN3-2 (8) and surrounding wiring harnesses	Min. 1 MΩ

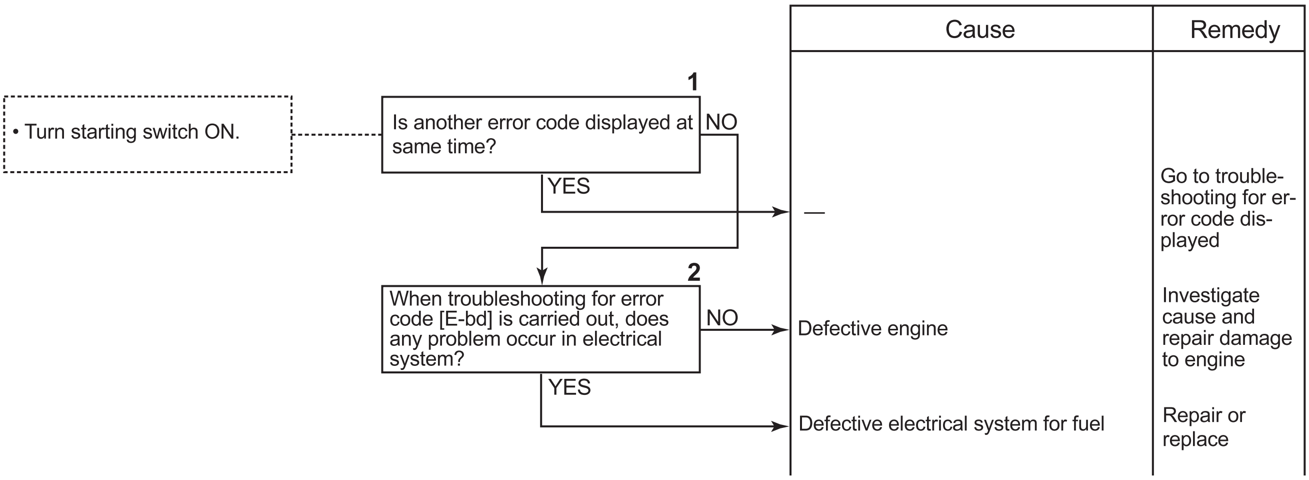
Table 2

CN3-1 (female), FLTP (female)	Resistance value
Between CN3-1 (14) and FLTP (B)	Max. 10Ω
Between CN3-1 (14) and surrounding wiring harnesses	Min. 1 MΩ

EB-44 Related electrical circuit diagram



EB-45 Error code [E-bE] (Abnormal rise in fuel temperature)



13 DISASSEMBLY AND ASSEMBLY

METHOD OF USING MANUAL

1. When removing or installing unit assemblies

① When removing or installing a unit assembly, the order of work and techniques used are given for the removal operation; the order of work for the installation operation is not given.

② Any special techniques applying only to the installation procedure are marked ※1, and the same mark is placed after the relevant step in the removal procedure to indicate which step in the installation procedure it applies to.

(Example)

REMOVAL OF ○○○○ ASSEMBLY..............Title of operation

....Precautions related to safety when carrying out the operation

1. X X X X (1)...Step in operation

★...Technique or important point to remember when removing XXXX (1).

2. △△△△ (2): ....※1 Indicates that a technique is listed for use during installation

3. □□□□ assembly (3)

..Quantity of oil or water drained

INSTALLATION OF ○○○○ ASSEMBLY ....Title of operation

- Carry out installation in the reverse order to removal.

※1 ....Technique used during installation

★..Technique or important point to remember when installing △△△△ (2).

- Adding water, oil ....Step in operation

★...Point to remember when adding water or oil

...Quantity when filling with oil and water

2. General precautions when carrying out installation or removal (disassembly or assembly) of units are given together as PRECAUTIONS WHEN CARRYING OUT OPERATION, so be sure to follow these precautions when carrying out the operation.

3. Listing of special tools

① For details of the description, part number, and quantity of any tools (A1, etc.) that appear in the operation procedure, see the SPECIAL TOOLS LIST given in this manual.

PRECAUTIONS WHEN CARRYING OUT OPERATION

[When carrying out removal or installation (disassembly or assembly) of units, be sure to follow the general precautions given below when carrying out the operation.]

1. Precautions when carrying out removal work

- If the coolant contains antifreeze, dispose of it correctly.
- After disconnecting hoses or tubes, cover them or fit blind plugs to prevent dirt or dust from entering.
- When draining oil, prepare a container of adequate size to catch the oil.
- Confirm the match marks showing the installation position, and make match marks in the necessary places before removal to prevent any mistake when assembling.
- To prevent any excessive force from being applied to the wiring, always hold the connectors when disconnecting the connectors. Do not pull the wires.
- Fit wires and hoses with tags to show their installation position to prevent any mistake when installing.
- Check the number and thickness of the shims, and keep in a safe place.
- When raising components, be sure to use lifting equipment of ample strength.
- When using forcing screws to remove any components, tighten the forcing screws uniformly in turn.
- Before removing any unit, clean the surrounding area and fit a cover to prevent any dust or dirt from entering after removal.

★ Precautions when handling piping during disassembly
Fit the following blind plugs into the piping after disconnecting it during disassembly operations.

1) Hoses and tubes using sleeve nuts

Nominal number	Plug (nut end)	Sleeve nut (elbow end) Use the two items below as a set
02	07376-50210	07221-20210 (Nut), 07222-00210 (Plug)
03	07376-50315	07221-20315 (Nut), 07222-00312 (Plug)
04	07376-50422	07221-20422 (Nut), 07222-00414 (Plug)
05	07376-50522	07221-20522 (Nut), 07222-00515 (Plug)
06	07376-50628	07221-20628 (Nut), 07222-00616 (Plug)
10	07376-51034	07221-21034 (Nut), 07222-01018 (Plug)
12	07376-51234	07221-21234 (Nut), 07222-01219 (Plug)

2) Split flange type hoses and tubes

Nominal number	Flange (hose end)	Sleeve head (tube end)	Split flange
04	07379-00400	07378-10400	07371-30400
05	07379-00500	07378-10500	07371-30500

3)If the part is not under hydraulic pressure, the following corks can be used.

Nominal number	Part Number	Dimensions		
		D	d	L
06	07049-00608	6	5	8
08	07049-00811	8	6.5	11
10	07049-01012	10	8.5	12
12	07049-01215	12	10	15
14	07049-01418	14	11.5	18
16	07049-01620	16	13.5	20
18	07049-01822	18	15	22
20	07049-02025	20	17	25
22	07049-02228	22	18.5	28
24	07049-02430	24	20	30
27	07049-02734	27	22.5	34

2. Precautions when carrying out installation work

- Tighten all bolts and nuts (sleeve nuts) to the specified (KES) torque.
- Install the hoses without twisting or interference.
- Replace all gaskets, O-rings, cotter pins, and lock plates with new parts.
- Bend the cotter pins and lock plates securely.
- When coating with adhesive, clean the part and remove all oil and grease, then coat the threaded portion with 2 – 3 drops of adhesive.
- When coating with gasket sealant, clean the surface and remove all oil and grease, check that there is no dirt or damage, then coat uniformly with gasket sealant.
- Clean all parts, and correct any damage, dents, burrs, or rust.
- Coat rotating parts and sliding parts with engine oil.
- When press fitting parts, coat the surface with anti-friction compound (LM-P).
- After fitting snap rings, check that the snap ring is fitted securely in the ring groove.
- When connecting wiring connectors, clean the connector to remove all oil, dirt, or water, then connect securely.
- When using eyebolts, check that there is no deformation or deterioration, screw them in fully, and align the direction of the hook.
- When tightening split flanges, tighten uniformly in turn to prevent excessive tightening on one side.

★ When operating the hydraulic cylinders for the first time after reassembling cylinders, pumps and other hydraulic equipment removed for repair, always bleed the air as follows:
   1. Start the engine and run at low idling.
   2. Operate the work equipment control lever to operate the hydraulic cylinder 4 – 5 times, stopping the cylinder 100 mm from the end of its stroke.
   3. Next, operate the hydraulic cylinder 3 – 4 times to the end of its stroke.
   4. After doing this, run the engine at normal speed.
   ★ When using the machine for the first time after repair or long storage, follow the same procedure.

3. Precautions when completing the operation

- If the coolant has been drained, tighten the drain valve, and add water to the specified level. Run the engine to circulate the water through the system. Then check the water level again.
- If the hydraulic equipment has been removed and installed again, add engine oil to the specified level. Run the engine to circulate the oil through the system. Then check the oil level again.
- If the piping or hydraulic equipment have been removed, always bleed the air from the system after reassembling the parts.
   ★ For details, see TESTING AND ADJUSTING, Bleeding air.
   - Add the specified amount of grease (molybdenum disulphide grease) to the work equipment parts.

SPECIAL TOOL LIST

★ Tools with part number 79○T-○○○-○○○○ cannot be supplied (they are items to be locally manufactured).

★ Necessity : ■:........Cannot be substituted, should always be installed (used)
●:........Extremely useful if available, can be substituted with commercially available part
New/remodel: N:........Tools with new part numbers, newly developed for this model
R:........Tools with upgraded part numbers, remodeled from items already available for other models
Blank . Tools already available for other models, used without any modification

★ Tools marked ○ in the Sketch column are tools introduced in special sketches (See SKETCHES OF SPECIAL TOOLS).

Component	Sym-bol		Part No.	Part Name	Nece-ssity	Q'ty	New/ remodel	Ske-tch	Nature of work, remarks
Removal, installation of injector assembly	A		795-799-5410	Adapter	■	1	N		
			795-799-5420	Remover	■	1	N		
Removal, installation of cylinder head valve spring	B		795-102-2102	Spring pusher	■	1			
			795-102-2110	• Handle		1			
			795-102-2120	• Bracket		1			
			795-102-4210	• Bracket		1			
			01016-50830	• Bolt		1			
			01580-10806	• Nut		1			
			01144-31270	• Stud		1			
			01580-11210	• Nut		1			
Lifting engine assembly	C		795-621-1110	Bracket	■	2	N		
			790-103-1520	Shackle	■	2			
			01016-31090	Bolt	■	4			
Disassembly, assembly of engine assembly	D	1	790-501-2001	Engine repair stand	■	1			
		2	790-901-1180	Bracket	■	1	N		
Removal, installation of camshaft	E	1	795-641-1110	Guide	■	1	N		
			01602-21442	Washer	■	1			
		2	795-641-1120	Cap	■	5	N		
Removal, installation of piston ring	F		795-100-1191	Piston ring tool	■	1			
Pulling out cylinder liner	G		795-102-1301	Liner puller	■	1			
Press fitting of cylinder liner	H		795-225-1512	Liner driver	■	1			
			790-101-5221	Grip	■	1			
			01010-81250	Bolt	■	1			
Insertion of piston assembly	J		795-225-1700	Piston holder	■	1			

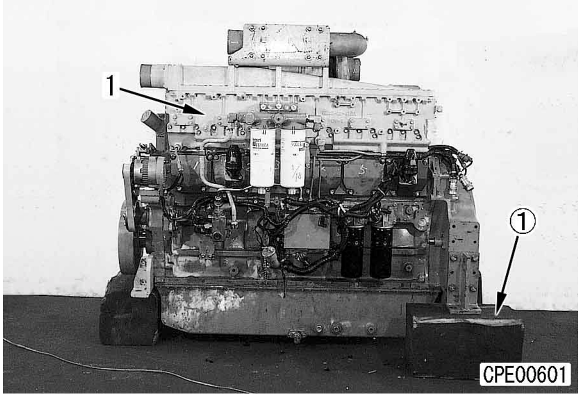
Component	Sym-bol	Part No.	Part Name	Nece-ssity	Q'ty	New/ remodel	Ske-tch	Nature of work, remarks
Press fitting of front oil seal, dust seal	K	795-621-1140	Push tool	■	1	N		
		795-902-1460	Bolt	■	3			
		01582-02218	Nut	■	3			
Press fitting of rear oil seal	L	795-621-1130	Push tool	■	1	N		
		01050-32280	Bolt	■	5			
Adjustment of valve clearance	M	Commercially	Feeler gauge	●	1			IN: 0.32 mm EX: 0.62 mm
Removal, installation of bolt	N	79A-212-4201	Socket kit	■	1			For 12-sided bolt
Measurement of piston ring groove wear	P	795-901-1120	Wear gauge	■	1			For measuring parts
Press fitting of valve stem seal	Q	795-611-1170	Screwdriver	■	1	N		
Cranking engine	R	6162-23-4500	Barring device	■	1			

DISASSEMBLY OF ENGINE

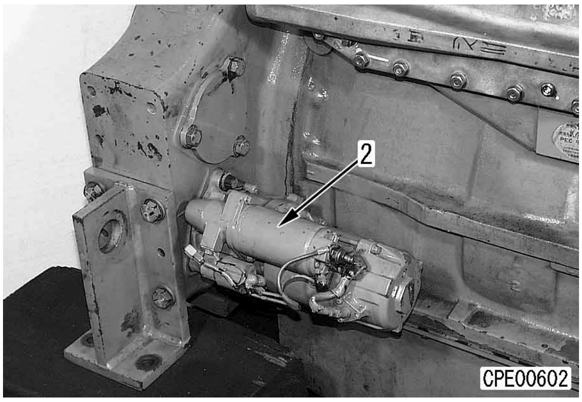
★ The procedure given here for disassembly and assembly is based on the SAA6D170E-3 generator specification.
The shape, number, and position of installation of parts may differ according to the machine they are mounted on, so check before starting the operation.

1. **Preparatory work**
   Before disassembling the engine, check all parts of the engine for cracks or damage. Wash all parts of the engine carefully to make it possible to carry out accurate inspection of the parts and swift disassembly and assembly.
   ★ Before washing the machine, carefully seal or remove open parts, electric components, or wiring connectors to prevent water from getting into them.

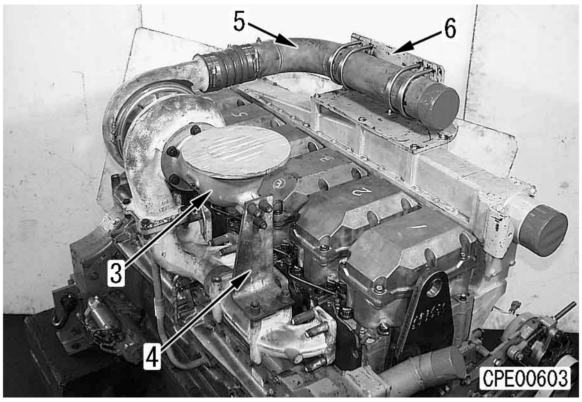
2. **Setting engine assembly**
   1) Set block ① to mount portion of engine assembly (1), and set engine horizontal.
      ★ The shape of the mounts differs according to the machine it is mounted on.
      kg Engine assembly: **Approx. 2,800 kg**
   2) Remove all wiring.
      ★ The large connectors for the ECVA & ECM are secured with bolts.
      ★ The position for connecting the wiring differs according to the machine it is mounted on.



3. **Starting motor assembly**
   Remove starting motor assembly (2).
   ★ The number of starting motors differs according to the machine they are mounted on.



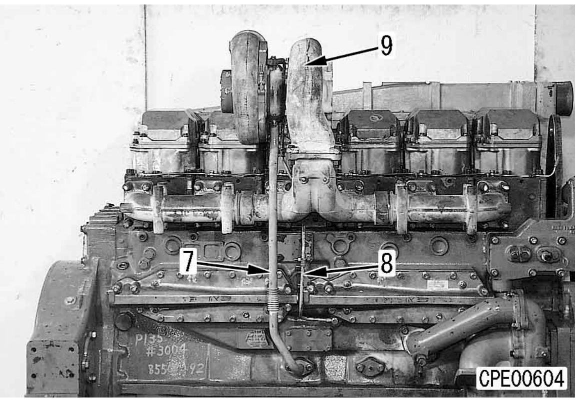
4. **Turbocharger assembly**
   1) Remove exhaust connector (3) and bracket (4).
      ★ The shape of the exhaust piping differs according to the machine it is mounted on.
   2) Remove intake connector (5) and bracket (6).
      ★ The shape of the intake piping differs according to the machine it is mounted on.



3) Remove turbocharger lubrication outlet tube (7) and lubrication inlet tube (8).
   - ★ The shape of the lubrication tubes differs according to the machine they are mounted on.

4) Lift off turbocharger assembly (9).
   - ★ The shape of the turbocharger differs according to the machine it is mounted on.

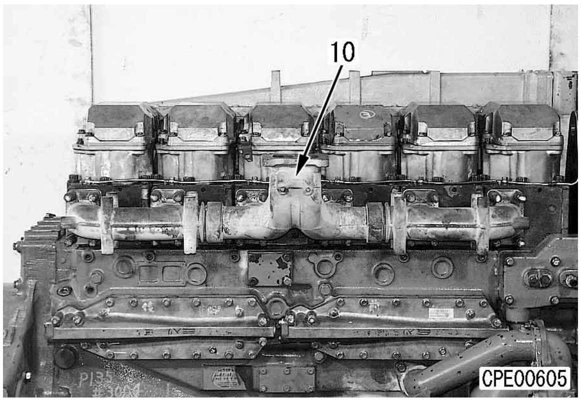
   kg Turbocharger assembly: **45 kg**



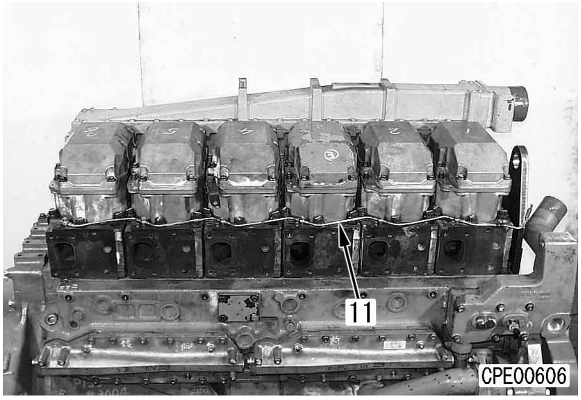
5. Exhaust manifold assembly

1) Lift off exhaust manifold assembly (10).

   kg Exhaust manifold assembly: **40 kg**

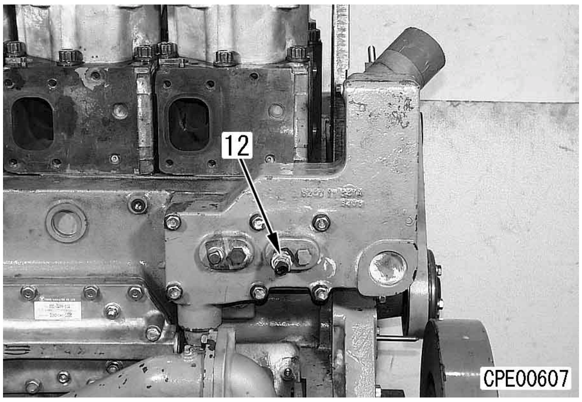


2) Remove air bleed tube (11).

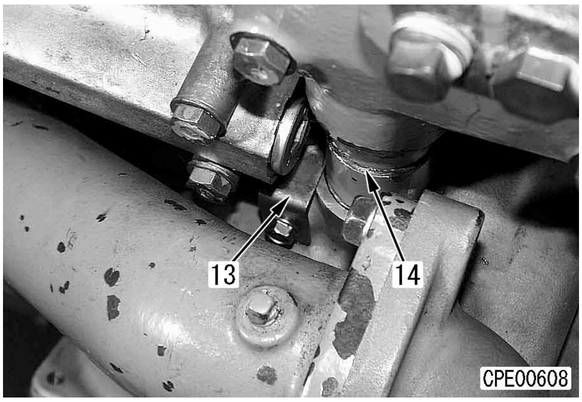


6. Thermostat housing, thermostat

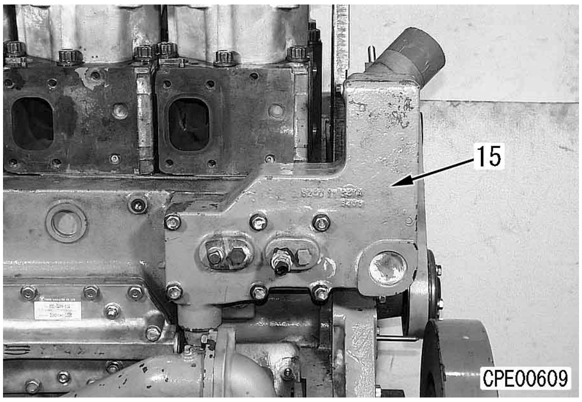
1) Remove water temperature sensor (12).



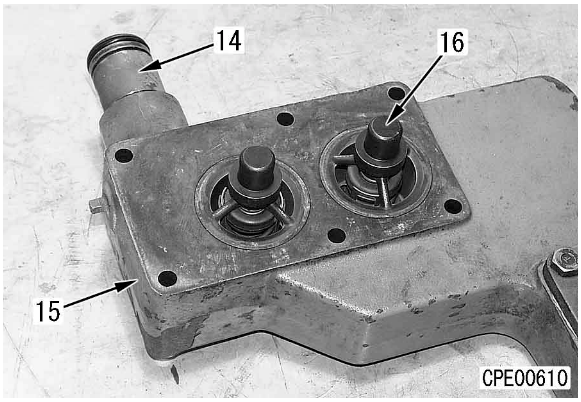
2) Remove stopper (13) of bypass tube.
3) Move bypass tube (14) up, and disconnect portion connecting water pump.



4) Remove thermostat housing (15).

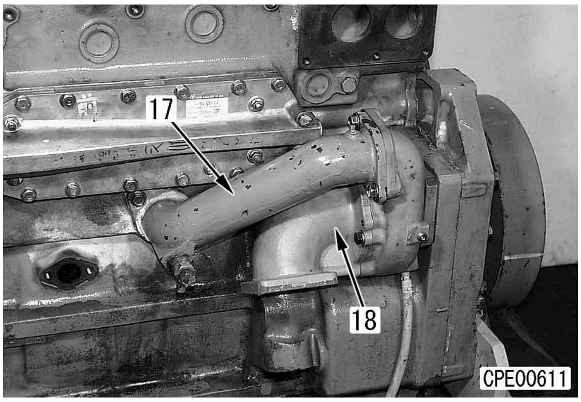


5) Remove 2 thermostats (16) from thermostat housing (15).
6) Remove bypass tube (14).



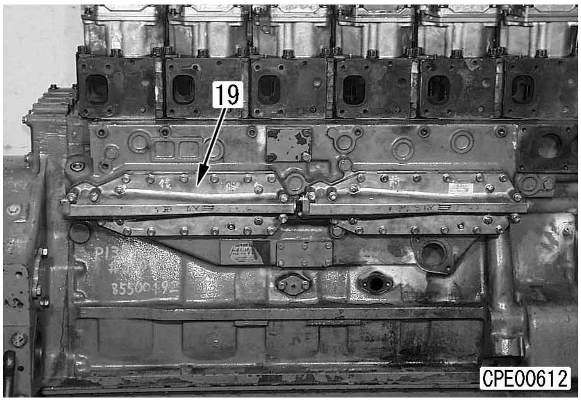
7. Water pump assembly

1) Remove water connector (17).
2) Remove water pump assembly (18).

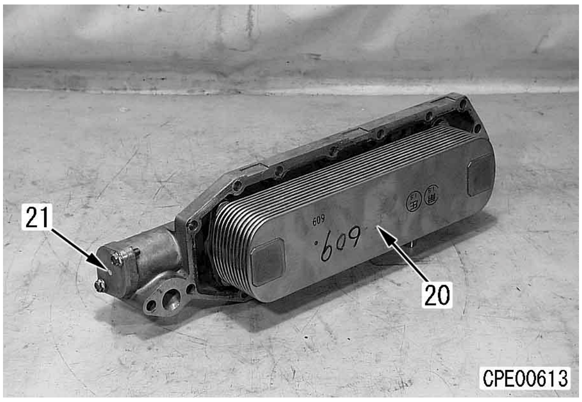


8. Oil cooler assembly

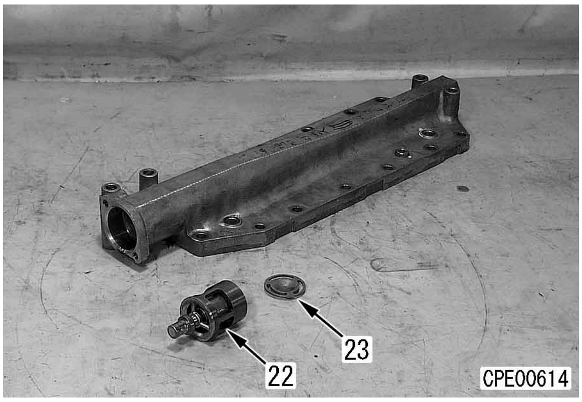
1) Remove 2 oil cooler assemblies (19).



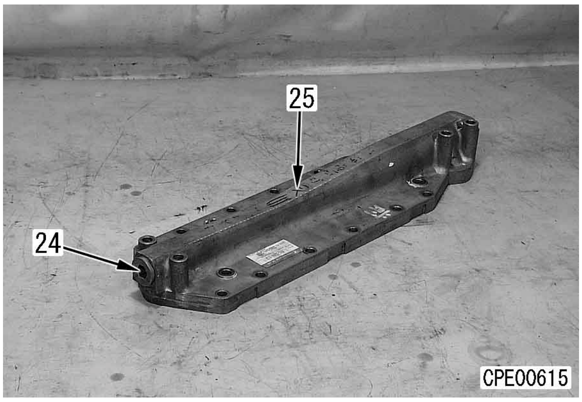
2) Disassemble oil cooler assembly as follows.
    i) Remove cooler core (20).
    ii) Remove cover (21).



iii) Remove thermo valve (22) and valve (23).

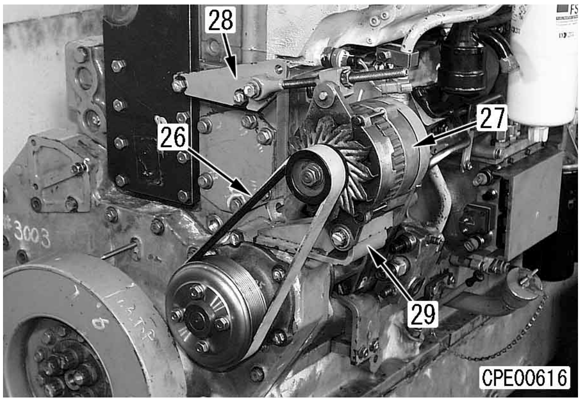


iv) Remove plug (24) from cooler body (25).



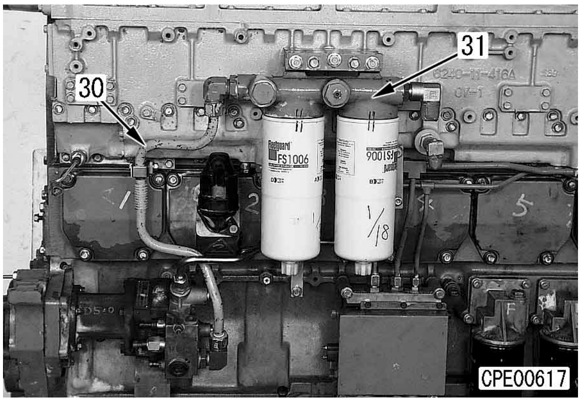
9. Alternator assembly

1) Loosen adjustment nut, locknut, and mounting bolts of alternator, then remove alternator belt (26).
2) Remove alternator assembly (27).
3) Remove brackets (28) and (29).
   ★ The shape of the bracket differs according to the machine it is mounted on.



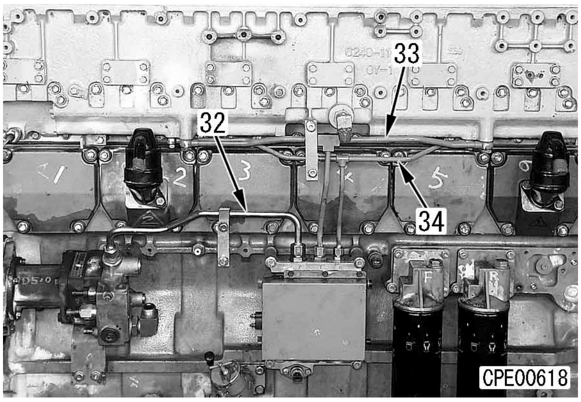
10. Fuel filter assembly

1) Remove fuel tube (30).
2) Remove fuel filter assembly (31).



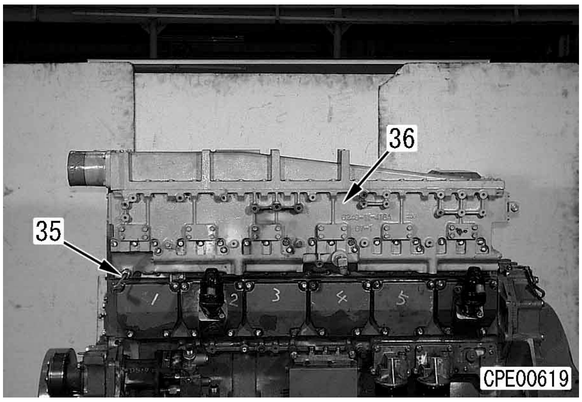
11. Intake manifold assembly

1) Remove fuel inlet tube (32).
2) Remove timing rail tube (33).
3) Remove fuel rail tube (34).



4) Remove boost sensor (35).
5) Lift off intake manifold assembly (36).
   ★ The shape of the manifold differs according to the machine it is mounted on.

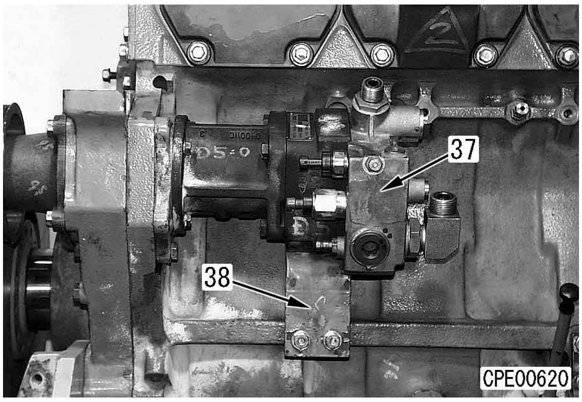
   kg Intake manifold assembly: **110 kg**



12. Fuel pump assembly

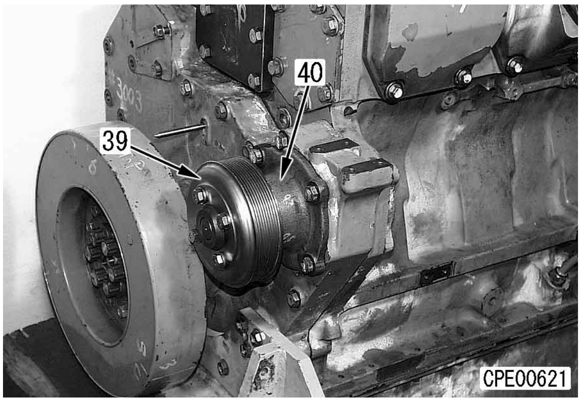
1) Remove fuel pump assembly (37).

   kg Fuel pump assembly: **20 kg**
2) Remove bracket (38).



3) Remove pulley (39).
   - ★ The shape of the pulley differs according to the machine it is mounted on.

4) Remove drive assembly (40).

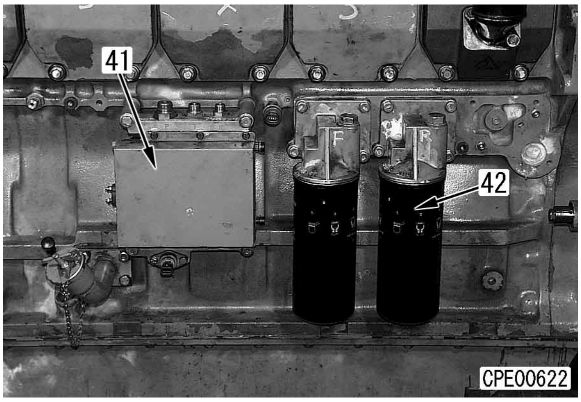


13. ECVA & ECM

Remove ECVA & ECM (41).

14. Oil filter assembly

Remove 2 oil filter assemblies (42).

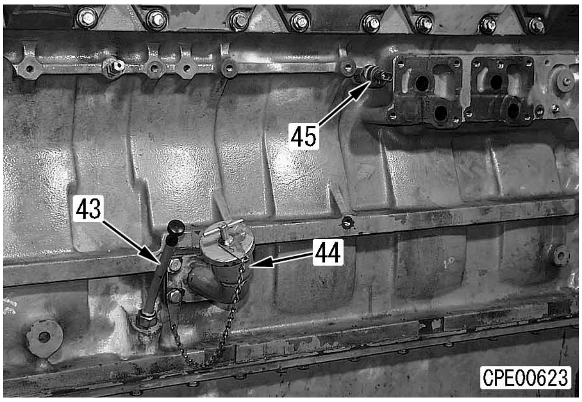


15. Oil pan, suction tube

1) Pull out dipstick, and remove gauge tube (43).
   - ★ The shape of the dipstick differs according to the machine it is mounted on.

2) Remove oil filler tube (44).
   - ★ The shape of the oil filler tube differs according to the machine it is mounted on.

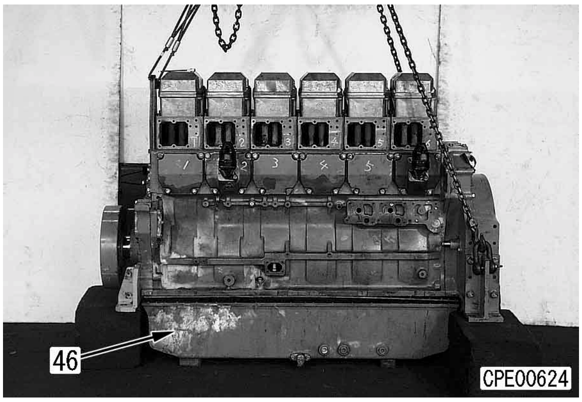
3) Remove oil pressure sensor (45).



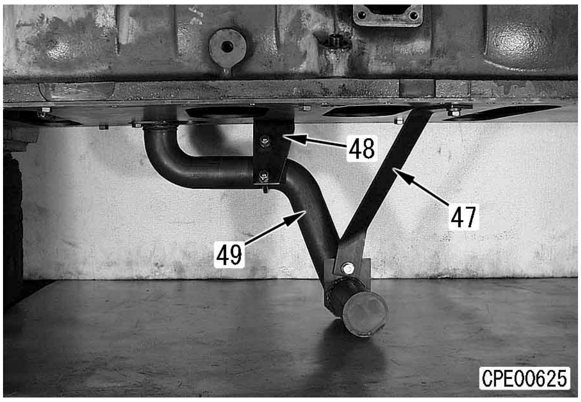
4) Remove mounting bolts, and lower oil pan (46) to ground.

   kg Oil pan: **70 kg**
   - ★ Support the bottom of the oil pan with a jack, then remove the mounting bolts.
   - ★ The underplate is tightened to the cylinder block with bolts together with the suction pipe, so disconnect between the underplate and oil pan.
   - ★ To prevent distortion or deformation of the underplate, leave the underplate temporarily assembled with several bolts.
   - ★ The shape of the oil pan differs according to the machine it is mounted on.

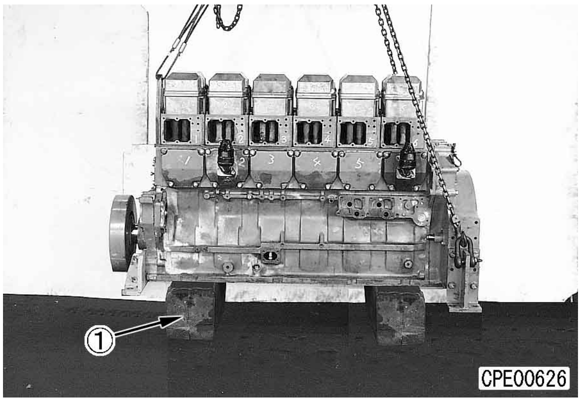
5) Sling engine assembly and pull out oil pan (46).
   - ★ After removing the oil pan, lower the engine assembly on the block again.



6) Remove brackets (47) and (48), then remove suction pipe (49).
   - ★ The shape of the suction pipe and brackets differs according to the machine they are mounted on.

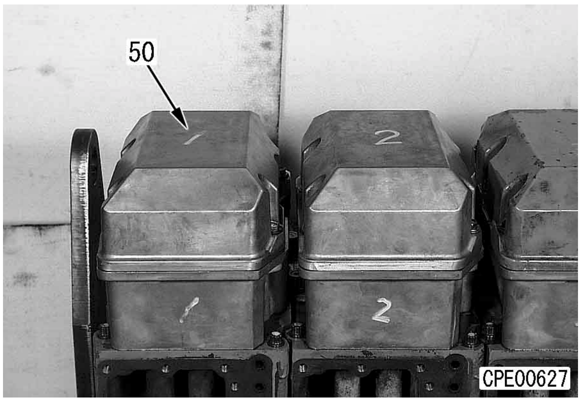


7) Sling engine assembly again and set block ① to bottom part of cylinder block (underplate), then lower engine assembly.



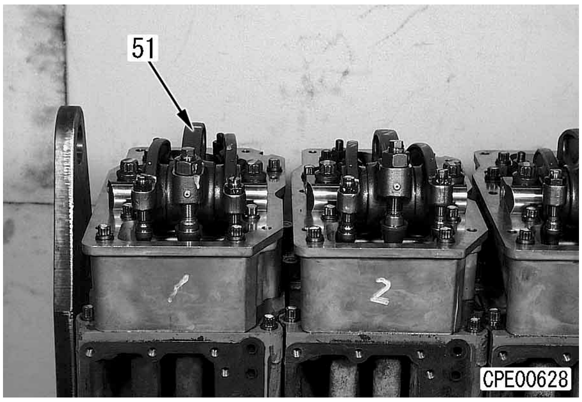
16. Cylinder head cover

Remove 6 cylinder head covers (50).

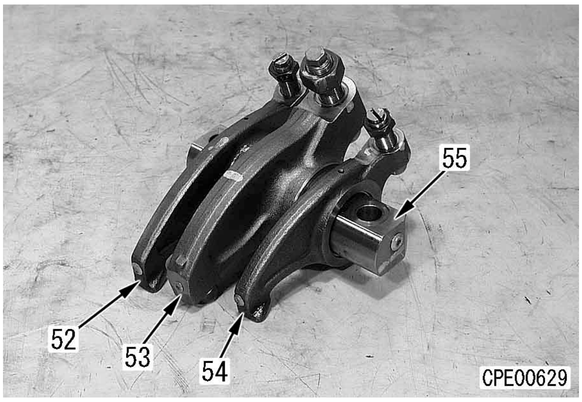


17. Rocker arm assembly

1) Loosen locknuts of valve rocker arm and injector rocker arm, then loosen adjustment screw fully.
   - ★ Set the rocker arm free so that no force is applied to it.
2) Remove 6 rocker arm assemblies (51).
   - ★ Fit tags and keep in sets for each cylinder No.

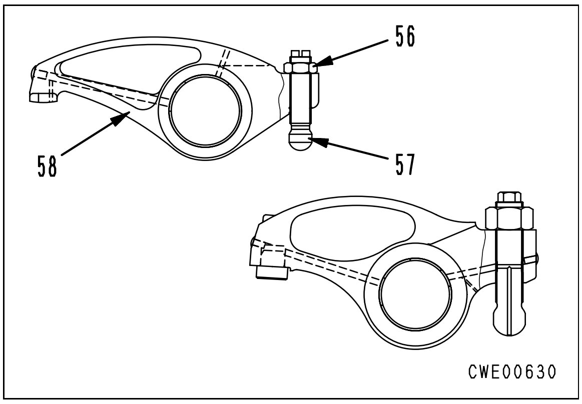


3) Disassemble rocker arm assembly as follows.
   i) Remove exhaust valve arm assembly (52), injector arm assembly (53), and intake valve arm assembly (54) from shaft (55).



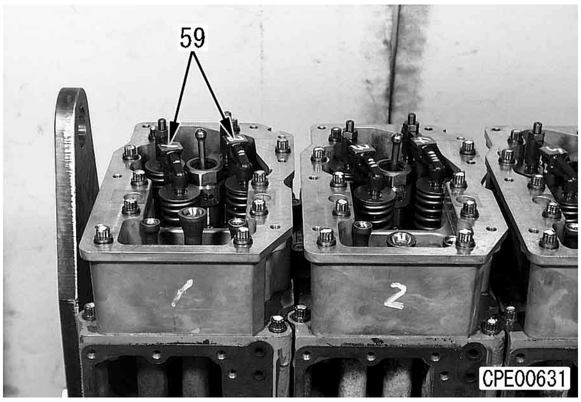
ii) Remove locknut (56) and adjustment screw (57) from arm (58).

★ For details of the procedure for replacing the bushing, see REBUILDING AND REPLACING.



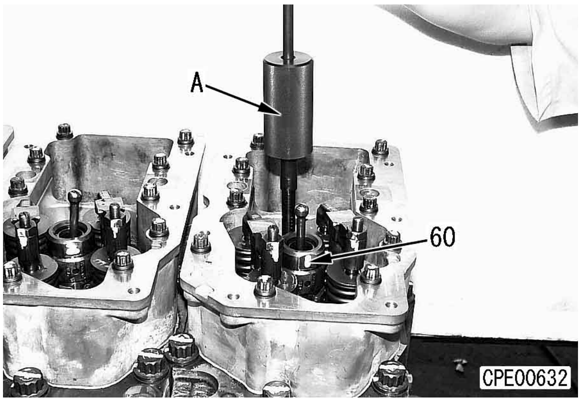
18. Crosshead

1) Loosen locknut.
2) Remove 12 crossheads (59).



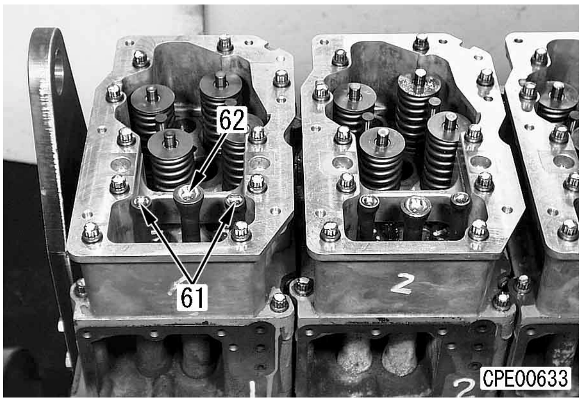
19. Injector assembly

1) Remove holder mounting bolts.
2) Using tool **A**, remove 6 injector assemblies (60).
   ★ Fit the pin at the tip of the tool into the fuel hole in the injector, then move the weight up and down to pull it out.



21. Push rods

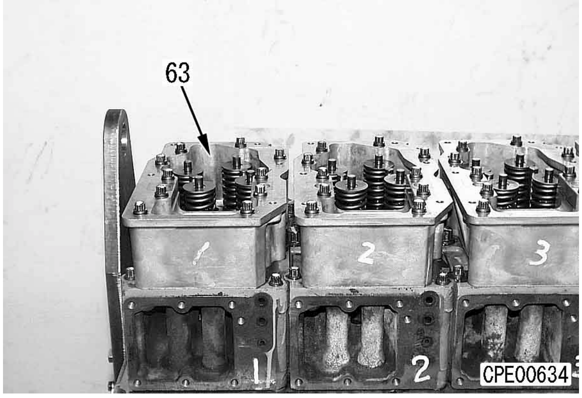
1) Remove 12 valve push rods (61).
2) Remove 6 injector push rods (62).



22. Rocker arm housing

Remove 6 rocker arm housing (63).

★ Fit tags and keep in sets for each cylinder No.



23. Cylinder head assembly

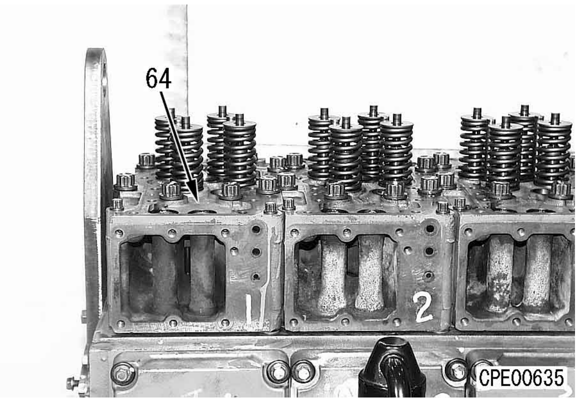
1) Lift off 6 cylinder head assemblies (64).

⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.

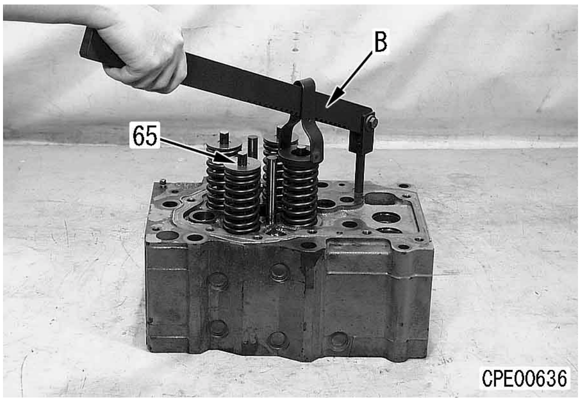
kg Cylinder head assembly: **60 kg**

★ Fit tags and keep in sets for each cylinder No.

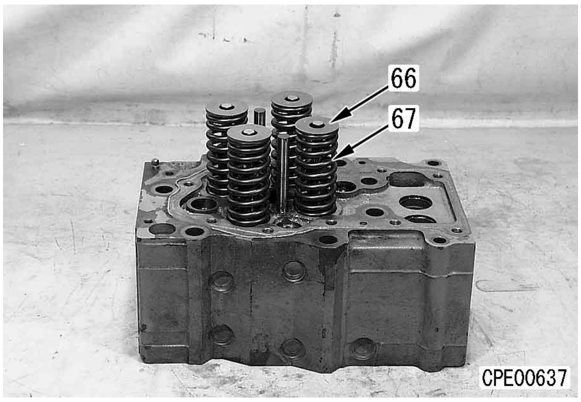
2) Remove 6 cylinder head gaskets.



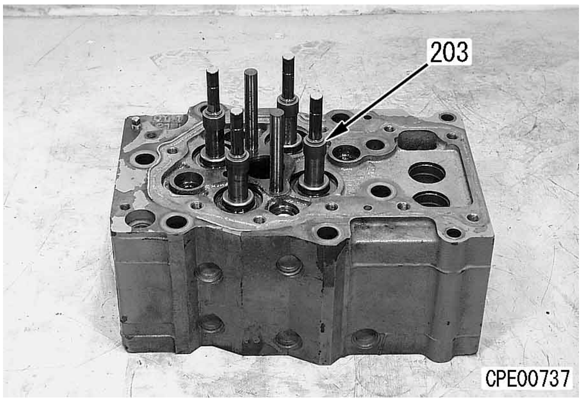
3) Disassemble cylinder head assembly as follows.
   i) Using tool B, compress valve spring and remove 8 valve cotters (65).



   ii) Remove 4 spring seats (66).
   iii) Remove 4 valve springs (67).

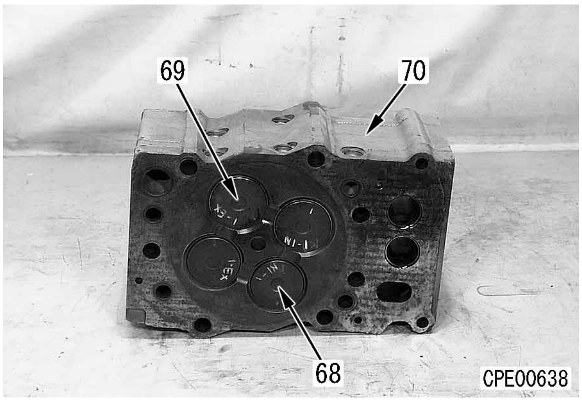


   iv) Remove 4 valve stem seals (203).



   v) Remove 2 intake valves (68) and 2 exhaust valves (69) from cylinder head (70).

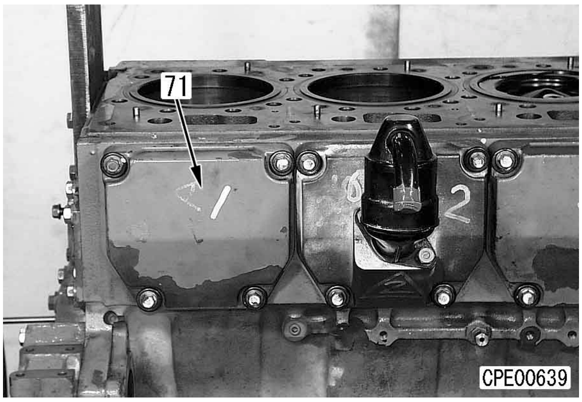
★ For details of the procedure for replacing the valve guide, valve seat, and plug, see REBUILDING AND REPLACING.



24. Cam follower cover

Remove 6 cam follower covers (71).

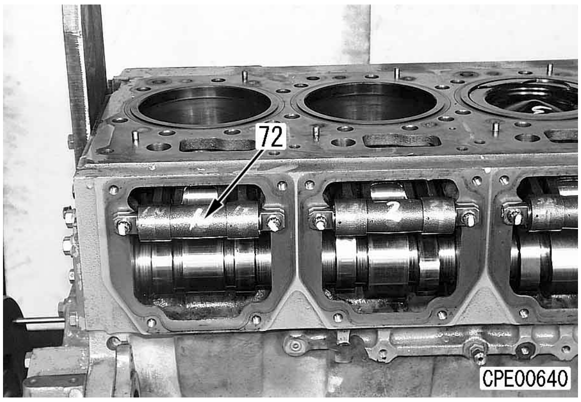
★ The position of the breather differs according to the machine it is mounted on.



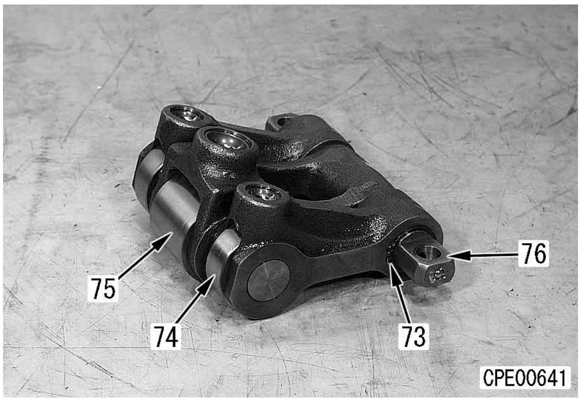
25. Cam follower assembly

1) Crank crankshaft and set No. 1 to No. 3 pistons in position as follows.
   - · No. 1 compression TDC: No. 1 and No. 5 can be removed
   - · No. 2 compression TDC: No. 2 and No. 4 can be removed
   - · No. 3 compression TDC: No. 3 and No. 6 can be removed
   - ★ Always set the cylinder to the compression top dead center position.
     If the cam follower will not come out, the cylinder is not at compression top dead center, so rotate it one more turn.
2) Remove 6 cam follower assemblies (72).

★ Fit tags and keep in sets for each cylinder No.



3) Disassemble cam follower assembly as follows.
   - i) Remove 2 snap rings (73).
   - ii) Remove 2 valve cam followers (74) and injector cam follower (75) from shaft (76).



26. Vibration damper

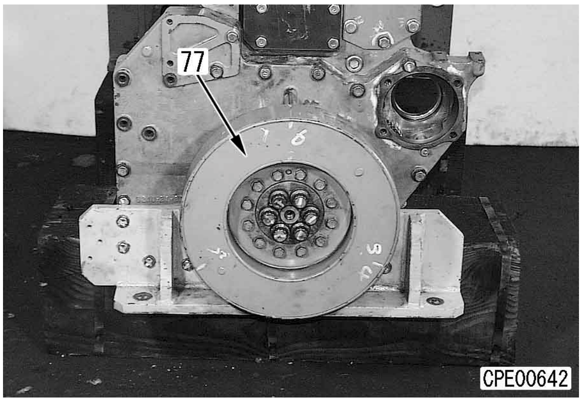
Lift off vibration damper (77).

★ The shape of the vibration damper differs according to the machine it is mounted on.

⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.

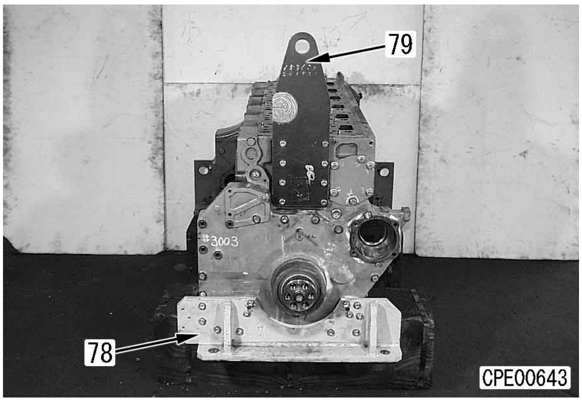
★ Using a forcing screw, disconnect the connection with the crankshaft.

kg Vibration damper: **60 kg**



27. Engine mount

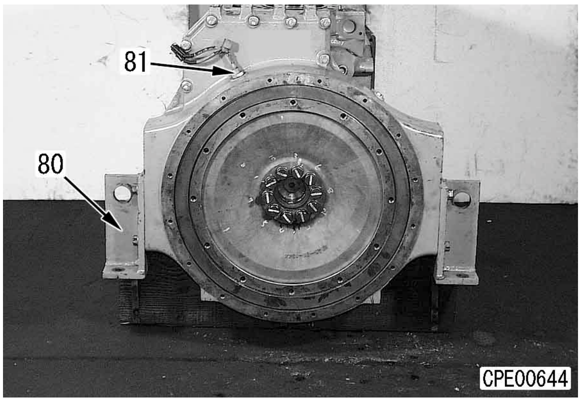
1) Remove front engine mount (78).
   - ★ The shape of the mount differs according to the machine it is mounted on.
2) Remove hanger (79).
   - ★ The shape of the hanger differs according to the machine it is mounted on.



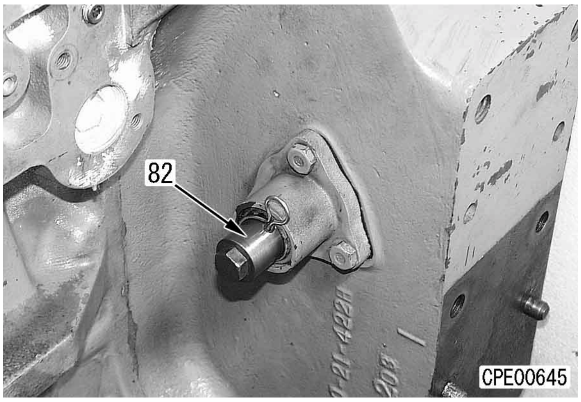
3) Remove rear engine mount (80).
   ★ The shape of the mount differs according to the machine it is mounted on.

28. Flywheel assembly

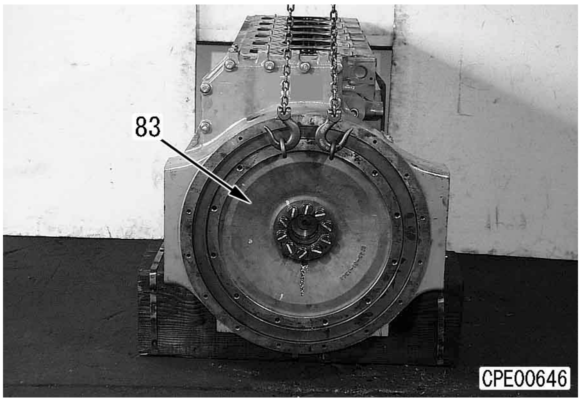
1) Remove engine speed sensor (81).



2) Remove barring device (82).

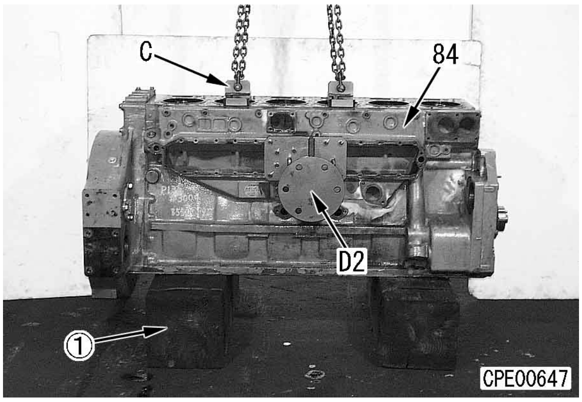


3) Lift off flywheel assembly (83).
   ⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.
   kg Flywheel housing: **150 kg**

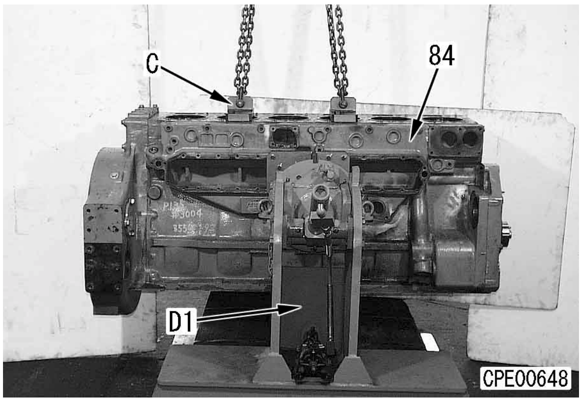


29. Setting to repair stand

1) Install tool **C** and tool **D2** to cylinder block and raise engine assembly (84).
   kg Engine assembly: Approx. **1,600 kg**

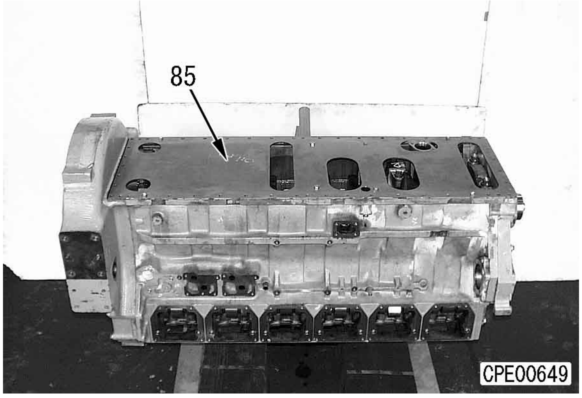


2) Install engine assembly (84) to tool **D1** and remove tool **C**.



30. Underplate

1) Sling cylinder block, turn it over, set oil pan at top, then lower it.
2) Remove underplate (85).



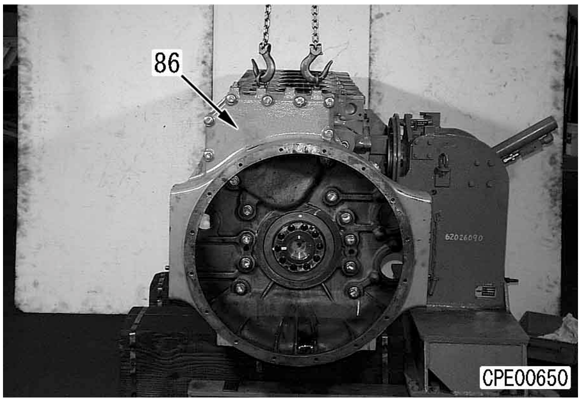
31. Flywheel housing

1) Sling cylinder block, turn it over, set cylinder head at top, then lower it.
2) Lift off flywheel housing (86).

   ⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.

   kg Flywheel housing: **150 kg**

   ★ The shape of the flywheel housing differs according to the machine it is mounted on.
3) Remove oil seal from flywheel housing.



32. Front cover

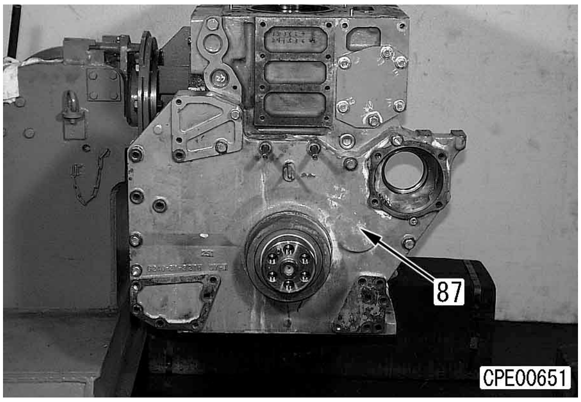
1) Lift off front cover (87).

   ★ Using a guide bolt, pull it out to the front.

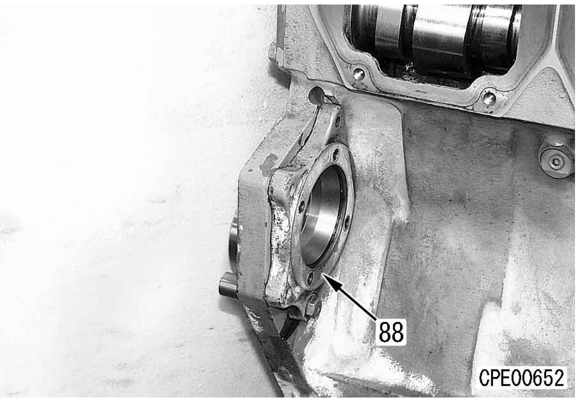
   kg Front cover: **45 kg**

   ★ The shape of the front cover differs according to the machine it is mounted on.
2) Remove oil seal and dust seal from front cover.

   ★ The dust seal is installed only on the engine for wheeled type machines.

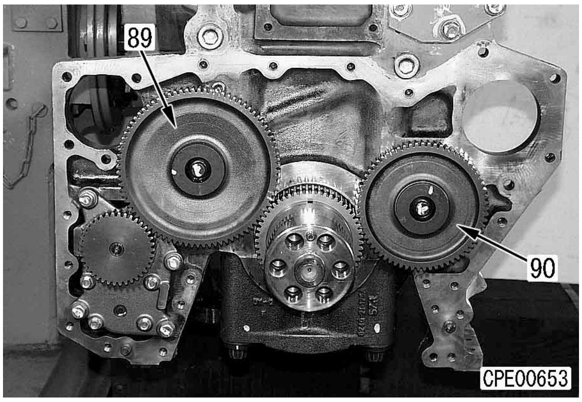


3) Remove bracket (88).



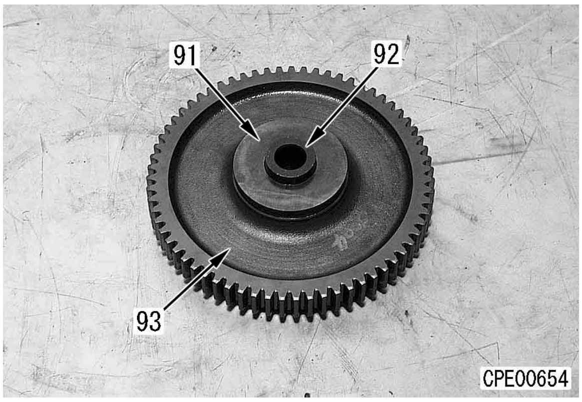
33. Front idler gear assembly

1) Remove idler gear assembly [large] (89) and idler gear assembly [small] (90).



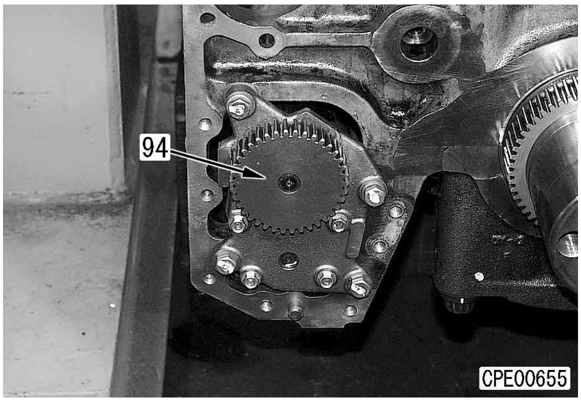
2) Remove spacer (91) and shaft (92) from gear (93).

★ For details of the procedure for replacing the bushing, see REBUILDING AND REPLACING.



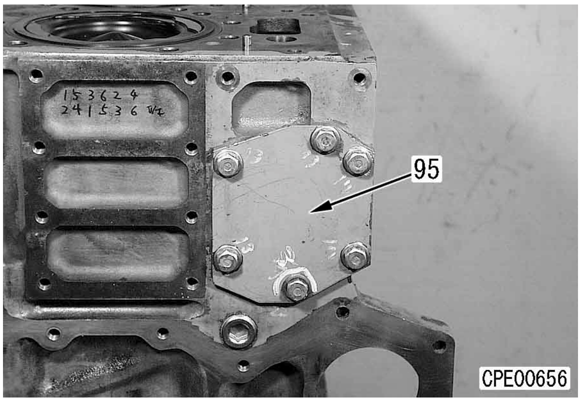
34. Oil pump assembly

Remove oil pump assembly (94).

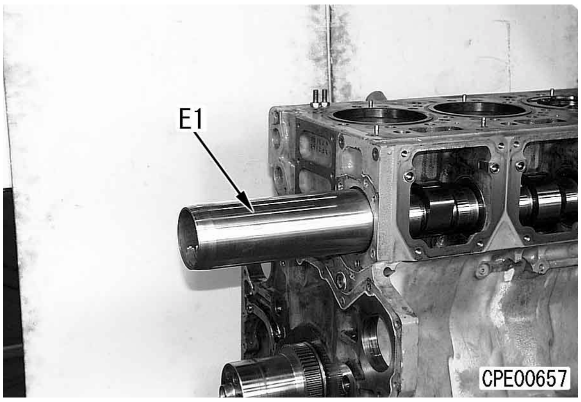


35. Camshaft assembly

1) Remove cover (95).

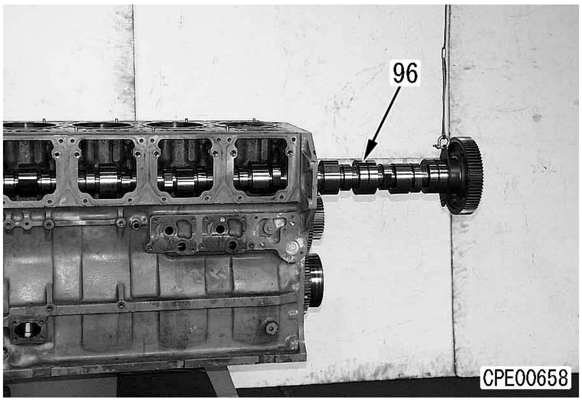


2) Install tool **E1** to end face of camshaft and tool **E2** to middle of camshaft.
   - ★ Do not tighten tool **E1** fully. Leave some play.
   - ★ Install tool **E2** to the front and rear of No. 2 and No. 4 injector cams and at the front of No. 6 injector cam.



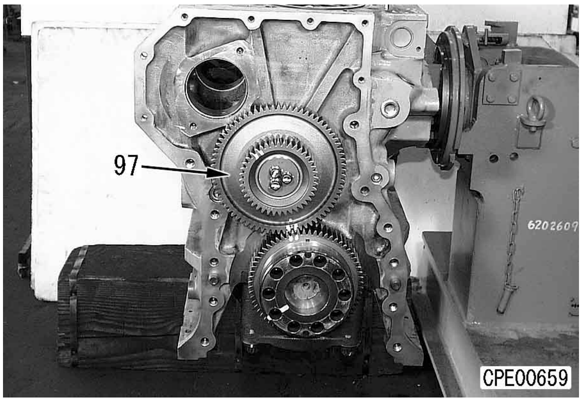
3) Sling camshaft assembly (96) and pull out towards the flywheel.
   - ★ First sling the gear end, then align the center of the camshaft and bushing hole, and pull out towards the flywheel.
     Next, pull out approx. 2/3, then sling the whole camshaft again and remove.

   kg Camshaft assembly: **80 kg**
   - ★ For details of the procedure for replacing the camshaft bushing and camshaft gear, see REBUILDING AND REPLACING.

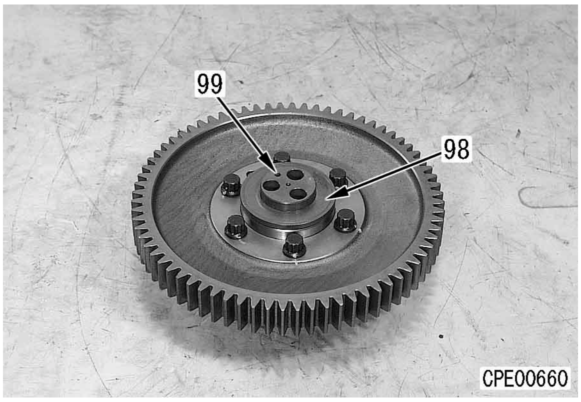


36. Rear idler gear assembly

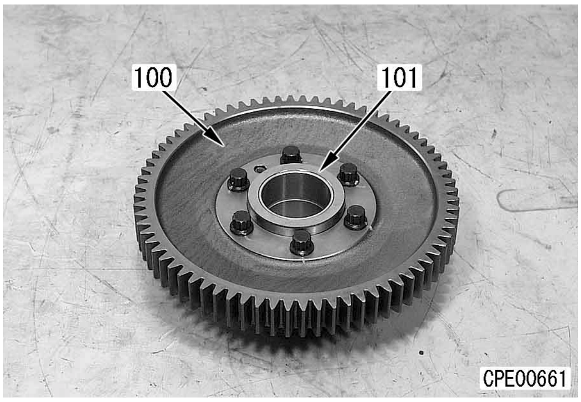
1) Remove idler gear assembly (97).



2) Disassemble idler gear assembly as follows.
   i) Remove spacer (98) and shaft (99).

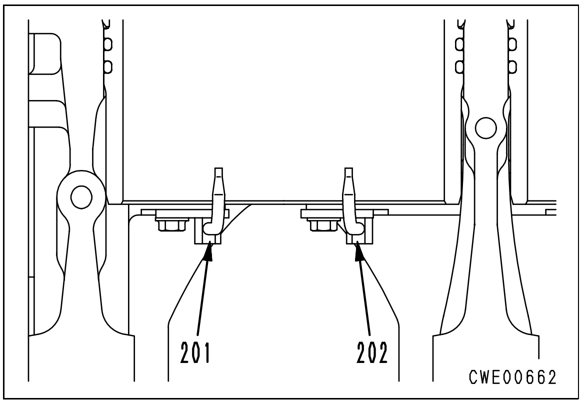


   ii) Remove gear [large] (100) and gear [small] (101).
   ★ For details of the procedure for replacing the bushing, see REBUILDING AND REPLACING.



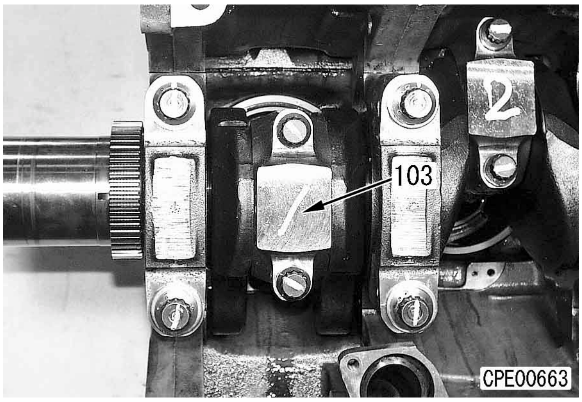
37. Piston cooling nozzles

1) Sling cylinder block and set cylinder horizontal.
2) Rotate crankshaft and set No. 1 to No. 3 pistons as follows.
   - No. 1 TDC:
     No. 1 and No. 6 can be removed.
   - No. 2 TDC:
     No. 2 and No. 5 can be removed.
   - No. 3 TDC:
     No. 3 and No. 4 can be removed.
3) Remove 6 piston cooling nozzles (201) and 6 piston cooling nozzles (202) in turn.
   ★ Fit tags and keep in sets for each cylinder No.

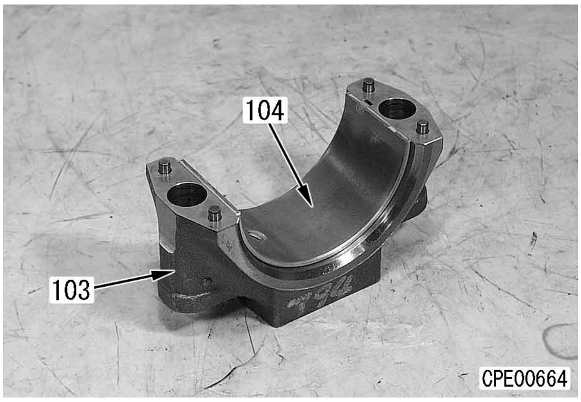


38. Piston, connecting rod assembly

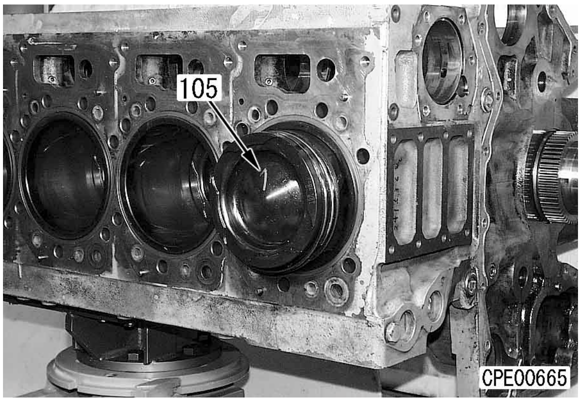
1) Rotate crankshaft and set piston of cylinder to be removed at bottom position.
2) Loosen connecting rod bolt 5 - 6 turns.
   ⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.
   ★ Tap the head of the connecting rod bolt lightly and disconnect the connecting rod cap and connecting rod.
3) Rotate crankshaft and set piston to top position.
4) Remove connecting rod cap (103).



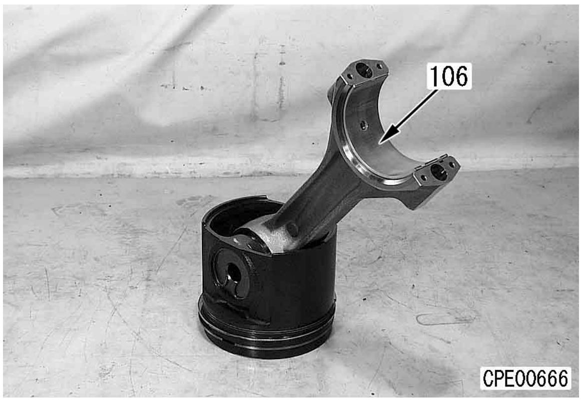
6) Remove connecting rod bearing (104) from connecting rod cap (103).
   ★ Fit tags and keep in sets for each cylinder No.



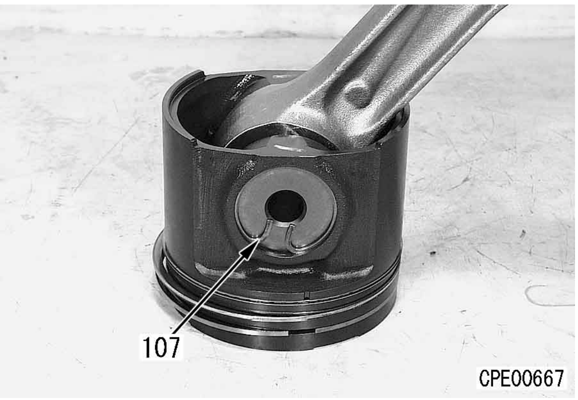
7) Push connecting rod from crankshaft end and remove piston and connecting rod assembly (105).
   ★ To prevent the piston and connecting rod assembly from falling, support the cylinder head and push the connecting rod end to remove.
   ★ Pull out horizontally to prevent the connecting rod from damaging the cylinder liner.
   ★ Fit tags and keep in sets for each cylinder No.



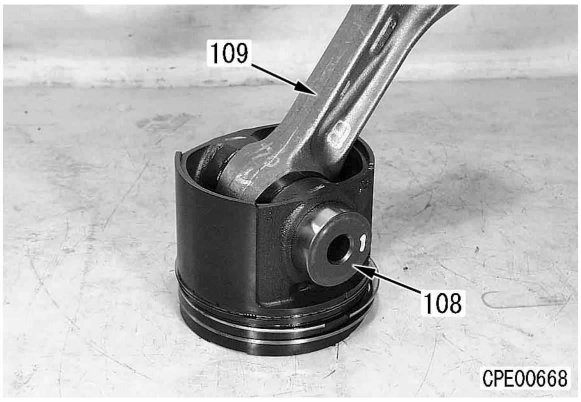
8) Disassemble piston and connecting rod assembly as follows.
   i) Remove connecting rod bearing (106).



   ii) Remove 2 snap rings (107).

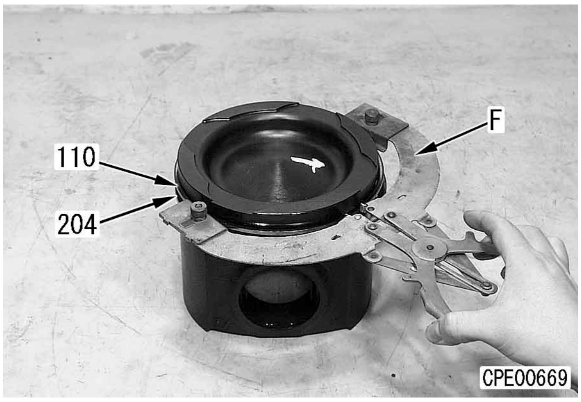


iii) Remove piston pin (108).
iv) Remove connecting rod (109).
★ The connecting rod and cap form a set, so assemble them temporarily after disassembly to prevent them from becoming separated.
★ For details of the procedure for replacing the bushing, see REBUILDING AND REPLACING.



CPE00668

v) Using tool **F**, remove top ring (110) and second ring (204).



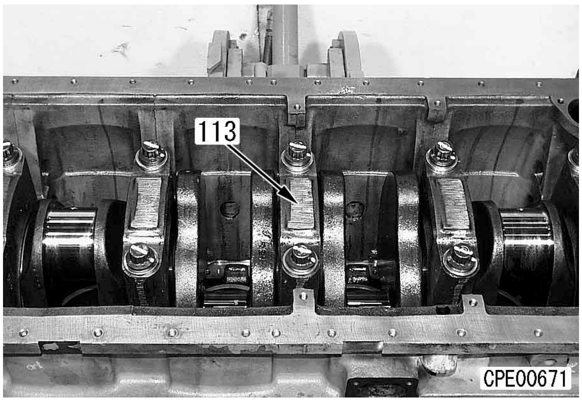
CPE00669

vi) Remove oil ring (111) from piston (112).

CPE00670

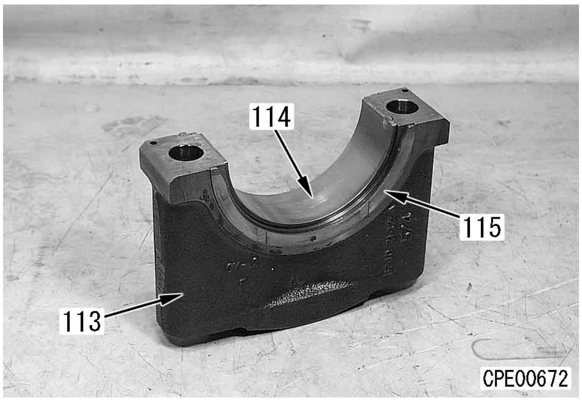
39. Crankshaft assembly

1) Lower cylinder block and set with crankshaft at top.
2) Remove mounting bolts of main cap.
   ⚠ There is danger of damaging the thread, so never use an impact wrench to loosen the mounting bolts.
3) Using mounting bolts, move main cap (113) to front and rear to remove it.
   ★ A thrust washer is installed to the No. 6 main cap, so be careful not to drop it.



CPE00671

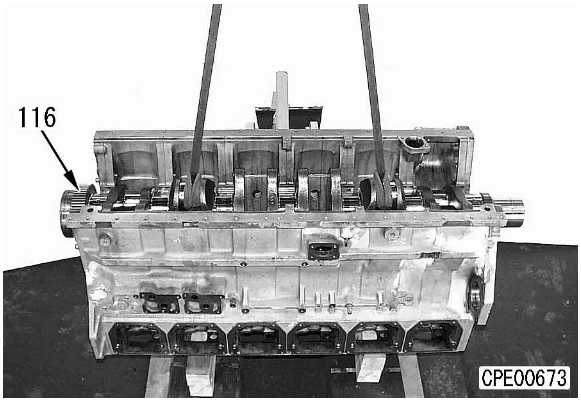
4) Remove main bearing (114) and 2 thrust washers (115) from main cap (113).
   ★ The thrust washer is installed only to the No. 6 main cap.
   ★ Fit tags and keep in sets for each main cap No.



CPE00672

5) Lift off crankshaft assembly (116).
   - ★ A thrust washer is installed to the No. 6 bearing, so be careful not to drop it.

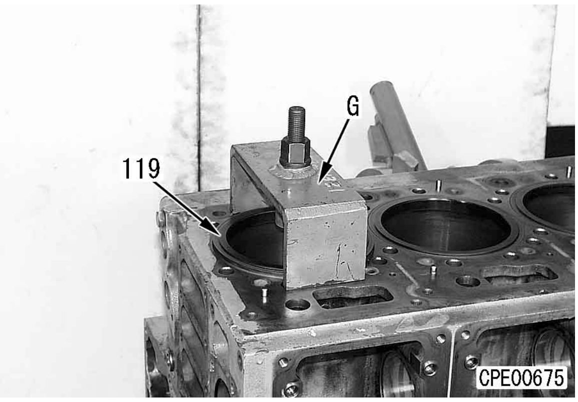
   kg Crankshaft assembly: **270 kg**
   - ★ For details of the procedure for replacing the crankshaft gear, see REBUILDING AND REPLACING.



6) Remove main bearing (117) and 2 thrust washers (118).
   - ★ The thrust washer is installed only to the No. 6 bearing.
   - ★ Fit tags and keep in sets for each main bearing No.

40. Cylinder liner

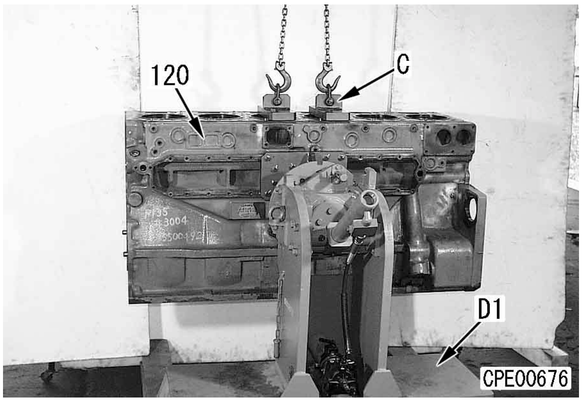
1) Sling cylinder block, turn it over, set cylinder head at top, then lower it.
2) Using tool **G**, remove cylinder liner (119).



41. Cylinder block

Using tool **C**, raise cylinder block (120) and remove from tool **D1**.

kg Cylinder block assembly: **800 kg**



ASSEMBLY OF ENGINE

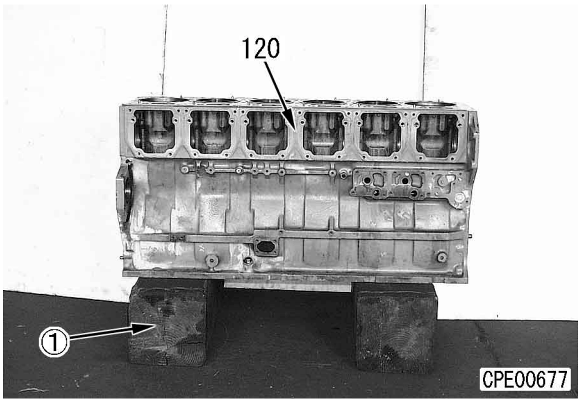
★ The procedure given here for disassembly and assembly is based on the SAA6D170E-3 generator specification.
The shape, number, and position of installation of parts may differ according to the machine they are mounted on, so check before starting the operation.

★ Wash all parts clean, then check that there are no dents, scratches, or blowholes.
Check also that the oil and water passages are clear before assembling.

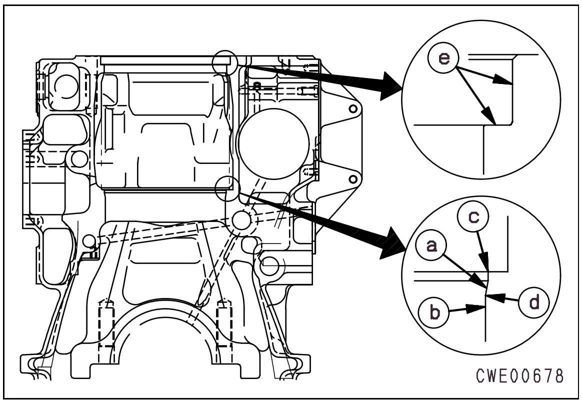
★ For bolts tightened using the angle tightening method (plastic range turning angle method), there is a limit to the bolt length and the number of times they can be reused, so before using them again, check the number of punch marks on the bolt head or the length of the bolt below the head. If the bolt cannot be used again, replace it with a new part (for details, see each section).

Angle tightening bolt	Impossible to reuse (replace with new part)
Main cap	5 punch marks
Connecting rod cap	4 punch marks
Rear idler gear	5 punch marks
Flywheel	5 punch marks
Cylinder head	3 punch marks
Injector holder	Length below head: 80 mm or more

1. **Cylinder block**
   1) Set cylinder block (120) to block ①.



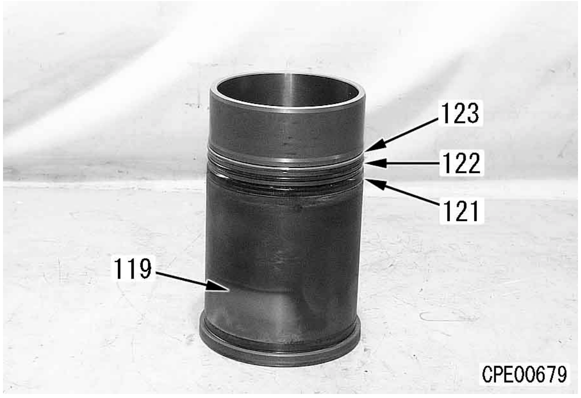
   2) Before inserting cylinder liner, repair cylinder block as follows.
      i) Use sandpaper to remove rust and scale from surface **a** at O-ring guide portion and surface **b** at O-ring bore portion, and polish until machining surface is exposed.
      ii) Use sandpaper of #240 to polish portion **c** and portion **d** until **R** face is smooth.
         ★ If portion **R** is pointed or there are any burrs or flushes, use a scraper or polish with sandpaper. To prevent this surface from damaging the O-ring, give it a particularly smooth finish.
         ★ If surface **a** or portion **c** are rough or pitted, give them a smooth finish.
         ★ If portion **d** is pitted and cannot be corrected, replace the cylinder block.
      iii) Check surface **e** of counterbore and remove any burrs or flushes.
         ★ If any metal powder or dirt is on the horizontal surface, the liner will not fit tightly, and this will cause leakage of water or incorrect protrusion of the liner.
         ★ Carry out machining if there is any drooping, corrosion, or pitting.

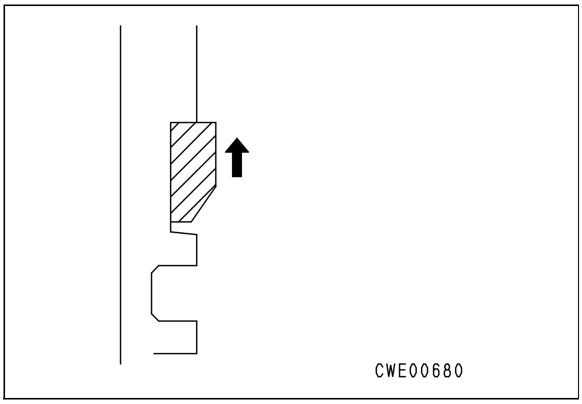


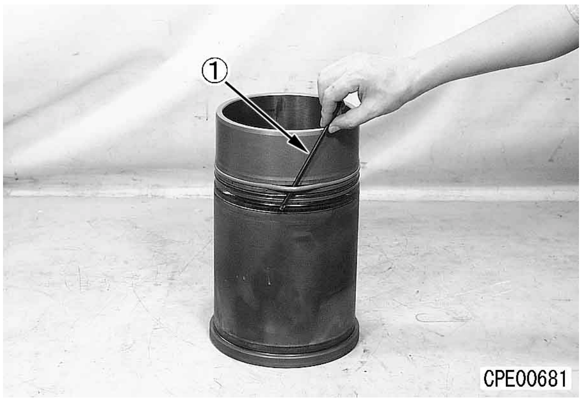
2. Cylinder liner

1) Insert clevis seal (121), O-ring [black] (122), and O- ring [red] (123) to cylinder liner (119).
   - ★ Check that there is not dirt or any burrs, flushes, or other damage to the liner O-ring groove.
   - ★ Assemble the clevis seal with the chamfered side facing down, and to prevent twisting, push the whole circumference down from the top so that it fits into the seal groove.

   O-ring: **Rubber lubricant (RF-1)**
   - ★ Immediately before installing, soak the part of the O- ring that is installed to the liner in rubber lubricant. Do not soak it for a long time.
   - ★ After installing the O-ring, check that it is not twisted. If any twisting is found, use a smooth bar ① (approx. ϕ10 mm) to remove the twisting.
   - ★ Do not remove the twisting of the clevis seal.



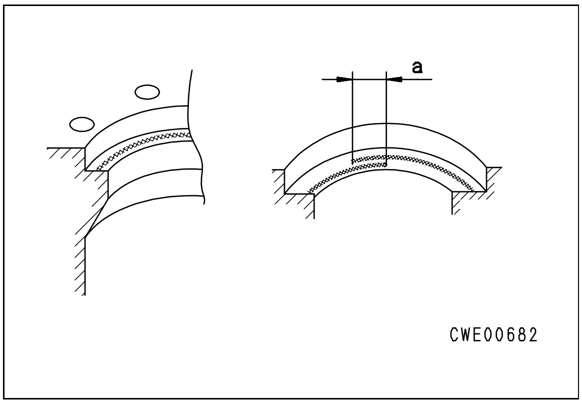




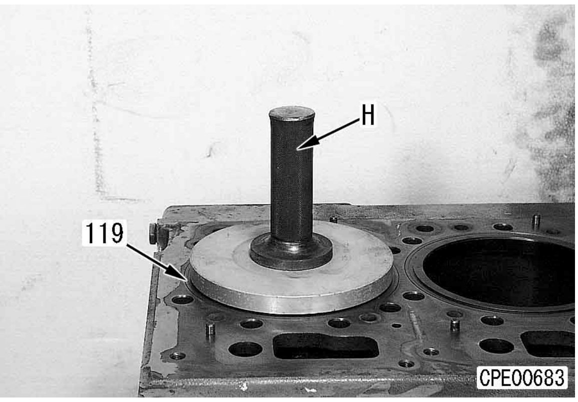
2) Coat the cylinder block with gasket sealant and rubber lubricant.
   - ★ Use compressed air or a cloth to wipe off all the dirt or oil from the surface of the cylinder block to be coated with gasket.

   Outside circumference of cylinder block deck: **Gasket sealant (LG-6)**
   - ★ Width of gasket sealant: ϕ2 – 3 mm
     Gasket sealant overlap **a**: 6 ± 6 mm
   - ★ If the parts are left for a long time after coating with gasket sealant, the surface will start to become hard, so complete assembly to the cylinder block within 50 minutes of coating the cylinder liner with gasket sealant.

   Cylinder block O-ring guide, bore: Rubber lubricant **(RF-1)**
   - ★ Coat the cylinder block O-ring guide portion and O-ring bore uniformly with rubber lubricant.

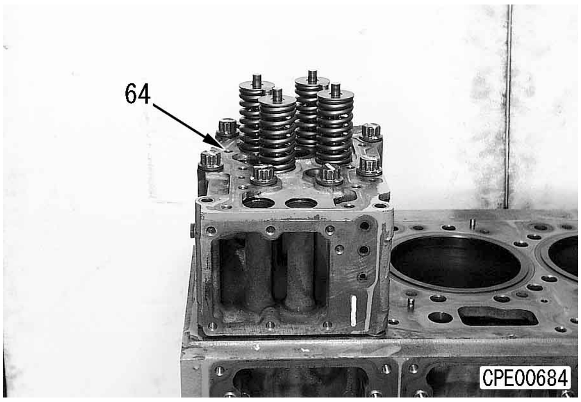


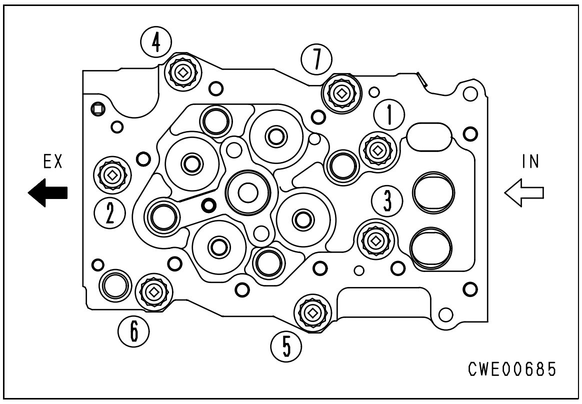
3) Insert cylinder liner (119) into cylinder block.
   ★ Taking care not to damage the O-ring, push in as far as the cylinder liner enters under its own weight.
4) Push cylinder liner (119) further by hand.
   ★ Align the center of the liner flange and block with the counterbore, then apply your weight to push into the liner flange portion.
   ★ Check that the O-ring is securely fitted as far as the bore portion.
   ★ If the O-ring does not pass the guide portion and fit into the bore portion, there is probably an abnormality, so remove the liner and check all parts.
5) Using tool **H**, press fit cylinder liner (119) to cylinder block.



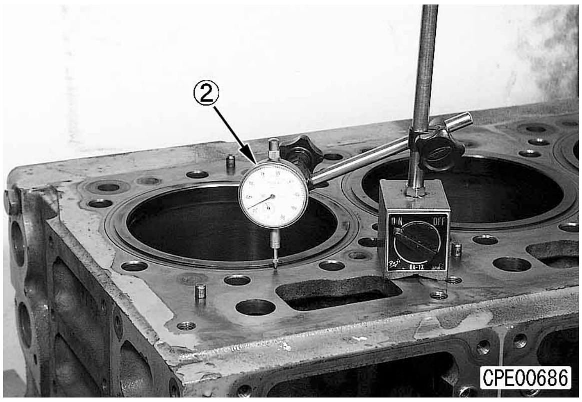
6) Fit head gasket and tighten cylinder head (64) temporarily.
   ★ An old head gasket can be used.
   ★ This work can also be done with the cylinder head assembled as an individual part.
   ★ Use the only the seven main mounting bolts and tighten in the specified order.

   Cylinder head bolt:
   245 – 265 Nm {25 – 27 kgm}



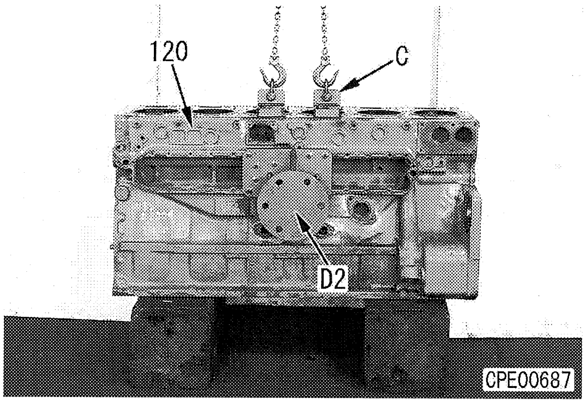


7) Remove cylinder head assembly (64).
   ★ If any gasket sealant is squeezed out on to the top surface of the cylinder block, wipe it off.
8) Using dial gauge ②, measure protrusion of cylinder liner.
   ★ Using the top surface of the block as the standard, measure the protrusion of the liner from the block surface.
   ★ Protrusion of cylinder liner: 0.07 – 0.15 mm
   ★ If it it not within the standard value, take the necessary action. For details, see MAINTENANCE STANDARD.



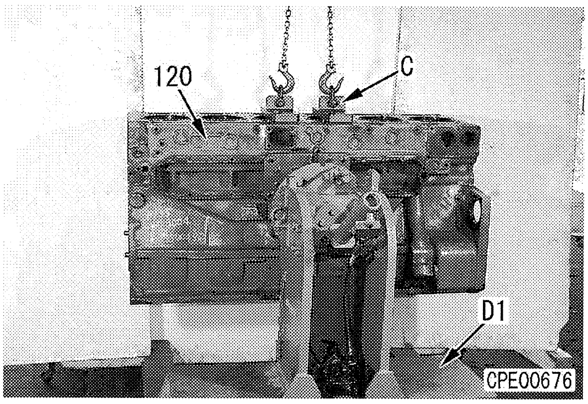
3. Setting to repair stand

1) Install tool **D2** and tool **C** to cylinder block (120).



2) Sling cylinder block (119) and install to tool **D1**.

Cylinder block: **850 kg**

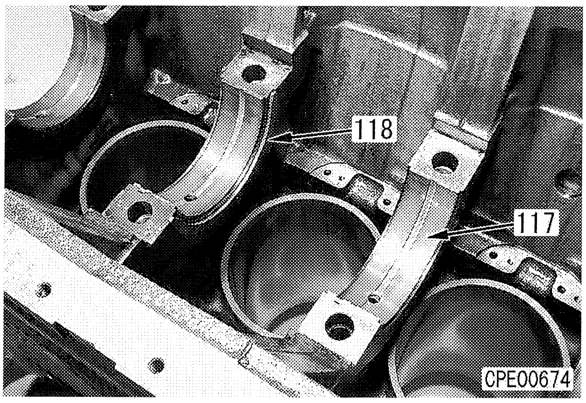


4. Crankshaft assembly

1) Turn over cylinder block, set oil pan at bottom, then lower it.
2) Install 7 main bearings (117) to cylinder block.
   - ★ The upper and lower main bearings are different. The upper bearing has an oil hole, so check this when installing.
   - ★ ALign the protruding part of the bearing with the notch in the cylinder block when installing.

Inside surface of bearing:
Engine oil (EO30-CD)

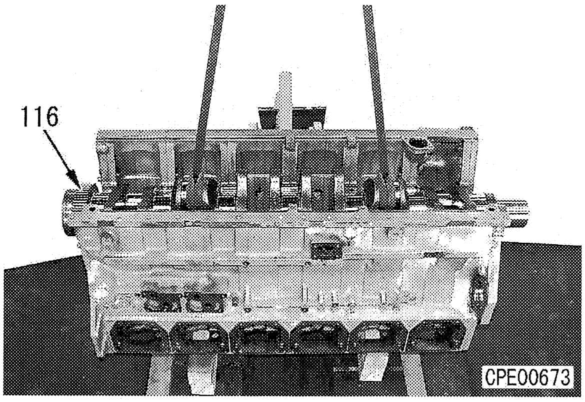
3) Install 2 thrust washers (118).
   - ★ Install the thrust washer only to No. 6 bearing.



4) Sling crankshaft assembly (116) and assemble to mounting position.

Crankshaft assembly: **270 kg**

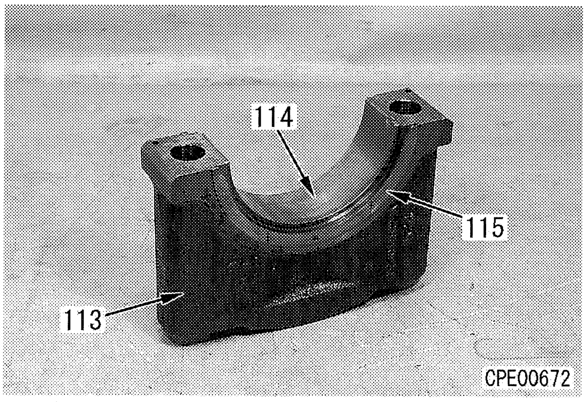
★ Be careful not to let the crankshaft hit the cylinder block when installing.



5) Install main bearing (116) to main cap (113).
   - ★ Align the protruding portion of the bearing with the notched portion of the main cap when installing.

Inside surface of main bearing:
Engine oil (EO30-CD)

6) Install 2 thrust washers (115).
   - ★ Install the thrust washer only to No. 6 main cap.



7) Install main cap (113).
   - ★ Match the bearing numbers for the main caps, set so that the surface with the [F] mark faces the front of the engine, and install.
   - ★ Check the number of punch marks on the head of the mounting bolts. If there are already 5 punch marks, do not reuse the bolt; replace it with a new part.

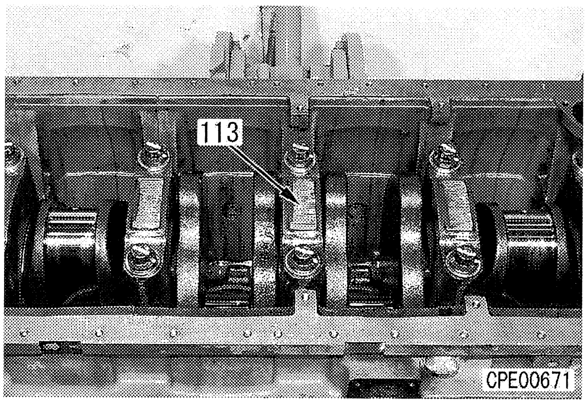
   Thread portion, seat surface of mounting bolt:

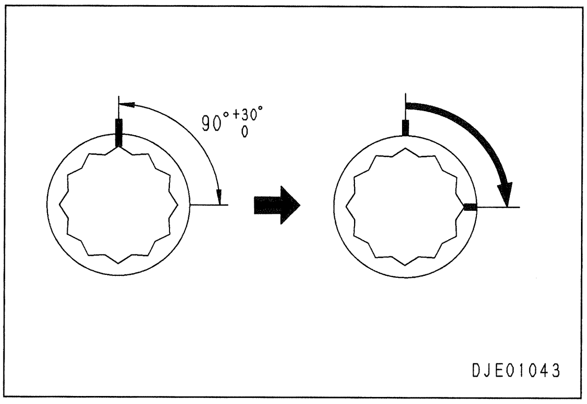
   Engine oil (EO30-CD)

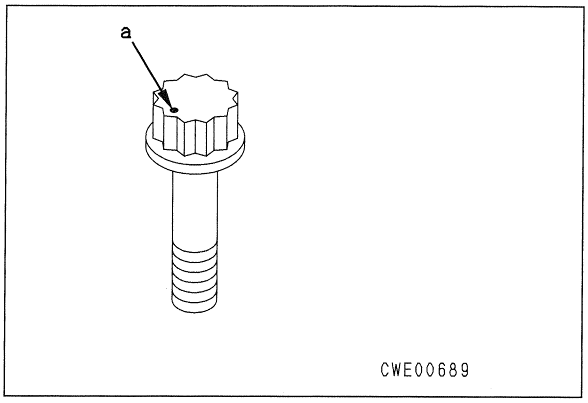
   Mounting bolt:

   1st step: 284 ± 15 Nm {29 ± 1.5 kgm}
   2nd step: 578 ± 10 Nm {28 ± 1.0 kgm}
   3rd step: Tighten $90^{\circ}{}^{+30^{\circ}}_{0}$

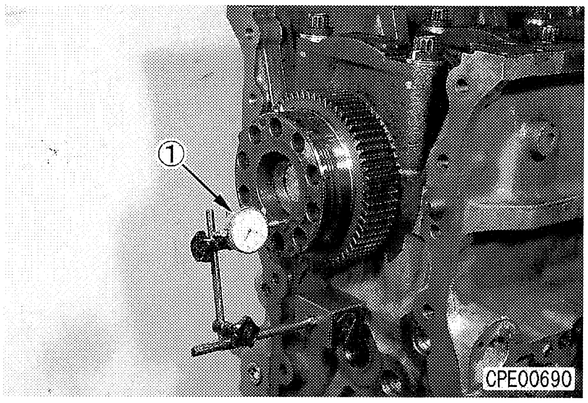
   - ★ After tightening the bolts, make 1 punch mark **a** each on the head of each bolt (do not make a punch mark when using a new bolt).





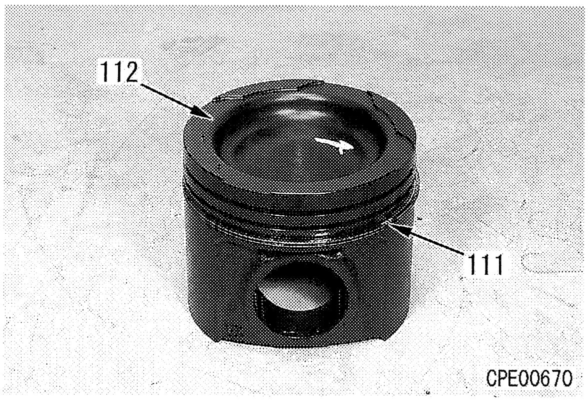


8) Using dial gauge ①, measure end play of crankshaft.
   - ★ End play: 0.14 – 0.32 mm
   - ★ If it it not within the standard value, take the necessary action. For details, see MAINTENANCE STANDARD.

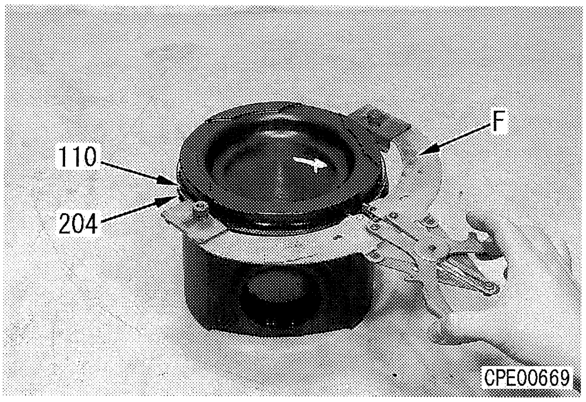


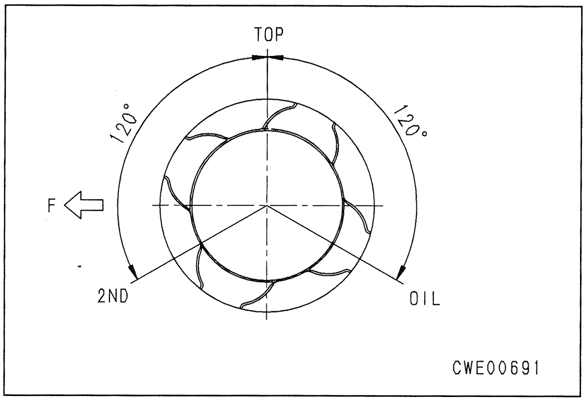
5. Piston, connecting rod assembly

1) Assemble piston and connecting rod assembly as follows.
   - i) Install oil ring (111) to piston (112).
   - ★ Connect both ends of the expander and fit in the groove inside the ring.
   - ★ Align the position of the end gaps as shown in the diagram.

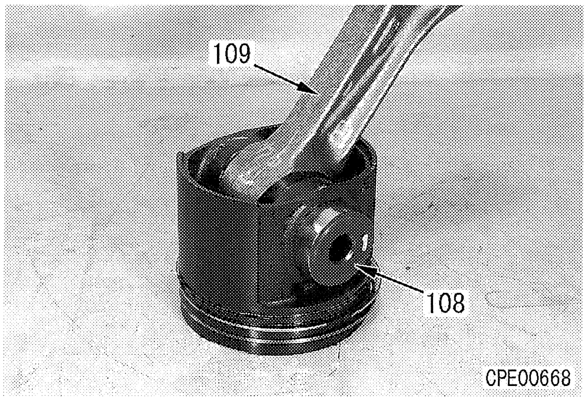


ii) Using tool F, install second ring (204) and top ring (110).
  - ★ Install the piston ring so that the surface with the stamped letters is at the top.
  - ★ Align the position of the end gaps as shown in the diagram.

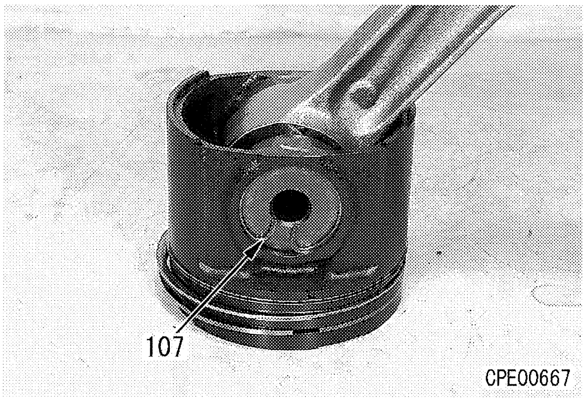




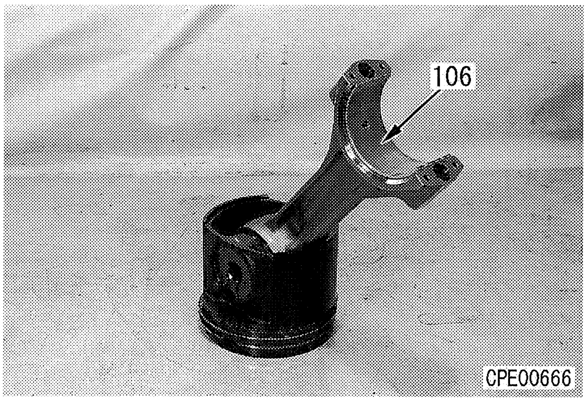
iii) Set connecting rod (109) to piston and insert piston pin (108).
  - ★ When using a new connecting rod, mark the cylinder No. on both the connecting rod and the cap with an electric pen.
  - ★ Assemble so that the [EX] casting letters on the side face of the piston and the part number casting letters on the side face of the connecting rod are facing in the same direction.



iv) Install 2 snap rings (107).
  - ★ Check that they are fitted securely in the ring groove.



v) Install connecting rod bearing (106).
  - ★ Align the protruding part of the bearing with the notched portion of the connecting rod and install.

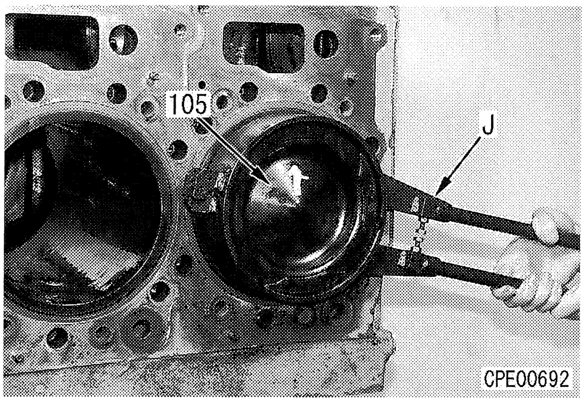


2) Rotate crankshaft and set pin journal of cylinder to be installed at top position.

3) Using tool **J**, insert piston and connecting rod assembly (105) in cylinder.

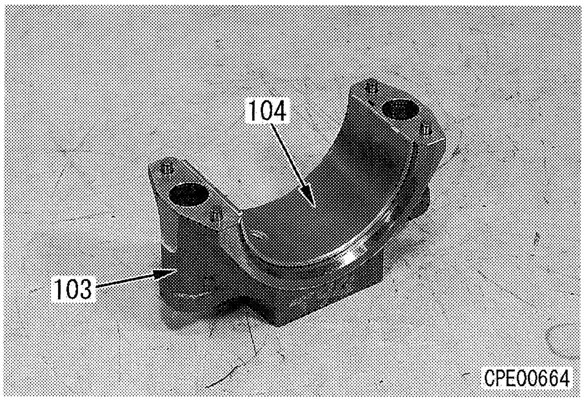
Piston ring: **Engine oil (EO30-CD)**

★ Insert so that the [EX] casting letters on the side face of the piston are facing the front of the engine.



4) Install connecting rod bearing (104) to connecting rod cap (103).

★ Align the protruding part of the bearing with the notched portion of the connecting rod cap and install.



5) Install connecting rod cap (103).

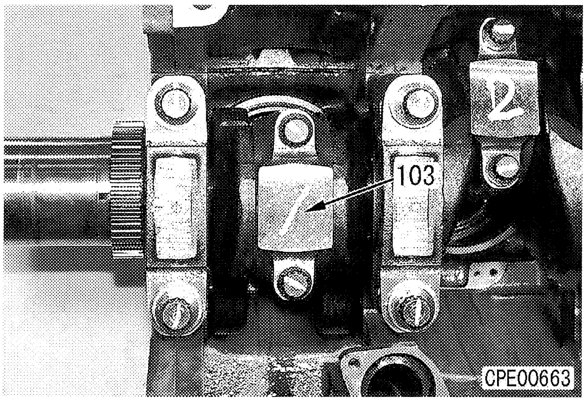
★ Set the cylinder No. mark on the connecting rod cap and connecting rod facing in the same direction, and install.

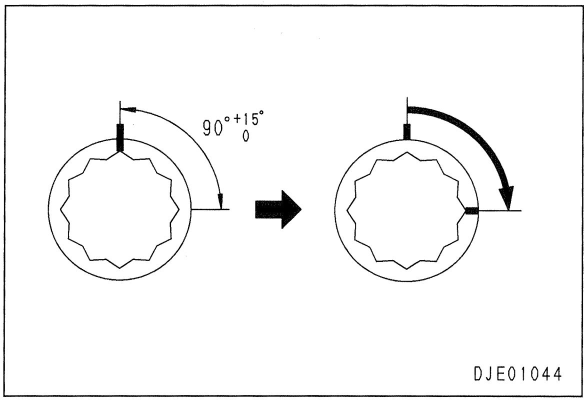
★ Check the number of punch marks on the head of the mounting bolts. If there are already 4 punch marks, do not reuse the bolt; replace it with a new part.

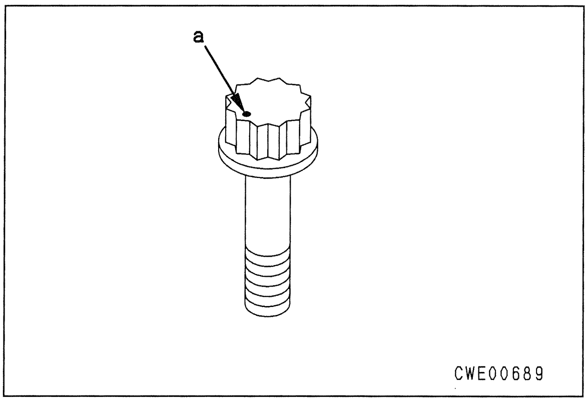
Mounting bolt, washer:
Engine oil (EO30-CD)

kg Mounting bolt:
1st step: 196 ± 10 Nm {20 ± 1.0 kgm}
2nd step: Tighten 90° $^{+15^\circ}_{0}$

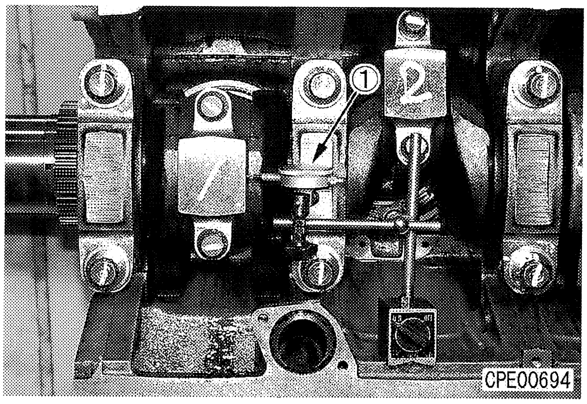
★ After tightening the bolts, make 1 punch mark **a** each on the head of each bolt (do not make a punch mark when using a new bolt).







6) Using dial gauge ①, measure side clearance of connecting rod.
   - ★ Side clearance: 0.200 – 0.374 mm
   - ★ If it is not within the standard value, disassemble again and investigate the cause.

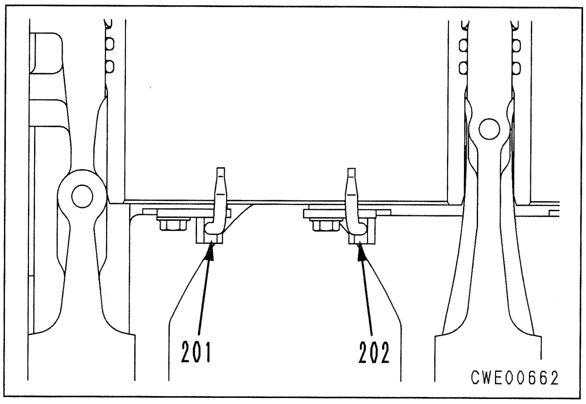


6. Piston cooling nozzles

1) Rotate crankshaft and set No. 1 to No. 3 pistons in position as follows.
   - · No. 1 TDC:
     No. 1 and No. 6 can be installed.
   - · No. 2 TDC:
     No. 2 and No. 5 can be installed.
   - · No. 3 BDC:
     No. 3 and No. 4 can be installed.

2) Install 6 piston cooling nozzles (201) and 6 piston cooling nozzles (202) in turn.
   - ★ Install the piston cooling nozzles so that those with the [F] stamped mark are at the front of the cylinder and those with the [R] stamped mark are at the rear of the cylinder.
   - ★ Push the piston cooling nozzle in by hand until the flange portion contacts the cylinder block surface, then tighten the mounting bolts.

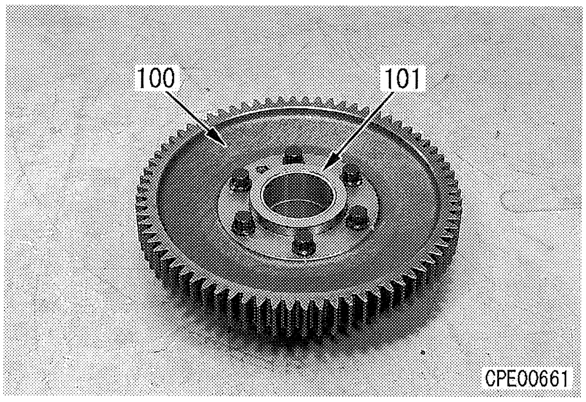
   kg Mounting bolt:
   27.4 – 34.3 Nm {2.8 – 3.5 kgm}



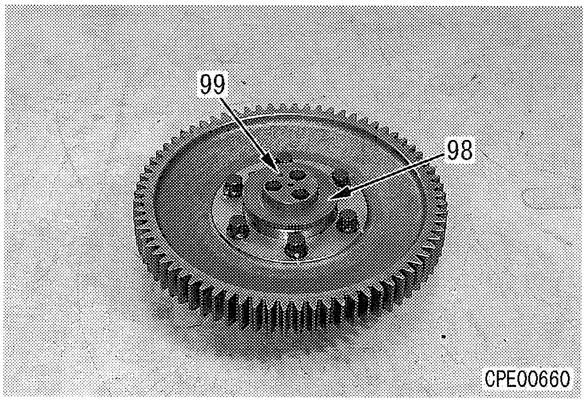
7. Rear idler gear assembly

1) Assemble rear idler gear assembly as follows.
   - i) Install gear [large] (100) and gear [small] (101).

     kgm Mounting bolt:
     98 – 123 Nm {10.0 – 12.5 kgm}



   - ii) Install shaft (99) and spacer (98).
     - ★ Install the spacer with the V-groove machined surface facing the outside.

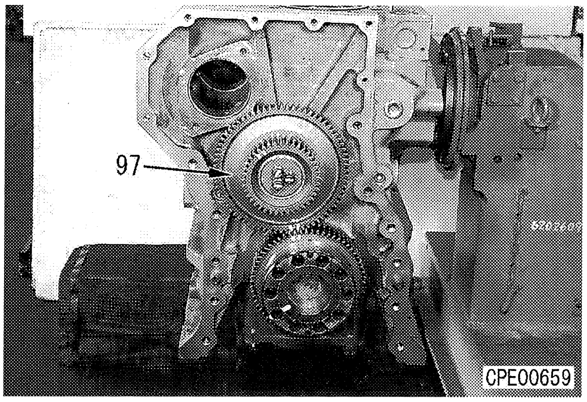


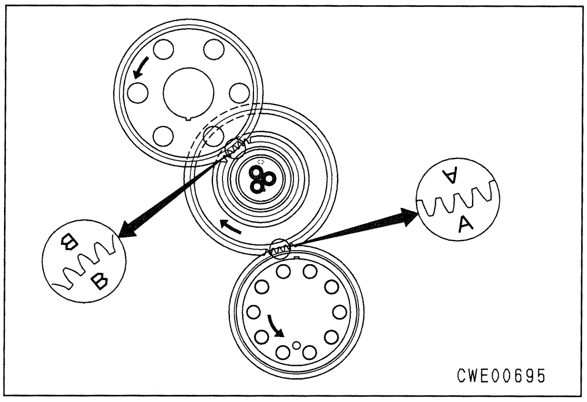
2) Sling engine, turn it over, set oil pan at top, then lower it.
3) Install rear idler gear assembly (97).
   - ★ Set the [UP] mark on the shaft facing up (cylinder head end), and install.
   - ★ Align the [A] marks on the crankshaft gear and large idler gear, and install.
   - ★ Check the number of punch marks on the head of the mounting bolts. If there are already 5 punch marks, do not reuse the bolt; replace it with a new part.

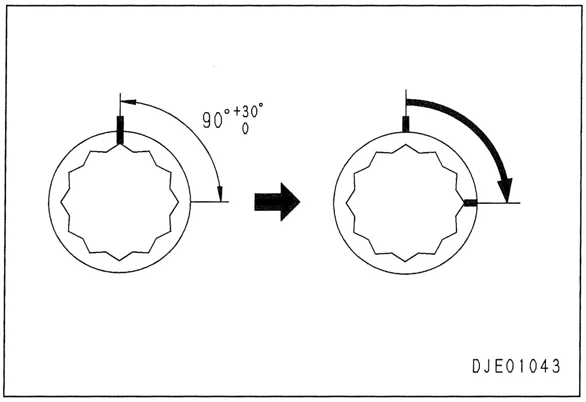
Mounting bolt, seat surface:
Engine oil (EO30-CD)

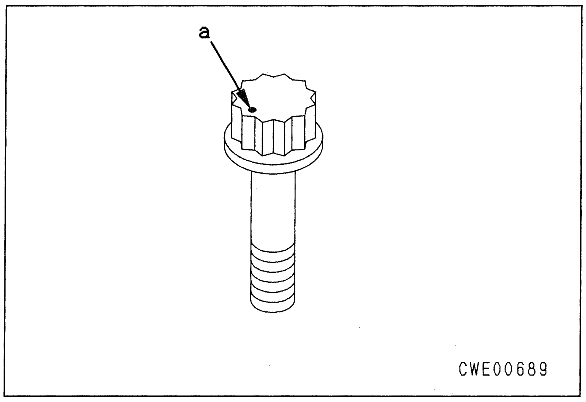
kgm Mounting bolt:
1st step: 56.8 ± 11.8 Nm {5.8 ± 1.2 kgm}
2nd step: Tighten $90^\circ {}^{+30^\circ}_{0}$

- ★ After tightening the bolts, make 1 punch mark **a** each on the head of each bolt (do not make a punch mark when using a new bolt).



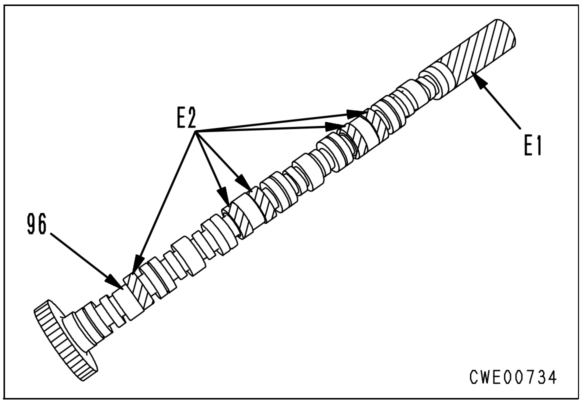






8. Camshaft assembly

1) Install tool **E1** and tool **E2** to camshaft assembly (96).
   - ★ Do not tighten tool E1 fully. Leave some play.
   - ★ Install tool **E2** to the front and rear of No. 2 and No. 4 injector cams and at the front of No. 6 injector cam.

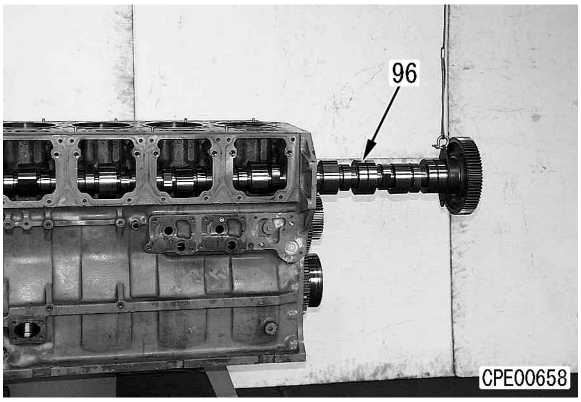


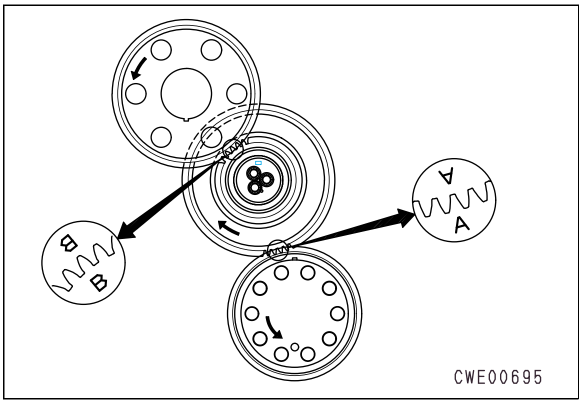
2) Sling camshaft assembly (96) and insert in cylinder block.
   - ★ At first, sling the whole camshaft, then guide the tool and insert into the cylinder block.
     Next, when approx. 1/3 has been inserted, sling the gear again and align the camshaft and bushing hole to insert.

   kg Camshaft assembly: **80 kg**

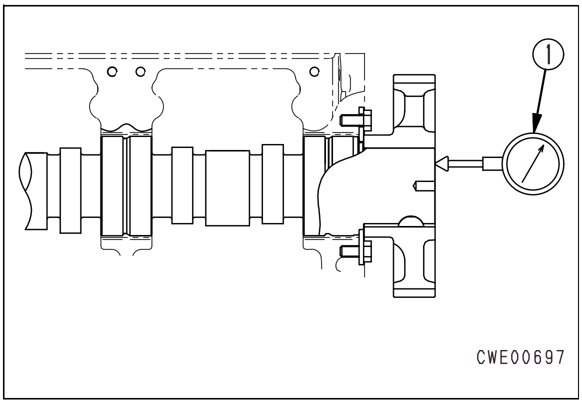
   - ★ Align the [B] marks on the camshaft gear and small idler gear, and install.

   kgm Mounting bolt:
   98 – 122.5 Nm {10 – 12.5 kgm}

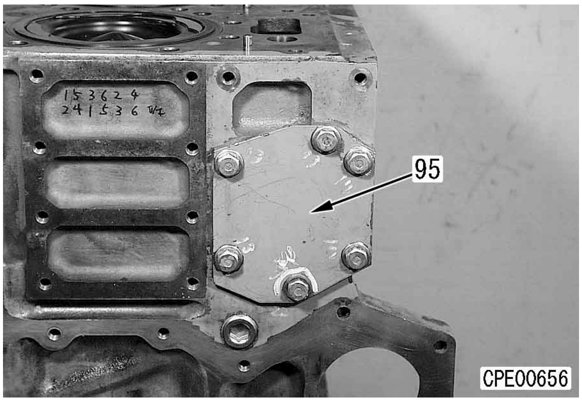




3) Using dial gauge ①, measure end play of camshaft.
   - ★ End play: 0.05 – 0.20 mm
   - ★ If it it not within the standard value, take the necessary action. For details, see MAINTENANCE STANDARD.



4) Fit gasket and install cover (95).



9. Measurement of gear backlash (rear)

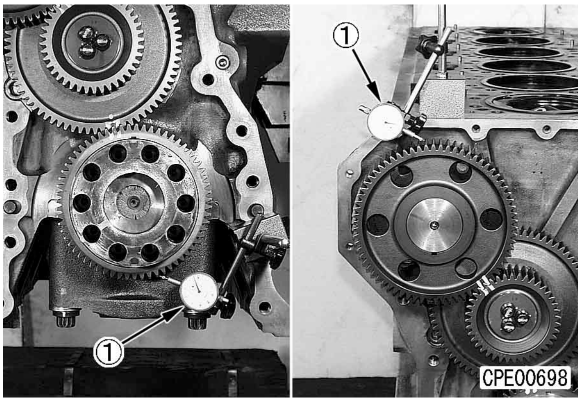
Using dial gauge ①, measure backlash of rear timing gear portion.

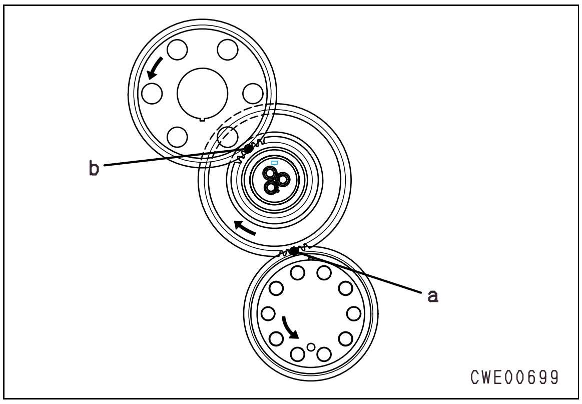
★ Set the dial gauge to the tip of the tooth of the crankshaft gear or camshaft gear, hold the idler gear in position, and measure the backlash.

★ Standard value of backlash:

Measurement position	Backlash (mm)
a	0.155 – 0.412
b	0.145 – 0.380

★ If it it not within the standard value, take the necessary action. For details, see MAINTENANCE STANDARD.

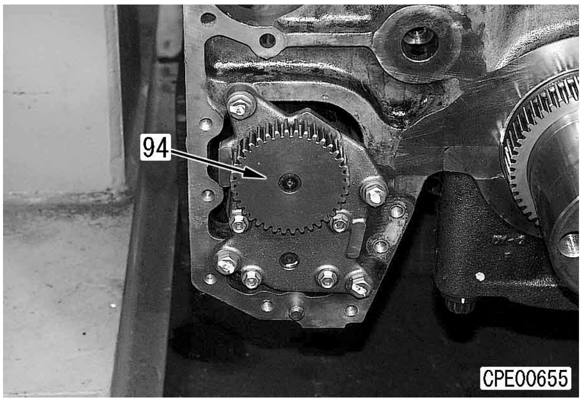




10. Oil pump assembly

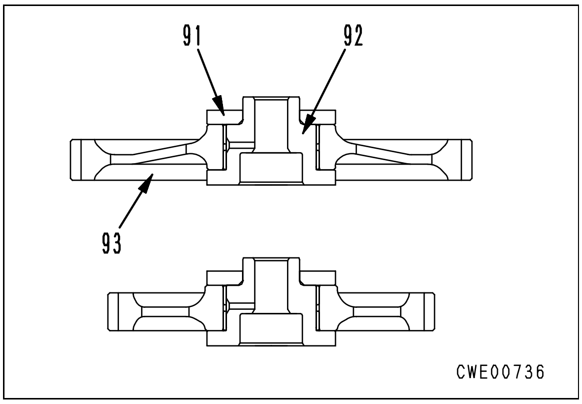
Fit angle ring and install oil pump assembly (94).

★ Use Loctite adhesive (Hitack 98D) on the angle ring and pump.



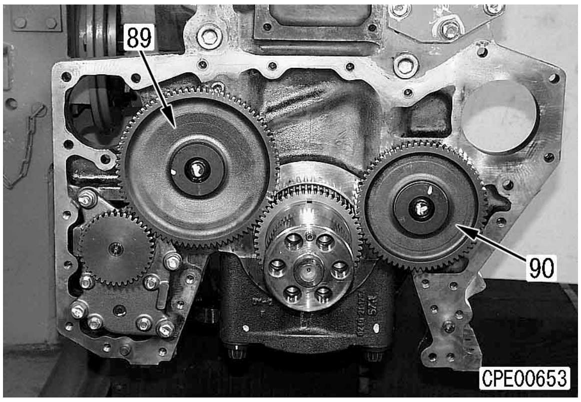
11. Front idler gear assembly

1) Install shaft (92) and spacer (91) to gear (93).
   - ★ Insert the end of the shaft where the protrusion of the gear bearing is smaller.
   - ★ Install the spacer so that the chamfered surface of the inside diameter is facing the gear.
   - ★ Both the large and small idler gears consist of the same parts.



2) Install idler gear [small] (90) and idler gear [large] (89).

kgm Mounting bolt:
245 – 309 Nm {25.0 – 31.5 kgm}



12. Measurement of gear backlash (front)

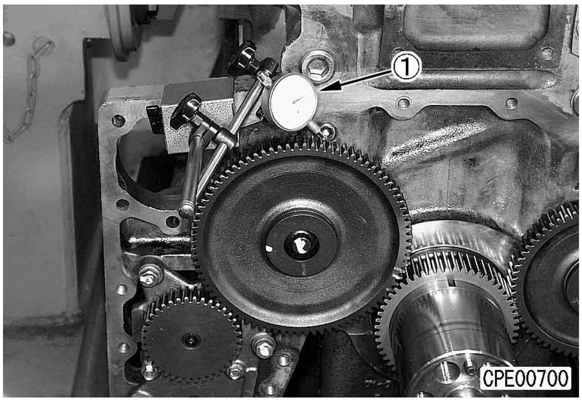
Using dial gauge ①, measure backlash of front accessory gear portion.

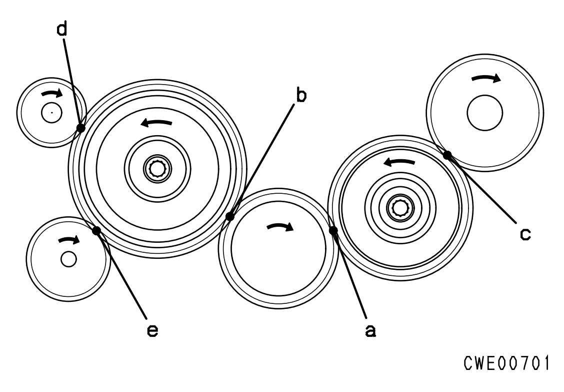
★ Set the dial gauge against the tip of the tooth of the gear to be measured, hold the other gear in position, and measure the backlash.

★ Standard value of backlash:

Measurement position	Backlash (mm)
a	0.144 – 0.320
b	0.134 – 0.362
c	0.114 – 0.320
d	0.121 – 0.333
e	0.121 – 0.333

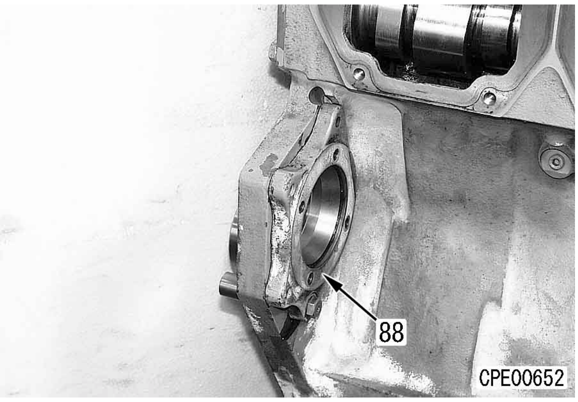
★ If it it not within the standard value, take the necessary action. For details, see MAINTENANCE STANDARD.





13. Front cover

1) Fit O-ring and install bracket (88).

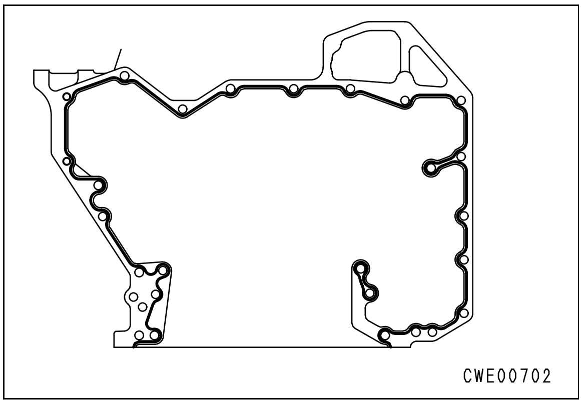


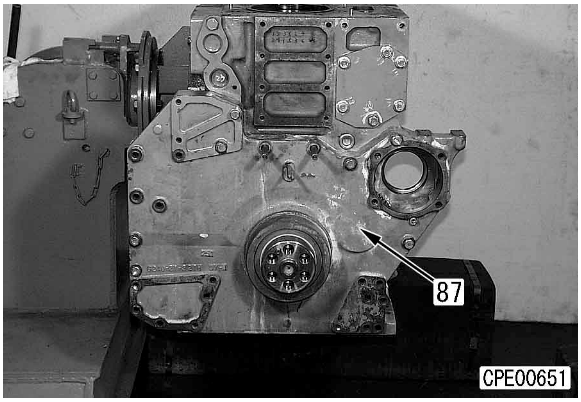
2) Coat with gasket sealant, then raise front cover (87) and install.

Front cover: **Gasket sealant (LG-7)**

★ Coat the gasket sealant as shown in the diagram with a line of width ϕ 2 – 3 mm.

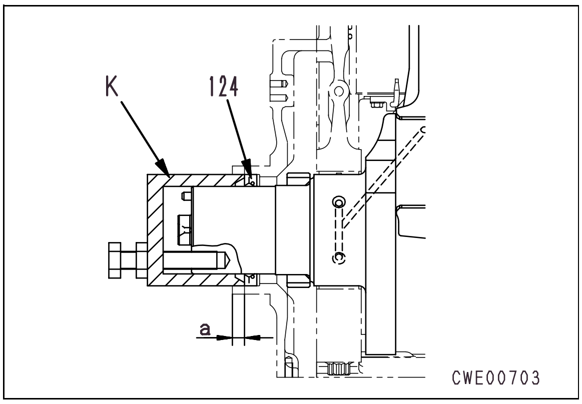
kg Front cover: **45 kg**





3) Using tool **K**, press fit oil seal (124) to front case. (When there is no dust seal)

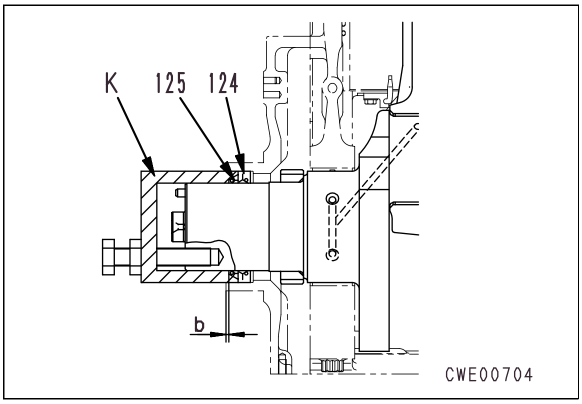
★ Press-fitting dimension **a** of oil seal: 15.7 mm



4) Using tool **K**, press fit oil seal (124) and dust seal (125) to front case at same time. (When there is no dust seal)

★ Press-fitting dimension **b** of dust seal: 4 mm

★ The dust seal is installed only to the engine for wheeled type machines.



15. Flywheel housing

1) Coat with gasket sealant, then raise flywheel housing (86) and install.

Flywheel housing:
Gasket sealant (LG-7)

★ Coat the gasket sealant as shown in the diagram with a line of width ϕ 2 – 3 mm.

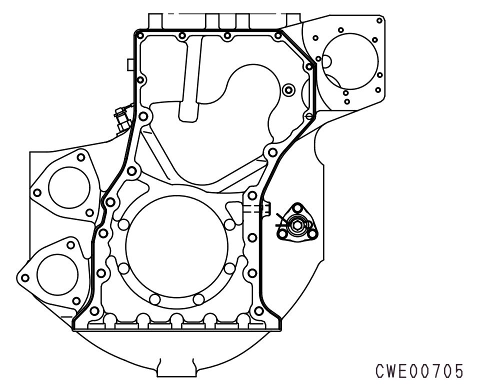
kg Flywheel housing: **150 kg**

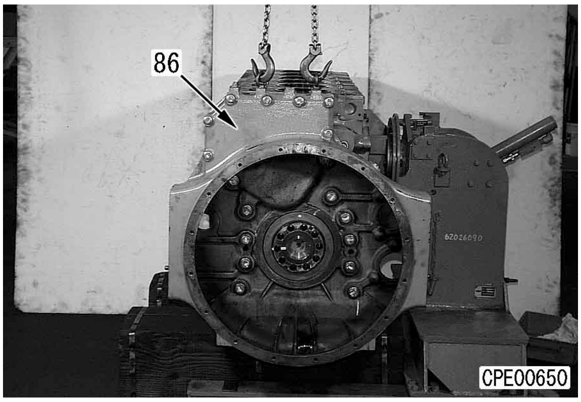
★ Tighten the mounting bolts (main) in the specified order.

Mounting bolt, washer:
Engine oil (EO30-CD)

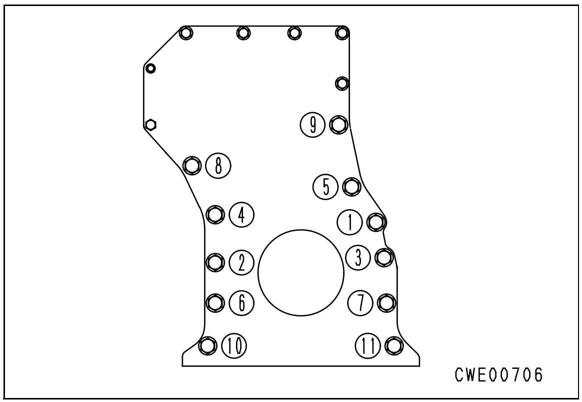
kgm Mounting bolt (① – ⑪):
1st step : 352.8 – 392 Nm {36 – 40 kgm}
2nd step: Loosen
3rd step : 392 – 431.2 Nm {40 – 44 kgm}

kgm Mounting bolt
(other than mentioned above)
98 – 122.5 Nm {10 – 12.5 kgm}


CWE00705

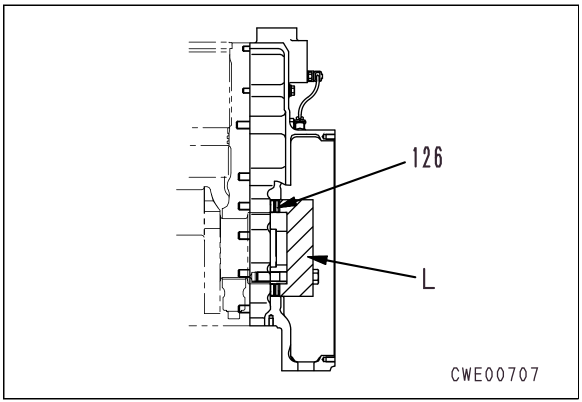


CPE00650



CWE00706

2) Using tool **L**, press fit rear oil seal (126).
★ Press fit until the end face on the inside of the tool contacts the crankshaft.



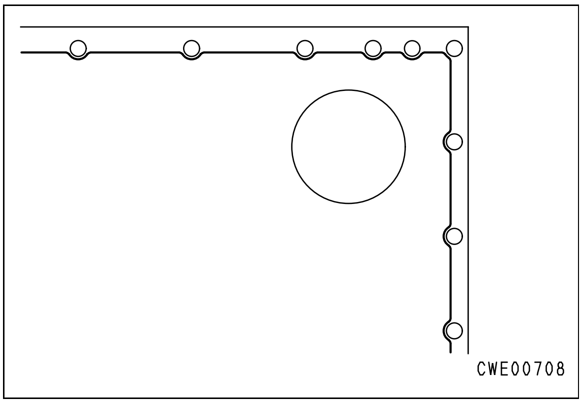
CWE00707

16. Underplate

1) Sling engine, turn it over, set oil pan at top, then lower it.
2) Coat with gasket sealant and install underplate (85).

Flywheel housing:
Gasket sealant (LG-7)

★ Coat the gasket sealant as shown in the diagram with a line of width ϕ 2 – 3 mm.
★ Temporarily tighten 4 bolts on the inside and several bolts on the outside until finally installing the suction tube and oil pan.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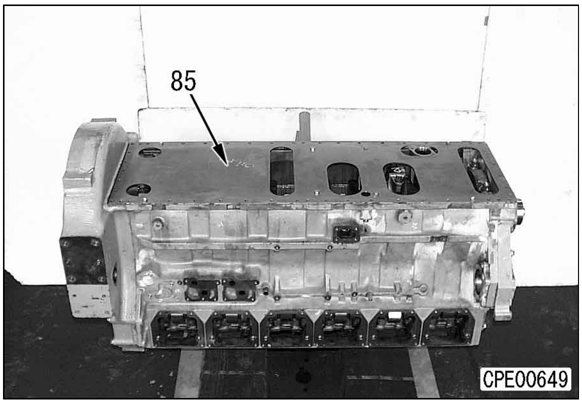
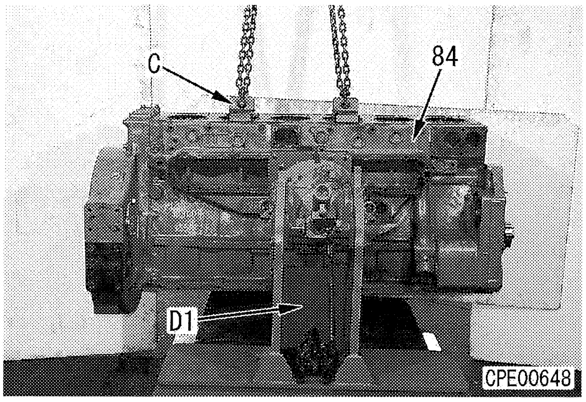


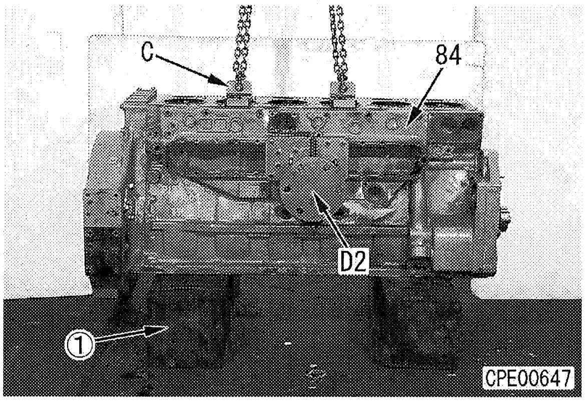
CPE00649

17. Removal from repair stand

1) Sling engine, turn it over, set cylinder head at top, then lower.
2) Install tool **C**, then raise engine assembly (84) and remove from tool **D1**.



3) Lower engine assembly (84) on block ①, then remove tool **C** and tool **D2**.



18. Flywheel assembly

1) Sling flywheel assembly (83) and install.

Flywheel assembly: **150 kg**

★ Check the number of punch marks on the head of the mounting bolts. If there are already 5 punch marks, do not reuse the bolt; replace it with a new part.

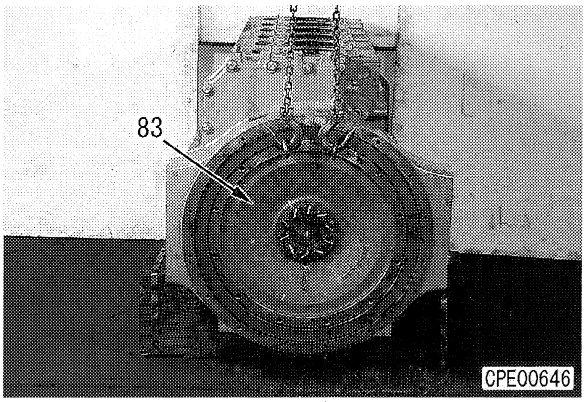
★ Fix the flywheel and flywheel housing in position so that the flywheel does not rotate.

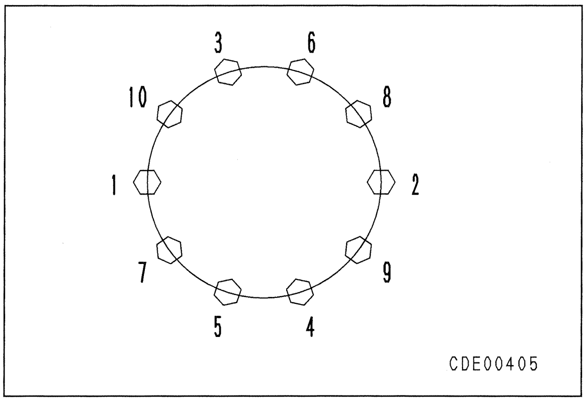
★ Tighten the mounting bolts in the specified order.

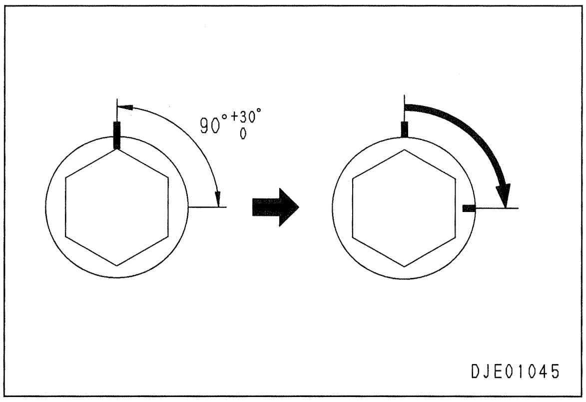
Mounting bolt: **Engine oil (EO30-CD)**

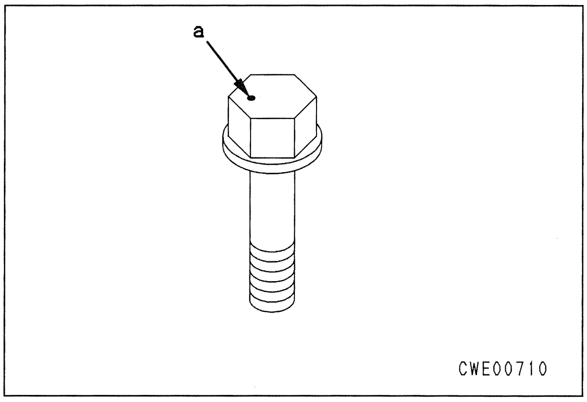
Mounting bolt:
1st step : 198 ± 9.8 Nm {20 ±1 kgm}
2nd step: 460.6 ± 19.6 Nm {47 ± 2 kgm}
3rd step : Tighten $90^{\circ}{}^{+15^{\circ}}_{0}$

★ After tightening the bolts, make 1 punch mark **a** each on the head of each bolt (do not make a punch mark when using a new bolt).

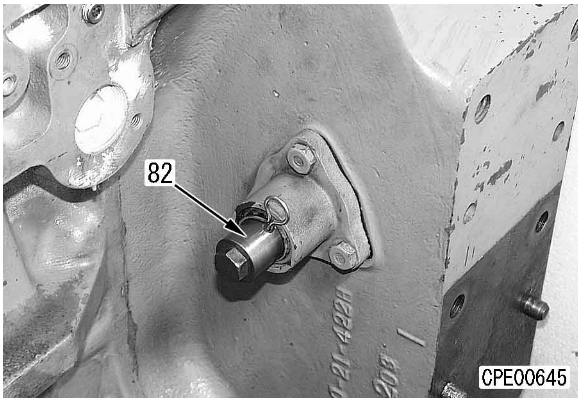








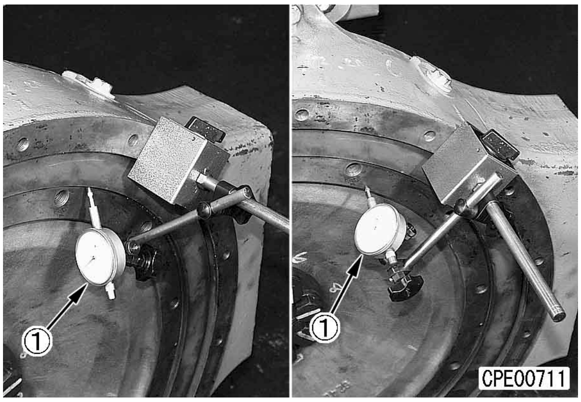
2) Fit gasket and install barring device (82).



3) Using dial gauge ①, measure the radial runout and face runout of flywheel.
   - ★ Standard values for radial runout, face runout:

Measurement item	Permissible value (mm)
Radial runout	0.13
Face runout	0.005 × Diameter at measurement point

   - ★ If it is not within the standard value, disassemble again and investigate the cause.



4) Install engine speed sensor (81).

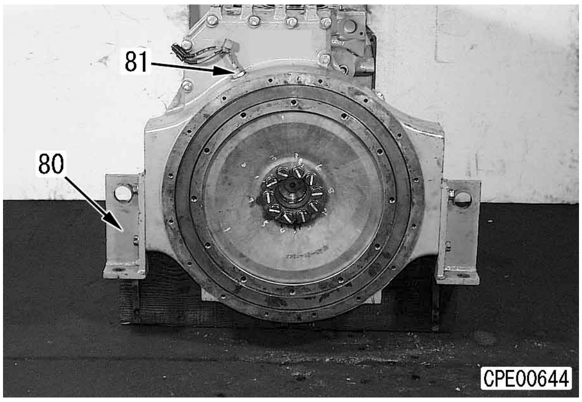
   Sensor thread portion:
   Loctite gasket
   (Hydraulic sealant No. 21028)
   - ★ Screw in until the tip of the sensor contacts the ring gear, then turn the sensor back 1/2 – 3/4 turns.

   kgm Locknut:
   33.9 – 47.5 Nm {3.5 – 4.8 kgm}

19. Engine mount

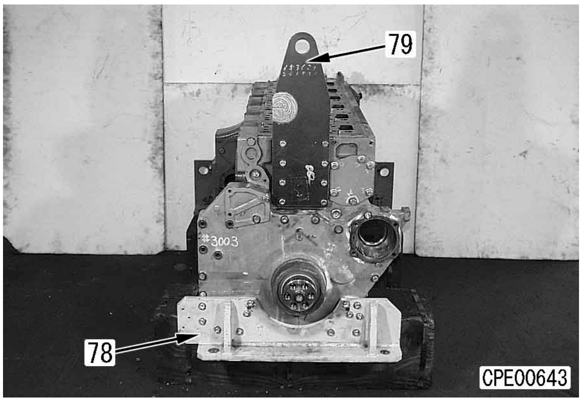
1) Install rear engine mount (80).
   - ★ The shape of the mount differs according to the machine it is mounted on.

   kgm Mounting bolt:
   320 – 400 Nm {33 – 41 kgm}



2) Install front mount (78).
   - ★ The shape of the mount differs according to the machine it is mounted on.

3) Install hanger (79).
   - ★ The shape of the hanger differs according to the machine it is mounted on.



20. Vibration damper

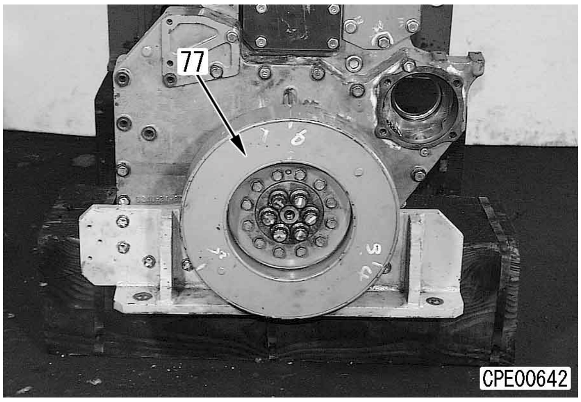
Sling vibration damper (77) and install.

kg Vibration damper: **60 kg**

★ Hold the flywheel and flywheel housing in position so that the damper does not rotate.

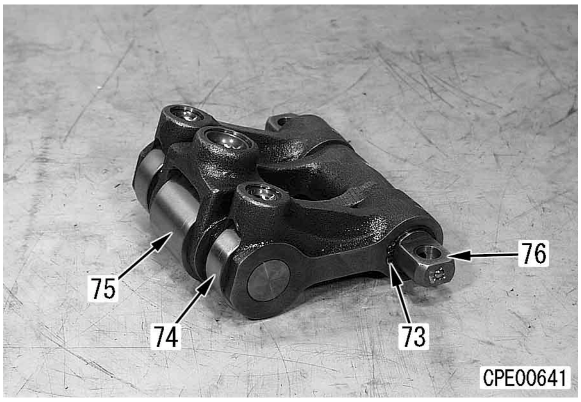
kgm Mounting bolt:

1st step : 53.9 – 93.1 Nm {7.5 ± 2 kgm}
2nd step: 225.4 – 264.6 Nm {25 ± 2 kgm}
3rd step: 617.4 – 656.6 Nm {65 ± 2 kgm}



22. Cam follower assembly

1) Assemble cam follower assembly as follows.
   - i) Install injector cam follower (75) and 2 valve cam followers (74) to shaft (76).
     - ★ Insert the cam follower so that the side of the shaft with the ball knocked in faces the front of the engine.
   - ii) Install snap ring (76).



2) Crank the crankshaft and set the No. 1 - No. 3 pistons to the following condition.
   - No. 1 compression TDC:
     No. 1 and No. 5 can be installed
   - No. 2 compression TDC:
     No. 2 and No. 4 can be installed
   - No. 3 compression TDC:
     No. 3 and No. 6 can be installed

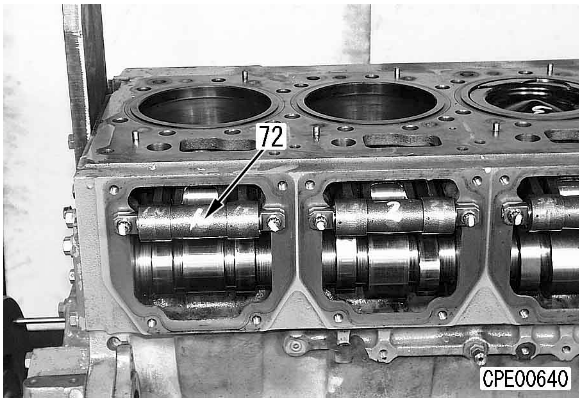
   ★ Always set the cylinder to the compression top dead center position.
   If the cam follower cannot be inserted, the cylinder is not at compression top dead center, so rotate it one more turn.

3) Install 6 cam follower assemblies (72) in order.

   kgm Mounting bolt:

   90.2 – 104.0 Nm {9.2 – 10.6 kgm}

   ★ Check that the side of the cam follower shaft with the ball knocked in is facing the front of the engine.

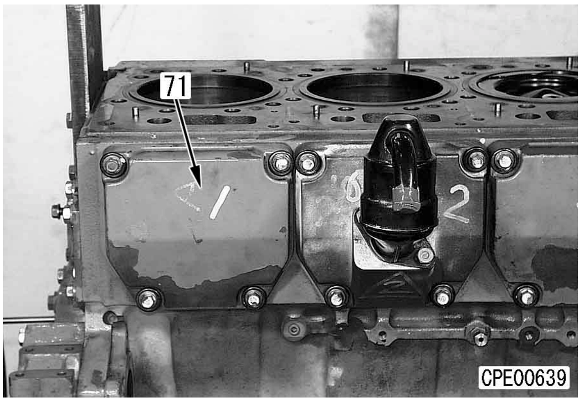


23. Cam follower cover

Fit O-ring and install 6 cam follower covers (71).

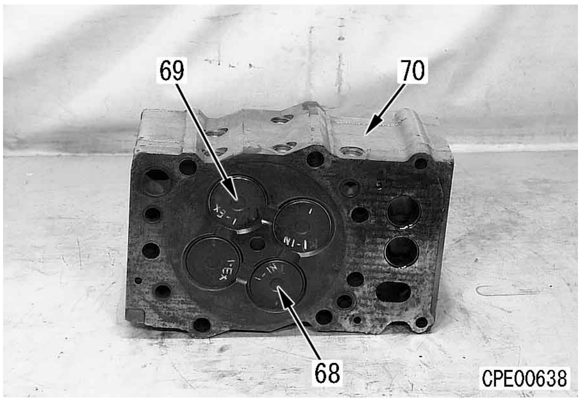
★ The position of the breather differs according to the machine it is mounted on.

kgm Mounting bolt:
9.8 ± 0.98 Nm {1 ± 0.1 kgm}

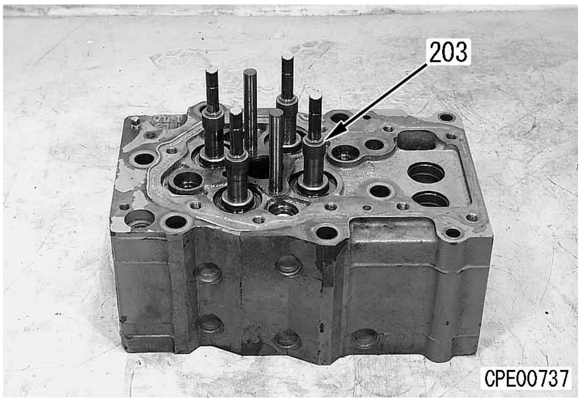


24. Cylinder head assembly

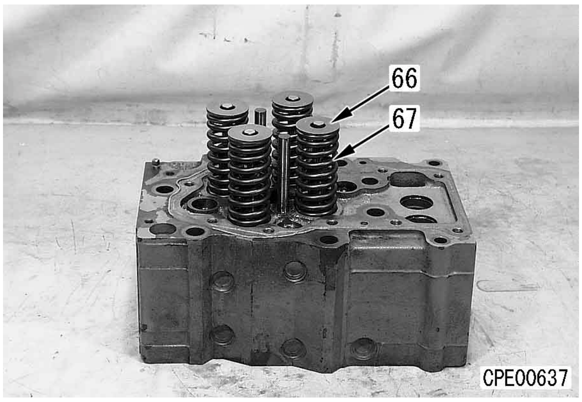
1) Assemble cylinder head assembly as follows.
    i) Install 2 intake valves (68) and 2 exhaust valves (69) to cylinder head.



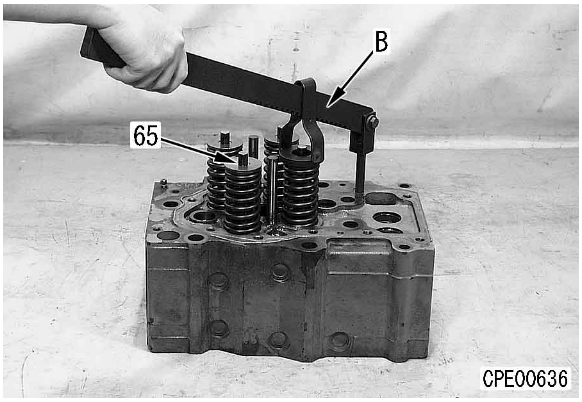
    ii) Using tool **Q**, press fit 4 valve stem seals (203).



    iii) Install 4 valve springs (67).
    iv) Install 4 spring seats (68).



    v) Using tool **B**, compress valve spring and install 8 valve cotters (65).
        ★ Tip over the cylinder head to face the side, tap the valve stem lightly with a plastic hammer, and check that the valve cotter is securely fitted into the valve stem.



2) Install 6 cylinder head gaskets.
3) Sling cylinder head assembly (64) and install.

kg Cylinder head assembly: **60 kg**

★ Check the number of punch marks on the head of the mounting bolts. If there are already 3 punch marks, do not reuse the bolt; replace it with a new part.

★ Tighten the mounting bolts in the specified order.

Mounting bolt:
Molybdenum disulphide grease (LM-P)

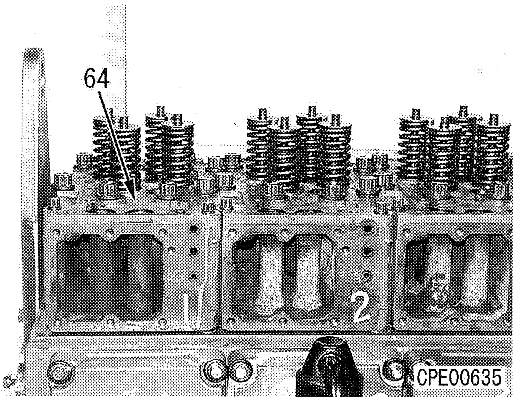
kgm Mounting bolt (① – ⑦):

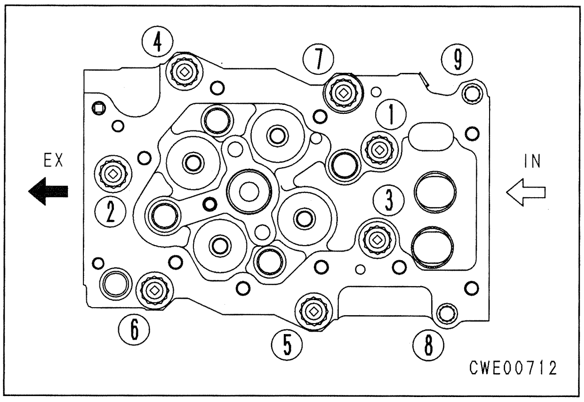
1st step: 245 ± 9.8 Nm {25 ± 1 kgm}
2nd step: 382.5 ± 9.8 Nm {39 ± 1 kgm}
3rd step: Tighten $90^{\circ}{}^{+30^{\circ}}_{0}$

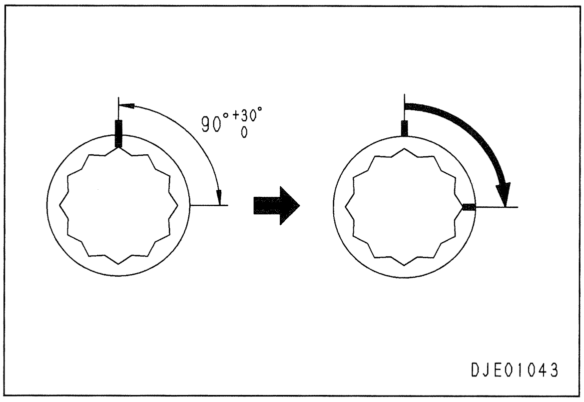
kgm Mounting bolt (⑧ – ⑨):

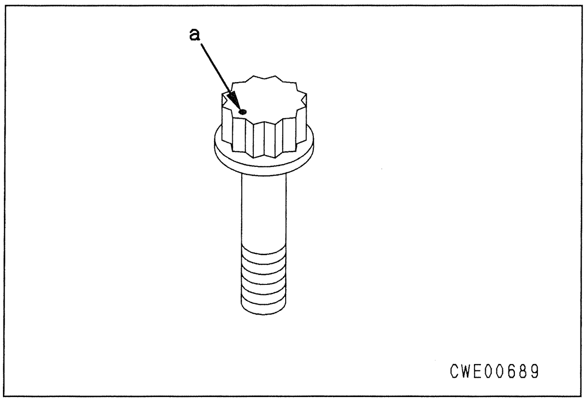
93.2 – 103 Nm {9.5 – 10.5 kgm}

★ After tightening the bolts, make 1 punch mark **a** each on the head of each main bolt (do not make a punch mark when using a new bolt).









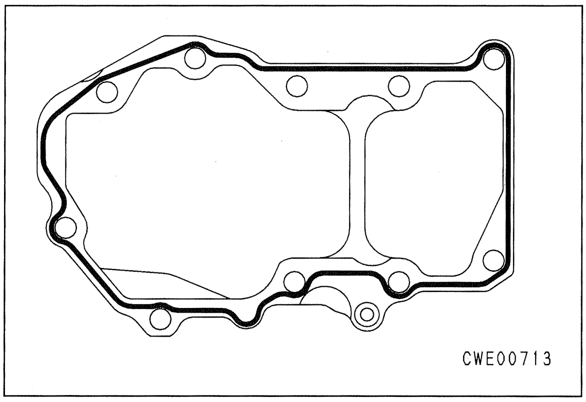
25. Rocker arm housing

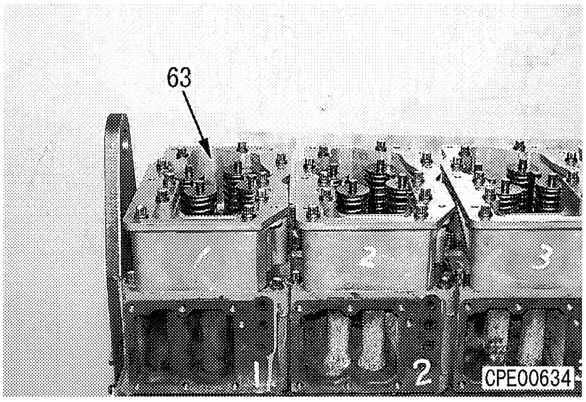
Coat with gasket sealant and install rocker arm housing (63).

Rocker arm housing:
Gasket sealant (LG-7)

★ Coat the gasket sealant as shown in the diagram with a line of width ϕ 2 – 3 mm along the housing groove.

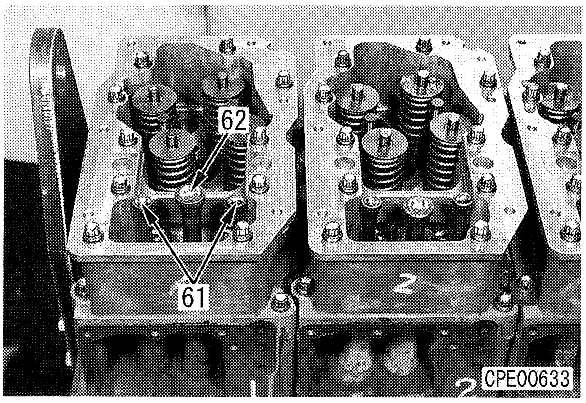
kgm Mounting bolt:
78.4 – 93.2 Nm {8.0 – 9.5 kgm}





26. Push rods

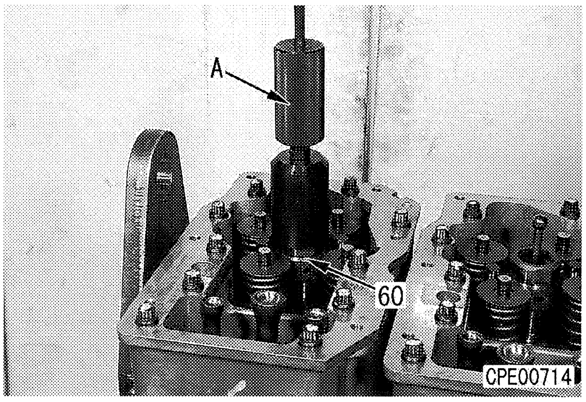
1) Install 6 injector push rods (62).
   - ★ Check that the tip of the push rod is fitted securely into the socket in the cam follower.
2) Install 12 valve push rods (61).
   - ★ Check that the tip of the push rod is fitted securely into the socket in the cam follower.



27. Injector

1) Using tool **A**, insert injector (60) in cylinder head.

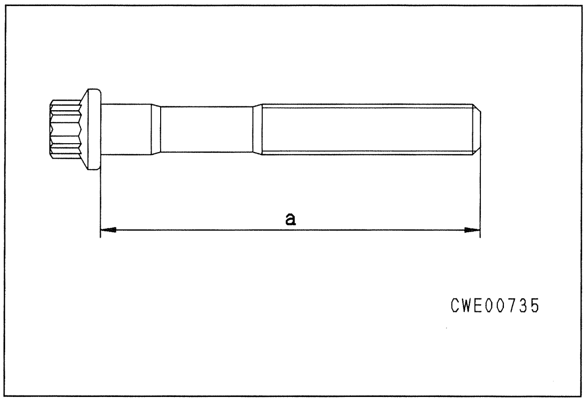
   O-ring: **Engine oil (EO30-CD)**
   - ★ Check that the gasket at the tip of the injector does not fall under its own weight when installing.
   - ★ Face the bleeder hole in the injector on the diametrically opposite side of the holder and set in the mounting position together with the holder.
   - ★ Insert the injector straight into the mounting hole, then use the cylinder end of tool **A** to push the top surface of the injector and seat the seal portion at the tip in the cylinder head.

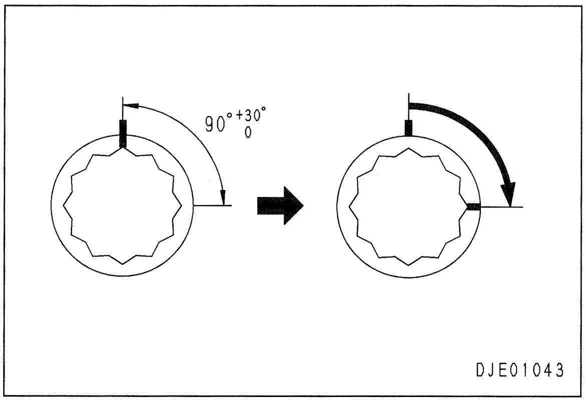


2) Tighten holder mounting bolts.
   - ★ Measure the length **a** of the portion below the bolt head. If it is more than 80 mm, do not reuse the bolt; replace it with a new part.

   Thread portion, seat surface of mounting bolt:
   Engine oil (EO30-CD)

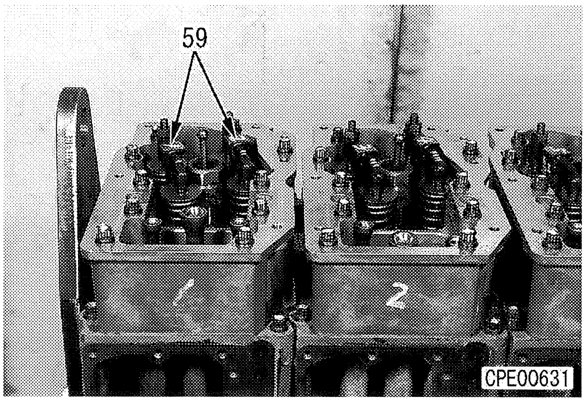
   kgm Mounting bolt:
   1st step : 24.5 – 34.3 Nm {2.5 – 3.5 kgm}
   2nd step: Tighten 90° $^{+30^{\circ}}_{0}$





28. Crossheads

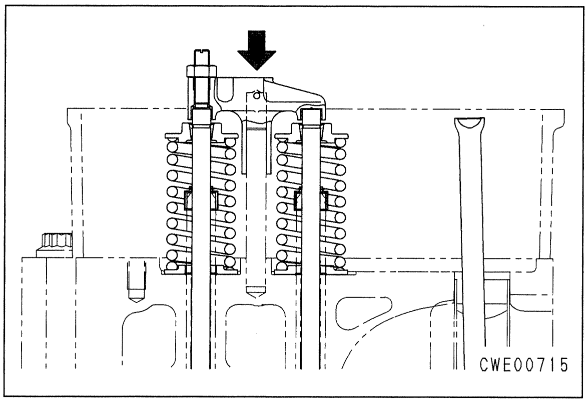
1) Install 12 crossheads (59).



2) Adjust crossheads as follows.
   i) Loosen locknut, and loosen adjustment screw to a position where it does not contact valve stem.
   ii) Hold contact surface with rocker arm with a finger, and hold so that it contacts valve stem at push rod end.
   iii) Tighten adjustment screw slowly and check position where adjustment screw contacts valve stem.
   iv) From position where it contacts valve stem, tighten adjustment screw a further 20° – 30°
   v) Secure in position with locknut.

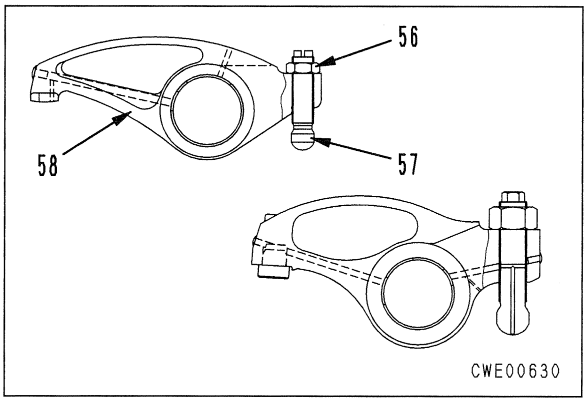
   kgm Locknut:

   53.0 – 68.6 Nm {5.4 – 6.6 kgm}

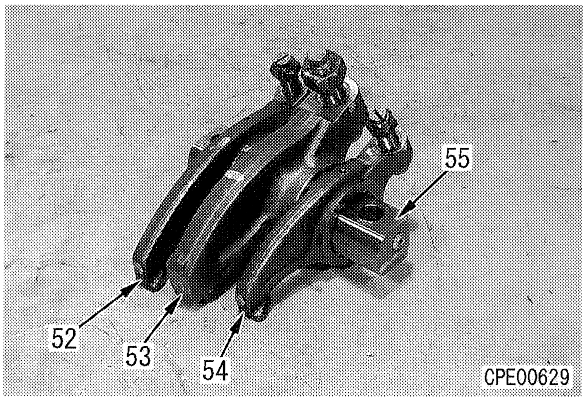


29. Rocker arm assembly

1) Assemble rocker arm assembly as follows.
   i) Install adjustment screw (57) to rocker arm (58), then install locknut (56).
      ★ Screw in adjustment screw until ball portion contacts arm.



   ii) Install intake valve arm (54), injector arm (53), and exhaust valve arm (52) to shaft (55).
      ★ Insert into the arm so that the inside of the shaft with the rivet knocked in faces the front of the engine.



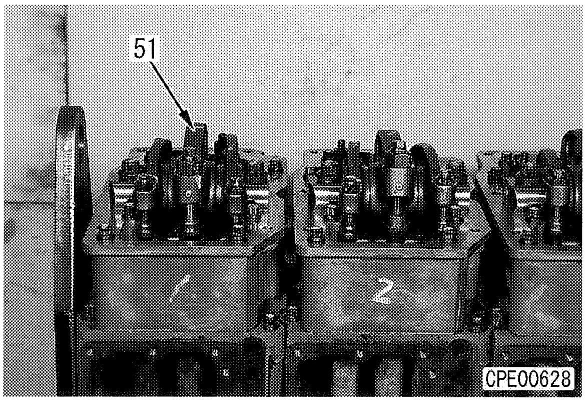
2) Install 6 rocker arm assemblies (51).
   ★ Install so that the shaft hole with the large inside diameter faces the rocker arm housing.

   Thread portion, seat surface of mounting bolt:

   Engine oil (EO30-CD)

   kgm Mounting bolt:

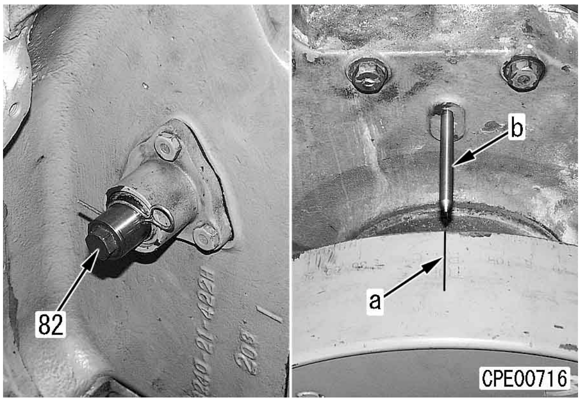
   235.2 – 254.8 Nm {24 – 26 kgm}



30. Adjustment of valve clearance

★ Adjustment of the valve clearance can be carried out at the same time as the next step (Adjustment of injector).

1) Crank the crankshaft with barring device (82), align 1.6 TOP line **a** on damper with pointer **b**, and set No. 1 cylinder to compression top dead center.
   ★ After aligning the line and pointer, rotate the crankshaft forward and backward and watch the movement of the push rod to check that the No. 1 cylinder is in the compression stroke. (If the push rod does not move, the cylinder is in the compression stroke.)



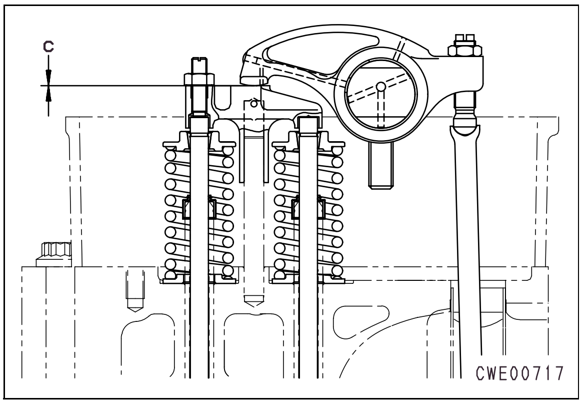
2) Insert specified thickness of tool **M** in clearance **c** between rocker arm and crosshead and adjust valve clearance.
   ★ Valve clearance (when cold)

Intake valve	Exhaust valve
0.32 ± 0.02 mm	0.62 ± 0.02 mm

   ★ Insert tool **M**, turn the adjustment screw, and adjust the adjustment screw so that tool **M** is a sliding fit.

3) Secure adjustment screw and tighten locknut.

   Locknut:
   57.8 – 77.4 Nm {5.9 – 7.9 kgm}



4) Crank the crankshaft 120° each time in the normal direction and repeat Steps 1) – 3) to adjust each cylinder according to the firing order.

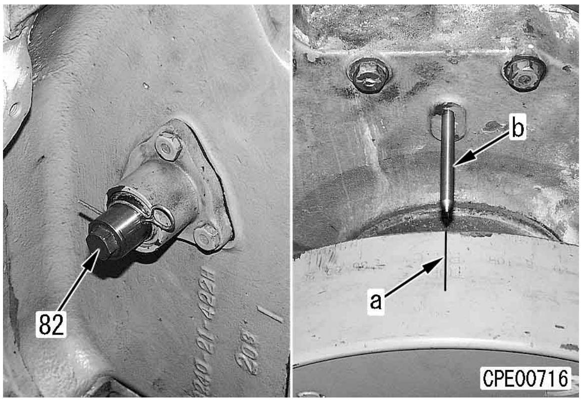
★ Firing order: 1 – 5 – 3 – 6 – 2 – 4

31. Adjustment of injector

★ Adjustment of the injector can be carried out at the same time as the previous step (Adjustment of valve clearance).

1) Crank the crankshaft with barring device (82), align 1.6 TOP line **a** on damper with pointer **b**, and set No. 1 cylinder to compression top dead center.
   ★ Watch the movement of the rocker arm to check that the No. 1 cylinder is in the compression stroke. (If the rocker arm has a play of only the amount of the valve clearance, the cylinder is in the compression stroke.)
   ★ The cylinder set to compression top dead center and the cylinder where the injector is adjusted are different, so check the table below when carrying out the work.
   ★ Cylinder at compression top dead center and cylinder where injector is adjusted:

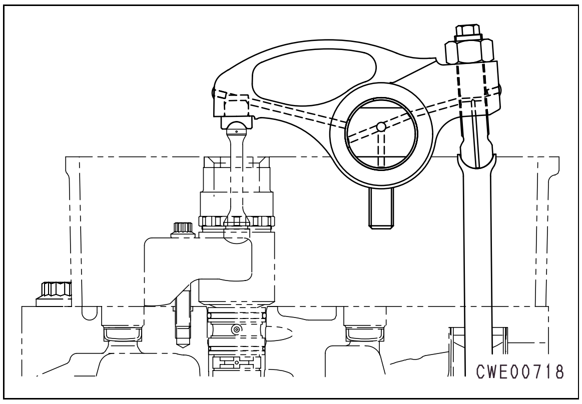
Compression TDC	1	5	3	6	2	4
Injector to adjust	2	4	1	5	3	6



2) Tighten by hand adjustment screw of injector to be adjusted.
   ★ Check that the ball of the push rod is fitted securely in the socket at the tip of the rocker arm for each injector and push rod.
3) Repeat the tightening and loosening of the adjustment screw, then tighten finally.

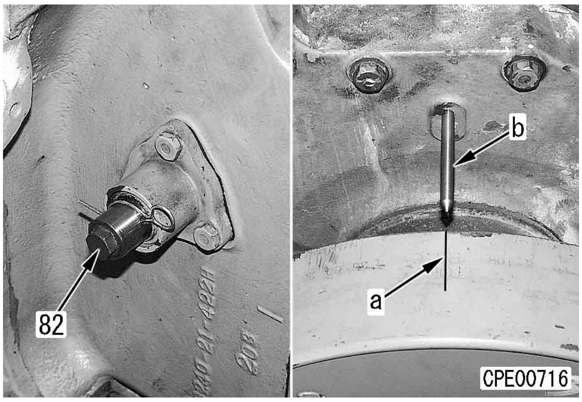
   kgm Adjustment screw:
   1st step : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}
   2nd step: Loosen completely
   3rd step : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}
   4th step : Loosen completely
   5th step : 29.4 – 34.3 Nm {3.0 – 3.5 kgm}
4) Secure adjustment screw and tighten locknut.

   kgm Locknut:
   205.8 – 245 Nm {21 – 25 kgm}

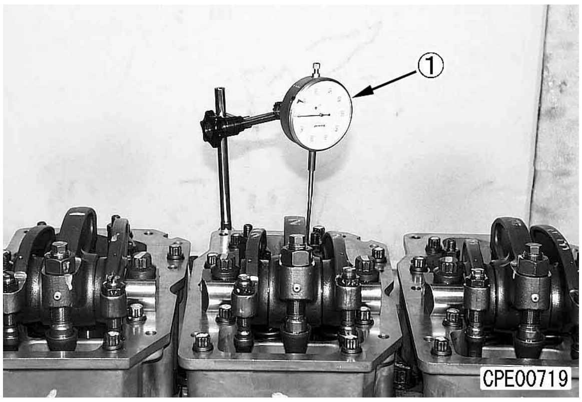


5) Crank the crankshaft 120° each time in the normal direction and repeat Steps 1) – 4) to adjust each injector according to the firing order.
6) After adjusting all the injectors, repeat Step 1) to set the No. 1 cylinder to compression top dead center.
   ★ The cylinder set to compression top dead center and the cylinder where the injector is to be inspected are different, so check the table below when carrying out the work.
   ★ Cylinder at compression top dead center and cylinder where injector is adjusted:

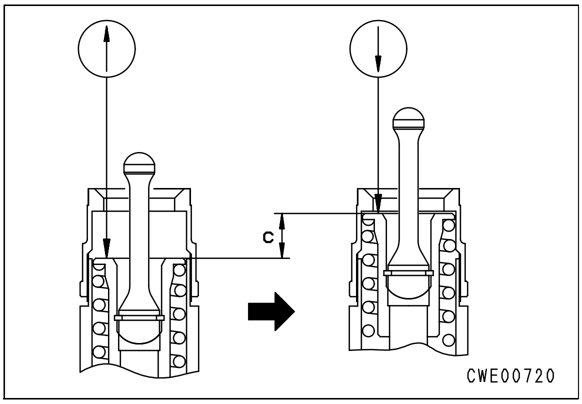
Compression TDC	1	5	3	6	2	4
Injector to adjust	2	4	1	5	3	6



7) Set dial gauge ① to the head of the plunger of the injector to be checked.
   ★ Use a dial gauge with a stroke of at least 30 mm.



8) Crank the crankshaft and measure lift **c** of the plunger at the point where the deflection of the dial gauge is the maximum.
   - ★ Maximum lift **c**: 20.00 mm
   - ★ If the measurement is not within the standard value, adjust the injector again.

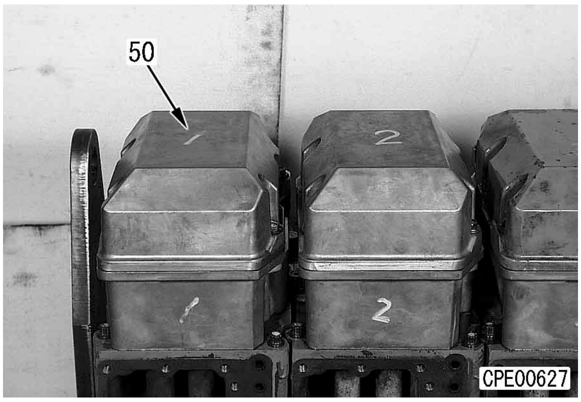


9) Repeat Steps 6) – 8) to check the injectors of each cylinder.

32. Cylinder head covers

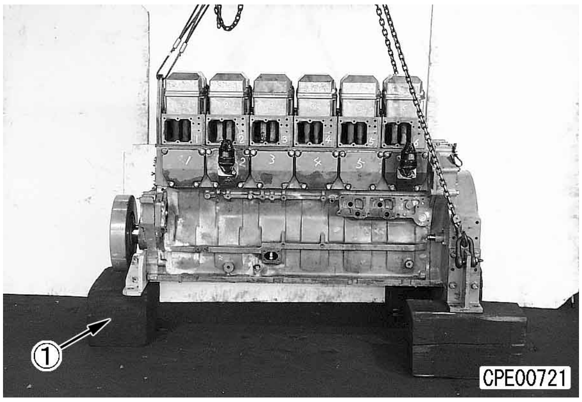
Fit O-rings and install 6 cylinder head covers (50).

kgm Mounting bolt:
9.8 ± 1.0 Nm {1 ± 0.1 kgm}



33. Suction pipe, oil pan

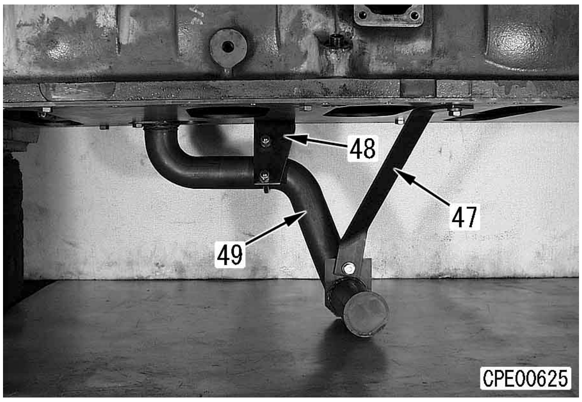
1) Sling engine assembly, set block ① under engine mount, then lower engine assembly again.



2) Fit O-ring and install suction tube (49), then install brackets (48) and (47).

   O-ring: **Engine oil (EO30-CD)**

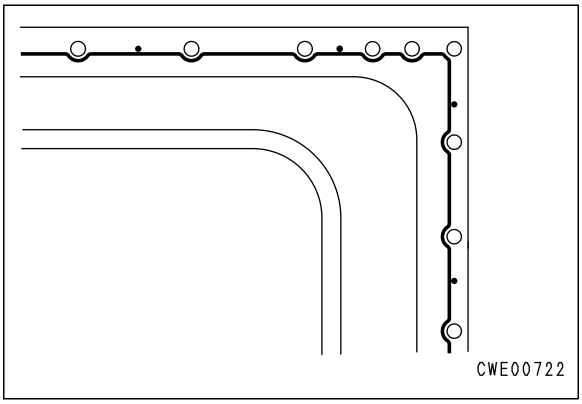
   - ★ Determine the position of the suction tube and brackets, then tighten the mounting bolts.
   - ★ After installing the suction tube, remove all the temporary mounting bolts (inside, outside) of the underplate.



3) Coat oil pan with gasket sealant.

Oil pan: **Gasket sealant (LG-7)**

★ Coat the gasket sealant as shown in the diagram with a line of width ϕ 2 – 3 mm.



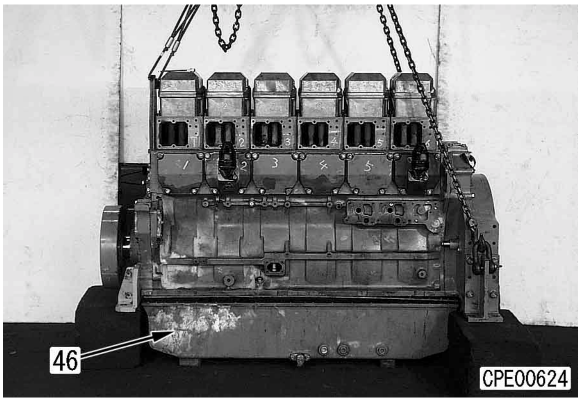
CWE00722

4) Sling engine assembly again, set oil pan (46) under cylinder block, then lower engine assembly on top of block.

★ The shape of the oil pan differs according to the machine it is mounted on.

5) Push oil pan (46) from under with jack, and install mounting bolts.

kg Oil pan: **70 kg**



CPE00624

6) Install oil pressure sensor (45).

kgm Oil pressure sensor:

13.4 ± 0.8 Nm {1.37 ± 0.08 kgm}

7) Fit gasket and install oil filler tube (44).

★ The shape of the oil filler tube differs according to the machine it is mounted on.

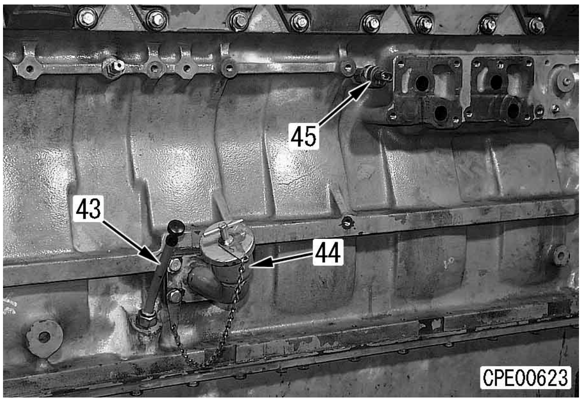
8) Install gauge tube (43) and insert dipstick.

★ Push the gauge tube against the oil pan and tighten the sleeve nut.

kgm Sleeve nut:

44.1 – 58.8 Nm {4.5 – 6 kgm}

★ The shape of the dipstick differs according to the machine it is mounted on.



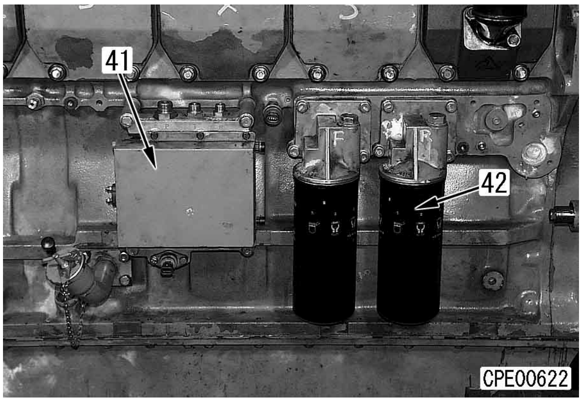
CPE00623

34. Oil filter assembly

Fit O-ring and install 2 oil filter assemblies (42).

35. ECVA & ECM

Install ECVA and ECM (41).



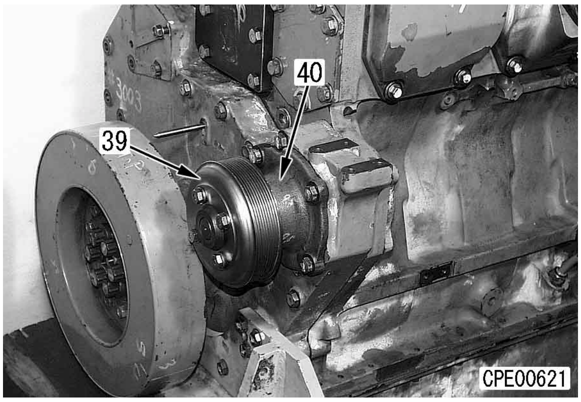
CPE00622

36. Fuel pump assembly

1) Fit gasket and install drive assembly (40).
2) Install pulley (39).

kgm Mounting bolt:
59 – 74 Nm {6 – 7.5 kgm}

★ The shape of the pulley differs according to the machine it is mounted on.



3) Temporarily assemble bracket (38) and fuel pump assembly (37) to engine.

kg Fuel pump assembly: **20 kg**

4) Tighten connecting bolt of bracket (38) and fuel pump assembly (37).

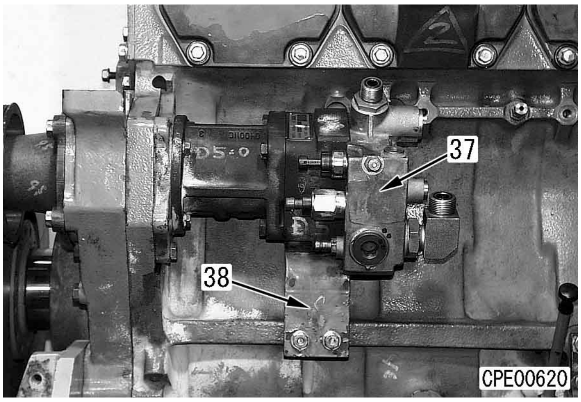
kgm Connecting bolt:
98 – 122.5 Nm {10 – 12.5 kgm}

5) Push fuel pump assembly (37) against front and tighten mounting bolts of fuel pump.

kgm Mounting bolt:
58.8 – 73.5 Nm {6 – 7.5 kgm}

6) Tighten mounting bolts of bracket (38).

kgm Mounting bolt:
58.8 – 73.5 Nm {6 – 7.5 kgm}



37. Intake manifold assembly

1) Raise intake manifold assembly (36) and install.

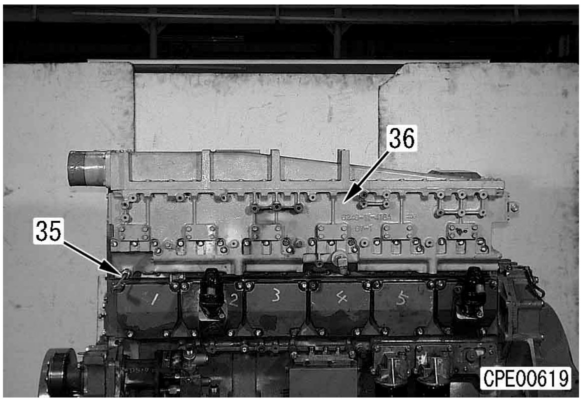
kg Intake manifold assembly: **110 kg**

★ When tightening the mounting bolts, start in the center and move outwards on each side in turn.

★ The shape of the intake manifold differs according to the machine it is mounted on.

2) Install boost sensor (35).

kgm Boost sensor:
13.4 ± 0.8 Nm {1.37 ± 0.08 kgm}



3) Fit O-ring and install fuel rail tube (34).

kgm Eyebolt:
24.5 – 34.3 Nm {2.5 – 3.5 kgm}

kgm Sleeve nut:
24 – 27 Nm {2.4 – 2.8 kgm}

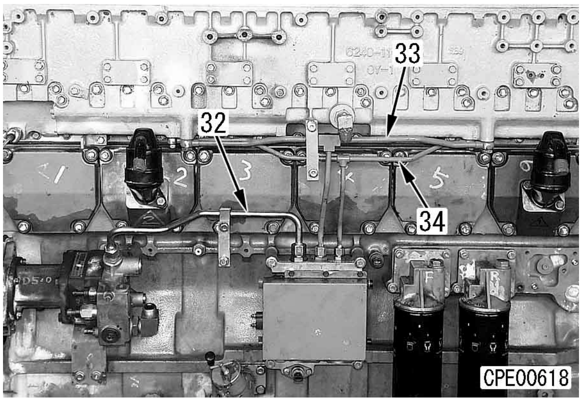
4) Fit O-ring and install timing rail tube (33).

kgm Eyebolt:
34.3 – 44.1 Nm {3.5 – 4.5 kgm}

kgm Sleeve nut:
43 – 47 Nm {4.4 – 4.8 kgm}

5) Fit O-ring and install fuel inlet tube (32).

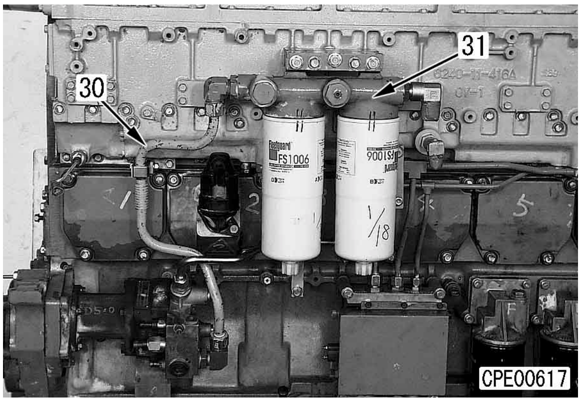
kgm Sleeve nut:
60 – 68 Nm {6.1 – 6.9 kgm}



38. Fuel filter assembly

1) Install fuel filter assembly (31).
2) Install fuel tube (30).

kgm Sleeve nut:
90 – 95 Nm {9.2 – 9.7 kgm}



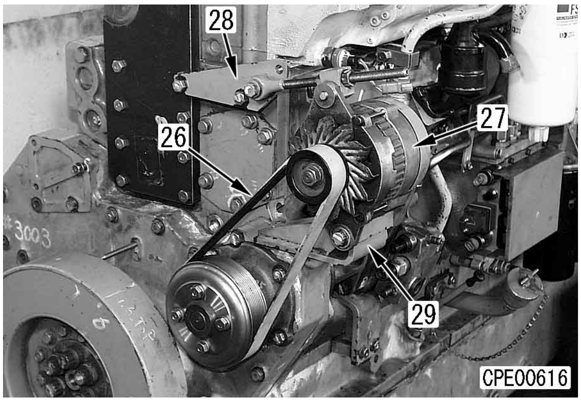
39. Alternator assembly

1) Install brackets (29) and (28).
   ★ The shape of the bracket differs according to the machine it is mounted on.
2) Install alternator assembly (27), then install alternator belt (26).
   ★ Adjust the belt tension. For details, see the manual for the machine.

kgm Adjustment bolt locknut:
147 – 245 Nm {15 – 25 kgm}

kgm Alternator top mounting bolt:
65 – 85 Nm {6.7 – 8.7 kgm}

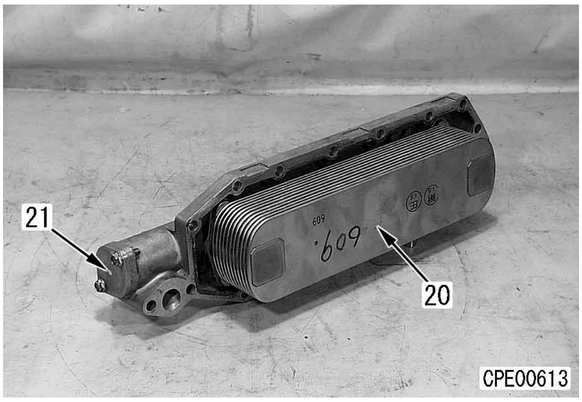
kgm Alternator bottom mounting bolt:
108 – 132 Nm {11 – 13.5 kgm}



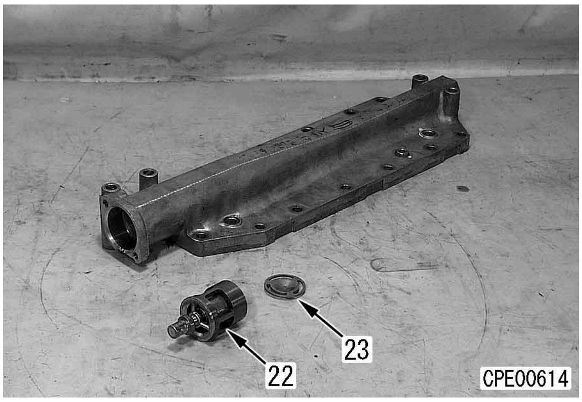
40. Oil cooler assembly

1) Assemble oil cooler assembly as follows.
   i) Fit O-ring and install plug (24) to cooler housing (25).

kgm Plug:
14.7 – 19.6 Nm {1.5 – 2.0 kgm}



   ii) Install valve (23) and thermo valve (22).
   ★ Insert valve (23) so that the convex surface faces the inside of the cooler housing.



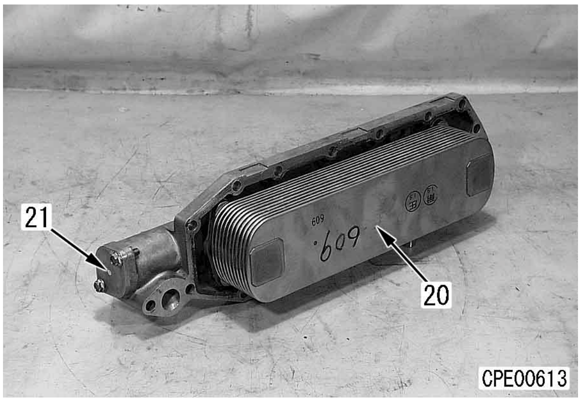
iii) Fit O-ring and install cover (21).

iv) Fit gasket and O-ring, and install element (20).

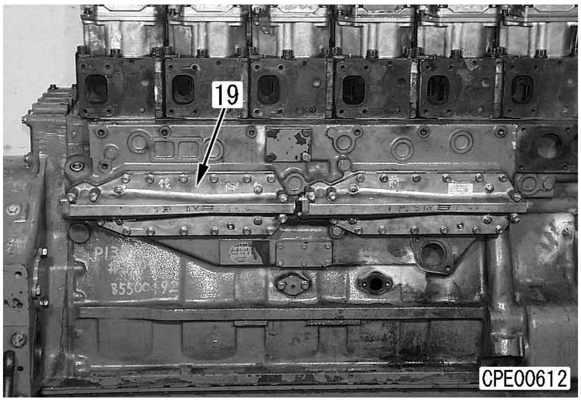
Both surfaces of gasket:
Gasket sealant (LG-6)

★ Install the element within 15 minutes after coating with gasket sealant.

kgm Mounting nut:
27.4 – 37.3 Nm {2.8 – 3.8 kgm}



2) Fit gasket and install 2 oil cooler assemblies (19).

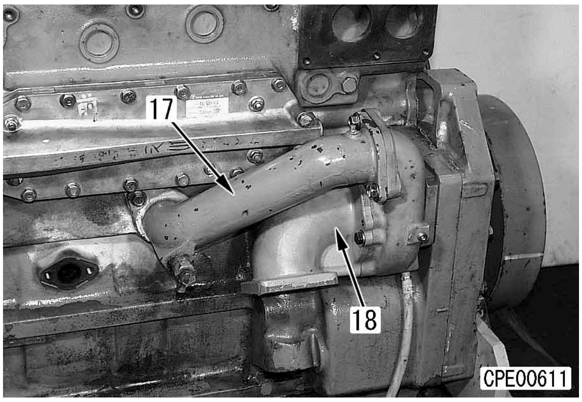


41. Water pump assembly

1) Fit O-ring and install water pump assembly (18).

2) Fit O-ring and install water connector (17).

★ The water connector can also be installed after installing the thermostat housing.

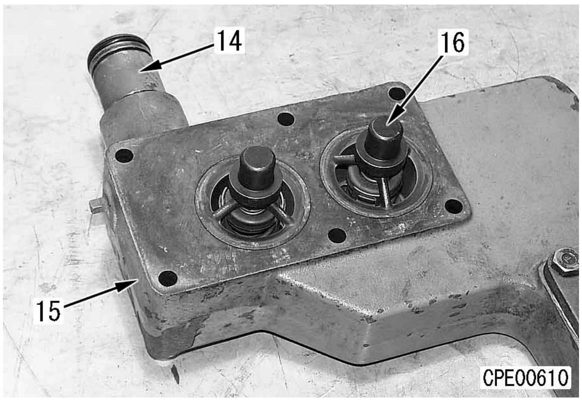


42. Thermostats, thermostat housing

1) Fit O-ring and install bypass tube (14) to thermostat housing (15).

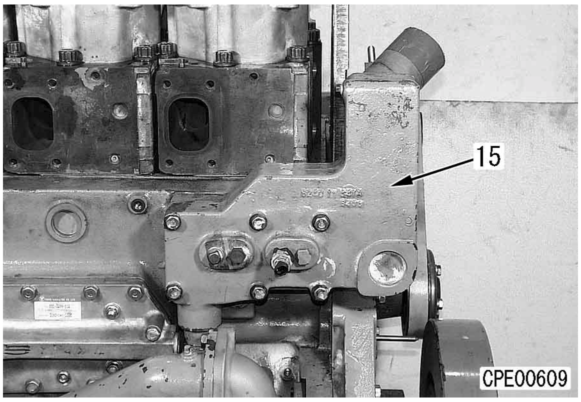
★ Push in the water connector until it contacts the inside of the thermostat housing.

2) Install 2 thermostats (16).

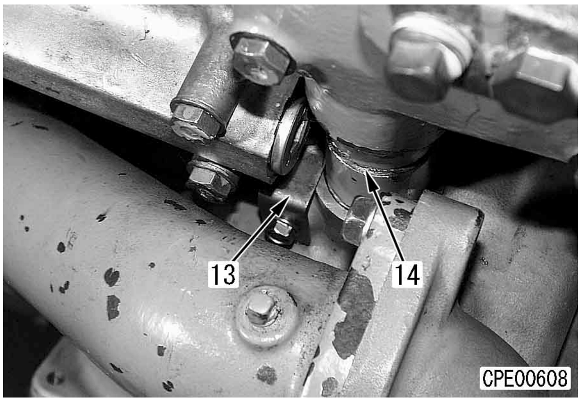


3) Fit gasket and install thermostat housing (15).
   ★ Coat the gasket on both sides with gasket sealant with a line of width ϕ 2 – 3 mm.

   Gasket: **Gasket sealant (LG-6)**

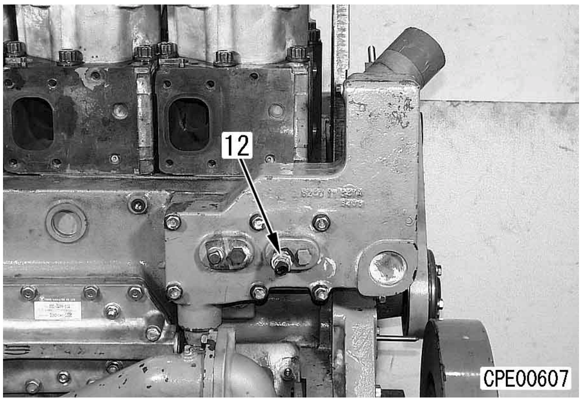


4) Push down bypass tube (14) until it contacts inside of water pump, then secure in position with stopper (13).



5) Install water temperature sensor (12).

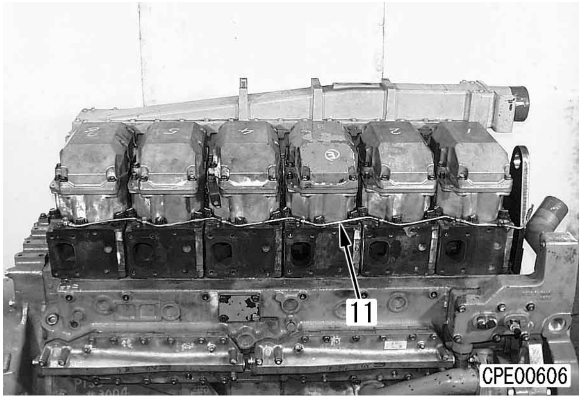
   kgm Water temperature sensor:
   13.4 ± 0.8 Nm {1.37 ± 0.08 kgm}



43. Exhaust manifold assembly

1) Install air bleed tube (11).

   kgm Eyebolt:
   9.8 – 12.7 Nm {1.0 – 1.3 kgm}



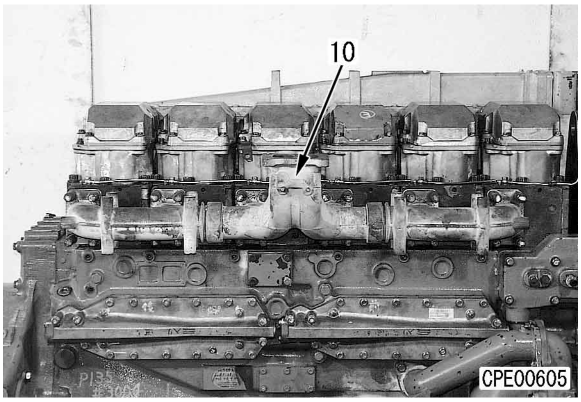
2) Fit gasket, then raise exhaust manifold assembly (10) and install.
   - ★ Install the gasket so that the [OUT] stamp faces the outside of the engine.

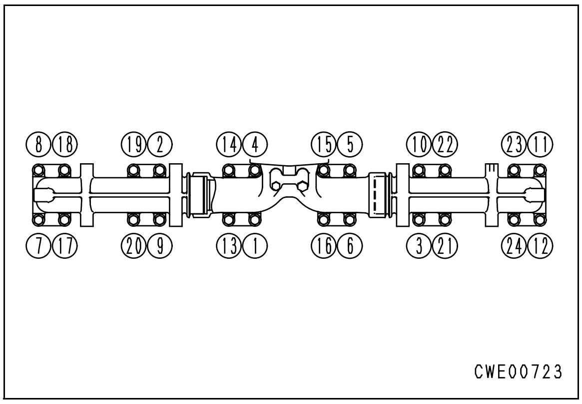
   Exhaust manifold assembly: **37 kg**

   - ★ Tighten the mounting bolts in the specified order.

   Thread portion, seat surface of mounting bolt:
   Seizure prevention and rust prevention lubricant (LC-G)

   Mounting bolt:
   1st step : 39.2 – 58.8 Nm {4 – 6 kgm}
   2nd step:
   11.2 – 122.5 Nm {11.5 – 12.5 kgm}





44. Turbocharger assembly

1) Fit gasket, then raise turbocharger assembly (9) and install.

   Turbocharger assembly: **45 kg**

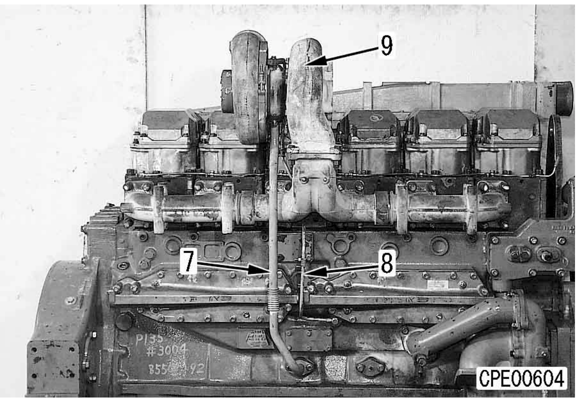
   Mounting bolt:
   58.8 – 73.5 Nm {6.0 – 7.5 kgm}

   - ★ The shape of the turbocharger differs according to the machine it is mounted on.

2) Fit gasket and install lubrication inlet tube (8) and lubrication outlet tube (7).

   Eyebolt for inlet tube:
   24.5 – 34.3 Nm {2.5 – 3.5 kgm}

   - ★ The shape of the lubrication tube differs according to the machine it is mounted on.



3) Install bracket (6) and intake connector (5).

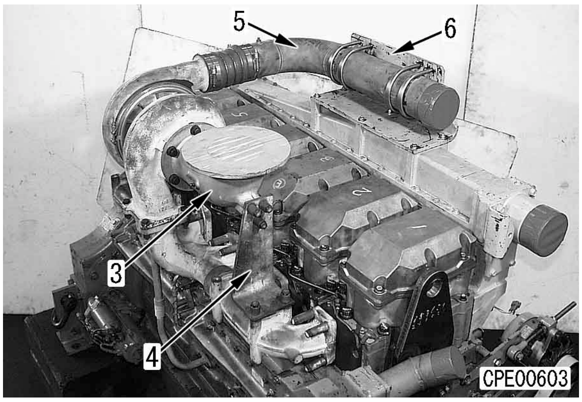
   Clamp bolt:
   9.8 ± 1.0 Nm {1.0 ± 0.1 kgm}

   - ★ The shape of the intake piping differs according to the machine it is mounted on.

4) Install bracket (4) and exhaust connector (3).

   Bracket mounting bolt:
   Seizure prevention and rust prevention lubricant (LC-G)

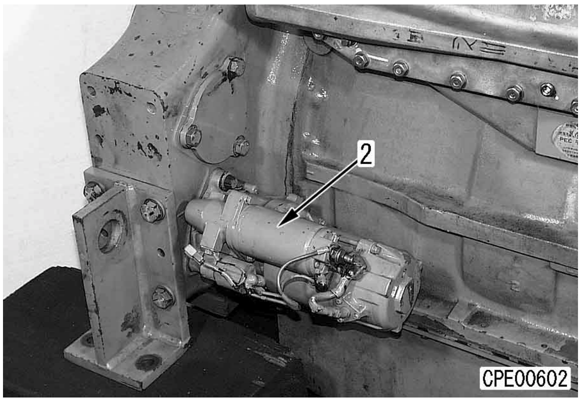
   - ★ The shape of the exhaust piping differs according to the machine it is mounted on.



45. Starting motor assembly

Fit gasket and install starting motor assembly (2).

★ The number of the starting motors differs according to the machine they are mounted on.

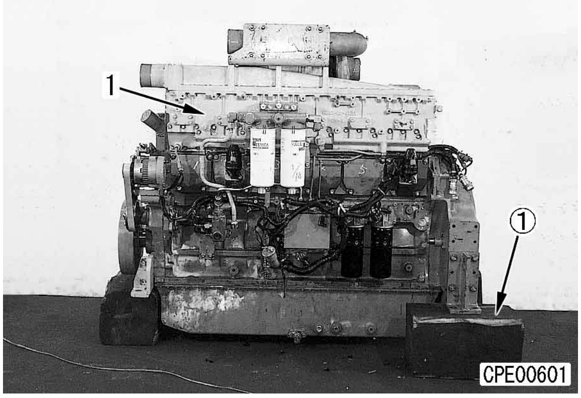


46. Wiring

Install all wiring.

★ The large connectors for ECVA & ECM are secured with bolts.

kg Engine assembly: Approx. **2,800 kg**



WASHING PARTS

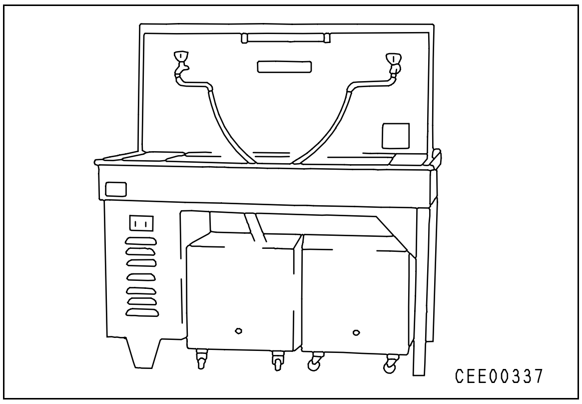
★ When washing, divide the parts into small parts and large parts, and wash the small parts in a bath like the one shown in the diagram.

★ Before washing disassembled parts, remove the gasket and carbon with a wire brush.

★ For the places using gasket sealant, check inside the tap holes that there is no gasket remaining before washing.

★ After washing, dry the washing fluid off completely with compressed air.

Be particularly careful that there is no washing fluid remaining in the bolt holes.



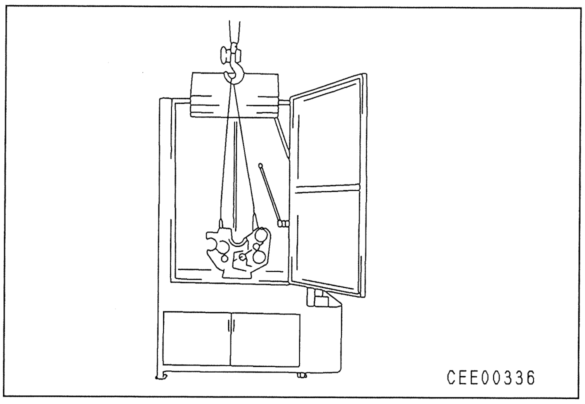
WASHING CYLINDER BLOCK

1. Before washing the cylinder block, remove the plugs of the oil line and cooling line.
2. Use a washing machine like the one in the diagram, and clean the oil line and cooling line thoroughly with the jet cleaner nozzle of the cleaning machine.
3. Clean with a stiff wire brush to prevent any metal particles from remaining in the oil line.
4. Use sandpaper to polish the O-ring contact surface smooth at the bottom of the liner bore and to remove the burrs and flashes from the liner bore.
5. Dry off the cleaning fluid completely with compressed air.

   Be particularly careful not to leave any cleaning fluid in the bolt holes.
6. Press fit the plugs for the oil line and cooling line completely.

   kgm Outer circumference of plug :

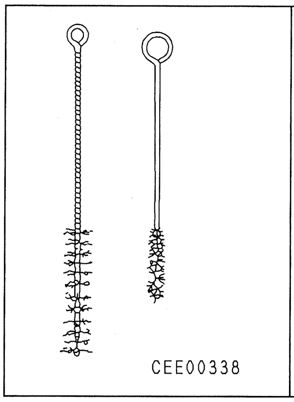
   Liquid adhesive (LT-4)


CEE00336

WASHING CRANKSHAFT

★ If the engine is disassembled, wash the crankshaft before inspecting the parts.

1. Clean the crankshaft with a steam cleaner, then use a wire brush like the one shown in the diagram to clean all the oil holes.
2. After washing, dry the cleaning fluid off thoroughly with compressed air.
3. Use a small magnet to completely remove all the metal particles from the oil holes.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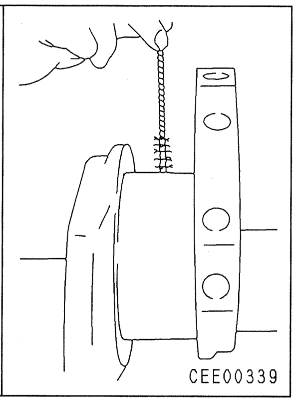
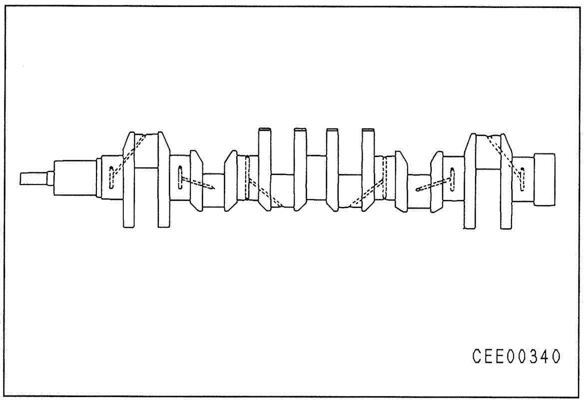

CEE00339


CEE00340

MEASURING PARTS

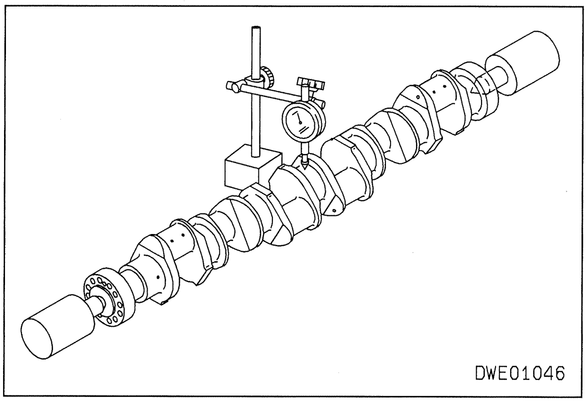
★ Before reassembling disassembled parts, check visually that there are no cracks, damage, or abnormal wear.

★ If no abnormalities are found during the visual inspection, use an accurate measuring device to measure the specified position precisely.

★ Action and judgement on whether the parts can be reused shall be in accordance with MAINTENANCE STANDARD.

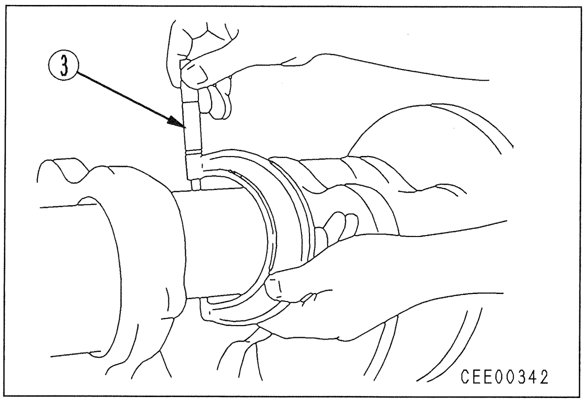
MEASURING CURVATURE OF CRANKSHAFT

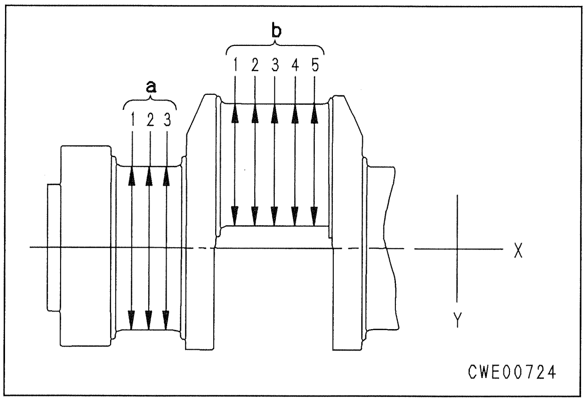
1. Support the center of both ends of the crankshaft with lathes, put the indicator of the dial gauge ② perpendicularly in contact with the journal at the center, and set it to 0.
2. Rotate the crankshaft one turn, and measure the maximum reading and minimum reading of the dial gauge.
   ★ Do not measure with both ends of the crankshaft supported on V blocks. This method produces an error because of the eccentric wear of the journal.


DWE01046

MEASURING OUTSIDE DIAMETER OF CRANKSHAFT JOURNAL

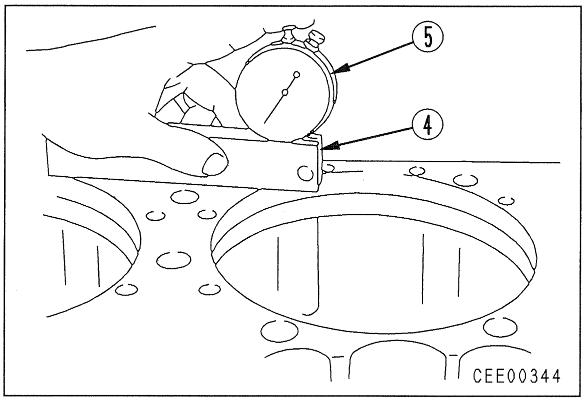
1. Using micrometer ③, measure the outside diameter of the main journal and crank pin journal in the X and Y directions.
   ★ Main journal portion **a**: Measure at 3 places
   Crank pin journal portion **b**: Measure at 5 places





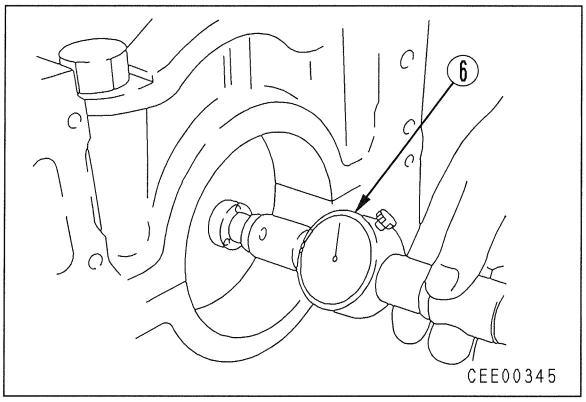
MEASURING DEPTH OF CYLINDER LINER COUNTERBORE

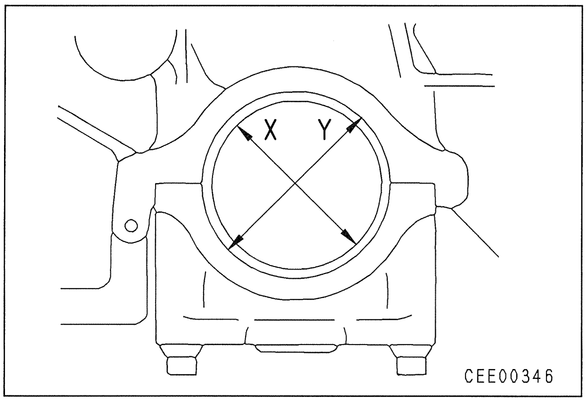
1. Set depth gauge ⑤ on gauge block ④, then set the gauge indicator to 0.
2. Set the gauge block parallel with the top surface of the cylinder block, and measure the depth of the counterbore.
   ★ Clean the counterbore and top surface of the cylinder block before measuring.



MEASURING MAIN BEARING BORE

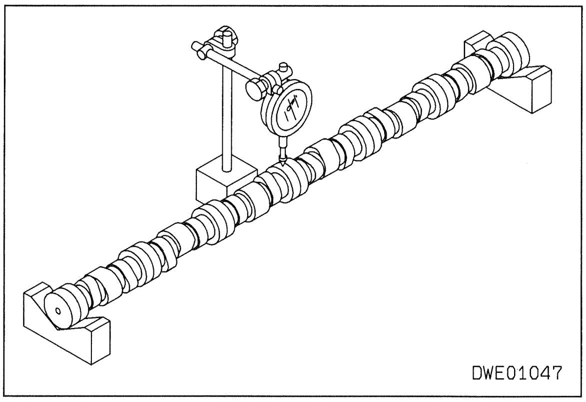
1. Install the main bearing cap to the cylinder block, and tighten to the specified torque.
2. Using a dial bore gauge or inside micrometer ⑥, measure the main bearing bore.
   ★ When measuring the bore, measure in two directions (X and Y).





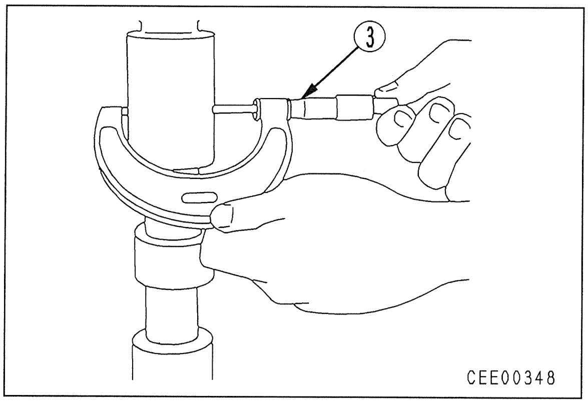
MEASURING CURVATURE OF CAMSHAFT

1. Support the center of both ends of the camshaft with lathes, put the indicator of dial gauge ② perpendicularly in contact with the journal at the center, and set it to 0.
2. Rotate the camshaft one turn, and measure the maximum reading and minimum reading of the dial gauge.



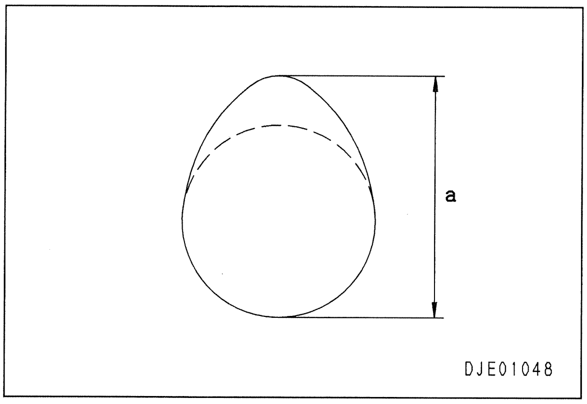
MEASURING OUTSIDE DIAMETER OF CAMSHAFT JOURNAL

1. Using micrometer ③, measure the outside diameter of the journal.



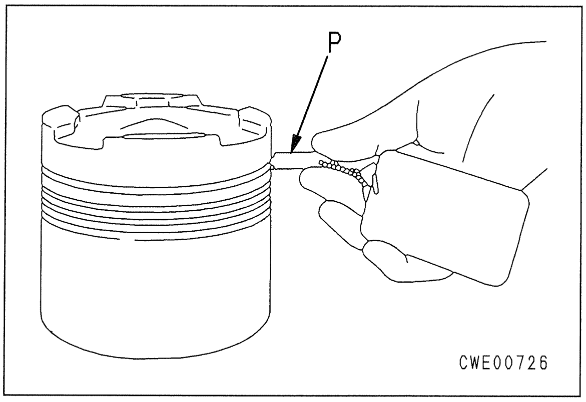
MEASURING HEIGHT OF CAM

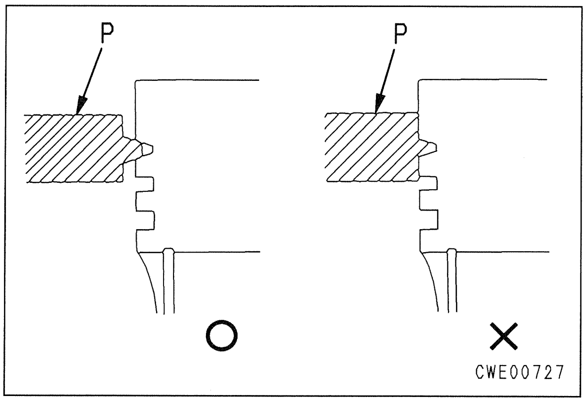
1. Using micrometer ③, measure cam height a for the intake, exhaust, and injector.



MEASURING PISTON RING GROOVE

1. **Measuring keystone ring groove**
   Push piston ring wear gauge **P** lightly into the ring grooves of the top ring and second ring, and measure the wear of the ring groove.
   ★ Carry out the measurement at several places.
   ★ If the shoulder of the wear gauge contacts the piston, replace the piston.

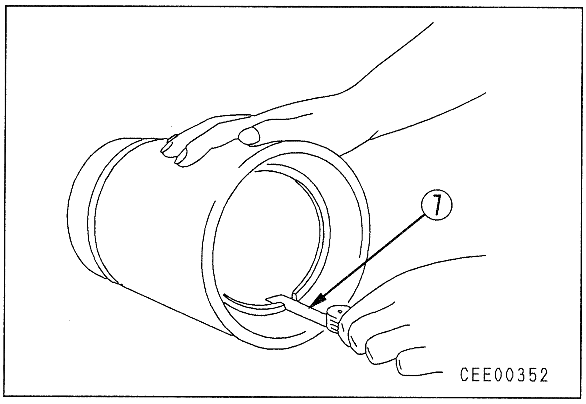




2. **Measuring oil ring groove**
   Assemble a new ring in the oil ring groove, and measure the clearance at the top and bottom with a feeler gauge.
   ★ If the clearance is greater than the permissible limit, replace the piston.

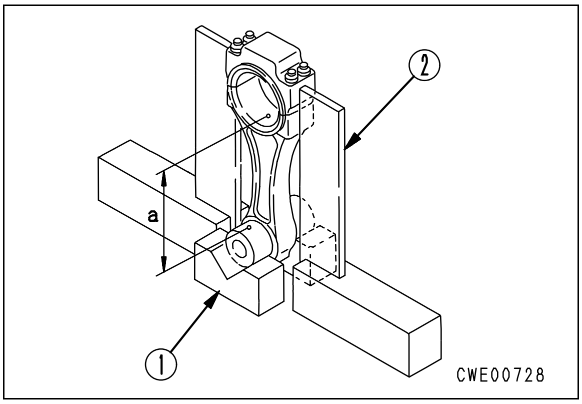
MEASURING PISTON RING END GAP

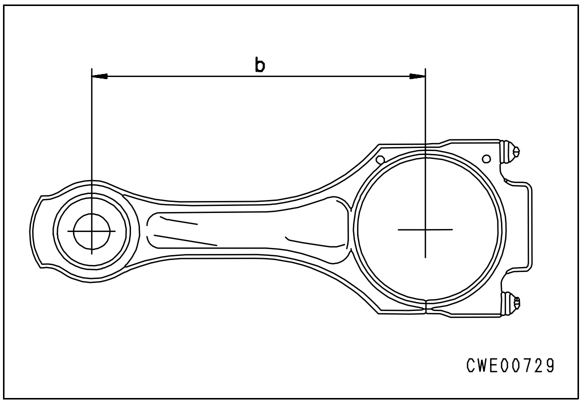
1. Assemble the piston ring to the cylinder liner, push the piston ring into the area of the cylinder where there is least wear, then measure the piston ring end gap with feeler gauge ⑦.
   ★ Insert the piston ring so that it is at right angles to the sliding portion of the liner.



MEASURING LENGTH OF CONNECTING ROD

1. Install the connecting rod cap and tighten the mounting bolts to the specified torque.
   - ★ Do not assemble the connecting rod bearing.
2. Assemble a new piston pin in the hole at the small end of the connecting rod.
   - ★ Coat the piston pin with grease (G2-LI) before installing.
3. Support both ends of the piston pin on V blocks ①, support both ends of the connecting rod on square blocks ②, and stand the connecting rod perpendicularly.
4. Measure distance **a** between the big end and small end with a height gauge.
5. Measure the inside diameter of the big end and small end.
6. Calculate the value for connecting rod length **b** as follows.
   - ★ **b** = (ID of big end ÷ 2) + (ID of small end ÷ 2) + **a**

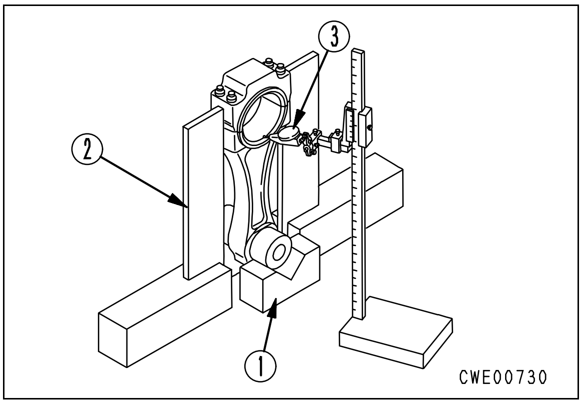


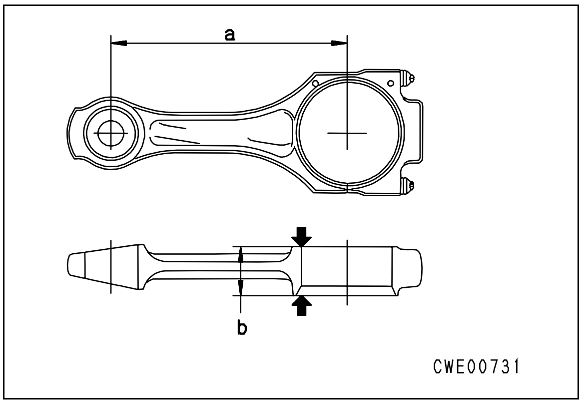


MEASURING CURVATURE, TWISTING OF CONNECTING ROD

1. Measuring curvature

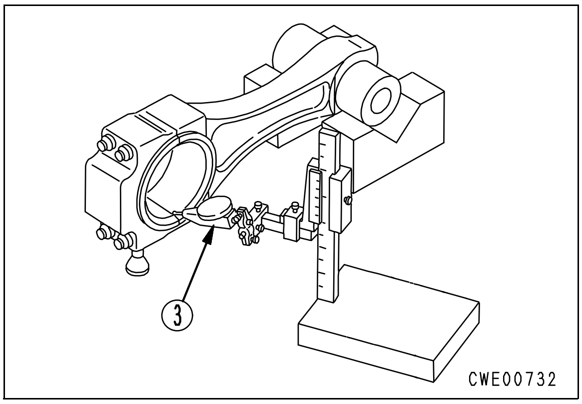
1) Install the connecting rod cap and tighten the mounting bolts to the specified torque.
   - ★ Do not assemble the connecting rod bearing.
2) Assemble a new piston pin to the small end of the connecting rod.
   - ★ Coat the piston pin with grease (G2-LI).
3) Support both ends of the piston pin on V blocks ①, support both ends of the connecting rod on square blocks ②, and stand the connecting rod perpendicularly.
4) Set the indicator of height gauge ③ at the front of the hole at the big end, set it in contact with the bottom, then set the gauge to 0.
5) Move the height gauge to the opposite side by a distance equal to the width of the big end, and read the measurement of the gauge.
6) Calculate the value for the curvature as follows.
   - ★ Curvature = (**a** ÷ **b**) x Actual measured value

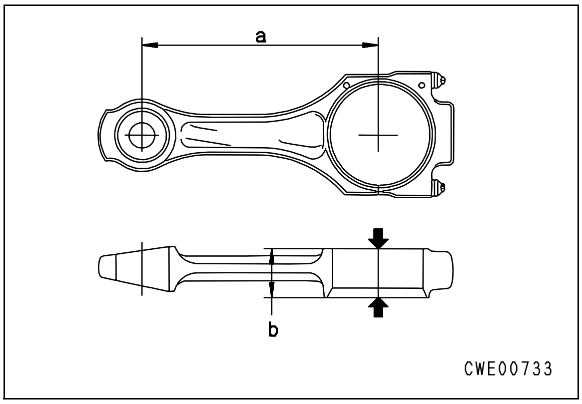




2. Measuring twisting

1) From the condition for measuring the curvature above, remove the square blocks, tip the connecting rod over, and support the conical part at the big end with the tip of a jack.
2) Using the same procedure as when measuring the curvature, move the point 90° and measure the big end.
3) Calculate the value for the twisting as follows.
   - ★ Twisting = (**a** ÷ **b**) x Actual measured value

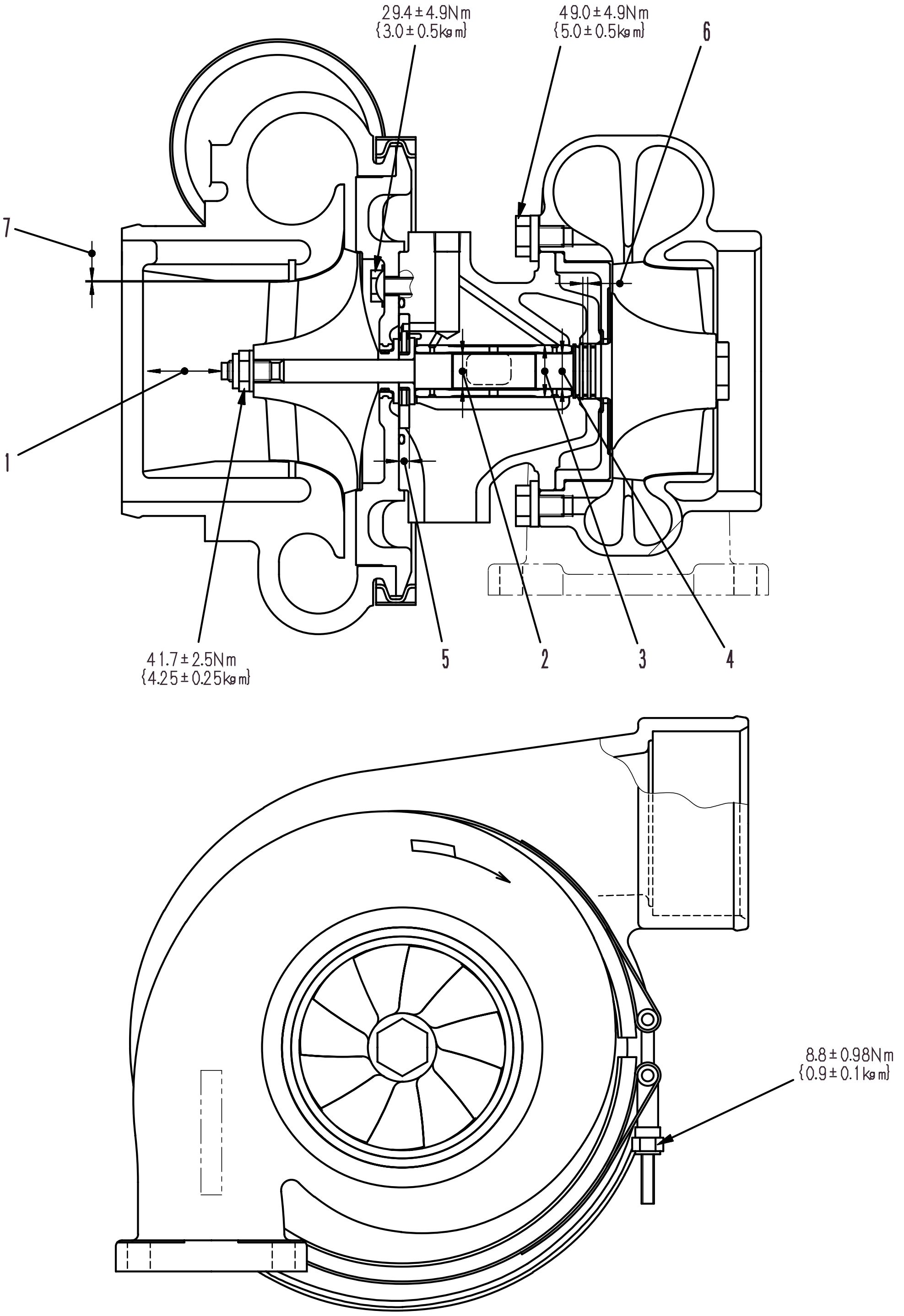




14 MAINTENANCE STANDARD

TURBOCHARGER

KTR110L



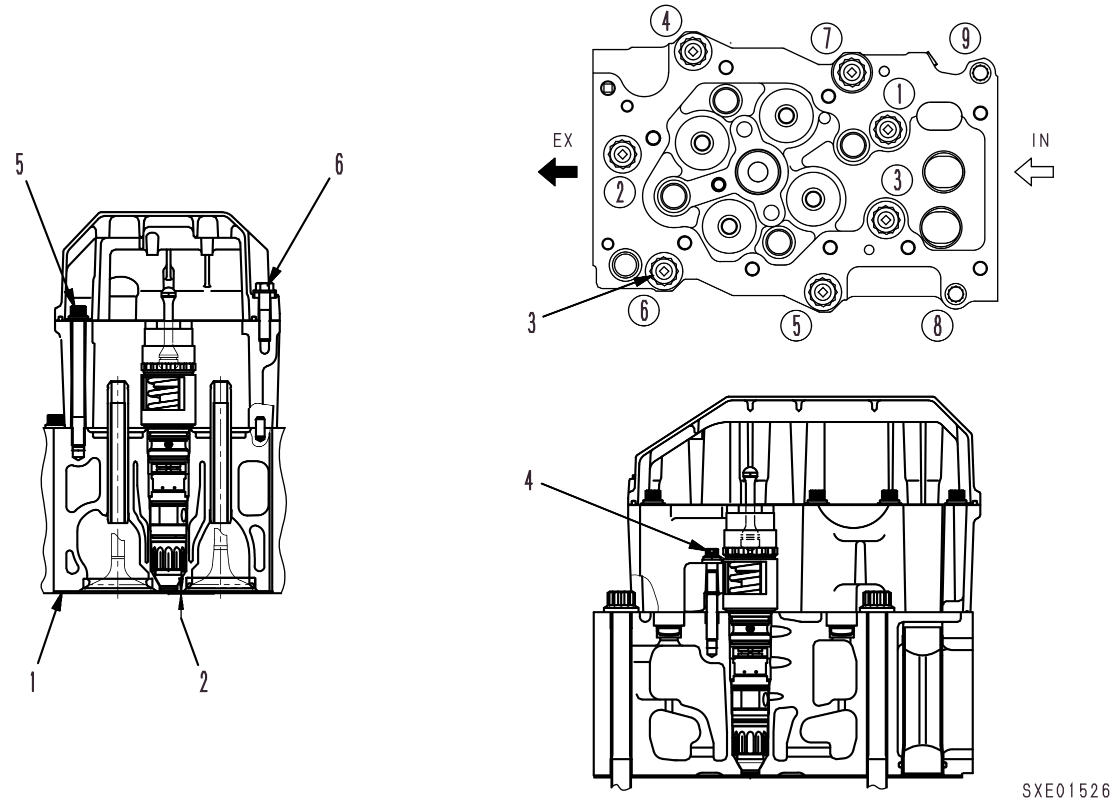
SXE01525

Unit: mm

<table>
<tr><th>No.</th><th colspan="2">Check item</th><th colspan="5">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="2">1</td><td colspan="2" rowspan="2">End play
(play in axial direction)</td><td colspan="3">Standard size</td><td colspan="2">Repair limit</td><td rowspan="2">Replace parts related to thrust</td></tr>
<tr><td colspan="3">0.08 – 0.13</td><td colspan="2">0.18</td></tr>
<tr><td>2</td><td colspan="2">Radial play
(play in radial direction)</td><td colspan="3">0.26 – 0.46</td><td colspan="2">0.60</td><td>Replace parts related to bearing</td></tr>
<tr><td rowspan="3">3</td><td colspan="2" rowspan="3">Outside diameter of journal bearing, inside diameter of center housing</td><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td colspan="2">Repair limit</td><td rowspan="11">Replace</td></tr>
<tr><td>Shaft</td><td>Hole</td><td>Shaft</td><td>Hole</td></tr>
<tr><td>25</td><td>–0.050
–0.067</td><td>+0.021
0</td><td>24.92</td><td>25.03</td></tr>
<tr><td rowspan="2">4</td><td colspan="2">Inside diameter of journal bearing, outside diameter of wheel shaft</td><td>17</td><td>–0.032
–0.043</td><td>+0.009
–0.003</td><td>16.95</td><td>17.04</td></tr>
<tr><td colspan="2">Curvature of wheel shaft</td><td colspan="5">Repair limit: 0.010 (total deflection of indicator)</td></tr>
<tr><td rowspan="3">5</td><td colspan="2" rowspan="3">Thickness of thrust bearing</td><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td colspan="2">Repair limit</td></tr>
<tr><td>Width</td><td>Groove</td><td>Width</td><td>Groove</td></tr>
<tr><td>5</td><td>–0.08
–0.11</td><td>+0.02
0</td><td>4.84</td><td>5.04</td></tr>
<tr><td rowspan="2">6</td><td rowspan="2">Thickness of seal ring</td><td>Turbine end</td><td>2.3</td><td>–0.08
–0.10</td><td>–0.03
–0.04</td><td>2.15</td><td>2.35</td></tr>
<tr><td>Blower end</td><td>2</td><td>–0.08
–0.10</td><td>–0.03
–0.04</td><td>1.85</td><td>2.05</td></tr>
<tr><td>7</td><td colspan="2">Clearance between blower housing and impeller</td><td colspan="5">Clearance limit: (Min.) 0.20</td><td>Replace parts related to bearing</td></tr>
</table>

CYLINDER HEAD

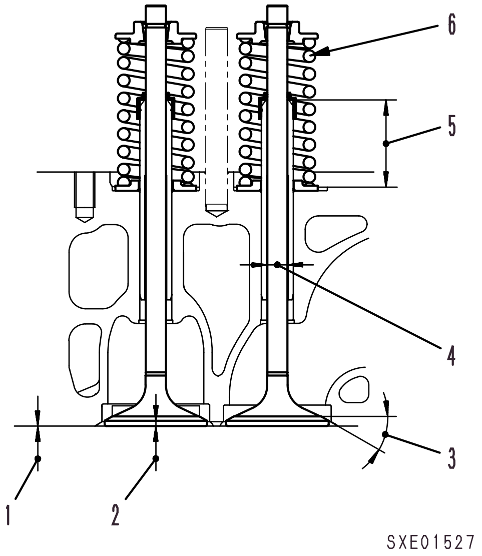
★ Nos. ① – ⑨ in the drawing indicate the order for tightening the cylinder head mounting bolts.



Unit: mm

No.	Check item	Criteria				Remedy
1	Distortion of cylinder head mounting surface	Tolerancee		Repair limit		Grind to correct, or replace
		Max. 0.05		0.1		
		Standard: 2.42 – 2.92				Replace nozzle sleeve
2	Protrusion of nozzle	Sequence		Target Nm{kgm}	Range Nm{kgm}	Tighten in order shown in diagram above
3	Tightening torque of cylinder head mounting bolt (Coat bolt thread and washer with lubricant (LM-P))	Bolts No. ① to ⑦	1st Step	245 {25}	235 – 255 {24 – 26}	
			2nd Step	382 {39}	373 – 392 {38 – 40}	
			3rd Step	Tighten 90°	$90^{\circ}{}^{+30^{\circ}}_{0}$	
		Bolts No. ⑧ and ⑨		98 {10}	93 – 103 {9.5 – 10.5}	
4	Tightening torque of injector mounting bolt (Coat bolt thread and area below bolt head with lubricant (LM-P))	1st Step		29 {3}	25 – 34 {2.5 – 3.5}	Tighten
		2nd Step		Tighten 90°	$90^{\circ}{}^{+30^{\circ}}_{0}$	
5	Tightening torque of rocker arm housing mounting bolt	Target Nm{kgm}		Range Nm{kgm}		
		86 {8.75}		78 – 93 {8.0 – 9.5}		
6	Tightening torque of cylinder head cover	10 {1}		9 – 11 {0.9 – 1.1}		

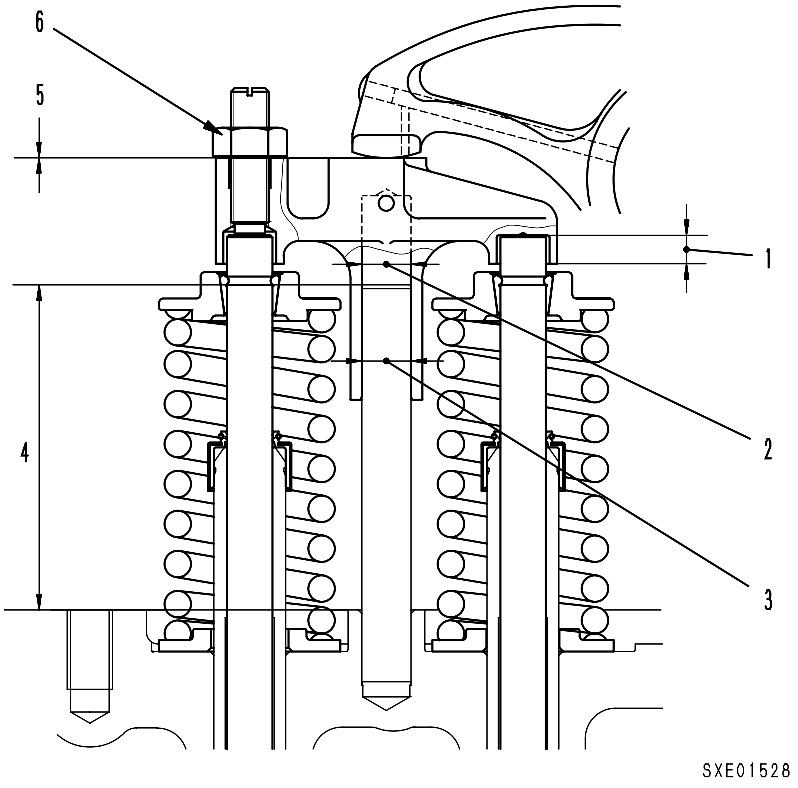
VALVE, VALVE GUIDE



Unit: mm

<table>
<tr><th>No.</th><th colspan="2">Check item</th><th colspan="7">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="2">1</td><td colspan="2" rowspan="2">Sinking of valve</td><td colspan="2"></td><td colspan="3">Standard</td><td colspan="2">Repair limit</td><td rowspan="2">Replace valve or valve seat</td></tr>
<tr><td colspan="2">Intake/exhaust valve</td><td colspan="3">0</td><td colspan="2">0.4</td></tr>
<tr><td rowspan="3">2</td><td colspan="2" rowspan="3">Thickness of valve lip</td><td colspan="2"></td><td colspan="2">Standard size</td><td colspan="2">Tolerance</td><td>Repair limit</td><td rowspan="3">Replace valve</td></tr>
<tr><td colspan="2">Intake valve</td><td colspan="2">3.2</td><td colspan="2">–</td><td>2.7</td></tr>
<tr><td colspan="2">Exhaust valve</td><td colspan="2">3.3</td><td colspan="2">–</td><td>2.8</td></tr>
<tr><td rowspan="3">3</td><td colspan="2" rowspan="3">Angle of valve seat</td><td colspan="2"></td><td colspan="3">Standard</td><td colspan="2">Tolerance</td><td rowspan="11">Replace</td></tr>
<tr><td colspan="2">Intake valve</td><td colspan="3">30°</td><td colspan="2">±0° 15’</td></tr>
<tr><td colspan="2">Exhaust valve</td><td colspan="3">45°</td><td colspan="2">±0° 15’</td></tr>
<tr><td rowspan="4">4</td><td rowspan="3">Outside diameter of valve stem</td><td rowspan="2">Intake valve</td><td colspan="2">Standard size</td><td colspan="3">Tolerance</td><td colspan="2">Repair limit</td></tr>
<tr><td colspan="2" rowspan="2">12</td><td colspan="3">–0.060
–0.080</td><td colspan="2">11.90</td></tr>
<tr><td>Exhaust valve</td><td colspan="3">–0.092
–0.107</td><td colspan="2">11.80</td></tr>
<tr><td colspan="2">Inside diameter of valve guide</td><td colspan="2">12</td><td colspan="3">–0.001
–0.019</td><td colspan="2">12.10</td></tr>
<tr><td>5</td><td colspan="2">Protrusion of valve guide</td><td colspan="2">43</td><td colspan="3">±0.5</td><td colspan="2">–</td></tr>
<tr><td rowspan="3">6</td><td colspan="2" rowspan="2">Valve spring</td><td>Free length</td><td colspan="2">Installed length</td><td colspan="3">Installed load N{kg}</td><td>Permissible load N{kg}</td></tr>
<tr><td>99.6</td><td colspan="2">87.4</td><td colspan="3">647±65{66.0±6.6}</td><td>608{62.0}</td></tr>
<tr><td colspan="2">Perpendicularity of valve spring</td><td colspan="7">Repair limit: 2°</td></tr>
</table>

CROSSHEAD AND CROSSHEAD GUIDE

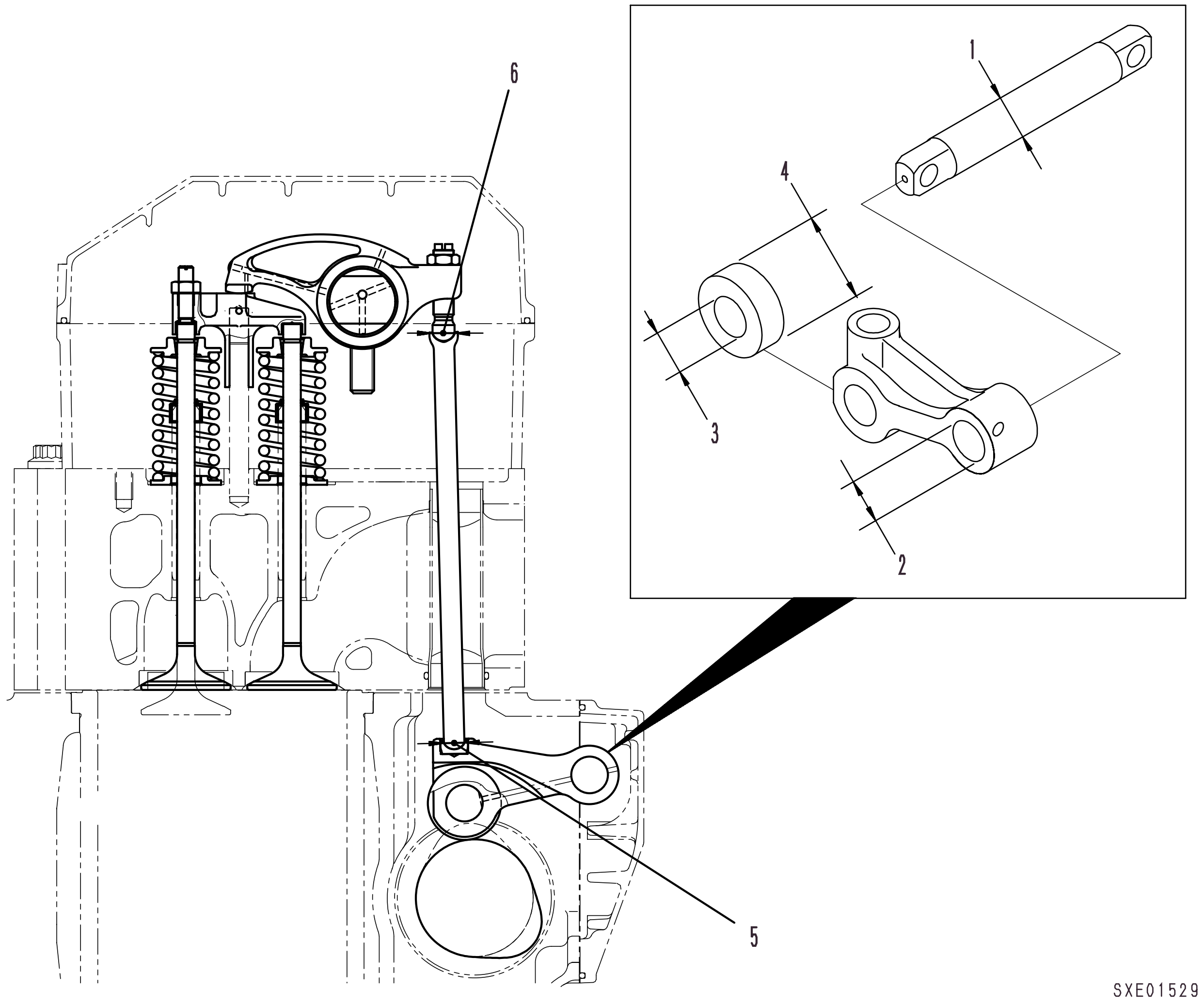


Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="4">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Depth of crosshead stem</td><td>Standard size</td><td colspan="2">Tolerance</td><td>Repair limit</td><td rowspan="4">Replace</td></tr>
<tr><td>7.5</td><td colspan="2">+0.3
0</td><td>–</td></tr>
<tr><td>2</td><td>Inside diameter of crosshead</td><td>13</td><td colspan="2">+0.10
+0.05</td><td>13.21</td></tr>
<tr><td rowspan="3">3</td><td>Outside diameter of cross-head guide</td><td>13</td><td colspan="2">+0.039
+0.028</td><td>13.00</td></tr>
<tr><td rowspan="2">Clearance between cross-head guide and crosshead</td><td colspan="2">Standard clearance</td><td colspan="2">Clearance limit</td><td rowspan="2">Adjust</td></tr>
<tr><td colspan="2">0.011 – 0.072</td><td colspan="2">–</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Protrusion of crosshead guide</td><td colspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="4">Replace</td></tr>
<tr><td colspan="2">86</td><td colspan="2">±0.25</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Valve clearance (at cold)</td><td colspan="2">Intake valve</td><td colspan="2">Exhaust valve</td></tr>
<tr><td colspan="2">0.32</td><td colspan="2">0.62</td></tr>
<tr><td>6</td><td>Tightening torque of cross-head lock nut</td><td colspan="4">59 ± 6 Nm {6.0 ± 0.6 kgm}</td><td>Tighten</td></tr>
</table>

TAPPET AND PUSH ROD

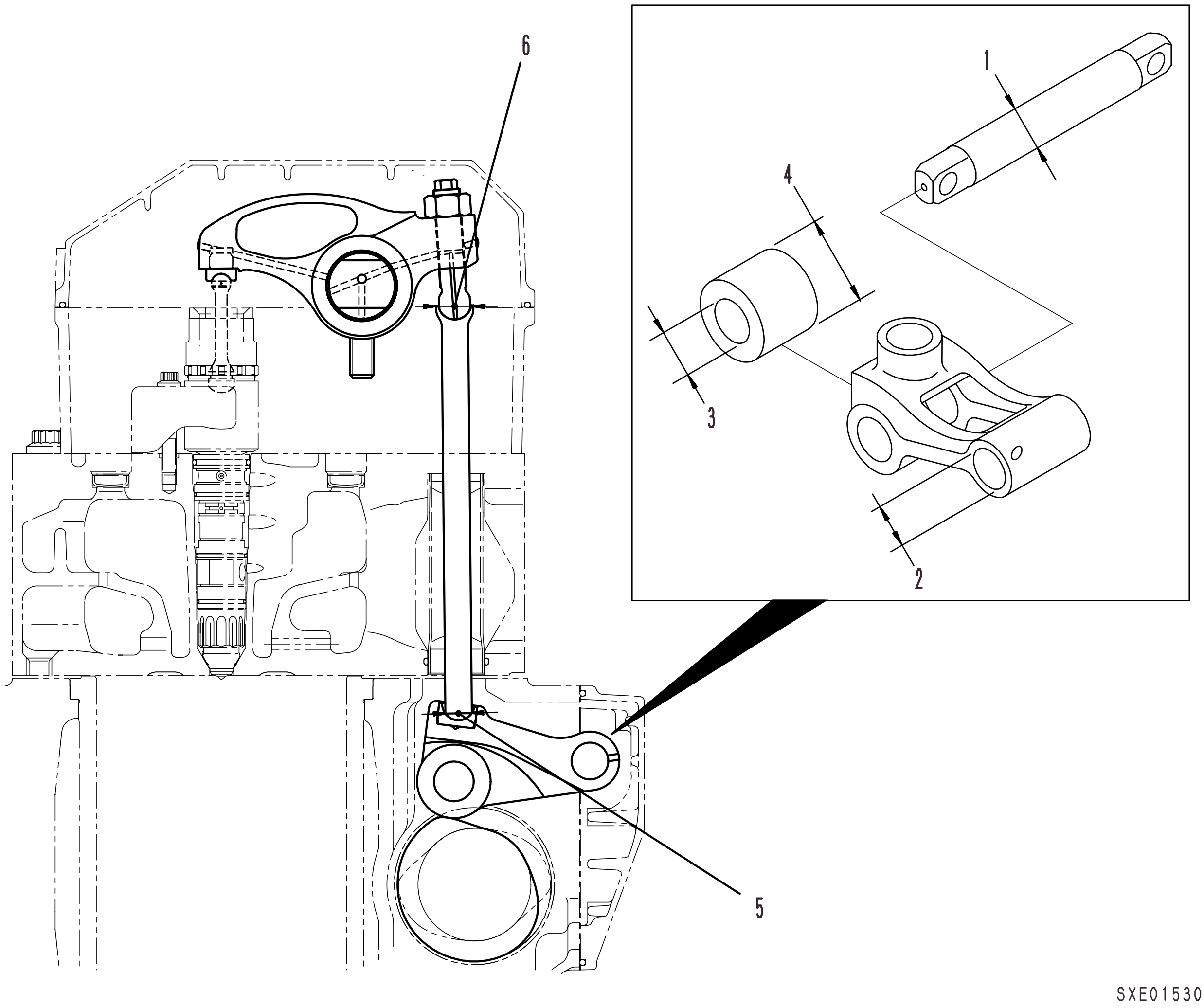
INTAKE VALVE, EXHAUST VALVE



Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Tolerance	Repair limit	
1	Outside diameter of cam follower shaft	25	–0.038 –0.053	25	Replace
2	Inside diameter of cam follower lever	25	–0.021 0	25	
3	Inside diameter of cam follower roller	25.167	±0.01	25.3	
	Outside diameter of cam follower roller pin	25	+0.075 +0.063	25.0	
4	Outside diameter of cam follower roller	50	+0.025 0	49.75	
5	Diameter of push rod tip ball	15.836	0 –0.2	–	
6	Inside diameter of push rod socket	16.676	0 –0.2	–	

IINJECTOR

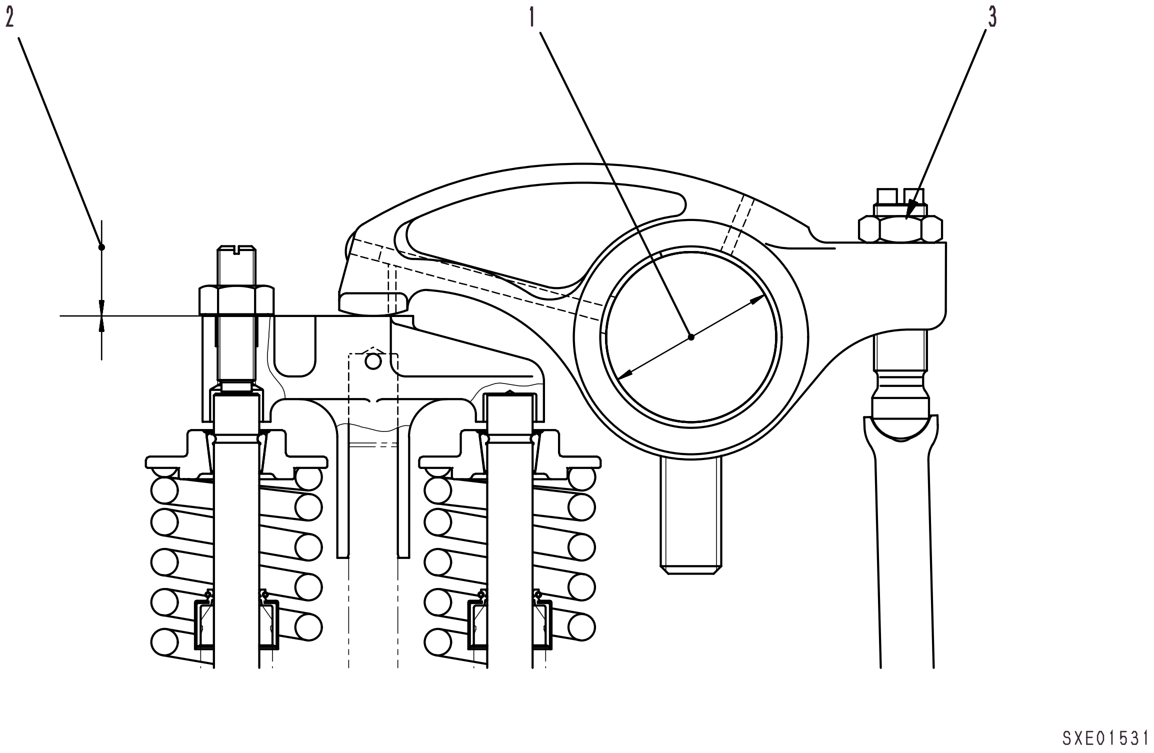


Unit: mm

No.	Check item	Criteria			Remedy
		Standard size	Tolerance	Repair limit	
1	Outside diameter of cam follower shaft	25	–0.038 –0.053	25	Replace
2	Inside diameter of cam follower lever	25	–0.021 0	25	
3	Inside diameter of cam follower roller	27	+0.177 +0.157	27.2	
	Outside diameter of cam follower roller pin	27	+0.145 +0.135	27.0	
4	Outside diameter of cam follower roller	50	+0.025 0	50.0	
5	Diameter of push rod tip ball	22.22	0 –0.2	–	
6	Inside diameter of push rod socket	23.5	±0.1	–	

ROCKER ARM

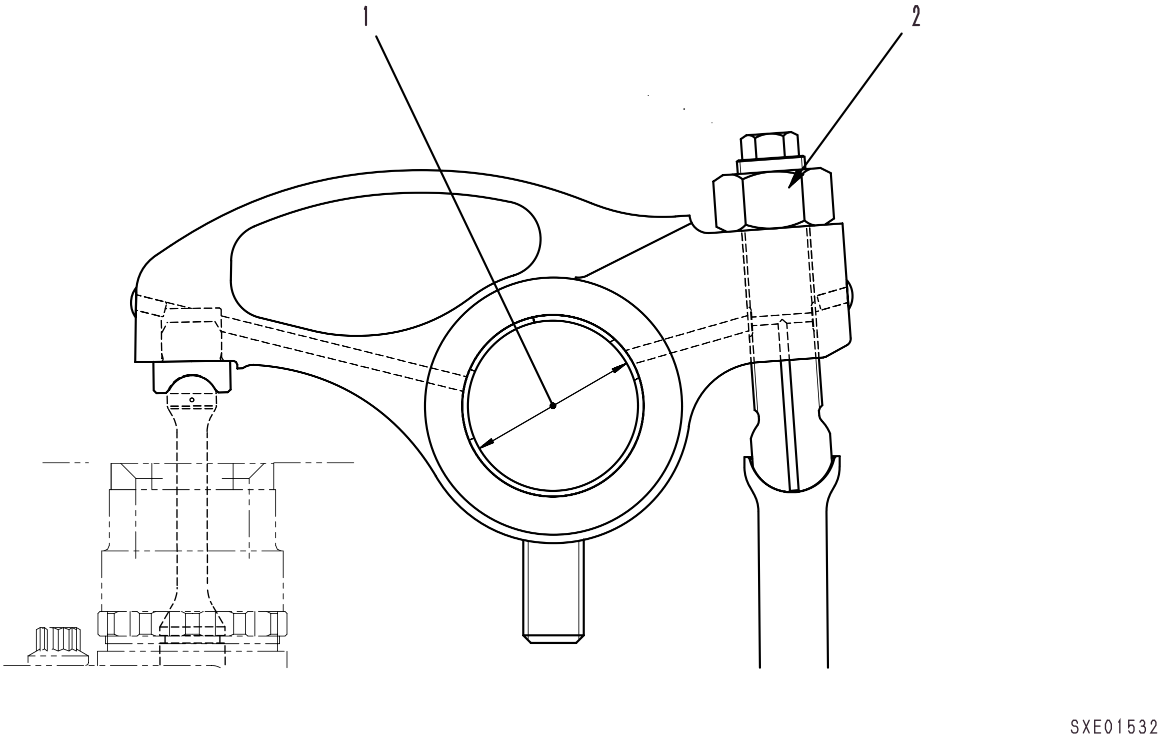
INTAKE VALVE, EXHAUST VALVE



Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="4">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="6">1</td><td rowspan="2">Outside diameter of rocker arm shaft</td><td colspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="2">Replace rocker arm shaft</td></tr>
<tr><td colspan="2">45.0</td><td colspan="2">–0.0150
–0.0280</td></tr>
<tr><td>Inside diameter of rocker arm bushing</td><td colspan="2">45.0</td><td colspan="2">+0.099
+0.024</td><td>Replace rocker arm</td></tr>
<tr><td rowspan="2">Clearance between rocker arm shaft and rocker arm</td><td colspan="2">Standard clearance</td><td colspan="2">Clearance limit</td><td rowspan="2">Replace rocker arm shaft or rocker arm</td></tr>
<tr><td colspan="2">0.039 – 0.0127</td><td colspan="2">0.16</td></tr>
<tr></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Valve clearance (at cold)</td><td>Valve</td><td colspan="2">Standard</td><td>Tolerance</td><td rowspan="3">Adjust</td></tr>
<tr><td>Intake valve</td><td colspan="2">0.32</td><td rowspan="2">±0.02</td></tr>
<tr><td>Exhaust valve</td><td colspan="2">0.62</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Tightening torque of locknut for rocker arm adjustment screw</td><td colspan="2">Target (Nm{kgm})</td><td colspan="2">Range (Nm{kgm})</td><td rowspan="2">Tighten</td></tr>
<tr><td colspan="2">68{6.9}</td><td colspan="2">58 – 77{5.9 – 7.9}</td></tr>
</table>

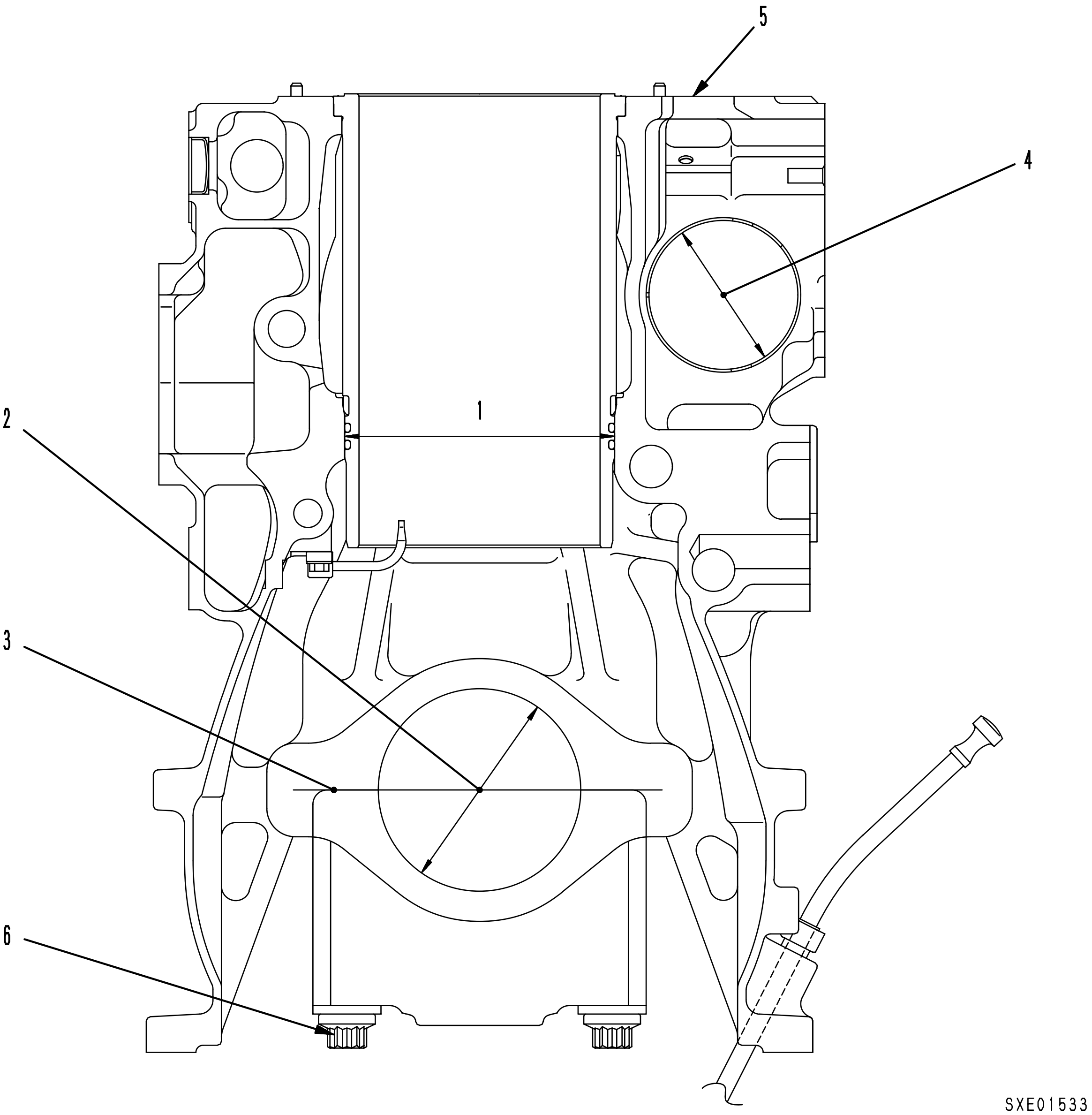
INJECTOR



Unit: mm

No.	Check item	Criteria		Remedy
1	Outside diameter of rocker arm shaft	Standard size	Tolerance	Replace rocker arm shaft
		45.0	–0.0150 –0.0280	
	Inside diameter of rocker arm bushing	45.0	+0.097 +0.021	Replace rocker arm
	Clearance between rocker arm shaft and rocker arm	Standard clearance	Clearance limit	Replace rocker arm shaft or rocker arm
		0.036 – 0.125	0.16	
2	Tightening torque of locknut for rocker arm adjustment screw	Target (Nm{kgm})	Range (Nm{kgm})	Tighten
		226 {23}	206 – 245 {21 – 25}	

CYLINDER BLOCK

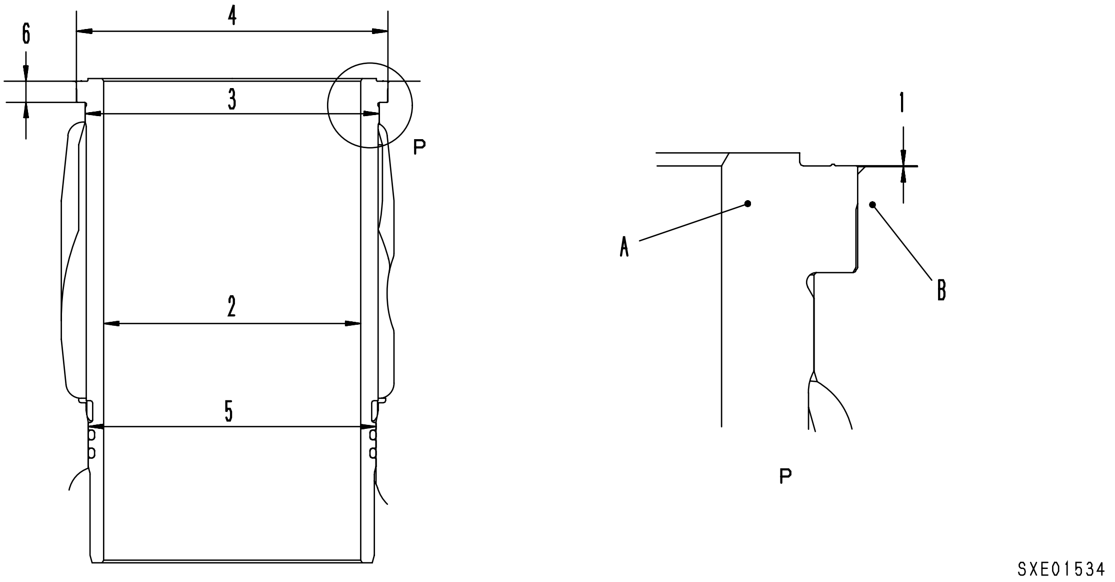


Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="8">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Clearance between cylinder block and liner</td><td rowspan="2">Standard size</td><td colspan="4">Tolerance</td><td colspan="2" rowspan="2">Standard clearance</td><td rowspan="2">Clearance limit</td><td rowspan="3">Replace liner or cylinder block</td></tr>
<tr><td colspan="2">ID of block</td><td colspan="2">OD of liner</td></tr>
<tr><td>190.4</td><td colspan="2">0
–0.06</td><td colspan="2">–0.11
–0.16</td><td colspan="2">0.05 – 0.16</td><td></td></tr>
<tr><td rowspan="6">2</td><td rowspan="2">Inside diameter of main bearing mounting hole (Tighten bolt to specified torque)</td><td colspan="2">Standard size</td><td colspan="4">Tolerance</td><td colspan="2">Repair limit</td><td rowspan="4">Replace</td></tr>
<tr><td colspan="2">148</td><td colspan="4">+0.025
–0.001</td><td colspan="2">–</td></tr>
<tr><td>Thickness of main bearing</td><td colspan="2">4.0</td><td colspan="4">–0.038
–0.051</td><td colspan="2">–</td></tr>
<tr><td>Inside diameter of main bearing</td><td colspan="2">140</td><td colspan="4">+0.127
+0.076</td><td colspan="2">140.20</td></tr>
<tr><td rowspan="2">Clearance between main bearing and crankshaft journal</td><td colspan="4">Standard clearance</td><td colspan="4">Clearance limit</td><td rowspan="10">Correct or replace</td></tr>
<tr><td colspan="4">0.076 – 0.152</td><td colspan="4">0.32</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Interference between cap and cylinder block</td><td colspan="4">Standard interference</td><td colspan="4">Interference limit</td></tr>
<tr><td colspan="4">0.090 – 0.140</td><td colspan="4">0.05</td></tr>
<tr><td rowspan="4">4</td><td rowspan="2">Inside diameter of camshaft bushing</td><td colspan="2">Standard size</td><td colspan="4">Tolerance</td><td colspan="2">Repair limit</td></tr>
<tr><td colspan="2">105</td><td colspan="4">+0.094
+0.011</td><td colspan="2">105.10</td></tr>
<tr><td rowspan="2">Clearance from camshaft journal</td><td colspan="4">Standard clearance</td><td colspan="4">Clearance limit</td></tr>
<tr><td colspan="4">0.053 – 0.166</td><td colspan="4">0.22</td></tr>
<tr><td rowspan="2">5</td><td rowspan="2">Distortion of cylinder head mounting surface</td><td colspan="4">Tolerance</td><td colspan="4">Repair limit</td></tr>
<tr><td colspan="4">0.09</td><td colspan="4">0.15</td></tr>
<tr><td rowspan="4">6</td><td rowspan="4">Tightening torque for main bearing cap mounting bolt (Coat thread and washer with engine oil)</td><td colspan="2">Sequence</td><td colspan="4">Target Nm{kgm}</td><td colspan="2">Range Nm{kgm}</td><td rowspan="4">Tighten</td></tr>
<tr><td colspan="2">1 st Step</td><td colspan="4">284 {29}</td><td colspan="2">270 – 299 {27.5 – 30.5}</td></tr>
<tr><td colspan="2">2 nd Step</td><td colspan="4">569 {58}</td><td colspan="2">559 – 579 {57.0 – 59.0}</td></tr>
<tr><td colspan="2">3 rd Step</td><td colspan="4">Tightening 90°</td><td colspan="2">$90^{\circ}{}^{+30^{\circ}}_{0}$</td></tr>
</table>

CYLINDER LINER

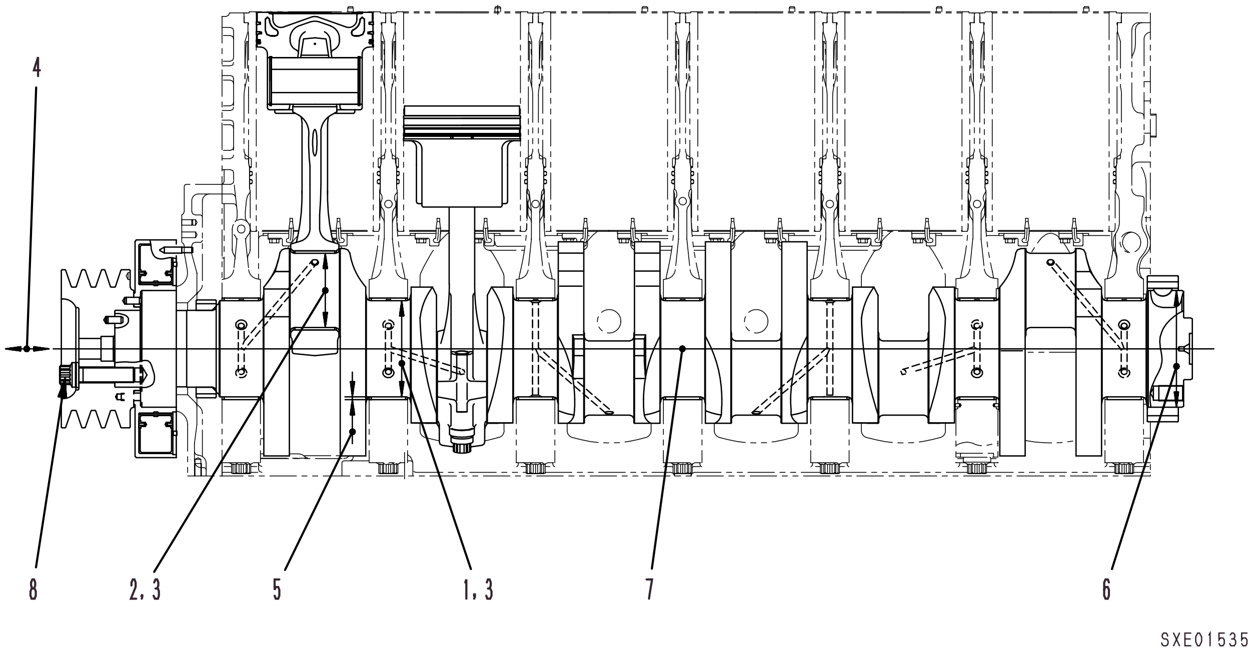
A. Cylinder liner portion
B. Cylinder block portion



Unit: mm

No.	Check item		Criteria			Remedy
1	Protrusion of cylinder liner		Permissible range: 0.07 – 0.15 Difference among cylinders: Max. 0.05			Replace cylinder liner or block
2	Inside diameter of cylinder liner		Standard size	Tolerance	Repair limit	Replaceor cylinder liner
			170	+0.04 0	170.24	
		Roundness	0.020		0.08	
		Cylindricity	0.020		0.08	
3	Outside diameter of cylinder liner (Counter bore lower part)		Standard size	Tolerance		
			194.5	194.565 – 194.615		
	Interference of cylinder liner and block (Counter bore lower bart)		Standard interference: 0.025 – 0.135			
4	Outside diameter of cylinder liner (Counter bore part)		Standard size	Tolerance		
			206	205.965 – 206.015		
	Clearance between cylinder liner and block (Counter bore part)		Interference: 0.85 to Clearance: 0.025			
5	Outside diameter of cylinder liner (O-ring part)		Standard size	Tolerance		
			190.40	190.24 – 190.29		
	Clearance between cylinder liner and block (O-ring part)		Standard clearance: 0.05 – 0.16			
6	Unevenness of counter bore depth		Tolerance	Repair limit		Repair by grinding
			–	0.05		

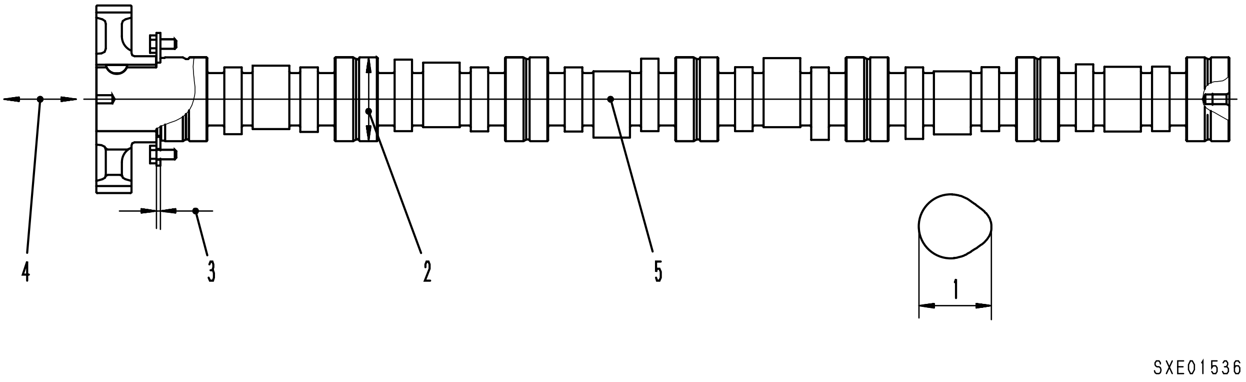
CRANKSHAFT



Unit: mm

No.	Check item	Criteria				Remedy
1	Outside diameter of main journal	Size	Standard size	Tolerance	Repair limit	Correct undersize or replace
		Standard	140	0 –0.025	139.91	
		0.25 US	139.75		139.66	
		0.50 US	139.50		139.41	
		0.75 US	139.25		139.16	
		1.000 US	139.00		138.91	
2	Outside diameter of crankshaft pin journal	Standard	108.00	0 –0.022	107.91	
		0.25 US	107.75		107.66	
		0.50 US	107.50		107.41	
		0.75 US	107.25		107.16	
		1.000 US	107.00		106.91	
3	Circularity of journal		Standard	Repair limit		Replace
		Main journal	Max. 0.010	0.015		
		Pin journal	Max. 0.010	0.015		
4	End play	Tolerance		Repair limit		
		0.14 – 0.32		0.6		
5	Thickness of main bearing (center)	Standard size	Tolerance	Repair limit		
		4.0	–0.038 –0.051	3.90		
6	Outside diameter of rear flange portion	170	±0.019	–		
7	Curvature of crankshaft (deflection of indicator)	Tolerance		Repair limit		
		0.09		0.09		
8	Tightening torque of crankshaft pulley mounting bolt	Sequence	Target Nm{kgm}	Range Nm{kgm}		Tighten
		1st Step	74{7.5}	54 – 93 {5.5 – 9.5}		
		2nd Step	245{25}	226 – 265 {23 – 27}		
		3rd Step	637{65}	618 – 657 {63 – 67}		

CAMSHAFT

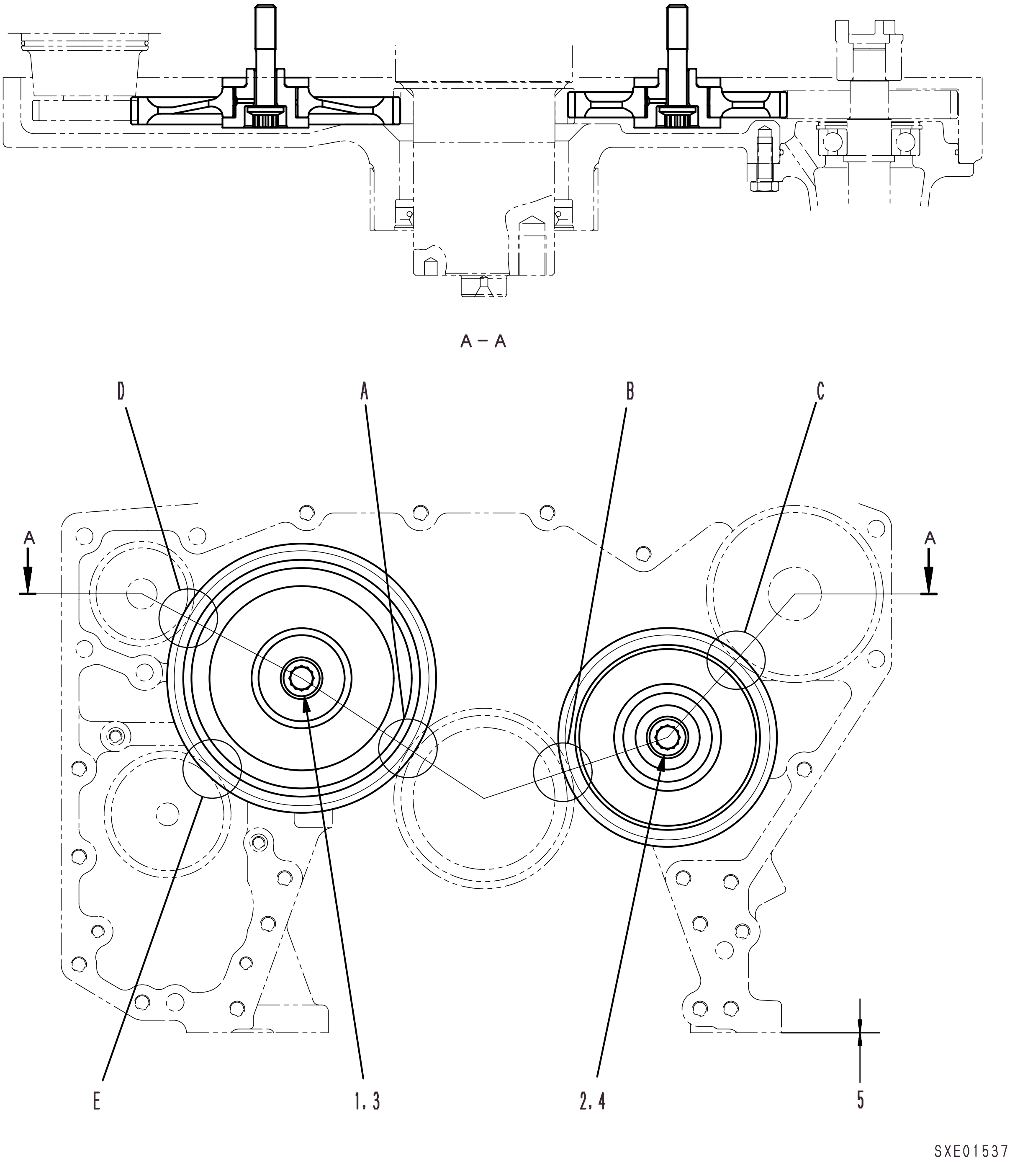


Unit: mm

No.	Check item		Criteria			Remedy
1	Cam height		Standard size	Tolerance	Repair limit	Repair or replace
		Intake side	89.800	+0.1081 –0.0919	89.20	
		Exhaust side	90.100	+0.1688 –0.0312	88.80	
2	Outside diameter of journal		105	–0.042 –0.072	104.88	Replace
3	Thrust plate thickness		5	0 –0.05	3.20	
4	Camshaft end play		Standard size		Clearance limit	Replace thrust plate
			0.05 – 0.20		0.40	
5	Bend of camshaft		Repair limit: 0.20 (by indicator)			Replace

GEAR TRAIN

FRONT SIDE

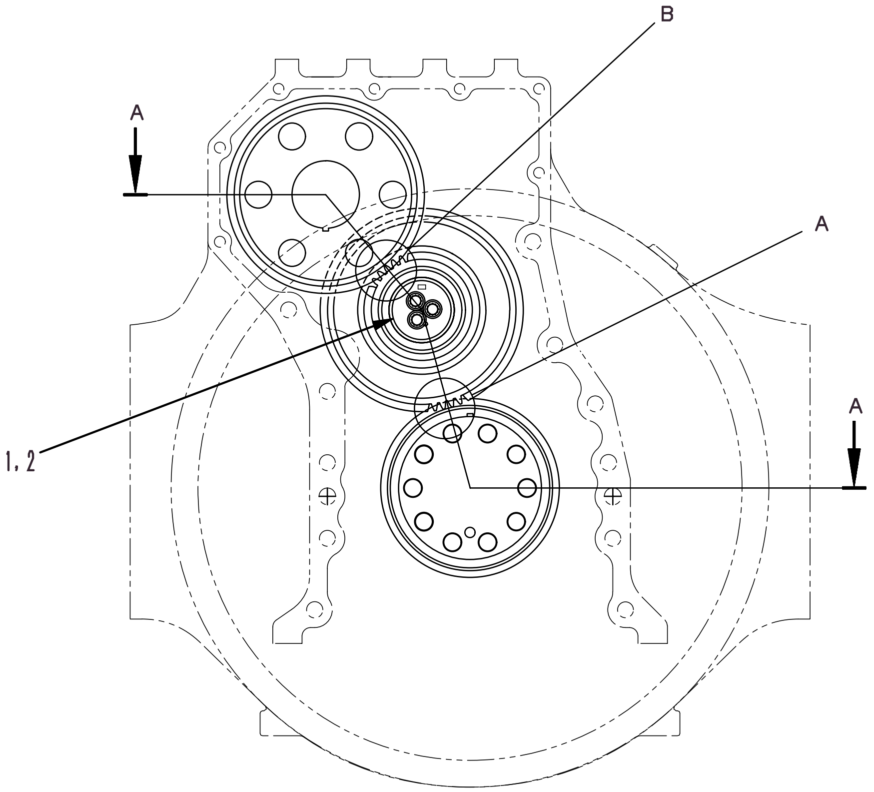


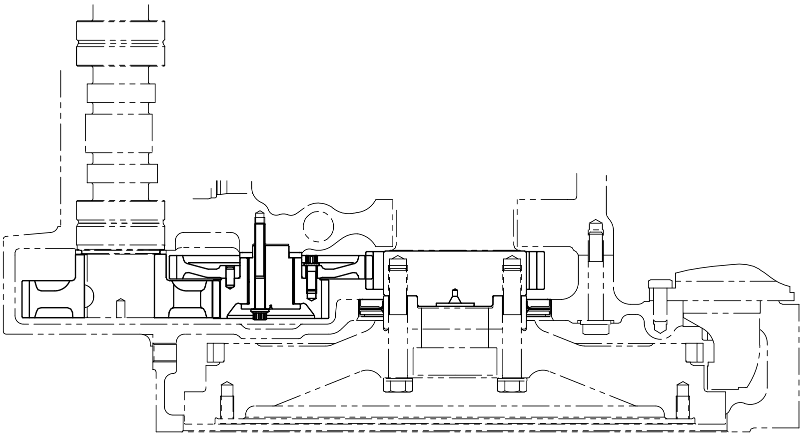
Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="5">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Clearance between idler gear (large) bushing and shaft</td><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="2">Standard clearance</td><td rowspan="2">Clearance limit</td><td rowspan="4">Replace bushing</td></tr>
<tr><td>Shaft</td><td>Hole</td></tr>
<tr><td>47.6</td><td>+0.014
+0.001</td><td>+0.063
+0.039</td><td>0.025 – 0.062</td><td>0.25</td></tr>
<tr><td>2</td><td>Clearance between idler gear (medium) bushing and shaft</td><td>47.6</td><td>+0.014
+0.001</td><td>+0.063
+0.039</td><td>0.025 – 0.062</td><td>0.25</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Clearance of idler gear (large) in axial direction</td><td colspan="3">Standard clearance</td><td colspan="2">Clearance limit</td><td rowspan="3">Replace thrust bearing</td></tr>
<tr><td colspan="3">0.05 – 0.17</td><td colspan="2">0.34</td></tr>
<tr><td>4</td><td>Clearance of idler gear (medium) in axial direction</td><td colspan="3">0.05 – 0.17</td><td colspan="2">0.34</td></tr>
<tr><td>5</td><td>Stepped difference of bottom surface between cylinder block and gear train case cover</td><td colspan="5">Repair limit: 0.15</td><td>Correct or replace</td></tr>
<tr><td rowspan="6">–</td><td rowspan="6">Backlash of each gears</td><td>Position</td><td colspan="2">Measurement place</td><td>Standard</td><td>Repair limit</td><td rowspan="6">Replace</td></tr>
<tr><td>A</td><td colspan="2">Crankshaft gear and idler gear (large)</td><td>0.134 – 0.326</td><td>0.5</td></tr>
<tr><td>B</td><td colspan="2">Crankshaft gear and idler gear (medium)</td><td>0.114 – 0.320</td><td>–</td></tr>
<tr><td>C</td><td colspan="2">Idler gear (medium) and fuel pump drive gear</td><td>0.114 – 0.320</td><td>0.5</td></tr>
<tr><td>D</td><td colspan="2">Idler gear (large) and water pump drive gear</td><td>0.121 – 0.333</td><td>0.5</td></tr>
<tr><td>E</td><td colspan="2">Idler gear (large) and oil pump drive gear</td><td>0.121 – 0.333</td><td>0.5</td></tr>
</table>

TIMING GEAR

REAR SIDE





A – A

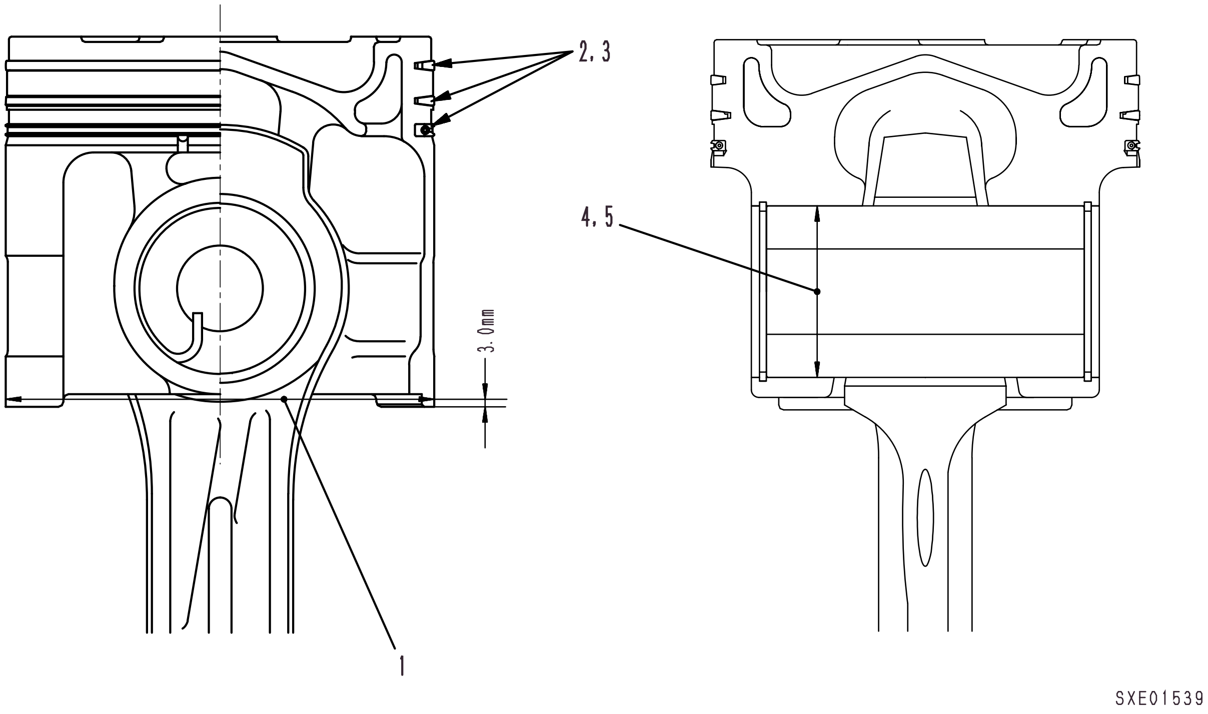
SXE01538

Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="5">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Clearance between idler gear bushing and shaft</td><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="2">Standard clearance</td><td rowspan="2">Clearance limit</td><td rowspan="3">Replace bushing</td></tr>
<tr><td>Shaft</td><td>Hole</td></tr>
<tr><td>52</td><td>–0.027
–0.040</td><td>+0.055
0</td><td>0.027 – 0.095</td><td>0.25</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Clearance of idler gear in axial direction</td><td colspan="3">Standard clearance</td><td colspan="2">Clearance limit</td><td rowspan="2">Replace thrust bearing</td></tr>
<tr><td colspan="3">0.04 – 0.18</td><td colspan="2">0.3</td></tr>
<tr><td rowspan="3">–</td><td rowspan="3">Backlash of each gear</td><td>Position</td><td colspan="2">Measurement place</td><td>Standard</td><td>Repair limit</td><td rowspan="3">Replace</td></tr>
<tr><td>A</td><td colspan="2">Crankshaft gear and idler gear (large)</td><td>0.155 – 0.412</td><td>0.6</td></tr>
<tr><td>B</td><td colspan="2">Crankshaft gear and idler gear (medium)</td><td>0.145 – 0.380</td><td>0.6</td></tr>
</table>

PISTON, PISTON RING, PISTON PIN

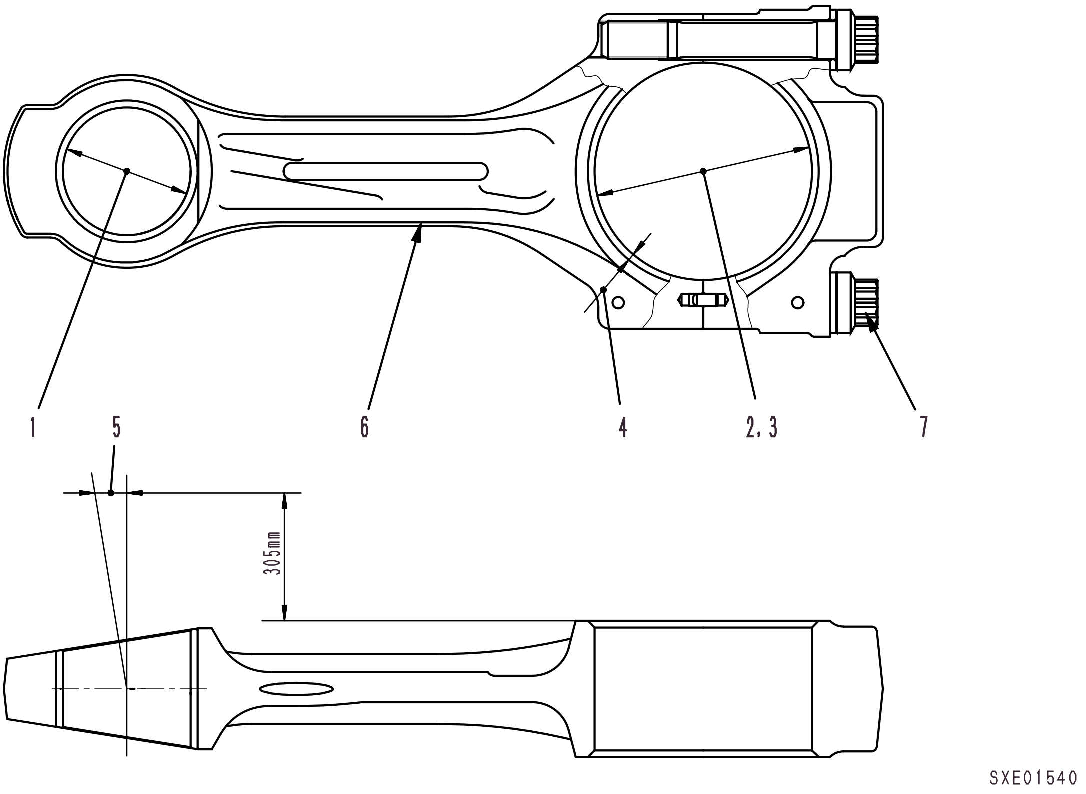
FCD PISTON TYPE



Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="8">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Outside diameter of piston
(At 3.0 mm from bottom of piston at 20°C)</td><td colspan="2">Standard size</td><td colspan="4">Tolerance</td><td colspan="2">Repair limit</td><td rowspan="13">Replace</td></tr>
<tr><td colspan="2">170
(at right angle from boss)</td><td colspan="4">–0.135
–0.165</td><td colspan="2">169.79</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">Piston ring groove</td><td rowspan="2"></td><td colspan="2" rowspan="2">Standard size</td><td colspan="4">Tolerance</td><td rowspan="2">Clearance limit
(clearance from new ring)</td></tr>
<tr><td colspan="2">Link groove</td><td colspan="2">Link thickness</td></tr>
<tr><td>Top ring
2nd ring</td><td colspan="2">Keystone
Keystone</td><td colspan="4">Check with piston loop wear gauge or check clearance from new ring</td><td>0.15</td></tr>
<tr><td>Oil ring</td><td colspan="2">4.00</td><td colspan="2">+0.05
+0.03</td><td colspan="2">–0.01
–0.03</td><td>0.3</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Gap in piston ring at end gap</td><td colspan="2"></td><td colspan="4">Standard clearance</td><td colspan="2">Clearance limit</td></tr>
<tr><td colspan="2">Top ring</td><td colspan="4">0.50 – 0.65</td><td colspan="2" rowspan="3">1.8</td></tr>
<tr><td colspan="2">2nd ring</td><td colspan="4">0.70 – 0.85</td></tr>
<tr><td colspan="2">Oil ring</td><td colspan="4">0.50 – 0.70</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Inside diameter of piston pin hole</td><td colspan="4">Standard clearance</td><td colspan="4">Clearance limit</td></tr>
<tr><td colspan="4">68</td><td colspan="4">+0.044
+0.034</td></tr>
<tr><td>5</td><td>Outside diameter of piston pin</td><td colspan="4">68</td><td colspan="4">0
–0.006</td></tr>
</table>

CONNECTING ROD

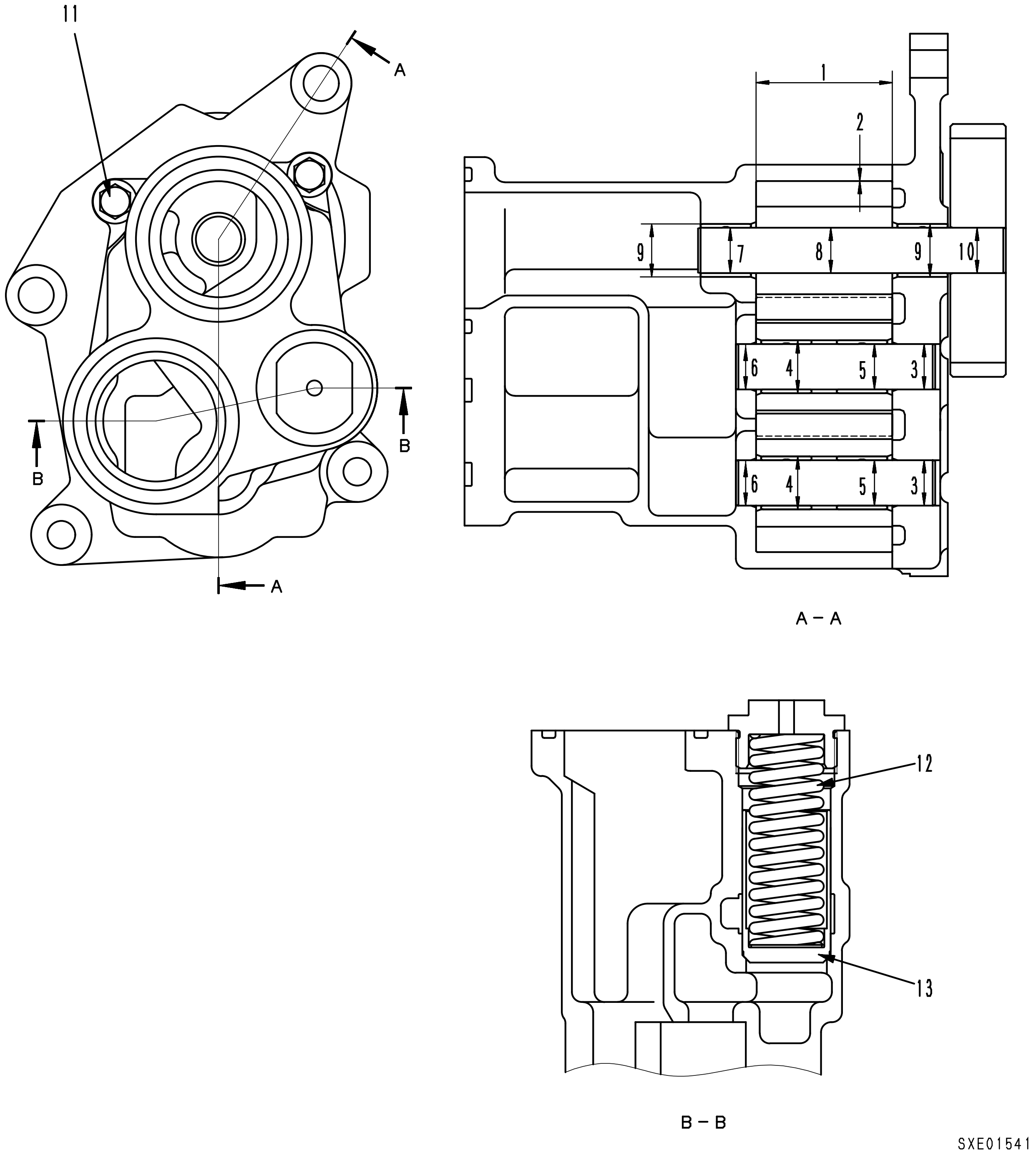


Unit: mm

No.	Check item	Criteria					Remedy
1	Clearance between connecting rod bushing and piston pin	Standard size	Tolerance		Standard clearance	Clearance limit	Replace (the bushing is supplied as a semi-finished product)
			Shaft	Hole			
		68	–0.020 –0.026	+0.049 +0.010	0.030 – 0.075	0.11	
2	Inside diameter of connecting rod big end	Standard size	Tolerance				Replace
		115	+0.026 0				
3	Clearance between inside diameter of connecting rod big end and crankshaft journal	Standard clearance	Clearance limit				
		0.058 – 0.132	0.34				
4	Connecting rod bearing thickness (Center)	Size	Standard size	Tolerance	Repair limit		
		S.T.D	3.500	–0.029 –0.042	3.41		
		0.25 US	3.625		3.54		
		0.50 US	3.750		3.66		
		0.75 US	3.875		3.79		
		1.00 US	4.000		3.91		
5	Bend or twist of connecting rod	Repair limit of bend: 0.10					
		Repair limit of twist : 0.25					
6	Connecting rod weight	10.29 ± 0.03 kg					
7	Tightening torque of connecting rod cap bolt (Coat bolt threads with engine oil)	Order	Target value (Nm{kgm})	Range (Nm{kgm})			Tighten
		1 st	196 {20}	186 – 206 {19 – 21}			
		2 nd	90°	$90^{\circ}{}^{+15^{\circ}}_{0}$			

OIL PUMP

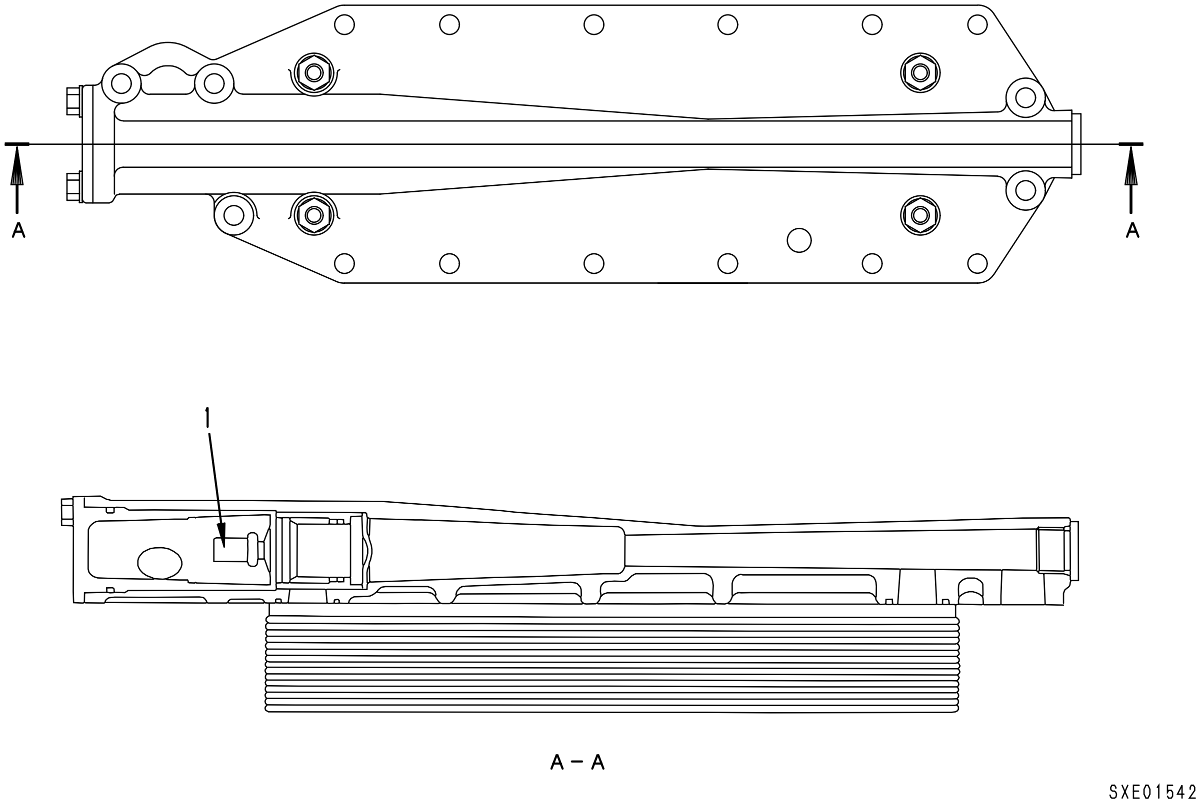
OIL PUMP, RERIEF VALVE



Unit: mm

No.	Check item	Criteria					Remedy
1	Clearance of pump gear in axial direction	Standard size	Tolerance		Standard clearance	Clearance limit	Replace gear
			Gear thickness	Body depth			
		54	0 –0.030	+0.067 +0.040	0.040 – 0.097	0.040 – 0.097	
2	Clearance of pump gear in radial direction	Standard size	Tolerance		Standard clearance	Clearance limit	
			Gear ID	Body OD			
		54.99	–0.15 –0.21	+0.04 0	0.15 – 0.25	0.15 – 0.25	
3	Interference of drive shaft and cover	Standard size	Tolerance		Standard clearance	Clearance limit	Replace bushing
			Shaft	Hole			
		18	+0.090 +0.070	+0.040 +0.022	0.030 – 0.068	–	
4	Interference of driven gear and bushing	21	+0.090 +0.065	+0.021 0	0.044 – 0.090	–	
5	Clearance between drive shaft and driven gear bushing	Standard size	Tolerance		Standard clearance	Clearance limit	
			Shaft	Hole			
		18	+0.090 +0.070	+0.147 +0.122	0.032 – 0.077	0.032 – 0.077	
6	Clearance between driven shaft and body	18	+0.090 +0.070	+0.129 +0.102	0.012 – 0.059	0.012 – 0.059	
7	Clearance between drive shaft and bushing	18	+0.106 +0.088	+0.173 +0.146	0.040 – 0.085	0.040 – 0.085	
8	Interference of pump gear and drive shaft	Standard size	Tolerance		Interference	–	
			Shaft	Hole			
		18	+0.106 +0.088	+0.064 +0.043	0.024 – 0.063	–	
9	Interference of body and body bushing	21	+0.090 +0.065	+0.021 0	0.044 – 0.090	–	
10	Interference of pump drive gear and driven shaft	18	+0.106 +0.088	+0.065 +0.047	0.023 – 0.059	–	
11	Tightening torque of pump cover mounting bolt	30.9±3.4 Nm {3.15±0.35 kgm}					Tighten
12	Main relief valve spring	Standard size			Repair limit		Replace
		Free length	Installed length	Installed load N{kg}	Free length	Installed load N{kg}	
		–	–	179.5 {73.0}	–		
13	Actuation pressure of main relief valve	Standard: 883±49 kPa {9.0±0.5 kg/cm^2}					Correct or replace spring

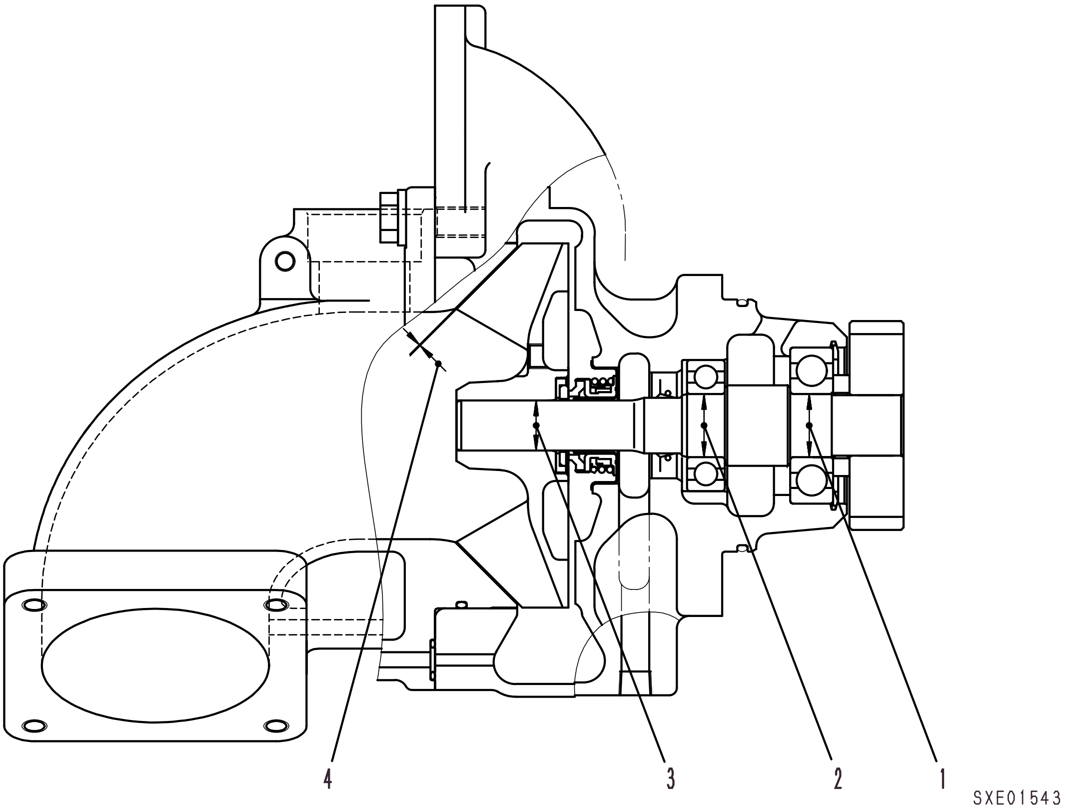
OIL COOLER



Unit: mm

No.	Check item	Criteria	Remedy
1	Thermostat full open lift	Min. 8 mm [soak valve in oil bath at 100°C for 4 – 5 minutes to check]	Replace
	Opening/closing of thermostat	Check that valve closes fully when oil temperature of 100°C at fully open is lowered to 85°C. [Soak valve in oil bath for 4 – 5 minutes to check]	

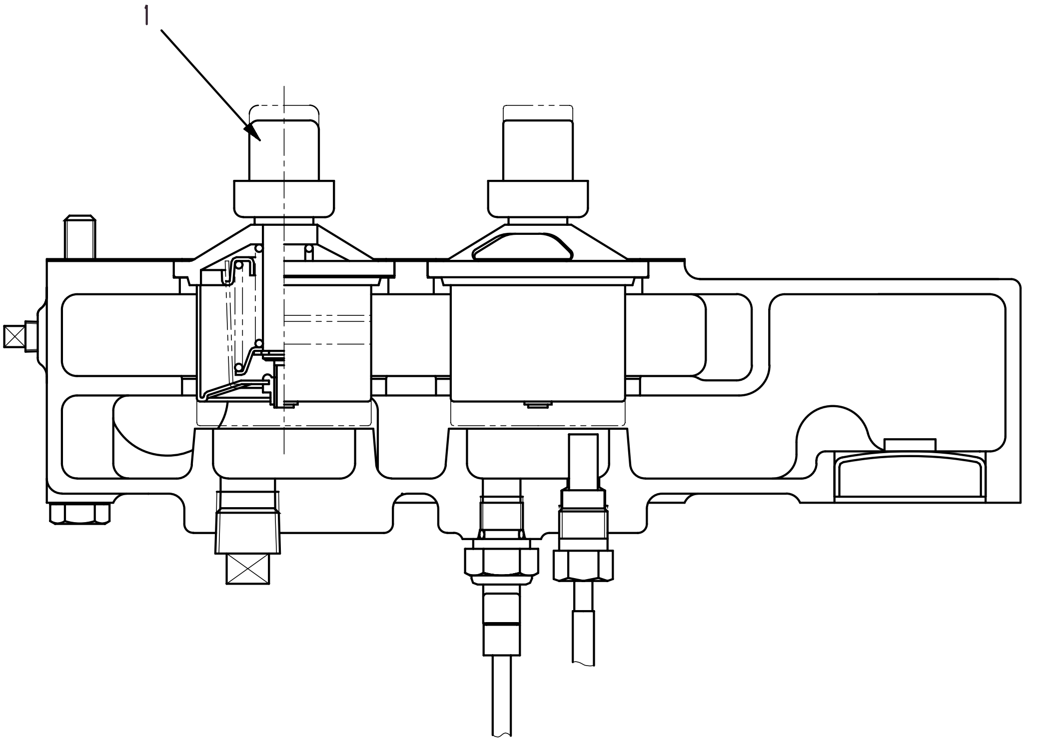
WATER PUMP



Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="4">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="3">1</td><td rowspan="3">Interference between front shaft and bearing</td><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="2">Standard interference</td><td rowspan="7">Replace</td></tr>
<tr><td>Shaft</td><td>Hole</td></tr>
<tr><td>25</td><td>+0.011
+0.002</td><td>0
–0.010</td><td>0.002 – 0.021</td></tr>
<tr><td>2</td><td>Interference between rear shaft and bearing</td><td>25</td><td>+0.011
+0.002</td><td>0
–0.010</td><td>0.002 – 0.021</td></tr>
<tr><td>3</td><td>Interference between rear shaft and impeller</td><td>19.9</td><td>+0.018
+0.006</td><td>–0.025
–0.050</td><td>0.002 – 0.0681</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Clearance between impeller and connection</td><td colspan="2">Standard clearance</td><td colspan="2">Clearance limit</td></tr>
<tr><td colspan="2">0.26 – 0.68</td><td colspan="2">–</td></tr>
</table>

THERMOSTAT



Unit: mm

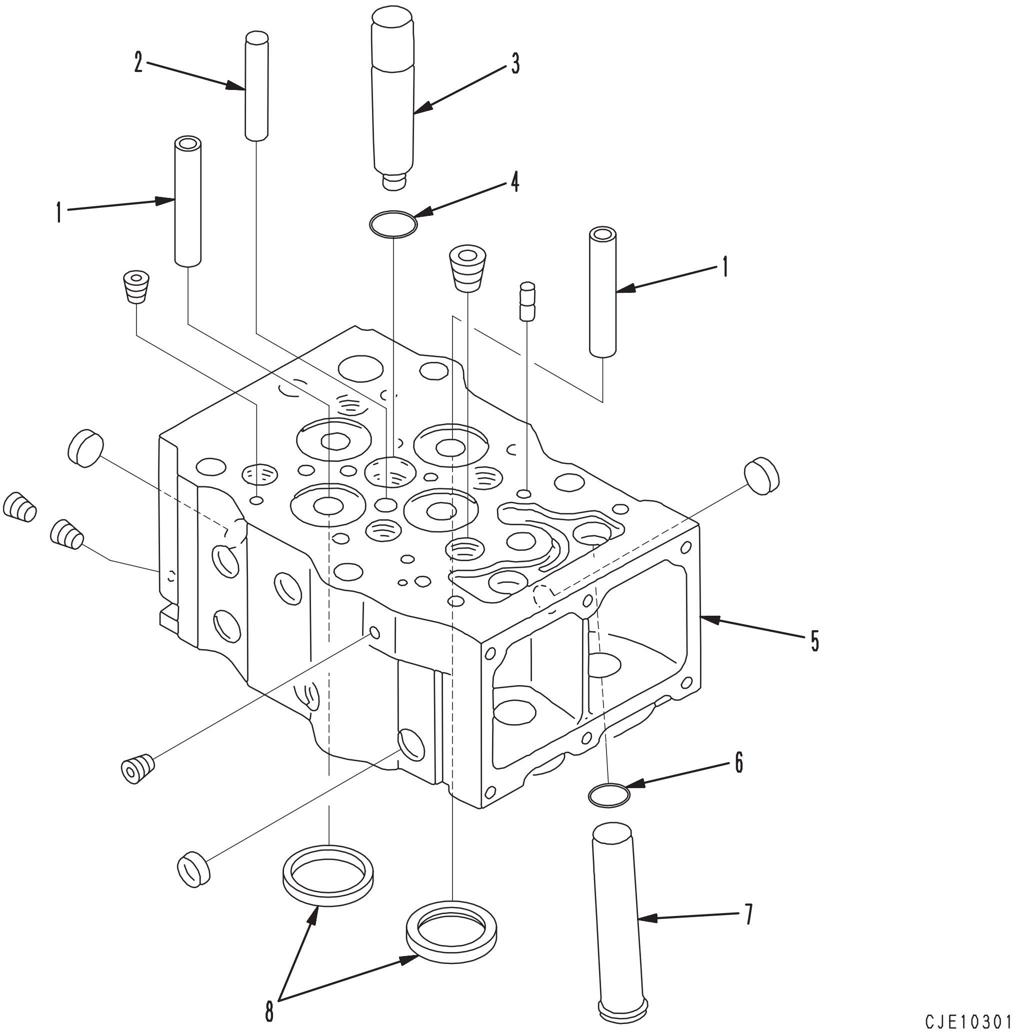
No.	Check item	Criteria	Remedy
1	Thermostat full open lift	Min. 9 mm [soak valve in water bath at 90°C for 4 – 5 minutes to check]	Replace
	Opening/closing of thermostat	Check that valve closes fully when water temperature of 90°C at fully open is lowered to 76.5°C. [Soak valve in water bath for 4 – 5 minutes to check]	

15 REPAIR AND REPLACEMENT OF PARTS

TABLE OF SPECIAL TOOLS

Operation	Symbol		Part No.	Part Name	Q'ty	Remarks
Replacing valve seat	A	1	795-100-4801	Puller	1	For valve seat
		2	795-100-3005	Seat cutter	1	
		3	795-611-1410	Push tool	1	For intake valve
			795-611-1420	Push tool	1	For exhaust valve
Pressure test of cylinder head	E		795-611-1500	Coolant tester	1	
	F		79A-471-1050	Pump assembly	1	
Replacing valve guide	G	1	795-611-1610	Valve guide remover	1	
		2	795-611-1620	Valve guide driver	1	
Replacing crosshead guide	H		795-611-1700	Crosshead guide pulle	1	
					1	
Grinding valve	I		Commercially available	Valve refacer	1	
Replacing cam bushing	J	1	795-621-1600	Push tool set	1	
		2	792-103-0400	Grip	1	
Replacing crankshaft gear	K	1	790-101-2800	Bearing puller	1	
		2	790-101-2300	Push puller	1	

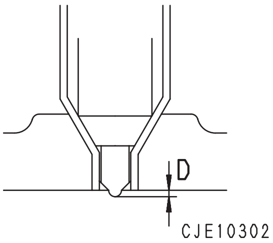
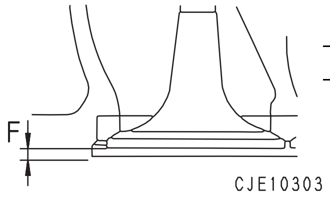
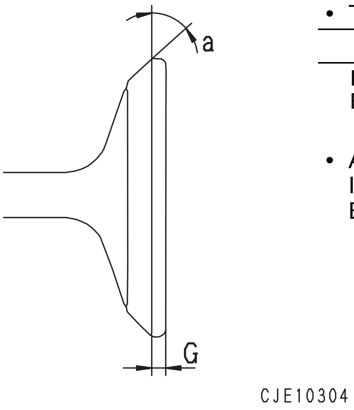
TESTING AND INSPECTING CYLINDER HEAD



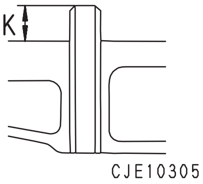
1. Valve guide
2. Closshead guide
3. Fuel injection nozzle sleeve
4. O-ring
5. Cylinder head
6. O-ring
7. Pushrod tube
8. Valve seat insert

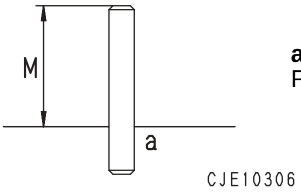
TESTING AND INSPECTING

Unit: mm

<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>A. Cracks, leakage from cylinder head</td><td>• Check for cracks (ext ernal color check)
• Check for water leakage with air pressure test (294 – 343 kPa {3.0 – 3.5 kg/cm^2}, 30sec.)
• Water pressure test (294 – 343 kPa {3.5 – 4.0 kg/cm^2}, 10 min.)</td><td>Replace</td></tr>
<tr><td>B. Distortion of top, bottom surface of cylinder head</td><td>• Tolerrance : 0.1</td><td>Grind to correct</td></tr>
<tr><td>C. Damage to injec-tion nozzle seat surface, contact width</td><td></td><td>Machine to repair or replace</td></tr>
<tr><td>D. Protrusion of injector</td><td>
Permissible range: 2.42 – 2.92</td><td>Replace cylinder head or injector</td></tr>
<tr><td>E. Damage to valve seat surface or loosening of seat</td><td>• Dent of seat surface
• Check contact between valve and seat surface
• Airtighteness test
• Tap cylinder head and chek for looseness</td><td>Correct seat surface or replace valve seat</td></tr>
<tr><td>F. Sinking and protrusion of valve (both intake and exhaust)</td><td>
<table>
<tr><th>Standard value</th><th>Repair limit</th></tr>
<tr><td>-0.39 (sinking) to 0.21(protrusion)</td><td>-0.80 (sinking)</td></tr>
</table></td><td>Replace valve or valve seat</td></tr>
<tr><td>G. Thickness of valve head</td><td>
• Thickness of valve head
<table>
<tr><th>Standard value</th><th>Repair limit</th></tr>
<tr><td>Intake valve 3.2</td><td>2.7</td></tr>
<tr><td>Exhaust valve 3.3</td><td>2.9</td></tr>
</table>
• Angle of seat surface "a"
Intake valve: 30°
Exhaust valve: 45°</td><td>Replace</td></tr>
</table>

Unit: mm

<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>H. Abnormality in valve</td><td>• Check if head has become flat, check for cracks or dent of seat surface
• Airtightness test
• Check for play in cotter when new cotter is inserted in cotter groove.
• Check for eccentric wear or curvature of stem.
• Check for dent in stem end.</td><td>Replace</td></tr>
<tr><td>I. Outside diameter of valve</td><td>• Outside diameter
<table>
<tr><th>Standard size</th><th>Standard value</th><th>Repair limit</th></tr>
<tr><td>Exhaust 12</td><td>11.893 – 11.908</td><td>11.80</td></tr>
<tr><td>Intake 12</td><td>11.920 – 11.940</td><td>11.90</td></tr>
</table></td><td>Replace</td></tr>
<tr><td>J. Inside diameter of valve guide (after press fitted to head)</td><td>
<table>
<tr><th>Standard size</th><th>Standard value</th><th>Repair limit</th></tr>
<tr><td>12</td><td>11.981 – 11.999</td><td>12.10</td></tr>
</table></td><td rowspan="3">Replace</td></tr>
<tr><td>K. Protrution of valve guide (after press fitted to head)</td><td>

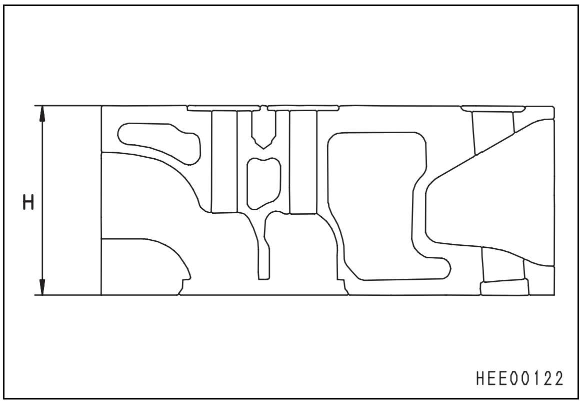
Permissible range: 42.5 – 43.5</td></tr>
<tr><td>L. Outside diameter of crosshead guide</td><td>
<table>
<tr><th>Standard size</th><th>Standard value</th><th>Repair limit</th></tr>
<tr><td>13</td><td>13.028 – 13.039</td><td>13.00</td></tr>
</table></td></tr>
<tr><td>M. Protrution of crosshed guide</td><td>

a: Cylinder head
Permissible range: 85.75 – 86.25</td><td>Replace</td></tr>
</table>

REPAIRING MOUNTING FACE OF CYLINDER HEAD BY GRINDING

1. Grinding

1) Remove the valve seat inserts. For details, see REPLACING VAVLE SEAT INSERTS.
2) Remove the nozzle holder sleeves. For details, see REPLACING NOZZLE HOLDER SLEEVES.
3) Grind the cylinder head to remove the strained or corroded portions within the limit of the height of the cylinder head (H).
   If any grinding is carried out, stamp the side face of the cylinder head with an (R) mark.
   - ★ Repair limit of cyinder head height (H):
     150.65 mm
     (Standard size:150.95 – 151.05 mm)
   - ★ Amount to remove per grinding:
     0.10 – 0.15 mm
   - ★ Surface roughness of grinding surface:
     Top surface: 12.5S
     Under surface: 4S
   - ★ Flatness (deformation): Max. 0.05 mm
   - ★ Grinding limit: 0.3 mm
   - ★ Difference in head height between 6 cylinders: Max. 0.15 mm
4) Press-fit the one-size-larger inserts. For details, see REPLACING VALVE SEAT INSERTS.
5) Press-fit the nozzle holder sleeves. For details, see REPLACENG NOZZLE HOLDER SLEEVES.



2. Check after grinding

- Check the sinking of the valves and protrution of the injector are within the standard values
  - ★ Standard sinking of valves:
    (sinking) 0.39 – (protrution) 0.21 mm
  - ★ Allowable protrusion of injector:
    3.7 – 4.3 mm

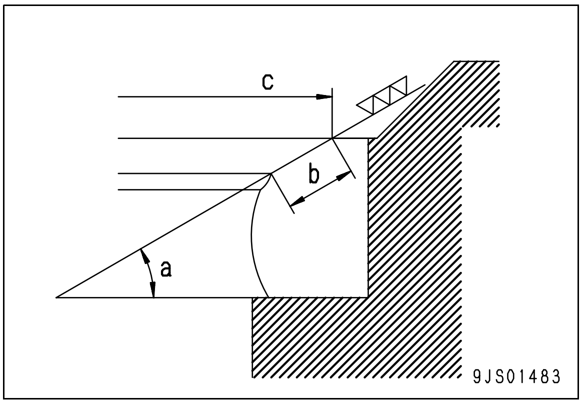
REPLACING VALVE SEAT INSERTS

★ When repairing without replacing the valve seat insert (when there is surface roughness or stepped wear), repair with the amount of sinking of the valve is within the repair limit.

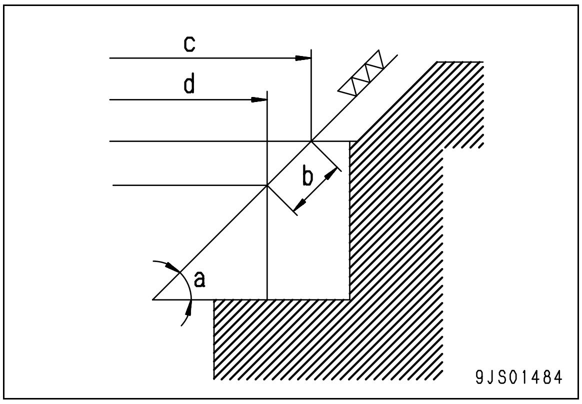
★ Machining drawings of new valve seat inserts is shown in the right.

Item	Intake valve	Exhaust valve
Seat surface angle (a)	30°	45°
Finish width (b)	3.5 mm	4 mm
Inside diameter (c)	62 ± 0.05mm	60.4 ± 0.05mm
Inside diameter (d)	–	53 mm
Seat surface roughness	Max. 3.2 S	

- Intake valve



- Exhaust valve



★ Checking for looseness of valve seat insert
Tap the outside of the valve insert of the cylinder head with a hammer to check for any looseness of the valve seat insert. If the valve seat insert is loose or springs back, replace the insert.

1. **Pulling out the valve seat insert**
   1) Using the grinder of valve e seat puller **A1**, make grooves on the inserts to pull them out according to the following procedure.

   ★ Set the air pressure to 490 – 588 kPa {5 to 6 kg/cm^2}.

   ★ When replacing the grindstone of the grinder, shut off the compressed air.

   ⚠ Before using the grinder, run it for one minute to check abnormality.

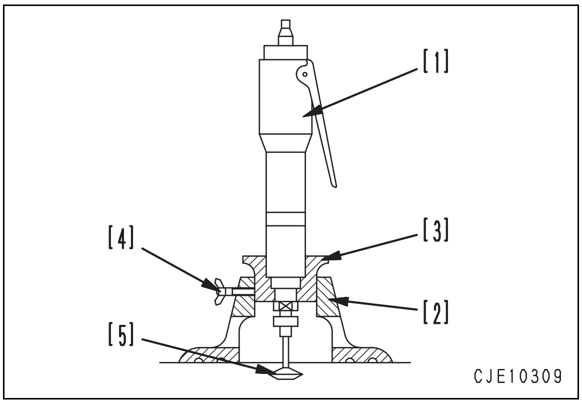
   ★ After replacing the grindstone, run the grinder for three minutes to test it.

   ⚠ Confirm that the grindstone is not damaged, then install it to the shaft of the grinder without applying excessive force.
   Confirm that there is no play between the grindstone and shaft.

   ⚠ When using the grinder, wear safety goggles.

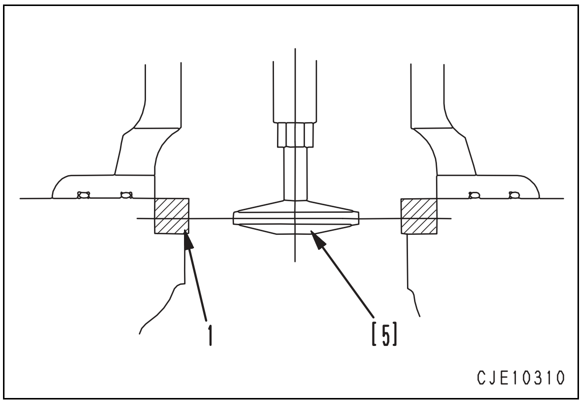
   i) Install grindstone [5] to grinder [1].
   ii) Install the sleeve and grinder after aligning the groove of sleeve [3] with holder [2].

   ★ Adjust the position of the grinder with set screw [4].

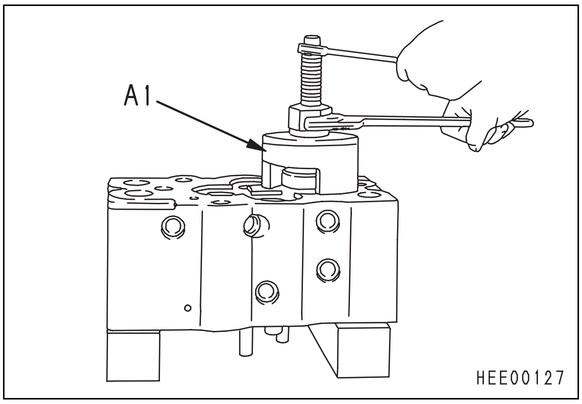


iii) Adjust the position of the grinder so that the center of grindstone [5] will be at the center of insert (1), then tighten the set screw to secure the grinder.

iv) Fully open the throttle of the grinder to rotate the grindstone and slowly move it until it contacts insert (1).



v) Press the grindstone against the inside of the insert, move it in a circular pattern.
★ Make a groove about 1 mm deep.

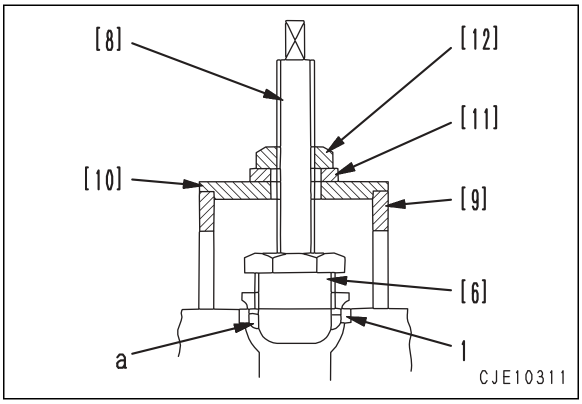


2) Pull out the insert with the puller head of valve seat puller **A1** according to the following procedure.

i) Push three claws (**a**) of puller head [6] inward by hand and put them in insert (1).

ii) Tighten screw [8] to press the three claws against the groove on the inside surface of the insert.
★ If the screw is tightened too strongly, the insert will break and it will be difficult to pull it out. Therefore, stop tightening the screw when the claws compretely contact the groove.

iii) Place bridge [9] over the puller head, then place plates [10] and [11] on the bridge. tighten nut [12] to pull out the insert.

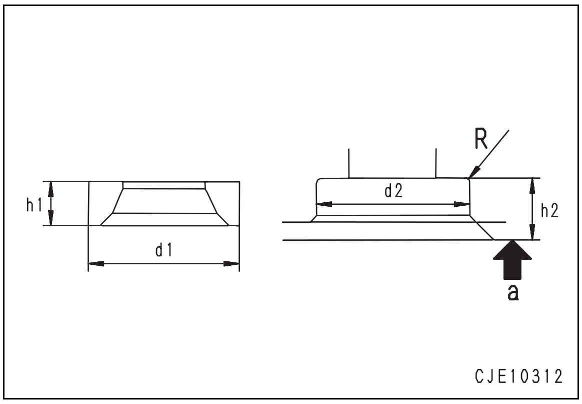


2. Machining valve seat insert mounting hole to oversize

1) Using valve seat cutter **A2**, machine the mounting hole to install a one-size-larger insert
    - Dimensions of insert and mounting hole

      a: Bottom surface of cylinder head

      R: $0.6^{\ 0}_{-0.1}$ mm

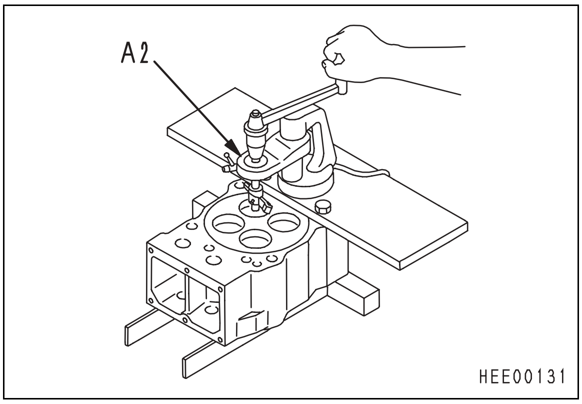


- Intake valve side Unit: mm

Stamp on insert	Insert		Mounting hole for insert	
	O.D.(d1)	Hight (h1)	I.D. (d2)	Depth (h2)
S.T.D.	$64.00^{+0.105}_{+0.080}$	$8.5^{+0.1}_{0}$	$64.00^{+0.019}_{0}$	11.4±0.1
0.25 O.S	$64.25^{+0.105}_{+0.080}$	$8.5^{+0.1}_{0}$	$64.25^{+0.019}_{0}$	11.4±0.1
0.50 O.S	$64.50^{+0.105}_{+0.080}$	$8.62^{+0.1}_{0}$	$64.50^{+0.019}_{0}$	11.52±0.1
0.75 O.S	$64.75^{+0.105}_{+0.080}$	$8.75^{+0.1}_{0}$	$64.75^{+0.019}_{0}$	11.65±0.1
1.00 O.S	$65.00^{+0.105}_{+0.080}$	$8.88^{+0.1}_{0}$	$65.00^{+0.019}_{0}$	11.78±0.1

- Exhaust valve side Unit: mm

Stamp on insert	Insert		Mounting hole for insert	
	O.D.(d1)	Hight (h1)	I.D. (d2)	Depth (h2)
S.T.D.	$63.60^{+0.100}_{+0.080}$	$9.7^{+0.1}_{0}$	$63.60^{+0.019}_{0}$	12.3±0.1
0.25 O.S	$63.85^{+0.100}_{+0.080}$	$9.7^{+0.1}_{0}$	$63.85^{+0.019}_{0}$	12.3±0.1
0.50 O.S	$64.10^{+0.100}_{+0.080}$	$9.82^{+0.1}_{0}$	$64.10^{+0.019}_{0}$	12.42±0.1
0.75 O.S	$64.35^{+0.100}_{+0.080}$	$9.95^{+0.1}_{0}$	$64.35^{+0.019}_{0}$	12.55±0.1
1.00 O.S	$64.60^{+0.100}_{+0.080}$	$10.08^{+0.1}_{0}$	$64.60^{+0.019}_{0}$	12.68±0.1



★ Inside diameter surface roughness: Max. 12.5S

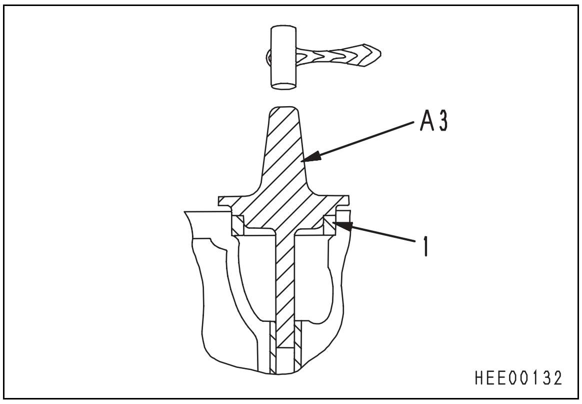
★ Mounting hole bottom roughness:Max. 12.5S

★ Concentricity of inside diameter of valve guide and inside diameter of insert hole: 0.07 mm (T.I.R) max.

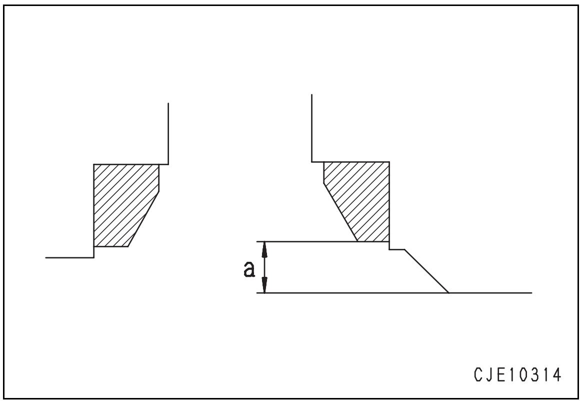
★ Rectangularity of inside diameter of valve guide and bottom of insert hole: Max. 0.03 mm (T.I.R)

3. Press fitting the insert

1) Using insert push tool **A3**, press-fit the insert (1).



2) Check the sinking distance **a** of the insert from the mounting surface of the cylinder head
   - ★ Srandard sinking distance **a** of insert: 2.8 – 3.1 mm



4. Finishing the seat surface

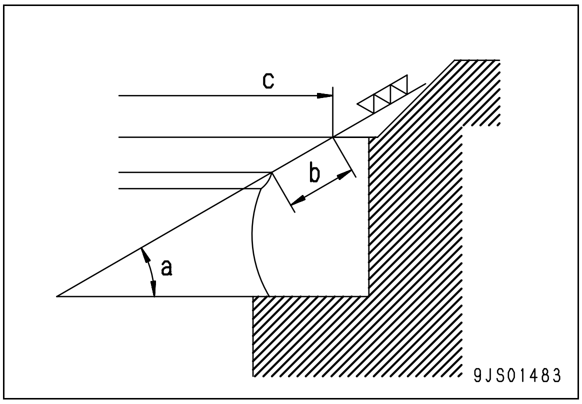
1) Finish the seat surface with valve seat cutter **A2** as shown in the figure.

Item	Intake valve	Exhaust valve
Seat surface angle (a)	30°	45°
Finish width (b)	3.5 mm	4 mm
Inside diameter (c)	62 ± 0.05mm	60.4 ± 0.05mm
Inside diameter (d)	–	53 mm
Seat surface roughness	Max. 3.2 S	

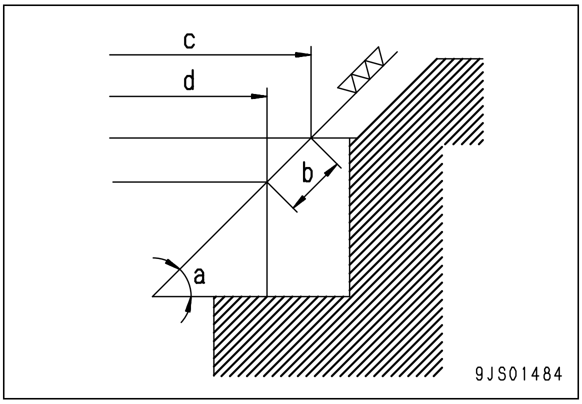
   - ★ Connectricity of valve guide and insert: Max. 0.07 mm (T.I .R)

2) Fit the seat surface using the compound.
   i) Coat the seat surface of the valve thinly with a rough compound mixed with oil insert it in the valve guide that forms a pair with that valve, then fit a rubbing bar to the valve head, and turn it with both hands to rub lightly against the valve seat.
   ii) When the rubbing removes the roughness, wipe off the compound. Then coat with a fine compound and repeat the above process to give a good contact surface with no break in contact.

- Intake valve



- Exhaust valve

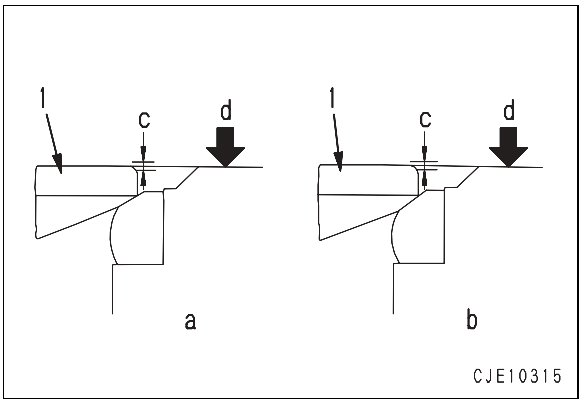


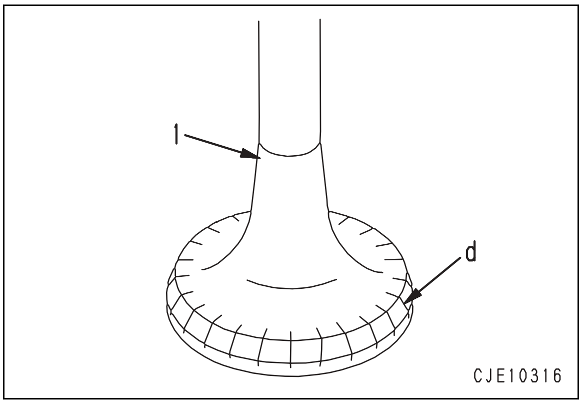
5. **Final check**

★ Sinking and protrusion amount C of valve (1): (sinking) 0.39 – (protrusion) 0.21mm

a: Intake side
b: Exhaust side
d: Bottom surface of cylinder head

- Coat the seat surface of the new valve thinly with red lead (minium), insert it in the valve guide, push lightely against the valve insert surface, and rotate 10°. Check the valve insert contact surface, and confirm that the contact is uniform without any breaks.
- or
  Mark marks **d** (about 20 places)with a pencil on the seal surface of the new valve as shown in the diagram, insert it in the valve guide, push lightly against the valve insert surface, and rotate 10°. Check that the pencil marks have been erased uniformly around the whole circumference.





Airtightness testing with vacuum tester

- When carrying out an airtightness test with a vacuum tester, test as follows

1) Wipe off all the dirt, dust, and oil from the valve and valve seat surface with a cloth.
2) Assmble the valve, valve spring, retainer, and cotter, tap the tip of the valve stem with a plastic hammer 2 or 3 times directly from above to bring it into tight contact with the seat sutface.
3) Fit a vacuum cup that matches the size of the valve in tight contact with the head surface. When doing this, to improve the airtightness of the vacuum cup, coat grease on the O-ring fitted to the vaccum cup, and fit it in tight contact with the flat surface of the head.
   (Be careful not to get any grease on the seat surface.)
4) Set the vacuum gauge to 93.3 kPa {700 mmHg}, and check that the pressure drops less than 1.3 kPa {10 mmHg} in 3 seconds. If it drops more than 1.3 kPa {10 mmHg} in 3 seconds, check for any dirt on the seat surface, or rub the surface to correct it.

PRESSURE TEST METHOD

- If the area around the head has been corrected, test as follows.

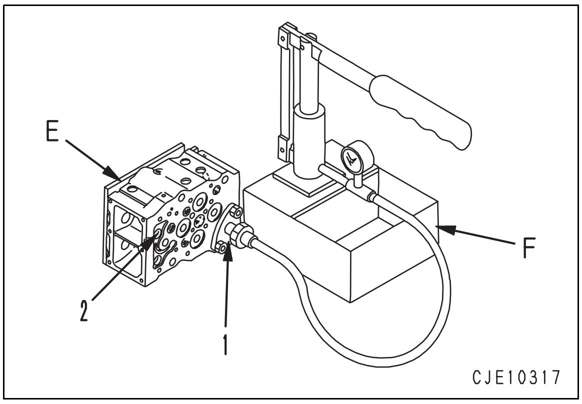
1. Water pressure test

1) Assemble tool **E** and tool **F**, and connect a hose to frange (1).

   ★ Block air vent (2) with the following parts.
   - 07037 – 11012 Plug
   - 07000 – 02012 O-ring

2) Apply water pressure 343 – 392 kPa {3.5 – 4.0 kg/cm^2} for approx. 10 minutes, and check for any leakage from around the head.

★ It is preferable to warm the whole cylinder head and carry out the test with hot water (82 – 93°C).



2. Air pressure test

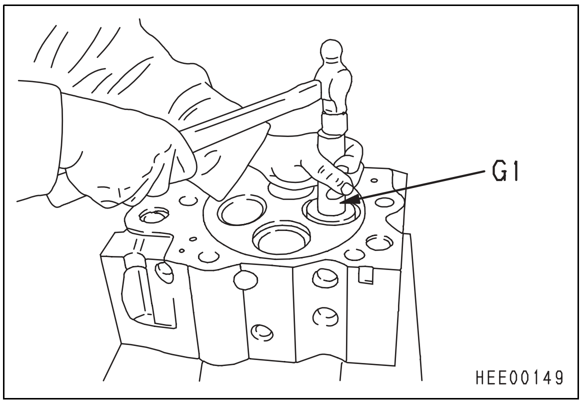
1) Connect the pump hose to flange (1).
2) Place the head in a water bath, apply air pressure 343 – 392 kPa {3.0 – 3.5 kg/cm^2} for approx. 30 seconds, and check for any air leakage in the water.

★ If the above test shows that there are cracks, replace the cylinder head.

REPLACING VALVE GUIDE

1. **Removing the valve guide**

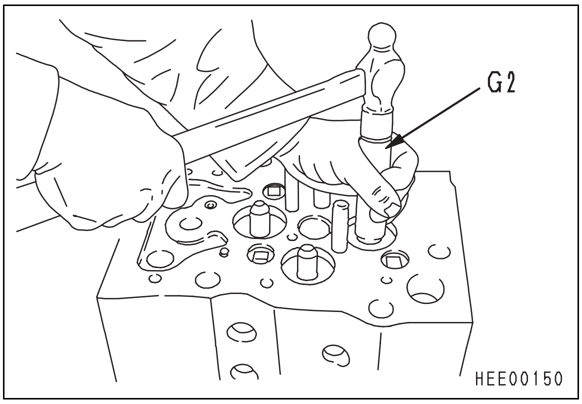
- Remove the valve guide with valve guide remover **G1**.



2. **Press-fitting the valve guide**
   1) Press-fit the valve guide until the tip of valve guide driver **G2** contacts the cylinder head.
   2) Confirm that the protrusion of the valve guide is within specification.

★ Protrusion of valve guide: 43 ± 0.5 mm

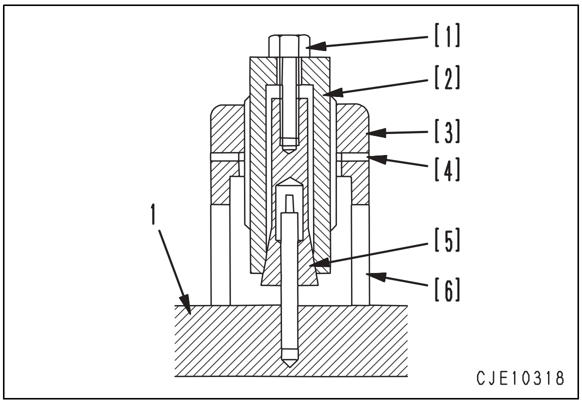
★ Inside diameter of valve guide hole in cylinder head: $\phi 19^{+0.021}_{0}$ mm



REPLACING CROSS HEAD GUIDE

1. Removing the cross head guide

- Using cross head guide puller **H**, pull out the cross head guide from cylinder head (1).
  1) As show in the figure, hold the cross head guide with collect [5] of the puller.
  2) Tighten the collect with bolt [1] to lock sleeve [2].
  3) Rotate nut [3] and pull out the cross head guide.
  4) Remove burrs, fins, etc. from the mounting place of the cross head guide and clean it.



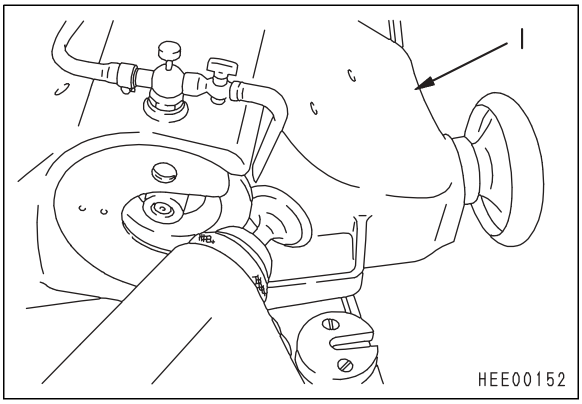
2. Press-fitting the cross head guide

- Insert the cross head guide in the cylinder head, then hit it into the cylinder head with a copper bar or plastic hammer until its protrusion is within specification.
  ★ Protrusion of cross head guide Toletance:
  86 ± 0.25 mm
  ★ Inside diameter of crosshead guide hole:
  $\phi 13^{+0.008}_{-0.010}$ mm

GRINDING VALVE

1. Grinding the seat surface

- Grind the seat sutface with valve refacer **I**.
  - ★ Angle of valve seat: intake valve: 30°
    EXhaust valve: 45°



2. Checking after grinding

- Confirm that the thickness of the valve head, protrusion of the valve, and the contact surface of the valve seat are within specification.

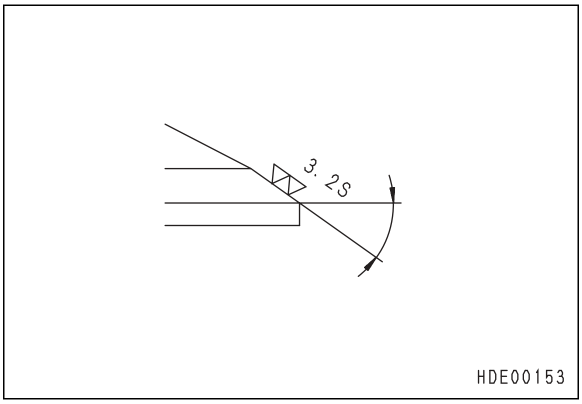
★ Thickness of valve head
Repair limit
Intake valve: 2.7 mm
(Standard size 3.2 mm)
Exhaust valve: 2.9 mm
(Standard size 3.3 mm)

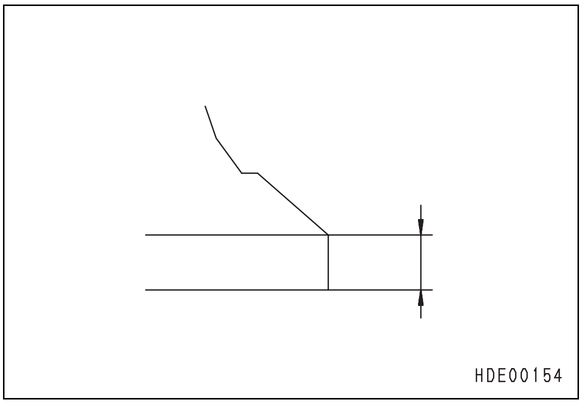
★ Sinking of valve Standard:
(sinking) 0.39 – (protrusion) 0.21 mm
Repair limit: (sinking) 0.8mm

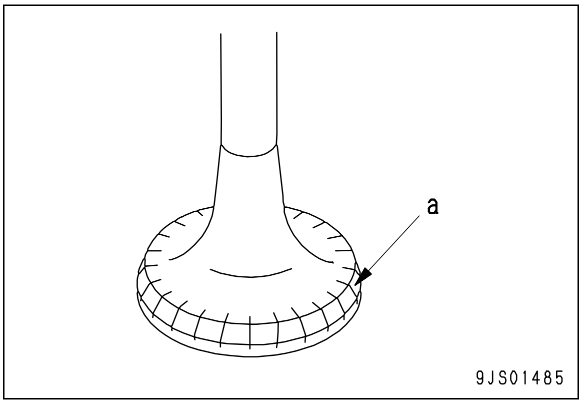
★ Check the contact of the valve with the seat surface using one of the following methods.

- Coat the seat surface of the ground valve thinly with red lead (minium), insert it in the valve guide, push lightly against the valve seat insert surface, and confirm that the contact is uniform without any breaks.

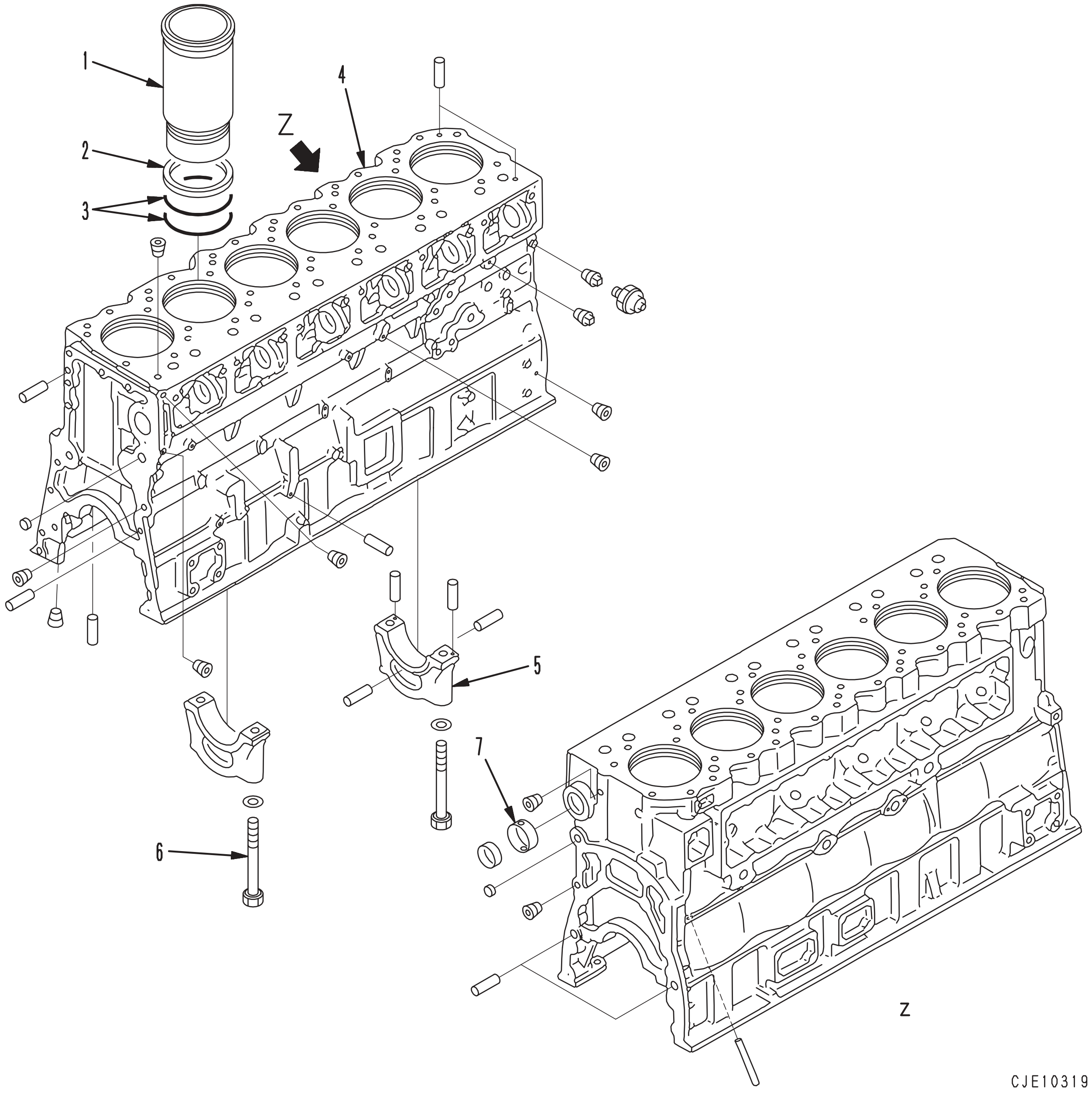
- Make marks **a** with a pencil on the seat surface of the ground valve as shown in the diagram, insert it in the valve guide, push lightly against the valve seat insert surface, and rotate 10°. Check that the pencil marks have been erased uniformly around the whole circumference.







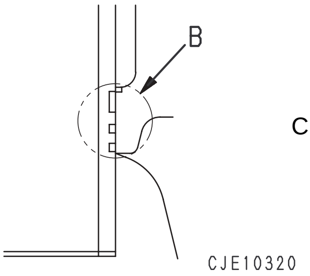
TESTING AND INSPECTING CYLINDER BLOCK

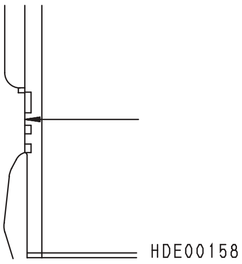
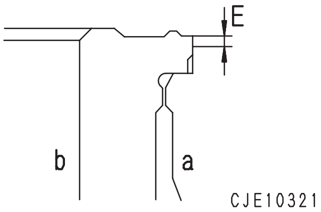


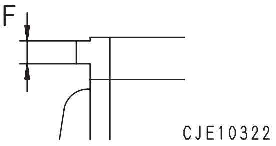
1. Cylinder liner
2. Crevice seal
3. O-ring
4. Cylinder block
5. Main bearing cap
6. Main bearing cap bolt
7. Camshaft bushing

TESTING AND INSPECTING

Unit: mm

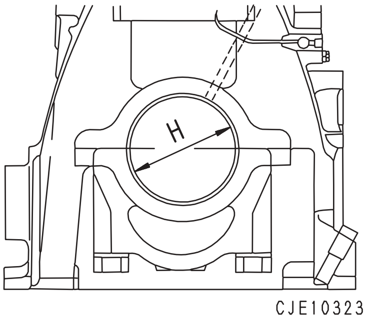
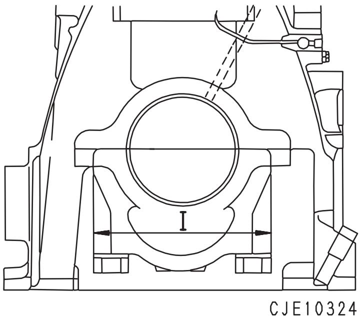
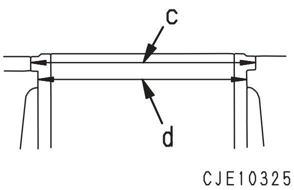
<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>A. Cracks</td><td>• Check for cracks (external color check)
• Cylinder head bolts hole portion, etc.</td><td>Replace</td></tr>
<tr><td>B. Correction of contact at packing portion</td><td>

Check for water leakage caused by corrosion</td><td>Replace</td></tr>
<tr><td>C. Clearance between liner and cylinder block

</td><td><table>
<tr><th>Standard size</th><th colspan="2">Standard valve</th><th>Standard Clearance</th></tr>
<tr><th></th><th>Inside diame-ter of block</th><th>Onside diam-eter of liner</th><th></th></tr>
<tr><td>190.4</td><td>190.34 – 190.40</td><td>190.19 – 190.29</td><td>0.05 – 0.21</td></tr>
</table></td><td>Replace cylinder liner or block</td></tr>
<tr><td>D. Inside diameter of camshaft bushing</td><td>• Inside diameter
<table>
<tr><th>Standard size</th><th>Standard valve</th><th>Repair limit</th></tr>
<tr><td>105</td><td>105.017 – 105.101</td><td>105.130</td></tr>
</table>
• Clearance between camshaft bearing and cylinder block
Standard clearanceStandard valve
<table>
<tr><th>Standard clearance</th><th>Standard valve</th></tr>
<tr><td>0.059 – 0.173</td><td>0.24</td></tr>
</table></td><td>Replace bushing</td></tr>
<tr><td>E. Protrusion of liner</td><td>

Permissible range: 0.07 – 0.15
a: Cylinder block
b: Cylinder liner</td><td>Replace cylinder liner or correct cylinder block</td></tr>
<tr><td>F. Depth of counter-bore and corro-sion of bot-tom surface</td><td>

<table>
<tr><th>Standard size</th><th>Standard value</th></tr>
<tr><td>14</td><td>14.00 – 14.05</td></tr>
</table>
• Check for corrosion</td><td>Repair by machining, add shim</td></tr>
</table>

Unit: mm

<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>G. Distortion, wear of cylinder head mounting surfac</td><td><table><tr><th colspan="2">Standard size</th><th>Repair limit</th></tr><tr><td>Overall top surface of block:</td><td>Max. 0.09</td><td>0.15</td></tr><tr><td>For one cylinder:</td><td>Max. 0.05</td><td>0.15</td></tr></table></td><td>Repair by machining</td></tr>
<tr><td>H. Inside diameter of main bearing mounting hole
• Tighten main bearing cap bolt with specified torque</td><td><table><tr><th>Standard size</th><th>Standard valve</th><th>Repair limit</th></tr><tr><td>148 (without bearing)</td><td>148.000 – 148.025</td><td>–</td></tr></table>

</td><td rowspan="2">Replace</td></tr>
<tr><td>I. Fitting of cap and cylinder block (Interference)</td><td>• Standerd Interface: 0.080 – 0.159

</td></tr>
<tr><td rowspan="2">J. Inside diameter of counterbore, outside diameter of cylinder liner flange</td><td>

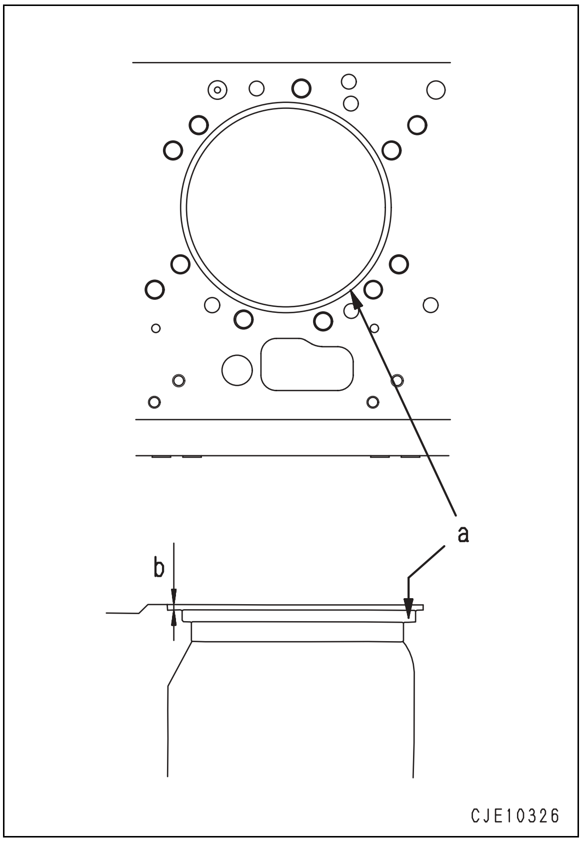
Cylinder liner
<table><tr><th colspan="2">Cylinder liner</th><th>Standerd size</th><th>Standerd valve</th><th>Repair limit</th></tr><tr><td>c</td><td>Top</td><td>206.0</td><td>205.965 – 206.015</td><td>–</td></tr><tr><td>d</td><td>Bottom</td><td>194.5</td><td>194.565 – 194.615</td><td>–</td></tr></table></td><td>Replace cylinder liner</td></tr>
<tr><td>Cylinder block
<table><tr><th colspan="2">Cylinder block</th><th>Standerd size</th><th>Standerd valve</th><th>Repair limit</th></tr><tr><td>c</td><td>Top</td><td>206.0</td><td>205.93 – 205.99</td><td>205.92 – 206.02</td></tr><tr><td>d</td><td>Bottom</td><td>194.5</td><td>194.48 – 194.54</td><td>194.46 – 194.57</td></tr></table></td><td>Replace cylinder block</td></tr>
</table>

GRINDING THE TOP SURFACE OF CYLINDER BLOCK

Grinding

Grind off the strained and corroded portions of the cylinder block within the allowable height (**H**) of the cylinder block.

- ★ Use the following as a guide to decide when to grind to the top surface.
  If the top surface of the cylinder block is worn or corroded in the shape of the head gasket, and the amonut of wear **a** is more than 0.10 mm, grind the top surface.
- ★ If there are blackened portions on the cylinder liner contact surface of the counterbore **b** (particularly in the front-to-rear direction), or there is speckled wear, and these portions extend over more than half of the contact width of the deck, and if grinding has been carried out on th top surface, correct the counterbore.

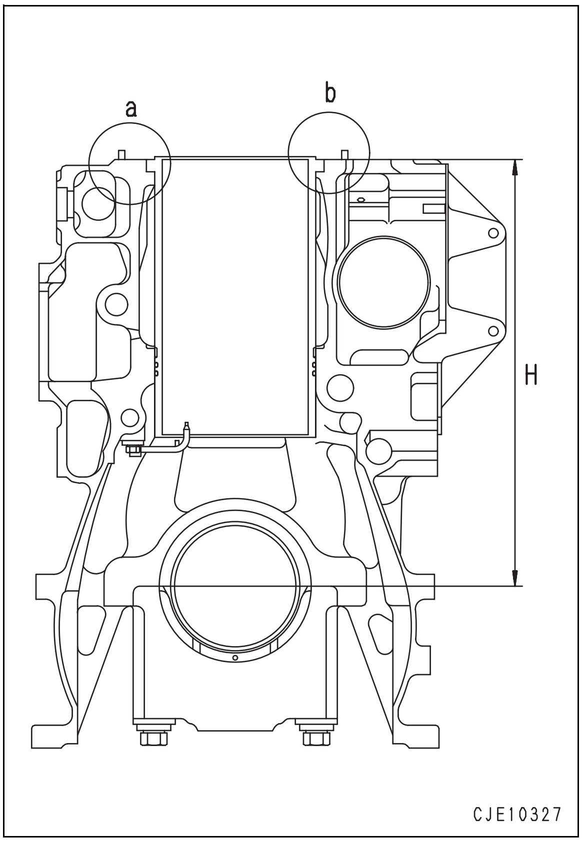


CJE10326

1. **Grinding top surface**
   1) Measure the wear and strain of the tops surface of the cylinder block, and if it is not within the repair limit, grind the top surface.
      Flatness of cylinder block:
        Standard dimension: 0.05 mm
        Repair limit: 0.10 mm (for one cylinder)
      Height of cylinder block (**H**):
        Standard dimension:
        488.96 – 489.04 mm
        Repair limit: 488.56 mm
      Roughness of top surface of cylinder block: Max. 12.5S

   If grinding with a grindstone (for reference)

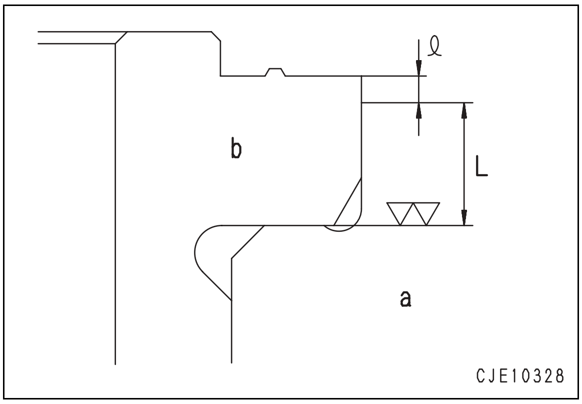
★ Speed of grindstkone:	1,650 – 1,950 m/min.
★ Speed of table:	15 – 30 m/min.
★ Grinding depth/time:	0.025 mm
★ Cross feed/time:	1 – 2 mm
★ Grindstone:	A461V
★ Grinding lubricant:	Water-soluble grind-ing lubricant

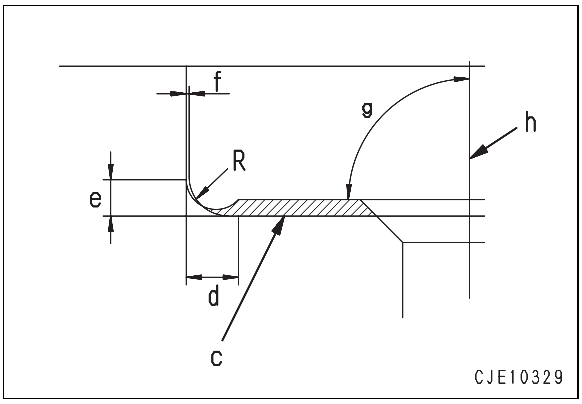


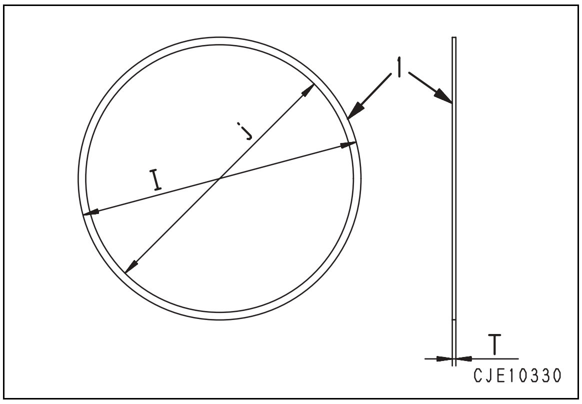
CJE10327

2. Grinding couterbore

After grinding the top surface of the cylinder block **a** , measure the depth of the counterbore. If it is not within the standard dimension, or if there are blackened portions on the cylinder liner **b** contact surface of the counterbore (patricularly in the front-to-rear direction), or there is speckled wear, and these portions extend over more than half of the contact width of the deck, correct the counterbore depth **L** within the repair limit. After correcting, if the counterbore depth is within 14.05 – 15.525 mm, combine with shims and adjust so that the liner protrusion "ℓ" is 0.07 – 0.15 mm.







- ★ Counterbore depth **L**:

  Standard dimension $14^{+0.05}_{0}$ mm
  Repair limit: 15.46 mm
- ★ Protrusion of cylinder liner "ℓ" :

  Standard value: 0.07 – 0.15 mm
- ★ Roughness of counterbore: Max. 12.5S (See diagram on the right)
- ★ Machined shape: (See diagram on the right)
- Machine only the shaded area to adjust the depth of part **c** of the counterbore.
- Machining dimension of part **d**: Max. 0.4 mm
- Machining dimension of part **e**: Max. 0.7 mm
- Machining dimension of part **f**:
  0 – Max. 0.06 mm
- Angle of part **g** to center (straight line) of cylinder: 90° $^{+30'}_{0}$
- Remove burrs from the tapered parts, etc.
- Letter **h** indicates the center of the cylinder.
- Set **R** to 0.2 – 0.4 mm.

For the extra amount for counterbore depth **L**, decide the machining amount so that the protrusion of the cylinder liner will be within the standard value.

When grinding within the repair limit when counterbore depth **L** exceeds the standard dimension, set the machining amount so that 1 of the shims (1) shown below will be used for each cylinder.

[Reference] Adjustment shims for counterbore depth
Unit: mm

Part No.	T	t	Weight (kg)	Remarks
6162-29-2260	1.50	0.025	0.004	
6162-29-2250	0.80	0.025	0.002	
6162-29-2240	0.50	0.025	0.001	
6162-29-2230	0.26	0.025	0.001	
6162-29-2220	0.20	0.020	0.001	
6162-29-2210	0.16	0.016	0.001	

- ★ Inside diameter **j** and outside diameter **I** of shims (1)
  - **I**: 205.5 ± 0.15 mm
  - **j**: $194.6^{+0.030}_{0}$ mm

3. Checking and distinguishing after grinding and correcting

After grinding and correcting, check for scratches on the flat surface around the water and oil holes in the cylinder block top surface.

Remove all burrs completely.

After grinding the top surface, if the cylinder block height **H** exceeds the standard dimension, but is within the repair limit (488.56 – 488.96 mm), always use an oversize head gasket.

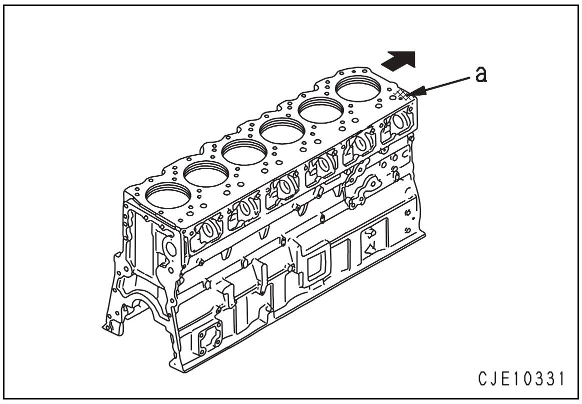
★ Oversize head gasket part number: 6240-19-1810

Thickness of plate: 2.4mm (standard: 2.0mm)

★ To distinguish, the letters "OS" are stamped on the plate.

After correcting, stamp the top surface of the cylinder block **a** according to the content of the correction as shown in the table below.

★ The arrow in the figure indicates the flywheel side of the cylinder block.



Talbe of letters to stamp

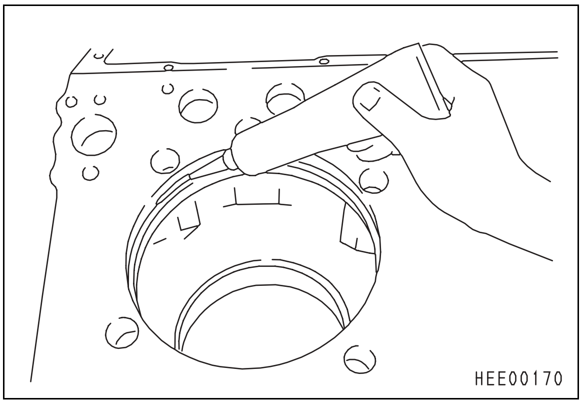
	Oversize head gaske	Shim	Stamp
Parts used for correction	–	–	Not needed
	○	–	OS
	–	○	SH
	○	○	WS

(Size of letters: 5 – 10mm)

4. Procedure for coating gasket sealant to cylinder block counterbore

When pulling out the cylinder liner and press fitting it again, coat gasket sealant LG-6 to the contact surface of the liner flange as follows. Use the same procedure when using a shim for the corresponding part.

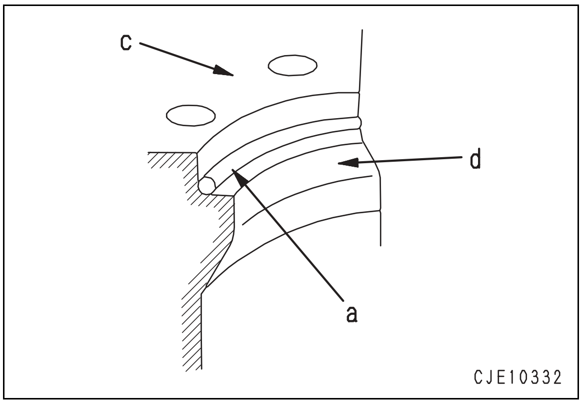
★ The following commercially available sealant is equivalent to LG-6.
- Three Bond: TB1215
- Nihon Hermetic: SS-60F

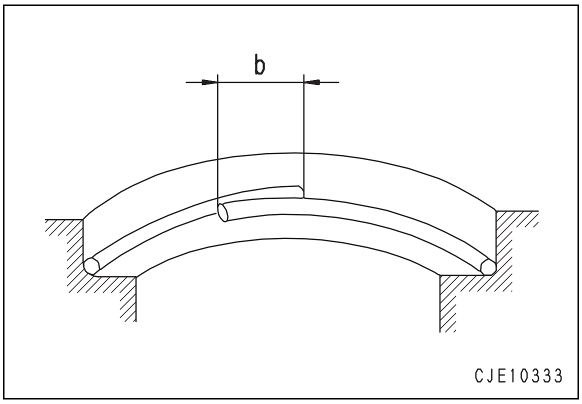


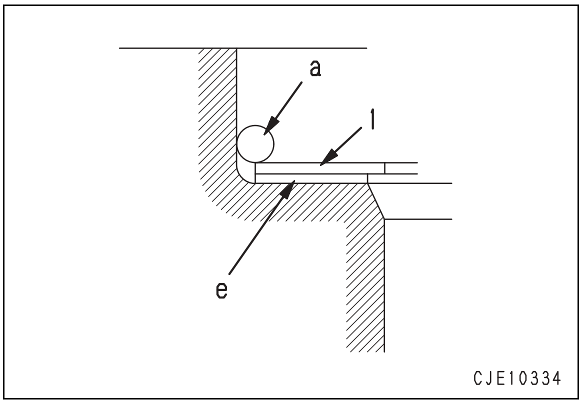
1) Use a cloth to wipe off all the dirt and oil from the contact surface of the liner flange and cylinder block counterbore.
2) Coat the position marked **a** in the diagram with LG-6.
   - Make the diameter of the line of gasket sealant ϕ 2 – 3 mm.
   - Make the overlapping portion **b** for beginning and ending the coating of sealant 6 ± 6mm as shown in the diagram.
     c: Top surface of cylinder block
     d: Mating portion of cylinder liner

   ★ When using shims
   i) Thinly coat underside **e** of shim (1) with LG-6, and then fit the shim to the deck of the block.
   ii) Similarly to the case where no shims are used, coat the position marked **a** with LG-6.

3) Press fit the liner in the cylinder block.
   When doing this, coat the seal and O-ring with rubber lubricant RF-1.
   ★ RF-1 is equivalent to the commercially available Daido Kagaku Kogyo DS-50.
   ★ If RF-1 is not available, coat the O-ring and seal contact surface with an extremely small amount of engine oil (SAE30) immediately before press fitting the liner.

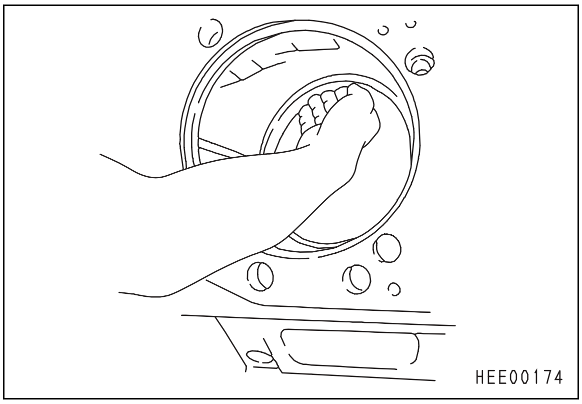






4) Coat the liner O-ring, clevis seal, and cylinder block contact surface with a small amount of engine oil (SAE = 30) immediately before press fitting the liner.

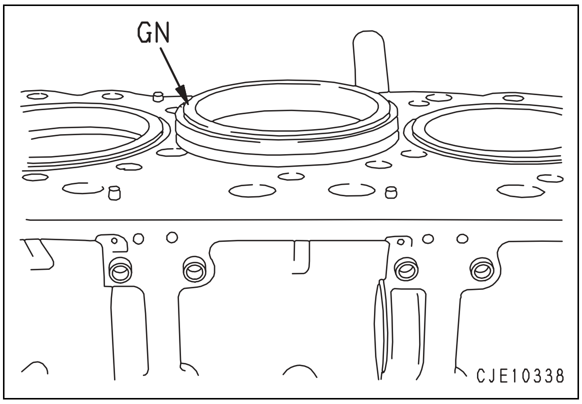
★ Coat the contact surface of the cylinder block uniformly around the whole circumference by hand.



5) Insert liner (1) facing liner top face stamp "**GN**" to front into the cylinder block, taking care not to damage the O-ring.

6) Use your weight and push the liner in with both hands.

★ If the liner does not go in smoothly when you apply your weight, there is danger that the O-ring may be damaged, so check the cylinder block for burrs or flashes.

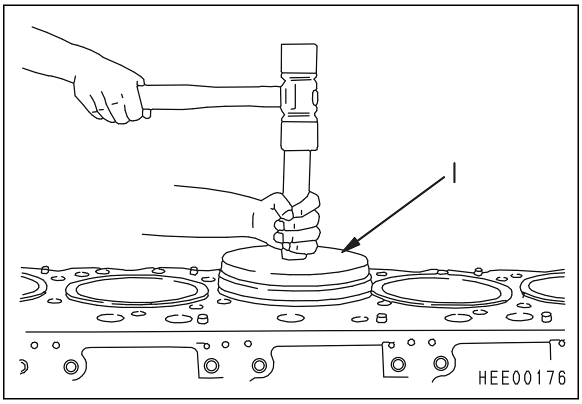


7) Using liner driver **I**, press fit cylinder liner (1) into the cylinder block.

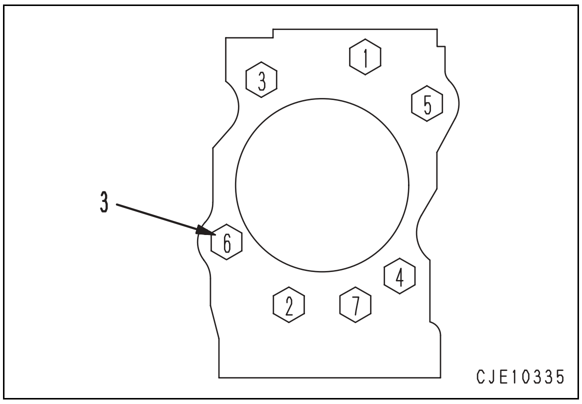
★ Using the following procedure, squeeze out the gasket sealant coated on the counterbore.

i) Tighten the cylinder head temporarily with a used head gasket.

Mounting bolt:
255 ± 10 Nm {26 ± 1 kgm}



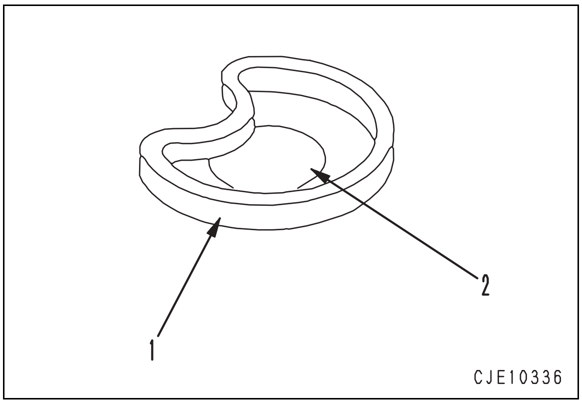
- Tighten order of head bolt (3)



ii) Remove the cylinder head, and wipe off the gasket sealant that has been squeezed out from between the cylinder liner and cylinder block.

★ If gasket sealant sticks to grommet (1) in the head gasket, the grommet will be deformed into the shape of a heart, and this may cause leakage of the coolant into water hole (2). To prevent this, wipe off the gasket sealant.

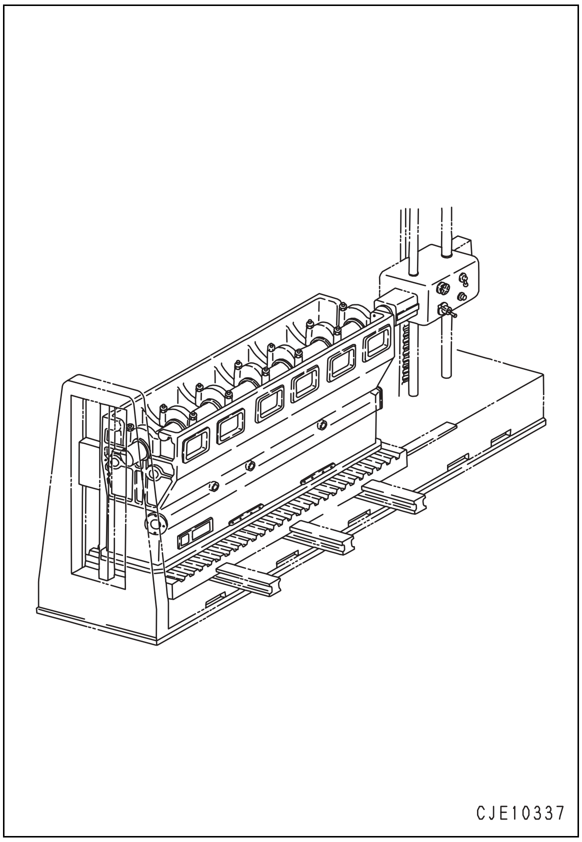
★ Be sure to perform i) and ii).



REPLACING MAIN BEARING CAP

★ When replacing the main bearing cap, machine the semi-finished part according to the following procedure.

- No. 1,2,3,4,5,7 Main cap 6240-29-1210
- No. 6 Main cap 6240-29-1250



1. Machining the bore of main bearing cap

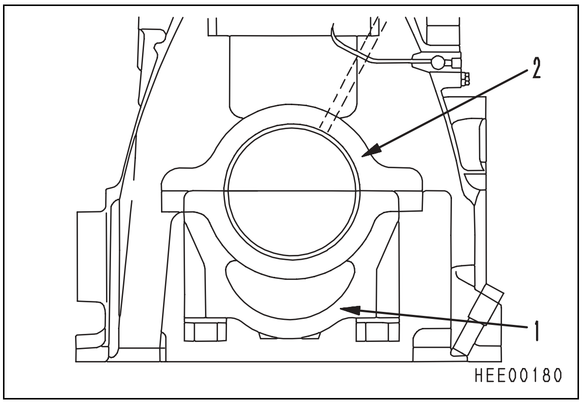
1) Remove the cylinder liner
2) Install the replacement bearing cap to the cylinder block and tighten it to specification.
   ★ Align the notches on the cylinder block and cap.
   ★ Coat the thread and seat with engine oil SAE30
   ★ Tighten the bolts at the 3rd time by angle tightening method.

   Main bearing cap mounting bolt:

Step	Target	Range
1st	284Nm {29kgm}	269 – 299Nm {27.5 – 30.5kgm}
2nd	578Nm {58kgm}	568 – 588Nm {57 – 59kgm}
3rd	105°	120° – 90°

3) Set the jig for mounting the cylinder block to the table of a horizontal boring machine. Install the cylinder block by mounting its hole for the liner to the datum plug of the jig.
4) Center the arbor of the boring machine by applying a dial gauge to the inside wall of the two bearing caps which have the largest pitch in the caps to be used again.
5) Cut the inside of bearing cap (1) little by little while checking its inside diameter.
   ★ Cut until the cutting tool contacts the inside wall of cylinder block (2).
   ★ Inside diameter of main cap:

   Tolerance: $148^{+0.025}_{0}$ mm
   ★ Surface roughness: Max. 12.5S
   ★ Never cut the inside wall of the cylinder block.



2. Correcting the width of the main bearing cap (Modifying No. 6 main cap only)

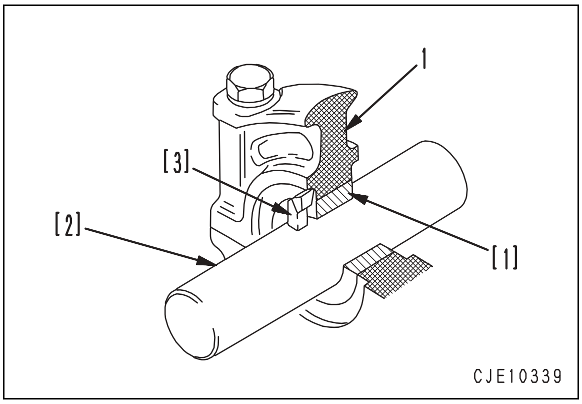
1) Insert cast iron bushing [1] and pass arbor [2] through.
2) Install facing tool [3] to the arbor.
3) Cut cap (1), until the cutting tool contacts the cylinder block.
4) Cut the opposite side in the same way.

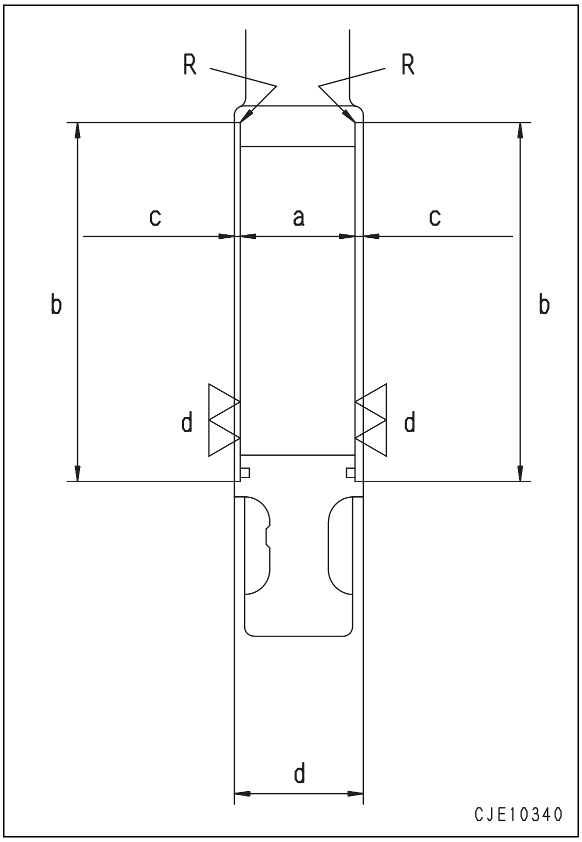
★ Surface roughness of thrust bearing:
Max. 12.5 S

★ Do not cut the cylinder block side.

★ Dimensions of main cap

- Radius **R**: Max. 0.5 mm
- Surface roughness of part **d**: Max. 12.5 S
- Inside width **a** of main cap: $56^{\,0}_{-0.030}$
- Outside diameter **b** of thrust bearing mounting part:
  175 ± 2 mm
- Depth **c** of thrust bearing mounting part:
  2.5 ± 0.2 mm
- Radius **R** of thrust bearing mounting part:
  Max. 0.5 mm
- Outside width **d** of main cap :
  61 ± 0.5 mm



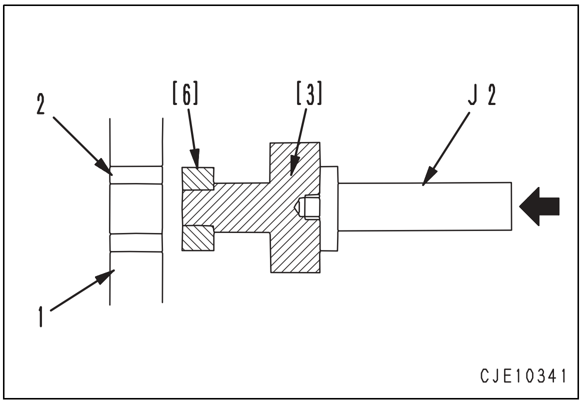


REPLACING CAM BUSHING

★ Before replacing the cam bushing, remove the seal plate from the front of the cylinder block.

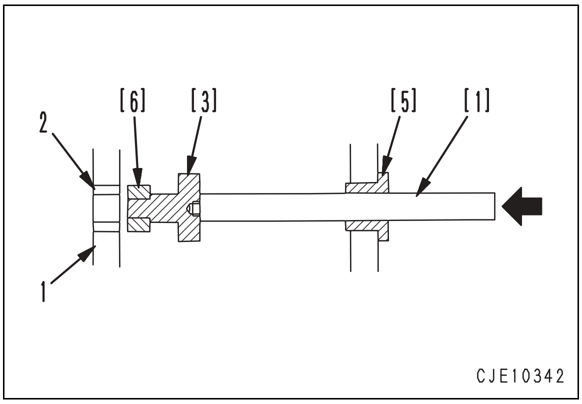
1. Removing No. 1 and No. 7 bushings

- As shown in the figure, assemble push tool [3] and collar [6] in push tool set **J1**, and grip **J2**, then pull bushing (2) out of cylinder block (1) by hitting the grip.



2. Removing No. 2 and No. 6 bushings

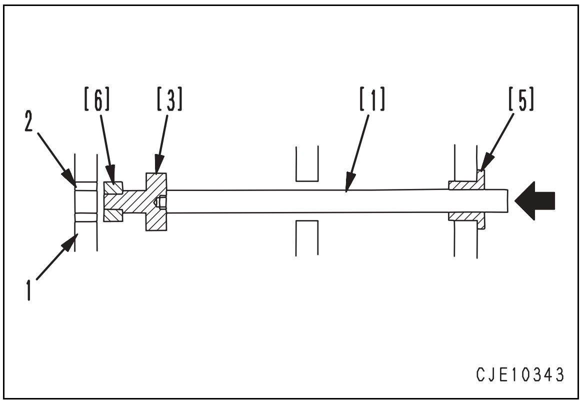
- Assemble push bar [1], push tool [3], guide [5], and collar [6] in push tool set **J1**, then pull bushing (2) out of cylinder block (1) while hitting the bar.



3. Removing No. 3 and No. 5 bushings

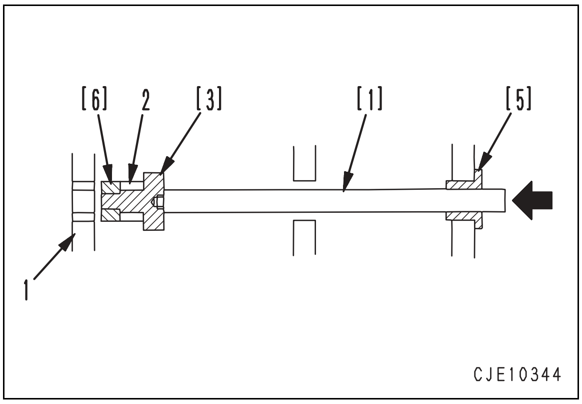
- Assemble push bar [1], push tool [3], guide [5], and collar [6] in push tool set **J1**, then pull bushing (2) out of cylinder block (1) while hitting the bar.

★ After removing the bushings, remove the burrs and foreign matter from the bushing mounting holes and clean those holes.

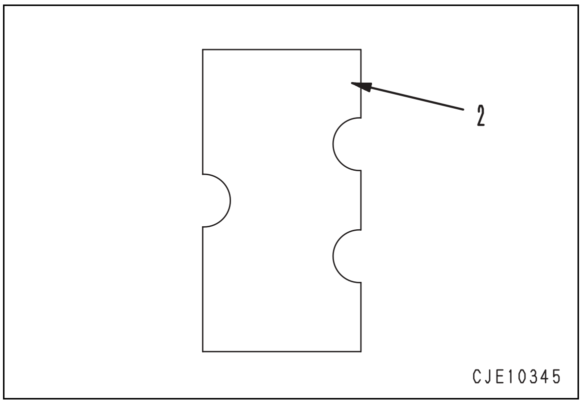


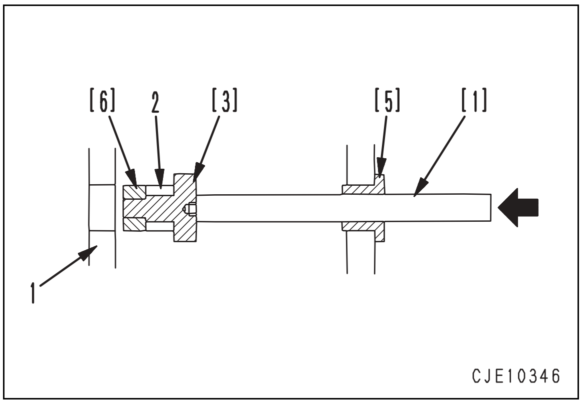
4. Press-fitting No. 3, No. 4, and No. 5 bushings

- Assemble tool set **J1** and bushing (2), then press-fit bushing (2) until its oil hole is matched to the oil hole of the cylinder block.
  - ★ Insert the bushing with the 1-cut end in front (See the following page).
  - ★ Match the oil hole of the bushing (Take this precaution for the following press-fitting work, too).

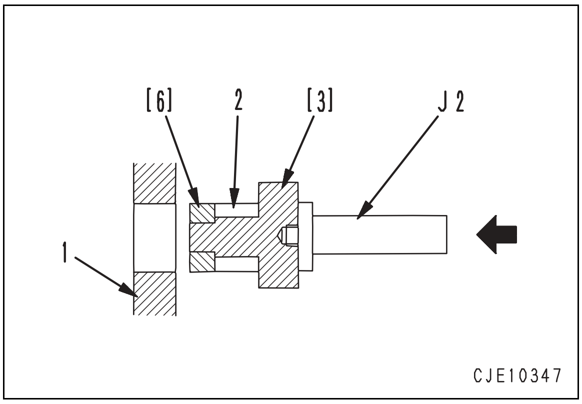


5. **Press-fitting No. 2. and No. 6 bushings**
- Assemble tool set **J1**, grip **J2**, and bushing (2), then press-fit bushing (2) until its oil hole is matched to the oil hole of the cylinder block.
  - ★ **Match the oil hole of the bushing.**

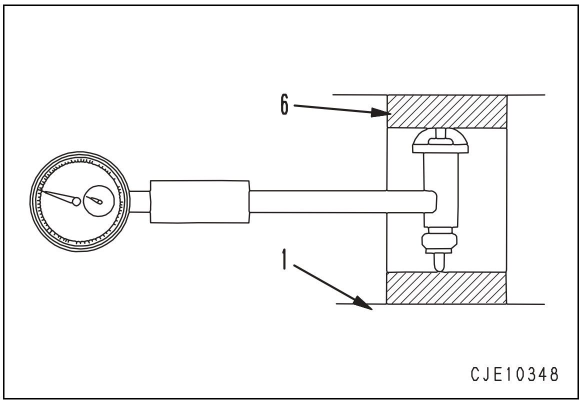




6. **Press-fitting No. 2. and No. 6 bushings**
- Assemble tool set **J1**, grip **J2**, and bushing (2), then press-fit bushing (2) until its oil hole is matched to the oil hole of the cylinder block.
  - ★ Match the oil hole of the bushing.



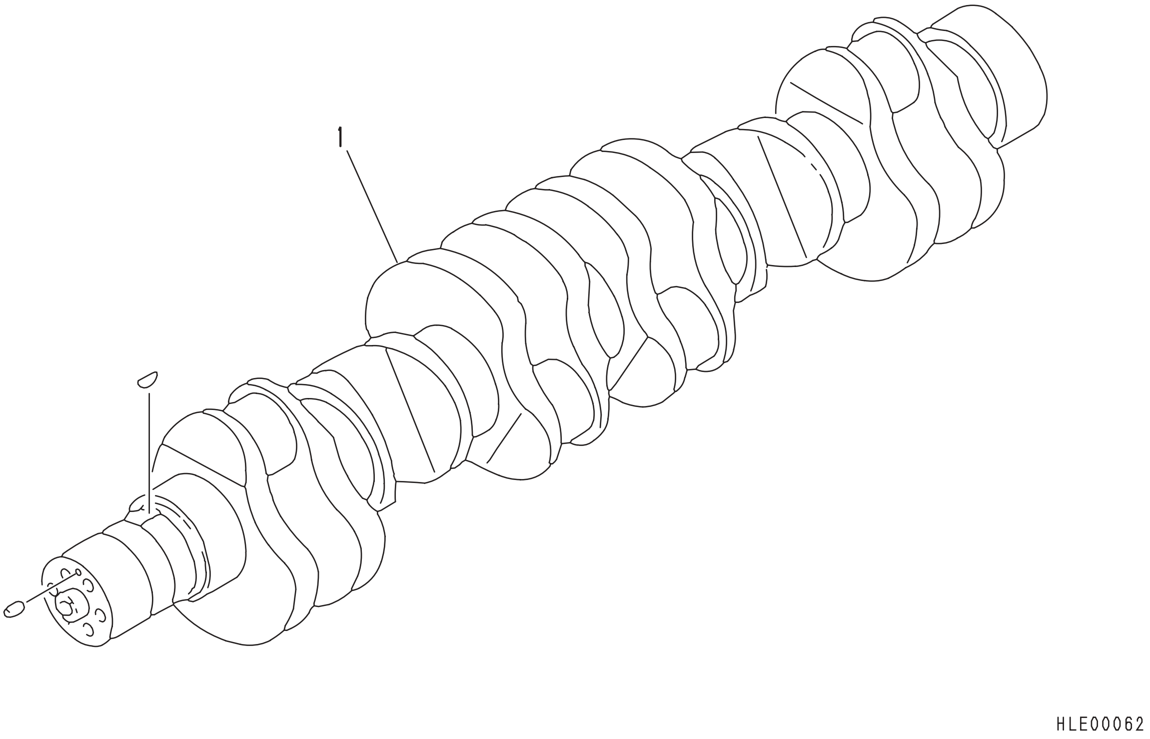
- Measure the inside diameter of the bushing with inside gauge.
- Check the clearance between the bushing and shaft. If the clearance is out of the allowable range or the shaft does not pass through smoothly, correct the inside of the bushing with a reamer.
  - If the inside of the bushing has been corrected with a reamer, remove the all chips from the oil holes and oil grooves.



★ Inside diameter of cam bushing: $\phi 105^{+0.101}_{+0.017}$ mm

★ Clearance of camshaft journal:
0.059 – 0.173 mm

TESTING AND INSPECTING CRANKSHAFT



1. Crankshaft

TESTING AND INSPECTING

Unit: mm

Inspection item	Judgement standards		Remedy
A. Cracks	Use a magnetic flaw detector to check for cracks		Replace
B. Damage	Check for damage to the journal portion	Scratches Seizure Discoloration	If the damage is slight, correct with an oilstone or correct by lapping. Replace if there is seizure
	Damage to cap hole at front and rear end		Correct
C. Clogging of oil hole	Check for clogging of oil hole		Correct

Unit: mm

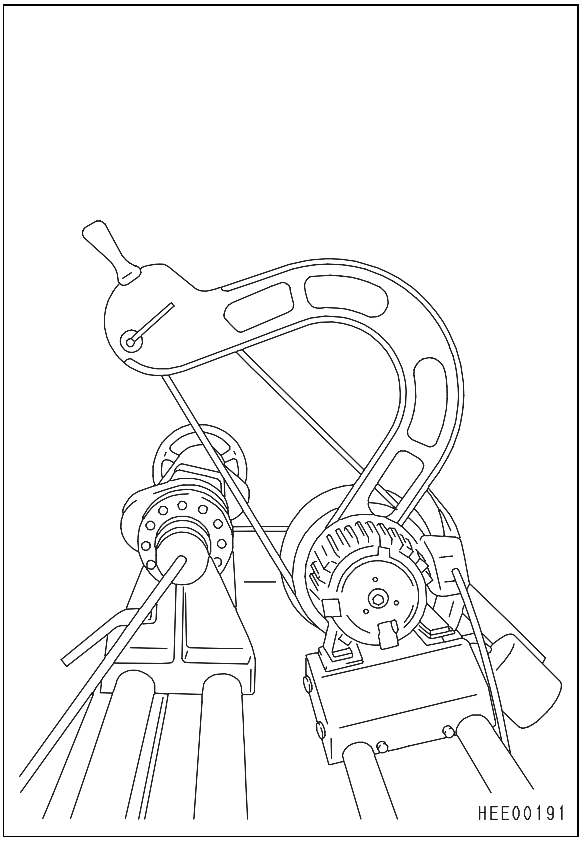
<table>
<tr><th>Inspection item</th><th colspan="4">Judgement standards</th><th>Remedy</th></tr>
<tr><td rowspan="2">D. End play of crankshaft</td><td colspan="2">Standard value</td><td colspan="2">Repair limit</td><td rowspan="2">Replace thrust bearing or correct with oversize</td></tr>
<tr><td colspan="2">0.140 – 0.320</td><td colspan="2">0.69</td></tr>
<tr><td rowspan="6">E. Thickness of thrust bearing</td><td>Size</td><td>Standard size</td><td>Tolerance</td><td>Repair limit</td><td rowspan="6">Replace thrust bearing or correct crankshaft with oversize</td></tr>
<tr><td>STD</td><td>4.0</td><td rowspan="5">-0.07
-0.12</td><td>3.79</td></tr>
<tr><td>0.25 US</td><td>4.125</td><td>3.92</td></tr>
<tr><td>0.50 US</td><td>4.25</td><td>4.04</td></tr>
<tr><td>0.75 US</td><td>4.375</td><td>4.17</td></tr>
<tr><td>1.00 US</td><td>4.5</td><td>4.29</td></tr>
<tr><td rowspan="6">F. Outside diameter of crankshaft pin journal</td><td>Size</td><td>Standard size</td><td>Tolerance</td><td>Repair limit</td><td rowspan="8">Correct with undersize or replace</td></tr>
<tr><td>STD</td><td>108.00</td><td rowspan="5">0
-0.022</td><td>107.91</td></tr>
<tr><td>0.25 US</td><td>107.75</td><td>107.66</td></tr>
<tr><td>0.50 US</td><td>107.50</td><td>107.41</td></tr>
<tr><td>0.75 US</td><td>107.25</td><td>107.16</td></tr>
<tr><td>1.00 US</td><td>107.00</td><td>106.91</td></tr>
<tr><td rowspan="2">G. Out-of-roundness of crankshaft pin journal</td><td colspan="2">Standard value</td><td colspan="2">Repair limit</td></tr>
<tr><td colspan="2">0 – 0.010</td><td colspan="2">0.010</td></tr>
<tr><td>H. Clearance of crankshaft pin journal</td><td colspan="2">0.058 – 0.132</td><td colspan="2">0.18</td><td>Replace connecting rod bearing</td></tr>
<tr><td rowspan="6">I. Outside diameter of main journal</td><td>Size</td><td>Standard size</td><td>Toleranc</td><td>Repair limit</td><td rowspan="8">Correct with undersize or replace</td></tr>
<tr><td>STD</td><td>140.00</td><td rowspan="5">0
-0.025</td><td>139.91</td></tr>
<tr><td>0.25US</td><td>139.75</td><td>139.66</td></tr>
<tr><td>0.50US</td><td>139.50</td><td>139.41</td></tr>
<tr><td>0.75US</td><td>139.25</td><td>139.16</td></tr>
<tr><td>1.00US</td><td>139.00</td><td>138.91</td></tr>
<tr><td rowspan="2">J. Out-of-roundness of main journal</td><td colspan="2">Standard value</td><td colspan="2">Repair limit</td></tr>
<tr><td colspan="2">0 – 0.010</td><td colspan="2">0.010</td></tr>
<tr><td>K. Clearance of main journal</td><td colspan="2">0.076 – 0.152</td><td colspan="2">0.20</td><td>Replace main bearing</td></tr>
<tr><td rowspan="3">L. Curvature of crankshaft (total runout of indicator)</td><td colspan="2"></td><td>Standard</td><td>Repair limit</td><td rowspan="3">Replace</td></tr>
<tr><td colspan="2">Total coaxiality of main journal</td><td>Max. 0.150</td><td>0.150</td></tr>
<tr><td colspan="2">Coaxiality of neighboring journals</td><td>Max. 0.070</td><td>0.070</td></tr>
</table>

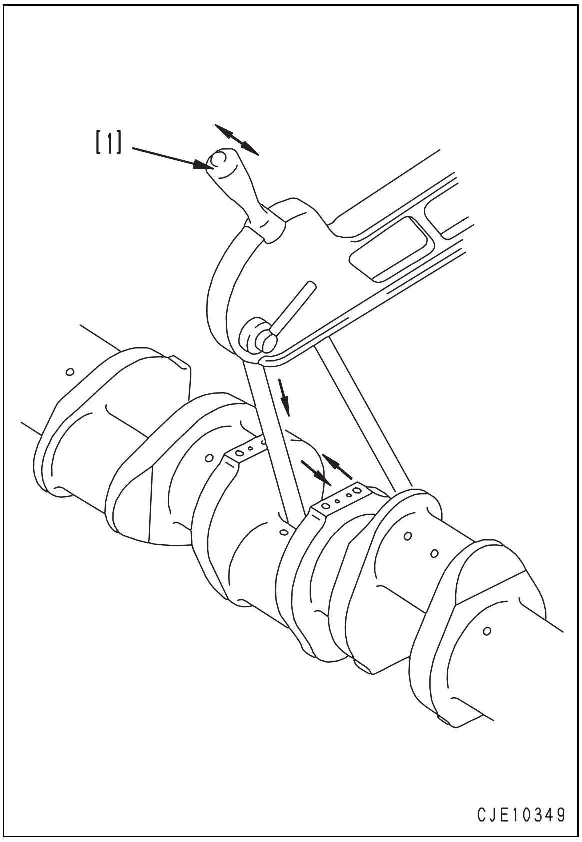
CORRECTING SURFACE ROUGHNESS OF CRANKSHAFT JOURNAL PORTION

If the roughness of the crankshaft journal portion does not fulfill the standard, correct the surface roughness.

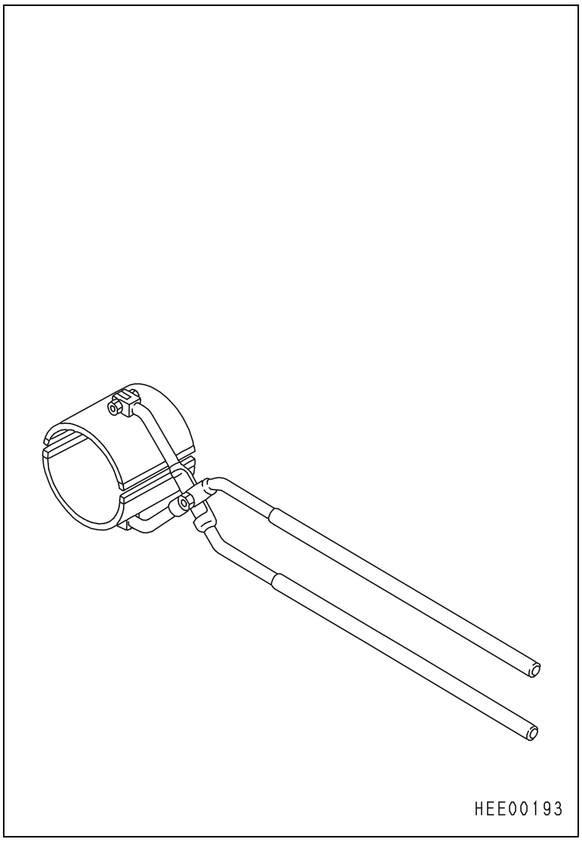
1. **Cleaning and blowing with air**
   Before polishing, brush the oil holes and blow with air.

2. **Correcting surface roughness of journal portion**
   1) When correcting with special polishing machine
      Use a special polishing machine as shown in the diagram on the right.
      i) Set the rotating speed for the work at 40 – 50 rpm, and use No. 320 paper (belt type). Perform dry polishing (do not use honing oil), and move the paper once up and down the whole journal width for each joutnal. Move the paper smoothly and do not stop at any point.
      ii) Next, replace with No. 500 paper, coat the jounal surface with honing oil, and move the handle [1] of the machine to the left and right by the amount of play to give fine movement. Use this movement to move once up and down the whole width of the jounal. Move the paper smoothly and do not stop at any point.
      iii) Check the surface roughness, and if it is not within the standard, polish again once up and down the width of the journol with No. 500 paper.

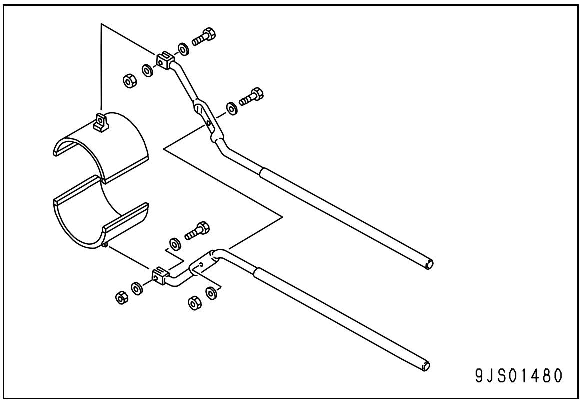




2) When using a work clamp jig for polishing (When a special polishing machine is not available)
   Use a work clamp jig such as shown in the diagram on the right.
   - i) Use a crankchaft grinding machine under the following polishing conditions.
     Paper: No. 800
     Machining oil: Honing oil
     Work speed: 40 rpm
   - ii) The polishing time for one journal is approx. 6 minutes. Move the clamp the amount of play of the clamp and joutnal width (approx. 5 mm), and move up and down the journal in the axial direction.
     After completing the honing of one journal, replace the paper with new paper.
     When honing the pin journal, it is safter to carry out the work with the pin journal is the rotation center.



3) Assembly of work clamp jig and method of use
   - i) Cramping jig for pin journal and main journal is assembled as shown in the diagram on the right. For details of the component parts, see the drawings on sepatate pages.

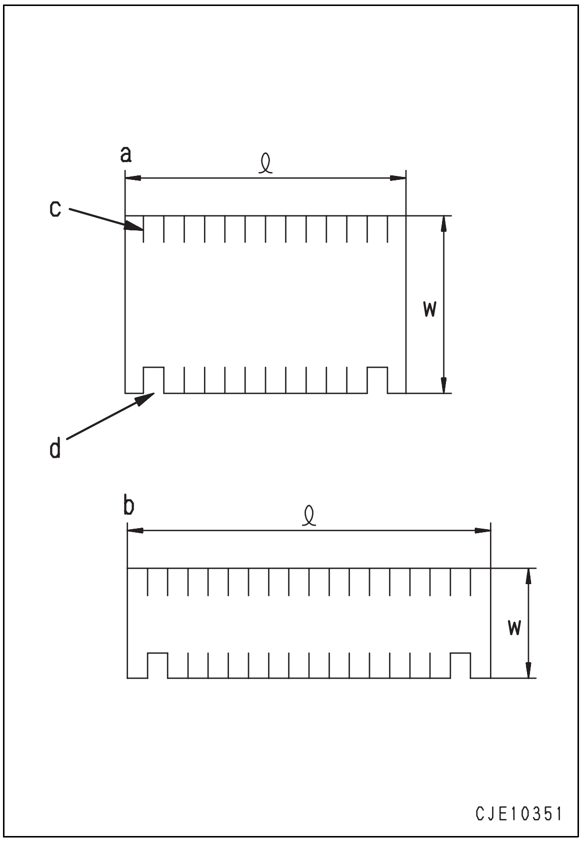


ii) Cut No. 800 sandpaper into shapes **a** and **b** as shown in the figure at right.
  - Piece **a** is 205 mm long "ℓ" and 95 mm wide **w** and used for the pin journal.
  - Piece **b** is 255 mm long "ℓ" and 88 mm wide **w** and used for the main journal.
  - ★ Make slits **c** 20 mm long on both sides of each piece of the sandpaper at intervals of 10 mm and cut off only parts **d**.

iii) Insert 2 pieces **a** or **b**, prepared in ii), in slits **e** of the clamp jig, 1 on the top and the other at the bottom, and fix their front ends with tapes **f**.

iv) Bend the slit portions **d** of the sandpaper along the round parts of the clamp.

v) Hold the journal with the clamp and fix the lever ends with rubber band **g**.

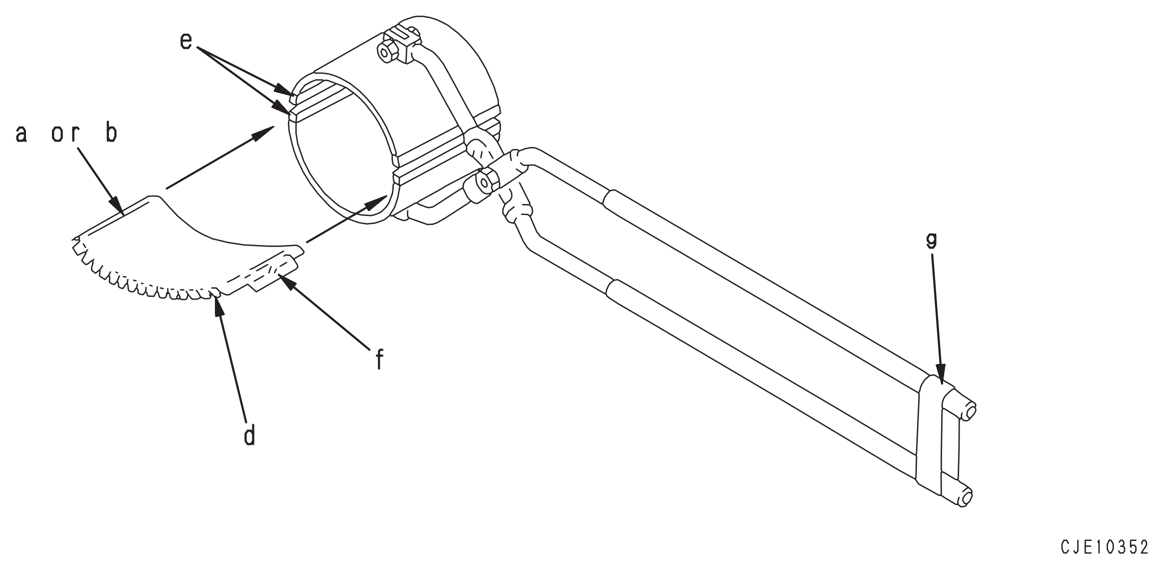


CJE10351

3. **Measuring surface roughness**
   Standard for surface roughness
   Main journal and pin journal: Max. 0.6 S
   Using a surface roughness measuring tool, check that the roughness is within the standard. If measuring tool is not available, rub No. 1500 paper extremely lightely in the axial direction,and use a 30-times magnifying galss to inspect the pattern on the paper. If the horizontal lines can be seen to be connected it is within the standard value. If the lines canot be seen to be connected, the roughness of the journal surface is not within standard, so polish it again.

4. **Cleaning after correcting surface roughness**
   After correcting the surface roughness, always brush the oil hole and blow with air.

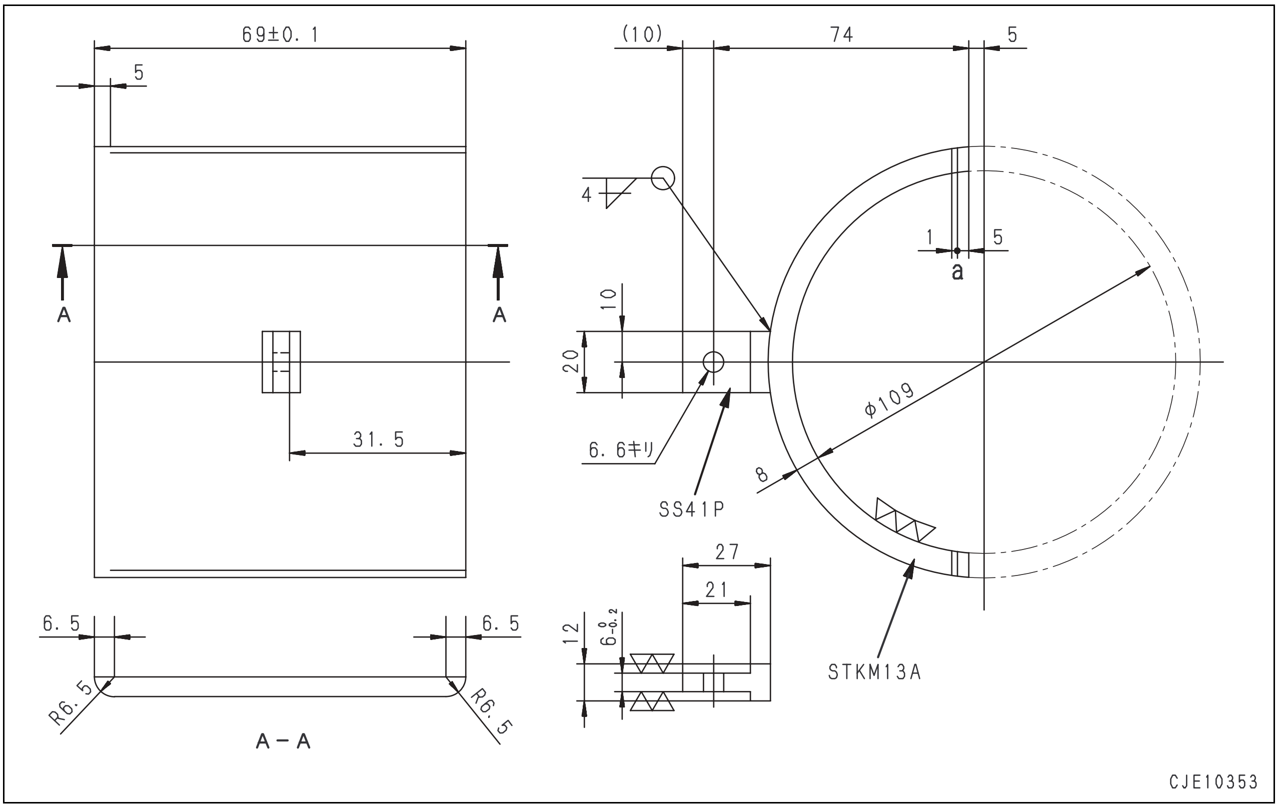
5. **Check that there are no scratches or dents at the journal portion and fillet R portion.**



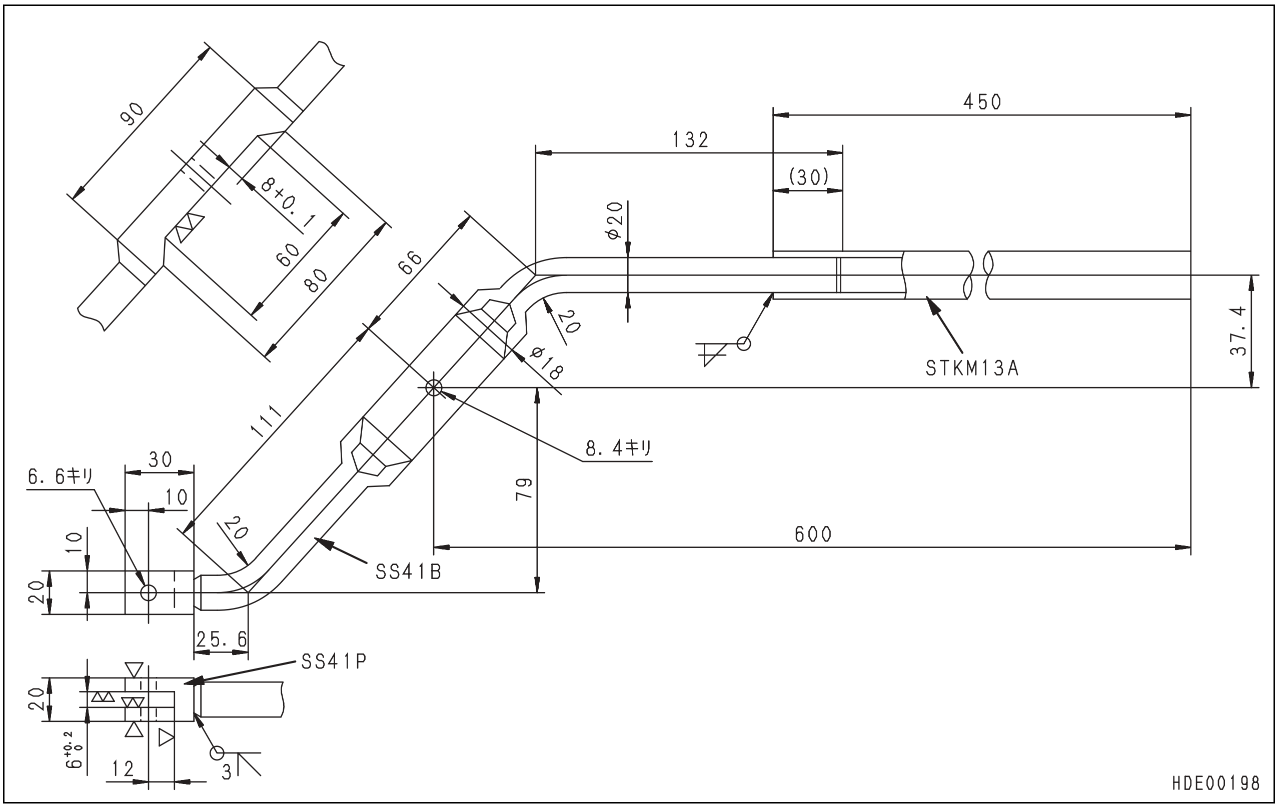
CJE10352

Clamp jig parts drawing (for pin journal)

1) Plate (2 are used for each jig) (**a** : Width of slit) Unit: mm

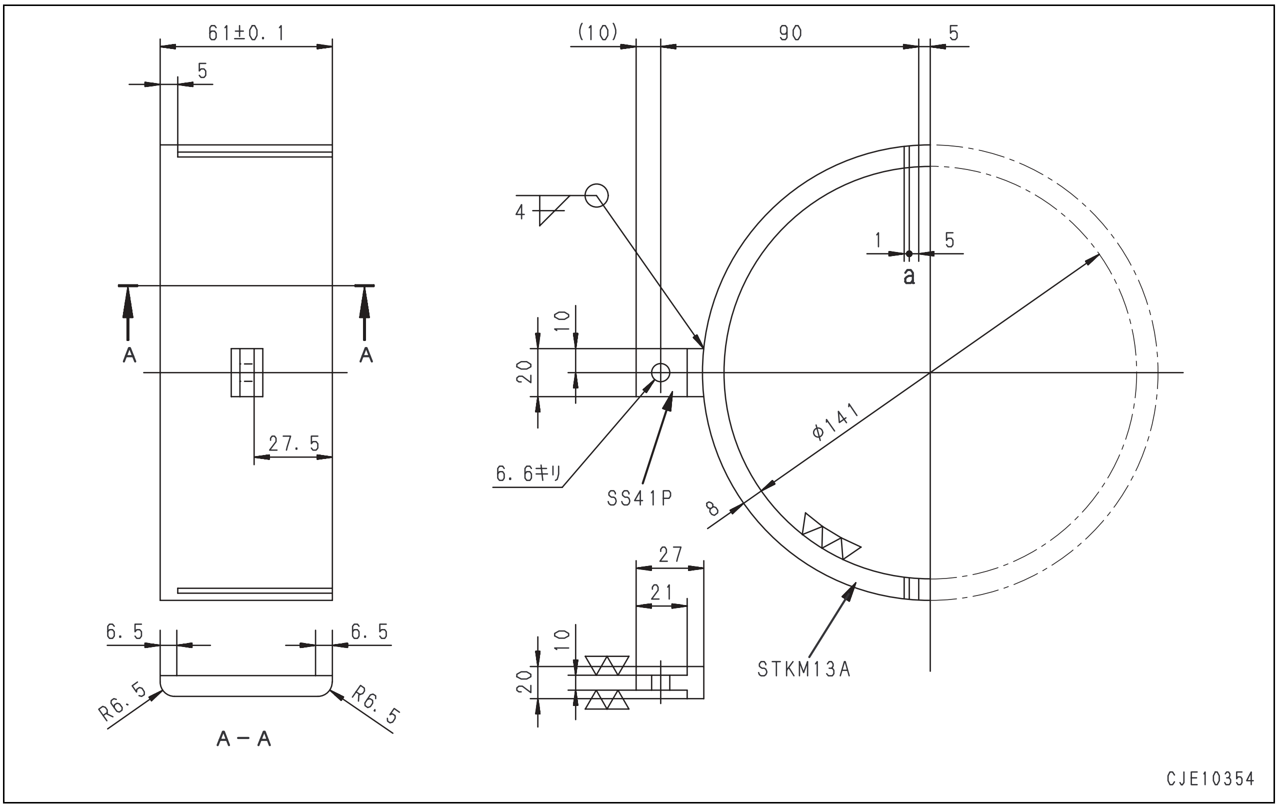


2) Handle (2 are used for each jig) Unit: mm

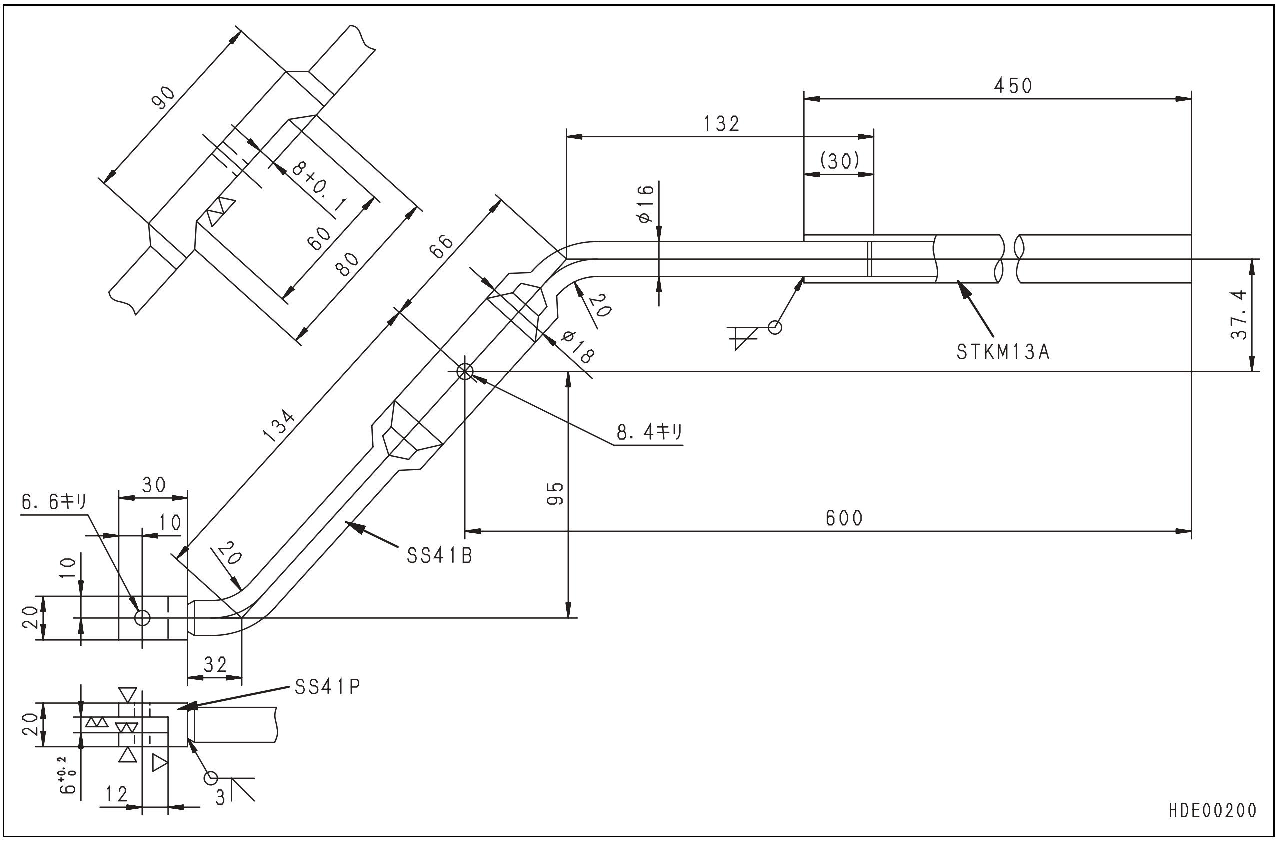


Clamp jig parts drawing (for main journal)

1) Plate (2 are used for each jig) (**a** : Width of slit) Unit: mm



2) Handle (2 are used for each jig) Unit: mm

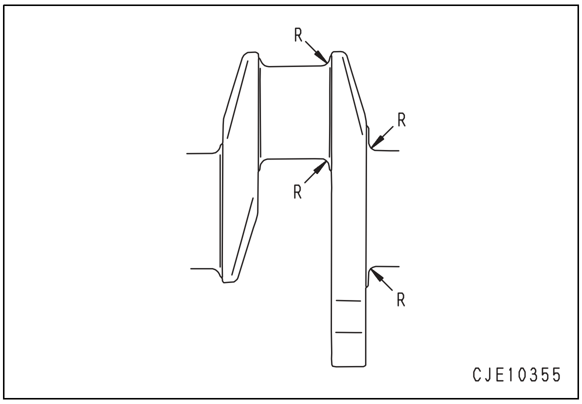


REPAIRING CRANKSHAFT

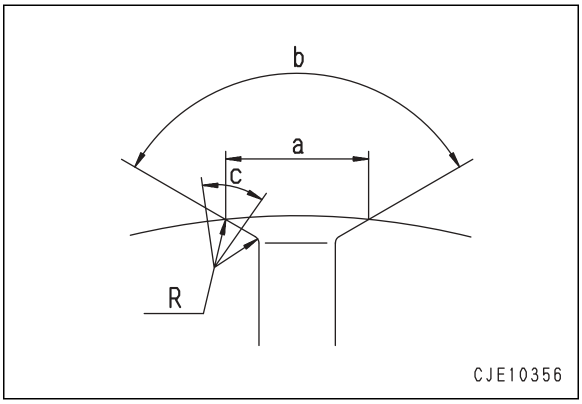
- If the crankshaft is worn or slightly seized or damaged, machine it to any one of the following thicknesses.
  Undersize dimensions: 0.25, 0.50, 0.75, 1.00 mm
- If the crankshaft is bent or worn unevenly, replace it instead of repairing it. (A lot of skill is required to repair it.)
- Carefully finish section **R** of the fillet of the crankshaft, section **R** on the shoulder, and section **R** facing the hole.
  - Finishing dimensions of fillet

    R: $6.5^{0}_{-0.5}$ mm,
    Surface roughness: 1.6S

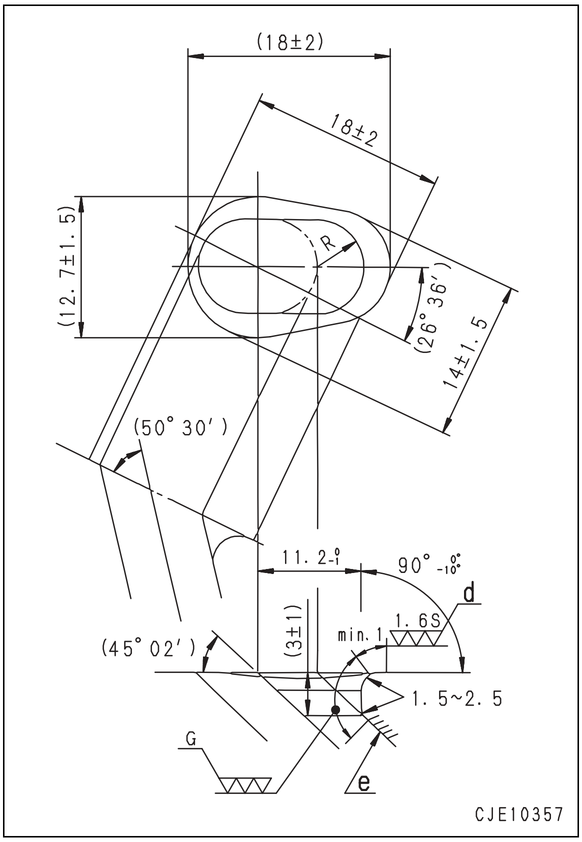
- Finishing dimensions for main journal and pin journal are show in diagram in the right.
  1) Oil hole of main journal (See figure at right)
     i) Dimension of tapered part **a** of oil hole: 16 mm
     ii) Angle **b** of tapered part of oil hole: 120°
     iii) Surface roughness of part **c** at top of oil hole: 1.6 S (Finished with sandpaper)
     iv) Radius **R** of 2 round parts: 1 – 2 mm
  2) Oil hole of pin journal (See figure at right)
     i) Finish part **d** with sandpaper.
     ii) Check part **e** particularly, since it tends to have a quenching crack.



Main journal portion



Pin journal portion

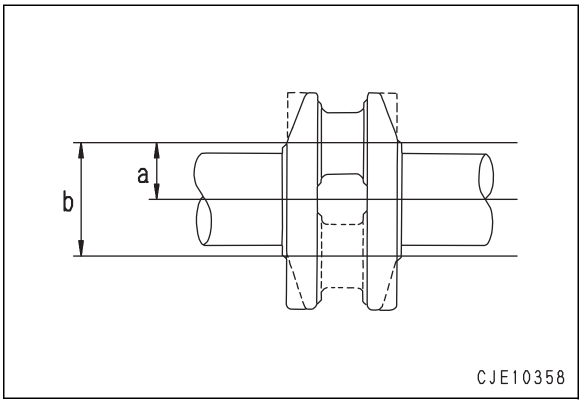


- The surface roughness of the pin journal and main journal must not exceed 0.6 S.

★ Equipment and jigs necessary for repair by grinding
  1) Magnaflux inspection equipment
  2) Shore hardness tester
  3) Etching kid
  4) Crankshaft grinder
  5) Crankshaft polisher
  6) Roughness gauge
  7) Fillet radius ball gauge
     For min. value: 795-500-1140
     For max. value: 795-500-1150

1. Inspection before repair by grinding

1) Visual inspection
   Check the journals for cracking, damage, discoloration by seizure, wear, etc. to see if they can be repaired by grinding.
2) Testing hardness of journal surface
   Permissible range: 74 – 81 HS
   Lower limit: 74 HS
   When using with output below 750 PS
   Permissible range: 60 – 67 HS
   Lower limit: 60 HS
   * The hardness of the spare crankshaft is 74 – 81 HS. On the other hand, the hardness of the crankshaft of an engine of 551.6 kW (750 PS) or less is 60 – 67 HS. The crankshaft of this class must be used for an engine of 551.6 kW (750 PS) or less. The crankshaft having hardness of 74 – 81 HS can be used for any engine.
   ★ If the hardness of a crankshaft is below the lower limit, discard it.
3) Check for torsion
   Permissible range of throw **a**: $85^{\ 0}_{-0.15}$ mm
   Permissible range of horizontal displacement (Difference between 1st cylinder and last cylinder): 0.94 mm
   Dispersion of throw **a** of each cylinder:
   Max. 0.20
   If any of the above item of a is out of the permissible range, discard the crankshaft.
   - Dimension **b** is the stroke.



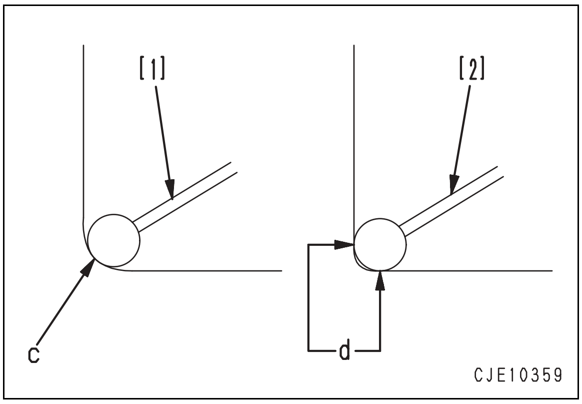
2. Inspection during and after repair by grinding

1) Inspection of radius **R** of fillet
   - i) Check that the radius **R** of each fillet is connected smoothly to the shoulder of the journal.
   - ii) Using the fillet radius ball gauges [1] and [2], check that the "radius" of the round part is between the radii of the minimum radius gauge and the maximum radius gauge.
     - **c**: Contact point of minimum radius gauge
     - **d**: Contact points of maximum radius gauge

   Radius **R** of fillet

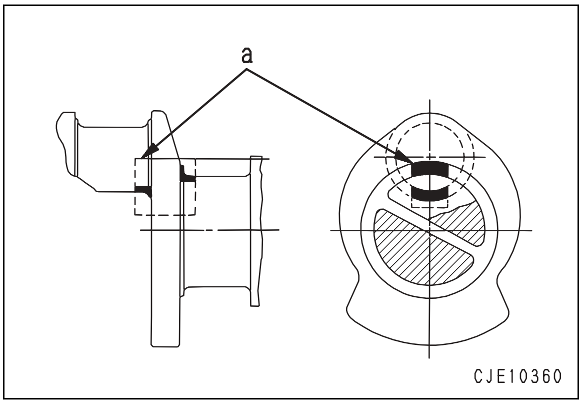
   Min. radius: 6.00 mm

   Max. radius:6.50 mm



2) Inspection by etching for burn
- After repairing by grinding, inspect the repaired part by etching for a grinding burn.
- If any grinding burn is detected, grind it about 0.02 mm to the next undersize.
- After inspecting, neutralize and clean the inspected parts and apply rust-preventive oil.

3) Magnaflux inspection
- Before using the repaired crankshaft, inspect it by magnaflux inspection for cracking.
- Inspect journal fillet **a** which is in the critical section of each web of the crankshaft with extreme care.
- After the magnaflux inspection, be sure to demagnetize the crankshaft.



4) Measuring bend (alignment)
- Measure the bend of the ground crankshaft and check that it is in the standard range.
- Measure the bend (the alignment) at the following 4 places.
  - i) Tolerance of overall length alignment: 0.09 mm
  - ii) Tolerance of adjacent crank: 0.05 mm
  - iii) Tolerance of front end: 0.04 mm
  - iv) Tolerance of rear end: 0.03 mm

3. Grinding main journals

★ Grind all the main journals to the same undersize.

★ When grinding, leave the polishing allowance of 0.007 – 0.008 mm.

- Undersizes of main journal

Unit: mm

Size	Basic dimension	Tolerance
S.T.D	140.000	0 -0.025
0.25 US	139.750	
0.50 US	139.500	
0.75 US	139.250	
1.00 US	139.000	

- Roundness, cylindricality of main journal (T.I.R) and surface roughness
  Permissible range: Max. 0.010 mm
  Repair limit: 0.015 mm
  Surface roughness: 0.6S

4. Grinding the thrust bearing surface

★ It is not always required to grind the front and rear thrust bearing surfaces to the same undersize.

★ If the thrust bearing surfaces have been ground, confirm that the end play of the crankshaft is within the permissible range (For details, see DISASSEMBLY AND ASSEMBLY).

- Undersizes of thrust bearing surfaces

Unit: mm

			Rear thrust bearing surface	
			S.T.D	0.25 O.S
Front thrust bearing surface	S.T.D	Basic dimension	$64^{+0.050}_{0}$	$64.25^{+0.050}_{0}$
		Limit	64.060	64.310
	0.25 O.S	Basic dimension	$64.25^{+0.050}_{0}$	$64.50^{+0.050}_{0}$
		Limit	64.310	64.560

- Squareness of thrust bearing surface (T.I.R)
  Limit: 0.04 mm

5. Grinding pin journals

★ Grind all the pin journals to the same undersize.

★ When grinding, count in finishing allowance for grinding 0.007 to 0.008 mm.

- Undersizes of pin journal

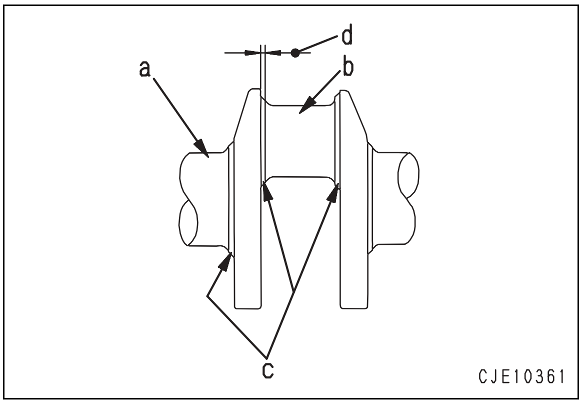
Unit: mm

Size	Basic dimension	Tolerance
S.T.D	108.00	0 -0.022
0.25 US	107.75	
0.50 US	107.50	
0.75 US	107.25	
1.00 US	107.00	

- Roundness and cylindricality of pin journal (T.I.R) and surface roughness
  Permissible range: Max. 0.010 mm
  Rpair limit: 0.015 mm
  Surface roughness: 0.6S

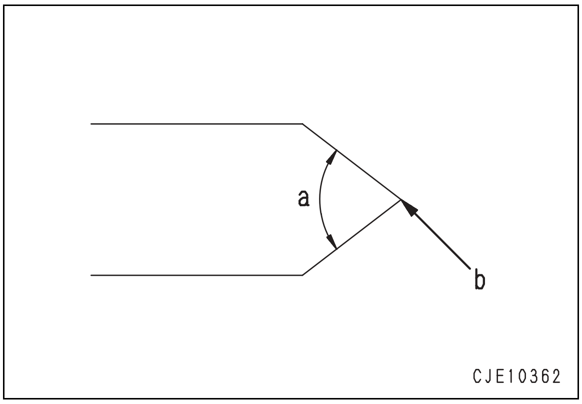
6. Correcting the width of the main journal and pin journal by grinding

- When correcting the worn surfaces **c** of the main journals **a** and pin journals, **b** limit the grinding thickness to the minimum.
  d: Thickness of wear
- Width of crank pin journal
  If cutting one side only:
  Standard: $72^{+0.074}_{0}$ mm
  Repair limit: 72.32 mm
  Width of main journal (For No. 6 only):
  Standard: $64^{+0.05}_{0}$ mm
  Repair limit: 64.30 mm
  Squareness of thrust bearing surface (T.I.R)
  Limit: 0.04 mm



7. Correcting the grindstone

- Dress the grindstone each time one journal is ground.
- Grindstone dresser
  Tip angle **a**: 75° ± 1°
  Radius of edge **b**: 0.38 ± 0.25 mm
  At the edge of the dresser, a diamond for industrial use must be embedded.



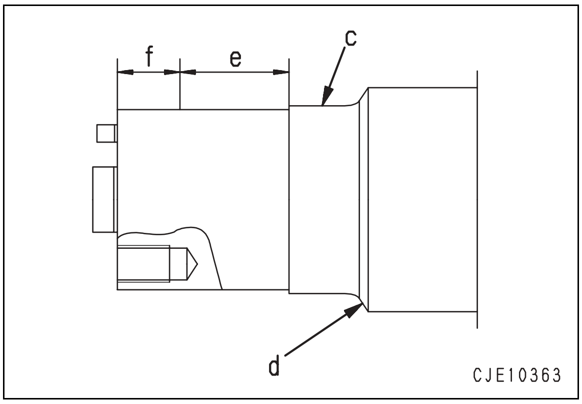
- Adjust the machine for correcting the grindstone, and correct the edge of the grindstone to the radius of the fillet.
- When checking and correcting the grindstone edge, grind a wood bar for trial and use ball gauges.

8. Preventing seizure caused by grinding

1) Use the plunge grinding method.
2) Use the overall width of the grindstone.
   Do not grind the bosses if possible.
3) Apply sufficient cooling oil.
4) Set the circumferential speed of the grindstone to 2,000 m/min when the speed of crankshaft is 50 rpm.

9. Surface finishing

- Standard surface roughness
  Journal **c**: 0.6S
  Thrust bearing, fillet **d**: Max. 1.6S
  Front seal inserting part **e** (Area of 32 – 85 mm from end):
  1 – 2 S (Finished with sandpaper)
  Front end **f** (Area of 32 mm from front end): 3.2 S
- Finishing allowance for grinding:
  0.007 to 0.008 mm



10. Treatment after grinding

- Confirm that each dimension is within specification.
- Carefully wash each section and apply oil to it.
- When storing the crankshaft for a long time, support it at three points or hang it vertically.

11. Balancing (for reference)

(Do not perform any repair which will have an adverse effect on the balance of the crank shaft.)

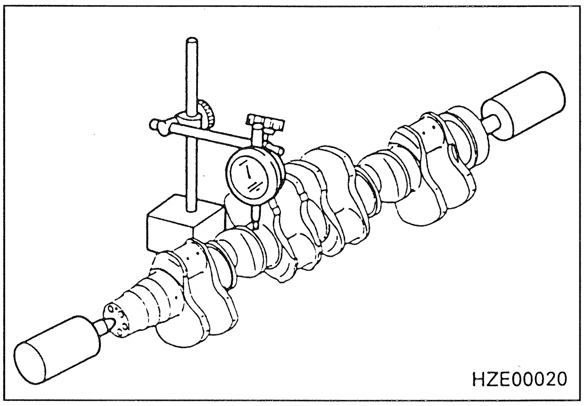
- Limit of unbalance: 110 gcm
- Limits for reading the balance correctly
  - Bend of crankshaft: 0.09 mm (T.I.R)
  - Speed of crankshaft: Max. 325 rpm
- Make the following correction to balance the crankshaft.
  - Rear key way: 66 gcm
  - Front reamed hole: 31.5 gcm
- To balance the crankshaft, make a hole on the counter weight with a drill or grind it.

  Limit amount of counterweight to be removed: 56 g

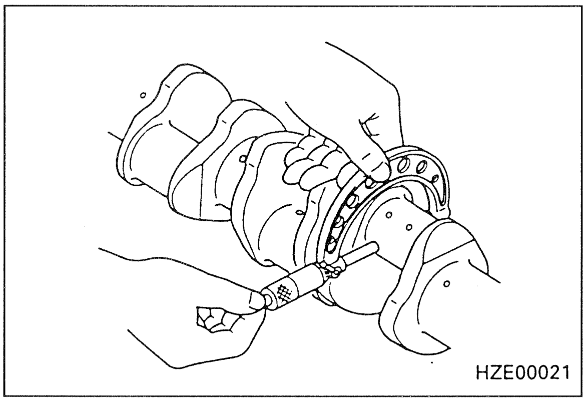
  Drill holes direction: Radial direction
  - Number of holes: Max. 6
  - Diameter of hole: 19 mm or 23 mm
  - Depth of hole: Max. 50 mm
  - Distance between hole and side face: Min. 3 mm
  - Distance among holes: Min. 5 mm

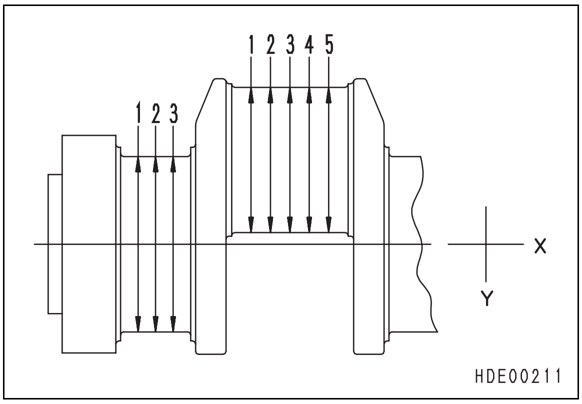
12. Procedure for measuring curvature of crankshaft and outside diameter of journal

1) When measuring the curvature, use No. 1 and No. 7 journals as the datum point, put the dial gauge in contact with the journal and set the dial to 0 at the peak.
   Then rotate one turn and read the minimum and maximum values.

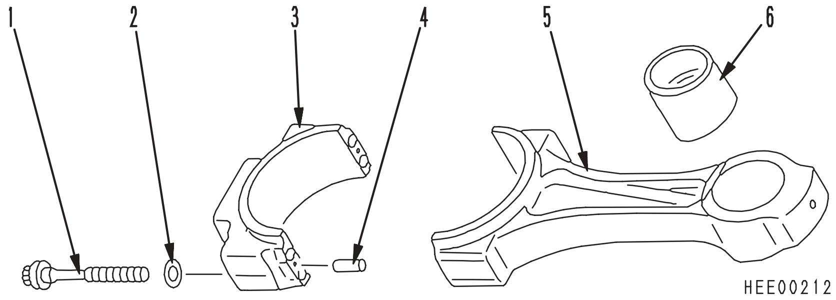


2) Measure the outside diameter of the main journal in the **XY** direction (No. 1 – 2) at 2 places, and the outside diameter of the pin journal in the **XY** direction (No. 1 – 2) at 2 places with a micrometer or air micrometer.





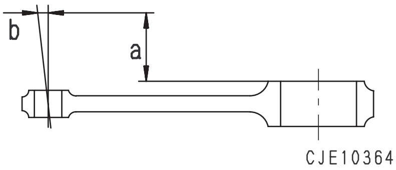
TESTING AND INSPECTING OF CONNECTING ROD



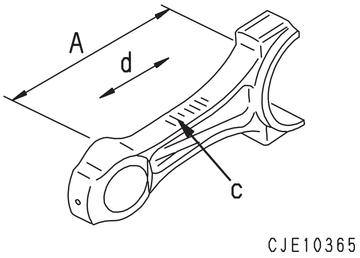
1. Bolt
2. Washer
3. Cap
4. Dowel pin
5. Connecting rod
6. Bushing

TESTING AND INSPECTING

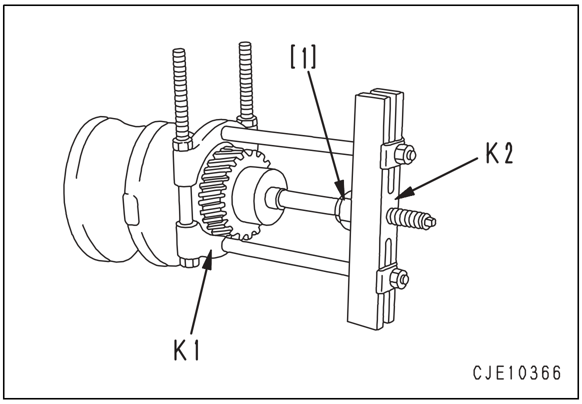
Unit: mm

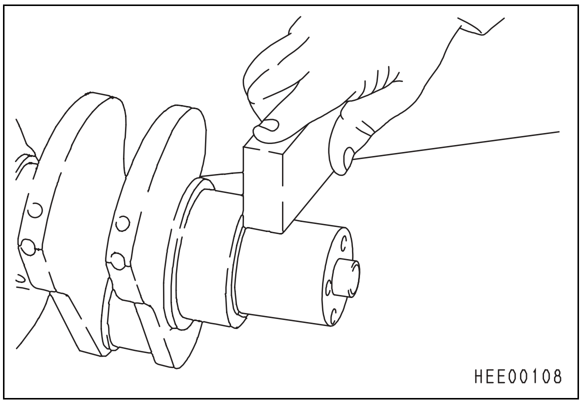
<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>A. Cracks</td><td>Check for cracks with a color check or magnetic flaw detector</td><td>Replace</td></tr>
<tr><td>B. Parallelism and torsion</td><td>Measure parallelism a and torsion b
(After installing pin bushing)
 </td><td>Replace</td></tr>
<tr><td>C. Clearance between connecting rod bushing and piston pin</td><td>
<table>
<tr><th rowspan="2">Standard size</th><th colspan="2">Tolerance</th><th rowspan="2">Standard clearance</th><th rowspan="2">Clearance limit</th></tr>
<tr><th>Shaft</th><th>Hole</th></tr>
<tr><td>68</td><td>-0.020
-0.026</td><td>+0.049
+0.030</td><td>0.030 – 0.075</td><td>0.075</td></tr>
</table>
</td><td>Replace bushing, roughness of inside surface of bushing: Max. 1.6S</td></tr>
<tr><td>D. Inside diameter of hole at big end of connecting rod</td><td>
• Inside diameter of hole at big end
• Without bearing
• Roughness of inside surface of hole at big end: Max. 6.3S
• Clearance between crankshaft journal (with bearing)
<table>
<tr><th>Standard size</th><th>Tolerance</th></tr>
<tr><td>115</td><td>+0.026
0</td></tr>
</table>
<table>
<tr><th>Standard clearance</th><th>Clearance limit</th></tr>
<tr><td>0.058 – 0.132</td><td>0.132</td></tr>
</table>
Even if each part is within the repair limit, if it is above the clearance limit, replace the part (bearing, etc.)
</td><td>Replace</td></tr>
<tr><td>E. Thickness of bearing</td><td>
<table>
<tr><th>Item</th><th>Standard size</th><th>Tolerance</th><th>Repair limit</th></tr>
<tr><td>S.T.D</td><td>3.500</td><td rowspan="5">-0.029
-0.042</td><td>3.41</td></tr>
<tr><td>U.S 0.25</td><td>3.625</td><td>3.54</td></tr>
<tr><td>U.S 0.50</td><td>3.725</td><td>3.66</td></tr>
<tr><td>U.S 0.75</td><td>3.875</td><td>3.79</td></tr>
<tr><td>U.S 1.00</td><td>4.000</td><td>3.91</td></tr>
</table>
</td><td></td></tr>
</table>

Unit: mm

<table>
<tr><th>Inspection item</th><th>Judgement standards</th><th>Remedy</th></tr>
<tr><td>F. Scratches on inside surface of bearing, seizure</td><td>Check for scratches or seizure</td><td>Replace, replace connecting rod also</td></tr>
<tr><td>G. Distance between holes at big end and small end</td><td><table><tr><th>Standard size</th><th>Tolerance</th></tr><tr><td>305</td><td>0
-0.05</td></tr></table></td><td>Replace</td></tr>
<tr><td rowspan="2">H. Scratches at I shape prttion of connecting rod (dents)</td><td rowspan="2">
• Check for scratches **c** in horizontal direction in area **A**
d: Direction of length
• Check for grinder grain in horizontal direction in area **A**</td><td>Replace</td></tr>
<tr><td>Replace if there are any dents, regardless of size</td></tr>
<tr><td>I. Fretting of mating surface of cap</td><td>Check for fretting of mating surface
Roughness of mating surface: Max. 6.3 S
Contact of mating sutface: Min. 70%</td><td>Replace if fingernail catches in fretting</td></tr>
<tr><td rowspan="3">J. Scuffing of bolt seat surface</td><td>Scuffing of cap bolt seat surface</td><td>Correct with oil-stone</td></tr>
<tr><td>Scuffing of bolt seat surface</td><td>Replace bolt</td></tr>
<tr><td>Scuffing of washer surface</td><td>Replace washer</td></tr>
<tr><td>K. Deformation of dowel pin</td><td>Check for deformation of dowel pin
Check for deformation of dowel pin hole</td><td>Replace</td></tr>
<tr><td>L. Damage to bolt</td><td>Check for cracks, damage to bolt thread
Check for curvature of bolt</td><td>Replace bolt</td></tr>
</table>

REPLACING CRANKSHAFT GEAR





1. Removal of gear

- Make a scratch in the surface at the root of the teeth with a grinder, then assemble tools **K1** and **K2** and turn nut [1] to remove the gear.
  - ★ If the gear cannot be removed in this way, make a scratch in the surface at the root of the teeth with a grinder, then heat the gear with a gas burner and knock the gear out with a copper rod.
  - ★ Be careful not to damage the crankshaft.

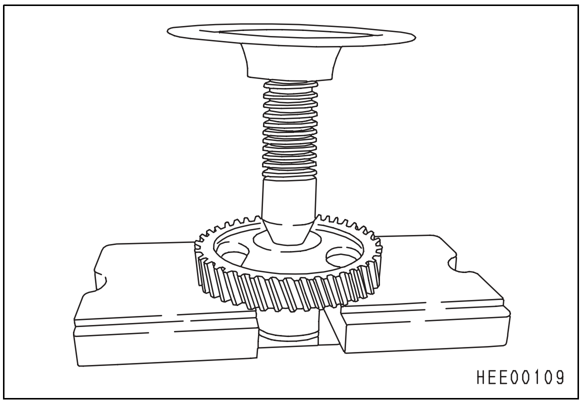
2. Press fitting gear

1) Check the gear mounting surface, key groove, and flange surface, and if there are any scratches, correct them with an oilstone.
2) Knock a new key into the key groove of the shaft.
3) Heat the gear for the specified time at the specified shrink-fitting temperature.

★ Gear shrink-fitting temperature: Max. 170°C
Heating time: Min. 30 minutes

4) Put the timing mark of the rear gear on the outside, then use a hitting tool to press fit until the side face of the gear is in close contact with the crankshaft flange.
   - ★ Knock in quickly before the gear becomes cool.
   - ★ There is not a timing mark on the front gear.

REPLACING CAMSHAFT GEAR



1. **Removal of gear**
   Set the camshaft assembly on the press stand, then push the camshaft to remove the gear

⚠ When setting the camshaft assembly on the press stand, be careful not to get your fingers caught between the press stand and the gear.

2. **Press fitting gear**
   1) Check the gear mounting surface, key groove, and flange surface, and if there are any scratches, correct them with an oilstone.
   2) Knock a new key into the key groove of the shaft.
   3) Assemble the thrust plate.
   4) Heat the gear for the specified time at the specified shrink-fitting temperature.

   ★ Gear shrink-fitting temperature: 200°C
   Heating time: Min. 30 minutes

   5) Put the timing mark of the gear on the outside, then use a hitting tool to press fit until the side face of the gear is in close contact with the camshaft flange.
      ★ Knock in quickly before the gear becomes cool.

REPLACING FLYWHEEL RING GEAR

⚠ Be careful not to let the flywheel fall and injure you.

1. Removal of gear

- Make a scratch in the surface at the root of the gear teeth with a grinder, then split with a chisel to remove.

⚠ Be careful when handling the grinder and chisel.

2. Press fitting gear

1) Check the gear mounting surface, and if there are any scratches, correct them with an oilstone.
2) Heat the gear for the specified time at the specified shrink-fitting temperature.

★ Gear shrink-fitting temperature: Max. 200°C
Heating time: Min. 20 minutes

3) Set the chamfered face of the gear facing the flywheel, and press fit until the side face of the gear is in close contact with the flywheel.