SERVICE MANUAL

MARINE ENGINES

3JH5E
4JH5E
4JH4-TE
4JH4-HTE

California
Proposition 65 Warning

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California
Proposition 65 Warning

Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm.
Wash hands after handling.

This Service Manual has been developed for the exclusive use of service and repair professionals such as Yanmar authorized Distributors and Yanmar authorized Dealers. It is written with these professionals in mind and may not contain the necessary detail or safety statements that may be required for a non-professional to perform the service or repair properly and/or safely. Please contact an authorized Yanmar repair or service professional before working on your Yanmar product.

Disclaimers:

All information, illustrations and specifications in this manual are based on the latest information available at the time of publishing. The illustrations used in this manual are intended as representative reference views only. Moreover, because of our continuous product improvement policy, we may modify information, illustrations and/or specifications to explain and/or exemplify a product, service or maintenance improvement. We reserve the right to make any change at any time without notice. Yanmar and **YANMAR** are registered trademarks of Yanmar Co., Ltd. in Japan, the United States and/or other countries.

Date of issue: Sep. 2009

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Section 1

INTRODUCTION

This manual gives specific instructions for the proper repair of Yanmar JH series marine engines.

Please follow the procedures carefully to ensure quality service.

Yanmar recommends that you read this *Service Manual* completely before starting repairs.

Along with standard tools, Yanmar recommends the use of special tools necessary to perform repairs correctly.

Yanmar products are continuously undergoing improvement. This *Service Manual* has been checked carefully in order to avoid errors. However Yanmar is not liable for any misrepresentations, errors of description or omissions. Contact an authorized Yanmar marine dealer or distributor for any questions you have regarding this *Service Manual*.

REVISION HISTORY

This manual is a living document. Periodic manual revisions are published to document product improvements and changes. This practice ensures the manual has the most current information.

As manual revisions become necessary, individual pages are prepared and sent to those who need the information. If a page, or number of pages should be replaced, the replacement information is sent along with a revised Revision Control Table. Discard the older, obsolete information.

At times, the revision involves inserting additional pages in one or more sections. Replace the Revision Control Table and insert the new pages.

This method of revision control represents the most cost-effective solution to providing current, updated information as needed.

Revision Control Table

Revision Date Revision Number	New Page Numbers Involved	Remarks	Initiating Dept.
Mar. 2009	first edition	Release 3JH5E and 4JH5E	Marine operations department

Section 2

SAFETY

SAFETY STATEMENTS

Yanmar is concerned for your safety and the condition of your marine engine. Safety statements are one of the primary ways to call your attention to the potential hazards associated with Yanmar Marine engines. Follow the precautions listed throughout the manual before operation, during operation and during periodic maintenance procedures for your safety, the safety of others and to protect the performance of your marine engine. Keep the decals from becoming dirty or torn and replace them if they are lost or damaged. Also, if you need to replace a part that has a decal attached to it, make sure you order the new part and decal at the same time.

This safety alert symbol appears with most safety statements. It means attention, become alert, your safety is involved! Please read and abide by the message that follows the safety alert 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 engine, personal property and / or the environment, or cause the equipment to operate improperly.

SAFETY PRECAUTIONS

There is no substitute for common sense and careful practices. Improper practices or carelessness can cause burns, cuts, mutilation, asphyxiation, other bodily injury or death. This information contains general safety precautions and guidelines that must be followed to reduce risk to personal safety. Special safety precautions are listed in specific procedures. Read and understand all of the safety precautions before operation or performing repairs or maintenance.

⚠ DANGER

The safety messages that follow have DANGER level hazards.

NEVER permit anyone to install or operate the engine without proper training.

- Read and understand this *Service Manual* before you operate or service the engine to ensure that you follow safe operating practices and maintenance procedures.
- Safety signs and decals are additional reminders for safe operating and maintenance techniques.
- Contact your Yanmar RHQ for additional training.

Crush Hazard

When attaching an engine to a repair stand, be sure to use a stand of adequate capacity to safely support the engine to be repaired, and that it is securely attached to the engine.

NEVER stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you.

ALWAYS secure the engine solidly to prevent the engine from falling during maintenance.

⚠ WARNING

The safety messages that follow have WARNING level hazards.

Explosion Hazard

While the engine is running or the battery is charging, hydrogen gas is being produced and can be easily ignited. Keep the area around the battery well-ventilated and keep sparks, open flame and any other form of ignition out of the area.

ALWAYS turn off the battery switch (if equipped) or disconnect the negative (-) battery cable before servicing the equipment.

Fire and Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions.

NEVER use a shop rag to catch the fuel.

Wipe up all spills immediately.

NEVER refuel with the engine running.

Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

⚠ WARNING

Fire Hazard

Have appropriate safety equipment available. Have all fire extinguishers checked periodically for proper operation and / or readiness.

ALWAYS read and follow safety-related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.

Undersized wiring systems can cause an electrical fire.

Coolant may be flammable under certain conditions. NEVER allow coolant to come into contact with hot surfaces or insulation material.

Entanglement Hazard

NEVER leave the key in the key switch when servicing the engine. Attach a "Do Not Operate" tag near the key switch while performing maintenance on the equipment.

ALWAYS stop the engine before beginning service.

If you must service the engine while it is operating, remove all jewelry, tie back long hair and keep your hands, other body parts and clothing away from moving / rotating parts.

Piercing Hazard

Avoid skin contact with high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.

NEVER check for a fuel leak with your hands. ALWAYS use a piece of wood or cardboard.

Flying Object Hazard

ALWAYS wear eye protection when servicing the engine or when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.

Coolant Hazard

Wear eye protection and rubber gloves when you handle Long Life Coolant (LLC). If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

⚠ WARNING

Sever Hazard

NEVER wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing and ALWAYS tie long hair back when working near moving / rotating parts such as the flywheel or PTO shaft. Keep hands, feet and tools away from all moving parts.

The propeller may rotate during towing or if the engine is running at idle speed. NEVER service the engine while being towed or when the engine is running.

If the vessel has more than one engine, NEVER service a engine if either of the engines are running. In multi-engine configurations the propeller for an engine that is shut down may rotate if any of the other engines are running.

NEVER operate the engine without the guards in place.

NEVER operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the warning signals.

Electrical Hazard

Make welding repairs safely.

- ALWAYS turn off the battery switch (if equipped) or disconnect the negative (-) battery cable and the leads to the alternator when welding on the equipment.
- Remove the multi-pin connector to the engine control unit. Connect the weld clamp to the component to be welded and as close as possible to the welding point.
- NEVER connect the weld clamp to the engine or in a manner which would allow current to pass through a mounting bracket.
- When welding is completed, reconnect the leads to the alternator and engine control unit prior to reconnecting the batteries.

ALWAYS keep the electrical connectors and terminals clean. Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors.

NEVER turn off the battery switch (if equipped) or short the battery cables during operation. Damage to the electrical system will result.

Exhaust Hazard

All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

- NEVER block windows, vents, or other means of ventilation if the engine is operating in an enclosed area.
- ALWAYS ensure that all connections are tightened to specifications after repair is made to the exhaust system.

Burn Hazard

Some of the engine surfaces become very hot during operation and shortly after shut-down.

- Keep hands and other body parts away from hot engine surfaces.
- Handle hot components with heat-resistant gloves.

Sudden Movement Hazard

To prevent accidental equipment movement, NEVER start the engine in gear.

Shift the marine gear into the NEUTRAL position any time the engine is at idle.

⚠ WARNING

Lifting Hazard

The engine lifting eyes are engineered to lift the weight of the marine engine only. ALWAYS use the engine lifting eyes when lifting the engine.

Additional equipment is necessary to lift the marine engine and marine gear together. ALWAYS use lifting equipment with sufficient capacity to lift the marine engine.

If you need to transport an engine for repair, have a helper assist you attach it to a hoist and load it on a truck.

Alcohol and Drug Hazard

NEVER operate the engine while you are under the influence of alcohol or drugs or are feeling ill.

Exposure Hazard

ALWAYS wear personal protective equipment including appropriate clothing, gloves, work shoes, and eye and hearing protection as required by the task at hand.

Tool Hazard

Always remove any tools or shop rags used during maintenance from the area before operation.

⚠ CAUTION

The safety messages that follow have CAUTION level hazards.

Poor Lighting Hazard

Ensure that the work area is adequately illuminated. ALWAYS install wire cages on portable safety lamps.

Tool Hazard

ALWAYS use tools appropriate for the task at hand and use the correct size tool for loosening or tightening machine parts.

NOTICE

The safety messages that follow have NOTICE level hazards.

Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.

ALWAYS tighten components to the specified torque. Loose parts can cause equipment damage or cause it to operate improperly.

Only use replacement parts specified. Other replacement parts may affect warranty coverage.

NEVER attempt to modify the engine design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.

Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use Yanmar genuine replacement parts.

ALWAYS be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

NEVER dispose of hazardous materials by dumping them into a sewer, on the ground, or into ground water or waterways.

If any indicator illuminates during engine operation, stop the engine immediately. Determine the cause and repair the problem before you continue to operate the engine.

Make sure the engine is installed on a level surface. If a Yanmar Marine engine is installed at an angle that exceeds the specifications stated in the Yanmar Marine *Installation Manuals*, engine oil may enter the combustion chamber causing excessive engine speed, white exhaust smoke and serious engine damage. This applies to engines that run continuously or those that run for short periods of time.

LOCATION OF SAFETY LABELS

To ensure safe work, safety labels are attached. The location of labels is shown below and they should always be visible. Replace if damaged or lost.

3JH5E Engine

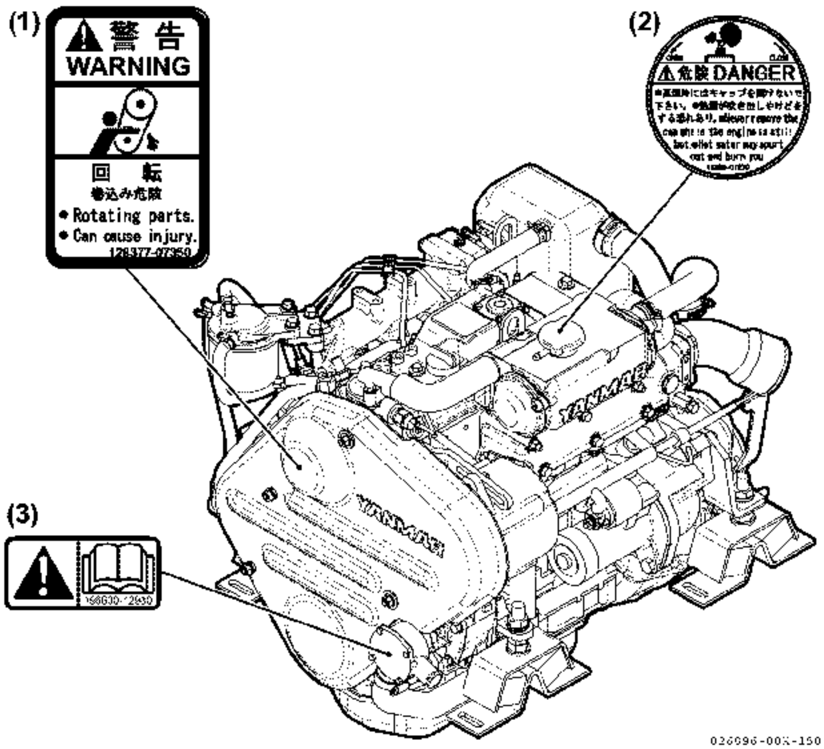


Figure 2-1

1 – Part No.: 128377–07350
2 – Part No.: 128990-07270
3 – Part No.: 196630–12980

4JH5E Engine

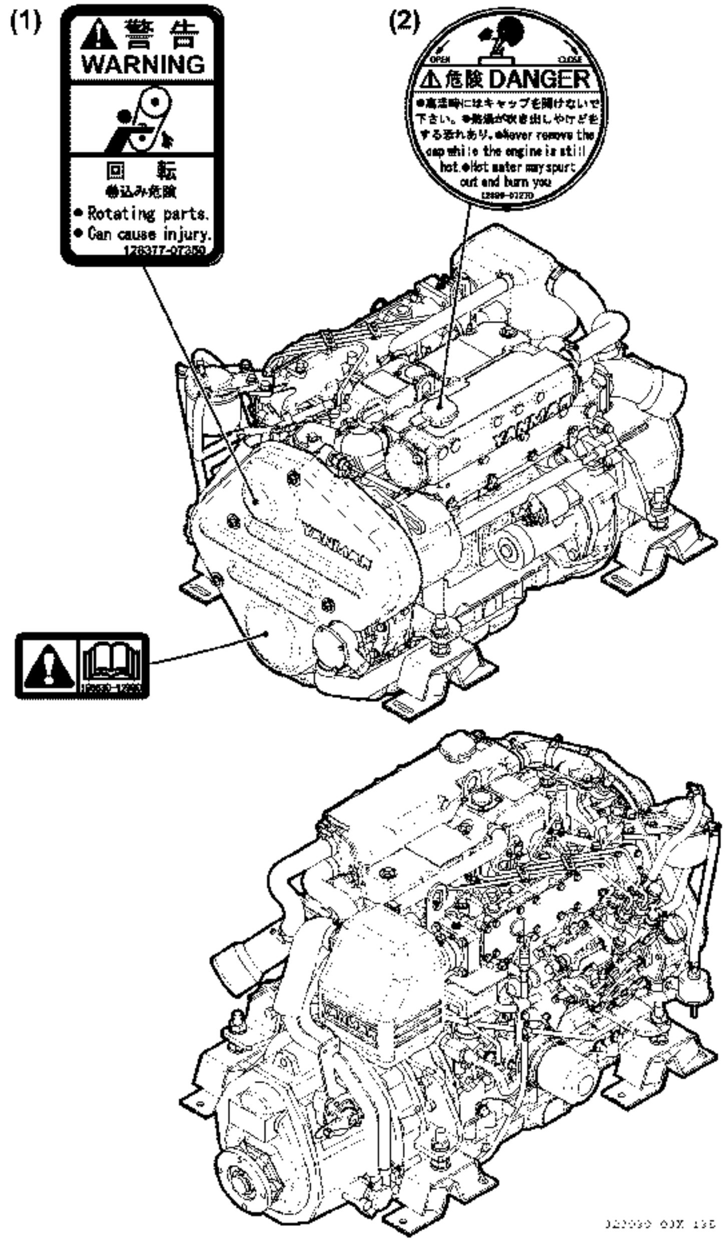


Figure 2-2

1 – Part No.: 128377–07350
2 – Part No.: 128990-07270
3 – Part No.: 196630–12980

4JH4-TE Engine

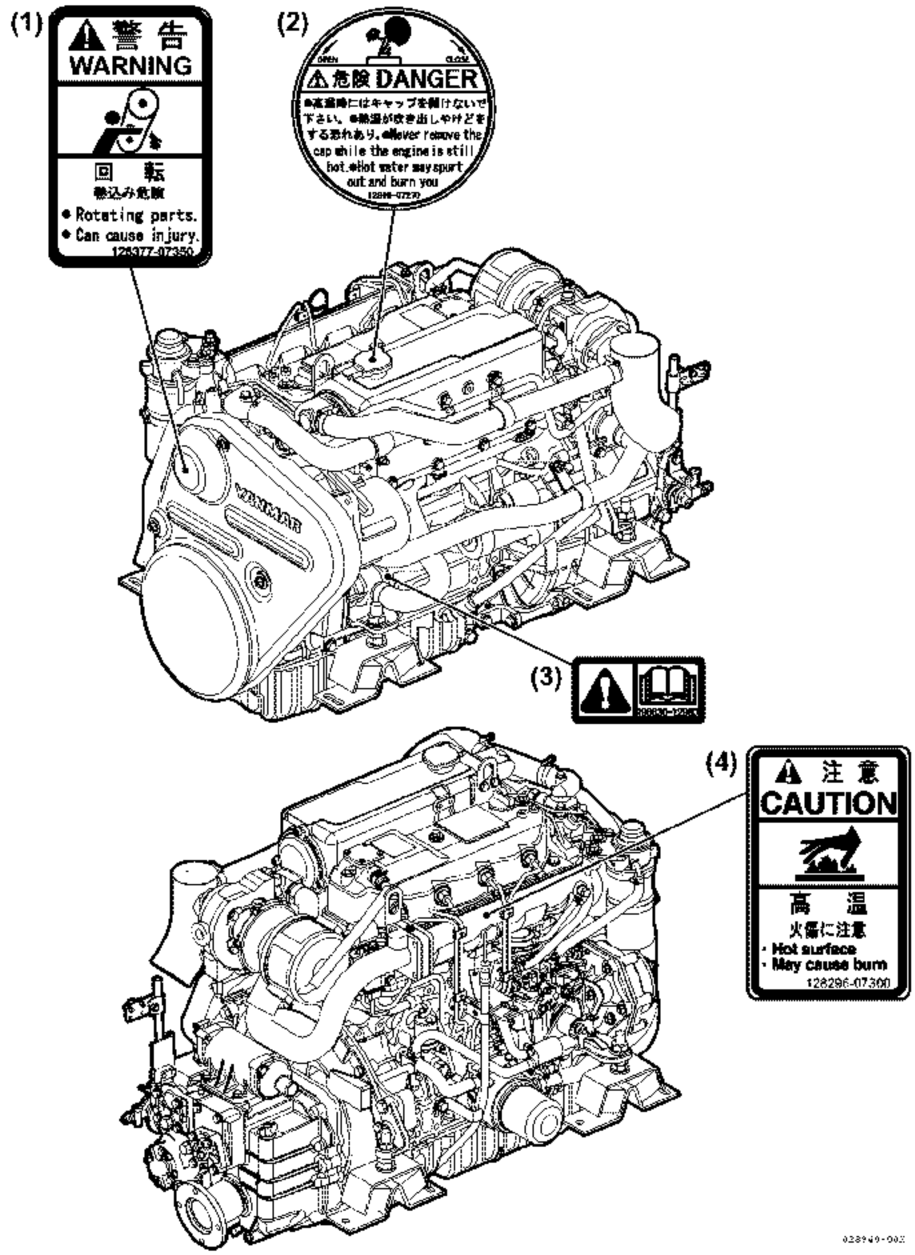


Figure 2-3

1 – **Part No.: 128377-07350**
2 – **Part No.: 128990-07270**
3 – **Part No.: 196630-12980**
4 – **Part No.: 128296-07300**

4JH4-HTE Engine

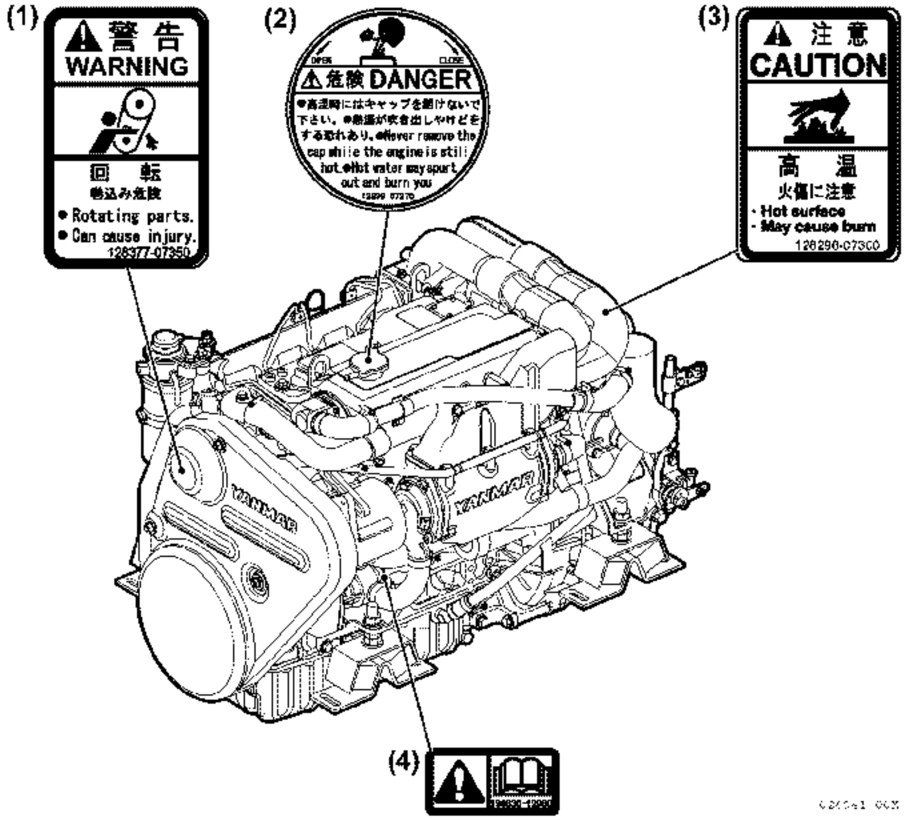


Figure 2-4

1 – Part No.: 128377-07350
2 – Part No.: 128990-07270
3 – Part No.: 128296-07300
4 – Part No.: 196630-12980

Section 3

GENERAL SERVICE INFORMATION

Page

SAFETY PRECAUTIONS

Before you service the engine, review the *Safety Section on page 2-1.*

ENGINE OUTLINE DRAWINGS

Note: All dimensions are metric (mm).

3JH5E Models

3JH5E - Inboard Version (KM35P)

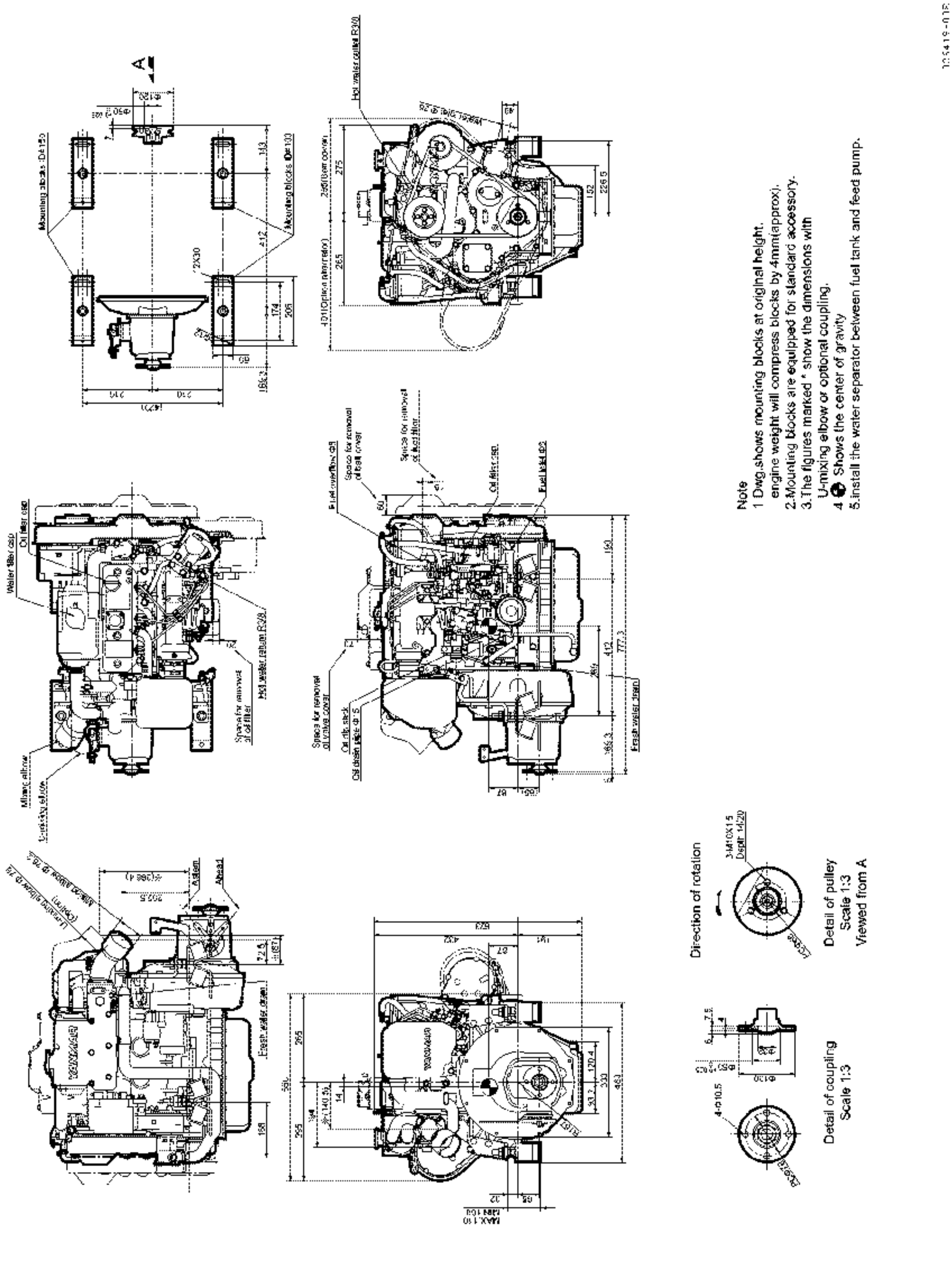


Figure 3-1

3JH5E - Inboard Version (KM35P) with KMG65E Generator (Optional)

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

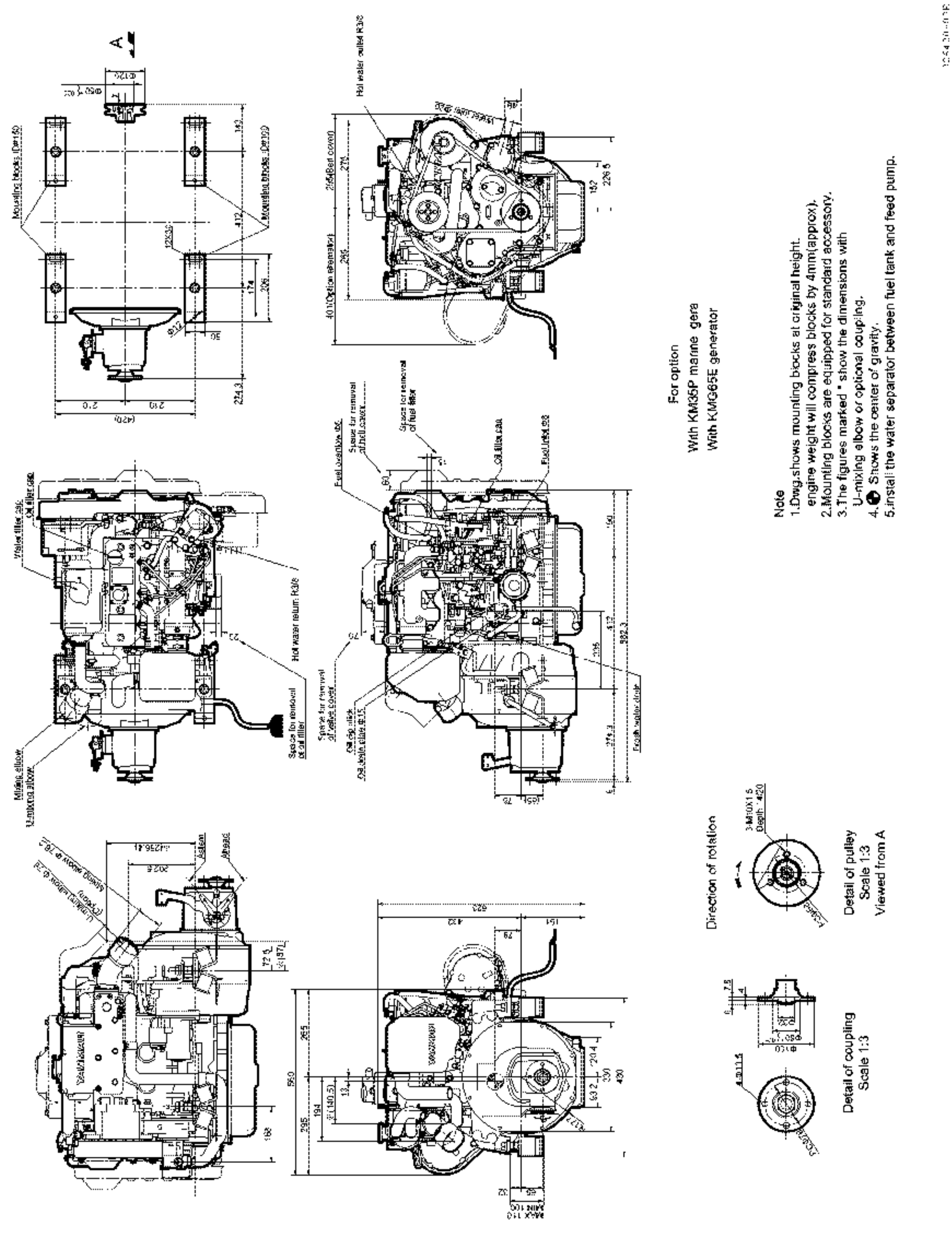


Figure 3-2

3JH5E - Inboard Version (KM35A)

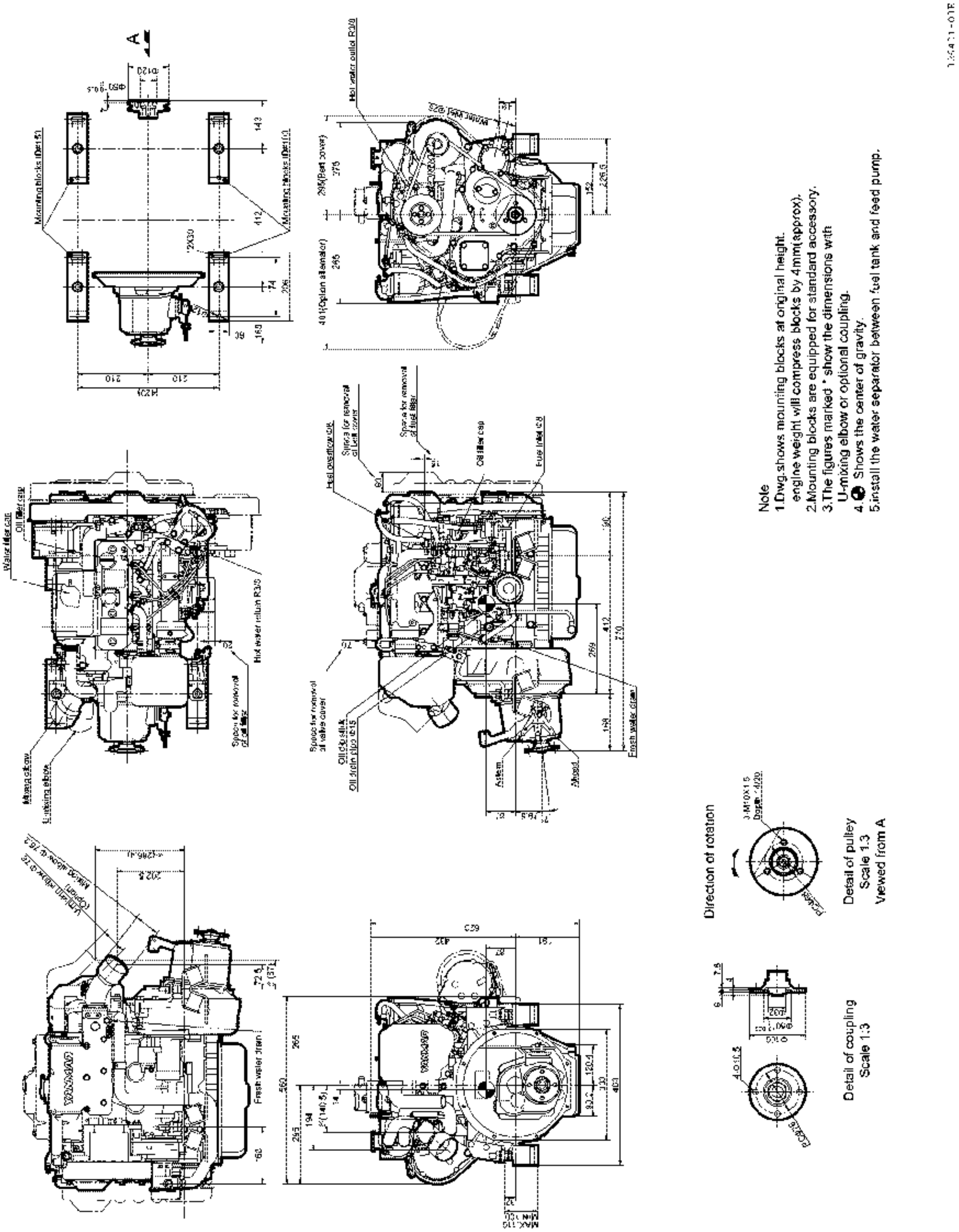


Figure 3-3

3JH5E - Inboard Version (KM35A) with KMG65E Generator (Optional)

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

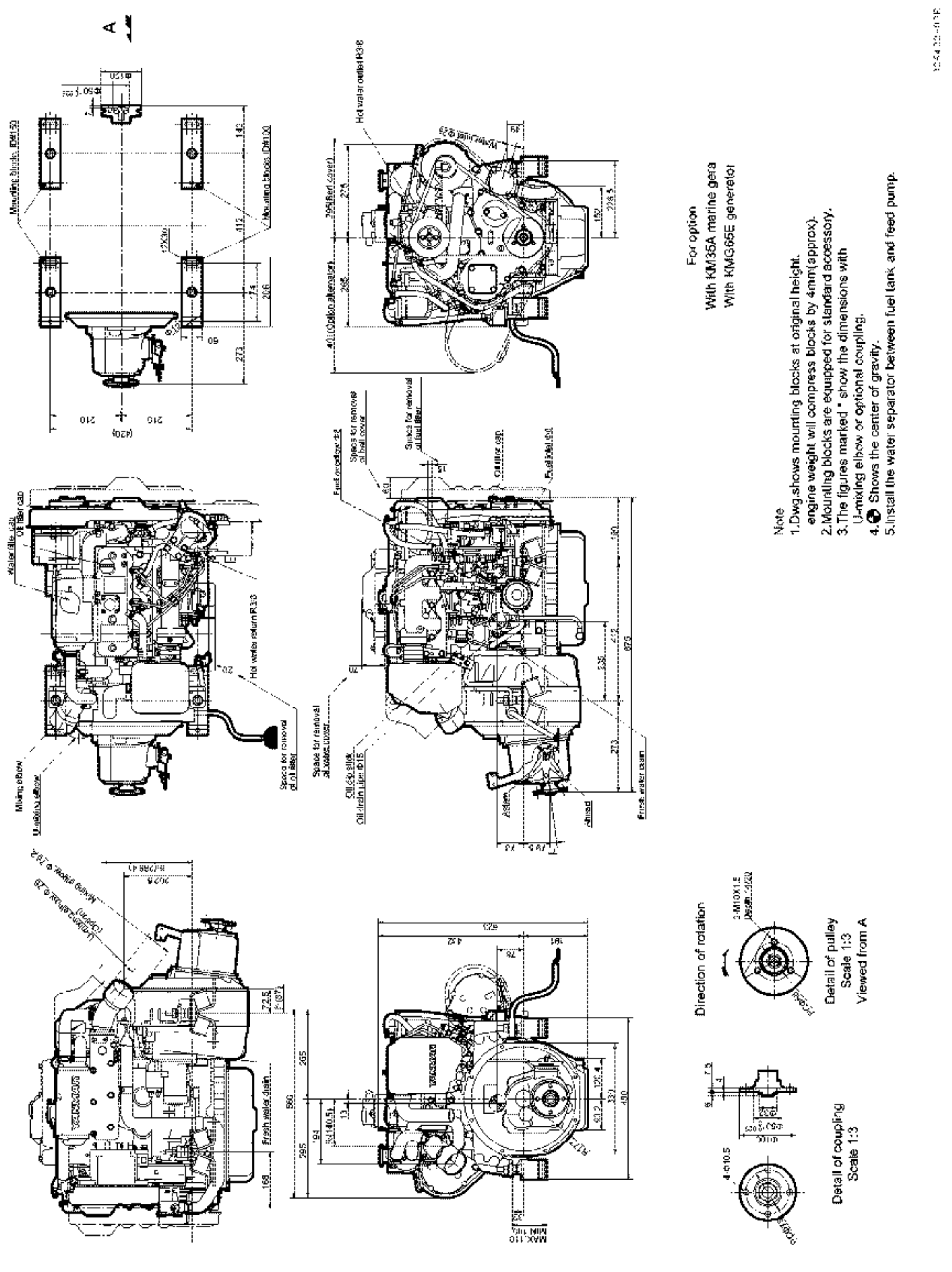


Figure 3-4

3JH5E - Sail Drive Version (SD50)

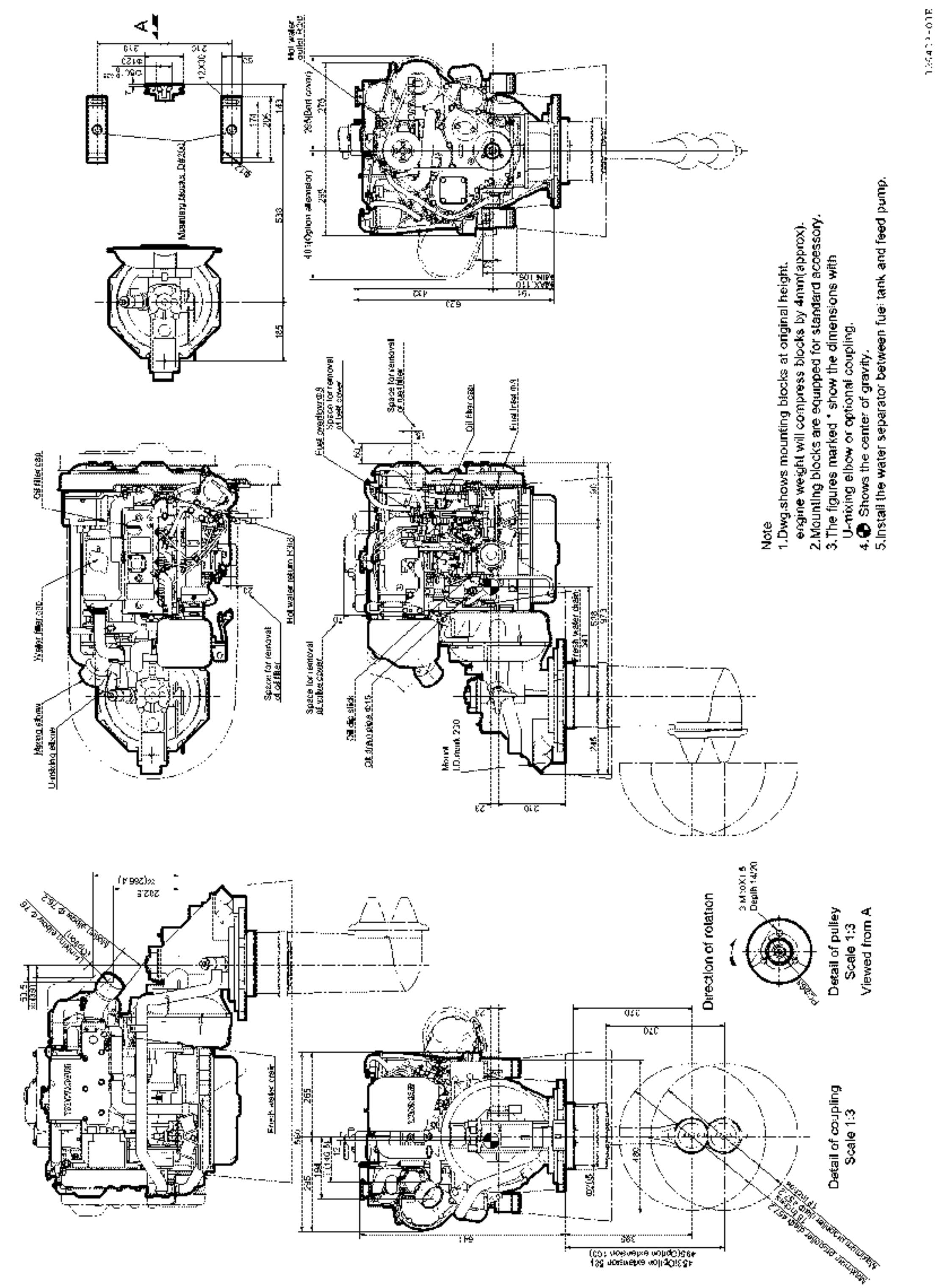


Figure 3-5

3JH5E - Sail Drive Version (SD50) with KMG65E Generator (Optional)

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

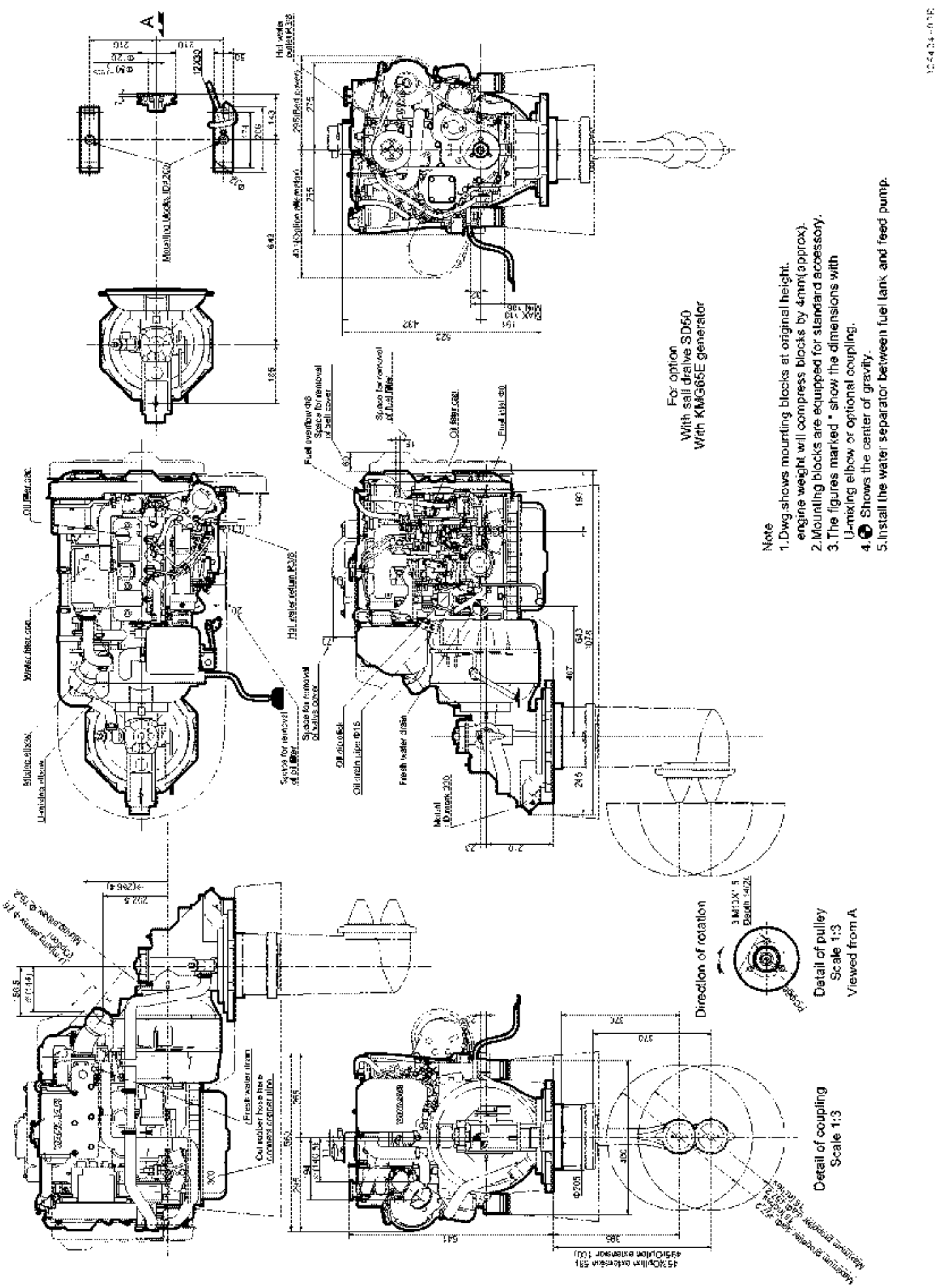


Figure 3-6

3JH5E - without Marine Gear

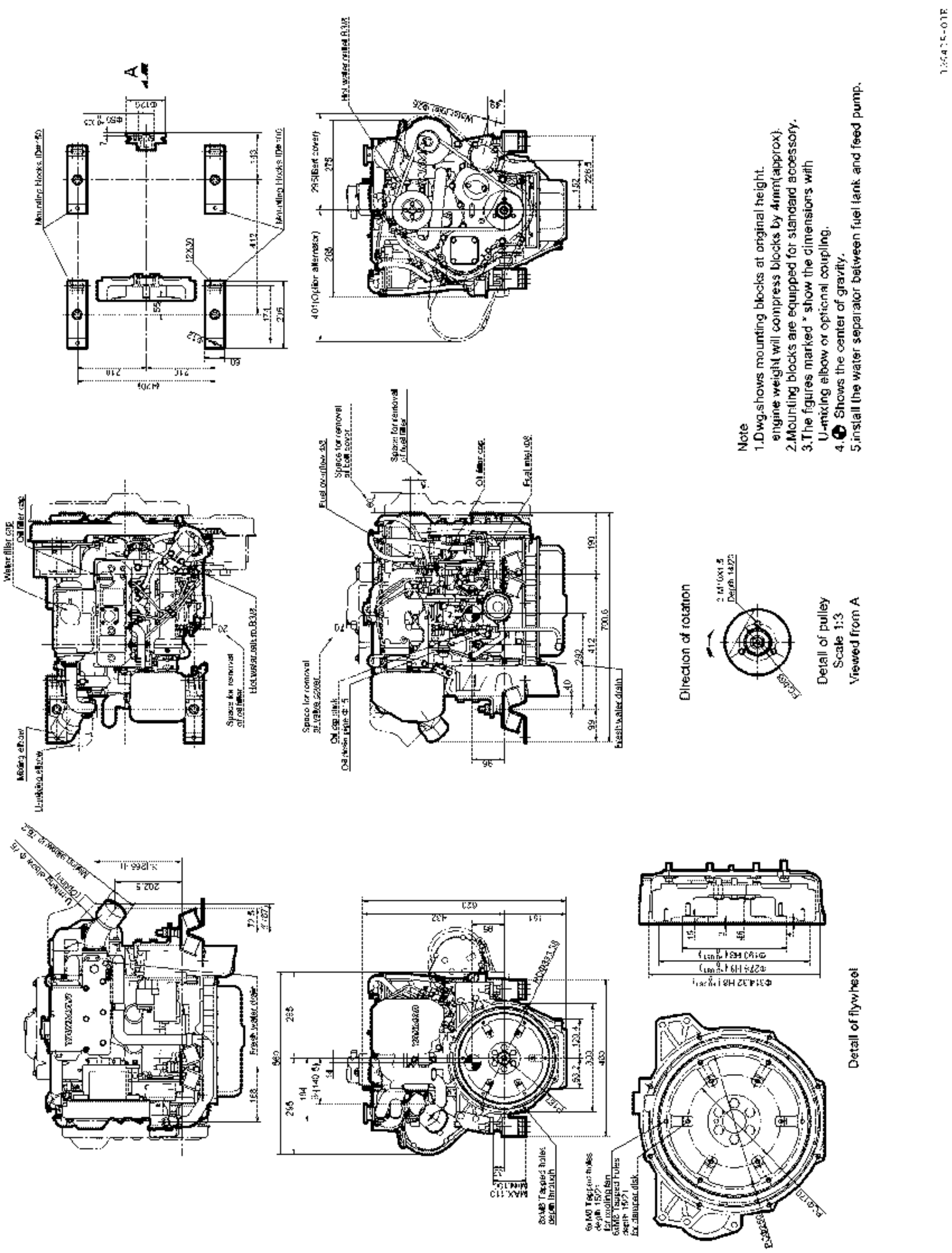


Figure 3-7

4JH5E Models

4JH5E - Inboard Version (ZF30M)

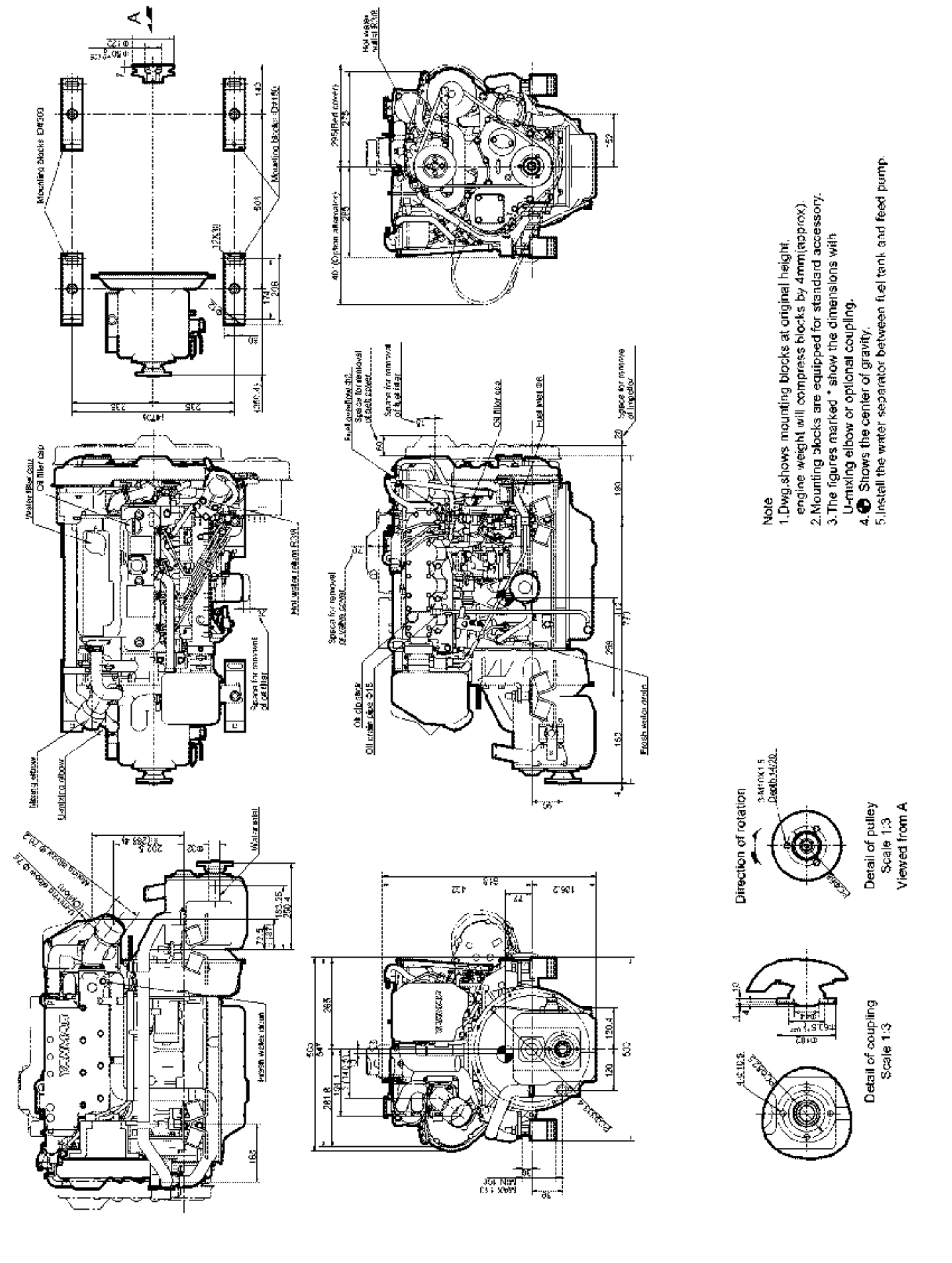


Figure 3-8

4JH5E - Inboard Version (KM35A2)

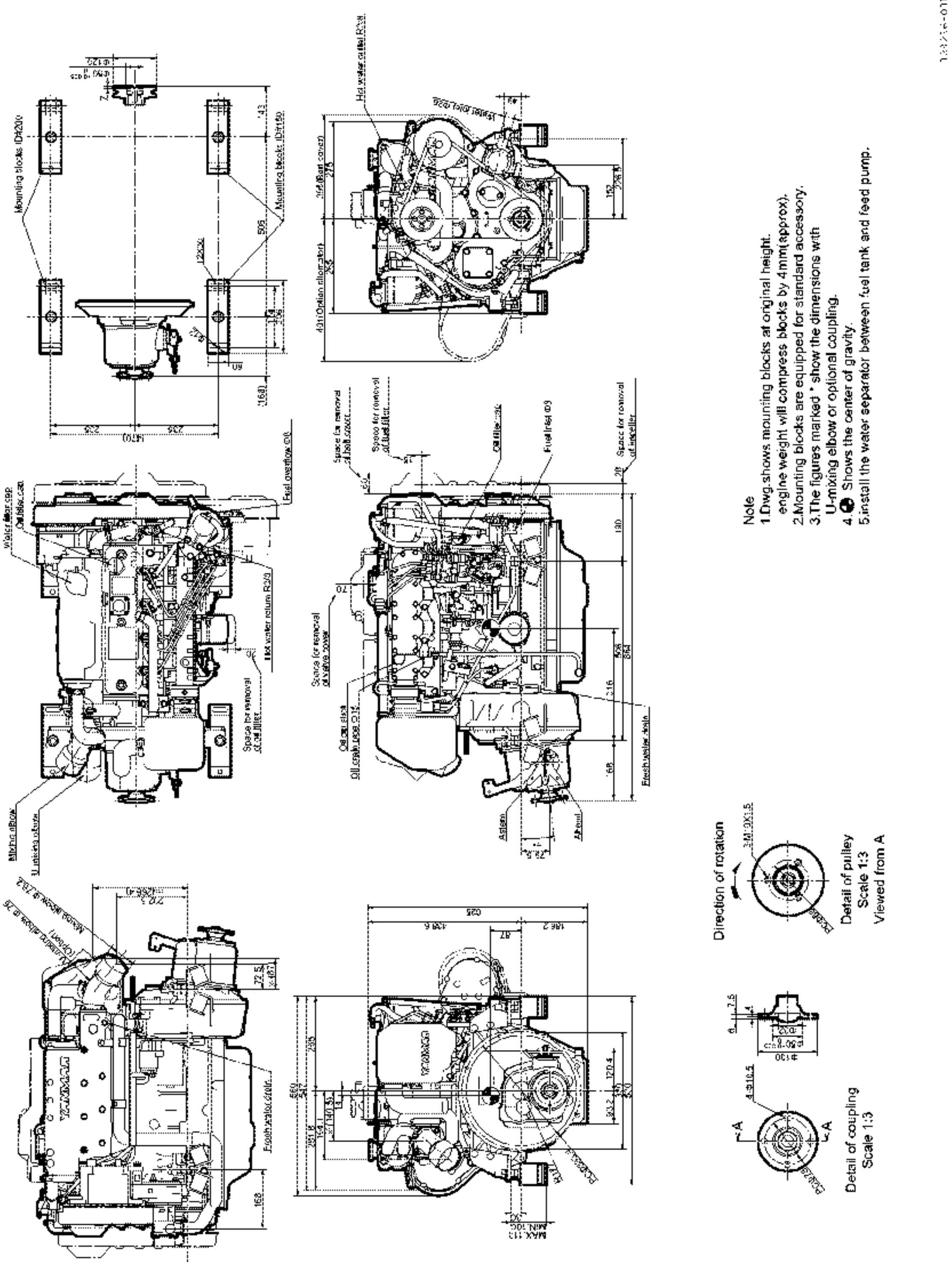


Figure 3-9

4JH5E - Inboard Version (KM35A2) with KMG65E Generator (Optional)

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

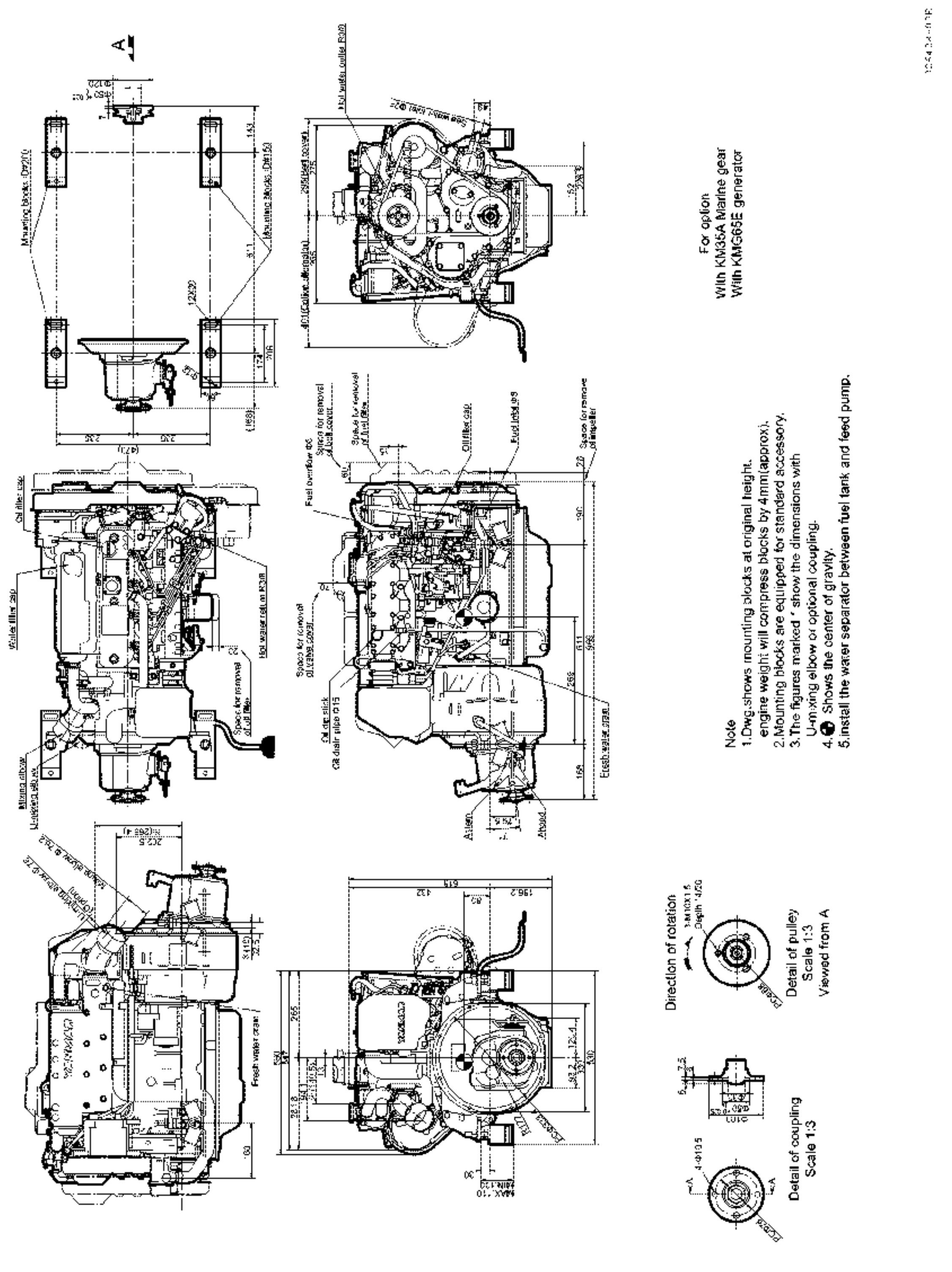


Figure 3-10

4JH5E - Inboard Version (KM35P)

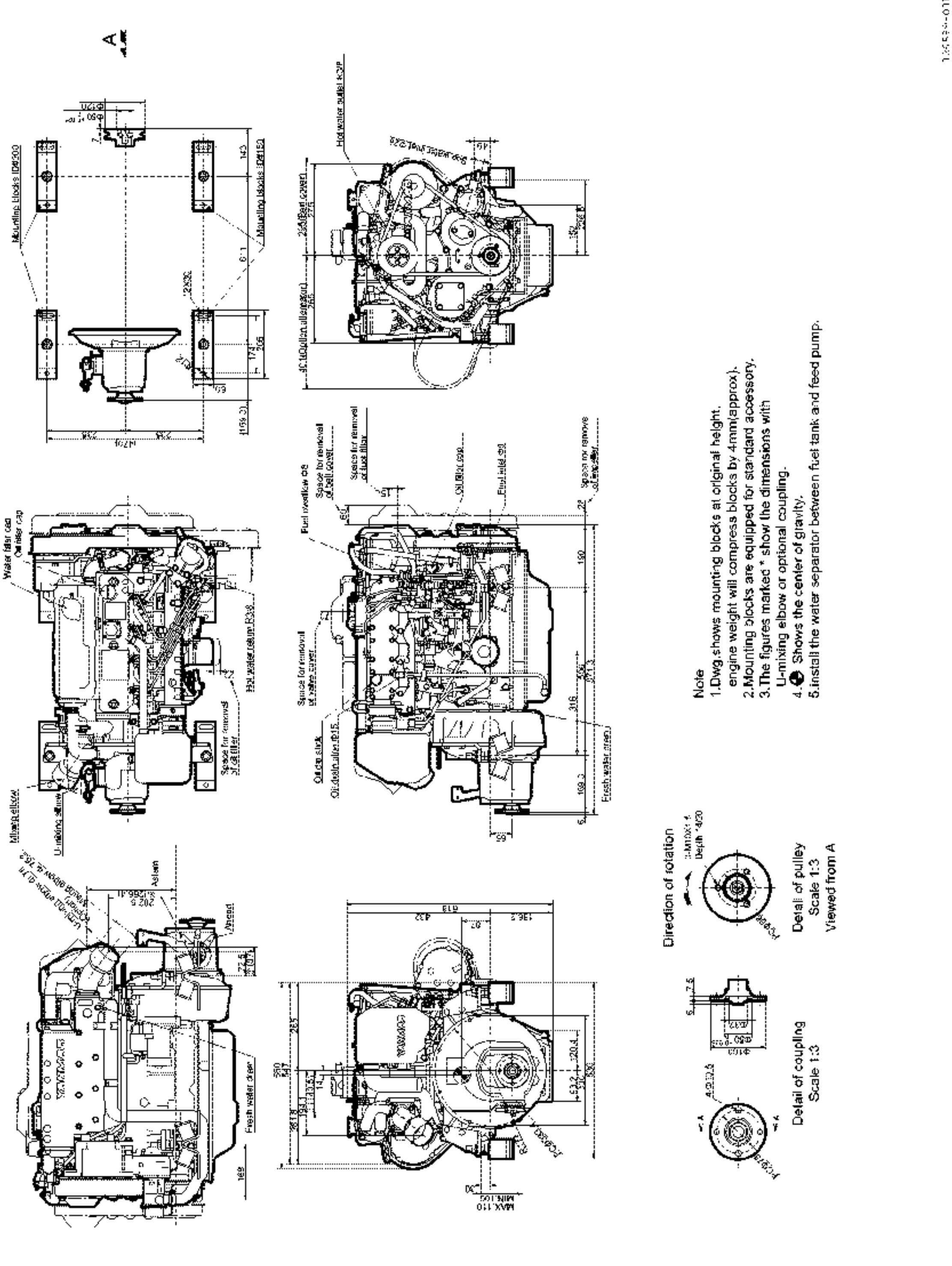


Figure 3-11

4JH5E - Inboard Version (KM35P) with KMG65E Generator (Optional)

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

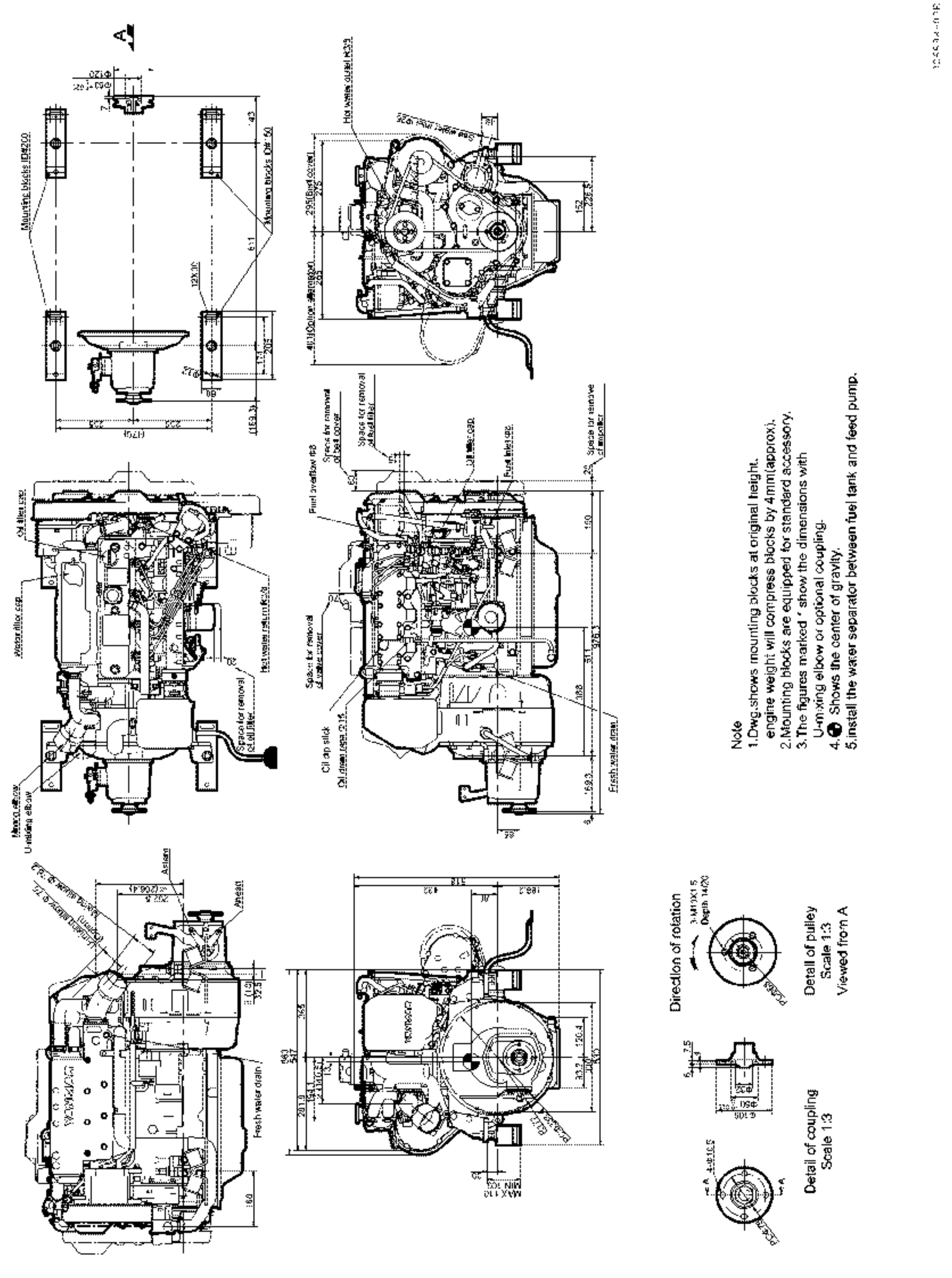


Figure 3-12

4JH5E - Inboard Version (KM4A1)

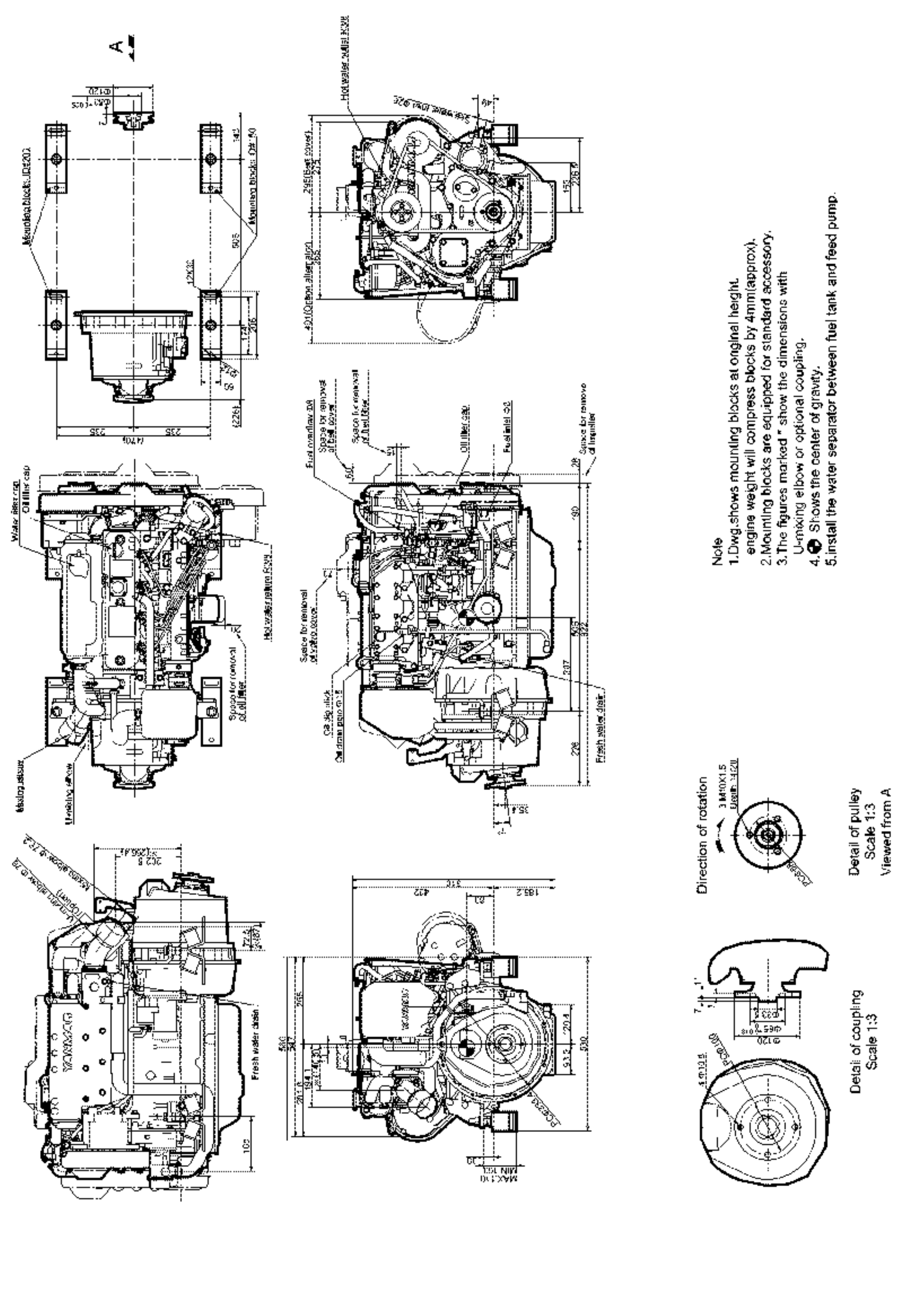
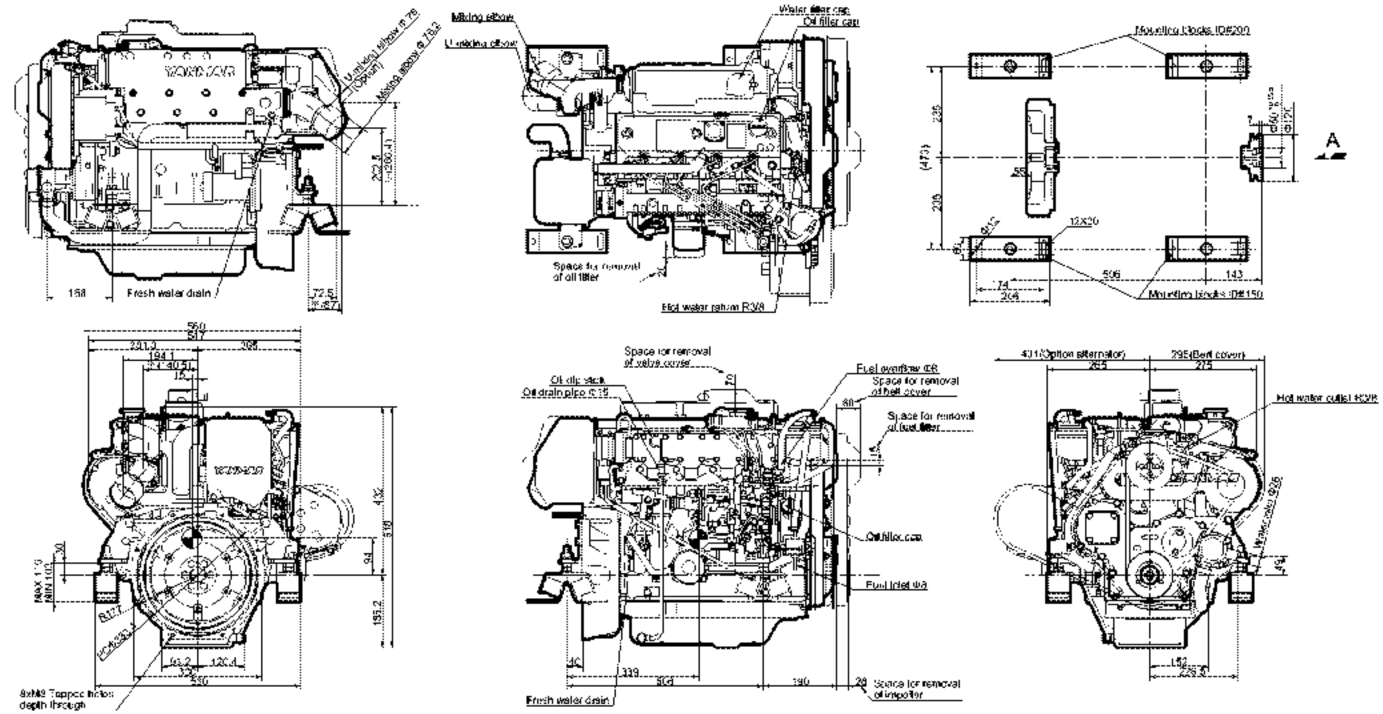
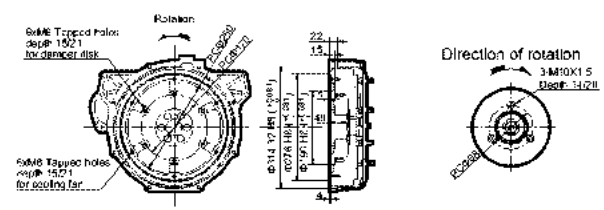


Figure 3-13





Detail of flywheel

Detail of pulley
Scale 1:3
Viewed from A

Note
1.Dwg.shows mounting blocks at original height.
engine weight will compress blocks by 4mm(approx).
2.Mounting blocks are equipped for standard accessory.
3.The figures marked * show the dimensions with
U-mixing elbow or optional coupling.
4.⊕ Shows the center of gravity.
5.install the water separator between fuel tank and feed pump.

Figure 3-14

4JH5E - Sail Drive Version (SD50)

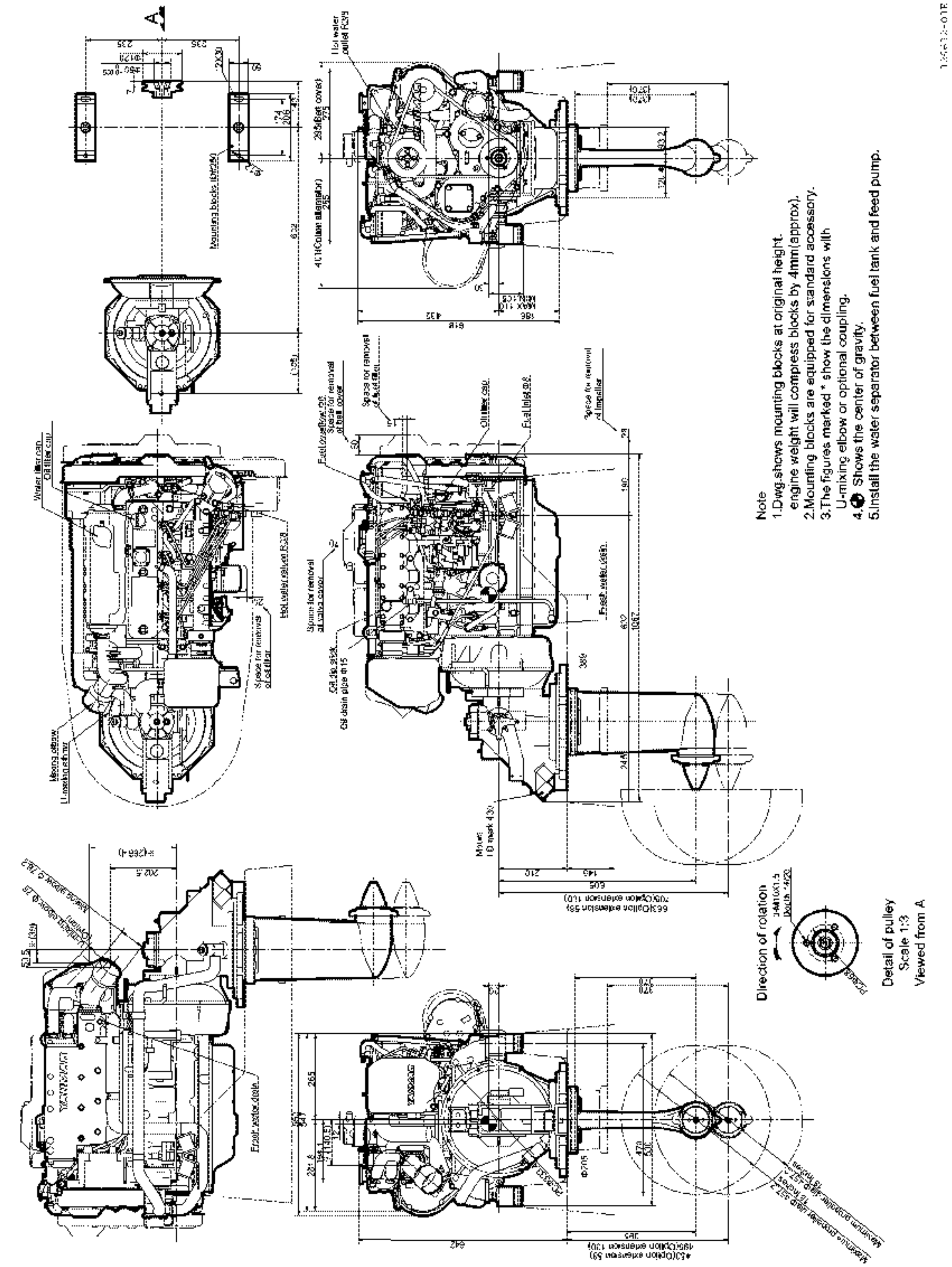


Figure 3-15

4JH5E - Sail Drive Version (SD50 with KMG65E Generator (Optional))

Please refer to the manuals below for KMG65E:

0AKMG-G00100 *Operation Manual*
0BKMG-G00100 *Service Manual*
0FKMG-G00100 *Installation Manual*

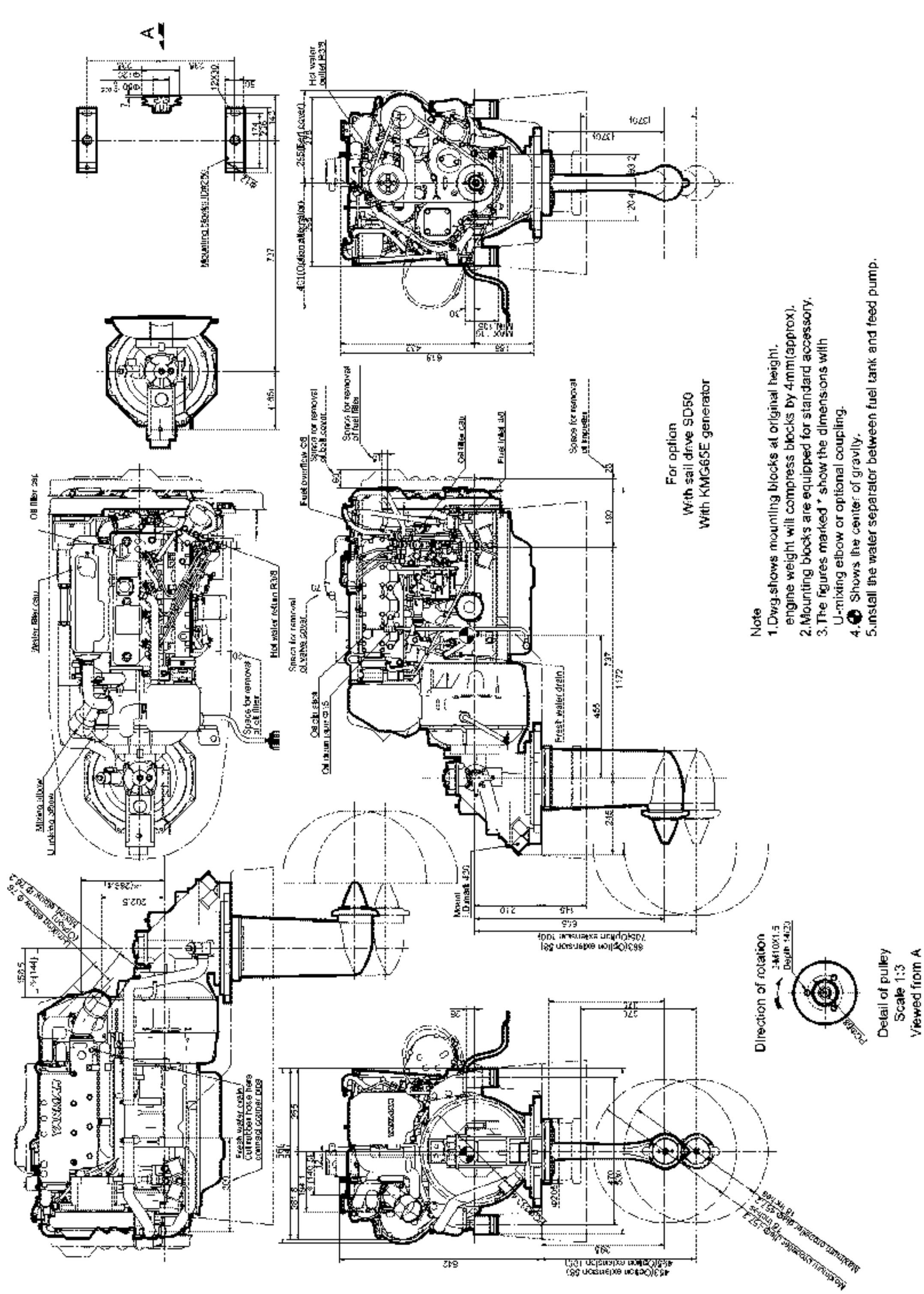


Figure 3-16

4JH4-TE Models

4JH4-TE - Inboard Version (ZF30M)

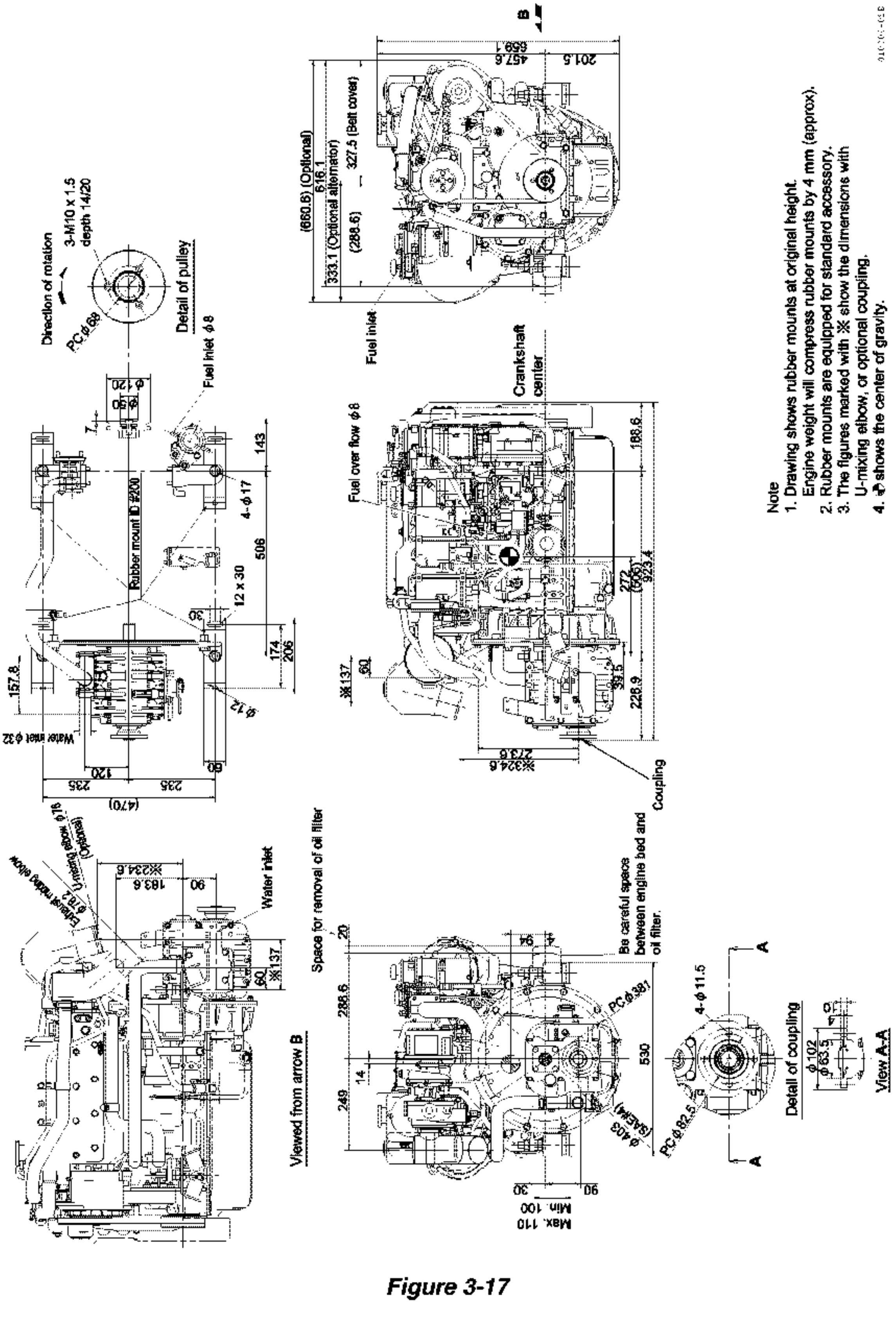
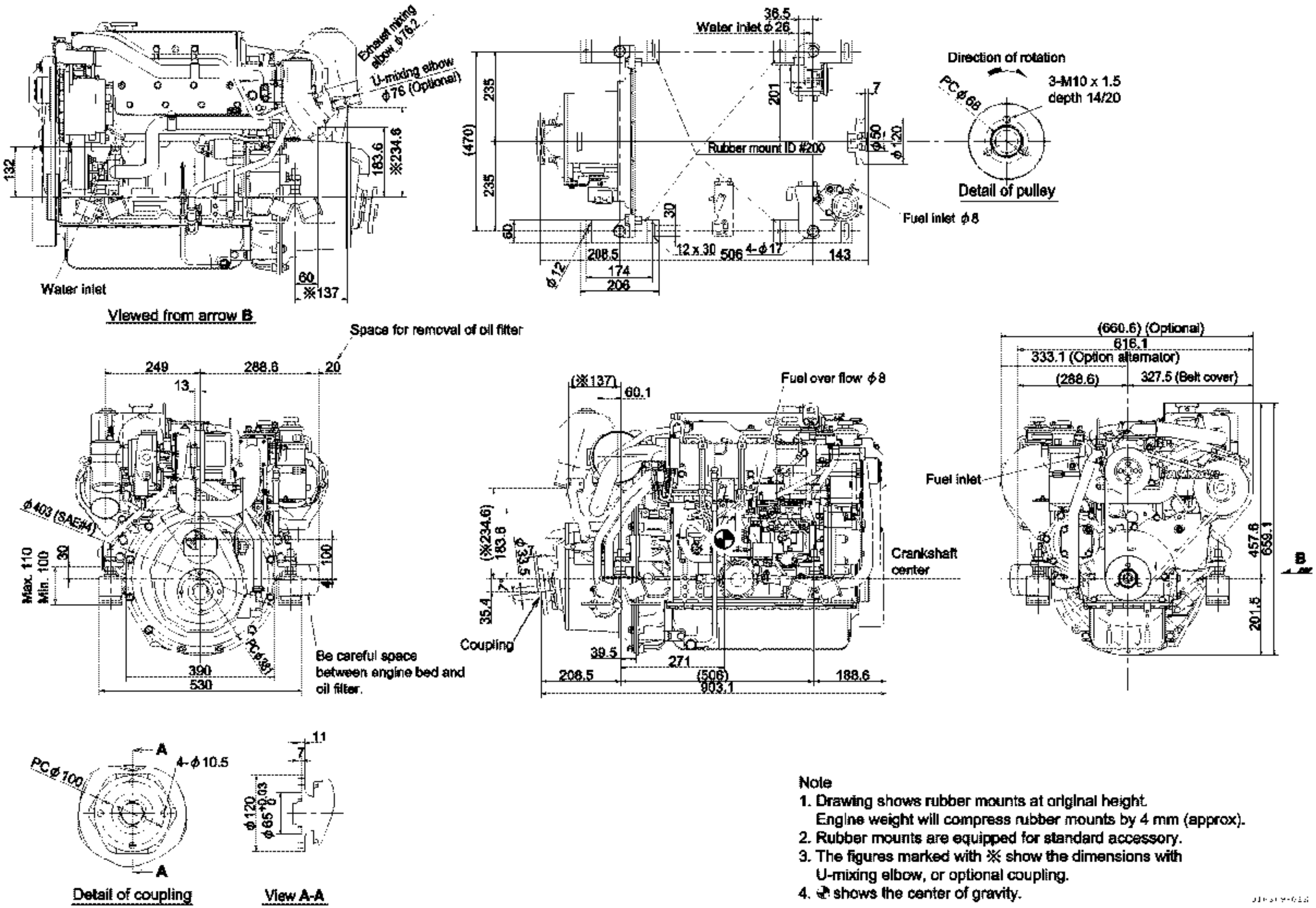


Figure 3-17

4JH4-TE - Inboard Version (KM4A2)



Note
1. Drawing shows rubber mounts at original height.
Engine weight will compress rubber mounts by 4 mm (approx).
2. Rubber mounts are equipped for standard accessory.
3. The figures marked with ※ show the dimensions with U-mixing elbow, or optional coupling.
4. ⊕ shows the center of gravity.

Figure 3-18

4JH4-TE - Inboard Version (KMH4A)

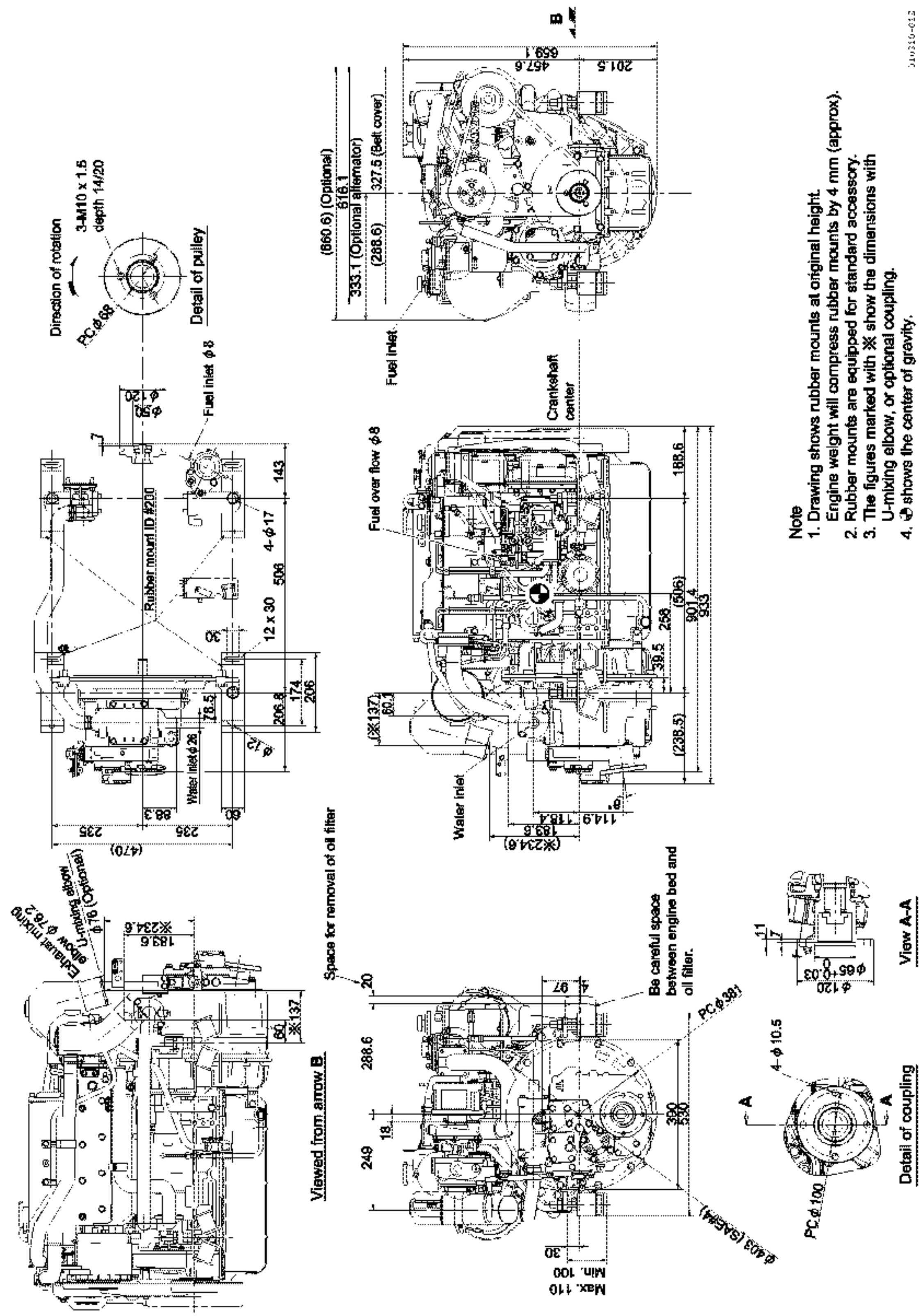


Figure 3-19

4JH4-TE - Inboard Version (ZF25A)

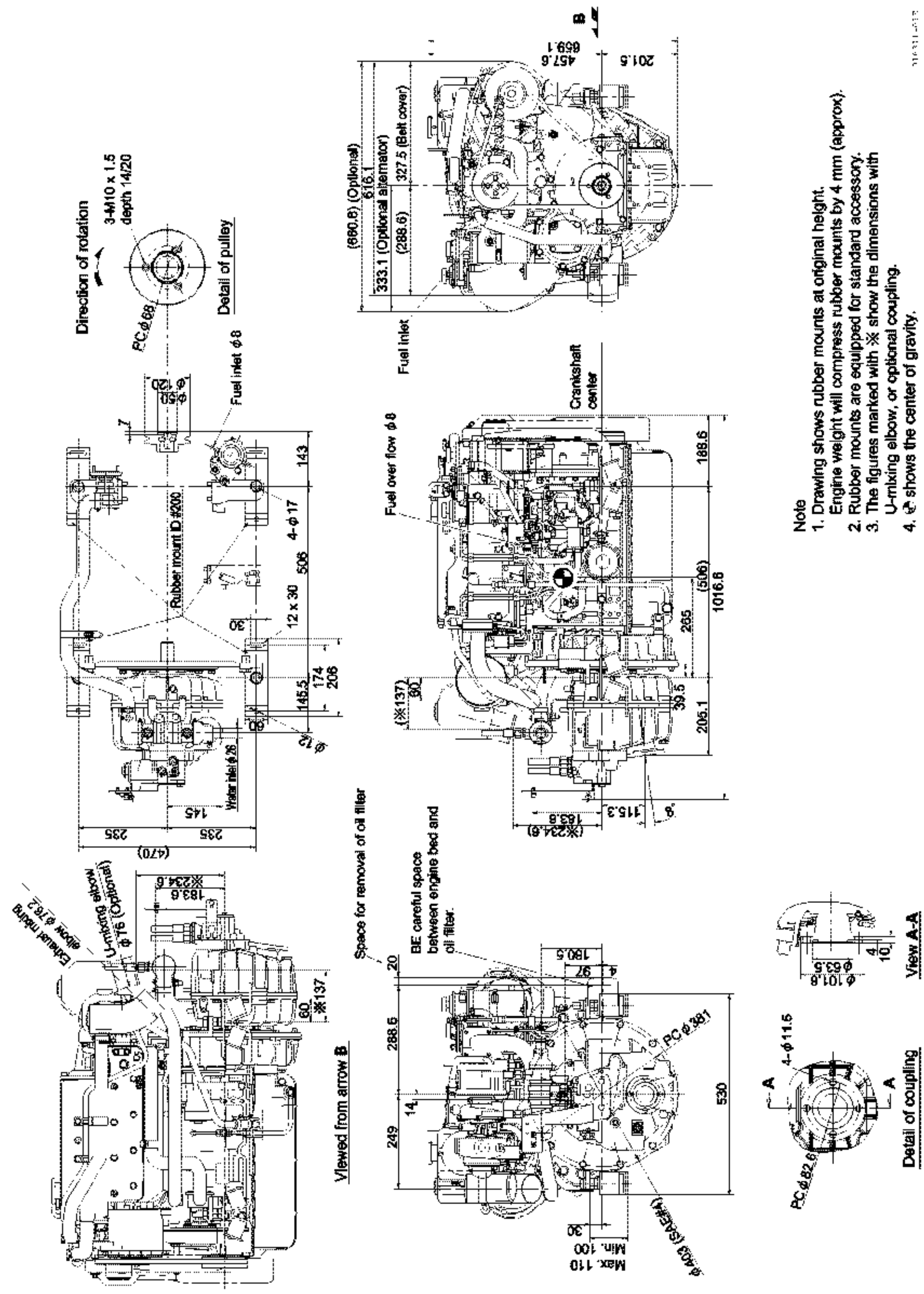


Figure 3-20

4JH4E-TE - Sail Drive Version (SD50-4T)

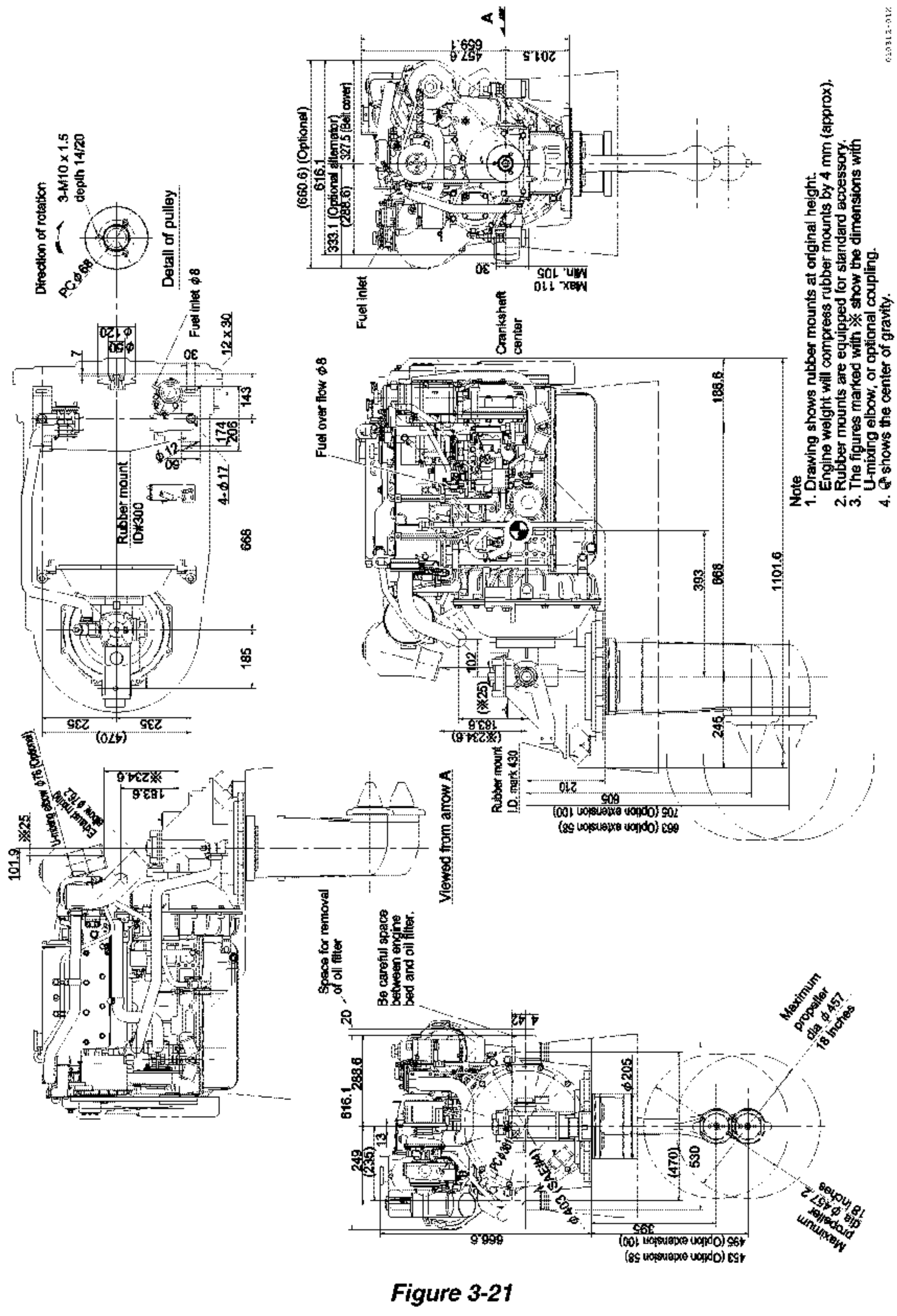


Figure 3-21

4JH4E-TE - without Marine Gear

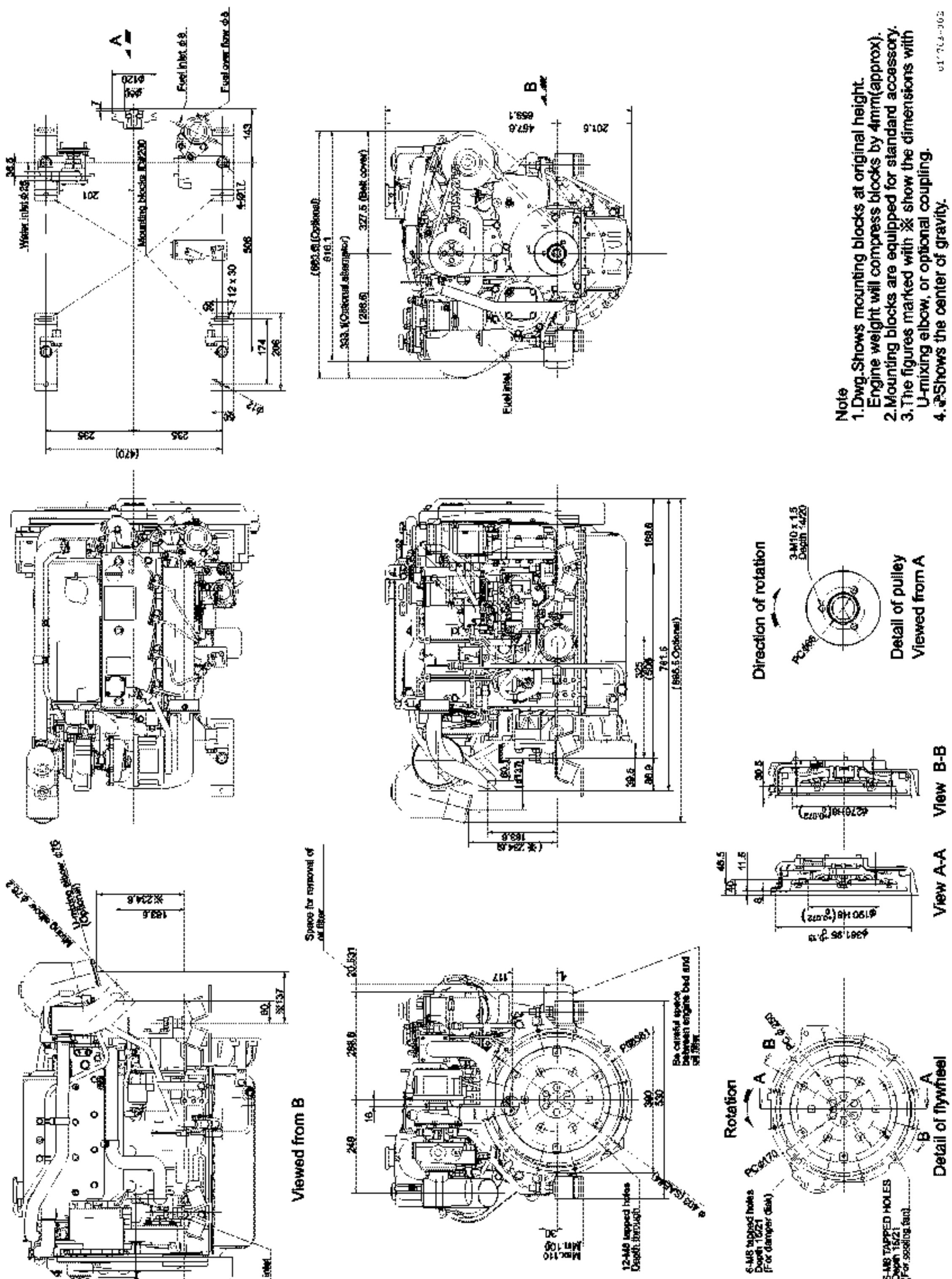


Figure 3-22

4JH4-HTE Models

4JH4-HTE - Inboard Version (ZF30M)

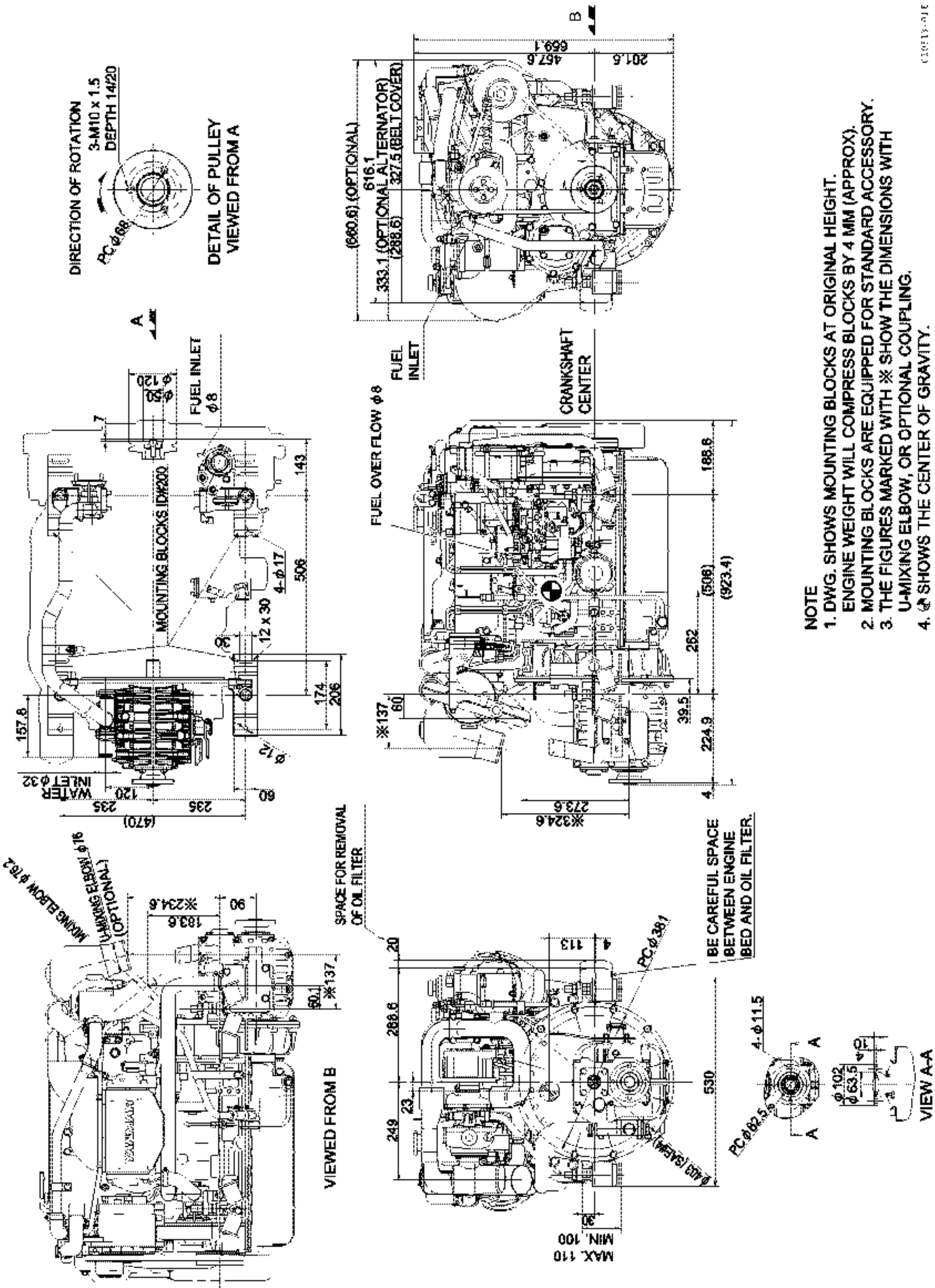
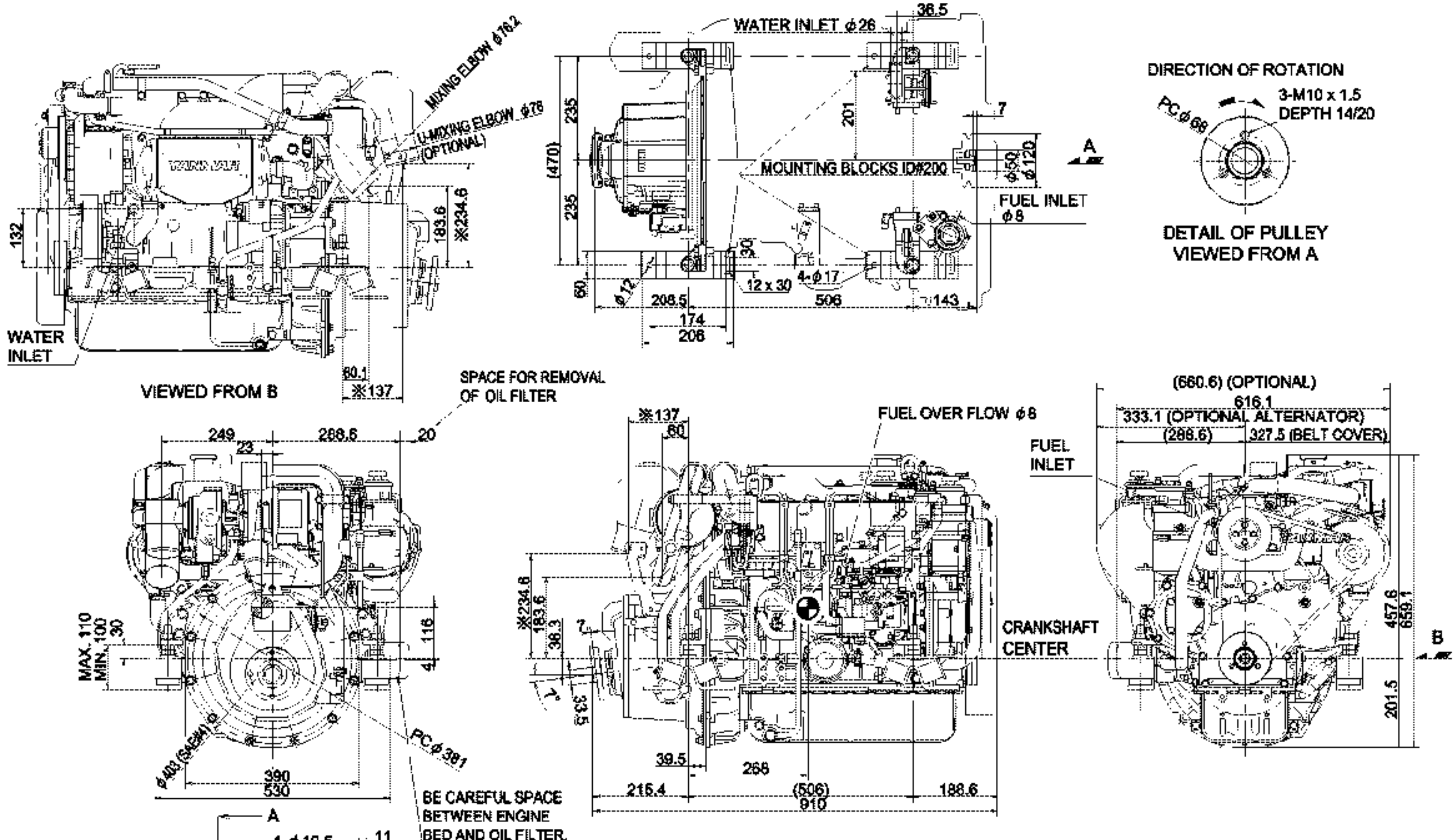
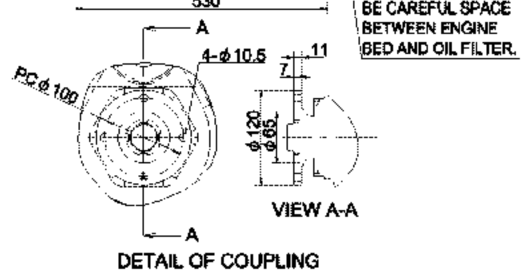


Figure 3-23

4JH4-HTE - Inboard Version (KM4A2)





NOTE
1. DWG. SHOWS MOUNTING BLOCKS AT ORIGINAL HEIGHT. ENGINE WEIGHT WILL COMPRESS BLOCKS BY 4 MM (APPROX).
2. MOUNTING BLOCKS ARE EQUIPPED FOR STANDARD ACCESSORY.
3. THE FIGURES MARKED WITH ※ SHOW THE DIMENSIONS WITH U-MIXING ELBOW, OR OPTIONAL COUPLING.
4. ⊕ SHOWS THE CENTER OF GRAVITY.

Figure 3-24

4JH4-HTE - Inboard Version (KMH4A)

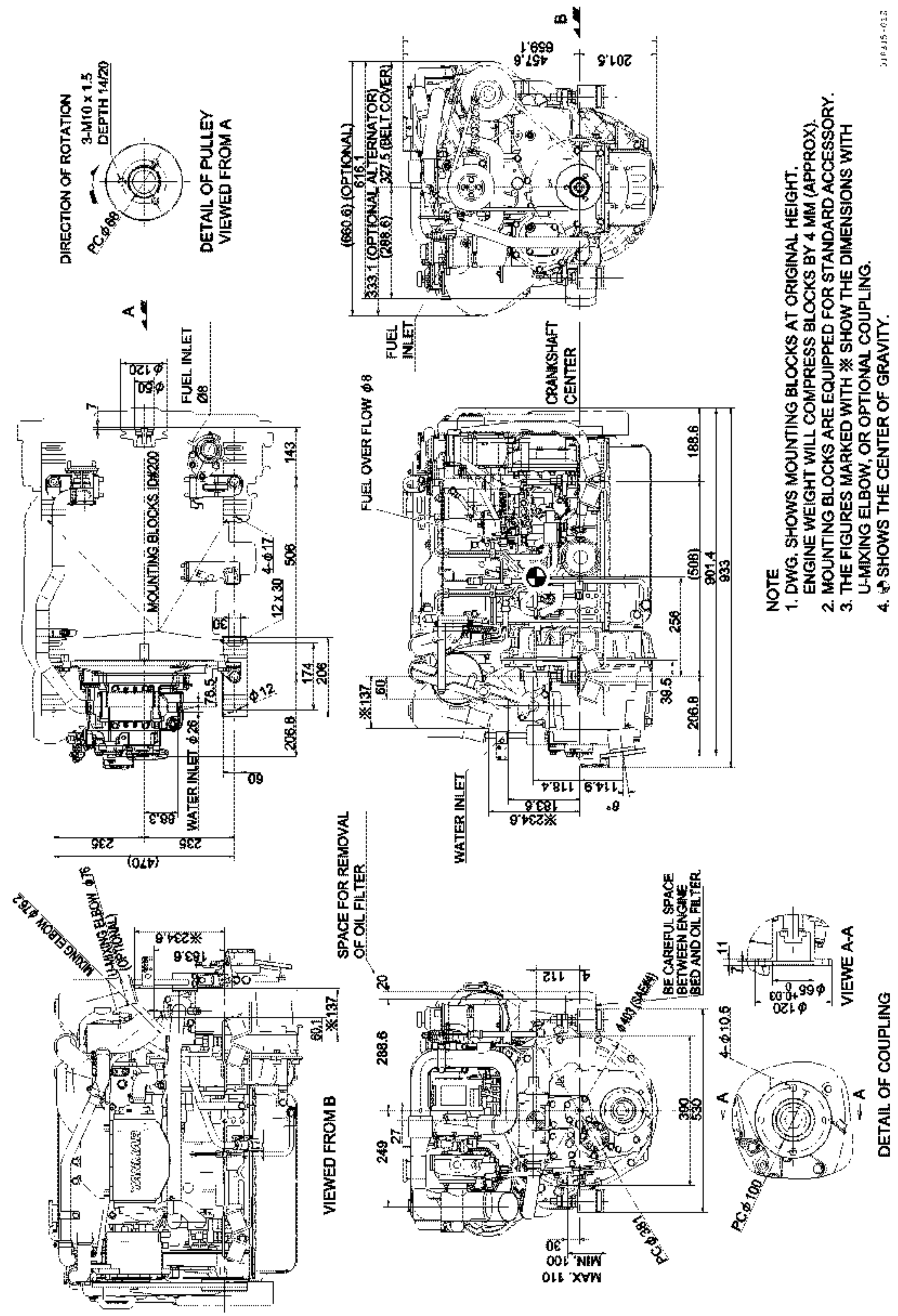
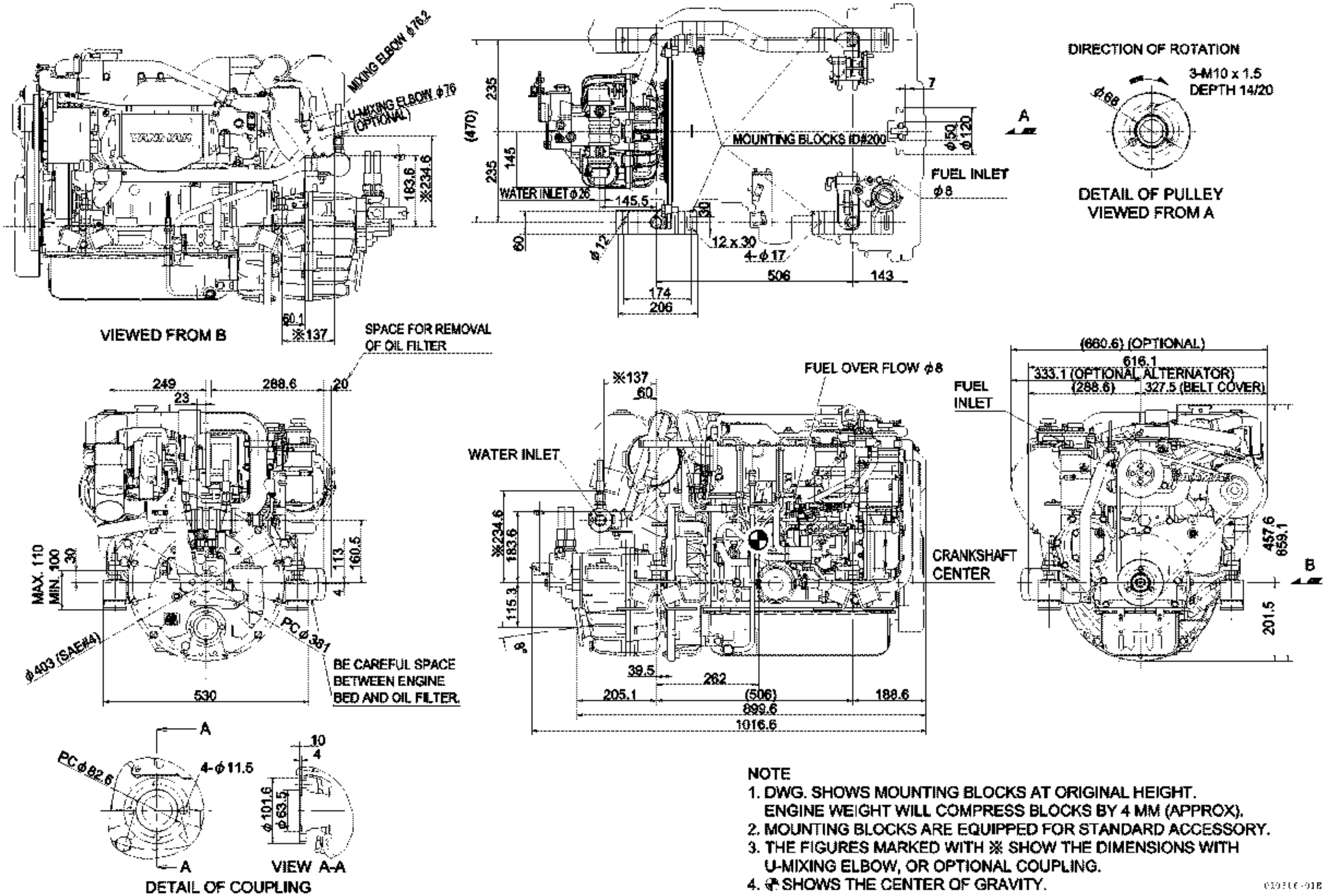


Figure 3-25

4JH4-HTE - Inboard Version (ZF25A)



NOTE
1. DWG. SHOWS MOUNTING BLOCKS AT ORIGINAL HEIGHT.
   ENGINE WEIGHT WILL COMPRESS BLOCKS BY 4 MM (APPROX).
2. MOUNTING BLOCKS ARE EQUIPPED FOR STANDARD ACCESSORY.
3. THE FIGURES MARKED WITH ※ SHOW THE DIMENSIONS WITH
   U-MIXING ELBOW, OR OPTIONAL COUPLING.
4. ⊕ SHOWS THE CENTER OF GRAVITY.

Figure 3-26

4JH4E-HTE - without Marine Gear

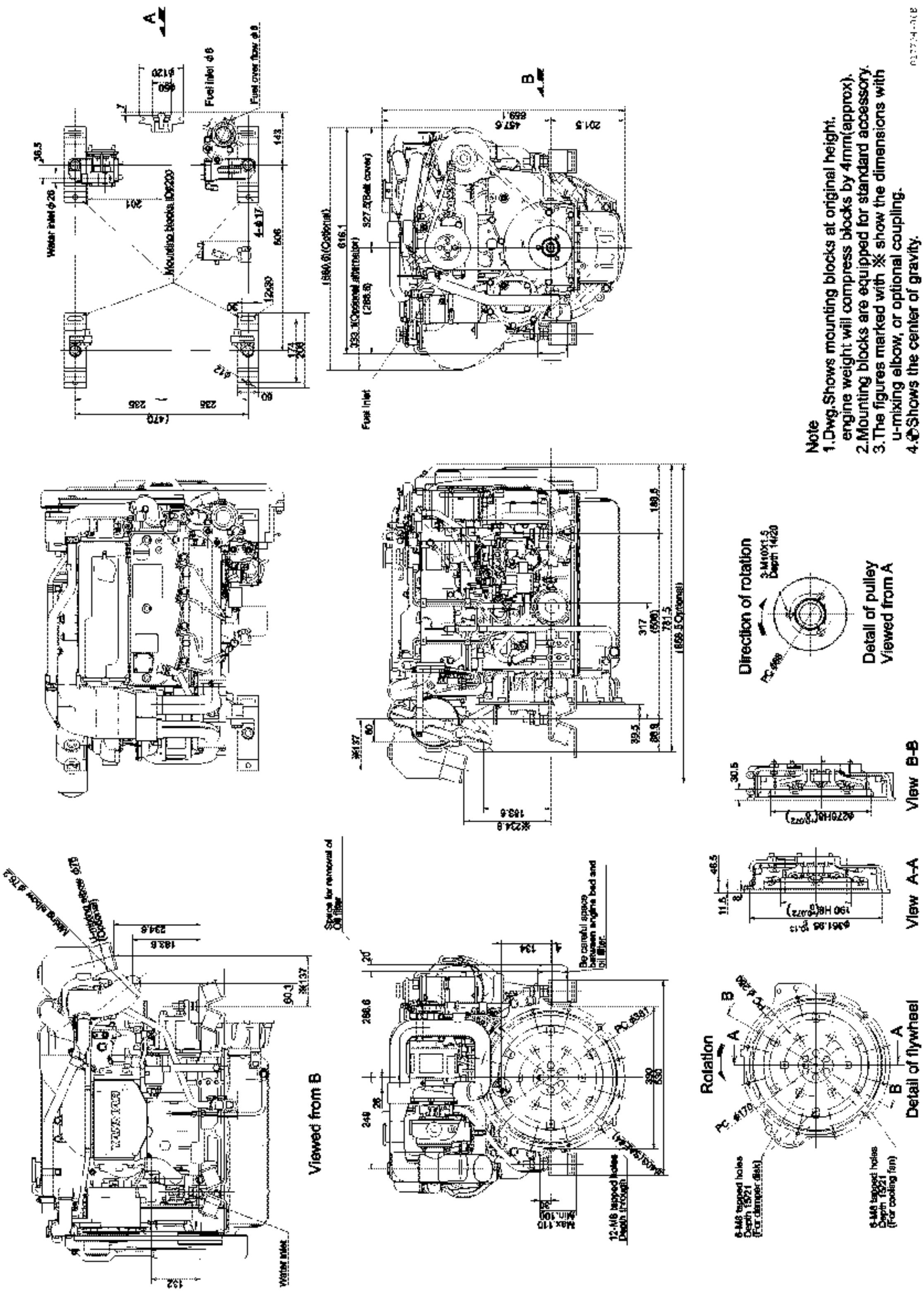


Figure 3-27

PIPING DIAGRAMS

Notation	Description
—‖|—	Screw Joint (Union)
—‖—	Flange Joint
—T—	Eye Joint
—<—	Insertion Joint
==========	Drilled Hole
----------	Coolant Piping
—··—··—	Cooling Seawater Piping
—·—·—·	Lubricating Oil Piping
———	Diesel Fuel Piping

Note:

- Dimension of steel pipe: outer diameter x thickness.
- Dimension of rubber hose: inner diameter x thickness.
- Fuel rubber hoses (marked *) satisfy EN / ISO7840.

3JH5E Models

3JH5E (KM35P, KM35A)

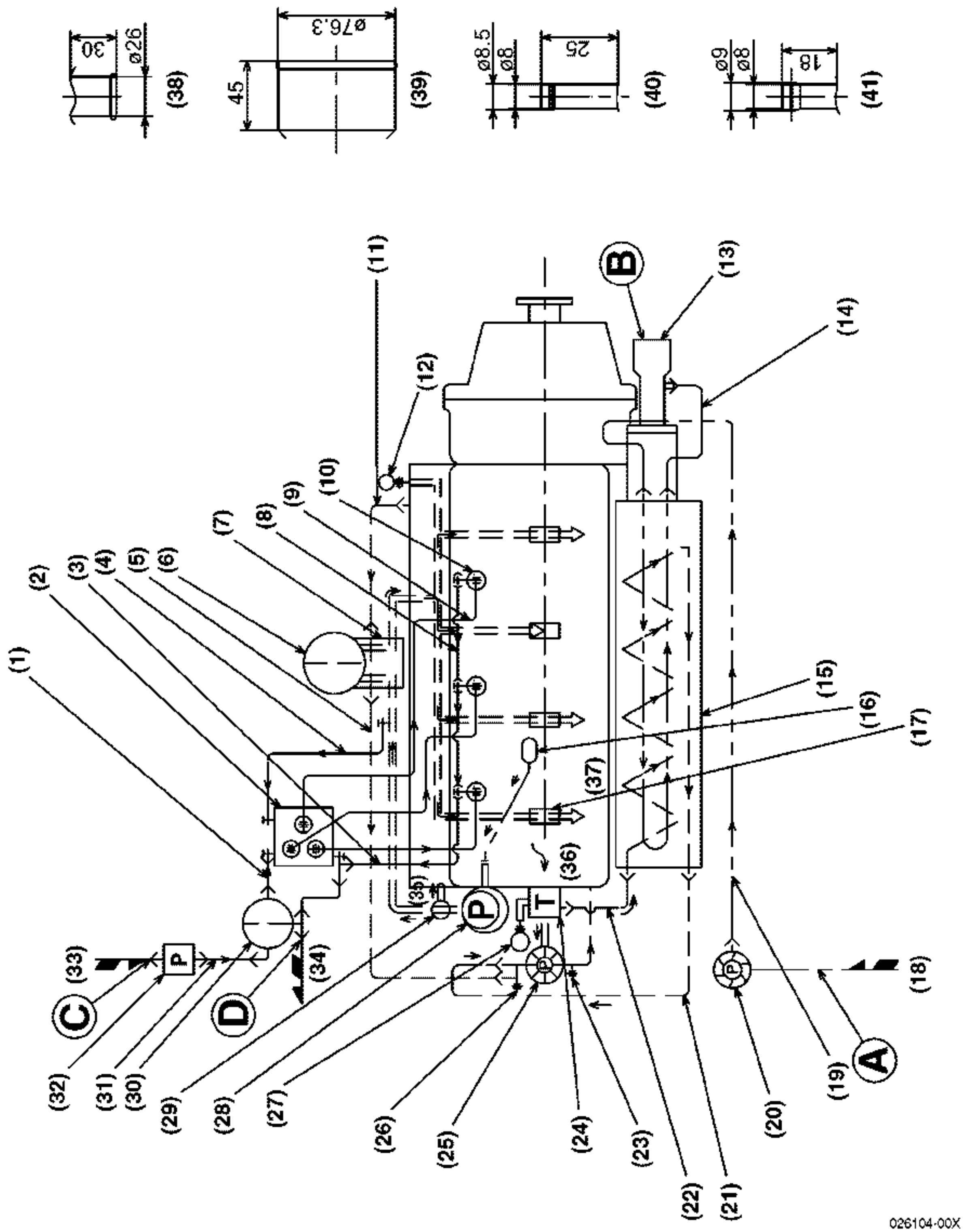


Figure 3-28

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – * 4.76 x t0.7 Steel Pipe
5 – * 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – Mixing Elbow
14 – 25.4 x t4.3 Rubber Hose
15 – Heat Exchanger
16 – Lubricating Oil Inlet Filter
17 – Main Bearing
18 – Seawater Inlet
19 – 25.4 x t4.3 Rubber Hose
20 – Cooling Water Pump (seawater)
21 – 28 x t4 Rubber Hose
22 – 28 x t4 Rubber Hose
23 – Hot Water Connection Outlet (R3/8)
24 – Thermostat
25 – Coolant Pump (freshwater)
26 – Hot Water Connection Inlet (R3/8)
27 – Coolant Temperature Switch
28 – Lubricating Oil Pump
29 – Pressure Control Valve
30 – Fuel Filter (cartridge type)
31 – * 7 x t4.5 Rubber Hose
32 – Fuel Feed Pump
33 – Fuel Inlet
34 – Fuel Overflow
35 – To Oil Pan
36 – From Cylinder Head
37 – To Camshaft
38 – Detail of Part A
39 – Detail of Part B
40 – Detail of Part C
41 – Detail of Part D

3JH5E (KM4A1)

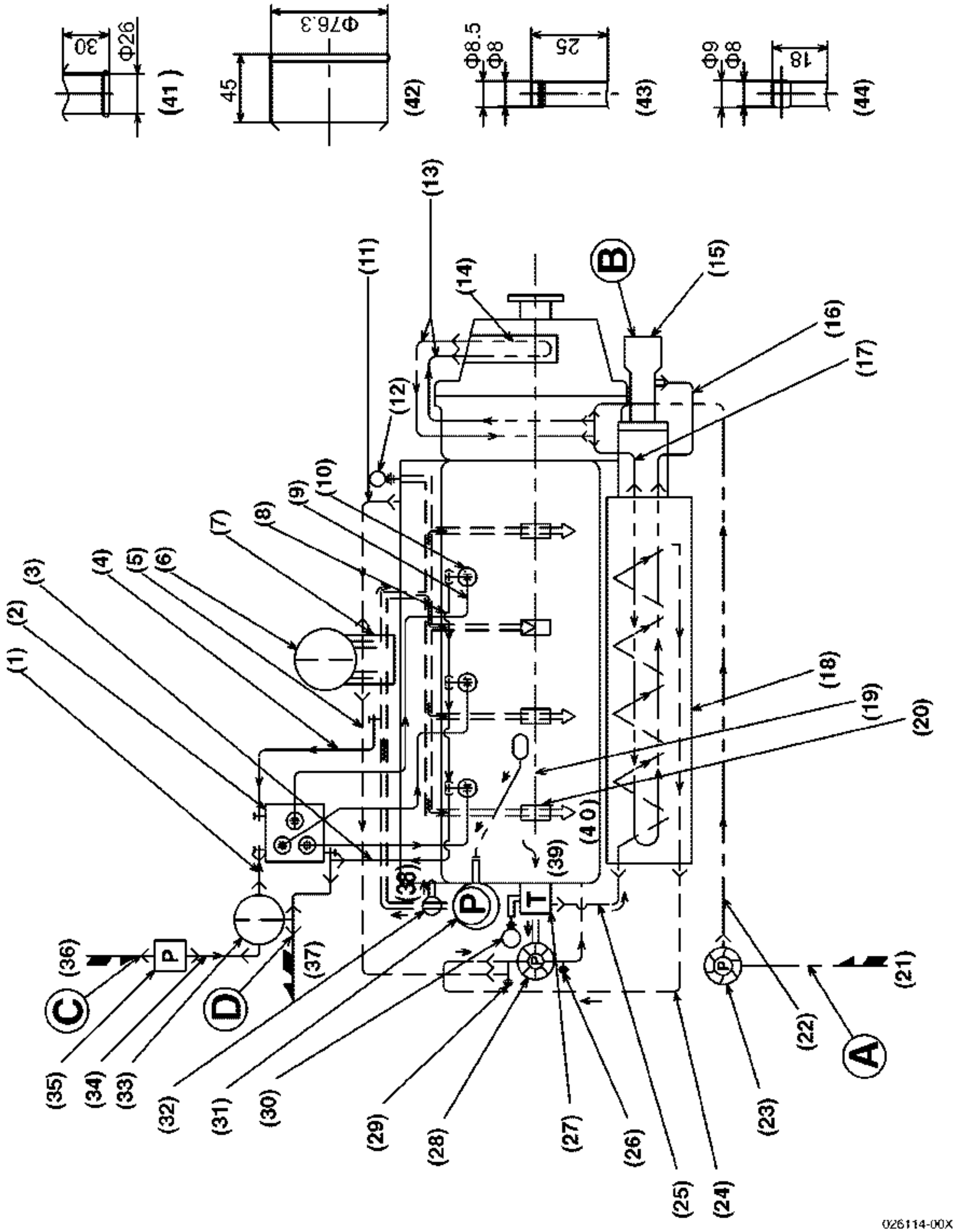


Figure 3-29

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76 x 0.7 Steel Pipe
5 – 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – 13 x t4 Rubber Hose
14 – Clutch Lubricating Oil Cooler
15 – Mixing Elbow
16 – 25.4 x t4.3 Rubber Hose
17 – 25.4 x t4.3 Rubber Hose
18 – Heat Exchanger
19 – Lubricating Oil Inlet Filter
20 – Main Bearing
21 – Seawater Inlet
22 – 25.4 x t4.3 Rubber Hose
23 – Cooling Water Pump (seawater)
24 – 28 x t4 Rubber Hose
25 – 28 x t4 Rubber Hose
26 – Hot Water Connection Outlet (R3/8)
27 – Thermostat
28 – Coolant Pump (freshwater)
29 – Hot Water Connection Inlet (R3/8)
30 – Coolant Temperature Switch
31 – Lubricating Oil Pump
32 – Pressure Control Valve
33 – Fuel Filter (cartridge type)
34 – * 7 x t4.5 Rubber Hose
35 – Fuel Feed Pump
36 – Fuel Inlet
37 – Fuel Overflow
38 – To Oil Pan
39 – From Cylinder Head
40 – To Camshaft
41 – Detail of Part A
42 – Detail of Part B
43 – Detail of Part C
44 – Detail of Part D

3JH5E (SD50 Sail Drive)

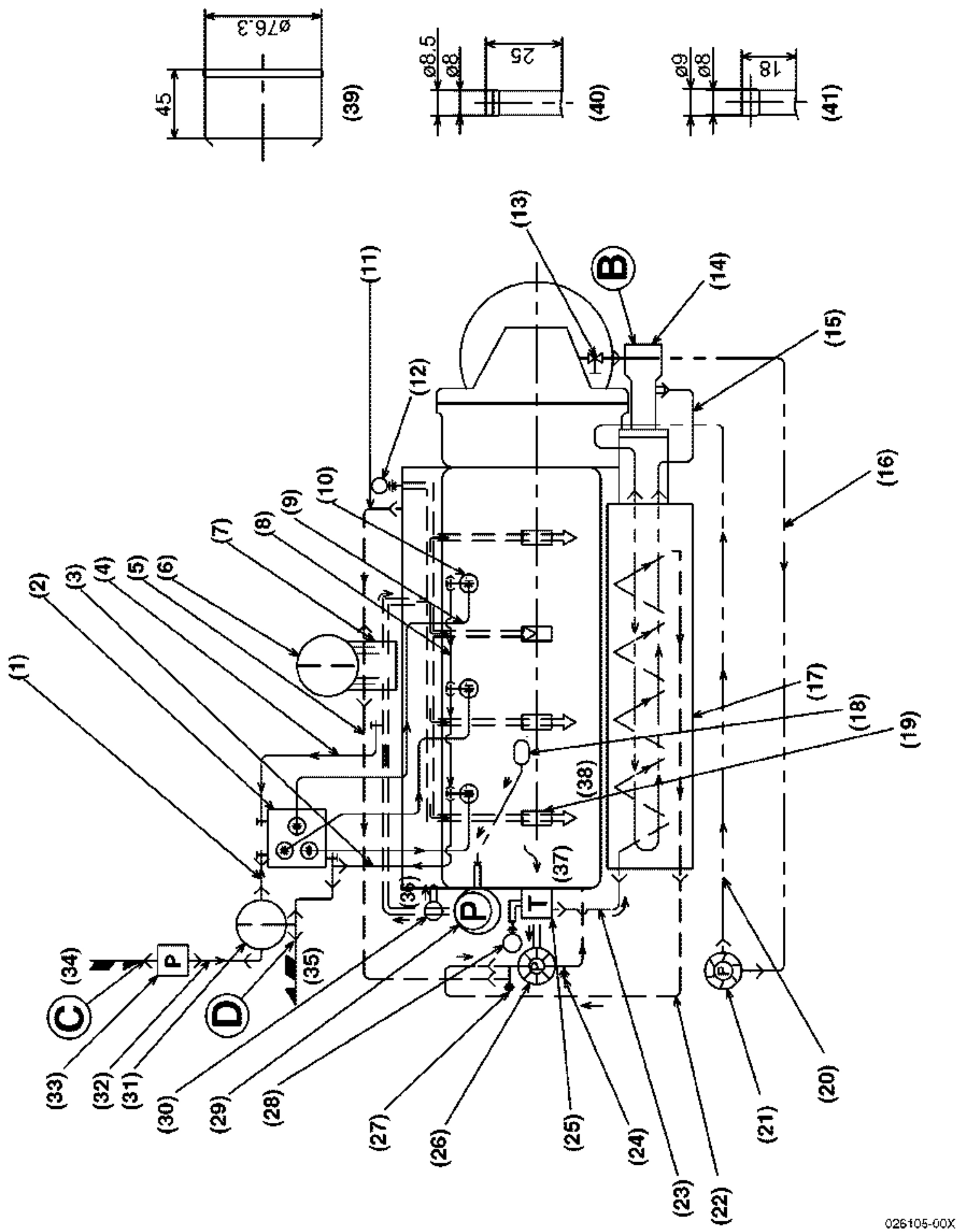


Figure 3-30

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76 x t0.7 Steel Pipe
5 – * 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – Cock (seawater inlet)
14 – Mixing Elbow
15 – 25.4 x t4.3 Rubber Hose
16 – 25.4 x t4.3 Rubber Hose
17 – Heat Exchanger
18 – Lubricating Oil Inlet Filter
19 – Main Bearing
20 – 25.4 x t4.3 Rubber Hose
21 – Cooling Water Pump (seawater)
22 – 28 x t4 Rubber Hose
23 – 28 x t4 Rubber Hose
24 – Hot Water Connection Outlet (R3/8)
25 – Thermostat
26 – Coolant Pump (freshwater)
27 – Hot Water Connection Inlet (R3/8)
28 – Coolant Temperature Switch
29 – Lubricating Oil Pump
30 – Pressure Control Valve
31 – Fuel Filter (cartridge type)
32 – * 7 x t4.5 Rubber Hose
33 – Fuel Feed Pump
34 – Fuel Inlet
35 – Fuel Overflow
36 – To Oil Pan
37 – From Cylinder Head
38 – To Camshaft
39 – Detail of Part B
40 – Detail of Part C
41 – Detail of Part D

4JH5E Models

4JH5E (KM35P, KM35A2)

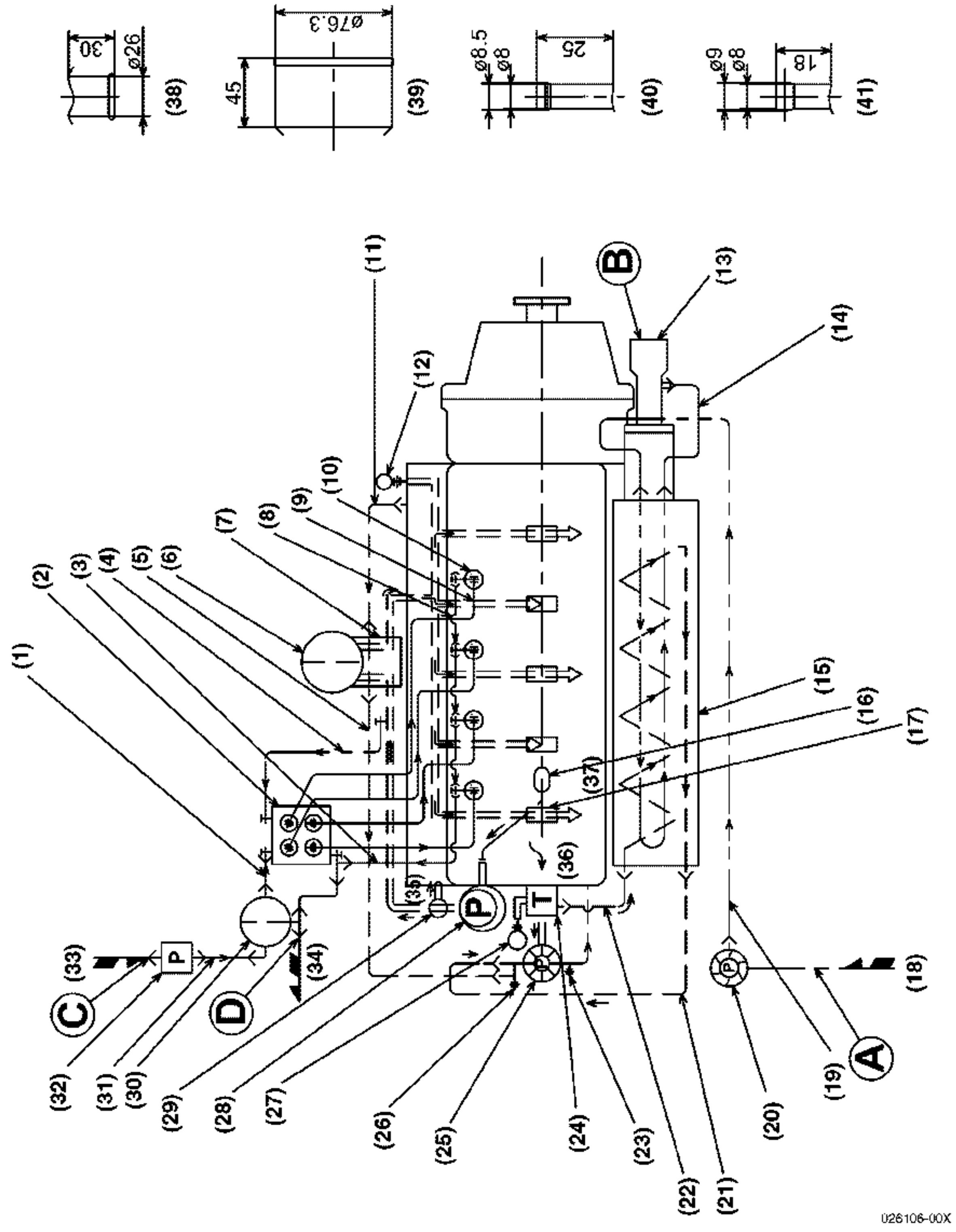


Figure 3-31

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76 x t0.7 Steel Pipe
5 – 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – Mixing Elbow
14 – 25.4 x t4.3 Rubber Hose
15 – Heat Exchanger
16 – Lubricating Oil Inlet Filter
17 – Main Bearing
18 – Seawater Inlet
19 – 25.4 x t4.3 Rubber Hose
20 – Cooling Water Pump (seawater)
21 – 28 x t4 Rubber Hose
22 – 28 x t4 Rubber Hose
23 – Hot Water Connection Outlet (R3/8)
24 – Thermostat
25 – Coolant Pump (freshwater)
26 – Hot Water Connection Inlet (R3/8)
27 – Coolant Temperature Switch
28 – Lubricating Oil Pump
29 – Pressure Control Valve
30 – Fuel Filter (cartridge type)
31 – * 7 x t4.5 Rubber Hose
32 – Fuel Feed Pump
33 – Fuel Inlet
34 – Fuel Overflow
35 – To Oil Pan
36 – From Cylinder Head
37 – To Camshaft
38 – Detail of Part A
39 – Detail of Part B
40 – Detail of Part C
41 – Detail of Part D

4JH5E (KM4A1)

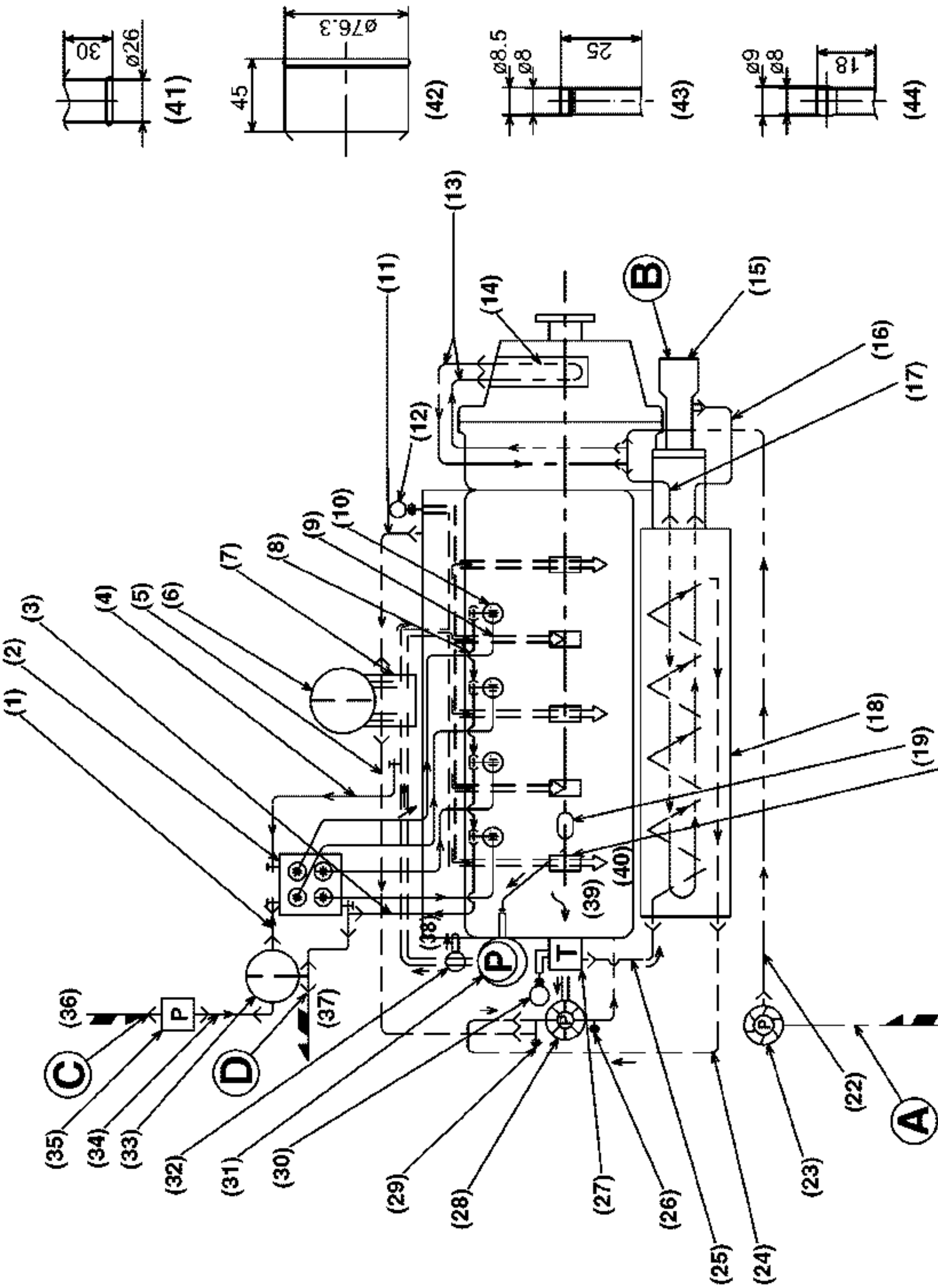


Figure 3-32

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76 x 0.7 Steel Pipe
5 – 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – 13 x t4 Rubber Hose
14 – Clutch Lubricating Oil Cooler
15 – Mixing Elbow
16 – 25.4 x t4.3 Rubber Hose
17 – 25.4 x t4.3 Rubber Hose
18 – Heat Exchanger
19 – Lubricating Oil Inlet Filter
20 – Main Bearing
21 – Seawater Inlet
22 – 25.4 x t4.3 Rubber Hose
23 – Cooling Water Pump (seawater)
24 – 28 x t4 Rubber Hose
25 – 28 x t4 Rubber Hose
26 – Hot Water Connection Outlet (R3/8)
27 – Thermostat
28 – Coolant Pump (freshwater)
29 – Hot Water Connection Inlet (R3/8)
30 – Coolant Temperature Switch
31 – Lubricating Oil Pump
32 – Pressure Control Valve
33 – Fuel Filter (cartridge type)
34 – * 7 x t4.5 Rubber Hose
35 – Fuel Feed Pump
36 – Fuel Inlet
37 – Fuel Overflow
38 – To Oil Pan
39 – From Cylinder Head
40 – To Camshaft
41 – Detail of Part A
42 – Detail of Part B
43 – Detail of Part C
44 – Detail of Part D

4JH5E (ZF30M)

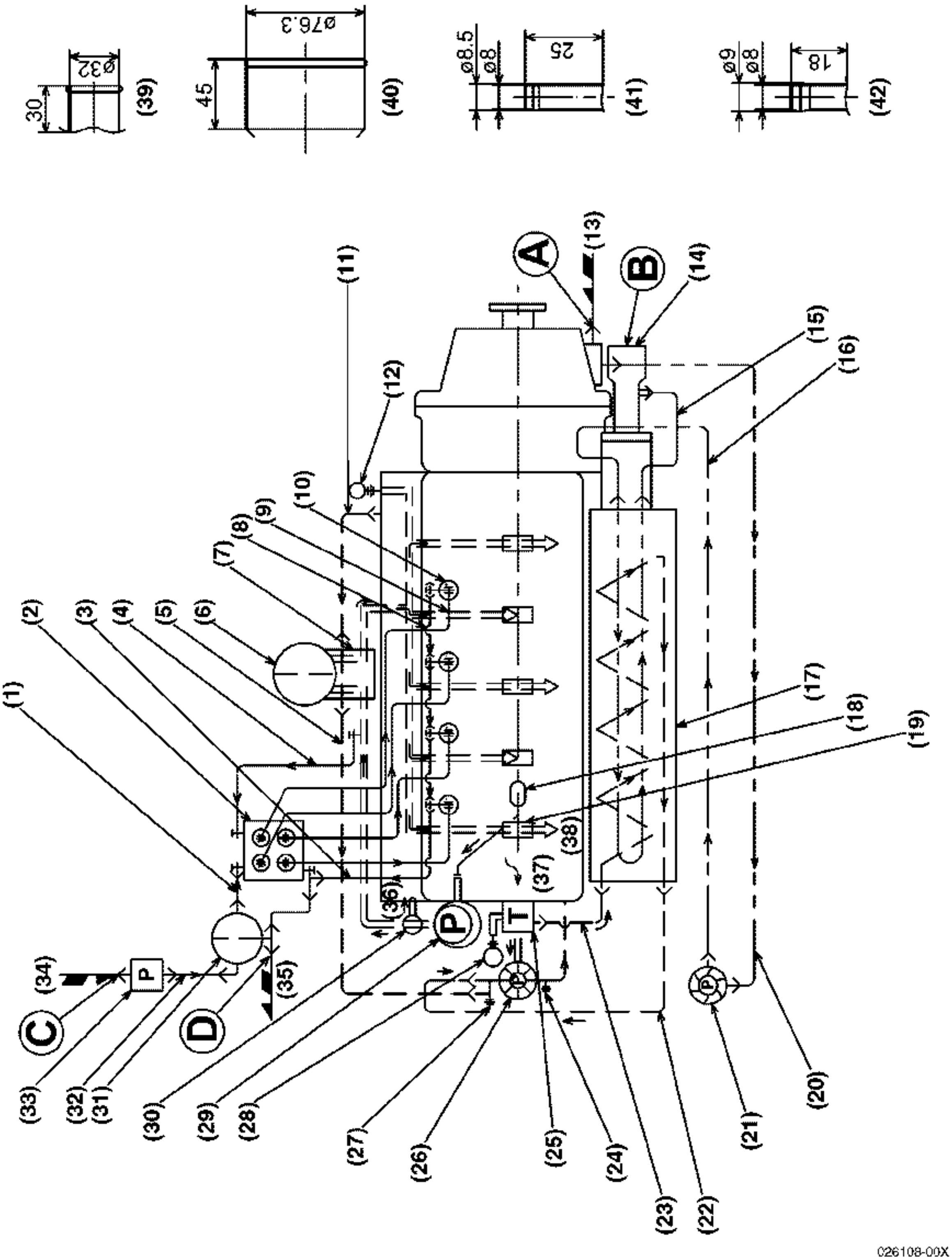


Figure 3-33

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76 x t0.7 Steel Pipe
5 – 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe 6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – Seawater Inlet
14 – Mixing Elbow
15 – 25.4 x t4.3 Rubber Hose
16 – 25.4 x t4.3 Rubber Hose
17 – Heat Exchanger
18 – Lubricating Oil Inlet Filter
19 – Main Bearing
20 – 25.4 x t4.3 Rubber Hose
21 – Cooling Water Pump (seawater)
22 – 28 x t4 Rubber Hose
23 – 28 x t4 Rubber Hose
24 – Hot Water Connection Outlet (R3/8)
25 – Thermostat
26 – Coolant Pump (freshwater)
27 – Hot Water Connection Inlet (R3/8)
28 – Coolant Temperature Switch
29 – Lubricating Oil Pump
30 – Pressure Control Valve
31 – Fuel Filter (cartridge type)
32 – * 7 x t4.5 Rubber Hose
33 – Fuel Feed Pump
34 – Fuel Inlet
35 – Fuel Overflow
36 – To Oil Pan
37 – From Cylinder Head
38 – To Camshaft
39 – Detail of Part A
40 – Detail of Part B
41 – Detail of Part C
42 – Detail of Part D

4JH5E (SD50 Sail Drive)

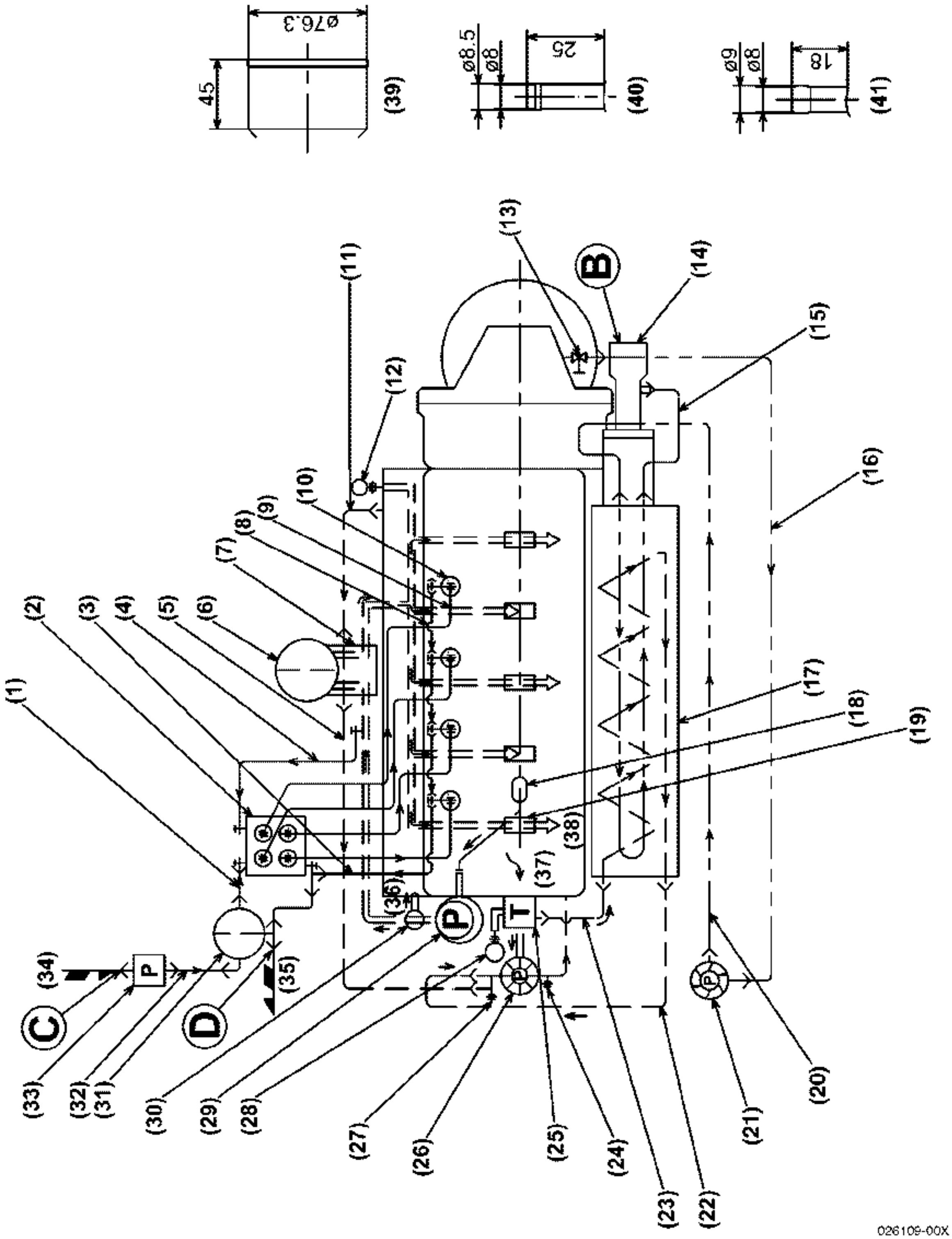


Figure 3-34

1 – * 7 x t4.5 Rubber Hose
2 – Fuel Injection Pump
3 – * 5 x t4.5 Rubber Hose
4 – 4.76x t0.7 Steel Pipe
5 – 9 x t3.5 Rubber Hose
6 – Lubricating Oil Filter (cartridge type)
7 – Lubricating Oil Cooler
8 – * 5 x t4.5 Rubber Hose
9 – Fuel High-Pressure Pipe
    6.35 x t2.375 Steel Pipe
10 – Fuel Injection Nozzle
11 – 9 x t3.5 Rubber Hose
12 – Oil Pressure Switch
13 – Seacock
14 – Mixing Elbow
15 – 25.4 x t4.3 Rubber Hose
16 – 25.4 x t4.3 Rubber Hose
17 – Heat Exchanger
18 – Lubricating Oil Inlet Filter
19 – Main Bearing
20 – 25.4 x t4.3 Rubber Hose
21 – Cooling Water Pump (seawater)
22 – 28 x t4 Rubber Hose
23 – 28 x t4 Rubber Hose
24 – Hot Water Connection Outlet (R3/8)
25 – Thermostat
26 – Coolant Pump (freshwater)
27 – Hot Water Connection Inlet (R3/8)
28 – Coolant Temperature Switch
29 – Lubricating Oil Pump
30 – Pressure Control Valve
31 – Fuel Filter (cartridge type)
32 – * 7 x t4.5 Rubber Hose
33 – Fuel Feed Pump
34 – Fuel Inlet
35 – Fuel Overflow
36 – To Oil Pan
37 – From Cylinder Head
38 – To Camshaft
39 – Detail of Part B
40 – Detail of Part C
41 – Detail of Part D

4JH4-TE Models

4JH4-TE (ZF30M)

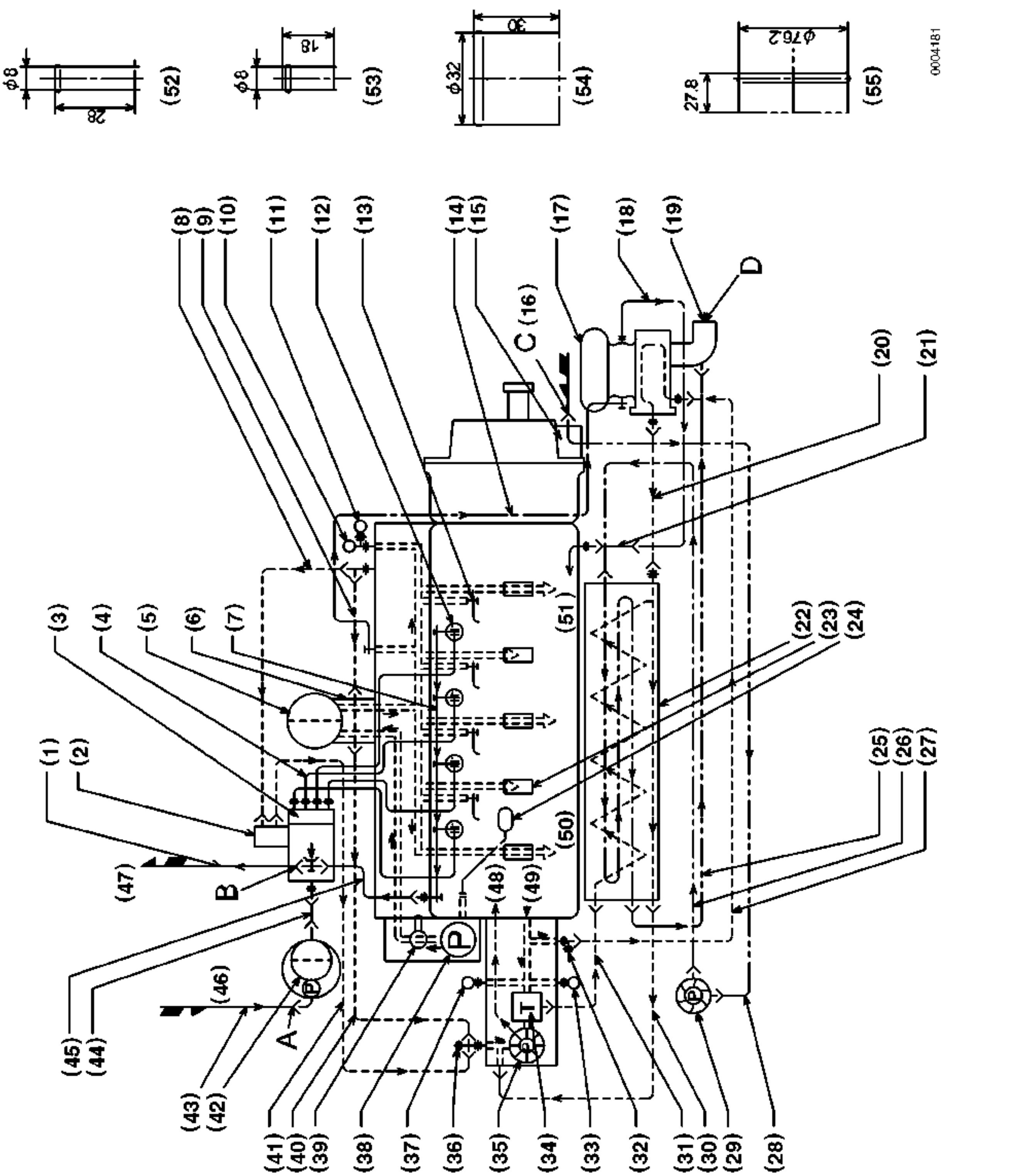


Figure 3-35

1 –* 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe 6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t4.3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – 8 x t0.8 STKM
15 – Clutch Lubrication Oil Cooler
16 – Seawater Inlet
17 – Turbocharger
18 – 17 x t1.2 STKM
19 – Mixing Elbow
20 – 8.5 x t3.5 Rubber Hose
21 – 17 x t3 Rubber Hose
22 – Heat Exchanger
23 – Main Bearing
24 – Lubrication Oil Inlet Filter
25 – 25.4 x t4.3 Rubber Hose
26 – 25.4 x t4.3 Rubber Hose
27 – 7.5 x t2.5 Rubber Hose
28 – 25.4 x t4.3 Rubber Hose
29 – Cooling Water Pump (seawater)
30 – 28 x t4 Rubber Hose
31 – 28 x t4 Rubber Hose
32 – Hot Water Connection Outlet
33 – Coolant Temperature Switch
34 – Thermostat
35 – Coolant Pump (freshwater)
36 – Hot Water Connection Return
37 – Coolant Temperature Sensor (option)
38 – Lubrication Oil Pump
39 – Pressure Control Valve
40 – 13 x t3.5 Rubber Hose
41 – 10 x t3 Rubber Hose
42 – Diesel Fuel Filter (cartridge type)
43 – 7 x t4.5 Rubber Hose
44 – 7 x t4.5 Rubber Hose
45 – 5 x t4.5 Rubber Hose
46 – Diesel Fuel Inlet
47 – Fuel Overflow
48 – To Block
49 – From Head
50 – To Camshaft
51 – To Oil Pan
52 – Detail of Part A
53 – Detail of Part B
54 – Detail of Part C
55 – Detail of Part D

4JH4-TE (KM4A2)

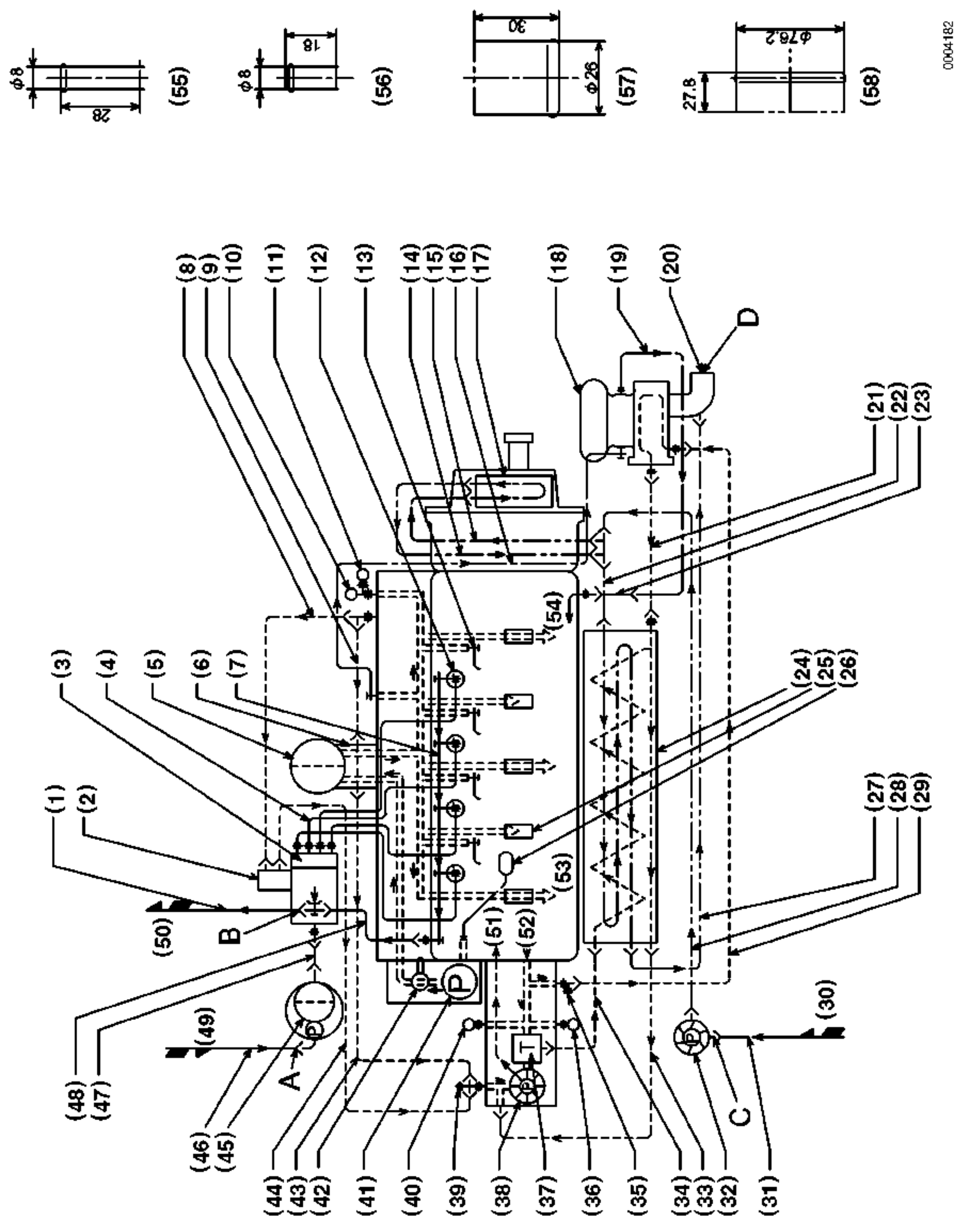


Figure 3-36

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe 6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t4.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – 13 x t4 Rubber Hose
15 – 13 x t4 Rubber Hose
16 – 8 x t0.8 STKM
17 – Clutch Lubrication Oil Cooler
18 – Turbocharger
19 – 17 x t1.2 STKM
20 – Mixing Elbow
21 – 8.5 x t3.5 Rubber Hose
22 – 25.4 x t4.3 Rubber Hose
23 – 17 x t3 Rubber Hose
24 – Heat Exchanger
25 – Main Bearing
26 – Lubrication Oil Inlet Filter
27 – 25.4 x t4.3 Rubber Hose
28 – 25.4 x t4.3 Rubber Hose
29 – 7.5 x t2.5 Rubber Hose
30 – Seawater Inlet
31 – 25.4 x t4.3 Rubber Hose
32 – Cooling Water Pump (seawater)
33 – 28 x t4 Rubber Hose
34 – 28 x t4 Rubber Hose
35 – Hot Water Connection Outlet
36 – Coolant Temperature Switch
37 – Thermostat
38 – Coolant Pump (freshwater)
39 – Hot Water Connection Return
40 – Coolant Temperature Sensor (Option)
41 – Lubrication Oil Pump
42 – Pressure Control Valve
43 – 13 x t3.5 Rubber Hose
44 – 10 x t3 Rubber Hose
45 – Diesel Fuel Filter (cartridge type)
46 – * 7 x t4.5 Rubber Hose
47 – * 7 x t4.5 Rubber Hose
48 – * 5 x t4.5 Rubber Hose
49 – Diesel Fuel Inlet
50 – Fuel Overflow
51 – To Block
52 – From Head
53 – To Camshaft
54 – To Oil Pan
55 – Detail of Part A
56 – Detail of Part B
57 – Detail of Part C
58 – Detail of Part D

4JH4-TE (KMH4A, ZF25A)

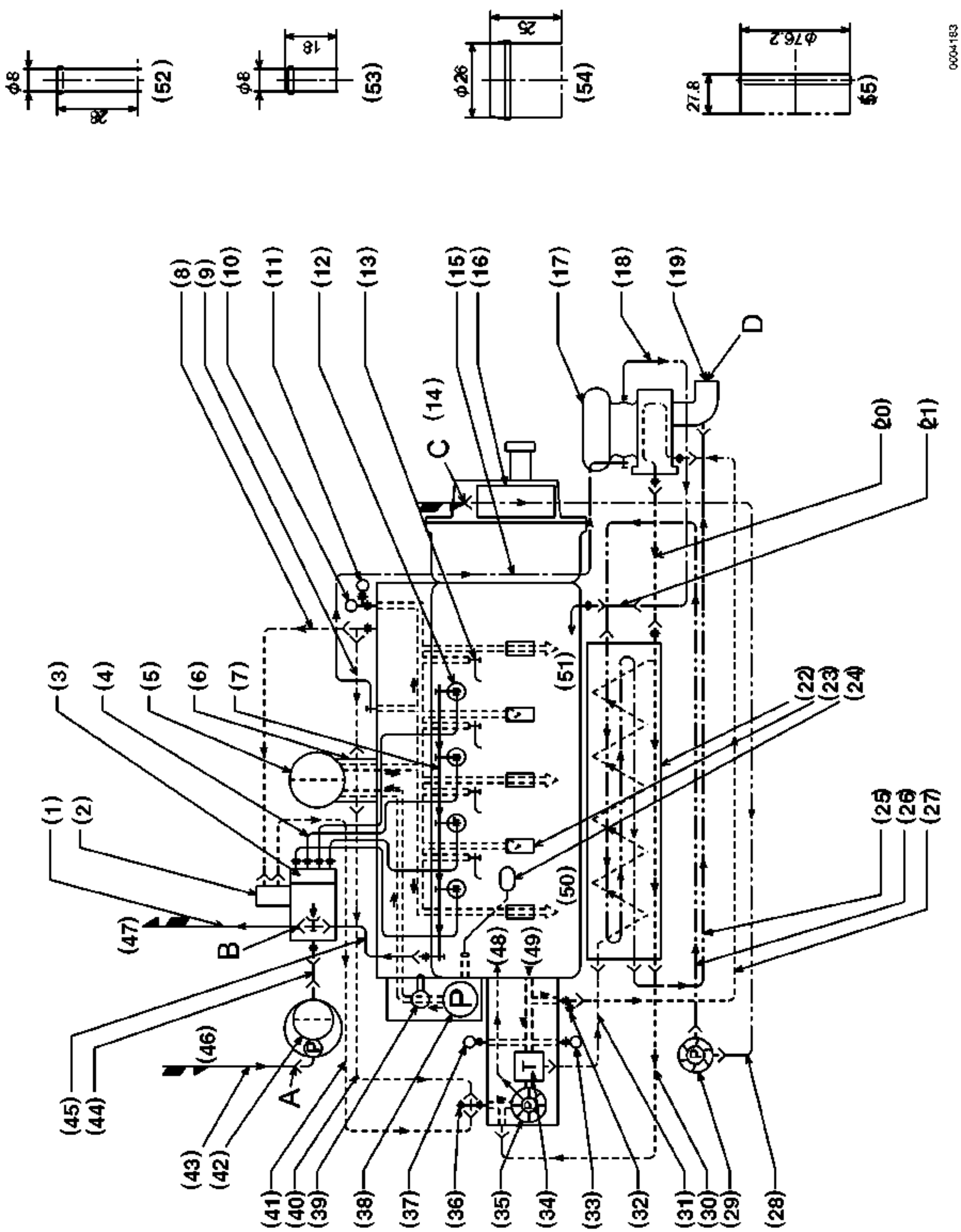


Figure 3-37

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe 6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – Seawater Inlet
15 – 8 x t0.8 STKM
16 – Clutch Lubrication Oil Cooler
17 – Turbocharger
18 – 17 x t1.2 STKM
19 – Mixing Elbow
20 – 8.5 x t3.5 Rubber Hose
21 – 17 x t3 Rubber Hose
22 – Heat Exchanger
23 – Main Bearing
24 – Lubrication Oil Inlet Filter
25 – 25.4 x t4.3 Rubber Hose
26 – 25.4 x t4.3 Rubber Hose
27 – 7.5 x t2.5 Rubber Hose
28 – 25.4 x t4.3 Rubber Hose
29 – Cooling Water Pump (seawater)
30 – 28 x t4 Rubber Hose
31 – 28 x t4 Rubber Hose
32 – Hot Water Connection Outlet
33 – Coolant Temperature Switch
34 – Thermostat
35 – Coolant Pump (freshwater)
36 – Hot Water Connection Return
37 – Coolant Temperature Sensor (option)
38 – Lubrication Oil Pump
39 – Pressure Control Valve
40 – 13 x t3.5 Rubber Hose
41 – 10 x t3 Rubber Hose
42 – Diesel Fuel Filter (cartridge type)
43 – * 7 x t4.5 Rubber Hose
44 – * 7 x t4.5 Rubber Hose
45 – * 5 x t4.5 Rubber Hose
46 – Diesel Fuel Inlet
47 – Fuel Overflow
48 – To Block
49 – From Head
50 – To Camshaft
51 – To Oil Pan
52 – Detail of Part A
53 – Detail of Part B
54 – Detail of Part C
55 – Detail of Part D

4JH4-TE (SD50 / SD40 Sail Drive)

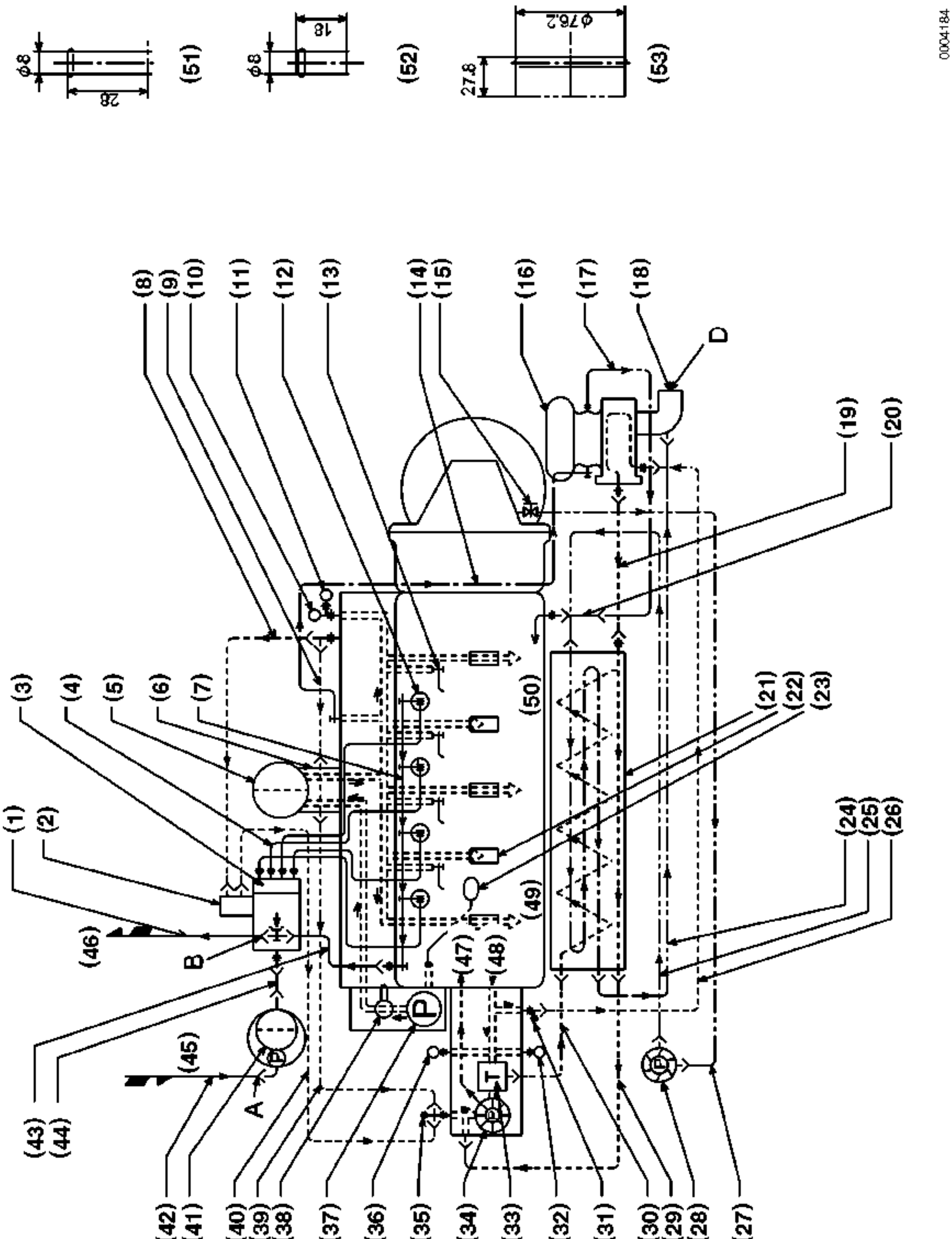


Figure 3-38

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe 6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – 8 x t0.8 STKM
15 – Seacock
16 – Turbocharger
17 – 17 x t1.2 STKM
18 – Mixing Elbow
19 – 8.5 x t3.5 Rubber Hose
20 – 17 x t3 Rubber Hose
21 – Heat Exchanger
22 – Main Bearing
23 – Lubrication Oil Inlet Filter
24 – 25.4 x t4.3 Rubber Hose
25 – 25.4 x t4.3 Rubber Hose
26 – 7.5 x t2.5 Rubber Hose
27 – 25.4 x t4.3 Rubber Hose
28 – Cooling Water Pump (seawater)
29 – 28 x t4 Rubber Hose
30 – 28 x t4 Rubber Hose
31 – Hot Water Connection Outlet
32 – Coolant Temperature Switch
33 – Thermostat
34 – Coolant Pump (freshwater)
35 – Hot Water Connection Return
36 – Coolant Temperature Sensor (option)
37 – Lubrication Oil Pump
38 – Pressure Control Valve
39 – 13 x t3.5 Rubber Hose
40 – 10 x t3 Rubber Hose
41 – Diesel Fuel Filter (cartridge type)
42 – * 7 x t4.5 Rubber Hose
43 – * 7 x t4.5 Rubber Hose
44 – * 5 x t4.5 Rubber Hose
45 – Diesel Fuel Inlet
46 – Fuel Overflow
47 – To Block
48 – From Head
49 – To Camshaft
50 – To Oil Pan
51 – Detail of Part A
52 – Detail of Part B
53 – Detail of Part D

4JH4-HTE Models

4JH4-HTE (KM4A2)

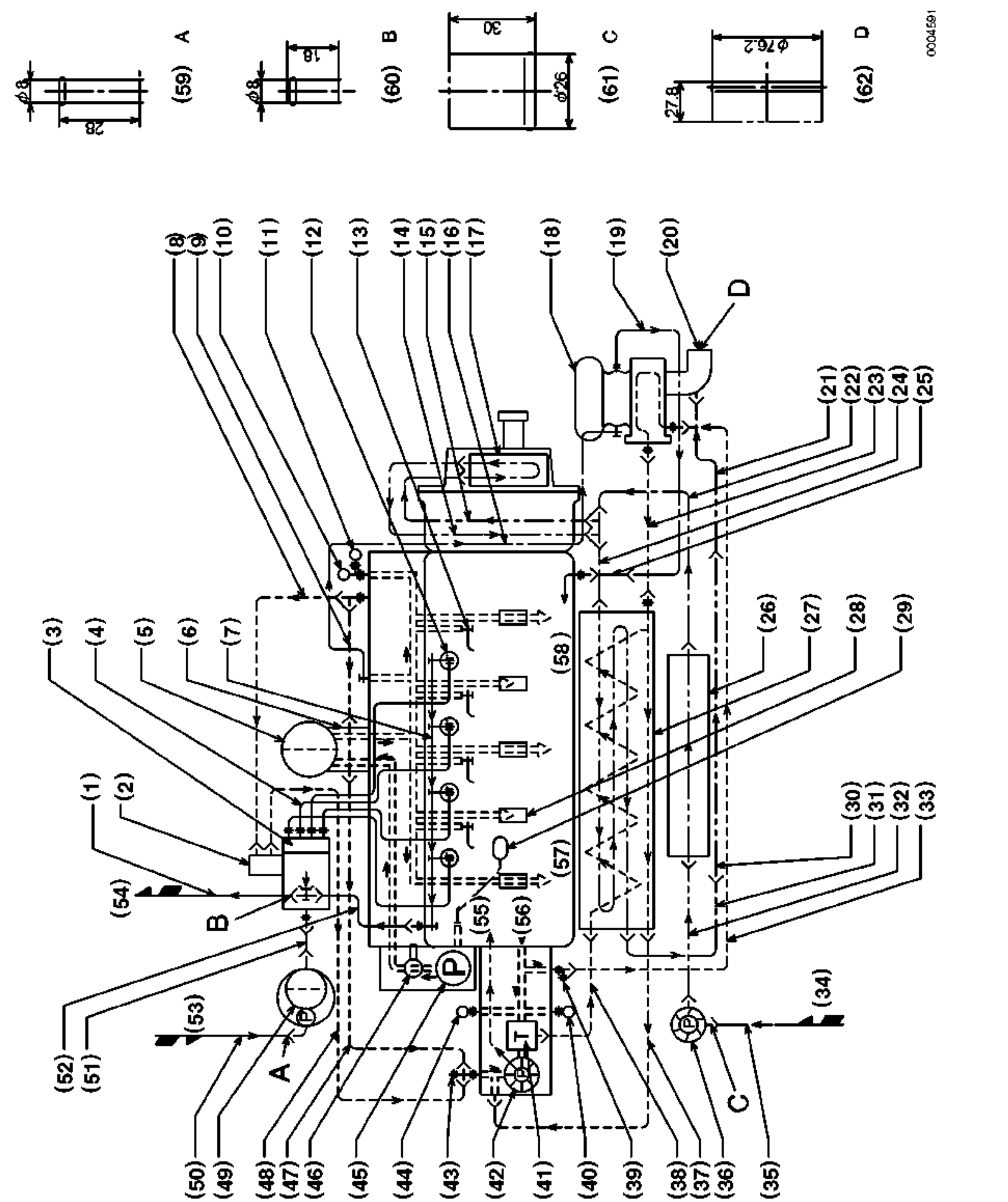


Figure 3-39

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High0-Pressure Pipe
6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – 13 x t4 Rubber Hose
15 – 13 x t4 Rubber Hose
16 – 8 x t0.8 STKM
17 – Clutch Lubrication Oil Cooler
18 – Turbocharger
19 – 17 x t1.2 STKM
20 – Mixing Elbow
21 – 25.4 x t4.3 Rubber Hose
22 – 25.4 x t4.3 Rubber Hose
23 – 8.5 x t3.5 Rubber Hose
24 – 25.4 x t4.3 Rubber Hose
25 – 17 x t3 Rubber Hose
26 – Intercooler
27 – Heat Exchanger
28 – Main Bearing
29 – Lubrication Oil Inlet Filter
30 – 25 x t2 C1201T
31 – 25.4 x t4.3 Rubber Hose
32 – 25.4 x t4.3 Rubber Hose
33 – 7.5 x t2.5 Rubber Hose
34 – Seawater Inlet
35 – 25.4 x t4.3 Rubber Hose
36 – Cooling Water Pump (seawater)
37 – 28 x t4 Rubber Hose
38 – 28 x t4 Rubber Hose
39 – Hot Water Connection Outlet
40 – Coolant Temperature Switch
41 – Thermostat
42 – Coolant Pump (freshwater)
43 – Hot Water Connection Return
44 – Coolant Temperature Sensor (Option)
45 – Lubrication Oil Pump
46 – Pressure Control Valve
47 – 13 x t3.5 Rubber Hose
48 – 10 x t3 Rubber Hose
49 – Diesel Fuel Filter (cartridge type)
50 – * 7 x t4.5 Rubber Hose
51 – * 7 x t4.5 Rubber Hose
52 – * 5 x t4.5 Rubber Hose
53 – Diesel Fuel Inlet
54 – Diesel Fuel Overflow
55 – To Block
56 – From Head
57 – To Camshaft
58 – To Oil Pan
59 – Detail of Part A
60 – Detail of Part B
61 – Detail of Part C
62 – Detail of Part B

4JH4-HTE (KMH4A, ZF25A)

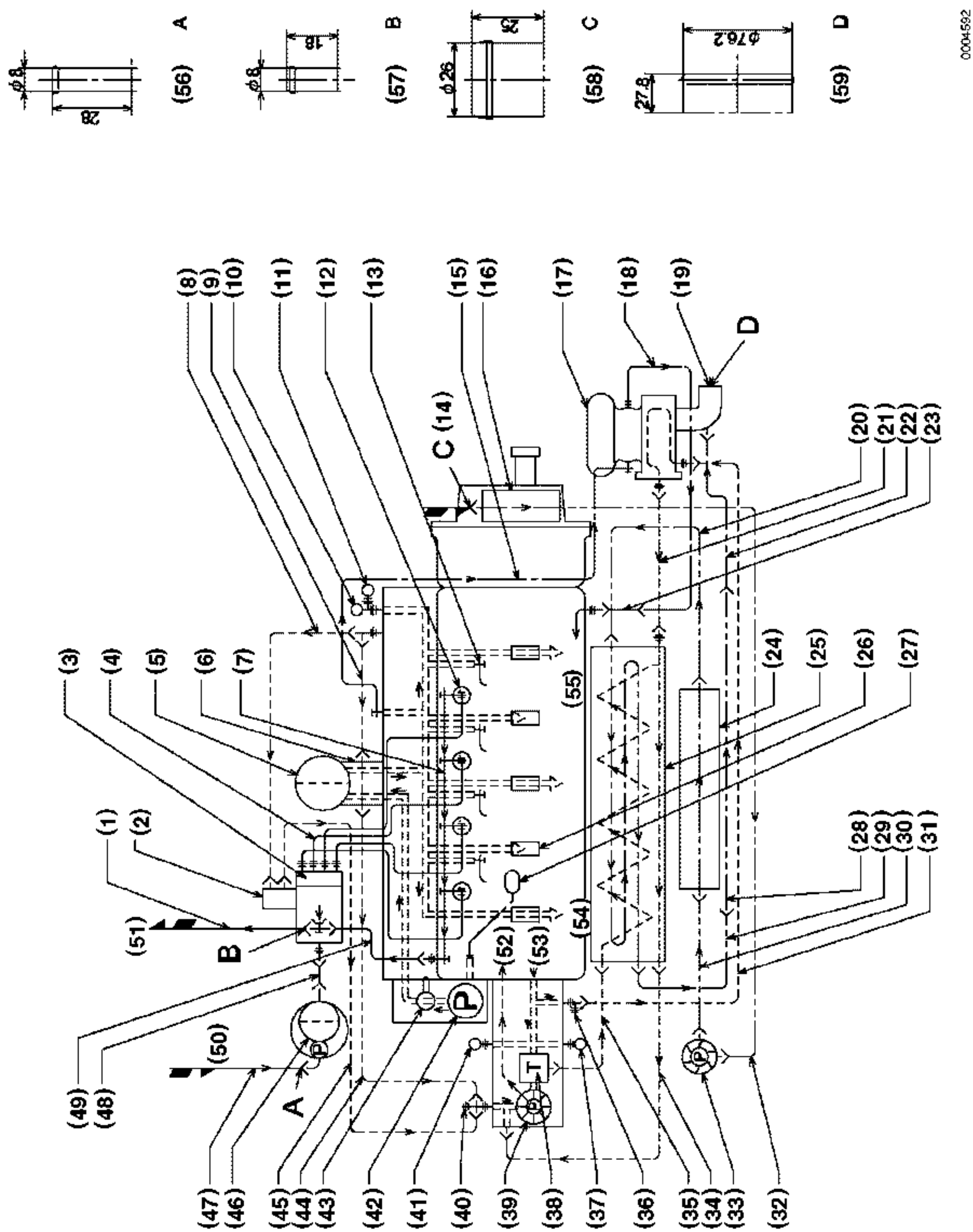


Figure 3-40

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe 6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – Seawater Inlet
15 – 8 x t0.8 STKM
16 – Clutch Lubrication Oil Cooler
17 – Turbocharger
18 – 17 x t1.2 STKM
19 – Mixing Elbow
20 – 25.4 x t4.3 Rubber Hose
21 – 8.5 x t3.5 Rubber Hose
22 – 25.4 x t4.3 Rubber Hose
23 – 17 x t3 Rubber Hose
24 – Intercooler
25 – Heat Exchanger
26 – Main Bearing
27 – Lubrication Oil Inlet Filter
28 – 25 x t2 C1201T
29 – 25.4 x t4.3 Rubber Hose
30 – 25.4 x t4.3 Rubber Hose
31 – 7.5 x t2.5 Rubber Hose
32 – 25.4 x t4.3 Rubber Hose
33 – Cooling Water Pump (seawater)
34 – 28 x t4 Rubber Hose
35 – 28 x t4 Rubber Hose
36 – Hot Water Connection Outlet
37 – Coolant Temperature Switch
38 – Thermostat
39 – Coolant Pump (freshwater)
40 – Hot Water Connection Return
41 – Coolant Temperature Sensor (option)
42 – Lubrication Oil Pump
43 – Pressure Control Valve
44 – 13 x t3.5 Rubber Hose
45 – 10 x t3 Rubber Hose
46 – Diesel Fuel Filter
47 – * 7 x t4.5 Rubber Hose
48 – * 7 x t4.5 Rubber Hose
49 – * 5 x t4.5 Rubber Hose
50 – Diesel Fuel Inlet
51 – Fuel Overflow
52 – To Block
53 – From Head
54 – To Camshaft
55 – To Oil Pan
56 – Detail of Part A
57 – Detail of Part B
58 – Detail of Part C
59 – Detail of Part D

4JH4-HTE (ZF30M)

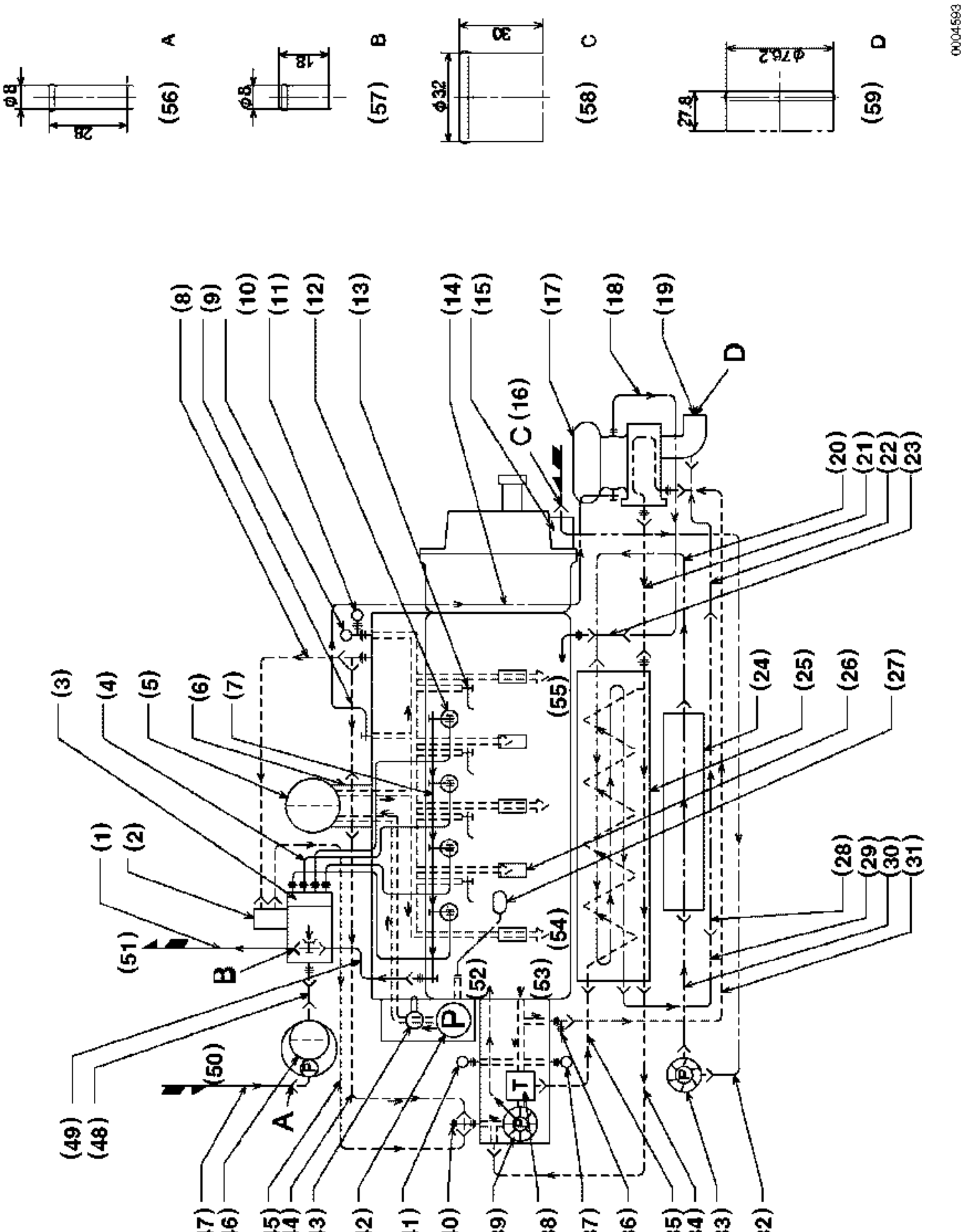


Figure 3-41

1 – * 7 x t4.5 Rubber Hose
2 – W-C S.D.
3 – Fuel Injection Pump
4 – Fuel High-Pressure Pipe
6.35 x t2.175 STS
5 – Lubrication Oil Filter (cartridge type)
6 – Lubrication Oil Cooler
7 – 4.76 x t0.7 Double-Walled Steel Tube
8 – 10 x t3 Rubber Hose
9 – 13 x t3.5 Rubber Hose
10 – Oil Pressure Switch
11 – Oil Pressure Sensor (option)
12 – Fuel Injection Nozzle
13 – Piston Cooling Oil Jet
14 – Seawater Inlet
15 – 8 x t0.8 STKM
16 – Clutch Lubrication Oil Cooler
17 – Turbocharger
18 – 17 x t1.2 STKM
19 – Mixing Elbow
20 – 25.4 x t4.3 Rubber Hose
21 – 8.5 x t3.5 Rubber Hose
22 – 25.4 x t4.3 Rubber Hose
23 – 17 x t3 Rubber Hose
24 – Intercooler
25 – Heat Exchanger
26 – Main Bearing
27 – Lubrication Oil Inlet Filter
28 – 25 x t2 C1201T
29 – 25.4 x t4.3 Rubber Hose
30 – 25.4 x t4.3 Rubber Hose
31 – 7.5 x t2.5 Rubber Hose
32 – 25.4 x t4.3 Rubber Hose
33 – Cooling Water Pump (seawater)
34 – 28 x t4 Rubber Hose
35 – 28 x t4 Rubber Hose
36 – Hot Water Connection Outlet
37 – Coolant Temperature Switch
38 – Thermostat
39 – Coolant Pump (freshwater)
40 – Hot Water Connection Return
41 – Coolant Temperature Sensor (option)
42 – Lubrication Oil Pump
43 – Pressure Control Valve
44 – 13 x t3.5 Rubber Hose
45 – 10 x t3 Rubber Hose
46 – Diesel Fuel Filter
47 – * 7 x t4.5 Rubber Hose
48 – * 7 x t4.5 Rubber Hose
49 – * 5 x t4.5 Rubber Hose
50 – Diesel Fuel Inlet
51 – Fuel Overflow
52 – To Block
53 – From Head
54 – To Camshaft
55 – To Oil Pan
56 – Detail of Part A
57 – Detail of Part B
58 – Detail of Part C
59 – Detail of Part D

EXHAUST GAS EMISSION REGULATIONS

3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE series engines are applicable with Non-road Compression Ignition engines regulations and Compression Ignition Marine engines regulations of the EPA (Environmental Protection Agency) and CARB (California Air Resources Board) in USA and RCD and BSO (Borehole Sites and Operations) regulations in Europe.

Engine Identification (EPA / CARB)

With the regulations on exhaust gas emission worldwide, it has become necessary to identify engines in a manner to determine with which regulations they comply.

Emission Control Label (EPA / CARB)

3JH5E EPA and CARB Label

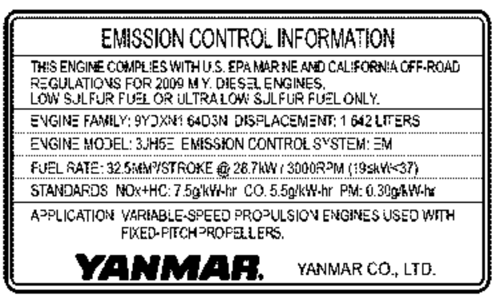


Figure 3-42

4JH5E / 4JH4-TE EPA Label

For Example (4JH4-TE)

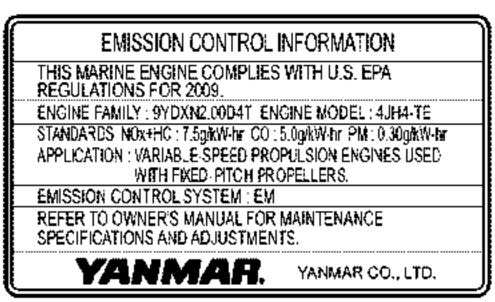


Figure 3-43

4JH4-HTE EPA Label

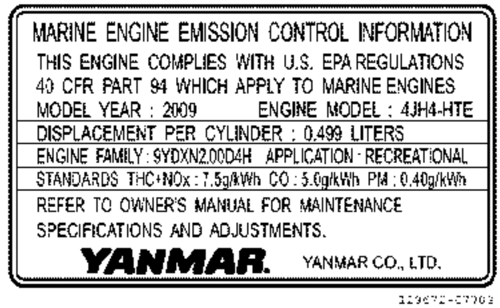


Figure 3-44

NOTICE: Emission Control is accomplished through Engine Modification (EM-Design).

A tamper-resistant device is installed on EPA / CARB-certified 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE series engines to prevent illegal modification of the fuel injection volume and high idling speed.

- Fuel injection volume: cap type
- High idling speed: cap type

LOCATION OF NAMEPLATES

The following figures show the location of informational nameplates on Yanmar JH series marine engines.

Engine Nameplates (Typical)

Engine Data and Drive Information Nameplates

The nameplate shown **(Figure 3-45)** is attached to the engine. Check the engine's model, output, rpm and serial numbers on the nameplate.

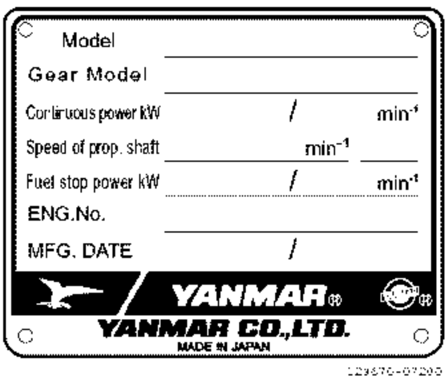


Figure 3-45

The nameplate shown **(Figure 3-46)** is attached to the marine gear. Check the marine gear's model, gear ration, oil used, oil quantity and serial number.

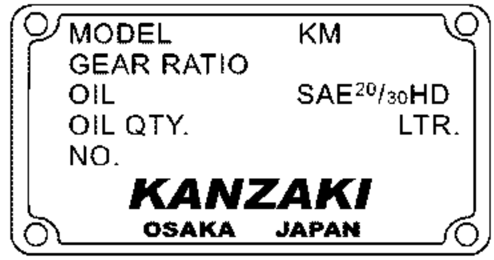


Figure 3-46

The nameplate shown **(Figure 3-47)** is attached to the sail drive (except 4JH4-HTE). Check the sail drive model and serial number.

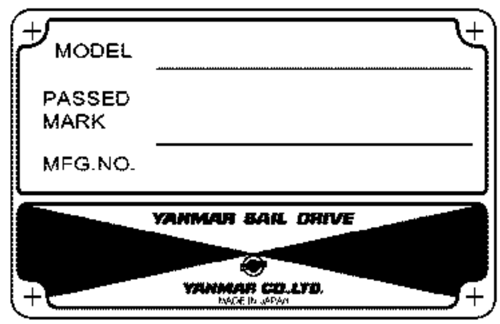


Figure 3-47

DIESEL FUEL

Diesel Fuel Specifications

Diesel fuel should comply with the following specifications. The table lists several specifications for diesel fuels.

DIESEL FUEL SPECIFICATION	LOCATION
No. 2-D, No. 1-D, ASTM D975	USA
EN590:96	European Union
ISO 8217 DMX	International
BS 2869-A1 or A2	United Kingdom
JIS K2204 Grade No. 2	Japan

Bio-Diesel Fuels

Yanmar approves the use of bio-diesel fuels that do not exceed a blend of 5% non-mineral oil based fuel with 95% standard diesel fuel. Such bio-diesel fuels are known in the marketplace as B5 bio-diesel fuels. B5 bio-diesel fuel can reduce particulate matter and the emission of "greenhouse" gases compared to standard diesel fuel. *NOTICE: If the B5 bio-diesel fuel used does not meet the approved specifications, it will cause abnormal wear of injectors, reduce the life of the engine and it may affect the warranty coverage of your engine.*

B5 diesel fuels must meet certain specifications

The bio-diesel fuels must meet the minimum specifications for the country in which they are used:

- In Europe, bio-diesel fuels must comply with the European Standard EN14214.
- In the United States, bio-diesel fuels must comply with the American Standard ASTM D-6751.

Bio-diesel should be purchased only from recognized and authorized diesel fuel suppliers.

Precautions and concerns regarding the use of bio-fuels:

- Bio-diesel fuels have a higher content of methyl-esters, which may deteriorate certain metal, rubber and plastic components of the fuel system. The customer and / or boat builder are responsible to verify the usage of bio-diesel compatible components on the vessel fuel supply and return systems.
- Free water in bio-diesel may result in plugging of fuel filters and increased bacterial growth.
- High viscosity at low temperatures may result in fuel delivery problems, injection pump seizures, and poor injection nozzle spray atomization.
- Bio-diesel may have adverse effects on some elastomers (seal materials) and may result in fuel leakage and dilution of the engine lubricating oil.
- Even bio-diesel fuels that comply with a suitable standard as delivered, will require additional care and attention to maintain the quality of the fuel in the equipment or other fuel tanks. It is important to maintain a supply of clean, fresh fuel. Regular flushing of the fuel system, and / or fuel storage containers, may be necessary.
- The use of bio-diesel fuels that do not comply with the standards as agreed to by the diesel engine manufacturers and the diesel fuel injection equipment manufacturers, or bio-diesel fuels that have degraded as per the precautions and concerns above, may affect the warranty coverage of your engine.

Additional Technical Fuel Requirements

- The fuel cetane number should be equal to 45 or higher.
- The sulfur content must not exceed 0.5% by volume. Less than 0.05% is preferred.
- NEVER mix kerosene, used engine oil, or residual fuels with the diesel fuel.
- Water and sediment in the fuel should not exceed 0.05% by volume.
- Keep the fuel tank and fuel-handling equipment clean at all times.
- Ash content not to exceed 0.01% by volume.
- Carbon residue content not to exceed 0.35% by volume. Less than 0.1% is preferred.
- Total aromatics content should not exceed 35% by volume. Less than 30% is preferred.
- PAH (polycyclic aromatic hydrocarbons) content should be below 10% by volume.
- Do not use Biocide or mix winter and summer fuels.
- Keep the fuel tank and fuel-handling equipment clean at all times.
- Poor quality fuel can reduce engine performance and / or cause engine damage.
- Fuel additives are not recommended. Some fuel additives may cause poor engine performance.

Diesel Fuel Lines

NOTICE: The fuel supply line between the fuel tank and engine must have minimum diameter of 8 mm (0.315 in.).

Shown is a typical installation of a boat fuel system. Fuel supply **(Figure 3-48, (2))** and return **(Figure 3-48, (8))** lines connect to fittings at the engine.

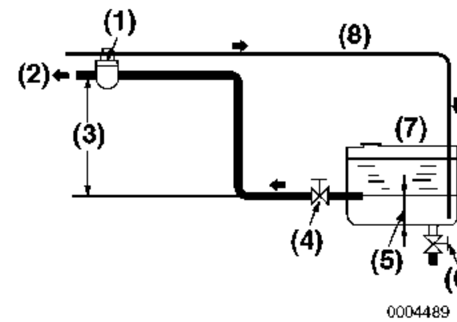


Figure 3-48

1 – Fuel Filter
2 – To Fuel Injection Pump
3 – Less than 500 mm (20.0 in.)
4 – Fuel Cock
5 – 20-30 mm (0.75-1.125 in.) Approximate
6 – Drain Cock
7 – Fuel Tank
8 – Fuel Return Line

Install a drain cock **(Figure 3-48, (6))** at the bottom of the fuel tank to remove water and contaminants.

Boat fuel return system restriction must not exceed 200 mmAq (7.87 in.Aq).

Note: Yanmar does not recommend installing additional fuel filtration before the engine. The engine is equipped with a fuel / water separation filter, plus a fine filter.

Diesel Fuel Lines for 3JH5E and 4JH5E Only

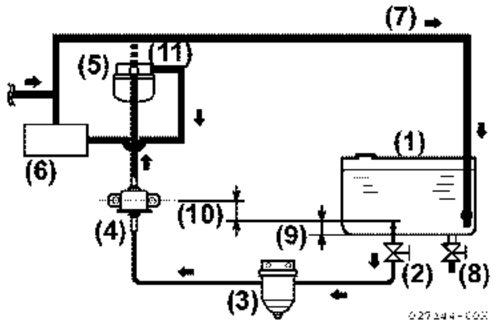


Figure 3-49

1 – Fuel Tank
2 – Fuel Cock
3 – Water Separator
4 – Fuel Feed Pump
5 – Fuel Filter
6 – Fuel Injection Pump
7 – Fuel Return Line
8 – Drain Cock
9 – 20-30 mm (0.75-1.25 in.) Approximate
10 – Less than 400 mm (16.38 in.)
11 – Orifice for Air Bleeding

Bleeding the Fuel System

The fuel system has an automatic air bleeding device that purges air from the fuel system. No manual air bleeding is required for normal operation. The fuel system needs to be bled under the following conditions:

- Starting the engine for the first time.
- After running out of fuel and fuel has been added to the fuel tank.
- After fuel system maintenance such as changing fuel filters, draining the fuel filter / water separator, or replacing a fuel system component. *NOTICE: NEVER crank the engine using the starter motor to prime the fuel system. This may cause the starter motor to overheat and damage the starter.*

3JH5E and 4JH5E Engine

1. Check the fuel level in the fuel tank. Replenish if insufficient.
2. Open the fuel cock of the fuel tank.
3. Turn the electric fuel feed pump **(Figure 3-50, (4))** on to release air out of the fuel return line.

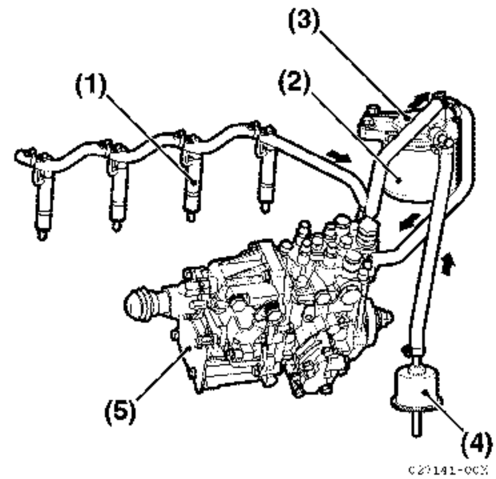


Figure 3-50

1 – Fuel Injector
2 – Fuel Filter
3 – Header (fuel filter)
4 – Electric Fuel Feed Pump
5 – Fuel Injection Pump

4. Continue pumping until a solid stream of fuel with no air bubbles begins to flow.
5. Tighten the air bleed screw.
6. After the engine start-up, the automatic air-bleeding device works to purge the air in the fuel system.

4JH4-TE and 4JH4-HTE Engine

1. Check the fuel level in the fuel tank. Replenish if insufficient.
2. Open the fuel cock of the fuel tank.
3. Loosen the air bleeding bolt **(Figure 3-51, (2))** of the fuel filter by turning it two or three turns.

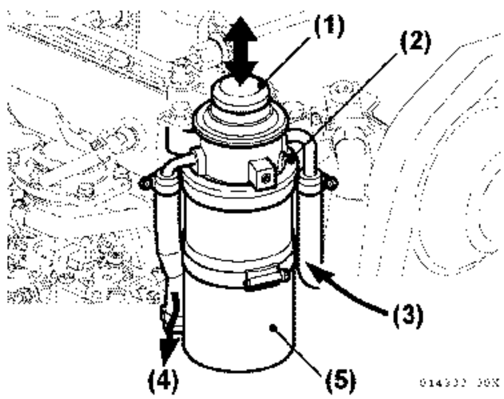


Figure 3-51

1 – Priming Pump
2 – Air Bleeding Bolt
3 – From Fuel Tank
4 – To Fuel Injection Pump
5 – Fuel Filter

4. Feed fuel with the fuel feed pump by moving the lever on the feed pump **(Figure 3-51, (1))** up and down.
5. Allow the fuel containing air bubbles to flow out from the air bleeding bolt hole. When the fuel no longer contains bubbles, tighten the air bleeding bolt. This completes the air bleeding of the fuel system.
6. After the engine start-up, the automatic air-bleeding device works to purge the air in the fuel system.

ENGINE OIL

Engine Oil Specifications

Use an engine oil that meets or exceeds the following guidelines and classifications:

Service Categories

- SAE Viscosity: 10W30 or 15W40
  The 10W30 and 15W40 can be used throughout the year. See **Figure 3-52.**

Selection of Viscosity (SAE Service Grade)

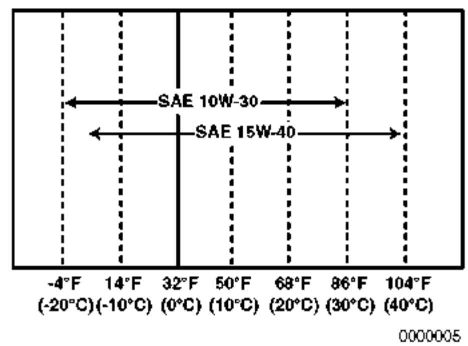


Figure 3-52

- API Classification:

4JH4-TE / 4JH4-HTE	CD or higher
3JH5E / 4JH5E	API CF-4, CI-4

Definitions

- SAE (Society of Automotive Engineer, API (American Petroleum Institute)

Notice:

- *Be sure the engine oil, engine oil storage containers and engine oil filling equipment are free of sediment and water.*
- *Change the engine oil after the first 50 hours of operation and then at every 250 hours (or annually) thereafter.*
- *Select the oil viscosity based on the ambient temperature where the engine is operated. See **Figure 3-52**.*
- *Yanmar does not recommend the use of engine oil additives.*

Note: Yanmar recommends using genuine Yanmar marine oil, specifically formulated for the JH engine.

ENGINE COOLANT

WARNING! *Fire Hazard. Coolant may be flammable under certain conditions. NEVER allow coolant to come into contact with hot surfaces or insulation material.*

WARNING! *Coolant Hazard. Wear protective rubber gloves and eye protection when handling Long Life Coolant Antifreeze. Flush eyes and exposed skin with water immediately after contact.*

Engine Coolant Specifications

Note: In the U.S., LLC is required for the warranty to be valid.

NOTICE: Follow the manufacturer's recommendations. Use the proper LLC which will not have any adverse effects on the materials (cast iron, aluminum, copper, etc.) of the engine's freshwater cooling system.

Engine Coolant Mixture

NOTICE: ALWAYS add LLC to deionized soft water, especially when operating in cold weather. Without LLC, cooling performance will decrease due to scale and rust in the cooling system. Water alone may freeze and form ice; it expands approximately 9% in volume.

Use the proper amount of coolant concentrate for the ambient temperature as specified by the LLC manufacturer. LLC concentration should be a minimum of 30% to a maximum of 60%. Too much LLC will decrease the cooling efficiency.

NEVER mix different types or brands of LLC or a harmful sludge may form.

NEVER use hard water. Use deionized water.

Recommended Engine Coolant

- Texaco Long Life Coolant, both standard and premixed. Product code 7997 and 7998.
- Havoline Extended Life Antifreeze / Coolant. Product code 7994.

Remove scale from the cooling system periodically by flushing the system.

Note: Yanmar recommends using genuine Yanmar antifreeze / coolant.

PRINCIPAL ENGINE SPECIFICATIONS

3JH5E Engine Specifications

Specification		3JH5E			
Marine Gear Model		**KM35P**	**KM35A**	**SD50**	**Bobtail**
Use		Pleasure use			
Type		Vertical water cooled 4-cycle diesel engine			
Combustion system		Direct injection			
Aspiration		Natural aspiration			
Number of cylinders		In-line 3			
Bore x stroke		88 mm x 90 mm (3.46 in. x 3.54 in.)			
Displacement		1.642 L (100.20 cu in.)			
Continuous power	Output at crankshaft / Engine speed	* 26.1 kW (35.5 hp metric)/2907 rpm			
Maximum Rated Output Power	Output at crankshaft / Engine speed	* 28.7 kW (39.0 hp metric) / 3000 rpm			
	Output at propeller / Engine speed	* 27.4 kW (37.3 hp metric) / 3000 rpm		-	-
Installation		Flexible mounting			
Fuel injection timing		FIR 5 ± 1 deg b.T.D.C (FIT 18.0 ± 1 deg b.T.D.C (at Plunger Lift 2.5 mm))			
Fuel injection opening pressure		21.6 – 22.6 MPa (3132-3277 psi)			
Main power take off		At flywheel end			
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern			
	Propeller shaft (Ahead)	Clockwise viewed from stern		-	-
Cooling system		Freshwater cooling with heat exchanger			
Lubricating system		Complete enclosed forced lubrication system			
Coolant capacity (fresh)		Engine 4.5 L (4.8 qt), Coolant recovery tank: 0.8 L (0.8 qt)			
Lubricating oil capacity (engine)	Rake angle	at rake angle 8°	at rake angle 0°		-
	** Total	5.0 ± 0.3 L (5.3 ± 0.3 qt)	5.5 ± 0.3 L (5.8 ± 0.3 qt)		
	Oil pan only	4.5 ± 0.3 L (4.8 ± 0.3 qt)	5.0 ± 0.3 L (5.3 ± 0.3 qt)		
	*** Effective	1.1 L (1.2 qt)	1.2 L (1.3 qt)		
Starting system	Type	Electric			
	Starting motor	DC 12V - 1.4 kW			
	AC generator	12V - 80A (12V - 60A optional)			
Engine dimension	Overall length	777 mm (30.6 in.)	776 mm (30.6 in.)		700 mm (27.6 in.)
	Overall width	560 mm (22.0 in.)			
	Overall height	623 mm (24.5 in.)			
Flywheel major dimension		D300 x 66 mm (11.8 x 2.6 in.)			
Engine dry mass (include marine gear)		185 kg (408 lb)	186 kg (410 lb)	213 kg engine: 173 kg (470 lb) (engine: 381 lb)	173 kg (467 lb)

* *Rating Condition: Temperature of fuel; 40°C at FO pump inlet; ISO 8665*

** *The "total" oil quantity includes oil in oil pan, channels, coolers and filter.*

*** *The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.*

Note: Density of fuel: 0.842g/cm^3 at 15°C
1 hp metric=0.7355 kW

4JH5E Engine Specifications

Engine Model		4JH5E			
Marine Gear Model		**KM35P**	**ZF30M**	**KM35A2**	**KM4A1**
Use		Pleasure use			
Type		Vertical water cooled 4-cycle diesel engine			
Combustion system		Direct injection			
Air charging		Natural aspiration			
Number of cylinders		4			
Bore x stroke		88 mm x 90 mm (3.46 in. x 3.54 in.)			
Displacement		2.190 L (133.64 cu in.)			
Continuous power	Output at crankshaft / Engine speed	* 36.0 kW (48.9 hp metric) / 2907 rpm			
Maximum Rated Output Power	Output at crankshaft / Engine speed	* 39.6 kW (53.8 hp metric) / 3000 rpm			
	Output at propeller / Engine speed	* 38.0 kW (51.7 hp metric) / 3000 rpm		-	-
Installation		Flexible mounting			
Fuel injection timing		FIR 6 ± 1° BTDC (at Maximum Rated Output Power) (FIT 20.0 ± 1° BTDC (at Plunger Lift 2.5))			
Fuel injection opening pressure		21.6-22.6 MPa (3132-3227 psi)			
Main power take off		At flywheel end			
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern			
	Propeller shaft (Ahead)	Clockwise viewed from stern			
Cooling system		Freshwater cooling with heat exchanger			
Lubricating system		Complete enclosed forced lubrication system			
Coolant capacity (fresh)		Engine 6.0 L (6.3 qt), Coolant recovery tank: 0.8 L (0.8 qt)			
Lubricating oil capacity (engine)	Rake angle	at rake angle 8°		at rake angle 0°	
	** Total	5.0 ± 0.3 L (5.3 ± 0.3 qt)		5.5 ± 0.3 L (5.8 ± 0.3 qt)	
	Oil pan only	4.5 ± 0.3 L (4.8 ± 0.3 qt)		5.0 ± 0.3 L (5.3 ± 0.3 qt)	
	*** Effective	1.2 L (1.3 qt)		1.4 L (1.5 qt)	
Starting system	Type	Electric			
	Starting motor	DC 12 V - 1.4 kW			
	AC generator	12 V - 80 A			
Engine dimension	Overall length	871 mm (34.3 in.)	950 mm (37.4 in.)	864 mm (34.0 in.)	922 mm (36.3 in.)
	Overall width	560 mm (22.0 in.)			
	Overall height	625 mm (24.6 in.)			
Flywheel major dimension		D300 x 66 mm (11.8 x 2.6 in.)			
Engine dry mass (include marine gear)		213 kg (470 lb)	229 kg (505 lb)	214 kg (472 lb)	230 kg (507 lb)
Engine dimension	Overall length	871 mm (34.3 in.)	950 mm (37.4 in.)	864 mm (34.0 in.)	922 mm (36.3 in.)
	Overall width	560 mm (22.0 in.)			
	Overall height	625 mm (24.6 in.)			
Flywheel major dimension		D300 x 66 mm (11.8 x 2.6 in.)			
Engine dry mass (include marine gear)		213 kg (470 lb)	229 kg (505 lb)	214 kg (472 lb)	230 kg (507 lb)

* *Rating Condition: Temperature of fuel; 40°C at FO pump inlet; ISO 8665*

** *The "total" oil quantity includes oil in oil pan, channels, coolers and filter.*

*** *The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.*

Note: Density of fuel: 0.842g/cm^3 at 15°C.
1 hp metric = 0.7355 kW

4JH5E Specifications (Continued)

Engine Model		4JH5E	
Sail Drive Model		**SD50**	**Bobtail**
Use		Pleasure use	
Type		Vertical water cooled 4-cycle diesel engine	
Combustion system		Direct injection	
Air charging		Natural aspiration	
Number of cylinders		4	
Bore x stroke		88 x 90 mm (3.46 x 3.54 in.)	
Displacement		2.190 L	
Continuous power	Output at crankshaft / Engine speed	* 36.0 kW (48.9 hp metric)/2907 rpm	
Maximum Rated Output Power	Output at crankshaft / Engine speed	* 39.6 kW (53.8 hp)/3000 rpm	
	Output at propeller / Engine speed	-	
Installation		Flexible mounting	
Fuel injection timing		FIR 6 ± 1° BTDC (at Maximum Rated Output Power) (FIT 20.0 ± 1° BTDC (at Plunger Lift 2.5)	
Fuel injection opening pressure		21.6-22.6 MPa (3132-3227 psi)	
Main power take off		At flywheel end	
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern	
	Propeller shaft (Ahead)	Clockwise viewed from stern	
Cooling system		Freshwater cooling with heat exchanger	
Lubricating system		Closed forced lubrication system	
Coolant capacity (fresh)		Engine 6.0 L (6.3 qt), Coolant recovery tank: 0.8 L (0.8 qt)	
Lubricating oil capacity (engine)	Rake angle	at rake angle 0°	
	** Total	5.5 ± 0.3 L (5.8 ± 0.3 qt)	
	Oil pan only	5.0 ± 0.3 L (5.3 ± 0.3 qt)	
	*** Effective	1.4 L (1.5 qt)	
Starting system	Type	Electric	
	Starting motor	DC 12 V - 1.4 kW	
	AC generator	12 V - 80 A	
Engine dimension	Overall length	795 mm (31.3 in.)	
	Overall width	560 mm (22.0 in.)	
	Overall height	625 mm (24.6 in.)	
Flywheel major dimension		D300 x 66 mm (11.8 x 2.6 in.)	
Engine dry mass (include marine gear)		241 kg engine: 201 kg (531 lb) (engine: 443 lb)	201 kg (443 lb)

* *Rating Condition: Temperature of fuel; 40°C at fuel pump inlet; ISO 8665*

** *The "total" oil quantity includes oil in oil pan, channels, coolers and filter.*

*** *The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.*

Note: Density of fuel: 0.842g/cm^3 at 15°C.
1 hp metric = 0.7355 kW

4JH4-TE Engine Specifications

Engine Model		4JH4-TE					
Marine Gear Model		**ZF30M**	**KM4A2**	**KMH4A**	**ZF25A**	**SD50-4T**	**Bobtail**
Use		Pleasure use					
Type		Vertical water cooled 4-cycle diesel engine					
Combustion system		Direct injection					
Air charging		Turbocharged					
Number of cylinders		4					
Bore x stroke		84 x 90 mm (3.31 x 3.54 in.)					
Displacement		1.995 L (121.74 cu in.)					
Continuous power	Output at crankshaft / Engine speed	* 50.2 kW (68.3 hp metric) / 3101 rpm					
Maximum Rated Output Power	Output at crankshaft / Engine speed	* 55.2 kW (75.1hp metric) / 3200 rpm					
	Output at propeller / Engine speed	* 53.0 kW (72.1hp metric) / 3200 rpm				-	
Installation		Flexible mounting					
Fuel injection timing		Plunger lift at TDC 1.26 ± 0.01 mm (when W-CSD is released)					
Fuel injection opening pressure		21.6 ± 0.5 MPa					
Main power take off		At flywheel end					
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern					
	Propeller shaft (Ahead)	Clockwise from stern	Clockwise or counterclockwise (Bi-rotation)			-	
Cooling system		Freshwater cooling with heat exchanger					
Lubricating system		Complete enclosed forced lubrication system					
Coolant capacity (fresh)		Engine: 7.2 L (7.6 qt), Coolant recovery tank: 0.8 L (0.8 qt)					
Lubricating oil capacity (engine)	Rake angle	7°	0°				7° or 0°
	** Total	5.7 ± 0.3 L (6.0 ± 0.3 qt)	6.9 ± 0.3 L (7.3 ± 0.3 qt)				Refer to left
	Oil pan only	5.2 ± 0.3 L (5.5 ± 0.3 qt)	6.4 ± 0.3 L (6.8 ± 0.3 qt)				Refer to left
	*** Effective	2.4 L (2.5 qt)					
Starting system	Type	Electric					
	Starting motor	DC 12 V - 1.4 kW					
	AC generator	12 V - 80 A (12 V - 60 A optional)					
Engine dimension	Overall length	923 mm (36.3 in.)	903 mm (35.6 in.)	933 mm (36.7 in.)	1017 mm (40.0 in.)	782 mm (30.8 in.)	782 mm (30.8 in.)
	Overall width	616 mm (24.3 in.)					
	Overall height	659 mm (25.9 in.)					
Flywheel major dimension		D339 x 66 mm (13.3 x 2.6 in.)					
Engine dry mass (include marine gear)		235 kg (518 lb)	237 kg (523 lb)	238 kg (525 lb)	237 kg (523 lb) engine: 173 kg (engine: 381 lb)	249 kg (549 lb) engine: 207 kg (engine: 456 lb)	207 kg (456 lb)

* *Rating Condition: Temperature of fuel; 40°C at fuel pump inlet; ISO 8665*

** *The "total" oil quantity includes oil in oil pan, channels, coolers and filter.*

*** *The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.*

Note: Density of fuel: 0.842g/cm^3 at 15°C.
1 hp metric = 0.7355 kW

4JH4-HTE Engine Specifications

Engine Model		4JH4-HTE				
Marine Gear Model		**ZF30M**	**KM4A2**	**KMH4A**	**ZF25A**	**Bobtail**
Use		Pleasure use				
Type		Vertical water cooled 4-cycle diesel engine				
Combustion system		Direct injection				
Aspiration		Turbocharged				
Number of cylinders		4				
Bore x stroke		84 x 90 mm (3.31 x 3.54 in.)				
Displacement		1.995 L				
Continuous power	Output at crankshaft / Engine speed	* 73.6 kW (100 hp metric) / 3101 rpm				
Maximum Rated Output Power	Output at crankshaft / Engine speed	* 80.9 kW (110 hp metric) / 3200 rpm				
	Output at propeller / Engine speed	* 77.7 kW (106 hp metric) / 3200 rpm				-
Installation		Flexible mounting				
Fuel injection timing		Plunger lift at TDC 1.26 ± 0.01 mm (when W-CSD is released)				
Fuel injection opening pressure		21.6 ± 0.5 MPa				
Main power take off		At flywheel end				
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern				
	Propeller shaft (Ahead)	Clockwise from stern	Clockwise or counterclockwise (Bi-rotation)			-
Cooling system		Freshwater cooling with heat exchanger				
Lubricating system		Complete enclosed forced lubrication system				
Coolant capacity (fresh)		Engine: 7.2 L (7.6 qt), Coolant recovery tank: 0.8 L (0.8 qt)				
Lubricating oil capacity (engine)	Rake angle	7°	0°			7° or 0°
	** Total	5.7 ± 0.3 L (6.0 ± 0.3 qt)	6.9 ± 0.3 L (7.3 ± 0.3 qt)			Refer to left
	Oil pan only	5.2 ± 0.3 L (5.5 ± 0.3 qt)	6.4 ± 0.3 L (6.8 ± 0.3 qt)			Refer to left
	*** Effective	2.4 L (2.5 qt)				
Starting system	Type	Electric				
	Starting motor	DC 12 V - 1.4 kW				
	AC generator	12 V - 80 A (12 V - 60 A optional)				
Engine dimension	Overall length	923 mm (36.3 in.)	903 mm (35.6 in.)	933 mm (36.7 in.)	1017 mm (40.0 in.)	782 mm (30.8 in.)
	Overall width	616 mm (24.3 in.)				
	Overall height	659 mm (25.9 in.)				
Flywheel major dimension		D339 x 66 mm (13.3 x 2.6 in.)				
Engine dry mass (include marine gear)		245 kg	247 kg	248 kg	247 kg	217 kg

* *Rating Condition: Temperature of fuel; 40°C at fuel pump inlet; ISO 8665*
** *The "total" oil quantity includes oil in oil pan, channels, coolers and filter.*
*** *The effective amount of oil shows the difference in maximum scale of the dipstick and minimum scale.*

Note: Density of fuel: 0.842g/cm^3 at 15°C.
1 hp metric = 0.7355 kW

TIGHTENING TORQUES

Use the correct amount of torque when tightening fasteners. Applying excessive torque may damage the fastener or component and not enough torque may cause a leak or component failure.

Hexagon Bolts and Nuts

Name	Bolt Diameter x pitch (mm)	Tightening Torque N·m (ft-lb)	Remarks
Hexagon bolt with a "7" head and hexagon nut. ("7" mark means JIS strength classification "7T".)	M6x1	9.8-11.8 (7.2-8.7)	Apply 80% torque when tightening to aluminum alloy. Apply 60% torque to 4T bolts and locknuts. (4T bolt has no mark on the head.)
	M8x1.25	22.5-28.5 (16.9-21.1)	
	M10x1.5	44-54 (33.4-40.6)	
	M12x1.75	78.2-98.2 (58.8-73.2)	
PT plug (Taper plug)	1/8	9.8 (7.3)	-
	1/4	19.6 (19.6)	
	3/8	29.4 (21.6)	
	1/2	58.8 (43.4)	
Line joint bolt	M8	12.7-16.7 (9.4-12.3)	-
	M10	19.5-25.5 (14.4-18.8)	
	M12	24.4-34.4 (18.0-25.4)	
	M14	39.1-49.1 (28.9-36.2)	
	M16	48.9-58.9 (36.1-43.5)	

Hose Clamps

Note: Reuse and retightening is prohibited for all hose clamps. Always install new hose clamps.

PREPARE ENGINE FOR LONG-TERM STORAGE

NOTICE: Do not drain engine coolant for long-term storage. Antifreeze must be used to avoid freezing and damage to components. Antifreeze will prevent rusting during long-term storage.

1. Change engine oil and filter. *See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.*
2. Drain seawater cooling system. *See Draining / Refilling Seawater Cooling System on page 7-8.*
3. Wipe off any dust or oil from the outside of the engine.
4. Drain fuel tank or fill the tank to prevent condensation.
5. Grease the exposed areas and joints of the remote control cables and the bearings of the remote control handle.
6. Seal the intake silencer, exhaust pipe, etc. to prevent moisture or contamination from entering engine.
7. Completely drain bilge in hull bottom.
8. Waterproof the engine room to prevent rain or seawater from entering.
9. Charge the battery once a month to compensate for battery's self-discharge.
10. Remove key from key switch and cover key switch with moisture cap (if equipped).

ABBREVIATIONS AND SYMBOLS

A	ampere
AC	alternating current
ACEA	Association des Constructeurs Européens d'Automobilies
Ah	ampere-hour
API	American Petroleum Institute
ARB	Air Resources Board
ATDC	after top dead center
BDC	bottom dead center
BTDC	before top dead center
°C	degree Celsius
CARB	California Air Resources Board
CCA	cold cranking amp
cfm	cubic feet per min.
cm	centimeter
cm³	cubic centimeter
cm³/minimum	cubic centimeter per min.
cu in.	cubic inch
D	diameter
DC	direct current
DI	direct injection
DVA	direct volt adapter
EPA	Environmental Protection Agency
ESG	electronic speed governor
°F	degree Fahrenheit
fl oz	fluid ounce (U.S.)
fl oz/minimum	fluid ounce (U.S.) per min.
ft	foot
ft-lb	foot pound*
ft-lbf/minimum	foot pound force per min.
g	gram
gal	gallon (U.S.)
gal/hr	gallon (U.S.) per hour
gal/minimum	gallon (U.S.) per min.
GL	gear lubricant
hp	horsepower (metric)
hr	hour
ID	inside diameter
ID	identification
IDI	indirect injection
in.	inch
in.Aq	inches Aqueous (water)
in.Hg	inches Mercury
in-lb	inch pound**
J	joule
JASO	Japanese Automobile Standards Organization
K	kelvin
kg	kilogram
kgf/cm²	kilogram force per square centimeter
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lbf	pound-force
lb-ft	pound foot (Tightening Torque)
lb-in	pound inch (Tightening Torque)
m	meter
mL	milliliter
mm	millimeter
mmAq	millimeter Aqueous (water)
MPa	megapascal
mV	millivolt
N	newton
N·m	newton meter
No.	number
O.D.	outside diameter
oz	ounce
Pa	pascal
PS	horsepower (metric)
psi	pound per square inch
qt	quart (U.S.)
R	radius
rpm	revolutions per min.
SAE	Society of Automotive Engineers
sec.	second
t	short ton 2000 lb
TBN	total base number
TDC	top dead center
V	volt
VAC	volt alternating current
VDC	volt direct current
W	watt

Symbols

°	degree
+	plus
-	minus
±	plus or minus
Ω	ohm
µ	micro
%	percent

* Work torque such as engine torque

** Work torque such as starter motor torque

UNIT CONVERSIONS

Unit Prefixes

Prefix	Symbol	Power
mega	M	x 1,000,000
kilo	k	x 1,000
centi	c	x 0.01
milli	m	x 0.001
micro	µ	x 0.000001

Units of Length

mile	x	1.6090	= km
ft	x	0.3050	= m
in.	x	2.5400	= cm
in.	x	25.4000	= mm
km	x	0.6210	= mile
m	x	3.2810	= ft
cm	x	0.3940	= in.
mm	x	0.0394	= in.

Units of Volume

gal (U.S.)	x	3.78540	= L
qt (U.S.)	x	0.94635	= L
cu in.	x	0.01639	= L
cu in.	x	16.38700	= mL
fl oz (U.S.)	x	0.02957	= L
fl oz (U.S.)	x	29.57000	= mL
cm³	x	1.00000	= mL
cm³	x	0.03382	= fl oz (U.S.)

Units of Mass

lb	x	0.45360	= kg
oz	x	28.35000	= g
kg	x	2.20500	= lb
g	x	0.03527	= oz

Units of Force

lbf	x	4.4480	= N
lbf	x	0.4536	= kgf
N	x	0.2248	= lbf
N	x	0.1020	= kgf
kgf	x	2.2050	= lbf
kgf	x	9.8070	= N

Units of Torque

lb-ft	x	1.3558	= N·m
lb-ft	x	0.1383	= kgf/m
lb-in	x	0.1130	= N·m
lb-in	x	0.0115	= kgf/m
kgf/m	x	7.2330	= lb-ft
kgf/m	x	86.8000	= lb-in
kgf/m	x	9.8070	= N·m
N·m	x	0.7376	= lb-ft
N·m	x	8.8510	= lb-in
N·m	x	0.1020	= kgf/m

Units of Pressure

psi	x	0.0689	= bar
psi	x	6.8950	= kPa
psi	x	0.0703	= kgf/cm²
bar	x	14.5030	= psi
bar	x	100.0000	= kPa
bar	x	29.5300	= inHg (60°F)
kPa	x	0.1450	= psi
kPa	x	0.0100	= bar
kPa	x	0.0102	= kgf/cm²
kgf/cm²	x	98.0700	= psi
kgf/cm²	x	0.9807	= bar
kgf/cm²	x	14.2200	= kPa
in.Hg (60°)	x	0.0333	= bar
in.Hg (60°)	x	3.3770	= kPa
in.Hg (60°)	x	0.0344	= kgf/cm²
mmAq	x	0.0394	= in.Aq

Units of Power

hp (metric or PS)	x	0.9863201	= hp SAE
hp (metric or PS)	x	0.7354988	= kW
hp SAE	x	1.0138697	= hp (metric or PS)
hp SAE	x	0.7456999	= kW
kW	x	1.3596216	= hp (metric or PS)
kW	x	1.3410221	= hp SAE

Units of Temperature

°F = (1.8 x °C) + 32
°C = 0.556 x (°F - 32)

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Section 4

PERIODIC MAINTENANCE

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SAFETY PRECAUTIONS

Before you perform maintenance, review the *Safety Section on page 2-1.*

INTRODUCTION

This section of the *Service Manual* describes the procedures for proper care and maintenance of the engine.

The Importance of Periodic Maintenance

Engine deterioration and wear occurs in proportion to length of time the engine has been in service and the conditions the engine is subject to during operation. Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the engine.

Performing Periodic Maintenance

Perform periodic maintenance procedures in an open, level area free from traffic. If possible, perform the procedures indoors to prevent environmental conditions such as rain, wind or snow from damaging the engine. **WARNING!** ***Exhaust Hazard. NEVER block windows, vents or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure will cause illness or even death.***

Yanmar Replacement Parts

Yanmar recommends that you use genuine Yanmar parts when replacement parts are needed. Genuine replacement parts help ensure long engine life.

Required EPA Maintenance

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulation Engines, it is essential that you follow the *Periodic Maintenance Schedule on page 4-4* and *Periodic Maintenance Procedures on page 4-6.*

EPA REQUIREMENTS

The EPA emission regulation is applicable only in USA.

Conditions to Ensure Compliance with EPA Emission Standards

This product is an EPA-approved engine.

The following are the conditions that must be met in order to ensure that the emissions during operation meet the EPA standards:

- Ambient temperature: -16° to +40°C (3° to 104°F)
- Relative humidity: 80% or lower

The fuel and lubricating oil used should be as follows:

- Diesel fuel: ASTM D975 No. 1-D or No. 2-D, or equivalent (minimum cetane No. 45)
- Lubricating oil: Type API, Class CD for Model 4JH4-TE and 4JH4-HTE engines
  Type API, Class CF-4, CI-4 or higher for Model 3JH5E and 4JH5E engine

Be sure to perform inspections as outlined in *Periodic Maintenance Schedule on page 4-4* and keep a record of the results.

Pay particular attention to these important points:

- Replacing the engine oil
- Replacing the lubricating oil filter
- Replacing the fuel filter
- Replacing the air filter

Note: Inspections are divided into two sections in accordance with who is responsible for performing the inspection: the user or the maker.

Inspection and Maintenance

See EPA Requirements on page 4-3.

Inspection and maintenance procedures not shown in this section are covered in *Periodic Maintenance Schedule on page 4-4.*

This maintenance must be performed to keep the emission values of your engine within standard values during the warranty period. The warranty period is determined by the age of the engine or the number of hours of operation.

PERIODIC MAINTENANCE SCHEDULE

Daily and periodic maintenance is important to keep the engine in good operating condition. The following is a summary of maintenance items by periodic maintenance intervals. Periodic maintenance intervals vary depending on engine application, loads, diesel fuel and engine oil used and are hard to establish definitively. The following should be treated only as a general guideline.

○: Check ◇: Replace

System	Item		Periodic Maintenance Interval			
			Every 50 hours or monthly whichever comes first	**Every 250 hours or one year whichever comes first**	**Every 500 hours or 2 years whichever comes first**	**Every 1000 hours or 4 years whichever comes first**
Whole	Visual inspection of engine exterior					
Fuel System	Check the fuel level and refill if necessary					
	Drain water and sediment from fuel tank		○ Initial 50	○		
	Drain the fuel / water separator		○			
	Replace the fuel filter element			◇		
	Check the fuel injection timing					○
	Check the fuel injector spray pattern*					○*
Lubricating System	Check the lubricating oil level	Engine				
		Marine Gear				
	Replace the lubricating oil	Engine	◇ Initial 50	◇		
		Marine Gear	◇ Initial 50	◇		
	Replace the oil filter element	Engine	◇ Initial 50	◇		
		Marine Gear (if equipped)	◇ Initial 50	◇		
Cooling System	Seawater outlet					
	Check coolant level					
	Check or replace the seawater pump impeller			○		◇
	Replace coolant		Every year When long life coolant is used, replace every two years. *See Engine Coolant Specifications on page 3-66.*			
	Clean and check the seawater passages					○
Air Intake / Exhaust System	Clean intake silencer (air cleaner) element			○		
	Clean the exhaust / water mixing elbow			○	◇	
	Clean the turbocharger* 4JH4-TE / 4JH4-HTE only			○*		
	Check diaphragm assembly 3JH4E / 4JH4AE only					○

O: Check ◇: Replace

System	Item	Periodic Maintenance Interval			
		Every 50 hours or monthly whichever comes first	Every 250 hours or one year whichever comes first	Every 500 hours or 2 years whichever comes first	Every 1000 hours or 4 years whichever comes first
Electrical System	Check alarm and indicators				
	Check the electrolyte level in the battery	O			
	Check tension of / replace alternator V-belt	O Initial 50	O		◇
	Check the wiring connectors		O		
Engine Cylinder Head and Block	Check for leakage of fuel, engine oil and engine coolant				
	Tighten all major nuts and bolts		O		
	Adjust intake / exhaust valve clearance	O Initial 50			O
Miscellaneous Items	Check the remote control cable operation	O Initial 50			O
	Adjust the propeller shaft alignment	O Initial 50			O
	Replace rubberized hoses (fuel and water)	Replace every 2 years or every 2000 hours, whichever comes first.			

* *For EPA requirements see Inspection and Maintenance of EPA Emission-Related Parts on page 4-5Periodic Maintenance Procedures.*

Note: These procedures are considered normal maintenance and are performed at the owner's expense.

Inspection and Maintenance of EPA Emission-Related Parts

- Marine diesel engines less than 37 kW: 3JH5E is certified as Non-Road and EPA CI marine engine
- Marine diesel engines greater than 37 kW: 4JH5E, 4JH4-TE and 4JH4-HTE are certified as EPA CI marine engines

Inspection and Maintenance of EPA Emission-Related Parts for Non-Road and CI Marine Engines

Parts	Interval
Clean fuel injection nozzle	1500 hours
Check fuel injection nozzle pressure and spray pattern	3000 hours
Check fuel injection pump adjustment	
Check turbocharger adjustment (if equipped)	
Check electronic engine control unit and its associated sensors and actuators (if equipped)	

Note: The inspection and maintenance items shown above to be performed at your Yanmar dealer or distributor.

PERIODIC MAINTENANCE PROCEDURES

After Initial 50 Hours of Operation

Perform the following maintenance after the initial 50 hours of operation.

- **Draining Water and Sediment from the Fuel Tank**
  See Cleaning Fuel Injection Nozzle Cavities on page 6-13.
- **Changing the Engine Oil and Replacing the Engine Oil Filter**
  See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.
- **Adjusting / Replacing the Alternator V-belt**
  See Replace V-Belt on page 11-8.
- **Adjusting Intake / Exhaust Valve Clearance**
  See Inspecting Intake / Exhaust Valves and Valve Guides on page 5-47.
- **Checking Remote Control Cable Operation**
  See Checking and Adjusting Remote Control Operation on page 5-100.
- **Adjusting Propeller Shaft Alignment (If Equipped with Marine Gear)**
  See Principal Engine Specifications on page 3-67.

Every 50 Hours of Operation

After you complete the initial 50 hour maintenance procedures, perform the following procedures every 50 hours or monthly thereafter, whichever comes first.

- **Draining the Fuel Filter / Water Separator**
  See Replacing the Fuel / Water Separator on page 6-49.
- **Checking Battery Electrolyte Level (Serviceable Batteries Only)**
  See Tests and Adjustments on page 5-22.

Every 250 Hours of Operation

Perform the following maintenance every 250 hours of operation or one year, whichever comes first.

- **Draining Water and Sediment from the Fuel Tank**
  See Cleaning Fuel Injection Nozzle Cavities on page 6-13.
- **Replacing the Fuel Filter Element**
  See Servicing the Fuel System on page 6-12.
- **Changing Engine Oil and Replacing the Engine Oil Filter Element**
  See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.
- **Checking or Replacing the Seawater Pump Impeller**
  See Seawater Pump on page 7-17.
- **Cleaning the Intake Silencer (Air Cleaner) Element**
  See Cleaning the Air Cleaner on page 9-6.
- **Replacing Coolant (LLC)**
  See Removing and Installing Coolant Pump on page 7-15.
- **Replacing the Anodes (4JH4-TE and 4JH4-HTE Only)**
  See Draining and Filling Closed Cooling System on page 7-10.
- **Cleaning the Exhaust / Water Mixing Elbow**
- **Cleaning the Turbocharger (4JH4-TE and 4JH4-HTE only)**
  See Turbocharger Service on page 9-6.
- **Adjusting / Replacing the Alternator V-belt**
  See Replace V-Belt on page 11-8.
- **Tightening All Major Nuts and Bolts**
  See Main Bolt and Nut on page 14-15.

Every 500 Hours of Operation

Perform the following maintenance every 500 hours of operation or 2 years, whichever comes first.

- **Cleaning the Engine Oil Cooler**
  See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.
- **Replacing Coolant (LLC)**
  See Removing and Installing Coolant Pump on page 7-15.
- **Replacing the Anodes (4JH4-TE and 4JH4-HTE Only)**
  See Draining and Filling Closed Cooling System on page 7-10.
- **Replacing Rubberized Hoses (Fuel and Water)**
  See Servicing the Fuel System on page 6-12 and Inspecting the Cylinder Block on page 5-40.

Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation or 4 years, whichever comes first.

- **Checking the Fuel Injection Timing**
  See Flywheel and Housing on page 5-70.
- **Checking the Fuel Injector Spray Pattern**
  See Fuel Injectors on page 6-52.
- **Checking or Replacing the Seawater Pump Impeller**
  See Seawater Pump on page 7-17.
- **Replacing Coolant (LLC)**
  See Removing and Installing Coolant Pump on page 7-15.
- **Cleaning the Seawater Passages**
  See Draining and Filling Closed Cooling System on page 7-10.
- **Replacing the Anodes (4JH4-TE and 4JH4-HTE Only)**
  See Draining and Filling Closed Cooling System on page 7-10.
- **Checking the Diaphragm Assembly (4JH4-TE and 4JH4-HTE only)**
  See 4JH4-TE and 4JH4-HTE Engines on page 5-30.
- **Replacing the Alternator V-belt**
  See Replace V-Belt on page 11-8.
- **Adjusting Intake / Exhaust Valve Clearance**
  See Inspecting Intake / Exhaust Valves and Valve Guides on page 5-47.
- **Checking Remote Control Cable Operation**
  See Checking and Adjusting Remote Control Operation on page 5-100.
- **Adjusting Propeller Shaft Alignment (If Equipped with Marine Gear)**
  See Principal Engine Specifications on page 3-67.
- **Replacing Rubberized Hoses (Fuel and Water)**
  See Servicing the Fuel System on page 6-12 and Inspecting the Cylinder Block on page 5-40.

Section 5

ENGINE

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SAFETY PRECAUTIONS

Before you service the engine, read the following safety information and review the *Safety Section on page 2-1*.

NOTICE

NEVER attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the engine and shorten its life. If adjustment is ever required, see your authorized Yanmar Marine dealer or distributor.

INTRODUCTION

This section of the *Service Manual* describes the disassembly, inspection, and reassembly of the JH Series engines.

SPECIFICATIONS

General Information

Engine Model	3JH5E	4JH5E	4JH4-TE	4JH4-HTE
Number of Cylinders	In-Line 3	In-Line 4		
Bore	88 mm (3.465 in.)		84 mm (3.307 in.)	
Stroke	90 mm (3.543 in.)			
Displacement	1642 cc (100.20 cu in.)	2190 cc (133.64 cu in.)	1995 cc (121.74 cu in.)	
Compression Ratio	19.0:1			
Compression Pressure (at 250 rpm)	3.4 ± 0.1 MPa (493 ± 14.5 psi)			3.2 ± 0.1 MPa (464 ±14.5 psi)
Valve Clearance -Intake / exhaust	0.2 ± 0.05 mm (0.0079 ± 0.0020 in.)			
Fuel Injection Pressure	21.6 +1.0 MPa (3133 +217 psi)	20.6 +1.0 MPa (2987 +145 psi)	21.6 ± 0.5 MPa (3133 ± 72 psi)	

Test and Adjustment Specifications

Test Item	Remarks	Specification	3JH5E	4JH5E	4JH4-TE	4JH4-HTE
Cylinder Compression Test	Compression Pressure at 250 rpm	All Cylinders Approximately Same	3.4 ± 0.1 MPa (493 ± 14 psi)			3.2 ± 0.1 MPa (464 ± 14 psi)

Repair Specifications

Component	Remarks	3JH5E	4JH5E	4JH4-TE	4JH4-HTE
Coolant	Coolant Capacity	4.5 L (4.8 qt)	6.0 L (6.3 qt)	7.2 L (7.6 qt)	
	Coolant Recovery Tank	0.8 L (0.85 qt)			

Component	Remarks		3JH5E	4JH5E	4JH4-TE	4JH4-HTE
Lubricating Oil	Lubricating oil capacity	Engine (with KM35P, at rake angle 8 degrees)	5.0 ±0.3 / effective 1.1 L (5.3 ±0.3 / effective 1.2 qt)	-	-	-
		Engine (with KM35A / SD40, at rake angle 0 degrees)	5.5 ±0.3 / effective 1.2 L (5.8 ±0.3 / effective 1.3 qt)	-	-	-
		Engine (with KM35P / ZF30M, at rake angle 8 degrees)	-	5.0 ±0.3 / effective 1.2 L (5.3 ±0.3 / effective 1.3 qt)	-	-
		Engine (with KM35A2 / KM4A1 / SD40, at rake angle 0 degrees)	-	5.0 ±0.3 / effective 1.4 L (5.3 ±0.3 / effective 1.5 qt)	-	-
		Engine (with ZF30F, at angle 7 degrees)	-	-	5.7 ±0.3 / effective 2.4 L (6.0 ±0.3 / effective 2.5 qt)	
		Engine (with KMH4A / KM4A2 / ZF25A / SD50, at rake angle 0 degrees)	-	-	6.9 ±0.3 / effective 2.4 L (7.3 ±0.3 / effective 2.5 qt)	
	Marine gear oil capacity	KM35P	0.50 L (0.53 qt)		-	-
		KM35A	0.65 L (0.69 qt)		-	-
		KM35A2	-	0.65 L (0.69 qt)	-	-
		ZF30M	-	1.1 L (1.1 qt)	-	-
		ZF30M	-	-	1.1 / effective 0.2 L (1.2 / effective 0.2 qt)	
		KM4A1	-	1.3 L (1.4 qt)	-	-
		KMH4A	-	-	2.00/ effective 0.2 L (2.1 / effective 0.2 qt)	
		KM4A2				
	Marine gear oil capacity	ZF25A	-	-	1.8 L (1.9 qt)	
		SD50-4T	-	-	2.2 / effective 0.1 L (2.3 / effective 0.1 qt)	-
	Lubricating oil pressure		0.54 -0.15 / -0.48 MPa or above (78 -22 / -67 psi or above)		-	-
			-	-	0.45 -0.17 / -0.39 MPa or above (65 -25 / -57 psi or above)	
Thermostat	Valve opening temperature		75 +3°C (167 +5°F)			
	Full opening lift at specified temperature		8 mm or above at 90°C (0.3 in. or above at 194°F)			
	Thermo switch actuating temperature	ON	97 +6°C (207 +11°F)			
		OFF	90°C or more (194°F or more)			

Refer to section 14, Service Standards, for other part repair specifications.

SPECIAL TORQUE CHART

System	Component	Model	Thread	Comments	Specification
Engine Block	Metal Cap Bolt	3JH5E 4JH5E	M12x1.5	Coat with lubricating oil	98 ± 2 N·m (72 ± 1.5 lb-ft)
Connecting Rod and Bearing	Connecting Rod Bolts	3JH5E 4JH5E	M9x1.0	Coat with lubricating oil	44.1 ± 5.0 N·m (32.5 ± 3.7 lb-ft)
Cylinder Head	Cylinder Head Bolts	3JH5E 4JH5E	M10x1.25	Coat with lubricating oil	88.2 ± 3.0 N·m (65.1 ± 2.2 lb-ft)
Crankshaft	Flywheel Bolt	3JH5E 4JH5E	M10x1.25	Coat with lubricating oil	83.3 ± 5.0 N·m (61.4 ± 3.7 lb-ft)
	Pulley Bolt (FC300 Pulley)	3JH5E 4JH5E	M12x1.5	Coat with lubricating oil	88.2 ± 5.0 N·m (65 ± 3.7 lb-ft)
Lubricating System	Plate machine bolt (Lubricating Oil Cover)	4JH5E	M6x1.0	No lubricating oil	6.9 ± 1.5 N·m (4.8 ± 1.1 lb-ft)
Fuel System	Nozzle Retainer Bolt	3JH5E 4JH5E	M8x1.25	No lubricating oil	26.4 ± 2.0 N·m (19.5 ± 1.5) lb-ft
	Fuel Injection Pump Drive Gear Nut	4JH5E	M8x1.0	No lubricating oil	34.3 ± 2.0 N·m (25.3 ± 1.5 lb-ft)
		4JH4-TE 4JH4-HTE	M14x1.5	Coat with lubricating oil	59 ± 10 N·m (44 ± 7.4 lb-ft)
	Fuel Injection Line Joint Nut	3JH5E 4JH5E	M12x1.5	No lubricating oil	29.4 ± 5.0 N·m (21.5 ± 3.7 lb-ft)
	Fuel Return Line Bolts	4JH5E	M6x1.0	No lubricating oil	7.8 ± 4.0 N·m (69 ± 18 lb-ft)
	Fuel Injection Pump Mounting Nuts	4JH5E	M8x1.25	No lubricating oil	23 ± 5 N·m (17 ± 4 lb-ft)
	Fuel Injection Nozzle Case Nuts	4JH5E	0.605-40 UNS-28	No lubricating oil	39.2 ± 4.9 N·m (30 ± 3 lb-ft)
	Fuel Injection Pump Plunger Plug	4JH5E	M14x1.0	No lubricating oil	30 ± 5 N·m (22 ± 4 lb-ft)
Electrical System	Starter Relay Terminal Nut (Magnetic Relay)	3JH5E 4JH5E	M6x1.0	No lubricating oil	3.6 ± 0.6 N·m (2.7 ± 0.45 lb-ft)

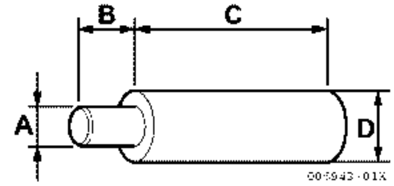
STANDARD TORQUE CHART (W/O LUBRICATING OIL)

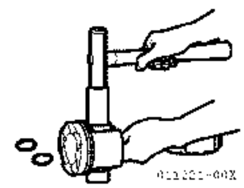
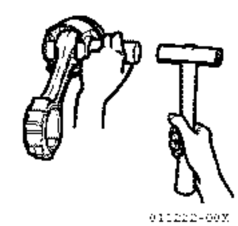
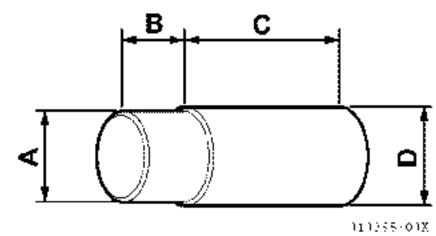
Name	Thread	Specification	Comments
Hexagon bolt with a "7" mark head and hexagon nut ("7" mark means JIS strength classification "7T".)	M6x1	9.8 ± 2.0 N·m (7.2 ± 1.5 lb-ft)	Apply 80% torque when tightening to aluminum alloy. Apply 60% torque to 4T bolts and locknuts (4T bolt has no mark on the head).
	M8x1.25	22.5 ± 6.0 N·m (16.6 ± 4.4 lb-ft)	
	M10x1.5	44 ± 6.0 N·m (37 ± 4.4 lb-ft)	
	M12x1.75	78.2 ± 10 N·m (57.7 ± 7.4 lb-ft)	
PT Plug (taper plug)	1/8	9.8 N·m (7.2 lb-ft)	When lock adhesive is applied, decide separately.
	1/4	19.6 N·m (14.5 lb-ft)	
	3/8	29.4 N·m (21.7 lb-ft)	
	1/2	58.8 N·m (43.4 lb-ft)	
Line Joint Bolt	M8	12.7 ± 4.0 N·m (9.4 ± 3.0 lb-ft)	-
	M10	19.5 ± 6.0 N·m (14.3 ± 4.4 lb-ft)	
	M12	24.4 ± 10 N·m (18.0 ± 7.4 lb-ft)	
	M14	39.1 ± 10 N·m (28.8 ± 7.4 lb-ft)	
	M16	48.9 ± 10 N·m (36.1 ± 7.4 lb-ft)	

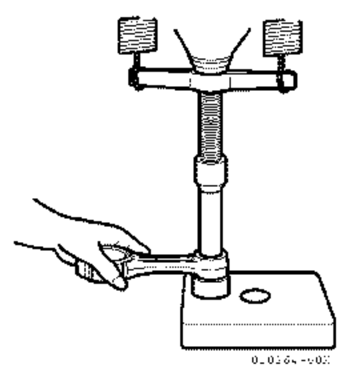
SPECIAL SERVICE TOOLS

The following tools are required when disassembling and reassembling the engine.

Please use them as instructed.

<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>1</td><td>Piston pin insertion/ extraction tool</td><td>


<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>mm</td><td>12</td><td>20</td><td>80</td><td>25</td></tr>
<tr><td>in.</td><td>0.472</td><td>0.787</td><td>3.150</td><td>0.984</td></tr>
</table>
</td><td>Extraction of piston pin

Insertion of piston pin
</td></tr>
<tr><td>2</td><td>Connecting rod small end bushing insertion/extraction tool for 3JH4E / 4JH4TE</td><td>


<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>mm</td><td>25.4-25.7</td><td>20</td><td>80</td><td>28.4-28.7</td></tr>
<tr><td>in.</td><td>1.000-1.012</td><td>0.787</td><td>3.150</td><td>1.118-1.130</td></tr>
</table>
</td><td>Extraction
</td></tr>
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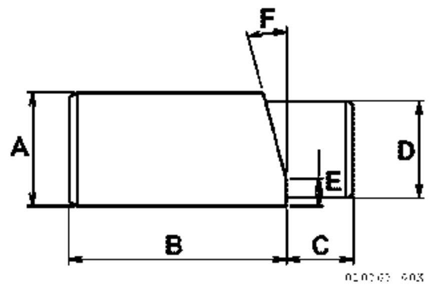
<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>3</td><td>Connecting rod small end bushing insertion/extraction tool for 4JH4-TE / 4JH4-HTE</td><td>


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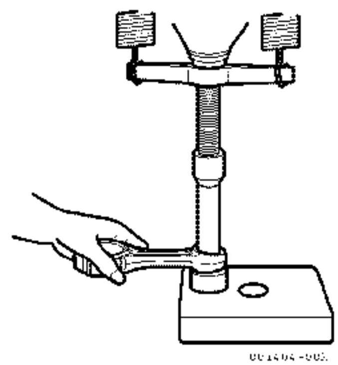
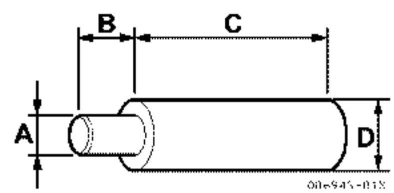
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>mm</td><td>28.4-28.7</td><td>80</td><td>20</td><td>27.4-27.7</td><td>8</td><td>8°</td></tr>
<tr><td>in.</td><td>1.118-1.130</td><td>3.15</td><td>0.79</td><td>1.079-1.091</td><td>0.315</td><td>8°</td></tr>
</table>
</td><td>Extraction

</td></tr>
<tr><td>4</td><td>Intake / exhaust valve guide insertion/extraction tool</td><td>


<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td>mm</td><td>7.5</td><td>20</td><td>75</td><td>11</td></tr>
<tr><td>in.</td><td>0.295</td><td>0.787</td><td>2.953</td><td>0.433</td></tr>
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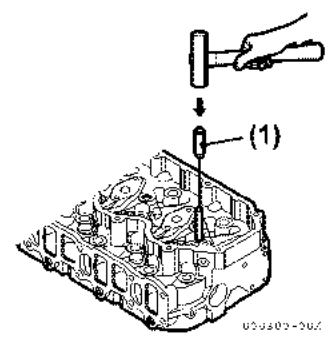
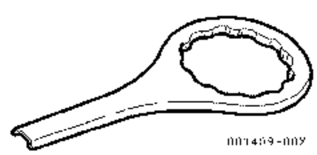
</td><td>


1 – Tool
</td></tr>
<tr><td>5</td><td>Lubricating oil filter case remover</td><td>

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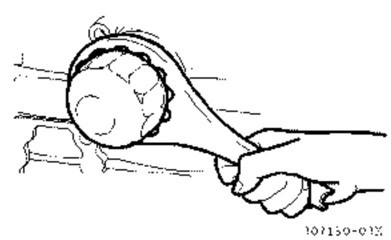
</td></tr>
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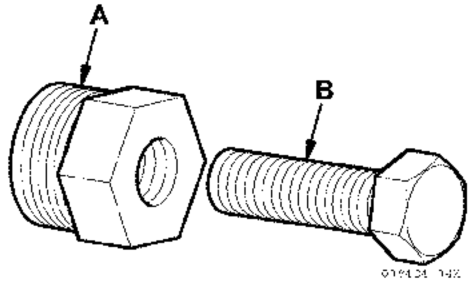
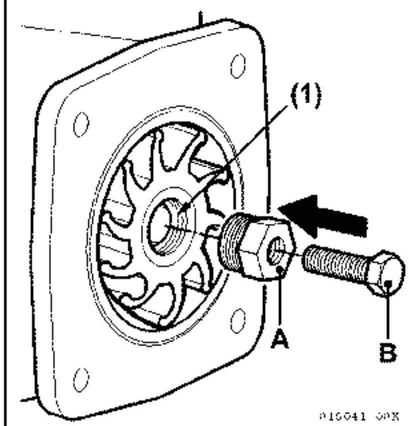
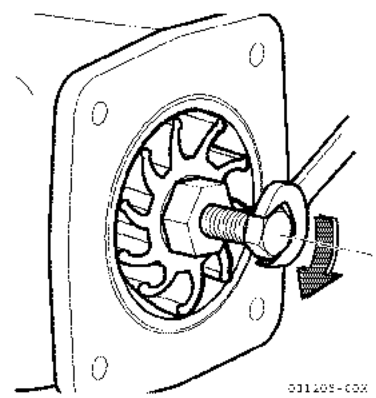
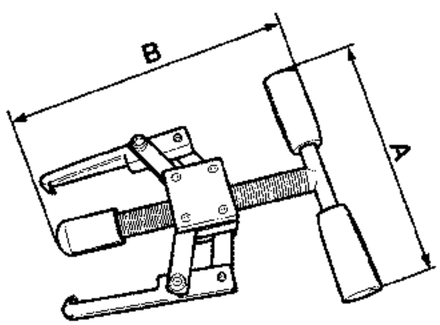
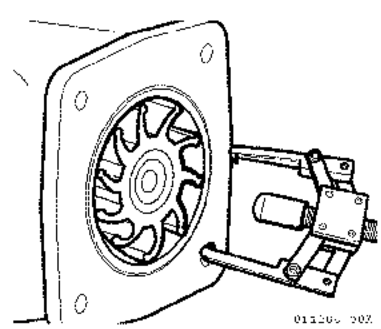
<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>6</td><td>Puller A (standard) for seawater pump impeller</td><td>Puller A: 129671-92110 (standard)


<table><tr><th>A</th><th>B</th></tr><tr><td>M18x1.5</td><td>M10-length 40 mm (1.57 in.)</td></tr></table></td><td>

1 – M18x1.5 Threaded
</td></tr>
<tr><td>7</td><td>Puller B (option) for seawater pump impeller</td><td>Puller B: 129671-92100 (option)


<table><tr><th>A</th><th>B</th></tr><tr><td>Around 110 mm (4.33 in.)</td><td>Around 140 mm (5.51 in.)</td></tr></table></td><td></td></tr>
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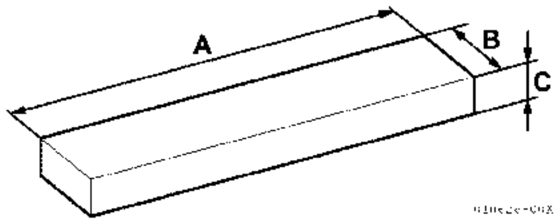
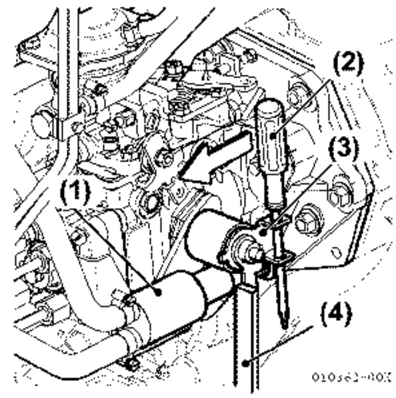
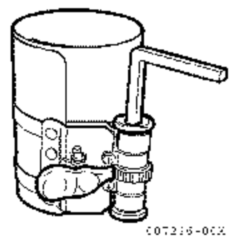
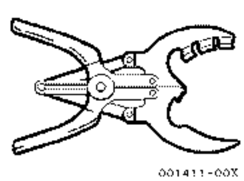
<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>8</td><td>C.S.D. cancel spacer for the adjustment of fuel injection timing</td><td>Spacer: 129671-51990

<table>
<tr><th>A</th><th>B</th><th>C</th></tr>
<tr><td>150 mm
(5.91 in.)</td><td>20 mm
(0.79 in.)</td><td>7.5 ± 0.1 mm
(0.30 ± 0.004 in.)</td></tr>
</table></td><td>
1 – Wax Pellet
2 – Screwdriver
3 – C.S.D. Lever
4 – Spacer</td></tr>
<tr><td>9</td><td>Piston ring compressor</td><td></td><td>-</td></tr>
<tr><td>10</td><td>Piston ring replacer (for removal / insertion of piston ring)</td><td></td><td>-</td></tr>
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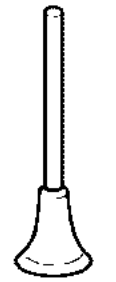
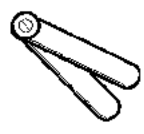
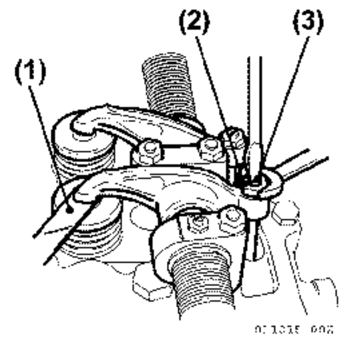
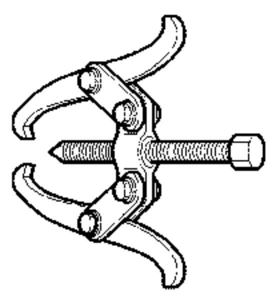
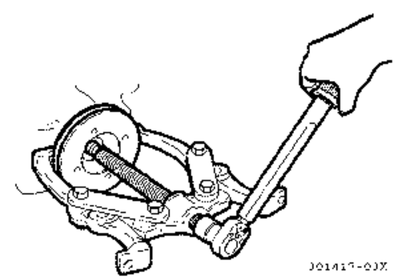
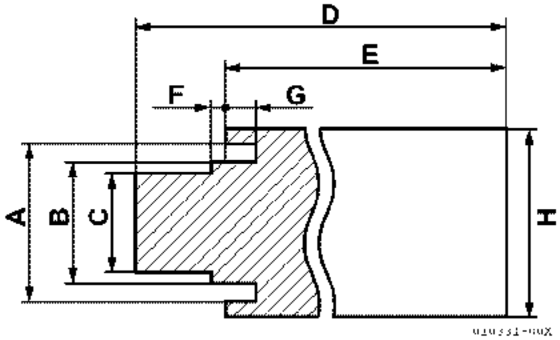
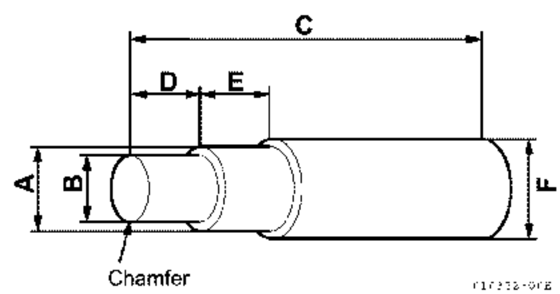
No.	Tool Name Applicable Model	Applicable Model and Tool Size	Illustration
11	Valve lapping tool (Rubber cap type)		
12	Valve lapping powder		
13	Feeler gauge		 **1 – Feeler Gauge** **2 – Locknut** **3 – Adjusting Bolt**
14	Pulley puller	Local supply 	Removing the coupling 

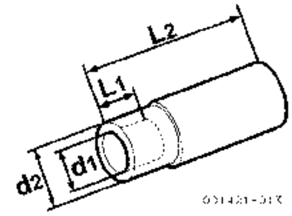
<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>15</td><td>Press tool 1 for filler neck</td><td>Tool 1

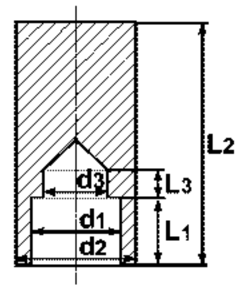


<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th><th>H</th></tr>
<tr><td>mm</td><td>ø35.5</td><td>ø27.5</td><td>ø25</td><td>105</td><td>89</td><td>1</td><td>2</td><td>ø40</td></tr>
<tr><td>in.</td><td>1.397</td><td>1.082</td><td>0.984</td><td>4.133</td><td>3.503</td><td>0.039</td><td>0.078</td><td>1.574</td></tr>
</table>
</td><td>-</td></tr>
<tr><td>16</td><td>Press tool 2 for filler neck copper tube</td><td>Tool 2



<table>
<tr><th></th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>mm</td><td>ø28</td><td>ø24.2</td><td>170</td><td>30</td><td>30</td><td>ø30</td></tr>
<tr><td>in.</td><td>1.102</td><td>0.952</td><td>6.692</td><td>1.181</td><td>1.181</td><td>1.181</td></tr>
</table>
</td><td>-</td></tr>
</table>

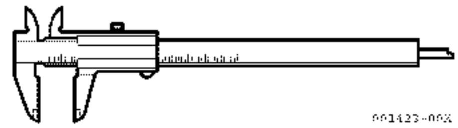
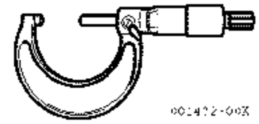
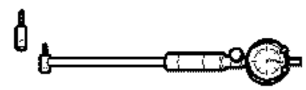
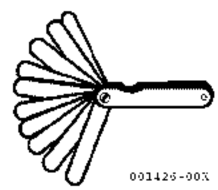
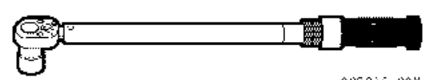
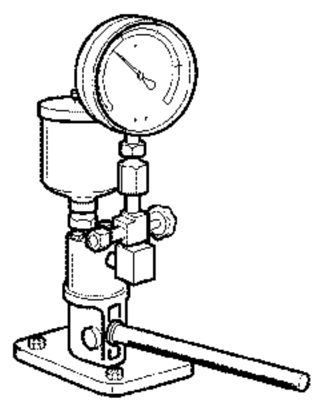
<table>
<tr><th>No.</th><th>Tool Name
Applicable Model</th><th>Applicable Model and Tool Size</th><th>Illustration</th></tr>
<tr><td>17</td><td>Stem seal insertion (for inserting stem seal)</td><td>


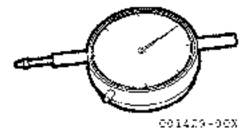
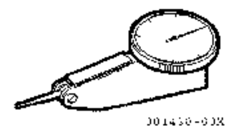
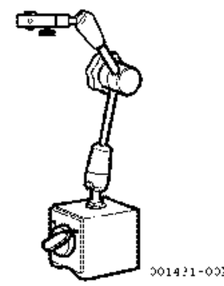
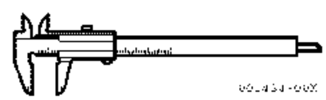
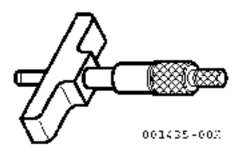


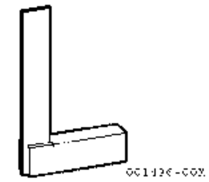
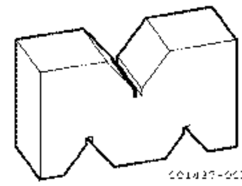
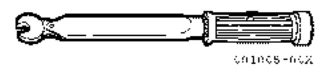
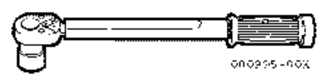
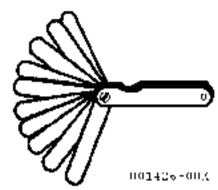
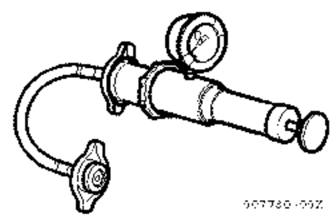
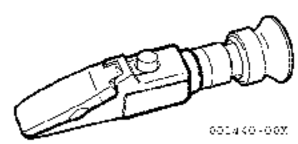
<table>
<tr><th></th><th>d1</th><th>d2</th><th>d3</th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>mm</td><td>16.2</td><td>22</td><td>13.5</td><td>18.8</td><td>65</td><td>4</td></tr>
<tr><td>in.</td><td>0.638</td><td>0.866</td><td>0.531</td><td>0.740</td><td>2.559</td><td>0.157</td></tr>
</table>
</td><td>-</td></tr>
<tr><td>18</td><td>Fuel nozzle extraction tool</td><td>

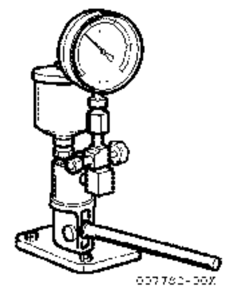
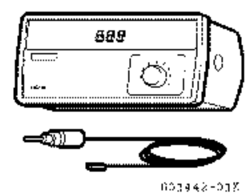
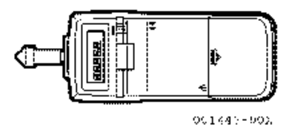
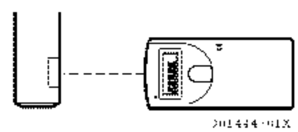
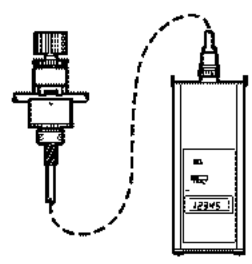
<table>
<tr><th>Part No.</th></tr>
<tr><td>129470-92300</td></tr>
</table>
</td><td>-</td></tr>
</table>

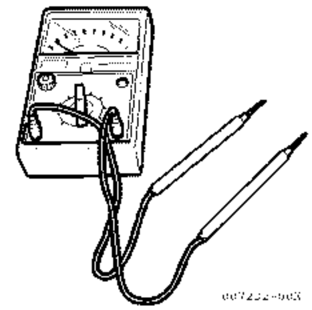
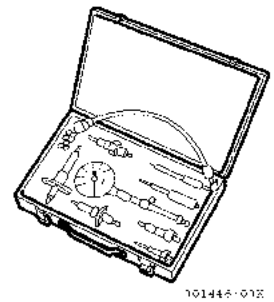
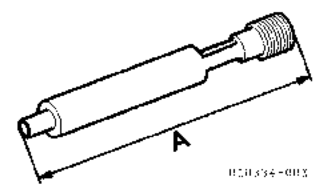
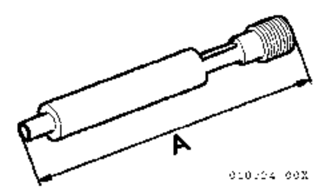
MEASURING INSTRUMENTS

No.	Name of tool	Use	Illustration
1	Vernier calipers	0.05 mm 0-150 mm	
2	Micrometer	0.01 mm 0-25 mm 25-50 mm 50-75 mm 75-100 mm 100-125 mm 125-150 mm Measures the outer diameter of the crankshaft, piston, piston pin, etc.	
3	Cylinder gauge	0.01 mm 18-35 mm 35-60 mm 50-100 mm Measures the inner diameter of the cylinder liner and rod metal.	
4	Thickness gauge	0.05-2 mm	
5	Torque wrench	128 N·m (0-13 kgf·m)	
6	Nozzle tester	0-49 Mpa (0-500 kgf/cm^2)	

No.	Name of tool	Use	Illustration
7	Dial gauge	Measures shaft bending, distortions of levelness, and gaps.	
8	Test indicator	Measures narrow and deep places, which cannot be measured with dial gauge.	
9	Magnetic stand	Keeps the dial gauge firmly in position, thereby permitting it to be used at various angles.	
10	Vernier calipers	Measures various outer diameter, thickness and width.	
11	Depth micrometer	Measures sinking of valves.	

No.	Name of tool	Use	Illustration
12	Square	Measures distortion in position of springs and perpendicularity of parts.	
13	V-block	Measures shaft distortion.	
14	Torque wrench	Used to tighten bolts and nuts to standard torque.	 
15	Thickness gauge	Measures the distance between the ring and ring groove, and between the shaft and shaft joint at time of assembling.	
16	Cap tester	Checks for leakage in the freshwater system.	
17	Battery current tester	Checks density of antifreeze and charging condition of battery fluid.	

No.	Name of tool		Use	Illustration
18	Nozzle tester		Checks the shape and pressure of spray emitted from the fuel injection valve at the time of injection.	
19	Digital thermostat		Measures temperature of various parts.	
20	Rotation gauge	Contact type	Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft.	
		Photoelectric type	Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft.	
		High-pressure fuel pipe clamp type	Measures rotation speed without reference to revolving shaft center or the exterior of the revolving shaft.	

No.	Name of tool	Use	Illustration
21	Circuit tester	Measure the resistance, voltage, and continuity of the electric circuit.	
22	Compression gauge	Measures the pressure of the compression. **Gauge Set Code No.** TOL-97190080	
		Adapter for direct injection 2-valve head. **Adapter Code No.** 119802-92950	 **A** 130 mm (5.12 in.)
		Adapter for direct injection 4-valve head. **Adapter Code No.** 129906-92950	 **A** 165 mm (6.50 in.)

SEALANTS AND COMPOUNDS

No.	Items		Usual Contents	Features and application
1	Liquid gasket	Three Bond No. 1 TB1101	200 g (1 kg also available)	Non-drying liquid gasket; solvent less type, easy to remove, superior in seawater resistance, applicable to various mating surfaces.
		Three Bond No. 2 TB1102	200 g (1 kg also available)	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance.
		Three Bond No. 3 TB1103	150 g	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts.
		Three Bond No. 4 TB1104	200 g (1 kg also available)	Semi-drying viscoelastic material, applicable to non-flat surface having many indentations and protrusions, superior in heat resistance, water resistance, and oil resistance.
		Three Bond No. 10 TB1211	100 g	Solvent-less type silicone-base sealant, applicable to high temperature areas. (-50 °C to 250)
		Three Bond TB1212	100 g	Silicone-base, non-fluid type, thick application possible.
2	Adhesive	Three Bond TB1401	200 g	Prevention of loose bolts, gas leakage, and corrosion. Torque required to loosen bolt: 10 to 20% larger than tightening torque.
		Locktite SUPER TB1324	50 g	Excellent adhesive strength locks bolt semi-permanently.
3	Seal tape		5 m round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: -150° to 200°C (-238° to 392°F)
4	O-ring kit		Ø1.9 x 2 m: 1 Ø2.4 x 2 m: 1 Ø3.1 x 2 m: 1 Ø3.5 x 2 m: 1 Ø5.7 x 2 m: 1	O-ring of any size can be prepared, whenever required. (Including adhesive, release agent, cutter, and jig)
5	EP lubricant (molybdenum disulfate)	Brand name (LOWCOL PASTE)	50 g	For assembly of engine cylinders, pistons, metals shafts, etc. Spray type facilitates application work.
		Brand name (PASTE SPRAY)	330 g	
		Brand name (MOLYPASTE)	50 g	Prevention of seizure of threaded parts at high temperature. Applicable to intake / exhaust valves (stem, guide, face).

No.	Items		Usual Contents	Features and application
5	Scale solvent	Scale solvent	1 box (4 kg x 4 removers)	• The scale solvent removes scale in a short time (1-10 hours). • Prepare water (seawater if possible) in an amount about 10 times the weight of the solvent. Mix the solvent with water. • Just dipping disassembled part into removes scale. To shorten removal time, stir remover mixture. • If cleaning performance drops, replace remover mixture with new remover mixture. • Neutralize used mixture, and then dispose of it. To judge cleaning performance of mixture, put pH test paper into mixture. If test paper turns red, remover mixture is still effective.
		Neutralizer (caustic soda)	1 box (2 kg x 4 neutralizers)	
		pH test paper	-	
6	Antifreeze		-	Add antirust to freshwater system at the cold area to engine operate.
7	Cleaning agent		-	• The cleaning agent removes even carbon adhering to disassembled parts. • If a cleaning machine is used, prepare 4-6% mixture at 60°-80°C (140°-176°) to ensure more effective cleaning.
8	Cleaning agent for turbocharger		4 L x 4	Special cleaning agent that requires no water, specially designed for blower of turbocharger and intercooler.
			18 L x 1	
			15 sets: 1, 500cc x 6	

NOTICE: It is recommended that liquid gasket Three Bond® TB1212 be used for service work. Before providing service, observe the cautions below:

1. Build up each sealant bead equally.
2. For bolt holes, apply liquid gasket to the inside surface of each hole.
3. Three Bond® TB1104 (Gray) or Three Bond® TB1102 (Yellow) is used with a gasket. The use of either of these sealant bonds without a gasket alone is not effective.
4. If a gasket is used, do not use sealant TB1212 **(Figure 5-1)**.

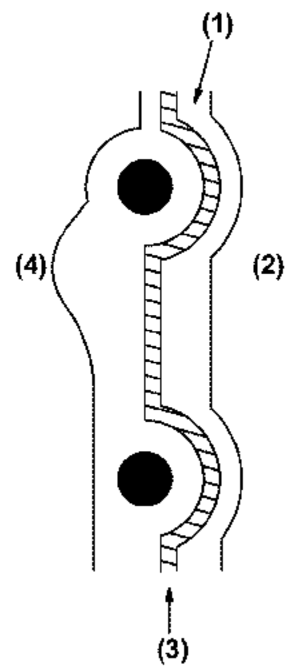


Figure 5-1

1 – Oil Pan Mating Surface
2 – Inside of Oil Pan
3 – Bead of TB1212
4 – Outside

TESTS AND ADJUSTMENTS

Test Compression

The compression tester is used to quickly and simply check wear and damage primarily to the cylinder head valves, but also to cylinders and piston rings.

The results are intended only for comparison between the cylinders. Lower compression in one or more of the cylinders is a sign of abnormal wear or damage. *NOTICE: The battery must have an adequate charge in order to carry out a reliable compression test. If necessary, connect an additional battery.*

1. Turn engine over several times using the starter motor to remove any loose debris in the cylinders.
2. Turn engine with the starter motor until reading on gauge stabilizes. Note the reading on the gauge.
3. Reset gauge and repeat procedure with the remaining cylinders.
4. Evaluate readings and assess if engine repair is necessary. If one or more cylinders have a lower compression pressure, components such as valves, cylinders and piston rings should be inspected. awaiting test specs.

Specification

Item	Cylinder Compression Pressure
3JH5E 4JH5E 4JH4-TE	3.4 ± 0.1 MPa (493 ± 14.5 psi)
4JH4-HTE	3.2 ± 0.1 MPa (464 ± 14.5 psi)

DISASSEMBLY

If the engine is to be completely disassembled, perform the following preliminary steps:

1. Disconnect battery cables at the battery. Always disconnect negative (-) battery cable first.
2. Close all valves in fuel supply line.
3. Remove electrical connections, intake / exhaust system connections, and fuel supply lines from engine. Cap or plug all open fuel connections.
4. Drain engine coolant.
   (a) Open the seawater drain cock(s) to drain the seawater.

Note: Open the drain cock on the clutch cooler for 4JH5E, 4JH4-TE and 4JH4-HTE.

   (b) Open the three cocks for freshwater and drain the freshwater.

Note: Only one drain cock is behind the belt cover for 3JH5E and 4JH5E. Remove the belt cover and open the drain cock.

Model	Drain Cocks in Freshwater line	Drain Cocks in Seawater line
3JH5E / 4JH5E	2 cocks	2 places (1 cock and a side cover of seawater pump) **(Figure 5-2)**, **(Figure 5-3)**, **(Figure 5-4)**, **(Figure 5-5)**
4JH4-TE/ 4JH4-HTE	3 cocks	3 places (1 cock, a side cover of seawater pump and 1 cock on marine gear cooler)* **(Figure 5-6)**, **(Figure 5-7)**, **(Figure 5-8)**, **(Figure 5-9)**

* *The marine gear coolers with a drain cock are as follows: 4JH5E: ZF30M, KM4A1*

3JH5E Engine

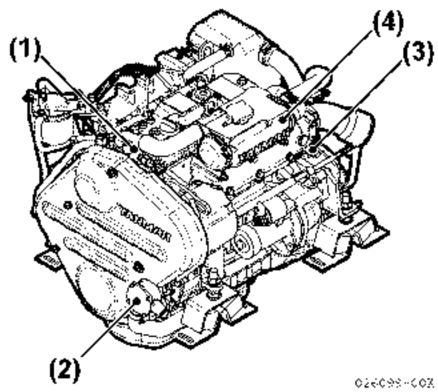


Figure 5-2

1 – Coolant Pump
2 – Seawater Drain from Seawater Pump Cover
3 – Coolant Drain Cock
4 – Coolant Tank (heat exchanger)

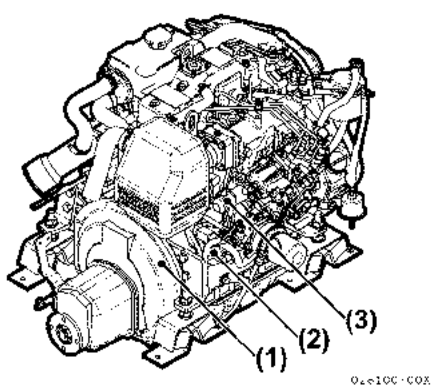


Figure 5-3

1 – Flywheel Housing
2 – Coolant Drain Cock
3 – Stop Solenoid

4JH5E Engine

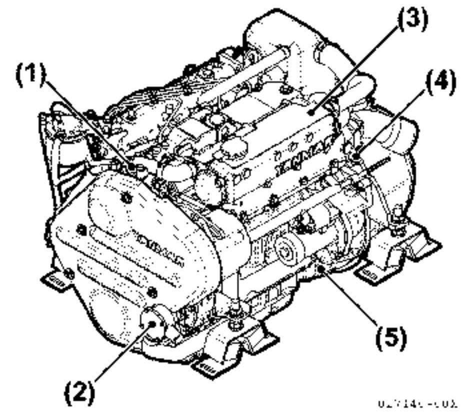


Figure 5-4

1 – Coolant Pump
2 – Seawater Drain from Seawater Pump Cover
3 – Coolant Tank (heat exchanger)
4 – Coolant Drain Cock
5 – Flywheel Housing

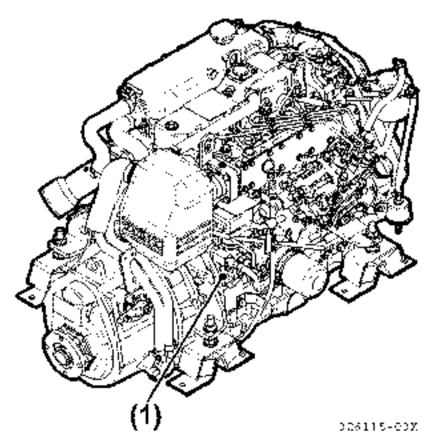


Figure 5-5

1 – Coolant Drain Cock

4JH4-TE Engine

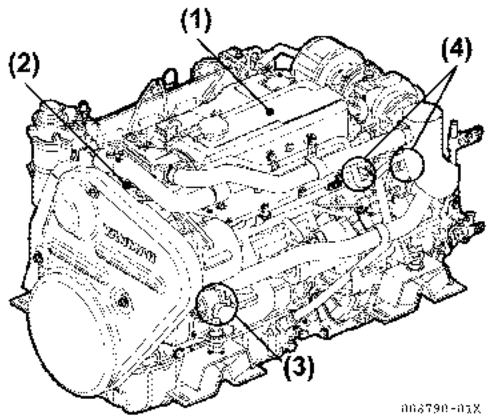


Figure 5-6

1 – Coolant Tank (heat exchanger)
2 – Coolant Pump (freshwater)
3 – Seawater Drain from Seawater Pump Cover
4 – Coolant Drain Cock (2 used)

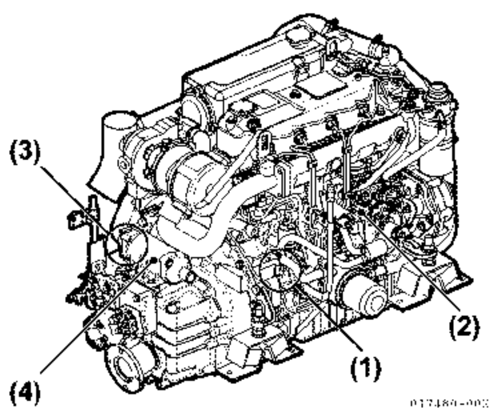


Figure 5-7

1 – Coolant Drain Cock
2 – Fuel Pump
3 – Seawater Drain Cock
4 – Marine Gear Cooler

4JH4-HTE Engine

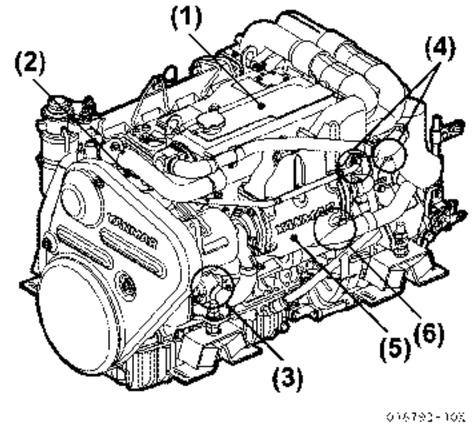


Figure 5-8

1 – Coolant Tank (heat exchanger)
2 – Coolant Pump (freshwater)
3 – Seawater Drain from Seawater Pump Cover
4 – Coolant Drain Cock
5 – Intercooler
6 – Seawater Drain from Heat Exchanger

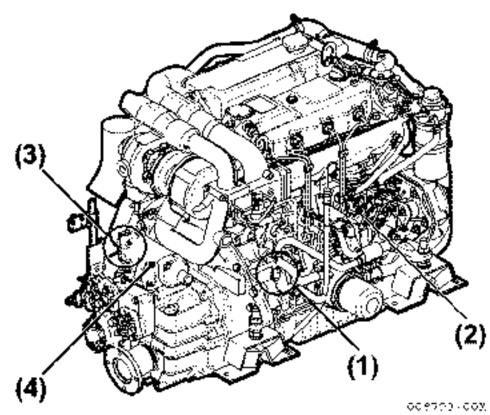


Figure 5-9

1 – Coolant Drain Cock
2 – Fuel Pump
3 – Seawater Drain Cock
4 – Marine Gear Cooler

5. Remove the engine from the boat. Mount the engine to a suitable engine repair stand having adequate weight capacity.
6. Cap or plug all openings to prevent contamination.
7. Remove the starting motor from the flywheel housing **(Figure 5-10)**.

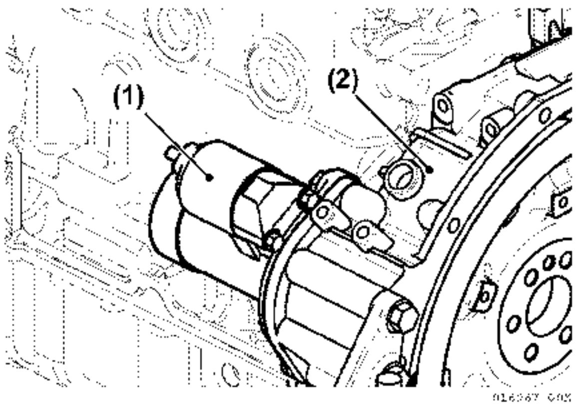


Figure 5-10

1 – Starting Motor
2 – Flywheel Housing

8. Loosen the alternator adjuster bolt and remove the V-belt.
9. Remove the adjuster from the freshwater pump, and remove the alternator from the gear case (with spacer) **(Figure 5-11)**.

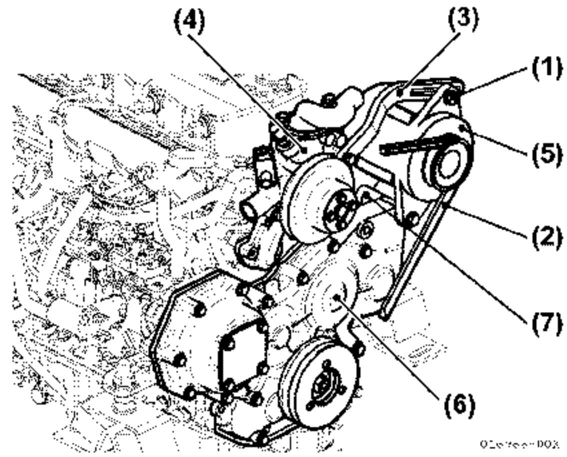


Figure 5-11

1 – Alternator Adjust Bolt
2 – V-belt
3 – Adjuster
4 – Freshwater Pump
5 – Alternator
6 – Gear Case
7 – With Distance Piece

10. Clean engine by washing with solvent, air or steam cleaning. *NOTICE: Ensure foreign matter or fluids do not contaminate the engine, fuel system or electrical components.*
11. Remove the fuel pipes (fuel filter-fuel feed pump, fuel filter-fuel injection pump and fuel nozzle-fuel filter).
12. Remove the fuel filter **(Figure 5-12, (2))** and **(Figure 5-13)**.

4JH5E Engine Shown

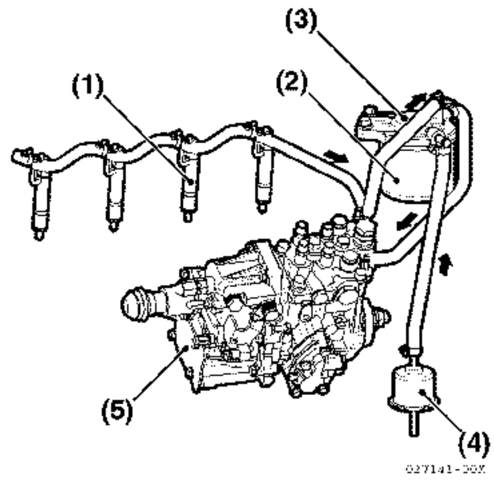


Figure 5-12

1 – **Fuel Injector**
2 – **Fuel Filter**
3 – **Header (fuel filter)**
4 – **Electric Fuel Feed Pump**
5 – **Fuel Injection Pump**

4JH4-TE and 4JH4-HTE Engines Shown

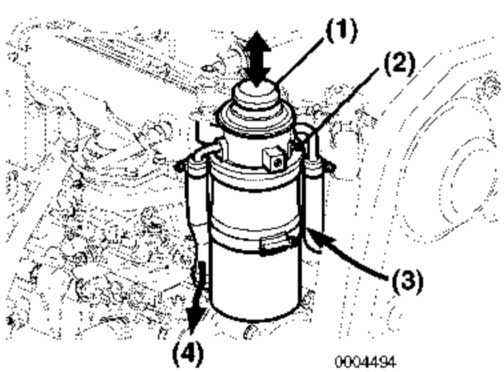


Figure 5-13

1 – **Priming Pump**
2 – **Air Bleed Screw**
3 – **From Fuel Tank**
4 – **To Fuel Injection Pump**

13. Remove the breather hose attached to the intake silencer.
14. Remove the intake silencer.

3JH5E and 4JH5E Engines Shown

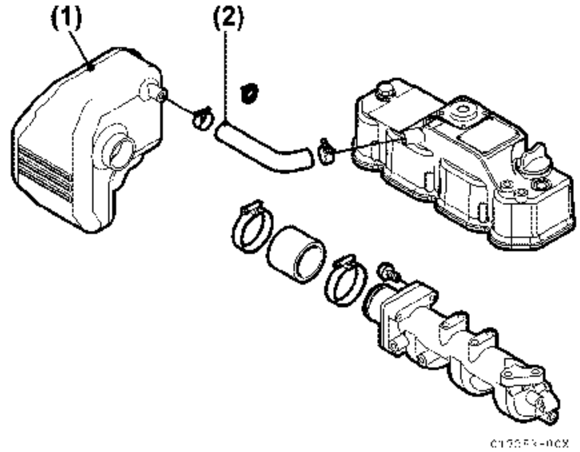


Figure 5-14

1 – **Intake Silencer**
2 – **Breather Hose**

4JH4-TE Engine Shown (4JH4-HTE Engine is Similar)

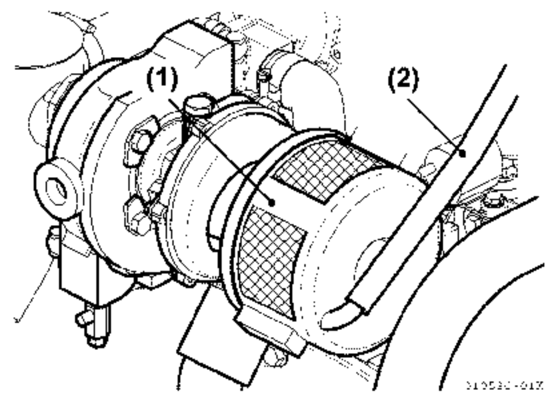


Figure 5-15

1 – **Intake Silencer**
2 – **Breather Hose**

15. Remove cooling system components from engine.
16. Remove the seawater hose connecting the heat exchanger and the mixing elbow.

17. Remove the mixing elbow from the exhaust manifold for 3JH5E and 4JH5E **(Figure 5-16)** or from the turbocharger for 4JH4-TE and 4JH4-HTE **(Figure 5-17)**.

3JH5E and 4JH5E Engines Shown

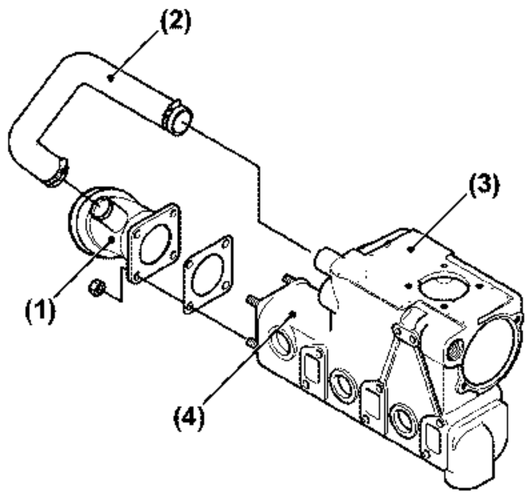


Figure 5-16

1 – Mixing Elbow
2 – Rubber Hose
3 – Heat Exchanger
4 – Exhaust Manifold

4JH4-TE and 4JH4HTE Engines Shown

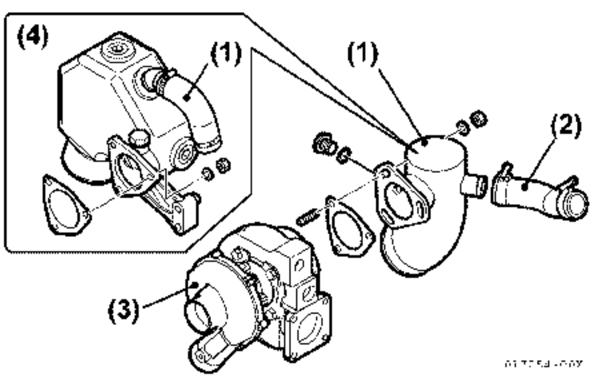


Figure 5-17

1 – Mixing Elbow
2 – Rubber Hose
3 – Turbocharger
4 – Option

18. Remove the turbocharger (only for 4JH4-TE and 4JH4-HTE):

(a) Remove the intake pipes (turbine, intercooler, intake manifold) **(Figure 5-18)** and **(Figure 5-19)**.

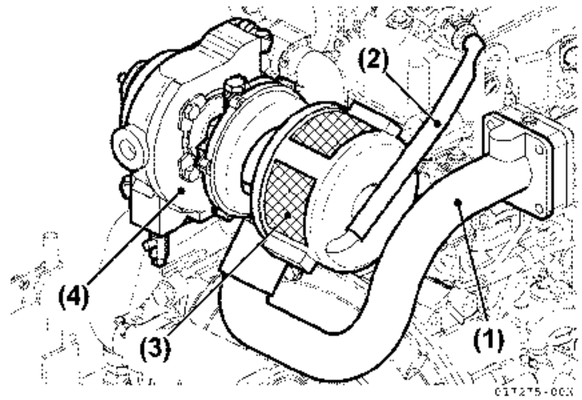


Figure 5-18

1 – Intake Pipe
2 – Rubber Hose for Breather
3 – Intake Silencer
4 – Turbocharger

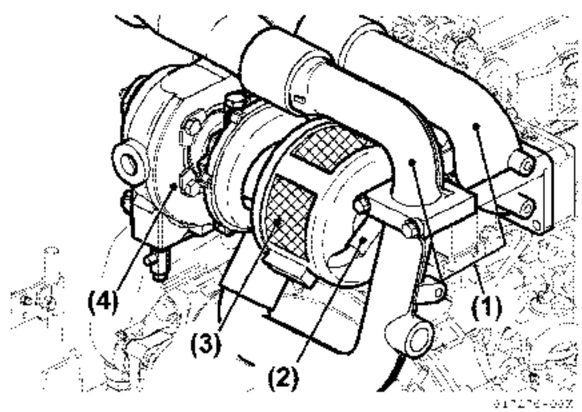


Figure 5-19

1 – Intake Pipe
2 – Rubber Hose for Breather
3 – Intake Silencer
4 – Turbocharger

(b) Remove the lubricating oil line from the turbine.

(c) Remove the oil return line from turbine **(Figure 5-20)**.

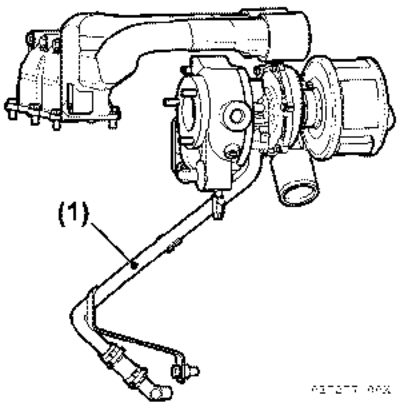


Figure 5-20

1 – Oil Return Line

(d) Remove the turbine.

19. Remove the intercooler (only for 4JH4-HTE) **(Figure 5-21)**:
    (a) Remove the seawater hoses (Heat exchanger, intercooler, lubricating oil cooler).
    (b) Remove the intercooler.

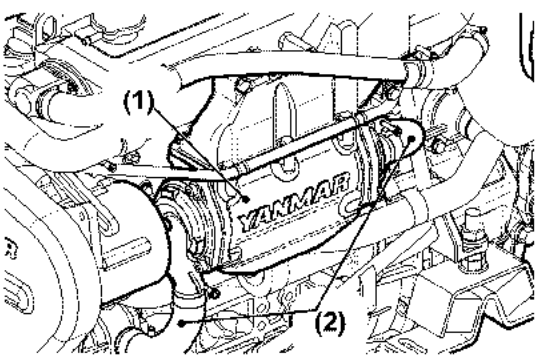


Figure 5-21

1 – Intercooler
2 – Seawater Hose

20. Remove the coolant pipe (seawater / freshwater) **(Figure 5-22)** through **(Figure 5-25)**:
    (a) Remove the seawater pipe (seawater pump, heat exchanger).
    (b) Remove the freshwater pipe (freshwater pump, heat exchanger, exhaust manifold, freshwater pump).
    (c) Remove the freshwater pipe (cylinder block, lubricating oil cooler, lubricating oil cooler, freshwater pump).

3JH5E and 4JH5E Freshwater System

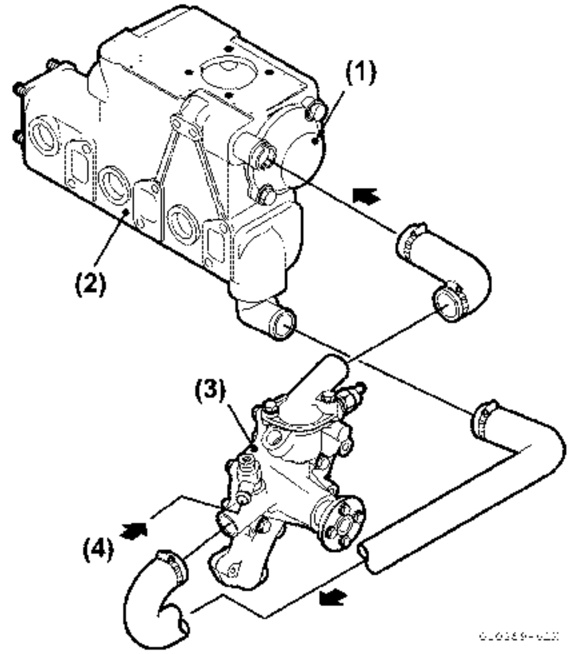


Figure 5-22

1 – Heat Exchanger
2 – Exhaust Manifold
3 – Freshwater Pump
4 – From Lubricating Oil Cooler

3JH5E and 4JH5E Seawater System

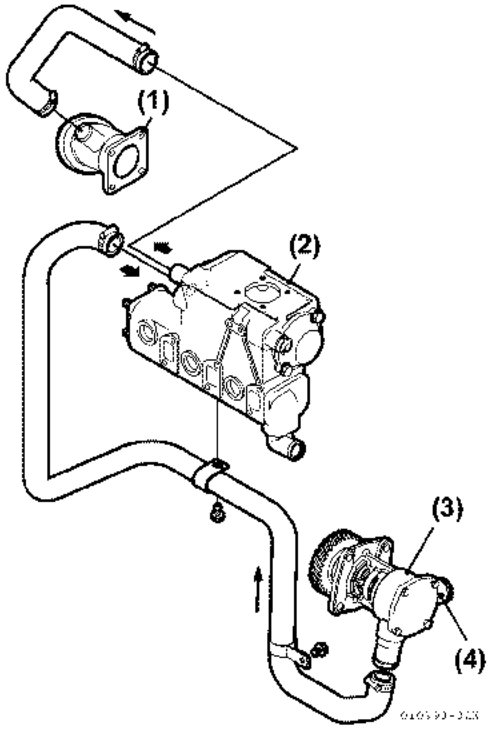


Figure 5-23

1 – Mixing Elbow
2 – Heat Exchanger
3 – Seawater Pump
4 – Seawater Inlet

4JH4-TE and 4JH4-HTE Freshwater System

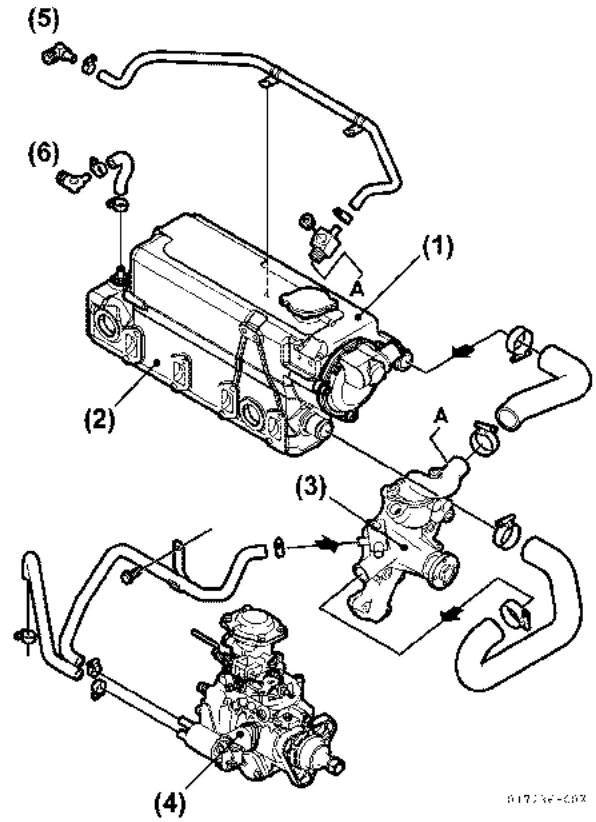


Figure 5-24

1 – Heat Exchanger
2 – Exhaust Manifold
3 – Freshwater Pump
4 – Fuel Injection Pump
5 – Turbocharger Freshwater Inlet
6 – Turbocharger Freshwater Outlet

4JH4-TE and 4JH4-HTE Seawater System

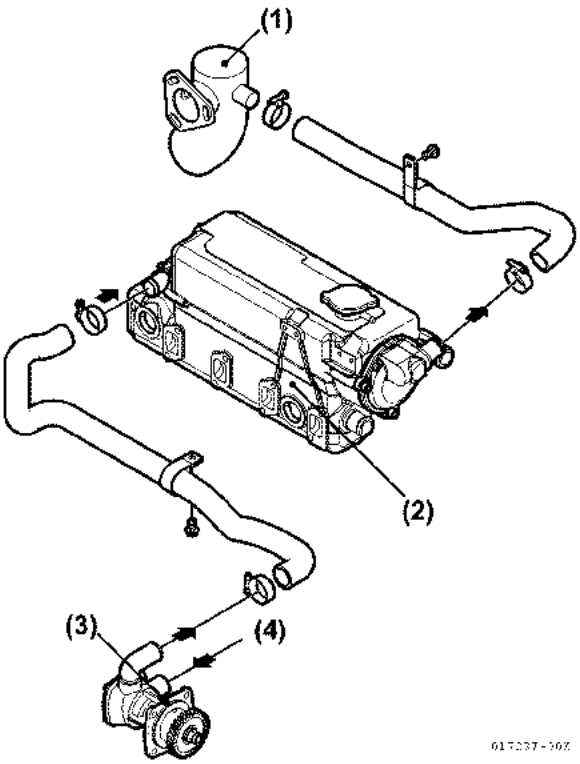


Figure 5-25

1 – Mixing Elbow
2 – Heat Exchanger
3 – Seawater Pump
4 – Seawater Inlet

21. Remove the heat exchanger and gasket packing **(Figure 5-25)**.
22. Remove the seawater pump from the gear case **(Figure 5-26)** and **(Figure 5-27)**.

3JH5E and 4JH5E Engines

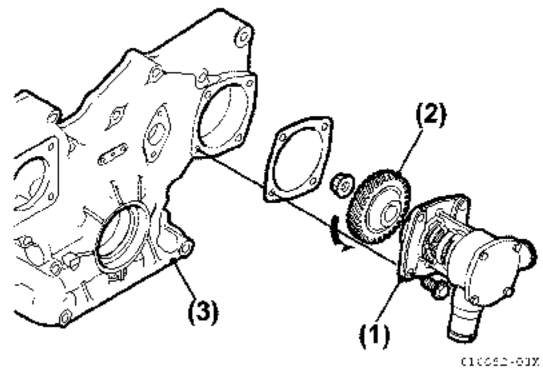


Figure 5-26

1 – Seawater Pump
2 – Pump Drive Gear
3 – Gear Case

4JH4-TE and 4JH4-HTE Engines

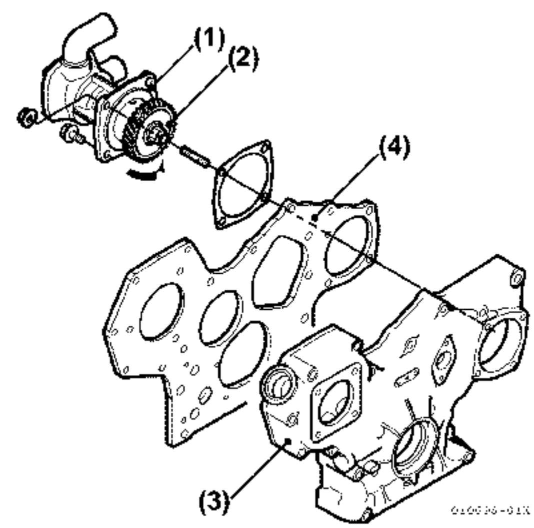


Figure 5-27

1 – Seawater Pump
2 – Pump Drive Gear
3 – Gear Case Cover
4 – Gear Case

23. Remove the lubricating oil filter **(Figure 5-28)**.

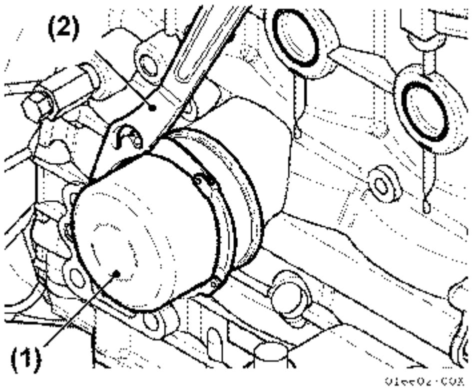


Figure 5-28

1 – Lubricating Oil Filter
2 – Filter Wrench

24. The lubricating oil cooler is located between the lubricating oil filter and the oil filter bracket, which is mounted on the cylinder block. The lubricating oil is cooled by fresh water **(Figure 5-29)**:
    (a) Remove the freshwater pipe (cylinder block, lubricating oil cooler, lubricating oil cooler outlet).
    (b) Remove the lubricating oil filter from the lubricating oil cooler. *NOTICE: Do not use an adjustable wrench or other open-end tool as there is a risk of damaging the filter.*

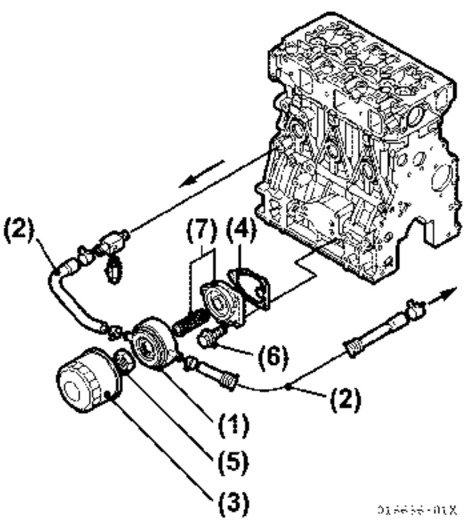


Figure 5-29

1 – Lubricating Oil Cooler
2 – Freshwater Pipes
3 – Lubricating Oil Filter
4 – Gasket
5 – Lubricating Oil Cooler Nut
6 – Bolt for Filter Bracket
7 – Filter Bracket

    (c) Remove the lubricating oil cooler nut and lubricating oil cooler.
    (d) Loosen the bolts for the filter bracket and remove the filter bracket.

25. Remove the lubricating oil dipstick and guide **(Figure 5-30)**.

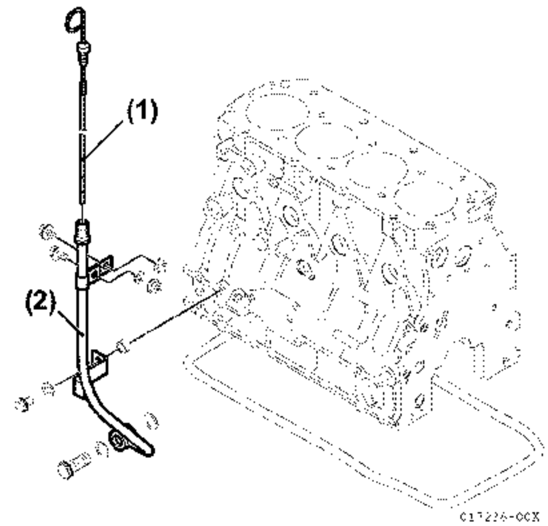


Figure 5-30

1 – Lubricating Oil Level Gauge
2 – Dipstick Guide

26. Drain engine oil into a suitable container. *NOTICE: ALWAYS be environmentally responsible.*
    (a) Remove the pipe coupling bolt, which holds the lubricating oil dipstick guide, and drain the lubricating oil from the engine.

Note: For easier draining, remove the oil filler cap (yellow) at the top of the rocker arm cover.

3JH5E and 4JH5E:
If the oil filler cap is installed while draining the oil, the oil cap rubber diaphragm may be damaged due to a vacuum being created while draining.

    (b) Remove the drain plug on the lower part of the case and drain the lubricating oil from the marine gearbox.

Note: When using a lubricating oil supply / discharge pump, place the intake hose in the dipstick guide for the engine or in the oil hole on top of the marine gear case.

3JH5E Engine Shown

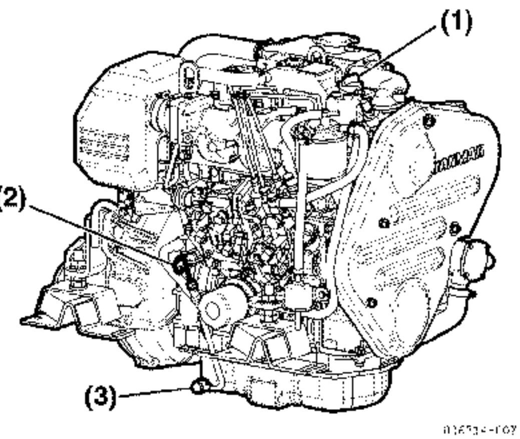


Figure 5-31

1 – **Oil Filler Cap**
2 – **Lubricating Oil Dipstick**
3 – **Drain Plug**

27. Remove the fuel injection line **(Figure 5-32)** through **(Figure 5-34)**:
    (a) Remove the fuel injection line retainer.
    (b) Loosen the cap nuts on both ends of the fuel injection line and remove fuel injection line.
    (c) Remove the fuel return line.

3JH5E Engine Shown

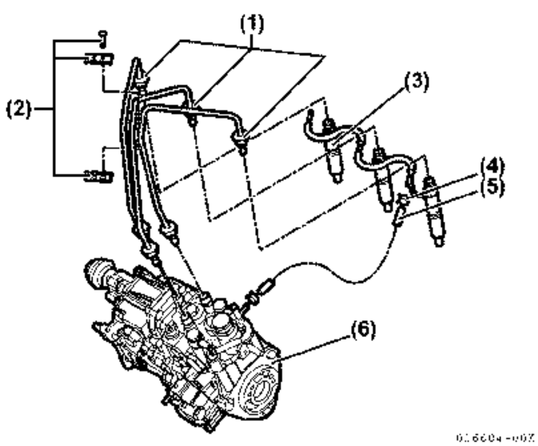


Figure 5-32

1 – **Fuel Injection Line**
2 – **Fuel Injection Line Retainer**
3 – **Fuel Injection Nozzle**
4 – **Clamp**
5 – **Fuel Return Line**
6 – **Fuel Injection Pump**

4JH5E Engine Shown

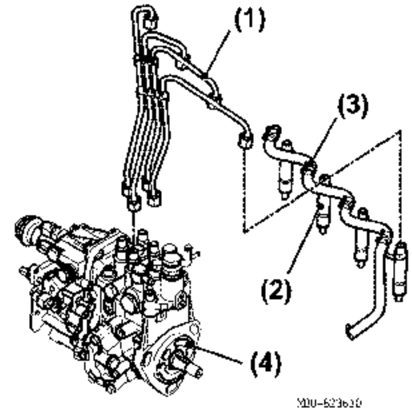


Figure 5-33

1 – **Fuel Injection Line**
2 – **Fuel Injection Nozzle**
3 – **Fuel Return Line**
4 – **Fuel Injection Pump**

4JH4-TE / 4JH4-HTE Engines Shown

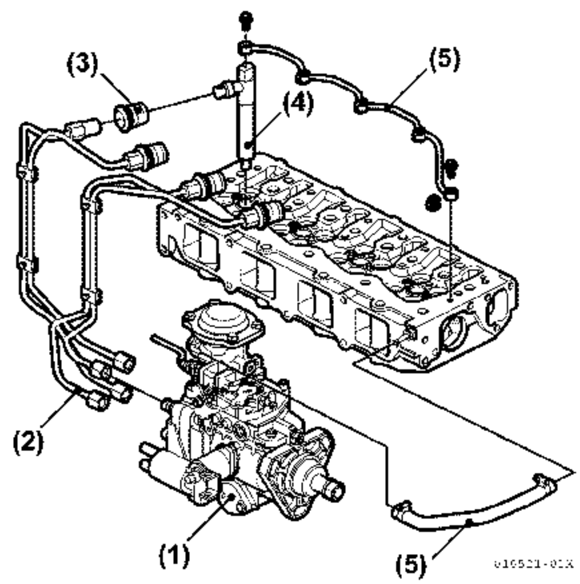


Figure 5-34

1 – **Fuel Injection Pump**
2 – **Fuel Injection Line**
3 – **Line Seal**
4 – **Fuel Injection Nozzle**
5 – **Fuel Return Line**

28. Remove the intake manifold and gasket.
29. Remove the freshwater pump and gasket from the cylinder head **(Figure 5-35)**.

3JH5E Engine Shown

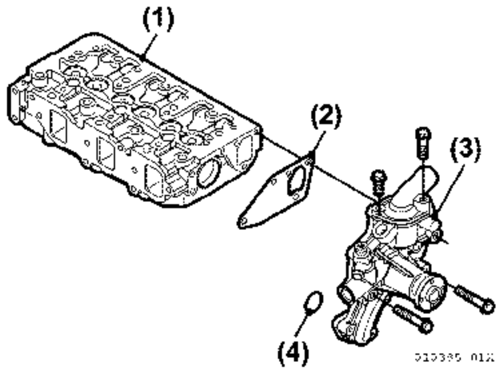


Figure 5-35

1 – Cylinder Head
2 – Gasket
3 – Freshwater Pump
4 – O-Ring

30. Remove the fuel injection nozzles:

    3JH5E and 4JH5E (2-valve head)
    Remove the bolt for the fuel nozzle retainer, and pull out the fuel nozzle retainer and fuel injection nozzle **(Figure 5-36)**.

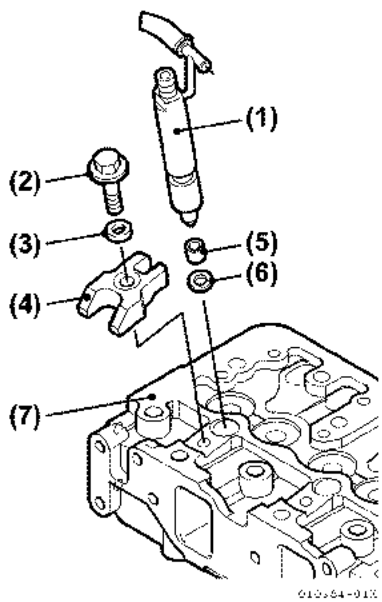


Figure 5-36

1 – Fuel Injection Nozzle
2 – Bolt
3 – Washer
4 – Fuel Nozzle Retainer
5 – Fuel Nozzle Protector
6 – Fuel Injection Seat
7 – Cylinder Head

Note: If the fuel nozzle protector stays in the cylinder head, make a note of the cylinder number and be sure to remove it when disassembling the cylinder head.

4JH4-TE and 4JH4-HTE (4-valve head)

(a) Remove the pipe seals from rocker arm cover. Insert a flat-bladed screwdriver into the slotted part of the rocker arm cover and remove it. Remove the rocker arm cover after removing the pipe seals **(Figure 5-37)**.

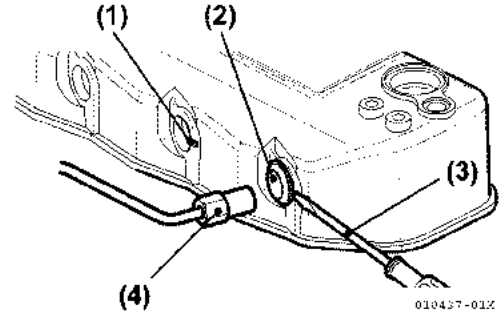


Figure 5-37

1 – Slit
2 – Line Seal
3 – Screwdriver
4 – Cap Nut of Fuel Injection Line

NOTICE: The fuel nozzles are held captive by the pipe seals. The pipe seals will be damaged if the rocker arm cover is removed with a pipe seal attached to the rocker arm cover.

(b) Loosen the bolts on the fuel injection nozzle retainers and extract the fuel injection nozzles **(Figure 5-38)**.

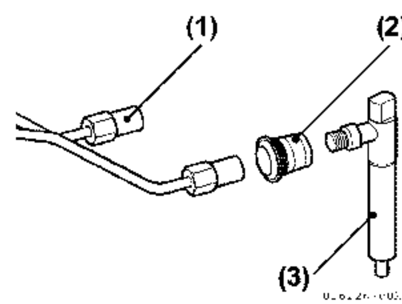


Figure 5-38

1 – Cap Nut of Fuel Injection Line
2 – Line Seal
3 – Fuel Injection Nozzle

Note:

- If nozzle seat is left in the cylinder head, extract the nozzle seat after removing the cylinder head from cylinder block.
- When extracting a fuel injection nozzle, replace the used nozzle protector with a new one.

31. Remove the fuel injection pump:
    (a) Loosen the nut on the fuel pump drive gear, and pull out the fuel pump drive gear with an extraction tool.

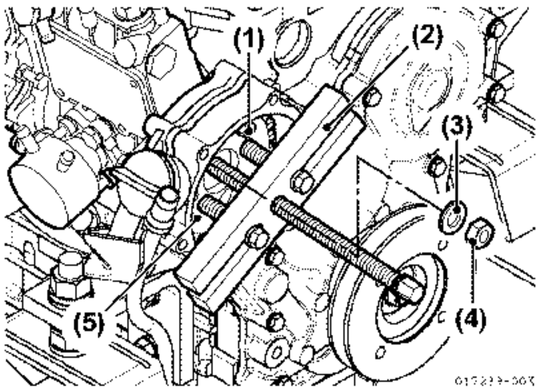


Figure 5-39

1 – Pump Flange Bolt
2 – Extraction Tool
3 – Spring Washer
4 – Pump Drive Gear Nut
5 – Fuel Pump Drive Gear

    (b) Remove the fuel injection pump and O-ring from the gear case flange (3JH4E and 4JH4AE).
    (c) Remove the fuel injection pump and O-ring from the VE pump bracket, which is fixed to the gear case flange (4JH4-TE and 4JH4-HTE).

3JH5E Engine Shown

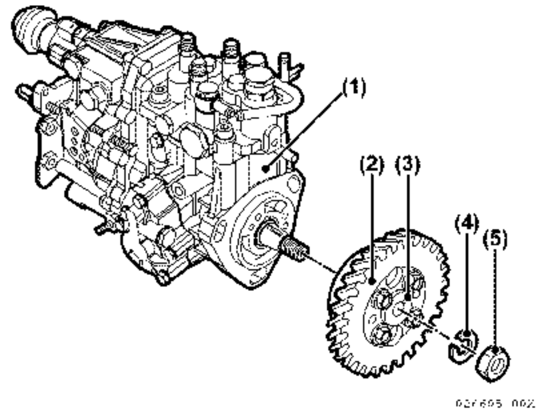


Figure 5-40

1 – Fuel Injection Pump
2 – Fuel Pump Drive Gear
3 – Pump Flange Bolt
4 – Spring Washer
5 – Pump Drive Gear Nut

NOTICE: Never disassemble pump drive gear and fuel pump flange.

32. Remove the rocker arm shaft assembly:
    (a) Remove the rocker arm cover.
    (b) Remove the bolts for the rocker arm shaft support, and remove the entire rocker arm shaft assembly.
    (c) Pull out the push rods.
33. Remove the cylinder head:

    Loosen the cylinder head bolts with a torque wrench, and remove the cylinder head.

Note:

(a) Loosen the cylinder head bolts in two steps in the illustrated order **(Figure 5-41)** and **(Figure 5-42)**.

(b) Place the cylinder head on cardboard to prevent the combustion surface from being damaged.

(c) Remove the cylinder head gasket.

3-Cylinder Head Bolt Disassembly Order

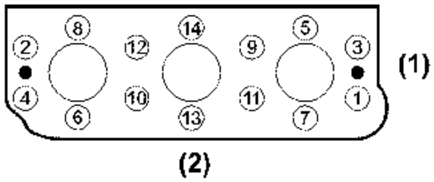


Figure 5-41

1 – **Gear Case Side**
2 – **Fuel Injection Pump Side**

4-Cylinder Head Bolt Disassembly Order

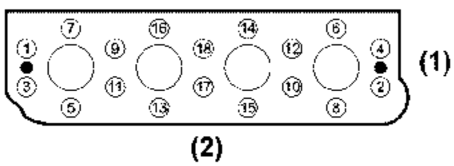


Figure 5-42

1 – **Gear Case Side**
2 – **Fuel Injection Pump Side**

34. Loosen the bolts for the clutch case flange, and remove the marine gear.
35. Loosen the flywheel bolts and remove the flywheel **(Figure 5-43)**.

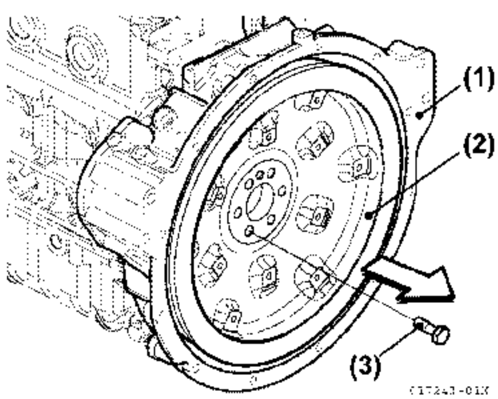


Figure 5-43

1 – **Flywheel Housing**
2 – **Flywheel**
3 – **Flywheel Bolts**

Note: Be careful not to scratch the ring gear. Loosen some of the bolts on the flywheel housing which attach to the oil pan spacer in preparation for the next disassembly step.

36. Turn the engine over:
    (a) Place a wood block of appropriate size on the floor, and stand the engine on the flywheel housing **(Figure 5-44)**.

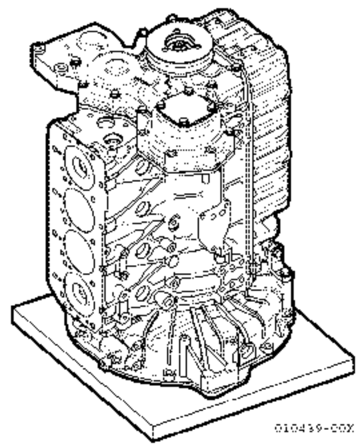


Figure 5-44

    (b) Remove the engine mounting feet.

37. Loosen the nut holding the crankshaft V-pulley and remove the crankshaft V-pulley **(Figure 5-45, (1))** with an extraction tool. When loosening the nut holding the V-pulley, be sure to use the correct tool to prevent rotation of the crankshaft.

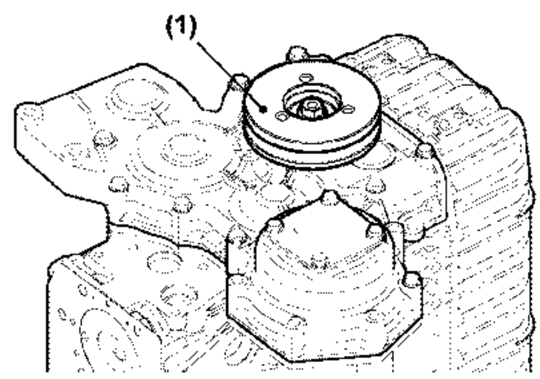


Figure 5-45

1 – **Crankshaft V-Pulley**

38. Remove the oil pan and spacer **(Figure 5-46)**.

Note: Some bolts of flywheel housing side should be loosened before removing the spacer.

3JH5E Engine Shown (4JH5E Engine is Similar)

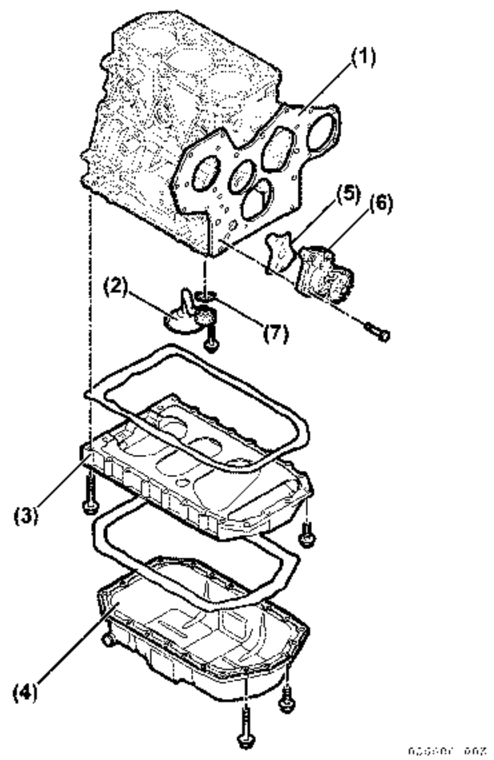


Figure 5-46

1 – **Gear Case**
2 – **Lubricating Oil Inlet Line**
3 – **Oil Pan Spacer**
4 – **Oil Pan**
5 – **Oil Pump Assembly**
6 – **Gasket**
7 – **Gasket**

39. Remove the lubricating oil inlet line **(Figure 5-46, (2))** and gasket **(Figure 5-46, (7))**.
40. Loosen the bolts, and remove the gear case cover from the gear case.
41. Remove the lubricating oil pump from the gear case flange **(Figure 5-47)**.

4JH4-TE and 4JH4-HTE Engines Shown

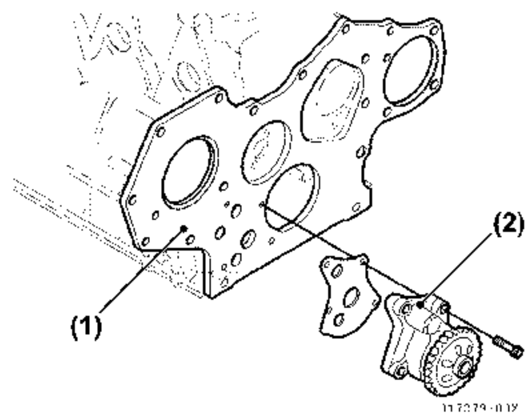


Figure 5-47

1 – **Gear Case**
2 – **Lubricating Oil Pump**

42. Loosen the three bolts holding the idle gear and pull out the idler gear and shaft **(Figure 5-48)**.

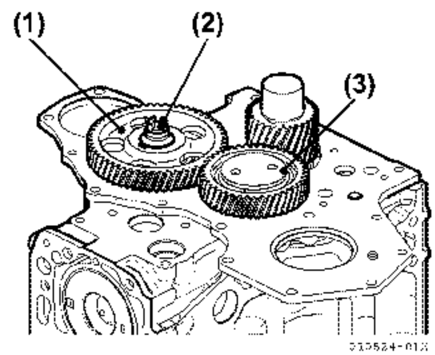


Figure 5-48

1 – **Camshaft Gear**
2 – **Camshaft Assembly**
3 – **Idler Gear**

43. Remove the camshaft **(Figure 5-49)**:

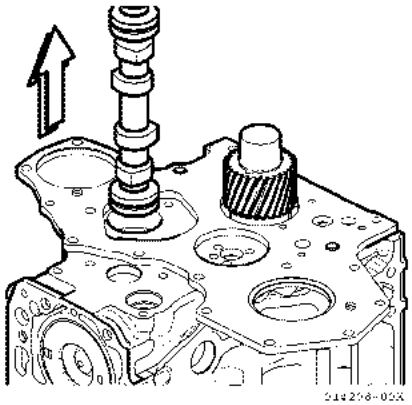


Figure 5-49

(a) Push up tappet by turning a camshaft to remove it from the cylinder block easily.

(b) Loosen the thrust metal bolts through the holes of the camshaft gear, and remove.

(c) Pull out the camshaft gear and camshaft assembly from the cylinder block.

Note: The camshaft gear and camshaft are shrink-fitted. They must be heated to 180° to 200°C (356° to 392°F) to disassemble.

44. Remove the pistons and connecting rods **(Figure 5-50)**.

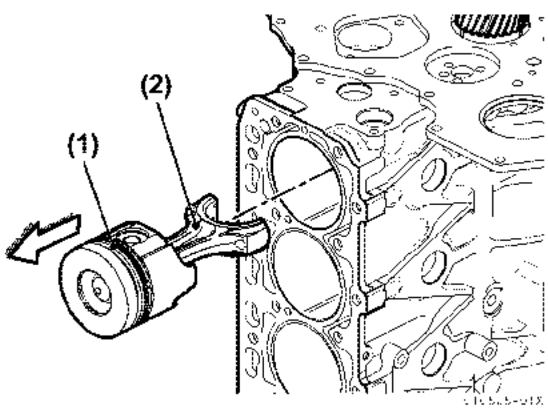


Figure 5-50

1 – Piston Connecting Rod
2 – Connecting Rod

(a) Loosen the rod bolts and remove the large end cap.

(b) Push the connecting rod and pull out the piston and connecting rod assembly.

45. Remove the gear case from the cylinder block **(Figure 5-51)**.

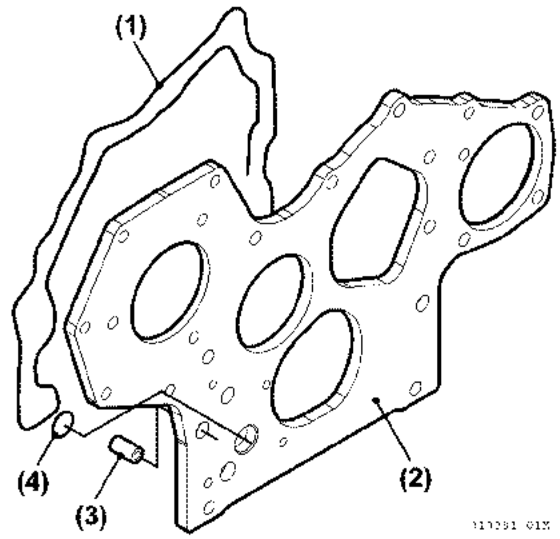


Figure 5-51

1 – Liquid Gasket
2 – Gear Case
3 – Knock Pin
4 – O-Ring

46. Remove the O-rings from the lubricating oil passage **(Figure 5-51)**.

Note:

- When mounting the gear case, match up the two knock pins for cylinder block.
- Coat the O-rings for the cylinder block lubricating oil passage with grease to maintain alignment when assembling.

47. Loosen but do not remove the main bearing bolts.

48. Turn the engine over, with the cylinder head mounting surface facing down **(Figure 5-52)**.

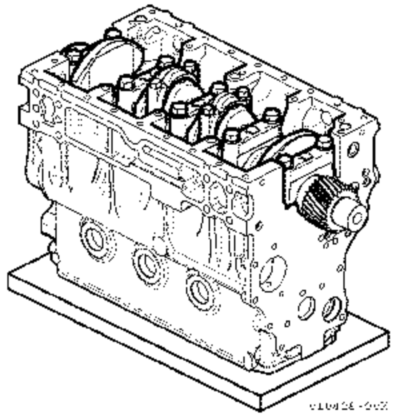


Figure 5-52

Note: Make sure that the cylinder head positioning pins on the cylinder block do not come in contact with the wood block.

49. Remove the flywheel housing and oil seal case from the cylinder block.
50. Remove the main bearing bolts **(Figure 5-53)**.

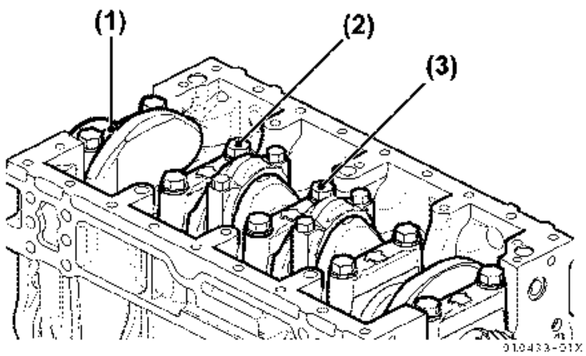


Figure 5-53

1 – Main Bearing Cap (base)
2 – Main Bearing Cap
3 – Main Bearing Bolt

51. Remove the main bearing cap and lower main bearing **(Figure 5-54)**.

Note: The thrust bearing (lower) is mounted to the main bearing cap base.

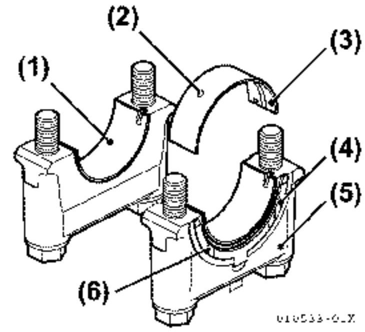


Figure 5-54

1 – Lower Main Bearing
2 – Oil Hole
3 – Upper Main Bearing
4 – Thrust Bearing
5 – Main Bearing Cap (base)
6 – Groove

52. Remove the crankshaft **(Figure 5-55)**.

Note:

- The thrust bearing (upper) is mounted to the standard main bearing.
- Remove the main bearing (upper) from the cylinder block.

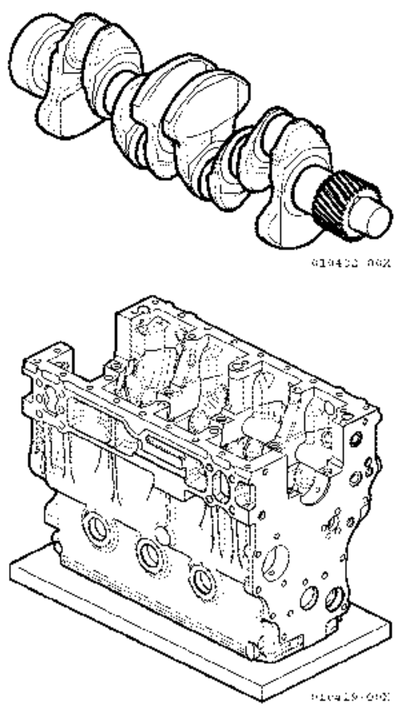


Figure 5-55

53. Remove the tappets from the tappet holes in the cylinder block **(Figure 5-56)**.

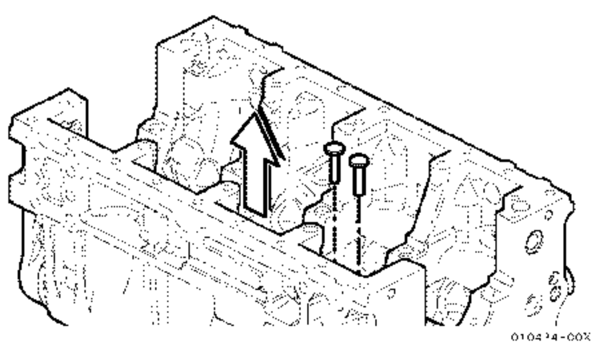


Figure 5-56

INSPECTION

Cylinder Block

The cylinder block is a light alloy casting machined with functionally designed ribs and support structures. The sidewalls are shaped to maximize rigidity, strength and quiet operation.

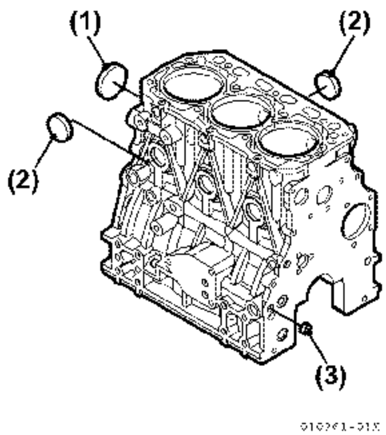


Figure 5-57

1 – Camshaft Hole Cap Plug 50 mm (1.97 in.)
2 – Cap Plug 30 mm (1.18 in.)
3 – Main Galley Cap Plug 12 mm (0.47 in.)

Inspecting the Cylinder Block

Perform a visual inspection for cracks on engines that have been exposed to freezing temperatures, overturned or have otherwise been subjected to undue stress. Perform a dye penetrant inspection on any suspected cracks. Replace the cylinder block if a crack is not repairable.

Inspecting Oil Passages and Cap Plugs

Clear all oil passages of any obstructions and ensure all cap plugs are secure.

Dye Penetrant Inspection Kit

Component	Quantity
Penetrant	1
Developer	2
Cleaner	3

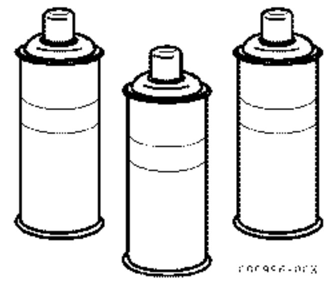


Figure 5-58

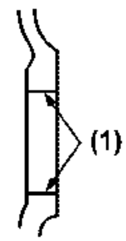
Dye Penetrant Inspection Procedure

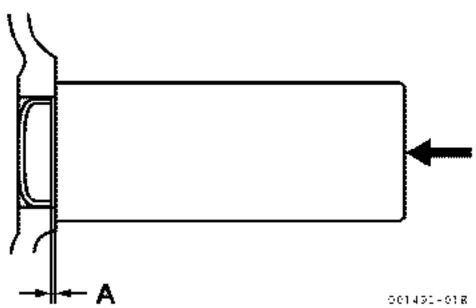
The dye penetrant kit consists of an aerosol cleaner, penetrant and developer.

Note: Always read the instructions included with your dye penetrant kit before use.

1. Clean the area to be inspected.
2. Spray the cleaner directly on the surface to soften heavily soiled areas or wipe the area with a cloth moistened with cleaner.
3. When the surface is clean and dry, spray the penetrant on the suspect area so that it is completely covered and the penetrant liquid shows a smooth surface tension. Use enough penetrant to maintain a wet appearance for at least 10 to 15 seconds. Do not disturb for 5 to 10 minutes.
4. Spray the developer on a clean shop towel and remove any excess dye penetrant. Spray a uniform thin film of developer on the remaining penetrant and allow to develop for several minutes. Cracks will appear as red dots or a continuos red line on the surface being inspected.
5. When finished, clean the surface with the cleaner.

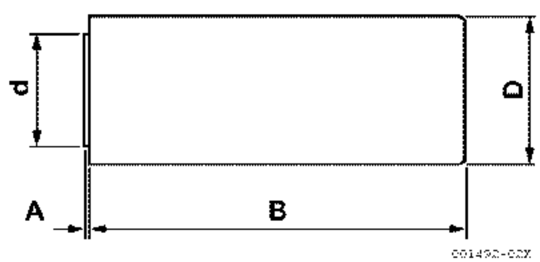
Replacement of Cup Plugs

Step No.	Description	Procedure	Tool of Material Used
1	Clean and remove glue from the hole into which the cap plug is to be driven. (Remove scale and sealing material previously applied.)	 **1 – Remove foreign materials with a screwdriver or saw blade.**	Screwdriver or saw blade Thinner
2	Remove grease from the cap plug.	Visually check the nick around the plug.	Thinner
3	Apply Three Bond No. 4 to the seat surface where the plug is to be driven in.	Apply over the whole outside of the plug.	Three Bond No. 4
4	Insert the plug into the hole.	Insert the plug so that it sits correctly.	-
5	Place a driving tool on the cap plug and drive it in using a hammer.	Drive in the plug parallel to the seating surface.	• Driving tool • Hammer



A
2-3 mm (0.08-0.12 in.)

*Using the special tool, drive the cup plug so that the edge of the plug is 2 mm (0.0787 in) below the cylinder surface.



A	B
3 mm (0.12 in.)	100 mm(3.94 in.)

Plug Diameter	d	D
12 mm (0.47 in.)	11.9-12.0 mm (0.469-0.472 in.)	20 mm (0.79 in.)
25 mm (0.98 in.)	24.9-25.0 mm (0.980-0.984 in.)	35 mm (1.38 in.)
30 mm (1.18 in.)	29.9-30.0 mm (1.178-1.181 in.)	40 mm (1.57 in.)
45 mm (1.77 in.)	44.9-45.0 mm (1.768-1.772 in.)	55 mm (2.17 in.)

Cylinder Bore Measurements

Clean the mating surface of the cylinder head, the cylinder bores and all oil passages. Check the following items after removing any carbon deposits and / or gasket material residue.

- Check for any discoloration or cracks. If a crack is suspected, perform a dye penetrant inspection. Clean and clear all oil passages.

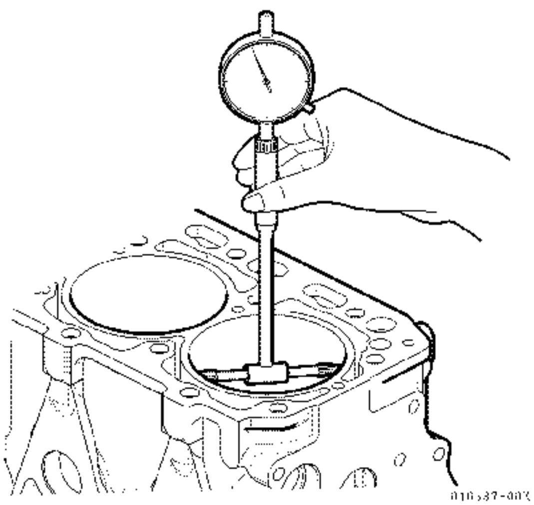


Figure 5-59

- Measure cylinder bore dimensions and compare measurements with allowable limits. Inspect cylinder bore(s) for physical damage and out-of-round conditions.
- Measure at 20 mm (0.8 in.) below the top of the cylinder bore **(Figure 5-60, (a))**.
- Measure at the center of piston travel **(Figure 5-60, (b))**.
- Measure at 20 mm (0.8 in.) from the bottom of the skirt in both directions **(Figure 5-60, (A), (B))**.

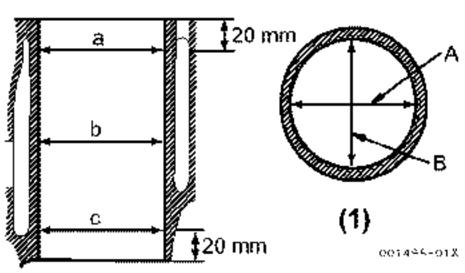


Figure 5-60

1 – Measure at 90° angles (A and B) at depths a, b and c.

Measuring Cylinder Bore for Out-of-Round:

Use a Dial Bore Gauge to measure the cylinder bore diameters. Measure the cylinder bore twice at right angles at position A and B, shown in **(Figure 5-60)**.

- First two measurements, at position **(Figure 5-60, (a))** at the top of the cylinder bore.
- Second two measurements, at position **(Figure 5-60, (b))** in the middle of the cylinder bore.
- Third two measurements, at position **(Figure 5-60, (c))** at the bottom of the piston ring travel in the cylinder bore.

This produces six different measurement values. Calculate the average value of all these measurements for each cylinder bore and compare with the Out-of-Round specifications listed below.

Measuring Cylinder Bore Diameters:

Measure the cylinder bore diameters as described above and compare values with wear limits stated below.

Item		Standard	Limit
Cylinder Bore Diameter	3JH5E 4JH5E	88.0-88.030 mm (3.465-3.466 in.)	88.200 mm (3.472 in.)
	4JH4-TE 4JH4-HTE	84.0-84.030 mm (3.307-3.308 in.)	84.200 mm (3.315 in.)
Cylinder Out-of-Round		0.01 mm or less (0.0004 in.)	0.03 mm (0.0012 in.)

Cylinder Head

The cylinder head can be designed with three or four cylinder bores. Valve seats are treated with a special stellite alloy for superior resistance to heat and wear. The intake / exhaust valves are cooled with internal circulating water.

General Guidelines

NOTICE: Identify all parts and their location using an appropriate method. It is important that all parts are returned to the same position during the reassembly process.

Note: Record all measurements taken during disassembly and inspection.

3JH5E and 4JH5E Engines Shown

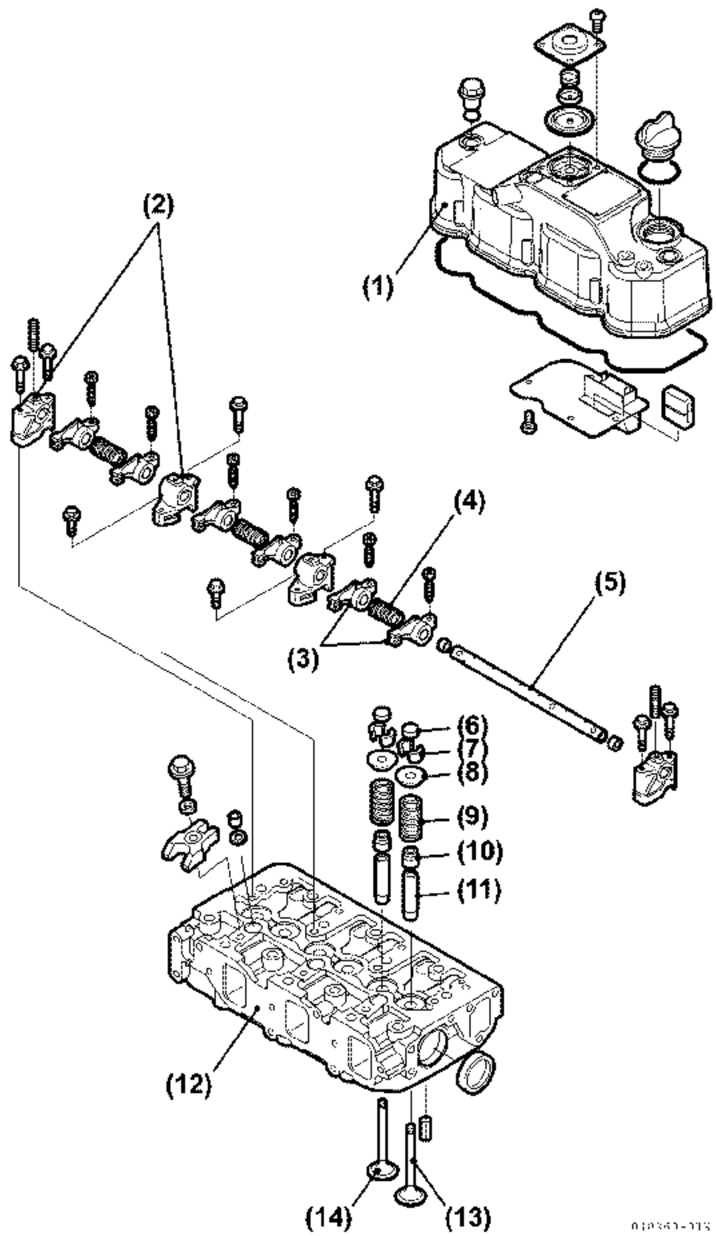


Figure 5-61

1 – Rocker Arm Cover
2 – Rocker Arm Support
3 – Rocker Arm
4 – Rocker Arm Spring (2-valve)
5 – Rocker Arm Shaft
6 – Valve Cap (2-valve)
7 – Cotter
8 – Spring Retainer
9 – Valve Spring
10 – Stem Seal
11 – Valve Guide
12 – Cylinder Head
13 – Intake Valve
14 – Exhaust Valve

4JH4-TE and 4JH4-HTE Engines Shown

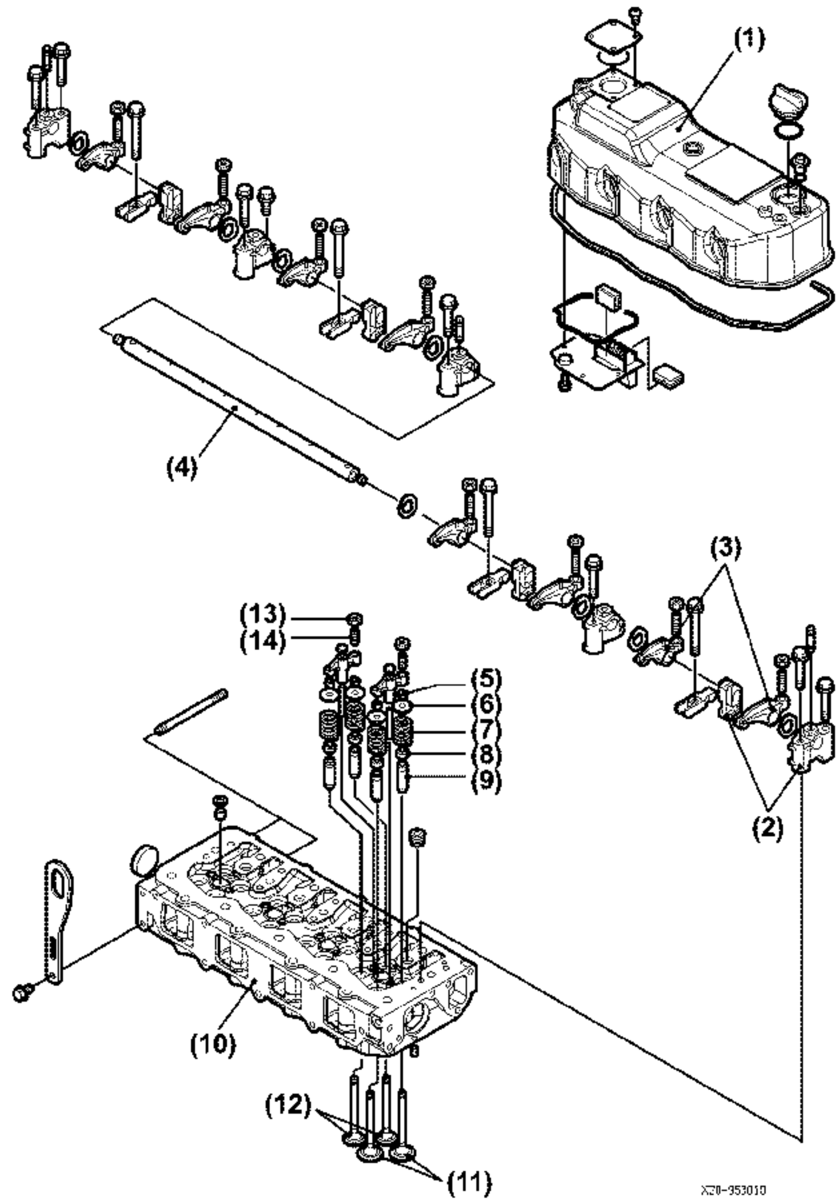


Figure 5-62

1 – Rocker Arm Cover
2 – Rocker Arm Support
3 – Rocker Arm
4 – Rocker Arm Shaft
5 – Cotter
6 – Spring Retainer
7 – Valve Spring
8 – Stem Seal
9 – Valve Guide
10 – Cylinder Head
11 – Intake Valve
12 – Exhaust Valve
13 – Adjusting Bolt (4-valve)
14 – Valve Bridge (4-valve)

Cylinder Head Inspection

Clean all gasket material, sealant and carbon from components. Use a suitable solvent and a soft-bristle brush to clean parts.

Visually inspect parts. Replace any parts that are obviously discolored, heavily pitted or otherwise damaged. Discard any part that does not meet its specified limit. **WARNING!** ***Exposure Hazard. Always read and follow safety-related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.***

NOTICE: Mark all valve train components so they can be installed in their original locations.

Note: Record all measurements taken during inspection.

The cylinder head is subjected to very severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.

Distortion of the combustion surface:

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

- Clean the cylinder head surface.
- Place a straightedge along each of the four sides and each diagonal. Measure the clearance between the straightedge and combustion surface with a feeler gauge **(Figure 5-63)**.

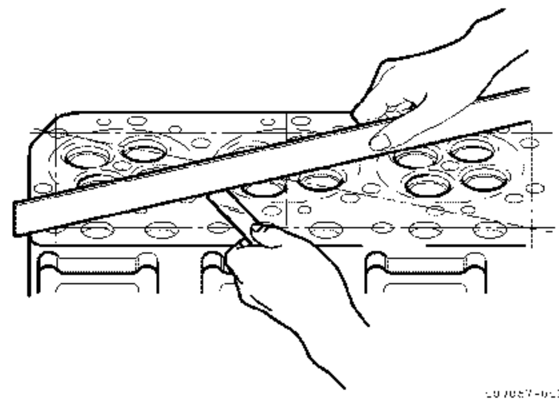


Figure 5-63

Item	Standard	Wear Limit
Cylinder Head Distortion	0.05 or less mm (0.002 or less in.)	0.15 mm (0.0059 in.)

- Check for cracks in the combustion surface. Remove the fuel injection nozzle, intake / exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a dye penetrant inspection to check for any cracks **(Figure 5-64)**.

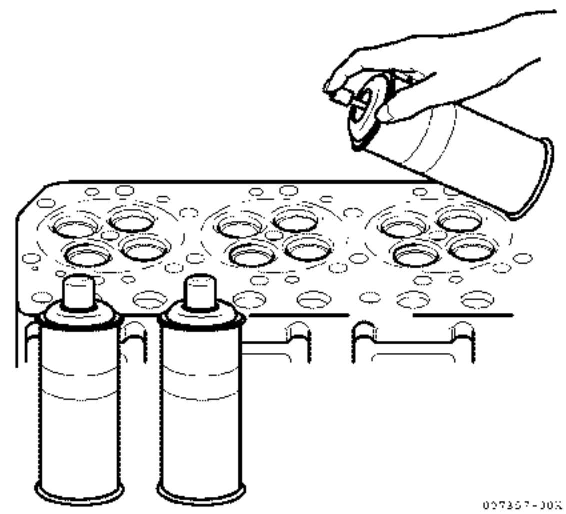


Figure 5-64

- Check the intake / exhaust valve seats. Check the surface and width of the valve seats. If they are too wide, or if the surfaces are rough, correct to the following standards **(Figure 5-65)**:

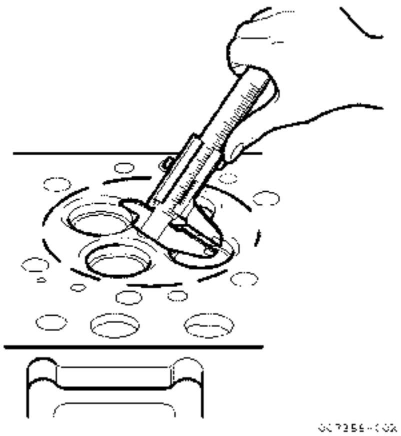


Figure 5-65

Seat Angle	Intake	120°
	Exhaust	90°

		Standard	Limit
Seat Width	Intake	1.07-1.24 mm (0.042-0.049 in.)	1.74 mm (0.069 in.)
	Exhaust	1.24-1.45 mm (0.049-0.057 in.)	1.94 mm (0.076 in.)

Valve Seat Correction Procedure

The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

- Use a seat grinder to make the surface even. As the valve seat width will be enlarged, first use a 70° grinder, then grind the seat to the standard dimension with a 15° grinder **(Figure 5-66)** and **(Figure 5-67)**.

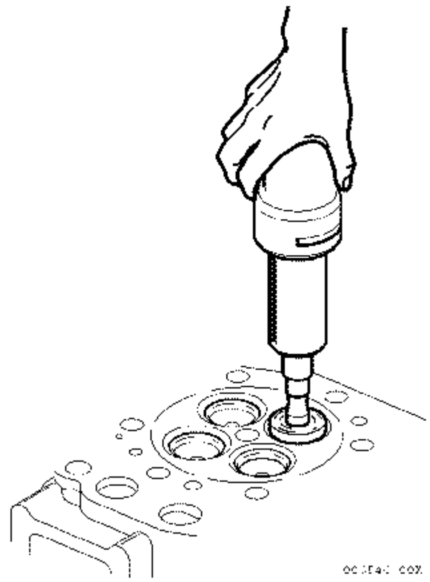


Figure 5-66

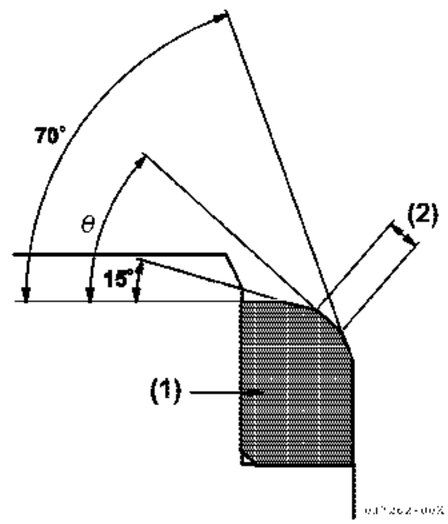


Figure 5-67

1 – Valve Seat
2 – Seat Width

Note: When valve seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.

- Knead valve compound with oil and finish the valve seat with a lapping tool.

- Final finishing should be done with oil only.
- Use a rubber cap type lapping tool for cylinders without a lapping tool groove with oil only **(Figure 5-68)**.

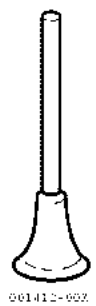


Figure 5-68

Note: Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed and make sure that there are no grindings remaining.

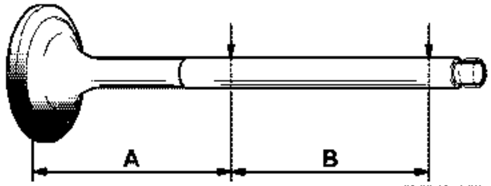
Insert adjusting shims between the valve spring and cylinder head when seats have been refinishing with a seat grinder.

Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance. *NOTICE: Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.*

Inspecting Intake / Exhaust Valves and Valve Guides

Wearing and corrosion of valve stem

- Replace the valve stem is excessively worn or corroded **(Figure 5-69)** and **(Figure 5-70)**.



A	B
40 mm (1.57 in.)	50 (1.97 in.)

Figure 5-69

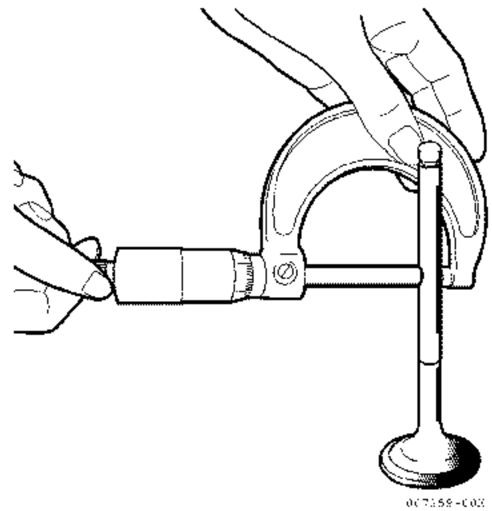


Figure 5-70

Model	Valve Stem O.D.	Standard	Limit
3JH5E 4JH5E	Intake	7.955-7.975 mm (0.3132-0.3140 in.)	7.90 mm (0.311 in.)
	Exhaust	7.955-7.970 mm (0.3132-0.3138 in.)	7.90 mm (0.311 in.)
4JH4-TE 4JH4-HTE	Intake	5.960-5.975 mm (0.2346-0.2352 in.)	5.90 mm (0.232 in.)
	Exhaust	5.945-5.960 mm (0.2341-0.2346 in.)	5.90 mm (0.232 in.)

- Inspection of valve seat wear and contact surface: Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is much smaller than the width of the valve seat.

Note: Keep in mind the fact that the intake and discharge valve have different diameters.

- Over long periods of use and repeated lapping, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.

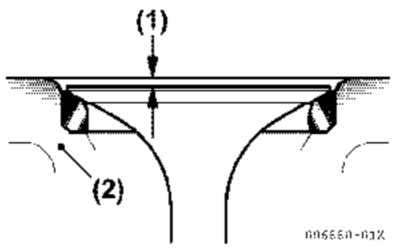


Figure 5-71

1 – Sink
2 – Cylinder Head

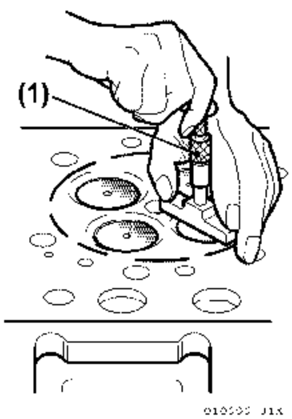


Figure 5-72

1 – Depth Micrometer

Item	Standard	Limit
Valve Sink	0.30-0.50 mm (0.012-0.020 in.)	0.8 mm (0.031 in.)

- Measure inside diameter of valve guide. Measure the inside diameter of the valve guide and replace it if it exceeds the wear limit.

			Standard	Limit
3JH5E 4JH5E	Valve Guide I.D.	Intake	8.010-8.025 mm (0.3154-0.3159 in.)	8.2 mm (0.323 in.)
		Exhaust	8.015-8.030 mm 0.3156-0.3161 in.)	8.2 mm (0.323 in.)
	Clearance	Intake	0.035-0.070 mm (0.0014-0.0028 in.)	0.18 mm (0.007 in.)
		Exhaust	0.045-0.075 mm (.0018-0.0030 in.)	0.18 mm (0.007 in.)

			Standard	Limit
4JH4-TE / 4JH4-HTE	Valve Guide I.D.	Intake	6.000-6.015 mm (0.2362-0.2368 in.)	6.1 mm (0.240 in.)
		Exhaust	6.000-6.015 mm (0.2362-0.2368 in.)	6.1 mm (0.240 in.)
	Clearance	Intake	0.025-0.055 mm (0.0010-0.0022 in.)	0.16 mm (0.0063 in.)
		Exhaust	0.040-0.070 mm (0.0016-0.0028 in.)	0.18 mm (0.0063 in.)

Note: The inside diameter standard dimensions assume a pressure fit.

Replace the Valve Guide

- Use a valve guide extraction tool and extract the valve guide from the cylinder head.
- Put liquid nitrogen or ether (or alcohol) with dry ice added in a container and put the valve guide for replacement in it for cooling. Then insert it in by a valve guide inserting tool and a mallet. **WARNING!** ***Exposure Hazard. Do not touch the cooled valve guide with bare hands to avoid skin damage.***
- Check the inside diameter and finish to the standard inside diameter as required with a reamer **(Figure 5-73)** and **(Figure 5-74)**.

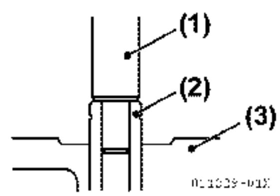


Figure 5-73

1 – Tool
2 – Valve Guide
3 – Cylinder Head

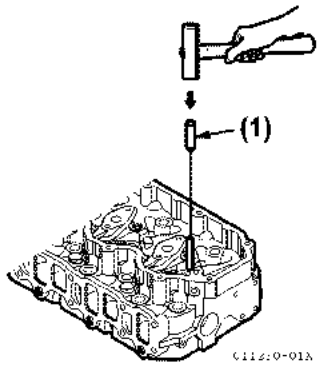


Figure 5-74

1 – Tool

Valve Guide Projection

Check the projection from the cylinder head **(Figure 5-75, (4))**.

Valve Guide Projection

3JH5E / 4JH5E	15.0 / -0.3 mm (0.591 / -0.012 in.)
4JH4-TE / 4JH4-HTE	8.50 / -0.3 mm (0.335 / -0.012 in.)

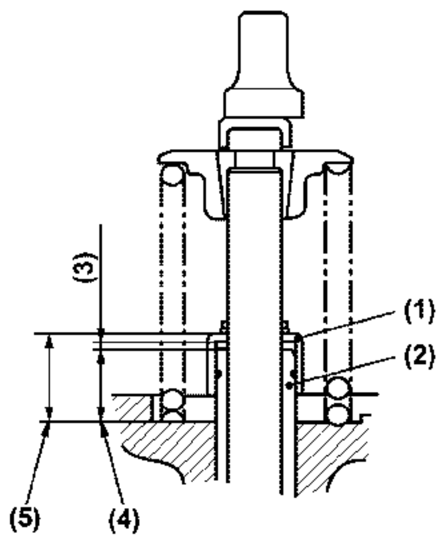


Figure 5-75

1 – Stem Seal
2 – Valve Guide
3 – Clearance
4 – Valve Guide Projection
5 – Stem Seal Projection

Valve Stem Seals

The valve stem seals on the intake/exhaust valve guides cannot be reused once they are removed. Be sure to replace them.

Install the valve stem seal to the valve guide by using a tool.

The stem seal projection is as follows. The clearance between the stem seal and the upper surface of valve guide is around 0.2 mm to 0.8 mm (0.008 to 0.03 in.) **(Figure 5-76)**.

Valve Stem Seal Projection

3JH5E / 4JH5E	190 / -0.3 mm (0.749 / -0.012 in.)
4JH4-TE / 4JH4-HTE	10.2 0 / -0.3 mm (0.788 / -0.012 in.)

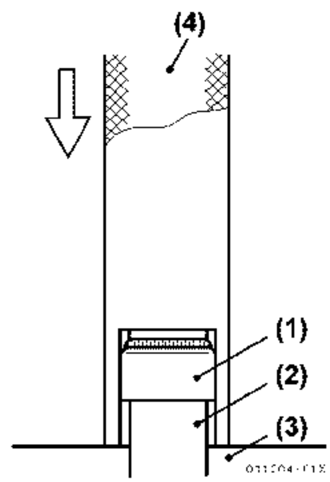


Figure 5-76

1 – Stem Seal
2 – Valve Guide
3 – Cylinder Head
4 – Valve Stem Seal Inserting Tool

The intake valve guide and exhaust valve guide are of different dimensions. The stem seal is marked by color for the distinction.

Model	Intake	Exhaust
3JH5E / 4JH5E	No mark	Yellow
4JH4-TE / 4JH4-HTE	White	Black

When assembling the intake / exhaust valves, apply an adequate quantity of engine oil on the valve stem before inserting.

Valve Springs

- Check the spring for scratches or corrosion.
- Measure the free length of the spring **(Figure 5-77)**.

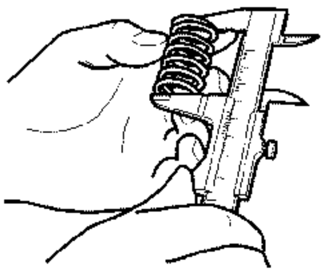


Figure 5-77

- Measure inclination **(Figure 5-78, (1))** and **(Figure 5-79)**.

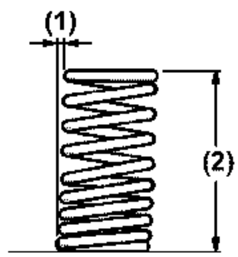


Figure 5-78

1 – Inclination
2 – Free Length

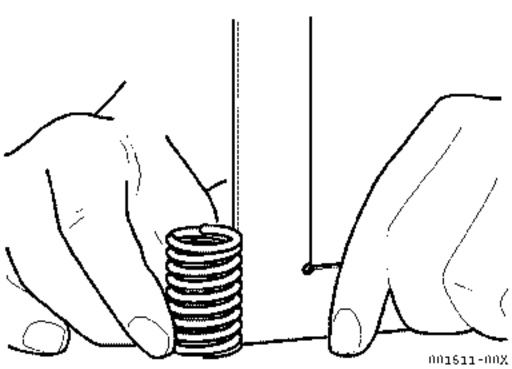


Figure 5-79

- Measure spring tension.

Item	3JH5E / 4JH5E		4JH4-TE / 4JH4-HTE	
Valve Spring	Standard	Limit	Standard	Limit
Free Length A	44.4 mm (1.75 in.)	43.0 mm (1.69 in.)	37.4 mm (1.47 in.)	36.9 mm (1.45 in.)
Inclination B	-	1.1 mm (0.043 in.)	-	1.0 mm (0.039 in.)

- Assemble valve springs. The side with the smaller pitch (painted yellow) should face down (cylinder head).

Note: The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled **(Figure 5-80)**.

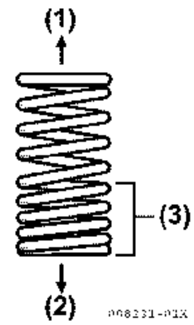


Figure 5-80

1 – Up Side
2 – Down Side
3 – Small Pitch Side (yellow)

- Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less than 70%, or when the spring cotter has been recessed because of wear.

Cylinder Head Assembly

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful that the head does not get distorted.

(a) Clean out the cylinder head bolt holes.

(b) Check for foreign matter on the cylinder head surface where it comes in contact with the block.

(c) Coat the head bolt threads and nut seats with lubricating oil.

(d) Use the positioning pins to line up the head gasket with the cylinder block.

(e) Match up the cylinder head with the head gasket and mount.

Figure 5-81 shows assembly head bolt tightening order for 3-cylinder head of 3JH5E and 4-cylinder head of 4JH5E, 4JH4-TE and 4JH4-HTE.

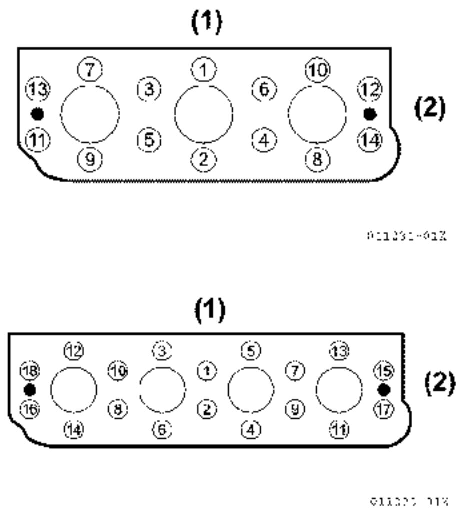


Figure 5-81

1 – Camshaft Side
2 – Gear Case Side

	First	Second
Cylinder Head Bolt Tightening Torque	44-54 N·m (32-40 lb-ft)	85.2-91.2 N·m (62.9-67.3 lb-ft)

Measuring Top Clearance

1. Place a high-quality fuse (1.0 mm [0.04 in.) diameter, 10 mm [0.39 in.]long) in three positions on the flat part of the piston head.
2. Assemble the cylinder head gasket and the cylinder head. Tighten the bolts in the specified order to the specified torque.
3. Turn the crankshaft, in the direction of engine revolution, and press the fuse against the piston until it breaks.
4. Remove the cylinder head. Remove the broken fuse.
5. Measure the three positions where each fuse is broken and calculate the average **(Figure 5-82)**.

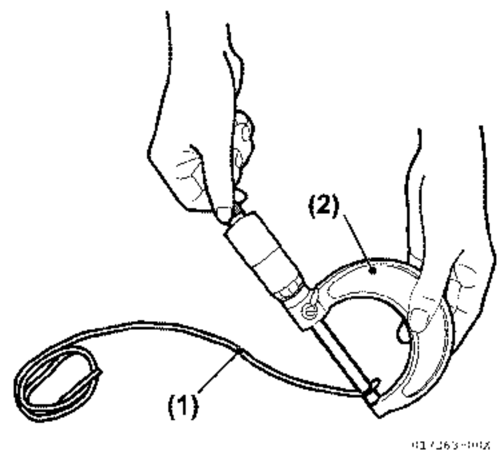


Figure 5-82

1 – Fuse Wire
2 – Micrometer

Top Clearance	0.68-0.80 mm (0.027-0.031 in.)

Intake / Exhaust Rocker Arms

The wear of rocker arms and rocker arm bushings may change opening / closing timing of the valve, and may in turn affect the engine performance according to the extent of the change.

Rocker arm shaft and rocker arm bushing:

Measure the outer diameter of the shaft and the inner diameter of the V-ring, and replace if wear exceeds the limit **(Figure 5-83)**.

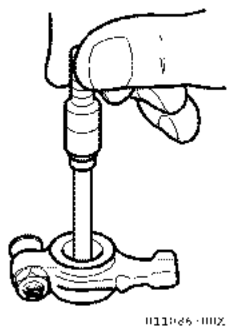


Figure 5-83

Item	Standard	Limit
Intake / Exhaust Rocker Arm Bushing I.D.	16.000-16.020 mm (0.6299-0.6307 in.)	16.090 mm (0.6335 in.)
Intake / Exhaust Rocker Arm Shaft O.D.	15.966-15.984 mm (0.6286-0.6293 in.)	15.955 mm (0.6281 in.)
Rocker Arm Shaft and Bushing Clearance at Assembly	0.016-0.054 mm (0.0006-0.0021 in.)	0.140 mm (0.0055 in.)

Replace the rocker arm bushing if it moves and replace the entire rocker arm if there is no tightening clearance.

- Check the rocker arm spring and replace it if it is corroded or worn.
- Inspect the contact surface of the rocker arm and replace it if there is abnormal wear or flaking.

Valve Clearance Adjustment

- Make adjustments when the engine is cool. See page *5-82*.

Intake / Exhaust Valve Clearance	0.15-0.25 mm (0.0059-0.0098 in.)

- Check the valve timing. Be sure that the opening and closing angles for both the intake and the exhaust valves are checked when the timing gear is disassembled (the gauge on the flywheel can be read). All JH series engines use the same valve timing procedure **(Figure 5-84)**.

Intake Valve Open	bTDC	10°-20°
Intake Valve Closed	aBDC	40°-50°
Exhaust Valve Open	bBDC	51°-61°
Exhaust Valve Closed	aTDC	13°-23°

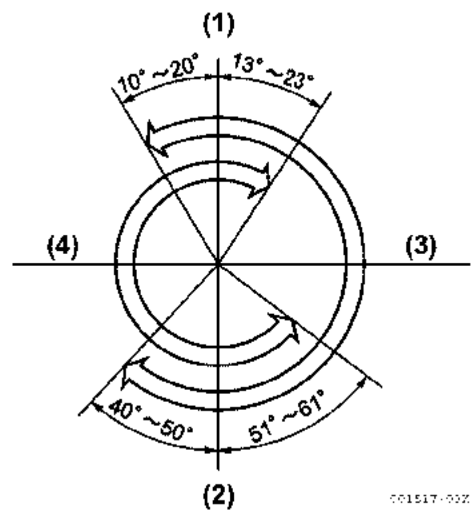


Figure 5-84

1 – Top Dead Center (TDC)
2 – Bottom Dead Center (BDC)
3 – Intake Valve Open Period 281°
4 – Exhaust Valve Open Period 254°

Piston and Piston Rings

Pistons are made of a special light alloy with superior thermal expansion characteristics. The back of the piston combustion chamber is oil-jet cooled.

The ID marks (model mark and size mark) are infused on the top surface of the piston **(Figure 5-85)**.

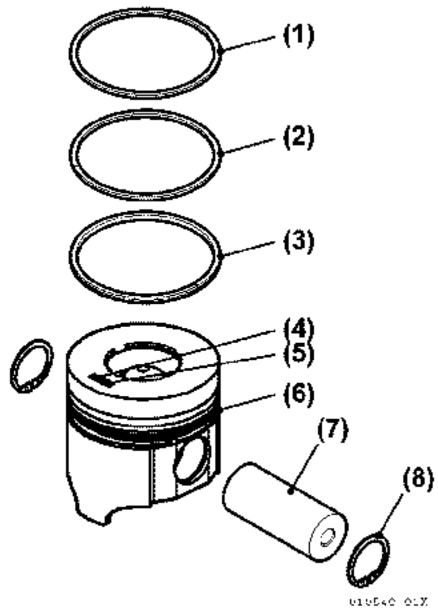


Figure 5-85

1 – Top Compression Ring
2 – Middle Compression Ring
3 – Oil Control Ring
4 – ID Mark (size Mark)
5 – ID Mark (model Mark
6 – Piston
7 – Piston Pin
8 – Circlip

Model Mark

Model	Mark
3JH5E	V88
4JH5E	4JH4
4JH4-TE	TE
4JH4-HTE	HTE

Size Mark

Size Mark
ML
MS

NOTICE: Piston shape differs among engine models. If any incorrect piston is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark.

Piston

Piston head and combustion surface:

- Remove the carbon that has accumulated on the piston head and combustion surface, taking care not to scratch the piston. Check the combustion surface for any damage.
- Measurement of piston outside diameter / inspection:
  - Replace the piston if the outsides of the piston or ring grooves are worn.
  - Measure the outside diameter in the position of 22 mm (0.86 in.) from the piston bottom in the direction vertical to the piston pin **(Figure 5-86)**.

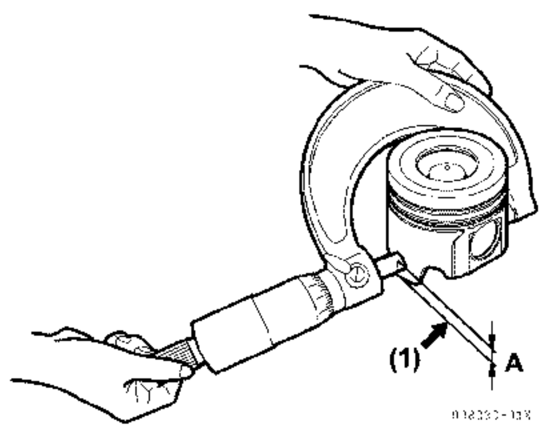


Figure 5-86

1 – Measurement Position
A–22 mm (0.86 in.)

Piston Outside Diameter

Model	Standard	Limit	Clearance Between Piston and Cylinder
3JH5E	87.960-87.950 mm (3.4630-3.4626 in.)	87.900 mm (3.4606 in.)	0.045-0.075 mm (0.0018-0.0030 in.)
4JH5E	87.945-87.935 mm (3.4624-3.4620 in.)	87.885 mm (3.4600 in.)	0.06-0.090 mm (0.0024-0.0036 in.)
4JH4-HT 4JH4-HTE	83.940-83.930 mm (3.3047-3.3043 in.)	83.340 mm (3.3023 in.)	0.065-0.095 mm (0.0026-0.0038 in.)

If the piston outside diameter exceeds the limit, replace the piston with new one.

Matching Cylinder and Piston

Piston must be matched with cylinder according to the below table. The size mark of a piston is shown on the top surface of the piston and the size mark of a cylinder block is shown on the non-operating side of the cylinder block. The service parts of pistons are provided.

			Piston Outside Diameter D2	
	Tolerance		Below +0.005 0 Minimum	Below 0 -0.005 Minimum
		Size Mark	ML	MS
Cylinder Inside Diameter D1	+0.030 maximum +0.020 minimum	L	O	X
	Below +0.020 +0.010 minimum	M	O	O
	Below +0.010 0 minimum	S	X	O

Model	Cylinder Inside Diameter D1	Piston Outside Diameter D2
3JH5E	88 mm (3.465 in.)	87.955 mm (3.4630 in.)
4JH5E		87.940 mm (3.4624 in.)
4JH4-TE 4JH4-HTE	84 mm (3.307 in.)	83.940 mm (3.3047 in.)

Piston Pin

A floating-type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide easily).

Measure the outer diameter and replace the pin if it is excessively worn.

Item	Model	Standard	Limit
Piston Pin Hole Inside Diameter	3JH5E / 4JH5E	26.000-26.009 mm (1.0236 -1.0240 in.)	26.020 mm (1.0244 in.)
	4JH4-TE / 4JH4-HTE	28.000-28.009 mm (1.1024-1.1028 in.)	28.020 mm (1.1032 in.)
Piston Pin Outside Diameter	3JH5E / 4JH5E	25.995-26.000 mm (1.0234-1.0236 in.)	25.965 mm (1.0222 in.)
	4JH4-TE / 4JH4-HTE	27.995-28.000 mm (1.1022-1.1024 in.)	27.965 mm (1.1010 in.)
Clearance	JH SERIES	0-0.014 (0-0.0006 in.)	0.074 mm (0.0029 in.)

Measure the piston pin hole diameter at positions a and b in directions A and B **(Figure 5-87)**.

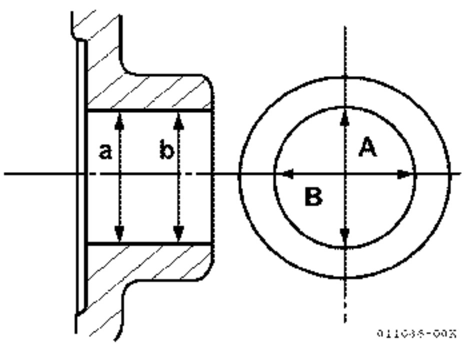


Figure 5-87

Measure the piston pin outside diameter at positions a and b in directions A and B **(Figure 5-88)**.

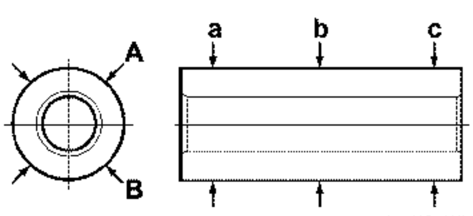


Figure 5-88

Piston Rings

There are two compression rings and one oil ring. The oil ring on the piston skirt keeps oil on the thrust surface and in turn provides good lubrication **(Figure 5-89)**.

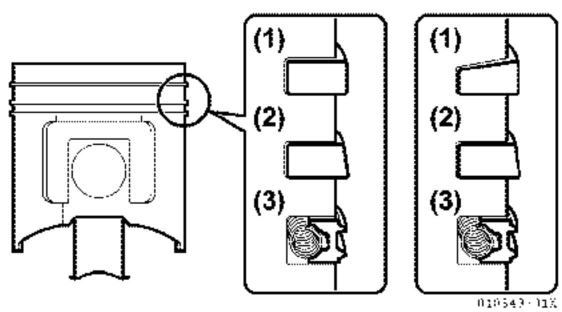


Figure 5-89

1 – Top Compression Ring
2 – Middle Compression Ring
3 – Oil Control Ring

- Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit **(Figure 5-90)**.

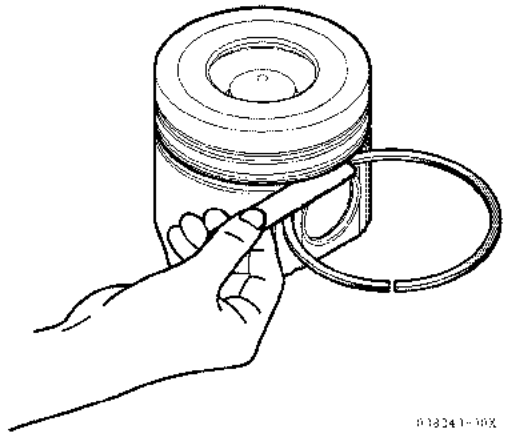


Figure 5-90

Model	Ring	Item	Standard	Limit
3JH5E 4JH5E	Top Ring	Groove Width	2.060-2.075 mm (0.0811-0.0817 in.)	2.170 mm (0.0854 in.)
		Ring Width	1.970-1.990 mm (0.3677-0.3685 in.)	1.950 mm (0.3669 in.)
		Clearance	0.070-0.105 mm (0.0028-0.0042 in.)	0.200 mm (0.0040 in.)
	Middle Ring	Groove Width	2.025-2.040 mm (0.0797-0.0803 in.)	2.140 mm (0.0842 in.)
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)
		Clearance	0.035-0.070 mm (0.0014-0.0028 in.)	0.190 mm (0.0075 in.)
	Oil Control Ring	Groove Width	4.015-4.030 mm (0.1587-0.1593 in.)	4.130 mm (0.1626 in.)
		Ring Width	3.970-3.990 mm (0.1563-0.1571 in.)	3.950 mm (0.1555 in.)
		Clearance	0.025-0.060 mm (0.0010-0.0024 in.)	0.180 mm (0.0071 in.)
4JH4-TE 4JH4-HTE	Top Ring	Groove Width	2.060-2.080 mm (0.0811-0.0819 in.)	2.180 mm (0.0858 in.)
		Ring Width	1.970-1.990 mm (0.3677-0.3685 in.)	1.950 mm (0.3669 in.)
		Clearance	(half-keystone)	-
	Middle Ring	Groove Width	2.050-2.065 mm (0.0807-0.0813 in.)	2.170 mm (0.0854 in.)
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)
		Clearance	0.060-0.095 mm (0.0024-0.0038 in.)	0.220 mm (0.0087 in.)
	Oil Control Ring	Groove Width	4.020-4.035 mm (0.1583-0.1589 in.)	4.120 mm (0.1622 in.)
		Ring Width	3.970-3.990 mm (0.1563 -0.1571 in.)	3.950 mm (0.1555 in.)
		Clearance	0.030-0.066 mm (0.0012-0.0026 in)	0.180 mm (0.0071 in.)

- Push the piston ring into a cylinder and measure the piston ring gap with a feeler gauge. Push the ring to about 30 mm (1.2 in.) from the bottom of the cylinder skirt **(Figure 5-91)**.

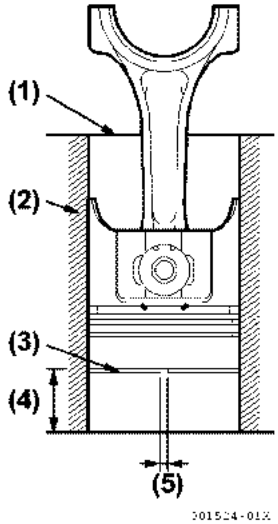


Figure 5-91

1 – Head Surface
2 – Cylinder Block
3 – Piston Ring
4 – Approximately 30 mm (1.2 in.)
5 – Gap

JH Series	Standard	Limit
Top Ring End Gap	0.200-0.400 mm (0.0079-0.0079 in.)	0.490 mm (0.193 in.)
Middle Ring End Gap	0.200-0.400 mm (0.0079-0.0079 in.)	0.490 mm (0.193 in.)
Oil Control Ring End Gap	0.200-0.400 mm (0.0079-0.0079 in.)	0.490 mm (0.193 in.)

- Remove the piston rings from the cylinder.
- Thoroughly clean the ring grooves in the piston.
- Install the rings with the manufacturer's mark facing up **(Figure 5-92)**.

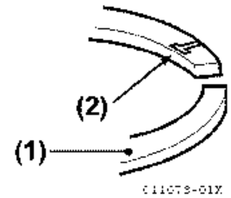


Figure 5-92

1 – Piston Ring
2 – Punched Manufacturer's Mark

- After installing the piston ring, make sure it moves easily and smoothly.
- Stagger the piston ring gaps at 120° intervals. *See Assemble the piston and connecting rod: on page 5-75.*
- The oil control ring includes a coil expander. The coil expander joint should be opposite (180°) the oil ring gap **(Figure 5-93)**.

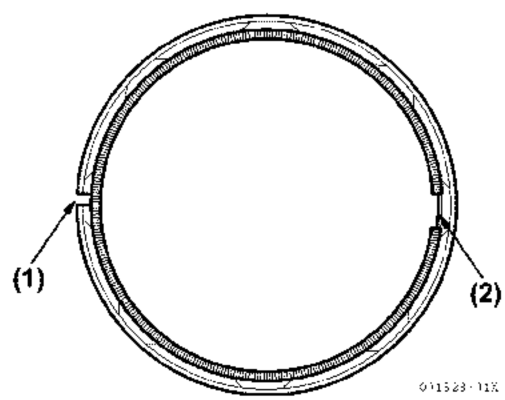


Figure 5-93

1 – Oil Control Ring Gap
2 – Joint of Coil Expander

Connecting Rod

The connecting rod is made of high-strength forged carbon steel. The large crankshaft bearing is equipped with a bearing cap and a two-piece aluminum bearing insert assembly. The piston pin bearing is a non-serviceable copper alloy bushing that is factory-installed **(Figure 5-94, (1))**.

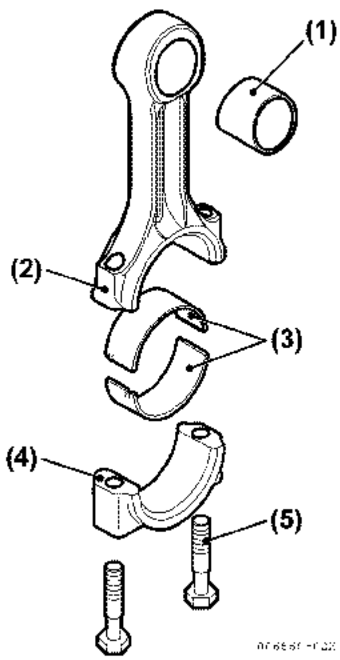


Figure 5-94

1 – Piston Pin Bearing
2 – Connecting Rod
3 – Crank Pin Bearing
4 – Connecting Rod Cap
5 – Connecting Rod Cap Bolts

Connecting Rod Bearing Alignment Inspection

Ensure the connecting rod is not twisted.

1. Insert the appropriate mandrel into both ends of the connecting rod **(Figure 5-95)**.
2. Measure alignment.
3. Replace connecting rod if it exceeds the specifications shown **(Figure 5-95)**.

Item	Standard	Limit
Connecting Rod Twist and Alignment	Less than 0.03 mm (at 100 mm) (Less than 0.0012 in. [at 3.937 in.])	0.08 mm (0.0031 in.)

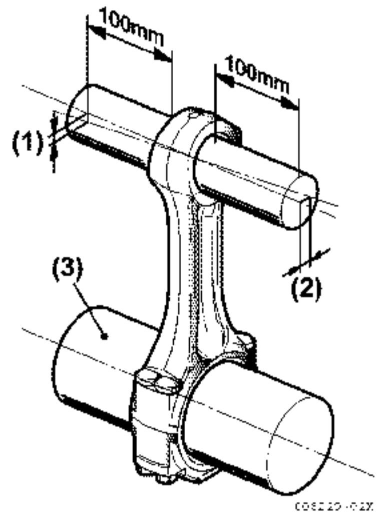


Figure 5-95

1 – Alignment
2 – Twist
3 – Mandrel

Figure 5-96 shows twist measurement using a connecting rod alignment tool.

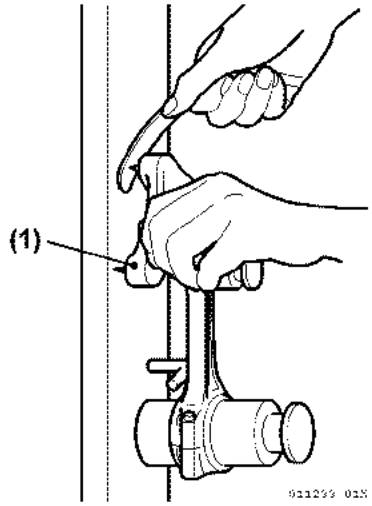


Figure 5-96

1 – Connecting Rod Alignment Tool

Check connecting rod side clearance.

1. Install the connecting rod to the crankshaft.
2. Check the side clearance as shown **(Figure 5-97)**.

Item	Standard	Limit
Connecting Rod Side Clearance	0.20-0.40 mm (0.008-0.016 in.)	0.55 mm (0.022 in.)

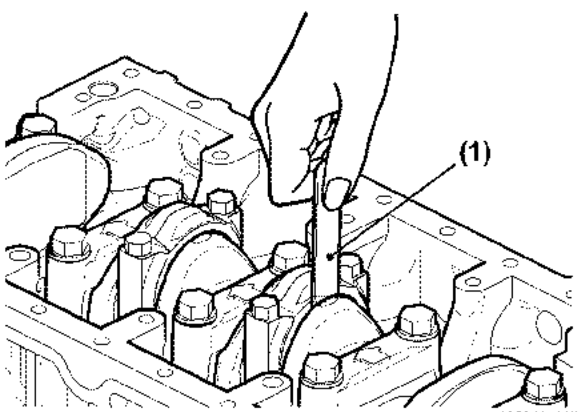


Figure 5-97

1 – Feeler Gauge

Inspecting Crank Pins

Inspect each crank pin surface for flaking, melting or discoloration and measure each crank pin for proper oil clearance.

1. Measure the crankpin outside diameter.
2. Measure the inside diameter of the connecting rod crankshaft bearing.
3. Calculate the oil clearance by subtracting the measured values.
4. Replace the connecting rod if the oil clearance is greater than the allowable limit.
5. Correct the crankshaft by grinding to a uniform undersize standard dimension (if available).

   Use an oversized bearing insert in the connecting rod, if available **(Figure 5-98)**.

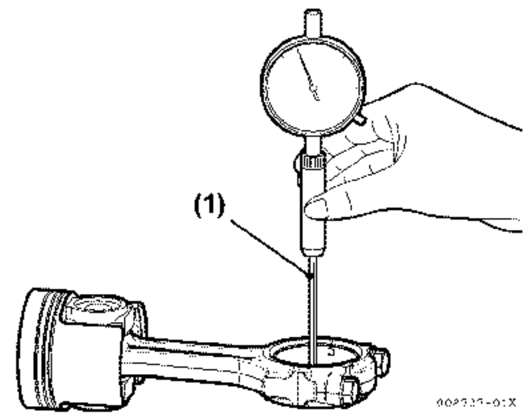


Figure 5-98

1 – Cylinder Gauge

NOTICE: When installing the connecting rod to the crankshaft, match the alignment marks on the rod cap and tighten the rod cap bolts to standard torque.

Rod Bolt Torque	44.1-49.1 N·m (4.50-5.01 lb·ft)

Item	Standard	Limit
Rod Bearing I.D.	48.000-48.026 mm (1.890-1.891 in.)	-
Crankpin O.D.	47.952-47.962 mm (1.888-1.888 in.)	47.902 mm (1.886 in.)
Bearing Thickness	1.492-1.500 mm (0.05874-0.05906 in.)	-
Clearance	0.038-0.074 mm (0.0015-0.0029 in.)	0.150 mm (0.0061 in.)

An alternate procedure of measuring crank pin oil clearance is to use a plastic gauge.

1. Lay the plastic gauge on the surface of the crank pin.
2. Mount the connecting rod on the crank pin and tighten to specified torque.
3. Remove the connecting rod and measure the plastic gauge with measuring paper **(Figure 5-99)**.

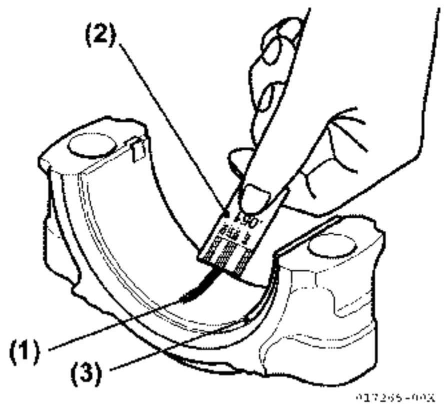


Figure 5-99

1 – Plastic Gauge
2 – Measuring Paper
3 – Connecting Rod Bearing Insert

Precautions for inspecting the crank pin clearances.

- Wash the crank pin surface thoroughly.
- Clean the crankshaft bearing of the connecting rod and install the crankshaft bearing inserts. Make sure the bearing inserts fit properly.
- When installing the connecting rod to the crankshaft, make sure to match the alignment marks on the rod cap **(Figure 5-100)**.
- Coat the cap bolts with engine oil and tighten to the specified torque.
- If a torque wrench is not available, make match marks on the bolt heads and rod cap (to indicate the proper torque position) and retighten the bolts to those positions **(Figure 5-101)**.

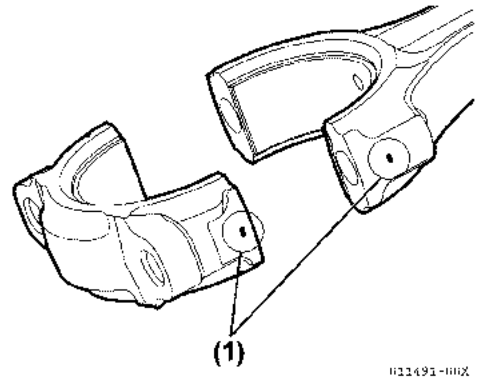


Figure 5-100

1 – Alignment Marks (punched mark)

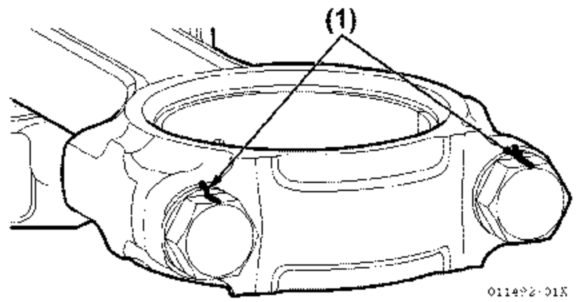


Figure 5-101

1 – Match Marks

- Be sure there is no sand, metal cuttings or other foreign matter in the oil.
- Ensure the crankshaft is not scratched.
- Clean and clear all oil holes.

Piston Pin Bushing

- Measure piston pin clearance. Excessive piston pin bearing wear may result in damage to the piston pin or the piston itself.
- Measure the piston pin bearing inside diameter and the piston pin outside diameter. Calculate the oil clearance from the difference of the measured values **(Figure 5-102)**. *See Crankshaft on page 5-62.*

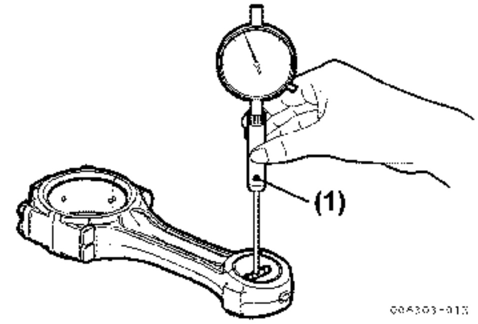


Figure 5-102

1 – Cylinder Gauge

Item	3JH5E and 4JH5E		4JH4-TE and 4JH4-HTE	
	Standard	**Limit**	**Standard**	**Limit**
Piston Pin Bushing Inside Diameter	26.025-26.038 mm (1.0246-1.0251 in.)	26.068 mm (1.0263 in.)	28.025-28.038 mm (1.1033-1.1039 in.)	26.068 mm (1.0263 in.)
Oil Clearance	0.025-0.043 mm (0.00098-0.00169 in.)	0.101 mm (0.00398 in.)	0.025-0.043 mm (0.00098-0.00169 in.)	0.101 mm (0.00398 in.)

Note: The piston pin bearing is not available as a service item. It is factory installed and is included in the connecting rod assembly.

Figure 5-103 shows the orientation of components when assembling connecting rods and pistons.

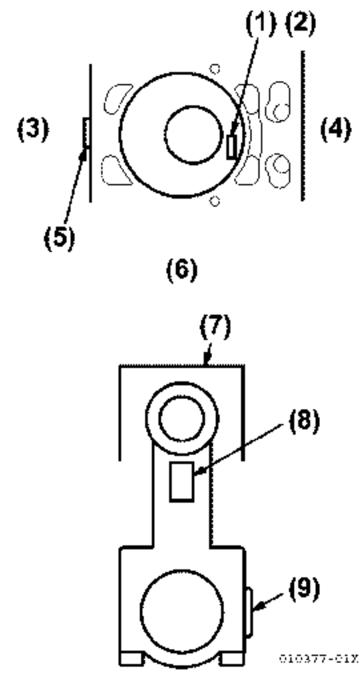


Figure 5-103

1 – Size Mark
2 – Model Mark
3 – Camshaft Side
4 – Nozzle Side
5 – Cylinder Size Mark
6 – Flywheel End
7 – Piston Mark
8 – Embossed Mark (flywheel end)
9 – Match Mark

Crankshaft and Main Bearings

The crank pins and crank journals are induction hardened for superior durability. The crankshaft is designed with balance weights for minimum vibration.

The crankshaft main bearing journals are of the hanger type. The upper bearing insert (cylinder block side) is provided with an oil groove. There is no oil groove on the lower bearing insert (bearing cap side). The journal cap (location cap) on the flywheel end has a thrust bearing which supports the thrust loads **(Figure 5-104)** and **(Figure 5-105)**.

3JH5E Crankshaft Shown

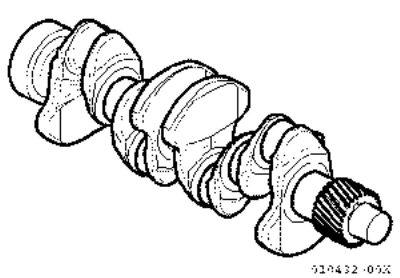


Figure 5-104

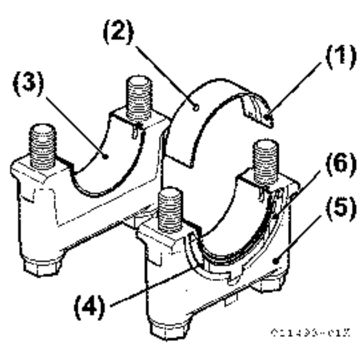


Figure 5-105

1 – Upper Main Bearing Insert
2 – Oil Hole
3 – Lower Main Bearing Insert
4 – Groove
5 – Main Bearing Cap (base)
6 – Thrust Bearing

Crankshaft

- Perform a dye penetrant inspection after cleaning the crankshaft, and replace the crankshaft if there are any cracks or other significant damage **(Figure 5-106)**.

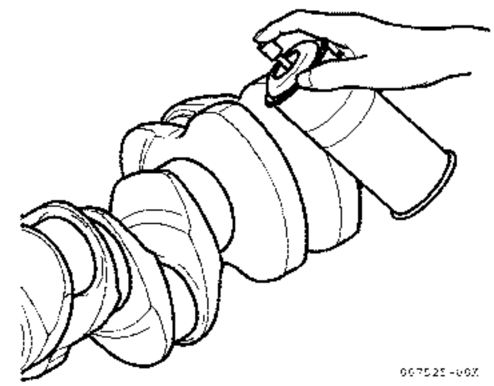


Figure 5-106

- Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check for crankshaft run-out **(Figure 5-107)**.

Crankshaft Run-Out Limit (1/2 the Dial Gauge Reading)	0.02 mm (0.0008 in.)

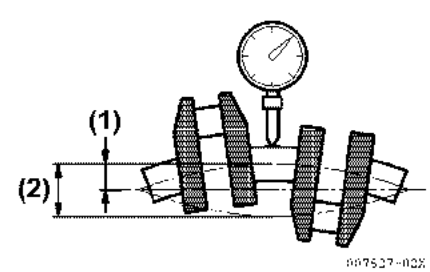


Figure 5-107

1 – Bend
2 – Deflection

- Measure the outside diameter, roundness and taper at each crank pin and journal. Resurface the crankshaft pins and journals if measurements exceed specifications.

Item	Limit (Diameter)
Roundness Taper	0.01 mm (0.0004 in.)

To determine the oil clearance of the crank pins, measure the diameter of crank pin and compare to the following chart **(Figure 5-108)** and **(Figure 5-109)**.

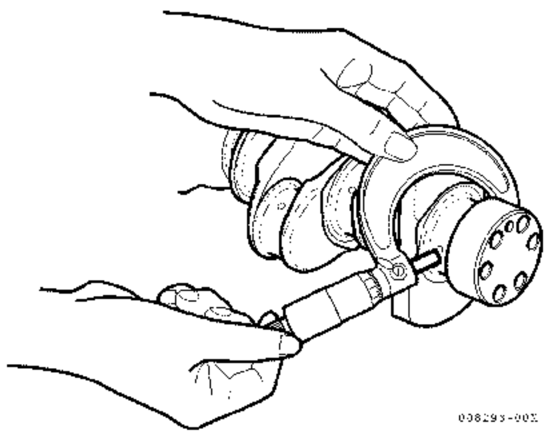


Figure 5-108

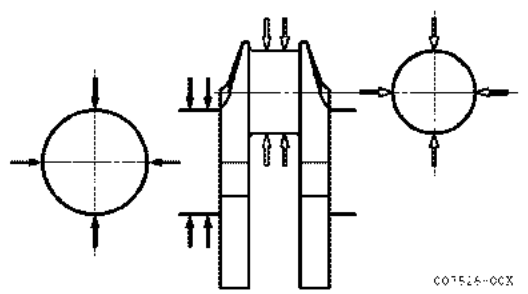


Figure 5-109

		Standard	Limit
Crank Pin	Outside Diameter	47.952-47.962 mm (1.8878-1.8883 in.)	47.91 mm (1.8862 in.)
	Oil Clearance	0.038-0.074 mm (0.0015-0.0029 in.)	0.150 mm (0.0060 in.)
Crank Journal	Outside Diameter	49.952-49.962 mm (1.9666-1.9670 in.)	49.75 mm (1.9587 in.)
	Oil Clearance	0.038-0.068 mm (0.0015-0.0017 in.)	0.150 mm (0.0059 in.)

- Use dimension R for grinding the crankshaft journals and pins **(Figure 5-110)**.

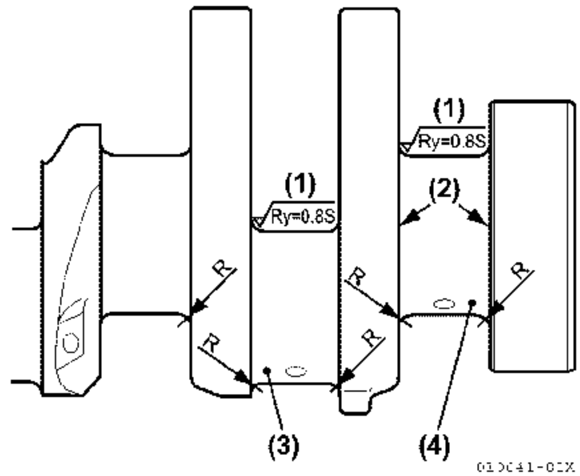


Figure 5-110

1 – Super Polishing
2 – Thrust Face
3 – Crank Pin
4 – Crank Journal

Surface finishing standard on journal and pin: Ry=0.8S super polishing
Surface finishing standard on the thrust side of crankshaft arm:

Finishing Standard of Dimension R
3.5 +0.3 / 0 mm (0.138 +0.012 / 0 in.)

NOTICE:

- *If oil clearances are excessive or if partial uneven wear is indicated on the crankpins and / or main bearing journals, regrind the crankshaft and use oversized bearings.*
- *If oxidation or other surface imperfections are apparent on the back side of the bearing insert, clean and coat the back surface with machinist's blue dye. Install the bearing inserts in the connecting rod and tighten the cap to the specified torque. Disassemble and check the bearing surface contact. If the contact surface equals 75% or more, the bearing is normal. If the contact surface is less, the bearing contact surface is insufficient. Replace bearing with a new one.*

- After assembling the crankshaft, tighten the main bearing caps to the specified torque, and move the crankshaft forward and aft. Place a dial gauge on one end of the crankshaft to measure thrust clearance **(Figure 5-111)**. Replace the thrust bearing if it exceeds the limit.

Item	Standard	Limit
Crankshaft Side Gap	0.14-0.22 mm (0.0055-0.0087 in.)	0.30 mm (0.0118 in.)

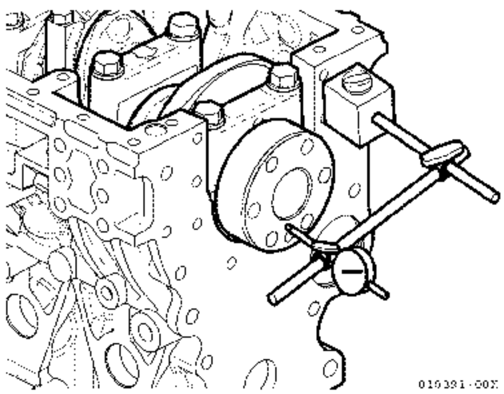


Figure 5-111

A second method of measuring thrust clearance is to insert a feeler gauge directly into the space between the thrust bearing and crankshaft thrust face **(Figure 5-112)**.

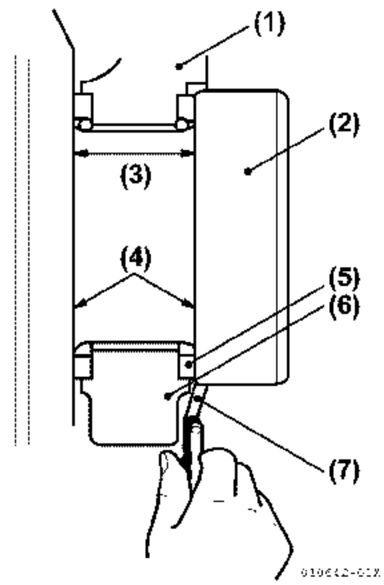


Figure 5-112

1 – Cylinder Block
2 – Crankshaft
3 – Standard Width
4 – Thrust Face
5 – Thrust Bearing
6 – Bearing Cap
7 – Feeler Gauge

Main Bearing

Inspect the main bearing.

- Check for flaking, seizure or discoloration of the contact surface.
- Replace if necessary.
- Tighten the cap to the specified torque and measure the inner diameter of the bearing.

Tightening Torque	96-100 N·m (70.8-73.8 lb-ft)

Inspection Items		Standard	Limit
Crank Journal (Selective Pairing)	Journal Outside Diameter	49.952-49.962 mm (1.9667-1.9670 in.)	49.902 mm (1.9646 in.)
	Bearing Inside Diameter	51.000-51.010 mm (2.0079-2.0083 in.)	-
	Bearing Thickness	1.995-2.010 mm (0.0785-0.07913 in.)	-
	Clearance	0.038-0.068 mm (0.00150-0.00268 in.)	0.150 mm (0.00591 in.)

Note: When assembling the bearing cap, keep the following in mind.

- The lower bearing insert (cap side) has no oil groove.
- The upper bearing insert (block side) has an oil groove.
- Check the cylinder block alignment number.
- The “FW” on the cap is used on the flywheel end.

Camshaft and Tappets

Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimizes the repeated shocks on the valve seats and maximizes valve seat life **(Figure 5-113)**.

3JH5E Camshaft Shown

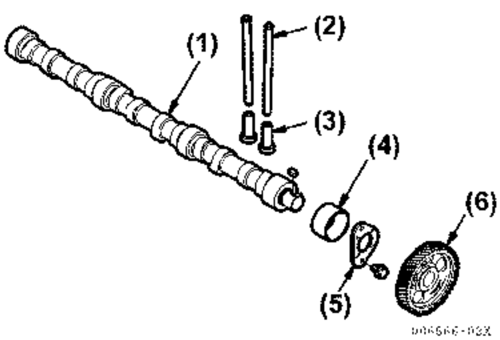


Figure 5-113

1 – **Camshaft**
2 – **Push Rod**
3 – **Tappet**
4 – **Camshaft Bushing**
5 – **Thrust Bearing**
6 – **Camshaft Gear**

- Checking the camshaft side gap. Measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing **(Figure 5-114)**.

Item	Standard	Limit
Camshaft Side Gap	0.05-0.20mm (0.0020-0.0079 in.)	0.35mm (0.0138 in.)

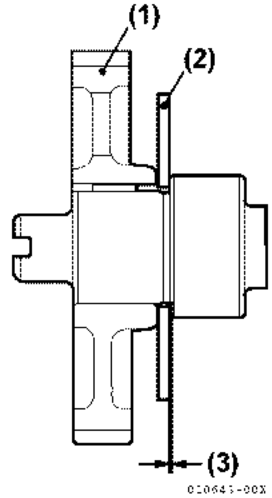


Figure 5-114

1 – **Camshaft Gear**
2 – **Thrust Bearing**
3 – **Camshaft Side Gap**

- Measure the camshaft height, and replace the cam if it is worn beyond the limit **(Figure 5-115)**.

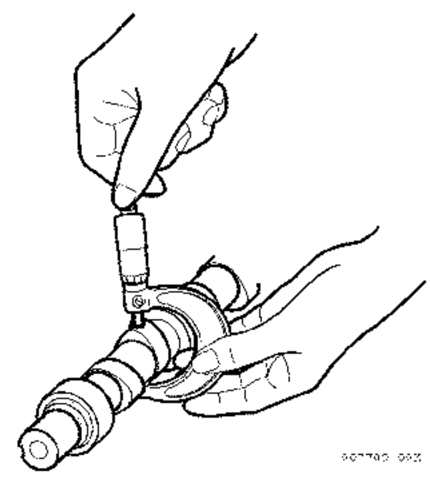


Figure 5-115

Item		3JH5E / 4JH5E		4JH4-TE / 4JH4-HTE	
		Standard	Limit	Standard	Limit
Cam Height	Intake	38.600-38.800mm (1.5197-1.5276 in.)	38.350mm (1.5098 in.)	39.800-40.000mm (1.5669-1.5748 in.)	39.550mm (1.5571 in.)
	Exhaust			37.800-38.000mm (1.4882-1.4961 in.)	37.550mm (1.4783 in.)

- Measure the camshaft outside diameter with a micrometer **(Figure 5-116).** The oil clearance shall be calculated by subtracting the measured camshaft outside diameter from the inside diameter of the camshaft bearing or bushing. The camshaft bushing at gear case side is measured with a cylinder gauge after insertion to the cylinder **(Figure 5-116).** Replace if they exceed the limit or are damaged.

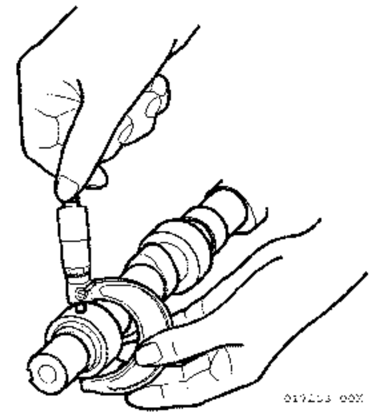


Figure 5-116

Place	Item	Standard	Limit
Gear Side	Bushing I.D.	44.990-45.055 mm (1.771-1.774 in.)	45.130 mm (1.777 in.)
	Camshaft O.D.	44.925-44.950 mm (1.769-1.770 in.)	44.890 mm (1.7673 in)
	Oil Clearance	0.040-0.130 mm (0.0016-0.0051 in.)	0.240 mm (0.0009 in.)
Intermediate Position (Metal Less)	Bushing I.D.	45.000-45.025 mm (1.772 -1.773 in.)	45.100 mm (1.7760 in.)
	Camshaft O.D.	44.910-44.935 mm (1.768-1.7691 in.)	44.875 mm (1.7667)
	Oil Clearance	0.065-0.115 mm (0.0026-0.0045 in.)	0.225 mm (858 in.)
Flywheel End (Metal Less)	Bushing I.D.	45.000-45.025 mm (1.772-1.773 in.)	45.100 mm (1.7756 in.)
	Camshaft O.D.	44.925-44.950 mm (1.769-1.770 in.)	44.890 mm (1.7674 in.)
	Oil Clearance	0.050-0.100 mm (0.0020-0.0039 in.)	0.210 mm (0.00827 in.)

- Support both ends of the crankshaft with V-blocks, place a dial gauge at the central bearing areas and measure bending **(Figure 5-117)**. Replace if excessive.

Note: The reading on the dial gauge is divided by two to obtain the camshaft bend.

Item	Standard	Limit
Camshaft Bend	0.02 or less mm (0.0008 or less in.)	0.05 mm (0.002 in.)

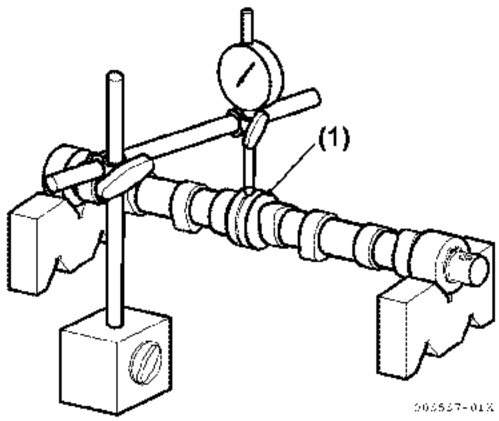


Figure 5-117

1 – Camshaft Central Bearing Area

Tappets

The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.

Note: When removing tappets, be sure to keep them separate for each cylinder and intake / exhaust valve **(Figure 5-118)**.

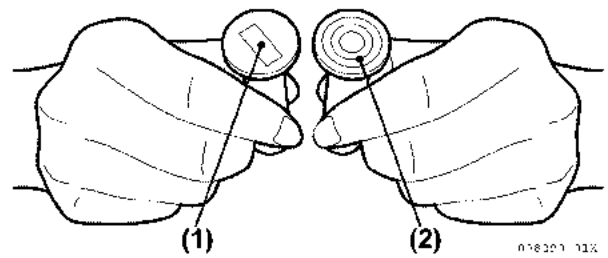


Figure 5-118

1 – Abnormal Contact Surface
2 – Normal Contact Surface

Measure the outer diameter of the tappet, and replace if worn beyond the limit **(Figure 5-119)**.

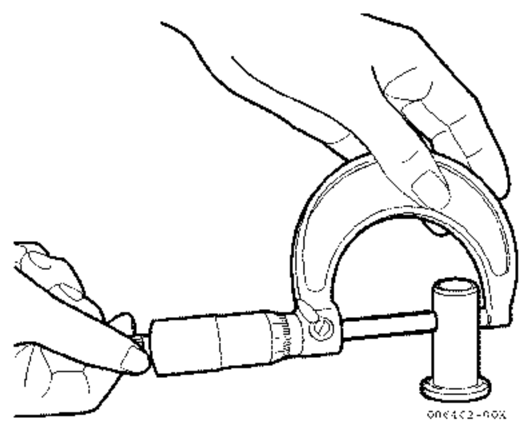


Figure 5-119

Item	3JH5E / 4JH5E		4JH4-TE / 4JH4-HTE	
	Standard	Limit	Standard	Limit
Tappet Stem Outside Diameter	11.975-11.990 mm (0.4715-0.4720 in.)	11.930 mm (0.4697 in.)	11.975-11.990 mm (0.4715-0.4720 in.)	11.930 mm (0.4697 in.)
Tappet Guide Hole Inside Diameter (Cylinder Block)	12.000-12.018 mm (0.4724-0.4731 in.)	12.045 mm (0.4742 in.)	12.000-12.025 mm (0.4724-0.4734 in.)	12.052 mm (0.4745 in.)
Oil Clearance	0.010-0.043 mm (0.0004-0.0017 in.)	0.090 mm (0.0035 in.)	0.010-0.050 mm (0.0004-0.0020 in.)	0.097 mm (0.0038 in.)

Push Rods

Measure the length and bending of the push rods **(Figure 5-120)**.

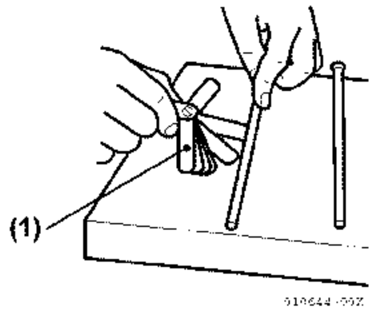


Figure 5-120

1 – Feeler Gauge

Item	Standard	Limit
Push Rod Length	178.25-178.75 mm (7.018-7.037 in.)	-
Push Rod Bend	Less than 0.03 mm (Less than 0.0012 in.)	0.3 mm (0.012 in.)
Push Rod Diameter	8.5 mm (0.3346 in.)	-

Timing Gear

The timing gear is the helical type for minimum noise and specially treated for high durability.

Gear Inspection

- Inspect the gears and replace if the teeth are damaged or worn.
- Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

Note: If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

Item	Standard	Limit
Backlash	0.07-0.15 mm (0.0018-0.0059 in.)	0.17 mm (0.0067 in.)

- The bushing is pressed into the idler gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idler gear shaft if the oil clearance exceeds the wear limit **(Figure 5-121)**.

A, B and C are inscribed on the end of the idler gear. When assembling, these marks should align with those on the cylinder block.

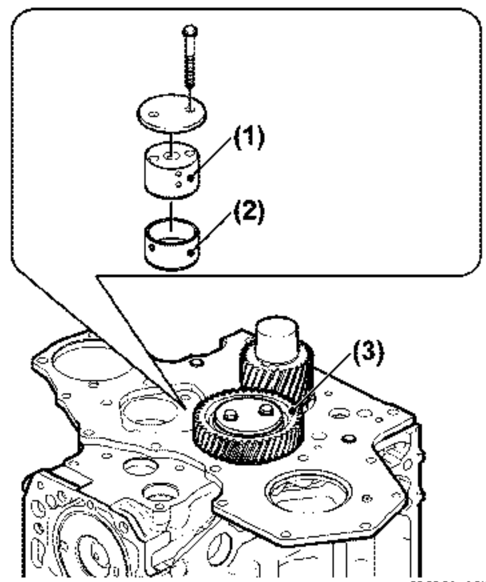


Figure 5-121

1 – Idler Gear Shaft
2 – Idler Gear Bushing
3 – Idler Gear

Item	Standard	Limit
Idler Shaft Diameter	45.950-45.975 mm (1.809-1.810 in.)	45.880 mm (1.806 in.)
Idler Gear Bushing Inside Diameter	46.000-46.025 mm (1.811-1.812 in.)	46.075 mm (1.814 in.)
Oil Clearance	0.025-0.075 mm (0.00098-0.0030 in.)	0.15 mm (0.0059 in.)

Gear Timing Marks

Match up the timing marks on each gear when assembling (A, B and C) **(Figure 5-122)**.

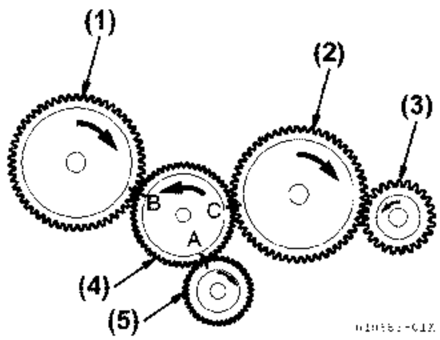


Figure 5-122

1 – Fuel Injection Pump Drive Gear
2 – Camshaft Gear
3 – Seawater Pump gear
4 – Idler Gear
5 – Camshaft Gear

Flywheel and Housing

The function of the flywheel is through inertia, to rotate the crankshaft in a uniform and smooth manner by absorbing the turning force created during the combustion stroke of the engine, and by compensating for the decrease in turning force during the other strokes.

The flywheel is mounted and secured by six bolts on the crankshaft end at the opposite end to the gear case; it is covered by the mounting flange (flywheel housing) which is bolted to the cylinder block.

The fitting surface for the damper disk is on the crankshaft side of the flywheel. The rotation of the crankshaft is transmitted through this disk to the input shaft of the reduction and reversing gear. The reduction and reversing gear is fitted to the mounting flange.

The flywheel's unbalanced force on the shaft center must be kept below the specified value for the crankshaft as the flywheel rotates with the crankshaft at high speed.

To achieve this, the valance is adjusted by drilling holes in the side of the flywheel, and the unbalanced momentum is adjusted by drilling holes in the circumference.

The ring gear is shrink fitted onto the circumference of the flywheel, and this ring gear serves to start the engine by meshing with the starter motor pinion.

The stamped letter and line which show top dead center of each cylinder are positioned on the flywheel circumference, and by matching these marks with the arrow mark at the hole of the flywheel housing, the rotary position of the crankshaft can be ascertained in order to adjust tappet clearance or fuel injection timing.

Position of Top Dead Center and Fuel Injection Timing

- The marking is applied on the flywheel to show the crankshaft angle **(Figure 5-123)**.

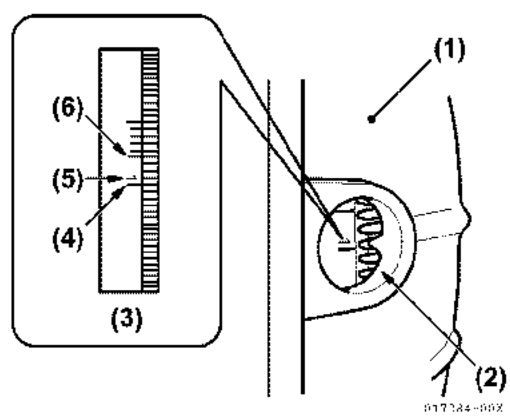


Figure 5-123

1 – Flywheel Housing
2 – Hole
3 – Flywheel
4 – TDC
5 – No. 1 Cylinder
6 – Injection Timing Mark

- The matching mark is made at the hole of the flywheel housing **(Figure 5-124)**.

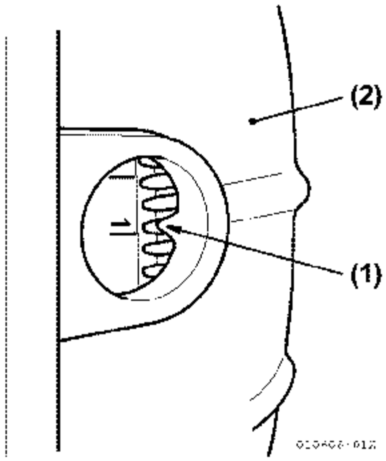


Figure 5-124

1 – **Matching Mark**
2 – **Flywheel Housing**

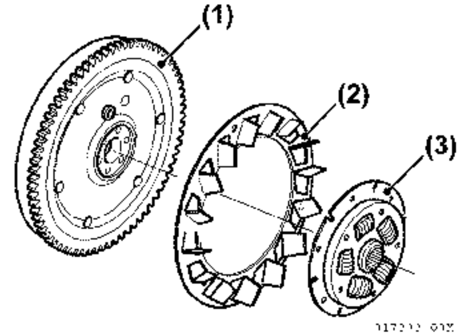


Figure 5-125

1 – **Flywheel**
2 – **Cooling Fan**
3 – **Damper Disk**

Damper Disk and Cooling Fan

When coupling a marine gear with an engine, a damper disk is used to absorb the torque fluctuations of the engine. *Refer to the Marine Gear Service Manual for details.*

Damper Disk (Parts No.: 177090-03500) for KM4A2 Marine Gear.

Torsional Rigidity	22.3 N·m / rad (16.45 lb-ft / rad)
Maximum Angle of Torsion	7.3 x 10 - 2 rad
Stopper Torque	2.12 N·m (1.565 lb-ft)

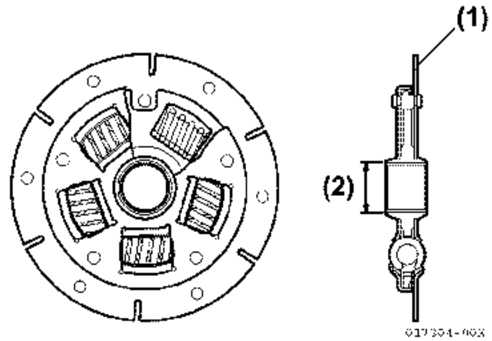
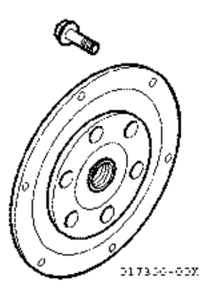
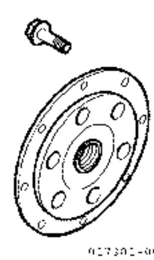
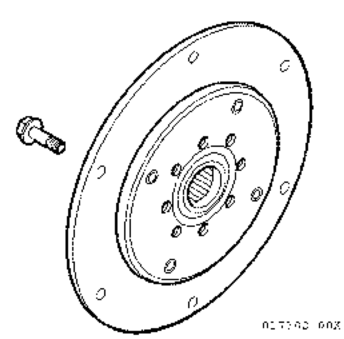


Figure 5-126

1 – **Flywheel End**
2 – **Spline SAE 20/40**

Damper Disks for KMH4A, ZF30M and SD50

Marine Gear	KMH4A	ZF30M	SD50
Damper Disk Part No.	129673-81760	129673-81250	196440-04300
			

ASSEMBLY

To reassemble the engine, perform the following preliminary steps:

1. Clean all parts using a cloth and clean diesel fuel or other cleaning agent.
   - Dust remaining on engine parts may cause seizing or other damage.
   - Cleaning agents will remove carbon adhering to disassembled parts.
2. Place a wood block on the floor and place the cylinder block upside down with the cylinder head mounting surface facing down **(Figure 5-127)**.

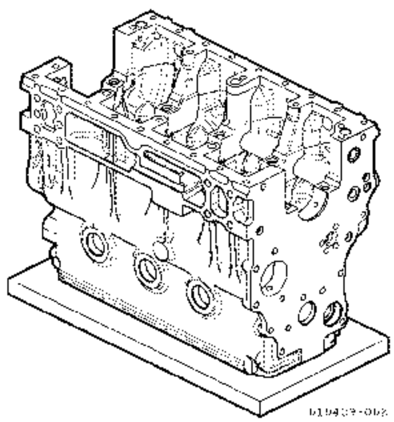


Figure 5-127

3. Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, then insert the tappets in the cylinder block **(Figure 5-128)**.

Note: Separate the tappets to make sure that they are reassembled in the same cylinder number and intake / exhaust side as they came from.

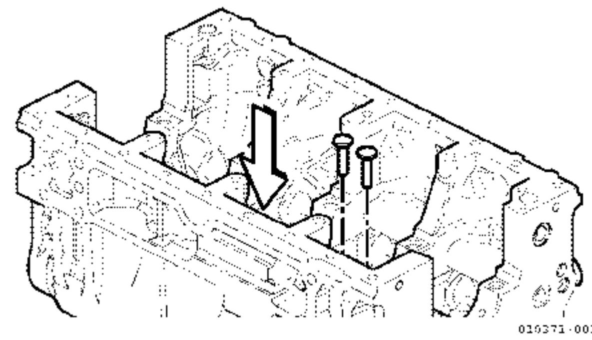


Figure 5-128

4. Install the crankshaft **(Figure 5-129)**:

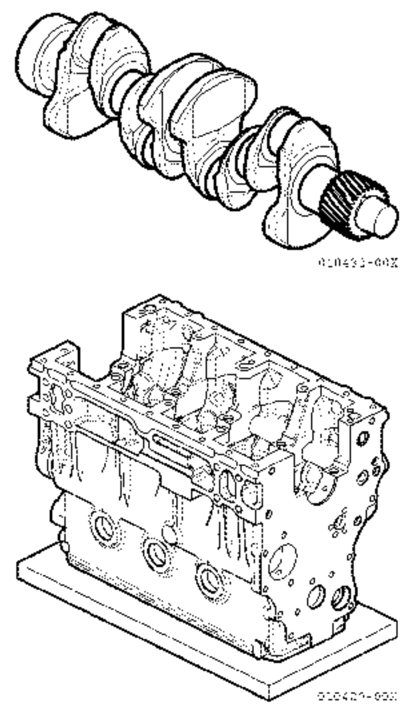


Figure 5-129

- The crankshaft and the crankshaft gear are shrink-fitted. If the crankshaft and the crankshaft gear have been disassembled, they have to be shrink-fitted. Heat the crankshaft gear to 180° to 200°C (356° to 392°F) in hot oil and press fit to the crankshaft.
- Coat the crank journal part of the cylinder block and the upper main bearing with engine oil, then fit the upper main bearing onto the cylinder block.
- Be sure not to confuse the upper and lower main bearings. The upper bearing has an oil groove.
- When mounting the thrust bearing, fit it so that the surface with the oil groove faces outward on the crankshaft side.
- Coat the crank pins and the crank journals of the crankshaft with engine oil and the crankshaft on the upper main bearings.
- Position the crankshaft so that the crankshaft gear is on the gear case side.
- Do not to let the thrust bearing drop.

5. Coat the lower main bearing with engine oil, and mount it to the main bearing cap **(Figure 5-130)**.
   - The lower main bearing does not have an oil hole.
   - The base thrust bearing is fitted with the oil groove facing outward.

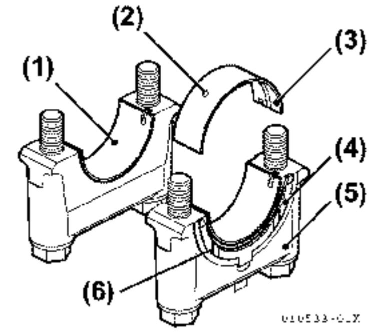


Figure 5-130

1 – Lower Main Bearing
2 – Oil Hole
3 – Upper Main Bearing
4 – Thrust Bearing
5 – Main Bearing Cap (base)
6 – Groove

6. Coat the flange and the thread of the main bearing bolts with engine oil, put them on the crankshaft journal and tighten the main bearing bolts to the specified torque **(Figure 5-131)**.

Main Bearing Bolt Torque	96-100 N·m (71-74 lb-ft)

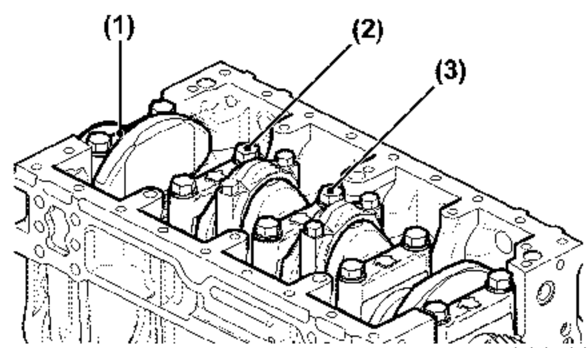


Figure 5-131

1 – Main Bearing Cap (base)
2 – Main Bearing Cap
3 – Main Bearing Bolt

Note: The main bearing cap should be mounted with the arrow on the cap pointing toward the flywheel. Ensure the cylinder alignment number is correct **(Figure 5-132)**.

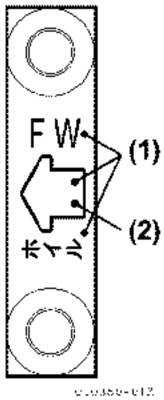


Figure 5-132

1 – Mark
2 – Flywheel End

7. Measure the crankshaft side clearance. Ensure the crankshaft rotates smoothly.

Crankshaft Side Clearance	**Standard**	**Limit**
	0.140-0.220 mm (0.0055 +0.0031 in.)	0.28 mm (0.011 in.)

8. Install a new oil seal. Press the oil seal in the oil seal case. Coat the lip of the oil seal with engine oil **(Figure 5-133)**.

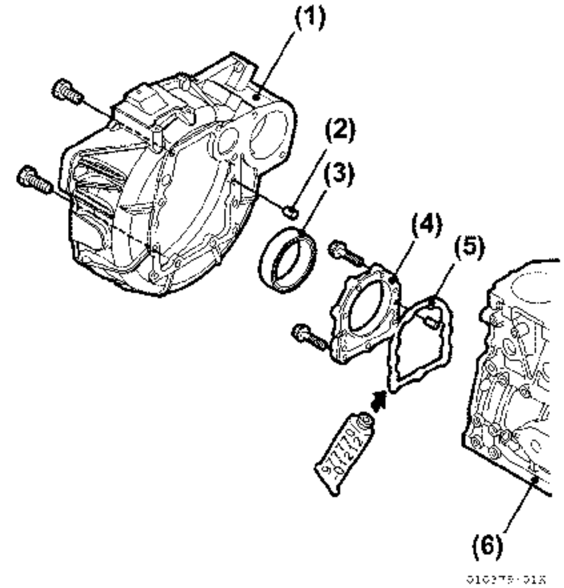


Figure 5-133

1 – Flywheel Housing
2 – Parallel Pin
3 – Oil Seal
4 – Oil Seal Case
5 – Liquid Gasket
6 – Cylinder Block

9. Apply liquid gasket to the mounting surface of the oil seal case. Mount the oil seal case to the cylinder block, while matching up the cylinder block positioning pins **(Figure 5-133)**.

Note: Be careful that the liquid gasket does not protrude onto the oil pan mounting surface.

10. Mount the flywheel housing to the cylinder block, while matching up with the cylinder block positioning pins **(Figure 5-133)**.
11. Stand the engine on the flywheel housing **(Figure 5-134)**.

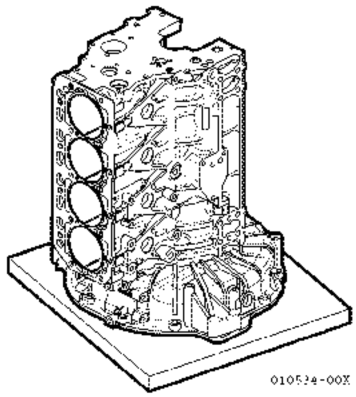


Figure 5-134

12. Apply the liquid gasket to the gear case flange. Mount the gear case and lubricating oil line O-ring to the cylinder block **(Figure 5-135)**.

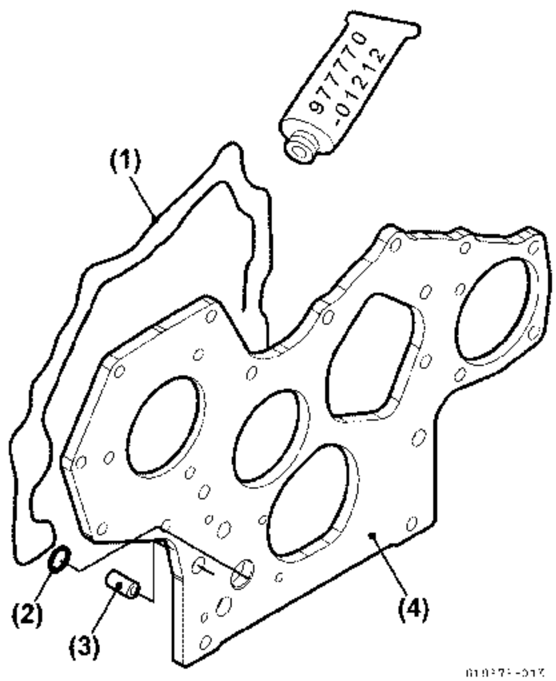


Figure 5-135

1 – Liquid Gasket
2 – O-Ring
3 – Knock Pin
4 – Gear Case

- When mounting the gear case, match the two cylinder block knock pins.
- Coat the O-ring for the cylinder block with lubricating oil and line with grease before installing **(Figure 5-135)**.

13. Assemble the piston and connecting rod:
    - When assembling the piston and connecting rod, ensure correct orientation.
    - Install each piston ring on the piston, with the punched manufacturer's mark facing upward **(Figure 5-136)**.

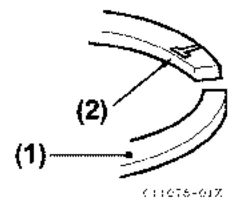


Figure 5-136

1 – Piston Ring
2 – Punched Manufacturer's Mark

- The piston ring joints must be staggered at 120° to each other. Do not position the top ring joint in line with the piston pin **(Figure 5-137)** and **(Figure 5-138)**. The coil expander joint must be opposite the oil ring joint **(Figure 5-139)**.

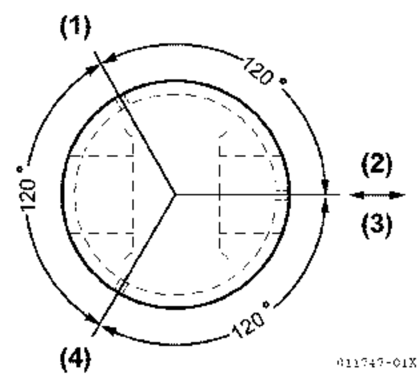


Figure 5-137

1 – Top Piston Ring Gap
2 – Direction of Piston Pin
3 – Oil Control Ring Gap
4 – Middle Piston Ring Gap

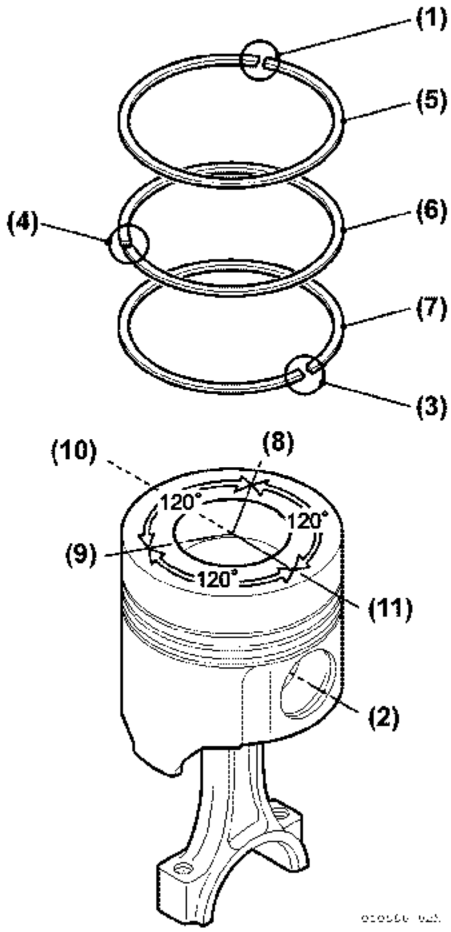


Figure 5-138

1 – Top Piston Ring Gap
2 – Direction of Piston Pin
3 – Oil Control Ring Gap
4 – Middle Piston Ring Gap
5 – Top Piston Ring
6 – Middle Piston Ring
7 – Oil Control Ring
8 – Top Piston Ring Gap
9 – Middle Piston Ring Gap
10 – Expander Joint
11 – Oil Control Ring Gap

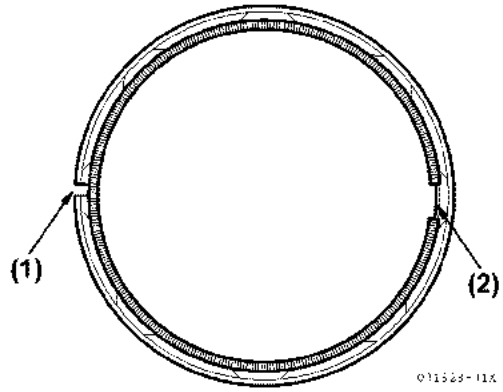


Figure 5-139

1 – Gap
2 – Joint of Coil Expander

14. Coat the outside of the piston and the inside of the crank pin bearing with engine oil and insert the piston by using the piston insertion tool.
    - Insert the piston so that the match mark on the large end of the connecting rod faces the fuel nozzle, and the manufacturer's embossed mark on the stem faces toward the flywheel.
    - After inserting the piston, make sure the ID marks (size mark and model mark) on the piston top are in the correct position, looking from the top of the piston **(Figure 5-140)** and **(Figure 5-141)**.

3JH5E and 4JH5E Engines

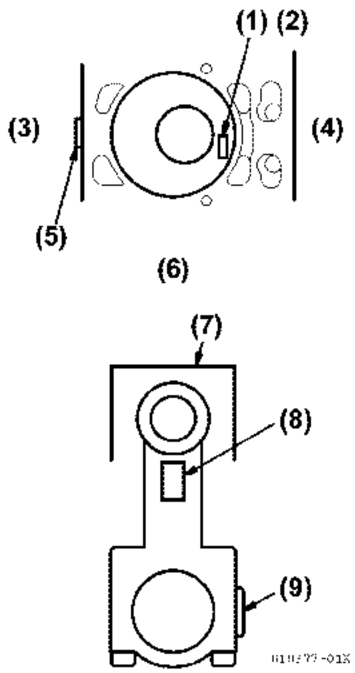


Figure 5-140

1 – Size Mark
2 – Model Mark
3 – Camshaft Side
4 – Nozzle Side
5 – Cylinder Size Mark
6 – Flywheel End
7 – Piston ID Mark
8 – Embossed Mark (flywheel end)
9 – Match Mark

4JH4-TE and 4JH4-HTE Engines

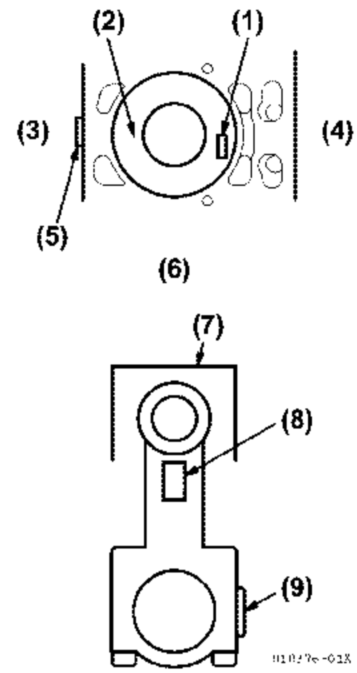


Figure 5-141

1 – Size Mark
2 – Model Mark
3 – Camshaft Side
4 – Nozzle Side
5 – Cylinder Size Mark
6 – Flywheel End
7 – Piston ID Mark
8 – Embossed Mark (flywheel end)
9 – Match Mark

- When inserting the piston / connecting rod assembly, ensure it does not hit the large end of the connecting rod with the piston cooling nozzle (4JH4-(H)TE) mounted on the back of the cylinder block. If this happens, the cooling nozzle may warp or be damaged.
- Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

Connecting Rod Bolt Torque	44.1-49.1 N·m (32.5-36.2 lb-ft)

Note: If a torque wrench is not available, match up with the mark made before disassembly.

15. If the camshaft and the camshaft gear have been disassembled, shrink fit the camshaft and the camshaft gear. Heat the camshaft gear in hot oil to 180° to 220°C (356° to 428°F) and press fit onto the camshaft.

Note: Ensure the thrust bearing assembly is in place when mounting the camshaft, ensuring orientation is correct.

16. Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block and tighten the thrust bearing bolts.
17. Measure the camshaft side gap **(Figure 5-142, (3))**. Ensure the camshaft rotates smoothly.

Item	Standard	Limit
Camshaft Side Gap	0.05-0.20 mm (0.002-0.008 in.)	0.30 mm (0.012 in.)

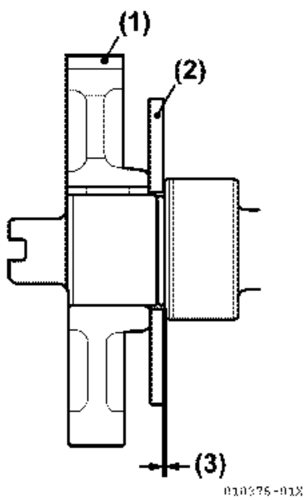


Figure 5-142

1 – **Camshaft Gear**
2 – **Thrust Bearing**
3 – **Side Gap**

18. Install the idler gear with the oil hole of the idler gear shaft faces up.

Note: The idler gear shaft must be installed with the shaft marking upward **(Figure 5-143)**.

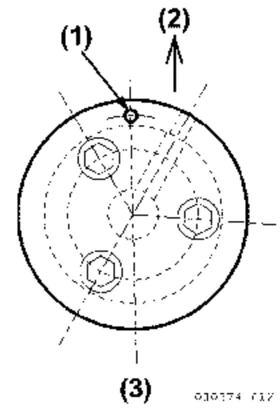


Figure 5-143

1 – **Mark**
2 – **UP Side**
3 – **Idler Gear Shaft**

19. Align the "A" and "C" match marks of the idler gear with the match marks of the camshaft gear and the crankshaft gear.
20. Measure the idler gear, camshaft gear and crankshaft gear backlash **(Figure 5-144).**

Item	Standard	Limit
Backlash	0.07-0.15 mm (0.003-0.006 in.)	0.17 mm (0.0067 in.)

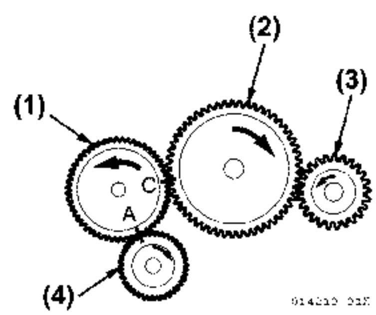


Figure 5-144

1 – **Idler Gear**
2 – **Camshaft Gear**
3 – **Seawater Pump Gear**
4 – **Crankshaft Gear**

21. Mount the lubricating oil pump to the gear case cover:

Oil Pump Bolt Torque	5.4-8.4 N·m (4.0-6.2 lb-ft)

- Before installing the outer / inner rotors, coat them with lubricating oil (10W30).
- Assemble the rotor so that the concave mark of the rotor is on the cover side.
- Ensure the rotor rotates smoothly.

22. Mount the gear case cover **(Figure 5-145)**:
    (a) Install a new oil seal. Coat the inside and outside of the oil seals with lubricating oil and press fit it into the gear case.
    (b) Apply liquid gasket to the gear case cover. Position the two knock pins and tighten the gear case bolts.

Note: Trim the liquid gasket material if it protrudes onto the oil pan mounting surface.

3JH5E and 4JH5E Engines Shown

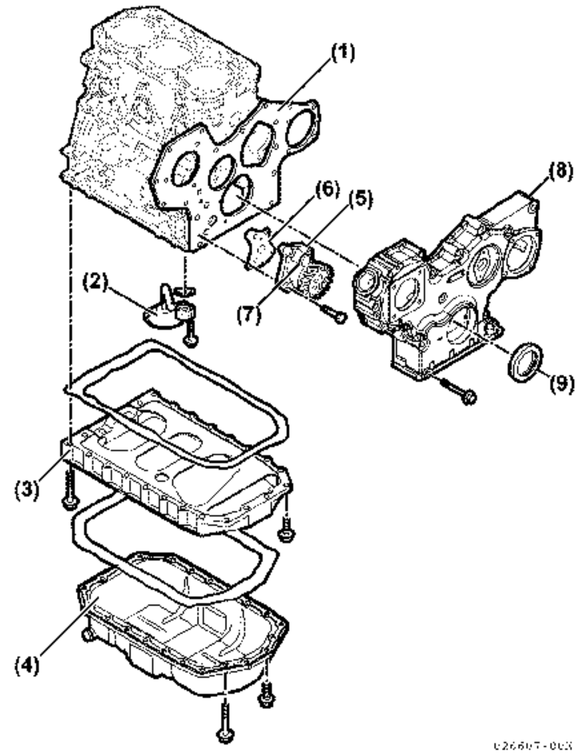


Figure 5-145

1 – Gear Case
2 – Lubricating Oil Inlet
3 – Spacer
4 – Oil Pan
5 – Lubricating Oil Pump
6 – Gasket
7 – Pressure Control Valve
8 – Gear Case Cover
9 – Oil Seal

23. Install the lubricating oil inlet pipe on the bottom of the cylinder block, using a new gasket.

Lubricating Oil Inlet Flange Torque	26 N·m (19 lb-ft)

24. Apply liquid gasket to the lubricating oil pump, gear case and oil seal case on the flywheel housing side that contacts the cylinder block.
25. Apply liquid gasket to the spacer. Install the spacer to the cylinder block and tighten the bolts.

26. Apply liquid gasket to the oil pan. Install the oil pan to the spacer and tighten the bolts.
27. Install the dipstick and dipstick guide.

Note: There are three surfaces requiring sealing for 4JH5E.

(a) Check the level gap of the three surfaces.

(b) Apply Three Bond 1207F to the three surfaces **(Figure 5-146)**.

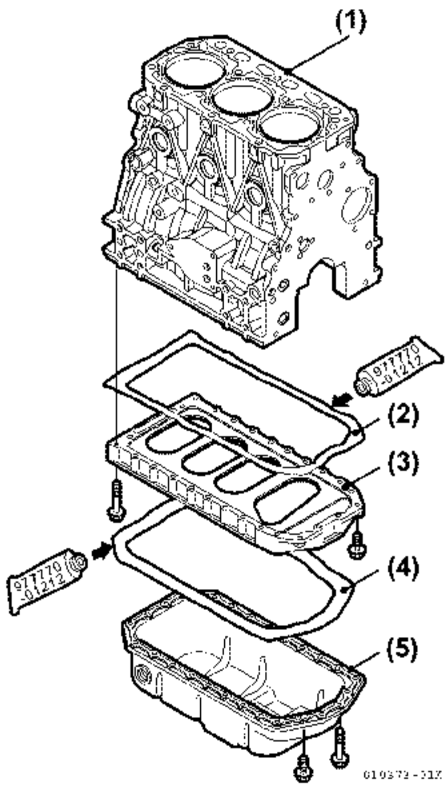


Figure 5-146

1 – Cylinder Block
2 – Liquid Gasket
3 – Spacer
4 – Liquid Gasket
5 – Oil Pan

28. Install the crankshaft V-pulley.

(a) Coat the oil seal with oil.

(b) Wipe oil from the taper surface.

(c) Tighten to the specified torque.

V-pulley Bolt Torque (Material: casting iron)	83.2-93.2 N·m (61.3-68.7 lb-ft)

29. Install the engine mounting feet and turn the engine upright.
30. Install the flywheel

(a) Coat the flywheel bolt threads with lubricating oil.

(b) Align the positioning pins, and tighten the flywheel bolts to the specified torque **(Figure 5-147)**.

Flywheel Bolt Torque	83.3-88.3 N·m (61.4-65.1 lb-ft)

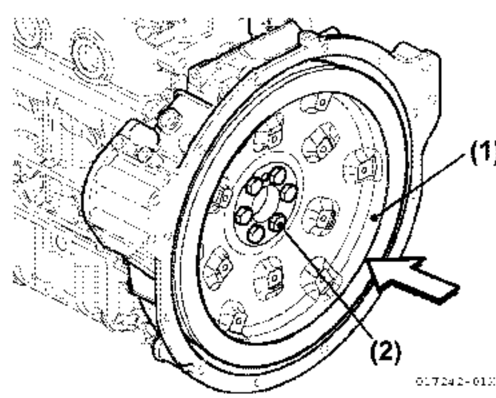


Figure 5-147

1 – Flywheel
2 – Flywheel Bolt

31. Install the marine gear:
    (a) Install the damper disk to the flywheel.
    (b) Align the damper disk with the input shaft spline and insert.
    (c) Install the marine gearbox to the flywheel housing.
32. Install the cylinder head. *NOTICE: Ensure the threaded bolt holes are clean and dry. If coolant or oil remains in the holes, there is a risk of cracking the cylinder block when the bolts are installed.*

    Replace the old cylinder head gasket with new one.

    (a) Put the cylinder head gasket on the cylinder block, aligning it with the cylinder block positioning pins.

Note: Select the proper head gasket using the holes shown in **Figure 5-148** for identification.

4JH5E, 4JH4-TE and 4JH4-HTE Engines Shown

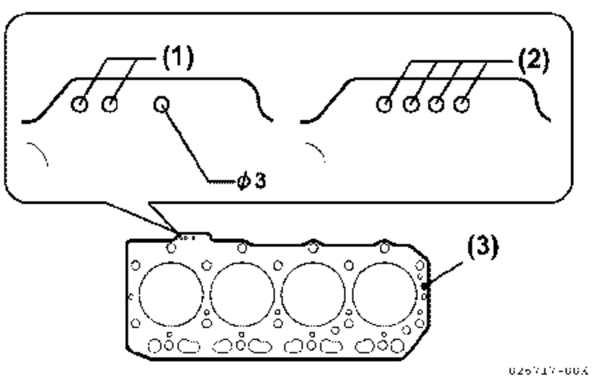


Figure 5-148

1 – Identification Holes 2-Ø3 for 4JH5E
2 – Identification Holes 4-Ø3 for 4JH4-TE and 4JH4-HTE
3 – Head Gasket

3JH5E Engine Shown

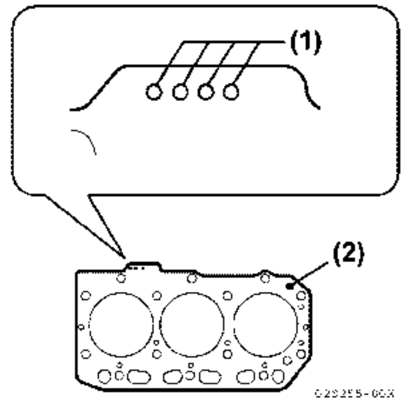


Figure 5-149

1 – Identification Holes 4-Ø3 for 3JH5E
2 – Head Gasket

(b) Lift the cylinder head horizontally and mount it aligning with the cylinder head gasket.

(c) Coat the flange part and thread of the cylinder head bolt with lubricating oil, and lightly tighten the bolts in the specified order.

(d) Then tighten to specified values in the same order.

Figure 5-150 shows head bolt tightening order for 3JH5E and **Figure 5-151** shows 4JH5E, 4JH4-TE and 4JH4-HTE.

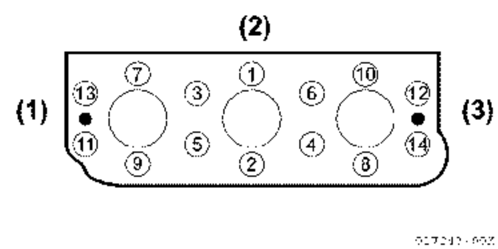


Figure 5-150

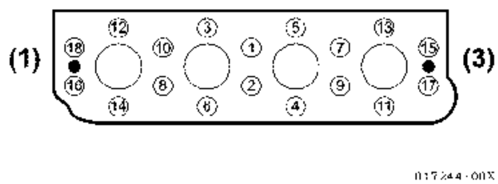


Figure 5-151

1 – Flywheel End
2 – Camshaft Side
3 – Gear Case Side

Item	1st step	Final
Cylinder Head Bolt Torque	39.2-49.1 N·m (28.9-36.2 lb-ft)	85.2-91.2 N·m (62.9-67.3 lb-ft)

(e) Measure the top clearance. *See Measuring Top Clearance on page 5-51.*

Clearance

Top Clearance	0.74 ± 0.06 mm (0.029 ± 0.002 in.)

33. Install the rocker arm shaft assembly and pushrods:
    (a) Fit the push rod to the tappet.
    (b) Coat the top of the push rod and the adjusting bolt of the rocker arm with lubricating oil. Install the rocker arm shaft assembly to the cylinder head. Apply lubricating oil to the bolt, locknut and hatched area of push rod.

Rocker Arm Shaft Support Torque	24-27 N·m (18-20 lb-ft)

    (c) Adjust valve clearance.

Clearance

Intake/Exhaust Valve Clearance	0.15-0.25 mm (0.0059-0.0098 in.)

    (d) Coat the rocker arm and valve spring with lubricating oil and install the rocker arm cover **(Figure 5-152)** and **(Figure 5-153)**.

2-Valve Head

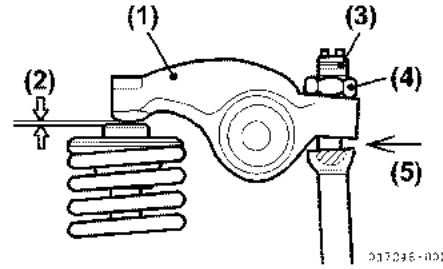


Figure 5-152

1 – Rocker Arm
2 – Valve Clearance
3 – Adjusting Bolt
4 – Locknut
5 – Engine Oil

4-Valve Head

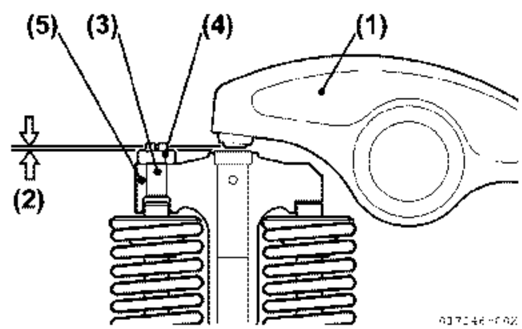


Figure 5-153

1 – Rocker Arm
2 – Valve Clearance
3 – Adjusting Bolt
4 – Locknut
5 – Valve Bridge (4JH4-TE and 4JH4-HTE only)

34. Adjust valve clearance - 2-valve cylinder head:
    (a) Loosen adjusting bolts.
    (b) Loosen the locknut and adjusting bolt, and check the valve for any inclination of valve cap, entrance of dirt or wear.
    (c) Insert a 0.2 mm (0.008 in.) feeler gauge between the rocker arm and valve cap.

(d) Adjust the valve clearance by turning the adjustment bolt until there is a slight "drag" on the feeler gauge when sliding it between the rocker arm and the valve cap.

Standard Intake / Exhaust Valve Clearance
0.15-0.25 mm (0.006-0.010 in.)

(e) Tighten the locknut.

(f) Apply oil to the contact surface between adjusting bolt and push rod.

(g) Adjusting other cylinders. *See step 36 on page 5-85.*

2-Valve Cylinder Head

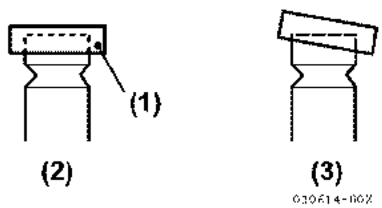


Figure 5-154

1 – Valve Cap
2 – Normal
3 – Abnormal

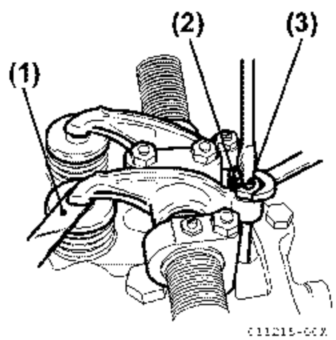


Figure 5-155

1 – Feeler Gauge
2 – Locknut
3 – Adjusting Bolt

35. Adjust valve clearance - 4 valve cylinder head:

(a) Loosen adjusting bolts. The 4-valve cylinder head has a valve bridge.

(b) Remove the injector to make space for inserting a wrench to hold the valve bridge. *NOTICE: Do not loosen or tighten the valve bridge adjusting bolt locknut without holding the valve bridge. Always hold the valve bridge using a wrench to prevent bending of the valve stems and / or valve bridge guide.*

(c) Loosen the bridge adjusting bolt locknut while holding the bridge with a wrench.

(d) Loosen the adjusting bolt by turning it two turns counterclockwise.

(e) Check for visible clearance between bolt and valve.

4-Valve Cylinder Head

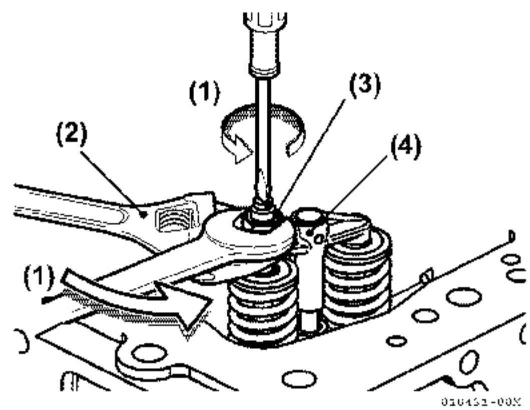


Figure 5-156

1 – Loosen
2 – Wrench
3 – Adjusting Bolt
4 – Valve Bridge

Adjusting valve bridge clearance:

- The valve bridge on the 4-valve system enables one rocker arm to operate two valves at the same time. The valve bridge should be adjusted exactly in horizontal position.
- The clearance between the valve bridge and valves must be set before adjusting the valve clearance between rocker arm and valve bridge.

(a) To assure the valve bridge has equal contact with the front and rear valves, apply light pressure to the rocker arm. Screw in the rocker arm adjusting bolt until rocker arm touches the valve bridge.

(b) Adjust the valve bridge adjusting bolt, so there is zero clearance between the adjustment bolt and the front valve.

(c) Tighten the locknut while holding the valve bridge with a wrench. Verify that the valve bridge clearance is zero.

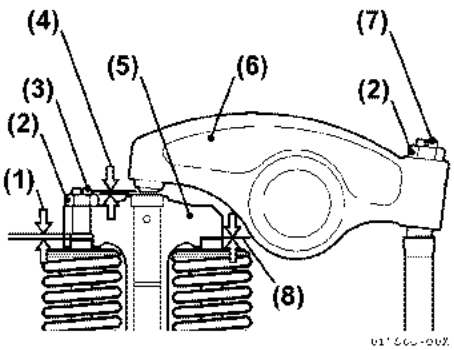


Figure 5-157

1 – Adjusting Valve Bridge Clearance to 0
2 – Locknut
3 – Valve Bridge Adjusting Bolt
4 – Valve Clearance
5 – Valve Bridge
6 – Rocker Arm
7 – Rocker Arm Adjusting Bolt
8 – Clearance 0

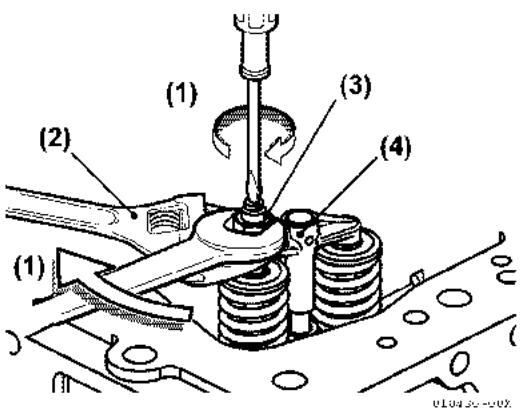


Figure 5-158

1 – Tighten
2 – Wrench
3 – Adjusting Bolt
4 – Valve Bridge

Valve clearance adjustment:

(a) Insert a 0.2 mm (0.008 in.) feeler gauge between the rocker arm and valve bridge.

(b) Adjust the valve clearance by turning the adjustment bolt until there is a slight “drag” on the feeler gauge when sliding it between the rocker arm and the valve bridge.

Standard Intake / Exhaust Valve Clearance
0.15-0.25 mm (0.006-0.010 in.)

(c) Tighten the locknut.

(d) Apply lubricating oil to the contact surface between adjusting bolt and push rod.

(e) Adjust other cylinders. See step 36 on page *5-85*.

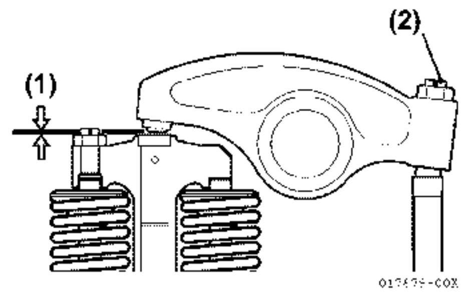


Figure 5-159

1 – Valve Clearance
2 – Rocker Arm Adjusting Bolt

36. Measuring other cylinders:

- 3JH5E engine:
  Turn the crankshaft 240° and make measurement and adjustment for the No. 3 cylinder. Then adjust the No. 2 cylinder.

  The cylinder to be measured and adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make measurement and adjustment for other cylinders in the order of ignition by turning the crankshaft 240° each time.

  The measurement and adjustment method of reducing the flywheel turning numbers (for reference):
  Set No. 1 cylinder to the compression TDC and adjust the clearance of the ● mark of the below table.
  Next, turn the flywheel once (the suction / exhaust valve of No. 1 cylinder is in the position of the overlap TDC at this time), and adjust the clearance of the O mark.
  Ignition order of 3-cylinder engines: 1 → 3 → 2

Cylinder No.	1		2		3		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No. 1 Compression TDC	●	●	●			●	The first time
No. 1 Overlap TDC				○	○		The second time

- 4JH5E / 4JH4-TE / 4JH4-HTE engines:
  Turn the crankshaft 180° and make measurement and adjustment for the No. 3 cylinder. Then adjust the No. 4 and No. 2 cylinders according to the order of injection.
  The cylinder to be adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is the nearest to the top dead center after turning, and make adjustment for other cylinders in the order of ignition by turning the crankshaft 180° each time.

  The measurement and adjustment method of reducing the flywheel turning numbers (for reference):
  Set No. 1 cylinder to the compression TDC and adjust the clearance of the ● mark of the bottom table.
  Next, turn the flywheel once, and adjust the clearance of the O mark.
  Ignition order of 4-cylinder engines: 1 → 3 → 4 → 2

Cylinder No.	1		2		3		4		
Valve	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	Suction	Exhaust	
No. 1 Compression TDC	●	●	●			●			The first time
No. 4 Compression TDC				○	○		○	○	The second time

37. 3JH5E and 4JH5E engines:
Install the fuel injection pump **(Figure 5-160, (1))**. *NOTICE: Never remove the bolts when tightening the fuel injection drive gear and fuel injection pump hub. Fuel injection timing may differ from the proper set value.*
   (a) Lightly fit the fuel injection pump on the gear case.
   (b) After adjusting injection timing, tighten the fuel injection pump.

Note: Do not scratch the O-ring between the fuel injection pump and gear case.

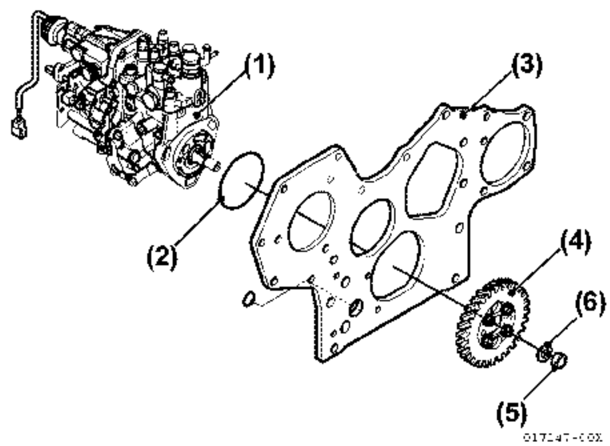


Figure 5-160

1 – Fuel Injection Pump
2 – O-Ring
3 – Gear Case
4 – Fuel Injection Pump Drive Gear and Fuel Injection Pump Hub
5 – Pump Drive Gear Nut
6 – Washer

   (c) Fit the fuel injection pump drive gear to the fuel pump camshaft.
   (d) Align the "B" match marks on the fuel injection pump drive gear and idler gear **(Figure 5-161)**.

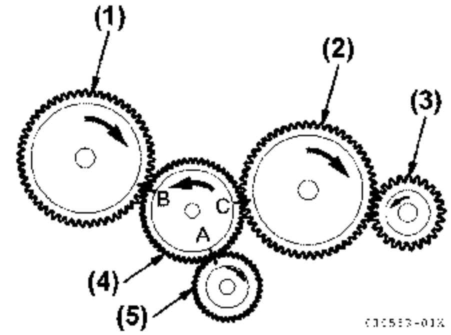


Figure 5-161

1 – Fuel Injection Pump Drive Gear
2 – Camshaft Gear
3 – Seawater Pump Gear
4 – Idler Gear
5 – Crankshaft Gear

   (e) Tighten the pump drive gear nut, fastening the fuel pump gear and camshaft to the specified torque.

3JH5E and 4JH5E Pump Drive Gear Nut Torque (No Lubricating Oil)	34.3 ± 2.0 N·m (25.3 ± 1.5 lb-ft)

   (f) Measure the backlash between the fuel injection pump drive gear and idle gear.

Fuel Injection Pump Drive Gear Backlash	0.07-0.15 mm (0.003-0.006 in.)

38. 4JH4-TE and 4JH4-HTE: Install the fuel injection pump.
   (a) Install the VE pump bracket and O-ring to the gear case while adjusting both mark-off lines of the bracket and gear case **(Figure 5-162)**.

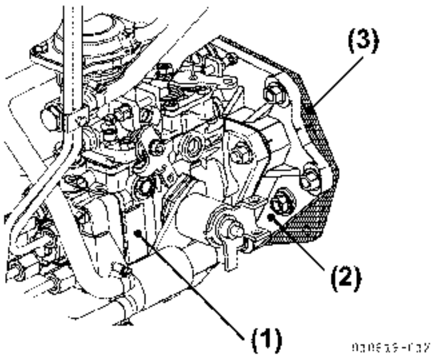


Figure 5-162

1 – VE Pump
2 – VE Pump Bracket
3 – Gear Case

(b) Install the fuel injection pump and O-ring to the VE pump bracket while adjusting both mark-off lines on the bracket with the VE pump. Lightly tighten the three nuts. After adjusting injection timing, tighten the fuel injection pump.

Note: Be careful not to scratch the O-ring between the fuel injection pump and bracket.

(c) Fit the pump drive gear to the pump camshaft **(Figure 5-163).**

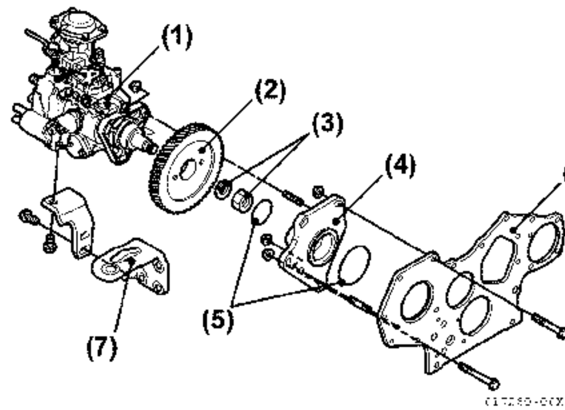


Figure 5-163

1 – Fuel Injection VE Pump
2 – Fuel Injection VE Pump Drive Gear
3 – Drive Gear Nut and Washer
4 – VE Pump Bracket
5 – O-Ring
6 – Gear Case
7 – VE Pump Support

(d) Align the "B" match marks on the pump drive gear and idler gear.

(e) After applying lubricating oil to the nut, tighten it to the specified torque.

4JH4-TE, 4JH4-HTE Pump Drive Gear Nut Torque (Coat with Lubricating Oil)	59-69 N·m (44-51 lb-ft)

(f) Measure the backlash between the pump drive gear and idler gear.

Backlash	0.07-0.15 mm (0.003-0.006 in.)

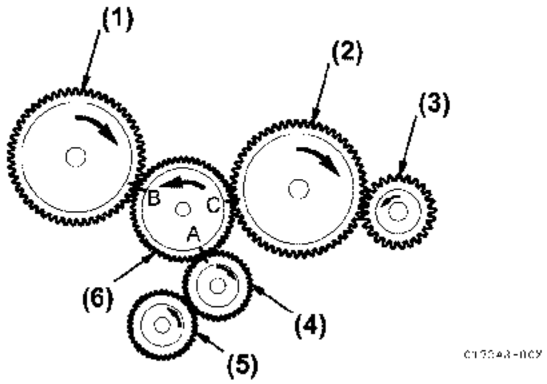


Figure 5-164

1 – Fuel Injection VE Pump Drive Gear
2 – Camshaft Gear
3 – Seawater Pump Gear
4 – Crankshaft Gear
5 – Lubricating Oil Pump Gear
6 – Idler Gear

(g) Install the VE pump supports for 4JH4-TE and 4JH4-HTE.

39. Install the fuel injection nozzle:

(a) Replace the used fuel nozzle protector and fuel nozzle seat. Put the seat in the cylinder head and the protector on the nozzle tip. Install the fuel injection nozzle to the cylinder head. *NOTICE: In the case of a 4-valve cylinder head, the fuel inlet of the fuel nozzle must align with the pipe seal, which is installed to the rocker arm cover. Replace the used pipe seal with a new one.*

3JH5E and 4JH5E Engines Shown

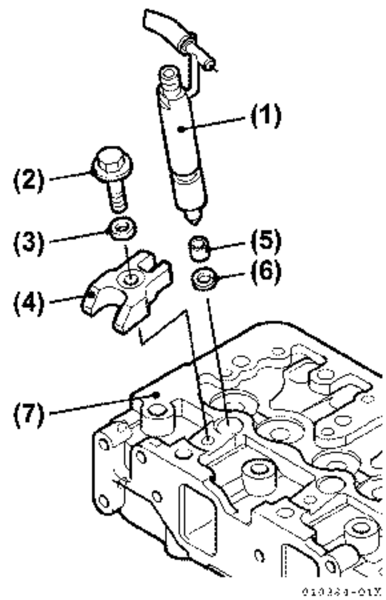


Figure 5-165

1 – Fuel Injection Nozzle
2 – Bolt
3 – Washer
4 – Fuel Nozzle Retainer
5 – Fuel Nozzle Protector
6 – Fuel Injection Seat
7 – Cylinder Head

4JH4-TE and 4JH4-HTE Engines Shown

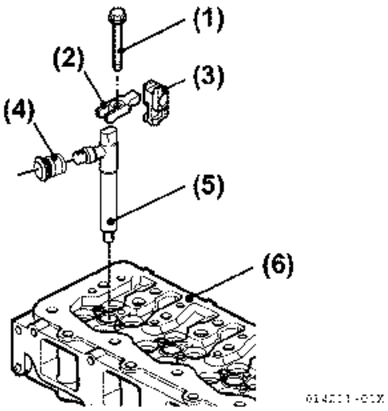


Figure 5-166

1 – Fuel Injection Nozzle
2 – Bolt
3 – Retainer
4 – Line Seal
5 – Fuel Injection Nozzle
6 – Cylinder Head

(b) Tighten the fuel nozzle retainer bolt to the specified torque. Do not apply lubricating oil to the bolt.

Tightening Torque of Fuel Nozzle Retainer Bolt

Model	Fuel Nozzle Retainer Bolt Torque
4JH4-TE and 4JH4-HTE	24.4-28.4 N·m (18-21 lb-ft.)
3JH5E and 4JH5E	26.4 ± 2.0 N·m (19.5 ± 1.5 lb-ft)

40. Install the freshwater pump:

(a) Thoroughly coat both sides of the gasket with adhesive.

(b) Replace the O-ring for the connecting part of the pump, which is inserted in the cylinder block, and tighten the freshwater pump to the specified torque **(Figure 5-167)**.

Freshwater Pump Torque	6.9 -11 N·m (5.1 -8.1 lb-ft.)

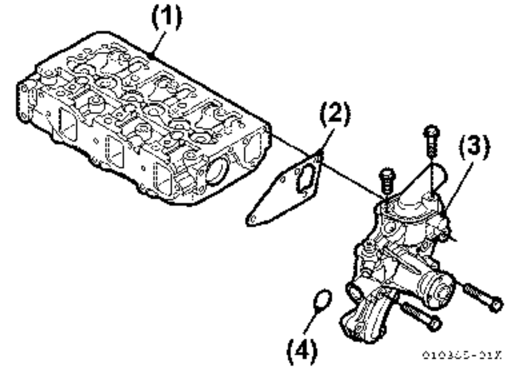


Figure 5-167

1 – Cylinder Head
2 – Gasket
3 – Freshwater Pump
4 – O-Ring

41. Thoroughly clean the inside of the intake manifold. Install the gasket and intake manifold **(Figure 5-168)**.

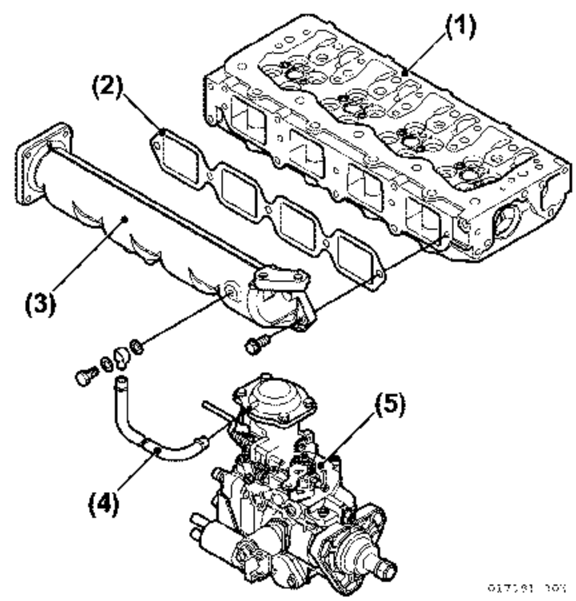


Figure 5-168

1 – Cylinder Head
2 – Gasket
3 – Intake Manifold
4 – B.C.S. Line of VE Pump
5 – VE Pump

Note: Connect the B.C.S. line to the VE Pump and intake manifold for the 4JH4-TE and 4JH4-HTE.

42. Install the fuel injection line and then assemble the fuel injection line retainer to prevent line vibration.

Note: Lightly tighten the line joint nuts on both ends of the fuel injection line. Completely tighten after adjusting the injection timing.

Fuel Injection Line Joint Nut Standard Torque	29.4-34.4 N·m (21.7-25.4 lb-ft)

43. Mount the fuel return line **(Figure 5-169, (5))** and **(Figure 5-170, (5))**.

4JH5E Engine Shown (3JH5E is Similar)

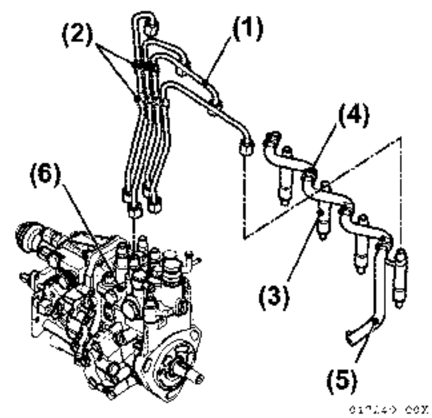


Figure 5-169

1 – Fuel Injection Line
2 – Fuel Injection Line Retainer
3 – Fuel Injection Nozzle
4 – Clamp
5 – Fuel Return Line
6 – Fuel Injection Pump

4JH4-TE and 4JH4-HTE Engines

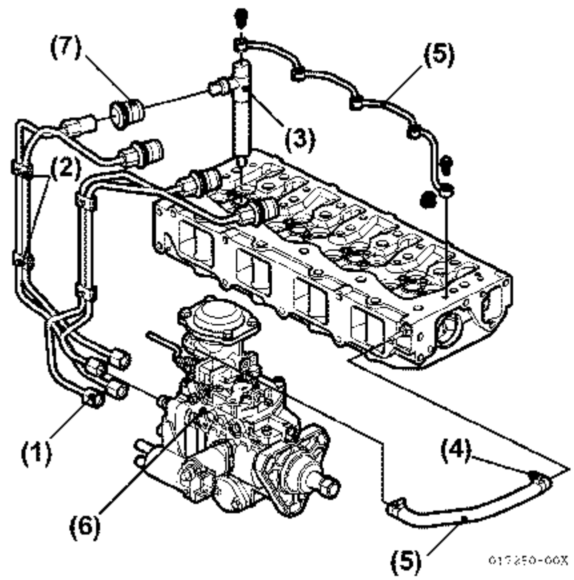


Figure 5-170

1 – Fuel Injection Line
2 – Fuel Injection Line Retainer
3 – Fuel Injection Nozzle
4 – Clamp
5 – Fuel Return Line
6 – Fuel Injection Pump
7 – Line Seal

44. Install the filter bracket and gasket on the cylinder block **(Figure 5-171)**.

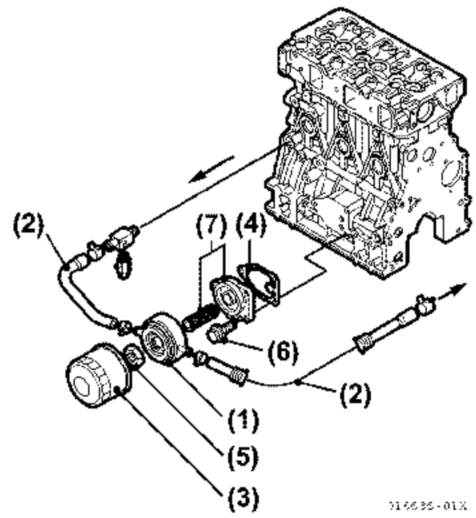


Figure 5-171

1 – **Lubricating Oil Cooler**
2 – **Freshwater Lines**
3 – **Lubricating Oil Filter**
4 – **Gasket**
5 – **Lubricating Oil Cooler Nut**
6 – **Bolt for Filter Bracket**
7 – **Filter Bracket**

45. Install the lubricating oil cooler to the filter bracket. Tighten the lubricating oil cooler nut **(Figure 5-171, (5))**.
46. Install the freshwater pipes: cylinder block, lubricating oil cooler, lubricating oil cooler, freshwater pump **(Figure 5-171)**.
47. Install the lubricating oil filter with the filter case remover tool **(Figure 5-171)**.
48. Install the seawater pump assembly and gasket to the gear case **(Figure 5-172)** and **(Figure 5-173)**.

4JH4-TE and 4JH4-HTE Engines

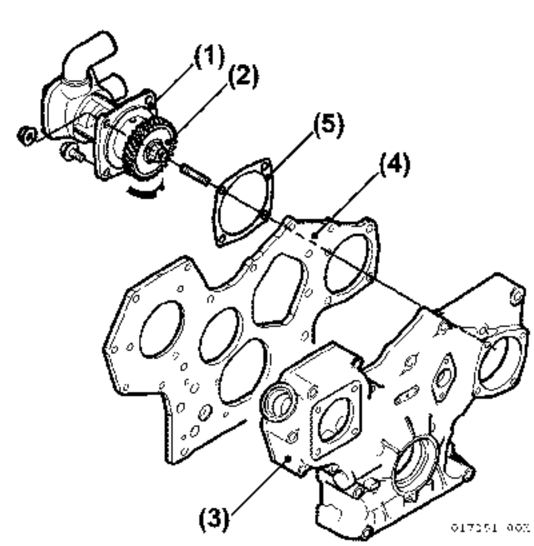


Figure 5-172

1 – **Seawater Pump**
2 – **Pump Drive Gear**
3 – **Gear Case**
4 – **Gear Case Flange**
5 – **Gasket**

3JH5E and 4JH5E Engines

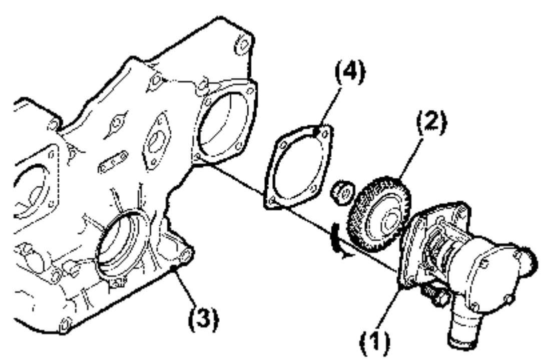


Figure 5-173

1 – **Seawater Pump**
2 – **Pump Drive Gear**
3 – **Gear Case Cover**
4 – **Gasket**

49. Lightly tap the gear case side bearing rest with a wood hammer, and tighten the bolts.

50. Attach the noise absorber to the rocker arm cover before assembling the heat exchanger for 4JH5E **(Figure 5-174),** and the 3JH5E is similar. For the 4JH4-TE and 4JH4-HTE, see **Figure 5-175**.

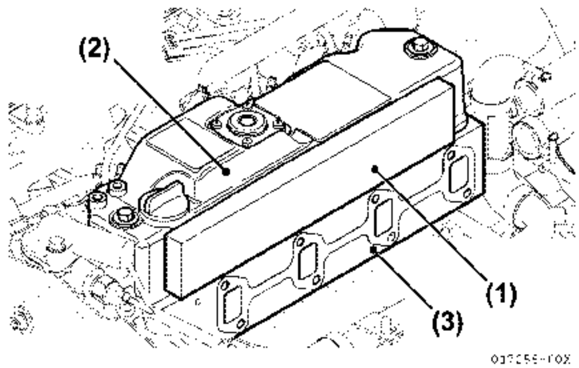


Figure 5-174

1 – Noise Absorber
2 – Heat Exchanger
3 – Cylinder Head

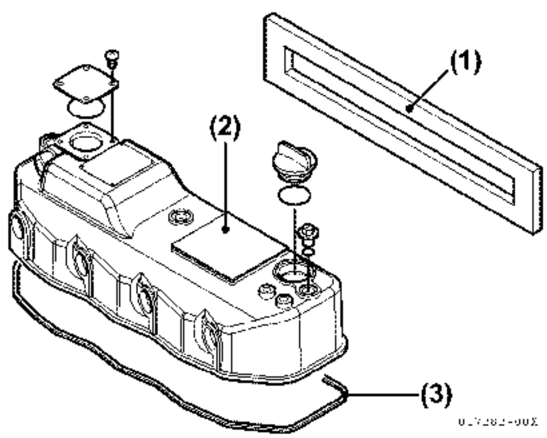


Figure 5-175

1 – Noise Absorber
2 – Heat Exchanger
3 – Gasket

51. Install the gasket and heat exchanger (exhaust manifold) to the cylinder head.
52. Install the coolant pipes (seawater / freshwater):
    - For 3JH5E, install the seawater pipes with the hose clips **(Figure 5-176)**.

Seawater Lines of 3JH5E Shown

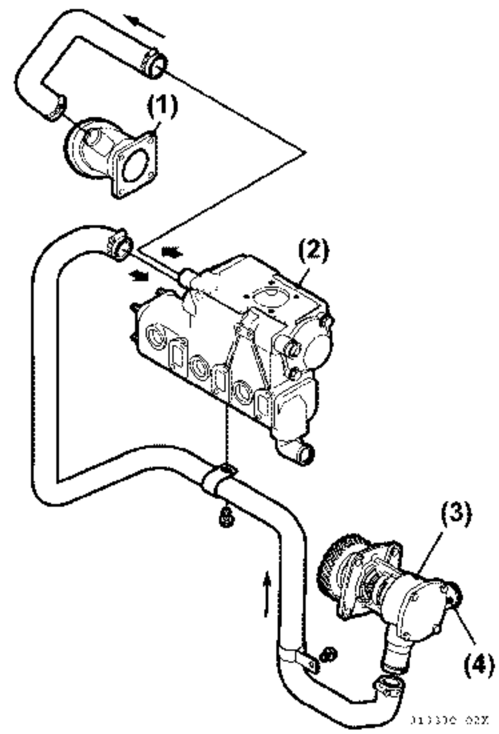


Figure 5-176

1 – Mixing Elbow
2 – Heat Exchanger
3 – Seawater Pump
4 – Seawater Inlet

- For 4JH5E gear case side seawater pipe, insert the pipe in the retainer. Fasten the retainer to the mounting foot with flange bolt **(Figure 5-177)**.

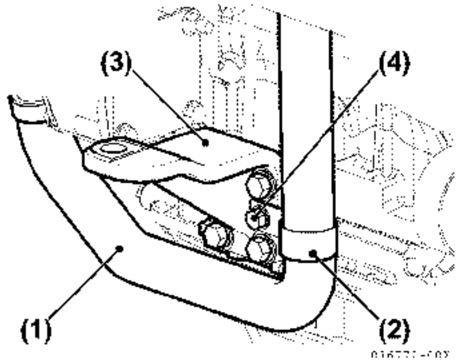


Figure 5-177

1 – Seawater Pipe
2 – Retainer
3 – Flange Bolt
4 – Mounting Foot

- For 4JH5E flywheel housing side seawater pipe, fasten the retainer together with the ground terminal to the flywheel housing by the ground bolt for sail drive and ZF30M **(Figure 5-178)**.

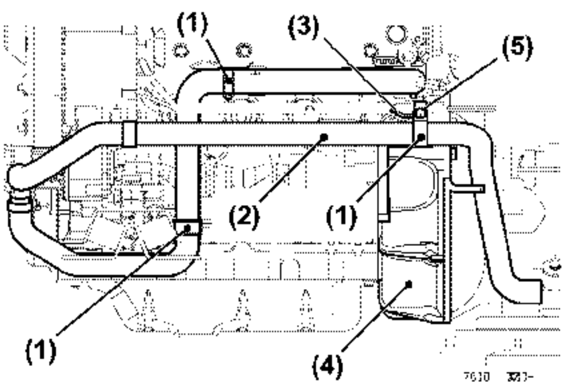


Figure 5-178

1 – Retainer
2 – Seawater Pipe
3 – Ground Terminal
4 – Flywheel Housing
5 – Ground Bolt

- When the 4JH5E is coupled with SD50:
  For gear case side seawater pipe, fasten the upper side bolt with the bracket. Clamp the pipe with the retainer and attach to bracket **(Figure 5-179)**.

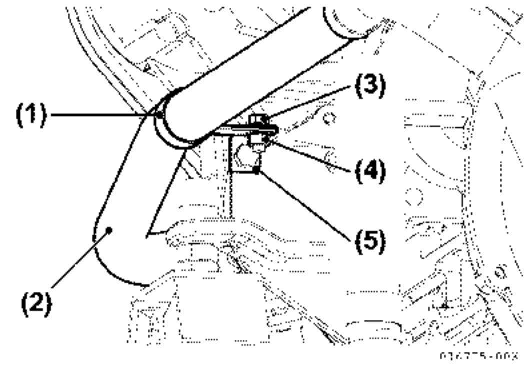


Figure 5-179

1 – Retainer
2 – Gear Case Side Seawater Pipe
3 – Bolt
4 – Nut
5 – Bracket

- When 4JH5E is coupled with KM4A1, seawater pipes for KM4A1 marine gear cooler are shown in **(Figure 5-180)** and **(Figure 5-181)**.

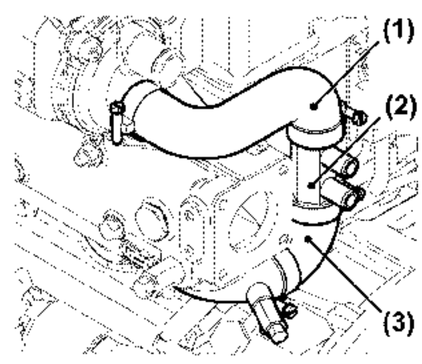


Figure 5-180

1 – Seawater Pipe to Heat Exchanger Inlet from Seawater Pump
2 – Joint
3 – Seawater Pipe from Seawater Pump

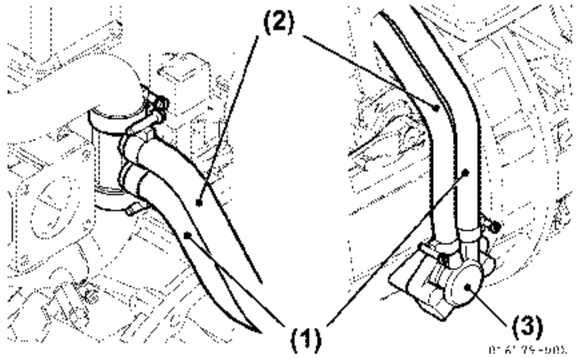


Figure 5-181

1 – Seawater Pipe to Marine Gear (KM4A1) Oil Cooler
2 – Seawater Pipe from Marine Gear (KM4A1) Oil Cooler
3 – Marine Gear Oil Cooler

- Install the freshwater pipes with the hose clips; exhaust manifold, freshwater pump, freshwater pump heat exchanger.
- Install the freshwater pipes; cylinder block, lubricating oil cooler, lubricating oil cooler, freshwater pump.

Freshwater Lines of 3JH5E Shown

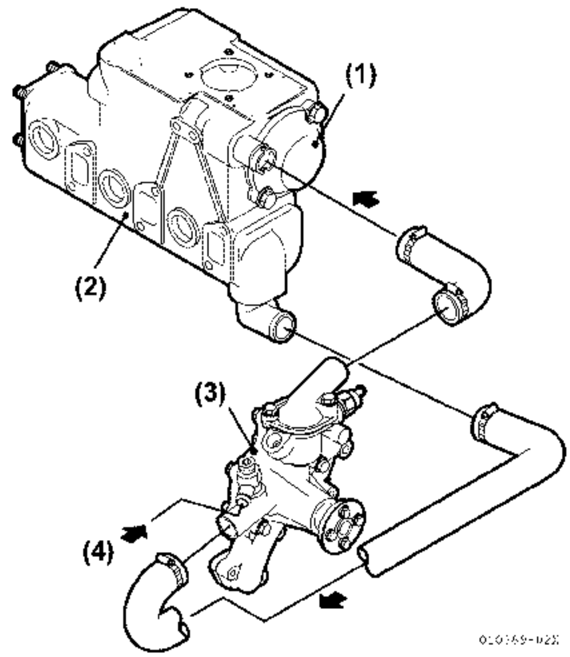


Figure 5-182

1 – Heat Exchanger
2 – Exhaust Manifold
3 – Freshwater Pump
4 – From Lubricating Oil Cooler

- Install the freshwater pipe: lubricating oil cooler, freshwater pump. Attach the pipe to the bracket of the feed pump by nylon band **(Figure 5-183).**

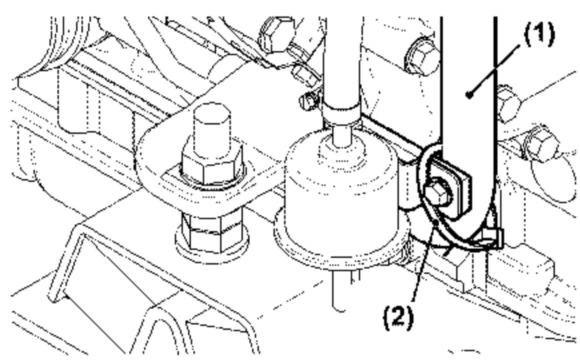


Figure 5-183

1 – Freshwater Pipe to Oil Cooler
2 – Nylon Band

- Attach the feed pump wire harness to the oil cooler water pipe by nylon band (for 4JH5E only) **(Figure 5-184)**.

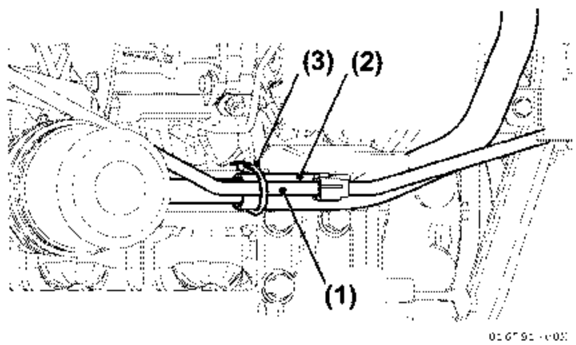


Figure 5-184

1 – Feed Pump Wire Harness
2 – Oil Cooler Water Pipe
3 – Nylon Band

53. Install the alternator:

Note: Connect the wires to the terminals before attaching the alternator to the gear case **(Figure 5-185)**.

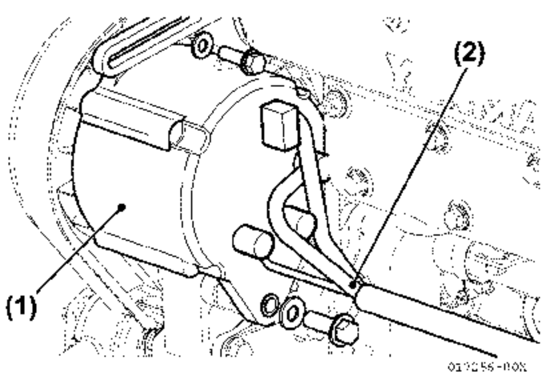


Figure 5-185

1 – Alternator
2 – Wires and Terminals

(a) Install the adjuster on the freshwater pump, the distance piece on the gear case and then the alternator.

(b) Adjust V-belt tension with the adjuster, and tighten the mounting bolts **(Figure 5-186)**.

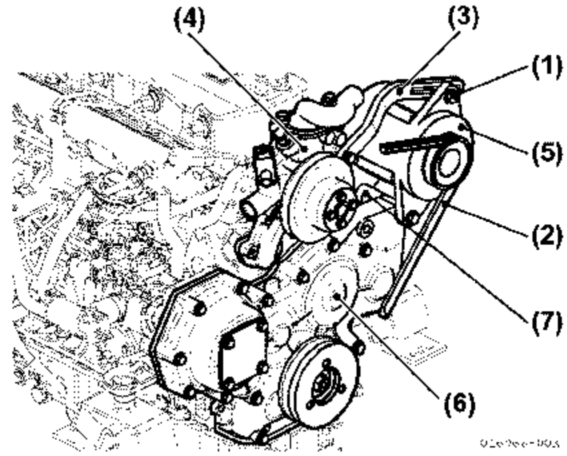


Figure 5-186

1 – Alternator Adjust Bolt
2 – V-Belt
3 – Adjuster
4 – Freshwater Pump
5 – Alternator
6 – Gear Case

54. Install the V-belt cover.
    (a) Install the water pump adjustment bolt.
    (b) Insert insulation rubbers and collars to the hole of belt cover.
    (c) Fasten the belt cover to the bolts with washers and nuts.

4JH5E Engine Shown (3JH5E is Similar)

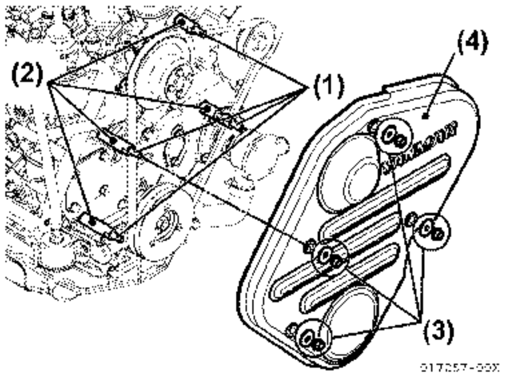


Figure 5-187

1 – **Bolt**
2 – **Insulation Rubber and Collar**
3 – **Washer and Nut**
4 – **V-Belt Cover**

55. Install the starting motor in the flywheel housing **(Figure 5-188)**.

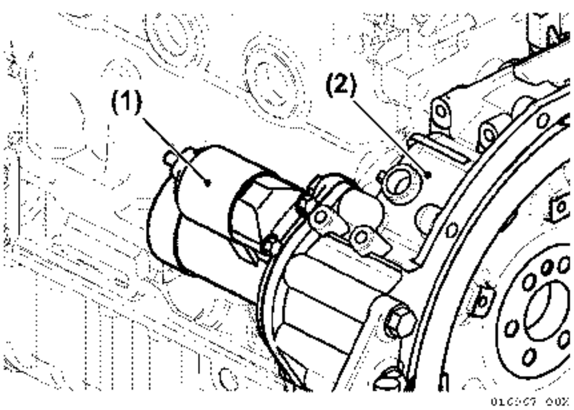


Figure 5-188

1 – **Starting Motor**
2 – **Flywheel Housing**

56. Install the starter relay, stop solenoid relay and air heater relay by flange bolts. Connect the harness to each relay.

4JH5E Engine Shown (3JH5E is Similar)

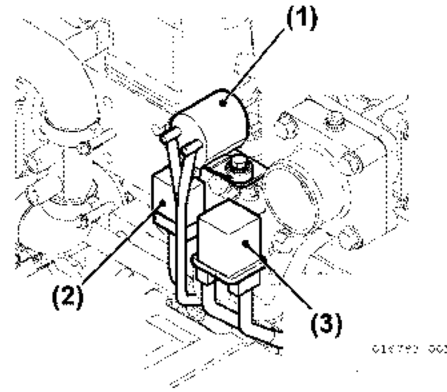


Figure 5-189

1 – **Starter Relay**
2 – **Stop Solenoid Relay**
3 – **Air Heater Relay**

Note: Fasten the wire harness clamp to the upside to avoid interfering with the mounting foot **(Figure 5-190)**.

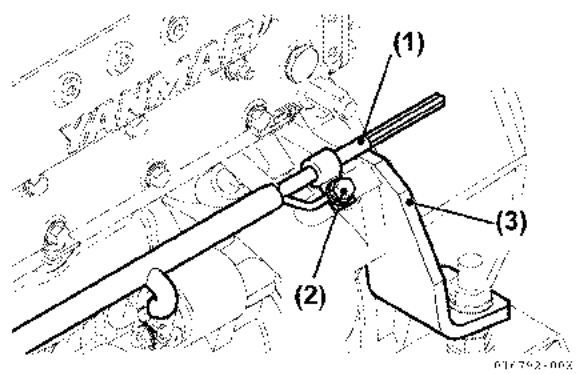


Figure 5-190

1 – **Wire Harness**
2 – **Clamp**
3 – **Mounting Foot**

57. 4JH4-HTE: Install the intercooler:
    (a) Install the seawater pipes with the hose clips.
    (b) Install the air duct from the intercooler to the intake manifold.
    (c) Install the air duct from the turbocharger to the intercooler **(Figure 5-191)**.

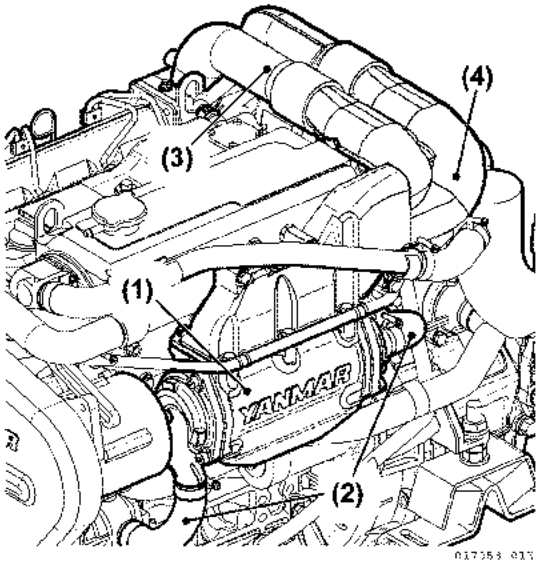


Figure 5-191

1 – Intercooler
2 – Seawater Pipe
3 – Air Duct to Intake Manifold
4 – Air Duct from Turbocharger

58. Install the turbocharger (for 4JH4-TE and 4JH4-HTE) **(Figure 5-192)**.
    (a) Install the turbocharger to the exhaust manifold.
    (b) Install the lubricating oil pipe and the freshwater pipe to the turbocharger.

4JH4-TE Engine Shown

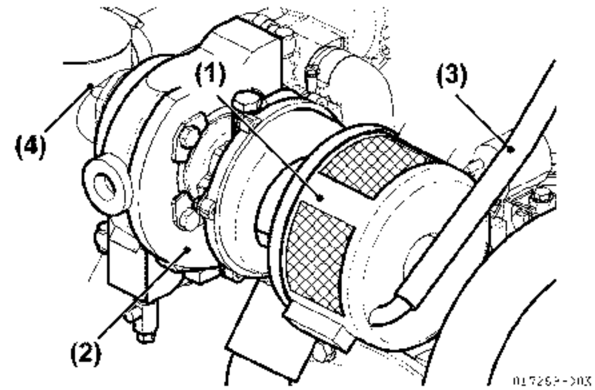


Figure 5-192

1 – Intake Silencer
2 – Turbocharger
3 – Lubricating Oil Pipe
4 – Mixing Elbow

59. Install the mixing elbow, on the exhaust manifold outlet for 3JH5E and 4JH5E, and on the turbocharger for 4JH4-TE and 4JH4-HTE.
60. Install the cooling seawater pipe (rubber hose) with the hose clips (heat exchanger-mixing elbow).
61. Install the intake silencer, on the intake manifold inlet coupling for 3JH5E and 4JH5E, and on the turbocharger for 4JH4-TE and 4JH4-HTE.
62. Install the breather hose to the silencer with the hose clips (intake silencer-rocker arm cover).
63. Install suction air silencer of 3JH5E and 4JH5E.
64. Install the bracket on the flywheel housing by bolt and mount the suction pipe to the silencer.

3JH5E and 4JH5E Engines Shown

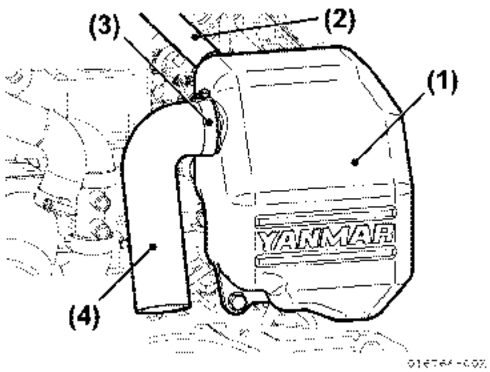


Figure 5-193

1 – **Suction Air Silencer**
2 – **Breather Hose**
3 – **Hose Band**
4 – **Suction Hose**

65. Secure the silencer to the suction manifold with rubber hose and hose band **(Figure 5-194).**

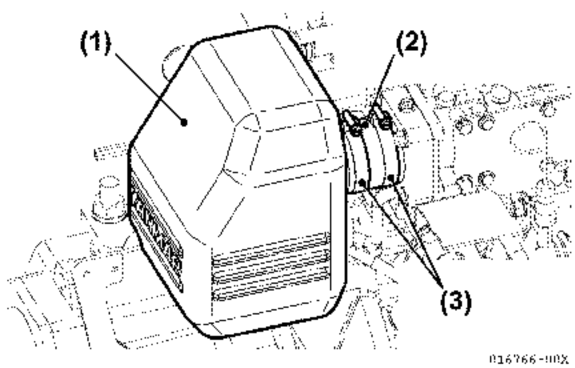


Figure 5-194

1 – **Silencer**
2 – **Rubber Hose**
3 – **Hose Band**

66. Insert the collar into the hole of silencer and fix to the bracket by bolt **(Figure 5-195).**

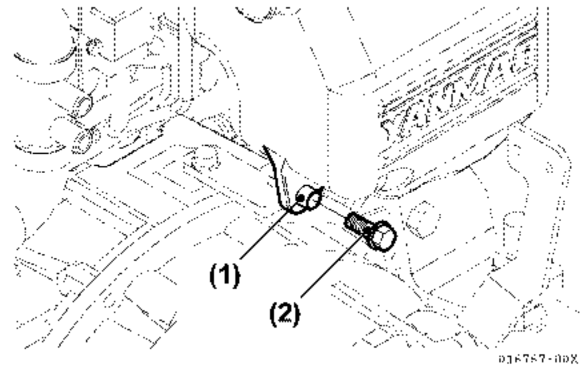


Figure 5-195

1 – **Collar**
2 – **Bolt**

67. Secure the intake pipe with a hose clamp.
68. Install the fuel filter bracket on the intake manifold **(Figure 5-196).**

4JH5E Filter and Bracket Shown (3JH5E is Similar)

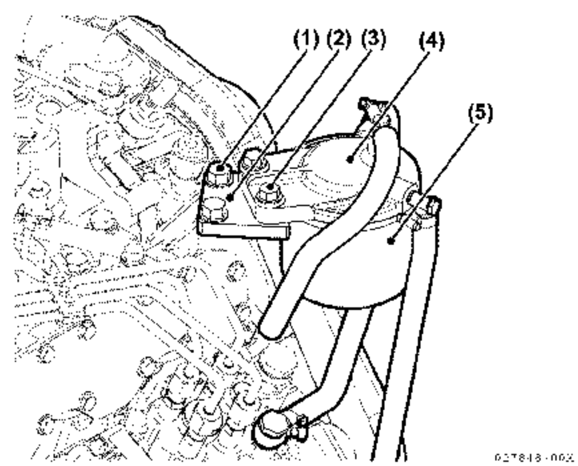


Figure 5-196

1 – **Bolt**
2 – **Fuel Filter Bracket**
3 – **Bolt**
4 – **Header (fuel filter)**
5 – **Fuel Filter**

69. Install the fuel filter **(Figure 5-196)**.
70. Install the fuel feed pump and bracket **(Figure 5-197)** to the cylinder block by bolt.

4JH5E Engine Shown (3JH5E is Similar)

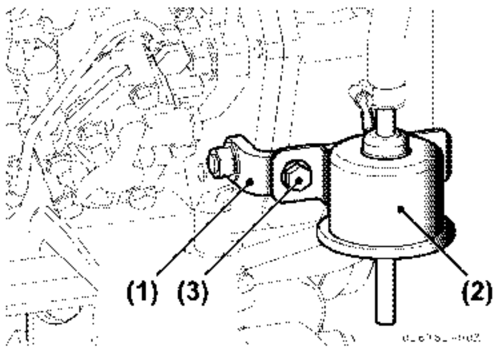


Figure 5-197

1 – **Bracket**
2 – **Electric Fuel Feed Pump**
3 – **Bolt**

71. Install the fuel pipe (fuel feed pump-fuel filter, fuel filter-fuel injection pump) **(Figure 5-198)**.

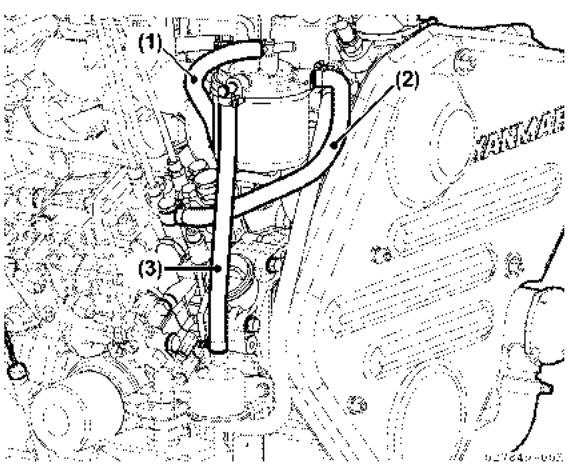


Figure 5-198

1 – **Fuel Line (bleed air)**
2 – **Fuel Line (fuel filter-fuel injection pump)**
3 – **Fuel Line (fuel feed pump-fuel filter)**

72. Connect the electric wiring to the proper terminals, observing the color coding to make sure the connections are correct. Clamp the wire harness by fastening the clamp to the upside to avoid interfering with the mounting foot **(Figure 5-199)**.

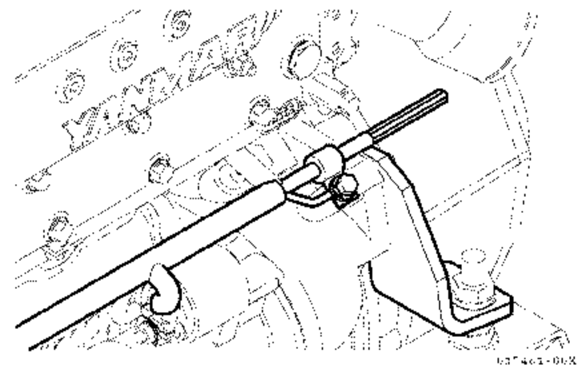


Figure 5-199

73. Connect the electric wires to the terminals before attaching the alternator to the gear case **(Figure 5-200)**.

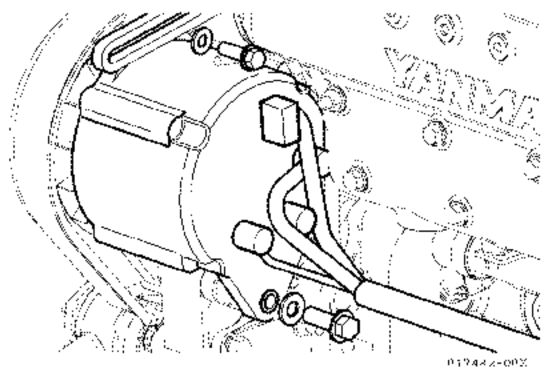


Figure 5-200

74. Installation in a boat and completion of the piping and wiring:
    (a) Mount the engine on the engine bed in the engine room of a boat after all engine assembly has been completed.
    (b) Connect the coolant pipes, fuel pipes, other pipes on the boat and the exhaust hoses.
    (c) Connect the battery, instrument panel, remote control cable and other wiring.

75. Fill the engine with lubricating oil from the supply port on top of the gear case or the rocker arm cover and fill the marine gearbox from the supply port on top of the reduction gear case **(Figure 5-201)** and **(Figure 5-202)**.

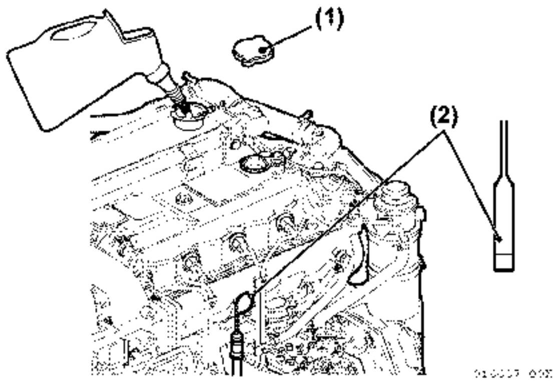


Figure 5-201

1 – Supply Port
2 – Dipstick

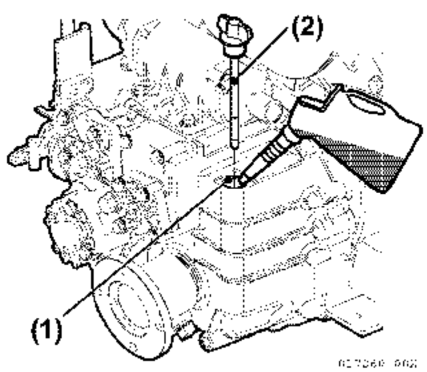


Figure 5-202

1 – Supply Port
2 – Dipstick

76. Remove the coolant (freshwater) tank filler cap and fill tank with water.

3JH5E	4.5 L (4.8 qt)
4JH5E	6.0 L (6.3 qt)
4JH4-TE / 4JH4-HTE	7.2 L (7.6 qt)

77. Fill with water in the coolant recovery tank until the level is between the full and low marks **(Figure 5-203)**.

Coolant Recovery Tank Capacity (Full)	0.8 L (0.85 qt)

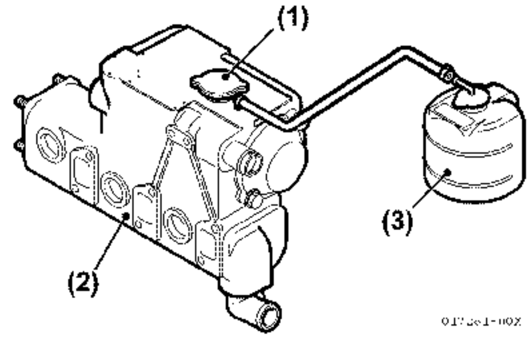


Figure 5-203

1 – Filler Cap
2 – Coolant Tank
3 – Coolant Recovery Tank

78. Check fuel injection timing. *See Checking and Adjusting Fuel Injection Timing on page 6-32.*

Checking and Adjusting Remote Control Operation

The various control levers on the engine side are connected to the remote control lever by the remote control cable. The cable will become stretched and the attachments loose after long hours of use, causing deviation. It is dangerous to control operation under these conditions, and the remote control cable must be checked and adjusted periodically.

- Adjusting the throttle remote control cable: Check to see that the control lever on the engine side moves to the high-speed stop position and low-speed stop position when the remote control lever is moved to H (high speed) and L (low speed) respectively.

  When there is deviation, loosen the bracket for the remote control cable on the engine side and adjust.

  Adjust the high-speed stop position first and then adjust the low-speed idling by the adjustment bolt on the remote control lever.

NOTICE: Never adjust the high-speed limiting bolt. This will void warranty.

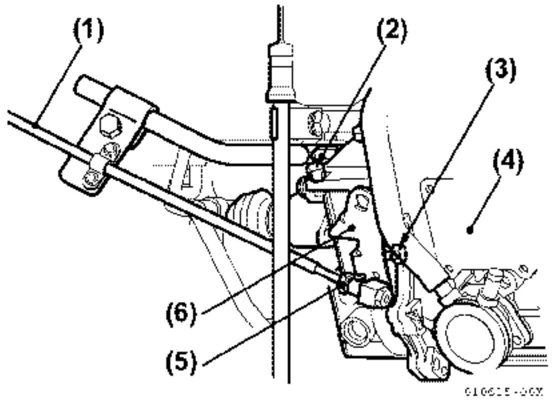


Figure 5-204

1 – Remote Control Cable
2 – High-Speed Limiting Bolt
3 – Low-Speed Limiting Bolt
4 – Fuel Injection Pump
5 – Cable Joint
6 – Control lever

- Adjusting the marine gear remote control cable: Check that the shift lever moves to the correct position when the remote control handle is put in the NEUTRAL, FORWARD and REVERSE positions. Use the NEUTRAL position as the standard for adjustment. When there is deviation, loosen the clamp for the remote control cable and adjust the shift lever position.

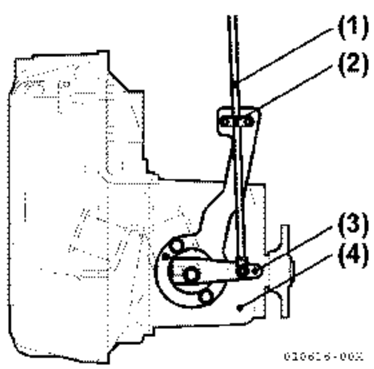


Figure 5-205

1 – Remote Control Cable
2 – Clamp
3 – Shaft Lever
4 – Marine gear

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Section 6

FUEL SYSTEM

SAFETY PRECAUTIONS

Before you service the fuel system, read the following safety information and review the *Safety Section on page 2-1.*

⚠ WARNING

Fire Hazard

NEVER put diesel fuel or other flammable material such as oil, hay or dried grass near the engine during engine operation or shortly after shutdown.

ALWAYS put an approved fuel container under the opening whenever you remove any fuel system component (such as changing the fuel filter). Dispose of waste properly.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to remove, install and repair fuel system components as used on the Yanmar 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE engines.

SPECIFICATIONS

Test and Adjustment Specifications

3JH5E (MP2 Pump)

Inspection Item	Specification Reference
High-Pressure Fuel Pump Pressure	21.6 MPa (3133 psi)
Fuel Feed Pump Pressure	20 kPa (2.9 psi)
Return Fuel Pressure	20 kPa (2.9 psi)
Fuel Supply Restriction	400 mmAq (16 in.Aq)

4JH5E (MP2 Pump)

Inspection Item	Specification Reference
High-Pressure Fuel Pump Pressure	21.6 MPa (3133 psi)
Fuel Feed Pump Pressure	20 kPa (2.9 psi)
Return Fuel Pressure	20 kPa (2.9 psi)
Fuel Supply Restriction	400 mmAq (16 in.Aq)

4JH4-TE (Bosch VE Pump)

Inspection Item	Specification Reference
High-Pressure Fuel Pump Pressure	21.6 MPa (3133 psi)
Fuel Feed Pump Pressure	20 kPa (2.9 psi)
Return Fuel Pressure	20 kPa (2.9 psi)
Fuel Supply Restriction	1000 mmAq (40 in.Aq)
Timer Advancing Angle	1.5° / 1100-1600 rpm pump speed

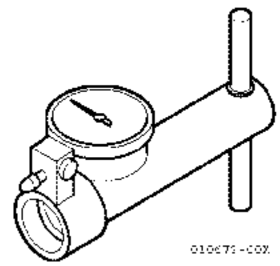
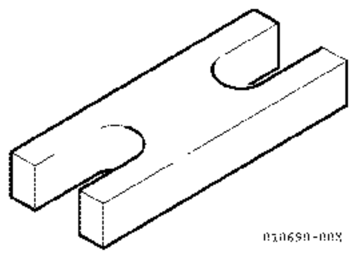
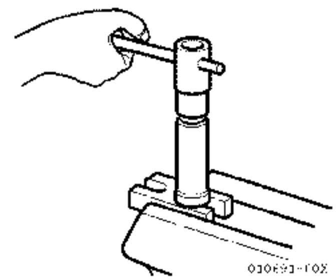
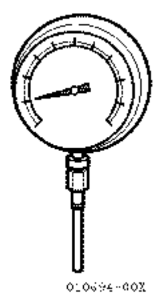
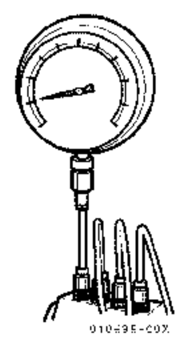
4JH4-HTE (Bosch VE Pump)

Inspection Item	Specification Reference
High-Pressure Fuel Pump Pressure	21.6 MPa (3133 psi)
Fuel Feed Pump Pressure	20 kPa (2.9 psi)
Return Fuel Pressure	20 kPa (2.9 psi)
Fuel Supply Restriction Excluding Fuel Filter Loss Pressure	1000 mmAq (40 in.Aq)
Timer Advancing Angle	2.6° / 1200-1600 rpm pump speed

Special Torque Chart

Component		Tightening Torque	Lubricating Oil Application (Thread Portion and Seat Surface)	Reference Page
Fuel Injection Nozzle Retaining Bolt		26 N·m (19.2 lb-ft)	Not Applied	*Install Fuel injection Nozzle. See Install the fuel injection nozzle: on page 5-88.*
Fuel Injection Pump Drive Gear Nut	3JH5E and 4JH5E	34.3 N·m (25.3 lb-ft)		*Install Fuel Injection Pump. See Installing the Fuel Injection Pump on page 6-28.*
	4JH4-TE and 4JH4-HTE	64 N·m (47 lb-ft)		
Fuel Injection Line Joint Nut		32 N·m (24 lb-ft)		*Remove and Install Fuel Injection Lines. See Remove the fuel injection line (Figure 5-32) through (Figure 5-34): on page 5-32.*

SPECIAL SERVICE TOOLS

Name of Tool	Shape and Size	Application
Measuring Device (Cam Backlash) 158090-51050		-
Nozzle Plate 158090-51700		
Top Clearance Gauge 158090-51300		

FUEL SYSTEM COMPONENTS

4JH5E Engine (3JH5E is Similar)

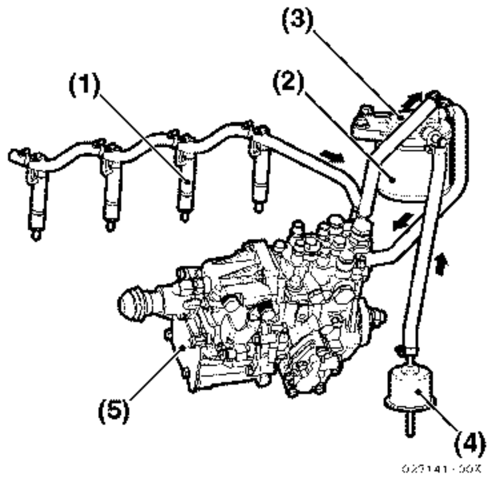


Figure 6-1

1 – **Fuel Injector**
2 – **Fuel Filter**
3 – **Header (fuel filter)**
4 – **Electric Fuel Feed Pump**
5 – **Fuel Injection Pump**

4JH4E-HT / 4JH4-HTE Engines

Note: 4JH4-HTE fuel system components are shown. 4JH4-TE is similar.

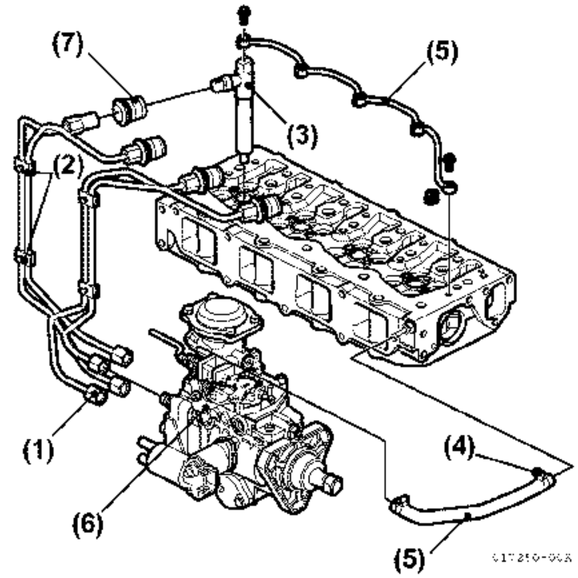


Figure 6-2

1 – **Fuel Injection Line**
2 – **Fuel Injection Line Retainer**
3 – **Fuel Injection Nozzle**
4 – **Clamp**
5 – **Fuel Return Line**
6 – **Fuel Injection Pump**
7 – **Line Seal**

FUEL SYSTEM DIAGRAM

3JH5E and 4JH5E System

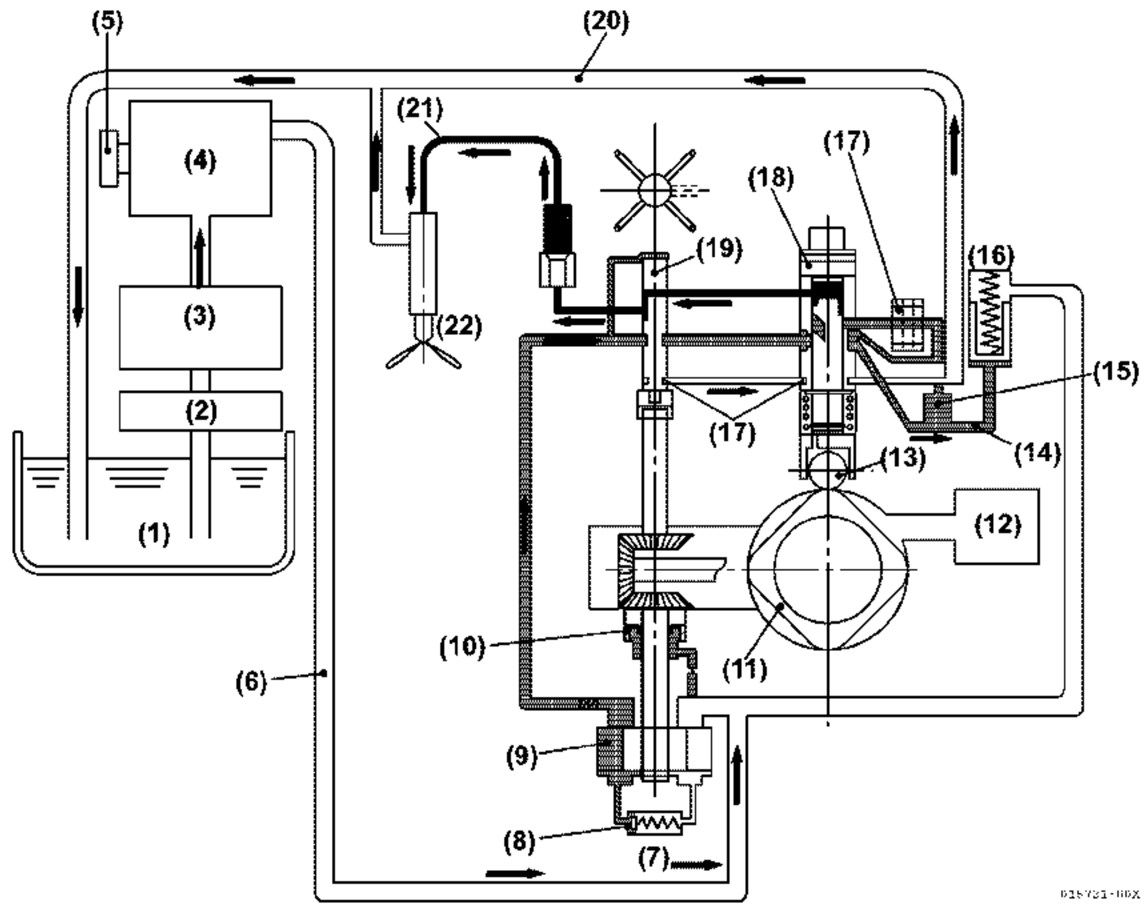


Figure 6-3

1 – Diesel Fuel Tank
2 – Fuel Filter / Water Separator
3 – Electric Fuel Feed Pump
4 – Fuel Filter
5 – Priming Pump
6 – Fuel Supply Line
7 – Low-Pressure Galley
8 – Pressure Control Valve
9 – Trochoid Pump
10 – Oil Seal
11 – Fuel Injection Pump Cam
12 – Engine Crankcase
13 – Tappet
14 – High-Pressure Galley
15 – Overflow Orifice
16 – Accumulator
17 – Timer Piston
18 – Mono-Plunger
19 – Distributor Shaft
20 – Fuel Return Line
21 – High-Pressure Fuel Injection Lines
22 – Fuel Injector

Note: 4JH4-TE system shown. 4JH4-HTE is similar.

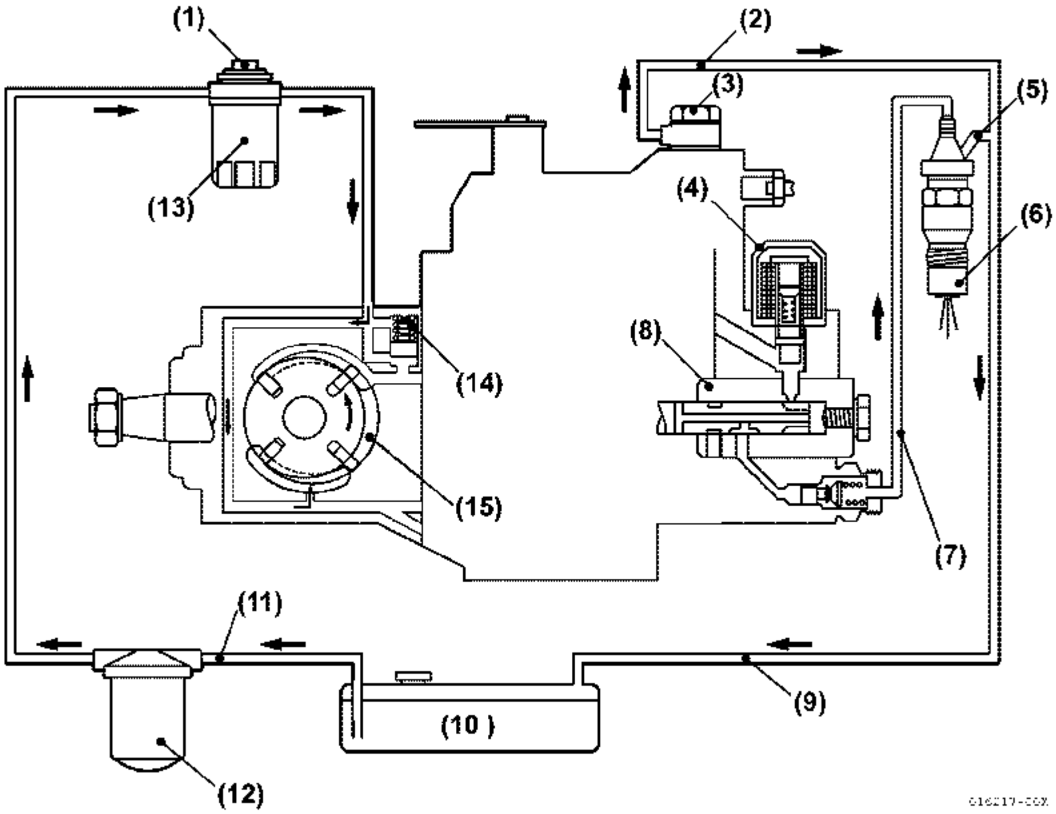


Figure 6-4

1 – Fuel Priming Pump
2 – Return Fuel to Fuel Tank
3 – Overflow Valve
4 – Magnetic Valve
5 – Fuel Injection Nozzle Return Line
6 – Fuel Injection Nozzle
7 – High-Pressure Fuel Supply Line
8 – Plunger Barrel
9 – Fuel Return Line
10 – Fuel Tank
11 – Fuel Injection Pump
12 – Fuel / Water Separator
13 – Fuel Filter
14 – Regulating Valve
15 – Fuel Feed Pump

FUEL SYSTEM TESTS

NOTICE: After completing work that involves opening the fuel system, do the following:

- *Bleed the system. See Bleeding the Fuel System on page 6-51.*
- *Start engine and check for leaks. Allow engine to run until it is running smoothly.*

Measuring Fuel Feed Pump Pressure

1. Attach a suitable fuel pressure gauge to a tee joint, and connect a short length of hose to one of the remaining two legs of the tee **(Figure 6-5, (1))**.

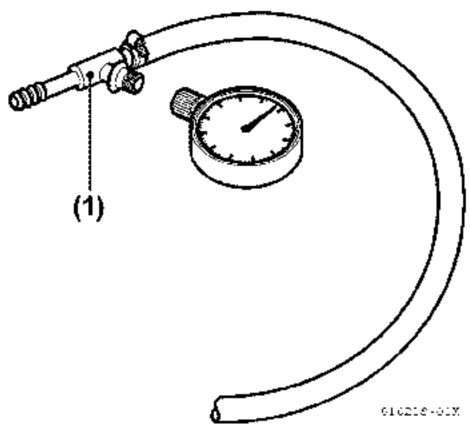


Figure 6-5

2. Disconnect the fuel hose from the fuel fine filter inlet **(Figure 6-6, (1))**.

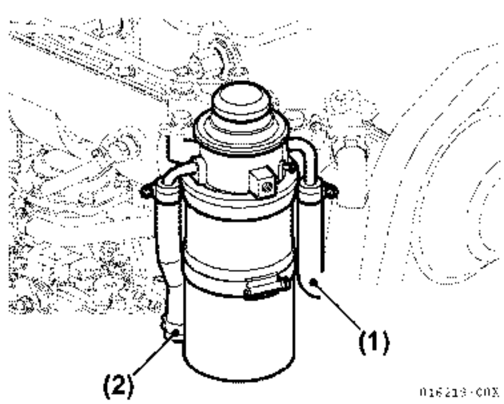


Figure 6-6

3. Connect the test gauge assembly between disconnected ends. Install and tighten hose clamps.
4. Start engine and set speed to low idle. Read and record pressure.
5. Operate engine at full load. Read and record pressure.
6. Repeat procedure at the outlet end of the fuel fine filter **(Figure 6-6, (2))**.

Inspection Item	rpm	Specification
Fuel Feed Pump Pressure (Minimum)	All	20 kPa (2.9 psi)

Results

- If pressure reading is not within specification, inspect pre-filter (if equipped), fuel filter / water separator, fuel fine filter and fuel feed pump.
- Measure vacuum / restriction before the electric pump. This value should not exceed 1000 mmAq (40 in.Aq). If it exceeds the specification, correct restriction from the fuel tank to the engine.
- If fuel feed pump pressure is significantly less than 20 kPa (2.9 psi), and inlet restriction and return line pressure are within specifications, replace the electric fuel feed pump.

Testing Return Fuel Pressure

Note: This test is dependent on the fuel supply. Test the low-pressure fuel system prior to performing this test. *See Measuring Fuel Feed Pump Pressure on page 6-10.*

1. Assemble a tee, hose and a 0 to 100 kPa (0 to 15 psi) pressure gauge.
2. Disconnect the hose from the fuel return line **(Figure 6-7, (5)), (Figure 6-8, (5)).**

3JH5E Shown (4JH5E is Similar)

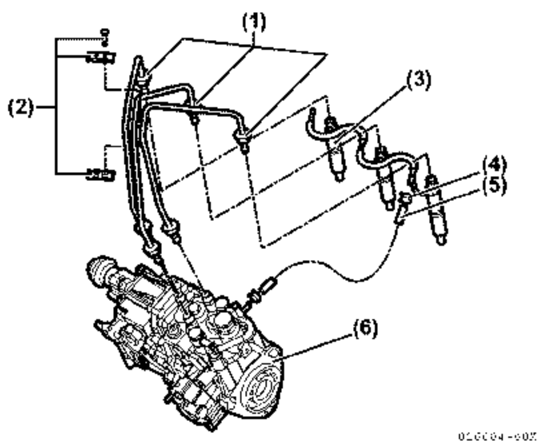


Figure 6-7

1 – Fuel Injection Line
2 – Fuel Injection Line Retainer
3 – Fuel Injection Nozzle
4 – Clamp
5 – Fuel Return Line
6 – Fuel Injection Pump

4JH4-HTE Shown (4JH4-TE is Similar)

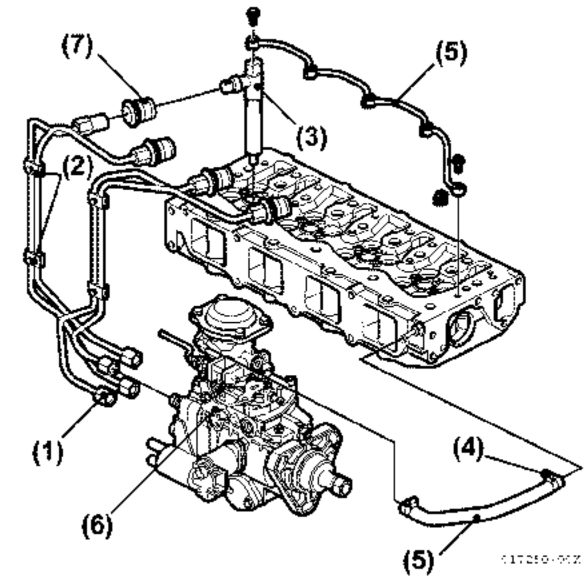


Figure 6-8

1 – Fuel Injection Line
2 – Fuel Injection Line Retainer
3 – Fuel Injection Nozzle
4 – Clamp
5 – Fuel Return Line
6 – Fuel Injection Pump
7 – Line Seal

3. Connect test gauge assembly between disconnected ends. Install and tighten hose clamps.
4. Start engine and allow speed to stabilize at normal low idle.
5. Read and record pressure.

Inspection Item	rpm	Pressure
Return Fuel Pressure	All speeds	20 kPa (2.9 psi)

Results

If test pressure reading is not within specifications, find and correct the return fuel restriction.

SERVICING THE FUEL SYSTEM

After completing work that involves opening the fuel system, do the following:

1. Bleed the system.
2. Start engine and check for leaks. Allow engine to run until it is running smoothly.

Removing the Fuel Injection Nozzle

NOTICE: When working on the oil, coolant or fuel circuits, you must protect the alternator from contamination. Cover alternator with suitable materials. Failure to comply may result in an alternator failure.

1. Disconnect the negative (-) battery cable.
2. Shut off all valves in the fuel supply system.
3. Remove bonnet.
4. Remove return fuel line from fuel injection nozzle **(Figure 6-9, (4))**.

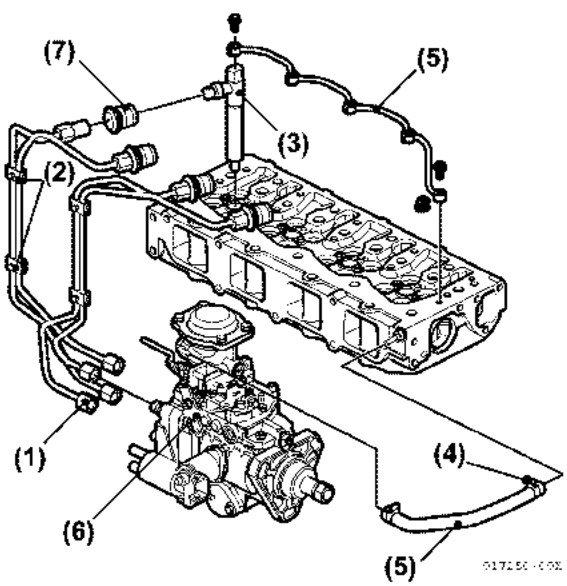


Figure 6-9

5. Remove the bolt retaining the fuel injection nozzle. Remove fuel injection nozzle **(Figure 6-9, (3))**. *See Remove the fuel injection line (Figure 5-32) through (Figure 5-34): on page 5-32.*
6. If the injection nozzle is stuck, use a slide hammer to remove it from the cylinder head. *NOTICE: DO NOT disassemble the fuel injection nozzle. Replace the entire unit as necessary.*
7. If the injection nozzle gasket did not come out together with the injection nozzle, remove it from the bottom of the injection nozzle seat **(Figure 6-10, (6))**.

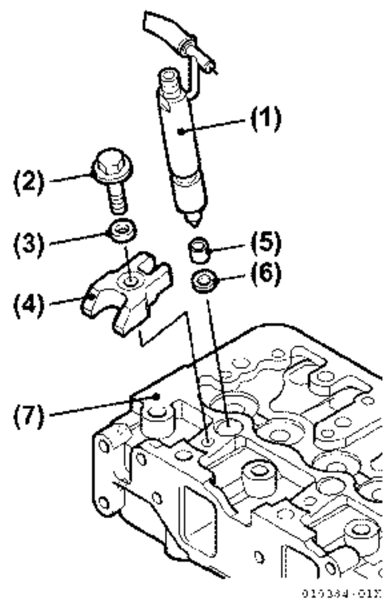


Figure 6-10

Cleaning Fuel Injection Nozzle Cavities

1. Remove fuel injection nozzle.
2. Clean the fuel injection cavities.
3. Inspect to ensure sealing surface is clean. Repeat cleaning if necessary.
4. Install fuel injection nozzle and high-pressure line.
5. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Run engine and check for fuel leaks.

Installing Fuel Injection Nozzles

1. Make sure that the old gasket is not at the bottom of the injection nozzle seat. Clean the sealing surfaces of the injection nozzle seat. *See Cleaning Fuel Injection Nozzle Cavities on page 6-13. NOTICE: Always install a new gasket when installing an injection nozzle. Make sure all sealing surfaces are clean.*
2. Install new gasket **(Figure 6-11, (6))** on tip of injection nozzle **(Figure 6-11, (1))** and **(Figure 6-12, (5))**.

2-Valve Head

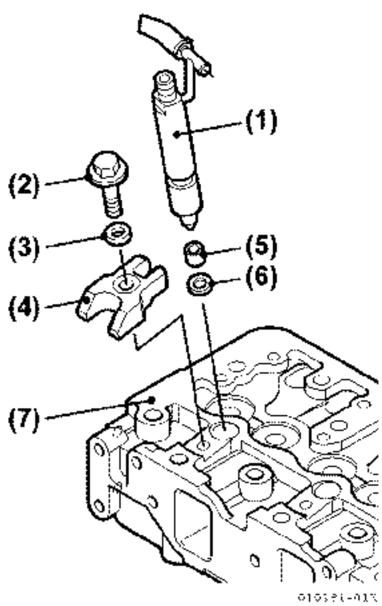


Figure 6-11

4-Valve Head

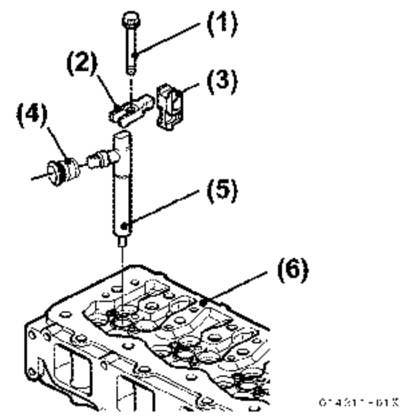


Figure 6-12

3. Place the retainer (**(Figure 6-11, (4))** for 3JH5E and 4JH5E or **(Figure 6-12, (3))** for 4JH4-TE and 4JH4-HTE) on the injection nozzle as shown.

Note: If installing used fuel injection nozzles, clean the injection nozzle prior to installation.

4. 4JH4-TE and 4JH4-HTE: Install the pipe seal **(Figure 6-12, (4))**.
5. Install the injection nozzle and retainer as an assembly.
6. Install bolt and washer **(Figure 6-11, (2, 3))** and tighten to 26 N·m (19.2 in.-lb).
7. Install the fuel injection lines **(Figure 6-13, (1))** and **(Figure 6-14, (1))**. *See Installing Fuel Injection Nozzles on page 6-13.*

3JH5E and 4JH5E Engines

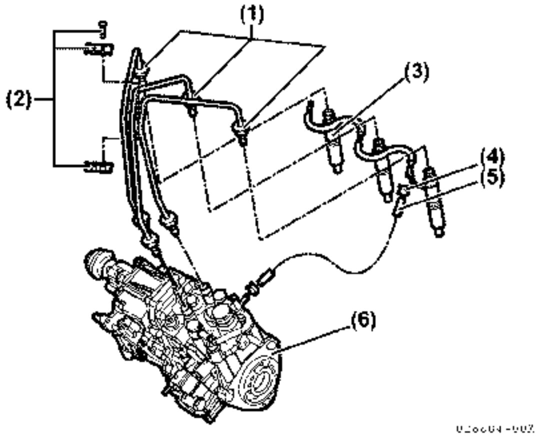


Figure 6-13

4JH4-TE and 4JH4-HTE Engines

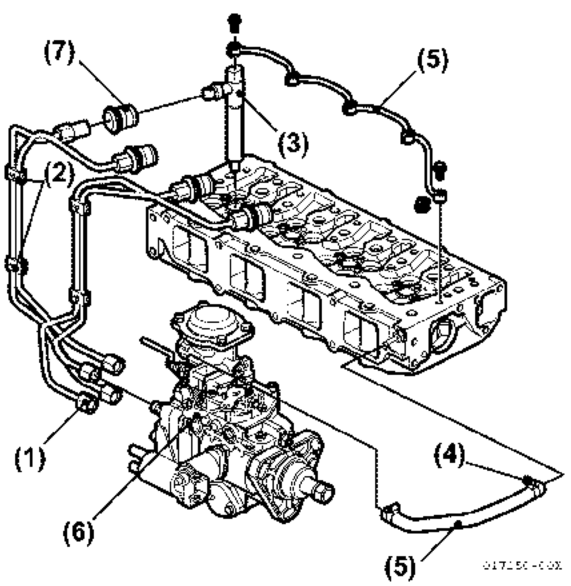


Figure 6-14

8. If removed, install clamp(s) **(Figure 6-13, (2))** and **(Figure 6-14, (2))**.
9. Install injection nozzle return fuel lines **(Figure 6-13, (4))** and **(Figure 6-14, (4), (5))**. *See Installing Fuel Injection Nozzles on page 6-13.*
10. 4JH4-TE and 4JH4-HTE: Install pipe seal **(Figure 6-14, (7)**.
11. Open all fuel supply valves.
12. Connect the negative (-) battery cable.
13. Fill and bleed fuel system. *See Bleeding the Fuel System on page 6-51.*
14. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start the engine and check for fuel leaks. Allow the engine to run until it is running smoothly. *NOTICE: When working on the oil, coolant or fuel circuits, you must protect the alternator from contamination. Cover alternator with suitable materials. Failure to comply may result in an alternator failure.*

Removing Fuel Injection Lines

1. Disconnect the negative (-) battery cable.
2. Shut off all valves in fuel supply system.
3. If removing only one line, remove the clamp joining the fuel injection lines to each other.

Note: Identify all lines to ease installation.

4. Loosen retainer bolts on fuel injection line(s) **(Figure 6-15, (2))** and **(Figure 6-16, (2))**.

3JH5E and 4JH5E Engines

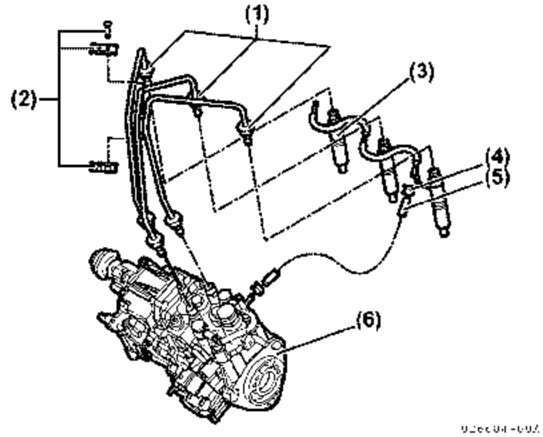


Figure 6-15

4JH4-TE and 4JH4-HTE Engines

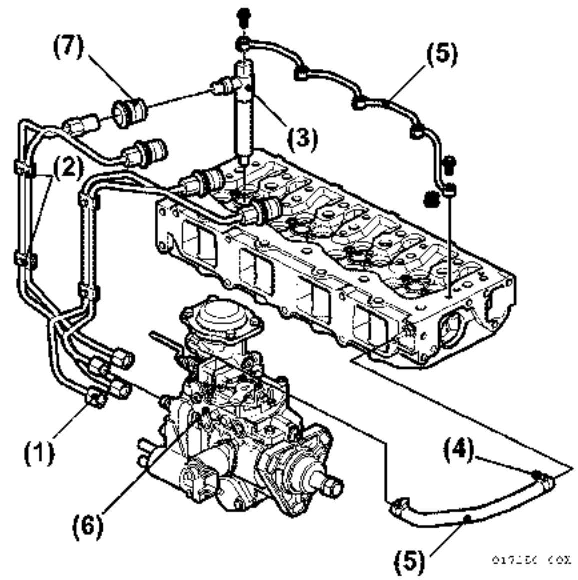


Figure 6-16

5. Remove fuel injection line(s). *NOTICE: Immediately cap or plug all openings to prevent contamination of system.*

Installing Fuel Injection Lines

1. Install line(s) and start all union nuts before tightening any. Hand-tighten all union nuts.

Note: Always use a special tool when loosening or tightening fuel injection line union nuts.

NOTICE: Be sure new fuel injection lines are properly positioned and installed.

2. Tighten union nuts to 32 N·m (24 lb-ft).
3. Bleed fuel system. *See Bleeding the Fuel System on page 6-51.*
4. **WARNING! *Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start engine and check for fuel leaks.

Replacing the Fuel Feed Pump

1. Disconnect the negative (-) battery cable.
2. Shut off fuel supply valve at fuel tank.
3. 3JH5E and 4JH5E: Disconnect electrical connector **(Figure 6-17, (1))**.

3JH5E and 4JH5E Engines

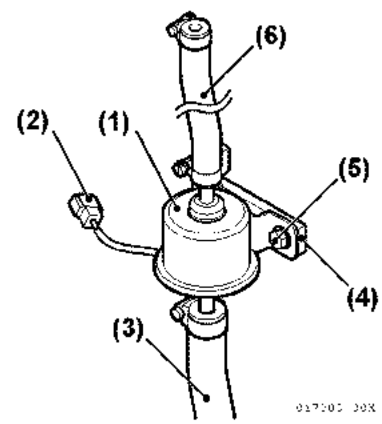


Figure 6-17

1 – Electric Fuel Feed Pump
2 – Electrical Connector
3 – Fuel Supply Line
4 – Bracket
5 – Bolt
6 – Fuel Feed Line to Filter

4. Remove supply line **(Figure 6-18, (16))** and pressure line **(Figure 6-18, (2))**, **(Figure 6-18, (7))** from fuel feed pump. Install caps or plugs on all open fittings to prevent contamination of the fuel system.
5. Transfer fuel pump mounts to new pump.
6. Install new fuel feed pump.
7. Connect supply and pressure lines.
8. Connect electrical wiring connector.
9. Open fuel supply valve.
10. Bleed fuel system. *See Bleeding the Fuel System on page 6-51.*
11. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start engine and check for leaks.

Note: For 4JH4-TE and 4JH4-HTE, the fuel feed pump is built in the fuel injection pump / governor system **(Figure 6-18)**. If fuel pump portion needs to be changed, contact an authorized Bosch service factory or dealer.

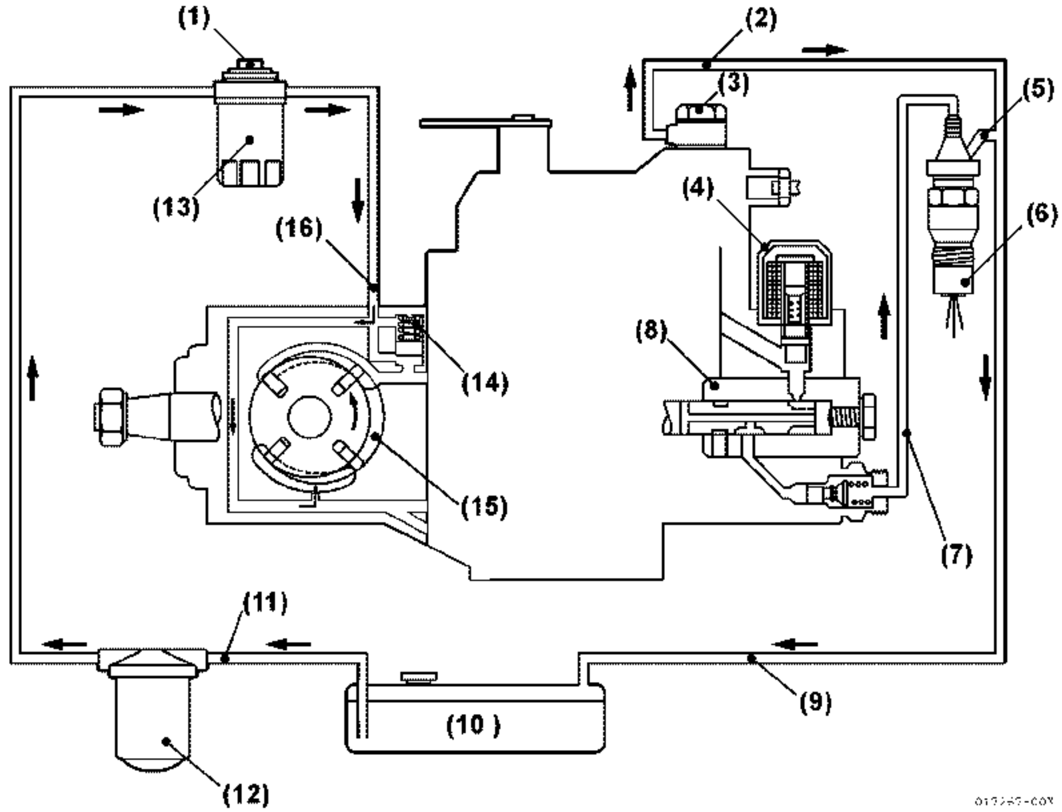


Figure 6-18

Replacing the Fuel Injection Pump

Removal

NOTICE: When working on the oil, coolant or fuel circuits, you must protect the alternator from contamination. Cover alternator with suitable materials. Failure to comply may result in an alternator failure.

1. Disconnect the negative (-) battery cable.
2. Close fuel supply valve at fuel tank.
3. Disconnect electrical connector **(Figure 6-19, (2))** from fuel measuring unit.

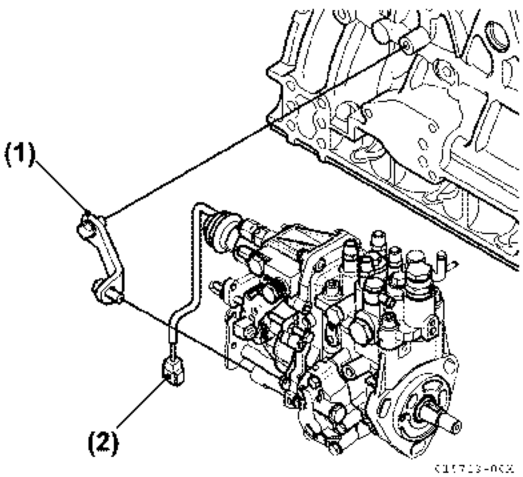


Figure 6-19

4. Disconnect fuel supply line **(Figure 6-20, (6))**.

4JH4-TE and 4JH4-HTE Engines

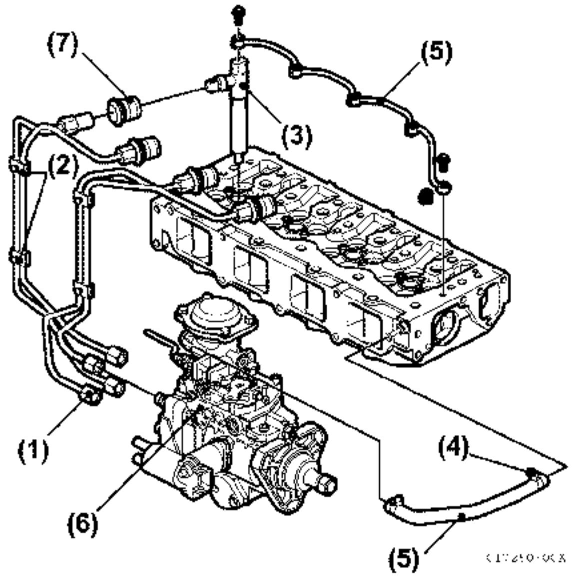


Figure 6-20

5. Disconnect fuel return line **(Figure 6-20, (4))**.
6. Remove fuel injection line **(Figure 6-20, (1))**.
7. Remove bolts and support **(Figure 6-19, (1))**.
8. Hold crankshaft to prevent it from turning and loosen the nut for fuel injection pump drive gear / flange assembly with an extraction tool **(Figure 6-21)**. *NOTICE: Do not disassemble pump flange, fuel pump drive gear and flange bolt.*

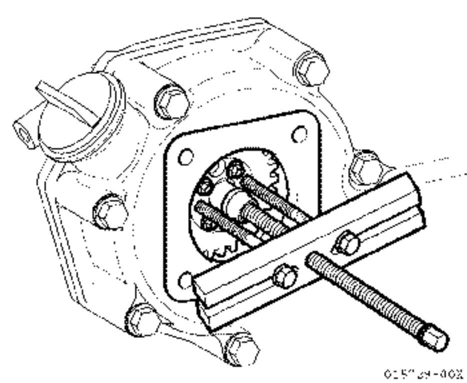


Figure 6-21

9. Remove the fuel injection pump and O-ring from the gear case flange (for 3JH5E and 4JH5E.) Remove the fuel injection pump and O-ring from the VE pump bracket, which is attached to the gear case flange (4JH4-TE and 4JH4-HTE) **(Figure 6-22)**.

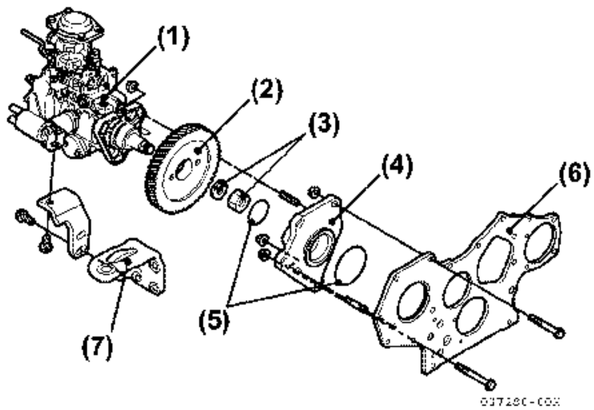


Figure 6-22

10. Install a new fuel injection pump.

Installation

1. Confirm whether the marks of the pump drive gear and the idler gear align.
2. Turn the camshaft so that the key of the camshaft begins to align with the key groove of the pump drive gear.
3. Insert the VE pump and a new O-ring into the hole of the pump bracket. Verify that the key of the camshaft and the key groove of the drive gear are aligned. Lightly tighten the three nuts for the VE pump **(Figure 6-23)**.

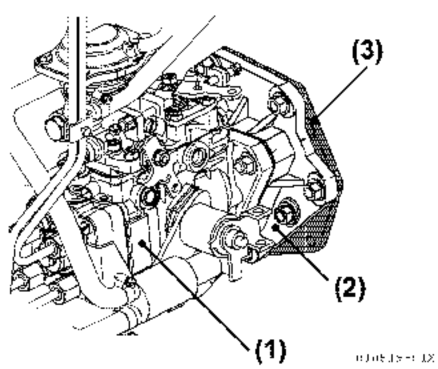


Figure 6-23

Note: Always use new O-rings on assembly. Be careful not to scratch the O-ring.

4. Tighten the pump drive gear nut and the washer together temporarily.
5. Turn the VE pump to the position where the marks of the VE pump bracket align.
6. Tighten the pump drive gear nut (with lubricating oil) firmly with the specified standard torque.

Tightening Torque	3JH5E 4JH5E	34.3 N·m (25.3 lb-ft)
	4JH4-TE 4JH4-HTE	64 N·m (47 lb-ft)

7. Tighten the three pump installation nuts firmly. After adjusting the injection timing, tighten the fuel injection pump.
8. Measure the backlash between the pump drive gear and idler gear.

Backlash	0.07-0.15 mm 0.0028-0.0059 in.

Adjusting Fuel Injection Timing

See Checking and Adjusting Fuel Injection Timing on page 6-32 and see *Position of Top Dead Center and Fuel Injection Timing on page 5-70.*

1. Install high-pressure line and tighten union nuts. *See Remove the fuel injection line (Figure 5-32) through (Figure 5-34): on page 5-32.*
2. Connect fuel return line.
3. Connect fuel supply line.
4. Connect electrical connector.
5. Open fuel supply valve.
6. Bleed fuel system. *See Bleeding the Fuel System on page 6-51.*
7. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.***
Start the engine and check for leaks.

MP2 FUEL INJECTION PUMP SYSTEM (3 / 4JH5E)

Introduction

This section of the *Service Manual* describes the procedures necessary to remove, install and perform timing adjustment of the MP fuel injection pump and its associated system components. This fuel injection pump is comparable to the fuel injection pumps used on model 3JH5E and 4JH5E engines.

Fuel Injection Pump

Note: If the MP fuel injection pump itself requires servicing, it must be taken to an authorized Yanmar FIE (Fuel Injection Equipment) repair facility.

NOTICE: NEVER remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

NOTICE:NEVER attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they can be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.

NOTICE: Tampering with or removing these devices may void the "Yanmar Limited Warranty."

The following describes the features of the MP fuel injection pump manufactured by Yanmar **(Figure 6-24)**.

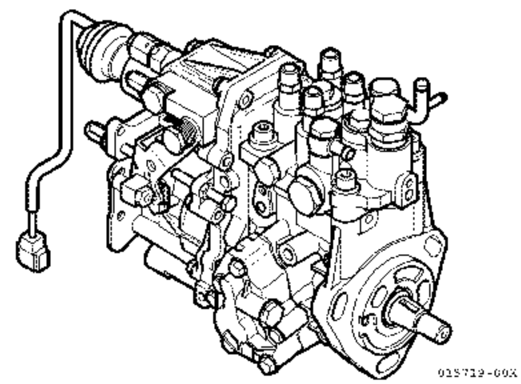


Figure 6-24

The fuel injection pump is a very important component of the engine. It is capable of making very precise fuel delivery adjustments according to the varied loads applied to the engine.

All of the fuel injection pump components are very precisely machined. It is extremely important to follow good service practices and maintain cleanliness when servicing the fuel injection pump.

The Yanmar MP "Mono-Plunger" Fuel Injection Pump is a distributor type pump which consists of a single fuel supply plunger, a distributor shaft, a hydraulic head and a pump housing. The hydraulic head has a delivery valve for each cylinder. The fuel injection pump housing contains a governor and an internal camshaft.

The fuel is pressurized by the up and down motion of the camshaft-driven single plunger. It is then distributed to the proper fuel injector by the rotating distributor shaft.

The MP2 pump is used on model 3JH5E and 4JH5E engines.

Stop Solenoid

The MP fuel injection pumps are equipped with a stop solenoid that controls the fuel flow inside the fuel injection pump.

Usually, no current flows to the stop solenoid and the solenoid plunger is extended, releasing the fuel injection pump fuel rack in the "opened" position and allowing fuel to flow through the injection pump and to the engine.

To stop the engine, push the stop button while the key switch is turned to the ON position. Current flows to the stop solenoid "hold coil," and the solenoid plunger extends and moves the injection pump fuel rack to the "closed" position, shutting off the fuel flow and stopping the engine.

Trochoid Fuel Pump

Note: The trochoid fuel pump located on the side of the MP fuel injection pump is not a "fuel supply" pump. The function of this pump is to raise the pressure of the fuel supplied by the electric fuel supply pump to the internal fuel pressure required by the MP fuel injection pump.

The use of an electric fuel supply pump is required on 3JH5E and 4JH5E model engines with the MP fuel injection pump.

FUEL SYSTEM SPECIFICATIONS

Special Torque Chart

Component		Tightening Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Fuel Injector Retainer Bolt		39.2 N·m (29 lb-ft)	Not Applied
Fuel Pump Drive Gear Nut	3JH5E and 4JH5E	32.3-36.3 N·m (24-27 lb-ft)	Not Applied
High-Pressure Fuel Injection Line Nuts		29-34 N·m (22-25 lb-ft)	Not Applied
Fuel Return Line Bolts		7.8-9.8 N·m (69-87 in-lb)	Not Applied
Fuel Injection Pump Mounting Nuts		23-28 N·m (17-21 lb-ft)	Not Applied
Fuel Injector Nozzle Case Nut 0.605-40 UNS-28		39.2-44.1 N·m (30-33 lb-ft)	Not Applied
Fuel Injection Pump Plunger Plug 119802-51560 M14 x 1.0	3JH5E and 4JH5E	30-35 N·m (22-26 lb-ft)	Not Applied

Test and Adjustment Specifications

Model	Injector ID Mark*	Fuel Injector Pressure	Fuel Injection Timing
3JH5E and 4JH5E	RDL	20.6-21.6 MPa (2988-3132 psi)	*See Checking and Adjusting Fuel Injection Timing on page 6-32.*

* *Fuel injector identification is critical as each engine has a unique fuel injection pressure. The fuel nozzle is specifically matched to the fuel injector by engine model and / or engine speed.*

Note: Fuel injection pressure of a new fuel injector is reduced approximately 72.5 psi (0.5 MPa) after about 5 hours of operation due to the initial break-in of the engine. When adjusting a new fuel injector or after it has been disassembled for service, adjust the fuel injector 72.5 psi (0.5 MPa) higher than the above standard.

Note: Every fuel injector has a three-character identification mark **(Figure 6-25, (1))** such as RDL (3JH5E and 4JH5E).

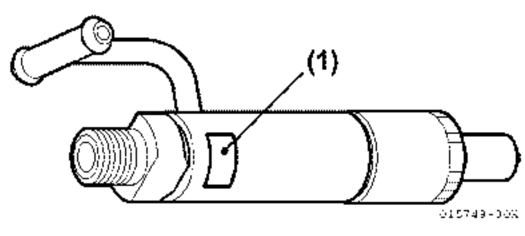
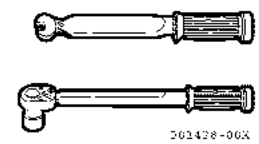
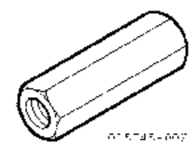
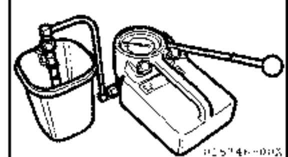
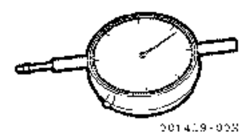
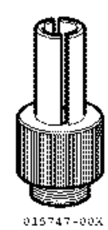
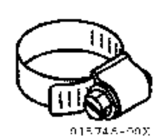


Figure 6-25

SPECIAL SERVICE TOOLS

No.	Tool Name		Application	Illustration
1	Torque Wrench	Locally Available	For tightening nuts and bolts to the specified torque	
2	Fuel Injector Removal Tool	Yanmar Part No. 129470-92305	Used in conjunction with a slide hammer to remove the fuel injectors (2-valve cylinder heads)	

MEASURING INSTRUMENTS

No.	Instrument Name		Application	Illustration
1	Fuel Injector Tester	Locally Available	For observing injection spray pattern of fuel injection nozzle and measuring injection pressure	
2	Dial Indicator*	Mituotoyo 2050SB - Locally Available	Check and adjust fuel injection timing	
	Extension Rod*	Mituotoyo 303613 - Locally Available	-	-
3	Fuel Injection Pump Plunger Adapter*	(M14) TNV82-88 - Yanmar Part No. 158090-51831	Mount dial indicator to fuel injection pump	
		(M16) TNV94-106 - Yanmar Part No. 158090-51841		
4	Plunger Adapter Clamp	Yanmar Part No. 23000-013000	Clamps stem of dial indicator in plunger adapter.	

* *These special service tools may also be available as an "MP Fuel Injection Pump Special Tool Set," under a different part number, in territories serviced by Yanmar America and Yanmar Europe.*

FUEL SYSTEM COMPONENTS

4JH5E Engine Shown (3JH5E is Similar)

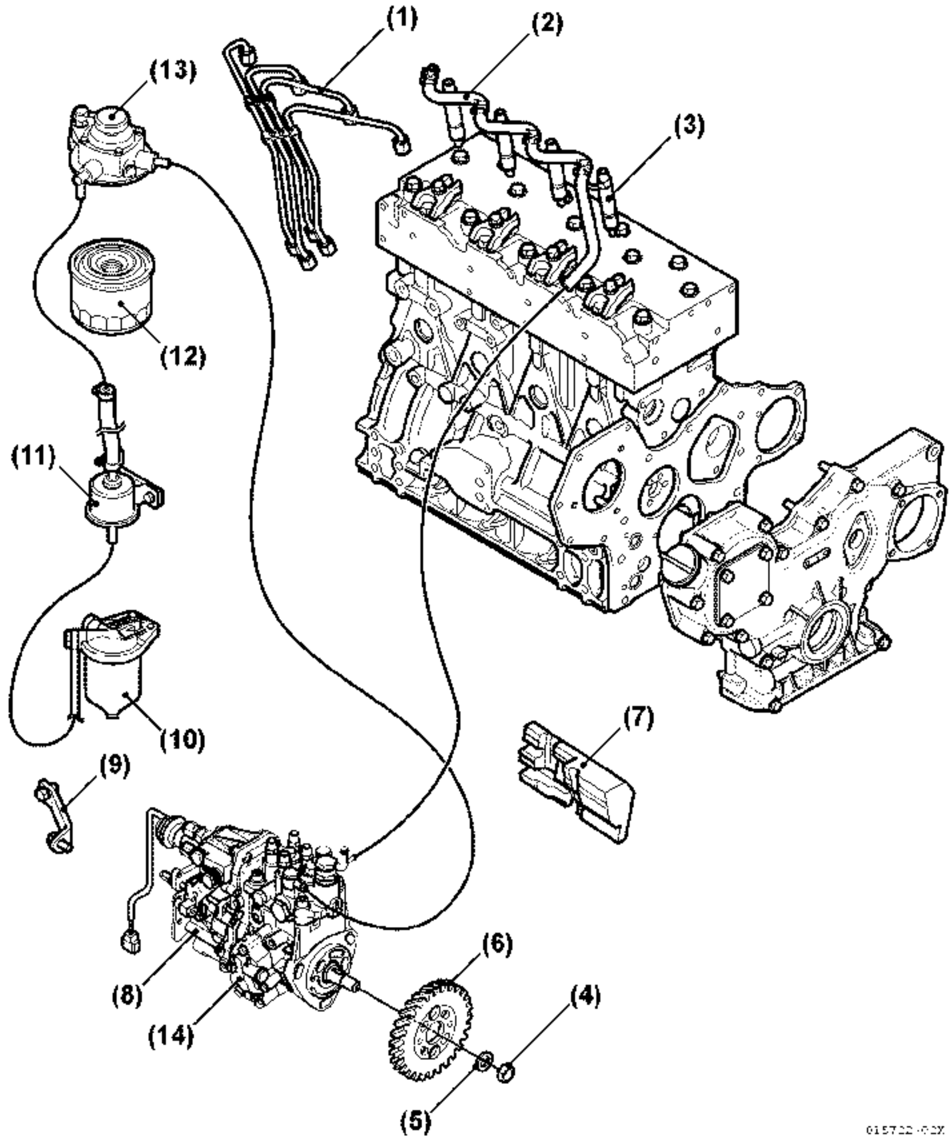


Figure 6-26

1 – High-Pressure Fuel Injection Lines
2 – Fuel Return Line
3 – Fuel Injector
4 – Fuel Injection Pump Drive Gear Nut
5 – Lock Washer
6 – Fuel Injection Pump Drive Gear Assembly (DO NOT remove or loosen the four bolts that fasten the injection pump drive gear to the injection pump drive gear hub.)
7 – Fuel Injection Pump Insulator
8 – Fuel Injection Pump
9 – Rear Fuel Injection Pump Support
10 – Fuel Filter / Water Separator
11 – Electric Fuel Feed Pump
12 – Fuel Filter
13 – Fuel Filter Housing with Priming Pump
14 – Trochoid Fuel Pump

FUEL INJECTION PUMP

Removing the Fuel Injection Pump

1. Loosen the cooling pump V-belt.
2. Remove the spacer, V-pulley **(Figure 6-27, (1))** and cooling fan V-belt **(Figure 6-27, (2))**.

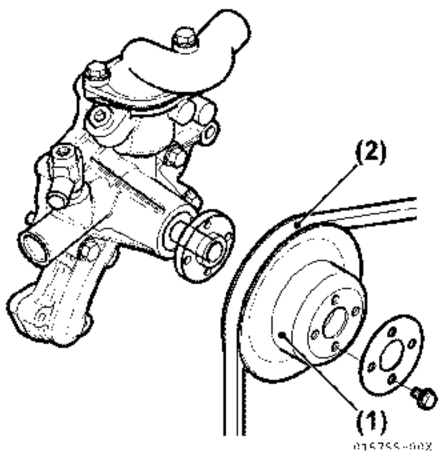


Figure 6-27

3. Close any fuel valves in the fuel supply line.
4. Place a drain pan under the fuel injection pump to catch spills.
5. Remove the high-pressure fuel injection lines as an assembly **(Figure 6-28, (1))**.

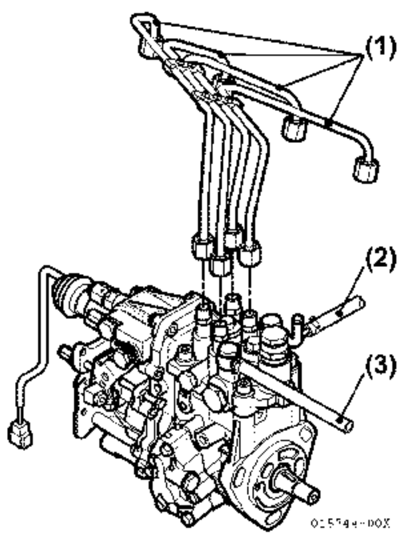


Figure 6-28

Note: To prevent rounding the fuel line nuts, always use a line or flare nut wrench. When loosening the fuel line nuts, always hold the fuel injection pump delivery valves with a "back up" wrench to prevent loosening the delivery valves.

6. First loosen the fuel line nuts at the fuel injectors and then at the fuel injection pump. *NOTICE: Remove or install the high-pressure fuel injection lines as an assembly. Disassembling the high-pressure fuel injection lines from the retainers or bending any of the fuel lines will make it difficult to reinstall the fuel lines.*
7. Finish loosening all the fuel line nuts and remove the high-pressure fuel lines as an assembly being careful not to bend any of the fuel lines. Be sure to protect the fuel system from contamination by covering all open connections.
8. Disconnect the fuel return lines from the fuel return fitting **(Figure 6-28, (2))**. Plug the open ends of the lines to minimize leaks and prevent contamination.
9. Remove the fuel supply line **(Figure 6-28, (3))**. Plug the open end of the line to minimize leakage and prevent contamination.
10. Remove the throttle cable from the fuel injection pump.
11. Separate the stop solenoid wiring connector **(Figure 6-29, (2))**.

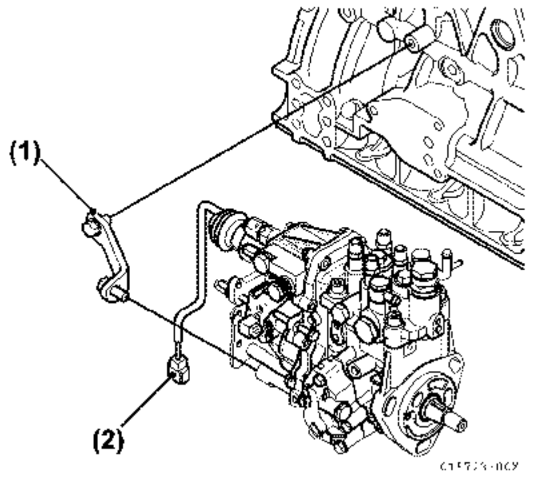


Figure 6-29

12. Remove the rear fuel injection pump bracket **(Figure 6-29, (1))** from the fuel injection pump.
13. Disconnect the lubricating oil line **(Figure 6-30, (1))** and the clamp **(Figure 6-30, (2))** from the pump. *NOTICE: Take care not to damage or bend the oil line. For 4JH5E and 3JH5E models, it may be preferable to remove the complete oil line assembly from the engine before proceeding.*

Note: On 4JH5E and 3JH5E models, the fuel injection pump drive gear cover is attached to the gear case cover by four bolts.

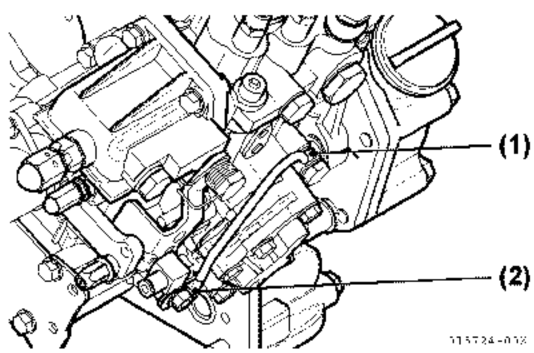


Figure 6-30

14. Remove the fuel injection pump drive gear cover **(Figure 6-31, (1))** from the gear case cover **(Figure 6-31, (2))**.

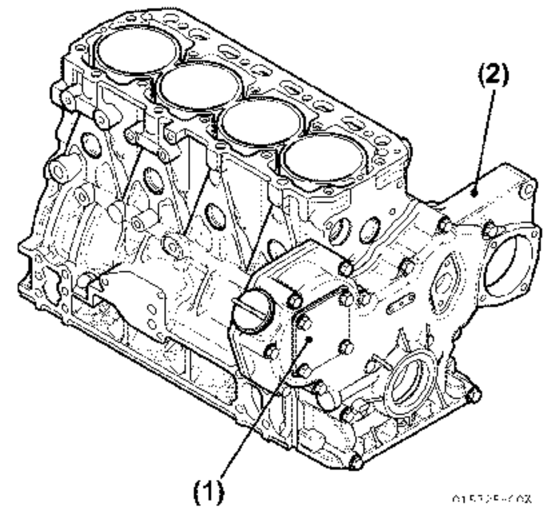


Figure 6-31

15. To position the fuel injection pump for easier removal and installation, install a dial gauge *(see Checking and Adjusting Fuel Injection Timing on page 6-32)* into the injection pump plunger opening. Using a wrench on the crankshaft pulley bolt, rotate the crankshaft until the dial gauge shows that the injection pump plunger is at the bottom of it's stroke.
16. To aid in reassembly, make reference marks on the fuel injection pump drive gear, and on the gear case cover or idler gear. *NOTICE: After marking the position of the pump drive gear, do not rotate the engine crankshaft. Rotating the crankshaft will cause the fuel injection pump to become misaligned.*
    - On 3JH5E and 4JH5E models, the idler gear is not visible. Make a reference mark on the fuel injection pump drive gear **(Figure 6-32, (1))** and a matching mark on the bore of the gear case opening **(Figure 6-32, (2))**. *NOTICE: Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.*

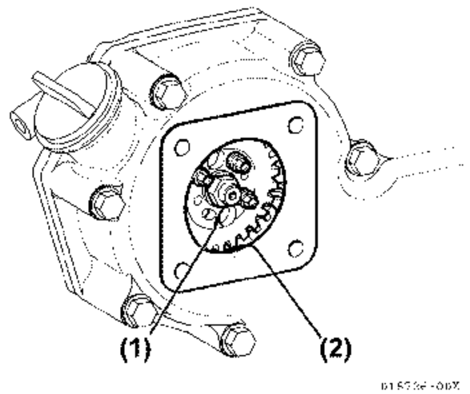


Figure 6-32

17. Do not loosen or remove the four bolts **(Figure 6-33, (3))** retaining the pump drive gear to the hub. Only remove the single drive gear nut **(Figure 6-33, (1))** and washer **(Figure 6-33, (2))**, leaving the hub attached to the gear.

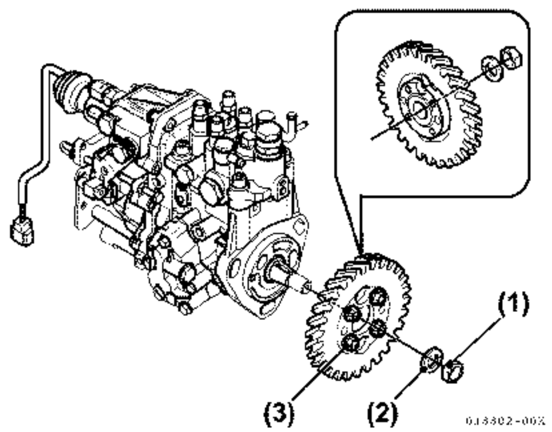


Figure 6-33

18. Hold the gear train using a large socket wrench on the crankshaft pulley nut. Loosen the fuel injection pump drive gear retaining nut **(Figure 6-33, (1))** and turn it out to the end of the fuel injection pump shaft.
19. Disconnect the injection pump from drive gear as an assembly using an appropriate two-bolt gear puller **(Figure 6-34).**

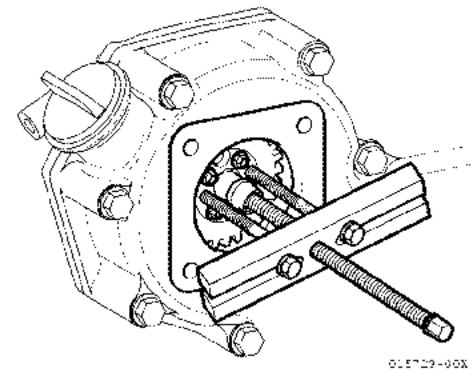


Figure 6-34

Note: On 3JH5E and 4JH5E models the injection pump drive gear will remain "captured" inside the gear case and will not be removable.

20. Once the fuel injection pump drive gear and hub assembly has "popped" loose from the tapered fuel injection pump driveshaft, carefully remove the drive gear nut **(Figure 6-35, (1))** and lock washer **(Figure 6-35, (2))**.

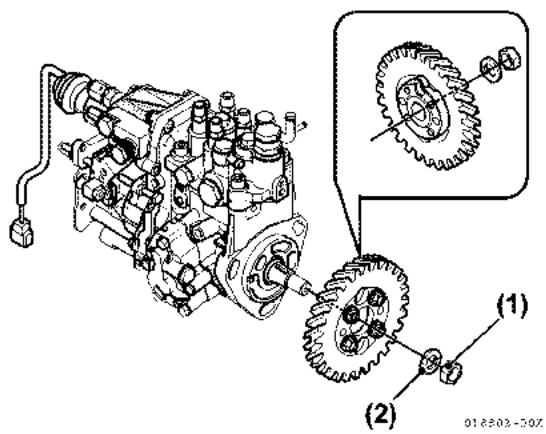


Figure 6-35

21. Locate the mark stamped into the upper outside mounting boss of the fuel injection pump. Highlight this mark and make a corresponding mark on the gear case **(Figure 6-36, (1)).**

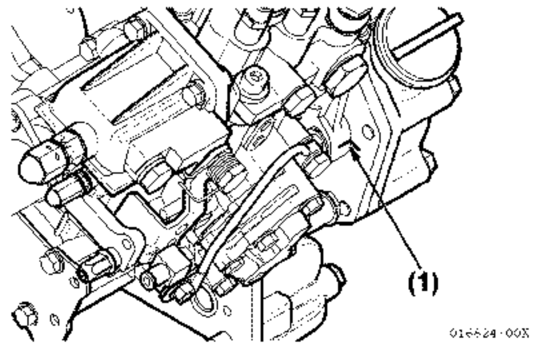


Figure 6-36

Note: The intake manifold and fuel injection pump insulator **(Figure 6-37, (2))** may need to be removed to access the inner fuel injection pump **(Figure 6-37, (1))** retaining nuts.

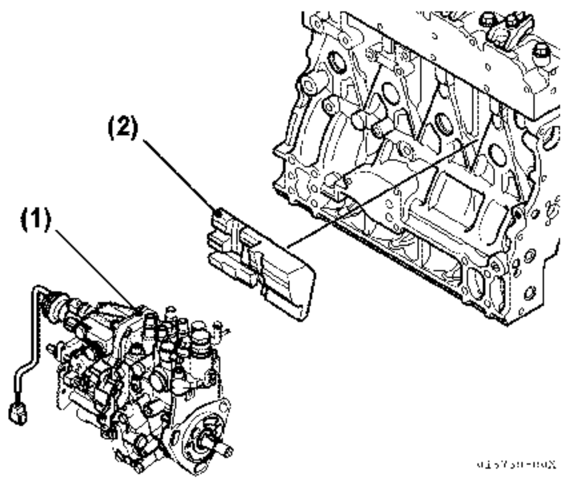


Figure 6-37

22. If required, remove the intake manifold and fuel pump insulator to access the fuel injection pump mounting nuts.

Note: The MP2 fuel injection pumps are fastened to the gear case with three studs and nuts.

23. Remove the fuel injection pump **(Figure 6-37, (1))**. For purposes of future injection timing purposes, record the fuel injection pump timing index number located on the boss on the engine side (back) of the fuel injection pump **(Figure 6-38, (1))**. *NOTICE: Do not rotate the crankshaft while the injection pump is removed.*

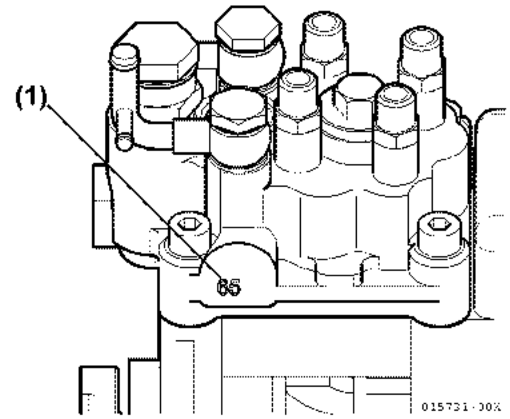


Figure 6-38

24. If the fuel injection pump requires servicing, it must be sent to an authorized Yanmar FIE repair facility for repair and calibration, or replaced with a new fuel injection pump.

NOTICE: NEVER remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

NOTICE: NEVER attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they should be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.

NOTICE: Tampering with or removing these devices may void the "Yanmar Limited Warranty."

Installing the Fuel Injection Pump

NOTICE: If installing a new or recalibrated fuel injection pump, record the timing index number located on the pump housing boss on the engine side of the new or recalibrated fuel injection pump **(Figure 6-39, *(1)*)**. *This number will be used to calculate and adjust the final fuel injection timing.*

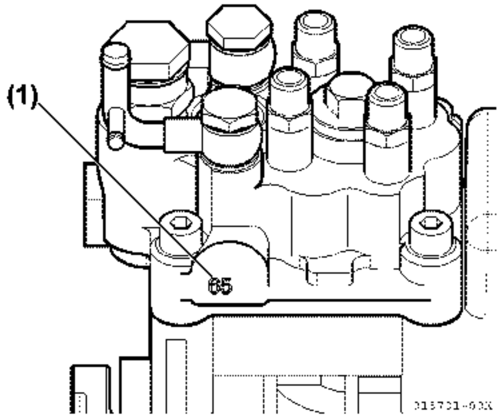


Figure 6-39

Note: If either or both of the fuel injection pumps do not have a timing index number, note the injection pump ID (example: XK42) on the injection pump ID label.

To locate the timing index number for the engine being serviced use the Timing Index Chart under "FIE Specs" on the Yanmar Distributor Website (http://distributor.yanmar.co.jp).

Note: Treat the timing index number as if it has a decimal point (65 = 6.5).

1. Align the pump drive gear with the idler gear using the reference marks made earlier **(Figure 6-40, (1))**.

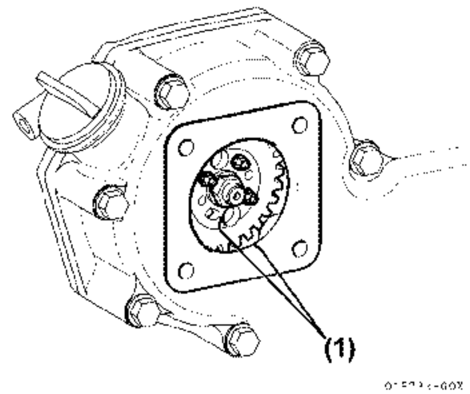
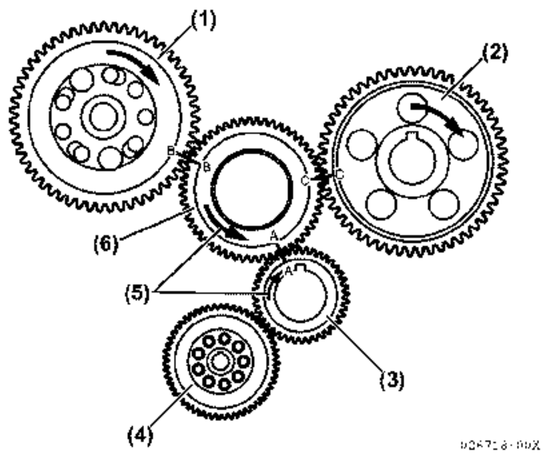


Figure 6-40

2. If installing the fuel injection pump on an engine with the front gear case cover removed, the fuel injection pump drive gear can be aligned with the idler gear by aligning the stamped marks **(A, B, C)** on the fuel injection pump drive gear, idler gear and crankshaft drive gear. Ensure all three timing marks **(Figure 6-41, (A, B, C))** are aligned.



1 – Fuel Injection Pump Drive Gear
2 – Camshaft Drive Gear
3 – Crankshaft Drive Gear
4 – Lubricating Oil Pump Drive Gear
5 – Direction of Rotation
6 – Idler Gear

Figure 6-41

3. Install a new O-ring on the pump mounting flange. Apply grease to the O-ring to hold it in place while the injection pump is installed.

Note: Ensure the tapered surface of the fuel injection pump shaft is clean and dry.

4. Align the key on the fuel injection pump shaft with the keyway in the fuel injection pump drive gear hub. Reinstall the fuel injection pump into the fuel injection pump drive gear and gear housing. Reinstall the pump retaining nuts finger-tight.
5. Reinstall the fuel injection pump drive gear lock washer **(Figure 6-42, (2))** and nut **(Figure 6-42, (1))**. Do not lubricate the threads of the nut or shaft. Hold the crankshaft pulley bolt with a socket wrench and tighten the drive gear nut to the specified torque. *See Special Torque Chart on page 6-5.*

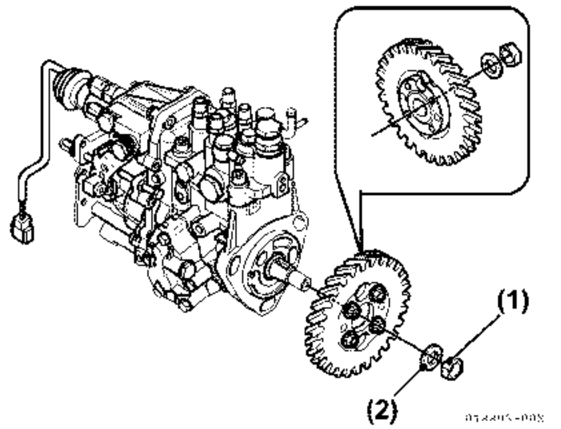


Figure 6-42

If reinstalling the original fuel injection pump:

(a) Align the reference marks **(Figure 6-43, (1))** previously made on both the fuel injection pump mounting flange and gear case or front plate.

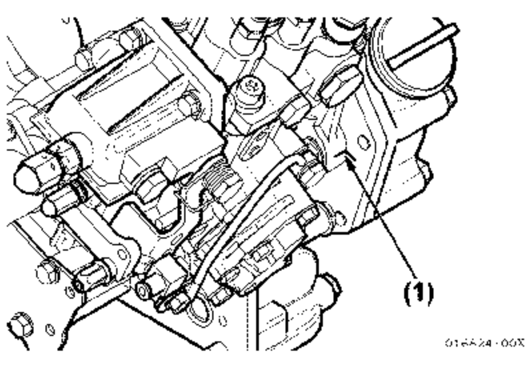


Figure 6-43

(b) Tighten the fuel injection pump retaining nuts to specification. *See Special Torque Chart on page 6-21.*

If installing a new fuel injection pump:

(a) Reinstall the timing grid sticker, provided with the new fuel injection pump, onto the back of the gear case / front plate **(Figure 6-44).** Align the "standard mark" **(Figure 6-44, (1))** with the reference mark **(Figure 6-44, (2))** made on the gear case during disassembly.

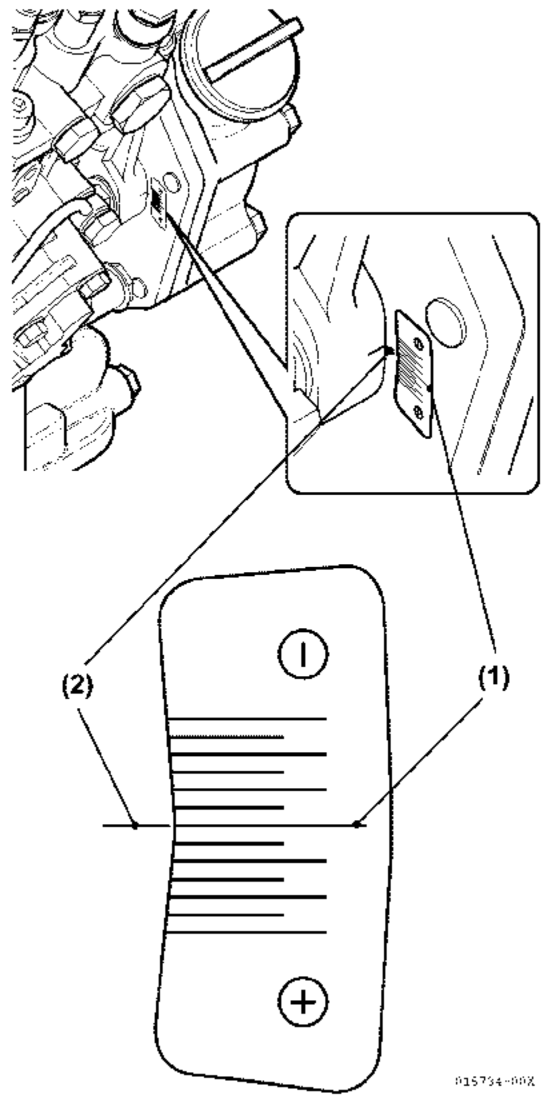


Figure 6-44

(b) Calculate the difference between the timing index numbers **(Figure 6-45, (1))** of the fuel injection pump that you removed and the replacement fuel injection pump. *See Calculation Example below.*

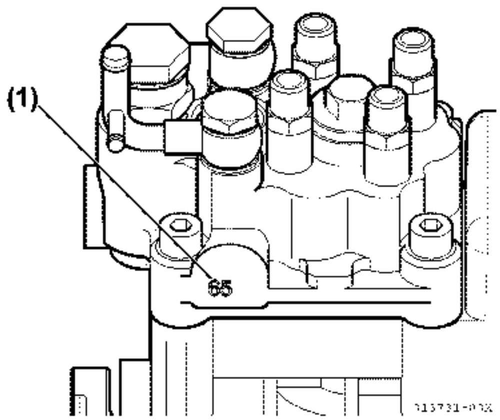


Figure 6-45

Adjusting the fuel injection timing to compensate for the difference in pump timing index numbers:

Calculation Example

Timing Index Number	
Original injection pump =	6.8
Replacement injection pump =	7.3
Difference =	+0.5

Difference = Replacement injection pump timing index number - original injection pump timing index number.

- If the difference between the timing index numbers is a positive (+) number, the fuel injection pump mounting position must be advanced **(Figure 6-46, (2))** (rotated away from the engine) as compared to the "standard mark" **(Figure 6-46, (1))** by the calculated positive (+) amount; adjust the fuel injection pump to the calculated value.

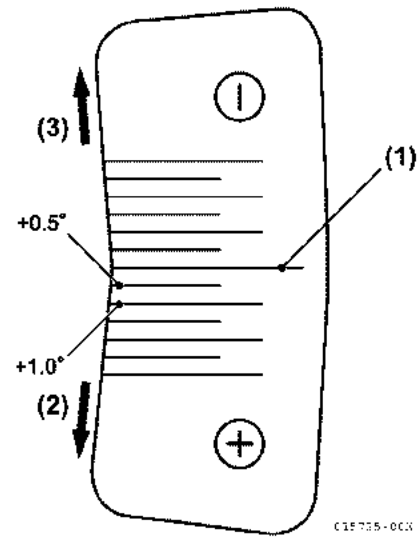


Figure 6-46

- If the difference between the timing index numbers is a negative (-) number, the replacement injection pump must be retarded **(Figure 6-46, (3))** (rotated toward the engine) by the calculated negative (-) amount.
- Each mark on the timing sticker represents 0.5° timing change.

The above calculated difference indicates that the replacement fuel injection pump is to be installed at +0.5° (advanced) from the "standard mark" **(Figure 6-46, (1))** on the timing sticker.

In this case, rotate the top of the fuel injection pump away from the cylinder block until the mark on the outside upper mounting boss **(Figure 6-47, (1))** of the fuel injection pump aligns with the +0.5° mark on the timing sticker.

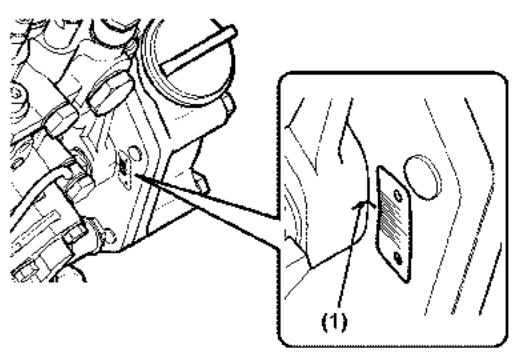


Figure 6-47

Tighten the fuel injection pump mounting nuts to specification. *See Special Torque Chart on page 6-21.*

6. Reinstall the rear bracket **(Figure 6-48, (1))** to the fuel injection pump. Tighten the rear support bolts.

Note: Configuration of the fuel injection pump rear brackets may vary depending on the model.

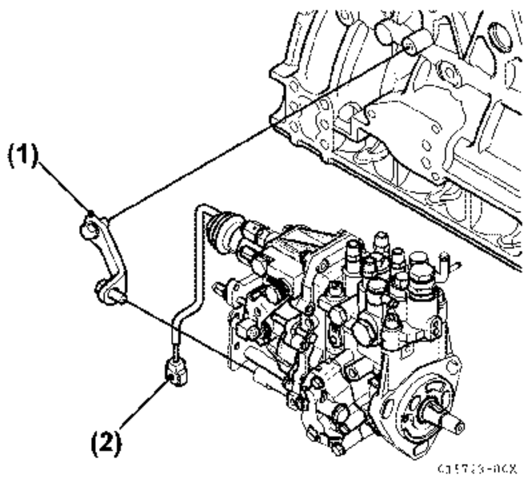


Figure 6-48

7. Reconnect the throttle linkage and the stop solenoid connector **(Figure 6-48, (2))**.
8. Reconnect the lubricating oil line **(Figure 6-49, (1))** and clamp **(Figure 6-49, (2))**.

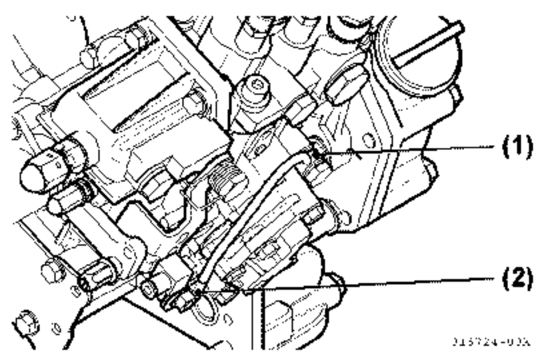


Figure 6-49

9. Apply Three Bond Liquid Gasket No. 1212, Yanmar P/N 977770-01212, or equivalent sealant to the sealing surface of the pump cover. Install the pump cover and tighten the cover bolts.
10. Reconnect the fuel return lines and fuel supply line to the fuel injection pump.
11. Reinstall the fuel injection high-pressure lines. Tighten the nuts to specification. *See Special Torque Chart on page 6-21. NOTICE: When reinstalling a new or repaired fuel injection pump, it is important to add engine oil to the fuel injection pump to provide lubrication for initial start-up. Add 5 to 7 oz (150 to 200 cc) of clean engine oil to the fuel injection pump at the fill plug located in the upper outside section of the governor housing.*
12. Verify the fuel injection pump insulator **(Figure 6-50, (2))** is not damaged, if equipped. Reinstall the insulator and intake manifold if previously removed.

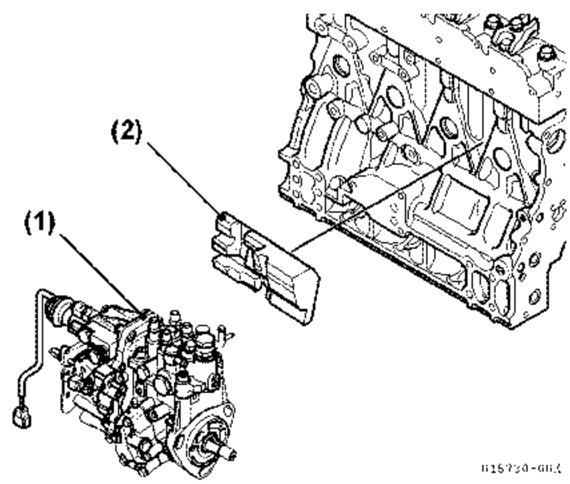


Figure 6-50

13. Reinstall the coolant pump V-pulley spacer **(Figure 6-51, (1))**.

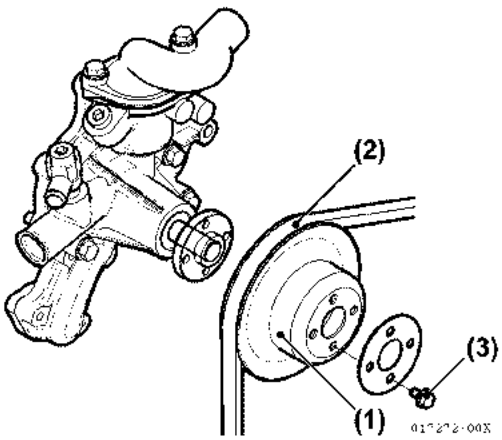


Figure 6-51

14. Reinstall the cooling pump V-belt **(Figure 6-51, (2))**. *See Replacing Coolant Pump Belt and Pulley on page 7-18.*
15. Prime the fuel system. *See Bleeding the Fuel System on page 6-51.*
16. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start the engine and check for fuel and coolant leaks.

CHECKING AND ADJUSTING FUEL INJECTION TIMING

Determining the Fuel Injection Timing Specification

1. Locate and record the fuel injection pump timing index number **(Figure 6-53, (1))** stamped into the boss on the engine side of the fuel injection pump housing **(Figure 6-52, (1))**.

Note: Treat the timing index number as if it has a decimal point (65 = 6.5).

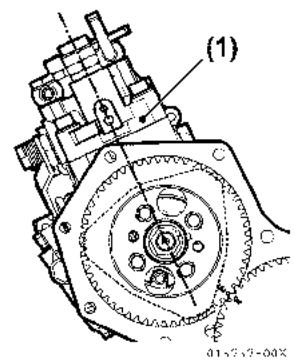


Figure 6-52

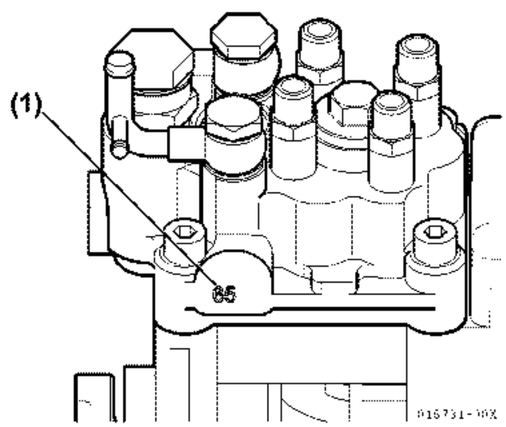


Figure 6-53

2. Using the Fuel Injection Reference (FIR) number for the engine being serviced, use the FIR Chart under “FIE Specs” on the Yanmar Distributor Website: (http://distributor.yanmar.co.jp).

   The FIR number is determined by the complete engine model number. The engine number is located on the engine nameplate **(Figure 6-54)**.

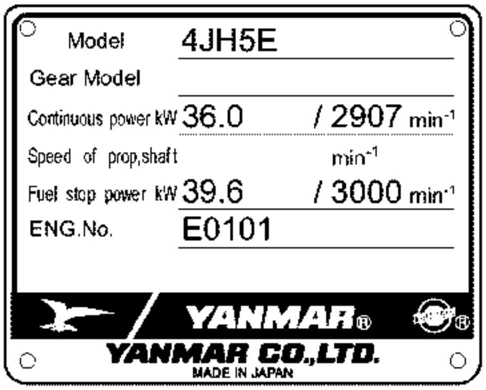


Figure 6-54

EXAMPLE: The following example is for a model 4JH5E engine.

(a) Find the engine model number in the FIR chart. Locate and record the FIR number (The FIR number for this engine is 5).

(b) Insert the numbers you have recorded into the following equation:

(Fuel Injection Pump Timing Index Number x 2) + FIR Number = FIT° (Fuel injection Timing in Degrees)

(6.5 x 2) = 13 + 6 = 19° Fuel injection Timing

(c) Record the calculated fuel injection timing specification.

Checking Fuel Injection Timing

Note: Some fuel may drain from the fuel injection pump during this process. Make provisions to contain any such spillage.

1. Close off the fuel valve in the fuel supply hose and the fuel return hose.
2. Clamp shut the fuel injection pump fuel return hose **(Figure 6-55, (1))**. *NOTICE: Clean the top of the fuel injection pump to prevent any contamination when the fuel injection pump plunger plug is removed.*

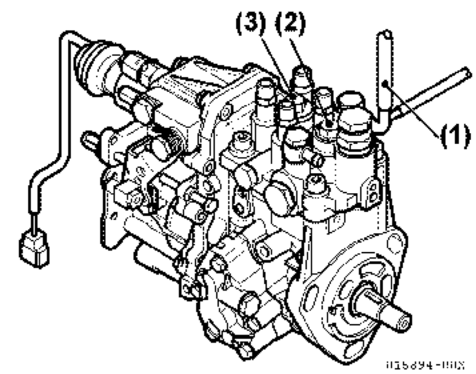


Figure 6-55

3. Remove the forward fuel injection pump plunger plug **(Figure 6-55, (2))** on the top of the fuel injection pump. *NOTICE: Do not release the distributor plug **(Figure 6-55, (3))**. Fuel injection order may change from the proper order.*
4. Install a dial gauge adapter and clamp into the pump plunger opening.

Note: Use the Yanmar part no. 158090-51831 M14 adapter for the MP2 fuel injection pumps and Yanmar part no. 23000-013000 plunger adapter clamp **(Figure 6-56, (1))**.

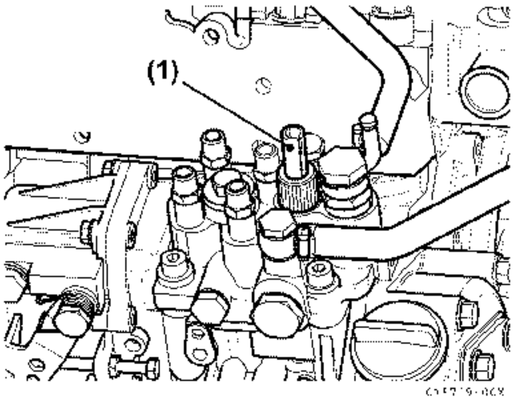


Figure 6-56

5. Install a dial gauge **(Figure 6-57, (1))**, Mitutoyo P/N 2050SB or equivalent, with a 30 mm extension, Yanmar P/N 158090-51870 or Mitutoyo P/N 303613, into the adapter. Secure with the Yanmar P/N 23000-013000 plunger adapter clamp **(Figure 6-56, (1))** at approximately the mid-point of its travel.

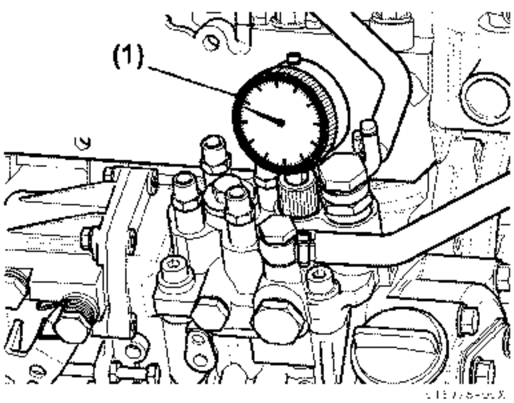


Figure 6-57

Note: The following references to the direction-of-rotation are facing the coolant pump end of the engine and are adjusted by turning the crankshaft pulley.

6. Using a wrench on the crankshaft pulley bolt, rotate the crankshaft in a clockwise direction while looking through the flywheel inspection port **(Figure 6-58, (1))**. Rotate the crankshaft until the injection timing marks on the flywheel are visible.

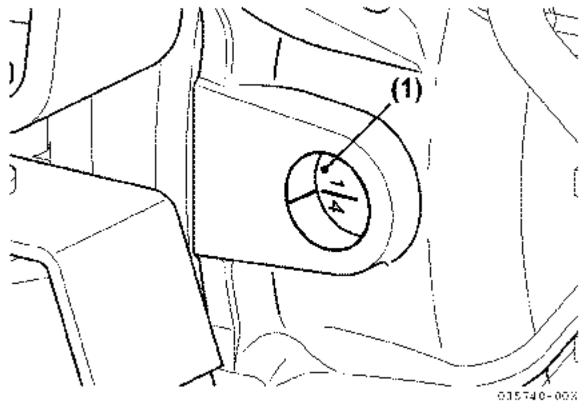
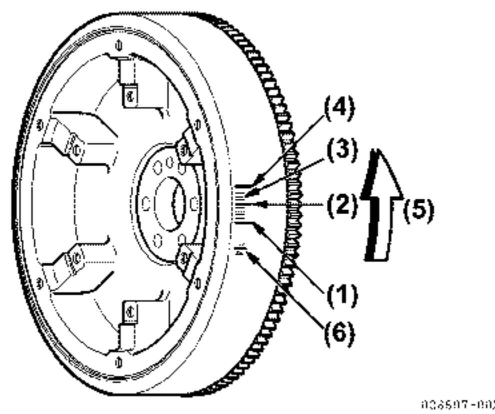


Figure 6-58

7. Typical flywheel markings are as shown in **(Figure 6-59, (1))**.



1 – 10° BTDC (Before Top Dead Center)
2 – 15° BTDC
3 – 18° BTDC
4 – 20° BTDC
5 – Direction of Rotation
6 – TDC (Top Dead Center)

Figure 6-59

Note: A typical flywheel will have multiple timing grids depending on the number of cylinders. Any grid can be used to check the fuel injection timing.

The flywheel shown in **Figure 6-59** is for a Yanmar standard specification DI engine.

Note: The TDC (Top Dead Center) mark can be identified by the cylinder numbers stamped near the TDC mark on the flywheel.

8. Highlight the timing reference mark **(Figure 6-60, (2))** on the flywheel housing. Highlight the TDC mark **(Figure 6-60, (1))** on the flywheel.

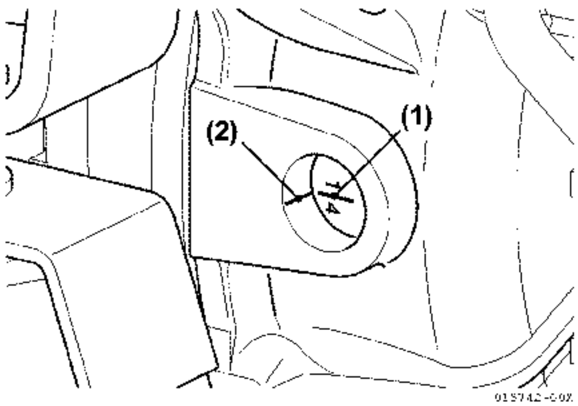


Figure 6-60

9. Highlight the target timing mark **(Figure 6-61, (1))** on the flywheel as calculated in *Determining the Fuel Injection Timing Specification on page 6-32* (FIT 18°).

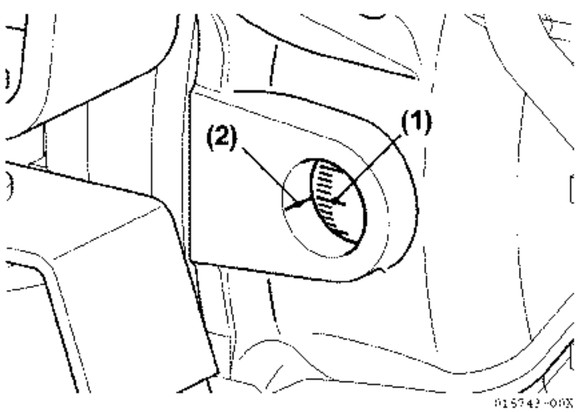


Figure 6-61

10. Rotate the crankshaft counterclockwise until the dial gauge shows that the injection pump plunger is at the bottom of its stroke. Rock the crankshaft back and forth slightly to confirm a point where the dial gauge shows no movement. Zero the dial gauge.
11. Slowly rotate the crankshaft clockwise until the dial gauge shows a pump plunger lift of 2.5 mm (0.098 in.).
12. Check the position of the previously determined flywheel target timing mark **(Figure 6-61, (1))** in relation to the timing reference mark **(Figure 6-61, (2))** on the flywheel housing. If the two marks are aligned, the fuel injection timing is correct. If the marks do not align, the fuel injection timing must be adjusted. *See Adjusting Fuel Injection Timing on page 6-36.*
13. If the injection timing is correct, remove the dial indicator and adapter. Replace the pump plunger plug and its copper gasket and tighten to specifications. Replace the flywheel inspection port cover. Open the fuel supply valve and remove the clamp from the fuel supply hose and the fuel return hose.
14. Prime the fuel system. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start the engine and check for leaks.

Adjusting Fuel Injection Timing

If the timing marks did not align when performing the *Checking Fuel Injection Timing on page 6-33* procedures, the following steps must be performed to properly time the engine.

1. Leave the dial gauge installed in the fuel injection pump. Do not disturb the reading on the dial gauge.
2. Rotate the flywheel until the target timing mark **(Figure 6-62, (1))** and the timing reference mark **(Figure 6-62, (2))** on the flywheel housing are aligned. *NOTICE: Do not rotate the crankshaft during the remainder of this procedure.*

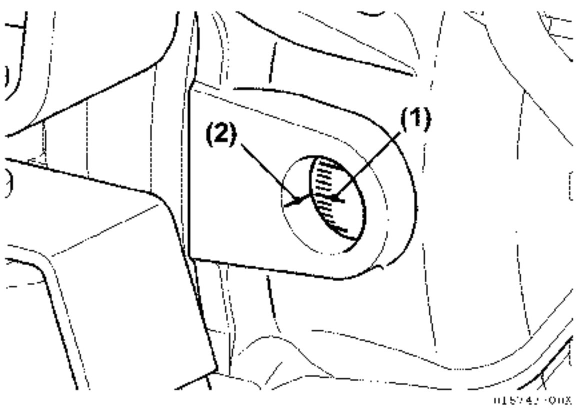


Figure 6-62

3. Note the reading on the dial gauge **(Figure 6-63, (1))**. If the reading is less than 2.5 mm (0.098 in.), the fuel injection timing is retarded. If the dial gauge reading is greater than 2.5 mm (0.098 in.), the fuel injection timing is advanced.

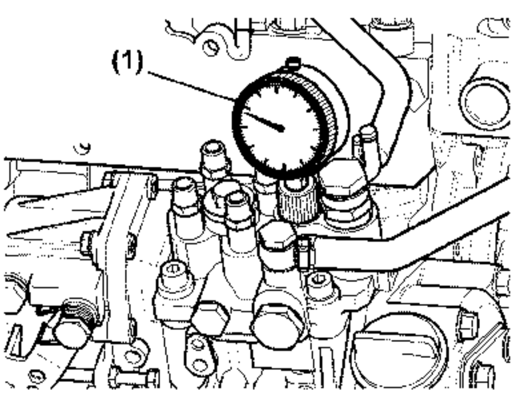


Figure 6-63

Note: Remove the intake manifold and the fuel injection pump insulator on the 4JH4TE model to access the inner fuel injection pump retaining nuts.

4. Loosen the nuts fastening the fuel injection pump to the gear case or front plate. Loosen the rear bracket(s) on the fuel injection pump.

Note: Loosening the high-pressure injection pipe nuts on the fuel injection pump may make rotating the pump easier.

5. Rotate the fuel injection pump until the dial indicator reads 2.5 mm (0.098 in.).
6. To advance the injection timing, rotate the top of the fuel injection pump away from the engine.
7. To retard the injection timing, rotate the top of the fuel injection pump toward the engine.
8. The injection timing is correct when the dial indicator reads 2.5 mm (0.098 in.) of pump plunger lift and the target timing mark on the flywheel aligns with the reference mark on the flywheel housing.
9. Tighten the nuts fastening the fuel injection pump and rear bracket(s).
10. Remove the dial gauge and adapter. Replace the plug in the pump plunger opening and tighten it to specification. If removed, install the intake manifold and pump insulator. Tighten the high-pressure injection pipe nuts to specification. Open the fuel supply valve, remove the clamp from the fuel return line and prime the fuel system. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start the engine and check it for leaks.

Fuel Injection Pump Structure for 4JH4-TE and 4JH4-HTE

NOTICE: The disassembly and adjustment of a fuel injection pump need expertise and facilities. Refer to a Bosch service shop for assistance.

Specifications: The fuel injection pump is VE type (Manufactured by Bosch).

Fuel Injection Pump	VE type
Fuel Feed Pump	Vane type (built-in)
Timer	Hydraulic (built-in)

Model	VE4 / 12F	
Direction of Rotation	Clockwise (viewed from the drive side)	
Plunger Diameter	ø12 mm	
Governor Type	All speed	
Fuel Feed Type	Vane	
Timer Advancing Angle	4JH4-TE	4JH4-HTE
	1.5° / 1100-1600 rpm (pump speed)	2.6°/1200-1600 rpm (pump speed)
Lubricating Method	Fuel oil lubricating	
Fuel Cut Method	• Magnetic valve (normal open) • With a manual stop lever	
Additional Device	Boost compensator	

Model Designation:

NP - VE 4 / 12 F 1600 R NP2586

- NP2586 — Identification No.
- R — Direction of rotation of pump (viewed from the drive side)
  - R: Clockwise
  - L: Counter clockwise
- 1600 — Maximum speed of governor control (rpm)
- F — Governor type
  - E: Electronic type
  - F: Mechanical type
- 12 — **Plunger diameter (ϕ)**
- 4 — Number of cylinders
- VE — VE type fuel injection pump
- NP — Bosch ID

E00-543010

Structure and Function

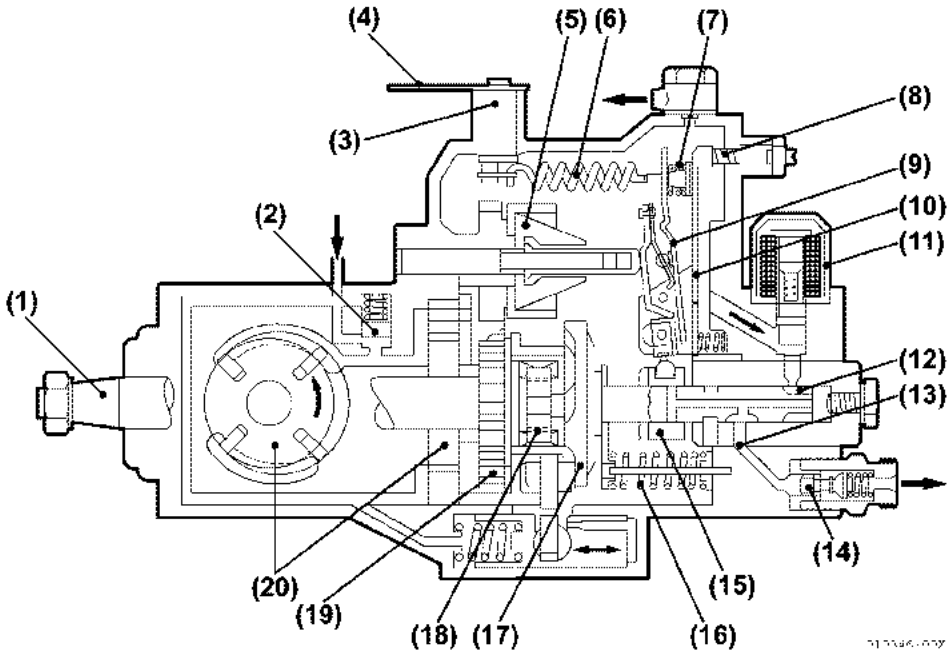


Figure 6-64

1 – Driveshaft
2 – Regulating Valve
3 – Control Lever Shaft
4 – Control Lever
5 – Flyweight
6 – Governor Spring
7 – Idling Spring
8 – Full Load Adjusting Screw
9 – Tension Lever
10 – Governor Lever Assembly
11 – Magnetic Valve
12 – Plunger
13 – Outlet Port
14 – Delivery Valve
15 – Control Sleeve
16 – Plunger Spring
17 – Cam Disk
18 – Cross Coupling
19 – Drive Gear
20 – Feed Pump

Plunger

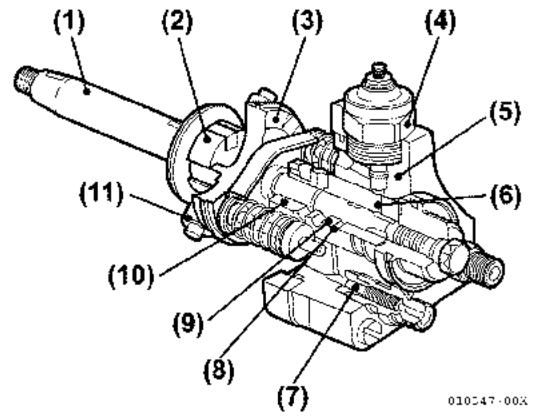


Figure 6-65

1 – **Driveshaft**
2 – **Cross Coupling**
3 – **Cam Disk**
4 – **Magnetic Valve**
5 – **Distributor Head**
6 – **Inlet Port**
7 – **Delivery Valve**
8 – **Outlet Port**
9 – **Plunger Barrel**
10 – **Control Sleeve**
11 – **Roller**

- The driveshaft directly receives the engine rotation by means of gears and transfers the rotation to the cam disk through the cross coupling. The positioning pin press-fitted to the cam disk is also inserted in the groove of the plunger flange, so that the plunger and cam disk rotate in the same direction.
  The cam disk has a face cam to reciprocate by a specified cam lift on the roller of the roller holder assembly.
- There are two plunger springs having setting forces on the outside of the plunger. The return the plunger which is pushed up by the cam disk, in the descending process. That is, the plunger rotates by means of the driveshaft and reciprocates by means of the cam disk.
  When the fuel whose pressure is increased by the plunger is sent to the outlet port, the delivery valve opens to allow the fuel to be injected into the combustion chamber through the fuel injection nozzle.

Governor

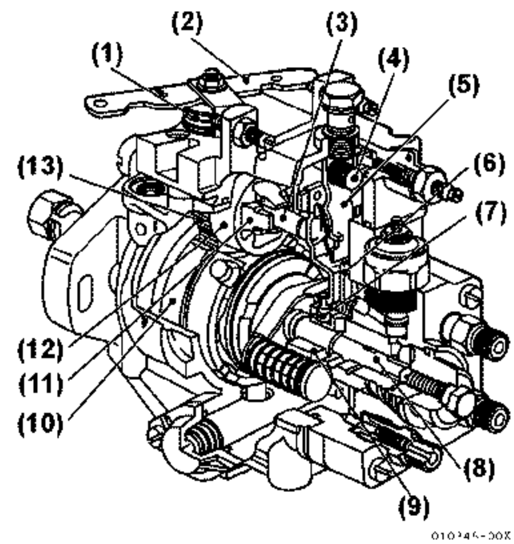


Figure 6-66

1 – **Control Lever Shaft**
2 – **Control Lever**
3 – **Governor Sleeve**
4 – **Retaining Pin**
5 – **Tension Lever**
6 – **Governor Lever Assembly**
7 – **Ball Pin**
8 – **Plunger**
9 – **Control Sleeve**
10 – **Drive Gear**
11 – **Flyweight**
12 – **Flyweight Holder**
13 – **Flyweight Holder Gear**

- The governor, which is located above the pump house, consists of a flyweight holder, governor lever assembly, etc. The flyweight holder holds four flyweights and governor sleeve and is supported by the governor shaft. The drive gear engages with the flyweight holder gear and speeds up the driveshaft rotation to rotate the flyweight holder assembly. The governor lever assembly is supported by the pivot bolt in the pump housing and the ball pin located at the bottom of it is inserted in the control sleeve which slides on the outside surface of the plunger.

- The governor spring located at the top of it is connected to the tension lever with the retaining pin and the governor spring end face is connected to the control lever through the control lever shaft.
  The control lever is linked to the governor handle through the link to vary the setting force of the governor spring according to the inclined angle. A difference between the setting force of the governor spring and the centrifugal force of the flyweight corresponds to the control sleeve movement which increases or decreases the injection quantity.

Timer

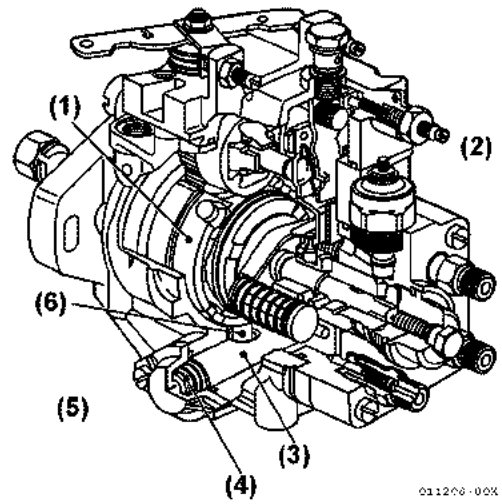


Figure 6-67

1 –Roller Holder
2 –High-Pressure Side
3 –Timer Pin
4 –Timer Spring
5 –Low-Pressure Side
6 –Roller Holder Pin

There is a built-in timer at the bottom of the injection pump. A timer spring having a setting force is installed on the low pressure side. The fuel pressure in the pump house is directly applied to the opposite side (high-pressure side). The position of the timer piston varies according to the relation between this fuel pressure and timer spring force and the roller holder is rotated through the roller holder pin.
When the piston moves in the direction where the timer spring is shrunk, a lead of angle takes place (the roller holder moves in the reverse direction of rotation) to advance the injection timing. That is, the timer controls the injection timing according to the fuel oil pressure in the pump house.

Boost Compensator

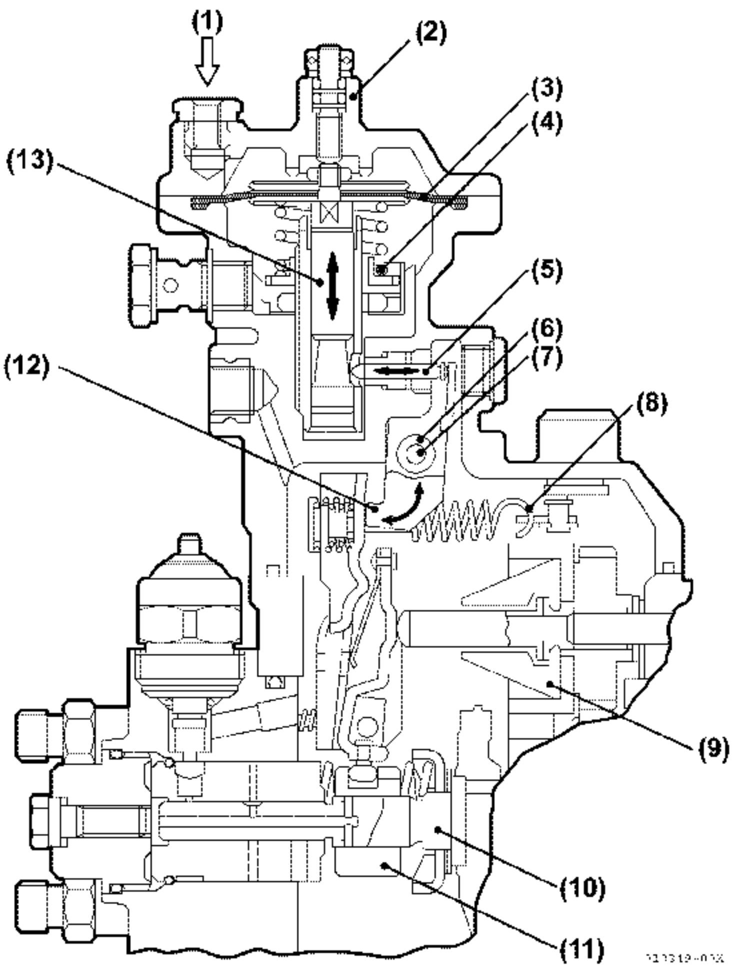


Figure 6-68

1 – Boost Pressure Inlet
2 – Boocon
3 – Diaphragm
4 – Boocon Spring
5 – Connecting Pin
6 – Boocon Lever
7 – Supporting Point A
8 – Governor Spring
9 – Flyweight
10 – Plunger
11 – Control Sleeve
12 – Tension Lever
13 – Adjusting Pin

Note: The following description is based on the service manual issued by the Service Department of Bosch.

- The boost compensator stopper (abbreviated to "boocon") is a device which increases the injection quantity when the air quantity (turbocharging boost) supplied to the suction manifold is increased.
- The boocon is installed on the top of the injection pump governor. There is a diaphragm in an upper part of the boocon and the boost pressure is applied to the upper part with this diaphragm as the boundary. A boocon spring with a setting force is installed under the diaphragm. An adjusting pin is directly connected to the diaphragm so that it will move in conjunction with the diaphragm. A specified amount of lubricant necessary for sliding is stored at the bottom of the adjusting pin.
- The tension lever in the injection pump is drawn to the right by the governor spring. This motion causes the boocon lever to rotate counterclockwise round the supporting point A to push the connecting pin against the taper of the adjusting pin. Therefore, when the adjusting pin moves downward or upward through the diaphragm, this movement is transferred to the connecting pin boocon lever tension lever, so that the control sleeve position (injection quantity) can be changed directly.
- For the boocon, the set value cannot be changed.

Wax Type Cold Start Device (W-C.S.D.)

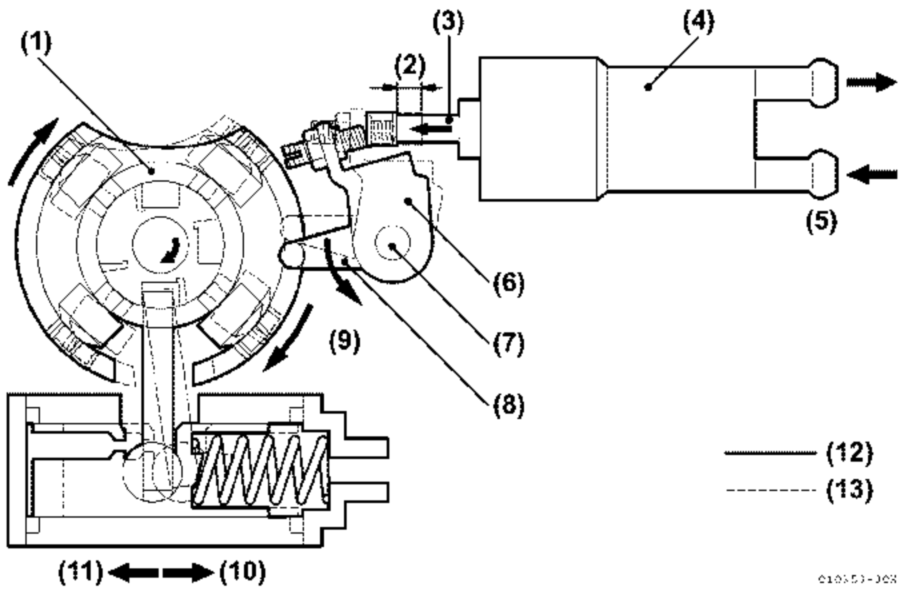


Figure 6-69

1 – Roller Holder
2 – Expand
3 – W-C.S.D. Piston
4 – W-C.S.D.
5 – Engine Coolant
6 – C.S.D. Lever
7 – Lever Shaft
8 – Pump Side Lever
9 – Cancel
10 – Advance
11 – Retard
12 – Cold
13 – Hot

W-C.S.D of 4JH4-TE / 4JH4-HTE

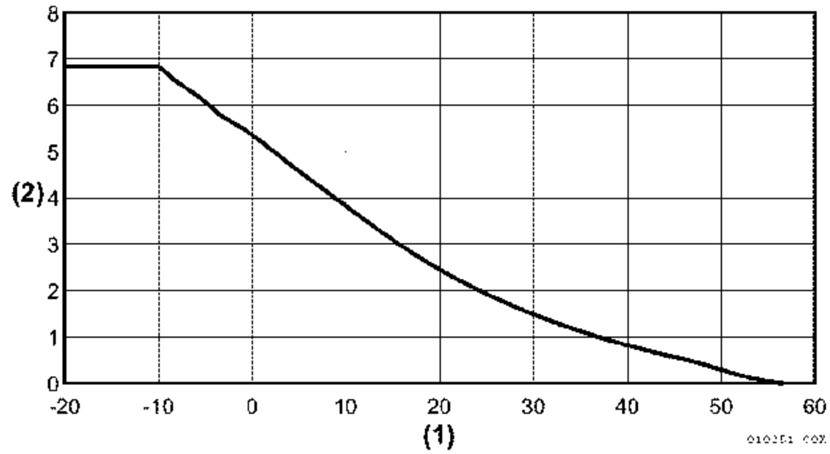


Figure 6-70

1 – **Temperature of Coolant (°C)**
2 – **Advance Angle (crank degrees)**

This device aids the easier start of the engine by advancing the fuel injection timing when the weather is cold.

The wax element is integrated into the body of the W-C.S.D. The engine coolant is led to the wax element and flows around it. The wax element is expanded by sensing the temperature of engine coolant and moves the W-C.S.D piston. The movement of W-C.S.D piston turns the pump side lever pin via the lever shaft. This pin is connected to the roller holder against the cam disk. The movement of W-C.S.D piston changes the fuel injection timing by changing the phase angle between the cam disk and roller holder.

When the engine coolant is below -10°C (14°F), the wax element is in a mostly compressed state; the roller holder comes to the maximum advance angle position (6.8 degrees of crankshaft). When the engine coolant becomes warmer, the wax element expands gradually. The roller holder turns from maximum advance angle position to smaller advance angle position. When the temperature is higher than 56°C (133°F), the advance function of W-C.S.D is completely canceled. At standard engine operation state, temperature of engine coolant becomes over 56°C (133°F), and W-C.S.D never affects the exhaust emission.

Fuel Injection Pump Service Data

3MP2 for 3JH5E Service Data

Part Code (Back No.)			-	729271-51300 (3E01)	
Adjustment Spec			-	ENG SPEC	SERVICE STD
Item	Fuel Valve (Valve Pressure)		(3MP2)	VBG (20.1)	-
	Nozzle Type (ID Mark)		-	156P165VAC0	Single Hole
	Fuel Injection Pipe		mm (in.)	ø1.6 x 390 (0.063 x 15.4)	-
Injection Adjustment	Starting	Pump Speed Ns	rpm	200	200
		Average Injection Volume Qs	mm^3/st	63 ± 2.0	74.3 ± 2.0
	Rated Load	Pump Speed No	rpm	1500	1500
		Injection Volume Qo	mm^3/st	32.4 ± 0.2	40.6 ± 0.2
		Nonunifomity	%	± 3	± 3
	Torque Rise	Pump Speed N_T	rpm	NYA	-
		Injection Volume Q_T	mm^3/st	NYA	-
		Nonunifomity	%	NYA	-
	Hi-Idle	Pump Speed N_{Hi}	rpm	1688	1688
		Injection Volume Q_{Hi}	mm^3/st	6.2 ± 0.5	7.7 ± 0.5
	Low-Idle	Pump Speed Ni	rpm	400	400
		Qi	mm^3/st	5.2 ± 0.5	6.4 ± 0.5
		Nonunifomity	%	± 20	± 20
Plunger Stroke			mm	NYA	
Plunger Diameter			mm (in.)	9 (0.3543)	
Suction Volume of Delivery Valve			mm^3	NYA	
Pre-stroke			mm (in.)	2.5 (0.0984)	
Top Clearance			mm	NYA	
Governor Spring	Spring Constant		N/mm (lb/in.)	3.73 (21.3)	
	Free Length		mm (in.)	38.5 (0.1516)	

4MP2 for 4JH5E Service Data

Part Code (Back No.)			-	729670-51330 (3F01)	
Adjustment Spec			-	ENG SPEC	SERVICE STD
Item	Fuel Valve (Valve Pressure)		(4MP2)	VBG (20.1)	-
	Nozzle Type (ID Mark)		-	156P165VAC0	Single Hole
	Fuel Injection Pipe		mm (in.)	ø1.6 x 450 (0.063 x 17.72)	-
Injection Adjustment	Starting	Pump Speed Ns	rpm	200	200
		Average Injection Volume Qs	mm^3/st	60 ± 2	73.3 ± 2.0
	Rated Load	Pump Speed No	rpm	1500	1500
		Injection Volume Qo	mm^3/st	32.3 ± 0.2	40.3 ± 0.2
		Nonunifomity	%	± 3	± 3
	Torque Rise	Pump Speed N_T	rpm	NYA	-
		Injection Volume Q_T	mm^3/st	NYA	-
		Nonunifomity	%	NYA	-
	Hi-Idle	Pump Speed N_{Hi}	rpm	1688	1688
		Injection Volume Q_{Hi}	mm^3/st	10.3 ± 0.5	14.2 ± 0.5
	Low-Idle	Pump Speed Ni	rpm	400	400
		Qi	mm^3/st	4.9 ± 0.5	4.5 ± 0.5
		Nonunifomity	%	± 20	± 20
Plunger Stroke			mm	NYA	
Plunger Diameter			mm (in.)	9 (0.3543)	
Suction Volume of Delivery Valve			mm^3	NYA	
Pre-stroke			mm (in.)	2.5 (0.0984)	
Top Clearance			mm	NYA	
Governor Spring	Spring Constant		N/mm (lb/in.)	3.73 (21.3)	
	Free Length		mm (in.)	38.5 (1.516)	

4JH4-TE / 4JH4-HTE Fuel Injection Pump Service Data

NOTICE: The disassembly and adjustment of a fuel injection pump need expertise and facilities. Refer to a Bosch service shop for assistance.

Adjustment Conditions	Nozzle Type	Bosch 105780-0060 (NP-DN0S1510)					
	Nozzle Holder	105780-2150					
	Nozzle Opening Pressure	13.0 MPa					
	Fuel Injection Line (Outside Diameter x Inside Diameter-length)	ø6 x 2-450 mm					
	Fuel Oil Feed Pressure	20 kPa					
Engine Model		4JH4-TE					
Adjustment Value		**Pump Speed (rpm)**	**Boost Pressure kPa (psi)**	**Injection Quantity mm^3/st**	**Ununiformity mm^3/st**	**Lubricating Oil Temperature °C (°F)**	**Remarks**
Injection Quantity and Governor		600	0	83.5	-	50 ± 2 (122 ± 3.6)	-
		800	40.0 ± 1.3 (5.80 ± 0.19)	112 ± 2	-	50 ± 2 (122 ± 3.6)	Standard
		900	66.7 ± 1.3 (9.76 ± 0.19)	127.7 ± 2	10.5	50 ± 2 (122 ± 3.6)	Standard
		1600	66.7 ± 1.3 (9.76 ± 0.19)	118.2 ± 6	-	50 ± 2 (122 ± 3.6)	
		1800	66.7 ± 1.3 (9.76 ± 0.19)	58.5 ± 5	-	50 ± 2 (122 ± 3.6)	Standard
		400	0	8.5 ± 2.5	3.0	48 ± 2 (118 ± 3.6)	Standard
		100	0	134.2	-	48 ± 2 (118 ± 3.6)	
Timer and Pump Room Pressure		**Pump Speed (rpm)**	**Boost Pressure kPa (psi)**	**Timer Piston Stroke mm (in.)**	**Pump Room Pressure kPa (psi)**	-	**Remarks**
		1000	66.7 ± 1.3 (9.76 ± 0.19)	0.5 (0.020) or less	-	-	-
		1500	66.7 ± 1.3 (9.76 ± 0.19)	0.9 ± 0.4 (0.035 ± 0.016)	520 ± 39 (75.4 ± 5.7)	-	Standard
		1600	66.7 ± 1.3 (9.76 ± 0.19)	1.0 ± 0.6 (0.039 ± 0.024)	-	-	-
Cold Advancer Characteristics		**Coolant Temperature °C (°F)**	**Timer Piston Stroke mm (in.)**	-	-	-	**Remarks**
		20 (68)	1.04 ± 0.6 (0.041 ± 0.02)	-	-	-	Standard
		-10 (14)	2.81 ± 0.8 (0.11 ± 0.03)	-	-	-	-

Adjustment Conditions	Nozzle Type	Bosh 105780-0060 (NP-DN0S1510)					
	Nozzle Holder	105780-2150					
	Nozzle Opening Pressure	13.0 MPa					
	Fuel Injection Line (Outside Diameter x Inside Diameter-length)	ø6 x 2-450 mm					
	Fuel Oil Feed Pressure	20 kPa					
Engine Model		4JH4-HTE					
Adjustment Value		**Pump Speed (rpm)**	**Boost Pressure kPa (psi)**	**Injection Quantity mm^3/st**	**Ununiformity (mm^3/st)**	**Lubricating Oil Temperature °C (°F)**	**Remarks**
Injection Quantity and Governor		500	0	43.1	-	48 ± 2 (118 ± 3.6)	-
		750	40.0 ± 1.3 (5.80 ± 0.19)	91.2 ± 2	-	50 ± 2 (122 ± 3.6)	Standard
		1100	80.0 ± 1.3 (11.6 ± 0.19)	128.2 ± 2	10.5	50 ± 2 (122 ± 3.6)	Standard
		1600	80.0 ± 1.3 (11.6 ± 0.19)	124.0 ± 6	-	50 ± 2 (122 ± 3.6)	-
		1750	80.0 ± 1.3 (11.6 ± 0.19)	60.3 ± 5	-	50 ± 2 (122 ± 3.6)	Standard
		380	0	8.0 ± 2.5	3.0	48 ± 2 (118 ± 3.6)	Standard
		100	0	110	-	48 ± 2 (118 ± 3.6)	-
Timer and Pump Room Pressure		**Pump Speed (rpm)**	**Boost Pressure kPa (psi)**	**Timer Piston Stroke (mm)**	**Pump Room Pressure kPa (psi)**	**-**	**Remarks**
		1200	80.0 ± 1.3 (11.6 ± 0.19)	0.5 (0.020) or less	-	-	-
		1500	80.0 ± 1.3 (11.6 ± 0.19)	1.2 ± 0.4 (0.047 ± 0.016)	569 ± 39 (82.5 ± 5.7)	-	Standard
		1600	80.0 ± 1.3 (11.6 ± 0.19)	(2.1 ± 0.6) (0.083 ± 0.016)	-	-	-
Cold Advancer Characteristics		**Coolant Temperature °C (°F)**	**Timer Piston Stroke mm (in.)**	**-**	**-**	**-**	**Remarks**
		20 (68)	1.04 ± 0.6 (0.041 ± 0.02)	-	-	-	Standard
		-10 (14)	2.81 ± 0.8 (0.11 ± 0.03)	-	-	-	-

Adjusting Fuel Limit Bolt at Starting

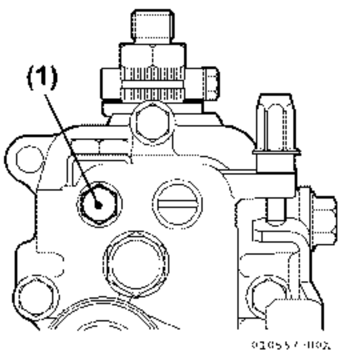
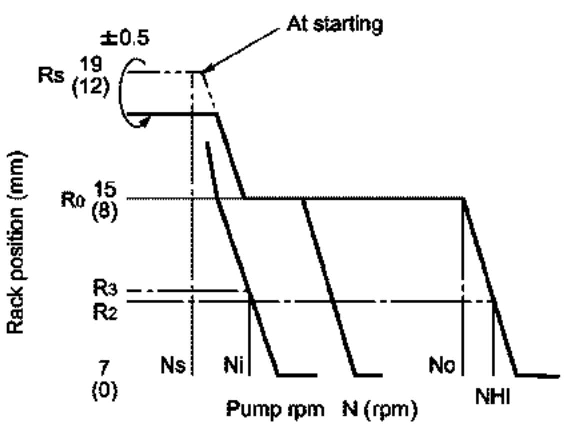


Figure 6-71

1 – Fuel Limit Bolt at Starting

1. Adjust the fuel limit bolt at starting to bring the rack position to the specified value (Rs), while keeping the pump at starting speed Ns.
2. Measure fuel injection volume at starting position (Rs).
3. If the injection volume is at the specified value, tighten the fuel limit bolt locknut at that position.



The figure in the blank ( ) is the indicator

010556-00E

Figure 6-72

Fuel Line Replacement Filter

1. Disconnect the negative (-) battery cable.
2. Close the fuel tank cock.
3. Loosen inlet **(Figure 6-73, (5))**, **(Figure 6-74, (1))** and outlet **(Figure 6-73, (4))**, **(Figure 6-74, (2))** hose clamps and remove hoses from filter.

3JH5E and 4JH5E Engine

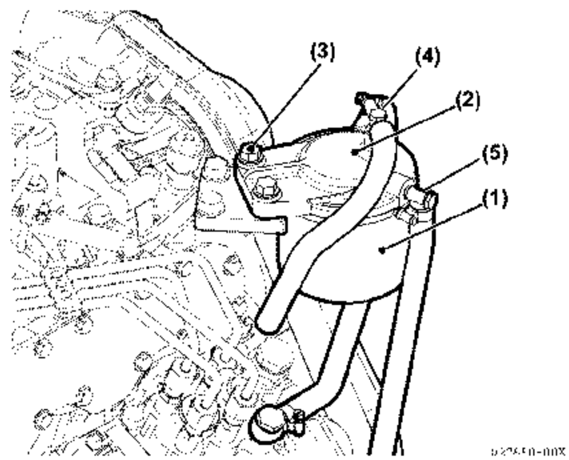


Figure 6-73

1 – Fuel Filter Cartridge
2 – Fuel Filter Header
3 – Bolt
4 – Outlet
5 – Inlet

4JH4-TE and 4JH4-HTE Engines

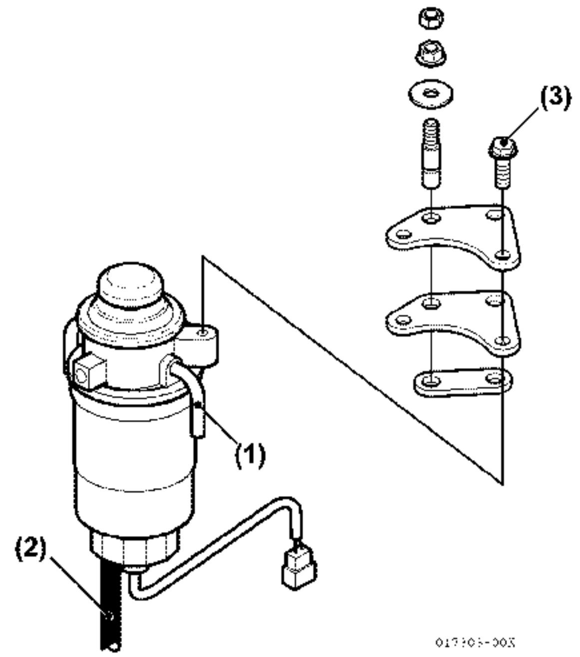


Figure 6-74

4. Remove bolts **(Figure 6-73, (3))**, **(Figure 6-74, (3))**.
5. Remove mounting brackets and install on new filter. Ensure fuel flow direction is correct. *NOTICE: When replacing fuel filters, always pre-fill them with fresh, clean fuel to improve the system's ability to be bled.*
6. Install electrical bracket and tighten bolts securely.
7. Install hoses and tighten new clamps to specification. *See Hose Clamps on page 3-72.*
8. Connect negative (-) battery cable.
9. **WARNING! *Piercing Hazard. NEVER check for fuel leaks with your hand.*** Bleed the fuel system and check for leaks. *See Bleeding the Fuel System on page 6-51.*

Replacing the Fuel / Water Separator

1. Disconnect the negative (-) battery cable.
2. Close the fuel supply valve.
3. Loosen the drain plug **(Figure 6-75, (2))** on the bottom of the water separator **(Figure 6-76, (1))** and drain off any water or dirt.

3JH5E and 4JH5E

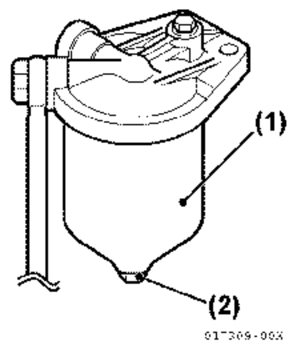


Figure 6-75

4JH4-TE and 4JH4-HTE

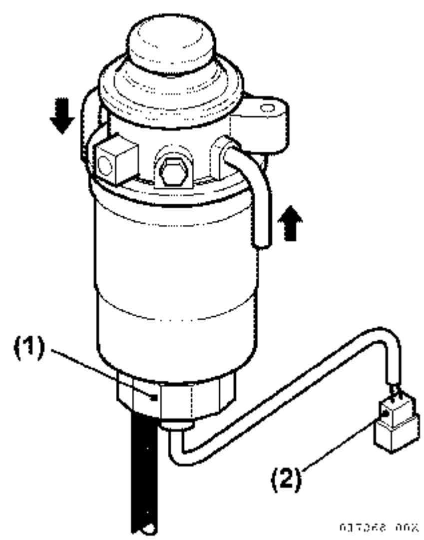


Figure 6-76

4. 4JH4-TE / 4JH4-HTE: Disconnect water sensor connector **(Figure 6-76, (2))**.
5. Remove the old filter element **(Figure 6-77, (1))**, **(Figure 6-78, (1))**.

3JH5E and 4JH5E

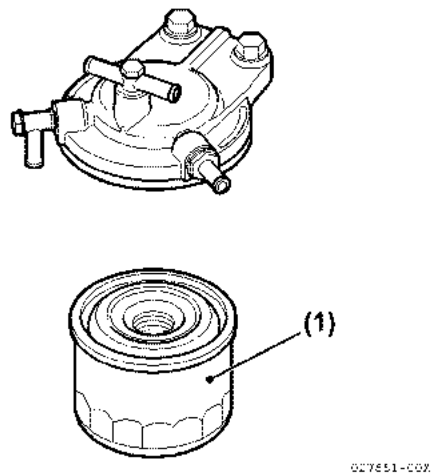


Figure 6-77

4JH4-TE and 4JH4-HTE

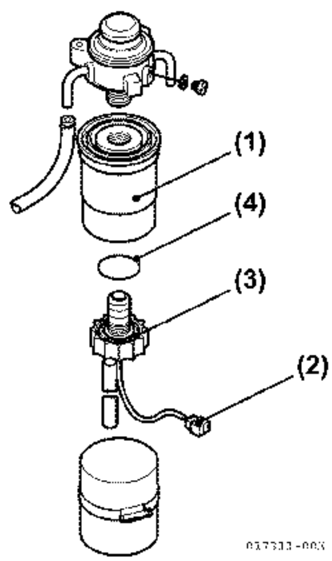


Figure 6-78

6. Clean the filter bowl. Inspect the water sensor probe **(Figure 6-78, (2))** for damage. Inspect the bowl seal **(Figure 6-78, (4))**. *NOTICE: When replacing fuel filters, always pre-fill them with fresh, clean fuel to improve the system's ability to be bled.*
7. Lubricate the seal at the top of the new filter element and install.
8. Lubricate the filter bowl seal and install the filter bowl. Turn clockwise by hand to tighten.
9. Ensure drain plug **(Figure 6-75, (2))** and **(Figure 6-76, (1))** is securely tightened.
10. Connect water sensor.
11. Open the fuel supply valve.
12. Connect the negative (-) battery cable.
13. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Bleed fuel system and check for leaks. *See Bleeding the Fuel System on page 6-51.*

Replacing the Injection Nozzle Return

Fuel Line

1. Disconnect the negative (-) battery cable.
2. Shut off fuel supply valve.
3. Loosen the clamps **(Figure 6-79, (1))**, **(Figure 6-80, (1))** and remove fitting from fuel injection nozzle top. Repeat with all fuel injection nozzles. *NOTICE: NEVER disassemble fuel return line assembly. No individual parts are available and it must be replaced as a complete assembly.*

3JH5E and 4JH5E Engines

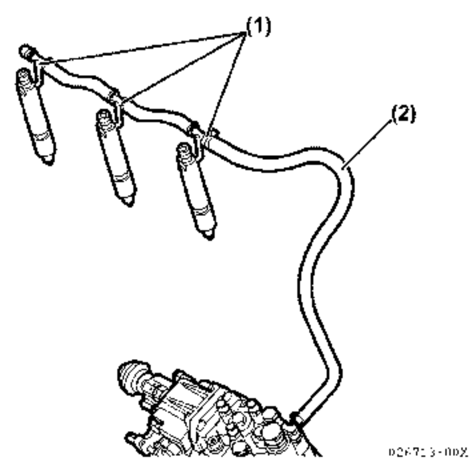


Figure 6-79

4JH4-TE and 4JH4-HTE Engines

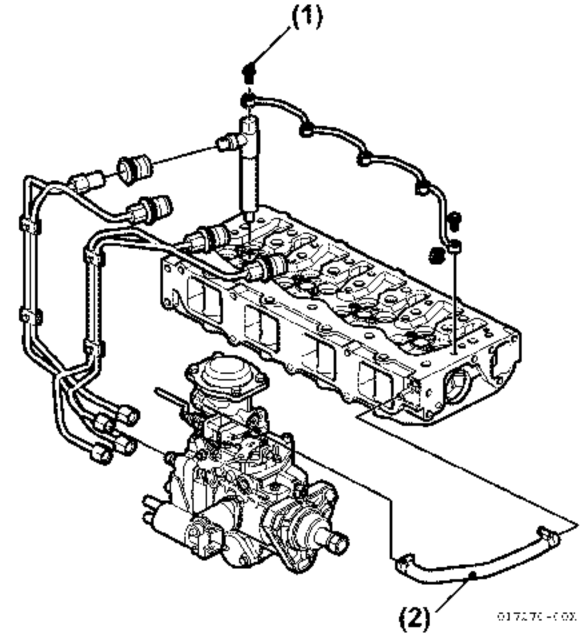


Figure 6-80

4. Disconnect return fuel hose **(Figure 6-79, (2))**.
5. Inspect seal **(Figure 6-80, (1))** on each fitting. If any packing is damaged, replace it as new packing.
6. Assembly is in the reverse order of disassembly.
7. Open fuel supply valve.
8. Connect the negative (-) battery cable.
9. **WARNING!** ***Piercing Hazard. NEVER check for fuel leaks with your hand.*** Start engine and check for fuel leaks.

Bleeding the Fuel System

The fuel system has an automatic air bleeding device that purges air from the fuel system. No manual air bleeding is required for normal operation. Bleeding must be done if any fuel system maintenance has been performed (replacement of fuel filter, etc.) or if the engine does not start after several attempts.

Bleeding the Fuel System - 3JH5E and 4JH5E

Figure 6-81 shows 4JH5E; 3JH5E is similar.

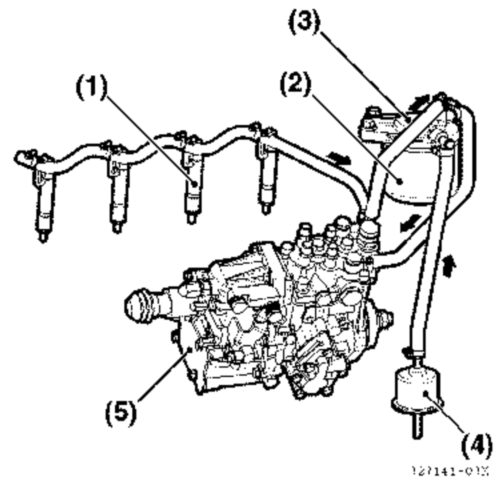


Figure 6-81

1 – Fuel Injector
2 – Fuel Filter
3 – Header (fuel filter)
4 – Electric Fuel Feed Pump
5 – Fuel Injection Pump

1. Check the fuel level in the fuel tank. Refill if necessary.
2. Open the fuel cock of the fuel tank.
3. Turn the electric fuel feed pump **(Figure 6-81, (4))** on to release air out of the fuel return line.
4. Continue pumping until a solid stream of fuel with no air bubbles begins to flow.
5. Tighten the air bleed screw.

Bleeding the Fuel System - 4JH4-TE and 4JH4-HTE

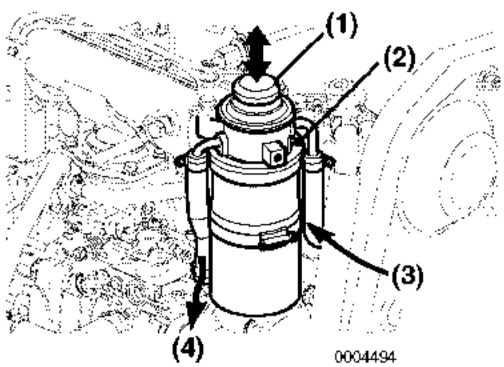


Figure 6-82

1 – Priming Pump
2 – Air Bleed Screw
3 – From Fuel Tank
4 – To Fuel Injection Pump

1. Check the fuel level in the fuel tank. Refill if necessary.
2. Open the fuel cock of the fuel tank.
3. Loosen the air bleed screw **(Figure 6-82, (2))** two to three turns.
4. Push up and down on the priming pump **(Figure 6-82, (1))** to release air out of the air bleed screw.
5. Continue pumping until a solid stream of fuel with no air bubbles begins to flow.
6. Tighten the air bleed screw.

NOTICE: NEVER use an engine starting aid such as ether. Engine damage will result.

FUEL INJECTORS

Removing Fuel Injectors

See Remove the fuel injection nozzles: on page 5-33.

Testing Fuel Injectors

Notice: Never use a steel wire brush to clean fuel injectors. Damage to the nozzle and other components may result.

1. Thoroughly clean the fuel injector nozzle using clean diesel fuel and a brass wire brush.
2. Visually inspect the fuel injectors and nozzle protectors for deposits or damage. Clean, repair or replace as necessary.

Note: Test the fuel injector using an injection nozzle tester. Operate the tester following the information provided by the tester manufacturer. Use clean, filtered fuel or FIE calibration fluid for the test.

WARNING! ***Piercing Hazard. Never point a fuel injector toward you. Since the fuel is ejected at high-pressure from the nozzle, it may penetrate the skin, resulting in injury.***

WARNING! ***Fire Hazard. Never inject fuel toward a fire source. Atomized fuel is highly flammable and may cause a fire or burn skin.***

WARNING! ***Exposure Hazard. ALWAYS wear eye protection when servicing the engine and when using compressed air or high-pressure fuel. Dust, flying debris, compressed air, pressurized fuel may injure your eyes.***

3. Using the correct adapter, connect a fuel injector to a nozzle tester. Aim the fuel injector into a suitable container to catch the fuel spray.
4. Pump the operating lever of the tester slowly, observing the pressure reading at the point where the fuel injector begins spraying fuel **(Figure 6-83)**.

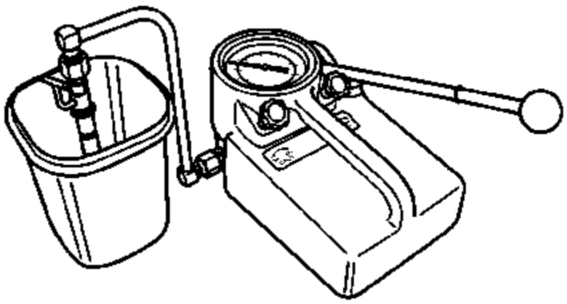


Figure 6-83

See **Figure 6-86** for injector ID location. *See Fuel System Tests on page 6-10* for correct pressure readings.

Note: The opening pressure of a new fuel injector will be approximately 5 MPa (725 psi) higher than one that has been operated for 5 hours or longer.

5. Pump the operating lever slowly to hold the pressure steady at a point just below the opening pressure and hold it for 5 seconds. Observe the injector to see that it is sealing properly and is not dripping. If fuel leaks from the return line fitting, check that the nozzle case nut is tight. Service or replace the injector if fuel continues to leak from either the return line fitting or nozzle.
6. Pump the operating lever more rapidly to repeatedly pop the injector and observe the spray pattern. The pattern should be a very fine uniform spray **(Figure 6-84). If** dripping or an uneven pattern is seen **(Figure 6-85)**, service or replace the injector.

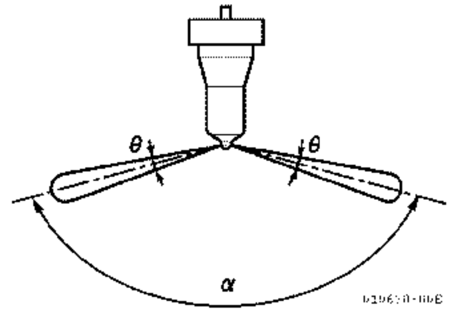


Figure 6-84

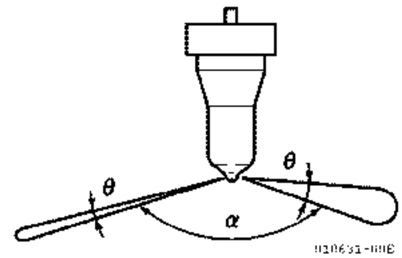


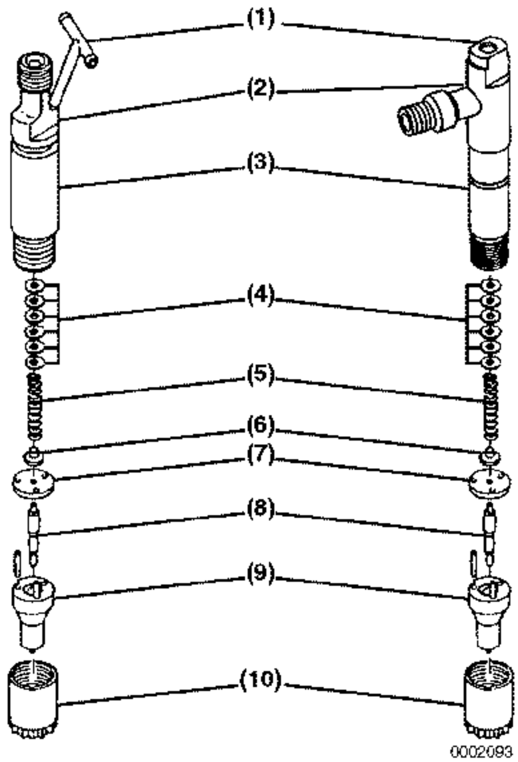
Figure 6-85

If the fuel injector fails any of these tests, it should be serviced or replaced as necessary. If the pressure is outside specified limits, adjust the pressure. *See Adjusting Fuel Injector Pressure on page 6-55.*

Disassembling and Inspecting Fuel Injectors

NOTICE: Never use a steel wire brush to clean fuel injectors. Damage to the nozzle and other components may result.

1. Clean carbon from used injectors using clean diesel fuel. Remove hardened deposits or varnish with a brass wire brush.



1 – Fuel Return Passage
2 – Injector ID Location
3 – Injector Body
4 – Pressure Adjusting Shims
5 – Spring
6 – Spring Seat
7 – Valve Stop Spacer
8 – Nozzle Valve
9 – Nozzle Body
10 – Nozzle Case Nut

Figure 6-86

2. Place the fuel injector in a soft-jawed vise with the nozzle pointing up.
3. Remove the nozzle case nut.
4. Carefully remove the injector from the vise.
5. Turn the injector over and remove the nozzle body, nozzle valve, valve stop spacer, nozzle spring seat, nozzle spring and shims.
6. Inspect the sealing surfaces **(Figure 6-87, (2))** between the valve stop spacer and nozzle body for nicks or scratches. Check the contact area between the valve stop spacer and the nozzle valve **(Figure 6-87, (1))** for scoring or pitting. Use a magnifying glass to inspect the area.

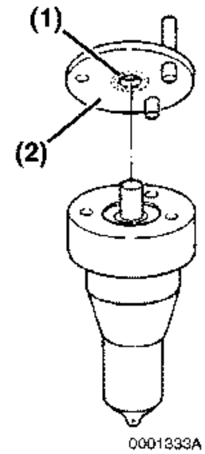


Figure 6-87

7. Perform a nozzle valve slide test:
   (a) Wash nozzle body and valve in clean diesel fuel.
   (b) While holding the nozzle body vertical, pull the nozzle valve about two-thirds of the way out **(Figure 6-88)**.

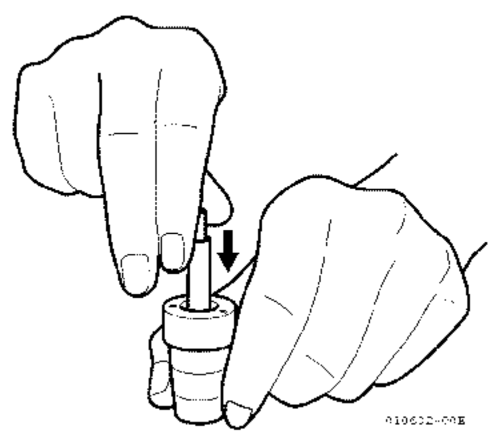


Figure 6-88

(c) Release the valve. It should fall smoothly to its seat by its own weight.

8. Replace the fuel injector assembly if it fails any inspection.

Adjusting Fuel Injector Pressure

The fuel injectors open when pressure reaches a predetermined pressure threshold. They close when the pressure is reduced below that threshold. The pressure threshold can be adjusted by adding or removing shims **(Figure 6-89, (4))**.

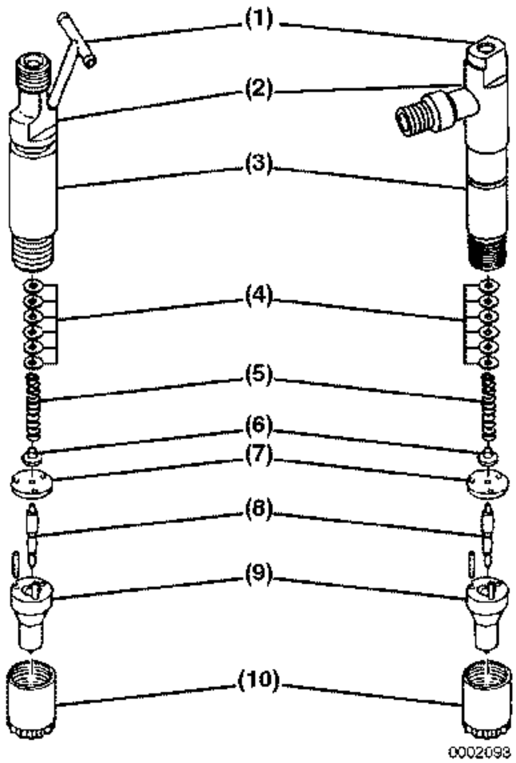


Figure 6-89

1 – Fuel Return Passage
2 – Injector ID Location
3 – Injector Body
4 – Pressure Adjusting Shims
5 – Spring
6 – Spring Seat
7 – Valve Stop Spacer
8 – Nozzle Valve
9 – Nozzle Body
10 – Nozzle Case Nut

The injection pressure will change by approximately 1.9 MPa (275 psi) for every 0.1 mm (0.004 in.) in shim thickness.

See the parts catalog for available shims.

Note: Each pressure adjusting shim removed or added changes the pressure threshold by approximately 275 psi (1.9 MPa). Adding adjusting shims increases the threshold pressure. Removing adjusting shims reduces the pressure threshold.

1. Disassemble the fuel injector assembly. *See Disassembling and Inspecting Fuel Injectors on page 6-54.*
2. Remove or add adjusting shims as needed.
3. Reassemble the fuel injector assembly. *See Reassembling the Fuel Injectors on page 6-55.*
4. Retest the fuel injector. *See Testing Fuel Injectors on page 6-52.* If the injector cannot be adjusted to the appropriate pressure, discard the fuel injector.

Reassembling the Fuel Injectors

1. Secure the injector in a soft-jawed vise with the nozzle end up.
2. Reinstall the shims, nozzle spring, nozzle spring seat, valve stop spacer, nozzle valve and nozzle body.
3. Reinstall the nozzle case nut. Tighten it to specification. *See Special Torque Chart on page 6-21. See Remove the fuel injection nozzles: on page 5-33.*

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Section 7

COOLING SYSTEM

Page

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SAFETY PRECAUTIONS

Before you service the cooling system, read the following safety information and review the *Safety Section on 2-1*.

NOTICE

Only use the engine coolant specified. Other engine coolants may affect warranty coverage, cause an internal buildup of rust and scale and / or shorten engine life.

Prevent dirt and debris from contaminating the engine coolant. Carefully clean the filler cap and the surrounding area before you remove the cap.

NEVER mix different types of engine coolants. This may adversely affect the properties of the engine coolant.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the JH series marine engine cooling systems.

SPECIFICATIONS

Test and Adjustment Specifications

Note: All pressure specifications are for an engine at normal operating temperature.

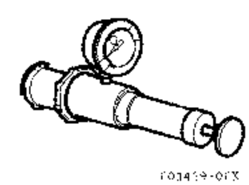
Inspection Item	Model	Specification			Reference Page
Cooling System Test Pressure	All	1.4 bar (20 psi)			*See Pressure Testing Cooling System and Filler Cap on page 7-6.*
Filler Cap Test Pressure	All	1.4 bar (20 psi)			
Thermostat	-	Marking	Begins Opening	Fully Open	*See Testing Thermostat on page 7-7.*
	All	76.5°C (170°F)	75-78°C (167-172°F)	90°C (194°F)	

Repair Specifications

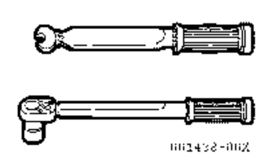
Coolant Capacity (Approximate)	3JH5E	4.5 L (4.8 qt)
	4JH5E	6.0 L (6.3 qt)
	4JH4-TE, 4JH4-HTE	7.2 L (7.6 qt)

SPECIAL SERVICE TOOLS

Note: Tools without part numbers must be obtained locally.

No.	Tool Name	Applicable Model and Tool Size	Illustration
1	Cooling System Tester (For pressure-testing and checking the leakage of the cooling system and filler cap)	Obtain locally	

MEASURING INSTRUMENTS

No.	Instrument Name	Application	Illustration
1	Torque Wrench	For tightening nuts and bolts to the specified torque	

COOLING FLOW DIAGRAM

3JH5E Engine Shown (4JH5E is Similar)

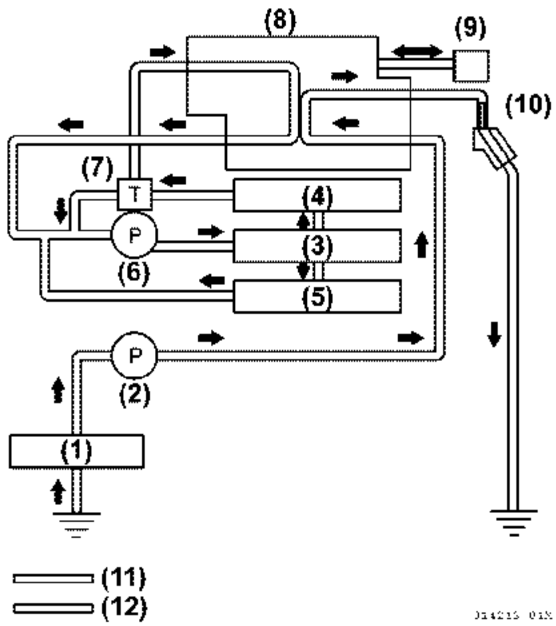


Figure 7-1

1 – Seacock
2 – Seawater Pump
3 – Cylinder Block
4 – Cylinder Head
5 – Lubricating Oil Cooler
6 – Freshwater Pump
7 – Thermostat
8 – Freshwater Cooler (heat exchanger)
9 – Recovery Tank
10 – Mixing Elbow
11 – Freshwater Circuit
12 – Seawater Circuit

4JH4-TE Engine

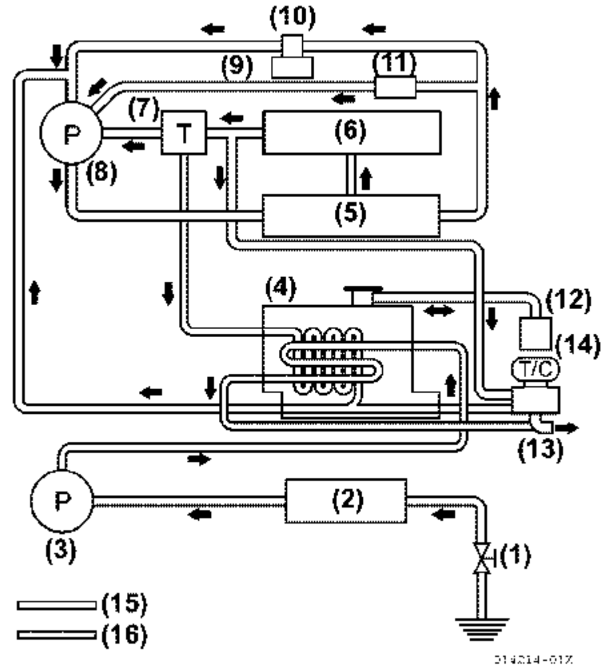


Figure 7-2

1 – Seacock
2 – Clutch Cooler
3 – Seawater Pump
4 – Freshwater Cooler (heat exchanger)
5 – Cylinder Block
6 – Cylinder Head
7 – Thermostat
8 – Freshwater Pump
9 – FO Pump
10 – W-C.S.D.
11 – Lubricating Oil Cooler
12 – Recovery Tank
13 – Mixing Elbow
14 – Turbocharger
15 – Freshwater Circuit
16 – Seawater Circuit

4JH4-HTE Engine

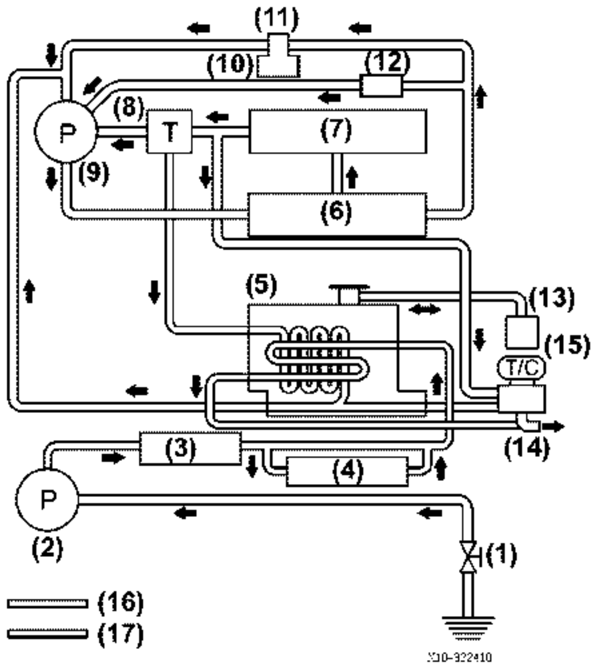


Figure 7-3

1 – Seacock
2 – Seawater Pump
3 – Inter Cooler
4 – Clutch Cooler
5 – Freshwater Cooler (heat exchanger)
6 – Cylinder Block
7 – Cylinder Head
8 – Thermostat
9 – Freshwater Pump
10 – FO Pump
11 – W-C.S.D.
12 – Lubricating Oil Cooler
13 – Recovery Tank
14 – Turbocharger
15 – Mixing Elbow
16 – Freshwater Circuit
17 – Seawater Circuit

TESTS AND ADJUSTMENTS

Pressure Testing Cooling System and Filler Cap

Cooling System

Use a cooling system tester with connections compatible with the Yanmar JH series cooling system.

1. **WARNING!** ***Burn Hazard. NEVER remove the coolant filler cap if the engine is hot. Steam and hot engine coolant will escape and seriously burn you. Allow the engine to cool before attempting to remove the filler cap.*** Remove the filler cap from the heat exchanger.
2. Check that the lugs and sealing flange on the filler pipe are undamaged and free of debris that will prevent a good seal.
3. Install the tester and adapter in place of the filler cap.
4. Pump until pressure is 1.45 bar (21 psi) **(Figure 7-4)**.

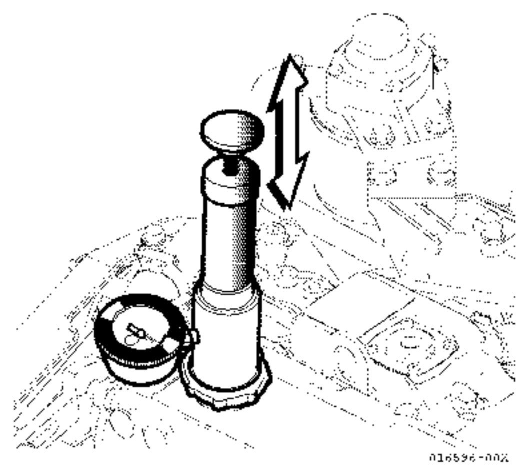


Figure 7-4

5. Pressure should hold steady. If the pressure drops, there is a leak in the system. Start by checking all hoses and pipe connections.

Filler Cap

1. Connect the cap to the cooling system tester using the adapter for the cap.
2. Pump until the cap opens **(Figure 7-5)**.

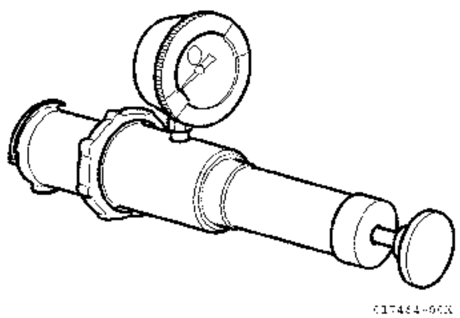


Figure 7-5

3. The tester needle should stop at approximately 1.45 bar (21 psi).

Testing Thermostat

The thermostat used in this engine is of the wax pellet type, with a solid wax pellet located in a smaller chamber.

When the temperature of the coolant rises, the wax melts and increases in volume. This expansion and contraction is used to open and close the valve **(Figure 7-6)**.

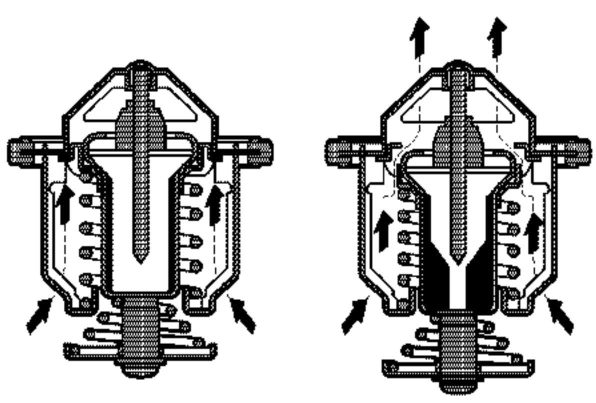


Figure 7-6

1. The design temperature for the thermostat is stamped into the thermostat body. Find and record this number.
2. Immerse the thermostat into a container of water. Suspend it so that it does not come into contact with the walls or bottom of the container **(Figure 7-7)**.

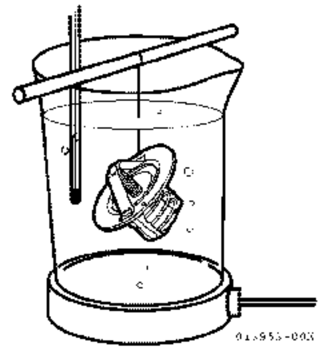


Figure 7-7

3. Slowly heat the water and monitor the temperature with a thermometer. Stir the water.
4. Check that the thermostat begins to open at the specified temperature, and that it is fully open at the temperature given in the specifications.
   If the test results are not within specification, replace the thermostat.

Specifications

Opening Temperature	Full Open Temperature	Valve Lift at Full Open
75-78°C (167-172°F)	90°C (194°F)	8 mm or more (0.31 in.)

DRAINING / REFILLING SEAWATER COOLING SYSTEM

Note: If water fails to drain from any open drain cock or port, remove the cock completely and probe the opening with a small piece of wire to loosen debris.

1. Loosen the seawater pump cover **(Figure 7-8, (2))** to allow water to drain. *See Seawater Pump on page 7-17.*

3JH5E Engine

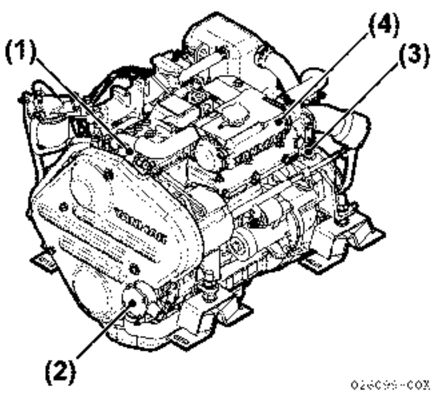


Figure 7-8

1 – Coolant Pump
2 – Seawater Drain from Seawater Pump Cover
3 – Coolant Drain Cock
4 – Coolant Tank (heat exchanger)

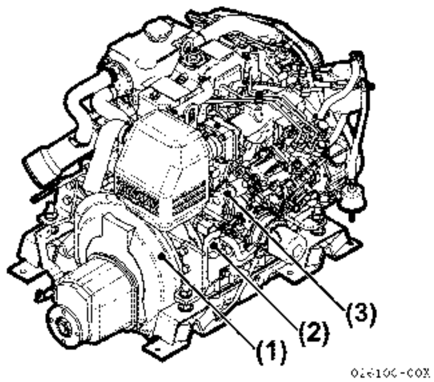


Figure 7-9

1 – Flywheel Housing
2 – Coolant Drain Cock
3 – Stop Solenoid

2. When water has drained, install cover and tighten bolts. *NOTICE: Be sure O-ring is in place in groove of housing.*
3. Close all drain cocks.

4JH5E Engine

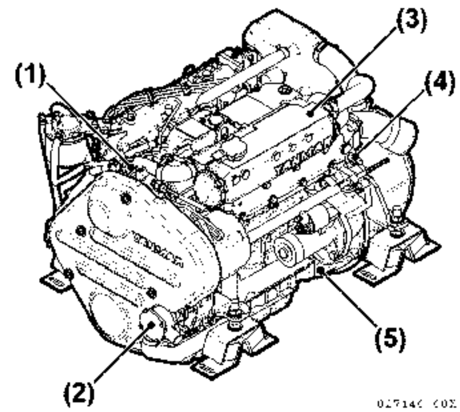


Figure 7-10

1 – Coolant Pump
2 – Seawater Drain from Seawater Pump Cover
3 – Coolant Tank (heat exchanger)
4 – Coolant Drain Cock
5 – Flywheel Housing

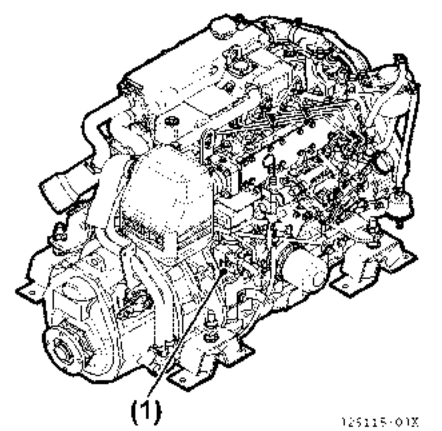


Figure 7-11

1 – Coolant Drain Cock

4JH4-TE Engine

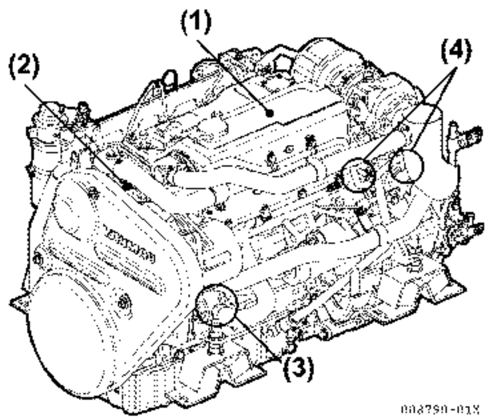


Figure 7-12

1 – **Heat Exchanger Coolant Tank**
2 – **Freshwater Coolant Pump**
3 – **Seawater Drain from Seawater Pump Cover**
4 – **Coolant Drain Cock (2 used)**

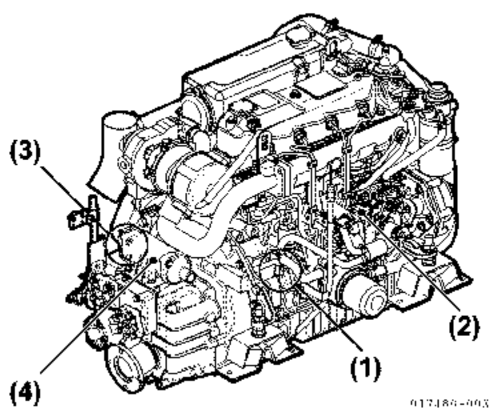


Figure 7-13

1 – **Coolant Drain Cock**
2 – **Fuel Pump**
3 – **Seawater Drain Cock**
4 – **Marine Gear Cooler**

4JH4-HTE Engine

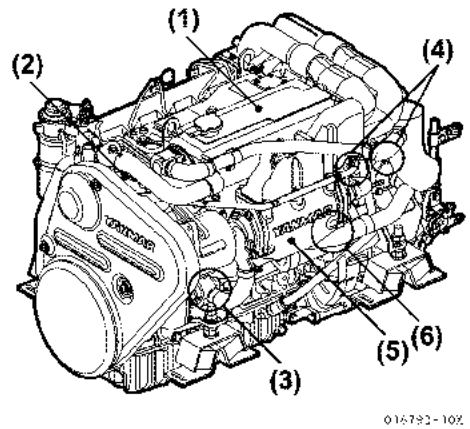


Figure 7-14

1 – **Heat Exchanger Coolant Tank**
2 – **Freshwater Coolant Pump**
3 – **Seawater Drain from Seawater Pump Cover**
4 – **Coolant Drain Cock**
5 – **Intercooler**
6 – **Seawater Drain from Heat Exchanger**

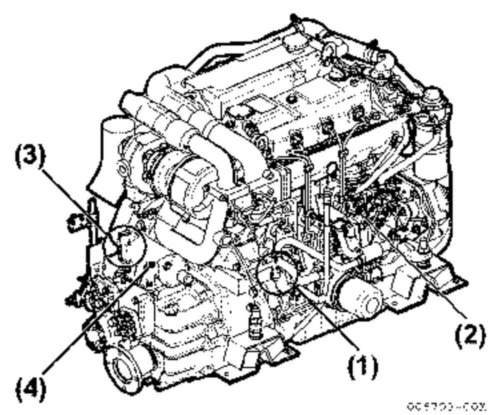


Figure 7-15

1 – **Coolant Drain Cock**
2 – **Fuel Pump**
3 – **Seawater Drain Cock**
4 – **Marine Gear Cooler**

Note: The drain cocks are opened before shipping from the factory.
Marine gear ZF25A does not have a drain cook on the clutch cooler.
If seawater is left inside, it may freeze and damage parts of the cooling system (freshwater cooler, seawater pump, etc.) when ambient temperature is below 0°C (32°F).

Draining and Filling Closed Cooling System

1. **WARNING!** ***Burn Hazard. NEVER remove the coolant filler cap if the engine is hot. Steam and hot engine coolant will escape and seriously burn you. Allow the engine to cool before attempting to remove the filler cap.*** Remove coolant filler cap **(Figure 7-16, (1))** from heat exchanger **(Figure 7-16, (2))**.

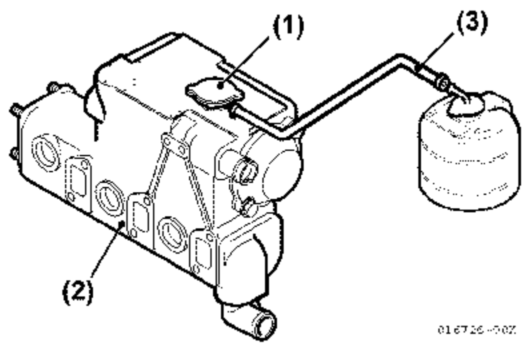


Figure 7-16

2. Inspect the cap gasket and flange on the filler neck for damage **(Figure 7-17, (1))**.

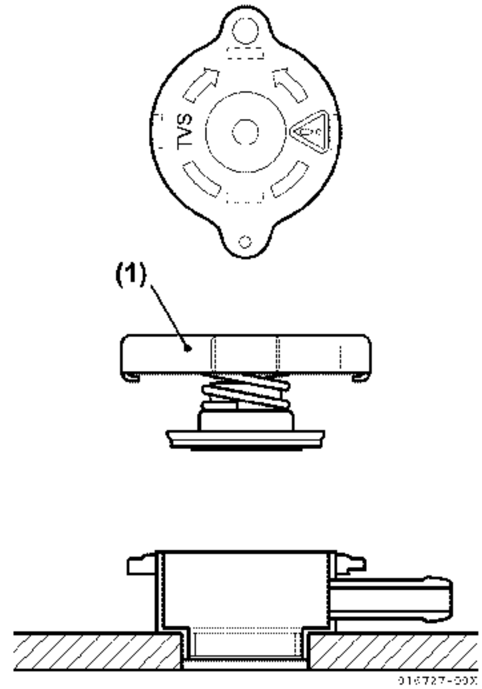


Figure 7-17

3. Check the rubber hose **(Figure 7-16, (3))** connecting the coolant recovery tank to the heat exchanger. Be sure the hose is securely connected and there is no damage.
4. Pour coolant mix slowly into the heat exchanger to prevent the formation of air pockets. Fill until the heat exchanger is completely full.
5. Install the filler cap and tighten firmly.
6. Remove the coolant recovery tank cap and fill with coolant mix to approximately 50 mm (2 in.) below the full line. Replace cap. Never fill to the full mark.
7. After filling an empty cooling system, test-run the engine for approximately 5 minutes and recheck the engine coolant level in the coolant recovery tank.

REMOVING / INSTALLING INTERCOOLER (4JH4-HTE)

1. Drain seawater from seawater drain cock **(Figure 7-18, (1))**.

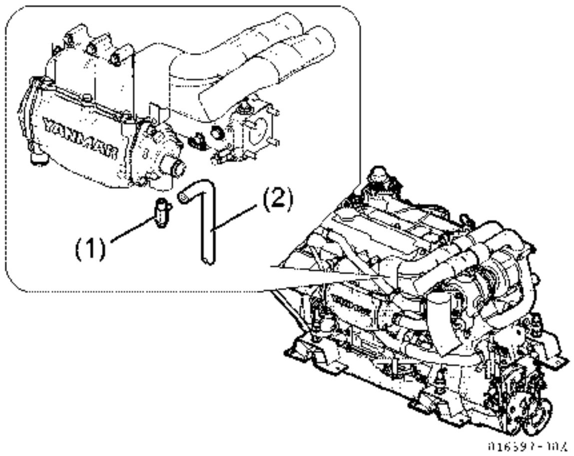


Figure 7-18

2. Remove the seawater drain pipe connected to seawater drain cock **(Figure 7-18, (2))**.
3. Disconnect seawater pipe between charge air cooler seawater inlet and seawater pump **(Figure 7-19, (2))**.

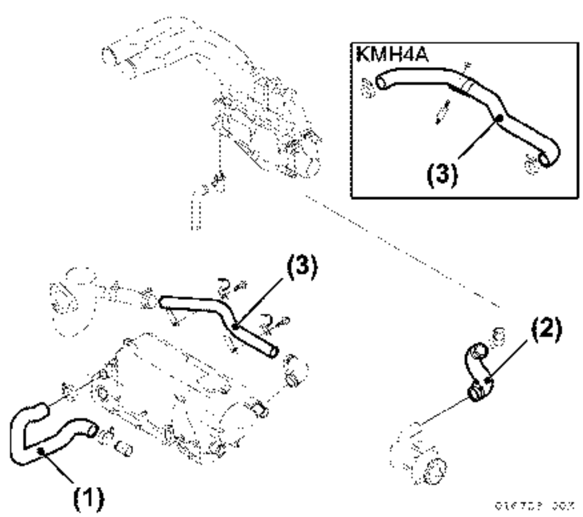


Figure 7-19

4. Disconnect cooling seawater pipe between charge air cooler seawater outlet and cooling freshwater cooler **(Figure 7-19, (1))**.
5. Disconnect clamp bolt of pipe between mixing elbow and cooling freshwater or marine gear cooler **(Figure 7-19, (3))**.
6. Loosen bolts **(Figure 7-20, (1))**.

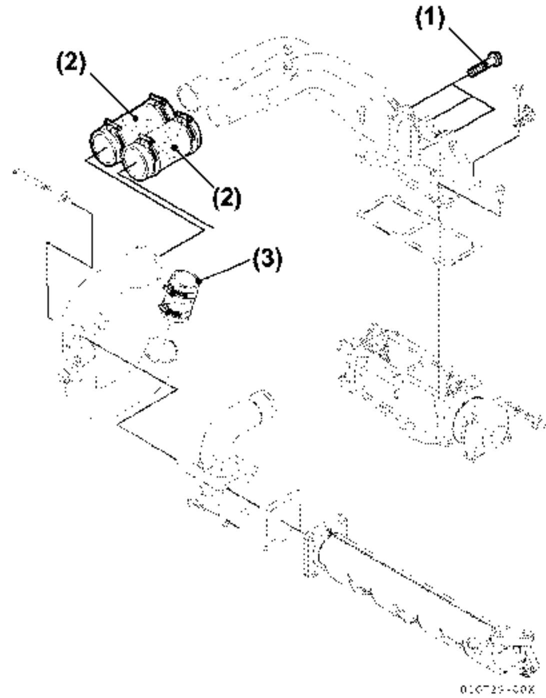


Figure 7-20

7. Remove rubber hose between air duct of intercooler and bend of intake manifold **(Figure 7-20, (2))**.
8. Remove rubber hose between air duct of intercooler and air duct of turbocharger **(Figure 7-20, (3))**.
9. Remove intercooler assembly from freshwater cooler.
10. Disassemble and repair as necessary. *See Disassembling and Assembling Intercooler on page 7-12.*
11. Install intercooler.
12. Install rubber hose between air duct of intercooler and bend of intake manifold.
13. Install rubber hose between air duct of intercooler and air duct of turbocharger.
14. Connect seawater pipes to each end of intercooler.
15. Tighten clamp bolt of cooling seawater pipe to mixing elbow.
16. Connect seawater drain cock and pipe.
17. Start the engine and check for coolant and air leaks. Check the level of the coolant and fill as necessary.

DISASSEMBLING AND ASSEMBLING INTERCOOLER

1. Loosen bolts **(Figure 7-21, (1))** and remove intercooler from cooling freshwater cooler. *See Remove the intercooler (only for 4JH4-HTE) (Figure 5-21): on page 5-28.*

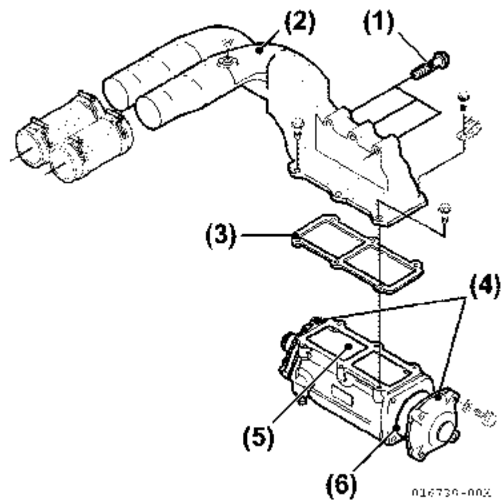


Figure 7-21

2. Remove air duct assembly **(Figure 7-21, (2))** and gasket **(Figure 7-21, (3))**.
3. Remove water box A and B **(Figure 7-21, (4))**.
4. Disassemble, inspect and clean intercooler assembly **(Figure 7-21, (5))** and change as necessary. *NOTICE: NEVER use caustic soda to clean the components. Use paraffin-based engine detergent to clean the cooler element. Thoroughly flush and rinse all components.*
5. If any internal deposits remain in the tubes, consult a local radiator repair shop.
6. *NOTICE: Always install new O-rings.* Install new O-rings **(Figure 7-21, (6))** on water boxes.
7. Install water boxes.
8. Install gasket and air duct assembly.
9. Install intercooler and tighten bolts to cooling freshwater cooler. *See 4JH4-HTE: Install the intercooler: on page 5-96.*

REMOVING AND INSTALLING HEAT EXCHANGER

1. Drain coolant from the engine and heat exchanger. *See Draining and Filling Closed Cooling System on page 7-10.*
2. Drain the seawater system. *See Draining / Refilling Seawater Cooling System on page 7-8.*
3. Disconnect seawater pipes **(Figure 7-22, (1))** and **(Figure 7-22, (2))** from heat exchanger.

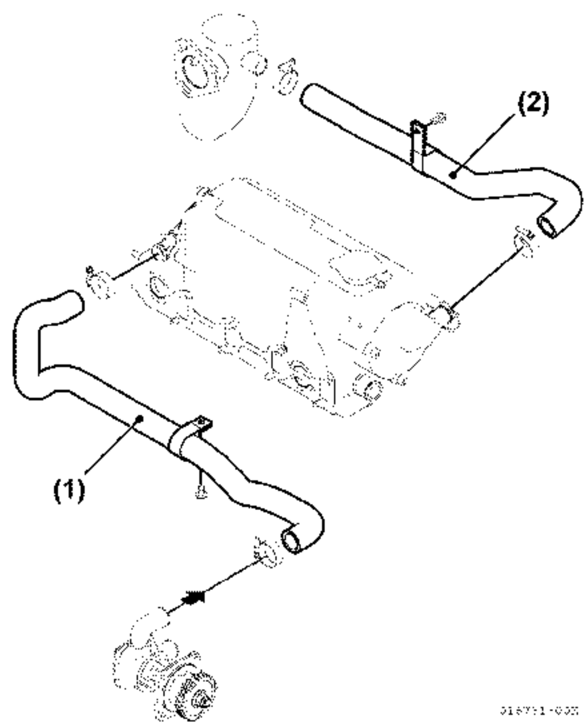


Figure 7-22

4. Remove six tightening bolts **(Figure 7-23, (1))**.

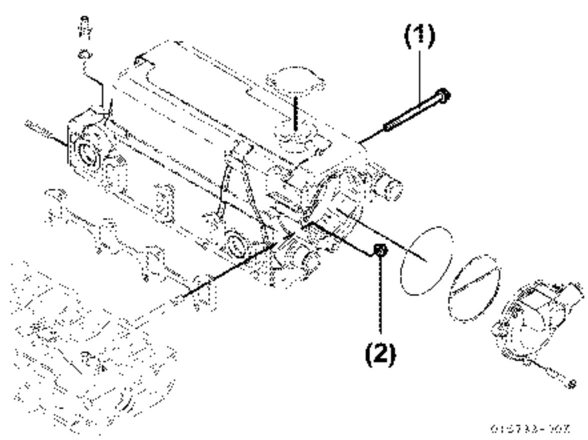


Figure 7-23

5. Loosen the two nuts on the cylinder head stud bolts **(Figure 7-23, (2))**.
6. Remove the heat exchanger.
7. The noise absorbers A and B **(Figure 7-25, (1), (2))** are installed between the heat exchanger and cylinder head for 3JH5E / 4JH5E (only one piece) and 4JH4-TE / 4JH4-HTE engines. Replace if the absorber deteriorates.

   Notice:

   - *Avoid damaging covers A and B **(Figure 7-25, (3), (4))**.*
   - *Avoid getting lubricating oil on the noise absorber.*

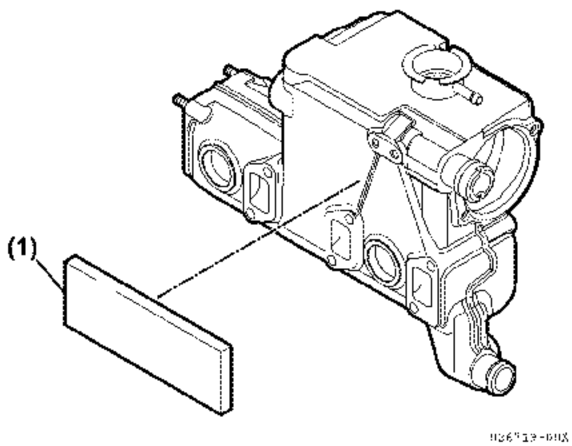


Figure 7-24

1 – Noise Absorber

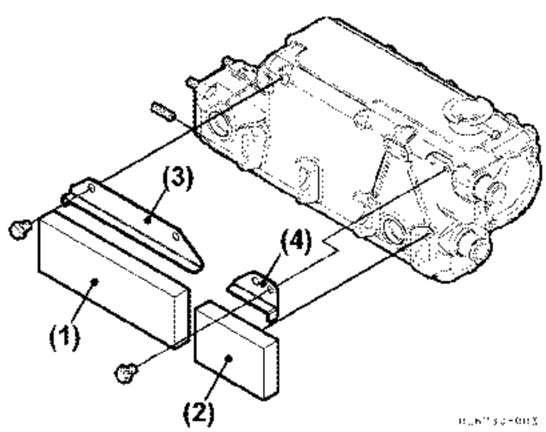


Figure 7-25

8. Disconnect, inspect and clean heat exchanger as necessary. *See Remove the heat exchanger and gasket packing (Figure 5-25). on page 5-30.*
9. Install the heat exchanger assembly on the engine. Install and tighten bolts and clamps **(Figure 7-26, (1), (2)).**

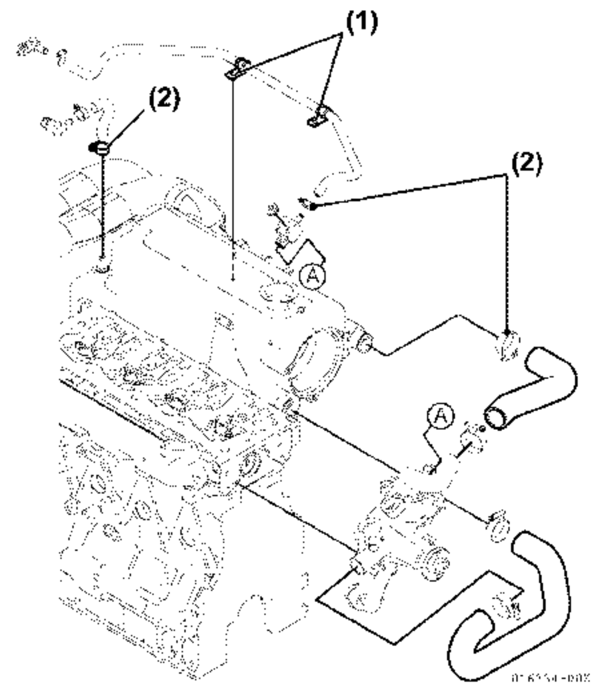


Figure 7-26

10. Connect coolant pipes to heat exchanger.
11. Connect remaining seawater and coolant pipes to heat exchanger.
12. Fill the system with coolant. *See Draining and Filling Closed Cooling System on page 7-10.*
13. Start the engine and check for coolant leaks. Check coolant level and fill as necessary.

DISASSEMBLING / ASSEMBLING HEAT EXCHANGER

1. Remove heat exchanger from engine. *See Remove the heat exchanger and gasket packing (Figure 5-25) on page 5-30.*
2. Remove outlet cover **(Figure 7-27, (1))**, **(Figure 7-28, (1))** and gasket **(Figure 7-27, (2))**, **(Figure 7-28, (2))**.

3JH5E Engine

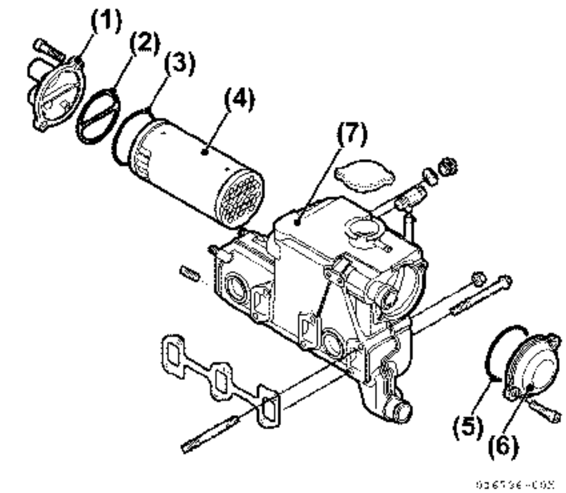


Figure 7-27

4JH5E / 4JH4-TE / 4JH4-HTE Engines

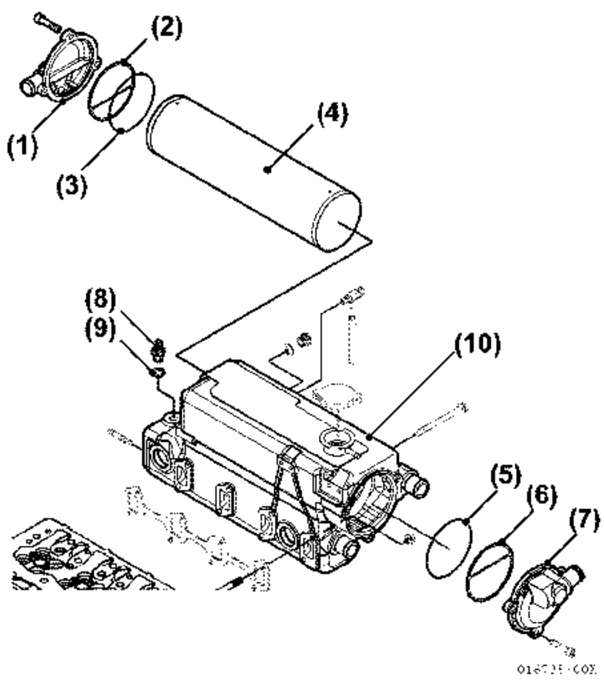


Figure 7-28

3. Remove inlet cover **(Figure 7-27, (6))** and **(Figure 7-28, (7))** and gasket **(Figure 7-27, (5))** and **(Figure 7-28, (6))**.
4. Pull core from housing **(Figure 7-27, (4))** and **(Figure 7-28, (4))**.
5. Remove O-rings **(Figure 7-27, (3), (5))**, **(Figure 7-28, (3), (5))**.
6. Remove anode **(Figure 7-28, (8))** and washer **(Figure 7-28, (9))**. *NOTICE: NEVER use caustic soda be used to clean the components. Use paraffin-based engine detergent to clean the cooler element. Thoroughly flush and rinse all components.*
7. If any internal deposits remain in the tubes, consult a local radiator repair shop.
8. *NOTICE: Always install new O-rings.* Install new O-ring **(Figure 7-27, (5))**, **(Figure 7-28, (5))** on cooler core.
9. Install cooler core **(Figure 7-27, (4))**, **(Figure 7-28, (4))**, gasket and inlet cover **(Figure 7-27, (6))**, **(Figure 7-28, (6), (7))**.
10. Install O-ring **(Figure 7-27, (3))**, **(Figure 7-28, (3))** on cooler core.
11. Install gasket and outlet cover **(Figure 7-27, (1), (2))**, **(Figure 7-28, (1), (2))**.
12. Install new anode **(Figure 7-28, (8))** and washer **(Figure 7-28, (9))**. *See Draining and Filling Closed Cooling System on page 7-10.*
13. Install heat exchanger and absorber A and B (for 4JH4-TE and 4JH4-HTE only) to cylinder head. *See Remove the heat exchanger and gasket packing (Figure 5-25) on page 5-30.*

REMOVING AND INSTALLING COOLANT PUMP

1. Drain coolant from engine. *See Draining and Filling Closed Cooling System on page 7-10.*
2. Remove belt cover.
3. Remove coolant pump belt and pulley. *See Replacing Coolant Pump Belt and Pulley on page 7-18.*
4. Remove thermostat assembly. *See Removing and Installing Thermostat on page 7-16.*
5. Remove four bolts **(Figure 7-29, (1))** and remove coolant pump **(Figure 7-29, (2))**. *NOTICE: Use caution when removing old gasket to avoid damage to the sealing surface of the cylinder block.*

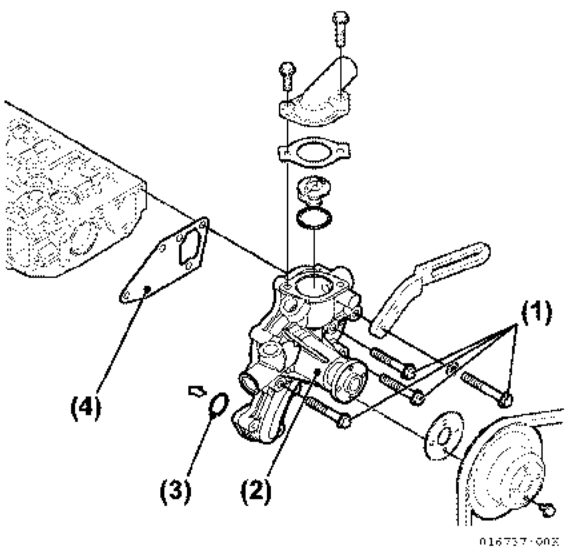


Figure 7-29

6. Remove the old gasket **(Figure 7-29, (4))** and clean any material off from cylinder head. *NOTICE: NEVER disassemble coolant pump. It is difficult to disassemble and, once disassembled, even more difficult to reassemble. Replace coolant pump assembly as necessary.*
7. Check new gasket **(Figure 7-29, (4))** and new O-ring **(Figure 7-29, (3))** fit on cylinder head and cylinder block before proceeding.
8. Hold new gasket in place and install coolant pump.
9. When installing coolant pump assembly to cylinder block, tighten two bolts (M6x20) at cylinder block inlet to specified torque **(Figure 7-30, (1))**.

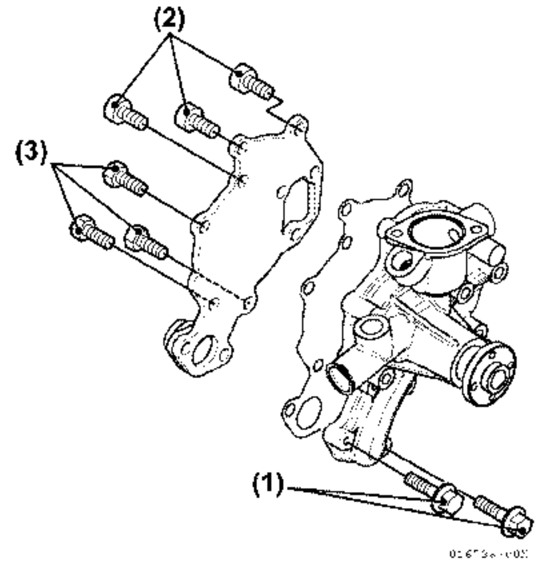


Figure 7-30

Note: When replacing coolant pump and pump cover, tighten M6 bolts to specified torque **(Figure 7-30, (2), (3))**.

Bolt Size	Torque
M6x20	8.82-10.8 N·m (6.5-8.0 lb-ft)

Bolt Size	Torque
M6x15	9.3-11.3 N·m (6.9-8.3 lb-ft)
M6x16	8.82-10.8 N·m (6.5-8.0 lb-ft)

10. Install thermostat assembly. *See Removing and Installing Thermostat on page 7-16.*
11. Fill engine block with coolant. *See Draining and Filling Closed Cooling System on page 7-10.*
12. Start the engine and check for coolant leaks. Check the level of the coolant and fill as necessary.

REMOVING AND INSTALLING THERMOSTAT

Removal

1. Allow the engine to cool and drain the coolant from the engine block. *See Draining and Filling Closed Cooling System on page 7-10.*
   CAUTION! ***Coolant Hazard. ALWAYS wear eye protection and rubber gloves when you handle Long Life engine coolant. If the coolant comes in contact with the eyes or skin, flush eyes and wash immediately with clean water.***
2. Release clamps on coolant lines **(Figure 7-31, (1))**.

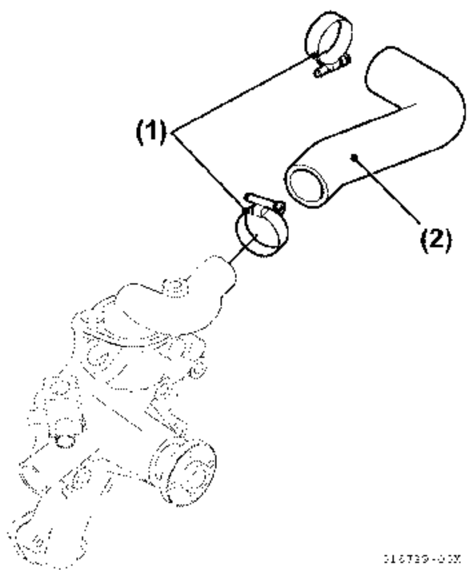


Figure 7-31

3. Disconnect pipe **(Figure 7-31, (2))** from coolant pump.
4. Remove two bolts **(Figure 7-32, (4))**.

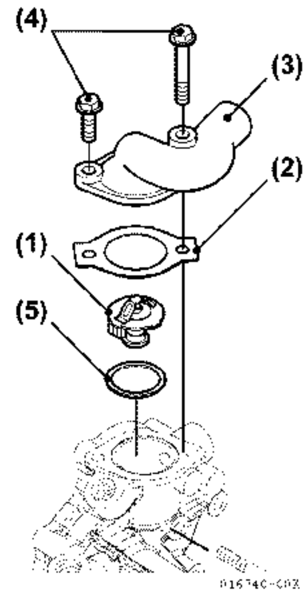


Figure 7-32

5. Remove cover and gasket **(Figure 7-32, (3), (2))**.
6. Remove the thermostat **(Figure 7-32, (1))**.
7. Test thermostat as required. *See Testing Thermostat on page 7-7.*

Installation

1. Clean the thermostat housing.
2. Install new gaskets **(Figure 7-32, (2), (5))** on coolant pump housing.
3. Install thermostat assembly.
4. Install cover and gasket and tighten bolts.
5. Install coolant pipe and secure with clamps.
6. Fill the system with coolant. *See Draining and Filling Closed Cooling System on page 7-10.*
7. Start the engine and check for coolant leaks. Check the level of the coolant and add as necessary.

SEAWATER PUMP

Inspecting / Replacing Impeller

The seawater pump is driven by the gear **(Figure 7-33 (3))**, **(Figure 7-34 (1))**.

3JH5E and 4JH5E Engines

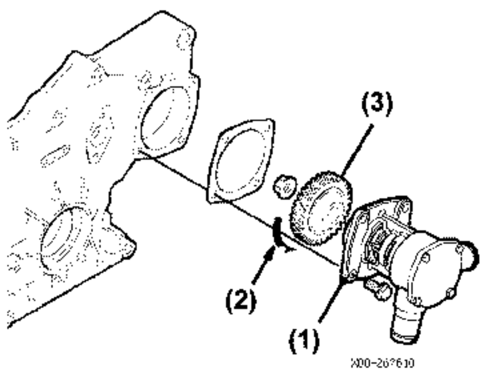


Figure 7-33

4JH4-TE and 4JH4-HTE Engines

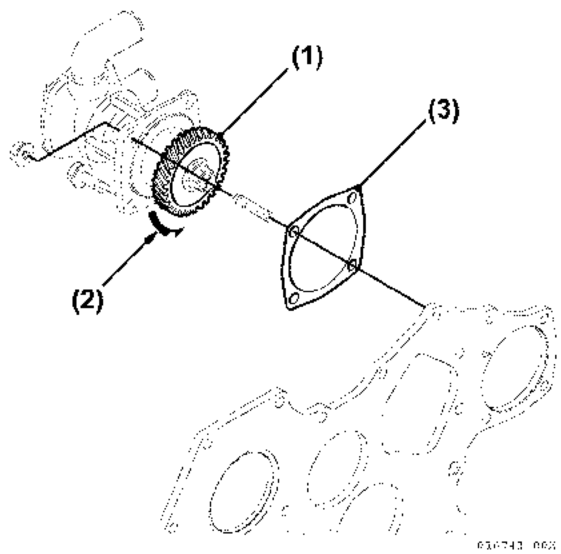


Figure 7-34

1. Drain the seawater by loosening the bolts of seawater pump side cover **(Figure 7-33, (1))**.
2. Disconnect seawater hoses from seawater pump inlet and outlet, then remove seawater pump assembly from gear case.
3. Remove seawater pump drive gear **(Figure 7-34, (1))**.
4. Remove four bolts, side cover **(Figure 7-35, (1))** and O-ring **(Figure 7-35, (2))**.

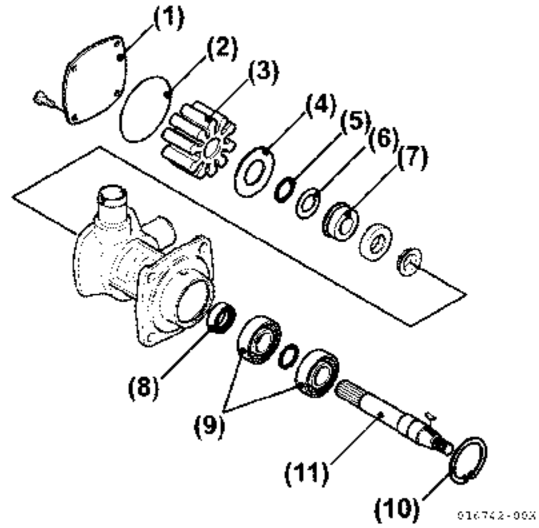


Figure 7-35

5. Remove the impeller **(Figure 7-35, (3))** and wear plate **(Figure 7-35, (4))** from the housing.
6. Remove retainer, washer and mechanical seal **(Figure 7-35, (5), (6), (7))**.
7. Using pliers from drive gear side, remove retainer **(Figure 7-35, (10))** which holds bearings **(Figure 7-35, (9))**.
8. Lightly tap pump shaft from impeller side and remove shaft and bearings as a set **(Figure 7-35, (11), (9))**.
9. Remove lip seal **(Figure 7-35, (8))** and mechanical seal if necessary.
10. Inspect the impeller for cracks, broken vanes or excessive wear. Replace as necessary.

Note: When installing the new impeller, rotate the impeller clockwise to bend the vanes in the direction of rotation **(Figure 7-35, (3))**.

11. Inspect wear plate and replace as necessary.
12. Inspect the housing and cover for excessive wear.

13. Inspect mechanical seal and replace if spring is damaged or seal is corroded.

Note: Replace mechanical seal if there is considerable coolant leakage during operation.

Coolant Leakage	Less than 3 cm^3/hour (0.101 ounce/hour)

14. Make sure ball bearings rotate smoothly. Replace if there is excessive play.
15. Install a new O-ring **(Figure 7-35, (2))** and hold it in the groove using petroleum jelly.
16. Install the shaft assembly, gear and side cover. Install and tighten four bolts.
17. Install the seawater pump assembly with new gasket **(Figure 7-36, (5))** to gear case.

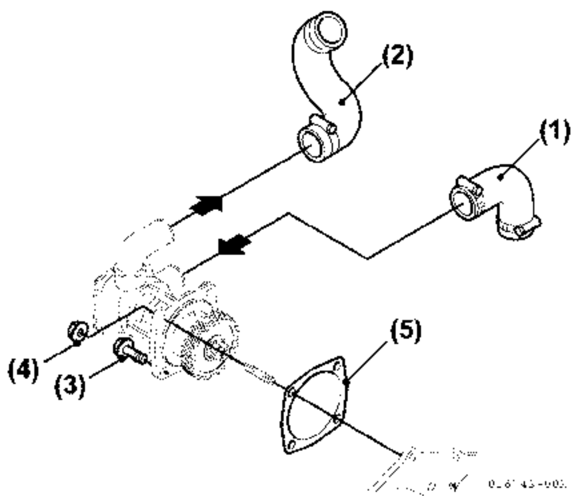


Figure 7-36

Removing and Installing Seawater Pump and Pump Drive Gear

1. Disconnect negative (-) battery cable.
2. Disconnect seawater supply hose from seawater pump **(Figure 7-36, (1))**.
3. Disconnect seawater pump-to-heat exchanger pipe **(Figure 7-36, (2))**.
4. Remove three bolts **(Figure 7-36, (3))** and one nut **(Figure 7-36, (4))** then remove seawater pump.
5. Repair as necessary.
6. Install the seawater pump in the reverse order of removal.

Note: When installing, use the new gasket **(Figure 7-36, (5))**.

7. Connect battery negative (-) cable.

Replacing Coolant Pump Belt and Pulley

1. Disconnect negative (-) battery cable.
2. Remove belt cover **(Figure 7-37, (1))**.

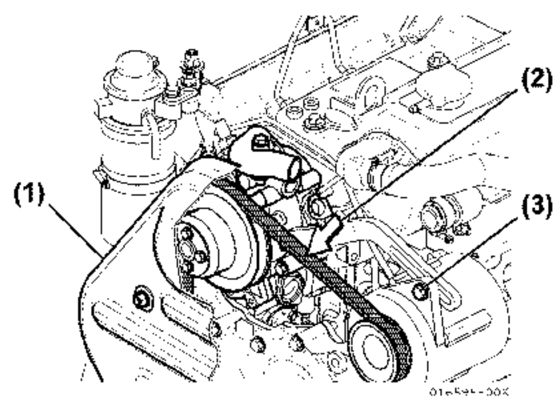


Figure 7-37

3. Check belt tension by pressing on the belt **(Figure 7-38, (A))**. Allowable belt deflection is shown below. If the belt is loose, it must be replaced.

Belt Category	Belt Deflection (A)
Used Belt	8-10 mm (0.3-0.4 in.)
New Belt	6-8 mm (0.24-0.3 in.)

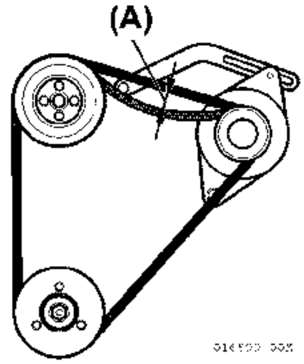


Figure 7-38

4. Loosen adjusting bolt **(Figure 7-37, (3))** to remove coolant pump belt.
5. Check grooves of pulleys and tightening bolts. Replace pulley or bolts as necessary **(Figure 7-39)**.

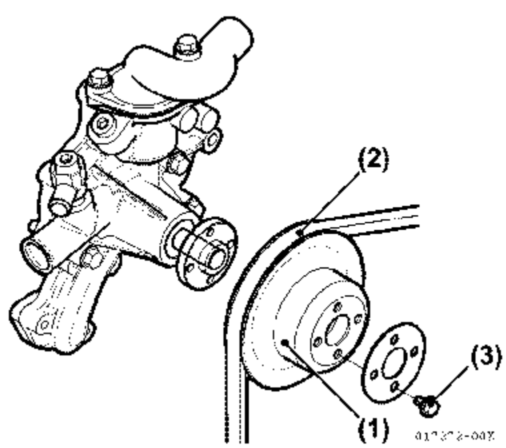


Figure 7-39

1 – Pulley
2 – V-Belt
3 – Bolt

6. **CAUTION!** ***Pinch Hazard. Use caution to avoid pinching fingers between belt and pulley while installing belt.*** Install new belt on crankshaft, alternator pulley and around coolant pump pulley. *NOTICE: Ensure belt is correctly engaged in all grooves of both pulleys.*
7. Install belt cover.
8. Connect negative (-) battery cable. Start engine and verify pump operation.

COOLANT RECOVERY TANK

Coolant Recovery Tank Function

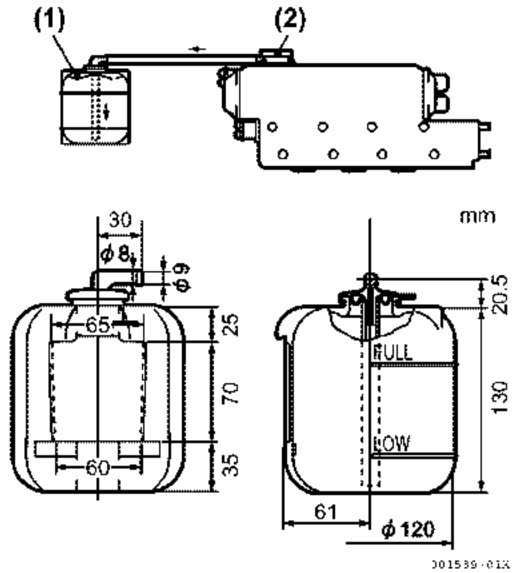


Figure 7-40

1 – Coolant Recovery Tank
2 – Filler Cap

The pressure valve opens to discharge steam when the steam pressure in the freshwater tank exceeds 82 to 109 kPa (12 to 16 psi).

This consumes water. The coolant recovery tank maintains the water level by preventing this discharge of water.

The steam discharged into the coolant recovery tank condenses into water, and the water level in the tank rises.

When the pressure in the freshwater system drops below the normal value, the water in the coolant recovery tank is sucked back into the freshwater tank to raise the water back to its original level.

The coolant recovery tank enables long hours of operation without water replacement and eliminates the possibility of burns when the steam is ejected from the filler neck because the pressure cap does not need to be removed.

Coolant Recovery Tank Capacity	Overall Capacity	1.3 L (1.37 qt)
	Full-Scale Level	0.8 L (0.85 qt)
	Low-Scale Level	0.2 L (0.21qt)

Mounting the Coolant Recovery Tank

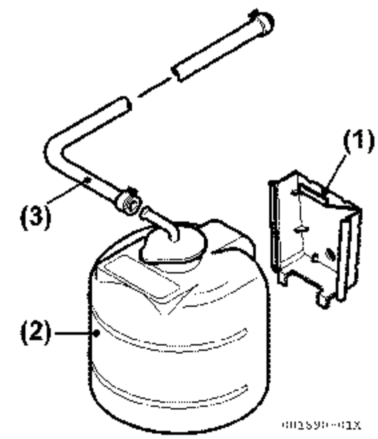


Figure 7-41

1 – Mounting Plate
2 – Subtank
3 – Overflow Tube

- The coolant recovery tank is mounted at approximately the same height as the heat exchanger (freshwater tank). Allowable difference in height: 300 mm (11.8 in.) or less.
- The overflow pipe should be less than 1000 mm (39.4 in) long, and mounted so that it does not sag or bend.

Note: Make sure that the overflow pipe of the coolant recovery tank is not submerged in bilge. If the overflow pipe is submerged in bilge, water in the bilge will be siphoned into the freshwater tank when the water is being cooled.

Before Using Coolant Recovery Tank

Check the coolant recovery tank when the engine is cool and refill with freshwater as necessary to bring the water level between the low and full marks. Check the overflow pipe and replace if bent or cracked. Clean out the pipe if it is clogged.

BILGE PUMP AND BILGE STRAINER (OPTIONAL)

Specification

Name	Bilge Pump
Time	10 minutes
Rotation Direction	Right (Viewed from the impeller side)
Mass Weight	Pump 1.4 kg (3 lb)
Negative (-) Pressure Detector	Diaphragm type
Temperature	-30°-80°C (86°-176°F)
Length	225 mm (8.8 in.)
Yoke Diameter	61 mm (2.4 in.)
Assembly Hole Diameter	5.3 mm (0.208 in.)
Assembly Pitch	50 x 90 mm (2 x 3.5 in.)

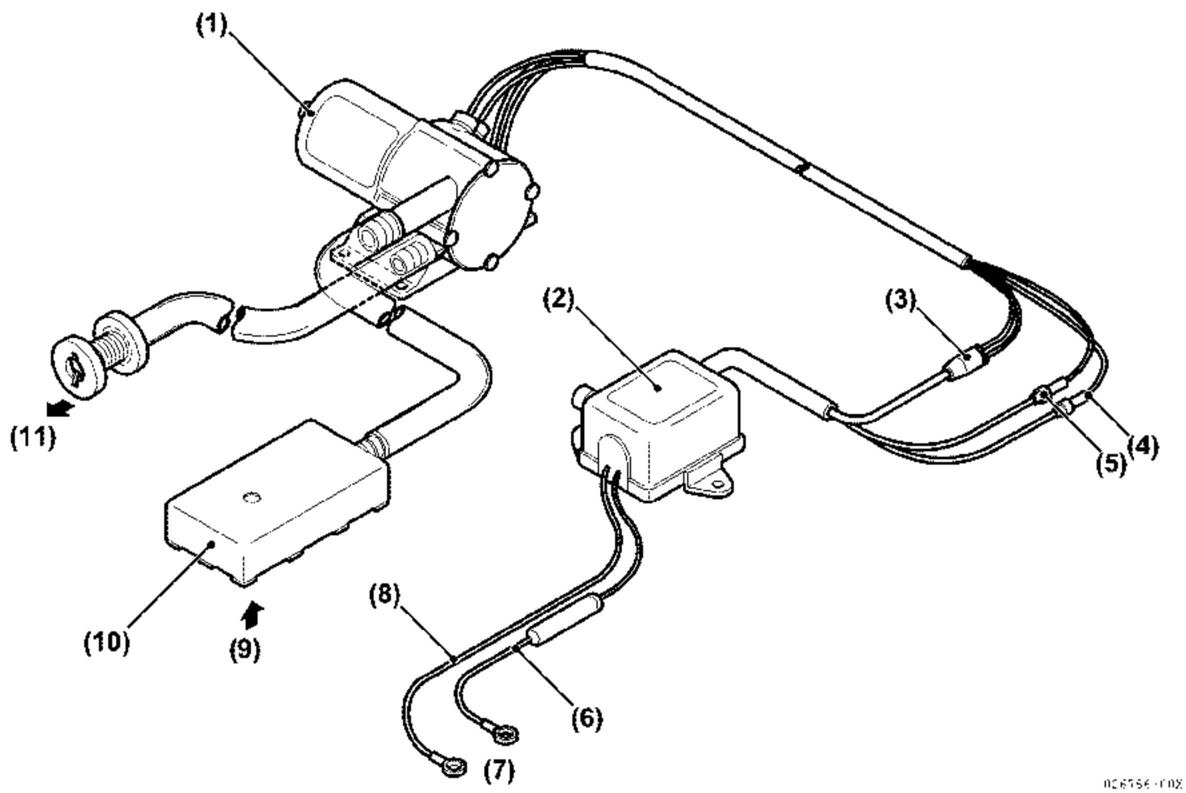


Figure 7-42

1 – Motor Assembly
2 – Controller
3 – Red
4 – White
5 – Black
6 – Red (+)
7 – Battery
8 – White (-)
9 – Oil Inlet
10 – Strainer
11 – Oil Outlet

Description

Characteristics

- Discharge at lift: 0 m (0 ft) discharge capacity: 20 L (5.2 gal) minimum or greater.
- Automatic feeding height: 1 m (3.2 ft) or greater (limit for automatic feeding height: new pump with inside parts wet, approximately 2 m [6.6 ft]).
- Automatic feeding time: 2 to 5 seconds (limit for automatic feeding time: new pump with inside parts wet, approximately 1 second).
- Automatic stopping: Air intake causes negative (-) pressure triggering automatic stopping.

Insulation

- Insulation resistance: 500V with a megatester when the difference between the continuity point and the body is 1MΩ or greater.
- Insulation proof stress: AC50 between the continuity point and the body, or 60hz 500V for 1 minute when impressed current leakage is 10 mA or lower.

Durability

Rated voltage when there is 3% salt water 60L + engine oil 3%, and operation is at 1800 cycles and there are no difficulties.

Vibration proof

Amplitude 0.51 mm (0.02 in.)
Vibration frequency 10 to 55 Hz
Sweep time 90 seconds.
Direction of vibration each direction 4 hours
No difficulties after test period

Cautions

- Attach at a position higher than the bilge water away from rain or other water, and 50 to 70 cm (19.7 to 27.6 in.) above the bottom of the boat.
- Never run the pump dry. Be sure that the strainer is inserted in the drain water before pushing the switch. If no water is being drawn up after a period of 10 seconds or more, prime the pump. (Do not run the pump for longer than 10 seconds when no water is being drawn up.)
- When the pump has not been used for a long period of time, the inside of the pump will be dry and drawing ability will be lowered. Before reusing, clean the inside of the pump or prime it to ensure that it is wet, and check to be sure that the pump operates correctly.
- When charging the diesel engine oil, wait a period of 30 minutes or longer from the time of stopping oil temperature 20° to 70°C (68° to 158°F). Refrain from operation when the oil temperature is below 15°C (59°F) or above 50°C (122°F).
- When the bilge inside the pump or hose freezes, completely melt the water with a steaming towel before beginning operation. When the temperature inside the pump is low, it will take a longer amount of time for the pump to drain off the bilge.
- The impeller replacement kit includes one impeller and three washers for adjusting the side gap. If after replacing the impeller the pump does not drain, place side gap adjustment washers underneath the bottom plate to adjust. Select the number of washers used in accordance with the following. When the pump is draining, the electric current load is about 5A. When there are too many washers, the electric current value will be too great and will blow a fuse.
- The pump cannot be used to drain off rain water or large amounts of flood water. The pump can be run continuously for a period of 10 minutes. After this time it must shut off for a period of 2 hours before reusing.
- NEVER use the pump for showering.
  If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.

- Fix the strainer so that it will not turn upside down or on its side.
- When sludge has built up in the bilge to be drained, position the strainer about 20 mm (0.79 in.) above the sludge. When the pump is stopped, be sure there is no sludge remaining inside the pump.
- The specific gravity of the battery fluid is 1.25 or more.

Assembly

When bilge is being used, assemble in accordance with the following.

1. Assembling the bilge pump:
    - Select a dry place above the bilge water level.
    - Select the location for the bilge pump taking into consideration the length of the switch cable (approximately 3 m [9.8 ft]) and its attachment point, and the position of the battery.
    - Position at a 45° angle **(Figure 7-43)** with the nozzle facing up, and 50 to 70 cm (19.7 to 27.6 in.) from the bottom of the boat.

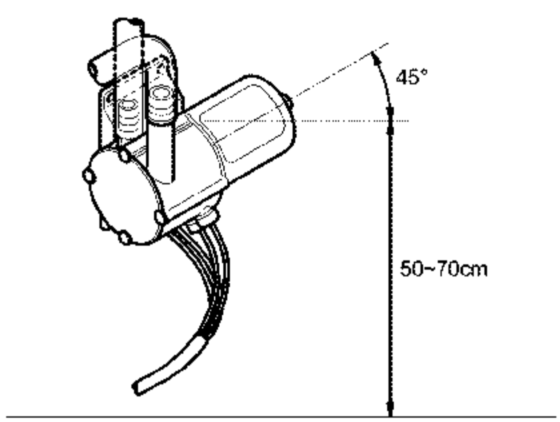


Figure 7-43

2. Assembling the switch:

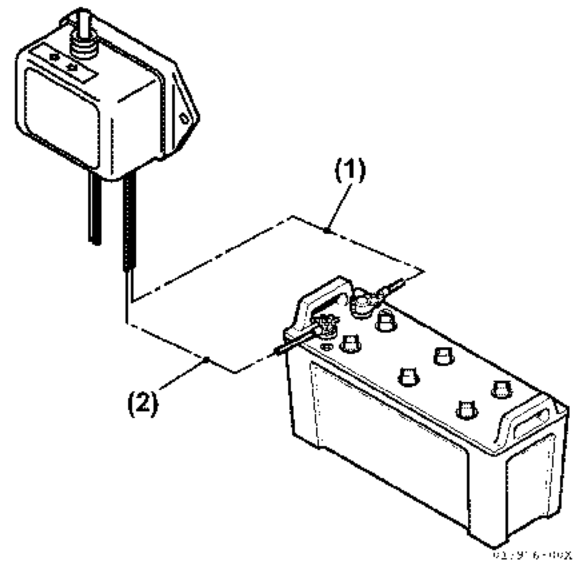


Figure 7-44

1 – Red Wire (+)
2 – White Wire (-)

- Attach in a place to ensure easy operation away from rainwater.
- Connect the terminal to the battery. When the cord will not reach the battery, an extension of no greater than 3 m (9.8 ft) length suitable for AV3mm^2 can be attached.
- Position the strainer. Attach at the place where the greatest amount of water is collected when the boat is stopped.

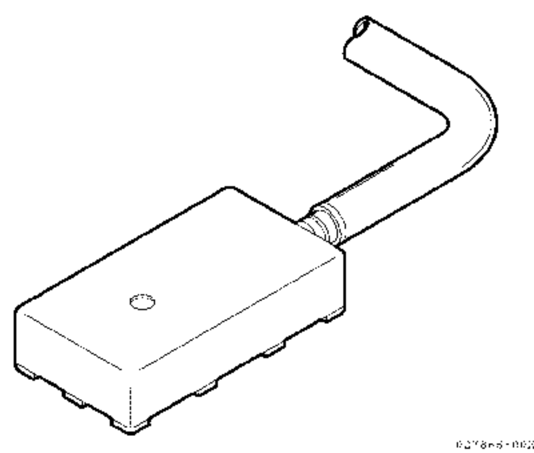


Figure 7-45

- It is best to place the strainer as close to the bilge pump as possible. Cut the 3 m (9.8 ft) hose to a length of 1.2 m to 1.8 m (3.9 to 5.9 ft) and attach, allowing plenty of give.
- Check the strainer during a test operation before screwing firmly into place. *NOTICE: When attaching the strainer, avoid damaging the bottom of the boat.*

Note: The strainer contains a weight, and can be used with the weight in place.

- Always keep the strainer clean.

3. Attaching the delivery nozzle (outlet):

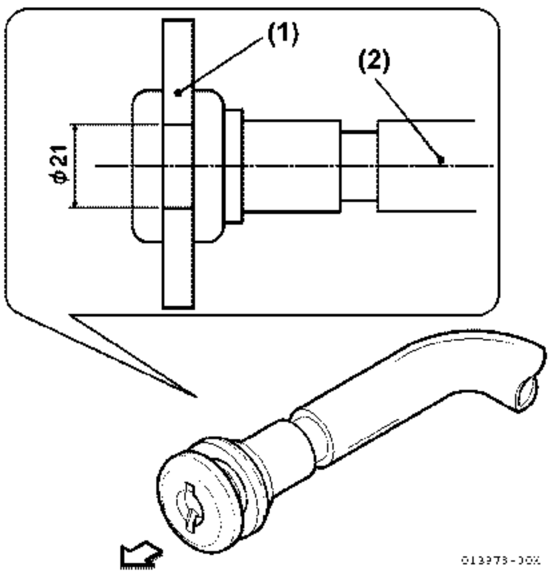


Figure 7-46

1 – Hull side
2 – Hose

- Make a hole of 21mm (0.8 in.) diameter or less for attaching the nozzle. The hose attached at the nozzle should be 1.8 m (5.9 ft) or less and should reach without any strain; therefore, care should be taken in deciding on the best position.
- Fix the outlet nozzle in place and attach to the discharge side of the pump.

4. Attaching the hose:
   (a) Attach the hose from the strainer to the pump inlet.
   (b) Attach the delivery nozzle hose to the pump outlet. Make the hose as short as possible and avoid sharp bends.
5. Test operation:
   (a) Collect water in the bottom of the boat and check for any problems with the hose or wiring. After doing this, connect the battery.
   (b) Turn on the pump switch, and check to see that water is being taken in and discharged properly. The pump will stop automatically when there is no water left.
   (c) If the inside of the pump is dry, or if the water is not being drawn up after a period of 10 seconds, lift the strainer above the water surface and stop the pump. Prime the pump before starting it up again.
6. Fixing the strainer:
   After the test operation, fix the strainer into place with bolts. *NOTICE: When attaching the strainer, avoid damaging the bottom of the boat.*

Cautions During Assembly

Observe the following cautions during handling:

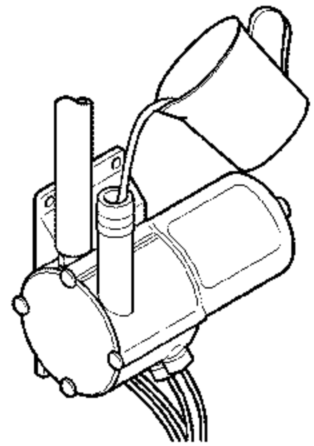


Figure 7-47

- NEVER use gasoline, solvents or lubricating oil at 70°C (158°F) or greater.
- NEVER run when there is no water in the bilge. Check to be sure that the strainer is in the water before turning on the switch.
- Keep the cord terminal away from the water. Water inside the motor or switch may lead to damage. When the insulation around the cord is damaged, water can seep in to the wires; thus, care should be taken not to scratch or nick the insulation.
- When the pump has not been used for a long period of time, the inside of the pump will be dry and it may not operate properly at first. If after 10 seconds the pump is not working, turn off the switch and prime the pump before trying again. *NOTICE: Never run the pump dry for period of greater than 10 seconds.*
- Replace the lubricating oil only after the engine has been stopped for a period of 30 minutes (oil temperature 20° to 70°C [60° to 158°F]). Whenever possible, refrain from operation when the oil temperature is below 15°C (59°F) or above 50°C (122°F).
- Bilge water left in the hose or inside the pump can freeze, and care should be taken to see that any excess bilge is completely discharged. If bilge water should freeze inside the hose or pump, it should be completely melted before starting up the pump. When the temperature inside the pump is low, the pump will take longer to operate. (0°C [32°F], 5 to 10 seconds).
- Keep the pump in a dry place away from rain or other water.
- Use the regulation hose; do no use thin vinyl hose or hose which is not heat-resistant.
- The pump cannot be used to drain off rainwater or large quantities of flood water. This pump can be operated continuously for a period of 10 minutes.
- NEVER use the pump for showering.
  If the pump outlet is deformed for showering, the increase in water pressure will increase the load on the motor and cause motor seizure.
- When sludge has built up in the bilge to be drained, position the strainer about 20 cm (7.9 in.) above the sludge. When the pump is stopped, be sure there is sludge remaining inside the pump housing.
- The specific gravity for the battery fluid is 1.25.

Steps for replacement

1. Remove the impeller plate by taking out the M4 bolts and opening the top of the diaphragm switch. Thread locking compound has been applied to the bolt, and a dryer should be used to heat the bolt before removing it.
2. Clean the inside of the pump.
3. Grease the plate, impeller and film for side gap adjustment, and then reassemble the pump by first inserting the film plate and then the impeller.

Troubleshooting

Refer to the following countermeasures for difficulties that arise.

No.	Problem	Cause	Countermeasure
1	Pump does not turn.	Faulty wiring	Check the wiring between the motor and battery.
		Faulty battery	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
		Faulty starter switch	Consult your local dealer.
		Faulty pump	Consult your local dealer.
2	Pump turns but does not draw up water.	Draws up air	Check hose connections. Retighten pump bolts.
		Low voltage in battery	Check to see if the specific gravity of the battery fluid is greater than 1.25. Recharge or replace the battery.
		The distance between the pump and the surface of the water is too great	Lower the pump. (Position the pump so that it is closer to the surface of the water.)
		The pump is too high	Lower the pump. (Position the pump so that it is 50-70 cm (19.7-27.6 in.) above the bottom of the boat.)
		Pump intake is weak	If intake is still faulty after priming, consult your local dealer.
3	Pump turns, but the amount of discharge is low.	Clogged strainer	Clean strainer.
		Hose is broken or damaged	Check for damage and repair. If incorrect hose has been used, replace with the regulation type of hose.
4	Water leakage from pump.	Water leakage from packing	Retighten pump bolts.
		Faulty pump seal	Consult your local dealer.
5	Pump draws up bilge, but motor stops when hand is removed from starter switch.	Faulty diaphragm switch	Check for loose wiring in diaphragm switch and correct.
		Damaged diaphragm switch	Consult your local dealer.
6	Motor does not stop, when there is no bilge water left.	Clogged strainer or hose	Clean strainer or hose.
		Damaged diaphragm switch	Check for continuity of diaphragm switch terminal. Consult your local dealer if there is continuity.

Section 8

LUBRICATION

Page

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SAFETY PRECAUTIONS

Before you service the lubrication system, read the following safety information and review the *Safety Section on 2-1*.

NOTICE

Only use the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and / or shorten engine life. NEVER mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE lubrication systems.

SPECIFICATIONS

Test and Adjustment Specifications

Note: All pressure specifications are with engine at normal operating temperature.

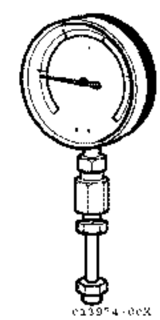
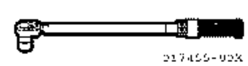
Inspection Item	Model	Pump Test RPM	Specification
Oil Pressure	3JH5E and 4JH5E	772	0.05 MPa (7.3 psi) or more
		3477	0.27-0.37 MP (39-44 psi)
	4JH4-TE and 4JH4-HTE	800	0.06 MPa (8.7 psi) or more
		3200	0.28-0.45 MPa (41-65 psi)

Special Torque Chart

Component	Tightening Torque	Lubricating Oil Application	Reference Page
Lubricating Oil Inlet Pipe	26 N·m (19.2 lb-ft)	Not Applied	*See Installing Engine Oil Pump on page 8-12.*

SPECIAL SERVICE TOOLS

Measuring Instruments

No.	Tool Name	Application	Illustration
1	Oil Pressure Test Gauge	For measuring oil pressure 0-10MPa (0-145.04 psi) obtained locally	
2	Torque Wrench	For tightening nuts and bolts to the specified torque 0-128 N·m (0-94.4 lb-ft) obtained locally	

TESTS AND ADJUSTMENTS

Engine Oil Flow

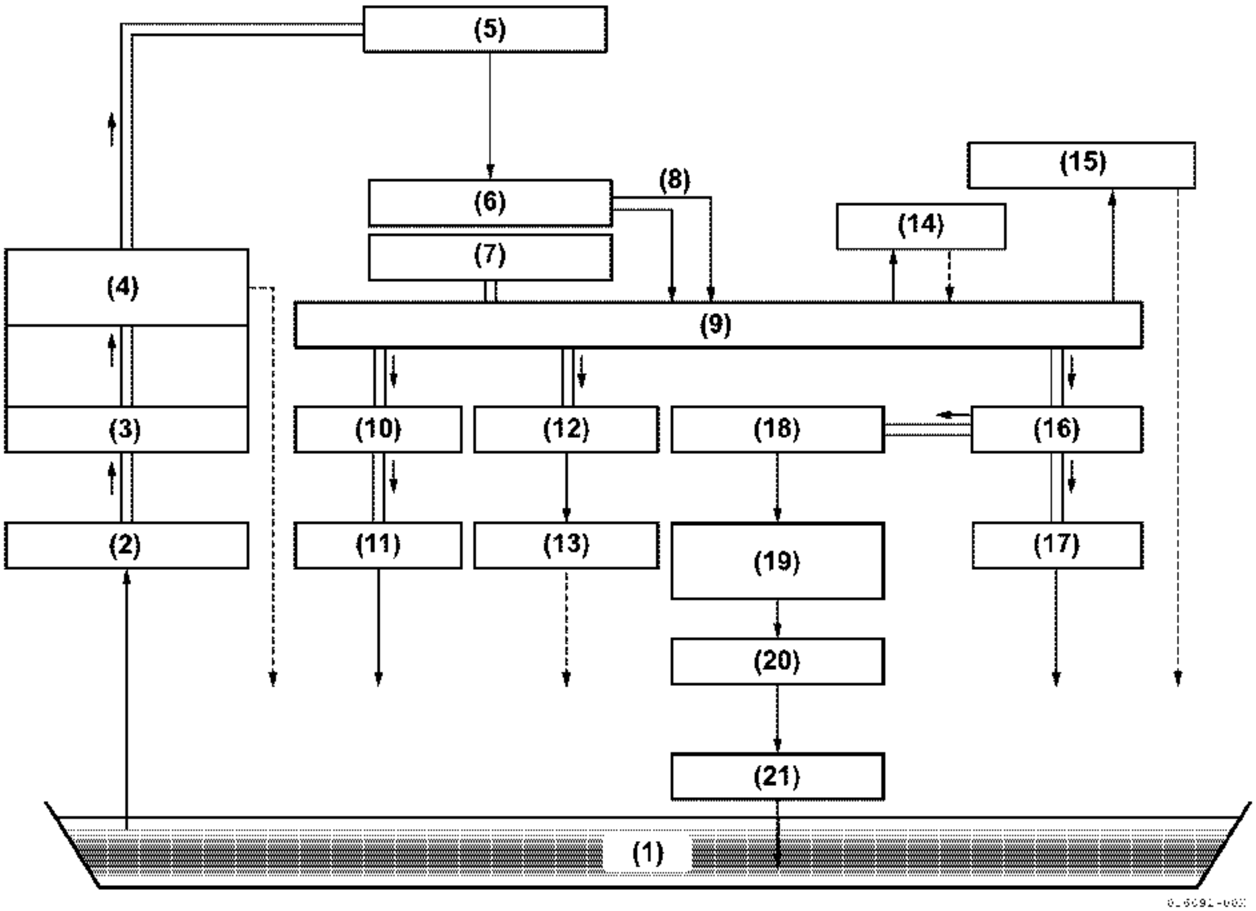


Figure 8-1

1 – Oil Sump
2 – Oil Filter (water / oil separator)
3 – Oil Pump
4 – Oil Pressure Regulating Valve
5 – Oil Cooler
6 – Oil Filter
7 – Oil Pressure Switch
8 – Oil Return
9 – Cylinder Block Main Galley
10 – Idler Gear Shaft
11 – Idler Gear Face
12 – Cooling Oil Nozzle
13 – Piston
14 – Turbocharger
15 – Fuel Injection Pump
16 – Crank Journal
17 – Crank Pin
18 – Camshaft Bearing
19 – Valve Rocker Arm Shaft
20 – Valve Rocker Arm
21 – Tappet and Cam Face

Checking Engine Oil Pressure

Perform an engine oil pressure check if there is any indication of low oil pressure.

1. Start the engine and allow it to warm to normal operating temperature.
2. Read the pressure gauge at the listed engine speeds.

Results:

3. If oil pressure is still indicated as low, check oil pressure switch or oil pressure gauge.

Inspection Item		Test Engine rpm	Specification
Engine Oil Pressure	3JH5E 4JH5E	Idle	0.05 MPa or more (7.3 psi or more)
		3000	0.27-0.37 MPa (39-44 psi)
	4JH4-TE 4JH4-HTE	Idle	0.06 MPa or more (8.7 psi or more)
		3200	0.28-0.45 MPa (40.6-65.3 psi)

4. Disconnect oil pressure switch connector. Keep voltmeter probes in contact with switch terminal and cylinder block while operating engine. Replace oil pressure switch **(Figure 8-2, (1))** if circuit is indicated closed.

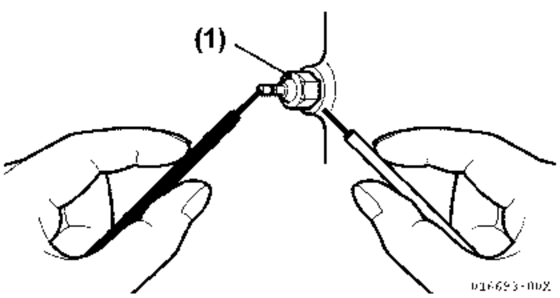


Figure 8-2

5. If oil pressure is still indicated as low, troubleshoot lubrication system to locate the cause of the low oil pressure. Repair as necessary.

REPAIR

Engine Lubrication System Components

4JH5E Engine Shown (3JH5E is Similar)

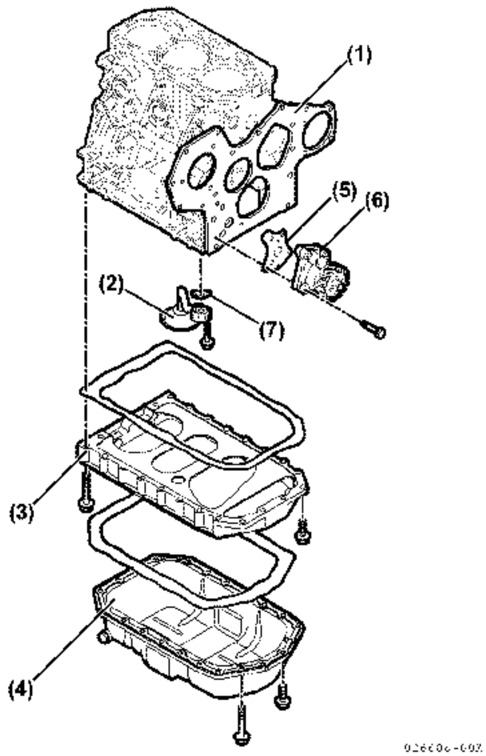


Figure 8-3

1 – Gear Case Housing
2 – Oil Inlet
3 – Spacer (oil pan)
4 – Oil Pan
5 – Gasket
6 – Oil Pump Assembly
7 – Gasket

4JH4-TE and 4JH4-HTE Engines

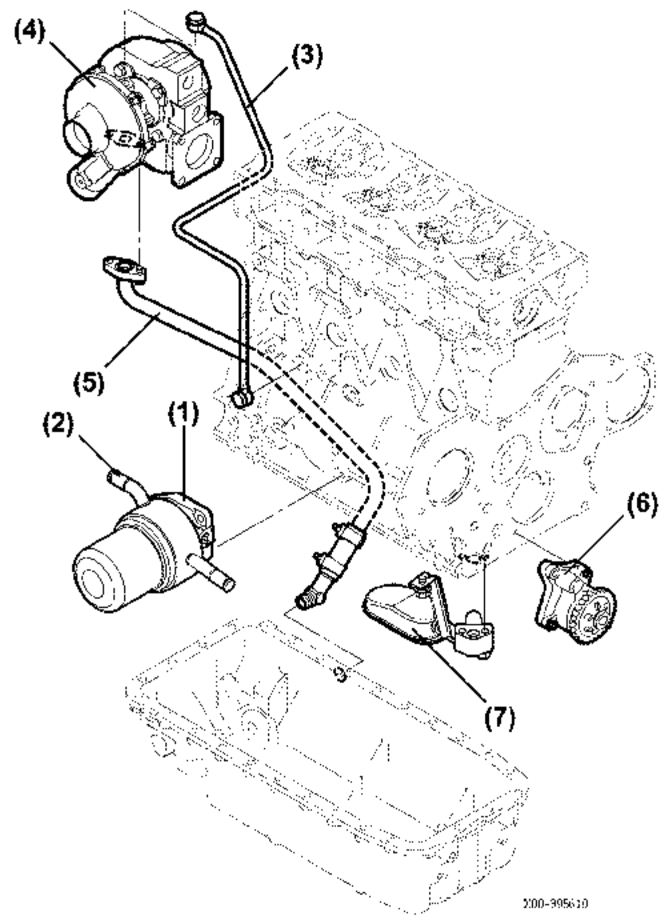


Figure 8-4

1 – Engine Oil Cooler
2 – Oil Filter Housing Sensor Line
3 – Turbocharger Lubrication Supply Line
4 – Turbocharger
5 – Turbocharger Lubrication Return Line
6 – Oil Pump
7 – Oil Pickup and Screen

Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler

The engine oil on a new engine becomes contaminated from the initial break-in of internal parts. It is very important that the initial oil replacement is performed as scheduled.

WARNING! ***Burn Hazard. If you must drain the engine oil while it is still hot, stay clear of the hot engine oil to avoid being burned. ALWAYS wear eye protection.*** Drain the lubricating oil while the engine is still warm.

1. Remove oil filler cap (yellow) at top of rocker arm cover **(Figure 8-5, (1))**.

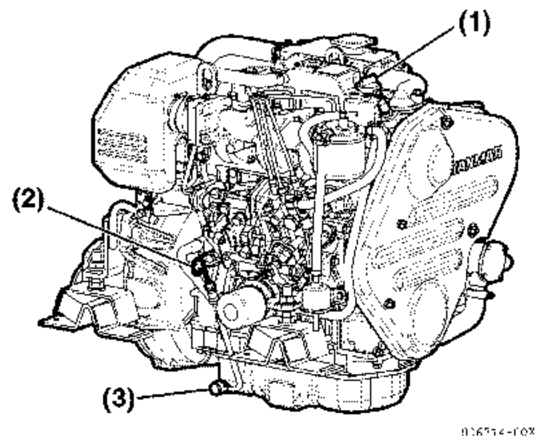


Figure 8-5

2. Remove the engine oil dipstick **(Figure 8-5, (2))**.
3. Attach an oil drain pump to dipstick guide and pump out the oil. Dispose of used oil properly.
4. Remove pipe joint bolt **(Figure 8-5, (3))** or drain plug **(Figure 8-6, (1))** and drain engine oil to appropriate vessel. Dispose of used oil properly. *NOTICE: ALWAYS be environmentally responsible.*

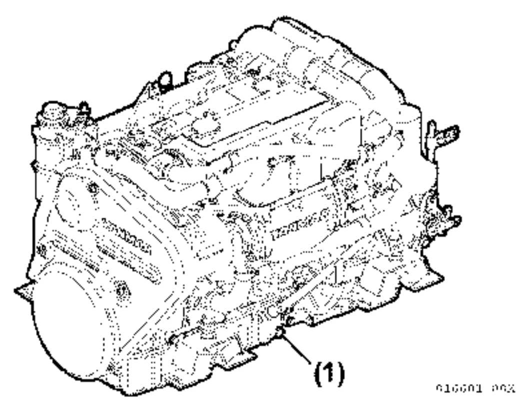


Figure 8-6

5. Tighten pipe joint bolt or drain plug.
6. Drain seawater. *See Draining / Refilling Seawater Cooling System on page 7-8.*
7. Remove coolant pipes.

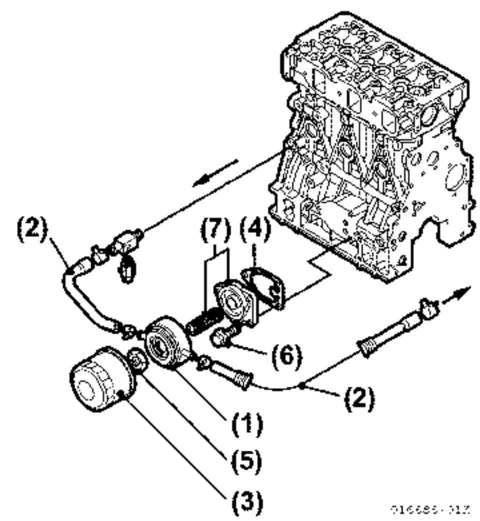


Figure 8-7

8. Turn lubricating oil filter **(Figure 8-7, (3))** counterclockwise using a filter wrench **(Figure 8-8, (2))** to remove from lubricating oil cooler **(Figure 8-7, (1))**.

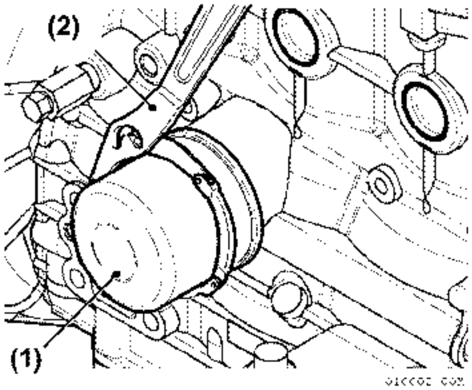


Figure 8-8

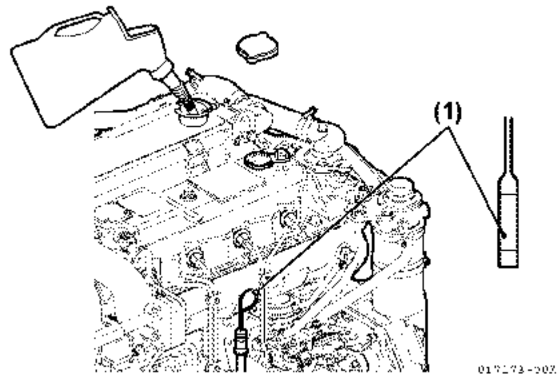


Figure 8-9

9. Remove lubricating oil cooler nut **(Figure 8-7, (5))** and lubricating oil cooler. Loosen bolts **(Figure 8-7, (6))** for filter bracket and remove filter bracket **(Figure 8-7, (7))**.
10. Clean or replace lubricating oil cooler and bracket as necessary.
11. Thoroughly clean all sealing surfaces.
12. Install a new filter bracket gasket, bracket and lubricating oil cooler. Secure to cylinder block with bolt.
13. Reassemble coolant pipes to lubricating oil cooler.
14. Coat the new lubricating oil filter seal with lubricating oil and install the lubricating oil filter **(Figure 8-8, (1))** manually turning it clockwise until the seal touches the mounting surface, and tighten it further to 3/4 of a turn using a filter wrench **(Figure 8-8, (2))**.
15. Tighten to 20 to 24 N·m (177 to 212 lb-in).
16. Fill with new lubricating oil. *See Engine Coolant Specifications on page 3-66.*
17. Fill the engine with coolant. *See Engine Coolant Specifications on page 3-66.*
18. Perform an engine trial run and check for oil or water leaks.
19. Approximately 10 minutes after stopping engine, remove oil dipstick and check oil level **(Figure 8-9, (1))**. Add oil if level is too low.

Removing and Installing Engine Oil Sump

1. Drain engine oil. *See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.*
2. Remove bolts **(Figure 8-10, (2), (3))** securing oil dipstick tube to cylinder block or support. Remove piping bolt **(Figure 8-10, (4))** and oil dipstick tube **(Figure 8-10, (1))** from oil sump.

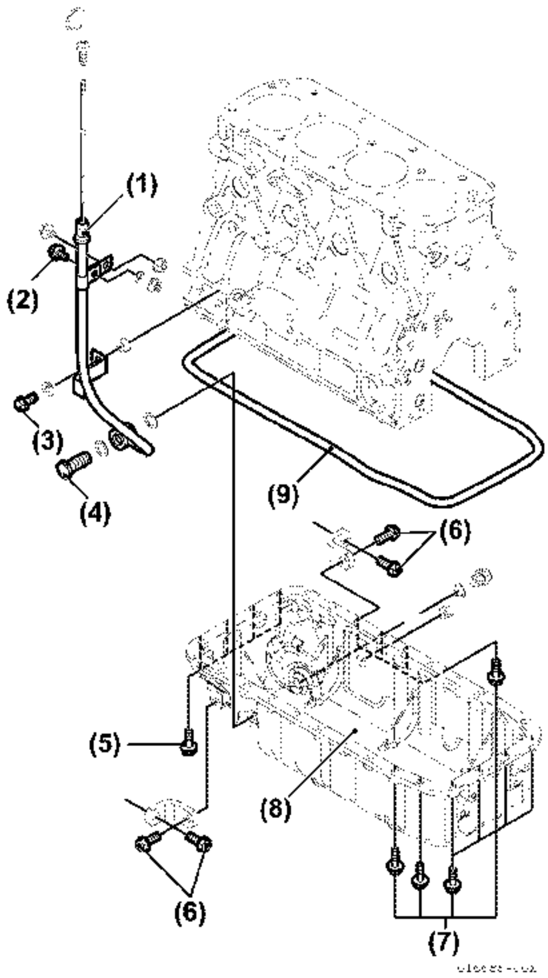


Figure 8-10

3. Remove bolts **(Figure 8-10, (5), (6))** that secure oil sump to flywheel housing.
4. Remove bolts **(Figure 8-10, (7))** securing oil sump to cylinder block.
5. Remove oil sump **(Figure 8-10, (8))** and gasket **(Figure 8-10, (9))**.
6. Clean gasket surfaces of old gasket material.
7. Install oil sump with a new gasket.
8. Tighten oil sump bolts beginning at the center and working alternately toward each end. Tighten bolts to 22.5 to 28.5 N·m (16.6 to 21.0 lb-in).
9. If removed, install oil drain plug and tighten to 48.9 to 58.9 N·m (36.1 to 43.4 lb-ft).
10. Fill engine with clean lubricating oil.
11. Run engine and check for leaks.
12. Check oil level and add as necessary.

Engine Oil Pump

The oil pump contains no serviceable parts. If the oil pump is damaged, it must be replaced as an assembly.

Removing Engine Oil Inlet Pipe

1. Drain oil from oil sump.
2. Remove oil sump. See **Figure 5-44** *on page 5-35.*
3. Remove bolts **(Figure 8-11, (1))**. Remove oil inlet pipe **(Figure 8-11, (2))** and gasket **(Figure 8-11, (3))**.

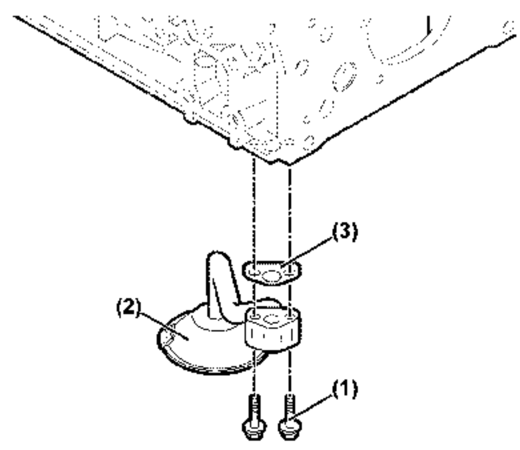


Figure 8-11

Removing Engine Oil Pump

The lubricating oil pump assembly with drive gear **(Figure 8-12, (1))** is driven by the crank gear **(Figure 8-12, (2))**. The lubricating oil pump is fitted with an oil pressure control valve **(Figure 8-12, (3))**.

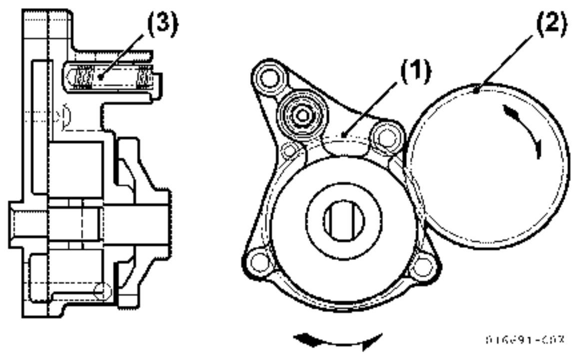


Figure 8-12

1. Remove crankshaft pulley. See **Figure 5-45** *on page 5-35.*
2. Remove gear case from gear case flange. See **Figure 5-47** *on page 5-36.*
3. Remove engine oil pump:

   Remove lubricating oil pump assembly from gear case flange. Do not disassemble inner / outer rotors, and check that pump rotates smoothly.
4. The oil pressure control valve plug is coated with adhesive and screwed in, so it cannot be disassembled. These parts cannot be reused after disassembling. Replace control valve assembly as necessary.

Checking Lubricating Oil Pump

Figure 8-13 shows an example of a lubricating oil pump.

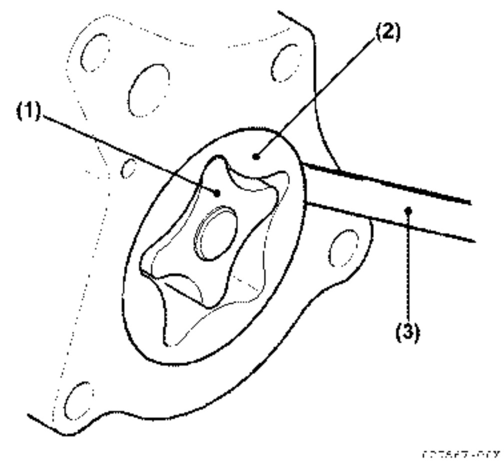


Figure 8-13

1 – Inner Rotor
2 – Outer Rotor
3 – Feeler Gauge

1. Using a feeler gauge, measure the clearance between the outer rotor **(Figure 8-13 (2))** and the pump case.

Outside Clearance

Model	Standard	Limit
3JH5E / 4JH5E	0.09-0.16 mm (0.0035-0.0063 in.)	-
4JH4-TE / 4JH4-HTE	0.09-0.16 mm (0.0035-0.0063 in.)	-

2. Using a feeler gauge, measure the clearance between the outer rotor **(Figure 8-13 (2))** and the inner rotor **(Figure 8-13 (1))**.

Inside Clearance

Model	Standard	Limit
3JH5E/4JH5E	-	0.16 mm (0.063 in.)
4JH4-TE/4JH4-HTE	-	0.16 mm (0.063 in.)

To measure side clearance of outer rotor:

3. Place a right-angle gauge against the pump body and insert a feeler gauge **(Figure 8-14)**.

Side Clearance

Model	Standard	Limit
3JH5E / 4JH5E	0.05-0.10 mm (0.002-0.004 in.)	0.12 mm (0.0047 in.)
4JH4-TE / 4JH4-HTE	0.05-0.10 mm (0.0020-0.0039 in.)	0.15 mm (0.0059 in.)

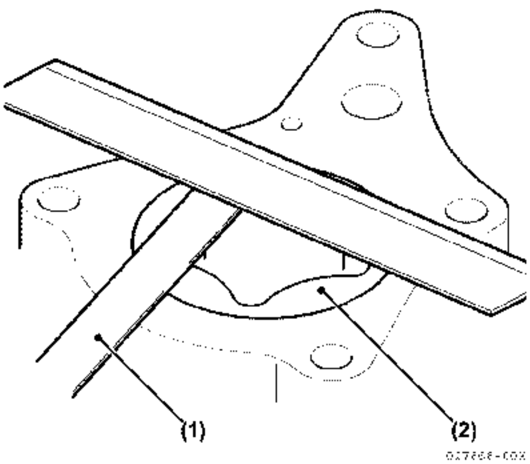


Figure 8-14

1 – Feeler Gauge
2 – Outer Rotor

Installing Engine Oil Pump

Note: Always check if pump rotates smoothly after installation on gear case. Running engine when pump rotation is stiff may cause damage to the pump.

1. Apply lubrication oil to outer and inner rotors.
2. Install oil pump assembly:

   Install lubrication oil pump assembly to gear case flange.
3. When replacing lubrication oil pump, replace whole assembly.
4. Install oil sump. *See Removing and Installing Engine Oil Sump on page 8-10.*
5. Fill crankcase to proper level with new lubrication oil.

Checking Piston Cooling Oil Nozzle

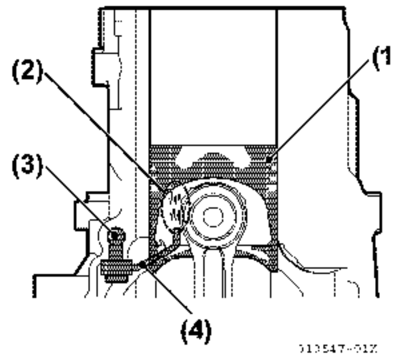


Figure 8-15

1 – Piston
2 – Splash
3 – Cylinder Block Main Galley
4 – Piston Cooling Oil Nozzle

1. Check the nozzle end hole (diameter 1.8 mm [0.071 in.]) for dust or other foreign matter **(Figure 8-15)**.
2. Check the brazed portion of the copper tube for fracture due to vibration.

Section 9

TURBOCHARGER

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SAFETY PRECAUTIONS

Before you service the engine turbocharger, review the *Safety Section on page 2-1*.

INTRODUCTION

This section of the *Service Manual* describes the removal, inspection and installation of turbochargers used on 4JH4-TE and 4JH4-HTE engines.

SPECIFICATIONS

Turbocharger Specifications

Model	4JH4-TE	4JH4-HTE
	RHB52W (IHI)	
Spec. No.	7000VNHP12NFW	7000VNHP15NFW
Turbine	Radial flow type	
Compressor	Centrifugal type	
Lubricating	Engine lubricating oil	
Bearing	Fuel floating	
Cooling	Freshwater cooling	
Dry Mass	3.6 kg (7.9 lb)	

TURBOCHARGER COMPONENTS

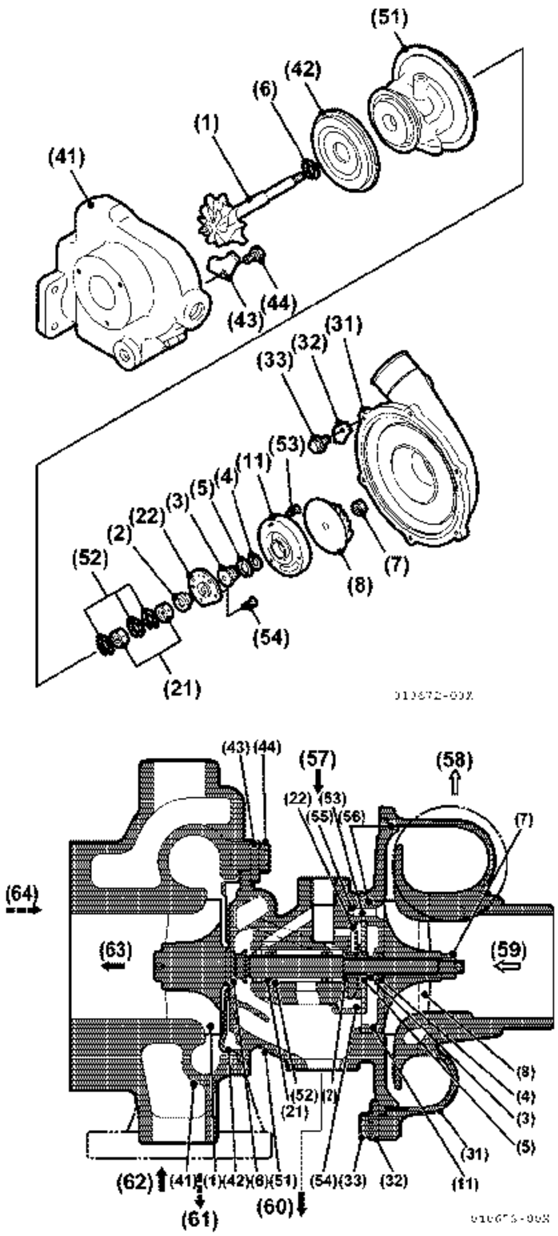


Figure 9-1

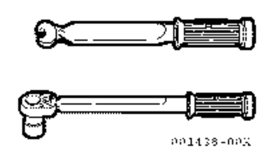
Sectional View and Tightening Torque

No.	Components	Qty.	Tightening Torque Kgf·cm (N·cm)
1	Turbine Shaft	1	-
2	Thrust Bushing	1	-
3	Oil Thrower	1	-
• 4	Compressor Side Seal Ring (Small)	1	-
• 5	Compressor Side Seal Ring (Large)	1	-
• 6	Turbine Side Seal Ring	1	-
7	Shaft End Nut / (Left Hand Thread)	1	20±2 (196±19)
8	Compressor Impeller	1	-
11	Seal Plate	1	-
21	Floating Bearing	2	-
22	Thrust Bearing	1	-
31	Compressor Housing	1	-
32	Compressor Side Plate Washer	4	-
33	Hexagon Bolt with Flange	6	48±5 (471±49)
41	Turbine Housing	1	-
42	Thermal Insulation Plate	1	-
43	Turbine Side Plate Washer	5	-
44	Hexagon Bolt	5	285±5 (2796±49)
51	Bearing Housing	1	-
52	Retaining Ring	3	-
• 53	TORXT Screw Bolt	3	13±1 (128±10)
• 54	TORXT Screw Bolt	4	13±1 (128±10)
55	Locktite	-	-
56	Liquid Gasket	-	Three-Bond 1207
57	Oil Inlet	-	-
58	Air Outlet	-	-
59	Air Inlet	-	-
60	Oil Outlet	-	-
61	Coolant Outlet	-	-
62	Gas Inlet	-	-
63	Gas Outlet	-	-
64	Coolant Inlet	-	-

• Non-reusable part.

SPECIAL SERVICE TOOLS

Note: The tool numbers used in this section are either Yanmar or IHI part numbers. Yanmar part numbers are referred to as **Yanmar Part No. and** IHI part numbers are referred to as **OEM Part No.** Tools not having part numbers must be obtained locally.

No.	Instrument Name	Application	Illustration
1	Torque Wrench	For tightening nuts and bolts to the specified torque	

WASHING THE TURBOCHARGER BLOWER

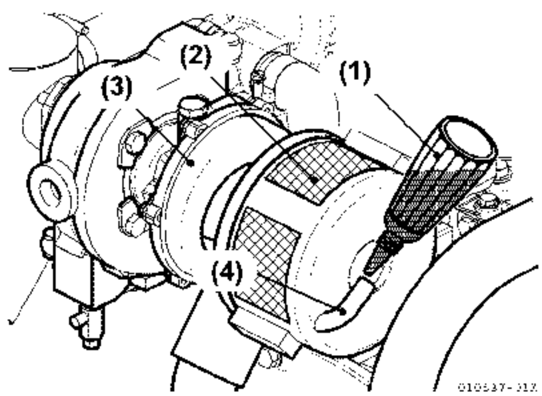


Figure 9-2

1 – Blower Wash
2 – Intake Silencer
3 – Turbocharger
4 – Inlet

When engine speed seems sluggish or the exhaust color poor, the blades of the turbocharger blower may be dirty. Wash the blower using the following procedure:

1. Prepare blower wash (liquid detergent), freshwater and a small pitcher.
   Blower wash (4L)
   Parts code: 974500-00400
2. Put the clutch in NEUTRAL and run the engine at high speed, 2500 to 3000 rpm minimum.
3. Slowly pour approximately 50 cc (1.7 oz) of blower wash into the inlet hole of the intake silencer over a period of about 10 seconds.
4. After about 3 minutes, pour in approximately 50 cc (1.7 oz) of fresh water in the same manner over a period of about 10 seconds.
5. After operating the engine for about 10 minutes, check the boost pressure and power output. If there is no improvement after washing the blower, repeat the washing process several times. *NOTICE: Do not pour in a large amount of blower wash at one time. This can damage the blower blades and cause water hammer in the combustion chamber and cause damage.*

CLEANING THE AIR CLEANER

Disassemble the intake silencer (air cleaner) periodically for inspection. With use, the air filter will become clogged over a period of time. A clogged air filter decreases the volume of intake air and may cause decreased power output and affect emissions.

1. Disassemble the air cleaner and clean it with a neutral detergent.
2. Reassemble after it is completely dry.

Turbocharger Service

Removal

NOTICE: Ensure the work area is clean at all times when working on the turbocharger. Never leave connections for oil inlets or outlets unprotected. Dust and debris in the turbocharger bearing housing will damage the turbocharger.

1. Remove intake pipe for 4JH4-TE **(Figure 9-3, (1))** and intake pipes (turbine, intercooler, intake manifold) for 4JH4-HTE **(Figure 9-4, (1))**.

4JH4-TE Engine

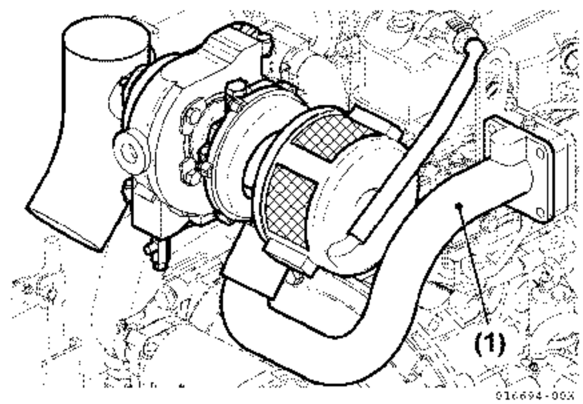


Figure 9-3

4JH4-HTE Engine

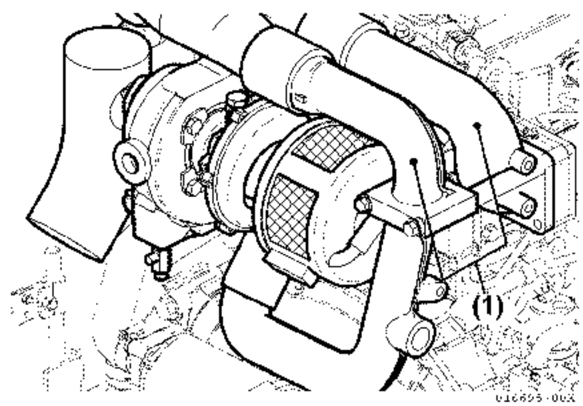


Figure 9-4

2. Remove mixing elbow for 4JH4-TE **(Figure 9-5, (1))** and 4JH4-HTE **(Figure 9-6, (1))**. *See Remove cooling system components from engine. on page 5-26.*

4JH4-TE Engine

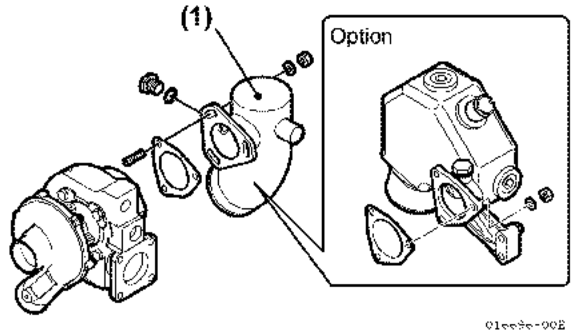


Figure 9-5

4JH4-HTE Engine

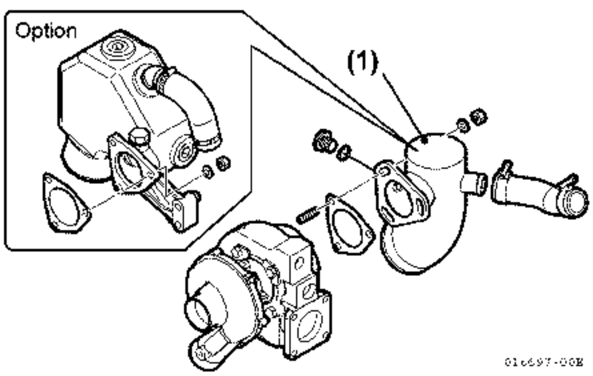


Figure 9-6

3. Remove the air cleaner for the 4JH4-TE **(Figure 9-7, (1))** and the 4JH4-HTE **(Figure 9-8, (1))**.

4JH4-TE Engine

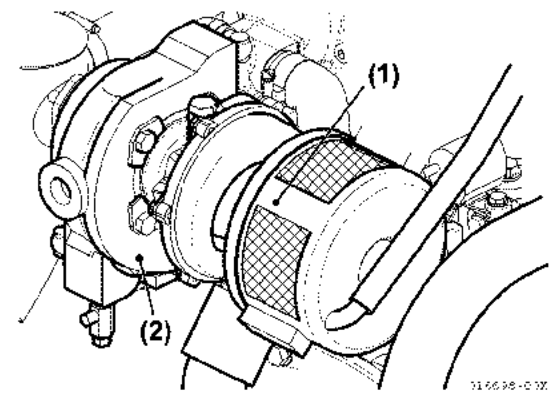


Figure 9-7

4JH4-HTE Engine

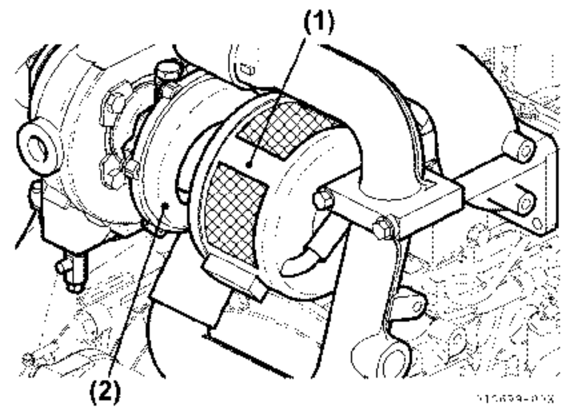


Figure 9-8

4. Remove turbocharger for 4JH4-TE **(Figure 9-7, (2))** and 4JH4-HTE **(Figure 9-8, (2))**.

(a) Remove four nuts and washers **(Figure 9-9, (2), (3))** and remove turbocharger **(Figure 9-9, (1))** from heat exchanger body **(Figure 9-9, (5))**.

(b) Remove gasket **(Figure 9-9, (4))**.

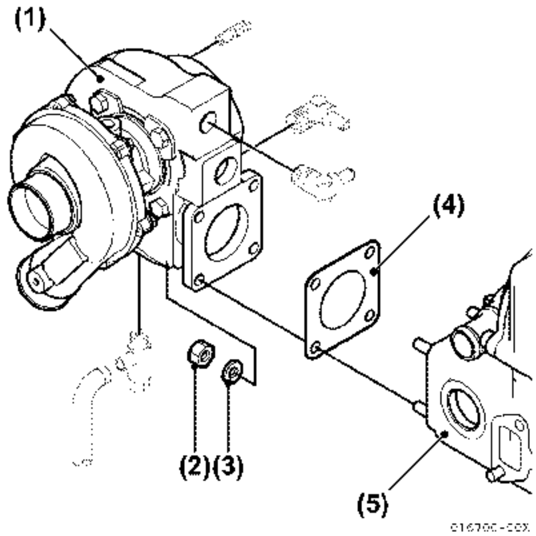


Figure 9-9

Check and Service Data

Service Interval

Item	Check Cycle
Check on Conditions of Turbine Shaft Rotation	Every 500 h
Check on Play in the Turbine Shaft	Every 1000 h
Overhaul	Every 4000 h

Check the conditions of turbine shaft rotation by listening for abnormal sounds during rotation.
To check using a listening bar, firmly push the end of the bar against the turbocharger case and gradually increase the engine speed.

In the event of a problem with the turbine shaft, a high-pitched sound will be produced every 2 to 3 seconds.

If this sound is heard, the bearing or turbine shaft may be defective. Replace or overhaul the turbocharger.

- Check for:
  End play in the turbine shaft
  Service standard: 0.03 to 0.06 mm (0.001 to 0.002 in.)
  Wear limit: 0.09 mm (0.004 in.)
- Check for:
  Radial play in the turbine shaft
  Service standard: 0.06 to 0.08 mm (0.002 to 0.003 in.)
  Wear limit: 0.17 mm (0.007 in.)
- Check play in the turbine shaft:
  Remove the turbocharger from the engine. Check end play and radial play in the turbine shaft as shown **Figure 9-10** and **Figure 9-11**.

  When the turbocharger is dismounted from the engine, cover the oil inlet / outlet with gummed cloth tape.

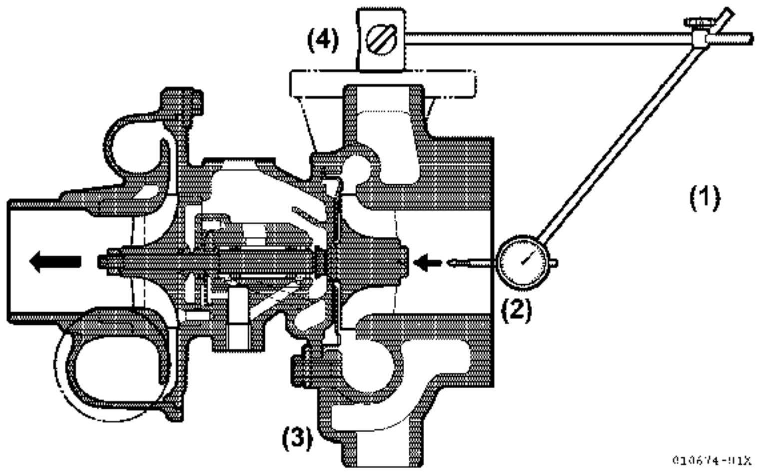


Figure 9-10

1 – Move the Turbine Shaft in the Axial Direction
2 – Dial Gauge
3 – Turbine Housing
4 – Magnet Base

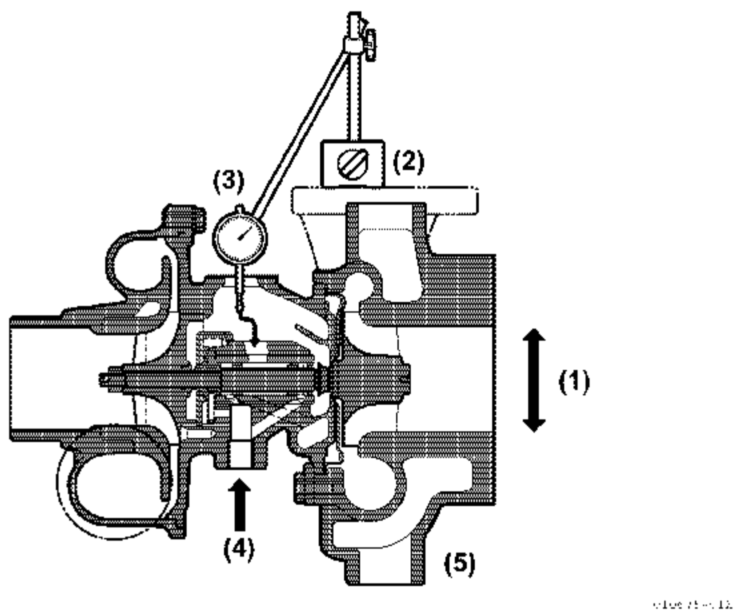


Figure 9-11

1 – Move the Turbine Shaft on the Left and Right Sides Simultaneously in the Radial Direction
2 – Magnet Base
3 – Dial Gauge
4 – Oil Inlet
5 – Turbine Housing

Cautions During Assembly

The upper retaining ring is applied only to the abutment that is located nearest the turbine side.

Retaining ring:

- Install the abutment as shown in **Figure 9-12**.
- Put the round ring surface on the metal side.

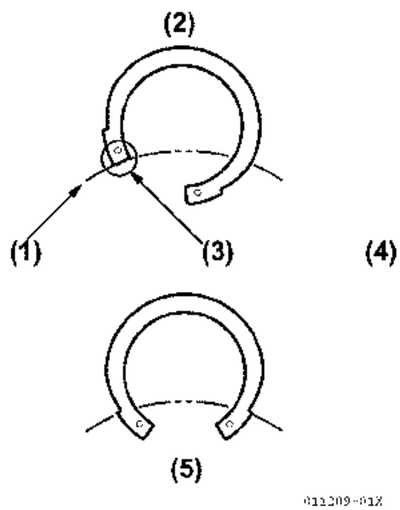


Figure 9-12

1 – Oil Inlet
2 – Cutter Groove
3 – Align Here
4 – Viewed from the Turbine Side
5 – All Except Upper One Ring

Seal ring on the turbine side:

- Put the abutment on the oil inlet side.

Seal ring on the compressor side:

- Insert the abutment as shown in **Figure 9-13**.

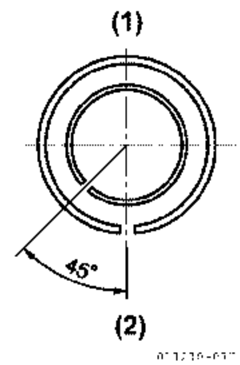


Figure 9-13

1 – Oil Inlet
2 – Viewed from the Compressor Side

Service Standards

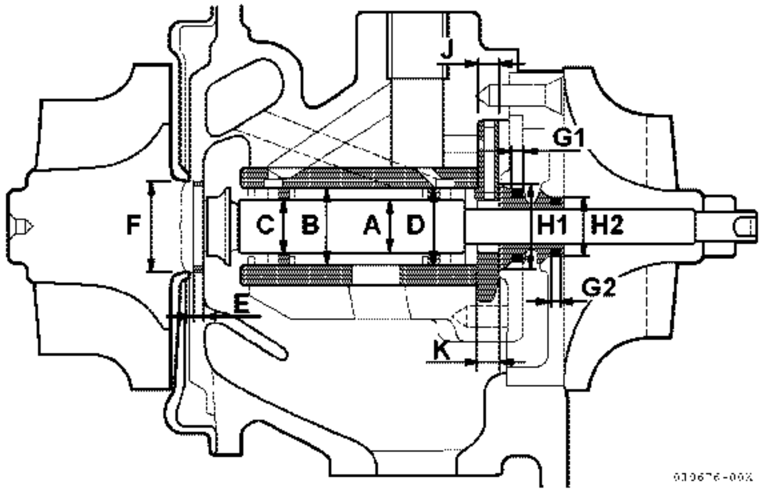


Figure 9-14

	Check Item	Usable Limit	Remarks
Turbine Shaft	Outside diameter (A) of turbine shaft journal Seal ring groove width (E) on turbine side Seal ring groove width (G1) on compressor side Seal ring groove width (G2) on compressor side Turbine shaft run-out	7.98 mm (0.314 in.) 1.29 mm (0.0508 in.) 1.31 mm (0.0516 in.) 1.11 mm (0.0437 in.) 0.011 mm (0.0004 in.)	-
Bearing	Floating bearing inside diameter (C) Floating bearing outside diameter (D) Bearing case inside diameter (B)	8.04 mm (0.317 in.) 12.31 mm (0.485 in.) 12.42 mm (0.489 in.)	-
Thrust Bearing	Thrust bearing width (J) Distance (K) between thrust bearing grooves	3.98 mm (0.157 in.) 4.07 mm (0.160 in.)	-
Seal Ring Inserting Area	Turbine side (bearing housing) (F) Compressor side (seal plate) (H1) Compressor side (seal plate) (H2)	15.05 mm (0.592 in.) 12.45 mm (0.490 in.) 10.05 mm (0.396 in.)	-
End Play in the Turbine Shaft		0.09 mm (0.004 in.)	Standard 0.03 to 0.06 mm (0.001 to 0.002 in.)
Radial Play in the Turbine Shaft		0.17 mm (0.007 in.)	Standard 0.08 to 0.13 mm (0.003 to 0.005 in.)

Installation

Note: When installing the turbocharger, replace all gaskets with new ones, change the engine oil and replace the engine oil filter. *See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.*

1. Clean the mounting surfaces of all gasket material.
2. Install the turbocharger **(Figure 9-15, (1))** with a new gasket. Tighten nuts to 22.5 to 28.5 N·m (199 to 252 lb-in.)

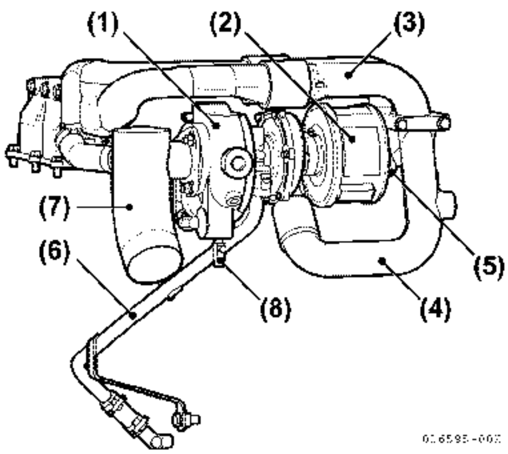


Figure 9-15

3. Instal air filter **(Figure 9-15, (2))**.
4. Connect the intake pipe **(Figure 9-15, (3), (4))** and tighten all clamps and bolts securely.
5. Connect lubricating oil lines **(Figure 9-15, (5), (6))** and tighten all bolts securely.
6. Connect the mixing elbow **(Figure 9-15, (7))** and seawater drain pipe **(Figure 9-15, (8))**. Tighten all clamps and bolts securely.
7. Start the engine and check for oil leaks.

Section 10

STARTER MOTOR

Page

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SAFETY PRECAUTIONS

Before you service the starter motor, read the following safety information and review the *Safety Section on page 2-1*.

NOTICE

NEVER engage the starter motor while the engine is running. Damage to the starter motor pinion and / or ring gear will result.

INTRODUCTION

This section of the *Service Manual* covers servicing of starter motor on 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE engines.

STARTER MOTOR SPECIFICATIONS

General Specifications

Item	Yanmar Part No.	HITACHI Model No.
	129608-77011	**S114-817A**
Nominal Power	1.4 kW (1.9 hp)	
Nominal Voltage	12 V	
Test Voltage	-	
Maximum Operating Temperature	80°C (176°F)	
Rotation	Clockwise	
Maximum Current Draw at 11V	90 A	
Mass	3.0 kg (6.6 lb)	

Special Torque Chart

Item	Specification
Battery Positive (+) Cable: B Terminal	7.4-9.8 N·m (65-87 lb-in.)
Solenoid Primary Wire: S and M Terminal	3.0-4.2 N·m (26-37 lb-in.)

Characteristics

Standard Performance 12V 1.4kW

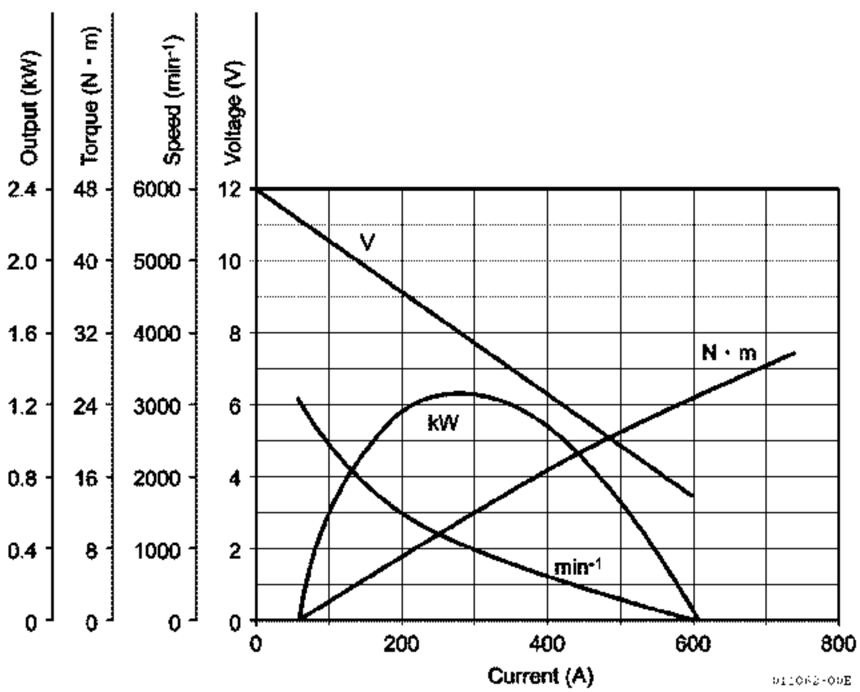

Figure 10-1

STARTER MOTOR TROUBLESHOOTING

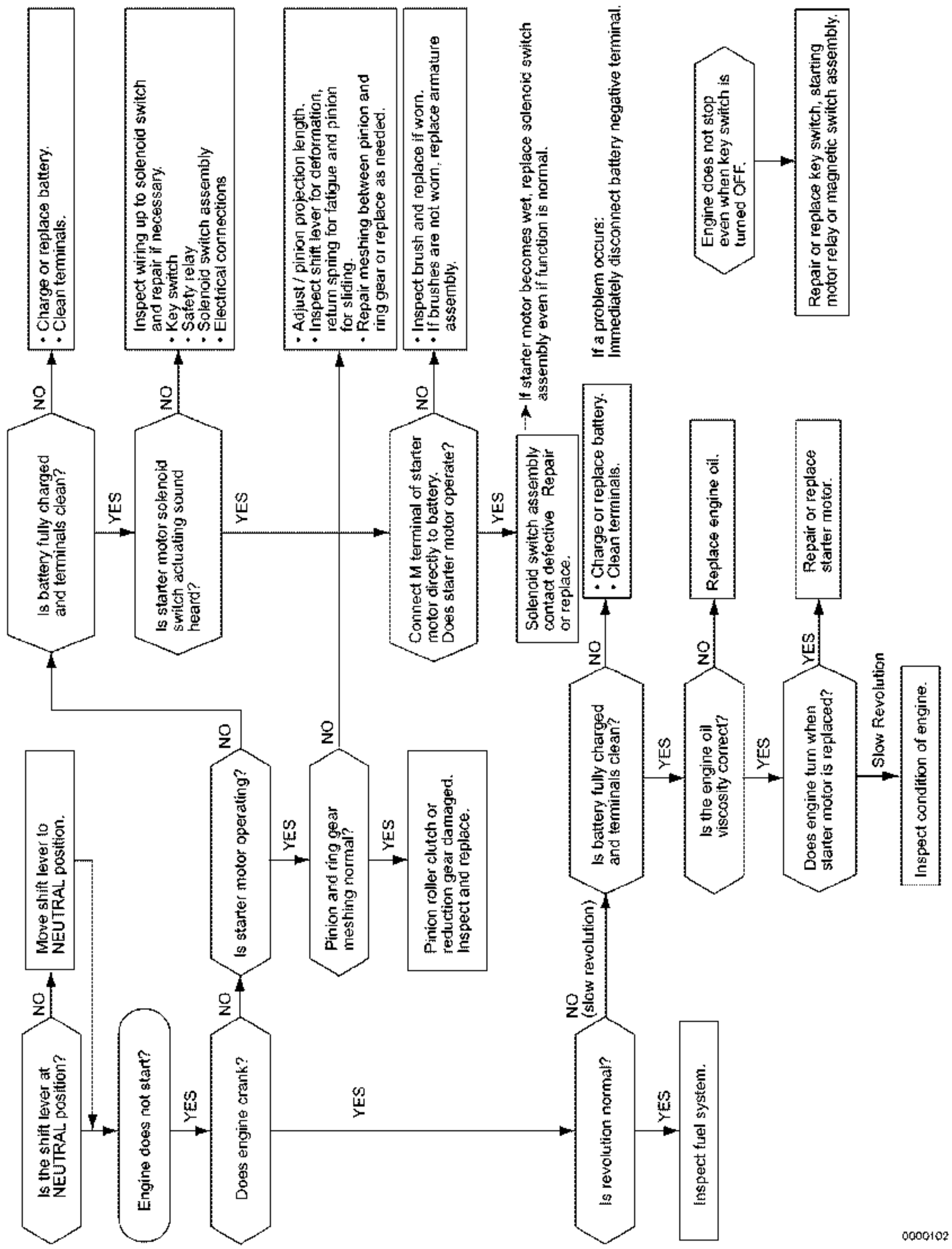

Figure 10-2

STARTER MOTOR SERVICE

1. Disconnect the negative (-) battery cable **(Figure 10-3, (1))** and turn the battery master switch to OFF (if equipped) **(Figure 10-3, (2))**.

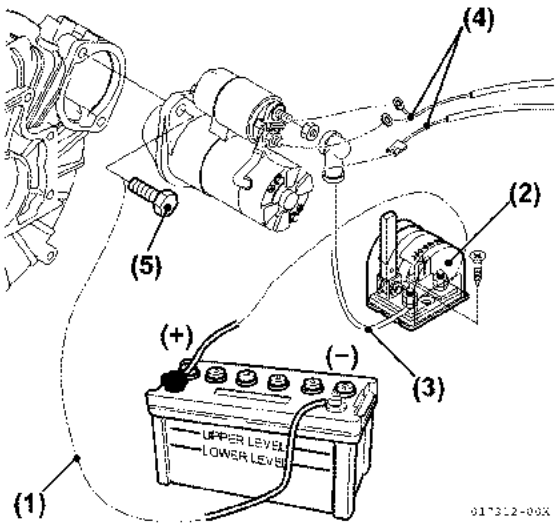

Figure 10-3

2. Disconnect positive (+) cable **(Figure 10-3, (3))** and primary wires **(Figure 10-3, (4))**.
3. Remove bolts **(Figure 10-3, (5))** securing the starter motor to the flywheel housing.
4. Carefully remove the starter motor. *NOTICE: Check the starter pinion for damage. If the starter pinion is damaged, check the flywheel ring gear for damage.*
5. Clean the starter mounting area of the flywheel housing.
6. Install the starter motor.
7. Clean the cable connections.
8. Connect the cable and primary wires to the appropriate terminals of the starter and connect positive (+) battery cable.
9. Connect the negative (-) battery cable and return the master switch to the ON position.
10. Operate the starter to verify operation.

Section 11

ALTERNATOR

Page

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SAFETY PRECAUTIONS

Before you service the alternator, read the following safety information and review the *Safety Section on page 2-1*.

NOTICE

NEVER operate the engine if the alternator is producing unusual sounds. Damage to the alternator will result.

NEVER remove the positive (+) battery cable from alternator terminal B while the engine is operating. Damage to the alternator will result.

NEVER turn the battery switch OFF while the engine is operating. Damage to the alternator will result.

NEVER use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.

INTRODUCTION

This section of the *Service Manual* covers servicing the alternator on 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE engines.

SPECIFICATIONS

General Specifications (Standard)

Item	Specification
Yanmar Code	119573-77201
Manufacturer	HITACHI
Model	LR180-03C
Nominal Voltage	12V
Nominal Output	80A
Rotation	Clockwise (viewed from pulley end)
Rated Speed	5000 (rpm)

General Specifications (Optional for 4JH4-TE and 4JH4-HTE)

Item	Specification
Yanmar Code	12871-77200
Manufacturer	HITACHI
Model	LR160-741
Nominal Voltage	12V
Nominal Output	60A
Rotation	Clockwise (viewed from pulley end)
Rated Speed	5000 (rpm)

Special Torque Chart

Item	Specification
Alternator Mounting Bolts	22.5-28.5 N·m (16.6-21.0 lb-ft)
Positive (+) Cable Nut	3.7-5.0 N·m (33-44 lb-in.)

Wiring Diagram

Standard Alternator - 12 Volt / 80 Amps

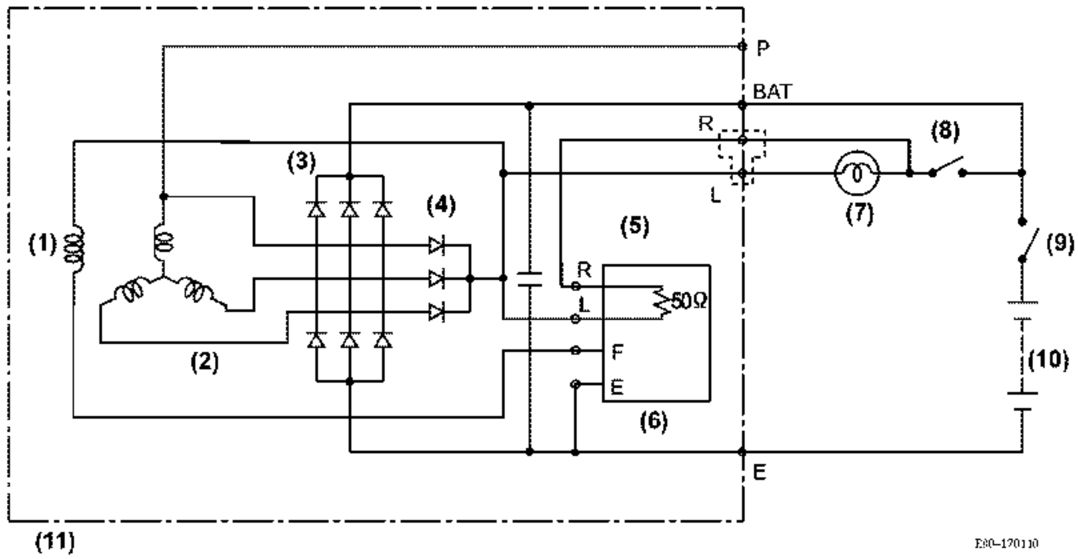

Figure 11-1

1 – Rotor Coil
2 – Stator Coil
3 – Diode
4 – Sub-Diode
5 – Condenser (3.2 μF)
6 – IC Regulator
7 – Charge Lamp 12V3.4W
8 – Key Switch
9 – Battery Switch
10 – Battery
11 – Alternator

Optional Alternator - 12 Volt / 60 Amps (for 4JH4-TE and 4JH4-HTE)

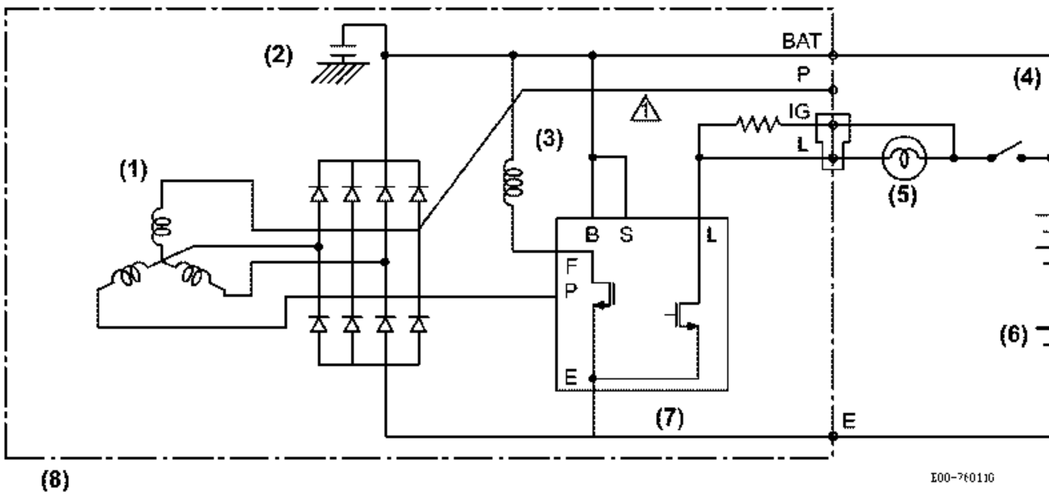

Figure 11-2

1 – Stator Coil
2 – Condenser 2.2 μ F
3 – Rotor Coil
4 – Key Switch
5 – Charge Lamp 12V3.4W
6 – Battery
7 – IC Regulator
8 – Alternator

Optional Double Alternator - 12 Volt x 80 Amps (for 4JH5E)

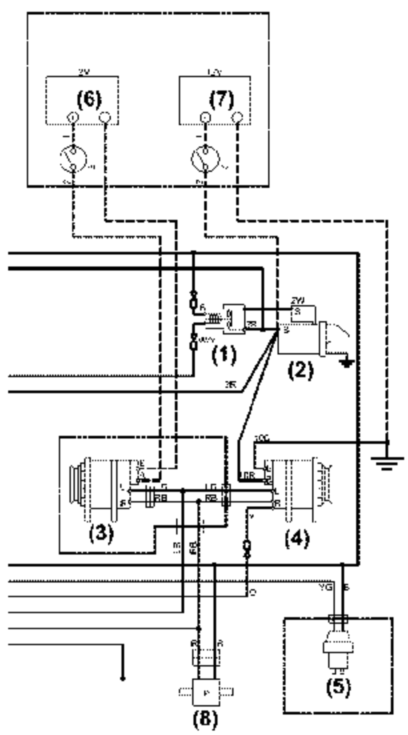

Figure 11-3

1 – Starter Relay
2 – Starter Motor
3 – Alternator 12V x 80A (optional)
4 – Alternator 12V x 80A (standard)
5 – Water Sensor (only for Sail Drive)
6 – Battery (optional)
7 – Battery (standard)
8 – Electric Feed Pump (4JH5E only)

Output Characteristics

Standard Alternator - 12 Volt / 80 Amps

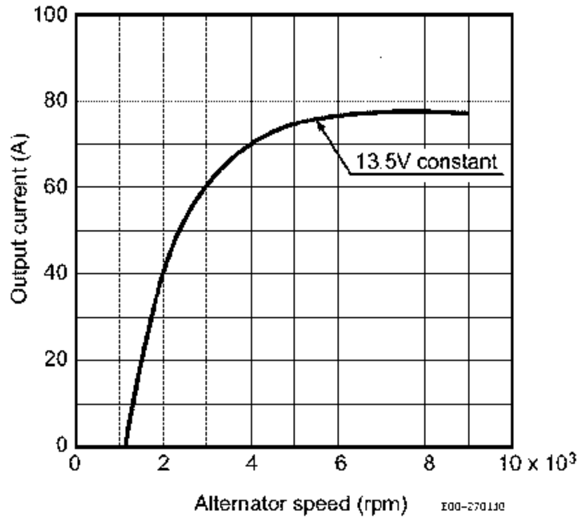

Figure 11-4

Optional Alternator - 12 Volt / 60 Amps (for 4JH4-TE and 4JH4-HTE)

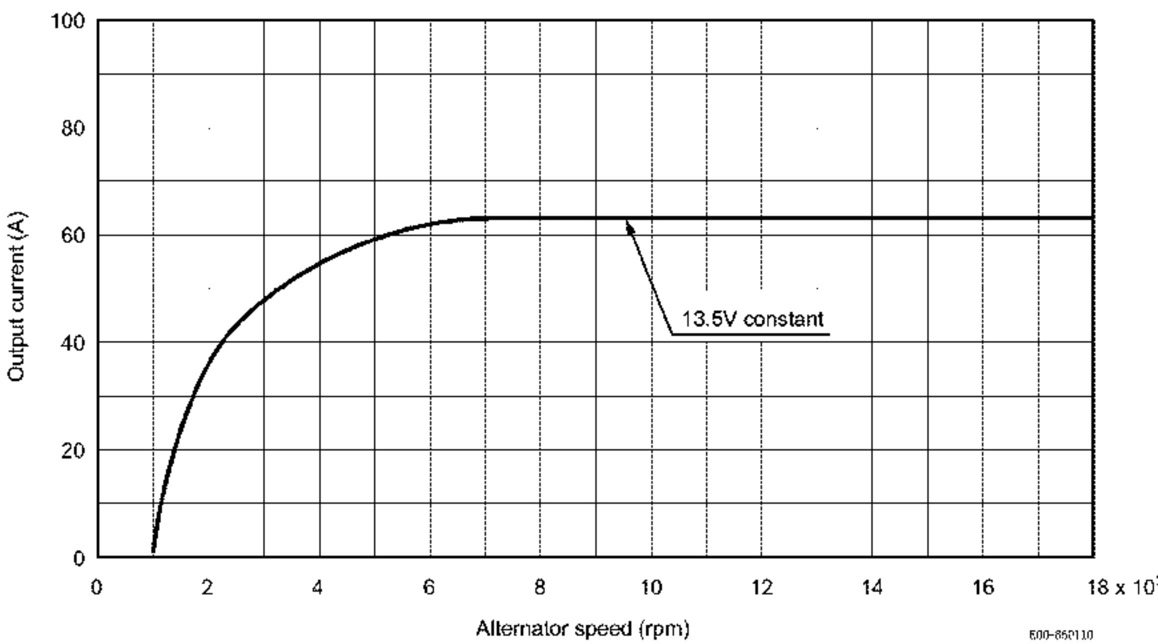

Figure 11-5

ALTERNATOR SERVICE

Replace V-Belt

1. Disconnect negative (-) battery cable.
2. Remove the V-belt cover.
3. Remove the V-belt. *See Replacing Coolant Pump Belt and Pulley on page 7-18.*

Belt Routing

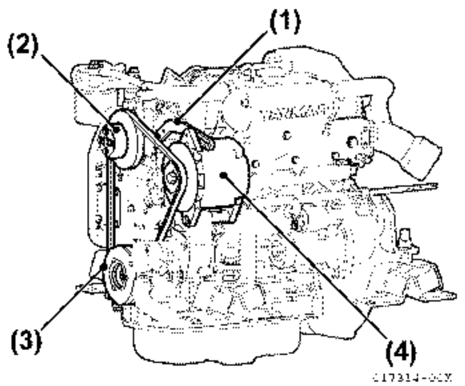

Figure 11-6

1 – Belt Adjuster
2 – Coolant Pump Pulley
3 – Crankshaft Pulley
4 – Alternator

4. Loosen the alternator adjuster bolt **(Figure 11-7, (1))** and relieve V-belt tension. Remove the V-belt. *NOTICE: If belt is to be reused, note direction of travel and install in same direction of travel.*

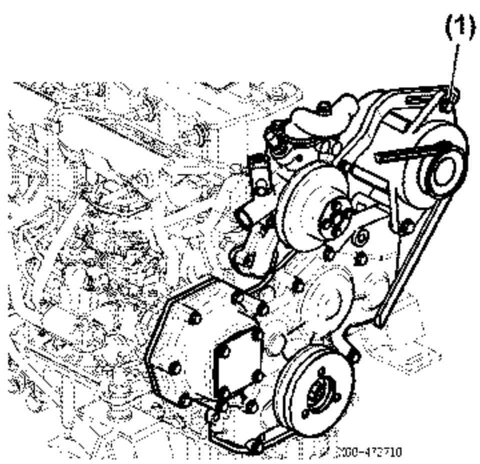

Figure 11-7

5. Installation is the reverse of removal. **CAUTION!** ***Pinch Hazard. ALWAYS use care not to pinch a finger between belt and pulley while installing belt. Failure to comply may result in minor or moderate injury.*** *NOTICE: Ensure belt correctly engages all grooves of each pulley. Failure to do so will lead to premature belt failure.*

Removing and Installing the Alternator

1. Disconnect negative (-) cable from E terminal **(Figure 11-8, (1))**.
2. Remove the V-belt cover.
3. Remove the alternator belt. *See Replacing Coolant Pump Belt and Pulley on page 7-18.*
4. Disconnect positive (+) cable from Battery terminal **(Figure 11-8, (2))**.

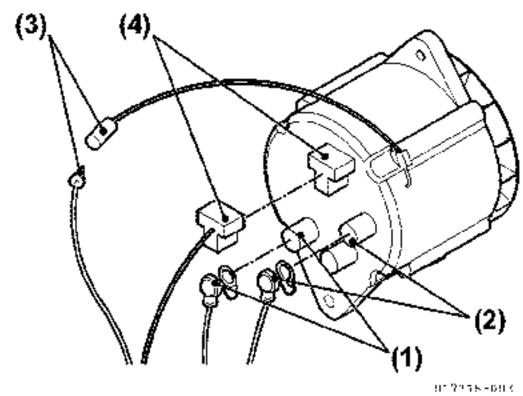

Figure 11-8

1 – E Terminal
2 – Battery Terminal
3 – Connector for Speed Sensor (if used)
4 – Connector for Charge Lamp

5. Disconnect wire connection for speed pulse **(Figure 11-8, (3))**.
6. Disconnect T-connection for charge lamp **(Figure 11-8, (4))**.

7. Remove two bolts **(Figure 11-9, (1))** and remove the alternator from engine.

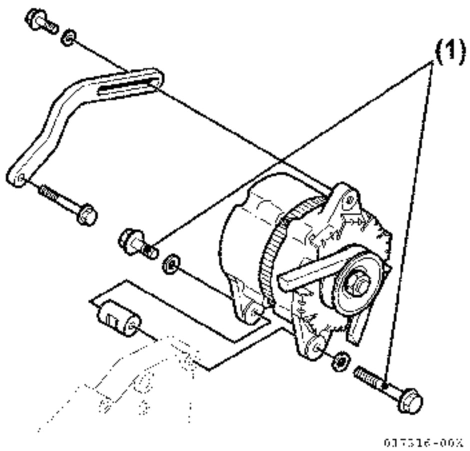

Figure 11-9

8. Install the alternator and tighten mounting bolts to 22.5 to 28.5 N·m (16.5 to 21.0 lb-ft).
9. Connect cables to alternator. Tighten positive (+) cable nut to 3.7 to 5.0 N·m (33 to 44 lb-in.).
10. Install the V-belt. *See Replacing Coolant Pump Belt and Pulley on page 7-18.*
11. Install the V-belt cover.
12. Connect negative (-) battery cable to the battery.

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Section 12

ELECTRICAL

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SAFETY PRECAUTIONS

Before you service the electrical components, review the *Safety Section on page 2-1*.

INTRODUCTION

This section of the *Service Manual* describes the operation of and procedures to replace the components of the electrical system as used on the Yanmar 3JH5E, 4JH5E, 4JH4-TE and 4JH4-HTE marine engines.

COMPONENT LOCATIONS

Sensor and Switch Locations

Note: 3JH5E Engine electrical system shown.

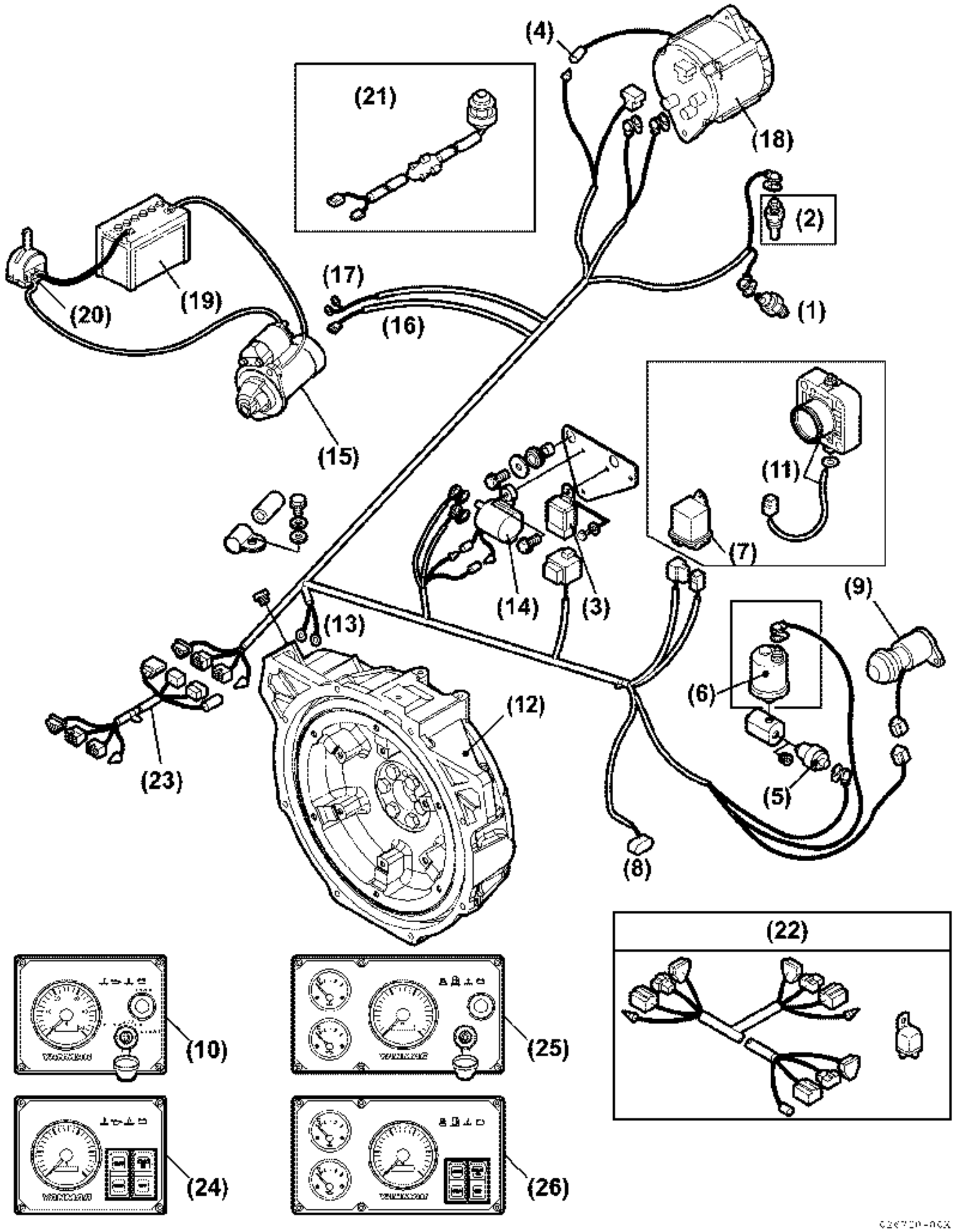

Figure 12-1

1 – Coolant Temperature Switch
2 – Coolant Temperature Sensor (optional)
3 – Magnetic Relay (safety relay)
4 – Speed Sensor (alternator)
5 – Oil Pressure Sensor
6 – Oil Temperature Sensor (optional)
7 – Air Heater
8 – Sail Drive Seal Water Leakage Sensor
9 – Fuel Stop Solenoid
10 – B Type Instrument Panel (optional)
11 – Air Heater Intake Manifold
12 – Flywheel Housing
13 – Ground Bolt
14 – Magnetic Relay
15 – Starting Motor
16 – Starter S Terminal
17 – Starter B Terminal
18 – Alternator
19 – Battery
20 – Battery Switch
21 – Neutral Safety Switch (fitting to marine gear, optional)
22 – 2-Place Extension (optional)
23 – Extension Wire Harness
24 – B Type (keyless) Instrument Panel (optional)
25 – C Type Instrument Panel (optional)
26 – C Type (Keyless) Instrument Panel (optional)

WIRING DIAGRAM

Allowable length by cross sectional area of battery cable	
Section of cable mm^2 ($in.^2$)	**Allowable length L = 1 + 2 + 3 m (ft)**
15 (0.023)	< 0.86 (0.26)
20 (0.031)	< 1.3 (0.40)
30 (0.046)	< 2.3 (0.70)
40 (0.062)	< 2.8 (0.85)
50 (0.077)	< 3.5 (1.07)
60 (0.093)	< 4.1 (1.25)

3JH5E / 4JH5E - C-Type Instrument Panel (Optional)

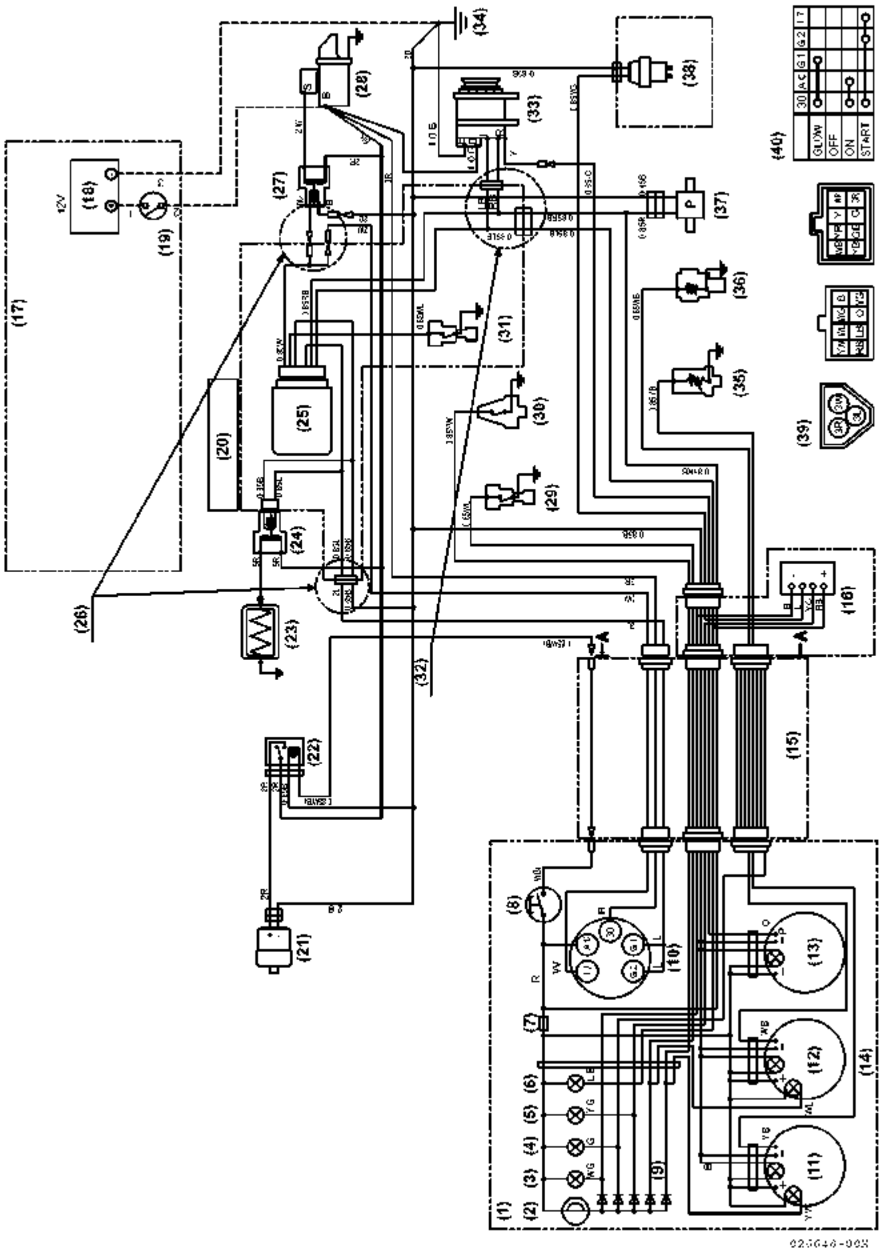

Figure 12-2

3JH5E / 4JH5E - C-Type Instrument Panel (Optional)

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Alarm Lamps
2 – Buzzer
3 – Seawater
4 – Fuel Filter
5 – Sail Drive Seal
6 – Battery Low Charge Alarm
7 – Fuse (3A)
8 – Stop Switch
9 – Diodes
10 – Key Switch
11 – Oil Pressure Meter / Alarm
12 – Water Temperature Meter / Alarm
13 – Tachometer / Hourmeter
14 – Instrument Panel (main station) (option)
15 – Wire Harness
16 – Water in Sail Drive Seal Sensor Amplifier (Sail Drive only)
17 – Procured by Customer
18 – Battery
19 – Battery Switch
20 – (option) Controller (heater) Assembly
21 – Engine Stop Solenoid
22 – Stop Relay
23 – Air Heater
24 – Heater Relay
25 – Heater Controller
26 – Remove the Connector of Engine Harness from Starter Relay and Heater Relay. Reconnect with the Connector of Heater Harness.
27 – Starter Relay
28 – Starter
29 – Coolant Temperature Switch
30 – Engine Oil Pressure Switch
31 – Coolant Temperature Switch (to controller)
32 – Remove the connector from alternator. Reconnect with the connector of heater harness.
33 – Alternator
34 – Ground Bolt
35 – Oil Pressure Sender
36 – Coolant Temperature Sender
37 – Fuel Feed Pump
38 – Water in Sail Drive Seal Sensor (Sail Drive only)
39 – Details of Coupler (view from A-A)
40 – Key Switch

3JH5E / 4JH5E 12V B- and B x B-Type Instrument Panel (Optional)

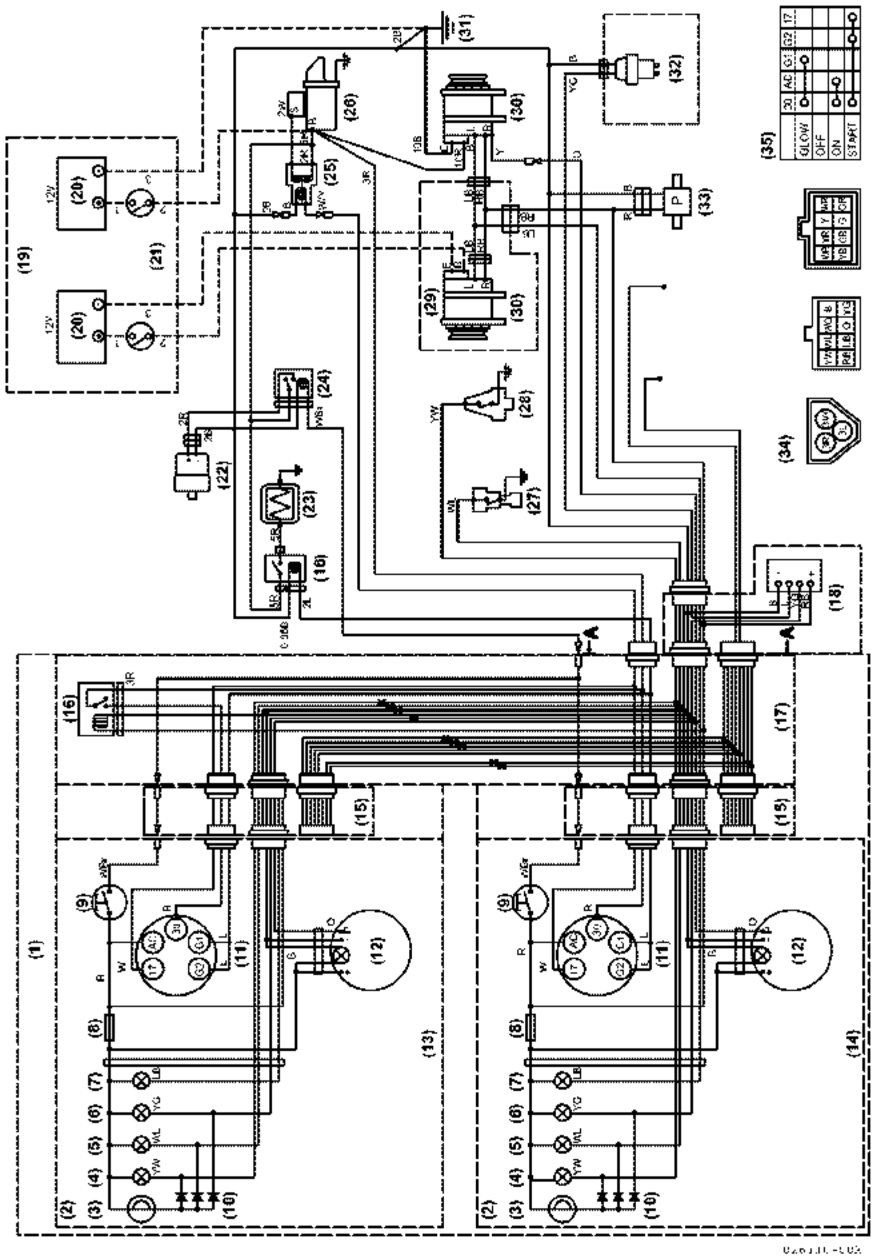

Figure 12-3

3JH5E / 4JH5E 12V B- and B x B-Type Instrument Panel (Optional)

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Alarm Lamps
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Battery Low Charge Alarm
8 – Fuse (3A)
9 – Stop Switch
10 – Diodes
11 – Key Switch
12 – Tachometer / Hourmeter
13 – Instrument Panel (sub station) (option)
14 – Instrument Panel (main station) (option)
15 – Wire Harness
16 – Relay
17 – Wire Harness for Sub Panel
18 – Water in Sail Drive Seal Sensor Amplifier (Sail Drive only)
19 – Procured by Customer
20 – Battery
21 – Battery Switch
22 – Engine Stop Solenoid
23 – Air Heater
24 – Stop Relay
25 – Starter Relay
26 – Starter
27 – Coolant Temperature Switch
28 – Engine Oil Pressure Switch
29 – Option
30 – Alternator
31 – Ground Bolt
32 – Water in Sail Drive Seal Sensor (Sail Drive only)
33 – Fuel Feed Pump
34 – Details of Coupler (view from A-A)
35 – Key Switch

3JH5E / 4JH5E 12V C x B-Type Instrument Panel (Optional)

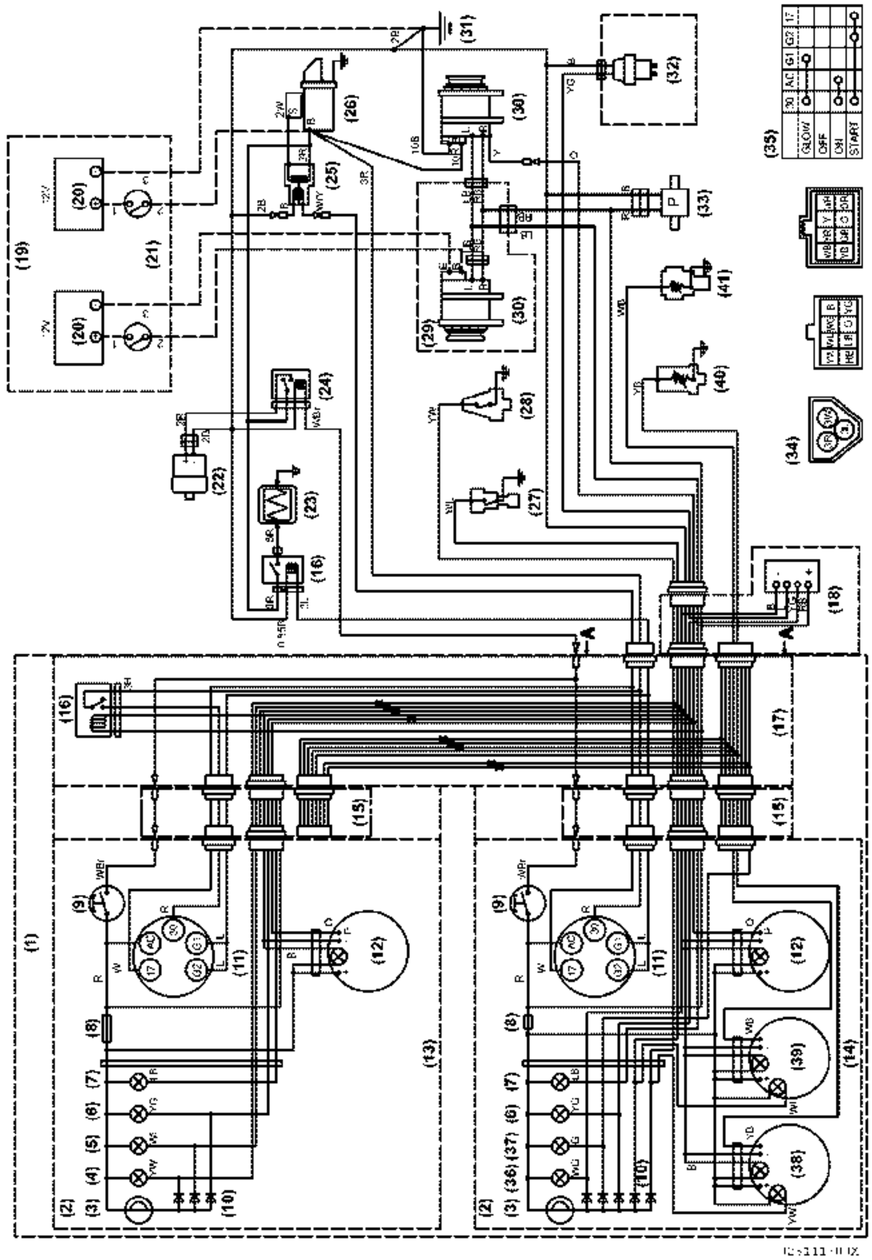

Figure 12-4

3JH5E / 4JH5E with 12V C x B-Type Instrument Panel (Optional)

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse For Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Alarm Lamps
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Battery Low Charge Alarm
8 – Fuse (3A)
9 – Stop Switch
10 – Diodes
11 – Key Switch
12 – Tachometer / Hourmeter
13 – Instrument Panel (sub station) (option)
14 – Instrument Panel (main station) (option)
15 – Wire Harness
16 – Relay
17 – Wire Harness for Sub Panel
18 – Water in Sail Drive Seal Sensor Amplifier (Sail Drive only)
19 – Procured by Customer
20 – Battery
21 – Battery Switch
22 – Engine Stop Solenoid
23 – Air Heater
24 – Stop Relay
25 – Starter Relay
26 – Starter
27 – Coolant Temperature Switch
28 – Engine Oil Pressure Switch
29 – Option
30 – Alternator
31 – Ground Bolt
32 – Water in Sail Drive Seal Sensor (Sail Drive only)
33 – Fuel Feed Pump
34 – Details of Coupler (view from A-A)
35 – Key Switch
36 – Seawater
37 – Fuel Filter
38 – Oil Pressure Meter / Alarm
39 – Water Temperature Meter / Alarm
40 – Oil Pressure Sender
41 – Coolant Temperature Sender

3JH5E / 4JH5E with Keyless B- and B x B-Type Instrument Panel (Optional)

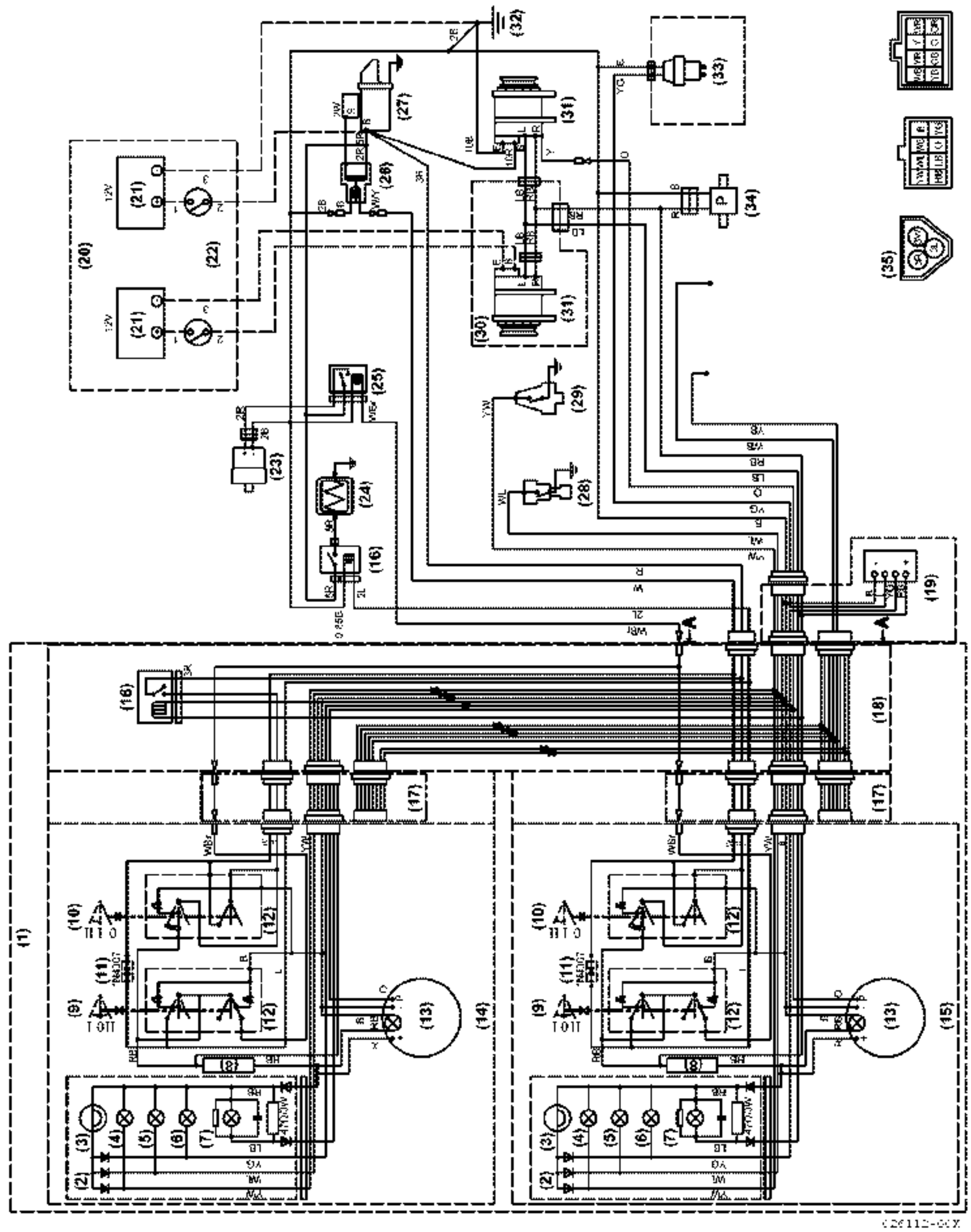

Figure 12-5

3JH5E / 4JH5E with Keyless B- and B x B-Type Instrument Panel (Optional)

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Diodes
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Battery Low Charge Alarm
8 – Fuse (3A)
9 – SWITCH GLOW (I) / OFF (0) / STOP (II)
10 – SWITCH START (II) / ON (I) / OFF (0)
11 – Diodes
12 – Switch
13 – Tachometer / Hourmeter
14 – Instrument Panel (sub station) (option)
15 – Instrument Panel (main station) (option)
16 – Relay
17 – Wire Harness
18 – Wire Harness for Sub Panel
19 – Water in Sail Drive Seal Sensor Amplifier (Sail Drive only)
20 – Procured by Customer
21 – Battery
22 – Battery Switch
23 – Engine Stop Solenoid
24 – Air Heater
25 – Stop Relay
26 – Starter Relay
27 – Starter
28 – Coolant Temperature Switch
29 – Engine Oil Pressure Switch
30 – Option
31 – Alternator
32 – Ground Bolt
33 – Water in Sail Drive Seal Sensor (Sail Drive only)
34 – Fuel Feed Pump
35 – Details of Coupler (view from A-A)

3JH5E / 4JH5E with Keyless C x B-Type Instrument Panel (Optional)

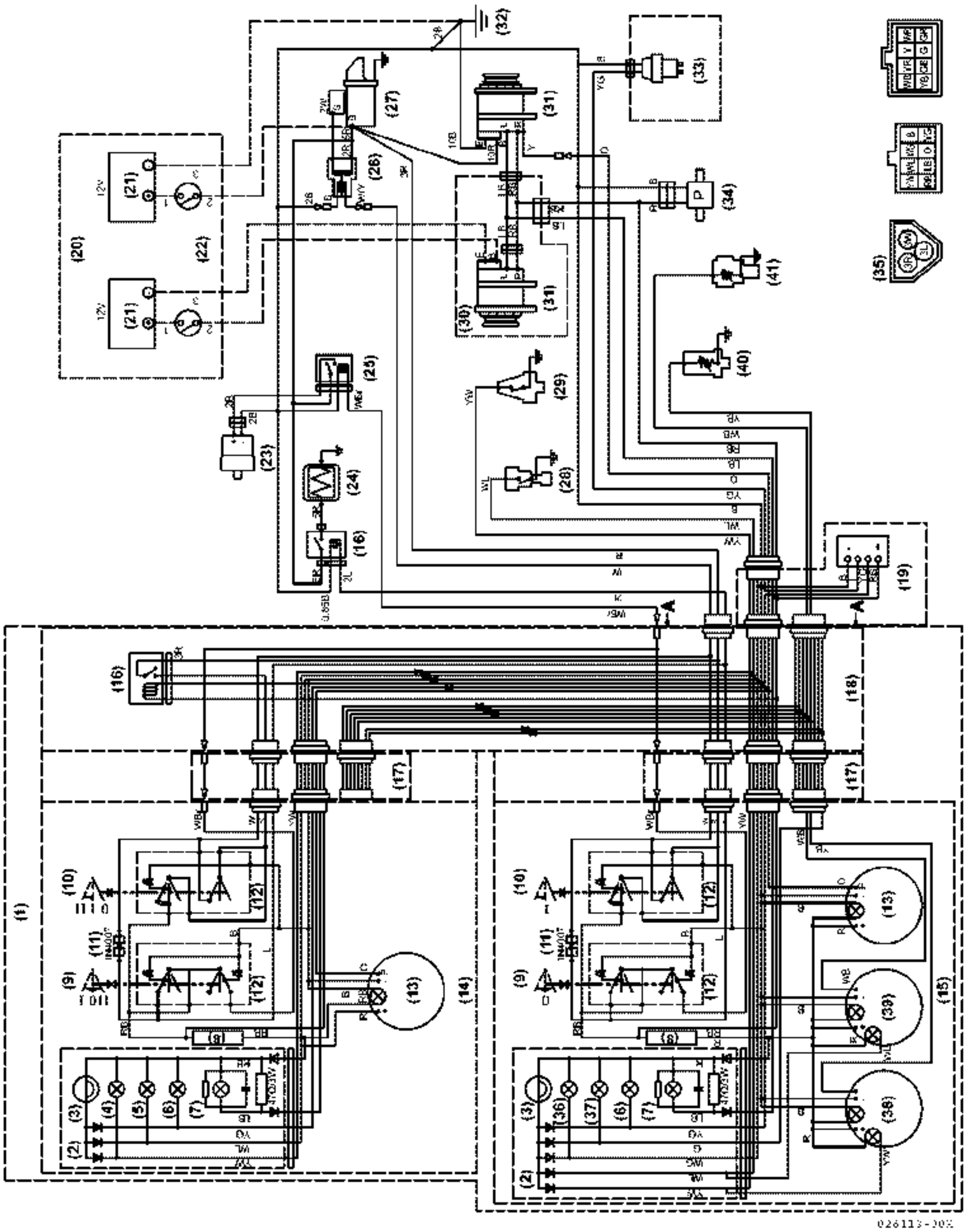

Figure 12-6

3JH5E / 4JH5E with Keyless C x B-Type Instrument Panel (Optional)

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Diodes
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Battery Low Charge Alarm
8 – Fuse (3A)
9 – SWITCH GLOW (I) / OFF (0) / STOP (II)
10 – SWITCH START (II) / ON (I) / OFF (0)
11 – Diodes
12 – Switch
13 – Tachometer / Hourmeter
14 – Instrument Panel (sub station) (option)
15 – Instrument Panel (main station) (option)
16 – Relay
17 – Wire Harness
18 – Wire Harness for Sub Panel
19 – Water in Sail Drive Seal Sensor Amplifier (Sail Drive only)
20 – Procured by Customer
21 – Battery
22 – Battery Switch
23 – Engine Stop Solenoid
24 – Air Heater
25 – Stop Relay
26 – Starter Relay
27 – Starter
28 – Coolant Temperature Switch
29 – Engine Oil Pressure Switch
30 – Option
31 – Alternator
32 – Ground Bolt
33 – Water in Sail Drive Seal Sensor (Sail Drive only)
34 – Fuel Feed Pump
35 – Details of Coupler (view from A-A)
36 – Seawater Flow
37 – Fuel Filter
38 – Oil Pressure Meter / Alarm
39 – Water Temperature Meter / Alarm
40 – Oil Pressure Sender
41 – Coolant Temperature Sender

4JH4-TE / 4JH4-HTE with Panel B x B-Type Instrument Panel

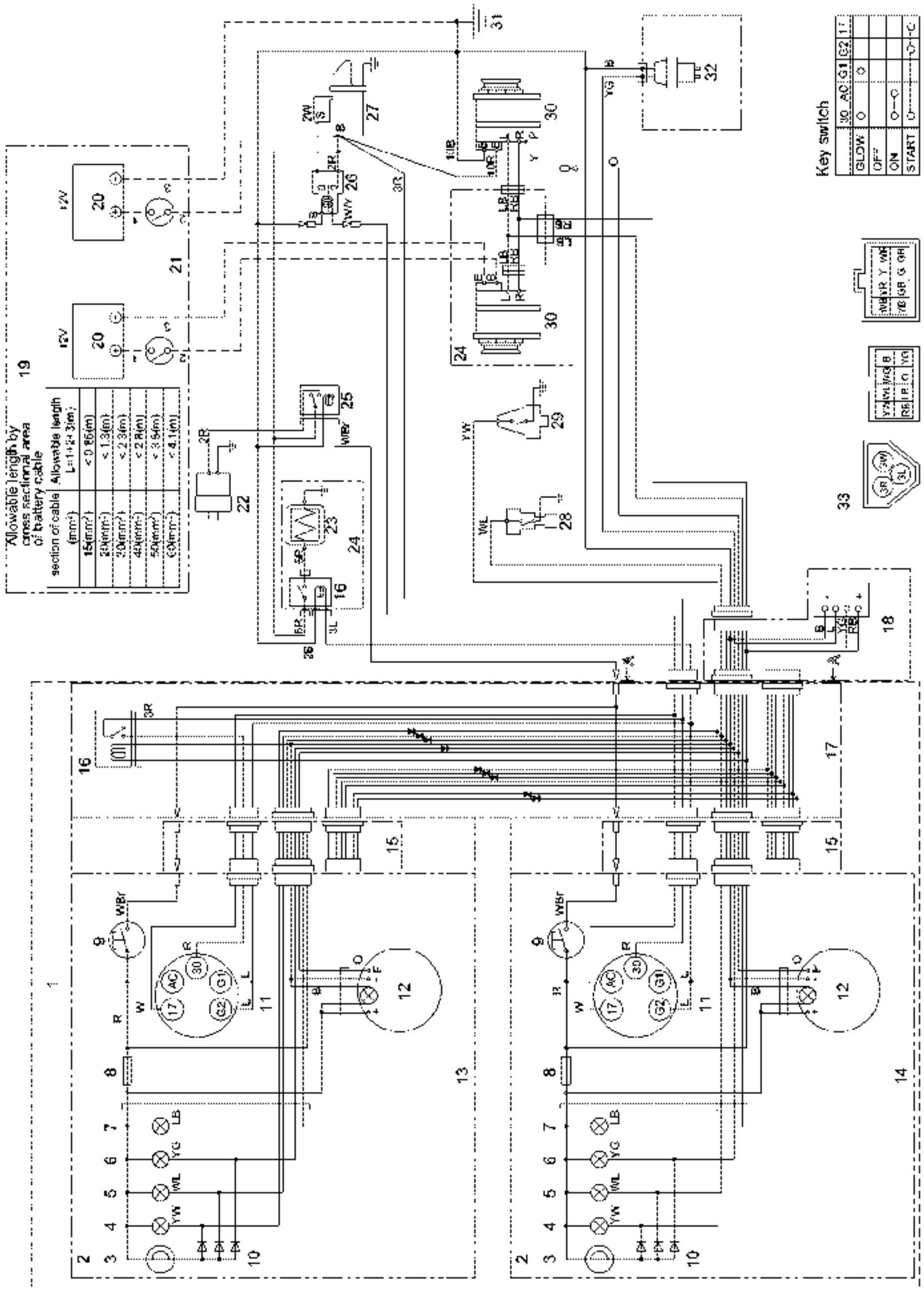

Figure 12-7

4JH4-TE / 4JH4-HTE with Panel B x B-Type Instrument Panel

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (Option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Alarm Lamps
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Charge
8 – Fuse (3A)
9 – Stop Switch
10 – Diodes
11 – Key Switch
12 – Tachometer / Hour Meter
13 – Instrument Panel (sub station) (option)
14 – Instrument Panel (main station) (option)
15 – Wire Harness
16 – Relay
17 – Wire Harness for Sub Panel
18 – Amplifier Only for Sail Drive
19 – Procured by Customer
20 – Battery
21 – Battery Switch
22 – Engine Stop Solenoid with VE Pump
23 – Air Heater
24 – Option
25 – Stop Relay
26 – Starter Relay
27 – Starter
28 – Coolant Temperature Switch
29 – Engine Oil Pressure Switch
30 – Alternator
31 – Ground Bolt
32 – Only for Sail Drive
33 – Details of Coupler (view from A-A)

4JH4-TE / 4JH4-HTE with Panel C x B-Type Instrument Panel

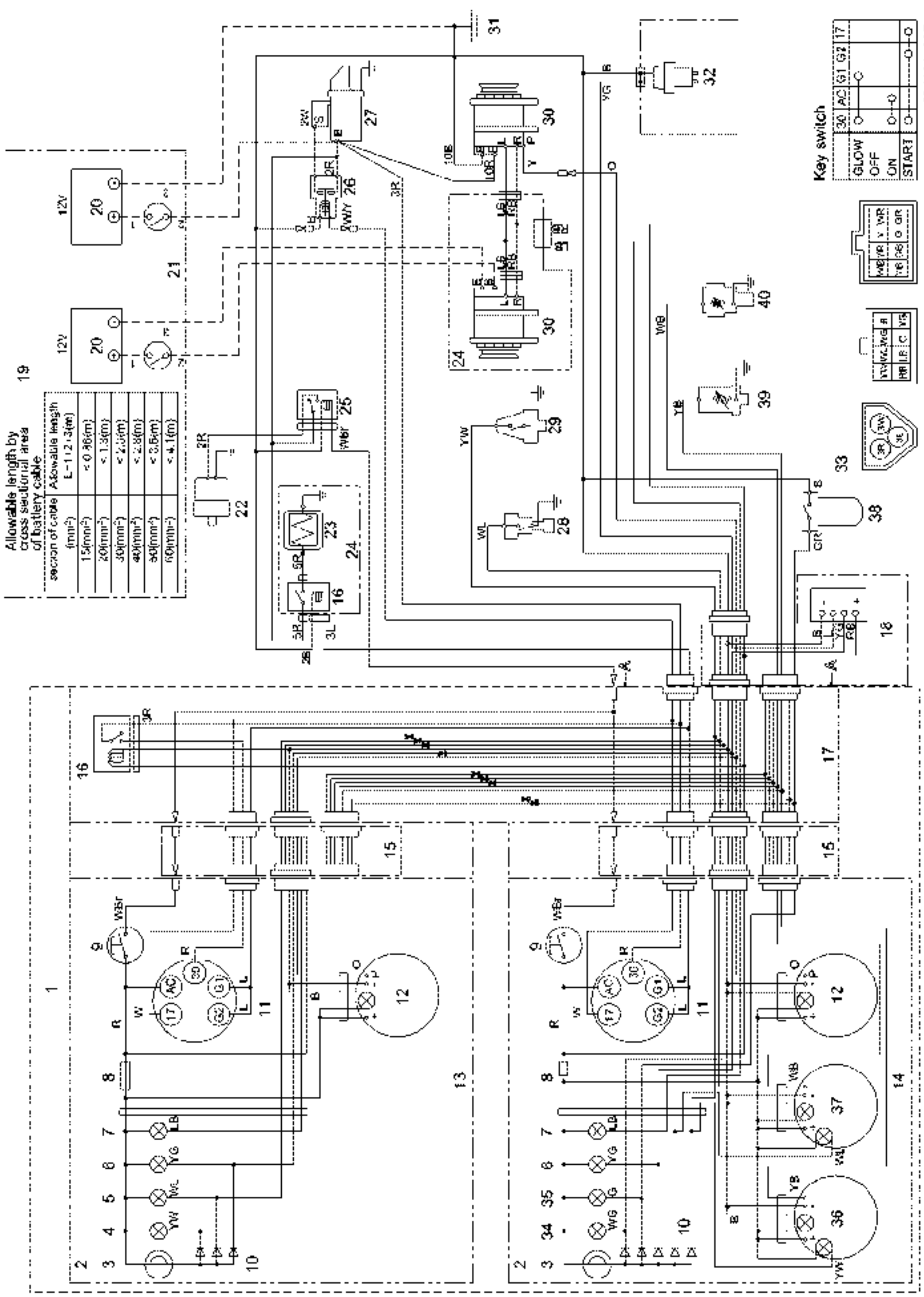

Figure 12-8

4JH4-TE / 4JH4-HTE with Panel C x B-Type Instrument Panel

Color Coding		Engine Harness
R	Red	+
B	Black	-
W	White	Ignition
L	Blue	Air Heater / Glow (Option)
RB	Red / Black	Alternator Exciter
LB	Blue / Black	Alternator Charge Alarm
YW	Yellow / White	Engine Oil Pressure Alarm
YB	Yellow / Black	Engine Oil Pressure
YG	Yellow / Green	Sail Drive Seal
WL	White / Blue	Water Temperature Alarm
WB	White / Black	Water Temperature
WG	White / Green	Seawater Flow Alarm
GR	Green / Red	Fuel Filter Alarm
O	Orange	Pulse for Tachometer
WBr	White / Brown	Electric Stop

1 – Option
2 – Alarm Lamps
3 – Buzzer
4 – Oil Pressure
5 – Coolant Temperature
6 – Sail Drive Seal
7 – Charge
8 – Fuse (3A)
9 – Stop Switch
10 – Diodes
11 – Key Switch
12 – Tachometer / Hour Meter
13 – Instrument Panel (sub station) (option)
14 – Instrument Panel (main station) (option)
15 – Wire Harness
16 – Relay
17 – Wire Harness for Sub Panel
18 – Amplifier Only for Sail Drive
19 – Procured by Customer
20 – Battery
21 – Battery Switch
22 – Engine Stop Solenoid with VE Pump
23 – Air Heater
24 – Option
25 – Stop Relay
26 – Starter Relay
27 – Starter
28 – Coolant Temperature Switch
29 – Engine Oil Pressure Switch
30 – Alternator
31 – Ground Bolt
32 – Only for Sail Drive
33 – Details of Coupler (view from A-A)
34 – Seawater Alarm
35 – Fuel Filter
36 – Oil Pressure Meter / Alarm
37 – Water Temperature Meter / Alarm
38 – Fuel Filter Switch
39 – Oil Pressure Sender
40 – Coolant Temperature Sender

INSTRUMENT PANEL

B-Type Instrument Panel (Selectable Optional)

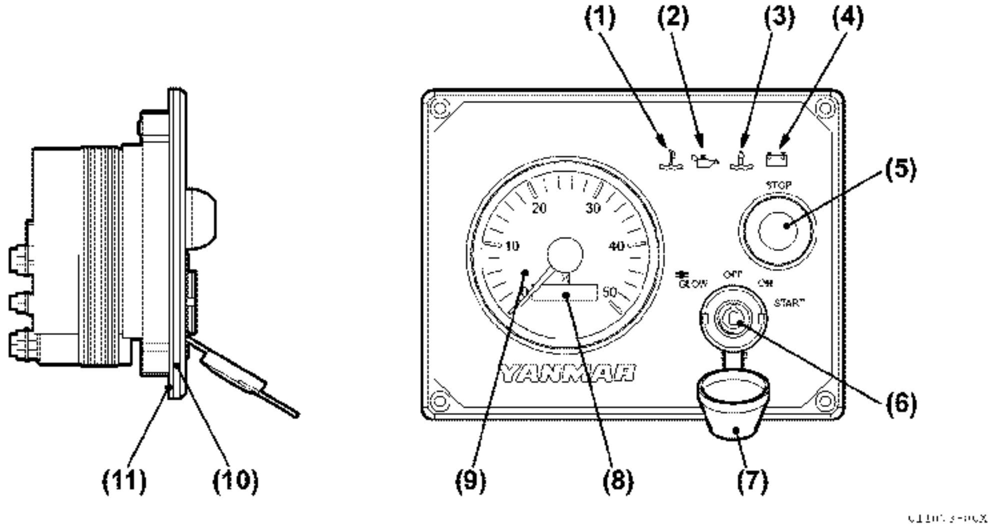

Figure 12-9

1 – Coolant High Temperature Alarm
2 – Lubricating Oil Low Pressure Alarm
3 – Water in Sail Drive Seal Alarm
4 – Battery Low Charge Alarm
5 – Stop Button Switch
6 – Key Switch
7 – Moisture Cap for Key Switch
8 – Hour Meter
9 – Tachometer
10 – Panel with Cover Foil
11 – Rubber Seal, B Panel

B-Type (Keyless) Instrument Panel (Selectable Optional)

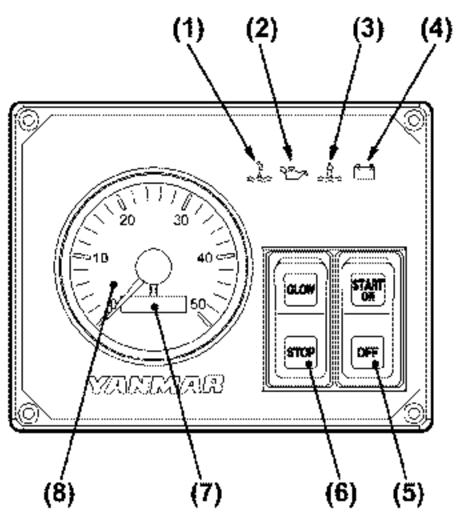

Figure 12-10

1 – Coolant High Temperature Indicator
2 – Engine Oil Low Pressure Indicator
3 – Water in Sail Drive Seal Indicator
4 – Battery Low Charge Indicator
5 – ON / OFF / START Switch
6 – GLOW / STOP Switch
7 – Hourmeter
8 – Tachometer

C-Type Instrument Panel (Selectable Optional)

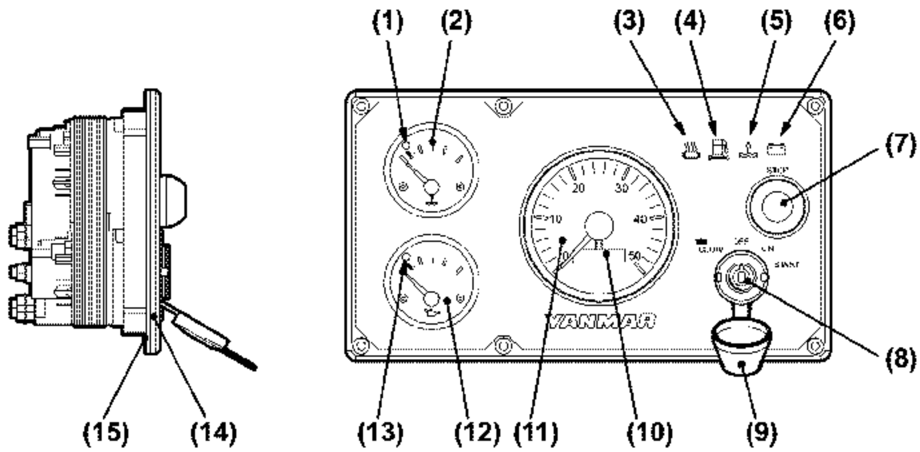

Figure 12-11

1 – Coolant High Temperature Alarm
2 – Coolant Temperature Meter
3 – Not Used on This Engine
4 – Water in Fuel Filter Alarm
5 – Water in Sail Drive Seal Alarm
6 – Battery Low Charge Alarm
7 – Stop Button Switch
8 – Key Switch
9 – Moisture Cap for Key Switch
10 – Hour Meter
11 – Tachometer
12 – Lubricating Oil Pressure Meter
13 – Lubricating Oil Low Pressure Alarm
14 – Panel With Cover Foil
15 – Rubber Seal, C Panel

C-Type (Keyless) Instrument Panel (Selectable Optional)

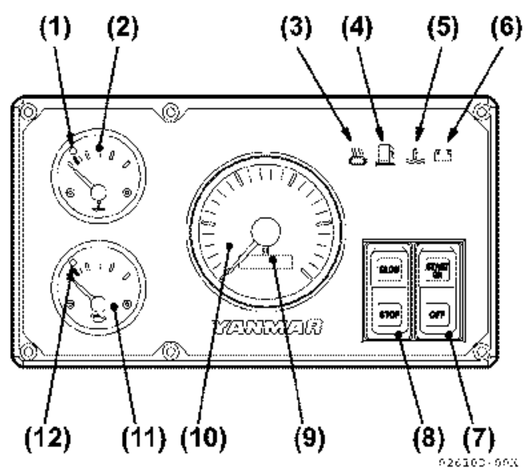

Figure 12-12

1 – Coolant High Temperature Indicator
2 – Coolant Temperature Gauge
3 – Not Used on This Engine
4 – Water in Fuel Filter Indicator
5 – Water in Sail Drive Charge Indicator
6 – Battery Low Charge Indicator
7 – ON / OFF / START Switch
8 – GLOW / STOP Switch
9 – Hourmeter
10 – Tachometer
11 – Engine Oil Pressure Gauge
12 – Engine Oil Low Pressure Indicator

FUNCTION DESCRIPTION - WARNING DEVICES

Oil Pressure Alarm

Oil Pressure Alarm Circuit

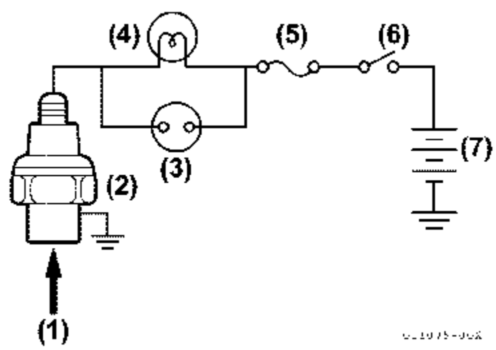

Figure 12-13

1 – Oil Pressure
2 – Oil Pressure Switch
3 – Alarm Buzzer
4 – Pilot Lamp
5 – Fuse
6 – Main Switch
7 – Battery

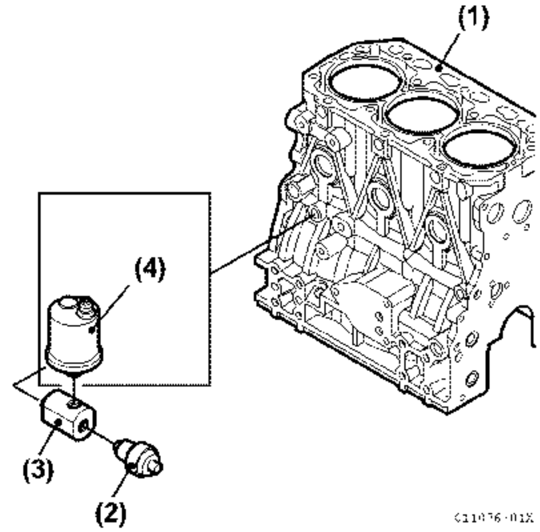

Figure 12-14

1 – Cylinder Block
2 – Oil Pressure Switch
3 – Damper
4 – Oil Pressure Sender (optional)

Oil Pressure Switch Structure

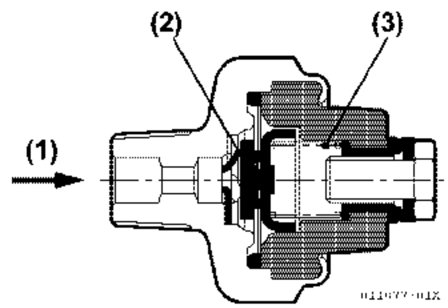

Figure 12-15

1 – Oil Pressure
2 – Contacts
3 – Spring

If the lubricating oil pressure is below 0.04 to 0.05 MPa (0.4 to 0.6 kgf/cm^2, 5.7 to 8.5 lb/in.^{2} (5.7 to 8.5 psi), with the main switch in the ON position, the contacts of the oil pressure switch are closed by a spring and the lamp is illuminated through the lamp / oil pressure switch / ground circuit system. If the oil pressure is normal, the switch contacts are opened by the lubricating oil pressure and the lamp remains off.

Inspection

Problem	Inspection Item	Inspection Method	Corrective Action
Lamp not illuminated when main switch set to ON.	Oil pressure lamp blown out.	1) Visual inspection. 2) Lamp not illuminated even when main switch set to ON position and terminals of oil pressure switch grounded.	Replace lamp.
	Operation of oil pressure switch.	Lamp illuminated when checked as described in 2) above.	Replace oil pressure switch.
Lamp not extinguished while engine running.	Oil level low.	Stop engine and check oil level with dipstick.	Add oil.
	Oil pressure low.	Measure oil pressure.	Repair bearing wear and adjust regulator valve.
	Oil pressure faulty.	Switch faulty if abnormal at 1) and 2) above.	Replace oil pressure switch.
	Wiring between lamp and oil pressure switch faulty.	Cut the wiring between the lamp and switch and wire with separate wire.	Repair wiring harness.

Sending Unit for Lubricating Oil Pressure Gauge

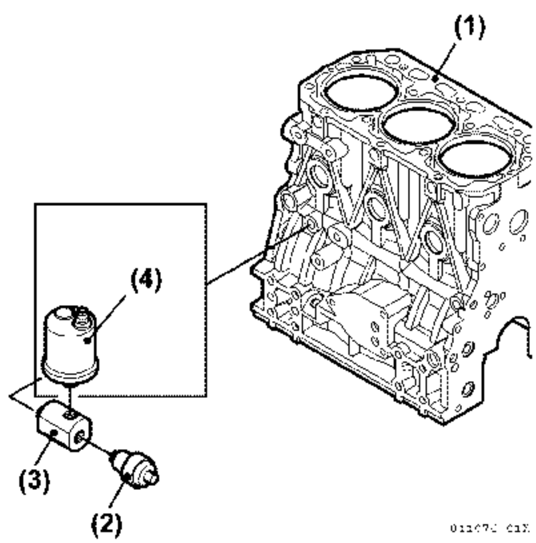

Figure 12-16

1 – Cylinder Block
2 – Oil Pressure Switch
3 – Damper
4 – Oil Pressure Sender (optional)

The sending unit for the lubricating oil pressure gauge has a mounting seat for mounting on the lubricating oil filter bracket. Oil pressure is measured when the oil enters into the main galley after being fed from the lubricating oil cooler and passing through the oil pressure control valve. Always install a damper when installing the oil pressure sender unit.

Lubricating Oil Pressure Sender Unit

Part Code No.	119773-91650
Type	Resistance switch
Rated Voltage	DC 12V
Maximum Operating Pressure	0.98 MPa (10 kgf/cm^2 [142 psi])

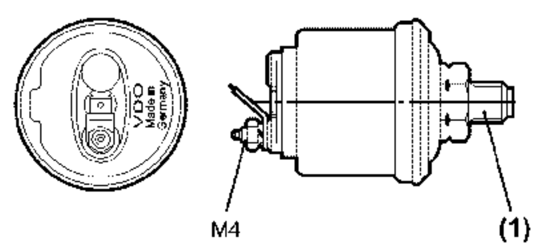

Figure 12-17

1 – ISO R1/8 Taper

Coolant Temperature Alarm

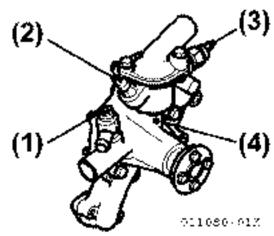

Figure 12-18

1 – Inlet for Water Heater
2 – Water Temperature Heater
3 – Water Temperature Switch
4 – Freshwater Pump

Water Temperature Alarm Circuit

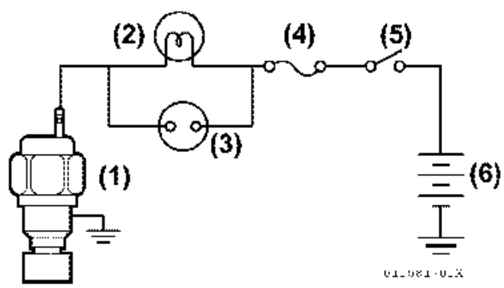

Figure 12-19

1 – Water Temperature Unit
2 – Pilot Lamp
3 – Alarm Buzzer
4 – Fuse
5 – Main Switch
6 – Battery

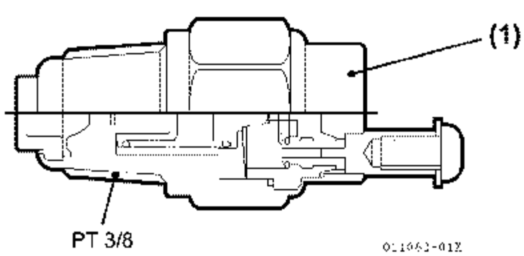

Figure 12-20

1 – Green Colored

A water temperature lamp and water temperature gauge, backed up by an alarm in the instrument panel, are used to monitor the temperature of the engine coolant. A high thermal expansion material is set on the end of the water temperature unit. When the coolant temperature reaches a specified high temperature, the contacts are closed, and an alarm lamp and buzzer are activated at the instrument panel.

Operating Temperature	ON	97-103°C (207-217°F)
Electric Capacity		DC 12V, 1A
Response Time		within 60 sec.
Indication Color		Black
Tightening Torque		23.5-31.4 N·m (2.40-3.20 kgf-m [17.3-23.2 lb-ft])

Sending Unit for the Coolant Temperature Gauge

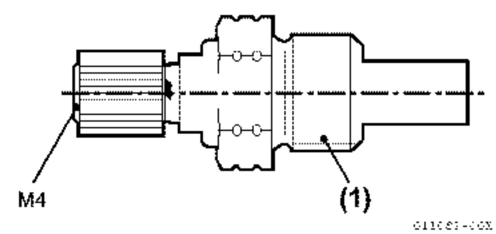

Figure 12-21

1 – ISO R3/8 Taper

The water temperature sending unit has a mounting seat for mounting on the freshwater pump unit. Water temperature is measured when the coolant flows into the thermostat housing after leaving the cylinder head.

Part Code No.	119773-91700
Type	Thermistor switch
Rated Voltage	12V

Air Heater (Standard)

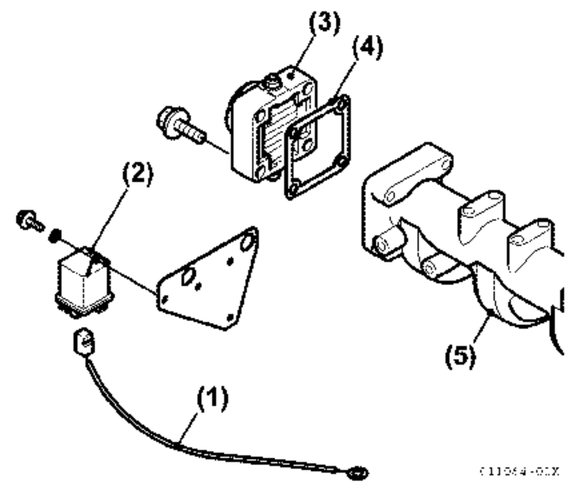

Figure 12-22

1 – **Wire Harness**
2 – **Relay**
3 – **Air Heater**
4 – **Gasket**
5 – **Intake Manifold**

3JH5E and 4JH5E

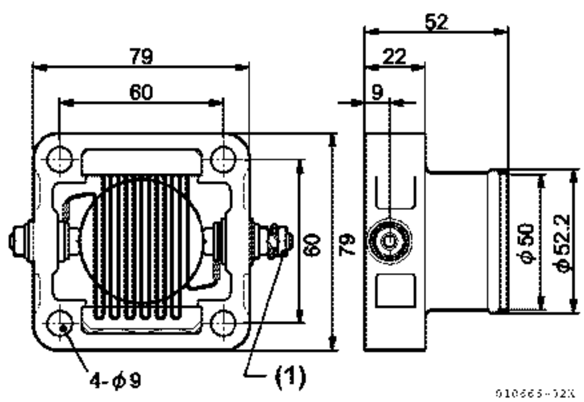

Figure 12-23

1 – **2-M6 x 1 Terminal**

4JH4-TE and 4JH4-HTE

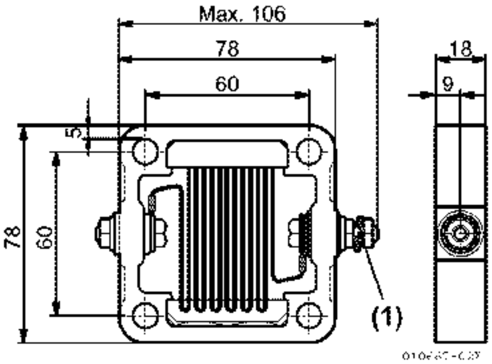

Figure 12-24

1 – **2-M6 x 1 Terminal**

An air heater is installed for warming intake air when starting in a cold weather. The air heater is mounted to the intake manifold. The device is operated by the glow switch on the instrument panel.

	3JH5E / 4JH5E	4JH4-TE / 4JH4-HTE
Part No.	129120-77502	129100-77501
Rated Output	390W (1332 BTU/hour)	
Rated Current	35.5A	
Rated Voltage	DC11V	

Electric Engine Stop Solenoid

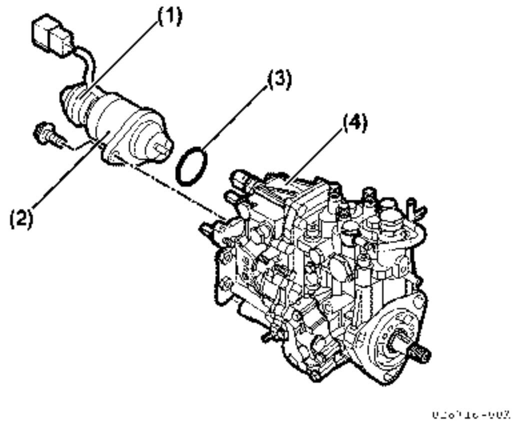

Figure 12-25

1 – Emergency Stop Button
2 – Stop Solenoid
3 – O-Ring
4 – Governor

The electric engine stop device is fitted to the governor. The device is operated by the stop switch on the instrument panel.

Electric Emergency Stop (for 3JH5E and 4JH5E)

The emergency stop button is integrated with the solenoid. When the stop button is pushed, the engine will shut down.

Section 13

TROUBLESHOOTING

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SAFETY PRECAUTIONS

Before you troubleshoot, review the *Safety Section on page 2-1.*

INTRODUCTION

This section of the *Service Manual* contains information and troubleshooting charts to accurately assess engine, starter or alternator problems.

TROUBLESHOOTING CHART

Starting Trouble

Problem / Symptom	Cause	Action	Reference
Engine Will Not Crank	Discharged battery	Charge / replace battery	See OEM information
	Blown fuse	Replace fuse	*See Wiring Diagram on page 12-5.*
	Defective starter motor	Replace starter motor	*See Starter Motor Service on page 10-6.*
	Loose wiring connections	Tighten connections	*See Wiring Diagram on page 12-5.*
	Faulty connection in starting switch	Repair using sandpaper or replace	*See Instrument Panel on page 12-20.*
	Rough cap movement	Repair using sandpaper and then grease	*See Starter Motor Service on page 10-6.*
	Edges of gear teeth misshapen	Adjust	*See Starter Motor Service on page 10-6.*
	Piston ring sticks	Disassemble and repair or replace	*See Tests and Adjustments on page 5-22.*
Engine Cranks but Will Not Start	No fuel to engine	Check fuel level in tank	See OEM information.
		Ensure all valves are on	See OEM information.
		Check fuel supply pump	*See Fuel Injectors on page 6-52.*
	No fuel to cylinders	Clean or replace clogged pre-filter (if equipped)	*See Fuel Line Replacement Filter on page 6-48.*
		Clean or replace fuel filter / water separator	*See Replacing the Fuel / Water Separator on page 6-49.*
		Replace clogged fine filter	*See Fuel Line Replacement Filter on page 6-48.*
		Bleed fuel system	*See Bleeding the Fuel System on page 6-51.*
		Check fuel injection pump and replace if necessary	*See Fuel Injectors on page 6-52.*
		Check fuel injection nozzle and replace if necessary	*See Fuel Injectors on page 6-52.*
		Check fuel injection pipes and replace if necessary	*See Fuel System Components on page 6-23.*
	Water in fuel tank	Drain water from fuel tank	See OEM information.
	Leakage pressurized air	Check cylinder gasket and bolt or suction / exhaust valves and piston ring. Replace if necessary	*See Test Compression on page 5-22.*
	Governor handle is in STOP position	Move governor handle to acceleration position	*See Governor on page 6-39.*
	Low ambient temperature	Install optional glow plug control	NA
		Install block heater	NA
	Oil viscosity too high	Replace with correct viscosity oil for operating conditions	*See Engine Oil Specifications on page 3-65.*

Exhaust Color

Problem / Symptom	Cause	Action	Reference
White Smoke	Cold engine	Allow engine to warm to operating temperature	NA
		Defective thermostat, replace	*See Removing and Installing Thermostat on page 7-16.*
	Incorrect fuel	Replace fuel with correct type	*See Diesel Fuel Specifications on page 3-62.*
	Incorrect fuel injection nozzle	Test / replace fuel injection nozzle	*See Fuel Injectors on page 6-52.*
	Injection timing is incorrect	Adjust	*See Adjusting Fuel Injection Timing on page 6-18.*
White Smoke with Water Vapor	Leaking cylinder head gasket	Repair	*See Test Compression on page 5-22.*
	Leaking charge intercooler	Repair as necessary	*See Disassembly on page 5-22.*
	Cracked cylinder head		
	Cracked cylinder		
Blue Smoke	Worn piston rings / cylinders	Repair as necessary	*See Disassembly on page 5-22.*
	Oil leak in turbocharger (oil present in intake manifold)		
Black Smoke Under Load	Clogged air filter	Clean / replace air filter	*See Cleaning the Air Cleaner on page 9-6.*
	Incorrect valve timing	Check / correct camshaft installation	*See Valve Clearance Adjustment on page 5-52.*
	Low injection pressure	Adjust fuel injection nozzle	*See Fuel Injectors on page 6-52.*
	Defective (leaking) fuel injection nozzle	Test / replace fuel injection nozzle	*See Fuel Injectors on page 6-52.*
	Low charge air pressure	Clean or replace	*See Turbocharger Service on page 9-6.*
		Damaged turbocharger. Repair or replace	*See Turbocharger Service on page 9-6.*
	Excessive exhaust backpressure	Correct as necessary	NA
	Excessive intake suction loss	Correct as necessary	NA
	Overloading	Reduce load	NA

Vibration - Drive Disengaged

Problem / Symptom	Cause	Action	Reference
Rough at All Engine Speeds	Air in fuel system	Bleed fuel system	*See Bleeding the Fuel System on page 6-51.*
	Faulty fuel injector	Replace as necessary	*See Fuel Injectors on page 6-52.*
	Leaking cylinder head gasket	Replace	*See Test Compression on page 5-22.*
	Damaged intake or exhaust valves	Repair / replace as necessary	*See Test Compression on page 5-22.*
	Damaged turbocharger	Replace	*See Turbocharger Service on page 9-6.*
	Incorrect injection pressure	Check / replace fuel injection nozzle	*See Fuel Injectors on page 6-52.*
		Check / replace fuel injection pump	*See Fuel Injectors on page 6-52.*
Vibration Increases with Engine Speed (Sail Drive Models)	Worn or damaged spline shaft	Replace as necessary	*See Assembly on page 5-72.*
Vibration Increases with Engine Speed	Loose parts	Tighten loose parts	NA

Vibration - Drive Engaged

Problem / Symptom	Cause	Action	Reference
Rough at All Speeds	Engine and propeller shaft misaligned	Check and adjust	*See Principal Engine Specifications on page 3-67.*
	Damaged bearing	Replace	*See Main Bearing on page 5-65.*
	Excessive backlash of gear	Repair / replace	*See Gear Inspection on page 5-69.*
	Leaking cylinder head gasket	Replace	*See Test Compression on page 5-22.*
	Bent propeller shaft	Replace as necessary	*See Main Bearing on page 5-65.*
Rough at Higher Speeds	Bent propeller	Replace as necessary	See OEM information.
	Slipping clutch / clutch dog	Repair as necessary	*See Damper Disk and Cooling Fan on page 5-71.*
	Incorrect injection pressure	Check / replace fuel injection nozzle	*See Servicing the Fuel System on page 6-12.*
		Check / replace fuel injection pump	*See Servicing the Fuel System on page 6-12.*

Engine Knocks

Problem / Symptom	Cause	Action	Reference
Excess Fuel Injected	Defective fuel injection nozzle	Check / replace fuel injection nozzle	*See Servicing the Fuel System on page 6-12.*
	High fuel injection pressure	Check / replace fuel injection pump	*See Servicing the Fuel System on page 6-12.*
Noise Changes with Engine Load	Incorrect or poor quality fuel	Drain and refill tank	*See Servicing the Fuel System on page 6-12.*
	Worn crankshaft / bearings	Repair / replace as necessary	*See Main Bearing on page 5-65.*
	Broken piston / rings	Repair / replace as necessary	*See Tests and Adjustments on page 5-22.*

Low Power Output

Problem / Symptom	Cause	Action	Reference
Miscellaneous	Clogged intake air filter	Clean / replace	*See Cleaning the Air Cleaner on page 9-6.*
	Leaking cylinder head gasket	Replace	*See Tests and Adjustments on page 5-22.*
	Damaged turbocharger	Replace	*See Turbocharger Service on page 9-6.*
	Seizure of moving parts	Disassemble, check and repair	*See Turbocharger Service on page 9-6.*
	Incorrect propeller	Replace	See OEM information.
	Excessive exhaust backpressure	Remove obstruction	NA
Fuel	Plugged fuel filter(s)	Clean / replace as necessary	*See Installing Fuel Injection Lines on page 6-15.*
	Faulty fuel feed pump	Replace	*See Replacing the Fuel Feed Pump on page 6-15.*
	Incorrect fuel quality	Replace with correct fuel	*See Diesel Fuel Specifications on page 3-62.*
Low Fuel Injection Pressure	Defective fuel injection nozzle	Check / replace	*See Fuel Injectors on page 6-52.*
	Worn fuel injection pump	Check / replace	*See Fuel Injectors on page 6-52.*
	Injection timing is incorrect	Adjust	*See Adjusting Fuel Injection Timing on page 6-18.*
Coolant	Insufficient coolant	Check / replace coolant pump	*See Engine Coolant on page 3-66.*
Lubricating Oil Supply	Insufficient lubricating oil supply	Check / replace lubricating oil pump or lubricating oil level	*See Engine Oil Specifications on page 3-65.*
Governor	Damaged bearing	Replace	*See Main Bearing on page 5-65.*
	Governor link length incorrect	Repair	See OEM information.

Problem / Symptom	Cause	Action	Reference
Low rpm at Wide Open Throttle	Propeller pitch too great	Replace	See OEM information.
	Engine overheated	Reduce load / repair cooling system	*See Tests and Adjustments on page 7-6.*
	Damaged turbocharger	Replace	*See Turbocharger Service on page 9-6.*

Engine Overheat

Problem / Symptom	Cause	Action	Reference
Instrument Shows High Temperature	Clogged seawater inlet	Clean	NA
	Low coolant level	Fill with coolant / inspect for leak	*See Engine Coolant on page 3-66.*
	Clogged seawater filter (if equipped)	Clean	NA
	Clogged heat exchanger	Clean	*See Removing and Installing Heat Exchanger on page 7-12.*
	Seawater pump worn or damaged	Repair / replace as necessary	*See Seawater Pump on page 7-17.*
	Defective sensor / instrument	Repair as necessary	*See Sensor and Switch Locations on page 12-4.*
	Defective thermostat	Replace	*See Testing Thermostat on page 7-7.*
	Damaged closed coolant pump	Replace	*See Removing and Installing Coolant Pump on page 7-15.*
	Combustion gas leakage (causes loss of coolant)	Repair as necessary	*See Test Compression on page 5-22.*
	Coolant water pump belt slips or pump pulley loose on pump shaft	Repair as necessary	*See Replacing Coolant Pump Belt and Pulley on page 7-18.*
	Faulty lubricating oil pump	Check and repair / replace	*See Engine Oil Pump on page 8-10.*
	Overloading	Reduce load	NA

Engine Runs Cold

Problem / Symptom	Cause	Action	Reference
Instrument Shows Low Temperature	Defective sensor / instrument	Repair / replace as necessary	*See Sensor and Switch Locations on page 12-4.*
	Defective thermostat	Replace	*See Testing Thermostat on page 7-7.*

Coolant Loss

Problem / Symptom	Cause	Action	Reference
Repeated Low Coolant Level	Defective cylinder head gasket (external leakage)	Replace	*See Test Compression on page 5-22.*
	External leakage at connection	Repair as necessary	*See Pressure Testing Cooling System and Filler Cap on page 7-6.*
Coolant Forced Out of Coolant Recovery Tank	Turbocharger pressure enters cooling system via leaking charge intercooler	Repair / replace as necessary	*See Coolant Recovery Tank on page 7-20.*
White Smoke when Engine is Hot	Crack in cylinder head	Repair / replace as necessary	*See Test Compression on page 5-22.*
	Leaking cylinder head gasket	Replace	*See Test Compression on page 5-22.*

Lubricating Oil Pressure Low

Problem / Symptom	Cause	Action	Reference
Insufficient Lubricating Oil Supply	Clogged lubricating oil filter	Clean or replace filter element	*See Changing Engine Oil, Replacing Engine Oil Filter Element and Cleaning Engine Oil Cooler on page 8-8.*
	Damaged lubricating oil pump	Repair / replace as necessary	*See Engine Oil Pump on page 8-10.*
	Loose pressure adjustment valve	Tighten adjustment valve	*See Engine Oil Pump on page 8-10.*
	Oil leakage from pump safety valve	Tighten safety valve	*See Engine Oil Pump on page 8-10.*
	Inadequate viscosity of lubricating oil	Change lubricating oil	*See Engine Oil Specifications on page 3-65.*
	Insufficient amount of lubricating oil	Add lubricating oil	*See Engine Oil Specifications on page 3-65.*
Instrument Faulty	Faulty pressure gauge	Replace	*See Checking Engine Oil Pressure on page 8-6.*
	Faulty pressure sensor or connector	Check / replace	*See Checking Engine Oil Pressure on page 8-6.*

Panel Display

Problem / Symptom	Cause	Action	References
No Display	Harness connector loose	Repair as necessary	*See Sensor and Switch Locations on page 12-4.*
	Defective fuse	Replace	*See Wiring Diagram on page 12-5.*

MEASURING COMPRESSION PRESSURE

Compression pressure drop is one of the major causes of increasing blow-by gas (lubricating oil contamination or increased lubricating oil consumption) or starting failure. The compression pressure is affected by the following factors:

- Degree of clearance between piston and cylinder
- Degree of clearance at intake / exhaust valve seat
- Gas leak from nozzle gasket or cylinder head gasket

The pressure drops because of increased parts wear and reduced durability resulting from long engine use.

A pressure drop may also be caused by a scratched cylinder or piston. The cylinder and piston may have been damaged because an air cleaner element is dirty or a piston ring is worn or broken.

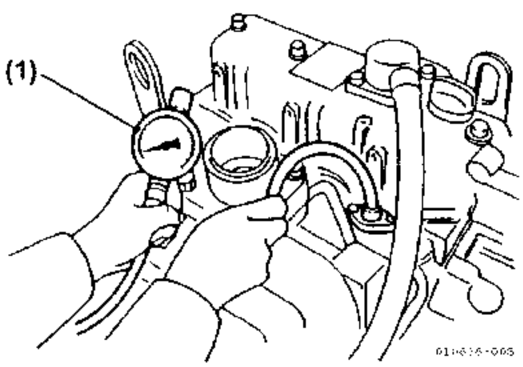

Figure 13-1

1 – Compression Gauge

- Compression pressure measurement method:
  1. After warming up the engine, remove the fuel injection pipe and valves from the cylinder to be measured.
  2. Crank the engine before installing the compression gauge adapter.
     (a) Perform cranking with the stop handle at the STOP position (no injection state).
     (b) *See Test Compression on page 5-22* for the compression gauge and compression gauge adapter.
  3. Install the compression gauge and compression gauge adapter at the cylinder to be measured.

     ALWAYS install a gasket at the tip end of the adapter.
  4. With the engine set to the same state as in 2.(a), crank the engine with the starter motor until the compression gauge reading is stabilized.

- Standard compression pressure:

Engine Compression Pressure List (Reference Value)

Model	Compression Pressure at 250 rpm	Deviation Among Cylinders MPa (psi)
	Standard	
3JH5E, 4JH5E and 4JH4-TE	3.4 ± 0.1 MPa (493 ±14 psi)	0.2 to 0.3 MPa (29 to 44 psi)
4JH4-HTE	3.2 ± 0.1 MPa (464 ± 14 psi)	

- Engine speed and compression pressure (for reference):

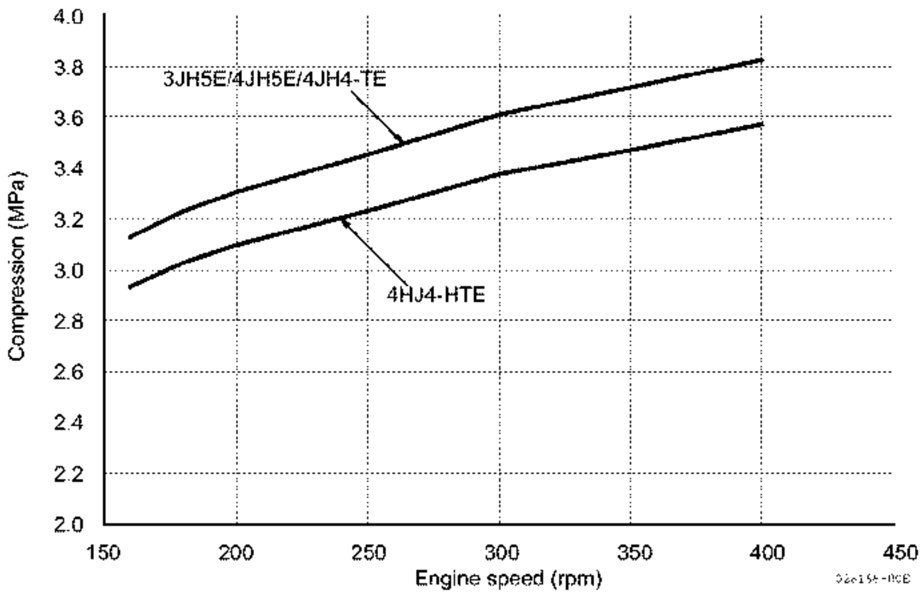

Figure 13-2

- Measured value and troubleshooting:

  When the measured compression pressure is below the limit value, inspect each part using the table below.

No.	Item	Cause	Corrective Action
1	Air cleaner element	• Clogged element • Broken element • Defect at element seal portion	• Clean the element. • Replace the element. • Replace seal.
2	Valve clearance	Excessive or no clearance	Adjust the valve clearance. (*See Adjust valve clearance - 2-valve cylinder head: on page 5-82* and *Adjust valve clearance - 4 valve cylinder head: on page 5-83*)
3	Valve timing	Incorrect valve clearance	Adjust the valve clearance. (*See Adjust valve clearance - 2-valve cylinder head: on page 5-82* and *Adjust valve clearance - 4 valve cylinder head: on page 5-83*)
4	Cylinder head gasket	Gas leak from gasket	• Replace the gasket. • Retighten the cylinder head bolts to the specified torque. (*See Install the cylinder head. NOTICE: Ensure the threaded bolt holes are clean and dry. If coolant or oil remains in the holes, there is a risk of cracking the cylinder block when the bolts are installed. on page 5-81*)
5	• Intake / exhaust valve • Valve seat	• Gas leak due to worn valve seat or foreign matter trapping • Sticking valve	• Lap the valve seat. (*See Valve Seat Correction Procedure on page 5-46*). • Replace the intake / exhaust valve.
6	• Piston • Piston ring • Cylinder	Gas leak due to scratching or wear	Perform honing and / or use an oversized part.

AFTER TROUBLESHOOTING OR REPAIR

Check and clear any problems after repairs are complete.

Section 14

SERVICE STANDARDS

Page

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ENGINE TUNING

No.	Inspection Item			Standard	Limit	Reference Page
1	Intake / Exhaust Valve Clearance			0.15-0.25 mm (0.006-0.010 in.)	-	5-61
2	V-belt Tension at 98 N, 10 kgf, 22 lbf	Between Alternator and F.W. Pump	Used Part	8-10 mm 0.31-0.39 in.	-	11-9
			New Part	6-8 mm (0.24-0.31 in.)	-	
3	Fuel Injection Pressure		4JH4-TE 4JH4-HTE	21.1-22.1 MPa (3060-3205 psi)	-	6-45
			3JH5E 4JH5E	20.6-21.6 MPa (2987-3132 psi)	-	6-45
4	Compression Pressure at 250 rpm MPa (kgf/cm^2)		3JH5E 4JH5E 4JH4-TE	3.4±0.1 MPa (493±14 psi)	-	13-13
			4JH4-HTE	3.2±0.1 MPa (464±14 psi	-	
5	Coolant Capacity	3JH5E		4.5 L (4.8 qt)	-	7-4
		4JH5E		6.0 L (6.3 qt)	-	
		4JH4-TE / 4JH4-HTE		7.2 L (7.6 qt)	-	
		Coolant Recovery Tank		0.8 L (0.8 qt)	-	
6				Total	Effective	Reference
	Lubricating Oil Capacity of 3JH5E	Engine (with KM35P, at rake angle 8°)		5.0±0.3 L (5.3±0.3 qt)	1.1 L (1.2 qt)	3-46
		Engine (with KM35A, at rake angle 0°)		5.5±0.3 L (5.8±0.3 qt)	1.2 L (1.3 qt)	3-46
		Marine Gear	KM35P	0.5 L (0.5 qt)	-	3-46
			KM35A	0.65 L (0.7 qt)	-	3-46
	Lubricating Oil Capacity of 4JH5E	Engine (with KM35P / ZF30M, at rake angle 8°)		5.0±0.3 L (5.3±0.3 qt)	1.2 L (1.3 qt)	3-47
		Engine (with KM35A2 / KM4A1 / SD50, at Rake Angle 0°)		5.0±0.3 L (5.3±0.3 qt)	1.4 L (1.5 qt)	3-47
		Marine Gear	KM35P	0.5 L (0.5 qt)	-	3-48
			KM35A2	0.65 L (0.7 qt)	-	3-48
			ZF30M	1.1 L (1.2 qt)	-	3-48
			KM4A	1.3 L (1.4 qt)	-	3-48

No.	Inspection Item			Standard	Limit	Reference Page
6				Total	Effective	
	Lubricating Oil Capacity of 4JH4-TE / 4JH4-HTE	Engine (with ZF30M, at rake angle 7°)		5.7±0.3 L (6±0.3 qt)	2.4 L (2.5 qt)	3-51
		Engine (with KMH4A / KM4A2 / SD50 at rake angle 0°)		6.9±0.3 L (7.3±0.3 qt)	2.4 L (2.5 qt)	3-51
		Marine Gear	ZF30M	1.1 L (1.2 qt)	0.2 L (0.2 qt)	3-52
			KMH4A	2.0 L (2.1 qt)	0.2 L (0.2 qt)	3-52
			KM4A2	2.0 L (2.1 qt)	0.2 L (0.2 qt)	3-52
			SD50-4T (4JH4-TE only)	2.2 L (2.3 qt)	0.1 L (0.1 qt)	3-52
7	Lubricating Oil Pressure	3JH5E		0.39-0.54 MPa, 4.0-5.5 kgf/cm^2 (57-78 psi)	0.06 MPa, 0.6 kgf/cm^2 (8.7 psi) or above	8-4
		4JH5E		0.29-0.39 MPa, 3.0-4.0 kgf/cm^2 (42-57 psi)	0.06 MPa, 0.6 kgf/cm^2 (8.7 psi) or above	8-4
		4JH4-TE / 4JH4-HTE		0.28-0.45 MPa, 2.9-4.6 kgf/cm^2 (41-65 psi)	0.06 MPa, 0.6 kgf/cm^2 (8.7 psi) or above	8-4
8	Oil Pressure Switch Operating Pressure			0.02±0.01 MPa, 0.2±0.1 kgf/cm^2 (2.9±1.5 psi)	-	8-6

No.	Inspection Item		Standard	Limit	Reference Page
9	Thermostat		Valve opening temperature	Full opening lift	Reference Page
			75.0-78.0°C (167-172°F)	8 mm (0.31 in.) or above at 90°C (194°F)	5-11
10	Thermo Switch Actuating Temperature	ON	97-103°C (207-217°F)	-	5-11
		OFF	90°C (194°F) or more	-	5-11
11	Top Clearance (Including Oil Clearance)		0.68-0.80 mm (0.0027-0.0031 in.)	-	5-60

ENGINE BODY

Cylinder Head

Cylinder Head

Inspection Item				Standard	Limit	Reference Page
Combustion Surface Distortion				0.05 mm (0.002 in.) or less	0.15 mm (0.006 in.)	5-5
Valve Sink		3JH5E 4JH5E 4JH4-TE 4JH4-HTE	Intake Exhaust	0.30-0.50 mm (0.001-0.002 in.)	0.8 mm (0.003 in.)	5-5
Valve Seat	Seat Angle		Intake	120°	-	5-5
			Exhaust	90°	-	5-5

Intake / Exhaust Valve and Guide

Model	Inspection Item		Standard	Limit	Reference Page
3JH5E 4JH5E	Intake	Guide Inside Diameter	8.010-8.025 mm (0.315-0.316 in.)	8.10 mm (0.32 in.)	5-56
		Valve Stem Outside Diameter	7.955-7.975 mm (0.313-0.314 in.)	7.90 mm (0.31 in.)	5-56
		Clearance	0.035-0.070 mm (0.0014-0.0028 in.)	0.18 mm (0.007 in.)	5-56
	Exhaust	Guide Inside Diameter	8.015-8.030 mm (0.3155-0.3161 in.)	8.10 mm (0.32 in.)	5-56
		Valve Stem Outside Diameter	7.955-7.970 mm (0.3132-0.3137 in.)	7.90 mm (0.31 in.)	5-56
		Clearance	0.045-0.075 mm (0.0018-0.003 in.)	0.18 mm (0.007 in.)	5-56
	Valve Guide Projection from Cylinder Head		14.7-15.0 mm (0.579-0.591 in.)	-	5-57
	Valve Guide Driving-in Method		Cold-fitted	-	5-56
4JH4-TE 4JH4-HTE	Intake	Guide Inside Diameter	6.000-6.015 mm (0.2362-0.2368 in.)	6.1 mm (0.24 in.)	5-56
		Valve Stem Outside Diameter	5.960-5.975 mm (0.2346-0.2352 in.)	5.90 mm (0.23 in.)	5-56
		Clearance	0.025-0.055 mm (0.00098-0.0021 in.)	0.16 mm (0.006 in.)	5-56
	Exhaust	Guide Inside Diameter	6.000-6.015 mm (0.2362-0.2368 in.)	6.1 mm (0.24 in.)	5-56
		Valve Stem Outside Diameter	5.945-5.960 mm (0.2341-0.2347 in.)	5.90 mm (0.23 in.)	5-56
		Clearance	0.040-0.070 mm (0.0016-0.0028 in.)	0.18 mm (0.007 in.)	5-56
	Valve Guide Projection from Cylinder Head		8.2-8.5 mm (0.32-0.34 in.)	-	5-57
	Valve Guide Driving-in Method		Cold-fitted	-	5-57

Valve Spring

Inspection Item		Standard	Limit	Reference Page
Free Length	3JH5E / 4JH5E	44.4 mm (1.75 in.)	43.0 mm (1.69 in.)	5-59
	4JH4-TE / 4JH4-HTE	37.4 mm (1.47 in.)	36.9 mm (1.45 in.)	5-59
Inclination		-	1.1°	5-59

Rocker Arm and Shaft

Inspection Item	Standard	Limit	Reference Page
Arm Shaft Hole Diameter	16.000-16.020 mm (0.6299-0.6307 in.)	16.090 mm (0.6335 in.)	5-6
Shaft Outside Diameter	15.966-15.984 mm (0.6286-0.6293 in.)	15.955 mm (0.6282 in.)	5-6
Clearance	0.016-0.054 mm (0.00059-0.0021 in.)	0.140 mm (0.0055 in.)	5-6

Push Rod

Inspection Item	Standard	Limit	Reference Page
Bend	Less than 0.03 mm (0.001 in.)	0.03 mm (0.001 in.)	5-80

Camshaft and Gear Train

Camshaft

Inspection Item		Standard	Limit	Reference Page
Side Gap		0.05-0.20 mm (0.002-0.008 in.)	0.35 mm (0.014 in.)	5-89
Bending (1/2 the Dial Gauge Reading)		0.02 mm or less (0.0008 in.)	0.05 mm (0.002 in.)	5-89
Cam Height	3JH5E / 4JH5E	38.600-38.800 mm (1.52-1.53 in.)	38.350 mm (1.51 in.)	5-6
	4JH4-TE / 4JH4-HTE	39.800-40.000 mm (1.567-1.575 in.)	39.550 mm (1.557 in.)	5-6
Shaft Outside Diameter / Metal Inside Diameter				
Gear Side	Bushing Inside Diameter	44.990-45.055 mm (1.771-1.773 in.)	45.130 mm (1.777 in.)	5-77
	Camshaft Outside Diameter	44.925-44.950 mm (1.7687-1.7697 in.)	44.890 mm (1.767 in.)	5-77
	Clearance	0.040-0.130 mm (0.0016-0.0051 in.)	0.240 mm (0.0095 in.)	5-77
Intermediate	Bushing Inside Diameter	45.000-45.025 mm (1.771-1.773 in.)	45.100 mm (1.776 in.)	5-77
	Camshaft Outside Diameter	44.910-44.935 mm (1.7681-1.7691 in.)	44.875 mm (1.7667 in.)	5-77
	Clearance	0.065-0.115 mm (0.0026-0.0045 in.)	0.225 mm (0.0089 in.)	5-77
Flywheel End	Bushing Inside Diameter	45.000-45.025 mm (1.771-1.773 in.)	45.100 mm (1.776 in.)	5-77
	Camshaft Outside Diameter	44.925-44.950 mm (1.7687-1.7697 in.)	44.890 mm (1.767 in.)	5-77
	Clearance	0.050-0.100 mm (0.002-0.004 in.)	0.210 mm (0.008 in.)	5-77

Idler Gear Shaft and Bushing

Inspection Item	Standard	Limit	Reference Page
Shaft Outside Diameter	45.950-45.975 mm (1.8091-1.810 in.)	45.880 mm (1.8063 in.)	5-80
Bushing Inside Diameter	46.000-46.025 mm (1.811-1.812 in.)	46.075 mm (1.814 in.)	5-80
Clearance	0.025-0.075 mm (0.00098 in.)	0.150 mm (0.0059 in.)	5-80

Backlash of Each Gear

Inspection Item	Standard	Limit	Reference Page
Crank Gear, Cam Gear, Idler Gear, Fuel Injection Pump Gear and Seawater Pump Gear	0.07-0.15 mm (0.003-0.006 in.)	0.17 mm (0.007 in)	5-80

Cylinder Block

Cylinder Block

Inspection Item		Standard	Limit	Reference Page
Cylinder Inside Diameter	3JH5E / 4JH5E	88.000-88.030 mm (3.465-3.466 in.)	88.200 mm (3.472 in.)	5-7
	4JH4-TE / 4JH4-HTE	84.000-84.030 mm (3.307-3.308 in.)	84.200 mm (3.315 in.)	5-7
Cylinder Bore	Roundness	0.01 mm or less (0.0004 in.)	0.03 mm (0.001 in.)	5-7
	Inclination			

Crankshaft

Inspection Item		Standard	Limit	Reference Page
Bending (1/2 the Dial Gauge Reading)		-	0.02 mm (0.0008 in.)	5-72
Crank Pin	Pin Outside Diameter	47.952-47.962 mm (1.8879-1.8883 in.)	47.902 mm (1.8859 in.)	5-73
	Metal Inside Diameter	48.000-48.026 mm (1.8898-1.8908 in.)	-	5-73
	Metal Thickness	1.492-1.500 mm (0.0587-0.0591 in.)	-	5-73
	Clearance	0.038-0.083 mm (0.0015-0.003 in.)	0.150 mm (0.006 in.)	5-73
Crank Journal (Selective Pairing)	Journal Outside Diameter	49.952-49.962 mm (1.9666-1.9670 in.)	49.902 mm (1.9646 in.)	5-73
	Metal Inside Diameter	51.000-51.010 mm (2.0078-2.0083 in.)	-	5-73
	Metal Thickness	1.995-2.010 mm (0.0785-0.0791 in.)	-	5-73
	Clearance	0.038-0.068 mm (0.015-0.027 in.)	0.150 mm (0.006 in.)	5-73

Thrust Bearing

Inspection Item	Standard	Limit	Reference Page
Crankshaft Side Gap	0.14-0.22 mm (0.0055-0.0087)	0.30 mm (0.012 in.)	5-74

Piston and Ring

Piston

Inspection Item		Standard	Limit	Reference Page
Piston Outside Diameter (Measure in the Direction Vertical to the Piston Pin)	3JH5E / 4JH5E	87.935-87.945 mm (3.4619-3.4624 in.)	87.885 mm (3.4600 in.)	5-63
	4JH4-TE / 4JH4-HTE	83.930-83.940 mm (3.4224-3.4228 in.)	83.880 mm (3.3024 in.)	5-63
Clearance Between Piston and Cylinder	3JH5E / 4JH5E	0.06-0.090 mm (0.0024-0.0035 in.)	-	5-63
	4JH4-TE / 4JH4-HTE	0.065-0.095 mm (0.0026-0.0037 in.)	-	5-63
Piston Diameter Measure Position (Upward from the Bottom End of the Piston)		22 mm (0.87 in.)	-	5-8
3JH5E 4JH5E	Piston Pin Hole Inside Diameter	26.000-26.009 mm (1.0236-1.0272 in.)	26.020 mm (1.0244 in.)	5-64
	Piston Pin Outside Diameter	25.995-26.000 mm (1.0234-1.0236 in.)	25.965 mm (1.0222 in.)	5-64
	Clearance Between Piston Pin and Hole	0.000-0.014 mm (0.0-0.00055 in.)	0.074 mm (0.0029 in.)	5-64
4JH4-TE 4JH4-HTE	Piston Pin Hole Inside Diameter	28.000-28.009 mm (1.1023-1.1027 in.)	28.020 mm (1.1031 in.)	5-64
	Piston Pin Outside Diameter	27.995-28.000 mm (1.1022-1.1024 in.)	27.965 mm (1.1010 in.)	5-64
	Clearance Between Piston Pin and Hole	0-0.014 mm (0.0-0.00055 in.)	0.074 mm (0.0029 in.)	5-64

Piston Ring

Inspection Item			Standard	Limit	Reference Page
3JH5E 4JH5E	Top Ring	Ring Groove Width	2.060-2.075 mm (0.0811-0.0817 in.)	2.170 mm (0.0854 in.)	5-66
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)	5-66
		Side Clearance	0.070-0.105 mm (0.0028-0.0041 in.)	0.200 mm (0.0079 in.)	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66
	Middle Ring	Ring Groove Width	2.025-2.040 mm (0.0797-0.0803 in.)	2.140 mm (0.0843 in.)	5-66
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)	5-66
		Side Clearance	0.035-0.070 mm (0.00138-0.00276 in.)	0.190 mm (0.0075 in.)	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66
	Oil Control Ring	Ring Groove Width	4.015-4.030 mm (0.1581-0.1587 in.)	4.130 mm (0.1626 in.)	5-66
		Ring Width	3.970-3.990 mm (0.1563-0.1571 in.)	3.950 mm (0.1555 in.)	5-66
		Side Clearance	0.025-0.060 mm (0.00098-0.0024 in.)	0.180 mm (0.0071 in.)	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66

Piston Ring (continued)

4JH4-TE 4JH4-HTE	Top Ring	Ring Groove Width	2.060-2.080 mm (0.0811-0.0818 in.)	2.180 mm (0.0858 in.)	5-66
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)	5-66
		Side Gap	(half-keystone)	-	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66
	Middle Ring	Ring Groove Width	2.050-2.065 mm (0.0807-0.0813 in.)	2.170 mm (0.0854 in.)	5-66
		Ring Width	1.970-1.990 mm (0.0776-0.0783 in.)	1.950 mm (0.0768 in.)	5-66
		Side Clearance	0.060-0.095 mm (0.0024-0.0037 in.)	0.220 mm (0.0087 in.)	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66
	Oil Control Ring	Ring Groove Width	4.020-4.035 mm (0.1583-0.1589 in.)	4.135 mm (0.1628 in.)	5-66
		Ring Width	3.970-3.990 mm (0.1563-0.1571 in.)	3.950 mm (0.1555 in.)	5-66
		Side Clearance	0.030-0.065 mm (0.0012-0.0026 in.)	0.180 mm (0.007 in.)	5-66
		End Clearance (Gap)	0.200-0.400 mm (0.0079-0.0157 in.)	0.490 mm (0.0193 in.)	5-66

Connecting Rod

Rod Big End

Inspection Item	Standard	Limit	Reference Page
Side Clearance	0.20-0.40 mm (0.0079-0.0157 in.)	0.55 mm (0.0217 in.)	5-7

Rod Small End

Item			Standard	Limit	Reference Page
Piston Pin Bushing Inside Diameter		3JH5E	26.025-26.038 mm (1.0246-1.0251 in.)	26.068 mm (1.0263 in.)	5-71
		4JH5E	26.000-26.009 mm (1.0236-1.0240 in.)	26.039 mm (1.0251)	5-71
3JH5E 4JH5E	Piston Pin Outside Diameter		25.995-26.000 mm (1.0234-1.0236 in.)	25.965 mm (1.0222 in.)	5-64
	Clearance		0.025-0.043 mm (0.00098-0.00169 in.)	0.101 mm (0.00397 in.)	5-71
4JH4-TE 4JH4-HTE	Piston Pin Bushing Inside Diameter		28.025-28.038 mm (1.1033-1.1039 in.)	28.068 mm (1.0263 in.)	5-71
	Piston Pin Outside Diameter		27.995-28.000 mm (1.1021-1.1023 in.)	27.965 mm (1.1010 in.)	5-64
	Clearance		0.025-0.043 mm (0.00098-0.00169 in.)	0.101 mm (0.00397 in.)	5-71

Tappet

Inspection item		Standard	Limit	Reference Page
3JH5E 4JH5E	Tappet Guide Hole Inside Diameter	12.000-12.018 mm (0.4724-0.4732 in.)	12.045 mm (0.4742 in.)	5-79
	Tappet Stem Outside Diameter	11.975-11.990 mm (0.4715-0.4721 in.)	11.930 mm (0.4697 in.)	5-79
	Clearance	0.010-0.043 mm (0.00039-0.00169 in.)	0.090 mm (0.0035 in.)	5-79
4JH4-TE 4JH4-HTE	Tappet Guide Hole Inside Diameter	12.000-12.025 mm (0.4724-0.4734 in.)	12.052 mm (0.4745 in.)	5-79
	Tappet Stem Outside Diameter	11.975-11.990 mm (0.4715-0.4721 in.)	11.930 mm (0.4697 in.)	5-79
	Clearance	0.010-0.050 mm (0.00039-0.00197 in.)	0.097 mm (0.0038)	5-79

LUBRICATING OIL SYSTEM (TROCHOID PUMP)

Outside Clearance of Outer Rotor

Standard	Limit	Reference Page
0.12-0.21 mm (0.0047-0.0083 in.)	0.30 mm (0.012 in.)	8-13

Tip Clearance Between Outer Rotor and Inner Rotor

Standard	Limit	Reference Page
-	0.16 mm (0.0063 in.)	8-13

Side Clearance of Outer Rotor

Standard	Limit	Reference Page
0.02-0.07 mm (0.0008-0.0028 in.)	0.12 mm (0.0047 in.)	8-13

Inside Clearance of Inner Rotor

Item	Parts	Standard	Standard	Limit	Reference Page
Inside Clearance of Inner Rotor	Gear Boss Diameter	53.05-53.15 mm (2.089-2.092 in.)	0.3-0.5 mm (0.012-0.020 in.)	0.6 mm (0.024 in.)	8-14
	Rotor Diameter	53.45-53.55 mm (2.104-2.108 in.)		-	
Width Across Flat Clearance of Inner Rotor	Width Across Flat of Gear Boss	49.45-49.75 mm (1.9468-1.9587 in.)	0.2-0.6 mm (0.0079-0.0236 in.)	0.7 mm (0.028 in.)	8-14
	Width Across Flat of Rotor	49.95-50.05 mm (1.9665-1.9705 in.)			
Flange Clearance	Gear Housing Inner Diameter	57.63-57.68 mm (2.269-2.271 in.)	0.13-0.20 mm (0.0051-0.0079 in.)	-	8-14
	Rotor	57.30-57.50 mm (2.256-2.264 in.)			

MAIN BOLT AND NUT

No.	Name	Thread Diameter x Pitch (mm)	Lubricating Oil Application (Thread Portion, and Seat Surface)	Torque
1	Head Bolt	M10x1.25	Coat with lubricating oil	85.2-91.2 N·m, (62.8-67.3 lb-ft)
2	Rod Bolt	M9x1.0	Coat with lubricating oil	44.1-49.1 N·m, (32.5-36.2 lb-ft)
3	Flywheel Bolt	M10x1.25	Coat with lubricating oil	83.3-88.3 N·m, (61.4-65.1 lb-ft)
4	Metal cap Bolt	M12x1.5	Coat with lubricating oil	96-100 N·m, (70.8-73.8 lb-ft)
5	Crankshaft Pulley Bolt (FC300 Pulley)	M14x1.5	Coat with lubricating oil	83.2-93.2 N·m, (61.4-68.7 lb-ft)
6	Nozzle Retainer Bolt	M8x1.25	No lubricating oil	24.4-28.4 N·m, (18.0-21.0 lb-ft)
7	Fuel Injection Pump Gear Nut	3JH5E 4JH5E: M8x1.0	No lubricating oil	32.3-36.3 N·m, (23.8-26.8 lb-ft)
		4JH4-TE 4JH4-HTE: M14x1.5	Coat with lubricating oil	59-69 N·m, (43.5-50.9 lb-ft)
8	Fuel Injection Line Joint Nut	M12x1.5	No lubricating oil	29.4-34.4 N·m, (21.7-25.4 lb-ft)
9	Heat Exchanger Set Bolt	M8x1.25	No lubricating oil	34.2-40.2 N·m, (25.2-29.7 lb-ft)
10	Starter Relay Terminal Nut (Magnetic Relay)	M6x1.0	No lubricating oil	3.0-4.2 N·m, (2.2-3.1 lb-ft)

STANDARD BOLTS AND NUTS (W/O LUBRICATING OIL)

Name	bolt dia. x pitch (mm)	Tightening torque	Remarks
Hexagon Bolt with a "7" Head and Hexagon Nut. ("7" Mark Means JIS Strength Classification "7T".)	M6x1	9.8-11.8 N·m, (7.2-8.7 lb-ft)	Apply 80% torque when tightening to aluminum alloy. Apply 60% torque to 4T bolts and locknuts. (4T bolt has no mark on the head.)
	M8x1.25	22.5-28.5 N·m, (16.6-21.0 lb-ft)	
	M10x1.5	44-54 N·m, (32.5-39.8 lb-ft)	
	M12x1.75	78.2-98.2 N·m, (57.7-72.4 lb-ft)	
Pt Plug (Taper Plug)	1/8	9.8 N·m, (7.2 lb-ft)	-
	1/4	19.6 N·m, (14.4 lb-ft)	
	3/8	29.4 N·m, (21.7 lb-ft)	
	1/2	58.8 N·m, (43.4 lb-ft)	
Line Joint Bolt	M8	12.7-16.7 N·m, (9.4-12.3 lb-ft)	-
	M10	19.5-25.5 N·m, (14.4-18.8 lb-ft)	
	M12	24.4-34.4 N·m, (18.0-25.4 lb-ft)	
	M14	39.1-49.1 N·m, (28.8-36.2 lb-ft)	
	M16	48.9-58.9 N·m, (36.1-43.4 lb-ft)	

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