

OPERATION MANUAL

MARINE AUXILIARY ENGINE

6EY22(A)LWS

H.F.O./MET SPEC.

6EY22LWS

6EY22ALWS

YANMAR

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|-------------------------------|----------------|
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APPENDIX

YANMAR Worldwide Service Network List
 TURBOTWIN engine and air starter T50-P service manual
 Integral relay valve installation and operation manual

1. Introduction

Thank you for purchasing a YANMAR diesel engine.

This Operation Manual has been prepared for your safe and effective use of this product. Before you use this product, carefully read and fully understand the instructions about operation, inspection and maintenance. Keep this manual in a safe location. Make sure that the operator can always read it.

Because the inspection and maintenance instructions are for professional technicians, necessary but basic knowledge has been omitted.

1.1 Using this manual

- The text and illustrations of this operation manual can partly disagree with products of some specifications. In that case, refer to the separate Engine Specification and Final Drawing.
- The contents of this operation manual can change without prior notification to improve the quality and performance of the product and to improve safety.
- For disassembly and maintenance of special specifications (e.g. the turbocharger and governor), refer to the separate operation manuals.
- If you lose or damage this operation manual, please contact YANMAR or your sales or service agent.
- If you transfer this engine, also transfer this Operation Manual, Final Document and Records of Shop Trial with the engine to the next owner.
- The numerical values in this manual are based on the SI system (International System of Units).

1.2 Inquiries

- Only use genuine YANMAR replacement parts or other specified parts. Order parts from your nearest YANMAR sales or service agent. When you order a part, clearly specify:
 - Engine name (model)
 - Engine serial number
 - Part name
 - Part number.
- If you:
 - use the engine differently from the intended usage purpose or conditions OR
 - operate the engine differently from the contents of this operation manual,you can cause accidents and malfunctions. Before you make a modification to the engine, contact YANMAR or your sales or service agent. Do not make a modification that is not approved by YANMAR.
- If you have questions or comments about this manual, please contact YANMAR or your sales or service agent.

2. About this operation manual

The major terms used in this operation manual are defined as follows:

The front of the engine: opposite side of the flywheel

The back of the engine: the flywheel side

Operation side: on the left side as viewed from the flywheel side (fuel injection pump side)

Non-operation side: on the right side as viewed from the flywheel side (exhaust manifold side)

Turn right: clockwise rotation as viewed from the flywheel side

Turn left: counterclockwise rotation as viewed from the flywheel side

Cylinder number: counted from the flywheel side (1, 2, 3, ...)

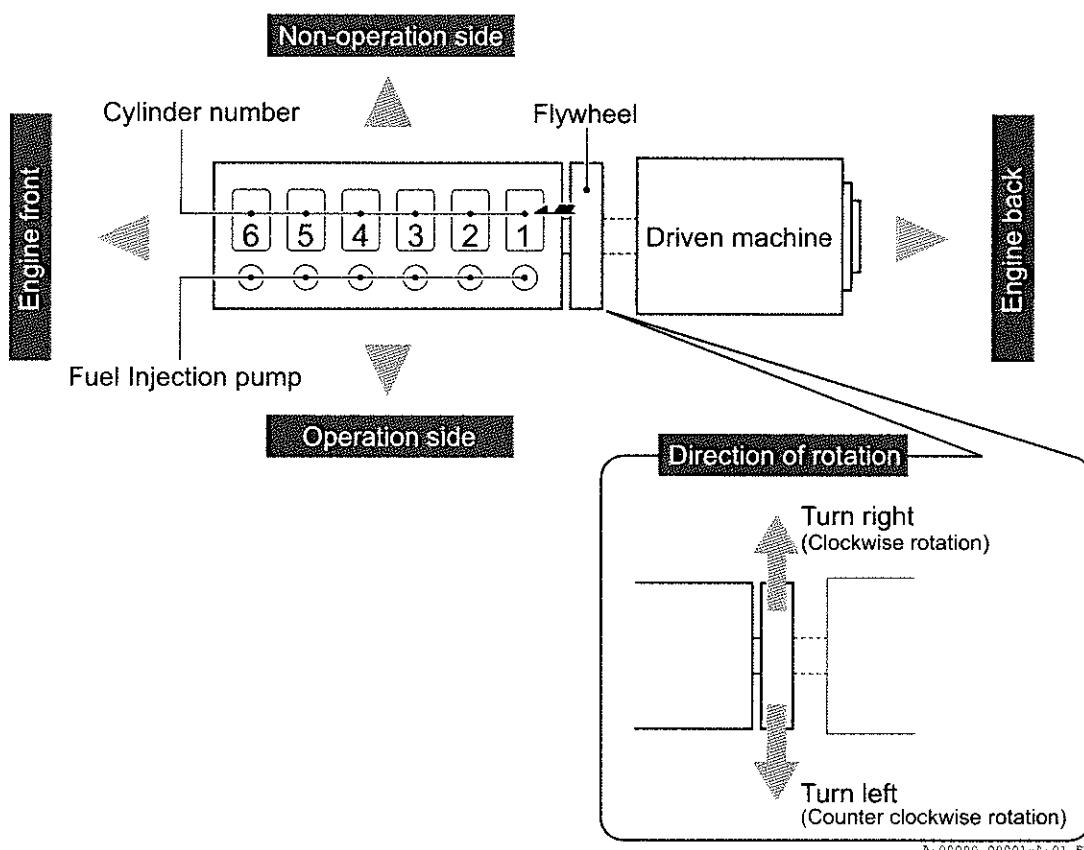


Fig. 1 List of terms

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3. About this operation manual

See the index for an overview of related contents.

The contents of the titles are as follows.

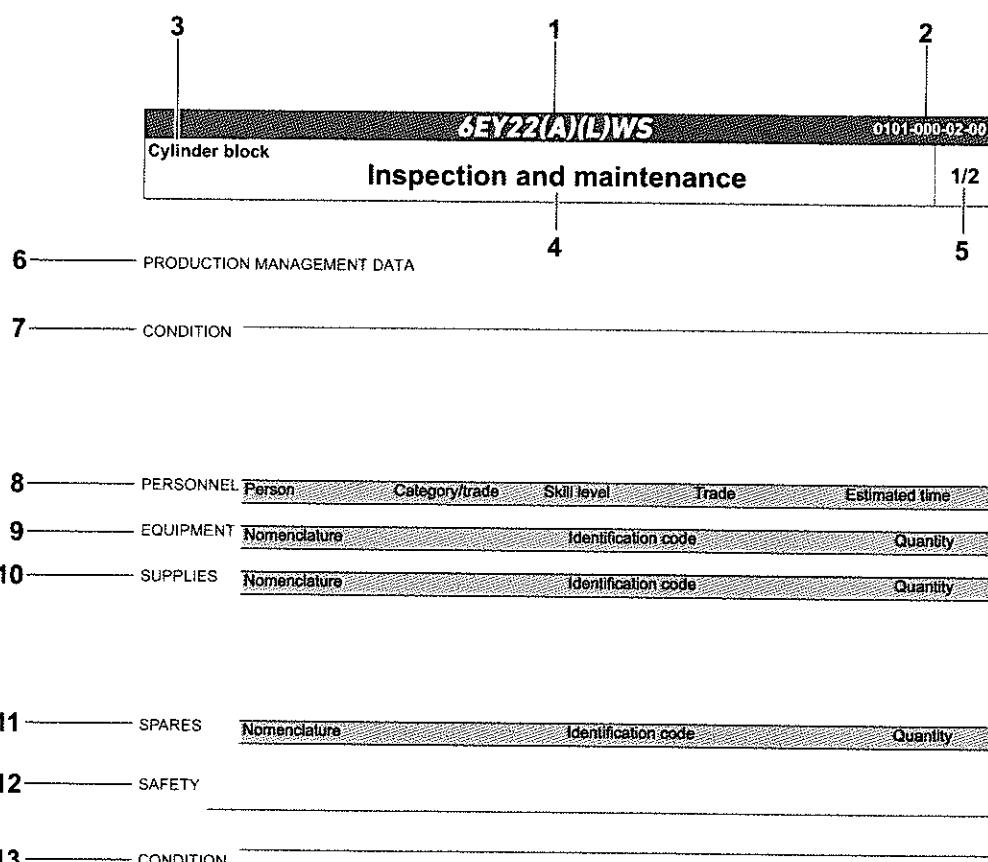


Fig.2 List of titles

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1. Engine series
2. Topic-specific codes
3. Function parts
4. Tasks
5. Number of pages
6. PRODUCTION MANAGEMENT DATA: shows the regular intervals to perform the task
7. CONDITIONS: shows the required preconditions for each part to perform the task
8. PERSONNEL: required standard man hours
Indicated with alphabet. For example when the personnel is only one person, "a" is indicated, and when it is two, it is indicated "a" "b".
9. EQUIPMENT: tools required for the task
10. SUPPLIES: consumable products (e.g. lubricating oil, grease, wire) (May not be included in the standard delivery.)
11. SPARES: consumable parts (e.g. O-rings, gaskets, toothed washers) (May not be included in the standard delivery.)
12. SAFETY: shows safety precautions that apply to the whole chapter
13. CONDITION: describes points to be checked after work

4. About the parts list

A parts list is attached to this manual. It is sorted by part categories.

A figure with the integrated parts and their reference numbers is on the first page.

The parts are listed with their part names and part numbers on the pages that follow.

The list is sorted as follows.

Illustrated parts data						2/2
No.	LV	Part No.	Part Name	LWS	ALWS	Remarks
1	2	150633-01010	BLOCK, CYLINDER	1	1	
2	2	150633-01200	BOLT, CYLINDER HEAD	24	24	
3	2	150633-01210	NUT, HEAD	24	24	
4	2	150633-01210	NUT, CAP	14	14	

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Fig.3 List of parts

1. Part category

In this operation manual, all parts are sorted in categories. Parts are listed together with related parts. Therefore, some parts are possibly listed in more than one category.

2. Reference number

The number in the figure.

3. Level

Nominal parent-child relationship of the parts

1: Parent parts (assembly parts)

2: Child parts included in "1"

3: Child parts included in "2", grandchild parts in terms of "1"

4. Part number

The individual number of the part. Please use this number when you order a part.

5. Part name

The official part name. Please use this name when you order a part.

6. Number of parts (sorted by model)

How many of the part are used per engine.

Abbreviation: Engine model

LWS: 6EY22LWS

ALWS: 6EY22ALWS

5. Symbols for piping and instruments

This operation manual uses these symbols for the piping system.

Instruments		Valves		Piping parts			
	Pump		Globe valve		Flange fitting		
	Plunger pump		Needle valve		Shut-off valve		
	Hand pump		Angle valve		Spectacle flange		
	Motor		Butterfly valve		Joint		
	Filter		Sluice valve		Boss		
	Centrifugal filter		Screwed check valve		Orifice		
	Automatic backwash filter		Swing check valve		Expansion joint		
	Porous plate filter cylinder		Piston valve		Flexible pipe coupling		
Meters & sensors			Three-way piston valve		Seal pot		
	Thermometer		Cock		Loop seal		
	Pressure gauge		Three-way cock		Reducer		
	Differential pressure gauge		Automatic pressure regulating valve		Air vent pipe		
	Oil signal		Automatic temp. regulating valve		Safety plate		
	Grazed level gauge		Safety valve		Accumulator		
	Pressure switch		Solenoid valve		Capillary tube		
	Temperature switch		Pressure reducing valve		Copper pipe		
	Float switch		Duplex check valve		Carbon steel pipe for pressure tube		
	Differential pressure SW		Velocity regulating valve		Carbon steel pipe for high pressure tube		
	Pressure transmitter		Flow volume regulating valve		Machine structural carbon steel pipe		
	Resistance temp. sensor			O.D.	Pipe outside diameter.		
	Thermocouple			I.D.	Pipe inner diameter.		
Remarks:							
Valves that are always closed (globe valve, angle valve and needle valve) are shown in black.							
: Always open							
: Always closed							

Fig.4 Symbols

1. For your safety

This manual and the engine have safety indications. They are important symbols and warnings that are necessary to operate this product safely.

The safety indications tell you this:



This safety symbol is used with most safety precautions.
It is a precaution and a warning. It tells you: Be careful! This is about your safety!
Carefully read and obey the instruction that comes with this symbol.



DANGER indicates a hazardous situation which, if not avoided,
will result in death or serious injury.



WARNING indicates a hazardous situation which, if not avoided,
could result in death or serious injury.



CAUTION indicates a hazardous situation which, if not avoided,
could result in minor or moderate injury.



NOTICE indicates a situation which can cause damage to the
machine, personal property and / or the environment or cause
the equipment to operate improperly.

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Fig. 1 Signal word

2. Basic precautions

2.1 Obey the safety instructions

When you operate or do maintenance on the engine, obey all safety instructions, precautions and work procedures.

- When you do work in a team, use signals (e.g. commands, hand signs). All personnel must know the signals.
- Put on the correct work clothes. Do not put on work clothes with oil stains. They burn easily.
- Put on protective equipment that is applicable for your task. E.g. helmet, safety goggles, safety shoes, protective mask, protective gloves, life-line.
- Use the applicable tools for the task. Use the correct special tools of the engine.
- Do not jump on or off the engine.
- Prepare a workbench that has the applicable dimensions for the engine. Safety the footing of the workbench. Do not do work from a dangerous body position.

2.2 Inappropriate modifications

YANMAR is not responsible for injury or damage that is the result of not approved modification. If a modification is necessary, speak to a representative of the service network (see the appendix).

- Your engine and its safety devices are sealed for safety. Do not remove the safety seals.
- If a safety seal is removed, immediately speak to a representative of the service network (see the appendix). Obey their instructions.

2.3 About airflow

Make sure that the engine room has good airflow and sufficient air (oxygen).

- It is very dangerous to breathe exhaust gas. If you find an exhaust gas leak, repair it immediately.
- A lot of air (oxygen) is necessary for the turbocharger.. Make sure that the room has sufficient air.
- The battery makes hydrogen gas when it charges. The gas is very flammable. Make sure that the hydrogen gas does not stay in the room.

2.4 Install a fire extinguisher and first-aid kit

Know where the fire extinguisher is. Know how to operate it. Make a decision about the safety procedures for fires or accidents. The safety procedures must include a contact person and a telephone number.

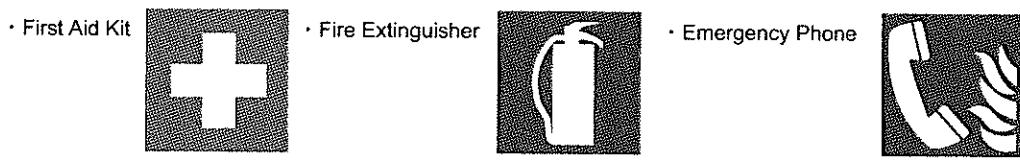


Fig.2 Symbols

2.5 Safety device check

This engine has safety devices, e.g. the covers of the rotating parts, the heat shielding covers of the exhaust pipe, and the protective covers of hot engine parts. Make sure that these safety devices are correctly installed. If they are damaged, repair them immediately.

- Never remove the covers of the rotating parts when the engine operates. If your clothing, hands or other body parts are caught, injury can occur.

2.6 Working with flammable material (e.g. fuel oil, lubricating oil)

All fire is strictly prohibited in the engine room. Fuel oil and lubricating oil burn easily. Especially the fuel oil is very flammable and dangerous.

- Cigarettes, matches and lighters are not permitted near flammable material.
- When you do welding or grinding, be careful of sparks and keep flammable material away.
- Keep the fuel oil and lubricating oil in the specified location. Make sure that only approved persons use them.
- Do not keep flammable material in the room that is not necessary.

2.7 Working on hot portions or portions under high pressure

During operation and immediately after the engine stops, all of the engine is very hot. Be careful that you do not get burned.

- Replace cooling water, lubricating oil and filters when the engine is cool.
- Do not touch hot engine parts (e.g. the exhaust pipe or pressure indicator cock) with bare hands. Put on gloves.
- Do not touch the heater and heated sections of the fuel oil system with bare hands.
- When you open a plug or cap, steam or hot water can come out and burn you. Stop the engine and wait until it is cool. Then slowly turn the cap and release the pressure. Then remove the cap.

2.8 Inspection of the electrical system

Obey the instructions that follow when you do maintenance of the electrical system.

- Before you start your task, disconnect the power source. It can cause an electric shock or fire.
- Before you do an inspection of the battery system, make sure that you disconnect the grounding cable (-) terminal. If you make an incorrect connection and cause a short circuit, a fire can occur.
- Battery fluid is a strong acid. It causes inflammation to the skin and eyes. If you get it on your skin or in your eyes, immediately flush the area with a lot of clean water. Get medical aid.

2.9 Using organic solvents

When you use organic solvents, obey the instructions that follow.

- Organic solvent turns into gas and can be breathed by personnel. This is dangerous. Make sure that the room has sufficient airflow.
- Organic solvent in high concentration can dissolve fats and is absorbed by the skin. This is dangerous. Put on protective gear when you use organic solvents.

2.10 Exporting or providing this product to non-residents

In case of exporting this product and providing the related technical material to non-residents in Japan or residents overseas, it is required to comply with the export and trade control laws and regulations of Japan and other relevant countries.

Please be sure to follow the necessary procedure.

3. How to lift the engine

Do not let the engine or driven machine fall when you lift or move it. It is very dangerous. To prevent an accident, obey the instructions that follow when you lift the engine.

- Use a wire rope and shackles that are applicable to the engine weight.
- Use a wire rope with the correct length. The engine or common bed must not tilt to one side.
- Put a padding (e.g. a wooden block) between the wire rope and the engine or a driven machine.
- Attach the padding to prevent damage to the engine or driven machine. Use a padding that does not break or fall during lifting.
- Do not go into the area below the lifted item.

3.1 Installation location for lifting tools

■ Generator set

When you lift the engine, use the lifting metal piece that is on the bottom of the common bed.

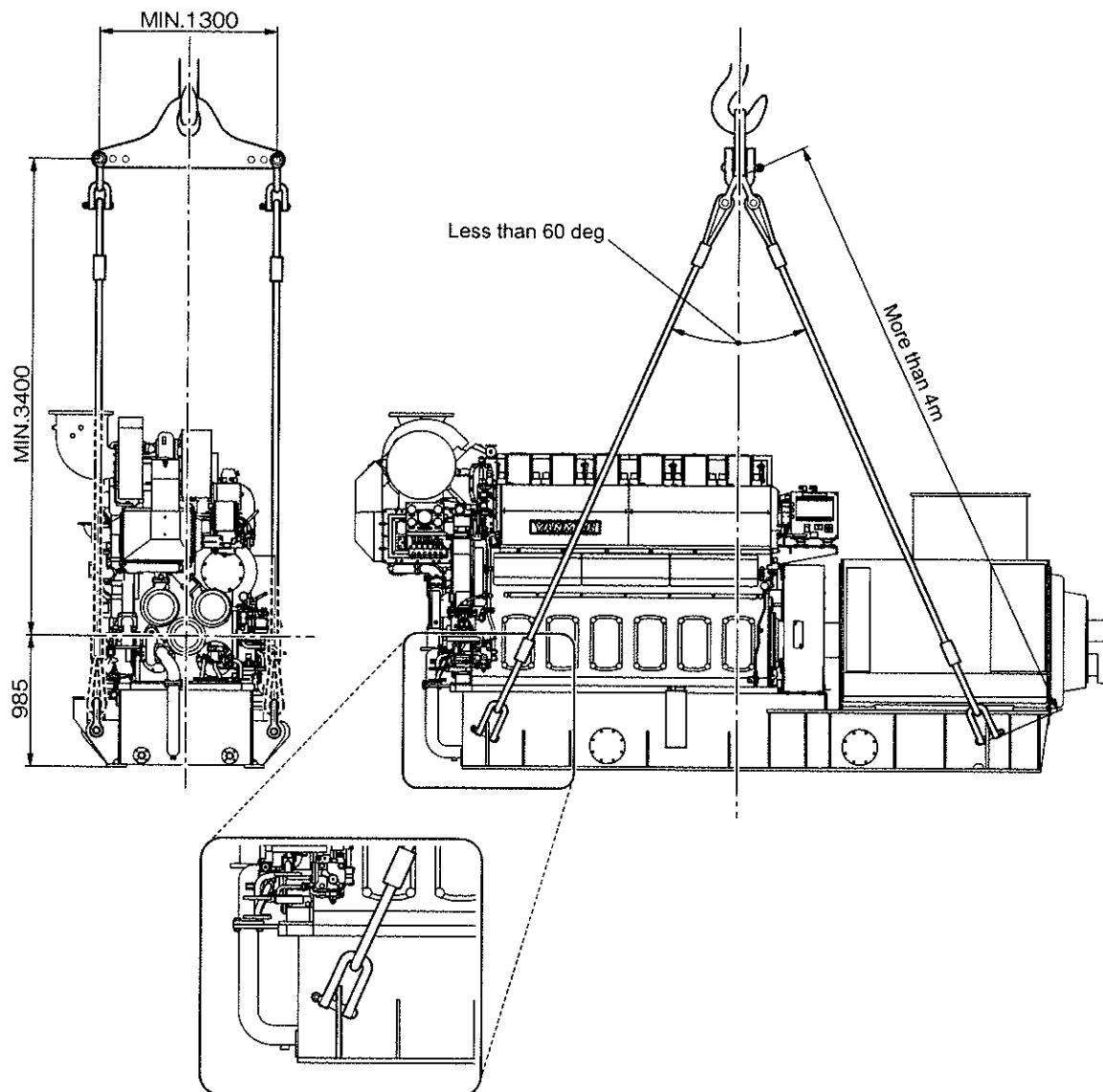


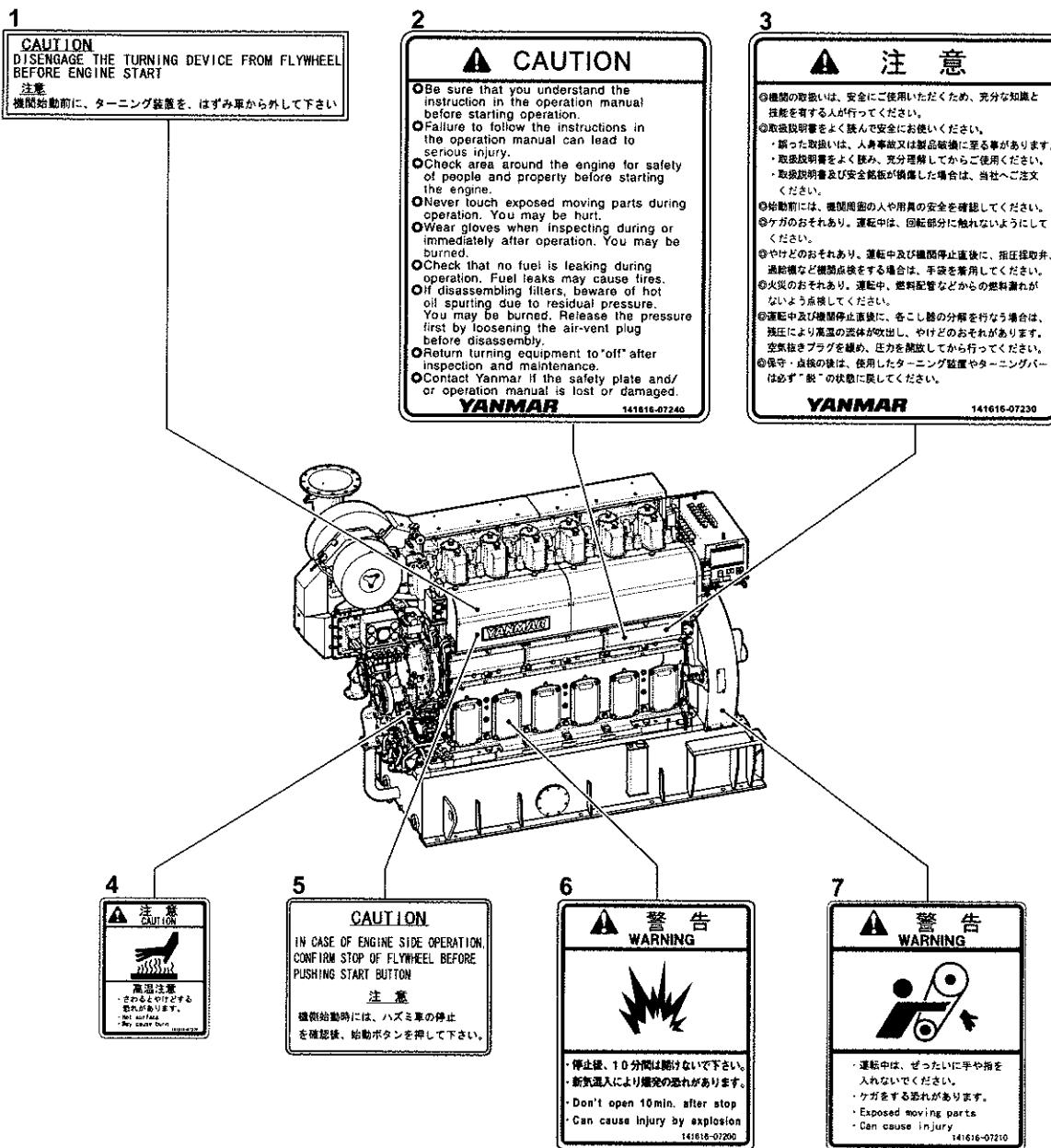
Fig.3 How to lift the generator set

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4. Location of safety labels (warning labels)

To make sure that you use the engine safely, the engine has safety labels (warning labels). Carefully read all safety labels to prevent accidents.

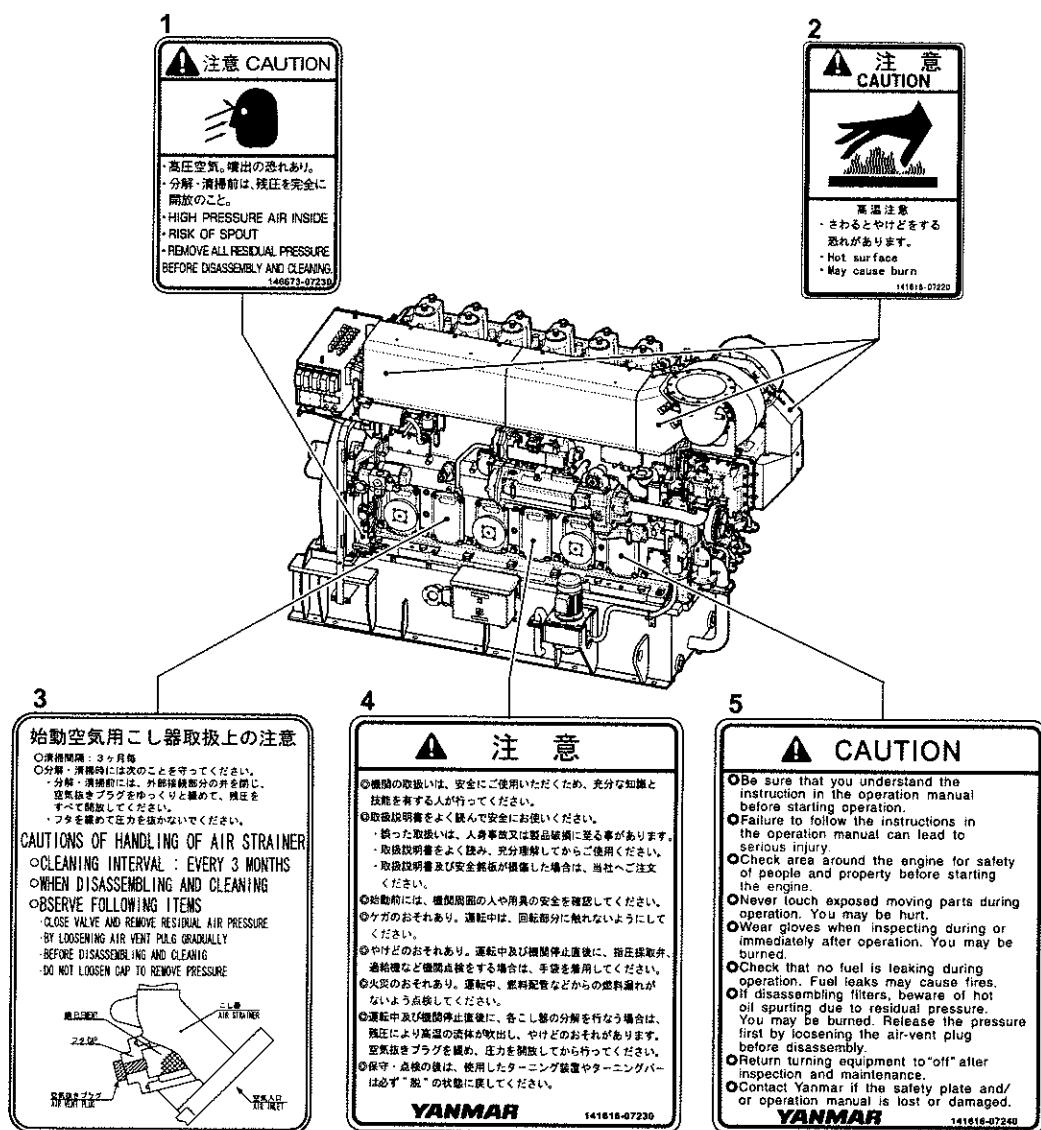
If a safety label is dirty or missing: Find the part number and send an order for a new safety label to your YANMAR sales agent. (Refer to the service network list "YANMAR Worldwide Service" in the appendix of this manual.) When you get the new safety label, attach it to the specified location.



No.	CODE	No.	CODE
1	42223-028790	5	42221-029450
2	141616-07240	6	141616-07200
3	141616-07230	7	141616-07210
4	141616-07270		

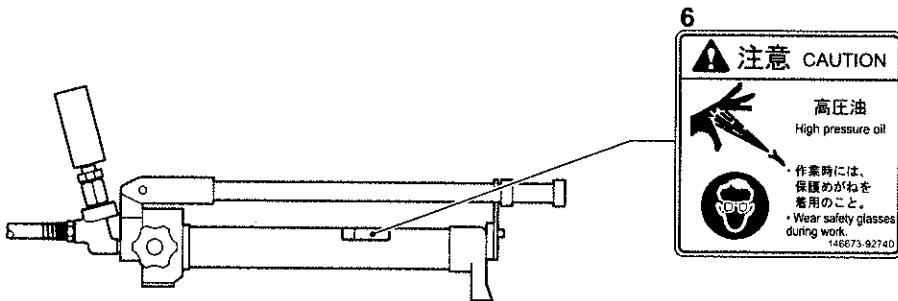
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Fig.4 Location of safety labels (warning labels)



No.	CODE	No.	CODE
1	146673-07230	4	141616-07230
2	141616-07220	5	141616-07240
3	146674-73910		

A-00000-02009-A-C1_EN



No.	CODE
6	146673-92740

A-00000-00010-A-01_EN

Fig.5 Location of safety labels (warning labels)

5. Precautions before maintenance

5.1 Putting a warning notice

Put a warning notice board when you do an inspection or servicing of the engine.

- Tell all related personnel about your work.
- Tell all unrelated personnel to not go in the engine room.

5.2 Maintenance immediately after engine stop

Do not open the cylinder side cover for 10 minutes after engine stop. If new air comes into the engine immediately after engine stop, an explosion can occur. Immediately after the engine stops, all of the engine is very hot. Obey the instructions that follow to prevent burn injuries.

- Make sure that you (e.g. your hands, body and clothing) do not touch the turbocharger, exhaust manifold, exhaust pipes or engine body.
- When you drain lubricating oil, be careful that you do not get burned by the oil (including small drops of oil).
- When you disassemble the cooling water system, steam or hot water can come out and burn you. Wait until the engine is cool. Then put the plug or tightening nut in a waste cloth. Slowly loosen it.

5.3 Preparation before work

Before you start work, make the engine room clean. Make sure that all spare parts and tools are at their specified locations. Prepare the following objects as necessary for the task.

- Tools and accessories
- Lubricating oil, genuine parts, waste cloths, wire and others
- Workbench suitable to the engine height
- Wire rope (Do not use wire rope that has broken strands, wear, twists, deformations or defective ends.)

6. Maintenance precautions

6.1 Precautions during work

When you do work in a team, carefully examine the area around you to prevent any dangers. Obey the instructions that follow during engine inspection and maintenance.

- Keep all removed parts safely and make sure that they do not fall.
- When you do work at a height, put on the safety belt or life-line.
- Put on the protective equipment that is applicable for your task.
- Be careful when you hold items with dirty gloves. The items can fall and cause damage or injury.
- If fuel or lubricating oil spills, clean the area immediately. You can slip and fall.

6.2 Use the applicable tools

Make sure that you understand how to operate the special tools before you use them.

- When you lift heavy objects, obey the instructions of the slinger (the person who puts the object on the crane).
- Carefully examine the rubber hose and the joints of the hydraulic jack for damage.
- Use the applicable lifting gear and be very careful when you do work with heavy objects.
- When you weld or grind, put on protective equipment.

7. Precautions after servicing

7.1 Precautions after work

Obey the instructions that follow after you do engine inspections and maintenance.

- Put back all tools (e.g. lifting gear and wires) to their correct location.
- Remove all lubricating oil that is not necessary from the engine room.
- Remove the warning notice board. Tell all related personnel that your work is complete.

1. Engine specification

Engine model			6EY22LWS						
Type	-		Vertical, water-cooled, 4-cycle diesel engine						
Number of cylinders	-		6						
Cylinder bore × stroke	mm		Ø 220 × 320						
Total displacement	l		72.99						
Combustion method	-		Direct injection						
Compression ratio	-		15.21						
Continuous rated output	Output	kW	660	745	800	880	970	1080	
		kWe	600	680	740	800	900	1020	
	Rotation	min ⁻¹	720						
Direction of crankshaft rotation	-		Left (viewed from the flywheel side)						
Firing order	-		1-4-2-6-3-5-1						
Operation side	-		Right (viewed from the opposite side of the flywheel)						
Type of turbocharger	-		Exhaust gas turbine turbocharger (with air cooler)						
Lubricating system	-		Forced lubrication by internal pump (The system oil is also used as turbocharger lubricating oil.) (The system oil is also used as rocker arm lubricating oil.)						
Type of lubricating oil sump	-		Sump incorporated in the common bed						
Type of cooling	-		Freshwater-freshwater mix cooling system						
Type of starting	-		Air starter						
Engine dimensions (engine body)	Overall length	mm	Refer to the Final Drawing.						
	Overall width	mm							
	Overall height	mm							
Engine dry weight (engine body)	kg								

Engine information

Technical data

2/4

Engine model		6EY22ALWS														
Type	-	Vertical, water-cooled, 4-cycle diesel engine														
Number of cylinders	-	6														
Cylinder bore × stroke	mm	Ø 220 × 320														
Total displacement	l	72.99														
Combustion method	-	Direct injection														
Compression ratio	-	15.21														
Continuous rated output	Output	kW	880	970	1020	1100	1180	1300	1370							
		kWe	800	900	950	1000	1100	1200	1300							
Direction of crankshaft rotation		min ⁻¹	900													
			Left (viewed from the flywheel side)													
Firing order	-	1-4-2-6-3-5-1														
Operation side	-	Right (viewed from the opposite side of the flywheel)														
Type of turbocharger	-	Exhaust gas turbine turbocharger (with air cooler)														
Lubricating system	-	Forced lubrication by internal pump (The system oil is also used as turbocharger lubricating oil.) (The system oil is also used as rocker arm lubricating oil.)														
Type of lubricating oil sump	-	Sump incorporated in the common bed														
Type of cooling	-	Freshwater-freshwater mix cooling system														
Type of starting	-	Air starter														
Engine dimensions (engine body)	Overall length	mm	Refer to the Final Drawing.													
	Overall width	mm														
	Overall height	mm														
Engine dry weight (engine body)	kg															

2. Accessories and attachments

Accessories and devices	Type	Remarks
Turbocharger	Exhaust gas turbine	-
Charge air cooler	Plate-finned, multi-tubular	-
Governor	Hydraulic	-
	Electric/mechanic governor	1300kW, 1370kW
Fuel injection pump	Bosch	-
Fuel injection valve	Multi-hole	Without cooling
Fuel feed pump	Gear	Option
Fuel strainer	Changeover, mesh type	with insulator and differential pressure gauge
Lubricating oil pump	Gear	-
Lubricating oil cooler	Low finned tube, multi-tubular	With thermostat
Lubricating oil strainer	Self-backwashing	-
Lubricating oil bypass filter	Centrifugal	-
Cooling water pump (freshwater)	Centrifugal	-
Air starter	Turbine	-

3. Weight of major parts

When you lift a part, use a rope, lifting gear and hook that is appropriate to the weight of the part.

Part name	Unit	6EY22LWS	6EY22ALWS	Remarks
Cylinder head *		179		-
Piston and connecting rod assembly *		77		-
Cylinder liner *		68		-
Charge air cooler (core) *		150		-
Lubricating oil cooler		185		-
Turbocharger		160	250	-
Fuel feed pump		25		-
Fuel strainer		17		-
Lubricating oil pump		45		-
Cooling water pump		35		-
Air starter		19.5		-
Camshaft (split in 2 parts)		96, 75		-
Camshaft drive gear		28		-
Idle gear assembly		17		-
Exhaust manifold cover *		41, 33, 9		-
(3 parts)				
Main bearing cap *		40		-
Gear housing on the opposite side of the flywheel		126		-
Cylinder block		2800		-
Crankshaft		1308	1101	including balance weights
Flywheel		1420	928	Including the ring gear

*: Use the special tool to disassemble.

1. Conversion table for the International System of Units (SI) and other units

The conversion values in this table are based on the SI and metric system.

Force

N	kgf
1	0.101972
9.80665	1

Force momentum, torque

N·m	kgf·m
1	0.101972
9.80665	1

Pressure

Pa	kgf/cm ²	mAq	mmHg
1	1.0197×10^{-5}	1.0197×10^{-4}	7.501×10^{-3}
9.80665×10^4	1	1.0000×10	7.356×10^2
9.80665×10^3	1.0000×10^{-1}	1	7.356×10
1.3332×10^2	1.3595×10^{-3}	1.3595×10^{-2}	1

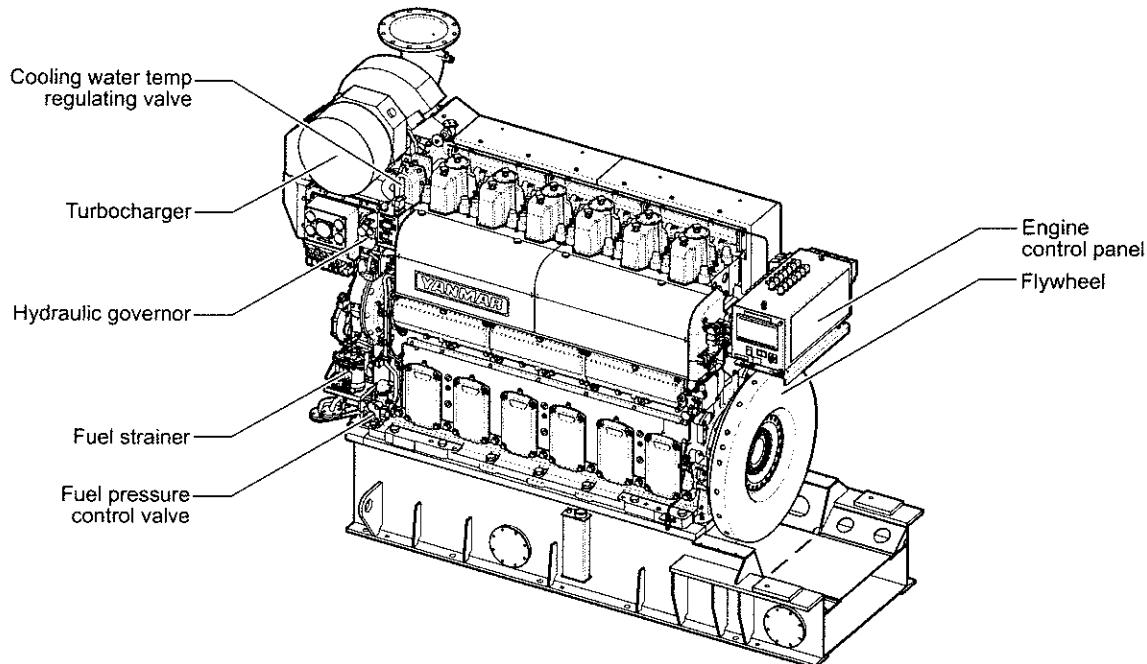
Work, energy

kW·h	J	kcal	kgf·m
1	3.6×10^6	8.600×10^2	3.671×10^5
2.778×10^{-7}	1	2.389×10^{-4}	1.0197×10^{-1}
1.163×10^{-3}	4.186×10^3	1	4.269×10^2
2.724×10^{-6}	9.80665	2.343×10^{-3}	1

Power

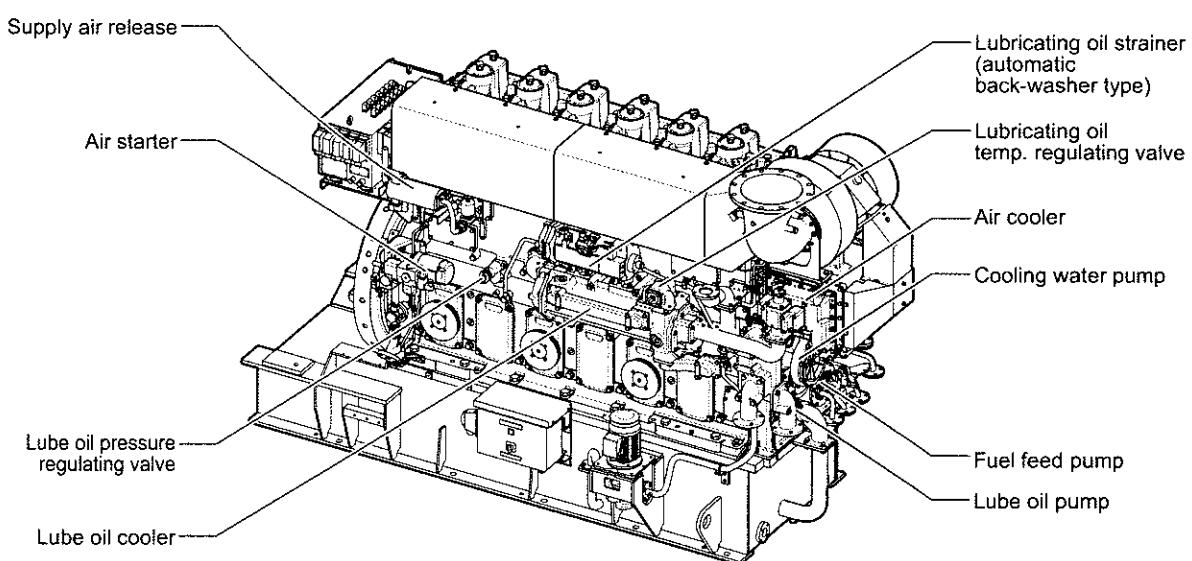
kW	PS
1	1.3596
0.7355	1

1. Engine view



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Fig.1 Operation side (fuel injection pump side)



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Fig.2 Non-operation side (exhaust manifold side)

2. Vertical view of the engine

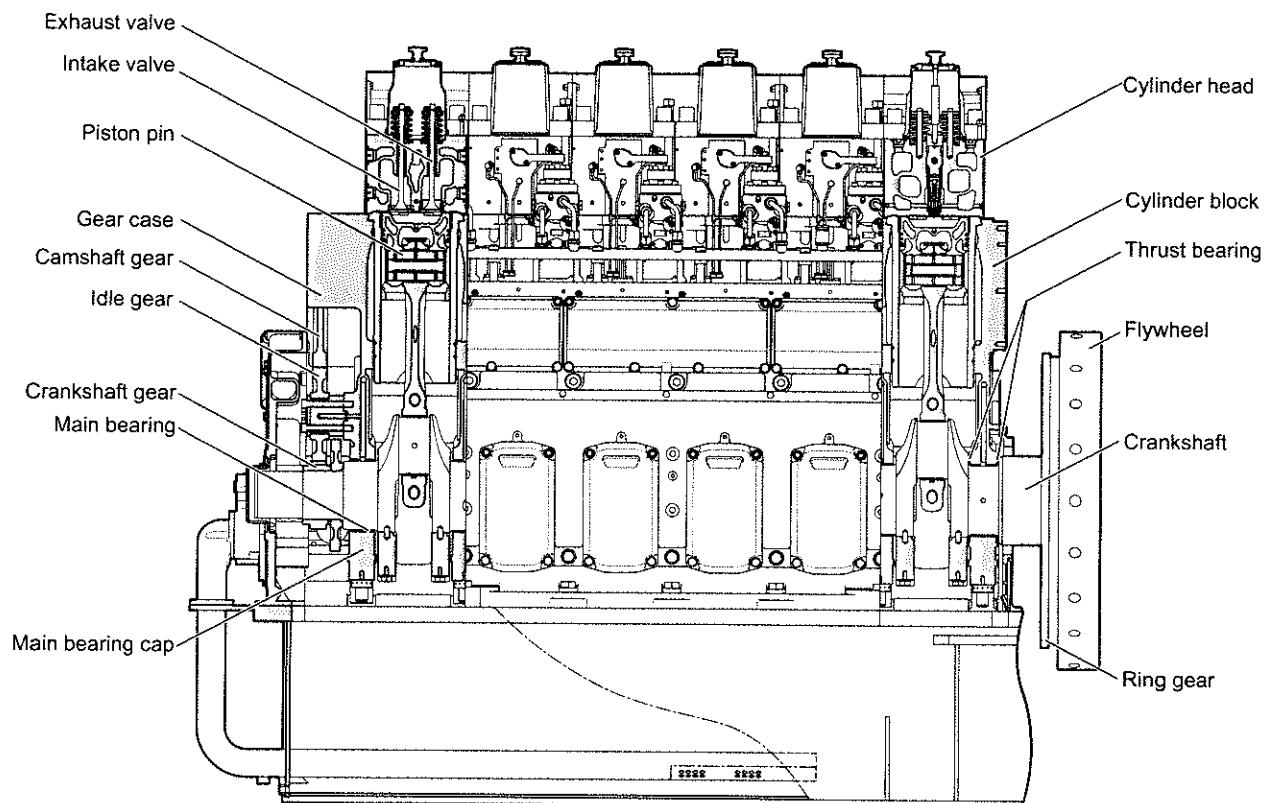


Fig.3 Vertical view of the engine

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3. Horizontal view of the engine

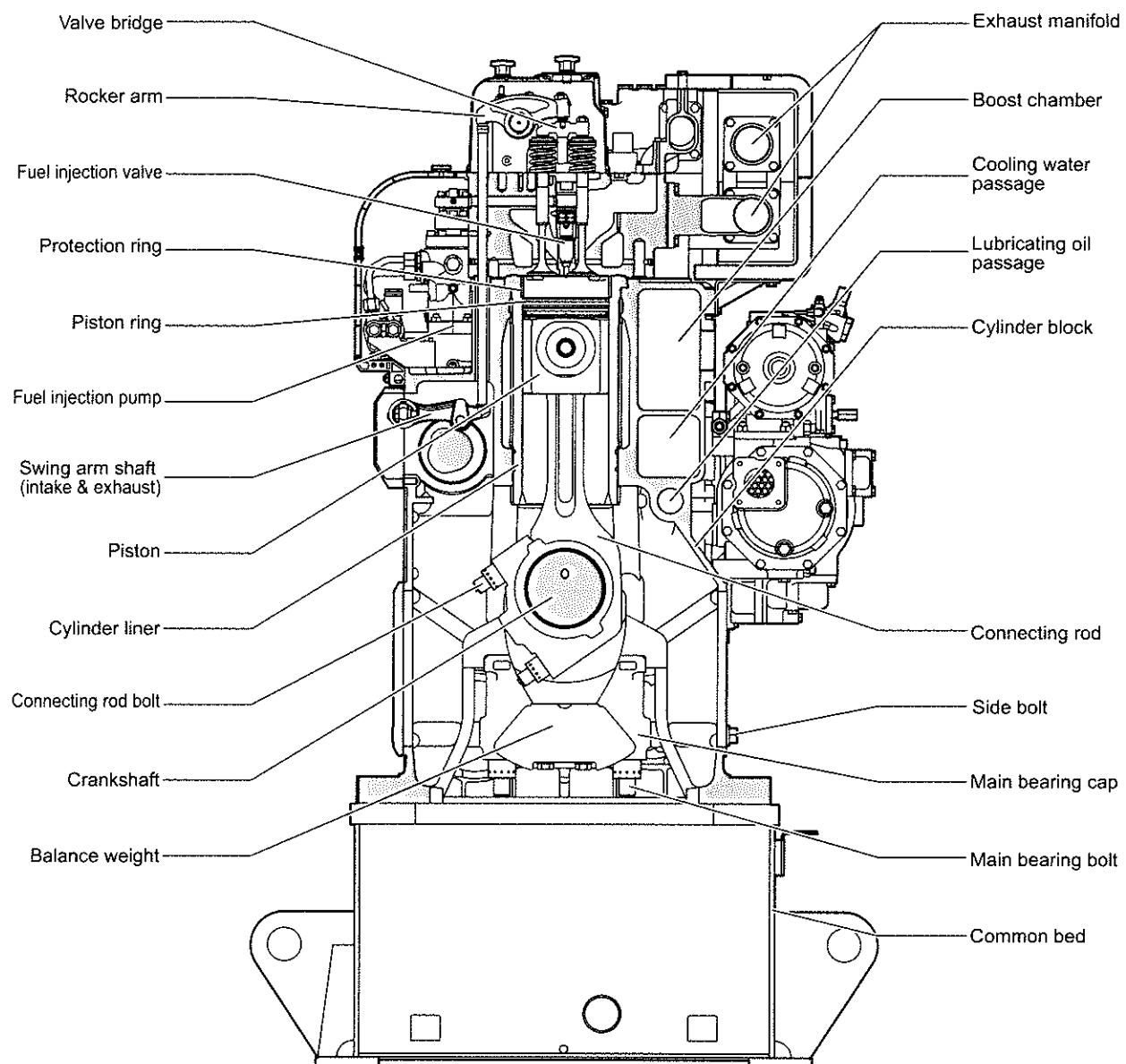


Fig.4 Horizontal view of the engine

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1. Protective device setting values

Item	Unit	Alarm setting value	Emergency stop setting value
Engine inlet lubricating oil pressure	MPa	0.5	0.45
Engine cooling freshwater temperature	°C	95	100
Rotational overspeed	min ⁻¹	-	112 % to 115 % of the rated speed

2. Holding volumes of lubricating oil and cooling water

Item		Unit	Holding volume
Lubricating oil	Engine (incl. cooler, filter and piping)	l	50
	Lubricating oil tank (common bed)		1200 *
	Governor	Type NZ61	1.3
		Type UG-8	1.5
		Type UG-25 ⁺	2.1
Cooling water (freshwater)	Engine (incl. piping)	150	
	Cooler (lubricating oil, air)	40	

*: The values may be different depending on the specification. Refer to the Final Drawing.

3. Pressure and temperature settings

Items shown in the table below for which monitoring are required vary depending on the regulation and specifications.

	Item	Unit	Setting value	Remarks
Pressure	Fuel supply pressure	MPa	0000-001-17 Recommended pressure in MPa	
	Internal maximum combustion pressure (Pmax)		*	Refer to the Records of Shop Trial
	Lubricating oil pressure		0.55 to 0.6	
	Cooling water pressure (jacket cooling line)		0.15 to 0.50	
	Cooling water pressure (cooler cooling line)		0.15 to 0.50	
	Start-air pressure		2.94	Lower limit: 1.18
	After decompression		0.90 to 1.1	At the air starter inlet
Temperature	Cooling water engine outlet temperature	°C	85 ± 4	
	Cooling water lubricating oil cooler inlet temperature		< 38	
	Lubricating oil engine inlet temperature (cooler outlet)		50 to 65	
	Exhaust temperature (at each cylinder outlet)		*	Refer to the Records of Shop Trial
	Exhaust gas turbocharger inlet temperature		*	Refer to the Records of Shop Trial

*: Refer to the Records of Shop Trial and records the values on this page. The values are different depending on the engine specification and output.

1. Assembly adjustment values

Item		Unit	Adjustment value	Remarks
Timing or clearance	Piston top clearance (A)	mm	2.24 ± 0.18	-
	Intake valve	deg.	50	-
			0	-
	Valve head clearance (B)	mm	0.4	When engine is cold
	Exhaust valve	deg.	49	-
			31	-
	Valve head clearance (B)	mm	0.9	When engine is cold
Fuel injection pump begins injections (before T.D.C.)		deg.	*	Refer to the Records of Shop Trial.
Opening pressure (fuel injection valve)		MPa	45.0 ± 0.5	1533510T90235U (marking KLA) or 1533410T90235U (marking KLC)
			40.0 ± 0.5	1533510T90235W (marking KLA_2) or 1533410T90235W (marking KLC_2) or 1533310T90255W (marking LT)

*: Refer to the Records of Shop Trial and records the values on this page. The values are different depending on the engine specification and output.

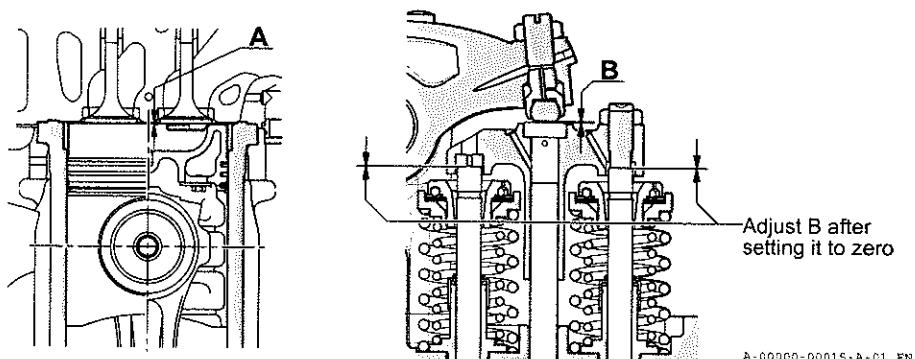
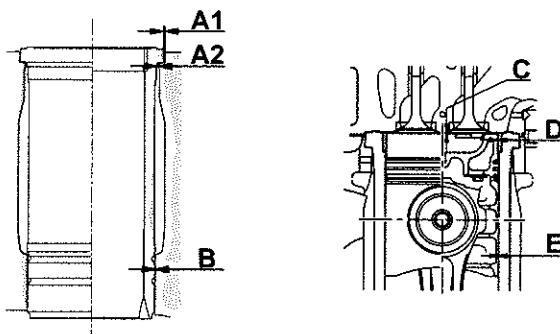


Fig.1 Assembly adjustment values

2. Clearance and wear limits of major parts

Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Inner diameter of the top part of the cylinder block (top)	$\varnothing 304$	+0.088 +0.056	A1 = 0.126 to 0.193	A1 = 0.25	+0.13
Outer diameter of the top part of the cylinder liner (top)		-0.070 -0.105			-0.17
Inner diameter of the top part of the cylinder block (bottom)		+0.032 0	A2 = 0.020 to 0.087	A2 = 0.2	+0.13
Outer diameter of the top part of the cylinder liner (bottom)		-0.020 -0.055			-0.13
Inner diameter of the cylinder (bottom)		+0.032 0	B=0.015 to 0.091	B=0.2	+0.13
Outer diameter of the cylinder liner (bottom)		-0.015 -0.059			-0.13
Top clearance	2.24	± 0.18	C=2.06 to 2.42	C=2.42	-
Inner diameter of the protection ring	$\varnothing 218.4$	± 0.05	D=1.55 to 1.69	-	+0.8
Outer diameter of the piston head *	$\varnothing 216.78$	± 0.02			-
Inner diameter of the cylinder liner	$\varnothing 220$	+0.040 0	E=0.112 to 0.192	E=0.3	+0.4 Uneven wear 0.2
Outer diameter of the piston skirt	$\varnothing 219.868$	± 0.02			-0.2

*: 20 mm from the piston head



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Fig.2 Cylinder and cylinder liner

Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Piston, piston pin and rings	Thickness of the piston rings No. 1 to No. 2 *1	F= No. 1: 7.5 No. 2: 7.4	±0.15	-	-
	Thickness of the oil rings *1	F=5.0	±0.25	-	-
	Width of the piston ring (No. 1) *1	6	-0.010 -0.030	No. 1 G=0.110 to 0.155	-0.15
	Width of the piston ring groove (No. 1)		+0.125 +0.100		+0.35
	Width of the piston ring (No. 2) *1	5	-0.030 -0.050	No. 2 G=0.055 to 0.100	-0.22
	Width of the piston ring groove (No. 2)		+0.050 +0.025		+0.28
	Width of the oil ring *1	9	-0.010 -0.030	H=0.030 to 0.075	-0.2
	Width of the oil ring groove		+0.045 +0.020		+0.3
	Inner diameter of piston pin bearing	Ø 95	+0.115 +0.095	J=0.095 to 0.130	+0.2
	Outer diameter of the piston pin		0 -0.015		-0.06
	Inner diameter of the piston pin hole		+0.050 +0.030	K=0.030 to 0.065	+0.16
	Outer diameter of the piston pin		0 -0.015		-0.06

*1: Replace the rings after 8000 to 12000 hours (2 to 3 years) at the time of a scheduled inspection. Replace all rings with new ones even if their dimensions agree with the wear limits.

*2: Replace the 1st ring with a new one when its plated layer is worn out and the base metal begins to be exposed. Replace the 2nd ring when the taper face is gone.

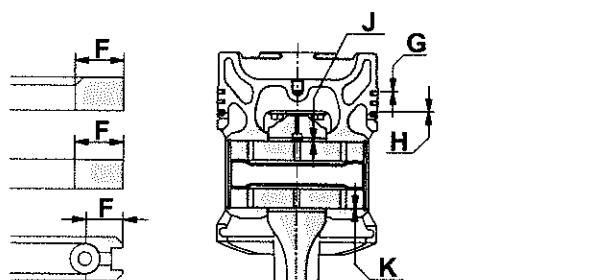


Fig.3 Piston, piston pin and rings

Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Inner diameter of the crank pin bearing	$\emptyset 180$	+0.209 +0.140	L=0.140 to 0.234	L=0.3	+0.25
Outer diameter of the crank pin		0 -0.025			Uneven wear 0.1
Inner diameter of the main bearing		+0.239 +0.170	M=0.170 to 0.268	M=0.32	+0.27
Outer diameter of the main shaft		0 -0.029			Uneven wear 0.1
Width of the base part main bearing		-0.177 -0.273	N=0.177 to 0.308	N=0.5	-0.4
Width of the base part main shaft		+0.035 0			+0.35
Deflection	-	-	2102-000-02 According to crankshaft inspection		

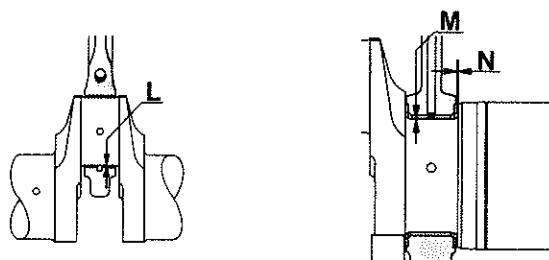


Fig.4 Crankshaft

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Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Outer diameter of the intake valve shaft	$\varnothing 16$	-0.070 -0.090	$R1=0.070$ to 0.116	$R1=0.32$	-0.32
Inner diameter of the intake valve guide		+0.026 0			+0.28
Outer diameter of the exhaust valve shaft		-0.080 -0.100	$R2=0.080$ to 0.126	$R2=0.35$	-0.35
Inner diameter of the exhaust valve guide		+0.026 0			+0.28
Inner diameter of the valve bridge		+0.080 +0.060	$S=0.014$ to 0.052	$S=0.2$	+0.18
Outer diameter of the valve bridge guide		+0.046 +0.028			-0.18
Thickness of the intake/exhaust valve	$T=5.4$	± 0.2	-	-	5.0
Width of the intake/exhaust valve seat	$U=6.8$	± 0.2	-	-	7.9
Diameter of the contact part of the valve sheet	$V=\varnothing 71$	± 0.1	-	-	$\varnothing 73$
Outer diameter of the rocker arm shaft	$\varnothing 45$	-0.009 -0.034	$W=0.029$ to 0.119	$W=0.25$	-0.1
Inner diameter of the rocker arm bush		+0.085 +0.020			+0.22
Inner diameter of the swing arm	$\varnothing 50$	+0.025 0	$X=0.010$ to 0.055	$X=0.2$	+0.2
Outer diameter of the swing arm shaft		-0.010 -0.030			-0.1

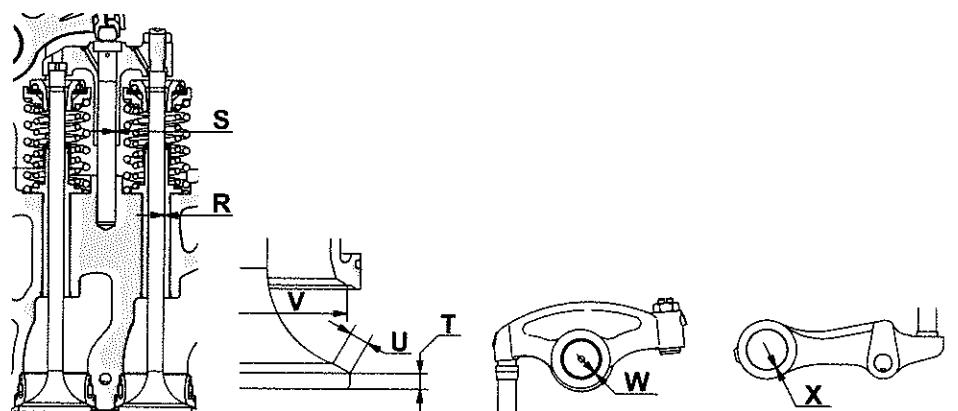


Fig.5 Valve mechanism

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Engine information

Design data/tolerances check

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Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Camshaft	Outer diameter of the standard camshaft	Ø 155	-0.085 -0.148	Y=0.085 to 0.238	-0.2
			+0.090 0		
	Inner diameter of the camshaft base part bearing				+0.17
	Thickness of the camshaft thrust bearing	11	-0.10 -0.12	Z=0.15 to 0.23	-
	Width of the camshaft thrust		+0.11 +0.05		
Outer diameter of the camshaft middle portion	Ø 155	-0.085 -0.148	a=0.085 to 0.238	a=0.33	-0.2
		+0.090 0			+0.17

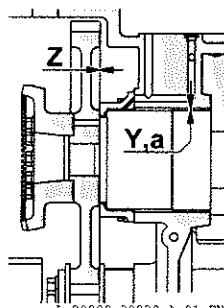


Fig.6 Camshaft

	Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Lubricating oil pump	Outer diameter of the pump shaft	$\varnothing 40$	+0.008 -0.008	b=0.052 to 0.084	b=0.15	-0.12
	Inner diameter of the pump shaft bush		+0.076 +0.060			+0.1
	Pump case	$\varnothing 84$	+0.054 0	c=0.200 to 0.304	c=0.5	-
	Outer diameter of the gear		-0.200 -0.250			-
	Width of the pump case	130	+0.063 0	d=0.080 to 0.193	d=0.22	-
	Width of the pump gear		-0.080 -0.130			-

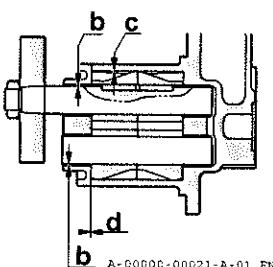


Fig.7 Lubricating oil pump

	Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Cooling water pump	Outer diameter of the impeller hub (boss)	$\varnothing 110$	-0.120 -0.174	e=0.770 to 0.864	e=1.60	-0.6
	Inner diameter of the casing		+0.690 +0.650			+1.0

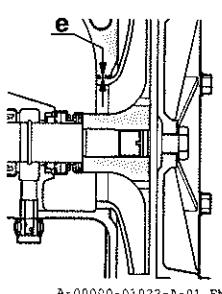


Fig.8 Cooling water pump

Engine information

Design data/tolerances check

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	Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Fuel feed pump	Outer diameter of the pump shaft	$\varnothing 25$	-0.020 -0.041	b=0.020 to 0.062	b=0.2	-0.1
	Inner diameter of the pump shaft bush		+0.021 0			+0.1
	Pump case	$\varnothing 48$	+0.025 0	c=0.080 to 0.130	-	-
	Outer diameter of the gear		-0.080 -0.105			-
	Width of the pump case		+0.018 0			-
	Width of the pump gear	16.5	-0.016 -0.034	d=0.026 to 0.062 (Liquid packing 0.02 or less)	-	-

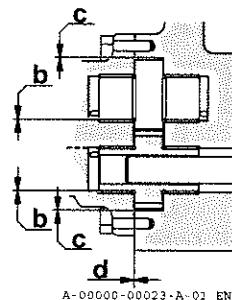


Fig.9 Fuel feed pump

	Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Idle gear	Gear backlash (timing gear and pump-driving gear) M=5.5	$\varnothing 107$	-0.036 -0.071 +0.035 0	f=0.19 to 0.29	f=0.5	-
	(Bevel gear) M=3			f=0.12 to 0.2	f=0.3	-
	Camshaft drive Outer diameter of the idle gear shaft			g=0.036 to 0.106	g=0.2	-0.17
	Inner diameter of the bush					+0.14

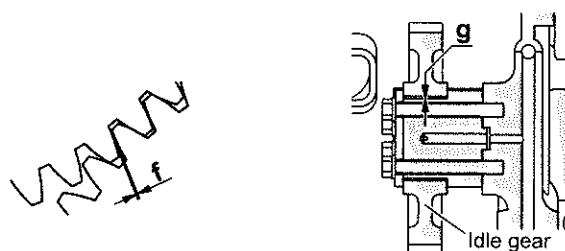


Fig.10 Idle gear

	Part name	Nominal dimension	Tolerance	Standard clearance	Max. allowable clearance	Usage limit of parts
Oil deflector flywheel side	Outer diameter of the crankshaft	$\varnothing 285$	0 -0.052	$j=0.50$ to 0.652	-	-
	Inner diameter of the oil deflector		+0.60 +0.50			

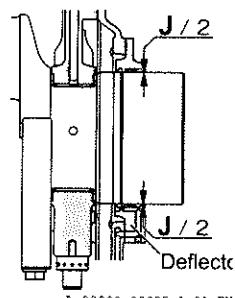


Fig.11 Oil deflector flywheel side

3. Table of Tightening Torques for Major Bolts and Nuts

There are three tightening methods for the major bolts and nuts of this engine: hydraulic tightening, angle tightening and torque tightening. Obey the instructions in the manual and tighten major bolts correctly.

Unless otherwise specified, apply lubricating oil on the thread and bearing surface.

3.1 Hydraulic tightening

This is a tightening method with a hydraulic jack. Obey the instructions in this manual for the hydraulic jack when you operate it. All specified pressure values are in the table that follows.

Part name	Screw diameter × pitch	Shape of nut	Specified hydraulic pressure (MPa)
Cylinder head tightening nut *	M39×2.0	Round	58.8 ± 0.5
Main bearing cap tightening nut *	M39×2.0	Round	58.8 ± 0.5
Connecting rod tightening nut *	M33 × 2.0	Round	55 ± 0.5

*: When you tighten any of these parts, refer to the match mark and tighten the part with the specified oil pressure.

3.2 Angle tightening

For this tightening method, first tighten the bolt until it is seated, then turn it to the specified turning angle. The seating torque and the turning angle are in the table that follows.

Part name	Screw diameter × pitch	Bolt face-to-face width (mm)	Seating tightening torque (N·m)	Specified tightening angle (°)
Balance weight tightening bolt *	M24 × 2.0	32	50	80 (0 to +3)

*: When you tighten any of these parts, refer to the match mark and tighten the part to the specified tightening angle.

3.3 Torque tightening

Tighten all major bolts with the torque method, if hydraulic tightening and angle tightening are not applicable. The specified tightening torque for major bolts is in table that follows.

Part name	Screw diameter × pitch	Bolt or nut face-to-face width (mm)	Tightening torque (N·m)	Remarks
Indicator cock tightening nut	M12×1.75	19	60 to 70	-
Rocker arm shaft support tightening nut	M20 × 1.5	30	330 to 370	-
Fuel injection valve nozzle sleeve *	M33 × 1.5	2 grooves	300 to 320	-
Fuel injection nozzle retainer tightening nut	M10 × 1.5	17	20 to 25	-
Fuel injection valve case nut *	M28 × 1.5	27	166 to 176	-
Fuel injection valve pressure-regulating locknut *	M33 × 1.5	41	97 to 103	-
Fuel injection pipe joint bolt *(cylinder head side)	M8 × 1.25	6 (hex-socket)	30 to 35	-
Fuel injection pipe joint bolt (pump side) *	M10 × 1.5	8 (hex-socket)	70 to 75	-
Fuel injection pump tightening nut *	M14 × 1.5	22	120 to 130	-
Fuel injection pump delivery valve body Tightening bolt	M12×1.75	10 (hex-socket)	85 to 90	-
Fuel injection pump barrel retaining bolt	M12×1.75	10 (hex-socket)	85 to 90	-
Fuel injection pump protector	M24 × 2.0	30	50 to 60	-
Fuel injection timing adjust bolt locknut *	M22 × 1.5	30	196 to 245	-
Camshaft coupling nut	M14 × 1.5	19	100 to 110	U-nut
Cam gear tightening bolt	M14 × 1.5	19	140 to 160	-
Idle gear shaft tightening bolt	M18 × 1.5	24	245 to 255	-
Cooling water pump impeller *	M24 × 1.5	Round-hole 4 places	430 to 450	Left-hand screw
Cooling water pump driving gear tightening nut	M24 × 2.0	36	235 to 255	-
Main bearing cap side bolt	M27 × 2.0	36	707 to 765	-
Flywheel tightening bolt	M22 × 1.5	27	640 to 670	-
Lubricating oil pump driving gear tightening nut	M30 × 2.0	46	460 to 520	-
Swing arm shaft tightening bolt	M16 × 1.5	24	150 to 180	-
Fuel injection pipe cap nut	M20 × 1.5	32	40 to 45	-
Fuel branch pipe cap nut	M25 × 2.0	32	80 to 90	-

*: The parts have a special tool.

3.4 General bolts

Tighten any bolts other than the major ones according to the table that follows.

- For parts with a tightening section made of aluminum: tighten to 80 % of the torque shown in the table that follows.
- For general bolts, do not apply lubricating oil to the thread and the bearing surface.
- This table is applicable only to the bolts whose part No. (an 11-digit numeral) shown in the attached parts list consists of 2 at its first place and 2, 5 or 6 at its fifth place.
(Example: 2XXX2-XXXXXX, 2XXX5-XXXXXX, 2XXX6-XXXXXX)

Screw diameter x pitch	Bolt or nut face-to-face width (mm)	Tightening torque (N·m)
M6 × 1.0	10	10 to 12
M8 × 1.25	13	24 to 27
M10 × 1.5	17	44 to 54
M12 × 1.75	19	78 to 98
M14 × 1.5	22	123 to 152
M16 × 1.5	24	206 to 245
M16 × 2.0	24	206 to 245

3.5 Tightening torque for pipe joint bolts (material: S25C)

Screw diameter x pitch	Bolt or nut face-to-face width (mm)	Tightening torque (N·m)	Outer diameter of pipe (mm)
M8 × 1.25	14	17 to 20	3
M12 × 1.25	17	25 to 34	6
M14 × 1.5	19	39 to 49	8
M16 × 1.5	22	49 to 59	10
M18 × 1.5	24	69 to 78	12
M20 × 1.5	27	88 to 98	15
M22 × 1.5	30	147 to 196	18

4. Principal dimensions for disassembly and servicing

These are the dimensions necessary for disassembly and servicing of the engine. Make sure that you have enough space for your work before you start the disassembly and servicing.

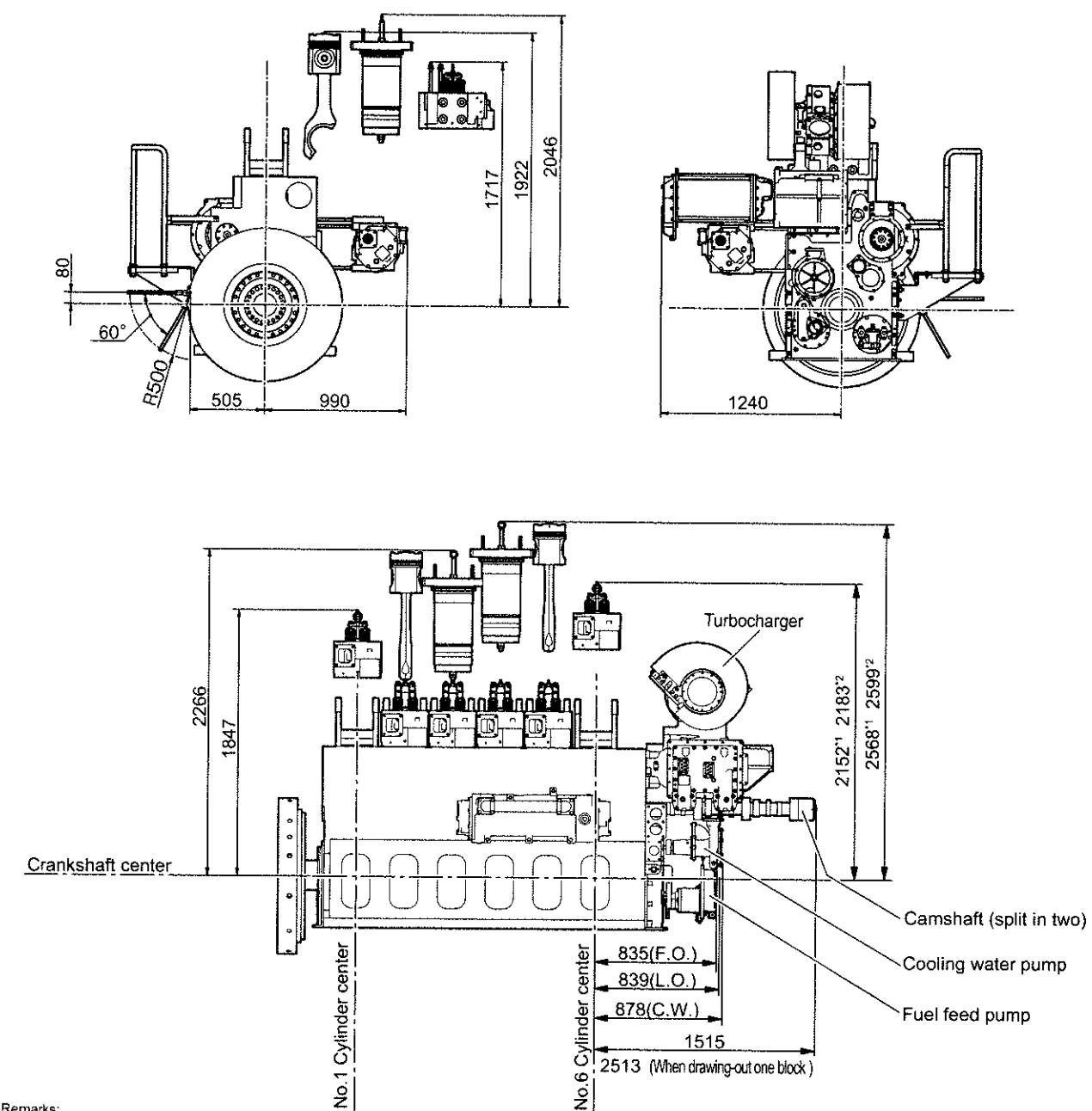


Fig.12 Principal dimensions for disassembly and servicing

Do the engine inspections at regular intervals. This makes sure that the engine operates in a good condition and prevents defects. The inspection intervals depend on the operating conditions and the quality of the fuel oil and lubrication oil. Thus it is difficult to recommend a fixed inspection schedule.

This inspection table shows the standard intervals. Do the first overhaul according to this table. Schedule the next inspection according to the results of your first overhaul (e.g. the wear, corrosion and contamination with carbon and sludge).

If an engine part has two inspection periods (operating hours and number of days), schedule the inspection at the earlier time.

1. Table of routine maintenance inspections

Part	Daily	Weekly	1 month (or 300 h to 500 h)
Starting air reservoir	Pressure inspection	Draining	
Speed control device	Governor oil level inspection		Linkage system inspection and lubrication
Fuel oil system	Fuel injection pump		Rack scale position inspection
			Inspection of the pinion lubrication volume
	Fuel strainer	Draining	Disassemble and clean (depending on the differential pressure gauge display)
	Injection-timing adjusting bolt		Inspection for loose locknuts
Lub. oil system	Lubrication oil tank (common bed)	Oil level inspection	
	Bypass filter		Disassembly and cleaning
Cooling water pump	Mechanical seal leak inspection		
Turbocharger		Cleaning of the air-filter 200h (MET)	
			Cleaning of the compressor (When entering/leaving port)
		Cleaning of the turbine 100h to 200h (MET)	
Air starter	Electric wiring		Inspection for loose wiring
	Air piping		Inspection for leaking connections
Instrument	All pressure gauges	Inspection for defective gauges	
	All thermometers	Inspection for defective gauges	
Each pressure temperature sensor			Check for looseness (small connector attaching screw)
Engine appearance	Bolt and nut inspection (looseness), leak inspection on all portions (cooling water, fuel oil, lubricating oil, intake air and exhaust gas)		
All pipings	Leak inspection		

2. Table of scheduled maintenance inspections

*: This is the first inspection after the first engine start or after you replace a part. Do the inspection at the normal frequency from the second time on.

Category	Part	Maintenance	Inspection and servicing frequency (in hours)					Remarks	
			3 months or 1000 to 1500	6 months or 2000 to 2500	1 year or 4000 to 5000	2 to 3 years or 8000 to 12000	5 year or 16000 to 20000		
	Fuel injection valve	Removal, inspection and adjustment	1500 to 2000						1st time: 500 to 800 hours Replacing the nozzle spring: 8000 hours
Cylinder head	Cylinder head	Inspection and adjustment of the valve head clearance	O						
		Inspection of the valve spring			O				
		Disassembly and inspection of the valve rotator							As necessary
		Disassembly, inspection and cleaning			O				
		Valve seat grinding			O				
		Scale cleaning and hydraulic test of the water chamber			O				
		Stem seal (intake/exhaust valves) replacement			O				
Major moving parts	Piston	Hydraulic test of the cylinder head bolt tightening	*		O				
		Removal, cleaning, inspection and measurement of the piston			O				
		Inspection and measurement of the piston rings			O				
	Connecting rod	Inspection and measurement of the piston pin			O				
		Inspection and measurement of the piston pin bearing			O				
		Crank pin bearing inspection and measurement			O				
		Inspection of the tightening force of the connecting rod bolt			O				
		Replacing the connecting rod bolts						20000 h	
	Cylinder liner	Inspection, cleaning and measurement of the inner diameter			O				
		Removal, inspection and cleaning of the water jacket				O			
	Crankshaft	Measurement of the journal and the outer diameter of the crank pin			O				
		Deflection measurement and adjustment	O						

Engine information

Scheduled inspection

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Category	Part	Maintenance	Inspection and servicing frequency (in hours)					Remarks
			3 months or 1000 to 1500	6 months or 2000 to 2500	1 year or 4000 to 5000	2 to 3 years or 8000 to 12000	5 year or 16000 to 20000	
Major moving parts	Main bearing	Disassembly, bearing inspection and measurement				O		
		Inspection of the tightening force of the main bearing bolts				O		
		Inspection of the tightening force of the side bolt				O		
	Camshaft	Inspection of the cam and roller contact			O			
		Disassembly and inspection of the fuel pump tappet				O		
		Disassembly, inspection and measurement of the swing arm				O		
Speed control mechanism	Timing gear	Crankshaft removal, bearing inspection and measurement					O	
		Inspection of tooth contact and backlash				O		
		Disassembly of the idle gear, inspection and measurement of the bearing					O	
	Fuel feed pump	Inspection of the idle gear mounted shaft tightening force					O	
		Lubricating oil pump driving gear	Inspection of tooth contact and backlash			O		
Governor	Governor	Replace hydraulic oil	*	O				
		Disassembly and inspection				O		
	Governor drive unit	Disassembly and inspection of the tooth contact and bearing					O	

Engine information

Scheduled inspection

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Category	Part	Maintenance	Inspection and servicing frequency (in hours)					Remarks
			3 months or 1000 to 1500	6 months or 2000 to 2500	1 year or 4000 to 5000	2 to 3 years or 8000 to 12000	5 year or 16000 to 20000	
Fuel oil system	Fuel injection pump	Inspection of the injection timing	O					1st time: 300 h to 500 h
		Deflector inspection and replacing	O					
		Disassembly, cleaning and inspection		O				
Fuel feed pump	Fuel feed pump	Disassembly and inspection		O				
		Replacing the oil seal		O				
		Replacing the ball bearing						8000 h to 10000 h
Pressure gauge seal pot	Pressure gauge seal pot	Ethylene glycol level inspection	(O)					Every 2 months
		Replace the ethylene glycol		O				
Accumulator (on the fuel oil primary piping and pressure control valve)	Accumulator (on the fuel oil primary piping and pressure control valve)	Replacing the accumulator					O	Optional specification
		(depending on the properties analysis)	O					
Lubricating oil system	Lubricating oil cooler	Disassembly, inspection, cleaning and hydraulic test			O			
	Thermostat	Disassembly, inspection and cleaning		O				
	Lubricating oil pump	Disassembly, inspection and measurement			O			
		Disassembly and inspection of the relief valve			O			
	Pressure control valve	Disassembly, inspection and cleaning			O			
	Lubricating oil strainer	Filter candle inspection			O			Every 2 years
		Replace the filter candle				(O)		Every 4 years
		Rotation check		O				Worm gear, turbine, flushing arm
		Replace the O-ring						Maintenance time
Cooling water system	Lubricating oil priming motor pump	Replacing the motor bearing		O				Replacement is recommended in 1 to 1.5 year regardless of operating time
	Thermostat	Disassembly, inspection and cleaning		O				
	Cooling water pump	Disassembly, inspection and measurement		O				
		Replacing the mechanical seal		O				
		Replacing the ball bearing						8000 h to 10000 h
	Freshwater cooler	Disassembly, inspection and hydraulic test		O				
	Cooling water (freshwater)	Replacing (depended on results of property analysis)		O				

Engine information

Scheduled inspection

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Category	Part	Maintenance	Inspection and servicing frequency (in hours)					Remarks
			3 months or 1000 to 1500	6 months or 2000 to 2500	1 year or 4000 to 5000	2 to 3 years or 8000 to 12000	5 year or 16000 to 20000	
Air system	Air starter	Cleaning the air filter	O					
	Fuel cut-off air piston	Replacing the O-ring				O		
Other	Turbocharger	Disassembling and cleaning				O		1st time: 8000 h or less
	Charge air cooler	Disassembly, inspection, cleaning and hydraulic test			O			
	Engine tachometer	Gauge inspection			O			
	Alarm switch	Actuation test	O					

Before the initial start of the engine after its installation or before its restart after its overhaul servicing or a long term stoppage, sufficiently perform the following inspection and operation preparation in addition to daily inspection and operational preparation.

- Make sure that the engine room is clean and tidy
- Check for a part not tightened yet
- Make sure no part and tool has been left in the crankcase

For the adjustment values (e.g. the clearance on the valve head of the intake/exhaust valves, and the beginning of the discharge from the fuel injection pump), refer to the "Assembly adjustment values" table in "Design data/tolerances check 0000-000-07".

1. Turning the flywheel

WARNING

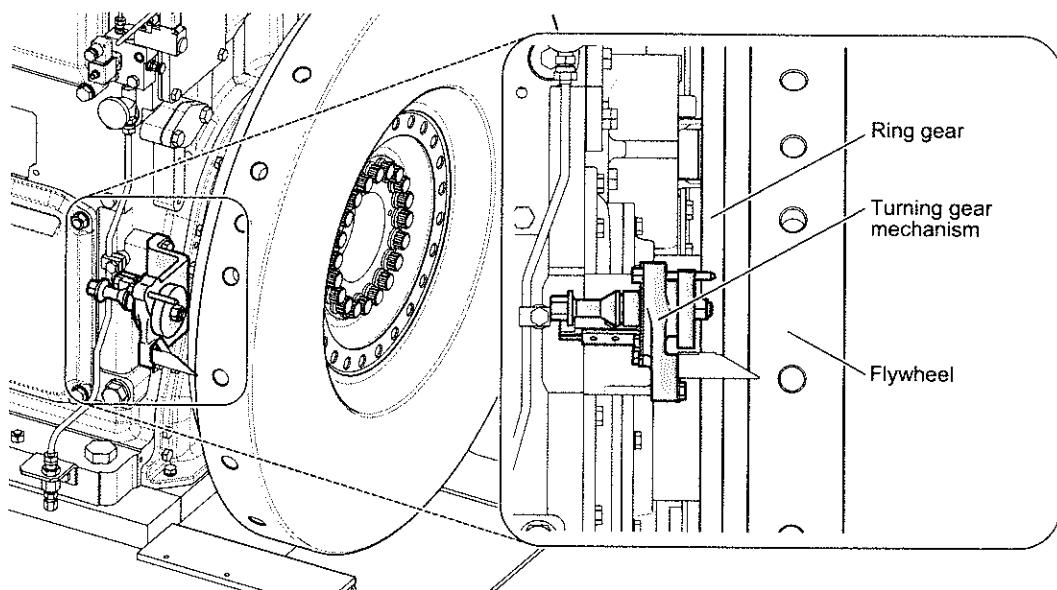
- Be careful that your body does not touch any moving parts when you turn the flywheel.
Never put your hand into the cylinder block.
- Make sure that the crankshaft does not turn suddenly when you disassemble or inspect the moving parts.
To do so, engage the turning gear and lock it with a lock bar.
Use the lock bar, because it prevents the crankshaft from turning suddenly during disassembly and inspection. Engage the turning gear and lock the turning shaft with the stopper. Tighten the lock bar.

When you adjust the clearance on the valve head of the intake/exhaust valves or the beginning of the discharge from the fuel injection pump, use the turning device.

Obey the instructions for the turning device that follow.

(Note)

After you finish turning, disengage the turning gear and put the stopper into the groove. Tighten the lock bolt. If you do not disengage the turning gear, the engagement/disengagement switch activates and you cannot start the engine.



A-00000-00027-A-01_EN

Fig. 1 Installation locations for the turning mechanism

1. Prepare the special turning tools.
2. Remove the lock bar.
3. Loosen the 2 lock bolts of the stopper.
4. Remove the stopper from the groove A of the turning shaft.
5. Push in the shaft until it engages with the gear.
6. Install the stopper in the groove B on the turning shaft. Tighten the 2 lock bolts.
7. Install the turning socket and the ratchet handle to the shaft. Turn.
8. After you finish turning, disengage the turning gear.
9. Put the stopper into groove A. Tighten the lock bolts.
Keep the lock bar in a safe place (e.g. a tool case) to prevent loss.

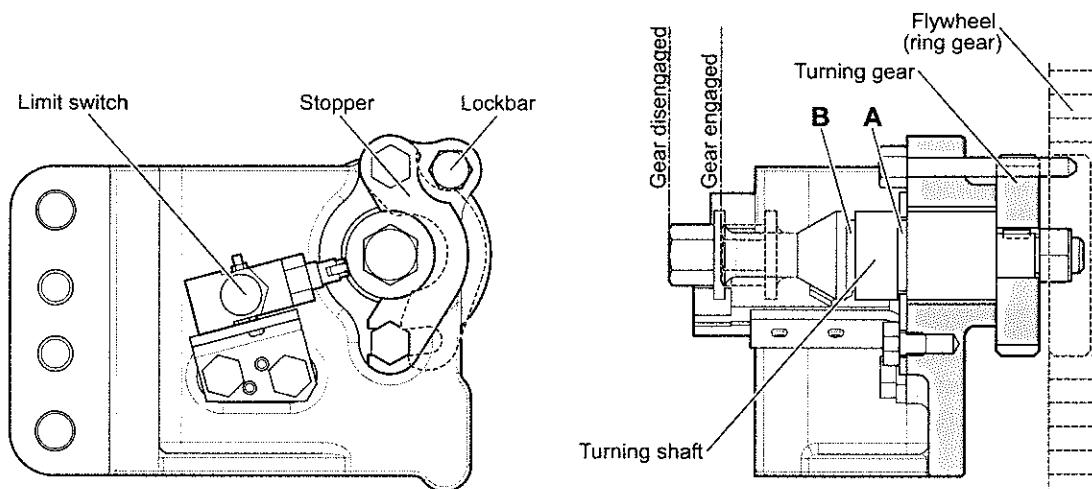


Fig.2 Maintenance of the turning mechanism

A-00000-00028-A-01_EN

2. Lubricating oil system (yellow coating)

2.1 Draining the lubricating oil system

Before you fill new lubricating oil, drain the fluids in the devices or parts that follow. Open the drain valve or plug to drain.

- The common bed of the lubricating oil sump tank
- Lubricating oil cooler
- Lubricating oil strainer
- Governor oil sump

2.2 Filling the lubricating oil

- 1 - Fill all devices with lubricating oil. Fill to the top limit of the oil level gauge or the dipstick.
For the necessary oil amount, refer to "Lubricating oil holding volume 0000-001-06".
- 2 - Remove the top cover of the governor.
- 3 - Fill the lubricating oil up to 2 mm to 3 mm higher than the center of the oil level gauge.
- 4 - Manually lubricate the area around the governor link. Make sure that it moves easily.

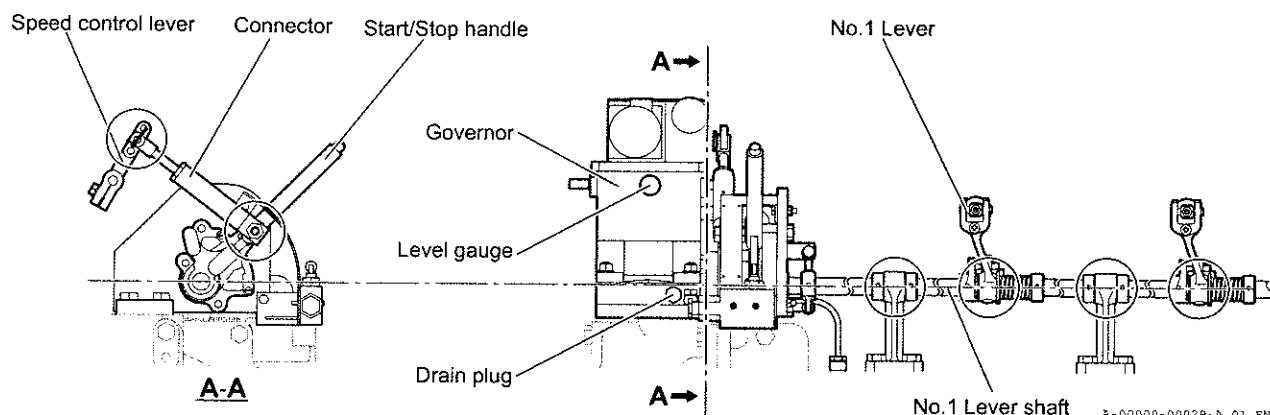


Fig.3 Lubrication points (governor link)

- 5 - Do a lubricating oil inspection.
 - 6 - Change it if it is very contaminated or deteriorated.
- Control of the lubricating oil 0000-001-17

2.3 Priming of the lubricating oil

When the engine stops, lubricating oil priming operates.

NOTICE

- Switch the control power supply for the motor-operated priming pump to ALWAYS ON.
- Turn the power supply off if:
 - The ship stops for a long term.
 - The power installation is inactive.
 - You do maintenance on the power installation.

- 1 - If priming stops for 2 hours or more, do a new priming for approximately 20 minutes or more.

Priming pressure: 0.02 MPa to 0.20 MPa

2.4 Releasing air from the lubricating oil strainer

Before you start the engine, release the air from the lubricating oil strainer if:

- The lubricating oil priming pump has stopped for 2 hours or more.
 - You disassemble and clean the lubricating oil strainer.
 - You change the lubricating oil.
- You disassemble and do maintenance on the lubricating oil system.

1 - Operate the lubricating oil priming pump.

2 - Loosen the lubricating oil air vent plug.

3 - Release the air.

4 - Tighten the air vent plug.

5 - If you cannot operate the lubricating oil priming pump, obey these instructions:

1 - Do an air running (5 times for approximately 3 seconds).

2 - Release the air.

3 - Release the air again after engine start.

3. Cooling water system (the freshwater system has blue coating and the seawater system has green coating)

3.1 Cooling water inspection

Examine the cooling water tank and look for contamination of the cooling water. If the cooling water is very dirty, replace it.

1. Fill the cooling water tank with cooling water. Fill it to the top limit of the water level gauge. Add corrosion inhibitor.

Selecting and controlling the corrosion inhibitor 0000-001-17

2. Open and close each valve of the cooling water pipe system according to the operation conditions.

3. Open the air vent cock on the top of the air cooler and release the air.

If you replaced the cylinder liner or removed it for servicing: Remove the cylinder side cover and make sure that there are no water leaks inside the cylinder.

4. Fuel oil system (red coating)

1. Drain the fuel oil strainer and the fuel oil tank.

2. Fill the fuel oil tank with fuel oil.

3. Measure the fuel level.

4. Open or close each valve according to the operation conditions.

- For heavy fuel oil engines with marine diesel oil start/stop specifications: Turn on the heater for the heavy fuel oil pipeline. Heat the heavy fuel oil until it has the correct viscosity. Then switch from marine diesel oil to heavy fuel oil.

M.D.O. Change-over 0000-001-10

- For engine specifications that use heavy fuel oil for the engine start and stop, make sure that the fuel oil temperature (viscosity) at the engine inlet is correct.

H.F.O. Direct start 0000-001-10

Properties of the fuel oil at engine inlet 0000-001-17

- The seal pot is at the fuel oil pressure gauge inlet. At the first start, fill ethylene glycol before you start the engine.

Servicing the fuel oil seal pot 5008-000-02

5. Release the air from the fuel oil system.

6. After engine installation, servicing or a long engine stop, drain air from the fuel system. Obey these instructions.

- 1 - Fully turn the handle of the bypass valve of the fuel feed pump counterclockwise to open the bypass valve.
- 2 - Open the air vent cock of the fuel oil strainer and release the air.
- 3 - Loosen the air vent plug of the fuel injection pump to release the air.

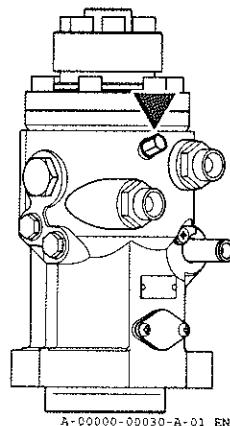


Fig.4 Releasing the air

- 4 - Turn the bypass valve handle clockwise to close it. Turn it until it stops.

Fuel feed pump - Inspection 5002-000-02

Fuel oil pressure control valve - Assemble procedure 5007-001-02

5. Air system

1. Open these drain cocks and drain.

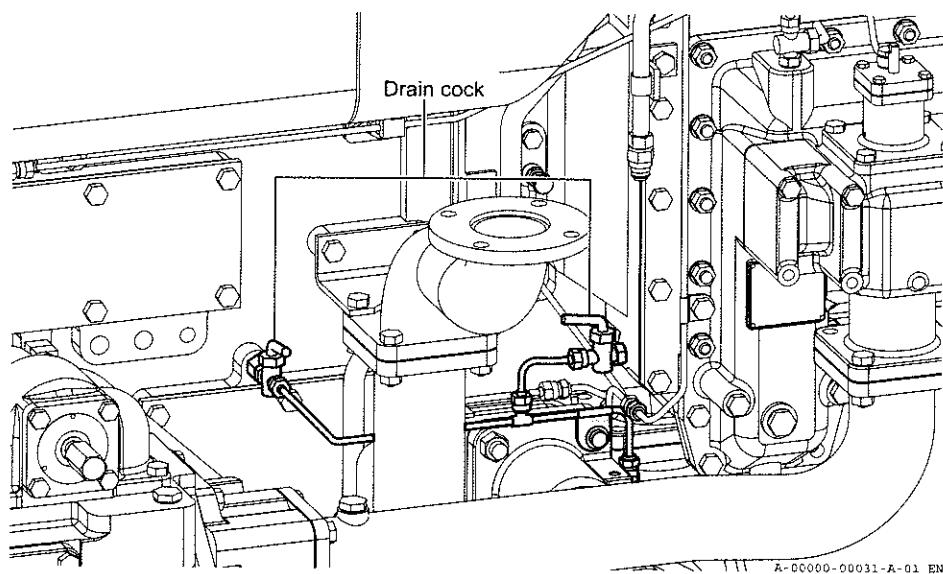


Fig.5 Draining the air system

6. Start air system (white coating)

1. Drain the start air reservoir.
2. Make sure that the pneumatic pressure in the air reservoir is high enough to start the engine (2.16 MPa or higher).
3. After pressure reduction, check that the pressure is between 0.90 MPa and 1.1 MPa.
If the pressure is different, adjust the reducing valve at the air starter inlet.

7. Protection and speed control devices

1. Make sure the turning gear is in the GEAR OUT position.
2. Set the power switch of the protective devices and the alarm devices to the ON position.

NOTICE

The protective devices and the alarm devices do not operate if the power switch is not set to ON.

3. Check that the devices operate.
4. Move the start/stop handle from STOP to START and back.
5. Make sure that the rack of the fuel injection pump, the first lever shaft of the governor link and the connector move easily.
6. Make sure that the pointer of that speed control shaft of the governor points between 1 and 2 on the scale.

NOTICE

After you replace or service the governor or the fuel injection pump, make sure that the link mechanism is correctly connected.

Speed control device (NZ) - Adjust 6003-000-03

Speed control device (UG-8, UG-25⁺) - Adjust 6003-002-03

Normal operation procedure

Attention on safety

⚠ WARNING

Moving part hazard: DO NOT touch or come close to moving parts with your hands, body or clothing.

NEVER touch a moving part.

Noise hazard: Put on ear protection (ear plugs) in the engine room to prevent hearing loss.

⚠ CAUTION

- Keep your face away from the air starter when you start the engine. Dirt on the exhaust port of the air starter can come into your eye and cause injury.
- High temperature hazard: DO NOT touch the parts that follow with your bare hands when the engine operates or immediately after engine stop. There is a risk of burn injury.
 - Turbocharger, exhaust piping, intake air piping
 - Indicator cock
 - Flue, funnel
- Make sure that the room has good airflow. A lot of air (oxygen) is necessary for the turbocharger.
- Keep the control air valve open during engine operation. If you close it, the protective devices do not operate.

1. Engine start

This engine is started by an air-starter.

Press the START switch. The battery-powered pilot-air solenoid valve on the air starter will open and start the engine.

NOTICE

- If someone is present, give a signal and make sure that the person is safe before you start the engine.
- Measure the amount of fuel oil, lubricating oil and air.
- Turn on the power supply of the engine protection device before you start the engine.
- After a long engine stop or servicing, make sure that you start the engine on the engine side.
- In case of an unusual increase of engine rotation, unusual sounds or smoke, immediately move the start/stop handle to STOP and stop the engine.

1.1 How to do an air running

Before the first start after installation, servicing or a long engine stop, do an air running and obey the procedures that follow. Make sure that there are no defects. Then start the engine on the engine side. A large quantity of fuel oil, cooling water or lubricating oil in the cylinders can cause water hammering.

- 1 - Make sure that the turning gear is disengaged (GEAR OUT position).
- 2 - Set the control position switch on the engine or the operation mode switch on the remote panel to the ENGINE position.
- 3 - Open the pressure indicator cocks on all cylinders.
- 4 - Set the start/stop handle to STOP.
- 5 - Press the START switch for 2 to 3 seconds to start the air running.

1.2 How to start the engine

- 1 - Make sure that the turning gear is disengaged (GEAR OUT position).
- 2 - Make sure that the pressure indicator cocks on all cylinders are closed.
- 3 - Set the control position switch on the engine or the operation mode switch on the remote panel to ENGINE or REMOTE, depending on the control position.
- 4 - Set the start/stop handle to RUN.
- 5 - Make sure that the needle of the governor speed control shaft shows the correct (specified) speed.
- 6 - Open the startup air reservoir and control air valve.
- 7 - Press the start switch for 2 to 3 seconds. Release the switch after ignition.

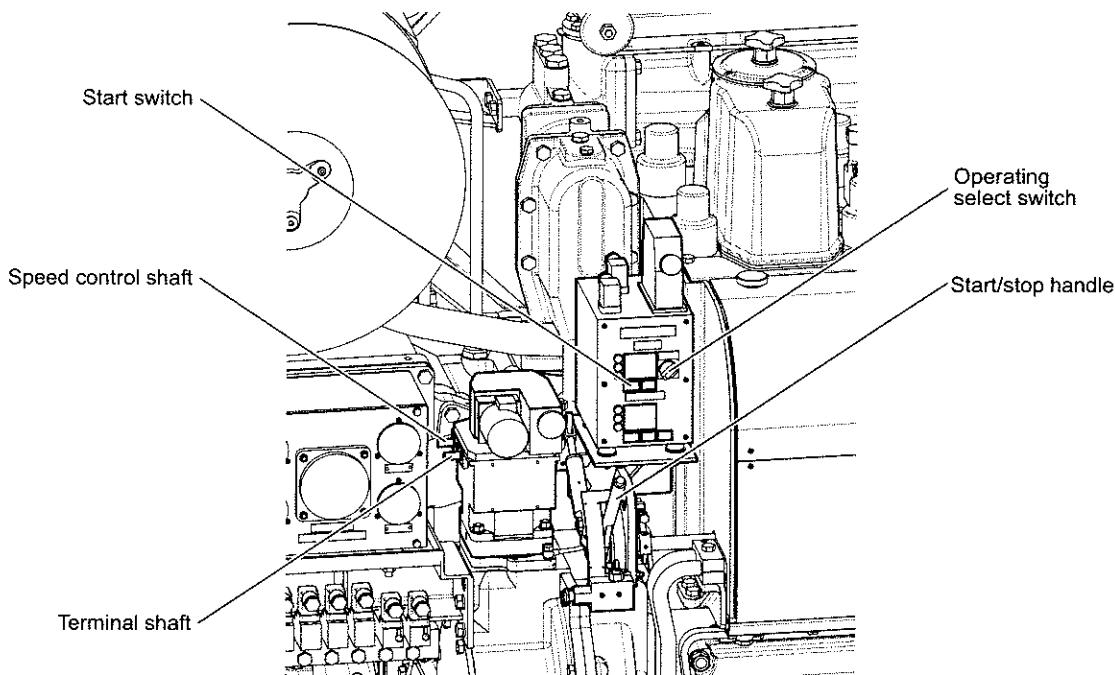


Fig.1 How to start the engine

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1.3 In case of start failure

Do not restart the engine immediately after a failed start. Unburned combustion gas in the flue can ignite and cause an explosion. If you try to start the engine without a cooling period, the starter can become too hot and malfunction.

- 1 - Do an air running and discharge the gas from the exhaust gas system. Then restart the engine.
- 2 - If the engine does not start in 30 seconds or less, stop the starter. Let the starter rest and cool for 2.5 minutes or more. Then try again.

1.4 Starting without control power

At manual start, the control module is not in operation. This can cause overspeed of the air starter. Use the manual start only in emergencies.

- 1 - If the battery for the START switch is empty (in case of emergency), push the manual button of the air starter to start the engine.
- 2 - Return the button to its original position immediately after the engine starts.

1.5 Checks after engine start

Do these checks. If you find any problems, stop the engine and do the necessary repairs.

- Make sure that the pressure values on the instrument panel are correct.
- Examine all pipes for leaks.
- Listen for unusual sounds and look for unusual heat.

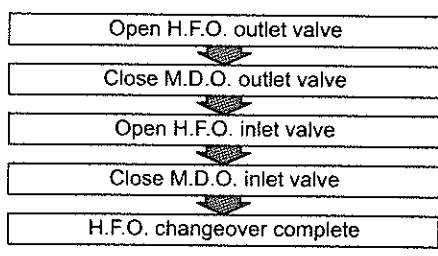
1.6 Automatic and remote starts

Refer to the respective sections.

2. Switching to heavy fuel oil

2.1 M.D.O. change-over

- 1 - Start the engine on marine diesel oil and operate it for 15 minutes or more in the M.D.O. setting.
- 2 - Increase the temperature of the heavy fuel oil. Make sure that the fuel oil in the circulating line has the specified viscosity (11 mm²/s to 14 mm²/s at engine inlet) and pressure. This prevents clogging of the fuel strainer and an unusual increase of pressure in the fuel injection pipe.
- 3 - Make sure that the temperature and pressure of all engine parts agrees with the specified range.



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Fig.2 Change-over switch

- 4 - Switch to heavy fuel operation when the engine reaches a load factor of 20 % or more.
- 5 - When you operate the engine with heavy fuel oil, make sure that the fuel oil viscosity and pressure are in the specified range.

2.2 H.F.O. direct start

- 1 - Increase the temperature of the heavy fuel oil and send it through the system until it has a viscosity at engine inlet of 11 mm²/s to 14 mm²/s.
- 2 - Send the jacket cooling water (65 °C to 70 °C) through the system to increase the temperature of the engine.
- 3 - Make sure that the above conditions are met. Then start the engine.

3. Operation

3.1 Initial running-in operation

Initial operation can cause very much wear to the piston rings and cylinder liner. To prevent this, operate the engine on marine diesel oil for this length of time:

- After installation: 10 to 20 hours
- After replacement of piston rings, a piston or cylinder liner: 20 to 30 hours

3.2 Regular (routine) operation

- Frequently examine the pressure and temperature. Make sure that there are no unusual sounds or unusual heat.
- If you find a defect, immediately stop the engine and make the necessary repairs.
- Torsional vibration can occur in the regular speed range. In that case, quickly increase the speed to the rated speed setting.

1 - Operate the engine without load for approximately 10 minutes to warm it up.

2 - If you run the engine at low load for more than 3 hours, the combustion becomes bad and fouling of the combustion chamber, exhaust pipe and turbocharger increases. Obey these instructions:

If you use marine diesel oil, operate the engine at a load factor of 15 % or more.

If you use heavy fuel oil, operate the engine at a load factor of 20 % or more.

- Operate the engine at a load factor of 15 % or more, if the engine has an air temperature control device (option) that increases the temperature of the intake air.

When the engine operates at a lower load factor, switch to M.D.O. operation.

3 - If humidity is high, the air moisture can condense and cause a lot of drain water. This is normal. (Keep fully open the drain cocks equipped at the charge air cooler outlet and the cylinder block of the supply air chamber.)

4 - Measure the engine performance at intervals of 1 day or shorter. Record the results. (Refer to the Records of Shop Trial and record the results in the engine log.)

Engine performance measurement and measurement locations 0000-001-14

Attention on safety

⚠ WARNING

When the engine is hot, fresh air that enters the engine can ignite oil mist and result in an explosion. Do not open the side cover of the cylinder block for 10 minutes or more after engine stop.

⚠ CAUTION

Immediately after the engine stops, all of the engine is very hot. Be careful that you do not get burned. Make sure that you (e.g. your hands, body and clothing) do not touch the turbocharger, exhaust manifold, exhaust pipes or engine body.

When you drain lubricating oil from the hot engine, be careful that you do not get burned by the oil (including small drops of oil).

When you disassemble the cooling water system while the engine is hot, steam or hot water can come out and burn you. Wait until the engine is cool. Then put the part that you want to remove in waste cloth. Slowly loosen it.

1. Preparations and checks at engine stop

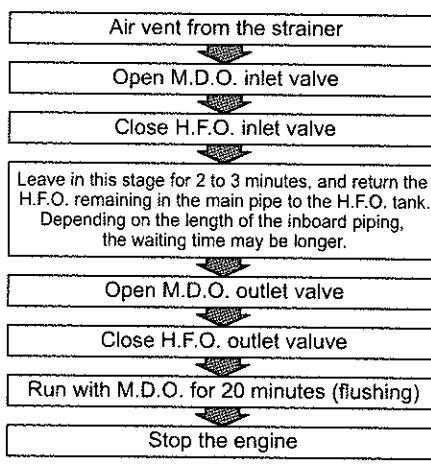
- 1 -Do not stop the engine at the same time as the load shutoff. Only do so in emergencies.
- 2 -After load shutoff, run the engine without load then stop it.
- 3 -Make sure that the engine is always ready to start.
- 4 -Immediately repair any defects of the operating engine.

2. How to perform the H.F.O. change-over

■ M.D.O. change-over specification

For the start/stop specifications for marine diesel oil on heavy fuel oil engines, switch from heavy fuel oil to marine diesel oil. This makes sure that no heavy fuel oil collects inside the fuel pipes, filters and pumps when the engines stops.

Operate the engine with marine diesel oil for approximately 20 to 30 minutes. The time varies with the load at the time of the switch and the capacity of the ship pipes. Confirm with the dockyard.



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Fig.1 Change-over switch

■ H.F.O. direct start specification

For heavy fuel oil, after the engine stopped, continue to heat and circulate the fuel oil to keep the specified viscosity. Make sure that the heavy fuel oil and the jacket cooling water meet the engine stand-by conditions 2 hours or more before you start the engine.

Before you stop the engine for a long time, switch to marine diesel oil operation. Make sure that no heavy fuel oil is left in the piping and that all heavy fuel oil is replaced by marine diesel oil.

3. Stopping the engine

1. Operate the engine without load for approximately 10 minutes.
2. Move the start/stop handle to STOP.
3. Operate the standby lubricating oil pump or the electric lubricating oil priming pump for 20 minutes or more. This decreases the temperature of the piston and the turbocharger.
4. Open the pressure indicator cock. Do an air running to release gas from the combustion chambers.
5. Open or close the valves of all circuits as it is specified for engine stops.
6. Drain the cooling water on the cylinder block side and the cooler side if:
 - The weather is cold and the cooling water can freeze.
 - You stop the engine for a long period.
7. Open the drain cock on the cylinder block boost air chamber and air cooler mount. Drain all water.
(Keep the cocks fully open.)
8. Open the drain cock on the breather pipe. Drain all water and other fluids. Close the drain cock.
9. Repair any defects of the operating engine.

1. Emergency stop

If any of the following problems occurs, immediately set the start/stop handle to STOP and stop the engine.

- The lubricating oil pressure decrease alarm operates.
 - The lubricating oil temperature increase alarm operates.
 - The cooling water temperature increase alarm operates.
 - The overspeed alarm operates.
 - Unusual noise
 - Unusual heat
 - Smoke from a bearing or other moving part
 - A broken pipe of the fuel oil system, lubricating oil system or cooling water system
 - The supply of cooling water has stopped, and it is impossible to supply it immediately.
 - A loose or broken bolt or setscrew of a moving part.
 - Water in the lubricating oil
 - The intake air pressure decreases and the exhaust temperature increases unusually.
 - The rack of the fuel injection pump is stuck.
 - The exhaust temperature of one cylinder is 40 °C higher or lower than the average temperature of all cylinders.
- (There is risk of misfiring and torsional vibration.)

NOTICE

If you set the start/stop handle to STOP or press the STOP switch and the engine does not stop, close the fuel oil inlet valve.

2. Precautions after an emergency stop

- When the engine is hot, fresh air that enters the engine can ignite oil mist and result in an explosion. Do not open the side cover of the cylinder block for 10 minutes or more after engine stop.
- If the engine stops during operation on heavy fuel oil: immediately drain all heavy fuel oil in the fuel oil pipes, fuel oil strainer and fuel injection pumps. Replace it with marine diesel oil. Obey the instructions below.
If the temperature of the fuel oil decreases and the viscosity increases. The engine becomes difficult to start.
 - Set the fuel oil changeover valves at the engine inlet and outlet to marine diesel oil.
 - Open the bypass valve of the fuel feed pump.
 - Open the drain cock of the fuel oil strainer and the drain valve of the fuel oil main pipe.
 - Turn the flywheel to drain the heavy fuel oil from the fuel injection pipes and fuel injection valves.
(If you set the start/stop handle to RUN and turn the flywheel, fuel spray comes out of the nozzles.)

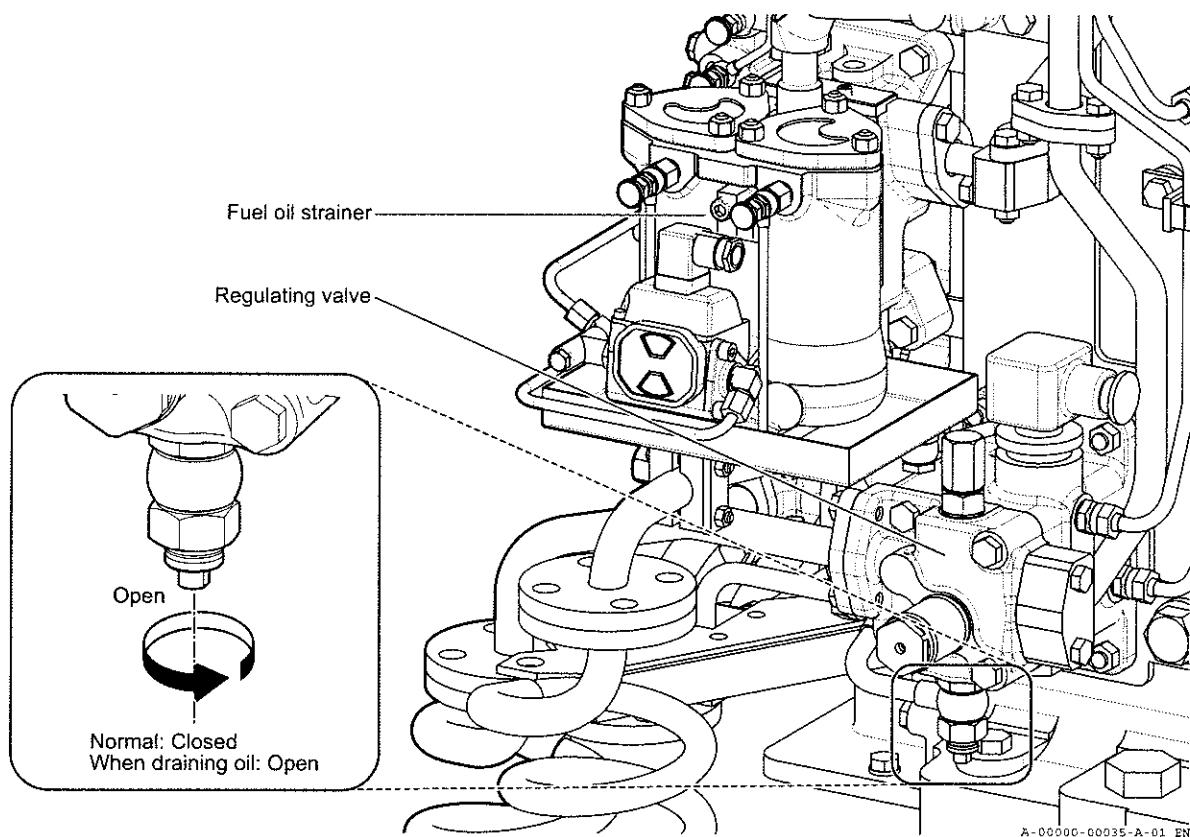


Fig. 1 After an emergency stop

Measure the temperature and pressure of all parts during operation. This makes sure that the engine properties are in the correct ranges. Record the values in the engine log.

1. Precautions during operation

Refer to "Normal operation procedures 0000-001-10 "

2. Measuring the operating performance

Measure and record these engine properties when the load is stable. Do it at intervals of 1 day or shorter.

Use the "Normal operation data sheet 0000-001-15 "

1	Maximum combustion pressure (Pmax) (all cylinders)	10	Cooling water temperature (low-temp air cooler inlet)
2	Exhaust temperature (at each cylinder outlet)	11	Cooling water temperature (high-temp air cooler inlet)
3	Exhaust temperature (turbocharger inlet)	12	Cooling water temperature (lubricating oil cooler outlet)
4	Exhaust temperature (total outlet) (for reference)	13	Intake air temperature (air cooler inlet) (for reference)
5	Lubricating oil temperature (cooler inlet)	14	Intake air temperature (engine inlet)
6	Lubricating oil temperature (engine inlet)	15	All pressure values on the gauge panel (lubricating oil, intake air, high-temperature cooling water, low-temperature cooling water)
7	Cooling water temperature (engine inlet)	16	Fuel oil pressure
8	Cooling water temperature (engine common outlet)	17	Fuel oil temperature (engine inlet)
9	Cooling water temperature (low-temp air cooler outlet)	18	Room temperature

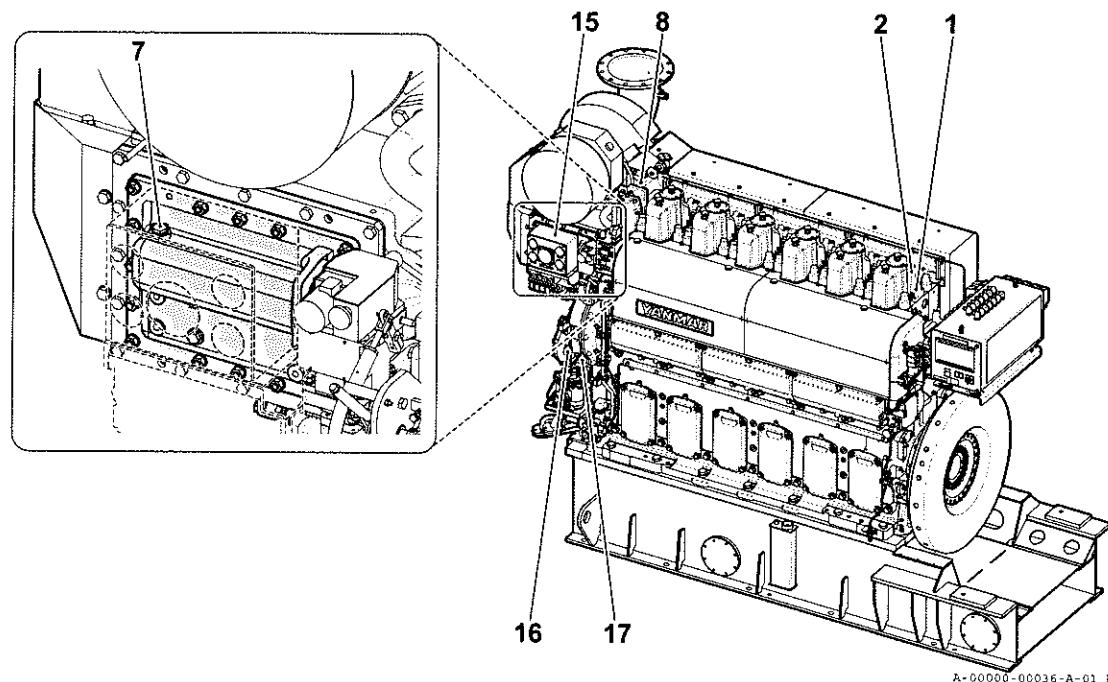
3. Measuring total maximum combustion pressure

Refer to "Other tools 9202-000-06 "

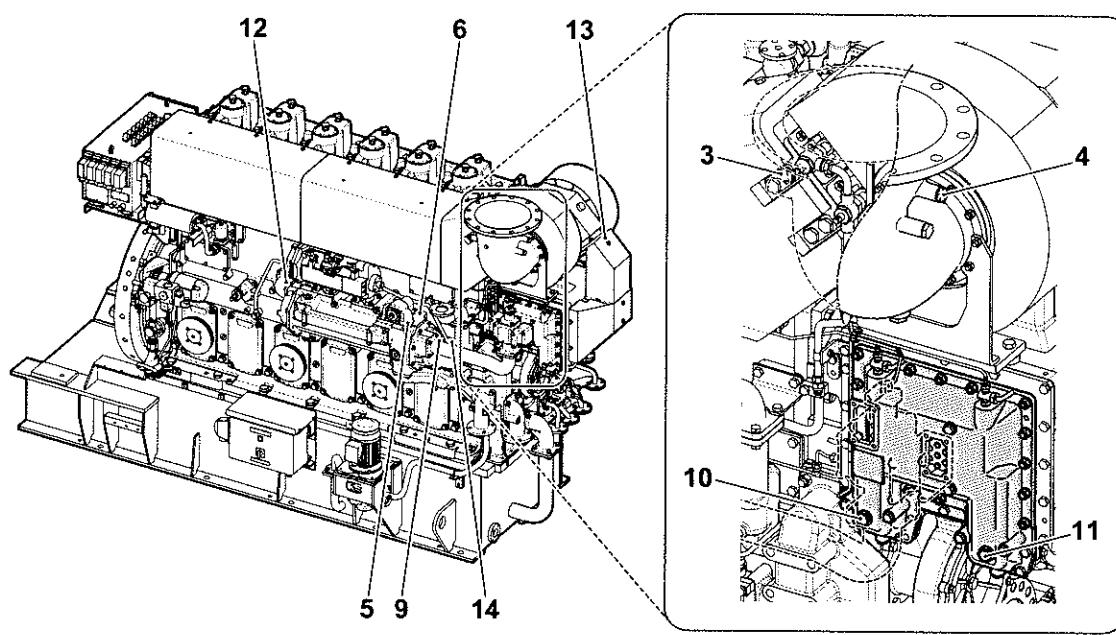
4. Precautions when measuring operation performance

Refer to the items that follow because the engine performance varies according to the room temperature, water temperature and load conditions.

- A difference in maximum combustion pressure (Pmax) within 0.6 MPa between cylinders is normal. Pmax can increase very much depending on the properties of the fuel oil. Keep the Pmax below 20.0 MPa.
If the room temperature increases, the Pmax decreases. If the room temperature decreases, the Pmax increases. If the room temperature changes by 2.5 °C, the Pmax changes by 0.1 MPa.
- Make sure that the exhaust temperatures are the same as in the Records of Transfer Trial or Records of Shop Trial.
A difference of exhaust temperature between the cylinder outlets is normal if it is less than 40 °C. It is not necessary to adjust this difference if the fuel injection volume and Pmax are equal among all cylinders.
If the difference of the exhaust temperature between the cylinder outlets is more than 40 °C, but less than ± 40 °C of the average exhaust temperature, the combustion is unbalanced. Stop the engine and do the appropriate maintenance.
If the difference of the exhaust temperature at the cylinder outlet of one cylinder is more than 40 °C higher or lower than the average exhaust temperature at cylinder outlet, misfiring can occur and cause torsional vibrations. Immediately stop the engine. Find the cause and repair it.
- The exhaust temperature changes at about twice the rate as the room temperature.
But contamination of the turbocharger and the intake/exhaust passage, exhaust pressure and properties of fuel oil can have an effect on this relation. Do maintenance, decrease the load and use the engine within its limits.



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Fig.1 Operating performance check locations

1. Data recording paper

Ship name			
Engine type		Engine number (E/ #)	Fuel oil
Turbocharger type		Turbocharger (S/ #)	Kinematic viscosity
Hydraulic oil		Lubricating oil viscosity (SAE)	Specific gravity

Load			
Room temperature		°C	
Date of measurement			
Time of measurement			
Total operating hours		h	
Engine speed		min ⁻¹	
Temperature	Exhaust	No. 1 cylinder	°C
		No. 2 cylinder	°C
		No. 3 cylinder	°C
		No. 4 cylinder	°C
		No. 5 cylinder	°C
		No. 6 cylinder	°C
	Turbo-charger	Inlet (No. 1 to 3)	°C
		Inlet (No. 4 to 6)	°C
		Outlet (for reference)	°C
	Cooling water	Engine inlet	°C
		Engine outlet	°C
		Lubricating oil cooler outlet	°C
		Air cooler inlet (low-temp side)	°C
		Air cooler inlet (high-temp side)	°C
		Air cooler outlet (low-temp side)	°C
	Lubricating oil	Cooler inlet	°C
		Engine inlet	°C
	Intake air	Air cooler inlet (for reference)	°C
		Engine inlet	°C
	Fuel oil	Engine inlet	°C
Pressure	Pmax	No. 1 cylinder	MPa
		No. 2 cylinder	MPa
		No. 3 cylinder	MPa
		No. 4 cylinder	MPa
		No. 5 cylinder	MPa
		No. 6 cylinder	MPa
	Lubricating oil		MPa
			MPa
	Intake air		MPa
			MPa
	Cylinder side cooling water		MPa
			MPa
	Cooler side cooling water		MPa
			MPa
	Fuel oil		MPa

This chapter shows the cause and recommended action for general malfunctions.

Find the malfunction in the list that follows and take the applicable action.

If the action is difficult, consult YANMAR or your sales or service agent.

No.	Malfunction	Page
1	Starting failure	2/21
2	Unstable engine rotation	6/21
3	Insufficient output	8/21
4	Incorrect exhaust temperature (t_e) or maximum combustion pressure (Pmax)	9/21
5	Bad color of exhaust gas	12/21
6	Unusual noise and vibration	14/21
7	Sudden engine stop	16/21
8	Engine does not stop	17/21
9	Overspeed	17/21
10	Low pressure of the lubricating oil	18/21
11	High temperature of the lubricating oil	19/21
12	Low pressure of the cooling water (jacket system)	20/21
13	High temperature of the cooling water (jacket system)	21/21

1. Starting failure

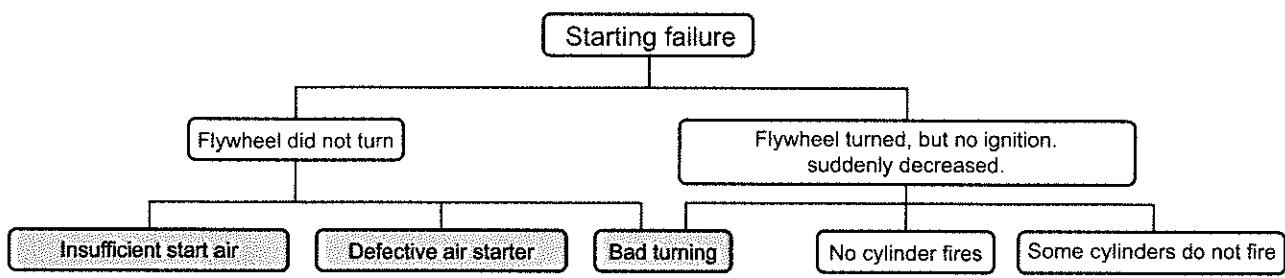


Fig. 1 Starting failure

Insufficient starting air

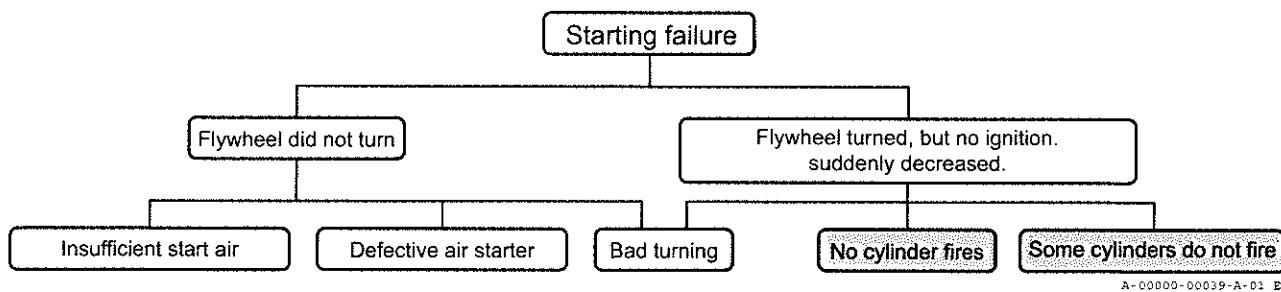
	Malfunction	Action
Insufficient starting air pressure	Insufficient air in the air reservoir	Fill air
	Leak of the main valve of the air reservoir	Do maintenance, repair or replace
	Leak of the relief valve	Do maintenance, repair or replace
	Defective air filler	Repair
	Defective automatic air filler starter	Repair
	Malfunction of the pressure gauge display	Repair or replace
Defective start air piping	Piping stop valve: closed	Open the valve
	Clogged piping	Clean
Defective control system	Low voltage of the battery for the control solenoid valve	Charge the battery
	Defective automatic control panel	Repair or replace
	Defective control contact	Repair or replace
	Disconnected control wire	Repair
	Defective control solenoid valve	Do maintenance, repair or replace
	Turning gear engagement/disengagement switch operates	Put the turning gear to the disengage position
	The stop switch engages	Put the stop handle to the operation position

Defective air starter

	Malfunction	Action
Defective starter	Incorrect pressure of the pressure reduction valve	Do maintenance or repair
	Relay valve is stuck	Do maintenance or repair
Defect of the air starter	Bearing is stuck	Do maintenance or repair
	Teeth of the pinion gear engage badly	Turn the gear
Defective control system	Low voltage of the battery for the control solenoid valve	Charge the battery
	Defective automatic control panel	Repair or replace
	Defective control contact	Repair or replace
	Disconnected control wire	Repair
	Defective control solenoid valve	Do maintenance, repair or replace
	Turning gear engagement/disengagement switch operates	Put the turning gear to the disengage position
	Stop switch operates	Move the stop handle in the operation position

Bad turning

	Malfunction	Action
High resistance of the moving parts (e.g. seizure)	Piston and cylinder liner	Do maintenance, repair or replace
	Crankshaft	Do maintenance, repair or replace
	Camshaft	Do maintenance, repair or replace
	Gear shaft bearing	Do maintenance, repair or replace
	Integrated pump	Do maintenance, repair or replace
High viscosity of the lubricating oil	-	Make sure that all valves of the pipes for engine warming open and close well
	-	Replace with a lubricating oil of lower viscosity



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Fig.2 Starting failure

No cylinder fires

Malfunction		Action
Low chamber temperature	-	Increase the chamber temperature
Cooling water temperature is too low	-	Increase the water temperature
Defective fuel control system	Defective governor	Do maintenance or repair
	Insufficient lubricating oil on the governor	Fill oil
	Stuck control link (rattling sound)	Do maintenance or repair
Malfunction of the fuel cut-off air piston	-	Inspect and repair
Problems with engine operation		
Malfunction of the air piston for fuel control	-	Inspect and repair
Problems with engine operation		
Low speed of the flywheel	High viscosity of the lubricating oil	Make sure that all valves of the pipes for engine warming open and close well Replace with a lubricating oil of lower viscosity
	High resistance of the moving parts - Seizure on piston or cylinder liner - Crankshaft	Do maintenance, repair or replace
Fuel oil is not send with pressure to the fuel injection pump	Empty fuel tank	Fill the fuel tank with fuel oil
	Clogged fuel pipe (valves do not open and close correctly)	Examine the opening/closing of all valves
	Clogged fuel strainer	Clean the strainer
	Defective fuel feed pump	Do maintenance or repair
	Air ingress at the joints	Examine and repair the part, then bleed the air
Poor quality of fuel oil	Incorrect properties (flash point)	Use a fuel oil with higher quality (cetane number 45 or higher)
	Water in the fuel oil	Remove the water
	Air in the fuel pipe system	Examine and repair the part, then bleed the air

Some cylinders do not fire

	Malfunction	Action
Defective fuel injection valve	Defective nozzle	Do maintenance or replace
	Incorrect open-valve pressure	Adjust the open-valve pressure
	Excessive oil leakage from the fuel injection valve	Examine and clean the mating surfaces of the nozzle, spacer and body Replace if necessary
	Damaged fuel injection pipe	Replace
	Loose fuel injection pipe	Tighten it
Defective fuel injection pump	Stuck rack	Examine, do maintenance
	Stuck plunger	Examine, do maintenance
	Worn plunger, barrel	Replace
	Defective delivery valve	Examine, repair or replace
	Incorrect assembly Checking the match mark	Install again and obey the match mark (rack and pinion)
Incorrect fuel injection timing	-	Adjust to the specified value
Insufficient compression pressure	Air leak of the piston ring (stuck, worn, broken)	Do maintenance or replace
	Intake/exhaust valve is not airtight (The valve stem is stuck or the valve spring is broken)	Do maintenance or replace
	Incorrect adjustment of the intake/exhaust valve head clearance	Do maintenance

2. Unstable engine rotation

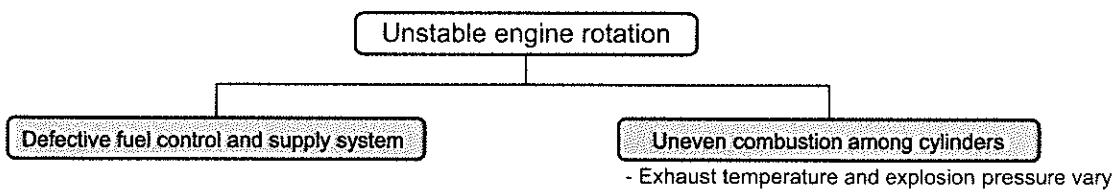


Fig.3 Unstable engine rotation

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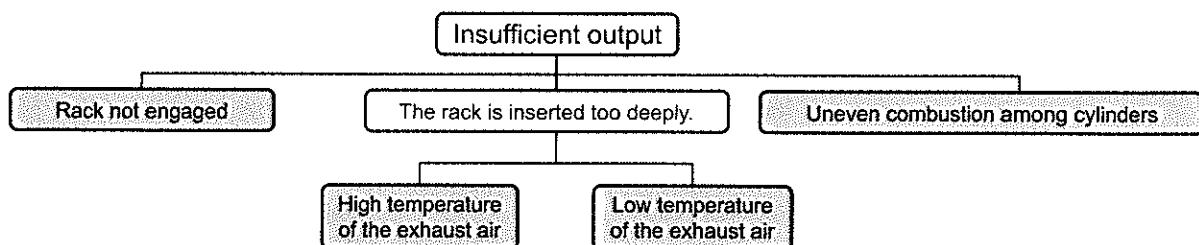
Defective fuel control and supply system

	Malfunction	Action
Defective fuel control system	Defective governor	Do maintenance or repair
	Insufficient lubricating oil on the governor	Fill oil
	Stuck control link (rattling sound)	Do maintenance or repair
Defective fuel feed system	Insufficient feed pressure (defective adjusting valve and pump)	Do maintenance or repair
	Clogged fuel oil strainer	Clean
	Water in the fuel oil	Remove the water
	Defective water separator	Do maintenance or repair
	Air in the fuel pipe system	Examine and repair the part, then bleed the air
	Incorrect viscosity of fuel oil	Change to an appropriate fuel oil

Uneven combustion among cylinders

	Malfunction	Action
Defective fuel injection valve	Defective nozzle	Do maintenance or replace
	Broken nozzle spring	Replace
	Incorrect open-valve pressure	Adjust the pressure
	Excessive oil leakage from the fuel injection valve	Examine and clean the mating surfaces of the nozzle, spacer and body Replace if necessary
	Damaged fuel injection pipe	Replace
	Fuel injection pipe is loose	Tighten
Defective fuel injection pump	Rack is uneven	Examine, adjust
	Stuck rack	Examine, do maintenance
	Stuck plunger	Examine, do maintenance or replace
	Worn plunger, barrel	Replace
	Defective delivery valve	Examine, do maintenance or replace
	Bad installation (match mark does not match)	Install again and obey the match mark (rack and pinion)
Incorrect fuel injection timing	-	Adjust to the specified value
Insufficient compression pressure	Air leak of the piston ring (stuck, worn, broken)	Do maintenance or replace
	Intake/exhaust valve is not airtight (The valve stem is stuck or the valve spring is broken)	Do maintenance or replace
	Incorrect adjustment of the intake/exhaust valve head clearance	Adjust

3. Insufficient output



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Fig.4 Insufficient output

Rack not engaged

	Malfunction	Action
Defective fuel control system	Defective governor	Do maintenance or repair
	Stuck control link (rattling sound)	Do maintenance or repair

High temperature of the exhaust air

	Malfunction	Action
Overload (torque rich)	-	Decrease the load
High resistance of the moving parts (e.g. seizure)	Piston and cylinder liner	Do maintenance or repair
	Crankshaft	Do maintenance or repair
	Camshaft	Do maintenance or repair

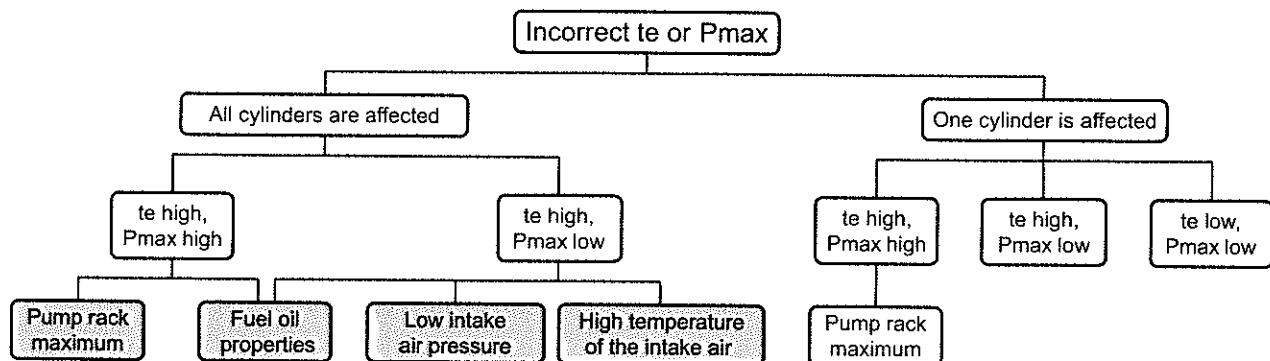
Low temperature of the exhaust air

	Malfunction	Action
Insufficient fuel feed pressure	Defective fuel pressure adjusting valve	Do maintenance or repair
	Defective fuel feed pump	Do maintenance or repair
Clogged fuel oil strainer	-	Clean
Water in the fuel oil	-	Remove the water
Air in the fuel pipe system	-	Examine and repair the part, then bleed the air

Uneven combustion among cylinders

See "2. Unstable engine rotation".

4. Incorrect exhaust temperature (te) or maximum combustion pressure (Pmax)



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Fig.5 Incorrect exhaust temperature (te) or maximum combustion pressure (Pmax)

Pump rack maximum

Malfunction		Action
Overload (torque rich)	-	Decrease the load
High resistance of the moving parts (e.g. seizure)	Piston and cylinder liner	Do maintenance or repair
	Crankshaft	Do maintenance or repair
	Camshaft	Do maintenance or repair

Fuel oil properties

Malfunction		Action
Incorrect fuel oil properties	-	Use high-quality fuel

Low intake air pressure

Malfunction		Action
Dirty turbocharger	Clogged pre-filter	Clean
	Dirty compressor side	Clean
	Dirty turbine side	Clean
Clogged air cooler fin	-	Clean
Clogged (high resistance) exhaust port (exhaust pipe)	-	Clean
Negative pressure in the engine chamber	-	Make the airflow better

High temperature of the intake air

Malfunction		Action
Failure of air cooler	Dirty or clogged fin	Clean
	High temperature of the cooling water	Adjust
	Insufficient cooling water	Adjust
High temperature of the intake air	-	Make the airflow better

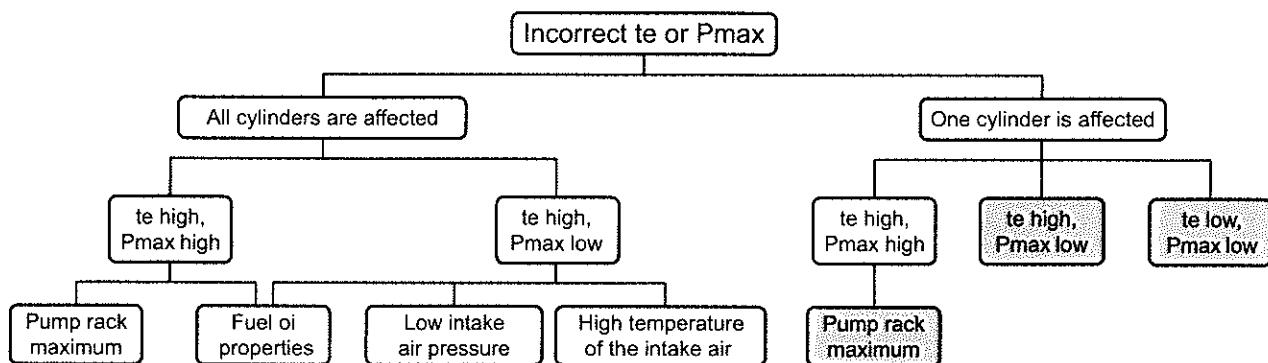


Fig.6 Incorrect exhaust temperature (te) or maximum combustion pressure (Pmax)

Pump rack maximum

Malfunction		Action
Excessive fuel injection quantity	Incorrectly adjusted fuel pump rack quantity	Adjust
	Stuck rack	Do maintenance or repair

High te, low Pmax

Malfunction		Action
Defective fuel injection valve	Defective nozzle	Do maintenance or replace
	Incorrect open-valve pressure	Adjust the open-valve pressure
Defective fuel injection pump	Stuck rack	Examine, do maintenance
	Stuck plunger	Examine, do maintenance
	Defective delivery valve	Examine, repair or replace
Inappropriate fuel injection timing	-	Adjust to the specified value
Insufficient compression pressure	Air leak of the piston ring (stuck, worn, broken)	Do maintenance or replace
	Intake/exhaust valve is not airtight (The valve stem is stuck or the valve spring is broken)	Do maintenance or replace
	Incorrect adjustment of the intake/exhaust valve head clearance	Adjust

Engine operation

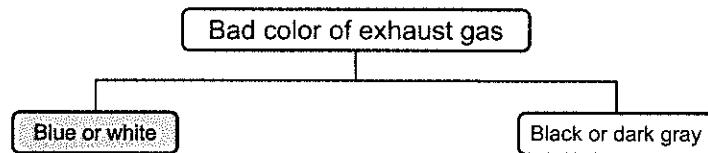
General fault description

11/21

Low te, low Pmax

	Malfunction	Action
Defective fuel injection valve	Defective nozzle	Do maintenance or replace
	Broken nozzle spring	Replace
	Incorrect open-valve pressure	Adjust
	Excessive oil leakage from the fuel injection valve	Examine and clean the mating surfaces of the nozzle, spacer and body Replace if necessary
	Damaged fuel injection pipe	Replace
	Loose fuel injection pipe	Tighten it
Defective fuel injection pump	Stuck rack	Examine, do maintenance
	Stuck plunger	Examine, do maintenance or replace
	Worn plunger, barrel	Replace
	Defective delivery valve	Examine, do maintenance or replace
	Incorrect assembly Checking the match mark	Re-install and obey the match mark (rack and pinion)
Leak or damage of the fuel injection system	-	Repair

5. Bad color of exhaust gas

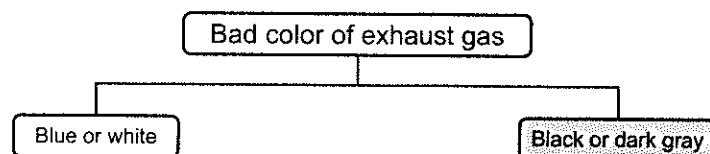


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Fig. 7 Bad color of exhaust gas

Blue or white exhaust gas

Malfunction	Action
Engine not warm	- Do a warm-up operation
Low temperature of the cooling water	- Fill water
Oil-up (large quantity of lubricating oil rises to the top of the piston)	Worn or stuck piston ring, oil ring Do maintenance or replace Worn cylinder liner Do maintenance or replace
Low temperature of the intake air	Low chamber temperature Increase the cooling water temperature of the air cooler
	Adjust the quantity of cooling water in the air cooler
Defective fuel injection valve	Cooling water temperature is too low Increase the cooling water temperature of the air cooler
	Adjust the quantity of cooling water in the air cooler
	Defective nozzle Do maintenance or replace Broken nozzle spring Replace Incorrect open-valve pressure Adjust the pressure
Defective fuel injection pump	Uneven rack Check, adjust Stuck rack Examine, do maintenance Stuck plunger Examine, do maintenance or replace Worn plunger, barrel Replace Defective delivery valve Examine, do maintenance or replace
Incorrect fuel injection timing	- Examine and adjust to the specified value
Fuel oil has poor quality	Incorrect properties (flash point) Use a fuel oil with higher quality (cetane number 45 or higher)
	Water in the fuel oil Remove the water
	Air in the fuel pipe system Examine and repair the part, then bleed the air
Insufficient compression pressure	Air leak of the piston ring (stuck, worn, broken) Do maintenance or replace
	Air leaks of the intake/exhaust valves (stuck valve stem, damaged valve spring or seat) Do maintenance or replace
	Incorrect adjustment of the intake/exhaust valve head clearance Adjust
Damaged camshaft	Fuel cam has damage Replace
	Damaged intake/exhaust cam Replace
Low load operation for a long time (dirty combustion chamber or exhaust gas system)	- Increase load



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Fig.8 Bad color of exhaust gas

Black or dark gray exhaust gas

Malfunction	Action
Dirty turbocharger	Clogged pre-filter
	Dirty compressor side
	Dirty turbine side
Failure of air cooler	Dirty or clogged fin
	High temperature of the cooling water
	Insufficient cooling water
Negative pressure in the engine chamber	-
High temperature of the intake air	-
Overload	-
Defective fuel injection valve	Defective nozzle
	Broken nozzle spring
	Incorrect open-valve pressure
Defective fuel injection pump	Uneven rack
	Stuck rack
	Stuck plunger
	Worn plunger, barrel
	Defective delivery valve
Incorrect fuel injection timing	-
Fuel oil has poor quality	Incorrect properties (flash point)
	Water in the fuel oil
	Air in the fuel pipe system
Insufficient compression pressure	Air leak of the piston ring (stuck, worn, broken)
	Air leaks of the intake/exhaust valves (stuck valve stem, damaged valve spring or seat)
	Incorrect adjustment of the intake/exhaust valve head clearance
Damaged camshaft	Damaged fuel cam
	Damaged intake/exhaust cam
Low load operation for a long time (dirty combustion chamber or exhaust gas system)	-
	Increase load

6. Unusual noise and vibration

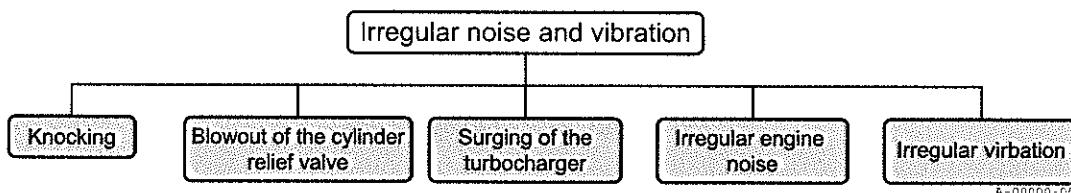


Fig.9 Unusual noise and vibration

Knocking

	Malfunction	Action
Unusual combustion	Engine too cold	Do a warm-up operation
	Defective fuel injection pump	Do maintenance or repair
	Bad spray from the fuel nozzle	Do maintenance or replace
	Bad fuel properties	Use high-quality fuel
	Bad timing of fuel injection	Check, adjust

Blowout of the cylinder relief valve

	Malfunction	Action
Defective cylinder relief valve	Stuck valve	Do maintenance, repair or replace
	Fatigued spring	Replace

Surging of the turbocharger

	Malfunction	Action
Incorrect load conditions	Overload (torque rich)	Adjust load
	Sudden load shift	Adjust load
	Sudden turn, sudden stop (main propulsion engine)	Adjust load
	Too much load application/cutoff (auxiliary engine)	Adjust load
Defective turbocharger	Dirty compressor side	Clean
	Dirty turbine side	Clean
	Deformation, damage - Diffuser - Turbine nozzle - Turbine rotor	Replace
Clogged exhaust pipe	-	Clean
Clogged or dirty air cooler	-	Clean
Defective fuel injection pump	-	Do maintenance, repair or replace
Defective fuel injection valve	-	Do maintenance, repair or replace

Unusual engine noise and vibration

Malfunction	Action
Loose installation bolt	Tighten the bolt
Moving part connecting bolt is loose	Tighten the bolt
Cylinder liner is very worn (seizure)	Do maintenance or replace
Too much clearance of intake/exhaust valve heads	Adjust
Increased gear backlash	Adjust or repair

7. Sudden engine stop

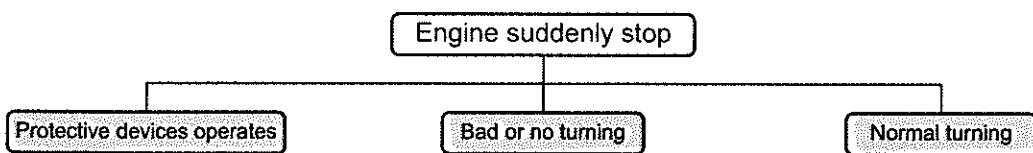


Fig. 10 Engine suddenly stops

Protective device operates

Malfunction		Action
Overspeed	-	See "9. Overspeed"
Lubricating oil pressure decreases	-	See "10. Low pressure of lubricating oil"
Unusual cooling water temperature	-	See "13. High temperature of cooling water (jacket system)"
Defective control power system	-	Repair
Defective fuel cut-off device	-	Repair

Bad or no turning

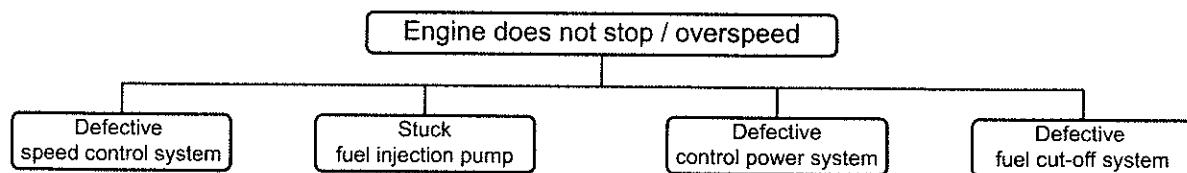
Malfunction		Action
Seizure and damage on moving parts	Piston	Repair or replace
	Crankshaft	Repair or replace
	Timing gear	Repair or replace
	Camshaft	Repair or replace
Defective speed detector - Generator - Other	-	Repair or replace

Normal turning

Malfunction		Action
Defective fuel feed system	Empty fuel tank	Refill
	Clogged fuel oil strainer	Clean
	Defective fuel pressure adjusting valve	Repair
	Defective fuel feed pump	Repair
	Air in the fuel oil	Release the air
	Incorrect viscosity of fuel oil	Change to an appropriate fuel oil
Defective speed control system	Defective governor	Repair
	Disconnected or stuck control link	Repair
Defective fuel injection valve	Defective nozzle	Examine, repair or replace
Damaged fuel injection pipe	-	Replace
Dirty fuel injection pipe	-	Tighten, repair or replace
Defective fuel injection pump	Stuck rack	Examine, do maintenance or replace
	Stuck plunger	Examine, do maintenance or replace
	Defective delivery valve	Examine, repair or replace

8. Engine does not stop

9. Overspeed



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Fig.11 Engine does not stop/overspeed

Malfunction		Action
Defective speed control system	Defective governor	Repair
	Disconnected or stuck control link	Do maintenance or repair
Stuck fuel injection pump	-	Do maintenance or repair
Defective control power system	Defective automatic control panel	Do maintenance or repair
	Bad or disconnected electric contact	Do maintenance or repair
	Malfunction of the solenoid valve	Do maintenance or repair
	Defective speed detector	Do maintenance or repair
Defective fuel cut-off system	Defective fuel cut-off device	Do maintenance or repair
	Defective speed detector	Do maintenance or repair
	Insufficient start air pressure - Clogged piping, filter - Pressure decreases	Clean or repair

10.Low pressure of the lubricating oil

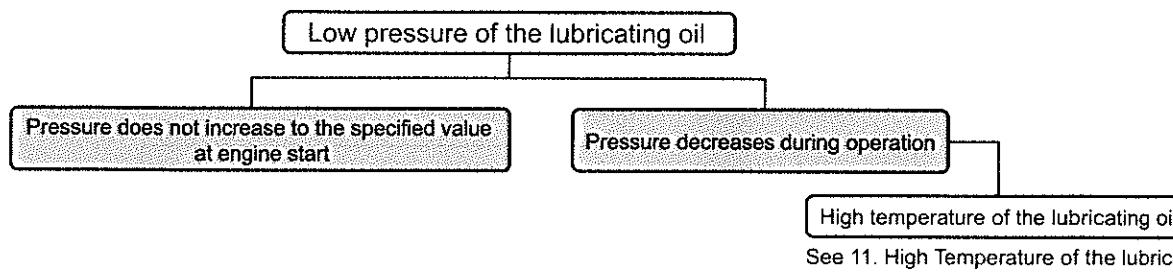


Fig.12 Low pressure of the lubricating oil

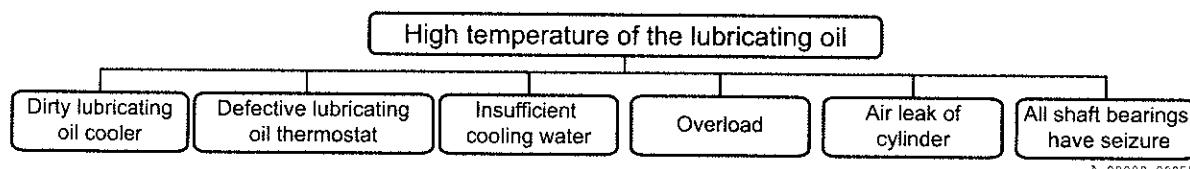
Pressure does not increase to the specified value at engine start

Malfunction		Action
Insufficient lubricating oil in the lubricating oil tank	Below the minimum level	Refill
Loose plug	Cylinder block oil hole plug	Tighten it to the specified torque
	Lubricating oil pipe plug	Tighten it to the specified torque
Incorrect lubricating oil viscosity	-	Replace
Clogged lubricating oil strainer (intake side)	-	Clean
Air intake	Damaged pipe	Do maintenance or repair
	Connecting parts not airtight	Do maintenance or repair
Leak or damage of the piping (exhaust side)	-	Do maintenance or repair
Defective lubricating oil pump	Stuck relief valve	Do maintenance or repair
	Broken relief valve spring	Do maintenance or repair
	Worn pump gear	Do maintenance or repair
Defective pressure adjusting valve	Stuck pressure-regulating valve	Do maintenance or repair
	Loose pressure-adjusting bolt	Adjust
Damaged cooling pipe of the lubricating oil cooler	-	Repair
Lubricating oil strainer (exhaust side) is clogged	-	Clean
Wear of all shaft bearing parts	-	Do maintenance or repair
High temperature of the lubricating oil	-	See "11. High temperature of lubricating oil is high"

Pressure decreases during operation

Same as "Pressure does not increase to the specified value at engine start".

11.High temperature of the lubricating oil

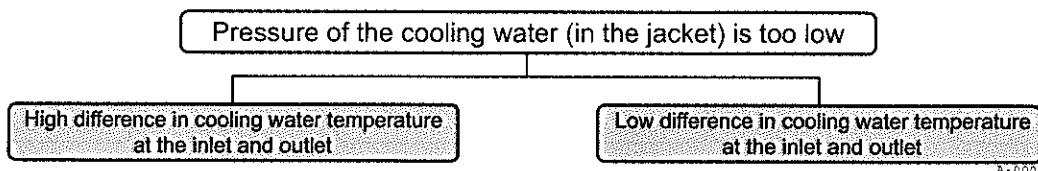


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Fig.13 High temperature of the lubricating oil

Malfunction	Action
Dirty lubricating oil cooler	Clean
Defective lubricating oil thermostat	Do maintenance or repair Valve is stuck
Insufficient cooling water	Do maintenance or repair Defective cooling water pump (impeller is worn) Clogged cooling water strainer and piping Incorrect adjustment of water quantity
Overload	Adjust load
Air leak of cylinder	Do maintenance or repair Worn or stuck piston ring Worn cylinder liner
All shaft bearings have seizure	Do maintenance or repair

12.Low pressure of the cooling water (jacket system)



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Fig.14 Low pressure of the cooling water (jacket system)

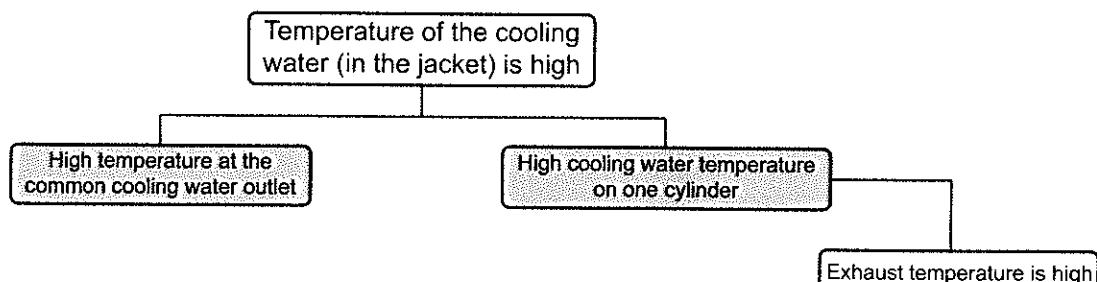
High difference in cooling water temperature at the inlet and outlet

Malfunction	Action
Insufficient cooling water	Defective cooling water pump (impeller is worn)
	Clogged cooling water strainer
	Clogged piping
	Defective cooling water thermostat
Air in the cooling water system	-
	Drain air

Low difference in cooling water temperature at the inlet and outlet

Malfunction	Action
Too much cooling water	Incorrect water level adjustment
	Defective cooling water thermostat

13.High temperature of the cooling water (jacket system)



See 4 Incorrect exhaust temperature (t_e) or maximum combustion pressure (P_{max})
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Fig. 15 High temperature of the cooling water (jacket system)

High temperature at the common cooling water outlet

Malfunction	Action
Air in the cooling water system	Drain air
Dirty freshwater cooler	Clean
High temperature of the cooling water in the cooler	Adjust
Insufficient cooling water	Defective cooling water pump (impeller is worn)
	Do maintenance or repair
	Clogged cooling water strainer
	Clean
Defective cooling water thermostat	Clogged piping
	Clean
Inappropriate amount of water	Adjust
Overload	Do maintenance or repair
Overload	Adjust load

High cooling water temperature on one cylinder

Malfunction	Action
Overheated cylinder	Clogged cooling water duct
	Clean
Seizure on piston or cylinder liner (seizure)	Repair or replace

1. Fuel oil

Refer to the table for the properties of suitable engine fuels.

The quality of fuel has an effect on engine operation, maintenance intervals and service life of engine parts. It can be necessary to change the engine specifications or add attachments to correspond to an applicable fuel oil.

1.1 Applicable fuel oil

The applicable fuel oils are shown in the table below and based on ISO 8217:2010.

Applicable fuel oil			M.G.O.	M.D.O.	H.F.O.		
Quality standards	at 50°C	mm ² /s			180 mm ² /s	380 mm ² /s	700 mm ² /s
Viscosity ^{*1}	at 40°C	mm ² /s	-	-	< 180	< 380	< 700
	Density ^{*2} at 15°C	kg/m ³	< 890	< 900	< 991	< 1010	< 1010
	Flash point	°C	> 60	> 60	> 60	> 60	> 60
	Residue carbon	mass %	< 0.3	< 0.3	< 18	< 20	< 20
	Sulfur content ^{*3}	mass %	< 1.0	< 1.0	< 4.5	< 4.5	< 4.5
	Ash content	mass %	< 0.01	< 0.01	< 0.10	< 0.15	< 0.15
	Water content	vol. %	< 0.1	< 0.1	< 0.5	< 0.5	< 0.5
	Vanadium	mg/kg	-	-	< 350	< 450	< 450
	Sodium	mg/kg	-	-	< 100	< 100	< 100
	Alumina and silica	mg/kg	-	-	< 80	< 80	< 80
Limit	Cetane index	-	> 45	> 45	-	-	-
	CCAI	-	-	-	< 870 ^{*4} (< 850)	< 870 ^{*4} (< 850)	< 870 ^{*4} (< 850)
	Lubricity HFRR wear scar diameter	µm	< 520 ^{*5} (< 460)	< 520 ^{*5} (< 460)	< 520 ^{*5} (< 460)	-	-
	Fuel oils that meet the quality standard		ISO	DMA, DMZ ^{*6}	DMB	RMG180	RMK380
			CIMAC	-	-	CIMAC E25	CIMAC G35
			BSI (Reference)	-	-	M6	M7
	JIS	Diesel oil No. 1, No. 2 ^{*7}	Fuel oil A	Fuel oil C			

*1: Keep a minimum viscosity at engine inlet of 1.8 mm²/s or more.

*2: If you use a fuel with a density higher than 991 kg/m³ at 15°C, use a centrifugal separator that can separate the water content.

*3: Regarding the sulfur content, use a fuel that complies to the local laws.

*4: As a guideline, use fuel oil with a CCAI value of 850 or less.

*5: When you use low-sulfur fuel (sulfur content 0.5% or less), use a fuel oil with a lubricating HFRR wear scar diameter of 460 µm or less.

*6: For safety reasons, you cannot use fuel oil that is equivalent to DMX of the ISO 8217. This is because of the low minimum flash point of 43°C.

*7: For safety reasons, you cannot use JIS K-2204 Number 3 or Number 3 Special diesel fuel. This is because of the low minimum flash point of 45°C.

1.2 About CCAI

CCAI stands for Calculated Carbon Aromaticity Index. The ignitability standard for fuel oil including residue oil can be calculated by this index.

The index measures the content of aromatic compounds in fuel oil, that is in relation to its ignitability. A large CCAI value means a large delay in ignition and bad ignitability.

In this case, the H.F.O. direct starting is not possible or exhaust color is aggravated due to faulty combustion.

Obtain the value from the equation that follows.

$$\text{CCAI} = D - 141 \log \log (V + C) - 81$$

D: density (15°C), kg/m³

V: viscosity (50°C), mm²/s

C: constant (0.3 for M.D.O and 0.85 for H.F.O.)

The graph in Fig. 1 shows the relation between CCAI, density and viscosity for H.F.O.

A small CCAI value means better ignitability.

Select an H.F.O. with a CCAI of 850 or less. The use of fuel with a CCAI higher than 850 can cause bad combustion, buildup of contamination in the combustion chamber and bad exhaust color. On engines that start and stop with H.F.O., if the fuel has a CCAI over 850, start with M.D.O.

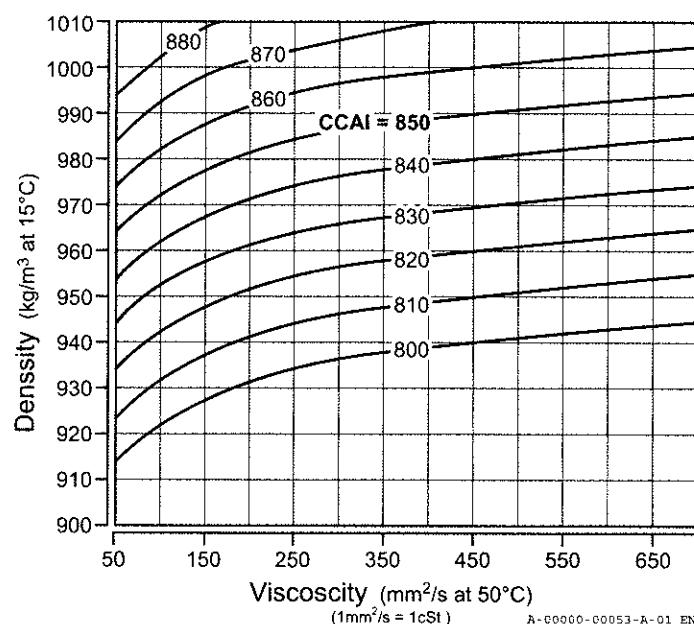


Fig.1 The relation between CCAI density and viscosity

1.3 Characteristics of H.F.O. and the effects on the engine

■ Viscosity

It is expected that the viscosity and viscosity index for high-viscosity fuels will change greatly. So it is even more important to control and keep the viscosity that is required by the engine.

■ Density, asphaltene and CCAI

When the density becomes higher, the asphaltene becomes more. Aromatic polymer hydrocarbons increase and thus the CCAI increases. This has a negative effect on the flash point and results in bad combustion.

How well you do the pretreatment of the fuel oil has the biggest effect on density. Consider the treatment devices and methods.

■ Vanadium

Generally, an increase of vanadium in the fuel oil causes high-temperature corrosion on the exhaust valves. It is necessary to decrease the temperature on the face of the exhaust valves and apply corrosive-resistant materials.

■ Alumina and silica

The alumina and silica catalytic particles mixed in fluid catalytic cracking oil (FCC oil) cause unusual wear on the sliding surfaces of the engine.

It is very important to set and handle the pretreatment devices appropriately. It is necessary to remove the catalytic particles that are 5 µm or larger.

■ Residue carbon

If the residue carbon is high (especially when the engine runs at low-load), combustion residue collects in the combustion chamber. The residue collects on the sliding parts of the engine and increases wear and consumption of lubricating oil.

■ Sulfur

An increase in sulfur content causes low-temperature corrosion on the combustion chamber. To prevent this, it is necessary to keep the appropriate temperature of the combustion chamber.

1.4 Properties of the fuel oil at engine inlet

Contamination in the heavy fuel oil can cause:

- Damage to the fuel injection pumps and fuel injection valves
- Excessive wear to the cylinder liners
- Degradation to exhaust valves and valve seats.

Clean the engine thoroughly during engine pretreatment. Make sure that the fuel oil has the correct pressure and viscosity.

Residue oil of catalytic cracking refined oil devices is sometimes used as industrial heavy fuel oil.

These devices use silica and alumina as catalysts. Fine particles remain in the residue oil.

Such heavy fuel oils cause unusual wear on piston rings, cylinder liners, fuel injection pumps and fuel injection valves. Use fuel treatment equipment and make sure that the fuel oil has less than 0.03 mass % of ash, a minimum of silicon (Si) and aluminum (Al) content. Remove all particles that are 5 µm or larger.

■ Recommended properties of heavy fuel oil at engine inlet

Viscosity at engine inlet	1.8 mm ² /s to 14 mm ² /s (see Fig. 2)
Water content	0.2 vol % or less
Solid particles content	20 ppm or less
Size of FCC catalytic particle	5 µm or less

FCC: Fluid Catalytic Cracking

1.5 Recommended viscosity and pressure of heavy fuel oil at engine inlet

Fuel oil	Recommended viscosity at engine inlet	Recommended pressure in MPa
180 mm ² /s		0.30 to 0.35
380 mm ² /s	Higher than 30 mm ² /s (@50°C): set at 11 to 14 mm ² /s 3 mm ² /s to 30 mm ² /s (@50°C): set inlet temperature at 80°C	0.40 to 0.45
700 mm ² /s		0.55 to 0.60
M.D.O.	2 mm ² /s to 11 mm ² /s (at 40°C)	The pressure after switching to M.D.O./M.G.O. is as specified above.
M.G.O.	2 mm ² /s to 6 mm ² /s (at 40°C)	

Heating temperature: refer to the next page - How to find the correct heating temperature for heavy fuel oil

1.6 How to find the correct heating temperature for heavy fuel oil

Example: Find the correct heating temperature for fuel oil with 380 mm²/s (at 50°C).

Find the point 1 for a viscosity of 380 mm²/s (at 50°C).

Find the recommended viscosity at engine inlet (intersection of 11 and 14) on the viscosity-temperature line 2 for 380 mm²/s oil.

From that intersection, draw a vertical line 3 to the x-axis. This indicates the required heating temperature.

The heating temperature is between 135°C and 145°C.

Using the same procedure, the correct heating temperature for fuel oil with 180 mm²/s (at 50°C) is 120°C to 130°C.

The correct heating temperature for fuel oil with 700 mm²/s (at 50°C) is 150°C to 160°C.

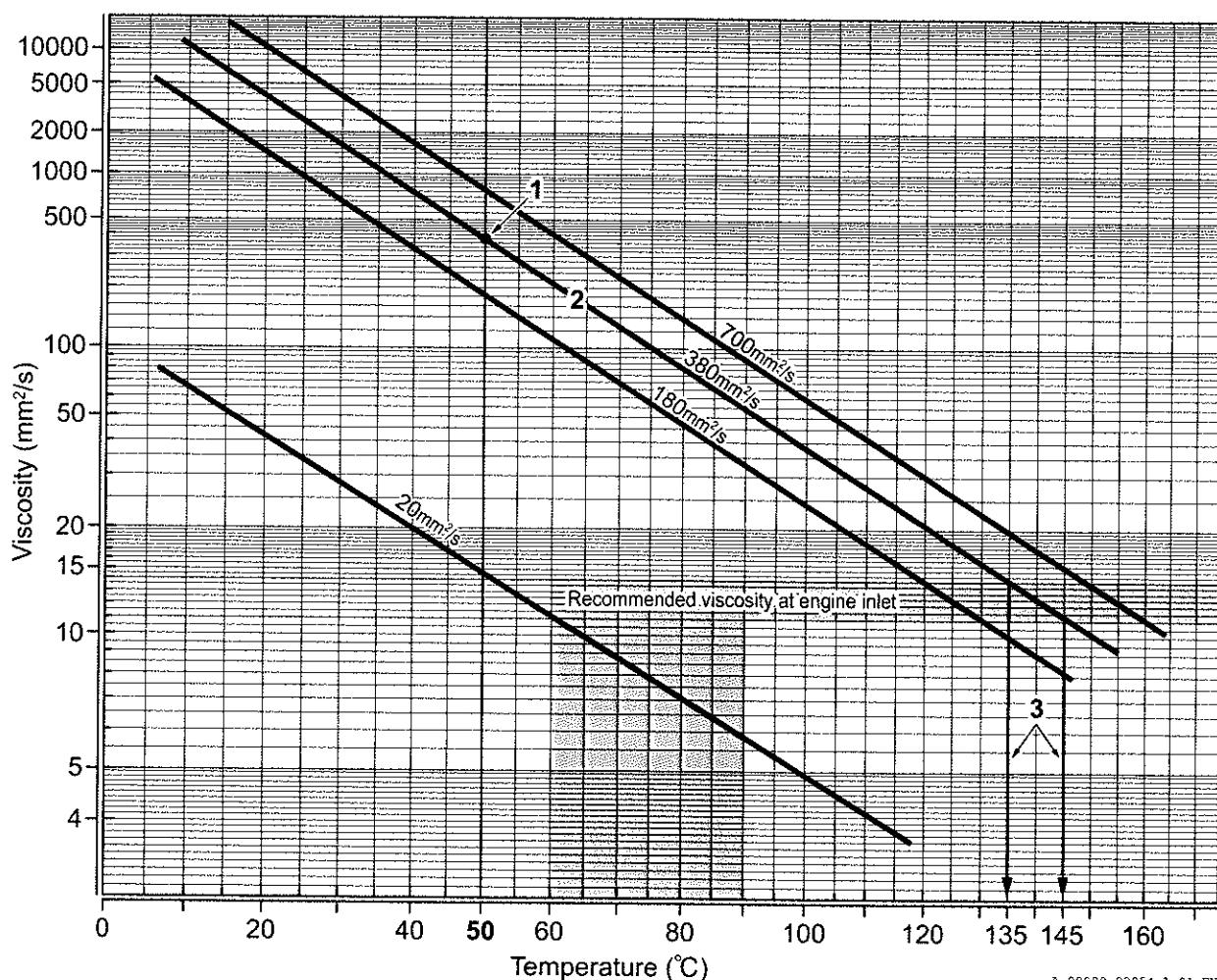


Fig. 2 How to find the correct heating temperature for heavy fuel oil

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NOTICE

- When the fuel oil is delivered, prepare a correct viscosity-temperature relation chart of the fuel oil.
- If there is no viscosity-temperature line for your fuel oil, enter the viscosity and temperature on the above chart and draw a parallel line to the nearest viscosity-temperature line. Find the heating temperature.
- Set the fuel heating temperature so that the fuel oil viscosity becomes the recommended viscosity and temperature as indicated in Fig. 2 at the engine inlet to allow a temperature decrease in the piping system.

1.7 Usage standard for low-sulfur fuel oil (0.5% or less)

■ Effects of low-sulfur fuel oil on the engine

Choose a lubricating oil with a total base number that conforms with the sulfur content of the fuel oil.

This is necessary because it neutralizes the sulfur oxides that occur during operation (not only during low load operation).

Use the correct lubricating oil. If the fuel oil has low sulfur content and the lubricating oil has a high total base number, additives (calcium carbonate) in the lubricating oil and carbon residue will stick to hot engine parts and collect on the piston head and in the combustion chamber. The below conditions can occur when additives collect.

- A piston ring does not move well
- A cylinder liner has scuffing
- Bite-in and blowby on the exhaust valve

If combustion products (e.g. resin fraction, asphaltene) collect on the honing groove of the cylinder liner wall, they cause lacquering, which increases the consumption of lubricating oil, and scuffing.

n Recommendations when using low-sulfur fuel oil

When you use M.D.O., M.G.O., low-sulfur H.F.O. (sulfur content of 0.5% or less) or low-quality heavy oil, use a lubricating oil that conforms with the respective sulfur content of each fuel oil. Each fuel oil shall be handled as follows:

- If you normally use high-sulfur fuel oil and a scrubber, and switch to low-sulfur fuel oil only when entering regulated areas

In that case, operate the engine for less than 300 hours (approximately 2 weeks) with a high-alkali lubricating oil for high-sulfur content. Leave the regulated area within 300 hours and switch back to high-sulfur fuel.

- If you always use low-sulfur fuel oil (0.5% or less)

Use a lubricating oil that is suitable for the sulfur content of the H.F.O. that you normally use.

If you use a combination of M.D.O., M.G.O. and low-sulfur H.F.O., there is no 300 hour operating limit.

- If you use both low- and high-sulfur fuel oils alternately and operate the engine irregularly for more than 300 hours

Use different lubricating oils that are suitable for the different fuel oils. If the vessel does not allow holding 2 different kinds of lubricating oil: Use a lubricating oil for high-sulfur fuel and leave the regulated area within 300 hours (approximately 2 weeks).

1.8 Precautions when using low-sulfur (sulfur content 0.5% or less) or low viscosity fuel oils

The sulfur content in the fuel oil has lubricity and serves as a lubricant. If the sulfur content becomes too small, lubricity may be insufficient. Obey the instructions that follow if you use a fuel with a sulfur content of 0.5% or less.

- Calculate the viscosity from the temperature of the supplied fuel. Keep a minimum viscosity at engine inlet at 1.8 mm²/s or more.
- If it is not possible to keep the viscosity at the above value, install a fuel cooler or chill cooler.
- Use a fuel oil with a HFRR wear scar diameter of 460 µm or less on the lubricity index.
- If you cannot keep the correct lubricity or the minimum viscosity, we recommend that you add a lubricity improver.

■ Lubricity of fuel oil

The HFRR (High Frequency Reciprocating Rig) test evaluates the lubricity of fuel oil.

The result is expressed in a wear scar diameter.

A large HFRR wear scar diameter means bad lubricity of the fuel oil.

Some parts (e.g. the plunger barrel of the fuel injection pump, the needle of the fuel injection valve) may not move freely.

- If you use a lubricity improver (fuel additive), consult with the manufacturer of the lubricity improver.
Reference: Infineum International Ltd.

Model F7458

1.9 Measures for complying with 2020 low-sulfur fuel regulations

In order for Yanmar engines to comply with SO_X regulations, there are the following three measures:

1. Use low-sulfur H.F.O. (low-sulfur heavy oil C)
2. Use low-sulfur M.D.O. (low-sulfur heavy oil A), or low-sulfur M.G.O. (low-sulfur gas oil)
3. Install a scrubber

In this section, measures 1. and 2. are explained.

1. Ships using low-sulfur H.F.O.

1. If the existing ship is H.F.O. compatible, there is no need to change the engine parts and onboard system.
2. To prevent corrosion of the combustion system, the recommended fuel viscosity at the engine inlet shall be reviewed as follows.

[A] For fuel oil with a kinematic viscosity higher than 30 mm²/s (@ 50°C), adjust the kinematic viscosity at the engine inlet to 11 mm²/s to 14 mm²/s. Control the viscosity with a viscosity controller and fuel heater as before.

[B] For fuel oil with a kinematic viscosity of 3 mm²/s to 30 mm²/s (@ 50°C), it is recommended to set the engine inlet temperature to 80°C.
(Allowable temperature: 60°C to 90°C) Use a temperature controller and a fuel heater to control the temperature.

If using both [A] and [B], switch between the viscosity controller and temperature controller.

Before starting the engine, check which fuel oil is being used, and make sure that the correct controller (viscosity or temperature) is installed.

2. Ships remodeled for mono-fuel combustion (low-sulfur M.D.O. or low-sulfur M.G.O.)

The parts required for remodeling vary depending on the engine model. For details, contact Yanmar Engineering Co., Ltd. or the Yanmar Marine Products Sales and Marketing Division.

1.2. General provisions

1. Since low-sulfur H.F.O. is a residual fuel oil, it should be pretreated at the engine inlet with a cleaning device as before.
2. There is no need to change the technical files as a result of this remodeling. However, maintenance records and parts replacement records shall be kept so that they can be presented to an inspector if required.

NOTICE

- Contact Yanmar Engineering Co., Ltd. or the Yanmar Marine Products Sales and Marketing Division if you have any queries about the content of this manual or any questions about remodeling.
- The content of this manual may be reviewed from time to time in accordance with market trends in fuel and developments in lubricating oil.

2. Lubricating oil

An inappropriate lubricating oil causes seizure and early wear of the pistons, cylinder liners and bearings and sticking of the piston rings. Select the lubricating oil carefully.

2.1 Selecting the lubricating oil

Select the lubricating oil depending on the properties of the fuel oil and the usage conditions of the engine. Select lubricating oil with API Service Grade and CE or CD Class.

■ Viscosity

Select the correct viscosity from this table.

The viscosity should be SAE40 on 1000min⁻¹ engines.

Viscosity (SAE)	Specific gravity	Flash point °C (open type)	Pour point °C	Viscosity mm ² /s		Viscosity index
				40°C	100°C	
30	0.89	230 or more	-10 or less	105 to 125	11 to 12.5	96 to 110
40	0.893	240 or more	-7.5 or less	140 to 155	14 to 15.5	96 to 110

■ Total base number

Select a lubricating oil based on the sulfur content in your fuel oil.

Fuel oil used	Sulfur content (mass %)	Total base number (mgKOH/g)
M.D.O./M.G.O.	0.5 or less	9 to 15
Low-sulfur H.F.O.	0.5 or less	15 to 20
H.F.O.	More than 0.5 and 3.5 or less	16 to 30
	More than 3.5 and 4.5 or less	30 to 42

Applicable lubricating oil: See 0000-001-17, 2.3 List of recommended lubricating oil brands.

NOTICE

- Do not mix different brands. (If you cannot avoid mixing different brands of lubricating oil, consult your lubricating oil supplier.)
- Use the correct lubricating oil. If the fuel oil has low sulfur content and the lubricating oil has a high total base number, additives (calcium carbonate) in the lubricating oil and carbon residue will stick to hot engine parts.
- If these particles collect in the combustion chamber, they prevent free movement of the piston rings. This causes scuffing of the rings and cylinder liners. The particles also cause bite-in and blowby in the exhaust valves.
- For "change-over" engines: If you go into a regulated area and change from high-sulfur fuel to low-sulfur fuel, and continue to use lubricating oil with a high alkali value for high-sulfur fuel, only do so for 300 hours (approximately 2 weeks) or less. If you leave the regulated area in less than 2 weeks, change to high-sulfur fuel.

2.2 Control of the lubricating oil

▲ CAUTION

- If you handle the lubricating oil inside the engine immediately after an engine stop, be careful not to get burned.
- Put on protective clothes (e.g. safety goggles and rubber gloves) if lubricating oil can get into your eyes or stick to your skin.
- If lubricating oil gets into your eyes or sticks to your skin, it can cause inflammation. Flush the affected region with clean water and consult a doctor.
- How to handle waste oil is stipulated by law. Make sure that you dispose of all oils correctly and lawfully. If you are not sure what to do with the oil, consult with your oil dealer.

■ Control standards

Do an analysis of the properties of the lubricating oil every 500 hours of engine operation. Change or make-up the lubricating oil according to the standards in this table.

Item		Unit	Control standards		Usage limit
Flash point (PM method)		°C	180 or more		140
Viscosity change		mm ² /s (40°C)	New oil within ± 15%		New oil ± 25%
Water content		vol. %	0.2 or less		0.3
n-pentane insoluble content (A method)		mass %	1.5 or less		2.0
Toluene insoluble matter (A method)		mass %	1.5 or less		2.0
Difference between n-pentane insoluble content and toluene insoluble content		mass %	-		0.5
Total base number	Fuel oil used	Sulfur content mass %	Measurement method		
	M.D.O. M.G.O.	0.5 or less	Hydrochloric acid method	Perchlorid acid method	Hydrochloric acid method
	Low-sulfur H.F.O.	0.5 or less	3.0	6.0	1.0
	H.F.O.	More than 0.5 and 3.5 or less	5.0	10.0	3.0
		More than 3.5 and 4.5 or less	5.0	10.0	3.0
			12.0	18.0	10.0
					15.0

T.B.N. = Total Base Number

■ Oil change standards

Use your own judgment when you schedule and perform oil changes. The standards cannot be decided on operating time alone and vary depending on the operating conditions of the engine.

- Ask your lubricating oil supplier to make an analysis of the lubricating oil and decide whether you can continue using the oil or not.

NOTICE

For the analysis, take an oil sample of 500 cc or more. Take it from the drain plug of the lubricating oil strainer immediately after engine stop.

- Ask the lubricating oil maker for a spot test kit. Use it to find the remaining total base number, degree of contamination and cleaning dispersion.

If you cannot make a decision:

Keep an oil level of 1.36 L/kW and replace all lubricating oil after approximately 1500 hours.

2.3 List of recommended lubricating oil brands

API Service Grade CE or CD, SAE 30 or 40

Fuel oil used	M.D.O./M.G.O.	LS H.F.O.	H.F.O.	
Sulfur content (mass %)	0.5 or less	0.5 or less	More than 0.5 and 3.5 or less	More than 3.5 and 4.5 or less
Total base number	9 to 15	15 to 20	16 to 30	30 to 42
YANMAR	YANMAR MARINE SUPER OIL 30, 40	-	-	-
IDEMITSU KOSAN	DAPHNE MARINE OIL SX-30, 40	DAPHNE MARINE OIL SW-30, 40	DAPHNE MARINE OIL MV-30, 40 SW-30, 40	DAPHNE MARINE OIL SA-30, 40 SH-40
EXXON MOBIL	Mobilgard 312, 412 ADL 30, 40	Mobilgard M420	Mobilgard M330, 430 M420	Mobilgard M330, 430 M440
CASTROL, BP	MHP153, 154 SEAMAX EXTRA 30, 40	TLX Xtra 203, 204	TLX Xtra 203, 204, 303, 304	TLX Xtra 303, 304, 404
CHEVRON (CALTEX, TEXACO)	Delo 1000 MARINE 30, 40 Delo SHP 30, 40	Taro 20 DP 30 (X) Taro 20 DP 40 (X)	Taro 20 DP 30, 40 (X) Taro 30 DP 30, 40 (X)	Taro 30 DP 30, 40 (X) Taro 40 XL 40 (X)
COSMO OIL	MARINE SUPER 30, 40 MARINE 3010, 4010	MARINE 3020, 4020	MARINE 3025, 4025 3030, 4030	MARINE 3040, 4040
SHOWA SHELL	GADINIA S3 30, 40	ARGINA S2 30, 40	ARGINA S2 30, 40 S3 30, 40	ARGINA S3 30, 40 S4 30, 40
TOTAL	DISOLA M3015, 4015	AURELIA TI 3020, 4020	AURELIA TI 3030, 4030	AURELIA TI 3040, 4040
JX Nippon Oil & Energy	MARINE T103, T104	MARINE T203, T204	MARINE T203, T204 T303, T304	MARINE T303, T304 T403, T404
Gulf	GulfSea Power M.D.O. 3012, 4012 GulfSea Power M.D.O. 3015, 4015	GulfSea Power M.D.O. 3020, 4020	GulfSea Power M.D.O. 3020, 4020 GulfSea Power 3030, 4030	GulfSea Power 3030, 4030 GulfSea Power 3040, 4040
LUKOIL	NAVIGO TPEO 12/30 NAVIGO TPEO 12/40 NAVIGO TPEO 15/30 NAVIGO TPEO 15/40	NAVIGO TPEO 20/30 NAVIGO TPEO 20/40 NAVIGO TPEO 20/40	NAVIGO TPEO 20/30 NAVIGO TPEO 20/40 NAVIGO TPEO 30/30 NAVIGO TPEO 30/40	NAVIGO TPEO 30/30 NAVIGO TPEO 30/40 NAVIGO TPEO 40/40

3. Cooling water (engine jacket water)

3.1 Criteria on cooling freshwater

Use pure (distilled) water or tap water.

Use water with the properties shown in the table.

Recommended water quality	
pH (25°C)	6.5 to 8.0
Total hardness (CaCO_3)	100 ppm or less
Chloride ion (Cl^-)	100 ppm or less
M alkalinity	30 to 100 ppm
Ammonium ion (NH_4^+)	0.05 ppm or less
Sulfate ion (SO_4^{2-}) concentration	100 ppm or less
Evaporation residue	400 ppm or less

NOTICE

Do not use hard water. If you use hard water, scale collects in the water chambers such as cylinder head and cylinder water jackets and cause overheating. Be very careful.

3.2 Selecting and controlling the corrosion inhibitor

CAUTION

- Do not discharge cooling water with corrosion inhibitor into the sea or rivers. This can cause environmental pollution. How to handle waste liquids is stipulated by law, and such liquids must be treated according to the instructions given by the supplier of the chemical.
- Do not mix different brands. (If you must mix different brands of lubricating oil, consult your lubricating oil supplier.)
- Corrosion inhibitors are water treatment chemicals for industrial use. Do not use them in the drinking water system.
- When you handle corrosion inhibitors, put on rubber gloves and a gauze mask to avoid contact with your hands or other body parts.
- If you get corrosion inhibitor on your skin or into your eyes or mouth, wash the area with a large amount of fresh water. If fresh water does not help, get medical aid.

- Add a corrosion inhibitor to the cooling freshwater. Even freshwater causes corrosion and scale on the water channels. This results in weak parts and less cooling effect.
- Some parts of the cooling water system are made of cast iron, carbon steel, brass and bronze. Select a corrosion inhibitor that has no negative effect on these parts.
- Obey the standard recommended by the supplier of the corrosion inhibitor about:
 - The quantity of corrosion inhibitor that you add
 - Controlling the concentration
 - Adding an adjustment agent
 - Handling the corrosion inhibitor.
- If you cannot control the concentration of corrosion inhibitor, change all the cooling water at intervals of 1 year.

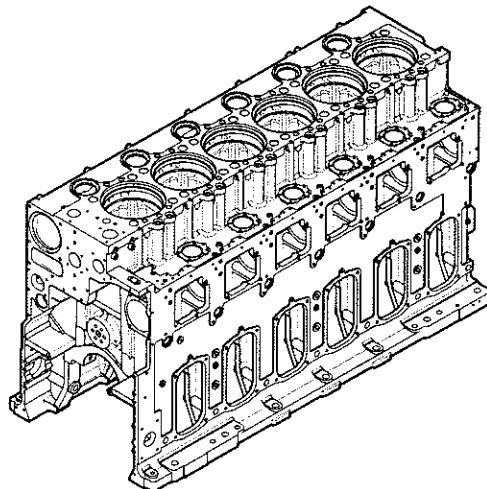
■ Recommended brands of corrosion inhibitor

- Find corrosion inhibitors that are applicable to the enclosed circuit specification of the cooling water system in this table.
- For enclosed circuit specifications, consult the supplier of the corrosion inhibitor. The concentration decreases earlier for some brands.
- Be careful with corrosion inhibitors that are also anti-freeze agents. They have low thermal conductivity and can overheat during a load run.

Brand	Supplier	Brand	Supplier
Royal Caviruston anti-corrosive	YANMAR Sangyo Co., Ltd.	DIESEL GUARD NB	Taiho Industries Co., Ltd.
YANMAR Royal Freeze *		ROCOR NB LIQUID	
Polycrin I-109	Kurita Water Industries Ltd.	NALCOOL 2000	NALCO Japan Co., Ltd.
Polycrin I-175		Nalfleet 9-111 *	
Kurilex L - 501 *		Nalfleet 9-108	
Neos PN-106S	Neos Co., Ltd.	Uniprot PC-200	Nippon Yuka Kogyo Co., Ltd.
Neos PN-106		Uniprot PC-300	
Hi-mol L-10	Taiho Industries Co., Ltd.	Shadan K	Otsuka Chemical Co., Ltd.
Hi-mol AM-5		LIQUIDE WT	ASHLAND JAPAN Co., Ltd.
Olgard C-601 *	Organo Co., Ltd.	-	-

*: If the cooling water system contains aluminum materials, use a corrosion inhibitor.

- The cylinder block is made of cast iron and is a box structure. The cam case, supply air chamber, lubricating oil passage and cooling water passages are cast into a single block. The block has a double-wall structure.
- There is few external piping. This makes maintenance and inspections easy.
- The structure of the main shaft bearing is a very rigid hanger type.



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Fig.1 Cylinder block outline

Cylinder block

Inspection and maintenance

1/2

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals	Unscheduled		
	Cylinder head inspection	1101-000-02(M.D.O.), 1101-001-02(H.F.O.)		
	Cylinder liner inspection	0102-000-02		
	Piston inspection	2201-000-02		
PERSONNEL	Person	Category/trade	Skill level	Trade
	a	Engine crew	Intermediate	-
EQUIPMENT	Nomenclature		Identification code	Quantity
SUPPLIES	Nomenclature		Identification code	Quantity
	Seizure inhibitor (Sumitomo Metal Mining Moly dry spray or equivalent)			
	White bond (ThreeBond 1211 silicone-based liquid gasket or equivalent)			
	Epoxy resin paint (Nippon Paint Hi-Pon 40 or equivalent)			
SPARES	Nomenclature		Identification code	Quantity
	O-ring		24311-000340	4 pc
	Bolt		150633-01201	4 pc
SAFETY				

When you disassemble the cylinder head, piston, and cylinder liner, do an inspection and maintenance of the cylinder block. Obey the instructions that follow.

1. Inspection and maintenance

1. Make sure that the cylinder head bolts and main bearing bolts are tight.

Replace the bolt if the thread is damaged.

1 - Apply seizure inhibitor (Sumitomo Metal Mining Moly dry spray or equivalent) to the thread on the studded side.

2 - Tighten the new bolt to the specified torque.

Tightening torque: 200 (0 to +50) N·m

3 - Install O-rings to the studded side of the head bolts.

4 - Apply white bond (ThreeBond 1211 silicone-based liquid gasket or equivalent) to the studded side of the head bolts.

2. Clean the supply air chamber.

If the anti-rust paint on the inner surface is damaged, apply new anti-rust paint (Nippon Paint Hi-Pon 40 epoxy resin paint or equivalent).

3. Clean the water jacket and the cylinder liner holes.

4. Examine the water jacket and the cylinder liner holes for corrosion and wear.

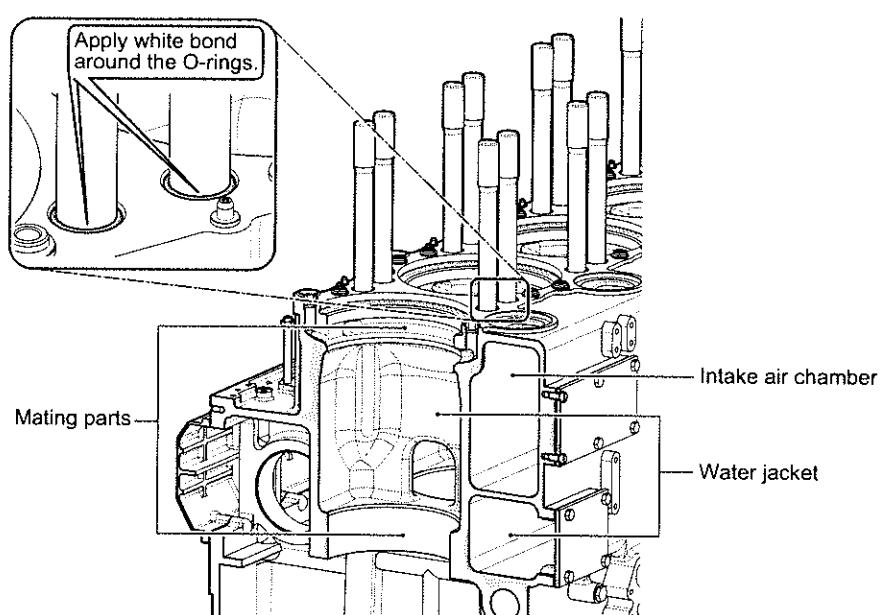


Fig.1 Inspection locations for the cylinder block

5. Examine the main bearing metals for seizure. If you find seizure, measure the dimensions of the main bearing cap hole.

Straightness: 0.03 mm or less deviation in 1 m of length

Roundness: 0.02 mm or less deviation

CONDITION

- The cylinder liner is a wet-type unit. It is made of a special cast iron that is very resistant to wear.
- Its thick walls are resistant to high combustion pressure and they prevent cavitation caused by piston slapping.
- The interior has a plateau honing finish. A protection ring is installed at the top of the liner. The ring prevents carbon buildup on the top of the piston. It also prevents wear on the liner caused by carbon buildup.

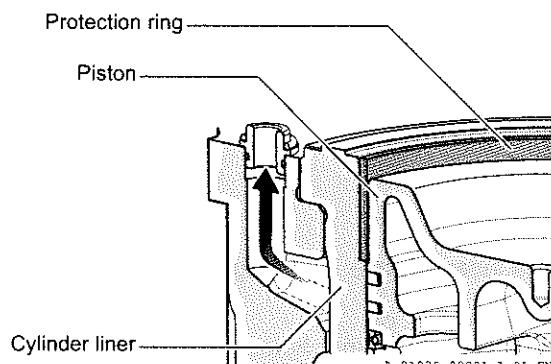


Fig. 1 Cylinder liner outline

Cylinder liner

Inspection and maintenance

1/5

PRODUCTION MANAGEMENT DATA

Intervals 5 years
16000 working hours

CONDITION Put a sheet on the crankshaft to keep cooling water or unwanted material out of the cylinder block.

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	9 h
	b	Engine crew	Intermediate	-	9 h
EQUIPMENT					
	Nomenclature	Identification code		Quantity	
	Spacer	150633-92040		2 pc	
	Top part of the liner drawing-out tool	150633-92010		1 pc	
	Drawing-out bolt	150633-92030		1 pc	
	Washer	22137-270000		1 pc	
	Nut	26732-270002		2 pc	
	Bottom part of the liner drawing-out tool	150633-92020		1 pc	
	Locknut	26772-270002		1 pc	
	Eye bolt	26610-120002		1 pc	
SUPPLIES					
	Nomenclature	Identification code		Quantity	
	Silicone liquid packing (ThreeBond 1107D or equivalent)				
	Anti-corrosion paint Hi-Pon P (made by Nippon Paint KK)				
SPARES					
	Nomenclature	Identification code		Quantity	
	O-ring	147646-01320		1 pc	
	O-ring	147644-01320		1 pc	
SAFETY					

Obey the instructions that follow when you do maintenance of the cylinder liner.

1. Disassembly

1. Install the special tools in this sequence. Refer to Fig. 1.

Put a sheet on the crankshaft to keep cooling water and unwanted material out of the cylinder block.

- 1 - Install the spacer 3 below the 2 cylinder head bolts that are diagonally opposite from each other.
- 2 - Install the top part of the liner drawing-out tool to the 2 cylinder head bolts. Make sure that the stepped side points down.
- 3 - Install the bottom part of the liner drawing-out tool 4 to the bottom of the cylinder liner. Make sure that the stepped part of the liner drawing-out tool engages with the inside of the cylinder liner. Install it in the direction of the crankshaft.
- 4 - Adjust the drawing-out bolt 7 so that the bottom part protrudes approximately 60 mm. Lock it with the nut 6 and the locknut 5.
- 5 - Install the washer 1. This makes it easier to install the nut 8.
- 6 - Hold the cylinder liner so that it does not touch the cylinder block. Tighten the nut.
- 7 - Move the top part of the liner drawing-out tool down on the cylinder liner. Make sure that the stepped part engages with the inside of the liner.
- 8 - Lock the cylinder liner and the drawing-out tools.

2. Screw the eye bolt 9 into the top end of the drawing-out bolt.

3. Attach a wire rope to the eye bolt. Lift the cylinder liner together with the drawing-out tools.

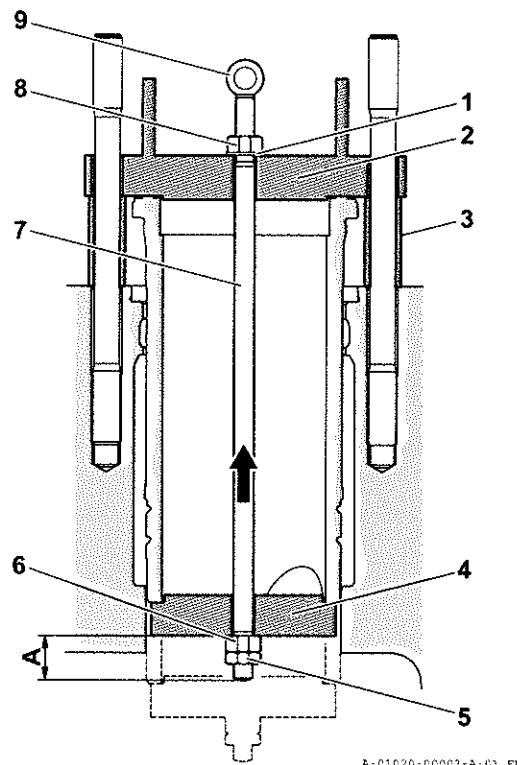


Fig.1 Removing the cylinder liner

2. Inspection

Periodically remove the cylinder liner and check it for corrosion. Cooling water causes cavitation and the cylinder liner can corrode from the outside.

1. Examine the sliding surfaces of the cylinder liner for seizure, streaks and corrosion.
2. Do a color-check on the rounded part of the collar of the cylinder liner. Look for cracks.
3. Examine the mating parts of the cylinder liner and the cylinder block for corrosion and wear.

3. Assembly

1. Replace the O-ring of the cylinder liner with a new one.
 - 1 - Install the O-ring to the cylinder liner. (Top: 147646-01320 Bottom: 147644-01320)
 - 2 - Apply silicone oil to the mating parts of the cylinder liner and cylinder block.
 - 3 - Remove torsion from the O-ring.
 - 4 - Again, apply silicone oil to the mating parts of the cylinder liner and cylinder block.

NOTICE

Bad storage conditions can cause cracks on the surface of the O-rings.
Stretch the O-rings and check for cracks before you install them.

2. When you install the liner, apply liquid packing or silicone oil to the mating parts of the cylinder liner and cylinder block. (Refer to Fig. 2.)
 - 1 - Apply silicone-based liquid packing (ThreeBond 1107D or equivalent) to the top of the cylinder block 1, 2.
 - Install the cylinder liner before the liquid packing becomes dry.
 - 2 - Apply lubricating oil to the parts 3 of the cylinder block that mate with the cylinder liner.

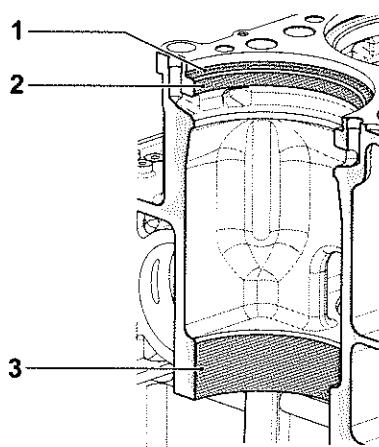


Fig.2 Locations for liquid packing and silicone oil

3. Install the special tools as shown in Fig. 4.

- 1 - Install the nut 6 and the locknut 5 to the drawing-out tool 7.
- 2 - Put this assembly into the bottom part of the drawing-out tool 4.
- 3 - Make sure that the stepped part is in the cylinder liner.
- 4 - Install the top part of the drawing-out tool 3 on the drawing-out bolt. Make sure that the stepped part points down.
- 5 - Install the spacer 2 and nut 8 to the drawing-out bolt. Now the cylinder liner and the special tool are one unit.
- 6 - Attach a wire rope to the eye bolt 11. Lift the cylinder liner and the drawing-out tools straight up.
- 7 - Move the bottom part of the liner into the cylinder block. Make sure that the liner does not hit the cylinder block.
- 8 - Align the holes of the top part of the special tool to the 2 diagonally opposed cylinder head bolts. Install the spacers 1.
- 9 - Align the 0 (zero) mark of the cylinder liner with the match mark 1 of the cylinder block.

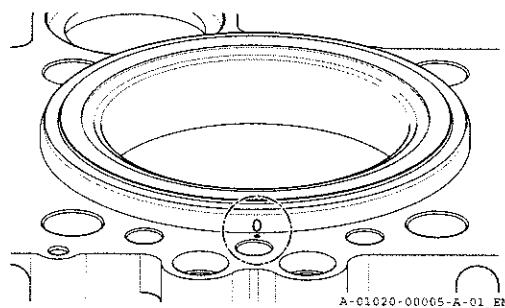


Fig.3 Location of the match mark

10 -Put a lever in the turning hole and tighten the two nuts 10 on the cylinder head bolt (left and right). Tighten them at the same time.

- 1 - After you tighten the nut 9 to the end of the thread, put the panel 9 between the top part of the special tool and the spacer 8. Then tighten the nut some more.
- 2 - The resistance of the O-ring can push the cylinder liner back up. In that case, keep the cylinder liner tightened and wait until the O-ring adjusts to the pressure.

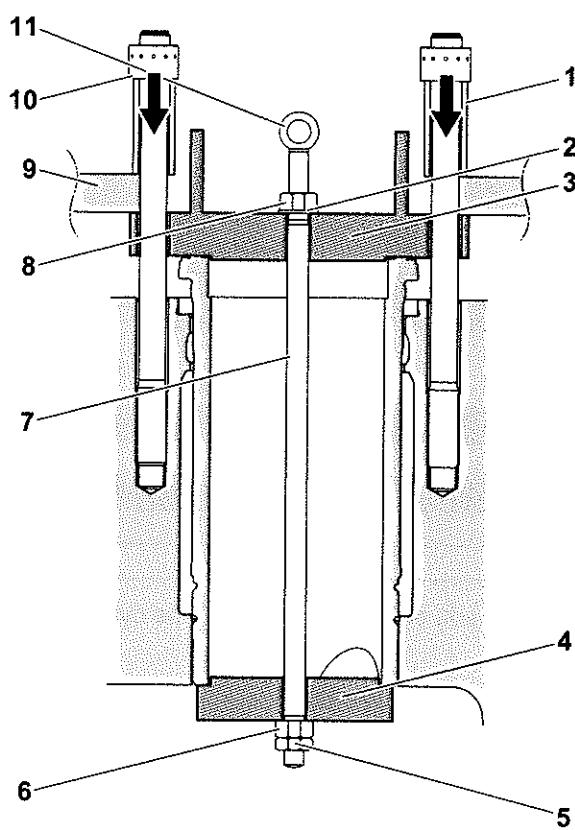


Fig.4 Assembling the cylinder liner

CONDITION	Measure the inside diameter of the cylinder liner. Make sure that the inside diameter has no deformation because of twisted O-rings. Examine the O-rings for water leaks when you: - Fill in cooling water. - Operate the engine for a test. Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07
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Cylinder liner

Measurement

1/2

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
	b	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Measuring tool for the inner diameter of the cylinder liner		150633-92250		1 pc
	Bore gauge		42111-004500		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do measurement of the cylinder liner.

1. Measurement

The amount of wear on the inner surface depends on: the control of the lubricating oil, the temperature of the cooling water and the regular working load. Regularly measure the inner diameter of the cylinder liner.

1. Measure the inner diameter of the cylinder liner with the measuring tool. Do it with the cylinder liner inside the cylinder block.

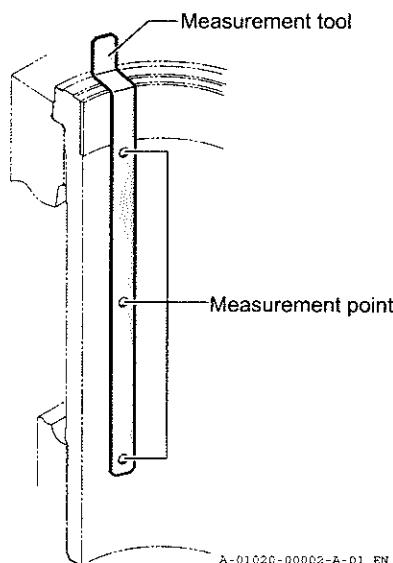


Fig.1 Attaching the measurement tool

Cylinder liner

Measurement

2/2

2. Compare the measured size with these limits.

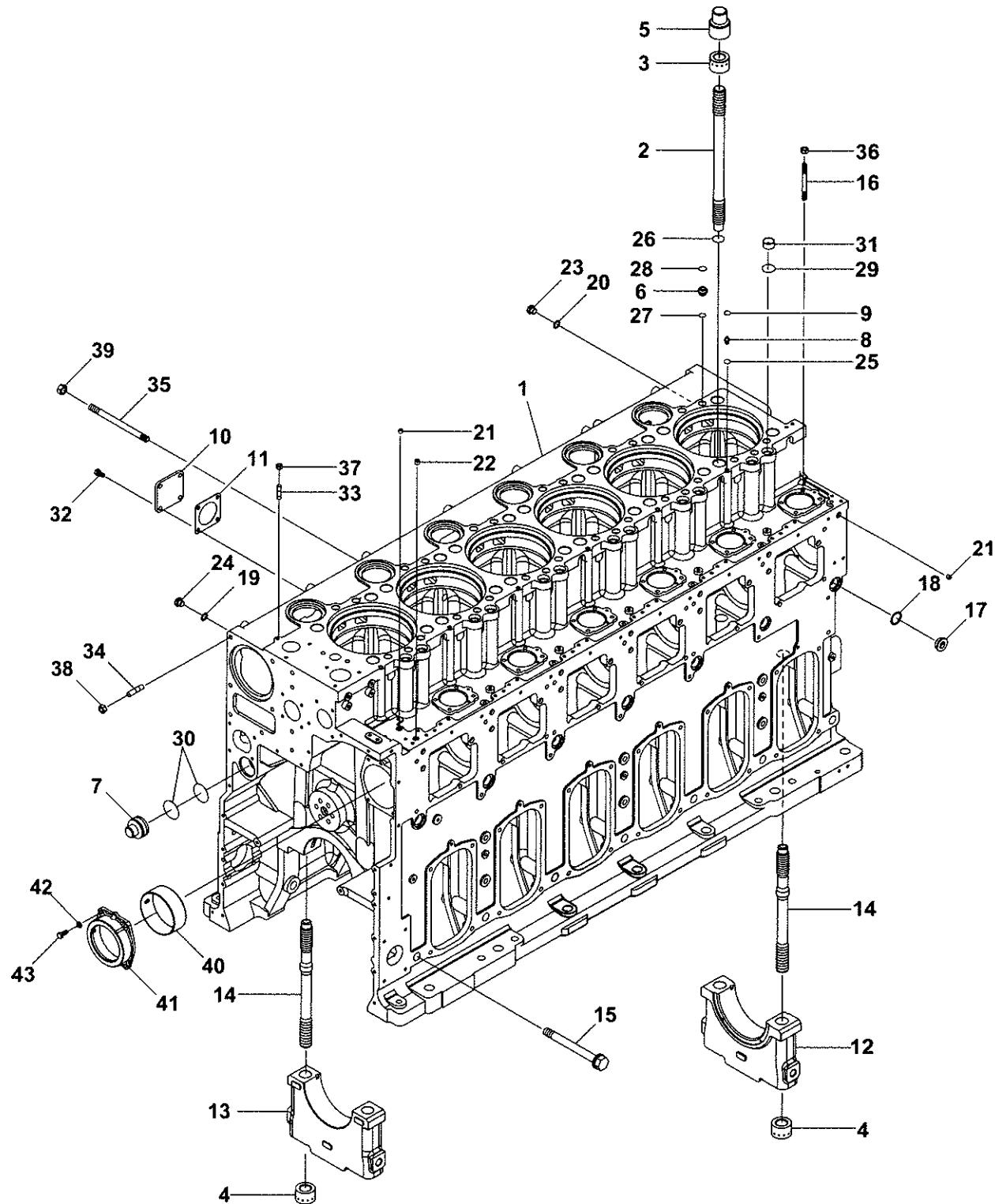
- Inner diameter: +0.4 mm or less
- Uneven wear: 0.2 mm or less
- Protection ring
Inner diameter: +0.8 mm or less

3. Replace the cylinder liner with a new one if:

- These limits are exceeded.
- It is possible that these limits will be exceeded before the subsequent servicing.

For the wear limit, refer to "Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07

CONDITION

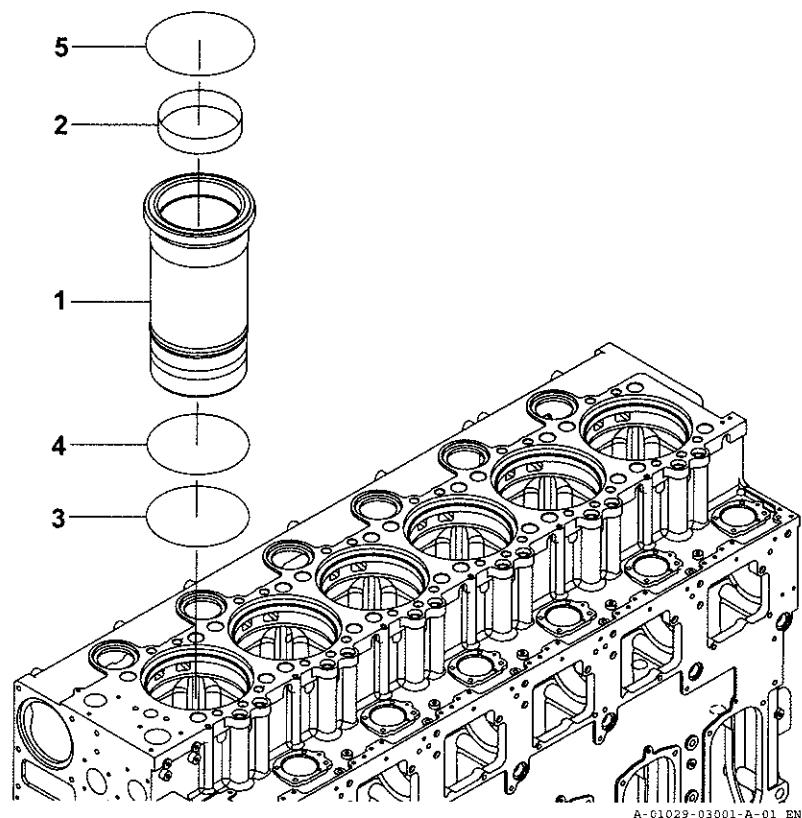


Cylinder block

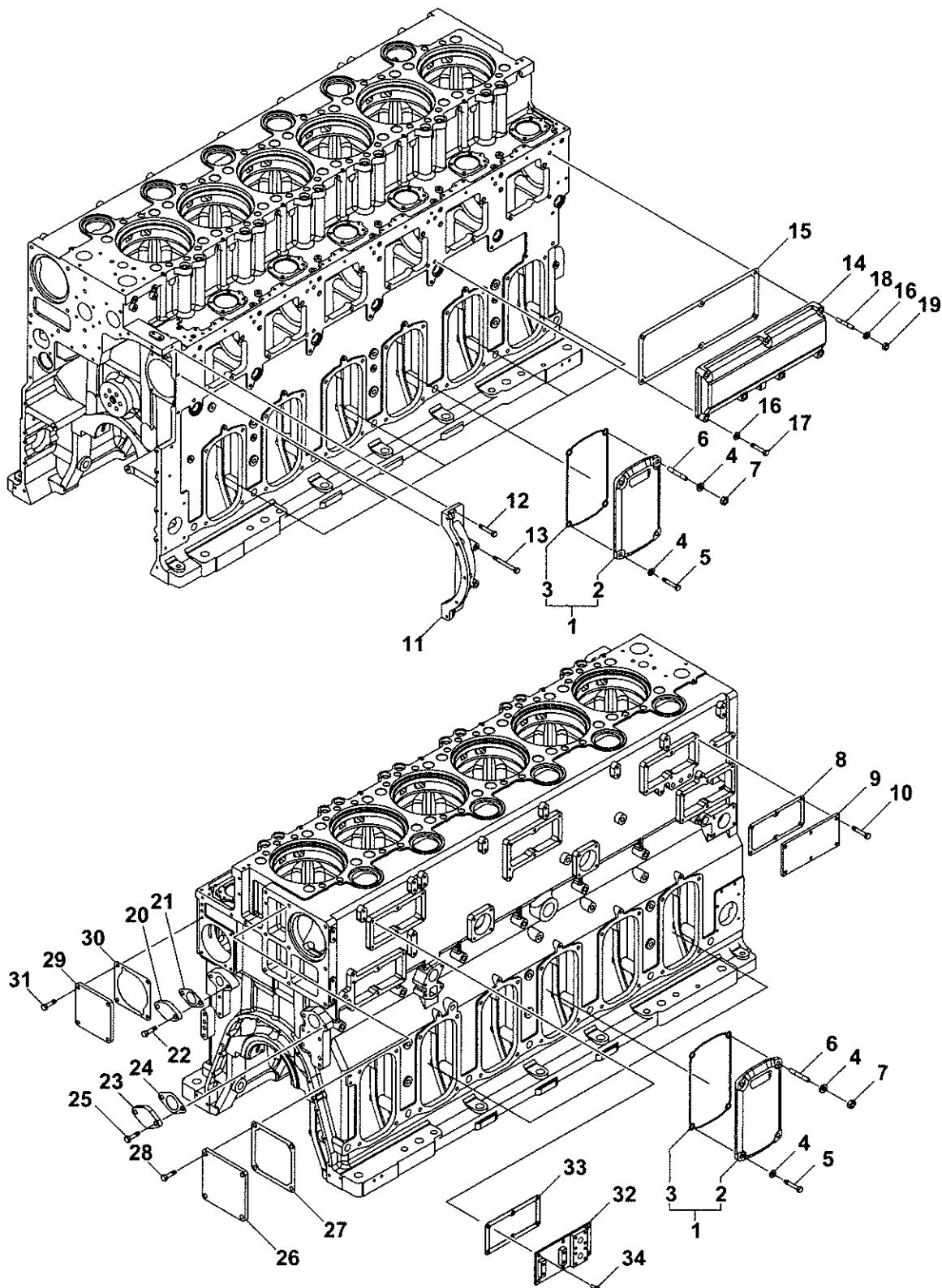
Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-01010	BLOCK, CYLINDER	1	1	
2	2	150633-01201	BOLT, CYLINDER HEAD	24	24	
3	2	150633-01210	NUT, HEAD	24	24	
4	2	150633-01210	NUT, CAP	14	14	
5	2	150633-01280	PROTECTOR	24	24	
6	2	147676-01410	PIPE, CONNECT. 14	30	30	
7	2	150633-01600	COVER,LO GALLERY	1	1	
8	2	146673-01720	PIECE, RLO CONNECT.	6	6	
9	2	152633-01810	O-RING	6	6	
10	2	147673-01850	FLANGE, CLOSE	1	1	
11	2	138673-01990	GASKET, OIL SUMP	1	1	
12	2	150633-02030	METAL CAP(BASE)	1	1	
13	2	150633-02050	METAL CAP	6	6	
14	2	150633-02071	BOLT, METAL CAP	14	14	
15	2	147673-02081	BOLT, SIDE	14	14	
16	2	150633-11910	BOLT,STUD FO VALVE	24	24	
17	2	146673-11950	PLUG, CYLINDER HEAD	7	7	
18	2	146673-11960	PACKING, PLUG	7	7	
19	2	23414-170000	GASKET, 17 X 1.0	1	1	
20	2	23414-200000	GASKET, 20 X 1.0	6	6	
21	2	23875-020000	PLUG, R02	8	8	
22	2	23875-030000	PLUG, R03	7	7	
23	2	23887-200002	PLUG, 20	6	6	
24	2	23897-030002	PLUG, G 3/8	1	1	
25	2	24311-000090	PACKING, P 9.0	6	6	
26	2	24311-000340	PACKING, P 34.0	24	24	
27	2	24316-000210	PACKING, P 21.0	30	30	
28	2	24316-000240	PACKING, P 24.0	30	30	
29	2	24316-000380	PACKING, P 38.0	12	12	
30	2	24321-000650	PACKING, G 65.0	2	2	
31	2	24550-035200	BEARING, 35 X 20	12	12	
32	2	26206-120252	BOLT, 12 X 25	4	4	
33	2	26216-120402	STUD,BOLT 12 X 40	6	6	
34	2	26232-160452	STUD,BOLT 16 X 45	10	10	
35	2	26232-202452	STUD,BOLT 20 X 245	5	5	
36	2	26606-140002	NUT, 14	24	24	
37	2	26706-120002	NUT, 12	6	6	
38	2	26732-160002	NUT, 16	10	10	
39	2	26732-200002	NUT, 20	5	5	
40	1	150633-02420	BEARING CAMSHAFT	7	7	
41	1	150633-02400	METAL,CAM THRUST	1	1	
42	1	22217-120000	WASHER, 12	4	4	
43	1	26206-120302	BOLT, 12 X 30	4	4	



No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-01150	LINER, CYLINDER	6	6	
2	1	150633-01121	PROTECTION RING	6	6	
3	1	147644-01320	PACKING, CYL.LINER	6	6	
4	1	147646-01320	PACKING, CYL.LINER	6	6	
5	1	150633-01340	PACKING, HEAD T=1.0	6	6	



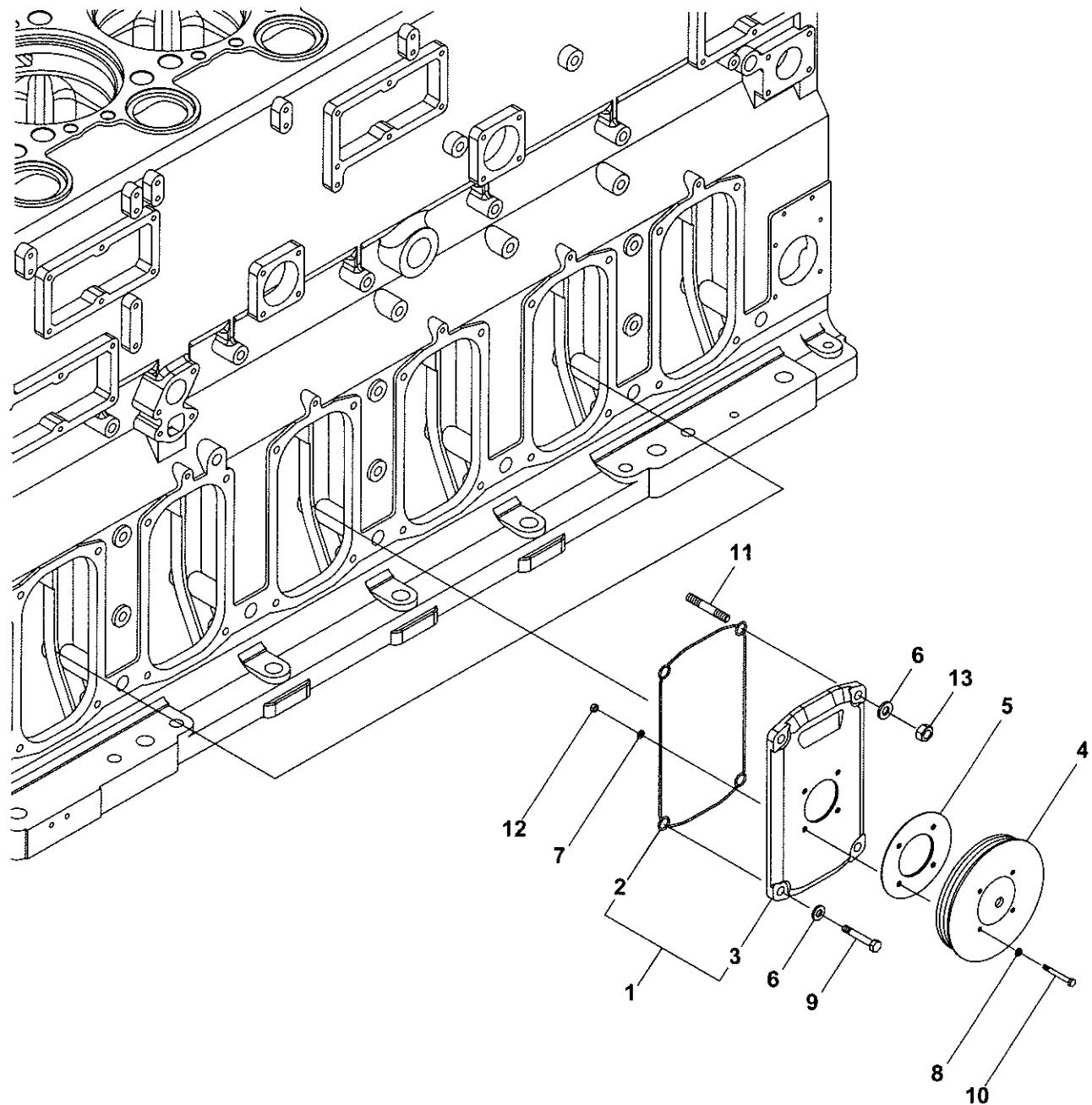
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Cylinder side cover

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-01380	COVER,CRANKCASE	9	9	
2	2	150633-01400	COVER,CRANKCASE	9	9	
3	2	150633-01410	PACKING,CYL.COVER	9	9	
4	1	22137-160000	WASHER, 16	36	36	
5	1	26152-160402	BOLT, 16 X 40	18	18	
6	1	26232-160402	STUD,BOLT 16 X 40	18	18	
7	1	26732-160002	NUT, 16	18	18	
8	1	146673-01620	PACKING, AIR COVER	4	4	
9	1	150633-01850	COVER,CW CHAMBER	4	4	
10	1	26206-120252	BOLT, 12 X 25	24	24	
11	1	150633-01840	COVER,CAM GEAR	1	1	
12	1	26206-120302	BOLT, 12 X 30	2	2	
13	1	26206-121152	BOLT, 12 X 115	2	2	
14	1	150633-01751	COVER,CAM ROOM	3	3	
15	1	150633-01760	PACKING,CAM ROOM	3	3	
16	1	22137-160000	WASHER, 16	21	21	
17	1	26152-160702	BOLT, 16 X 70	15	15	
18	1	26232-160702	STUD,BOLT 16 X 70	6	6	
19	1	26732-160002	NUT, 16	6	6	
20	1	23221-490001	FLANGE, 49	1	1	
21	1	23428-510000	GASKET, 51 X 1.5	1	1	
22	1	26152-160402	BOLT, 16 X 40	2	2	
23	1	23221-610001	FLANGE, 61	1	1	
24	1	23428-620000	GASKET, 62 X 1.5	1	1	
25	1	26152-160402	BOLT, 16 X 40	2	2	
26	1	150633-01720	COVER,AIR CHAMBER	1	1	
27	1	150633-18220	PACKING,I/C-BLOCK	1	1	
28	1	26152-160352	BOLT, 16 X 35	4	4	
29	1	150633-01700	COVER,CAM SHAFT END	1	1	
30	1	150633-01710	PK, CAM SHAFT END	1	1	
31	1	26206-120302	BOLT, 12 X 30	4	4	
32	1	150635-01210	COVER,AIR CHAMBER	1	1	
33	1	146673-01620	PACKING, AIR COVER	1	1	
34	1	26206-120252	BOLT, 12 X 25	6	6	

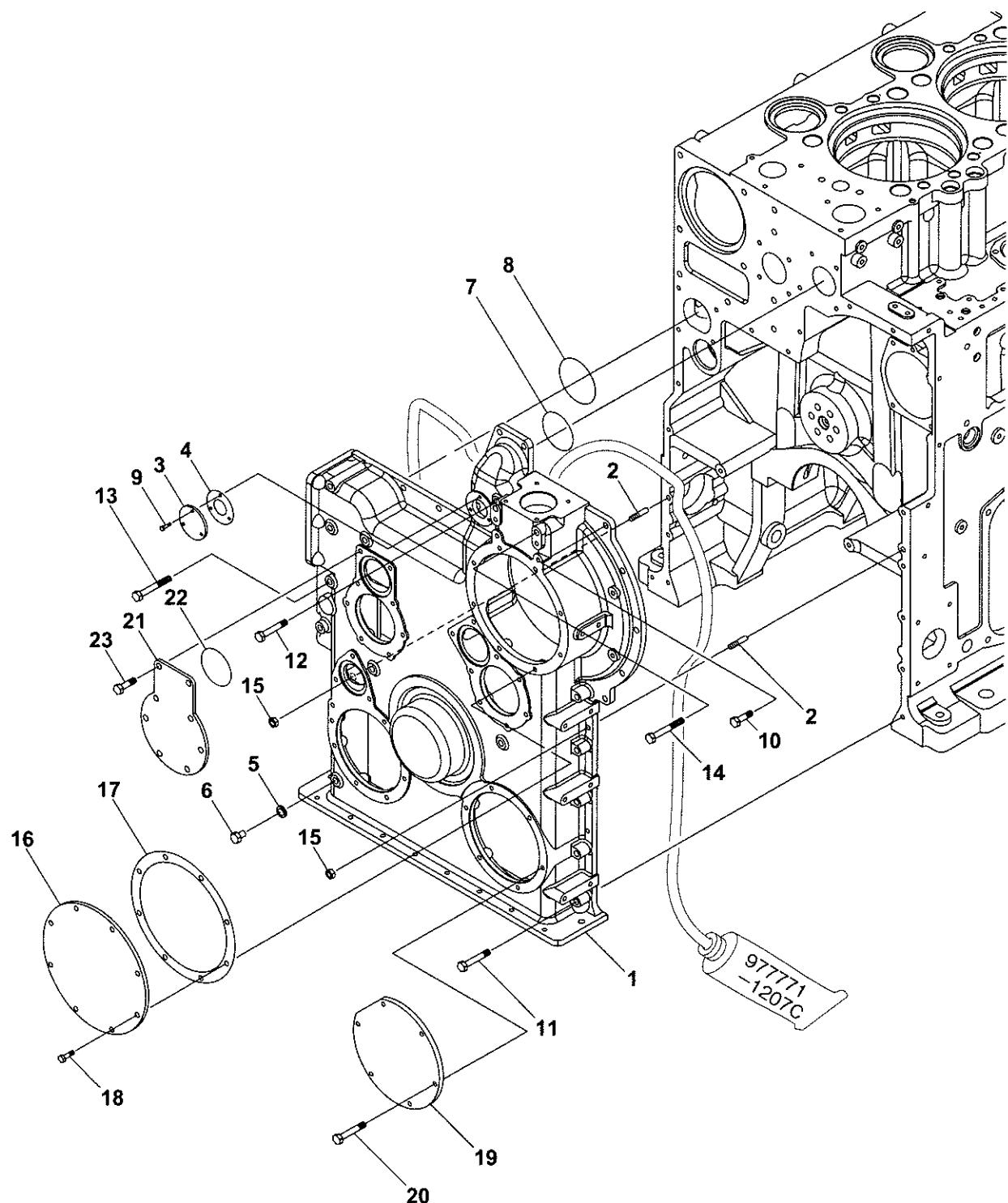


Cylinder side cover (relief valve)

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-01370	COVER,CRANKCASE	3	3	
2	2	150633-01410	PACKING,CYL.COVER	3	3	
3	2	150633-01430	COVER,CRANKCASE	3	3	
4	1	150633-03712	VALVE,RELIEF CR51-98	3	3	
5	1	146673-03760	GASKET, RELIEF VALVE	3	3	
6	1	22137-160000	WASHER, 16	12	12	
7	1	22190-080003	WASHER, SEAL 8	12	12	
8	1	22217-080000	WASHER, 8	12	12	
9	1	26152-160402	BOLT, 16 X 40	6	6	
10	1	26206-080852	BOLT, 8 X 85	12	12	
11	1	26232-160402	STUD,BOLT 16 X 40	6	6	
12	1	26706-080002	NUT, 8	12	12	
13	1	26732-160002	NUT, 16	6	6	

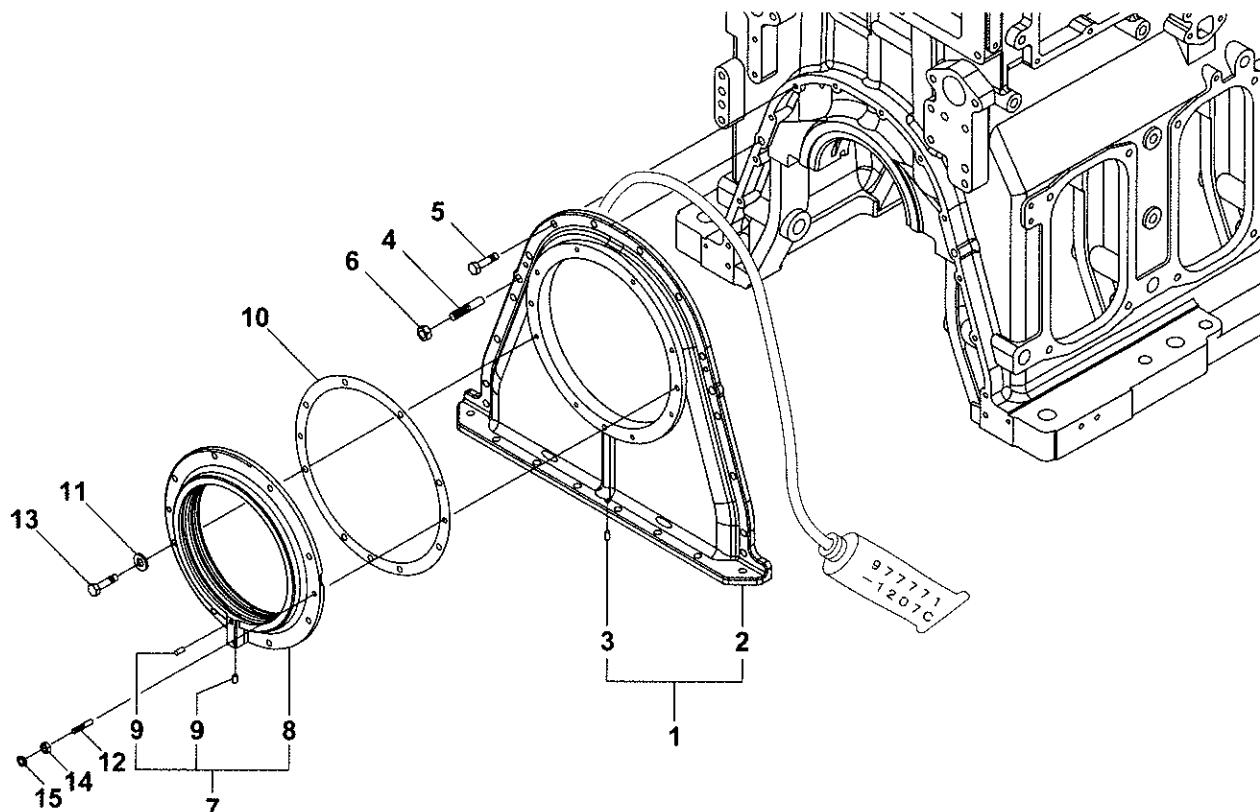


Gear case

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-01500	GEAR CASE	1	1	
2	1	138613-01590	PIN, PARALLEL M12X28	2	2	
3	1	153605-11720	COVER, BLIND	1	1	
4	1	153605-11731	GASKET	1	1	
5	1	23414-120000	GASKET, 12 X 1.0	1	1	
6	1	23887-120002	PLUG, 12	1	1	
7	1	24316-000800	PACKING, P 80.0	1	1	
8	1	24316-000950	PACKING, P 95.0	1	1	
9	1	26206-080162	BOLT, 8 X 16	3	3	
10	1	26206-120302	BOLT, 12 X 30	12	12	
11	1	26206-120652	BOLT, 12 X 65	8	8	
12	1	26206-121152	BOLT, 12 X 115	1	1	
13	1	26206-121402	BOLT, 12 X 140	7	7	
14	1	26206-121602	BOLT, 12 X 160	2	2	
15	1	26706-120002	NUT, 12	2	2	
16	1	150633-01510	COVER, GEAR CASE	1	1	
17	1	150633-01520	PK, GEAR CASE COVER	1	1	
18	1	26206-120252	BOLT, 12 X 25	8	8	
19	1	150633-01630	COVER, FO FEED PUMP	1	1	
20	1	26206-120202	BOLT, 12 X 20	6	6	
21	1	150633-01640	COVER, LCW PUMP	1	1	
22	1	24316-000900	PACKING, P 90.0	1	1	
23	1	26206-120202	BOLT, 12 X 20	8	8	



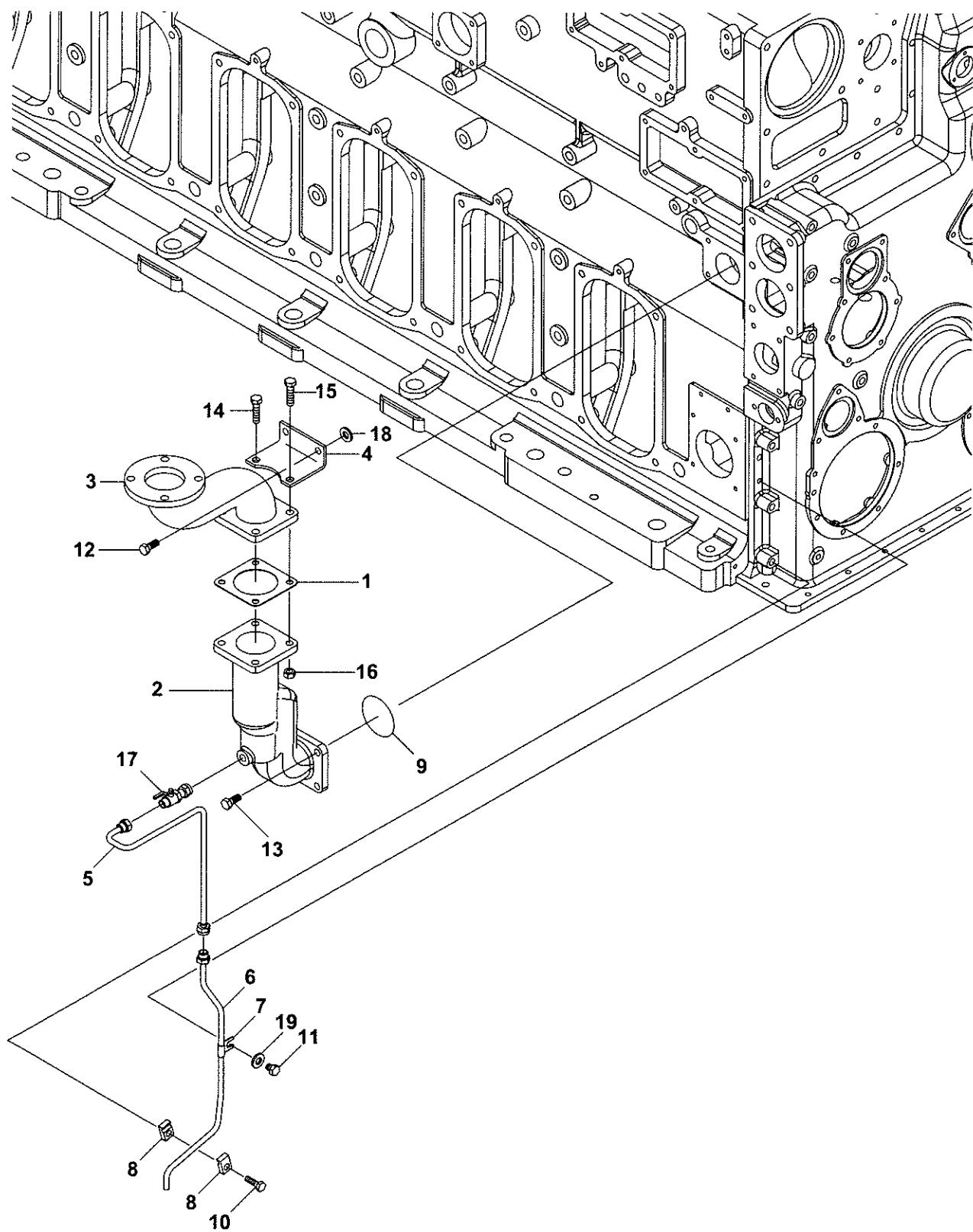
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-01530	COVER ASSY,SFW	1	1	
2	2	150633-01540	COVER,SFW	1	1	
3	2	26911-100102	SCREW, 10 X 10	1	1	
4	1	147673-01590	PIN, PARALLEL 16X24	2	2	
5	1	26206-120302	BOLT, 12 X 30	14	14	
6	1	26711-160002	NUT, 16	2	2	
7	1	150633-01441	OIL THROWER ASSY,SFW	1	1	
8	2	150633-01491	OIL THROWER,SFW	1	1	
9	2	26911-100102	SCREW, 10 X 10	2	2	
10	1	150633-01480	PK,SEALING	1	1	
11	1	22137-100000	WASHER, 10	8	8	
12	1	22340-100252	PIN, 10 X 25	2	2	
13	1	26206-100252	BOLT, 10 X 25	8	8	
14	1	26706-100002	NUT, 10	2	2	
15	1	26796-100002	NUT, 10	2	2	

Breather pipe

Illustrated parts data

1/2



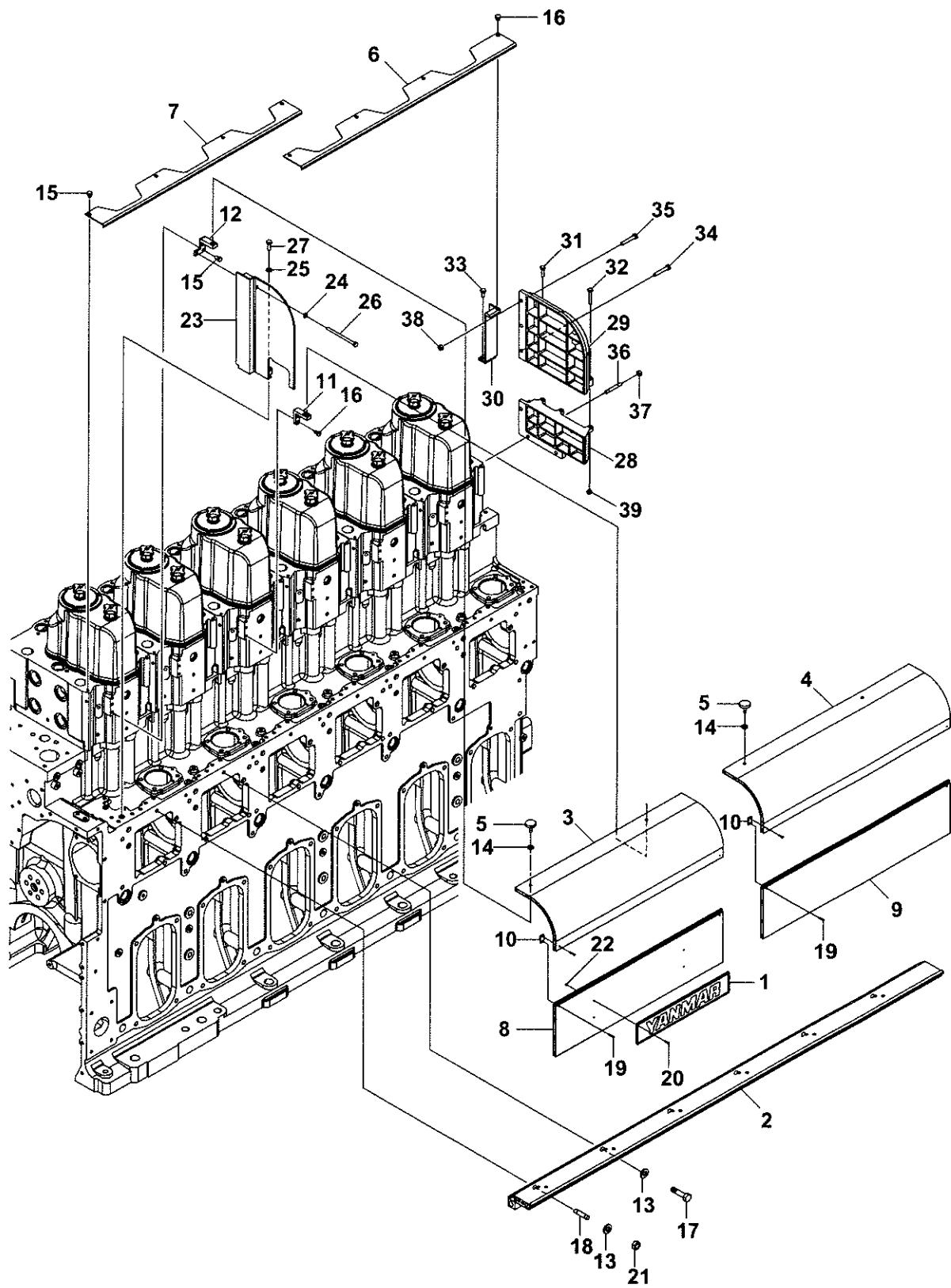
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Breather pipe

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	138673-01990	GASKET, OIL SUMP	1	1	
2	1	150633-03100	BREATHER	1	1	
3	1	150633-03090	PIPE,BREATHER	1	1	
4	1	150633-03150	BRACKET,BREATHER	1	1	
5	1	150633-03300	DRAIN PIPE,MIST	1	1	
6	1	150633-03310	DRAIN PIPE,MIST	1	1	
7	1	138623-39260	CLAMP	1	1	
8	1	152696-59550	SUPPORT, 10X1	2	2	
9	1	24324-000800	PACKING, G 80.0	1	1	
10	1	26206-100352	BOLT, 10 X 35	1	1	
11	1	26206-120152	BOLT, 12 X 15	1	1	
12	1	26206-120202	BOLT, 12 X 20	2	2	
13	1	26206-120302	BOLT, 12 X 30	4	4	
14	1	26206-120452	BOLT, 12 X 45	2	2	
15	1	26206-120502	BOLT, 12 X 50	2	2	
16	1	26706-120002	NUT, 12	4	4	
17	1	43600-026420	VALVE, BALL PT3/8	1	1	
18	1	22137-120000	WASHER, 12	2	2	
19	1	22117-120000	WASHER, 12	1	1	



Pump case cover

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146673-07400	LABEL, YANMAR	1	1	
2	1	150633-09090	SUPPORT, PUMP COVER	1	1	
3	1	150633-09100	COVER, FOP UPPER	1	1	
4	1	150633-09110	COVER, FOP UPPER	1	1	
5	1	146673-09150	KNOB	4	4	
6	1	150633-09150	COVER, FOP	1	1	
7	1	150633-09160	COVER, FOP	1	1	
8	1	150633-09200	COVER, FOP LOWER	1	1	
9	1	150633-09210	COVER, FOP LOWER	1	1	
10	1	146673-09250	PLATE, FIXED	4	4	
11	1	151695-09300	SUPPORT, PUMP CHAMBER	3	3	
12	1	150633-09310	SUPPORT, FOP COVER	1	1	
13	1	22137-120000	WASHER, 12	6	6	
14	1	22272-000070	RING, 7	4	4	
15	1	26206-100122	BOLT, 10 X 12	8	8	
16	1	26206-100222	BOLT, 10 X 22	8	8	
17	1	26206-120502	BOLT, 12 X 50	4	4	
18	1	26216-120502	STUD,BOLT 12 X 50	2	2	
19	1	26553-040202	SCREW, 4 X 20	8	8	
20	1	26573-040252	SCREW, 4 X 25	4	4	
21	1	26706-120002	NUT, 12	2	2	
22	1	26716-040002	NUT, 4	4	4	
23	1	150633-09060	COVER, SIDE	1	1	
24	1	22137-100000	WASHER, 10	1	1	
25	1	22137-120000	WASHER, 12	2	2	
26	1	26206-101602	BOLT, 10 X 160	1	1	
27	1	26206-120352	BOLT, 12 X 35	2	2	
28	1	150633-09072	COVER, SIDE	1	1	
29	1	150633-09081	COVER, SIDE	1	1	
30	1	150633-09350	SUPPORT, SIDE COVER	1	1	
31	1	26206-100402	BOLT, 10 X 40	2	2	
32	1	26206-100652	BOLT, 10 X 65	1	1	
33	1	26206-120252	BOLT, 12 X 25	2	2	
34	1	26206-120652	BOLT, 12 X 65	2	2	
35	1	26206-120752	BOLT, 12 X 75	2	2	
36	1	26212-120702	STUD,BOLT 12 X 70	2	2	
37	1	26706-100002	NUT, 10	3	3	
38	1	26706-120002	NUT, 12	2	2	
39	1	26706-120002	NUT, 12	2	2	

- Each cylinder head is made of cast iron and water-cooled. The cylinder head has 4 valves: 2 intake valves and 2 exhaust valves. The fuel injection valve is at the center. The intake and exhaust valves are laid out in pairs and the intake and exhaust air systems are on the same operation side. This makes maintenance and inspection from the camshaft and fuel injection pump easy.
- The cylinder head is attached to the engine with 4 bolts and nuts. Use a special hydraulic tool to disassemble and assemble the tightening nuts.

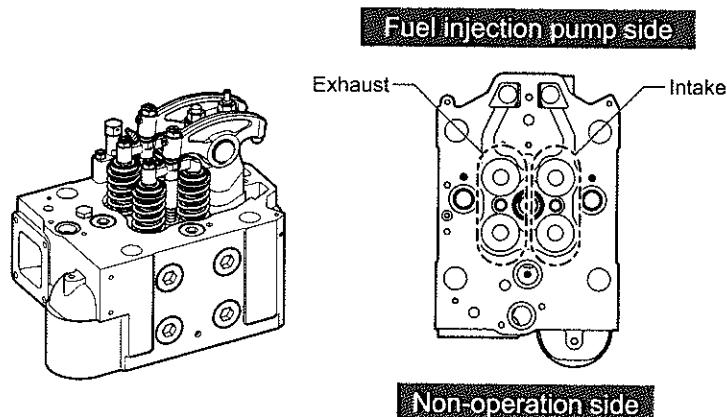


Fig. 1 Cylinder head - Description of function

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Cylinder head

Inspection and maintenance

1/6

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION Maintenance inspections 0000-001-08

Hydraulic jack - Description of function 9201-000-01

Intake/exhaust valve - Inspection 1102-000-02

Valve seat - Inspection 1103-000-02

Valve guide - Replacement 1104-000-05

Valve bridge guide - Inspection 1105-000-02

Valve rotator - Inspection 1106-000-02

Nozzle sleeve - Inspection 1107-000-02

Close all valves of the cooling water inlet and outlet.

Release the cooling water from the cylinder block.

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	27 h
	b	Engine crew	Intermediate	-	27 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Lifting tool body	150633-92310	1 pc
	Drawing-out tool B	146673-92320	2 pc
	Eye nut	26620-160002	1 pc
	Bolt	26116-160502	1 pc
	Bolt	26152-160402	2 pc
	Hydraulic pump	746673-92112	1 pc
	Angle elbow (L-pipe)	151605-92740	4 pc
	Coupler (female)	153625-92780	4 pc
	Hydraulic jack	150633-92650	4 pc
	Spacer	150633-92510	4 pc
	Handle	146673-92510	1 pc
	Spacer bolt	150633-92680	4 pc
	Nut	26732-360002	4 pc

SUPPLIES	Nomenclature	Identification code	Quantity
	Unicon -146		

SPARES	Nomenclature	Identification code	Quantity
	Packing	150633-12310	2 pc
	Head packing	150633-01340	2 pc
	O-ring	24316-000380	2 pc
	O-ring	24316-000240	5 pc
	O-ring	24316-000210	5 pc
	O-ring	153633-01810	1 pc
	O-ring	24311-000090	1 pc

SAFETY

Obey the instructions that follow when you do regular maintenance of the cylinder head.

1. Disassembly

1. Lift the exhaust manifold cover with the eyebolt and remove it.
2. Remove the exhaust manifold.
3. Remove the exhaust thermometer and cooling water thermometer.
4. Disconnect the pipes and accessories from the cylinder head.

Overflow oil pipe of the injection pipe 7

Overflow oil pipe of the injection valve 6

Pinion lubrication pipe of the fuel injection pump 9

Cooling water manifold pipe 1

Pressure indicator cock 4

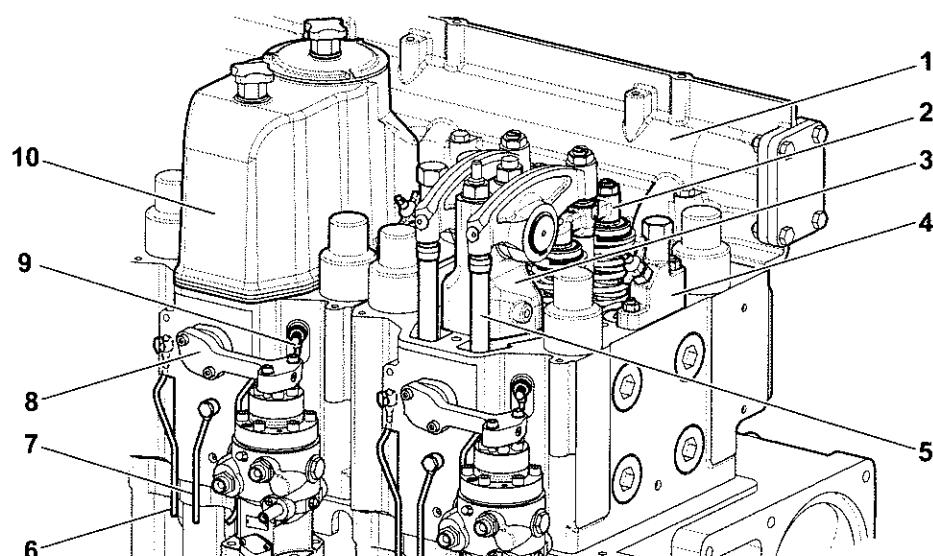
Injection pipe joint 8

5. Remove the bonnet 10 and the inner accessories.

Intake/exhaust valve bridge 2

Rocker arm shaft pedestal 3

Push rod 5



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Fig.1 Cylinder head accessories

6. Remove the fuel valve tightening nut.
7. Remove the protective cap of the cylinder bolt.
8. Clean the area around the cylinder head tightening nuts.
9. Apply a match mark to the bolt and nut when you disassemble them.
10. Remove the cylinder head tightening nut with the hydraulic jack.

1 - If you cannot turn the nut with the handle, slowly increase the hydraulic pressure and then turn the nut again. Do not increase the hydraulic pressure to more than 63.7 MPa.

2 - After you remove the tightening nut, make sure that the studded bolt is tight.

Hydraulic jack - Operation procedures (Paragraph 2)

Hydraulic jack - Description of function 9201-000-01

11.Lock the cylinder head lifting tool on the cylinder head. Lift the cylinder head straight up.

- 1 - Tighten the eye nut 1 with the bolt 5 to the lifting tool body 4.
- 2 - With the eye nut installed, put the lifting tool body on the center of the cylinder head.
- 3 - Install the drawing-out tool B 3 to the tightening bolt 6 of the fuel valve bridge.
- 4 - Align the bolt 2 to the top face of the valve bridge guide.
- 5 - Lightly tighten the drawing-out tool B to prevent looseness.
- 6 - Lift the cylinder head straight up.

NOTICE

Lift the cylinder head carefully to prevent damage to the thread of the head bolt.

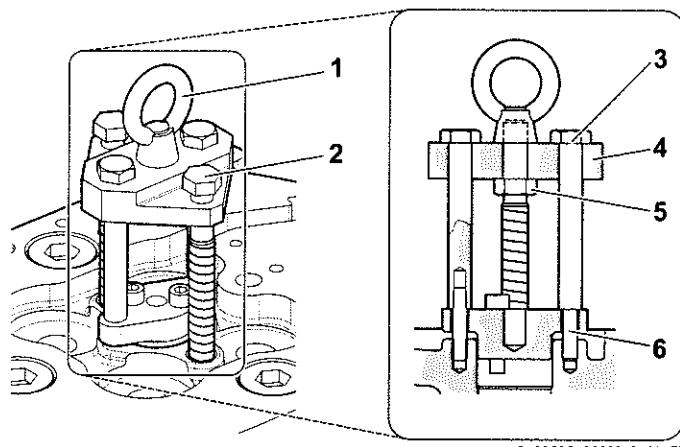


Fig.2 Lifting the cylinder head

12.After you remove the cylinder head, cover the cylinder to keep unwanted material out of the supply air chamber.

Put a protective tube on the threaded part of the cylinder head bolt to prevent damage.

2. Hydraulic jack

1. Fit the spacer 4 to the outer circumference of the head nut.
Align the notched part of the spacer with the adjacent head. (See 3B in the figure.)
2. Screw the spacer bolt 1 into the head bolt. Do this until the bolt touches the bottom.
3. Put the hydraulic jack 3 on the spacer bolt and put it on the top of the spacer.
4. Tighten the spacer nut 2.
5. Make sure that the distance between the piston of the hydraulic jack and the end face of the body is less than 1.5 mm. (See 3A in the figure.)
6. Loosen the spacer nut for 1/2 turn.
7. Connect the hose to the hydraulic jack.
8. Increase the hydraulic pressure to the specified value.
Specified hydraulic pressure: $58.8 \text{ MPa} \pm 0.5 \text{ MPa}$
9. Put the handle 5 into the hole of the nut through the turning window of the spacer. Then turn the nut.
10. Slowly open the relief valve of the hydraulic pump and decrease the hydraulic pressure to zero.
11. Tighten the spacer nut until the piston of the hydraulic jack fits well in the housing. Drain the hydraulic fluid from the jack.
12. Remove the rubber hoses from the hydraulic jack. Remove the hydraulic jack, the spacer and the spacer bolt.

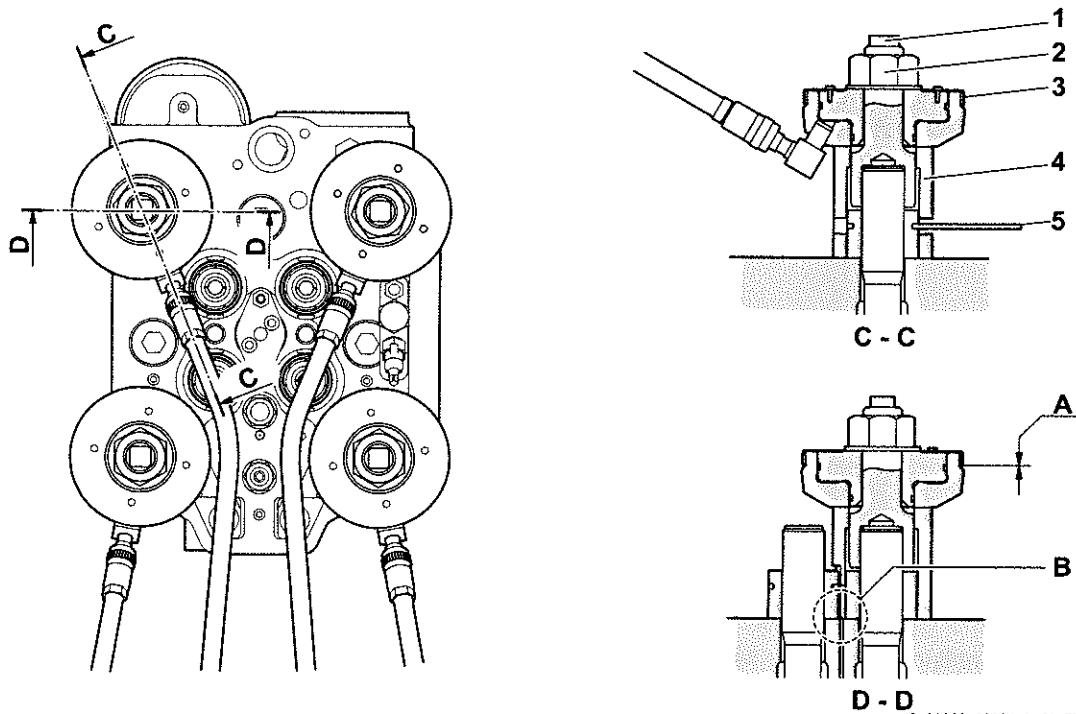


Fig.3 How to install the hydraulic jack for the cylinder head

3. Inspection

Look for carbon buildup in the combustion chamber and the intake and exhaust ports. The quantity of carbon buildup helps you to decide the intervals for subsequent servicing.

NOTICE

Do not use a gas burner to remove carbon from the combustion surface or the exhaust port. If the flame directly touches the exhaust valve seat, the seat can become loose and the O-ring can deteriorate. This can cause water leakage.

1. Examine the cylinder head for cracks and corrosion.
2. Examine the water jacket for scale.

Clean the water jacket with a descaling agent at least one time in 2 years. A lot of scale can collect depending on the water quality. (Use YANMAR Unicon 146 to remove scale from the water jacket. You can do this during an engine stop without opening the engine.)

3. Examine the inlaid part on the fitting surface of the cylinder head. If the mating holes are damaged or dirty, blowby will occur during operation.

Carefully clean the whole area, especially the holes. Cover the whole area with a sheet during your task. Do not put anything in the holes (e.g. waste cloth) to prevent clogging.

4. Do a test with water pressure of 0.75 MPa. There must be no water leaks.

4. Assembly

1. Install to the cylinder block:

- The cooling water connection pipes 1 (5 locations)
- The lubricating oil connection pipes 3
- The dry bushing 2 for the push rod cover.

The pipes connect the cylinder block and the cylinder head.

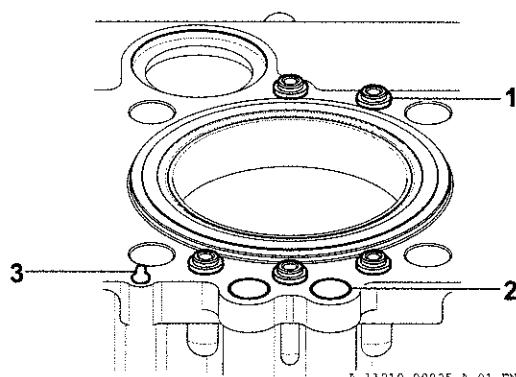


Fig.4 Installation location of the connection pipes for cooling water, lubricating oil and others

2. Lock the cylinder head lifting tool onto the fuel valve clamping bolt.

Disassembling the cylinder head (1 page)

3. Lift up the cylinder head and put it straight on the cylinder liner.

Be careful not to hit the thread of the cylinder head bolt.

4. Clean the area around the cylinder head tightening nuts.

5. Lubricate the thread and seating surface of the cylinder head bolt and tightening nut.

6. Tighten the head nut manually or with the turning handle. Turn the head nut up to the washer.

7. Tighten the cylinder head tightening nut with the hydraulic jack.

Hydraulic jack - Operation procedures (Paragraph 2)

Hydraulic jack - Description of function 9201-000-01

Table of tightening torques for major bolts and nuts 0000-000-07

8. Install the push rod and the intake/exhaust valve bridge.

9. Install the rocker arm intake/exhaust valve to the support of the rocker-arm shaft. Tighten the tightening nut of the support of the rocker-arm shaft to the specified torque.

10. Install the indicator cock and tighten the tightening nut to the specified hydraulic pressure.

Table of tightening torques for major bolts and nuts 0000-000-07

11. Adjust the intake/exhaust valve head clearance.

Adjusting 1102-000-02

Assembly adjustment values 0000-000-07

12. Install the bonnet.

NOTICE

- Replace all packings, head packings and O-rings with new ones. If you must use a packing or an O-ring again, examine it carefully for flaws, deformation and deterioration.
- If you use a head packing of the initial dimensions, the standard top clearance is the same and adjustment is not necessary.
- Before you install the cylinder head, look for unwanted material in:
 - The intake and exhaust passages of the cylinder
 - The top part of the piston
 - The supply air chamber of the cylinder block.

CONDITION

- The intake/exhaust valves are poppet valves. There are 2 pairs for a total of 4 valves. The intake valves are made of heat-resistant steel. The exhaust valves are made of very heat-resistant and corrosion-resistant Nimonic.
- The valve sheet has an overlay. The exhaust valve seat is cooled.
- The intake and exhaust valves are laid out in pairs, with the intake and exhaust air systems on the same operation side. This makes maintenance and inspection access from the camshaft and fuel injection pump easy.
- The valve mechanism can operate 2 intake or exhaust valves at the same time through a T-shaped valve bridge. To operate 2 intake or exhaust valves at the same time, it is necessary to adjust the valve head clearance. This prevents problems with the valve bridges.

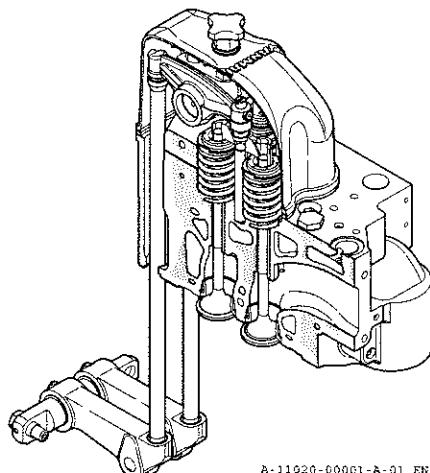


Fig.1 Intake/exhaust valve - Description of function

Intake/exhaust valve

Inspection and maintenance

1/5

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION Before you disassemble the intake/exhaust valves, remove the valve rotator, cotter and valve spring.
Examine the valve seat for blowby and carbon bite-in. Grind the face of the seat if necessary.

PERSONNEL

Person	Category	Skill	Trade	Estimated time
a	Engine crew	Intermediate	-	30 h

EQUIPMENT

Nomenclature	Identification code	Quantity
Drawing-out tool B	146673-92320	2 pc
Valve spring detaching/attaching tool A	150633-92321	1 pc
Valve spring detaching/attaching tool B	150633-92330	1 pc
Bolt	150633-92351	1 pc
Grinding compound	28210-000070	1 pc
Grinding tool	150633-92700	1 pc

SUPPLIES

Nomenclature	Identification code	Quantity
--------------	---------------------	----------

SPARES

Nomenclature	Identification code	Quantity
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SAFETY

|--|--|--|

Obey the instructions that follow when you do maintenance of the intake/exhaust valves.

1. Disassembly

1. Align the valve spring tool B 4 to the four holes of the intake/exhaust valve.
2. Put the valve spring tool A 3 on the valve spring tool B. Lock the valve spring tools to the fuel valve clamping bolt 5 with the drawing-out tool B 2.
3. Screw in the bolt 1, hold down the valve rotator and the valve spring, and remove the cotter key.

NOTICE

One intake/exhaust valve is locked with 2 cotters. Keep the cotters together as a pair and record the number of the intake/exhaust valve. If you install different cotters, bad contact can cause damage to the valve stem.

4. Turn the bolt in the opposite direction and release the compression of the valve spring.
5. Loosen the drawing-out tool B and remove all special tools.
6. Remove the valve rotator and the valve spring.

NOTICE

When you remove the valve spring or the valve rotator with the cylinder head installed, set the piston to top dead center. This makes sure that the intake/exhaust valves do not fall down.

7. Remove the intake/exhaust valves. Do it carefully to prevent damage to the stem seal lip.

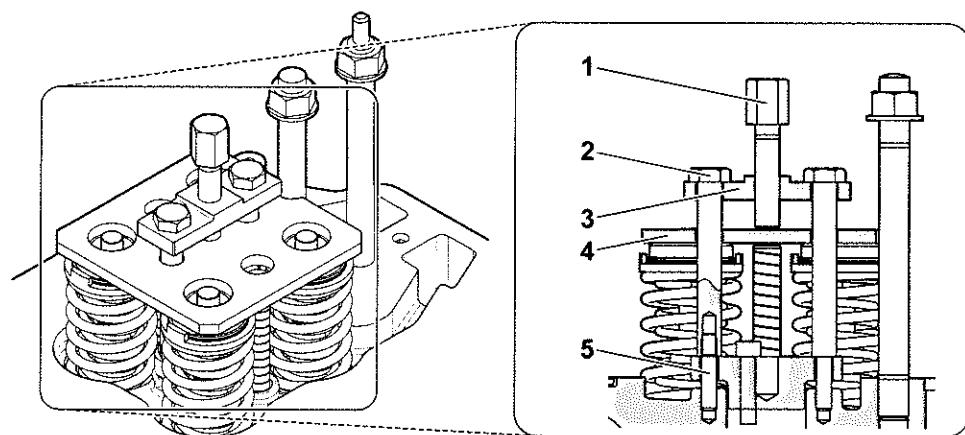


Fig.1 Intake/exhaust valve - Disassemble procedure

2. Inspection

1. Examine the intake/exhaust valves for sulfuric acid corrosion and bent stems. Measure the clearance between the valve stem and the corresponding valve guide. If the clearance to the valve guide is more than the wear limit, replace the valve or the valve guide. Replace the part that is more worn.
Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07
2. Examine the valve head for high-temperature corrosion.

NOTICE

Carefully examine the valve head tip. If it becomes too thin, it can be damaged and pieces cause secondary damage in the combustion chamber and the turbocharger. Adjust the valve head tip if necessary. Do not grind the combustion surface side of the valve head to correct this.

3. Check the valve seat for blowby and carbon bite-in. Grind the face of the seat if necessary.
Valve seat grinding (paragraph 4)
4. Measure the dimensions of the valve seat. If the measurement is more than the wear limit, replace the valve seat.
Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07
5. Examine the valve springs for cracks and corrosion.

3. Assembly

1. Install the intake/exhaust valve to the valve guide. Do it carefully to prevent damage to the stem seal lip.

NOTICE

Make sure that you install the correct valves. The intake valves and the exhaust valves look almost the same, but they are made of different materials. Look at the identification mark.

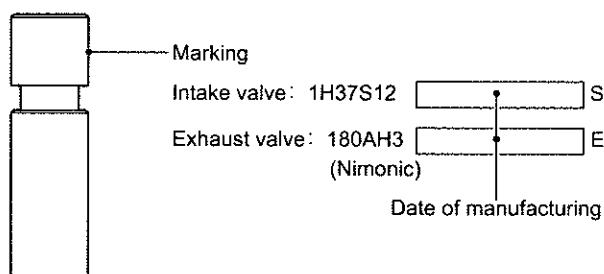


Fig.2 Identification marks for the intake and exhaust valves

2. Install the valve spring and use the collar of the valve guide as a guide. Put the valve rotator on top of the valve spring.
3. Align the valve spring tool B 4 to the four holes of the intake/exhaust valve.
4. Lock the valve spring tool tool A to the fuel valve clamping bolt with the drawing-out tool B.
5. Turn the bolt, hold down the valve rotator and the valve spring, and install the cotter.

NOTICE

Each intake/exhaust valve is locked with 2 cotters. Install the same pair of cotters to the same valve when you assemble the parts again. If you install different cotters, bad contact can cause damage to the valve stem.

6. Turn the bolt in the opposite direction and release the compression of the valve spring.
7. Loosen the drawing-out tool B and remove all special tools.

4. Adjust

1. Grinding the intake/exhaust valves

1 - Measure these dimensions:

- The thickness of the intake/exhaust valve
- The width of the seat
- The contact diameter on the valve seat.

If the measurement is more than the wear limit, replace the part.

Assembly adjustment values / Clearance & wear limits of major parts 0000-000-07

2 - Do the initial valve grinding sooner than specified in the Table of Periodic Checks in "Precautions before maintenance". Compare the measurements with the wear limits and decide on the subsequent servicing intervals.

3 - Measure the clearance between the valve guide and the stem. Replace with new parts if necessary.

Assembly adjustment values / Clearance & wear limits of major parts 0000-000-07

4 - Install the holder A 2, the holder B 3 and the grinding tool 4 lightly with bolts to the poppet of the intake/exhaust valve.

5 - Make sure that the diameter bolt 1 and the nut are not blocked.

6 - Tighten the outer nut of the diameter bolt by 1/4 turn.

7 - Install the holder A to the grinding tool with 2 bolts.

8 - Hold the holder B against the poppet of the intake/exhaust valve and install the holder to the grinding tool 4 with 2 bolts.

9 - Loosen the outer nut 5 of the diameter bolt by 3/4 turn.

10 -Tighten the inner nut 6 of the diameter bolt by 3/4 turn from its seated position.

11 -Apply the correct quantity of grinding compound to the valve.

12 -Put the spring 7 into the stem of the intake/exhaust valve.

13 -Press the valve into the valve seat and twist. Move the valve vertically and twist it against the valve seat. Repeat the motion.

14 -Do an oil grind.

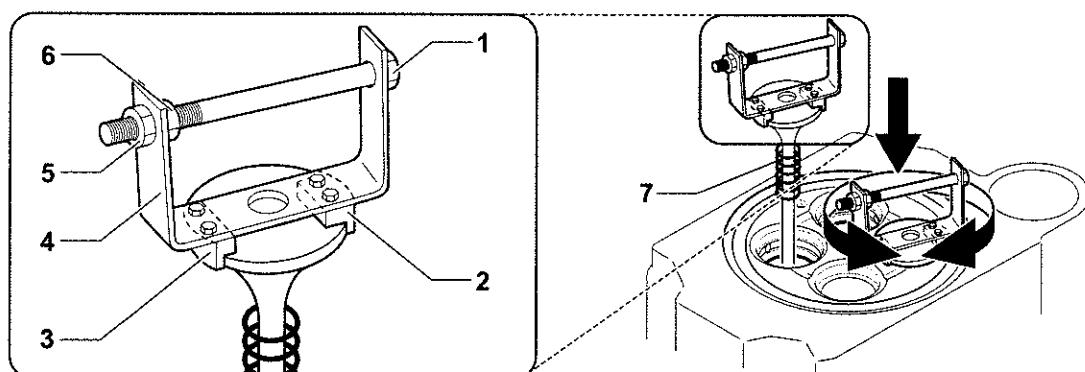
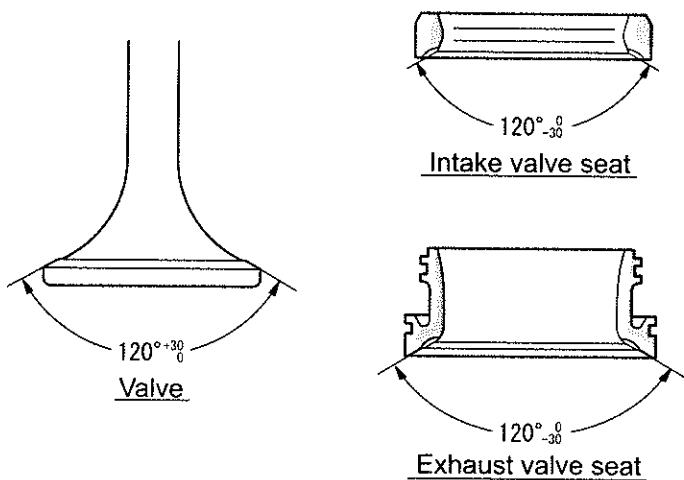


Fig.3 Grinding the intake/exhaust valves

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15 -If you repair a deep flaw on the face of the intake/exhaust valve seat, grind the valve at the angle shown in the figure so that the outer circumference of the seat face aligns.



A-11020-00005-A-01_EN

Fig.4 Angle of the intake/exhaust valve seat

CONDITION

Intake/exhaust valve

Adjust

1/2

PRODUCTION MANAGEMENT DATA

Intervals 3 months
1000 working hours

CONDITION

	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1.5 h
EQUIPMENT	Nomenclature			Identification code	Quantity
	Feeler gauge, (0.4 mm): intake			28312-400750	1 pc
	Feeler gauge, (0.5 mm): exhaust			28312-500750	1 pc
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
SAFETY					

Obey the instructions that follow when you do adjust of the valve head clearance.

To hold the 2 intake (or exhaust) valve heads at the same time, adjust the valve head clearance and obey the instructions that follow. Adjust correctly to prevent problems with the valve bridge and unusual wear inside the valve bridge guide and valve guide.

1. Turn the flywheel and move the relevant cylinder to the top dead center of the compression stroke.

NOTICE

Make sure that you do not move it to the top dead center of the valve overlap.

2. Loosen the locknuts 1 and 3.
 3. Loosen the rocker arm adjusting screw 2.
 4. Loosen the valve bridge adjusting screw 4.
 5. Press down the center of the valve bridge. Hold it and gradually tighten the valve bridge adjusting screw. Lock it to prevent movement.
 6. Tighten the locknut 3 securely.
 7. Put the rocker arm adjusting screw and the feeler gauge into the valve bridge clearance A.
 8. Gradually tighten the rocker arm adjusting screw. Make sure that there is enough space to easily remove the clearance gauge.
- Valve head clearance 0000-000-07
9. Tighten the locknut 1.
 10. Make sure that the feeler gauge can be removed easily.

NOTICE

The valve head clearance of an intake valve and an exhaust valve are different. Make sure that you use the correct clearance.

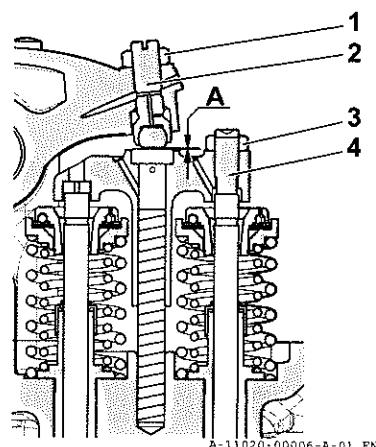


Fig.1 Adjusting the valve head clearance

CONDITION

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	12 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
	Seat cutter (option)				1 pc
SPARES	Nomenclature			Identification code	Quantity
	O-ring			150633-11810	2 pc
	O-ring			150633-11800	2 pc
SAFETY					

Obey the instructions that follow when you adjust the valve seat.

1. Inspection

1. Examine the valve seat for blowby and carbon bite-in. Grind the seat if necessary.

The valve seat face has a stellite welding. When you correct a deep flaw, grind the valve seat with a rough correction seat cutter (with grinder). (A seat cutter is available as an option.)

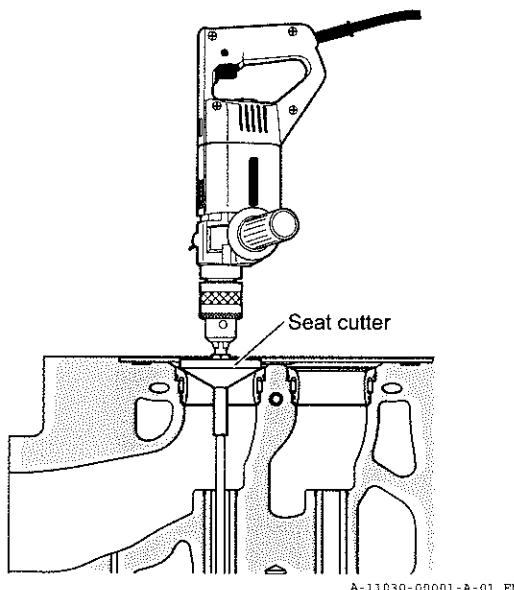


Fig.1 How to correct the valve seat (rough correction)

2. Examine the exhaust valve seat for water leaks on the mating parts. (If you find a water leak, replace the valve seat with a new one.)
3. Measure the contact diameter of the valve seat. If it is more than the wear limit, replace the valve seat with a new one.

2. Disassembly

1. Do an arc-welding and make a padding around the whole seat face. Remove the valve seat. If you cannot remove the exhaust valve seat easily because of the O-rings, weld an iron plate to the valve seat. Put a round rod through the valve guide. Hit the round rod with a hammer to remove the valve seat.

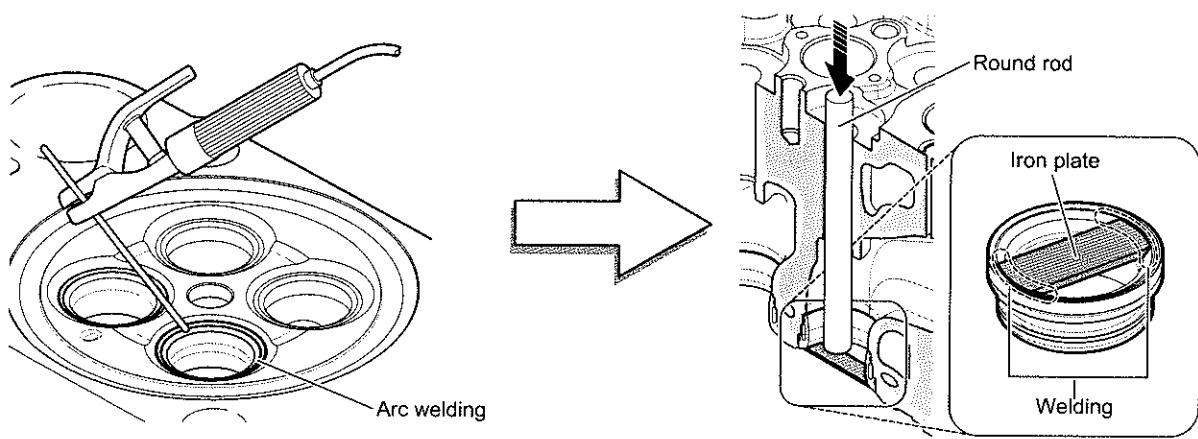


Fig.2 Removing the valve seat

3. Assembly

1. Examine the hole of the valve seat in the cylinder head. Examine the outer edge of the valve seat. Repair all flaws, dents and burrs.
2. Measure the diameter of the new valve seat and the valve seat hole. Measure the interference.
Intake valve seat: 0.050 to 0.100 mm
Exhaust valve seat: 0.046 to 0.085 mm (ϕ A part)
: 0.076 to 0.110 mm (ϕ B part)

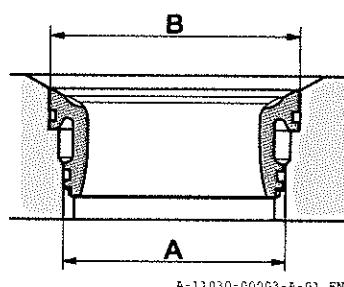


Fig.3 Measurement position of the valve seat hole

3. Increase the temperature of the whole cylinder head to between 40 °C and 60 °C. Steam cleaning is the best method.
4. Decrease the temperature of the valve seat with liquid carbon dioxide. If liquid carbon dioxide is not available, make a mixture of dry ice (a piece of 10 kg) and alcohol (1.5 l). Soak the valve seat in this mixture for 1 hour or more.

NOTICE

Decrease the temperature of the exhaust valve seat with the O-ring installed. Do not use liquid nitrogen. Liquid nitrogen causes the O-rings to become hard and break when you put the valve seat in the cylinder head.

5. Apply seizure inhibitor liquid (spray) 1 and silicone-based liquid packing (ThreeBond 1211 or equivalent) 2 to the valve seat hole. Do it immediately before you put the exhaust valve seat into the hole.

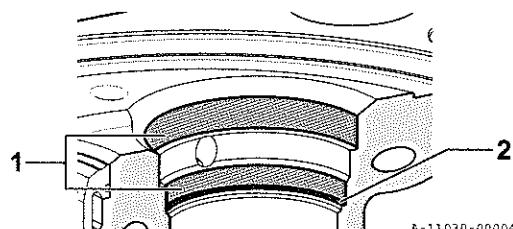


Fig.4 Press-fitting the exhaust valve seat

6. Use the intake valve (or exhaust valve) as a guide and quickly put the valve seat 3 into its hole.

NOTICE

Be careful that you do not tilt the valve seat. Apply pressure to the valve seat for 1 to 2 minutes and make sure that it is correctly seated in the hole.

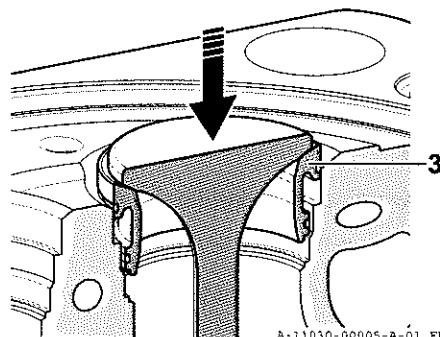


Fig.5 Press-fitting the valve seat

CONDITION Do a test on the exhaust valve seat with water pressure of 0.75 MPa. There must be no water leaks.

Valve guide

Replacement

1/2

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	4 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Stem seal inserting tool		150633-92050		1 pc
	Bar (see Fig. 1)				
SUPPLIES	Nomenclature		Identification code		Quantity
	Seal, valve stem		150633-11620		2 pc
	Seal, valve stem		150633-11640		2 pc
	Guide, valve		150633-11170		2 pc
SAFETY					

The valve guide is shrink-fitted and installed with a stem seal, obey the instructions that follow when you do replacement of the valve seat.

1. Measure the clearance between the valve guide and the valve stem. Replace the valve guide or the valve if the measurement is more than the wear limit.
Clearance and wear limits of major parts 0000-000-07
2. Replace the stem seal each time you do a servicing of the valves.
3. Hit the intake/exhaust valve guide with a stepped bar 1 and remove the valve guide from the valve side.

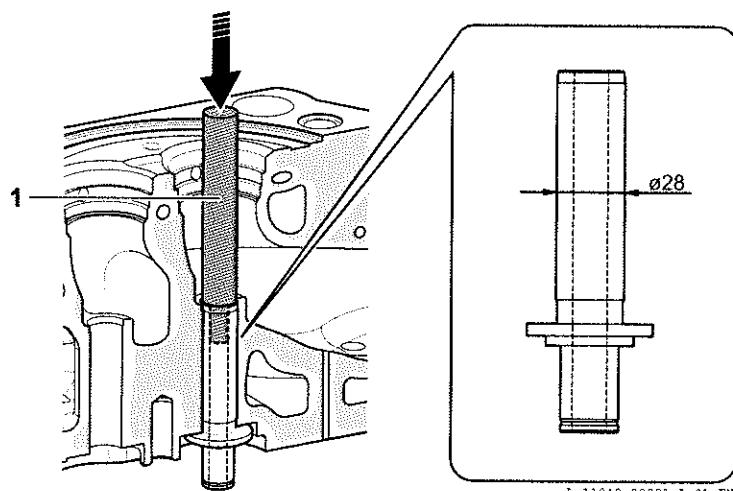


Fig.1 Removing the valve guide

4. Decrease the temperature of the valve guide in liquid nitrogen or liquid carbon dioxide. Press-fit it. For installation, hold the flange part of the valve guide and insert it.

Interference: 0.001 mm to 0.032 mm

5. Install the stem seal with a jig (Fig. 2). This prevents damage to the stem seal lip.

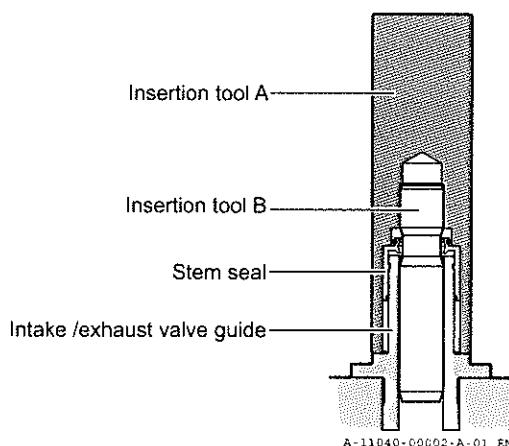


Fig.2 Install the stem seal with a jig

CONDITION

Valve bridge guide

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	2 h
EQUIPMENT	Nomenclature				Identification code
SUPPLIES	Nomenclature				Identification code
SPARES	Nomenclature				Identification code
SAFETY					

The valve bridge guide is shrink-fitted into the cylinder head, obey the instructions that follow when you do maintenance of the valve bridge guide.

- Measure the clearance between the valve bridge and valve bridge guide. If the clearance is more than the wear limit, replace the valve bridge or the valve guide. Replace the part that is more worn.
Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07
- Decrease the temperature of the valve bridge guide in liquid nitrogen or liquid carbon dioxide.

NOTICE

Too much clearance between the valve bridge and the valve bridge guide can cause the valve bridge to fall while the valves are in operation. This can cause a malfunction in the valves and uneven wear in the valve guide.

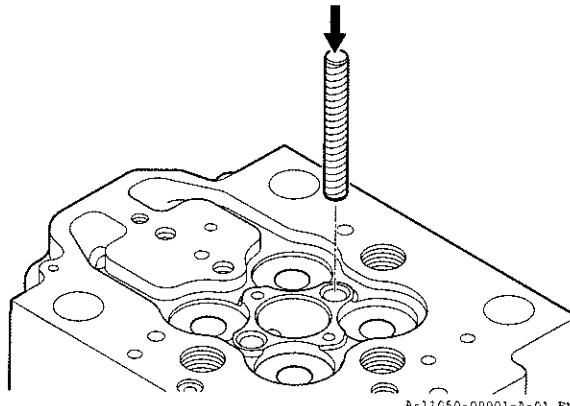


Fig.1 Press-fit the valve bridge guide

CONDITION

Valve rotator

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION Incorrect rotation of the valve rotator causes carbon bite-in on the valve seat part. This causes blowby at the seat and decreases the service life of the valve and valve seat. Disassemble and examine the valve rotator at regular intervals.

When you remove the valve rotator without disassembling the cylinder head, set the piston to top dead center of the compression stroke. This makes sure that the intake/exhaust valves do not fall down.

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	3 h
EQUIPMENT	Nomenclature				Identification code
SUPPLIES	Nomenclature				Identification code
SPARES	Nomenclature				Identification code
SAFETY					

Obey the instructions that follow when you adjust the valve rotator.

1. Inspection

1. Remove the circlip 1.
2. Examine the mating parts of the ball in the ball bearing 4 for groove wear and corrosion.
3. Examine the mating parts of the inside body of the Belleville spring 3 and the outside of the spring retainer 2 for wear and corrosion.
4. Examine the ball 6 for wear, deformation and corrosion.
5. Examine the coil spring 7 for wear and breakage.
6. Examine the mating parts of the ball in the groove of the body 5 and the coil spring for wear.

Examine the ball in the groove and how much it sticks out. If it sticks out more than the wear groove of the Belleville spring, you can continue to use it. (There is a clearance A.)

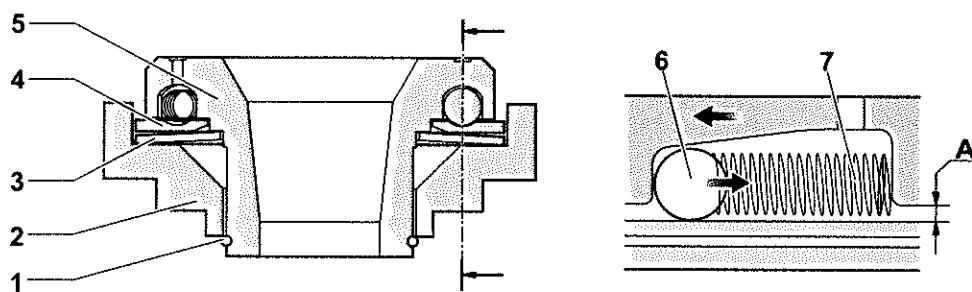


Fig. 1 Valve rotator

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2. Assembly

1. Replace parts that have corrosion or wear.
2. Install the coil spring, the ball, the ball bearing and the Belleville spring. Make sure that you install them in the correct direction.
3. Make sure that there is a clearance A.

CONDITION _____

PRODUCTION MANAGEMENT DATA

Intervals 4 years

CONDITION The nozzle sleeve is screwed into the cylinder head. Disassemble the nozzle sleeve with the special tools at intervals of 4 years. Examine the water chamber side for corrosion. Clean the water chamber side.

	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	3 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Nozzle sleeve disassembling tool		146673-92250		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
	O-ring		24326-000400		2 pc
	Packing		150633-11870		1 pc
SAFETY					

Obey the instructions that follow when you adjust the nozzle sleeve.

1. Disassembly

1. Fit the nozzle sleeve tool 5 into the top groove of the nozzle sleeve 2.
2. Loosen the hexagon head 6 of the nozzle sleeve tool with a double-sided 36 mm wrench.
3. Remove the nozzle sleeve, the O-rings 1 and the packing 3 from the cylinder head 4.

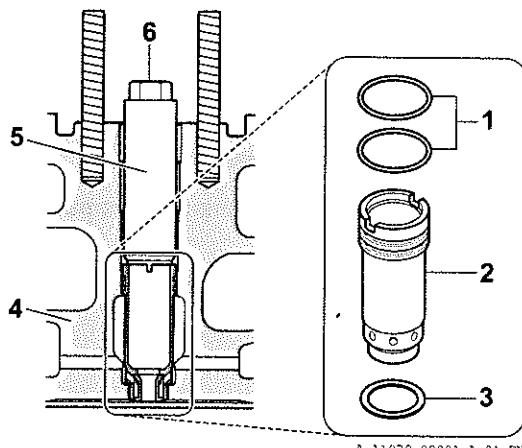


Fig.1 Disassembling the nozzle sleeve

2. Inspection

1. Check the following parts for corrosion, wear and flaws:
 - The mating parts of the O-rings 2 on the cylinder head 1
 - The face of the packing sheet 4
 - The cooling water passage 3.
2. Check the water jacket for scale. Clean if necessary. Depending on the water quality, a lot of scale can collect even in the water jacket of a freshwater-cooled engine. (Use YANMAR Unicon 146 to remove scale from the water jacket. You can do this during an engine stop without opening the engine.)
3. Carefully look for cracks and corrosion.

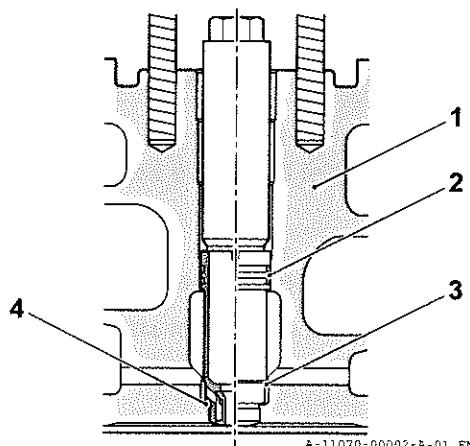
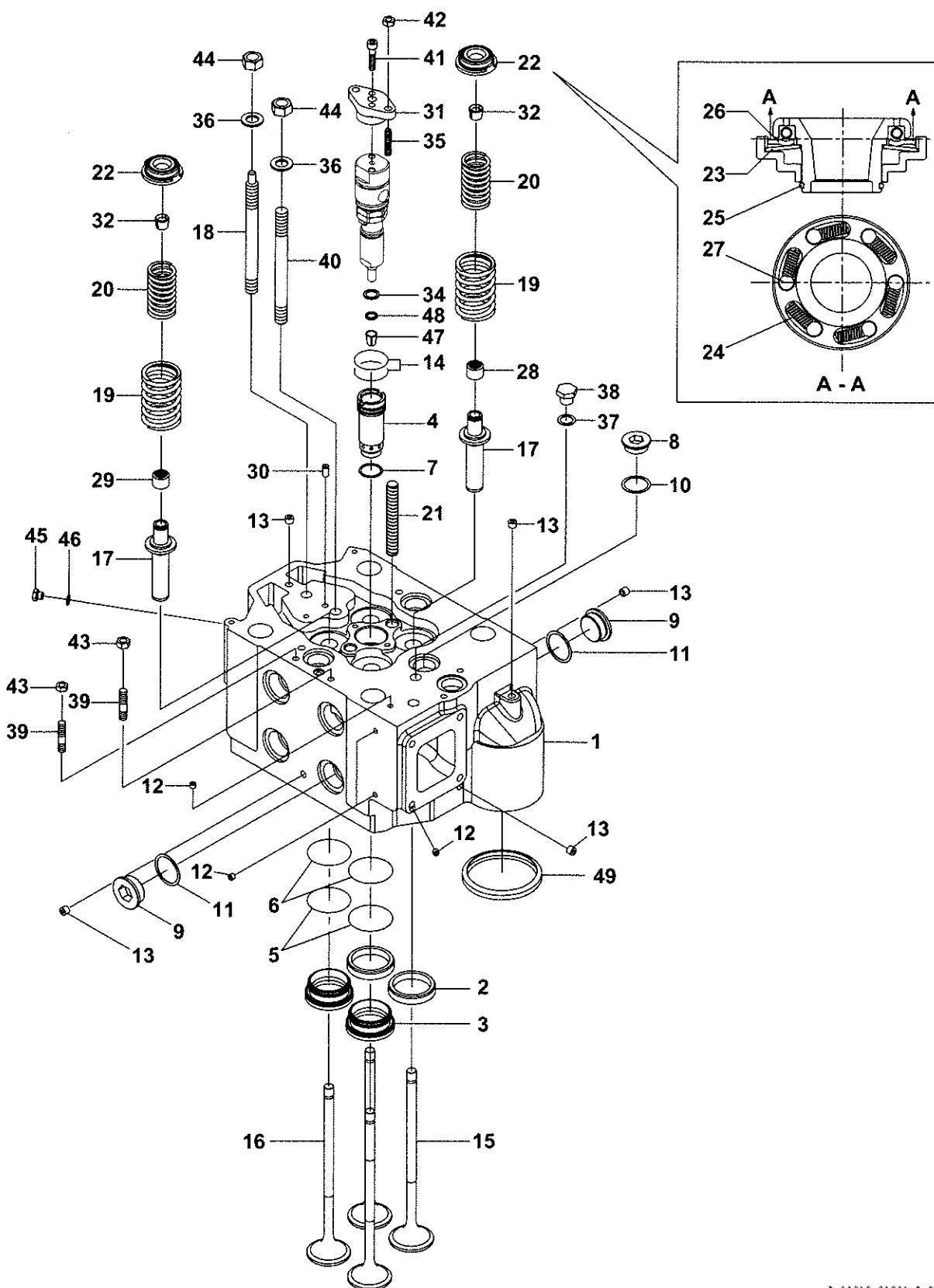


Fig.2 Inspecting the insertion part of the nozzle sleeve

3. Assembly

1. Replace the packing and the O-rings with new ones.
2. Apply lubricating oil to the thread of the nozzle sleeve and the packing seating face.
3. Tighten it to the specified torque.
Table of tightening torques for major bolts and nuts 0000-000-07
4. Do a hydraulic test.

CONDITION Do a test on the nozzle sleeve with water pressure of 0.75 MPa. There must be no water leaks.



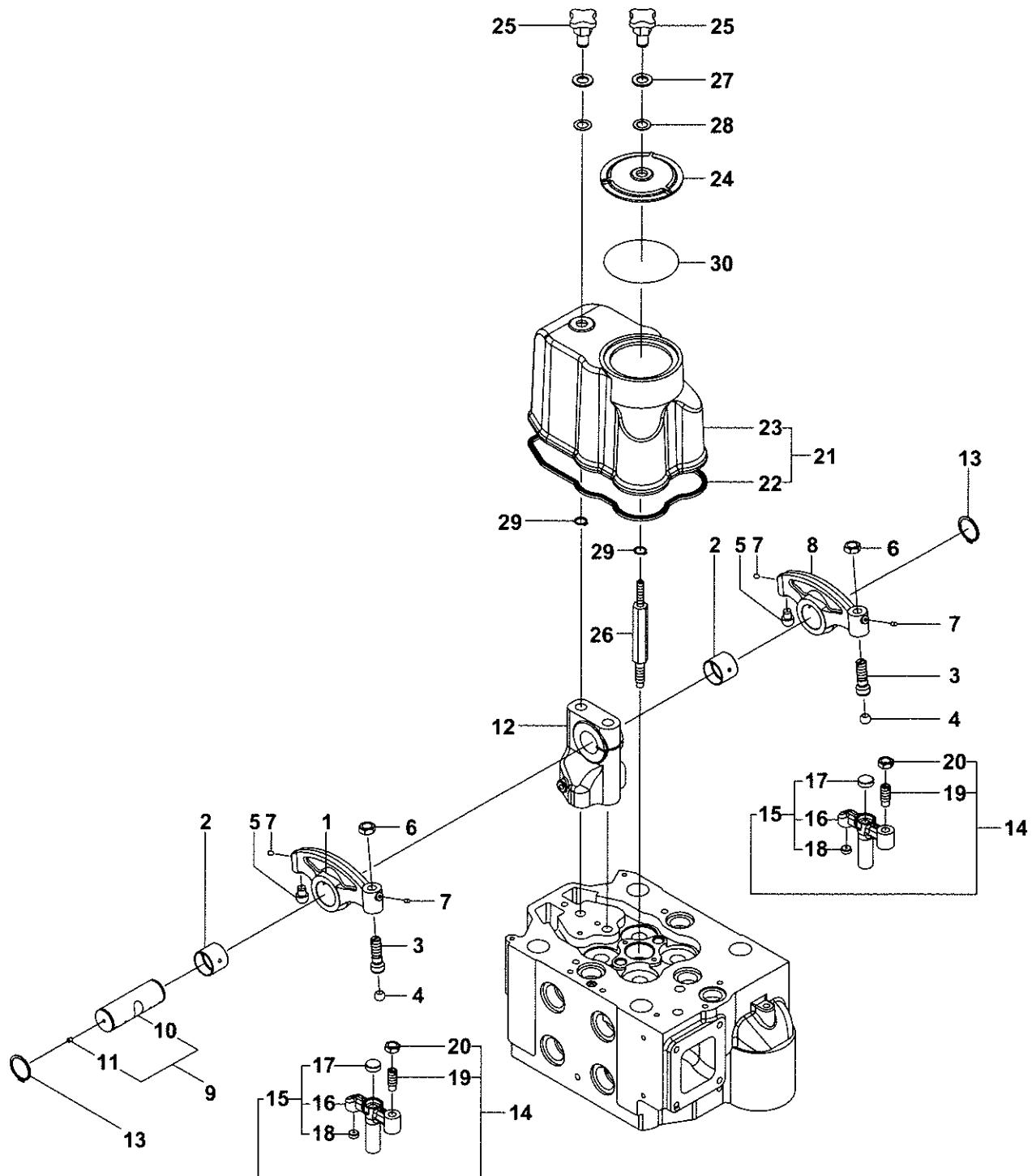
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Cylinder head

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	2	750633-11210	HEAD, CYLINDER	6	6	
1	3	150633-11030	HEAD, CYLINDER	6	6	
2	3	150633-11080	SEAT, INTAKE VALVE	12	12	
3	3	150633-11090	SEAT, EXHAUST VALVE	12	12	
4	3	150633-11670	NOZZLE SLEEVE	6	6	For H.F.O.
5	3	150633-11800	O-RING,EXH.SEAT,LOWE	12	12	
6	3	150633-11810	O-RING,EXH.SEAT,UPPE	12	12	
7	3	150633-11870	PACKING,NOZZLE SLEEV	6	6	
8	3	146673-11950	PLUG, CYLINDER HEAD	18	18	
9	3	150633-11950	PLUG, M48	48	48	
10	3	146673-11960	PACKING, PLUG	18	18	
11	3	150633-11960	GASKET, 48	48	48	
12	3	23876-010000	PLUG, R01	36	36	
13	3	23876-020000	PLUG, R02	54	54	
14	3	24326-000400	PACKING, G 40.0	12	12	
15	2	150633-11110	INTAKE VALVE	12	12	
16	2	150633-11120	EXHAUST VALVE	12	12	
17	2	150633-11170	GUIDE,VALVE	24	24	
18	2	150633-11360	STUD BOLT,ROCKR ARM	6	6	
19	2	150633-11460	SPRING,VALVE OUTER	24	24	
20	2	150633-11470	SPRING,VALVE INNER	24	24	
21	2	150633-11550	BRIDGE GUIDE	12	12	
22	2	150633-11600	VALVE ROTATOR	24	24	
23	3	150633-11700	SPRING, ROTATOR	24	24	
24	3	150633-11710	SPRING, COIL	168	168	
25	3	150633-11720	CIRCLIP, ROTATOR	24	24	
26	3	150633-11730	LACE, BALL ROTATOR	24	24	
27	3	150633-11740	BALL, STEEL	168	168	
28	2	150633-11620	SEAL, VALVE STEM	12	12	
29	2	150633-11640	SEAL, VALVE STEM	12	12	
30	2	146673-11750	PIN, CONNECTING	6	6	
31	2	150633-11880	FIXING PLATE,FO	6	6	
32	2	150633-11970	COTTER,STEM 16	48	48	
34	2	137600-53091	PACKING	6	6	
35	2	133670-54300	STUD, M10X35	12	12	
36	2	22137-200000	WASHER, 20	12	12	
37	2	23414-210000	GASKET, 21 X 1.0	6	6	
38	2	23894-040002	PLUG, G 1/2	6	6	
39	2	26216-120352	STUD,BOLT 12 X 35	12	12	
40	2	26232-202002	STUD,BOLT 20 X 200	6	6	
41	2	26450-100452	BOLT, 10 X 45	12	12	
42	2	26706-100002	NUT, 10	12	12	
43	2	26706-120002	NUT, 12	12	12	
44	2	150633-11270	NUT, 20	12	12	
45	2	23887-120002	PLUG 12	6	6	
46	2	23414-120000	GASKET, 12 X 1.0	6	6	
47	2	146673-11622	SPACER, NOZZLE	6	6	
48	2	150633-11850	RETAINER, SPACER	6	6	
49	1	150633-12310	GASKET, CYLINDER OUT	6	6	

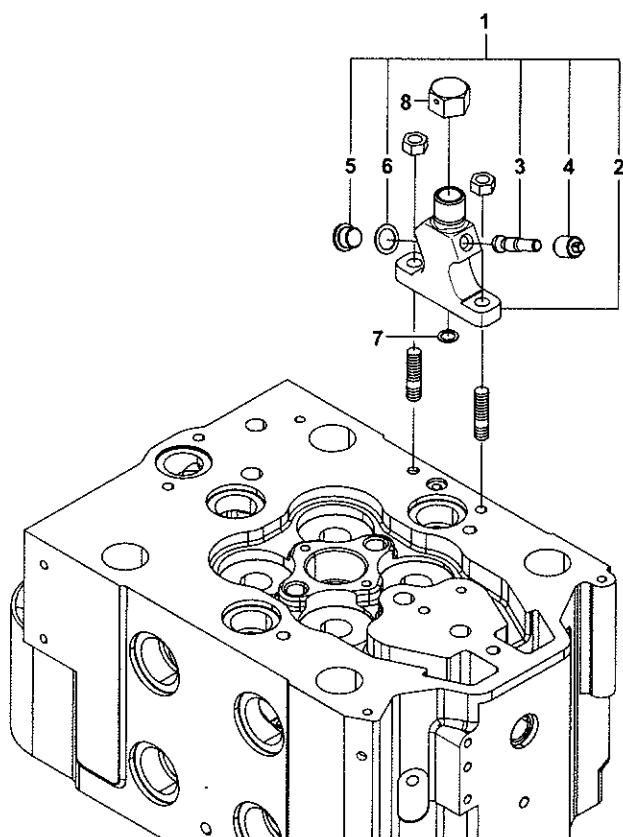


Valve arm ass'y and bonnet

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	750633-11130	ROCKER ARM	6	6	
1	2	150633-11200	ROCKER ARM,INTAKE	6	6	
2	2	147673-11220	BUSH	12	12	
3	2	150633-11230	ADJUST SCREW	12	12	
4	2	142613-11351	RETAINER, ROCKER ARM	12	12	
5	2	138613-11390	RETAINER, ROCKER ARM	12	12	
6	2	26772-180002	NUT, 18	12	12	
7	2	27225-050060	PLUG, 5 X 6	24	24	
8	2	150633-11210	ROCKER ARM,EXHAUST	6	6	
9	2	150633-11240	SHAFT ASSY,ROCKER AR	6	6	
10	3	150633-11250	SHAFT,ROCKER ARM	6	6	
11	3	27225-060080	PLUG, 6 X 8	6	6	
12	2	150633-11260	BRACKET,ROCKER ARM	6	6	
13	2	22242-000450	RING, 45	12	12	
14	1	150633-11520	VALVE BRIDGE ASSY	12	12	
15	2	150633-11510	BRIDGE VALVE	12	12	
16	3	150633-11500	VALVE BRIDGE	12	12	
17	3	134673-11530	SEAT, VALVE BRIDGE	12	12	
18	3	151636-11540	SEAT, VALVE	12	12	
19	2	151695-11580	SCREW, ADJUSTING	12	12	
20	2	26772-160002	NUT, 16	12	12	
21	1	150633-11300	BONNET ASSY	6	6	
22	2	150633-11280	GASKET,BONNET	6	6	
23	2	150633-11290	BONNET	6	6	
24	1	150633-11320	PLUG,BONNET	6	6	
25	1	153605-11431	KNOB, ROCKER ARM	12	12	
26	1	150633-11890	BOLT,BONNET	6	6	
27	1	22137-200000	WASHER, 20	12	12	
28	1	22190-200003	WASHER, SEAL 20	12	12	
29	1	22242-000200	RING, 20	12	12	
30	1	24311-001250	PACKING, P125.0	6	6	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-15200	INDICATOR ASSY	6	6	
2	2	146623-15210	BODY, INDICATOR COCK	6	6	
3	2	146623-15220	VALVE, INDICATOR COCK	6	6	
4	2	146623-15230	NUT, INDICATOR COCK	6	6	
5	2	146623-15240	PLUG, INDICATOR COCK	6	6	
6	2	23414-180000	GASKET, 18 X 1.0	6	6	
7	1	23414-120000	GASKET, 12 X 1.0	6	6	
8	1	138613-15170	COVER, BLIND	6	6	

- All driving gears and the idle gear are inside the gear case on the opposite side of the flywheel.
- Only the governor gear is a bevel gear. All other gears are helical gears. All gears are made of carburized and quenched alloy steel.
- The gear on the crankshaft operates the lubricating oil pump and the fuel feed pump driving gear directly, and the cam gear through the idle gear. The idle gear is also connected to the 2 driving gears of the cooling water pump (one for the high-temperature side and one for the low-temperature side).
- The governor driving gear is tightened to the camshaft. Both are installed to the camshaft.

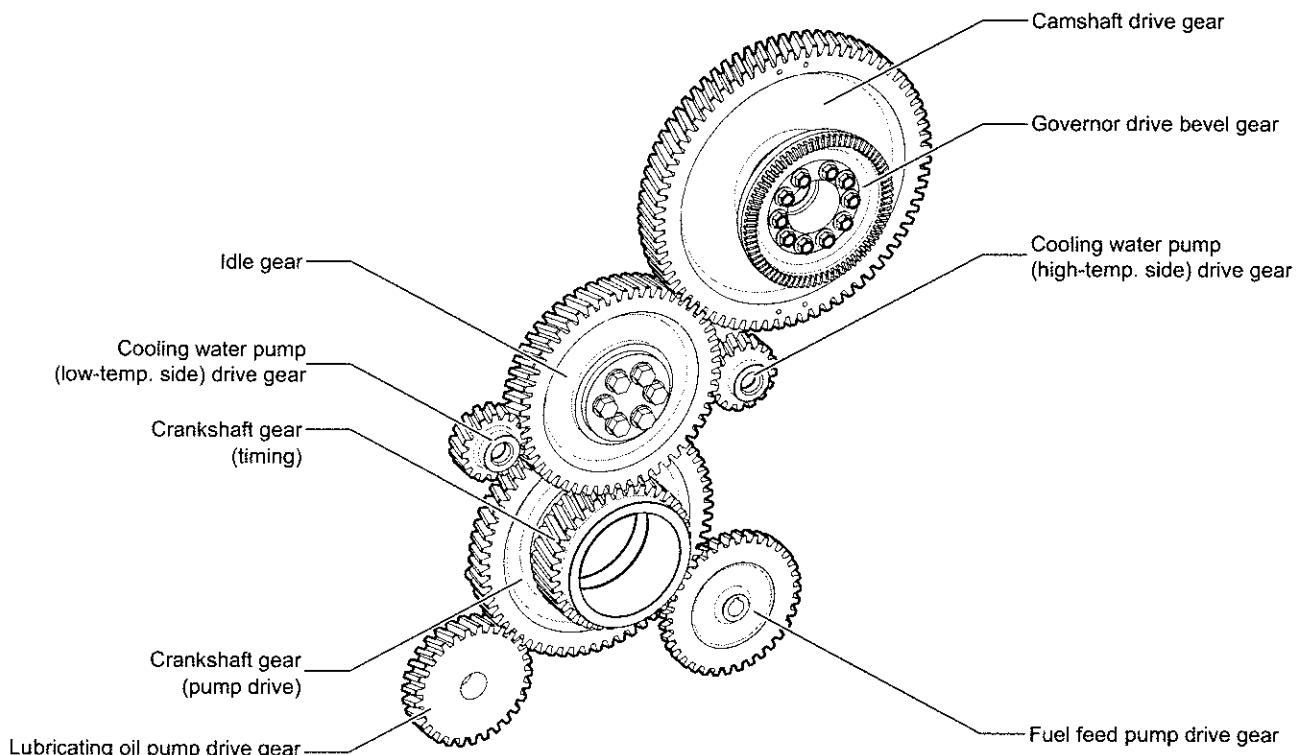


Fig.1 Timing gear - Description of function

Timing gear

Inspection

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION Periodical inspections table 0000-000-08(M.D.O.), 0000-001-08(H.F.O.)

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
SAFETY					

Examine the tooth surfaces and backlash of all gears according to the periodical inspections table.

1. Inspection

1. Remove the governor and governor drive unit.
2. Remove the cooling water pump, fuel feed pump, lubricating oil pump and fuel filter together with its mount.
3. Remove the gear housing.

NOTICE

Be careful that you do not drop the gear housing 1. Lift the gear housing up with a rope.

4. The gear housing is positioned with 2 knock pins 2. Lift it with the hydraulic jack and the M12 bolts. Remove the 2 knock pins.
5. Examine the tooth surface for good contact, damage and wear.
6. Examine backlash of all gears.

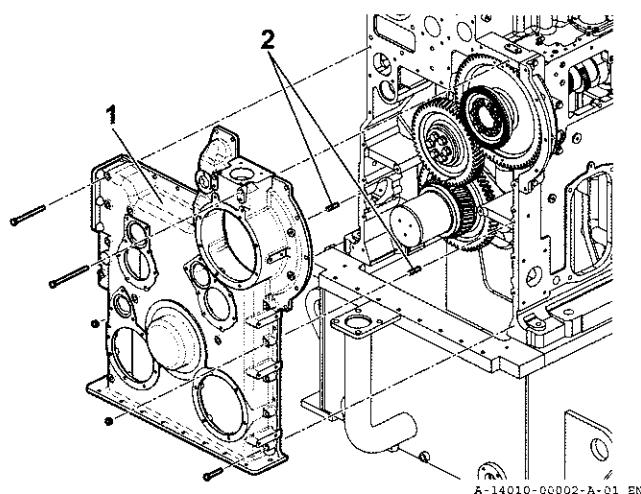


Fig.1 Timing gear inspection

CONDITION

Timing gear

Inspection and maintenance

1/5

PRODUCTION MANAGEMENT DATA

Intervals 5 years

16000 working hours

CONDITION Periodical inspections table 0000-000-08(M.D.O.), 0000-001-08(H.F.O.)

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	9 h
	b	Engine crew	Intermediate	-	9 h
	c	Engine crew	Intermediate	-	9 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
SAFETY					

If you find pitting wear, plucking, hair cracks or other damage, obey the instructions that follow.

1. Disassembly**1. Preparing the timing gear disassembly**

- 1 - Remove the governor and governor drive unit.
- 2 - Remove the cooling water pump, fuel feed pump, lubricating oil pump and fuel filter together with its mount.
- 3 - Remove the gear housing.

NOTICE

Be careful that you do not drop the gear housing 1. Lift the gear housing up with a rope.

- 4 - The gear housing is positioned with 2 knock pins 2. Lift it with the hydraulic jack and the M12 bolts. Remove the 2 knock pins.

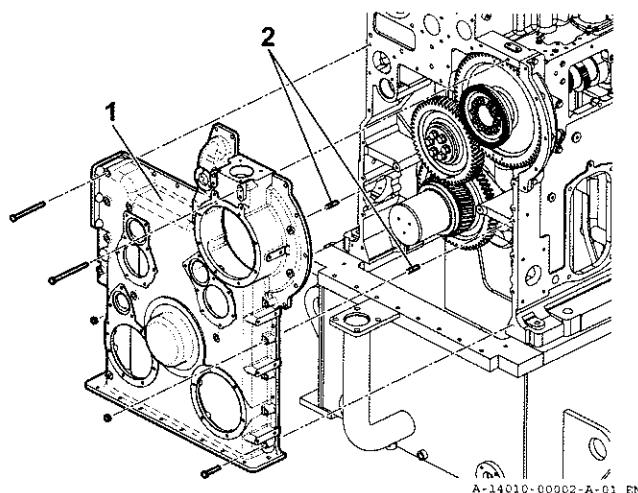


Fig.1 Preparing the timing gear disassembly

2. Idle gear

- 1 - Loosen the bolts 1 on the retainer plate. Remove the retainer plate 2.
- 2 - Remove the idle gear 3 together with the shaft bearing 4.
- 3 - Remove the idle gear shaft 5.

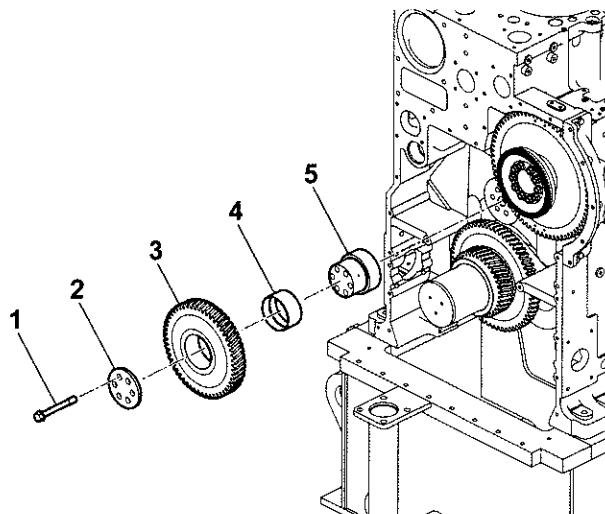


Fig.2 Disassembling the idle gears

3. Camshaft gear

- 1 - Loosen the bolts 1 of the camshaft gear. Remove the governor driving gear 2.
- 2 - Remove the camshaft gear 3.

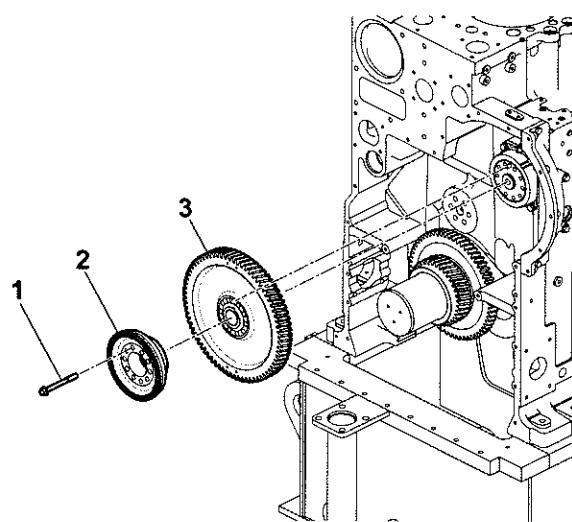


Fig.3 Disassembling the camshaft gear

4. Crankshaft gear

- 1 - Drill a hole 1 below the bottom land of the gear.
- 2 - Drive a chisel 2 into the hole.
- 3 - Remove the crankshaft gear. Do not use this crankshaft gear again.

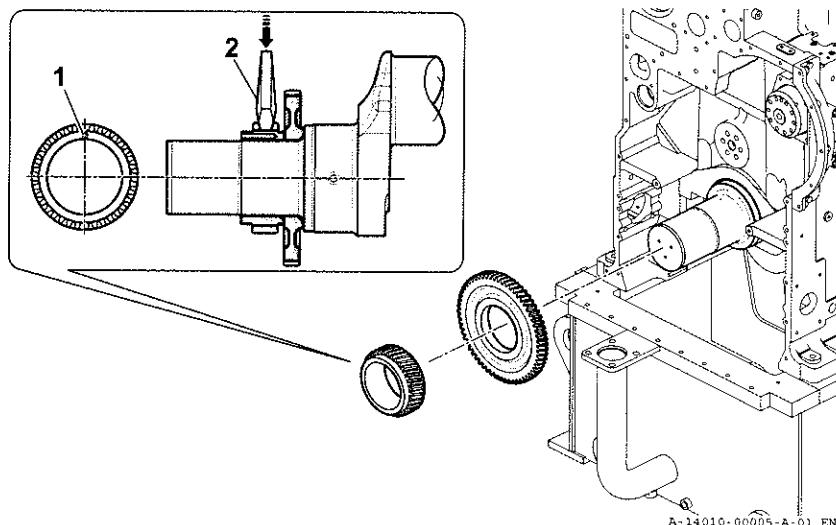


Fig.4 Disassembling the crankshaft gear

2. Inspection

1. Check the idle gear bearing and the mounting shaft for seizure and uneven wear.
2. Measure the dimensions of the idle gear bearing and the mounting shaft.

If the bearing clearance is more than the permitted value, replace the bearing or the mounting shaft.

3. Examine the back of the idle gear retainer for uneven contact and damage.

3. Assembly

1. Camshaft gear

1 - Align the camshaft gear 3 with the straight pin 4 and the mating socket. Install the camshaft gear 3 to the camshaft.

2 - Align the governor drive gear 2 with the mating socket of the camshaft gear and install it.

Make sure that the mating surfaces (the pin and the mating socket) of the camshaft gear and the governor driving gear are free from lubricating oil and other unwanted material.

3 - Apply seizure inhibitor (ThreeBond 1910 or equivalent) to the bearing surface and the thread of the camshaft gear bolt 1.

4 - Tighten it to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

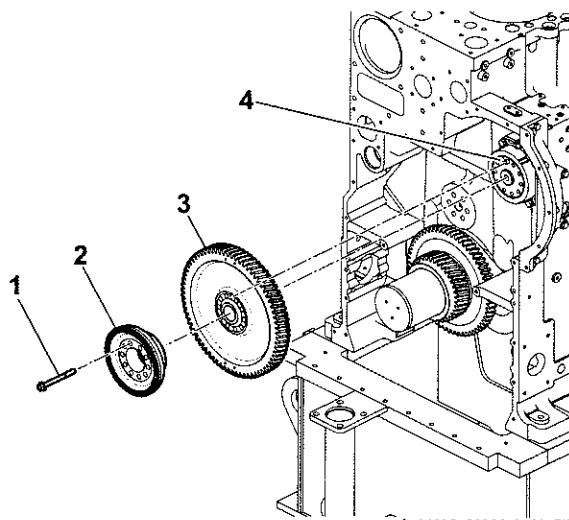


Fig.5 Camshaft gear assembly

2. Crankshaft gear

1 - Put the crankshaft gear 1 in an oil bath of approximately 150 °C to 190 °C. Soak it for approximately 60 minutes.

2 - Quickly install the crankshaft gear to the crankshaft. Align it with the positioning pin 2.

Do not increase the temperature of the crank gear with a gas burner. Too much temperature causes deformation and weakens its material and strength. Use the oil bath instead.

3 - Remove the positioning pin 2.

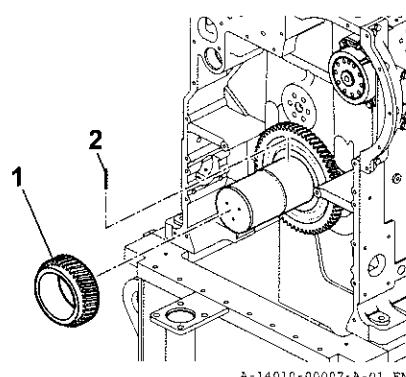


Fig.6 Crankshaft gear assembly

3. Idle gear

- 1 - Align the idle gear shaft 5 with the mating hole of the cylinder block and install it.
- 2 - Align the match mark of the idle gear 3 with the match marks of the crankshaft gear 7 and the camshaft gear 6. Install the idle gear 3.
- 3 - Install the retainer plate 2.
- 4 - Tighten the mounting bolt 1 to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

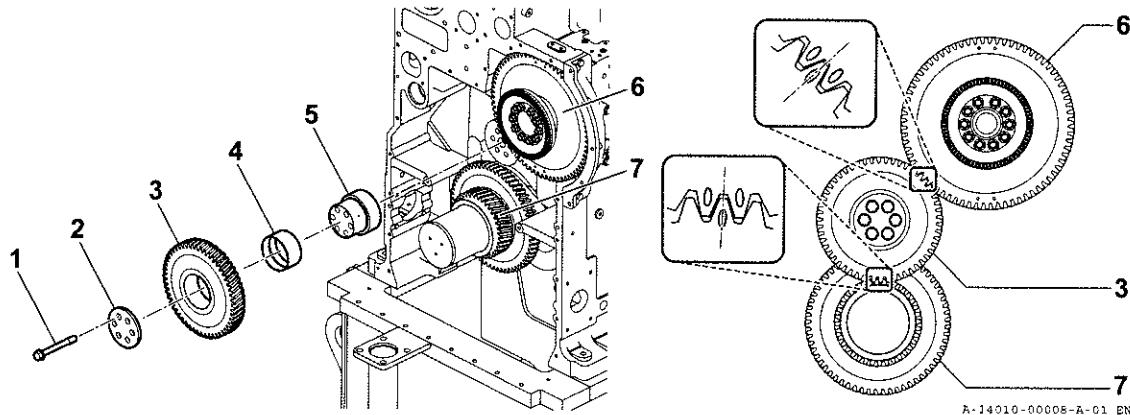
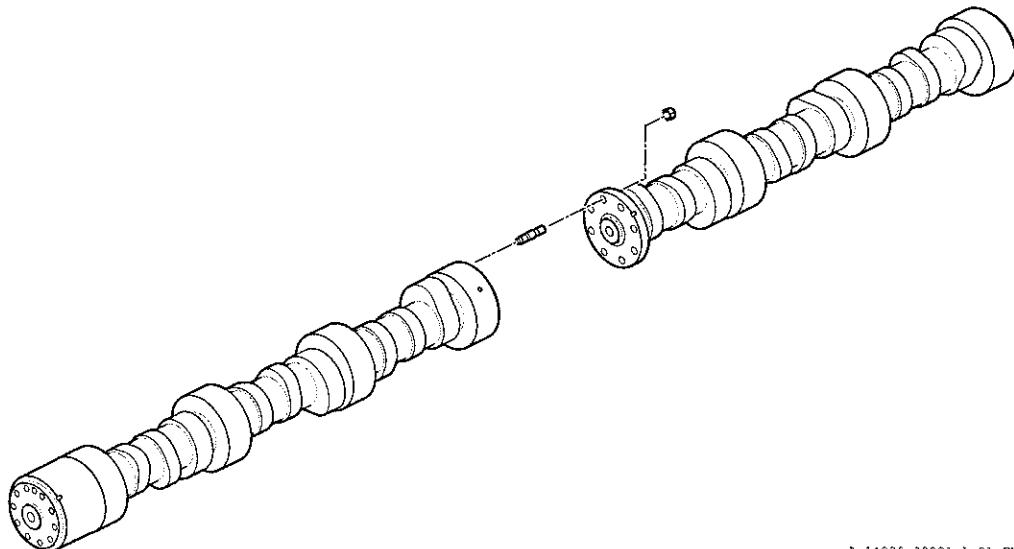


Fig.7 Idle gear assembly

CONDITION Standard clearance at installation 0000-000-07
Inspection of tooth contact and backlash

- The camshaft is an integrated structure with an intake cam, an exhaust cam and a fuel pump cam. The required space to remove the camshaft is shorter than in previous models of the engine. The camshaft is divided into 2 parts. The breaks are between cylinders No. 3 and No. 4. Reamer bolts attach each part. This allows easy disassembly and assembly in confined spaces.
- The cams and bearing faces are induction-hardened and very wear-resistant.



A-14020-00001-A-01_EN

Fig.1 Camshaft - Description of function

Camshaft

Inspection and maintenance

1/4

PRODUCTION MANAGEMENT DATA

Intervals 5 years
16000 working hours

CONDITION Examine the timing gear 1401-000-02

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	6 h
	b	Engine crew	Intermediate	-	6 h
	c	Engine crew	Intermediate	-	6 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Seizure inhibitor (ThreeBond 1910 or equivalent)		

SUPPLIES	Nomenclature	Identification code	Quantity
	Seizure inhibitor (ThreeBond 1910 or equivalent)		

SPARES	Nomenclature	Identification code	Quantity

SAFETY	CAUTION		
	<p>Put on protective gloves when you disassemble or assemble the camshaft. If your hands move over the edge of the cam, you can cut yourself.</p>		

Obey the instructions that follow when you adjust the camshaft according to the periodical inspections table.

1. Disassembly

1. Remove these parts before you disassemble the camshaft:

- 1 - Bonnet
- 2 - Rocker shaft pedestal
- 3 - Push rod
- 4 - Fuel injection pipe joint
- 5 - Fuel injection pump
- 6 - Fuel injection pump drive unit
- 7 - Intake/exhaust swing arm

Removing instructions 1403-000-02

- 8 - Governor
- 9 - Governor drive unit
- 10 - Idle gear
- 11 - Governor drive bevel gear 1
- 12 - Camshaft gear 2

How to disassemble the timing gear 1401-000-02, paragraph 1

2. Loosen the thrust bearing mounting bolt 3. Remove the camshaft thrust bearing 5 together with the Belleville spring 4.
3. Remove the camshaft 6 to the front side (the opposite side of the flywheel).

If the engine room does not have sufficient space to remove the camshaft:

- Remove the U-nut 8 that connects the cylinders No. 3 and No. 4.
- Pull the camshaft out to the front side (the opposite side of the flywheel).

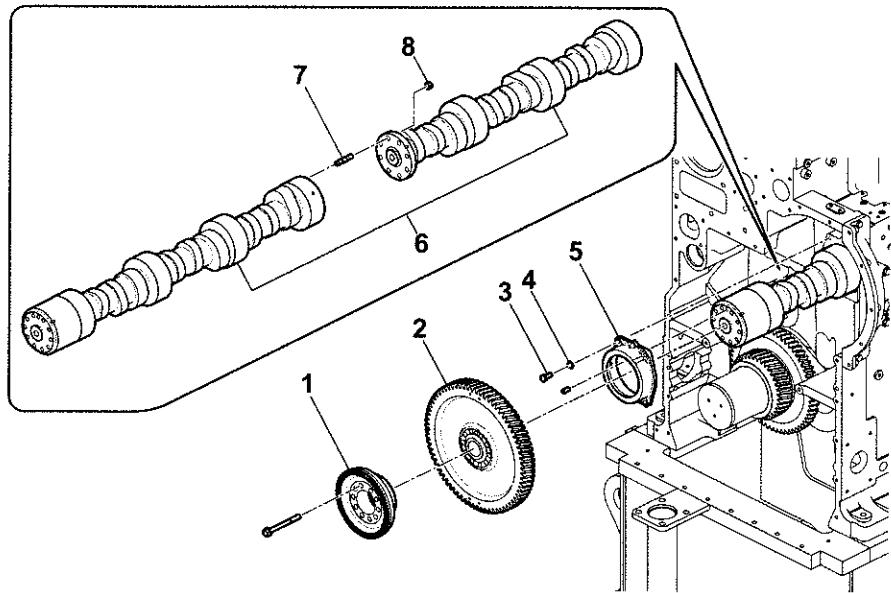


Fig. 1 Camshaft disassembly

2. Inspection

1. Look for flaws and unusual wear on the fuel pump cam, intake and exhaust cams and bearings.
2. Measure the dimensions of the camshaft bearing parts and the bearings. Measure the clearance between each bearing and the shaft.
3. Replace the camshaft or the camshaft bearing with a new one if:
 - The wear on the camshaft or the camshaft bearing is more than the wear limits.
 - The surfaces of the fuel pump cam and the intake and exhaust cams have unusual wear or damage. Replace the part that is more worn.
4. Check the thrust bearing for lopsided contact and other damage.

Standard clearance at installation 0000-000-07

3. Assembly

1. Press-fitting the camshaft bearings

- 1 - Press-fit the camshaft 5 bearings into the camshaft bearing hole on the cylinder block. Use a jig (jack).

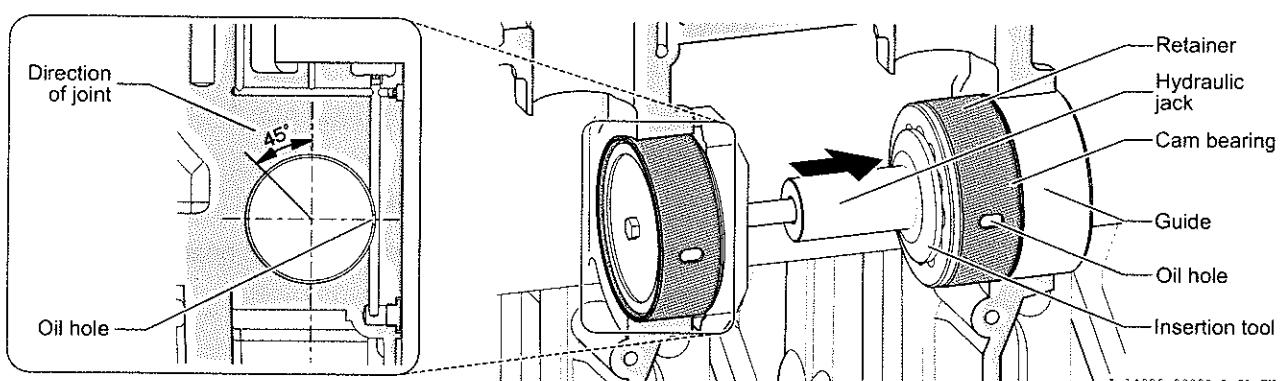


Fig.2 Press-fitting the camshaft bearings

NOTICE

When you press-fit a bearing on the camshaft, make sure that:

- The joint points up at an angle of 45°.
- The oil hole is mated with the oil hole in the camshaft.

- 2 - After you install the camshaft bearing, measure the inner diameter of the bearing.

2. Camshaft

1 - If you disassembled the camshaft into 2 parts, obey these instructions to re-assemble it.

1 - Make sure that the camshaft coupling surface is free from unwanted material or lubricating oil.

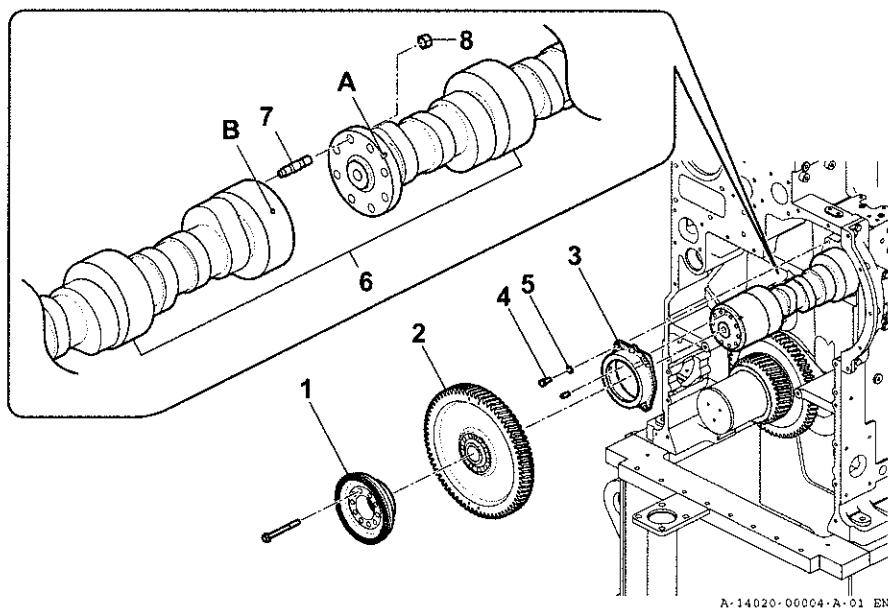


Fig.3 Camshaft assembly

2 - Align the machined groove A with the drilled hole B. Install the camshaft.

3 - Apply seizure inhibitor (ThreeBond 1910 or equivalent) to the thread and bearing surface.

4 - Tighten the U-nut 8 to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

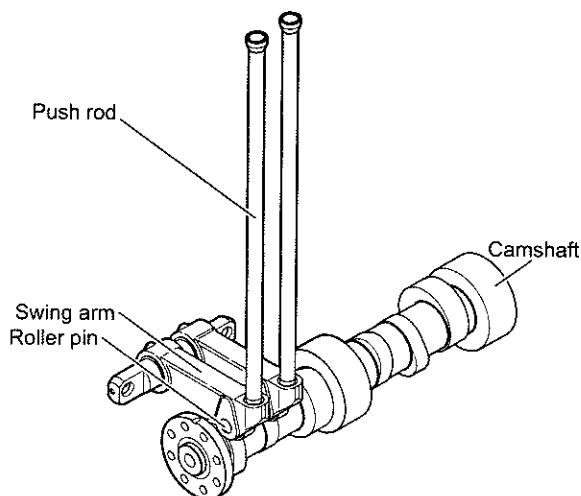
2 - Install the camshaft thrust bearing 3.

3 - Install the camshaft gear 2 and governor driving gear 1.

4 - Make sure that the clearances in the direction of the thrust bearing and the camshaft gear are the specified values.

CONDITION Standard clearance at installation 0000-000-07

- The valve mechanism (valve train) uses a swing arm system. The design of the swing arm system is simple with no moving parts in the tappet guides. Thus the valve train has little inertial mass and superior dynamic qualities.
- The roller pin is force-lubricated.



A-14030-00001-A-01_EN

Fig. 1 Intake/exhaust swing arm - Description of function

Intake/exhaust swing arm

Inspection

1/1

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	4 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
SAFETY					

Examine the outer circumference of the roller of the intake/exhaust swing arm according to the periodical inspections table. Look for damage and one-sided contact.

1. Disassembly

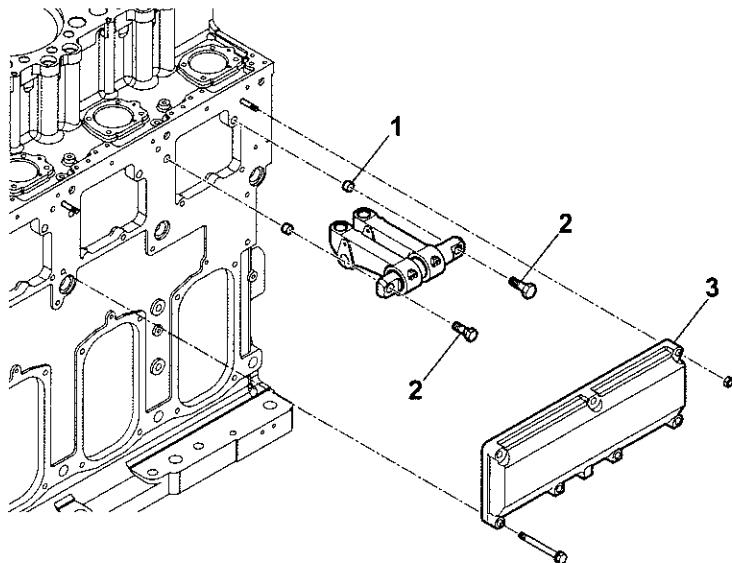
1. Remove the parts in this sequence:
 - 1 - Bonnet
 - 2 - Rocker shaft pedestal
 - 3 - Push rod
2. Remove the cam case cover 3.

2. Inspection

1. Make sure that the roller turns easily and does not catch. Examine the outer diameter for flaws and lopsided contact.

NOTICE

If you find a defect, replace the whole swing arm assembly.



A-14030-00005-A-01_BN

Fig. 1 Swing arm disassembly

CONDITION

Intake/exhaust swing arm

Inspection and maintenance

1/2

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	9 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Circlip pliers		28190-000020		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
	Seizure inhibitor (ThreeBond 1910 or equivalent)				
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do maintenance of the intake/exhaust swing arm.

1. Disassembly

1. Remove the parts in this sequence:
 - 1 - Bonnet
 - 2 - Rocker shaft pedestal
 - 3 - Push rod
2. Remove the cam case cover 3.
3. Remove the clamping bolt 2.
4. Remove the the swing arm shaft 6 together with the swing arm 5.
5. Remove the swing arm shaft circlips 4 with the circlip pliers
6. Remove the swing arm 5.

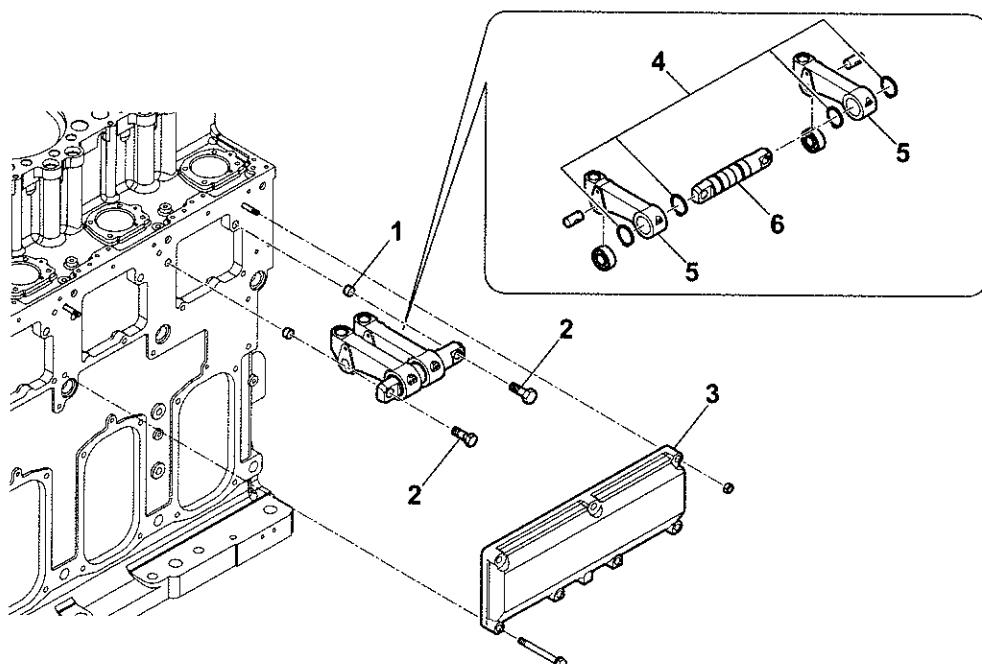


Fig. 1 Swing arm disassembly

A-14030-00002-A-C1_EN

2. Inspection

1. Examine the push rod bearing for uneven wear and lopsided contact.

Measure the dimensions X of the swing arm shaft and the swing arm shaft bearing. If the measurements are more than the wear limit, replace the swing arm shaft or the swing arm.

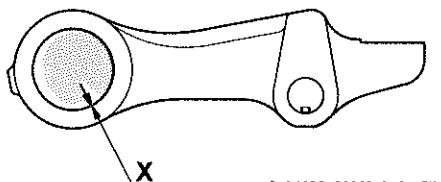


Fig.2 Intake/exhaust swing arm

A-14030-00003-A-01_EN

2. Check for deformed or missing collars in the clamping bolt holes of the swing arm shaft.

Replace with new ones if necessary.

Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07

3. Assembly

1. When you install covers for the bolt holes on the swing arm shaft, the mating surface of the collars 1 is on the right side seen from the operation side. Install the swing arm shaft.
2. When you install the swing arm shaft, make sure that the "R" match mark is on the right side. When you install the clamping bolt, make sure that the "L" match mark on the left side. The right side has no match mark.

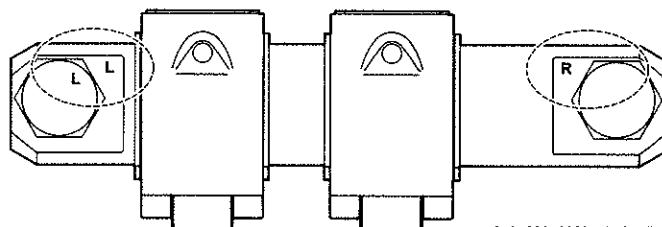


Fig.3 Location of the match mark

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3. Tighten the tightening bolts to the specified torque.

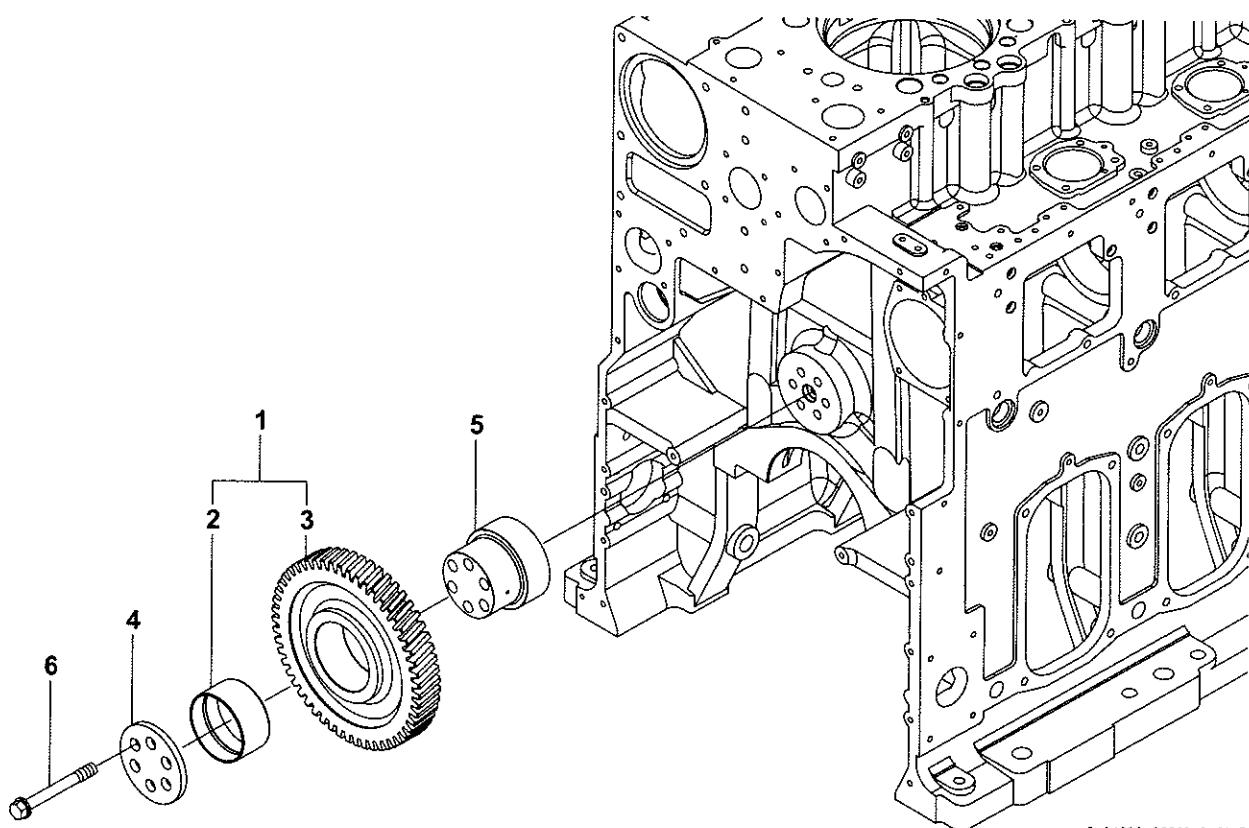
NOTICE

A mistake during installation can cause blockage of the lubricating oil passage. This causes seizure on the swing arm shaft and the roller pins.

Table of tightening torques for major bolts and nuts 0000-000-07

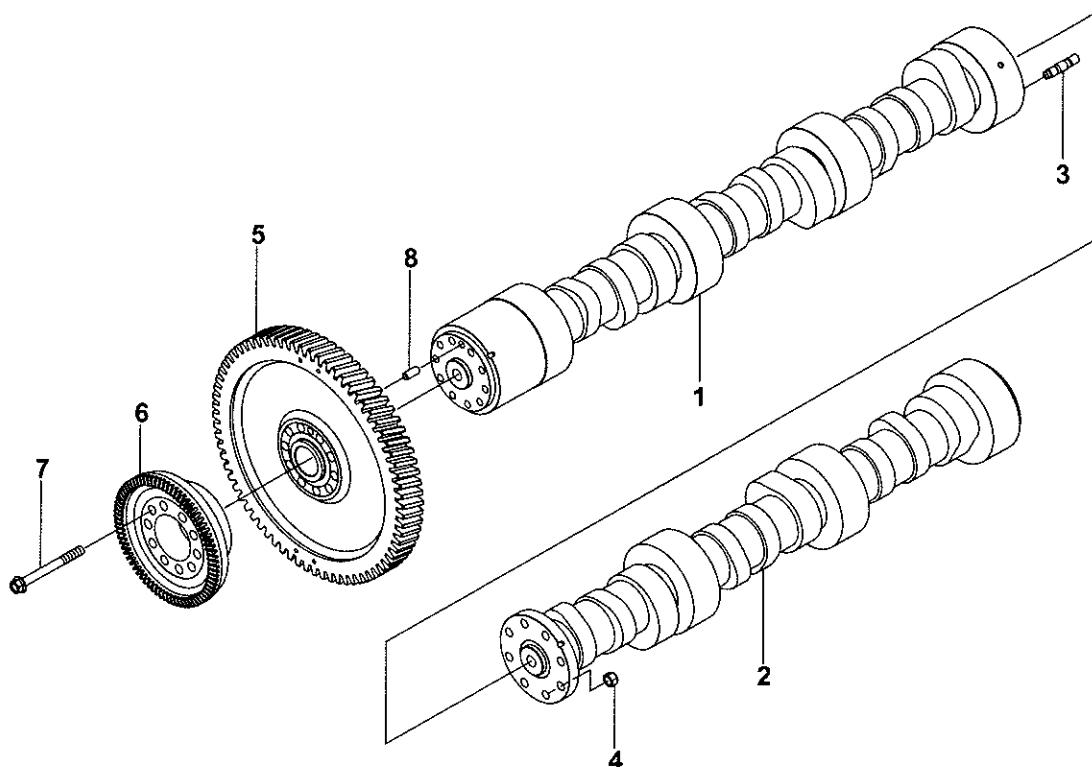
4. Install the push rod.
5. Install the rocker shaft pedestal.
6. Adjust the intake/exhaust valve head clearance. 1102-000-02

CONDITION Standard clearance at installation 0000-000-07



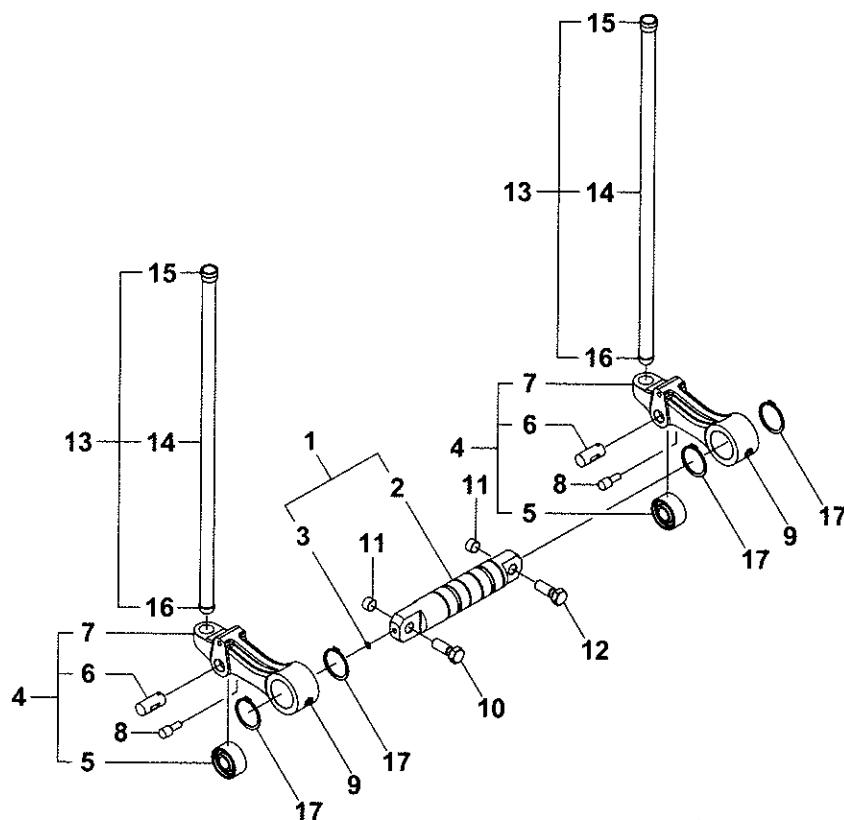
A-14C19-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-14550	GEAR CMP, CAM IDLE	1	1	
2	2	150633-14520	BUSH,CAM IDLE	1	1	
3	2	150633-14530	GEAR, CAM IDLE	1	1	
4	1	150633-14570	PLATE, CAM IDLE	1	1	
5	1	150633-14580	MOUNT,CAM IDLE	1	1	
6	1	147673-14820	BOLT, CAM IDLE	6	6	



A-14029-G2001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-14150	CAMSHAFT,XL,OFW	1	1	
2	2	150633-14160	CAMSHAFT,XL,SFW	1	1	
3	2	153605-14730	BOLT, REAMER	8	8	
4	2	26356-140002	U-NUT, 14	8	8	
5	1	150633-14100	GEAR, CAMSHAFT	1	1	
6	1	150633-14170	GEAR, GOV.DRIVE	-	1	NZ (900,1000min ⁻¹)
6A	1	150633-14180	GEAR, GOV.DRIVE	1	-	NZ (720,750min ⁻¹)
6B	1	150633-14190	GEAR, GOV.DRIVE	-	1	UG-8 (900,1000min ⁻¹)
6C	1	150633-14170	GEAR, GOV.DRIVE	1	-	UG-8 (720,750min ⁻¹)
7	1	150633-14810	BOLT, CAM GEAR	10	10	
8	1	22312-120250	PIN, 12 X 25	1	1	



A-14039-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-14280	SHAFT ASSY,SWING ARM	6	6	
2	3	150633-14270	SHAFT,SWING ARM	6	6	
3	3	24190-100001	BALL, 5/16	6	6	
4	2	150633-14310	SWING ARM ASSY	12	12	
5	3	150633-14200	ROLLER,SWING ARM	12	12	
6	3	150633-14230	PIN,SWING ARM	12	12	
7	3	150633-14250	SWING ARM	12	12	
8	3	137600-14270	SCREW	12	12	
9	3	24190-100001	BALL, 5/16	24	24	
10	2	150633-14350	BOLT,SWING ARM SHAFT	6	6	
11	2	24550-018120	BEARING, 18 X 12	12	12	
12	2	26152-160452	BOLT, 16 X 45	6	6	
13	1	150633-14400	PUSH ROD ASSY	12	12	
14	2	150633-14410	PUSH ROD	12	12	
15	2	151605-14410	SEAT, PUSH ROD UPPER	12	12	
16	2	151605-14430	SEAT, PUSH ROD LOWER	12	12	
17	1	22242-000500	RING, 50	24	24	

- The cooler is a box structure with plate fins. It is also a mount for the turbocharger.
- The turbocharger and the air cooler are installed on the opposite side of the flywheel. The core can be removed from the engine without removing the air cooler.
- The air cooler quickly becomes dirty on the cooling water side and the air side. Clean it at regular intervals. Consider the operating conditions and the performance deterioration.

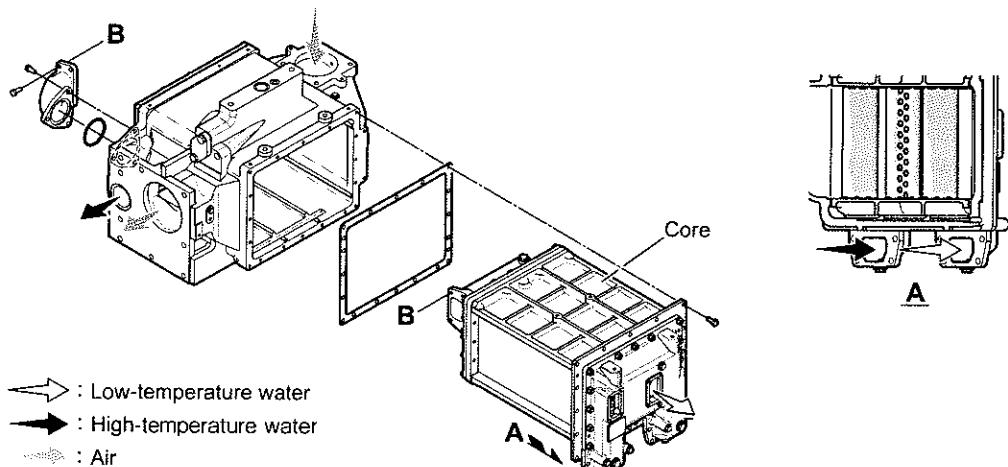


Fig.1 Air cooler - Description of function

Air cooler

Inspection and maintenance

1/4

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
	b	Engine crew	Intermediate	-	2.5 h
	c	Engine crew	Intermediate	-	2.5 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Drawing-out tool A	150633-92800	1 pc
	Drawing-out tool B	150633-92810	1 pc
	Drawing-out tool C	150633-92820	1 pc
	Drawing-out tool D	150633-92830	1 pc
	Drawing-out tool E	150633-92840	1 pc
	Eye bolt (M12)	26610-120002	2 pc
	Jack bolt	26206-121104	2 pc
	Bolt 10 x 40	26206-100402	2 pc
	Bolt 12 x 40	26206-120402	8 pc

SUPPLIES	Nomenclature	Identification code	Quantity
	Neos Co., Ltd.: Neos One-1 or equivalent		
	Oshima Kogyo Co., Ltd.: PYROSIN IN COLOR G2		

SPARES	Nomenclature	Identification code	Quantity
	O-ring, I/C	150633-18730	1 pc
	Packing D, I/C	150633-18961	1 pc
	Packing, P 85.0	24316-000850	1 pc
	Packing E, I/C	150633-18970	1 pc

SAFETY

Obey the instructions that follow when you adjust the air cooler.

1. Disassembly

1. Remove these parts on the cooling water outlet side:
 - The cooling water pipe
 - The bypass valve
 - The air-bleed pipe
 - The drain pipe.
2. Remove these parts on the operation side:
 - The seal flange 1
 - The seal packing 2
 - The seal plate 3.

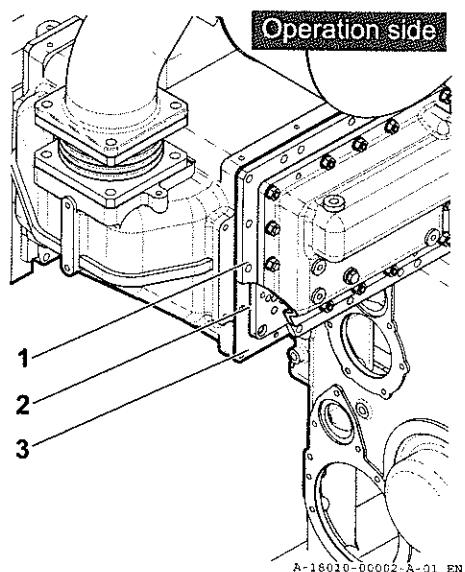
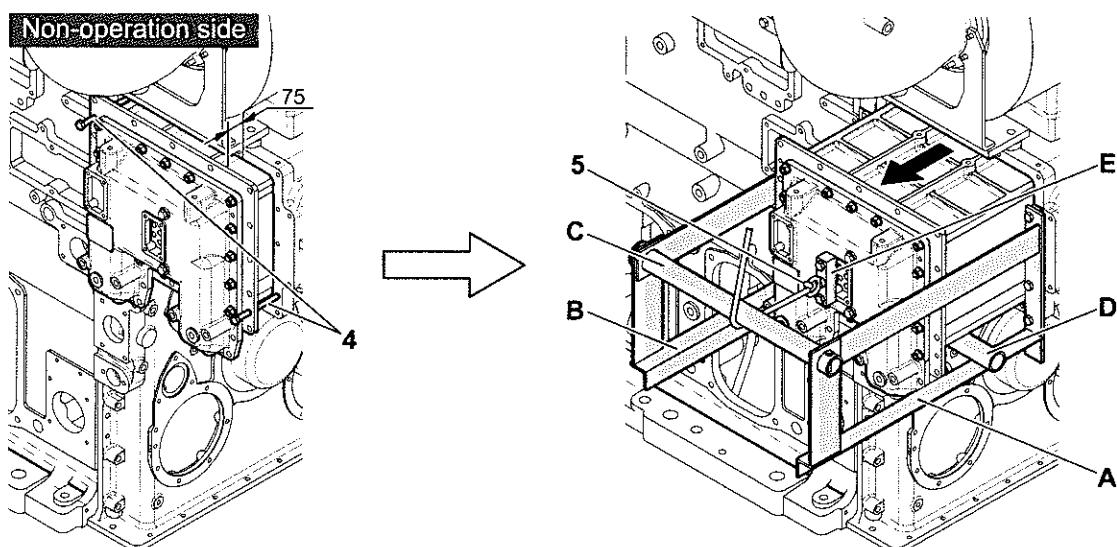


Fig.1 Charge air cooler

3. Screw the bolt 4 into the thread for drawing-out of the tube seat on the non-operation side. Lift it with the hydraulic jack. Pull it out for 75 mm or more.
4. Install the drawing-out tools A and B to the cooler casing. Install the drawing-out tool C to the drawing-out tools A and B.
5. Install the drawing-out tool E to the cooler cover. Install the eye bolt 5 to the drawing-out tool E.
6. Pull the core out of the cooler, until it is approximately 450 mm out. Use a wire and a chain block lifter.
7. Put tool D on tools A and B. This prevents the core from tilting or falling.
8. Install two eye bolts in the screw holes on the top of the core. Lift the core.

NOTICE

The mass of the core is 150kg. DO NOT lift the core with only one eye bolt.



A-18010-00003-A-01_EN

Fig.2 Drawing out the core

2. Inspection

1. Clean the plate-fin on the air side of the air cooler with steam or soak it in a cleaning fluid.
2. These products or their equivalent are appropriate cleaning fluids:
NEOS Co., Ltd.: NEOS One-1
Kurita Water Industries Ltd.: Emocon 1E-55
3. Blow away the cleaning fluid with compressed air.
4. Clean the plate-fin with water.
5. Remove the cover on the cooling water inlet/outlet side. Remove the cover on the water return (flushback) side.
6. Wash the cooling water side and clean it with a long-handled brush.
7. Examine the coating on the inner surface of the intake air duct and side covers. If the coating is damaged, apply new coating.
8. Look for clogged drain holes.
9. Look for clogged air vent holes.

3. Assembly

1. Replace the packing and the O-rings with new ones.
2. Examine the coating on the inner surface of the charge air passage of the air cooler body.
3. If the coating is damaged, apply this paint:
 - Heat-resistant silicone paint
 - Oshima Kogyo: PYROSIN IN COLOR G2 or equivalent
4. Apply lubricating oil to the bottom lib inside the cooler casing.
5. Install the drawing-out tools A and B to the cooler casing.
6. Install the drawing-out tool C to the drawing-out tools A and B.
7. Install the casing packing 6 to the core.
8. Install two eye bolts 5 in the screw holes on the top of the core.
9. Put the drawing-out tool D on the drawing-out tools A and B.
10. Push the core into the cooler body. Push it until you cannot push it more.
11. Install the drawing-out tool E to the header flange.
12. Attach the eye bolt again.
13. Push the core into the cooler, until it is approximately 75 mm out. Use a wire and a chain block lifter.
14. Remove the drawing-out tools A, B, C and D.
15. Push the core fully into the cooler.
16. Tighten the mounting bolt.
17. Install the seal plate 3. Make sure that you can see the match mark. (It must point to the operation side.)
18. Equally apply liquid packing to the back of the seal plate.
19. Install the seal packing 2. Make sure that it is not twisted.
20. Install the seal flange 1.

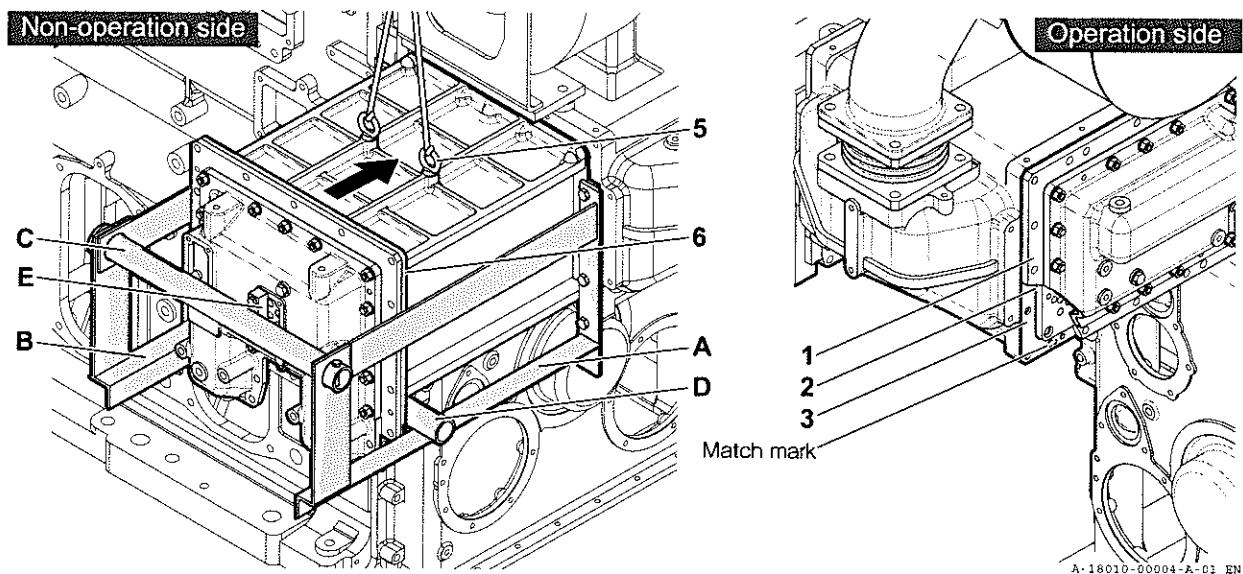


Fig.3 Charge air cooler

CONDITION Check for water and oil leaks during operation.

- The exhaust manifolds are made of cast-iron. The exhaust gas is collected by two manifolds, each fed by 3 cylinders matching the turbocharging system, and guided to the turbocharger. The exhaust manifolds have expansion joints to allow for thermal expansion.
- The exhaust manifold cover has 3 parts. It is installed to the cylinder block and cooling water connecting duct. The cover is box-shaped and filled with glass wool. This is protection against fire.
- When you disassemble, lift the exhaust manifold cover with a lifting eye bolt and a chain block lifter.

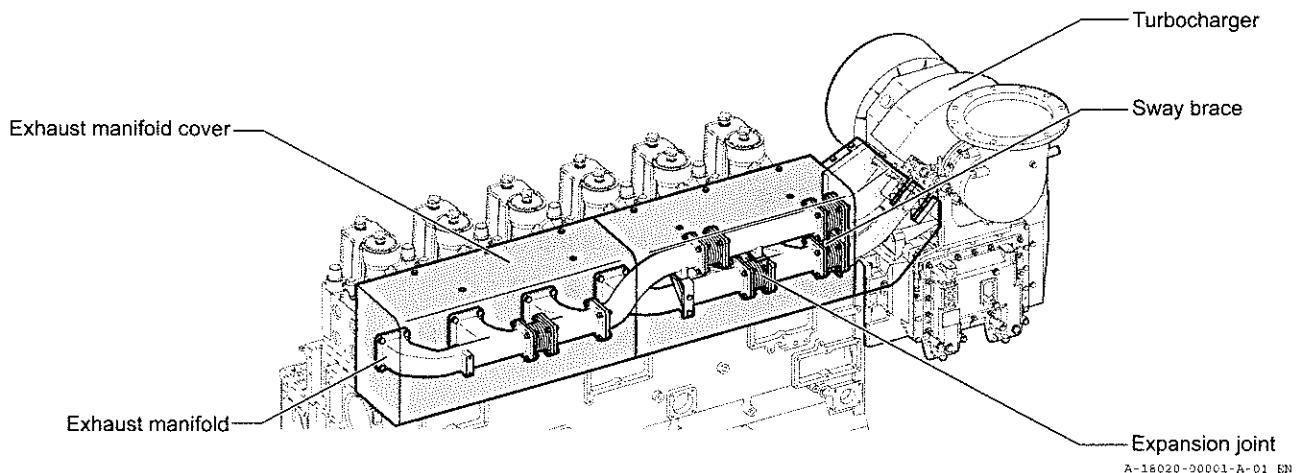


Fig.1 Exhaust manifold - Description of function

Exhaust manifold

Inspection and maintenance

1/3

PRODUCTION MANAGEMENT DATA

CONDITION Intervals Unscheduled

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	3 h
	b	Engine crew	Intermediate	-	3 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Lifting eye bolt		26617-120002		2 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you adjust the exhaust manifold.

1. Disassembly

1. Lift the exhaust manifold cover by the lifting eye bolts. Use a chain block lifter or an equivalent device. Remove the cover in the numerical sequence.

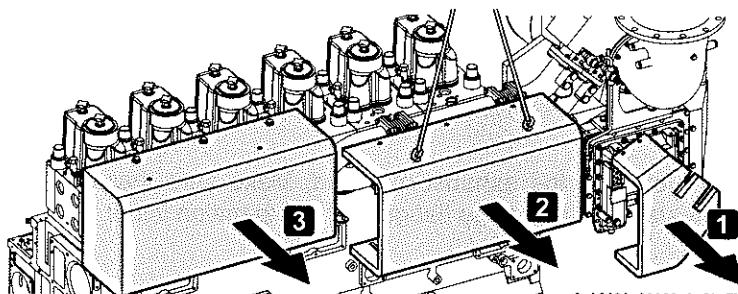


Fig. 1 Exhaust manifold cover disassembly

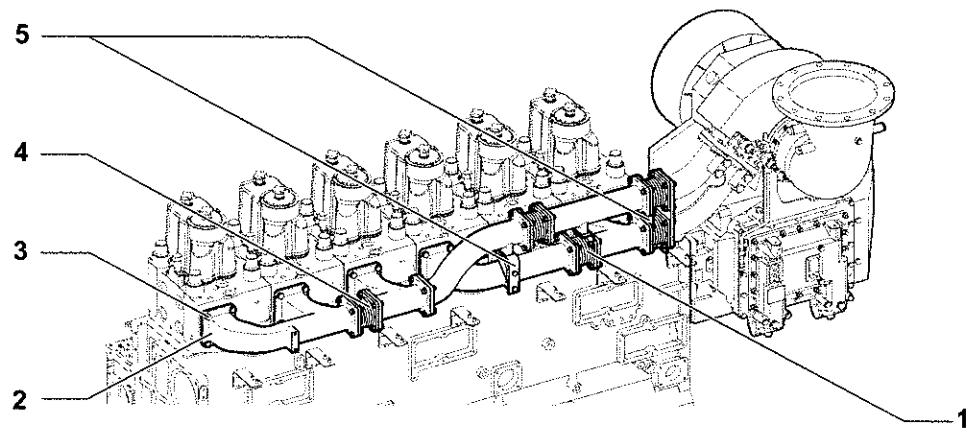
2. Loosen the bolt 4 that connects the exhaust connecting pipe with the expansion joint and exhaust manifold.

While you disassemble, make sure that the sway brace and all tightening bolts are tight.

The bolts and nuts of the exhaust manifold, the expansion joint and the sway brace are made of stainless steel. Make sure that you do not use other bolts or nuts.

Inspection and maintenance

3. Remove the expansion joint 1.
4. Remove the sway brace 5.
5. Remove the bolt 3 that connects the exhaust manifold and the cylinder head.
6. Remove the exhaust manifold 2.

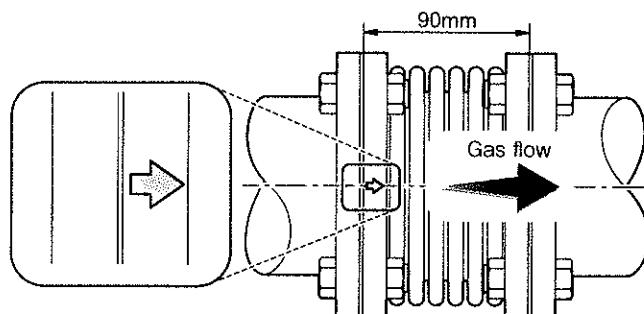


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Fig.2 Exhaust manifold disassembly

2. Assembly

1. Extend the expansion joints to 90 mm. This absorbs the expansion caused by the high temperature of the manifold.
2. Install the expansion joints to the exhaust manifold. Make sure that you install them in the correct direction. Look at the stamp mark on the flange of the expansion joints.



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Fig.3 Expansion joint match mark

NOTICE

If you install the expansion joint in the incorrect direction, carbon collects inside the clearances. The part will break in a short time.

3. Apply seizure inhibitor to all bolts and nuts.
4. Tighten all bolts and nuts.

5. There is a fire-proof cover (lagging) at the locations shown in Fig. 4.

- Expansion joint on the turbocharger inlet side 1
- Flange of the exhaust connection pipe on the turbocharger inlet 2
- Intake connection pipe on the turbocharger outlet 3
- Flange of the exhaust connection pipe on the turbocharger outlet 4
- Support of the exhaust connection pipe on the turbocharger outlet 5
- Digital thermometer on the turbocharger inlet 6
- Connection of the turbine cleaning on the turbocharger 7
- Socket of the turbine cleaning on the turbocharger 8
- Indicator cock 9

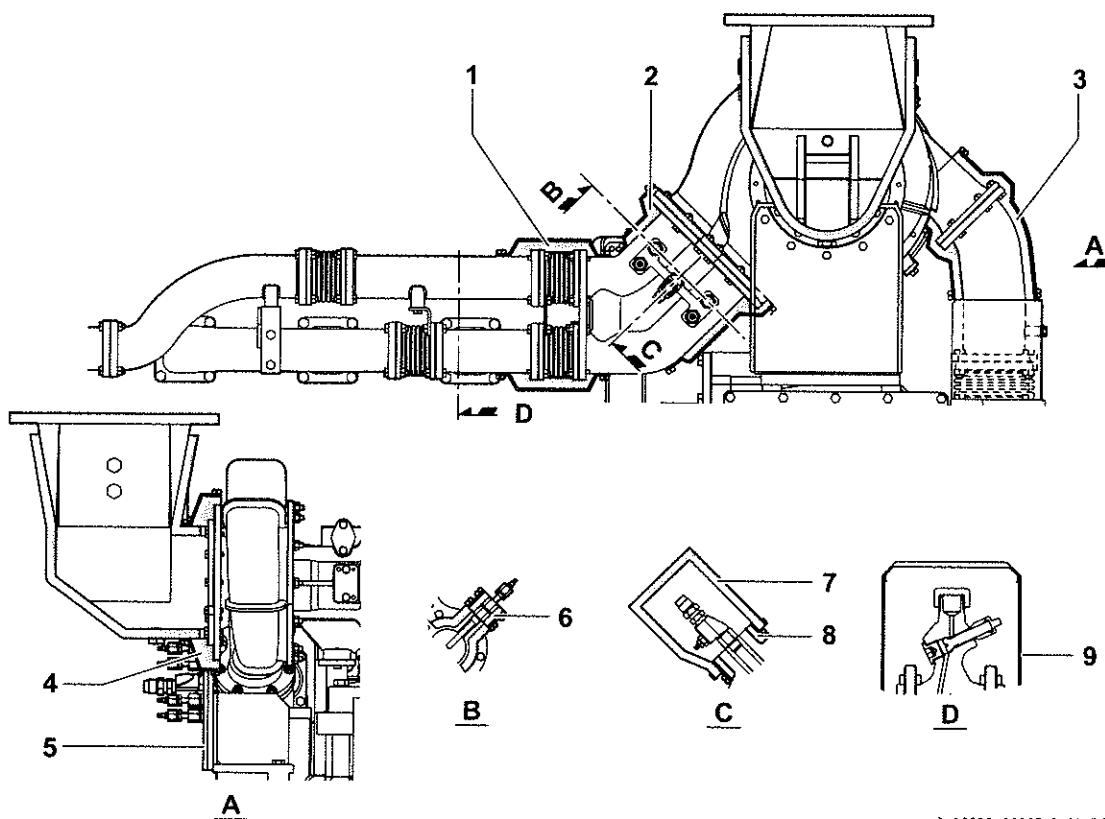


Fig.4 Fire-proof cover of the exhaust manifold

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6. Lock the mating surfaces by sewing the cover or with a wire.

- It is prohibited to use asbestos as cover material.

7. Install the cover of the exhaust manifold.

CONDITION

- This exhaust gas turbine turbocharger is a high-performance, air-cooled radial model. It is installed on the opposite side of the flywheel. The lubricating oil system of the engine lubricates and decreases the temperature of the turbocharger bearing by force-lubrication.
- For disassembly and maintenance of the turbocharger, refer to the operation manual.
- When you remove the turbocharger, put the cover on the air cooler body. This keeps unwanted material out of the intake air chamber and the lubricating oil passage.

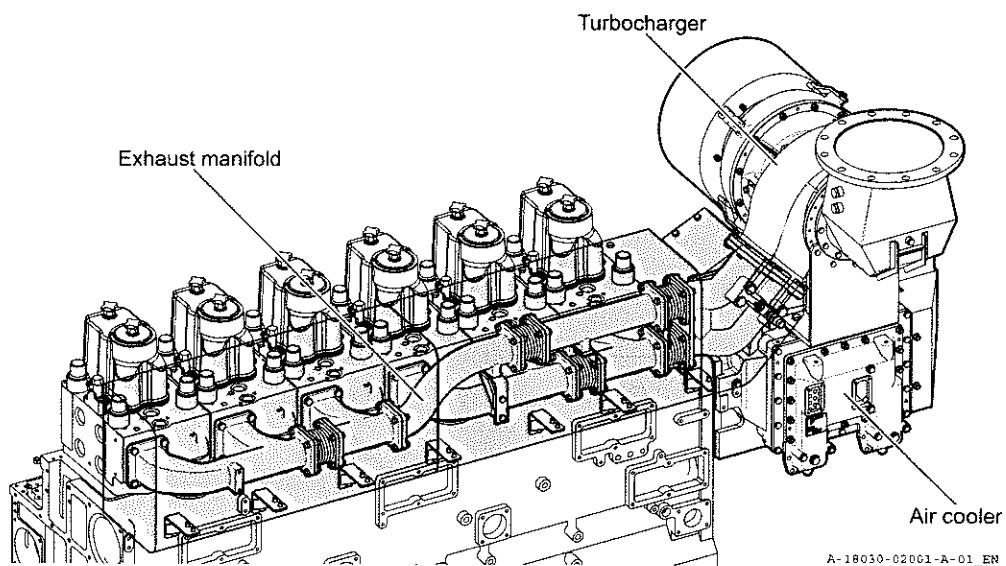


Fig.1 Turbocharger - Description of function

Turbocharger (MET)

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	12 h
	b	Engine crew	Intermediate	-	12 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
SAFETY					

Obey the attached operation manual when you do inspection and maintenance of the turbocharger.

CONDITION

Turbocharger (MET)

Cleaning (compressor)

1/1

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals When entering/leaving port When the compressor of the turbocharger is dirty, the exhaust temperature increases. This shortens the service life of the fuel injection valves and exhaust valves. Clean the compressor at regular intervals.				
PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Blower cleaning mechanism		153602-92900		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you clean the compressor.

1. Cleaning of the compressor

1. Operate the engine at a load that is 0.03 to 0.07 MPa in air pressure.
2. Open the drain cock of the intake air chamber.
3. Fill cleaning water into a hand pump (approx. 0.5 l).
4. Connect the cleaning hose to the filler of the turbocharger.
5. Slowly fill in the cleaning water (take approx. 20 to 40 seconds).
6. If the charge air pressure does not come back, wait 10 minutes or more and do the cleaning again.
7. After you clean the compressor, close the drain cock and the cap on the filler plug.
8. After you complete the compressor cleaning, perform the load operation at least 1 hour to dry.

NOTICE

- If the intake air pressure does not go back to its normal value, disassemble the turbocharger and clean it.
- Always use freshwater. Never use seawater because it causes corrosion. Do not use cleaning water with coolant. The coolant particles can collect and contaminate the part.
- Do not clean the compressor immediately before you stop the engine. It can cause rust.

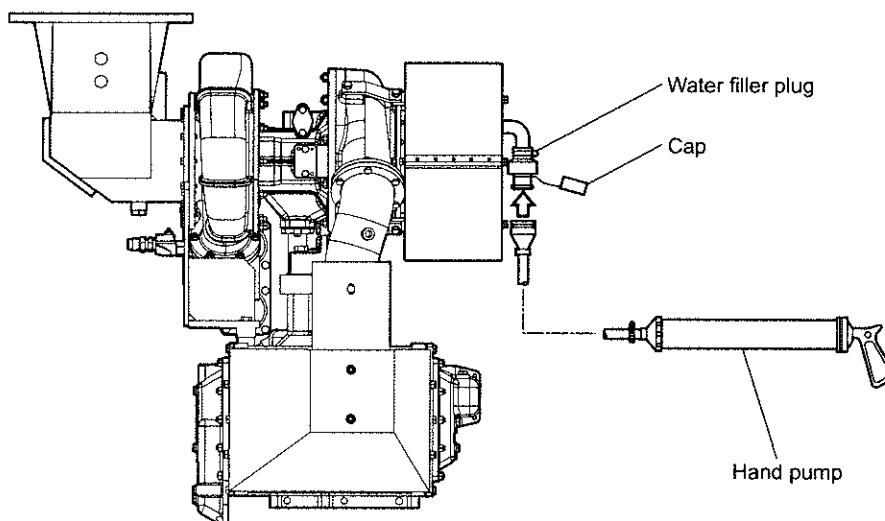


Fig.1 Cleaning the compressor of the turbocharger

CONDITION Check the result of the cleaning. Measure the intake air pressure and the exhaust air temperature before and after the cleaning. Do it at identical power levels (e.g. 75 % or 100 %). Record the result.

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals 100 to 200 working hours				
	When the engine operates on heavy fuel oil, particles and sediment collect at the nozzle ring and turbine wheel. Because the pressure of the intake air increases, the engine performance decreases.				
Clean the turbocharger turbine at regular intervals. Refer to the operation manual of the turbocharger.					
PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Turning handle of the pressure indicator cock		153605-92360		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

To do a turbine solid cleaning, fill plant solids into the front of the turbine. The plant solids hit the nozzle and rotor blades and remove buildup.

Obey the instructions that follow when you clean the turbine.

1. Cleaning the turbine

1. Cleaning procedure

1 - Cleaning intervals

As an initial guideline, cleaning is performed at intervals of 100 to 200 hours.

The cleaning intervals change due to the decrease of the performance values including exhaust temperature, intake pressure, and turbocharger speed.

2 - Air pressure and turbine inlet exhaust temperature at cleaning

The limit value of the air pressure and the turbine inlet exhaust temperature at cleaning is as follows. If the actual load value is higher, decrease the load.

Air pressure: 0.1 to 0.15 MPa

Turbine inlet temperature: 510 °C or less

2. Precautions for installing and piping the solid cleaning device

- 1 - To send a cleaning medium to the turbine, connect the auxiliary air source with the pressure 0.4 MPa to 0.9 MPa.
- 2 - Connect the flexible rubber hose. It should be a smooth one with the bend part radius R 150 mm or more. Avoid drawing the pipe at the bend part to prevent clogging of the solid cleaning medium.

3. Cleaning medium

Type of cleaning medium	Diameter	Amount of solid cleaning agent
Walnut shell	1.7 to 2.4 mm (Marine grid #10)	0.05 to 0.1 ℥/implementation

4. Amount of cleaning medium to be used

As an initial guideline of the quantity of one cleaning, refer to the table. If the amount is too much, surging may occur. Decide the appropriate value by the engine condition.

5. Cleaning procedure

- 1 - Open the valve in the following procedure to cool the device through the air for 0.5 to 1 minute.
The turning handle of the pressure indicator cock is used for the opening and shutting of the valve4.
Valve 4 → Valve 1 → Valve 3
- 2 - Close the valve in the following procedure.
Valve 1 → Valve 3
- 3 - Open the cap of the tank 2 and insert the specified quantity of the plant solid cleaning medium.
Tighten the cap of the tank 2 firmly.
- 4 - Open the valve in the following procedure to throw the cleaning medium through the air.
Valve 1 → Valve 3
- 5 - Close the valve in the following procedure.
Valve 4 → Valve 3 → Valve 1

NOTICE

Tighten the drain plug of the turbocharger gas outlet casing until the cleaning is complete.

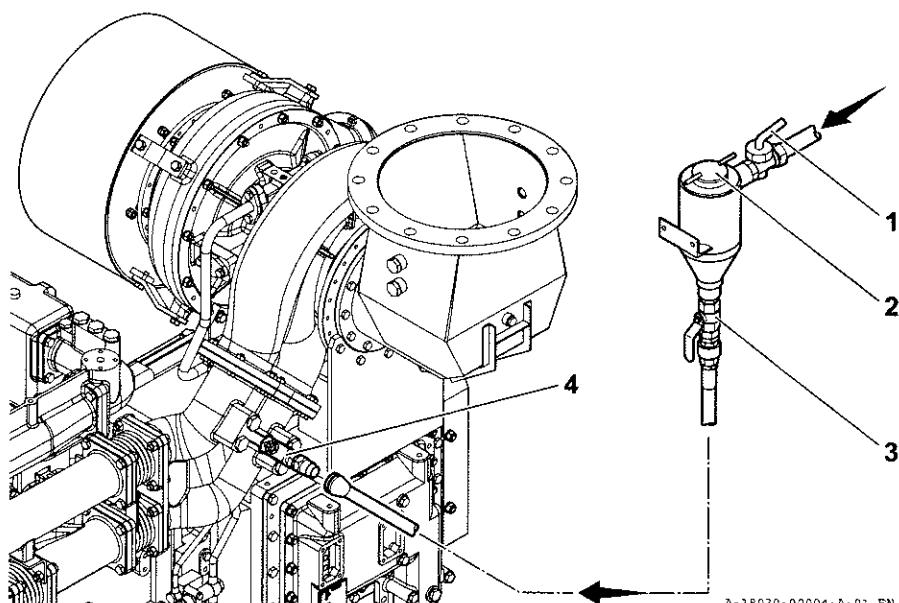


Fig.1 Solid cleaning device

6. Repeat cleaning

- 1 - If there is a sudden change in the engine at the time of throwing the cleaning medium, such as the occurrence of great surging, etc., perform the cleaning with approximately half the recommended amount of cleaning agent shown in the table.
Make sure that there is no sudden change in the engine. Repeat the cleaning process.
- 2 - If there is no change in the performance value including exhaust temperature, intake pressure, and turbocharger speed, repeat the procedure 1. If you cannot see the change after repeating the cleaning for a few times, discharge and cleaning are required.

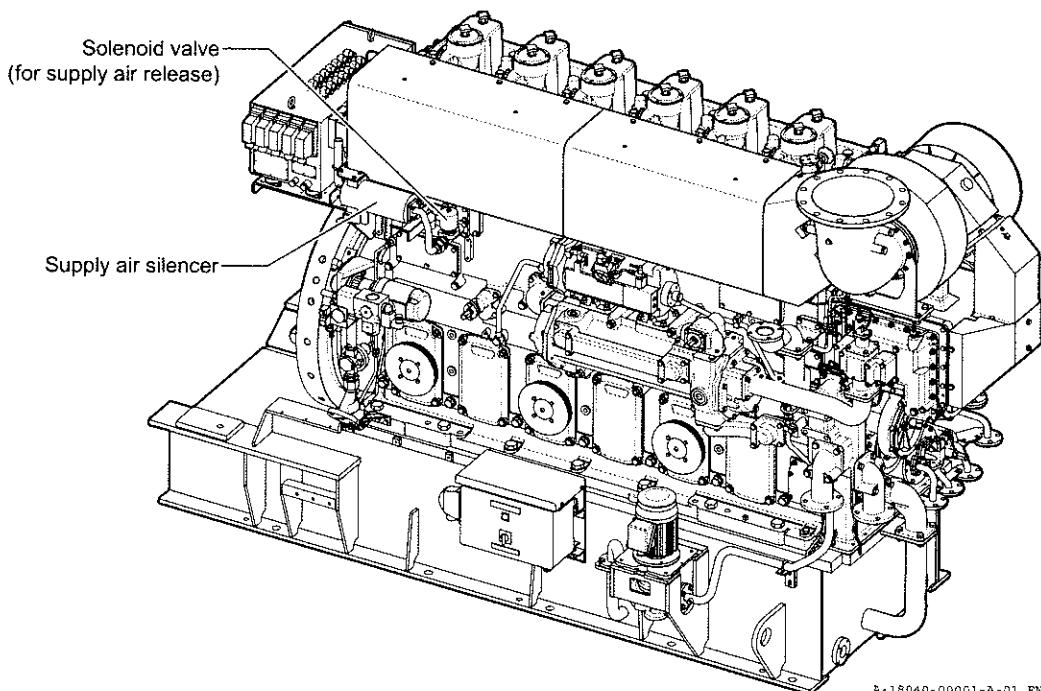
CONDITION Check the result of the cleaning. Measure the intake air pressure and the exhaust air temperature before and after the cleaning. Do it at identical power levels (e.g. 75 % or 100 %). Record the result.

1. Outline

- The SCR system is an exhaust gas after treatment system that processes NOx gas exhausted from diesel engines to turn into harmless gas.
- The SCR system reduces NOx exhausted from the engine by the selective catalytic reduction. It consists of the catalytic reactor, urea injection system, control panel, and others.
- In order for the SCR system to operate properly, certain exhaust temperature must be kept. This engine includes a supply air silencer and a solenoid valve for releasing a part of the air supplied from the supply air manifold to the engine.
- When the exhaust temperature of the SCR inlet is below a predetermined value, the solenoid valve for releasing supply air opens. By releasing the supply air to the atmosphere via the silencer, the exhaust temperature rises.
- The activation of the supply air relief device does not affect the engine operation.

NOTICE

Do not put your face close to the muffler. If the supply air includes foreign objects, it will be injected strong and may get into your eyes.



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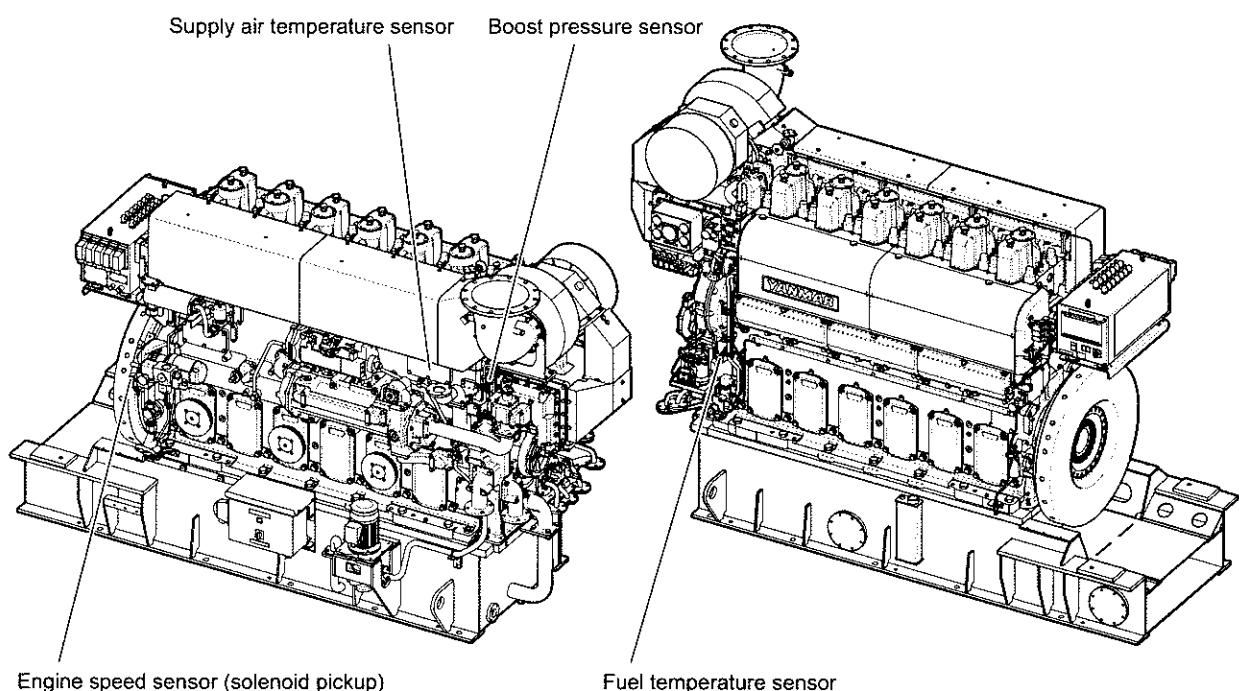
Fig.1 Supply air release overview

2. SCR control sensor

This engine includes a sensor for controlling the SCR system.

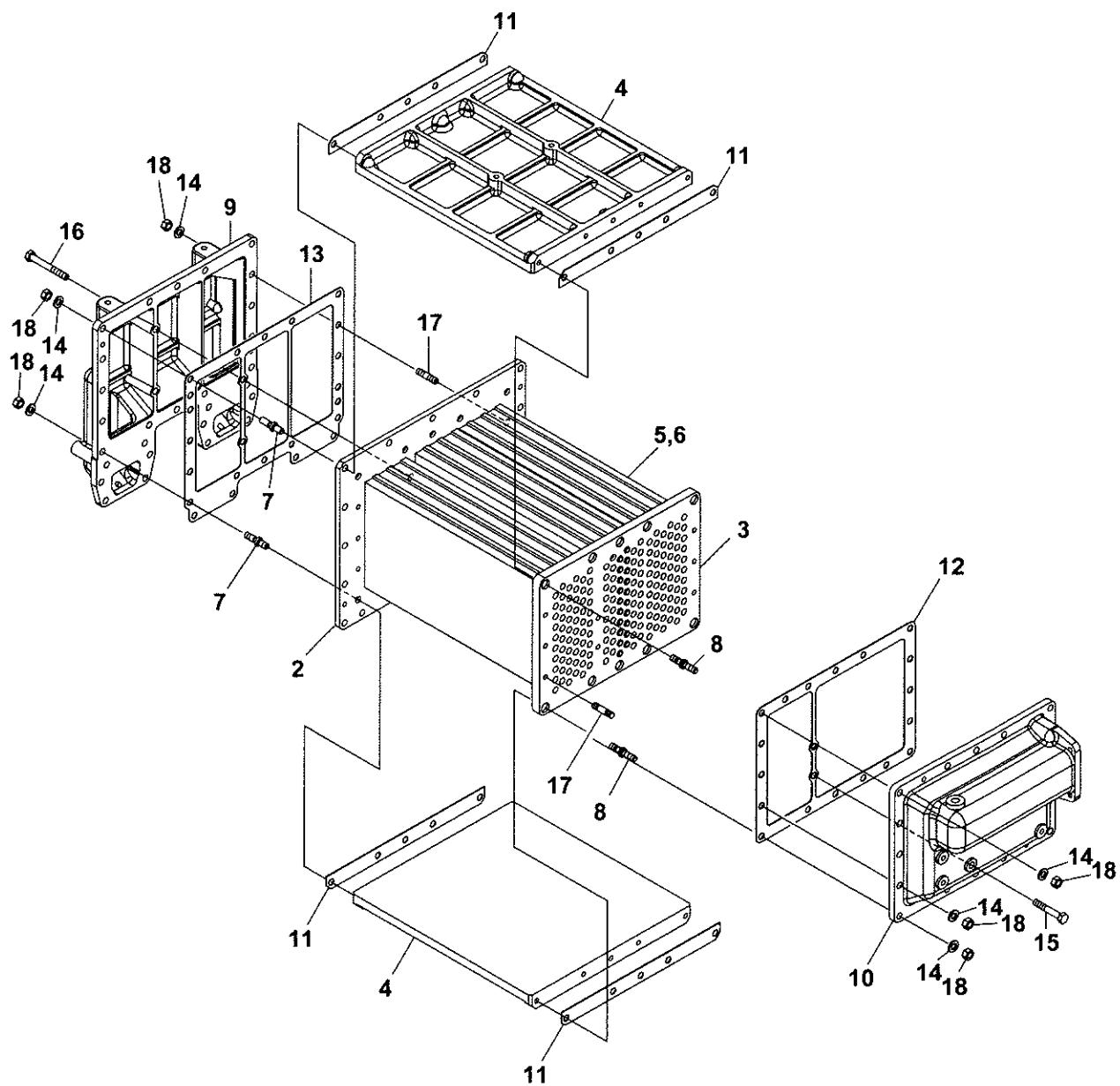
- Fuel temperature sensor
- Supply air temperature sensor
- Boost pressure sensor
- Engine speed sensor (solenoid pickup)

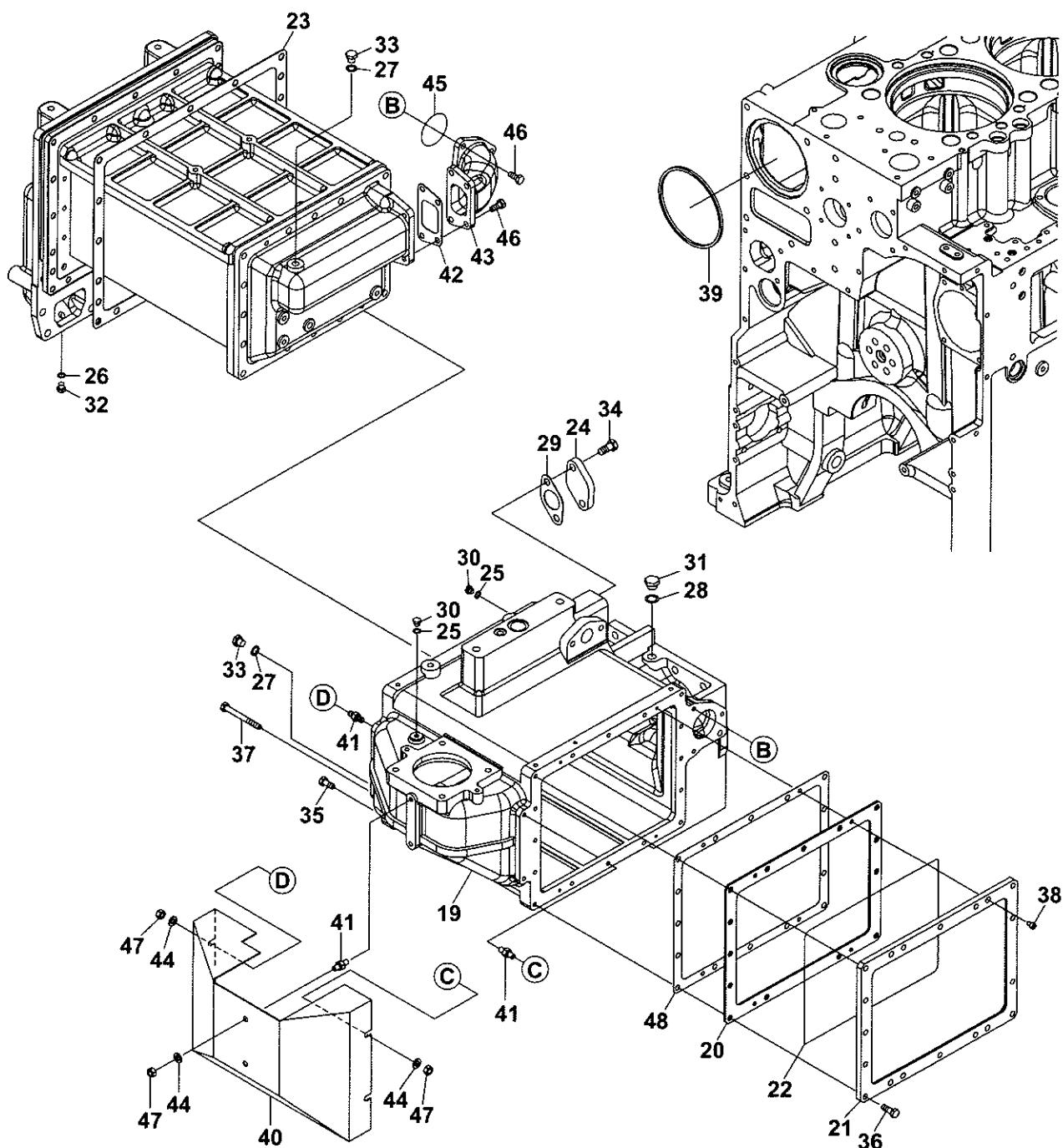
The SCR system does not operate correctly when the sensor fails. Immediately replace a failed sensor.



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Fig.2 SCR control sensor



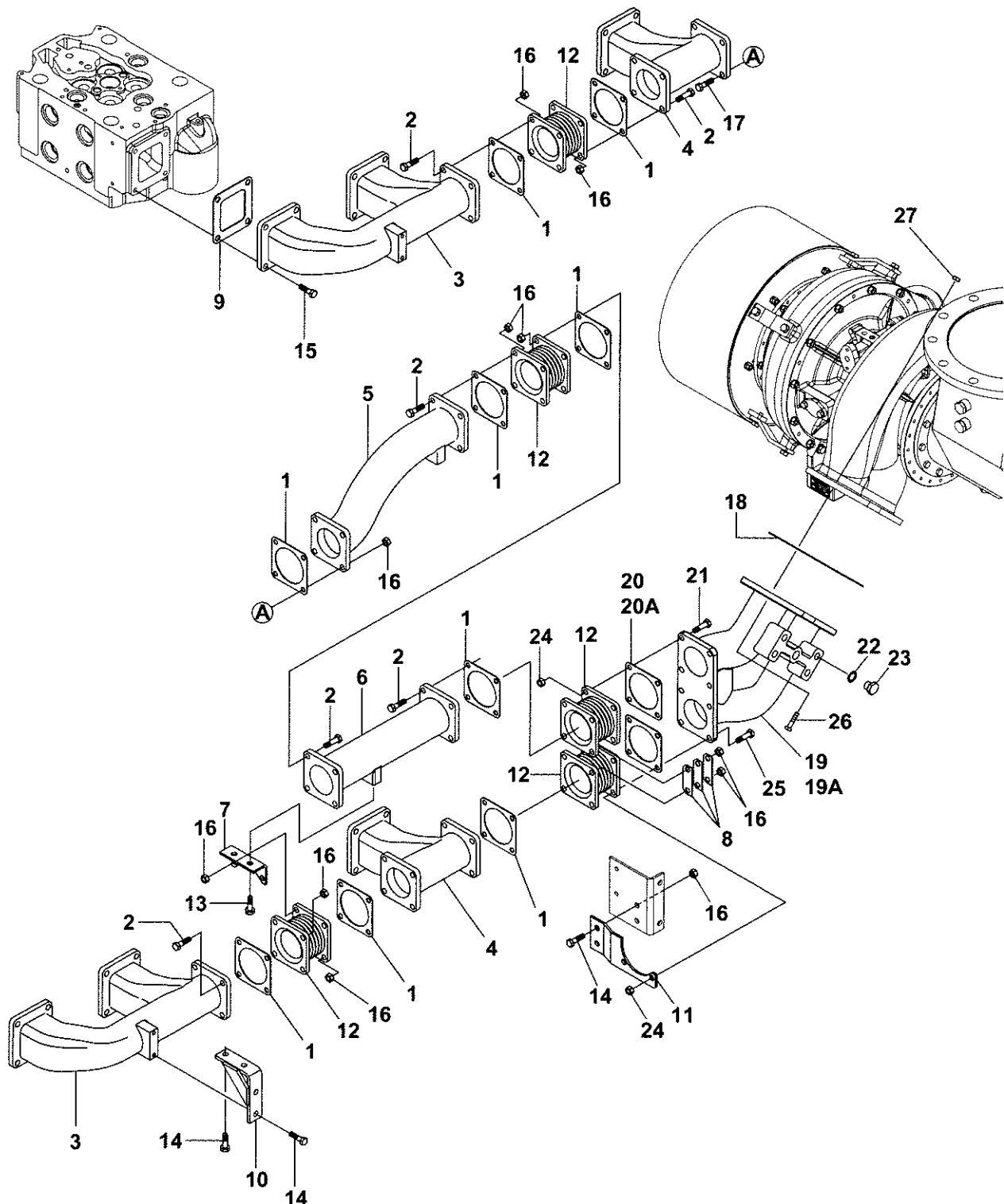


Air cooler

Illustrated parts data

3/3

No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	750633-18312	AIR COOLER ASSY	1	1	
1	2	150633-18060	CORE,AIR COOLER	1	1	
2	3	150633-18520	SEAT B,TUBE	1	1	
3	3	150633-18530	SEAT A,TUBE	1	1	
4	3	150633-18540	SIDE PLATE,AIR COOLE	2	2	
5	3	150633-18610	TUBE,AIR COOLER	180	180	
6	3	150633-18620	FIN, PLAT	996	996	
7	3	136606-18720	BOLT, COLLAR	10	10	
8	3	151604-18720	BOLT, COLLAR	10	10	
9	3	150633-18780	COVER A,AIR COOLER	1	1	
10	3	150633-18790	COVER B,AIR COOLER	1	1	
11	3	150633-18930	PACKING A,I/C	4	4	
12	3	150633-18940	PACKING B,I/C	1	1	
13	3	150633-18950	PACKING C,I/C	1	1	
14	3	22212-120000	WASHER, 12	32	32	
15	3	26206-120752	BOLT, 12 X 75	2	2	
16	3	26206-121002	BOLT, 12 X 100	2	2	
17	3	26212-120352	STUD,BOLT 12 X 35	12	12	
18	3	26706-120002	NUT, 12	32	32	
19	2	150633-18090	CASING(I/C)	1	1	
20	2	150633-18550	SEAL PLATE	1	1	
21	2	150633-18561	FLANGE,SEAL	1	1	
22	2	150633-18730	O-RING,I/C	1	1	
23	2	150633-18961	PACKING D,I/C	1	1	
24	2	23221-490001	FLANGE, 49	1	1	
25	2	23414-120000	GASKET, 12 X 1.0	2	2	
26	2	23414-130000	GASKET, 13 X 1.0	2	2	
27	2	23414-170000	GASKET, 17 X 1.0	3	3	
28	2	23414-220000	GASKET, 22 X 1.0	1	1	
29	2	23428-510000	GASKET, 51 X 1.5	1	1	
30	2	23884-120002	PLUG, 12	2	2	
31	2	23884-220002	PLUG, 22	1	1	
32	2	23894-020002	PLUG, G 1/4	2	2	
33	2	23894-030002	PLUG, G 3/8	3	3	
34	2	26152-160352	BOLT, 16 X 35	2	2	
35	2	26206-120302	BOLT, 12 X 30	14	14	
36	2	26206-120352	BOLT, 12 X 35	16	16	
37	2	26206-121152	BOLT, 12 X 115	4	4	
38	2	26453-080162	BOLT, 8 X 16	4	4	
48	2	150633-18970	PACKING E,I/C	1	1	
39	1	150633-18221	PACKING,I/C-BLOCK	1	1	
40	1	150633-18310	COVER,AIR COOLER	1	1	
41	1	147673-18330	BOLT, COVER SPACER A	6	6	
42	1	150633-49350	PACKING(I/C IN)	1	1	
43	1	150633-49420	PIPE,HCW I/C OUT	1	1	
44	1	22137-120000	WASHER, 12	6	6	
45	1	24316-000850	PACKING, P 85.0	2	2	
46	1	26206-120302	BOLT, 12 X 30	7	7	
47	1	26706-120002	NUT, 12	6	6	



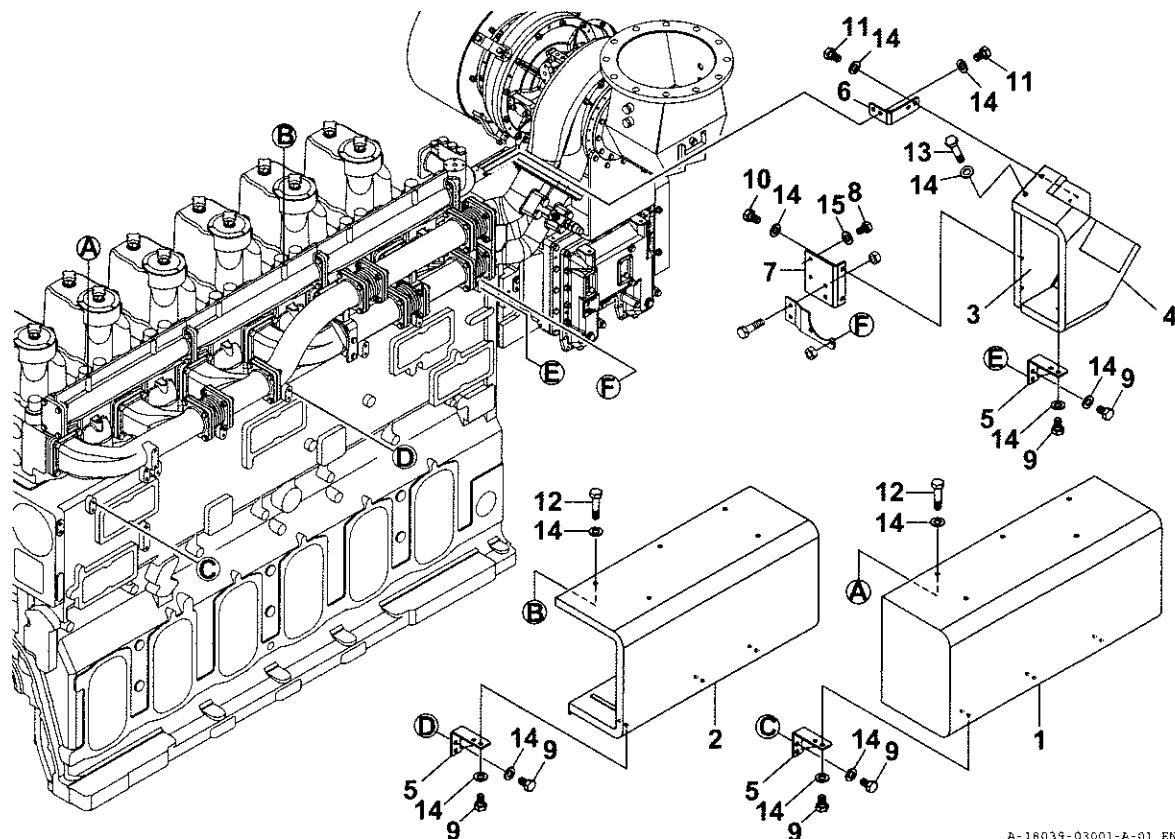
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Exhaust gas manifold (MET)

Illustrated parts data

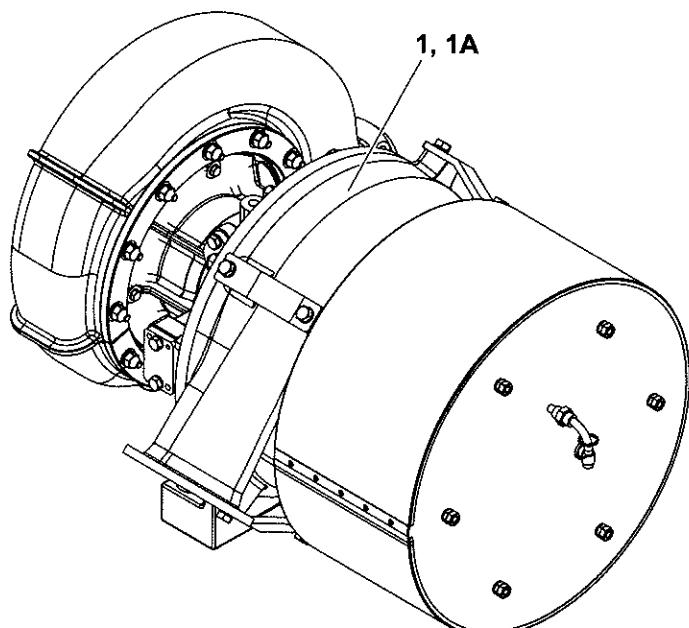
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	147673-13250	GASKET	9	9	
2	1	147673-13400	BOLT, M12X45	26	26	
3	1	150633-13400	EXHAUST MANIFOLD	2	2	
4	1	150633-13410	EXHAUST MANIFOLD	2	2	
5	1	150633-13420	EXHAUST A MANIFOLD	1	1	
6	1	150633-13430	EXHAUST B MANIFOLD	1	1	
7	1	150633-13460	SUPPORT A (EXH	1	1	
8	1	150633-13470	SUPPORT B (EXH	12	12	
9	1	150633-13480	GASCKET (HEAD OUT	6	6	
10	1	150633-13500	SUPPORT C, EXH	1	1	
11	1	150633-13510	SUPPORT D, EXH	1	1	
12	1	147673-13900	BELLOWS, EXHAUST	5	5	
13	1	26206-120202	BOLT, 12 X 20	2	2	
14	1	26206-120252	BOLT, 12 X 25	6	6	
15	1	26293-140352	BOLT, 14 X 35	24	24	
16	1	26703-120002	NUT, 12	38	38	
17	1	45521-013670	BOLT, M12X50	10	10	
18	1	150634-13400	GASKET	2	2	
19	1	150634-13550	MANIFOLD, EXHAUST	-	1	
19A	1	150634-13560	MANIFOLD, EXHAUST	1	-	
20	1	147673-13250	GASKET	-	2	
20A	1	146670-13400	GASKET(T/C IN	2	-	
21	1	147673-13400	BOLT, M12X45	6	6	
22	1	23414-210000	GASKET, 21 X 1.0	4	4	
23	1	23893-040002	PLUG, G 1/2	4	4	
24	1	26703-120002	NUT, 12	16	16	
25	1	45521-013670	BOLT, M12X50	10	10	
26	1	26703-100002	NUT, M10	12	12	
27	1	133154-13450	BOLT, M10X45	12	12	



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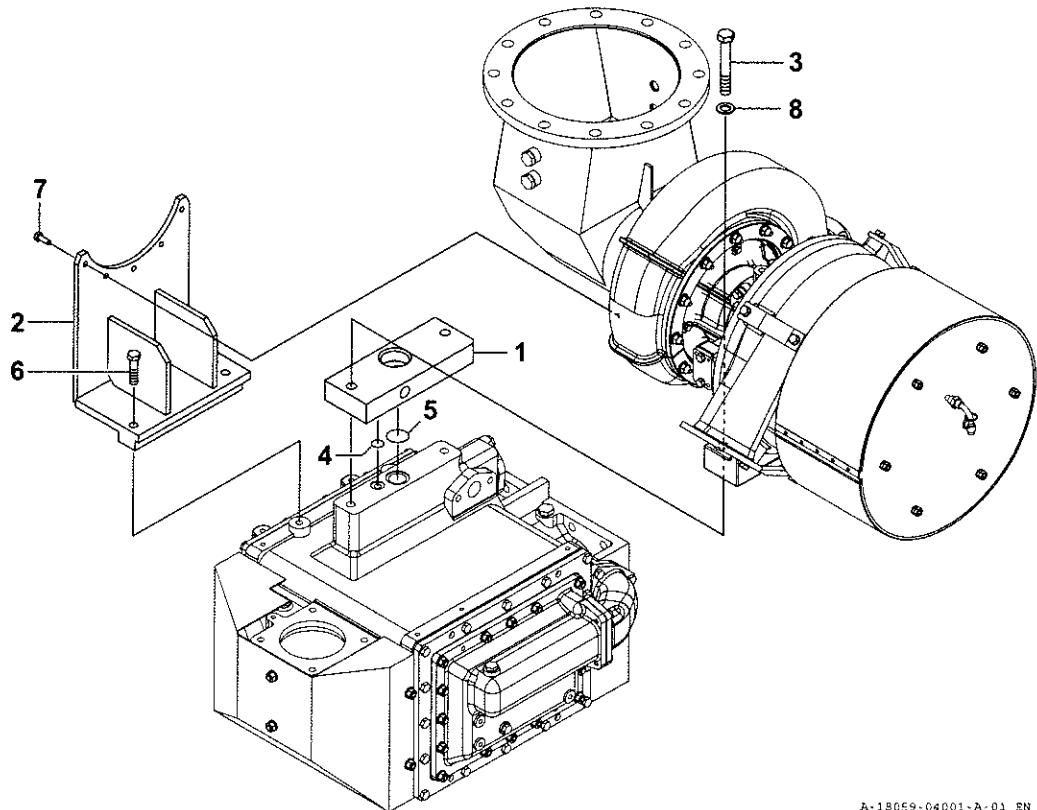
No	LV	Part No.	Part name	ALWS	Remarks
1	1	150633-13261	COVER, EXH.MANIFOLD	1	
2	1	150633-13271	COVER, EXH.MANIFOLD	1	
3	1	150633-13282	COVER, EXH.MANIFOLD	1	
4	1	150634-13500	COVER, EXH.MANIFOLD	1	
5	1	150633-13301	SUPPORT, EXH.COVER	7	
6	1	150633-13360	SUPPORT B, EXH.COVER	1	
7	1	150633-13390	SUPPORT E, EXH.COVER	1	
8	1	26206-100202	BOLT, 10 X 20	2	
9	1	26206-120252	BOLT, 12 X 25	28	
10	1	26206-120252	BOLT, 12 X 25	2	
11	1	26206-120252	BOLT, 12 X 25	4	
12	1	26206-120502	BOLT, 12 X 50	6	
13	1	26206-120552	BOLT, 12 X 55	2	
14	1	22137-120000	WASHER, 12	42	
15	1	22137-100000	WASHER, 10	2	



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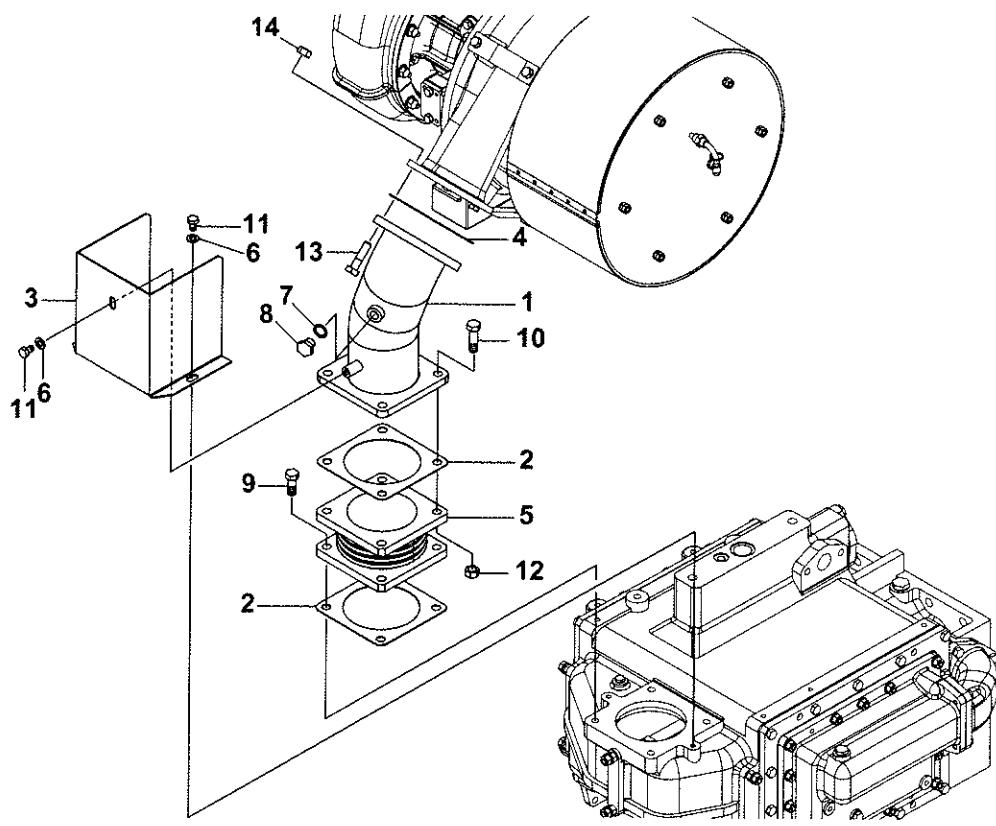
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150634-18701	TURBOCHARGER,MET22	-	1	
1A	1	150634-18740	TURBOCHARGER,MET18	1	-	

Illustrated parts data



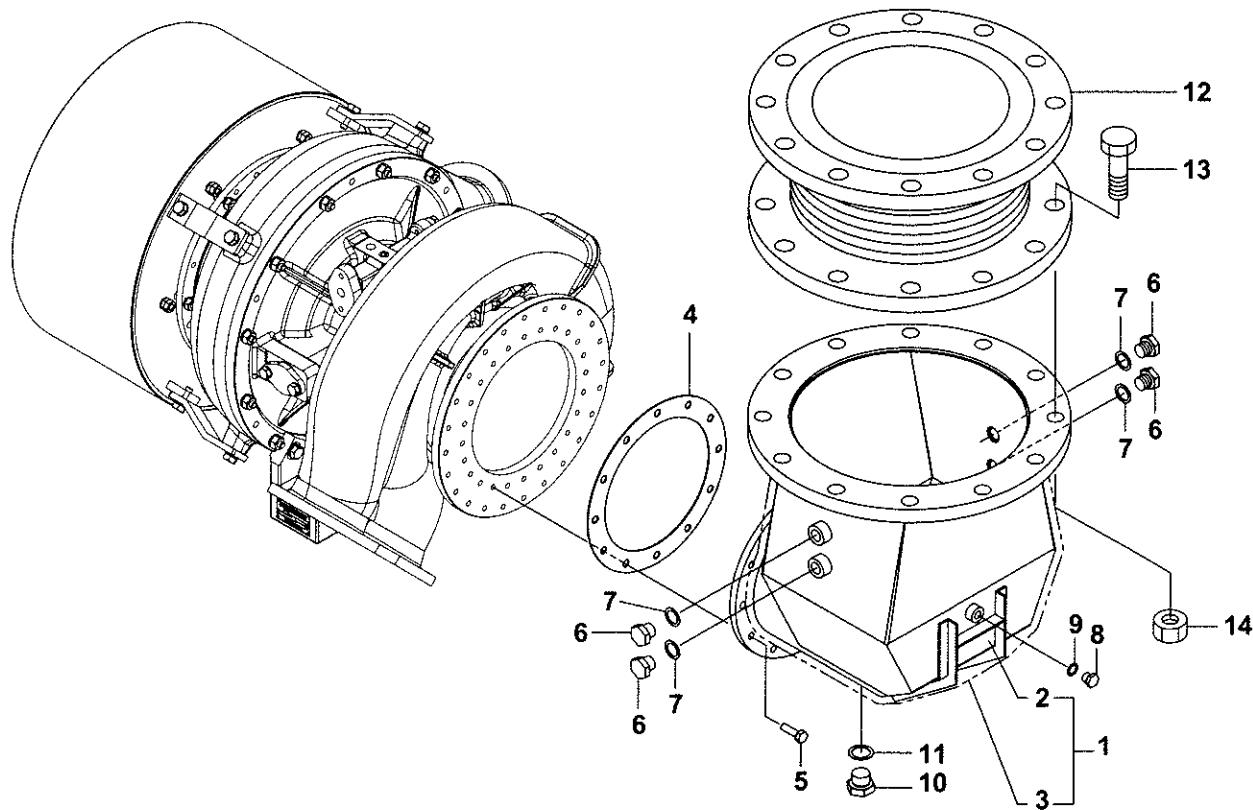
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No	LV	Part No.	Part name	ALWS	Remarks
1	1	150634-18100	MOUNT,T/C MET22	1	
2	1	150634-18130	SUPPORT,MET22	1	
3	1	26156-201402	BOLT, 20 X 140	2	
4	1	24316-000240	PACKING, P 24.0	1	
5	1	24316-000440	PACKING, P 44.0	1	
6	1	26152-160652	BOLT, 16 X 65	2	
7	1	26203-100302	BOLT, 10 X 30	5	
8	1	22133-200000	WASHER, 20	2	



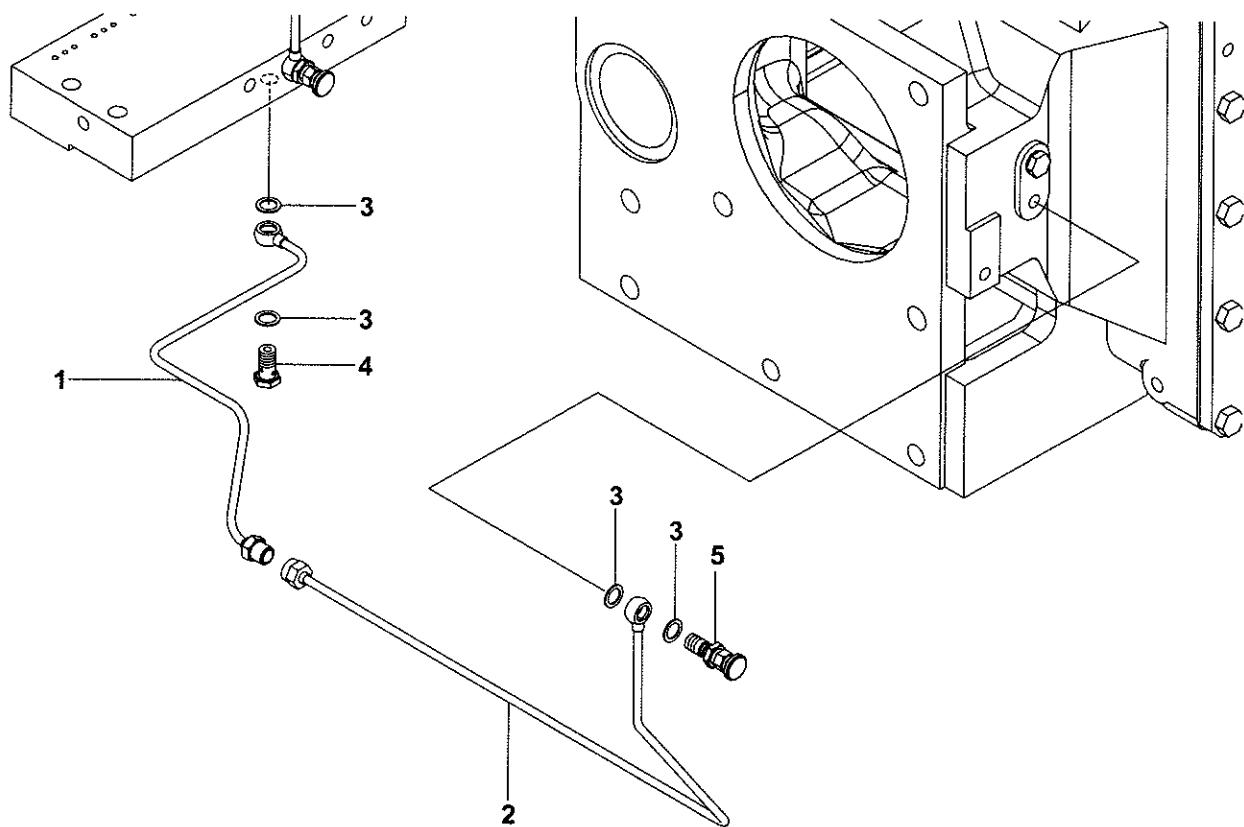
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No	LV	Part No.	Part name	ALWS	Remarks
1	1	150634-18200	DUCT, AIR T/C MET22	1	
2	1	150633-18210	GASKET,I/C IN	2	
3	1	150634-18550	COVER,AIR.DUCT MET22	1	
4	1	150634-18210	GASKET,T/C OUT MET22	1	
5	1	150633-18900	EXPANSION JOINT,SUC	1	
6	1	22137-120000	WASHER, 12	3	
7	1	23414-210000	GASKET, 21 X 1.0	1	
8	1	23894-040002	PLUG, G 1/2	1	
9	1	26152-160402	BOLT, 16 X 40	4	
10	1	26152-160552	BOLT, 16 X 55	4	
11	1	26206-120202	BOLT, 12 X 20	3	
12	1	26732-160002	NUT, 16	4	
13	1	26206-100402	BOLT, 10 X 40	6	
14	1	26706-100002	NUT, 10	6	



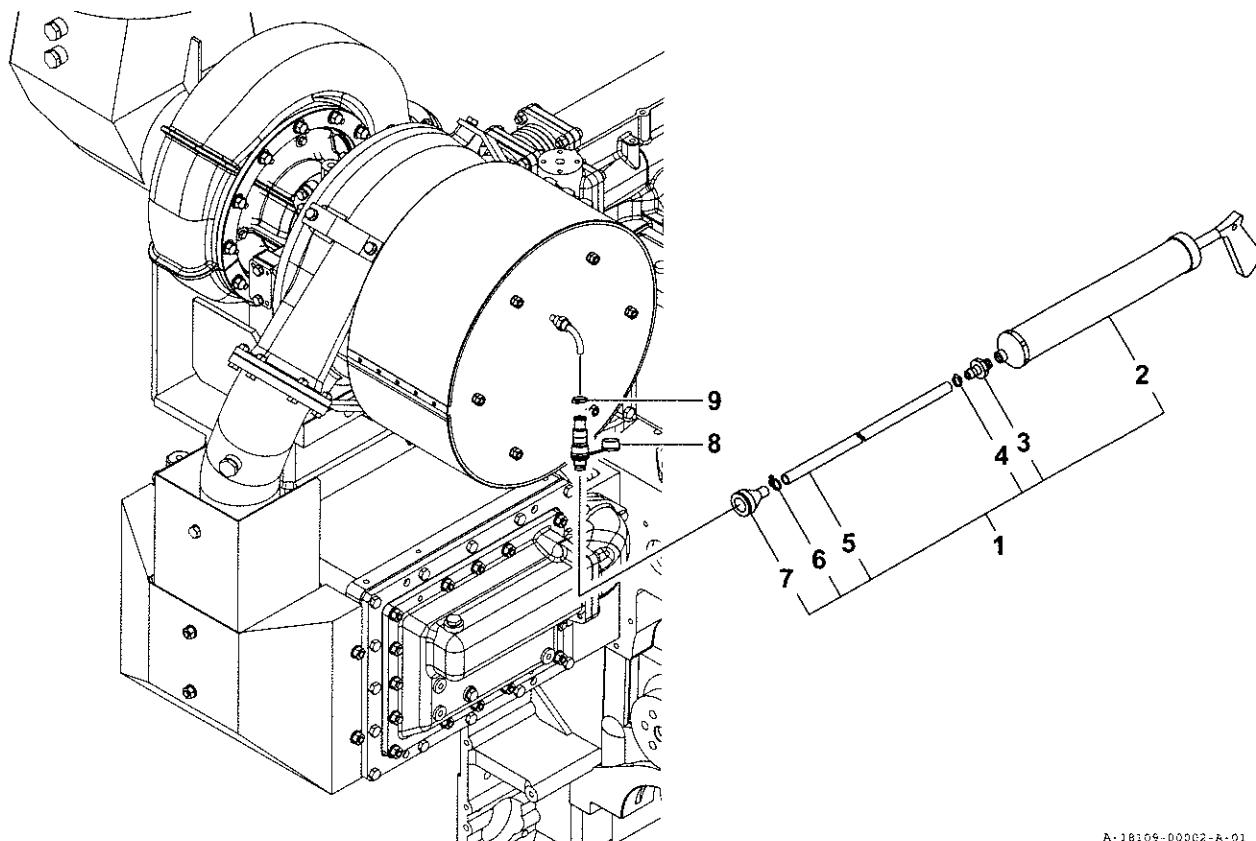
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No	LV	Part No.	Part name	ALWS	Remarks
1	1	150634-18960	PIPE, EXHAUST OUTLET	1	
2	2	150634-18940	PIPE, EXHAUST OUTLET	1	
3	2	150634-18950	MAT, GLASS	1	
4	1	150634-18600	GASKET,T/C EXH OUT	1	
5	1	26203-100352	BOLT, 10 X 35	12	
6	1	23893-040002	PLUG, G 1/2	4	
7	1	23414-210000	GASKET, 21 X 1.0	4	
8	1	23883-140002	PLUG, 14	1	
9	1	23414-140000	GASKET, 14 X 1.0	1	
10	1	23893-060002	PLUG, G 3/4	1	
11	1	23414-270000	GASKET, 27 X 1.0	1	
12	1	23970-350001	BELLOWS, 350A	1	
13	1	26111-220752	BOLT, 22 X 75	12	
14	1	26711-220002	NUT, 22	12	



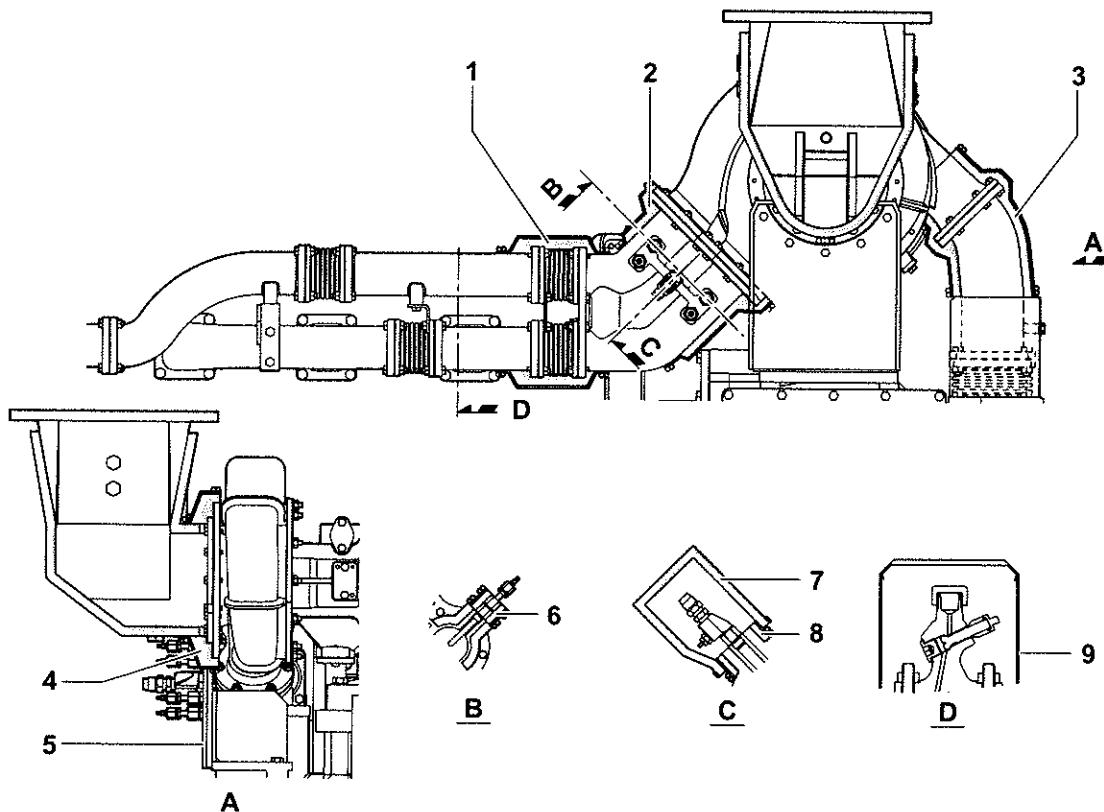
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-12400	PIPE A,SUC	1	1	
2	1	150633-12410	PIPE B,SUC	1	1	
3	1	23414-120000	GASKET, 12 X 1.0	4	4	
4	1	23854-060000	BOLT, JOINT 6	1	1	
5	1	43600-030772	VALVE, NEEDLE	1	1	



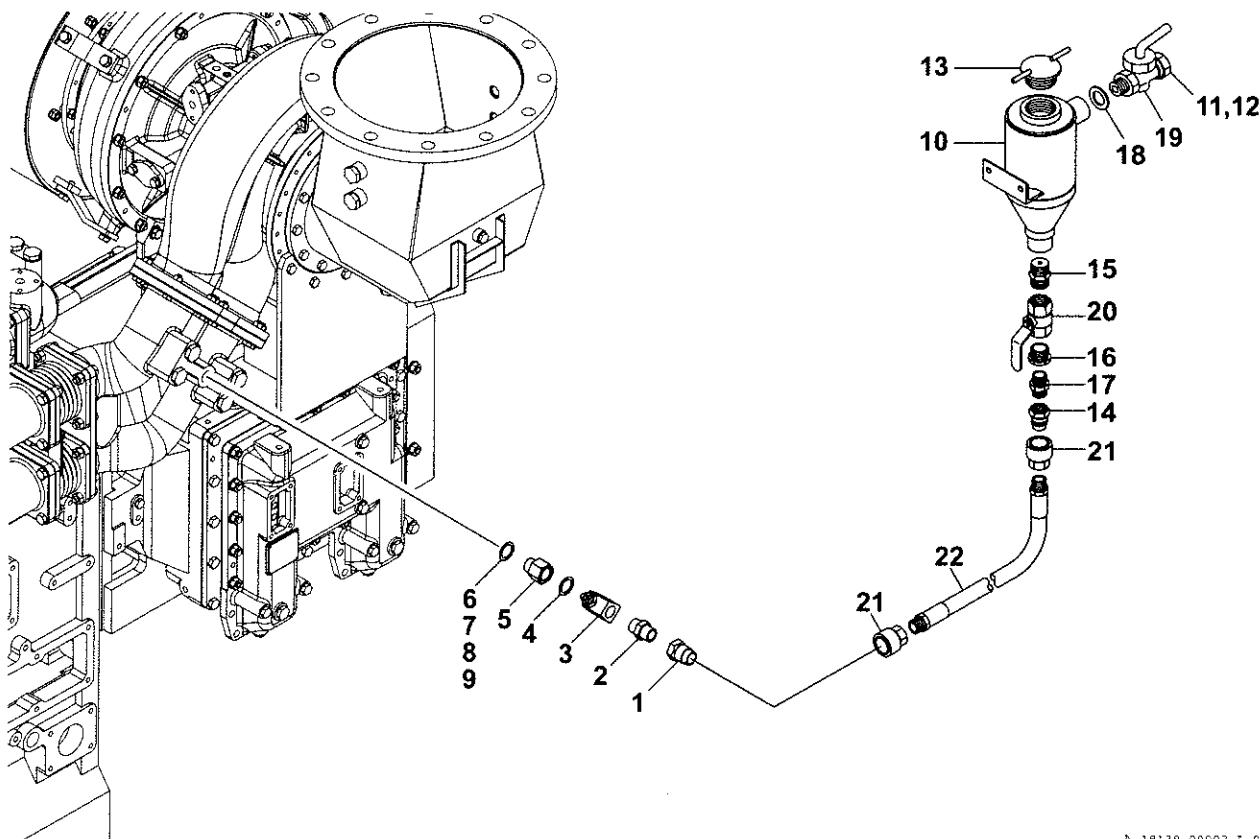
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No	LV	Part No.	Part name	ALWS	Remarks
1	1	153602-92900	WASHER UNIT,BLOWER	1	
2	2	153602-92910	SYRINGE	1	
3	2	153602-92920	NIPPLE 1/4	1	
4	2	23000-016000	CLAMP 16	1	
5	2	23091-090650	TUBE 9X650	1	
6	2	23010-018000	CLAMP 18	1	
7	2	153602-92930	SOCKET	1	
8	1	153602-92950	PLUG	1	
9	1	23010-018000	CLAMP, HOSE 18	1	



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No	LV	Part No.	Part name	ALWS	Remarks
1	1	150633-13770	COVER, FIREPROOF	1	
2	1	150634-13750	COVERING, FIREPROOF	1	
3	1	150634-13790	COVERING, FIREPROOF	1	
4	1	150634-13760	COVERING, FIREPROOF	1	
5	1	150634-13800	COVERING, FIREPROOF	1	
6	1	147883-91900	INSULATOR	1	
7	1	146623-13910	COVER, FIREPROOF	1	
8	1	146623-13890	COVER, FIREPROOF	1	
9	1	146623-13950	INSULATOR	6	



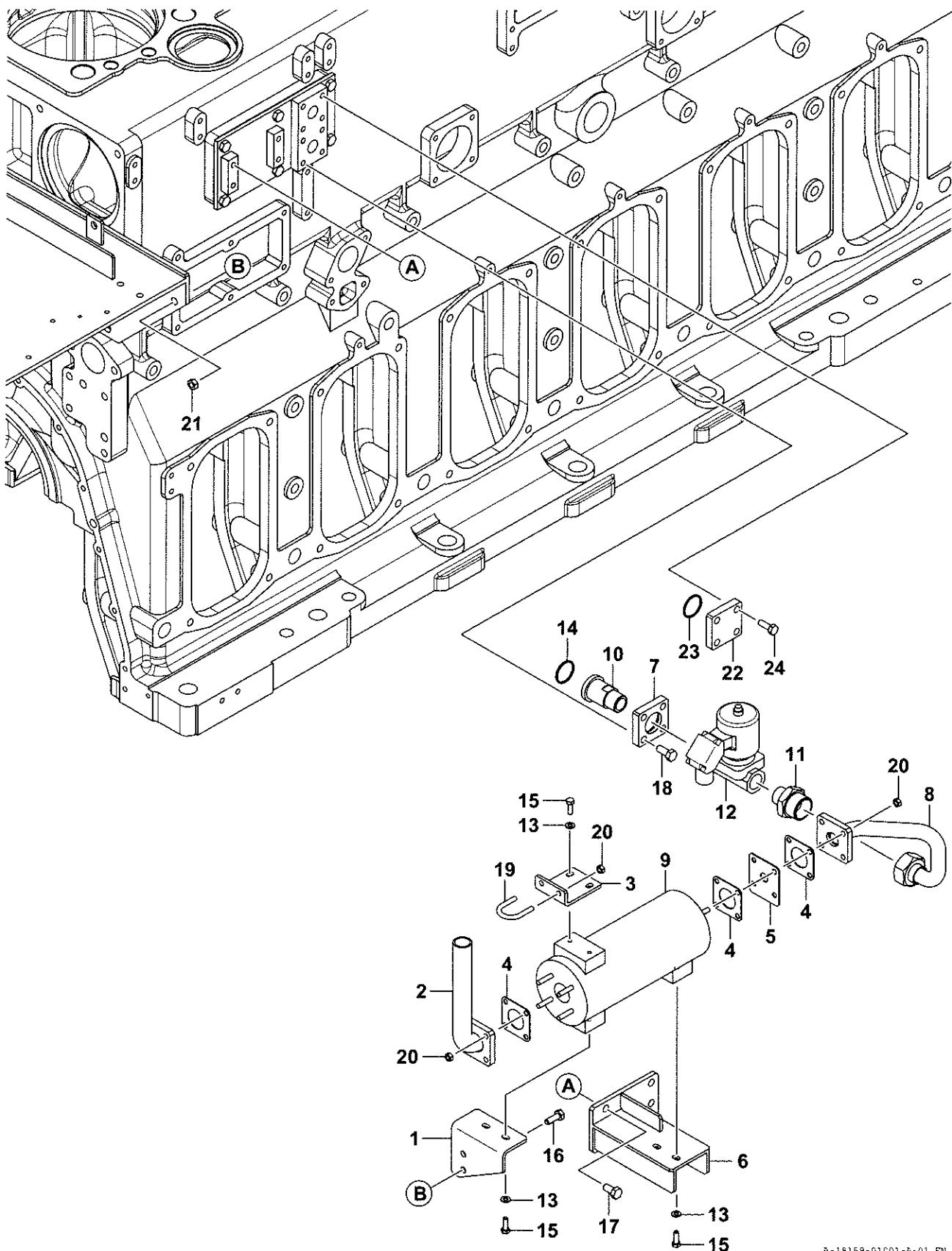
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No	LV	Part No.	Part name	ALWS	Remarks
1	1	153603-18910	JOINT, SNAP	1	
2	1	23163-060007	NIPPLE,R 3/4	1	
3	1	146623-18400	VALVE ASSY	1	
4	1	23414-270000	GASKET, 27 X 1.0	1	
5	1	146623-18900	SOCKET,G3/4-G3/4	1	
6	1	23414-270000	GASKET, 27 X 1.0	1	
7	1	146623-18910	GASKET,21X0.25	1	
8	1	146623-18920	GASKET,21X0.5	1	
9	1	146623-18930	GASKET,21X0.75	1	
10	1	153603-18851	TANK, WASHER MET	1	
11	1	146670-18150	JOINT(10K,COCK 15	1	
12	1	146670-18160	CAP NUT(10K COCK 15	1	
13	1	153603-18880	COVER, WASHER	1	
14	1	153603-18910	JOINT, SNAP	1	
15	1	146670-18390	THROTTLE	1	
16	1	23161-100607	BUSH,R 1 X 3/4	1	
17	1	23163-060007	NIPPLE,R 3/4	1	
18	1	23414-300000	GASKET, 30 X 1.0	1	
19	1	153605-49940	VALVE, BALL A	1	
20	1	43600-023250	VALVE, BALL	1	
21	1	153603-18900	JOINT, SNAP	2	
22	1	153603-18920	HOSE ASSY, 10M	1	

Supply air release

Illustrated parts data

1/2



A-16159-01001-A-01_EN

Supply air release

Illustrated parts data

2/2

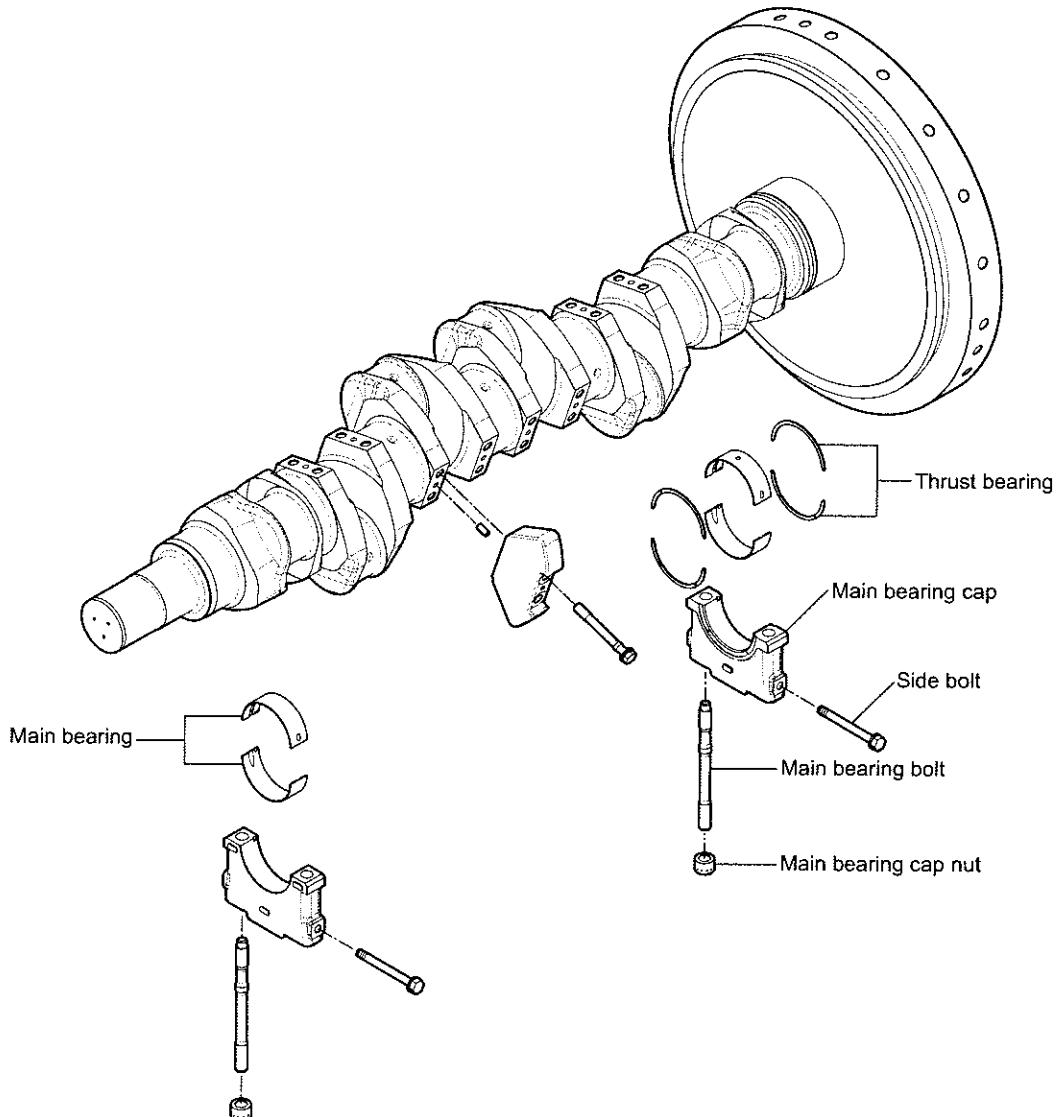
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150635-12360	SUPPORT,AIR REGULATO	1	1	
2	1	150635-12400	PIPE,A AIR REGULATOR	1	1	
3	1	150635-12410	SUPPORT,AIR REGULATO	1	1	
4	1	150635-12420	PACKING,SUC. OUT	3	3	
5	1	150635-12430	ORIFICE,18 SUC OUT	1	1	
6	1	150635-12500	SUPPORT,AIR REGULATO	1	1	
7	1	150635-12510	FLANGE	1	1	
8	1	150635-12530	PIPE,B AIR REGULATOR	1	1	
9	1	150635-12600	SILENCER,AIR REGULAT	1	1	
10	1	146623-73241	PIPE, START AIR	1	1	
11	1	147673-73620	UNION, R1XM45	1	1	
12	1	150633-73800	SOLENOID VALVE	1	1	
13	1	22137-080000	WASHER, 8	6	6	
14	1	24321-000400	PACKING, G 40.0	1	1	
15	1	26206-080252	BOLT, 8 X 25	6	6	
16	1	26206-100302	BOLT, 10 X 30	2	2	
17	1	26206-120252	BOLT, 12 X 25	4	4	
18	1	26206-120302	BOLT, 12 X 30	4	4	
19	1	26464-025000	U-BOLT, 25	1	1	
20	1	26706-080002	NUT, 8	10	10	
21	1	26706-100002	NUT, 10	2	2	
22	1	150635-01220	FLANGE,BLANK	1	1	
23	1	24321-000400	PACKING, G 40.0	1	1	
24	1	26206-100302	BOLT, 10 X 30	4	4	

Main bearing

Description of function

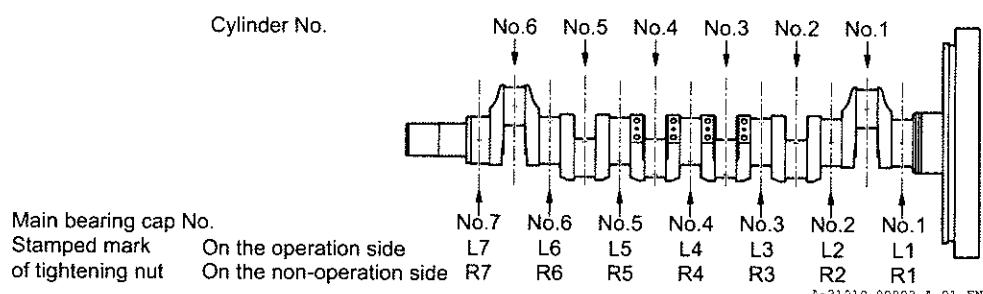
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- The main bearing cap is a hanger type and firmly fastened to the cylinder block with 2 main bearing bolts and 2 side bolts. When you disassemble and assemble the fastening nut of the main bearing cap, use the special hydraulic tool.
- The main bearing and crank pin bearing are made of aluminum.
- The thrust bearings are installed on the front and back of the main bearing cap that is nearest to the flywheel.



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Fig.1 Main bearing outline



A-21010-00002-A-01_EN

Fig.2 Main bearing numbers

The main bearing caps cannot be removed through the cylinder side cover.

Main bearing

Inspection and maintenance

1/8

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION Make sure that the crankshaft does not turn spontaneously when you disassemble or assemble the main bearing cap. To do so, engage the main bearing cap with the turning gear and lock it with a lock bar.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	18 h
	b	Engine crew	Intermediate	-	18 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Body	150633-92100	1 pc
	Mounting bolt (M10 × 65)	26206-100652	2 pc
	Drawing-out bolt	26206-121554	1 pc
	Nut	26706-120002	1 pc
	Disassembly tool B	146673-92120	2 pc
	Support nut	150633-92110	2 pc
	Top bearing detaching/attaching pin	153604-92970	1 pc
	Hydraulic pump	746673-92112	1 pc
	Hydraulic jack	150633-92650	2 pc
	Spacer	150633-92510	2 pc
	Spacer bolt	150633-92680	2 pc
	Angle elbow	151605-92740	2 pc
	Female coupler	153625-92780	2 pc
	Turning handle	146673-92510	1 pc
	Nut (M36)	26732-360002	2 pc
	Bolt (M4)	26116-040122	2 pc
	Top bearing inserting tool	150633-92950	1 pc

SUPPLIES	Nomenclature	Identification code	Quantity
SPARES	Nomenclature	Identification code	Quantity

Obey the instructions that follow when you adjust the main bearing according to the periodical inspections table.

1. Disassembly

1. Remove the bearing and the adjacent cylinder side cover.
2. Remove the side bolts of the bearing on the operation and non-operation side.
3. Set the piston adjacent to the main bearing to a position of approximately 120° before or after top dead center.
4. Simultaneously remove the 2 main bearing cap tightening nuts together with the hydraulic jack.

Hydraulic jack - Operation procedures (Paragraph 2)

Hydraulic jack - Description of function 9201-000-01

When you cannot turn the handle, slowly increase the hydraulic pressure and turn again.

Do not increase the pressure to more than 63.7 MPa.

5. Loosen the side bolt of the adjacent main bearing cap. This makes the main bearing cap easier to remove.
6. Loosen the nuts of the main bearing 2 to 3 turns with the turning handle.
7. Lock the body 1 of the drawing-out tool with the bolt 4 to the main bearing cap bolt. (Refer to Fig. 1.)
8. Install the drawing-out bolt 2 and nut 3 to the main bearing cap.

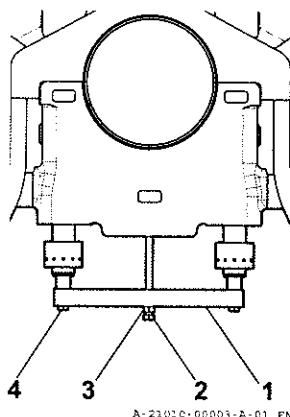


Fig. 1 Installing the drawing-out tool

9. Turn the nut 3 to remove the main bearing cap. (Refer to Fig. 2.)

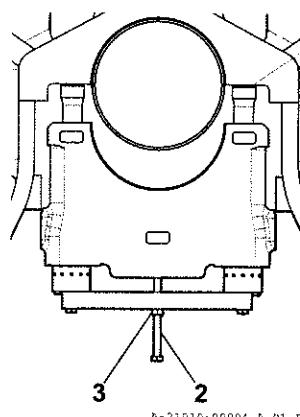


Fig. 2 Removing the main bearing cap

10. Remove the drawing-out tools 1, 2, 3, 4.
11. Remove the tightening nut of the main bearing cap on one side.

- 12.Immediately install the cap support tool 5 and support nut 6 to the main bearing cap bolt. (Refer to Fig. 3.)
 13.Adjust the position of the support nut to hold the main bearing cap.

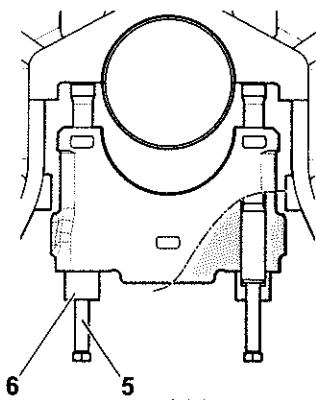


Fig.3 Holding the main bearing cap

- 14.Carefully loosen the support nuts. First, loosen all nuts only a little bit. Then loosen each nut some more. Continue until all nuts are loose. Then lower the main bearing cap.
 15.Remove the bottom main bearing. (Refer to Fig. 4.)

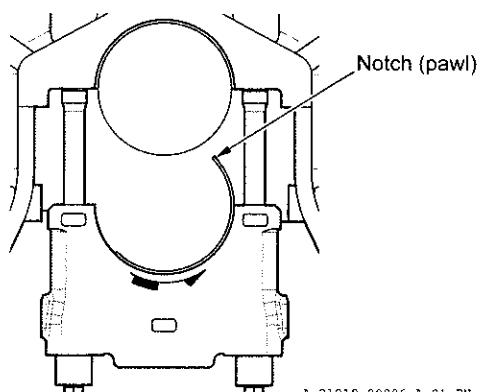


Fig.4 Removing the bottom bearing

- 16.Install the detaching pin 7 to the crankshaft oil hole that is on the non-operation side. (Install the detaching pin so that its head lies along the outer diameter of the crankshaft. Refer to Fig. 5.)
 17.Slowly turn the flywheel in the direction of engine rotation. Remove the top bearing towards the operation side.

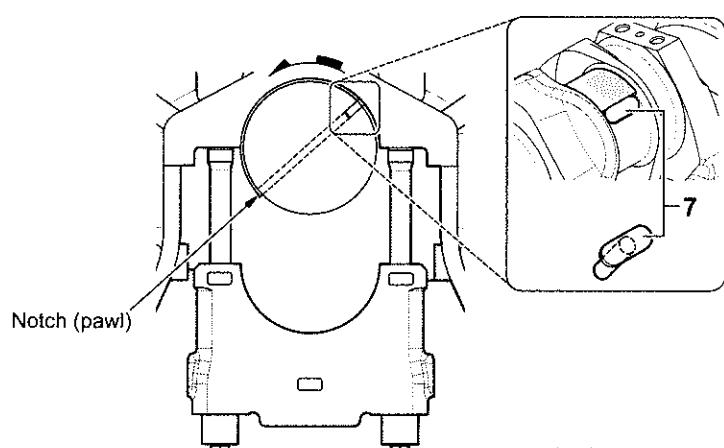


Fig.5 Removing the top bearing

18. To remove the thrust bearings, first remove the main bearing cap. Remove it downwards in the same way as the other main bearing caps.

The bottom thrust bearing is locked to the main bearing cap with 2 pins on the front and back. To remove it, press the end face in the direction of the shaft.

To remove the top thrust bearing, press the end face against the shaft. Press it with a wooden tool (e.g. a wooden spatula). This prevents damage to the bearing.

2. How to operate the hydraulic jack

1. Put a spacer 2 into the tightening nut.
2. Lock with the spacer lock bolt 1 to the main bearing cap nut.
3. Tighten the spacer bolt 5 by hand until it touches the end of the main bearing cap tightening nut.
4. Put the hydraulic jack 3 on the spacer bolt.
5. Tighten the spacer bolt tightening nut 4.
6. Make sure that the distance between the piston of the hydraulic jack and the end face of the body is not more than 1.5 mm. (See A in Fig. 6.)
7. Loosen the spacer bolt tightening nut by 1/2 turn.
8. Connect the hydraulic jack with the rubber hose 7.
9. Remove the spacer lock bolt.
10. Close the relief valve of the hydraulic pump. Operate the pump lever and increase the hydraulic pressure to the specified value.
Specified hydraulic pressure: $58.8 \text{ MPa} \pm 0.5 \text{ MPa}$
11. Insert the handle 6 into the hole of the nut through the turning window of the spacer. Then turn the nut.
12. Gradually open the relief valve of the hydraulic pump and decrease the hydraulic pressure to 0 (zero).
13. Tighten the hydraulic jack spacer bolt tightening nut until it fits well. This drains the oil from the jack.
14. Disconnect the rubber hoses and the couplers from the hydraulic jack.
15. Remove the tightening nut, hydraulic jack, spacer and spacer bolt.

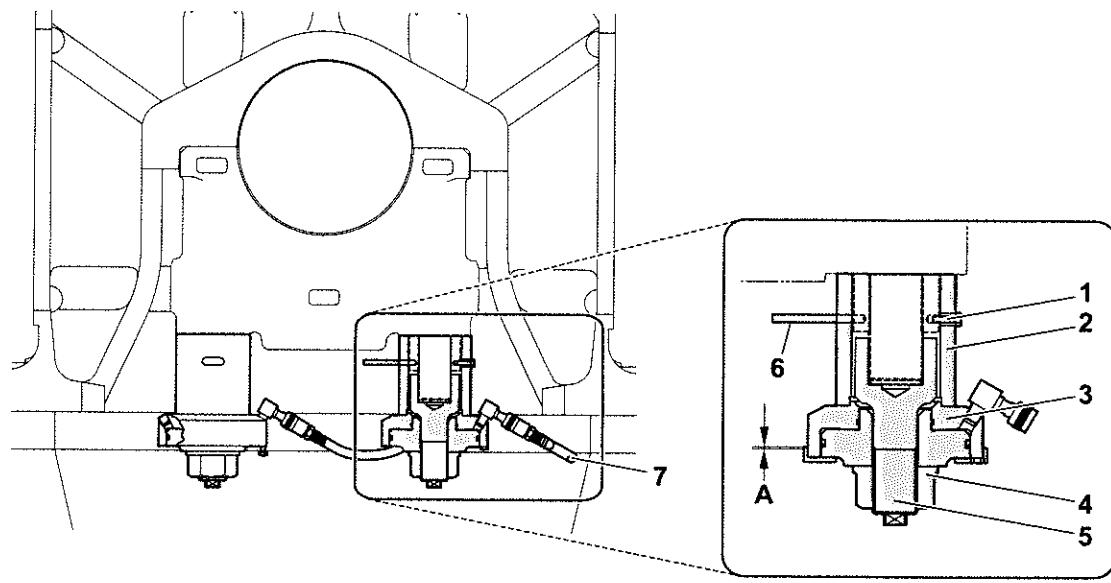


Fig.6 Operating the hydraulic jack

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3. Inspection

1. Main bearings

- 1 - Check for hit marks and flaws on the mating surfaces of the main bearing cap fitted with and against the cylinder block.
- 2 - Check for hit marks on the mating surface and rear of the main bearings. Also check for flaws, seizures and bite-in of unwanted material on their sliding surface.

NOTICE

Do not correct the rear and sliding surface of the main bearings or the thrust bearings. Such a corrective repair changes the clearance between the bearing and the crankshaft.

- 3 - Make sure that the cap tightening bolt of the main bearing is tight.

Stud torque: 200 (0 to +50) N·m

- 4 - Measure the clearance between the crankshaft and the bearings.

- 1 - An accurate method to measure the clearance is this:

- Remove the crankshaft.
- Measure its outer diameter.
- Measure the inner diameter of the main bearing cap.
- The difference is the clearance.

- 2 - To measure the clearance without removing the crankshaft:

- Put a lead wire with a diameter of about 0.5 mm on the sliding surface of the bottom main bearing. (Do it along the crankshaft to prevent the lead wire from slipping with grease.) Tighten the main bearing cap to the specified hydraulic pressure. Take out the lead wire and measure its thickness. This is the clearance between the crankshaft and the bearings.

- 5 - If the clearance is more than the permitted wear limit, replace the bearing with a new one.

NOTICE

If you replace the bearing, make sure that you replace the top bearing and the bottom bearing together as a pair.

If the crankshaft is very worn or unevenly worn, replace the bearings with undersized bearings. In that case, it is necessary to polish the crankshaft until it fits the undersized bearings.

2. Thrust bearings

- 1 - Examine the thrust bearing for wear and seizure.
- 2 - Measure the clearance of the thrust bearing:
 - 1 - Install the dial gauge stand to the cylinder block.
 - 2 - Put the dial gauge in contact with the crankshaft.
 - 3 - Move the crankshaft forward to set the indicator of the gauge to 0 (zero).
 - 4 - Move the crankshaft backward.
 - 5 - Read the value indicated by the gauge. The indicated value is the thrust clearance.
- 3 - If the clearance is more than the permitted value, replace the top and bottom thrust bearings as a pair.

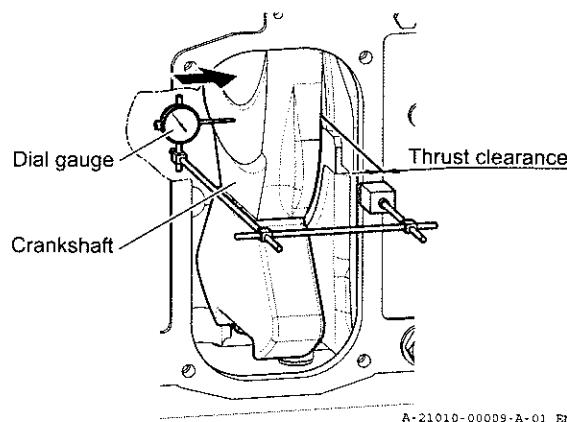


Fig.7 Measuring the clearance of the thrust bearings

NOTICE

When you install the thrust bearings, obey these instructions:

- Install each of the top and bottom bearings of the front and rear parts in their correct original position. Be careful not to mistake one for another.
- Align the printed part of the top bearing with the cylinder block side and move it along the crankshaft. Install it.
- Install the bottom bearing by mating its groove with the crankshaft side.

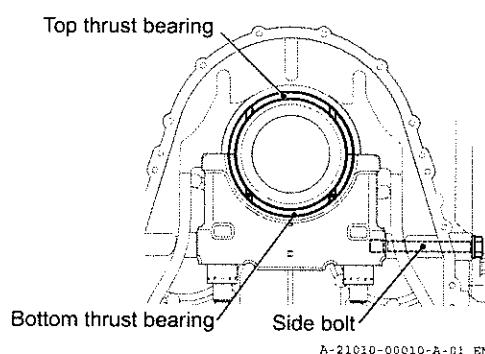


Fig.8 Installation of the thrust bearing

4. Assembly

1. Turn the flywheel and move the crankshaft oil hole below the center of the crankshaft.
2. Move the pawl of the top bearing towards the non-operation side. Align the pawl along the crankshaft and put the pawl into the pawl hole.
3. The pawl must mate with the pawl hole of the cylinder block. (This is a back-and-forth position.)
4. Install the top bearing inserting tool 8 to the main bearing cap (the bottom bearing is detached from the main bearing cap). To install it:
 - On one end, the round end face (R) must align with the outer (non-operation side) main bearing cap clamping bolt.
 - On the other end, the stepped part must mate with the inner (pawl hole side) main bearing cap.
5. Install the detaching pin 7 to the crankshaft oil hole that is on the non-operation side.
 - Put the head of the pin along the outer side of the crankshaft.
 - Apply grease to the pin to prevent it from falling during turning.
6. Tighten the support nut 6 of the main bearing cap holding tool until the top bearing inserting tool almost touches the rear of the bearing.

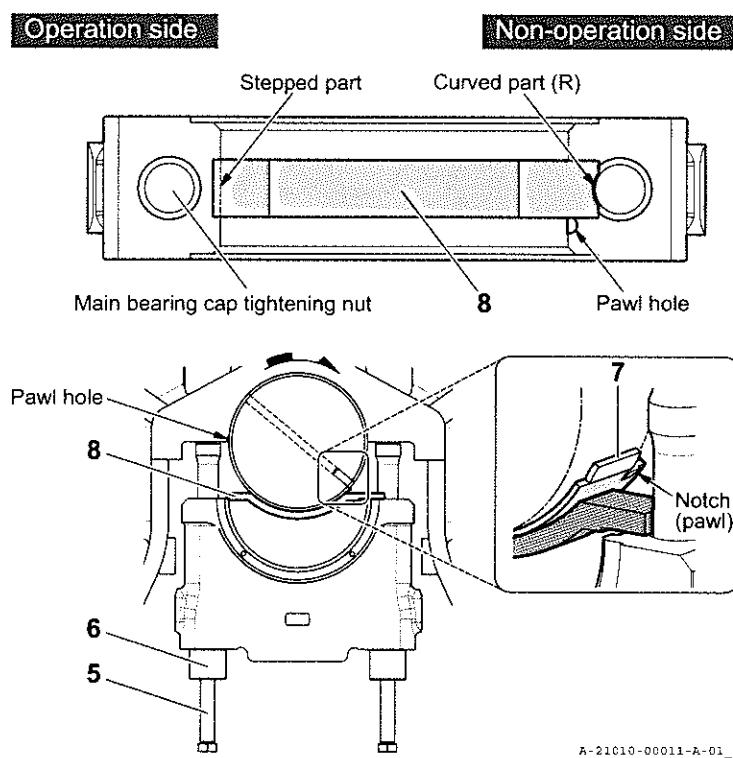


Fig. 9 Installing the top bearing

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7. Slowly turn the flywheel in the direction opposite to engine rotation.

NOTICE

Make sure that the side of the pawl of the top bearing touches the side of the bearing inserting tool. If they do not touch, the pawl does not fit in the pawl hole.

8. When the pawl of the bearing is aligned with the pawl hole in the cylinder block, continue to turn the flywheel until the bearing end aligns with the cylinder block end.
9. Loosen the support nut and lower the main bearing cap.
10. Remove the attaching/detaching pin and bearing inserting tool.
11. Install the bottom bearing.

- 12.Tighten the support nut.
- 13.Remove the holding bolt 5.
- 14.Remove the support nut. Install the tightening nut of the main bearing cap.
First install the nuts of the main bearing cap on one side, then on the other side.
The main bearing cap can fall and cause injury.
- 15.Install the nuts of the main bearing cap. Tighten them until the main bearing cap touches the cylinder block.

NOTICE

If you loosened the side bolts of the adjacent bearing during disassembly, tighten them now to the specified torque. First, do it on the operation side, then on the non-operation side.

- 16.Tighten the side bolt on the operation side to half of the specified torque. (Remove the bolt on the non-operation side.)
- 17.Tighten the side bolt on the non-operation side by hand until it is seated.
- 18.Tighten the nut of the main bearing cap to the specified hydraulic pressure.
Hydraulic jack - Operation procedures (Paragraph 2)
- 19.Tighten the side bolt on the operation side to the specified torque.
- 20.Tighten the side bolt on the non-operation to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

NOTICE

After you install the main bearing, measure the crankshaft deflection.
Refer to the separate document for measuring instructions.
How to measure the crankshaft deflection 2102-000-06

CONDITION Standard clearance at installation 0000-000-07

- The crankshaft is made of forged alloy steel. The pins and journals are induction-hardened and then polish-finished. Each arm has balance weights that decrease the engine vibration.

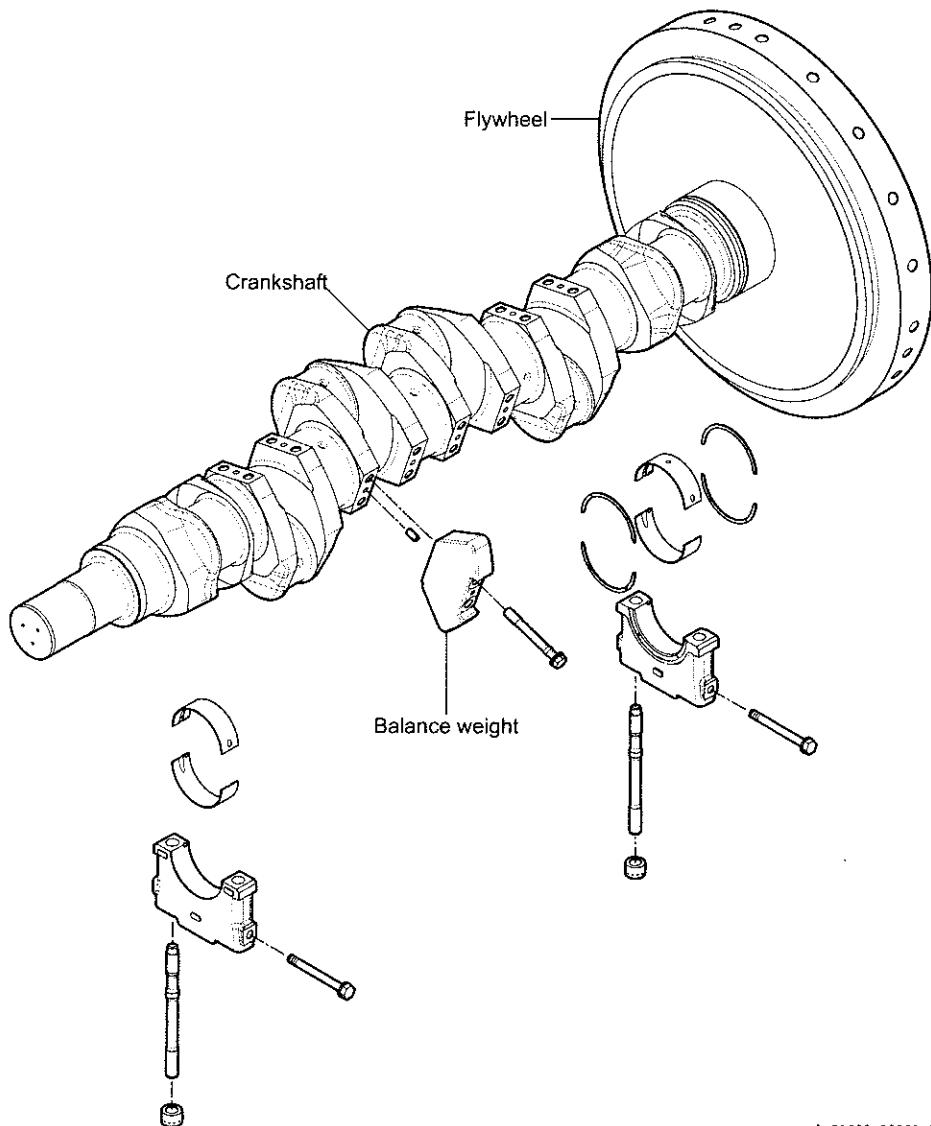


Fig.1 Crankshaft - Description of function

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Crankshaft

Inspection and maintenance

1/2

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION Carefully examine and measure the crankshaft. The conditions that follow can cause breakage or burn damage of the crankshaft:

- Uneven wear on the crankshaft
- Too much clearance of the bearings (because of wear on the crankshaft)
- Operation exceeding the permitted values for crankshaft deflection
- Operating in the critical region of torsional vibration rotation speed

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	4 h
	b	Engine crew	Intermediate	-	4 h
	c	Engine crew	Intermediate	-	4 h
	d	Manufacturer service engineer	Advanced	-	4 h

EQUIPMENT	Nomenclature	Identification code	Quantity

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity

SAFETY			

Obey the instructions that follow when you do maintenance of the crankshaft.

1. Disassembly

1. The procedure to remove the crankshaft is the same whether you lift the engine and remove the crankshaft downwards or turn the engine upside down and remove the crankshaft upwards.
(The engine lifting tool is available as an option.)
2. Loosen the side bolt and the tightening nut of the main-bearing cap , and remove the main-bearing cap.
3. Attach a lifting rope to the No. 2 and No. 5 crank pin parts.
4. Lift and remove the crankshaft vertically.

2. Inspection

1. Examine the bearings for flaws, bad contact and unusual wear.
2. Do a color-check on the root area of the crank arms.
3. Make sure that the balance weight tightening bolts are tight.
4. Measure the dimensions of the bearings. Examine the bearings for uneven wear.

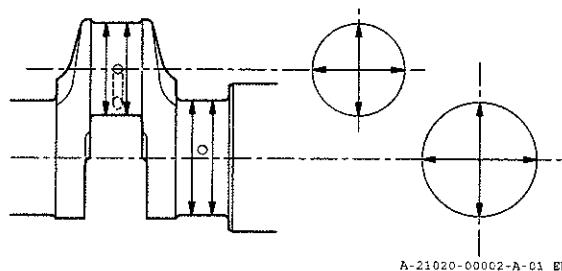


Fig. 1 Measuring locations for the crankshaft bearings

NOTICE

If the crankshaft bearing has seizure, repair or replace the main bearing or thrust bearings. Also, examine the crankshaft for hair cracks:

- Measure the surface hardness.
- Do a magnetic check for deep flaws.

Crankshaft surface hardness: must be between HS 65 and 85

Hair cracks: not permitted

Make sure that the crankshaft is in good condition and does not have flaws, too much wear or hair cracks.

3. Assembly

1. When you assemble the crankshaft, clean all parts and make sure that there is no dirt, flaw or rust.
2. If it is difficult to install or remove the crankshaft, change the position of the crane.
3. Lastly, measure the thrust clearance of the crankshaft.
Design data/tolerances check 0000-000-07
4. Make sure that you can easily turn the crankshaft.
If you cannot turn it, examine all parts again. Adjust until the crankshaft turns easily.
5. When the flywheel is assembled, the crankshaft is matched to the knock pin of the flywheel.
6. Tighten the flywheel bolt by the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

CONDITION

PRODUCTION MANAGEMENT DATA

Intervals 6 months
2000 working hours

CONDITION When you install the crankshaft, measure the crankshaft deflection (the open position and the closed position of the crank arms). The result tells you if the center of the crankshaft is in the correct position or if the main bearings have wear.
Measure the deflection at regular intervals. If the crankshaft deflection becomes too large, the crankshaft can break.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	3 h
	b	Engine crew	Intermediate	-	3 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Deflection gauge		42111-002520		1 pc
	Deflection gauge mirror		42111-001421		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do maintenance of the crankshaft.

Measure the crankshaft deflection every time you remove or tighten:

- The engine installation bolts
 - The common bed tightening bolts
 - The tightening bolts of driven equipment (such as a generator).
- Obey the instructions that follow.

- Measure the crankshaft deflection when the engine is cold.
- Move the contact of the deflection gauge and make sure that the dial gauge needle goes back to the initial position.

1. How to measure deflection

1. Open the pressure indicator cocks on all cylinders.
2. Turn the flywheel to 30° after bottom dead center. This is the EB position.
3. Install the deflection gauge at the D/2 position.
4. Set the dial gauge needle to 0 (zero).

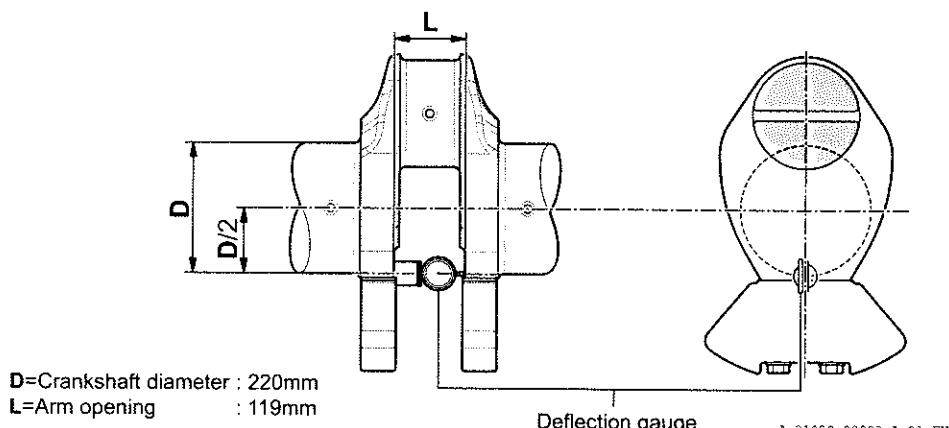
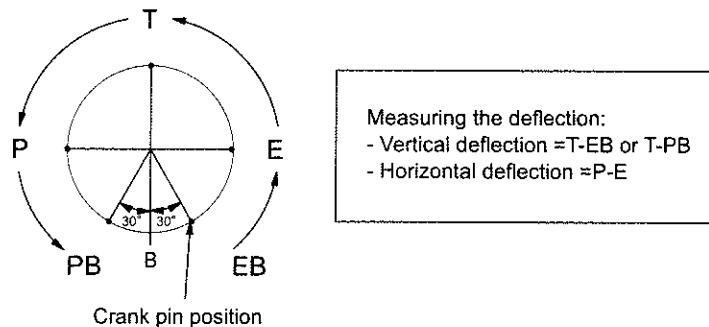


Fig.1 Installing the deflection gauge

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5. Slowly turn the flywheel in the direction of engine rotation. Record the readings of the dial gauge at the crank pin positions E, T, P and PB.



EB : 30° after B.D.C. (exhaust manifold side)
 E : 90° before T.D.C. (exhaust manifold side)
 T : T.D.C.= top dead center
 P : 90° after T.D.C. (fuel injection pump side)
 PB : 30° before B.D.C. (fuel injection pump side)
 B : B.D.C.= bottom dead center

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Fig.2 Deflection measurement locations

2. How to evaluate the results of the deflection measurement

1. Measure the vertical deflection by calculating the difference between T and PB or EB. The horizontal deflection is calculated by the difference between P and E.

The relation between the deflection readings at each crank pin position and the open and closed positions of the crank arms are defined in Fig. 3.

Dial gauge reading	+	-
Crankshaft		

A-21020-00005-A-01_EN

Fig.3 Crankshaft deflection and open/closed positions of the crank arms

- If the deflection increases every time it is measured, the crankshaft or the main bearings are probably worn. If the deflection increases suddenly in only one cylinder, the corresponding main bearing probably has unusual wear. In these cases, do a check of the relevant parts.
- If deflection is measured when the engine is hot, the results will vary largely depending on the engine temperature at the time of the measurement. The measurement is not reliable. According to our test results, that deflection is approximately 2/10000 to 3/10000 × stroke value (bottom closed).

3. Permitted deflection

- If the crankshaft deflection is more than the permitted amount, correct the deflection. Consider the distribution of the attachment shims and the center of the crankshaft of the engine and driven machines (or outer bearings).

NOTICE

For the direct coupling systems A and C, the normal deflection for the No. 1 cylinder is "bottom closed". For the direct coupling system B, adjust the deflection for the No. 1 cylinder until the bottom opens. This is because during operation, the temperature increase in the engine bearings is greater than that in generator bearings, and the crankshaft rises.

Coupling system	Driven machine	Installation system	Cylinder No. 1		Cylinders No. 2 to No. 6
			(T-PB, T-EB)	(P-E)	(T-PB, T-EB) (P-E)
A (direct coupling)	Generator (one-sided bearing)	Attached (lock)	-6.4 to +3.2 (-2S to 1S /10000)		
B (direct coupling)	Generator (double-sided bearing)	Attached (lock)	±3.2 (±1S /10000)	±3.2 (±1S /10000)	±3.2 (±1S /10000)
C (air clutch and flexible coupling)	Pump and compressor	Attached (lock)	-9.6 to +3.2 (-3S to 1S /10000)		

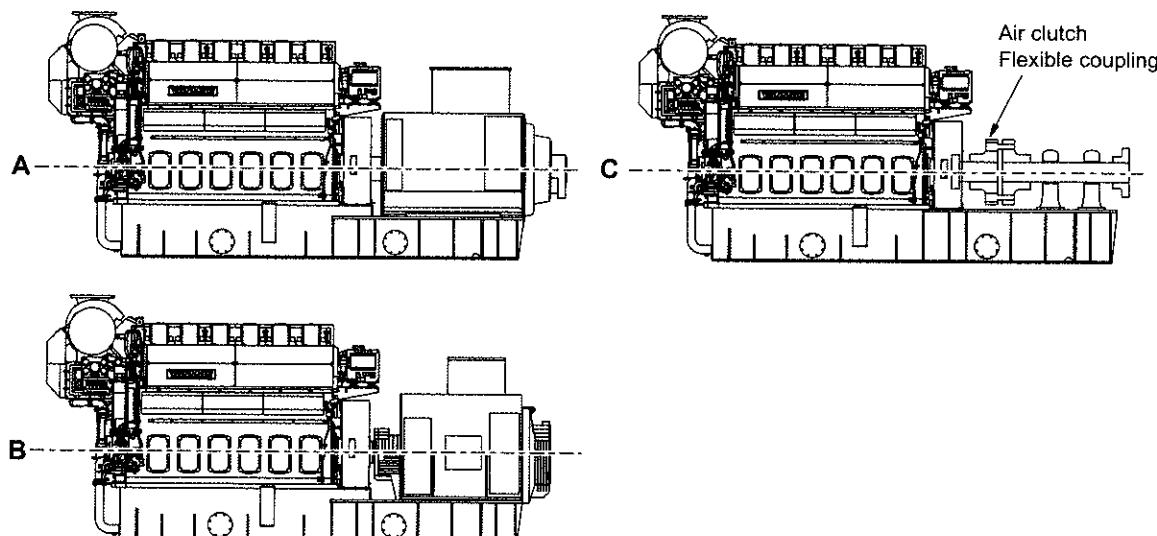
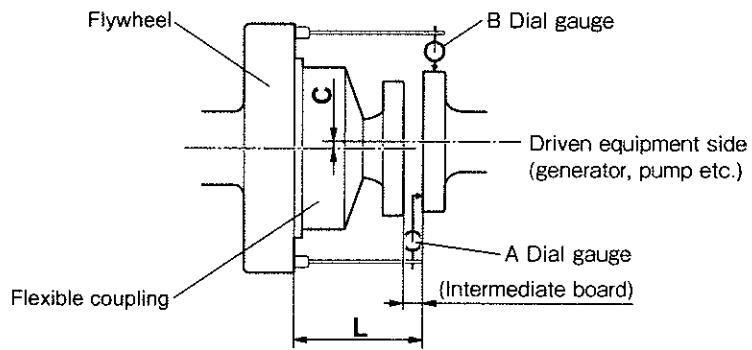


Fig. 4 Driven machine direct coupling system

A-21020-00006-A-01_EN

4. Centering with the flexible joint couplings

1. Make sure that the crankshaft deflection for cylinders No. 2 to No. 6 agrees with the permitted values.
2. Remove the intermediate plate from the flexible coupling area.
3. Measure the length L across the faces of the coupling.
4. Install a dial gauge on the flexible coupling.
5. Turn the flywheel and measure the deflection on the face and outer circumference.



A-21020-00007-A-01_EN

Fig.5 Centering

6. Install the intermediate board and the reamer bolts.
7. Standard values

Face deflection: Less than 0.2 mm (dial gauge at point A)

Outer circumference deflection: Less than 0.1 mm (dial gauge at point B)

In engines that have a flexible coupling or a single bearing generator, install all parts on the driven equipment side (generator, pump etc.) 0.2 mm higher than measured. This makes up for sag from the flywheel.

CONDITION

1. Flywheel

- The flywheel is installed on the output side of the crankshaft rear end.
- Be careful not to touch moving parts when you turn the flywheel. Be careful not to hurt people near you.
- Before you start your work, make sure that the crankshaft does not turn spontaneously. To do so, securely lock the flywheel to prevent the crankshaft from turning.

2. Turning switch

- The ON/OFF signal from this switch is a starting condition in the automatic and remote starting circuits of the engine. When the turning gear is disengaged, the contact of the limit switch is ON. When the turning gear is engaged, the contact of the limit switch is OFF and you cannot start the engine (automatically or remotely).
- This switch is on the bottom of the turning gear on the operation side. It prevents an automatic or remote start while the engine is turning.
- Because this switch is turned on when the roller is inserted, the main terminal in use is the COM-NO terminal.
- The NC terminal is not used. Do a performance test on this switch at intervals of 3 months.

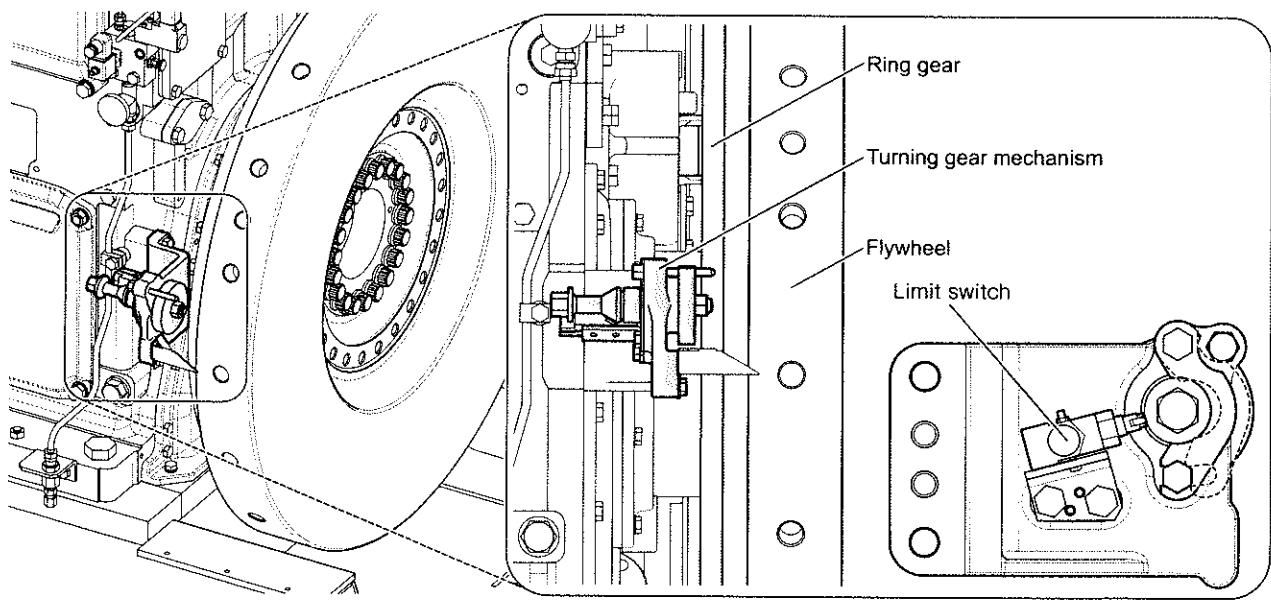


Fig.1 Turning switch

3. Speed pickup sensor

- The solenoid pickup sensor is near the outer edge of the flywheel ring gear. It detects the engine speed.

Flywheel

Adjust

1/1

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals Unscheduled Make sure that you adjust the clearance when you replace or remove the solenoid pickup sensor.			
PERSONNEL	Person	Category	Skill	Trade
	a	Engine crew	Intermediate	-
EQUIPMENT	Nomenclature		Identification code	Quantity
SUPPLIES	Nomenclature		Identification code	Quantity
SPARES	Nomenclature		Identification code	Quantity
SAFETY				

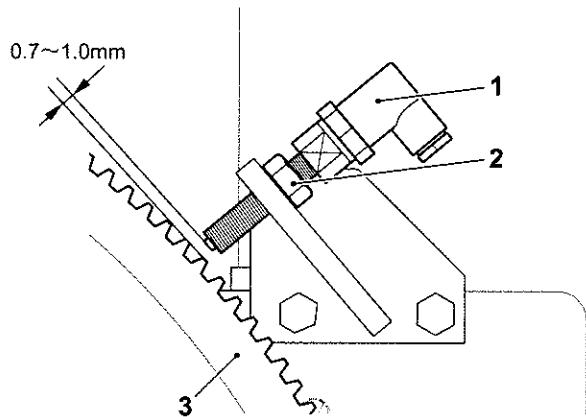
Obey the instructions that follow when you adjust the main bearing according to the periodical inspections table.

1. Adjust the screw in the solenoid pickup sensor 1 so that the clearance between the pickup sensor tip and the flywheel's outer edge of the ring gear 3 is between 0.7 mm and 1.0mm. (To do so, screw in the pickup sensor tip until it touches the outer edge of the ring gear. Then turn it back by 1/2 turn. Turn the flywheel, and make sure that the pickup sensor tip does not touch the ring gear. If it still touches the ring gear, then further turn the pickup sensor back by 1/4 turn.)

NOTICE

If you adjust the clearance incorrectly, the engine rotation cannot be measured and the protective device for over-speeding does not activate.

2. Tighten the locknut 2 securely.



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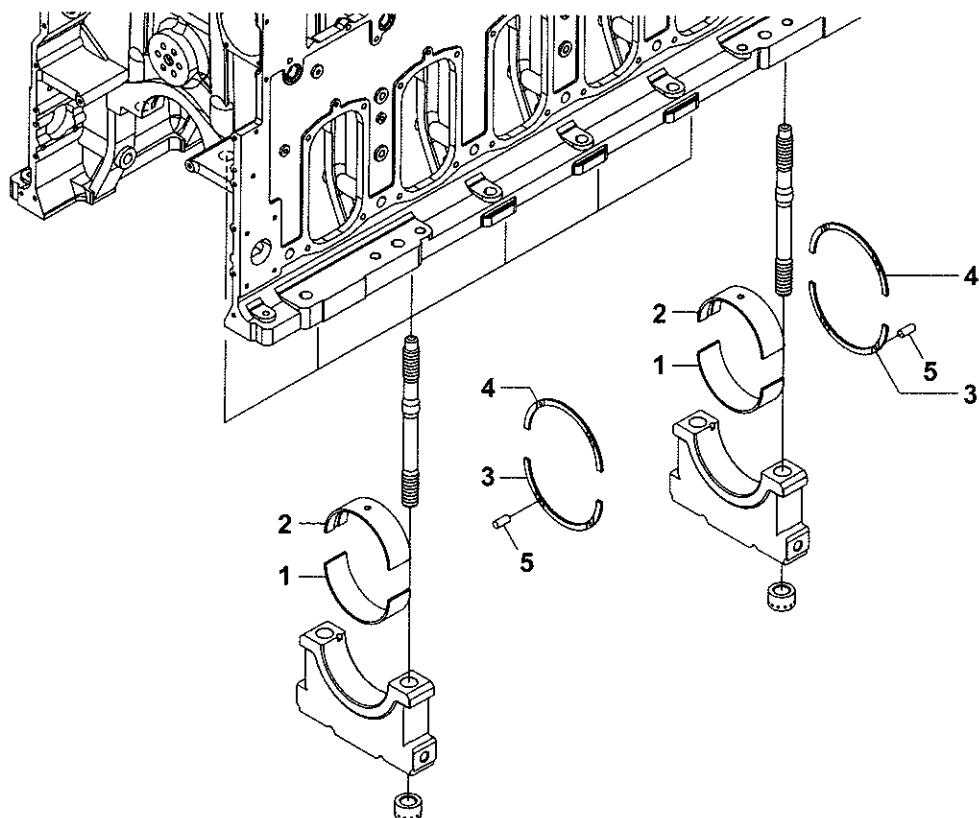
Fig. 1 Installing the solenoid pickup

CONDITION

Main bearing

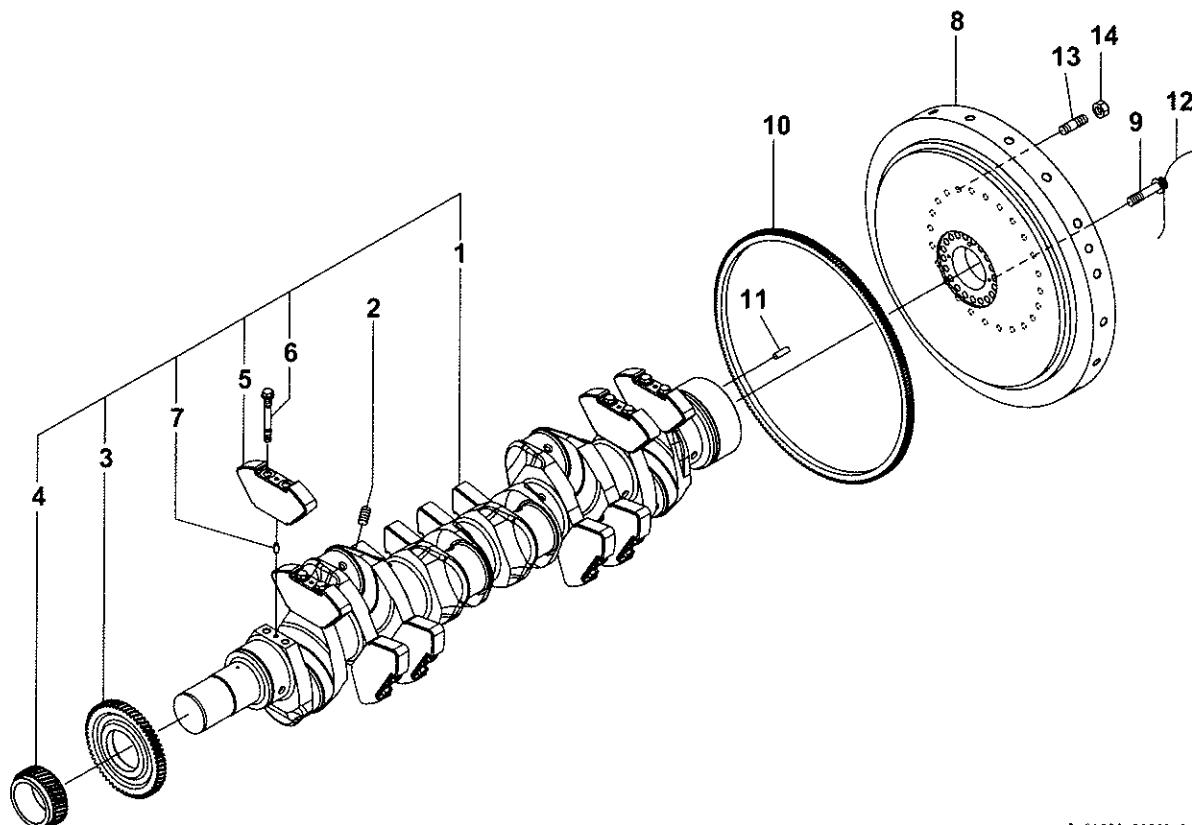
Illustrated parts data

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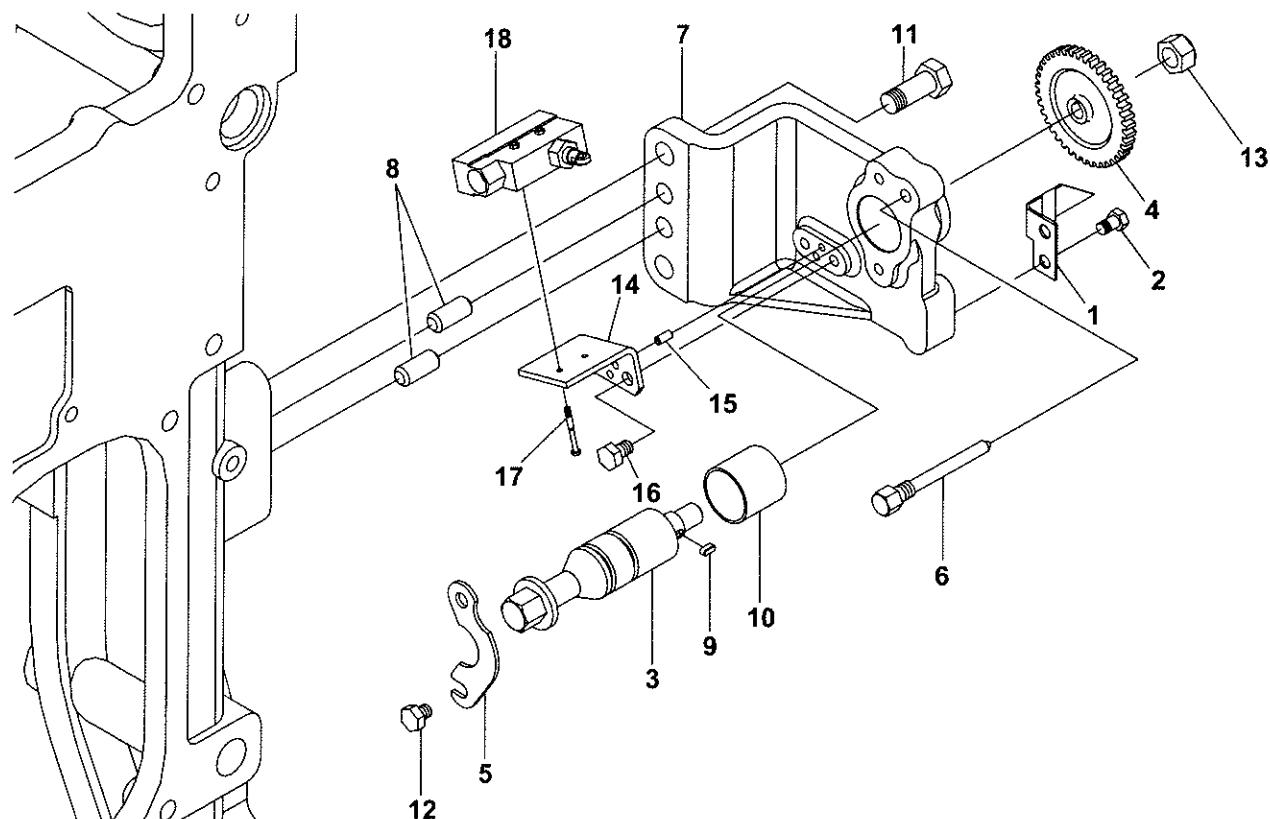
A-21019-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-02210	METAL, MAIN	7	7	
2	1	150633-02220	METAL, MAIN	7	7	
3	1	150633-02160	METAL, THRUST	2	2	
4	1	150633-02170	METAL, THRUST	2	2	
5	1	22312-060120	PIN, 6 X 12	4	4	



A-21029-00001-A-01_EN

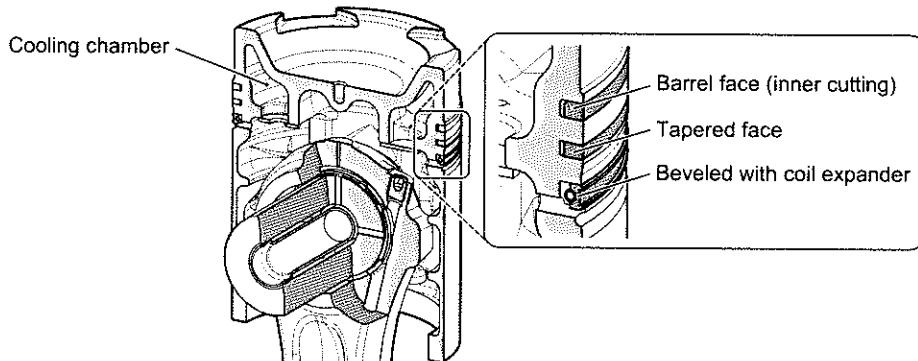
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-21010	CRANKSHAFT	1	1	
2	2	153605-21050	SCREW, M18X2.0	6	6	
3	2	150633-21210	GEAR A, CRANKSHAFT	1	1	
4	2	150633-21220	GEAR B, CRANKSHAFT	1	1	
5	2	147673-21100	WEIGHT, BALANCE	-	12	
5A	2	150633-21110	WEIGHT, BALANCE	12	-	
6	2	146673-21132	BOLT, BALANCE WEIGHT	24	24	
7	2	22312-160300	PIN, 16 X 30	12	12	
8	1	150633-21351	FLYWHEEL, 1080X186	-	1	
8A	1	150633-21301	FLYWHEEL, 1100X280	1	-	
9	1	150633-21501	BOLT, FLYWHEEL	20	20	
10	1	146623-21400	GEAR, RING	1	1	
11	1	22312-160700	PIN, 16 X 70	1	1	
12	1	22451-120000	WIRE, 1.2	1	1	
13	1	26232-200652	STUD,BOLT 20 X 65	24	24	
14	1	26356-200002	U-NUT, 20	24	24	



A-21039-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	147673-07330	POINTER, FLYWHEEL	1	1	
2	1	26206-100162	BOLT, 10 X 16	2	2	
3	1	146673-08300	SHAFT, WHEEL SIDE	1	1	
4	1	146673-08310	GEAR, TURNING	1	1	
5	1	146673-08320	STOPPER, F/W TURNING	1	1	
6	1	146673-08330	BAR, LOCK	1	1	
7	1	150633-08350	BRACKET, TURNING GEAR	1	1	
8	1	22312-160300	PIN, 16 X 30	2	2	
9	1	22512-050120	KEY, 5 X 12	1	1	
10	1	24550-040400	BEARING, 40 X 40	1	1	
11	1	26156-160402	BOLT, 16 X 40	2	2	
12	1	26206-100122	BOLT, 10 X 12	2	2	
13	1	26356-160002	U-NUT, 16	1	1	
14	1	147673-73600	MOUNT, LIMIT SWITCH	1	1	
15	1	22312-060120	PIN, 6 X 12	2	2	
16	1	26206-100162	BOLT, 10 X 16	2	2	
17	1	26557-040352	SCREW, 4 X 35	2	2	
18	1	46150-000960	SWITCH, LIMIT	1	1	

- The piston is a thin-walled, integral structure made of ductile cast iron. Lubricating oil is sent with pressure from the oil hole on the connecting rod to the piston cooling chamber. This so-called cocktail-shaker cooling system decreases the temperature of the top of the piston.
- There are 3 piston rings: 2 compression rings and 1 oil ring. All rings have a chrome plating on their sliding surface.



A-22010-00001-A-01_EN

Fig.1 Piston outline

Inspection and maintenance

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION How often you remove and examine the piston depends on the daily maintenance, especially the control of lubricating oil and load (i.e. overload and very low load). The supervisor must decide the correct frequency. Do the first disassembly and inspection as shown in the table Scheduled inspections. Examine the results of that inspection (e.g. the increase of blowby and the increase in consumption of lubricating oil). Schedule the subsequent inspections accordingly. When the consumption of lubricating oil becomes twice the initial value, disassemble and clean the piston and replace the piston rings.

Examine the carbon buildup on the pistons and the wear of all parts. Schedule the subsequent inspections accordingly.

PERSONNEL	Person	Category/trade	Skill level	Trade	Estimated time
	a	Engine crew	Intermediate	-	18 h
	b	Engine crew	Intermediate	-	18 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Protection ring drawing-out tool	150633-92200	1 pc
	Liner drawing-out tool (top part)	150633-92010	1 pc
	Spacer	150633-92040	1 pc
	Eye bolt	26610-120002	1 pc
	Pliers	28190-000130	1 pc
	Piston insertion guide	150633-92140	1 pc

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity

SAFETY	CAUTION		
<ul style="list-style-type: none"> • The crankshaft can turn spontaneously while you remove or install the piston. This is dangerous. Make sure that the flywheel is locked. Make sure that the crankshaft does not move. • Be careful when you remove the piston pin. If the pliers slip from the circlip hole, the circlip can come off flying and cause injury. • Be careful when you remove the piston rings. Put on gloves because the edges of the rings are sharp and can cause injury. 			

Obey the instructions that follow when you do maintenance on the piston according to the periodical inspections table.

1. Disassembly

1. Removing the piston

1 - Set the piston to approximately 60° to 70° before top dead center.

2 - Put the protection ring drawing-out tool 5 on the piston.

Move its outer taper A in the direction of the piston. Make sure that it does not touch the cylinder liner.

3 - Install the top part of the liner drawing-out tool 3 and the spacer 2. Lock it with the cylinder head clamping nut 1. Refer to Fig. 1.

4 - Turn the flywheel and push the protection ring up.

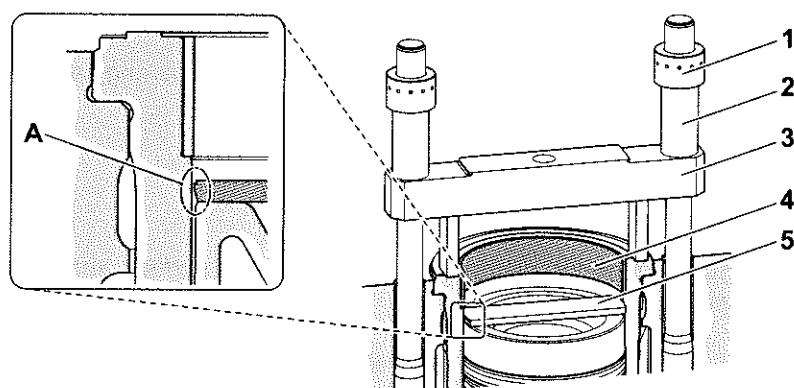


Fig. 1 Removing the protection ring

5 - Remove the disassembling tools and the protection ring.

6 - Remove the carbon from the top part of the cylinder liner.

7 - Set the piston to approximately 72° after top dead center.

8 - Apply a match mark to the connecting rod and the tightening nut.

9 - Loosen the connecting rod tightening nut with the hydraulic jack.

Hydraulic jack - Operation procedures 2202-000-02 (Paragraph 2)

Hydraulic jack - Description of function 9201-000-01

When you cannot turn the handle, slowly increase the hydraulic pressure and turn again. Do not increase the pressure to more than 4.9 MPa.

10 - Remove the cap together with the tightening nut and the bottom bearing.

11 - Remove the connecting rod bolt.

12 - Screw the lifting eye bolt into the piston. Lift it by 20 mm to 30 mm.

13 - Remove the top bearing.

14 - Remove the piston.

Make sure that the connecting rod does not touch the crankshaft or cylinder liner.

2. Removing the piston pin and piston rings

- 1 - Remove the piston pin circlip with pliers.
- 2 - Remove the piston pin while you hold the connecting rod.
- 3 - Obey these instructions when you remove a piston ring.
 - 1 - Make 2 loops from wire (diameter: 40 mm to 50 mm).
 - 2 - Put the loops on the opening of the piston ring. Hold them with your thumbs.
 - 3 - Make the opening larger.
 - 4 - Remove the piston ring.

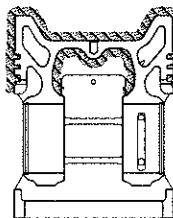
NOTICE

Do not bend the opening of a ring wider than 70 mm. The ring can break.

2. Inspection

1. Examine the contact of the piston skirt and piston hole.
2. Do a color-check and examine the piston for cracks on its top surface and ring groove. Examine the outside and the inside.

※ : Do the color-check on this area.



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Fig. 2 Parts for the color-check

3. Remove the cover of the piston cooling chamber.
4. Look for scale.
5. Measure the dimensions of all piston parts and the piston pin.
6. Consider the time to the next servicing and replace the piston rings with new ones.
7. If you replace the piston with a new one, make the same match mark as on the old piston.

Clearance and wear limits of major parts 0000-000-07

NOTICE

Do not use sandpaper when you clean the piston. The piston skirt has a special coating. (We recommend a carbon removing agent such as Unicon 146 or Neos.)

3. Assembly

1. Install the perforated cover of the piston cooling chamber on the top of the piston. Install it on the side that has a stamp "PUMP SIDE" (operation side).
2. Apply a screw lock agent (Tokyo ThreeBond 1303 or equivalent) to the bolt.
3. Tighten the bolt and install the cover.
4. Align the match marks and install the connecting rod to the piston.
5. When you install a piston pin circlip, make sure that the opening faces straight down.
6. When you install a piston ring, make sure that the stamped side faces up and the openings of the 3 rings are 120° apart.

NOTICE

If the top ring groove was repaired with chrome-plating, do not use the triangular chrome-plated ring.

7. Install the oil ring with its coil joint shifted 180° from the ring opening.

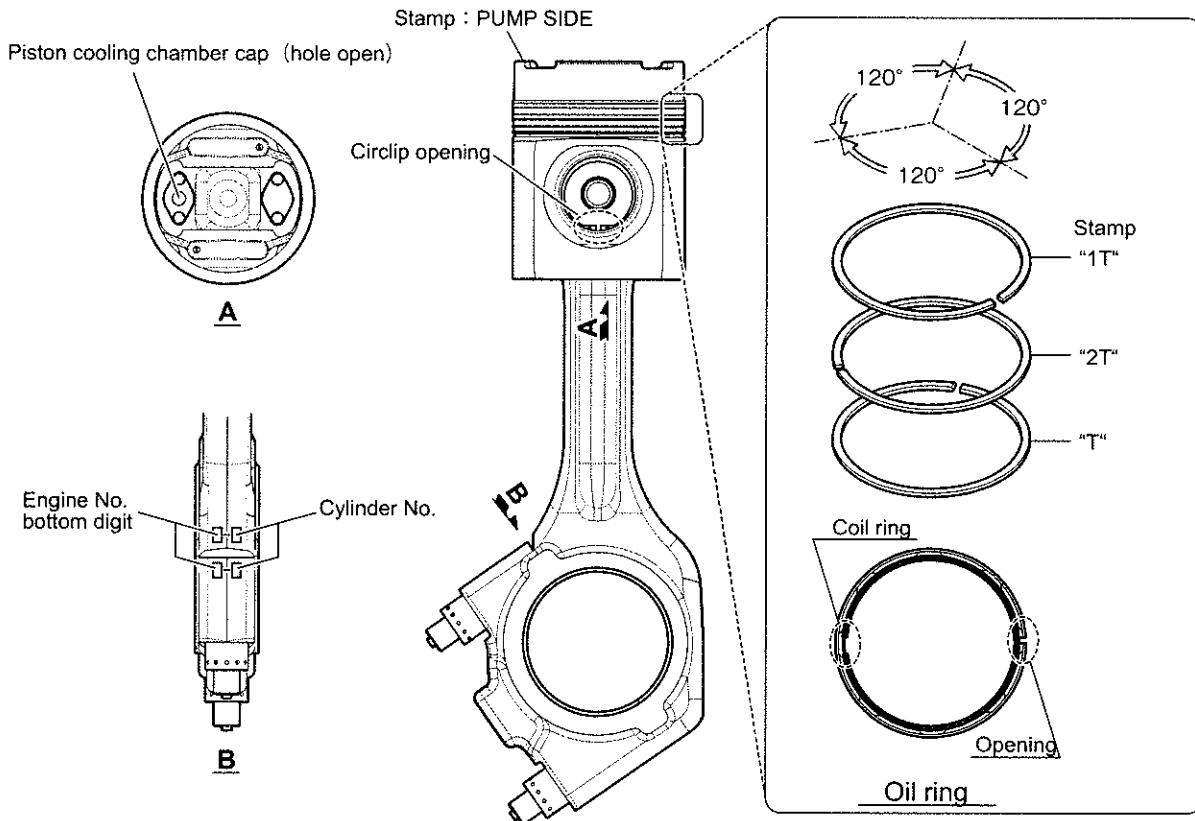


Fig.3 Piston assembly

8. Apply lubricating oil to the piston, cylinder liner and crankshaft.
9. Install the piston inserting guide to the top of the cylinder liner.
10. Screw the eye bolt into the piston head.
11. Lift the piston connecting rod and install it to the upper bearing.

Inspection and maintenance

12. Lift the piston connecting rod and the upper bearing and install them to the cylinder liner.

Make sure that the connecting rod does not touch the cylinder liner or crankshaft.

NOTICE

- Do not apply lubricating oil to the rear of the crank pin bearing.
- Inspection of the crank pin bearing 2202-000-02

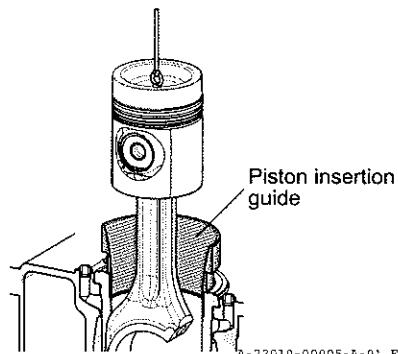


Fig.4 Piston and connecting rod assembly

13. Move the crankshaft to approximately 72° after the top dead center position.

14. Tighten the connecting rod bolt by hand until it touches the bottom.

15. Tighten the square part of the nut with a double-ended wrench (13 mm).

Specified torque: 50 (0 to +5) N·m

16. Align the match marks with the connecting rod body and install the bottom bearing and the cap.

17. Tighten each tightening nut by hand or with a handle until it is seated.

18. Tighten the connecting rod tightening nut with the hydraulic jack.

Hydraulic jack - Operation procedures 2202-000-02 (Paragraph 2)

Hydraulic jack - Description of function 9201-000-01

NOTICE

If you made a new match mark on the connecting rod tightening nut: Make sure that you know which one is the new match mark or the old match mark.

19. Turn the tightening nut for 3 or 4 holes until it is seated.

If you cannot turn the nut until it is seated:

- Examine the nut thread for damage.
- Make sure that the couplers are correctly connected.

CONDITION

- The connecting rod is made of forged carbon steel. The large end of the connecting rod is split diagonally and the joint faces come together in a serration joint.
- The bolts of the connecting rod are stud bolts and hydraulically tightened to obtain stable axial force.
- Use a hydraulic jack and remove or tighten the two connecting rod tightening nuts at the same time.
- For disassemble and assemble procedures, refer to Piston 2201-000-02.
- The crank pin bearing on the large end is made of an aluminum metal with high bearing resistance strength. The small end bearing is made of a thin lead bronze metal with a steel backing plate. The plate has excellent break-in characteristics and durability.

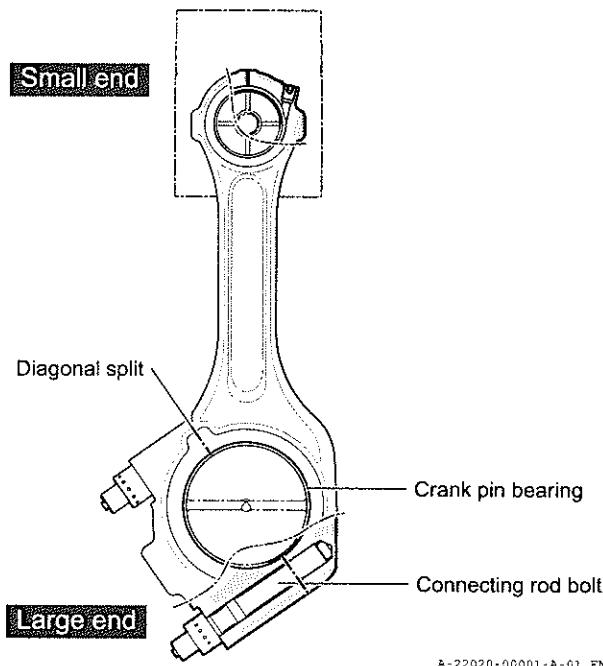


Fig. 1 Connecting rod

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	12 h
	b	Engine crew	Intermediate	-	12 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Hydraulic pump		746673-92112		1 pc
	Hydraulic jack		150633-92650		2 pc
	Angle elbow		151605-92740		2 pc
	Spacer		150633-92460		2 pc
	Spacer bolt		150633-92530		2 pc
	Nut		26732-360002		2 pc
	Coupler (female)		153625-92780		2 pc
	Turning handle		146673-92510		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
	Sealing tape		1F1240-75800		1 pc
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you disassemble and do maintenance of the connecting rod.

1. Inspection

1. Inspection of the connecting rod

- 1 - Check the piston pin bearings for contact.
- 2 - Measure the inner diameter of the piston pin bearings. If the measurement is more than the wear limit, replace the piston pin bearing.
 - 1 - When you remove the bearings, make sure that you do not cause damage to the bearing insertion hole. Use a retainer and hit the bearings out with a hammer or draw them out with a press.
 - 2 - When you install the bearings, align them with the oil hole and press-fit them with a press. Measure the inner diameter after press-fitting.
- 3 - Check the serration mating surface on the big end of the connecting rod for cracks and wear.

Clearance and wear limits of major parts 0000-000-07

NOTICE

If you find water-hammering or a lot of burns on the piston, measure the bend and inclination of the connecting rod. Look for cracks with a color-check.

<How to do a simple bend check>

- 1 - Remove the piston pin bearing.
- 2 - Remove the oil hole plug on the small end side.
- 3 - Put a bar or long drill (12 mm diameter) into the lubricating oil hole of the connecting rod.

The connecting rod is bent if:

- The bar or drill cannot be inserted or
- It can be inserted but it cannot be turned.

2. Inspection of the crank pin bearing

Be sure to replace both the top and bottom bearings as a pair.

- 1 - Check the contact of the mating surface and rear surface of the bearing. Check the sliding surface for cracks, seizure and bite-in of unwanted material.
- 2 - Install the crank pin bearing to the connecting rod. Install the connecting rod. Tighten the nut of the connecting rod to the specified pressure.
- 3 - Measure the inner diameter. If the measurement is more than the wear limit, replace the bearing.
Clearance and wear limits of major parts 0000-000-07
Table of tightening torques for major bolts and nuts 0000-000-07
- 4 - Measure the thickness of the top and bottom bearings. If the difference between A-B and C-B is more than 0.04 mm, replace the bearings.

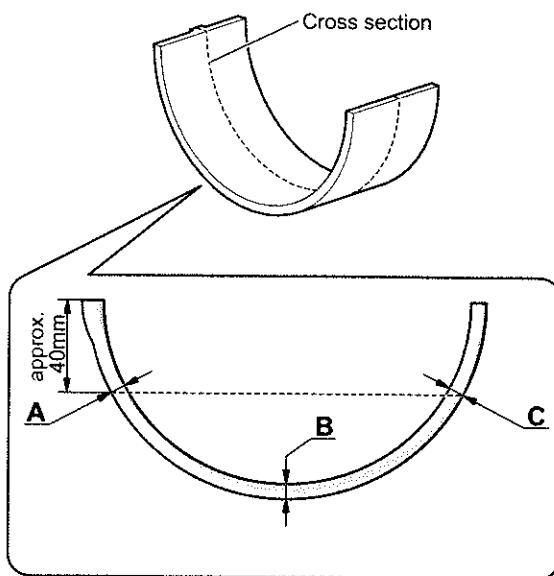


Fig.1 Measuring locations for bearing thickness

3. Inspection of the connecting rod bolts

- 1 - Look for dents and plucking on the bearing surfaces and threads of all bolts. If you find a defect, correct it.

NOTICE

Be sure to make a new match mark on the tightening nut every time you disassemble the connecting rod. The tightening nuts have a match mark when they leave the factory. But the tightening torque of the bolt varies depending on break-in between the bolt thread, the bearing surface and the large end serration of the connecting rod.

- 2 - Replace the bolts approximately every 20000 hours even if their appearance is normal. This prevents them from breaking due to fatigue.

NOTICE

If you replace the connecting rod bolts and the connecting rod, make a stamp with the same Cylinder No. and Bolt No. as the old parts.

2. Hydraulic jack

1. Move the crankshaft to 72° after the top dead center position.
 2. Put the spacer 2 into the nut of the connecting rod bolt.
 3. Screw the spacer bolt 1 into the connecting rod bolt. Do it until the spacer bolt touches the bottom.
 4. Put the hydraulic jack 3 on the spacer bolt. Tighten it with the nut 4.
 5. Connect the hydraulic jack and the rubber hoses with couplers 5.
 6. Make sure that the distance between the piston of the hydraulic jack and the end face of the body is less than 1.5 mm. (See A in Fig. 2.)
 7. Loosen the nut by 1/2 turn from where it is seated.
 8. Close the relief valve of the hydraulic pump. Increase the hydraulic pressure to the specified value with the pump lever.
- Specified hydraulic pressure: 55 MPa ± 0.5 MPa
9. Insert the handle 6 into the hole of the nut through the window of the spacer. Turn the nut.
 10. Gradually open the relief valve of the hydraulic pump and decrease the hydraulic pressure to 0 (zero).
 11. Screw in the hydraulic jack until it makes good contact with the spacer. Drain the oil from the jack.
 12. Remove the rubber hose (and the couplers) from the hydraulic jack.
 13. Remove the hydraulic jack and the spacer.

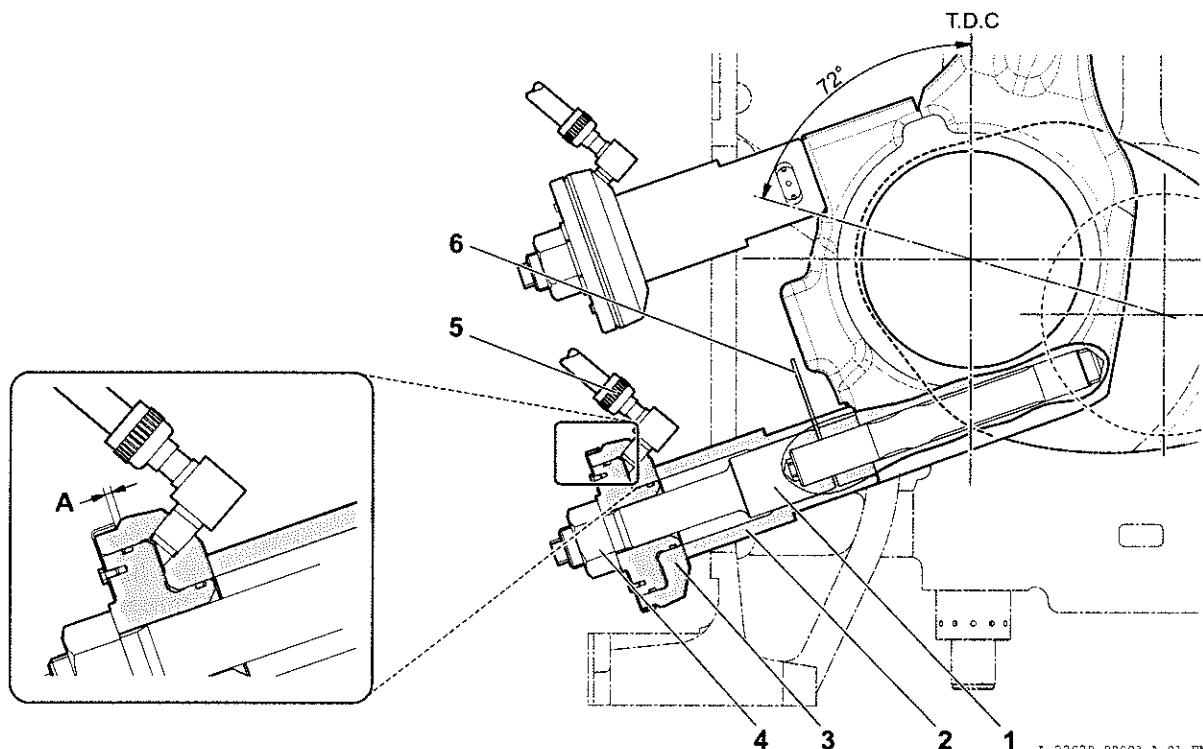


Fig.2 Operating the hydraulic jack

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CONDITION Measure the difference between the match marks on the cap side and the nut side.

If it is more than the permitted value, disassemble and tighten the parts again.

Permitted value (length in direction of circumference): -2 mm to +5 mm

Connecting rod bolt

Replacement

1/1

PRODUCTION MANAGEMENT DATA

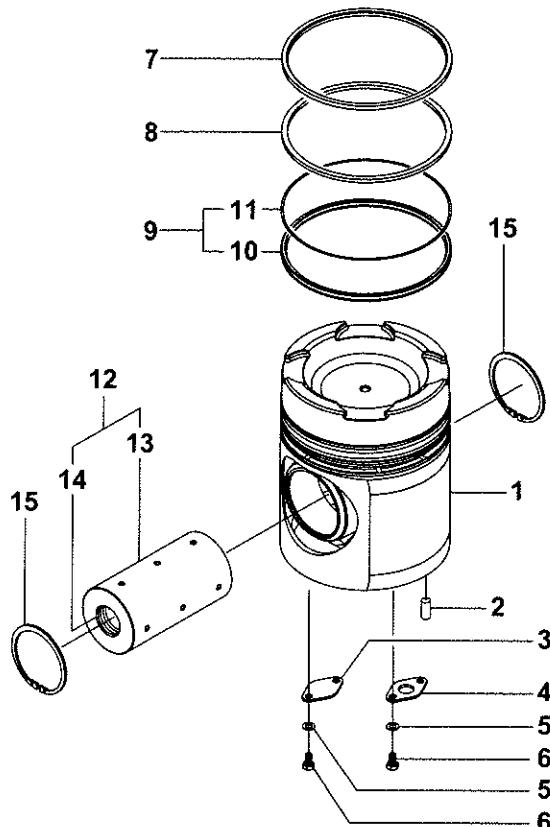
Intervals 20000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	10 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY	Rod bolt		150633-23201		2 pc

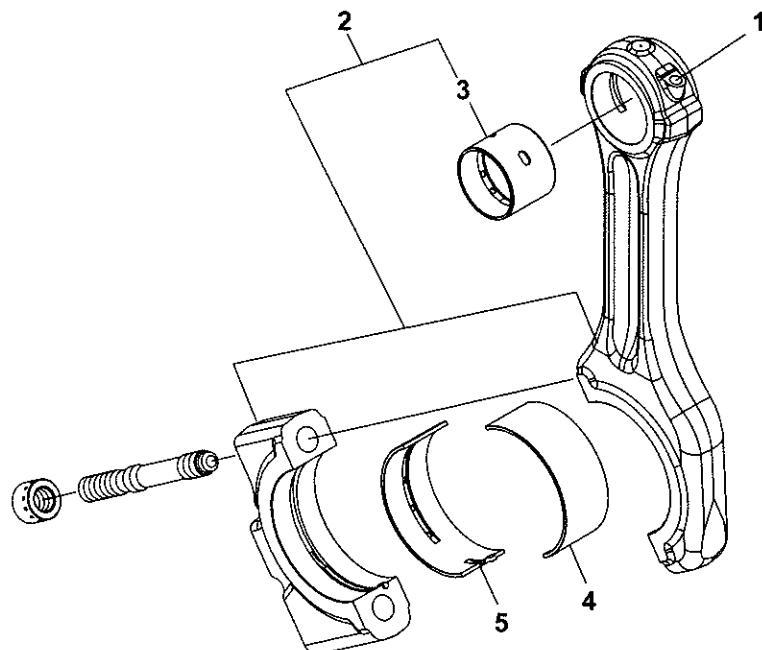
Replace the connecting rod bolts (2 bolts) every 20000 hours. If you find seizure on the piston, replace the bolts of that cylinder. It is possible that too much force applies to the bolts. Refer to 2202-000-02 when doing maintenance, including disassembly and re-assembly of the connecting rod and rod bolts.

CONDITION



A-22019-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-22010	PISTON	6	6	
2	2	26911-100122	SCREW, 10 X 12	12	12	
3	1	141616-22900	COVER, CHAMBER	6	6	
4	1	141616-22920	COVER, CHAMBER	6	6	
5	1	138613-23290	WASHER, BELLEVILLE	24	24	
6	1	26206-080162	BOLT, 8 X 16	24	24	
7	1	150633-22110	PISTON PING,NO.1	6	6	
8	1	150633-22240	PISTON RING,NO.2	6	6	
9	1	150633-22280	PISTON RING,OIL	6	6	
10	2	150633-22160	PISTON RING,OIL	6	6	
11	2	150633-22270	COIL EXPANDER	6	6	
12	1	150633-22300	PISTON PIN	6	6	
13	2	150633-22310	PISTON PIN	6	6	
14	2	150633-22320	OIL SEALING PIPE	6	6	
15	1	22252-000950	RING, 95	12	12	



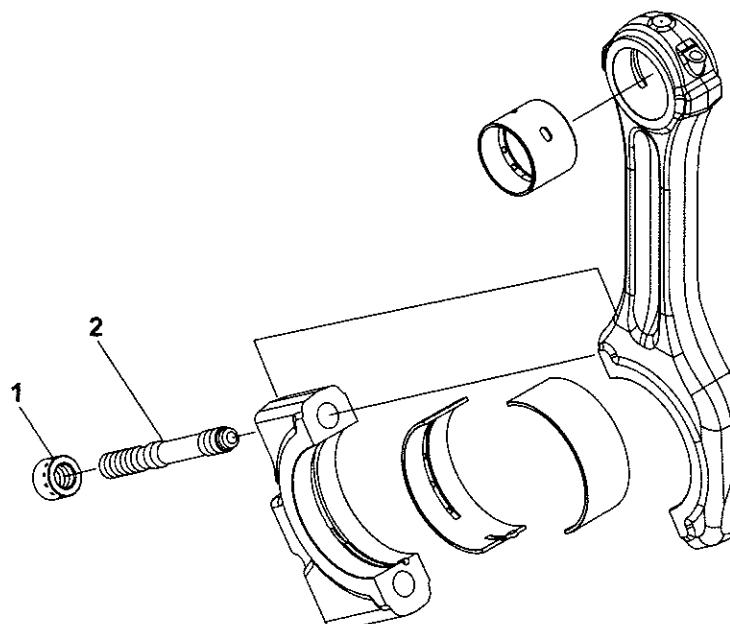
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	153605-21050	SCREW, M18X2.0	6	6	
2	1	150633-23011	CONNECTING ROD	6	6	
3	2	150633-23100	BEARING PISTON PIN	6	6	
4	1	150633-23310	BEARING CRANK PIN	6	6	
5	1	150633-23320	BEARING CRANK PIN	6	6	

Connecting rod bolt

Illustrated parts data

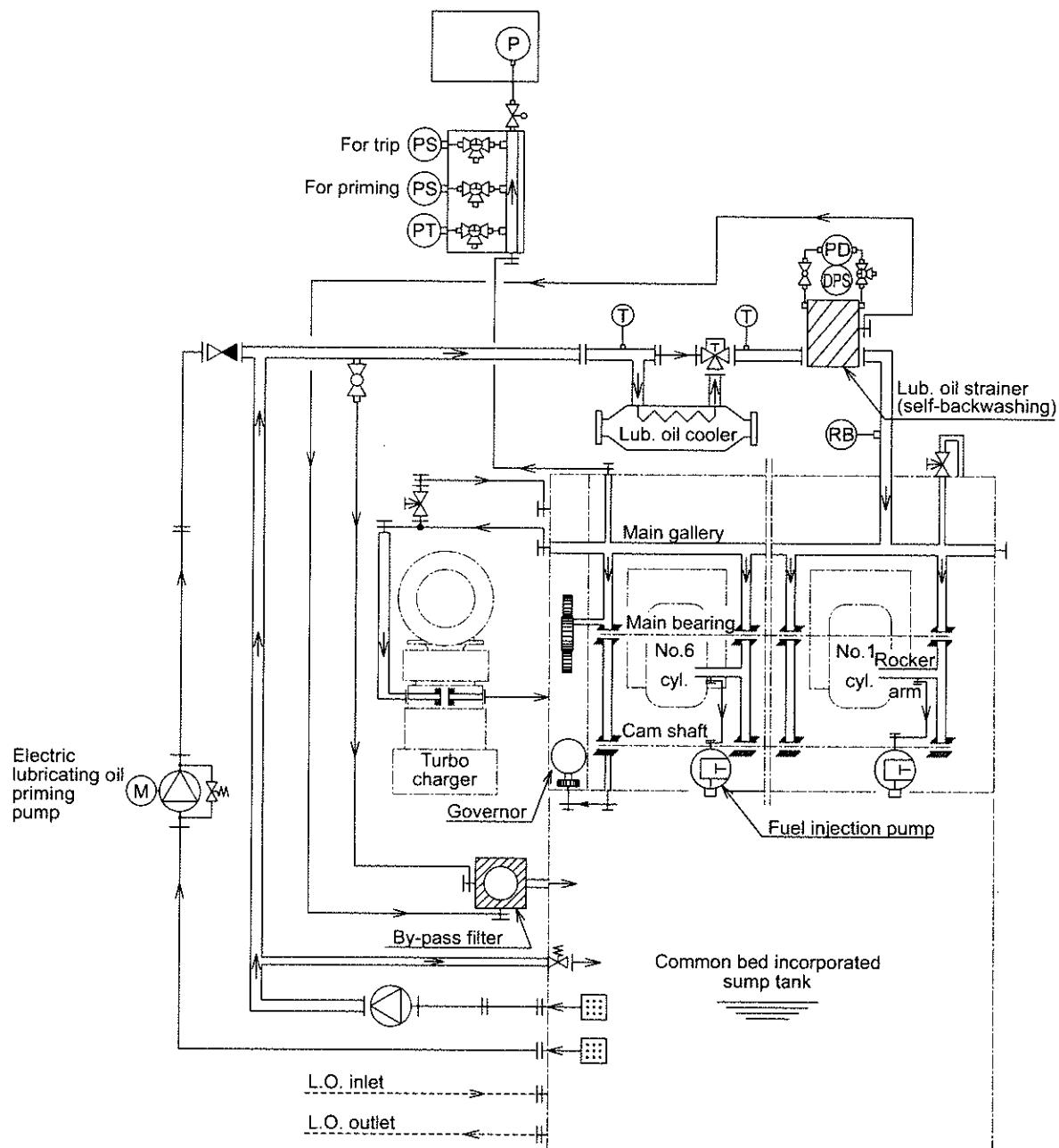
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A-22039-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	146673-01212	NUT, HEAD CAP	12	12	
2	2	150633-23201	BOLT, CONNECTING ROD	12	12	

- The lubricating device has a sump tank incorporated in the common bed. It has a lubricating oil pump, lubricating oil cooler, lubricating oil thermostat, lubricating oil strainer and lubricating oil pressure control valve.
- The pump sends oil to the cooler, strainer and through the main gallery to all moving parts of the engine and the shaft bearings. The oil also decreases the temperature of the piston.



(Remarks)

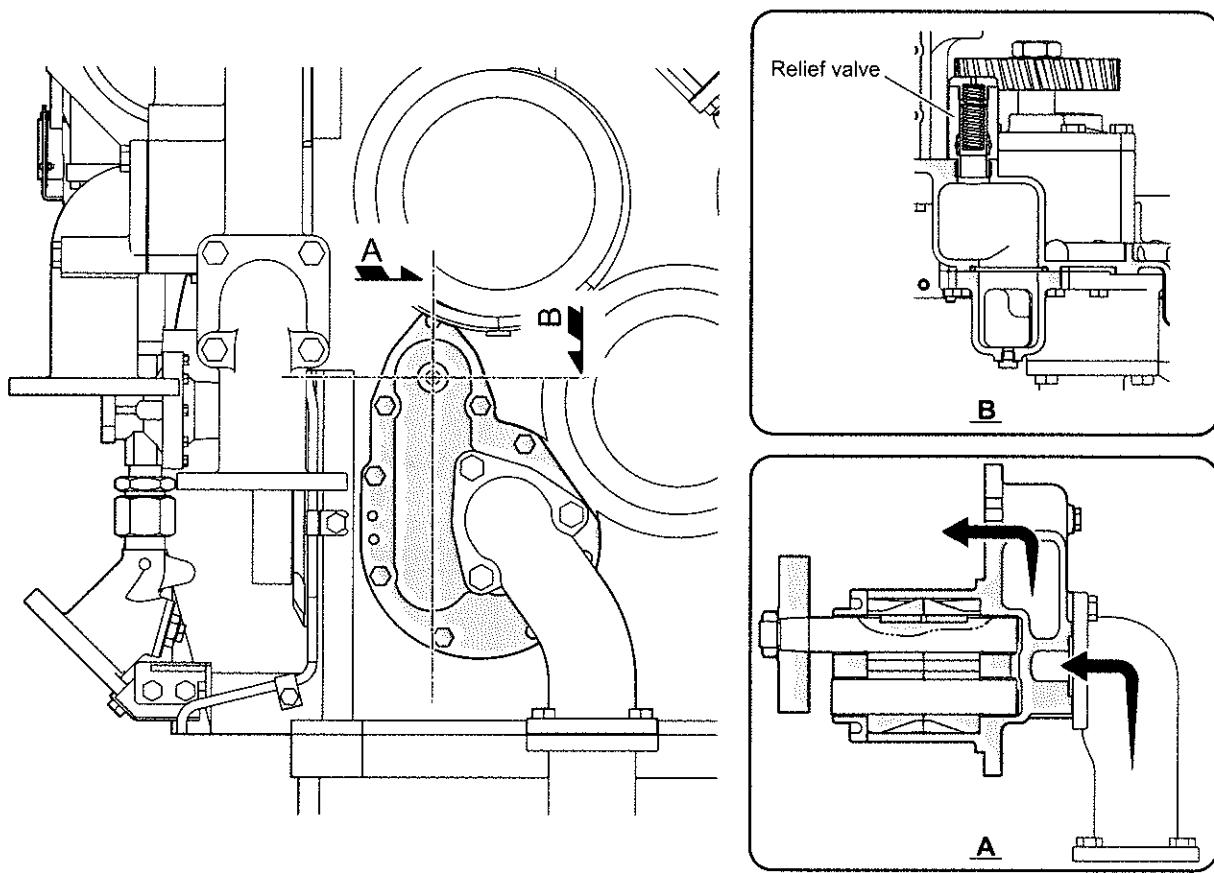
This is a standard system diagram.

Details at each construction have been described to the drawing.

A-30000-05001-A-01_EN

Fig. 1 Lubricating device

- The lubricating oil pump is on the opposite side of the flywheel. It is directly driven by the crank gear and has 2 shafts.
- The relief valve is in the gear housing lubricating oil passage on the pump discharge side.



A-30010-00001-A-01_EN

Fig.1 Lubricating oil pump - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 2 years

8000 working hours

CONDITION Before you disassemble, measure the backlash of the drive gear.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	3 h
	b	Engine crew	Intermediate	-	3 h

EQUIPMENT	Nomenclature	Identification code	Quantity

SUPPLIES	Nomenclature	Identification code	Quantity
	Molykote (molybdenum disulfide grease)		
	Liquid packing		

SPARES	Nomenclature	Identification code	Quantity

SAFETY	

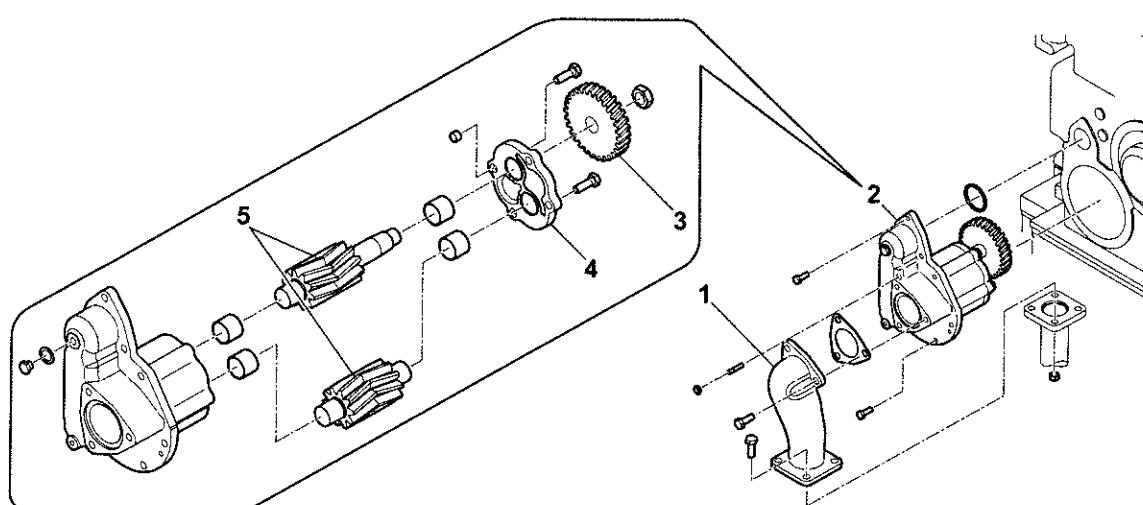
Obey the instructions that follow when you do maintenance on the lubrication oil pump according to the periodical inspections table.

1. Disassembly

1. Remove the suction pipe 1 from the lubricating oil pump.
2. Remove the lubricating oil pump 2 from the gear housing.
3. Remove the pump drive gear 3.
4. Remove the cover 4.
5. Remove the pump gear 5.

NOTICE

Because the pump gear and the shaft are shrink-fitted, lock the drive gear and remove the tightening nut.



A-30010-00002-A-01_EN

Fig. 1 Disassembling the lubricating oil pump

Inspection and maintenance

2. Inspection

1. Examine the pump gear teeth for unusual contact and wear.
2. Examine the side surfaces of the pump gears for damage or seizure.
3. Examine the pump gear shafts and bushings for burns or unusual wear.
4. Measure the radial clearance and side clearance between the pump gear and the pump body.
5. Measure the clearance between the pump gear and the cover.
6. Measure the teeth contact and backlash of the drive gear.

3. Assembly

1. Apply lubricating oil to the sliding parts of the pump gear.
2. Apply Molykote (molybdenum disulfate grease) to the bearings.
3. Put the pump gear mechanism for the drive side and the driven side into the lubricating oil pump.
4. Install the cover.

NOTICE

Apply liquid packing to the mating surfaces of the body and the cover. Do not use too much liquid packing. Make sure that it does not fall into the gear case.

5. Install the drive gear on the pump driving shaft.

Table of tightening torques for major bolts and nuts 0000-000-07

NOTICE

Lock the drive gear with the nut, because the pump gear and the drive shaft are shrink-fitted.

6. Install the pump assembly to the engine.
7. Check the backlash.
8. Install the suction pipe of the lubricating oil pump.

CONDITION Assembly adjustment values / Clearance & wear limits of major parts 0000-000-07

- The lubricating oil pressure control valve is a barrel-shaped valve with an adjustment spring.
- If the lubricating oil pressure does not agree with the specified value: Remove the cap nut. Loosen the locknut. Then, screw the adjusting bolt in or out to adjust the pressure.
- Before you adjust the pressure: Clean the strainer. Operate the engine. Wait for the lubricating oil temperature to stabilize.

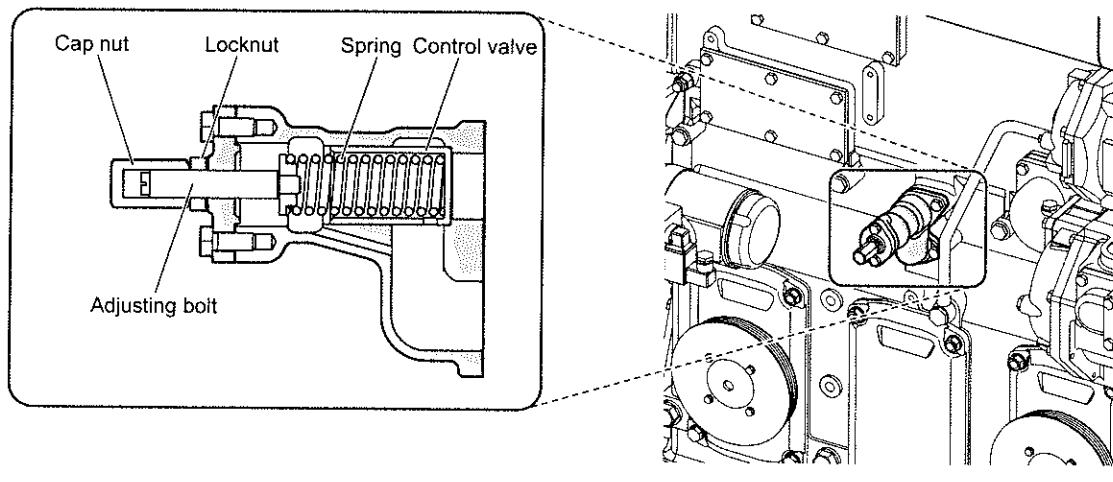


Fig.1 Lubricating oil pressure control valve - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
	Packing			23414-160000	2 pc
	Packing			139653-34080	1 pc
	Packing			147673-34020	1 pc

SAFETY

CAUTION

- When you loosen the adjusting bolt until it comes out, oil can come out and burn you. If you loosen the adjusting bolt but the pressure does not change, stop when the spring retainer touches the cover. Do not loosen the adjusting bolt too far.
- Be careful. The spring of the pressure control valve can suddenly come off and cause injury. Loosen the adjusting bolt before you disassemble the pressure control valve.

Obey the instructions that follow when you adjust, disassemble and examine the lubricating oil pressure control valve.

1. Adjust

1. If the lubricating oil pressure is not within the specified value, adjust it and obey these instructions:

1 - Clean the lubricating oil filter.

2 - Operate the engine.

Wait for the lubricating oil temperature to stabilize. Adjust to the specified value.

3 - Remove the cap nut 1.

4 - Loosen the locknut 2.

5 - Screw the adjusting bolt 3 in or out to adjust the pressure.

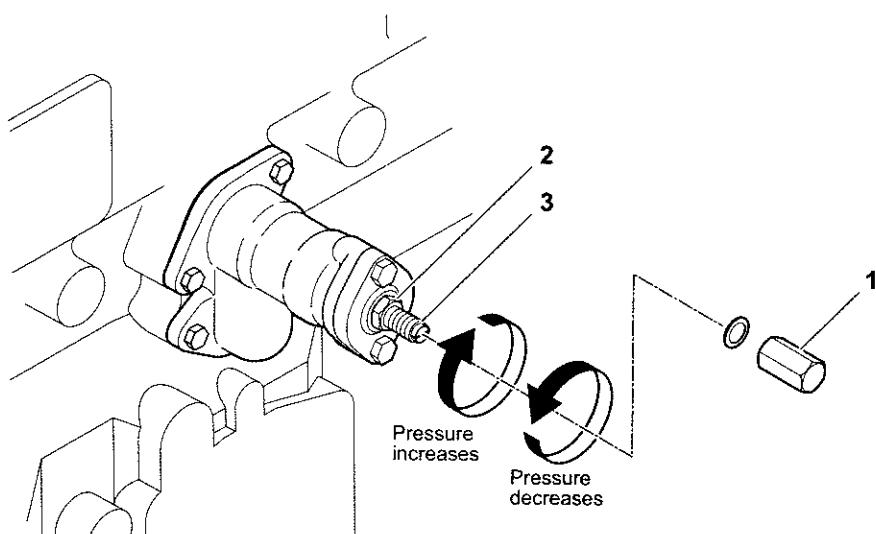
Turn right (clockwise): the pressure increases.

Turn left (counterclockwise): the pressure decreases.

6 - Tighten the locknut securely.

7 - Install the cap nut.

Engine information Preparation setting values 0000-000-06(M.D.O.), 0000-001-06 (H.F.O.)

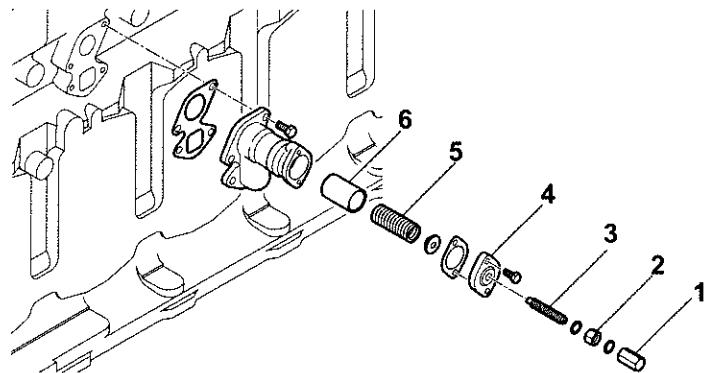


A-30020-00002-A-02_EN

Fig.1 Lubricating oil pressure control valve

2. Disassembly

1. Remove the cap nut 1.
2. Loosen the locknut 2.
3. Loosen the adjusting bolt 3.
4. Remove the cover 4 together with the adjusting bolt.
5. Remove the valve 6 and the valve spring 5 together.



A-30020-00003-A-01_EN

Fig.2 Lubricating oil pressure control valve

3. Inspection

1. Examine the valve seat for damage.
2. Make sure that the valve moves correctly.
3. Examine the spring for breakage and fatigue.

Replace the spring with a new one if it does not have enough force to adjust the oil pressure.

(Spring free height: 120 mm)

4. Assembly

1. Install the valve and the valve spring together.
2. Install the cover and the adjusting bolt together.
3. Adjust the pressure.
4. Tighten the locknut securely.
5. Install the cap nut.

CONDITION Adjust the lubricating oil pressure control valve 1

- The lubricating oil cooler has a thermostat. It increases the temperature of the lubricating oil for a short time after engine start. It keeps the correct temperature during engine operation.
 - The thermostat keeps the temperature at the engine inlet between 50 °C and 65 °C. If the temperature of the lubricating oil does not decrease, this can be the cause:
 - The lubricating oil cooler is dirty.
 - The piston is stuck.
 - The element does not work properly.
- It is necessary to find the cause and repair it.

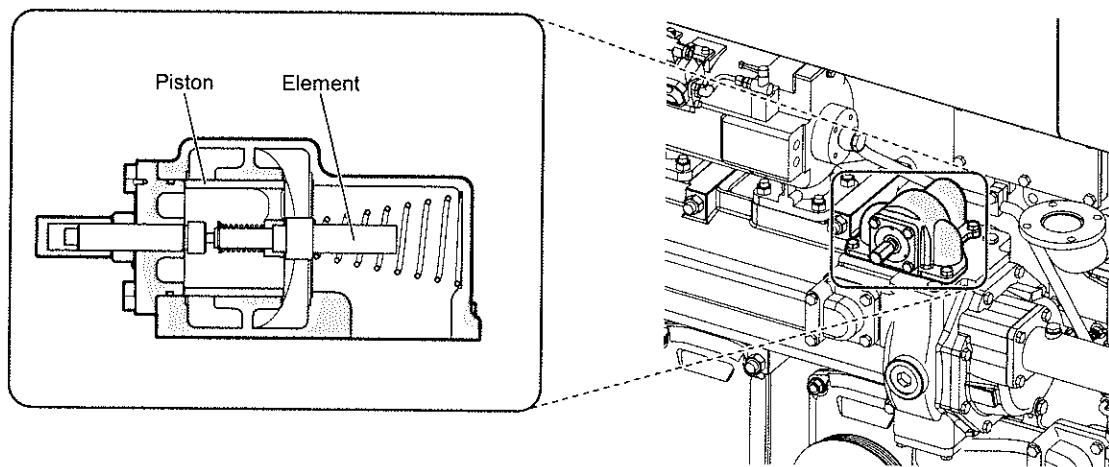


Fig.1 Lubricating oil thermostat outline

A-30030-00001-A-01_EN

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

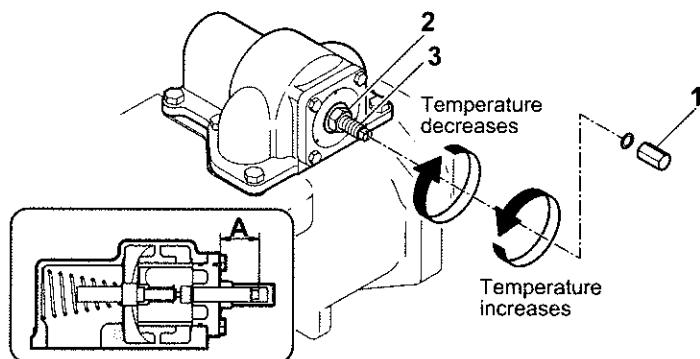
PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
	Packing				2 pc
	O-ring				1 pc
SAFETY					

Obey the instructions that follow when you adjust, examine and assemble the lubricating oil thermostat.

1. Adjust

1. Remove the cap nut 1.
2. Make sure that the position (distance A) of the adjusting bolt 3 is correct. (The standard distance A is 43.5 mm.)
3. Loosen the locknut 2 lightly.
4. Turn the adjusting bolt and adjust the temperature.

Turn right (clockwise): the temperature decreases.
Turn left (counterclockwise): the temperature increases.
5. Tighten the locknut securely.
6. Install the cap nut.

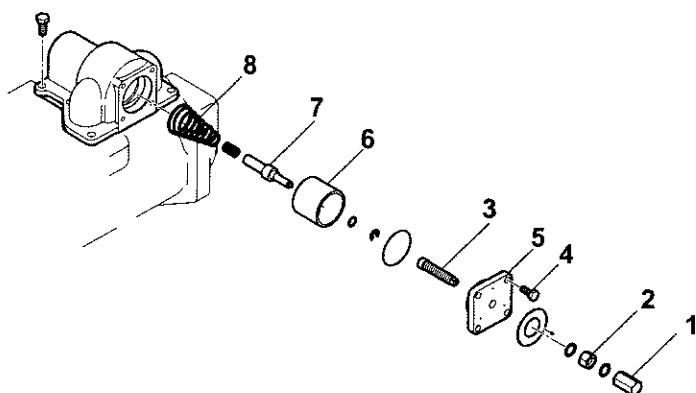


A-30030-00002-A-01_EN

Fig. 1 Adjusting the lubricating oil temperature

2. Disassembly

1. Remove the cap nut 1.
2. Loosen the locknut 2.
3. Loosen the adjusting bolt 3.
4. Remove the bolt 4.
5. Remove the cover 5 and the adjusting bolt 3 together.
6. Remove the piston 6 and the element 7 together.
7. Remove the conical spring 8.

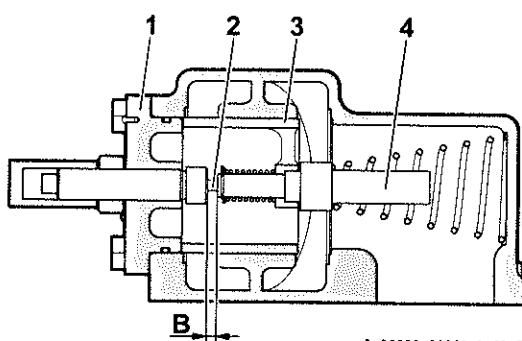


A-30030-00003-A-01_EN

Fig.2 Lubricating oil thermostat

3. Inspection

1. Make sure that the piston 3 moves easily. Repair the piston if it is caught or stuck.
2. Remove the element 4 that is installed with the piston.
3. Soak the element in cold water for 3 to 5 minutes.
4. Soak the element in warm water for 3 to 5 minutes.
5. Measure lift B on the element spindle 2.



A-30030-00004-A-01_EN

Fig.3 Element inspection

If the lift of the element spindle is different from these values, replace the element with a new one.

Cold water (30 °C or less): $B = 5 \text{ mm} \pm 0.1 \text{ mm}$

Warm water (60 °C or more): $B = 23 \text{ mm}$ or more

4. Assembly

1. Replace the packing and the O-rings with new ones.
2. Measure the position (See A dimension in Fig. 1.) of the adjusting bolt.
(The standard length for A is 43.5 mm.)
3. Adjust the temperature of the lubricating oil.
4. Tighten the locknut. Make sure that it is tight.
5. Install the cap nut.

CONDITION Adjust the lubricating oil thermostat 1

- The lubricating oil strainer is an automatic backwashing strainer (model 6.46).
- It has multiple columns, the element is a hollow candle and a polyester resin wire is woven in. The strainer removes dirt and unwanted material as the oil passes from the inside to the outside of the strainer.
- At intervals of 20 seconds, the dirt and unwanted material flows through the flushing arm canal back to the oil pan. This automatic backwashing is done continuously during operation.
- The flushing arm is moved by the turbine wheel. That wheel is driven by the oil flowing into the strainer. A gear slows the rotation of the flushing arm to less than 1/200th. The flushing arm takes 20 seconds for one rotation.

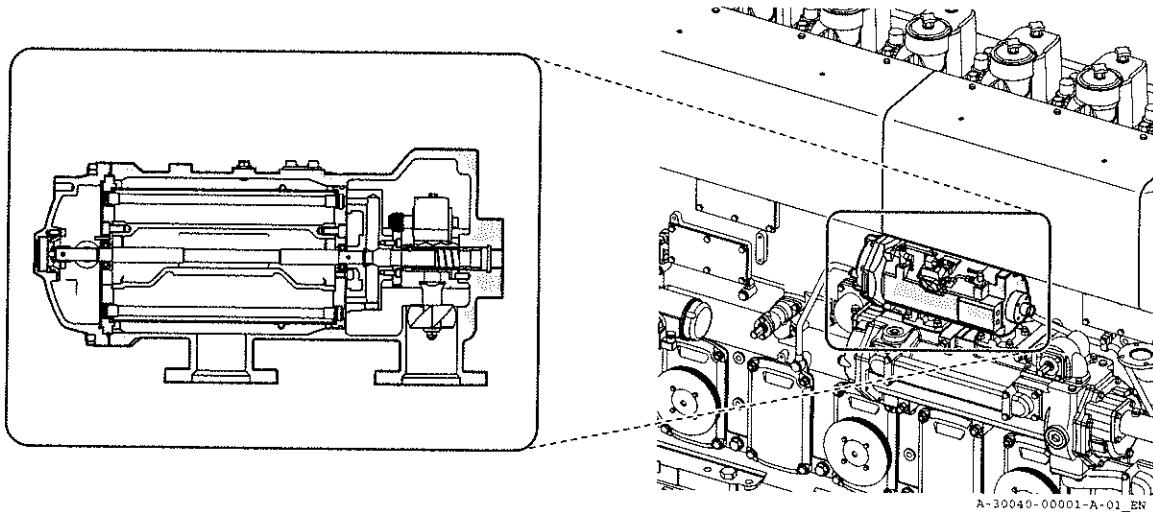


Fig.1 Lubricating oil strainer - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Oil pan		150633-92360		1 pc
	Bolt M8 × 20		26206-080202		2 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
	O-ring		150633-35410		1 pc
	O-ring		150633-35420		1 pc
	O-ring		150633-35430		2 pc
	O-ring		146623-35440		64 pc
	O-ring		132659-35550		1 pc
	O-ring		151695-35950		1 pc

SAFETY

The lubricating oil strainer is an automatic backwashing strainer. It is necessary to replace the element at regular intervals. Obey these inspection instructions for everyday operations.

Disassemble and clean the strainer during regular inspections or if the differential pressure alarm operates.

1. Inspection

1. Differential pressure indicator

The red part of the differential pressure indicator shows the differential pressure. The red indicator changes its size depending on the differential pressure. If it reaches 50 %, the alarm operates. When the alarm operates, clean the lubricating oil strainer. Of course it is more effective to clean before the alarm operates. The red indicator can be visible because of initial pressure loss. But if approximately 5 mm of the red indicator is visible, there is no problem.

2. Flushing arm rotation

Examine the rotation of the flushing arm through the glass window at the center of the body cover. Approximately 1 rotation per 20 seconds is normal.

3. Examining all strainer connections for leaks

Examine all connections and seals of the strainer for oil leaks.

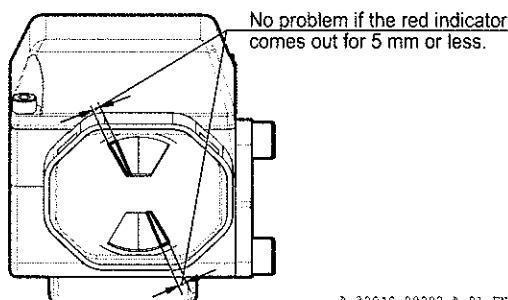


Fig.1 Differential pressure gauge

A-30040-00002-A-01_EN

2. Disassembly

1. Install the oil pan 8.
2. Remove the air relief plug 3.
3. Drain the fluids from the inside of the lubricating oil strainer.
4. Remove the cover 1.
5. Remove the whole element together with the flushing arm 6 and the gear 5 from the strainer body 4.
Be careful not to cause damage to the teeth of the gear.
6. Remove the element retainer plate 2.
7. Remove the element 7 from the holder by pushing it from the bottom or pulling it from the top.

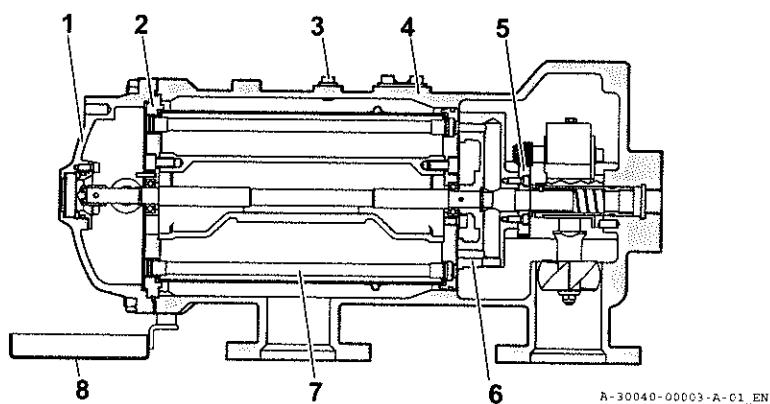


Fig.2 Disassembling the lubricating oil strainer

3. Clean

1. Clean the element with cleaning fluid.

We recommend BOLL CLEAN 2000 as cleaning fluid. Mix 2 parts of cleaning fluid with 5 parts of water. Soak the element for 24 hours.

2. Then blow the element from the outside with compressed air.

High-pressure hot water is even more effective than compressed air.

Make sure that the water pressure is less than 6.0 MPa. You can cause damage to the mesh.

3. Examine the element and look for damage. If necessary, replace it.

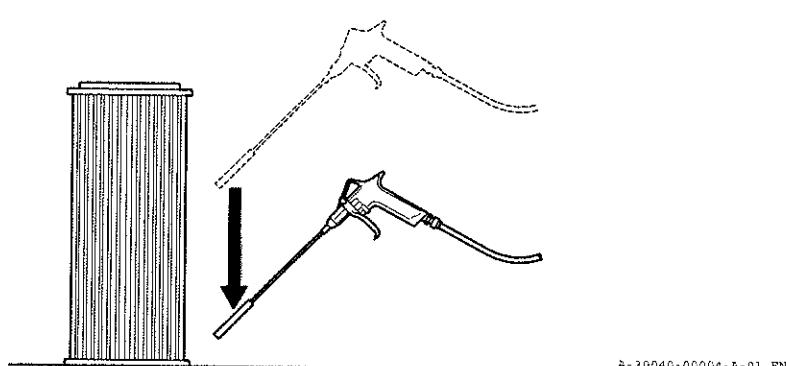
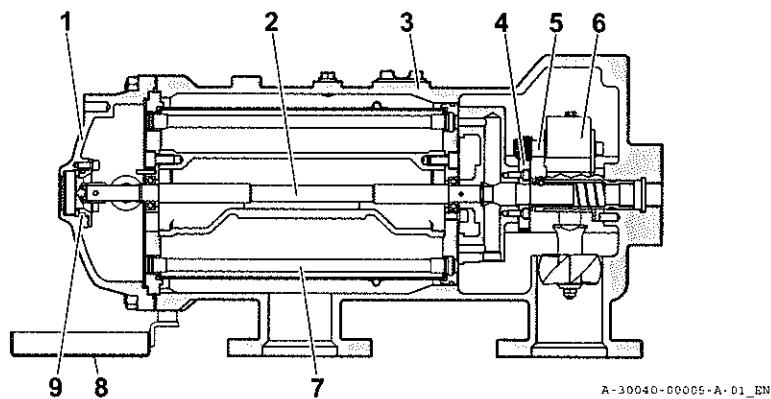


Fig.3 Cleaning the element

4. Assembly

1. Install the element 7. Put it into the housing 3.
Do not use a damaged element again.
2. Turn the flushing shaft 2 a little bit. Make sure that the gear 4 engages with the drive pinion 5 of the reduction gear 6.
3. Replace all O-rings.
4. Install the cover 1.
5. Also replace the O-ring 9 in the center of the cover.
6. Remove the oil pan 8.

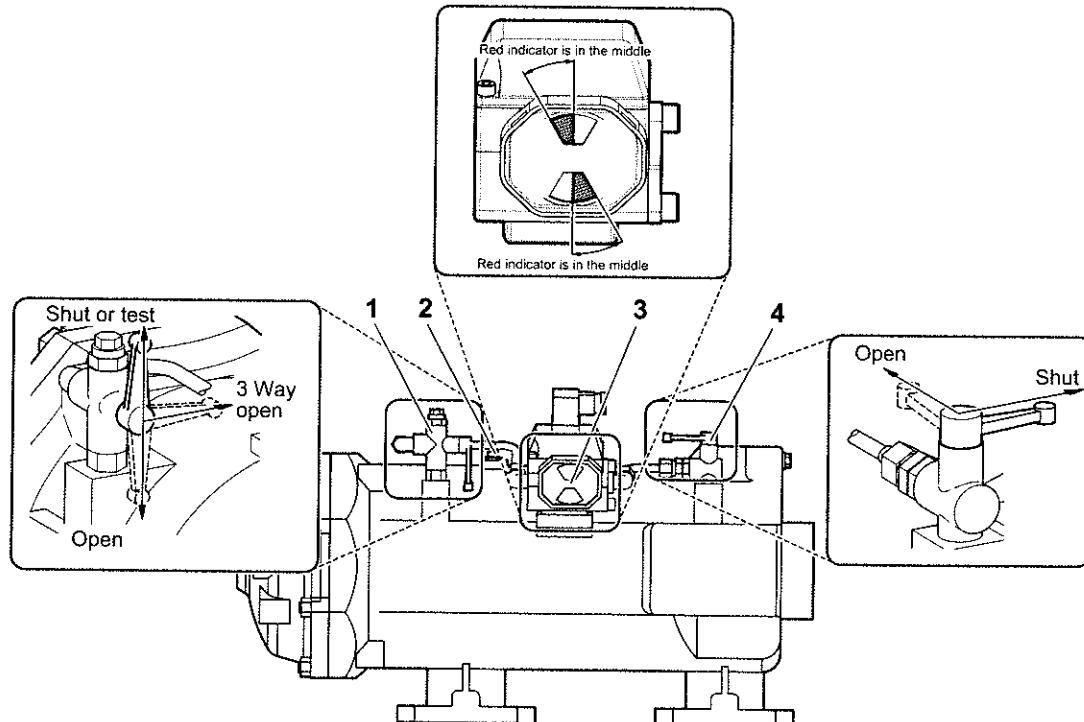


A-30040-00005-A-01_EN

Fig.4 Lubricating oil strainer - Assemble procedure

5. Pressure check

1. Make sure that the differential pressure indicator 3 actuates.
2. Close the cock on the inlet side 4.
3. Turn the 3-way cock 1 on the outlet side to the test side.
4. Loosen the plug 2.
5. The pressure on the filter outlet side decreases. This will cause differential pressure.



A-30040-01006-A-01_EN

Fig.5 Checking the differential pressure indicator

Make sure that an alarm operates when the red indicator reaches the middle.

6. Troubleshooting and countermeasures

Cause of the problem	Cause	Probable cause and countermeasure
The differential pressure increases	High viscosity	Wait until the normal operating temperature is reached
	High amount of contamination	If there is a cleaner, make sure that it operates correctly
	Clogged filter candle	Clean the filter candle
	Insufficient amount of backwashing oil	Do an inspection of the flow control devices on the outlet side Examine the sludge discharge lines for clogging
	Inoperable backwashing mechanism	The turbine is stuck and does not move Remove the unwanted material between the turbine and the turbine casing
		The reduction gear is stuck and does not move Remove the unwanted material between the reduction gear and the gear of the back-washing arm
		The reduction gear has a malfunction Make sure that the gear can move easily Replace the reduction gear if necessary
		The flushing arm is stuck and does not move Remove the unwanted material on the arm
		The operating pressure is less than 0.2 MPa Increase the engine rotation Operate between 0.55 MPa and 0.60 MPa for a short time Remove the clogging from the line
		The amount of operating oil is not sufficient Add oil

CONDITION

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	3.5 h
	b	Engine crew	Intermediate	-	3.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY	O-ring		24321-002300		2 pc

The lubricating oil cooler is a multi-tubular cooler. It uses low-temperature water. Disassemble and clean if the cooling effect decreases or during regular inspections. Obey the instructions that follow when you do maintenance of the lubricating oil cooler.

1. Disassembly

1. Remove the drain plug 6.
 2. Drain the lubricating oil from the cooler.
 3. Remove the cooling water pipe and the lubricating oil pipe of the cooler inlet and outlet.
 4. Remove the lubricating oil strainer.
 5. Remove the tightening nut of the lubricating oil cooler. Lock the cooler assembly with a rope. Remove it from the engine.
 6. Remove the cover 5 on the cooling water inlet side.
 7. Remove the cover 1 on the cooling water outlet side.
 8. Remove the O-rings 2 and 4 that seal the outer circumference on both ends of the cooling pipe assembly.
 9. Remove the cooling pipe assembly 3.

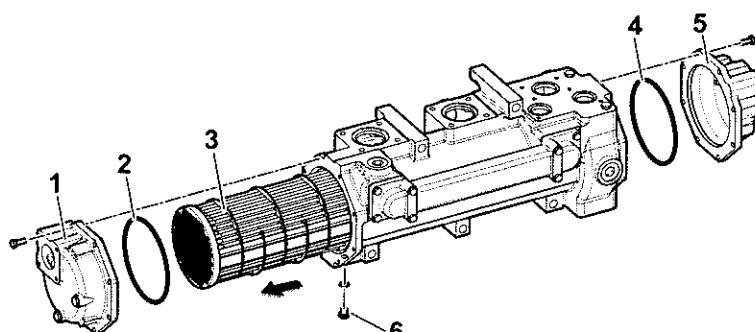


Fig. 1 Lubricating oil cooler

2. Cleaning

1. Clean the pipes on the cooling water side and on the lubricating oil side of the cooling pipe assembly.
2. Remove scale on the cooling water side with a long-handled brush.
3. On the lubricating oil side, cleaning with a sludge detergent (such as Neos) or steam cleaning are both appropriate.

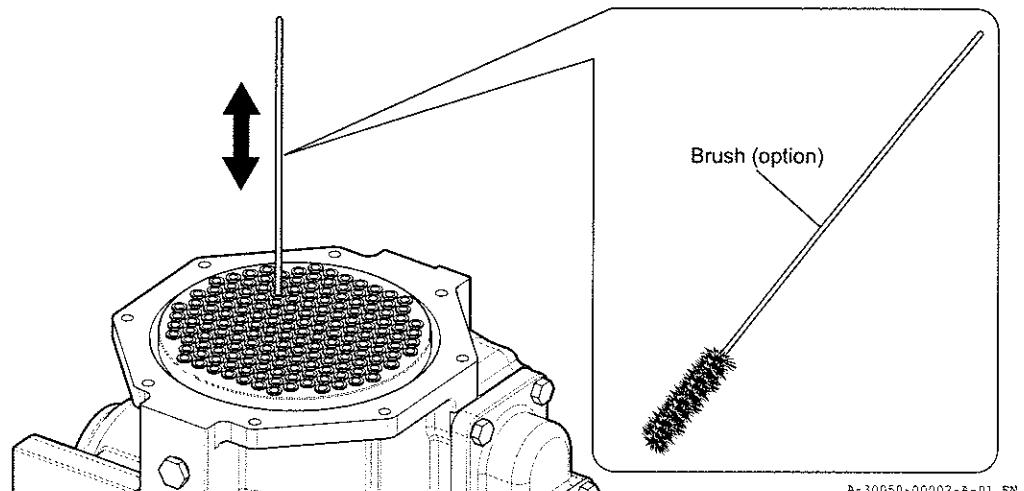


Fig.2 Cleaning of the cooling tube

3. Assembly

1. Install the cooling pipe assembly 3 on the cooler.

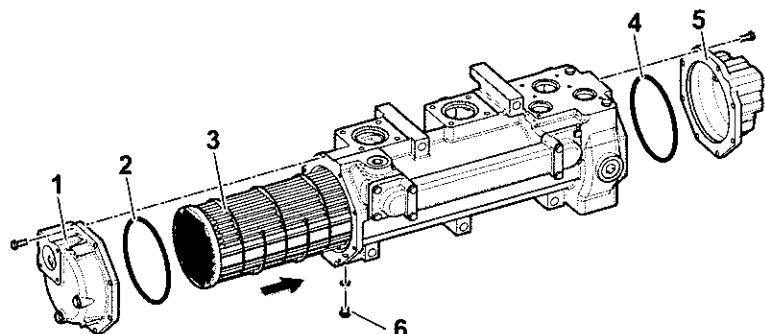


Fig.3 Lubricating oil cooler

2. Align the "O" match mark on the cooler body and the cooling pipe plate.

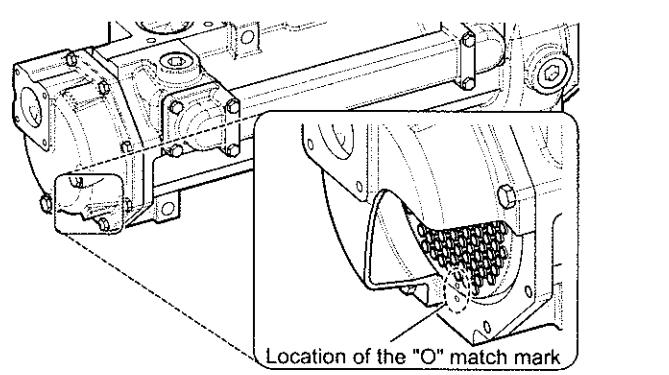


Fig.4 Location of the "O" match mark

3. Replace the O-rings 2 and 4 with new ones.
4. Install the side covers on the cooling water inlet side 5 and outlet side 1.

Lubricating oil cooler

Inspection and maintenance

3/3

5. Do a water-pressure test on the assembly.

Test pressure: 1.2 MPa

Hold the pressure for 20 minutes and look for leaks.

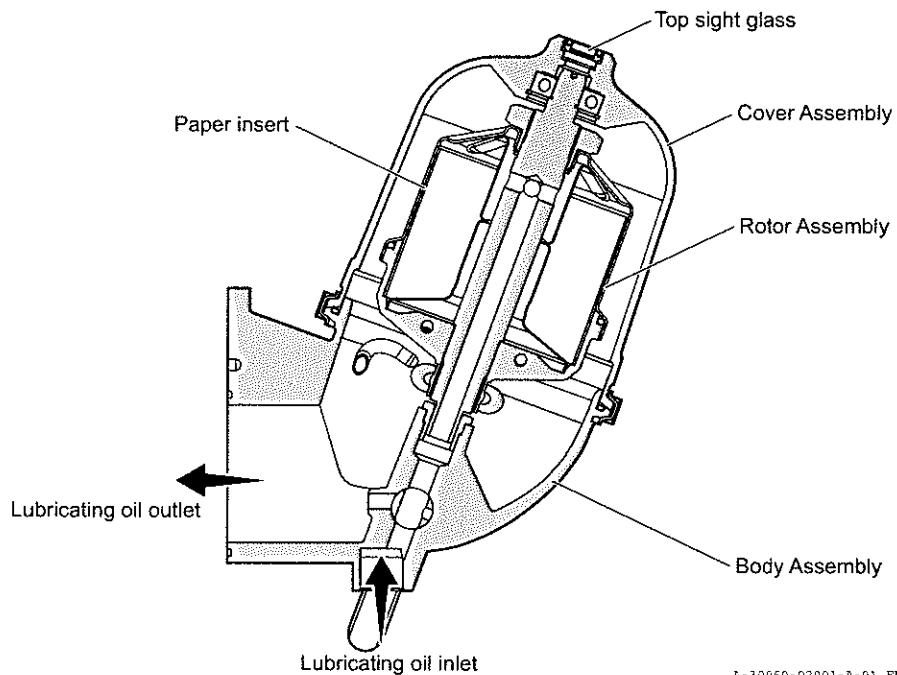
Use water with corrosion inhibitor for testing.

6. Install it to the engine.

7. Install the cooling water pipe and the lubricating oil pipe of the cooler inlet and outlet.

CONDITION

- This engine has a centrifugal bypass filter in addition to the automatic backwashing strainer.
- This bypass filter is designed to operate for an extended period without the replacement of major parts. But if the period between inspections is long, wear or damage can occur in the rotor assembly. To avoid this, we recommend that you do regular visual inspections during disassembly and cleaning. Examine the filter bearing for wear or damage. If you find too much wear on a part or if a bearing is loose, replace it with a new one.



A-30060-02001-A-01_EN

Fig.1 Lubricating oil bypass filter - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 1 weeks

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
EQUIPMENT		Nomenclature		Identification code	Quantity
SUPPLIES		Nomenclature		Identification code	Quantity
SPARES		Nomenclature		Identification code	Quantity
	Bearing assembly		746623-35481		1 pc
	Rotor assembly		746623-35420		1 pc
	Paper insert (5 piece set)		746623-35450		1 pc
	O-ring		746623-35460		1 pc

SAFETY

CAUTION**Stop the engine before you disassemble and clean the bypass filter.****Do not disassemble the bypass filter during operation. Oil mist can come out and burn you.**

Disassemble and clean the lubricating oil bypass filter at regular intervals. Make sure that the sludge on the inside of the rotor is not thicker than 35 mm. This ensures that the filter operates correctly. The buildup of sludge varies depending on the operating conditions of the engine, properties of the fuel oil and quality of the lubricating oil. Do the first inspection as shown in this manual "Table of routine maintenance inspections". Examine the operating conditions and the amount of sludge. Schedule the subsequent inspections earlier or later, accordingly.

Obey the instructions that follow when you disassemble or do maintenance of the lubricating oil bypass filter.

1. Disassembly

1. Stop the engine.
2. Move the selecting valve of the bypass filter to "SERVICE".
3. Move the ball valve of the lubricating oil pipe (the one that drives the filter) to "CLOSE". This stops the oil flow to the bypass filter.
4. Look through the top sight glass 2. Make sure that the rotor does not move.

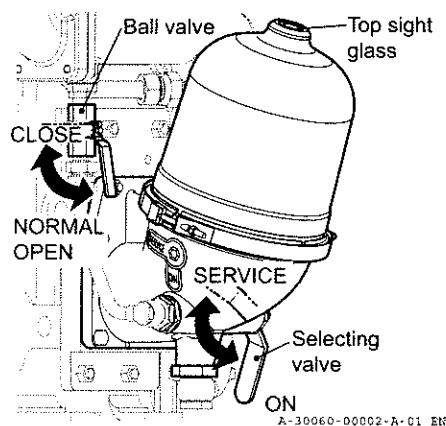


Fig.1 Lubricating oil bypass filter

5. Loosen the bolts on the band clamp 5.
6. Remove the band clamp.
7. Remove the safety ring 5.
8. Drain the oil from the rotor assembly 11.

The oil drains better if you lift the rotor assembly a little and let in air.

9. Lift up the rotor assembly and remove it from the filter body.

Make sure that you do not cause damage to the bottom journal bearing 8, the Pelton wheel and the drive tube 10.

10. Put the rotor assembly into a safe place.

11. Loosen the locknut 18.

12. Remove the rotor cover 17 from the rotor body 13.

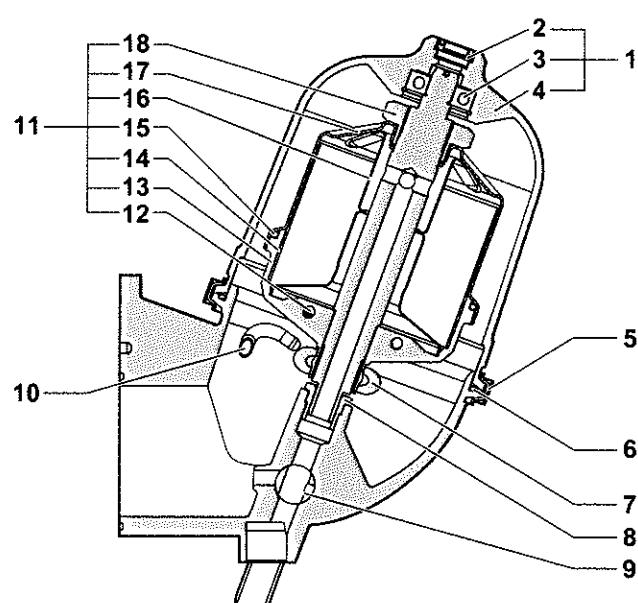


Fig.2 Lubricating oil bypass filter

2. Cleaning

1. Remove sludge deposition from the inside of the rotor cover with a spatula.
2. Dispose of the paper inlet 14.
3. Clean all parts of the rotor assembly 12 including the 4 nozzles of the rotor body with an applicable cleaning fluid. Make sure that they are free from sludge.
4. Examine these parts for wear and damage. If you find any, replace the part with a new one.
 - Ball bearing 3
 - Bottom journal shaft bearingRotor assembly

3. Assembly

1. Examine the nozzle for clogging.
2. Examine the holes for damage.
3. Install a new paper insert to the rotor body.
4. Align the rotor body and the stand tube 16.
5. Install the stand tube.
6. Let the rotor cover slide over the paper insert of the rotor body and install it.
7. Tighten the rotor cover nut 18.
Tightening torque: 20 N·m
(Alternatively, tighten the rotor cover nut tightly by hand. Then tighten it another 1/3 of a turn.)
8. Examine the bottom journal bearing, the Pelton wheel and the drive tube for damage.
9. Install the rotor assembly to the filter body.
10. Make sure that the rotor assembly moves easily.
11. Install the cover of the filter body.
12. Make sure that the spigot on the end of the rotor goes smoothly into the top of the ball bearing. Install the filter cover assembly.
13. Move the filter cover assembly and make sure that it fits in the flange of the filter body.
14. Install the band clamp.
15. Tighten the band clamp with bolt, so that it does not come loose during operation.
Tightening torque: 6 N·m
Examine the band clamp for looseness

4. Flow check

1. Start the engine.
2. Move the selecting valve on the filter body side surface to ON.
3. Move the cock of the ball valve to NORMAL OPEN.
4. Look through the top sight glass and make sure that the rotor turns. If the rotor does not turn, make sure that:
 - The filter cover assembly is correctly installed.
 - The ball bearing turns easily.
 - The band clamps are tightened equally.
5. With the filter in operation, examine all joints for leaks and unusual vibration. Repair if necessary.

CONDITION _____

Lubricating oil pipe (pinion lubrication)

Adjust

1/2

PRODUCTION MANAGEMENT DATA

Intervals 200 working hours

CONDITION

	Person	Category	Skill	Trade	Estimated time
EQUIPMENT	a	Engine crew	Intermediate	-	0.5h
		Nomenclature	Identification code		Quantity
SUPPLIES		Nomenclature	Identification code		Quantity
SPARES		Nomenclature	Identification code		Quantity
SAFETY					

On H.F.O. engines, drops of oil fall on the pinion sleeve and lubricate the bottom sliding parts of the fuel injection pump. This prevents bad movement of the rack, sliding part, and pinion part, and malfunctions of the fuel pump.

Obey the instructions that follow when you do inspection of the pinion lubrication volume.

1. Remove the cap nut 1 from the oil control valve.
2. Loosen the locknut 2.
3. Screw in the oil control screw 3. This stops the oil flow.
4. Remove the drip rate check screw 4 on the fuel injection pump side.
5. Slowly loosen the oil control screw until the lubricating volume reaches the specified value. (Turn the oil control screw counter-clockwise.)
6. When the specified lubrication quantity is reached, securely tighten the locknut.
7. Securely tighten the cap nut.
8. Securely tighten the check screw.
9. Wait 30 minutes after you adjust the lubrication quantity. Then open the check screw.
10. Measure the lubrication quantity again.
11. Confirm the lubrication quantity.
12. Securely tighten the check screw.

NOTICE

Make sure that the temperature of the lubricating oil is stable. If necessary, operate the engine and wait for the temperature to increase.

Set the lubrication to 1 drop every 10 to 12 seconds.

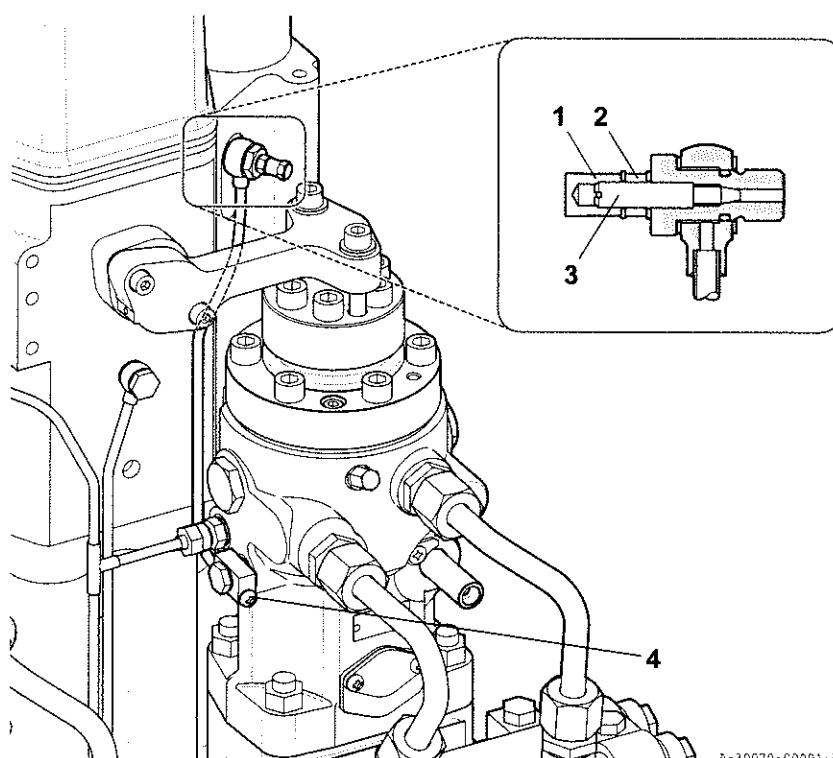
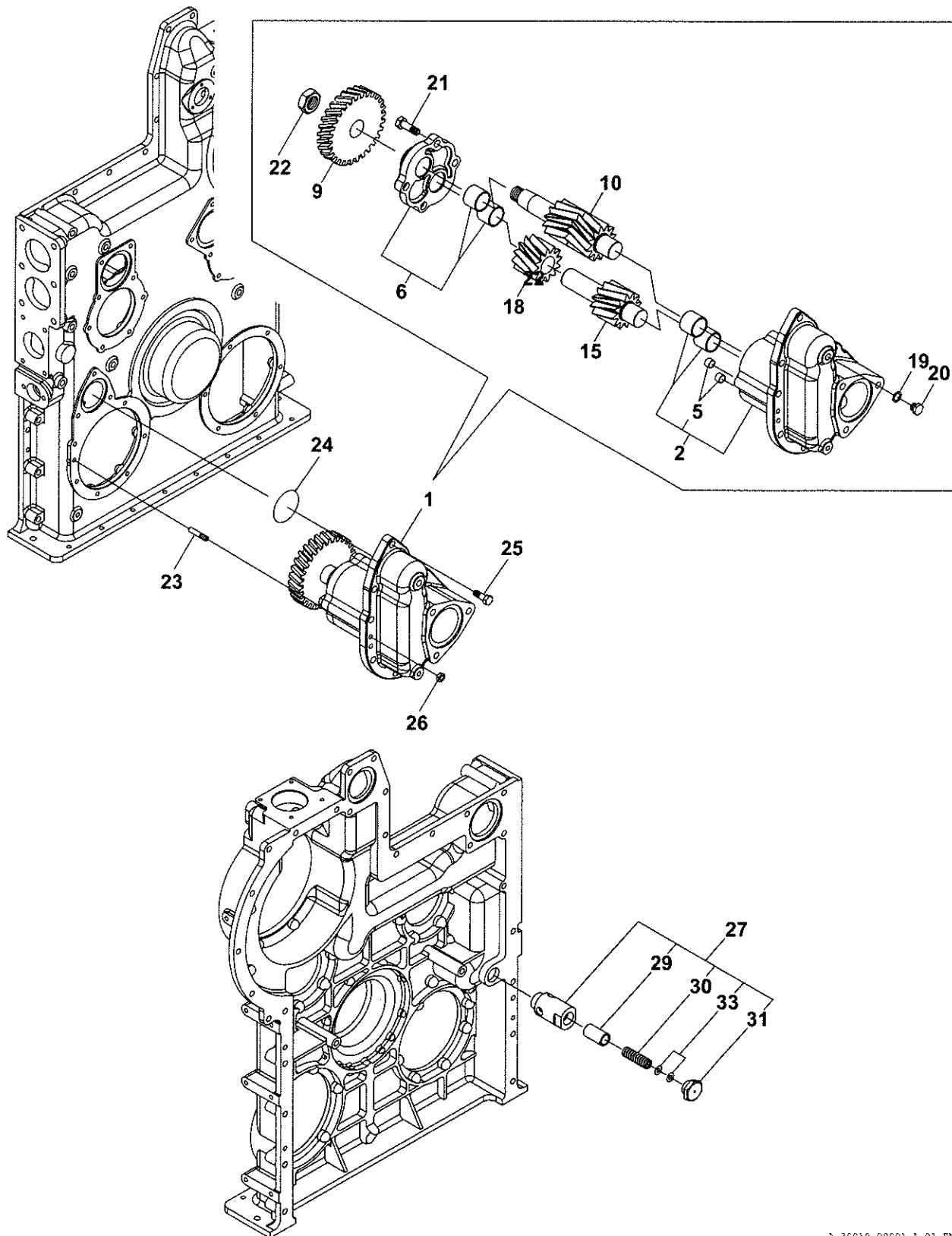


Fig. 1 Adjusting the lubricating volume

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CONDITION

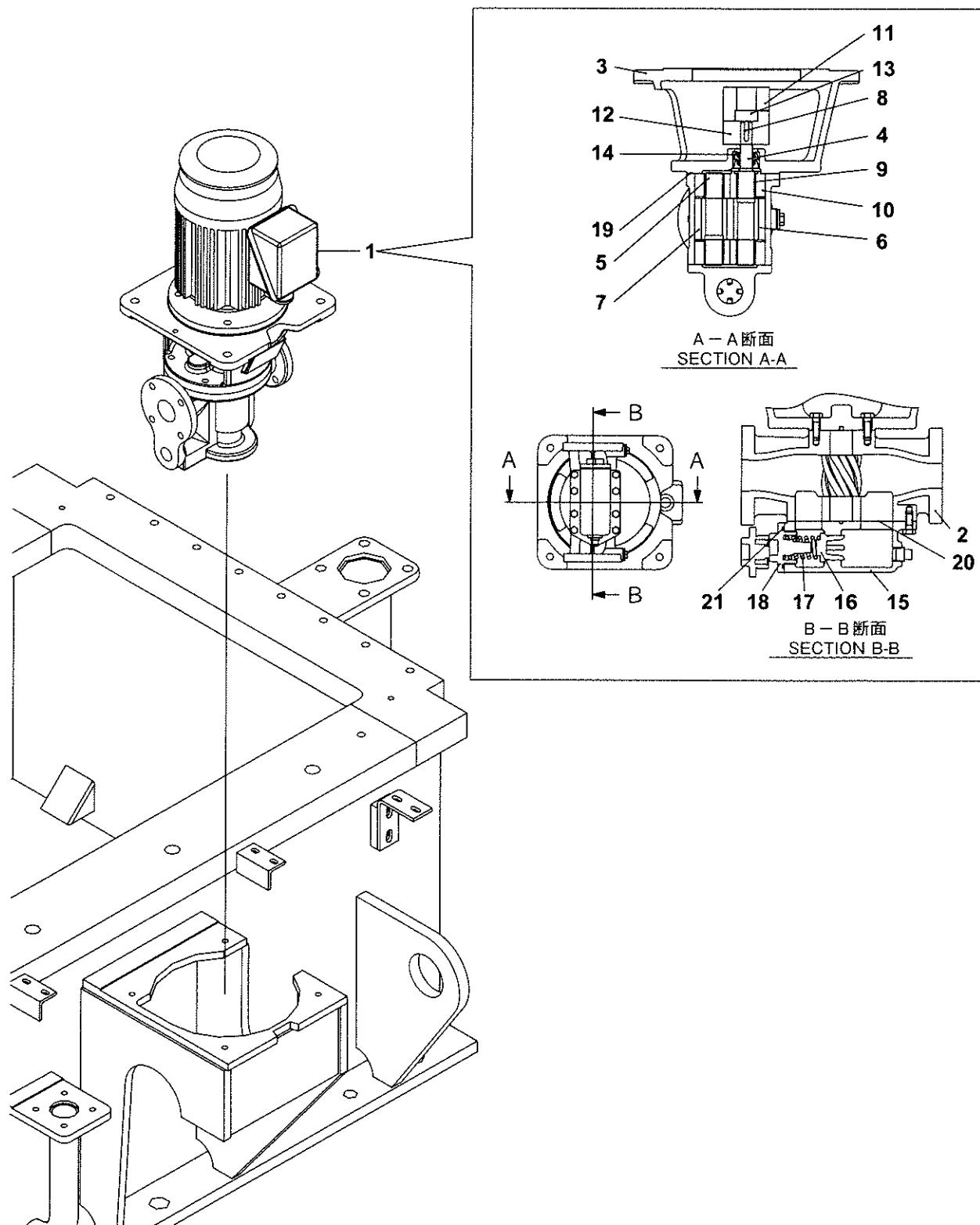


Lubricating oil pump

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	750633-32110	LO PUMP XL	1	1	
2	2	150633-32010	LOP BODY ASSY	1	1	
5	3	24550-016120	BEARING, 16 X 12	2	2	
6	2	147673-32070	COVER ASSY, L/O PUMP	1	1	
9	2	150633-32210	GEAR,LOP	1	1	
10	2	150633-32310	LOP GEAR ASSY,DRIVIN	1	1	
15	2	150633-32350	LOP GEAR ASSY,DRIVEN	1	1	
18	2	150633-32370	LOP GEAR D	1	1	
19	2	23414-160000	GASKET, 16 X 1.0	1	1	
20	2	23887-160002	PLUG, 16	1	1	
21	2	26292-140452	BOLT, 14 X 45	4	4	
22	2	26772-300002	NUT, 30	1	1	
23	1	22340-100322	PIN, 10 X 32	1	1	
24	1	24311-000750	PACKING, P 75.0	1	1	
25	1	26206-120352	BOLT, 12 X 35	9	9	
26	1	26796-100002	NUT, 10	1	1	
27	1	728633-32200	SAFETY VALVE ASSY	1	1	
29	3	128633-32410	VALVE	1	1	
30	3	128633-32420	SPRING, SAFETY VALVE	1	1	
31	3	128633-32430	SHUTTER	1	1	
33	2	128633-32450	SHIM SET, ADJUSTING	1	1	



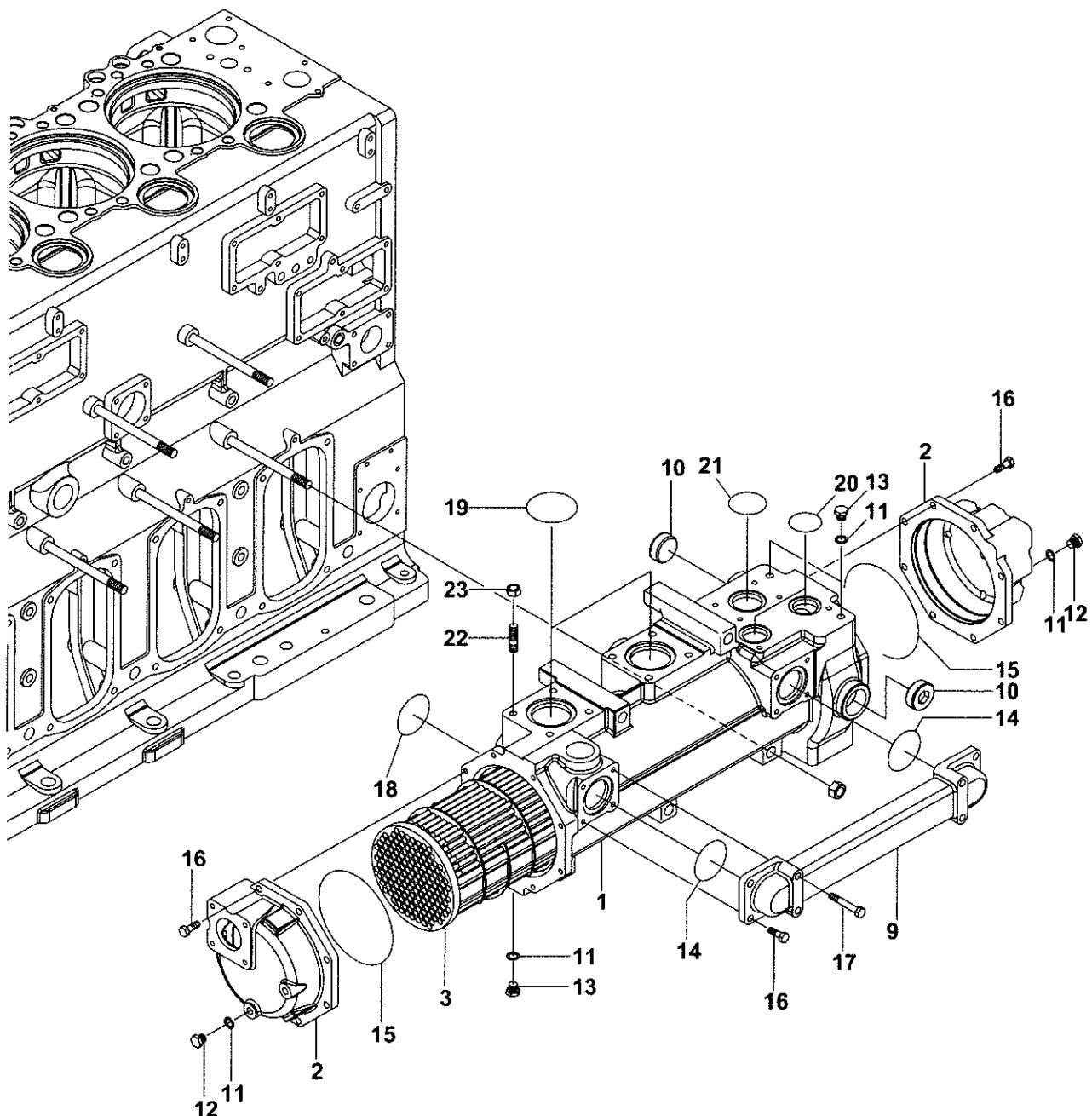
A-30029-00001-A-01_EN

Lubricating oil priming pump

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46130-061720	PUMP,LO PRIM.MOTOR	1	1	
2	2	40000-018390	PUMP CASING	1	1	
3	2	40000-018180	MOTOR FRAME	1	1	
4	2	40000-018400	DRIVE SHAFT	1	1	
5	2	40000-018410	DRIVEN SHAFT	1	1	
6	2	40000-018420	DRIVE GEAR	1	1	
7	2	40000-018430	DRIVEN GEAR	1	1	
8	2	40000-018230	KEY	1	1	
9	2	40000-018240	BEARING	4	4	
10	2	40000-018250	HOUSING, BEARING	4	4	
11	2	40000-018260	COUPLING	1	1	
12	2	40000-018270	COUPLING	1	1	
13	2	40000-018280	BUSH, COUPLING	1	1	
14	2	40000-018290	OIL SEAL	2	2	
15	2	40000-018300	BODY, SAFETY VALVE	1	1	
16	2	40000-018310	SAFETY VALVE	1	1	
17	2	40000-018320	SPRING, SAFETY VALVE	1	1	
18	2	40000-018331	COVER, SPRING	1	1	
19	2	40000-018340	GASKET	1	1	
20	2	40000-018350	GASKET	1	1	
21	2	24321-000450	O-RING G45	1	1	

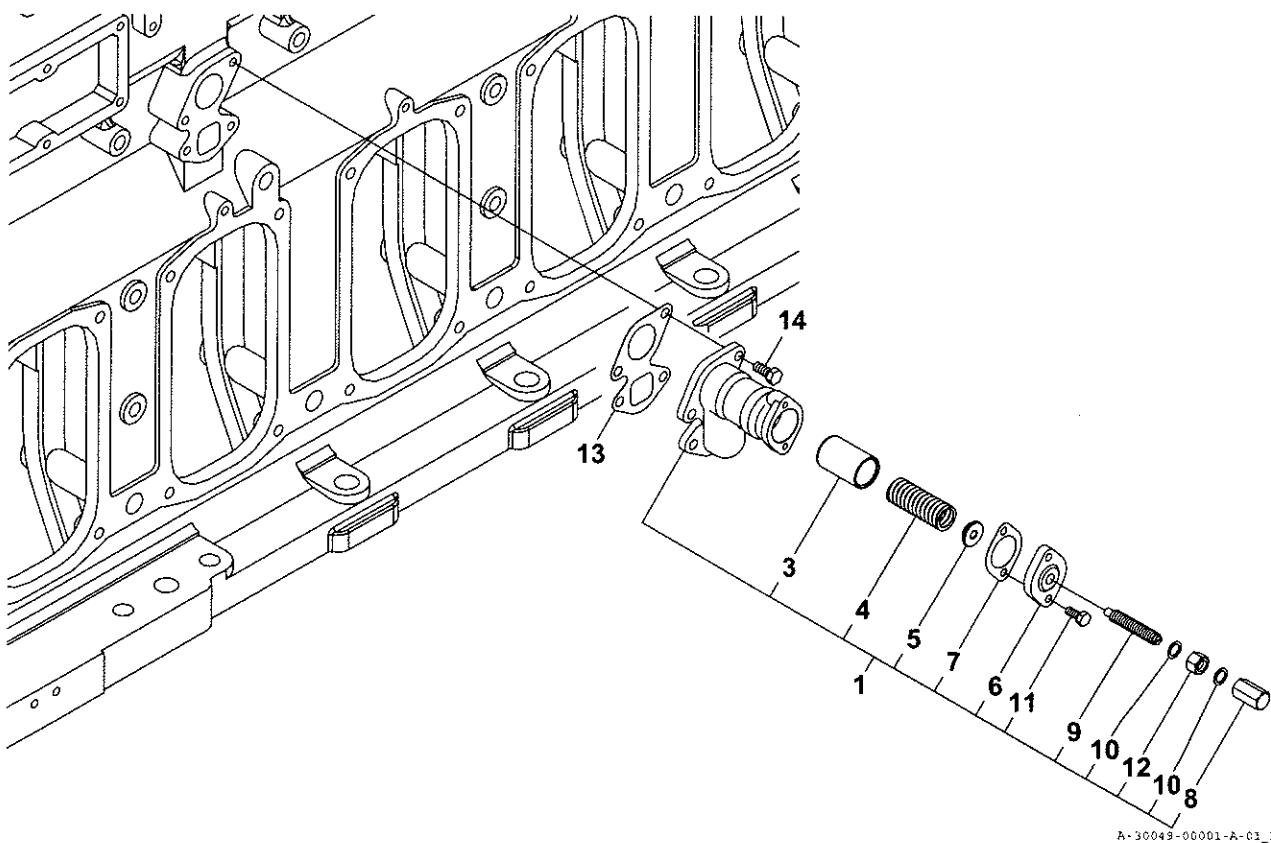


Lubricating oil cooler

Illustrated parts data

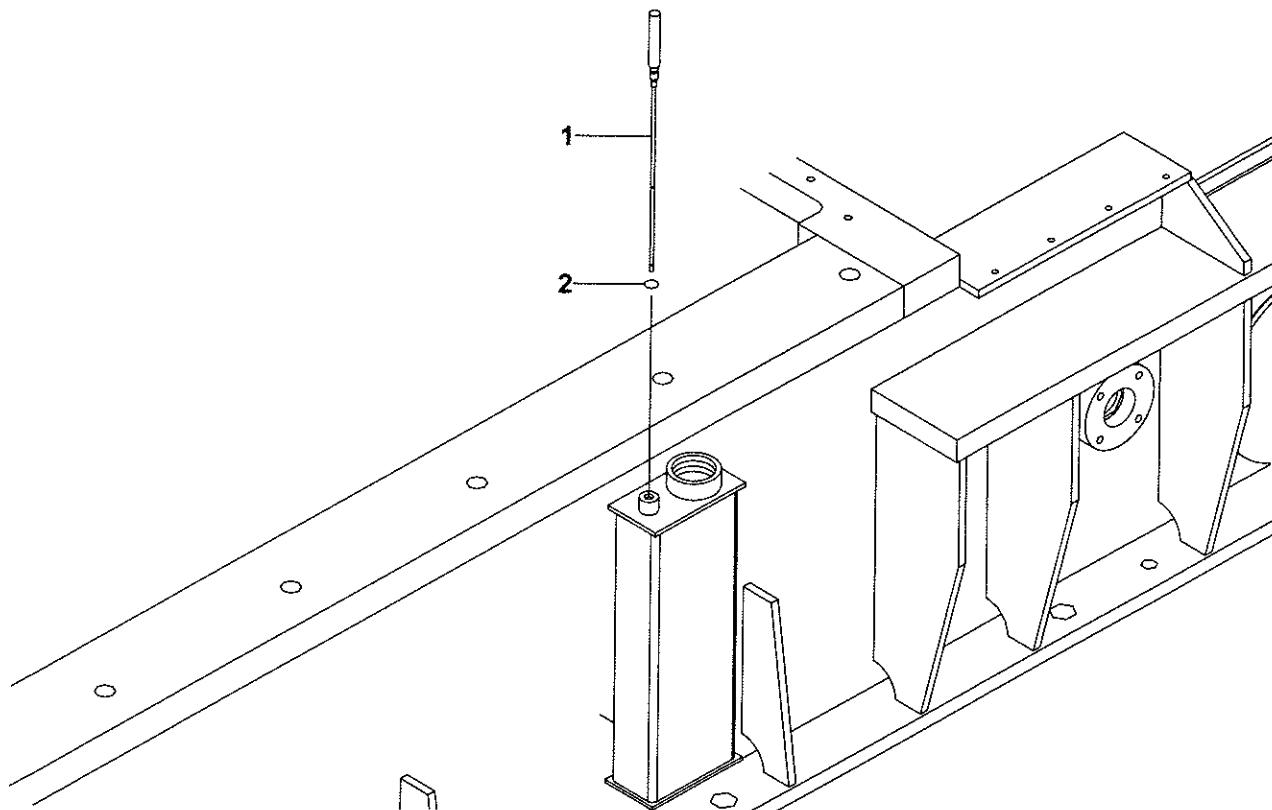
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-33040	BODY,LUB OIL COOLER	1	1	
2	1	150633-33160	COVER,LO COOLER	2	2	
3	1	150633-33190	COOLING PIPE ASSY	1	1	
4	2	133970-33202	SEAT, COOLER TUBE	2	2	
5	2	150633-33230	COOLING PIPE	170	170	
6	2	150633-33250	DISTANCE PLATE	4	4	
7	2	150633-33260	DISTANCE PLATE	20	20	
8	2	150633-33270	BAFFLE PLATE	11	11	
9	1	150633-33320	PIPE,LO BY-PASS	1	1	
10	1	150633-33910	PLUG,R20	5	5	
11	1	23414-170000	GASKET, 17 X 1.0	7	7	
12	1	23894-030002	PLUG, G 3/8	4	4	
13	1	23897-030002	PLUG, G 3/8	3	3	
14	1	24311-000750	PACKING, P 75.0	2	2	
15	1	24321-002300	PACKING, G230.0	2	2	
16	1	26206-120352	BOLT, 12 X 35	20	20	
17	1	26206-120802	BOLT, 12 X 80	4	4	
18	1	24311-000750	PACKING, P 75.0	1	1	
19	1	24311-000900	PACKING, P 90.0	2	2	
20	1	24321-000600	PACKING, G 60.0	2	2	
21	1	24321-000700	PACKING, G 70.0	1	1	
22	1	26232-160402	STUD,BOLT 16 X 40	8	8	
23	1	26732-160002	NUT, 16	8	8	



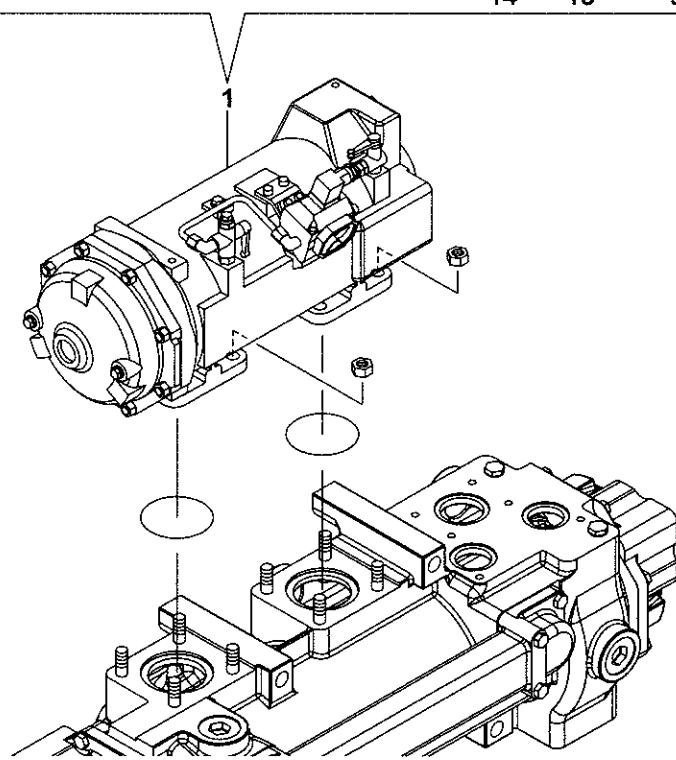
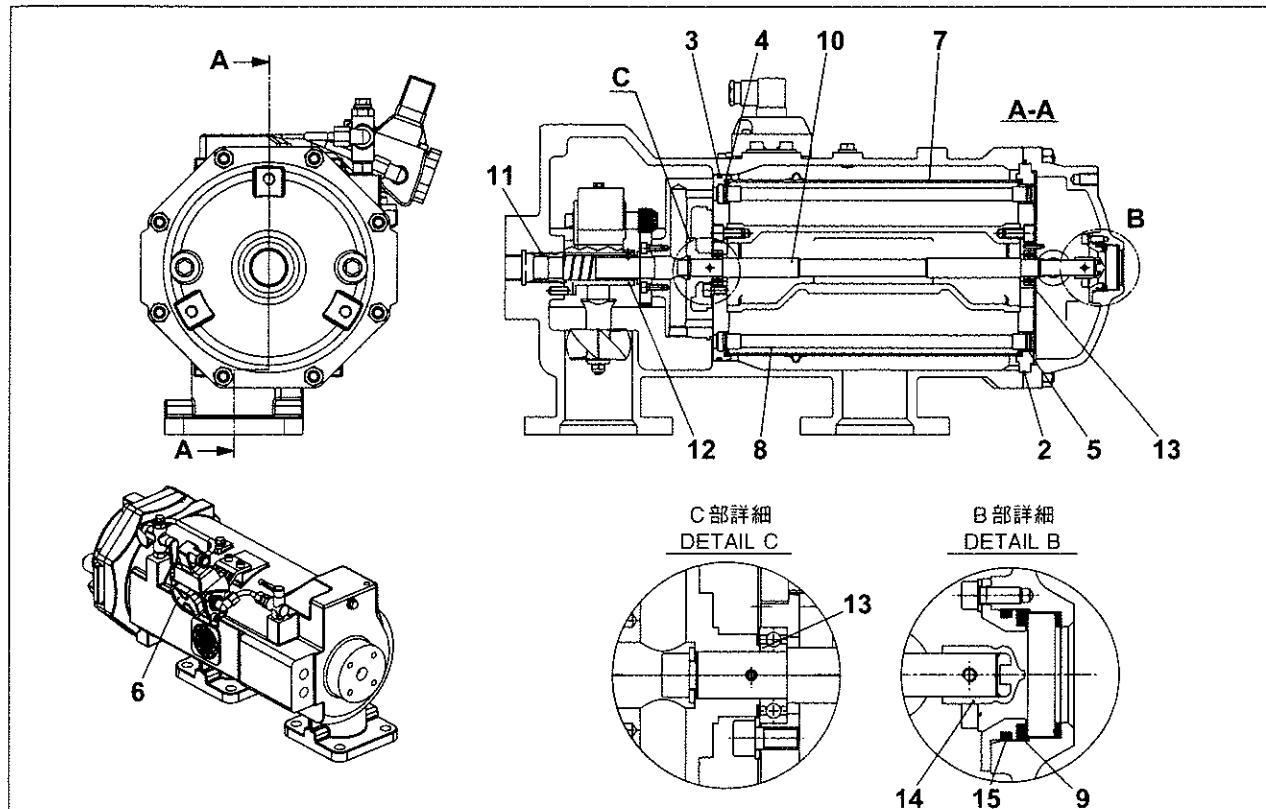
A-30049-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	747673-34020	VALVE ASSY, CONTROL	1	1	
2	2	147673-34010	BODY, CONTROL VALVE	1	1	
3	2	139653-34030	VALVE, CONTROL	1	1	
4	2	139653-34040	SPRING, VALVE	1	1	
5	2	139653-34060	RETAINER, SPRING	1	1	
6	2	139653-34070	RETAINER, SPRING	1	1	
7	2	139653-34080	PACKING	1	1	
8	2	139653-34090	NUT, CAP	1	1	
9	2	138613-34100	BOLT, ADJUSTING	1	1	
10	2	23414-160000	GASKET, 16 X 1.0	2	2	
11	2	26206-100252	BOLT, 10 X 25	2	2	
12	2	26772-160002	NUT, 16	1	1	
13	1	147673-34020	PACKING, VALVE	1	1	
14	1	26206-120302	BOLT, 12 X 30	4	4	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	41632-011210	DIPSTICK,LUB OIL	1	1	
2	1	24311-000070	PACKING, P 7.0	1	1	

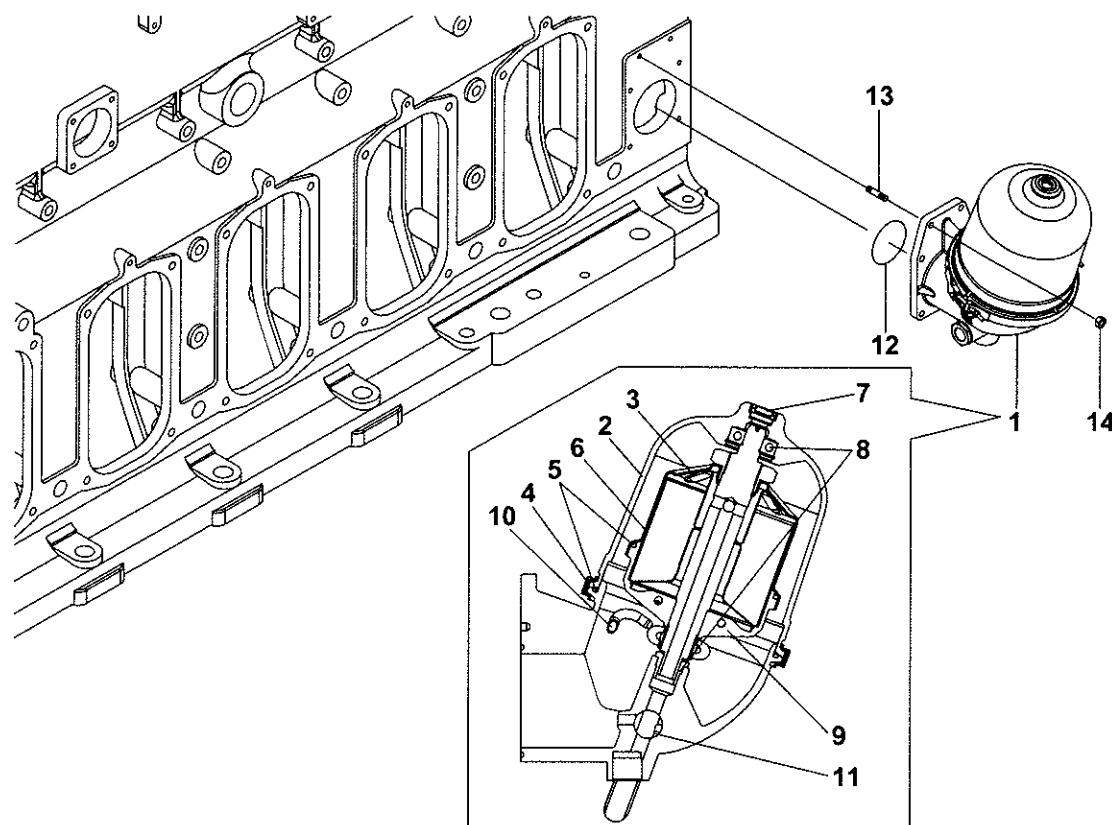


Lubricating oil strainer

Illustrated parts data

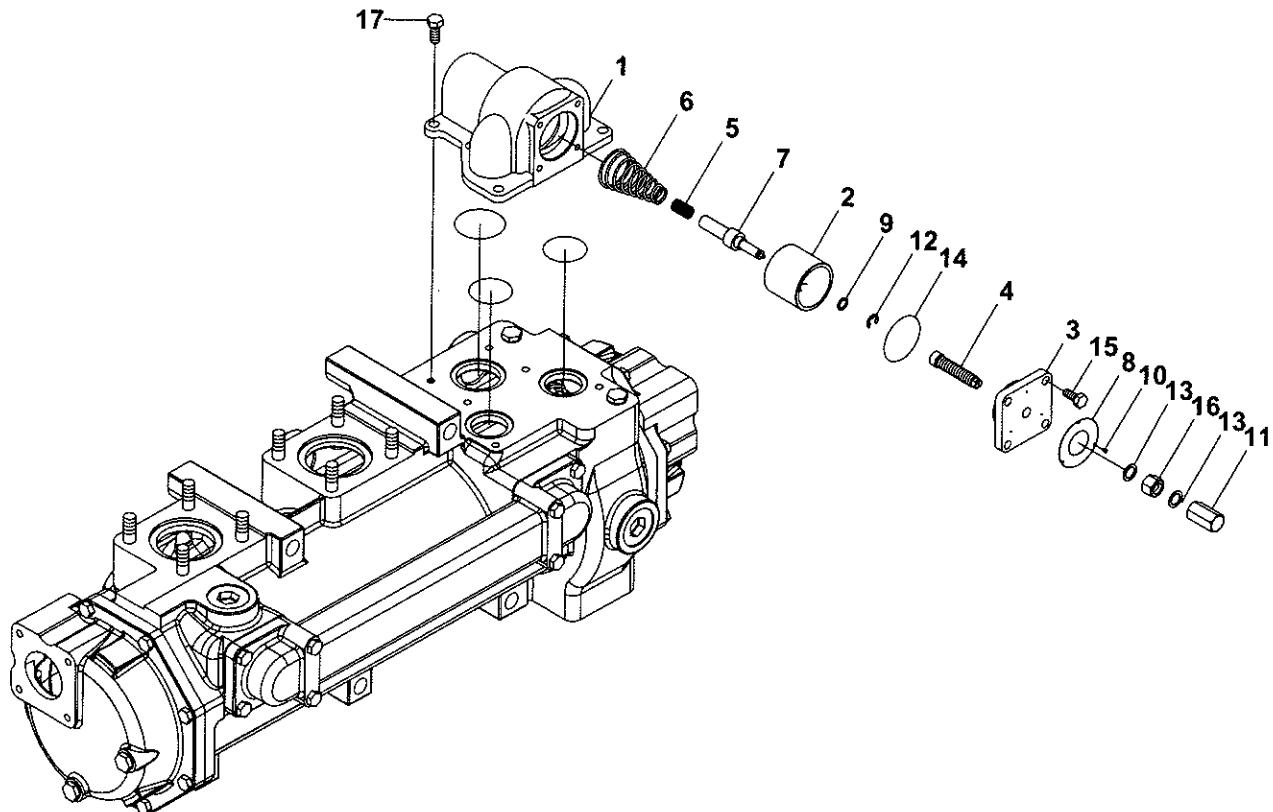
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-35051	STRAINER,AUTO B&K	1	1	
2	2	150633-35410	O-RING,D209 B&K	1	1	
3	2	150633-35420	O-RING,D177 B&K	1	1	
4	2	150633-35430	O-RING,D171 B&K	2	2	
5	2	146623-35440	O-RING, D16 B&K	64	64	
6	2	42130-018460	SWITCH, DEFF. PRESS.	1	1	
7	2	150633-35490	INDICATION FILTER	1	1	
8	2	132659-35501	ELEMENT, FILTER	32	32	
9	2	132659-35550	O-RING, D37 B&K	1	1	
10	2	151695-35820	FLUSHING ARM SHAFT	1	1	
11	2	150633-35830	MOUNTING BUSHING(B&K)	1	1	
12	2	150633-35840	FLUSHING BUSH (B&K)	1	1	
13	2	151695-35860	BALL BEARING (B&K)	2	2	
14	2	151695-35870	INDICATION BUSH (B&K)	1	1	
15	2	151695-35950	O-RING, (B&K)	1	1	



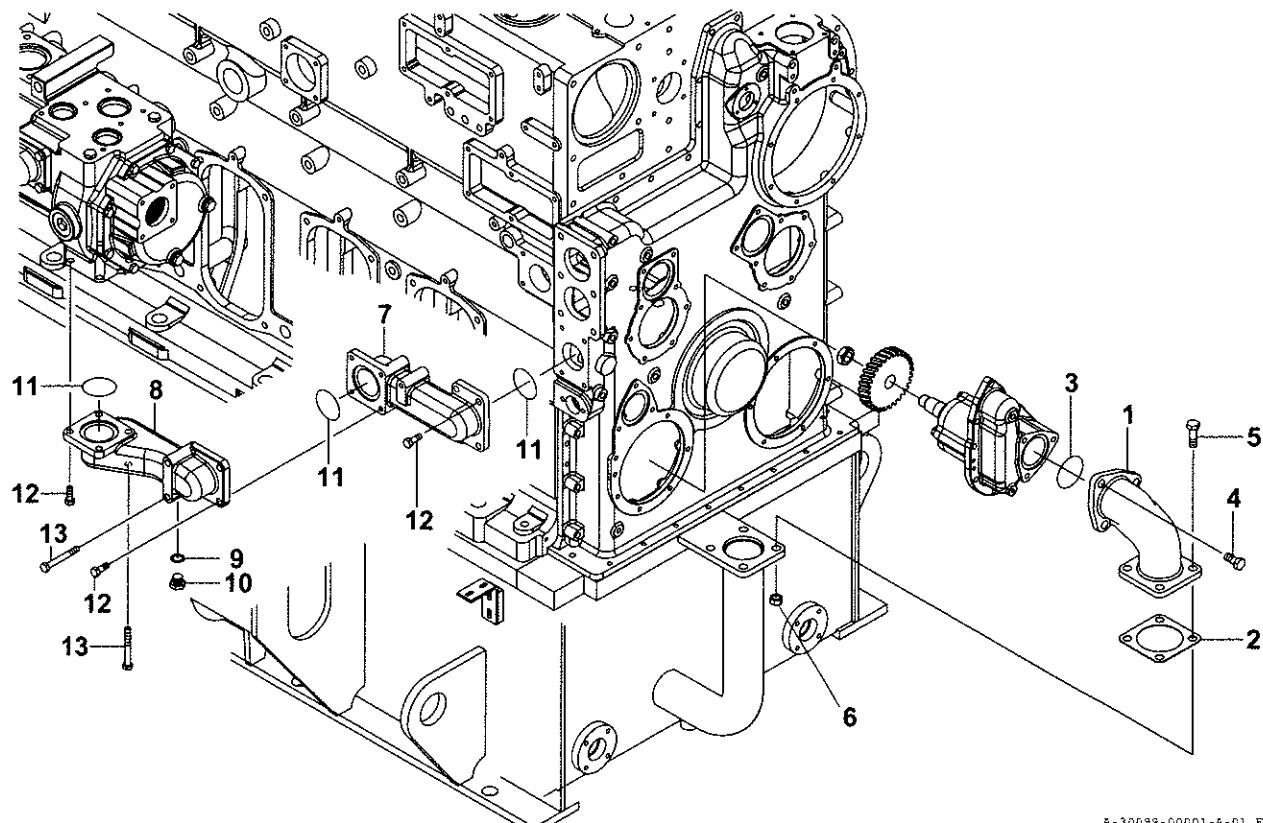
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-35201	CENTRIFUGAL FILTER	1	1	
2	2	746623-35411	COVER ASSY	1	1	
3	2	746623-35420	ROTOR ASSY	1	1	
4	2	146623-35901	BAND	1	1	
5	2	746623-35460	O-RING, SEAL KIT	1	1	
6	2	746623-35450	PAPER INSERT	1	1	
7	2	746623-35470	WINDOW, INSPECTION	1	1	
8	2	746623-35481	BEARING ASSY	1	1	
9	2	746623-35490	BODY, ROTOR	1	1	
10	2	146623-35930	PIPE, DRIVE	1	1	
11	2	746623-35430	VALVE ASSY	1	1	
12	1	122310-01300	O-RING, CYL. LINER	1	1	
13	1	26216-100302	STUD,BOLT 10 X 30	6	6	
14	1	26706-100002	NUT, 10	6	6	



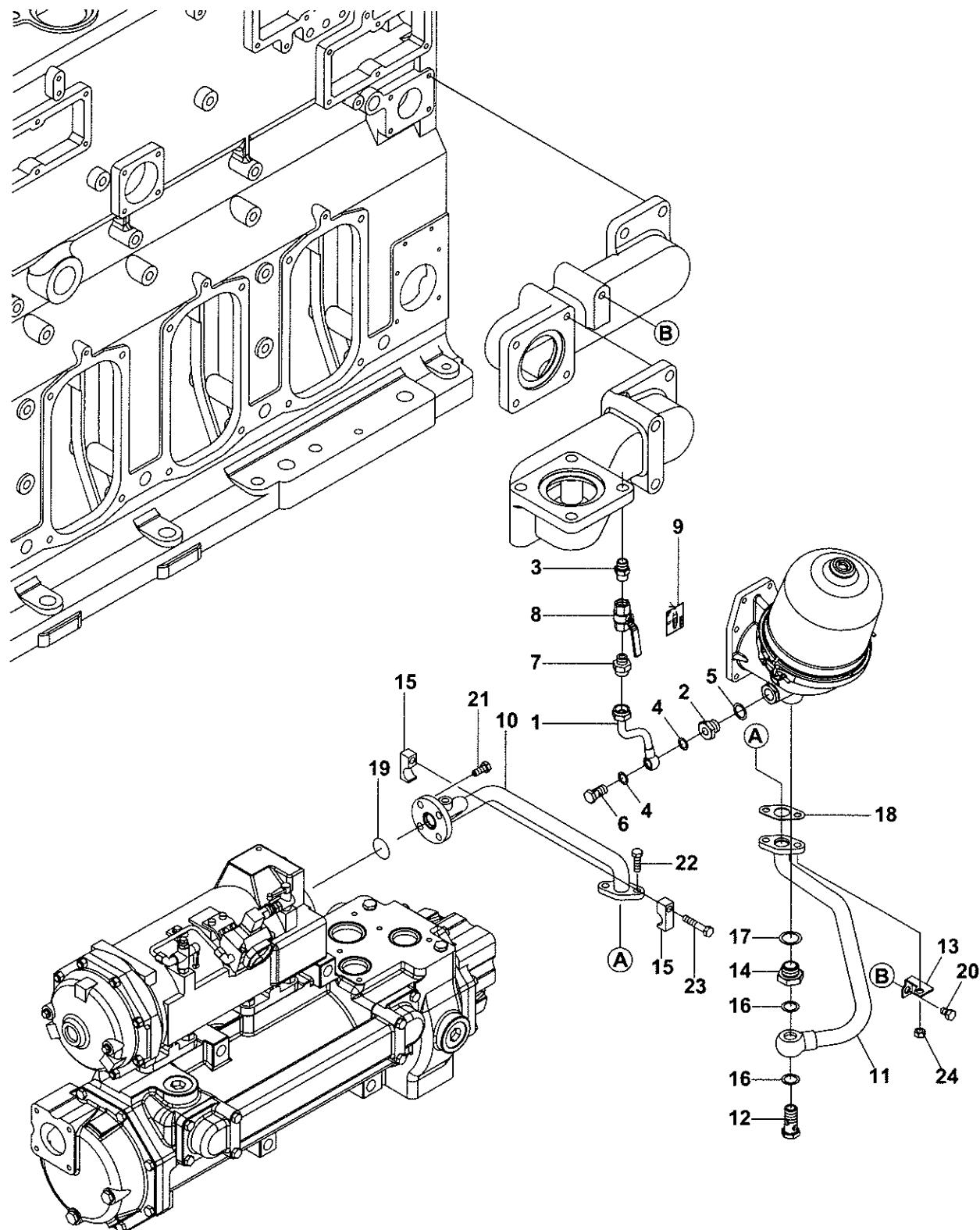
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	147673-38100	BODY	1	1	
2	1	141616-38110	PISTON	1	1	
3	1	141616-38120	COVER	1	1	
4	1	141616-38130	ADJUSTING BOLT	1	1	
5	1	141616-38140	SPRING	1	1	
6	1	141616-38150	SPRING	1	1	
7	1	141616-38210	ELEMENT	1	1	
8	1	141616-38260	LABEL,LO.THERMOSTAT	1	1	
9	1	137600-64260	SPACER (B)	1	1	
10	1	137900-91451	RIVET	3	3	
11	1	139653-34090	CAP NUT	1	1	
12	1	22272-000100	CIRCLIP E-10	1	1	
13	1	23414-160000	GASKET 16, ROUND	2	2	
14	1	24321-000650	O-RING 1A G-65.0	1	1	
15	1	26206-100252	BOLT M10X25	4	4	
16	1	26772-160002	NUT M16,LOCK	1	1	
17	1	26206-120302	BOLT M12X 30	6	6	

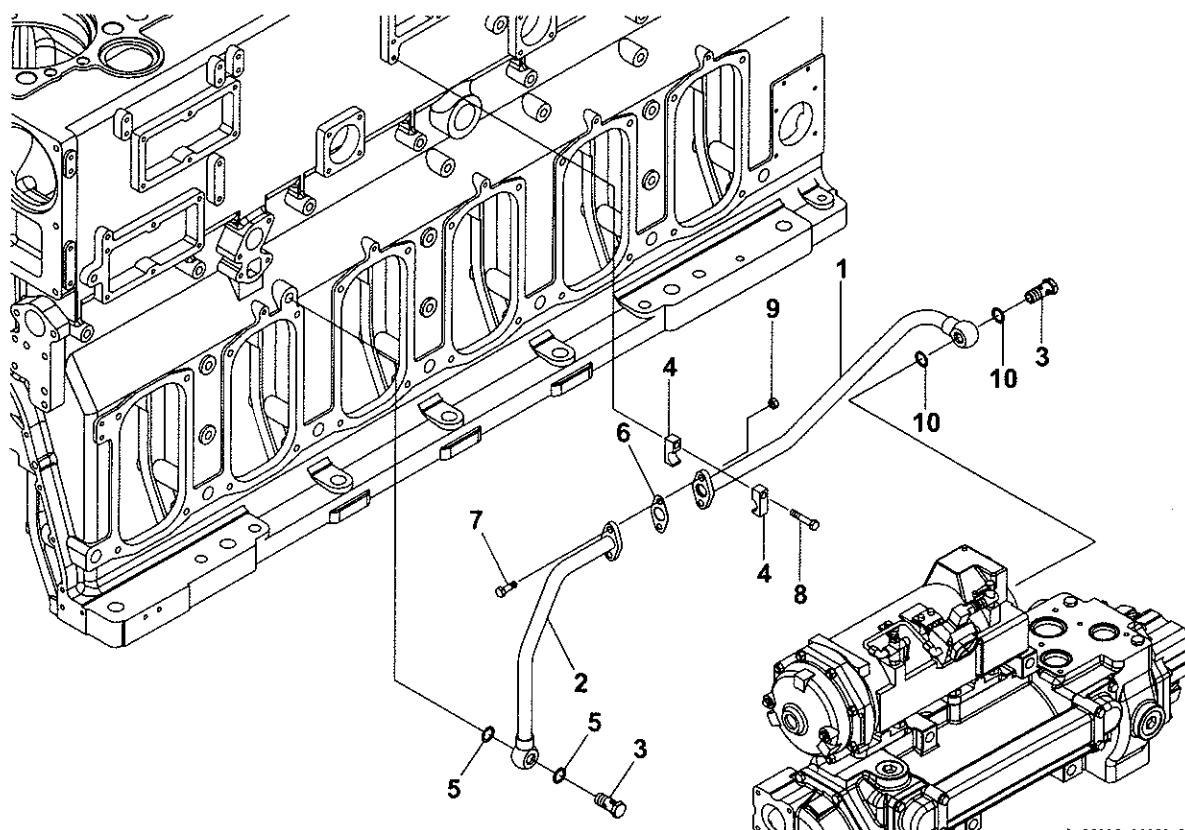


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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39110	LO PIPE, PUMP INLET	1	1	
2	1	153605-34100	PACKING, VALVE	1	1	
3	1	24311-000900	PACKING, P 90.0	1	1	
4	1	26152-160352	BOLT, 16 X 35	3	3	
5	1	26152-160502	BOLT, 16 X 50	4	4	
6	1	26732-160002	NUT, 16	4	4	
7	1	150633-39400	LO PIPE, LOP-LOC	1	1	
8	1	150633-39410	LO PIPE, LOP-LOC	1	1	
9	1	23414-210000	GASKET, 21 X 1.0	1	1	
10	1	23897-040002	PLUG, G 1/2	1	1	
11	1	24311-000750	PACKING, P 75.0	3	3	
12	1	26206-120352	BOLT, 12 X 35	8	8	
13	1	26206-121002	BOLT, 12 X 100	4	4	

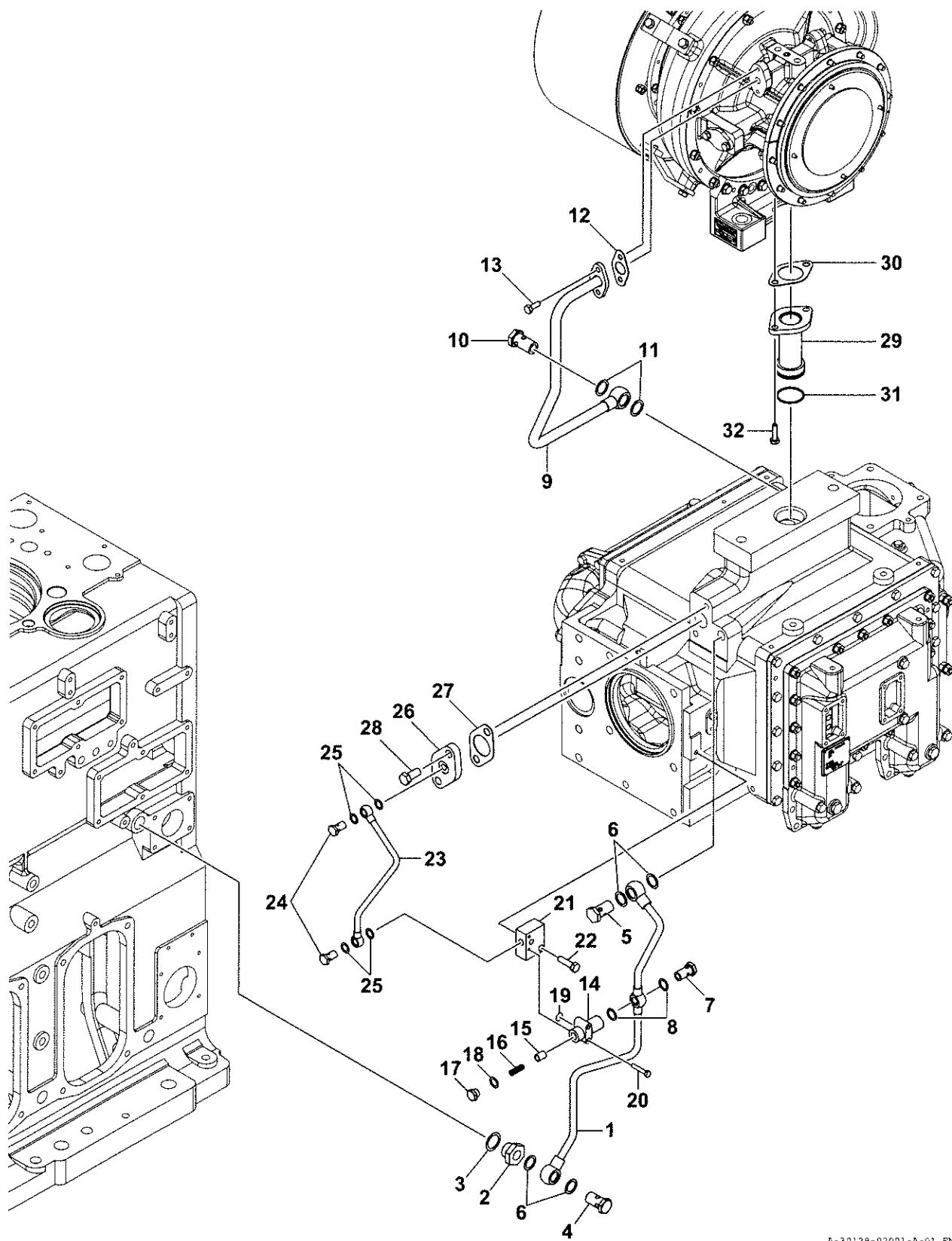


No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39191	LO PIPE, FM200 DRIVE	1	1	
2	1	146623-39370	UNION, M26-M18	1	1	
3	1	23163-040000	NIPPLE,R 1/2	1	1	
4	1	23414-180000	GASKET, 18 X 1.0	2	2	
5	1	23414-260000	GASKET, 26 X 1.0	1	1	
6	1	23857-120000	BOLT, JOINT 12	1	1	
7	1	43551-001711	UNION, PT1/2X15	1	1	
8	1	43600-023230	VALVE, BALL	1	1	
9	1	146673-07150	LABEL, VALVE	1	1	
10	1	150633-39451	LO PIPE A,FILTER OUT	1	1	
11	1	150633-39471	LO PIPE B,FILTER OUT	1	1	
12	1	146623-39050	JOINT BOLT	1	1	
13	1	150633-39280	SUPPORT,LO PIPE,FILT	1	1	
14	1	146623-39480	UNION,M33-M25	1	1	
15	1	146625-39820	SUPPORT, 30X1	2	2	
16	1	23414-250000	GASKET, 25 X 1.0	2	2	
17	1	23414-330000	GASKET, 33 X 1.0	1	1	
18	1	23428-310000	GASKET, 31 X 1.5	1	1	
19	1	24321-000400	PACKING, G 40.0	1	1	
20	1	26206-120202	BOLT, 12 X 20	1	1	
21	1	26206-120302	BOLT, 12 X 30	4	4	
22	1	26206-120402	BOLT, 12 X 40	2	2	
23	1	26206-120652	BOLT, 12 X 65	1	1	
24	1	26706-120002	NUT, 12	2	2	



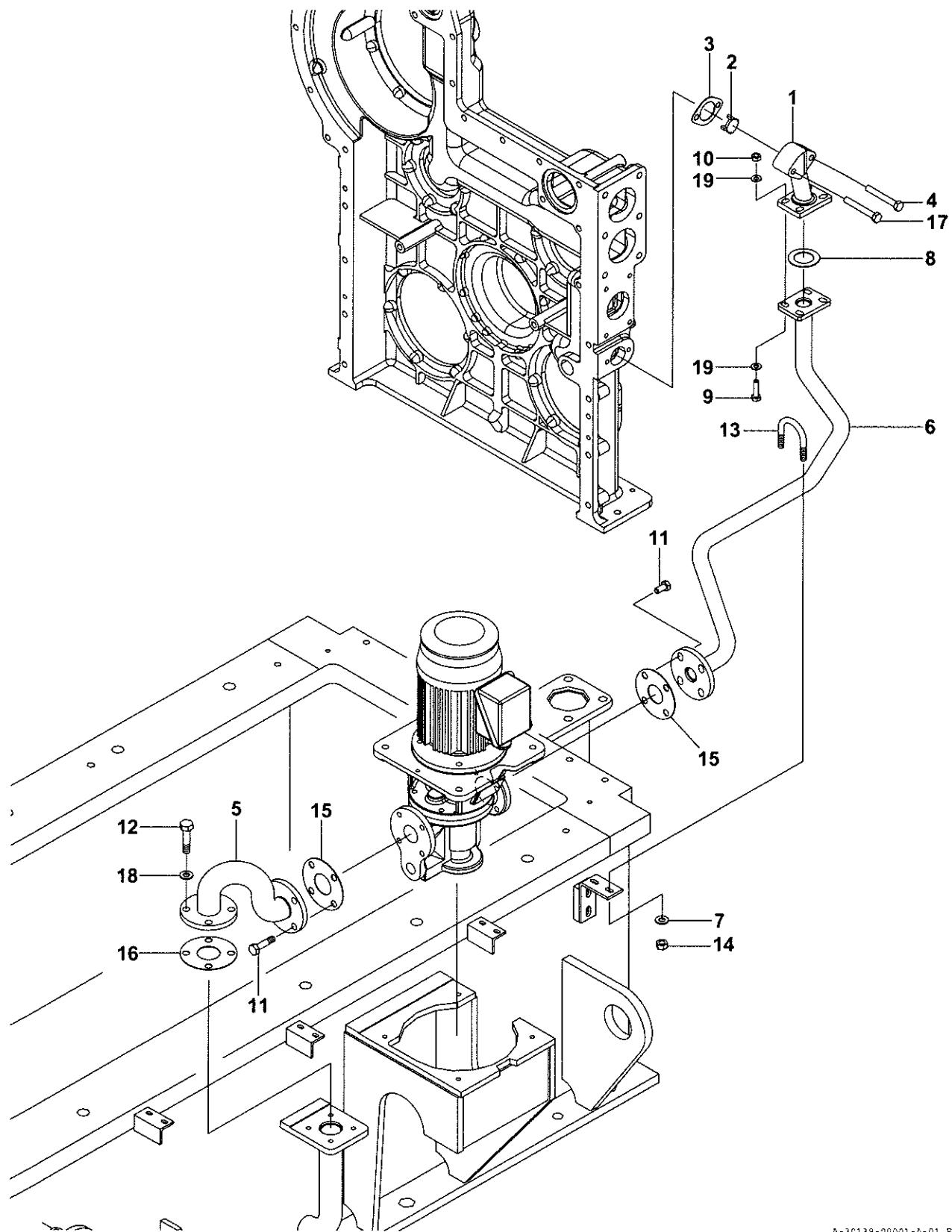
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39310	LO PIPE A,FILTER OUT	1	1	
2	1	150633-39321	LO PIPE B,FILTER OUT	1	1	
3	1	146623-39050	JOINT BOLT	2	2	
4	1	146625-39820	SUPPORT, 30X1	2	2	
5	1	23414-250000	GASKET, 25 X 1.0	4	4	
6	1	23428-310000	GASKET, 31 X 1.5	1	1	
7	1	26206-120402	BOLT, 12 X 40	2	2	
8	1	26206-120652	BOLT, 12 X 65	1	1	
9	1	26706-120002	NUT, 12	2	2	
10	1	153672-59840	WASHER, SEAL 25	2	2	



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No	LV	Part No.	Part name	ALW	Remarks
1	1	150634-39050	PIPE, LO T/C IN A	1	
2	1	146623-39480	UNION, M33-M25	1	
3	1	23414-330000	GASKET, 33 X 1.0	1	
4	1	150633-39480	BALL JOINT BOLT 20	1	
5	1	23857-200000	BOLT, JOINT 20	1	
6	1	23414-250000	GASKET, 25 X 1.0	4	
7	1	23857-150000	BOLT, JOINT 15	1	
8	1	23414-200000	GASKET, 20 X 1.0	2	
9	1	150634-39100	PIPE, LO T/C IN B	1	
10	1	23857-220000	BOLT, JOINT 22	1	
11	1	23414-280000	GASKET, 28 X 1.0	2	
12	1	146670-39240	PACKING	1	
13	1	26206-100302	BOLT, 10 X 30	2	
14	1	41634-000262	BODY, ADJUST VALVE	1	
15	1	125310-34031	VALVE, CONTROL	1	
16	1	138613-52580	SPRING, L46 10RD.	1	
17	1	146623-34210	HEXAGON PLUG M18	1	
18	1	23414-180000	GASKET, 18 X 1.0	1	
19	1	24311-000200	PACKING, P 20.0	1	
20	1	26206-080452	BOLT, 8 X 45	2	
21	1	150634-39070	BRACKET, LO VALVE	1	
22	1	26206-120452	BOLT, 12 X 45	1	
23	1	150634-39060	PIPE, LO VALVE	1	
24	1	23857-100000	BOLT, JOINT 10	2	
25	1	23414-160000	GASKET, 16 X 1.0	4	
26	1	150634-39080	FLANGE, OVAL M16	1	
27	1	23428-510000	GASKET, 51 X 1.5	1	
28	1	26152-160352	BOLT, 16 X 35	2	
29	1	150634-39120	PIPE, LO T/C OUT	1	
30	1	148616-49711	GASKET, PUMP OUT	1	
31	1	24326-000550	PACKING, G 55.0	1	
32	1	26206-100402	BOLT, 10 X 40	2	



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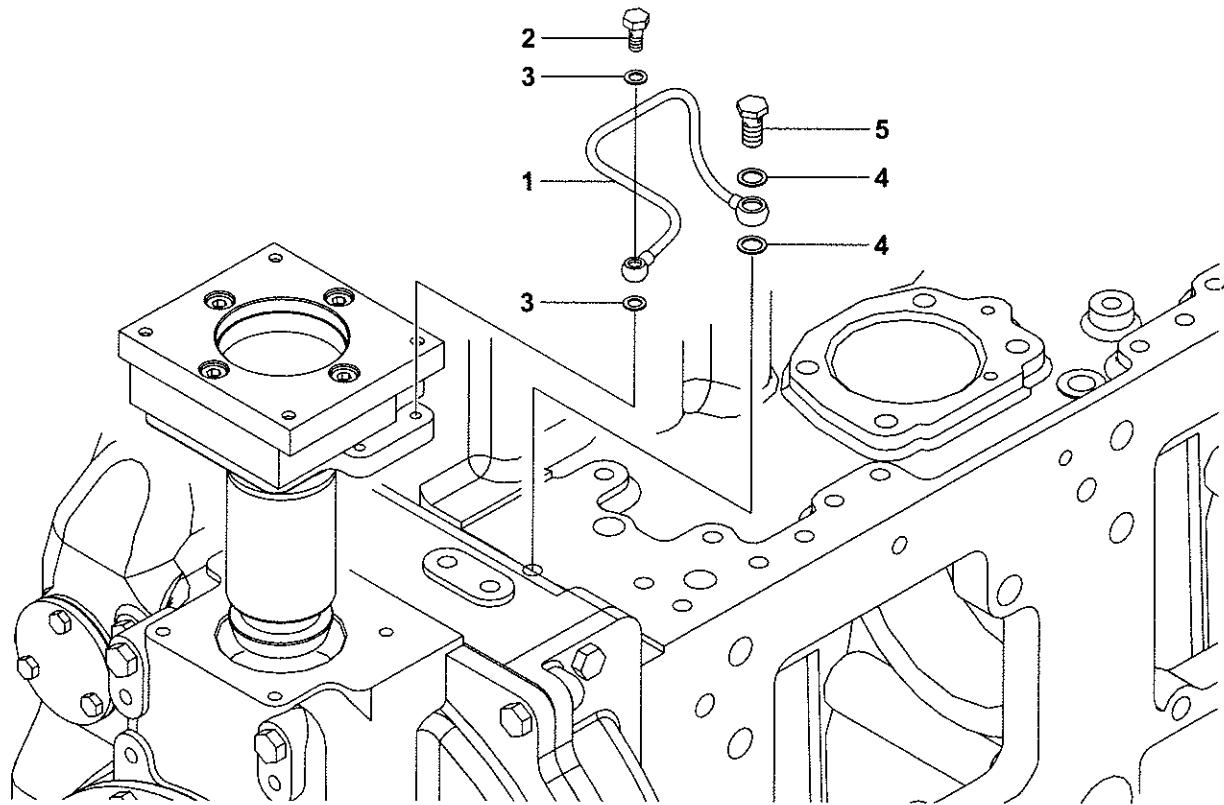
Lubricating oil pipe (priming)

Illustrated parts data

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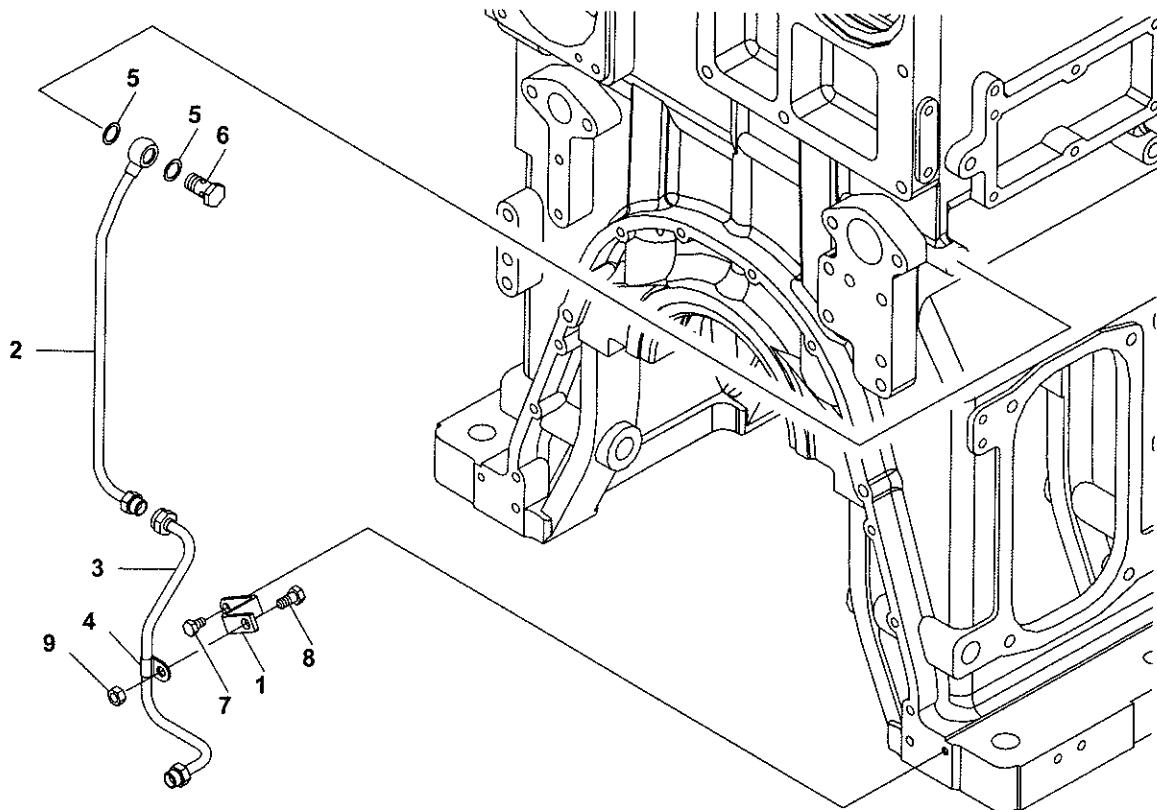
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39642	PIPE (LO PRIMING)	1	1	
2	1	146623-39641	CHECK VALVE	1	1	
3	1	146623-39680	PACKING	1	1	
4	1	26206-120552	BOLT, 12 X 55	1	1	
17	1	26206-120652	BOLT, 12 X 65	1	1	
5	1	43711-102300	PIPE, LOP PUMP IN	1	1	
6	1	43711-107663	PIPE, LUB OIL	1	1	
7	1	22137-080000	WASHER, 8	2	2	
8	1	23438-025000	COUPLING, 25S	1	1	
9	1	26206-100402	BOLT, 10 X 40	4	4	
10	1	26706-100002	NUT, 10	4	4	
11	1	26206-120302	BOLT, 12 X 30	8	8	
12	1	26206-120302	BOLT, 12 X 30	4	4	
13	1	26464-025000	U-BOLT, 25	1	1	
14	1	26706-080002	NUT, 8	2	2	
15	1	43400-004150	PACKING, 32	2	2	
16	1	43400-004160	GASKET, 5K-40	3	3	
18	1	22137-120000	WASHER, 12	4	4	
19	1	22137-100000	WASHER, 10	8	8	

Illustrated parts data



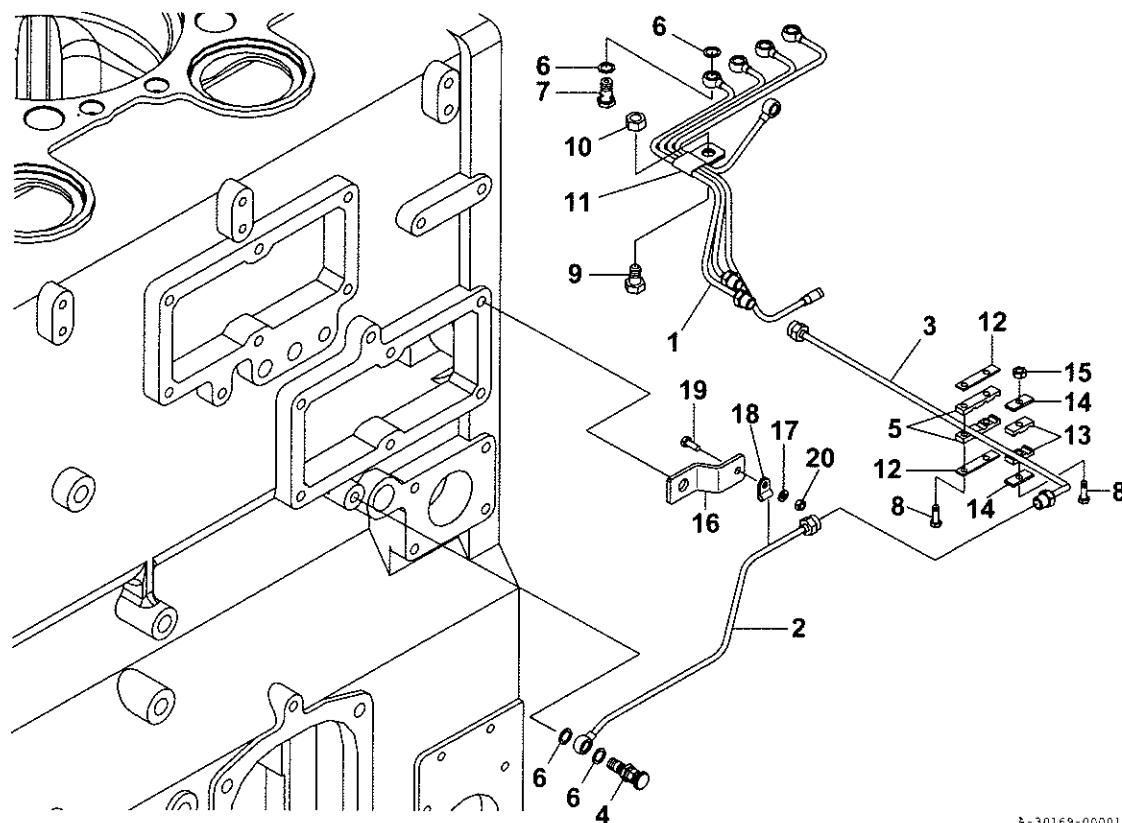
A-3014B-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39380	LO PIPE, GOVERNOR	1	1	
2	1	101147-59810	BOLT, PIPE JOINT M8	1	1	
3	1	23414-080000	GASKET, 8 X 1.0	2	2	
4	1	23414-120000	GASKET, 12 X 1.0	2	2	
5	1	23857-060000	BOLT, JOINT 6	1	1	



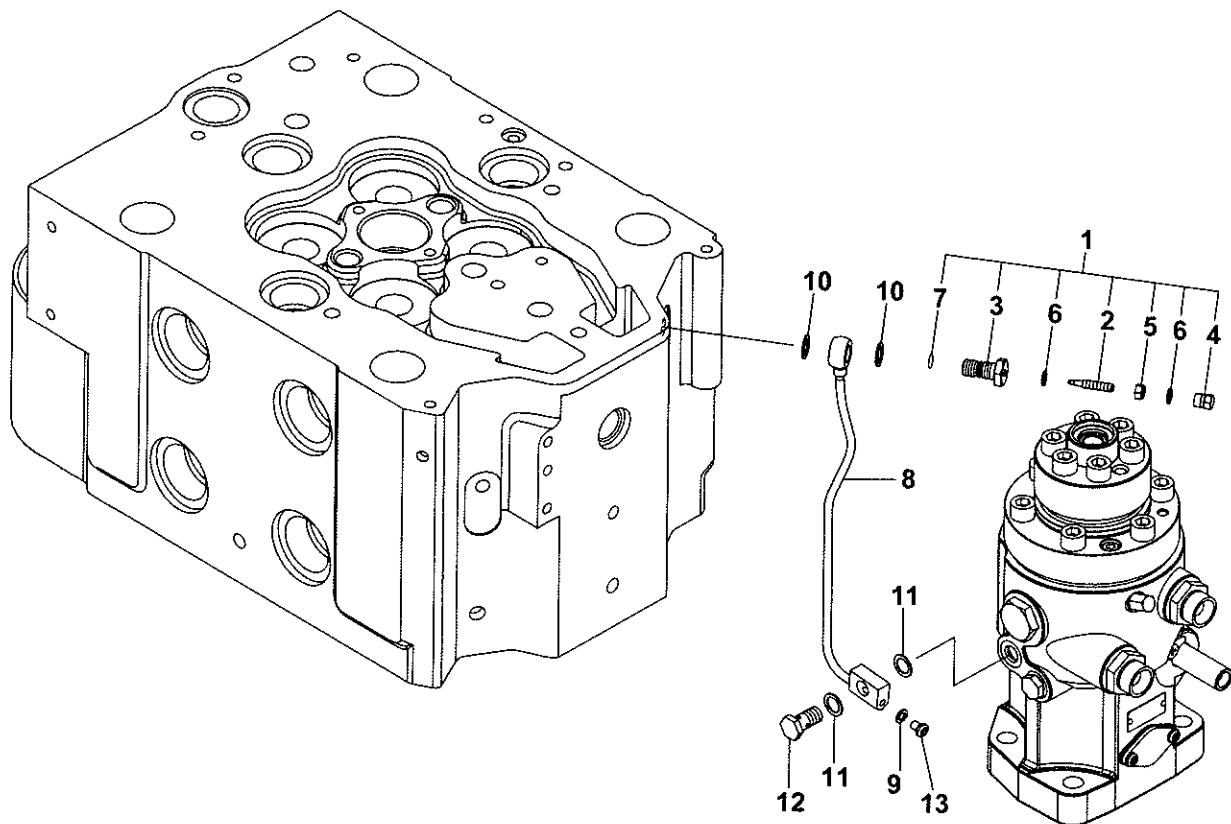
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39870	SUPPORT,LO PIPE	1	1	
2	1	150633-39880	LO PIPE A,GEN	1	1	
3	1	150633-39890	LO PIPE B,GEN	1	1	
4	1	23297-120121	CLAMP, 12 X 12	1	1	
5	1	23414-200000	GASKET, 20 X 1.0	2	2	
6	1	23857-150000	BOLT, JOINT 15	1	1	
7	1	26206-100182	BOLT, 10 X 18	1	1	
8	1	26206-120252	BOLT, 12 X 25	1	1	
9	1	26706-120002	NUT, 12	1	1	



A-30169-00001-A-C1_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-39801	PIPE,LO PRESSURE A	1	1	
2	1	150633-39810	PIPE B,LO	1	1	
3	1	150633-39821	PIPE,LO PRESSURE C	1	1	
4	1	146625-59710	VALVE,NEEDLE	1	1	
5	1	153605-91760	SUPPORT	2	2	
6	1	23414-120000	GASKET, 12 X 1.0	4	4	
7	1	23857-060000	BOLT, JOINT 6	1	1	
8	1	26116-060202	BOLT, 6 X 20	2	2	
9	1	26206-120202	BOLT, 12 X 20	1	1	
10	1	26706-120002	NUT, 12	1	1	
11	1	43720-005830	CLAMP	1	1	
12	1	153605-91770	SUPPORT,B	2	2	
13	1	152623-91200	SUPPORT, PIPE A	2	2	
14	1	152623-91210	SUPPORT, PIPE A	2	2	
15	1	26716-060002	NUT, 6	1	1	
16	1	150633-39830	SUPPORT,PIPE LO PRES	1	1	
17	1	22137-060000	WASHER, 6	1	1	
18	1	23297-060061	CLAMP, 6 X 6	1	1	
19	1	26116-060162	BOLT, 6 X 16	1	1	
20	1	26716-060002	NUT, 6	1	1	



A-30179-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	147678-39700	VALVE ASSY, CONTROL	6	6	
2	2	147678-39710	VALVE, CONTROL	6	6	
3	2	147678-39720	BODY, ADJUST VALVE	6	6	
4	2	147678-39730	CAP NUT, M6 FINE	6	6	
5	2	147678-39740	NUT,M6 FINE	6	6	
6	2	23414-060000	GASKET, 6 X 1.0	12	12	
7	2	24311-000090	PACKING, P 9.0	6	6	
8	1	150633-39791	PIPE,LO FOP PINION	6	6	
9	1	23414-060000	GASKET, 6 X 1.0	6	6	
10	1	23414-120000	GASKET, 12 X 1.0	12	12	
11	1	23414-120000	GASKET, 12 X 1.0	12	12	
12	1	23857-060000	BOLT, JOINT 6	6	6	
13	1	26557-060082	SCREW, 6 X 8	6	6	

- The internal cooling water is divided into 2 circuits. The high-temperature side circuit decreases the temperature of the cylinder liner and cylinder head. The low-temperature side circuit decreases the temperature the air cooler, lubricating oil cooler and other auxiliary equipment.

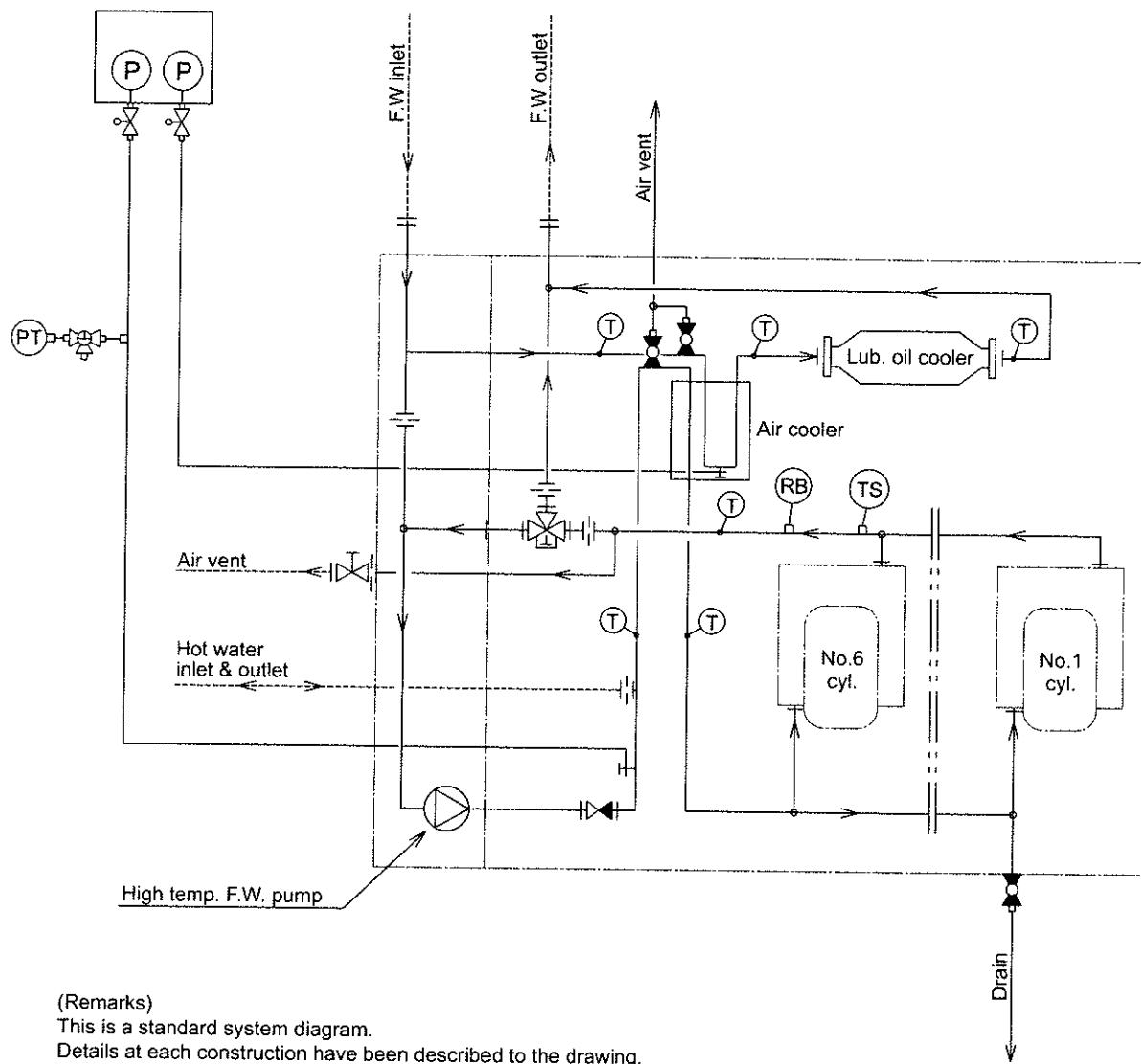


Fig. 1 Cooling water system (one-pump mixing specification)

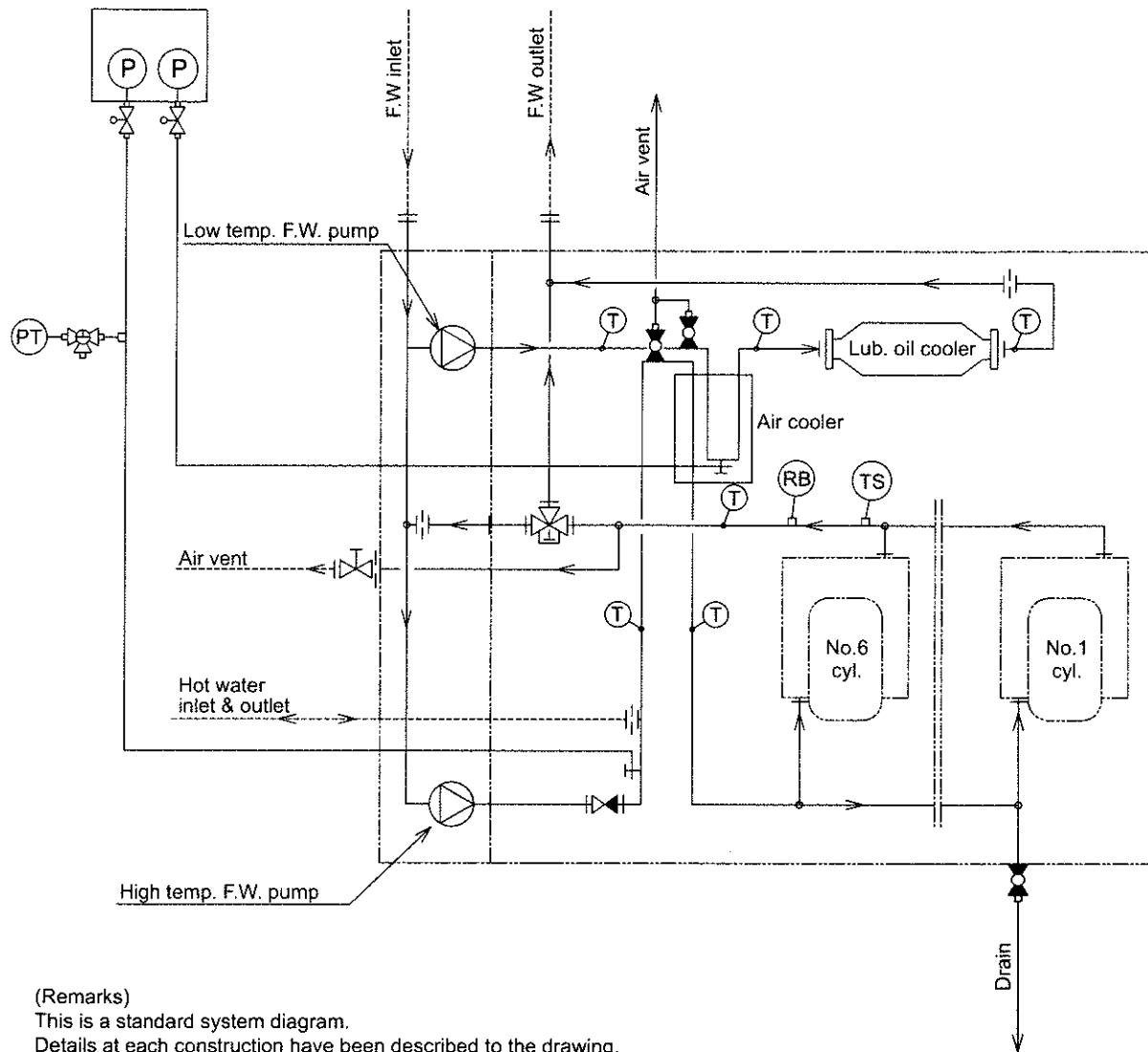


Fig.2 Cooling water system (two-pump mixing specification)

1. Cooling water system (double pump specification)

The high-temperature cooling water is pressure-fed by the high-temperature water pump mounted on the engine. It decreases the temperature of the intake air cooler, and then passes through the cylinder block and decreases the temperature of the cylinder liner and cylinder head. Then it flows through the cooling water manifold into the thermostat. Here it divides into 2 routes: one route returns to the cooling water pump and the other route returns to the freshwater cooler.

2. Low-temperature cooling water system (double pump specification)

The low-temperature cooling water is pressure-fed by the low-temperature water pump mounted on the engine. It decreases the temperature of the intake air cooler and then the lubricating oil cooler. The cooling water of the low-temperature side joins the cooling water of the high-temperature side that passes the thermostat. Then it returns to the freshwater cooler.

3. Cooling water pump

The cooling water pump is a centrifugal pump. It is driven by the engine. It is installed on the opposite side of the flywheel. It is used on the low-temperature side and the high-temperature side. The impeller and the shaft are tightened by screws.

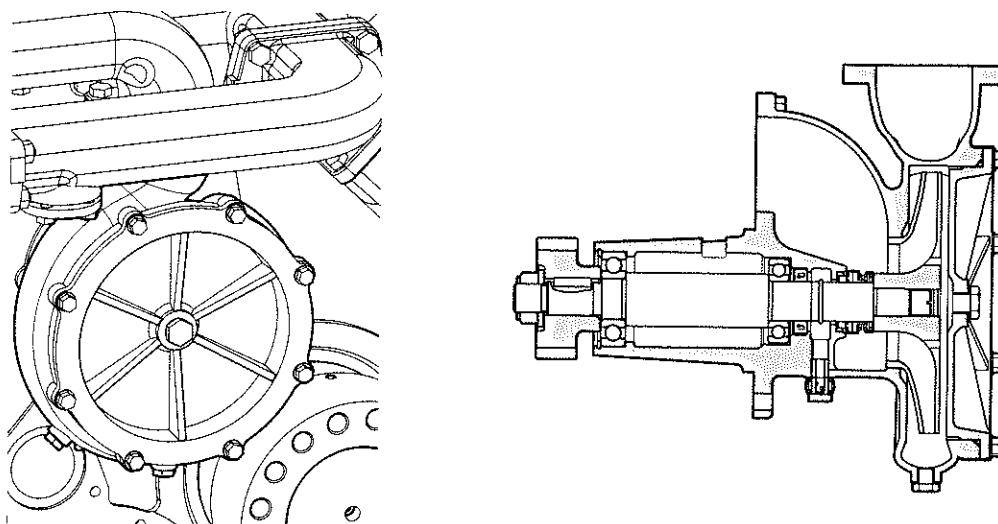


Fig.3 Cooling water pump

4. Cooling water thermostat

The cooling water thermostat is a wax-type device with very little leakage. It controls the temperature of the cooling water at the engine outlet.

PRODUCTION MANAGEMENT DATA

Intervals 1 years

4000 working hours

CONDITION Examine the drain pipe for water and oil leaks.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
	b	Engine crew	Intermediate	-	2.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	TOOL, IMPELLER		146673-92751		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
	O-ring		24321-002300		1 pc
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do maintenance of the cooling water pump.

1. Disassembly

1. Loosen the bolt 1.
2. Remove the cover 2. Remove the O-ring 3.
3. Remove the impeller 4 (left-handed thread).

The thread of the impeller is reverse-threaded. Make sure that you turn it in the correct direction.

4. Remove the mechanical seal 12.
5. Lock the driving gear 7.
6. Remove the tightening nut 6.
7. Remove the key 5 together with the driving gear.
8. Remove the circlip 8.
9. Remove the ball bearings 9 and 11 together with the shaft 10. The bearings are press-fitted into the shaft.

If you do not replace the key, leave it installed to the shaft.

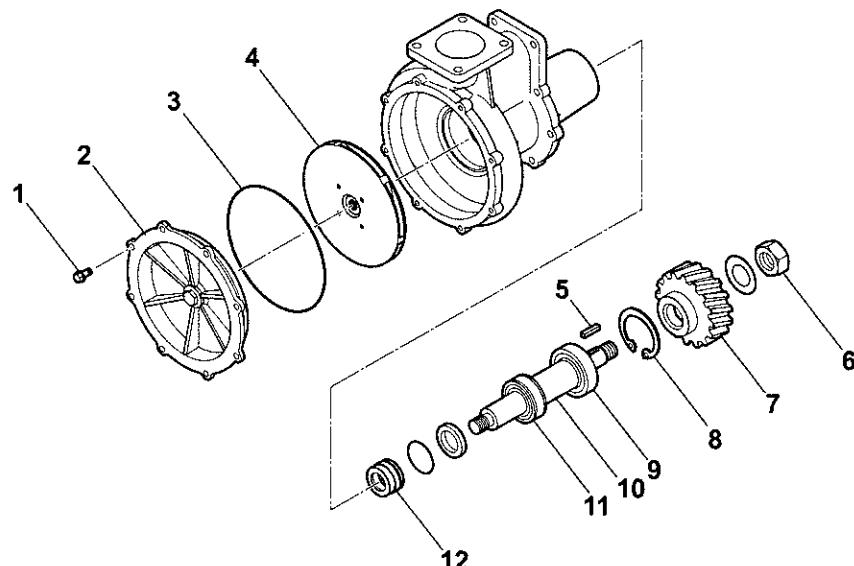


Fig.1 Cooling water pump

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2. Inspection

1. Measure the clearance e between the impeller 2 and casing 1. If the measurement is more than the permitted value, replace the part that is more worn.

Clearance & wear limits of major parts 0000-000-07

2. Replace the mechanical seal 3 and the oil seal 4 if necessary.
3. Replace the ball bearings 5 and 7 every 8000 to 10000 operating hours, even if the appearance is good.

When you press-fit the ball bearings on the shaft 6, apply load to the inner race of the bearings.

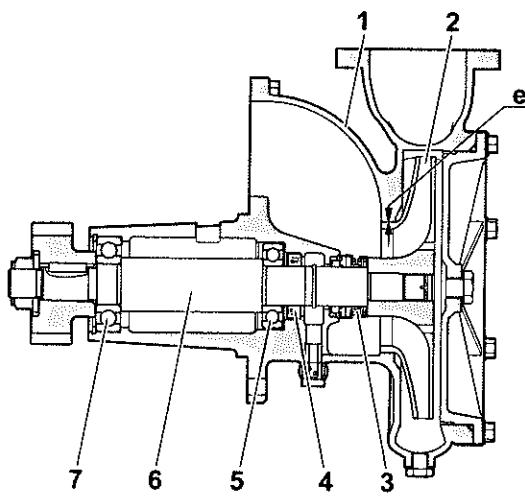
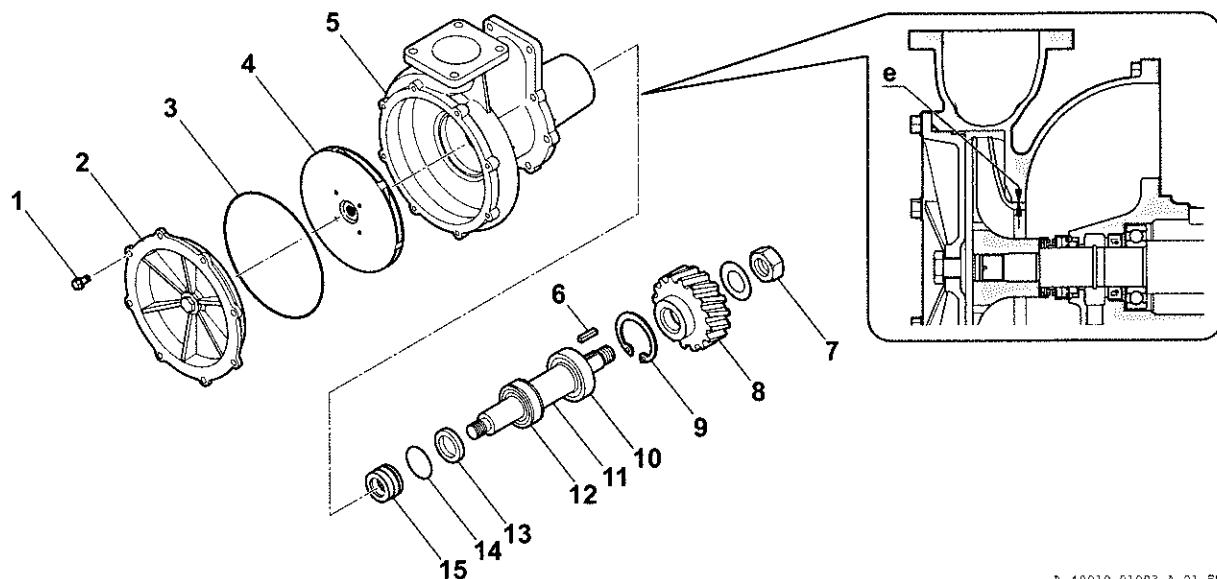


Fig.2 Cooling water pump

3. Assembly

1. Press-fit the bearings 10 and 12 to the shaft 11.
2. Install the shaft 11 and the bearings 10 and 12 together. Make sure that you do not cause damage to the lip of the oil seal 13.
3. Lock the assembly in the correct position with the circlip 9.
4. Install the driving gear 8 and the key 6.
5. Tighten the driving gear tightening nut 7 to the specified torque.
6. Install the mechanical seal 15.
7. Make sure that you install the mechanical seal and the oil seal in the correct location.
8. Apply corrosion inhibitor (ETON 2300F or equivalent) to the area (e) of the clearance between the casing 5 and the impeller 4. (casing side)
9. Install the impeller to the shaft.
10. Tighten it to the specified torque.
Impeller: 430 N·m to 450 N·m
Driving gear tightening nut: 235 N·m to 255 N·m
11. Replace the O-rings 3 with new ones.
12. Tighten the cover 2 with the bolt 1.



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Fig.3 Cooling water pump

CONDITION Do a hydraulic test at 0.75 MPa. There must be no water leaks.

- The cylinder jacket has a thermostat. It increases the temperature of the cooling water in the cylinder jacket for a short time after engine start. It keeps the temperature in the correct range during operation.
- When you operate the engine at low load or if there is a lot of radiated heat, the cooling water temperature decreases. As long as the cooling water temperature at the engine outlet is over 75 °C, sulfuric corrosion does not occur.

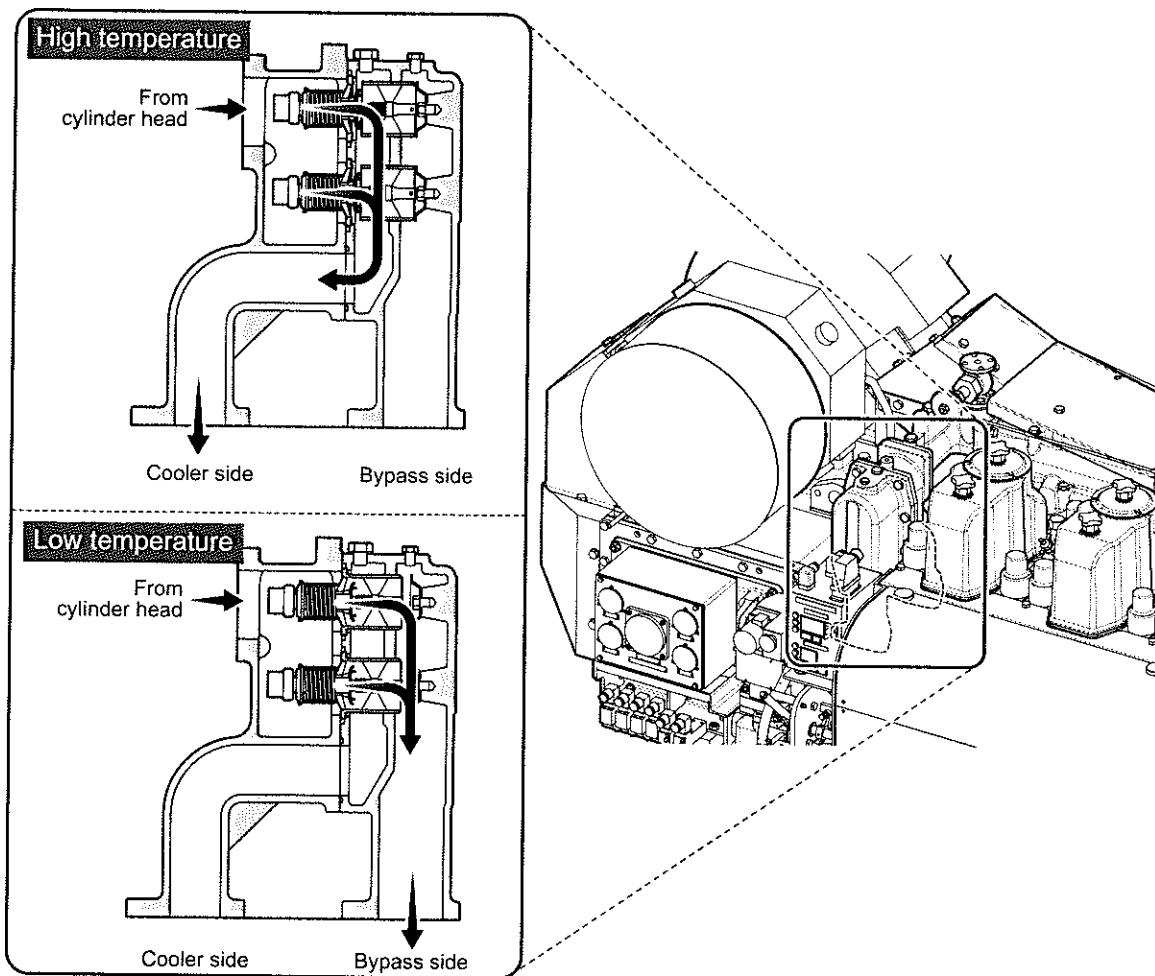


Fig.1 Cooling water thermostat outline

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
	b	Engine crew	Intermediate	-	2.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
	O-ring		150633-48200		1 pc
	O-ring		150633-48210		2 pc
	O-ring		150633-48220		2 pc
SAFETY					

Obey the instructions that follow when you do maintenance of the cooling water thermostat (high-temperature water).

1. Disassembly

1. Close all valves at the inlet and the outlet of the cooling water system.
2. Drain the cooling water from inside the cylinder jacket.
3. Remove the tightening bolt of the cooling water manifold 1.
4. Loosen the tightening nut of the thermostat. Remove the thermostat assembly.
5. Remove the orifice on the inlet and outlet sides.
6. Loosen the tightening bolts on the mating surface of the thermostat cases 2 and 4.
7. Remove the thermostat case.
8. Remove the thermostat 3.

Be careful that you do not let the thermostat fall.

9. Make sure that the temperature setting of the thermostat is correct.

Opening temperature and number of thermostats: 82 °C × 2.

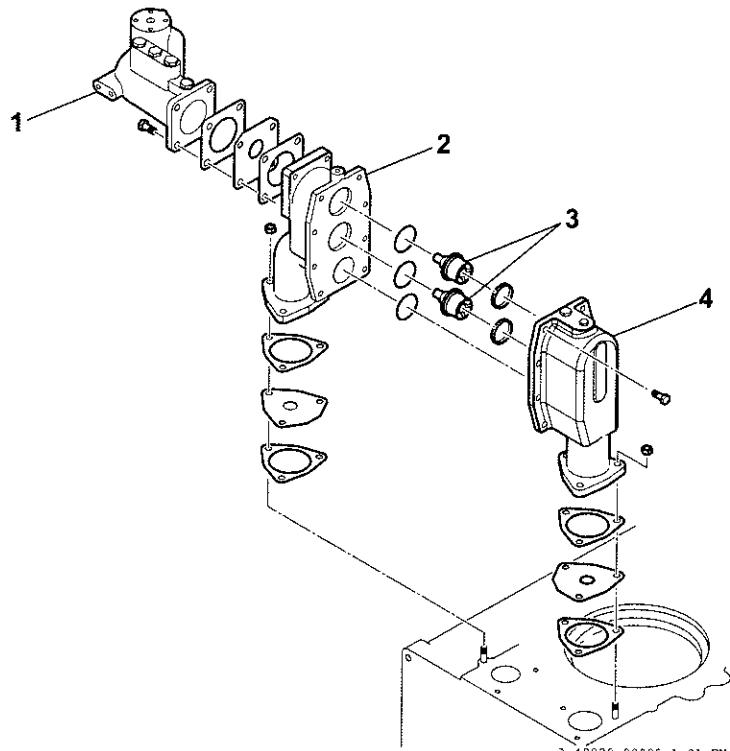


Fig.1 Cooling water thermostat

2. Inspection

1. Thermostat inspection

- 1 - Look for cracks in the valve, breakage of the spring and bite-in of unwanted material on the valve seat surface.
- 2 - Put the thermostat into cold and hot water for 2 to 3 minutes each.
- 3 - Measure the valve lift A.
- 4 - If the valve lift is different from these values, replace the thermostat with a new one.

Cold water (30 °C or less): A = 66.3mm

Warm water (95 °C to 100 °C): A = 76.3mm or more

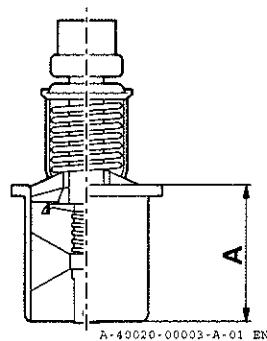


Fig.2 Valve lift check

2. Thermostat case inspection

- 1 - Examine the thermostat seal for damage and wear.
- 2 - Examine the thermostat seat surface for wear and corrosion.

3. Assembly

1. Replace all O-rings with new ones.
2. Install the thermostat to the body. Make sure that you install it in the correct location and direction.
3. Tighten the mating surface of the thermostat case with a bolt.
4. Install the orifice on the inlet/outlet side.
5. Install the thermostat assembly to the engine.

CONDITION

- This engine has an intake air heating device (option) to control continuous low-load operation.
- The device is at the low-temperature side cooling water outlet of the air cooler. It stops the flow of cooling water on the low-temperature side to the air cooler and thus increases the temperature of the intake air.
- This device has a solenoid valve. Depending on its ON/OFF position, the control air moves the air piston. It moves the piston on the cooling water side up or down. This stops the flow of cooling water on the low-temperature side to the air cooler and thus controls the temperature of the intake air.
- You can confirm the operating state of this device by measuring the length L of the shaft that extends from the top of the device.
- The relation between the length L and the operating state is described in the table.

Length L	Operating state	Flow of low-temperature side cooling water	Engine load
28mm	Intake air is not heated	All cooling water flows through the air cooler	High load
8mm	Intake air is heated	All cooling water is bypassed	Low load

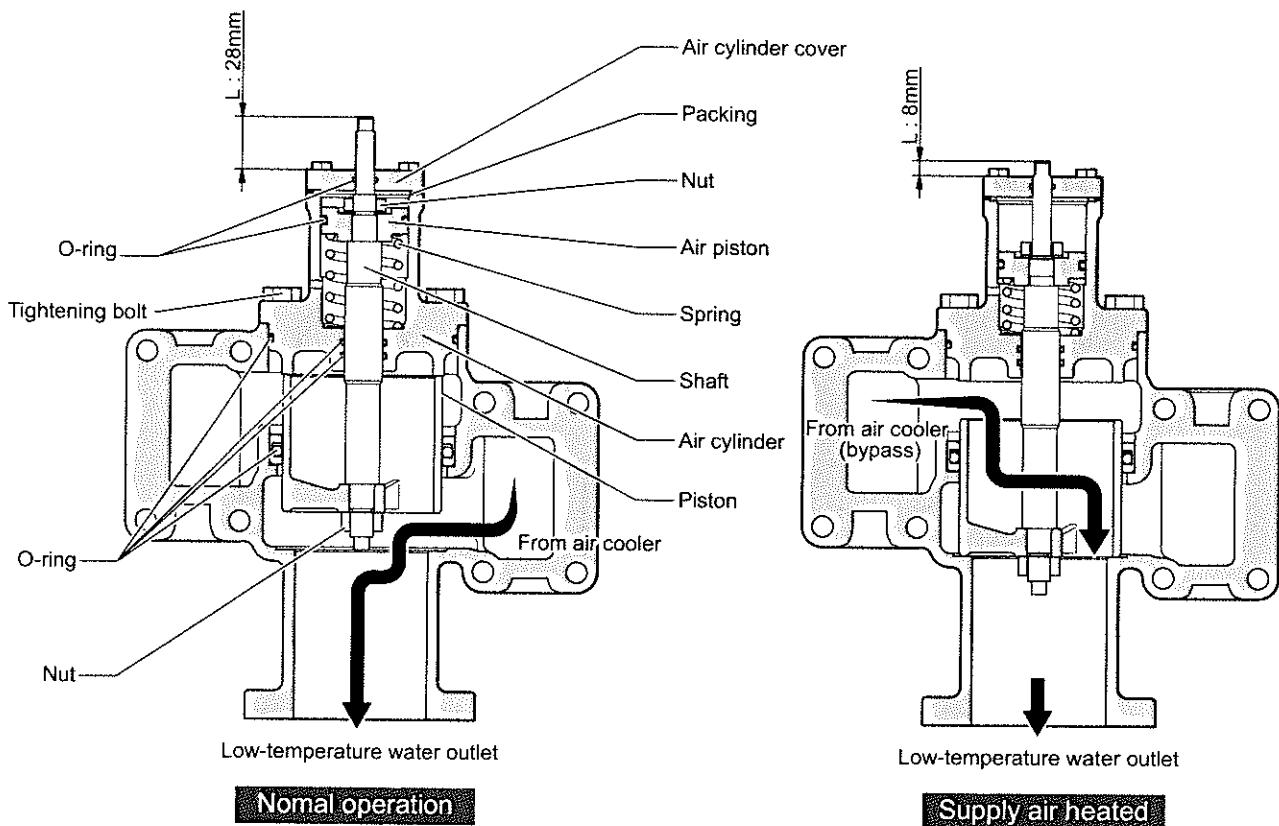


Fig. 1 Cooling water selecting valve (low-temperature water) outline

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PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2 h

EQUIPMENT	Nomenclature	Identification code	Quantity

SUPPLIES	Nomenclature	Identification code	Quantity

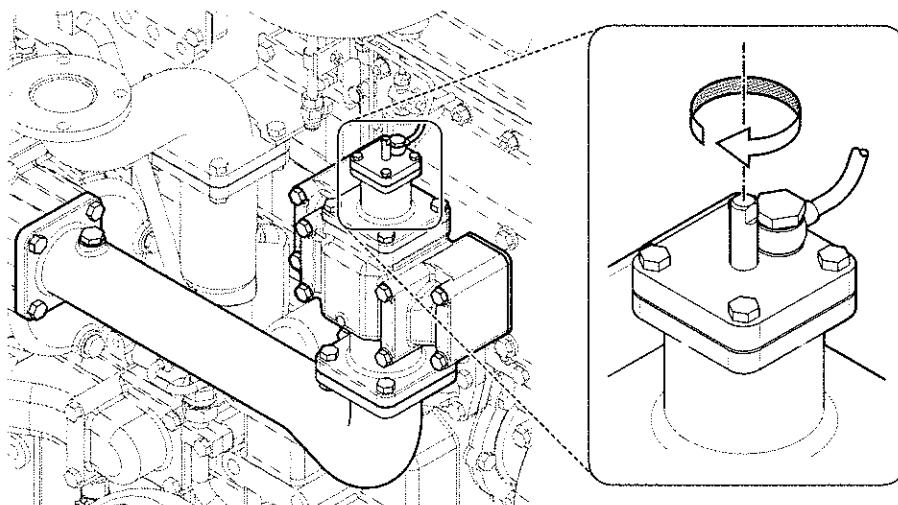
SPARES	Nomenclature	Identification code	Quantity
	Packing	44100-018310	1 pc
	O-ring	24311-000400	1 pc
	O-ring	24316-000200	2 pc
	O-ring	24316-000850	1 pc
	O-ring	24316-000950	1 pc

SAFETY

Obey the instructions that follow when you do maintenance of the cooling water switch valve (low-temperature water) (option).

1. Periodic inspections

- Turn the shaft 1 clockwise rotation or more per week with a wrench (width: 8 mm) to prevent the air piston and the cooling water side piston from getting stuck.

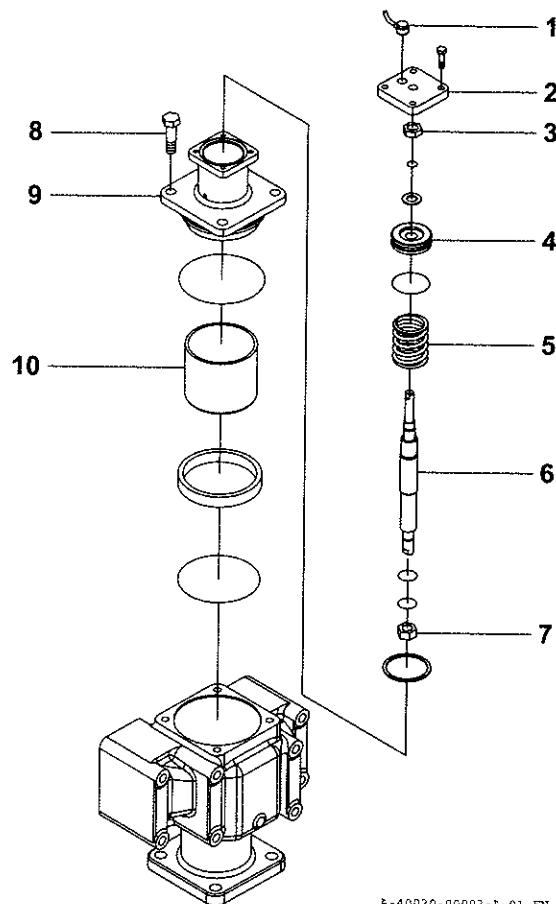


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Fig.1 Cooling water selecting valve (low-temperature water)

2. Disassembly

1. Remove the control air pipe 1.
2. Loosen the air cylinder tightening bolt 8.
3. Remove the cylinder 9 together with the shaft 6 and the piston 10 on the cooling water side.
4. Remove the air cylinder cover 2.
5. Remove the nut 3 on the top of the shaft.
6. Remove the nut 7 on the bottom of the shaft.
7. Remove the piston.
8. Remove the air piston 4 together with the spring 5.



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Fig.2 Cooling water selecting valve (low-temperature water)

3. Inspection

1. Clean the seat on the top and the bottom sides of the piston.
2. Look for poor contact or damage.
3. Examine the area around the piston for unusual wear.
4. Examine the inside of the air cylinder for wear.
 - Correct areas of bad contact with sandpaper.

4. Assembly

1. Replace the O-ring, packing and seal washer with new ones.
2. Put the air cylinder into the shaft.
3. Install the piston from the bottom. Tighten the nut.
4. Install the spring and air piston from the top. Lock the parts with the nut.
5. Apply spray grease (Taihou Industry Co. Ltd. Pro SG480 MP or equivalent) to the sliding areas of the air piston and the shaft. (Refer to Fig. 3.)

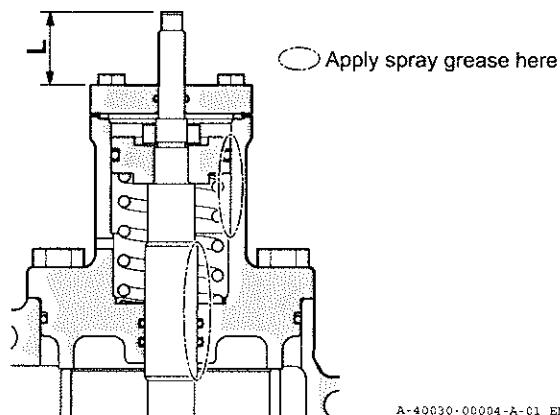
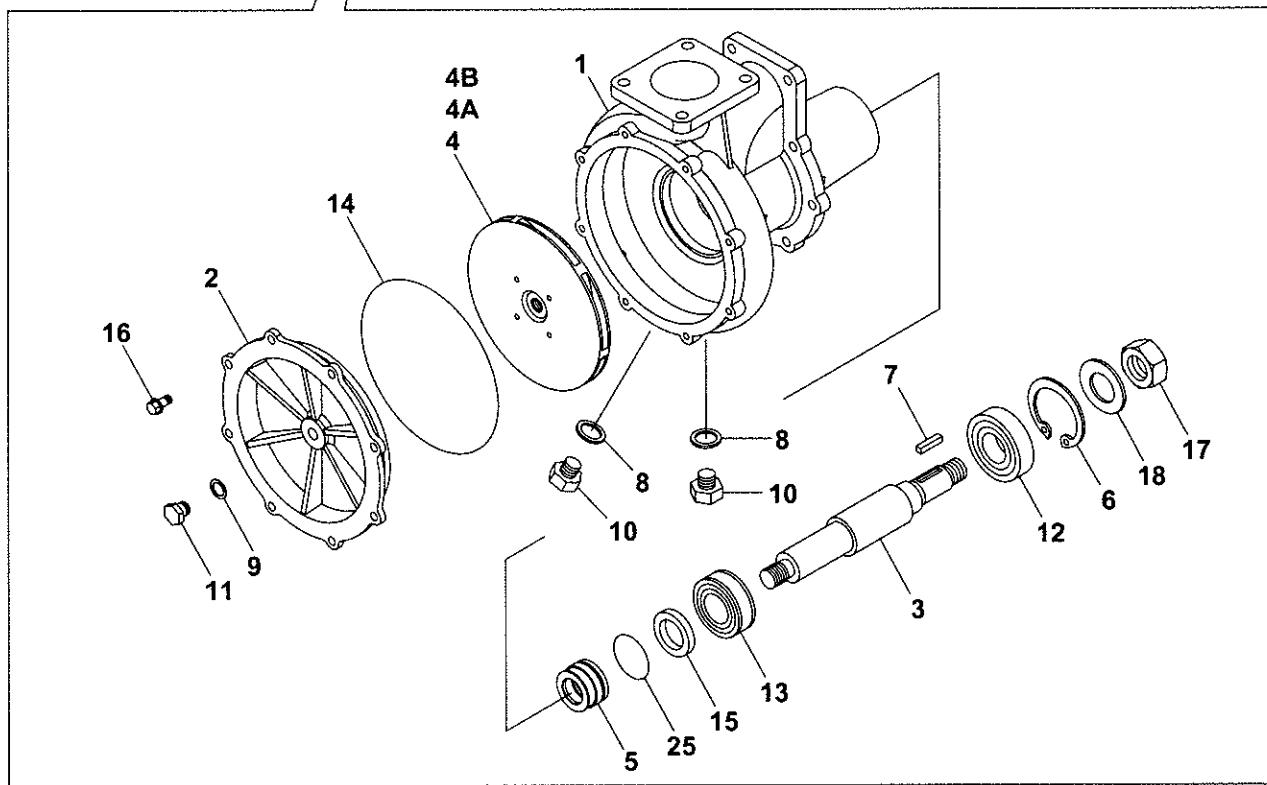
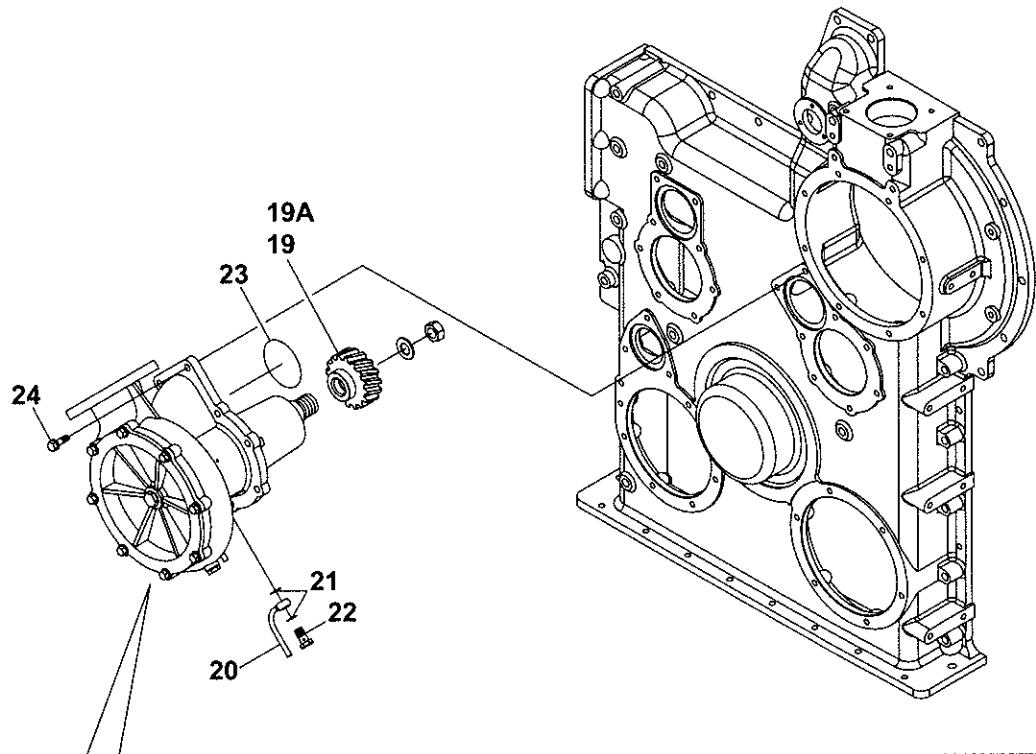


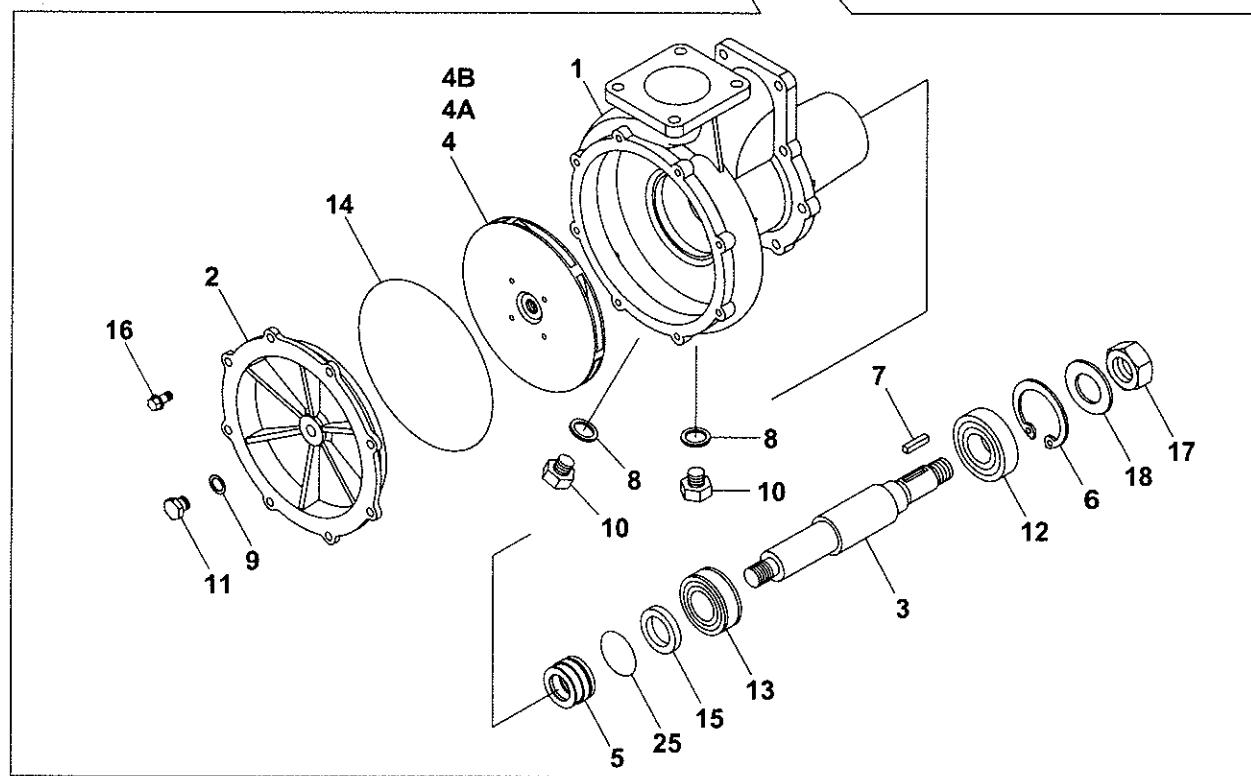
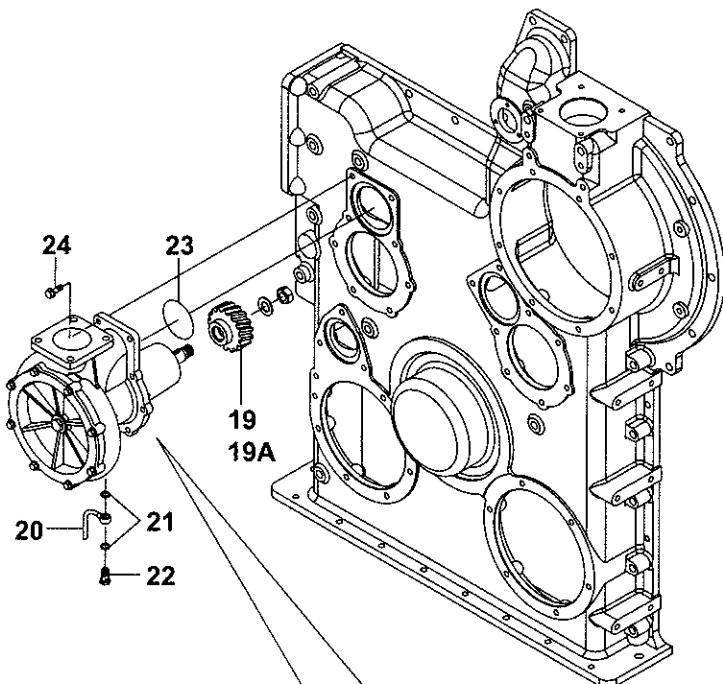
Fig.3 Spreading area of the spray grease

6. Install the air cylinder cover to the air cylinder.
7. Install the air cylinder assembly to the body.
8. Tighten the air cylinder tightening bolt.
9. Install the control air pipe

CONDITION Make sure that the length of the shaft that extends out to the top part of the device (length L) is 28 mm.



No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	750633-42190	CW PUMP, FCD	1	-	
-	1	750633-42200	CW PUMP, FCD	-	1	900 min ⁻¹
-	1	750633-42210	CW PUMP, FCD	-	1	1000 min ⁻¹
1	2	150633-42110	CASE	1	1	
2	2	150633-42120	COVER	1	1	
3	2	150633-42210	SHAFT	1	1	
4	2	150633-42370	IMPELLER, WATER PUMP	1	-	
4A	2	150633-42380	IMPELLER, WATER PUMP	-	1	900 min ⁻¹
4B	2	150633-42390	IMPELLER, WATER PUMP	-	1	1000 min ⁻¹
5	2	146623-42510	MECHANICAL SEAL	1	1	
6	2	22252-000800	RING, 80	1	1	
7	2	22512-070360	KEY, 7 X 36	1	1	
8	2	23414-130000	GASKET, 13 X 1.0	2	2	
9	2	23414-170000	GASKET, 17 X 1.0	1	1	
10	2	23894-020002	PLUG, G 1/4	2	2	
11	2	23894-030002	PLUG, G 3/8	1	1	
12	2	24101-063074	BEARING, 6307	1	1	
13	2	24102-062074	BEARING, 6207U	1	1	
14	2	24321-002300	PACKING, G230.0	1	1	
15	2	24423-355511	SEAL, TC355511	1	1	
16	2	26106-100202	BOLT, 10 X 20	8	8	
17	2	26732-240002	NUT, 24	1	1	
18	2	22137-240000	WASHER, 24	1	1	
25	2	24311-000350	PACKING, P 35.0	1	1	
19	1	147673-42451	GEAR,WATER PUMP Z=15	1	-	
19A	1	147673-42480	GEAR,WATER PUMP Z=16	-	1	
20	1	146673-42481	PIPE, LEAK DETECT.	1	1	
21	1	23414-140000	GASKET, 14 X 1.0	2	2	
22	1	23854-080000	BOLT, JOINT 8	1	1	
23	1	24316-000900	PACKING, P 90.0	1	1	
24	1	26206-120302	BOLT, 12 X 30	8	8	

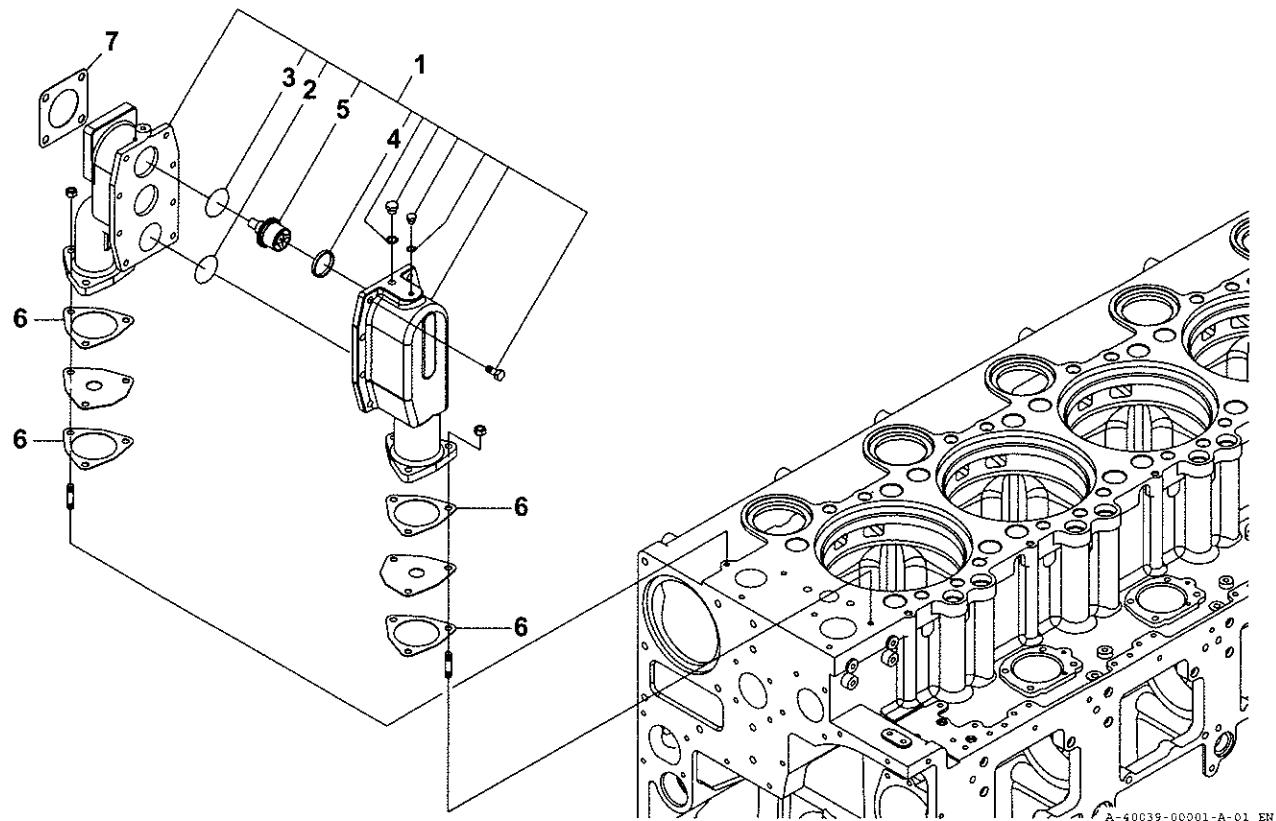


Cooling water pump (low-temperature water)

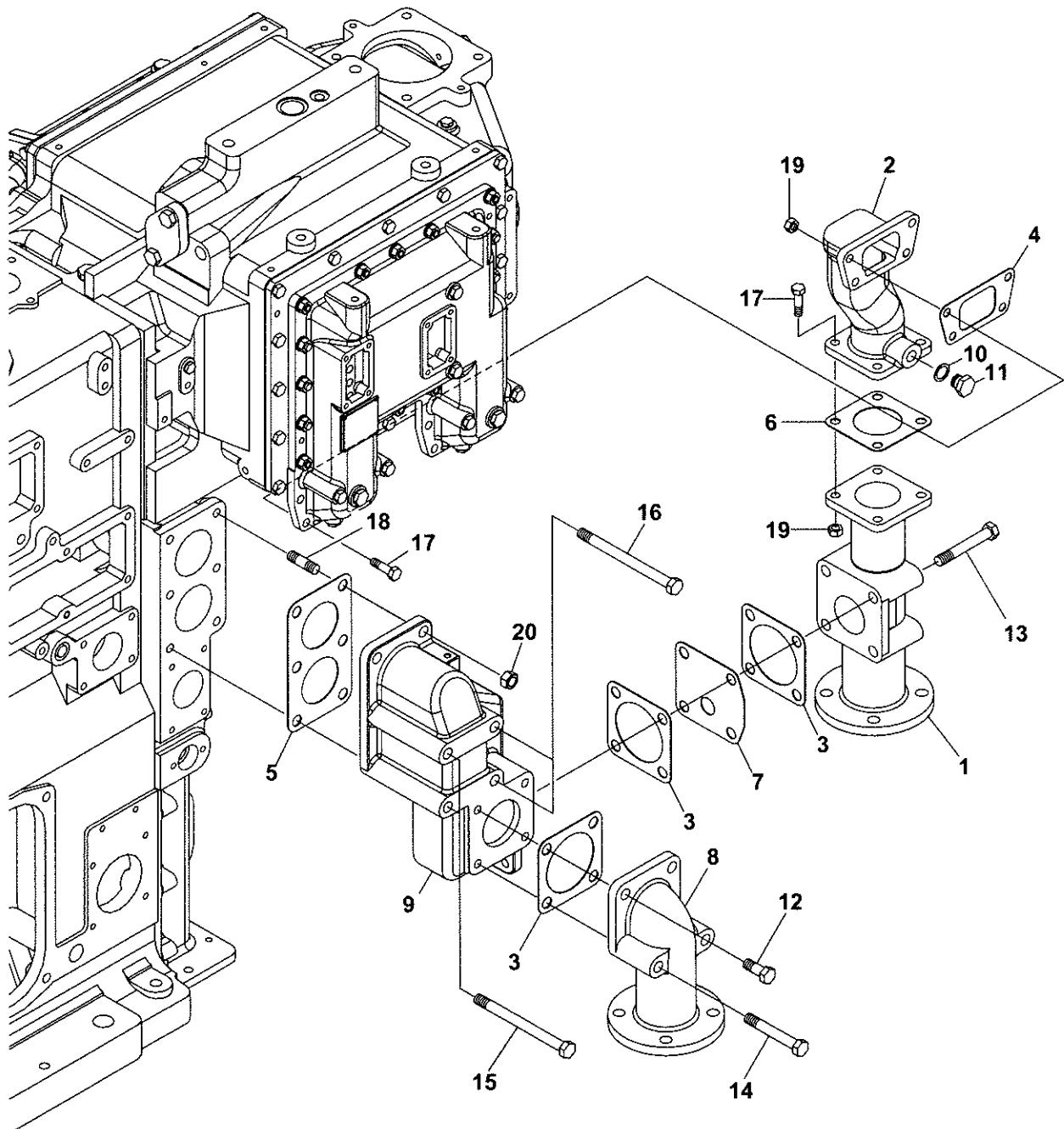
Illustrated parts data

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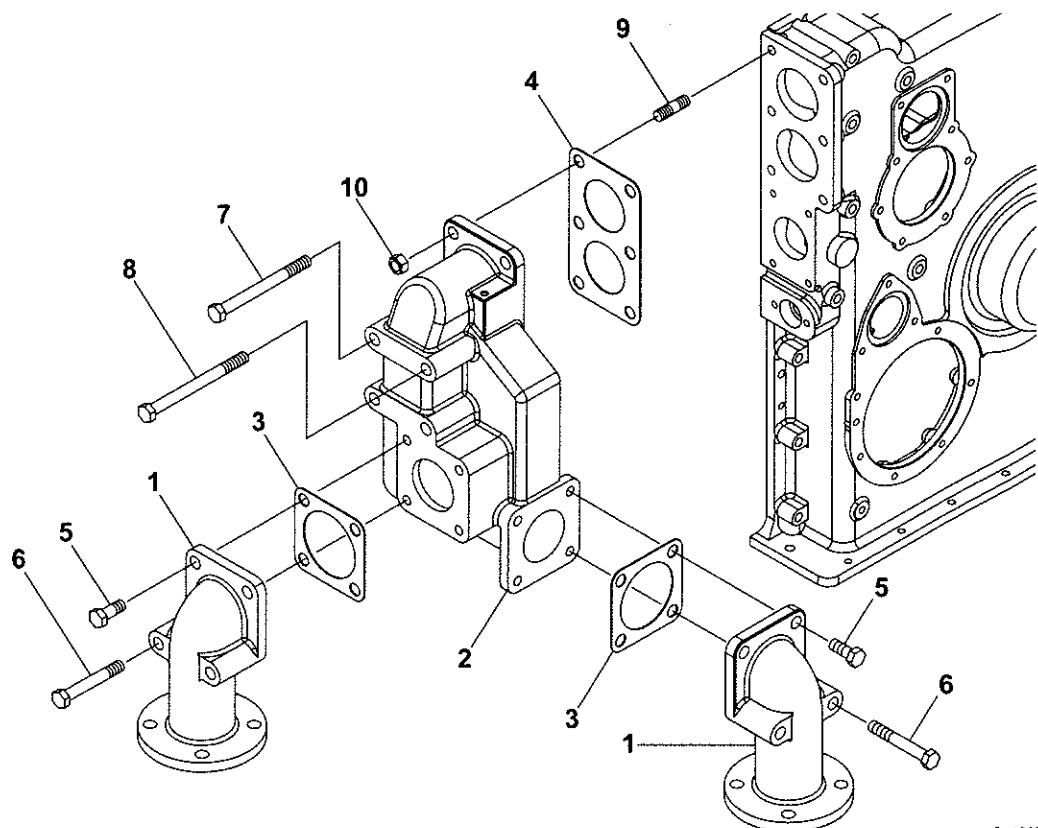
No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	750633-42190	CW PUMP, FCD	1	-	
-	1	750633-42200	CW PUMP, FCD	-	1	900 min ⁻¹
-	1	750633-42210	CW PUMP, FCD	-	1	1000 min ⁻¹
1	2	150633-42110	CASE	1	1	
2	2	150633-42120	COVER	1	1	
3	2	150633-42210	SHAFT	1	1	
4	2	150633-42370	IMPELLER, WATER PUMP	1	-	
4A	2	150633-42380	IMPELLER, WATER PUMP	-	1	900 min ⁻¹
4B	2	150633-42390	IMPELLER, WATER PUMP	-	1	1000 min ⁻¹
5	2	146623-42510	MECHANICAL SEAL	1	1	
6	2	22252-000800	RING, 80	1	1	
7	2	22512-070360	KEY, 7 X 36	1	1	
8	2	23414-130000	GASKET, 13 X 1.0	2	2	
9	2	23414-170000	GASKET, 17 X 1.0	1	1	
10	2	23894-020002	PLUG, G 1/4	2	2	
11	2	23894-030002	PLUG, G 3/8	1	1	
12	2	24101-063074	BEARING, 6307	1	1	
13	2	24102-062074	BEARING, 6207U	1	1	
14	2	24321-002300	PACKING, G230.0	1	1	
15	2	24423-355511	SEAL, TC355511	1	1	
16	2	26106-100202	BOLT, 10 X 20	8	8	
17	2	26732-240002	NUT, 24	1	1	
18	2	22137-240000	WASHER, 24	1	1	
25	2	24311-000350	PACKING, P 35.0	1	1	
19	1	147673-42451	GEAR,WATER PUMP Z=15	1	-	
19A	1	147673-42480	GEAR,WATER PUMP Z=16	-	1	
20	1	146673-42481	PIPE, LEAK DETECT.	1	1	
21	1	23414-140000	GASKET, 14 X 1.0	2	2	
22	1	23854-080000	BOLT, JOINT 8	1	1	
23	1	24316-000900	PACKING, P 90.0	1	1	
24	1	26206-120302	BOLT, 12 X 30	8	8	



No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-48021	THERMOSTAT,HCW	1	1	
2	2	150633-48200	COVER SEAL(1)	1	1	
3	2	150633-48210	COVER SEAL(2)	2	2	
4	2	150633-48220	SLEEVE SEAL	2	2	
5	2	150633-48411	ELEMENT,CWTW 82	2	2	
6	1	146673-49560	PACKING, PUMP-OUT	4	4	
7	1	147673-49570	PACKING, I/C.OUT A	1	1	

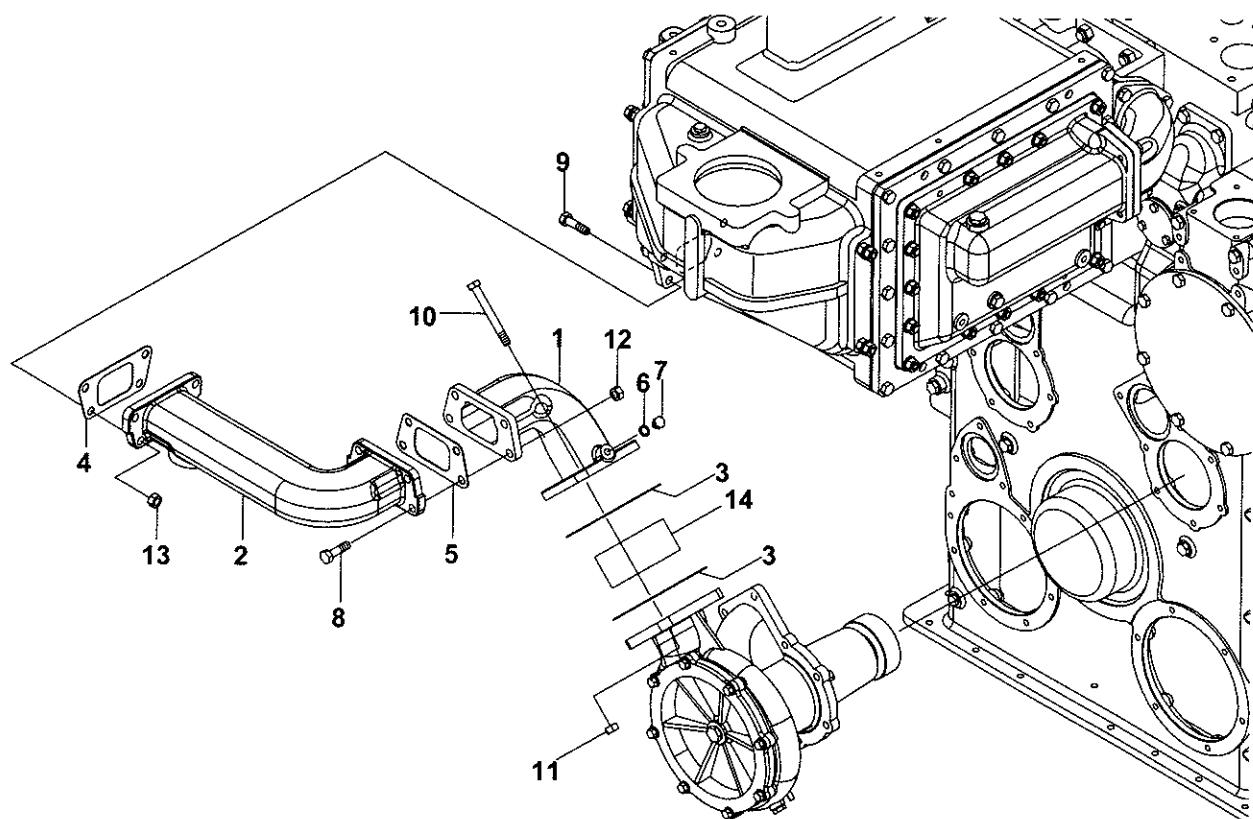


No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49250	PIPE(LCW ENGIN 1PMIX	1	1	
2	1	150633-49260	PIPE(LCW I/CIN 1PMIX	1	1	
3	1	153605-34100	PACKING, VALVE	3	3	
4	1	150633-49350	PACKING(I/C IN)	1	1	
5	1	146623-49550	PACKING(CW INOUT)	1	1	
6	1	147673-49570	PACKING, I/C.OUT A	1	1	
7	1	150633-49600	ORIFICE(D30	1	1	
8	1	146623-49750	PIPE (CW)	1	1	
9	1	146623-49763	PIPE, CW INOUT	1	1	
10	1	23414-210000	GASKET, 21 X 1.0	1	1	
11	1	23897-040002	PLUG, G 1/2	1	1	
12	1	26116-160402	BOLT, 16 X 40	2	2	
13	1	26116-161102	BOLT, 16 X 110	4	4	
14	1	26116-161102	BOLT, 16 X 110	2	2	
15	1	26116-161902	BOLT, 16 X 190	2	2	
16	1	26116-162002	BOLT, 16 X 200	2	2	
17	1	26206-120452	BOLT, 12 X 45	8	8	
18	1	26212-160352	STUD,BOLT 16 X 35	2	2	
19	1	26706-120002	NUT, 12	8	8	
20	1	26716-160002	NUT, 16	2	2	



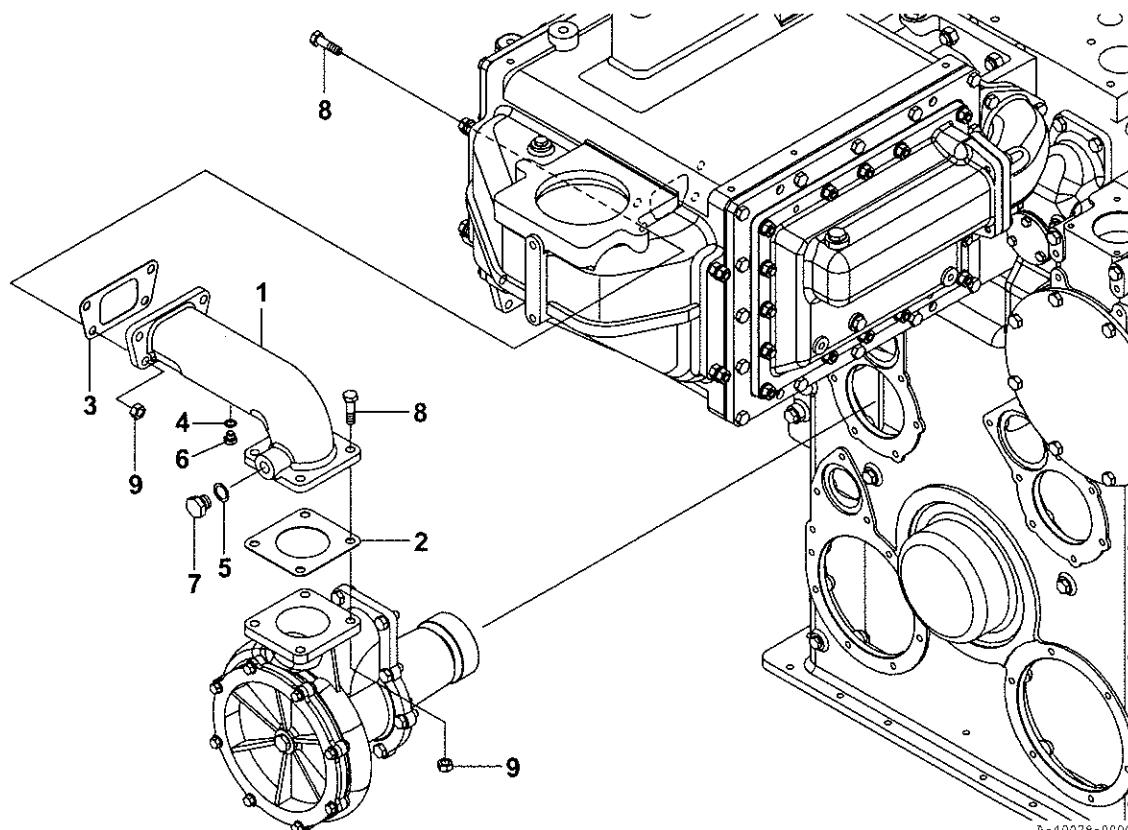
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-49750	PIPE (CW)	2	2	
2	1	146623-49760	PIPE (CW INOUT)	1	1	
3	1	153605-34100	PACKING, VALVE	2	2	
4	1	146623-49550	PACKING(CW INOUT)	1	1	
5	1	26116-160402	BOLT, 16 X 40	4	4	
6	1	26116-161102	BOLT, 16 X 110	4	4	
7	1	26116-161902	BOLT, 16 X 190	2	2	
8	1	26116-162002	BOLT, 16 X 200	2	2	
9	1	26212-160352	STUD,BOLT 16 X 35	2	2	
10	1	26716-160002	NUT, 16	2	2	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49402	PIPE,HCW PUMP OUT	1	1	
2	1	150633-49410	PIPE (HCW I/C IN)	1	1	
3	1	150633-49290	PACKING(PUMP OUT)	2	2	
4	1	150633-49350	PACKING(I/C IN)	1	1	
5	1	150633-49350	PACKING(I/C IN)	1	1	
6	1	23414-120000	GASKET, 12 X 1.0	1	1	
7	1	23884-120002	PLUG, 12	1	1	
8	1	26206-120452	BOLT, 12 X 45	4	4	
9	1	26206-120452	BOLT, 12 X 45	4	4	
10	1	26206-121052	BOLT, 12 X 105	4	4	
11	1	26706-120002	NUT, 12	4	4	
12	1	26706-120002	NUT, 12	4	4	
13	1	26706-120002	NUT, 12	4	4	
14	1	43600-021210	VALVE, REVERSE 80A	1	1	

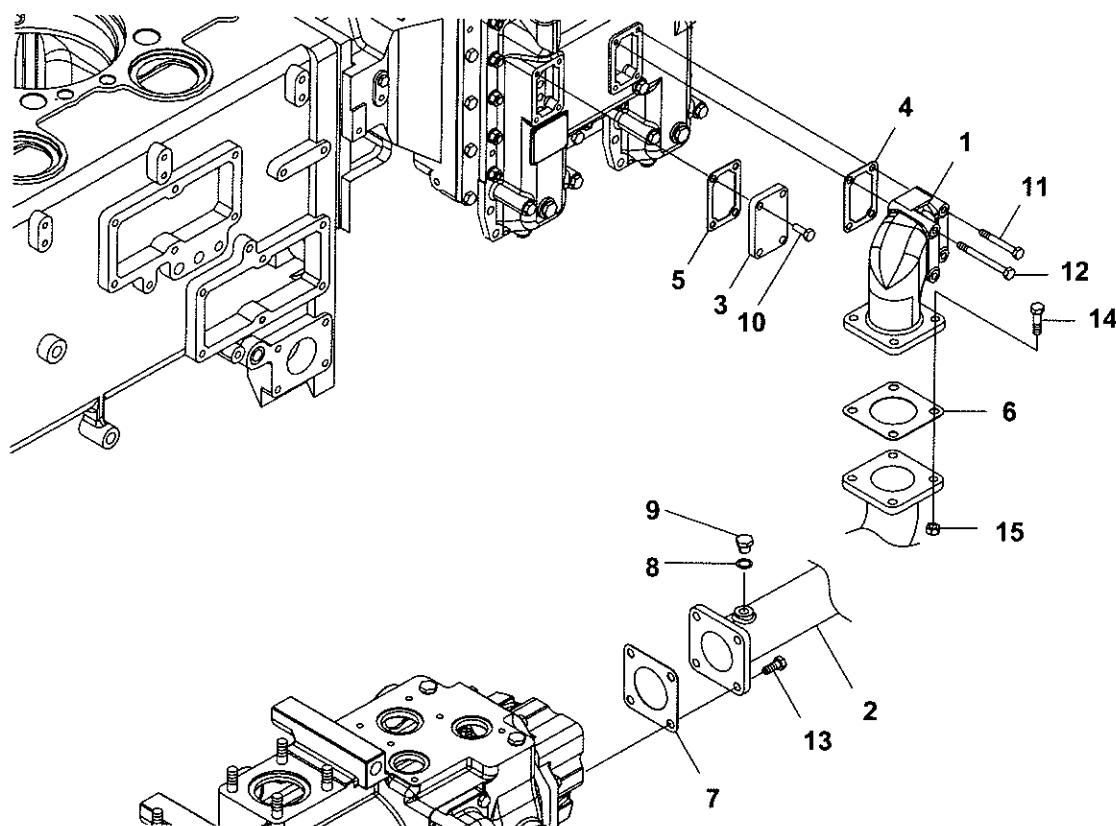


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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49300	PIPE (LCW PUMP-I/C)	1	1	
2	1	150633-49290	PACKING(PUMP OUT)	1	1	
3	1	150633-49350	PACKING(I/C IN)	1	1	
4	1	23414-120000	GASKET, 12 X 1.0	1	1	
5	1	23414-210000	GASKET, 21 X 1.0	1	1	
6	1	23884-120002	PLUG, 12	1	1	
7	1	23894-040002	PLUG, G 1/2	1	1	
8	1	26206-120452	BOLT, 12 X 45	8	8	
9	1	26706-120002	NUT, 12	8	8	

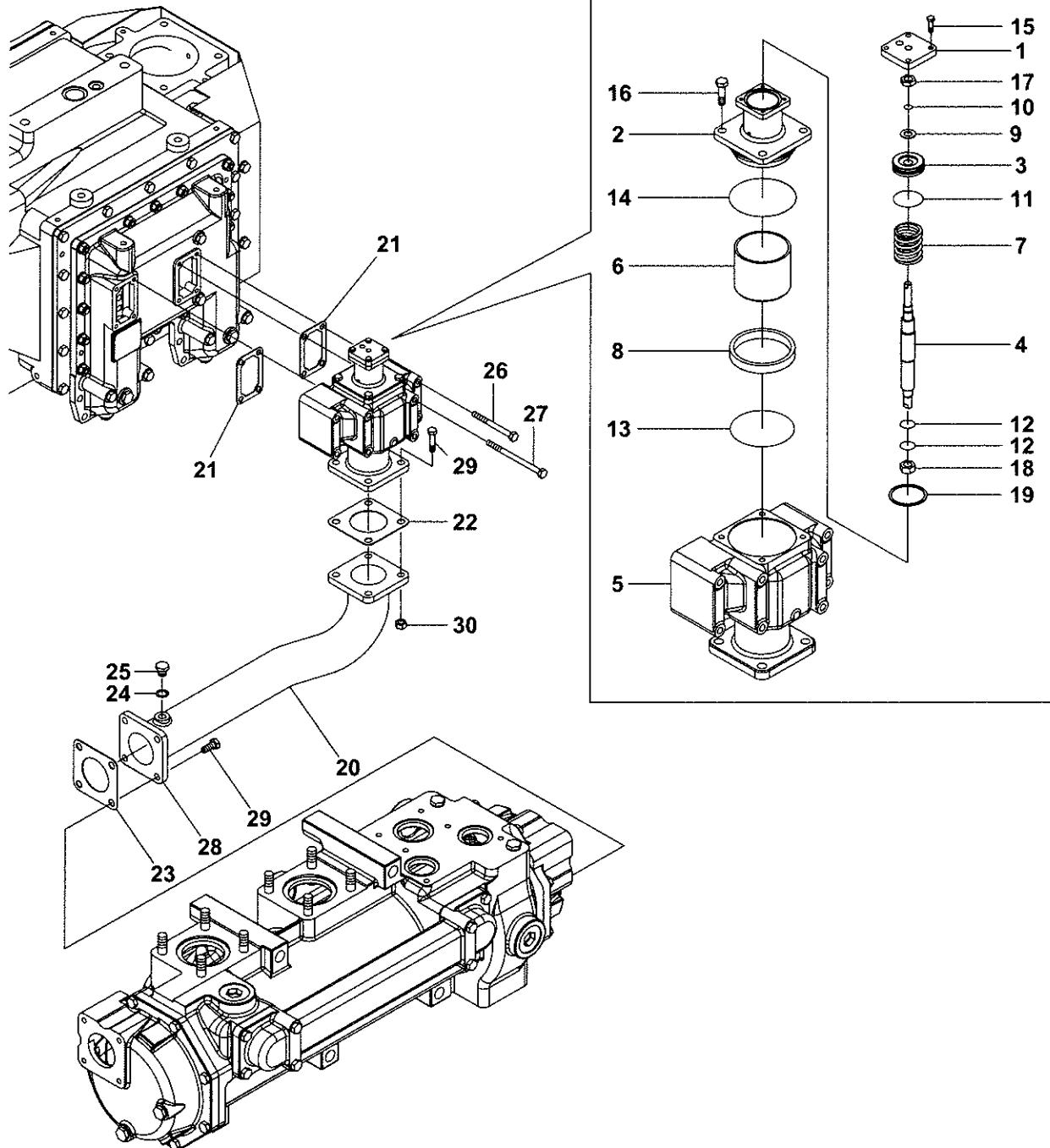
Cooling water pipe (low-temperature water) (without switch valve)
Illustrated parts data

1/1



A-40089-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49310	PIPE (LCW I/C OUT)	1	1	
2	1	150633-49320	PIPE (LCW LOC IN)	1	1	
3	1	150633-49340	COVER (I/C BYPASS)	1	1	
4	1	150633-49360	PACKING(I/C OUT)	1	1	
5	1	150633-49360	PACKING(I/C OUT)	1	1	
6	1	147673-49570	PACKING, I/C.OUT A	1	1	
7	1	147673-49570	PACKING, I/C.OUT A	1	1	
8	1	23414-170000	GASKET, 17 X 1.0	1	1	
9	1	23894-030002	PLUG, G 3/8	1	1	
10	1	26206-100302	BOLT, 10 X 30	4	4	
11	1	26206-100802	BOLT, 10 X 80	2	2	
12	1	26206-101102	BOLT, 10 X 110	2	2	
13	1	26206-120302	BOLT, 12 X 30	4	4	
14	1	26206-120452	BOLT, 12 X 45	4	4	
15	1	26706-120002	NUT, 12	4	4	

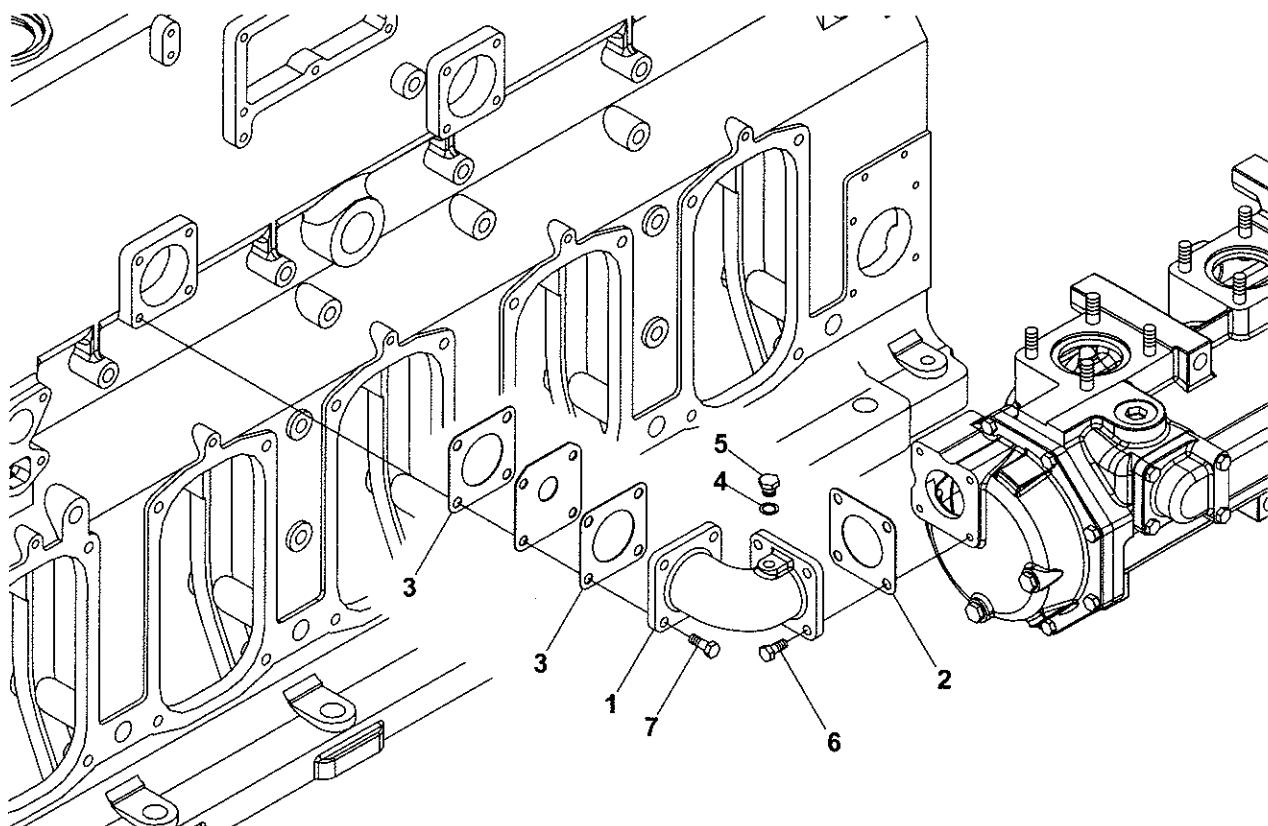


Switch valve (low-temperature water) (option)

Illustrated parts data

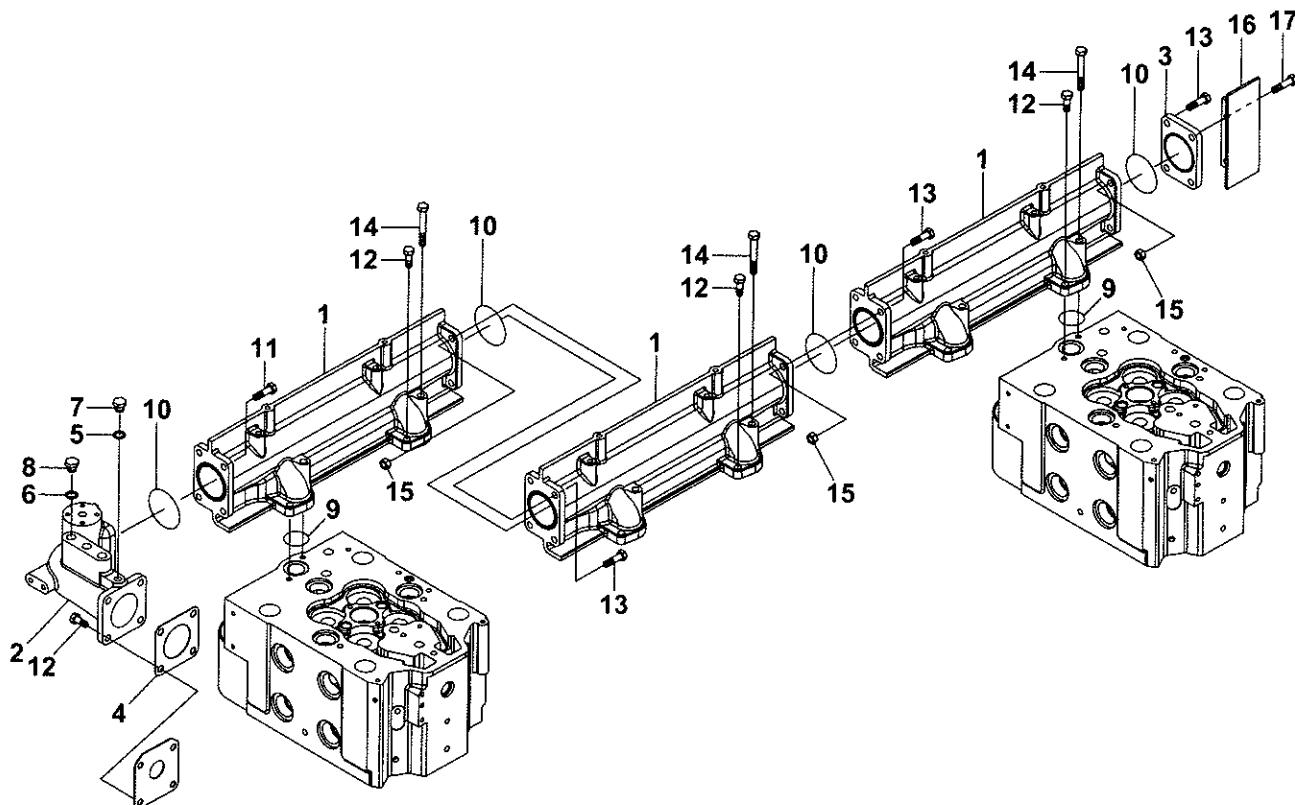
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	146623-49790	COVER(AIR CYLINDER)	1	1	
2	2	150633-49810	AIR CYLINDER LCWV	1	1	
3	2	146623-49820	AIR PISTON	1	1	
4	2	146623-49830	SHAFT A	1	1	
5	2	150633-49900	BODY(LCW VALVE)	1	1	
6	2	150633-49920	PISTON (LCW VALVE)	1	1	
7	2	146623-49960	SPRING	1	1	
8	2	150633-49980	GUIDE(LCW VALVE)	1	1	
9	2	22190-120003	WASHER, SEAL 12	1	1	
10	2	24311-000100	PACKING, P 10.0	1	1	
11	2	24311-000400	PACKING, P 40.0	1	1	
12	2	24316-000200	PACKING, P 20.0	2	2	
13	2	24316-000850	PACKING, P 85.0	1	1	
14	2	24321-000950	PACKING, G 95.0	1	1	
15	2	26116-060222	BOLT, 6 X 22	4	4	
16	2	26206-100252	BOLT, 10 X 25	4	4	
17	2	26696-120002	NUT, 12	1	1	
18	2	26703-120002	NUT, 12	1	1	
19	2	44100-018310	PACKING, STOPPING	1	1	
20	1	150633-49320	PIPE (LCW LOC IN)	1	1	
21	1	150633-49360	PACKING(I/C OUT)	2	2	
22	1	147673-49570	PACKING, I/C.OUT A	1	1	
23	1	147673-49570	PACKING, I/C.OUT A	1	1	
24	1	23414-170000	GASKET, 17 X 1.0	1	1	
25	1	23894-030002	PLUG, G 3/8	1	1	
26	1	26206-101102	BOLT, 10 X 110	4	4	
27	1	26206-101502	BOLT, 10 X 150	4	4	
28	1	26206-120302	BOLT, 12 X 30	4	4	
29	1	26206-120452	BOLT, 12 X 45	4	4	
30	1	26706-120002	NUT, 12	4	4	



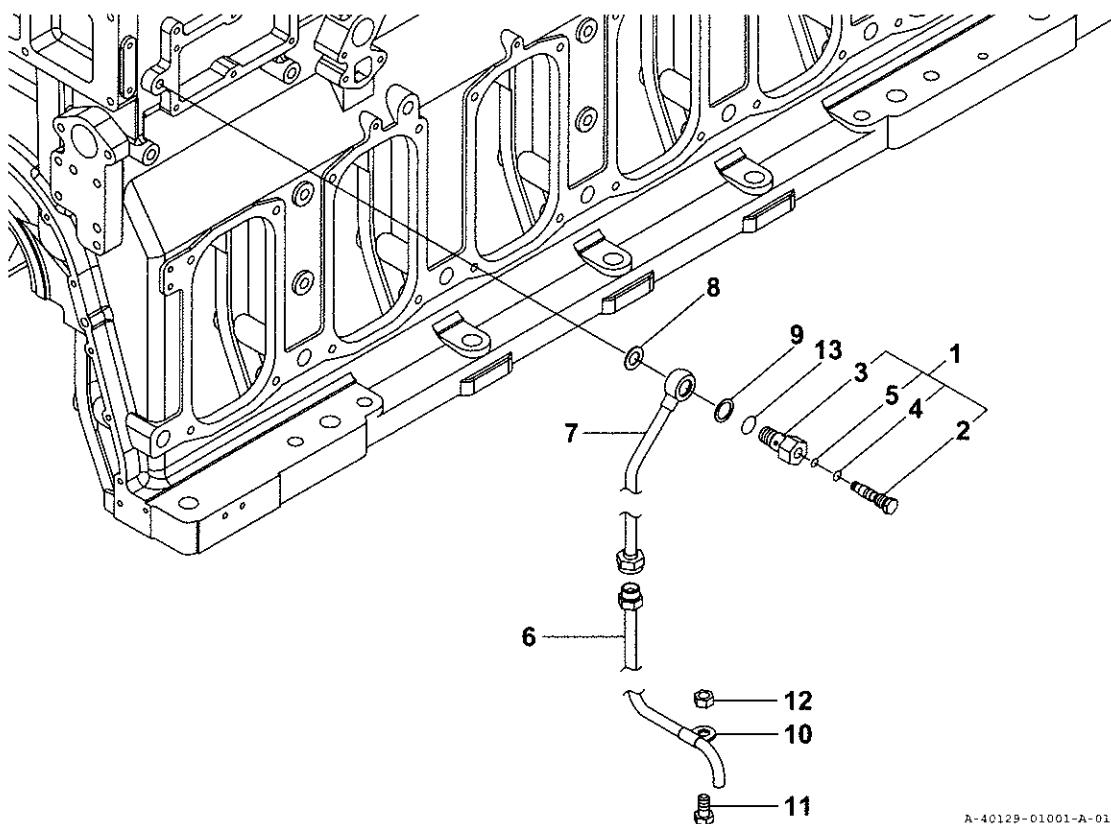
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49330	PIPE (LCW LOC OUT)	1	1	
2	1	147673-49570	PACKING, I/C.OUT A	1	1	
3	1	147673-49570	PACKING, I/C.OUT A	2	2	
4	1	23414-170000	GASKET, 17 X 1.0	1	1	
5	1	23894-030002	PLUG, G 3/8	1	1	
6	1	26206-120302	BOLT, 12 X 30	4	4	
7	1	26206-120352	BOLT, 12 X 35	4	4	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49450	PIPE(HCW COLLECT A)	3	3	
2	1	150633-49460	PIPE(HCW COLLECT B)	1	1	
3	1	150633-49470	COVER (HCW COLLECT)	1	1	
4	1	147673-49570	PACKING, I/C.OUT A	1	1	
5	1	23414-170000	GASKET, 17 X 1.0	1	1	
6	1	23414-210000	GASKET, 21 X 1.0	3	3	
7	1	23894-030002	PLUG, G 3/8	1	1	
8	1	23894-040002	PLUG, G 1/2	3	3	
9	1	24326-000450	PACKING, G 45.0	6	6	
10	1	24326-000800	PACKING, G 80.0	4	4	
11	1	26206-120302	BOLT, 12 X 30	4	4	
12	1	26206-120352	BOLT, 12 X 35	10	10	
13	1	26206-120452	BOLT, 12 X 45	10	10	
14	1	26206-120902	BOLT, 12 X 90	6	6	
15	1	26706-120002	NUT, 12	12	12	
16	1	150633-49780	COVER,HEAT SHIELD	1	1	
17	1	26206-120502	BOLT, 12 X 50	2	2	

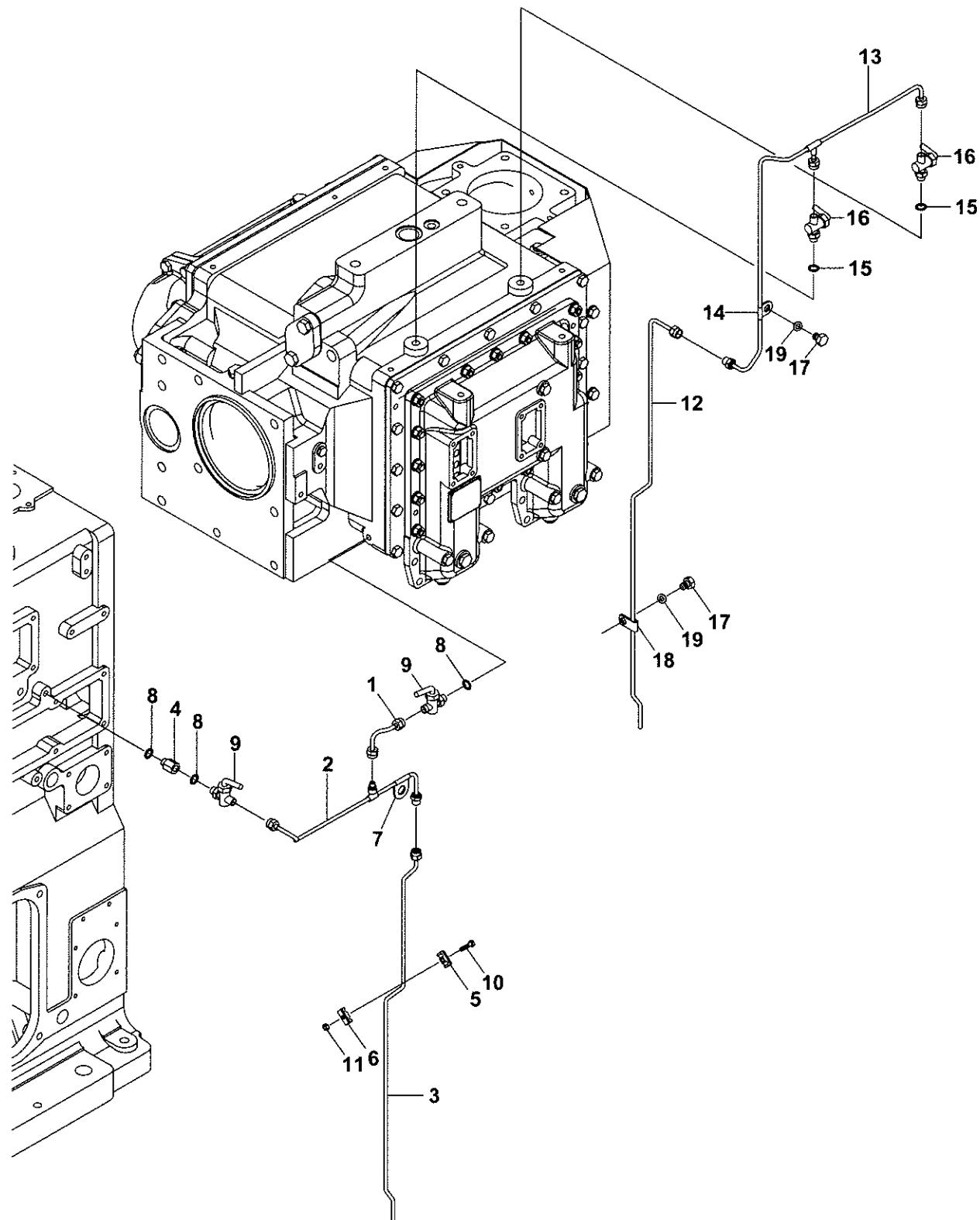


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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	152623-49400	VALVE ASSY, DRAIN	1	1	
2	2	152623-49410	VALVE STICK	1	1	
3	2	152623-49420	VALVE BODY	1	1	
4	2	24316-000090	PACKING, P 9.0	1	1	
5	2	24316-000060	PACKING, P 6.0	1	1	
6	1	150633-49640	DRAIN PIPE,CYL	1	1	
7	1	150633-49651	PIPE,CW DRAIN.CYL	1	1	
8	1	22190-180003	WASHER, SEAL 18	1	1	
9	1	22190-200003	WASHER, SEAL 20	1	1	
10	1	23297-120121	CLAMP, 12 X 12	1	1	
11	1	26206-120252	BOLT, 12 X 25	1	1	
12	1	26706-120002	NUT, 12	1	1	
13	1	24316-000200	PACKING, P 20.0	1	1	

Air vent pipe (air cooler) and water drain pipe (boost air chamber)
Illustrated parts data

1/2

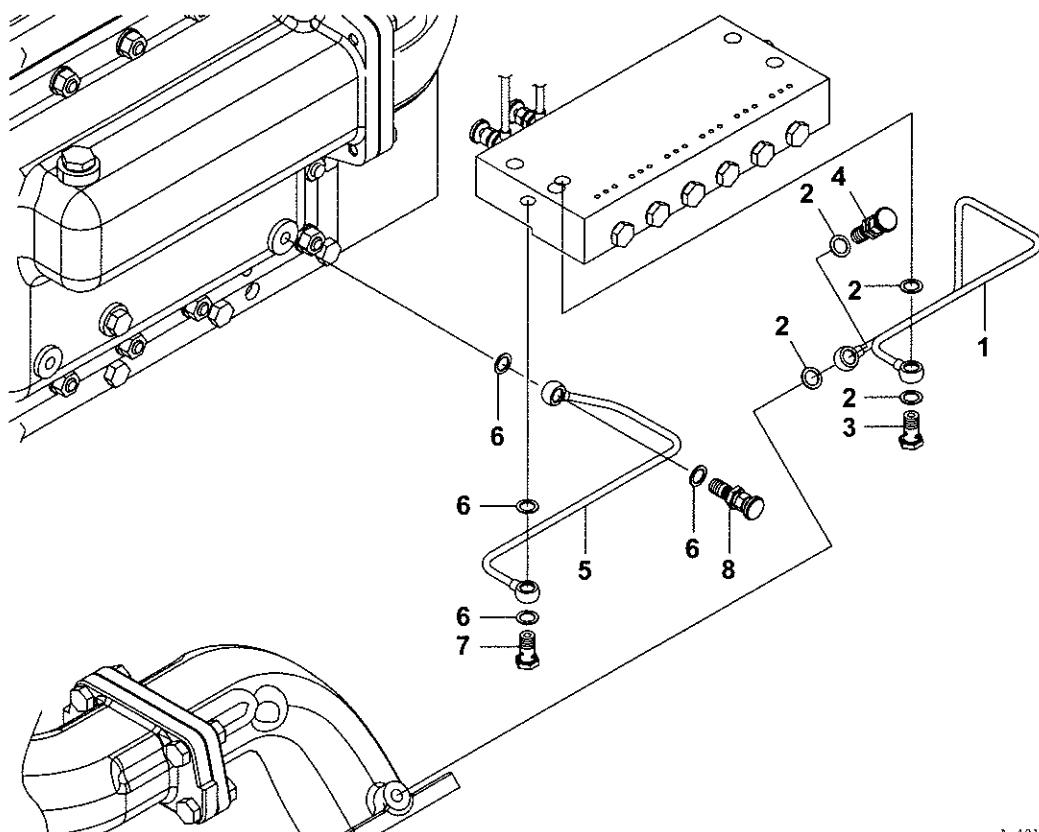


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Air vent pipe (air cooler) and water drain pipe (boost air chamber)
Illustrated parts data

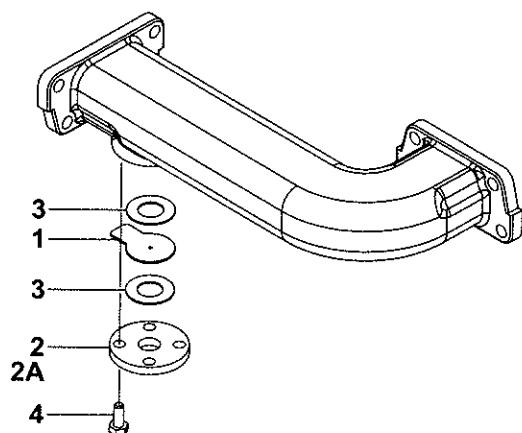
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49680	DRAIN PIPE,I/C	1	1	
2	1	150633-49690	DRAIN PIPE A	1	1	
3	1	150633-49700	DRAIN PIPE B	1	1	
4	1	139694-18300	SPACER	1	1	
5	1	152623-91200	SUPPORT, PIPE A	2	2	
6	1	152623-91210	SUPPORT, PIPE A	2	2	
7	1	23297-060161	CLAMP, 6 X 16	1	1	
8	1	23414-130000	GASKET, 13 X 1.0	3	3	
9	1	146622-49730	COCK, 1/4	2	2	
10	1	26116-060252	BOLT, 6 X 25	1	1	
11	1	26716-060002	NUT, 6	1	1	
12	1	150633-49660	PIPE B,I/C AIR	1	1	
13	1	150633-49670	PIPE A,I/C AIR	1	1	
14	1	23297-060121	CLAMP, 6 X 12	1	1	
15	1	23414-130000	GASKET, 13 X 1.0	2	2	
16	1	146622-49610	COCK, 1/4	2	2	
17	1	26206-120152	BOLT, 12 X 15	2	2	
18	1	43730-014240	FITTING, CLAMP 6X2	1	1	
19	1	22137-120000	WASHER, 12	3	3	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-49720	PIPE,HCW	1	1	High-temperature water
2	1	23414-120000	GASKET, 12 X 1.0	4	4	
3	1	23854-060000	BOLT, JOINT 6	1	1	
4	1	43600-030772	VALVE, NEEDLE	1	1	
5	1	150633-49730	PIPE,LCW	1	1	Low-temperature water
6	1	23414-120000	GASKET, 12 X 1.0	4	4	
7	1	23854-060000	BOLT, JOINT 6	1	1	
8	1	43600-030772	VALVE, NEEDLE	1	1	



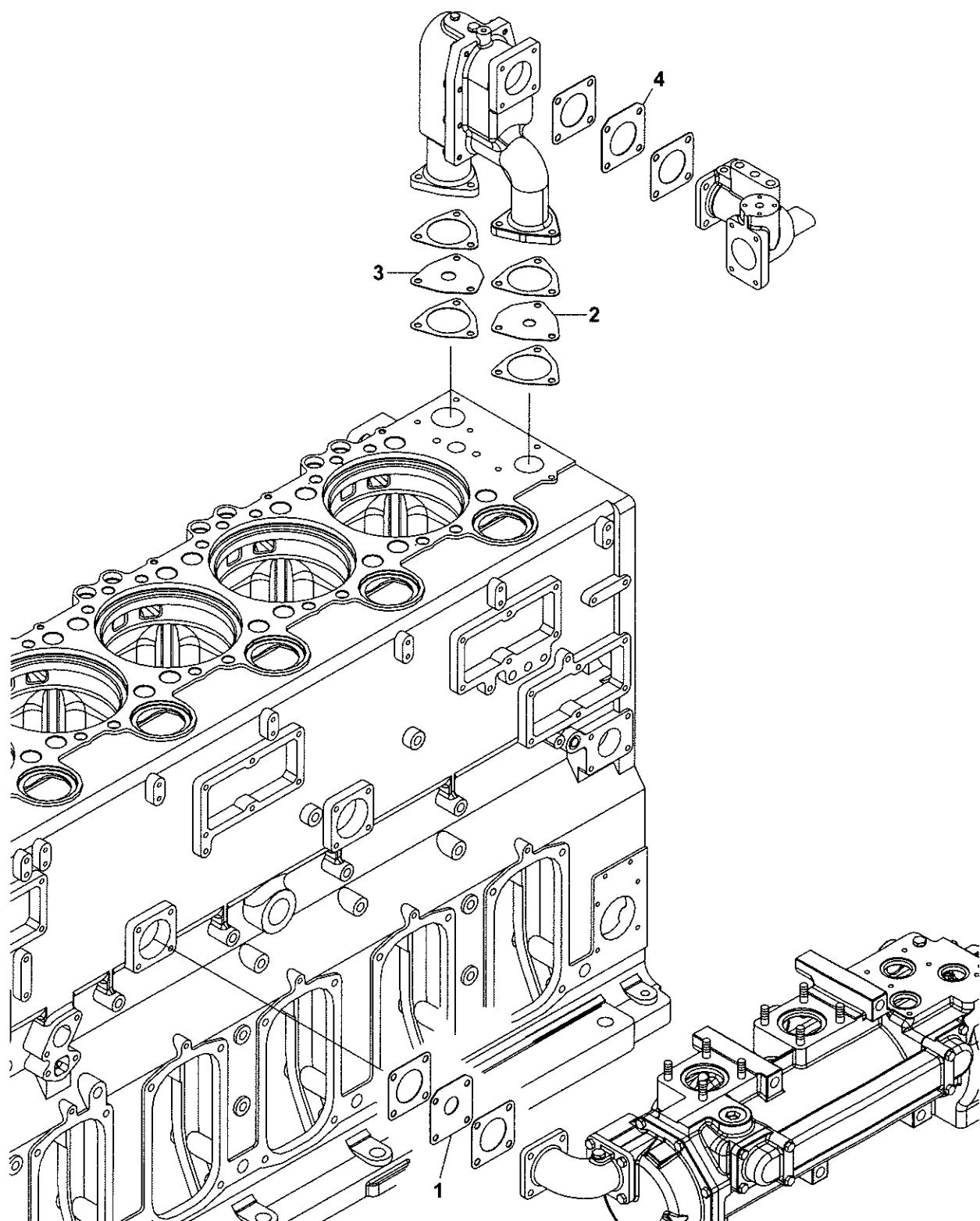
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146673-49891	ORIFICE, 3	1	1	
2	1	23211-015022	FLANGE, 15	1	1	Hole
2A	1	23211-015000	FLANGE, 15	1	1	Without hole
3	1	23438-015000	GASKET, 15 X 1.5	1	1	
4	1	26206-100252	BOLT, 10 X 25	1	1	

Orifice

Illustrated parts data

1/2



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Orifice

Illustrated parts data

2/2

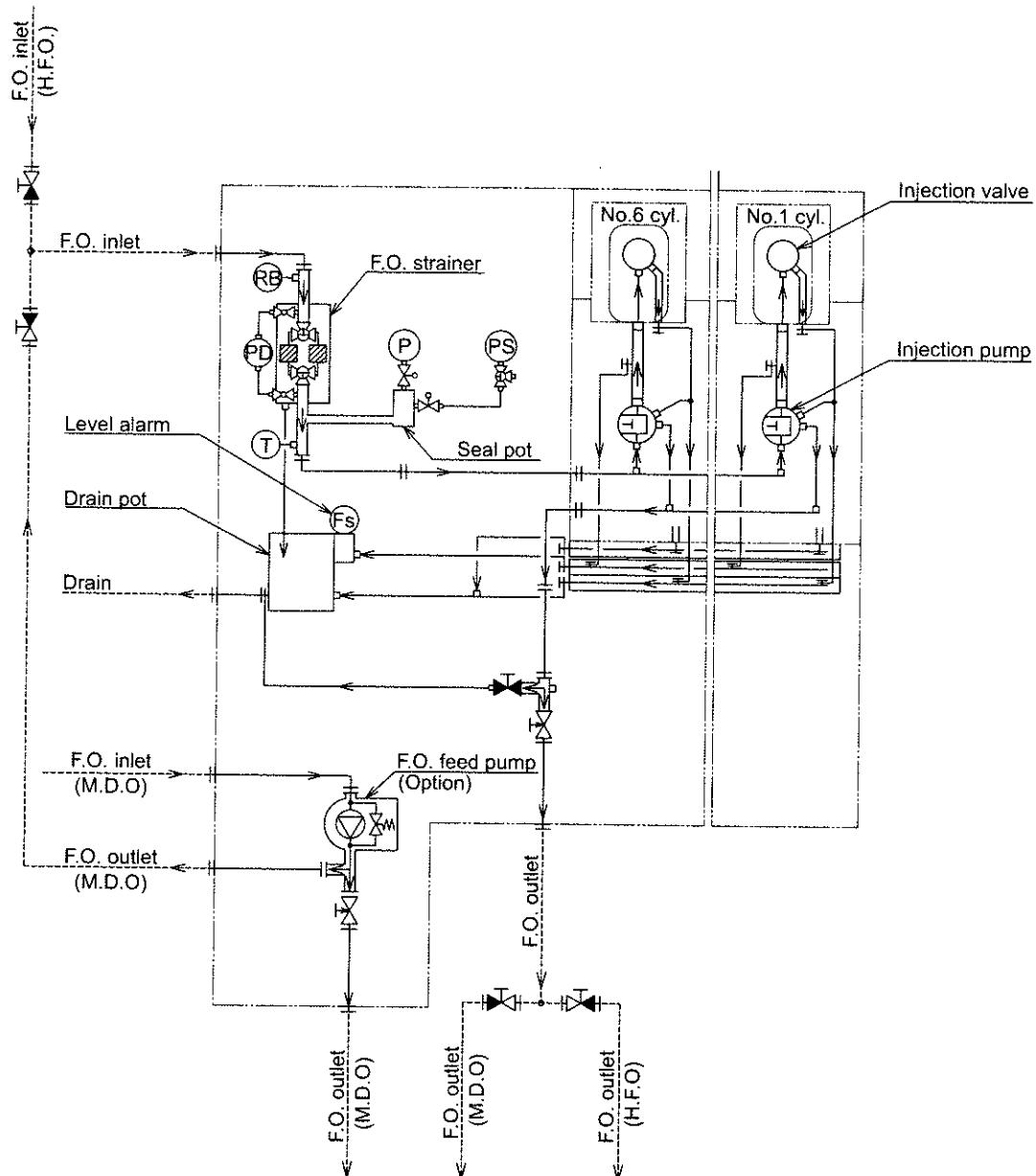
(two pump mixing)

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146673-49481	ORIFICE(D40)	1	1	
2	1	150633-49500	ORIFICE(D75)	1	1	
3	1	150633-49520	ORIFICE(D30)	1	1	
4	1	150633-49610	ORIFICE(D75)	1	1	

(one pump mixing)

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146673-49500	ORIFICE(D70)	1	1	
2	1	150633-49510	ORIFICE(D25)	1	1	
3	1	150633-49500	ORIFICE(D75)	1	1	
4	1	156673-49481	ORIFICE(D40)	1	1	

- This engine can use marine diesel oil (M.D.O.) and heavy fuel oil (H.F.O.). For a diagram of the H.F.O. supply system, refer to the fuel system diagram by the constructor. This manual describes the fuel system on the engine side.
- The internal fuel system has the fuel supply (e.g. fuel feed pump, fuel strainer), high-pressure injection parts (e.g. fuel injection pump, fuel injection valve), discharge parts and the piping that connects these parts.



(Remarks)

The diagram shows the standard circuit.

Details for each engine are provided in the final drawing.

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Fig. 1 Fuel oil system

- The fuel injection valve is a low-inertia build with very light moving parts. It has a needle valve that is responsive and makes the injection characteristics better. This engine has a zigzag nozzle. Compared with standard nozzles, the zigzag nozzle has smaller, but more injection holes. The holes are arranged so that fuel can be injected into the combustion chamber at 2 angles. The small holes make the flow of air into the fuel spray easier and make the use of air more efficient. The result is better quality of emissions. The increase in the number of holes also decreases the fuel injection time.
- The fuel injection pipe leads from the side to the inside of the cylinder head and then to the fuel injection valve body. This pipe is made of forged high-carbon steel and a drilled hole in the pipe is used as the fuel oil passage. This design gives the pipe sufficient strength against high pressure. Both ends of the joint are conical-tight, improving the sealing.

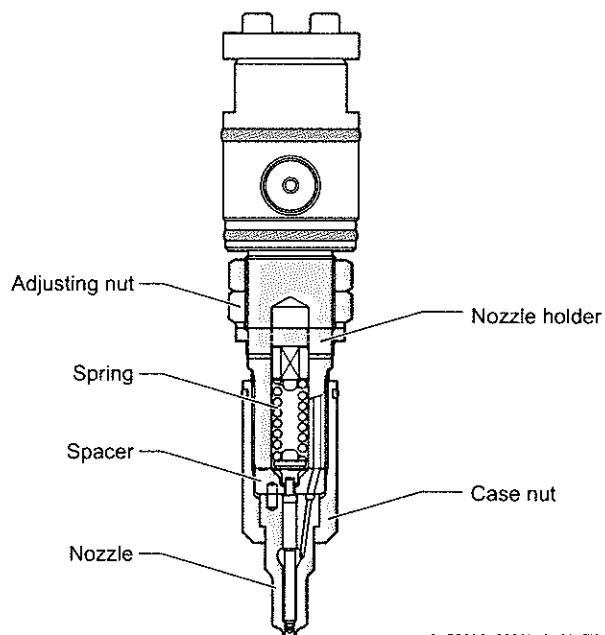


Fig.1 Fuel injection valve - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 1500 to 2000 working hours

CONDITION

PERSONNEL

Person	Category	Skill	Trade	Estimated time
a	Engine crew	Intermediate	-	4 h

EQUIPMENT

Nomenclature	Identification code	Quantity
Body of the fuel injection valve drawing-out tool	150633-92300	1 pc
Nut	26732-120002	2 pc
Washer	22137-120000	1 pc
Hexagonal wrench (M8)	28150-080000	1 pc
Hexagonal wrench (M6)	28150-060000	1 pc
Cleaning tool (FOV)	146673-92810	1 pc
Drawing-out tool (FOV)	150633-92400	1 pc
Socket for the case nut	146673-92260	1 pc
Nozzle tester	746623-93100	1 pc
Injection pipe for the nozzle tester	141616-93421	1 pc
Single-ended wrench (M41) for injection pressure adjustment	146673-92270	1 pc
Double-ended wrench (M41 x M46)	28110-410460	1 pc

SUPPLIES

Nomenclature	Identification code	Quantity
O-ring	151673-51381	1 pc
O-ring	146673-53900	1 pc
O-ring	128633-11880	1 pc
Packing	137600-53091	1 pc
Spacer retainer	150633-11850	1 pc
Copper spacer	146673-11622	1 pc

SAFETY

WARNING

When you operate the nozzle tester, make sure that you do not get in contact with spray from the fuel injection valve.

The very high injection pressure of 45 MPa will cause severe injury.

It is difficult to specify the servicing interval of the fuel injection valve, because it depends on the fuel oil and service load.

Examine changes (e.g. change of the exhaust temperature and exhaust color) and schedule the servicing interval accordingly.

Obey the instructions that follow when you do maintenance of the fuel injection valve.

1. Removing

1. Remove the clamping bolts 3 of the injection pipe joint 2 with a hexagonal wrench. Remove the bolt 1 on the fuel injection pump side.
2. Remove the injection pipe joint.

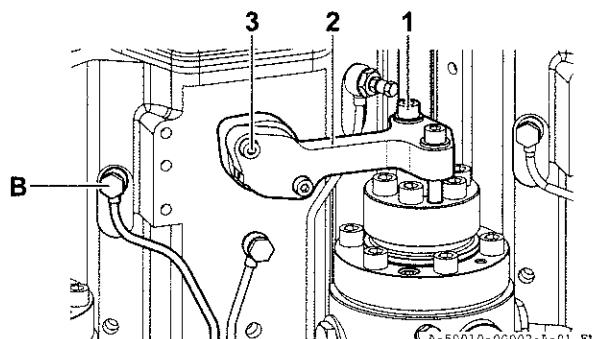


Fig.1 Removing the fuel injection valve 1

3. Remove the fuel injection valve tightening nut 8.
4. Loosen the injection pipe capnut 13. Remove it together with the injection pipe 12.

NOTICE

Handle the injection pipe with care: Damage to the round ends of the injection pipe can cause oil leaks.

5. Install the drawing-out tool body 6 to the bolt of the rocker-arm shaft support 14 and the spacer bolt 7.
6. Tighten the washer 5 and the nut 4 to the spacer bolt. Remove the fuel injection valve.
7. Remove the case nut packing 9.

It is possible that the packing comes out together with the fuel injection valve.

NOTICE

Make sure that no leakage oil in the fuel injection valve drips on the cylinder liner.

Leakage oil in the combustion chamber can cause an oil hammer before engine start. This can cause damage on the inside of the engine.

Before you remove the fuel injection valve from the cylinder head, remove the coupling bolt B of the fuel oil drain pipes and drain the leakage oil from the injection valve. Additionally, you can drain the leakage oil effectively by blowing with compressed air.

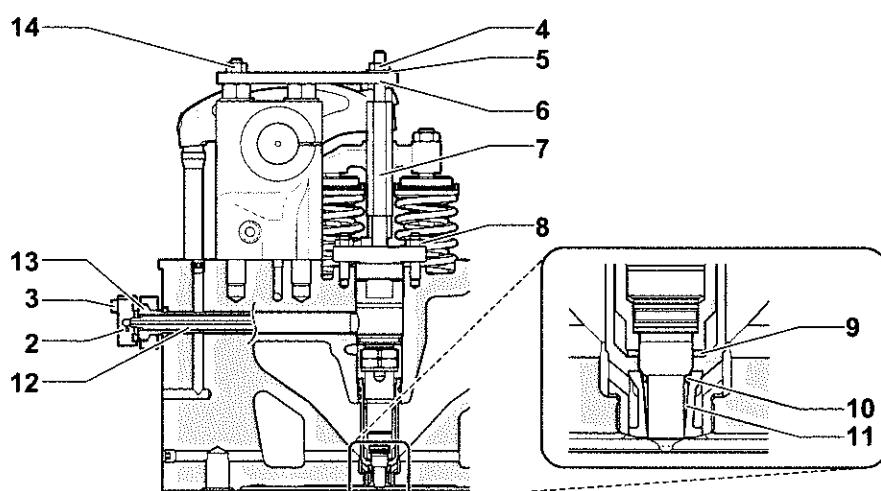


Fig.2 Removing the fuel injection valve 2

8. Remove the spacer retainer 10 and the copper spacer 11 on the bottom end of the nozzle sleeve.

NOTICE

H.F.O. engines have an indirect cooling system with a copper spacer. When you do maintenance, replace the copper spacer and the spacer retainer together with the nozzle case packing.

9. Put the cleaning tool 15 into the nozzle hole. Pull it up. Pull out the spacer retainer 10.

If you cannot pull it out, remove it with a stick that has a hook.

10. Put the cleaning tool into the spacer 11. Push it to the end.

11. Remove the carbon from the spacer: Turn the cleaning tool 4 to 5 times. Move it in and out 2 to 3 times.

12. Align the stepped part on the end of the drawing-out tool 16 with the end of the copper spacer.

13. Align the shoulder part on the end of the drawing-out tool with the copper spacer.

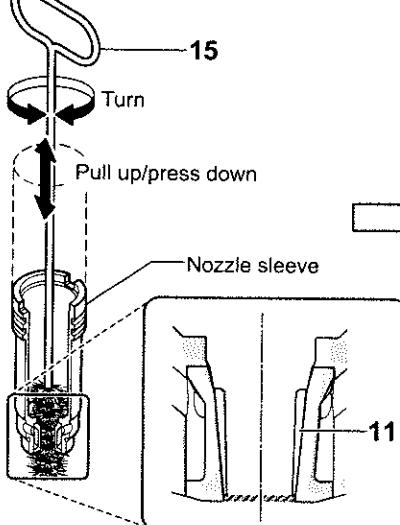
NOTICE

Do not tap the drawing-out tool with a hammer. If the shoulder part causes damage to the copper spacer, the drawing-out tool will not be in the correct position. If you operate it, you will cause damage to the tool.

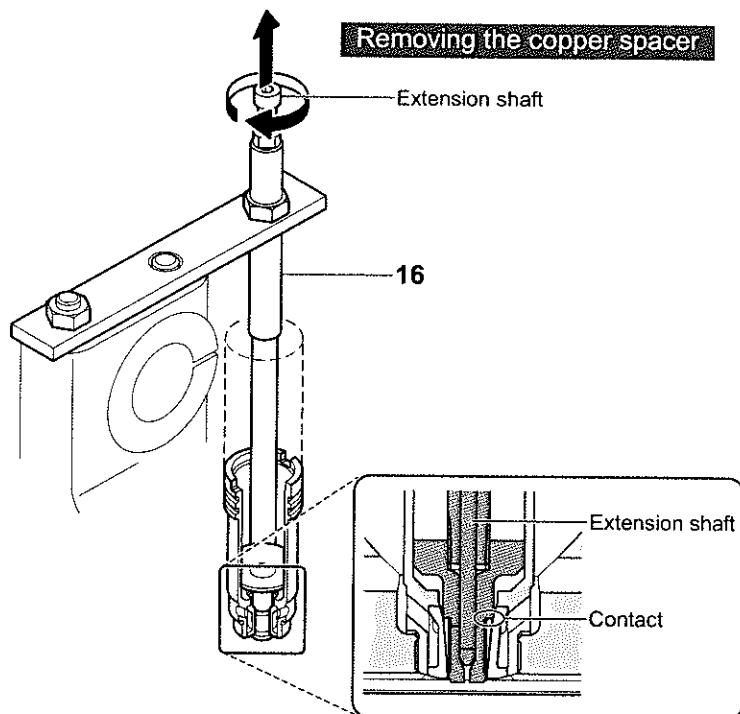
14. Manually turn the extension shaft of the drawing-out tool in the clockwise direction. When it becomes difficult to turn, pull up the tool.

When it is difficult to pull up, turn the nut on the tool and pull out copper spacer.

Removing scale



Removing the copper spacer



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Fig.3 Removing the copper spacer

2. Disassembly

1. Remove carbon from the outside of the nozzle.
Soak the valve in carbon remover or Cresol stock solution to make cleaning easier.
2. Before you disassemble the fuel injection valve, remove the fuel injection nozzle retainer and lock the fuel injection valve so that it does not move.
3. Loosen the locknut 1.
4. Loosen the pressure-adjusting nut 2.
5. Loosen the case nut 8.
If carbon stays on the nozzle, the case nut 8 and the nozzle 9 come off together. Be careful that the positioning pin 10 does not fall down.
6. Remove the nozzle 9.
Be careful that the positioning pin 10 does not fall down.
7. Remove the valve stop spacer 11.
Be careful that the positioning pin 12 does not fall down.
8. Remove the spring seat 7, spring 6, spring retainer 5 and spring retainer guide 4 together.
9. Remove the spacer 3.

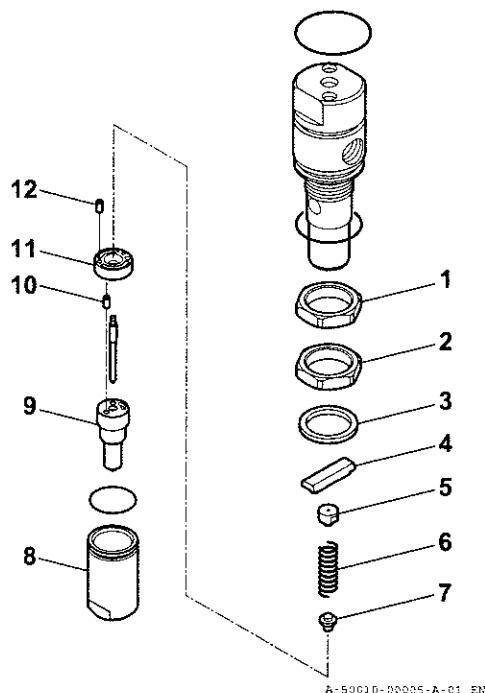


Fig.4 Disassembling the fuel injection valve

3. Inspection

1. Examine the outside of the nozzle for sulfuric acid corrosion. If you find a lot of corrosion, replace the nozzle with a new one.
2. Make sure that the nozzle valve moves easily. If the nozzle valve is stuck or if it does not move easily, replace it with a new one.
3. When the stepped wear "A" of the valve stop spacer is more than 0.15 mm, replace it with a new one.
4. Examine the case nut and the O-ring of the fuel injection valve.

The average service life of the nozzle is about 2500 hours. We recommend that you have a spare nozzle in stock.

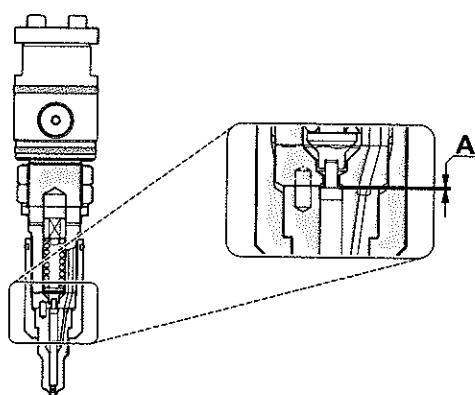


Fig.5 Fuel injection valve - Inspection

5. Put the cleaning tool inside the nozzle sleeve.
6. Clean the mating part of the copper spacer: Move the cleaning tool up and down, and turn the cleaning tool.

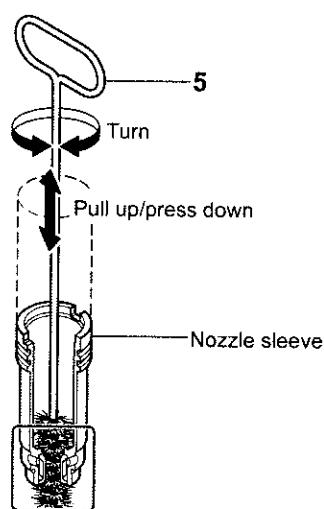


Fig.6 Cleaning the inside of the sleeve

7. Make sure that the cleaning part is clean.

NOTICE

If the mating part is not clean when you install the fuel injection valve, this causes early degradation (bad injection).

4. Assembly

Clean the nozzle with light oil.

1. Replace the O-ring with a new one.
2. Put the needle valve into the nozzle.

Look for damage and unwanted material.

3. Put the spacer and the spring guide into the fuel injection valve.
4. Put in the spring seat.
5. Put in the spring.
6. Install the spring seat.

Make sure that you install the spring seat and nozzle in the correct direction. Be careful that the pin does not fall down.

7. Put the pin into the valve stop spacer.
8. Align the nozzle to the pin and install the nozzle to the pin. Be careful that the needle valve of the nozzle does not fall down.
9. Put the case nut on the nozzle.

10. Tighten the case nut with the special socket to the specified torque.

Be careful that the nozzle and the case nut do not turn together and come off the pin.

If you tighten too much, the nozzle can malfunction or the pin can break.

Table of tightening torques for major bolts and nuts 0000-000-07

5. Adjust

1. Install the injector to the nozzle tester 4. Make sure that it points down.
2. Set the nozzle tester to the specified injection pressure. To do so, slowly operate the hand lever of the nozzle tester and turn the pressure-adjusting nut.
 - Assembly adjustment values / Clearance & wear limits of major parts 0000-000-07
3. Quickly operate the hand lever of the tester (at a rate of 2 or 3 strokes per second) and examine the spray.

If you operate the hand lever slowly, fuel oil can leak. This is normal and the nozzle is not defective.
4. Replace the nozzle with a new one if it is clogged or if the injection is in streaks.
 - 1 - Do not loosen the case nut 3 under high injection pressure. It can cause damage to the straight pin and to the mating surfaces of the nozzle and the spacer.
 - 2 - When you replace the nozzle, remove the case nut while the pressure-adjusting nut is loose.
 - 3 - Tighten the case nut to the specified torque with the special socket.
 - Table of tightening torques for major bolts and nuts 0000-000-07
 - 4 - Do not tighten the case nut too tightly. It can bend the nozzle and cause incorrect movement and damage to the straight pin.
5. Alternatively, you can examine the seat for oil leaks. Apply a pressure of 2.0 MPa lower than the specified opening pressure. If only a little bit of fuel oil comes out of the nozzle tip, the nozzle can be used again.
6. After you completed the injection test and adjusted the injection pressure, tighten the locknut 1 with the special single-ended wrench.

To prevent the adjusting nut from turning with the locknut, lock the adjusting nut with a double-ended wrench.

7. Do the injection test again and make sure that the injection pressure is correct.

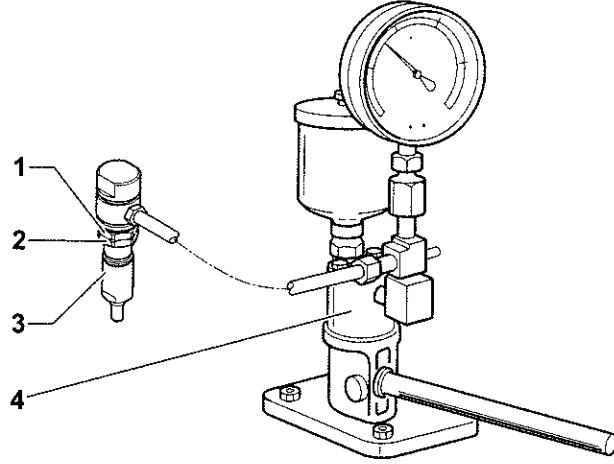


Fig.7 Injection test and adjusting the injection pressure

6. How to install

- Replace the case nut packing 1, spacer retainer 2 and copper spacer 3 with a new one.

NOTICE

When you clean the mounting hole of the fuel injection valve, be careful not to cause damage to the contact surface of the case nut packing on the nozzle sleeve tip.

- Apply Protec grease to these parts of the fuel injection valve:

- The outer circumference of the nozzle
- The spacer retainer
- The inner and outer circumference of the copper spacer.

- Install the spacer retainer and the copper spacer to the fuel injection pump.

NOTICE

Make sure that the copper spacer does not come out when you lift up the injection valve.

- Install the case nut packing to the nozzle sleeve.

- Install the fuel injection valve to the cylinder head.

- Install the injection pipe cap nut 6.

- Tighten the fuel injection valve tightening nut.

- Install the clamping bolt 9 of the injection pipe joint on the fuel injection pump side. Make sure that you install the parts in the correct direction, because the washer 10 is spherical.

- Tighten the injection pipe joint 11 on the cylinder head side and the fuel injection pump side. Tighten it gradually 2 to 3 times one each side, up to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

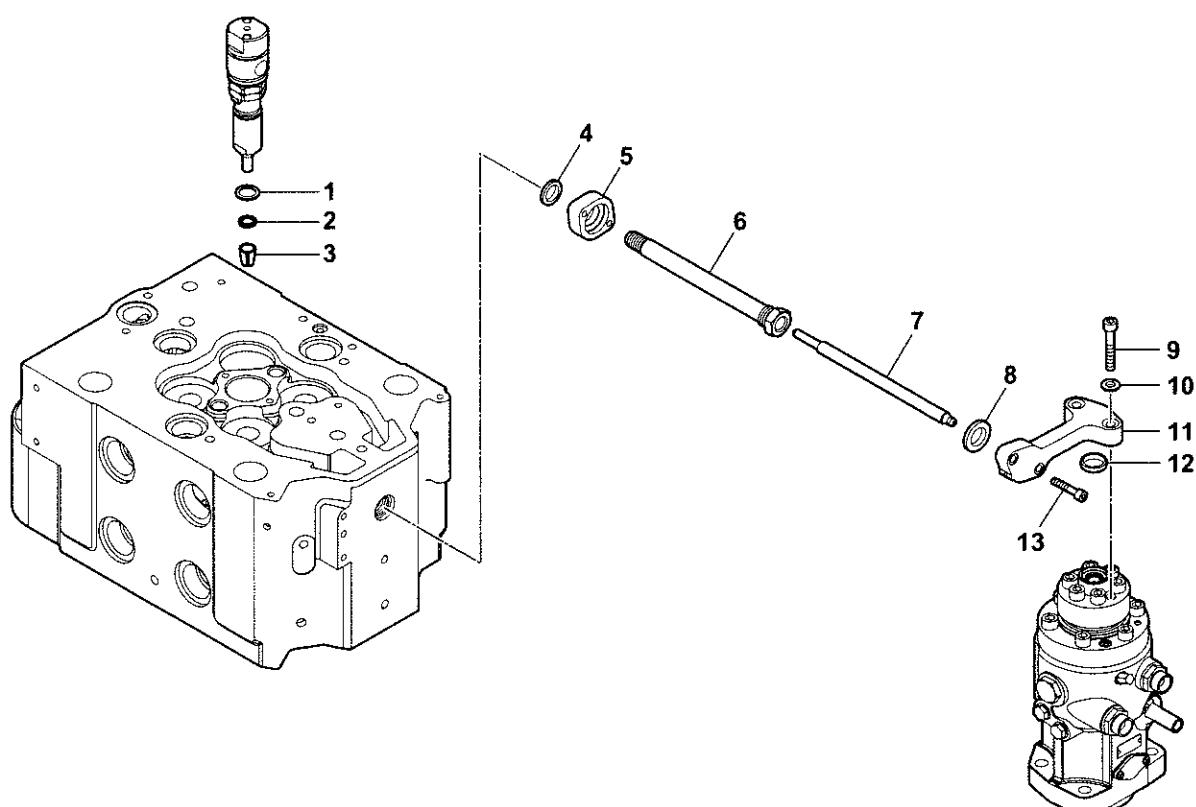


Fig.8 Installing the fuel injection valve

7. Visual inspection

1. Make sure that the copper spacer is correctly seated and does not come out on the combustion side.
2. After you do servicing on a fuel injection valve, look for leakage oil from the overflow pipe during engine operation.
 - A: Oil that leaked from the fuel injection pipe or the fuel injection pipe joint
 - B: Oil that leaked from the nozzle clearance

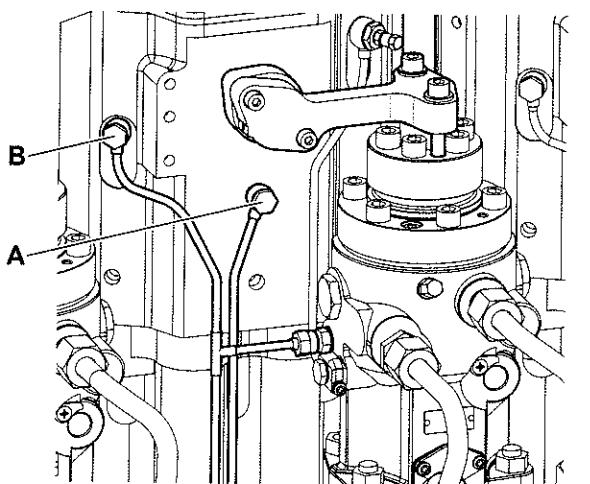


Fig.9 Leakage oil removal parts

CONDITION

- The fuel feed pump is a gear pump. The pump gears on the driving shaft side are attached to the shaft by a spline.
- The fuel feed pump is installed to the gear case on the opposite side of the flywheel. It directly drives the drive gear of the fuel feed pump with the crankshaft gear.

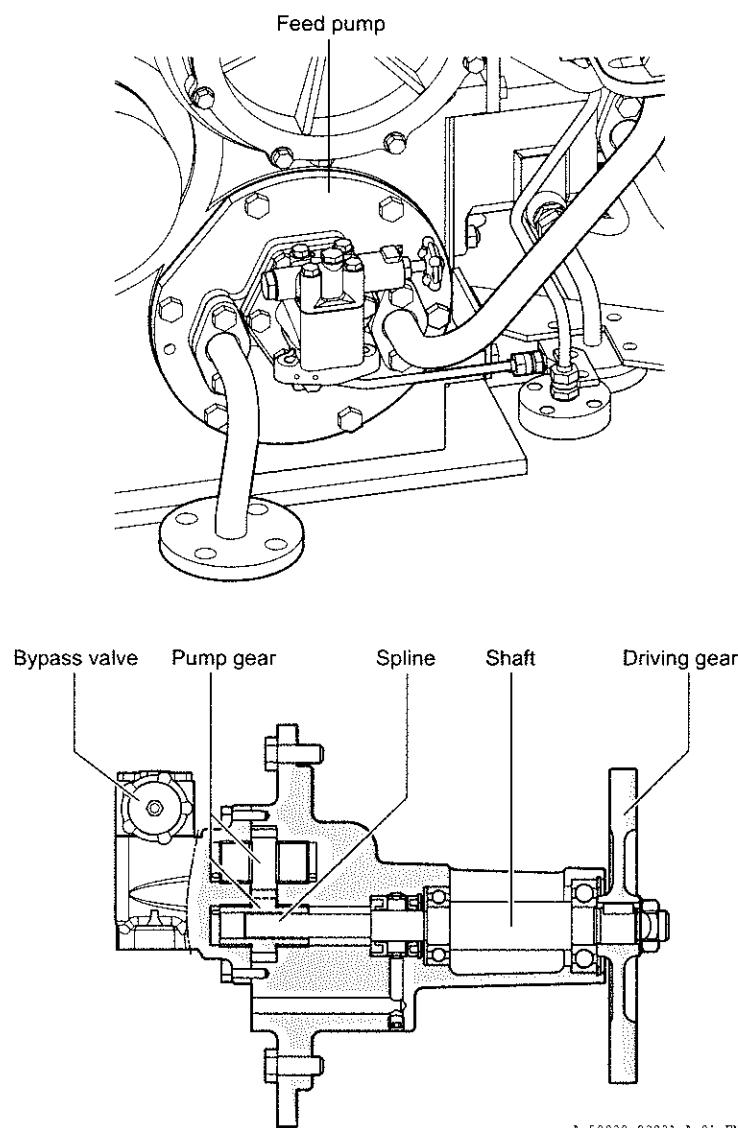


Fig.1 Fuel feed pump - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
	Bend washer			122310-83410	1 pc
	O-ring			24316-000140	1 pc
SAFETY					

Obey the instructions that follow when you do maintenance of the fuel feed pump.

1. Disassembly

1. Straighten the bends of the bend washer 2.
2. Remove the nut 1.
3. Remove the driving gear 3.
4. Remove the key 5.
5. Remove the circlip 4.
6. Remove the ball bearings 7 and 6 together with the driving shaft 8. The bearings are press-fitted into the shaft.
7. Remove the bypass valve assembly 15.
8. Remove the pump cover 16 from the pump body.
9. Remove the driving-side gear 14 and the driven-side gear 13 from the pump body.
10. Remove the circlip 9.
11. Pull out the oil seals 10 and 12 and the spacer 11 in the direction of the driving gear 3 side.

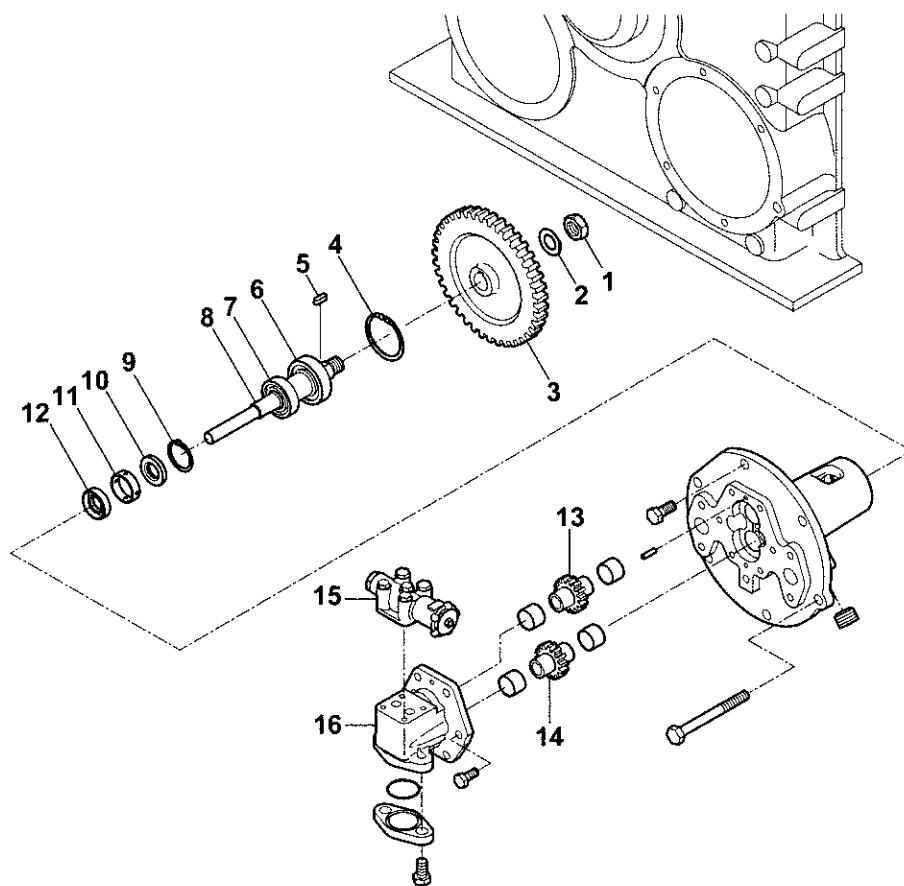


Fig.1 Fuel feed pump

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2. Inspection

1. Check the contact A of the spline mating parts of the driving shaft and the pump gear. If the clearance is too big, replace the part that is more worn.
2. Check the parts of the driving shaft that touch the oil seals. If you find a lot of wear, replace the shaft.
3. If necessary, replace the oil seals with new ones.

Replace the oil seals every 4000 to 5000 hours even if the appearance is good.

The two oil seals are different parts. Make sure that you install them in the correct location and direction.

4. Replace the ball bearings.

Replace the ball bearings every 8000 to 10000 hours even if the appearance is good.

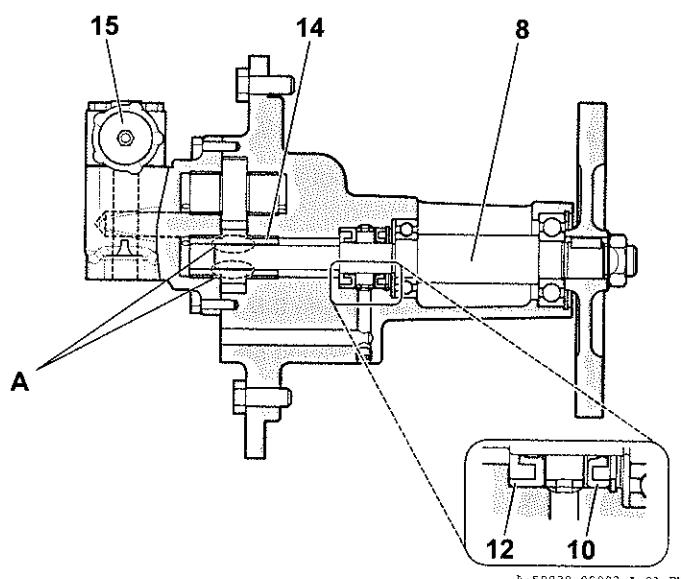


Fig.2 Fuel feed pump Inspection

5. Keep the bypass valve closed during operation. It is also a relief valve for the fuel feed pump.
The handle shaft turns left-handed. Turn the handle fully to the right (clockwise) to close the valve.
6. Remove the plug 20.
7. Make sure that the piston 19 moves easily.
8. If fuel comes out of the handle shaft 17, replace the O-ring 18 with a new one.

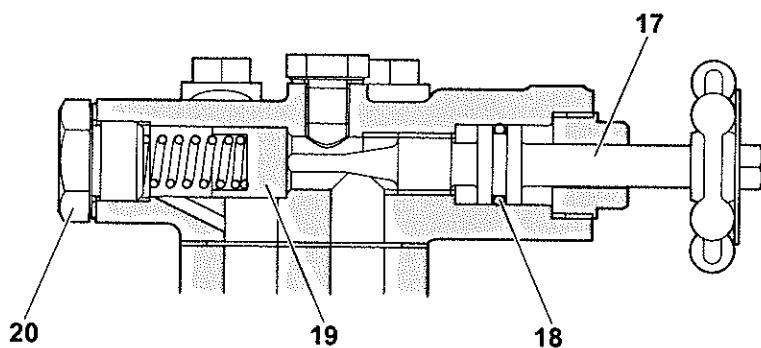


Fig.3 Bypass valve

3. Assembly

1. Install the driving-side gear and the driven-side gear to the pump body.
2. Install the pump cover to the pump body.

Apply a thin and smooth layer of liquid packing (ThreeBond 1201 or equivalent) on the mating surfaces of the pump cover and the pump body. (The thickness of the packing after clamping must be 0.02 mm or less.)

3. Install the bypass valve assembly.
4. Install the oil seal from the driving gear side.

Align the hole of the oil seal spacer to the direction of the oil overflow of the pump body.

5. Fix the oil seals in the correct position with the circlip.
6. Press-fit the ball bearings to the driving shaft.

When you do so, apply load to the inner ring of the ball bearings.

7. Install the driving shaft together with the two ball bearings from the driving gear side.

When you install the driving shaft, be careful not to cause damage to the lip of the oil seal. Put it in slowly.

8. Lock the ball bearing 6 in the correct position with the circlip.
9. Engage the key into the driving shaft and assemble the driving gear.

10. Put in the bend washer. Tighten the nut to the driving shaft with the specified torque.

Tightening torque: $140 \text{ N}\cdot\text{m} \pm 10\text{N}\cdot\text{m}$

Replace the bend washer with a new one every time you disassemble the fuel feed pump.

11. Bend the bend washer to lock it.

CONDITION

- The fuel oil injection pump is a high-pressure injection pump for high-pressure, short-period fuel oil injection. The allowed pressure is 150 MPa.
- To prevent deformation caused by high pressure, the plunger barrel has a closed top and is firmly attached to the fuel injection pump.
- The discharge valve has a two-way delivery valve. This prevents cavitation inside the injection system.
- The oil circuit returns oil that leaks from the plunger barrel. This prevents the fuel adjust rack from getting stuck and negative effects on the plunger.
- On H.F.O. engines, the system that lubricates the bottom sliding parts of the fuel injection pump by dropping oil on the pinion sleeve prevents the fuel adjust rack from getting stuck and malfunctions of the fuel pump.

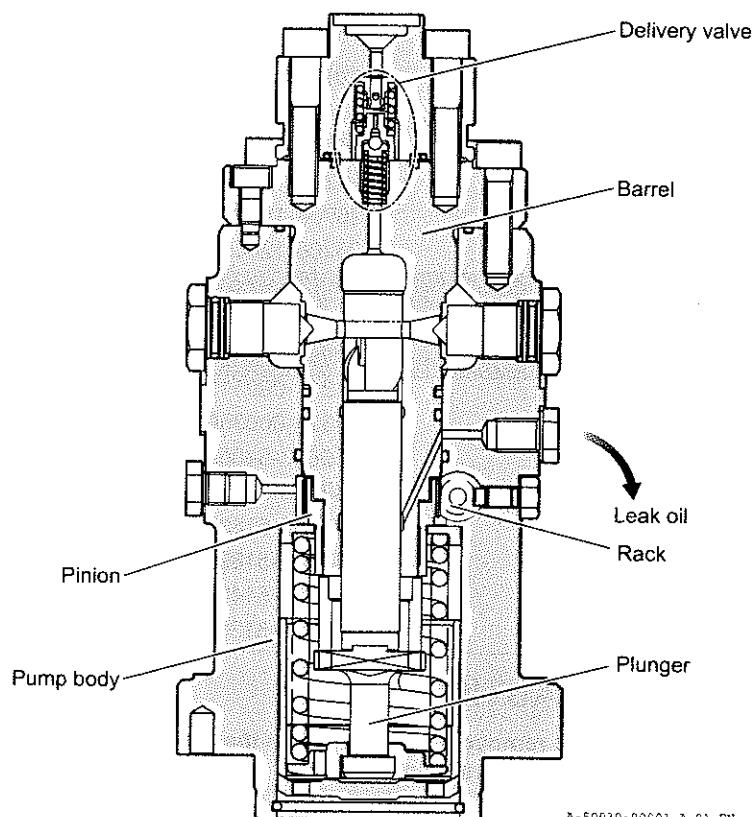


Fig.1 Fuel feed pump - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION Compare the quantity and time of fuel injections to the data recorded during load operation. If necessary, stop the engine and adjust the fuel injections.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	9 h
	b	Engine crew	Intermediate	-	9 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Socket wrench for pump-mounting (flywheel side)	150633-92560	1 pc
	Socket wrench for pump-mounting (opposite side of the flywheel)	150633-92570	1 pc
	Hexagonal wrench (6 mm)	28150-060000	1 pc
	Hexagonal wrench (8 mm)	28150-080000	1 pc
	Plunger guide assembly tool	150633-92900	1 pc
	Bolt 12 x 100	26206-121002	2 pc
	Nut 12	26706-120002	2 pc
	Jack bolt	26206-120454	1 pc

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity
	O-ring	24311-000110	1 pc
	O-ring	24321-000350	1 pc
	Packing	150633-54050	1 pc
	O-ring	146685-51810	1 pc
	O-ring	146685-51830	1 pc
	O-ring	153685-51890	1 pc
	O-ring	153604-51401	1 pc
	O-ring	153604-51381	1 pc

SAFETY**▲ CAUTION**

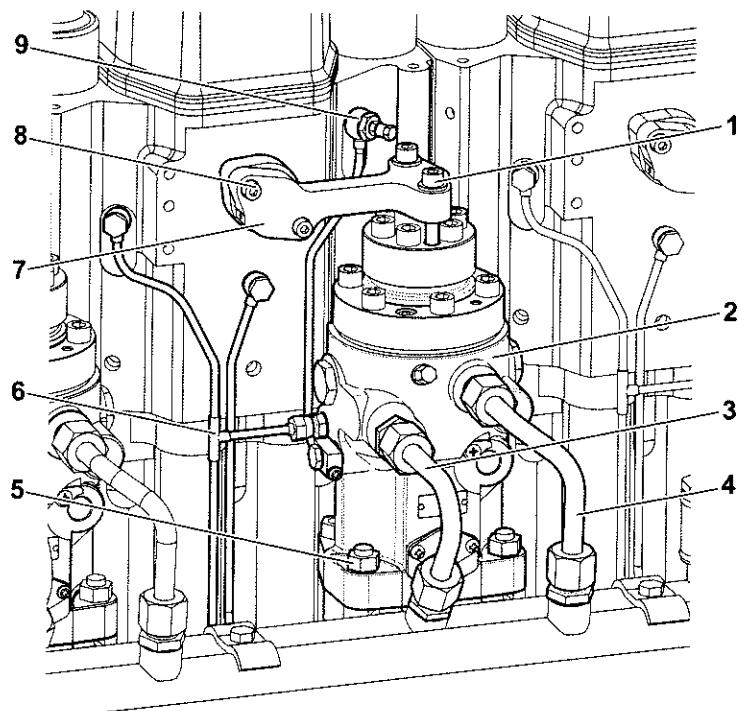
At disassembly, when you remove the circlip 1 from the groove, it can suddenly come off and cause injury. To prevent this, cover it with a cloth.

Obey the instructions that follow when you do maintenance of the fuel injection pump.

It is a precision instrument and any defect will have a bad effect on combustion performance and engine output. Be careful with the fuel injection pump during disassembly and assembly.

1. Removing

1. Loosen the clamping bolts of the fuel injection pipe joint 7 with a hexagonal wrench key. Do it on the pump side 1 and on the head side 8.
2. Remove the injection pipe joint.
3. Remove the overflow oil pipe 6.
4. Remove the pinion lubrication pipe 9.
5. Remove the fuel oil inlet pipe 3.
6. Remove the fuel oil outlet pipe 4.
7. Loosen the tightening nuts 5 of the fuel injection pump with the special box wrench.
8. Remove the pump 2.



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Fig.1 How to remove the fuel injection pump

2. Disassembly

1. Turn the pump in the opposite direction of operation and install the assembly tool.
2. Screw in the jack bolt. Push in the plunger guide 2. Make the opening of the circlip 1 larger.

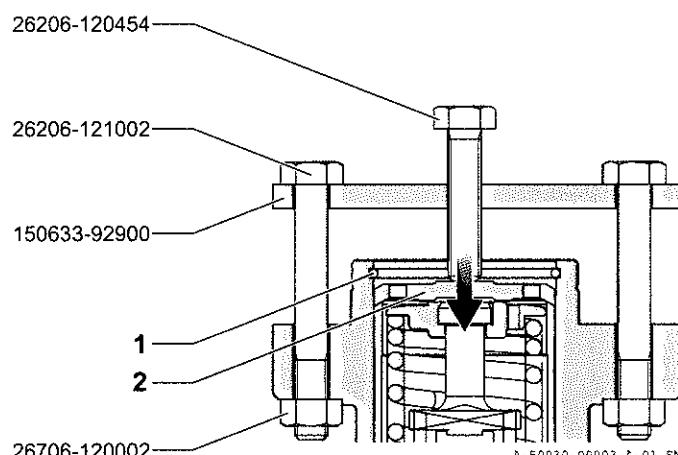


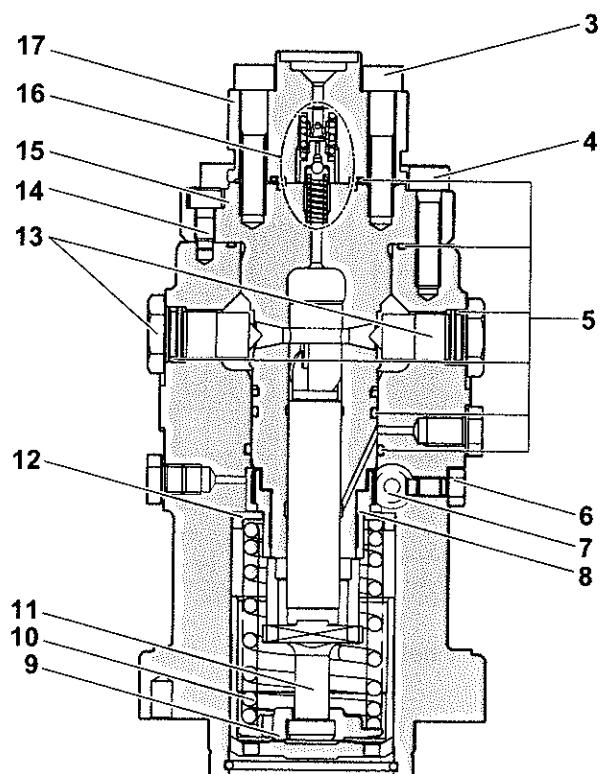
Fig.2 Disassembling the fuel injection pump

3. Remove the circlip.
4. Remove the plunger guide.
5. Remove the plunger spring retainer 9.
6. Remove the plunger 11.
7. Remove the plunger spring 10.
8. Remove the spring seat 12.
9. Remove the pinion 8.
10. Loosen the bolt of the rack guide 6.
11. Remove the rack 7.
12. Remove the two deflectors 13.
13. Loosen the clamping bolt of the delivery valve 3.
14. Loosen the barrel clamping bolt 4.
15. Loosen the lock bolt 14.

16. Remove the barrel 15.

Notice

Keep the plunger and the barrel together as a pair.



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Fig.3 Disassembling the fuel injection pump

3. Inspection

1. Clean all parts. Make sure that there is no rust.
2. Examine the spring of the delivery valve 6 for breakage.
3. Examine the mating surfaces of the deliver valve body 7 and the barrel 5 for blowby from fuel oil.
4. Clean the oil hole of the barrel 3 and the oil hole of the pinion 2 on the pump body.
5. If the end of the deflector 4 has dents from corrosion, replace it.
6. Replace all O-rings 1 with new ones.

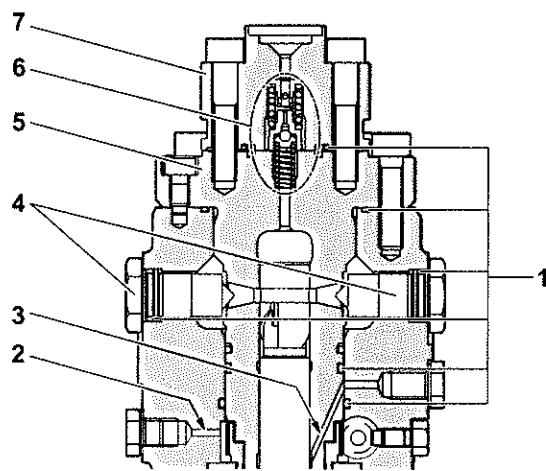


Fig.4 Fuel injection pump - Inspection

4. Assembly

Assembles it in the reverse order of the disassembly procedure. (Fig.6)

1. Install the O-rings. Make sure that they are not twisted.
2. Apply lubricating oil to the barrel 11.
3. Install the barrel to the fuel injection pump body.
4. Install the delivery valve 14.
5. Tighten the barrel clamping bolt 13 and the clamping bolt 16 of the delivery valve body. Tighten them gradually in 3 steps to the specified torque.

Table of tightening torques for major bolts and nuts 0000-000-07

6. Align the match marks of the rack 8, pinion 1 and plunger 3.
7. Spring seat 2 and plunger spring 4 are built in, and spring retainer 5 is set in the plunger.
8. When you install the circlip 7, be careful that you do not damage the guide of the pinion by the collar of the plunger. To avoid damage, adjust the movement of the rack while you push in the plunger guide 6.
9. Align the opening of the circlip with the notch of the body.

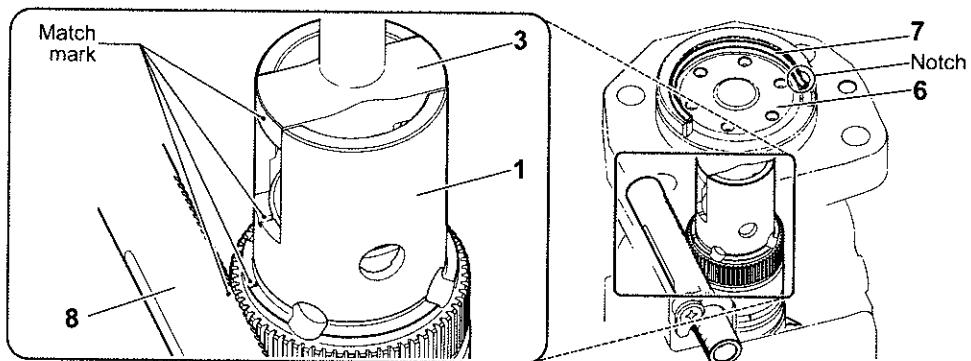
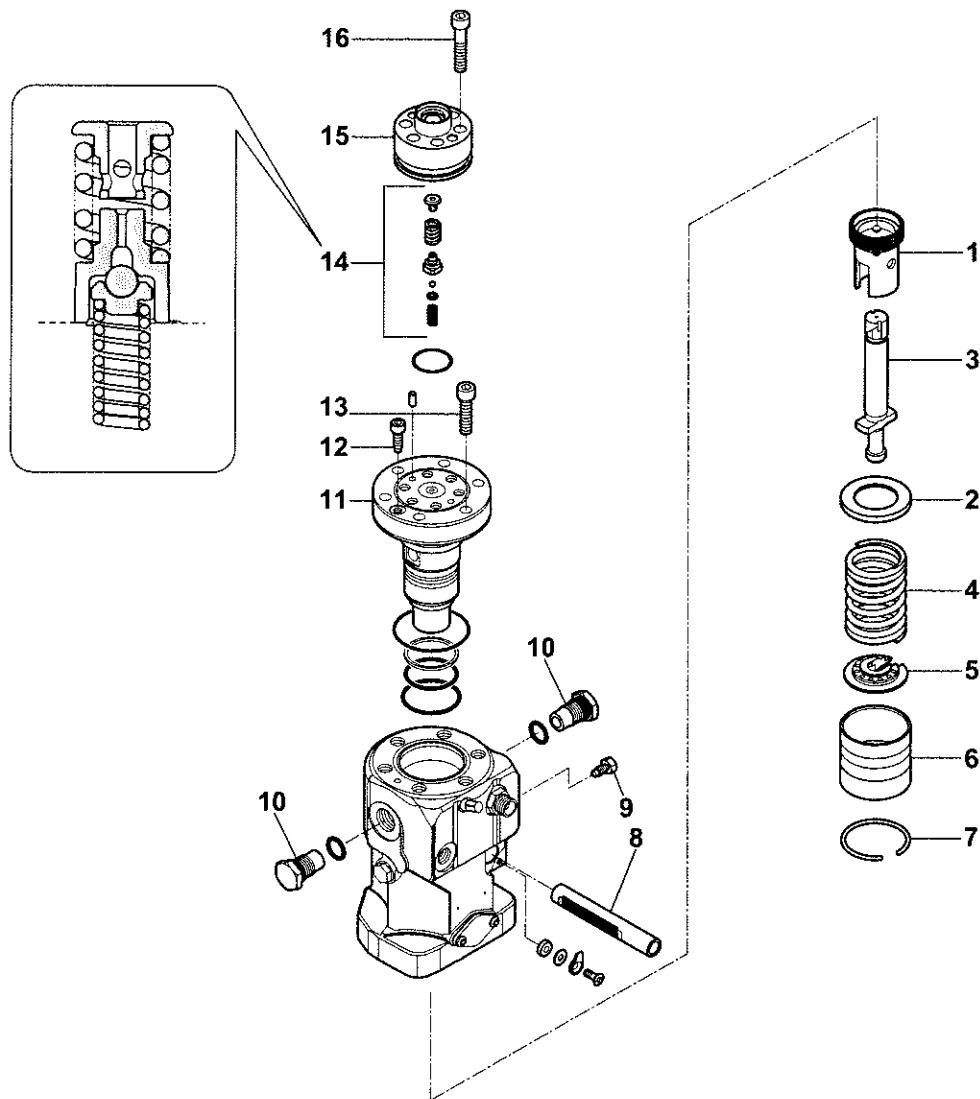


Fig.5 Match marks on the rack, pinion and plunger

10. After you assemble the fuel injection pump, make sure that the rack moves easily.



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Fig.6 Fuel injection pump - Assemble procedure

CONDITION

Fuel injection pump

Adjust

1/2

PRODUCTION MANAGEMENT DATA

Intervals 6 months
2000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1.5 h
	b	Engine crew	Intermediate	-	1.5 h

EQUIPMENT

	Nomenclature	Identification code	Quantity
	Single-ended wrench (M24) for the adjusting bolt	138603-92510	1 pc
	Double-headed wrench	28110-220240	1 pc
	Ratchet handle for turning	147673-92851	1 pc
	Socket (for turning)	42111-001850	1 pc

SUPPLIES

	Nomenclature	Identification code	Quantity

SPARES

	Nomenclature	Identification code	Quantity

SAFETY

CAUTION

At Adjusting the injection timing, when you turn the flywheel, do not let your fingers come close to the locknut 2 or the oil shield plate. Your fingers can get caught, resulting in injury.

Obey the instructions that follow when you replace the protector and adjust the injection timing.

1. Replace

1. Remove the protector.
2. If the end of the protector has dents from corrosion, replace it.

2. Adjust

1. How to check the injection timing

- 1 - Open the cover of the marking line check window.
- 2 - Turn the flywheel and align the marking lines on the pump body and on the plunger guide.

When aligned, the flywheel pointer shows the fuel injection time on the flywheel scale.

(In the range of 0° to 30 °C before and after top dead center, one mark indicates 2°. Outside this range, one mark indicates 5°.).

2. Adjusting the injection timing

- 1 - Open the cover of the marking line check window.
- 2 - Turn the flywheel and move the adjusting bolt 1 to the lowest position.
- 3 - Loosen the locknut.
- 4 - Turn the flywheel in the direction of engine rotation. Align the flywheel pointer with the injection time mark (on the flywheel scale) for the cylinder that you want to adjust.
 - Speed up the injection time: Pmax increases
 - Slow down the injection time: Pmax decreases
- 5 - Turn the adjusting bolt and align the marking line on the pump body with the line on the plunger guide.

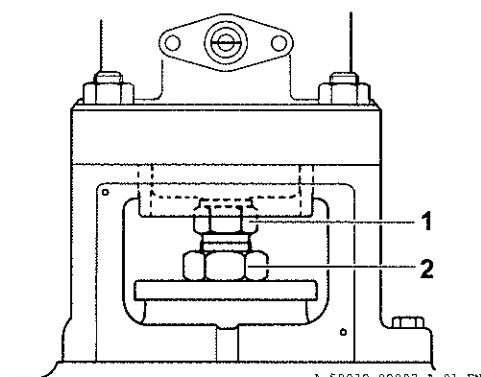


Fig.1 Adjusting the fuel injection timing

- 6 - Turn the flywheel and move the adjusting bolt to the lowest position.
- 7 - Tighten the locknut to the specified torque. To prevent the adjusting bolt from turning with the locknut, lock it with a wrench.

Table of tightening torques for major bolts and nuts 0000-000-07

Make sure that the plunger is not pushed up. After the adjustment, turn the flywheel and make sure that it turns easily.

- 8 - Install the cover of the marking line check window.

CONDITION

PRODUCTION MANAGEMENT DATA

CONDITION Intervals Unscheduled

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

If the difference in exhaust temperatures between the cylinders is more than 40 °C (and you serviced the fuel injection valve), adjust the rack 4 of the relevant cylinder's fuel injection pump 1.

Obey the instructions that follow when you do adjust the fuel injection quantity. Keep the difference between cylinders to less than one mark of the rack index on the indicator board 5.

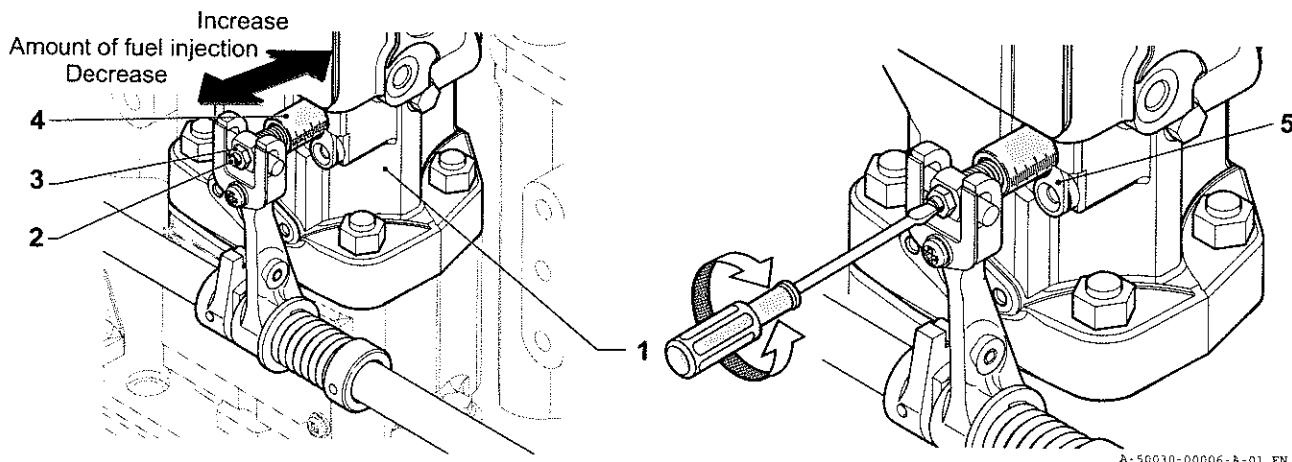


Fig. 1 Fuel injection quantity - Adjust

1. Loosen the locknut 3.
2. To adjust the injection amount, turn the rack-adjuster bolt 2 as follows:
Turn right (clockwise): increase the injection quantity (exhaust temperature increases)
Turn left (counterclockwise): Decrease the injection quantity (exhaust temperature decreases)
3. Tighten the locknut.

CONDITION _____

- The drive unit of the fuel injection pump is installed on the top of the cam case on the cylinder block. The fuel injection pump is installed on top of the drive unit.
- The injection timing is adjusted by changing the length of the adjusting bolt on the drive unit.
- The fuel injection pump driver uses the tappet roller to force-lubricate the roller pins. The body of the pump has an oil hole that lubricates the outside of the roller.

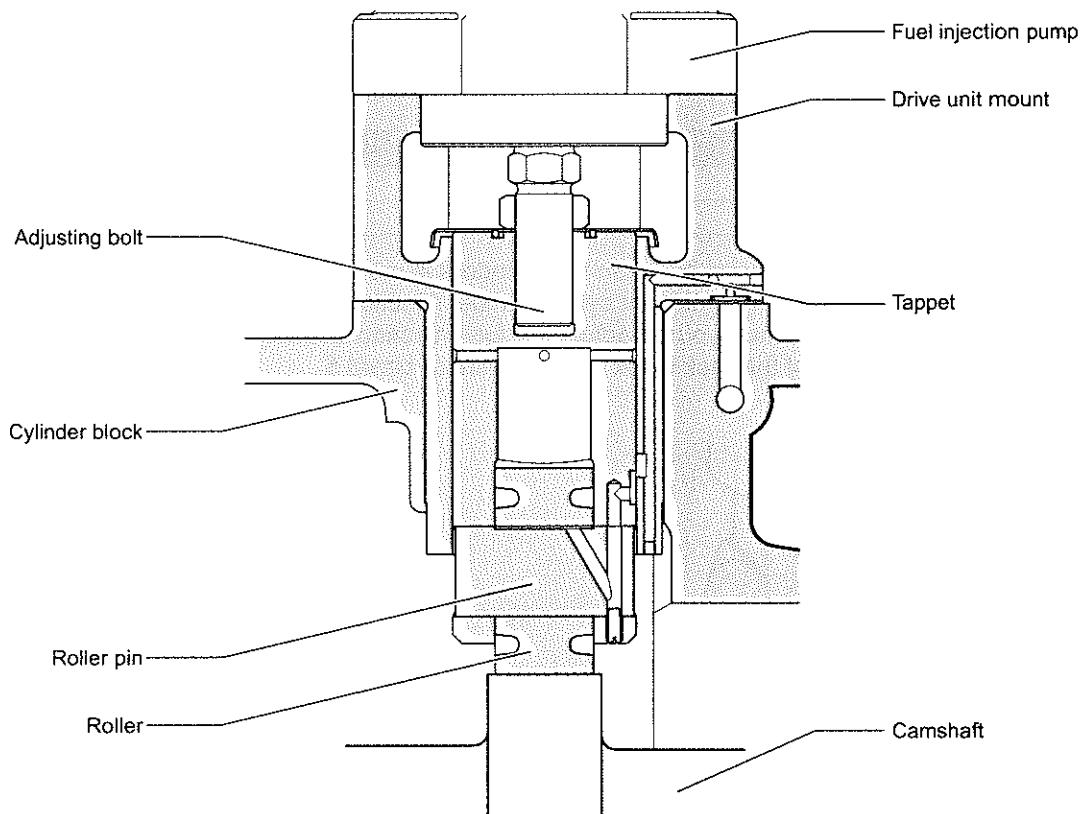


Fig.1 Fuel injection pump drive unit - Description of function

PRODUCTION MANAGEMENT DATA

Intervals 1 months
300 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Wrench, 24		138603-92510		1 pc
	Spanner, 22 X 24		28110-220240		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you examine the locknut for looseness.

1. Disassembly

1. Open the window cover of the fuel injection pump bracket.
2. Turn the flywheel and move the adjusting bolt 1 to the lowest position.
3. Examine the locknut 2 for looseness.
4. Tighten the locknut. To prevent the adjusting bolt from turning with the locknut, lock it with a wrench.

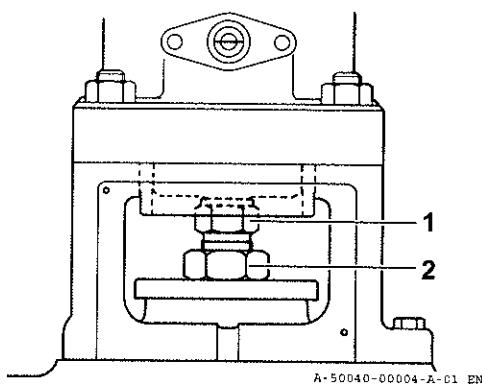


Fig.1 Examining the locknut for looseness

CONDITION

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	6 h
EQUIPMENT	Nomenclature			Identification code	Quantity
	Socket wrench for pump-mounting (flywheel side)			150633-92560	1 pc
	Socket wrench for pump-mounting (opposite side of the flywheel)			150633-92570	1 pc
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
	O-ring			24311-000110	1 pc
	O-ring			24321-000350	1 pc
	Packing			150633-54050	1 pc
SAFETY					

Obey the instructions that follow when you do maintenance of the fuel injection pump driving unit.

1. Disassembly

1. Remove the fuel injection pump.
- Inspection of the fuel injection pump 5003-000-02
2. Remove the drive unit assembly from the cylinder block.
 3. Loosen the locknut 2.
 4. Loosen the injection-timing adjusting bolt 5.
 5. Remove the oil shield 3 together with the O-ring 6.
 6. Remove the rotor tappet assembly 4 to the bottom.

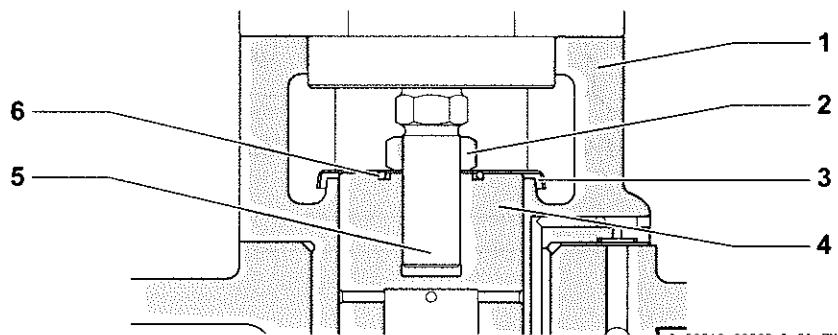


Fig. 1 Drive unit - Disassembly

2. Inspection

1. Examine the outside of the roller 2 for bad contact and damage.
2. Make sure that the roller turns smoothly.
3. Blow air into the oil hole in the body and look for clogging.
4. Replace all O-rings 1 with new ones.

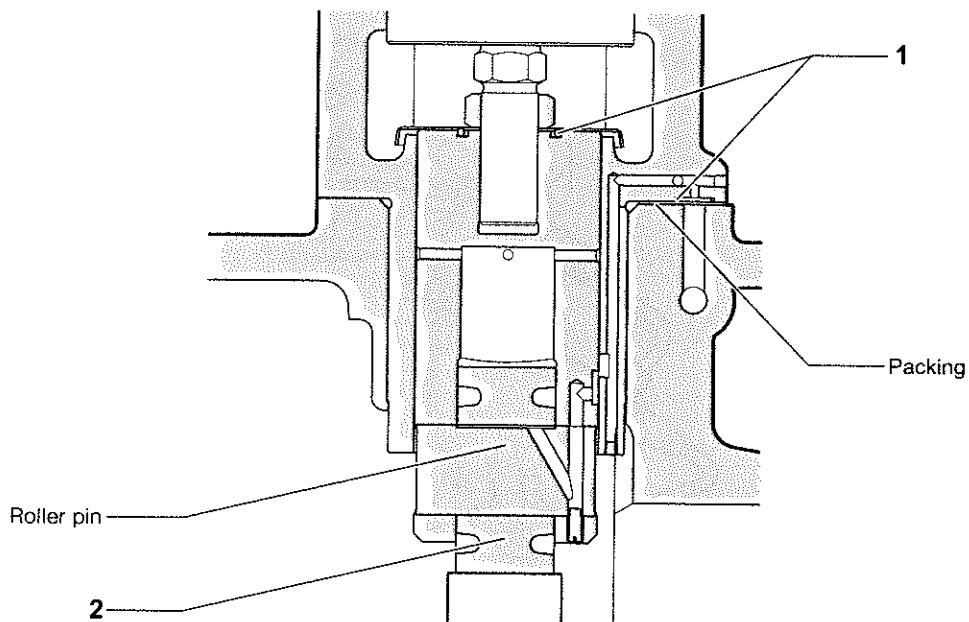


Fig.2 Drive unit - Inspection

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3. Assembly

1. Replace the O-rings and the packings with new ones.
2. Align the position of the plugs on the drive unit body of the fuel injection pump and the tappet.
3. Install the oil shield plate.
4. Install the injection-timing adjusting bolt and screw it in fully.
5. Install the fuel injection pump.
6. For details on the procedure, refer to this document:
How to adjust the fuel injection timing 5003-000-02

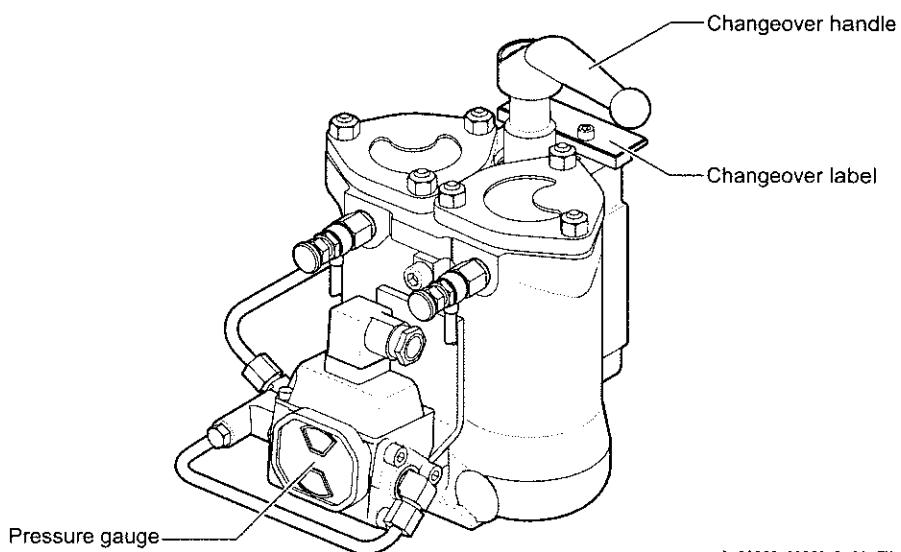
CONDITION

Fuel strainer

Description of function

1/1

- The fuel strainer is a manual, duplex changeover strainer and has a heat-insulating cover. The element is made of star-pleated material. During engine operation, the fuel oil passes through the elements on both sides.
- The strainer body has a differential pressure gauge. It measures the pressure at the strainer inlet/outlet and senses if the strainer is clogged.
- The differential pressure alarm operates if the pressure difference at the strainer inlet/outlet is 0.09 MPa.



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Fig.1 Fuel strainer

PRODUCTION MANAGEMENT DATA

Intervals 1 months
300 to 500 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature				Identification code
SUPPLIES	Nomenclature				Identification code
SPARES	Nomenclature				Identification code
	O-ring			151695-55070	2 pc
	O-ring			151695-55080	2 pc
SAFETY					



Be careful of burn injury. The filter becomes hot during H.F.O. operation.

Obey the instructions that follow when you do maintenance of the fuel strainer.

1. Disassembly

- Move the changeover handle 1 to LEFT (or RIGHT) DISASSEMBLY.

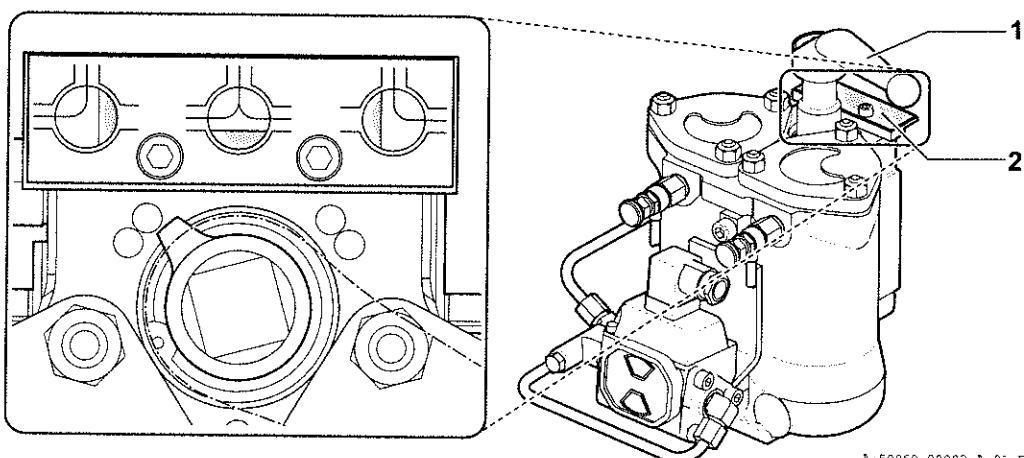


Fig.1 Changeover label

Inspection and maintenance

2. Open the air relief cock 3.
3. Open the drain plug 9 and drain the fuel oil.
4. Remove the cover 5.
5. Remove the element 8 from the body 7.

NOTICE

- Examine the oil pressure during disassembly. If the filter is very dirty and only one side is used, the pressure decreases and the engine rotation slows down.
- The filter body has a label 2 that shows the changeover position. If you switch the filter to use on one side only, move the changeover handle to the applicable position.

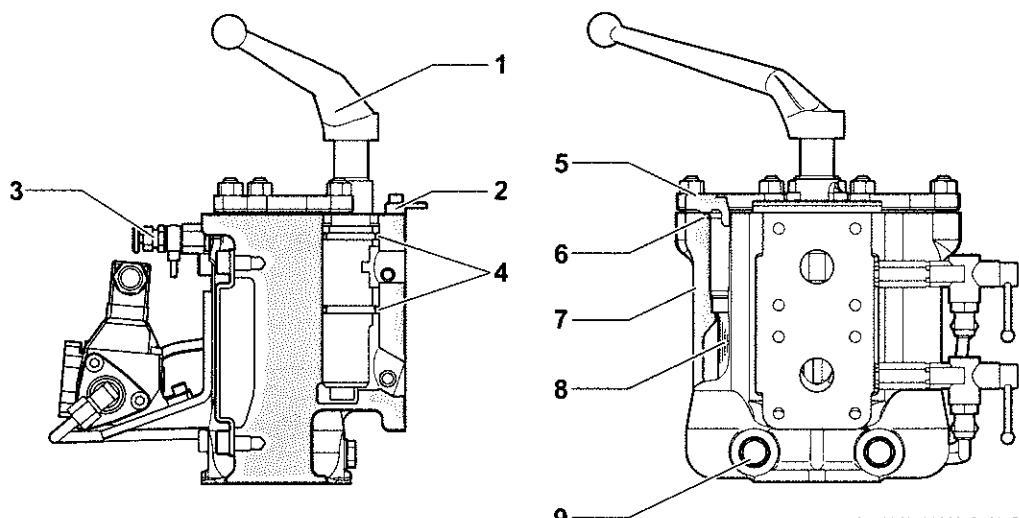


Fig.2 Fuel strainer - Disassembly

2. Cleaning

1. Soak the element in light oil or cleaning fluid.
2. Remove sludge from the surface of the element with a wire brush.
3. Prepare a nozzle as shown in Fig. 3.
4. Inject high-pressure water at a pressure of 6.0 MPa or less from inside the element.
5. Illuminate the element from the inside and make sure that you removed all dirt and unwanted material.
6. Examine the surface of the notch wire for damage, broken wires and corrosion.
7. Clean the inside of the strainer body.

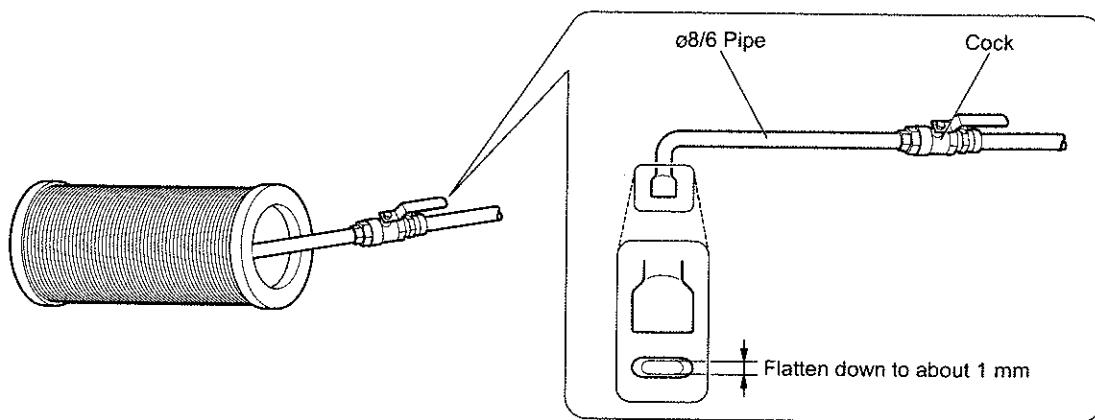


Fig.3 Cleaning the element

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3. Assembly

1. Replace the O-ring (4.6) with a new one.
2. Insert the element in the body of the strainer.
3. Install the cover.
4. Close the drain plug.
5. Return the changeover handle to the position for both sides.

NOTICE

Make sure that you move it slowly. If you do it quickly, the oil pressure can decrease until the filter is filled with fuel oil.

-
6. Open the air relief cock and release the air.
 7. Install the heat-insulating cover.

CONDITION

- The fuel oil pressure control valve keeps the pressure at the front and back of the fuel injection pump constant. It is at the end of the fuel oil return pipe.
- The pressure control valve is barrel-shaped and has a valve spring on the inside.

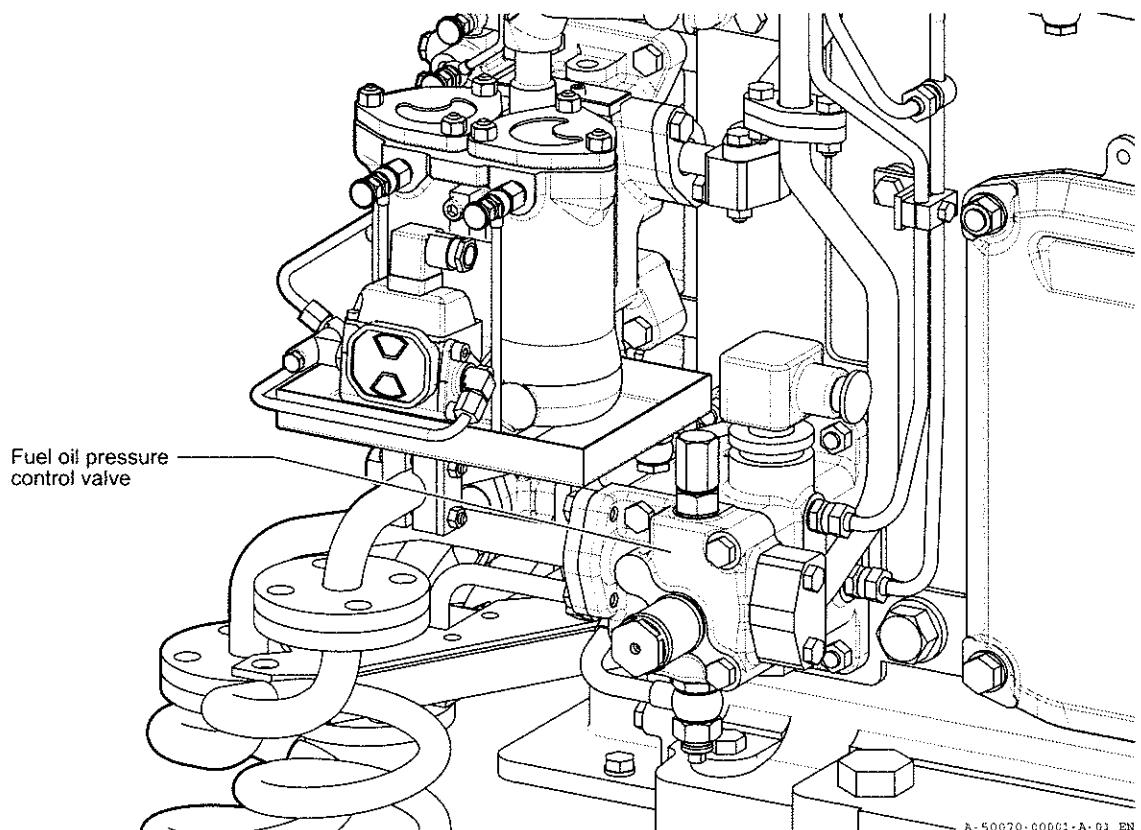


Fig.1 Location of the pressure control valve

PRODUCTION MANAGEMENT DATA

Intervals 2 years

8000 working hours

CONDITION When the fuel oil supply pressure of the engine is different from the specified standard value, adjust it according to the procedure that follows.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
	Seal washer		153672-59950		1 pc
	Seal washer		153672-59970		1 pc
SAFETY					

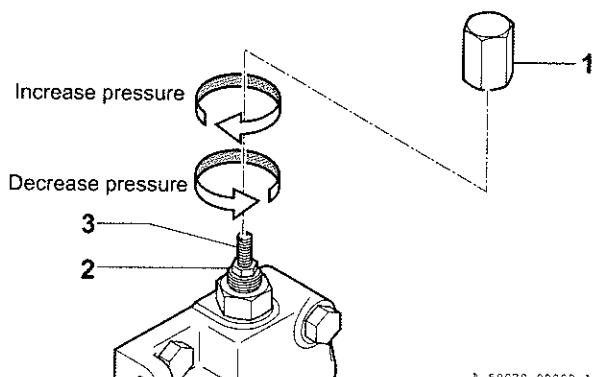
Obey the instructions that follow when you do maintenance of the fuel oil pressure control valve.

1. Adjust

1. Remove the cap nut 1.
2. Loosen the locknut 2.
3. Screw the adjusting bolt 3 (right-handed screw) in or out to adjust the pressure.
 - Clockwise (right): Increase pressure.
 - Counter-clockwise (left): Decrease pressure.
4. Tighten the locknut.
5. Securely tighten the cap nut.

NOTICE

Clean the fuel oil strainer before you adjust the fuel oil pressure.
 Examine the tank head pressure when you adjust the fuel oil pressure.



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Fig. 1 Pressure control valve

Inspection and maintenance

2. Disassembly

1. Remove the cap nut 1.
2. Loosen the locknut 2.
3. Loosen the adjusting bolt 3.
4. Remove the valve holder 4 and the seal washer 5.

NOTICE

Be careful. The valve spring 7 can suddenly come out and cause injury.

5. Remove the valve spring.
6. Remove the valve 6.

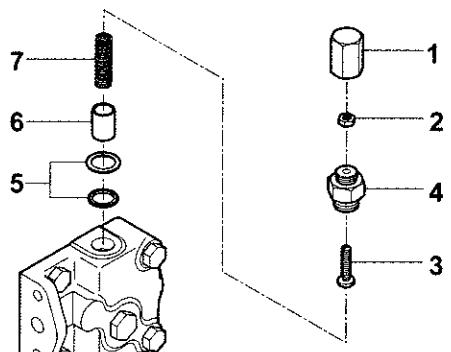


Fig.2 Fuel oil pressure control valve

3. Inspection

1. Examine the valve for damage.
2. Examine the valve seat for damage.
3. Make sure that the valve moves smoothly (no catching or rattling).
4. Examine the valve spring for breaks and fatigue.

If the pressure control is defective, the cause can be fatigue of the valve spring. Replace the spring with a new one.

4. Assembling

1. Install the control valve and the valve spring to the pressure control valve body.

NOTICE

The control valve is different depending on the engine specification. Make sure that you install the correct control valve.

The valve spring is also different for M.D.O. specifications, 180 mm²/s and mono-fuel specifications, and 380 mm²/s to 700 mm²/s specifications. Make sure that you install the correct valve spring.

Make sure that the engine has a 1.5 mm hole at the valve bottom or not.

M.D.O. specification: no hole

H.F.O. specification: hole

2. Replace the seal washer with a new one.
3. Screw the adjustment bolt into the valve bridge.
4. Screw the valve bridge into the pressure control valve body.
5. Lock the adjustment bolt with the locknut.
6. Install the cap nut.

CONDITION Recommended fuel oil pressure values 0000-001-17 1.6

- The seal pot is on the inlet of the pressure gauge. It ensures that the pressure indicator continues to operate when the temperature decreases and the heavy fuel oil inside the Bourdon tube of the fuel oil pressure gauge and the inside of the pressure transmitter becomes hard.
- Put ethylene glycol into the seal pot.

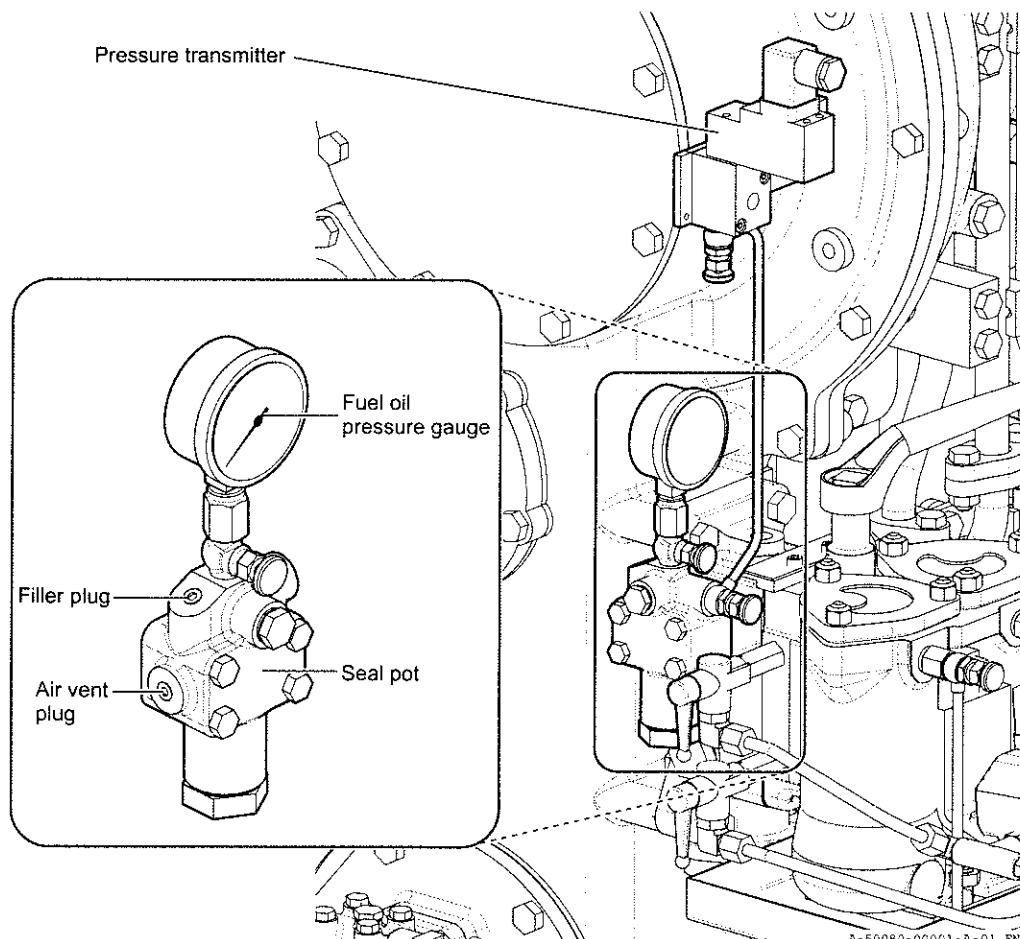


Fig.1 Fuel oil seal pot - Description of function

Seal pot

Inspection

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 months
500 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h
EQUIPMENT	Nomenclature				Identification code
					Quantity
SUPPLIES	Nomenclature				Identification code
					Quantity
SPARES	Nomenclature				Identification code
					Quantity
SAFETY					

Obey the instructions that follow when you do an inspection and fill of the seal pot.
 Loosen the air vent plug at regular intervals (approximately every 2 months). Make sure that no heavy fuel oil comes out.

NOTICE

Always fill the seal pot and the piping with ethylene glycol. If the temperature decreases, heavy fuel oil in the Bourdon tube of the pressure gauge and in the pressure transmitter becomes hard. This can cause the devices to malfunction.

CONDITION

Seal pot

Replacement

1/1

PRODUCTION MANAGEMENT DATA

Intervals 1 years
4000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h
EQUIPMENT	Nomenclature				Identification code
					Quantity
SUPPLIES	Nomenclature				Identification code
					Quantity
SPARES	Nomenclature				Identification code
					Quantity
SAFETY	Ethylene glycol				41650-003380
					1 pc

Obey the instruction that follow when you replace the ethylene glycol. (See 5008-000-01 Fig.1).

1. Replacement

1. When the engine is stopped, remove the filler plug.
2. Loosen the plug A.
3. Remove the drain plug. Drain the liquid that is inside the seal pot.
4. Install the drain plug.
5. Put ethylene glycol into the filler until it comes out of the plug A.
6. Securely tighten the plugs.

CONDITION

When the level in the fuel oil tank increases, the float switch opens the NC (normally closed) contact (B contact). Since the position of this float switch is set at the factory, it is not necessary to disassemble, adjust or do maintenance on it. Do not remove the stopper under the float. The float will fall. Be careful with the float switch. Shocks can cause a malfunction. This can cause a malfunction of the float switch.

Precautions for long-term storage

- Store the switch indoors where it is not in direct sunlight, rain or wind. Seal it in a plastic bag or a similar container.
- Do not put it directly on the floor. Store it on a palette.
- Do not remove the cover of the switch case until:
 - The float switch is installed on the device and
 - The wires are connected.
- Do a visual inspection at regular intervals (approximately every 6 months).

When you use the float switch after long-term storage:

- Make sure that the bolts and screws are tight.
- Measure the insulation resistance of the microswitch and make sure that it is $10\text{ M}\Omega$ or more.

1. Working principle

A magnet is inside the float. When the magnet passes through the detection range of the reed switch, the float switch is activated.

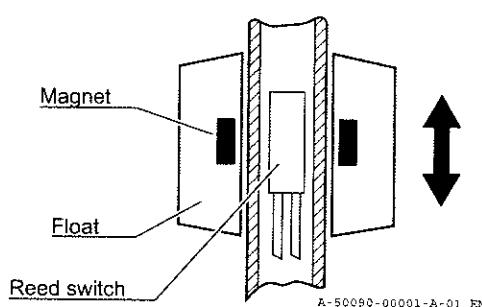


Fig.1 Float switch - Working principle

2. Operation oil level

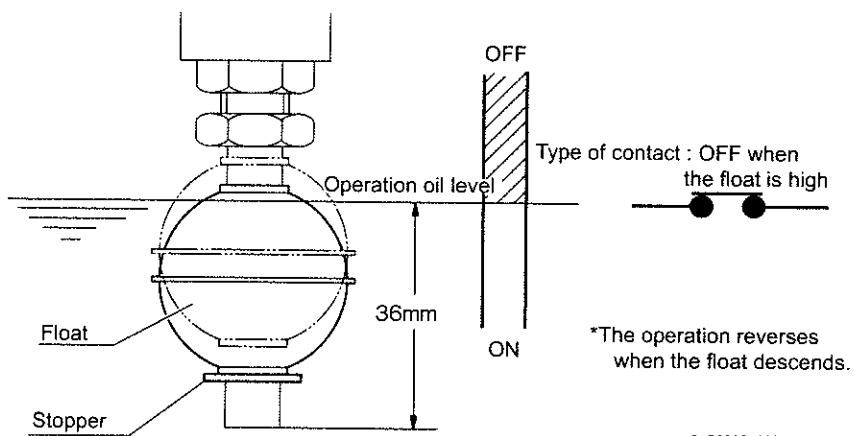
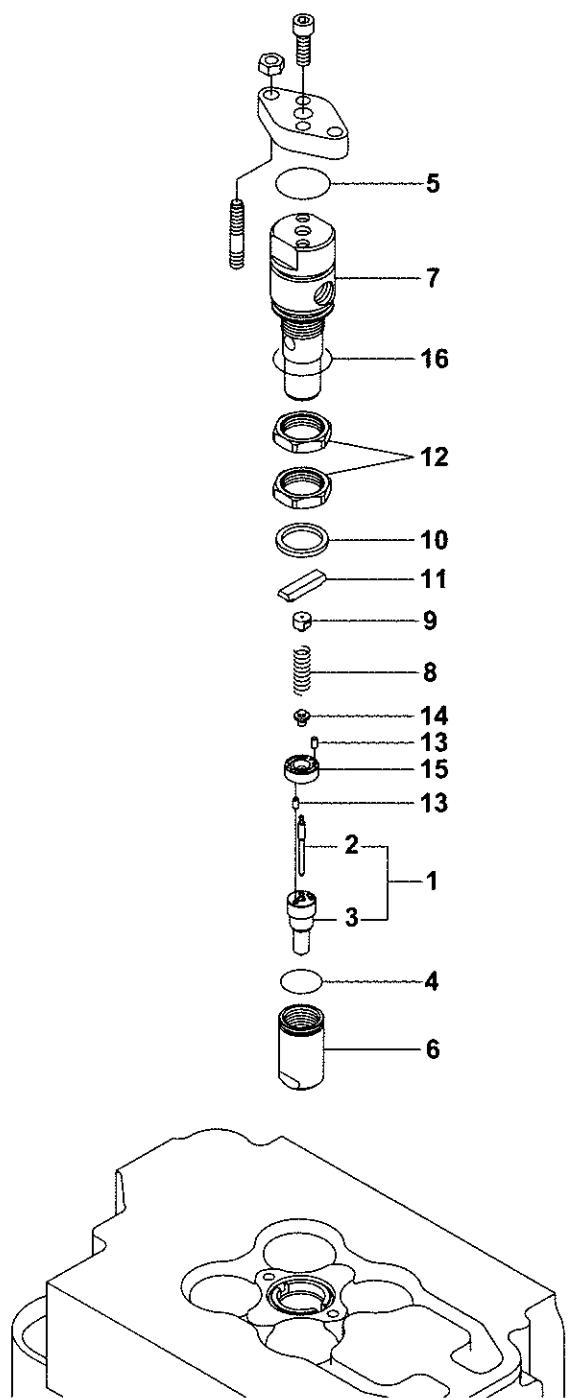


Fig.2 Float switch - Operation oil level

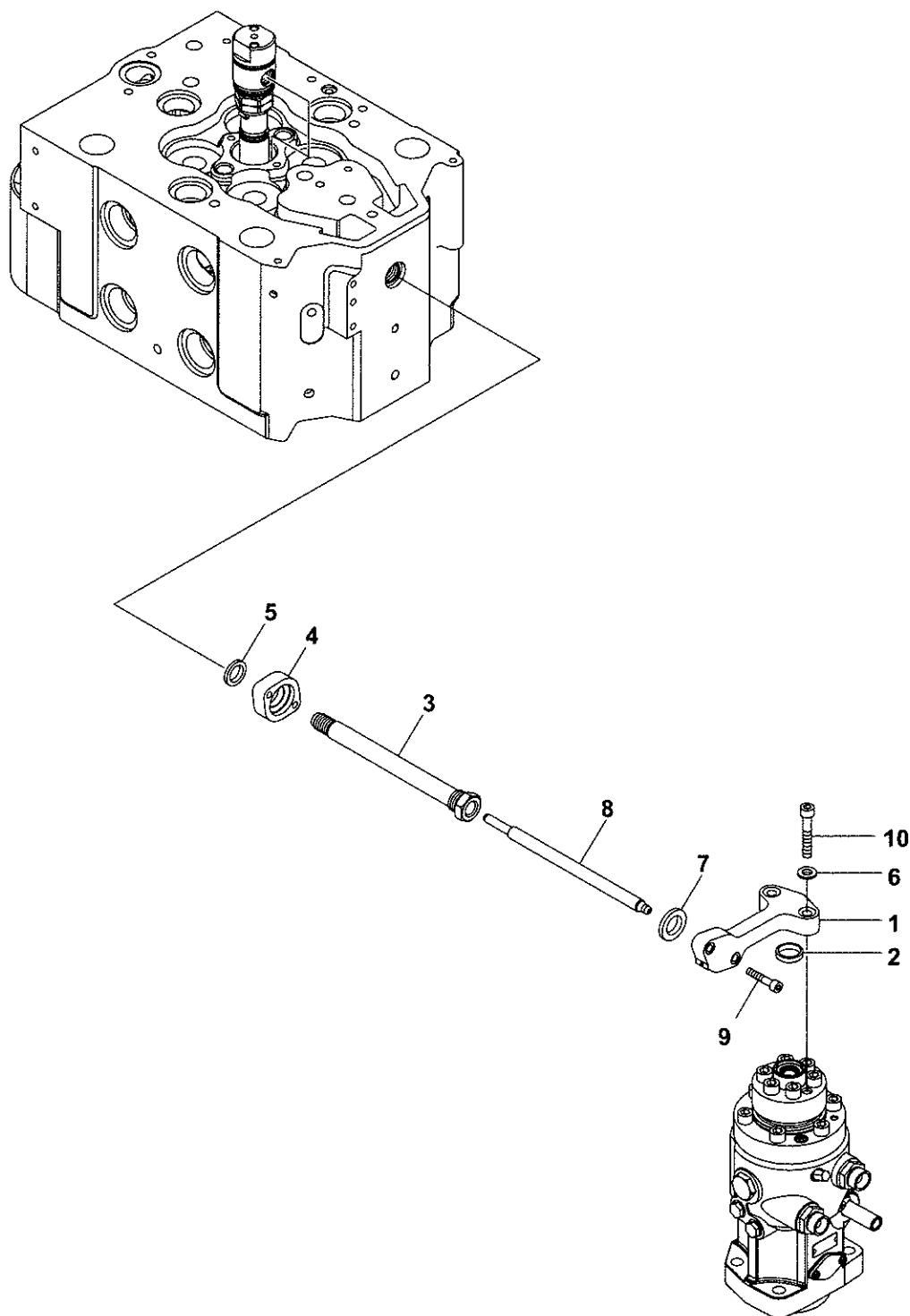


Fuel injection valve

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	750633-53600	FUEL INJECTOR ASSY	6	-	660, 754, 800kW
-	1	750633-53201	FUEL INJECTOR	6	-	880, 970, 1080kW
-	1	750633-53201	FUEL INJECTOR	-	6	880, 970, 1020kW
-	1	750633-53101	FUEL INJECTOR	-	6	1100, 1180, 1300, 1370kW
1	2	150633-53230	NOZZLE ASSY	6	-	660, 754, 800kW
1	2	150633-53211	NOZZLE ASSY	6	-	880, 970, 1080kW
1	2	150633-53211	NOZZLE ASSY	-	6	880, 970, 1020kW
1	2	150633-53001	NOZZLE ASSY	-	6	1100, 1180, 1300, 1370kW
2	3	159676-53010	VALVE, NOZZLE	6	6	
3	3	150633-53240	BODY,NOZZLE	6	-	660, 754, 800kW
3	3	150633-53221	BODY,NOZZLE	6	-	880, 970, 1080kW
3	3	150633-53221	BODY,NOZZLE	-	6	880, 970, 1020kW
3	3	150633-53041	BODY,NOZZLE	-	6	1100, 1180, 1300, 1370kW
4	2	128633-11880	O-RING, SLEEVE	6	6	
5	2	151673-51381	O-RING	6	6	
6	2	146673-53080	NUT, NOZZLE	6	6	
7	2	147673-53101	HOLDER, NOZZLE	6	6	
8	2	150633-53120	SPRING,NOZZLE	6	6	
9	2	150633-53140	RETAINER,SPRING	6	6	
10	2	146673-53150	SPACER	6	6	
11	2	146673-53160	GUIDE	6	6	
12	2	146673-53170	NUT, ADJUSTING	12	12	
13	2	138613-53200	PIN, PARALLEL	24	24	
14	2	146673-53210	SEAT, SPRING	6	6	
15	2	146673-53230	SPACER	6	6	
16	2	146673-53900	O-RING P42	6	6	

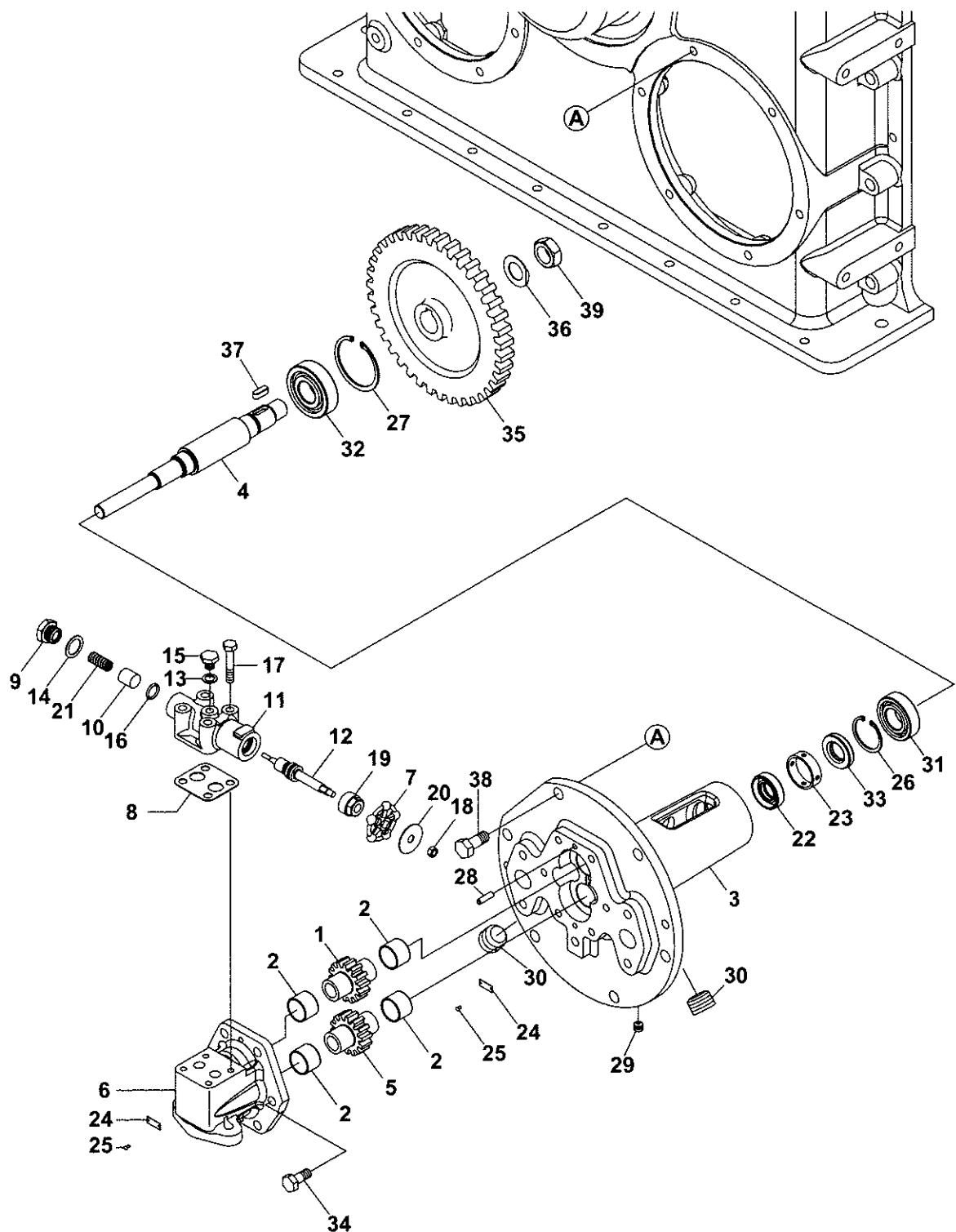


Fuel injection pipe

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150635-59050	JOINT, PRESSURE PIPE	6	6	
2	1	146673-59020	PACKING	6	6	
3	1	150633-59160	CASE NUT, INJ. PIPE	6	6	
4	1	146673-59201	FLANGE, OVAL	6	6	
5	1	151695-59220	PACKING	6	6	
6	1	146673-59240	WASHER, M10	12	12	
7	1	146673-59250	PACKING	6	6	
8	1	150635-59070	PIPE, FO INJ.	6	6	
9	1	26450-080402	BOLT, 8 X 40	12	12	
10	1	26450-100602	BOLT, 10 X 60	12	12	

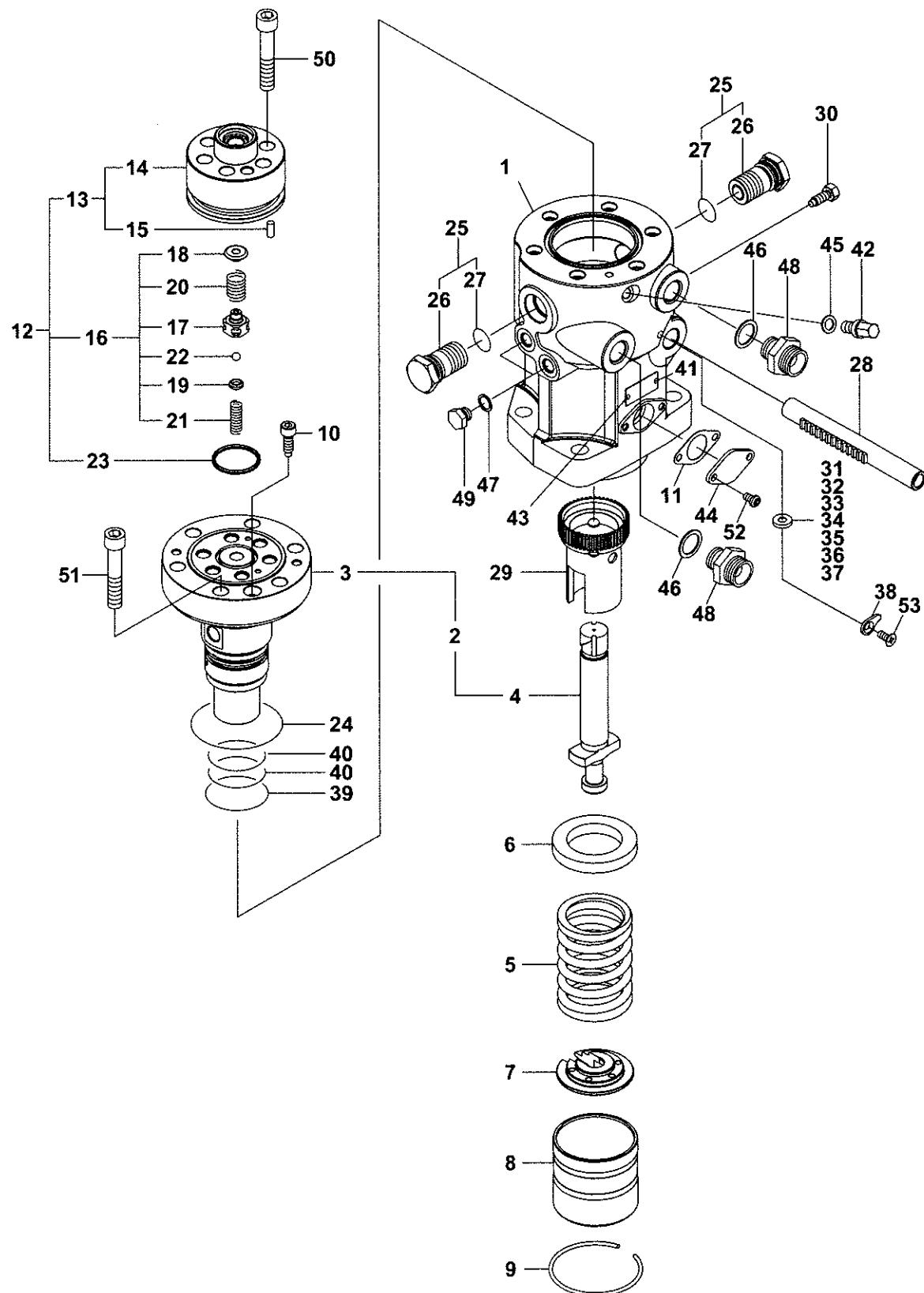


Fuel feed pump (M.D.O.) (option)

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	147873-52130	GEAR,FEED PUMP DRIVE	1	1	
2	2	151605-52140	BUSH	4	4	
3	2	150633-52210	BODY, FEED PUMP	1	1	
4	2	150633-52230	SHAFT, PUMP DRIVING	1	1	
5	2	147873-52240	GEAR,FEED PUMP DRIVE	1	1	
6	2	146623-52250	COVER, FEED PUMP	1	1	
-	2	746673-52350	VALVE ASSY , ADJUDT	1	1	
7	3	132310-34100	HANDLE	1	1	
8	3	137600-52490	PACKING	1	1	
9	3	146673-52590	PLUG, FUEL OIL	1	1	
10	3	146673-52600	VALVE, SAFETY VALVE	1	1	
11	3	139654-52901	BODY, BY-PASS VALVE	1	1	
12	3	139654-52921	ROD, VALVE	1	1	
13	3	23414-100000	GASKET, 10 X 1.0	1	1	
14	3	23414-180000	GASKET, 18 X 1.0	1	1	
15	3	23897-010002	PLUG, G 1/8	1	1	
16	3	24316-000140	PACKING, P 14.0	1	1	
17	3	26206-080452	BOLT, 8 X 45	4	4	
18	3	26716-060002	NUT, 6	1	1	
19	3	41652-000811	GLAND, PACKING	1	1	
20	3	42221-003540	LABEL	1	1	
21	3	43255-000032	SPRING, SAFETY VALVE	1	1	
22	2	141646-52660	SEAL, OIL TCN	1	1	
23	2	141646-52710	SPACER, OIL SEAL	1	1	
24	2	137903-52740	LABEL, DELIVERY	1	1	
25	2	137900-91451	RIVET, PARKERIZED	2	2	
26	2	22252-000400	RING, 40	1	1	
27	2	22252-000620	RING, 62	1	1	
28	2	22312-060200	PIN, 6 X 20	2	2	
29	2	23876-010000	PLUG, R01	1	1	
30	2	23876-060000	PLUG, R06	2	2	
31	2	24101-062054	BEARING, 6205	1	1	
32	2	24101-063054	BEARING, 6305	1	1	
33	2	24411-204007	SEAL, SC204007	1	1	
34	2	26206-100252	BOLT, 10 X 25	6	6	
35	1	150633-52100	GEAR, FEED PUMP	1	1	
36	1	122310-83410	WASHER	1	1	
37	1	22512-070200	KEY, 7 X 20	1	1	
38	1	26206-120302	BOLT, 12 X 30	6	6	
39	1	26772-200002	NUT, 20	1	1	

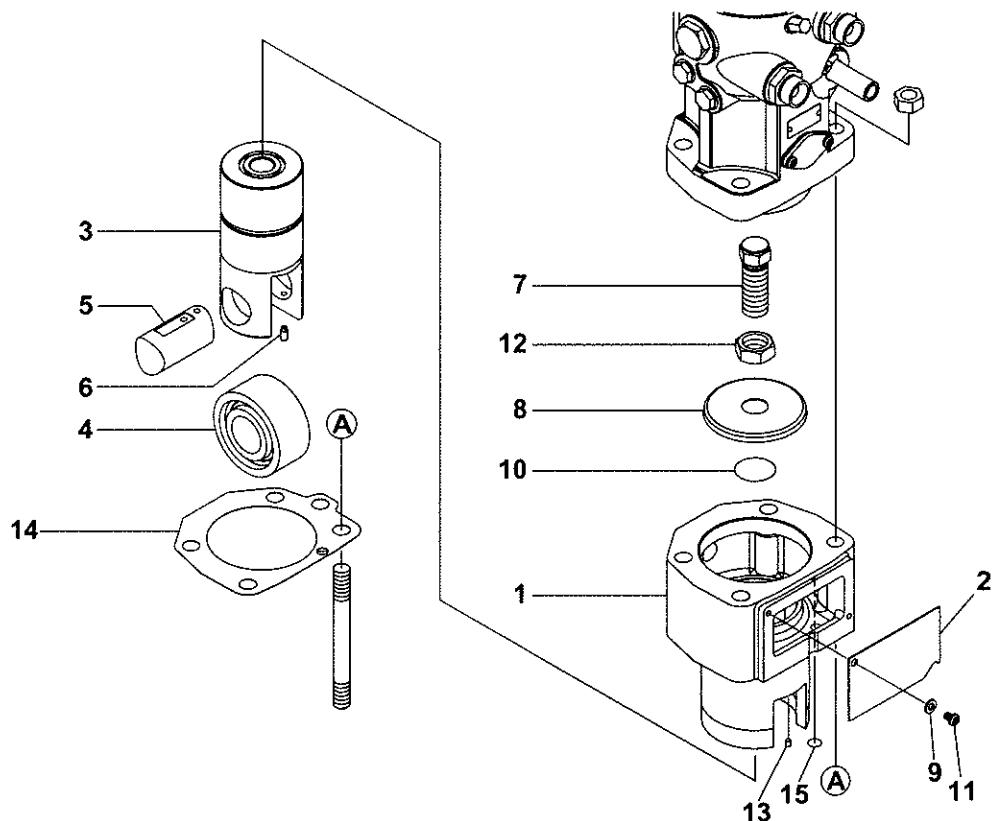


Fuel injection pump

Illustrated parts data

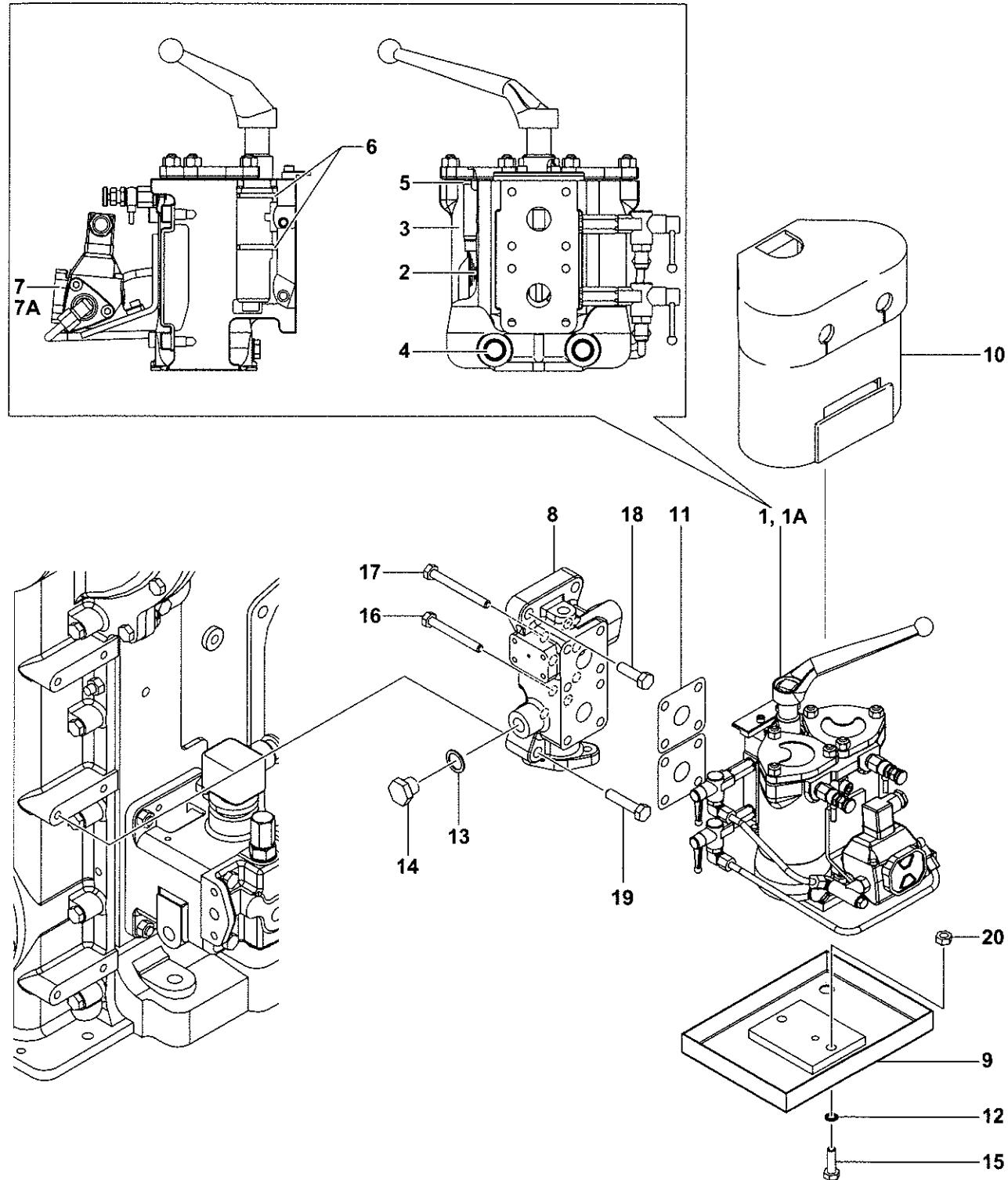
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-51010	BODY, PUMP	6	6	
2	1	150633-51600	PLUNGER ASSY	6	6	
3	2	150633-51111	BARREL	6	6	
4	2	150633-51630	PLUNGER	6	6	
5	1	150633-51170	SPRING, PLUNGER	6	6	
6	1	150633-51180	RETAINER	6	6	
7	1	153605-51191	RETAINER, SPRING	6	6	
8	1	150633-51200	GUIDE, PLUNGER	6	6	
9	1	159646-51210	CIRCLIP	6	6	
10	1	151673-51250	BOLT, BARREL	6	6	
11	1	153605-51250	GASKET	6	6	
12	1	151695-51300	VALVE ASSY, DELIVERY	6	6	
13	2	151695-51310	PARTS KIT	6	6	
14	3	151695-51320	HOLDER, DELIVERY	6	6	
15	3	22312-040120	PIN, 4 X 12	12	12	
16	2	151695-51330	VALVE ASSY, DELIVERY	6	6	
17	3	151695-51350	VALVE, DELIVERY	6	6	
18	3	151695-51360	STOPPER, DELIVERY	6	6	
19	3	151695-51370	RETAINER, SPRING	6	6	
20	3	151695-51380	SPRING, DELIVERY	6	6	
21	3	151695-51390	SPRING, RETURN VALVE	6	6	
22	3	24190-070003	BALL, 7/32	6	6	
23	2	153604-51381	RING	6	6	
24	1	153604-51401	O-RING	6	6	
25	1	150633-51380	PROTECTOR ASSY	12	12	
26	2	153604-51391	PROTECTOR	12	12	
27	2	148633-53600	O-RING	12	12	
28	1	150633-51500	RACK, CONTROL	6	6	
29	1	150633-51510	PINION	6	6	
30	1	153605-51550	BOLT	6	6	
31	1	138688-51570	SHIM SET	6	6	
32	2	138688-51580	SHIM T=0.1	6	6	
33	2	138688-51590	SHIM T=0.2	6	6	
34	2	138688-51600	SHIM T=0.3	6	6	
35	2	138688-51610	SHIM T=0.5	6	6	
36	2	138688-51620	SHIM T=0.8	6	6	
37	2	138688-51630	SHIM T=1.5	6	6	
38	1	138613-51730	POINTER	6	6	
39	1	146685-51810	O-RING	6	6	
40	1	146685-51830	O-RING	12	12	
41	1	124220-51890	RIVET	6	6	
42	1	153605-51902	BOLT, AIR VENT	6	6	
43	1	150633-51950	LABEL, FUEL OIL PUMP	6	6	
44	1	129100-52200	COVER	6	6	
45	1	22190-100006	WASHER, SEAL 10	6	6	
46	1	22190-200006	WASHER, SEAL 20	12	12	
47	1	23414-120016	GASKET, 12 X 1.0	12	12	
48	1	23831-150000	UNION, 15	12	12	
49	1	23887-120002	PLUG, 12	12	12	
50	1	26450-120602	BOLT, 12 X 60	36	36	
51	1	26450-120602	BOLT, 12 X 60	36	36	
52	1	26557-060102	SCREW, 6 X 10	12	12	
53	1	26577-060142	SCREW, 6 X 14	6	6	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-54011	BRACKET, FUEL PUMP	6	6	
2	2	146673-54030	COVER, PUMP MOUNT	6	6	
-	2	-	TAPPET ASSY	6	6	
3	3	150633-54101	TAPPET, FOP	6	6	
4	3	150633-54110	ROLLER, TAPPET	6	6	
5	3	150633-54120	PIN, TAPPET ROLLER	6	6	
6	3	138613-54270	SCREW	6	6	
7	2	151605-54200	SCREW, TAPPET ADJUST	6	6	
8	2	150633-54231	SEALING, OIL TAPPET	6	6	
9	2	22137-060000	WASHER, 6	12	12	
10	2	24321-000350	PACKING, G 35.0	6	6	
11	2	26557-060082	SCREW, 6 X 8	12	12	
12	2	26782-220002	NUT, 22	6	6	
13	2	27221-040050	PLUG, 4 X 5	24	24	
14	1	150633-54050	PACKING, FOP MOUNT	6	6	
15	1	24311-000110	PACKING, P 11.0	6	6	

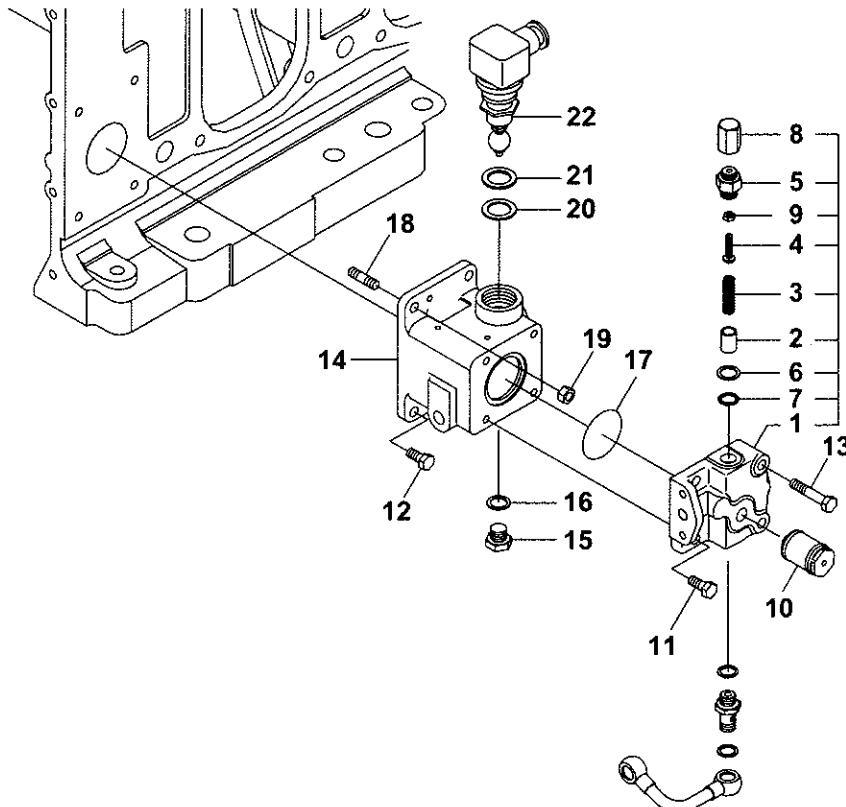


Fuel strainer

Illustrated parts data

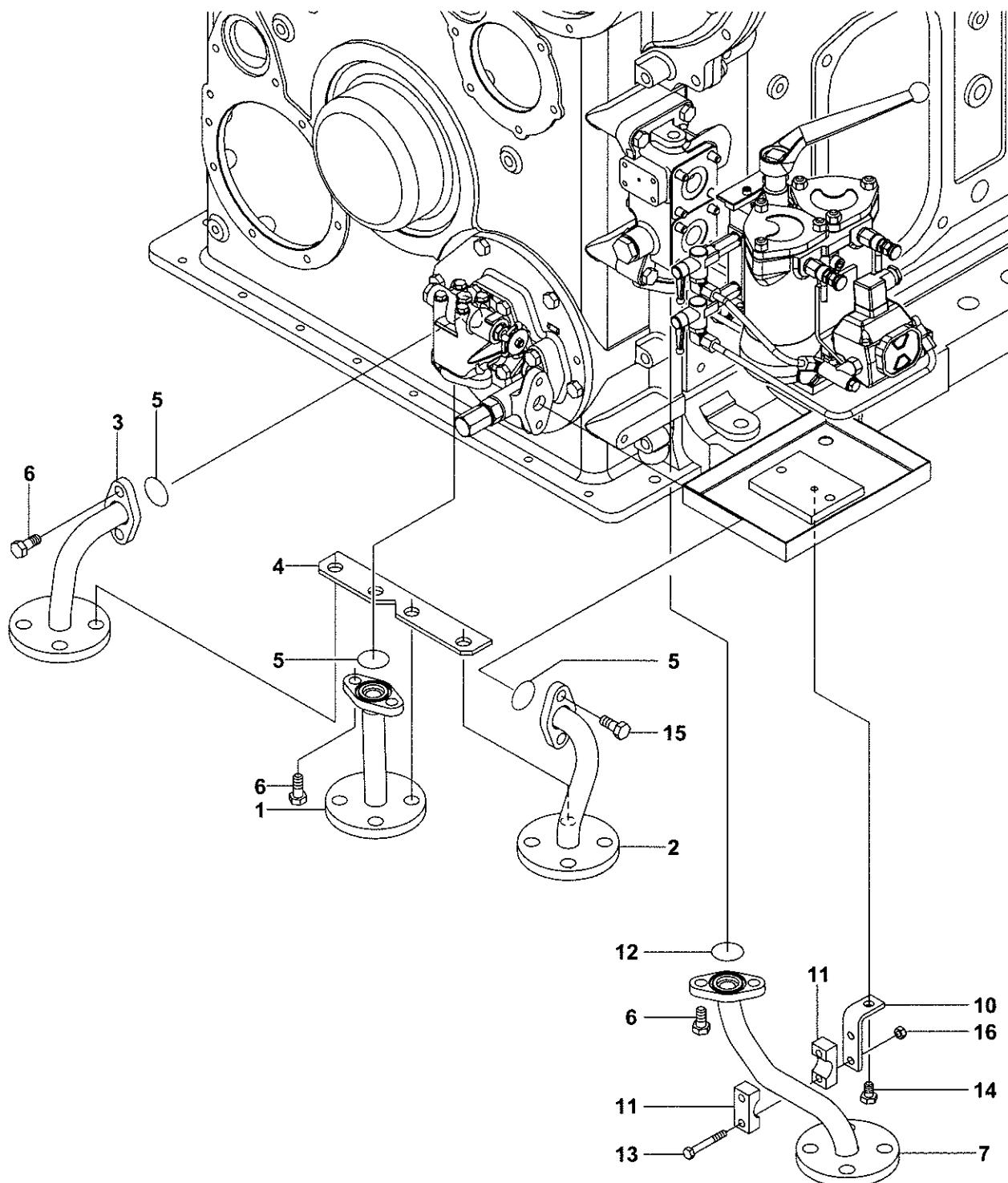
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-55120	STRAINER,HFO	1	1	
1A	1	150633-55130	STRAINER,HFO	1	1	With alarm
2	2	151695-55010	ELEMENT(FO FILTER	2	2	
3	2	151695-55020	BODY(FO FILTER,B&K	1	1	
4	2	151695-55040	GASKET,FILTER B&K	2	2	
5	2	151695-55070	O-RING,FILTER B&K	2	2	
6	2	151695-55080	O-RING,FILTER B&K	2	2	
7	2	42130-018470	DIFFERENTIAL PRSS.	1	1	
7A	2	42130-018460	DIFFERENTIAL PRSS.	1	1	With alarm
8	1	150633-55201	BRACKET(HFO FILTER)	1	1	
9	1	150633-55210	OIL PAN(HFO FILTER)	1	1	
10	1	150633-55800	COVER(HFO FILTER	1	1	
11	1	151695-59690	PACKING, FLANGE	2	2	
12	1	153672-59910	WASHER, SEAL 10	2	2	
13	1	153672-59950	WASHER, SEAL D=22	1	1	
14	1	23897-040002	PLUG, G 1/2	1	1	
15	1	26206-100352	BOLT, 10 X 35	2	2	
16	1	26206-100852	BOLT, 10 X 85	4	4	
17	1	26206-100952	BOLT, 10 X 95	4	4	
18	1	26206-120402	BOLT, 12 X 40	2	2	
19	1	26206-120552	BOLT, 12 X 55	2	2	
20	1	26706-100002	NUT, 10	2	2	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	746623-59330	VALVE ASSY, CONTROL C	1	1	380mm ² /s, 700mm ² /s
-	1	746623-59340	VALVE ASSY, PRESS.	1	1	180mm ² /s, Mono-fuel
1	2	146623-59740	BODY, CONTROL VALVE	1	1	
2	2	141646-59940	VALVE	1	1	hole size : ø 1.5
3	2	41660-003020	SPRING	1	1	380mm ² /s, 700mm ² /s
3A	2	137670-66540	SPRING	1	1	180mm ² /s, Mono-fuel
4	2	135410-84281	ADJUST SCREW	1	1	
5	2	141644-59860	RETAINER, VALVE	1	1	
6	2	153672-59950	SEAL WASHER 22S.<F>	1	1	
7	2	153672-59970	SEAL WASHER 20S.<F>	1	1	
8	2	135410-84301	CAP NUT	1	1	
9	2	26796-080002	LOCK NUT M 8	1	1	
10	1	146676-59330	ACCUMULATOR, FUEL	1	1	
-	1	23887-200002	PLUG 20, HEX.	1	1	Without accumulator
-	1	153672-59970	WASHER, SEAL 20X1.2	1	1	Without accumulator
11	1	26206-120302	BOLT M12X 30	2	2	
12	1	26206-120282	BOLT M12X 28 PLATED	2	2	
13	1	26206-120652	BOLT M12X 65 PLATED	2	2	
14	1	146623-59130	FO LEAK TANK	1	1	
15	1	23897-040002	PLUG G1/2,HEX.	1	1	
16	1	153672-59950	SEAL WASHER 22S.<F>	1	1	
17	1	24326-000700	O-RING 70	1	1	
18	1	26216-120302	STUD M12X 30 PLATED	4	4	
19	1	26706-120002	NUT M12	2	2	
20	1	43230-014360	GASKET,FLOAT SWITCH	1	1	
21	1	43230-014440	WASHER,FLOAT SWITCH	1	1	
22	1	46111-018771	FLOAT SWITCH	1	1	

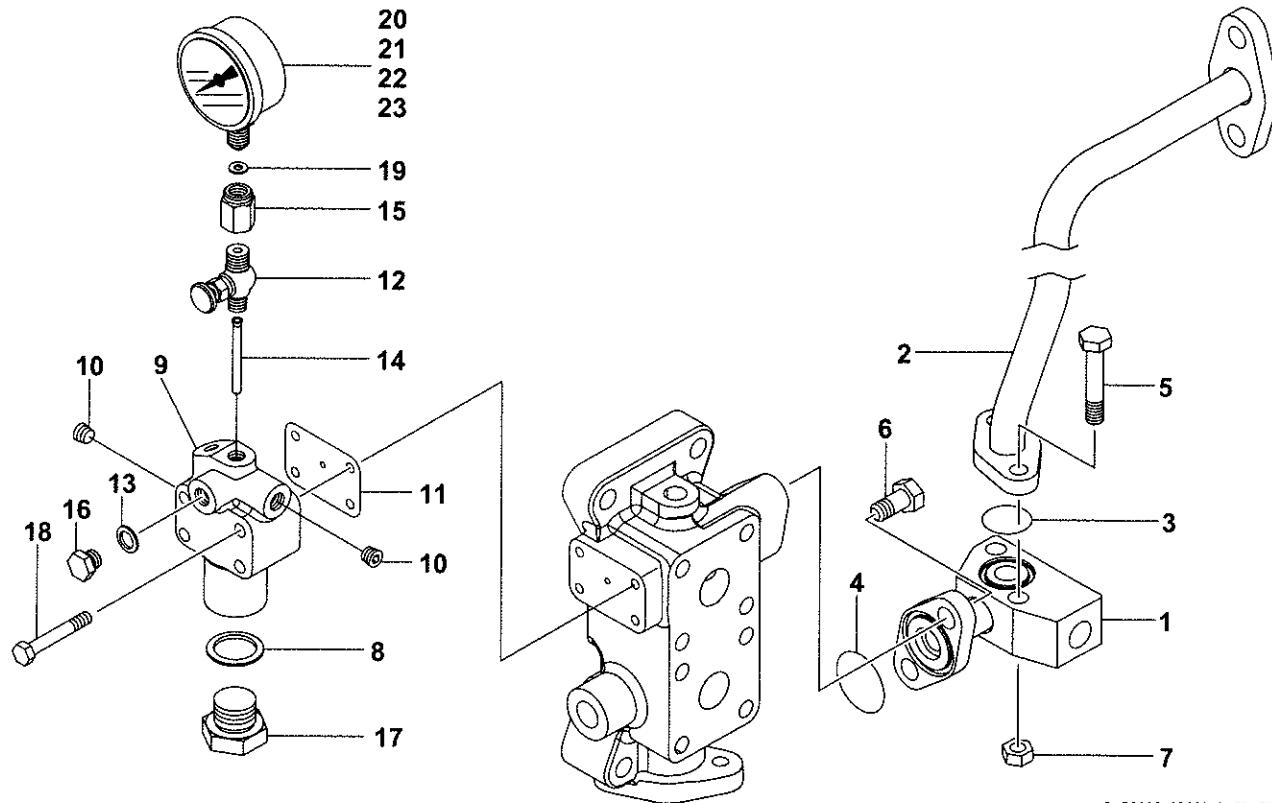


Fuel pipe (feed pump inlet / outlet) (option)

Illustrated parts data

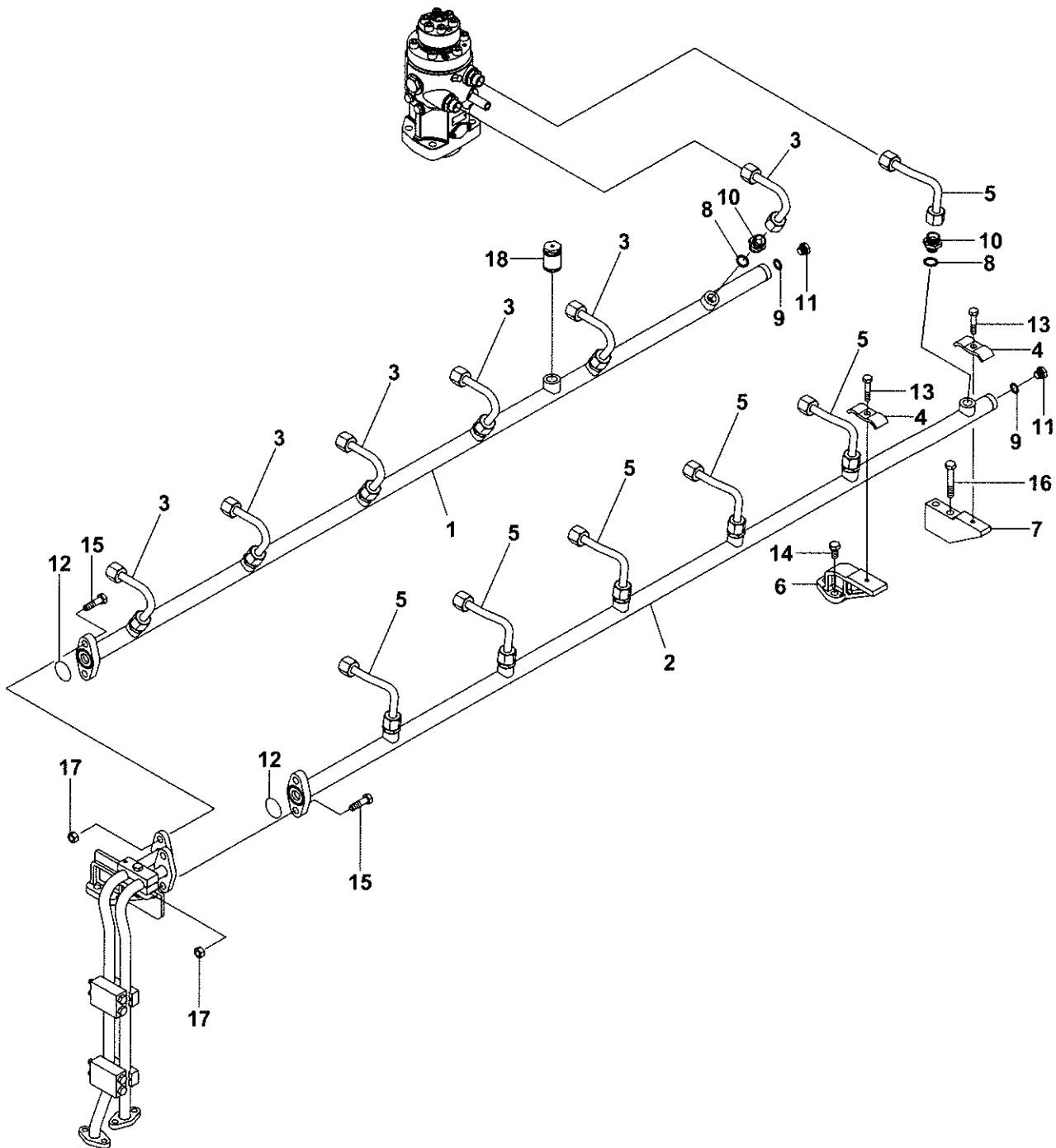
2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-59370	PIPE,FO (FOFP OUT)	1	1	
2	1	146623-59380	PIPE,FO (BYPASS OUT)	1	1	
3	1	146623-59420	PIPE,FO (FOFP IN)	1	1	
4	1	146623-59570	SUPPORT (FO PIPE)	1	1	
5	1	24326-000400	PACKING, G 40.0	3	3	
6	1	26206-120302	BOLT, 12 X 30	6	6	
7	1	150633-59370	PIPE,FO FILTER IN	1	1	
8	2	146673-59470	FLANGE, OVAL	1	1	
9	2	23231-025027	FLANGE, 25	1	1	
10	1	150633-59480	BRACKET,FO PIPE	1	1	
11	1	151674-59980	CLAMP, RETURN PIPE	2	2	
12	1	24326-000400	PACKING, G 40.0	1	1	
13	1	26206-080602	BOLT, 8 X 60	2	2	
14	1	26206-100182	BOLT, 10 X 18	1	1	
15	1	26206-120252	BOLT, 12 X 25	2	2	
16	1	26706-080002	NUT, 8	2	2	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150635-59110	PIPE,A FO TO MAIN	1	1	
2	1	150635-59120	PIPE,B FO TO MAIN	1	1	
3	1	24326-000300	PACKING, G 30.0	1	1	
4	1	24326-000400	PACKING, G 40.0	1	1	
5	1	26206-100602	BOLT, 10 X 60	2	2	
6	1	26206-120252	BOLT, 12 X 25	2	2	
7	1	26706-100002	NUT, 10	2	2	
8	1	153672-59850	WASHER, SEAL 27	1	1	
9	1	146673-59881	BODY, SEAL POT	1	1	
10	2	23875-010000	PLUG, R01	2	2	
11	1	146673-59890	GASKET, SEAL POT	1	1	
12	1	146625-59910	VALVE,PRESSURE	1	1	
13	1	153672-59920	WASHER, SEAL 12X1.2	2	2	
14	1	146673-59980	PIPE, INNER	1	1	
15	1	139653-91170	CONNECTOR	1	1	
16	1	23887-120002	PLUG, 12	2	2	
17	1	23897-060002	PLUG, G 3/4	1	1	
18	1	26206-080552	BOLT, 8 X 55	4	4	
19	1	43400-005640	GASKET, T=1.0 G1/4	2	2	
20	1	42130-017181	GAUGE, PRESS.1.0MPA	1	1	
21	1	42130-017201	GAUGE, PRESS.2.0MPA	1	1	
22	1	42130-017231	GAUGE, PRESS.2.0MPA	1	1	
23	1	42130-017321	GAUGE, PRESS.2.0MPA	1	1	

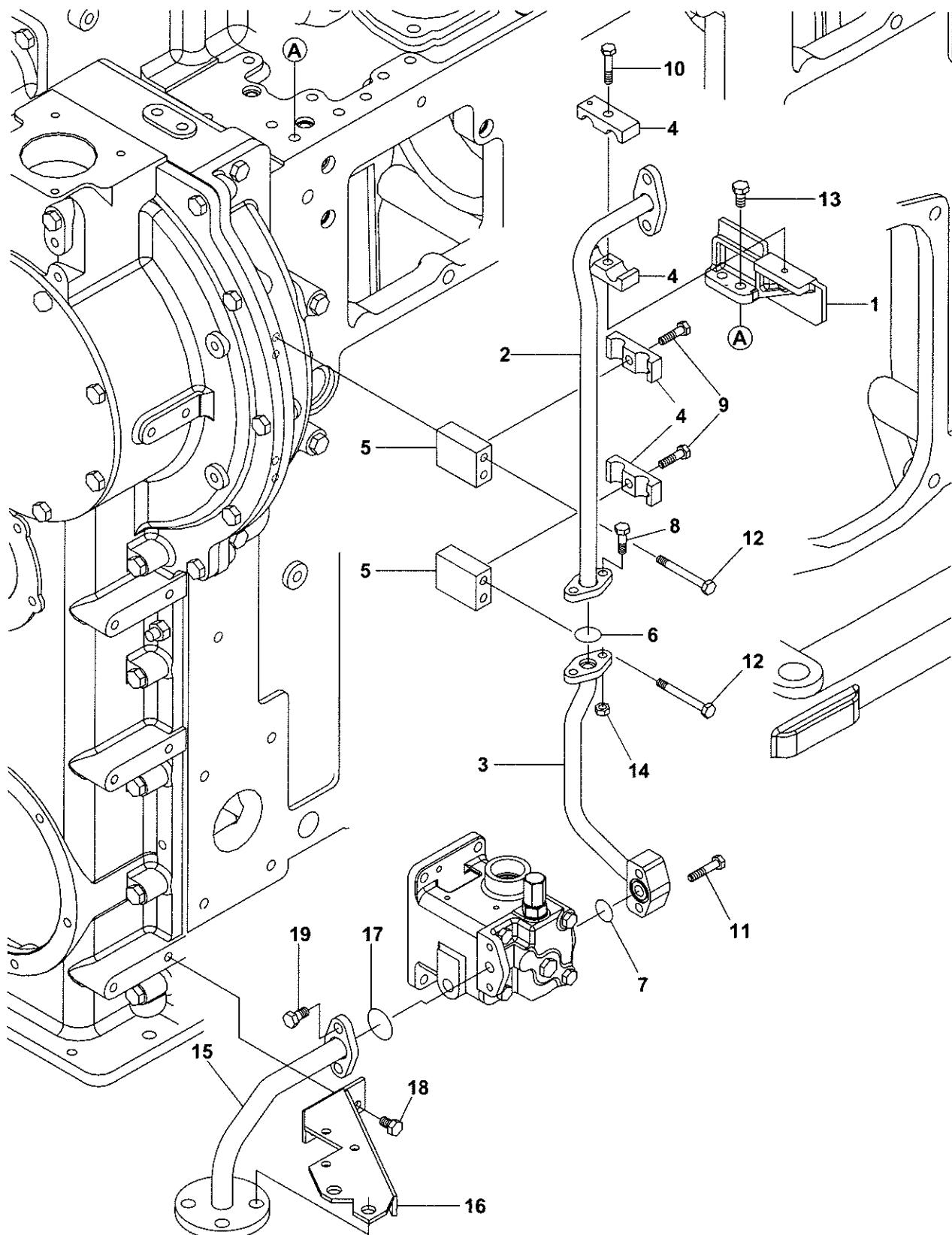


Fuel main pipe

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-59040	PIPE, FUEL OIL MAIN	1	1	Mono-fuel
1A	1	150633-59050	PIPE, FUEL OIL MAIN	1	1	
2	1	150633-59150	PIPE, FUEL RETURN	1	1	
3	1	150633-59170	PIPE, FUEL OIL	6	6	
4	1	147676-59181	SUPPORT, 34X2	6	6	
5	1	150633-59180	PIPE, FUEL OIL	6	6	
6	1	150633-59200	SUPPORT, MAIN PIPE	5	5	
7	1	150633-59220	SUPPORT, MAIN PIPE	1	1	
8	1	153672-59970	WASHER, SEAL 20X1.2	12	12	
9	1	153672-59980	WASHER, SEAL 16X1.2	2	2	
10	1	23831-150000	UNION, 15	12	12	
11	1	23887-160002	PLUG, 16	2	2	
12	1	24326-000400	PACKING, G 40.0	2	2	
13	1	26206-100502	BOLT, 10 X 50	6	6	
14	1	26206-120252	BOLT, 12 X 25	15	15	
15	1	26206-120452	BOLT, 12 X 45	4	4	
16	1	26206-120752	BOLT, 12 X 75	2	2	
17	1	26706-120002	NUT, 12	4	4	
18	1	146676-59330	ACCUMULATOR, FUEL	1	1	Mono-fuel



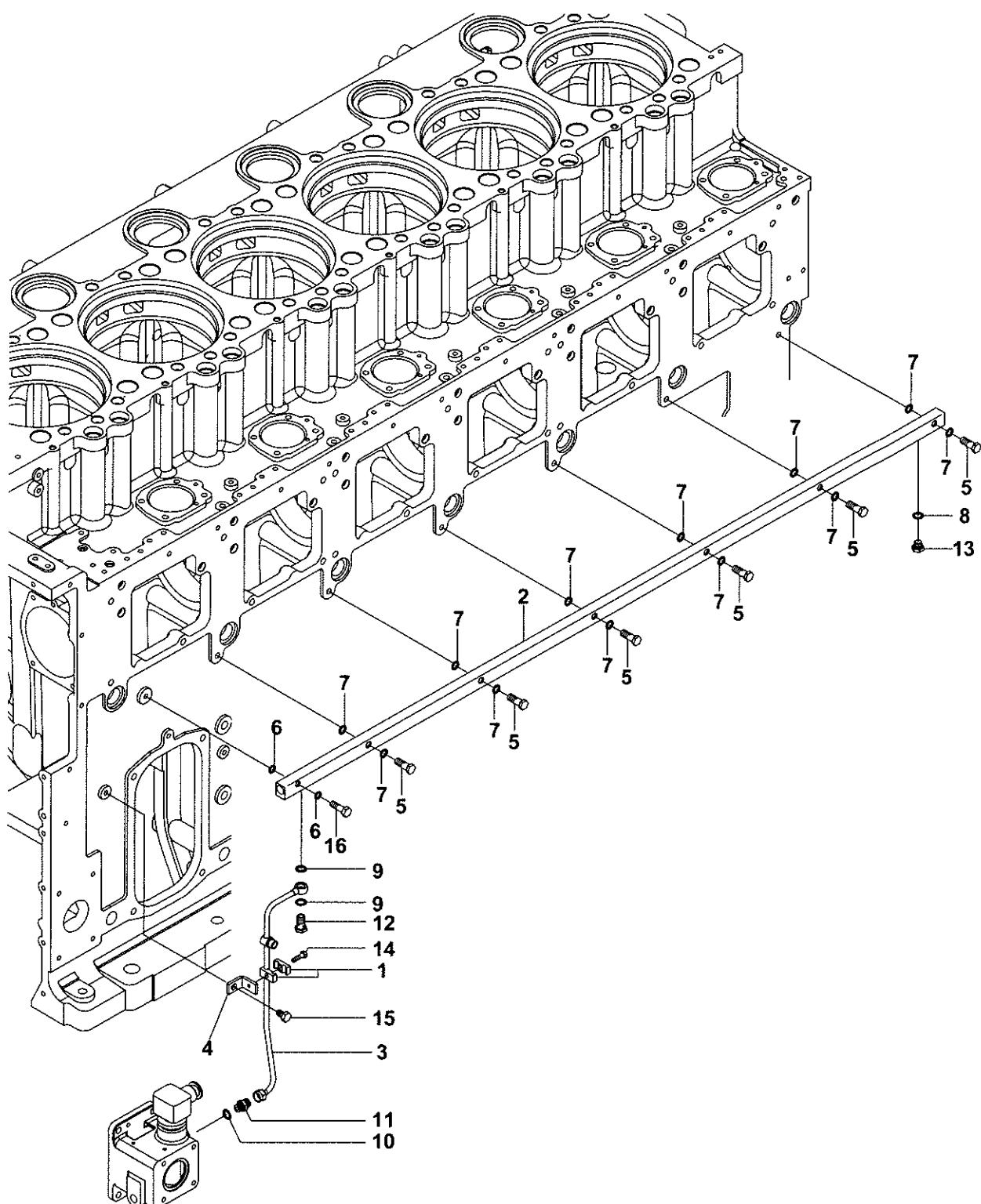
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Fuel pipe (main pipe to pressure control valve)

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-59240	SUPPORT, MAIN PIPE	1	1	
2	1	150633-59441	PIPE,FO MAIN TO PCV	1	1	
3	1	150633-59451	PIPE,FO MAIN TO PCV	1	1	
4	1	150633-59920	SUPPORT,21.7X2	4	4	
5	1	150633-59930	BRACKET,FO PIPE	2	2	
6	1	24326-000300	PACKING, G 30.0	1	1	
7	1	24326-000300	PACKING, G 30.0	1	1	
8	1	26206-100352	BOLT, 10 X 35	2	2	
9	1	26206-100402	BOLT, 10 X 40	2	2	
10	1	26206-100502	BOLT, 10 X 50	1	1	
11	1	26206-100502	BOLT, 10 X 50	2	2	
12	1	26206-100902	BOLT, 10 X 90	4	4	
13	1	26206-120252	BOLT, 12 X 25	2	2	
14	1	26706-100002	NUT, 10	2	2	
15	1	150633-59460	PIPE,FO PCV OUT	1	1	
16	1	150633-59470	BRACKET,FO OUTLET	1	1	
17	1	24326-000400	PACKING, G 40.0	1	1	
18	1	26206-120202	BOLT, 12 X 20	2	2	
19	1	26206-120252	BOLT, 12 X 25	2	2	

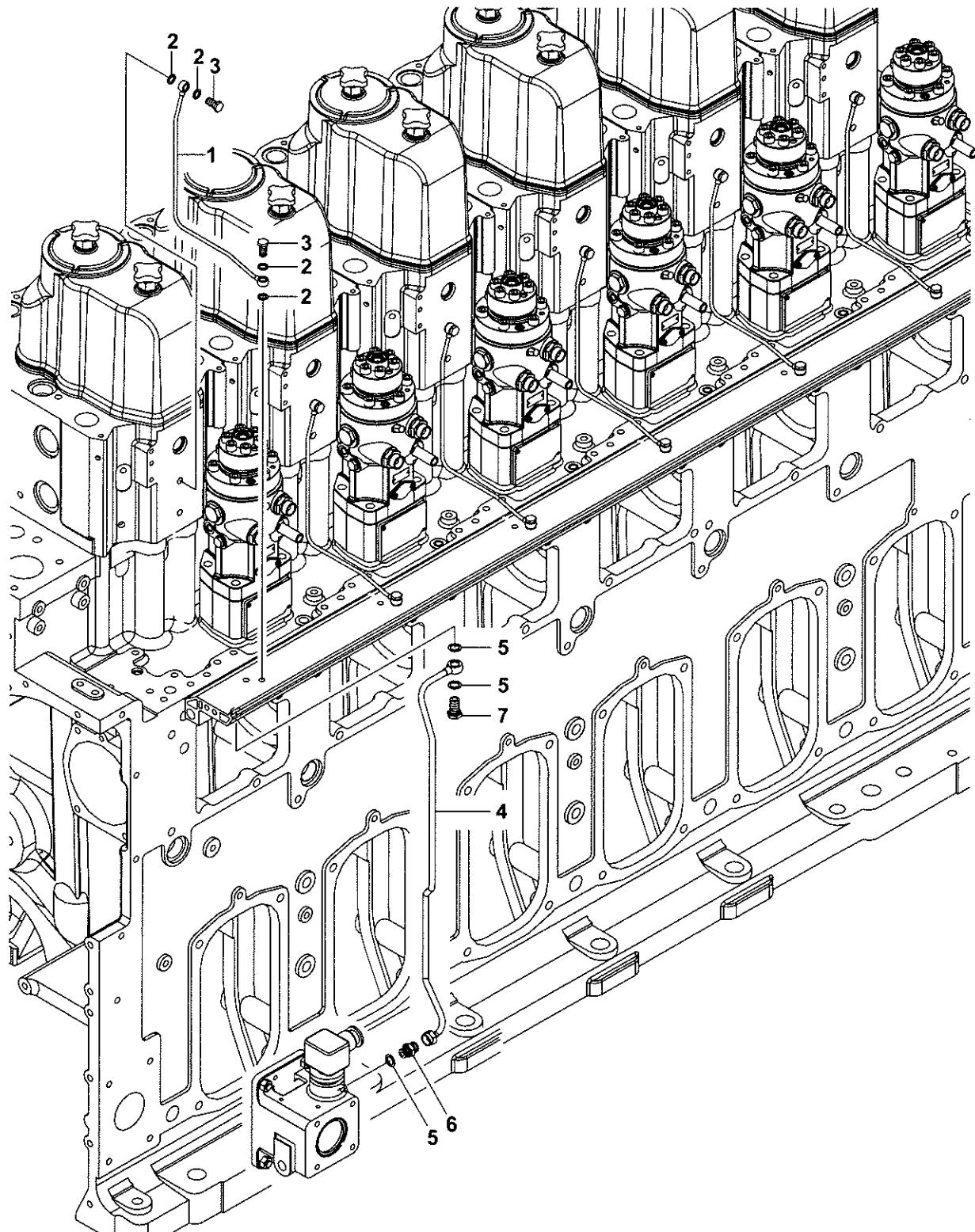


Overflow fuel oil pipe (cylinder)

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	152672-59560	SUPPORT, 10	2	2	
2	1	150633-59700	PIPE,FO OVER FLOW	1	1	
3	1	150633-59720	PIPE,FO OVER FLOW	1	1	
4	1	150633-59730	BRACKET,FO PIPE	1	1	
5	1	141646-59860	BOLT, PIPE JOINT	6	6	
6	1	153672-59920	WASHER, SEAL 12X1.2	2	2	
7	1	153672-59930	WASHER, SEAL 14	12	12	
8	1	153672-59980	WASHER, SEAL 16X1.2	2	2	
9	1	153672-59980	WASHER, SEAL 16X1.2	1	1	
10	1	153672-59980	WASHER, SEAL 16X1.2	1	1	
11	1	23831-100000	UNION, 10	1	1	
12	1	23857-100000	BOLT, JOINT 10	1	1	
13	1	23887-160002	PLUG, 16	1	1	
14	1	26206-080302	BOLT, 8 X 30	1	1	
15	1	26206-120202	BOLT, 12 X 20	1	1	
16	1	26206-120402	BOLT, 12 X 40	1	1	

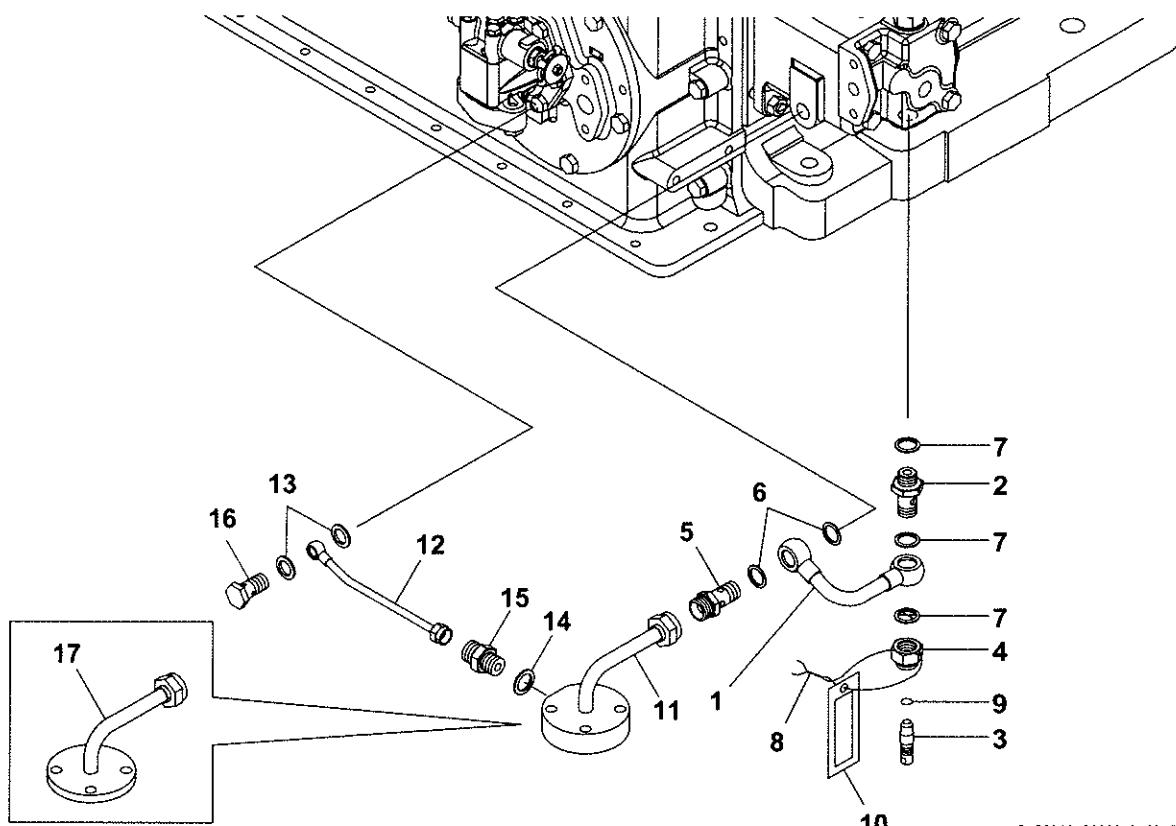


Fuel leak deflection pipe

Illustrated parts data

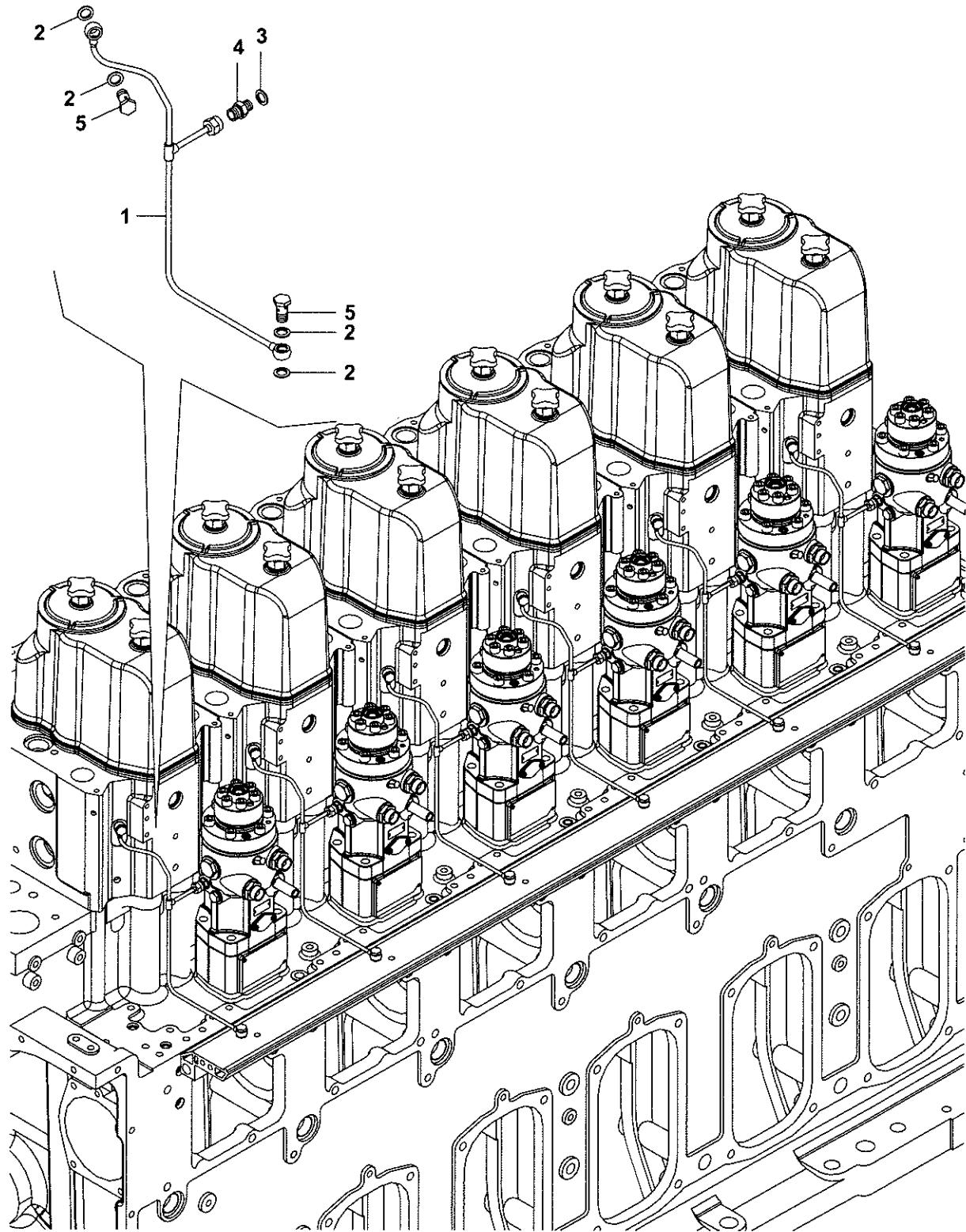
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-59800	PIPE,FO OVER FLOW	6	6	
2	1	153672-59920	WASHER, SEAL 12X1.2	24	24	
3	1	23857-060000	BOLT, JOINT 6	12	12	
4	1	150633-59810	PIPE,FO OVER FLOW	1	1	
5	1	153672-59980	WASHER, SEAL 16X1.2	3	3	
6	1	23831-100000	UNION, 10	1	1	
7	1	23857-100000	BOLT, JOINT 10	1	1	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-59750	PIPE, FUEL DRAIN	1	1	
2	1	141646-59650	BODY, DRAIN COCK	1	1	
3	1	141646-59660	ROD, DRAIN COCK	1	1	
4	1	141646-59670	NUT, CAP	1	1	
5	1	146623-59700	JOINT,2WAY	1	1	
6	1	153672-59970	WASHER, SEAL 20X1.2	2	2	
7	1	153672-59970	WASHER, SEAL 20X1.2	3	3	
8	1	22451-060000	WIRE, 0.6	1	1	
9	1	24316-000100	PACKING, P 10.0	1	1	
10	1	42221-012780	LABEL	1	1	
11	1	150633-59520	PIPE,FO OVER FLOW	1	1	
12	1	150633-59690	PIPE,FO OVER FLOW	1	1	
13	1	153672-59920	WASHER, SEAL 12X1.2	2	2	
14	1	153672-59930	WASHER, SEAL 14	1	1	
15	1	23831-080000	UNION, 8	1	1	
16	1	23857-060000	BOLT, JOINT 6	1	1	
17	1	150633-59540	PIPE,FO OVER FLOW	1	1	Without Fuel Feed Pump

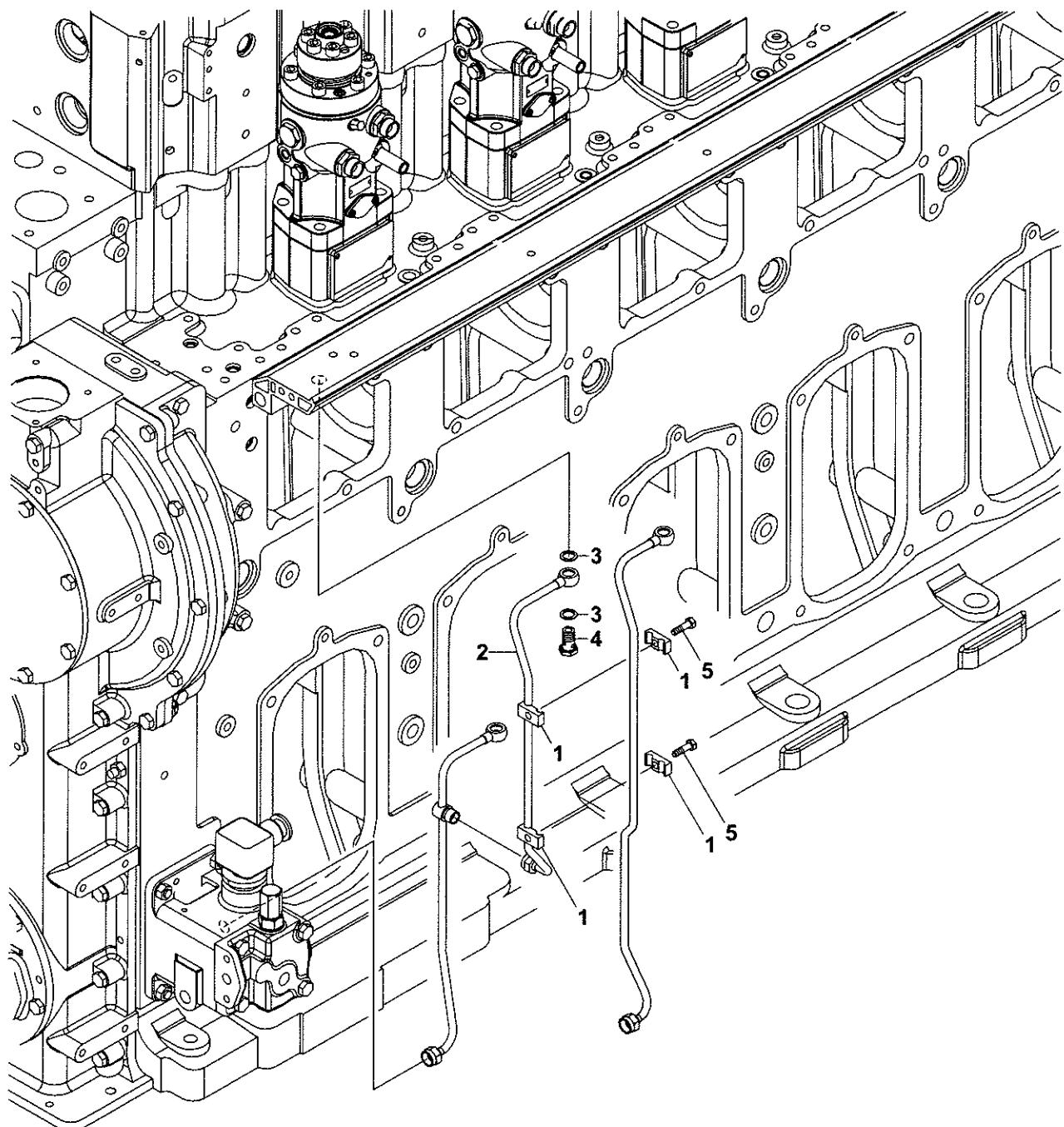


Fuel valve overflow fuel oil pipe (head OUT)

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-59600	PIPE.FO OVER FLOW	6	6	
2	1	153672-59920	WASHER, SEAL 12X1.2	24	24	
3	1	153672-59920	WASHER, SEAL 12X1.2	6	6	
4	1	23831-060000	UNION, 6	6	6	
5	1	23857-060000	BOLT, JOINT 6	12	12	

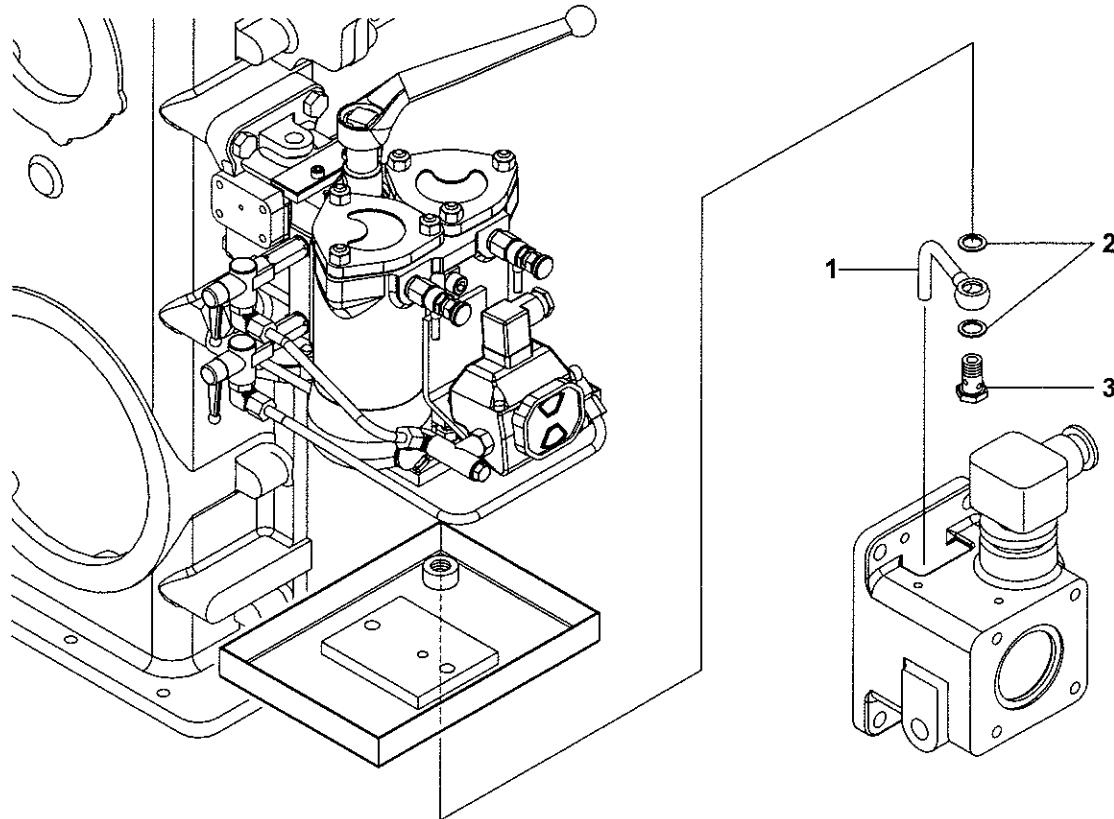


Fuel valve overflow fuel oil pipe

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	152672-59560	SUPPORT, 10	4	4	
2	1	150633-59650	PIPE, FO OVER FLOW	1	1	
3	1	153672-59980	WASHER, SEAL 16X1.2	2	2	
4	1	23857-100000	BOLT, JOINT 10	1	1	
5	1	26206-080302	BOLT, 8 X 30	2	2	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-59551	PIPE,FO OVER FLOW	1	1	
2	1	153672-59980	WASHER, SEAL 16X1.2	2	2	
3	1	23857-100000	BOLT, JOINT 10	1	1	

Governor (NZ)

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
EQUIPMENT		Nomenclature	Identification code		Quantity

SUPPLIES	Nomenclature	Identification code	Quantity
SPARES	Nomenclature	Identification code	Quantity

SAFETY

The all-speed YANMAR NZ hydraulic governor is on the opposite side of the flywheel. It has a compact design with an internal hydraulic fluid system and no piping or subtank.

For details about the design, operation, assembly and disassembly, and adjustment, please refer to the NZ HYDRAULIC GOVERNOR SERVICE MANUAL.

CONDITION

Governor (NZ)

Replacement (governor oil)

1/1

PRODUCTION MANAGEMENT DATA

Intervals 6 months
2000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h

EQUIPMENT	Nomenclature	Identification code	Quantity

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity

SAFETY	

Refer to the NZ HYDRAULIC GOVERNOR SERVICE MANUAL when you do replacement of the governor oil.

CONDITION	

Governor (UG-8)

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h

EQUIPMENT

SUPPLIES	Nomenclature	Identification code	Quantity
SPARES	Nomenclature	Identification code	Quantity

SAFETY

This engine has an optional all-speed Woodward UG-8 hydraulic governor. It has a compact design with an internal hydraulic fluid system and no piping or subtank.

For details about the design, operation, assembly and disassembly, and adjustment, please refer to the UG-8 HYDRAULIC GOVERNOR SERVICE MANUAL.

CONDITION

Governor (UG-8)

Replacement (governor oil)

1/1

PRODUCTION MANAGEMENT DATA

Intervals 6 months
2000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h

EQUIPMENT	Nomenclature	Identification code	Quantity

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity

SAFETY	

Refer to the UG-8 HYDRAULIC GOVERNOR SERVICE MANUAL when you do replacement of the governor oil.

CONDITION	

Governor (UG-25+)

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
EQUIPMENT		Nomenclature	Identification code		Quantity

SUPPLIES	Nomenclature	Identification code	Quantity
SPARES	Nomenclature	Identification code	Quantity

SAFETY

This engine has an optional Woodward UG-25⁺ microprocessor controlled mechanical hydraulic governor. It has a compact design with an internal hydraulic fluid system and no piping or subtank.

For design and operation of the governor, refer to the separate UG-25⁺ governor installation and operation manual (26330).

Obey the operation manual (26330) when you do inspection and maintenance of the governor.

CONDITION

Governor (UG-25+)

Replacement (governor oil)

1/1

PRODUCTION MANAGEMENT DATA

Intervals 6 months
2000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h

EQUIPMENT

	Nomenclature	Identification code	Quantity

SUPPLIES

	Nomenclature	Identification code	Quantity

SPARES

	Nomenclature	Identification code	Quantity

SAFETY

For design and operation of the governor, refer to the separate UG-25⁺ governor installation and operation manual (26330).

Obey the operation manual (26330) when you do replacement of the governor oil.

CONDITION

- The governor drive unit is installed on the opposite side of the flywheel. It is driven by the camshaft gear and the bevel gear.
- The governor is driven through the spline coupling of the drive unit.

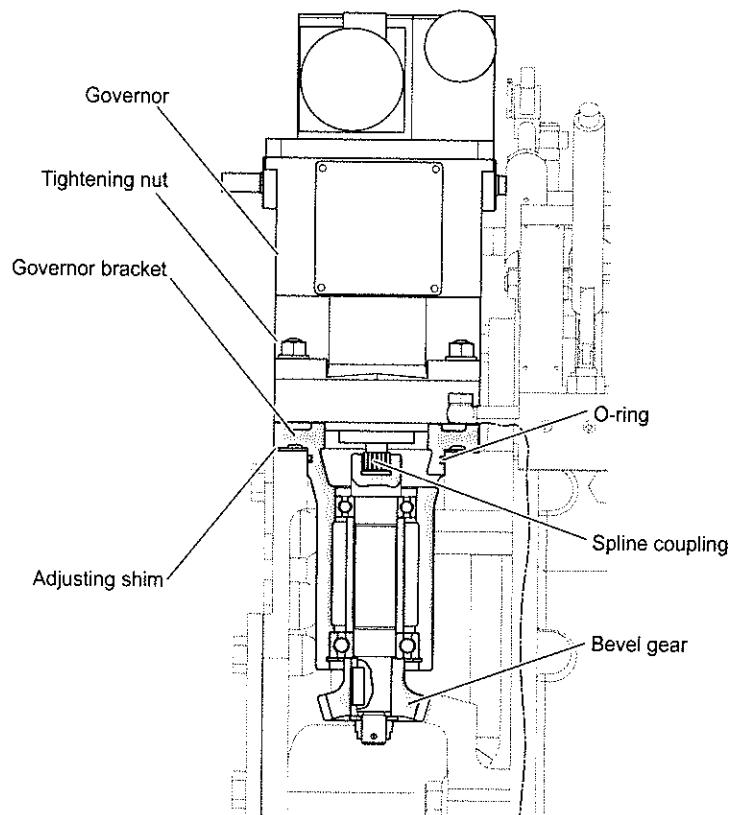


Fig.1 Governor drive unit - Description of function

Governor drive unit

Inspection and maintenance

1/3

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION	Remove the governor before you disassemble the governor drive unit. Before you remove the governor, make a record of the speed fluctuation and the condition of each adjusting point.				
	<ul style="list-style-type: none"> - Speed variation - Droop adjuster reading - Needle valve opening 				
PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	2.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
	Shim (0.1 mm)		148016-66210		1 pc
	Shim (0.3 mm)		148016-66220		1 pc
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY	O-ring		24321-0000750		1 pc

Obey the instructions that follow when you do maintenance of the governor drive unit.

1. Disassembly

1. To remove the drive unit, pull it straight up with the bearing and the governor drive gear installed.
 2. Put the drive gear on a safe workbench.
 3. Remove the cotter pin 6.
 4. Remove the gear tightening nut 5 together with the washer 4.
 5. Remove the governor driving gear 3.
 6. Remove the key 2.
- If you do not replace the key, leave it as it is.
7. Remove the circlip 1 with the circlip pliers.
 8. Remove the governor drive shaft 10 together with the washer 8 and the ball bearings 7, 9 toward the gear side.

NOTICE

When you remove the governor, make sure that you do not hit other parts (e.g. the gear shaft, terminal shaft, speed control shaft).

Remove the governor vertically and be careful not to damage the spline of the gear shaft.

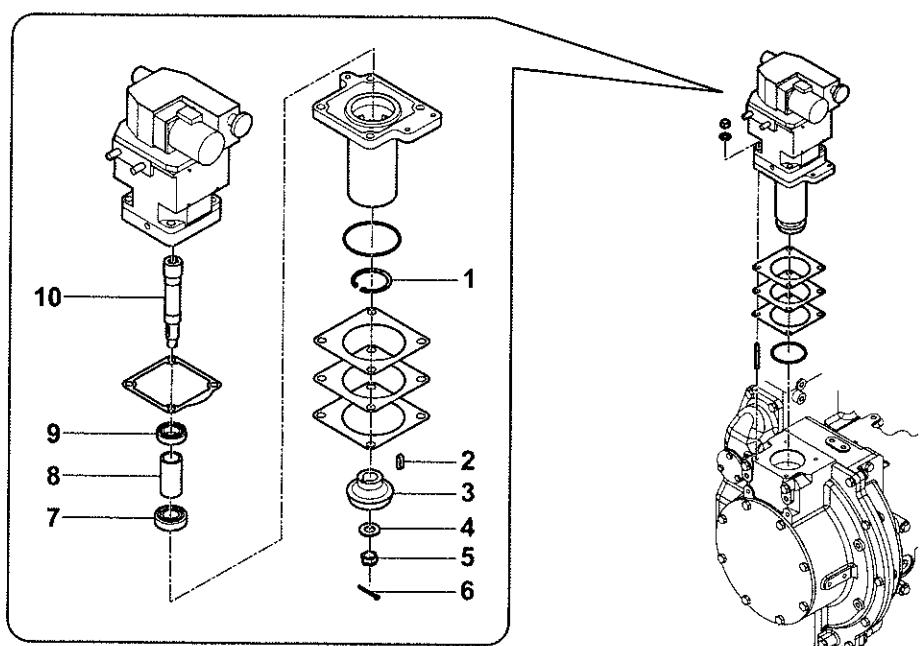


Fig. 1 Governor drive unit

2. Inspection

1. Make sure that the tooth of the bevel gear makes good contact.
2. Examine the spline of the driving shaft for good contact and stepped wear.
3. Put the spline coupling in the gear shaft of the governor.
4. Make sure that it moves smoothly (no rattles).
5. Replace the ball bearing every 8000 to 10000 hours, even if the appearance is good.

3. Assembly

1. Install the bearings and the spacer to the driving shaft. Install the assembly on the governor bracket.
2. Lock the bearings in the correct direction with the circlip.
3. Fit the driving gear together with the key to the driving shaft.
4. Install the washer.
5. Tighten the nut.
6. Install a cotter pin to prevent turning.
7. Replace the O-ring with a new one.
8. Install the drive unit to the gear case.
9. Measure the backlash of the bevel gear on the camshaft side and the governor drive gear.

To adjust the backlash, change the thickness of the adjusting shim under the governor bracket.

Find your specification and the correct shim thickness:

148016-66210: 0.1 mm

148016-66220: 0.3 mm

Thicker adjusting shim: increase backlash

Thinner adjusting shim: decrease backlash

NOTICE

- When you install the ball bearings and the spacer to the driving shaft, apply load to the inner race of the bearings and press-fit them.
- For installing the governor, put the governor into the spline of the driving shaft. Let it sink in by its own weight, do not force it in.

CONDITION Assembly adjustment values/Clearance and wear limits of major parts 0000-000-07

- The speed control device of the governor has these parts:
 - No. 1 lever: transmits any change in the injection quantity to the fuel injection pump
 - No. 1 lever shaft: connects the no. 1 lever of all cylinders
 - Linkage system (e.g. the connector): connects to the governor.
 - An incorrect coupling of the governor and fuel injection pump can cause these malfunctions:
 - Incorrect speed regulation
 - Engine cannot be stopped
 - Unusual increase in engine speed.
- Carefully examine and adjust the coupling after you:
- Replace or do maintenance in the governor.
 - Replace or do maintenance on the fuel injection pump.

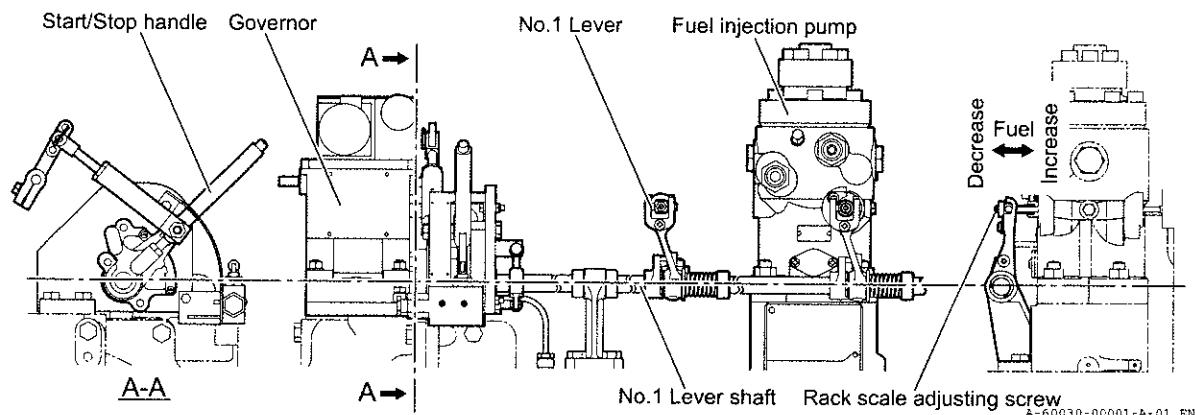


Fig.1 Speed control device - Description of function

Speed control device (NZ)

Adjust

1/2

PRODUCTION MANAGEMENT DATA

Intervals Unscheduled

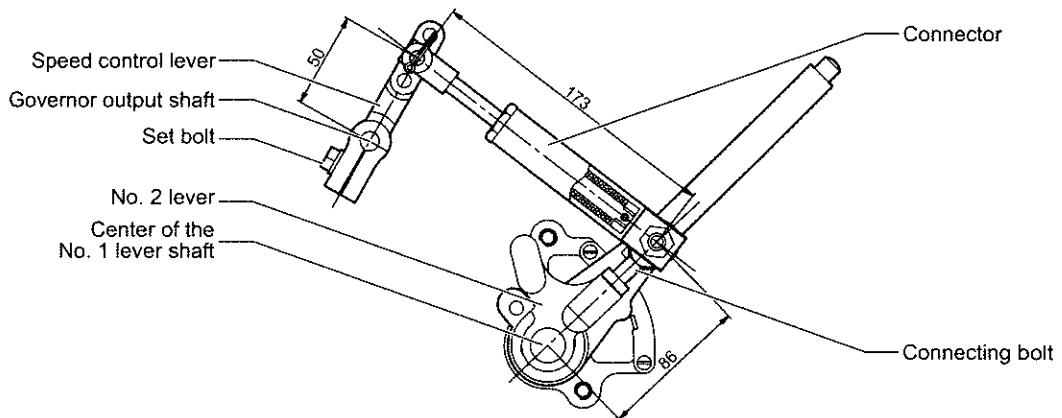
CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do maintenance of the speed control device (NZ).

1. Move the start/stop handle to STOP.
2. Set the rack scales between 6 and 7. Do it for the fuel injection pumps of all cylinders. Use the rack adjusting bolt. Make sure that the No. 1 lever moves easily.

Adjusting the fuel injection amount (rack scale) 5003-000-03-10



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Fig. 1 Speed control device (NZ governor)

3. Make sure that the distance between the center of the No. 1 lever shaft and the center of the connector is approximately 86mm. If necessary, screw the connecting bolt in or out to adjust the length.
4. Connect the connecting bolt of lever No. 2 to the connector.

Speed control device (NZ)

Adjust

2/2

5. Put a minus screwdriver into the end of the governor output shaft. Turn it fully in the direction of the fuel DECREASE side. Set the pointer to 0 (zero) on the scale. (Refer to Fig. 2.)
6. Install the speed control lever to the end of the governor output shaft. Loosen the set bolt of the speed control lever.
7. Connect the connector to the speed control lever.
8. Set the pointer to 1 on the scale. Turn the governor output shaft to the fuel INCREASE side. Tighten and lock the speed control lever with the set bolt to the output shaft.
9. Examine the governor link mechanism for defects.
10. Move the start/stop handle to RUN and then to STOP. Do a check of the scales of all fuel injection pumps.

To find the STOP position, turn the flywheel until you do not hear any injection sounds.

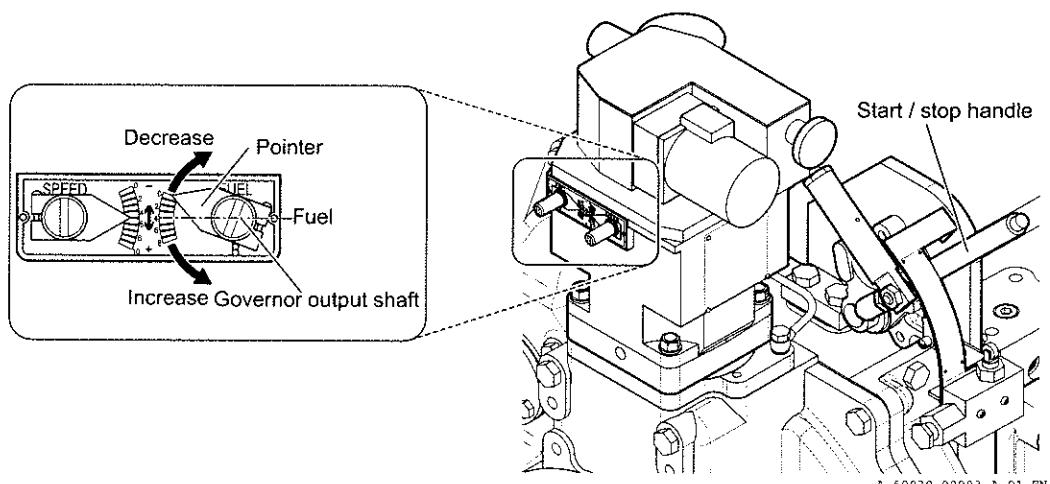


Fig.2 About the position of the speed control lever

CONDITION

Speed control device (UG-8, UG-25+)

Adjust

1/2

PRODUCTION MANAGEMENT DATA

Intervals Unscheduled

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY					

Obey the instructions that follow when you do maintenance of the speed control device (UG-8, UG-25⁺).

1. Move the start/stop handle to STOP.
2. Set the rack scales between 6 and 7. Do it for the fuel injection pumps of all cylinders. Use the rack adjusting bolt.

Make sure that the No. 1 lever moves easily.

Adjusting the fuel injection amount (rack scale) 5003-000-03-10

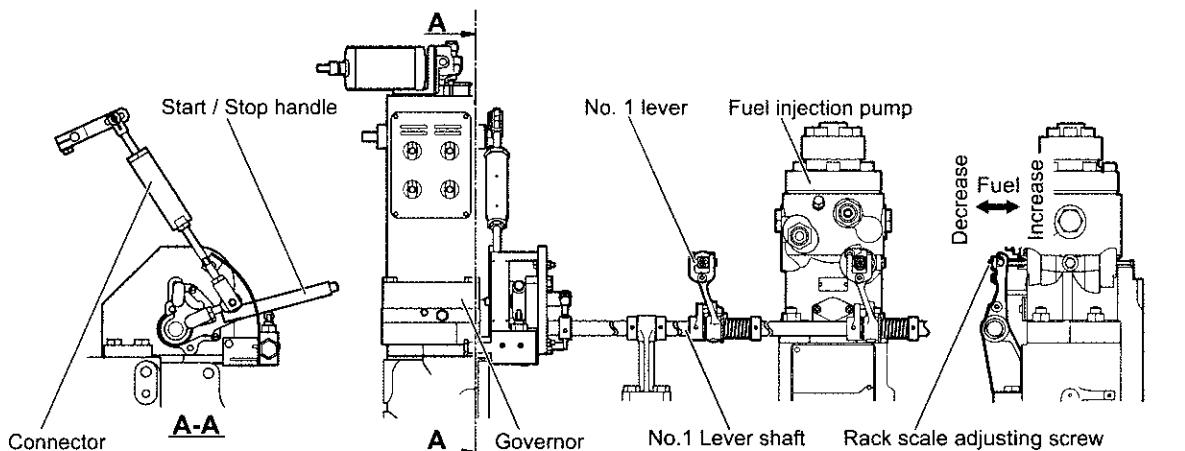


Fig.1 Speed control device (UG-8 governor)

3. Make sure that the distance between the center of the No. 1 lever shaft and the center of the connector is approximately 86 mm. Adjust the coupling bolt of the No. 2 lever if necessary.
4. Connect the connector to the speed control lever.
5. Fully turn the governor output shaft in the direction of the fuel DECREASE side. Tighten and lock the speed control lever to the output shaft with the set bolt.
6. Examine the governor links for defects.
7. Move the start/stop handle to RUN and then to STOP. Do a check of the scales of all fuel injection pumps. To find the STOP position, turn the flywheel until you do not hear any injection sounds.

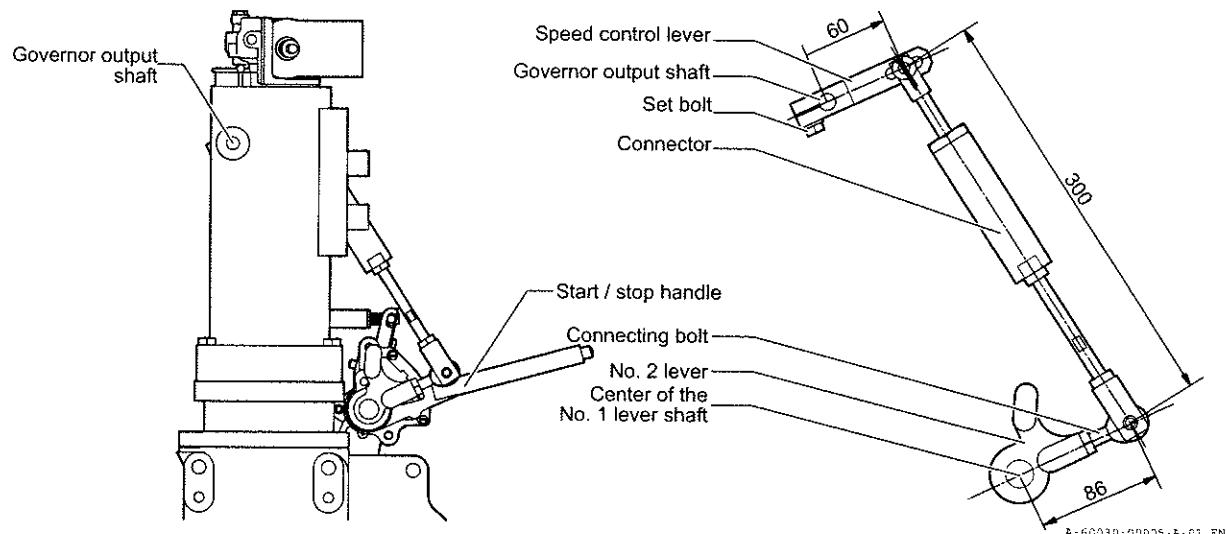


Fig.2 About the position of the speed control lever

CONDITION

- The switch can sense three settings:
 - The start/stop handle is set to engine-stop (no fuel oil injected).
 - The start/stop handle is set to remote-start (automatic start).
 - The engine start operation is in progress.
- The switch transmits an electric signal (ON/OFF) to the remote monitoring room. The signal tells whether fuel injection is possible.
- This signal is one of the conditions in the automatic start sequence. If the start/stop handle is set to engine-stop, you cannot transmit the start command to the engine. This prevents the waste of startup air and is one of the safety measures during maintenance.
- The switch is a microswitch. When the start/stop handle is set to engine-stop:
 - The actuator is pushed in.
 - The COM-NO contacts are ON.
 - The COM-NC contacts are OFF.
- When the start/stop handle is set to remote-start:
 - The actuator returns to its original position.
 - The COM-NO contacts are OFF.
 - The COM-NC contacts are ON.
- This switch has a contact capacity of 5 A maximum at 24 V DC.
- If the engine is stopped, the switch prevents false alarms.

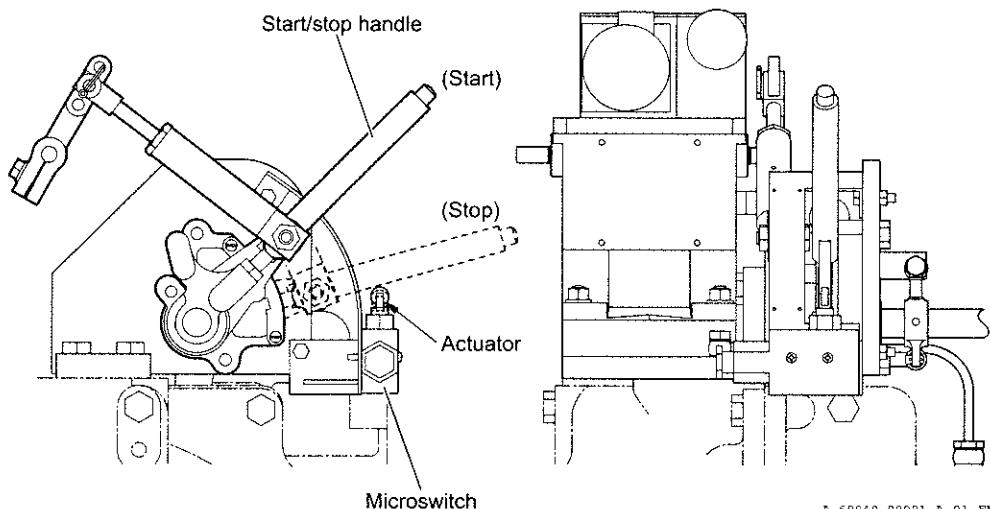


Fig.1 Diagram of the start/stop handle switch assembly

Start/stop handle

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

	Intervals	Unscheduled		
CONDITION	Do a performance test once every 3 months.			
PERSONNEL	Person	Category	Skill	Trade
	a	Engine crew	Intermediate	-
EQUIPMENT	Nomenclature		Identification code	Quantity
SUPPLIES	Nomenclature		Identification code	Quantity
SPARES	Nomenclature		Identification code	Quantity
SAFETY				

CAUTION

DO NOT touch the actuator of the microswitch when the engine is operating or on stand-by. Its signal is important for the control of the engine.

Obey the instructions that follow when you adjust the start/stop handle.

1. Make sure that the start/stop handle 1 and the interlock switch 2 are set to engine-stop (no fuel oil is injected) when you do servicing and inspections.
If the engine is on stand-by, set the start/stop handle to remote-start.
2. If you need to re-set the microswitch: Install the microswitch with the start/stop handle so that the actuator 3 moves a distance A of 2 mm to 5 mm from the free position.

NOTICE

Check the distance that the actuator of the microswitch moves. If you set it to another distance, the switch does not work or becomes damaged.

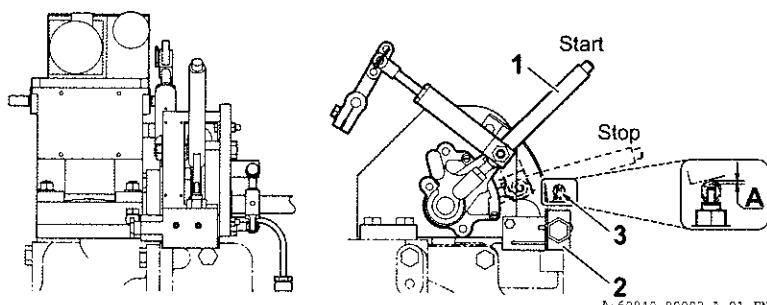
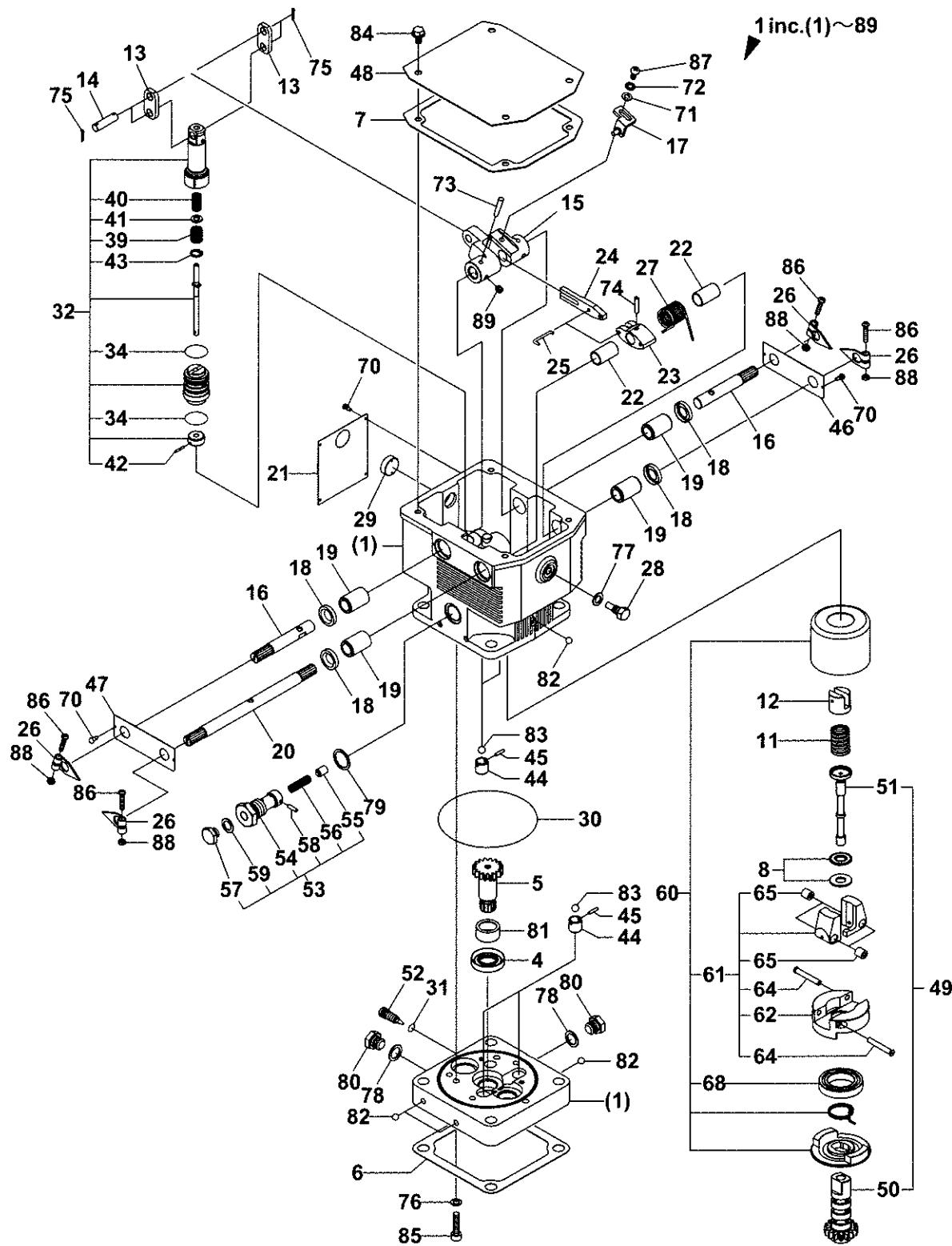


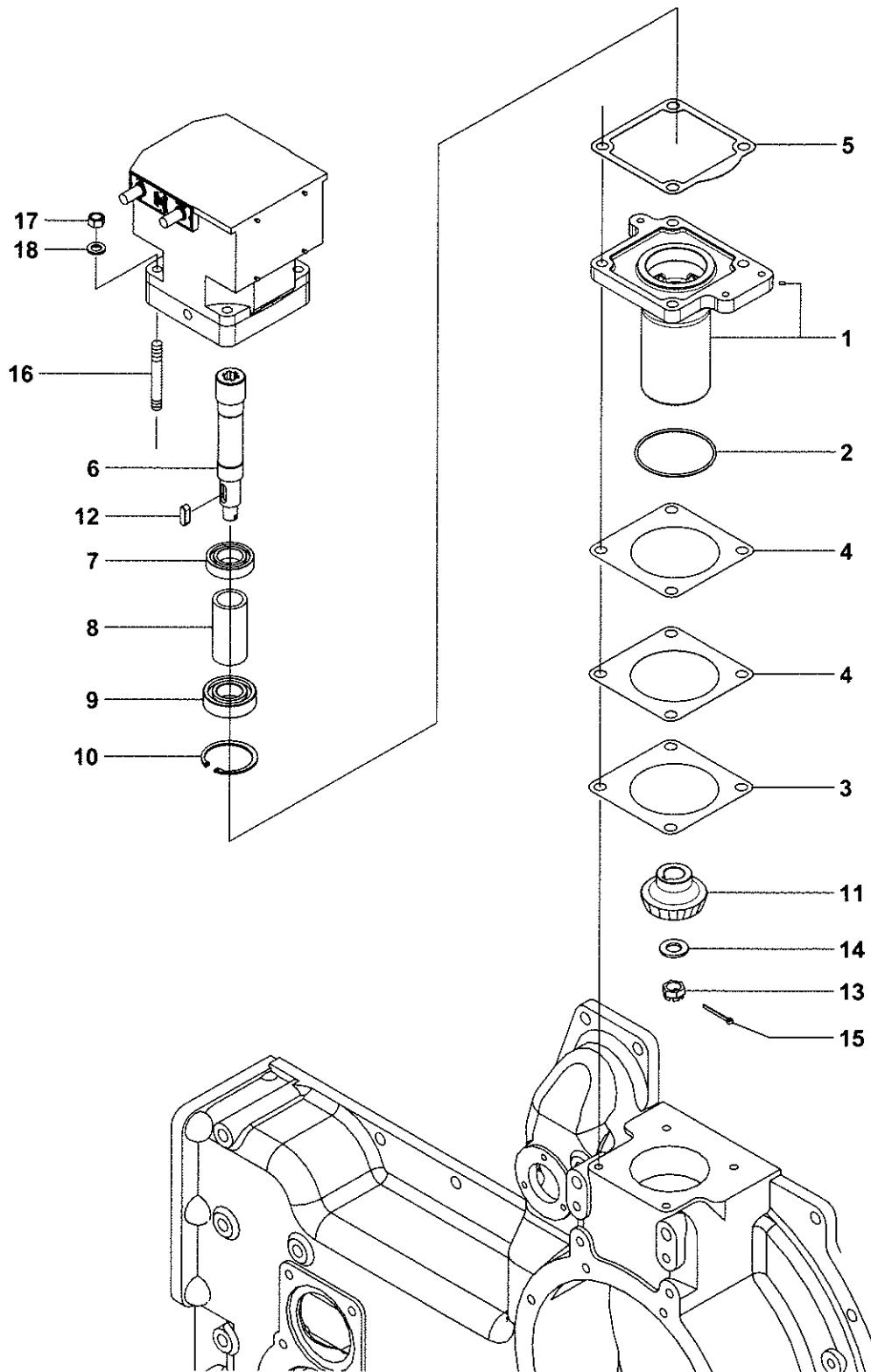
Fig.1 Start/stop handle switch assembly

CONDITION



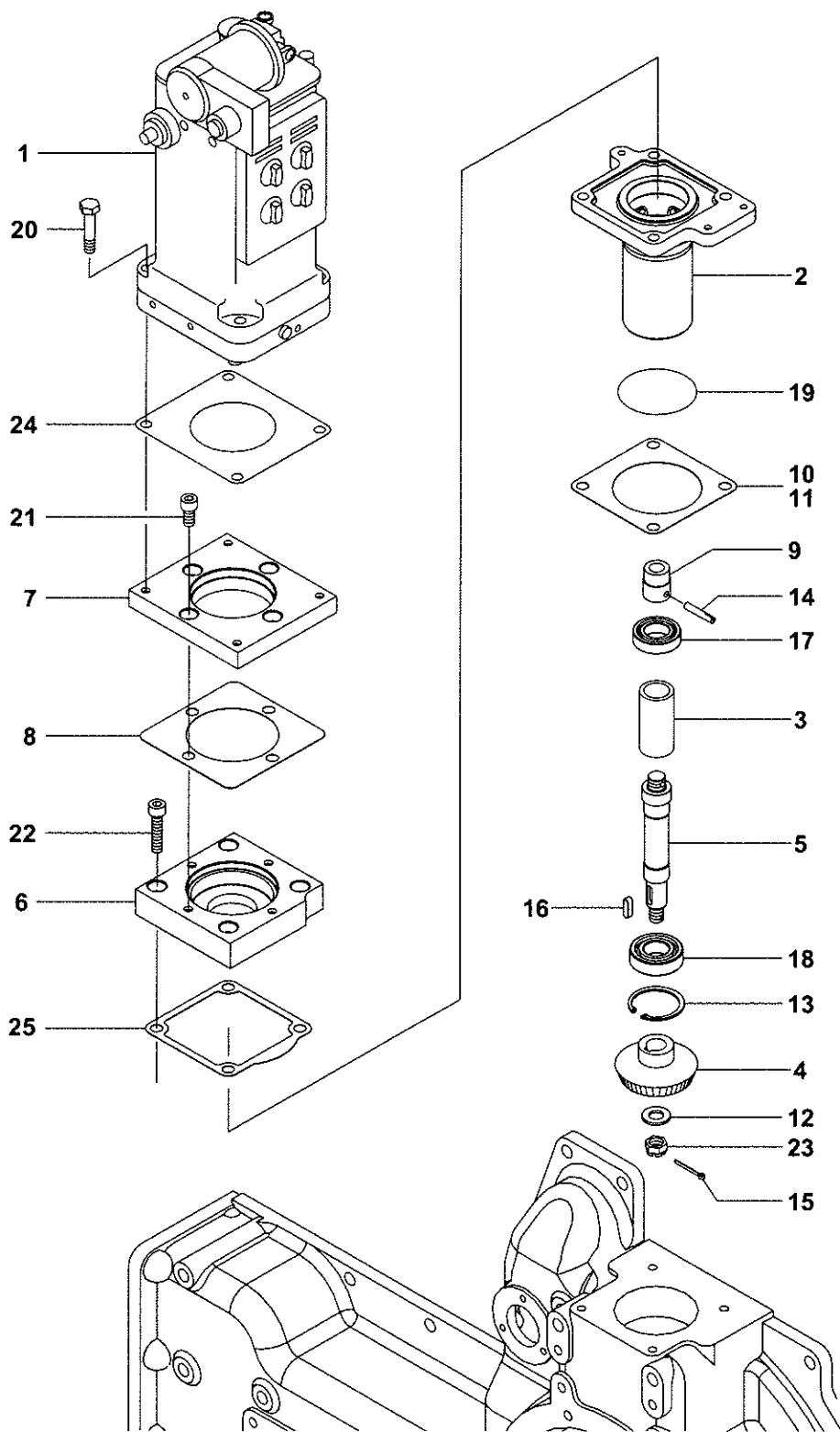
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	758510-61160	GOVERNOR ASSY	1	1	
4	2	158510-61030	SEAL, OIL	1	1	
5	2	158510-61040	SHAFT	1	1	
6	2	158510-61061	PACKING	1	1	
7	2	158510-61071	PACKING, HOUSING	1	1	
8	2	758510-61180	BEARING & RACE	1	1	
11	2	158510-61310	SPRING, GOVERNOR	1	1	
12	2	158510-61320	FORK, SPRING	1	1	
13	2	158512-61330	LEVER, GUIDE	2	2	
14	2	158510-61340	PIN	2	2	
15	2	158512-61351	ARM, TERMINAL	1	1	
16	2	158510-61360	SHAFT, TERMINAL	2	2	
17	2	158510-61370	ADJUSTER, DOOR	1	1	
18	2	158510-61380	SEAL, OIL	4	4	
19	2	158510-61390	BUSH	4	4	
20	2	158510-61400	SHAFT, CONTROL	1	1	
21	2	158512-61400	LABEL	1	1	
22	2	158510-61410	COLLAR	2	2	
23	2	158510-61420	FORK	1	1	
24	2	158512-61430	LEVER	1	1	
25	2	158510-61440	WIRE	2	2	
26	2	158510-61450	POINTER	4	4	
27	2	158510-61460	SPRING	1	1	
28	2	158510-61480	STOPPER	1	1	
29	2	158510-61490	GAUGE, OIL	1	1	
30	2	158510-61610	O-RING	1	1	
31	2	158510-61620	O-RING	1	1	
32	2	158510-61680	POWER PISTON & COMP	1	1	
34	3	158510-61591	O-RING	2	2	
39	3	158510-61720	SPRING, COMPENSATOR	1	1	
40	3	158510-61750	SPRING, COMPENSATOR	1	1	
41	3	158510-61780	SPACER, COMPENSATOR	1	1	
42	3	158510-61790	PIN	1	1	
43	3	22252-000120	RING, 12	1	1	
44	2	158510-61850	CASE, VALVE	4	4	
45	2	158510-61860	PIN	4	4	
46	2	158512-61930	LABEL, SHAFT L	1	1	
47	2	158512-61940	LABEL, SHAFT R	1	1	
48	2	158510-61990	COVER	1	1	
49	2	158510-66050	VALVE ASSY, PILOT	1	1	
50	3	158510-66120	BUSH	1	1	
51	3	158510-66220	VALVE, PILOT	1	1	
52	2	158510-66700	VALVE, NEEDLE	1	1	
53	2	158510-66801	VALVE ASSY, RELIEF	1	1	
54	3	158510-66810	BODY	1	1	
55	3	158510-66820	PISTON	1	1	
56	3	158510-66831	SPRING, VALVE	1	1	
57	3	158510-66841	PLUG, VALVE	1	1	
58	3	22351-030012	PIN, 3.0A X 12	1	1	
59	3	23414-100000	GASKET, 10 X 1.0	1	1	
60	2	158510-66930	WEIGHT ASSY, GOVERNOR	1	1	
61	3	158510-66930	SUPPORT ASSY	1	1	
62	4	158510-66200	SUPPORT, WEIGHT	1	1	
65	4	158510-66430	BEARING	4	4	

No	LV	Part No.	Part name	LWS	ALWS	Remarks
68	3	158510-66460	BEARING	1	1	
70	2	102210-07990	RIVET	8	8	
71	2	22117-050000	WASHER, 5	1	1	
72	2	22222-050000	WASHER, 5	1	1	
73	2	22322-040250	PIN, 4 X 25	2	2	
74	2	22351-040018	PIN, 4.0A X 18	1	1	
75	2	22417-200160	PIN, 2.0 X 16	4	4	
76	2	23414-060000	GASKET, 6 X 1.0	3	3	
77	2	23414-080000	GASKET, 8 X 1.0	1	1	
78	2	23414-120000	GASKET, 12 X 1.0	2	2	
79	2	23414-180023	GASKET, 18 X 1.0	1	1	
80	2	23887-120002	PLUG, 12	2	2	
81	1	24162-182412	NEEDLE, 182412	1	1	
82	1	24190-080002	BALL, 1/4	7	7	
83	1	24190-090003	BALL, 9/32	4	4	
84	1	26106-060102	BOLT, 6 X 10	4	4	
85	1	26450-060252	BOLT, 6 X 25	3	3	
86	1	26557-040202	SCREW, 4 X 20	4	4	
87	1	26557-050102	SCREW, 5 X 10	1	1	
88	1	26757-040002	NUT, 4	4	4	
89	1	26979-050062	SCREW, 5 X 6	2	2	

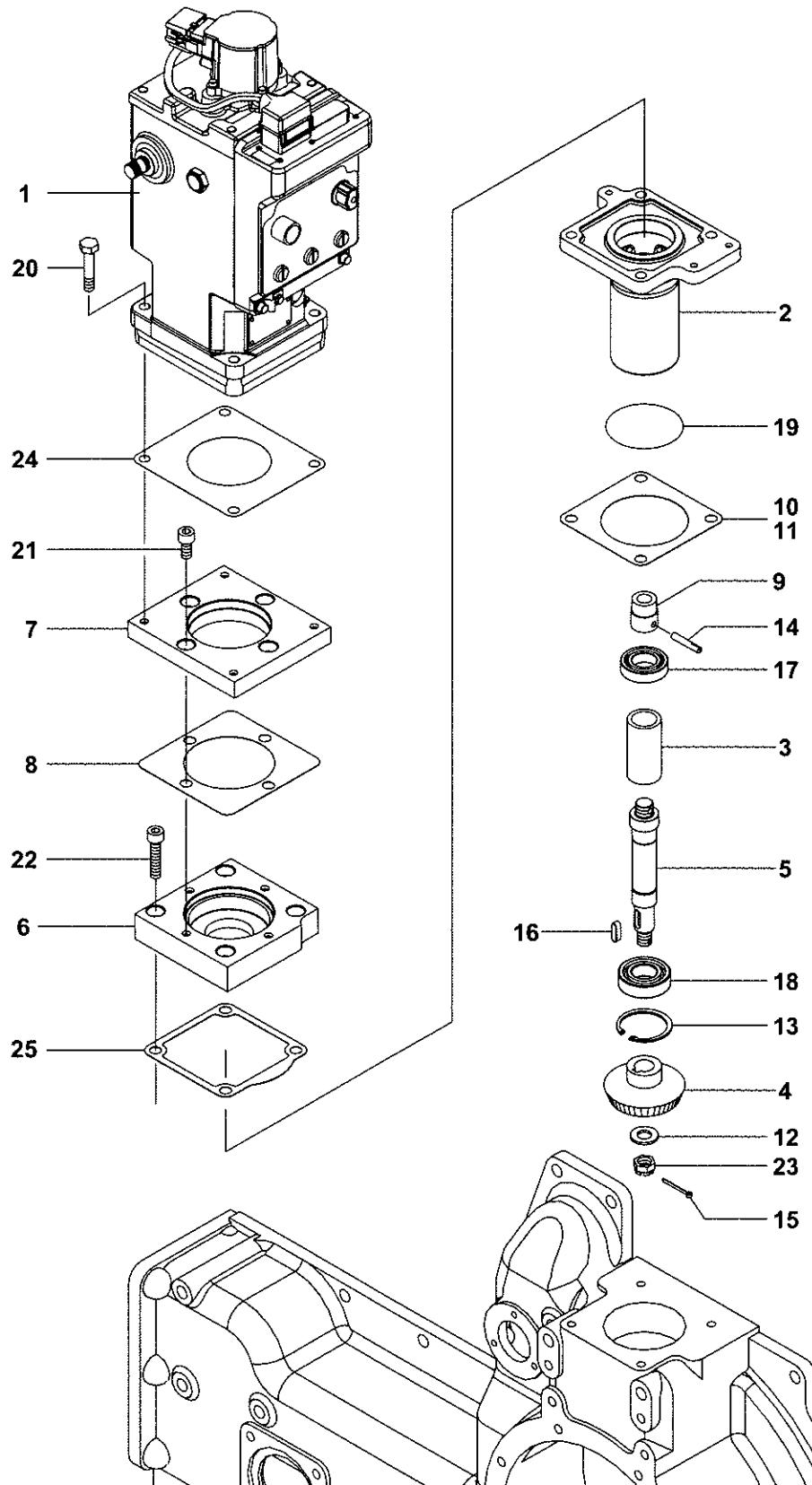


A-60029-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-61080	BRACKET, GOVERNOR	1	1	
2	1	24321-000750	PACKING, G 75.0	1	1	
3	1	148016-66210	SHIM, T=0.1	2	2	
4	1	148016-66220	SHIM, T=0.3	1	1	
5	1	43400-004020	GASKET, GOVERNOR	1	1	
6	1	150633-61110	SHAFT, GOVERNOR DRIVE	1	1	
7	1	24101-060054	BEARING, 6005	1	1	
8	1	150633-61120	SPACER, RHD GOVERNOR	1	1	
9	1	24101-062054	BEARING, 6205	1	1	
10	1	22252-000520	RING, 52	1	1	
11	1	146673-61140	GEAR, BEVEL	1	-	720min ⁻¹
11A	1	146673-61130	GEAR, BEVEL	-	1	900min ⁻¹
12	1	22512-070220	KEY, 7 X 22	1	1	
13	1	26871-140002	NUT, 14	1	1	
14	1	22137-140000	WASHER, 14	1	1	
15	1	22417-320320	PIN, 3.2 X 32	1	1	
16	1	26212-100652	STUD,BOLT 10 X 65	4	4	
17	1	26716-100002	NUT, 10	4	4	
18	1	22117-100000	WASHER, 10	4	4	



No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	41100-007230	GOVERNOR (UG8) (DC24,IP44	1	1	
2	1	150633-61080	BRACKET, GOVERNOR	1	1	
3	1	150633-61120	SPACER	1	1	
4	1	146673-61130	GEAR, BEVEL	1	-	720 min ⁻¹
4	1	147673-61130	GEAR, BEVEL UG8	-	1	900 min ⁻¹
5	1	150633-61150	SHAFT, GOVERNOR DRIVE	1	1	
6	1	150633-61160	BRACKET A, UG GOV.	1	1	
7	1	150633-61170	BRACKET B, UG GOV.	1	1	
8	1	150633-61180	PK, BRACKET GOV.	1	1	
9	1	138603-61780	JOINT	1	1	
10	1	148016-66210	SHIM, T=0.1	2	2	
11	1	148016-66220	SHIM, T=0.3	1	1	
12	1	22137-140000	WASHER, 14	1	1	
13	1	22252-000520	RING, 52	1	1	
14	1	22301-060360	PIN, 6 X 36	1	1	
15	1	22417-320320	PIN, 3.2 X 32	1	1	
16	1	22512-070220	KEY, 7 X 22	1	1	
17	1	24101-060054	BEARING, 6005	1	1	
18	1	24101-062054	BEARING, 6205	1	1	
19	1	24321-000750	PACKING, G 75.0	1	1	
20	1	26206-100552	BOLT, 10 X 55	4	4	
21	1	26450-100202	BOLT, 10 X 20	4	4	
22	1	26450-100452	BOLT, 10 X 45	4	4	
23	1	26871-140002	NUT, 14	1	1	
24	1	41121-000020	PACKING, GOVERNOR	1	1	
25	1	43400-004020	GASKET, GOVERNOR	1	1	

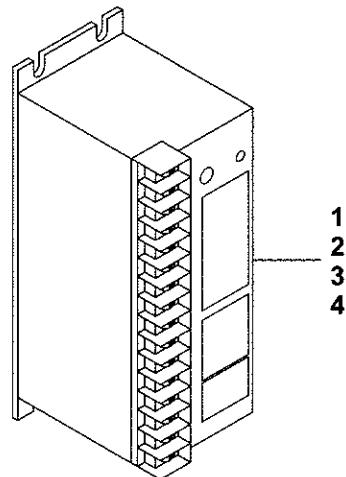


A-60029-00003-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	41100-007181	GOVERNOR,UG-25+	1	1	
2	1	150633-61080	BRACKET, GOVERNOR	1	1	
3	1	150633-61120	SPACER, RHD GOVERNOR	1	1	
4	1	147673-61130	GEAR, BEVEL UG8	1	1	
5	1	150633-61150	SHAFT,GOVERNOR DRIVE	1	1	
6	1	150633-61160	BRACKET A, UG GOV.	1	1	
7	1	150633-61170	BRACKET B, UG GOV.	1	1	
8	1	150633-61180	PK, BRACKET GOV.	1	1	
9	1	138603-61780	JOINT	1	1	
10	1	148016-66210	SHIM, T=0.1	2	2	
11	1	148016-66220	SHIM, T=0.3	1	1	
12	1	22137-140000	WASHER, 14	1	1	
13	1	22252-000520	RING, 52	1	1	
14	1	22301-060360	PIN, 6 X 36	1	1	
15	1	22417-320320	PIN, 3.2 X 32	1	1	
16	1	22512-070220	KEY, 7 X 22	1	1	
17	1	24101-060054	BEARING, 6005	1	1	
18	1	24101-062054	BEARING, 6205	1	1	
19	1	24321-000750	PACKING, G 75.0	1	1	
20	1	26206-100552	BOLT, 10 X 55	4	4	
21	1	26450-100202	BOLT, 10 X 20	4	4	
22	1	26450-100452	BOLT, 10 X 45	4	4	
23	1	26871-140002	NUT, 14	1	1	
24	1	41121-000020	GASKET, GOVERNOR	1	1	
25	1	43400-004020	GASKET, GOVERNOR	1	1	

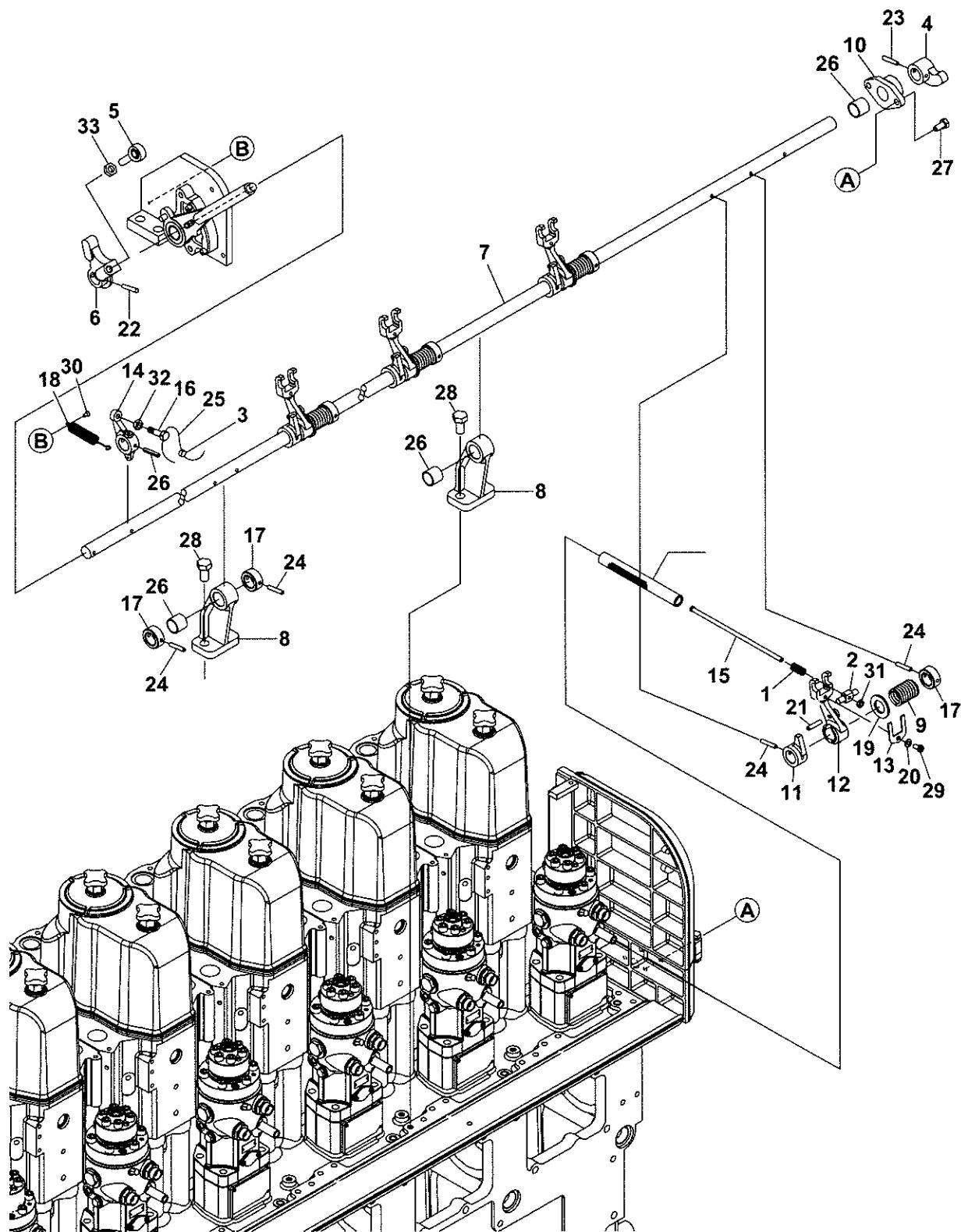
LWS, ALWS (1180kW or less): Lloyd's Register spec.

ALWS (1300kW or more): Standard



A-60039-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46111-045280	SPEED RELAY	1	-	
2	1	46111-045290	SPEED RELAY	1	-	
3	1	46111-045300	SPEED RELAY	-	1	
4	1	46111-045310	SPEED RELAY	-	1	



Speed control device

Illustrated parts data

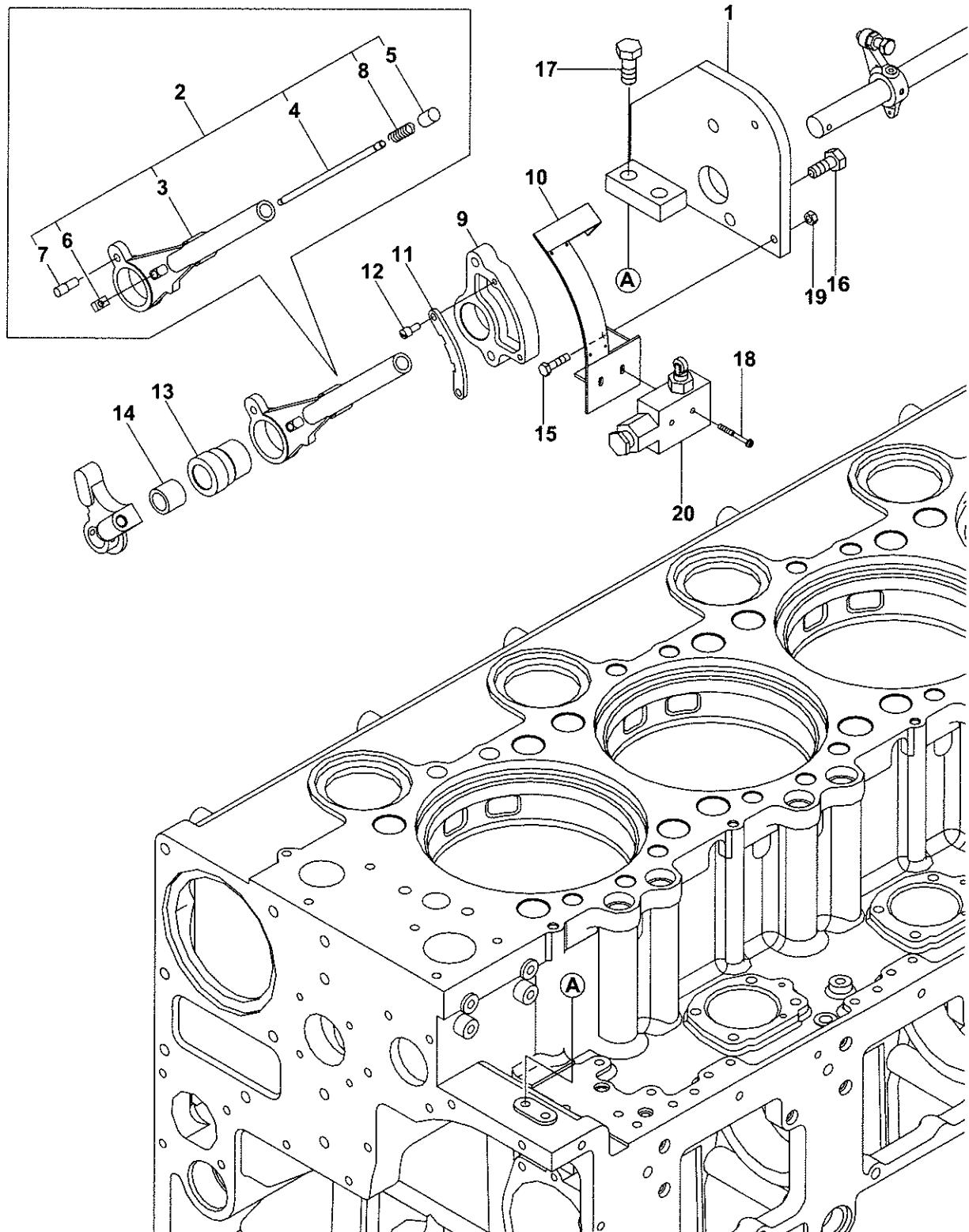
2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	137600-51540	SPRING, SHAFT	6	6	
2	1	137600-51560	JOINT	6	6	
3	1	151695-61090	TIN	1	1	
4	1	146673-65090	LEVER, AIR PISTON	1	1	
5	1	153605-66480	JOINT, ROD END	1	1	
6	1	141616-66602	LEVER, 2ND	1	1	
7	1	150633-66700	SHAFT, 1ST LEVER	1	1	
8	1	150633-66770	STAND, BEARING	3	3	
9	1	139653-66780	SPRING, NO.1 LEVER	6	6	
10	1	146673-66780	CASE, NO.1 BEARING	1	1	
11	1	141616-66790	PIECE, FIXING	6	6	
12	1	141616-66802	LEVER, 1ST	6	6	
13	1	139653-66810	RETAINER, LEVER	6	6	
14	1	141616-66820	LEVER, F/O LIMITER	1	1	
15	1	153605-66830	BOLT, RACK ADJUST	6	6	
16	1	138613-66840	SCREW, ADJUSTING	1	1	
17	1	139653-66840	COLLAR	8	8	
18	1	138613-66920	SPRING	1	1	
19	1	22137-200000	WASHER, 20	6	6	
20	1	22212-060000	WASHER, 6	6	6	
21	1	22312-060250	PIN, 6 X 25	6	6	
22	1	22322-050300	PIN, 5 X 30	1	1	
23	1	22322-050300	PIN, 5 X 30	1	1	
24	1	22351-050030	PIN, 5.0A X 30	15	15	
25	1	22451-100100	WIRE, 1.0 X 100	1	1	
26	1	24550-020200	BEARING, 20 X 20	4	4	
27	1	26206-080182	BOLT, 8 X 18	2	2	
28	1	26206-120252	BOLT, 12 X 25	6	6	
29	1	26557-060122	SCREW, 6 X 12	6	6	
30	1	26577-040082	SCREW, 4 X 8	1	1	
31	1	26756-060002	NUT, 6	6	6	
32	1	26796-080002	NUT, 8	1	1	
33	1	26796-100002	NUT, 10	1	1	

Start/stop handle

Illustrated parts data

1/2



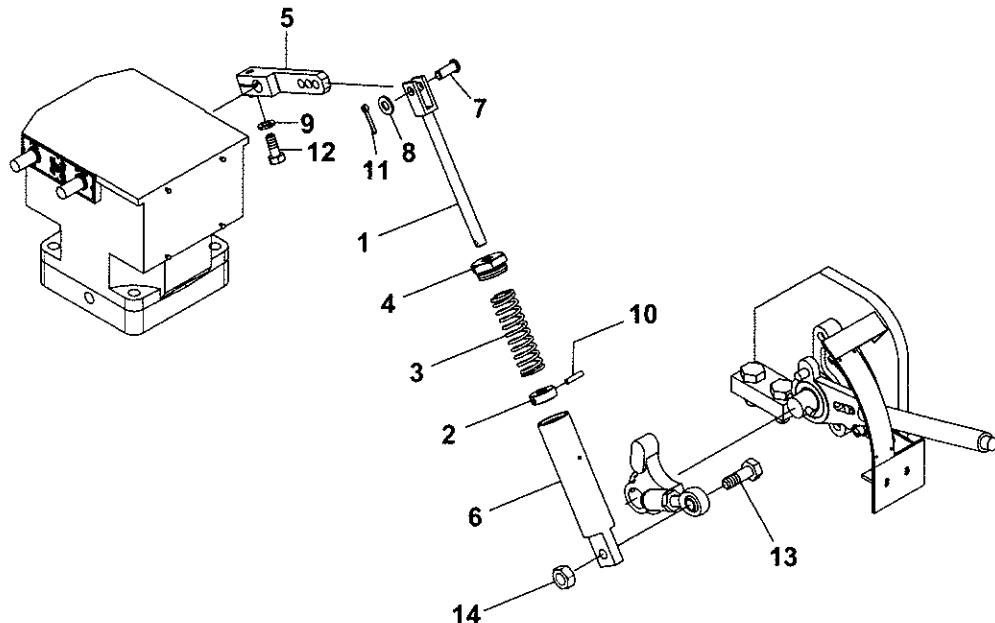
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Start/stop handle

Illustrated parts data

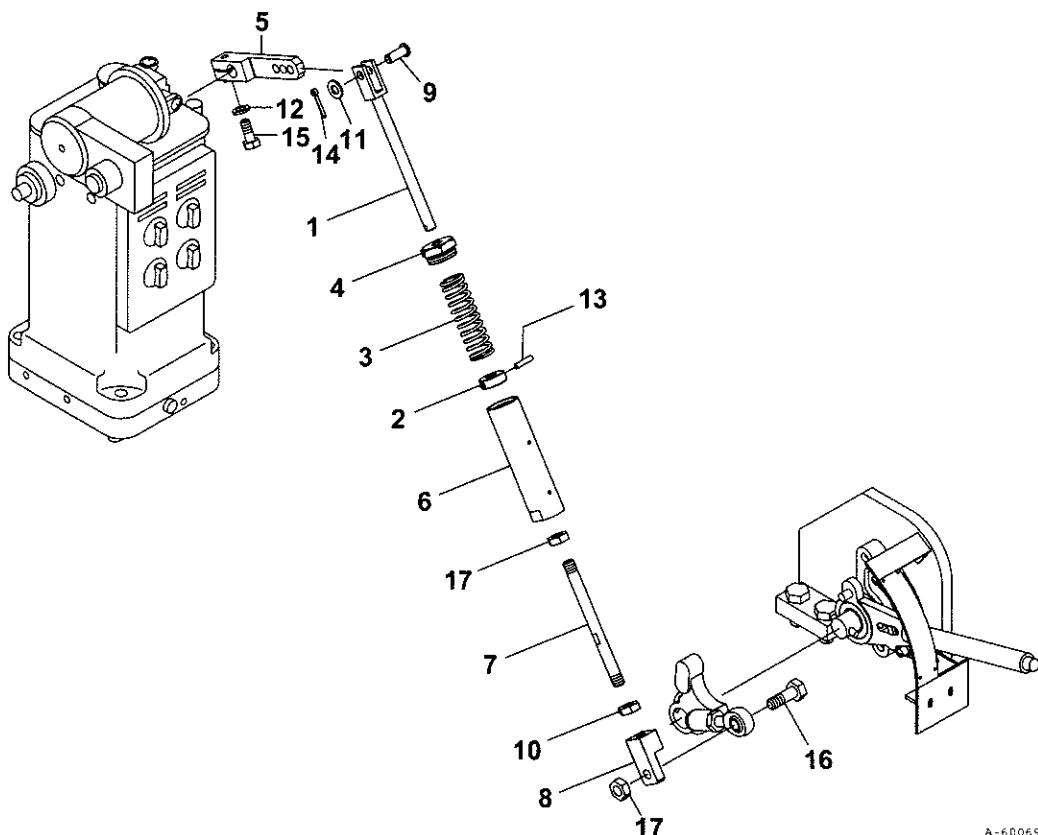
2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-66010	BRACKET, HANDLE	1	1	
2	1	139653-66050	HANDLE, START/STOP A	1	1	
3	2	139653-66253	HANDLE, START/STOP	1	1	
4	2	139653-66261	SHAFT, START/STOP	1	1	
5	2	138613-66270	KNOB, HANDLE	1	1	
6	2	139653-66280	CLAW, HANDLE	1	1	
7	2	137600-66300	PIN, HANDLE	1	1	
8	2	130140-66540	SPRING	1	1	
9	1	150633-66200	BRACKET, HANDLE	1	1	
10	1	151695-66210	PLATE, LABEL SETTING	1	1	
11	1	141616-66220	PLATE, STOPPER	1	1	
12	1	137600-66230	BOLT, STOPPING	2	2	
13	1	141616-66340	BUSH, HANDLE	1	1	
14	1	24550-020200	BEARING, 20 X 20	1	1	
15	1	26116-060252	BOLT, 6 X 25	2	2	
16	1	26206-100252	BOLT, 10 X 25	2	2	
17	1	26206-120302	BOLT, 12 X 30	2	2	
18	1	26557-040352	SCREW, 4 X 35	2	2	
19	1	26716-060002	NUT, 6	2	2	
20	1	46130-000110	SWITCH, MICRO	1	1	



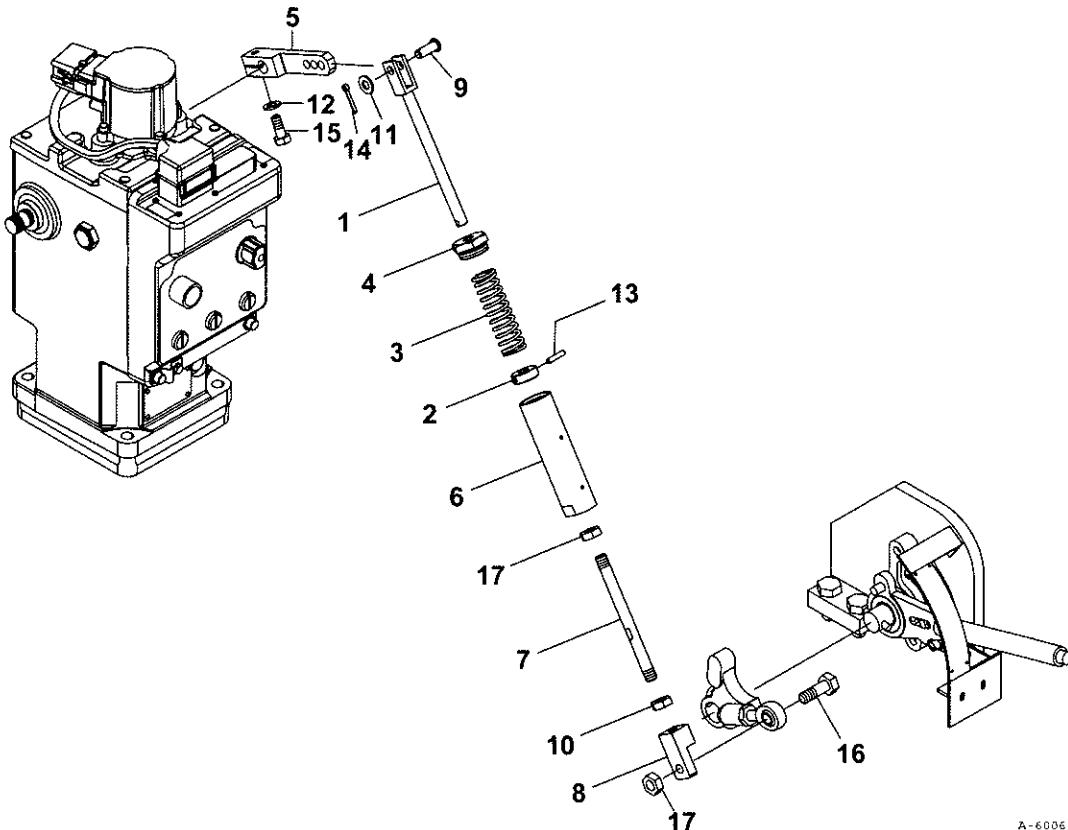
A-60069-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-66390	ROD(CONNECTER)	1	1	
2	1	137900-66420	COLLAR, CONNECTING	1	1	
3	1	146673-66430	SPRING, CONNECT PIPE	1	1	
4	1	138613-66440	NUT, CONNECTING PIPE	1	1	
5	1	147673-61650	LEVER, GOVERNOR	1	1	
6	1	146623-66401	PIPE, CONNECTING	1	1	
7	1	132310-66590	PIN, CONNECT PIPE	1	1	
8	1	22137-080000	WASHER, 8	1	1	
9	1	22212-080000	WASHER, 8	1	1	
10	1	22351-040016	PIN, 4.0AX 16	1	1	
11	1	22417-320200	PIN, 3.2X 20	1	1	
12	1	26206-080202	BOLT, 8 X 20	1	1	
13	1	150633-66600	BOLT, 10 X 30	1	1	
14	1	26796-100002	NUT, 10	1	1	



A-60069-00002-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-66390	ROD(CONNECTER)	1	1	
2	1	151695-66420	COLLAR, CONNECTING	1	1	
3	1	151695-66430	SPRING, CONNECT PIPE	1	1	
4	1	151695-66440	NUT, CONNECTING PIPE	1	1	
5	1	147673-66450	LEVER, GOVERNOR UG8	1	1	
6	1	150633-66450	ROD, CONNECTING	1	1	
7	1	150633-66500	SHAFT, CONNECTING	1	1	
8	1	150633-66530	CONNECTOR(UG8)	1	1	
9	1	132310-66590	PIN, CONNECT PIPE	1	1	
10	1	142972-66660	NUT, M10	1	1	
11	1	22137-080000	WASHER, 8	1	1	
12	1	22212-080000	WASHER, 8	1	1	
13	1	22351-040020	PIN, 4.0AX 20	1	1	
14	1	22417-320200	PIN, 3.2 X 20	1	1	
15	1	26206-080202	BOLT, 8 X 20	1	1	
16	1	150633-66600	BOLT, 10 X 30	1	1	
17	1	26796-100002	NUT, 10	2	2	



A-60069-00003-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-66390	ROD(CONNECTER)	1	1	
2	1	151695-66420	COLLAR, CONNECTING	1	1	
3	1	151695-66430	SPRING, CONNECT PIPE	1	1	
4	1	151695-66440	NUT, CONNECTING PIPE	1	1	
5	1	151695-66650	LEVER (UG25 ⁺)	1	1	
6	1	150633-66450	ROD, CONNECTING	1	1	
7	1	150633-66500	SHAFT, CONNECTING	1	1	
8	1	150633-66530	CONNECTOR(UG8	1	1	
9	1	132310-66590	PIN, CONNECT PIPE	1	1	
10	1	142972-66660	NUT, M10	1	1	
11	1	22137-080000	WASHER, 8	1	1	
12	1	22212-080000	WASHER, 8	1	1	
13	1	22351-040020	PIN, 4.0A X 20	1	1	
14	1	22417-320200	PIN, 3.2 X 20	1	1	
15	1	26206-080202	BOLT, 8 X 20	1	1	
16	1	150633-66600	BOLT, 10 X 30	1	1	
17	1	26796-100002	NUT, 10	2	2	

LWS, ALWS (1180kW or less): Lloyd's Register spec.

ALWS (1300kW or more): Standard

- The stop solenoid valve opens and closes to supply and discharge the control air. When the solenoid is stimulated by an electric current, it pulls up the plunger and the A port opens and the B port closes. This way, the control air that is supplied from the E port and that was stopped at the A port, is supplied via the D port to the air piston that stops the engine. When the electric current stops and the solenoid is no longer stimulated, the plunger is pushed down by the spring and the A port closes and the B port opens. The control air that was supplied via the D port to the air piston is cut off and the control air from the A port passes the B port and is released through the C port into the atmosphere.
- The solenoid valve does not require any special maintenance or inspection. But do the check at regular intervals (at intervals of 6 months to 1 year) to make sure that it operates in good condition.

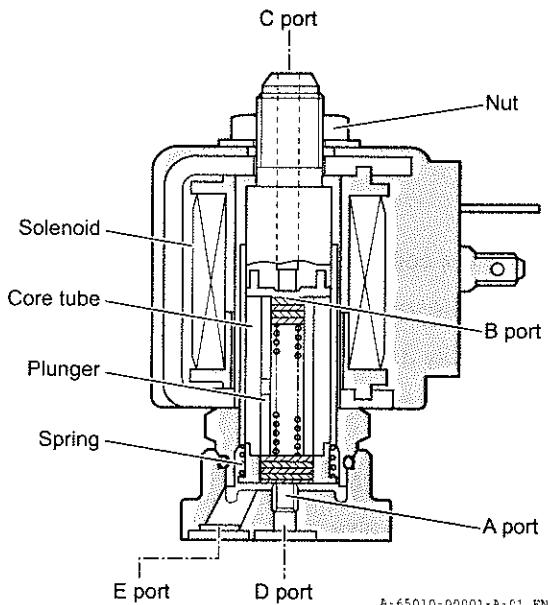


Fig.1 Stop solenoid valve

NOTICE

This solenoid valve requires 24 V DC and 0.38 A of current (constant rating).

If the voltage must be changed, make sure that it is between -10 % and +15 % of the specified voltage.

Stop solenoid valve

Inspection and maintenance

1/2

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals	Unscheduled		
PERSONNEL	Person	Category	Skill	Trade
	a	Engine crew	Intermediate	-
EQUIPMENT	Nomenclature		Identification code	Quantity
SUPPLIES	Nomenclature		Identification code	Quantity
SPARES	Nomenclature		Identification code	Quantity
SAFETY				

Obey the instructions that follow when you do maintenance of the stop solenoid valve.

1. Disassembly

1. Remove the nut 5 on top of the coil housing.
2. Remove the solenoid 4 from the valve.
3. Remove the core tube assembly 3.
4. Remove the parts inside the plunger in the correct sequence.

NOTICE

- When you remove the solenoid valve or do maintenance, make sure that you:
 - Turn off the power.
 - Release the control air and the remaining pressure.
 - Be careful not to cause damage to the parts.

2. Inspection

1. Make sure that the actual voltage is the same as the voltage specified for the coil.
2. Examine the coil for damage.
3. Examine if the inside of the plunger 2 or the orifice are dirty or clogged (e.g. by sealing tape or other dirt).
4. Examine the inside of the plunger for contamination from oil mist or oil residue.
5. Examine the seat of the plunger for damage or unusual wear.
6. Examine the spring 1 for breakage or fatigue.

Resistance at DC 24 V: 45 Ω

3. Assembly

1. Carefully clean the parts that you want to use again.
2. Tighten the core tube assembly 3 to a torque of 30 N·m.
3. Securely fasten the nut 5 on the top of the coil housing.

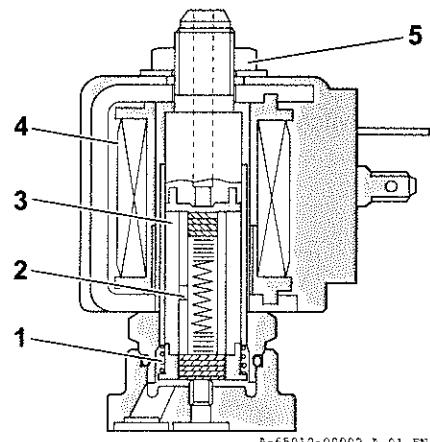


Fig.1 Stop solenoid valve

CONDITION Make sure that the solenoid valve operates correctly under minimum and maximum pressure.
Make sure that there are no internal leaks when the solenoid is demagnetized.

- This switch is near the start/stop handle of the engine. The switch transmits an electric signal (ON/OFF) to the remote monitoring room. The signal tells whether the controls are set to engine-control or remote-control (automatic control).
- This signal is one of the conditions in the automatic start sequence. If the switch is set to engine-control, the start command cannot be transmitted remotely.
- This switch has a contact capacity of 8 A maximum at 24 V DC.
- The stop command and the safety measures operate independently of the selection of this switch.
- Do a performance test at intervals of 1 year.
- Make sure that the switch is set to ENGINE when you do servicing and inspections.
- If the engine is on stand-by, set the switch to REMOTE.

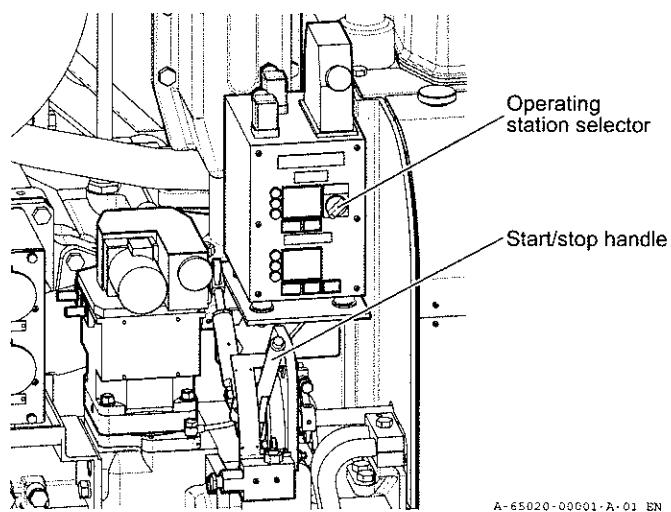


Fig.1 Select switch of the operating station

Pressure gauge

Adjust

1/2

PRODUCTION MANAGEMENT DATA

CONDITION Intervals Unscheduled

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.2 h
EQUIPMENT	Nomenclature				Identification code
SUPPLIES	Nomenclature				Identification code
SPARES	Nomenclature				Identification code
SAFETY	Sealing liquid				42111-002800
					1 pc

Obey the instructions that follow when you adjust the pressure gauge.

1. Servicing the glycerin-filled pressure gauge

The pressure gauges on the instrument panel are filled with a glycerol-water solution. This prevents wear of the gear and link mechanism inside the gauge. Obey the instructions that follow when you do work on the pressure gauge.

1. Make sure that the rubber cap of the pressure gauge points up when you remove the gauge panel or the pressure gauge for servicing.
If it points to the side, the sealing liquid leaks through the ventilating hole in the rubber cap.
2. Make sure that the level of the sealing liquid is always higher than A and lower than B.

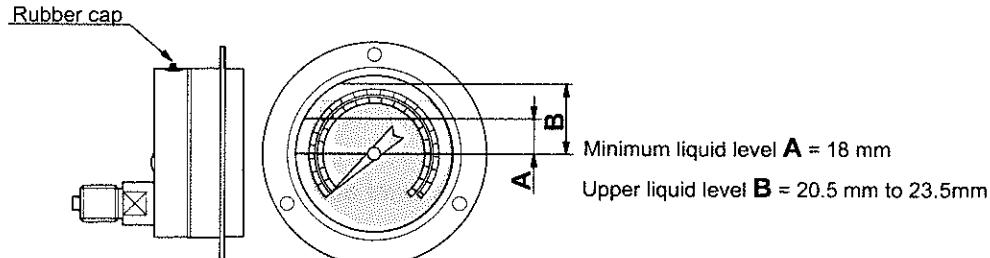


Fig. 1 Level of the sealing liquid for the pressure gauge

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3. Remove the rubber cap if the sealing liquid is dirty or if the level decreases. Replace or refill the sealing liquid.
4. When you replace the pressure gauge with a new one, cut the navel of the rubber cap and open an air hole.

The gauge does not show the correct value without a vent hole.

2. Adjusting the pressure take-off main valve

Measure the opening of the needle valve at the piping of the pressure transmitter or pressure gauge. Adjust it if necessary. Surging (pulsation) causes damage and malfunction of the pressure gauge and pressure transmitter.

Fuel pressure gauges and pressure transmitters: open 1/4 turn from the closed position.

Other pressure gauges and pressure transmitters: open 1 turn from the closed position.

3. Adjusting the remote pressure indicator

The device has a pressure transmitter to indicate the pressure remotely. If you need to make adjustments on the remote side, obey these instructions.

1. Remove the top cover from the pressure transmitter.
2. Turn the ZERO or SPAN adjust screw with a small (2 mm) Phillips screwdriver. Apply light pressure to the screw.
3. If you turn the screw clockwise (to the right), the indicator moves in the direction of the arrow in the figure.

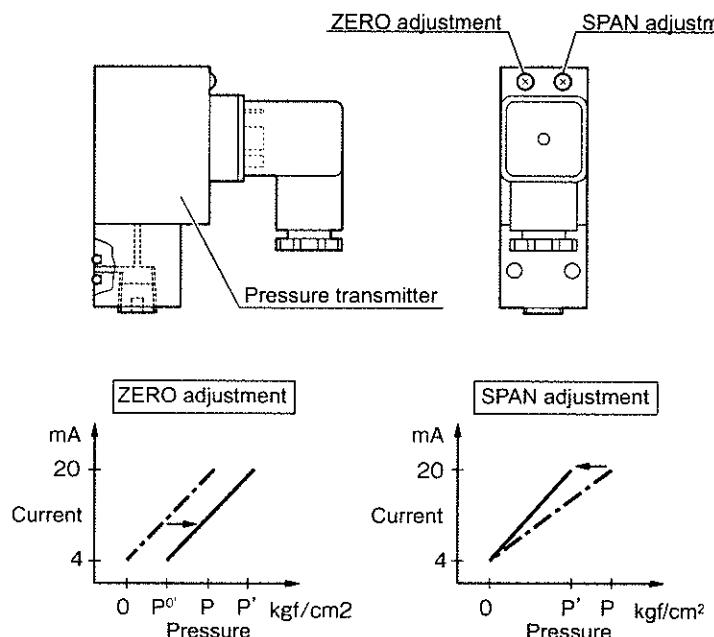


Fig.2 How to adjust the pressure transmitter

CONDITION

PRODUCTION MANAGEMENT DATA

CONDITION	Intervals	Unscheduled		
PERSONNEL	Person	Category	Skill	Trade
	a	Engine crew	Intermediate	-
EQUIPMENT	Nomenclature		Identification code	Quantity
SUPPLIES	Nomenclature		Identification code	Quantity
SPARES	Nomenclature		Identification code	Quantity
	Battery (CR2450YU)		147883-91350	1 pc

If you cannot read the display of the thermometer well, the battery charge is low. If you cannot read the display, replace the battery in the instructions that follow.

1. Inspection of the battery

1. Removing the upper cover

Loosen the screws 6 that are locking the upper cover 1 with a M3 Phillips head screwdriver. Then remove the upper cover while caring not to drop it. (You cannot fully remove the screw.)

2. Removing the connector

Pinch the tip of the connector 4 of the lead wire 7 coming out from the battery holder 3 and pull it up from the PCB to remove it. Never pull the lead wire when you remove the connector. It will cause disconnection.

3. Removing the battery holder

Pinch the battery holder and lift it up above the cover to remove it.

4. Opening the battery holder

The battery holder 3 has a shell structure with a hinge on one side. Pull the pawl of the battery holder outside like opening the shell to open the battery holder. The battery 2 comes out at this time. Care must be taken not to drop it.

5. Replacing the battery

Insert the new battery 2 to the battery holder 3. There are "+" and "-" marks inside the battery holder to show the polarity. Care must be taken not to insert the battery in the incorrect polarity. (The red lead wire side is "+" and the black lead wire side is "-".)

If you insert the battery in the incorrect polarity, a defect can occur.

6. Closing the battery holder

Close the battery holder while making sure that the pawl of the holder is securely stuck. (Check that the pawl is stuck with a click sound). If you insert the battery in the incorrect polarity, the holder does not close completely. Check that the battery is inserted in the correct polarity.

7. Inserting the battery holder

Store the battery holder in the body case 5.

8. Setting the system voltage to 0V

Touch the connector polarity on the board with a screwdriver for approximately 3 seconds before inserting the connector 4. This is to secure the system reset at the time of inserting the connector (the system voltage must be cleared to 0V).

9. Inserting the connector

Insert the connector on the tip of the lead wire 7 attached in the battery holder 3 to the connector of the printed circuit board. The connector has a polarity. You cannot insert the connector in a reverse direction. If you find it difficult to insert the connector, do not forcibly insert the connector and check the polarity. (Care must be taken not to pinch the lead wire when you close the upper cover).

10.Closing the upper cover

Install the upper cover 1 to the body case 5. Tighten the screws 6 equally. (Standard tightening torque: 0.4 N·m) If the tightening of the screws is inappropriate, the front cover may be removed while using. It can cause an accident.

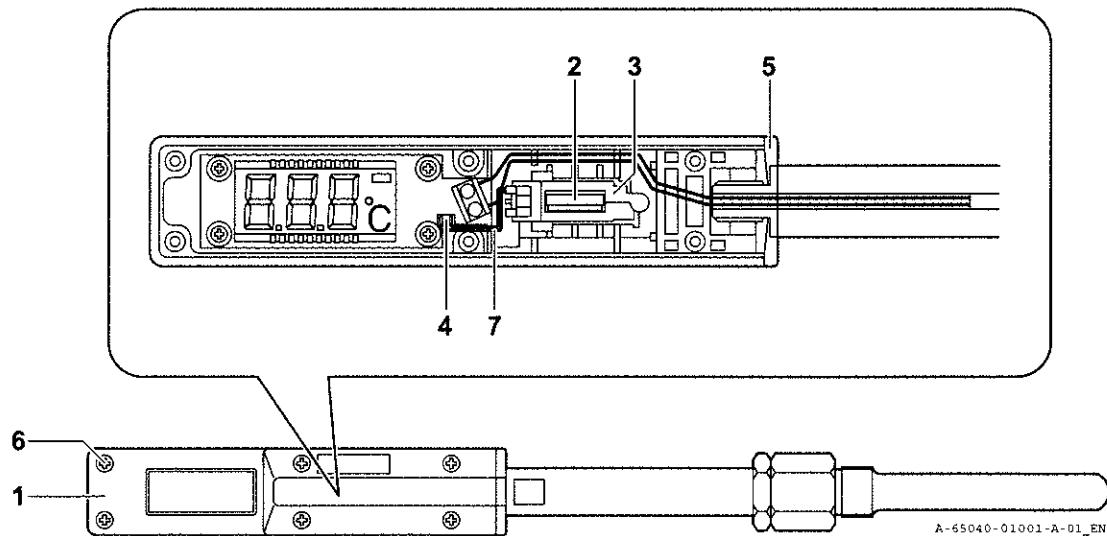


Fig.1 Replacing the digital thermometer battery

2. Installing the temperature sensor

1. Remove the protective tube 4 and the joint 3 from the thermometer. The protective tube and the joint are attached with left-handed threads.
2. Install the protective tube to the thermostat seat.
3. Screw the joint into the protective tube for 2 to 3 turns (approximately 5 mm). The thread is left-handed.
4. Put the temperature sensor 1 with the locknut 2 attached into the joint.
5. Turn the joint counter-clockwise without turning the temperature sensor. Screw the joint in until it is seated in the protective tube.
6. Tighten the locknut.

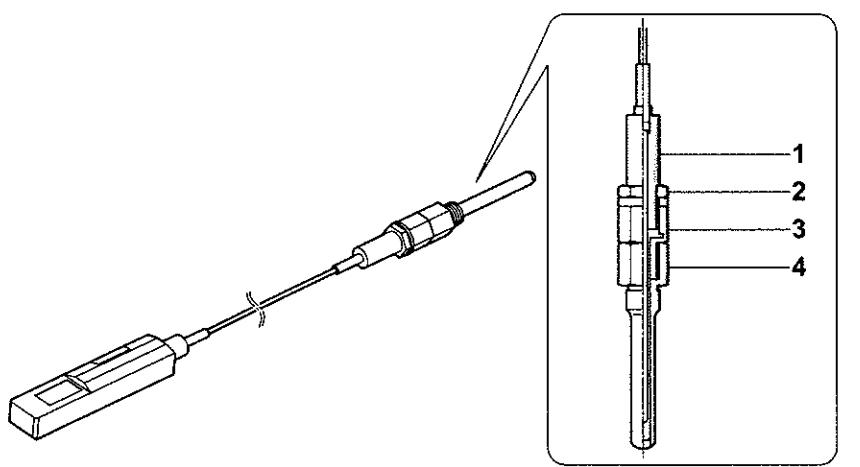
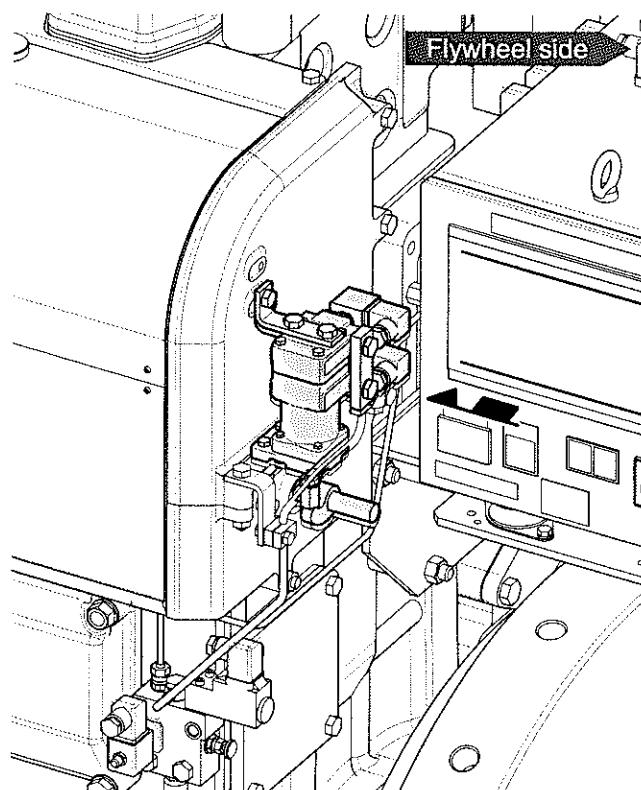


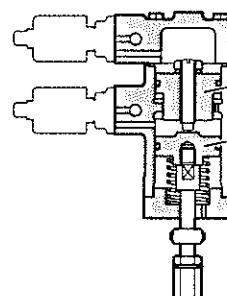
Fig.2 Installing the temperature sensor

CONDITION

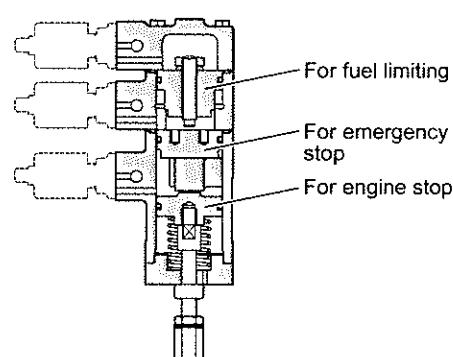
1. Outline



Double assembly



Triple assembly



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Fig. 1 Air piston

- There are 2 specifications of the air piston:

A double assembly that controls the fuel injection volume at engine start and that stops the fuel at engine stop.

A triple assembly that, in addition to the above, also has an emergency stop function.

- The air piston assembly is on the fuel injection pump chamber cover on the flywheel side.
- To do a check of the injection volume control air piston, the stopping air piston and the emergency stop air piston: Send control air and confirm the movement of the lever. Do a performance test at intervals of 3 months.

2. Structure

2.1 Fuel injection volume control air piston

- When the engine starts automatically or remotely, the fuel control air piston controls the volume of injected fuel to allow the engine to build up speed slowly.
- A startup command actuates the start solenoid valve. The control air passes the speed control valve with a pressure of 0.7 MPa to 1.0 MPa. It flows from the air cylinder inlet into the air cylinder cover. It moves the fuel control air piston and the stopping air piston. This moves the connecting rod down. It moves the No. 1 lever that is connected to the No. 1 lever shaft 7 via the connecting rod. It decreases the fuel injection volume.
- The control air is released into the atmosphere from the start solenoid valve at the same time that the engine starts. When the air flows out, the spring moves the air pistons up. The fuel control is stopped and the previous state is restored.
- You can turn the adjusting screw to regulate the fuel injection volume. But the screw is correctly adjusted when shipped from our factory. Do not adjust it unless it is required for some specific reason.

Fuel injection volume control air piston and stopping air piston
Description of function

2/3

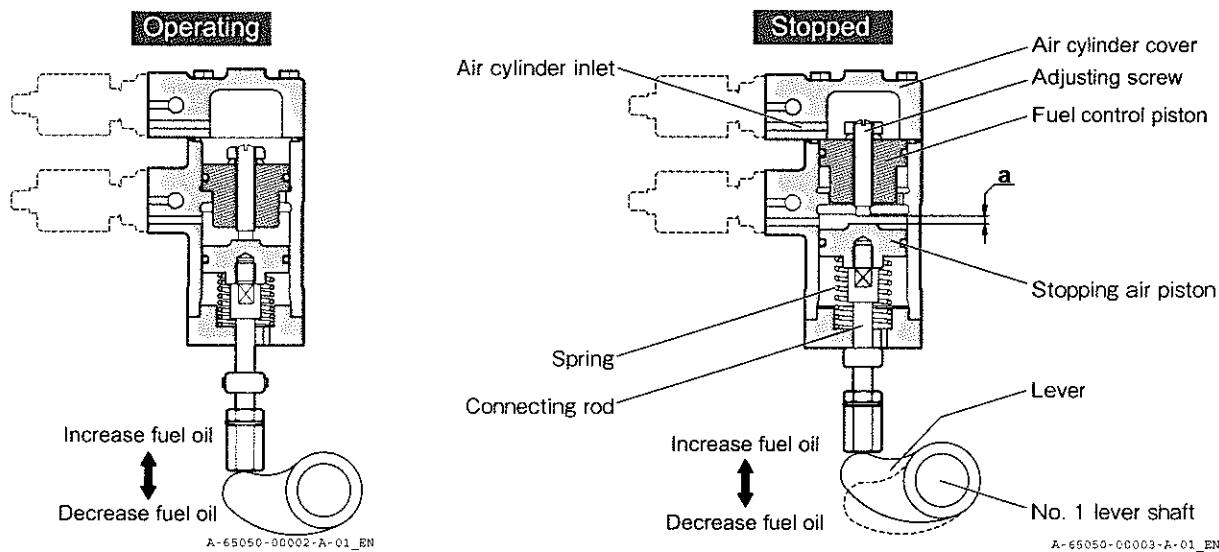


Fig.2 Fuel injection volume control air piston & stopping air piston

- To increase the fuel injection volume, turn the screw and increase the gap "a" between the adjusting screw and the stopping air piston. To decrease the fuel injection volume, decrease the gap "a".

NOTICE

If you increase the gap "a" too much, fuel injection control becomes impossible at engine start. On the other hand, if you decrease the gap "a" too much, the engine does not start at all. Be very careful when you make this adjustment.

2.2 Fuel cut-off air piston

- When the engine stops automatically or remotely, the stopping air piston stops the supply of fuel oil in order to stop the engine.
- Fig. 3 shows the stopped engine. The control air is supplied through the stop solenoid valve at a pressure of 0.7 MPa to 1.0 MPa. It flows from the air cylinder inlet into the air cylinder. It moves the stopping air piston down.
- It moves the No. 1 lever that is locked to the No. 1 lever shaft via the connecting rod. It stops the fuel injection and the engine.
- 40 to 60 seconds after the control air is cut off, the air inside the air cylinder is released into the atmosphere from the stop solenoid valve. The spring moves the air piston up. This restores the previous state.

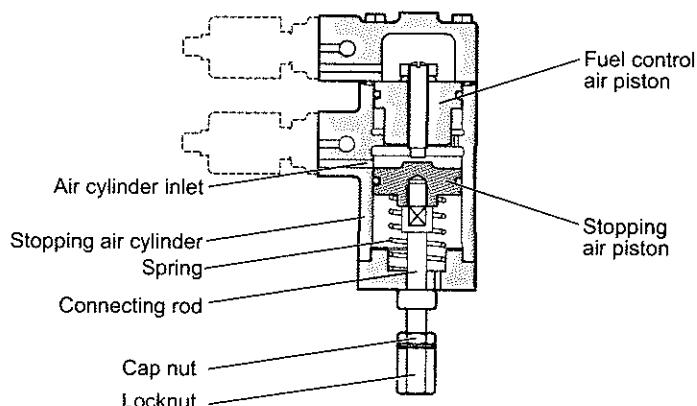
NOTICE

You can set the fuel pump rack scale (4 mm to 5 mm) to the correct no-fuel-injection with the cap nut (at the end of the connecting rod) and the locknut. But the rack scale is correctly adjusted when shipped from our factory. Do not adjust it unless it is required for a specific reason. If an adjustment becomes necessary, obey these instructions:

- If the rack scale gets close to 0 (zero), the movement that is transmitted by the stroke of the fuel cut-off air piston to the lever becomes too large and interferes with the rack. This causes malfunctions.
- On the other hand, if the rack scale becomes too large, the movement that is transmitted by the stroke of the fuel cut-off air piston to the lever becomes too small and the piston becomes unable to stop the engine.

Fuel injection volume control air piston and stopping air piston
Description of function

3/3

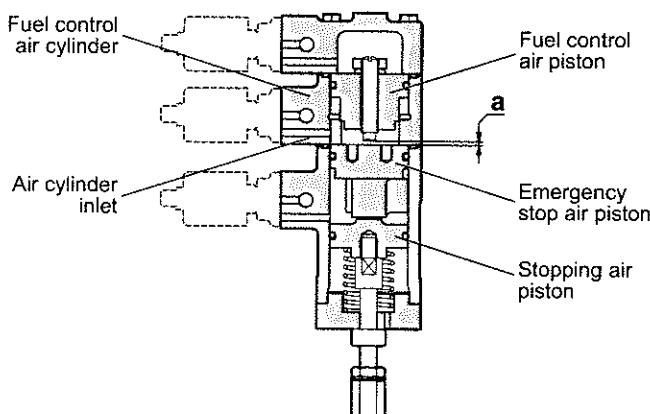


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Fig.3 Fuel cut-off air piston

2.3 Emergency stop air piston

- Triple air pistons have, in addition to the fuel injection volume control and the engine stop function, an extra emergency stop air piston. The emergency stop air piston is a safety system that is demanded by ship rules. It stops the fuel and the engine, in case the lubricating oil pressure decreases or if overspeeding occurs.
- The fuel injection amount control and stop air piston is operated by each solenoid valve. Control air (0.7 MPa to 1.0 MPa) enters from the air cylinder inlet to the inside of the air cylinder, and moves the air piston.
- The emergency stop air piston is operated by the control air that is supplied by the stop solenoid valve at a pressure of 0.7 MPa to 1.0 MPa. The air flows from the air cylinder inlet into the air cylinder. It moves the emergency stop piston down. The connecting rod is also moved down. It moves the No. 1 lever that is locked to the No. 1 lever shaft via the connecting rod. It stops the fuel injection and the engine. 40 to 60 seconds after the control air is cut off, the air inside the air cylinder is released into the atmosphere from the stop solenoid valve. The spring moves the air piston back up. This restores the previous state.
- The adjusting procedures are the same as described in Section 2.2 for the stopping air piston. But the air piston is correctly adjusted when shipped from our factory. Do not adjust it unless absolutely necessary.



A-65050-00005-A-01_EN

Fig.4 Emergency stop air piston

Fuel injection volume control air piston and stopping air piston
Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
 8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	b	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
SAFETY	O-ring		24311-000400		3 pc

Obey the instructions that follow when you do maintenance of the air piston.

1. Disassembly

1. Remove the clamping bolt from the air piston.
2. Remove the air piston from the engine.
3. Remove the cylinder cover 1.
4. Remove the fuel control piston 2.
5. Remove the fuel control air cylinder. (Only for emergency stops.)
6. Remove the air piston cover 5.
7. Remove the cut-off piston 3, the connecting rod 6 and the spring 4 together.

2. Assembly

1. Apply lubricating oil or lithium grease to all sliding parts of the injection control piston and the stopping piston.
2. Install the piston, connecting rod and spring.
3. Replace the O-ring with a new one.
4. Send control air to all air pistons. Make sure that the stopping piston moves.

NOTICE

When you install the emergency stop piston, carefully obey these instructions.

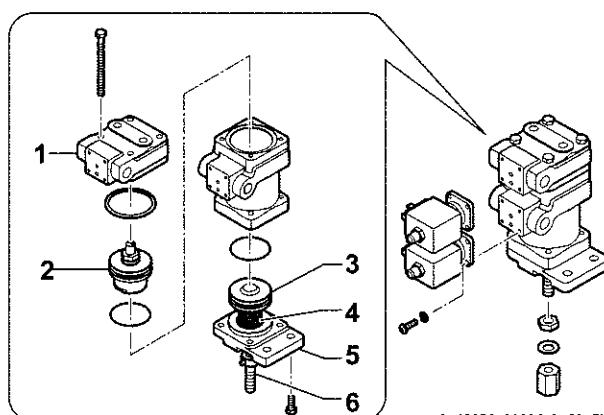


Fig.1 Air piston

CONDITION

1. Outline

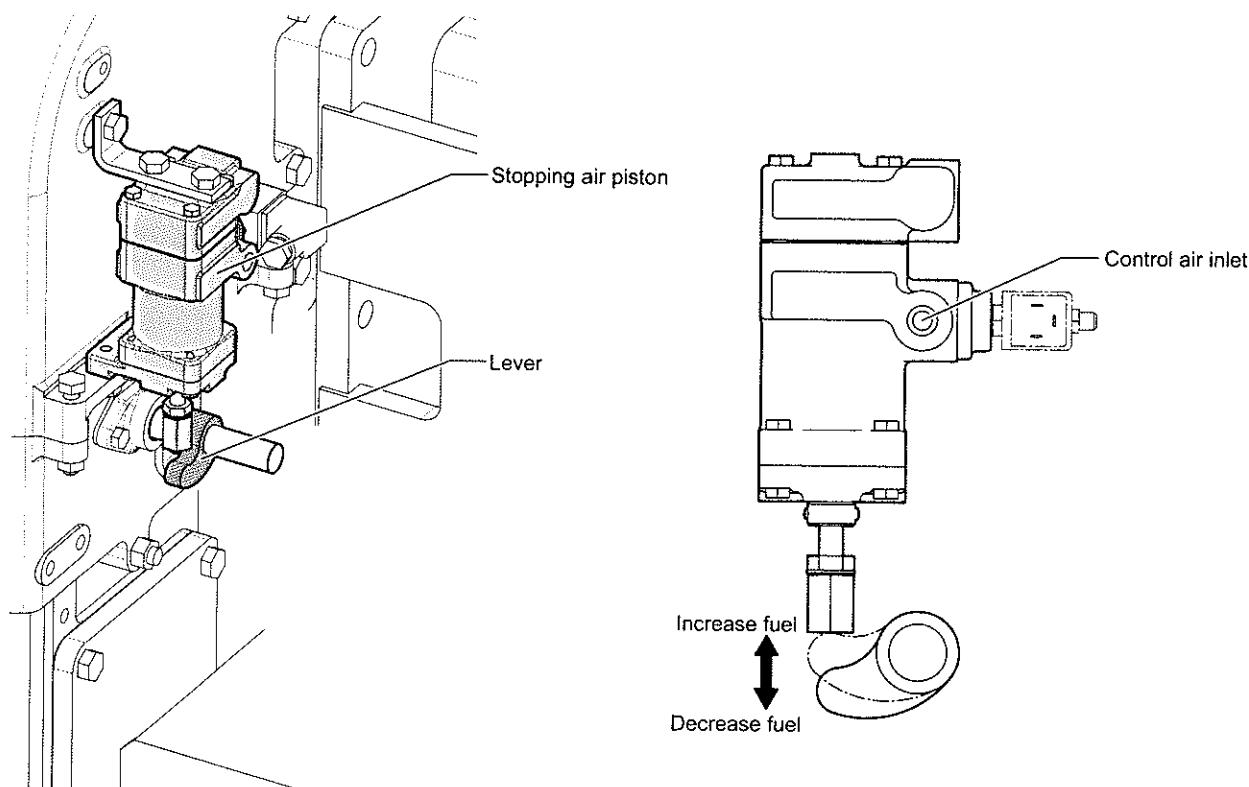


Fig. 1 Air piston

A-65050-00007-A-01_EN

- The air piston assembly is on the fuel injection pump chamber cover on the flywheel side.
- To do an inspection of the fuel cut-off air piston, send control air and examine the movement of the lever. Do a performance test at intervals of 3 months.

2. Structure

- When the engine stops automatically or remotely, the fuel cut-off air piston stops the supply of fuel oil in order to stop the engine.
- For this operation, the control air is supplied through the stopping solenoid valve at a pressure of 0.7 MPa to 1.0 MPa. It flows from the air cylinder inlet into the air cylinder. It moves the fuel cut-off air piston down.
- It moves the No. 1 lever that is locked to the No. 1 lever shaft via the connecting rod. It stops the fuel injection and the engine.
- 40 to 60 seconds after the control air is cut off, the air inside the air cylinder is released into the atmosphere from the stop solenoid valve. The spring moves the air piston up. This restores the previous state.

NOTICE

You can set the fuel pump rack scale (4 mm to 5 mm) to the correct no-fuel-injection with the cap nut (at the end of the connecting rod) and the locknut. But the rack scale is correctly adjusted when shipped from our factory. Do not adjust it unless it is required for a specific reason. If an adjustment becomes necessary, obey these instructions:

- If the rack scale gets close to 0 (zero), the movement that is transmitted by the stroke of the fuel cut-off air piston to the lever becomes too large and interferes with the rack. This causes malfunctions.
- On the other hand, if the rack scale becomes too large, the movement that is transmitted by the stroke of the fuel cut-off air piston to the lever becomes too small and the piston becomes unable to stop the engine.

Stopping air piston

Inspection and maintenance

1/1

PRODUCTION MANAGEMENT DATA

Intervals 2 years
8000 working hours

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	1 h
EQUIPMENT	Nomenclature			Identification code	Quantity
SUPPLIES	Nomenclature			Identification code	Quantity
SPARES	Nomenclature			Identification code	Quantity
	O-ring			24311-000400	1 pc
	Packing			44100-018310	1 pc
SAFETY					

Obey the instructions that follow when you do maintenance of the air piston.

1. Disassembly

1. Remove the mounting bolt 7 from the air piston.
2. Remove the air piston from the engine.
3. Remove the cylinder cover 1.
4. Remove the air piston cover 5.
5. Remove the cut-off piston 3, the connecting rod 6 and the spring 4 together.

2. Assembly

1. Apply lubricating oil or lithium grease to the sliding part of the piston.
2. Install the piston, connecting rod and spring.
3. Replace the O-rings and the packings with new ones.
4. Send control air to the air piston. Make sure that the fuel cut-off piston moves.

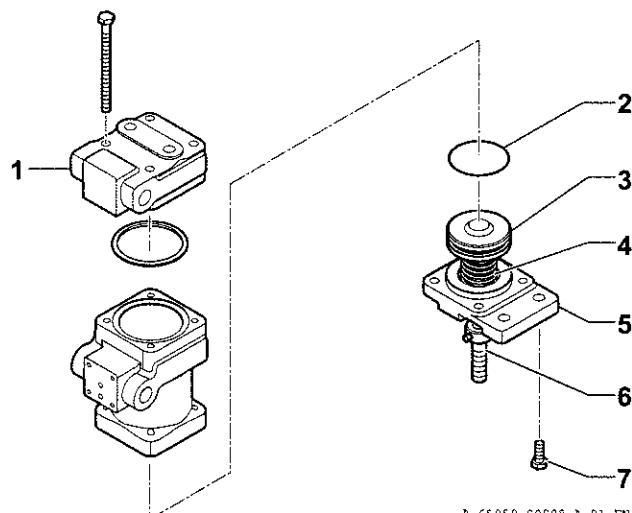
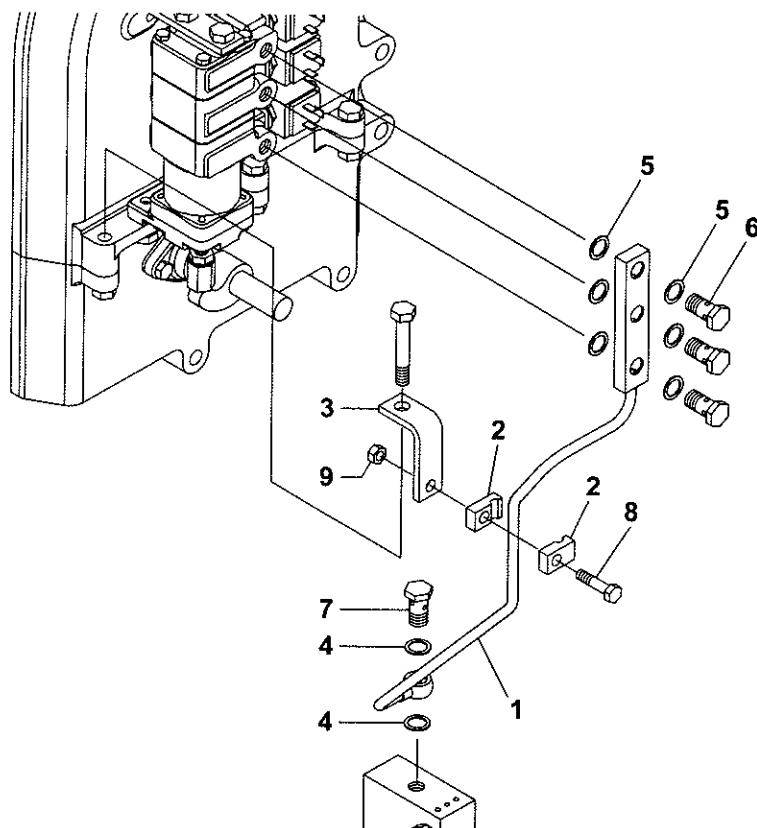


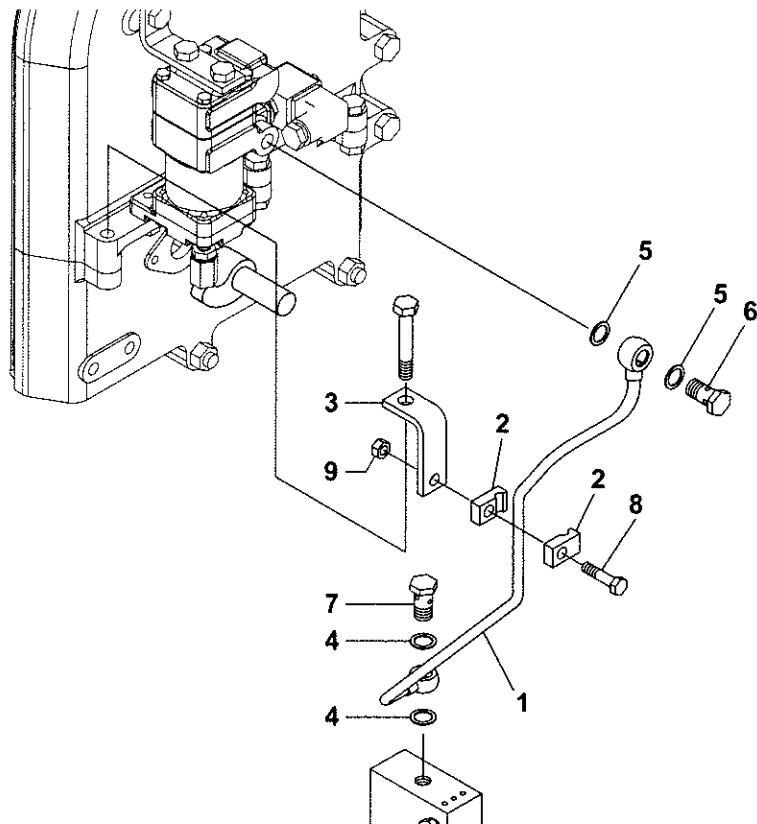
Fig.1 Air piston

CONDITION



A-65019-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-73400	PIPE, CONTROL AIR	1	1	
2	1	152623-59550	SUPPORT, INJ.PIPE 1	2	2	
3	1	150633-73390	BRACKET, CONTROL AIR	1	1	
4	1	23414-140000	GASKET, 14 X 1.0	2	2	
5	1	23414-140000	GASKET, 14 X 1.0	6	6	
6	1	23854-080000	BOLT, JOINT 8	3	3	
7	1	23854-080000	BOLT, JOINT 8	1	1	
8	1	26206-080352	BOLT, 8 X 35	1	1	
9	1	26706-080002	NUT, 8	1	1	

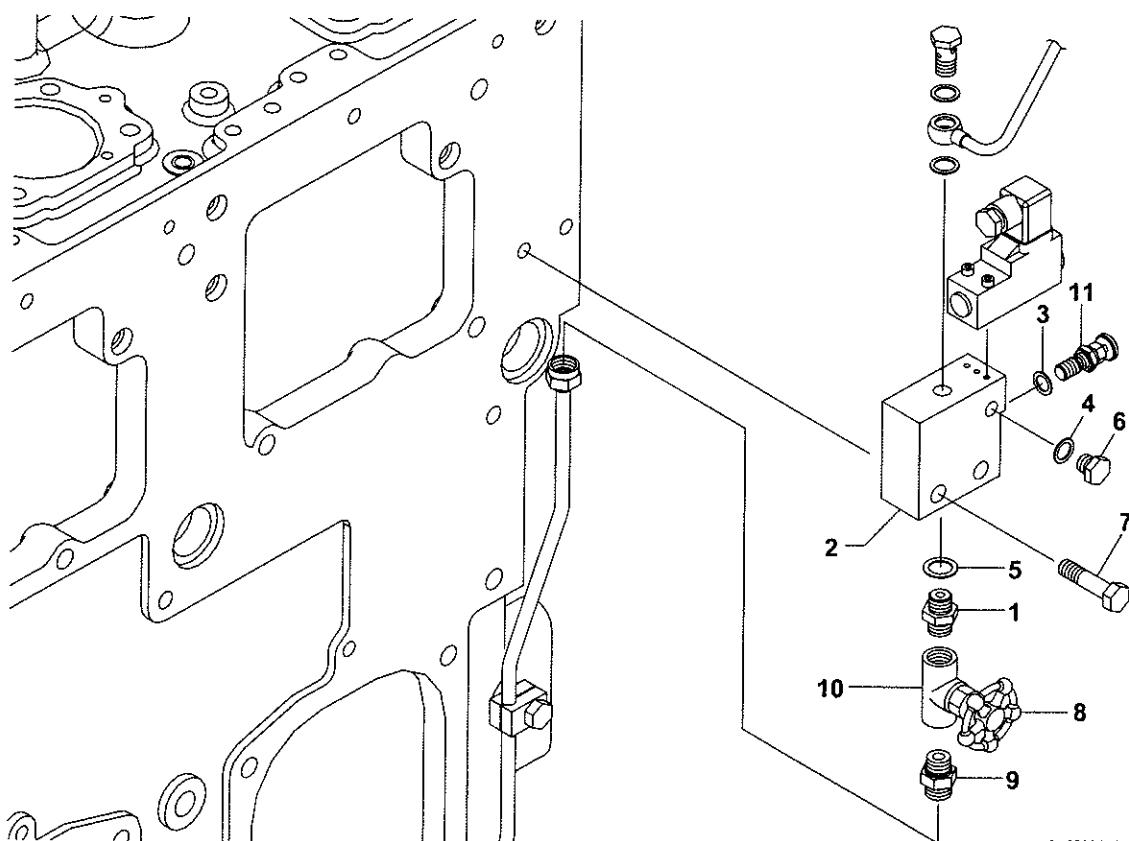


A-65019-00002-A-C1_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-73420	PIPE, CONTROL AIR	1	1	
2	1	152623-59550	SUPPORT, INJ.PIPE 1	2	2	
3	1	150633-73390	BRACKET, CONTROL AIR	1	1	
4	1	23414-140000	GASKET, 14 X 1.0	2	2	
5	1	23414-140000	GASKET, 14 X 1.0	2	2	
6	1	23854-080000	BOLT, JOINT 8	1	1	
7	1	23854-080000	BOLT, JOINT 8	1	1	
8	1	26206-080352	BOLT, 8 X 35	1	1	
9	1	26706-080002	NUT, 8	1	1	

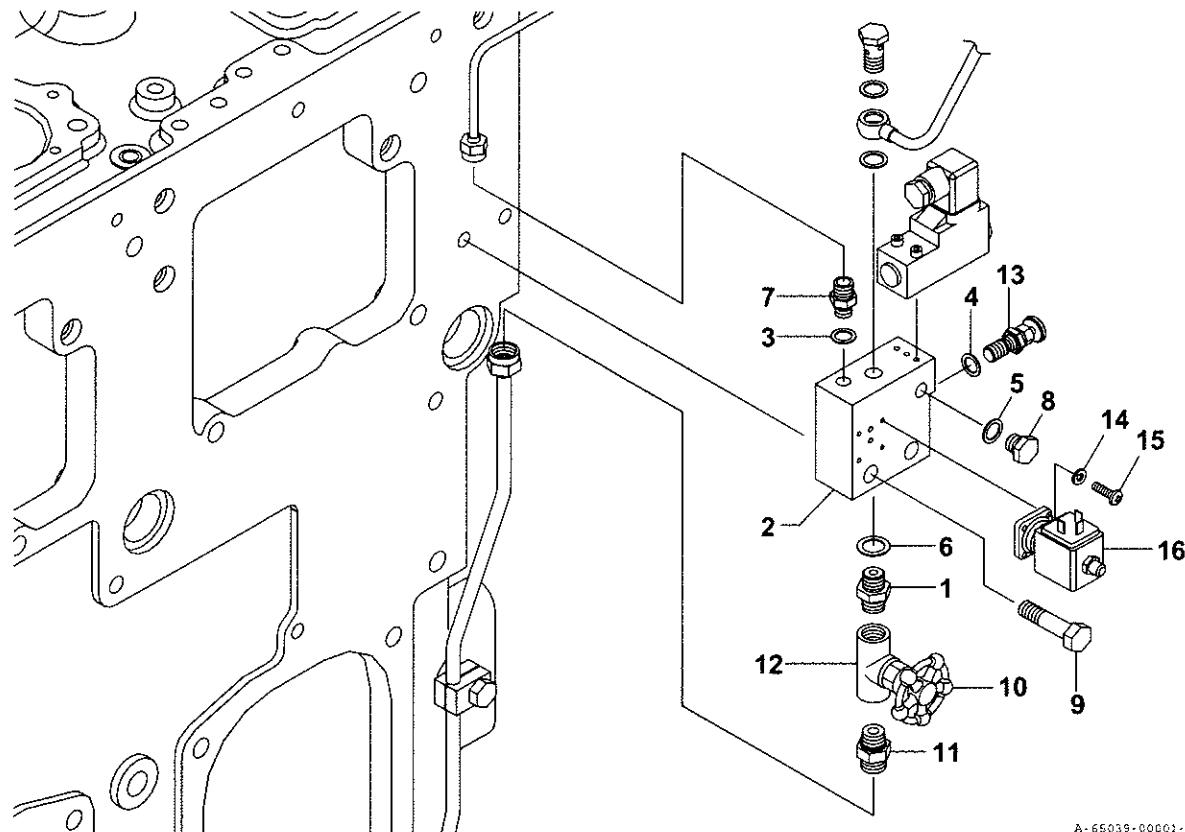
LWS, ALWS (1180kW or less): Lloyd's Register spec.

ALWS (1300kW or more): Standard



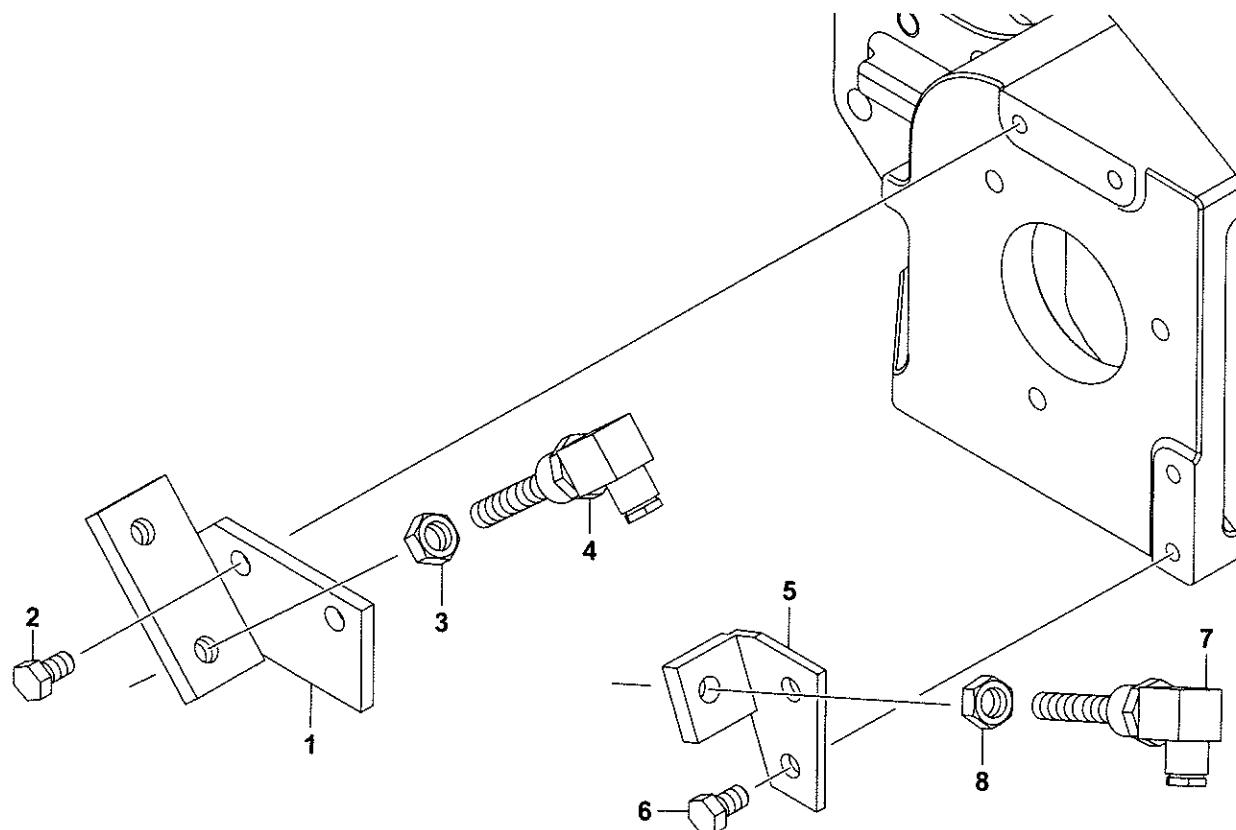
A-65029-00061-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	153605-59920	UNION,M16-PT3/8	1	1	
2	1	150633-73630	JOINT,CONTROL AIR	1	1	
3	1	23414-120000	GASKET, 12 X 1.0	1	1	
4	1	23414-130000	GASKET, 13 X 1.0	1	1	
5	1	23414-160000	GASKET, 16 X 1.0	1	1	
6	1	23897-020002	PLUG, G 1/4	1	1	
7	1	26206-120502	BOLT, 12 X 50	2	2	
8	1	42223-025570	LABEL, AIR VALVE	1	1	
9	1	43554-001621	UNION	1	1	
10	1	43600-016270	VALVE, BALL CHECK	1	1	
11	1	43600-030772	VALVE, NEEDLE	1	1	



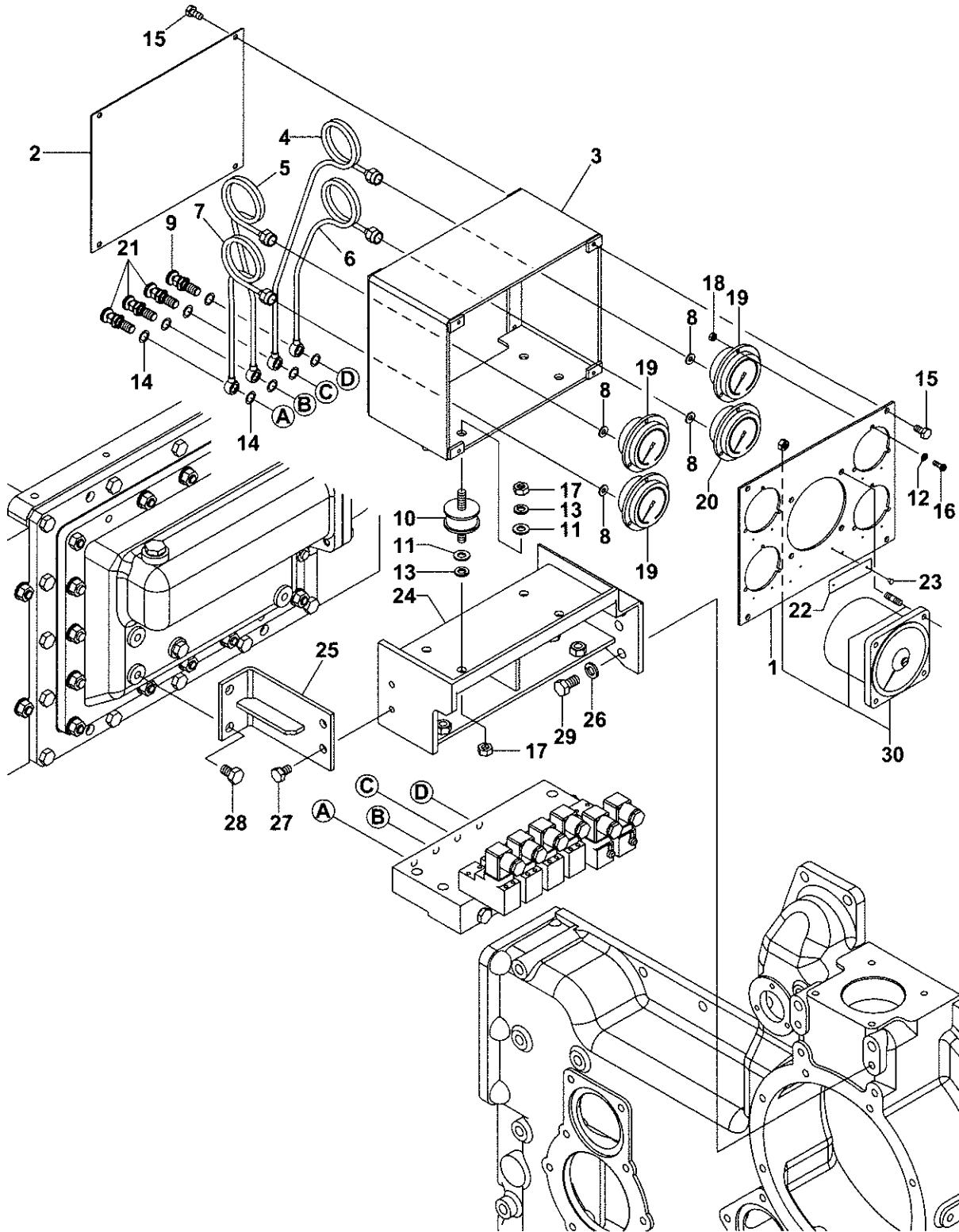
A-65039-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	153605-59920	UNION,M16-PT3/8	1	1	
2	1	150633-73640	JOINT,CONTROL AIR	1	1	
3	1	23414-120000	GASKET, 12 X 1.0	1	1	
4	1	23414-120000	GASKET, 12 X 1.0	1	1	
5	1	23414-130000	GASKET, 13 X 1.0	1	1	
6	1	23414-160000	GASKET, 16 X 1.0	1	1	
7	1	23834-060000	UNION, 6	1	1	
8	1	23897-020002	PLUG, G 1/4	1	1	
9	1	26206-120502	BOLT, 12 X 50	2	2	
10	1	42223-025570	LABEL, AIR VALVE	1	1	
11	1	43554-001621	UNION	1	1	
12	1	43600-016270	VALVE, BALL CHECK	1	1	
13	1	43600-030772	VALVE, NEEDLE	1	1	
14	1	22212-040000	WASHER, 4	1	1	
15	1	26557-040142	SCREW, 4 X 14	1	1	
16	1	46116-011340	3WAY MAGNETIC VALVE	1	1	



A-65049-01001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-86140	SUPPORT(PICKUP)	1	1	
2	1	26206-120222	BOLT, 12 X 22	2	2	
3	1	45511-006890	NUT, 5/8-18UNF	1	1	
4	1	46150-078200	PICKUP, MAGNET	1	1	
5	1	150635-86100	SUPPORT,PICKUP	-	1	LR 1100kW or more
6	1	26206-120252	BOLT, 12 X 25	-	2	LR 1100kW or more
7	1	46150-078200	PICKUP, MAGNET	-	1	LR 1100kW or more
8	1	45511-006890	NUT, 5/8-18UN	-	1	LR 1100kW or more



Gauge panel

Illustrated parts data

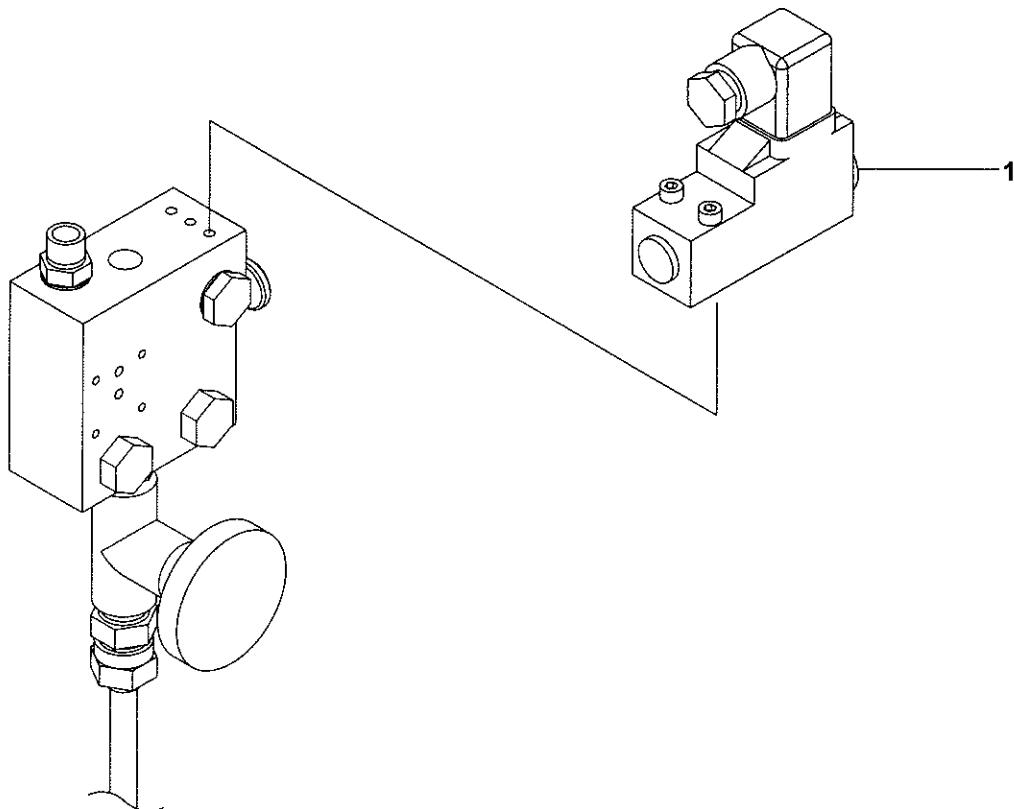
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	146623-91011	SSPPORT, GAUGE BOARD	1	1	
2	1	150633-91161	COVER, GAUGE BOARD	1	2	
3	1	150633-91190	CASE, GAUGE BOARD	1	3	
4	1	150633-91820	PIPE, PRESS.GAUGE	1	4	
5	1	150633-91830	PIPE, PRESS.GAUGE	1	5	
6	1	150633-91840	PIPE, PRESS.GAUGE	1	6	
7	1	150633-91850	PIPE, PRESS.GAUGE	1	7	
8	1	122117-39150	PACKING	4	8	
9	1	146625-59710	VALVE, NEEDLE	1	9	
10	1	147673-86380	RUBBER, CUSHION M10	4	10	
11	1	22137-100000	WASHER, 10	8	11	
12	1	22217-040000	WASHER, 4	12	12	
13	1	22217-100000	WASHER, 10	8	13	
14	1	23414-120000	GASKET, 12 X 1.0	8	14	
15	1	26106-060122	BOLT, 6 X 12	8	15	
16	1	26557-040122	SCREW, 4 X 12	12	16	
17	1	26706-100002	NUT, 10	8	17	
18	1	26717-040002	NUT, 4	12	18	
19	1	28886-060000	PRESSUREGA, 0.6MP	3	19	
20	1	28886-105560	PRESSUREGA, 1.0MP	1	20	
21	1	43600-030773	VALVE, NEEDLE	3	21	
22	1	42221-021240	LABEL, PRM	1	22	
23	1	137900-91451	RIVET, PARKERIZED	2	23	
24	1	150633-91150	BRACKET, GAUGE BOARD	1	24	
25	1	150633-91170	SUPPORT, GAUGE BOARD	1	25	
26	1	22217-120000	WASHER, 12	4	26	
27	1	26206-100182	BOLT, 10 X 18	2	27	
28	1	26206-120202	BOLT, 12 X 20	2	28	
29	1	26206-120252	BOLT, 12 X 25	4	29	
30	1	146623-91781	INDICATOR	1	30	

Pressure switch (control air)

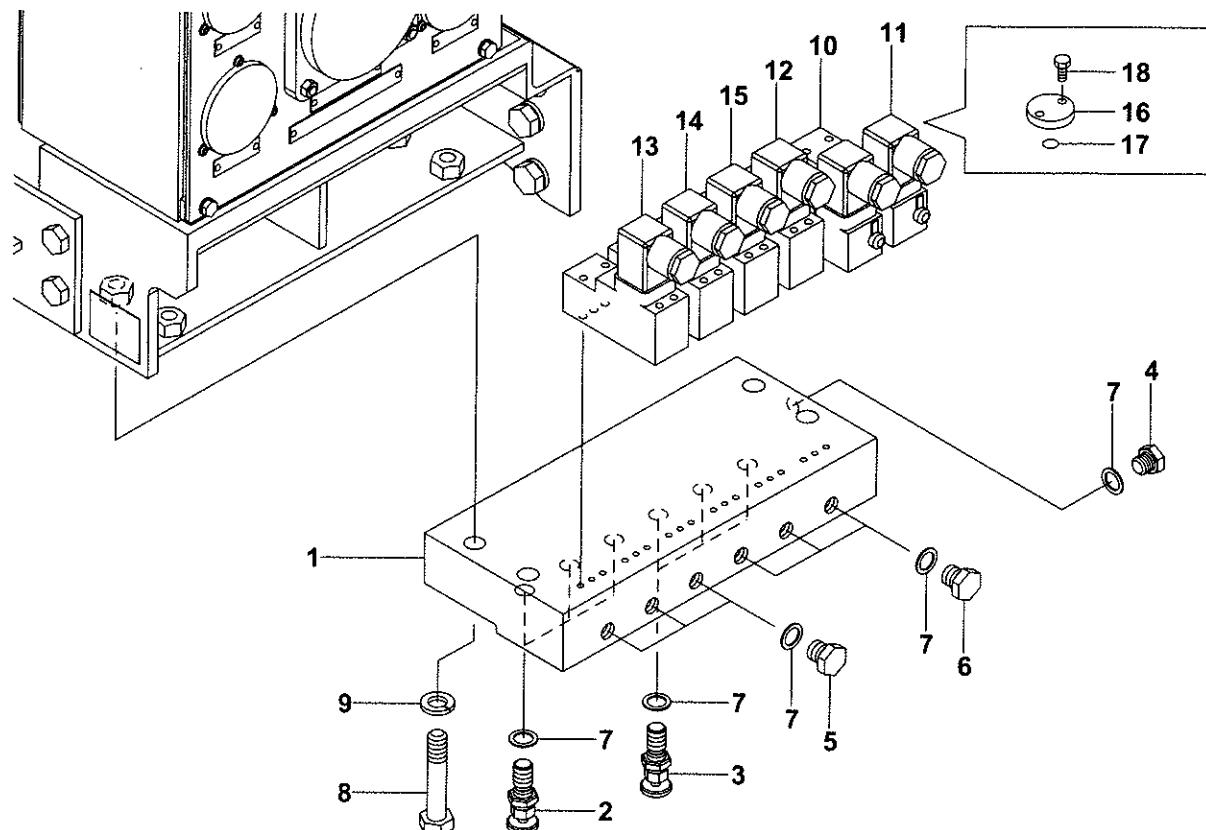
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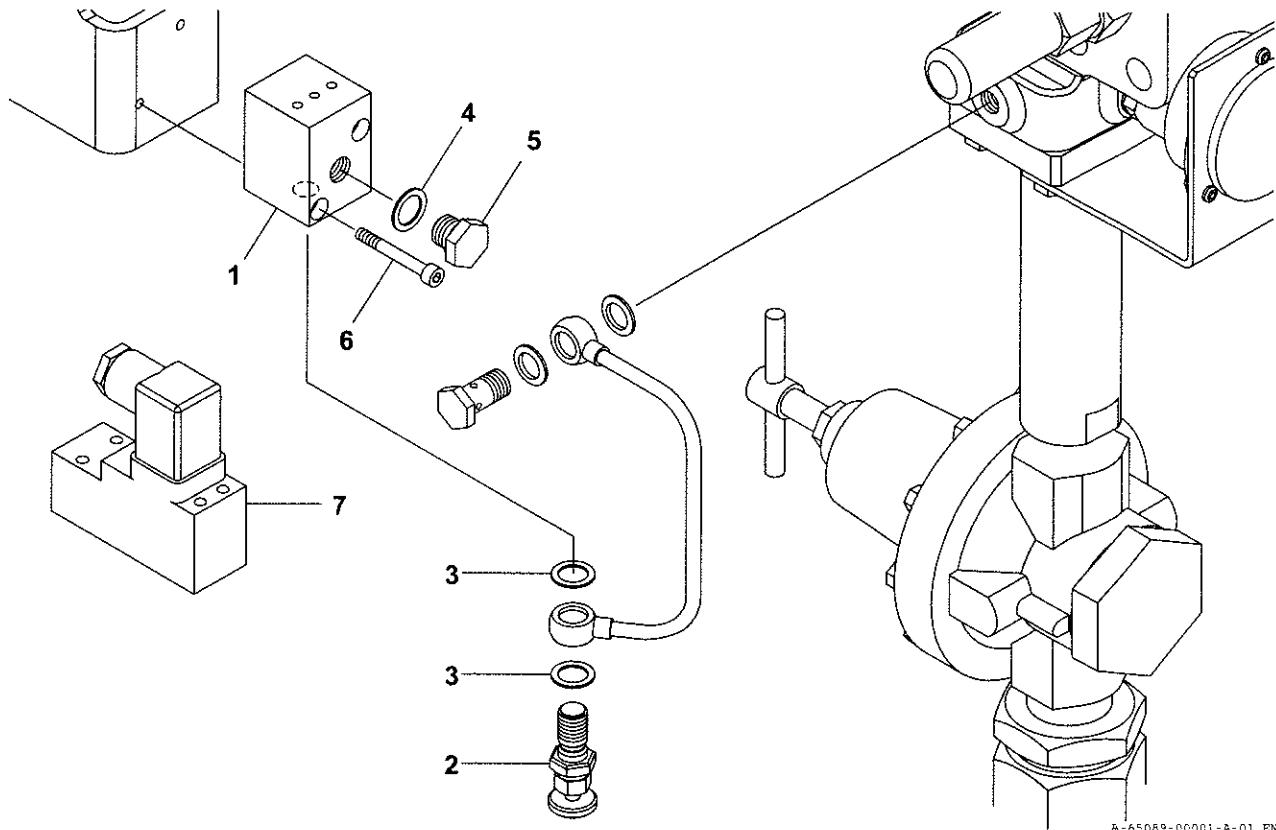
A-65069-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46111-027621	PRESSURE SWITCH	1	1	

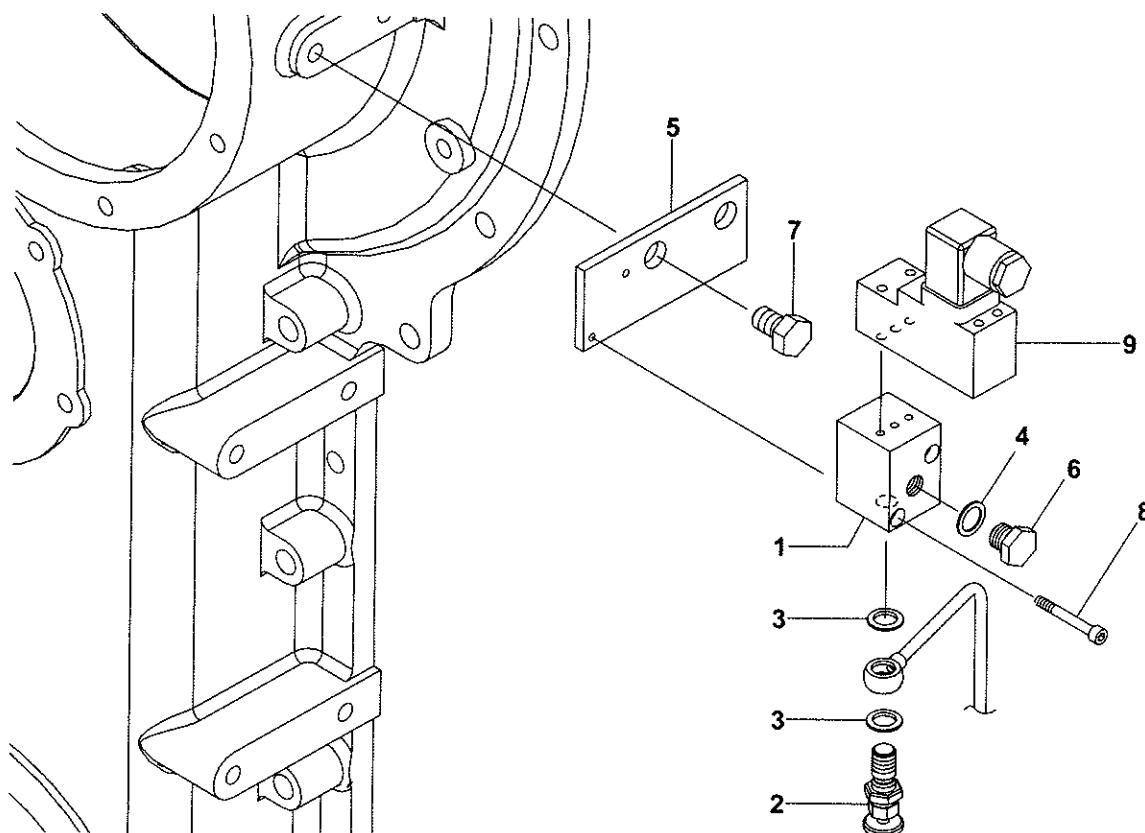


A-65079-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-86100	TEST VALVE	1	1	
2	1	146625-59710	VALVE, NEEDLE	3	3	
3	1	43600-030772	VALVE, NEEDLE	3	3	
4	1	23887-120002	PLUG, 12	1	1	
5	1	23894-020002	PLUG, G 1/4	3	3	
6	1	23897-020002	PLUG, G 1/4	3	3	
7	1	23414-120000	GASKET, 12 X 1.0	13	13	
8	1	26206-120652	BOLT, 12 X 65	4	4	
9	1	22212-120000	WASHER, 12	4	4	
10	1	46111-027601	PRESSURE SWITCH	1	1	
11	1	46111-027371	PRESSURE SWITCH	1	1	
12	1	46150-050131	PRESSURE TRANSMITTER	1	1	
13	1	46150-050121	PRESSURE TRANSMITTER	1	1	
14	1	46150-050121	PRESSURE TRANSMITTER	1	1	
15	1	46150-050121	PRESSURE TRANSMITTER	1	1	
16	1	43310-007770	FLANGE, CLOSE	1	1	
17	1	24311-000070	PACKING, P 7.0	1	1	
18	1	26116-050122	BOLT, 5 X 12	2	2	



No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46150-052411	VALVE,TEST 1	1	1	
2	1	43600-030772	VALVE, NEEDLE	1	1	
3	1	23414-120000	GASKET, 12 X 1.0	2	2	
4	1	23414-130000	GASKET, 13 X 1.0	1	1	
5	1	23897-020002	PLUG, G 1/4	1	1	
6	1	26450-050402	BOLT, 5 X 40	2	2	
7	1	46111-027651	PRESSURE SWITCH	1	1	



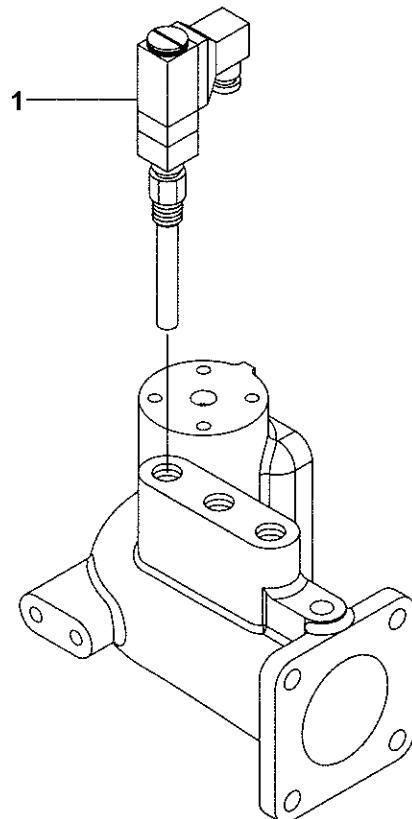
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46150-076180	VALVE TEST 1	1	1	
2	1	146625-59710	VALVE, NEEDLE	1	1	
3	1	153672-59920	WASHER, SEAL 12X1.2	2	2	
4	1	153672-59930	WASHER, SEAL 14	1	1	
5	1	150633-86300	BRACKET, FO PRESS SW	1	1	
6	1	23897-020002	PLUG, G 1/4	1	1	
7	1	26206-120202	BOLT, 12 X 20	2	2	
8	1	26450-050402	BOLT, 5 X 40	2	2	
9	1	46150-051011	PRESSURE TRANSMITTER	1	1	

Temperature switch

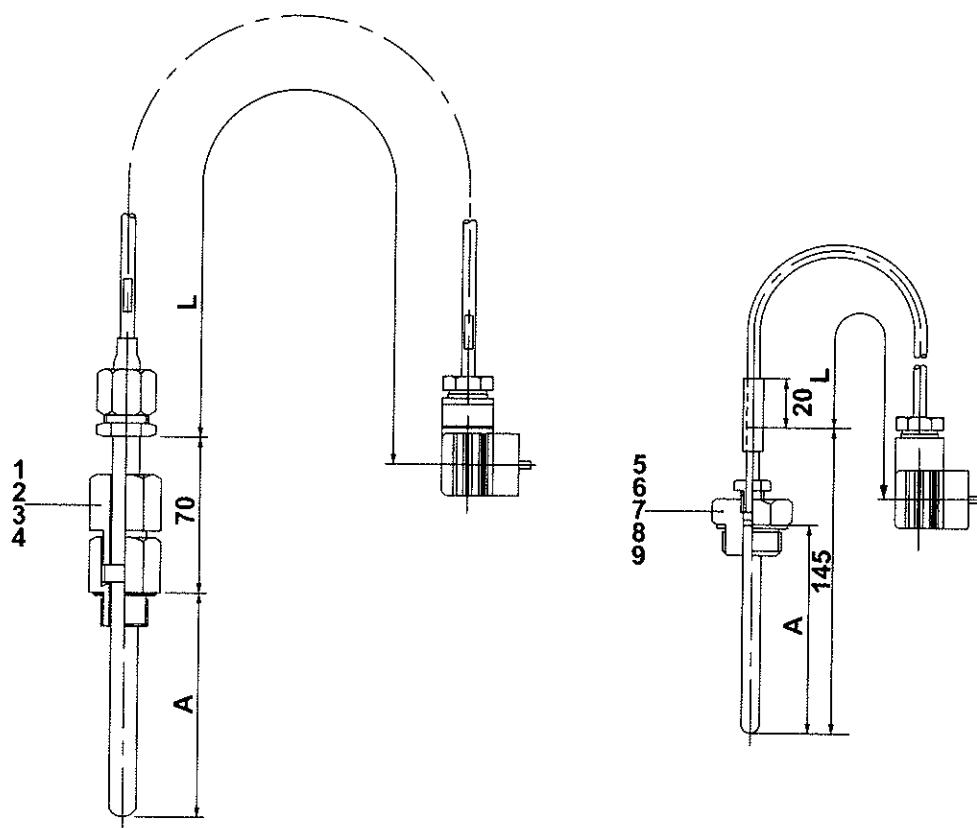
Illustrated parts data

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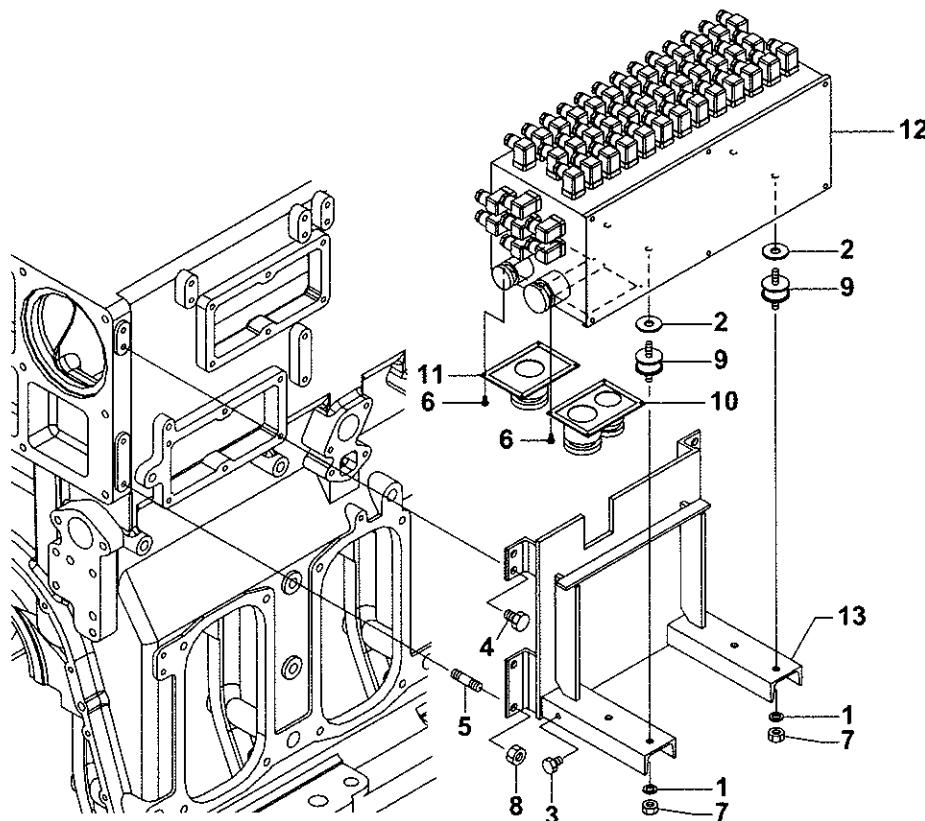
A-65109-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46111-042311	RELAY,THERMO. 100C	1	1	



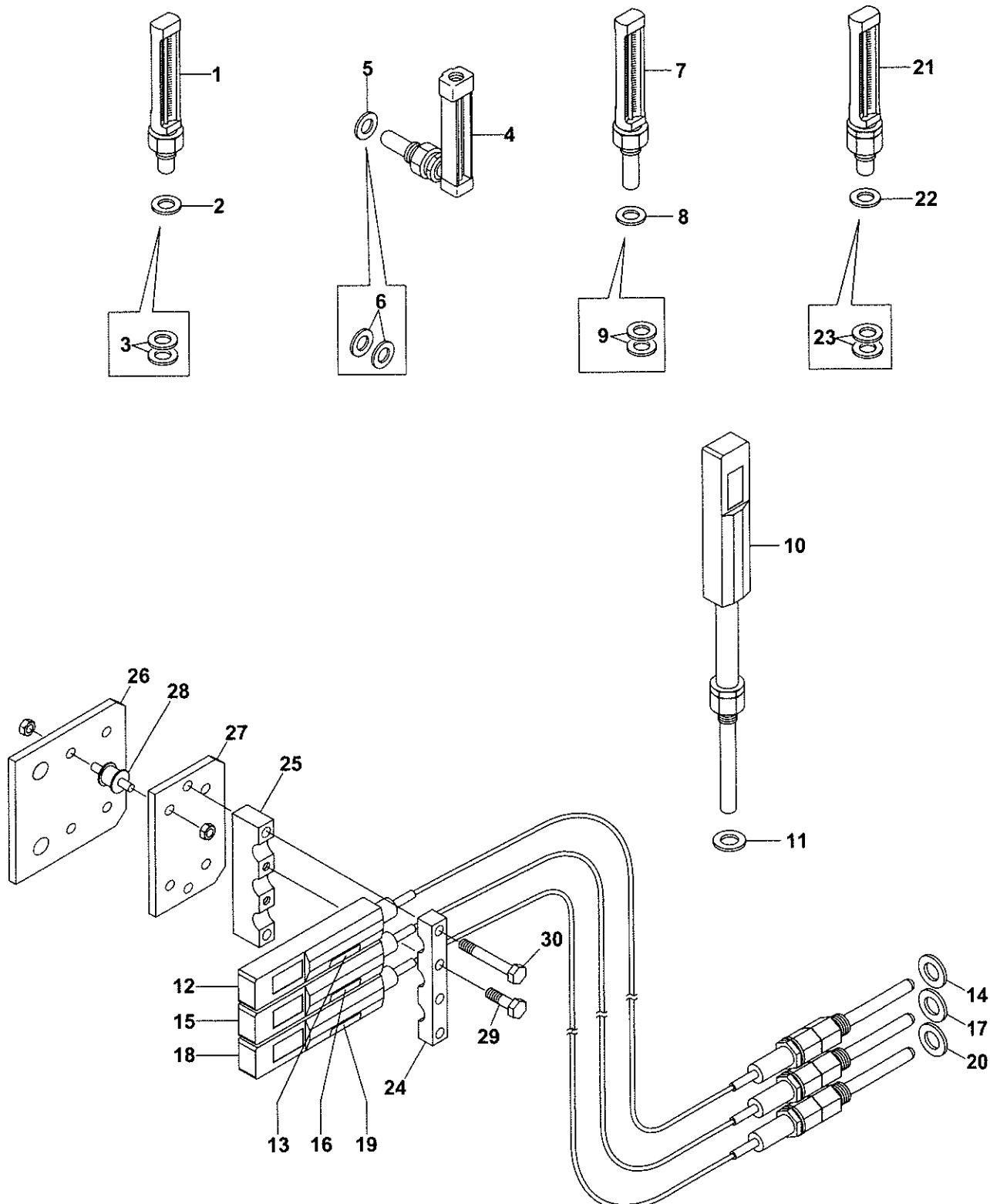
A-65119-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	46150-053950	RESISTANCE THERMOMETER	1	1	A=100,I=4500 T/C OUT
2	1	46150-065850	RESISTANCE THERMOMETER	1	1	A=100,I=4100 T/C OUT
3	1	46150-078120	RESISTANCE THERMOMETER	1	1	A=100,I=3900 T/C IN
4	1	46150-078140	RESISTANCE THERMOMETER	1	1	A=100,I=3500 T/C IN
5	1	46150-078150	RESISTANCE THERMOMETER	1	1	A=100,I=2800 L.O IN
6	1	46150-078160	RESISTANCE THERMOMETER	1	1	A=100,I=4100 HCW OUT
7	1	46150-078170	RESISTANCE THERMOMETER	1	1	A=100,I=4200 LCW IN
8	1	46150-078180	RESISTANCE THERMOMETER	1	1	A=100,I=2800 I/C OUT
9	1	46150-078190	RESISTANCE THERMOMETER	1	1	A=60,I=5100 F.O IN



A-65129-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	22137-100000	WASHER, 10	4	4	
2	1	22151-140000	WASHER, 14	4	4	
3	1	26206-100122	BOLT, 10 X 12	1	1	
4	1	26206-120202	BOLT, 12 X 20	4	4	
5	1	26212-120252	STUD,BOLT 12 X 25	4	4	
6	1	26557-030062	SCREW, 3 X 6	8	8	
7	1	26706-100002	NUT, 10	4	4	
8	1	26706-120002	NUT, 12	4	4	
9	1	41411-001641	ABSORBER, SHOCK M10	4	4	
10	1	46150-054390	COVER, JB OUT 15.15	1	1	
11	1	46150-052840	COVER, JB OUT 30	1	1	
12	1	46150-075180	JUNCTION BOX,114P	1	1	
13	1	46150-075191	BRACKET,J/B	1	1	

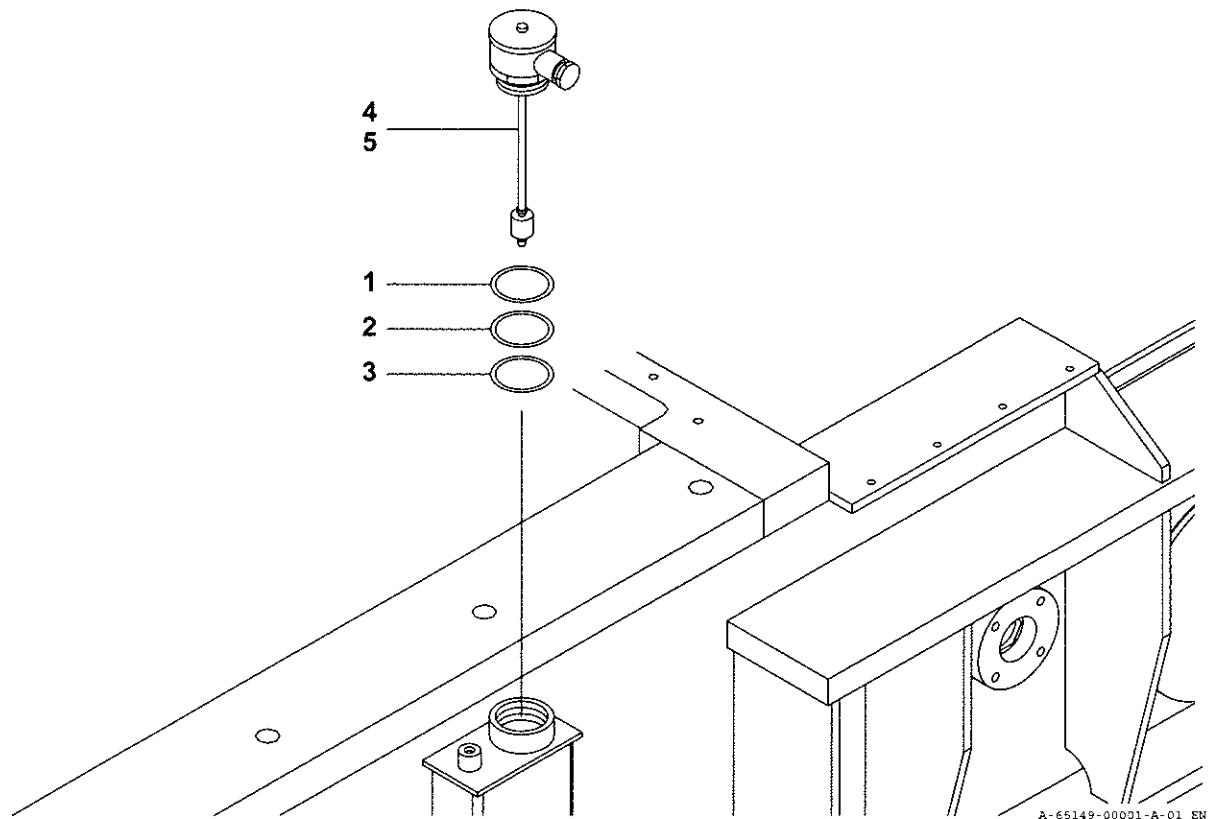


Thermometer

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	28551-030300	THERMOMETER, 100	4	4	
2	1	23414-170500	GASKET, 17 X 0.5	4	4	
3	1	23414-170250	GASKET, 17 X 0.25	8	8	
4	1	42130-012860	THERMOMETER, L 100C	3	3	
5	1	23414-170500	GASKET, 17 X 0.5	3	3	
6	1	23414-170250	GASKET, 17 X 0.25	6	6	
7	1	146673-91310	THERMOMETER, 120C S	1	1	
8	1	23414-170500	GASKET, 17 X 0.5	1	1	
9	1	23414-170250	GASKET, 17 X 0.25	2	2	
10	1	150633-91306	DIGITAL THERMOMETER	6	6	
11	1	23414-210000	GASKET, 21 X 1.0	6	6	
12	1	150633-91317	DIGITAL THERMOMETER	1	1	
13	1	150633-91350	NAME PLATE, THERMO	1	1	
14	1	23414-210000	GASKET, 21 X 1.0	1	1	
15	1	150633-91317	DIGITAL THERMOMETER	1	1	
16	1	150633-91360	NAME PLATE, THERMO	1	1	
17	1	23414-210000	GASKET, 21 X 1.0	1	1	
18	1	150633-91317	DIGITAL THERMOMETER	1	1	
19	1	150633-91370	NAME PLATE, THERMO	1	1	
20	1	23414-210000	GASKET, 21 X 1.0	1	1	
21	1	150633-91290	THERMOMETER(200 G3/8)	1	1	
22	1	23414-170500	GASKET, 17 X 0.5	1	1	
23	1	23414-170250	GASKET, 17 X 0.25	2	2	
24	1	150633-91430	BRACKET, THERMO	1	1	
25	1	150633-91440	BRACKET, THERMO	1	1	
26	1	150633-91450	BRACKET, THERMO	1	1	
27	1	150633-91470	BRACKET, THERMO	1	1	
28	1	41411-001591	RUBBER CUSHION	4	4	
29	1	26206-100352	BOLT, 10 X 35	2	2	
30	1	26206-100702	BOLT, 10 X 70	2	2	

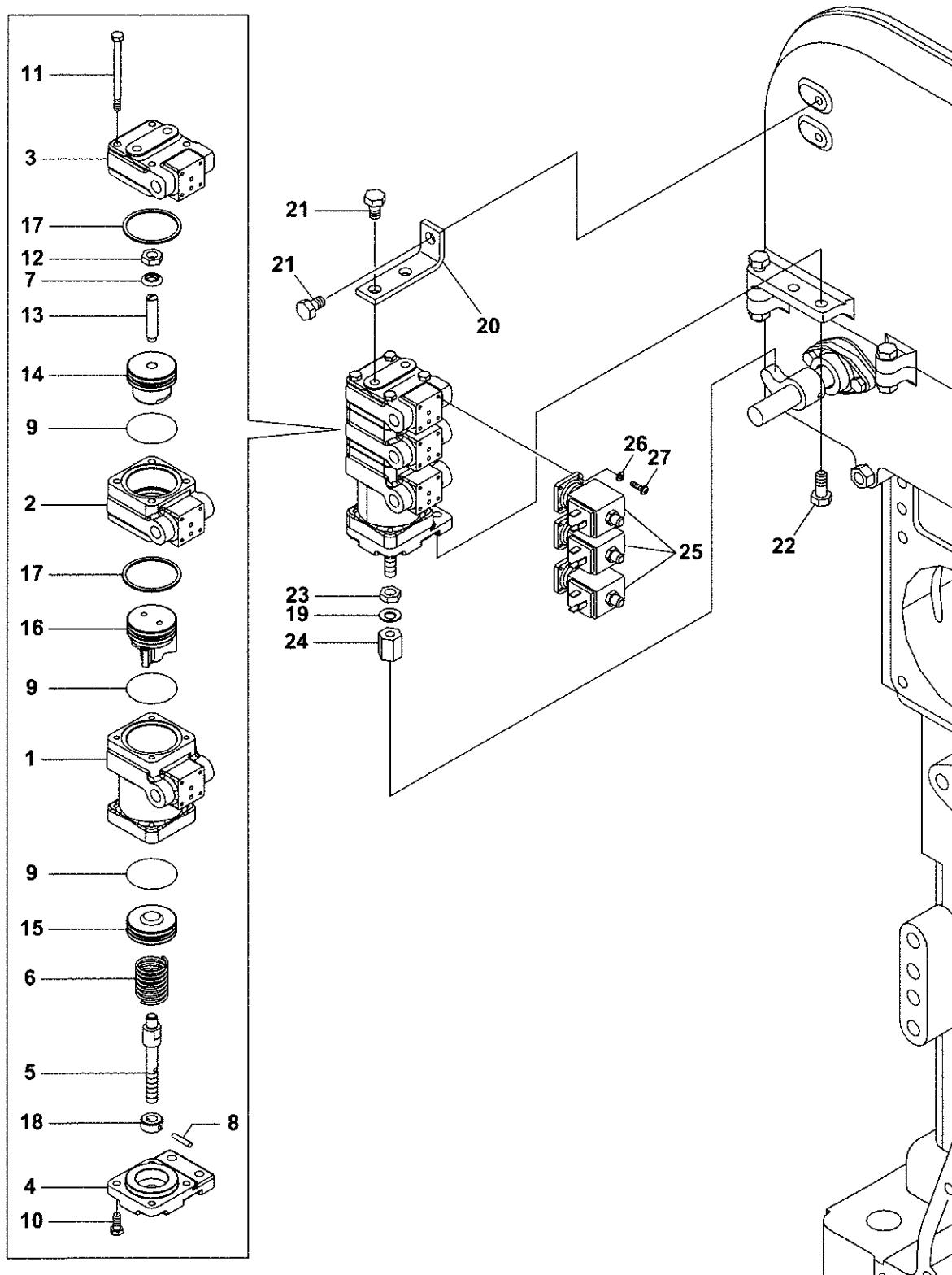


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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	43400-004030	GASKET, FLORT SWITCH	1	1	
2	1	43400-006030	GASKET, FLORT SWITCH 0.5	1	1	
3	1	43400-006240	GASKET, FLORT SWITCH 0.8	1	1	
4	1	46111-047920	FLOAT SWITCH(LOW)	1	1	
5	1	46111-047930	FLOAT SWITCH(H,L)	1	1	

Fuel injection volume control air piston and stopping air piston
Illustrated parts data

1/2



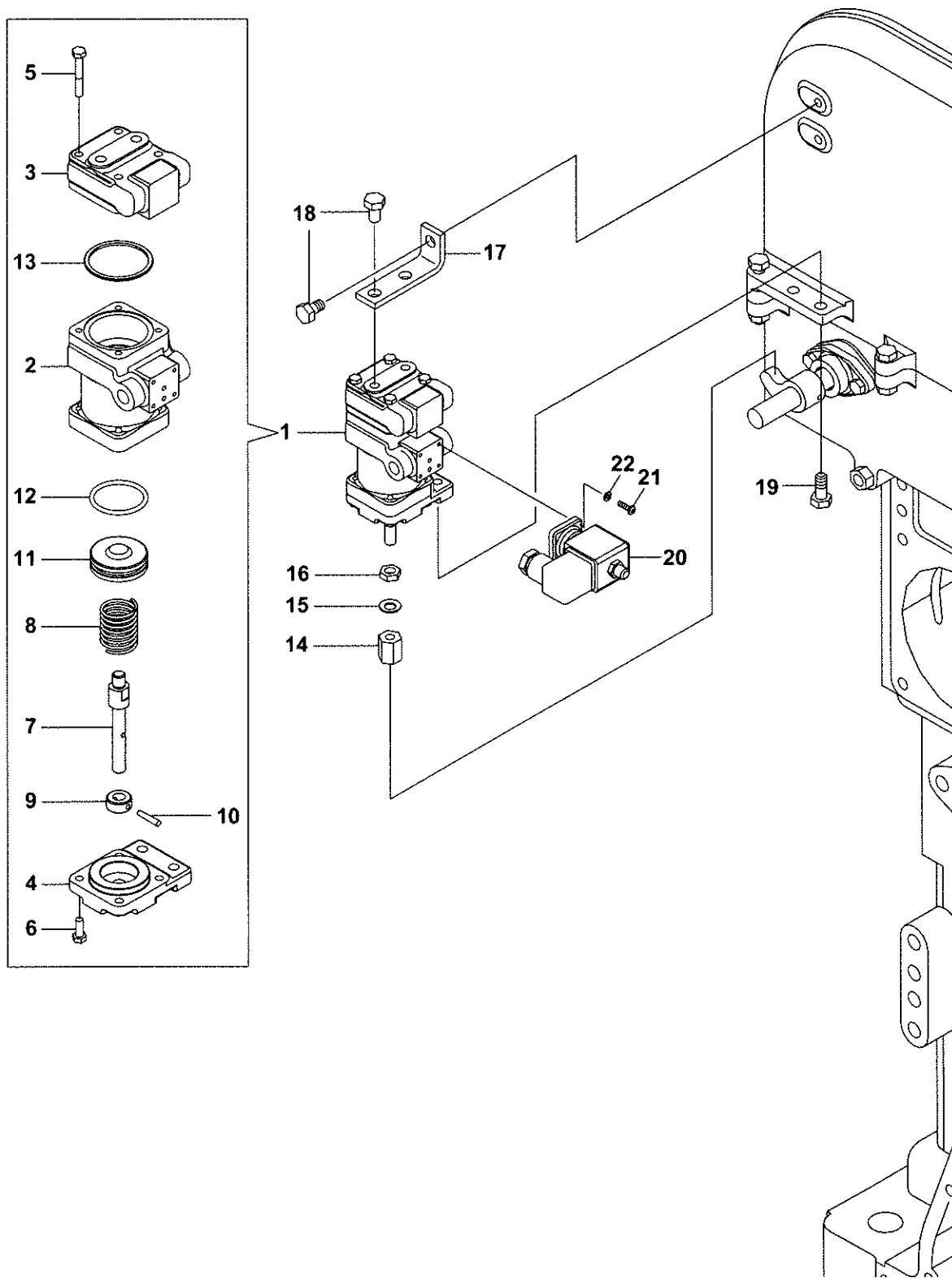
A-65159-00001-A-01_EN

Fuel injection volume control air piston and stopping air piston
Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	146623-65050	AIR CYLINDER, STOP	1	1	
2	2	146623-65060	AIR CYLINDER, LIMIT	1	1	
3	2	146623-65070	COVER, AIR CYLINDER	1	1	
4	2	146623-65200	COVER, AIR PISTON	1	1	
5	2	146623-65400	ROD, AIR PISTON	1	1	
6	2	134673-66420	SPRING, CONNECT PIPE	1	1	
7	2	22190-100001	WASHER, SEAL 10	1	1	
8	2	22322-040220	PIN, 4 X 22	1	1	
9	2	24311-000400	PACKING, P 40.0	3	3	
10	2	26116-060162	BOLT, 6 X 16	4	4	
11	2	26116-060802	BOLT, 6 X 80	4	4	
12	2	26696-100002	NUT, 10	1	1	
13	2	44100-002370	BOLT, ADJUSTING	1	1	
14	2	44100-004260	PISTON, AIR	1	1	
15	2	44100-004270	PISTON, AIR	1	1	
16	2	44100-009960	PISTON, AIR	1	1	
17	2	44100-018310	PACKING, STOPPING	2	2	
18	2	44112-000170	COLLAR, OPERATE ROD	1	1	
19	1	159616-23570	SPRING, CONICAL	1	1	
20	1	150633-65300	SUPPORT,AIR PISTON	1	1	
21	1	26206-100182	BOLT, 10 X 18	3	3	
22	1	26206-100252	BOLT, 10 X 25	2	2	
23	1	26796-100002	NUT, 10	1	1	
24	1	44112-000440	FITTING, LEVER	1	1	
25	1	46116-011340	3WAY MAGNETIC VALVE	3	3	
26	1	22212-040000	WASHER, 4	12	12	
27	1	26557-040142	SCREW, 4 X 14	12	12	

Illustrated parts data



A-65159-00002-A-01_EN

Stopping air piston

Illustrated parts data

2/2

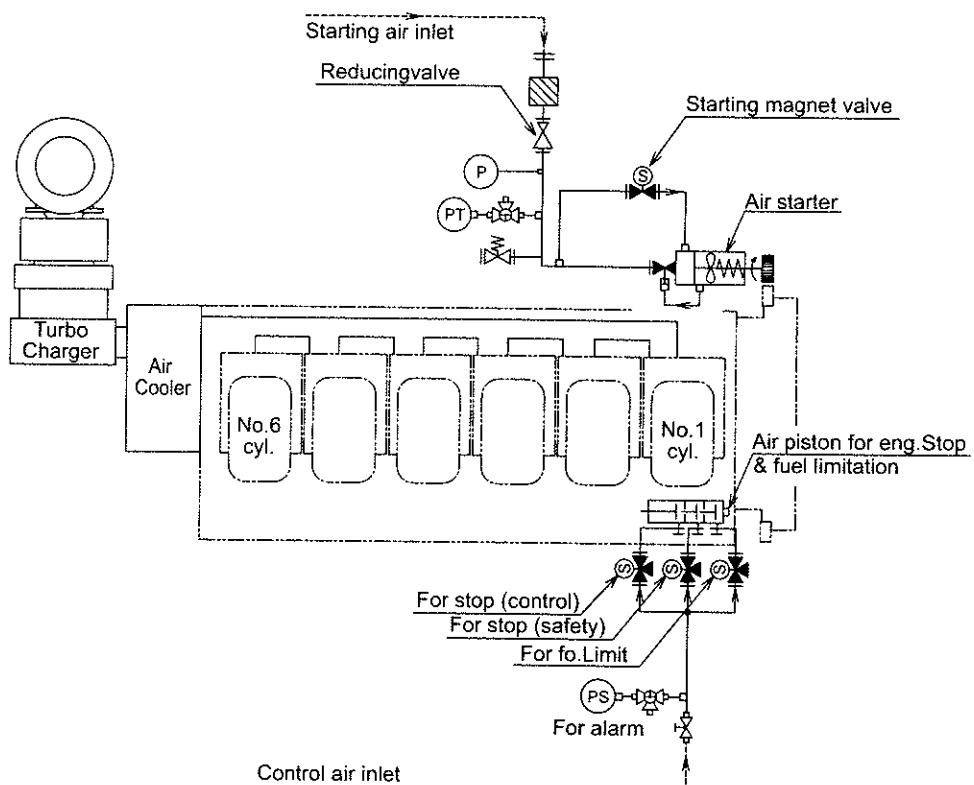
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	750643-65020	AIR PISTON ,FO CUT	1	1	
2	2	146623-65050	AIR CYLINDER, STOP	1	1	
3	2	150643-65010	COVER, AIR CYLINDER	1	1	
4	2	150643-65020	COVER, AIR PISTON	1	1	
5	2	26116-060162	BOLT, 6 X 16	4	4	
6	2	26116-060402	BOLT, 6 X 40	4	4	
7	2	146623-65400	ROD, AIR PISTON	1	1	
8	2	134673-66420	SPRING, CONNECT PIPE	1	1	
9	2	44112-000170	COLLAR, OPERATE ROD	1	1	
10	2	22322-040220	PIN, 4 X 22	1	1	
11	2	44100-004270	PISTON, AIR	1	1	
12	2	24311-000400	PACKING, P 40.0	1	1	
13	2	44100-018310	PACKING, STOPPING	1	1	
14	1	44112-000440	FITTING, LEVER	1	1	
15	1	159616-23570	SPRING, CONICAL	1	1	
16	1	26796-100002	NUT, 10	1	1	
17	1	150633-65300	SUPPORT,AIR PISTON	1	1	
18	1	26206-100182	BOLT, 10 X 18	3	3	
19	1	26206-100252	BOLT, 10 X 25	2	2	
20	1	46116-011340	3WAY MAGNETIC VALVE	1	1	
21	1	26557-040142	SCREW, 4 X 14	4	4	
22	1	22212-040000	WASHER, 4	4	4	

LWS, ALWS (1180kW or less): Lloyd's Register spec.

ALWS (1300kW or more): Standard

1. Outline

- The air system of this engine has 2 components:
 - The starting air system that starts the engine.
 - The safety/control air system that controls the volume of fuel injected when the engine starts and that also stops the engine.
- This engine has an air starter starts the engine.
- The reducing valve reduces the pressure of the compressed air that starts the engine (maximum pressure: 2.9 MPa) to 0.90 MPa - 1.1 MPa. Then the compressed air is sent to the air starter.
- The safety and control air system sends air from inside the vessel with a pressure of 0.7 MPa to 1.0 MPa and moves the air piston.
- Install the drain valve or the automatic drain device in the lowest part of the piping between the air reservoir and the air starter.
- Always use dry air for control air.



(Remarks)

The diagram shows the standard circuit.

Details for each engine are provided in the final drawing.

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Fig. 1 Starting and control air system

2. Startup device

- The startup device is a turbine-type air starter that drives the ring gear through the pinion gear and starts the engine. The model number is TDITURBOTWIN T510. The starting air pressure of 1.0 MPa creates a maximum torque of 325N·m.
- The air starter has a combined relay valve and start solenoid valve.

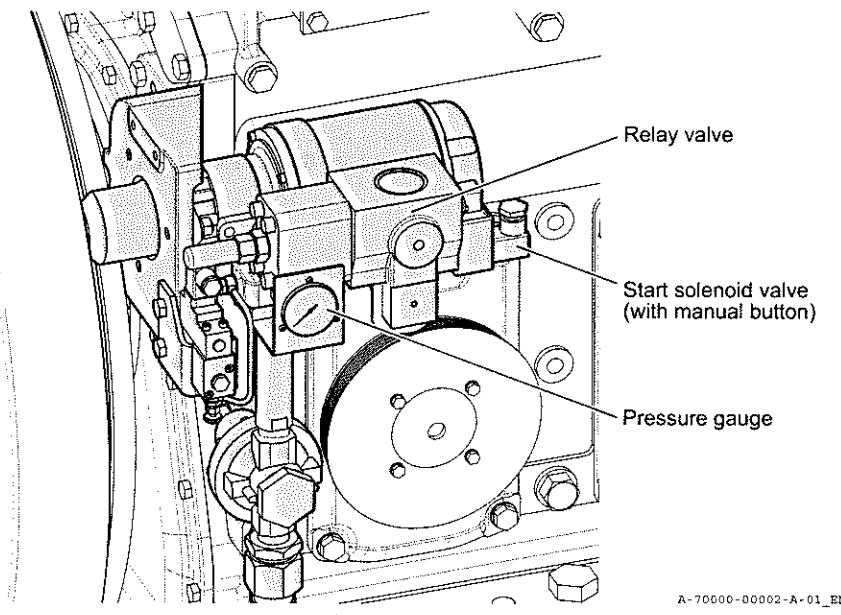


Fig.2 Air starter

A-70600-00002-A-01_EN

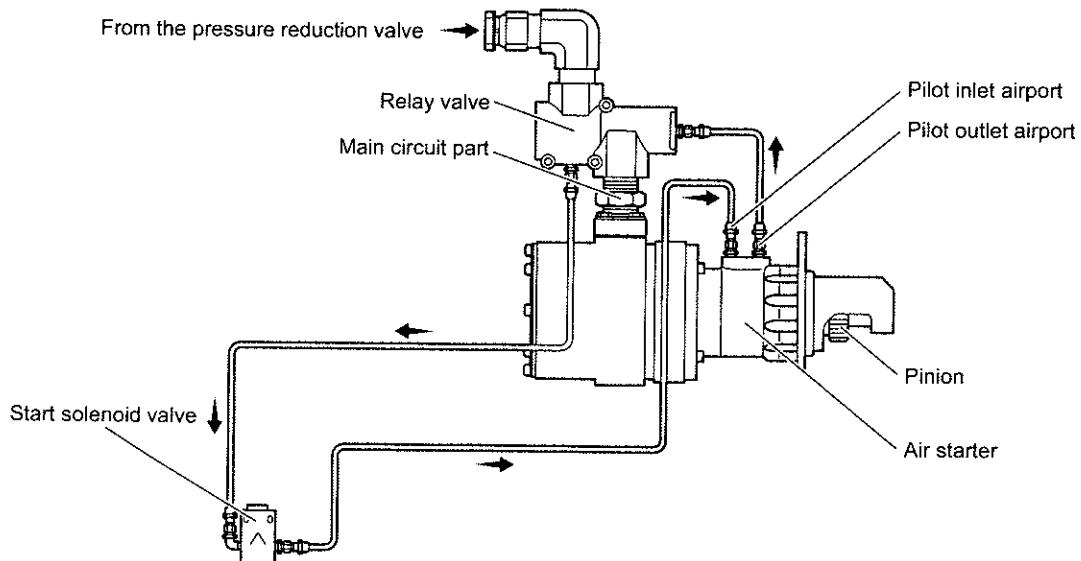
- For everyday start procedures, refer to the section Engine Operation of this manual.
- For the disassembly, assembly and inspection procedures of the air starter, refer to the manuals by the manufacturer. They are included with this engine.

Included manuals:

- TURBOTWIN engine & air starter T50-P service manual
- Integral relay valve installation and operation manual

3. Engine start sequence

- When the start solenoid valve opens, air flows into the housing of the pinion drive shaft into the air starter. As a result, the pinion gear is pushed out and engages the ring gear.
- When the pinion gear fully engages the ring gear, air flows into the main circuit. This air rotates the turbine and the pinion gear starts the engine.
- When the engines reach the specified speed (125min^{-1}), the relay valve closes due to the turn signal of the speed relay and the pinion gear disengages from the ring gear.
- In emergencies, push the manual air starter button to start the engine.



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Fig.3 Air starter operation diagram

4. Safety and control unit

The safety and control system has a governor, start/stop handle, fuel injection pump, air piston and linking parts (e.g. levers and shafts).

- The control air operates the air piston. The operation depends on whether the stop solenoid valve (for control and safety) and the fuel limit solenoid valve are open or closed. At engine start, the air piston moves the connecting lever shaft between the fuel injection pumps. This limits the fuel injection volume. At engine stop, it stops the injection.
Fuel injection volume control air piston & stopping air piston 6505-000-01
- Operate the stop solenoid valve to stop the engine remotely. Operate the start/stop handle to stop the engine on the machine side.
- Operate the start/stop handle to stop the engine manually.
Start/stop handle 6004-000-01

Air filter

Cleaning

1/1

PRODUCTION MANAGEMENT DATA

Intervals 3 months
1000 working hours

CONDITION The filter for the starting air is on the starting air inlet of the engine.
Clean the filter at intervals of 3 months.

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	a	Engine crew	Intermediate	-	0.5 h
EQUIPMENT	Nomenclature		Identification code		Quantity
SUPPLIES	Nomenclature		Identification code		Quantity
SPARES	Nomenclature		Identification code		Quantity
	O-ring		24311-000490		1 pc
SAFETY					

CAUTION

Do not loosen the cover 1 on the air filter to release pressure.
The element 3 can suddenly come off and cause injury.

Obey the instructions that follow when you clean the air filter.

1. Close the main valve on the starting air pipe.
2. Loosen the air relief plug 2 slowly and release the remaining pressure.
3. Soak the element in kerosene or cleaning fluid to clean it.

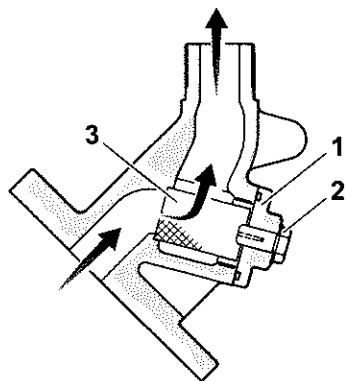


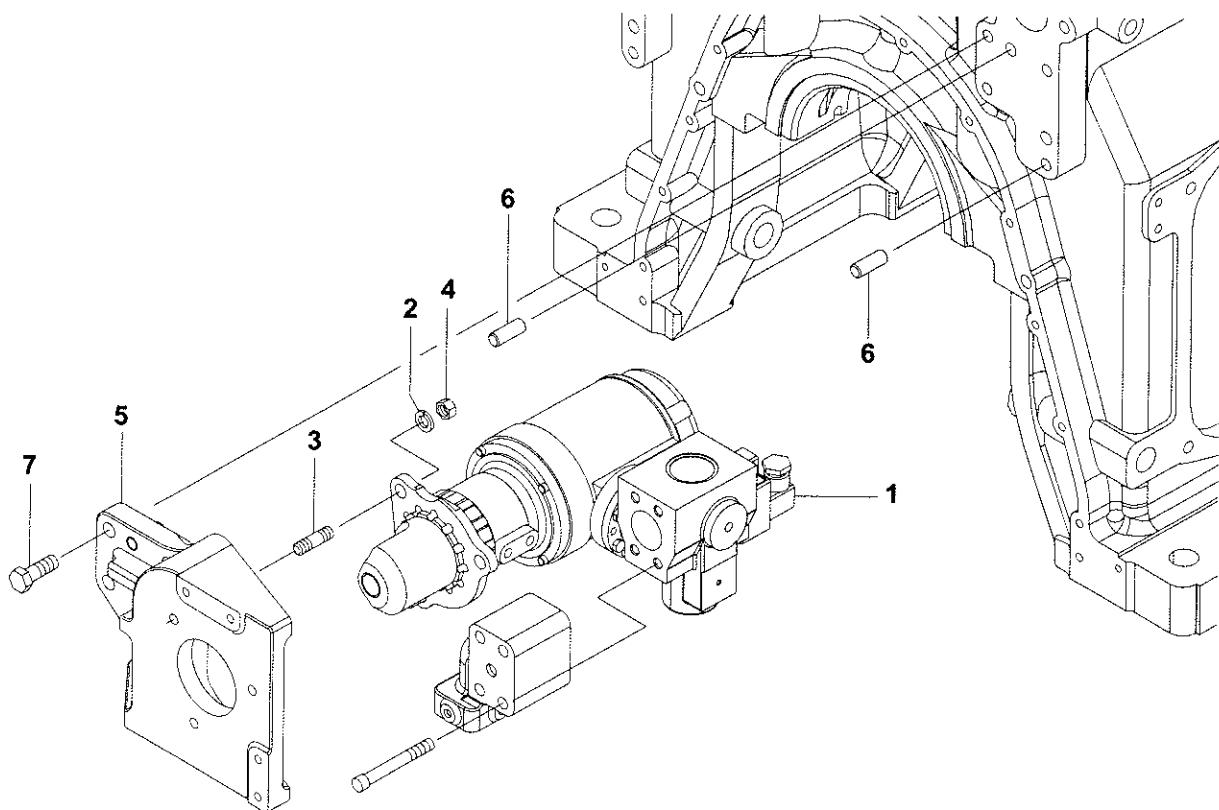
Fig. 1 Air filter

CONDITION

Air starter

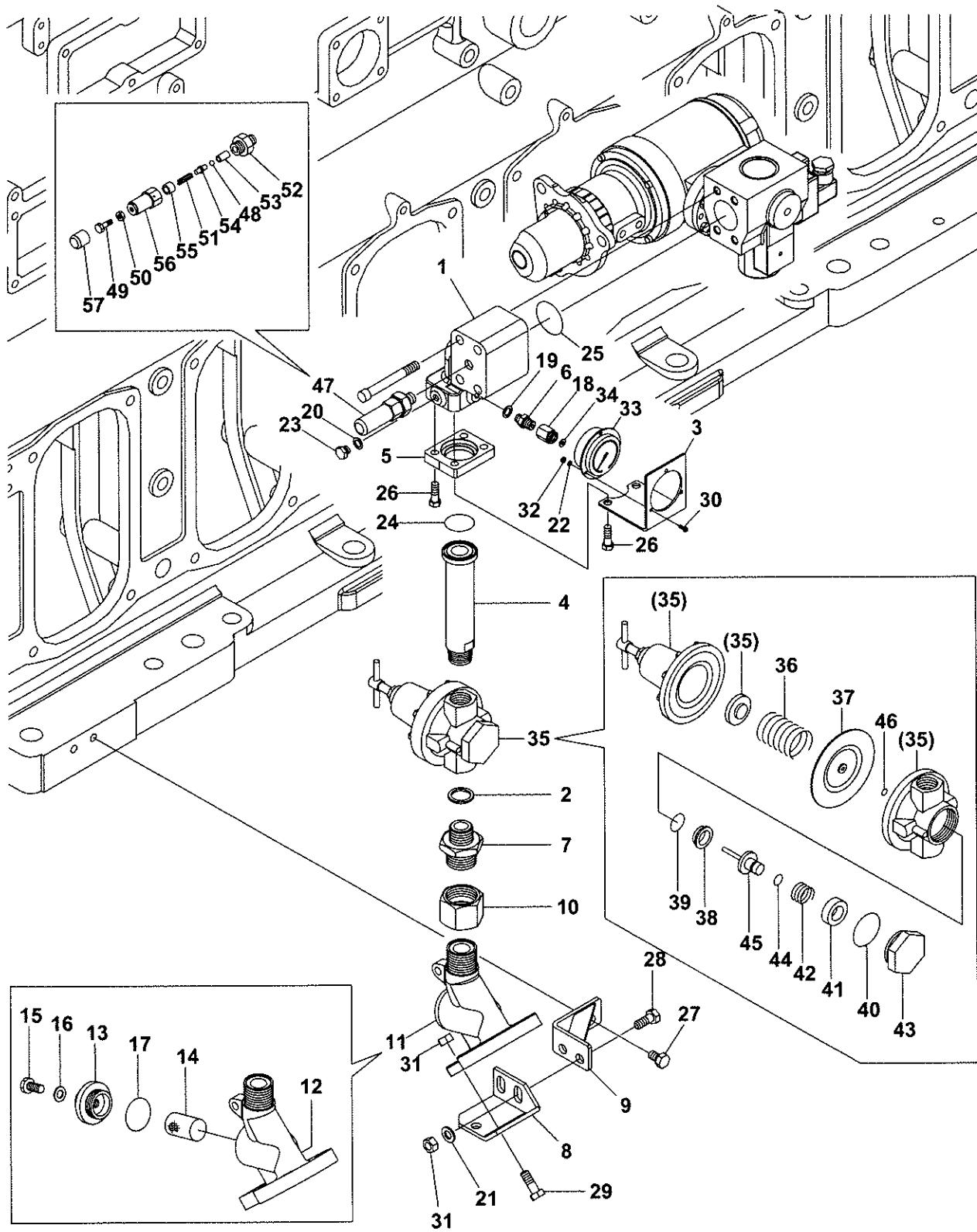
Illustrated parts data

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A-70019-00001-A-01_EN

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-77050	MOTOR, STARTING(24V)	1	1	
2	1	22212-140000	WASHER, 14	3	3	
3	1	26232-140302	STUD,BOLT 14 X 30	3	3	
4	1	26732-140002	NUT, 14	3	3	
5	1	150633-77150	BRACKET, START MOTOR	1	1	
6	1	22312-160400	PIN, 16 X 40	2	2	
7	1	26152-160452	BOLT, 16 X 45	4	4	



Starting air pipe (air starter inlet)

Illustrated parts data

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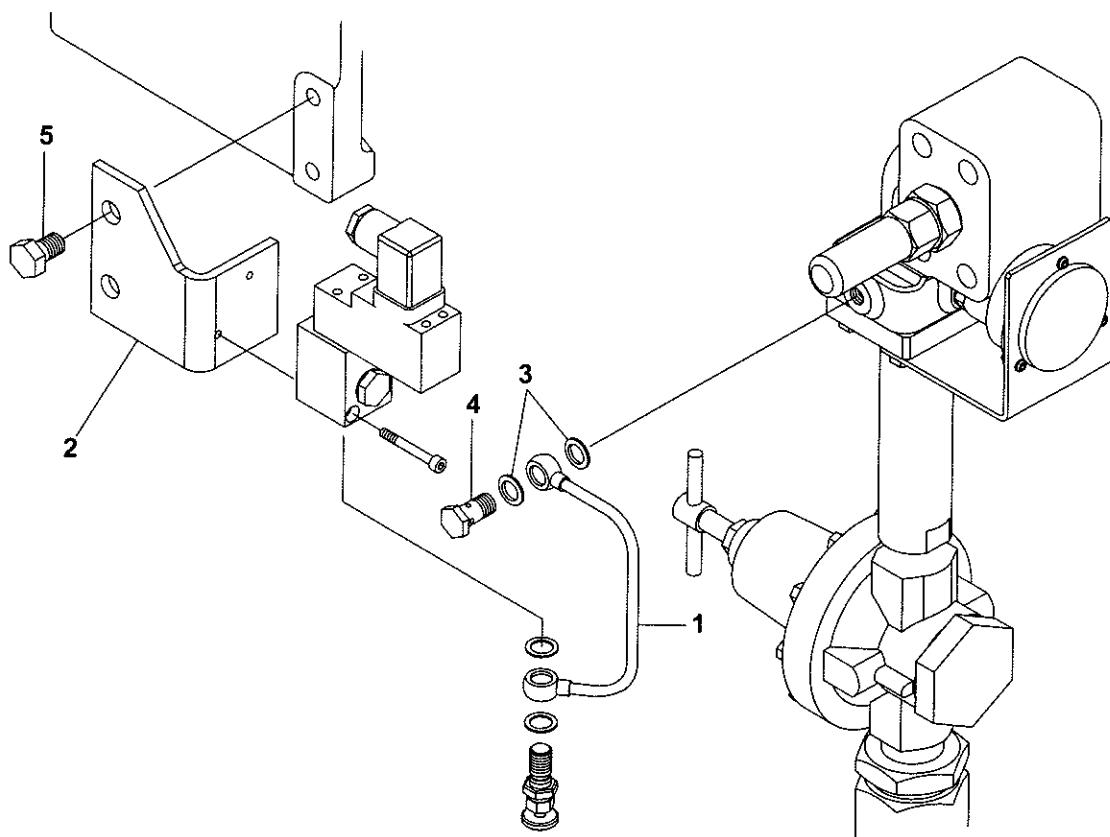
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-73100	AIR BEND,STARTER IN	1	1	
2	1	136600-73060	PACKING	1	1	
3	1	150633-73110	SUPPORT,PRESS. GAUGE	1	1	
4	1	150633-73240	PIPE, START AIR	1	1	
5	1	146623-73270	FLANGE, SPLIT	1	1	
6	1	147673-73290	UNION, M14-M12	1	1	
7	1	147673-73630	UNION, R1XM42	1	1	
8	1	150633-73660	SUPPORT, AIR FILTER	1	1	
9	1	150633-73670	SUPPORT, AIR FILTER	1	1	
10	1	146673-73810	JOINT, AIR PIPE	1	1	
11	1	146673-73881	FILTER, AIR W/FLANGE	1	1	
12	2	146673-73840	BODY, AIR FILTER	1	1	
13	2	146673-73851	COVER, AIR FILTER	1	1	
14	2	146673-73870	ELEMENT, AIR MOTOR	1	1	
15	2	146673-73930	PLUG, AIR FILTER	1	1	
16	2	23414-120000	GASKET, 12 X 1.0	1	1	
17	2	24311-000490	PACKING, P 49.0	1	1	
18	1	139653-91170	CONNECTOR	1	1	
19	1	153672-59920	WASHER, SEAL 12X1.2	1	1	
20	1	153672-59920	WASHER, SEAL 12X1.2	1	1	
21	1	22137-120000	WASHER, 12	2	2	
22	1	22212-040000	WASHER, 4	3	3	
23	1	23884-120002	PLUG, 12	1	1	
24	1	24321-000400	PACKING, G 40.0	1	1	
25	1	24321-000500	PACKING, G 50.0	1	1	
26	1	26116-100302	BOLT, 10 X 30	4	4	
27	1	26206-120202	BOLT, 12 X 20	2	2	
28	1	26206-120302	BOLT, 12 X 30	2	2	
29	1	26206-120352	BOLT, 12 X 35	2	2	
30	1	26557-040122	SCREW, 4 X 12	3	3	
31	1	26706-120002	NUT, 12	4	4	
32	1	26717-040002	NUT, 4	3	3	
33	1	150633-91500	PRESSUREGA, 2.5MP	1	1	
34	1	43400-005640	GASKET, T=1.0 G1/4	1	1	
35	1	44100-555543	VALVE, RELIEF	1	1	
36	2	44100-555850	CONTROLLER, SPRING	1	1	
37	2	44100-555860	DAIPHHRAGM ASSY	1	1	
38	2	44100-555880	SEAT,VALVE	1	1	
39	2	44100-555890	O-RING	1	1	
40	2	44100-555900	O-RING,P48	1	1	
41	2	44100-555910	STRAINER	1	1	
42	2	44100-555920	SPRING, VALVE	1	1	
43	2	44100-555930	PLUG	1	1	
44	2	44100-555940	O-RING	1	1	
45	2	44100-555950	VALVE ASSY	1	1	
46	2	44100-555990	O-RING,P5	1	1	
47	1	83255-103312	VALVE ASSY, SAFETY	1	1	
48	2	24190-100001	BALL, 5/16	1	1	
49	2	26206-080252	BOLT, 8 X 25	1	1	
50	2	26796-080002	NUT, 8	1	1	
51	2	43255-000020	SPRING, SAFETY VALVE	1	1	
52	2	43255-000090	BODY, SAFETY VALVE	1	1	
53	2	43255-103021	VALVE, SAFETY VALVE	1	1	
54	2	43255-103050	SHOE, SPRING	1	1	

Starting air pipe (air starter inlet)

Illustrated parts data

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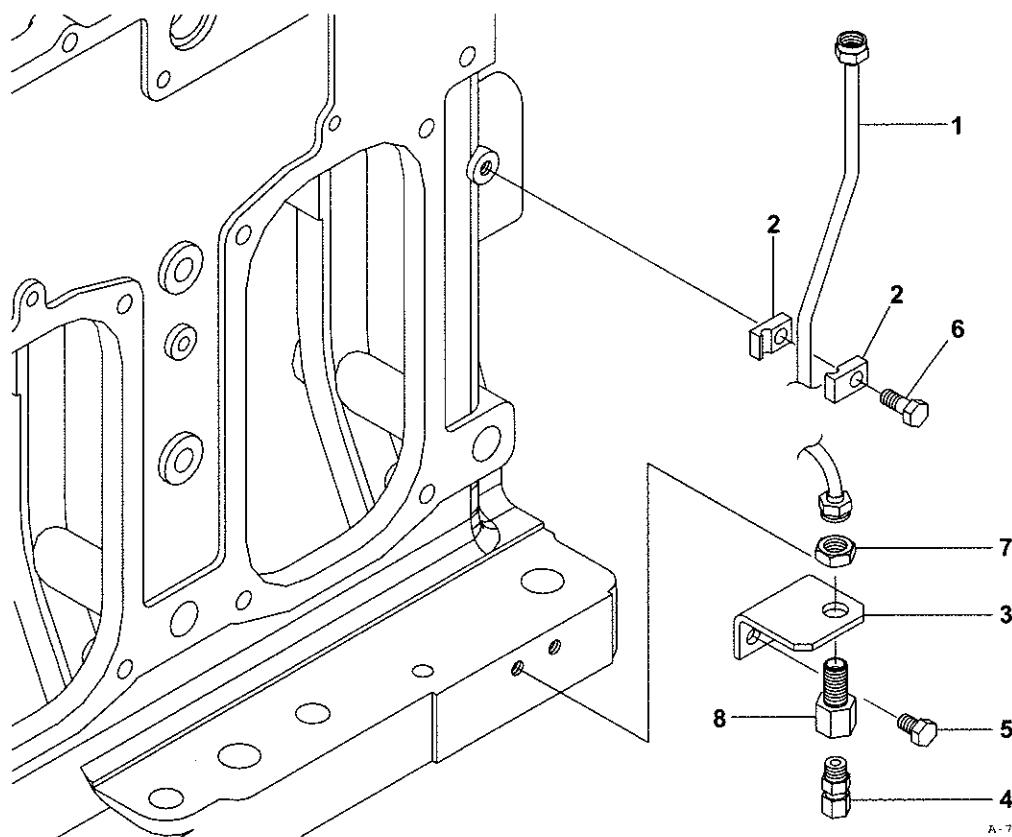
No	LV	Part No.	Part name	LWS	ALWS	Remarks
55	2	43255-103060	RETAINER, SPRING	1	1	
56	2	43255-103071	RETAINER, SPRING	1	1	
57	2	43255-103080	CAP, VALVE	1	1	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-73220	PIPE,AIR(START SW)	1	1	
2	1	150633-86310	BRACKET,AIR PRESS SW	1	1	
3	1	153672-59920	WASHER, SEAL 12X1.2	2	2	
4	1	23857-060000	BOLT, JOINT 6	1	1	
5	1	26206-120202	BOLT, 12 X 20	2	2	

Illustrated parts data



No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-73300	PIPE, CONTROL AIR	1	1	
2	1	152696-59550	SUPPORT, 10X1	2	2	
3	1	150633-73310	BRACKET, CONTROL AIR	1	1	
4	1	23102-100034	FITTING, 10-R 3/8	1	1	
5	1	26206-120202	BOLT, 12 X 20	2	2	
6	1	26206-120302	BOLT, 12 X 30	1	1	
7	1	26772-180002	NUT, 18	1	1	
8	1	43550-000500	UNION	1	1	

- Use the hydraulic jack when you remove or install:
 - The clamping nuts of the cylinder head
 - The tightening nuts of the main bearing cap
 - The tightening nuts of the connecting rod bolt.
- Loosen or tighten the 4 nuts on each cylinder head at the same time. Loosen or tighten the 2 nuts on each main bearing at the same time.

CAUTION

Oil leaks from a hydraulic jack are dangerous. The hydraulic fluid is under high pressure and can cause injury. Obey these precautions:

- Do not use rubber hoses with flaws or oil leaks.
- Do not put heavy objects on the rubber hose. Do not let heavy objects fall on the rubber hose.
- Do not squeeze the rubber hose. Keep your face away from the jack or branch.

1. Special tool

The special tools for the hydraulic jack and how many parts are used for the task is listed below.

No.	Special tool	Part no.	Number/amount used		
			Cylinder head	For the main bearing	For the connecting rod
1	Hydraulic pump	146673-92200		1	
2	Pressure gauge fixture	146673-92210		1	
3	Gauge damper	153605-92481		1	
4	Pressure gauge	153625-92801		1	
5	Rubber hose (3 m) (Hydraulic pump to branch)	153625-92760		1	
6	Branch	146673-92220		1	
7	Rubber hose (1 m) (branch to hydraulic jack)	153625-92750	4	2	2
8	Angle elbow (L-pipe)	151605-92740	4	2	2
9	Coupler (male) (with dust caps)	153625-92770	4	2	2
10	Coupler (female) (with dust caps)	153625-92780	4	2	2
11	Hydraulic jack assembly	150633-92650	4	2	2
12	Spacer	150633-92510	4	2	-
13	Spacer	150633-92460	-	-	2
14	Spacer bolt	150633-92680	4	2	-
15	Spacer bolt	150633-92530	-	-	2
16	Nut	26732-360002	4	2	2
17	Turning handle	146673-92510	1	1	1
18	Spacer lock bolt	26116-040122	-	2	-

2. Structure of all parts

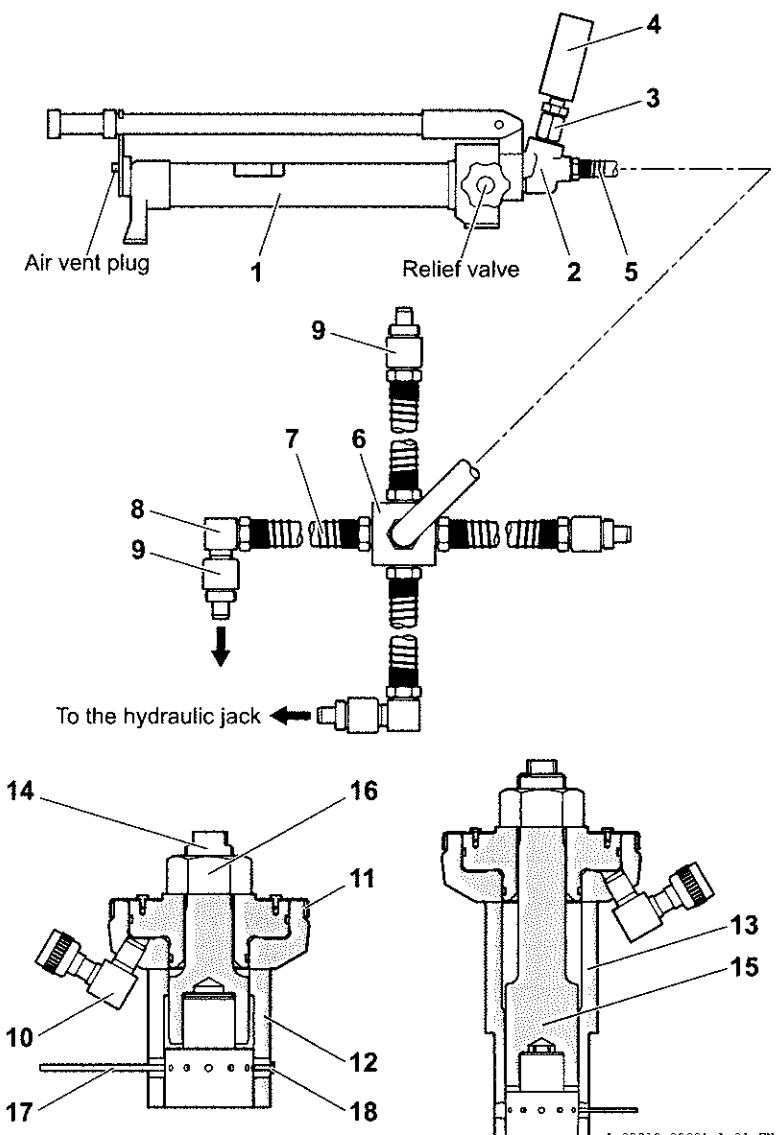


Fig.1 Connecting the hoses for the hydraulic jack

3. How to use the hydraulic jack

- When you assemble the hydraulic jack, be sure to use sealing tape on the thread of the coupler. This prevents leakage.
- Connect the hydraulic pump 1 to the branch 6 with the 3 m rubber hose.
- When you disassemble or assemble the cylinder head, connect the branch 6 and the hydraulic jack with four 1 m rubber hoses.
- When you disassemble or assemble the main bearing cap, connect the branch 6 and the hydraulic jack with two 1 m rubber hoses.
- Put a dust cap on any coupler that you do not connect to the hydraulic jack.
- Use hydraulic oil with a viscosity grade of ISO VG32 for the hydraulic pump.

Maker	Brand	Normal hydraulic oil Wear-resistant hydraulic oil
SHOWA SHELL	Tellus Oil C32	
	Tellus Oil 32	
NIPPON OIL CORPORATION	Super Hiland 32	
	Super Hiland V32	
COSMO OIL	Cosmo Epoch ES32	
	Cosmo Hydro AW32	
JAPAN ENERGY TOTAL Lubmarine	JOMO Hydrax 32	
	JOMO Hydrax ES32	
IDEMITSU KOSAN	Daphne Hydraulic Fluid 32	
	Daphne Super Hydro 32A	
EXXON MOBIL	DTE Oil Light, Unipower 32	
	DTE 24 Oil, Unipower SQ32	

- Make sure that the hydraulic pump is in a horizontal position.
- When you operate the hydraulic pump, open the air vent plug.
- At first, the rubber hose fills with hydraulic fluid. When the hydraulic pressure begins to increase, measure the oil level of the hydraulic pump. Refill if necessary.
- If the hydraulic pressure is at the specified value, but the hydraulic jack does not operate, the couplers are loose.
- Loosen the relief valve of the hydraulic pump and decrease the hydraulic pressure. Then check the connection of the couplers.

4. Storage of the hydraulic jack

- Apply lubricating oil to the hydraulic jack before you store it. This prevents rust.
- Put a cap on every coupler before you store it. This prevents unwanted material from entering.

5. How to mount and operate

- Refer to the previous section when you install the hydraulic pump, hydraulic jack and related hydraulic tools.
- Refer to the manuals of each part for details on operating these parts.
- These manuals are:

Cylinder head tightening nut

Hydraulic jack - Operation procedures 1101-000-02 (Paragraph 2) (M.D.O.) 1101-001-02 (Paragraph 2) (H.F.O.)

Main bearing cap tightening nut

Hydraulic jack - Operation procedures 2101-000-02 (Paragraph 2)

Connecting rod tightening nut

Hydraulic jack - Operation procedures 2202-000-02 (Paragraph 2)

Other tools

Measurement

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PRODUCTION MANAGEMENT DATA

Intervals Unscheduled

CONDITION

PERSONNEL	Person	Category	Skill	Trade	Estimated time
	b	Engine crew	Intermediate	-	0.2 h

EQUIPMENT	Nomenclature	Identification code	Quantity
	Turning handle of the pressure indicator cock	153605-92360	1 pc
	Pressure indicator	147673-93753	1 pc

SUPPLIES	Nomenclature	Identification code	Quantity

SPARES	Nomenclature	Identification code	Quantity

SAFETY	CAUTION

CAUTION

Put on gloves when you take a measurement. The pressure indicator and the pressure indicator cock are hot.

Be careful not to burn yourself.

Obey the instructions that follow when you measure maximum combustion pressure (Pmax) in the cylinder.

1. Measurement

1. Open the valve of the pressure indicator cock with the open/close handle 1. Lightly rev up the engine (i.e. increase the engine speed for a short time) 2 to 3 times. (This prevents dirt and unwanted material from collecting in the pressure indicator.)
2. Examine if the screw of the pressure indicator 2 fits easily with the screw of the indicator cock. Manually tighten it.
3. Tighten the screw of the pressure indicator 2 to the screw of the indicator cock with the turning handle.
4. Close the exhaust valve 3 of the pressure indicator.
5. Fully open the valve of the indicator cock with the turning handle.
6. Close the valve 4 of the indicator cock with the handle when the pressure is at the maximum.
7. Read the Pmax.
8. Open the exhaust valve of the pressure indicator. Make sure that the needle of the pressure indicator shows 0 MPa.
9. Remove the pressure indicator.

(Use the turning handle when it is difficult to loosen the pressure indicator.)

NOTICE

If the difference in maximum combustion pressure (Pmax) between cylinders is greater than 0.6 MPa, adjust the injection timing by less than 1°.

If the Pmax is greater than its limit, examine the engine performance and adjust the injection timing.

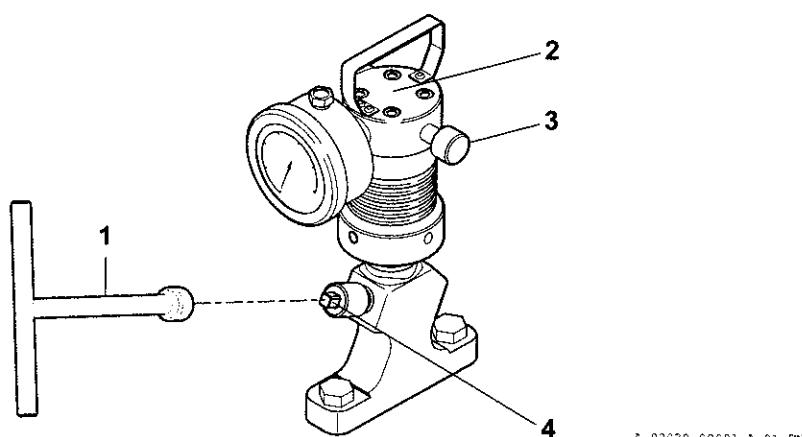
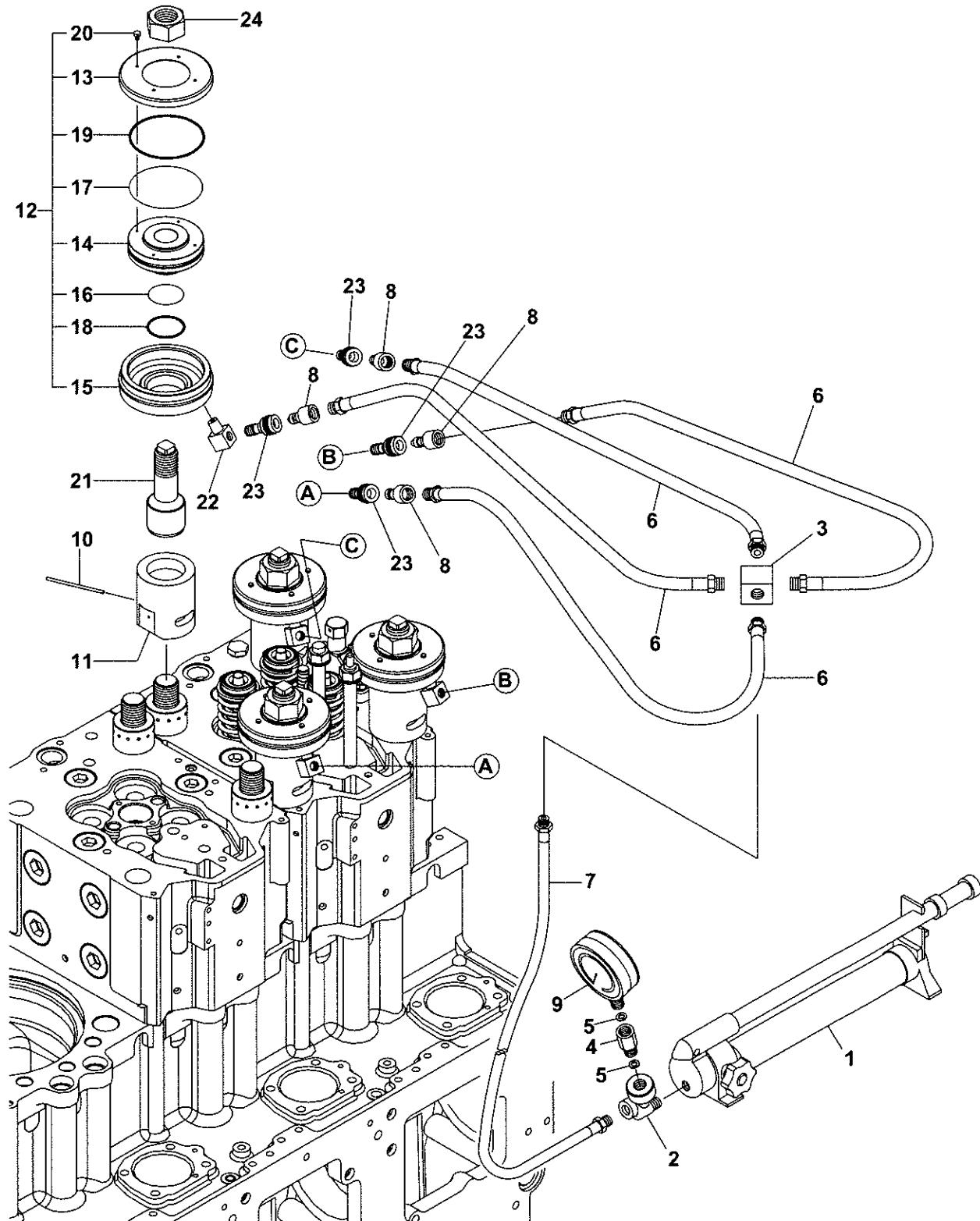


Fig.1 Pmax measurement

CONDITION Standard setting values (3. Specified values for pressure and temperature) 0000-000-06(M.D.O.), 0000-001-06(H.F.O.)

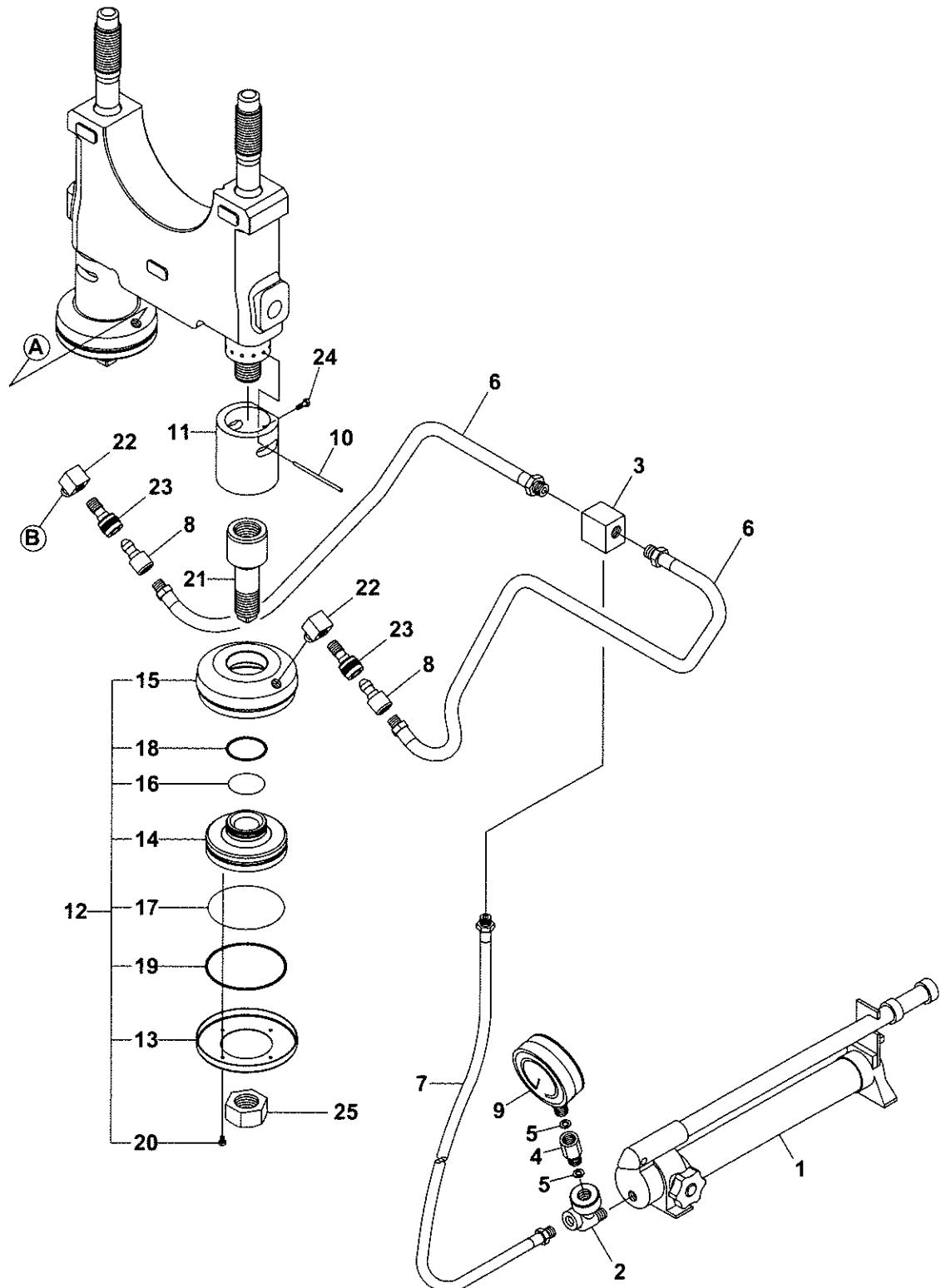


Hydraulic pump and hydraulic jack (cylinder head)

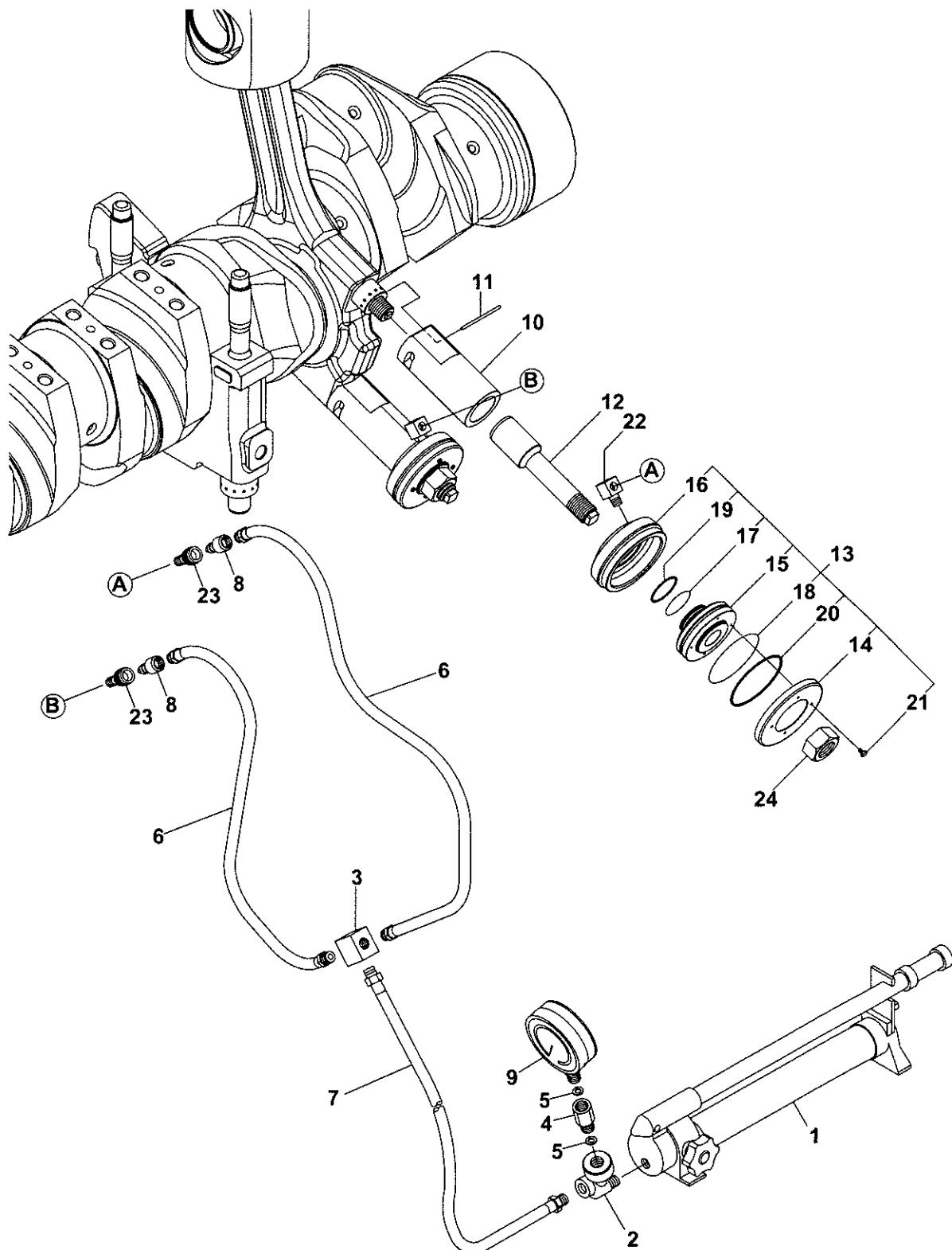
Illustrated parts data

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No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	746673-92112	PUMP, HYDRAULIC	1	1	
1	2	146673-92200	PUMP, HYDRAULIC	1	1	
2	2	146673-92210	BRACKET, MOUNTING	1	1	
3	2	146673-92220	BRANCH	1	1	
4	2	153605-92481	DAMPER, GAUGE	1	1	
5	3	153605-92460	GASKET	2	2	
6	2	153625-92750	HOSE, RUBBER 700KG	4	4	
7	2	153625-92760	HOSE, RUBBER 700KG	1	1	
8	2	153625-92770	COUPLER, S-1H	4	4	
9	2	153625-92801	GAUGE, PRESSURE	1	1	
10	1	146673-92510	HANDLE, TURNING	1	1	
11	1	150633-92510	SPACER, HYD.JACK	4	4	
12	1	150633-92650	JACK, HYDRAULIC	4	4	
13	2	150633-92640	COVER, HYD.JACK	4	4	
14	2	150633-92660	PISTON, HYD.JACK	4	4	
15	2	150633-92670	BODY, HYDRAULIC JACK	4	4	
16	2	24321-000550	PACKING, G 55.0	4	4	
17	2	24321-001150	PACKING, G115.0	4	4	
18	2	24375-000550	RING, BACKUP T2 G 55	4	4	
19	2	24375-001150	RING, BACKUP T2 G 115	4	4	
20	2	26116-040062	BOLT, 4 X 6	16	16	
21	1	150633-92680	BOLT, HYD.JACK	4	4	
22	1	151605-92740	ELBOW, FML-3/8	4	4	
23	1	153625-92780	COUPLER, R	4	4	
24	1	26732-360002	NUT, 36	4	4	

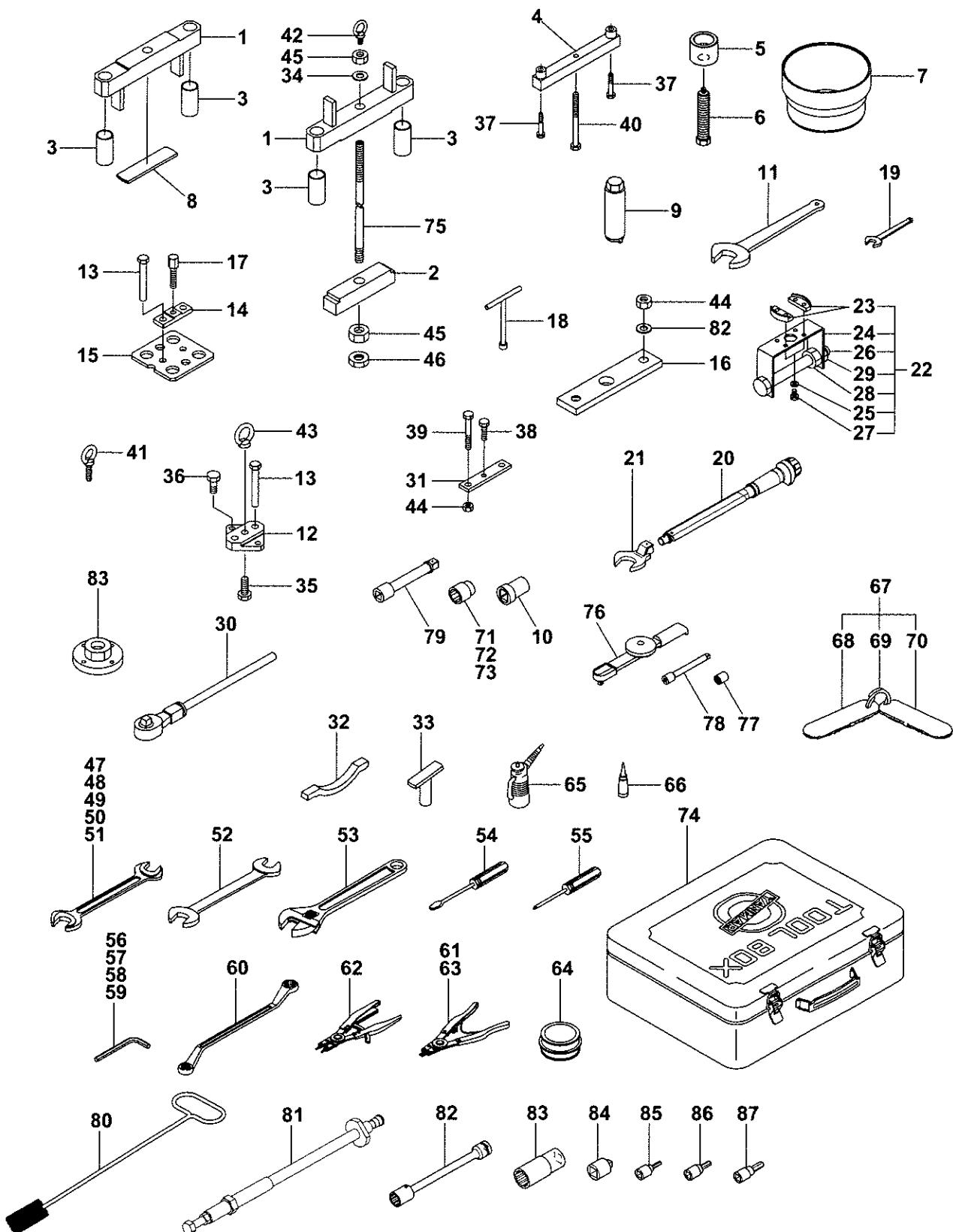


No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	746673-92112	PUMP, HYDRAULIC	1	1	
1	2	146673-92200	PUMP, HYDRAULIC	1	1	
2	2	146673-92210	BRACKET, MOUNTING	1	1	
3	2	146673-92220	BRANCH	1	1	
4	2	153605-92481	DAMPER, GAUGE	1	1	
5	3	153605-92460	GASKET	2	2	
6	2	153625-92750	HOSE, RUBBER 700KG	2	2	
7	2	153625-92760	HOSE, RUBBER 700KG	1	1	
8	2	153625-92770	COUPLER, S-1H	2	2	
9	2	153625-92801	GAUGE, PRESSURE	1	1	
10	1	146673-92510	HANDLE, TURNING	1	1	
11	1	150633-92510	SPACER, HYD.JACK	2	2	
12	1	150633-92650	JACK, HYDRAULIC	2	2	
13	2	150633-92640	COVER, HYD.JACK	2	2	
14	2	150633-92660	PISTON, HYD.JACK	2	2	
15	2	150633-92670	BODY, HYDRAULIC JACK	2	2	
16	2	24321-000550	PACKING, G 55.0	2	2	
17	2	24321-001150	PACKING, G115.0	2	2	
18	2	24375-000550	RING, BACKUP T2 G 55	2	2	
19	2	24375-001150	RING, BACKUP T2 G 115	2	2	
20	2	26116-040062	BOLT, 4 X 6	8	8	
21	1	150633-92680	BOLT, HYD.JACK	2	2	
22	1	151605-92740	ELBOW, FML-3/8	2	2	
23	1	153625-92780	COUPLER, R	2	2	
24	1	26116-040122	BOLT, 4 X 12	2	2	
25	1	26732-360002	NUT, 36	2	2	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
-	1	746673-92112	PUMP, HYDRAULIC	1	1	
1	2	146673-92200	PUMP, HYDRAULIC	1	1	
2	2	146673-92210	BRACKET, MOUNTING	1	1	
3	2	146673-92220	BRANCH	1	1	
4	2	153605-92481	DAMPER, GAUGE	1	1	
5	3	153605-92460	GASKET	2	2	
6	2	153625-92750	HOSE, RUBBER 700KG	2	2	
7	2	153625-92760	HOSE, RUBBER 700KG	1	1	
8	2	153625-92770	COUPLER, S-1H	2	2	
9	2	153625-92801	GAUGE, PRESSURE	1	1	
10	1	150633-92460	SPACER, HYD.JACK	2	2	
11	1	146673-92510	HANDLE, TURNING	1	1	
12	1	150633-92530	BOLT, HYD.JACK	2	2	
13	1	150633-92650	JACK, HYDRAULIC	2	2	
14	2	150633-92640	COVER, HYD.JACK	2	2	
15	2	150633-92660	PISTON, HYD.JACK	2	2	
16	2	150633-92670	BODY, HYDRAULIC JACK	2	2	
17	2	24321-000550	PACKING, G 55.0	2	2	
18	2	24321-001150	PACKING, G115.0	2	2	
19	2	24375-000550	RING, BACKUP T2 G 55	2	2	
20	2	24375-001150	RING, BACKUP T2 G 115	2	2	
21	2	26116-040062	BOLT, 4 X 6	8	8	
22	1	151605-92740	ELBOW, FML-3/8	2	2	
23	1	153625-92780	COUPLER, R	2	2	
24	1	26732-360002	NUT, 36	2	2	



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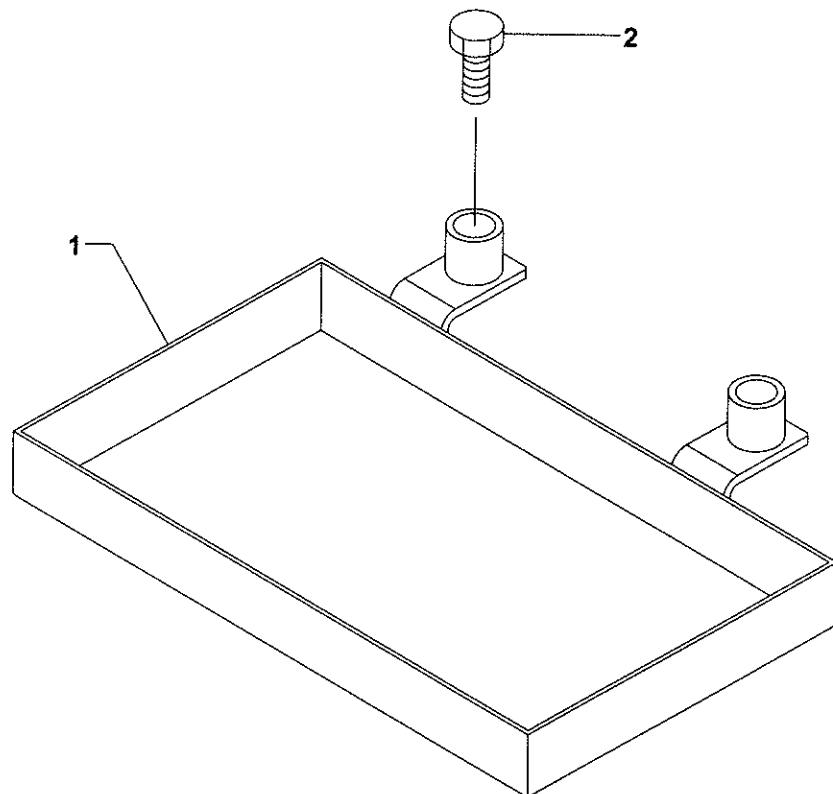
No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	2	150633-92010	REMOVER(LINER UPPER	1	1	
2	2	150623-92020	REMOVER, LINER LOWER	1	1	
3	2	150633-92040	DISTANCE PIECE	2	2	
4	2	150633-92100	REMOVER,METAL CAP	1	1	
5	2	150633-92110	TOOL A,METAL CAP	2	2	
6	2	146673-92120	TOOL, OVERHAUL B	2	2	
7	2	150633-92140	TOOL,PISTON INSERT	1	1	
8	2	150633-92200	REMOVER(P-RING	1	1	
9	2	146673-92250	TOOL,SLEEVE OVERHALL	1	1	
10	2	146673-92260	SOCKET, F/O VALVE	1	1	
11	2	146673-92270	WRENCH, F/O VALVE	1	1	
12	2	150633-92310	TOOL,CYLINDER HEAD	1	1	
13	2	146673-92320	REMOVER, HEAD B	2	2	
14	2	150633-92321	TOOL,SUC&EXH VALVE	1	1	
15	2	150633-92330	TOOL,SUC&EXH VALVE	1	1	
16	2	150633-92290	TOOL,FO.INJECTION VA	1	1	
17	2	150633-92351	BOLT,M16X70	1	1	
18	2	153605-92360	HANDLE, INDICATOR	1	1	
19	2	138603-92510	WRENCH, 24	1	1	
20	2	146623-92600	WRENCH, TORQUE	1	1	
20	2	146623-92620	WRENCH, TORQUE	1	1	
21	2	146623-92610	SOCKET,OPEN 41	1	1	
21	2	146623-92630	SOCKET,OPEN 30	1	1	
22	2	150633-92700	TOOL, LAPPING	1	1	
23	3	150633-92710	RETAINER, VALVE	2	2	
24	3	146673-92720	BODY, LAPPING TOOL	1	1	
25	3	22137-060000	WASHER, 6	4	4	
26	3	26111-161302	BOLT, 16 X 130	1	1	
27	3	26116-060102	BOLT, 6 X 10	4	4	
28	3	26712-160002	NUT, 16	1	1	
29	3	26751-160002	NUT, 16	1	1	
30	2	147673-92851	HANDLE, RATCHET	1	1	
31	2	150633-92900	TOOL, PLUNGER	1	1	
32	2	150633-92950	TOOL,MAIN BEARING	1	1	
33	2	153604-92971	PIN, REMOVER	1	1	
34	2	22137-270000	WASHER, 27	1	1	
35	2	26116-160502	BOLT, 16 X 50	1	1	
36	2	26152-160402	BOLT, 16 X 40	2	2	
37	2	26206-100652	BOLT, 10 X 65	2	2	
38	2	26206-120454	BOLT, 12 X 45	1	1	
39	2	26206-121002	BOLT, 12 X 100	2	2	
40	2	26206-121554	BOLT, 12 X 155	1	1	
41	2	26617-080002	BOLT, EYE 8	2	2	
42	2	26617-120002	BOLT, EYE 12	2	2	
43	2	26620-160002	NUT, EYE 16	1	1	
44	2	26706-120002	NUT, 12	2	2	
82	2	22137-120000	WASHER	1	1	
45	2	26732-270002	NUT, 27	2	2	
46	2	26772-270002	NUT, 27	1	1	
47	2	28110-100130	SPANNER, 10 X 13	1	1	
48	2	28110-170190	SPANNER, 17 X 19	1	1	
49	2	28110-220240	SPANNER, 22 X 24	1	1	
50	2	28110-270300	SPANNER, 27 X 30	1	1	
51	2	28110-320360	SPANNER, 32 X 36	1	1	

Standard tools

Illustrated parts data

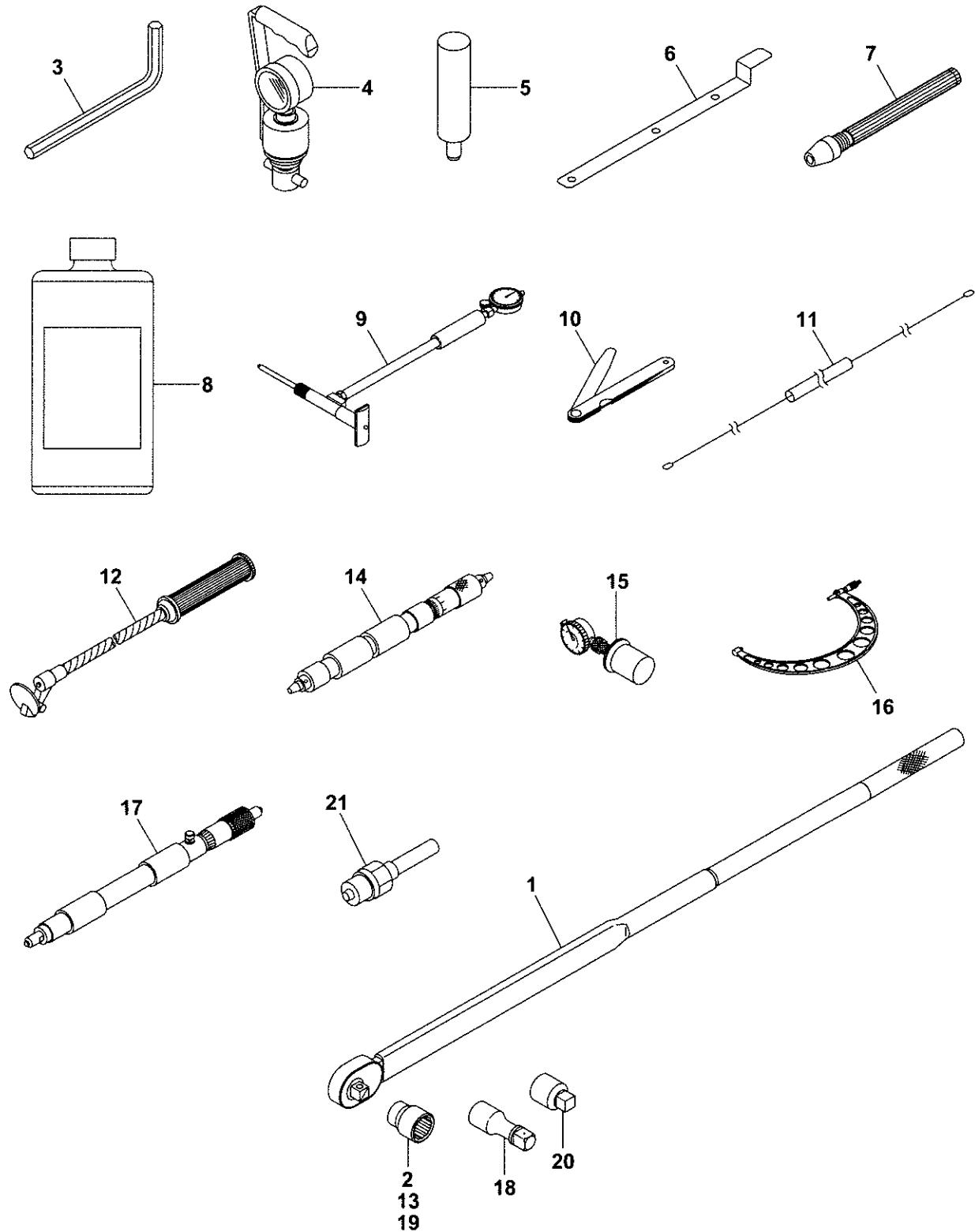
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No	LV	Part No.	Part name	LWS	ALWS	Remarks
52	2	28110-410460	SPANNER, 41 X 46	1	1	
53	2	28120-002000	WRENCH, 200	1	1	
54	2	28130-061000	DRIVER, 6 X 100	1	1	
55	2	28140-081000	DRIVER, 8 X 100	1	1	
56	2	28150-040000	WRENCH, BAR 4	1	1	
57	2	28150-050000	WRENCH, BAR 5	1	1	
58	2	28150-060000	WRENCH, BAR 6	1	1	
59	2	28150-080000	WRENCH, BAR 8	1	1	
60	2	28160-170190	WRENCH, 17 X 19	1	1	
61	2	28190-000020	PLIER, ST-2	1	1	
62	2	28190-000140	PLIER, RT-4	1	1	
63	2	28190-002020	PLIER, ST-2N	1	1	
64	2	28210-000070	COMPOUND, LAPPING	1	1	
65	2	28210-000130	OILER	1	1	
66	2	28210-000140	OILER	1	1	
67	2	28312-004050	GAUGE, 0.40,0.50	1	1	
68	3	28312-400750	GAUGE, 0.40 X 75	1	1	
69	4	28322-020000	RING, GAUGE	1	1	
70	3	28312-500750	GAUGE, 0.50 X 75	1	1	
71	2	42111-001850	SOCKET, 24	1	1	
72	2	42111-001860	SOCKET, 27	1	1	
73	2	42112-002740	SOCKET,TORQUE WRE 36	1	1	
83	2	146673-92751	TOOL, IMPELLER	1	1	
74	2	42112-007291	BOX, TOOL	1	1	
75	1	150633-92030	BOLT, REMOVING LINER	1	1	
76	1	152633-92253	WRENCH, 5ON.M	1	1	
77	1	142613-92740	SOCKET	1	1	
78	1	146673-92790	BAR, EXTENSION	1	1	
79	1	42112-002930	BAR, EXTENSION	1	1	
80	1	146673-92810	TOOL, VALVE CLEANING	1	1	
81	1	150633-92400	REMOVER, F/I PIPE	1	1	
82	3	150633-92580	JOINT, UNIVERSAL	1	1	
83	3	150633-92590	SOCKET,30	1	1	
84	3	132673-92080	ADAPTER,SOCKET	1	1	
85	3	132674-92810	SOCKET,HEXAGON 6	1	1	
86	3	42112-007910	HEXAGON SOCKET (8MM)	1	1	
87	3	132674-92830	SOCKET,HEXAGON 10	1	1	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	150633-92360	OIL PAN,LO FILTER	1	1	
2	1	26206-080202	BOLT, 8 X 20	2	2	



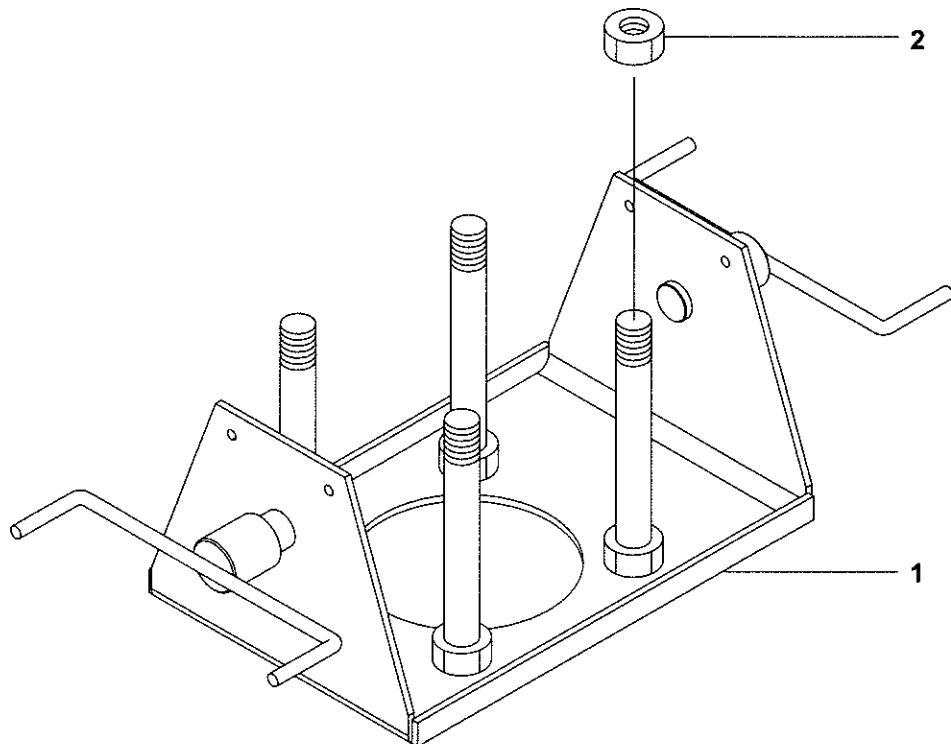
A-92069-00001-A-01_EN

Special tools

Illustrated parts data

2/2

No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	138603-92952	WRENCH, 1000N.M	1	1	
2	1	142613-92820	SOCKET, 30	1	1	
3	1	146673-92980	SPANNER SET	1	1	
4	1	147673-93753	INDICATOR, 25MPA	1	1	
5	1	150633-92050	TOOL, STEM SEAL	1	1	
6	1	150633-92250	TOOL INDICATING	1	1	
7	1	28210-000010	TOOL	1	1	
8	1	41650-003380	OIL, PRESS.GAUGE	1	1	
9	1	42111-004500	GAUGE, BORE	1	1	
10	1	42111-000901	GAUGE, THICKNESS	1	1	
11	1	42111-001280	BRUSH, COOLER PIPE	1	1	
12	1	42111-001420	MIRROR, GAUGE	1	1	
13	1	42111-001860	SOCKET, 27	1	1	
14	1	42111-002200	GAUGE, BORE	1	1	
15	1	42111-002520	GAUGE, DEFLECTION	1	1	
16	1	42111-002650	MICRO, OUTTER BORE	1	1	
17	1	42111-003940	METER, MICRO	1	1	
18	1	42112-001650	BAR, EXTENSION	1	1	
19	1	42112-002140	SOCKET, 36	1	1	
20	1	42112-007010	ADAPTER, SOCKET	1	1	
21	1	42112-000860	REPLACER,COOLER PIPE	1	1	



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No	LV	Part No.	Part name	LWS	ALWS	Remarks
1	1	42112-007840	HOLDER,CYLINDER HEAD	1	1	
2	1	26732-390002	NUT, 39	4	4	

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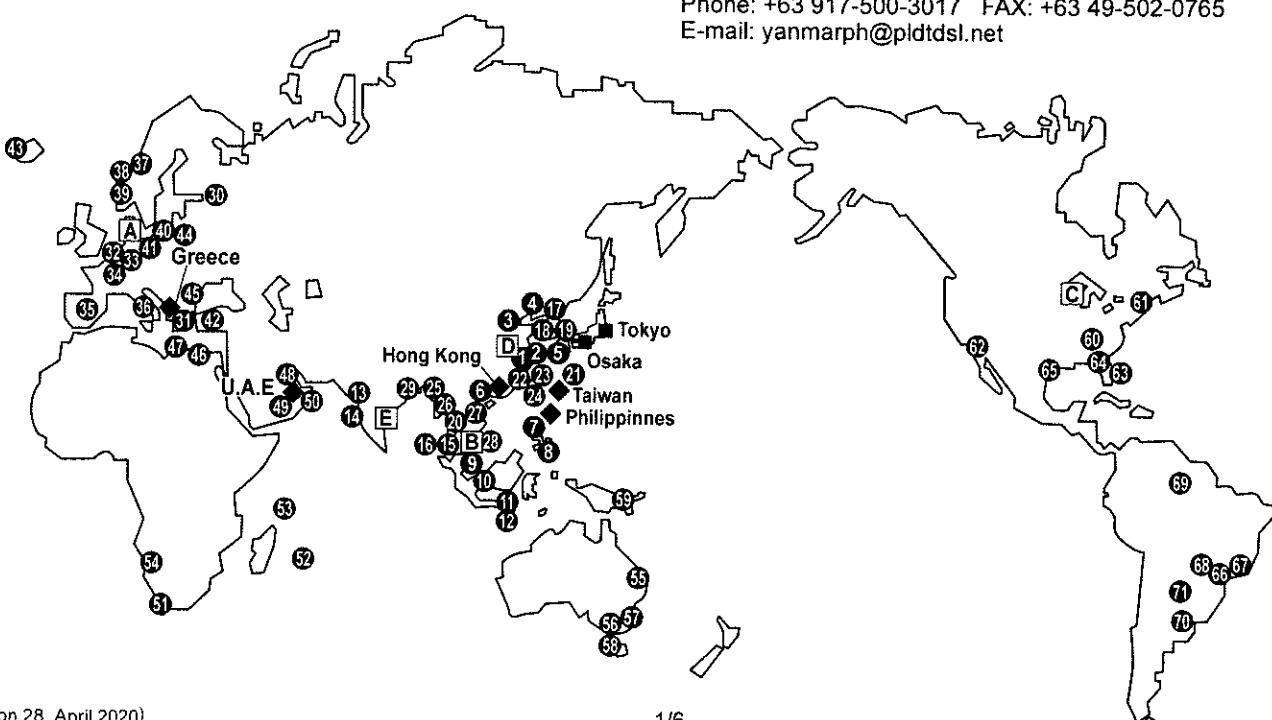
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