SHOP MANUAL

KOMATSU

95-2 SERIES

DIESEL ENGINE

Printed in Japan 11-02(01)

CONTENTS

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.

Mark	Indication	Action required
○	Page to be newly added	Add
●	Page to be replaced	Replace
( )	Page to be deleted	Discard

Pages having no marks are those previously revised or made additions.

LIST OF REVISED PAGE

Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision
●	00- 1	③		01- 3	②		11-18	①		12- 6			12-115	
	00- 2	①	●	01- 4	③		11-19	①		12- 7			12-116	
●	00- 2-1	③		01-21	①		11-20	①		12- 8			12-117	①
●	00- 2-2	③		01-22	①		11-21	①		12- 9			12-118	
●	00- 3			01-23	①		11-22	①	●	12-10	③		12-119	①
●	00- 4		●	01-24	③		11-23	①		12-11	①		12-120	①
●	00- 5		●	01-25	③		11-25	①		12-12			12-121	①
●	00- 6			01-26	②	●	11-26	③	●	12-13	③		12-122	
●	00- 7		●	01-27	③		11-27	①		12-14	②		12-123	
●	00- 8						11-28	①	●	12-15	③		12-124	①
●	00- 9						11-29	①	●	12-41	③		12-125	
●	00-10			11- 1	①		11-30	①	●	12-70	③		12-126	②
●	00-11			11- 2	①		11-31	①		12-71	①	●	12-127	③
●	00-12			11- 3	①		11-32	①						
●	00-13		●	11- 4	③		11-33	①		12-101				
●	00-14			11- 5	①	●	11-34	③		12-102			13- 1	
●	00-15			11- 6	①		11-35	①		12-103			13- 2	
●	00-16			11- 7	①		11-36	①		12-104			13- 3	①
●	00-17			11- 8	①	●	11-37	③		12-105			13- 4	
●	00-18			11- 9	①	●	11-38	③		12-106			13- 5	①
●	00-19			11-10	①		11-39	①		12-107	①		13- 6	
●	00-20			11-11	①					12-108	①		13- 7	
●	00-21			11-12	①					12-109	①		13- 8	
●	00-22			11-13	①		12- 1	①		12-110	①		13- 9	
				11-14	①		12- 2	①		12-111	①		13-10	
				11-15	①		12- 3			12-112	①		13-11	
	01- 1			11-16	①		12- 4			12-113	①		13-12	
●	01- 2	③		11-17	①		12- 5			12-114			13-13	

Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision	Mark	Page	Time of revision
	13-14			15- 5										
	13-15			15- 6										
	13-16			15- 7										
	13-17			15- 8	①									
	13-18	①		15- 9	①									
	13-19			15-10	①									
	13-20			15-11	①									
	13-21			15-12	①									
	13-22			15-13	①									
	13-23			15-14	①									
	13-24			15-15	①									
	13-25	①												
	13-26													
	13-27	①												
	13-28	①												
	13-29													
	13-30													
	14- 1													
	14- 2	①												
	14- 3	①												
	14- 4													
	14- 5													
	14- 6													
	14- 7													
	14- 8													
	14- 9													
	14-10													
	14-11	①												
	14-12													
	14-13													
	14-14													
	14-15	①												
	15- 1													
	15- 2													
	15- 3													
	15- 4													

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

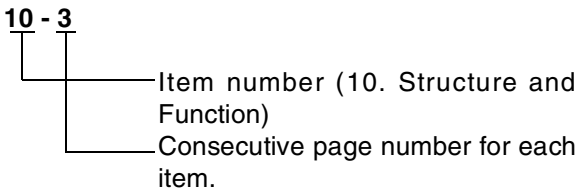
VOLUMES
Shop manuals are issued as a guide to carrying out repairs. They are divided as follows:

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

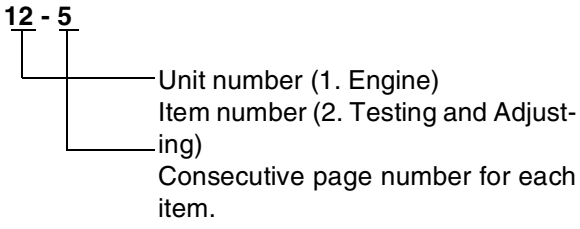
These various volumes are designed to avoid duplicating the same information. Therefore, to deal with all repairs for any model , it is necessary that chassis, engine, electrical and attachment volumes be available.

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.

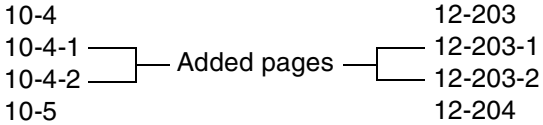
FILING METHOD
1. See the page number on the bottom of the page. File the pages in correct order.
2. Following examples show how to read the page number.
   Example 1 (Chassis volume):



   Example 2 (Engine volume):



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



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.
	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:

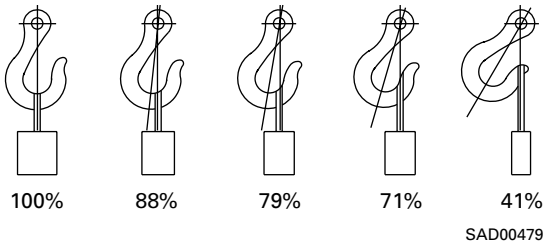
Wire ropes
(Standard "Z" or "S" twist ropes
without galvanizing)

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.

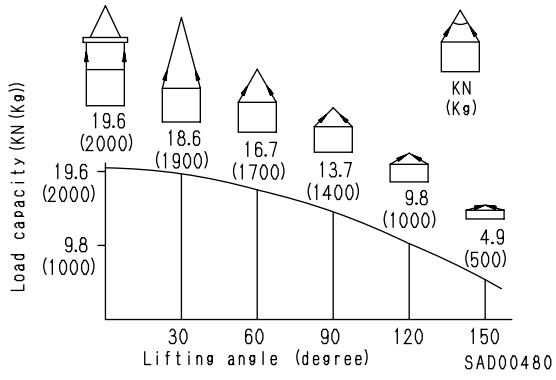
Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



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

Fig. 1

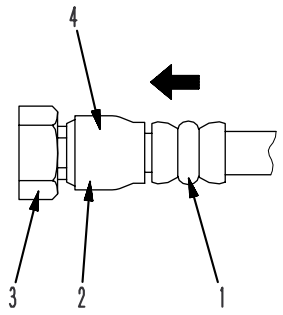


Fig. 2

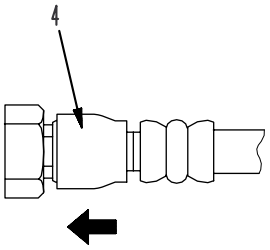


Fig. 3

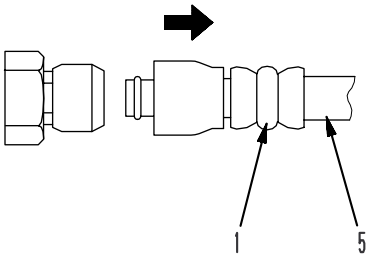


Fig. 4

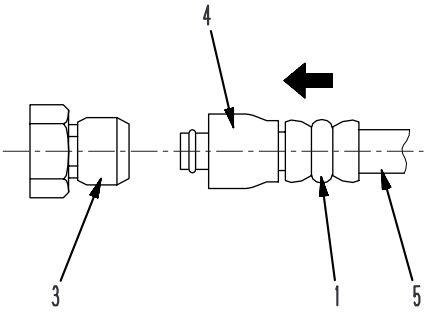
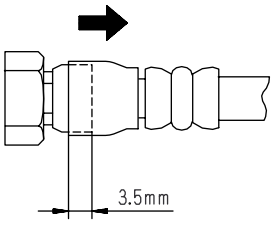
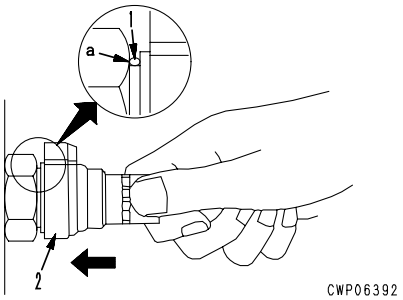
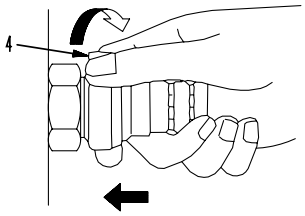


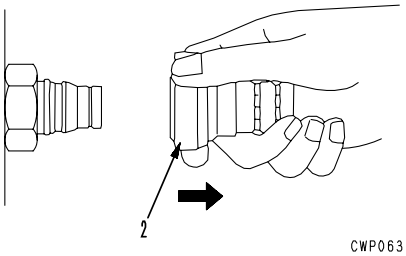
Fig. 5

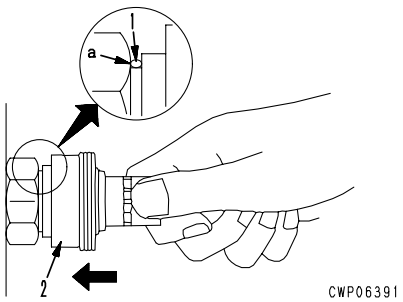


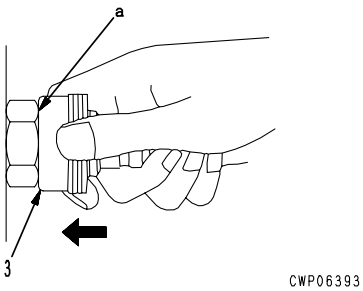
CWP10701

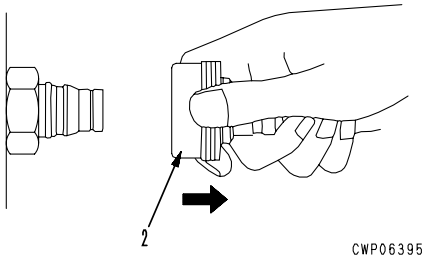
<table>
<tr><th></th><th>Type 2</th><th>Type 3</th></tr>
<tr><td>Disassembly</td><td>1) Hold the mouthpiece of the tightening portion and push body (2) in straight until sliding prevention ring (1) contacts contact surface a of the hexagonal portion at the male end.
 

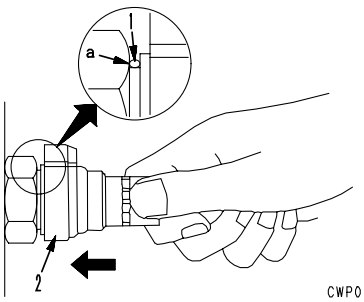
CWP06392
2) Hold in the condition in Step 1), and turn lever (4) to the right (clockwise).
 

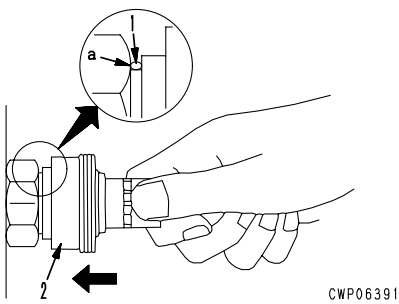
CWP06394
3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it.
 

CWP06396</td><td>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.
 

CWP06391
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.
 

CWP06393
3) Hold in the condition in Steps 1) and 2), and pull out whole body (2) to disconnect it.
 

CWP06395</td></tr>
<tr><td>Connection</td><td>• 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.
 

CWP06392</td><td>• 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.
 

CWP06391</td></tr>
</table>

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)

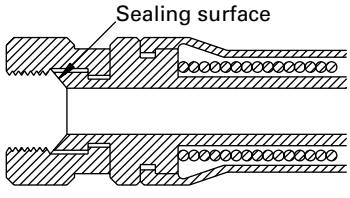
★ In the case of metric nuts and bolts for which there is no special instruction, tighten to the torque given in the table below.

Thread diameter of bolt	Width across flats	 CDL00372	
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	 CDL00373	
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.



SAD00483

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	14	65.7 ± 6.8	6.7 ± 0.7
12	17	112 ± 9.8	11.5 ± 1
16	22	279 ± 29	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	14	Varies depending on type of connector.	34.3 ± 4.9	3.5 ± 0.5
03, 04	20		93.1 ± 9.8	9.5 ± 1
05, 06	24		142.1 ± 19.6	14.5 ± 2
10, 12	33		421.4 ± 58.8	43 ± 6
14	42		877.1 ± 132.3	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

Priority	Classification \ Circuits		Charging	Ground	Starting	Lighting	Instrument	Signal	Other
1	Primary	Code	W	B	B	R	Y	G	L
		Color	White	Black	Black	Red	Yellow	Green	Blue
2	Auxiliary	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/cm² to lb/in²

1kg/cm² = 14.2233 lb/in²

	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_2O}
kPa {mmHg}
kW/rpm {HP/rpm}
g/kWh {g/HPh}

01 GENERAL

APPLICABLE MACHINE

Engine	Serial No.	Applicable machine	
4D95LE-2		PC60-7	Hydraulic excavator
		PC75UU-3	Hydraulic excavator
		PC78US-6	Hydraulic excavator
		PC78UU-6	Hydraulic excavator
		BR100JG-2	Mobile crusher

★ Serial No. shows for engine serial No.

SPECIFICATIONS

Engine model			4D95LE-2		
Applicable machine			PC60-7	PC75UU-3	BR100JG-2
	Number of cylinder — Bore × Stroke	mm	4 – 95 × 115		
	Total piston displacement	ℓ {cc}	3.26 {3,260}		
	Firing order		1 – 2 – 4 – 3		
Dimensions	Overall length	mm	1,105		
	Overall width	mm	632		
	Overall height (excluding exhaust pipe)	mm	—		
	Overall height (including exhaust pipe)	mm	1,093		
Performance	Flywheel horsepower	kW/rpm {HP/rpm}	40/2,100 {54/2,100}		
	Maximum torque	Nm/rpm {kgm/rpm}	235/1,500 {24/1,500}		
	High idling speed	rpm	2,250 ± 60		
	Low idling speed	rpm	$1{,}100^{+50}_{0}$		
	Minimum fuel consumption ratio	g/kW•h{g/HP•h}	224 {163}		
Dry weight		N {kg}	2,840 {290}		
Fuel injection pump			Bosch PES-A type		
Governor			Bosch RSV centrifugal all-speed control type		
Lubricating oil amount (refill capacity)		ℓ	7.5 (7.0)		
Coolant amount		ℓ	10 (Engine side: 4.5)		
Alternator			24V, 25A		
Starting motor			24V, 3.0kW		
Battery			12V 60Ah × 2		
Turbocharger			—		
Air compressor			—		
Others			—		

Engine model			4D95LE-2	
Applicable machine			PC78US-6	PC78UU-6
Number of cylinder — Bore × Stroke		mm	4 – 95 × 115	
Total piston displacement		ℓ {cc}	3.260 {3,260}	
Firing order			1 – 2 – 4 – 3	
Dimensions	Overall length	mm	948	
	Overall width	mm	640	
	Overall height (excluding exhaust pipe)	mm	—	
	Overall height (including exhaust pipe)	mm	1,082	
Performance	Flywheel horsepower	kW/rpm {HP/rpm}	40.1/1,850 {53.7/1,850}	
	Maximum torque	Nm/rpm {kgm/rpm}	Min. 226/1,500 {Min. 23/1,500}	
	High idling speed	rpm	2,050 ± 50	
	Low idling speed	rpm	$1,150^{+50}_{0}$	
	Minimum fuel consumption ratio	g/kW•h{g/HP•h}	221 {167}	
Dry weight		N {kg}	300	
Fuel injection pump			Bosch PES-A type	
Governor			Bosch RSV centrifugal all-speed control type	
Lubricating oil amount (refill capacity)		ℓ	7.5 (7.0)	
Coolant amount		ℓ	(Engine side: 4.5)	
Alternator			24V, 25A	
Starting motor			24V, 3.0kW	
Battery			12V 60Ah × 2	
Turbocharger			—	
Air compressor			—	
Others			—	

WEIGHT TABLE

★ The specifications may be different depending on the type of machine.

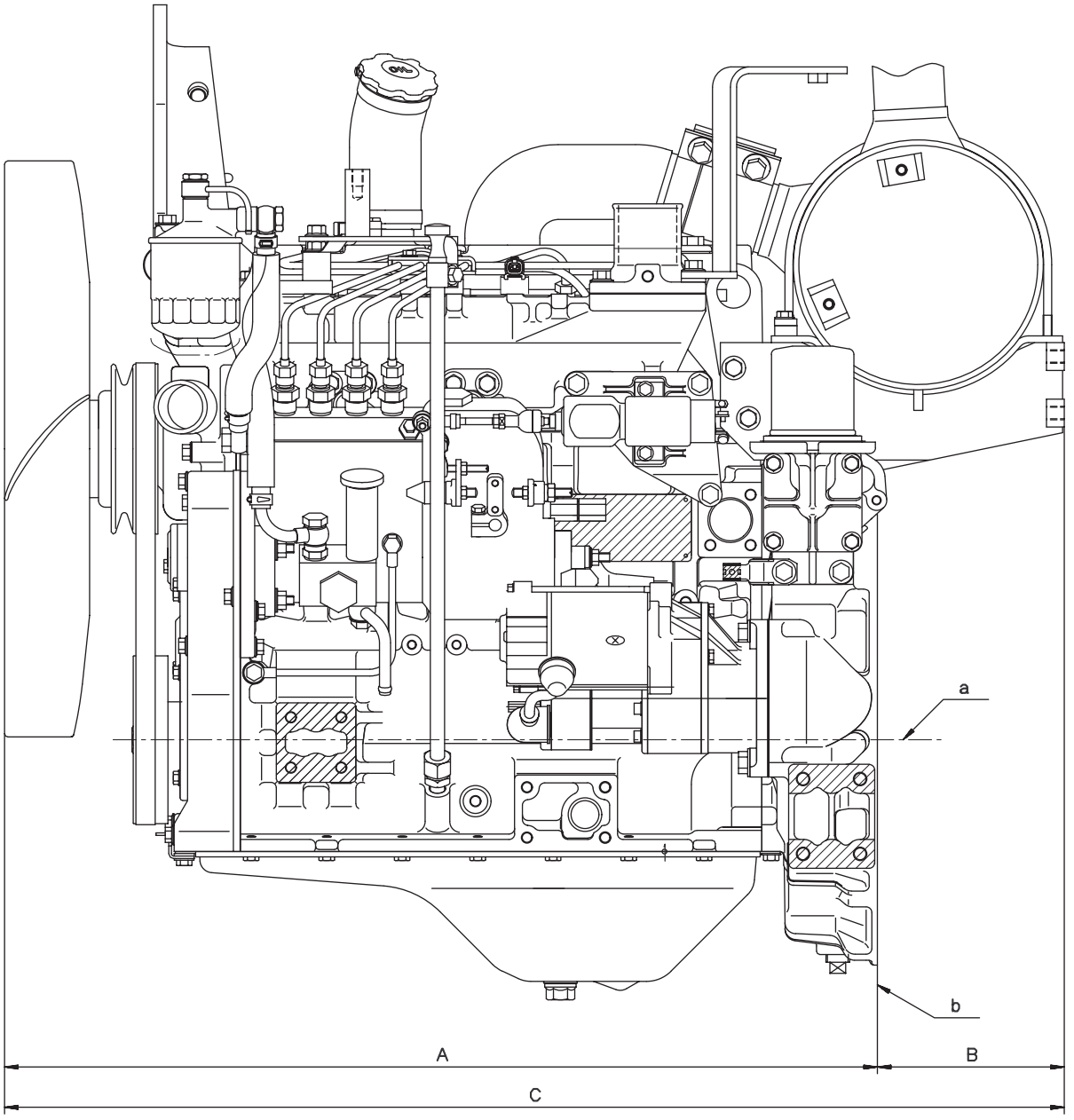
Unit: kg

No.	Item	Components	4D95LE-2
1	Turbocharger		—
2	Cylinder head assembly	Cylinder head, valve, valve spring	28
3	Cylinder block assembly	Cylinder block, main metal block, cylinder liner	70
4	Gear case (Front cover)		2.6
5	Oil pan		2
6	Flywheel assembly	Flywheel, ring gear	22
7	Flywheel housing		11
8	Crankshaft assembly	Crankshaft, crankshaft gear	25
9	Camshaft assembly	Camshaft, camshaft gear, thrust plate	5.5
10	Piston and connecting rod assembly	Piston, piston ring, piston pin, connecting rod	2
11	Oil pump		0.5
12	Fuel injection pump		10.5
13	Water pump		6
14	Alternator		The weight is different depending on the type of machine.
15	Starting motor		
16	Air compressor		—
17	Aftercooler assembly		—

OVERALL DRAWING

4D95LE-2 LEFT SIDE DRAWING

★ The diagram shows the equipment for the PC78US-6.
★ The shape may differ according to the machine model.

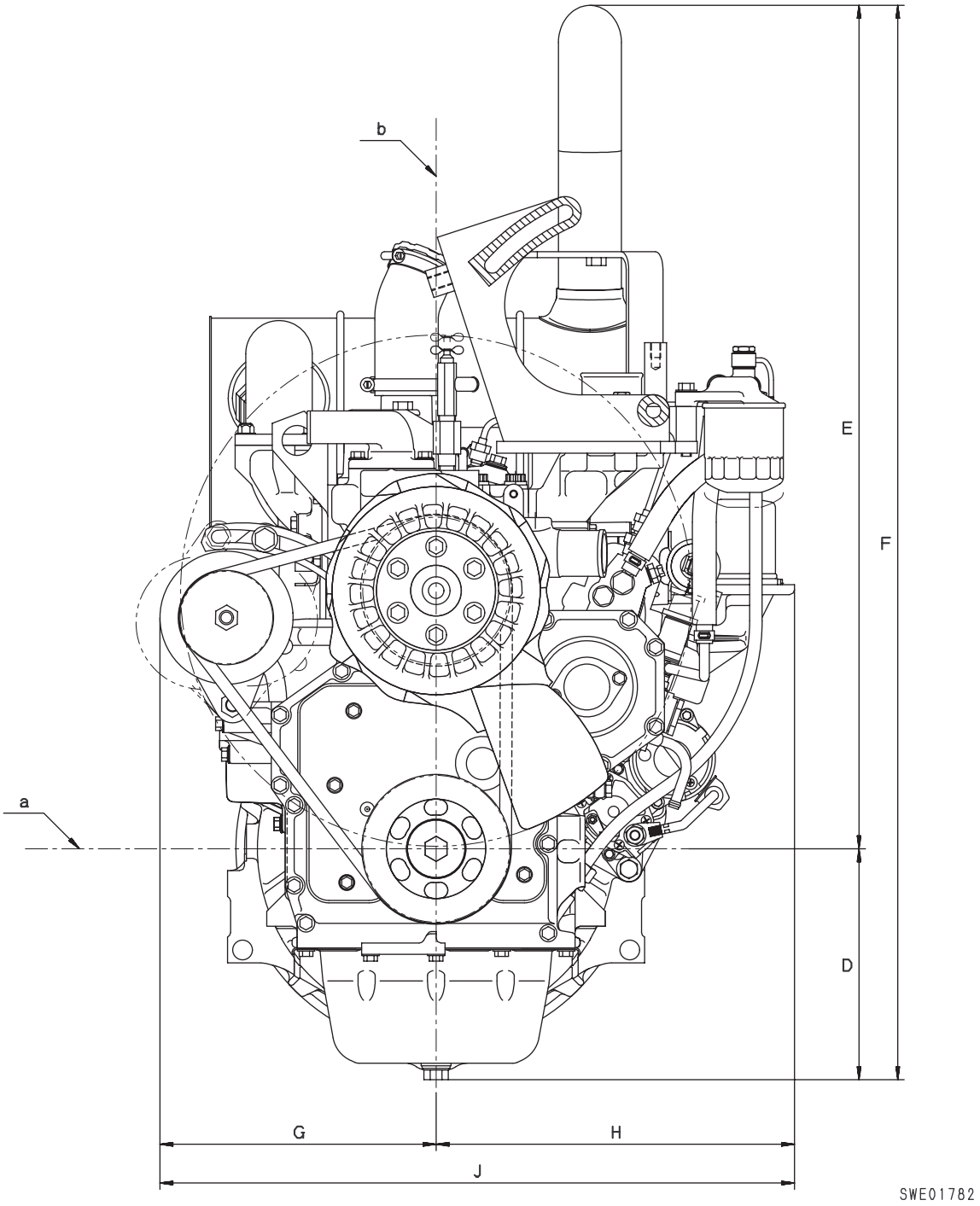


SWE01781

a. Crankshaft center
b. Flywheel housing rear surface

4D95LE-2 FRONT DRAWING

★ The diagram shows the equipment for the PC78US-6.
★ The shape may differ according to the machine model.



a. Crankshaft center
b. Cylinder liner center

DIMENSION TABLE

★ These dimensions are reference values for use when installing to a test bench.

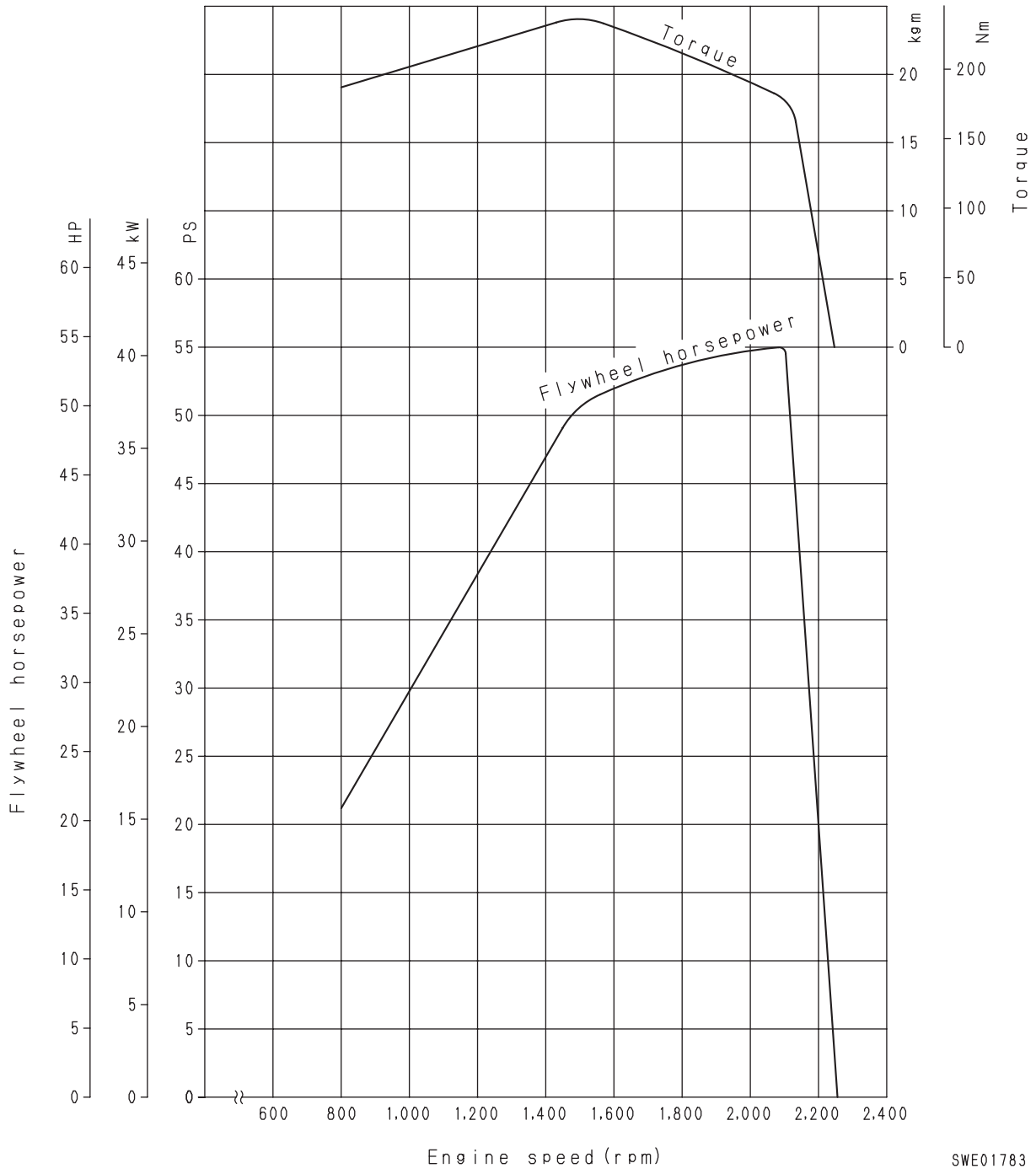
Engine	Machine model	Dimensions for each part (mm)								
		A	B	C	D	E	F	G	H	J
4D95LE-2	PC78US-6 PC78UU-6	781	167	948	232	850	1,082	279	361	640

ENGINE PERFORMANCE CURVE

Engine	Engine Serial. No.	Machine model	Page
4D95LE-2		PC60-7, PC75UU-3, BR100JG-2	01-26
		PC78US-6, PC78UU-6	01-27

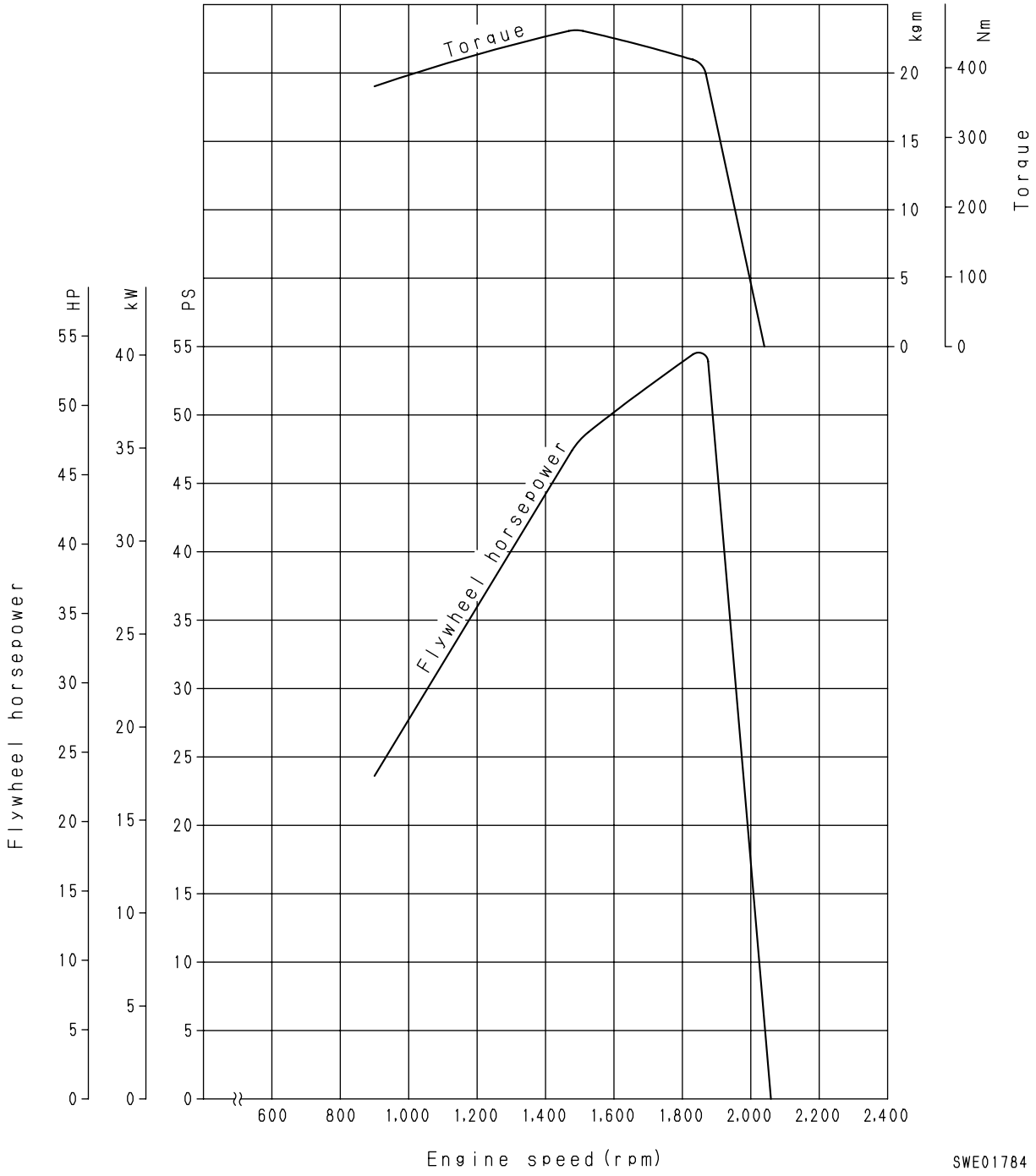
4D95LE-2 [For PC60-7, PC75UU-3, BR100JG-2]

Rated output: 40 kW {54 HP}/2,100 rpm (Net)
Max. torque: 235 Nm {24 kgm}/1,500 rpm (Net)



4D95LE-2 [For PC78US-6, PC78UU-6]

Rated output: Min. 40.1 kW {53.7 HP}/1,850 rpm (Net)
Max. torque: Min. 226 Nm {23 kgm}/1,500 rpm (Net)

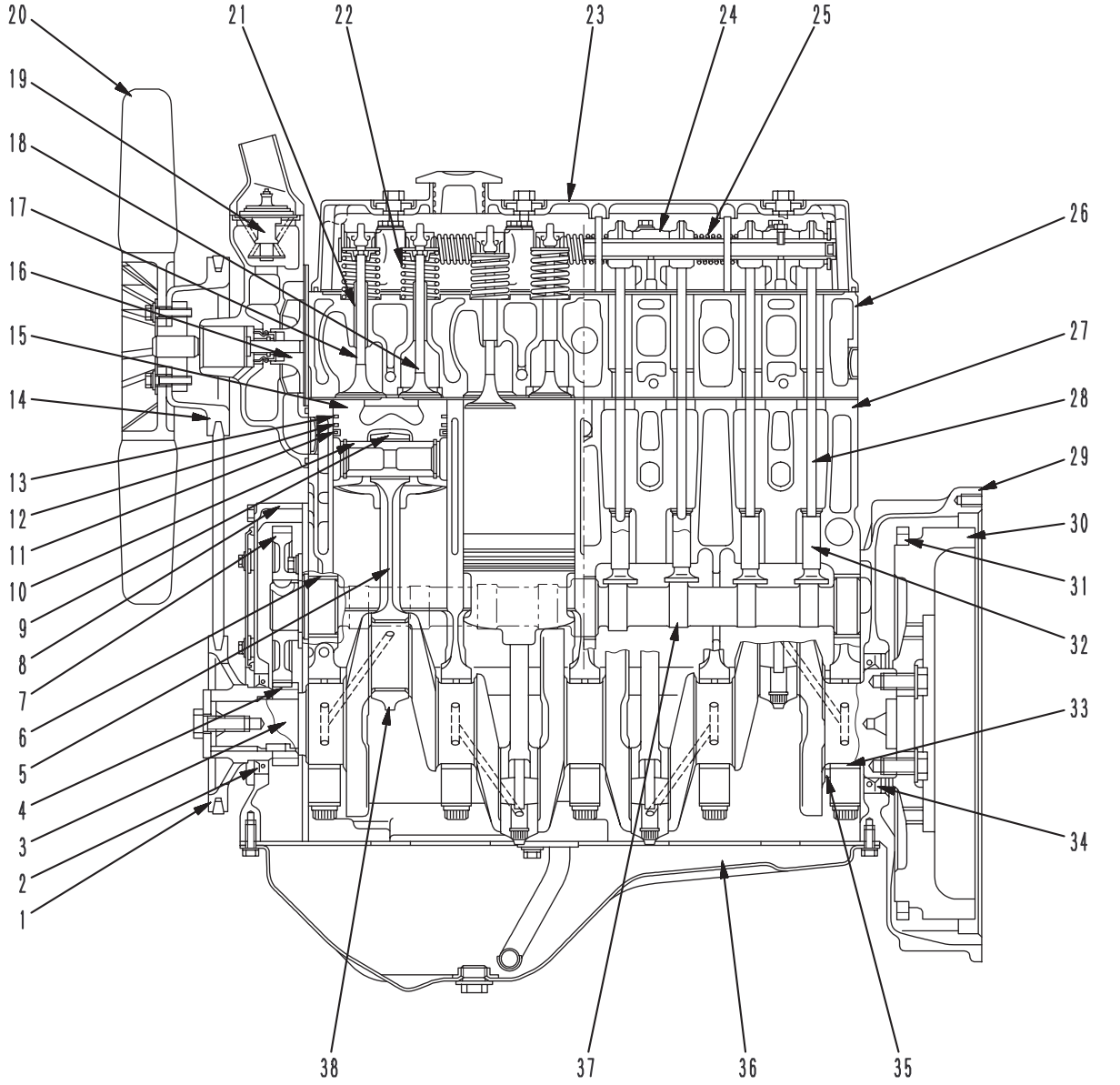


11 STRUCTURE AND FUNCTION

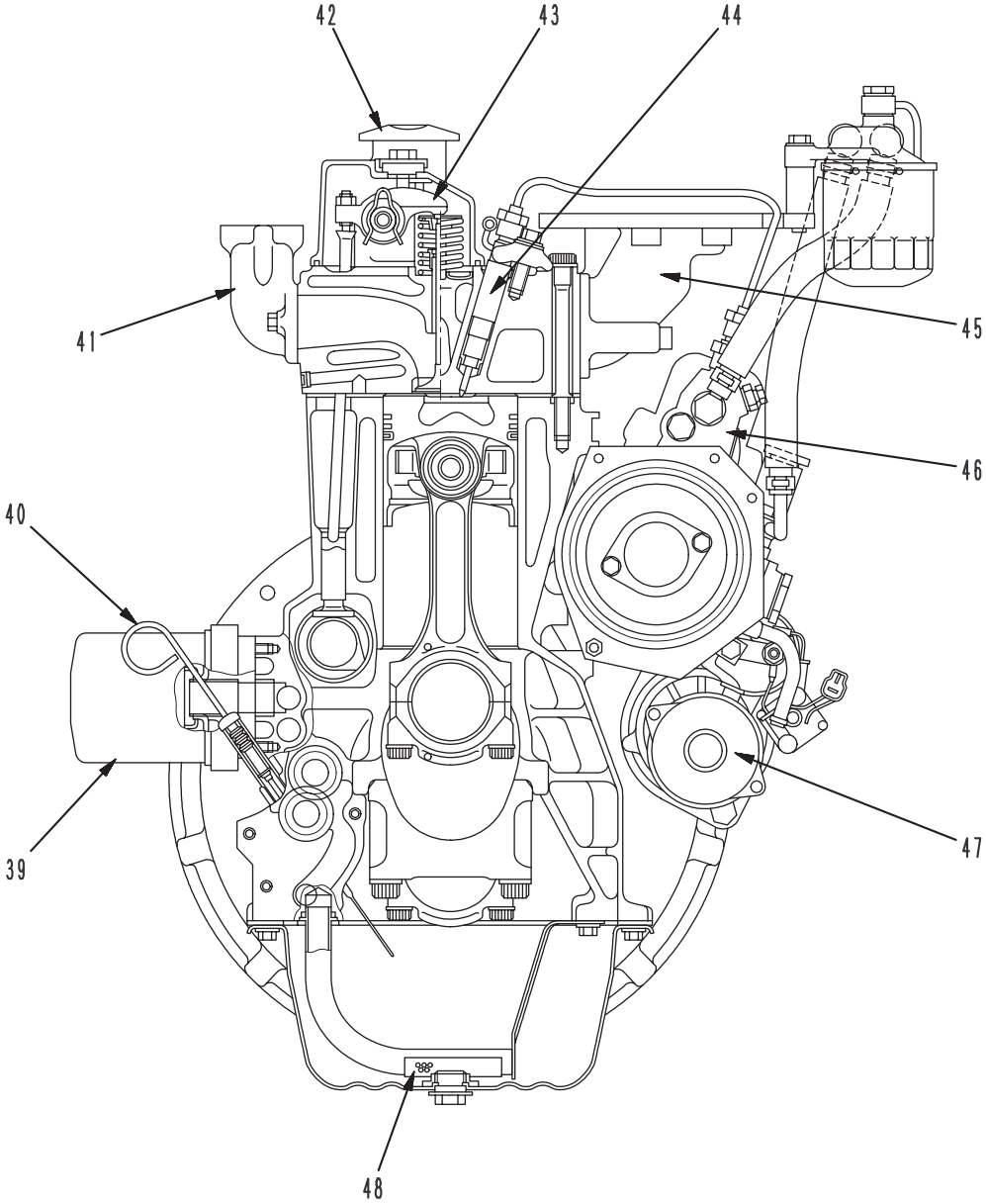
GENERAL STRUCTURE

4D95LE-2

★ There may be differences according to the machine model.



1. Crankshaft pulley
2. Front oil seal
3. Crankshaft
4. Crankshaft gear
5. Connecting rod
6. Camshaft bushing
7. Camshaft gear
8. Front cover
9. Connecting rod bushing
10. Piston pin
11. Oil ring
12. Second ring
13. Top ring
14. Fan pulley
15. Piston
16. Water pump
17. Intake valve
18. Exhaust valve
19. Thermostat
20. Fan
21. Valve guide
22. Valve spring
23. Cylinder head cover
24. Rocker arm bracket
25. Rocker arm spring
26. Cylinder head
27. Cylinder block
28. Push rod
29. Flywheel housing
30. Flywheel



31. Ring gear
32. Tappet
33. Main bearing
34. Rear oil seal
35. Thrust bearing
36. Oil pan
37. Camshaft
38. Connecting rod cap
39. Oil filter
40. Dipstick
41. Exhaust manifold
42. Oil filler cap
43. Rocker arm
44. Fuel injection nozzle
45. Intake manifold
46. Fuel injection pump
47. Starting motor
48. Oil strainer

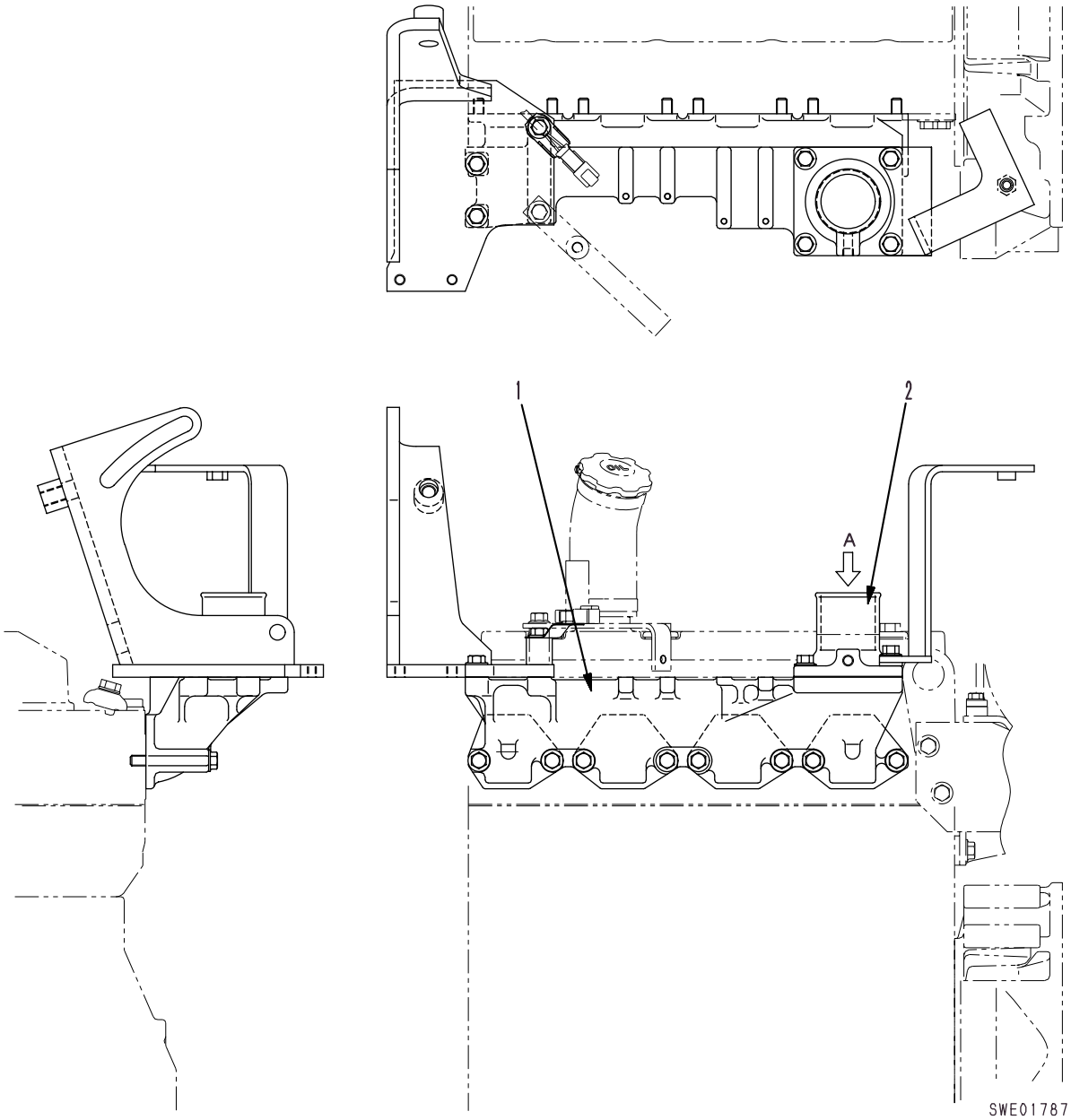
Specifications

Type: In-line, 4-cylinder, water-cooled, direct fuel injection, 4-cycle diesel engine

INTAKE AND EXHAUST SYSTEM

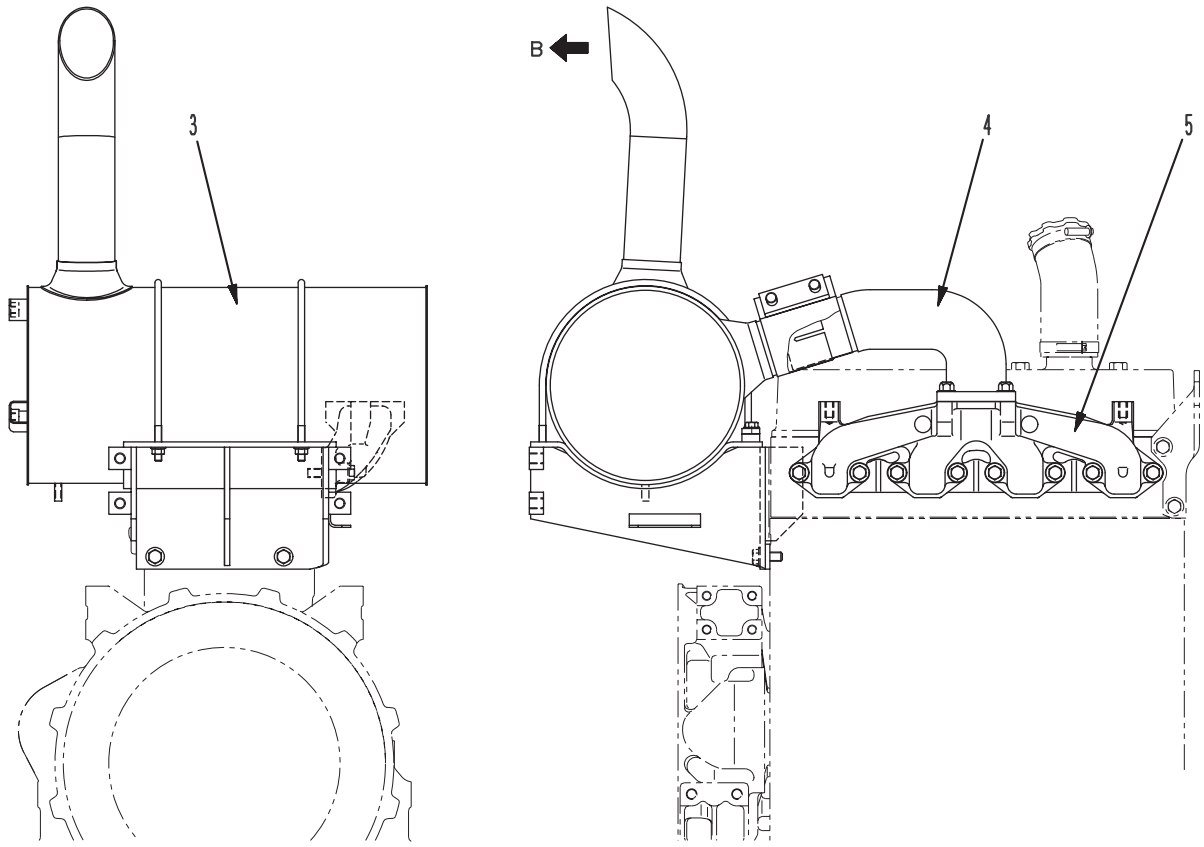
4D95LE-2 (PC78US-6, PC78UU-6)

★ There may be differences according to the machine model.



1. Intake manifold
2. Air connector
3. Muffler
4. Exhaust connector
5. Exhaust manifold

A. Air intake (Air cleaner is mounted on chassis end.)
B. Exhaust outlet



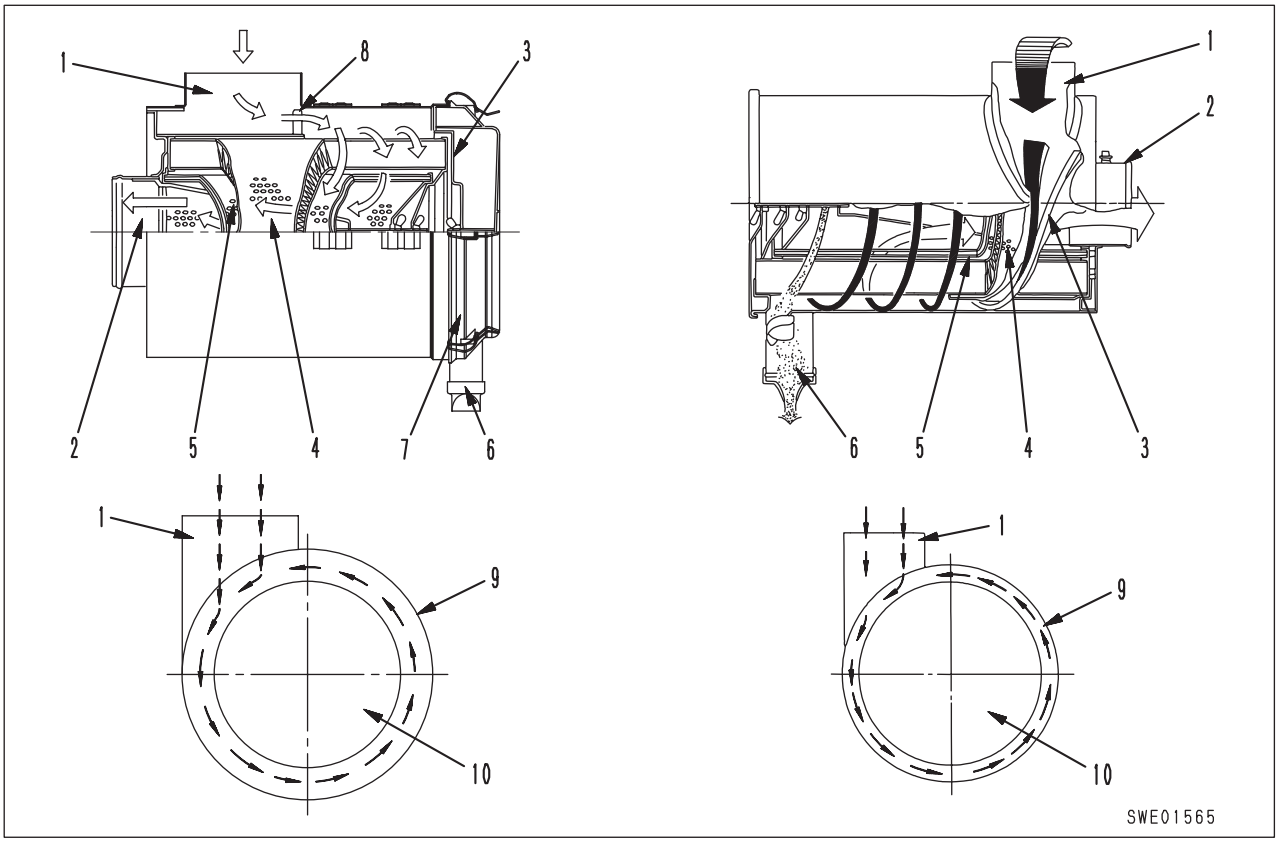
SWE01788

AIR CLEANER

FRG, FTG TYPE (CYCLOPACK TYPE)

★ Details may differ according to the machine model.

FRG type (radial seal type) **FTG type**



1. Inlet
2. Outlet
3. Guide vane
4. Primary element
5. Safety element
6. Vacuator valve
7. Dust pan
8. Guide vane (sleeve)
9. Body
10. Element

Features (FRG, FTG type)

- The element diameter is the same and the outside diameter of the body is small.
  The inlet is placed in the direction of connection, so no guide vane is used; a simple spiral guide vane can give ample centrifugal force.
- The dust pan has no guide vane and its structure is simple.

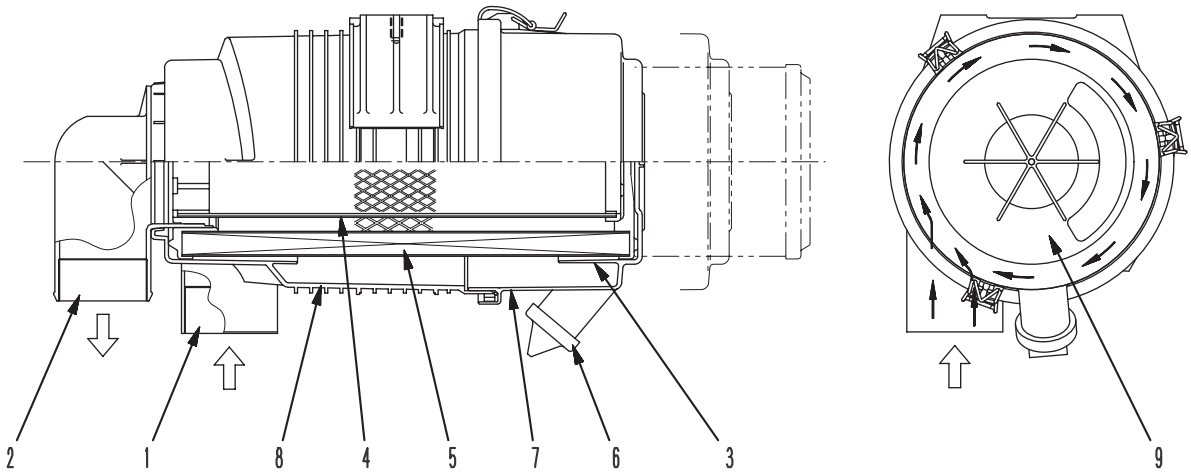
Structure

- Air containing dust is sucked into the tangential from inlet (1). The dust is separated by the centrifugal separation effect of guide vane (3). More than 99.9% of the dust is then removed by primary element (4), and the clean air then passes through safety element (5) and outlet (2), and is sent to the engine.
- The dust and water separated by guide vane (3) circulates around the inside wall of body (9), flies into vacuator valve (6), and is automatically discharged.

FPG TYP

★ Details may differ according to the machine model.

FPG type



SWE01789

1. Inlet
2. Outlet
3. Guide vane
4. Primary element
5. Safety element
6. Vacuator valve
7. Dust pan
8. Body
9. Element

Features (FPG type)

- The element diameter is the same and the outside diameter of the body is small.
  The inlet is placed in the direction of connection, so no guide vane is used; a simple spiral guide vane can give ample centrifugal force.
- The dust pan has no guide vane and its structure is simple.

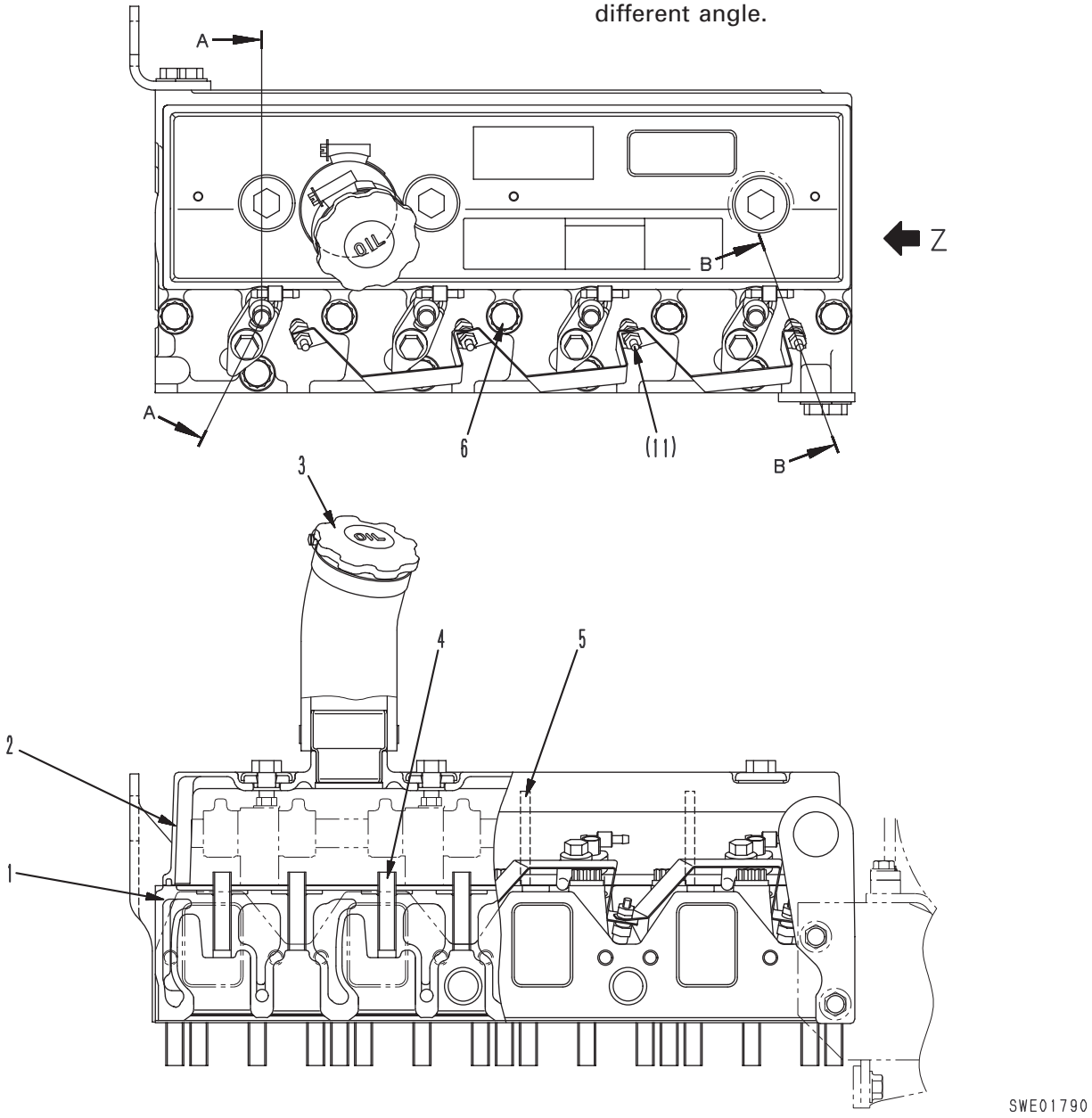
Structure

- Air containing dust is sucked into the tangential from inlet (1). The dust is separated by the centrifugal separation effect of guide vane (3). More than 99.9% of the dust is then removed by primary element (4), and the clean air then passes through safety element (5) and outlet (2), and is sent to the engine.
- The dust and water separated by guide vane (3) circulates around the inside wall of body (8), flies into vacuator valve (6), and is automatically discharged.

CYLINDER HEAD

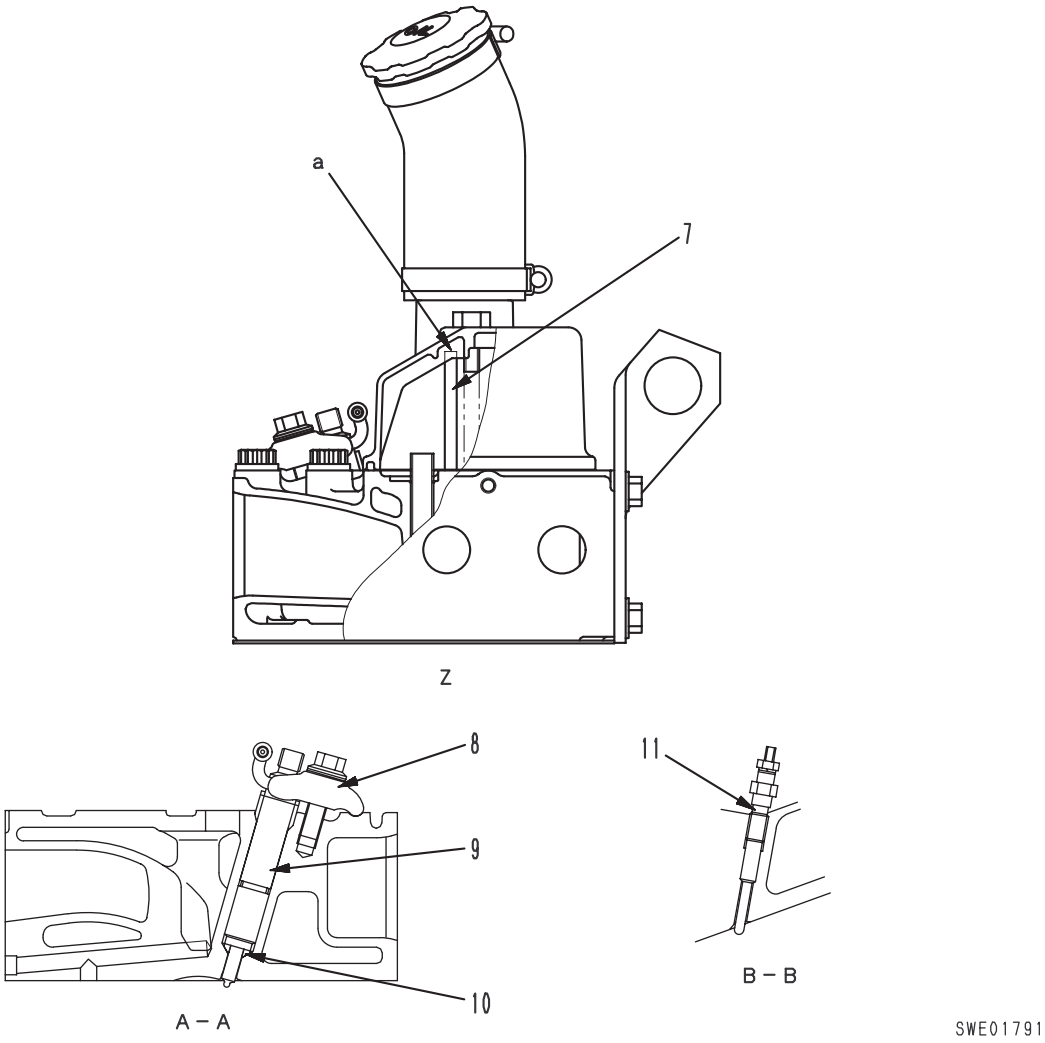
4D95LE-2

★ There may be differences according to the machine model.
★ 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. Cylinder head
2. Head cover
3. Oil filler cap
4. Valve guide
5. Intake air return tube
6. Head bolt
7. Breather pipe
8. Bracket
9. Nozzle holder
10. Seat gasket
11. Glow plug

a. Blow-by suction port (to intake)



Specifications

Cylinder head

- Direct fuel injection type
- Unitized type
- 2 valves (1 cylinder)
- Injection nozzle:
  Assembled outside head cover
  Mount: Dry type (without sleeve)
- Glow plug installed

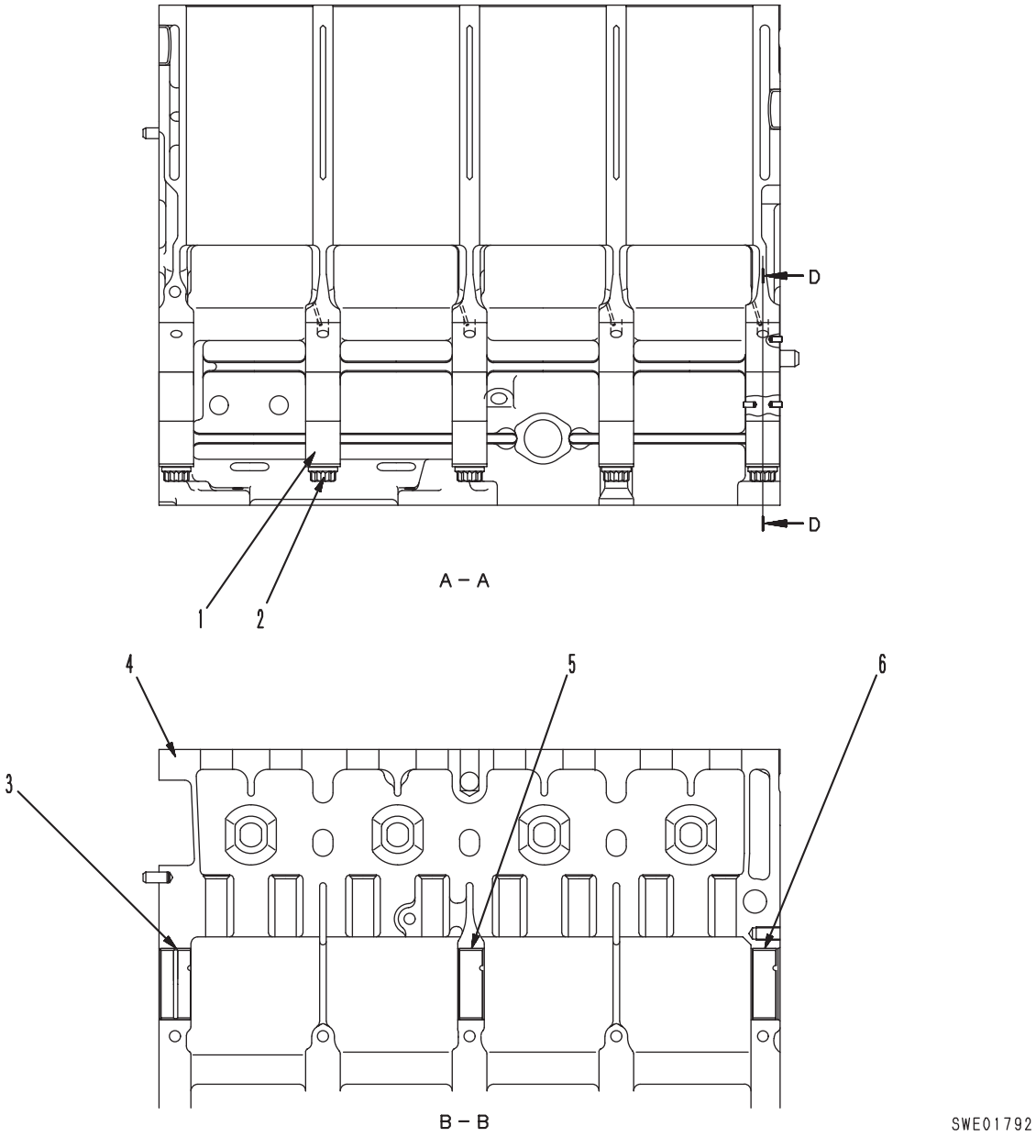
Head cover

- Float mount type

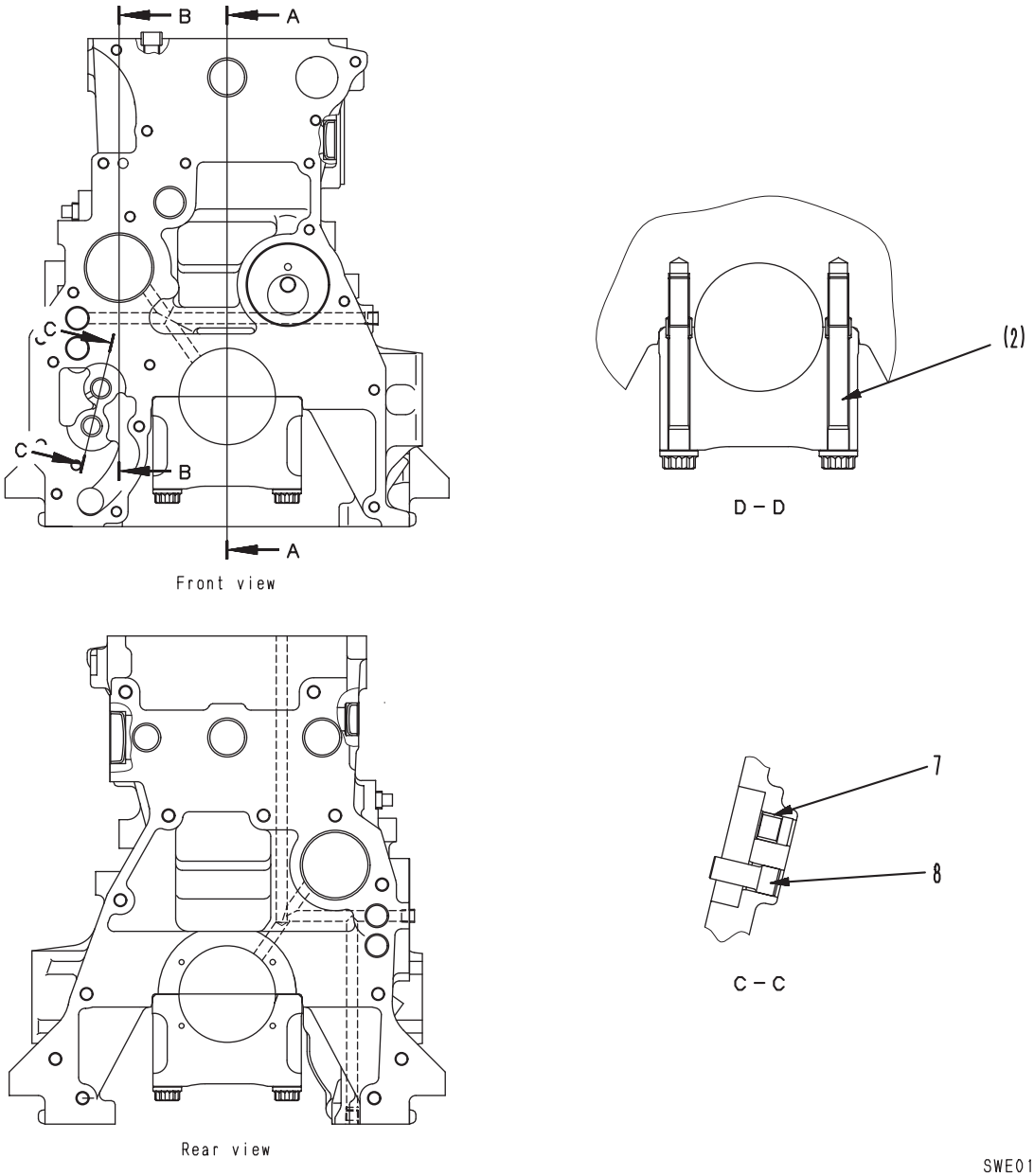
CYLINDER BLOCK

4D95LE-2

★ There may be differences according to the machine model.
★ 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. Main bearing cap
2. Main bearing cap bolt
3. Camshaft bushing (No. 1 journal)
4. Cylinder block
5. Camshaft bushing (No. 2 journal)
6. Camshaft bushing (No. 3 journal)
7. Oil pump drive shaft bushing
8. Oil pump driven shaft

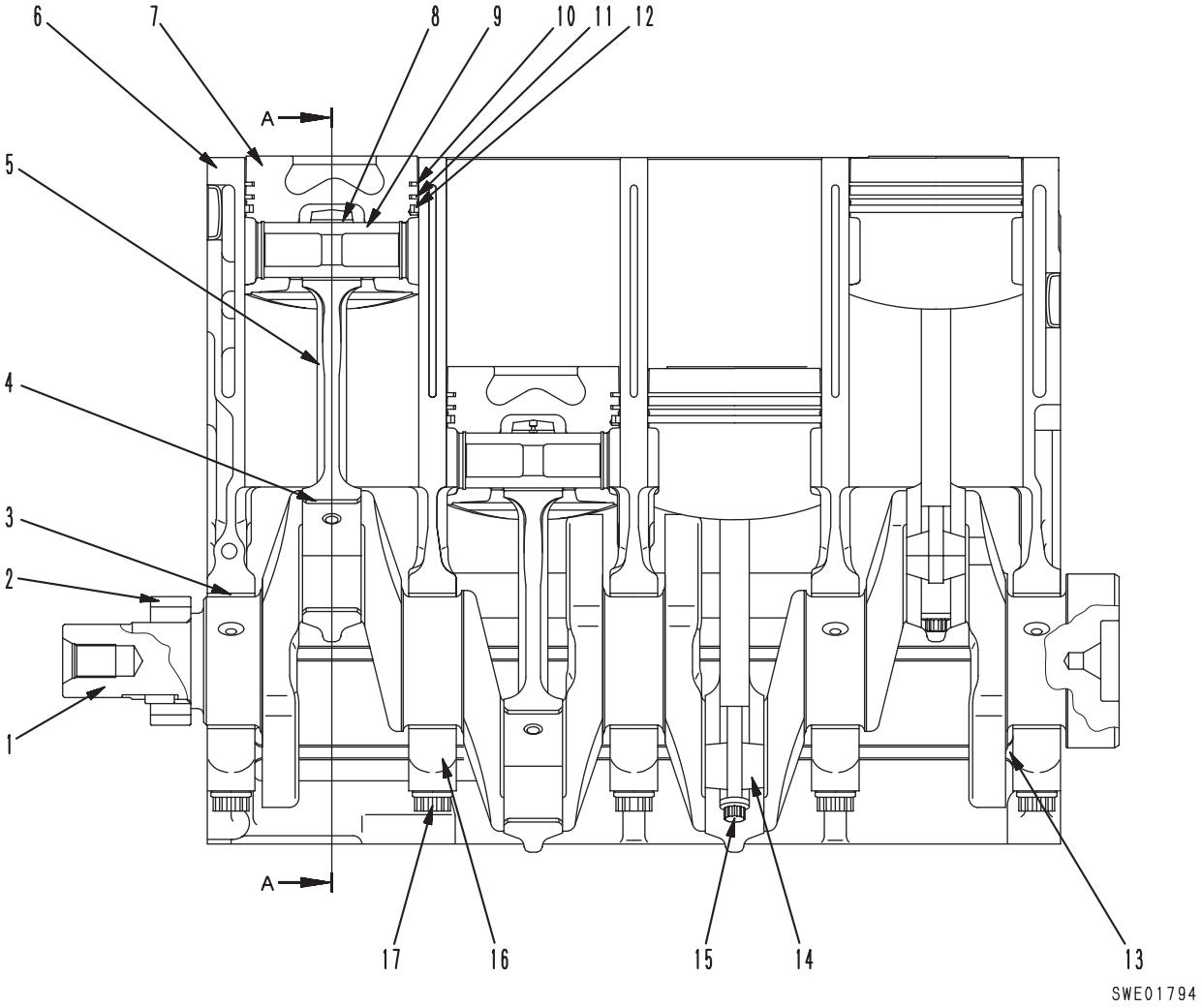


Specifications
Cylinder block
- Crankshaft: 5 bearings
- Camshaft: 3 bearings

Cylinder
- Linerless
- Inside surface finishing: Honing

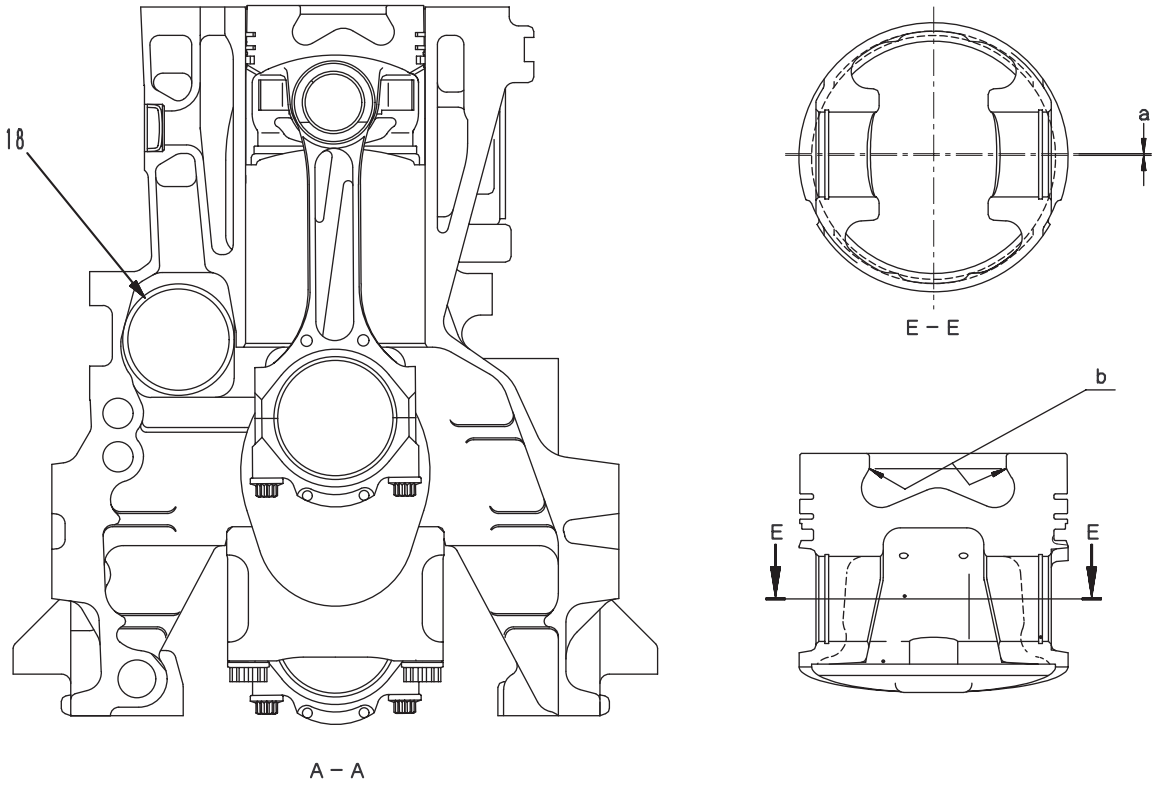
MAIN CIRCULATION SYSTEM

4D95LE-2



1. Crankshaft
2. Crankshaft gear (No. of teeth: 24)
3. Main bearing
4. Connecting rod bearing
5. Connecting rod
6. Cylinder block
7. Piston
8. Connecting rod bushing
9. Piston pin
10. Top ring
11. Second ring
12. Oil ring
13. Thrust bearing
14. Connecting rod cap
15. Connecting rod cap bolt
16. Main cap
17. Main cap bolt
18. Cam bushing

a. Offset
b. Re-entrant



SWE01795

Specifications

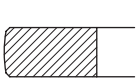
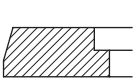
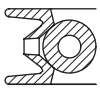
Crankshaft

- Closed die forging

Piston

- Direct fuel injection type re-entrant combustion chamber
- Auto thermatic piston with steel strut (Suppresses heat expansion and keeps clearance from cylinder small)
- Center of piston hole offset 1.0 mm (to reduce vibration)
- Selected mating
  (When the piston is assembled at the manufacturing plant, an L or S size piston is selected to match the inside diameter of the cylinder, but parts supplied for piston replacement are all assembled with S size pistons.)

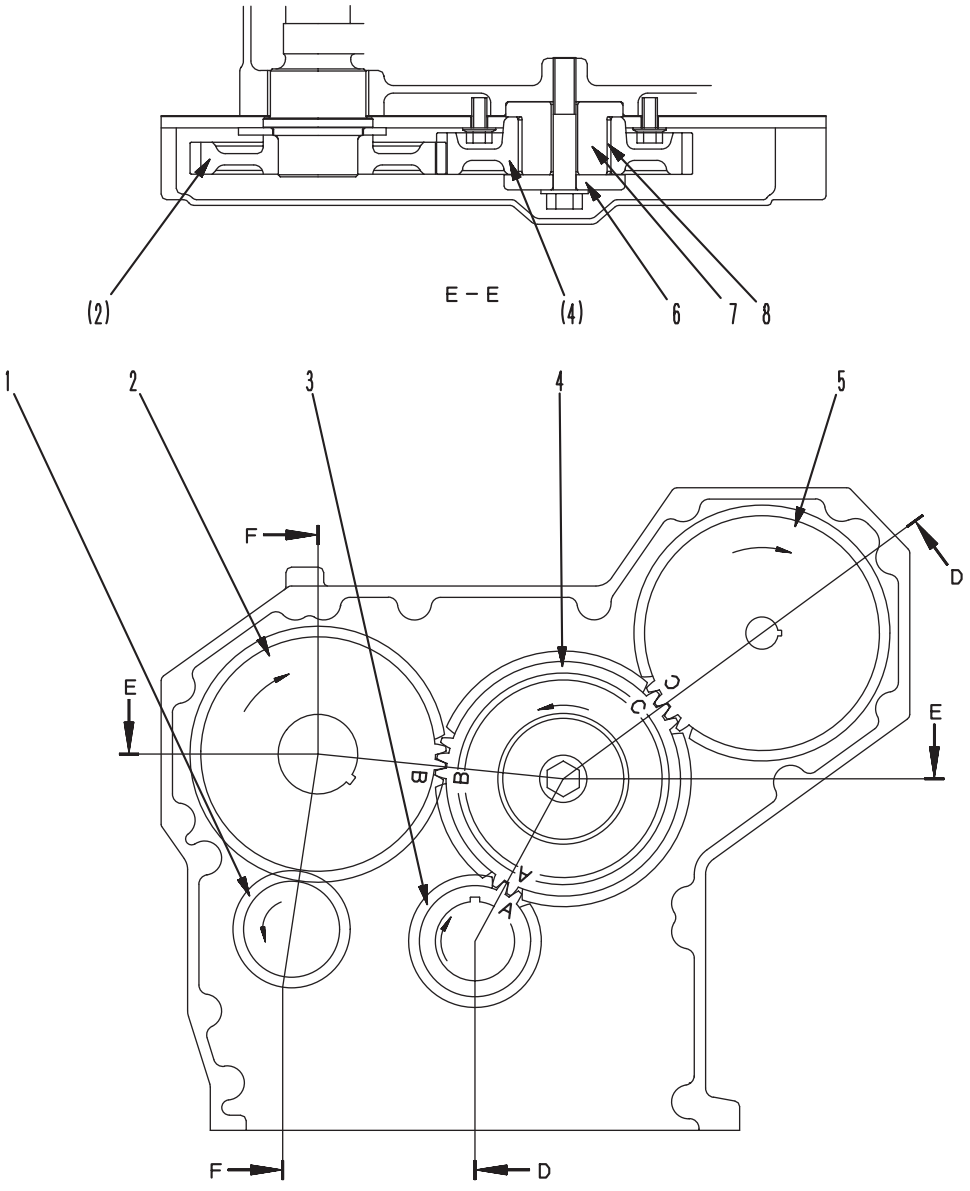
Piston ring

Engine	Top ring	Second ring	Oil ring
4D95LE-2	 SWE01796	 SWE01797	 SWE01721
	Flat barrel face, Hard chrome plating	Tapered face, Parkerizing treatment, flat inner cut	M-shape steel ring, Hard chrome plating with coil expander

TIMING GEAR

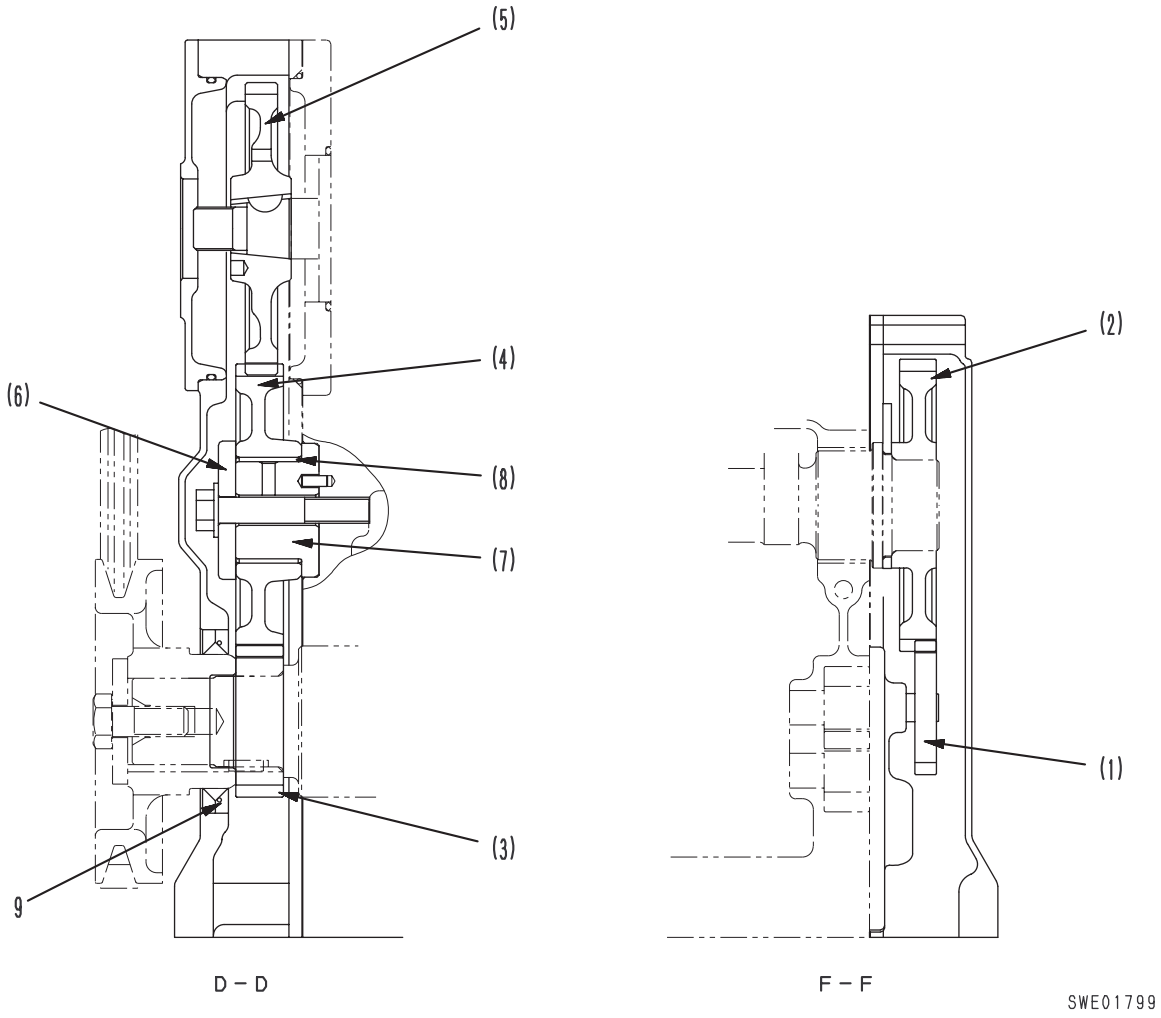
WITHOUT FRONT PTO TYPE (HELICAL GEAR)

★ 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. Oil pump drive gear (No. of teeth: 21)
2. Camshaft gear (No. of teeth: 48)
3. Crankshaft gear (No. of teeth: 24)
4. Idler gear (No. of teeth: 48)
5. Fuel Injection pump drive gear (No. of teeth: 48)
6. Thrust plate
7. Idler gear shaft
8. Idler gear bushing
9. Front seal

A, B, C: Match marks for timing gears

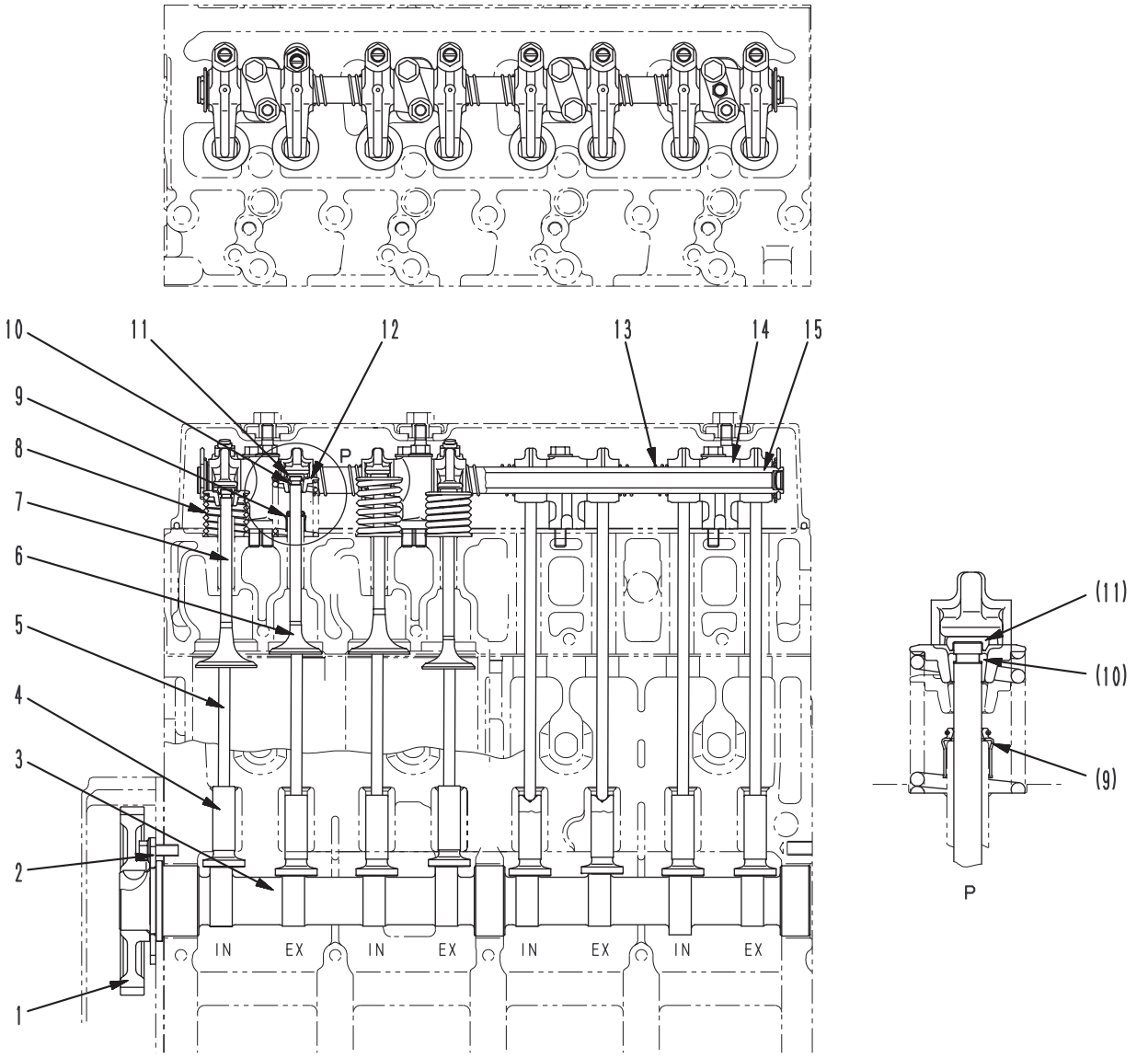


Specification
Front oil seal
- Single lip with dust seal

VALVE SYSTEM

4D95LE-2

★ 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.

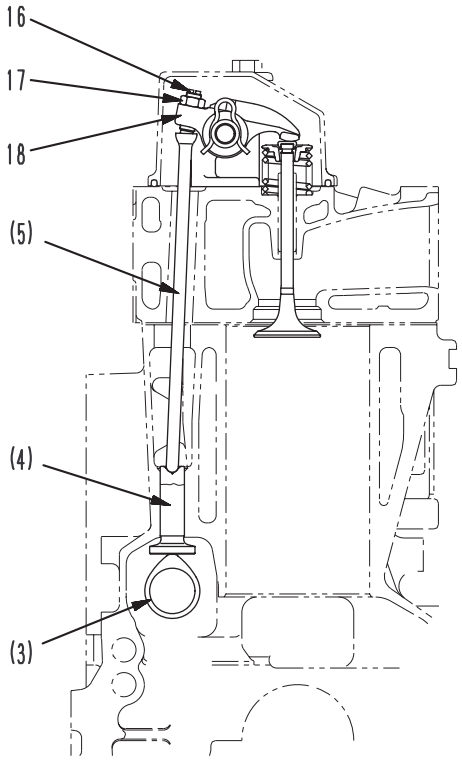


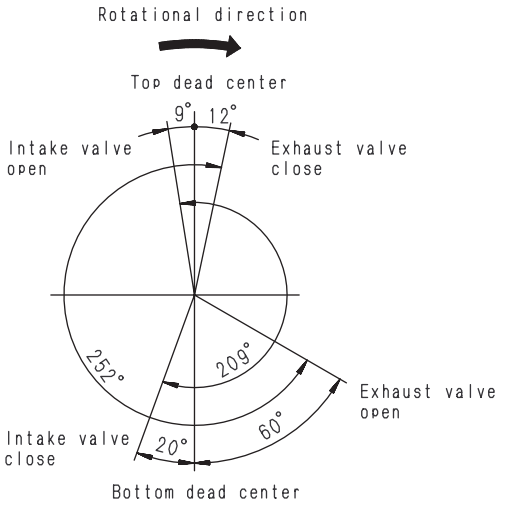
SWE01800

1. Cam gear (No. of teeth: 48)
2. Thrust plate
3. Camshaft
4. Tappet
5. Push rod
6. Exhaust valve
7. Intake valve
8. Valve spring
9. Valve seal (intake and exhaust side)
10. Valve cotter
11. Valve stem cap (only for PC78US-6)
12. Spring seat
13. Rocker arm spring
14. Rocker arm bracket
15. Rocker arm shaft
16. Adjustment screw
17. Locknut
18. Rocker arm

VALVE TIMING

4D95LE-2





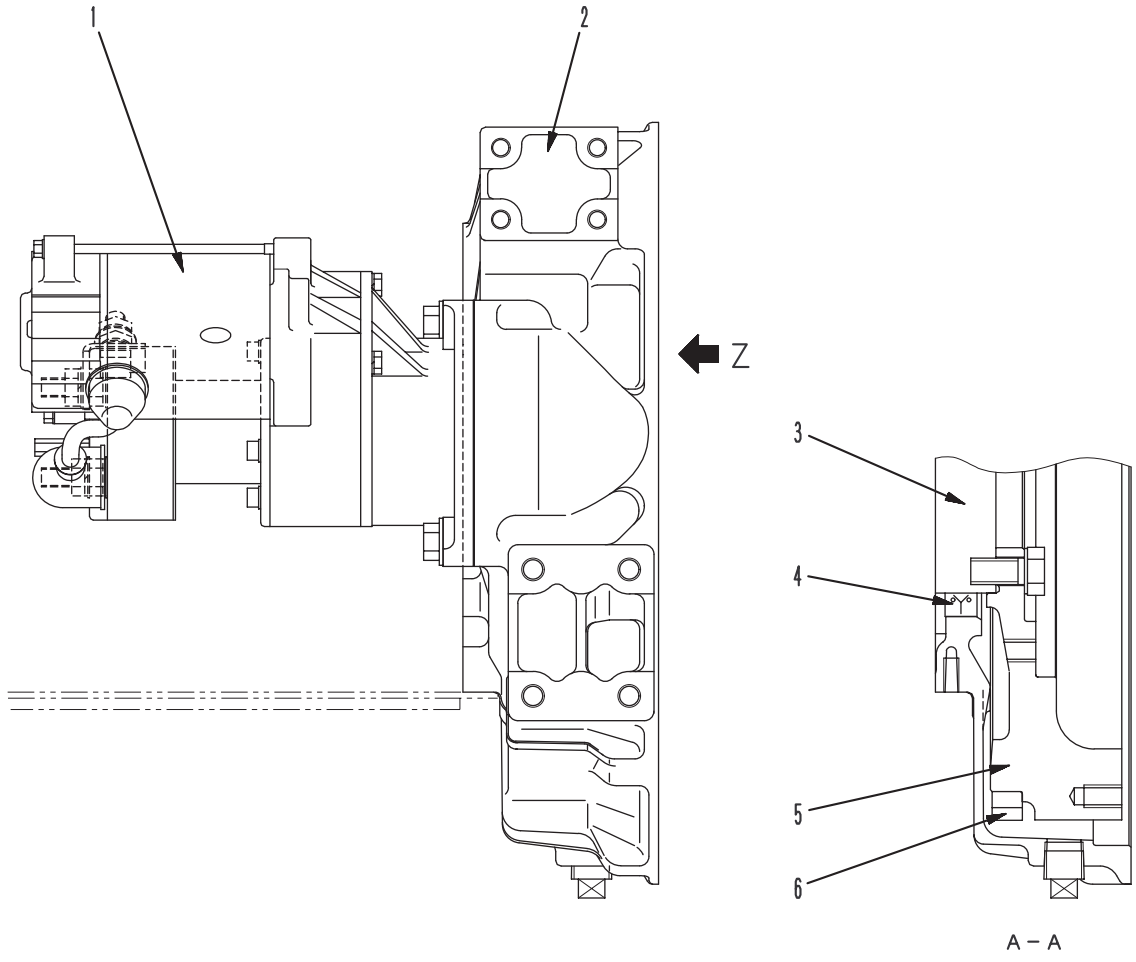
SXE01881

Specifications
Valve lift
- Intake valve: 9.6 mm
- Exhaust valve: 10.6 mm

FLYWHEEL AND FLYWHEEL HOUSING

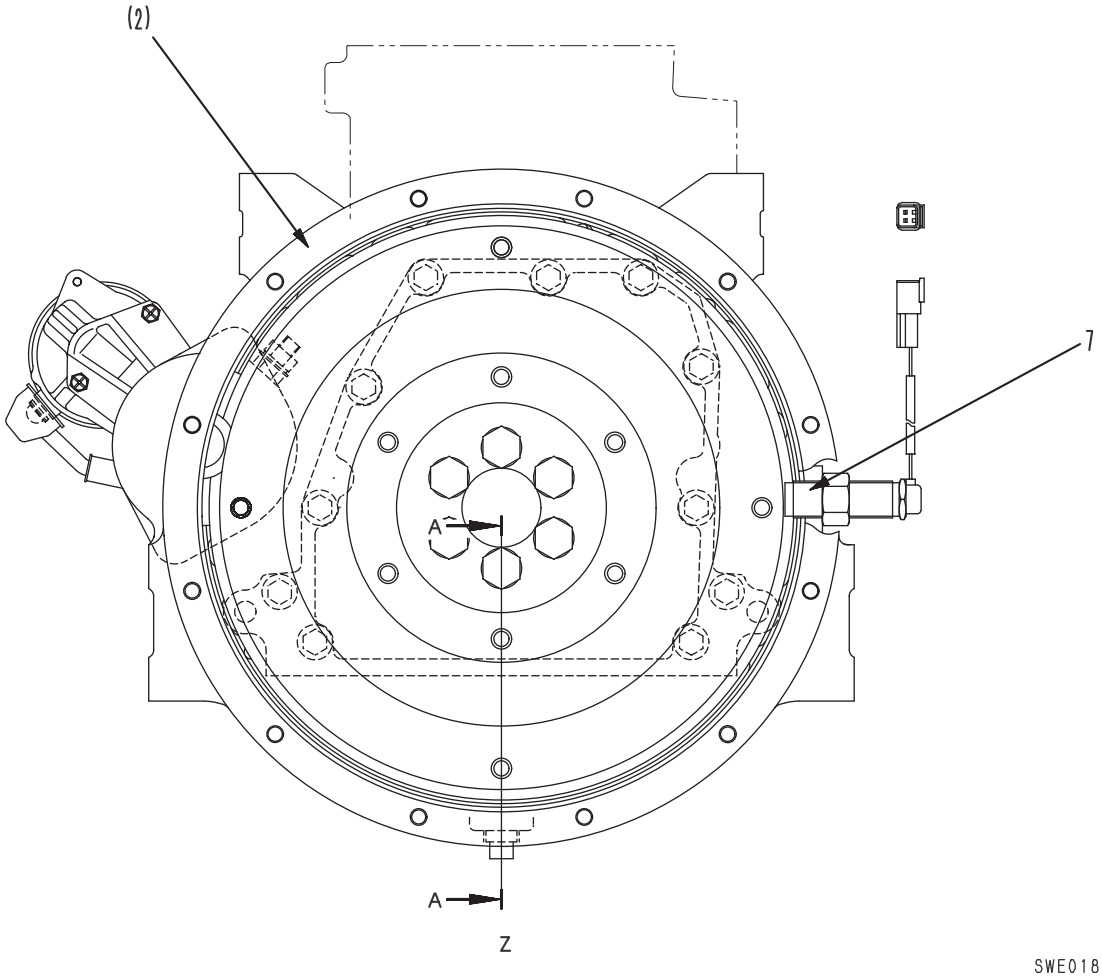
WITHOUT REAR PTO TYPE

★ There may be differences according to the machine model.
★ 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.



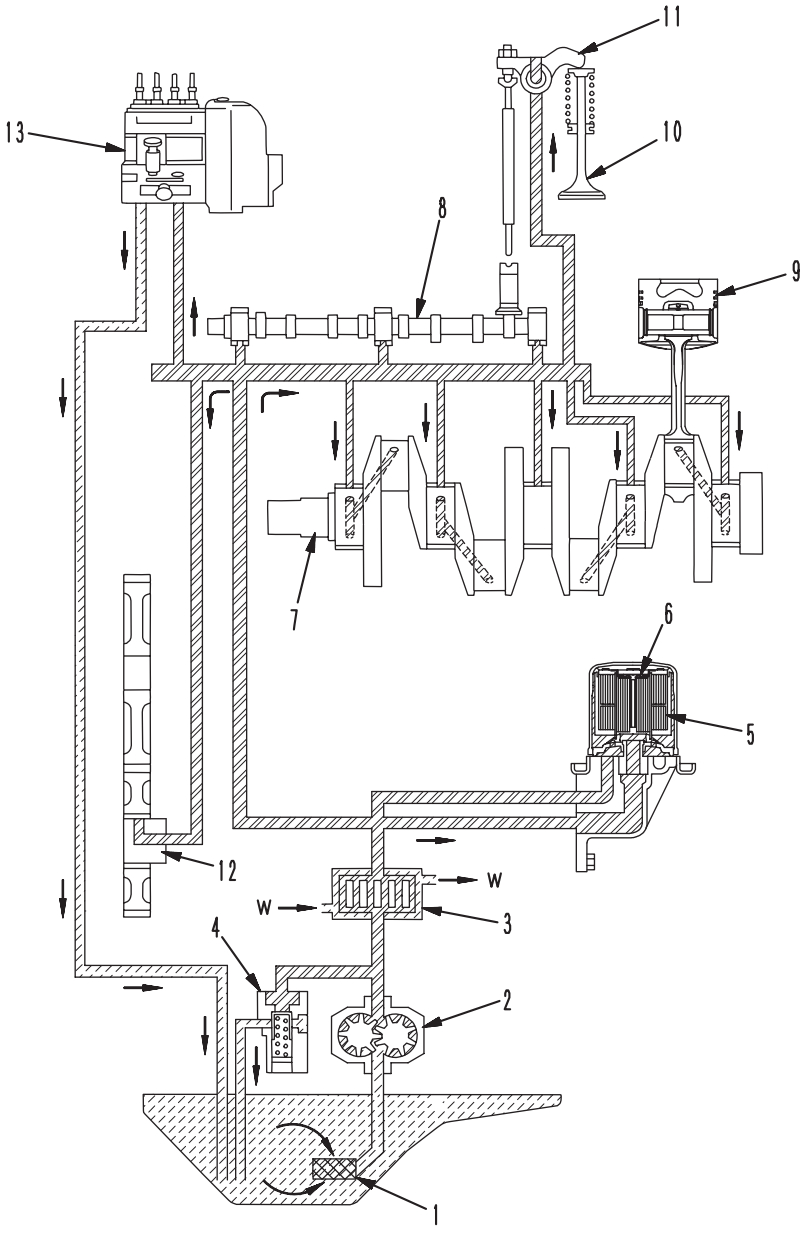
SWE01802

1. Starting motor
2. Flywheel housing
3. Crankshaft
4. Rear oil seal (Wet type: Double lip)
5. Flywheel
6. Ring gear (No. of teeth: 119)
7. Engine speed sensor


(2)
1
A
A
Z
SWE01803

LUBRICATION SYSTEM CHART

4D95LE-2

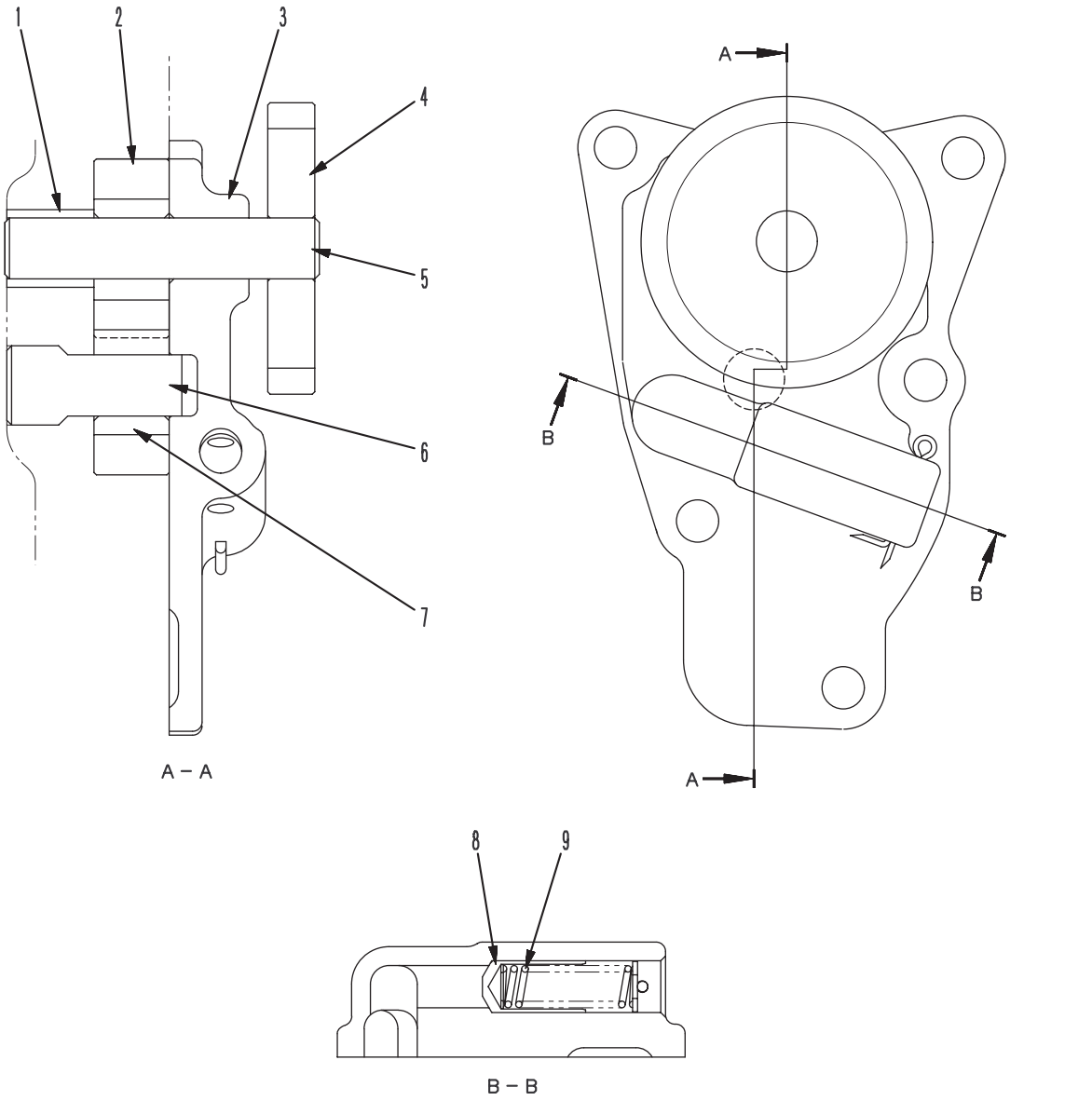


SWE01804

1. Oil strainer
2. Oil pan
3. Oil cooler
4. Regulator valve
5. Oil filter
6. Safety valve
7. Crankshaft
8. Camshaft
9. Piston
10. Intake, exhaust valve
11. Rocker arm
12. Timing gears
13. Fuel injection pump

W: Cooling water

OIL PUMP



SWE01805

1. Bushing
2. Drive gear (No. of teeth: 7)
3. Pump cover
4. Oil pump drive gear (No. of teeth: 21)
5. Drive shaft
6. Driven shaft
7. Driven gear (No. of teeth: 7)
8. Regulator valve
9. Valve spring

Specifications

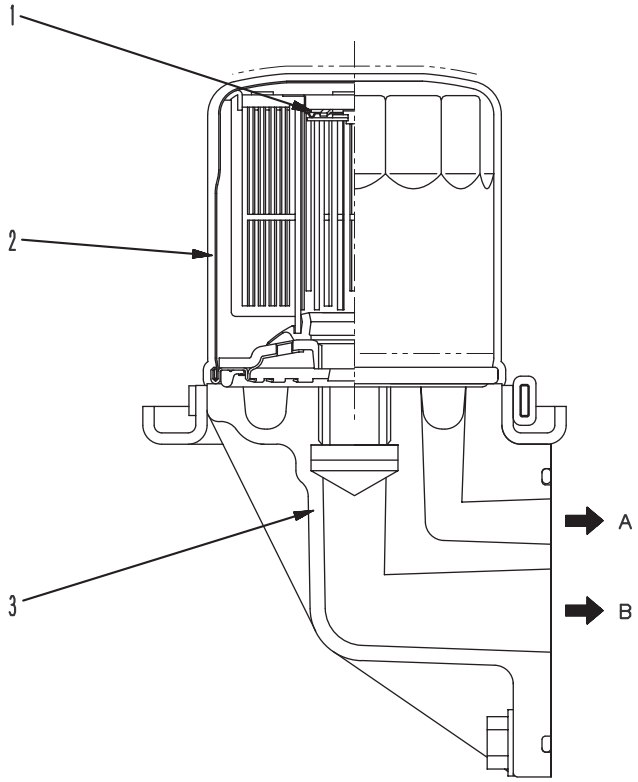
Oil pump

- Type: Gear pump
- Pump speed: Engine speed x 1.143

Regulator valve

- Set pressure: 588 ± 49 kPa {6.0 ± 0.5 kg/cm^2}

OIL FILTER



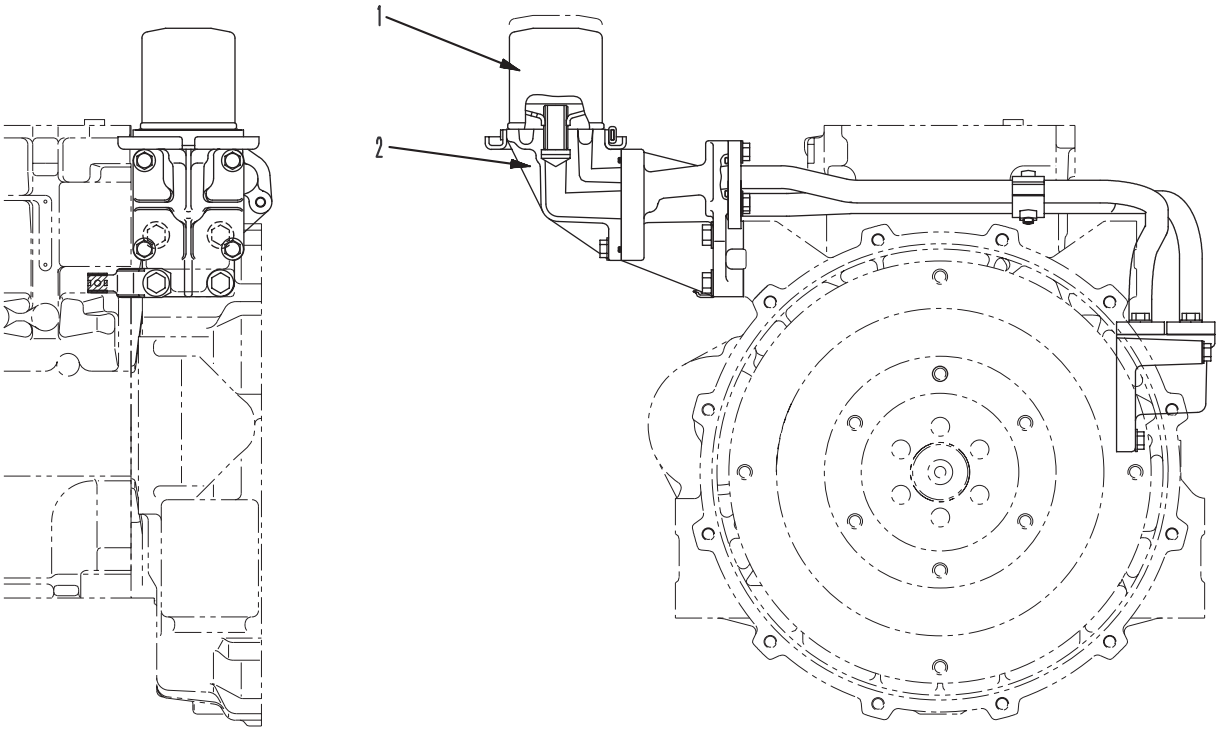
SWE01806

1. Relief valve
2. Cartridge
3. Bracket

A. Oil inlet
B. Oil outlet

Specifications
Relief valve
- Cracking pressure:
  100 ± 20 kPa {1 ± 0.2 kg/cm^2}

OIL FILTER MOUNT

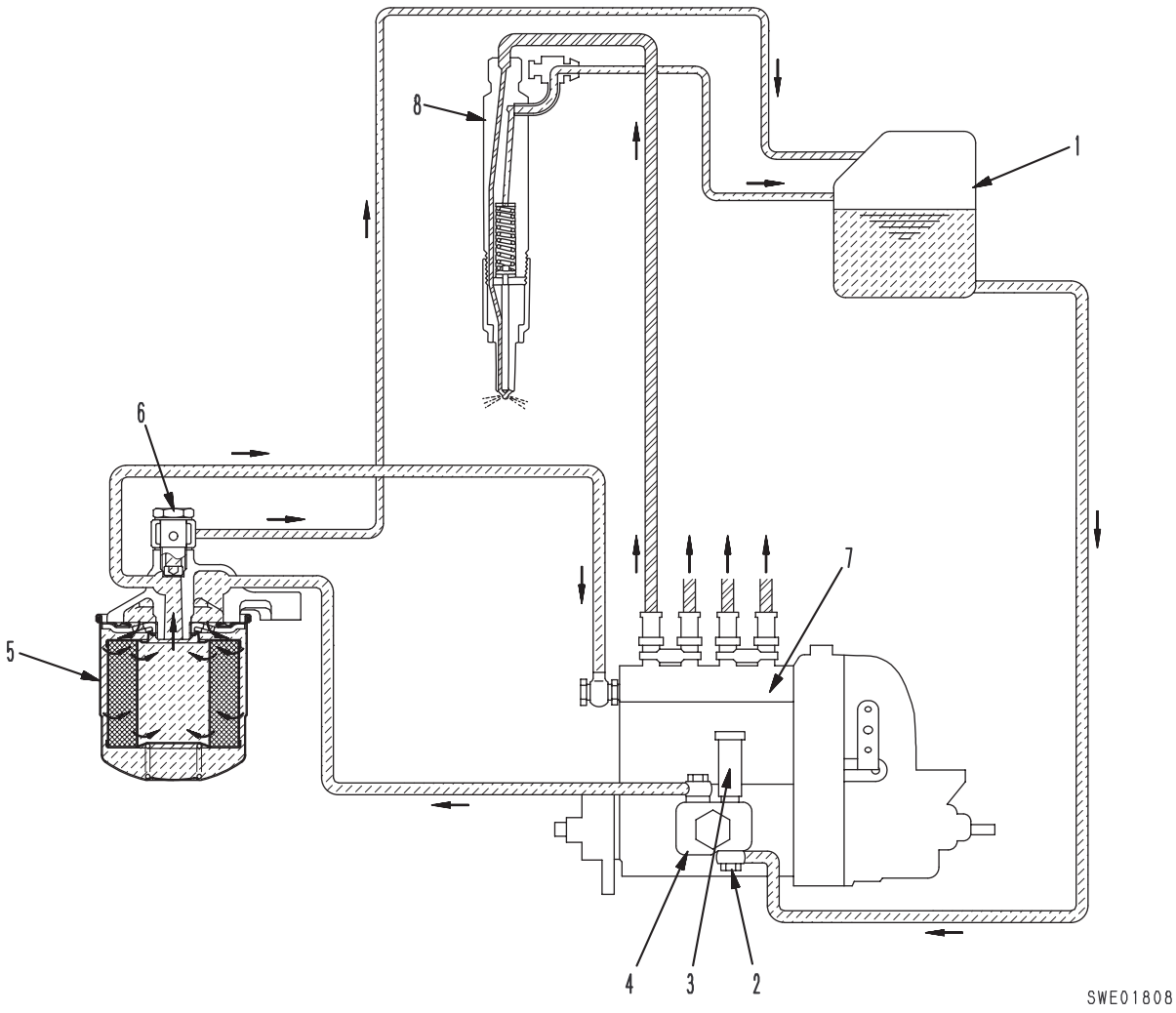


SWE01807

1. Cartridge
2. Bracket

FUEL SYSTEM CHART

4D95LE-2
(WITH AUTOMATIC AIR BLEED MECHANISM)

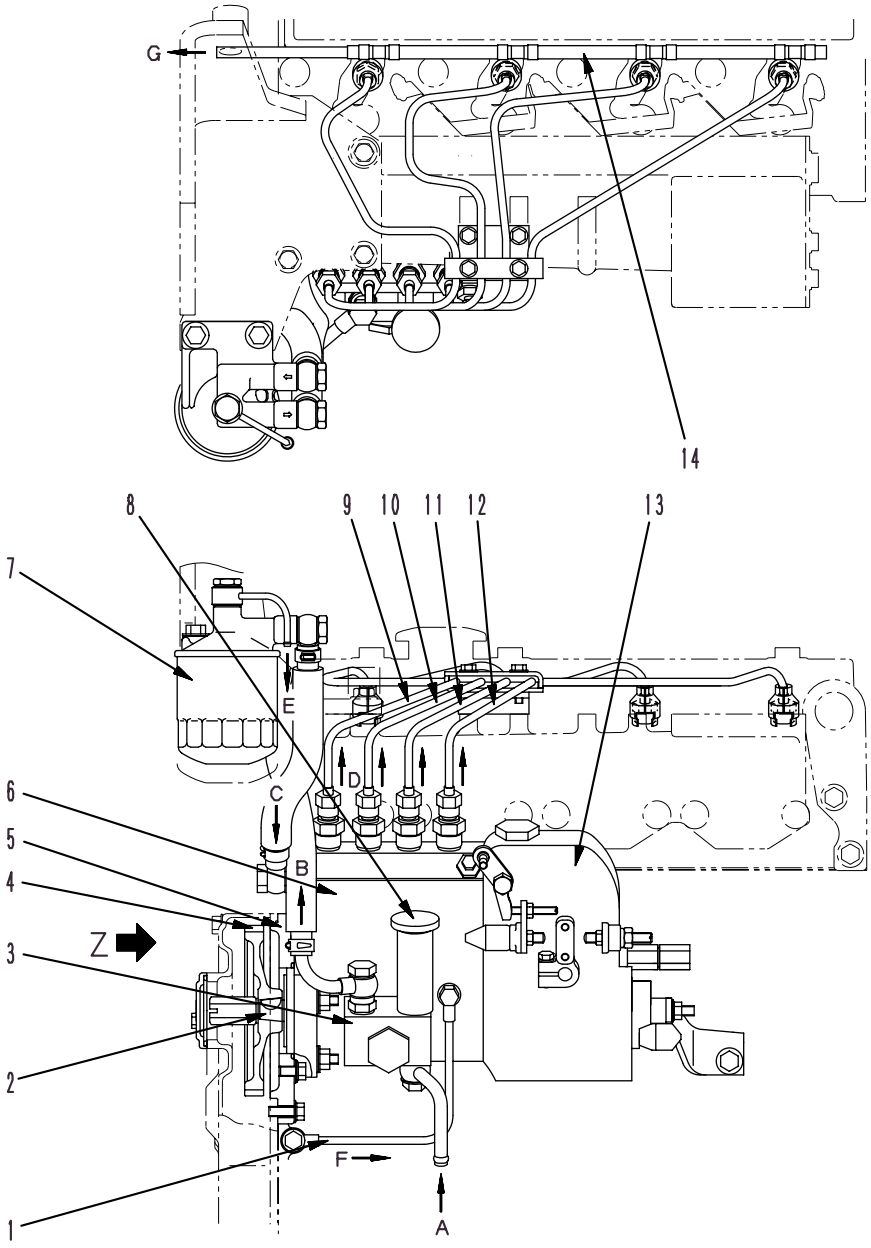


1. Fuel tank
2. Gauze filter
3. Priming pump
4. Feed pump
5. Fuel filter
6. Overflow valve
7. Fuel injection pump
8. Fuel injection nozzle

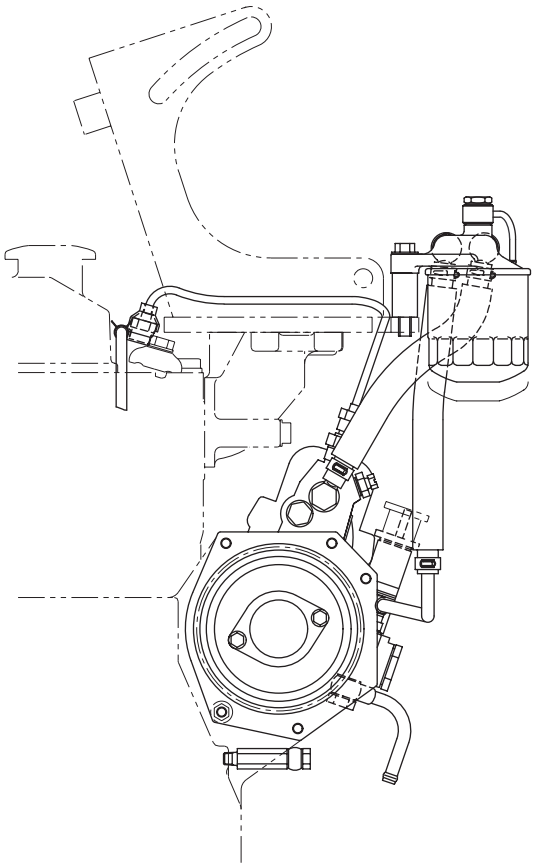
FUEL INJECTION PUMP

4D95LE-2 (For PC78US-6, PC78UU-6)

★ Details may differ according to the machine model.



1. Lubricating tube
2. Drive shaft
3. Feed pump
4. Fuel injection pump drive gear (No. of teeth 48)
5. Pump holder
6. Fuel injection pump
7. Fuel filter
8. Priming pump
9. Fuel injection pipe (No. 1)
10. Fuel injection pipe (No. 2)
11. Fuel injection pipe (No. 3)
12. Fuel injection pipe (No. 4)
13. Governor
14. Spill tube



Z

SWE01810

A. Fuel inlet (From fuel tank)
B. To fuel filter
C. From fuel filter
D. To fuel injection nozzle
E. To fuel tank
F. From oil pump (Lubrication oil)
G. To fuel tank

Specifications

Fuel injection pump

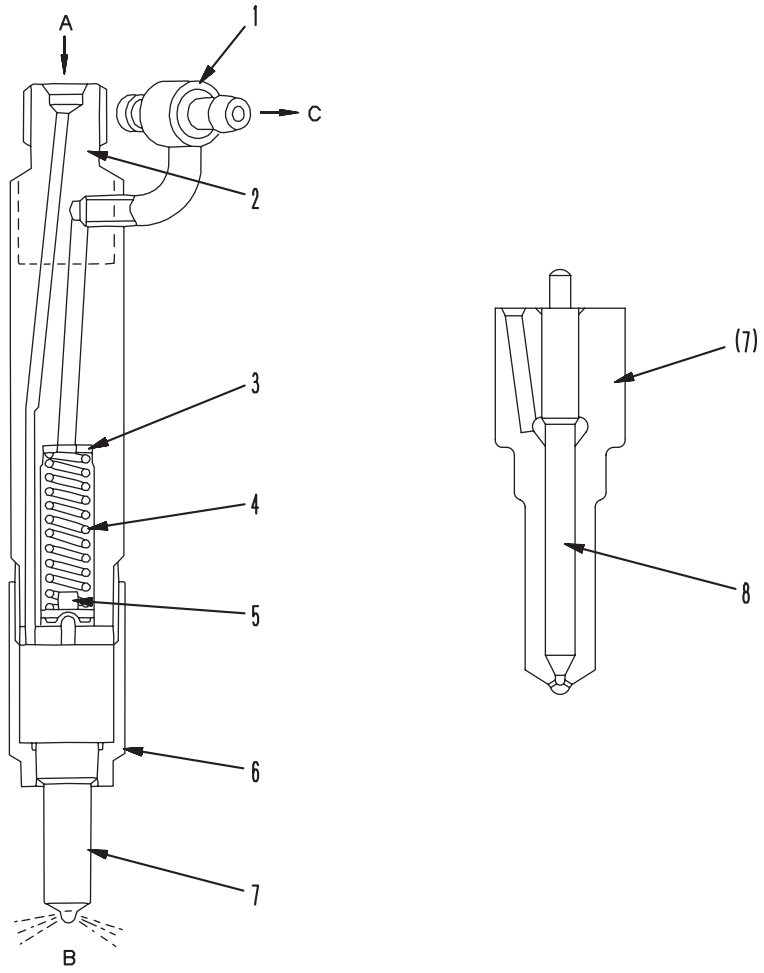
- Type: Bosch type PES-A
- Lubrication method:
  Forced lubrication with engine oil

Governor

- Type: Bosch RSV, Centrifugal, all-speed type

FUEL INJECTION NOZZLE

FOR DIRECT FUEL INJECTION TYPE
4D95LE-2



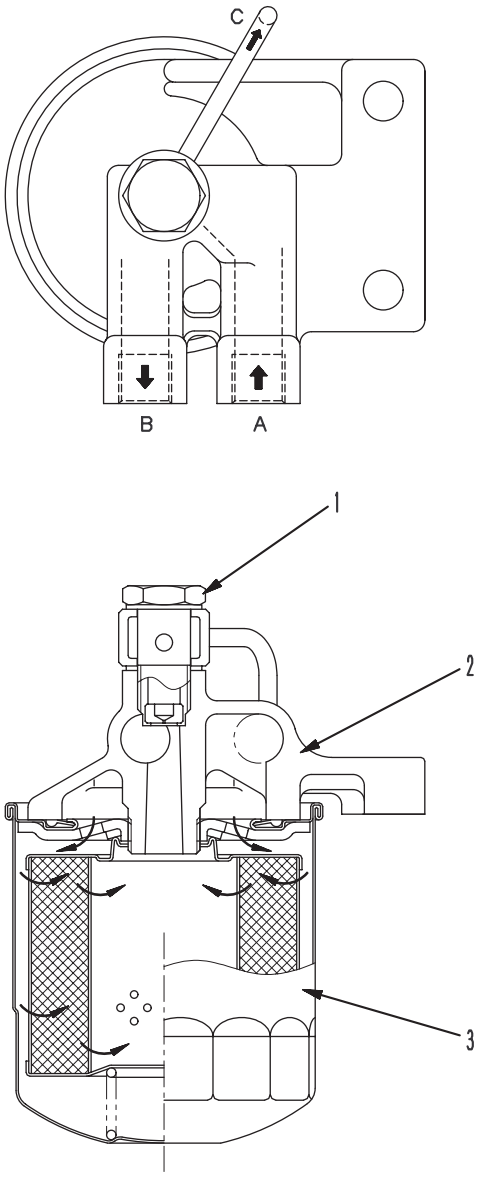
SWE01811

1. Connector
2. Nozzle holder
3. Adjustment shim
4. Nozzle spring
5. Spring seat (there are two types)
6. Retaining cap
7. Nozzle body
8. Needle valve

A. Fuel inlet port (from injection pump)
B. Fuel spray (inside cylinder)
C. Fuel return port (to fuel tank)

Specifications
- Type: Bosch multiple-hole cylindrical type
- Injection pressure (cracking pressure): 19.6 MPa {200 kg/cm^2}
- Cracking pressure adjustment: shim adjustment

FUEL FILTER



SWE01812

1. Overflow
2. Filter bracket
3. Cartridge

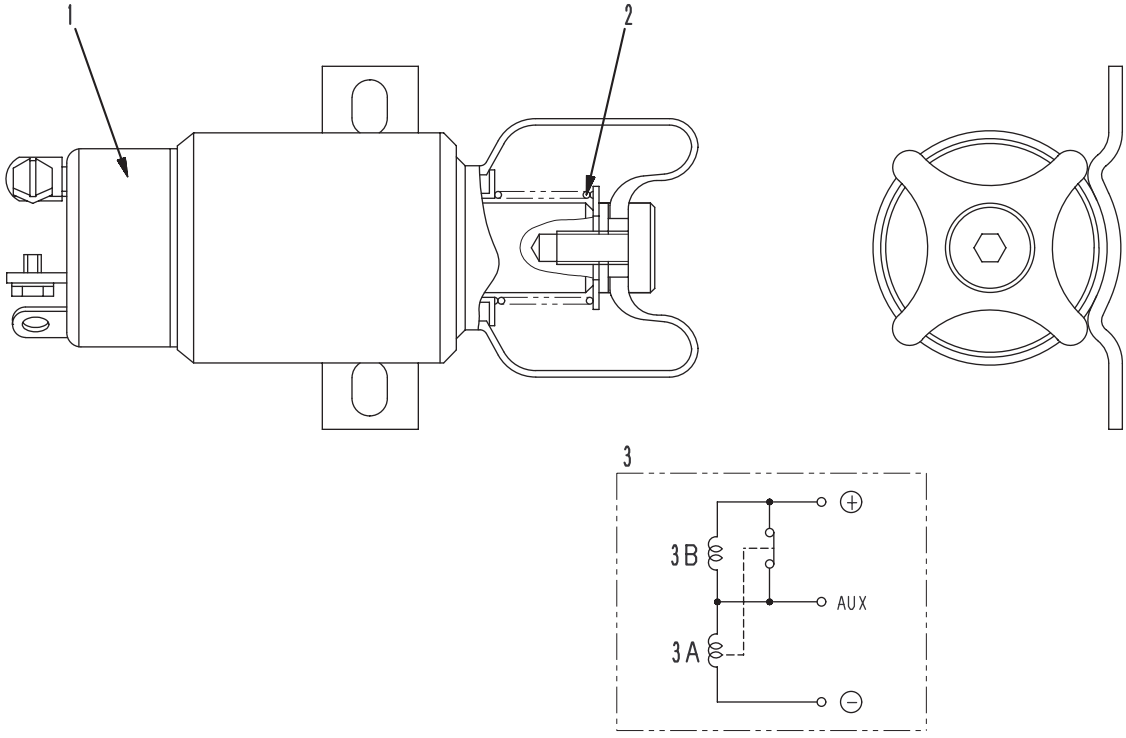
A. Fuel inlet
B. Fuel outlet

Specification

- Filtration area: 0.15 m^2

FUEL CUT SOLENOID

B CONTACT SYSTEM (CONSTANT CURRENT)



SWE01813

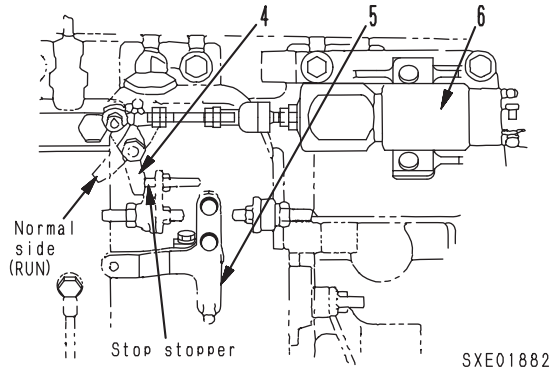
1. Case
2. Return spring
3. Internal wiring diagram
   3A. C1 Attraction coil
   3B. C2 Holding coil
4. Stop lever
5. Fuel control lever
6. Solenoid

- When the engine started, electricity passes through the solenoid and the solenoid plunger is actuated. This extends return spring (2) (built into the solenoid) and pulls it to the engine run position, and holds it in position.
- When stopping the engine, the key is turned to the STOP position and the flow of current through the solenoid is stopped. The magnetic force of the solenoid disappears, so the force of the return spring moves the injection pump stop lever to the engine STOP position (no injection). The solenoid plunger is also pulled back at the same time, and the engine stops.
- The fuel injection amount is controlled by fuel control lever (4) when the engine is running.
- Adjust length of rod when installing the fuel solenoid valve (see TESTING AND ADJUSTING).

Specifications

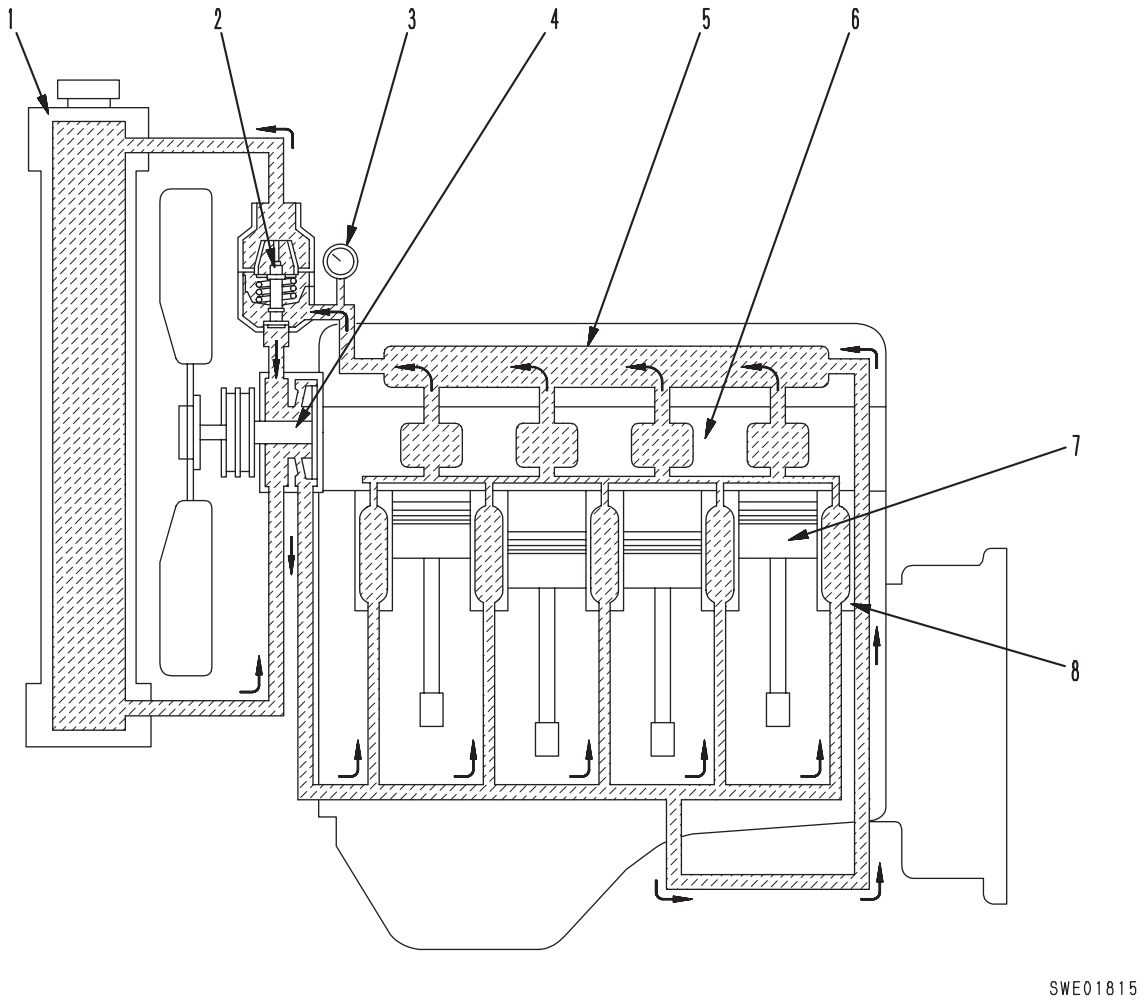
Solenoid

- Type: Synchrostart drip-proof type
- Rated voltage: DC24V
- Actuating current:
  When starting to pull: Approx. 25 A
  When finishing pulling: 0.5 A
- Stroke: 25.4 mm
- Weight: 1 kg



SXE01882

COOLING SYSTEM CHART

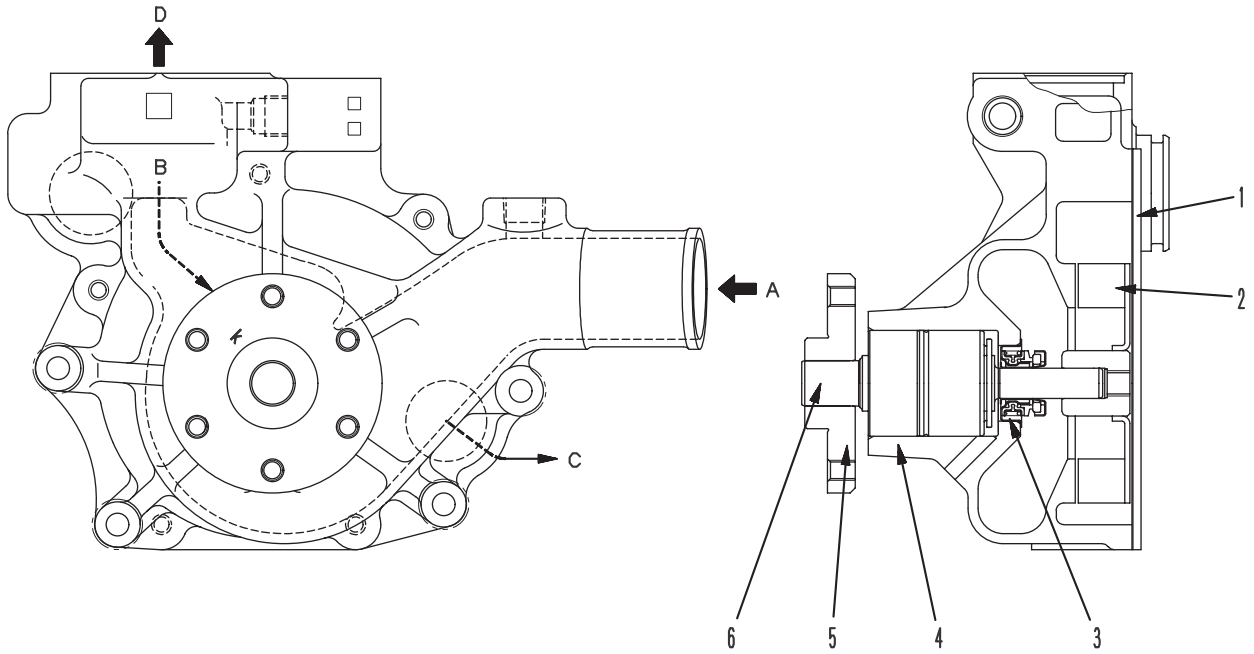


1. Radiator
2. Thermostat
3. Water temperature sensor
4. Water pump
5. Water manifold
6. Cylinder head
7. Piston
8. Cylinder block

WATER PUMP

(WITH SEPARATE TYPE WATER SEAL, INTEGRATED BEARING, SHAFT)

★ The shape may differ according to the machine model.



SWE01816

1. Pump cover
2. Impeller
3. Water seal
4. Pump body
5. Boss
6. Drive shaft

A. Water inlet port (from radiator)
B. Water inlet port (from thermostat)
C. Water outlet port (from engine)
D. Water outlet port (from radiator)

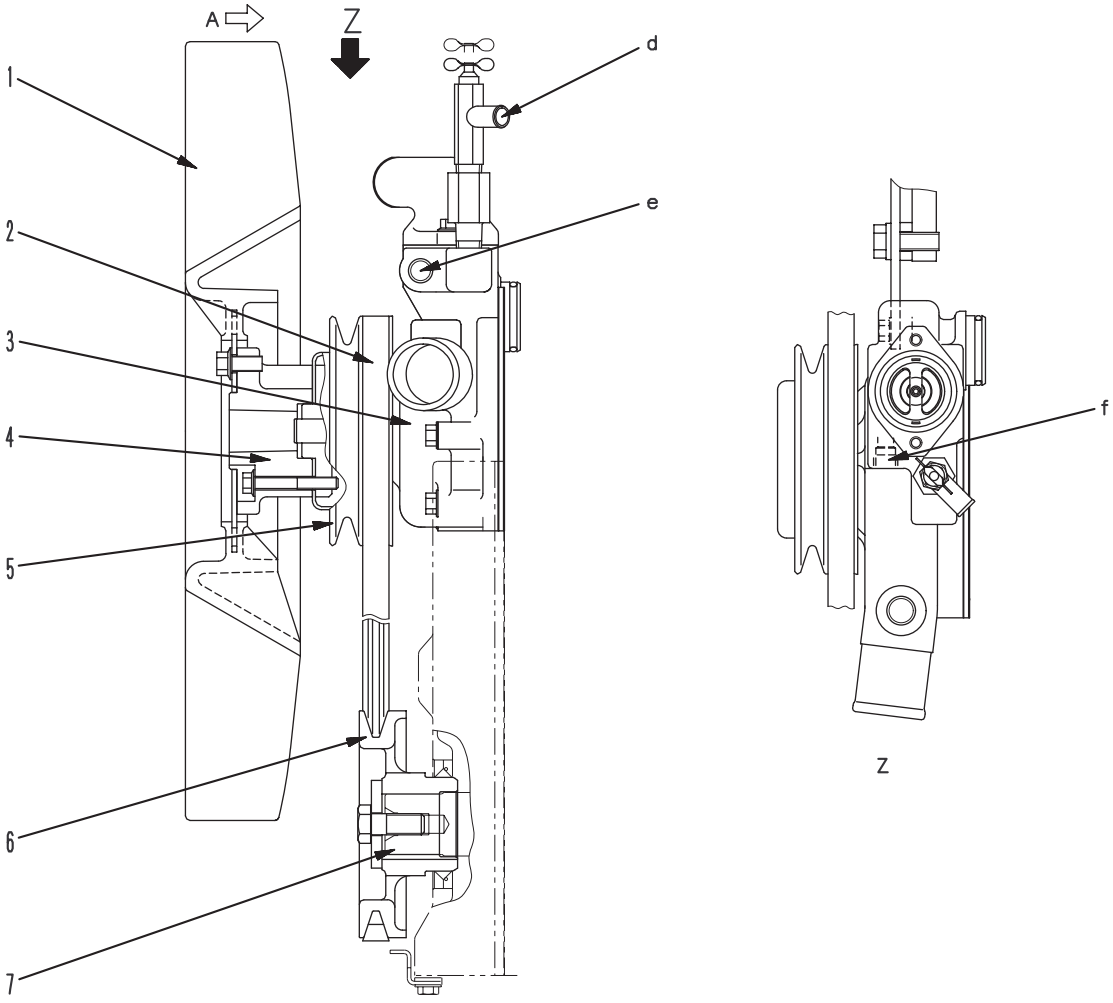
Specification

- Type: Centrifugal type (V-belt drive)

FAN DRIVE AND THERMOSTAT

4D95LE-2

★ The shape may differ according to the machine model.



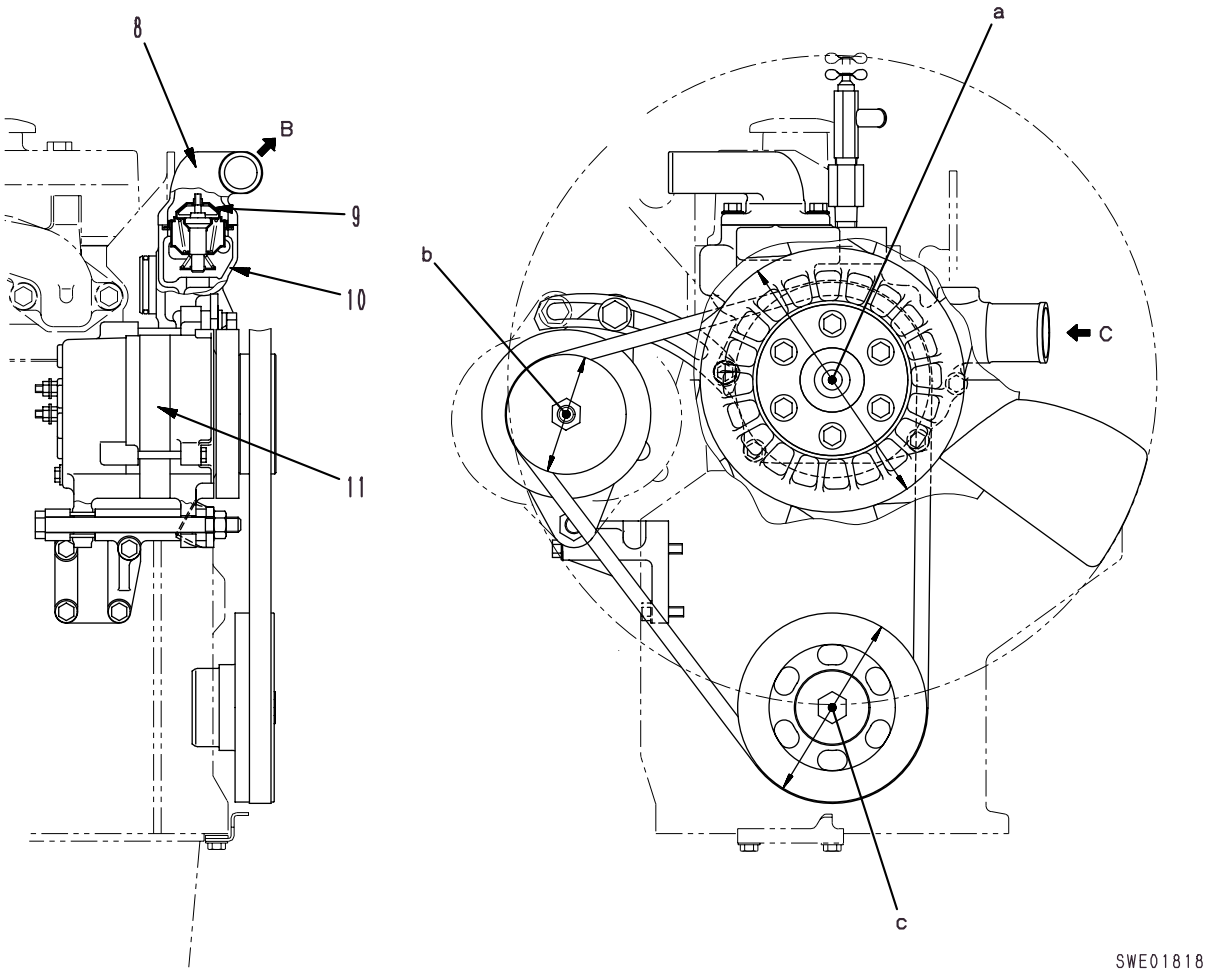
SWE01817

1. Fan
2. Fan belt
3. Water pump
4. Fan spacer
5. Fan pulley
6. Crankshaft pulley
7. Crankshaft
8. Thermostat case cover
9. Thermostat
10. Thermostat case
11. Alternator

A. Direction of wind
B. To radiator (cooling water)
C. From engine (cooling water)
a, b, c: Outside diameter of pulley
d. Heater pickup port
e. Thermo sensor (installed on some models)
f. Water temperature gauge pickup port

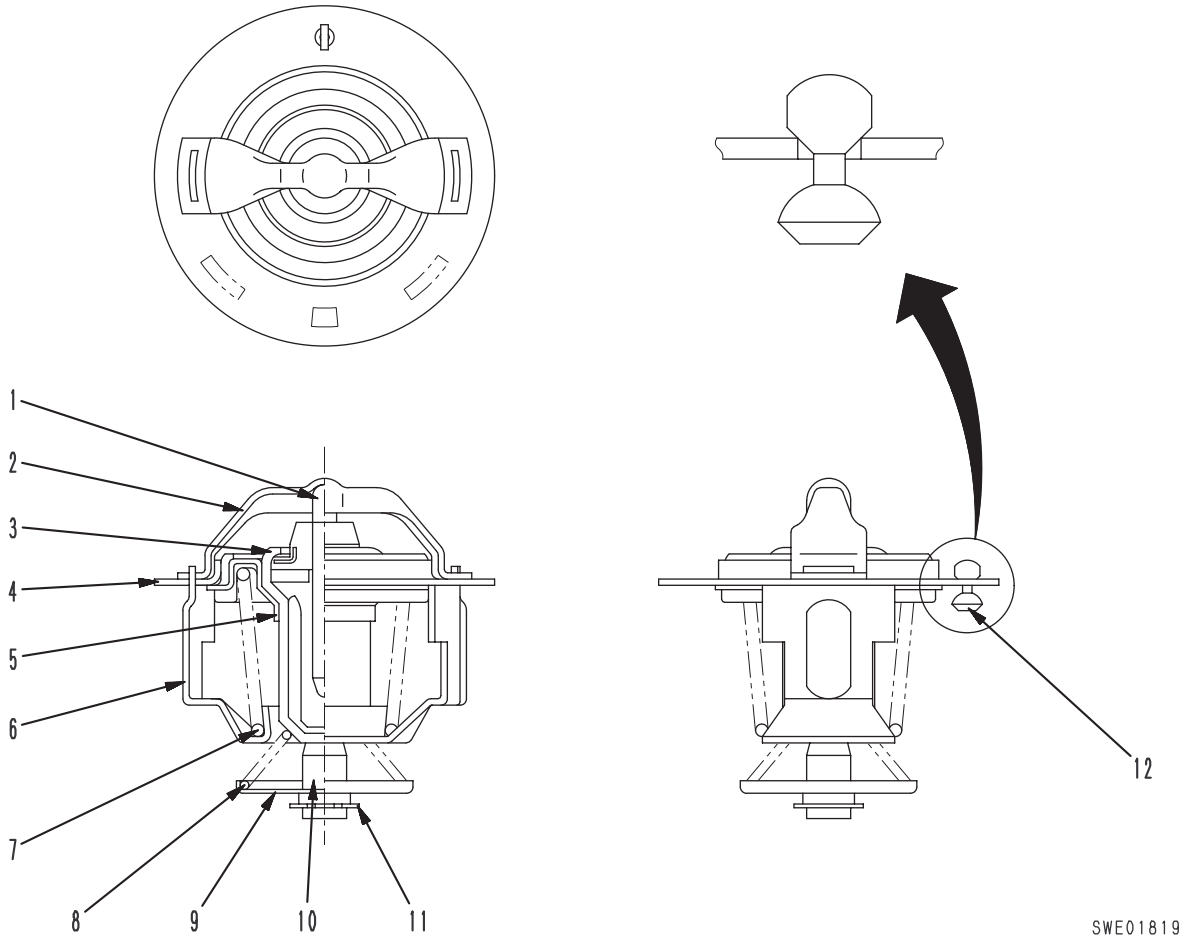
FAN DRIVE

★ The diagram shows the PC78US-6.



Engine	Applicable machine	Outer diameter of pulley (mm)		
		a (Fan)	b (Alternator)	c (Crankshaft)
4D95LE-2	PC60-7	152	95	150
	PC75UU-3, BR100JG-2	189	95	150
	PC78US-6, PC78UU-6	152	95	150

THERMOSTAT (WITH JIGGLE VALVE)

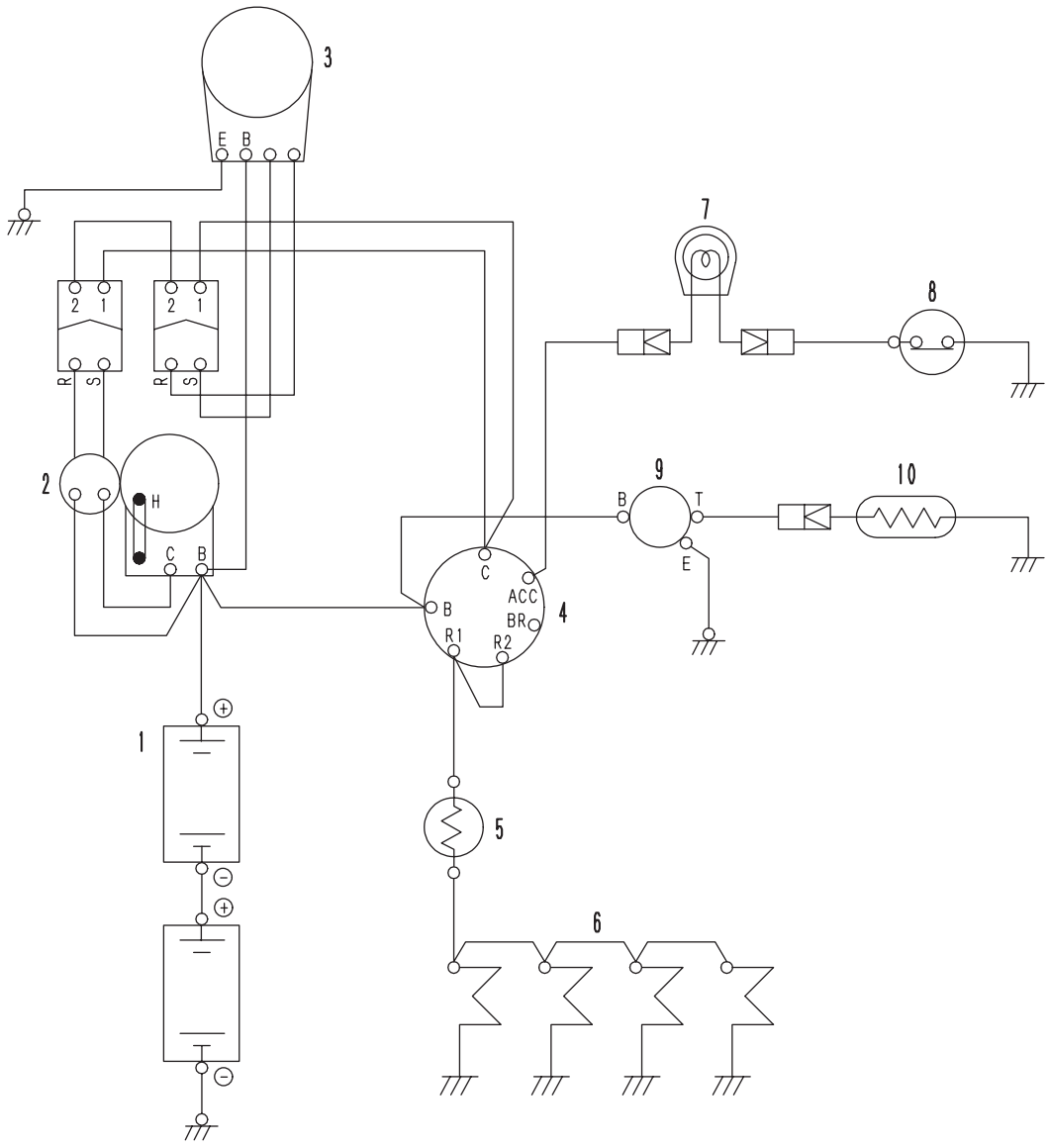


1. Piston
2. Case
3. Pellet
4. Seat
5. Valve
6. Case
7. Spring
8. Bypass spring
9. Bypass valve
10. Bypass seat
11. E-ring
12. Jiggle valve

- The jiggle valve allows air to flow but stops water from flowing to the top of thermostat. It allows the engine water temperature to rise in a short time.

STARTING AND CHARGING SYSTEM ELECTRICAL CIRCUIT DIAGRAM

4D95LE-2

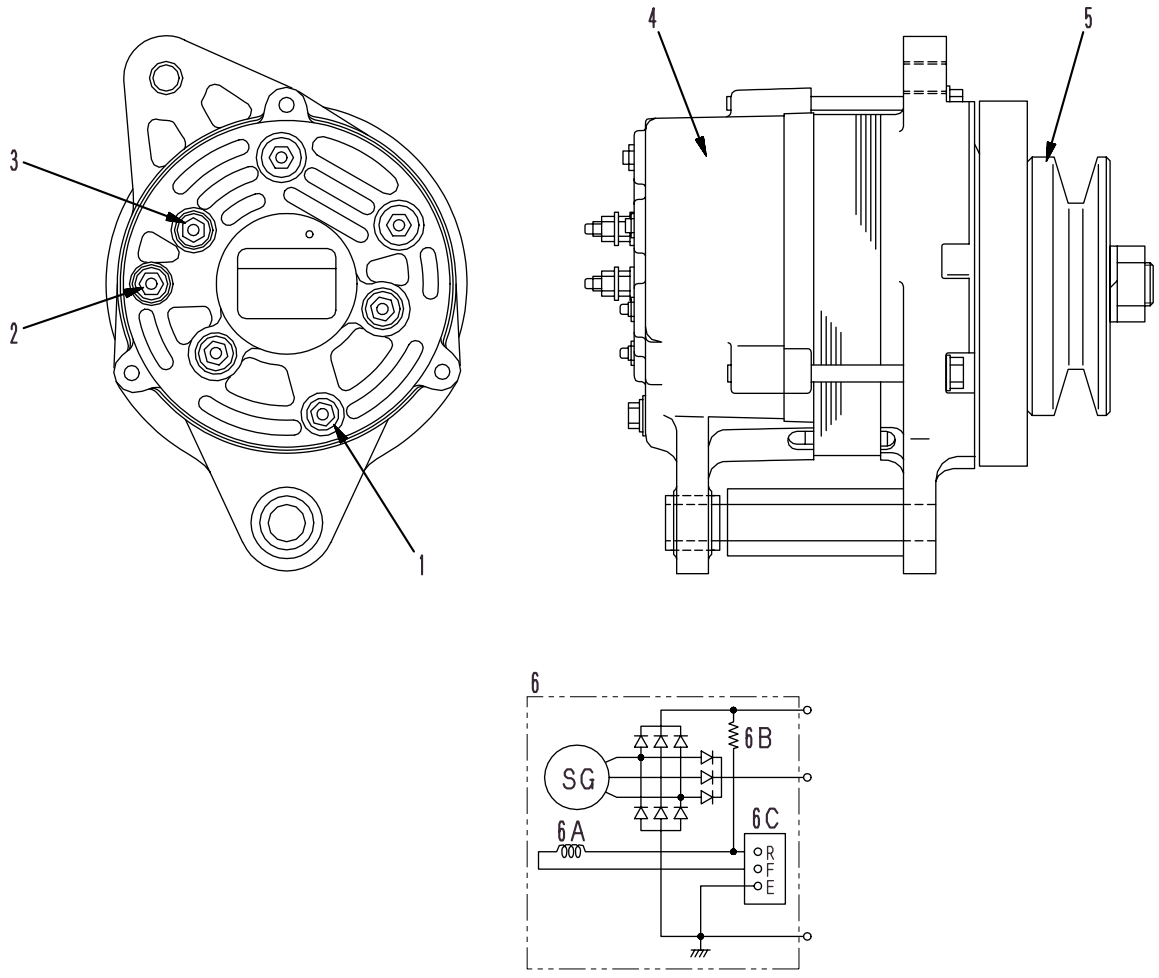


SWE01821

1. Battery
2. Starting motor
3. Alternator
4. Starting switch
5. Glow signal
6. Glow plug
7. Oil pressure caution lamp
8. Oil pressure switch
9. Water temperature gauge (electrical type)
10. Thermo sensor

ALTERNATOR

BUILT-IN REGULATOR TYPE (25A)



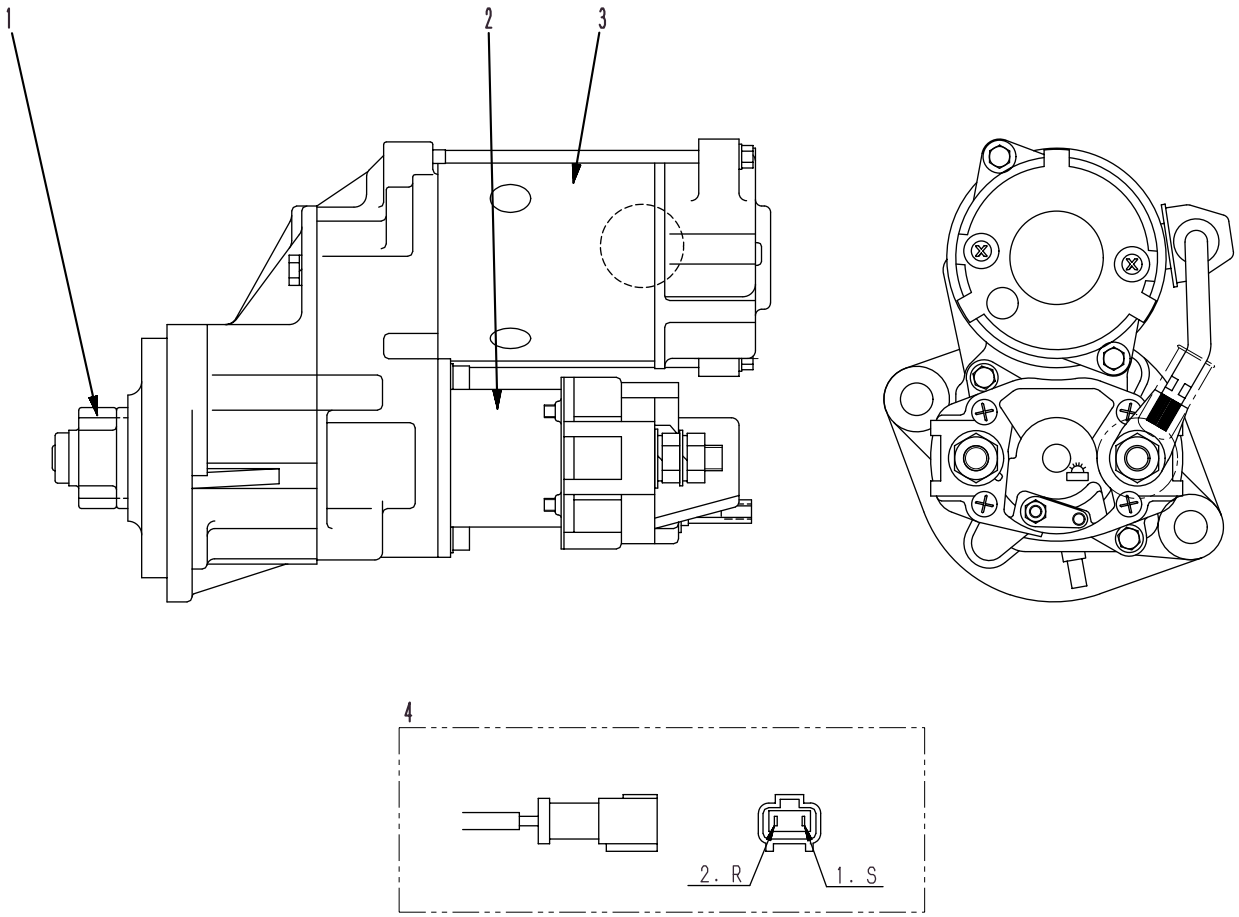
SWE01820

1. E terminal
2. B terminal
3. R terminal
4. Alternator
5. Alternator pulley
6. Internal connection diagram
   6A. Field coil
   6B. Initial excitation resistance
   6C. Regulator

Engine	Machine model	Type	Specification	Pulley		Weight (kg)
				No. of pulley grooves	Outside diameter (mm)	
4D95LE-2	PC60-7	Nikko Denki, open type	24 V, 25 A	1	95	6.0
	PC75UU-3	Nikko Denki, open type	24 V, 25 A	1	95	6.0
	PC78US-6, PC78UU-6	Nikko Denki, open type	24 V, 25 A	1	95	6.0
	BR100JG-2	Nikko Denki, open type	24 V, 25 A	1	95	6.0

STARTING MOTOR

SEPARATELY LOCATED SAFETY RELAY TYPE



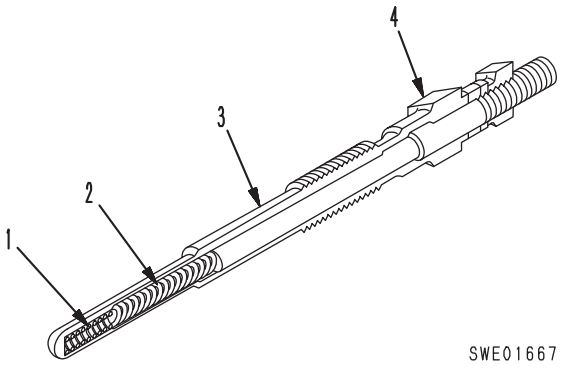
SWE01822

1. Pinion gear
2. Magnetic switch
3. Starting motor (yoke)
4. Connector
   (sealed type, 2 pins connector, x type)

Engine	Machine model	Type	Specification	No. of pinion teeth	Weight (kg)
4D95LE-2	PC60-7 PC75UU-3 PC78US-6, PC78UU-6	Hitachi sealed type	24 V, 3 kW	11	7.8
	BR100JG-2	Nikko Denki, sealed type	24 V, 3 kW	11	7.8

ENGINE STARTING DEVICE

GLOW PLUG (METAL 2-WIRE TYPE GLOW PLUG)



1. Heat generation coil (Fe-Cr)
2. Control coil (Fe)
3. Body
4. Rated voltage color marking

Specification

Rated voltage (color marking)	Type	Name
24 V (Red)	Standard type	Self-control type ceramic glow plug

12 TESTING AND ADJUSTING

⚠ When carrying out testing and adjusting, or troubleshooting, stop the machine on level ground, fit safety pins, block the wheels, and apply the parking brake.

⚠ When carrying out operations with two or more workers, always use signals, and do not allow any unauthorized person near the machine.

⚠ When checking the water level, if the radiator cap is removed when the engine is hot, boiling water will spurt out and may cause burns, so always wait for the engine to cool down before checking the water level.

⚠ Be extremely careful not to touch any hot parts.

⚠ Be extremely careful not to get caught in the fan or any other rotating parts.

⚠ When removing the plugs or caps from places under hydraulic pressure, water pressure, or air pressure, release the internal pressure first. Fit the measuring tools securely before carrying out any testing, adjusting, or troubleshooting.

★ When using the standard values table for judgement in testing, adjusting, or troubleshooting, it is necessary to be careful of the following points.

1. The standard values for the new machines in the standard values table are values given as reference from the standards for new machines and machines shipped from the factory. They should be used as values for estimating wear during operation or as target values when carrying out repairs.

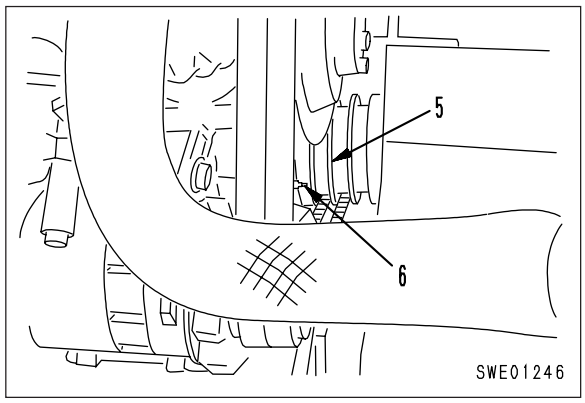
2. The failure judgement standard values in the standard values table are values using estimated values based on the results of various tests and standard values for machines shipped from the factory. Use these values for reference together with the repair and operation history of the machine when judging failures.

3. Do not use this standard values table as a standard for judging claims.

ADJUSTING VALVE CLEARANCE

1. Remove cylinder head cover.

2. Rotate the crankshaft in the normal direction. While watching the movement of the intake valve of No. 4 cylinder, bring the No. 1 cylinder into Compression Top Dead Center position and align the TOP engraved mark on crankshaft pulley (5) with pointer (6).
★ When the No. 1 cylinder comes near Compression Top Dead Center position, the No. 4 intake valve will start to move (open).



3. Adjust the valve clearance for valves marked ● in the valve arrangement chart.

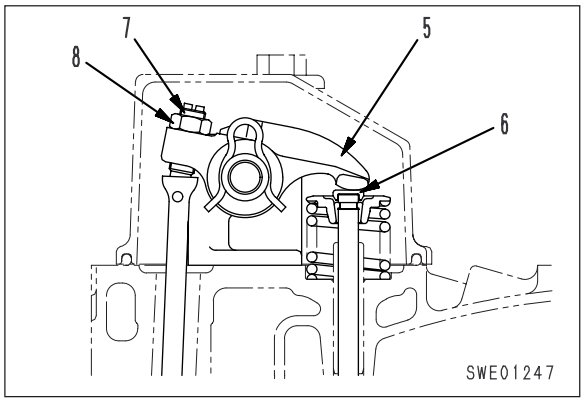
4. Rotate the crankshaft in the normal direction by one revolution and adjust the valve clearance for the remaining valves marked ○.

Valve arrangement

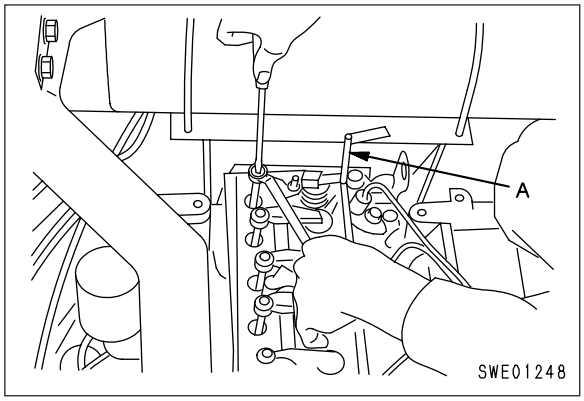
Cylinder No.	1		2		3		4	
Exhaust valve		●		●		○		○
Intake valve	●		○		●		○	

TDP00308

★ To adjust the valve clearance, loosen lock nut (8) on adjustment screw (7), insert feeler gauge **A** corresponding to the specified clearance between valve stem (6) and rocker arm (5), and adjust the clearance with the adjustment screw until the thickness gauge can slide lightly.



5. After the clearance is properly adjusted, tighten the lock nut to secure the adjustment screw.
kgm Lock nut: **44 ± 5.0 Nm {4.5 ± 0.5 kgm}**



★ Firing order: 1 – 2 – 4 – 3.
★ Intake and exhaust valve clearances may be adjusted for each cylinder in a firing order by rotating the crankshaft 180° at a time in the normal direction.
★ Valve clearance: see TESTING AND ADJUSTING DATA.

MEASURING COMPRESSION PRESSURE

MEASUREMENT PROCEDURE

⚠ While measuring the compression pressure, take care not burn yourself on the exhaust manifold or muffler, and be careful not to get caught in any revolving part of the engine.

★ Measure the compression pressure while the engine is warm.
(Oil temperature: 40 – 60°C)

1. Adjust the valve clearance properly. For details, see ADJUSTING VALVE CLEARANCE.

2. Remove spill tube and disconnect fuel injection pipe.

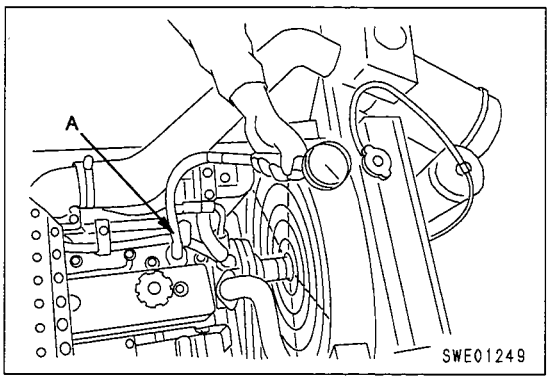
3. For machines with a key stop system, remove the wiring of the fuel cut solenoid.
(For machines with a stop motor installed, remove the wiring of the connector.)

4. Remove nozzle holder assembly for each cylinder.
   ★ Remove the nozzle holder assembly by prying it with the spill tube mounting bolt.
   ★ Take care not to let any dirt or foreign matter get into the cylinder.
   ★ When the nozzle holder assembly is removed, replace the seat gasket.

5. Install adapter **A** to the nozzle holder mounting section of the cylinder to be measured, and tighten the adapter to the specified torque.
   kgm Torque: **44 ± 5 Nm {4.5 ± 0.5 kgm}**

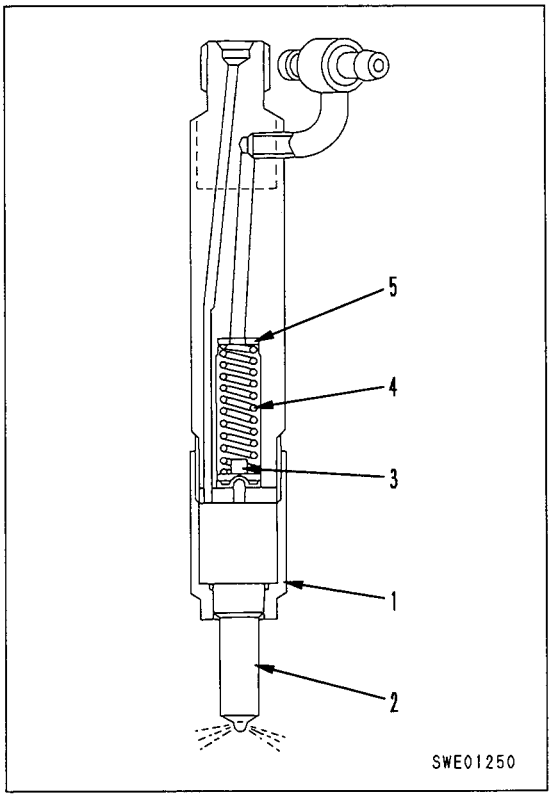
6. Connect compression gauge **A** to the adapter.

7. Place the fuel control lever in NO INJECTION position, crank the engine with the starting motor, and read the gauge when the pointer is stabilized.
   ⚠ If you do not put the fuel control lever in NO INJECTION position, fuel will blow out.
   ★ Most compression leakage can be prevented by applying a small amount of oil to the mounting section of the adapter.
   ★ For the reference values of the compression pressure, see TESTING AND ADJUSTING DATA.



ADJUSTING FUEL INJECTION PRESSURE (CRACKING PRESSURE)

1. Remove retaining cap (1).
2. Remove nozzle (2), spring seat (3), and nozzle spring (4).
3. Adjust thickness of shim (5) to adjust injection pressure (cracking pressure).
   ★ Pressure adjustment for 0.1 mm of shim thickness:
   Approx. 1.47 MPa {15 kg/cm²}
   kgm Retaining cap:
   44 ± 5 Nm {4.5 ± 0.5 kgm}



SHIM DATA FOR ADJUSTING INJECTION PRESSURE

Unit: mm

Engine	Shape	Range of shim thickness	Range of shim clearance
4D95LE-2	Inner dia.= 2.1 Outer dia.= 7.2	0.1 – 0.58	0.025

Part No.	Thickness (mm)	Part No.	Thickness (mm)
DK150534-3600	0.100	DK150534-4100	0.520
DK150534-3700	0.200	DK150534-4200	0.540
DK150534-3800	0.300	DK150534-4300	0.560
DK150534-3900	0.400	DK150534-4400	0.580
DK150534-4000	0.500		

TESTING AND ADJUSTING FUEL INJECTION TIMING

Counter mark method

★ Adjustment is normally carried out using this method.
(In cases when the fuel injection pump has not been repaired and is assembled again to the same engine, or when only the fuel injection timing is checked)

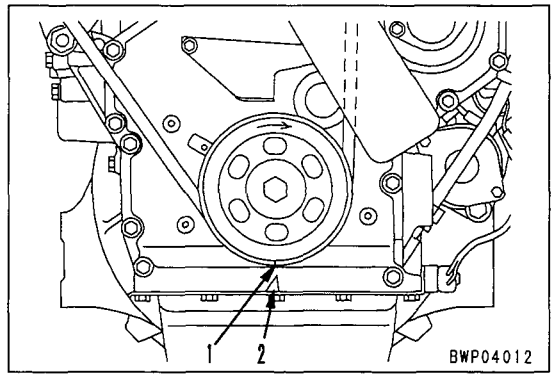
1. Set the No. 1 cylinder to the compression top dead center.
   1) Rotate the crankshaft in the normal direction and align pointer (2) with (1.4 TOP line) (1) on the crankshaft pulley.
   2) Use the procedures below to check that the No. 1 cylinder is at compression top dead center. If the condition is not as shown below, rotate the crankshaft one more turn.
      ★ When fuel injection pump has been removed: Check that it is possible to see the **C** at the tip of the idler gear teeth.
      ★ When fuel injection pump is installed to engine: Remove the head cover and check that the intake and exhaust valves of the No. 1 cylinder are closed (there is a clearance for both the No. 1 intake and exhaust valves).

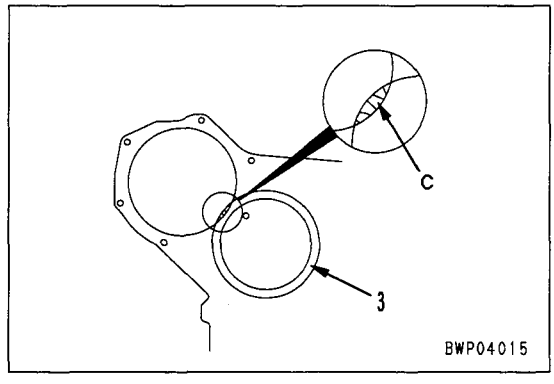
2. Remove cover (3) at the front of the fuel injection pump.

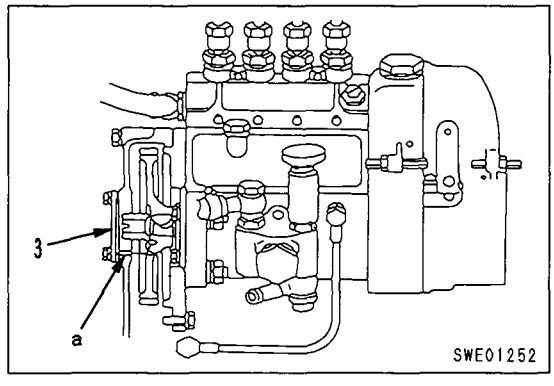
3. Install to the engine with the fuel injection pump holder and drive gear as one unit.

4. Insert the timing check pin (diameter: 4 – 4.5 mm, length: 80 mm) through hole **a** in the front gear cover and align with the hole in the drive gear.
   ★ The timing check pin must enter straight. Check that the hole in the fuel injection pump holder is aligned with the mounting hole in the front gear cover (the mounting bolt goes in).
   ★ If the position is not aligned, remove the fuel injection pump again and check the meshing of the drive gear.

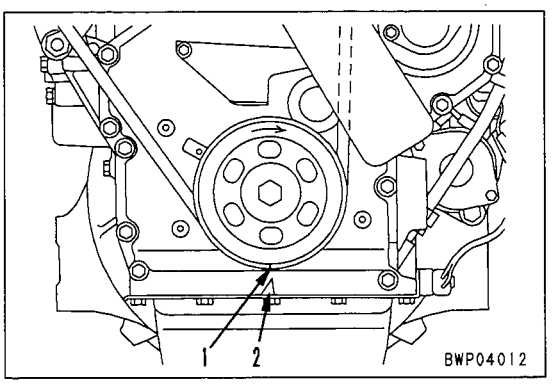
5. Remove the timing check pin and tighten all bolts.





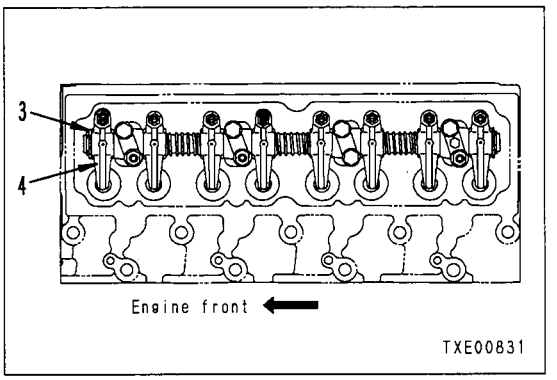


Delivery valve method
(In cases when the fuel injection pump has been repaired or replaced and is assembled again, or when the gear train parts have been disassembled or replaced)



1. Remove the cylinder head cover.

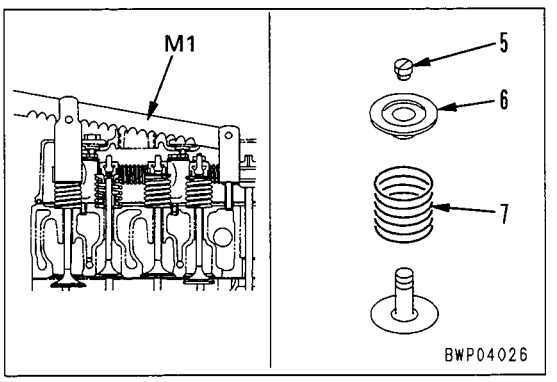
2. Set the No. 1 cylinder at compression top dead center.
   1) Rotate the crankshaft in the normal direction to align pointer (2) with injection timing line (1) on the crankshaft pulley.
   2) Check that there is a clearance at the intake and exhaust valves of the No. 1 cylinder.
      ★ If there is no clearance, rotate the crankshaft one more turn.



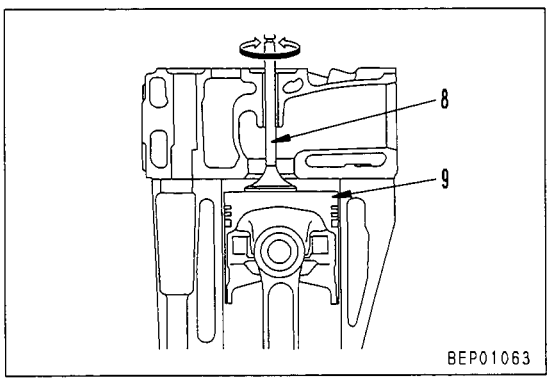
3. Remove snap ring (3) at the front end of the rocker shaft, then remove No. 1 cylinder intake rocker arm (4).

4. Using spring pusher **M1**, compress the valve spring and remove valve cotter (5).

5. Loosen spring pusher **M1**, then remove spring seat (6) and valve spring (7).



6. Put intake valve (8) in contact with the top surface of piston (9), then rotate the shaft by hand to check that it is securely in contact.



7. Put dial gauge **M2** in contact with the tip of the valve shaft, then rotate the crankshaft in the normal and reverse direction and set the gauge to 0 at the point where the indicator starts to turn in the reverse direction.

8. Put the No. 1 cylinder at compression top dead center, then rotate the crankshaft approx. 45° in the reverse direction.

9. Rotate the crankshaft in the normal direction until the dial gauge shows the standard dimension **a**. This dimension corresponds to BTDC 12 ± 0.8°.
   - ★ Standard dimension **a**: 1.69 ± 0.22 mm
   - ★ Always rotate in the normal direction when aligning.

10. Disconnect fuel injection pipe (10) of No. 1 cylinder.

11. Remove delivery valve holder (11), take out delivery valve (12) and spring (13), then install delivery valve holder (11) again.

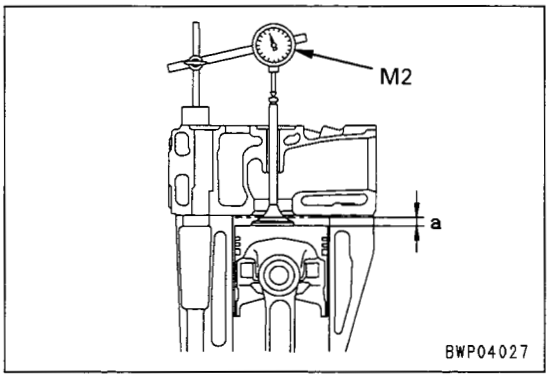
12. Place the fuel injection lever at the FULL position.

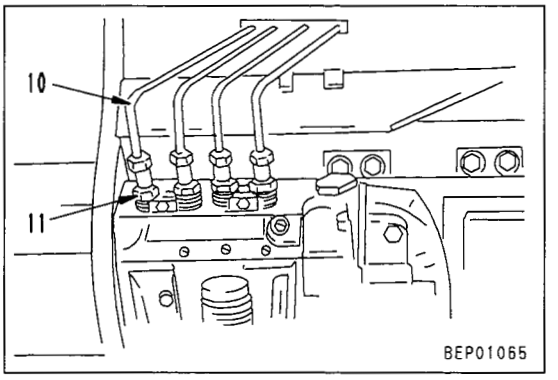
13. Loosen the nut in the oblong hole of the mounting flange of the fuel injection pump, then loosen injection pump mounting bolts (14).

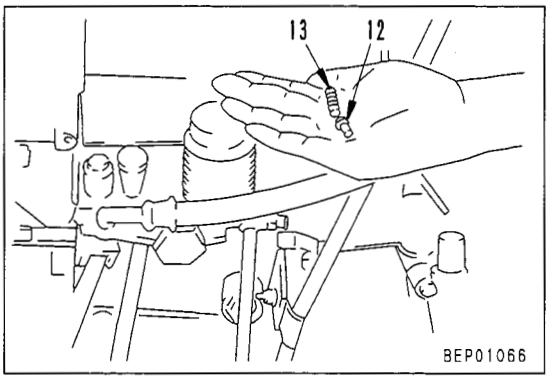
14. Move the fuel injection pump towards the outside, then move the injection pump towards the cylinder block a little at a time while operating the priming pump. Stop at the point where the fuel stops flowing from the delivery valve holder.
   - ★ Adjust the fuel injection timing by moving the fuel injection pump as follows.
     To RETARD timing, move towards OUTSIDE
     To ADVANCE timing, move towards CYLINDER BLOCK

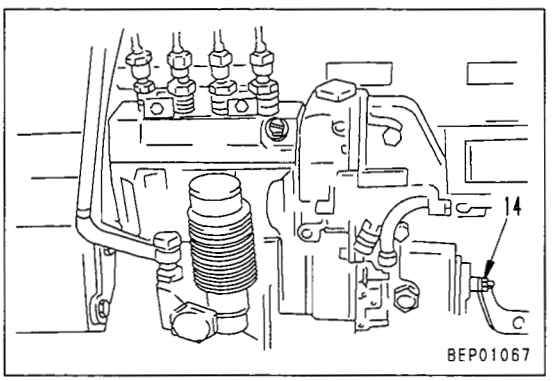
15. Tighten fuel injection pump mounting bolts (14) in turn.

16. Tighten the nut in the oblong hole of the injection pump mounting flange.









17. Rotate the crankshaft in the normal direction and check that the indicator of the dial gauge is at 0 ± 0.22 mm when the No. 1 cylinder is at top dead center (the point where the indicator of the dial gauge starts to turn in the reverse direction). If this dimension is not correct, carry out the operation again from Step 7.

18. Remove delivery valve holder (11), assemble delivery valve (12) and spring (13), then install delivery valve holder (11) again.
    ★ Replace the O-rings and copper gaskets of the delivery valve with new parts.
    ⚠ Tighten the delivery valve holder securely in 3 passes. (If the tightening is insufficient, it may cause the gasket to split.)
    kgm Delivery valve holder:
    32.4 ± 2.0 Nm {3.3 ± 0.2 kgm}

19. Connect fuel injection pipe (3).
    kgm Sleeve nut :
    23.5 ± 1.0 Nm {2.4 ± 0.1 kgm}

20. Install valve spring (7) and spring seat (6).

21. Compress the valve spring with spring pusher **M1** and install valve cotter (5).

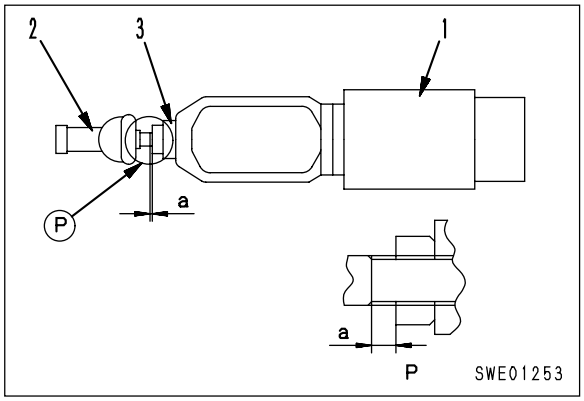
22. Assemble No. 1 cylinder intake rocker arm (4), then install snap ring (3).
    ★ Install the snap ring securely.

23. Install the cylinder head cover.
    kgm Cylinder head cover mounting bolt :
    8.8 ± 1.0 Nm {0.9 ± 0.1 kgm}

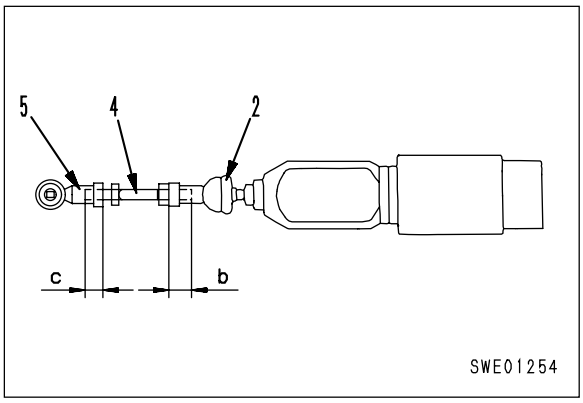
ADJUSTING FUEL CUT SOLENOID

4D95LE-2 (For PC60-7, PC75UU-3, PC78US-6, PC78UU-6)

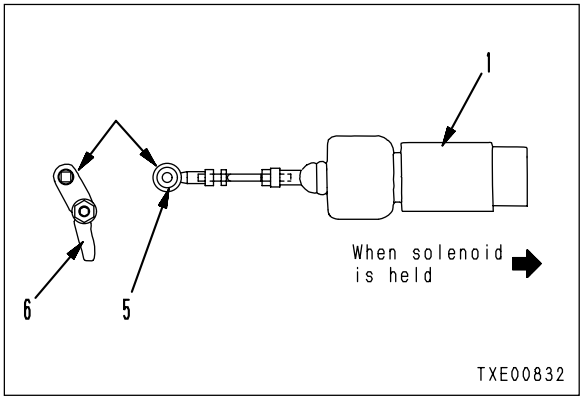
1. Install ball joint (2) to solenoid (1) and tighten locknut (3).
★ **a**: Approx. 1 mm (1 thread)



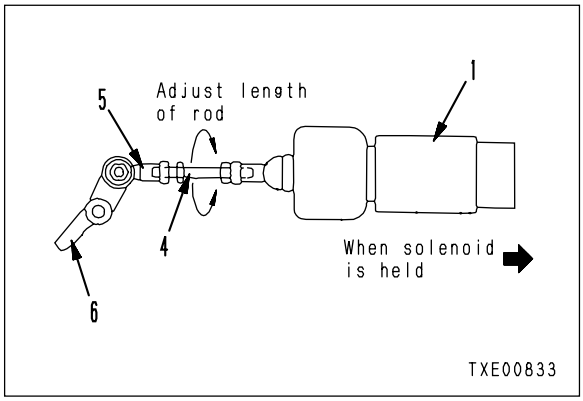
2. Assemble rod (4) and rod end (5) temporarily to ball joint (2).
★ Depth **b** for screwing rod into ball joint: Approx. 12.5 mm
★ Depth **c** for screwing rod end into rod: Approx. 10.0 mm



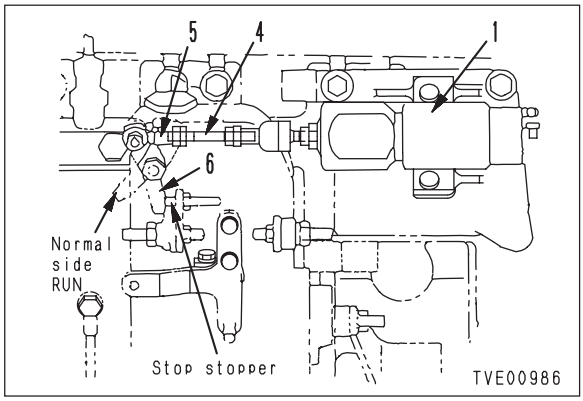
3. Pass electricity through solenoid (1) to make it attract.
★ When doing this, if rod end (5) and stop lever (6) of the fuel injection pump are connected before the solenoid is actuated, the solenoid will not be pulled away (the actuating current will continue to flow) when the solenoid is actuated, and the coil will burn out. To prevent this, do not connect the rod end and stop lever.

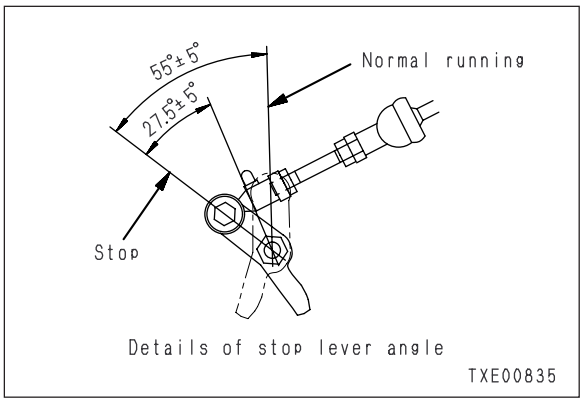


4. Check that solenoid (1) is attracted, then connect rod end (5) to stop lever (6), and adjust the length of rod (4) so that the stop lever contacts the end of the lever at the constant end.

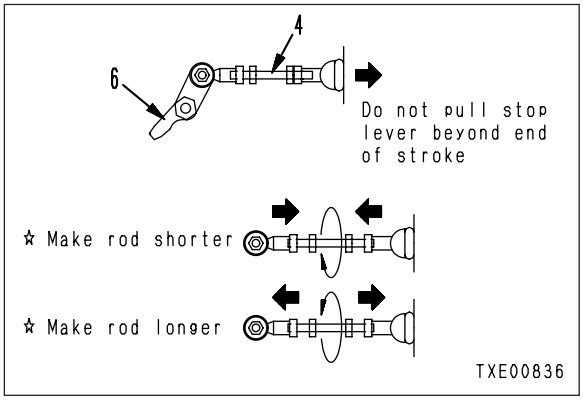


★ Stop lever (6) contacts the end of the lever at the constant end. (Contacts inside the injection pump)
★ Play: 0 mm

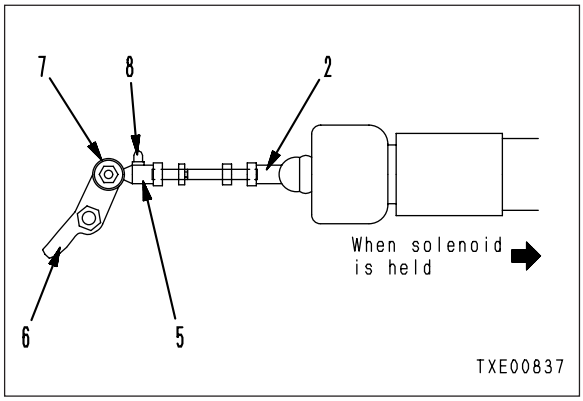




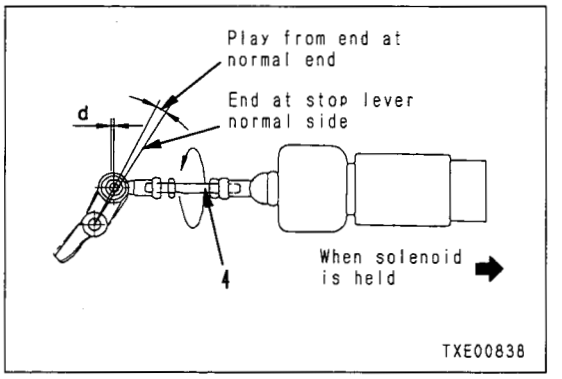
★ When adjusting the length of rod (4), do not apply any excessive force to pull stop lever (6) beyond the lever end.
★ The method for adjusting the rod length is as shown in the diagram on the right.



5. Tighten nut (7) at the connection of stop lever (6) and rod end (5), then install a split pin.
★ Install the rod end so that greasing port (8) is at the top.
Rod end: **Grease (G2-LI)**

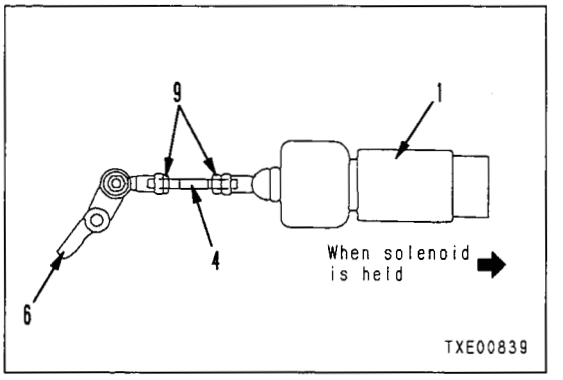


6. Make rod (4) longer to give play at the constant end of the stop lever.
   ★ Play **d**: 1.0 – 2.0 mm
   (loosen the rod 1/2 – 1 turn)



7. Tighten locknut (8).
   ★ When doing this, be careful that rod (4) does not turn together with locknut (9). Be careful also not to twist stop lever (6) with excessive force.

8. Start and stop the engine 2 or 3 times and check that solenoid (6) is actuated smoothly and that the engine stops.



FUEL INJECTION PUMP CALIBRATION DATA

Engine model	Pump assembly No.	Engine serial No.	Applicable machine	Page
4D95LE-2	6204-73-1340		PC60-7, PC75UU-3, BR100JG-2	12-14
	6204-73-1350		PC78US-6, PC78UU-6	12-15

Injection Pump Assembly Number
6204-73-1340 (101495-3411)

( ): Injection pump manufacturer's part No.

Injection Pump Type	Injection pump Manufacturer
PES-A	BOSCH

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
PC60-7 PC75UU-3 BR100JG-2	58001 and up 19001 and up 1301 and up	4D95LE-2	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 2 – 4 – 3
Injection interval	90° ± 30′
Plunger pre-stroke (mm)	3.2 ± 0.05
Delivery valve (mm³/st) retraction volume	51

Engine Specification

Flywheel horsepower (kW {HP}) / rpm)	42.1{56.5}/2,100 (Gross)
Maximum torque (Nm {kgm}/ rpm)	239{24.4}/1,500 (Gross)
High idling speed (rpm)	2,250 ± 60
Low idling speed (rpm)	$1{,}100^{+50}_{0}$

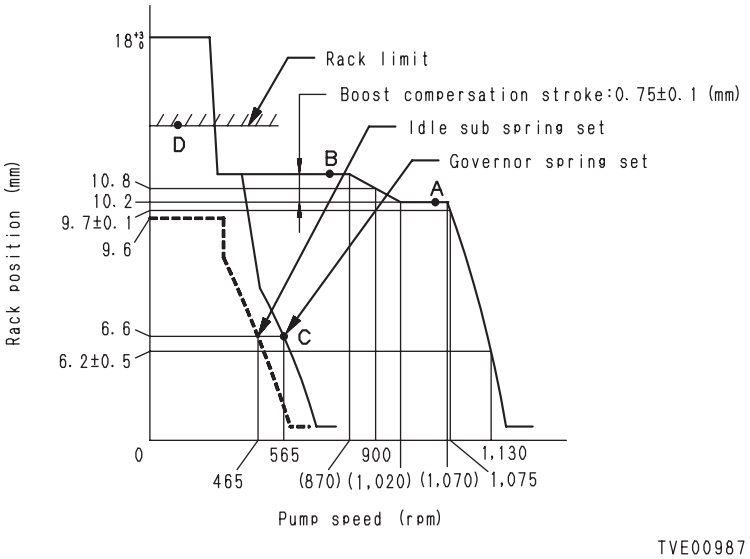
Pump tester capacity for Service standard	Motor 7.5 kW

Calibration Standard ( ): Injection pump manufacturer's part number

		Service standard	Manufacturer standard
Conditions ● **Service standard** indicates data using calibration test parts. ● **Manufacturer standard** is data for the engine on the machine.	Nozzle & nozzle holder part No.	(105780-8140)	6204-11-3100 (105118-6700)
	Nozzle part No.	(105780-0000)	6204-11-3120 (105017-2670)
	Nozzle holder part No.	(105780-2080)	6202-13-3110 (105048-3300)
	Injection pipe (mm) (Outside dia. x inside dia. x length)	6 x 2 x 600	6 x 1.6 x 600
	Test oil	ASTM D975 No. 2 diesel fuel or equivalent	
	Oil temperature (°C)	40 – 45	
	Nozzle opening pressure (MPa{kg/cm²})	17.2 {175}	19.6 {200}
	Transfer pump pressure (kPa{kg/cm²})	157 {1.60}	157 {1.6}

Injection volume ● **Rack positions** B to E are the reference volume when adjusting the injection volume. ● **Marks** ★ are average volumes.	Rack point	Rack position (mm)	Pump speed (rpm)	**Service standard** (cc/1000 st.)		**Manufacturer standard** (cc/1000 st.)	
				Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
	A (Basic point)	10.2	1,050	★56.0±1	±2.5	★48.4	
	B	10.95	750	★57.0±2	–	★62.0	
	C	approx. 6.6	565	★8.0±1	±15	★8.0	
	D		100	★60±5	–	★80	

Governor Performance Curve



TVE00987

Injection Pump Assembly Number

6204-73-1350 (101495-3460)

( ): Injection pump manufacturer's part No.

Injection Pump Type	Injection pump Manufacturer
PES-A	BOSCH

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
PC78US-6 PC78UU-6		4D95LE-2	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 2 – 4 – 3
Injection interval	90° ± 30′
Plunger pre-stroke (mm)	2.5 ± 0.05
Delivery valve (mm³/st) retraction volume	51

Engine Specification

Flywheel horsepower (kW {HP}) / rpm)	41.8{56}/1,850 (Gross)
Maximum torque (Nm {kgm}/ rpm)	229{23.4}/1,500 (Gross)
High idling speed (rpm)	2,050 ± 50
Low idling speed (rpm)	$1{,}150\ ^{+50}_{0}$

Pump tester capacity for Service standard	Motor 7.5 kW

Calibration Standard

( ): Injection pump manufacturer's part number

Conditions

- **Service standard** indicates data using calibration test parts.
- **Manufacturer standard** is data for the engine on the machine.

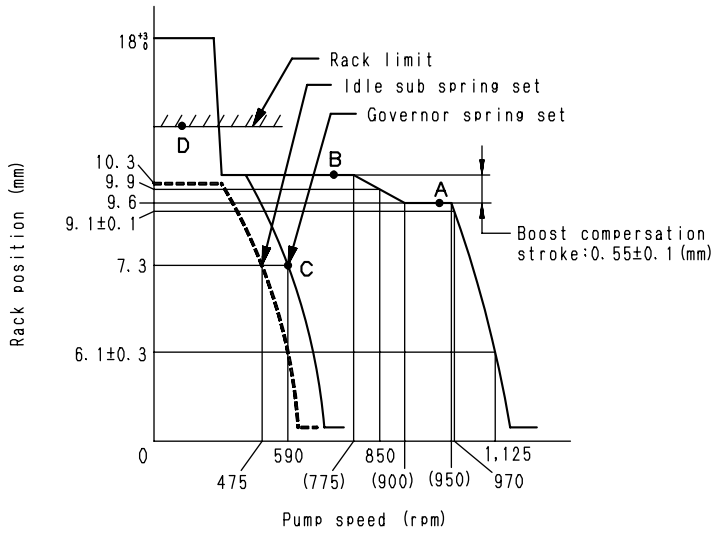
	Service standard	Manufacturer standard
Nozzle & nozzle holder part No.	(105780-8140)	6205-11-3100 (105118-6690)
Nozzle part No.	(105780-0000)	6205-11-3120 (105017-2660)
Nozzle holder part No.	(105780-2080)	6202-13-3110 (105048-3300)
Injection pipe (mm) (Outside dia. x inside dia. x length)	6 x 2 x 600	6 x 1.6 x 600
Test oil	ASTM D975 No. 2 diesel fuel or equivalent	
Oil temperature (°C)	40 – 50	
Nozzle opening pressure (MPa{kg/cm²})	17.2 {175}	19.6 {200}
Transfer pump pressure (kPa{kg/cm²})	157 {1.60}	157 {1.6}

Injection volume

- **Rack positions** B to E are the reference volume when adjusting the injection volume.
- **Marks** ★ are average volumes.

Rack point	Rack position (mm)	Pump speed (rpm)	**Service standard** (cc/1000 st.)		**Manufacturer standard** (cc/1000 st.)	
			Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
A (Basic point)	9.6	925	★42.4±1	±2.5	★52	
B	10.15	750	★44.3	–	★62.5	
C	approx. 7.3	590	★18±1	±15	★18	
D	–	100	★60±5	–	★80	

Governor Performance Curve



TVE00988

PERFORMANCE TEST

RUN-IN STANDARD

★ The table gives the standard values for machines without fan.
★ The loads for the dynamometer are at an arm's length of 716 mm.

Engine model	Applicable machine	Item		Order					
				1	2	3	4	5	6
4D95LE-2	PC60-7 PC75UU-3 BR100JG-2	Running time	min.	2	10	2	3		
		Engine speed	rpm	1,100 $^{+50}_{0}$	1,000	1,200	1,600		
		Load	N {kg}	0 {0}	98 {10}	147 {15}	245 {25}		
		Flywheel horsepower	kW {HP}	0 {0}	7 {10}	13 {18}	29 {39}		
	PC78US-6 PC78UU-6	Running time	min.	2	10	2	3		
		Engine speed	rpm	1,150 $^{+50}_{0}$	1,000	1,200	1,600		
		Load	N {kg}	0 {0}	98 {10}	147 {15}	245 {25}		
		Flywheel horsepower	kW {HP}	0 {0}	7.4 {9.8}	13.2 {17.7}	29.4 {39.4}		
		Running time	min.						
		Engine speed	rpm						
		Load	N {kg}						
		Flywheel horsepower	kW {HP}						
		Running time	min.						
		Engine speed	rpm						
		Load	N {kg}						
		Flywheel horsepower	kW {HP}						
		Running time	min.						
		Engine speed	rpm						
		Load	N {kg}						
		Flywheel horsepower	kW {HP}						

PERFORMANCE TEST CRITERIA

★ The table gives the standard values using the JIS compensator factor.
★ The values in the table are the standard values for machines with the muffler installed, air cleaner installed, alternator under no load, and air compressor open (if installed).
★ The loads for the dynamometer are at an arm's length of 716 mm.

Engine model	Applicable machine	Test item	Specified value	Engine speed (rpm)	Dynamometer Load (N{kg})
4D95LE-2	PC60-7 PC75UU-3 BR100JG-2	Flywheel horsepower	40 kW/2,100 rpm {54 HP/2,100 rpm}	2,100 ± 5	260 – 275 {26.5 – 28.0}
		Maximum torque	235 Nm/1,500 rpm {24 kgm/1,500 rpm}	1,500 ± 100	327 – 342 {33.3 – 34.9}
		High idling speed	2,250 ± 60 rpm	2,250 ± 60	—
		Low idling speed	$1{,}100\,^{+50}_{0}$ rpm	$1{,}100\,^{+50}_{0}$ rpm	—
	PC78US-6 PC78UU-6	Flywheel horsepower	40.1 kW/1,850 rpm(Net) {53.7 HP/1,850 rpm}(Net)	1,850 ± 5	286 – 316 {28.8 – 31.7}
		Maximum torque	Min. 226 Nm/1,500 rpm(Net) {Min. 23 kgm/1,500 rpm}(Net)	1,500 ± 100	321 – 343 {32.7 – 35.0}
		High idling speed	2,050 ± 50 rpm	—	—
		Low idling speed	$1{,}150\,^{+50}_{0}$ rpm	—	—
		Flywheel horsepower			
		Maximum torque			
		High idling speed			
		Low idling speed			
		Flywheel horsepower			
		Maximum torque			
		High idling speed			
		Low idling speed			
		Flywheel horsepower			
		Maximum torque			
		High idling speed			
		Low idling speed			
		Flywheel horsepower			
		Maximum torque			
		High idling speed			
		Low idling speed			

★ For fuel, use ASTM D975 No. 1 or No. 2.
★ For lubricant, use SAE15W-40 or SAE30 oil.

Flywheel horsepower (kW{HP})	Torque (kW{kgm})	Fuel consumption (sec/200cc)	Coolant temperature (°C)	Lubrication oil temperature (°C)	Lubrication oil pressure (MPa{kg/cm^2})	Exhaust temperature (°C)
40.9 – 43.4(Gross) {54.8 – 58.2}(Gross)	—	Min.	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	Max. 650
—	233 – 245 {23.8 – 25.0}	—	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	Max. 650
—	—	—	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	—
—	—	—	80 – 95	80 – 110	Min. 0.18 {1.8}	—
39.7 – 43.8(Gross) {53.2 – 58.8}(Gross)	—	Min.	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	Max. 650
—	229 – 246(Gross) {23.4 – 25.1}(Gross)	—	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	Max. 650
—	—	—	80 – 95	90 – 110	0.34 – 0.54 {3.5 – 5.0}	—
—	—	—	80 – 95	80 – 110	Min. 0.18 {1.8}	—

TROUBLESHOOTING

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.

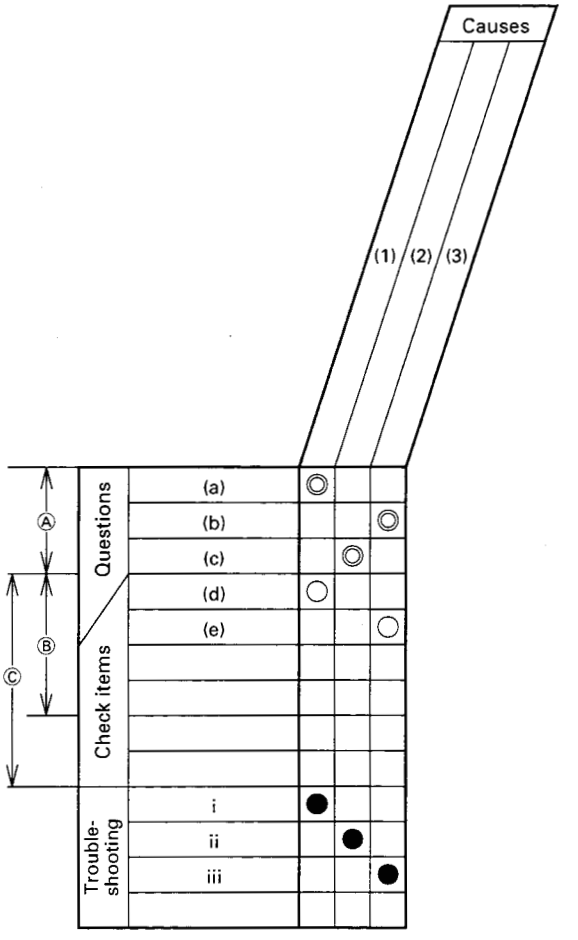
[Check items]

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]

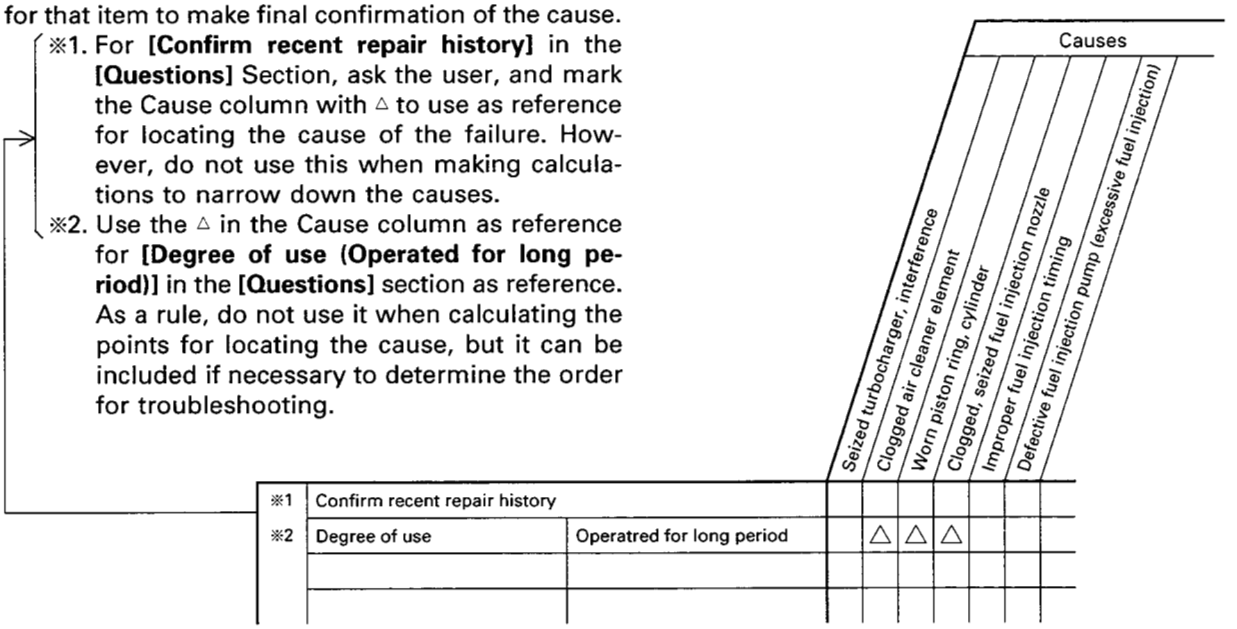
Troubleshooting is carried out in the order of probability, starting with the causes that have been marked as having the highest probability from information gained from **[Questions]** and **[Check items]**.



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.

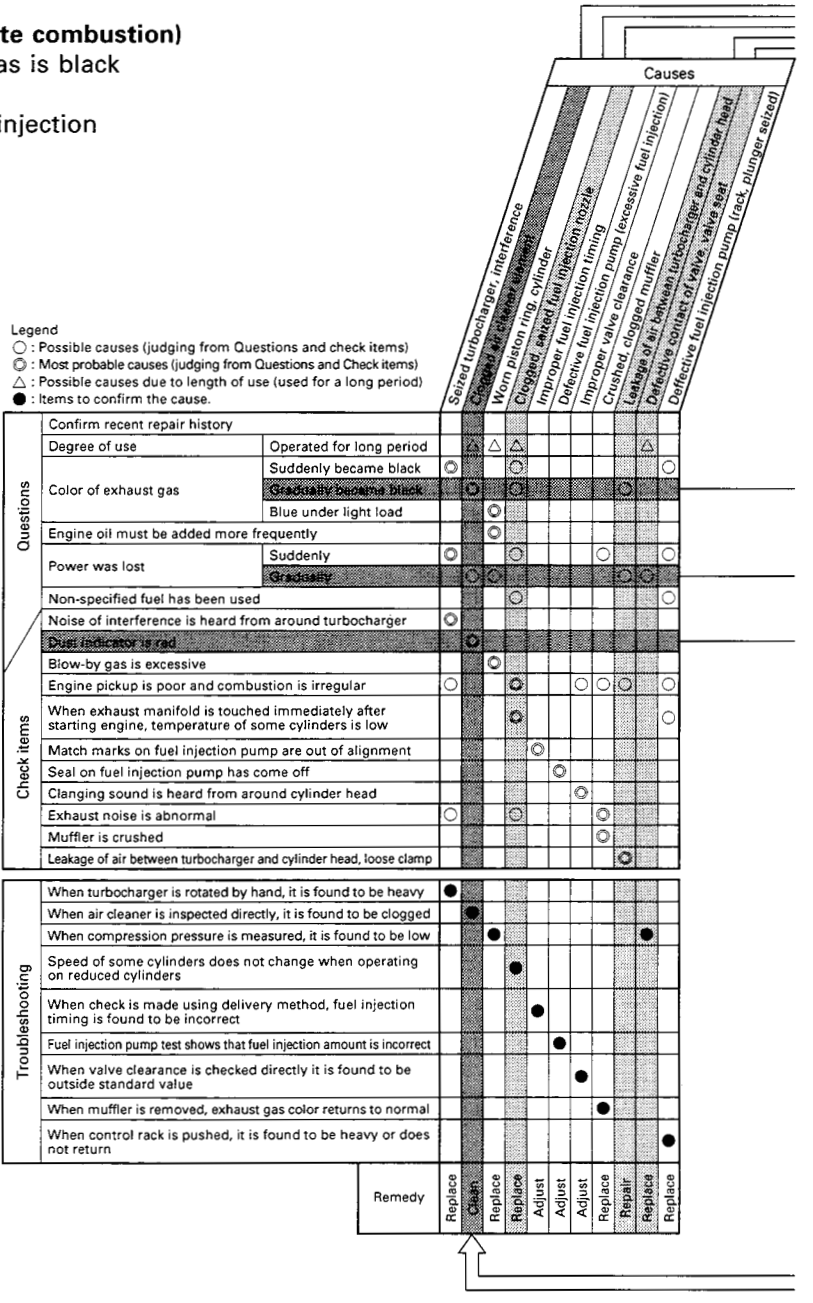
※1. For **[Confirm recent repair history]** in the **[Questions]** Section, ask the user, and mark the Cause column with △ to use as reference for locating the cause of the failure. However, do not use this when making calculations to narrow down the causes.

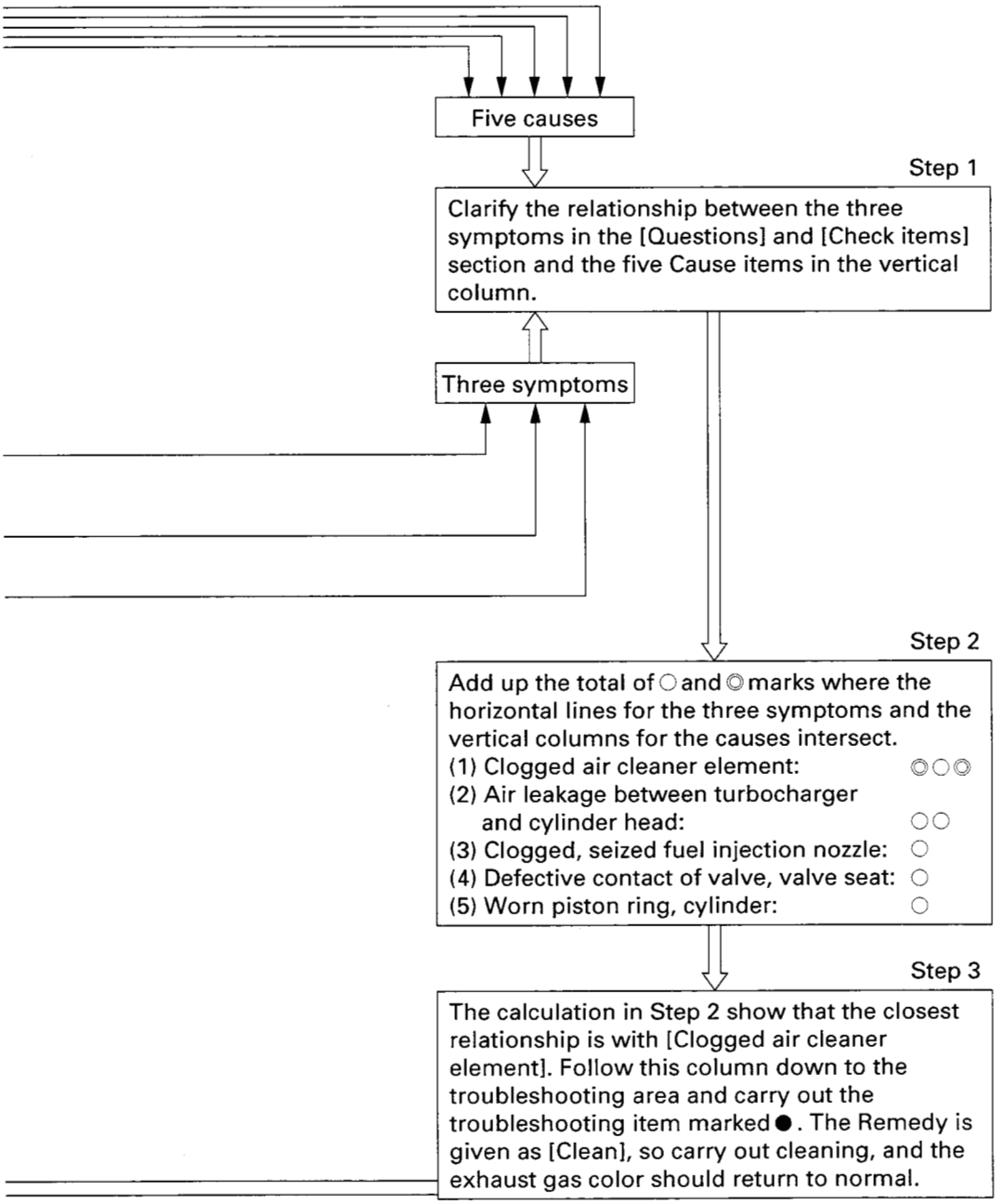
※2. Use the △ in the Cause column as reference for **[Degree of use (Operated for long period)]** in the **[Questions]** section as reference. As a rule, do not use it when calculating the points for locating the cause, but it can be included if necessary to determine the order for troubleshooting.



- **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 gas is black (incomplete combustion)
General causes why exhaust gas is black
- Insufficient intake of air
- Improper condition of fuel injection
- Excessive injection of fuel




Five causes
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.
Three symptoms
Step 2
Add up the total of ○ and ◎ marks where the horizontal lines for the three symptoms and the vertical columns for the causes intersect.
(1) Clogged air cleaner element: ◎○◎
(2) Air leakage between turbocharger and cylinder head: ○○
(3) Clogged, seized fuel injection nozzle: ○
(4) Defective contact of valve, valve seat: ○
(5) Worn piston ring, cylinder: ○
Step 3
The calculation in Step 2 show that the closest relationship is with [Clogged air cleaner element]. 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.

POINTS TO REMEMBER WHEN TROUBLESHOOTING

Troubleshooting means locating the basic cause of the failure, and carrying out swift repairs, and ensuring that the failure does not occur again.
When carrying out troubleshooting, it is of course important to understand the structure and function. But to carry out the troubleshooting effectively, a quick method is to carry out troubleshooting using the problems mentioned by the operator as a guide in locating the cause.

1. **Do not disassemble the machine simply because there is a failure**
   If the machine is disassembled immediately just because there is a failure:
   - Unrelated or unnecessary places are also disassembled
   - It becomes difficult to locate the cause of the failure

   This means that there is not only a waste of time and money on replacement parts, oil, and grease, but this action will also lose the confidence of the user and operator.
   For this reason also, it is important to carry out troubleshooting based on full investigation before starting and troubleshooting following before the correct order.

2. **Questions to ask the user and operator**
   1) Are there any problems other than those already reported?
   2) Did anything unusual happen before the failure occurred?
   3) Did the failure occur suddenly, or had the condition of the machine been poor before the failure occurred?
   4) What were the conditions when the failure occurred?
   5) Had any repairs been carried out before the failure occurred?
   6) Had any similar failure occurred before?

3. **Check before troubleshooting**
   1) Check the oil level.
   2) Check for any external leakage of oil from the piping and hydraulic equipment.
   3) Check the travel of the control levers.
   4) Other maintenance items can also be carried out visually, so carry out any check that is considered necessary.

4. **Confirming failure**
   Check the degree of the problem to judge for yourself if it is really a failure, or if there is some problem in the handling or operation of the machine.
   ★ When driving the machine and re-enacting the failure, be sure that the investigation or measurement does not make the failure worse.

5. **Troubleshooting**
   Narrow down the cause of the failure from the results of the questions and checks in the above Items 2 – 4, then follow the troubleshooting flow charts to locate the failure.
   ★ Basic procedure for troubleshooting
      1) Start from the simple places.
      2) Start from the most probable places.
      3) Investigate related parts also.

6. **Basic action to remedy 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, it is necessary to investigate why the failure occurred, and to remove the root cause of the failure.

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

★ Check that the monitor panel does not display any abnormality in the governor control system.
General causes why exhaust smoke comes out but engine takes time to start
- Defective electrical system
- Insufficient supply of fuel
- Insufficient intake of air
- Improper selection of fuel
(At ambient temperature of 10˚C or below, use ASTM D975 No. 1)

★ Battery charging rate

Ambient temperature \ Charging rate	100%	90%	80%	75%	70%
20°C	1.28	1.26	1.24	1.23	1.22
0°C	1.29	1.27	1.25	1.24	1.23
–10°C	1.30	1.28	1.26	1.25	1.24

- The specific gravity should exceed the value for the charging rate of 70% in the above table.
- In cold areas the specific gravity must exceed the value for the charging rate of 75% in the above table.

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: Worn piston ring, cylinder	Defective contact of valve, valve seat	Clogged air cleaner element	Clogged fuel filter, strainer	Clogged feed pump strainer	Electrical intake air heater	Glow plug	Defective regulator	Auxiliary starting system	Defective alternator	Defective or deteriorated battery	Defective fuel injection nozzle	Leakage, clogging, air in fuel piping	Defective fuel injection timing	Leakage, clogging, pump (rack, plunger stuck)	Clogged air breather hole in fuel tank cap
Questions	Confirm recent repair history																	
	Degree of use of machine	Operated for long period			△	△	△				△							
	Ease of starting	Gradually became worse	◎	◎	○	○	○											
		Starts when warm						◎	◎		◎							
	Indicator lamp does not light up							◎	◎									
	Engine oil must be added more frequently		◎															
	Replacement of filters has not been carried out according to Operation Manual				◎	◎	◎					○		○				
	Non-specified fuel is being used					○	○					○		○				
Check items	Dust indicator is red				◎													
	Battery charge lamp is ON									◎	◎							
	Starting motor cranks engine slowly										◎							
	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		○	○								◎						
	Blow-by gas is excessive		◎															
	Match marks on fuel injection pump are out of alignment												◎					
	Mud is stuck to fuel tank cap																	○
	When engine is cranked with starting motor, 1) Little fuel comes out even when fuel injection pipe sleeve nut is loosened													◎				
	2) Little fuel comes out even when fuel filter air bleed plug is loosened				◎	◎								◎				
	Leakage from fuel piping													○	◎			
	There is hunting from engine (rotation is irregular)				○	○									◎			○
Troubleshooting	When compression pressure is measured, it is found to be low		●	●														
	When air cleaner element is inspected directly, it is found to be clogged				●													
	When fuel filter, strainer are inspected directly, they are found to be clogged					●										●		
	When feed pump strainer is inspected directly, it is found to be clogged						●											
	Glow plug mount does not become warm							●	●									
	Is voltage 26 – 30V between alternator terminal B and terminal E with engine at low idling?	Yes								●								
		No									●							
	Either specific gravity of electrolyte or voltage of battery is low											●						
	Speed does not change when operation of certain cylinders is stopped												●					
	When check is made using delivery method, injection timing is found to be incorrect													●				
	When control rack is pushed, it is found to be heavy or does not return (when blind cover at rear of pump is removed, it can be seen that plunger control sleeve does not move)														●			
	When fuel cap is inspected directly, it is found to be clogged																	●
	Remedy		Replace	Correct	Clean	Clean	Clean	Replace	Replace	Replace	Replace	Replace	Adjust	Replace	Correct	Clean		

S-2 Engine does not start

(1) Engine does not turn

General causes why engine does not turn
- Internal parts of engine seized
  - ★ If internal parts of the engine are seized, carry out troubleshooting for "Engine stops during operations".
- Failure in power train
- Defective electrical system

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: Defective wiring of starting circuit	Defective or deteriorated battery	Defective starting motor	Broken ring gear	Defective safety relay or safety switch	Defectinve battery relay	Defective battery terminal connection	Defective fuel cut solenoid	Defective adjustment of engine stop motor wire	Defective engine stop motor	Defective starting switch
Questions	Confirm recent repair history												
	Degree of use	Operated for long period		△		△							
	Condition of horn when starting switch is turned ON	Horn does not sound	◎					○					○
		Horn sound level is low		◎									
	When starting switch is turned to START, pinion moves out, but	Roaing speed is slow		◎									
		Makes grating noise			◎	◎							
		Soon disengages again					◎						
		Makes rattling noise and does not turn		○	○		○						
Check items	When starting switch is turned to START, pinion does not move out		◎	○									○
	When starting switch is turned to ON, there is no clicking sound			○				◎					
	Battery terminal is loose								◎				
	When starting switch is turned to ON, linkage dose not move									◎	◎	◎	
	When battery is checked, battery electrolyte is found to be low			◎									
Troubleshooting	Specific gravity of electrolyte, voltage of battery is low			●									
	For the following conditions 1) – 5), turn the starting switch OFF, connect the cord, and carry out troubleshooting at ON												●
	1) When terminal B and terminal C of starting switch are connected, engine starts												
	2) When terminal B and terminal C of starting motor are connected, engine starts				●								
	3) When terminal B and terminal C of safety relay are connected, engine starts						●						
	4) When terminal of safety switch and terminal B of starting motor are connected, engine starts						●						
	5) There is no 24V voltage between battery relay terminal b and terminal E							●					
	When ring gear is inspected directly, tooth surface is found to be chipped				●								
	Does not move even when fuel cut solenoid linkage is disconnected								●				
	Does not move even when engine stop motor linkage is disconnected										●	●	
		Remedy	—	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Adjust	Replace	Replace

Carry out troubleshooting for defective wiring of starting circuit

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

General causes why engine turns but no exhaust smoke comes out
- Supply of fuel impossible
- Supply of fuel is extremely small
- Improper selection of fuel (particularly in winter)

★ Standards for use of fuel

Type of fuel	Ambient temprature
	–22 –4 14 32 50 68 86 104°F –30 –20 –10 0 10 20 30 40°C
Diesel fuel	ASTM D975 No.2 ASTM D975 No.1

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: Broken fuel injection pump drive shaft, key	Defective fuel injection pump (rack, plunger seized)	Seized, broken feed pump piston	Clogged fuel filter, strainer	Clogged feed pump strainer	Lack of fuel	Clogged, leaking fuel piping	Clogged fuel tank air breather hole	Defective fuel cut solenoid	Defective engine stop motor	Improper fuel used
Questions	Confirm recent repair history											
	Degree of use — Operated for long period				△	△			△			
	Exhaust smoke suddenly stops coming out (when starting again)	◎	◎	◎								
	Replacement of filters has not been carried out according to operation manual				◎	◎						
Check items	Fuel tank is found to be empty						◎					
	There is leakage from fuel piping							◎				
	Mud is stuck to fuel tank cap								◎			
	When starting switch is turned ON, linkage does not move									◎	◎	
	When fuel filter is drained, fuel does not come out											◎
	When engine is cranked with starting motor, 1) Fuel injection pump coupling does not rotate	◎										
	2) No fuel comes out even when fuel filter air bleed plug is loosened	◎			○	○						○
	3) No fuel spurts out even when fuel injection pipe sleeve nut is loosened	◎	◎	◎								
	Rust and water are found when fuel tank is drained				○	○						
Troubleshooting	Check fuel injection pump directly	●										
	When control rack is pushed, it is found to be heavy, or does not return		●									
	Check feed pump directly			●								
	When fuel filter, strainer are inspected directly, they are found to be clogged				●							●
	When feed pump strainer is inspected directly, it is found to be clogged					●						
	When fuel cap is inspected directly, it is found to be clogged							●				
	Does not move even when fuel cut solenoid linkage is disconnected								●			
	Does not move even when engine stop motor linkage is disconnected									●		
	Remedy	Replace	Replace	Replace	Clean	Clean	Add	Repair	Repair	Replace	Replace	Replace

(3) 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

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												
		Defective, broken valve system (valve, rocker lever, etc.)	Defective fuel injection pump (rack, plunger stuck)	Worn piston ring, cylinder liner	Clogged fuel filter, strainer	Clogged feed pump strainer	Clogged air cleaner element	Electrical intake air heater	Glow plug	Defective or deteriorated battery	Auxiliary starting system: Leakage, clogging, air in fuel system	Clogged fuel injection nozzle, defective spray	Clogged air breather hole in fuel tank cap	Improper fuel used
Questions	Confirm recent repair history													
	Degree of use of machine — Operated for long period			△	△	△					△			
	Suddenly failed to start	◎	◎											
	When engine is cranked, abnormal noise is heard from around cylinder head	◎												
	Engine oil must be added more frequently			◎										
	Non-specified fuel is being used		○									○		
	Replacement of filters has not been carried out according to Operation Manual				◎	◎	◎							
	Rust and water are found when fuel tank is drained						◎							
Check items	Dust indicator is red				◎	◎								
	Indicator lamp does not light up							◎	◎					
	Starting motor cranks engine slowly									◎				
	Mud is stuck to fuel tank cap												○	
	When fuel lever is placed at FULL position, it does not contact stopper		○											
	When engine is cranked with starting motor, 1) Little fuel comes out even when fuel injection pipe sleeve nut is loosened		◎											
	2) Little fuel comes out even when fuel filter air bleed plug is loosened				◎	◎								○
	There is leakage from fuel piping									◎				
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low										◎			
	When fuel filter is drained, no fuel comes out													◎
Troubleshooting	Remove head cover and check directly	●												
	When control rack is pushed, it is found to be heavy, or does not return		●											
	When compression pressure is measured, it is found to be low			●										
	When fuel filter, strainer are inspected directly, they are found to be clogged				●									●
	When feed pump strainer is inspected directly, it is found to be clogged					●								
	When air cleaner element is inspected directly, it is found to be clogged						●							
	Glow plug mount does not become warm							●	●					
	Either specific gravity of electrolyte or voltage of battery is low									●				
	When feed pump is operated, operation is too light or too heavy										●			
	Speed does not change when operation of certain cylinders is stopped											●		
	When fuel cap is inspected directly, it is found to be clogged												●	
	Remedy	Replace	Replace	Replace	Clean	Clean	Clean	Replace	Replace	Replace	Correct	Clean	Clean	Replace

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

★ Check that the monitor panel does not display any abnormality in the governor control system.

General causes why engine does not pick up smoothly

- Insufficient intake of air
- Insufficient supply of fuel
- Improper condition of fuel injection
- Improper fuel used

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	Clogged fuel filter, strainer	Clogged feed pump strainer	Clogged injection nozzle, defective spray	Seized injection pump plunger	Worn piston ring, cylinder liner	Seized turbocharger, interference	Improper valve clearance	Clogged air breather hole in fuel tank cap	Clogged, leaking fuel piping	Defective contact of valve and valve seat
Questions	Confirm recent repair history												
	Degree of use of machine	Operated for long period	△	△	△			△					△
	Replacement of filters has not been carried out according to Operation Manual		◎	◎	◎								
	Non-specified fuel is being used			◎	◎	◎	◎						
	Engine oil must be added more frequently							◎					
	Rust and water are found when fuel tank is drained			◎	◎								
	Dust indicator is red		◎										
	Noise of interference is heard from around turbocharger								◎				
	Engine pick-up suddenly became poor					◯			◎		◯	◯	
	Color of exhaust gas	Blue under light load						◎					
		Black	◎			◎			◎				◯
	Clanging sound is heard from around cylinder head									◎			
	Mud is stuck to fuel tank cap										◎		
	There is leakage from fuel piping											◎	
	High idling speed is normal, but speed suddenly drops when load is applied			◎	◎						◯		
	There is hunting from engine (rotation is irregular)			◯	◎	◯					◯		
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low					◎	◯						
	Blow-by gas is excessive							◎					
Troubleshooting	When air cleaner element is inspected directly, it is found to be clogged		●										
	When fuel filter, strainer are inspected directly, they are found to be clogged			●									
	When feed pump strainer is inspected directly, it is found to be clogged				●								
	Speed does not change when operation of certain cylinders is stopped					●							
	When control rack is pushed, it is found to be heavy, or does not return						●						
	When compression pressure is measured, it is found to be low							●					●
	When turbocharger is rotated by hand, it is found to be heavy								●				
	When valve clearance is checked directly, it is found to be outside standard value									●			
	When fuel cap is inspected directly, it is found to be clogged										●		
	When feed pump is operated, operation is too light or too heavy											●	
		Remedy	Clean	Clean	Clean	Correct	Replace	Replace	Replace	Adjust	Clean	Correct	Replace

S-4 Engine stops during operations

General causes why engine stops during operations

- Seized parts inside engine
- Insufficient supply of fuel
- Overheating
  - ★ If there is overheating and insufficient output, carry out troubleshooting for overheating.
- Failure in power train
  - ★ If the engine stops because of a failure in the power train, carry out troubleshooting for the chassis.

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: Broken, seized piston, connecting rod	Broken, seized crankshaft bearing	Broken valve system (valve, rocker lever, etc.)	Broken, seized gear train	Broken pump auxiliary equipment	Broken fuel injection pump drive shaft, key	Lack of fuel	Clogged fuel filter, strainer	Clogged feed pump strainer	Broken, seized feed pump piston	Clogged, leaking fuel piping	Clogged fuel tank air breather hole	Defective injection pump (rack, plunger stuck)	Failure in chassis power train
Questions	Confirm recent repair history															
	Degree of use	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							◎	○	○	○		○		
	Replacement of filters has not been carried out according to operation manual									◎	◎					
	Non-specified fuel is being used									○	○	○			○	
Check items	Fuel gauge lamp lights up								◎							
	Fuel tank is found to be empty								◎							
	When feed pump is operated, there is no response or it is heavy									○	○		◎			
	Mud is stuck to fuel tank cap													◎		
	Engine turns, but stops when transmission control lever is operated															◎
	Try to turn by hand using barring tool	Does not turn at all	◎	◎												
		Turns in opposite direction			◎											
		Moves amount of backlash				◎	◎									
		Shaft does not turn						◎								
	Rust and water are found when fuel is drained								◎	◎						
	Metal particles are found when oil is drained		◎	◎					○	○						
Troubleshooting	Remove oil pan and check directly		●	●												
	Remove head cover and check directly				●											
	When gear train is inspected, it does not turn					●										
	Turns when pump auxiliary equipment is removed						●									
	When fuel filter, strainer are inspected directly, they are found to be clogged								●							
	When feed pump strainer is inspected directly, it is found to be clogged									●						
	Check feed pump directly										●					
	When control rack is pushed, it is found to be heavy or does not return													●		
		Remedy	Replace	Replace	Replace	Replace	Replace	Replace	Add	Clean	Clean	Replace	Repair	Clean	Replace	—

Carry out troubleshooting in chassis volume

S-5 Engine does not rotate smoothly (hunting)

General causes why engine does not rotate smoothly

- Air in fuel system
- Defective governor mechanism
- Defective electric governor mechanism
  - ★ If hunting does not occur when the rod between the governor motor and the injection pump is disconnected, troubleshoot by using the electrical system troubleshooting (E mode).

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: Defective operation of governor	Defective adjustment of governor	Defective operation of control rack	Low idling speed is too low	Lack of fuel	Clogged feed pump strainer	Clogged fuel filter, strainer	Clogged, air in circuit between fuel tank and feed pump	Clogged, air in circuit between feed pump and fuel injection nozzle	Clogged air breather hole in fuel tank cap
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					◎					
	Replacement of filters has not been carried out according to Operation Manual							◎	◎			
Check items	Fuel tank is found to be empty						◎					
	Rust, water are found when fuel tank is drained							◯	◯			
	Leakage from fuel piping									◎	◎	
	When feed pump is operated,											
	1) No response, light, return is quick									◎	◎	
	2) No response, light, return is normal									◎		
	Engine speed sometimes rises too far		◎	◎								
	Engine is sometimes difficult to stop		◎		◎							
	Seal on injection pump has come off			◎		◎						
Troubleshooting	When governor lever is moved it is found to be stiff		●		●							
	When injection pump is tested, governor is found to be improperly adjusted			●								
	When control rack is pushed, it is found to be heavy, or does not return				●							
	When fuel cap is inspected directly, it is found to be clogged					●						●
	When feed pump strainer is inspected directly, it is found to be clogged						●					
	When fuel filter, strainer are inspected directly, they are found to be clogged							●				
		Remedy	Adjust	Adjust	Adjust	Adjust	Add	Clean	Clean	Correct	Correct	Clean

S-6 Engine lacks output (no power)

General causes why engine lacks output
- Insufficient intake of air
- Insufficient supply of fuel
- Improper condition of fuel injection
- Improper fuel used
  (if non-specified fuel is used, output drops)
- Lack of output due to overheating
  ★ If there is overheating and insufficient output, carry out troubleshooting for overheating.

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	Worn piston ring, cylinder liner	Clogged fuel filter, strainer	Clogged feed pump strainer	Seized fuel injection nozzle, defective spray	Improper valve clearance	Defective contact of valve and valve seat	Bent fuel control linkage, defective adjustment	Clogged, leaking fuel piping	Clogged air breather hole in fuel tank cap
Questions	Confirm recent repair history												
	Degree of use of machine	Operated for long period	△		△	△	△			△			
	Power was lost	Suddenly		◎									
		Gradually	○		○	○	○	○		○			
	Engine oil must be added more frequently				◎								
	Replacement of filters has not been carried out according to Operation Manual		◎			◎	◎						
	Non-specified fuel is being used					◎	◎	◎	◎				
Check items	Dust indicator is red		◎										
	Color of exhaust gas	Black	◎	◎									
		Blue under light load			◎								
	Noise of interference is heard from around turbocharger			◎									
	Blow-by gas is excessive				◎								
	Engine pickup is poor and combustion is irregular			◎				◎				○	○
	High idling speed is normal, but speed suddenly drops when load is applied					◎	◎						○
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low							◎	○				
	There is hunting from engine (rotation is irregular)					○	○					○	○
	Clanging sound is heard from around cylinder head								◎				
	High idling speed of engine is low							○			◎		
	Leakage from fuel piping											◎	
Troubleshooting	When air cleaner element is inspected directly, it is found to be clogged		●										
	When turbocharger is rotated by hand, it is found to be heavy			●									
	When compression pressure is measured, it is found to be low				●					●			
	When fuel filter, strainer are inspected directly, they are found to be clogged					●							
	When feed pump strainer is inspected directly, it is found to be clogged						●						
	Speed does not change when operation of certain cylinders is stopped							●					
	When control rack is pushed, it is found to be heavy, or does not return								●				
	When valve clearance is checked directly, it is found to be outside standard value									●			
	When lever is placed at FULL position, it does not contact stopper										●		
	When feed pump is operated, operation is too light or too heavy											●	
	When fuel cap is inspected directly, it is found to be clogged												●
		Remedy	Clean	Replace	Replace	Clean	Clean	Correct	Replace	Adjust	Replace	Adjust	Correct	Clean

S-7 Exhaust smoke is black (incomplete combustion)

General causes why exhaust smoke is black
- Insufficient intake of air
- Improper 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: Seized turbocharger, interference	Clogged air cleaner element	Worn piston ring, cylinder liner	Clogged fuel injection nozzle, defective spray	Improper fuel injection timing	Defective fuel injection pump (excessive injection)	Improper valve clearance	Crushed, clogged muffler	Leakage of air between turbocharger and cylinder head	Defective contact of valve and valve seat	Defective injection pump (rack, plunger seized)
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			◎								
	Engine oil must be added more frequently				◎								
	Power was lost	Suddenly	◎						◯				◯
		Gradually		◯	◯						◯	◯	
	Non-specified fuel is being used					◯							◯
	Noise of interference is heard from around turbocharger		◎										
Check items	Dust indicator is red			◎									
	Blow-by gas is excessive				◎								
	Engine pickup is poor and combustion is irregular		◯			◎			◯	◯	◯		◯
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low					◎							◯
	Match marks on fuel injection pump are out of alignment						◎						
	Seal on fuel injection pump has come off							◎					
	Clanging sound is heard from around cylinder head								◎				
	Exhaust noise is abnormal		◯			◯				◎			
	Muffler is crushed									◎			
	Leakage of air between turbocharger and cylinder head, loose clamp										◎		
Troubleshooting	When turbocharger is rotated by hand, it is found to be heavy		●										
	When air cleaner is inspected directly, it is found to be clogged			●									
	When compression pressure is measured, it is found to be low				●							●	
	Speed does not change when operation of certain cylinders is stopped					●							
	When check is made using delivery method, injection timing is found to be incorrect						●						
	Fuel injection pump test shows that fuel injection amount is incorrect							●					
	When valve clearance is checked directly it is found to be outside standard value								●				
	When muffler is removed, exhaust color returns to normal									●			
	When control rack is pushed, it is found to be heavy, or does not return												●
		Remedy	Replace	Clean	Replace	Replace	Adjust	Adjust	Adjust	Replace	Correct	Replace	Replace

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

★ 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 lubrication system

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: Broken piston ring	Worn piston ring, cylinder liner	Clogged breather or breather hose	Leakage from oil filter or oil cooler	Leakage from oil piping	Leakage from oil drain plug	Leakage from oil pan or cylinder head	Broken oil cooler	Turbocharger: Worn seal at turbine end	Turbocharger: Worn seal at blower end	Turbocharger: Worn, broken rear seal, seal surface	Dust sucked in from intake system	Worn valve (stem, guide), broken seal
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			◎					◯						
	Engine oil becomes contaminated quickly		◯	◎	◯										
	Exhaust smoke is blue under light load		◎	◎											
Check items	Amount of blow-by gas	Excessive	◎	◎							◯				◯
		None			◎										
	Area around engine is dirty with oil					◎	◎	◎	◎						
	There is oil in engine cooling water								◎						
	When exhaust pipe is removed, inside is found to be dirty with oil									◎					◯
	When turbocharger air supply pipe is removed, inside is found to be dirty with oil										◎				
	Oil level in clutch or TORQFLOW transmission damper chamber rises											◎			
	Clamps for intake system are loose												◎		
Check items	When compression pressure is measured, it is found to be low		●	●											
	When breather element is inspected, it is found to be clogged with dirty oil				●										
	There is external leakage of oil from engine					●	●	●	●						
	Pressure-tightness test of oil cooler shows there is leakage									●					
	Excessive play of turbocharger shaft										●	●			
	Inspect rear seal directly												●		
	When intake manifold is removed, dust is found inside													●	
	When intake manifold is removed, inside is found to be dirty with oil														●
	Remedy		Replace	Replace	Clean	Correct	Correct	Correct	Correct	Replace	Replace	Replace	Correct	Correct	Correct

S-9 Oil becomes contaminated quickly

General causes why oil becomes contaminated quickly

- Intake of exhaust gas due to internal wear
- Clogging of lubrication passage
- Improper fuel
- Improper oil used
- Operation under excessive load

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: Worn piston ring, cylinder liner	Clogged breather, breather hose	Clogged oil filter	Worn valve, valve guide	Clogged oil cooler	Clogged turbocharger drain tube	Defective seal at turbocharger turbine end	Defective safety valve	Exhaust smoke is black
Questions	Confirm recent repair history										
	Degree of use of machine	Operated for long period	△			△			△		
	Engine oil must be added more frequently		◎								
	Non-specified oil is being used				◯						
Check items	Color of exhaust gas	Blue under light load	◎								
		Black									◎
	Amount of blow-by gas	Excessive	◎			◯		◯	◯		
		None		◎							
	Oil filter caution lamp stays on even when oil pressure rises			◎						◯	
	When oil filter is inspected, metal particles are found		◯		◎	◯					
	When exhaust pipe is removed, inside is found to be dirty with oil					◎					
	Engine oil temperature rises quickly						◎				
Troubleshooting	When compression pressure is measured, it is found to be low		●			●					
	When breather element is inspected directly, hose is broken or is found to be clogged with dirty oil			●							
	When oil filter is inspected directly, it is found to be clogged				●						
	When oil cooler is inspected directly, it is found to be clogged						●				
	Turbocharger drain tube is clogged							●			
	Excessive play of turbocharger shaft								●		
	When safety valve is directly inspected, spring is found to be catching or broken									●	
		Remedy	Replace	Clean	Replace	Replace	Clean	Clean	Replace	Replace	—

Carry out troubleshooting for "Exhaust smoke is black".

S-10 Fuel consumption is excessive

General causes why fuel consumption is excessive

- Leakage of fuel
- Improper 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: Defective fuel injection pump (excessive injection)	Defective fuel injection nozzle spray	Defective fuel injection pump plunger	Defective fuel injection timing	External leakage from fuel piping, fuel filter	Leakage of fuel inside head cover	Defective oil seal inside feed pump (piston)	Defective adjustment of fuel control linkage
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					◯	◯		
	Exhaust smoke color	Black	◎	◯		◯				◯
		White						◯		
Check items	Seal on fuel injection pump has come off		◎							
	There is irregular combustion			◎						
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low			◎	◯					
	Match mark on fuel injection pump is misaligned					◎				
	There is external leakage of fuel from engine						◎			
	Engine oil level rises and smells of diesel fuel		◯					◎	◎	
	Engine low idling speed is high		◯							◎
Troubleshooting	Fuel injection pump measurement shows that fuel injection amount is excessive		●							
	Speed does not change when operation of certain cylinders is stopped			●						
	When control rack is pushed, it is found to be heavy, or does not return				●					
	When check is made using delivery method, fuel injection timing is found to be incorrect					●				
	Remove head cover and inspect directly							●		
	Remove feed pump and inspect directly								●	
	When engine speed is measured, low idling speed is found to be high									●
	Remedy		Adjust	Replace	Replace	Adjust	Correct	Correct	Correct	Adjust

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

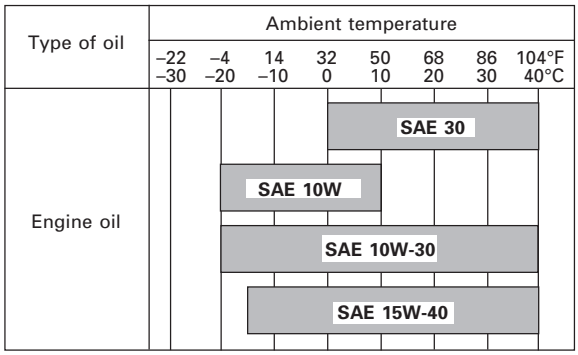
Legend
◯ : Possible causes (judging from Questions and check items)
◎ : Most probable causes (judging from Questions and Check items)
△ : Possible causes due to length of use (used for a long period)
● : Items to confirm the cause.

			Causes: Broken oil cooler core, O-ring	Broken cylinder head, head gasket	Insufficient protrusion of liner	Broken oil cooler for power train	Broken liner O-ring, holes caused by pitting	Internal cracks in cylinder block
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		◯				◯	
Check items	Engine oil level has risen, oil is cloudy white		◎				◯	◯
	Excessive air bubbles inside radiator, spurts back			◎	◎			
	Hydraulic oil, torque converter, transmission oil is cloudy white					◎		
	When hydraulic oil, torque converter, transmission oil is drained, water is found					◎		
Troubleshooting	Pressure-tightness test of oil cooler shows there is leakage		●			●		
	Pressure-tightness test of cylinder head shows there is leakage			●				
	Remove cylinder head and inspect directly				●			
	Remove oil pan and inspect directly						●	●
	Remedy		Replace	Replace	Replace	Replace	Replace	Replace

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

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

★ Standards for engine oil selection



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 oil filter	Worn bearing, journal	Clogged strainer inside oil pan	Clogged, broken oil pipe inside oil pan	Broken suction pipe brazing	Defective oil pump	Lack of oil in oil pan	Defective regulator valve	Defective main relief valve	Leaking, crushed hydraulic piping	Defective oil level sensor	Defective oil pressure sensor	Water, fuel in oil
Questions	Confirm recent repair history														
	Degree of use of machine	Operated for long period	△	△				△							
	Replacement of filters has not been carried out according to Operation Manual		◎												
	Caution lamp lights up		◎							◯					
	Non-specified oil is being used		◯	◯											
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							◎	◎		◯	◯		
	There is clogging, leakage from hydraulic piping (external)										◎				
	Oil level sensor lamp lights up							◎				◎			
	When oil level in oil pan is checked, it is found to be low							◎							
	Metal particles are found when oil is drained			◎											
	Metal particles are stuck to oil filter element			◎			◯								
	Oil is cloudy white or smells of diesel oil														◎
Troubleshooting	When oil filter is inspected directly, it is found to be clogged		●	●											
	Remove oil pan and inspect directly				●	●	●								
	Oil pump rotation is heavy, there is play						●								
	There is catching of relief valve or regulator valve, spring or valve guide is broken								●	●					
	When oil level sensor is replaced, oil pressure sensor lamp goes out											●			
	When oil pressure is measured, it is found to be within standard value												●		
		Remedy	Clean	Clean	Clean	Clean	Correct	Replace	Add	Adjust	Adjust	Correct	Replace	Replace	—

Carry out troubleshooting for "Oil level rises".

S-13 Oil level rises (water, fuel in oil)

★ If there is oil in the cooling water, carry out troubleshooting for "Oil is in cooling water".

General causes why oil level rises
- Water in oil
- Fuel in oil (diluted, and smells of diesel fuel)
- Entry of oil from other component

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										
		Broken oil cooler core, O-ring	Defective nozzle holder sleeve	Broken cylinder head, head gasket (precombustion chamber)	Clogged water pump breather hole, defective seal	Worn, damaged rear seal surface	Defective main pump seal	Leakage of fuel inside head cover	Defective part inside fuel injection pump (flange type)	Defective thermostat seat portion	Damaged liner O-ring, holes made by pitting	Cracks inside cylinder block
Questions	Confirm recent repair history											
	Degree of use of machine / Operated for long period		△		△	△	△				△	
	There is oil in radiator cooling water	◎	◯	◯							◯	◯
	Exhaust smoke is white		◎					◯		◯		
	When engine is first started, drops of water come from muffler		◎									
Check items	Leave radiator cap open. When engine is run at idling, an abnormal number of bubbles appear, or water spurts back			◎							◯	
	Water pump breather hole is clogged with mud				◎							
	When water pump breather hole is cleaned, water comes out				◎							
	Oil level goes down in clutch, TORQFLOW transmission or damper chamber					◎						
	Oil level goes down in hydraulic tank						◎					
	Engine oil smells of diesel fuel							◎	◎	◎		
	Fuel must be added more frequently							◎	◎	◎		
Troubleshooting	Pressure-tightness test of oil cooler shows there is leakage	●										
	Pressure-tightness test of cylinder head shows there is leakage		●									
	When compression pressure is measured, it is found to be low			●								
	Remove water pump and inspect directly				●							
	Remove rear seal and inspect directly					●						
	When main pump is removed, seal is found to be damaged						●					
	Remove head cover and inspect directly							●				
	Remove fuel injection pump and inspect directly								●			
	Defective contact of thermostat seal valve									●		
	Remove oil pan and check directly										●	●
	Remedy	Replace	Replace	Replace	Replace	Correct	Replace	Correct	Replace	Replace	Replace	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
- Defective cooling circulation system
- Power train oil temperature rises excessively

★ Carry out troubleshooting for chassis.

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: Broken water pump	Clogged, crushed radiator fins	Clogged radiator core	Defective thermostat (does not open)	Defective water temperature gauge	Insufficient cooling water	Fan belt slipping, worn fan pulley	Clogged, broken oil cooler	Defective pressure valve	Broken cylinder head, head gasket	Damaged liner O-ring, holes made by pitting	Torque converter oil temperature too high
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					◎							
Check items	Radiator water level sensor lights up							◎						
	Fan belt whines under sudden load								◎					
	Cloudy white oil is floating on cooling water									◎				
	Cooling water flows out from overflow hose										◎			
	Excessive air bubbles inside radiator, water spurts back											◎		
	Engine oil level has risen, oil is cloudy white									◯			◎	
	There is play when fan pulley is rotated		◎											
	Radiator shroud, inside of underguard are clogged with dirt or mud			◎					◎					
	When light bulb is held behind radiator, no light passes through			◎										
	Water is leaking because of cracks in hose or loose clamps							◎						
	When belt tension is inspected, it is found to be loose								◎					
	Power train oil temperature enters red range before engine water temperature													◎
Troubleshooting	Temperature difference between top and bottom radiator tanks is excessive		●											Carry out troubleshooting for chassis.
	Temperature difference between top and bottom radiator tanks is slight			●										
	When water filler port is inspected, core is found to be clogged				●									
	When function test is carried out on thermostat, it does not open even at cracking temperature					●								
	When water temperature is measured, it is found to be normal						●							
	When oil cooler is inspected directly, it is found to be clogged									●				
	When measurement is made with radiator cap tester, set pressure is found to be low										●			
	When compression pressure is measured, it is found to be low											●		
	Remove oil pan and inspect directly												●	
	Remedy		Replace	Correct	Correct	Replace	Replace	Add	Correct	Replace	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
- Air sucked in from intake system

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: Excessive wear of piston ring, cylinder liner	Seized turbocharger, interference	Missing, seized bushing	Clogged, seized fuel injection nozzle	Defective fuel injection pump (rack, plunger seized)	Defective fuel injection pump (excessive fuel injection)	Deformed fan, fan belt interference	Defective adjustment of valve clearance	Broken dynamic valve system (valve, rocker lever, etc.)	Improper gear train backlash	Leakage of air between turbocharger and cylinder head	Defect inside muffler (dividing board out of position)
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		◎											
	Color of exhaust gas	Blue under light load	◎											
		Black		◎						○			○	
Check items	Metal particles are found in oil filter		◎		◎									
	Blow-by gas is excessive		◎											
	Noise of interference is heard from around turbocharger			◎										
	Engine pickup is poor and combustion is abnormal					◎								
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low					◎	○							
	Seal on injection pump has come off							◎						
	Abnormal noise is loud when accelerating engine					○	○	○	○	○		○		
	Clanging sound is heard from around cylinder head									◎	◎			
	Leakage of air between turbocharger and cylinder head, loose clamp												◎	
	Vibrating noise is heard from around muffler													◎
Troubleshooting	When compression pressure is measured, it is found to be low		●											
	When turbocharger is rotated by hand, it is found to be heavy			●										
	Remove gear cover and inspect directly				●							●		
	Speed does not change when operation of certain cylinders is stopped					●								
	When control rack is pushed, it is found to be heavy, or does not return						●							
	Fuel injection pump test shows that fuel injection amount is incorrect							●						
	Fan is deformed, belt is loose								●					
	When valve clearance is checked, it is found to be outside standard value									●				
	Remove cylinder head cover and inspect directly										●			
	When muffler is removed, abnormal noise disappears													●
	Remedy		Replace	Replace	Replace	Replace	Correct	Replace	Correct	Replace	Correct	Replace	Replace	Replace

S-16 Vibration is excessive

★ If there is abnormal noise together with the vibration, carry out troubleshooting for "Abnormal noise is made".

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

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: Worn connecting rod, main bearing	Worn cam bushing	Worn support pilot	Loose engine mounting bolts, broken cushion	Broken part inside output shaft (damper)	Misalignment between engine and power train	Improper gear train backlash	Defective dynamic valve system (valve, rocker lever, etc.)	Defective fuel injection pump (excessive fuel injection)
Questions	Confirm recent repair history										
	Degree of use of machine	Operated for long period	△	△	△	△					
	Condition of vibration	Suddenly increased					◯			◯	
		Gradually increased	◯	◯	◯	◯					
	Non-specified oil is being used		◯	◯							
Check items	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									◎	◯
	Seal on fuel injection pump has come off										◎
Troubleshooting	Remove oil pan and inspect directly		●								
	Remove side cover and inspect directly			●							
	Check directly for worn support pilot, play				●						
	Inspect directly for loose engine mounting bolts, broken cushion					●					
	Inspect inside of output shaft (damper) directly						●				
	When radial runout, face runout are measured, they are found to be outside standard value							●			
	Remove front cover and inspect directly								●		
	Remove head cover and inspect directly									●	
	Fuel injection pump test shows that fuel injection amount is incorrect										●
		Remedy	Replace	Replace	Replace	Replace	Replace	Correct	Correct	Replace	Adjust

TESTING AND ADJUSTING TOOL LIST

No.	Testing and measuring item	Fault finding tool	Part No.	Remarks
1	Engine speed	Multi-tachometer	799-203-8001	Digital reading: L: 60 – 2,000 rpm H: 60 – 19,999 rpm
		Clamp set or gear box	799-203-8000 6210-81-4111	
2	Battery S.G.	Battery, coolant tester	795-500-1001	1.100 – 1.300
3	Freezing temperature of cooling water			–5 – –50°C
4	Water temperature, oil temprature, air intake temperature	Digital temperature gauge	799-101-1500	–99.90 – 1,299°C
5	Exhaust temperature			
6	Lubrication oil pressure	Engine pressure measuring kit	799-203-2002	0 – 2 MPa {0 – 20 kg/cm^2}
7	Fuel pressure			0 – 4.9 MPa {0 – 50 kg/cm^2}
8	Intake pressure, exhaust pressure			0 – 133 kPa {0 – 1,000 mmHg}
9	Blow-by pressure			0 – 4.9 kPa {0 – 500 mmH_2O}
10	Intake resistance			–0.98 – 0 kPa {–100 – 0 mmH_2O}
11	Compression pressure	Compression gauge kit • Adapter	795-502-1205 • 795-502-1370	0 – 0.69 MPa {0 – 70 kg/cm^2}
12	Blow-by pressure	Blow-by checker	799-201-1504	0 – 4.9 kPa {0 – 500 mmH_2O}
13	Valve clearance	Feeler gauge	795-114-1370	0.35, 0.50 mm
14	Exhaust gas color	Handy smoke checker	799-201-9000	Dirtiness 0 – 70% with standard color (Dirtiness % × 1/10 ≒ Bosch scale)
15	Water and fuel content in oil	Engine oil checker	799-201-6000	Provided with 0.1 and 0.2% water content standard sample
16	Fuel injection pressure	Nozzle tester	Commercially available	0 – 29.4 MPa {0 – 300 kg/cm^2}
17	Fuel injection nozzle spray condition			
18	Coolant quality	Water quality tester	799-202-7001	PH, nitrite ion concentration
19	Pressure valve function	Radiator cap tester	799-202-9001	0 – 0.2 MPa {0 – 2 kg/cm^2}
20	Leakage in cooling system			
21	Radiator blockage	Anemometer	799-202-2001	1 – 4 m/s
22	Engine cranking	Cranking kit	795-610-1000	Engine with DC 24 V starting motor

TESTING AND ADJUSTING DATA

Engine model				4D95LE-2			
Applicable machine model				PC60-7, PC75UU-3, BR100JG-2			
Category	Item	Measurement conditions	Unit	Standard value	Permissible value		
Performance	Engine speed	High idling speed	rpm	2,250 ± 60	2,250 ± 60		
		Low idling speed	rpm	1,100 $^{+50}_{0}$	1,100 $^{+50}_{0}$		
	Necessary starting speed	0°C (without starting aid)	rpm	Min. 150	Min. 150		
		–20°C (with starting aid)	rpm	Min. 100	Min. 100		
Intake, exhaust system	Intake resistance	At all speed	kPa {mmH_2O}	Max. 2.94 {Max. 300}	7.47 {762}		
	Boost pressure	At rated flywheel horsepower	kPa {mmHg}	—	—		
	Exhaust pressure (Turbine inlet press.)	At rated flywheel horsepower	kPa {mmHg}	—	—		
	Exhaust temperature (Turbine inlet temp.)	All speed (20°C)	°C	Max. 650	700		
	Exhaust gas color	Quick acceleration (Low idle → high idle)	Bosch index	Max. 4.0	6.0		
		At rated flywheel horsepower		Max. 2.0	3.5		
		High idling speed		Max. 1.0	2.0		
	Valve clearance (When engine is hot or cold)	Intake valve	mm	0.35	—		
		Exhaust valve	mm	0.50	—		
Engine proper	Compression pressure (SAE30 or SAE 15W-40)	Oil temperature: 40 – 60°C (Engine speed: 320 – 360 rpm)	MPa {kg/cm^2}	Min. 2.9 {Min. 30}	2.0 {20}		
	Blow-by pressure (SAE30 or SAE 15W-40)	At rated flywheel horsepower (Water temp: Min. 70°C)	kPa {mmH_2O}	Max. 0.49 {Max. 50}	0.98 {100}		
Lubrication system	Oil pressure (Oil temperature: Min. 80°C)	At rated flywheel horsepower SAE30 or SAE15W-40 oil	kPa {kg/cm^2}	0.34 – 0.54 {3.5 – 5.5}	0.25 {2.5}		
		SAE 10W oil	kPa {kg/cm^2}	0.29 – 0.49 {3.0 – 5.0}	0.21 {2.1}		
		At low idling SAE30 or SAE15W-40 oil	kPa {kg/cm^2}	Min. 0.18 {Min. 1.8}	0.15 {1.5}		
		SAE 10W oil	kPa {kg/cm^2}	Min. 0.15 {Min. 1.5}	0.13 {1.3}		
	Oil temperature	All speed (Oil in oil pan)	°C	90 – 110	120		
	Oil consumption ratio	At continuous rated horsepower (Ratio to fuel consumption)	%	Max. 0.5	1.0		
Fuel	Fuel injection pressure	Nozzle tester	MPa {kg/cm^2}	20.1 – 21.1 {205 – 215}	16.7 {170}		
	Fuel injection timing	B.T.D.C.	degree	12 ± 0.75	12 ± 0.75		
Cooling	Radiator pressure valve	Opening pressure (Differential pressure)	MPa {kg/cm^2}	—	—		
	Fan speed	At rated engine speed	rpm	1,680 ± 50	1,680 ± 50		
	Fan belt tension	Deflects when pushed with a force of 60N{6kg}	mm	8	7 – 10		

★ This STANDARD VALUE TABLE does not give the standard value for adjusting the engine output. Do not use the values in this table to change the setting for fuel injection pump.

4D95LE-2							
PC78US-6, PC78UU-6							
Standard value	Permissible value						
2,050 ± 50 1,150 $^{+50}_{0}$	2,050 ± 50 1,150 $^{+50}_{0}$						
Min. 150 Min. 100	Min. 150 Min. 100						
Max. 2.94 {Max. 300} — — Max. 650	7.47 {762} — — 700						
Max. 4.0 Max. 2.0 Max. 1.0	6.0 3.5 2.0						
0.35 0.50	— —						
Min. 2.9 {Min. 30}	2.0 {20}						
Max. 0.49 {Max. 50}	0.98 {100}						
0.34 – 0.54 {3.5 – 5.5} 0.29 – 0.49 {3.0 – 5.0} Min. 0.18 {Min. 1.8} Min. 0.15 {Min. 1.5}	0.25 {2.5} 0.21 {2.1} 0.15 {1.5} 0.13 {1.3}						
90 – 110	120						
Max. 0.5	1.0						
20.1 – 21.1 {205 – 215}	16.7 {170}						
12 ± 0.5	12 ± 0.5						
—	—						
1,850 ± 55	1,850 ± 55						
8	7 – 10						

★ This STANDARD VALUE TABLE does not give the standard value for adjusting the engine output. Do not use the values in this table to change the setting for fuel injection pump.

13 DISASSEMBLY AND ASSEMBLY

★ The description of the procedure for overall disassembly and assembly of the engine given in this section gives the procedure and operation when using a repair stand.

★ If the machine model or the engine stand are different, the actual procedure may be different from the procedure given in this section, but the work is basically the same.

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

Component	Symbol	Part No.	Part Name	Necessity	Q'ty	New/ remodeled	Sketch	Nature of work, remarks
Disassembly, assembly of engine	A	790-501-2001	Engine repair stand	■	1			Turning engine
	B	790-901-1250	Bracket	■	1			Installation of engine to repair stand
Removal, installation of valve cotter	C	795-102-2102	Spring pusher(kit)	●	1			Installation of spring, spring seat, and cotter to intake and exhaust valves
		· 795-102-2110	· Handle		1			
		· 795-102-2150	· Bracket		1			
		· 795-102-2130	· Bracket		1			
		· 795-102-2170	· Stud		1			
		· 01016-50830	· Bolt		1			
		· 01580-10806	· Nut		2			
Pulling out valve guide	D	795-100-4710	Remover	●	1			Pulling out valve guide
Press fitting of valve guide	D1	795-100-4720	Guide driver	■	1			Press fitting of valve guide
Removal, installation of piston ring	E	795-100-2800	Piston ring tool	■	1			Installation of piston ring to piston
Removal, installation of oil seal (for front)	F	790-101-5201	Push tool (kit)	■	1			Removal, installation of front oil seal
		· 790-101-5271	· Plate		1			
		· 790-101-5221	· Grip		1			
		· 01010-51225	· Bolt		1			
Removal, installation of oil seal (for rear)	G	790-101-5401	Push tool (kit)	■	1			Removal, installation of rear oil seal
		· 790-101-5431	· Plate		1			
		· 790-101-5421	· Grip		1			
		· 01010-51240	· Bolt		1			
Insertion of piston	H	795-213-1800	Piston holder	■	1			Insertion of piston assembly into cylinder
Adjustment of valve clearance	I	790-125-1370	Feeler gauge	●	1			

OVERALL DISASSEMBLY, ASSEMBLY
4D95LE-2

OVERALL DISASSEMBLY

ASSEMBLY

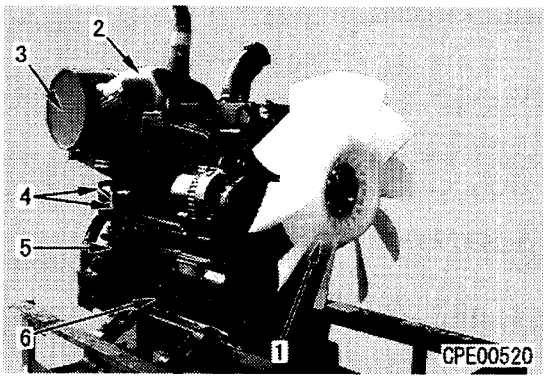
DISASSEMBLY

Preparatory work

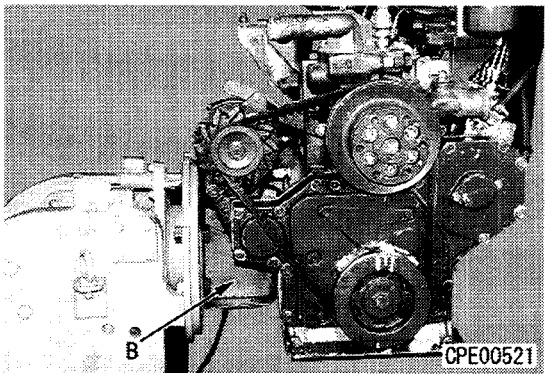
- Remove all dirt and mud from around the engine.
- Drain the oil from the engine.

Engine oil : **Approx. 6 ℓ**

⚠ Set engine repair stand **A** on horizontal ground to prevent the engine from falling over.
- Remove fan (1), exhaust pipe (2), muffler (3), oil tubes (4), block (5), and cover (6).

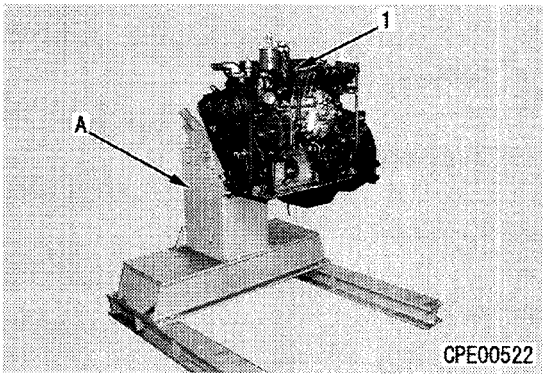


- Install bracket **B** to the position of block (5) and cover (6).

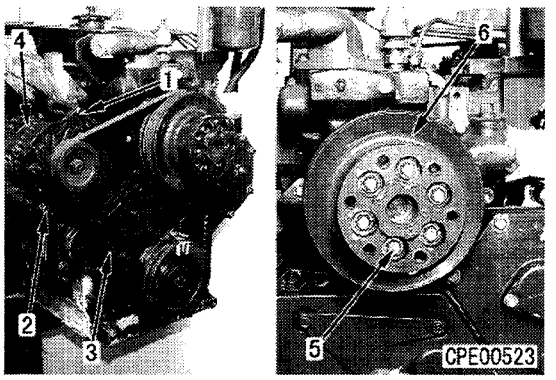


- Install engine assembly (1) to engine repair stand **A**.

kg Engine assembly : **300 kg**
(The weight differs according to the machine model.)

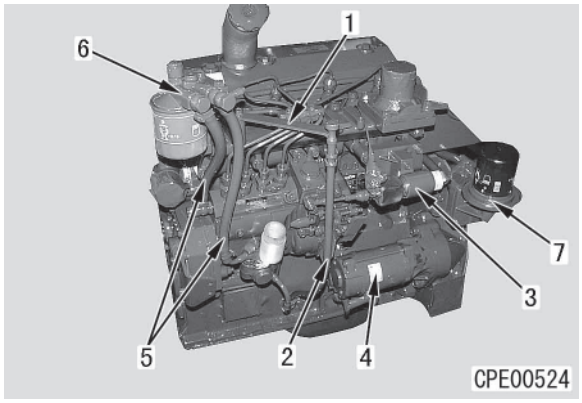


1. Alternator, fan pulley
1) Loosen adjustment bolt (1) and mount bolt (2), then move alternator (4) towards engine block and remove fan belt (3).
2) Remove adjustment bolt, and mount bolt (1) and (2), then remove alternator assembly (4).
3) Remove mounting bolts (5), then remove fan pulley (6).



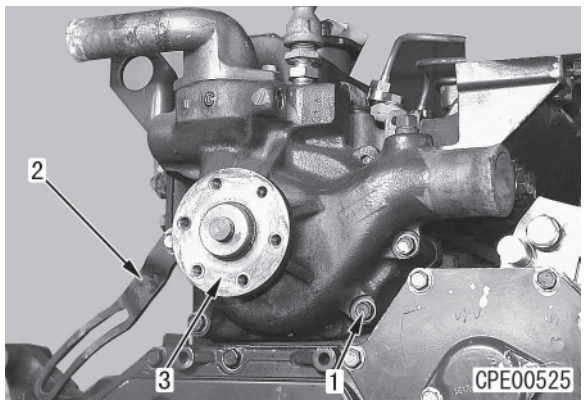
2. Starting motor, engine stop solenoid, fuel and oil filter, dipstick

1) Remove bracket (1), then remove dipstick (2).
2) Remove engine stop solenoid (3).
3) Remove starting motor (4).
4) Disconnect fuel hoses (5) and remove fuel filter assembly (6) from intake manifold.
5) Remove oil filter (7) from engine block together with tube.



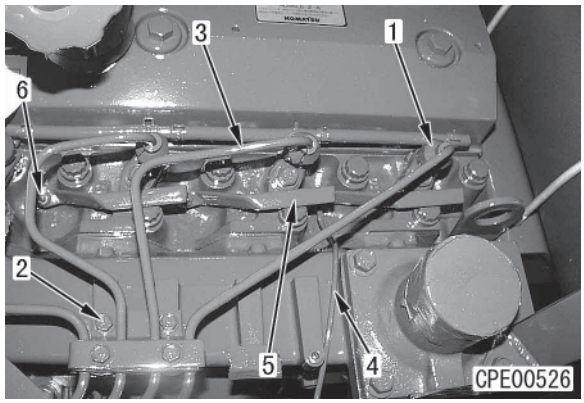
3. Water pump

1) Remove 4 mounting bolts (1) and adjustment plate (2).
2) Pull out pilot portion and remove water pump assembly (3).



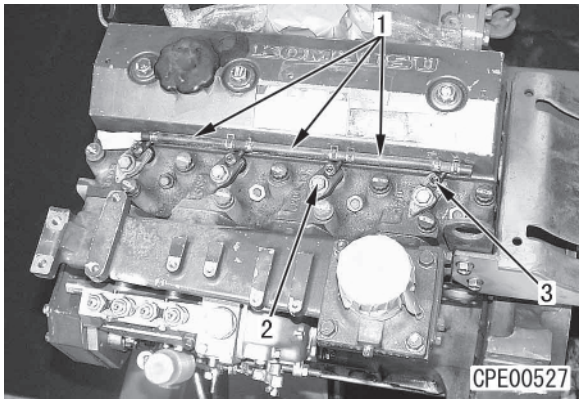
4. Fuel injection pipe, glow plug

1) Remove 4 boots (1) and disconnect sleeve nut from injector.
   ★ Disconnect the injection pump end in the same way.
2) Remove 2 bracket mounting bolts (2), then remove fuel injection pipe (3) together with bracket.
3) Remove 3 nuts of glow plug, then remove 3 each of wiring connector (4), lead (5), and plug (6).

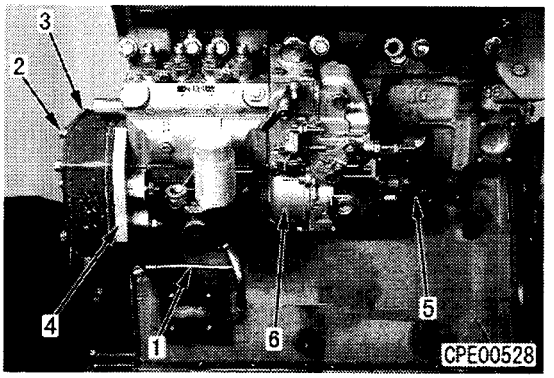


5. Injection nozzle

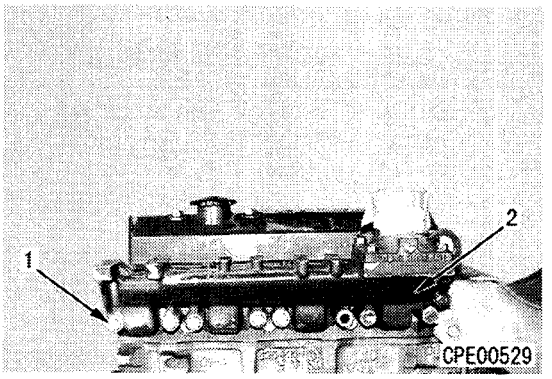
1) Remove spill hoses (1).
2) Remove 4 nozzle holders (2), then remove 4 injection nozzles (3) from cylinder head.



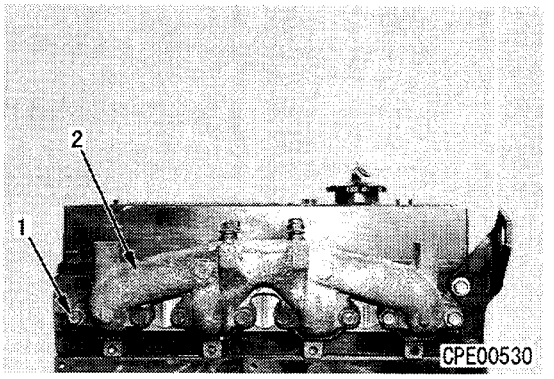
6. **Fuel injection pump**
   1) Remove eyebolt, then remove lubrication oil tube (1).
   2) Remove 6 mounting bolts (2), then remove cover (3).
   3) Remove 1 mounting bolt (at bottom block) of holder (4).
   4) Remove bracket (5), then remove fuel injection pump assembly (6) together with drive gear and holder.



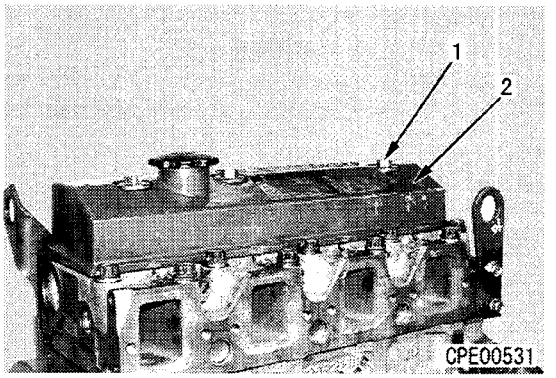
7. **Intake manifold**
   Remove 7 mounting bolts (1), then remove intake manifold (2).



8. **Exhaust manifold**
   Remove 8 mounting bolts (1), then remove exhaust manifold (2).

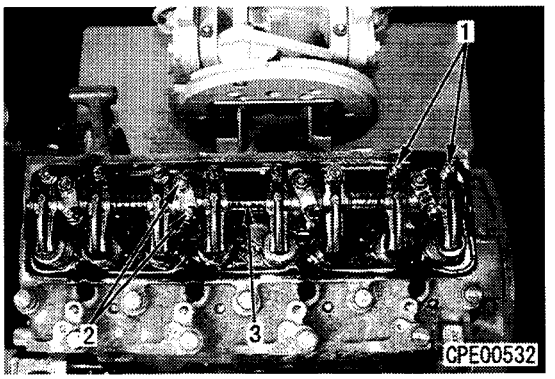


9. **Head cover**
   Remove 3 nuts (1), then remove head cover (2).



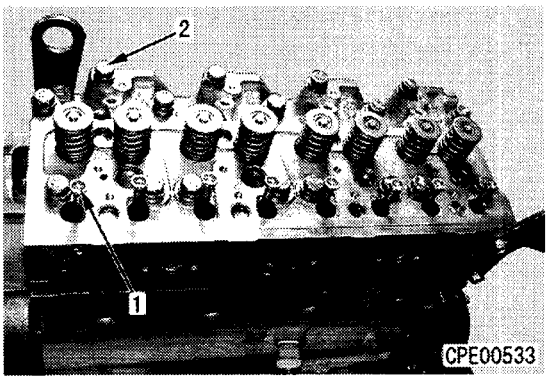
10. Rocker arm

1) Loosen locknut, then loosen adjustment screw (1) 3 – 4 turns.
   ★ Loosen the intake and exhaust adjustment screws of all cylinders.
2) Remove 8 mounting bolts (2), then remove rocker arm assembly (3).



11. Push rods, cylinder head mounting bolts

1) Pull out 8 push rods (1).
2) Remove 17 cylinder head mounting bolts (2).

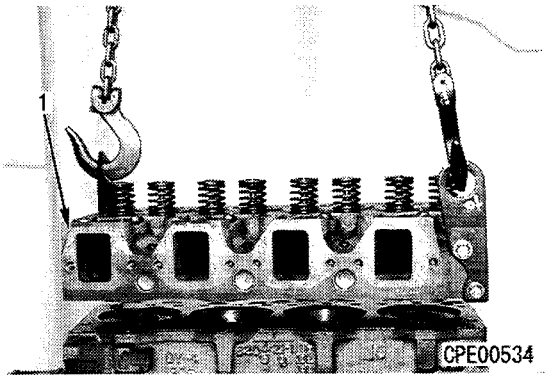


12. Cylinder head cover

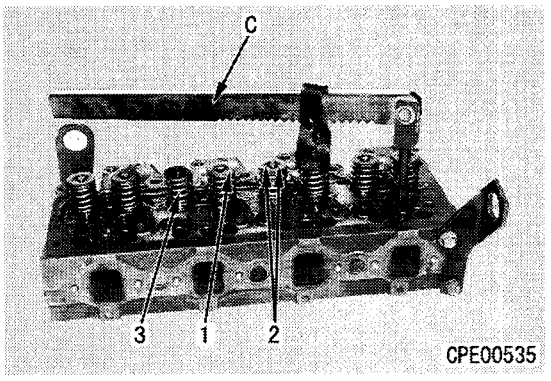
Lift off cylinder head assembly (1).

kg Cylinder head assembly : **30 kg**

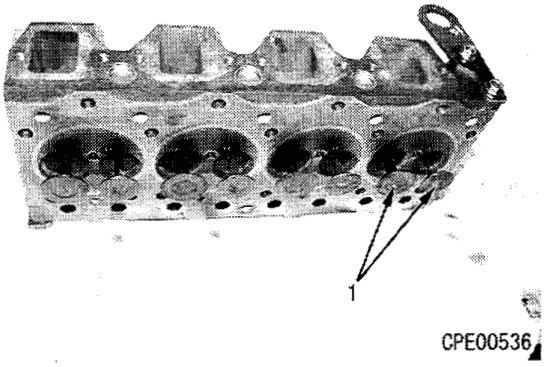
★ Lay cloth on the floor to protect the mounting portion of the cylinder head from damage.



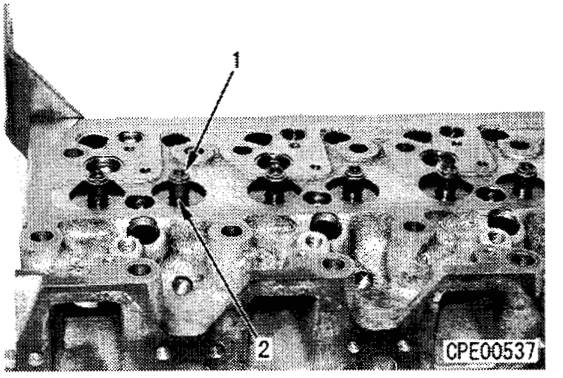
- When disassembling the cylinder head assembly, do as follows.
  1) Using spring pusher **C**, compress valve spring (3), then remove cotter (2).
  2) After removing cotter (2), release pressure on spring pusher **C** slowly, and remove spring seat (1) and spring (3).
     ★ Remove from all cylinders in the same way.



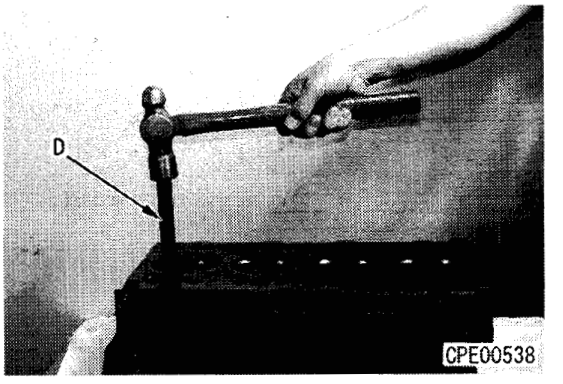
- Intake, exhaust valves
  Remove 8 intake and exhaust valves (1) from cylinder head.
  ★ After removing the valves, fit tags to distinguish the mounting position, and keep them in a safe place.



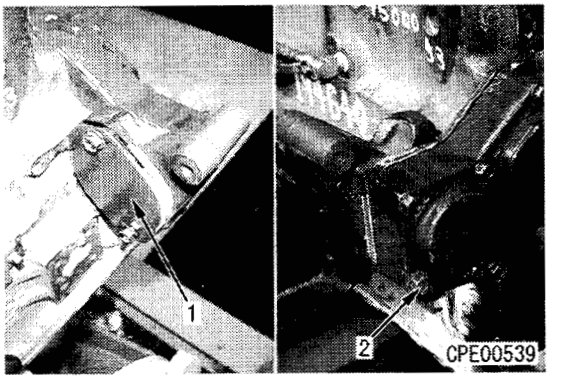
- Valve guide, valve seals
  1) Remove 8 valve seals (1).



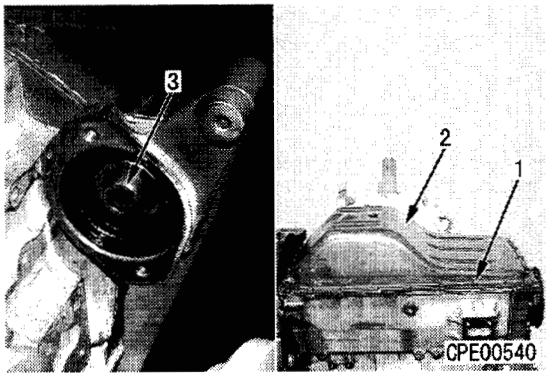
  2) Using valve guide remover **D**, remove valve guide (2).



13. PTO shaft
  1) Remove mounting bolt, then remove cover (1).
  2) Remove 4 mounting bolts (2).

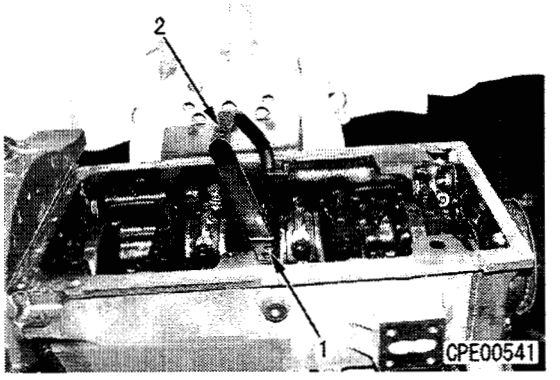


3) Remove PTO shaft (3).
★ Tap with a plastic hammer to remove.

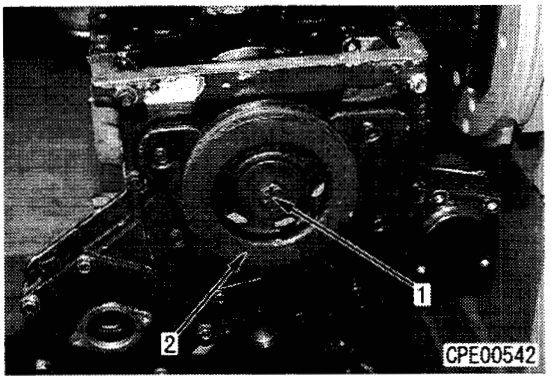


14. Oil pan
Remove 24 mounting bolts (1), then remove oil pan (2).

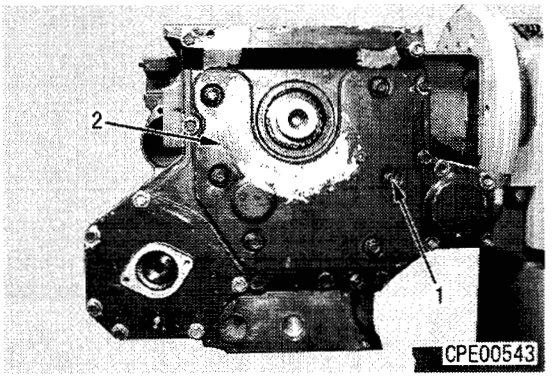
15. Oil suction pipe
Remove 2 mounting bolts, then remove oil suction pipe (2).



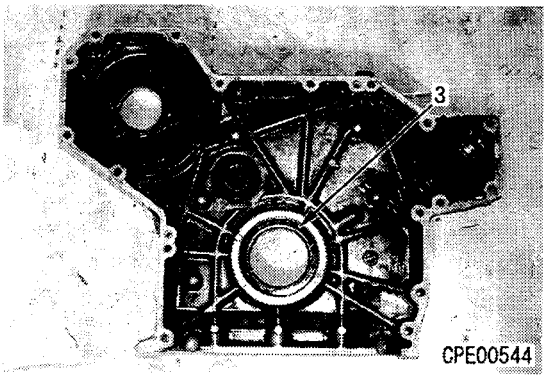
16. Crankshaft pulley
Remove mounting bolt (1), then remove crankshaft pulley (2).
★ If it cannot be removed, use a puller to remove it.



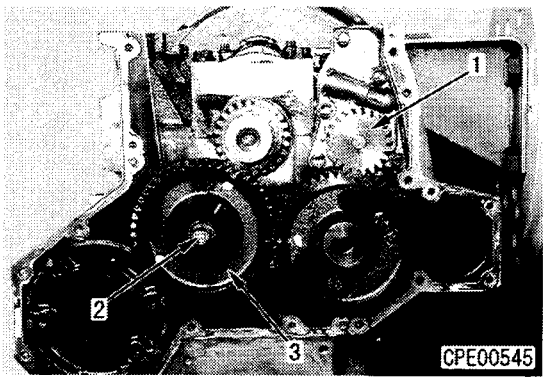
17. Gear case cover
1) Remove 12 mounting bolts (1), then remove gear case cover (2).
★ Be careful not to damage the front oil seal.



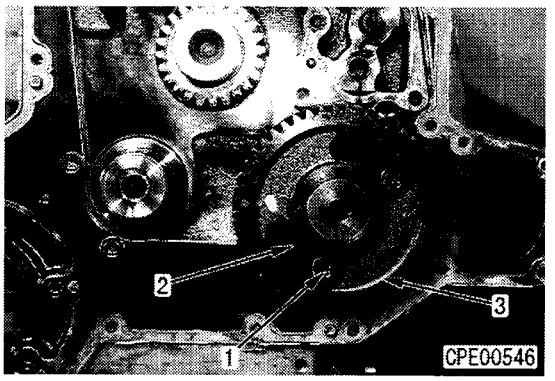
2) Remove front oil seal (3).
★ Use push tool **F** and knock it out.



18. Oil pump, idler gear
1) Remove 5 mounting bolts, then remove oil pump assembly (1).
★ After removing the oil pump, remove the driven gear from the cylinder block.
2) Remove mounting bolt (2), then remove idler gear (3).
★ If the machine is equipped with a PTO, a bearing is used for the idler gear bushing.



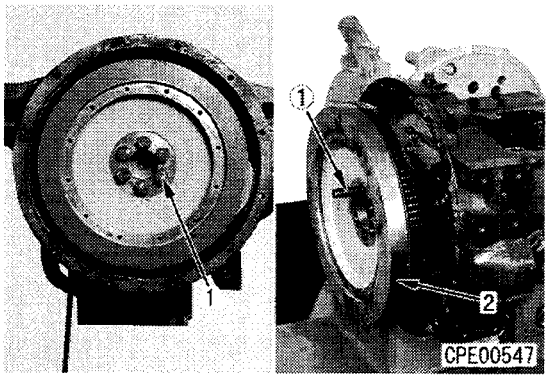
19. Camshaft assembly
1) Tappets are installed, so set with the cylinder head mounting surface facing down.
2) Remove mounting bolts (1) through casting hole in gear.
3) Pull out camshaft assembly (3) from cylinder block together with thrust plate (2).
★ When removing, rotate the camshaft lightly and be careful not to damage the bushing.



20. Flywheel
1) Remove 6 mounting bolts (1).
★ After removing 1 mounting bolt, install guide bolt ①.
2) Remove flywheel (2).

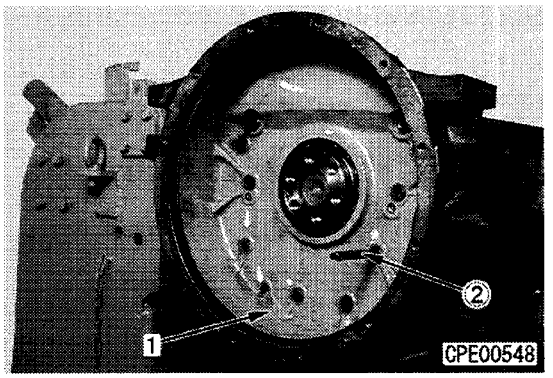
kg Flywheel : **25 kg**

⚠ The flywheel pilot is shallow and it may suddenly fall, so use a guide bolt.

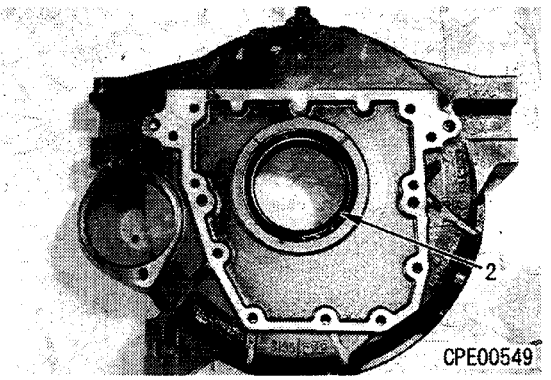


21. Flywheel housing

1) Remove mounting bolts, and set guide bolt ② in position.
   ★ Install 2 guide bolts to prevent damage to the rear oil seal.
2) Remove flywheel housing (1) horizontally.

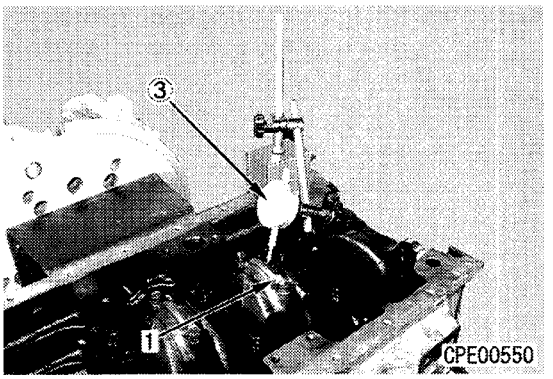


3) Remove rear oil seal (2).
   ★ Use push tool **G** and knock it out.

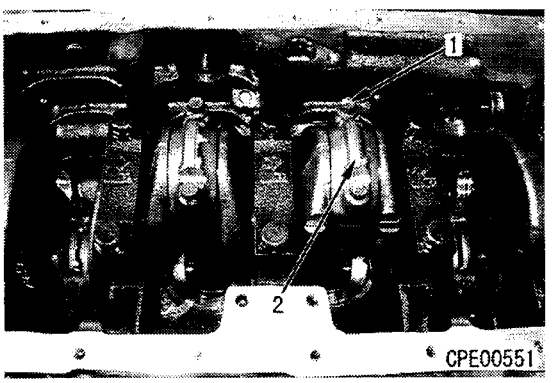


22. Piston, connecting rod assembly

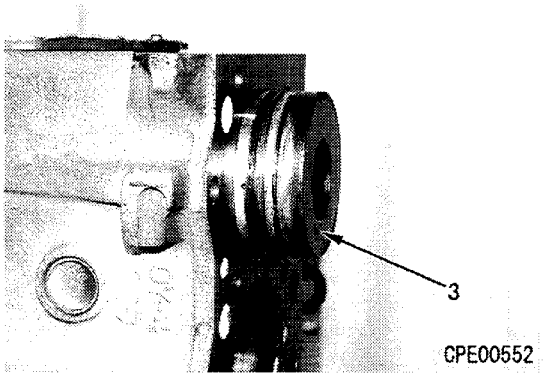
1) Measure side clearance of connecting rod (1) with dial gauge ③.



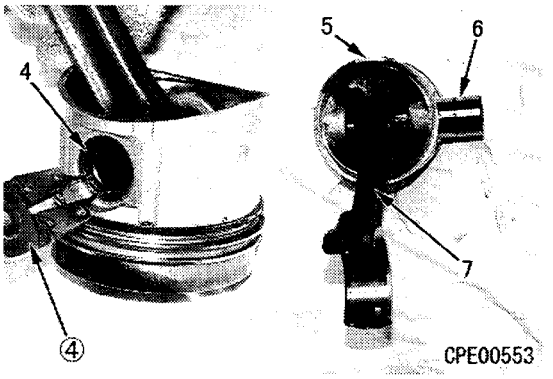
2) Set piston to be pulled out to bottom dead center position, then remove 2 connecting rod cap mounting bolts (1).
3) Tap with a plastic hammer, and remove connecting rod cap (2) together with bearing.
   ★ Check that the number stamped on the connecting rod cap matches the cylinder number.
   ★ If there is no stamped number, stamp a number at the camshaft end.



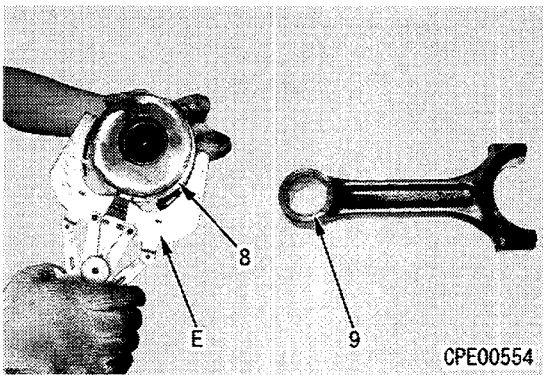
4) Use a wooden bar from oil pan side to push piston skirt, support piston at cylinder head end, then push more from oil pan side and pull out piston and connecting rod assembly (3).



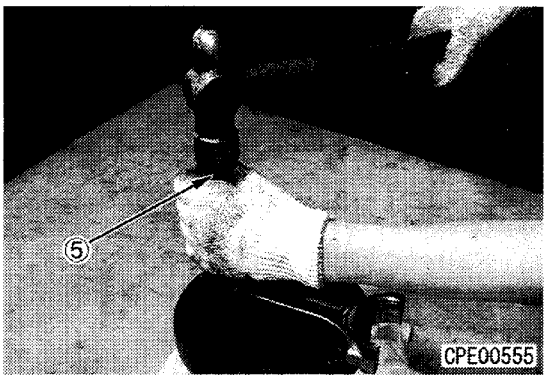
5) Disassemble piston and connecting rod assembly as follows.
   i) Using snap ring pliers ④, remove snap ring (4).
   ii) Pull out piston pin (6) and separate connecting rod (7) and piston (5).
   ★ If the pin does not come out, soak in hot water.



   iii) Using piston ring tool **E**, remove piston rings (8) from piston in order starting from top.

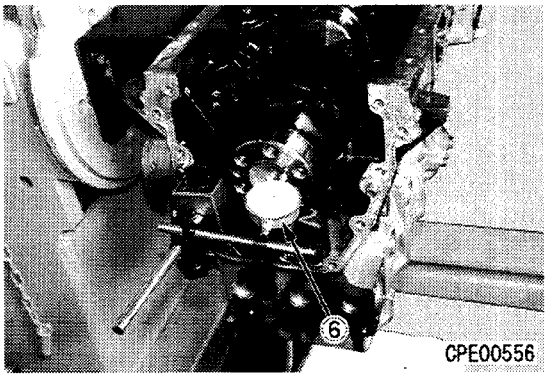


   iv) If bushing (9) is worn, use push tool ⑤ (outside diameter: 32 mm) to remove it.

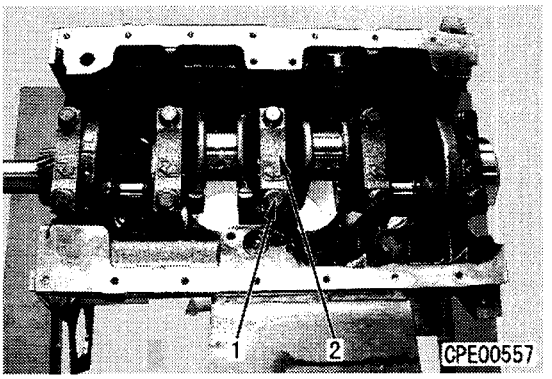


23. Main cap

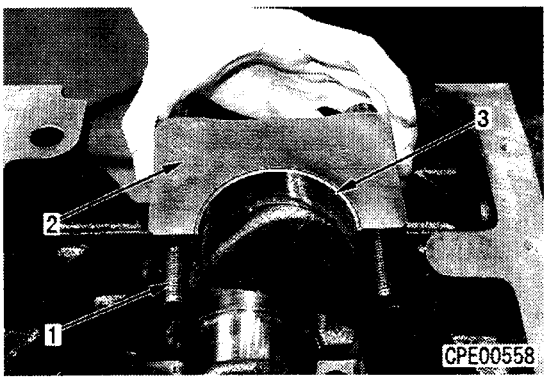
1) Measurement of end play
   i) Set cylinder block oil pan side at top, then install dial gauge ⑥.
   ii) Measure end play of crankshaft.
   ★ The end play measurement is necessary for judging wear of the thrust bearing and abnormal wear of the crankshaft, so measure before removing the crankshaft.



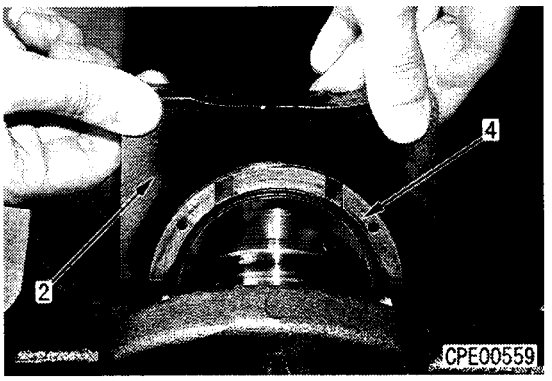
2) Main cap
   i) Remove 2 mounting bolts (1) of main cap, then remove main cap (2).



★ Insert the mounting bolts in the bolt holes in the cap, move the cap from side to side or tap it to the left and right with a plastic hammer to remove it together with bearing (3).

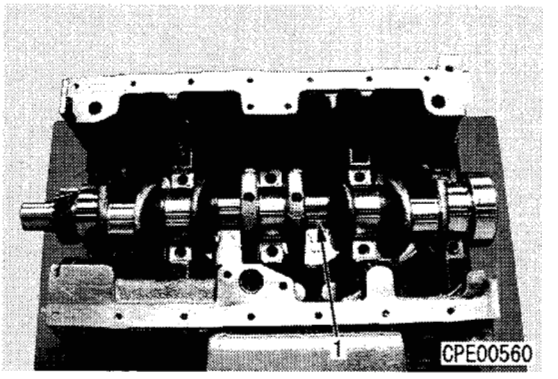


★ Thrust bearings (4) are assembled to both surfaces of cap (2) at the flywheel end, so after removing, mark the assembly positions of the sets.

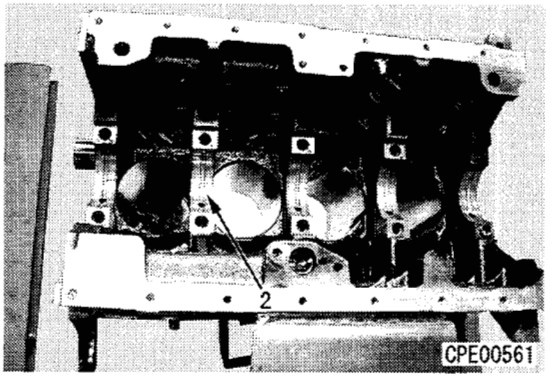


24. Crankshaft

1) Remove crankshaft (1).
   ★ Be careful not to damage the sliding portion of the crankshaft.

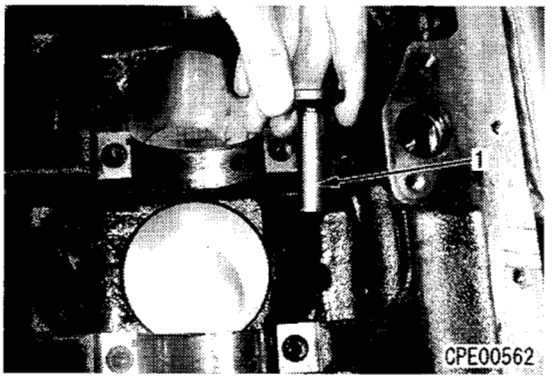


2) Remove 5 main bearings (2).
   ★ Push the tip of the bearing down and remove it.
   ★ Mark the mounting positions of the sets for the main bearing and thrust bearing, and keep in sets for each cap number.



25. Tappets

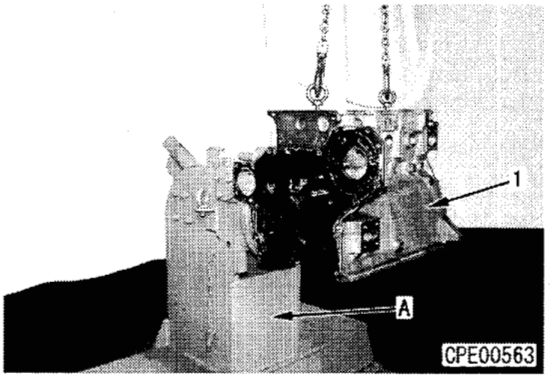
Pull out 10 tappets (1) from cylinder block.
★ Check for wear at the cam sliding portion.
★ If there is any wear, the thrust bearing of the camshaft may also be worn, so check it.



26. Cylinder block assembly

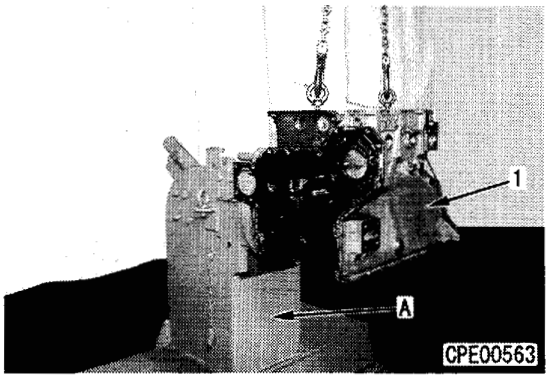
Sling cylinder block assembly (1), disconnect from repair stand **A** and lift off.

kg Cylinder block assembly : **70 kg**

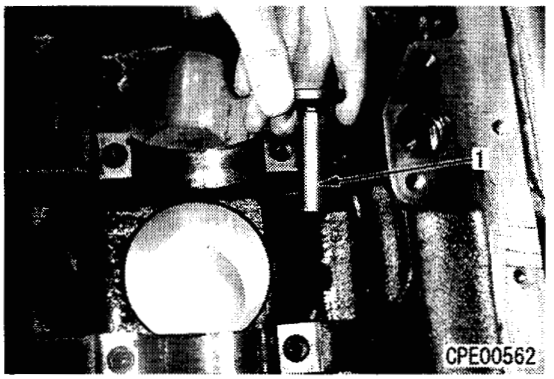


OVERALL ASSEMBLY

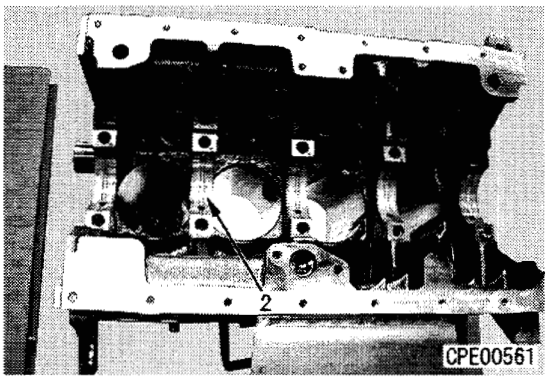
1. **Cylinder block assembly**
   Fit bracket **B** to cylinder block assembly (1), then set on engine repair stand **A**.



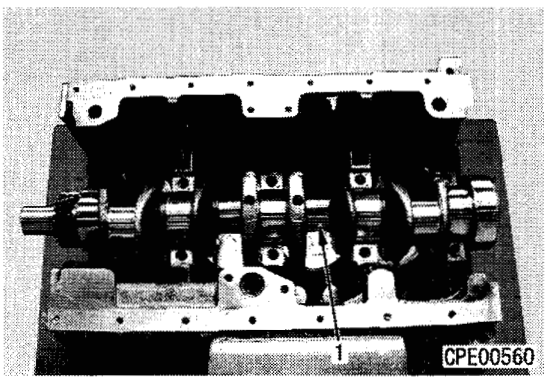
2. **Tappets**
   1) Turn over cylinder block assembly.
   2) Coat with engine oil and assemble 10 tappets (1).



3. **Crankshaft**
   1) Align protruding portion of upper main bearing (2) with notch in cylinder block, then assemble.
      ★ Check that there is no dirt or dust stuck to the rear face of the bearing before assembling it.
      ★ Do not coat the rear face of the bearing with engine oil.
      ★ Coat the inside surface of the bearing with engine oil (SAE30).



   2) Be careful not to let crankshaft (1) contact block, and set it carefully on upper main bearing.
      ★ If the crankshaft gear has been replaced, put the crankshaft gear in an electric furnace, heat it for approx. 30 minutes at 230 – 250°C, then shrink fit the gear.



4. Main cap

1) Align with notched portion of each cap (2), then install lower bearing (3).
   - ★ Check that there is no dirt or dust stuck to the rear face of the bearing before assembling it.
   - ★ Do not coat the rear face of the bearing with engine oil.

2) Align thrust bearing (4) with dowel pin, then install to both surfaces of main cap (2).
   - ★ Install the thrust bearing so that the oil groove is on the outside.

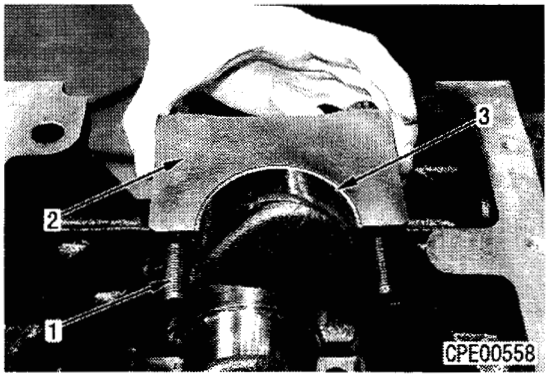
3) Fit main cap (2) to cylinder block, then tighten with mounting bolts (1).
   - ★ Check that the stamped mark on the main cap is the same as the stamped mark on the cylinder block.
   - ★ Assemble so that the casting arrow is facing the gear case.
   - ★ Be careful not to let the thrust bearing move out of position.
   - ★ Use a torque wrench to tighten the connecting rod cap bolts in the order given below.
   - i) Coat the thread portion and seat surface of the bolt with engine oil (SAE30).
   - ii) When tightening, start from middle main cap and move in turn to left and right to tighten towards outside. After that, go on to tightening torque for next step.

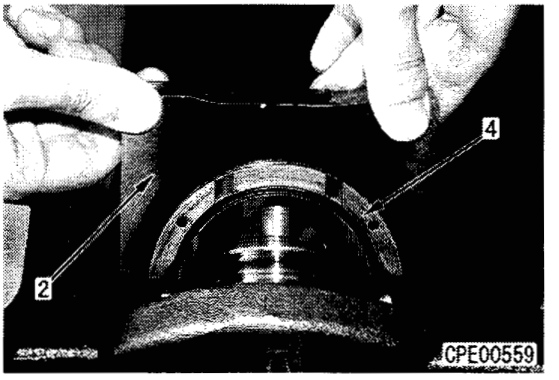
kgm Tightening torque of main cap:
Unit : Nm {kgm}

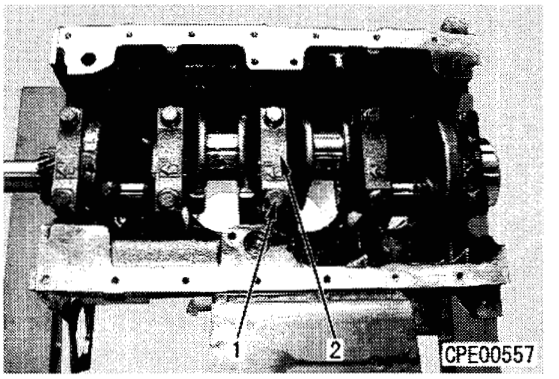
Step	Target	Range
1st step	113.0 {11.5}	108.0 – 118.0 {11.0 – 12.0}
2nd step	0 {0}	Loosen completely
3rd step	132.0 {13.5}	127.0 – 137.0 {13.0 – 14.0}

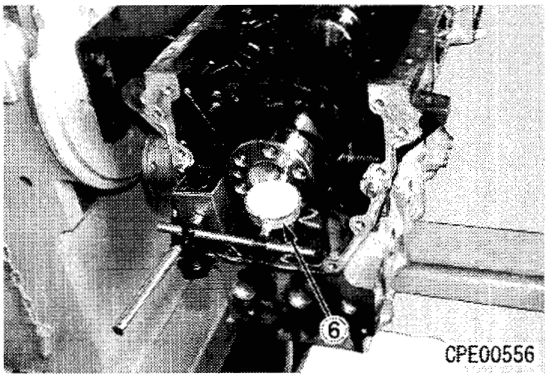
   - ★ After tightening, check that the crankshaft rotates smoothly.

4) Put probe of dial gauge ⑥ in contact with end face of crankshaft, move crankshaft to front and rear, and measure reading of gauge indicator.
   - ★ Permissible range for end play: 0.13 – 0.35 mm

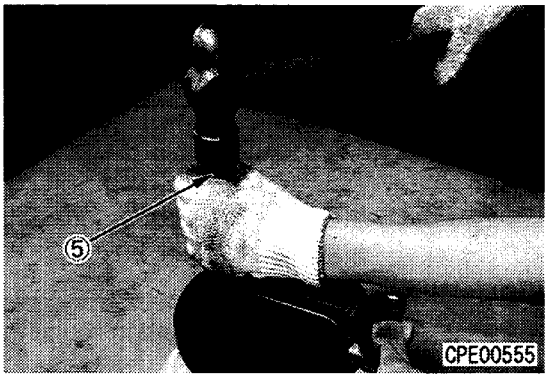




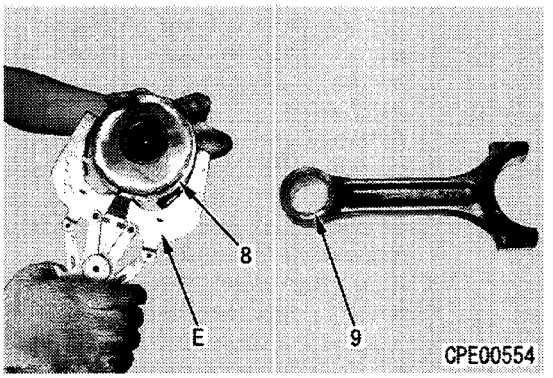




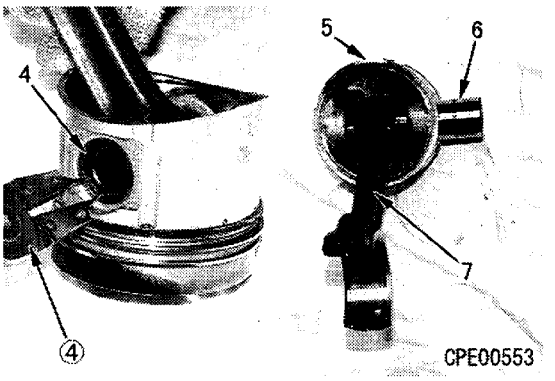
5) Assemble piston and connecting rod assembly as follows.
   i) Assembly of piston and connecting rod assembly.
   Using push tool ⑤ (outside diameter: 32 mm), press fit bushing (9) to connecting rod.



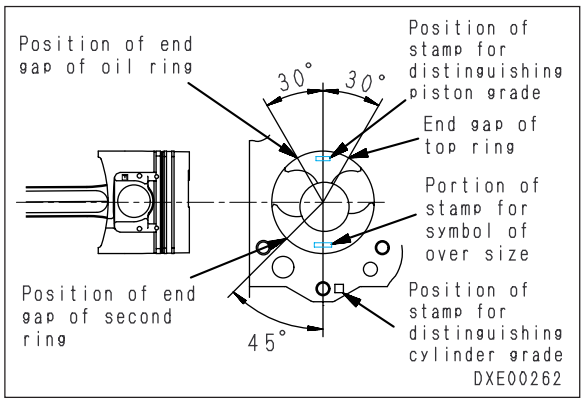
   ii) Set face with stamped mark on end gap facing up (compression ring only), then use piston ring tool **E** to assemble each piston ring (8).
   ★ Be careful not to damage the piston or break the ring.
   ★ Fit the expander in the groove on the inside diameter, then assemble the oil ring. When doing this, check that the expander is completely fitted in the ring groove.
   ★ Set so that the end gap of the ring is at 180° to the join of the coil of the expander.

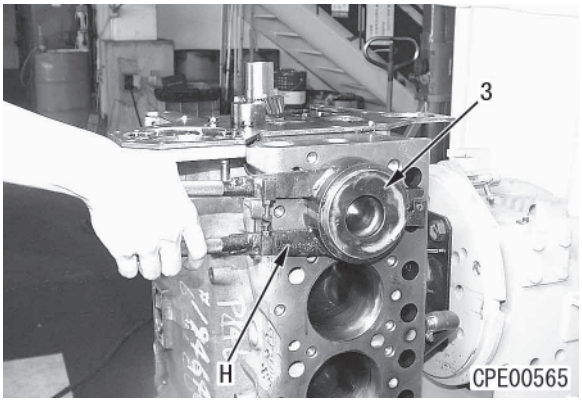


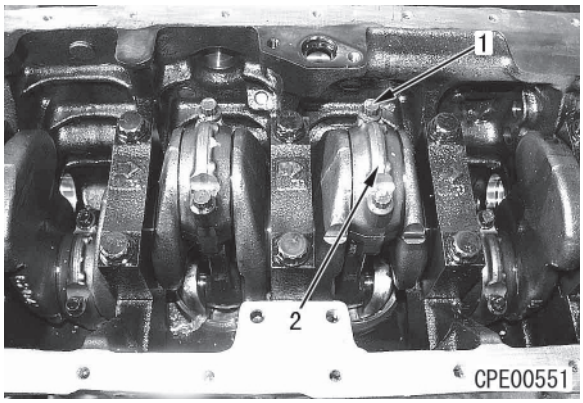
   iii) Using pliers ④, assemble one snap ring (4) in snap ring groove on piston.
      ★ Set the [F] mark on the piston pin boss surface facing in the same direction as the casting number on the connecting rod, then insert piston pin (6) and assemble connecting rod (7) and piston (5).
      Assemble the remaining snap ring to the piston.
      ★ After assembling the snap rings, check that the connecting rod moves smoothly forward and backward.
   iv) Align the protrusion of the connecting rod upper bearing and the notch on the connecting rod, then assemble.

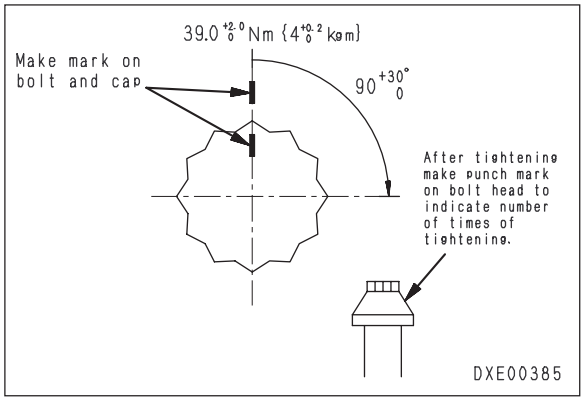


6) Assemble piston and connecting rod assembly inside cylinder block.
   i) Turn over cylinder block, and set so that crankshaft is perpendicular.
   ii) Set so that the relationship between the end gaps of the piston rings is as shown in the diagram.
   iii) Set crankshaft to bottom dead center for cylinder where piston and connecting rod assembly is to be assembled.
      ★ Coat the inside face of the cylinder, the piston rings, and the surface of the connecting rod bearing with engine oil.
   iv) Align direction of **F** mark on piston side surface to face front of engine. Using piston holder **H**, insert piston and connecting rod assembly (3) from cylinder head end.
   v) When piston rings are inserted inside cylinder liner, push in head of piston with flat of hand or wooden rod. In addition, pull in big end of connecting rod and fit in crankshaft.
   vi) Align protrusion of lower bearing with notch in cap, then assemble bearing to connecting rod cap (12).
      ★ Check that there is no dirt or dust stuck to the rear face of the bearing.
   vii) Set so that stamped mark is at camshaft end, then install connecting rod cap (2).
      ★ Coat the connecting rod bearing with engine oil.
      ★ Check that the stamped number on the connecting rod cap is the same as the number of the cylinder.
      ★ Tighten mounting bolts of connecting rod cap as follows.
      ★ Coat mounting bolt thread and bolt seat with engine oil.
      kgm Cap mounting bolt :
      1st step: Tighten in turn to 39.0 $^{+2.0}_{0}$ Nm {4.0 $^{+0.2}_{0}$ kgm}
      2nd step: Mark bolt head and cap seat, then turn bolt 90 $^{+30^\circ}_{0}$ to tighten.
      ★ After tightening, make a punch mark on the bolt head to indicate the number of times the bolt has been tightened. The bolt can be used a maximum of five times. Always replace any bolt that already has five punch marks.
      ★ After assembling the connecting rods, check that the crankshaft rotates smoothly.

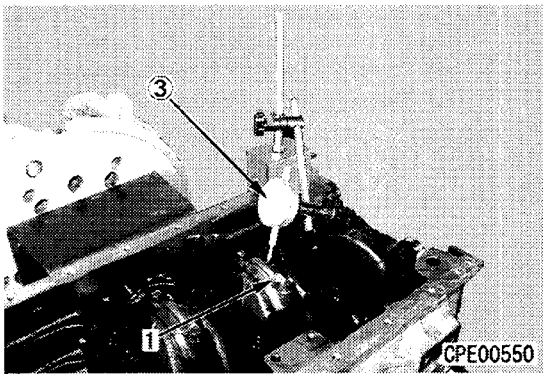




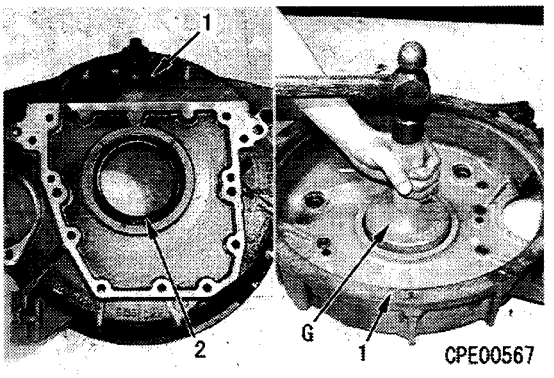




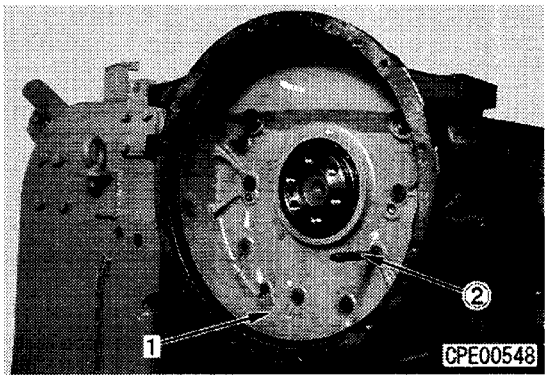
viii) Measure side clearance of connecting rod cap.
★ Turn over the cylinder block and set the oil pan at the top.
★ Using dial gauge ③, measure the side clearance of the connecting rod cap.
Permissible range of side clearance:
0.20 – 0.40 mm



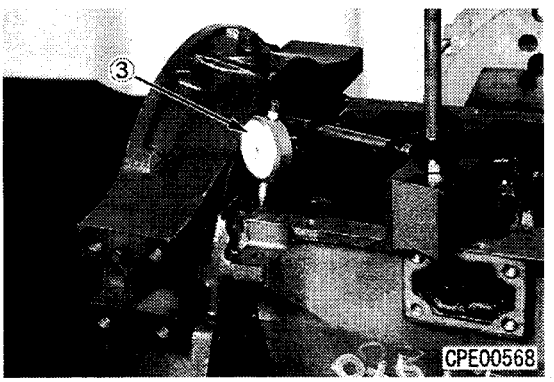
5. **Flywheel housing**
1) Using push tool **G** (outside diameter: 120 mm), install rear oil seal (2) to flywheel housing (1).
★ After press fitting, fill 40 – 60% of space at seal lip with grease.
Rear oil seal: **Grease (G2-LI)**



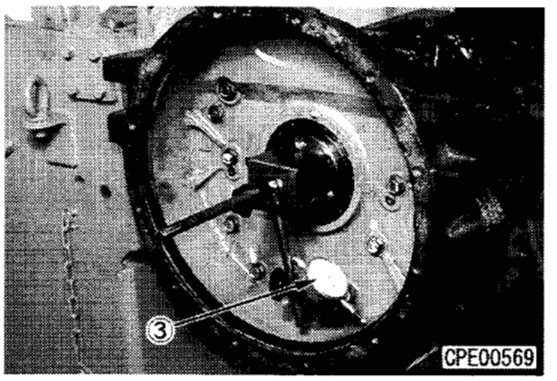
2) Set on guide bolt ②, and install flywheel housing (1).
Flywheel mounting surface:
Gasket sealant (LG-7)
★ When fitting the lip of the rear oil seal to the crankshaft flange, be careful not to apply excessive force to the lip surface.
kgm Mounting bolt:
66 ± 7.4 Nm {6.75 ± 0.75 kgm}



3) Measuring stepped difference at mounting surface
Measure stepped difference between oil pan mounting surface of cylinder block and flywheel housing with dial gauge ③.
★ Permissible limit for stepped difference at oil pan mounting surface :
Within 0.15 mm



4) Measure radial runout and face runout of flywheel housing with dial gauge ③.
   ★ Radial runout : Max. 0.30 mm
   ★ Face runout : Max. 0.35 mm



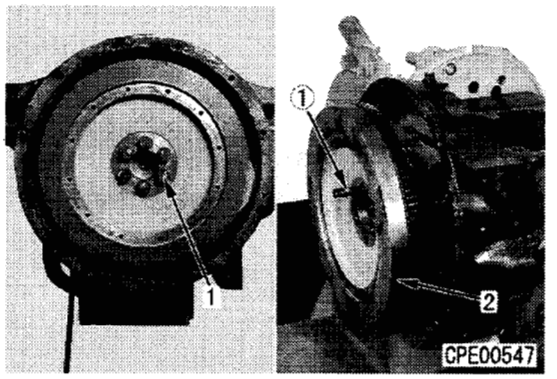
6. Flywheel

1) Set on guide bolt ①, then fit flywheel (2) to crankshaft and tighten with mounting bolts (1).
   kgm Mounting bolt :

Unit: Nm {kgm}

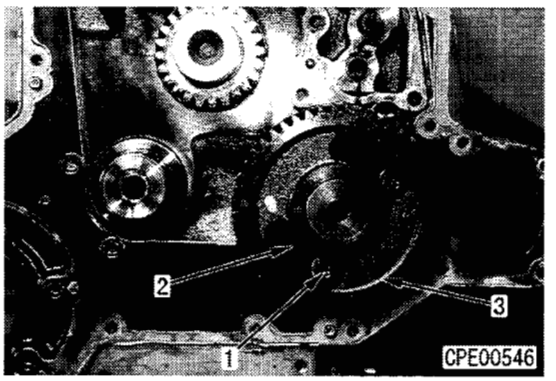
Order	Target	Range
1st step	108.0 {11.0}	98.0 – 118.0 {10.0 – 12.0}
2nd step	191.0 {19.5}	186.0 – 196.0 {19.0 – 20.0}

2) Measure radial runout and face runout of flywheel.
   Radial runout : Max. 0.15 mm
   Face runout : Max. 0.25 mm

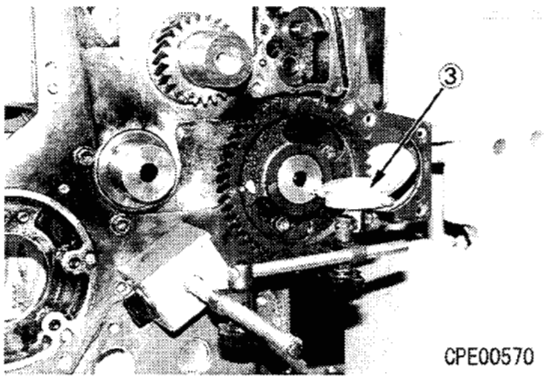


7. Camshaft

1) Insert camshaft assembly (3) in cylinder block.
   ★ Rotate the camshaft lightly while pushing it in. This makes it possible to insert the camshaft without damaging the bushing.
2) Tighten thrust plate (2) with mounting bolt from casting hole in gear to secure camshaft assembly.
   kgm Thrust plate mounting bolt :
   19.0 ± 4.9 Nm {1.9 ± 0.5 kgm}

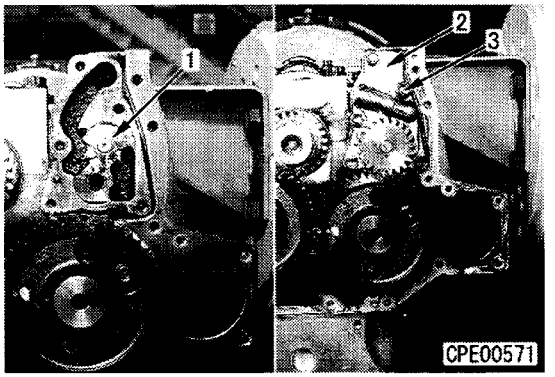


3) Put dial gauge ③ in contact with end face of camshaft, move camshaft to front and rear, and measure end play.
   ★ Camshaft end play : 0.15 – 0.35 mm

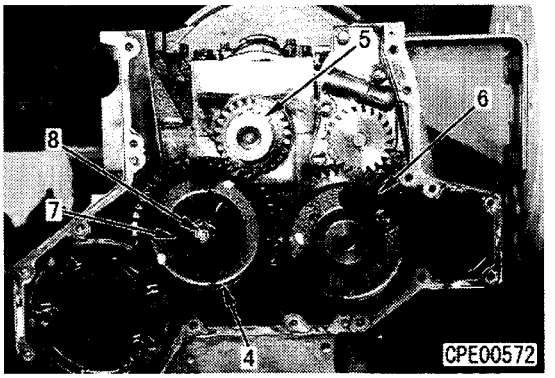


8. Oil pump, idler gear

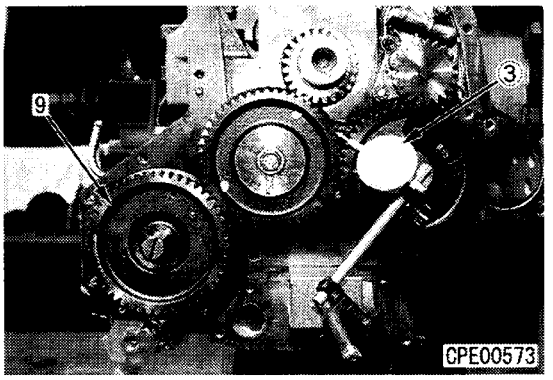
1) Installation of oil pump
   a) Install oil pump driven gear (1).
   b) Install oil pump drive gear (2).
      ★ There is a spacer fitted to mounting bolt (3).
   c) Measure end play of oil pump gear.
      Permissible range for end play :
      0.02 – 0.07 mm



2) Installation of idler gear
   a) Align gear counter marks and install idler gear (4).
      ★ Counter marks
      Crankshaft gear (5) and idler gear (4): **A**
      Idler gear (5) and cam gear (6): **B**
   b) Fit plate (7) and tighten idler gear mounting bolt (8).
   kgm Idler gear mounting bolt :
   110.0 ± 12.3 Nm {11.25 ± 1.25 kgm}



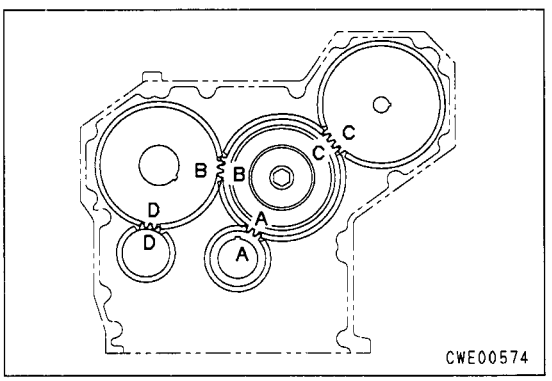
   c) Put dial gauge in contact with end face of idler gear, move idler gear to front and rear, and measure end play.
      Permissible range for end play :
      0.03 – 0.09 mm
      ★ Measuring backlash for each gear
      Install fuel injection pump assembly (9) temporarily, then use dial gauge ③ to measure the backlash of each gear.
      ★ When measuring the backlash of each gear, hold one gear in position and move the gear to be measured.



      ★ Gear backlash (helical gear)

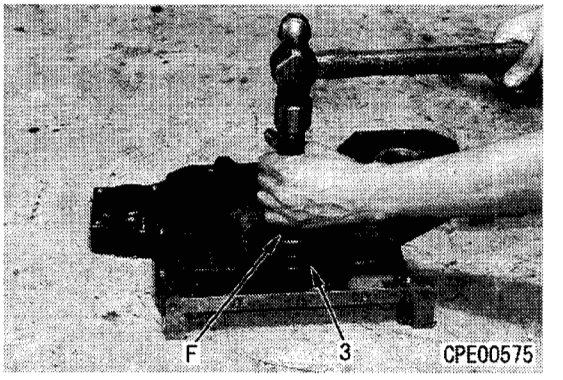
Unit : mm

Counter mark	Measurement place	Range
A-A	Crankshaft gear and idler gear	0.08 – 0.29
B-B	Cam gear and idler gear	0.08 – 0.19
C-C	Fuel injection pump gear and idler gear	0.07 – 0.29
D-D	Cam gear and oil pump gear	0.07 – 0.29

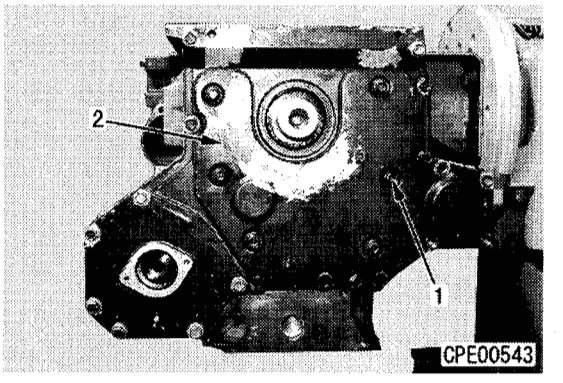


9. Gear case cover

1) Using push tool **F** (outside diameter: 72 mm), install front oil seal (3).
2) After press fitting front oil seal, fill 40 – 60% of space at seal lip with grease.
   Front oil seal : **Grease (G2-LI)**
3) Coat cylinder block mounting surface with gasket sealant.
   Cylinder block :
   Gasket sealant (LG-7)

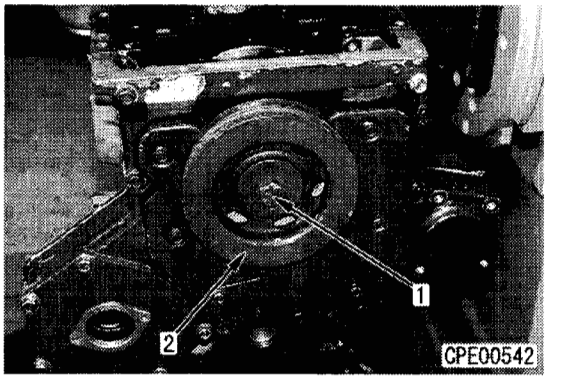


4) Fit gear case cover (2), and tighten with mounting bolts (1).
5) Measure stepped difference at mounting surface
   Measure the stepped difference at the mounting surface of the gear case cover and cylinder block oil pan.
   ★ Permissible limit for stepped difference at oil pan mount: Within 0.15 mm



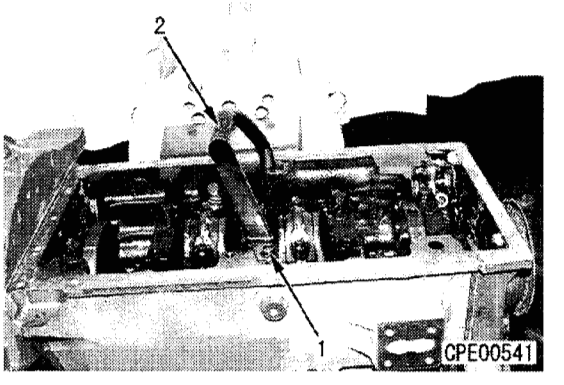
10. Crankshaft pulley

1) Align with key of crankshaft and install crankshaft pulley (2).
2) Fit plate and tighten mounting bolts (1).
   kgm Mounting bolt :
   93.0 ± 4.9 Nm {9.5 ± 0.5 kgm}



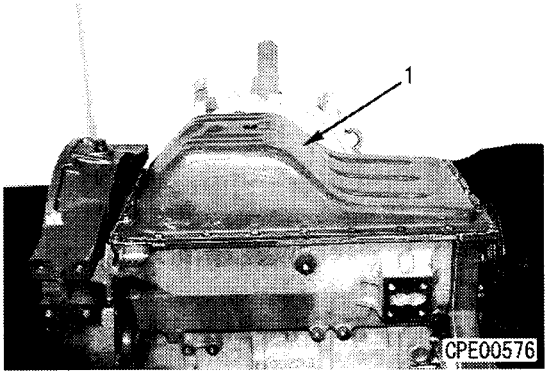
11. Oil suction pipe

1) Fit O-ring and install oil suction pipe (2) to cylinder block.
2) Tighten mounting bolts (1).



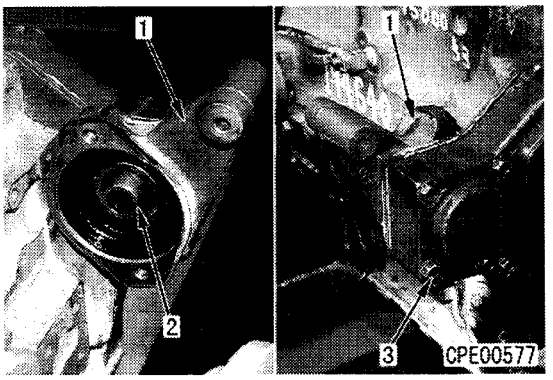
12. Oil pan

1) Coat oil pan mounting surface of cylinder block with gasket sealant.
2) Fit oil pan (1), and tighten mounting bolts.
   - Cylinder block : **Gasket sealant (LG-7)**
   - kgm Mounting bolt : **32.0 ± 2.5 Nm {3.25 ± 0.25 kgm}**
   - kgm Drain plug : **59.0 ± 9.8 Nm {6.0 ± 1.0 kgm}**



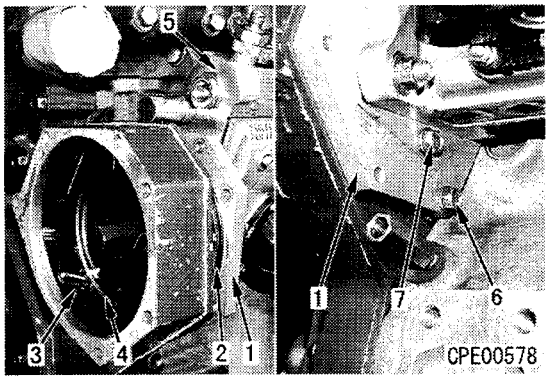
13. PTO shaft

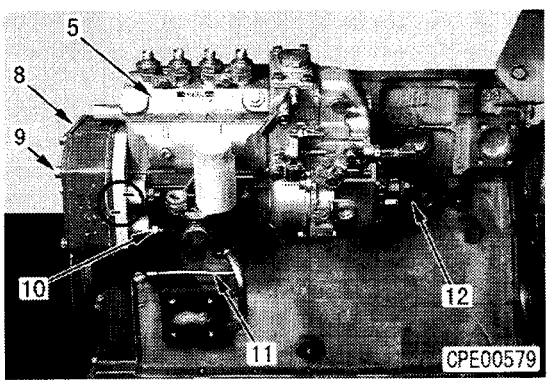
1) Align shaft (2) of PTO assembly (1) with camshaft gear, and assemble.
2) Install PTO assembly (1) with 4 mounting bolts (3).
   ★ Install the cover at the shaft end.



14. Fuel injection pump

1) Set head side of cylinder block facing up.
2) Fit O-ring (2) to holder (1), align counter mark **C-C** of drive gear (4) and idler gear (3), then insert in gear case together with fuel injection pump assembly (5).
3) Secure holder (1) to gear case with bolt (6).
4) Remove bolt (7), and secure drive gear (4) with other bolts.
   ★ Prepare a bolt with the same diameter and pitch as bolt (7).
   Remove bolt (7), insert the bolt through the hole, and screw the bolt into the drive gear bolt hole. When doing this, check that the counter marks are aligned.
5) Fit cover (8) and tighten with mounting bolts (9).
6) Tighten mounting nut (10) of fuel injection pump assembly (5) and holder (1).
   ★ Mark the holder and fuel injection pump, and the holder and gear case.
7) Remove the bolt holding the drive gear, then install bolt (7).
8) Install oil supply tube (11) and bracket (12).



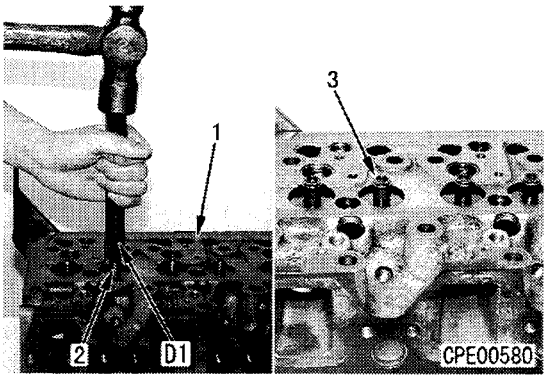


15. Cylinder head

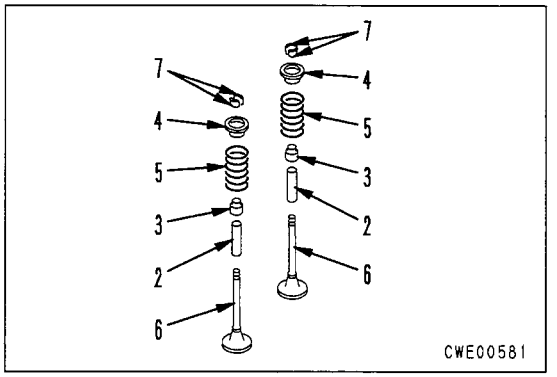
1) Assembly of cylinder head

i) Using push tool **D1**, install valve guide (2) to cylinder head (1).

ii) Install valve seal (3) to head of valve guide.



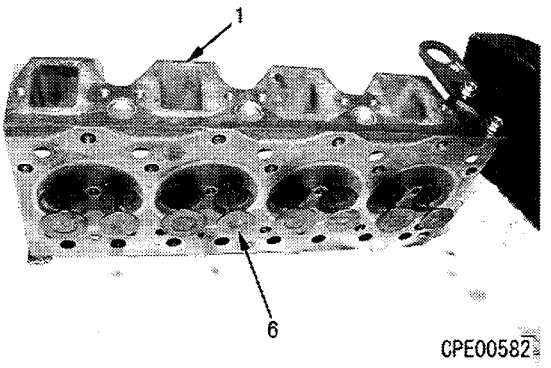
iii) Coat inside surface of valve guide and stem of intake and exhaust valves (6) with engine oil (SAE-30CD).



iv) Install intake and exhaust valves (6) to cylinder head (1).

★ Install in the order of intake valve and exhaust valve starting from the timing gear case end.

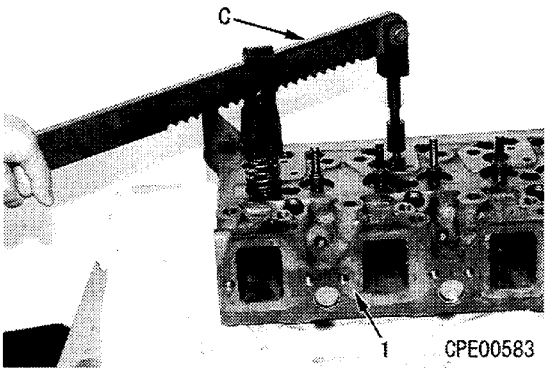
★ Check that there is no carbon stuck to the valve seat, cracks in valve seat, or other problems.



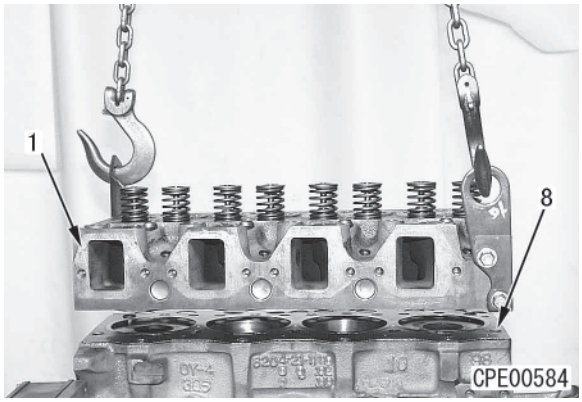
v) Using spring pusher **C**, compress valve spring (5), then fit valve cotter (7) into groove in valve stem.

★ Tap the top end face of the valve stem with a plastic hammer and check that the cotter is completely fitted.

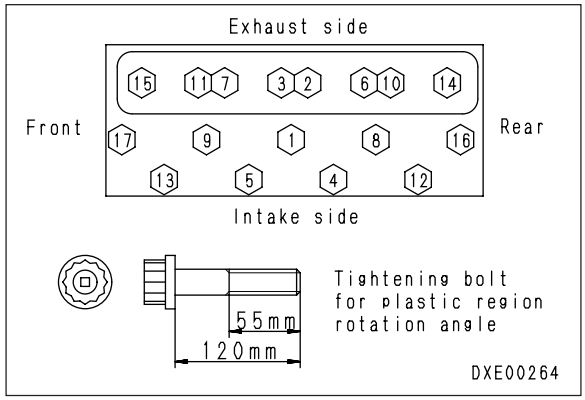
⚠ Be careful not to tap too much. There is danger that the cotter may fly out.



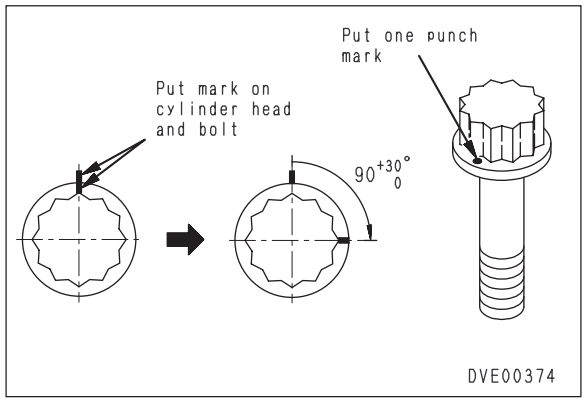
2) Installation of cylinder head
   ★ Check that there is no dirt on the mounting face of the cylinder head and cylinder block and that there is no dirt or dust inside the cylinder.
   i) Install cylinder head gasket (8).
      ★ Install with the TOP mark at the top.
   ii) Raise cylinder head (1), use 4 head bolts as guides, and install to cylinder block.



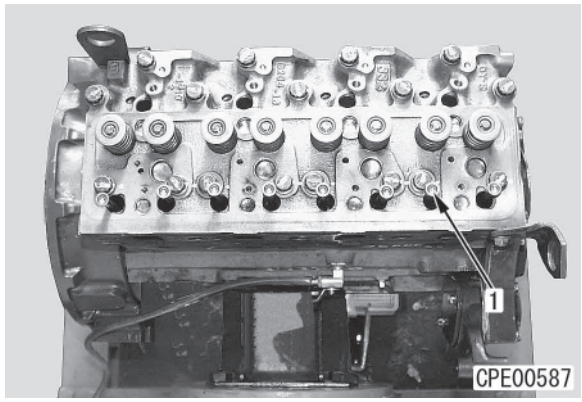
3) Tightening cylinder head
   Coat thread of cylinder head mounting bolts with molybdenum disulphide lubricant (LM-P) and tighten as follows in order shown in diagram.
   kgm Cylinder head mounting bolt :
   (Tightening torque using plastic turning angle tightening)
   1st step: **69 ± 9.8 Nm {7.0 ± 1.0 kgm}**
   2nd step:
   168.0 ± 4.9 Nm {11.0 ± 0.5 kgm}
   3rd step: Mark bolt head and cylinder head, then turn bolt $90^{+30^\circ}_{0}$ to tighten.



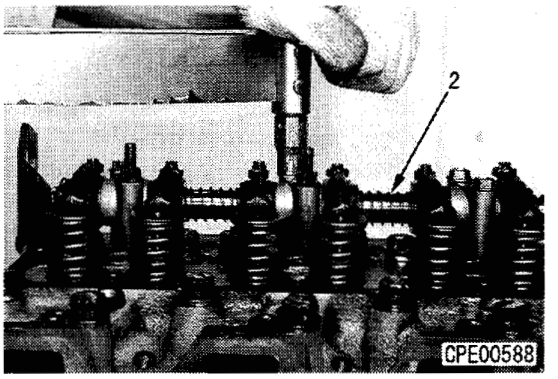
   ★ After tightening, make a punch mark on the bolt head to indicate the number of times the bolt has been tightened.
   ★ The bolt can be used a maximum of five times. Always replace any bolt that already has five punch marks.



4) Push rod
   Insert push rod (1) in tappet guide.
   ★ The push rods use the same part for both the intake and exhaust sides.
   ★ If there is no abnormality in the push rod, assemble it to the same position as it was at disassembly.



5) Rocker arm assembly
   a) Install rocker arm assembly (2).
   b) Check that ball of adjustment screw is fitted securely in socket of push rod, and tighten mounting bolts in turn.
      kgm Rocker arm mounting bolt:
      25.0 ± 4.9 Nm {2.5 ± 0.5 kgm}
   ★ Turn back the adjustment screw 3 – 4 turns.

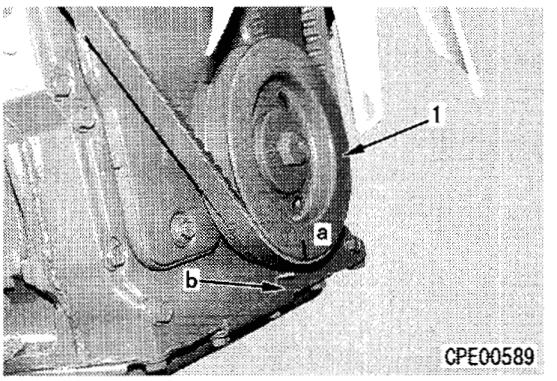


16. Adjustment of valve clearance

Adjust the valve clearance so that the clearance between the valve and rocker arm is the following value.

★ Standard value for valve clearance (both when warm and when cold)
   Intake valve: 0.35 mm;
   Exhaust valve: 0.50 mm

1) Rotate the crankshaft in the normal direction to align pointer **b** with the 1.4 TOP mark **a** on crankshaft pulley (1). When rotating, check the movement of the intake valves of No. 4 cylinder.



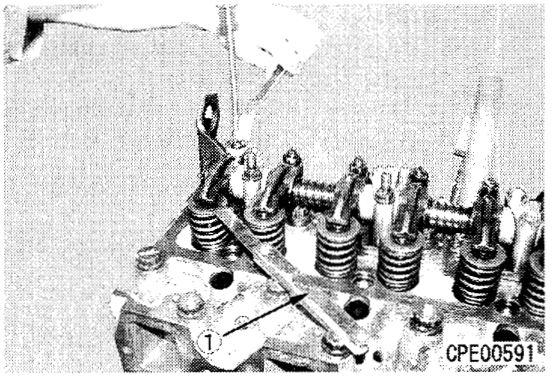
2) With No. 1 cylinder at compression top dead center, adjust valves marked ● in valve arrangement diagram. Then rotate crankshaft a further 360° and adjust valves marked ○.

Valve arrangement

Cylinder No.	1		2		3		4	
Exhaust valve		●		●		○		○
Intake valve	●		○		●		○	

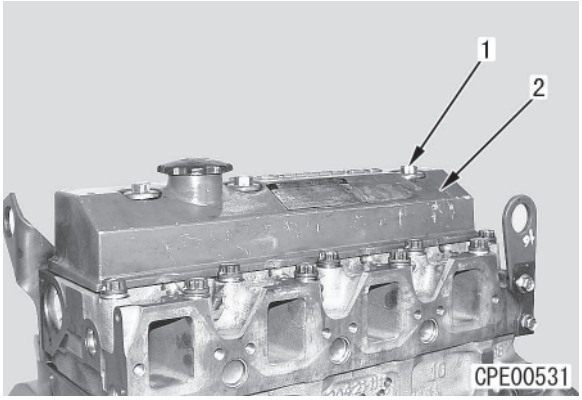
TDP00308

3) To adjust, insert feeler gauge ① between rocker lever and valve stem, turn adjustment screw until clearance is a sliding fit, then tighten locknut.
   kgm Locknut:
   44.0 ± 4.9 Nm {4.5 ± 0.5 kgm}
4) It is also possible to set the No. 1 cylinder to compression top dead center and adjust the valves of the No. 1 cylinder, then rotate 180° each time and adjust the valve clearance of the other cylinders according to firing order.
   Firing order: 1 – 2 – 4 – 3



17. Head cover

1) Install O-ring to cylinder head cover.
2) Fit cylinder head cover (2) to cylinder head, then tighten with 3 nuts (1).
   ★ Check that there is no damage to the gasket before installing.

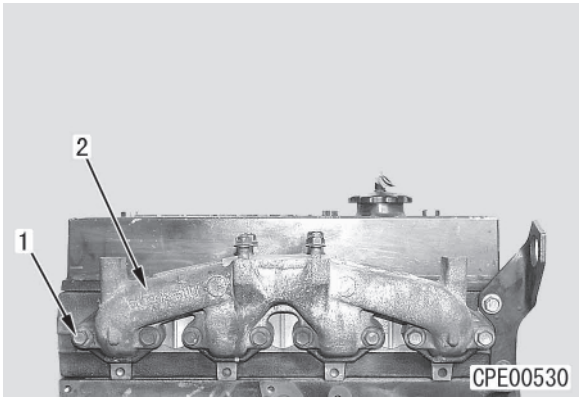


18. Exhaust manifold

Fit gasket to exhaust manifold (2), and install to cylinder block with mounting bolt (1).

★ Install the gasket stamped 6205 at the manifold end.

kgm Mounting bolt :
44.0 ± 9.8 Nm {4.5 ± 1.0 kgm}



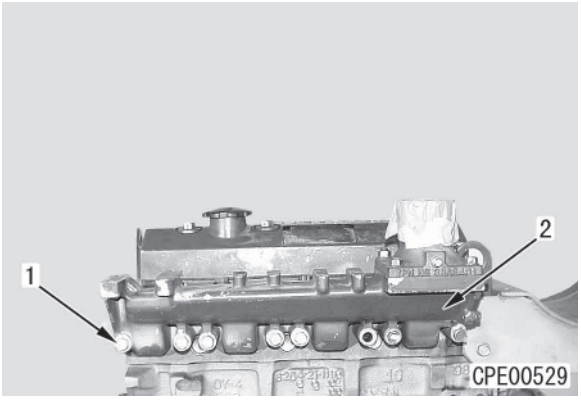
19. Intake manifold

Coat intake manifold with gasket sealant and install to cylinder block with mounting bolt (1).

Mounting surface :
Gasket sealant (LG-7)

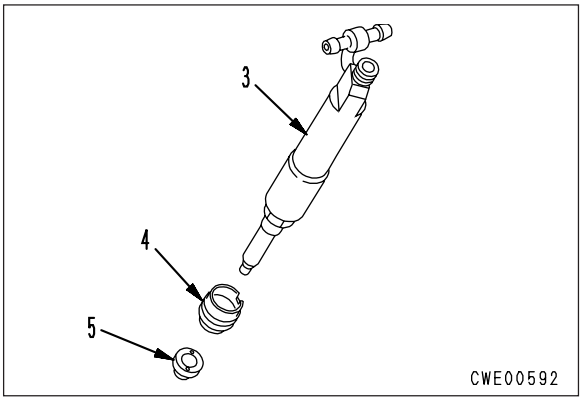
kgm Mounting bolt :
40.0 ± 4.9 Nm {4.1 ± 0.6 kgm}

★ Coat the gasket sealant in a line with a width of approximately ø1 mm.

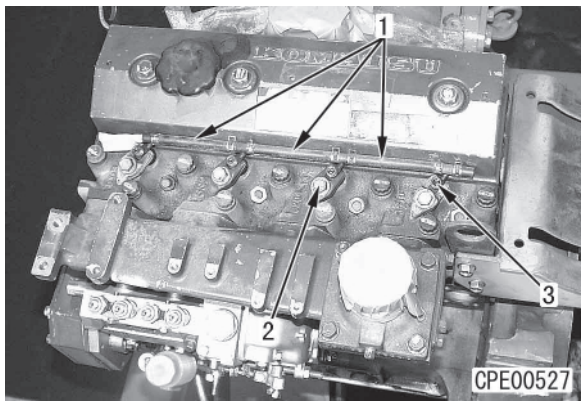


20. Injection nozzle

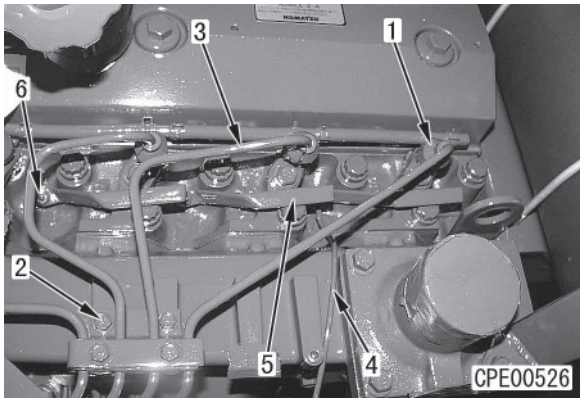
1) Install dust seal (4) to nozzle holder.
2) Install copper gasket (5) to nozzle holder.



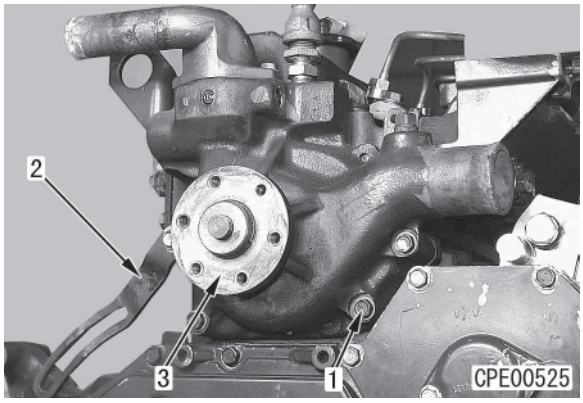
3) Insert nozzle holder (3) in cylinder head and tighten holder (2).
   kgm Holder mounting bolt :
   44.0 ± 4.9 Nm {4.5 ± 0.5 kgm}
4) Install spill hoses (1).



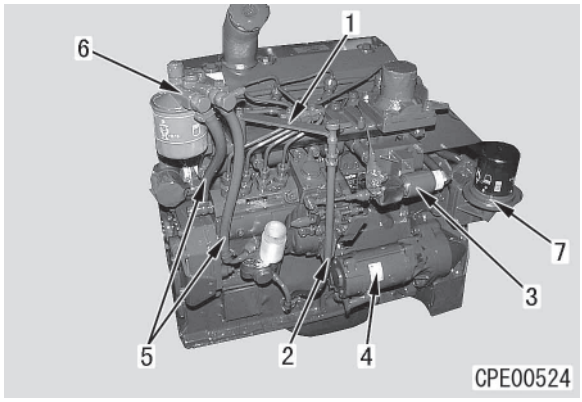
21. Fuel injection pipe, glow plug
1) Fit glow plug (6) to cylinder head and install lead (5) and wiring connector (4),.
2) Tighten lead (5) and wiring connector (4) with nut of glow plug.
3) Fit fuel injection tube (3) to injection nozzle and install boot (1).
   ★ Before installing the fuel injection pipe, blow with compressed air to clean the inside of the pipe.
   ★ Tighten the sleeve nuts at the fuel injection pump end in the same way.
4) Tighten 2 bracket mounting bolts (2).
   kgm Sleeve nut :
   23.0 ± 2.0 Nm {2.3 ± 0.3 kgm}



22. Water pump
1) Fit gasket to mounting surface and O-ring to pilot portion, then install water pump assembly (3).
2) Fit adjustment plate (2) for alternator, and tighten 4 mounting bolts (1).

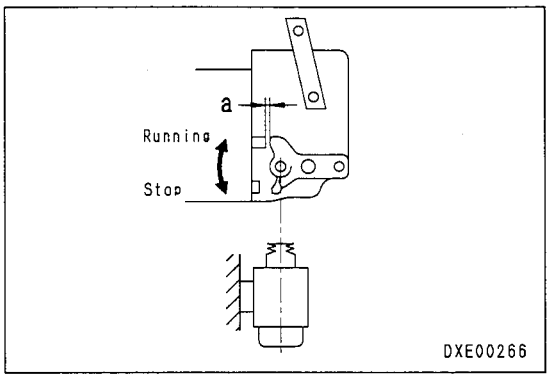


23. Starting motor, engine stop solenoid, fuel and engine oil filters, dipstick
1) Install engine oil filter (7) to engine block together with tube.
2) Fit fuel filter assembly (6) to intake manifold, and install fuel hoses (5) to fuel injection pump.

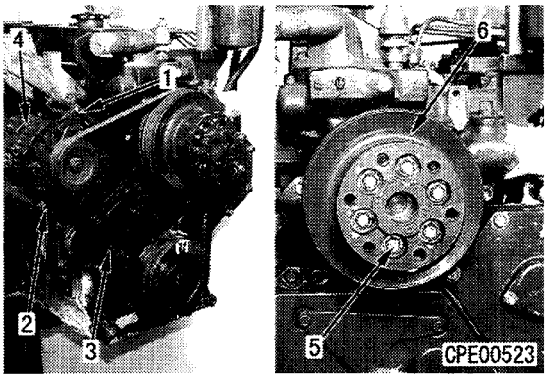


3) Install starting motor (4).
4) Install engine stop solenoid (3).
   ★ Adjust clearance **A**.
   For details, see TESTING AND ADJUSTING.
5) Fit dipstick (2) to engine block and install bracket (1).
   ★ Fill engine with oil.

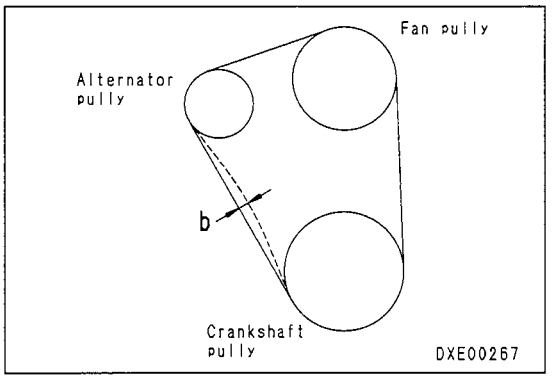
Engine oil : **6 ℓ (SAE-30CD)**



24. Alternator, fan pulley
1) Fit fan pulley (6) to water pump drive shaft, and tighten with mounting bolts (5).
2) Fit alternator assembly (4) to PTO housing, and install mount bolt (2).
3) Fit fan belt (3), insert a bar between alternator and cylinder block, raise to outside while watching belt tension, and tighten lock bolt (1).

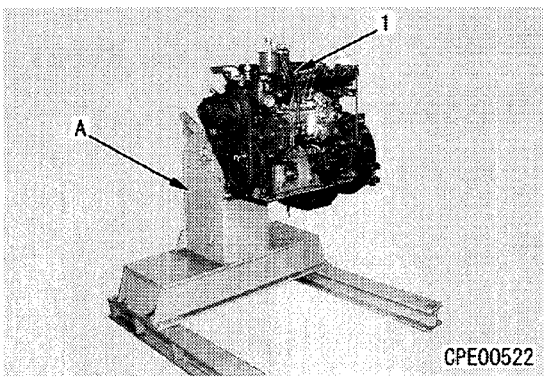


★ Adjust so that the belt deflects the amount shown below when the belt is pressed with a finger pressure of 59.0 N {approx. 6 kg} at a point midway between the crankshaft pulley and alternator.
   Deflection of fan belt : 14 – 17 mm
★ After adjusting, tighten the bolts.

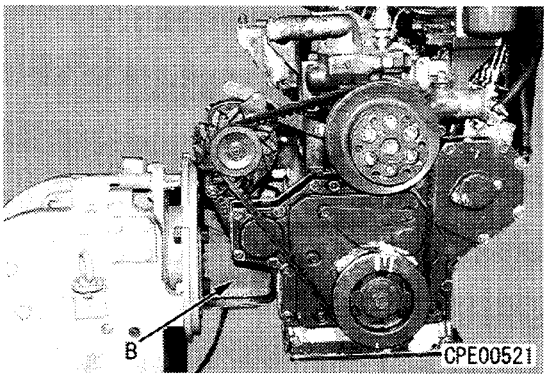


25. Engine assembly
1) Sling engine assembly (1).

kg Engine assembly : **300 kg**
(The weight differs according to the machine model.)

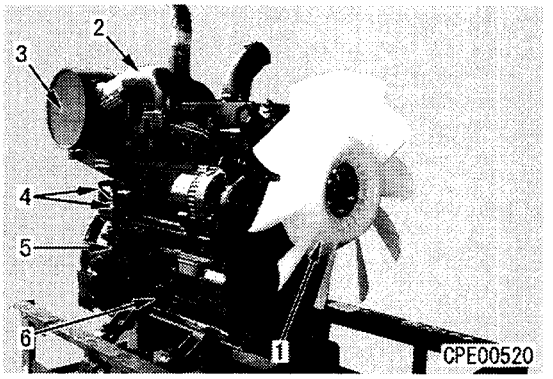


2) Disconnect engine assembly (1) from engine repair stand **A**, and remove bracket **B** from engine assembly (1).



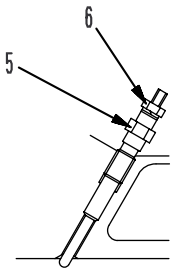
26. Fan, exhaust pipe, muffler, engine oil tube, block, cover

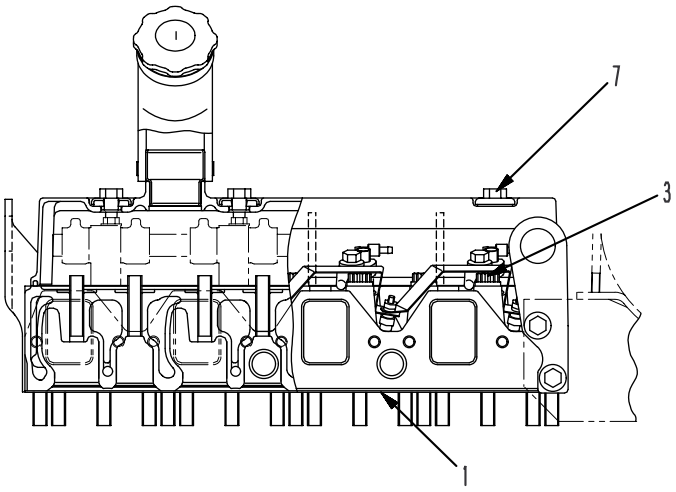
1) Set engine assembly to engine stand.
2) Install cover (6).
3) Fit block (5) to tube (4), then install to cylinder block.
4) Install muffler (3).
5) Fit gasket to exhaust manifold, then install exhaust pipe (2).
6) Install fan (1) to fan pulley.

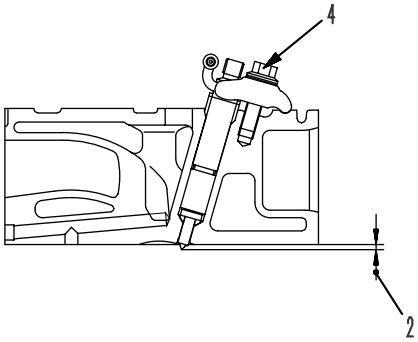


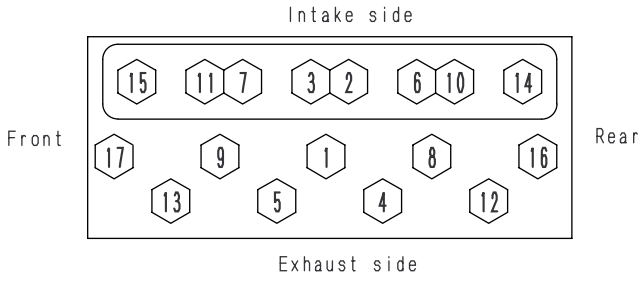
ENGINE
14 MAINTENANCE STANDARD

CYLINDER HEAD









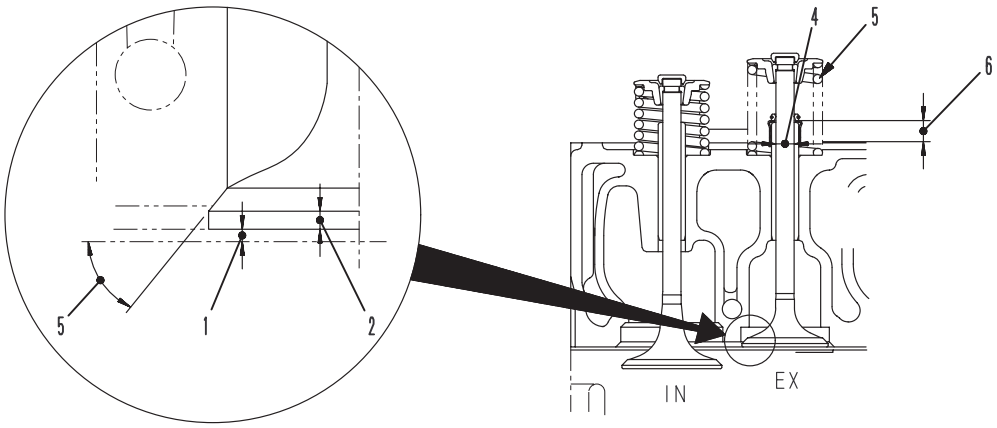
3. Tightening order of cylinder head bolt

SXE01338

Unit: mm

No.	Check item	Criteria			Remedy
1	Distortion of cylinder head mounting surface	Standard		Repair limit	Repair by grinding or replace
		0 – 0.05		0 – 0.30	
2	Protrusion of hot plug	3.12 ± 0.28		2.7 – 3.5	Replace nozzle gasket
3	Tightening torque of cylinder head mounting bolt (Coat bolt threads and washers with molybdenum disulphide (LM-P))	Order	Target Nm {kgm}	Range Nm {kgm}	Retighten, following order of above figure
		1st step	68.6 {7}	58.8 – 78.4 {6 – 8}	
		2nd step	107.8 {11}	102.9 – 112.7 {10.5 – 11.5}	
		3rd step	Retighten 90°	$90^{+30°}_{0}$	
		Tightening bolt for plastic region rotation angle			
4	Tightening torque of nozzle holder	Target Nm {kgm}		Range Nm {kgm}	Retighten
		44 {4.5}		39 – 49 {4 – 5}	
5	Tightening torque of glow plug	17 {1.75}		15 – 20 {1.5 – 2.0}	
6	Tightening torque of terminal nut	2.2 {0.225}		2.0 – 2.5 {0.2 – 0.25}	
7	Tightening torque of head cover mounting bolt	8.8 {0.9}		7.8 – 9.8 {0.8 – 1.0}	

VALVE, VALVE GUIDE

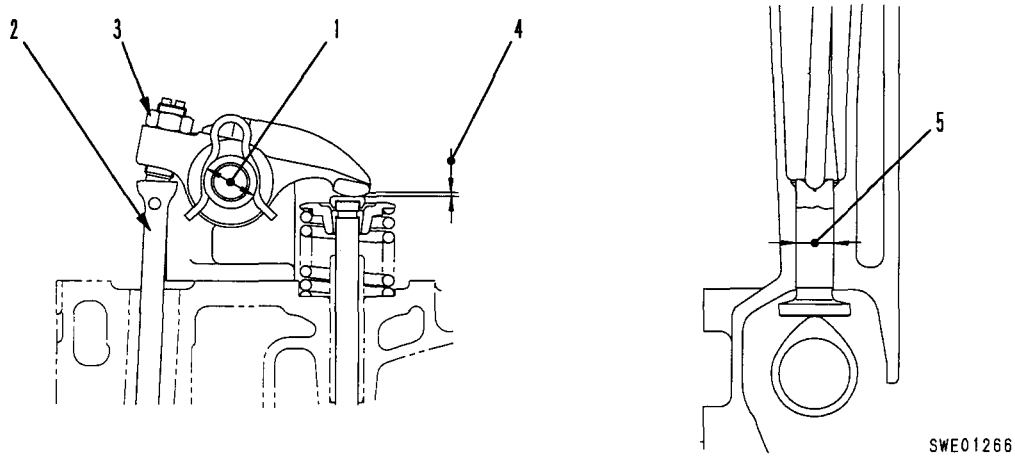


SWE01823 Unit: mm

No.	Check item	Criteria						Remedy
1	Sinking of valve	Tolerance			Repair limit			Repair valve or valve seat
		0 ± 0.18			1.00			
2	Thickness of valve head	14.0 – 16.0			1.00			Replace
3	Valve seat angle	Standard		Tolerance		Repair limit		Correct valve or valve seat, or replace
		45°		±15′		Judge contact surface condition with vacuum test		
4	Clearance between valve guide and valve stem	Standard size		Tolerance		Standard clearance	Clearance limit	Replace either valve or valve guide or both
				Shaft	Hole			
		Intake	8	–0.035 –0.050	+0.015 0	0.035 – 0.065	0.20	
		Exhaust	8	–0.050 –0.065	+0.015 0	0.050 – 0.080	0.20	
5	Free length of valve spring	Part No. (distinguishing feature)		Standard size		Repair limit		Replace
		6204-41-4410 (Peach-color)		49.2		48.5		
		6204-41-4431 (Red)		56.0		55.0		
	Installed load of valve spring	Part No. (distinguishing feature)		Installed length		Standard load N {kg}	Load limit N {kg}	
		6204-41-4410 (Peach-color)		40.5		181 ± 8.8 {18.5 ± 0.9}	162 {16.5}	
		6204-41-4431 (Red)		40.5		153 ± 14.7 {15.6 ± 1.5}	127 {13.0}	
	Out-of-square of valve spring	Repair limit: 18.5°						
6	Driving-in height of valve guide	Standard size			Tolerance			Correct
		14.5			± 0.2			

★ 4D95LE-2 engine: No valve seat insert (EX, IN)

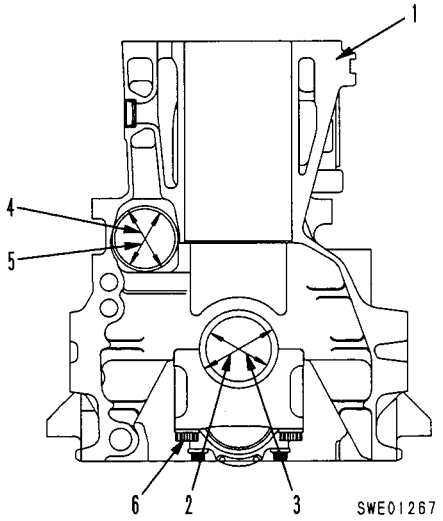
ROCKER ARM SHAFT, PUSH ROD AND TAPPET



Unit: mm

No.	Check item	Criteria			Remedy
1	Outside diameter of rocker arm shaft	Standard: 19	Tolerance: 0 / –0.020		Replace rocker arm shaft
	Inside diameter of rocker arm shaft hole	19	+0.030 / +0.010		Replace rocker arm
	Clearance between rocker arm and rocker arm shaft	Standard clearance: 0.010 – 0.050	Clearance limit: 0.12		Replace rocker arm or rocker arm shaft
	Bend of rocker arm shaft	Repair limit: 0.20 (Total indicated runout)			Replace rocker arm shaft
2	Bend of push rod	Repair limit: 0.30 (Total indicated runout)			Replace push rod
3	Tightening torque of adjustment nut of rocker arm	Target Nm {kgm}: 44 {4.5}	Range Nm {kgm}: 39 – 49 {4 – 5}		Retighten
4	Valve clearance (at warm and cold)	Valve	Standard	Tolerance	Adjust
		Intake	0.35	±0.02	
		Exhaust	0.50	±0.02	
5	Outside diameter of tappet	Standard: 16	Tolerance: –0.015 / –0.030		Replace tappet
	Inside diameter of tappet hole	16	+0.018 / 0		Replace cylinder block
	Clearance between tappet and tappet hole	Standard clearance: 0.015 – 0.048	Clearance limit: 0.12		Replace tappet or cylinder block

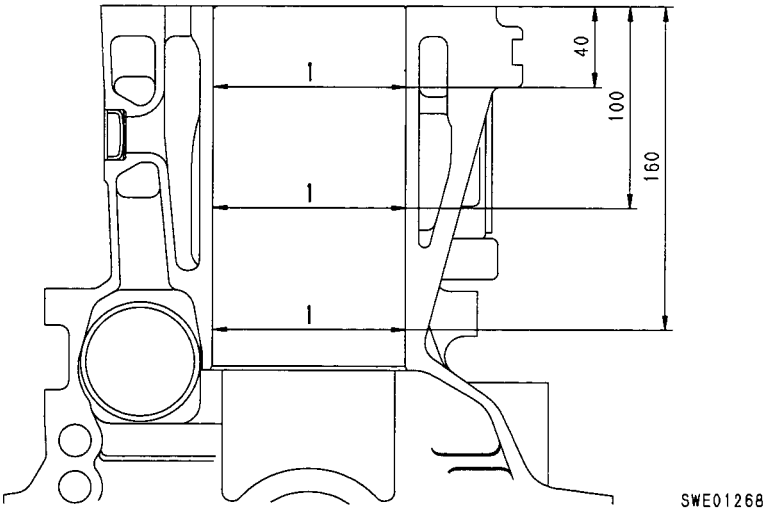
CYLINDER BLOCK



Unit: mm

No.	Check item	Criteria				Remedy
1	Distortion of cylinder head mounting surface	Standard: 0 – 0.08		Repair limit: 0.15		Replace by grinding
2	Inside diameter of main bearing hole	Standard: 74		Tolerance: +0.019 0		Repair or replace cylinder block
	Roundness of main bearing hole	Repair limit: 0.005				
	Straightness of main bearing holes	Repair limit: 0.010				
3	Inside diameter of main bearing		Standard size	Tolerance	Repair limit	Replace main bearing
		STD	70.00	+0.103 +0.058	70.20	
		0.25 U.S.	69.75		69.95	
		0.50 U.S.	69.50		69.70	
		0.75 U.S.	69.25		69.45	
		1.00 U.S.	69.00		69.20	
4	Inside diameter of cam bushing hole	Standard: 53.5		Tolerance: +0.030 0		Repair or replace cylinder block
5	Inside diameter of cam bushing	Journal: No. 1	Standard: 50.5	Tolerance: +0.030 –0.040	Repair limit: 50.60	Replace
	Inside diameter of cylinder block	No. 2 No. 3	50.5	–0.031 –0.050	50.60	Press fit bushing
6	Tightening torque of main bearing cap mounting bolts (Coat bolt threads and washers with engine oil)	Order	Target Nm {kgm}	Range Nm {kgm}		Retighten
		1st step	113 {11.5}	108 – 118 {11 – 12}		
		2nd step	0 {0}	Loosen completely		
		3rd step	132 {13.5}	127 – 137 {13 – 14}		

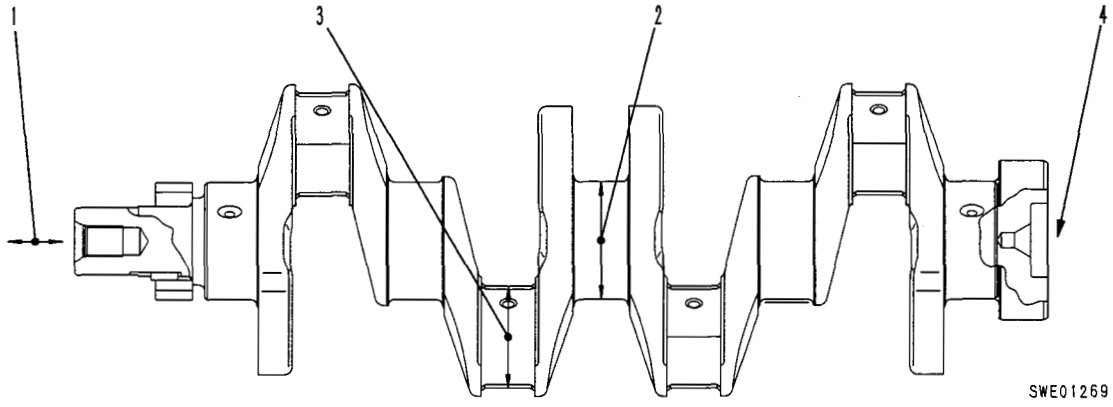
CYLINDER



Unit: mm

No.	Check item	Criteria				Remedy
1	Inside diameter		Standard size	Tolerance	Repair limit	Correct with oversize, or install cylinder liner, or replace cylinder block
		STD	95	+0.022 0	95.15	
		0.25 OS	95.25		95.40	
		0.50 OS	95.50		95.65	
	Roundness of inside diameter	Repair limit: 0.020				
	Cylindricity of inside diameter	Repair limit: 0.020				
	Procedure for overhaul size	Measure inside diameter at position 40, 100, and 160 from top surface of cylinder block. Use largest value to determine overhaul size. (1) If cylinder bore is less than 95.15: Select 0.25 oversize piston and machine cylinder bore in cylinder block to $95.25^{+0.022}_{0}$. (2) If cylinder bore is between 95.16 and 95.40: Select 0.50 oversize piston and machine cylinder bore in cylinder block to $95.50^{+0.022}_{0}$. (3) If cylinder bore is more than 95.40: Carry out stepped machining of cylinder block and insert cylinder liner. For details of the method for machining the cylinder block and selecting the cylinder liner, see REBUILDING AND REPLACING.				(When carrying out overhaul) Rank cylinder bore at top face of cylinder block and correct mark (S or L)

CRANKSHAFT

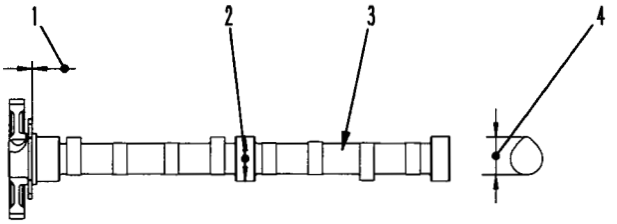


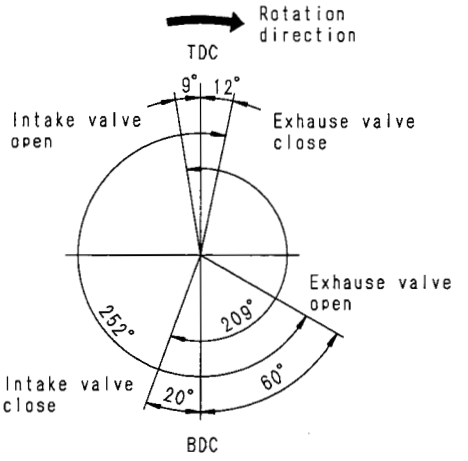
Unit: mm

No.	Check item	Criteria				Remedy
1	End play	Standard		Repair limit		Repair by using over size thrust bearing or replace
		0.131 – 0.351		0.40		
2	Outside diameter of main journal		Standard size	Tolerance	Repair limit	Repair by using under size bearing or replace
		STD	70.00	+0.015 0	69.86	
		0.25 U.S.	69.75		69.61	
		0.50 U.S.	69.50		69.36	
		0.75 U.S.	69.25		69.11	
		1.00 U.S.	69.00		68.86	
	Roundness of main journal	Repair limit: 0.020				
	Clearance of main journal	Standard clearance		Clearance limit		Replace main bearing
		0.043 – 0.103		0.25		
3	Outside diameter of crankpin journal		Standard size	Tolerance	Repair limit	Repair by using under size bearing or replace
		STD	57.00	+0.015 0	56.91	
		0.25 U.S.	56.75		56.66	
		0.50 U.S.	56.50		56.41	
		0.75 U.S.	56.25		56.16	
		1.00 U.S.	56.00		55.91	
	Roundness of crankpin journal	Repair limit: 0.020				
	Clearance of crankpin journal	Standard clearance		Clearance limit		Replace connecting rod bearing
		0.029 – 0.089		0.22		
4	Bend of crankshaft	Repair limit: 0.09 (Total indicated runout)				Repair by using under size bearing or replace

CAMSHAFT

(Bushing installed to journal No. 2 and 3)





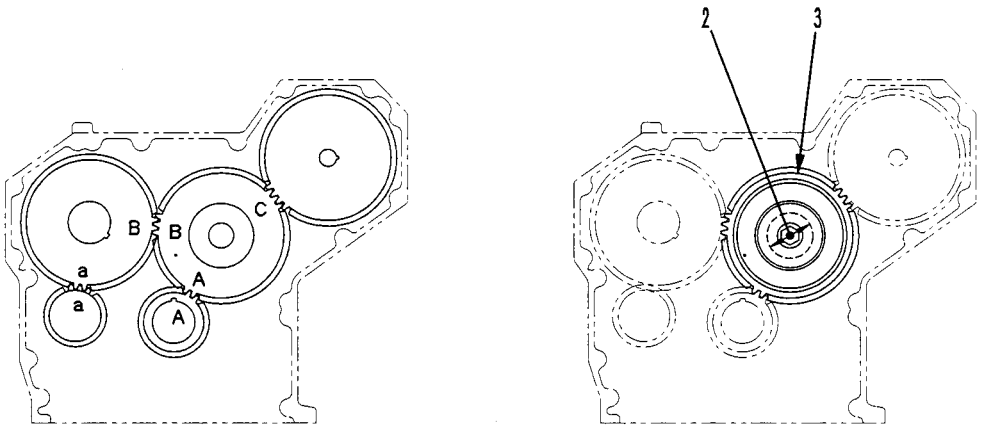
5. Valve timing

SXE01339

Unit: mm

No.	Check item	Criteria							Remedy
1	End play	Standard size			Repair limit				Replace thrust plate
		0.150 – 0.350			0.5				
2	Outside diameter of camshaft bearing journal	Journal	Standard size	Tolerance		Standard clearance	Clearance limit		Replace bushing
				Shaft	Hole				
		No.1 No.2 No.3	50.5	–0.080 –0.110	+0.030 –0.040	0.040 – 0.140	0.25		
3	Curvature of camshaft	Repair limit: 0.03 (Total deflection of indicator)							
4	Height of camshaft	Standard size		Tolerance		Repair limit			Replace
		Intake	42.69	±0.10		42.2			
		Exhaust	43.04			42.5			
5	Valve timing	Valve position	Crankshaft angle			When testing (Crankshaft angle when valve has gone down 1 mm)			Check for curvature or wear of valve, camshaft, push rod. Correct or replace
						Standard		Tolerance	
		Intake open	Before TDC	9°		Before TDC	8°	±3°	
		Intake closed	After BDC	20°		After BDC	4°		
		Exhaust open	Before BDC	60°		Before BDC	45°		
		Exhaust closed	After TDC	12°		After TDC	9°		

TIMING GEAR



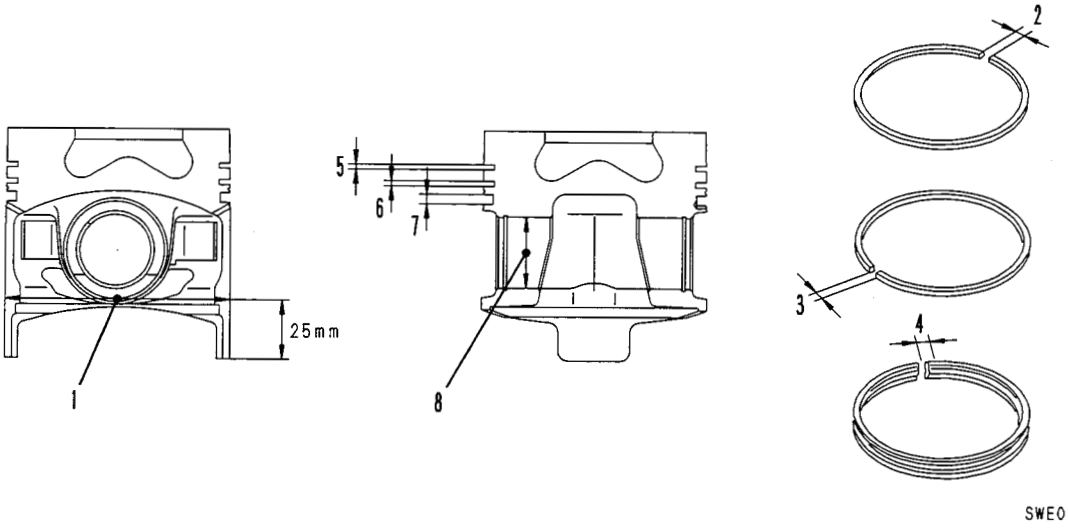
1. Gear backlash

SXE01340

Unit: mm

No.	Check item	Criteria				Remedy
1	Backlash of each gear	Measuring point	Gears	Standard	Repair limit	Replace bushing or gear
		A	Crankshaft gear and idler gear	0.08 – 0.29	0.04	
		B	Idler gear and camshaft gear	0.09 – 0.19		
		C	Idler gear and fuel injection pump gear	0.07 – 0.29		
		a	Camshaft gear and oil pump gear	0.07 – 0.29		
2	Clearance between idler gear bushing and shaft	Standard size	Tolerance: Shaft	Tolerance: Hole	Standard clearance	Clearance limit
		45	0 –0.015	+0.035 +0.015	0.015 – 0.050	0.10
3	End play of idler gear	Standard			Repair limit	Replace idler shaft, thrust plate or gear
		0.03 – 0.09			0.20	

PISTON, PISTON RING AND PISTON PIN

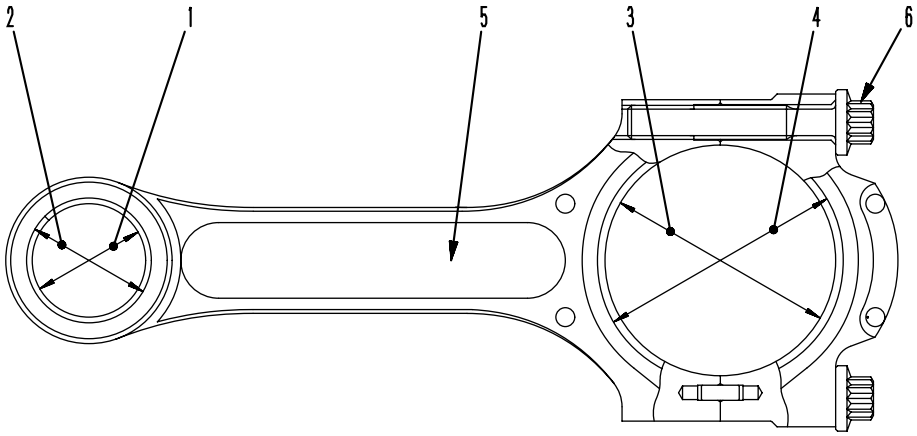


SWE01272

Unit: mm

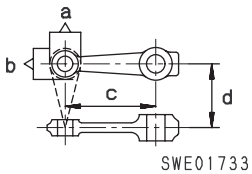
No.	Check item	Criteria					Remedy
1	Outside diameter of piston (at right angle to boss)		Standard size	Size mark	Tolerance	Repair limit	Replace piston (only S size supplied as replacement part)
		STD	95.00	L	−0.045 −0.060	94.85	
		0.25 O.S.	95.25			95.10	
		0.50 O.S.	95.50	S	−0.060 −0.075	95.35	
2 3 4	Piston ring gap	No.	Measuring point	Standard clearance	Clearance limit		Replace piston ring or liner
		2	Top ring	0.30 – 0.45	2.0		
		3	Second ring	0.30 – 0.45	2.0		
		4	Oil ring	0.25 – 0.45	1.5		
5 6 7	Clearance between piston ring groove and piston ring	No.	Measuring point	Standard size	Tolerance: Ring	Tolerance: Piston	Standard clearance / Clearance limit	Replace piston ring or piston
		5	Top ring	2	−0.01 −0.03	+0.07 +0.05	0.06 – 0.10 / 0.15	
		6	Second ring	2	−0.01 −0.03	+0.04 +0.02	0.03 – 0.07 / 0.20	
		7	Oil ring	4	−0.01 −0.03	+0.04 +0.02	0.03 – 0.07 / 0.15	
8	Clearance between piston and piston pin	Standard size	Tolerance: Shaft	Tolerance: Hole	Standard clearance	Clearance limit	Replace piston or piston pin
		30	0 −0.006	+0.012 +0.004	0.004 – 0.018	0.05	

CONNECTING ROD

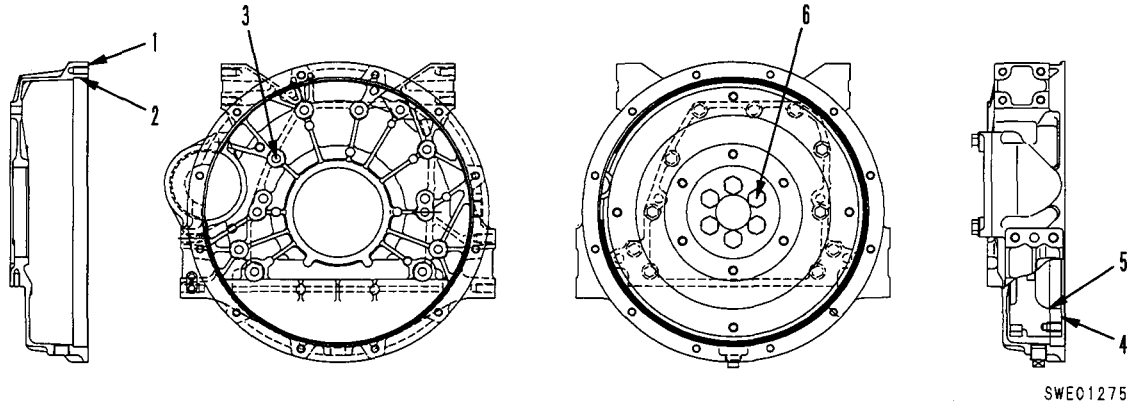


SWE01273

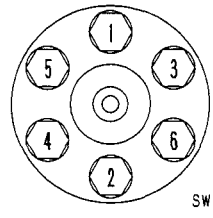
Unit: mm

<table>
<tr><th>No.</th><th>Check item</th><th colspan="6">Criteria</th><th>Remedy</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Clearance between connecting rod bushing and piston pin
(carry out reaming after press fitting)</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="2">Replace bushing (semi-finished part supplied as replacement part)</td></tr>
<tr><td>Shaft</td><td>Hole</td></tr>
<tr><td>30</td><td>0
–0.006</td><td>+0.033
+0.020</td><td>0.020 –
0.039</td><td>0.10</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Inside diameter of connecting rod bushing hole</td><td colspan="3">Standard</td><td colspan="2">Tolerance</td><td rowspan="2">Replace connecting rod</td></tr>
<tr><td colspan="3">33</td><td colspan="2">+0.025
0</td></tr>
<tr><td rowspan="6">3</td><td rowspan="6">Inside diameter of connecting rod bearing</td><td></td><td colspan="2">Standard size</td><td>Tolerance</td><td colspan="2">Repair limit</td><td rowspan="6">Replace connecting rod bearing</td></tr>
<tr><td>STD</td><td colspan="2">57.00</td><td rowspan="5">+0.095
+0.045</td><td colspan="2">57.20</td></tr>
<tr><td>0.25 U.S.</td><td colspan="2">56.75</td><td colspan="2">56.95</td></tr>
<tr><td>0.50 U.S.</td><td colspan="2">56.50</td><td colspan="2">56.70</td></tr>
<tr><td>0.7 U.S.</td><td colspan="2">56.25</td><td colspan="2">56.45</td></tr>
<tr><td>1.00 U.S.</td><td colspan="2">56.00</td><td colspan="2">56.20</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">Inside diameter of connecting rod bearing hole</td><td colspan="3">Standard</td><td colspan="2">Tolerance</td><td rowspan="6">Replace connecting rod</td></tr>
<tr><td colspan="3">61</td><td colspan="2">+0.025
0</td></tr>
<tr><td rowspan="5">5</td><td rowspan="5">Bend and twist of connecting rod</td><td colspan="3" rowspan="5"> 
SWE01733</td><td></td><td>Standard</td><td>Repair limit</td></tr>
<tr><td>Bend a</td><td>Max. 0.20</td><td>0.25</td></tr>
<tr><td>Twist b</td><td>Max. 0.30</td><td>0.35</td></tr>
<tr><td>Dimension c</td><td>167</td><td>—</td></tr>
<tr><td>Dimension d</td><td>167</td><td>—</td></tr>
<tr><td rowspan="4">6</td><td rowspan="4">Tightening torque of connecting rod cap mounting bolts
(Coat bolt threads and washers with engine oil)</td><td colspan="2">Order</td><td colspan="2">Target Nm {kgm}</td><td colspan="2">Range Nm {kgm}</td><td rowspan="4">Retighter</td></tr>
<tr><td colspan="2">1st step</td><td colspan="2">39.2 {4}</td><td colspan="2">37.2 – 41.2
{3.8 – 4.2}</td></tr>
<tr><td colspan="2">2nd step</td><td colspan="2">Retighten with 90°</td><td colspan="2">$90^{+30°}_{0}$</td></tr>
<tr><td colspan="2"></td><td colspan="4">Tightening bolt for plastic region rotation angle</td></tr>
</table>

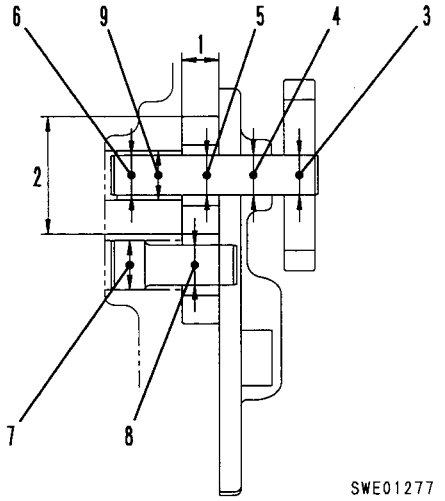
FLYWHEEL AND FLYWHEEL HOUSING



Unit: mm

No.	Check item	Criteria				Remedy
1	Face runout of flywheel housing	Repair limit: 0.35				Repair by reassembling
2	Radial runout of flywheel housing	Repair limit: 0.30				
3	Tightening torque of flywheel housing mounting bolts	68.6 ± 4.9 Nm {7 ± 0.5 kgm}				
4	Radial runout of flywheel housing	Repair limit: 0.15				
5	Face runout of flywheel	Repair limit: 0.20				
6	Tightening torque of flywheel mounting bolts (Coat bolt threads and washers with engine oil)	 SWE01276	Order	Target Nm {kgm}	Range Nm {kgm}	Retighten
			1st step	107.8 {11}	98 – 117.6 {10 – 12}	
			2nd step	191.1 {19.5}	186.2 – 196 {19 – 20}	

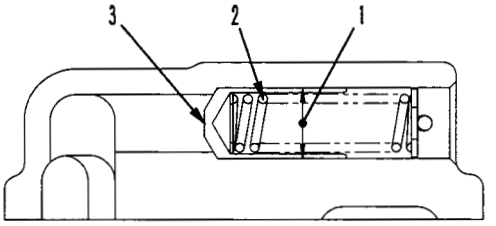
OIL PUMP



Unit: mm

No.	Check item	Criteria					Remedy
1	Axial clearance of pump gear	Standard size	Tolerance: Gear width	Tolerance: Body depth	Standard clearance (End play)	Clearance limit (End play)	Replace gear
		12	0 −0.015	−0.070 +0.030	0.030 – 0.085	0.10	
2	Radial clearance of pump gear	Standard size	Tolerance: Gear width	Tolerance: Body I.D.	Standard clearance	Clearance limit	
		38	+0.115 +0.065	+0.245 +0.205	0.045 – 0.090	0.13	
3	Interference between pump drive gear and drive shaft	Standard size	Tolerance: Shaft	Tolerance: Hole	Standard clearance or interference	Clearance or interference limit	Replace
		13	−0.024 −0.042	−0.065 −0.086	0.025 – 0.061	–	
4	Clearance between drive shaft and cover	13	−0.024 −0.042	+0.018 0	0.024 – 0.060	–	Replace bushing
5	Interference between pump gear and drive shaft	13	−0.024 −0.042	−0.065 −0.086	0.025 – 0.061	–	Replace
6	Clearance between drive shaft and bushing	13	−0.024 −0.042	+0.048 +0.004	0.028 – 0.09	–	Replace bushing
7	Clearance between driven shaft and cylinder block	16	−0.064 +0.046	+0.018 0	0.028 – 0.060	–	Replace cylinder block
8	Clearance between driven shaft and gear	13	−0.110 −0.125	−0.065 −0.086	0.024 – 0.060	–	Replace shaft or gear
9	Clearance between drive shaft bushing hole and cylinder block	16	−0.087 +0.060	+0.018 0	0.042 – 0.087	–	Replace cylinder block

REGULATOR VALVE

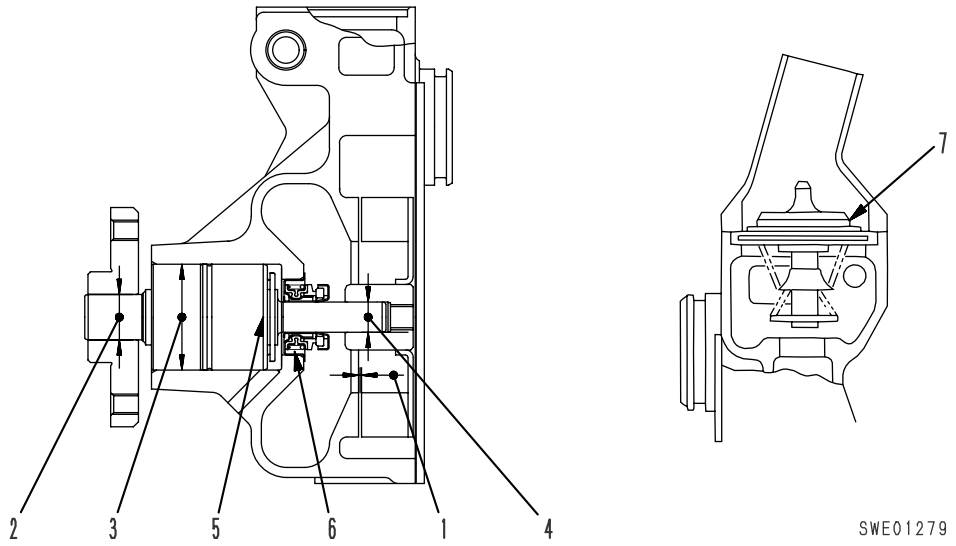


SWE01278

Unit: mm

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Check item</th><th colspan="5">Criteria</th><th rowspan="2">Remedy</th></tr>
<tr><td rowspan="2">Standard size</td><td colspan="2">Tolerance</td><td rowspan="2">Standard clearance</td><td rowspan="2">Clearance limit</td></tr>
<tr><td>Shaft</td><td>Hole</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Clearance between valve and body</td><td>11</td><td>–0.050
–0.077</td><td>+0.020
–0.020</td><td>0.030 –
0.097</td><td></td><td rowspan="4">Replace</td></tr>
<tr><td colspan="3">Standard</td><td colspan="2">Repair limit</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Regulator valve spring</td><td>Free length</td><td>Installation length</td><td>Installation load</td><td>Free length</td><td>Installation load</td></tr>
<tr><td>33.1</td><td>27.8</td><td>23.9 N
{2.44 kg}</td><td>–</td><td>22.6 N
{2.3 kg}</td></tr>
<tr><td>3</td><td>Regulator valve set pressure</td><td colspan="5">Standard: 0.5 ± 0.05 MPa {5.0 ± 0.5 kg/cm²}</td><td>Repair or replace spring</td></tr>
</table>

WATER PUMP, THERMOSTAT
(WITH SEPARATE TYPE WATER SEAL, INTEGRATED BEARING, SHAFT)

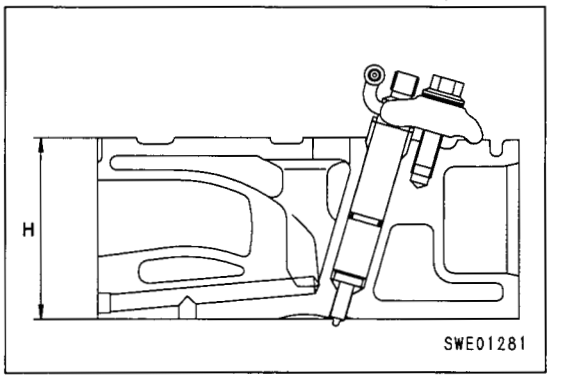


Unit: mm

No.	Check item	Criteria				Remedy
1	Clearance of impeller body	Standard clearance: 0.3 – 2.0				Replace
2	Interference between shaft and fan pulley boss	Standard size	Tolerance		Standard interference	
			Shaft	Hole		
		18	0 –0.013	–0.066 –0.082	0.053 – 0.082	
3	Interference between shaft and body	42	0 –0.013	–0.025 –0.046	0.012 – 0.046	
4	Interference between shaft and impeller	12	0 –0.013	–0.035 –0.062	0.022 – 0.062	
5	Curvature of shaft	Repair limit: Runout at face A: 0.1				
6	Wear of seal of water seal ring	 SWE01280		Repair limit: Dimension A: 0		
7	Thermostat	Cracking temperature: 82 ± 2°C		Fully open: Shall open fully when immersed in hot water bath at temperature between 95°C and 77°C for 4 – 5 minutes (when immersed in hot water bath at 95°C for 4 – 5 minutes))		
		Fully open temperature: 95°C				
		Fully open lift: Min. 8				

ENGINE
15 REPAIR AND REPLACEMENT OF PARTS

GRINDING CYLINDER HEAD MOUNTING SURFACE



1. **Grinding**
   Grind the bottom surface of the cylinder head with a surface grinding machine to remove deformation or corrosion. Do not exceed the repair limit of cylinder head height **H**. After grinding, make an R mark at the rear on the left side (intake side) of the cylinder head.
   - ★ Standard dimension of cylinder head height **H**: $90^{0}_{-0.2}$ mm
     Repair limit: 89.5 mm
   - ★ Amount to remove per grinding. 0.10 – 0.15 mm
   - ★ Surface roughness of grinding surface: Within 6S
   - ★ Flatness (deformation): Within 0.05 mm
   - ★ Grinding limit: 0.3 mm

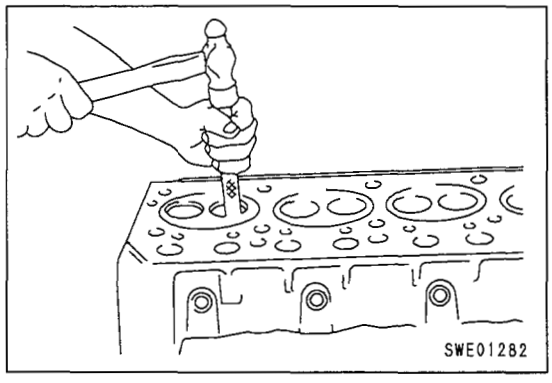
2. **Check after grinding**
   Check that the insertion depth of the valve is within the standard value.
   - ★ Insertion depth of valve:
     Intake side: 1.0 ± 0.1 mm
     Exhaust side: 0.9 ± 0.1 mm

REPLACING VALVE GUIDE

Special tools

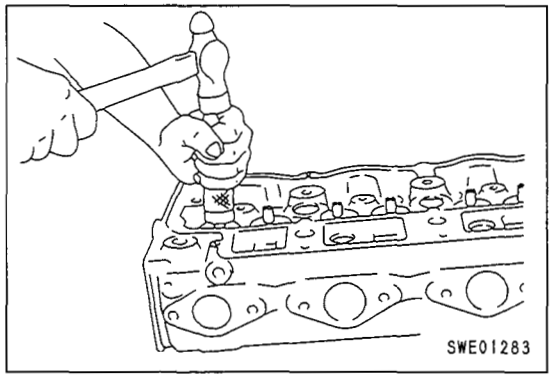
No.	Part No.	Part Name	Q'ty
A	795-100-4710	Valve guide remover	1
B	795-100-4720	Valve guide remover	1

1. **Removal of valve guide**
   Insert tool **A** from the top surface of the cylinder head, put it in contact with the valve guide, then hit with a hammer to remove the valve guide.



2. **Press fitting valve guide**
   1) Press fit the valve guide until the tip of tool **B** contacts the cylinder head.
      ★ After press fitting, insert the valve, and if the valve does not enter smoothly, machine the hole with a reamer ($\phi 8^{+0.015}_{0}$ mm)

   2) Measure the protrusion of the valve guide and check that it is within the standard range.
   ★ Valve guide protrusion
   Tolerance: 14.5 ± 0.2 mm



GRINDING VALVE

Special tool

No.	Part No.	Part Name	Q'ty
A	Commercially available	Valve refacer	1

1. **Grinding seat face**
   After using tool **A** to adjust the valve seat angle, grind the seat face.
   ★ For details of the angle of the valve seat, see the Maintenance Standard Table.

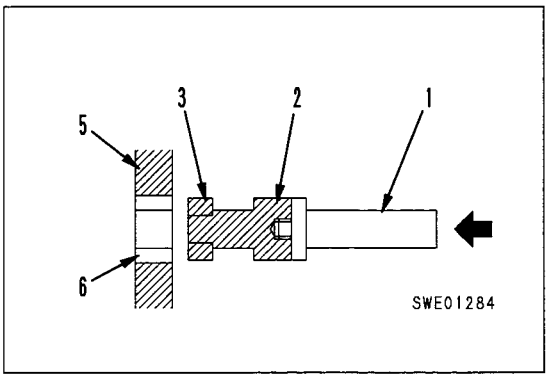
2. **Checking after grinding**
   Measure the thickness of the valve head, insertion depth of the valve and the contact of the valve seat face to check that they are within the standard range.
   ★ Thickness of valve head:
   1.40 – 1.60 mm
   ★ Insertion depth of valve
   Intake side: 1.0 ± 0.1 mm
   Exhaust side: 0.9 ± 0.1 mm
   ★ Contact width of valve
   Standard
   Intake valve: 2.0 mm
   Exhaust valve: 2.0 mm
   ★ For details of handling the valve refacer, see the operation manual.

REPLACING CAMSHAFT BUSHING

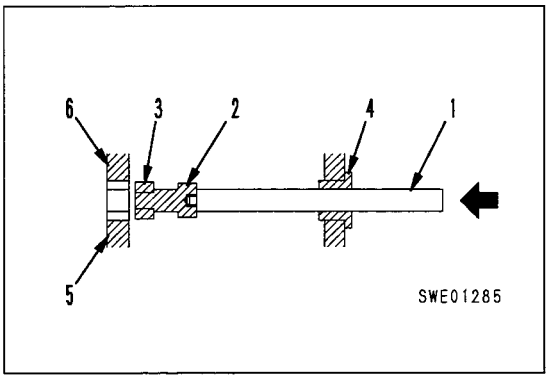
Special tools

No.		Part No.	Part Name	Q'ty
A		795-215-1101	Push tool (KIT)	1
A	1	795-215-1110	Push bar	1
	2	795-215-1120	Push tool	1
	3	795-215-1140	Collar	1
	4	795-215-1150	Guide	1

1. **Removing front and rear bushings**
   As shown in the diagram, assemble push tool (2), collar (3), and push bar (1) of push tools **A**, then hit the push bar to knock bushing (6) out from cylinder block (5).

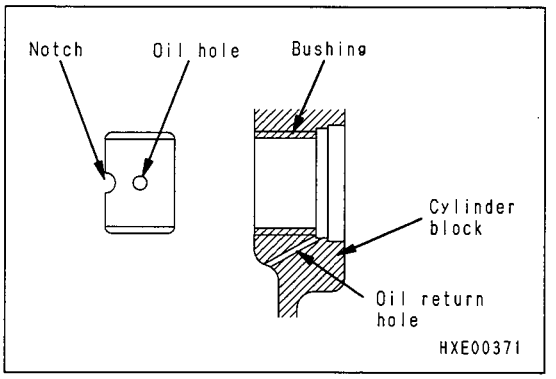


2. **Removing center bushing**
   1) Assemble push bar (1), push tool (2), collar (3), and guide (4) of push tool **A**, then hit the push bar to knock bushing (6) out from cylinder block (5).



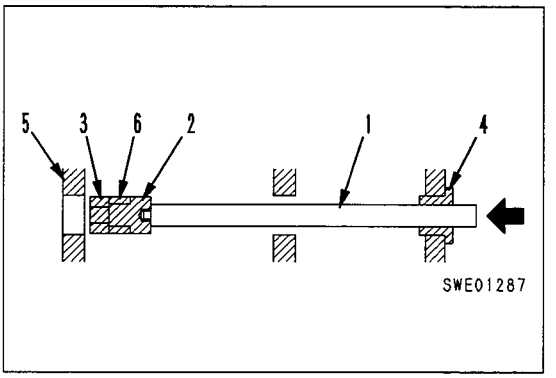
2) After removing the bushing, remove any burrs or dirt from the mounting hole of the bushing.

★ **Cam bushing assembly drawing**



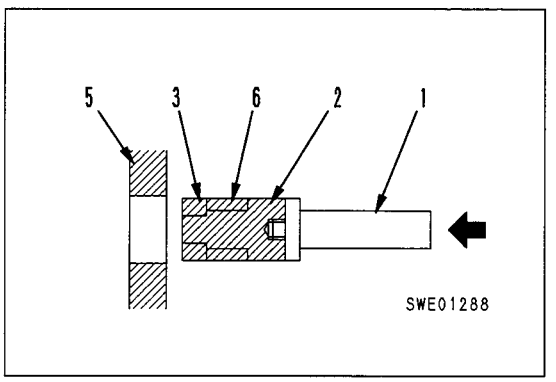
3. Press fitting center bushings

Assemble bushing (6) to tool **A** and press fit the bushing until the oil hole in cylinder block (5) is aligned with the oil hole in the bushing.



4. Press fitting front and rear bushings

Assemble bushing (6) to tool **A**, and press fit the bushing until the oil hole in cylinder clock (5) is aligned with the oil hole of the bushing.

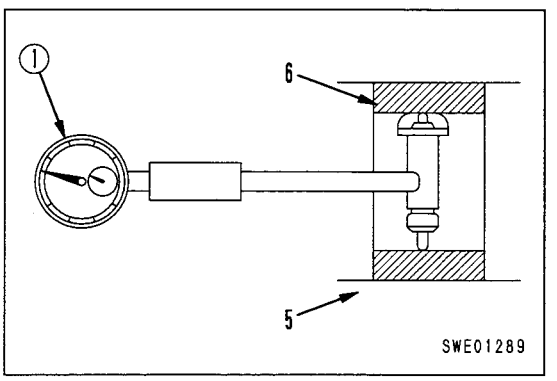


5. After press fitting bushings

1) Using inside gauge ①, measure the inside diameter of the bushing.
2) Check the clearance between the bushing and shaft, and if the clearance is not within the specified range, or the shaft does not pass through smoothly, correct the inside diameter of the bushing with a reamer.
   - When correcting the inside diameter of the bushing with a reamer, clean all chips from the oil hole and oil groove.

★ Inside diameter of cam bushing:
$\phi 50.5\ ^{+0.030}_{-0.040}$ mm

★ Clearance of camshaft journal:
0.030 – 0.130 mm



REPLACING CRANKSHAFT GEAR

1. **Removal of gear**
   Remove the gear with a gear puller.

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 the key into the key groove of the shaft.
   3) Heat the gear for the specified time at the specified shrink-fitting temperature.
   ★ Crankshaft gear shrink-fitting temperature:
   230 – 250°C
   Heating time: Min. 30 minutes
   4) Put the timing mark on the outside, then use a hitting tool to press fit until the side face of the gear is in tight contact with the shaft flange.
   ★ Knock in quickly before the gear becomes cool.

REPLACING CAM GEAR

1. When using only shrink fitting

1) Check the gear mounting surface, key groove, and flange surface, and if there are any scratches, correct them with an oilstone.
2) Knock the key into the key groove of the shaft.
3) Heat the gear for the specified time at the specified shrink-fitting temperature.
   ★ Cam gear shrink-fitting temperature: 250 – 270°C
   Heating time: Min. 30 minutes

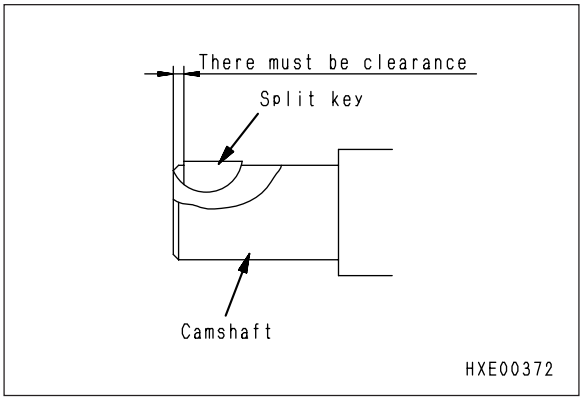
2. When combining shrink fitting and tightening with bolt

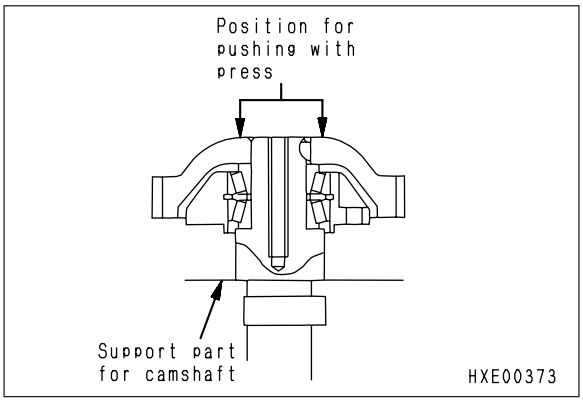
1) Press fit with the bearing installed to the camshaft.
   Put the inner race of the bearing in contact with the shoulder of the No. 1 journal.
2) Knock the key (6206-41-1380) into the camshaft.
   When doing this, check that the key is below the surface of the tip of the camshaft. (See diagram on right)
3) Heat the cam gear in a furnace at 220 – 240°C for approx. 35 minutes.
4) When press fitting the cam gear to the camshaft, use a press to apply a force of approx. 29.4 kN {3 tons} to the outer shoulder of the gear so that the bearing inner race is pressed against the end of the inside of the cam gear. When the cam gear has cooled to room temperature, push with a press to press fit it fully.
5) Insert the bolts in the plates and coat the thread with LT-2, then tighten to the camshaft.

★ After tightening to the specified torque, loosen the bolts, then tighten again to the specified torque.

kgm Bolt: **98 – 123.5 Nm {10 – 12.5 kgm}**

After press fitting, tighten the bolts fully within 2 minutes, and be sure that the cam gear temperature has not gone down.





REPLACING FLYWHEEL RING GEAR

⚠ Be careful not to let the flywheel fall and injure you.

1. Removal of ring gear

1) Prepare a support for the flywheel, and set on the support with the ring gear surface facing down.
2) Heat the area around the ring tear with a torch lamp, then hit it with a hammer to remove it.

2. Press fitting ring gear

1) Check the ring gear mounting surface, and if there are any scratches, correct them with an oilstone.
2) Heat the ring gear for the specified time at the specified shrink-fitting temperature.
   ★ Ring gear shrink-fitting temperature: Max. 200°C
   Heating time: Min. 45 minutes
3) Set the chamfered face of the ring gear facing the flywheel, and press fit until the side face of the gear is in tight contact with the flywheel.

PROCEDURE FOR PRESSURE TEST

- When corrections have been made around the cylinder head, test the pressure as follows.

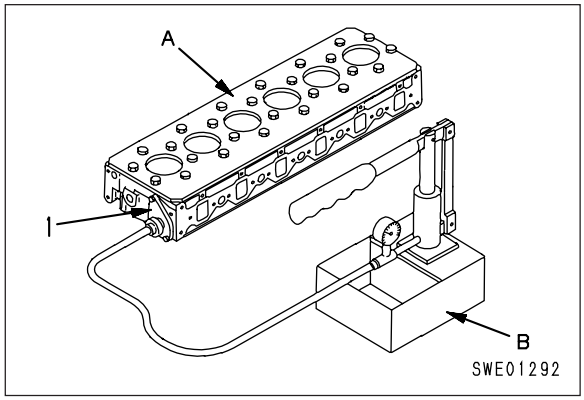
Special tools

No.	Part No.	Part Name	Q'ty
A	790-513-4200	Coolant test kit	1
B	79A-471-1050	Pump assembly	1

1. Water pressure test

1) Tighten the nozzle holder assembly to the specified torque.
2) Assemble tool **A** and tool **B**, and connect the hose to flange (1).
3) Apply water pressure 0.25 – 0.6 MPa {2.5 – 6.0 kg/cm^2} for approx. 10 minutes, and check that there is no leakage from around the head.

★ When carrying out this test, heat the whole cylinder head and carry out the test with hot water (82 – 93°C).

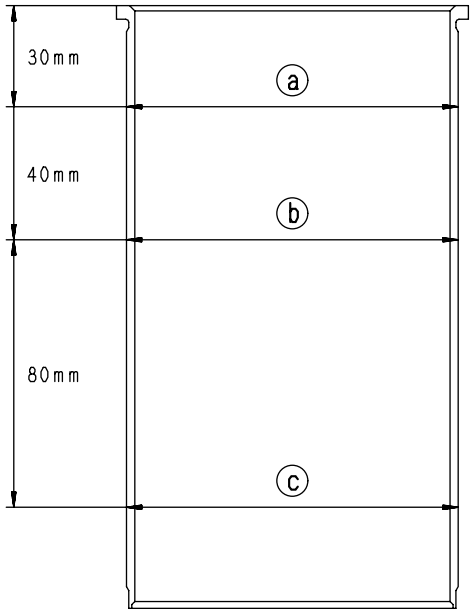


2. Air pressure test

1) Tighten the nozzle holder assembly to the specified torque.
2) Connect the compressor hose to flange (1).
3) Put the head in the container of water, apply air pressure 0.2 MPa {2.0 kg/cm^2} for approx. 30 seconds, and check that there is no leakage in the water.

★ If the above test shows any cracks in the nozzle holder or around the plate plugs, replace the cylinder head.
★ If cracks are found in any other places, weld to repair.

CYLINDER LINER (SPECIAL RESTORATION PART)



Cylinder liner

- The 95-2 Series engine has a liner-less cylinder, so if the cylinder bore exceeds 95.40 mm because of wear, the cylinder is bored, and this cylinder liner is used to restore the cylinder.

  Selection of liner
  There are two sizes of cylinder liner: A and B. After machining the cylinder bore, select the size of liner to match the bore.

- **Outside diameter of cylinder liner**

Unit: mm

Part No.	Category mark		Measurement location			[Remark] Machined dimension of cylinder
	Letter	line	ⓐ	ⓑ	ⓒ	
6207-21-2110	A	I	$98^{+0.020}_{+0.005}$	$98^{+0.025}_{-0.010}$	$98^{+0.025}_{-0.020}$	$98^{+0.0125}_{0}$
6207-21-2120	B	II	$98^{+0.035}_{+0.020}$	$98^{+0.040}_{+0.005}$	$98^{+0.040}_{-0.005}$	$98^{+0.0250}_{+0.0125}$

MACHINING DRAWING FOR CYLINDER BLOCK BORE

- **Honing**

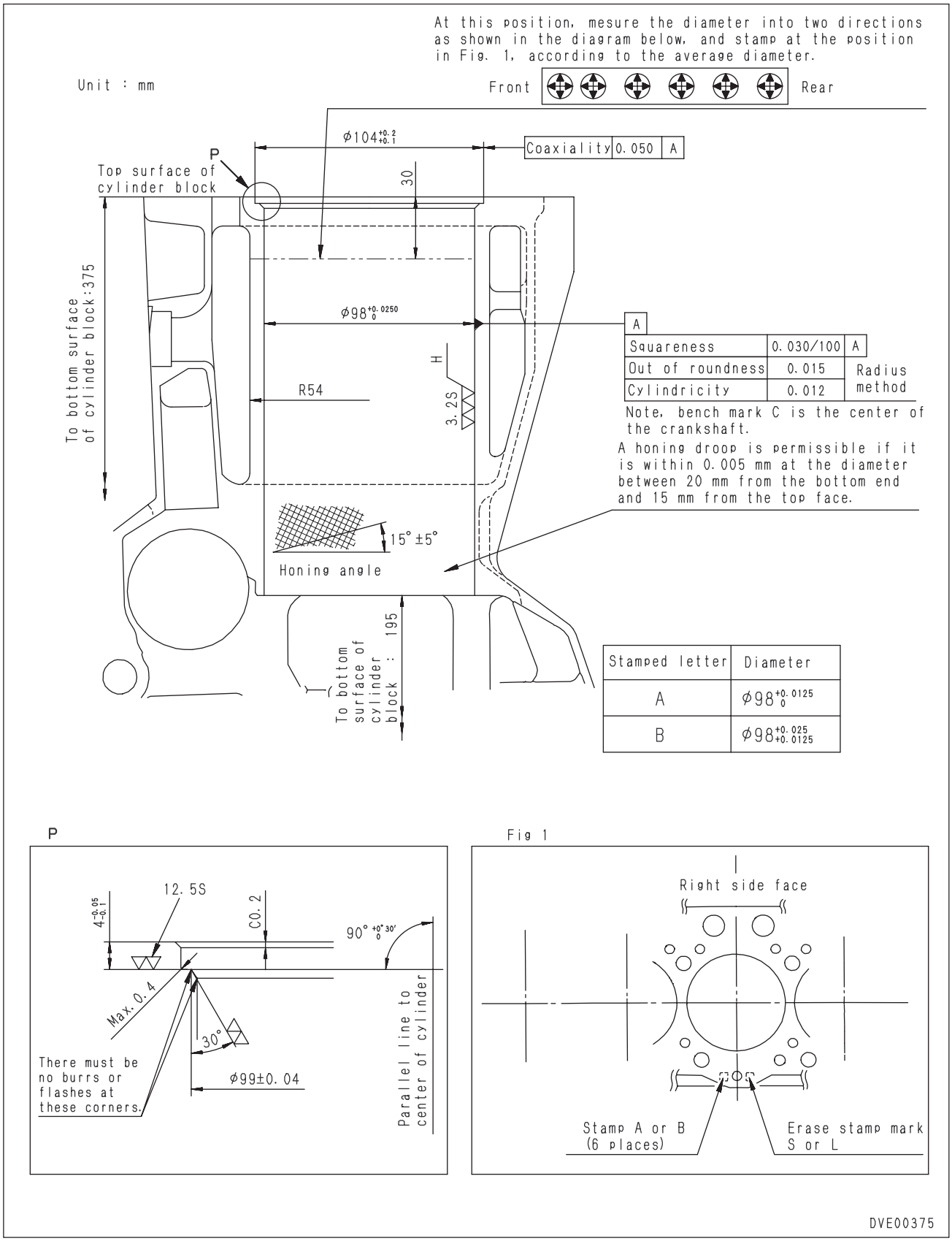
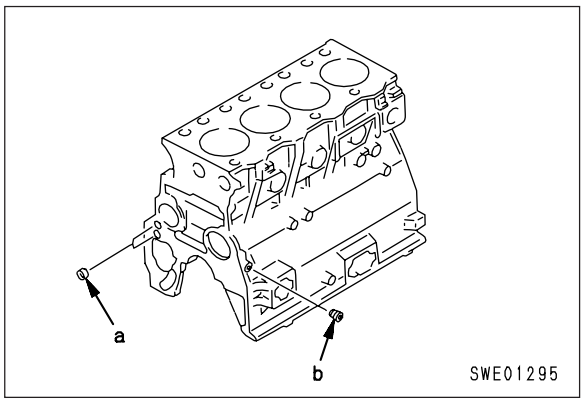


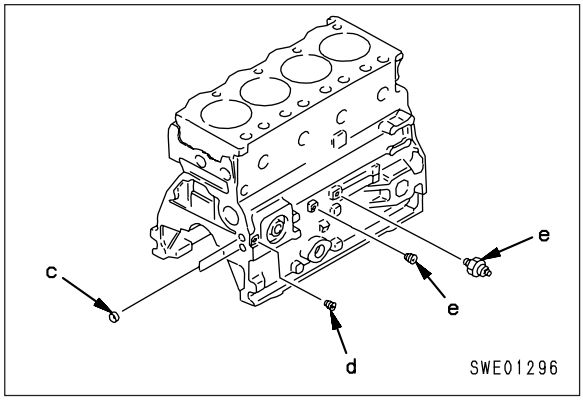
Fig 1

ADDITIONAL MACHINING OF CAM JOURNAL

Carry out additional machining of the cam journal, and install a cam bushing (Part No.: 6206-21-1420) to correct the damage.

1. To carry out the additional machining, disassemble to make the cylinder block into an individual part.
   ★ To clean out the metal particles after machining, remove the taper plug from the oil hole, the μ-plug, and the oil pressure caution switch. Remove parts **a – e** in the diagram.





2. Center with an undamaged cam journal and carry out additional machining. (See Cross-sectional diagram (1)
Inside diameter ø after machining: $53.5^{+0.03}_{0}$ mm
(Surface roughness: Max. 12.5 S)

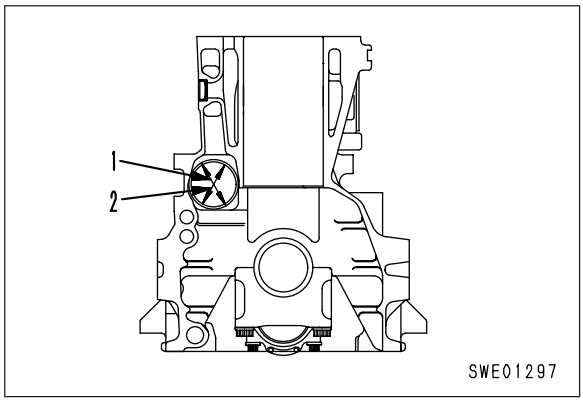
3. Align the oil hole in the cam bushing with the oil hole in the cylinder block, and press fit.
After press fitting, insert a ø 3.5 check bar through the oil hole in the main journal and check that it presses through the oil hole.
(Diameter of bushing oil hole: ø 4)

4. After press fitting, check the inside diameter of the bushing. (See Cross-sectional diagram (2)
Inside diameter of bushing: ø $50.5^{+0.02}_{-0.05}$ mm

5. Clean thoroughly and check that there are no metal particles remaining in the oil hole.

6. To check the alignment of the journal at three places, insert the cam shaft and check that it rotates smoothly by hand.

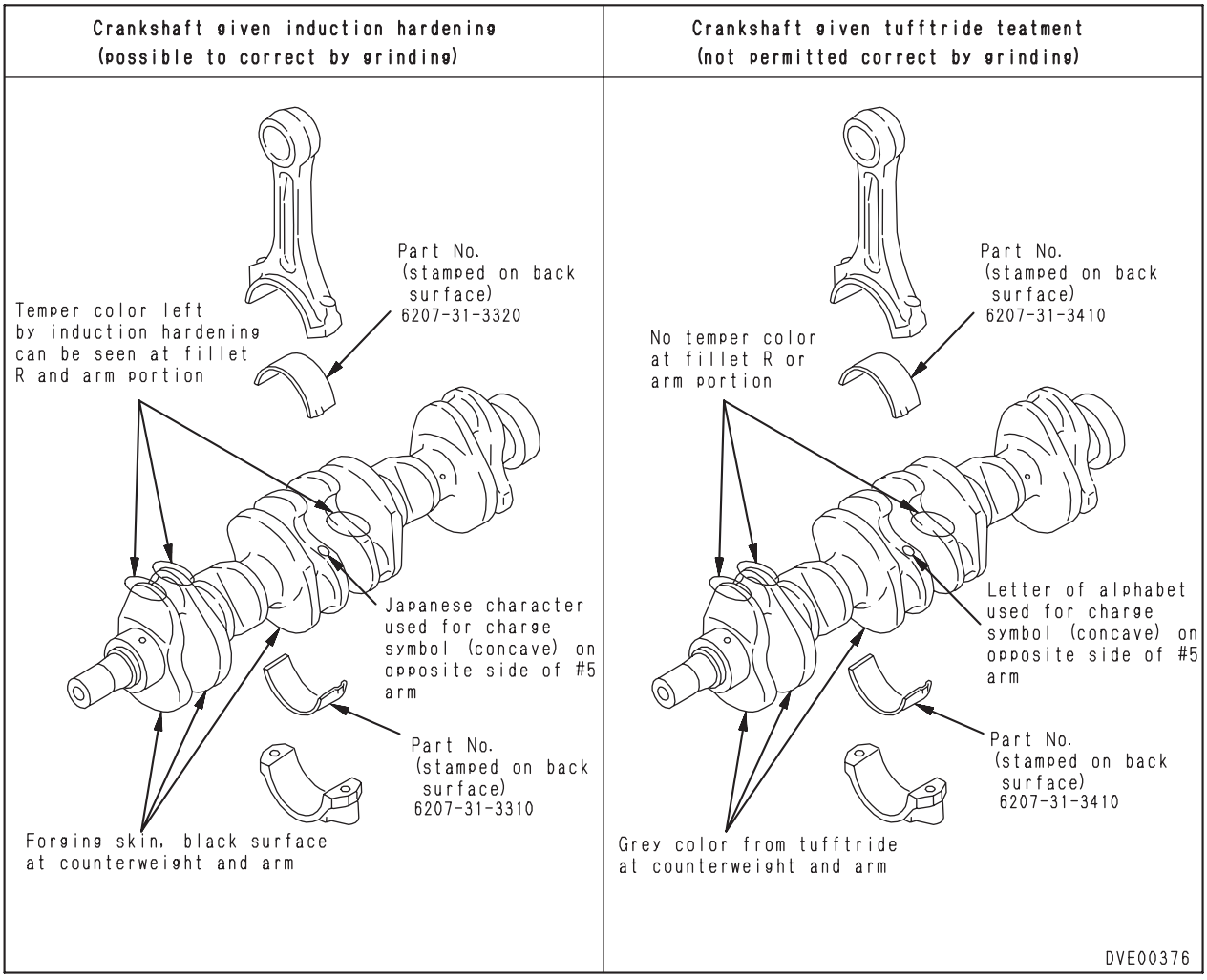
7. Remove the cam shaft, then install the taper plug for the oil hole, the μ-plug (replace with a new part), and the oil pressure caution switch to the cylinder block.



GRINDING CRANKSHAFT

Applicable crankshaft

- It is possible to correct by grinding and rebuild so that undersize bearings can be used only with crankshafts which have received induction hardening.
  This method of repair may not be used for crankshafts that have received tufftride treatment. (*1)
- It is possible to distinguish these two types of crankshaft from the engine serial number (*2), but check the crankshaft as follows to ensure that there is no mistake.



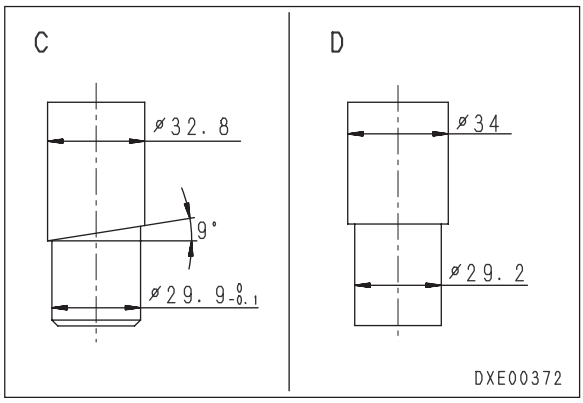
(*1) With tufftride treatment, the hardened layer is thin, so if additional grinding is carried out, the hardened layer will be removed and it will be impossible to ensure the strength and wear resistance.

(*2) The part number does not change when there is change in the surface treatment of the crankshaft, but as shown above, the crankshaft pin bearing is changed at the same time.

REPLACING CONNECTING ROD SMALL END BUSHING

Special tools

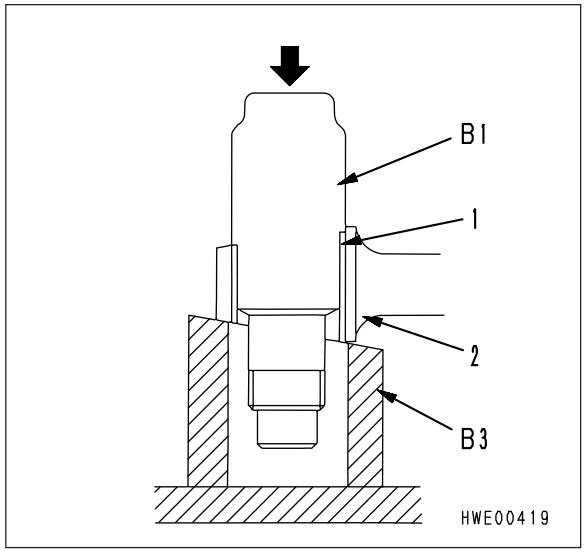
No.		Part No.	Part Name	Q'ty
A		795-233-1100	Push tool (KIT)	1
B	1	795-233-1110	Push tool	1
	2	795-233-1120	Push tool	1
	3	795-233-1130	Nut	1
	4	795-233-1140	Block	1
C		—	Jig for pulling out bushing	1
D		—	Jig for press fitting bushing	1



★ If the special tools are not available, prepare substitutive jigs **C** and **D**.

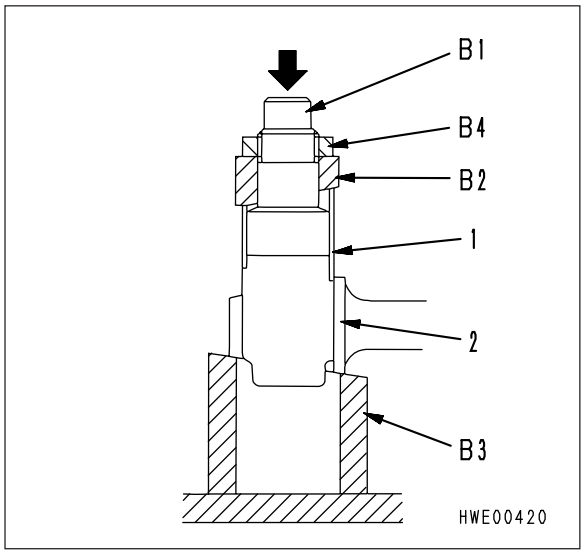
1. Removal of connecting rod bushing

1) Set connecting rod (2) to tool **B3**.
2) Using tools **B1** and **B3**, remove connecting rod bushing (1) with press.
   ★ After removing the bushing, remove any burrs or flashes, and clean the mounting hole of the bushing.



2. Press fitting connecting rod bushing

1) Set connecting rod (2) to tool **B3**.
2) Assemble connecting rod bushing (1) in tool **B1**, set tool **B2** in position, then secure with tool **B4** so that it does not move.
   ★ Align the oil hole of the connecting rod bushing with the oil hole of the connecting rod.
3) Push tool **B1** with press, and press fit connecting rod bushing (1).



- The bushing is supplied as a semi-finished product, so the inside diameter is too small and the piston pin will not go in.
  After press fitting the bushing, machine the inside diameter of the bushing with a reamer or honing machine in accordance with the maintenance standard.
  ★ After machining, clean all the metal particles from the oil hole and oil groove.

DataKom Publishing Corporation
440 North Fairway Drive
Vernon Hills, IL 60061-8112 U.S.A.
Attn: Service Publications
Fax No. (847) 970-4186

PROPOSAL FOR MANUAL OR CSS REVISION

	DATE:	FOR INTERNAL USE ONLY -- No. PMR
PROPOSER	NAME OF COMPANY:	CITY:
		STATE OR PROVINCE::
	DEPARTMENT:	COUNTRY:
	NAME:	FAX NO:

MANUAL DESCRIPTION:	CSS PROGRAM - e.g: Lookup, Parts or Service
MANUAL OR CSS CD NO:	CSS PROGRAM RELEASE VERSION:
MANUAL OR CSS CD ISSUE DATE:	CSS BOOK PUBLISHER:

BOOK DESCRIPTION
MACHINE MODEL & S/N:

MANUAL SECTION/PAGE NUMBERS OR CSS REFERENCE & PAGE NUMBERS:

PROBLEM:

Attach photo or sketch.
If more space is needed, use another sheet.

FOR INTERNAL USE ONLY

CORRECTIVE ACTION: