SERVICE MANUAL

MARINE ENGINE

YM

2YM15
3YM20
3YM30
3YM30AE

YANMAR

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.

Foreword:

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:

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SERVICE MANUAL	MODEL	2YM15, 3YM20, 3YM30, 3YM30AE
	CODE	0BYMM-EN0021

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Section 1

INTRODUCTION

This manual gives specific instructions for the proper repair of Yanmar YM 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. 2004 0BYMM-G00100		New edition	
Apr. 2005 Rev.1		Add : Eug. Model 2YM15 1. Specifications table added. 2. Engine outline added. 3. Piping diagram added. 4. Other data added.	Quality Control Dept. Marine Factory
	 P6-P9 P32	Corrected data. (3YM30, 3YM20) 1. Front cover added to engine outline. 2. Notice on seawater pump rotating direction was changed. 3. Incorrect word corrected.	
Nov. 2006 Rev. 2	 P6 P7 P44	Corrected data. 1. Engine mounting bolt side pitch (3YM30 with KM2P-1). 2. Engine mounting bolt side pitch (3YM30C with SD20). 3. No-load max. speed (3YM20).	YMI Business Development Department
Mar. 2009 0BYMM-G00200	 P3-10~P3-33 P3-35~P3-43 P3-44~P3-47 P3-48~P3-49, P10-5~P10-7 P4-5 P11-4 P11-14	Corrected data. 1. Outline drawings change. Standard alternator change. Standard pump inlet dia. ø17.3 → ø19.5 2. Piping Diagrams Standard pump inlet dia. ø17.3 → ø19.5 3. Exhaust Gas Emission Control System Warranty EPA Marine Tier3 and ARB Nonload. 4. Standard alternator 12V-60A (12V-80A optional) → 12V-80A (12V-60A optional) from 2009 5. Periodic Maintenance Schedule Delete Clean the breather pipe. 6. Add Wiring Diagram for B (Keyless) - type Instrument Panel. 7. Add B (Keyless) - Type Instrument Panel.	Marine Operations Department
Aug. 2019 0BYMM-EN0021		Added new model: 3YM30AE Added new page: Marine gear Added new page: Alternator (Valeo)	Marine Recreational Promotion Division

Section 2

SAFETY

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 a part needs to be replaced that has a decal attached to it, make sure to 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.

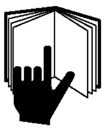
NOTICE

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 operating 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 operating or servicing the engine to ensure that safe operating practices and maintenance procedures are followed.
- Safety signs and decals are additional reminders for safe operating and maintenance techniques.
- Contact your Yanmar RHQ for additional training.

Crush Hazard

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.

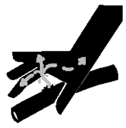
Entanglement Hazard

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

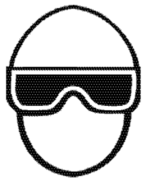
Piercing Hazard



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. Have your authorized Yanmar Marine dealer or distributor repair the damage.

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 handling 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 an engine if either of the engines is 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

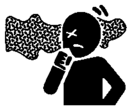
Make welding repairs safely.

- 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 complete, 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 shutdown.

- 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

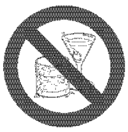
Lifting Hazard

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 transport is needed for engine repair, have a helper assist in attaching it to a hoist and loading it onto a truck.

Alcohol and Drug Hazard



Never operate the engine while under the influence of alcohol, drugs or when 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.

Shock Hazard

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

⚠ 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.

Section 3

GENERAL SERVICE INFORMATION

Page

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SAFETY PRECAUTIONS

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

Precautions for Engine Service and Repair Work

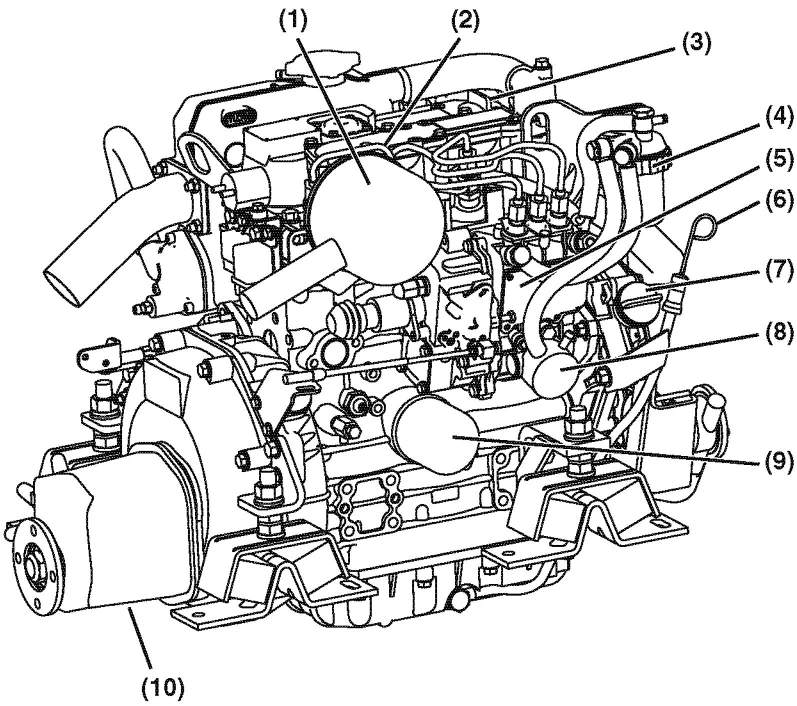
Read the safety precautions at the beginning of this manual carefully and always be mindful of safety considerations when working on engines.

Preparation is necessary for accurate and efficient service work. Check the customer maintenance records and become familiar with the history of the engine.

- Preceding service date
- Period / operation hours after preceding service
- Problems and actions in preceding service
- Replacement parts expected to be required for service
- Recording form / check sheet required for service
- Locate and collect all general tools, special service tools, measuring instruments, oil, grease, non-reusable parts, and parts expected to be used for the work being performed.
- When disassembling complicated assemblies, use index marks and other indicators that will not adversely affect the function of the engine for easy reassembly.
- Each time a part is removed, inspect it for deformation, damage, roughening, surface defects, etc.
- Arrange the removed parts in an orderly fashion. Separate those that will be replaced from those that will be used again.
- Clean all parts that will be used again.
- Keep your work area clean and use the correct tool for the job. This is very important when working on hydraulic units and the fuel injection pump.
- Inspect and measure all parts.
- Compare measurement values to the serviceable limits to determine if they can be used again.
- Reassemble components in the correct order and use the tightening torques and adjustment standards outlined in this *Service Manual*.
- Install and tighten all important bolts and nuts when specified.
- Always use genuine replacement parts.
- Always use new oil seals, O-rings, packings and cotter pins.
- Apply sealant to seals when directed.
- Apply grease and / or oil to all friction surfaces and lubricate oil seal during installation.
- Use calibrated measuring instruments and make adjustments according to specified service standards.

EXTERIOR VIEWS

Right Side (viewed from flywheel)



Left Side (viewed from flywheel)

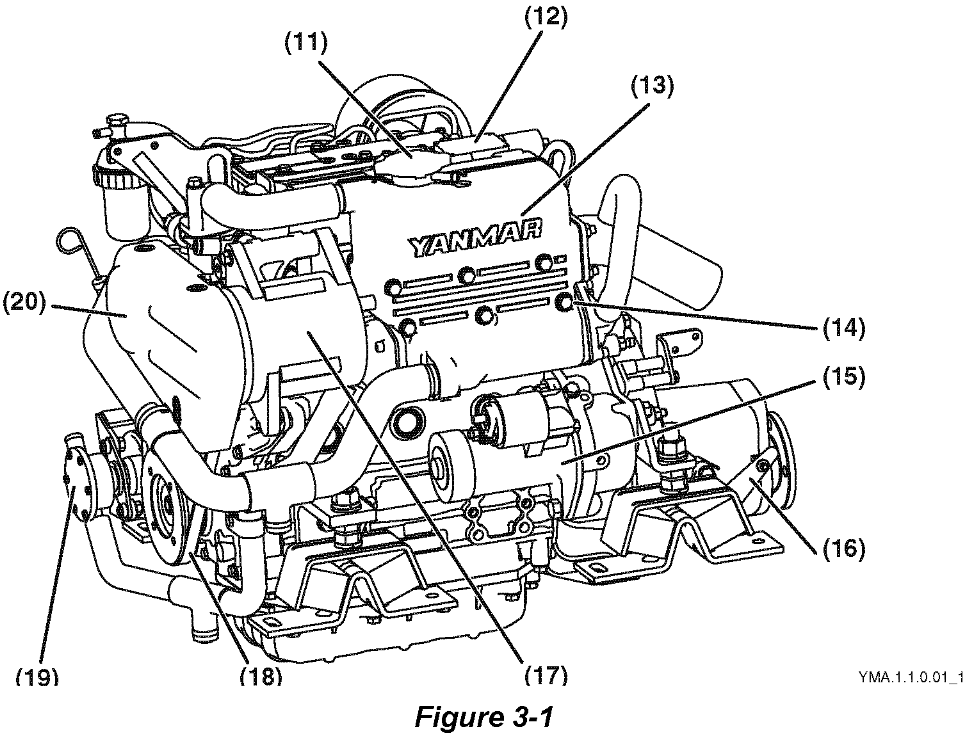


Figure 3-1

1 – Intake Silencer
2 – Intake Manifold
3 – Oil Filler Cap
4 – Fuel Filter
5 – Fuel Injection Pump
6 – Dipstick
7 – Oil Filler Cap
8 – Fuel Feed Pump
9 – Engine Oil Filter
10 – Marine Gear
11 – Coolant Filler Cap
12 – Engine Nameplate (on the rocker arm cover)
13 – Coolant Tank / Heat Exchanger
14 – Exhaust Manifold
15 – Starter Motor
16 – Shift Lever
17 – Alternator
18 – V-belt
19 – Seawater Pump
20 – Cover

Note: **Figure 3-1** shows the 3YM30 with Yanmar marine gear (Model: KM2P-1).

DIESEL FUEL

Diesel Fuel Specifications

⚠ DANGER

Fire Hazard

***Diesel fuel is flammable and explosive under certain conditions. Refer to Fire and Explosion Hazard on page** 2-2.*

Only use diesel fuels recommended by Yanmar for the best engine performance, to prevent engine damage and to comply with EPA warranty requirements. Only use clean diesel fuel.

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

Biodiesel Fuels

Yanmar approves the use of biodiesel fuels that do not exceed a blend of 5% non-mineral oil based fuel with 95% standard diesel fuel. Such biodiesel fuels are known in the marketplace as B5 biodiesel fuels. B5 biodiesel fuel can reduce particulate matter and the emission of “greenhouse” gases compared to standard diesel fuel.

NOTICE

If the B5 biodiesel 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.

The biodiesel fuels must meet the minimum specifications for the country in which they are used:

- In Europe, biodiesel fuels must comply with the European Standard EN14214.
- In the United States, biodiesel fuels must comply with the American Standard ASTM D-6751.
- Biodiesel should be purchased only from recognized and authorized diesel fuel suppliers.

Precautions and concerns regarding the use of biofuels:

- Biodiesel 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 biodiesel compatible components on the vessel fuel supply and return systems.
- Free water in biodiesel 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.
- Biodiesel may have adverse effects on some elastomers (seal materials) and may result in fuel leakage and dilution of the engine lubricating oil.
- Even biodiesel 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 biodiesel fuels that do not comply with the standards as agreed to by the diesel engine manufacturers and the diesel fuel injection equipment manufacturers, or biodiesel fuels that have degraded as per the precautions and concerns above, may affect the warranty coverage of your engine.

Additional Technical Fuel Requirements

- Fuel cetane number should be 45 or greater
- 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.
- Do not use kerosene or residual fuels.

NOTICE

Only use the recommended fuel to obtain the best engine performance, prevent parts damage and prevent air pollution.

Handling Diesel Fuel

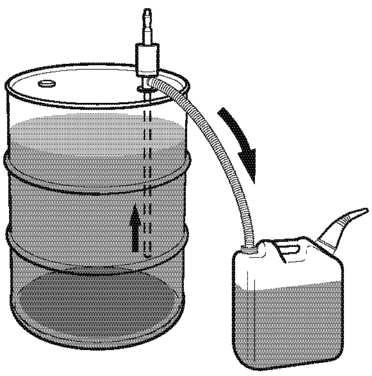


Figure 3-2

If filling the tank from a storage container **(Figure 3-2)**, keep the fuel container stationary for several hours to allow any dirt or water to settle to the bottom of the container. Use a pump to extract the clear, filtered fuel from the top of the container.

NOTICE

Water and / or dust in the fuel may cause engine failure. When fuel is stored, check that the inside of the storage container is clean and dry, and that the fuel is stored away from dirt or rain.

Fuel Tank

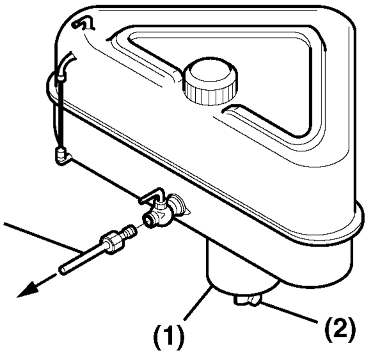


Figure 3-3

1 – Sediment Bowl
2 – Drain Cock
3 – Fuel Line To Engine

Inspect the inside of the fuel tank before initial use. Be sure it is clean and dry. Always drain any water from the tank with the fuel tank drain cock **(Figure 3-3, (2))** according to the maintenance schedule.

ENGINE OIL

Engine Oil Specifications

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.

Selection of Engine Oil

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

- API Service Categories: CD or higher
- TBN value: 9 or more
- The oil must be changed when the Total Base Number (TBN) has been reduced to 2.0.
- TBN (mgKOH/g) test method: JIS K-2501–5.2–2(HCI), ASTM D4739(HCI)
- Recommended SAE Viscosity: 10W30, 15W40. Engine oil 10W30 and 15W40 can be used throughout the year.
- Never use API Service Category CG-4 or CH-4 oils.

NOTICE

- Be sure the engine oil, engine oil storage containers and engine oil filling equipment are free of sediment or water.
- Change the engine oil after the first 50 hours of operation and then at every 150 hours thereafter.
- Select the oil viscosity based on the ambient temperature where the engine is being operated. See the SAE Service Grade Viscosity Chart **(Figure 3-4)**.
- Yanmar does not recommend the use of engine oil “additives.”

Handling Engine Oil

- When handling and storing engine oil, be careful not to allow dust and water to contaminate the oil. Clean around the filler port before filling.
- Do not mix lube oils of different types or brands. Mixing may cause the chemical characteristics of the oil to change and lubricating performance to decrease, reducing the engine’s life.
- Engine oil should be replaced at the specified intervals, regardless of the engine’s operation history.

Engine Oil Viscosity

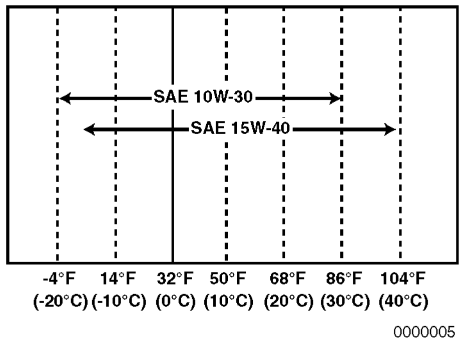


Figure 3-4

Select the appropriate engine oil viscosity based on the ambient temperature shown in the SAE Service Grade Viscosity Chart in **Figure 3-4**.

NOTICE

If you intend to operate your equipment at temperatures outside the limits shown, you must consult your authorized Yanmar Marine dealer or distributor for special lubricants or starting aids.

Marine Gear Oil

Selection of Marine Gear Oil

Use marine gear oil that meets or exceeds the following guidelines and classifications:

- API classification..................... CD or higher
- SAE viscosity.............................. #20 or #30

Selection of Oil for Sail-Drive Unit

Refer to the *Sail-Drive Operation Manual* for the procedure to fill or replace the sail-drive oil.

- API service grade........................... GL4, 5
- SAE viscosity...................... #90 or 80W-90
- Quicksilver[1] High Performance Gear Lube

[1] Quicksilver® is a registered trademark of Brunswick Corporation.

ENGINE COOLANT

Engine Coolant Specifications

⚠ 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.

- Texaco Long Life Coolant (LLC), both standard and premixed, product code 7997 and 7998.
- Havoline Extended Life Antifreeze / Coolant, product code 7994.

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

Note: The drain cocks are opened before shipping from the factory. Close all drain cocks before filling the system with coolant.

NOTICE

Following the manufacturer's recommendations, use a proper LLC which will not have any adverse effects on the materials (cast iron, aluminum, copper, etc.) of the engine's cooling system.

Handling of Coolant

Always use the mixing ratios specified by the antifreeze manufacturer for the temperature range.

NOTICE

Always add LLC to soft water – especially when operating in cold weather. Never use hard water. Water should be clean and free from sludge or particles. Without LLC, cooling performance will decrease due to scale and rust in the coolant 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. Excessive use of antifreeze also lowers the cooling efficiency of the engine. Never mix different types or brands of LLC, as a harmful sludge may form. Mixing different brands of antifreeze may cause chemical reactions, and may make the antifreeze useless or cause engine problems.

- Remove scale from the cooling system periodically by flushing the system.
- Replace coolant periodically, according to the maintenance schedule.

ENGINE OUTLINE DRAWINGS

3YM30AE (With KM2P-1 Marine Gear)

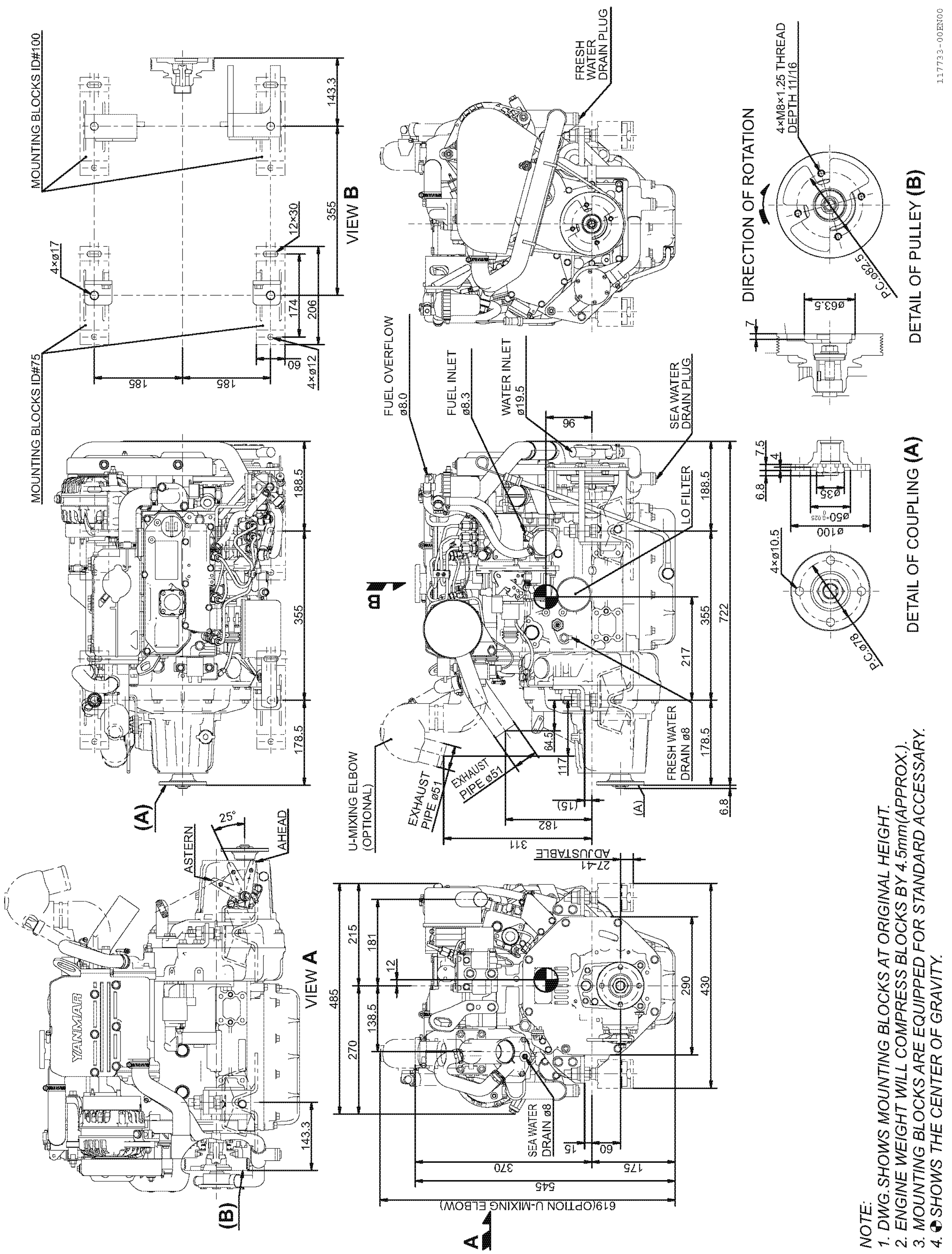


Figure 3-5

3YM30AE-C (With SD20/SD25 Sail-Drive)

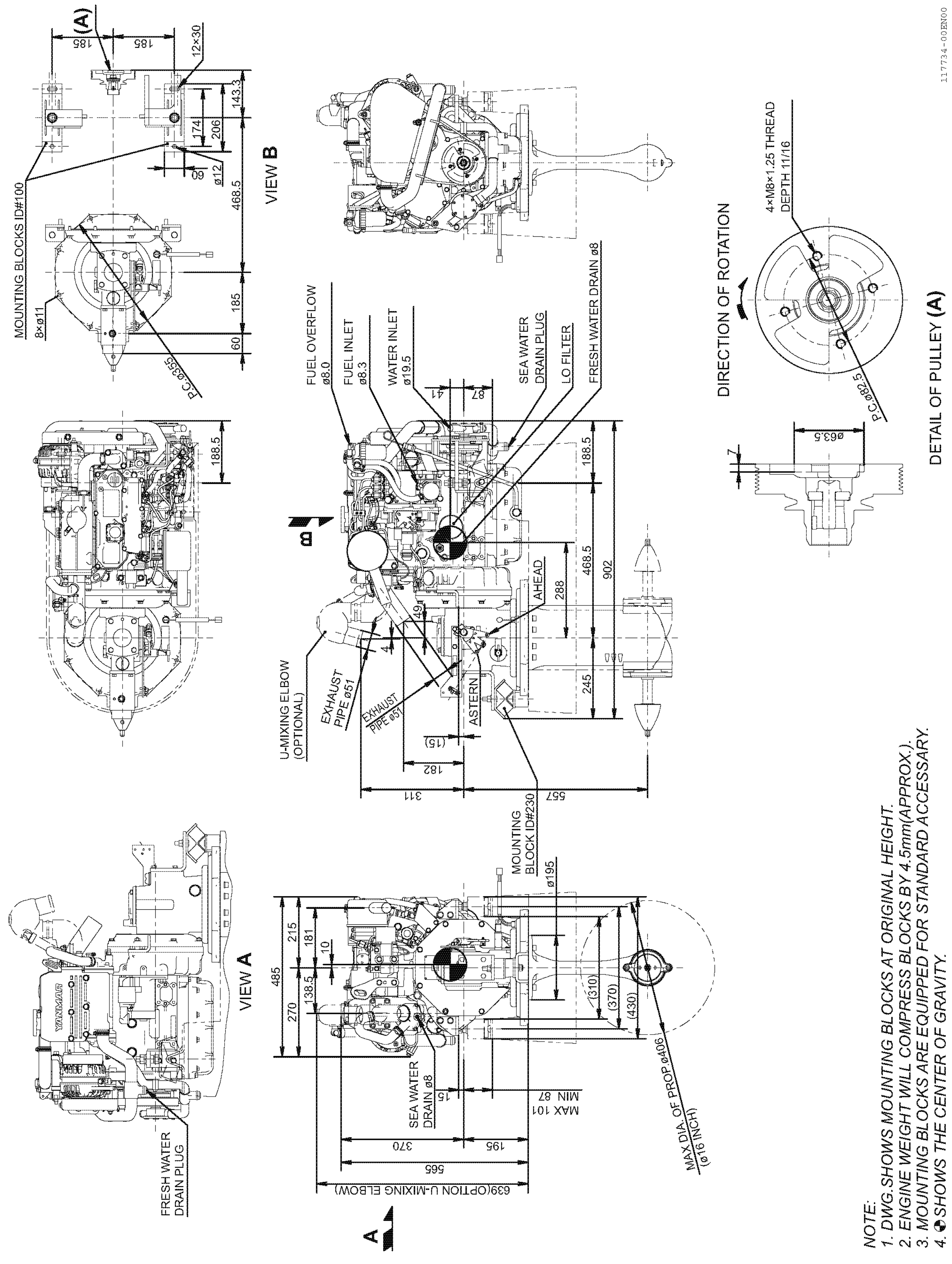


Figure 3-6

3YM30 (With KM2P-1 Marine Gear)

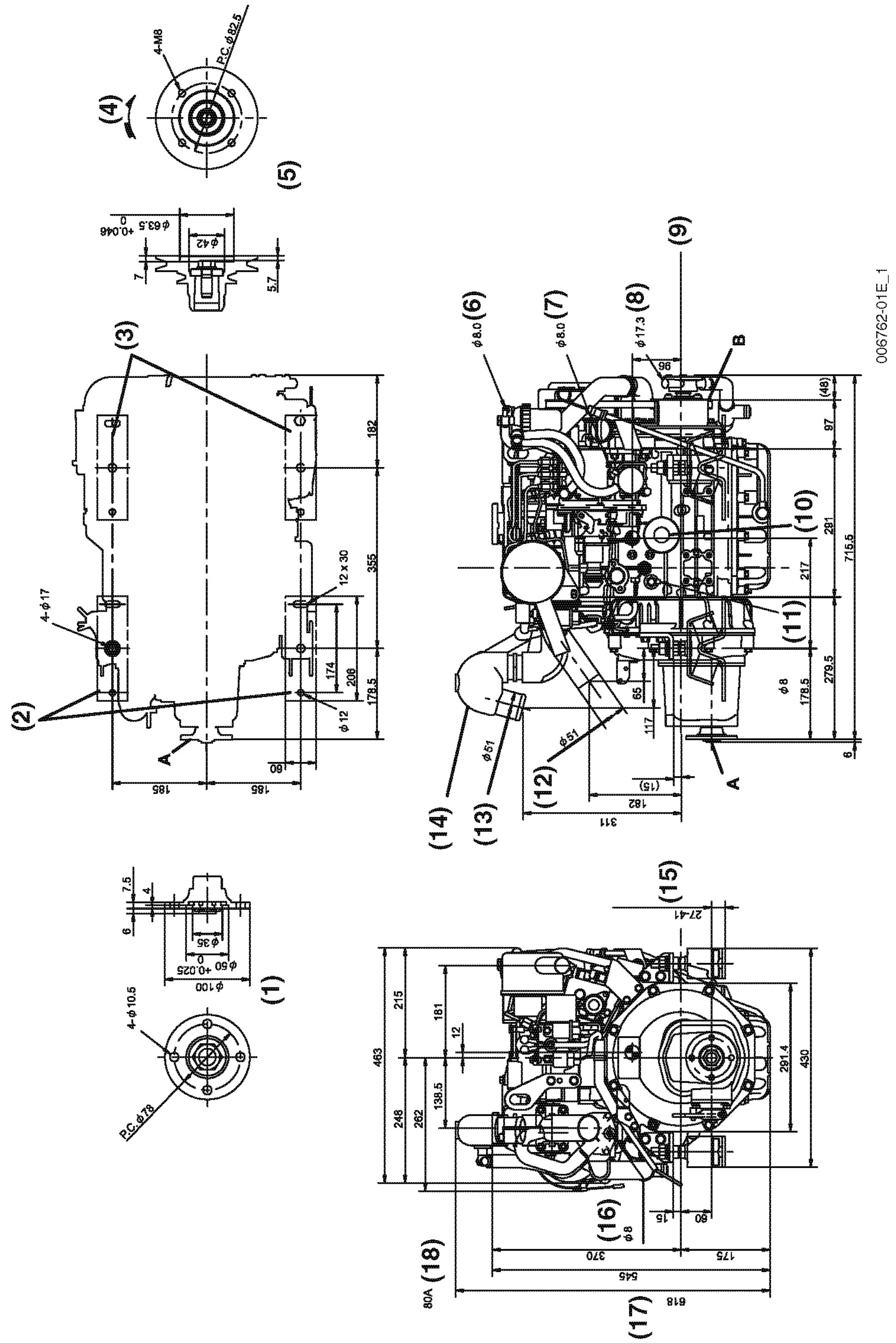


Figure 3-7

1 – Detail of Coupling A
2 – Mounting Blocks ID #75
3 – Mounting Blocks ID #100
4 – Direction of Rotation
5 – Detail of Pulley B
6 – Fuel Overflow
7 – Fuel Inlet
8 – Seawater Inlet
9 – Crankshaft Center
10 – Engine Oil Filter
11 – Coolant Drain
12 – Exhaust Pipe
13 – Exhaust Pipe
14 – U-Mixing Elbow (optional)
15 – Adjustable
16 – Seawater Drain
17 – U-Mixing Elbow
18 – 80A Alternator (optional)

Note:

- Drawing shows mounting blocks at original height.
- Engine weight will compress blocks by approximately 4.5 mm (0.18 in.).
- Mounting blocks are equipped for standard accessory.
- ⊕ shows center of gravity.

3YM30C (With SD20/SD25 Sail-Drive)

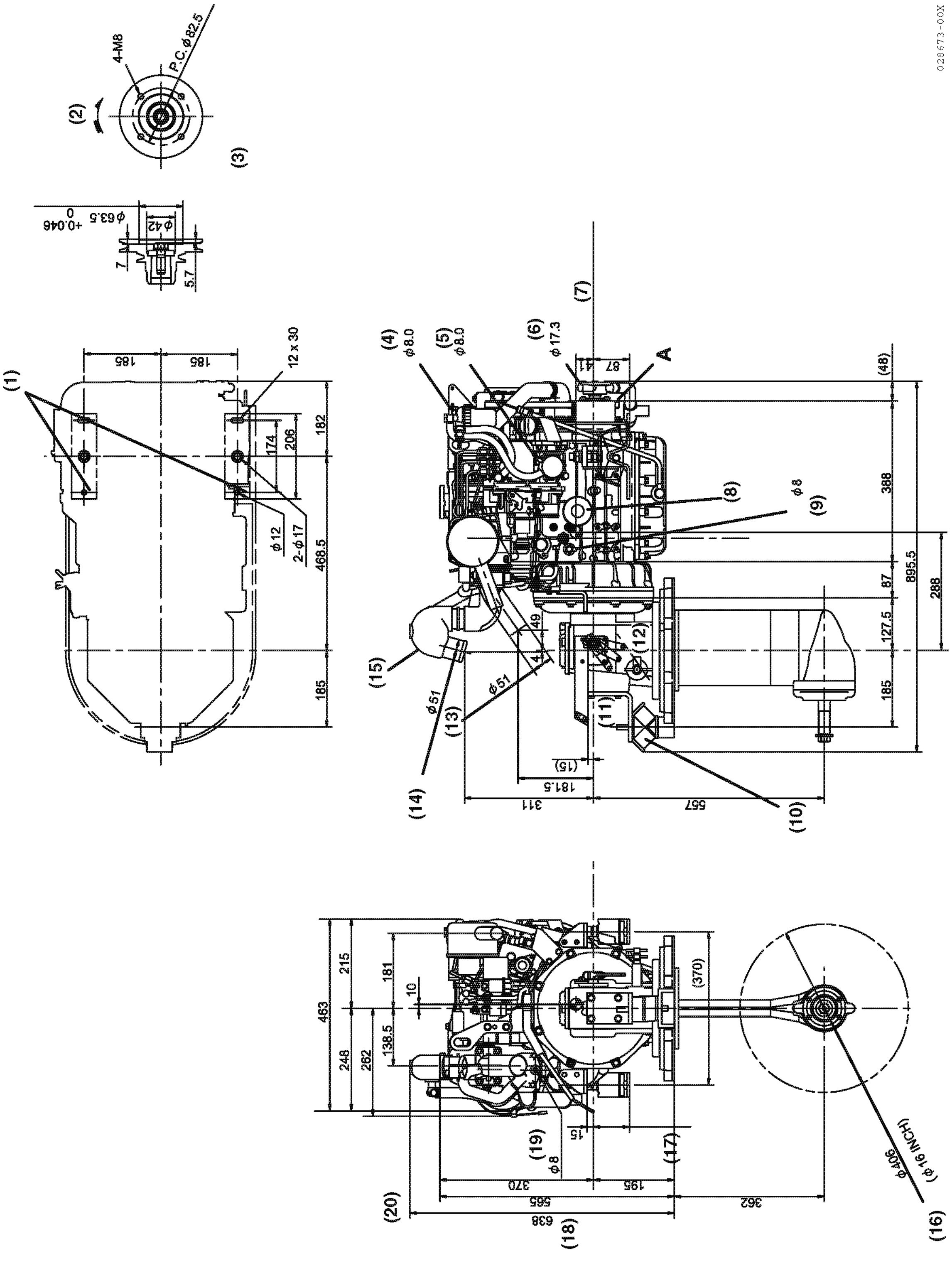


Figure 3-8

1 – Mounting Blocks ID #100
2 – Direction of Rotation
3 – Detail of Pulley A
4 – Fuel Overflow
5 – Fuel Inlet
6 – Seawater Inlet
7 – Crankshaft Center
8 – Engine Oil Filter
9 – Coolant Drain
10 – Mounting Block ID #230
11 – Astern
12 – Ahead
13 – Exhaust Pipe
14 – Exhaust Pipe
15 – U-Mixing Elbow (optional)
16 – Maximum Diameter of Prop
17 – Maximum = 101
Minimum = 87
18 – U-Mixing Elbow
19 – Seawater Drain
20 – 80A Alternator (optional)

Note:

- Drawing shows mounting blocks at original height.
- Engine weight will compress blocks by approximately 4.5 mm (0.18 in.).
- Mounting blocks are equipped for standard accessory.
- shows center of gravity.

3YM20 (With KM2P-1 Marine Gear)

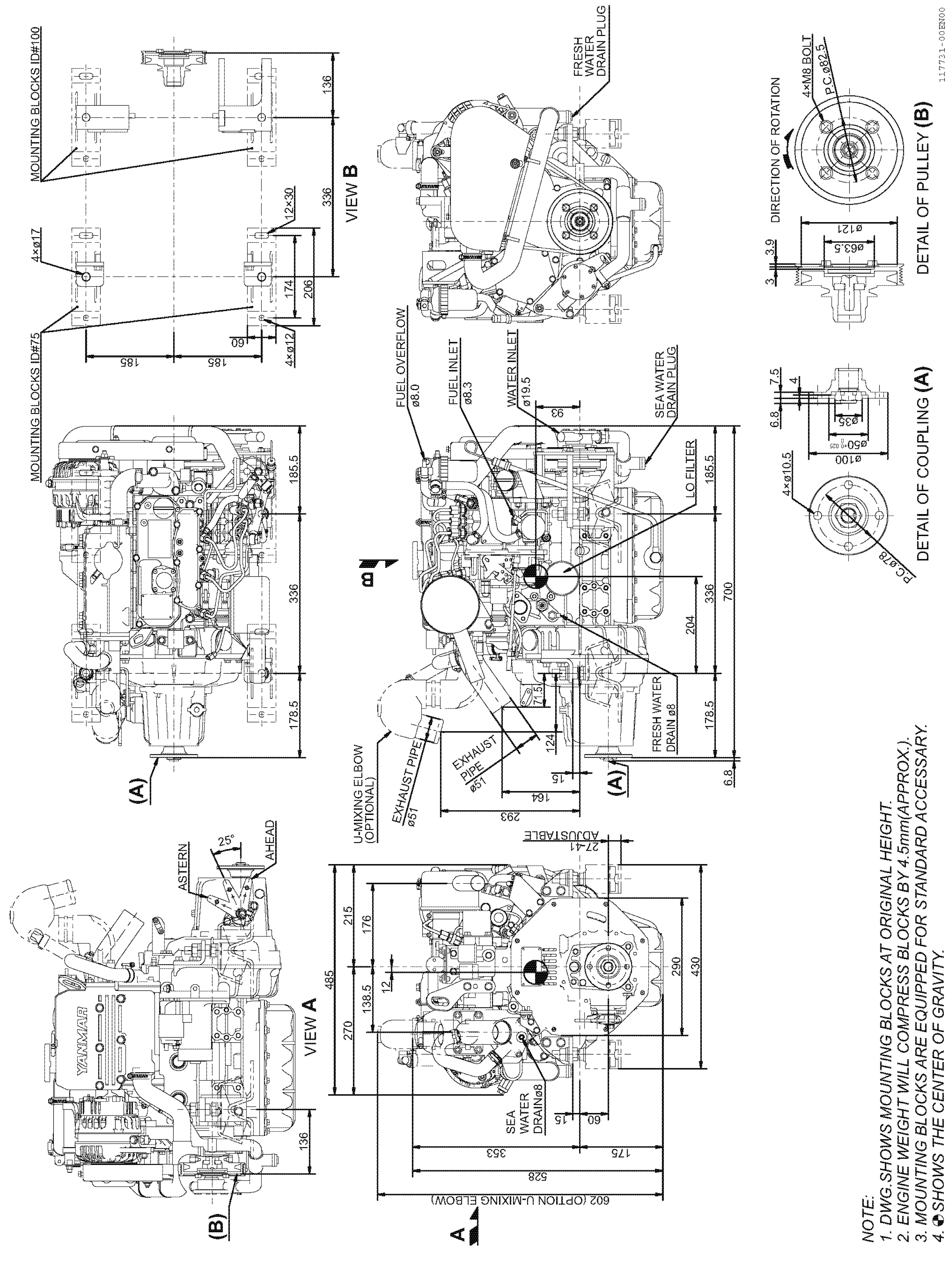


Figure 3-9

3YM20C (With SD20/SD25 Sail-Drive)

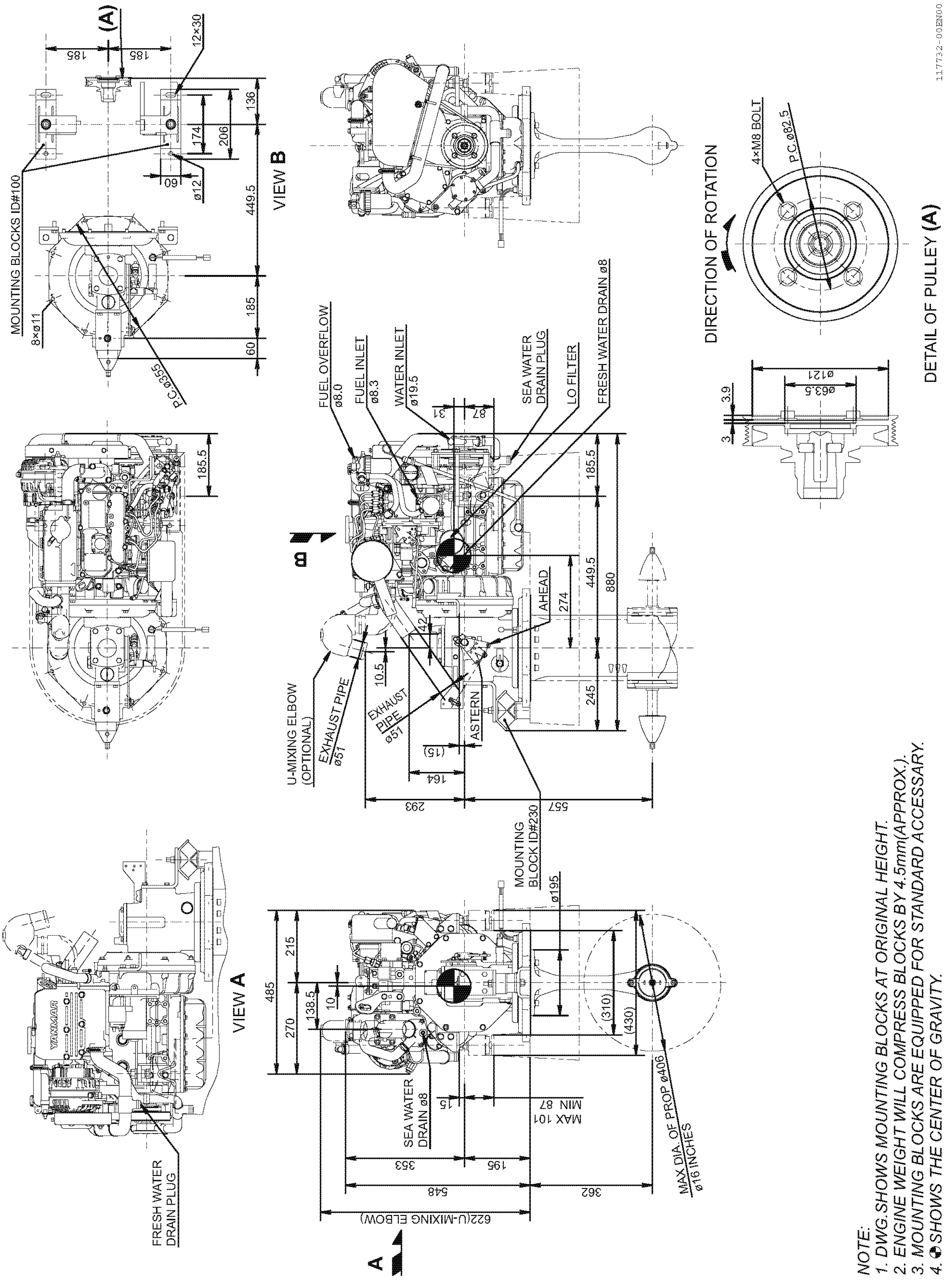


Figure 3-10

2YM15 (With KM2P-1 Marine Gear)

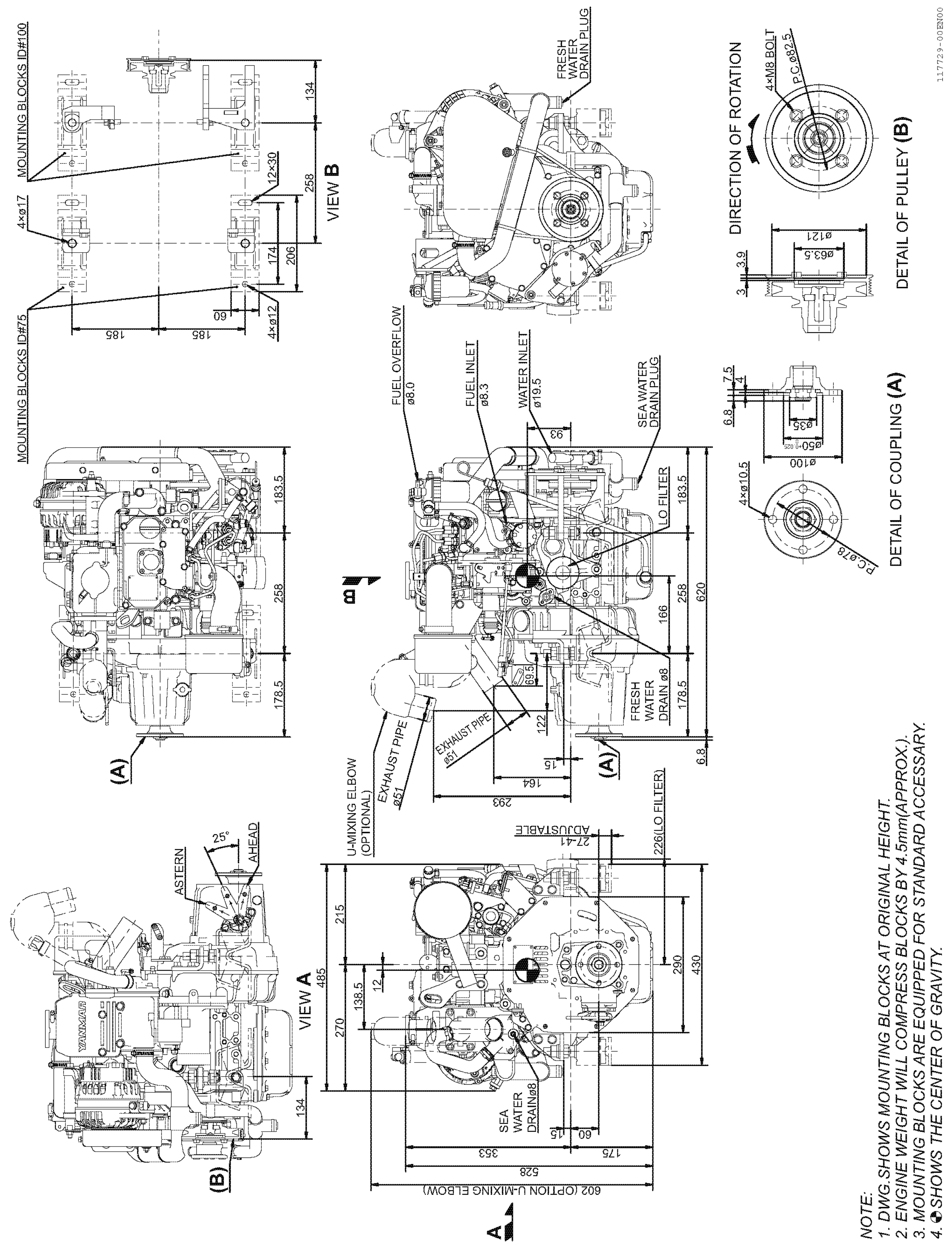


Figure 3-11

2YM15C (With SD20/SD25 Sail-Drive)

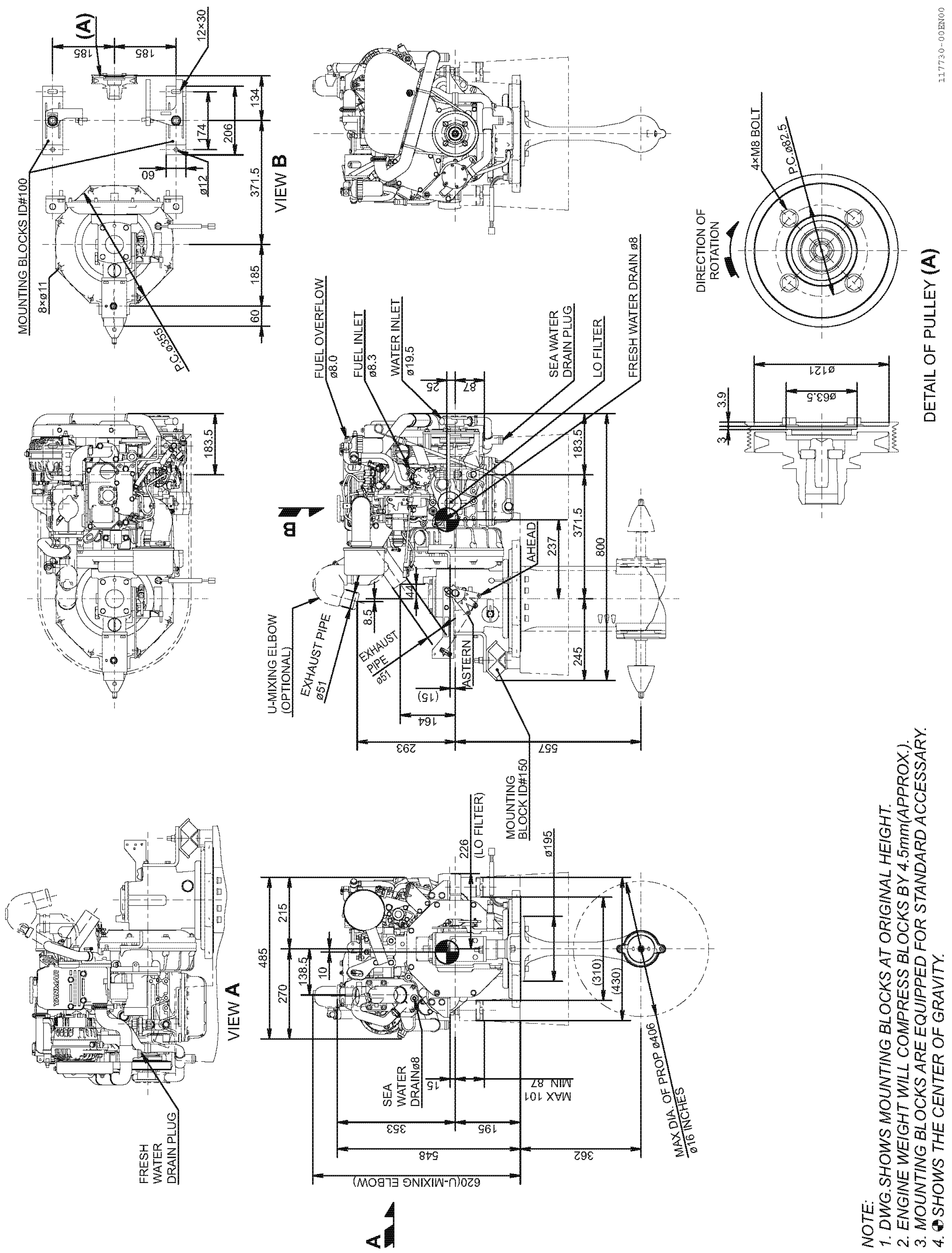


Figure 3-12

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PIPING DIAGRAMS

Piping diagrams and wiring diagrams are provided for reference only. Contact your authorized Yanmar Marine dealer or distributor for the most current diagrams.

Notation	Description
—|||—	Screw Joint (Union)
—||—	Flange Joint
—T—	Eye Joint
——<—	Insertion Joint
---------- ----------	Drilled Hole
----------	Coolant Piping
— - - — - - —	Seawater Piping
— - — - — -	Engine Oil Piping
————	Diesel Fuel Piping

Notes:

- Steel pipe shows OD x wall thickness, rubber hose shows ID x wall thickness.
- Rubber fuel lines meet EN/ISO7840.
- Unit: mm (in.)

2YM15 with KM2P-1 Marine Gear

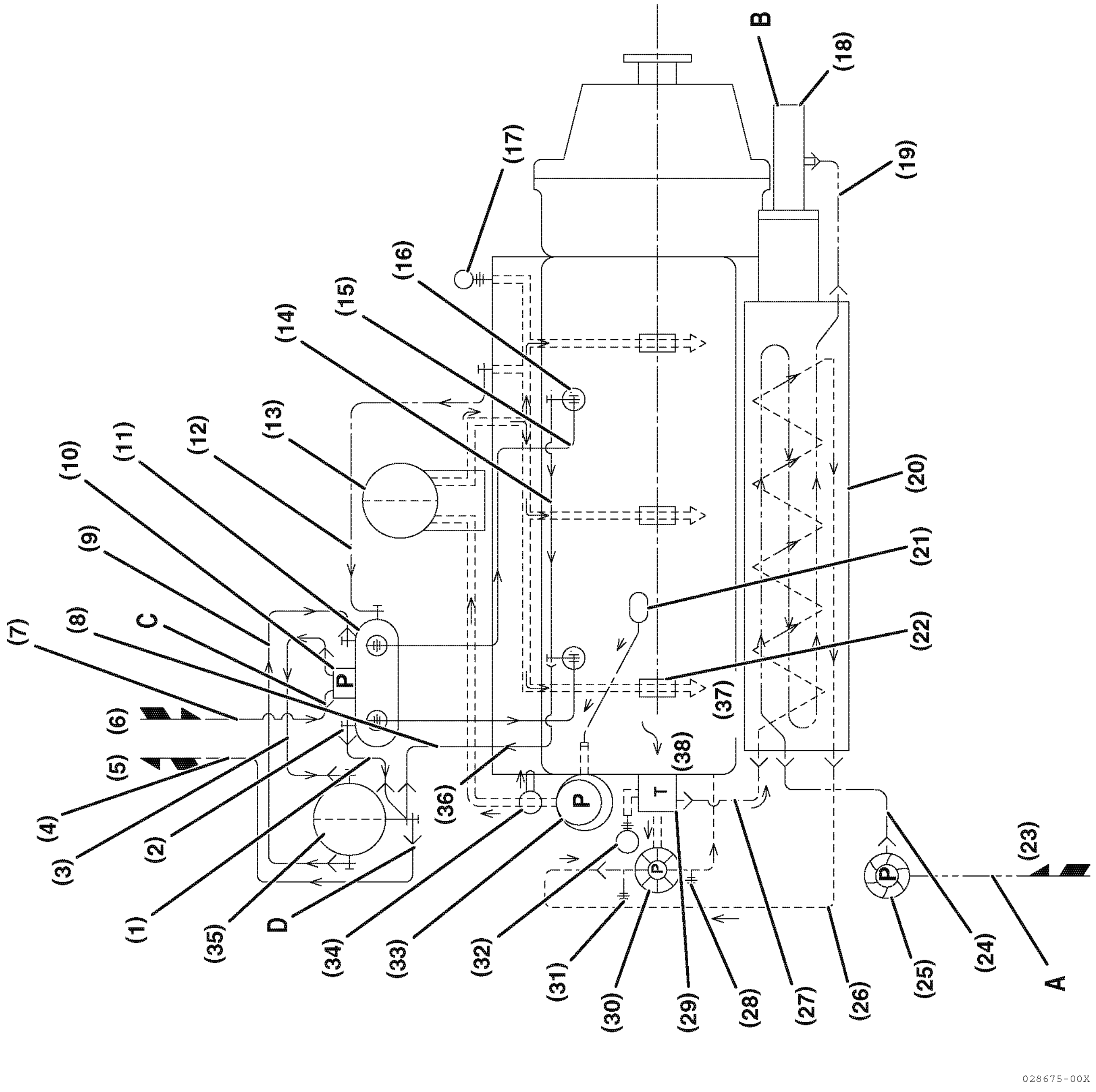
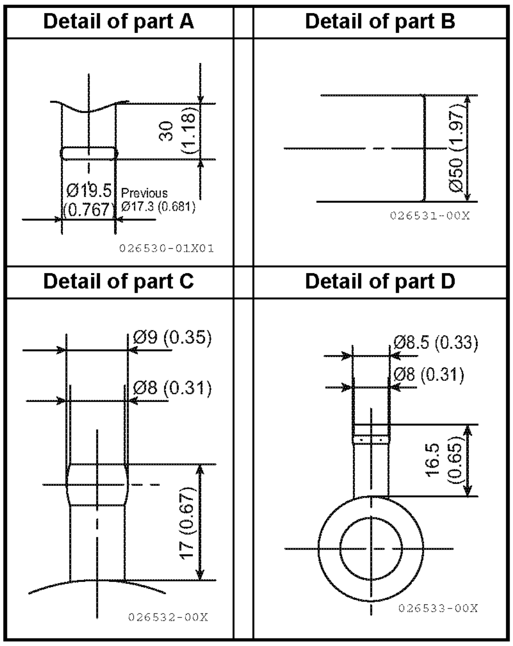


Figure 3-13

Unit: mm (in.)



1 – 7 x t4.5 Rubber Hose
2 – Check Valve
3 – 7 x t4.5 Rubber Hose
4 – 7 x t4.5 Rubber Hose
5 – Overflow
6 – Fuel Inlet
7 – 7 x t4.5 Rubber Hose
8 – 5 x t4.5 Rubber Hose
9 – 7 x t4.5 Rubber Hose
10 – Fuel Feel Pump
11 – Fuel Injection Pump
12 – 4.76 x t0.7 Steel Pipe
13 – Engine Oil Filter (cartridge type)
14 – 4.76 x t0.7 Steel Pipe
15 – Fuel High-Pressure Pipe
16 – Fuel Injection Nozzle
17 – Oil Pressure Switch
18 – Mixing Elbow
19 – 17 x 14 Rubber Hose
20 – Heat Exchanger
21 – Engine Oil Inlet Filter
22 – Main Bearing
23 – Seawater Inlet
24 – 17 x t4 Rubber Hose
25 – Seawater Pump
26 – 28 x t4 Rubber Hose
27 – 28 x t4 Rubber Hose
28 – Hot Water Connection Outlet (R3/8)
29 – Thermostat
30 – Coolant Pump
31 – Hot Water Connection Inlet (R3/8)
32 – Coolant Temperature Switch
33 – Engine Oil Pump
34 – Pressure Control Valve
35 – Diesel Fuel
36 – To Oil Pan
37 – To Camshaft
38 – From Cylinder Head

3YM20, 3YM30 and 3YM30AE with KM2P-1 Marine Gear

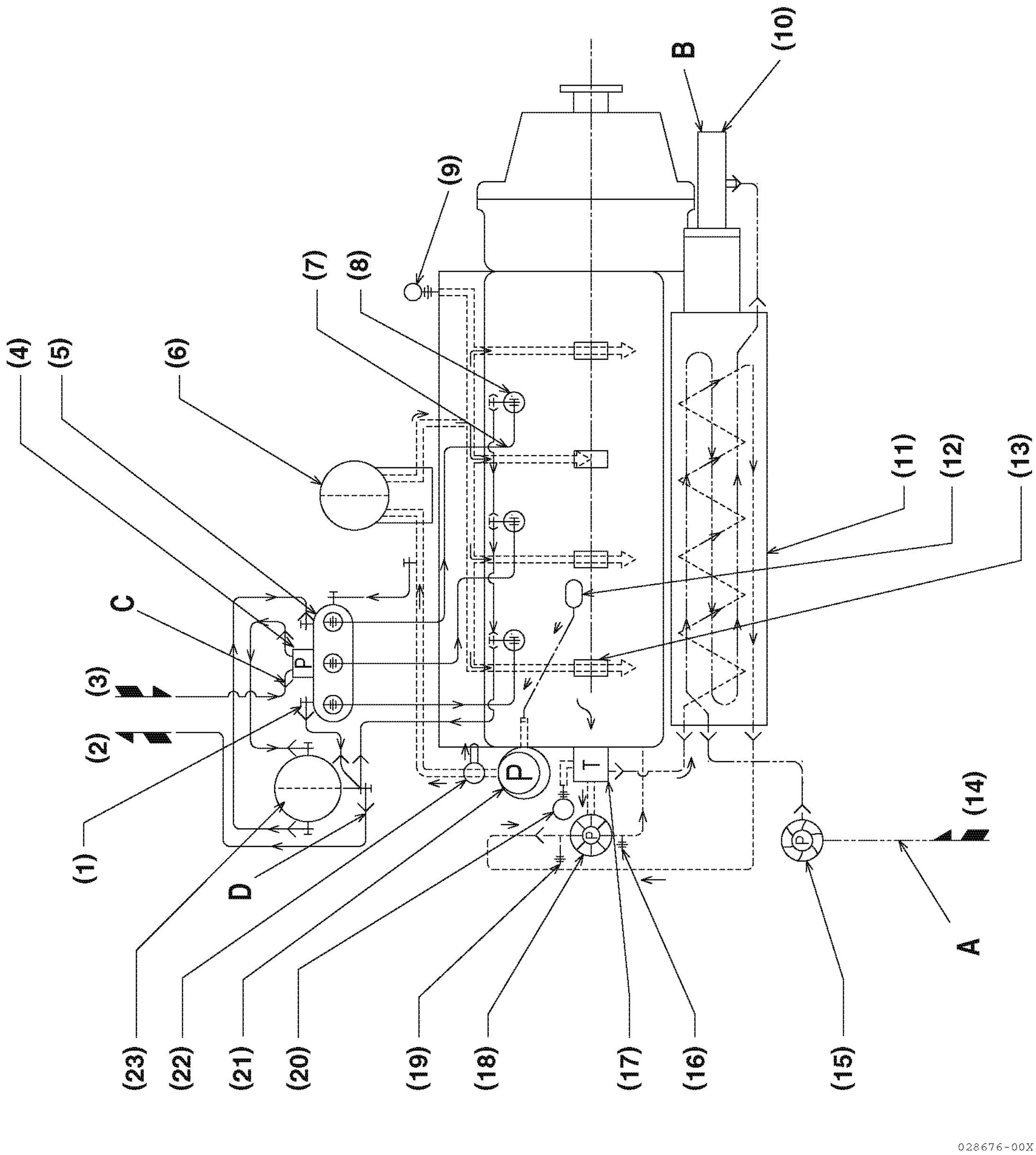
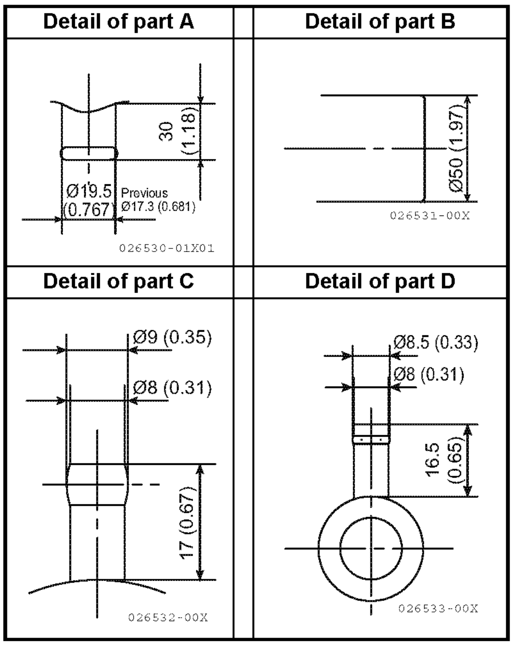


Figure 3-14

Unit: mm (in.)



1 – PCV
2 – Overflow
3 – Fuel Inlet
4 – Fuel Feed Pump
5 – Fuel Injection Pump
6 – Engine Oil Filter (cartridge type)
7 – Fuel High-Pressure Pipe
8 – Fuel Injection Nozzle
9 – Oil Pressure Switch
10 – Mixing Elbow
11 – Heat Exchanger
12 – Engine Oil Inlet Filter
13 – Main Bearing
14 – Seawater Inlet
15 – Seawater Pump
16 – Hot Water Connection Outlet
17 – Thermostat
18 – Coolant Pump
19 – Hot Water Connection Inlet
20 – Coolant Temperature Switch
21 – Engine Oil Pump
22 – Pressure Control Valve
23 – Fuel Filter
24 – To Oil Pan
25 – To Camshaft
26 – From Cylinder Head

3YM20C, 3YM30C and 3YM30AE-C with SD20/SD25 Sail-Drive

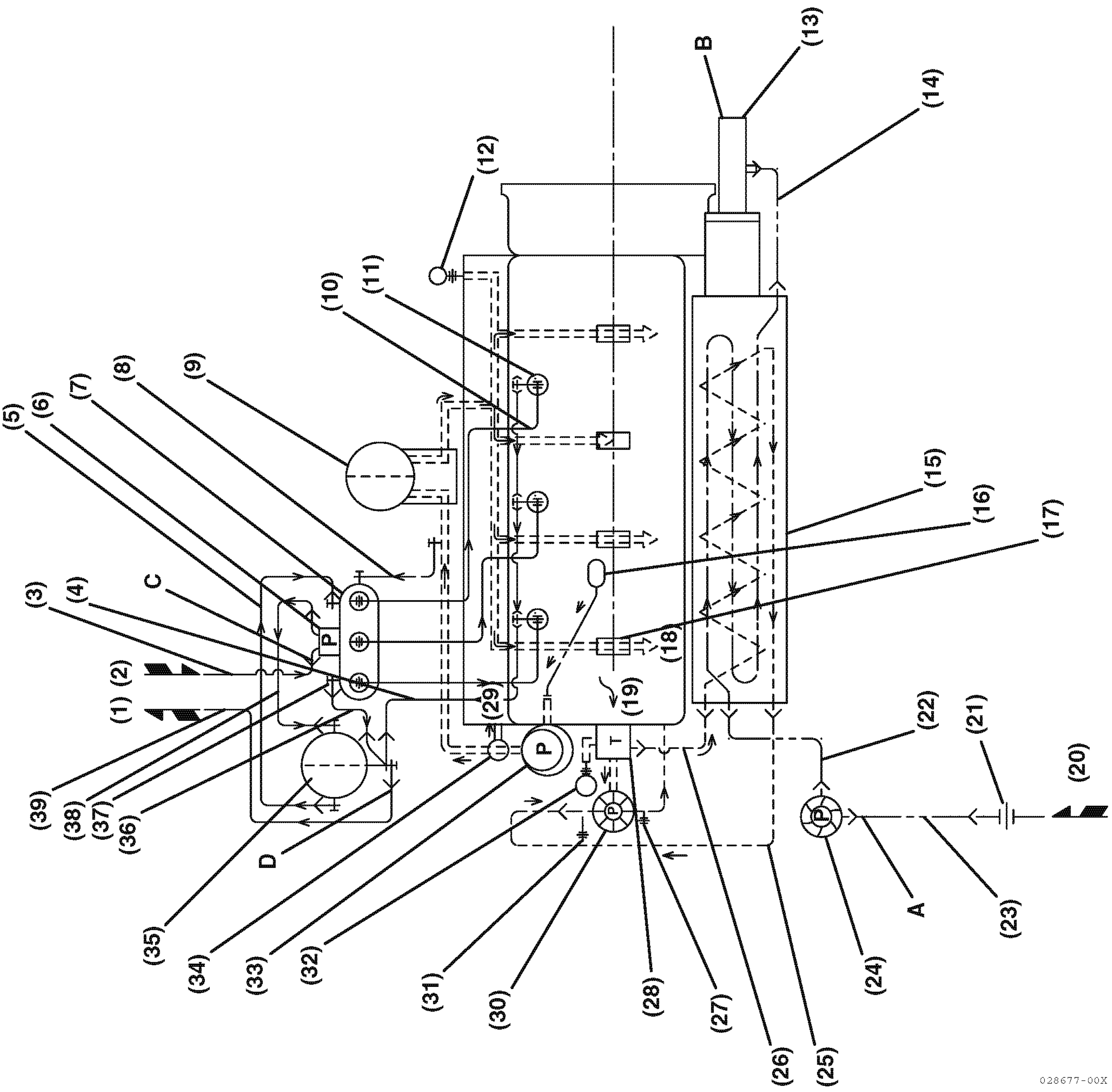
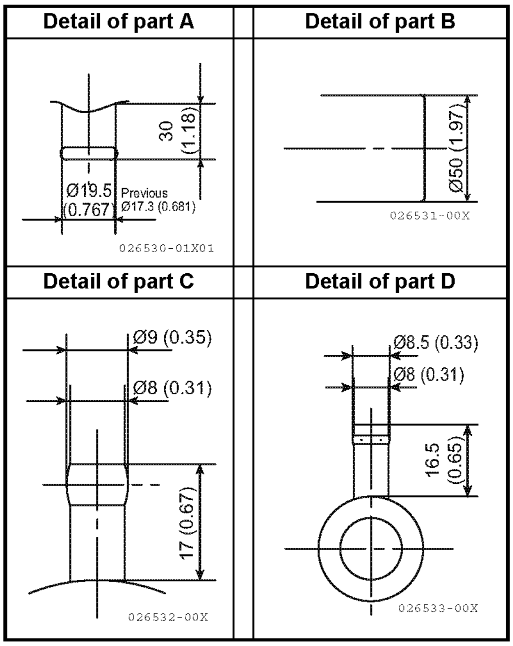


Figure 3-15

Unit: mm (in.)



1 – Overflow
2 – Diesel Fuel Inlet
3 – ※Ø 7.8 x t4.5 Rubber Hose*
4 – ※Ø 5 x t4.5 Rubber Hose
5 – ※Ø 7.8 x t4.5 Rubber Hose
6 – Fuel Feed Pump
7 – Fuel Injection Pump
8 – Ø 4.76 x t0.7 Steel Pipe**
9 – Engine Oil Filter (cartridge type)
10 – Fuel High Pressure Pipe
11 – Fuel Injection Nozzle
12 – Oil Pressure Switch
13 – Mixing Elbow
14 – Ø 17 x t4 Rubber Hose
15 – Heat Exchanger
16 – Engine Oil Inlet Filter
17 – Main Bearing
18 – To Camshaft
19 – From Cylinder Head
20 – Seawater Inlet
21 – From Drive
22 – Ø 17 x t4 Rubber Hose
23 – Ø 17 x t4 Rubber Hose
24 – Coolant Pump (seawater)
25 – Ø 28 x t4 Rubber Hose
26 – Ø 28 x t4 Rubber Hose
27 – Hot Water Connection Outlet (R3/8)
28 – Thermostat
29 – To Oil Pan
30 – Coolant Pump (fresh water)
31 – Hot Water Connection Inlet (R3/8)
32 – Coolant Temperature Switch
33 – Engine Oil Pump
34 – Pressure Control Valve
35 – Diesel Fuel Filter
36 – ※Ø 7.8 x t4.5 Rubber Hose
37 – Check Valve
38 – ※Ø 7.8 x t4.5 Rubber Hose
39 – ※Ø 7.8 x t4.5 Rubber Hose

* Dimension of rubber hose: inner diameter x thickness

** Dimension of steel pipe: outer diameter x thickness

Note: Fuel rubber hoses (marked ※) satisfy EN/ISO7840.

2YM15C with SD20/SD25 Sail-Drive

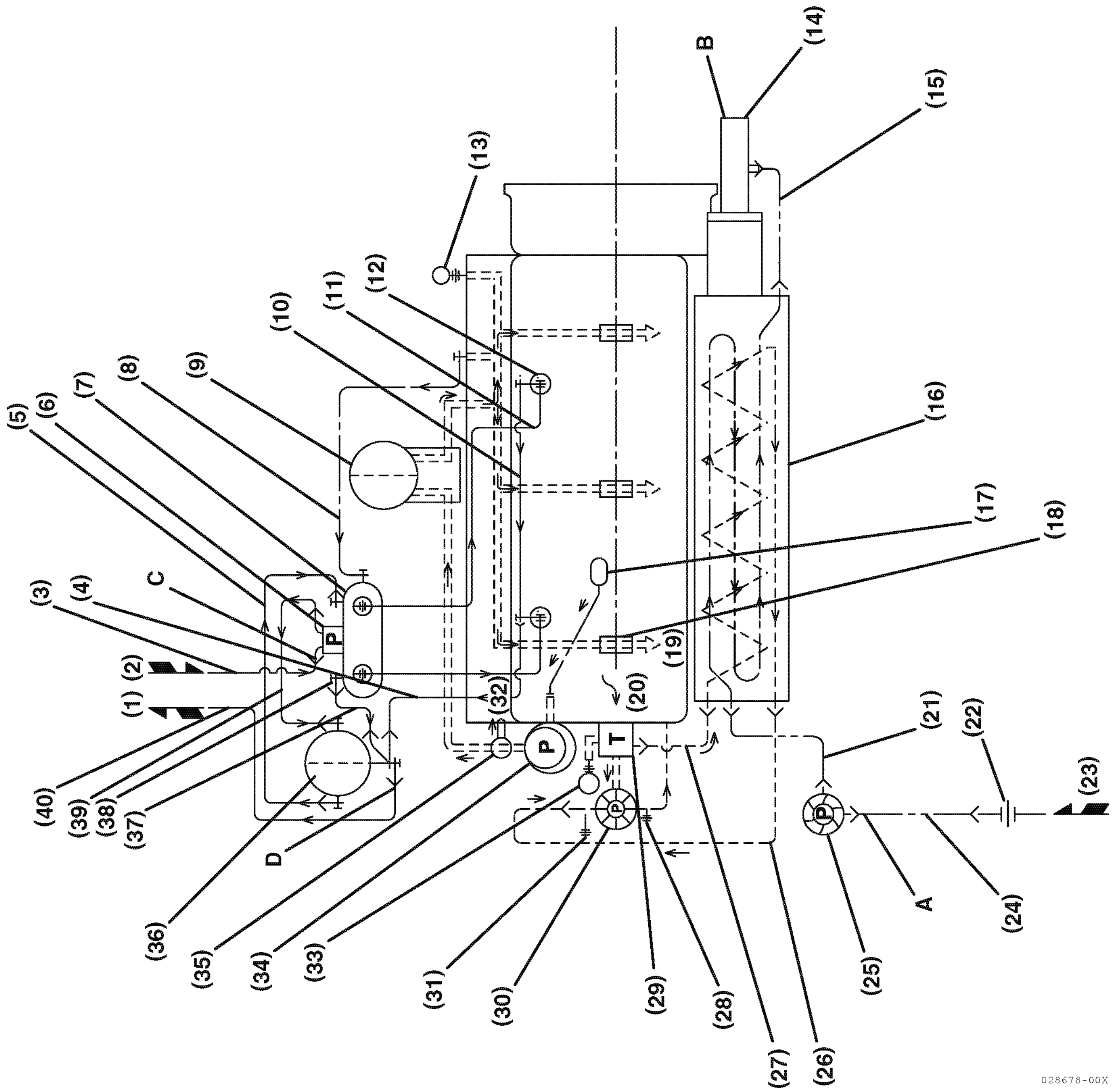
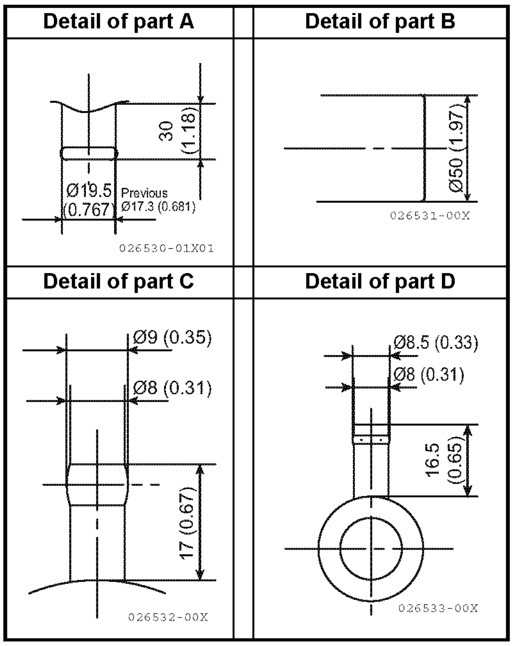


Figure 3-16

Unit: mm (in.)



1 – Overflow
2 – Diesel Fuel Inlet
3 – ※Ø 7 x t4.5 Rubber Hose*
4 – ※Ø 5 x t4.5 Rubber Hose
5 – ※Ø 7 x t4.5 Rubber Hose
6 – Fuel Feed Pump
7 – Fuel Injection Pump
8 – Ø 4.76 x t0.7 Steel Pipe**
9 – Engine Oil Filter (cartridge type)
10 – Ø 4.76 x t0.7 Steel Pipe
11 – Fuel High Pressure Pipe
12 – Fuel Injection Nozzle
13 – Oil Pressure Switch
14 – Mixing Elbow
15 – Ø 17 x t4 Rubber Hose
16 – Heat Exchanger
17 – Engine Oil Inlet Filter
18 – Main Bearing
19 – To Camshaft
20 – From Cylinder Head
21 – Ø 17 x t4 Rubber Hose
22 – From Drive
23 – Seawater Inlet
24 – Ø 17 x t4 Rubber Hose
25 – Coolant Pump (seawater)
26 – Ø 28 x t4 Rubber Hose
27 – Ø 28 x t4 Rubber Hose
28 – Hot Water Connection Outlet (R3/8)
29 – Thermostat
30 – Coolant Pump (fresh water)
31 – Hot Water Connection Inlet (R3/8)
32 – To Oil Pan
33 – Coolant Temperature Switch
34 – Engine Oil Pump
35 – Pressure Control Valve
36 – Diesel Fuel Filter
37 – ※Ø 7 x t4.5 Rubber Hose
38 – Check Valve
39 – ※Ø 7 x t4.5 Rubber Hose
40 – ※Ø 7 x t4.5 Rubber Hose

* Dimension of rubber hose: inner diameter x thickness

** Dimension of steel pipe: outer diameter x thickness

Note: Fuel rubber hoses (marked ※) satisfy EN/ISO7840.

EXHAUST GAS EMISSION REGULATIONS

3YM30AE, 3YM20 and 2YM15 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 / ARB)

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 / ARB)

EPA and ARB Emission Control Label for 2YM15

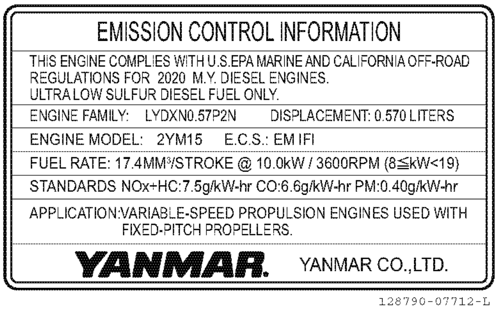


Figure 3-17

EPA and ARB Emission Control Label for 3YM20

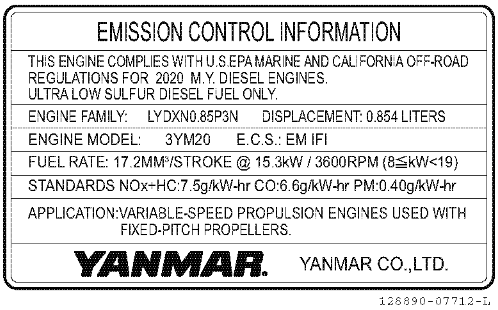


Figure 3-18

EPA and ARB Emission Control Label for 3YM30AE

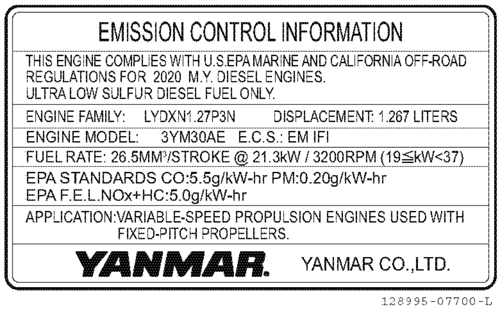


Figure 3-19

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

A tamper-resistant device is installed on EPA / ARB-certified 3YM30AE, 3YM20 and 2YM15 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

The engine family name is assigned by EPA / ARB and identifies the engine family group:

8 YDX N 1.11 P 3 N

- N – Air Aspiration Method
- 3 – Number of Cylinders
- P – Combustion Chamber Design
- 1.11 – Displacement (liter)
- N – Marine Engine
- YDX – Yanmar
- 8 – * 2008 Model Year

8*: 2008
9: 2009
A: 2010
B: 2011
C: 2012
D: 2013
E: 2014
F: 2015
G: 2016
H: 2017
J: 2018
K: 2019
L: 2020
M: 2021
N: 2022
P: 2023
R: 2024
S: 2025
T: 2026
V: 2027

Label Location

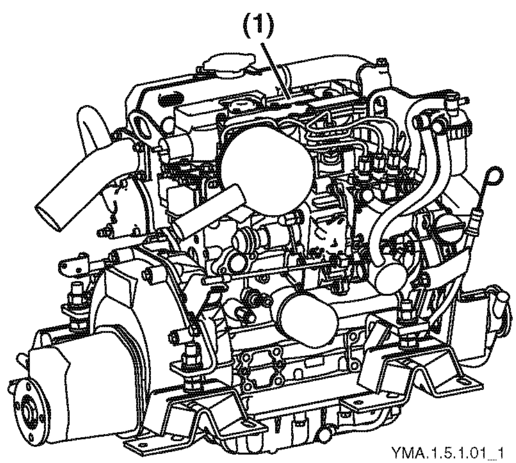


Figure 3-20

1 – EPA / ARB Emission Control Label

Exhaust Gas Emission Standard (EPA / ARB)

Engine Power	Tier	Model Year	NOx + THC	NMHC + NOx	CO	PM
8 <= kW < 19	Tier 1	2000	-	9.5	6.6	0.80
	Tier 2	2005	-	7.5	6.6	0.80
	EPA Marine Tier 3	2009	7.5	-	6.6	0.40
19<= kW < 37	Tier 1	1999	-	9.5	5.5	0.80
	Tier 2	2004	-	7.5	5.5	0.60
	EPA Marine Tier 3	2009	7.5	-	5.5	0.30
		2014	F.E.L. 5.0	-	5.5	0.20

NOTE:

- *The transit smoke (ACC / LUG / PEAK) is not applicable.*
- *The EPA recommended fuel is used.*
- *The ARB emission standard is the same as Tier 2 applied for 2009 year Model engines.*
- *The year to which a regulation is applicable is shown.*

Warranty Conditions for Emission Standard (EPA / ARB)

In addition to making sure that these conditions are met, check for any deterioration that may occur before the required periodic maintenance times.

Requirements for Engine Installation:

The EPA recommends the following maintenance schedule for emission-related parts:

Power Rating	Fuel Nozzle Cleaning	Adjustment, Cleaning, Fuel Nozzle Repairs, Fuel Pump, Electronic Control Unit, etc.
19 kW (25 hp) or less	Every 1500 hours	Every 3000 hours
19 to 37 kW (25 to 50 hp)	Every 1500 hours	Every 3000 hours

Warranty Period:

The warranty starts on either the date of delivery to the first end-user, or the date the unit is first leased, rented or loaned.

Engine Model	Warranty Period
2YM15, 3YM20 (kW < 19)	**30 months or 1,500 hours** of use, whichever comes first.
3YM30AE (19 ≤ kW < 37)	**60 months or 3,000 hours** of use, whichever comes first.

When a measurement device of use hours is not equipped, warranties apply a period of use months.

Engine Nameplate

The nameplate of the Yanmar YM series engine is shown in **Figure 3-21**. Check the engine's model, output, rpm and serial number on the nameplate. Replace it if it is damaged or lost.

The engine nameplate is attached to the engine rocker arm cover.

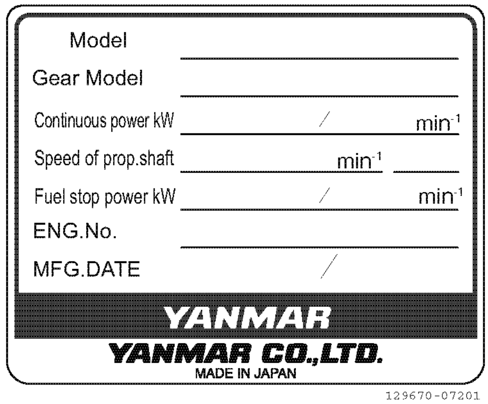


Figure 3-21

PRINCIPLE ENGINE SPECIFICATIONS

Official Engine Model Name		**3YM30AE**	
Company Internal Model Name		**3YM30AE**	**3YM30AE-C**
Marine Gear Model		**KM2P-1**	**SD20/SD25**
Use		Pleasure use	
Type		Vertical water-cooled 4-cycle diesel engine	
Combustion System		Indirect injection	
Air Charging		Naturally aspirated	
Number of Cylinders		3	
Bore x Stroke		80 x 84 mm (3.15 x 3.31 in.)	
Displacement		1.266 L (77.3 cu in.)	
Maximum Output	Output at Crankshaft / Engine Speed	* 21.3 kW (29 hp) / 3200 min^{-1} (at fuel temperature 40°C [104°F])	
	Output at Propeller Shaft / Engine Speed	* 20.7 kW (28.1 hp) / 3200 min^{-1} (at fuel temperature 40°C [104°F])	-
Installation		Flexible mounting	
Fuel Injection Timing		FID 17 ± 1 (FIC-Air: 19 ± 1) °BTDC	
Fuel Injection Opening Pressure		12.3 - 13.28 Mpa (1784 - 1926 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		Closed coolant system with heat exchanger	
Lubrication System		Complete enclosed forced lubrication system	
Coolant Capacity		Engine: 4.9 L (5.2 qt) Coolant recovery tank: 0.8 L (0.8 qt)	
Engine Oil Capacity	Rake Angle	at rake angle 8°	at rake angle 0°
	** Total	2.8 L (2.96 qt)	2.5 L (2.64 qt)
	*** Effective	1.4 L (1.48 qt)	1.5 L (1.59 qt)
Starting System	Type	Electric	
	Starting Motor	DC 12V-1.4 kW	
	Alternator	12V - 125A	
Engine Dimension	Overall Length	719 mm (28.3 in.)	
	Overall Width	485 mm (19.1 in.)	
	Overall Height	545 mm (21.5 in.)	
Engine Dry Mass (include marine gear)		133 kg (293 lb)	157 kg (346 lb) (with SD20/SD25)

* *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/cm3 at 15°C.
1 hp metric = 0.7355 kW

Official Engine Model Name		3YM30		3YM20	
Company Internal Model Name		**3YM30**	**3YM30C**	**3YM20**	**3YM20C**
Marine Gear Model		**KM2P-1**	**SD20/SD25**	**KM2P-1**	**SD20/SD25**
Use		Pleasure use			
Type		Vertical water-cooled 4-cycle diesel engine			
Combustion System		Indirect injection			
Air Charging		Naturally aspirated			
Number of Cylinders		3			
Bore x Stroke		76 x 82 mm (2.99 x 3.23 in.)		70 x 74 mm (2.76 x 2.91 in.)	
Displacement		1.115 L (68 cu in.)		0.854 L (52 cu in.)	
Maximum Output	Output at Crankshaft / Engine Speed	* 21.3 kW (29 hp) / 3600 min^{-1} (at fuel temperature 40°C [104°F])		* 15.3 kW (20.8 hp) / 3600 min^{-1} (at fuel temperature 40°C [104°F])	
	Output at Propeller Shaft / Engine Speed	* 20.7 kW (28.1 hp) / 3600 min^{-1} (at fuel temperature 40°C [104°F])	-	* 14.9 kW (20.2 hp) / 3600 min^{-1} (at fuel temperature 40°C [104°F])	-
Installation		Flexible mounting			
Fuel Injection Timing		FID 16 ± 1 (FIC-Air: 18 ± 1) °BTDC		FID 22 ± 1 (FIC-Air: 24 ± 1) °BTDC	
Fuel Injection Opening Pressure		12.3 - 13.28 Mpa (1784 - 1926 psi)			
Main Power Take Off		At flywheel end			
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern			
	Propeller Shaft (ahead)	Clockwise viewed from stern	-	Clockwise viewed from stern	-
Cooling System		Closed coolant system with heat exchanger			
Lubrication System		Complete enclosed forced lubrication system			
Coolant Capacity		Engine: 4.9 L (5.2 qt) Coolant recovery tank: 0.8 L (0.8 qt)		Engine: 4.1 L (4.3 qt) Coolant recovery tank: 0.8 L (0.8 qt)	
Engine Oil Capacity	Rake Angle	at rake angle 8°	at rake angle 0°	at rake angle 8°	at rake angle 0°
	** Total	2.8 L (2.96 qt)	2.5 L (2.64 qt)	2.7 L (2.85 qt)	2.4 L (2.53 qt)
	*** Effective	1.4 L (1.48 qt)	1.5 L (1.59 qt)	1.4 L (1.48 qt)	1.5 L (1.59 qt)
Starting System	Type	Electric			
	Starting Motor	DC 12V-1.4 kW			
	Alternator	12V-60A (12V-80A optional) until 2008 year 12V-80A (12V-60A optional) from 2009 year 12V-125A (Valeo Alternator from 2013 year)			
Engine Dimension	Overall Length	715 mm (28.1 in.)		693 mm (27.3 in.)	
	Overall Width	463 mm (18.2 in.)			
	Overall Height	545 mm (21.5 in.)		528 mm (20.8 in.)	
Engine Dry Mass (include marine gear)		133 kg (293 lb)	154 kg (339 lb) (with SD20/SD25)	130 kg (287 lb)	151 kg (333 lb) (with SD20/SD25)

* *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/cm3 at 15°C.
1 hp metric = 0.7355 kW

Official Engine Model Name		**2YM15**	
Company Internal Model Name		**2YM15**	**2YM15C**
Marine Gear Model		**KM2P-1**	**SD20/SD25**
Use		Pleasure use	
Type		Vertical water-cooled 4-cycle diesel engine	
Combustion System		Indirect injection	
Air Charging		Naturally aspirated	
Number of Cylinders		2	
Bore x Stroke		70 x 74 mm (2.76 x 2.91 in.)	
Displacement		0.570 L (35 cu in.)	
Maximum Output	Output at Crankshaft / Engine Speed	* 10.0 kW (13.6 hp) / 3600 min^{-1} (at fuel temperature 40°C (104°F))	
	Output at Propeller Shaft / Engine Speed	* 9.7 kW (13.2 hp) / 3600 min^{-1} (at fuel temperature 40°C (104°F))	-
Installation		Flexible mounting	
Fuel Injection Timing		FID 21 ± 1 (FIC-Air: 23 ± 1) °BTDC	
Fuel Injection Opening Pressure		12.3 - 13.28 Mpa (125 - 135 kgf/cm^2)	
Main Power Take Off		At flywheel end	
Direction of Rotation	Crankshaft	Counterclockwise viewed from stern	
	Propeller Shaft (ahead)	Clockwise viewed from stern	-
Cooling System		Closed coolant system with heat exchanger	
Lubrication System		Complete enclosed forced lubrication system	
Coolant Capacity		Engine: 3.0 L (3.17 qt), Coolant recovery tank: 0.8 L (0.85 qt)	
Engine Oil Capacity	Rake Angle	at rake angle 8°	at rake angle 0°
	** Total	2.0 L (2.11 qt)	1.8 L (1.90 qt)
	*** Effective	0.95 L (1.00 qt)	0.9 L (0.95 qt)
Starting System	Type	Electric	
	Starting Motor	DC 12V-1.4 kW	
	Alternator	12V-60A (12V-80A optional) until 2008 year 12V-80A (12V-60A optional) from 2009 year 12V-125A (Valeo Alternator from 2013 year)	
Engine Dimension	Overall Length	613 mm (24.1 in.)	
	Overall Width	463 mm (18.2 in.)	
	Overall Height	528 mm (20.8 in.)	
Engine Dry Mass (include marine gear)		115 kg (253 lb)	134 kg (295 lb) (with SD20/SD25)

* *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/cm3 at 15°C.
1 hp metric = 0.7355 kW

MARINE GEAR

The KM2P-1 marine gear is used with the 3YM30AE, 3YM30, 3YM20 and 2YM15 series engines.

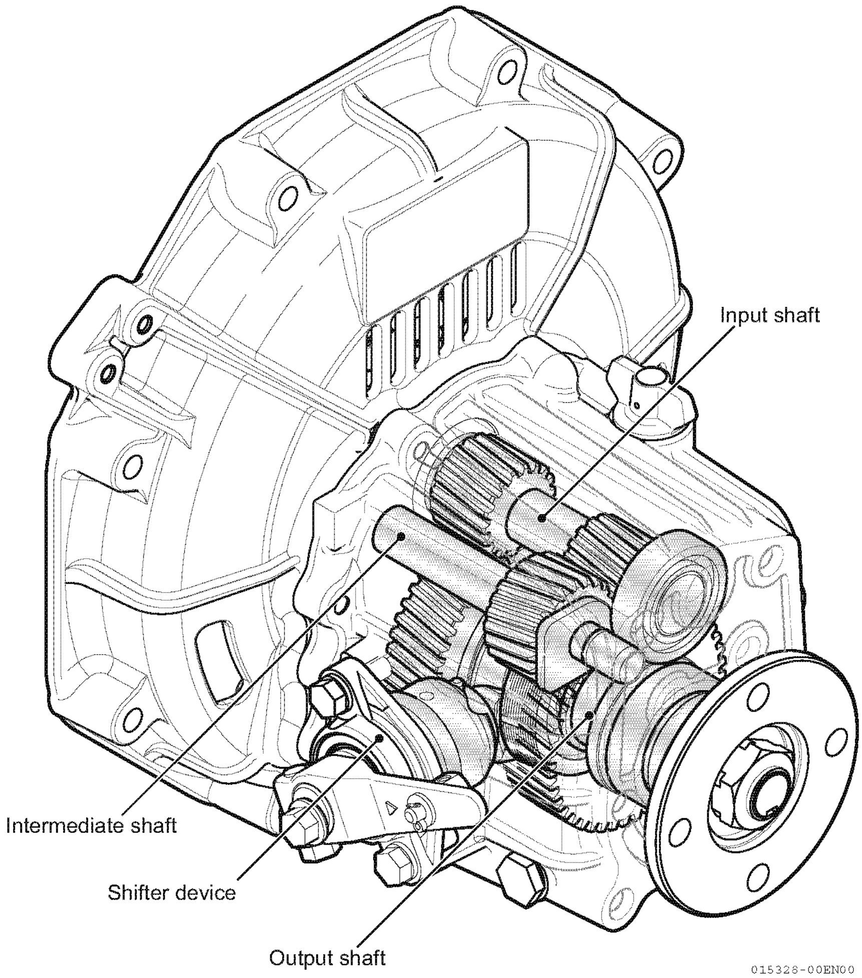


Figure 3-22

Marine Gear Specifications

Model			KM2P-1				
For Engine Models			3YM30AE		3YM30, 3YM20, 2YM15		
Clutch			Constant mesh gear with servo cone clutch (wet type)				
Reduction Ratio	Forward		2.21	2.62	2.21	2.62	3.22
	Reverse		3.06	3.06	3.06	3.06	3.06
Propeller Shaft Speed (at Continuous Power, Forward)			1404 min^{-1}	1184 min^{-1}	1580 min^{-1}	1332 min^{-1}	1083 min^{-1}
Direction of Rotation	Input Shaft		Counterclockwise, viewed from stern				
	Output Shaft	Forward	Clockwise, viewed from stern				
		Reverse	Counterclockwise, viewed from stern				
Remote Control	Control Head		Single lever control				
	Cable		Morse. 33-C Cable travel 76.2 mm (2.9999 in.)				
	Clamp		Yanmar-made standard accessory				
	Cable Connector		Yanmar-made standard accessory				
Output Shaft Coupling	Outer Diameter		100 mm (3.9369 in.)				
	Pitch Circle Diameter		78 mm (3.0708 in.)				
	Connecting Bolt Holes		4 to 10.5 mm (0.1574 to 0.4133 in.)				
Position of Shift Lever, Viewed from Stern			Left side				
Engine Oil			API CC class, SAE #10W30				
Engine Oil Capacity			0.3 L (0.3 qt)				
Dry Mass			9.8 kg (22 lb)				

Components

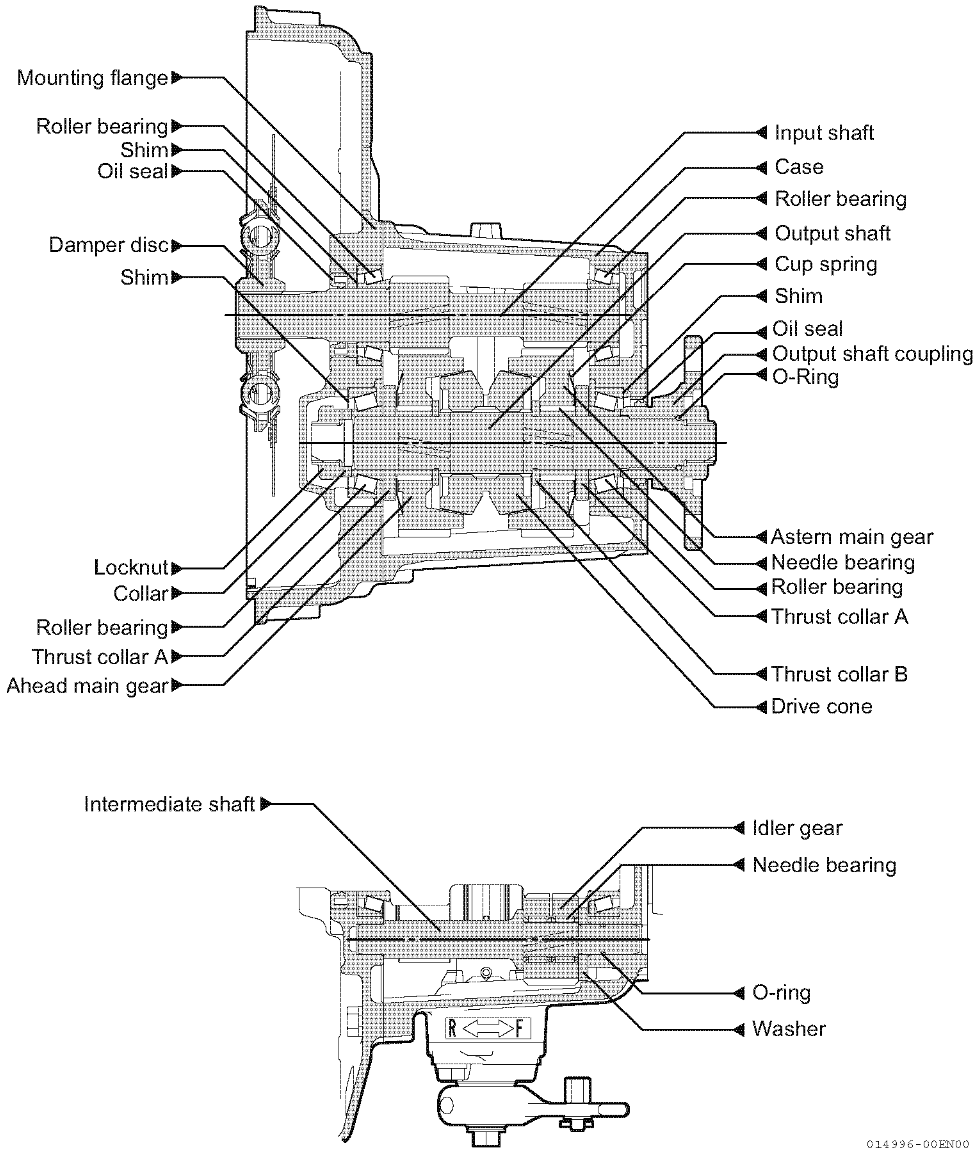


Figure 3-23

Power train

Ahead

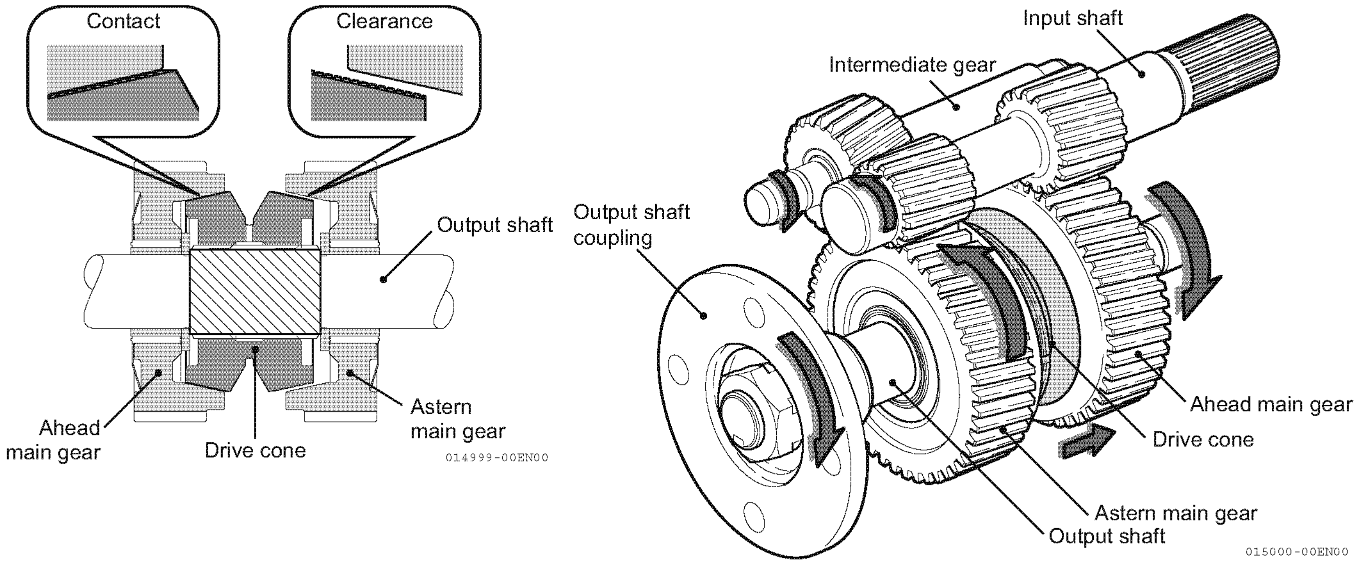


Figure 3-24

Astern

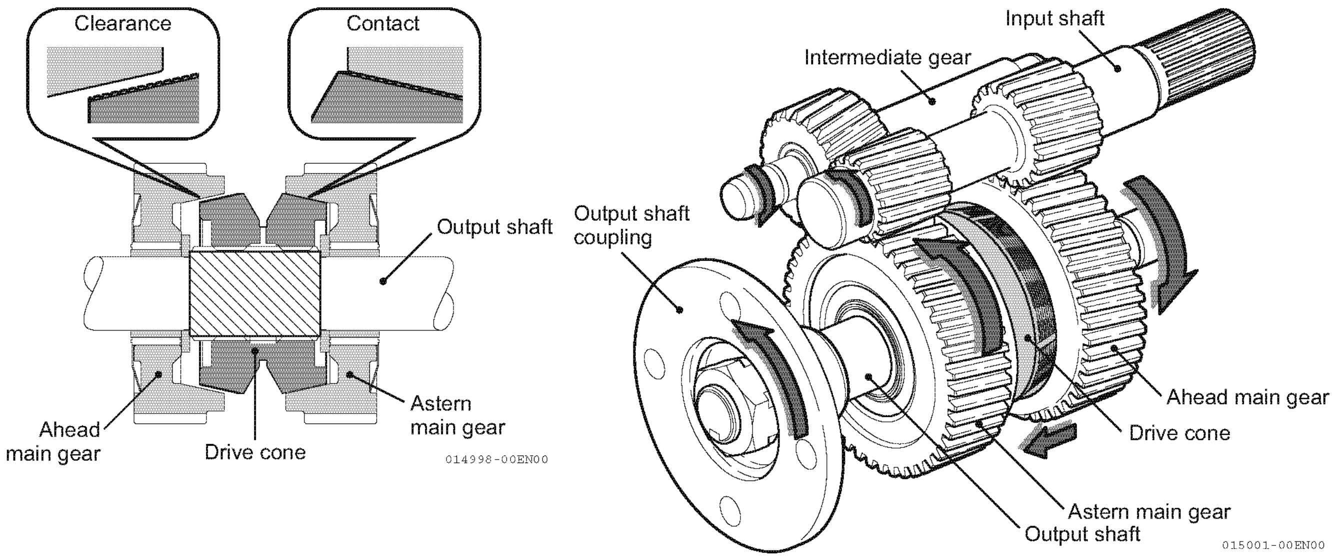


Figure 3-25

Neutral

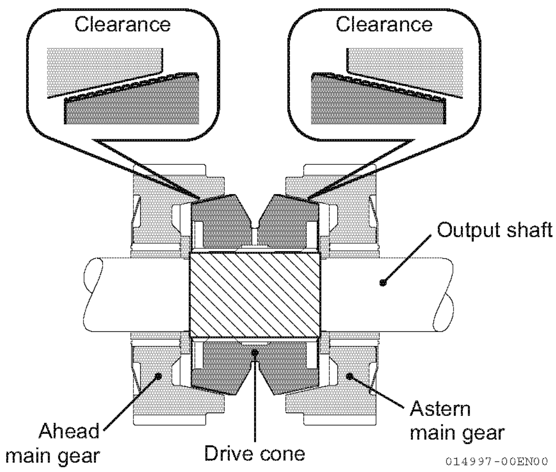
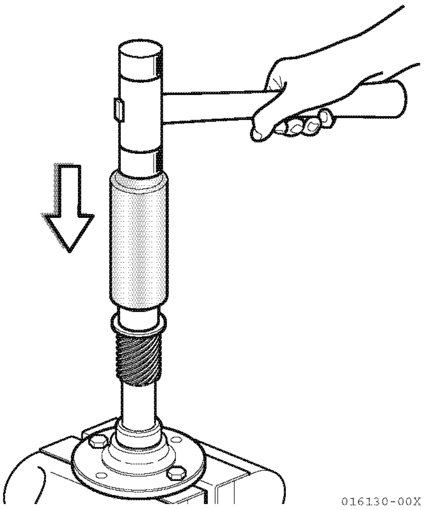


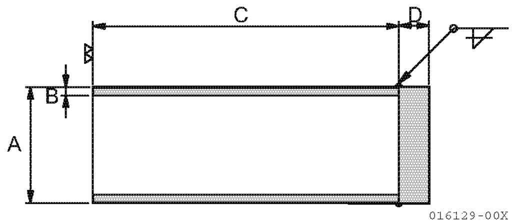
Figure 3-26

Special tools

Special tools

Inner race drive-in tool

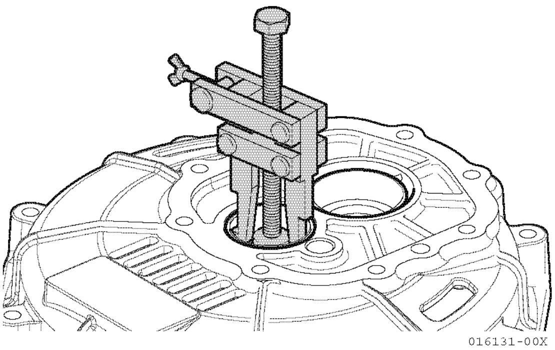


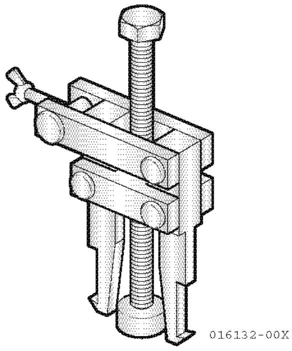


Part number: 177088-09150

A	B	C	D
Ø30±0.3	2±0.3	80	8

Bearing outer race remover tool





Part No.: 177088-09010

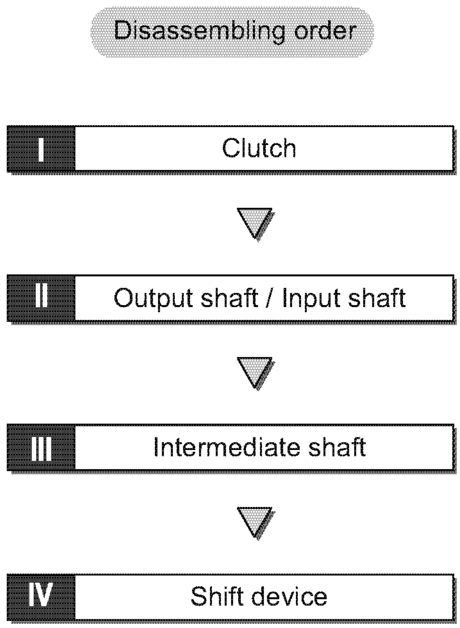
Disassembling the clutch

Preparations before work

- Prepare necessary disassembling tools, measuring instruments, and recording forms.
- Prepare the appropriate washing machine and washing cans.
- Prepare the appropriate space and containers to keep the parts.
- Drain the lubricating oil.
- Bolts and nuts should be reinstalled in the original positions, and lightly tighten them to prevent incorrect attachment of bolts and nuts with different materials and dimensions.
- When repairing a faulty engine, clearly identify the cause of the failure, and remove or disassemble only those parts that need repairs or replacement.

Disassembling orders

This section describes the procedures for disassembling the major assembly parts by dividing the procedures into four sequential processes. These procedures are applicable to overhauling at a maintenance shop.

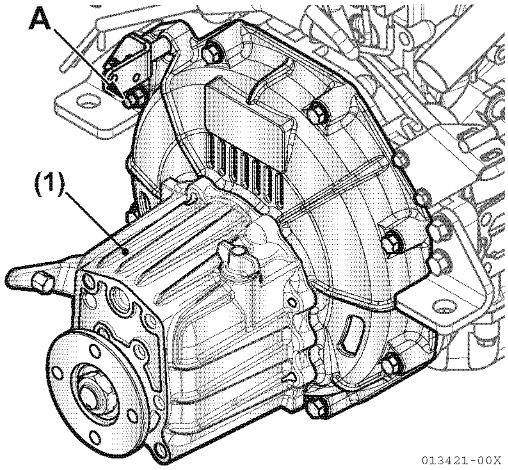
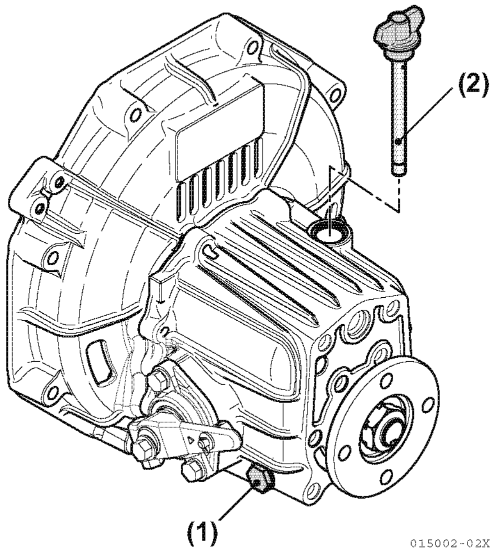
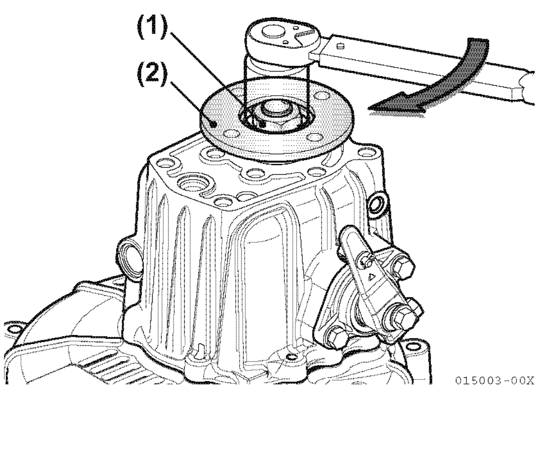


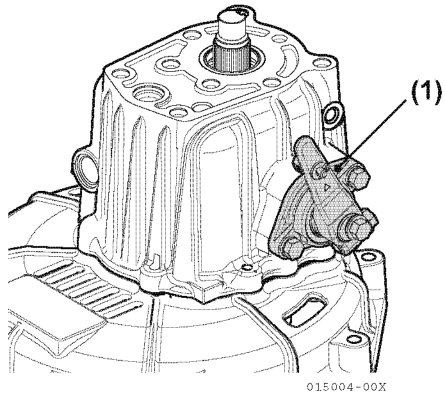
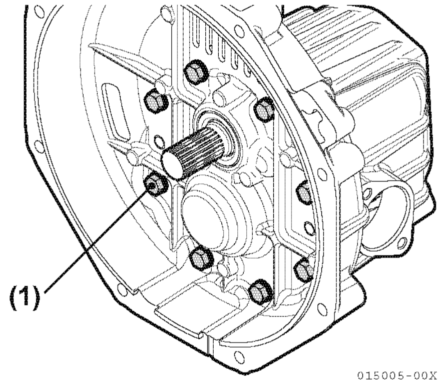
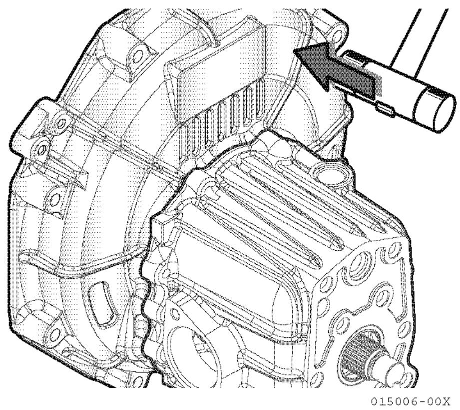
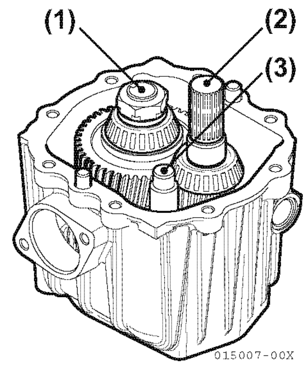
120385-00EN00

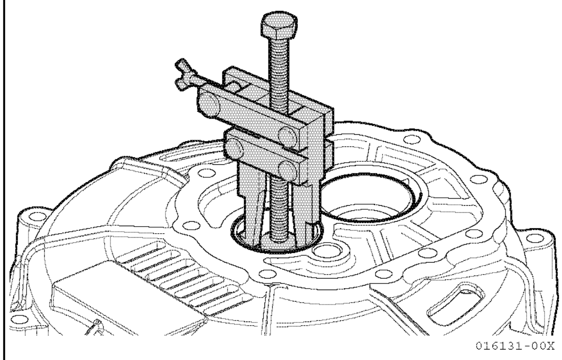
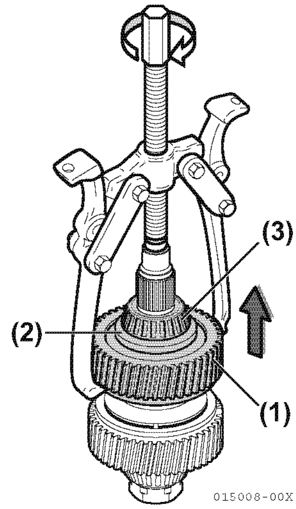
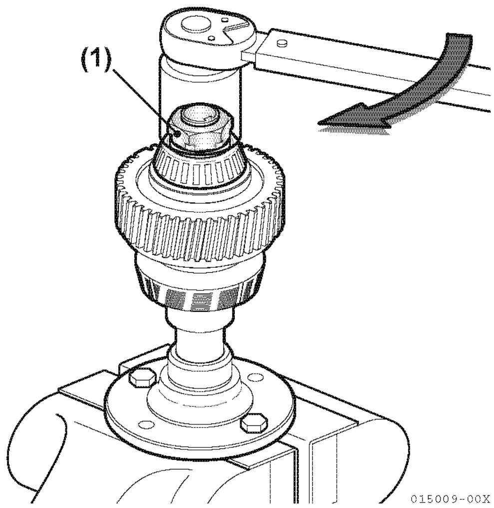
Figure 3-27

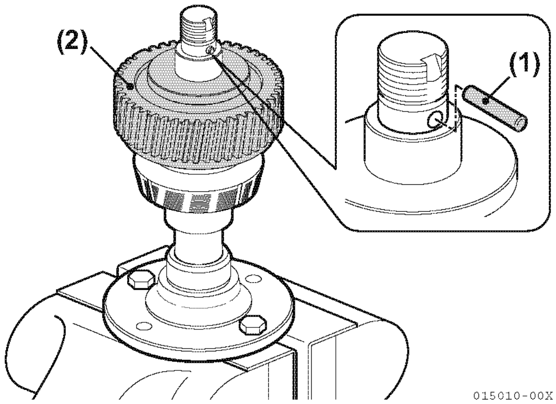
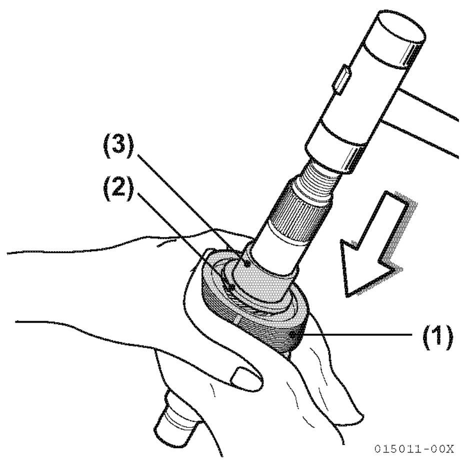
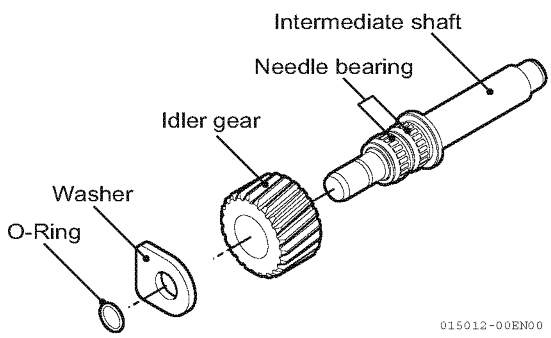
NOTICE

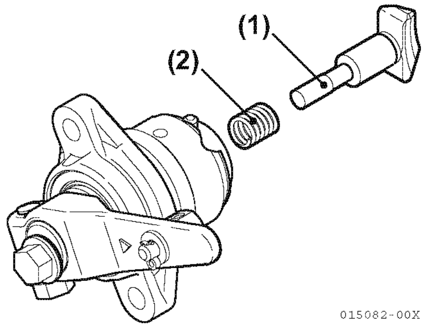
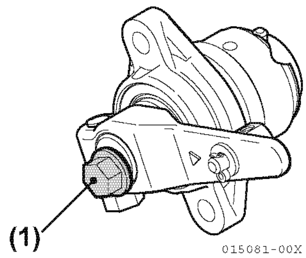
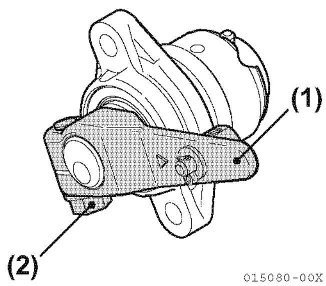
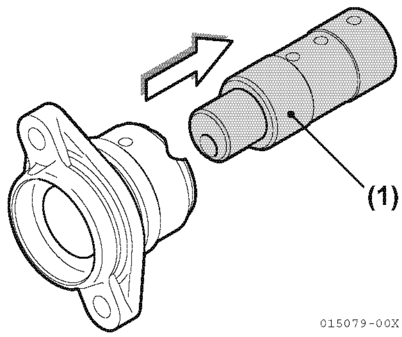
- Be sure to use specified tools.
- Openings of disassembled parts must be covered with a tape, clean cloth, or the like to keep them free of foreign matter. Be sure to remove those coverings before reassembling the parts.
- Disassembled parts should be kept in an organized manner to prevent damage or loss, and to ensure that they can be efficiently reassembled.

Step	Item and disassembling procedures	Illustration
I	**1. Clutch** 1. Remove the remote control cable. • Remove the bolts that couple the flanges of the clutch and engine, and then remove the clutch (1).	
	2. Lubricating oil 1. Remove the drain plug (1) at the bottom of the clutch case to drain the lubricating oil. • Place an oil container underneath the drain plug in advance. • Remove the oil dipstick in advance.	
	3. Output shaft coupling 1. Clamp the input shaft using a vice. • Engage the clutch into the astern position in advance. 2. Remove the locknut (1) on the coupling side. 3. Remove the output shaft coupling (2). **NOTICE** Note that the nut is left-hand screw.	

Step	Item and disassembling procedures	Illustration
I	**4. Shift lever assembly** 1. Remove the fixing bolts from the case, and then remove the shift lever assembly (1). 2. Remove the clutch (assembly) from the vice.	
	5. Mounting flange 1. Remove the bolts (1) that couple the mounting flange and case. • Lightly tap the areas where straight pins are attached alternatively using a plastic hammer or the like, and remove the mounting flange from the case.	 
	6. Clutch case 1. Pull out the output shaft assembly (1), input shaft assembly (2), and intermediate shaft assembly (3) from the case. • When pulling out the intermediate shaft, insert a bolt or spacer into the case's shaft hole, and lightly tap the shaft to remove it.	

Step	Item and disassembling procedures	Illustration
I	**7. Bearing and oil seal** 1. Using the special tool, remove the roller bearing outer race from the case. 2. Remove the input shaft oil seal from the mounting flange. 3. Using the same procedures as removal from the case, remove the roller bearing outer race from the mounting flange.	
II	**1. Output shaft assembly** 1. Clamp the locknut using a vice. 2. Using the remover tool, draw out the thrust collar A (2) and roller bearing (3) together with the main gear (1).	
	3. Insert two adequate bolts into the coupling's bolt holes, and clamp it using a vice. 4. Insert the output shaft spline into the coupling, and then loosen the locknut (1) using a torque wrench. **NOTICE** • Note that the nut is caulked to prevent looseness. • Note that the nut is left-hand screw.	

Step	Item and disassembling procedures	Illustration
II	5. Remove the collar. Insert the remover tool to the main gear, and pull out the roller bearing. 6. After removing the bearing, pull out the straight pin (1), and remove the main gear (2).	
	7. Lightly tap the shaft end using a plastic hammer while holding the drive cone with your hands, and then pull out the drive cone (1) together with the thrust collar B (2) and inner race (3). • If the drive cone cannot be pulled out, use the remover.	
III	**1. Intermediate shaft** 1. Remove the O-ring (1). 2. Remove the thrust washer (2). 3. Remove the idler gear (3). 4. The needle bearing (4) may be left attached unless it needs replacement.	

Step	Item and disassembling procedures	Illustration
IV	**1. Shift device**	
	1. Remove the shifter (1) and spring (2).	
	2. Remove the stopper bolt (1) for the shifter and shim.	
	3. Loosen the bolt (2) of the shift lever (1), and then remove the shift lever (1) from the shift lever shaft.	
	4. Remove the shift lever shaft (1) by pulling it away from the shift lever.	
	5. Remove the oil seal and O-ring.	

Assembling the clutch

Preparations before work

- Parts must be sufficiently cleaned and inspected before installation.
- Sliding or rotating portions must be lubricated with lubricating oil or specified lubricating agent before installation.
- Gaskets, copper gaskets, and other packings must be replaced with new ones.
- Use liquid gaskets as needed to prevent water or oil leak.
- Check oil clearances, thrust clearances, and other clearances while installing the parts.
- Parts with match marks must be installed in accordance with the match marks. For parts that must be selectively coupled, make sure that they are in a correct combination.
- Be sure to use correct bolts, nuts, washers, and tighten major bolts and nuts to the specified torques. Care must be taken especially when tightening aluminum alloy parts.
- For major bolts, apply lubricating oil to their threads and bearing surfaces and tighten them to the specified torques. (Do not use other lubricating agents or anti-seize agents.) Tools and replacement parts must be prepared in advance.

Assembling orders

- This section describes the procedures for disassembling the major assembly parts by dividing the procedures into four sequential processes. These procedures are applicable to overhauling at a maintenance shop.
- This chapter does not cover the details for inspecting and servicing the major assembly parts during installation, which are covered in *3-58* instead.

NOTICE

- Be sure to use Yanmar genuine or specified parts for replacement.
- Parts with stamped numbers (such as cylinder or bearing numbers) or match marks that indicate their installation positions must be reinstalled in their original positions. If you have replaced any such parts, be sure to apply the same markings to the new parts as the old parts.

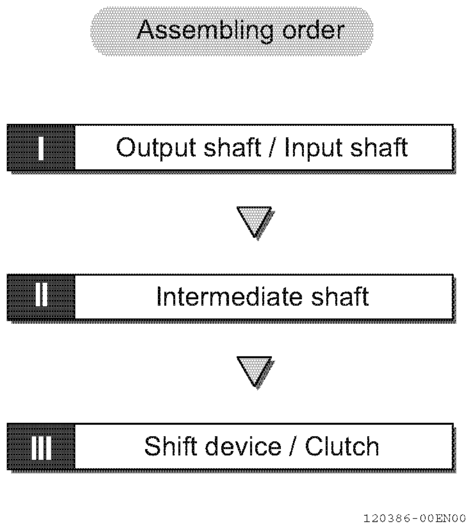
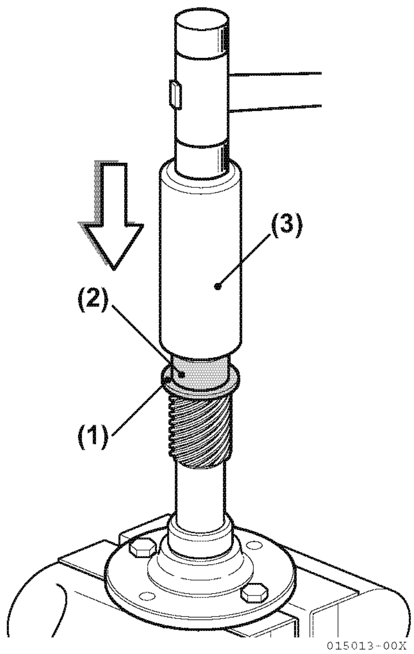
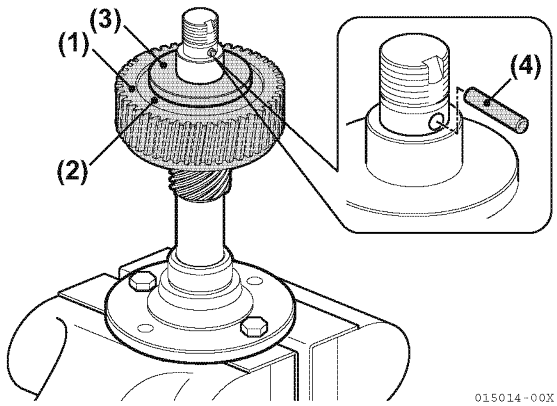


Figure 3-28

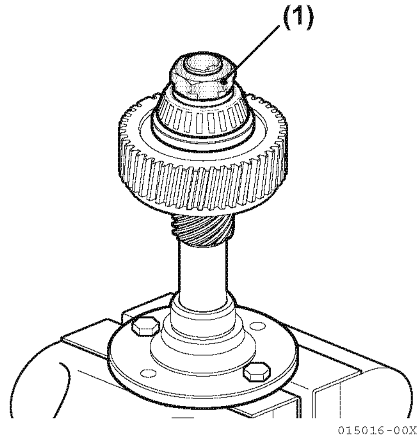
Step	Item/Assembling Procedures	Illustration
I	**1. Output shaft** 1. Temporarily install the output shaft spline to the coupling. Insert two adequate bolts into the coupling, and clamp it using a vice. 2. Install the ahead side thrust collar B (1) to the shaft. 3. Drive in the ahead side needle bearing's inner race (2). • Use the inner race drive-in tool (3).	
	4. Install the needle bearing to the ahead side main gear (1). • Make sure that the main gear turns lightly. • Install the cup spring (2). 5. Install the thrust collar A (3), and install the straight pin (4). 6. Insert the roller bearing using the drive-in tool. • Lightly drive it in. **NOTICE** • The pin must be driven in before inserting the bearing.	

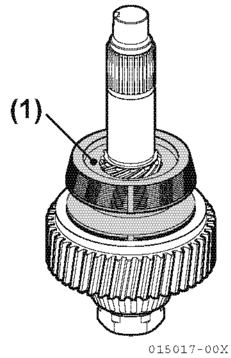
<table>
<tr><th>Step</th><th>Item/Assembling Procedures</th><th>Illustration</th></tr>
<tr><td>I</td><td>7. Install the collar, and tighten the nut (1) to the specified torque.

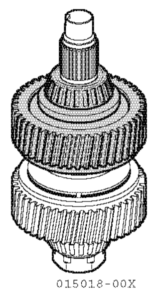
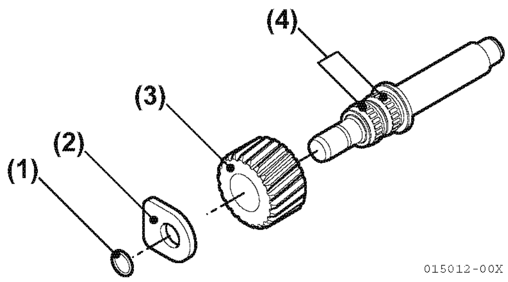
Tightening torque | 20±1.5 kgf·m

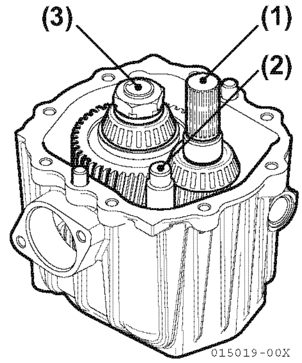
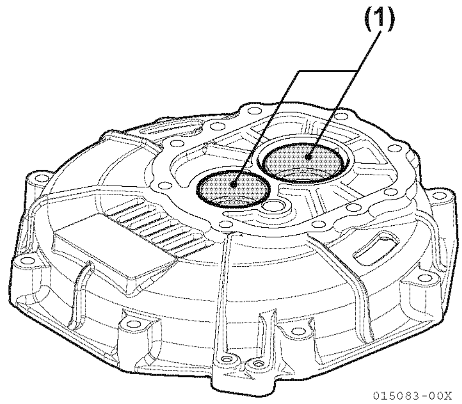
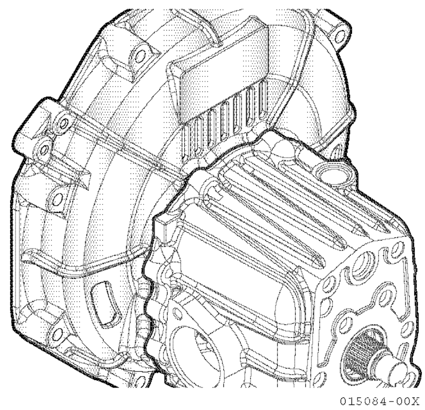
NOTICE
• Note that the nut is left-hand screw.

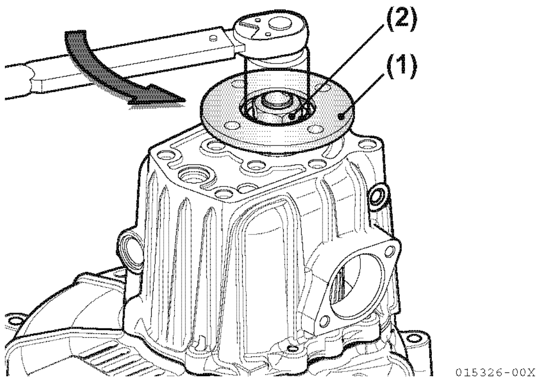
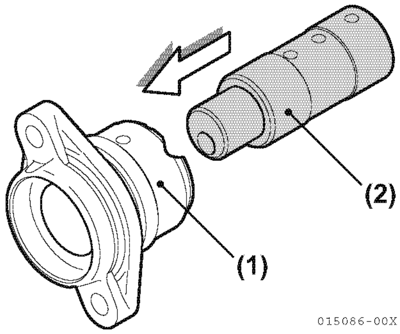
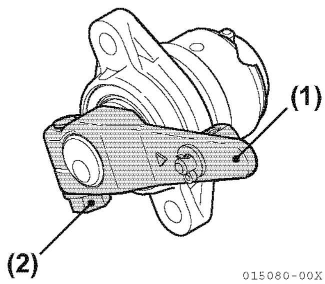
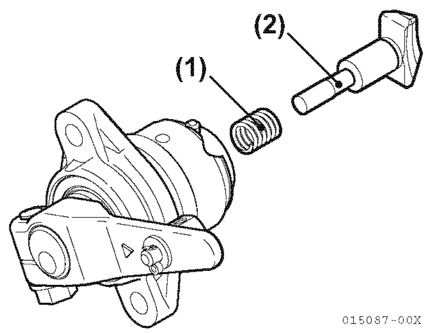
8. Using a chisel, lightly caulk the nut to prevent looseness.
• Stop it at the point where the shaft is notched.
9. Remove the output shaft assembly from the vice.
10.Install the drive cone (1) to the output shaft.

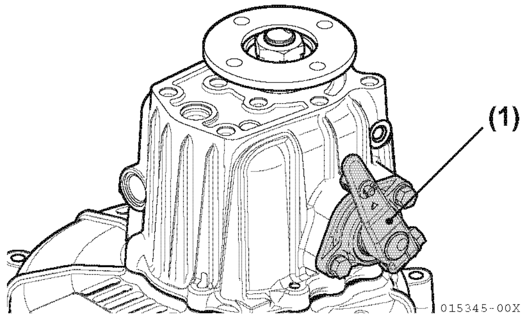
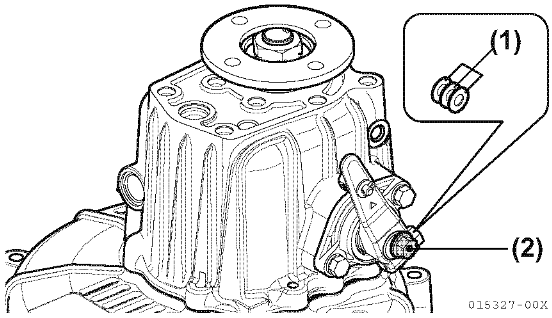
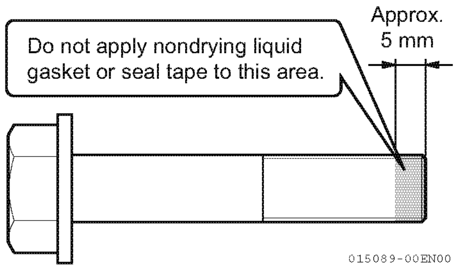
11.Assemble the astern side main gear, referring to the procedure for assembling the ahead side main gear.</td><td>




</td></tr>
<tr><td>II</td><td>1. Intermediate shaft
1. Install the needle bearing (1).
2. Install the idler gear (2).
3. Install the thrust washer (3).
4. Install the O-ring (4).</td><td>
</td></tr>
</table>

Step	Item/Assembling Procedures	Illustration
III	**1. Clutch case** 1. Install the oil seal, bearing outer race, and (output shaft side) shim to the clutch case. 2. Insert the input shaft (1) into the clutch case. 3. Insert the intermediate shaft (2) into the clutch case. • Insert the shaft while lightly tapping it. **NOTICE** • The intermediate shaft (2) cannot be installed unless the output shaft has already been installed to the clutch case. • Be sure to set the thrust washer in the correct position. 4. Insert the output shaft (3) into the clutch case. • The clearance adjusting shims are inserted between the case and the ahead side bearing of the input shaft and output shaft, so when replacing the main parts (such as a shaft bearing or collar), re-adjust the shims. (See *Adjusting the shims for the input and output shafts* page on 3-63)	
	2. Mounting flange 1. Insert the bearing outer race (1) into the mounting flange. **NOTICE** • Inserting the bearing outer face (1) can be done easily by heating the mounting flange to approximately 100°C or chilling the outer ring with liquid nitrogen. 2. Apply nondrying liquid gasket to the outer surface of the oil seal, and insert the oil seal into the mounting flange while setting the oil seal spring position facing to the case's inner surface. 3. Apply nondrying liquid gasket to the contacting faces of the mounting flange and case. 4. Insert the input shaft and output shaft into the shaft holes through the mounting flange. Set the mounting flange of the case, and install the bolts. **NOTICE** • Apply nondrying liquid gasket to the contacting faces of both the mounting flange and the case.	

Step	Item/Assembling Procedures	Illustration
III	**3. Output shaft coupling** 1. Install the output shaft coupling (1) to the output shaft, and install the O-ring. 2. Tighten the end nut using a torque wrench, and then caulk it. Note that the nut is left-hand screw. Tightening torque: 20±1.5 kgf·m	
	4. Shift device 1. Install the oil seal and O-ring to the side cover (1). 2. Insert the shift lever shaft (2) into the side cover.	
	3. Install the shift lever (1) to the shift lever shaft, and install the shift lever bolt (2). **NOTICE** • Check the triangle mark on the shift lever.	
	4. Insert the shifter spring (1) and shifter (2) into the shift lever shaft.	

Step	Item/Assembling Procedures	Illustration
III	5. Install the shift device (1) to the clutch case. **NOTICE** • Be sure to install the shifter (2) in the correct position. (Do not confuse between the top and bottom). *(See How to measure and adjust the clearance page on 3-56)*	
	6. Install the shims (1) and stopper bolt (2) to the shift lever shaft.	
	NOTICE • Apply nondrying liquid gasket or sealing tape to the thread of the stopper bolt.	

Shift device

The shift lever shaft, installed through the side cover, is used to shift among the neutral, ahead, and astern positions. The shift lever shaft has a positioning pin that is pushed outward by the shifter spring. When a shifting action to the neutral, ahead, or astern position is made, this positioning pin engages with one of the three grooves that corresponds to the new position. The shifter, installed to the shift lever shaft through an eccentric hole, moves the drive cone from the neutral position to the ahead or astern position, or from the ahead or astern position to the neutral position. (When the shift lever shaft is set into the ahead or astern position, the shift lever shaft slightly slides to either the shift lever or the drive cone).

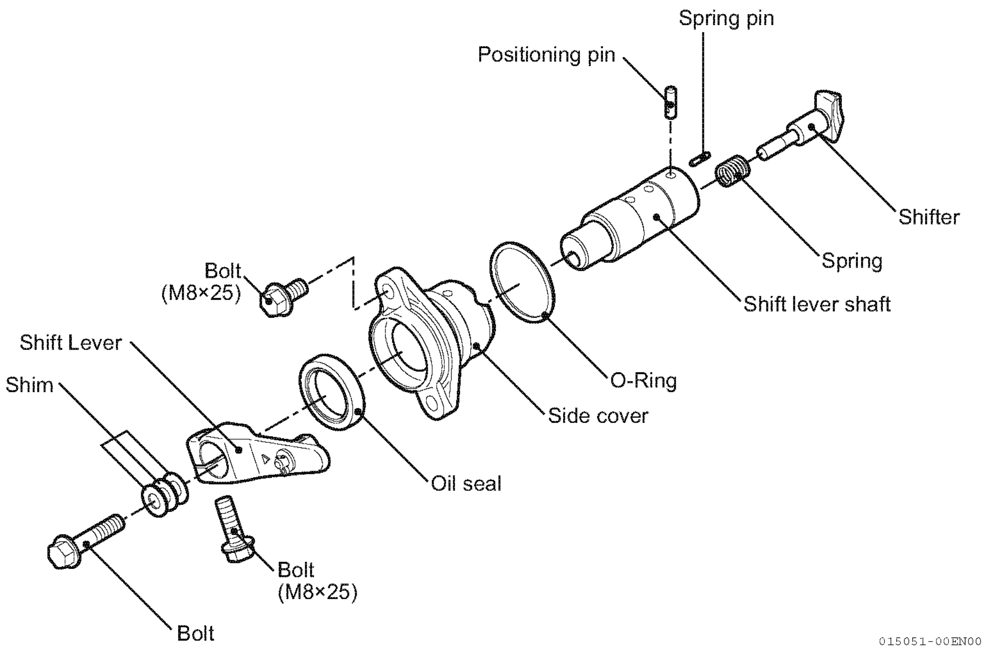


Figure 3-29

Feature of the shift device

- Engaging the clutch into the ahead or astern position
  (Neutral - Ahead, Neutral - Astern)
  As the shift lever is moved from the neutral position to the ahead position, the shift lever shaft begins turning and the positioning pin is disengaged from the neutral position V groove on the side cover. (At this time, the shift lever shaft slides by approximately 0.5 mm to the drive cone). When this takes place, the shifter installed eccentrically to the shift lever shaft moves the drive cone's V groove to the ahead main gear. Once the shift lever shaft's positioning pin engages with the ahead position groove on the side cover (with the shift lever shaft having slid approximately 3 mm to the shift lever), the shifter begins pressing, with the spring force, the drive cone's V groove to the ahead main gear.

Neutral position (V groove)

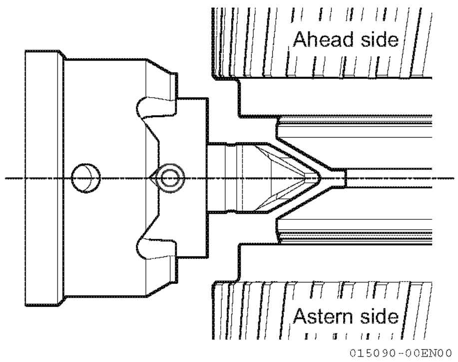


Figure 3-30

- Clutch on/off actions
  (Ahead - Neutral, Astern - Neutral)
  As the shift lever is moved from the ahead position to the neutral position, the shift lever shaft begins turning and the positioning pin is disengaged from the ahead position V groove on the side cover. (At this time, the shift lever shaft slides by approximately 3mm to the drive cone). When this takes place, the shifter installed eccentrically to the shift lever shaft moves to the neutral position (the astern main gear). However, the drive cone remains engaged with the ahead main gear because of the torque generated by the centrifugal force of its rotation.

Ahead

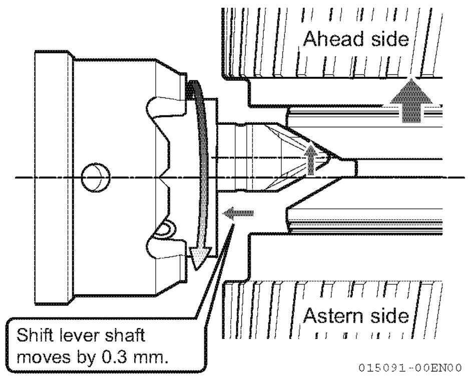


Figure 3-31

- The shift lever shaft continues to rotate. Once the positioning pin engages with the neutral position V groove on the side cover (with the shift lever shaft moves approximately 0.5 mm to the shift lever), the shifter slides toward the shift lever (spring), thereby moving the V groove on the drive cone to the astern main gear. The shifter stops sliding to the shift lever when its end comes into contact with the stopper bolt. The shifter then moves in such a way that it presses the drive cone's V groove to the astern main gear, whereby the drive cone is disengaged from the ahead main gear. Once this clutch-off action takes place, the torque transmitted by the drive cone falls to zero, and the shift lever gets returned to the neutral position by the spring force.

Astern position

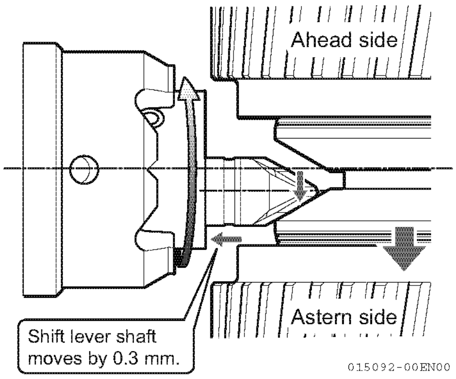


Figure 3-32

- Adjusting the shift device
  If you have removed any of the side cover, shift lever, stopper bolt, and/or drive cone, adjust the clearance between the shifter end and stopper bolt using the shims. Without this clearance properly adjusted, the drive cone might not work properly when the shift lever is moved from the ahead or astern position to the neutral position.

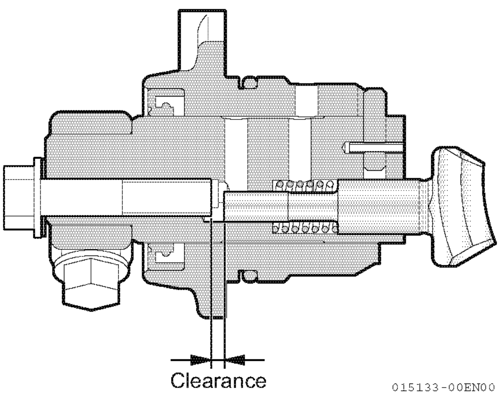


Figure 3-33

How to measure and adjust the clearance

- Install the shift mechanism to the clutch case (without installing the stopper bolt).

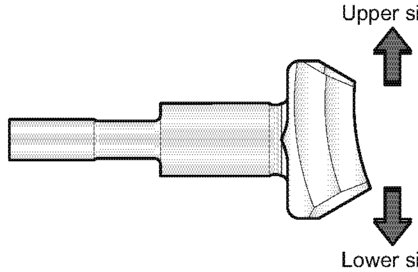


Figure 3-34

NOTICE

Be sure to correctly orient the shifter before installing it.

- Turn the shift lever at 10 to 15 degrees from the neutral position to the ahead position, and then to the astern position.

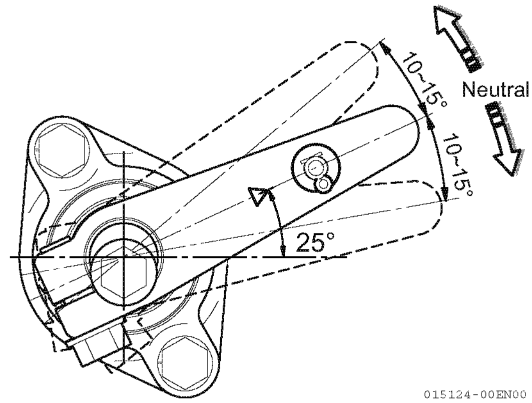


Figure 3-35

NOTICE

The neutral position must be at the installation angle (25°). Be sure to install the shift lever in accordance with the triangle mark on the shift lever.

- The clutch mechanism covered by this manual differs from the clutch mechanism for GM in terms of the installation position angle, the joint used, and the joint installation position. The installation angle for GM is 40°.

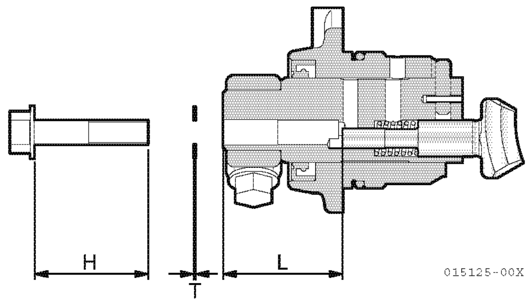


Figure 3-36

Measure the dimension (L) of the clearance between the shift lever shaft and shifter end.

- Measure the height (H) of the under head of the stopper bolt.
- Determine the thickness of the shims, T, using the following formula:
  T = (H - L + 1.25) ± 0.1mm

NOTICE

One shim set includes 1 mm, 0.4 mm, 0.3 mm, and 0.25 mm shims.

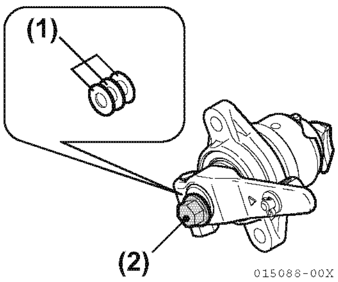


Figure 3-37

- Set the shims of the adjusted thickness to the stopper bolt, and install the bolt to the shift lever shaft.

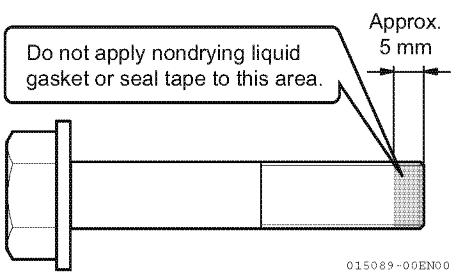


Figure 3-38

NOTICE

Before tightening the stopper bolt, apply nondrying liquid gasket (ThreeBond No.1215) or sealing tape to its thread.

Adjusting the remote control wire

- Make sure that the cable connector and remote controller are not stuck with each other.
- Make sure that the cable connector and shift lever locknut are not stuck with each other.

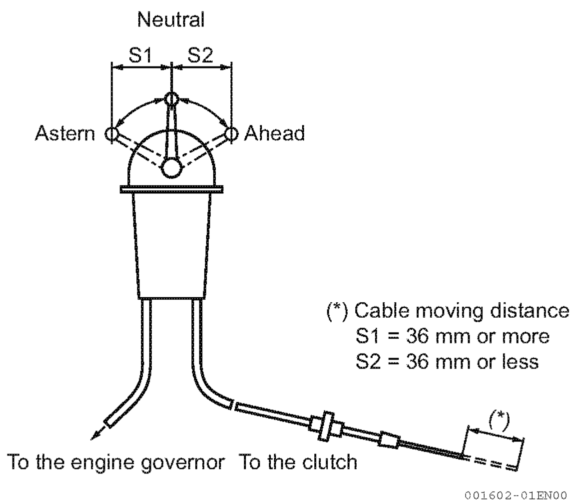


Figure 3-39

1. Ensure that the control lever's two strokes are equal:
   The stroke from the neutral position to the ahead position (S2) must be equal to the stroke from the neutral position to the astern position (S1).
   If one of the strokes is shorter than the other, the clutch may not properly be engaged.
2. After making sure that the two strokes are equal as described in above (1), connect the cable to the control head. Adjust the cable shift moving lengths in accordance with the control lever strokes (H).

NOTICE

- Be sure to stop the engine before installation, adjustment, or inspection.
- When conducting an inspection immediately after stopping the engine, never touch the clutch. The lubricating oil temperature may rise as high as 90°C.
- Because of its design and structure, this clutch does not support a half-engaged state. Do not stop turning the shift lever before the clutch completely engages or disengages.
- The engine idling speed must be set at 750 to 800 rpm.
- Do not use a dual lever remote controller.

Inspection and maintenance

Clutch case

1. Knock the clutch case using a test hammer to check for cracks. Also, check for deterioration if necessary. If the case is cracked, replace it with a new one.
2. Check the internal surfaces of the bearing for contamination, and measure the inside diameter of the case. If the case is worn beyond the allowable limit, replace it with a new one.

Bearing

1. Rusts and breakage
   If the bearing is rusted or any of the tapered roller retainers is broken, replace the entire bearing.
2. Make sure that the bearing rotates lightly. If it does not rotate smoothly or generates an abnormal sound, or the binding is chipped, replace the entire bearing.

Gear

Inspect each gear in terms of surface and tooth flank conditions as well as backlashes, and replace any worn or deteriorated parts.

1. Wear of tooth flanks
   Check the tooth flanks for pitching, abnormal sound, abrasion, dents, and cracks. If the gear is found worn or deteriorated, either repair or replace it depending on the degree of wear or deterioration.

	Criteria for maintenance (mm)	Allowable wear limit (mm)
Ahead gears for input/output shafts	0.06 to 0.12	0.2
Ahead and intermediate gears for input shaft	0.06 to 0.12	0.2
Intermediate gears and output shaft astern gears	0.06 to 0.12	0.2

2. Tooth contact faces
   Inspect the gear teeth to make sure that the tooth contact faces from the tooth top to bottom are at least 70% of the tooth width.
3. Backlashes
   Inspect each gear for backlashes, and replace it if beyond the allowable wear limit.

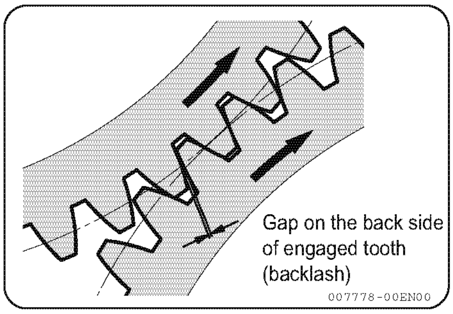


Figure 3-40

Astern and ahead main gears

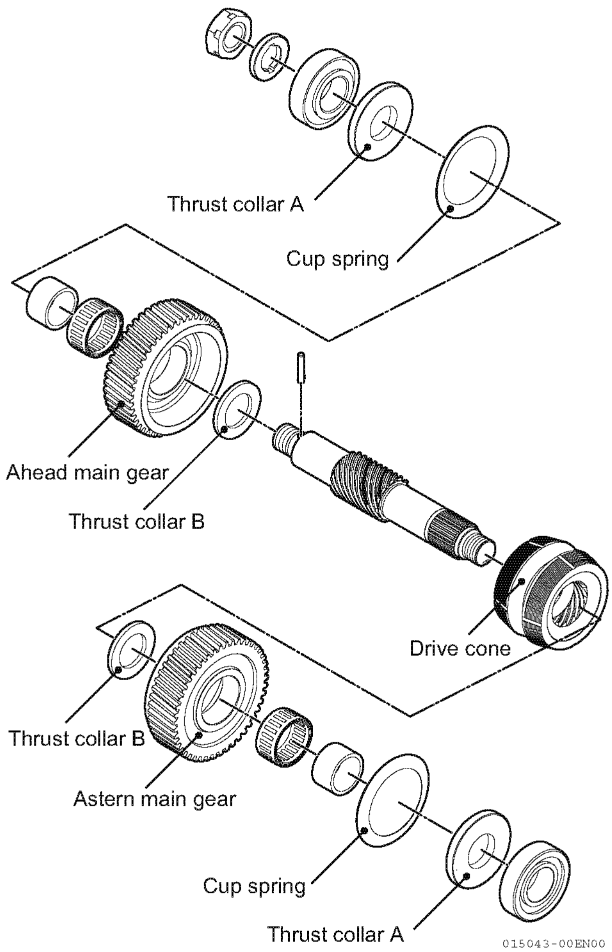


Figure 3-41

- Drive cone contacting faces
  For each of the ahead and astern main gears, visually check the tapered faces that contact the drive cone for any abnormality or sign of overheat. Replace any defective gear.

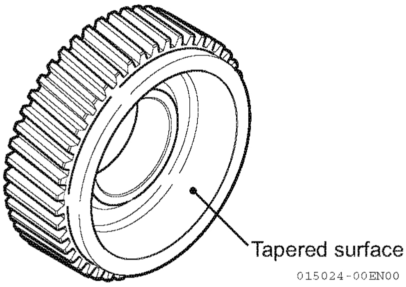


Figure 3-42

- Needle bearings for the ahead and astern gears
  If any of the needle bearings generates an abnormal sound, visually check its roller and replace the bearing if defective.

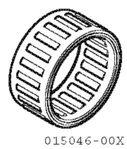


Figure 3-43

Drive cone

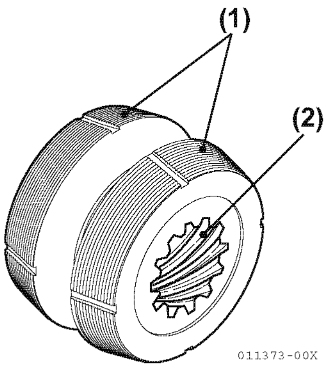


Figure 3-44

- Inspect the drive cone to make sure that its circumferential triangular grooves and contact faces (1) are free of scratches, wears, and signs of overheat. If any deep scratch or sign of overheat is found, replace the drive cone.
- Inspect the helical involute spline (2) to make sure that its tooth surfaces are free of defects. Replace or repair it if any detect is found.
- Measure the worn dimension of the tapered contact surface. If beyond the allowable wear limit specified below, replace the drive cone.
- If the drive cone V groove is excessively worn, replace the drive cone

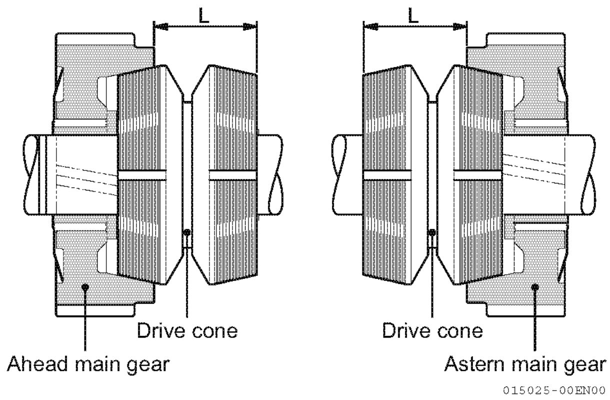


Figure 3-45

	Standard value	Limit value
Length (L)	32.7 to 33.3 mm	32.4 mm

Thrust collars

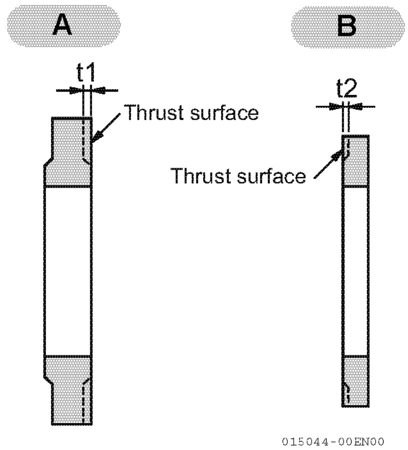


Figure 3-46

1. Visually inspect the thrust faces of the thrust collars A and B to make sure that they are free of scratches, cracks, and signs of overheat. If defective, replace the thrust collar.
2. Measure the thicknesses of the thrust collars A and B. If beyond the allowable wear limit specified below, replace the thrust collar.

Thickness difference	Usable limit (mm)
Thrust collar A, t1	0.05
Thrust collar B, t2	0.20

Cup spring

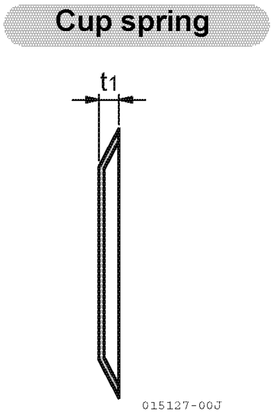


Figure 3-47

1. Inspect the cup spring for cracks and flaws. If defective, replace the cup spring.
2. Measure the free height of the cup spring. If the length is beyond the standard value range, replace the part

	Standard value	Limit value
Cup spring t1	2.8 to 3.1 mm	2.6 mm

Oil seal of the output shaft

Visually inspect the oil seal of the output shaft for oil leak or flaw. If defective, replace the oil seal.

Input shaft

- Spline
  If worn unevenly or scratched, replace the part with new one.

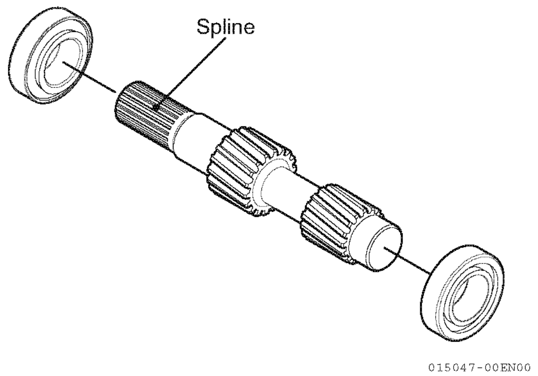


Figure 3-48

Output shaft

- Visually inspect the spline and helical involute spline. If any defect is found on their surfaces, replace the part.

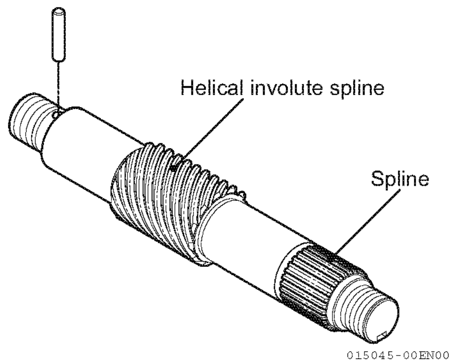


Figure 3-49

Intermediate shaft

- Dimensions and oil stain of the needle bearing
  Visually check the needle bearing surface for stickiness and flaws. If defective, replace the part.

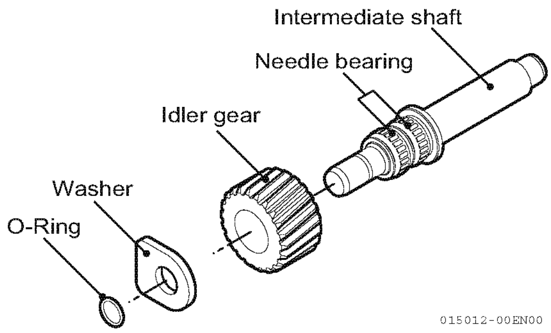


Figure 3-50

Shift device

- **Shifter**

- Visually check the shifter's contact surfaces for flaws, wears, and signs of overheat. If defective, replace the shifter.

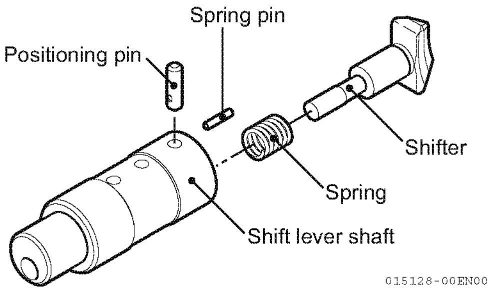


Figure 3-51

- Measure the shifter shaft diameter. If the diameter is beyond the standard value range, replace the shifter.

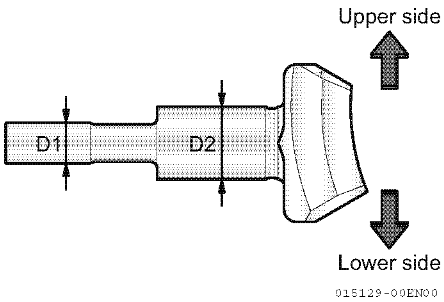


Figure 3-52

	Standard value (mm)	Limit value (mm)
D1	6.69 to 6.70	6.5
D2	11.966 to 11.984	11.95
Shift lever shaft Shifter insertion hole	12.0 to 12.018	12.05

- **Shift lever shaft and positioning pin**

- Check the shift lever shaft and positioning pin for any flaws and torsions. If defective, replace the part. When replacing the positioning pin, the shift lever shaft must be replaced as well.

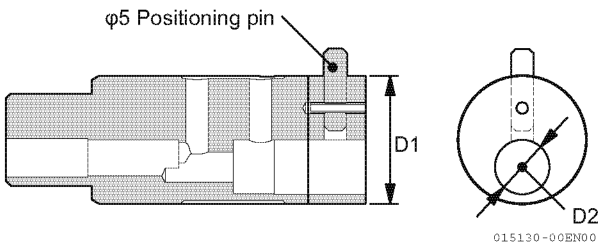


Figure 3-53

- Measure the shift lever shaft and shifter diameters. If beyond the standard value range, replace the part.

	Standard value (mm)	Limit value (mm)
D1	27.959 to 27.980	27.90
D2	12.0 to 12.018	12.05

- **Shifter spring**

- Inspect the spring for scratches and rusts.
- Measure the free length of the spring

Shifter spring	Standard value	Limit value
Free length	22.6 mm	19.8 mm
Spring constant	0.854 kg/mm	-
Installed length	14.35 mm	-
Installed load	7.046 kg	6.08 kg

- **Stopper bolt**

Inspect the stopper bolt. If any wear or thickness difference is found, replace the stopper bolt.

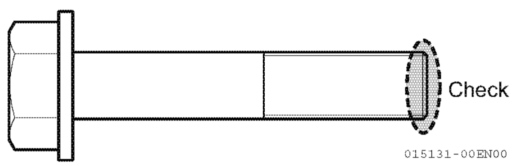


Figure 3-54

- **Side cover and oil seal**

- Inspect the grooves for the neutral, astern, and ahead positions, respectively. If any groove is worn, replace the part.

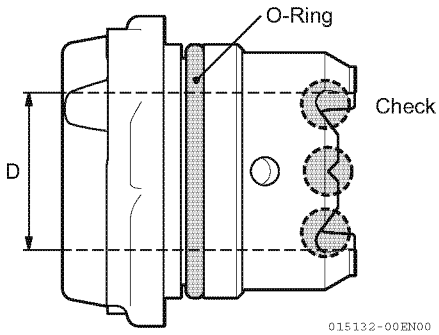


Figure 3-55

- Measure the shift lever shaft insertion hole (D). If beyond the standard value range, replace the part.

	Standard value (mm)	Limit value (mm)
D	28.0 to 28.021	28.08

- Inspect the oil seal and O-ring. If defective, replace the part.

Inspecting the damper disc

The damper disc consists of a disc-shaped steel plate fitted with torque springs, whereby it damps shocks due to power transmission.

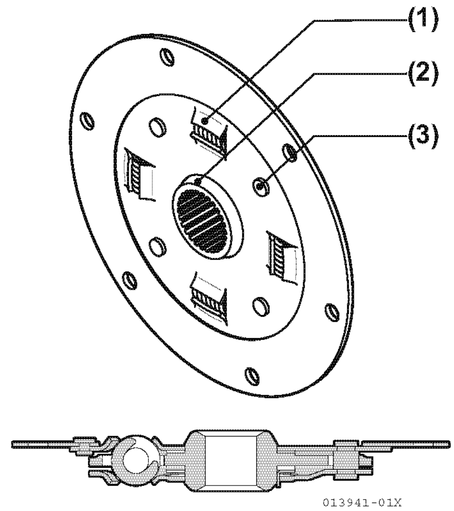


Figure 3-56

- If any of the following parts is found worn unevenly or flawed, replace it with new one.

  Springs (1), spline (2), pins (3)

Adjusting the shims for the input and output shafts

For each of the input and output shafts, check the thickness of the installed shims. If you have not replaced any component while disassembling the shaft, you can use the same shims. If you have replaced the clutch case, flange, and/or any of the parts listed below, readjust the shims using the procedures described in the following sections:

Input shaft: Input shaft, bearing
Output shaft: Output shaft, thrust collar A, thrust collar B, gears, bearings

1. Measuring the shim thickness (T1) for the input shaft

- Measure the depth (A) of the bearing insertion hole through the mounting flange as well as the depth (A') of the bearing insertion hole of the clutch case.
- Measure the outer race length (B) of the bearing of the input shaft assembly.
- Determine the thickness (T1) using the following formula:
  T1 = A + A' - B (T1: clearance ± 0.05 mm)

2. Measuring the shim thicknesses (T2 and T3) for the output shaft

- Measure the depth (C) of the bearing insertion hole through the mounting flange as well as the depth (C') of the bearing insertion hole of the clutch case.
- Measure the length (D) between the bearing outer race of the output shaft assembly.

NOTICE

Tighten the mounting flange nut of the output shaft assembly to the specified torque, and then press the inner race of the roller bearing of the clutch case to the main gear.

- Measure the lengths (E) and (F) from the clutch-case-side bearing outer race of the output shaft assembly.

NOTICE

Before measuring the (E) and (F) dimensions, press the ahead main gear and astern main gear to the drive cone to make sure that there is no clearance in between.

- Determine the thicknesses (T2) and (T3) using the following formula:
  T2 = C + C' - D - T3 (clearance ± 0.1 mm)
  T3 = C' - 48.3 - E / 2 - F (clearance ± 0.05 mm)

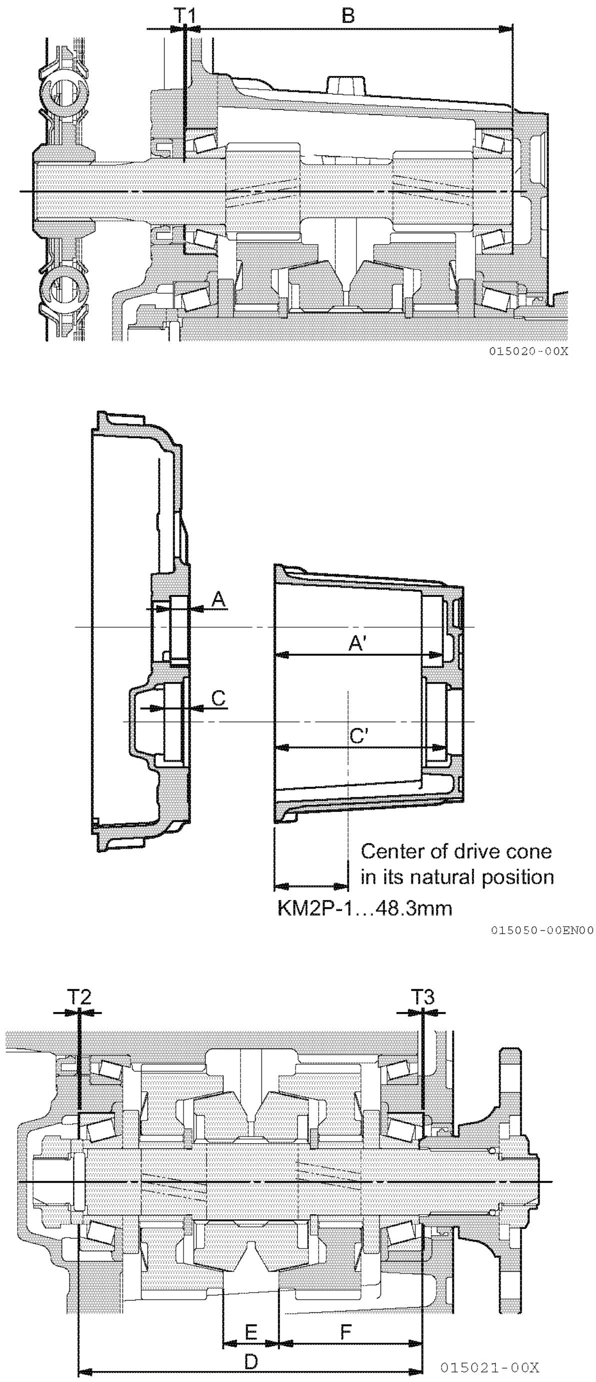


Figure 3-57

Standard parts dimensions

	A + A' (mm)	B (mm)	C + C' (mm)	D (mm)	E (mm)	F (mm)	Center of drive cone in its natural position (mm)
KM2P-1	123.40 to 123.75	122.20 to 123.10	129.8 to 130.15	127.8 to 129.46	20.5 to 21.1	53.73 to 54.35	48.3

NOTICE

Compare the actually measured values with the standard value ranges specified above. If any measured value differs significantly from the corresponding standard value range, it is very likely that the value is not correctly measured. If this is the case, measure the dimension again.

Adjusting the shims

	Part number	Thickness	Number of shims
Input shaft	177088-02350	0.5 0.4 0.3	1 1 2
Output shaft	177088-02300	1.0 0.5 0.3 0.1	1 1 2 3

REMOTE CONTROL SYSTEM (OPTIONAL)

The remote control gives the operator one-handed adjustment of engine speed and selection of forward, reverse and stop. Fittings and hardware that allow for easy connection of the remote control cables to the fuel injection pump and transmission are provided with the remote control as a set. The use of a Morse remote control cable, clamps and control head is also available and is explained in the Electrical Systems section.

Remote Control Device Components

Device	Morse Description
Remote Control Head	Morse MT3 top mounting single lever Morse MN side mounting single lever
Remote Control Cable	Morse 33C x 4m Morse 33C x 7m
Engine Stop Cable	Yanmar 4m Yanmar 7m

Remote Control Handle

The model MT-3 remote control **(Figure 3-37)** has been designed so the operation of the clutch (shift) and governor (throttle) can be controlled with one lever. Two cables are required for the MT-2 single lever unit, one for the clutch and the other for the governor.

When warming up the engine, control the governor separately from the clutch by putting the lever in NEUTRAL (central position) and pulling the knob in the center of the control lever out. When the lever is returned to the NEUTRAL position, the knob automatically returns to its original position and the clutch is free. The governor (engine speed) can then be operated.

MT-3 Type

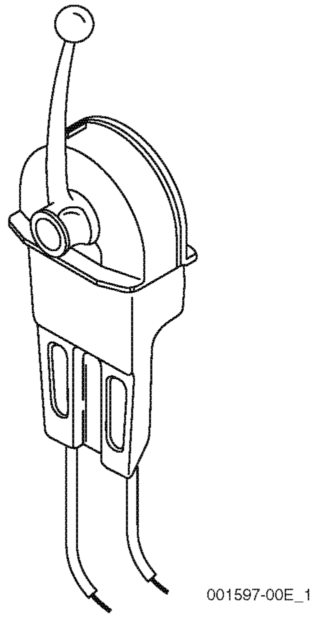


Figure 3-58

The MN type controller **(Figure 3-38)** has been designed so that operation of the clutch and throttle can be controlled with one lever. When the button next to the control lever is pulled out with the lever in the central position, it holds the clutch in the NEUTRAL position so that the throttle can be opened all the way and warm up the engine. When the engine is warm, return the handle to the central position and push the button back in. Control of the clutch and throttle is accomplished with one handle.

MN Type

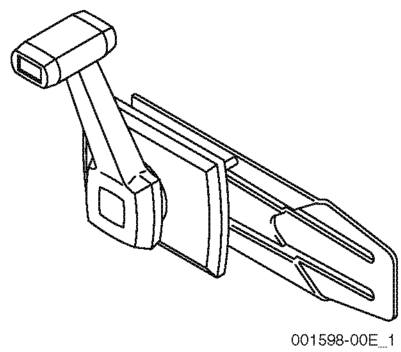


Figure 3-59

Remote Control Cable

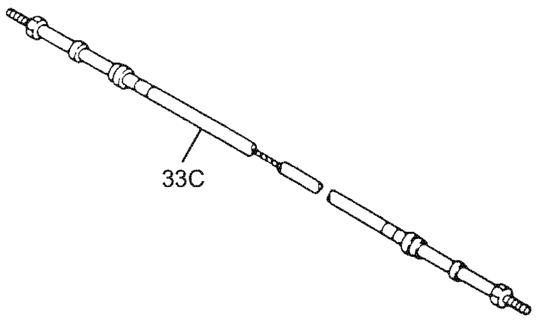


Figure 3-60

Use only Super Responsive Morse Control Cables. These cables are designed specifically for use with the Morse control heads. This engineered system of Morse cables, control head and engine connection hardware ensures dependable and smooth operation with an absolute minimum of control backlash.

Engine Stop Cable

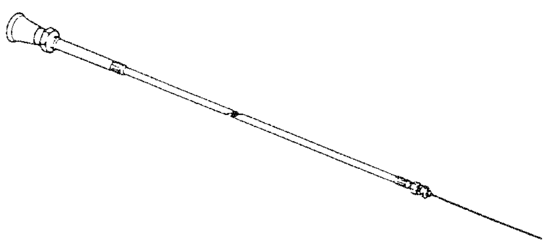


Figure 3-61

Remote Control Installation Drawings

Speed Control

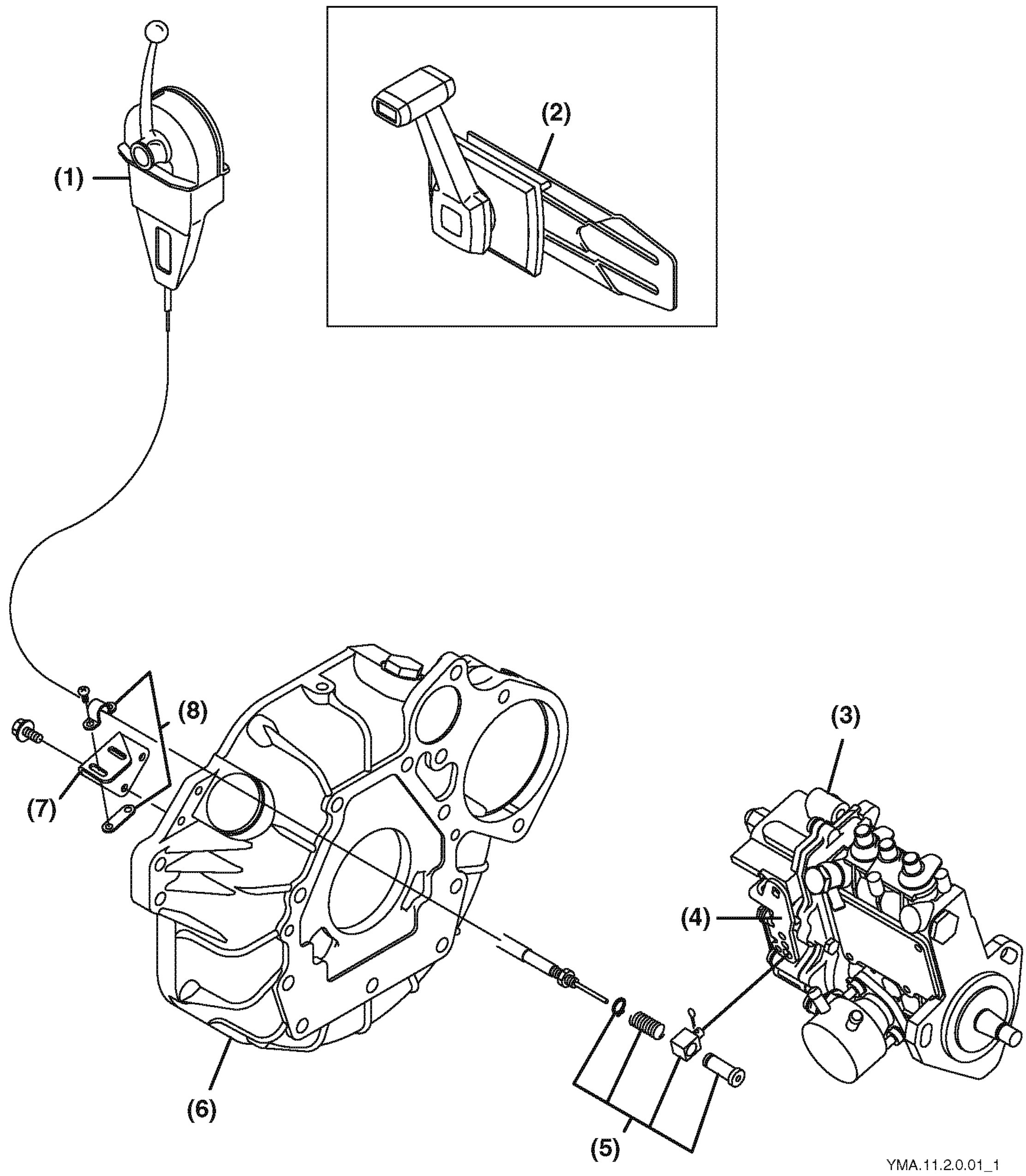


Figure 3-62

1 – Remote Control Handle (MT-3)
2 – Remote Control Handle (MN) (optional)
3 – Governor
4 – Control Lever
5 – Cable Joint
6 – Flywheel Housing
7 – Cable Bracket
8 – Clamp

Clutch Control

Remote Control Cable Clamp

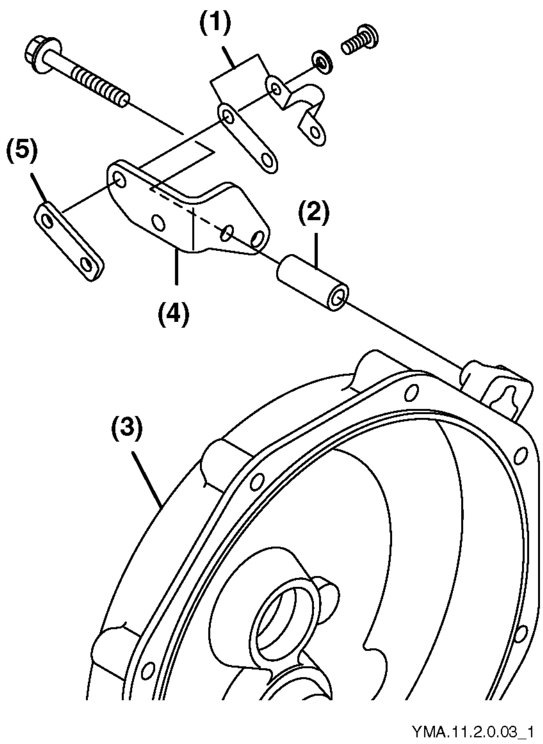


Figure 3-63

1 – **Clamp**
2 – **Spacer**
3 – **Clutch Flange**
4 – **Cable Bracket**
5 – **Retainer**

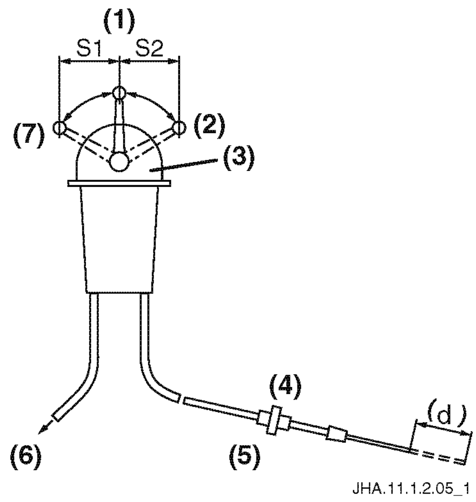


Figure 3-64

1 – **NEUTRAL**
2 – **FORWARD**
3 – **Remote Control Head**
4 – **Clamp**
5 – **To Marine Gear**
6 – **To Engine Speed**
7 – **Reverse**

Note: (d) Cable Shift Travel
S1 = More than 36 mm (1.42 in.)
S2 = More than 36 mm (1.42 in.)

KM2P-1 Marine Gear

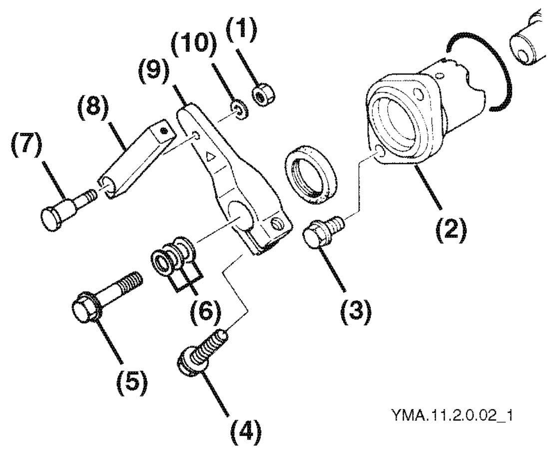


Figure 3-65

1 – Locknut (M6)
2 – Side Cover
3 – Bolt (M8x25)
4 – Bolt (M8x25)
5 – Bolt
6 – Shims
7 – Connector
8 – Holder
9 – Shift Lever
10 – Washer

Engine Stop

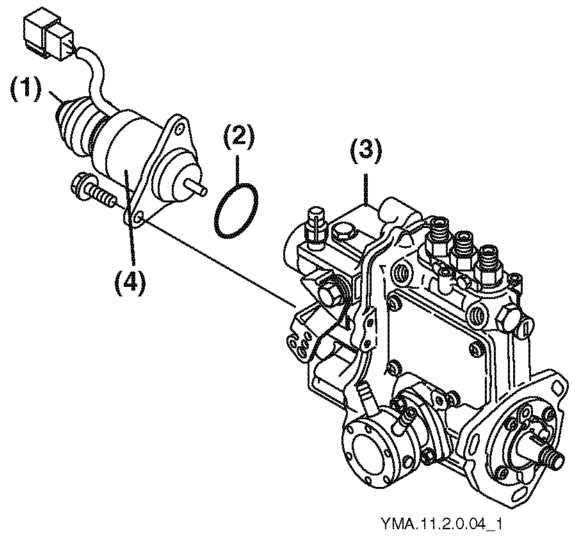


Figure 3-66

1 – Emergency Stop Button
2 – O-Ring
3 – Governor
4 – Stop Solenoid

The engine is usually stopped by pushing the stop button on the instrument panel. However, the engine can also be stopped by pushing the emergency stop button **(Figure 3-45, (1))**, which is located on the stop solenoid **(Figure 3-45, (4))**.

Remote Control Inspection

- If control lever movement does not coincide with engine operation, check the cable end stop nut. Adjust / tighten as necessary.

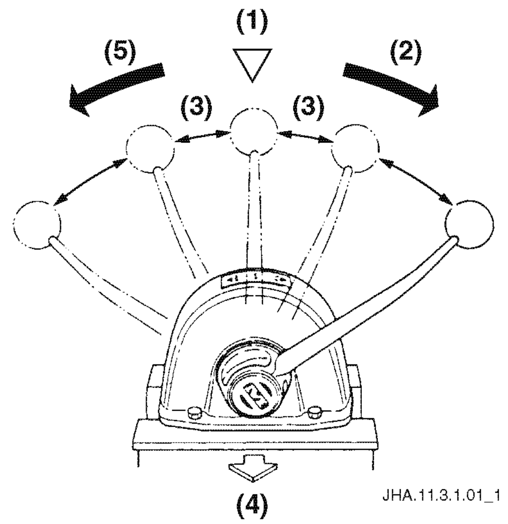


Figure 3-67

1 – NEUTRAL
2 – FORWARD
3 – Shim In
4 – Free Throttle
5 – REVERSE

- Too many bends or bends with too extreme an angle will make it difficult to move the lever. Reroute the cable to reduce the number of bends and / or increase the bend radius to approximately 200 mm (8 in.) or more.
- Check for loose cable brackets / clamp bolts or locknuts. Tighten as necessary.
- Check cable connection screw heads, cable sleeves and other metal parts for rust or corrosion. Clean off minor rust and wax or grease the parts. Replace if the parts are heavily rusted or corroded.

Remote Control Adjustments

Shift Lever Adjustment

The movement of the clutch lever on the engine must coincide with the movement of the control lever at the helm. If they do not, adjust the cable as follows:

1. Inspect and adjust the engine end of the cable.
2. Move the control lever to NEUTRAL **(Figure 3-46, (1))** and check the position of the engine control lever.
3. Make adjustments to the cable fittings and attachment points as necessary to ensure that the engine control lever rests in the NEUTRAL position without any binding.
4. Repeat this process for the FORWARD **(Figure 3-46, (2))** and REVERSE **(Figure 3-46, (5))** selections of the control lever.
5. Inspect and adjust the control end when you are sure the engine control lever is moving correctly.
6. Move the control lever several times to ensure that all controls are functioning properly.

Throttle Lever Adjustment

1. Move the control lever all the way to full throttle several times, and then return the lever to idle.
2. The throttle lever on the engine should lightly push against the idle switch. If it is property adjusted, the knob can easily be pulled out when the lever is in the NEUTRAL position and will automatically return when the control lever is brought back to the NEUTRAL position.

Note: If the control lever presses too hard against the knob, it will not return automatically. Follow the adjustment steps that were outlined for the clutch.

Note: The control knob cannot be pulled out when the lever is not in the NEUTRAL (central) position.

ABBREVIATIONS AND SYMBOLS

Abbreviations

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
BTDC	before top dead center
°C	Celsius
CARB	California Air Resources Board
CCA	cold cranking amp
cm	centimeter
cm^3	cubic centimeter
cm^3/min	cubic centimeter per minute
cu. in.	cubic inch
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/min	fluid ounce (U.S.) per minute
ft	foot
ft-lb	foot pound*
ft·lbf/min	foot pound force per minute
g	gram
gal	gallon (U.S.)
gal/hr	gallon (U.S.) per hour
GL	gear lubricant
hp	horsepower (metric)
hrs	hours
I.D.	inside diameter
IDI	indirect injection
in.	inch
in.Aq	inches of water
in.Hg	inches of mercury
in.-lb	inch pound**
JASO	Japanese Automobile Standards Organization
kg	kilogram
kgf/cm^2	kilogram force per square centimeter
kgf·cm	kilogram force centimeter
kgf·m	kilogram force 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)
min	minute
mL	milliliter
mm	millimeter
mm^3/st	millimeters cubed stere
mmAq	millimeters of water
MPa	megapascal
mV	millivolt
N	newton
N·m	newton meter
No.	number
O.D.	outside diameter
oz	ounce
PS	horsepower (Deutsch)
psi	pound per square inch
qt	quart (U.S.)
rpm	revolutions per minute
SAE	Society of Automotive Engineers
sec	second
t	short ton (2000 lb)
TBN	Total Base Number
TDC	top dead center
V	volt
V AC	volt alternating current
V DC	volt direct current
W	watt
WOT	Wide-Open Throttle

Symbols

°	angular degree
+	plus
-	minus
±	plus or minus
W	ohm
m	micro
%	percent
~	approximate

* 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	m	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
cm^3	x	1.00000	= mL
cm^3	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/cm^2
bar	x	14.5030	= psi
bar	x	100.0000	= kPa
bar	x	29.5300	= in. Hg (60°F)
kPa	x	0.1450	= psi
kPa	x	0.0100	= bar
kPa	x	0.0102	= kgf/cm^2
kgf/cm^2	x	98.0700	= psi
kgf/cm^2	x	0.9807	= bar
kgf/cm^2	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/cm^2
psi	x	0.0689	= bar

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)

Section 4

PERIODIC MAINTENANCE

Page

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SAFETY PRECAUTIONS

Before performing maintenance procedures, review the *Safety Section on page 2-1*.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary for proper care and maintenance of the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

The Importance of Periodic Maintenance

Engine deterioration and wear occurs in proportion to the length of time the engine has been in service and the conditions the engine is subjected 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 using genuine Yanmar parts when replacement parts are needed. Genuine replacement parts help ensure long engine life.

Required EPA Maintenance

It is essential to follow the *Periodic Maintenance Schedule on page 4-5* and *Periodic Maintenance Procedures on page 4-7* to maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulation Engines.

EPA REQUIREMENTS

The EPA emission regulation is applicable only in the USA.

Inspection and Maintenance

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 its 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.

○: User-maintenance ◇: Parts replacement ●: Shop-inspection

System	Item		Before Starting	Initial 50 hrs.	Every 50 hours or monthly which-ever comes first	Every 100 hours or six months which-ever comes first	Every 150 hours or one year which-ever comes first	Every 250 hours or one year which-ever comes first	Every 1000 hours or 4 years which-ever comes first
Whole	Visual inspection of engine exterior		○						
Fuel System	Check the fuel level and refill if necessary		○						
	Drain water and sediment from the fuel tank			○				○	
	Drain the fuel filter / water separator				○				
	Replace the fuel filter element							◇	
	Check the fuel injection timing								●
	Check the fuel injector spray pattern*								●*
Lubricating System	Check the engine oil level	Engine	○						
		Marine Gear	○						
	Replace the engine oil			◇			◇		
	Replace the oil filter element	Engine		◇				◇	
Cooling System	Seawater Outlet		○ During operation						
	Check coolant level		○						
	Check or replace the seawater pump impeller							○	◇
	Replace coolant		Every year. When Long Life Coolant (LLC) is used, replace every 2 years.						
	Clean and check the seawater passages								●

○: User-maintenance ◇: Parts replacement ●: Shop-inspection

System	Item	Before Starting	Initial 50 hrs.	Every 50 hours or monthly which-ever comes first	Every 100 hours or six months which-ever comes first	Every 150 hours or one year which-ever comes first	Every 250 hours or one year which-ever comes first	Every 1000 hours or 4 years which-ever comes first
Air Intake and Exhaust System	Clean the intake silencer (air cleaner) element						○	
	Clean or replace the exhaust / water mixing elbow						○	
	Check the exhaust gas condition	○ During operation						
	Check diaphragm assembly							●
Electrical System	Check the alarm and indicators	○						
	Check the electrolyte level in the battery			○				
	Adjust the tension of the alternator V-belt or replace V-belt		○				○	◇
	Check the wiring connectors						○	
Engine Cylinder Head and Block	Check for leakage of fuel, engine oil and engine coolant	○ After starting						
	Tighten all major nuts and bolts							●
	Adjust intake / exhaust valve clearance		○					●
Miscellane-ous Items	Check the remote control cables	○	○					●
	Adjust the propeller shaft alignment		○					●
	For maintenance intervals and procedures, refer to the applicable Marine Gear or Sail-Drive manual.							

* *For EPA requirements, see Exhaust Gas Emission Regulations on page 3-30.*

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

PERIODIC MAINTENANCE PROCEDURES

Inspect Before Starting

Be sure to check the following before every engine start.

- **Visually Inspecting the Engine Exterior**
- **Checking the Fuel Level**
- **Checking the Engine Oil Level**
- **Checking the Marine Gear / Sail-Drive Oil Level**
- **Checking the Seawater Outlet**
- **Checking the Coolant Level**
- **Checking Alarm Functions**
- **Checking for Engine Fluid Leaks**
- **Checking / Adjusting the Remote Control Cables**

Visually Inspecting the Engine Exterior

Correct any problems before starting engine.

- Oil leaks
- Fuel leaks
- Coolant leaks
- Any damaged parts
- Loose or missing bolts
- Fuel condition, rubber hoses, V-belt, loose clamps
- Check the fuel level. Refill as necessary.
- Check the engine oil level (crankcase).

Checking the Fuel Level

Check the fuel level to ensure there is adequate fuel in the fuel tank.

Checking the Engine Oil Level

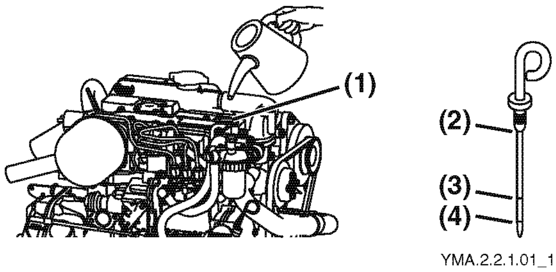


Figure 4-1

1 – Filler Port
2 – Dipstick
3 – Upper Limit
4 – Lower Limit

Check the engine oil level with the dipstick **(Figure 4-1, (2))**.

Insert the dipstick fully and check the oil level.

- The oil should not be contaminated and should be the correct viscosity.
- There should be no evidence of coolant or diesel fuel in the oil.
- The oil level should be between the upper **(Figure 4-1, (3))** and lower **(Figure 4-1, (4))** limit lines on the dipstick.

Model	Rake Angle	Engine Oil Capacity (Full)
3YM30AE with KM2P-1	8°	2.8 L (2.96 qt)
3YM30 with KM2P-1		
3YM20 with KM2P-1		2.7 L (2.85 qt)
2YM15 with KM2P-1		2.0 L (2.11 qt)
3YM30AE-C with SD20/SD25	0°	2.5 L (2.64 qt)
3YM30C with SD20/SD25		
3YM20C with SD20/SD25		2.4 L (2.53 qt)
2YM15C with SD20/SD25		1.8 L (1.90 qt)

NOTICE

Avoid overfilling the engine oil. Add oil to the upper limit line on the dipstick. Overfilling may induce oil into the combustion chamber and damage components.

Checking the Marine Gear / Sail-Drive Oil Level

Remove the oil dipstick and check the oil level. Add oil if the level is too low. See applicable manual for procedure and specifications.

Checking the Seawater Outlet

Check for seawater discharge immediately after engine start. Shut down right away if no discharge water is present. Troubleshoot and correct seawater discharge problems before operating engine.

Check for leaks in the seawater pump and lines.

Checking the Coolant Level

WARNING! Burn Hazard. ***NEVER open the filler cap while the engine is hot. Always check coolant level when engine is cold.***

1. Check the fluid level in the coolant recovery tank by looking through the container walls. The fluid level of the coolant recovery tank **(Figure 4-2, (3))** should be between the upper **(Figure 4-2, (5))** and lower **(Figure 4-2, (4))** limit lines. Avoid opening the filler cap **(Figure 4-2, (2))** unnecessarily.
2. If the fluid level is below the LOW mark, replenish the coolant recovery tank with the correct coolant until the level reaches the FULL mark.
3. Tighten the filler cap after checking the coolant tank.

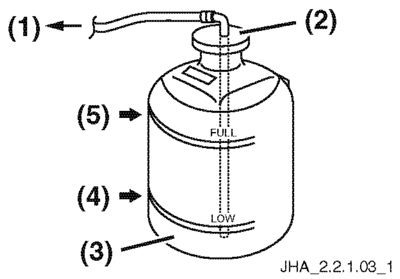


Figure 4-2

1 – To Heat Exchanger
2 – Cap
3 – Coolant Recovery Tank
4 – Lower Limit
5 – Upper Limit

Coolant Volume		
Model	**Engine**	**Coolant Recovery Tank**
3YM30AE	4.9 L (5.2 qt)	0.8 L (0.85 qt)
3YM30		
3YM20	4.1 L (4.3 qt)	
2YM15	3.0 L (3.2 qt)	

NOTICE

If coolant levels drop quickly or the coolant tank depletes with the recovery tank unchanged, check for a fluid or air leak in the system. Adding coolant to the recovery tank during operation is not abnormal. The increased coolant in the coolant recovery tank returns to the coolant tank when the engine cools. If the engine coolant level is normal in the coolant recovery tank but low in the engine coolant tank, check for loose hose clamps, broken hoses or other leaks.

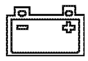
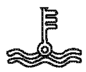
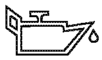
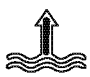
Checking Alarm Functions

Check all alarm functions before and after starting the engine. Check to see that all alarm functions operate normally. Failure of an alarm system can lead to major engine damage. Check the alarm functions before and after starting the engine every day.

When pushing the start switch to the ON position before starting the engine, the alarm window appears (with sound) on the display for about 3 seconds, then goes off. This alarm operation is normal.

When the sensor detects a problem during operation, the alarm indicator comes on (with sound) on the display.

Under normal conditions, the display shows the engine information such as engine speed, oil pressure, coolant temperature, etc.

Symbol	Function	Description
	Battery Low Charge Alarm	When the alternator output is too low, the indicator will come on. When charge begins, the indicator will turn off. (The alarm buzzer will not sound when the indicator comes on.)
	Coolant High Temperature Alarm	When the temperature reaches the maximum (95°C [203°F] or higher), the indicator will light. Continuing operation at temperatures exceeding the maximum limit will result in damage and seizure. Check the load and the coolant system for any abnormalities.
	Low Oil Pressure Alarm	When the oil pressure falls below normal, the oil pressure switch will register, the indicator will come on and the alarm will sound. Continuing operation with insufficient oil pressure will result in damage and seizure. Check the engine oil level.
	Water in Sail-Drive Seal Alarm	When seawater is detected between the seals of Sail-Drive, the indicator will come on and the alarm will sound.

Normal action of alarm devices:

Alarm devices act as shown below. Check that the alarm indicators and buzzers are working normally when the power switch is turned on.

Correct operation of the warning devices				
Instrument panel (power switch)	Power ON			
	Immediately	After 2 seconds	After 4 seconds	
	Before start engine			Running
Alarm buzzer	ON			OFF
Charge lamp	ON	ON	ON	OFF
Coolant temperature lamp	ON	ON	OFF	OFF
Engine lubricating oil pressure lamp	ON	ON	ON	OFF
LCD display	Yanmar	Full display	Hourmeter	

Checking for Engine Fluid Leaks

Before and after starting the engine, check for coolant and seawater leaks. Also, check for engine oil and fuel leaks.

Checking / Adjusting the Remote Control Cables

Make sure that the throttle of the vessel can be operated smoothly before starting the engine. If it feels rough or binds, lubricate the cable joints and pivots. Repair and adjust the cable if it is disconnected or there is excessive play between the accelerator and the governor lever.

Check Points and Precautions During Running

Step	Item	Instructions	Precautions
1	Checks Before Operation	Make sure that the seacock is open. Make sure there is enough oil and coolant. Operate the remote control handle and check if the device connected to the engine works property.	Indicator should go off when engine is running
2	No-Load Operation, Warm-up Operation	When the oil temperature is raised to allow the engine to start, the pilot indicator goes off. When the engine is started, check the following: There is no leakage of water, fuel and engine oil. Exhaust gas does not leak when the engine is started. There is no abnormal indication on the instrument panel. There is no abnormality in coolant discharge, engine vibration or engine sound. To warm up the engine, operate at low speed for about 5 minutes, then raise the speed to the rated speed and then to maximum speed.	Fix leaks if any. Check the intake / exhaust valves, fuel injection nozzle and cylinder head. Do not raise the engine speed abruptly.
3	Cruising (Load) Operation	Do not operate the engine at full load yet, but raise the speed gradually for about 10 minutes until it reaches the rated speed. Make sure that exhaust gas color and temperature are normal. Check the instrument panel and see if the water temperature and oil pressure are normal.	-
4	Stopping the Engine	Before stopping the engine, operate it at 650 to 700 min^{-1} (rpm) for about 5 minutes. Raise engine speed to 1800 min^{-1} (rpm) just before stopping the engine and idle the engine for about 3 to 4 seconds.	Stopping the engine suddenly during high-speed operation increases the temperature of engine parts. This procedure prevents carbon from being deposited on the valve seats, etc.
5	Checks After Stopping the Engine	Check for water and oil leaks. Make sure that no nuts and bolts are loose. Close the seacock and fuel cocks. When the temperature is expected to fall below freezing, drain the seawater. Turn off the battery switch.	Check the oil seal area. Check the engine installation bolts. Drain water from the seawater pump.

After Initial 50 Hours of Operation

Check the following points after initial 50 hours or 1 month of operation, whichever comes first.

- **Draining the Fuel Tank**
- **Replacing the Engine Oil Filter Element**
- **Changing the Engine Oil**
- **Changing the Marine Gear / Sail-Drive Oil**
- **Checking and Adjusting Alternator V-Belt Tension**
- **Checking and Adjusting Intake / Exhaust Valve Clearance**
- **Checking and Adjusting Remote Control Cables**
- **Adjusting the Propeller Shaft Alignment**

Draining the Fuel Tank

⚠ WARNING

Fire Hazard

Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.

Exposure Hazard

Wipe up any spills immediately. Wear eye protection. The fuel system is under pressure and fuel could spray out when you remove any fuel system component.

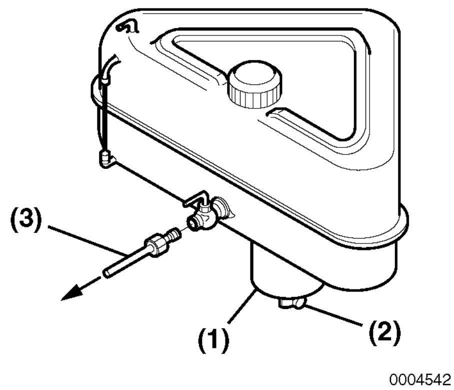


Figure 4-3

1 – **Sediment Bowl**
2 – **Drain Cock**
3 – **Fuel Line To Engine**

1. Put a pan under the drain cock **(Figure 4-3, (2))** to catch the fuel.
2. Open the drain cock and drain any water or dirt that has accumulated in the tank.
3. Close the drain cock.

Replacing the Engine Oil Filter Element

1. Turn the engine OFF.
2. Turn the engine oil filter **(Figure 4-4)** counterclockwise with a filter wrench.

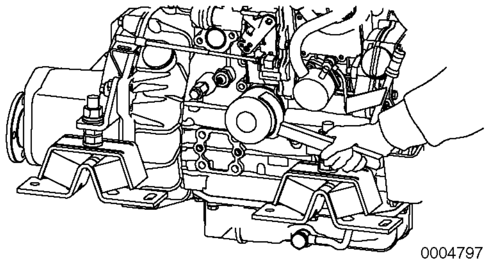


Figure 4-4

3. Remove the engine oil filter.
4. Install a new filter element and hand-tighten until the seal touches the housing.
5. Tighten it another 3/4 of a turn with the filter wrench.

Oil Filter Torque
20 to 24 N•m (14.7 to 17.7 lb-ft)

Applicable Oil Filter Part No.
119305-35150

6. Test run the engine and check for oil leaks.

Changing the Engine Oil

During the engine operation, the oil deteriorates due to high temperatures, friction and wear of internal parts. The oil must be changed periodically. It is easiest and most effective to drain the engine oil just after engine operation while the engine is still warm.

⚠ WARNING

Burn Hazard

Avoid contact with hot engine oil. Wear protective clothing when handling hot engine oil.

1. Remove the oil dipstick **(Figure 4-5, (2))** and primary oil filler cap **(Figure 4-5, (1))**. Attach the oil drain pump **(Figure 4-6)** to the dipstick guide and drain the oil.

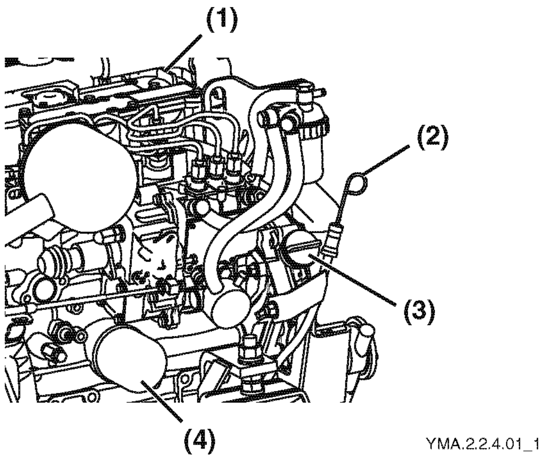


Figure 4-5

1 – Primary Oil Filler Cap (yellow)
2 – Dipstick
3 – Auxiliary Oil Filler Cap
4 – Engine Oil Filter

2. Fill with new oil.
3. Test run the engine and check for leaks.
4. Wait approximately 10 minutes after shutting the engine down. Check the oil level by using the oil dipstick. Add oil as necessary.

Optional Oil Drain Pump

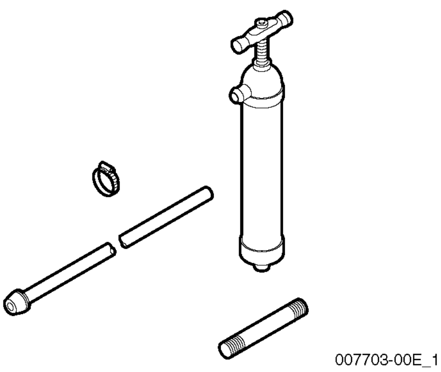


Figure 4-6

The oil level should be between the upper and lower limit lines on the dipstick.

Model	Rake Angle	Engine Oil Capacity (Full)
3YM30AE with KM2P-1	8°	2.8 L (2.96 qt)
3YM30 with KM2P-1		
3YM20 with KM2P-1		2.7 L (2.85 qt)
2YM15 with KM2P-1		2.0 L (2.11 qt)
3YM30AE-C with SD20/SD25	0°	2.5 L (2.64 qt)
3YM30C with SD20/SD25		
3YM20C with SD20/SD25		2.4 L (2.53 qt)
2YM15C with SD20/SD25		1.8 L (1.90 qt)

NOTICE

Always remove the oil filler cap when draining or removing engine oil from the crankcase. Negative pressure in the system may damage the breather diaphragm.

Remove the oil filler cap when checking the engine oil level immediately after running the engine. The breather diaphragm will cause oil to remain in the block for about 10 minutes after engine shutdown.

This yellow label is attached to the dipstick:

OIL CHECK 10 MINUTES AFTER ENGINE STOP

Figure 4-7

Changing the Marine Gear / Sail-Drive Oil

During the initial engine break-in period, oil is quickly contaminated due to the initial wear of internal parts. The oil must therefore be changed shortly after engine break-in.

See the applicable manual for procedure and specifications.

1. Remove the cap from the filler port and attach an oil drain pump.
2. Drain the oil.
3. Fill with new oil.
4. Test run and check for oil leaks.
5. Approximately 10 minutes after stopping the engine, remove the oil dipstick and check the oil level. Add oil if the level is too low.

Checking and Adjusting Alternator V-Belt Tension

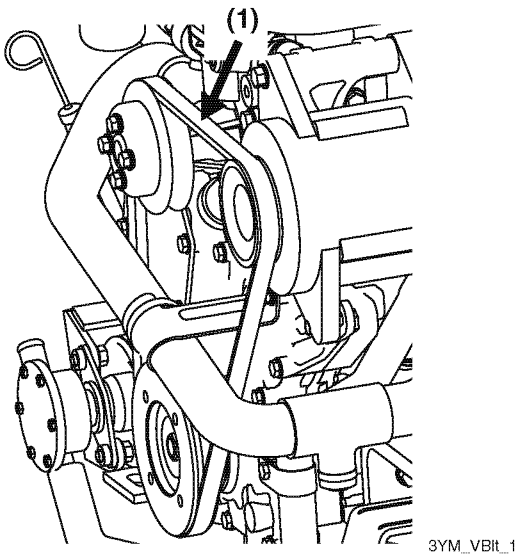


Figure 4-8

1 – Test Deflection

Insufficient V-belt tension will cause slippage and possible overheating of the engine. Excessive V-belt tension will cause the belt to wear prematurely and may cause damage to the coolant pump bearing.

NOTICE

Avoid getting oil on the V-belt. Oil will cause the belt to slip, stretch and age prematurely.

⚠ WARNING

Sever Hazard

Perform this check with engine OFF and key removed to avoid contact with moving parts.

1. Remove the belt cover.
2. Check the tension of the V-belt by pressing down on the middle of the belt **(Figure 4-8, (1))** with your finger with moderate force.

The specified deflection should be as follows:

V-Belt Deflection	
Used V-belt	8 to 10 mm (5/16 to 3/8 in.)
New V-belt	6 to 8 mm (1/4 to 5/16 in.)

A “new V-belt” refers to a V-belt which has been used for less than 5 minutes on a running engine.

A “used V-belt” refers to a V-belt which has been used on a running engine for 5 minutes or more.

3. If necessary, adjust the V-belt tension (deflection).

3YM30

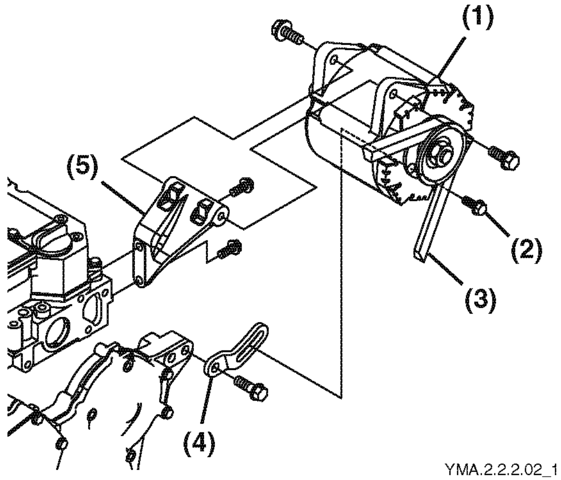


Figure 4-9

1 – Alternator
2 – Set Bolt
3 – V-belt
4 – Belt Adjuster
5 – Bracket

Note: 3YM30 shown. Other models are similar.

To adjust the V-belt tension:

1. Loosen the set bolt **(Figure 4-9, (2))** for the belt adjuster **(Figure 4-9, (4))** and move the alternator **(Figure 4-9, (1))** in the direction that tightens the V-belt **(Figure 4-9, (3))**.
2. Visually check the V-belt for cracks, oiliness or wear.
3. Replace the V-belt if any defects are found.

NOTICE

When replacing the V-belt, loosen the set bolt and move the alternator. Loosen the V-pulley set bolts for the coolant pump and remove the V-belt.

After replacing the V-belt and adjusting the tension, run the engine for 5 minutes and readjust the deflection to the listed specifications.

Checking and Adjusting Intake / Exhaust Valve Clearance

Note: Always check the valve clearances when the engine is cold.

1. Remove the rocker arm cover.

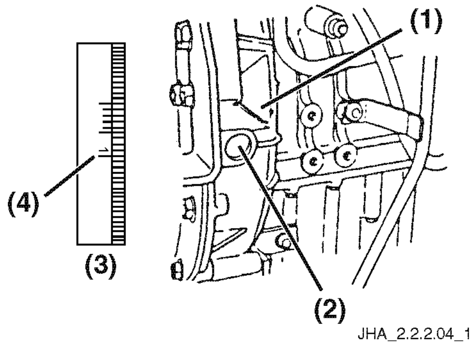


Figure 4-10

1 – Flywheel Housing
2 – Hole
3 – Flywheel
4 – TDC No. 1 Cylinder

2. Set the No. 1 cylinder to TDC **(Figure 4-10, (4))** during its compression stroke.
   - Turn the crankshaft clockwise as viewed from the gear housing end, while watching the rocker arm motion.
   - The No. 1 cylinder position is on the opposite end of the gear housing.
3. The timing mark on the flywheel housing **(Figure 4-10, (1))** and the top mark of the flywheel **(Figure 4-10, (3))** will align. (Position where both the intake and exhaust valves are closed.)
4. Try to move both No. 1 cylinder rocker arms or push rods.

   If the rocker arm push rods are not loose, rotate the flywheel one revolution (360°). If both rocker arm push rods are loose, the piston is at TDC on the compression stroke.

NOTICE

If you still cannot move both rocker arms, there is no valve clearance. Disassemble and inspect around the valve seat. No valve clearance indicates a valve seat that is abnormally worn.

5. With the No. 1 cylinder at TDC on the compression stroke, you can now check the clearance of the valves with the ● mark in the table below.

Cylinder No.	1		2		3	
Valve	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
No. 1 Compression TDC	●	●	●			●
No. 1 Overlap TDC				○	○	

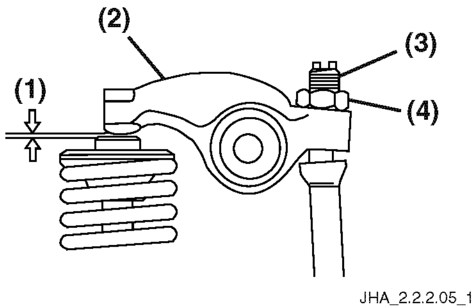


Figure 4-11

1 – Valve Clearance
2 – Rocker Arm
3 – Adjusting Screw
4 – Locknut

6. Insert a feeler gauge between the rocker arm **(Figure 4-11, (2))** and the top of the valve.
7. Measure the clearance **(Figure 4-11, (1))** and compare to specification.

Standard Valve Clearance
0.15 to 0.25 mm (0.0059 to 0.0098 in.)

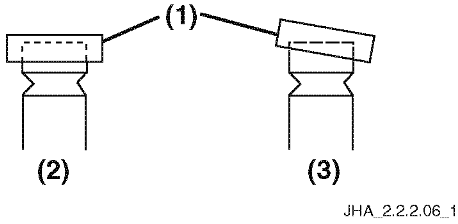


Figure 4-12

1 – Valve Cap
2 – Normal
3 – Abnormal

8. If there is excessive clearance, check the valve for any inclination of the valve cap **(Figure 4-12, (1))**, dirt or excessive wear.
9. If adjustment is required, loosen the locknut **(Figure 4-11, (4))** and turn the adjusting screw **(Figure 4-11, (3))**.
10. When clearance is correct, tighten the locknut while holding the adjusting screw. Recheck clearance after tightening the locknut.
11. Complete checking and adjusting the rest of the valves.
12. Rotate the engine 360° and line up the No. 1 cylinder mark as explained in Step 3. The No. 1 cylinder is at TDC at overlap.
13. Adjust the clearance of the valves with the O mark from the table above by repeating Steps 6 through 11.
14. Install the rocker arm cover.

Checking and Adjusting the Remote Control Cables

The various engine controls are connected to the remote control lever **(Figure 4-13, (6))** by the remote control cable **(Figure 4-13, (1))**.

NOTICE

The cable will stretch and the attachment points will become loose after extended use. This can cause sloppy control and unpredictable operation. It is dangerous to operate under these conditions and the remote control cable must be checked and adjusted periodically or whenever a discrepancy is suspected.

Adjusting the Remote Control Cable

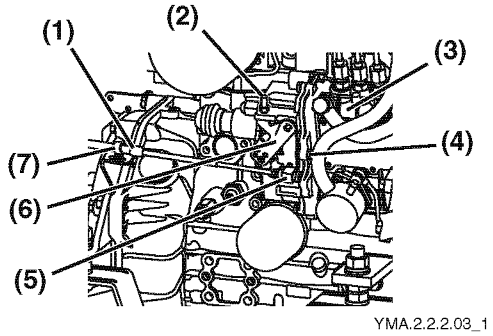


Figure 4-13

1 – Remote Control Cable
2 – High-Idle Limiting Screw
3 – Fuel Injection Pump
4 – Low-Idle Limiting Screw
5 – Cable Joint
6 – Control Lever
7 – Clamp

1. Check that the control lever **(Figure 4-13, (6))** on the engine moves to the high-idle and low-idle stop positions when the remote control lever is moved to “H” (high idle) and / or “L” (low idle) respectively.
2. If there is a discrepancy, loosen the clamp **(Figure 4-13, (7))** for the remote control cable **(Figure 4-13, (1))** on the engine and adjust as necessary.
3. Adjust the high-idle stop position first and then adjust the low-idle position.

NOTICE

Do not adjust the high-idle limiting screw **(Figure 4-13,** ***(2))****. This will void the engine warranty.*

Adjusting the Clutch Remote Control Cable

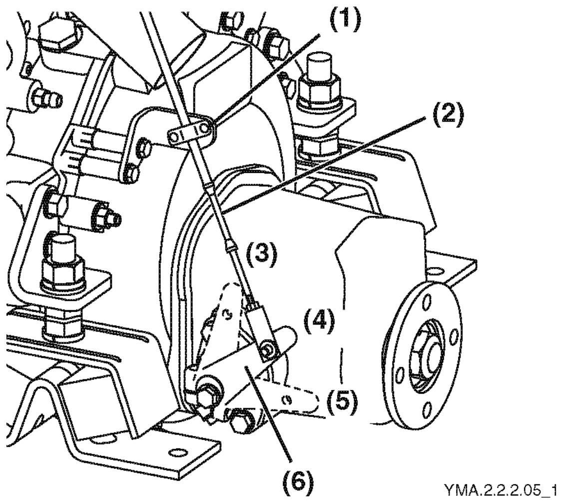


Figure 4-14

1 – Clamp
2 – Clutch Remote Control Cable
3 – REVERSE
4 – NEUTRAL
5 – FORWARD
6 – Shift Lever

1. Check that the shift lever **(Figure 4-14, (6))** moves to the correct position when the remote control handle is put in NEUTRAL **(Figure 4-14, (4))**, FORWARD **(Figure 4-14, (5))** and REVERSE **(Figure 4-14, (3))** positions.
2. Use the NEUTRAL position as the center for adjustment.
3. If there is a discrepancy, loosen the clamp **(Figure 4-14, (1))** that secures the remote control cable **(Figure 4-14, (2))** and adjust the shift lever position as necessary.

Adjusting the Propeller Shaft Alignment

During the initial break-in period, the flexible engine mounts may compress slightly. This may cause a misalignment of the engine and the propeller shaft.

Check for any unusual noise and vibration of the engine and / or vessel hull, while increasing and decreasing engine speed.

If unusual noise and / or vibration is detected, adjust the propeller shaft alignment. (See the relevant volume of the *Installation Manual*.)

Every 50 Hours of Operation

Be sure to check the following points every 50 hours of operation or monthly, whichever comes first.

- **Draining the Fuel Filter / Water Separator**
- **Bleeding Air from the Fuel System**
- **Checking the Battery Electrolyte Level**
- **Measuring the Battery Charge**

Draining the Fuel Filter / Water Separator

⚠ WARNING

Fire Hazard

Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive. Wipe up any spills immediately.

Exposure Hazard

Wear eye protection. The fuel system is under pressure and fuel could spray out when removing any fuel system component.

1. Close the fuel cock at the fuel tank.
2. Put a pan under the fuel water separator.
3. Loosen the retaining ring **(Figure 4-15, (6))** and remove the filter cap **(Figure 4-15, (5))**.
4. Drain off any water and dirt collected inside.
5. After draining, tighten the air bleed screw **(Figure 4-15, (1))**.
6. After reassembly, be sure to bleed air from the fuel system.

NOTICE

If air is in the fuel system, fuel cannot reach the fuel injection pump.

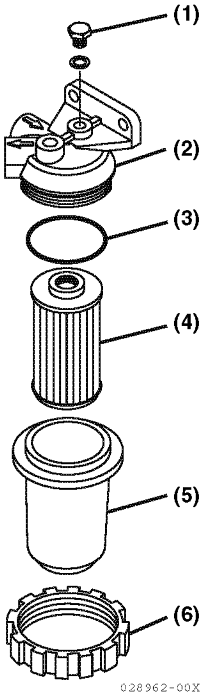


Figure 4-15

1 – Air Bleed Screw
2 – Bracket
3 – O-Ring
4 – Filter Element
5 – Filter Cap
6 – Retaining Ring

Bleeding Air from the Fuel System

1. Check the fuel level in the fuel tank. Replenish if necessary.
2. Loosen the air bleed screw **(Figure 4-15, (1))** at the top of the fuel filter by turning it two or three times.
3. Feed fuel with the fuel feed pump by moving the lever on the left side of the feed pump up and down.
4. Allow the fuel containing air bubbles to flow out from the air bleed screw hole. When the fuel no longer contains bubbles, tighten the air bleed screw. This completes bleeding the fuel system.
5. After the engine start-up, the automatic bleeding device works to purge the air in the fuel system. No manual air venting is required for normal engine operation.

Fuel System

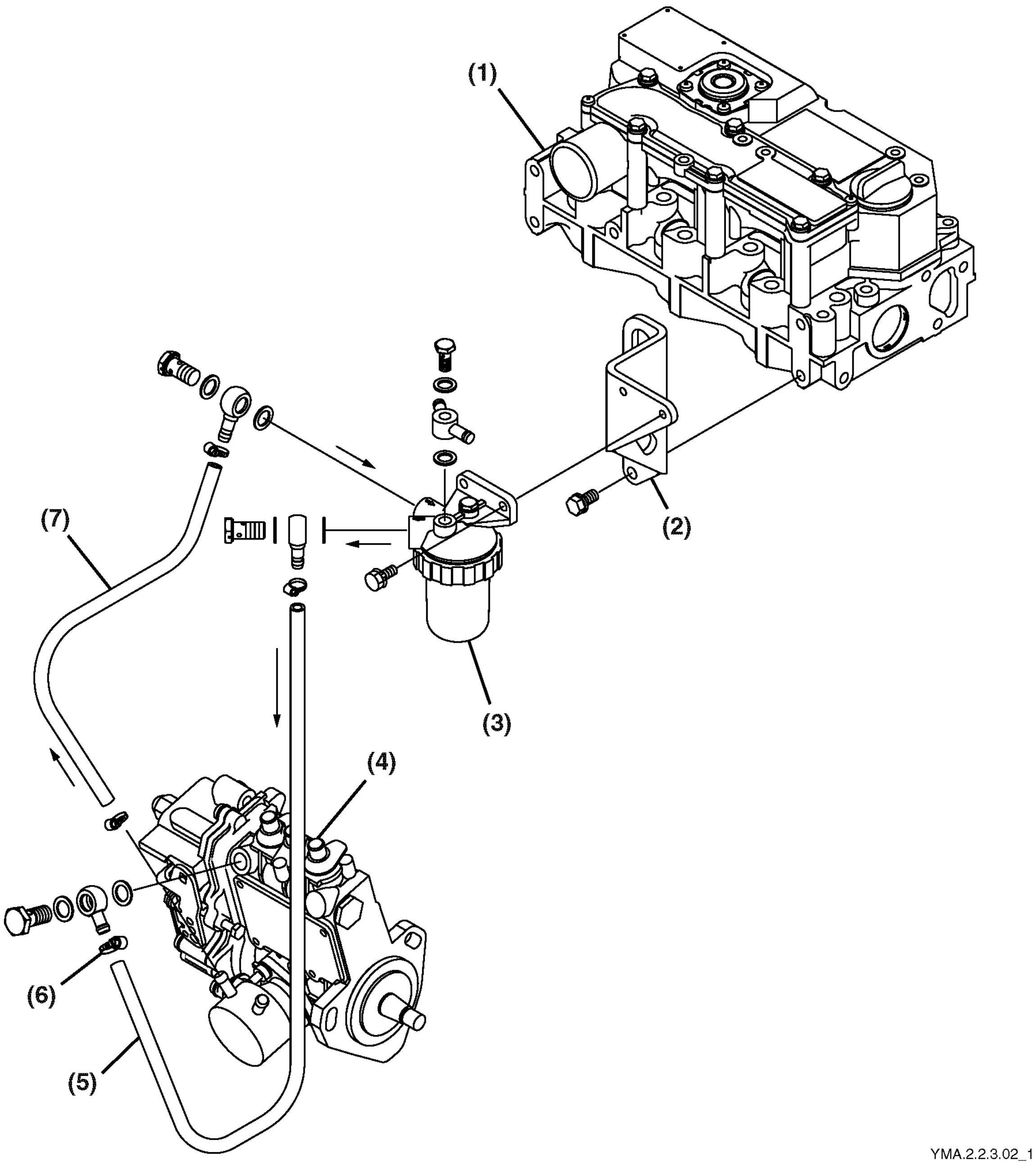


Figure 4-16

1 – Cylinder Head
2 – Bracket
3 – Fuel Filter
4 – Fuel Injection Pump
5 – Fuel Line
6 – Clamp
7 – Fuel Line

Checking the Battery Electrolyte Level

⚠ WARNING

Fire Hazard

Always turn off the battery switch or disconnect the negative (-) cable before inspecting the electrical system. Failure to do so could cause short-circuiting and fires. Always disconnect the negative (-) battery cable first. An accidental short circuit may cause damage, fire and / or personal injury. ALWAYS connect the negative (-) battery cable (back onto the battery) LAST.

Fire Hazard

Keep the area around the battery well-ventilated, paying attention to keep the battery away from any fire source. During operation or charging, hydrogen gas is generated from the battery and can be easily ignited.

Exposure Hazard

Make sure your eyes and skin do not come in contact with the fluid. The battery electrolyte is dilute sulfuric acid and causes severe acid burns. If you come in contact with electrolyte, wash and rinse it off immediately with a large amount of fresh water and baking soda.

Battery Parts

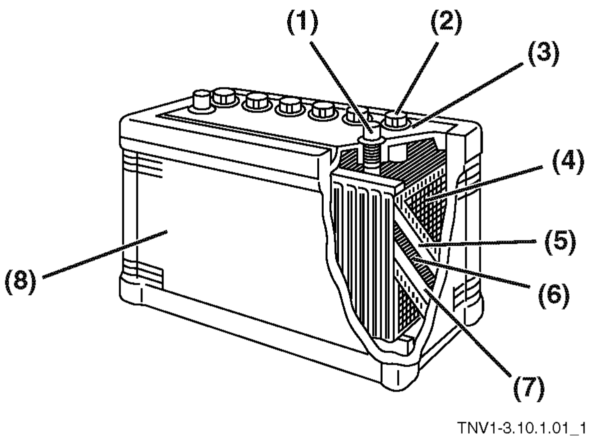


Figure 4-17

1 – Terminal
2 – Filler Cap
3 – Cover
4 – Glass Mat
5 – Negative Plate
6 – Separator Plate
7 – Positive Plate
8 – Battery Case

Visual Inspection

- Inspect the case for cracks, damage and electrolyte leakage.
- Inspect the battery holder for tightness, corrosion and damage.
- Inspect the terminals for corrosion and check the cables for damage.
- Inspect the caps for cracking, electrolyte leakage and clogged vent holes. Correct any abnormal conditions that are found. Clean corroded terminals with a wire brush before reconnecting the battery cable.

Electrolyte Level

Check the level of fluid in the battery.

1. Make sure the engine is off and the key is removed.
2. Turn the battery master switch to OFF (if equipped) or disconnect the negative (-) battery cable.
3. Remove the plugs and check the electrolyte level in all cells.

NOTICE

Never attempt to remove the covers or fill a maintenance-free battery.

4. If the amount of fluid nears the lower limit **(Figure 4-18, (1))**, fill with distilled water (available locally) up to the upper limit **(Figure 4-18, (6))** of the battery.

⚠ WARNING

Fire and Explosion Hazard

If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode.

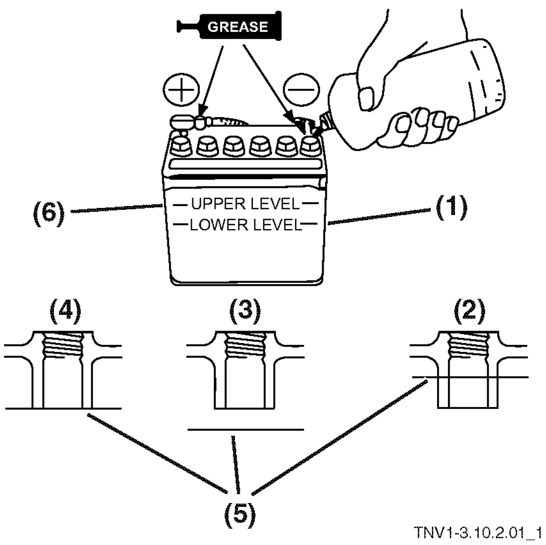


Figure 4-18

1 – Lower Limit
2 – Excessive
3 – Too Low
4 – Correct Level
5 – Electrolyte Level
6 – Upper Limit

Note: The maximum fill level is approximately 10 to 15 mm (3/8 to 9/16 in.) above the plates.

- Battery fluid tends to evaporate more quickly in the summer, and the fluid level should be checked earlier than the specified times.
- If the engine cranking speed is so slow that the engine does not start, recharge the battery.
- If the engine still will not start after charging, replace the battery.
- When parking, remove the battery and store in a warm place if the vessel will be left in ambient temperatures below -15°C (5°F).

Measuring the Battery Charge

Use a battery tester **(Figure 4-19)** or hydrometer **(Figure 4-20)** to check the battery condition. If the battery is discharged, recharge it.

Measuring Battery Charge with a Battery Tester

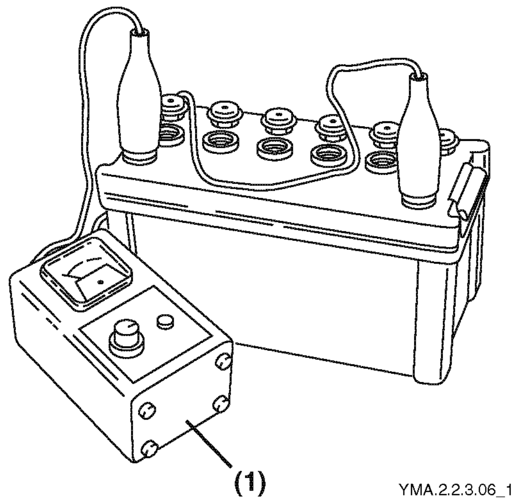


Figure 4-19

1 – Battery Tester

When checking the battery with the battery tester, connect the red clip of the tester to the battery positive (+) terminal and the black clip to the battery negative (-) terminal. Read the battery charge indicator.

- Green zone: Normal
- Yellow zone: Slightly discharged
- Red zone: Defective or completely discharged

Measuring Battery Charge with a Hydrometer

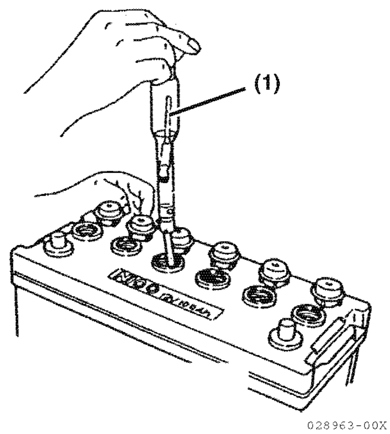


Figure 4-20

1 – Float

When using a hydrometer, the measured specific gravity must be corrected according to the temperature at the time of measurement. The specific gravity of battery electrolyte is defined using 20°C (68°F) as the standard. Since the specific gravity increases or decreases by 0.0007 when the temperature varies by 1°C (1°F), correct the value according to the equation below.

$$S_{20} = St + 0.007 (t - 20)$$

(1)
(2)
(3)

TNVD-2.2.3.10_1

Figure 4-21

1 – Electrolyte Temperature at Measurement
2 – Specific Gravity at Measurement
3 – Converted Specific Gravity at 20°C (68°F)

Specific Gravity and Remaining Battery Charge

Hydrometer Structure

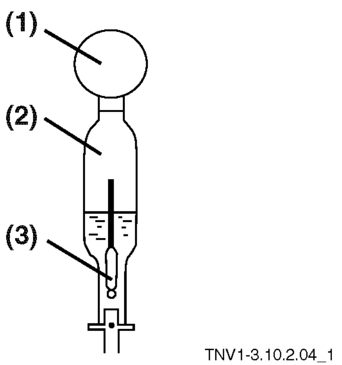


Figure 4-22

1 – Rubber Bulb
2 – Glass Tube
3 – Float

Specific Gravity at 20°C (68°F)	Discharged Quantity of Electricity	Remaining Charge
1.28	0%	100%
1.26	10%	90%
1.24	20%	80%
1.23	25%	75%

How to Read a Hydrometer

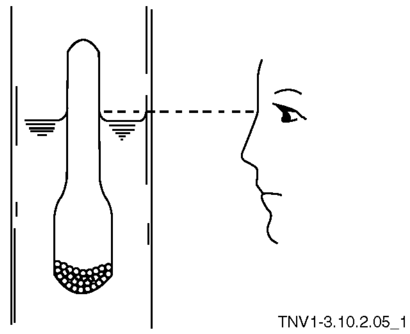


Figure 4-23

Check the following battery items:

- Terminals:
  - Clean if corroded or soiled.
- Mounting bracket:
  - Repair or replace if corroded.
  - Retighten if loosened.
- Battery appearance:
  - Replace the battery if cracked or deformed.
  - Clean with fresh water if contaminated.

Every 100 Hours of Operation

Check the following points every 100 hours or 6 months of operation, whichever comes first.

- **Changing the Sail-Drive Oil**

Changing the Sail-Drive Oil

See *Changing the Marine Gear / Sail-Drive Oil on page 4-12*.

Every 150 Hours of Operation

Check the following points every 150 hours or 1 year of operation, whichever comes first.

- **Changing the Engine Oil**

Changing the Engine Oil

See Changing the Engine Oil on page 4-11 for the procedure.

Every 250 Hours of Operation

Check the following points every 250 hours or 1 year of operation, whichever comes first.

- **Draining the Fuel Tank**
- **Replacing the Fuel Filter Element**
- **Replacing the Engine Oil Filter Element**
- **Checking or Replacing the Seawater Pump Impeller**
- **Changing the Coolant**
- **Cleaning Intake Silencer (Air Cleaner) Element**
- **Cleaning or Replacing the Exhaust / Water Mixing Elbow**
- **Adjusting the Alternator V-Belt Tension**
- **Checking the Wiring Connectors**

Draining the Fuel Tank

See Draining the Fuel Tank on page 4-11 for the procedure.

Replacing the Fuel Filter Element

Replace the fuel filter at the specified interval or any time it is suspected of obstructing the fuel flow.

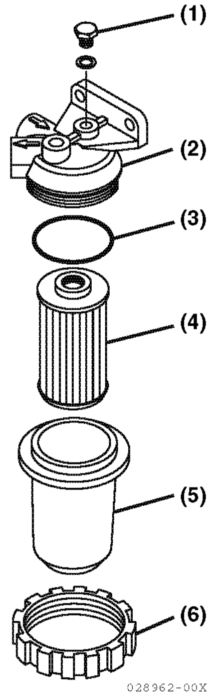


Figure 4-24

1 – Air Bleed Screw
2 – Bracket
3 – O-Ring
4 – Filter Element
5 – Filter Cap
6 – Retaining Ring

⚠ WARNING

Burn Hazard

Avoid contact with hot engine components. Wait until the engine has fully cooled to replace the fuel filter.

1. Close the fuel cock on the fuel tank.
2. Place an approved container under the fuel tank.
3. Remove the filter case by loosening the retaining ring **(Figure 4-24, (6))**. Turn the ring counterclockwise using a filter wrench.

   When removing the fuel filter, hold the bottom of the fuel filter with a rag to prevent the diesel fuel from spilling. Wipe up any spilled fuel immediately.

4. Remove the filter cap **(Figure 4-24, (5))** and remove the filter element **(Figure 4-24, (4))**. Replace the element with a new one.

5. Clean the filter mounting surface and apply clean diesel fuel to the gasket of the new fuel filter.
6. Clean the inside of the housing thoroughly, install the O-ring **(Figure 4-24, (3))** and hand tighten the retainer ring until the new filter element comes into contact with the mounting surface.
7. Tighten one additional turn, using a filter wrench.

Fuel Filter Torque
20 to 24 N•m (14.7 to 17.7 lb-ft)

Applicable Fuel Filter Element Part No.	O-ring Part No.
104500-55710	24341-000440

8. Bleed the fuel system. *See Bleeding Air from the Fuel System on page 4-17.*

NOTICE

Be sure to use a genuine Yanmar fuel filter (super fine mesh). Engine damage, uneven engine performance and shortened engine life may occur when using other parts.

Replacing the Engine Oil Filter Element

See Replacing the Engine Oil Filter Element on page 4-11 for the procedure.

Checking or Replacing the Seawater Pump Impeller

1. Remove the seawater pump cover **(Figure 4-25, (4))**.
2. Take out the O-ring **(Figure 4-25, (3))**, impeller **(Figure 4-25, (2))** and wear plate.

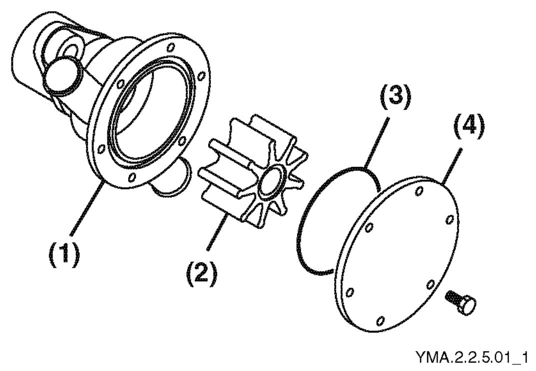


Figure 4-25

1 – Pump Body
2 – Impeller
3 – O-Ring
4 – Cover

3. Inspect the rubber impeller.

   Check for splitting around the outside, damage or cracks, and replace if necessary.

With heavy use, the internal parts of the seawater pump may deteriorate. This will cause a reduction of discharge performance. At the specified interval or whenever the discharge volume of seawater is reduced, inspect the seawater pump as follows:

1. Loosen the seawater pump cover setscrews and remove the cover.
2. Inspect the pump components.
3. If no damage is found, reassemble the cover.
4. If any discrepancies are found, remove the O-ring and impeller and replace, if necessary.
5. Reassemble the cover.

NOTICE

The impeller must be replaced periodically (every 1000 hours or 4 years, whichever comes first).

If a large amount of water leaks continuously from the water drain pipe beneath the seawater pump during engine operation, check the oil seal inside the seawater pump.

The seawater pump turns in the counterclockwise direction as viewed from driving end. If the impeller **(Figure 4-26, (2))** has been removed for any reason, install the impeller in the proper direction **(Figure 4-26, (3))**. Additionally, if the engine crankshaft is being turned manually, be careful to turn it in the normal direction. *NOTICE: Incorrect turning could twist and damage the impeller blades.*

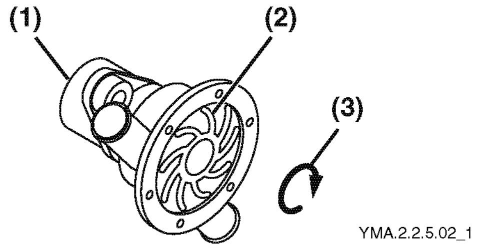


Figure 4-26

1 – Seawater Pump
2 – Impeller
3 – Impeller Rotation Direction

Changing the Coolant

Change the coolant every year. When the Long Life Coolant Antifreeze (LLC) of the correct specified type is used, the replacement period may be extended to 2 years.

Use clean, soft water and add the LLC to prevent rust buildup and freezing.

Cooling performance drops when coolant is contaminated with rust and scale. The coolant must be replaced periodically because the cooling properties degenerate with time.

1. Open the coolant cock **(Figure 4-27, (3)),** remove the plug **(Figure 4-27, (4))** and drain the coolant.

   One drain cock is behind the belt cover. Remove the belt cover and open the cock.

2. Close the two coolant drain cocks.

Coolant Line	Seawater Line
2	2

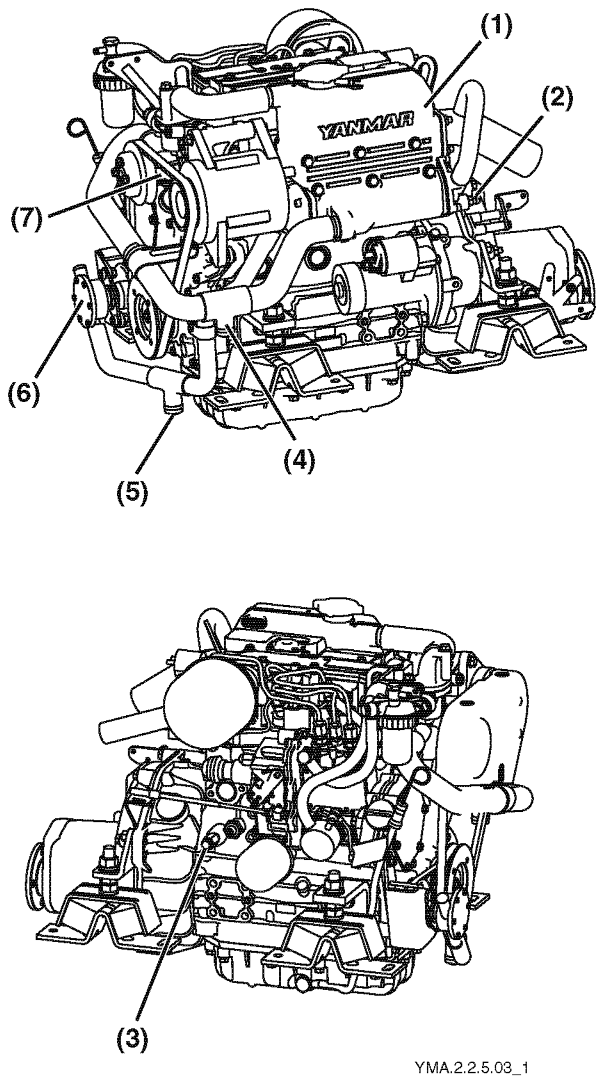


Figure 4-27

1 – Heat Exchanger
2 – Drain Cock for Seawater
3 – Drain Cock for Coolant
4 – Drain Plug for Coolant
5 – Drain Plug for Seawater
6 – Seawater Pump
7 – Coolant Pump

3. Remove the pressure cap **(Figure 4-28, (1))** of the coolant tank **(Figure 4-28, (2))** by turning the cap counterclockwise 1/3 of a turn.

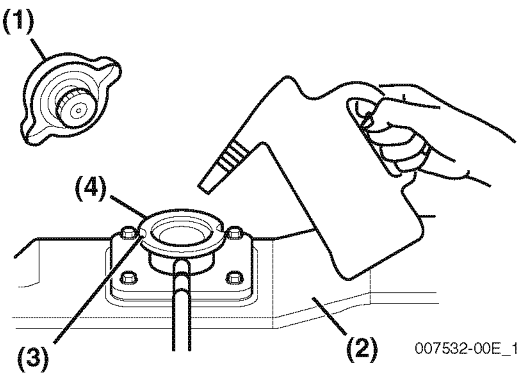


Figure 4-28

1 – Pressure Cap
2 – Coolant Tank
3 – Notches
4 – Coolant Supply Port

4. Pour coolant slowly into the coolant tank so that air bubbles do not develop. Continue to pour until the coolant overflows from the supply port **(Figure 4-28, (4))**.
5. Install the cap **(Figure 4-28, (1))** and turn clockwise 1/3 of a turn. Tighten the cap firmly. **WARNING! Burn Hazard.** ***Always tighten the coolant tank cap securely.***
6. Remove the coolant recovery tank cap **(Figure 4-29, (3))** and fill with coolant mix to the lower limit.
7. Replace the cap to the coolant recovery tank.

Coolant Recovery Tank Capacity
0.8 L (0.8 qt)

8. Check the rubber hose **(Figure 4-29, (2))** connecting the coolant recovery tank **(Figure 4-29, (4))** to the heat exchanger for damage and security, making sure there are no loose connections.

NOTICE

If the hose leaks, an excessive amount of coolant will be lost.

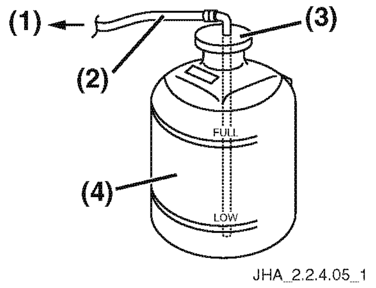


Figure 4-29

1 – To Heat Exchanger
2 – Rubber Hose
3 – Cap
4 – Coolant Recovery Tank

Cleaning Intake Silencer (Air Cleaner) Element

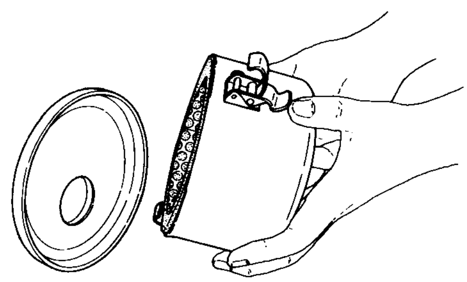


Figure 4-30

1. Disassemble the intake silencer.
2. Remove the polyurethane element and inspect it for damage or clogging.
3. Wash the intake silencer element **(Figure 4-31, (1))** with a neutral detergent.

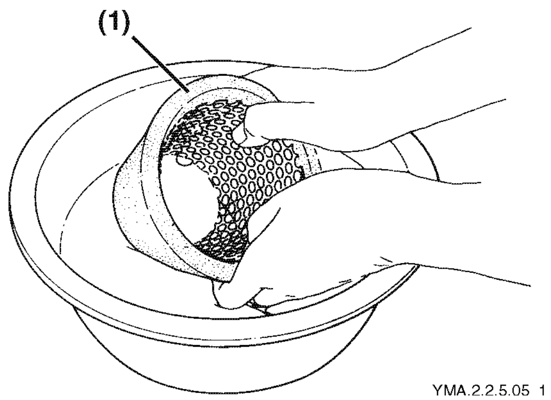


Figure 4-31

1 – Element

Cleaning or Replacing the Exhaust / Water Mixing Elbow

There are two types of mixing elbows, the L-type **(Figure 4-32, (7))** and the U-type **(Figure 4-32, (1))**. The mixing elbow is attached to the exhaust manifold. The exhaust gas is mixed with seawater in the mixing elbow.

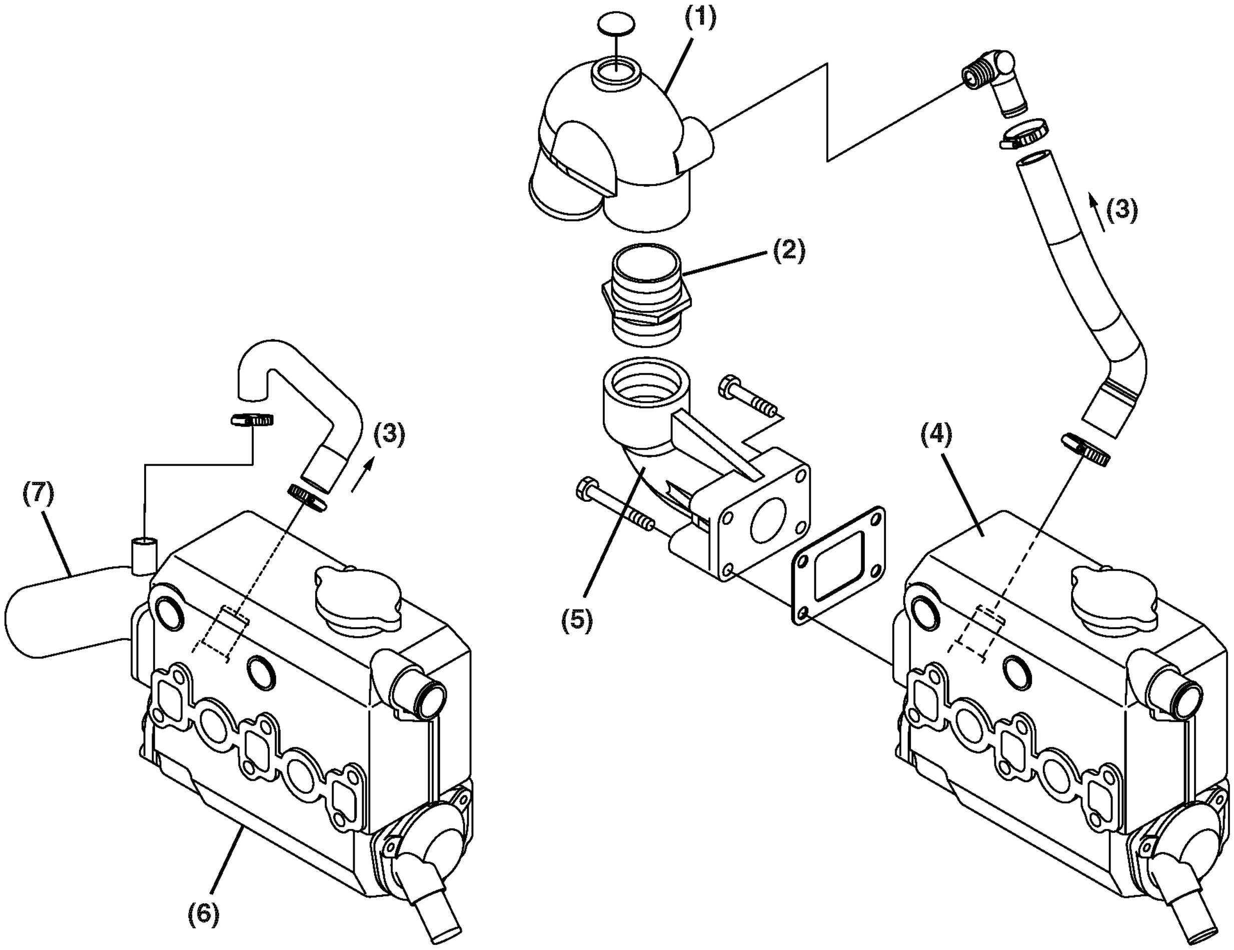


Figure 4-32

1 – U-type Mixing Elbow (optional)
2 – Joint
3 – Seawater
4 – Heat Exchanger
5 – Exhaust Elbow
6 – Heat Exchanger
7 – L-type Mixing Elbow

1. Remove the mixing elbow.
2. Clean dirt and scale out of the air passage and seawater passage **(Figure 4-32, (3))** of the mixing elbow.
3. Repair any cracks or damage to the mixing elbow by welding or replacement if necessary.
4. Inspect the gasket and replace if necessary.

Adjusting the Alternator V-Belt Tension

See Checking and Adjusting Alternator V-Belt Tension on page 4-13.

Checking the Wiring Connectors

Check each connector for security of attachment.

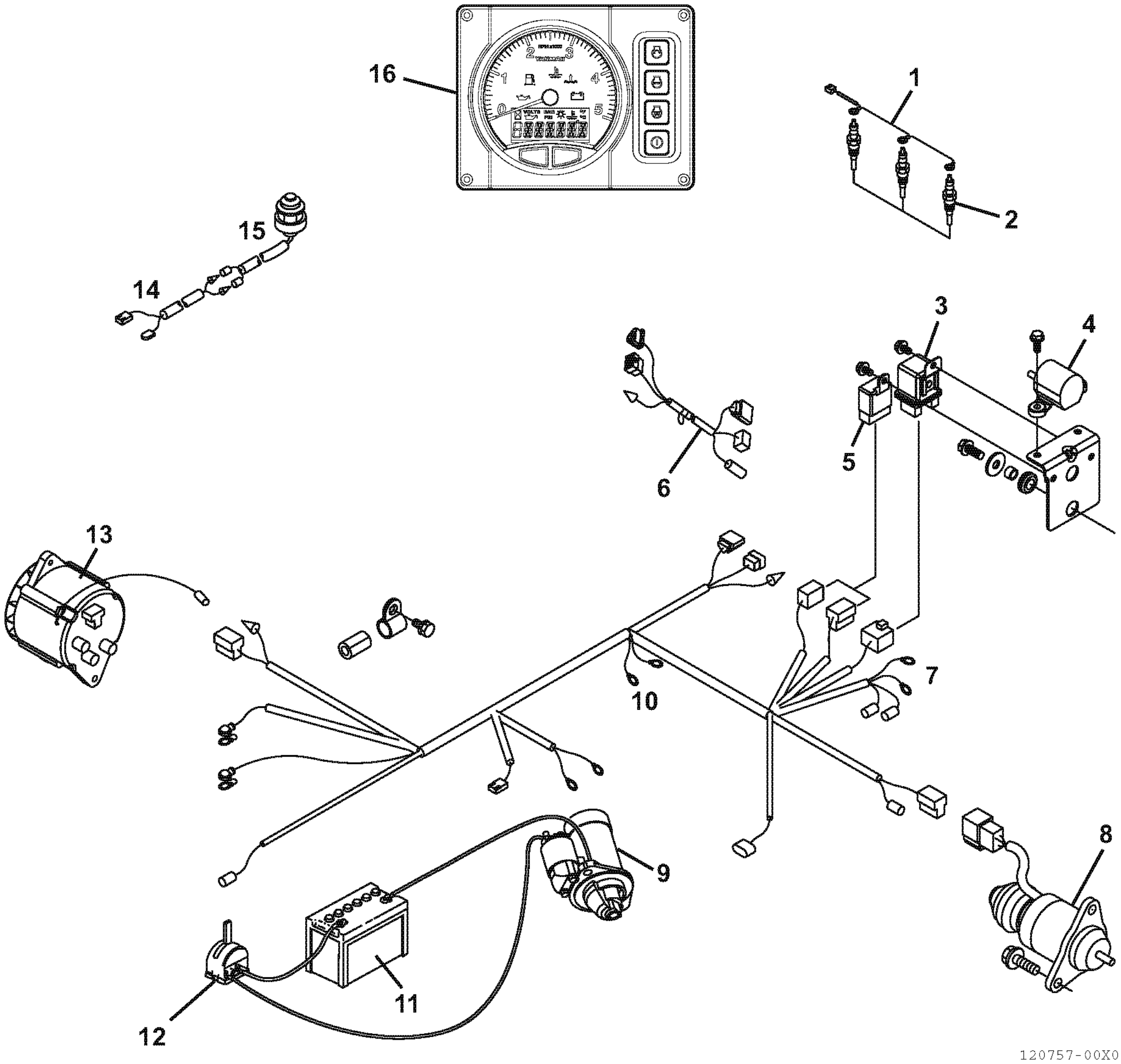


Figure 4-33

1 – Glow Connector
2 – Glow Plug
3 – Glow Relay
4 – Magnet Relay
5 – Safety Relay
6 – Extension Wire Harness
7 – To Engine Oil Pressure Switch and Coolant Temperature Switch
8 – Stop Solenoid
9 – Starting Motor
10 – To Ground Bolt
11 – Battery
12 – Battery Switch
13 – Alternator
14 – Fitting to Marine Gear
15 – Neutral Safety Switch
16 – B20 Type Instrument Panel

Every 1000 Hours of Operation

Check the following points every 1,000 hours or 4 years of operation, whichever comes first.

- **Checking the Fuel Injection Timing**
- **Checking the Fuel Injector Spray Pattern**
- **Replacing the Seawater Pump Impeller**
- **Cleaning and Checking the Seawater Passages**
- **Checking the Diaphragm Assembly**
- **Replacing the Alternator V-Belt**
- **Tightening all Major Nuts and Bolts**
- **Adjusting the Intake / Exhaust Valve Clearance**
- **Checking / Adjusting the Remote Control Cables**
- **Adjusting the Propeller Shaft Alignment**

Checking the Fuel Injection Timing

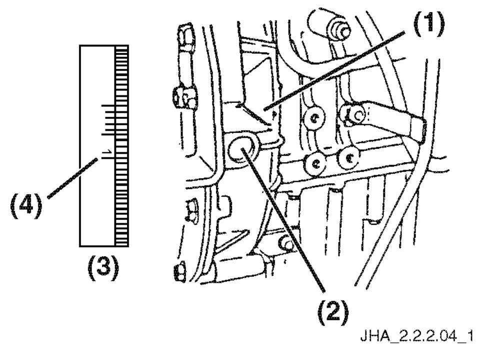


Figure 4-34

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

The fuel injection timing is adjusted to maximize engine performance. Inspect and adjust the fuel pump according to the ML pump *Service Manual*.

Adjust the fuel injection timing as follows:

1. Bleed the fuel line and prepare the engine for starting.
2. Align the timing marks on the fuel pump mounting flange and gear housing.
3. Set the speed control lever to the operating position.
4. Disconnect the injection line on the fuel pump side for the No. 1 cylinder **(Figure 4-34, (5))**. (Do not remove the delivery holder.)
5. Check the fuel discharge from the delivery holder while turning the crankshaft clockwise as seen from the radiator.
6. Stop turning it when the fuel comes out. Wipe the fuel out of the delivery holder exit.
7. Turn the crankshaft in the opposite direction (counterclockwise), and return it to about 20° BTDC.
8. Check the fuel discharge from the delivery holder while turning the crankshaft clockwise.

9. Stop turning it at the same time when the fuel comes out.
10. Read the timing scale on the flywheel through the hole in the flywheel housing **(Figure 4-34, (2))**.

    Standard fuel injection timing is listed below.

Model	Injection Timing FID (FIC-Air) degree BTDC
3YM30AE	17 ± 1 (19 ± 1)
3YM30	16 ± 1 (18 ± 1)
3YM20	22 ± 1 (24 ± 1)
2YM15	21 ± 1 (23 ± 1)

11. Repeat steps 5 through 7 several times.

Checking the injection timing for one cylinder is generally sufficient. If all cylinders are to be checked, check each cylinder in the ignition firing order. The firing order is 1-3-2-1 for 3-cylinder engines and 1-2-1 for 2-cylinder engines.

If the injection timing is out of standard:

Loosen the fuel pump mounting nut and incline the fuel injection pump toward or away from the engine for adjustment. Incline toward the engine to delay the timing, and away from the engine to advance it.

Checking the Fuel Injector Spray Pattern

⚠ WARNING

Exposure Hazard

Wear protective glasses when testing injection streams from the fuel injection nozzle **(Figure 4-35, *(2))*.**

Piercing Hazard

Never use your bare hand to check injection fuel pressure. Use a piece of wood or cardboard.

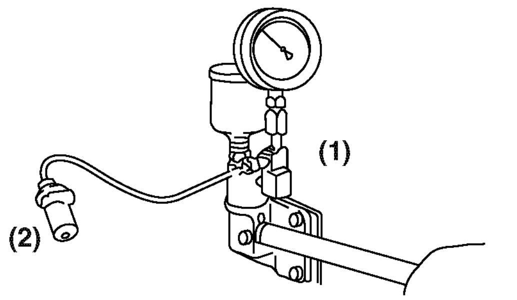


Figure 4-35

1 – Nozzle Tester
2 – Injection Nozzle

Standard Fuel Injection Pressure
12.3 to 13.28 MPa (1783 to 1926 psi)

NOTICE

Adjust new nozzles about 0.5 MPa (72 psi) higher than standard values. This allows the nozzles to wear in after about 5 hours of operation.

Measuring the Injection Pressure

1. Remove carbon deposits from the nozzle **(Figure 4-35, (2))** before measurement.
2. Connect the fuel injection valve to the high-pressure line of the nozzle tester.
3. Operate the nozzle tester lever slowly and read the pressure at the moment the fuel exits from the nozzle.
4. If the measured injection pressure is lower than the standard value, replace the pressure adjusting shim with a thicker one.

Thickness of Pressure Adjusting Shims	Injection Pressure Adjustment
0.1 mm (0.0039 in.) 0.2 mm (0.0078 in.) 0.3 mm (0.0118 in.) 0.4 mm (0.0157 in.) 0.5 mm (0.0196 in.) 0.52 mm (0.020 in.) 0.54 mm (0.212 in.) 0.56 mm (0.0220 in) 0.58 mm (0.0228 in.) 0.8 mm (0.0314 in.)	The injection pressure is increased by approximately 1.1 MPa (160 psi), when the adjusting shim thickness is increased by 0.1 mm (0.0039 in.).

5. Retest after different shims have been installed.

Fuel Injection Valve Components

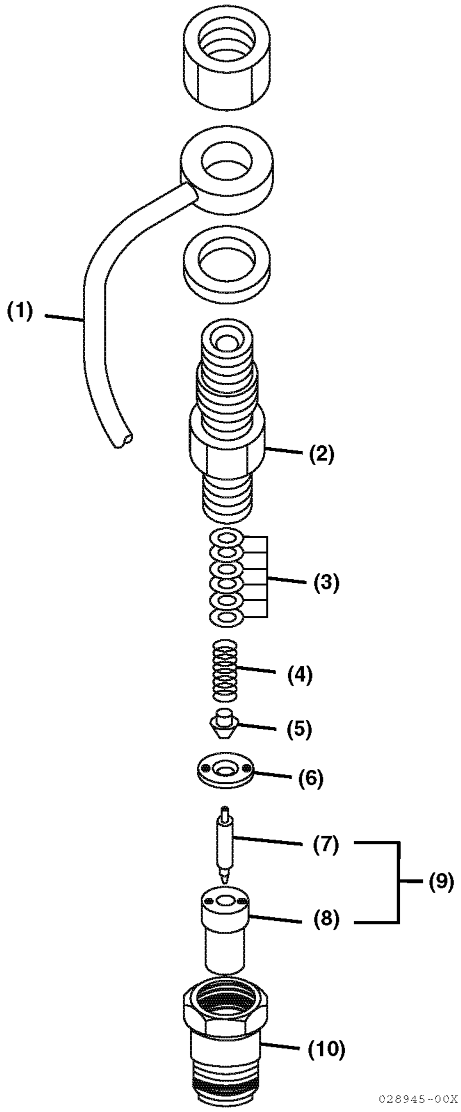


Figure 4-36

1 – Fuel Return Line
2 – Nozzle Holder
3 – Pressure Adjusting Shim
4 – Nozzle Spring
5 – Nozzle Spring Seat
6 – Valve Stop Spacer
7 – Nozzle Valve
8 – Nozzle Body
9 – Nozzle
10 – Nozzle Case Nut

Inspecting the Nozzle Spray Pattern

After setting the specified valve opening pressure, use a nozzle tester and check the leakage and spray pattern.

To check the nozzle for leakage:

1. Clear the nozzle by injecting a few times.
2. Increase the pressure gradually and hold the pressure for about 5 seconds at a little above the valve opening pressure of 1.96 MPa (284 psi).

   Check to see that fuel does not drip from the tip of the nozzle.

If fuel leaks excessively, replace the nozzle assembly.

To check the spray pattern:

1. Operate the nozzle tester lever at a rate of once or twice a second and check for a normal spray pattern **(Figure 4-38)**.
2. If a normal spray pattern cannot be obtained, replace the fuel injection nozzle. *See Removing the Fuel Injection Nozzles on page 5-87*.
3. Look for the following:
   - No extreme difference in spray angle
   - Finely atomized spray
   - Excellent spray departure

   Abnormal Spray Pattern

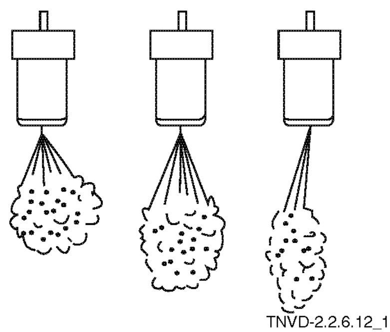


Figure 4-37

Normal Spray Pattern

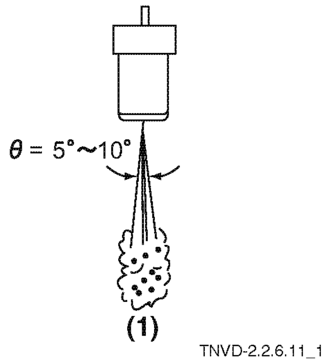


Figure 4-38

Nozzle Valve Sliding Test

Nozzle Valve Sliding Check by Gravity

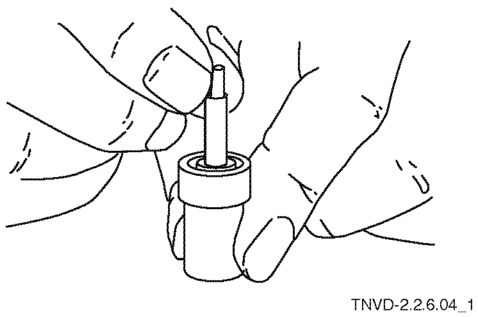


Figure 4-39

1. Wash the nozzle valve in clean diesel fuel.
2. Hold the nozzle body vertically and insert the nozzle into the body about 1/3 of its length **(Figure 4-39)**.

The valve is normal if it smoothly falls by its own weight into the body. For new nozzles, remove the seal packaging and immerse it in clean diesel fuel to clean the inner and outer surfaces.

Note: New nozzles are coated with rust-preventive oil and are packaged with an airtight seal. Thoroughly remove any rust-preventive oil before using the nozzle.

Nozzle Punch Marks

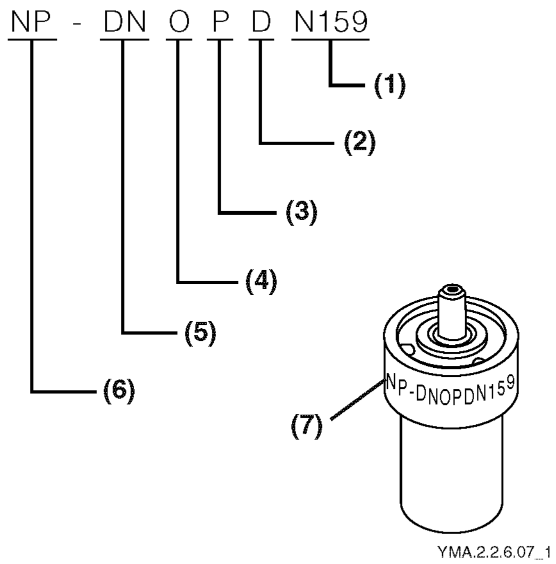


Figure 4-40

1 – Design Code
2 – Throttle Type
3 – Size: P
4 – Injection Angle
5 – Type: Pintle
6 – Manufacturer: BOSCH
7 – Identification Number Location

Replacing the Seawater Pump Impeller

The impeller must be replaced periodically (every 1000 hours or 4 years, whichever comes first).

See Checking or Replacing the Seawater Pump Impeller on page 4-24 for the procedure.

Cleaning and Checking the Seawater Passages

With extended use, trash, scale and rust collect in the coolant passages and the cooling performance declines. Clean the coolant passages periodically or as necessary.

1. Remove the hoses for the coolant lines and seawater lines.
2. Check the interior of the hoses for damage and debris.
3. Check for cracks and the deterioration of the hoses. Replace if necessary.
4. Replace the used hose clamps, if necessary.

Inspecting the Heat Exchanger Core

- Inspect the inside of the tubes for rust or scale buildup from seawater.
- Clean with a wire brush if necessary.

- Check the joints at both ends of the tubes for looseness or damage, and repair if loose. Replace if damaged or corroded.
- Check each tube and replace if leaking.
- Clean any scale or rust from the outside of the tubes.

Inspecting the Heat Exchanger Body

- Check heat exchanger body and side cover for dirt and corrosion. Replace if excessively corroded or cracked.
- Inspect the seawater and freshwater inlets and outlets, retighten any connections as necessary and clean the insides of the pipes.
- Check the exhaust gas intake flange and line and replace if corroded or cracked.

Heat Exchanger Body Water Leakage Test

Compressed Air / Water Tank Test

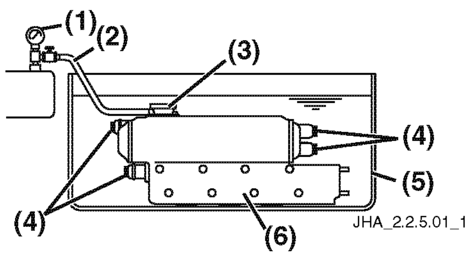


Figure 4-41

1 – Pressure Gauge
2 – Air Hose
3 – Filler Cap
4 – Rubber Plug
5 – Test Tank
6 – Heat Exchanger

1. Install rubber plugs on the coolant and seawater inlets and outlets.
2. Submerge the heat exchanger **(Figure 4-41, (6))** in a water tank and feed compressed air into the heat exchanger through the overflow pipe.
3. Check for any leaks.

Heat Exchanger Body Test Pressure
0.20 MPa (29 psi)

Using the Tester

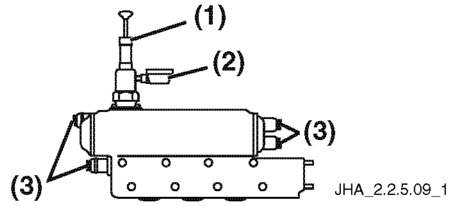


Figure 4-42

1 – Pressure Tester
2 – Pressure Gauge
3 – Rubber Plug

1. Install rubber plugs on the fresh and seawater inlets and outlets and fill the coolant tank with coolant.
2. Install a pressure cap tester **(Figure 4-42, (1))** in place of the pressure cap and operate the pump for 1 minute.
3. Set the pressure at 0.15 Mpa (28 psi).
   - If there are leaks, the pressure will fall.
   - If there are no leaks, the pressure will remain constant.

Inspecting the Pressure Cap

WARNING! Burn Hazard*. NEVER open the pressure cap while the engine is running or right after stopping. Remove the cap only after the coolant cools down.*

1. Remove any scale and rust.
2. Check the seat and seat valve for scratches or wear.
3. Check the spring for corrosion or settling and replace if necessary.

NOTICE

Clean the pressure cap **(Figure 4-43, *(2))*** *with fresh water because it will not close completely if dirty.*

4. Install the adapter **(Figure 4-43, (3))** to the tester **(Figure 4-43, (1))**.
5. Install the pressure cap to the other end of the adapter.

6. Pump until the pressure gauge is within the specified pressure range of 0.074 to 0.103 MPa (11 to 15 psi) and note the gauge reading.
7. The cap is normal if the pressure holds for 6 seconds. If the pressure does not rise, or drops immediately, inspect the cap and / or replace as necessary.

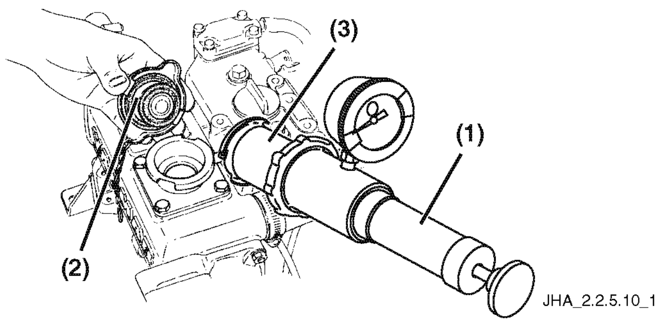


Figure 4-43

1 – Tester
2 – Pressure Cap
3 – Adapter

Checking the Diaphragm Assembly

Inspect the diaphragm **(Figure 4-44, (5))** on the rocker arm cover **(Figure 4-44, (1))**.

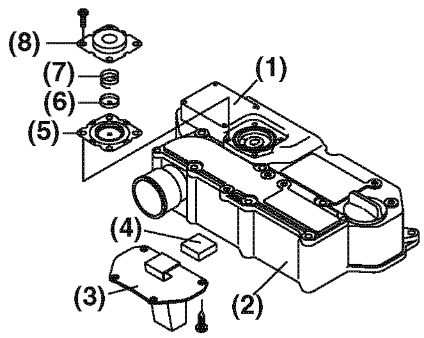


Figure 4-44

1 – Rocker Arm Cover
2 – Intake Manifold
3 – Baffle Plate
4 – Breather Baffle
5 – Diaphragm
6 – Center Plate
7 – Spring
8 – Diaphragm Cover

1. Loosen the screws and remove the diaphragm assembly.
2. Check to make sure the small hole in the diaphragm cover is not plugged with oil or other debris.
3. Check for damage to the diaphragm rubber and the spring.
4. Replace the diaphragm assembly, if necessary.

NOTICE

- *If the diaphragm is inoperative, crankcase pressure drops and engine damage may occur. When the internal pressure of the crankcase decreases too much, excessive blow-by gas is directed into the intake air system and may cause a reduction in engine performance by contaminating the intake valves, causing excessive oil consumption and / or reduced engine compression.*
- *If pressure increases in the crankcase, it may cause leakage of oil seals and / or seeping at the gasket of the oil pan.*
- *A damaged diaphragm causes blow-by to be exhausted through a breather hole on the side of diaphragm cover, and not into the intake manifold.*

- *Inspect the diaphragm carefully and correct any suspected problems.*
- *Do not overfill the oil pan. An excessive amount of engine oil will cause the oil to be directed into the combustion chamber, which can lead to oil hammering of the piston. Fill the oil to the upper mark on the engine oil dipstick.*

Replacing the Alternator V-Belt

Replace the alternator V-belt every 1000 hours or 4 years, whichever comes first, even if no cracks are evident.

See Checking and Adjusting Alternator V-Belt Tension on page 4-13 for the procedure.

Tightening all Major Nuts and Bolts

Retorque the major nuts and bolts listed below and ensure they are tightened to specified torque values. (*See Tightening Torque for Bolts and Nuts on page 13-11.*)

- Cylinder head bolts
- Crankshaft pulley bolts
- Fuel injection nozzle set bolts
- Fuel pump gear set bolts
- Fuel injection line sleeve nut

Retighten the following major bolts as required.

- Connecting rod bolts
- Flywheel set bolts
- Metal cap bolts

Adjusting the Intake / Exhaust Valve Clearance

See Checking and Adjusting Intake / Exhaust Valve Clearance on page 4-14 for the procedure.

Checking / Adjusting the Remote Control Cables

See Checking / Adjusting the Remote Control Cables on page 4-9 for the procedure.

Adjusting the Propeller Shaft Alignment

After extended use, the flexible engine mounts may compress slightly. This may cause a misalignment of the engine and the propeller shaft.

Check for any unusual noise and vibration of the engine and / or vessel hull, while increasing and decreasing engine speed.

If unusual noise is detected, see “Centering the Engine” in the *Installation Manual* for pleasure vessel use.

NOTICE

Replace the Yanmar flexible engine mounts every 1000 hours or 4 years, whichever comes first.

ADJUSTING NO-LOAD MINIMUM AND MAXIMUM ENGINE SPEED

1. Start the engine and allow it to warm up.

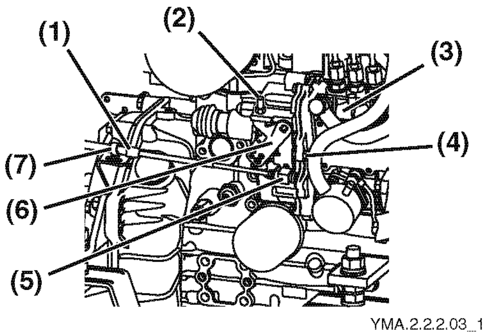


Figure 4-45

1 – Remote Control Cable
2 – High Idle Limiting Screw
3 – Fuel Injection Pump
4 – Low Idle Limiting Screw
5 – Cable Joint
6 – Control Lever
7 – Clamp

2. Gradually raise the speed and set it to the no-load maximum speed.
   - If the no-load maximum speed is out of the standard, adjust it by turning the high idle limiting screw **(Figure 4-45, (2))**.
   - Then set the no-load minimum speed by adjusting the low idle limiting screw **(Figure 4-45, (4))**.

Standards

Model	No-Load Maximum Speed	No-Load Minimum Speed
3YM30AE	3485 ± 25 min^{-1}	850 ± 25 min^{-1}
3YM30	3850 ± 25 min^{-1}	
3YM20	3890 ± 25 min^{-1}	
2YM15	3850 ± 25 min^{-1}	

SWITCH INSPECTIONS

Oil Pressure Switch

Continuity Test

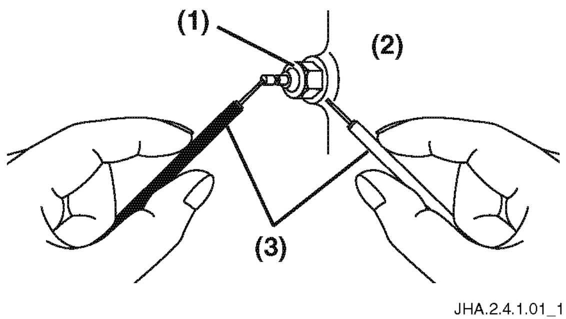


Figure 4-46

1 – Oil Pressure Switch
2 – Cylinder Block (flywheel side)
3 – Meter Probes

1. Disconnect the connector from the oil pressure switch **(Figure 4-46, (1))**.
2. Keep the meter probes **(Figure 4-46, (3))** in contact with the switch terminals and cylinder block **(Figure 4-46, (2))** while operating the engine.

Coolant Temperature Switch

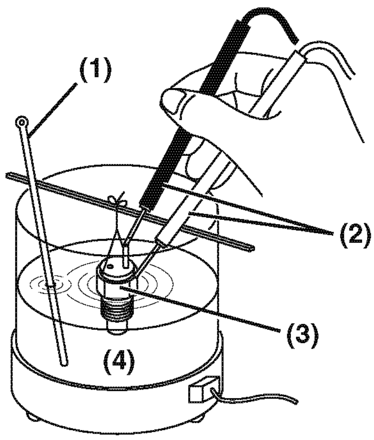


Figure 4-47

1 – Thermometer
2 – Meter Probes
3 – Coolant Temperature Switch
4 – Hot Water

1. Place the coolant temperature switch **(Figure 4-47, (3))** in a container filled with water.
2. Heat the water while measuring the temperature.

   The switch is normal if the meter shows continuity when the fluid temperature is 93° to 97°C (199° to 206°F).

Inspecting the Thermostat

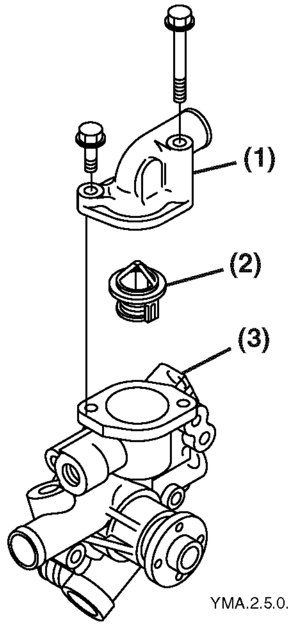


Figure 4-48

1 – Thermostat Cover
2 – Thermostat
3 – Coolant Pump Body

Inspect the thermostat every 500 hours of operation, any time coolant temperature rises abnormally or if white smoke comes from the exhaust.

Replace the thermostat every year or 2000 hours of operation, whichever comes first.

Put the thermostat **(Figure 4-49, (2))** in a beaker with fresh water, and heat the water while measuring the temperature.

- The thermostat is functioning normally if it starts to open between 75° and 78°C (167° and 172°F) and opens 8 mm (0.3149 in.) or more at 90°C (194°F).
- Replace the thermostat if it not functioning normally.

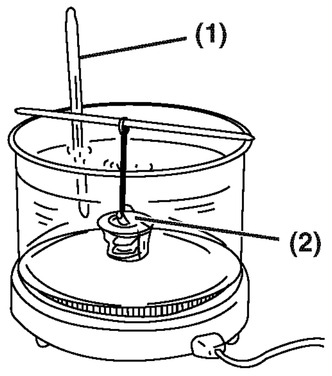


Figure 4-49

1 – Thermometer
2 – Thermostat

Valve Opening Temperature*	Full Open Lift
69.5° to 72.5°C (157.1° to 162.5°F)	8 mm (0.31 in.) or more at 85°C (185°F)

* *Valve opening temperature is marked on flange.*

ENGINE TESTS AND ADJUSTMENTS

Perform engine test runs and adjustments after maintenance is performed.

Preliminary Precautions

1. Warm the engine up.
2. Remove any water from the fuel filter, water separator and fuel tank.
3. Use oil recommended by Yanmar.
4. Add Long Life Coolant Antifreeze (LLC) to cooling fresh water.
5. Provide good ventilation in the engine room.

Test Run Procedure

1. Start the engine, and run at low speed (825 to 900 min^{-1} (rpm)) for a few minutes.
2. Run the engine for about 5 minutes at the rated speed (no load).
3. Check for any water, fuel or oil leaks.
4. Check for abnormal vibration or noise.
5. Check the oil pressure, coolant temperature and exhaust gas color.
6. Adjust the no-load minimum and maximum speed. (*See Adjusting No-Load Minimum and Maximum Engine Speed on page 4-36*.)
7. Perform loaded operations as required.

LONG-TERM STORAGE

Observe the following instructions when the engine is to be stored for a long period of time:

1. Wipe off any dust or oil from the outside of engine.
2. Drain water from the fuel filters.
3. Drain the fuel tank completely or fill the tank to prevent condensation.
4. Drain the Cooling System (see *Draining the Cooling System on page 4-40*).
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 the 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 the key from key switch and cover the key switch with moisture cap.
11. When storing an engine for a long time, run the engine periodically, according to the following procedure, because rust inside the engine, the rack agglutination of the fuel pump, etc. are likely to occur.
    - Change the engine oil and replace the filter before running the engine *(see Replacing the Engine Oil Filter Element on page 4-11)*.
    - Fill fuel tank if the diesel fuel was removed, and bleed the fuel system.
    - Confirm that there is coolant in the engine.
    - Operate the engine at idle speed for about 5 minutes. Repeat monthly, if possible.

Draining the Cooling System

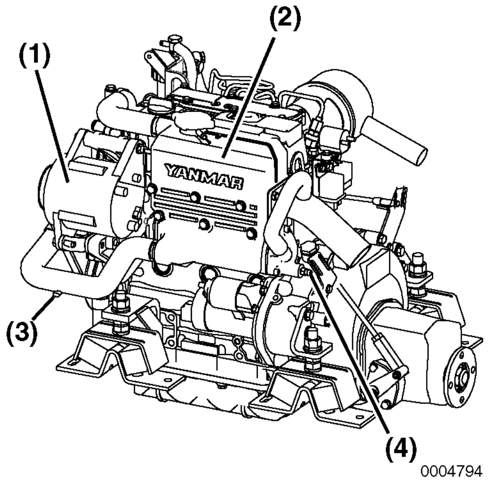


Figure 4-50

1 – Alternator
2 – Coolant Tank / Heat Exchanger
3 – Coolant Drain Cock
4 – Seawater Drain Cock

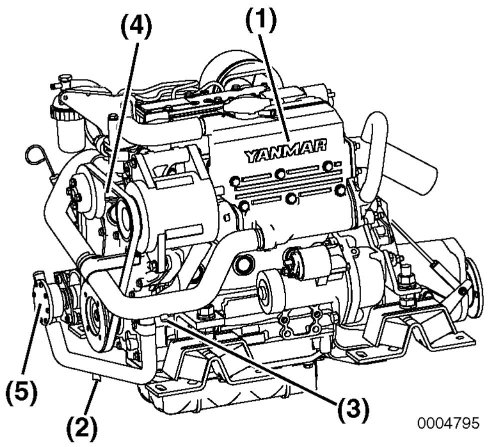


Figure 4-51

1 – Coolant Tank / Heat Exchanger
2 – Seawater Drain Cock
3 – Coolant Drain Cock
4 – Coolant Pump
5 – Seawater Pump

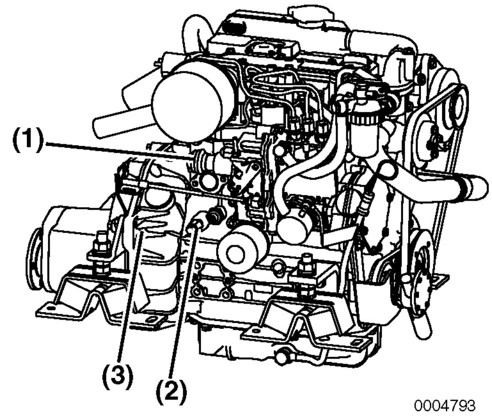


Figure 4-52

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

Note: The drain cocks are opened before shipping from the factory. Close all drain cocks before filling the system with coolant.

NOTICE

If seawater is left inside, it may freeze and damage parts of the cooling system (heat exchanger, seawater pump, etc.) when ambient temperature is below 0°C (32°F).

1. Put a pan under the seawater drain cocks.
2. Open the seawater drain cocks on the pipe and on the heat exchanger. Allow to drain.
3. Remove the four bolts fastening the side cover of the seawater pump. Remove the cover and drain the seawater.
4. Install the cover and tighten bolts.
5. Close all drain cocks.

NOTICE

Never drain engine coolant in the cold season or before long storage. If LLC (Long Life Coolant) has not been added to the cooling system, add LLC or drain the coolant from the coolant system after daily use. If the coolant without LLC is not removed, it may freeze and damage parts of the cooling system or engine when ambient temperature is below 0°C (32°F).

Section 5

ENGINE

Page

SAFETY PRECAUTIONS

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

DANGER

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

WARNING

Always ensure that all connections are tightened to specifications after repair is made to the exhaust system. All internal combustion engines create carbon monoxide gas during operation and special precautions are required to avoid carbon monoxide poisoning.

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

Always wear safety glasses when servicing the engine and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.

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 procedures necessary to disassemble, inspect and reassemble the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

Cylinder Head Specifications

Inspection Item		Standard	Limit
Cylinder Head Distortion		0.05 mm (0.0019 in.) or less	0.15 mm (0.0059 in.)
Valve Recession	Intake and Exhaust	0.4 to 0.6 mm (0.0157 to 0.0236 in.)	0.8 mm (0.0314 in.)
Valve Seat Angle	Intake	120°	–
	Exhaust	90°	–
Valve Seat Width	Intake	1.07 to 1.24 mm (0.042 to 0.048 in.)	1.74 mm (0.068 in.)
	Exhaust	1.24 to 1.45 mm (0.048 to 0.057 in.)	1.94 mm (0.076 in.)
Intake / Exhaust Valve Clearance		0.15 to 0.25 mm (0.0004 to 0.0008 in.)	–

Valve Stem and Valve Guide Specifications

Inspection Item		Standard	Limit
Intake	Guide I.D.	6.000 to 6.012 mm (0.2362 to 0.2366 in.)	6.08 mm (0.2393 in.)
	Valve Stem O.D.	5.960 to 5.975 mm (0.2396 to 0.2352 in.)	5.90 mm (0.2322 in.)
	Clearance	0.025 to 0.052 mm (0.0009 to 0.0020 in.)	0.16 mm (0.0006 in.)
Exhaust	Guide I.D.	6.000 to 6.012 mm (0.2362 to 0.2366 in.)	6.08 mm (0.2393 in.)
	Valve Stem O.D.	5.945 to 5.960 mm (0.2340 to 0.2346 in.)	5.90 mm (0.2322 in.)
	Clearance	0.040 to 0.067 mm (0.0015 to 0.0026 in.)	0.17 mm (0.0066 in.)
Valve Guide Projection from Cylinder Head		9.8 to 10.0 mm (0.3858 to 0.3936 in.)	–
Valve Guide Installation Method		Cold-Fit	–
Valve Stem Seal Projection		10.9 to 11.2 mm (0.4291 to 0.4409 in.)	–

Valve Spring Specifications

Inspection Item	Standard	Limit
Free Length	37.8 mm (1.4881 in.)	36.3 mm (1.4291 in.)
Inclination	–	1.3 mm (0.0511 in.)
Tension	26.6 to 35.4 N•mm (95.6 to 127.3 ozf)	–

Rocker Arm and Shaft Specifications

Inspection Item	Standard	Limit
Rocker Arm Bushing I.D.	12.000 to 12.020 mm (0.4724 to 0.4732 in.)	12.07 mm (0.4751 in.)
Shaft O.D.	11.966 to 11.984 mm (0.4711 to 0.4718 in.)	11.94 mm (0.4700 in.)
Clearance	0.016 to 0.054 mm (0.0006 to 0.0021 in.)	0.13 mm (0.0051 in.)

Tappet and Push Rod Specifications

Inspection item	Standard	Limit
Tappet O.D.	20.927 to 20.960 mm (0.8238 to 0.8251 in.)	20.907 mm (0.8231 in.)
Tappet Bore	21.000 to 21.021 mm (0.8267 to 0.8275 in.)	21.041 mm (0.8283 in.)
Tappet Oil Clearance	0.040 to 0.094 mm (0.0015 to 0.0037 in.)	0.134 mm (0.0052 in.)
Push Rod Bend	Less than 0.03 mm (0.0011 in.)	0.03 mm (0.0011 in.)

Camshaft and Gear Train Specifications

Camshaft

Inspection item		Standard	Limit
End Play		0.05 to 0.15 mm (0.0019 to 0.0059 in.)	0.25 mm (0.0098 in.)
Straightness (1/2 the dial gauge reading)		0.02 mm (0.0007 in.) or less	0.05 mm (0.0019 in.)
Cam Lobe Height	3YM30AE / 3YM30	34.135 to 34.265 mm (1.1438 to 1.3490 in.)	33.89 mm (1.3342 in.)
	3YM20 / 2YM15	34.535 to 34.665 mm (1.3596 to 1.3647 in.)	34.29 mm (1.3499 in.)

Inspection item		Standard	Limit
Shaft Bearing O.D. and Bushing I.D. (gear side)	Bushing I.D.	40.000 to 40.075 mm (1.5747 to 1.5777 in.)	40.150 mm (1.5807 in.)
	Camshaft O.D.	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)
	Clearance	0.040 to 0.135 mm (0.0015 to 0.0053 in.)	0.245 mm (0.0096 in.)
Shaft Bearing O.D. and Bushing I.D. (intermediate)	Bushing I.D.	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)
	Camshaft O.D.	39.910 to 39.935 mm (1.5712 to 1.5722 in.)	39.875 mm (1.5698 in.)
	Clearance	0.065 to 0.115 mm (0.0025 to 0.0045 in.)	0.225 mm (0.0088 in.)
Shaft Bearing O.D. and Bushing I.D. (flywheel side)	Bushing I.D.	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)
	Camshaft O.D.	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)
	Clearance	0.04 to 0.085 mm (0.0015 to 0.0083 in.)	0.195 mm (0.0076 in.)

Idler Gear Shaft and Bushing

Inspection item	Standard	Limit
Shaft O.D.	36.950 to 36.975 mm (1.4547 to 1.4557 in.)	36.900 mm (1.4527 in.)
Bushing I.D.	37.000 to 37.025 mm (1.4566 to 1.4576 in.)	37.075 mm (1.4596 in.)
Clearance	0.025 to 0.075 mm (0.0009 to 0.0029 in.)	0.175 mm (0.0068 in.)

Gear Backlash

Inspection item	Standard	Limit
Crank Gear, Cam Gear, Idler Gear and Fuel Injection Pump Gear	0.06 to 0.12 mm (0.0023 to 0.0047 in.)	0.14 mm (0.0055 in.)

Cylinder Block Specifications

Inspection item		Standard	Limit
Cylinder I.D.	3YM30AE	80.000 to 80.030 mm (3.1496 to 3.1508 in.)	80.200 mm (3.1574 in.)
	3YM30	76.000 to 76.030 mm (2.9921 to 2.9932 in.)	76.200 mm (2.9999 in.)
	3YM20 / 2YM15	70.000 to 70.030 mm (2.7558 to 2.7570 in.)	70.200 mm (2.7637 in.)
Cylinder Bore	Roundness	0.01 mm (0.0003 in.) or less	0.03 mm (0.0011 in.)
	Inclination		

Crankshaft

Inspection item		Standard	Limit
Straightness (1/2 the dial gauge reading)		-	0.01 mm (0.0003 in.)
Crank Pin 3YM30AE / 3YM30	Pin O.D.	41.952 to 41.962 mm (1.6516 to 1.6520 in.)	41.902 mm (1.6496 in.)
	I.D.	41.982 to 42.010 mm (1.6528 to 1.6539 in.)	–
	Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–
	Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)
Crank Pin 3YM20 / 2YM15	Pin O.D.	37.952 to 37.962 mm (10.4941 to 1.4945 in.)	37.902 mm (1.4922 in.)
	Bearing I.D.	37.982 to 38.010 mm (1.4953 to 1.4964 in.)	–
	Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–
	Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)
Crank Journal (selective pairing) All Models	Journal O.D.	46.952 to 46.962 mm (1.8484 to 1.8488 in.)	46.902 mm (1.8465 in.)
	I.D.	46.982 to 47.002 mm (1.8496 to 1.8504 in.)	–
	Thickness	2.009 to 2.014 mm (0.0790 to 0.0792 in.)	–
	Clearance	0.020 to 0.050 mm (0.0007 to 0.0019 in.)	0.120 mm (0.0047 in.)
Crankshaft End Play		0.111 to 0.250 mm (0.0043 to 0.0098 in.)	0.30 mm (0.0118 in.)

Pistons and Piston Rings Specifications

Inspection item		Standard	Limit
Piston O.D. (Measure in the direction vertical to the piston pin.)	3YM30AE	79.962 to 79.972 mm (3.1481 to 3.1484 in.)	79.917 mm (3.146 in.)
	3YM30	75.965 to 75.975 mm (2.9907 to 2.9911 in.)	75.920 mm (2.9889 in.)
	3YM20 / 2YM15	69.970 to 69.980 mm (2.7547 to 2.7551 in.)	69.925 mm (2.7529 in.)
Piston O.D. (Measure upward from the bottom end of the piston)	3YM30AE	13 mm (0.5118 in.)	–
	3YM30 / 3YM20 / 2YM15	22 mm (0.8661 in.)	–
Clearance Between Piston and Cylinder	3YM30AE	0.038 to 0.058 mm (0.0014 to 0.0022 in.)	–
	3YM30	0.035 to 0.055 mm (0.0013 to 0.0021 in.)	–
	3YM20 / 2YM15	0.030 to 0.050 mm (0.0011 to 0.0019 in.)	–
Piston Pin Hole I.D.		22.000 to 22.009 mm (0.8661 to 0.8664 in.)	22.039 mm (0.8676 in.)
Piston Pin O.D.		21.995 to 22.000 mm (0.8659 to 0.8661 in.)	21.965 mm (0.8647 in.)
Piston Pin to Piston Clearance		0.000 to 0.014 mm (0.0000 to 0.0005 in.)	0.074 mm (0.0029 in.)

Piston Rings (3YM30AE Model)

Inspection item		Standard	Limit
Top Ring	Groove Width	2.04 to 2.06 mm (0.0803 to 0.0811 in.)	–
	Ring Width	1.94 to 1.96 mm (0.0763 to 0.0771 in.)	1.92 mm (0.0755 in.)
	Side Clearance	0.08 to 0.12 mm (0.0031 to 0.0047 in.)	–
	Ring Gap	0.20 to 0.35 mm (0.0078 to 0.0137 in.)	0.44 mm (0.0173 in.)
Middle Ring	Groove Width	1.54 to 1.56 mm (0.0606 to 0.0614 in.)	1.66 mm (0.0653 in.)
	Ring Width	1.47 to 1.49 mm (0.0578 to 0.0586 in.)	1.45 mm (0.0570 in.)
	Side Clearance	0.05 to 0.09 mm (0.0019 to 0.0035 in.)	0.21 mm (0.0082 in.)
	Ring Gap	0.35 to 0.50 mm (0.0137 to 0.0196 in.)	0.59 mm (0.0232 in.)
Oil Control Ring	Groove Width	3.010 to 3.025 mm (0.1185 to 0.1190 in.)	3.125 mm (0.1230 in.)
	Ring Width	2.97 to 2.99 mm (0.1169 to 0.1177 in.)	2.950 mm (0.1161 in.)
	Side Clearance	0.020 to 0.055 mm (0.0007 to 0.0021 in.)	0.135 mm (0.0053 in.)
	Ring Gap	0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.49 mm (0.0192 in.)

Piston Rings (3YM30 Model)

Inspection item		Standard	Limit
Top Ring	Groove Width	1.550 to 1.570 mm (0.0610 to 0.0618 in.)	–
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0586 in.)	1.450 mm (0.0570 in.)
	Side Clearance	0.060 to 0.100 mm (0.0023 to 0.0039 in.)	–
	Ring Gap	0.15 to 0.30 mm (0.0059 to 0.0118 in.)	0.390 mm (0.0153 in.)
Middle Ring	Groove Width	1.580 to 1.595 mm (0.0622 to 0.0627 in.)	1.695 mm (0.0667 in.)
	Ring Width	1.430 to 1.450 mm (0.0562 to 0.0570 in.)	1.410 mm (0.0555 in.)
	Side Clearance	0.013 to 0.165 mm (0.0005 to 0.0164 in.)	0.285 mm (0.0112 in.)
	Ring Gap	0.18 to 0.33 mm (0.0070 to 0.0129 in.)	0.420 mm (0.0165 in.)
Oil Control Ring	Groove Width	3.010 to 3.030 mm (0.1185 to 0.1192 in.)	3.130 mm (0.1232 in.)
	Ring Width	2.970 to 2.990 mm (0.1169 to 0.1177 in.)	2.950 mm (0.1161 in.)
	Side Clearance	0.020 to 0.060 mm (0.0007 to 0.0023 in.)	0.180 mm (0.0070 in.)
	Ring Gap	0.20 to 0.45 mm (0.0078 to 0.0177 in.)	0.540 mm (0.0212 in.)

Piston Rings (3YM20, 2YM15 Models)

Inspection item		Standard	Limit
Top Ring	Groove Width	1.550 to 1.570 mm (0.610 to 0.0618 in.)	–
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0586 in.)	1.450 mm (0.0570 in.)
	Side Clearance	0.060 to 0.100 mm (0.0023 to 0.0039 in.)	–
	Ring Gap	0.15 to 0.30 mm (0.0059 to 0.0118 in.)	0.390 mm (0.0153 in.)
Middle Ring	Groove Width	1.540 to 1.560 mm (0.060 to 0.0614 in.)	1.660 mm (0.0653 in.)
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0588 in.)	1.450 mm (0.0570 in.)
	Side Clearance	0.050 to 0.090 mm (0.0019 to 0.0035 in.)	0.210 mm (0.0082 in.)
	Ring Gap	0.18 to 0.33 mm (0.0070 to 0.2129 in.)	0.420 mm (0.0165 in.)
Oil Control Ring	Groove Width	3.010 to 3.030 mm (0.1185 to 0.1192 in.)	3.130 mm (0.1232 in.)
	Ring Width	2.970 to 3.010 mm (0.1169 to 0.1185 in.)	2.950 mm (0.1161 in.)
	Side Clearance	0.020 to 0.060 mm (0.0007 to 0.0023 in.)	0.180 mm (0.0070 in.)
	Ring Gap	0.15 to 0.35 mm (0.0059 to 0.0137 in.)	0.44 mm (0.0173 in.)

Connecting Rod Specifications

Crankshaft End

Inspection item	Standard	Limit
Side Clearance	0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.55 mm (0.0216 in.)

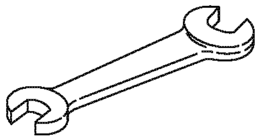
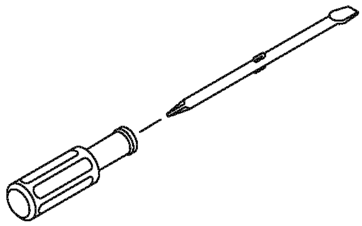
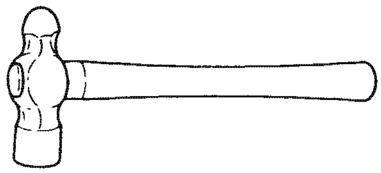
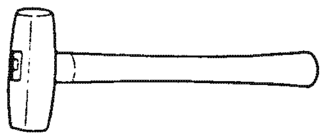
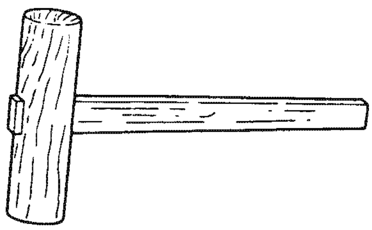
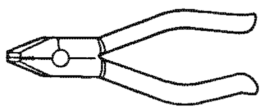
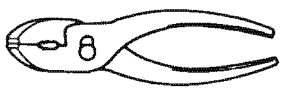
Piston Pin End

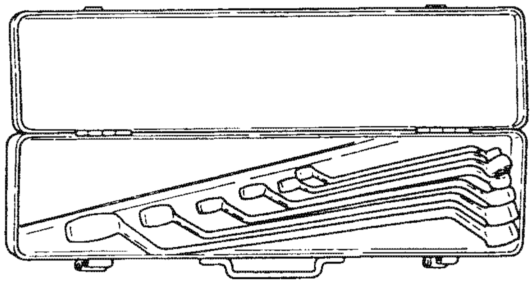
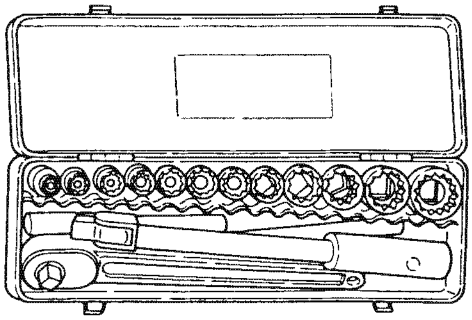
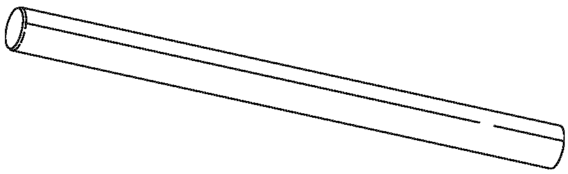
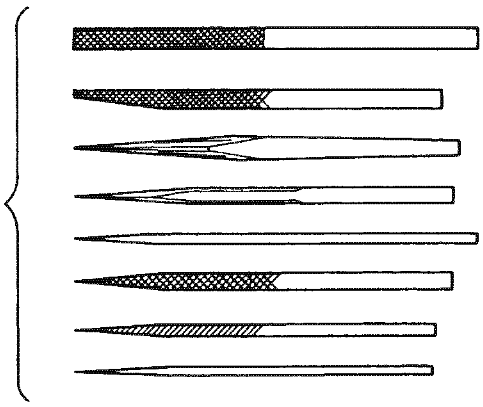
Item	Standard	Limit
Bushing I.D.	22.025 to 22.038 mm (0.8671 to 0.8676 in.)	22.068 mm (0.8688 in.)
Clearance	0.025 to 0.047 mm (0.0009 to 0.0018 in.)	0.105 mm (0.0041 in.)
Insert Pin O.D.	21.025 to 22.038 mm (0.8659 to 0.8661 in.)	21.965 mm (0.8647 in.)

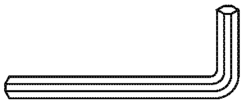
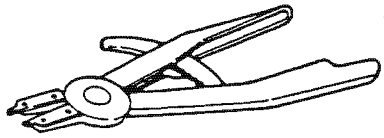
SPECIAL TOOLS

The following tools are required when disassembling and reassembling the engine. Please use them as instructed.

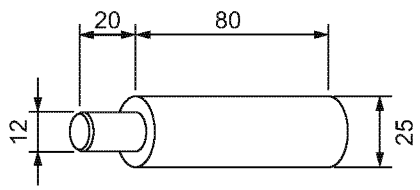
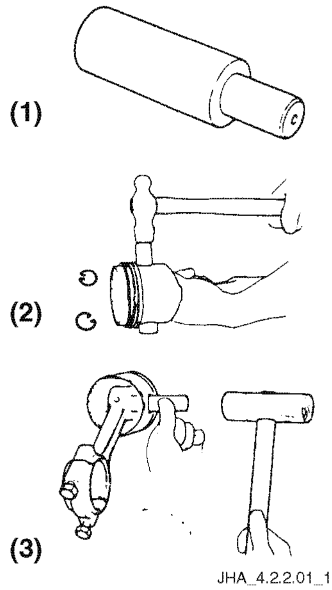
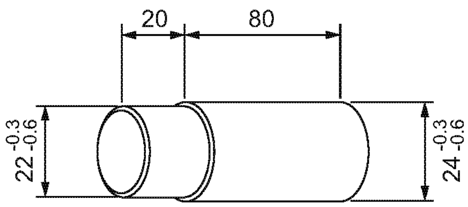
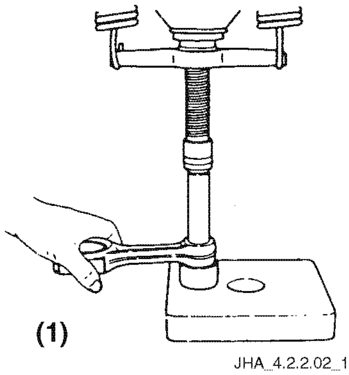
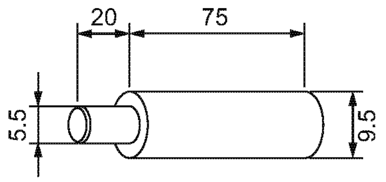
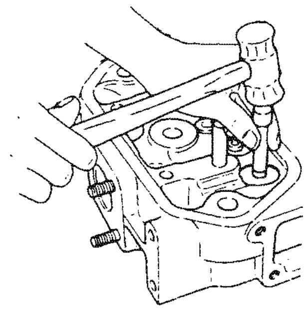
General Hand Tools

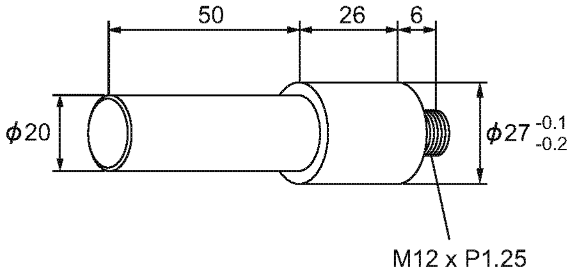
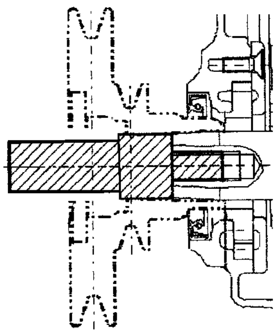
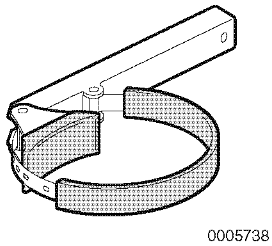
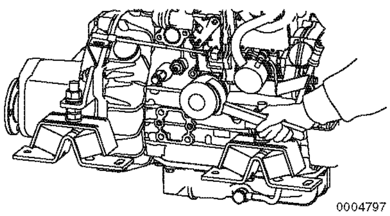
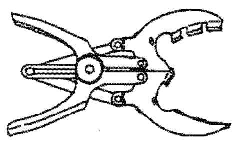
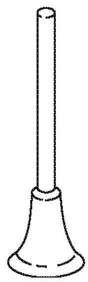
Tool Name	Illustration	Remarks
Wrench		Sizes: 10 x 13 mm 12 x 14 mm 17 x 19 mm 22 x 24 mm Local supply
Screwdriver		Local supply
Steel Hammer		Local supply
Soft-Faced Hammer		Local supply
Wooden Mallet		Local supply
Cutting Pliers		Local supply
Pliers		Local supply

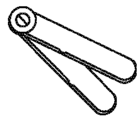
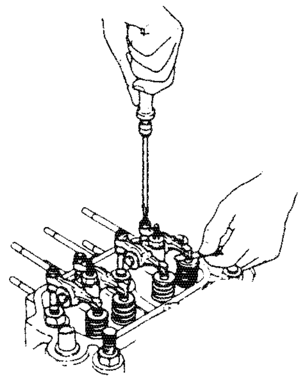
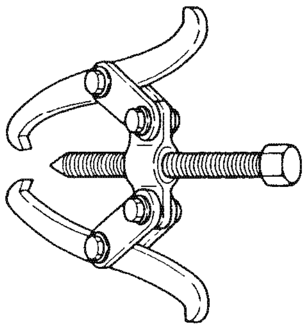
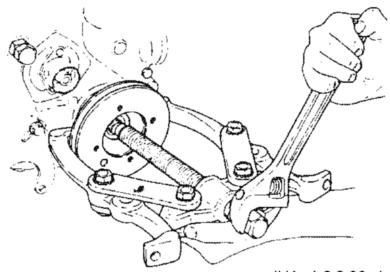
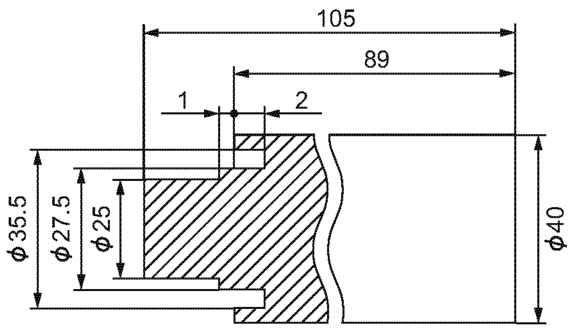
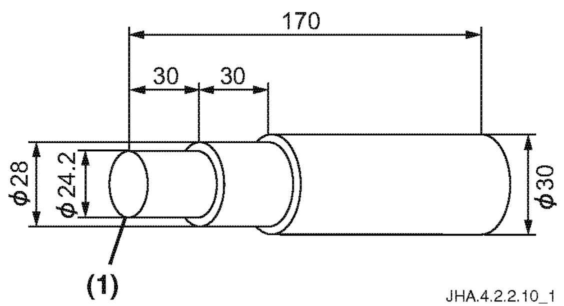
Tool Name	Illustration	Remarks
Offset Wrench		Local supply 1 set
Box Spanner		Local supply 1 set
Scraper		Local supply
Lead Rod		Local supply
File		Local supply 1 set

Tool Name	Illustration	Remarks
Hex Wrench		Size: 6 mm, 8 mm, 10 mm Local supply
Retaining Ring Pliers Hole Type Shaft Type	 S - 0  H4 - H8	Local supply

Special Hand Tools

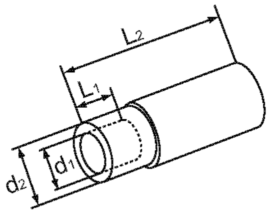
Tool Name	Illustration	Remarks
Piston Pin Insertion / Extraction Tool	 * Locally manufactured	 **1 – Piston Pin Extractor** **2 – Extraction of Piston Pin** **3 – Insertion of Piston Pin**
Connecting Rod Small End Bushing Insertion / Extraction Tool	 * Locally manufactured	 **1 – Extraction**
Intake and Exhaust Valve Insertion / Extraction Tool	 * Locally manufactured	

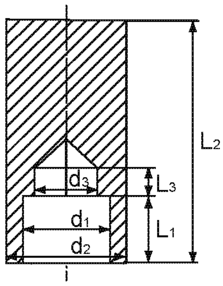
Tool Name	Illustration	Remarks
Crankshaft Pulley Insertion Tool	 * Locally manufactured	
Engine Oil Filter Wrench (for removal of engine oil filter)		
Piston Ring Replacer (for removal / installation of piston ring)		Local supply
Valve Lapping Tool (rubber cap type)		Local supply
Valve Lapping Compound	 Code No. 28210-000070	

Tool Name	Illustration	Remarks
Feeler Gauge	 Local Supply	
Pulley Puller	 SH-009_1	 JHA_4.2.2.08_1
Press Tool 1 for Filler Neck		* Locally manufactured
Press Tool 2 for Filler Neck Copper Tube	 JHA.4.2.2.10_1 **1 – Chamfer**	* Locally manufactured

<table>
<tr><th>Tool Name</th><th>Illustration</th><th>Remarks</th></tr>
<tr><td>Stem Seal Insertion Tool
(for inserting stem seal)</td><td>

d1	d2	d3	L1	L2	L3
15.0 mm (0.591 in.)	21 mm (0.83 in.)	12 mm (0.47 in.)	11.0 mm (0.433 in.)	65 mm (2.56 in.)	4 mm (0.16 in.) or more

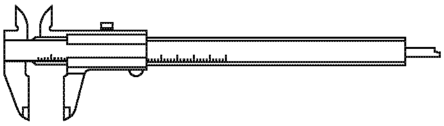
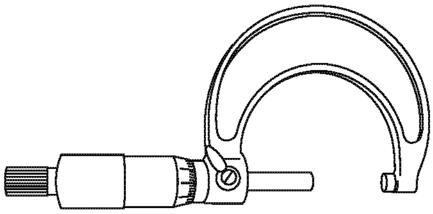
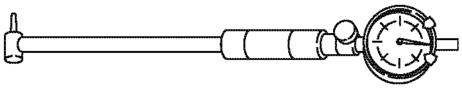
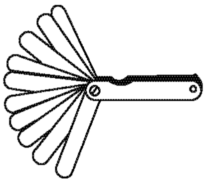
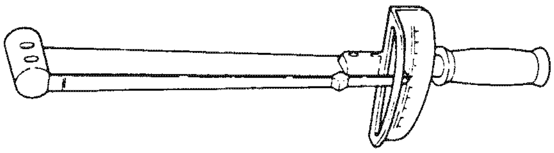
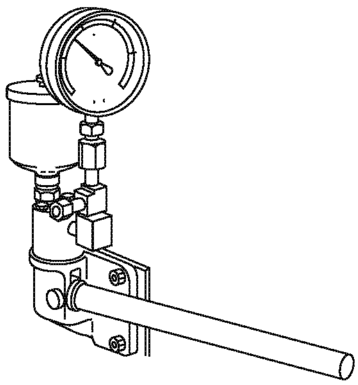




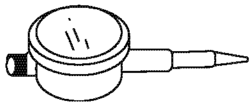
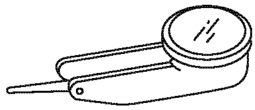
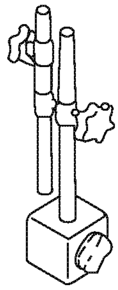
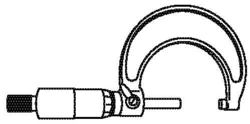
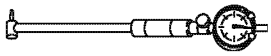
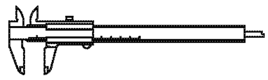
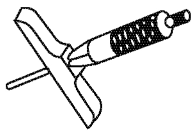
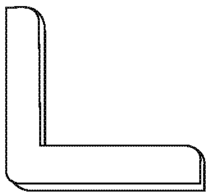
</td><td>* Locally manufactured</td></tr>
</table>

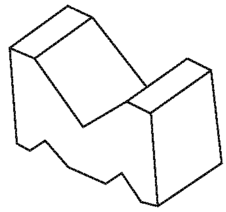
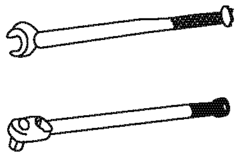
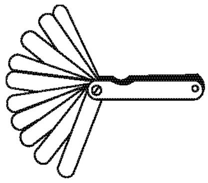
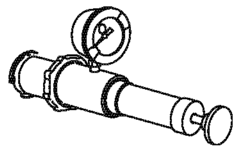
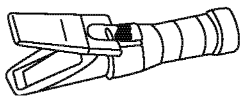
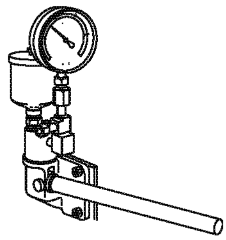
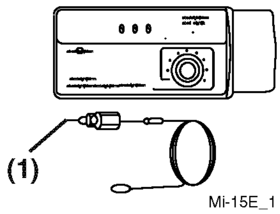
MEASURING INSTRUMENTS

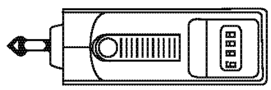
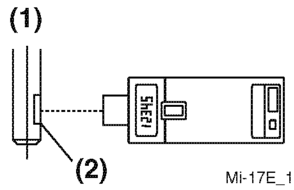
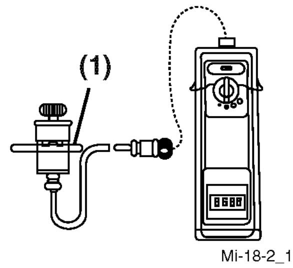
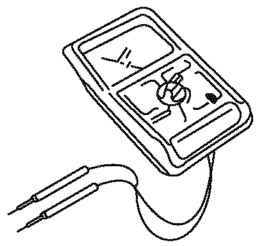
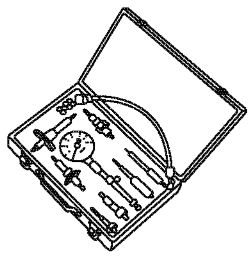
Tool Application

Tool Name	Illustration	Remarks
Vernier Calipers		0.05 mm (0.002 in.) 0 to 150 mm (0 to 6 in.)
Micrometer		0.01 mm (0.0004 in.) 0 to 25 mm (0 to 1 in.) 25 to 50 mm (1 to 2 in.) 50 to 75 mm (2 to 3 in.) 75 to 100 mm (3 to 4 in.) 100 to 125 mm (4 to 5 in.) 125 to 150 mm (5 to 6 in.)
Dial Bore Gauge		0.01 mm (0.0004 in.) 18 to 35 mm (0 to 1 in.) 35 to 60 mm (1 to 2 in.) 50 to 100 mm (2 to 4 in.)
Feeler Gauge		0.05 to 2 mm (0.002 to 0.08 in.)
Torque Wrench		0 to 128 N•m (0 to 100 lb-ft)
Nozzle Tester		0 to 49 Mpa (0 to 8000 psi)

Tool Usage

No.	Tool Name	Use	Illustration
1	Dial Indicator	Measures shaft straightness, flatness, and gaps	
2	Test Indicator	Measures narrow and deep places, which cannot be measured with dial indicator	
3	Magnetic Stand	Keeps the dial indicator firmly in position, thereby permitting it to be used at various angles	
4	Micrometer	Measures the outer diameter of the crankshaft, piston, piston pin, etc.	
5	Dial Bore Gauge	Measures the inner diameter of the cylinder liner and rod metal	
6	Vernier Calipers	Measures various outer diameters, thicknesses, and widths	
7	Depth Micrometer	Measures valve recession	
8	Square	Measures distortion in position of springs and perpendicularity of parts	

No.	Tool Name	Use	Illustration
9	V-Block	Measures shaft distortion	
10	Torque Wrench	Used to tighten bolts and nuts to standard torque	
11	Feeler Gauge	Measures the distance between the ring and ring groove, and between the shaft and shaft joint at time of assembling	
12	Coolant Pressure Tester	Checks for leakage in the coolant system	
13	Battery Current Tester	Checks density of antifreeze and charging condition of battery fluid	
14	Nozzle Tester	Checks the shape and pressure of spray emitted from the fuel injection valve at the time of injection	
15	Digital Thermostat	Measures temperature of various parts	 1 – Float

No.	Tool Name		Use	Illustration
16	Rotation Gauge	Contact Type	Measures rotation speed by placing at the indentation hole of the revolving shaft	
		Photoelectric Type	Measures rotation speed by using a reflector seal which is placed on the exterior of the revolving shaft	 **1 – Revolving Shaft** **2 – Reflection Mark**
		High-Pressure Fuel Pipe Clamp Type	Measures rotation speed without reference to revolving shaft center or the exterior of the revolving shaft	 **1 – High-Pressure Pipe**
17	Circuit Tester		Measures the resistance, voltage and continuity of the electric circuit	
18	Compression Gauge		Measures the pressure of the compression Yanmar Code No.: TOL-97190080	

SEALANTS, ADHESIVES, LUBRICANTS AND CLEANERS

Items		Usual Contents	Features and Application
Liquid Gasket	ThreeBond® No.1 TB1101	200 g (6 oz) 1 kg (32 oz) also available	Non-drying liquid gasket; solvent-less type, easy to remove, superior in seawater resistance, applicable to various mating surfaces
	ThreeBond® No.2 TB1102	200 g (6 oz) 1 kg (32 oz) also available	Non-drying liquid gasket; easy to apply, superior in water resistance and oil resistance, especially superior in gasoline resistance
	ThreeBond® No.3 TB1103	150 g (5 oz)	Drying film, low viscosity and forming of thin film, appropriate for mating surface of precision parts
	ThreeBond® No.4 TB1104	200 g (6 oz) 1 kg (32 oz) 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
	ThreeBond® No.10 TB1211	100 g (3 oz)	Solvent-less type silicone-base sealant, applicable to high temperature areas (-50° to 250°C [-58° to 482°F])
	ThreeBond® TB1212	100 g (3 oz)	Silicone-base, non-fluid type, thick application possible
Adhesive	ThreeBond® TB1401	200 g (6 oz)	Prevention of loose bolts, gas leakage and corrosion. Torque required to loosen bolt: 10 to 20% larger than tightening torque
	Loctite® SUPER TB1324	50 g (2 oz)	Excellent adhesive strength locks screw semi-permanently
Seal Tape		5 m (16 ft) round tape	Sealing material for threaded parts of various pipes. Ambient temperature range: -150° to 200°C (-238° to 392°F)
O-ring Kit		Ø 1.92-m dia.:1 Ø 2.42-m dia.:1 Ø 3.12-m dia.:1 Ø 3.52-m dia.:1 Ø 5.72-m dia.:1	Used to make various sizes of O-rings (including adhesive, release agent, cutter and jig)
EP Lubricant (Molybdenum Disulfate)	Brand Name (LOWCOL PASTE)	50 g (2 oz)	For assembly of engine cylinders, pistons, metals shafts, etc. Spray type facilitates application work
	Brand Name (PASTE SPRAY)	330 g (12 oz)	
	Brand Name (MOLYPASTE)	50 g (2 oz)	Prevention of seizure of threaded parts at high temperature. Applicable to intake and exhaust valves (stem, guide, face)
Scale Solvent	Scale Solvent	1 box (4 kg [8.8 lb] x 4 removers)	The scale solvent removes scale in a short time (1 to 10 hours). Prepare fresh water in an amount that is about 10 times the weight of the solvent. Mix the solvent with water. Dipping disassembled part removes scale. To shorten removal time, stir remover mixture. If cleaning performance drops, replace used mixture with a 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 [4.4 lb] x 4 neutralizers)	
	pH Test Paper	–	
Antirust		–	Add antirust to coolant system. Then operate engine for approximately 5 minutes. Antirust will be effective for 6 months.
Antifreeze		–	Add antifreeze to the cooling system when the engine is cold.
Cleaning Agent		–	The cleaning agent removes even carbon adhering to disassembled parts. If a cleaning machine is used, prepare 4 to 6% mixture of 60° to 80°C (140° to 176°F) to ensure more effective cleaning.

Liquid Gasket Sealant

WARNING! Exposure Hazard. ***ALWAYS read and follow safety-related precautions found on containers of hazardous substances such as parts cleaners, primers, sealants and sealant removers.***

Note: ThreeBond® liquid gasket products are the recommended sealants used for assembly.

Before providing service, observe the cautions below:

- Build up each sealant bead equally.
- For bolt holes, apply the sealant to the inside surface of each hole.
- ThreeBond® TB1104 (Gray) or ThreeBond® TB1102 (Yellow) is used with a gasket. The use of either of these sealant bonds without a gasket is not effective.
- When gaskets are used, do not use sealant ThreeBond® TB1212.

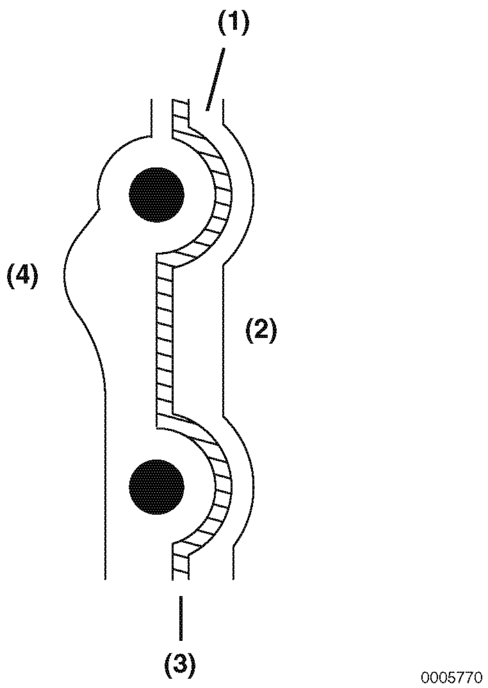


Figure 5-1

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

SERVICE INFORMATION

Before Engine Disassembly

- Diagnose the cause of the trouble and determine if the engine will require to be removed from the vessel. Disassemble only those parts which are necessary.
- If the engine requires disassembly, remove engine from vessel. Mount engine to a suitable engine repair stand having adequate weight capacity. See *Removing the Engine from the Vessel on page 5-27*.

⚠ DANGER

Crush Hazard

Always secure the engine solidly to prevent the engine from falling during service.

- Cap or plug all openings to prevent contamination.
- Clean engine by washing with solvent, air or steam cleaning. Carefully operate cleaning equipment so as to prevent any foreign matter or fluids from entering engine or damaging any fuel system or electrical components remaining on the engine.

⚠ WARNING

Exposure Hazard

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

- Keep all disassembled parts in order.
- Have all required tools on hand.
- Clear an adequate area for parts and prepare a container.
- Close the seawater supply seacock.

Before Engine Assembly

- Perform all inspection procedures before assembling the engine.
- Clean all parts. Use a cloth with diesel oil and / or a cleaning agent before reassembly. Make sure there is no sand, metal shavings or other debris in the oil.
- Use a cleaning agent that removes carbon deposits adhering to disassembled parts.

⚠ WARNING

Exposure Hazard

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

- Remove all gaskets and liquid gasket sealing material.

NOTICE

If dirt is allowed to remain on components, the engine may be damaged due to seizure or lubrication obstructions.

- Clean parts with an approved cleaner in a suitable location.
- Clean and clear all oil passages.

After Engine Assembly

After the engine has been repaired, perform engine tests to ensure engine is operating at optimum performance. *see Engine Tests and Adjustments on page 4-38*.

Dye Penetrant Inspection Procedure

The dye penetrant inspection kit consists of an aerosol cleaner, penetrant and developer **(Figure 5-2)**.

Dye Penetrant Inspection Kit	
Item	**Quantity**
Penetrant	1
Developer	2
Cleaner	3

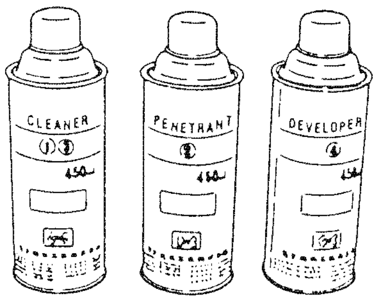


Figure 5-2

NOTICE: ALWAYS read and follow the instructions included with the dye penetrant kit before use.

1. Spray the cleaner directly on the surface and wipe clean or wipe the area with a cloth moistened with cleaner.
2. Spray on the penetrant and allow 10 to 15 minutes to soak in. Use more as necessary to ensure all areas are covered.
3. Wipe dry any excess penetrant.
4. Spray a light coat (300 to 400 mm [11.81 to 15.75 in.] spray distance) of developer on the penetrant and allow to dry for several minutes. Cracks will appear as red dots or a continuous red line on the surface being inspected.
5. When finished, clean the surface with the cleaner.

ENGINE REMOVAL AND INSTALLATION

⚠ WARNING

Crush Hazard

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

Crush Hazard

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

Fire Hazard

NEVER use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.

Fire Hazard

Wipe up any spills immediately.

Exposure Hazard

Wear eye protection. The fuel system is under pressure and fuel could spray out when you service any fuel system component.

Removing the Engine from the Vessel

1. Disconnect battery cables at the battery. Always disconnect negative (-) battery cable first.
2. Remove the wiring between the starter motor and the battery.
3. Unplug the wiring harness connector from instrument panel to the engine.
4. Close all valves in the fuel supply system. Cap or plug all open fuel connections.
5. Remove the fuel feed line from the fuel feed pump.
6. Remove starter motor and alternator.
7. Remove the remote control cable (from the engine and marine gearbox).
8. Remove all associated lines and wiring that connect the engine to the vessel.

9. Remove cooling system components from engine.
10. Drain engine oil into a suitable container.
11. Remove the oil filter.
12. Remove the exhaust hose from the mixing elbow.
13. Remove the rubber hose that connects the coolant recovery tank to the filler cap. *NOTICE: Make sure the seacock is closed.*
14. Remove the seawater inlet hose from the seawater pump.
15. Remove the mounting bolts and disassemble the propeller shaft coupling and the thrust shaft coupling.
16. If an additional coupling is mounted to the front drive coupling, remove the mounting hardware and disassemble.
17. Remove the nut from the flexible engine mount, lift the engine and remove it from the engine base. Leave the engine mount attached to the engine base.

Installing the Engine in the Vessel

1. Install the engine on the engine mount supports in the vessel. Install the nuts on the flexible engine mounts and tighten.
2. Install any additional couplings mounted to the front drive.
3. Install the thrust shaft coupling and propeller shaft coupling.
4. Install the seawater inlet hose from the seacock to the seawater pump.
5. Install the rubber coolant hose between the coolant recovery tank and the filler cap.
6. Install the exhaust hose on the mixing elbow.
7. Fill the engine with oil and replace the oil filter.
8. Install all cooling system components to the engine.
9. Open the seawater seacock.
10. Connect all associated lines and wiring that connect the engine to the vessel.
11. Connect the remote control cables to the engine and marine gear.
12. Install the starter motor and alternator.
13. Install the fuel supply line to the fuel feed pump. Connect and tighten all fuel system lines.
14. Connect the wiring between the starter motor and the battery.
15. Connect the engine wiring harness connector to the instrument panel. Observe the color coding and ensure that the connections are correct.
16. Connect the battery cables to the battery. Always connect negative (-) battery cable last.
17. Open all valves in the fuel supply system.

CYLINDER HEAD

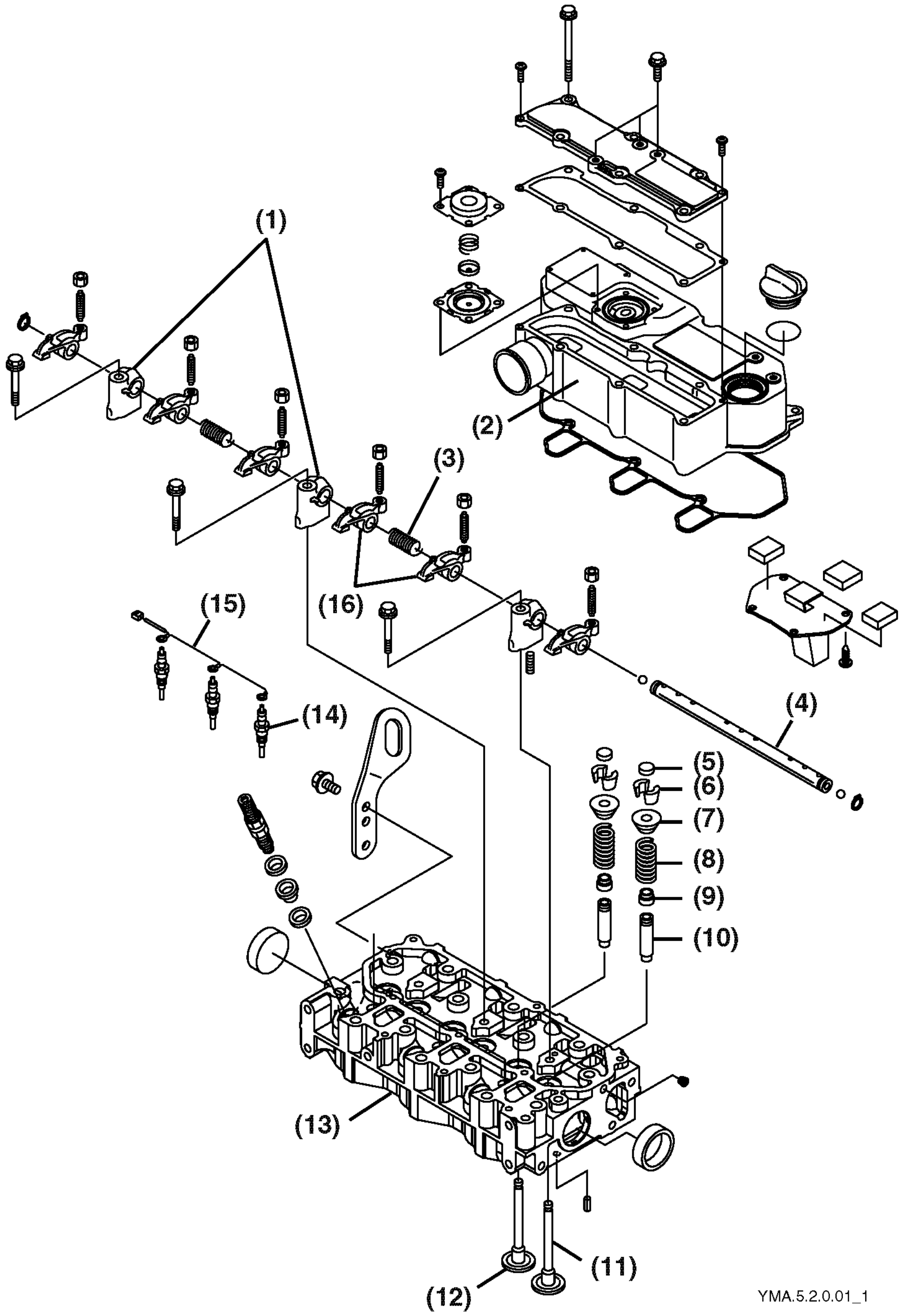


Figure 5-3

1 – Rocker Arm Support
2 – Rocker Arm Cover
3 – Rocker Arm Spring
4 – Rocker Arm Shaft
5 – Valve Cap
6 – Valve Keeper
7 – Spring Retainer
8 – Valve Spring
9 – Stem Seal
10 – Valve Guide
11 – Intake Valve
12 – Exhaust Valve
13 – Cylinder Head
14 – Glow Plug
15 – Glow Plug Wiring Harness
16 – Rocker Arm

The cylinder head **(Figure 5-3, (13))** may be of the two or three cylinder (3YM30 model shown) design, depending on the model. The valve seats are treated with a special stellite alloy for superior resistance to heat and wear. The areas between the intake valves **(Figure 5-3, (11))** and exhaust valves **(Figure 5-3, (12))** are cooled with internal circulating water.

Removing the Rocker Arm Assembly and Push Rods

1. Remove the hex head bolts **(Figure 5-4, (1))**.
   NOTICE:

NOTICE

When removing the rocker arm cover, do not loosen the cross head bolts **(Figure 5-4,** ***(2)).***

2. Remove the rocker arm cover.
3. Remove the bolts that secure the rocker arm shaft support.
4. Remove the entire rocker arm shaft as an assembly.
5. Pull out the push rods.

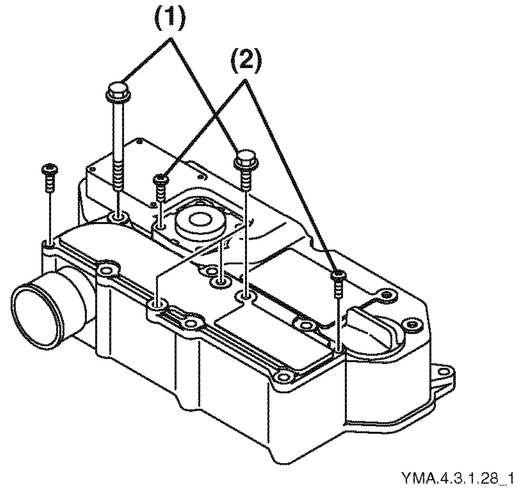


Figure 5-4

1 – Hex Head Bolts
2 – Cross Head Bolts (do not remove)

Removing the Cylinder Head

1. Remove the cylinder head bolts in the order shown.

2-Cylinder Head

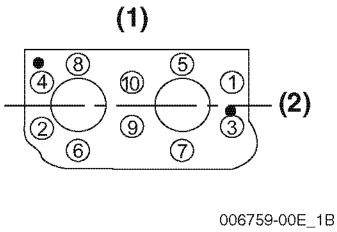


Figure 5-5

1 – Camshaft Side
2 – Gear Housing Side

3-Cylinder Head

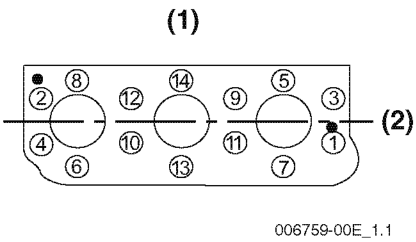


Figure 5-6

1 – Camshaft Side
2 – Gear Housing Side

2. Remove the cylinder head assembly.
3. Remove the cylinder head gasket.

Inspecting the Cylinder Head

The cylinder head is subjected to very severe operating conditions, with repeated fluctuations of high pressure, high temperature and rapid cooling. Thoroughly remove all carbon deposits after disassembly and carefully inspect each part.

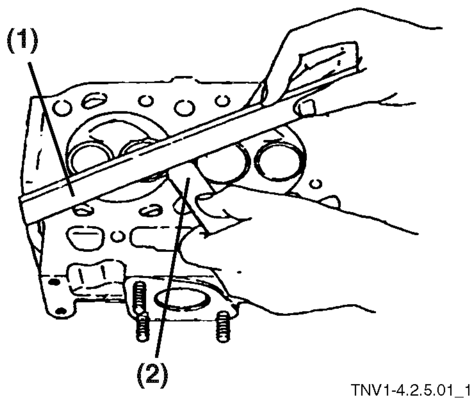


Figure 5-7

1 – Straightedge
2 – Feeler Gauge

1. Carefully check the cylinder head mating surfaces for any sign of distortion.
   (a) Clean the cylinder head surface.
   (b) Place a straightedge **(Figure 5-7, (1))** along each of the four sides and each diagonal.
   (c) Measure the clearance between the straightedge and the surface of the cylinder head mating surface with a feeler gauge **(Figure 5-7, (2))**.

Cylinder Head Distortion	
Standard	**Wear Limit**
0.05 mm (0.001 in.) or less	0.15 mm (0.005 in.)

2. Check for cracks in the cylinder combustion surfaces on the head.

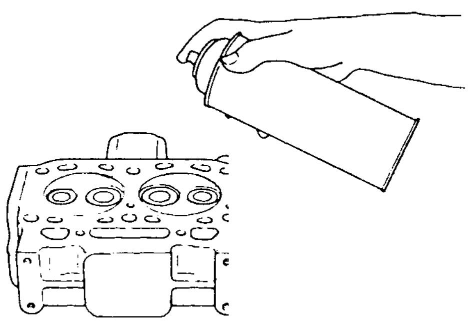


Figure 5-8

(a) Remove the fuel injection nozzles and the intake and exhaust valves.

(b) Clean the cylinder head combustion surfaces.

(c) Check for discoloration or distortion.

(d) Perform a dye penetrant inspection to check for cracks. *see Dye Penetrant Inspection Procedure on page 5-27*.

3. Check the intake and exhaust valve seats.

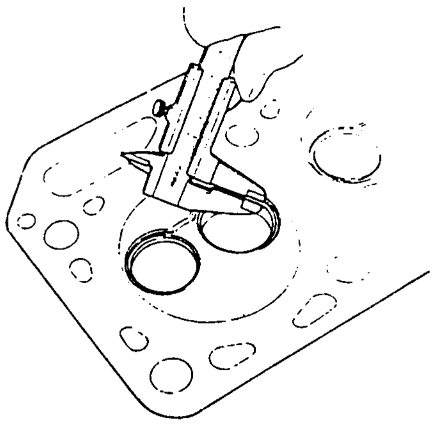


Figure 5-9

(a) Check the surface and width of the valve seats.

(b) Correct any discrepancies that exceed the following limits.

(c) Replace any component that cannot be repaired.

Seat Angle	
Intake	120°
Exhaust	90°

Seat Width	Standard	Limit
Intake	1.07 to 1.24 mm (0.042 to 0.048 in.)	1.74 mm (0.068 in.)
Exhaust	1.24 to 1.45 mm (0.048 to 0.057 in.)	1.94 mm (0.076 in.)

Measuring Valve Sink

Over long periods of use and repeated lapping, the combustion efficiency may drop. Measure valve sink **(Figure 5-10, (1))** using a depth gauge **(Figure 5-11, (1))**.

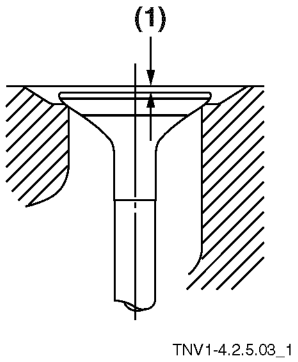


Figure 5-10

1 – Valve Sink

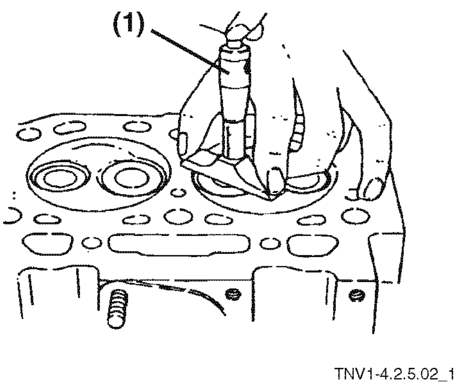


Figure 5-11

1 – Depth Gauge

Replace the valve and seat together if valve sink exceeds the limit.

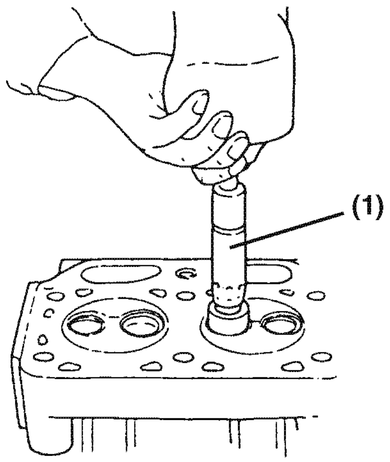
Valve Sink	
Standard	**Limit**
0.4 to 0.6 mm (0.0157 to 0.0236 in.)	0.8 mm (0.0314 in.)

Inspecting the Valve Seat and Contact Surface

Inspect the valve seat and contact surface for scratches and excessive wear.

The seat angle must be adjusted if the valve seat contact surface is smaller than the width of the valve seat.

Machining the Valve Seat Angles



JHA.5.2.2.01_1

Figure 5-12

1 – Seat Grinder

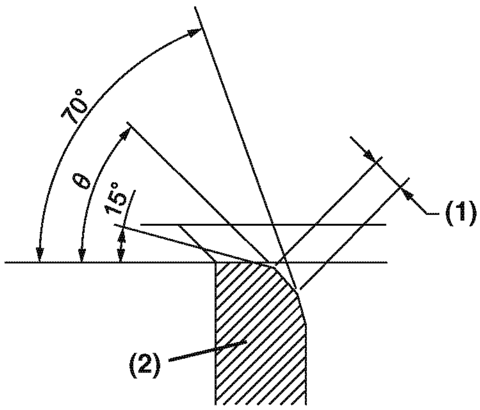


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Figure 5-13

1 – Valve Seat Width
2 – Valve Seat

Use the following method to correct valve seat angle using a valve seat grinder **(Figure 5-12, (1))**.

1. Widen the seat with a 70° grinding stone.
2. Grind the seat to the standard dimension using a 15° grinding stone.

NOTICE

When seat adjustment is necessary, check the valve and valve guide. If the guide clearance exceeds the tolerance, replace the guides first, then grind the seat.

3. Knead the valve compound with oil and finish the valve seat with a lapping tool **(Figure 5-14)**

Note: Use a rubber-cap type lapping tool for valves without a lapping tool groove slit.

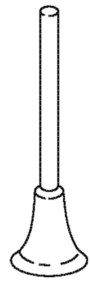

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Figure 5-14

Note: Finish using oil only.

4. Clean the valve and cylinder head with light oil or the equivalent after finishing valve seat.
5. Remove all metal grinding shavings.
6. Insert adjustment shims between the valve spring and cylinder head after valve seats have been refinished with a seat grinder.
7. Measure valve recession after refinishing the valve seat. Replace the valve and valve seat if recession exceeds the specification limit. *see Measuring Valve Sink on page 5-32.*

Inspecting Valve Components

Inspecting Intake / Exhaust Valves

1. Measure the diameter **(Figure 5-15 and Figure 5-16)** of each valve stem and check for excessive wear and corrosion.

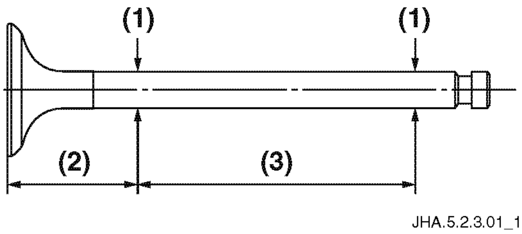


Figure 5-15

1 – Measurement Point
2 – 30 mm (1.181 in.)
3 – 60 mm (2.362 in.)

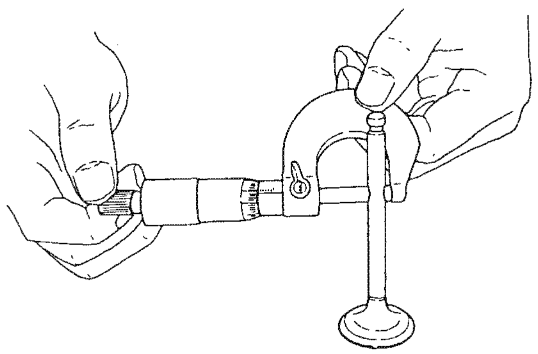


Figure 5-16

2. Replace the valve if the stem is worn beyond the following limits.

Note: The intake and exhaust valves are different diameters.

Valve Stem Diameter	Standard	Limit
Intake	5.960 to 5.975 mm (0.2346 to 0.2353 in.)	5.90 mm (0.2322 in.)
Exhaust	5.945 to 5.960 mm (0.2340 to 0.2346 in.)	5.90 mm (0.2322 in.)

3. Inspect the valve stem keeper groove for wear and damage. Replace the valve as needed.

Inspecting the Valve Guides

1. Measure the inside diameter of each valve guide.
2. Replace the valve guide if it exceeds the following wear limits.

Measurement	Type	Standard	Limit
Valve Guide I.D.	Intake and Exhaust	6.000 to 6.012 mm (0.2362 to 0.2366 in.)	6.08 mm (0.2393 in.)
Clearance	Intake	0.025 to 0.052 mm (0.0009 to 0.0020 in.)	0.16 mm (0.0062 in.)
	Exhaust	0.040 to 0.067 mm (0.0015 to 0.0018 in.)	0.17 mm (0.0066 in.)

Replacing the Valve Guides

1. Cool the new valve guide in a container of dry ice.

⚠ WARNING

Exposure Hazard

Wear thermal gloves when handling super-cooled components. Failure to comply could result in moderate to severe frost injuries.

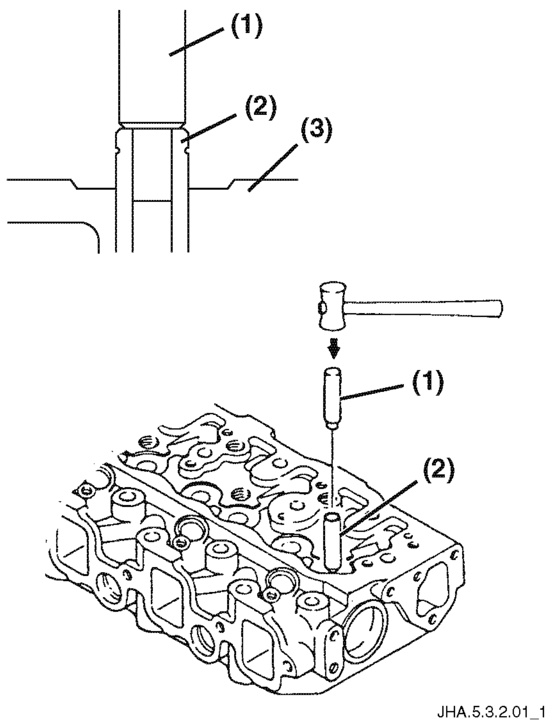


Figure 5-17

1 – Insertion Tool
2 – Valve Guide
3 – Cylinder Head

2. Using the insertion tool **(Figure 5-17, (1))**, tap the new guide **(Figure 5-17, (2))** into place with a mallet.

Note: The intake and exhaust valve guides are different dimensions.

3. Check the inside diameter and ream to the standard inside diameter as required.
4. Measure the valve guide projection from the valve spring seat surface and set to the specified height.

Valve Guide Projection
9.8 to 10.0 mm (0.3858 to 0.3936 in.)

Replacing the Valve Stem Seals

The valve stem seals **(Figure 5-18, (2))** cannot be reused. Replace all used seals.

Note: Exhaust stem seals are marked in yellow. Intake seals are not marked.

1. Apply a liberal amount of oil to the lip of the seal and valve guide.
2. Push the seal into position with the insertion tool **(Figure 5-18, (1))**.

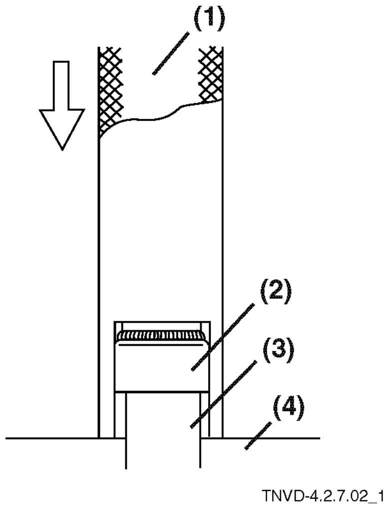


Figure 5-18

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

3. Measure the projection of the valve stem seal **(Figure 5-19, (1))** and set to the specified height to maintain clearance.

Valve Stem Seal Projection
10.9 to 11.2 mm (0.4291 to 0.4409 in.)

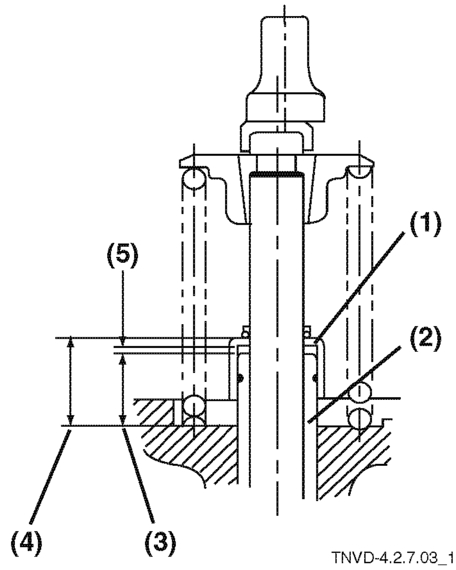


Figure 5-19

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

Inspecting the Valve Springs

1. Check the spring for scratches or corrosion.
2. Measure the free length **(Figure 5-20)** of the spring.

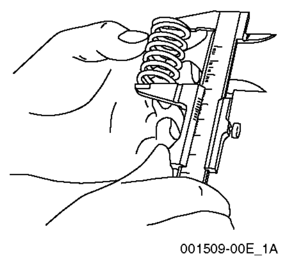


Figure 5-20

3. Measure the spring inclination **(Figure 5-21, (2))**.

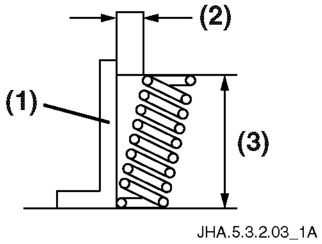


Figure 5-21

1 – Square Gauge
2 – Inclination
3 – Free Length

NOTICE

The pitch orientation of the valve springs is not the same. The side with the smaller pitch (yellow) **(Figure 5-22, *(2)*)** *should be installed down (toward the cylinder head). The spring should be tested in the same orientation.*

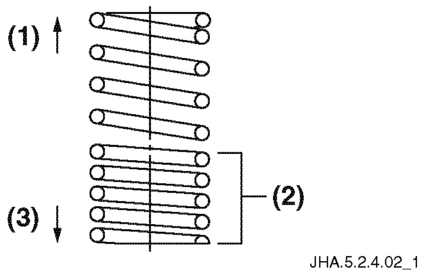


Figure 5-22

1 – Up
2 – Smaller Spring Pitch
3 – Down

4. Measure spring tension using a spring tension gauge **(Figure 5-23, (1))**.

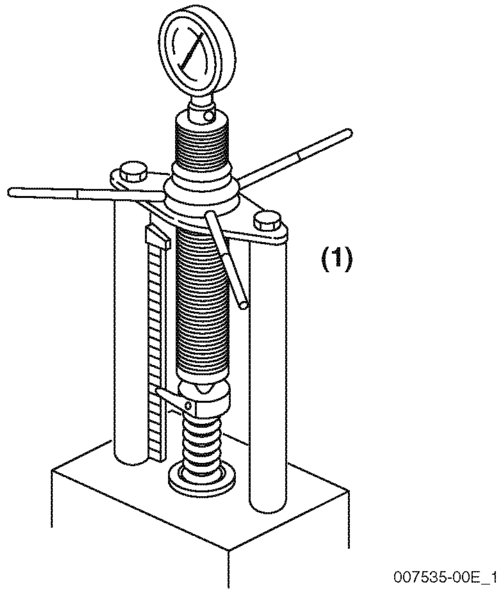


Figure 5-23

1 – Spring Tension Gauge

Valve Spring	Standard	Limit
Free Length	37.8 mm (1.488 in.)	36.3 mm (1.492 in.)
Inclination	–	1.3 mm (0.051 in.)
Tension	26.6 to 35.4 N•mm (95.6 to 127.3 ozf)	–

Inspecting Valve Spring Keepers and Retainers

1. Inspect the inside face of the spring retainer.
2. Check the contact areas of the spring keeper. Replace the spring retainer and spring keepers as a set when the contact area is less than 70%, or when the spring keeper has been recessed due to wear.

Inspecting the Rocker Arms

Excessive wear of the rocker arm bushings and rocker arms will affect the duration and timing of the valves. This will reduce the engine performance.

1. Measure the outer diameter of the rocker arm shaft.
2. Measure the inner diameter of the rocker arm bushing **(Figure 5-24, (1))**.
   - Replace the rocker arm if there is no clearance.
   - Replace the rocker arm bushing if it exceeds the specified limit.

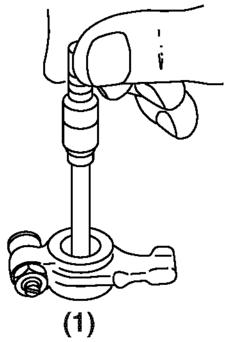


Figure 5-24

1 – Rocker Arm Bushing Inner Diameter

Measurement	Standard	Limits
Rocker Arm Shaft O.D.	11.966 to 11.984 mm (0.4711 to 0.4718 in.)	11.94 mm (0.4700 in.)
Rocker Arm Bushing I.D.	12.000 to 12.020 mm (0.4724 to 0.4732 in.)	12.07 mm (0.4751 in.)
Rocker Arm Shaft and Bushing Clearance After Assembly	0.016 to 0.054 mm (0.0006 to 0.0021 in.)	0.13 mm (0.0051 in.)

3. Inspect the rocker arm spring for wear and corrosion and replace as needed.
4. Inspect the rocker arm contact surfaces and valve top retainer for signs of wear. Replace as needed.

Inspecting the Push Rods

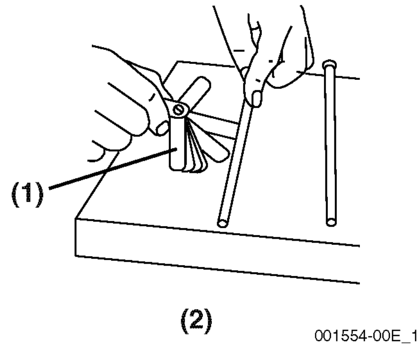


Figure 5-25

1 – Feeler Gauge
2 – Push Rod Bend Measurement

1. Measure the bend of the push rods using a feeler gauge **(Figure 5-25, (1))**.
2. Replace if wear exceeds the specified limit.

Push Rod Bend	
Standard	**Limit**
Less than 0.03 mm (0.0011 in.)	0.03 mm (0.0011 in.)

Installing the Cylinder Head

1. Clean out the cylinder head bolt holes.
2. Clean away any foreign matter on the cylinder head surface where it comes in contact with the block.
3. Coat the head bolt threads with engine oil.
4. Align the head gasket with the alignment pins and install the head gasket on the cylinder block.
5. Align the cylinder head with the alignment pins on the cylinder block and install.
6. Tighten the cylinder head bolts in sequence to the torque in the first step and then again in the same sequence to the torque in the second step as shown in **Figure 5-26** and **Figure 5-27**.

NOTICE

Avoid distorting the cylinder head; do not over-tighten the cylinder head bolts.

Cylinder Head Bolt Torque	
First Step	**Second Step**
27.0 to 33.0 N•m (19.9 to 24.3 lb-ft)	53.9 to 57.9 N•m (39.7 to 42.7 lb-ft)

2-Cylinder Head

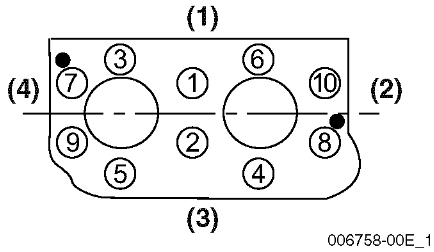


Figure 5-26

1 – Camshaft Side
2 – Gear Housing Side
3 – Fuel Pump Side
4 – Flywheel Side

3-Cylinder Head

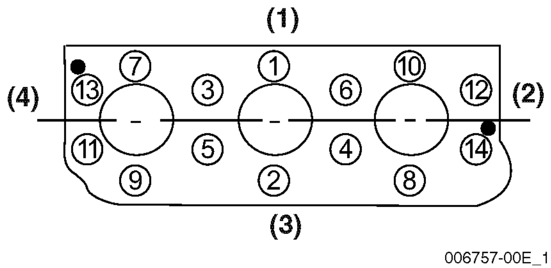


Figure 5-27

1 – Camshaft Side
2 – Gear Housing Side
3 – Fuel Pump Side
4 – Flywheel Side

Installing the Rocker Arm Assembly and Push Rods

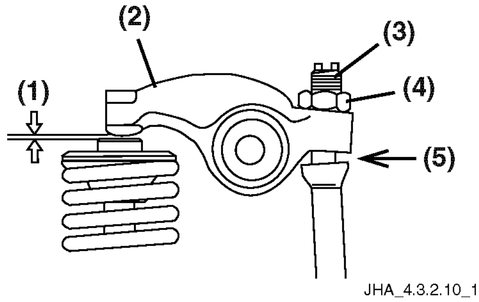


Figure 5-28

1 – Valve Clearance
2 – Rocker Arm
3 – Adjusting Screw
4 – Locknut
5 – Push Rod to Rocker Arm Contact

1. Install the push rods on the tappets.
2. Coat the top of the push rod and the adjusting screw assembly of the rocker arm **(Figure 5-28, (2))** with engine oil.
3. Install the rocker arm shaft assembly to the cylinder head and tighten the bolts.
4. Adjust valve clearance **(Figure 5-28, (1))**. *see Adjusting the Valve Clearance on page 5-39*.
5. Coat the rocker arm and valve spring with engine oil and install the rocker arm cover.

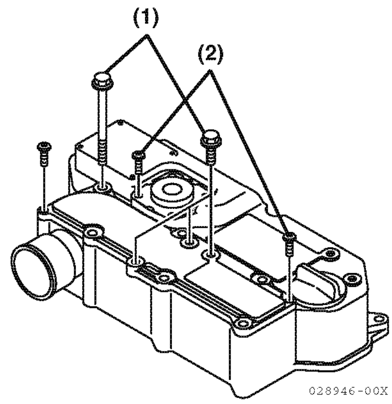


Figure 5-29

1 – Hex Head Bolts
2 – Cross Head Bolts (do not remove)

Adjusting the Valve Clearance

Perform valve adjustments when the engine is cool. *see Checking and Adjusting Intake / Exhaust Valve Clearance on page 4-14.*

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

NOTICE

Check the opening and closing angles of all the valves whenever the timing gear is disassembled.

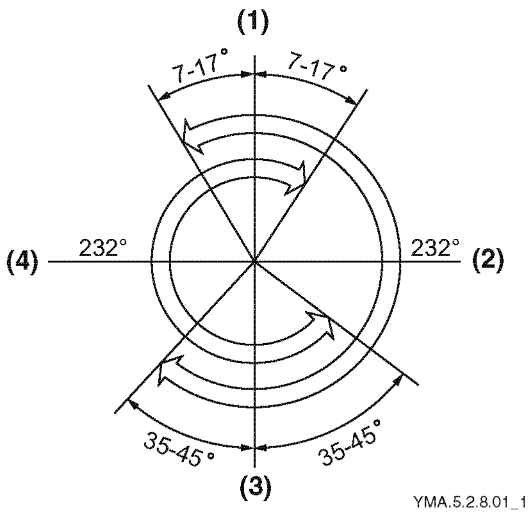


Figure 5-30

1 – TDC
2 – Intake
3 – BDC
4 – Exhaust

Intake Valve Open	BTDC	7 to 17°
Intake Valve Closed	ABDC	35 to 45°
Exhaust Valve Open	BBDC	35 to 45°
Exhaust Valve Closed	ATDC	7 to 17°

Finding Top Dead Center

The stamped letter and line, which show TDC of each cylinder, are positioned on the flywheel circumference. 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.

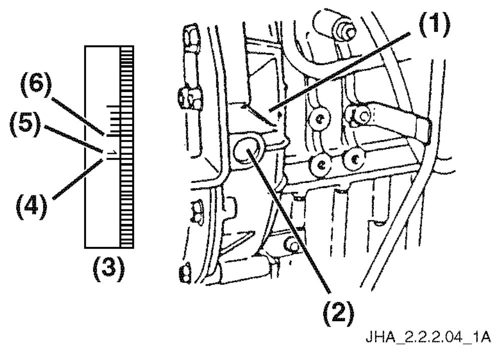


Figure 5-31

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

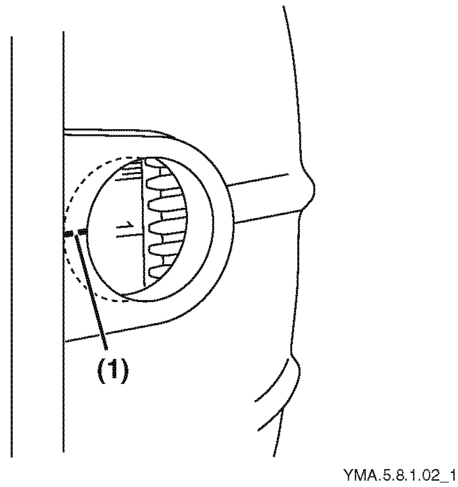


Figure 5-32

1 – Index Mark

The index mark **(Figure 5-32, (1))** is located on the side of the timing inspection hole **(Figure 5-31, (2))** in the flywheel housing **(Figure 5-31, (1))**.

Measuring Piston Top Clearance

1. Place a high-quality fuse wire 1.5 mm diameter and 10 mm long (0.059 in. and 0.393 in.) in three positions on the top, flat part of the piston.
2. Clean out the cylinder head bolt holes.
3. Clean away any foreign matter on the cylinder head surface where it comes in contact with the block.
4. Coat the head bolt threads with engine oil.
5. Align the head gasket with the alignment pins and install the head gasket on the cylinder block.
6. Align the cylinder head with the alignment pins on the cylinder block and install.
7. Tighten the cylinder head bolts in sequence to the torque in the first step and then again in the same sequence to the torque in the second step as shown in **Figure 5-33** and **Figure 5-34**.

NOTICE

Avoid distorting the cylinder head; do not over-tighten the cylinder head bolts.

Cylinder Head Bolt Torque	
First Step	**Second Step**
27.0 to 33.0 N•m (19.9 to 24.3 lb-ft)	53.9 to 57.9 N•m (39.7 to 42.7 lb-ft)

2-Cylinder Head

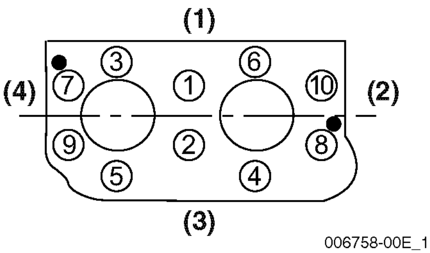


Figure 5-33

1 – Camshaft Side
2 – Gear Housing Side
3 – Fuel Pump Side
4 – Flywheel Side

3-Cylinder Head

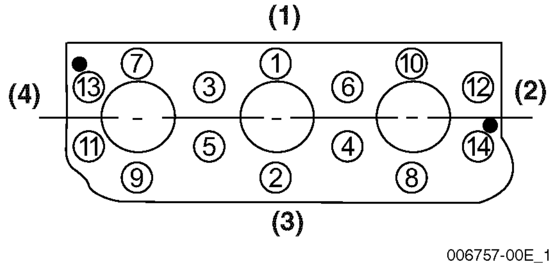


Figure 5-34

1 – Camshaft Side
2 – Gear Housing Side
3 – Fuel Pump Side
4 – Flywheel Side

8. Rotate the engine in the direction of engine rotation.
9. Remove the cylinder head and take out the compressed fuse wire **(Figure 5-35)**.
10. Repeat this for all cylinders.
11. Measure the three positions where each fuse is compressed and calculate the average.

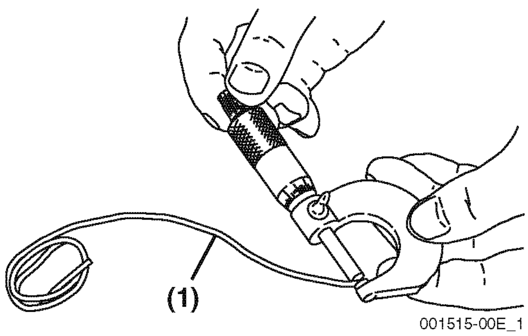


Figure 5-35

1 – Fuse Wire

Model	Piston Top Clearance
3YM30AE	0.71 to 0.85 mm (0.0279 to 0.0344 in.)
3YM30	0.747 to 0.891 mm (0.0294 to 0.0350 in.)
3YM20 / 2YM15	0.70 to 0.84 mm (0.0275 to 0.0330 in.)

PISTONS AND CONNECTING RODS

Measuring the Connecting Rod Side Clearance

Before removing the piston and connecting rods, measure the connecting rod side clearance.

Check the side clearance as shown in **Figure 5-36** and compare values with stated limits.

Connecting Rod Side Clearance	
Standard	**Limit**
0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.55 mm (0.0216 in.)

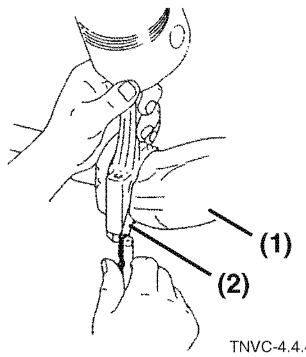


Figure 5-36

1 – Crankshaft
2 – Feeler Gauge

Removing the Pistons and Connecting Rods

NOTICE

If a torque wrench is not available, make index marks **(Figure 5-44, *(2)*)** *on the bolt heads and the large end cap (to indicate the proper torque position) and retighten the bolts to those positions.*

1. Remove the connecting rod bolts **(Figure 5-37, (2))**.
2. Remove the connecting rod end cap **(Figure 5-37, (3))** and bearing insert **(Figure 5-37, (4))**.

NOTICE

Engines with high operating hours may have a ridge near the top of the cylinders that will catch the piston rings and make it impossible to remove the pistons. Use a suitable ridge reamer to remove ridges and carbon prior to removing pistons.

3. Push out to remove the connecting rod **(Figure 5-37, (6))** and piston **(Figure 5-37, (5))**. Repeat for each connecting rod assembly.

NOTICE

Do not allow the connecting rod to bump the crankshaft journal during piston removal. Damage to the bearing journal may result.

Keep the piston and pin assemblies, and connecting rod assemblies together. Assemble in the same position during reassembly. Label the parts using an appropriate method.

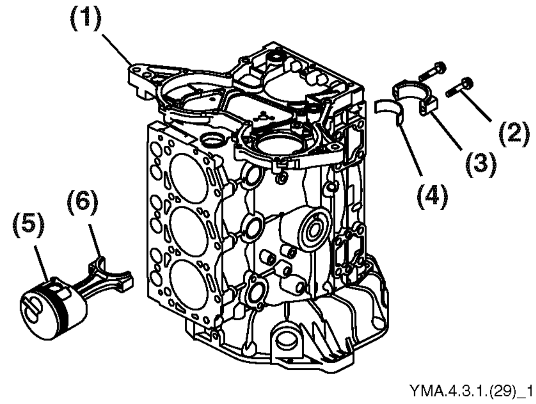


Figure 5-37

1 – Gear Housing
2 – Connecting Rod Bolt
3 – Connecting Rod End Cap
4 – Bearing Insert
5 – Piston
6 – Connecting Rod

Disassembling the Piston and Connecting Rods

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

Inspecting the Connecting Rods

The connecting rods **(Figure 5-38, (1))** are made of high-strength forged carbon steel. The connecting rods are equipped with a connecting rod cap **(Figure 5-38, (4))** and a 2-piece bearing insert assembly **(Figure 5-38, (3))**. The piston pin bushing **(Figure 5-38, (2))** is non-serviceable.

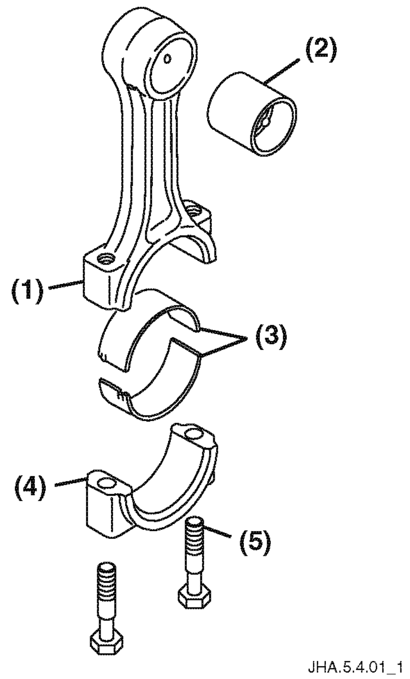


Figure 5-38

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

Measuring the Connecting Rod Alignment

NOTICE

ALWAYS inspect the connecting rod in cylinders which have seized, been filled with water or where a valve has broken. Bent connecting rods cannot be straightened; replace the connecting rod.

Ensure that the connecting rod is not twisted.

1. Insert the appropriate mandrel **(Figure 5-39, (3))** into both ends of the connecting rod.

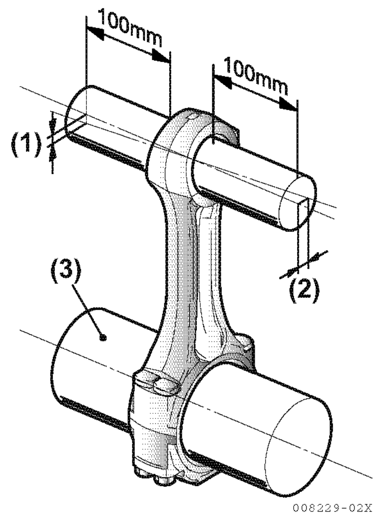


Figure 5-39

1 – Parallel Measurement
2 – Twist Measurement
3 – Mandrel

2. Measure the alignment using connecting rod alignment tool **(Figure 5-40, (1))**.
3. Replace the connecting rod if it exceeds the specified limit.

Connecting Rod Twist	
Standard	**Limit**
Less than 0.03 mm at 100 mm (0.0011 in. at 3.936 in.)	0.08 mm (0.0031 in.)

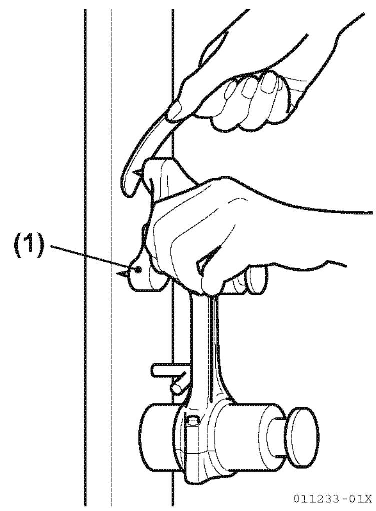


Figure 5-40

1 – Connecting Rod Alignment Tool

Measuring Connecting Rod Bearing Oil Clearance

Check for flaking, melting or seizure on the contact surface of the connecting rod bearings and replace as needed.

Method 1:

1. Measure the connecting rod crankshaft journal outside diameter.

NOTICE

When measuring the inside diameter of connecting rod bearing inserts, be aware of the alignment marks on the connecting rod and bearing cap and tighten the connecting rod cap bolts to the specified torque.

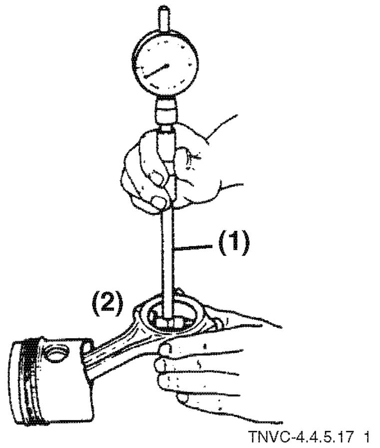


Figure 5-41

1 – Dial Bore Gauge
2 – Connecting Rod Bearing

Connecting Rod Bolt Torque
22.6 to 27.5 N•m (16.6 to 20.2 lb-ft)

2. Measure the connecting rod bearing **(Figure 5-41, (2))** inside diameter using a dial bore gauge **(Figure 5-41, (1))**.
3. Calculate the oil clearance from the difference of the measured values.
4. Replace the connecting rod bearing if the oil clearance exceeds the stated limits or correct the crankshaft by grinding to a uniform undersized dimension (if available) and use an oversized bearing insert in the connecting rod.

3YM30AE / 3YM30		
Item	**Standard**	**Limit**
Crankshaft Pin O.D.	41.952 to 41.962 mm (1.6516 to 1.6520 in.)	41.902 mm (1.6496 in.)
Bearing I.D.	41.982 to 42.010 mm (1.6528 to 1.6539 in.)	–
Bearing Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–
Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)

3YM20 / 2YM15		
Item	**Standard**	**Limit**
Crankshaft Pin O.D.	37.952 to 37.962 mm (1.491 to 1.4945 in.)	37.902 mm (1.4922 in.)
Bearing I.D.	37.982 to 38.010 mm (1.4953 to 1.4964 in.)	–
Bearing Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–
Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)

Method 2:

An alternate method for measuring connecting rod crankshaft pin oil clearance is to use PLASTIGAGE®.

1. Lay the PLASTIGAGE **(Figure 5-42, (1))** on the surface of the bearing insert on the connecting rod.
2. Install the connecting rod on the crankshaft journal and tighten to the specified torque.

Connecting Rod Bolt Torque
22.6 to 27.5 N•m (16.6 to 20.2 lb-ft)

3. Remove the connecting rod and measure the PLASTIGAGE with PLASTIGAGE measuring paper **(Figure 5-42, (2))**.

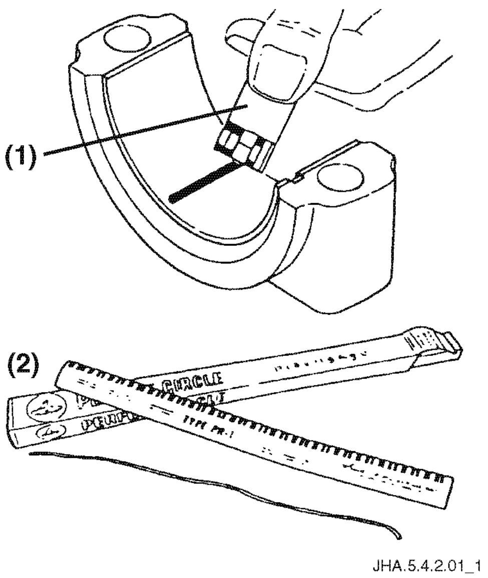


Figure 5-42

1 – PLASTIGAGE
2 – PLASTIGAGE Measuring Paper

Inspecting the Connecting Rod Piston Pin Bushing

Excessive connecting rod piston pin bushing wear may result in damage to the piston pin and / or the piston itself.

1. Measure the inside diameter of the connecting rod piston pin bushing.
2. Measure the outside diameter of the piston pin *(see Measuring the Piston Pin on page 5-47)*.
3. Calculate the oil clearance from the difference of the two values. Replace if wear exceeds the specification limits.

Measurement	Standard	Limit
Connecting Rod Piston Pin Bushing I.D.	22.025 to 22.038 mm (0.8671 to 0.8676 in.)	22.068 mm (0.8688 in.)
Piston Pin O.D.	21.991 to 22.000 mm (0.8657 to 0.8661 in.)	21.963 mm (0.8646 in.)
Clearance	0.025 to 0.047 mm (0.0009 to 0.0018 in.)	0.105 mm (0.0041 in.)

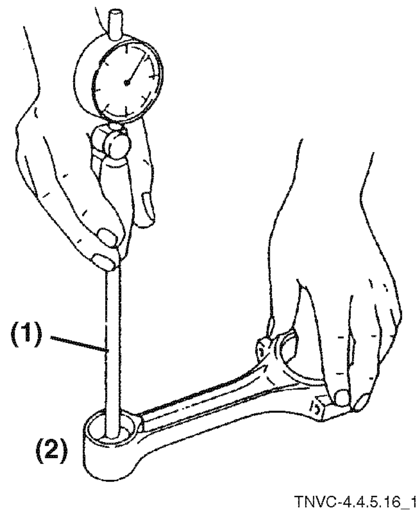


Figure 5-43

1 – Dial Bore Gauge
2 – Piston Pin Bushing

Replacing the Connecting Rod Bearings

NOTICE

- *Make sure there is no sand, metal shavings or other debris in the oil.*
- *Make sure the crankshaft is not scratched.*
- *Clean and clear all oil holes.*

1. Clean the large end of the connecting rod and install the connecting rod bearing inserts.
2. Match the alignment marks **(Figure 5-44, (1))** on the connecting rod and the rod cap.

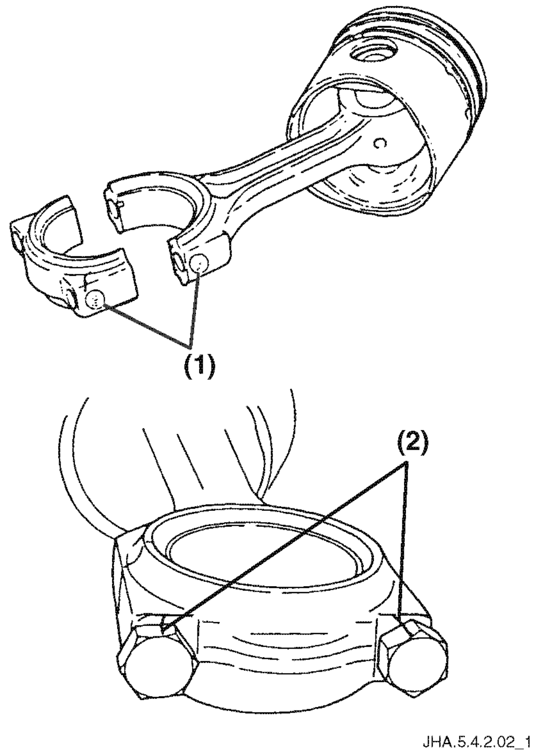


Figure 5-44

1 – Alignment Marks (punched)
2 – Index Marks

3. Hand tighten the rod cap bolts.

Inspecting the Pistons, Piston Pins and Piston Rings

Pistons are made of special light alloy with superior thermal expansion characteristics. The top of the piston forms a combustion chamber. A piston size identification mark is located on the piston head.

Piston Size I.D. Marks
ML
MS

NOTICE

Piston shape will vary between engine models. If an incorrect piston is installed, combustion performance will drop. Verify the engine model identification mark when ordering replacement pistons.

Engine Model I.D. Mark	
3YM30AE	V80T
3YM30	76K
3YM20 / 2YM15	70

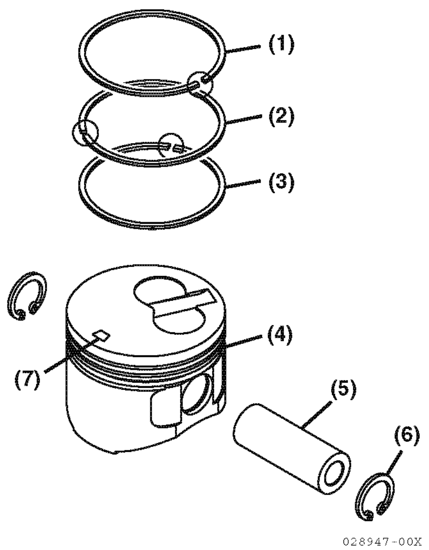


Figure 5-45

1 – Top Compression Ring
2 – Second Compression Ring
3 – Oil Control Ring
4 – Piston
5 – Piston Pin
6 – Circlip
7 – Piston I.D. Mark

1. Remove any carbon from the piston head and inspect the combustion surface for damage.

NOTICE

Avoid scratching or damaging the piston during carbon removal.

2. Measure the outside diameter **(Figure 5-46, (1))** of the piston 22 mm (0.866 in.) above the piston skirt at a right angle from the piston pin **(Figure 5-46, (2))**.

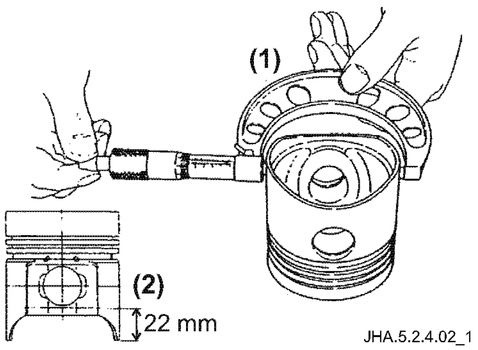


Figure 5-46

1 – Outside Diameter
2 – Measurement Position

3. Replace the piston if the piston or ring grooves are worn or exceed specification limits.

Piston Outside Diameter			
Model	**Standard**	**Limit**	**Clearance Between Piston and Cylinder**
3YM30AE	79.962 to 79.972 mm (3.1481 to 3.1484 in.)	79.917 mm (3.146 in.)	0.038 to 0.058 mm (0.0014 to 0.0022 in.)
3YM30	75.965 to 75.975 mm (2.9907 to 2.9911 in.)	75.920 mm (2.9889 in.)	0.035 to 0.055 mm (0.0013 to 0.0021 in.)
3YM20 / 2YM15	69.970 to 69.980 mm (2.7547 to 2.7551 in.)	69.925 mm (2.7529 in.)	0.030 to 0.050 mm (0.0011 to 0.0019 in.)

Matching Pistons to Cylinder Sleeves

Piston must be paired with cylinder according to the table below. 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-service side of the cylinder block. The service parts of pistons are provided.

			Piston Outside Diameter: D2	
	Tolerance	**Size Mark**	**Below 0.005 mm (0.0001 in.) 0 Minimum**	**Below 0 -0.005 mm (-0.0001 in.) Minimum**
			ML	**MS**
Cylinder Inside Diameter: D1	+0.030 mm (0.0118 in.) Maximum +0.020 mm (0.0078 in.) Minimum	L	O	X
	Below +0.020 mm (0.0078 in.) +0.010 mm (0.0003 in.) Minimum	M	O	O
	Below +0.010 mm (0.0003 in.) 0 Minimum	S	X	O

Model	Cylinder Inside Diameter: D1	Piston Outside Diameter: D2
3YM30AE	80 mm (3.1496 in.)	79.967 mm (3.1483 in.)
3YM30	76 mm (2.9921 in.)	75.970 mm (2.9909 in.)
3YM20 / 2YM15	70 mm (2.7558 in.)	69.975 mm (2.7549 in.)

Measuring the Piston Pin

1. Measure the piston pin hole at **a** and **b** in directions **A** and **B (Figure 5-47)**.

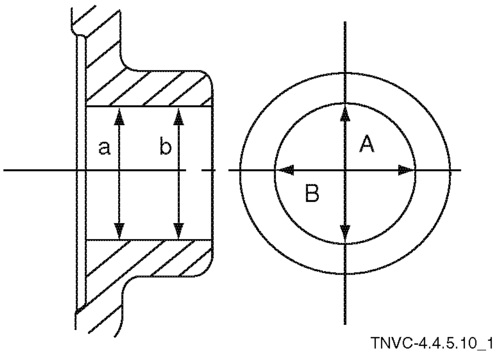


Figure 5-47

2. Measure the outer diameter of the piston pin at **a**, **b**, and **c** in directions **A** and **B (Figure 5-48)**.
3. Replace the pin if it is excessively worn.

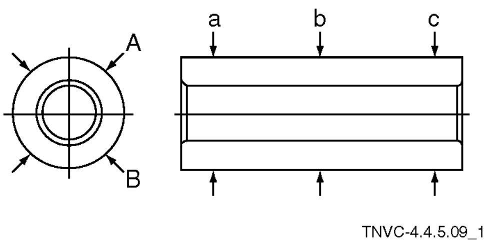


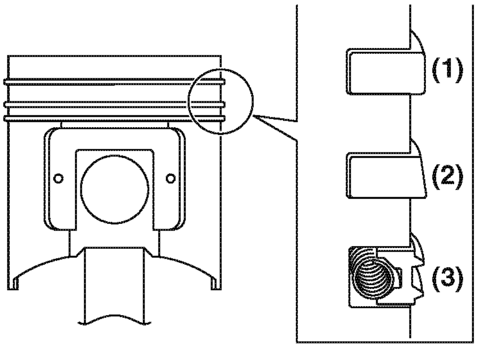
Figure 5-48

Measurement	Standard	Limit
Piston Pin Hole I.D.	22.000 to 22.009 mm (0.8661 to 0.8664 in.)	22.039 mm (0.8676 in.)
Piston Pin O.D.	21.995 to 22.000 mm (0.8659 to 0.8647 in.)	21.965 mm (0.8647 in.)
Clearance	0.000 to 0.014 mm (0.0000 to 0.0005 in.)	0.074 mm (0.0029 in.)

Measuring the Piston Rings

There are two compression rings **(Figure 5-49, (1) and (2))** and one oil control ring **(Figure 5-49, (3))**.

In order to provide adequate lubrication, an oil ring must be present on the piston skirt to ensure oil is kept on the thrust surface.

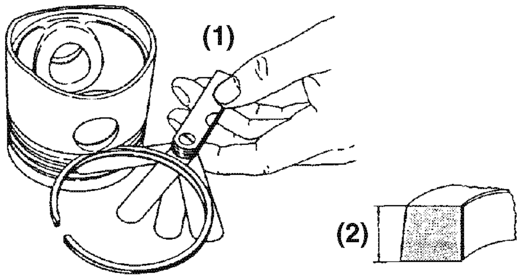


TNVC-4.4.5.11_1

Figure 5-49

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

1. Measure the piston ring width **(Figure 5-50, (2))**.
2. Measure the ring-to-groove clearance **(Figure 5-50, (1))** after installation.
3. Replace if wear exceeds the specified limits. *see Piston Ring and Groove Specifications on page 5-48.*



TNVC-4.4.5.12_1A

Figure 5-50

1 – Ring-to-Groove Clearance
2 – Ring Width

Measuring the Piston Ring Gap

1. Push the piston ring **(Figure 5-51, (3))** into a cylinder bore approximately 30 mm (1.2 in.) **(Figure 5-51, (4))** from the bottom of the cylinder.
2. Measure the piston ring gap **(Figure 5-51, (5))** with a feeler gauge.

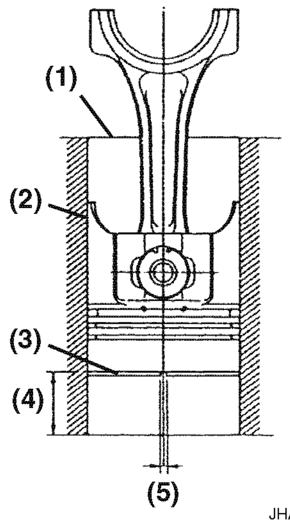


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Figure 5-51

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

Piston Ring and Groove Specifications

Item		Standard	Limit
Top Ring Gap		0.15 to 0.30 mm (0.0059 to 0.0118 in.)	0.390 mm (0.0153 in.)
Second Ring Gap		0.18 to 0.33 mm (0.0070 to 0.0129 in.)	0.420 mm (0.0165 in.)
Oil Ring Gap	3YM30AE	0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.490 mm (0.0192 in.)
	3YM30	0.20 to 0.45 mm (0.0078 to 0.0177 in.)	0.540 mm (0.0212 in.)
	3YM20 / 2YM15	0.15 to 0.35 mm (0.0059 to 0.0137 in.)	0.44 mm (0.0173 in.)

Replacing the Piston Rings

1. Thoroughly clean the ring grooves when removing piston rings.
2. Install the rings with the manufacturer's mark **(Figure 5-52, (1))** facing up.

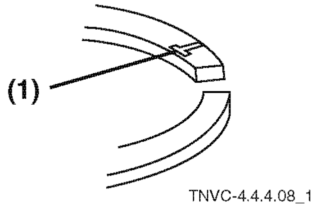


Figure 5-52

1 – Manufacturer's Mark

3. Make sure the rings move easily and smoothly in the piston ring grooves.

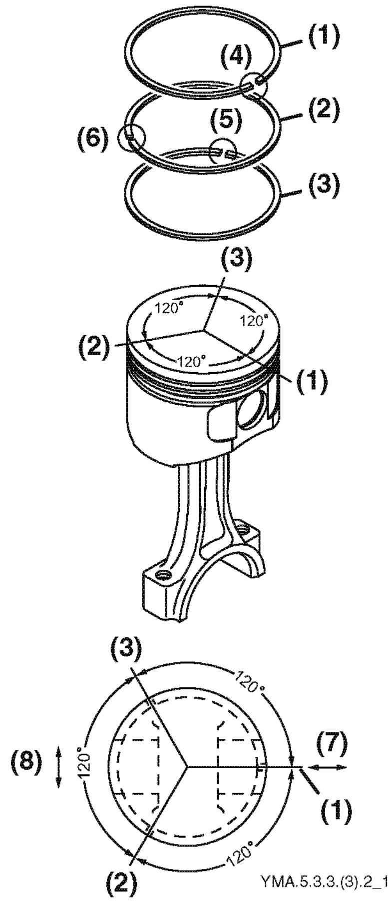


Figure 5-53

1 – Top Compression Ring
2 – Second Compression Ring
3 – Oil Control Ring
4 – Top Compression Ring Gap
5 – Oil Control Ring Gap
6 – Second Compression Ring Gap
7 – Direction of Piston Pin
8 – Direction of Side Pressure

4. Stagger the piston ring gaps at 120° intervals **(Figure 5-53)**. Make sure none of the ring gaps **(Figure 5-53, (4), (5) and (6))** line up with each other on the piston.
5. The oil control ring is equipped with a coil expander. Stagger the coil expander joint **(Figure 5-54, (2))** 180° away (opposite) from the oil ring gap **(Figure 5-54, (1))**.

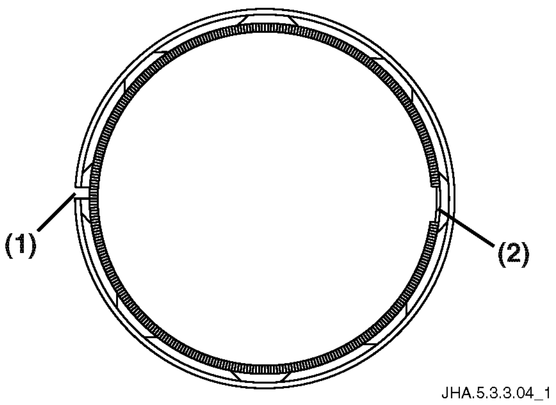


Figure 5-54

1 – Oil Ring Gap
2 – Coil Expander Joint

Assembling the Piston and Connecting Rods

A floating-type piston pin is used in this engine. The piston pin can be palm-pressed into the piston pin hole at room temperature (coat with oil to make it slide easily). Install new piston pin circlips into the piston pin bore grooves on each side to retain the piston pin.

NOTICE

When assembling the piston and connecting rod, make sure to follow the correct orientation.

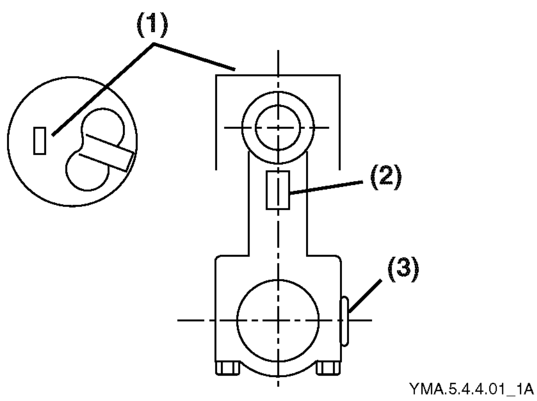


Figure 5-55

1 – Piston I.D. Mark
2 – Embossed Mark on Connecting Rod
3 – Rod Cap Alignment Marks

Installing the Piston and Connecting Rods

NOTICE

The piston and connecting rod should be installed with the alignment marks **(Figure 5-56, *(6)*)** *on the connecting rod large end facing the fuel nozzle side* **(Figure 5-56, *(3)*)** *of the engine.*

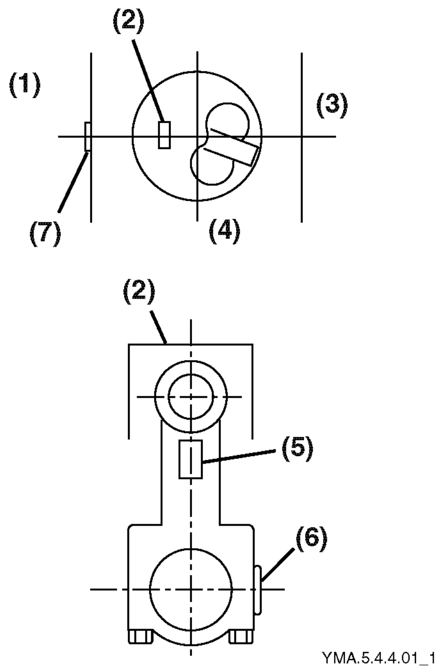


Figure 5-56

1 – Camshaft Side
2 – Piston I.D. Mark
3 – Nozzle Side
4 – Flywheel Side
5 – Embossed Mark on Connecting Rod (facing flywheel)
6 – Rod Cap Alignment Marks
7 – Cylinder Size Mark

1. Ensure the bearing inserts, connecting rod and cap mounting surfaces are clean. Coat the piston and the connecting rod bearing with engine oil.
2. Using a piston ring compressor, insert the piston and connecting rod assembly into the cylinder block, while aligning the connecting rod to the crankshaft journal.

3. After inserting the piston, make sure the I.D. mark **(Figure 5-56, (2))** on the piston top is located on the camshaft end **(Figure 5-56, (1))**, looking from the top of the piston.
4. Align the large end index marks. Position the connecting rod caps and bearings. Tighten the connecting rod bolts to the specified torque.

Connecting Rod Bolt Torque
22.6 to 27.5 N•m (16.6 to 20.2 lb-ft)

NOTICE

If a torque wrench is not available, match the index marks made during disassembly.

TIMING GEAR TRAIN

Removing the Oil Seal and Gear Housing Cover

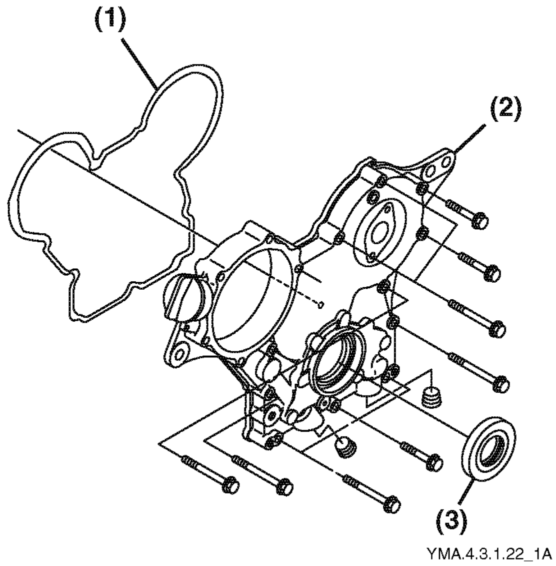


Figure 5-57

1 – Liquid Gasket
2 – Gear Housing Cover
3 – Oil Seal

1. Remove the oil seal **(Figure 5-57, (3))** from the gear housing cover **(Figure 5-57, (2))**.
2. Remove the gear housing cover and all liquid gasket **(Figure 5-57, (1))** from the sealing surface.

Removing the Gear Housing

1. Remove the gear housing **(Figure 5-58, (1))** from the cylinder block.
2. Remove all O-rings **(Figure 5-58, (3))** from the oil passages.

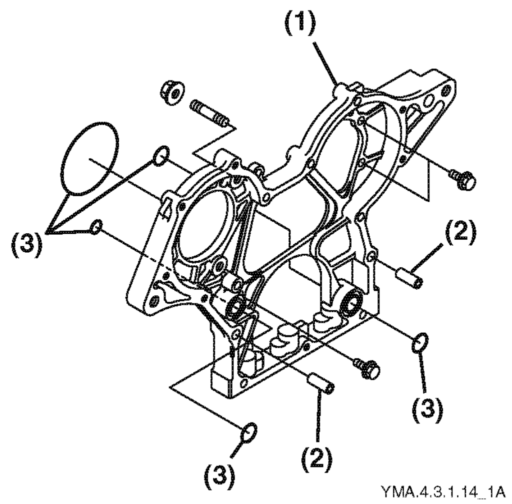


Figure 5-58

1 – Gear Housing
2 – Alignment Pins
3 – O-Rings

Inspecting the Timing Gears and Measuring Backlash

The timing gears are a helical design for quiet operation and treated for high durability.

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

NOTICE

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

Backlash	
Standard	**Limit**
0.06 to 0.12 mm (0.0023 to 0.0004 in.)	0.14 mm (0.0055 in.)

Removing the Idler Gear

1. Remove the idler gear bolts **(Figure 5-59, (1))**, idler gear **(Figure 5-59, (3))** and shaft **(Figure 5-59, (2))**.

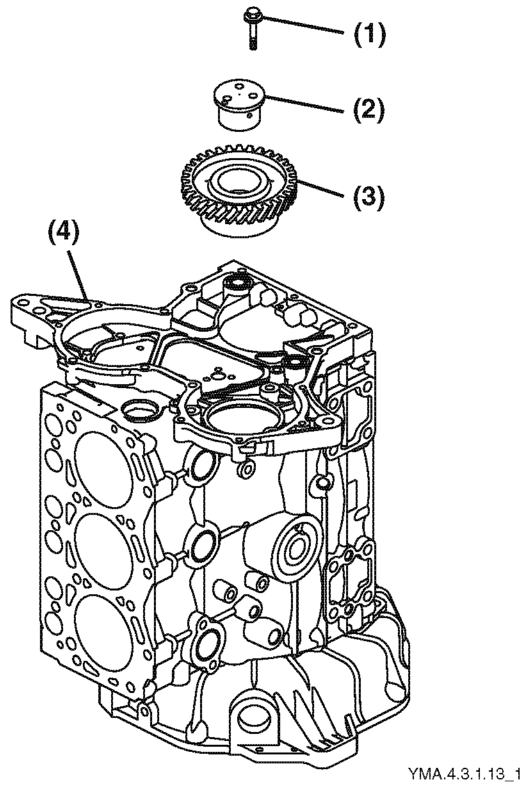


Figure 5-59

1 – Idler Gear Bolts
2 – Idler Gear Shaft
3 – Idler Gear with Bearing CMP
4 – Gear Housing

Inspecting the Idler Gear

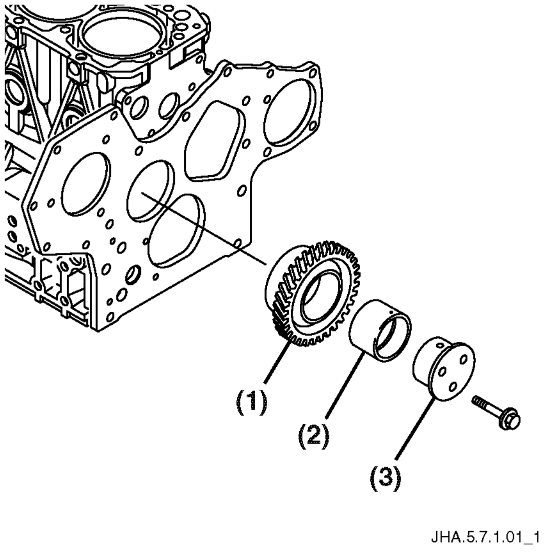


Figure 5-60

1 – Idler Gear
2 – Idler Gear Bearing
3 – Idler Gear Shaft

The idler gear bearing **(Figure 5-60, (2))** is pressed into the idler gear **(Figure 5-60, (1))**.

1. Measure the bearing inside diameter.
2. Measure the diameter of the idler gear shaft **(Figure 5-60, (3))**.
3. Replace the bearing and / or idler gear shaft if the oil clearance exceeds the specified limit.

Measurement	Standard	Limit
Idler Gear Shaft Diameter	36.950 to 36.975 mm (1.4547 to 1.4557 in.)	36.900 mm (1.4527 in.)
Idler Gear Bearing Diameter	37.000 to 37.025 mm (1.4566 to 1.4576 in.)	37.075 mm (1.4596 in.)
Oil Clearance	0.025 to 0.075 mm (0.0009 to 0.0029 in.)	0.175 mm (0.0068 in.)

Indexing the Timing Gear Marks

A, **B** and **C** are inscribed on the end of the idler gear. Match up the timing marks on each gear when assembling **(Figure 5-61, (A)**, **(B) and (C))**.

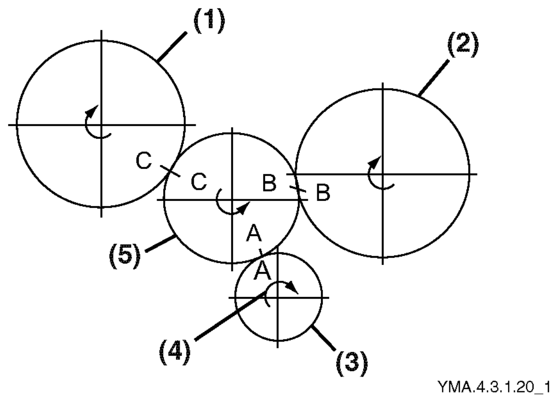


Figure 5-61

1 – Fuel Injection Pump Drive Gear
2 – Camshaft Gear
3 – Crankshaft Gear
4 – Direction of Rotation
5 – Idler Gear

Installing the Idler Gear

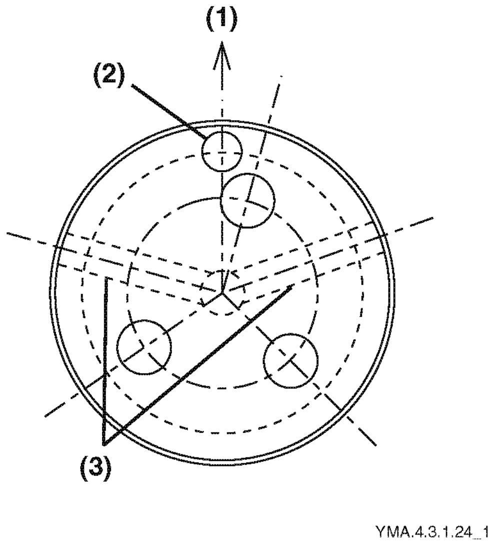


Figure 5-62

1 – Upside
2 – Mark
3 – Oil Hole

1. Install the idler gear with the mark **(Figure 5-61, (2))** on the idler gear shaft up.

NOTICE

A, B and C marks are inscribed on the idler gear. During assembly these marks should align with those of the mating timing gears.

2. Align the **A** and **B** marks on the idler gear **(Figure 5-62, (5))** with the matching **A** and **B** marks on the crankshaft gear **(Figure 5-62, (3))** and the camshaft gear **(Figure 5-62, (2))**.
3. Measure the idler gear, camshaft gear and crankshaft gear backlash. *see Inspecting the Timing Gears and Measuring Backlash on page 5-52.*

Installing the Gear Housing

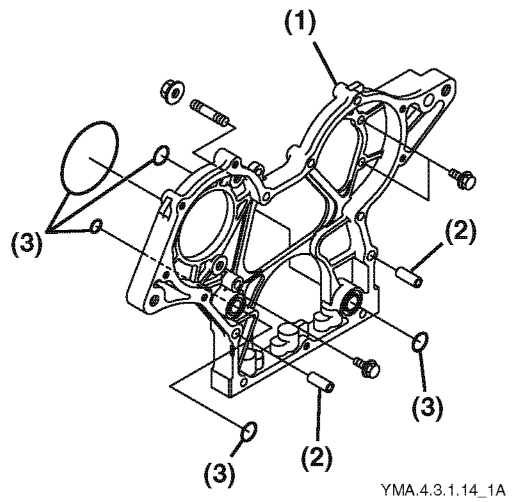


Figure 5-63

1 – **Gear Housing**
2 – **Alignment Pins**
3 – **O-Rings**

1. Apply liquid gasket to the gear housing **(Figure 5-63, (1))**.
2. Coat the O-rings **(Figure 5-63, (3))** with a light coat of grease to hold in position during assembly and place on cylinder block.
3. Align and install the gear housing on the alignment pins **(Figure 5-63, (2))** and O-rings on the cylinder block.

Installing the Oil Seal and Gear Housing Cover

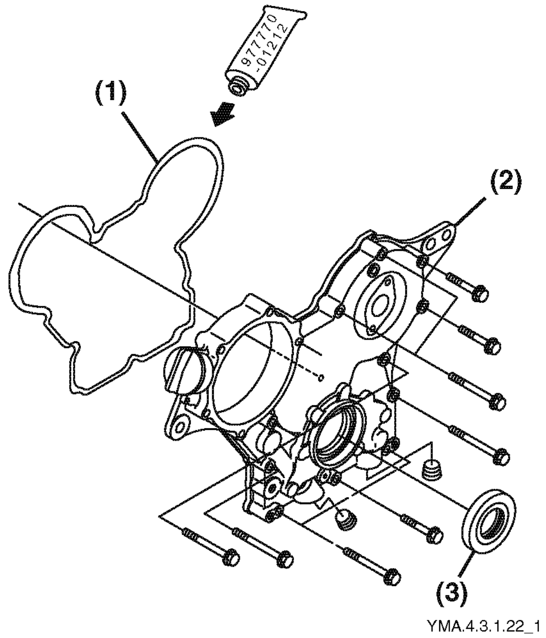


Figure 5-64

1 – **Liquid Gasket**
2 – **Gear Housing Cover**
3 – **Oil Seal**

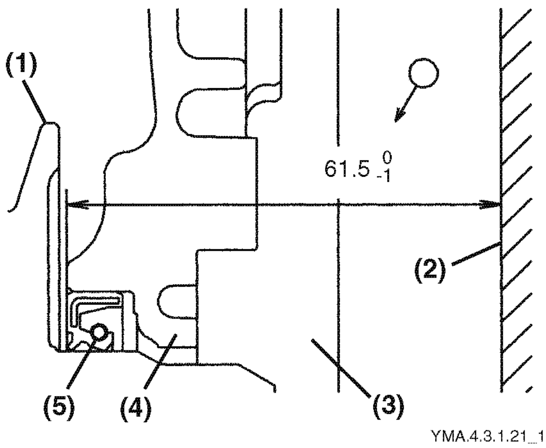


Figure 5-65

1 – **Crankshaft Pulley**
2 – **Cylinder Block**
3 – **Gear Housing**
4 – **Gear Housing Cover**
5 – **Oil Seal**

1. Use a new oil seal **(Figure 5-64, (3))** and **(Figure 5-65, (5))**.
2. Insert the oil seal using the oil seal insertion tool 61.5 mm (2.421 in.) from the end of the cylinder block **(Figure 5-64, (2))**.
3. Apply lithium grease to the oil seal lips.
4. Replace the pulley **(Figure 5-64, (1))** if wear is found on the surface that contacts the oil seal.
5. Install the pulley without damaging the oil seal.
6. Apply liquid gasket **(Figure 5-64, (1))** to the gear housing cover **(Figure 5-64, (2))** and **(Figure 5-65, (4))** then align and install the covers on the two alignment pins and tighten the cover bolts.

NOTICE

Do not allow the liquid gasket to protrude onto the oil pan mounting surface.

CRANKSHAFT

Removing the Crankshaft V-Pulley

1. Remove the bolt **(Figure 5-66, (1))** securing the crankshaft V-pulley **(Figure 5-66, (3))**.
2. Remove the crankshaft V-pulley with a pulley puller tool.

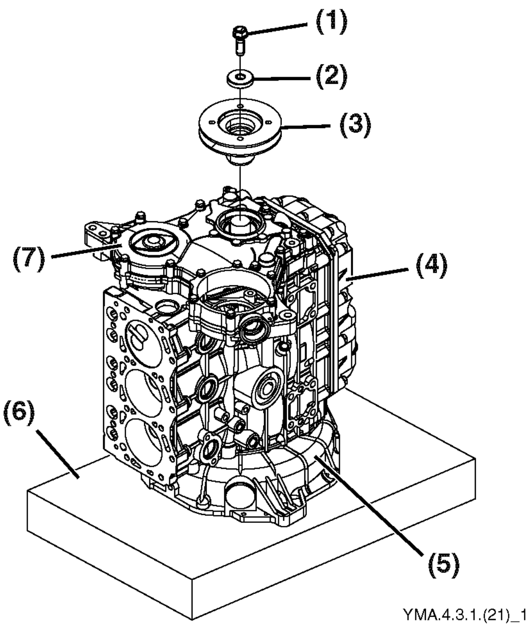


Figure 5-66

1 – Bolt
2 – Washer
3 – Crankshaft V-Pulley
4 – Oil Pan
5 – Flywheel Housing
6 – Wood Block
7 – Gear Housing Cover

Measuring Crankshaft End Play

Measure crankshaft end play before removing the crankshaft.

Method 1:

1. Placing a dial indicator on one end of the crankshaft and move the crankshaft to one side, to measure end play **(Figure 5-67)**.

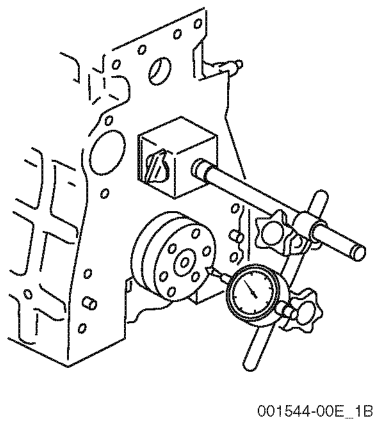


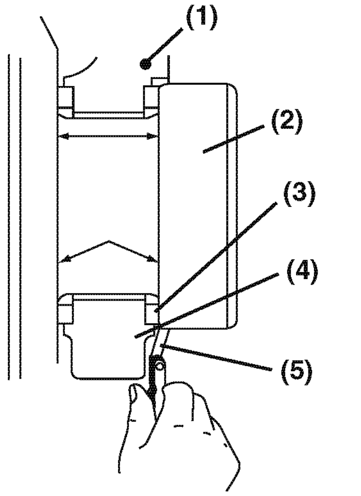
Figure 5-67

2. Replace the thrust bearing if it is worn beyond the limit stated.

Crankshaft End Play	
Standard	**Limit**
0.111 to 0.250 mm (0.0043 to 0.0098 in.)	0.30 mm (0.0118 in.)

Method 2:

Use a feeler gauge **(Figure 5-68, (5))** to measure the clearance between the thrust bearing **(Figure 5-68, (3))** and crankshaft thrust face.



TNVC-4.4.4.03_1B

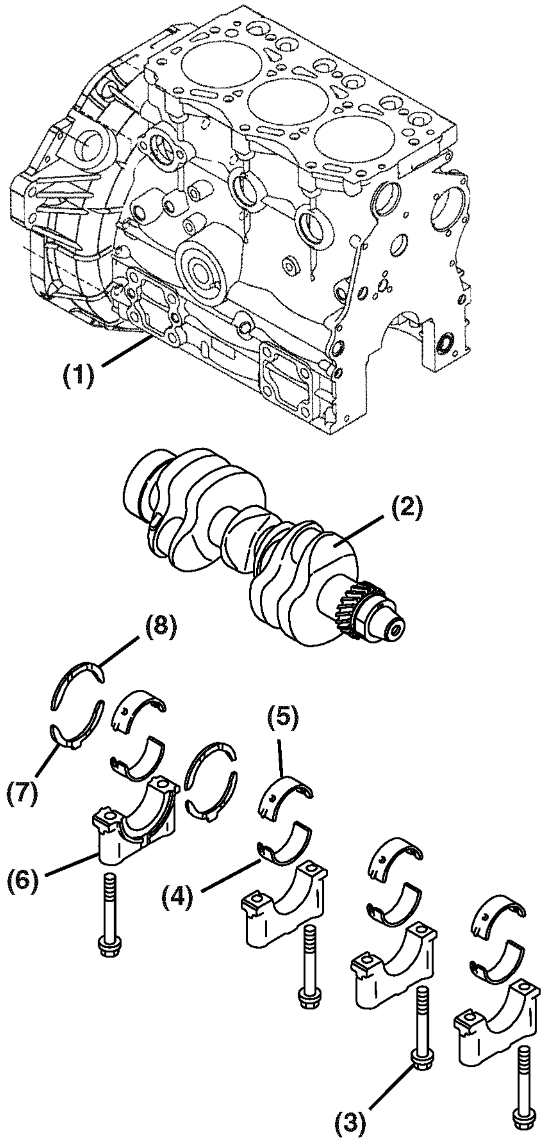
Figure 5-68

1 – Cylinder Block
2 – Crankshaft
3 – Thrust Bearing
4 – Bearing Cap
5 – Feeler Gauge

Removing the Crankshaft

1. Remove the main bearing bolts **(Figure 5-69, (3))**.
2. Remove the main bearing caps **(Figure 5-69, (6))** and the lower main bearing inserts **(Figure 5-69, (4))**.

Note: The lower thrust bearing **(Figure 5-69, (7))** is mounted to the base of the main bearing cap.



YMA.4.3.1.17_1

Figure 5-69

1 – Cylinder Block
2 – Crankshaft
3 – Main Bearing Bolts
4 – Lower Main Bearing Inserts
5 – Upper Main Bearing Inserts
6 – Main Bearing Cap
7 – Lower Thrust Bearing
8 – Upper Thrust Bearing

3. Remove the crankshaft **(Figure 5-69, (2))**.

Note: The upper thrust bearing **(Figure 5-69, (8))** is mounted to the main bearing cap **(Figure 5-69, (6))** of the cylinder block **(Figure 5-69, (1))**.

4. Remove the upper main bearing inserts **(Figure 5-69, (5))** from the cylinder block.

Inspecting the Crankshaft and Bearings

The crankshaft journals have been induction-hardened for superior durability. The crankshaft **(Figure 5-70, (1))** is equipped with four balance weights **(Figure 5-70, (2))** for minimum vibration.

The crankshaft main bearing caps **(Figure 5-70, (5))** are the hanger type. The upper bearing insert (cylinder block side) is designed with an oil groove. There is no oil groove on the lower bearing insert (bearing cap side). The main bearing cap (location cap) on the flywheel end is equipped with a thrust bearing **(Figure 5-70, (7))** which supports the thrust loads of the engine.

Check for the bearing inserts for flaking, seizure or burning of the contact surface and replace if necessary.

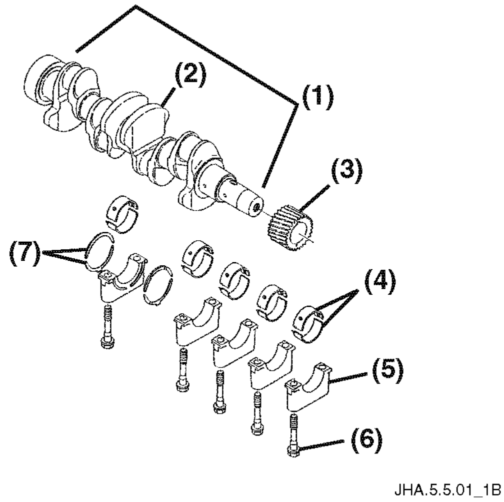


Figure 5-70

1 – Crankshaft
2 – Balance Weight
3 – Crankshaft Gear
4 – Main Bearing Inserts (upper and lower)
5 – Main Bearing Cap
6 – Main Bearing Bolt
7 – Thrust Bearing

1. Perform a dye penetrant inspection **(Figure 5-71)** of the crankshaft main bearing journals and the connecting rod pins. *see Dye Penetrant Inspection Procedure on page 5-27*.
2. Replace the crankshaft if any cracks or damage are found.

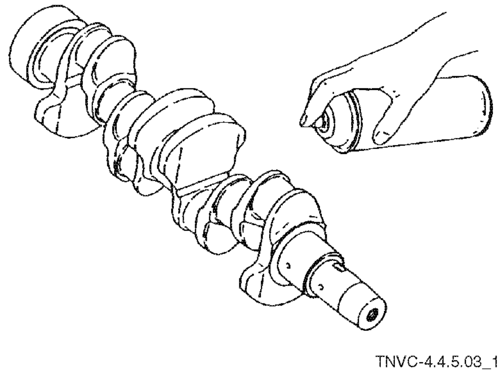


Figure 5-71

Measuring Crankshaft Bend and Deflection

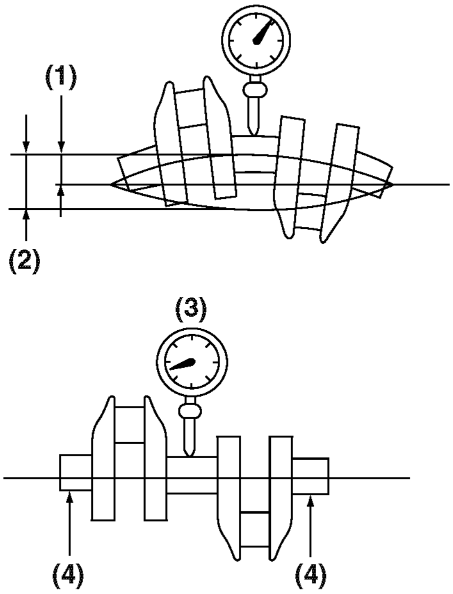


Figure 5-72

1 – Bend
2 – Deflection
3 – Dial Indicator
4 – V-block

1. Support the crankshaft with V-blocks **(Figure 5-72, (4))** at both ends of the main bearing journals.
2. Rotate the crankshaft and measure the deflection of the center journal with a dial indicator **(Figure 5-72, (3))**.
3. The total indicated reading on the dial indicator should be divided by two to obtain the crankshaft deflection.
4. Compare the readings with the specified limit.

Crankshaft Bend Limit
0.01 mm (0.0003 in.)

Measuring the Crankshaft Journals and Bearing

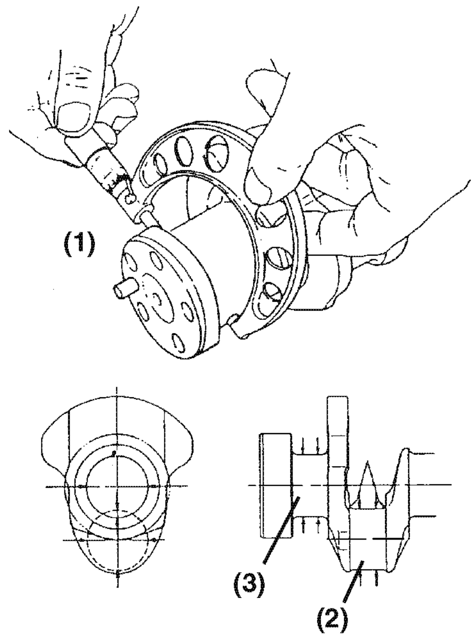


Figure 5-73

1 – Measuring Position
2 – Connecting Rod Journal
3 – Main Bearing Journal

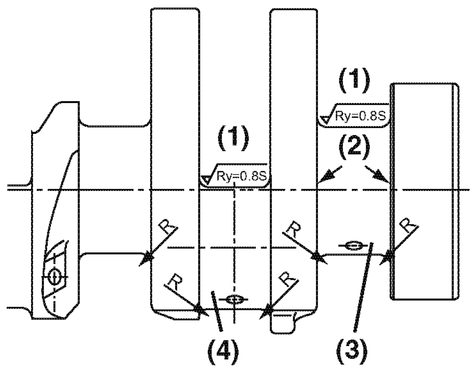


Figure 5-74

1 – Super Polishing
2 – Thrust Face
3 – Main Bearing Journal
4 – Connecting Rod Journal

1. Measure the diameter, roundness and taper of each crankshaft connecting rod journal **(Figure 5-73, (2))** and each main bearing journal **(Figure 5-73, (3))**.
2. Resurface the connecting rod and main bearing journals if measurements exceed specifications, or replace the crankshaft if excessive.

Note: Measure the inside diameter of the connecting rod bearing and the crankshaft connecting rod journal to determine oil clearance.

Item	Standard (Diameter)	Limit (Diameter)
Roundness Taper	0.01 mm (0.0003 in.) or less	0.02 mm (0.0006 in.)

Item		Standard	Limit
Crankshaft Pin 3YM30AE / 3YM30	O.D.	41.952 to 41.962 mm (1.6516 to 1.6520 in.)	41.902 mm (1.6496 in.)
	Oil Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.	0.120 mm (0.0047 in.)
Crankshaft Pin 3YM20 / 2YM15	O.D.	37.952 to 37.962 mm (1.4941 to 1.4945 in.)	37.902 mm (1.4922 in.)
	Oil Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)
Crankshaft Journal (selective pair) All Models	O.D.	46.952 to 46.962 mm (1.8484 to 1.8488 in.)	46.902 mm (1.8465 in.)
	Oil Clearance	0.020 to 0.050 mm (0.0007 to 0.0019 in.)	0.120 mm (0.0047 in.)

- Dimension R and finishing precision of crankshaft journal and pin

As for grinding processing of journal and pin, machine it by using the grinding wheel of the dimension R of below table.

Surface finishing precision standard on journal and pin:

Ry = 0.8S super polishing

Surface finishing precision standard on the thrust side of crankshaft arm:

1.6

Finishing Precision Standard of Dimension R
3.5+0.3/0 mm (0.1377 to 0.0118 in./0)

NOTICE

If the oil clearance is excessive even though the thickness of the journal and connecting rod bearings are normal or if partial uneven wear is observed, regrind the crankshaft and use undersized bearings.

If rust or surface damage is present on the rear of the bearing inserts, coat them with indigo blue or equivalent. Then, assemble the connecting rod bearings to the connecting rod and tighten the connecting rod bolts to the specified torque (see Installing the Piston and Connecting Rods on page 5-50 for connecting rod torque specification) to check the bearing insert for contact. If the contact surface is 75% or more, the bearing is normal. If the contact surface is less, the bearing interference fit is insufficient. Replace the bearing.

Installing the Crankshaft

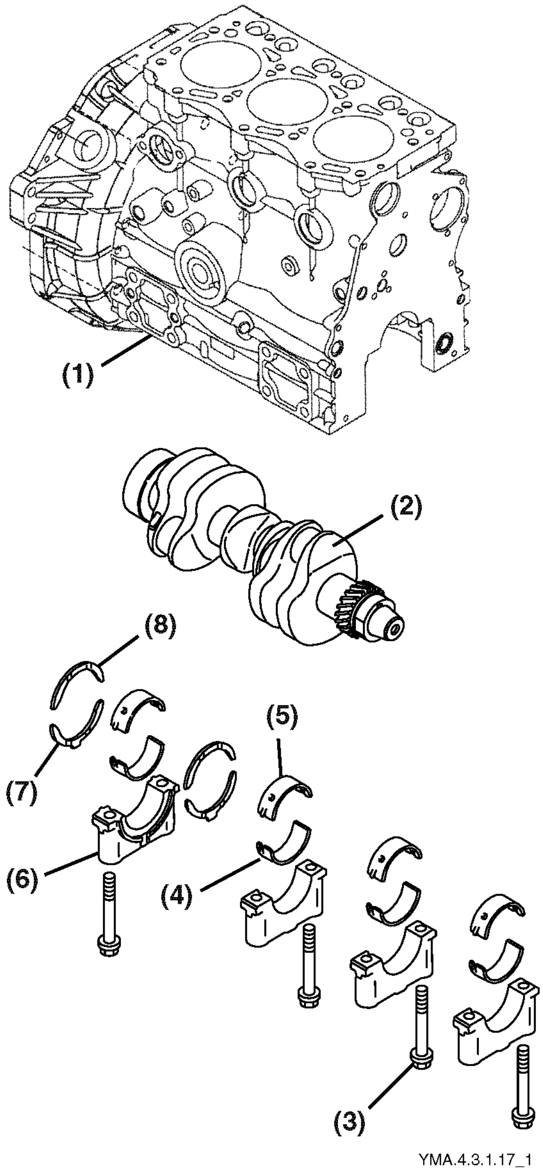


Figure 5-75

1 – Cylinder Block
2 – Crankshaft
3 – Main Bearing Bolts
4 – Lower Main Bearing Insert
5 – Upper Main Bearing Insert
6 – Main Bearing Cap
7 – Lower Thrust Bearing
8 – Upper Thrust Bearing

The crankshaft gear is pressed onto the crankshaft **(Figure 5-75, (2))**.

If the crankshaft gear has been removed, heat the crankshaft gear to 180° to 200°C (365° to 392°F) in oil. **WARNING! Burn Hazard.** ***Wear protective eye glasses and heat-resistant gloves when handling heated parts.*** Then, press the crankshaft gear on the crankshaft.

1. Position the crankshaft so that the crankshaft gear is at the gear housing end.
2. Coat the inside diameter of the upper main bearing inserts **(Figure 5-75, (5))** with oil.
3. Install the upper main bearing inserts onto the cylinder block **(Figure 5-75, (1))**.

Note: The upper bearing inserts have an oil hole; the lower inserts do not.

4. Install the thrust bearings **(Figure 5-75, (7) and (8))** with the oil grooves facing outward toward the crankshaft. Avoid dropping the thrust bearing during installation.
5. Coat the main bearing journals of the crankshaft with engine oil and install the crankshaft.

Installing the Main Bearing Caps

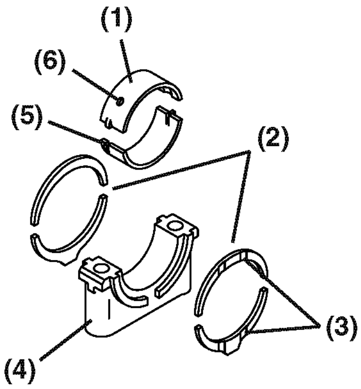


Figure 5-76

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

1. Coat the inside diameter of the lower main bearing inserts **(Figure 5-76, (5))** with engine oil, and install them onto the main bearing caps **(Figure 5-76, (4))**.

Note: The lower bearings do not have an oil hole.

2. Install the thrust bearings **(Figure 5-76, (2))** with the oil grooves **(Figure 5-76, (3))** facing outward toward the crankshaft.
3. Coat the flanges and the threads of the main bearing bolts with engine oil.

When assembling the bearing caps, check the following.

- The lower main bearing insert (cap side) has no oil hole.
- The upper main bearing insert (block side) has an oil hole.
- Check the cylinder block alignment number.
- The main bearing cap should be installed with the arrow and "FW" ***(Figure 5-77,* (1))** on the cap facing the flywheel.

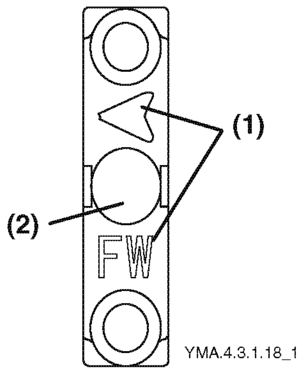


Figure 5-77

1 – Arrow and "FW" Mark
2 – Position Number

4. Install the main bearing cap bolts and tighten to the specified torque.

Main Bearing Cap Bolt Torque
75.5 to 81.5 N•m (55.6 to 60.1 lb-ft)

5. Ensure the main bearing cap is positioned with the correct cylinder alignment number.
6. Measure the crankshaft end play. *see Measuring Crankshaft End Play on page 5-56.*
7. Make sure that the crankshaft rotates smoothly and easily.

Installing the Crankshaft V-Pulley

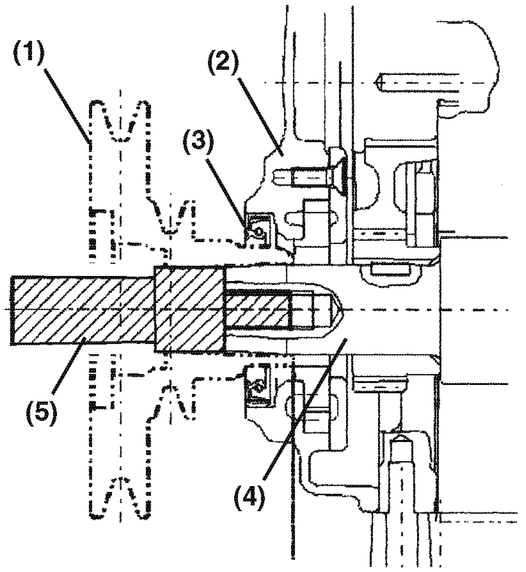


Figure 5-78

1 – Crankshaft Pulley
2 – Gear Housing Cover
3 – Oil Seal
4 – Crankshaft
5 – Pulley Insertion Tool

1. Coat the inner lips of the oil seal **(Figure 5-78, (3))** with oil.
2. Remove all oil from the tapered surfaces of the crankshaft **(Figure 5-78, (4))** and pulley **(Figure 5-78, (1))**.
3. Install the pulley insertion tool **(Figure 5-78, (5))** to the crankshaft and mount the pulley on the crankshaft without damaging the oil seal.
4. Tighten the V-pulley bolts to the specified torque.

V-Pulley Bolt Torque	
(Material: Casting Iron)	83.3 to 93.3 N•m (61.4 to 68.8 lb-ft)

CAMSHAFT AND TAPPETS

Measuring the Camshaft End Play

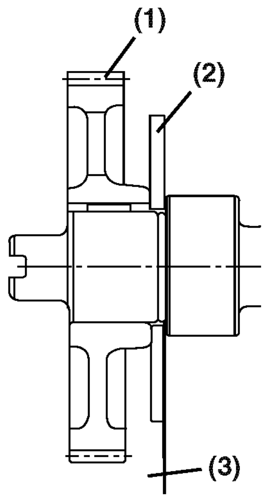


Figure 5-79

1 – Camshaft Gear
2 – Thrust Bearing
3 – End Play

Measure the camshaft end play **(Figure 5-79, (3))** before removing the camshaft.

Camshaft End Play	
Standard	Limit
0.05 to 0.15 mm (0.0019 to 0.0059 in.)	0.25 mm (0.0098 in.)

Removing the Camshaft and Tappets

1. Turn the engine block over with the cylinder head mounting surface facing down.

NOTICE

Make sure that the cylinder head alignment pins **(Figure 5-80, *(1)*)** *on the cylinder block do not come in contact with the wood block.*

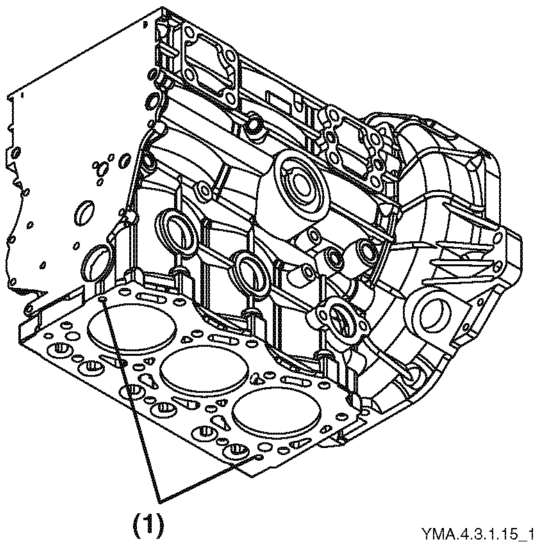


Figure 5-80

1 – Cylinder Head Alignment Pins

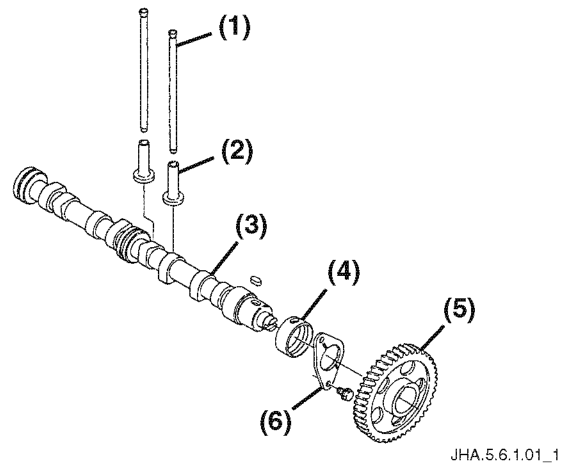


Figure 5-81

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

2. Remove all push rods **(Figure 5-81, (1))**. Rotate the camshaft **(Figure 5-81, (3))** to raise the tappets **(Figure 5-81, (2))** and then remove all tappets. *NOTICE: Keep all parts in order during removal.*
3. Remove the thrust bearing bolts and remove the thrust bearing **(Figure 5-81, (6))**.
4. Carefully remove the camshaft and camshaft gear **(Figure 5-81, (5))** from the cylinder block.

NOTICE

If the camshaft gear is to be removed from the camshaft, use caution. The camshaft gear is pressed on and must be heated to 180° to 200°C (365° to 392°F) to disassemble.

⚠ WARNING

Burn Hazard

Wear protective eye glasses and heat-resistant gloves when working with heat or flames during the removal of the camshaft gear.

Inspecting the Camshaft and Tappets

The camshaft bearing surfaces are surface hardened and ground. The camshaft lobes have a curve that minimizes the repeated shocks to the valve seats and maximizes valve seat life.

Measuring the Camshaft Lobe Height

Measure the camshaft lobe height **(Figure 5-82, (1))**, and replace the camshaft if wear exceeds the specified limit.

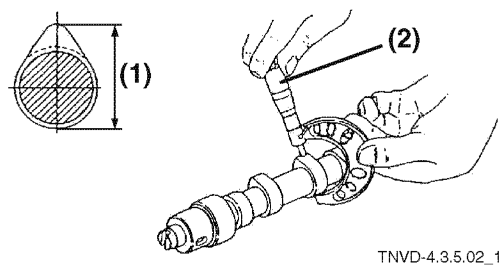


Figure 5-82

1 – Camshaft Lobe Height
2 – Micrometer

Camshaft Lobe Height		
Model	**Standard**	**Limit**
3YM30AE / 3YM30	34.135 to 34.265 mm (1.3438 to 1.3490 in.)	33.89 mm (1.3342 in.)
3YM20 / 2YM15	34.535 to 34.665 mm (1.3596 to 1.36 in.)	34.29 mm (1.3499 in.)

Measuring Camshaft Straightness

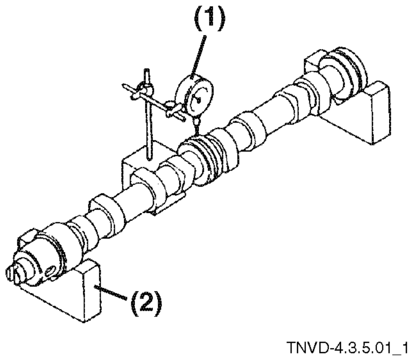


Figure 5-83

1 – Dial Indicator
2 – V-Block

1. Support both ends of the camshaft on V-blocks **(Figure 5-83, (2))**.
2. Place a dial indicator **(Figure 5-83, (1))** on the center camshaft journal and measure the deflection.
3. Replace the camshaft if wear exceeds the specified limit.

Note: The reading on the dial indicator is divided by two to obtain the camshaft deflection.

Camshaft Bend	
Standard	**Limit**
0.02 mm (0.0007 in.) or less	0.05 mm (0.0019 in.)

Measuring the Camshaft Journals and Bearings

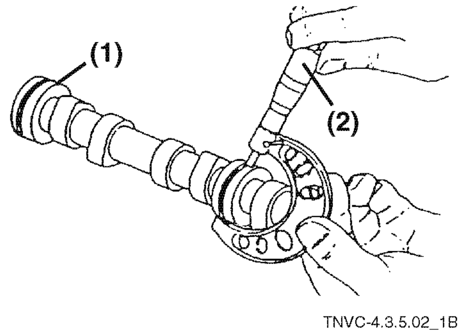


Figure 5-84

1 – Flywheel Side Camshaft Journal
2 – Micrometer

1. Measure the camshaft journals using a micrometer **(Figure 5-84, (2))**.
2. To calculate oil clearance, subtract the measured camshaft journal diameter from the diameter of the camshaft bearing in the cylinder block.
3. Measure the camshaft bearing in the gear housing end with a dial bore gauge.
4. Replace the camshaft bearings if wear exceeds the specified limit or if damaged.

Item	Measurement	Standard	Limit
Gear Side	Camshaft Bearing	40.000 to 40.075 mm (1.5747 to 1.5777 in.)	40.150 mm (1.5807 in.)
	Camshaft Journal	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)
	Oil Clearance	0.040 to 0.135 mm (0.0015 to 0.0053 in.)	0.245 mm (0.0096 in.)
Intermediate Position	Camshaft Bearing	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)
	Camshaft Journal	39.910 to 39.935 mm (1.5712 to 1.5722 in.)	39.875 mm (1.5698 in.)
	Oil Clearance	0.065 to 0.115 mm (0.0025 to 0.0045 in.)	0.225 mm (0.0088 in.)
Flywheel Side	Camshaft Bearing	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)
	Camshaft Journal	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)
	Oil Clearance	0.040 to 0.085 mm (0.0015 to 0.0033 in.)	0.195 mm (0.0076 in.)

Inspecting the Tappets

The tappets **(Figure 5-85, (3))** are offset to prevent uneven wear.

Check the contact of each tappet and replace if excessively or unevenly worn.

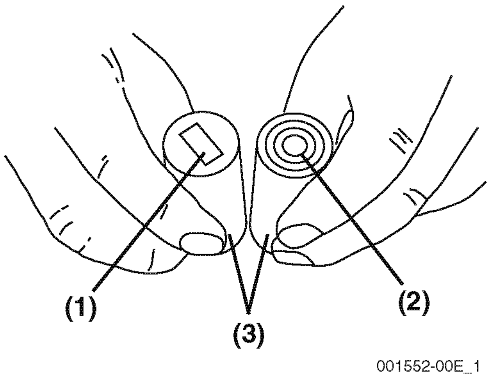


Figure 5-85

1 – Abnormal Contact Surface
2 – Normal Contact Surface
3 – Tappet

1. Measure the outer diameter of the tappet and compare the readings with the limits stated.
2. Replace if wear exceeds the specified limit.

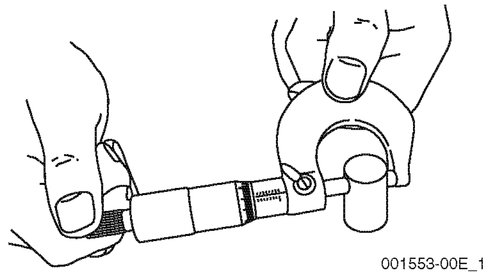


Figure 5-86

Item	Standard	Limit
Tappet Diameter	20.927 to 20.960 mm (0.8283 to 0.8251 in.)	20.907 mm (0.8231 in.)
Tappet Bore (cylinder block)	21.000 to 21.021 mm (0.8267 to 0.8275 in.)	21.041 mm (0.8283 in.)
Oil Clearance	0.040 to 0.094 mm (0.0016 to 0.0037 in.)	0.134 mm (0.0052 in.)

Installing the Camshaft and Tappets

1. If the camshaft and the camshaft gear have been disassembled, heat the camshaft gear to 180° to 200°C (365° to 392°F) in oil.

⚠ WARNING

Burn Hazard

Wear protective eye glasses and heat-resistant gloves when working with heat or flames during the removal of the camshaft gear.

2. Press the camshaft gear onto the camshaft.

NOTICE

When installing the camshaft and the camshaft gear, be sure to assemble the thrust bearing in the correct orientation.

3. Coat the cylinder block camshaft bearings and the camshaft with engine oil.
4. Insert the camshaft into the cylinder block and tighten the thrust bearing bolts.
5. Measure the camshaft end play. *see Measuring the Camshaft End Play on page 5-63.*
6. Make sure that the camshaft rotates smoothly.
7. Turn the engine block over with the cylinder head mounting surface facing down.

   *NOTICE: Make sure that the cylinder head alignment pins **(Figure 5-87, (1))** on the cylinder block do not come in contact with the wood block.*

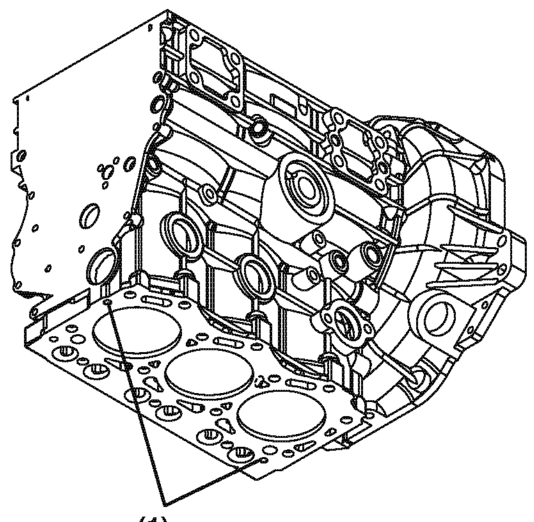


Figure 5-87

1 – Cylinder Head Alignment Pins

8. Coat the inside of the cylinder block tappet bores and the tappets with engine oil and insert the tappets in the cylinder block.

NOTICE

Be sure the tappets are installed in the same location from which they were removed.

ENGINE CYLINDER BLOCK

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

Perform a visual inspection for cracks on engines that have been exposed to freezing temperatures, have overturned or been subjected to undue stress. Perform a dye penetrant inspection on any suspected cracks. *see Dye Penetrant Inspection Procedure on page 5-27*. Replace the cylinder block if a crack is not repairable.

Measuring the Cylinder Bores

Perform the following before measuring the cylinder bores:

- Clean the cylinder block deck surface, cylinders and all oil passages.
- Remove all carbon deposits and / or gasket material residue.
- Check for any discoloration or cracks. If a crack is suspected, perform a dye penetrant inspection. *see Dye Penetrant Inspection Procedure on page 5-27*.
- Check for cylinder damage and scoring.
- Consider honing or cylinder block replacement if the measurements are not within specifications.

Cylinder Specifications

Item	Model	Standard	Limit
Cylinder Bore Diameter	3YM30AE	80.000 to 80.030 mm (3.1496 to 3.1508 in.)	80.200 mm (3.1574 in.)
	3YM30	76.000 to 76.030 mm (2.992 to 2.993 in.)	76.200 mm (2.999 in.)
	3YM20 / 2YM15	70.000 to 70.030 mm (2.755 to 2.757 in.)	70.200 mm (2.999 in.)
Roundness		0.01 mm (0.0003 in.) or less	0.03 mm (0.0011 in.)
Taper		0.01 mm (0.0003 in.) or less	0.03 mm (0.0011 in.)

Measure cylinders for roundness and taper using a dial bore gauge **(Figure 5-88)**.

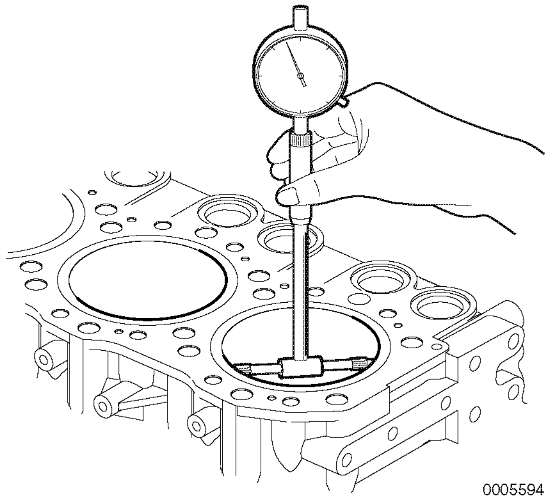


Figure 5-88

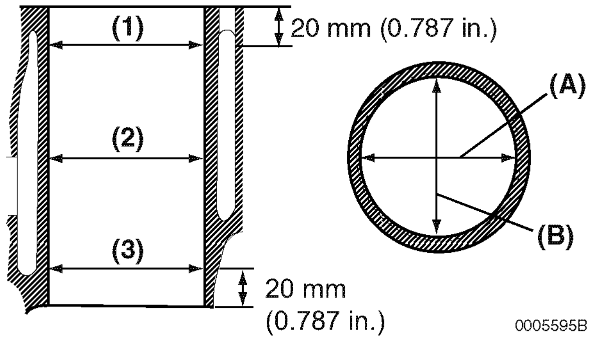


Figure 5-89

1 – 20 mm (0.787 in.) Below Top of Cylinder
2 – Center of Cylinder
3 – 20 mm (0.787 in.) Above Cylinder Bottom

Measure cylinder bore diameter at three places **(Figure 5-89, (1)**, **(2) and (3))** in two directions **(Figure 5-89, (A) and (B))** in each cylinder. Collect and record the measurements.

- **A** - Dimension “A” is measured parallel with the crankshaft.
- **B** - Dimension “B” is measured perpendicular to the crankshaft.

Roundness

The roundness can be calculated by subtracting the smaller measured value from the larger measured value of **Figure 5-89 (A)** or **(B)** at each measuring location **(Figure 5-89, (1)**, **(2) and (3))**.

Taper

The taper can be calculated by subtracting the minimum measured value from the maximum measured value at three locations **Figure 5-89 (1)**, **(2) and (3)**. Calculate along both the **Figure 5-89 (A) and (B)** axis and use the larger of the two calculations as the value to compare to the specifications.

ENGINE OIL LUBRICATION SYSTEM

see Lubrication System on page 8-1 for additional lubrication system and lubrication system component specifications and service procedures.

Draining the Engine Oil

Remove the mounting bolt that holds the oil dipstick tube and drain the oil from the engine.

Note: If an oil supply / discharge pump is used for the engine, the pump hose is placed in the dipstick tube. *see Replacing the Engine Oil Filter Element on page 4-11.*

Removing the Oil Filter

1. Remove the oil filter **(Figure 5-90, (2))** from the cylinder block **(Figure 5-90, (1))**.
2. Remove the oil pressure switch **(Figure 5-90, (3))**.

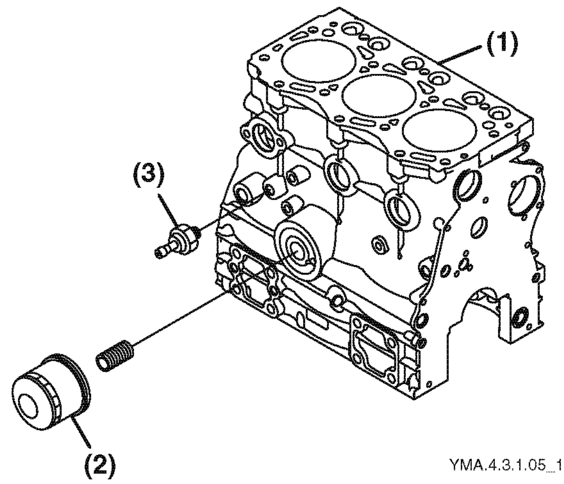


Figure 5-90

1 – Cylinder Block
2 – Oil Filter
3 – Oil Pressure Switch

Removing the Oil Pan Spacer and Oil Pan

Remove the oil pan **(Figure 5-91, (2))** and spacer **(Figure 5-91, (1))**.

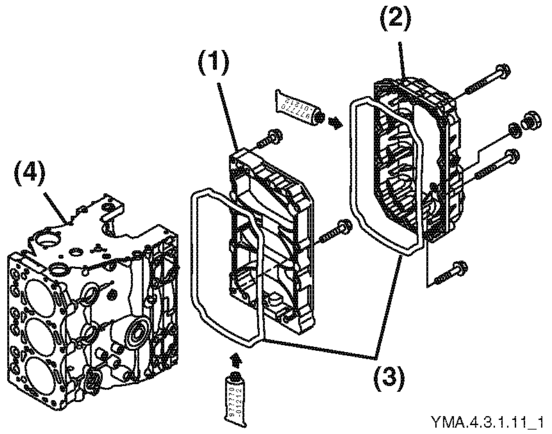


Figure 5-91

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

Removing the Oil Inlet Tube

Remove the oil inlet tube **(Figure 5-92, (2))** and O-ring **(Figure 5-92, (1))**.

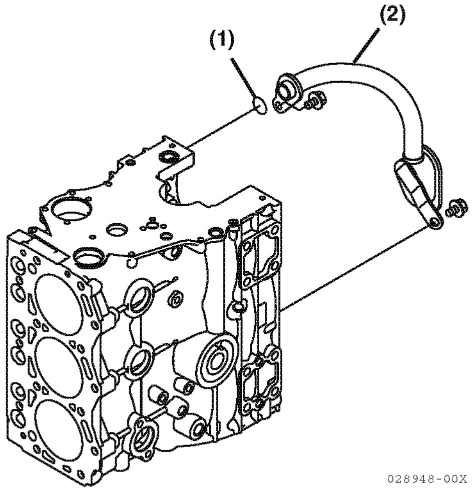


Figure 5-92

1 – O-Ring
2 – Oil Inlet Tube

Removing the Oil Pump

1. Remove the oil gear housing cover bolts and remove the cover **(Figure 5-93, (2))**.
2. Remove the oil pump from the oil gear housing cover **(Figure 5-93, (5))**.

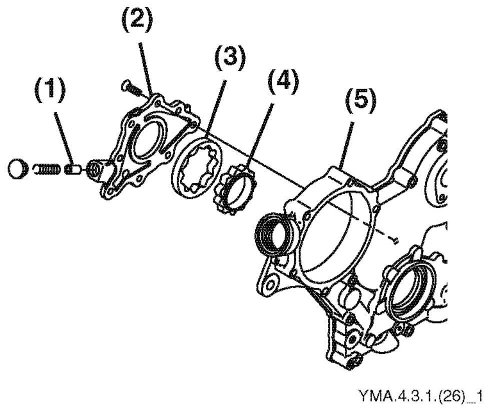


Figure 5-93

1 – Control Valve
2 – Cover
3 – Outer Rotor
4 – Inner Rotor
5 – Gear Housing Cover

Inspecting Oil Passages and Cap Plugs

Clear all oil passages of any obstructions. Ensure all cap plugs are secured in the cylinder block.

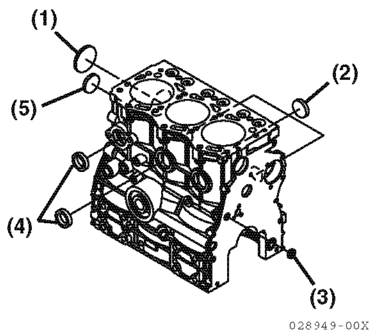
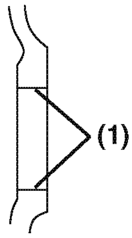
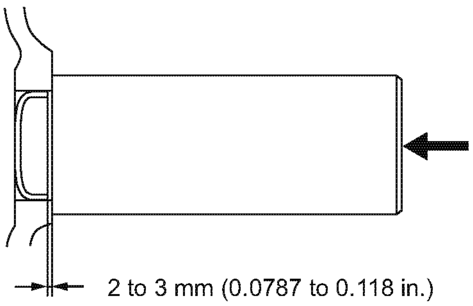
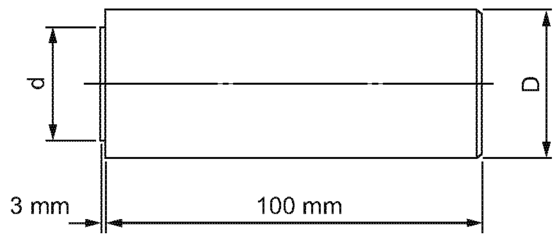


Figure 5-94

1 – 45 mm (1.771 in.) Cap Plug
2 – 25 mm (0.984 in.) Cap Plug
3 – 12 mm (0.475 in.) Main Galley Cap Plug
4 – 30 mm (1.181 in.) Cap Plug
5 – 30 mm (1.181 in.) Cap Plug

Replacing Cap Plugs

Step No.	Description	Procedure	Tool or Material
1	Clean and remove grease or foreign materials from the cap plug hole.	 **(1)** Remove foreign materials with a screwdriver or saw blade.	Screwdriver or Saw Blade Cleaning Solvent
2	Remove grease from the cap plug.	Visually check for damage on the cap plug sealing surface.	Cleaning Solvent
3	Apply ThreeBond® No. 4 to the cap plug hole.	Apply over the outside of the plug.	ThreeBond® No. 4
4	Insert the cap plug into the hole securely.	–	–
5	Using a driving tool, seat the cap plug. 	Drive in the plug parallel to the seating surface then finish driving until the edge of the plug is 2 to 3 mm (0.0787 to 0.118 in.) below the cylinder surface.	Hammer Driving Tool (Fabricate locally using the dimensions shown below)



Cap Plug Diameter	d	D
12 mm (0.472 in.)	11.9 to 12.0 mm (0.4685 to 0.4724 in.)	20 mm (0.787 in.)
25 mm (0.984 in.)	24.9 to 25.0 mm (0.9803 to 0.9842 in.)	35 mm (1.38 in.)
30 mm (1.18 in.)	29.9 to 30.0 mm (1.177 to 1.178 in.)	40 mm (1.57 in.)
45 mm (1.77 in.)	44.9 to 45.0 mm (1.768 to 1.772 in.)	55 mm (2.17 in.)

Installing the Oil Pump

1. Coat the outer and inner rotors **(Figure 5-95, (3) *and* (4))** with engine oil. Install the oil pump to the gear housing cover **(Figure 5-95, (5))**.
2. Apply engine oil to the oil pump cover bolts and tighten to the specified torque.

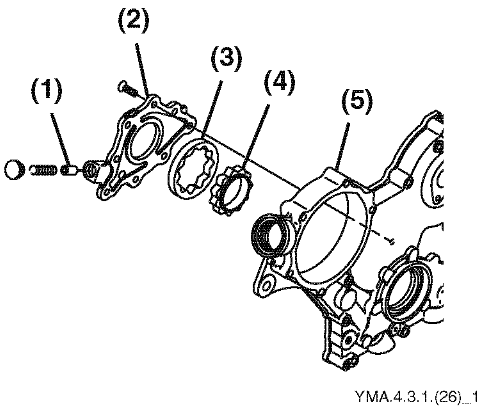


Figure 5-95

1 – Control Valve
2 – Oil Pump Cover
3 – Outer Rotor
4 – Inner Rotor
5 – Gear Housing Cover

Oil Pump Cover Bolt Torque
5.9 to 7.9 N•m (4.3 to 5.8 lb-ft)

3. Assemble the rotor so that the mark on the rotor faces the cover **(Figure 5-95, (2))**.
4. Confirm that the rotor moves smoothly.

Installing the Oil Inlet Tube

1. Install the oil inlet tube on the bottom of the cylinder block using a new gasket.
2. Tighten oil inlet tube to the specified torque.

Oil Inlet Tube Torque
26 N•m (19.1 lb-ft)

Installing the Oil Pan Spacer and Oil Pan

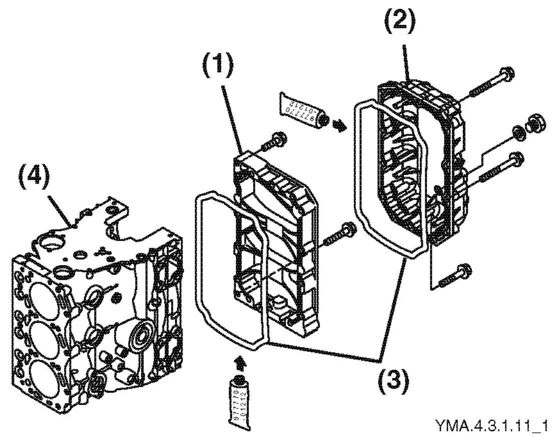


Figure 5-96

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

1. Apply liquid gasket **(Figure 5-96, (3))** to the surfaces of the gear housing cover, the gear housing and the surface of the flywheel housing that contacts the cylinder block **(Figure 5-96, (4))**.
2. Apply the liquid gasket to the spacer **(Figure 5-96, (1))**.
3. Install the spacer on the cylinder block and tighten the bolts.
4. Apply liquid gasket to the oil pan **(Figure 5-96, (2))**.
5. Install the oil pan to the spacer and tighten all oil pan bolts.
6. Install the dipstick and dipstick guide.

Installing the Oil Filter

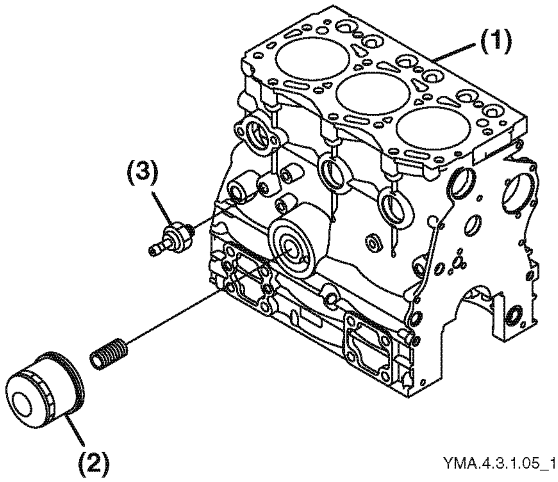


Figure 5-97

1 – Cylinder Block
2 – Oil Filter
3 – Oil Pressure Switch

Install the oil filter **(Figure 5-97, (2))** and oil pressure switch **(Figure 5-97, (3))**. *see Replacing the Engine Oil Filter Element on page 4-11.*

Filling the Engine with Oil

see Checking the Engine Oil Level on page 4-7.

FLYWHEEL, FLYWHEEL HOUSING AND ENGINE MOUNTS

Removing the Flywheel Housing

1. Loosen but do not remove the crankshaft main bearing bolts.
2. Turn the engine block over with the cylinder head mounting surface facing down.

NOTICE

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

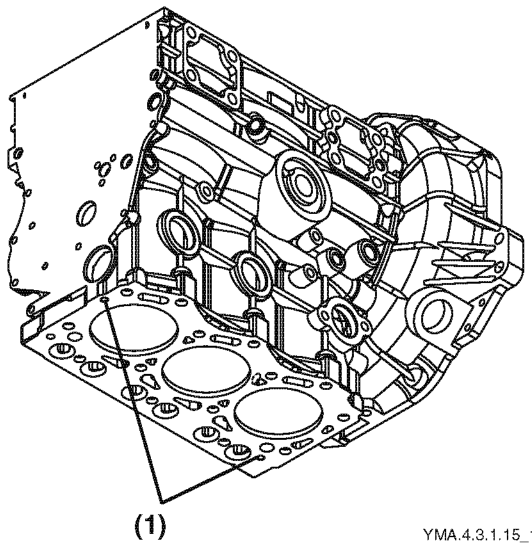


Figure 5-98

1 – Cylinder Head Alignment Pins

3. Remove the flywheel housing **(Figure 5-99, (4))** and the oil seal **(Figure 5-99, (3))** from the cylinder block **(Figure 5-99, (2))**.

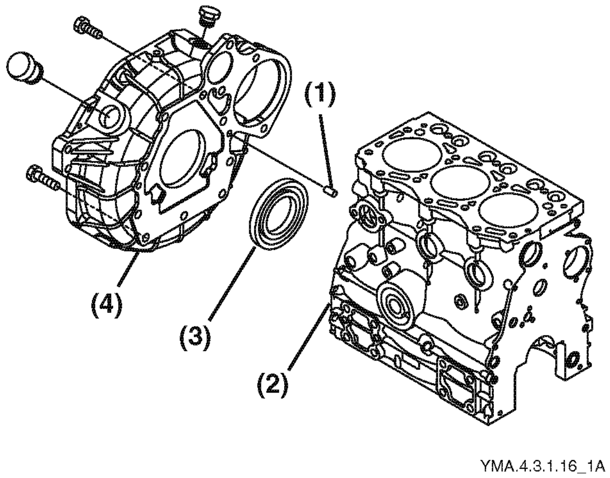


Figure 5-99

1 – Alignment Pin
2 – Cylinder Block
3 – Oil Seal
4 – Flywheel Housing

Removing the Damper Disk

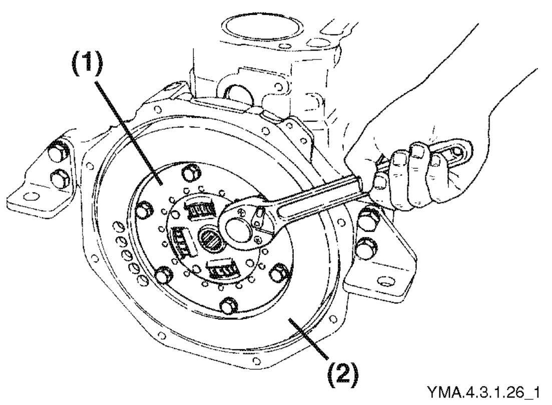


Figure 5-100

1 – Damper Disk
2 – Flywheel

1. Lock the flywheel **(Figure 5-100, (2))** with a flywheel holder and remove the damper disk bolts.
2. Remove the damper disk **(Figure 5-100, (1))** from the flywheel.

Removing the Flywheel and Engine Mounts

CAUTION

Crush Hazard

The flywheel is heavy and may fall unexpectedly when loose from the engine.

WARNING

Exosure Hazard

Always use guide pins and wear gloves when removing or installing the flywheel.

1. Remove the flywheel bolts **(Figure 5-101, (1))** and install guidepins.
2. Remove the flywheel **(Figure 5-101, (2))**.

NOTICE

Avoid damaging the ring gear **(Figure 5-101,** ***4))*** *during removal.*

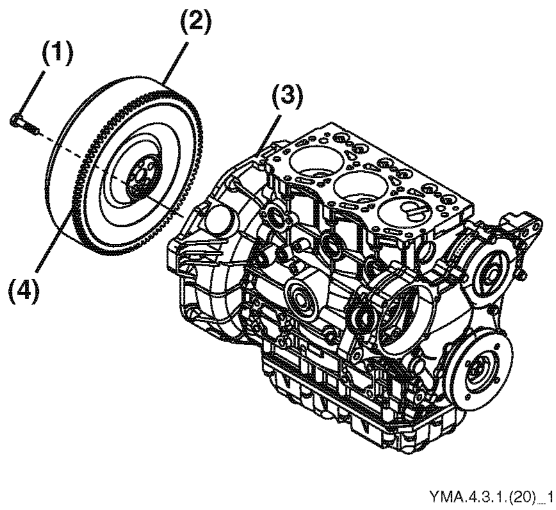


Figure 5-101

1 – Bolt
2 – Flywheel
3 – Flywheel Housing
4 – Ring Gear

3. Place a wood block of appropriate size on the floor, and stand the engine up on the flywheel housing.
4. Remove the engine mounts.

Inspecting the Damper Disk

The damper disk is installed 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 installed to the flywheel housing.

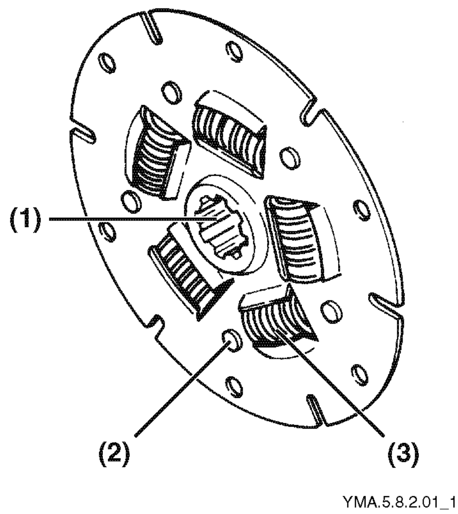


Figure 5-102

1 – **Spline**
2 – **Pin**
3 – **Spring**

Replace the damper disk plate whenever uneven wear or scratches are evident in the spline area **(Figure 5-102, (1))**, on the springs **(Figure 5-102, (3))** or on the spring slots or pins **(Figure 5-102, (2))**.

Inspecting the Flywheel and Ring Gear

The function of the flywheel is to dampen the fluctuating torque loads delivered by the crankshaft and deliver smooth crankshaft rotation. It does so by resisting intermittent rotational force during the power stroke and provides inertial momentum during the non-power strokes. The flywheel is secured to the crankshaft at the end opposite the driveshaft housing with six bolts. It is covered by the flywheel housing, which is bolted to the cylinder block.

The flywheel is balanced by holes drilled in its circumference.

The ring gear is shrink-fit to the circumference of the flywheel. The ring gear serves to start the engine by meshing with the starter motor pinion.

Replace the flywheel or ring gear if excessively worn, corroded or damaged in any manner.

Installing the Flywheel Housing

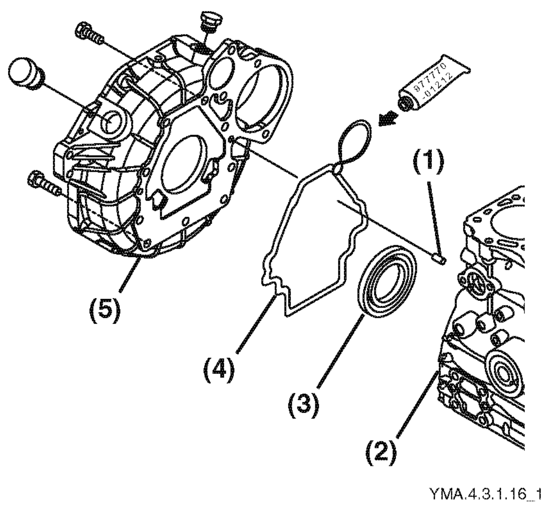


Figure 5-103

1 – **Alignment Pins (qty. 2)**
2 – **Cylinder Block**
3 – **Oil Seal**
4 – **Liquid Gasket**
5 – **Flywheel Housing**

1. Press a new oil seal **(Figure 5-103, (3))** into the flywheel housing **(Figure 5-103, (5))** and coat the lip of the oil seal with engine oil.
2. Apply liquid gasket **(Figure 5-103, (4))** on the mounting surface of the flywheel housing.

NOTICE

Do not allow the liquid gasket to protrude onto the oil pan mounting surface.

3. Align the flywheel housing to the cylinder block alignment pins **(Figure 5-103, (1))** and install.
4. Stand the engine up on the flywheel housing **(Figure 5-104, (2))**.

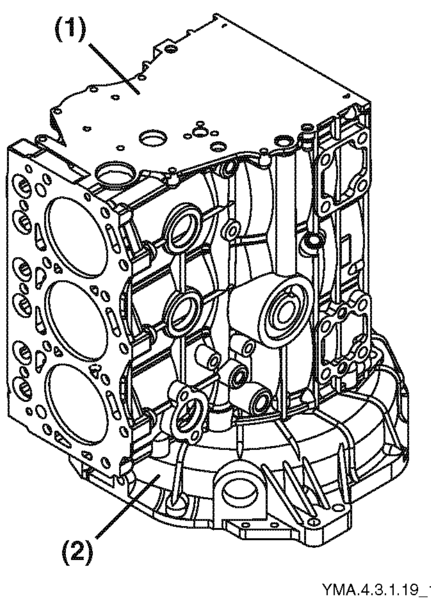


Figure 5-104

1 – Cylinder Block
2 – Flywheel Housing

Installing the Engine Mounts and Flywheel

1. Install the engine mounts.
2. Turn the engine upright (oil pan facing down).
3. Coat the flywheel bolt threads with engine oil.
4. Align the flywheel on the guide pins and install the flywheel.

⚠ CAUTION

Crush Hazard

***The flywheel is heavy and may fall unexpectedly when loose from the engine*.**

⚠ WARNING

Exposure Hazard

Always use guide pins and wear gloves when removing or installing the flywheel.

5. Tighten the flywheel bolts to the specified torque.

Flywheel Bolt Torque
80.4 to 86.4 N•m (59.2 to 63.7 lb-ft)

Installing the Damper Disk

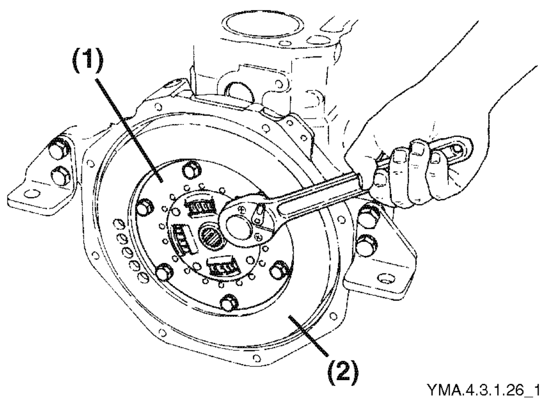


Figure 5-105

1 – Damper Disk
2 – Flywheel

Install the damper disk **(Figure 5-105, (1))** to the flywheel **(Figure 5-105, (2))** and tighten all damper disk bolts.

COOLING SYSTEM

see Cooling System on page 7-1 for additional cooling system and cooling system component specifications and service procedures.

Draining the Coolant

1. Open the seawater drain cock **(Figure 5-106, (2))** and drain the seawater.
2. Open the coolant drain cock **(Figure 5-106, (3))** on the cylinder body and drain the coolant from the cylinder head and cylinder body.
3. Remove the coolant drain plug **(Figure 5-106, (4))** on the lower part of the heat exchanger assembly and drain the coolant.
4. Open the coolant drain cock on the lower part of the coolant pump **(Figure 5-106, (7))** and drain.

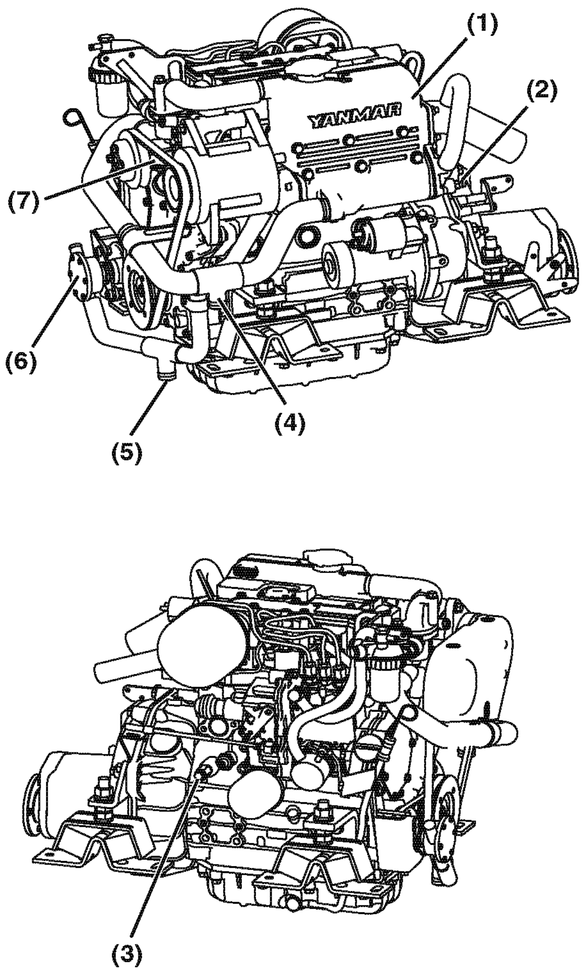


Figure 5-106

1 – Heat Exchanger Assembly
2 – Seawater Drain Cock
3 – Coolant Drain Cock
4 – Coolant Drain Plug
5 – Seawater Drain Plug
6 – Seawater Pump
7 – Coolant Pump

Removing the Heat Exchanger Assembly, Cooling Hoses and Mixing Elbow

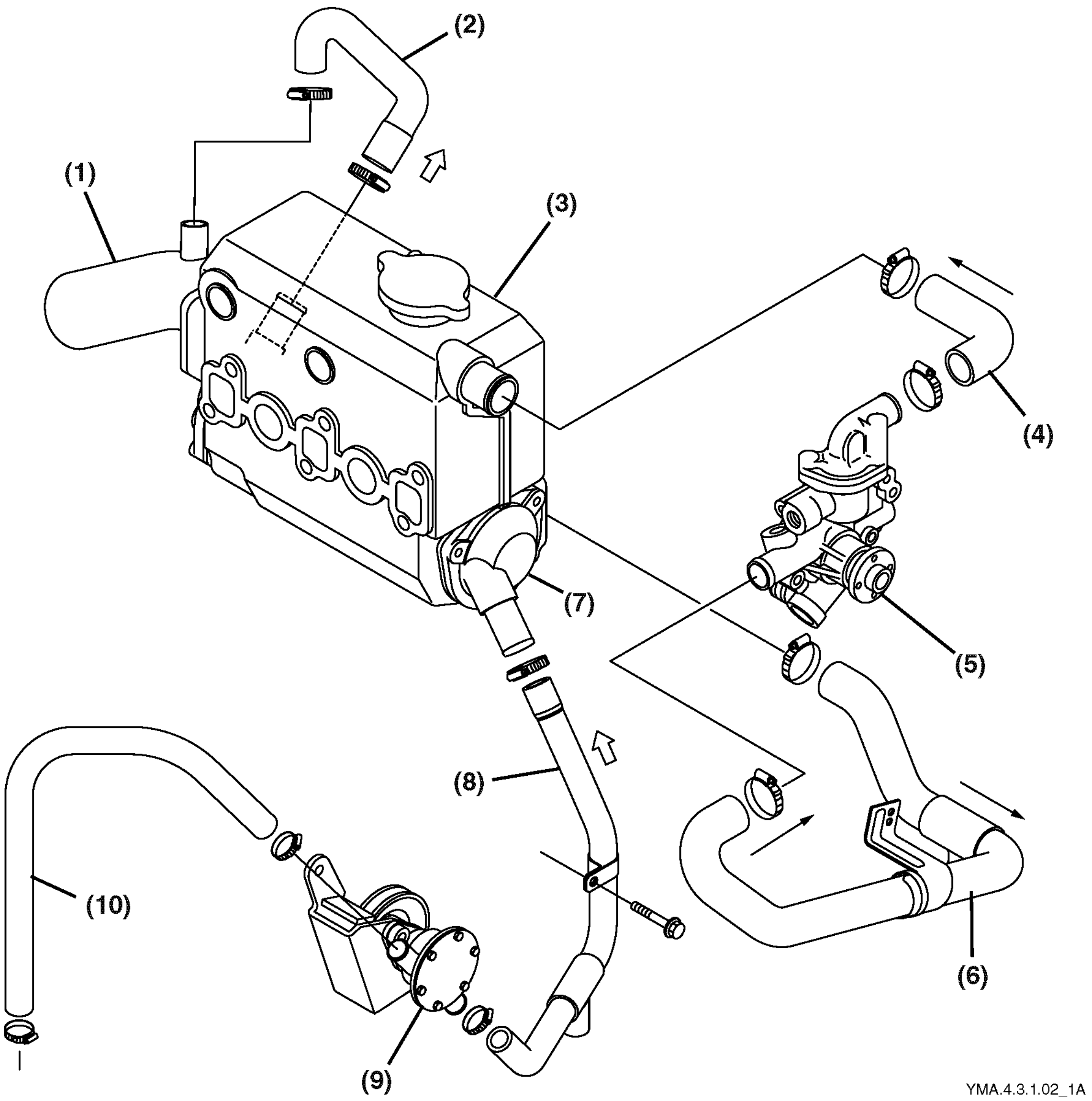


Figure 5-107

1 – Mixing Elbow
2 – Seawater Hose
3 – Heat Exchanger Assembly
4 – Coolant Hose
5 – Coolant Pump
6 – Coolant Hose
7 – Heat Exchanger Unit
8 – Seawater Hose
9 – Seawater Pump
10 – Hose from the Seacock

1. Remove coolant hoses **(Figure 5-107, (4)** and **(6))**.
2. Remove the seawater hose **(Figure 5-108, (2))** or **(Figure 5-109, (3))**, then remove the mixing elbow **(Figure 5-108, (1))** or **(Figure 5-109, (1))**.

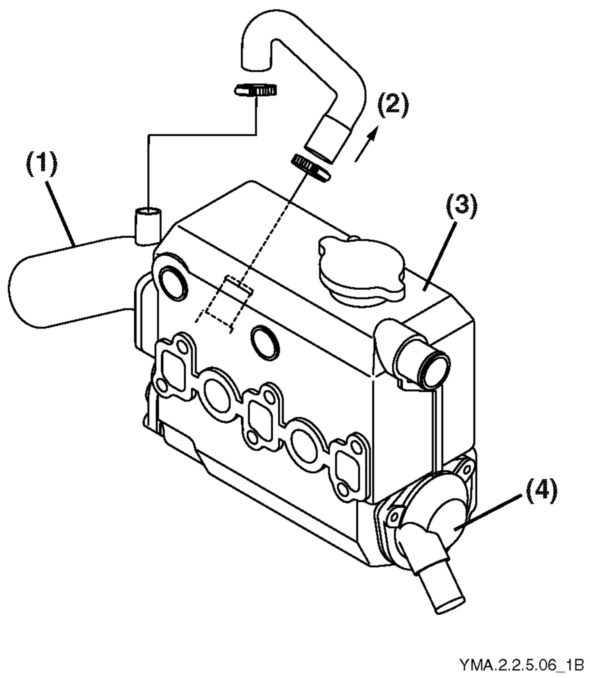


Figure 5-108

1 – L-Type Mixing Elbow (standard)
2 – Seawater Hose
3 – Heat Exchanger Assembly
4 – Heat Exchanger Unit

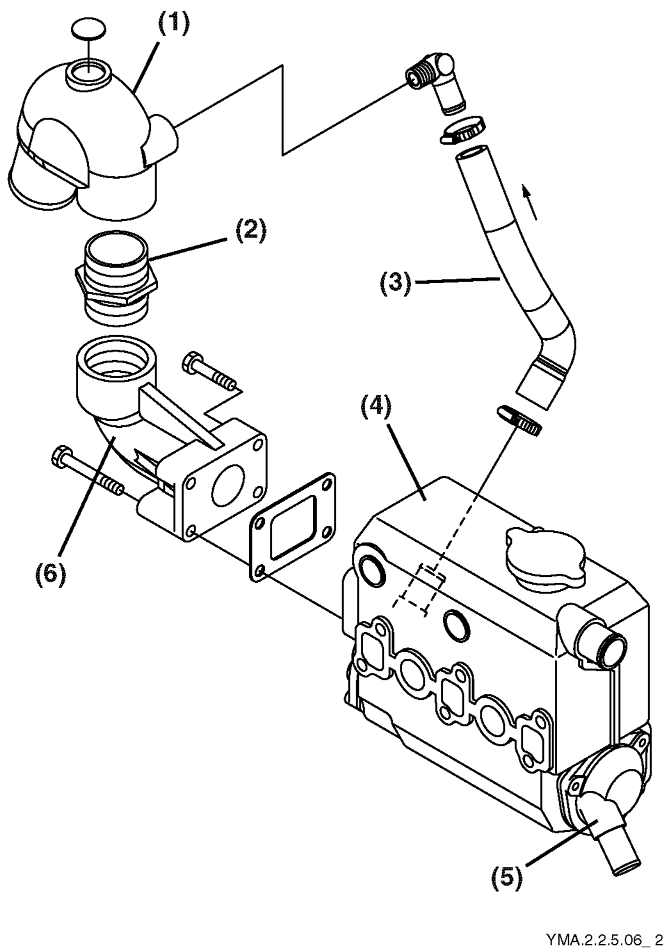


Figure 5-109

1 – U-Type Mixing Elbow (optional)
2 – Joint
3 – Seawater Hose
4 – Heat Exchanger Assembly
5 – Heat Exchanger Unit
6 – Exhaust Elbow

3. Remove the heat exchanger assembly **(Figure 5-108, (3))** or **(Figure 5-109, (4))** from the engine and remove all gaskets.

Removing the Seawater Pump

1. Remove the nut on the spacer bolt **(Figure 5-110, (2))**.
2. Remove the seawater pump **(Figure 5-110, (4))**.
3. Remove the mounting hardware from the gear housing cover **(Figure 5-110, (1))** and keep the brackets **(Figure 5-110, (5))** with the pump.

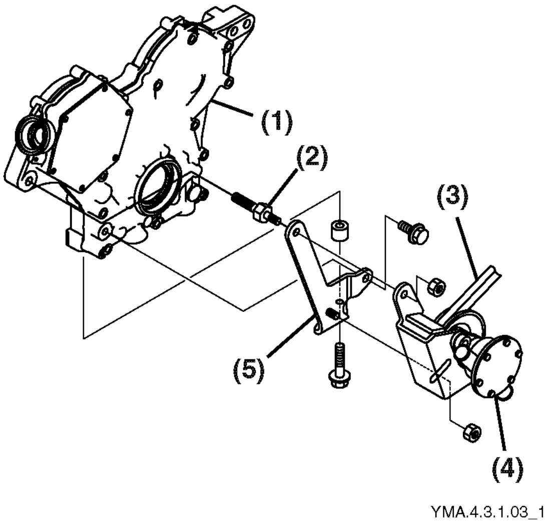


Figure 5-110

1 – Gear Housing Cover
2 – Spacer Bolt
3 – V-Belt
4 – Seawater Pump
5 – Bracket

Removing the Coolant Pump

Remove the coolant pump **(Figure 5-111, (3))**, gasket **(Figure 5-111, (2))** and O-ring **(Figure 5-111, (4))**.

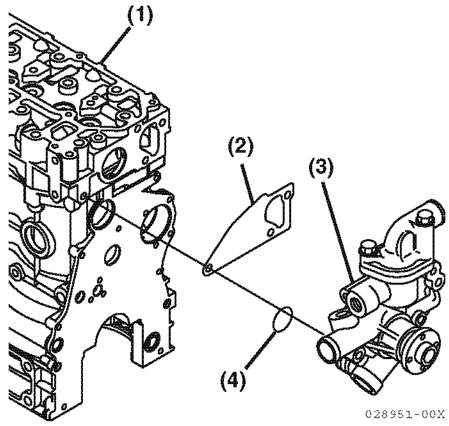


Figure 5-111

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

Inspecting the Heat Exchanger Assembly

Exhaust gases flow from the cylinder head exhaust outlets into the exhaust manifold inside the heat exchanger assembly. The exhaust gases are cooled as they flow through the heat exchanger assembly and to the mixing elbow where seawater is mixed with the exhaust gases. The exhaust gas and seawater mixture is then discharged through the exhaust fitting in the hull of the vessel.

Inspect all the components of the heat exchanger assembly for corrosion and damage.

1. Clean all dirt and scale from the exhaust and coolant passages.
2. Inspect the following for leaks and damage. Repair or replace any component as needed:
   - All hoses and clamps
   - Seawater pump
   - Coolant pump
   - Heat exchanger assembly
   - Mixing elbow
   - All joints, seals and gaskets

Installing the Coolant Pump

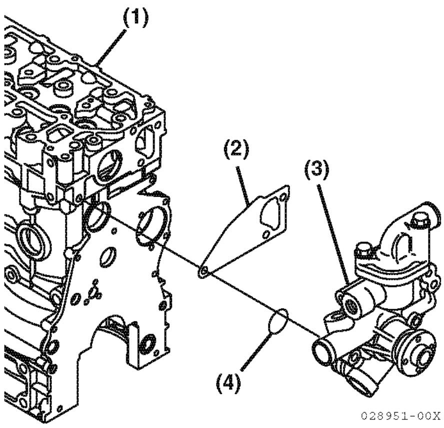


Figure 5-112

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

1. Coat both sides of a new gasket **(Figure 5-112, (2))** with adhesive.
2. Install a new O-ring **(Figure 5-112, (4))** and tighten the coolant pump **(Figure 5-112, (3))** to the specified torque.

Coolant Pump Bolt Torque
9.3 to 11.3 N•m (9.3 to 8.3 lb-ft)

Installing the Seawater Pump

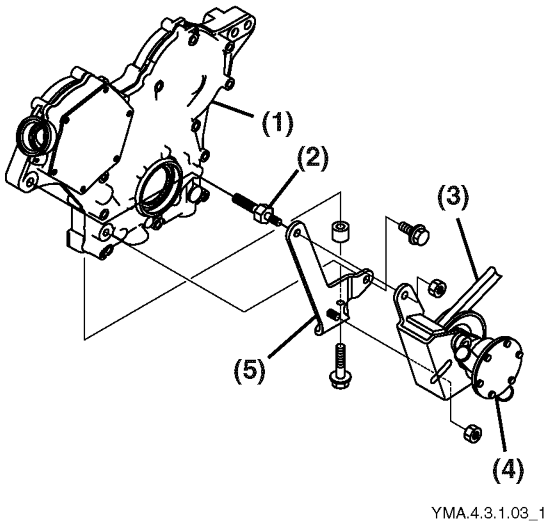


Figure 5-113

1 – Gear Housing Cover
2 – Spacer Bolt
3 – V-Belt
4 – Seawater Pump
5 – Bracket

1. Tighten the spacer bolt **(Figure 5-113, (2))** to the gear housing cover **(Figure 5-113, (1))**.
2. Install the bracket **(Figure 5-113, (5))** and the seawater pump assembly **(Figure 5-113, (4))** to the gear housing cover.

Installing the Mixing Elbow

Install the mixing elbow **(Figure 5-114, (1))** or **(Figure 5-115, (1))** on the heat exchanger assembly outlet.

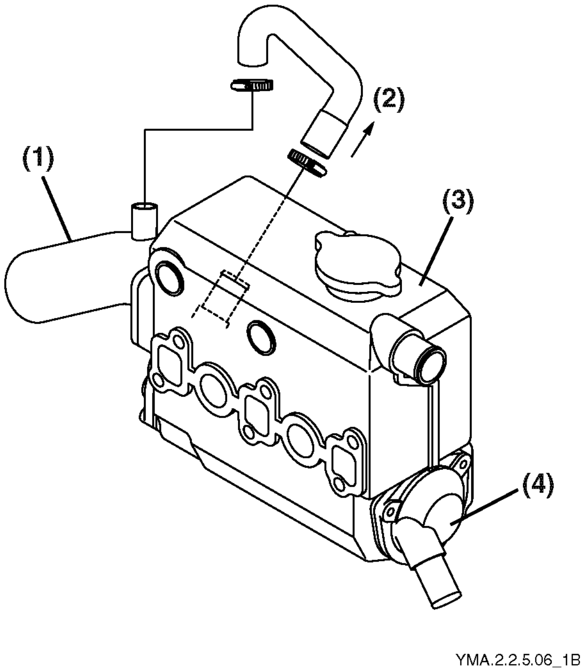


Figure 5-114

1 – **L-Type Mixing Elbow (standard)**
2 – **Seawater Hose**
3 – **Heat Exchanger Assembly**
4 – **Heat Exchanger Unit**

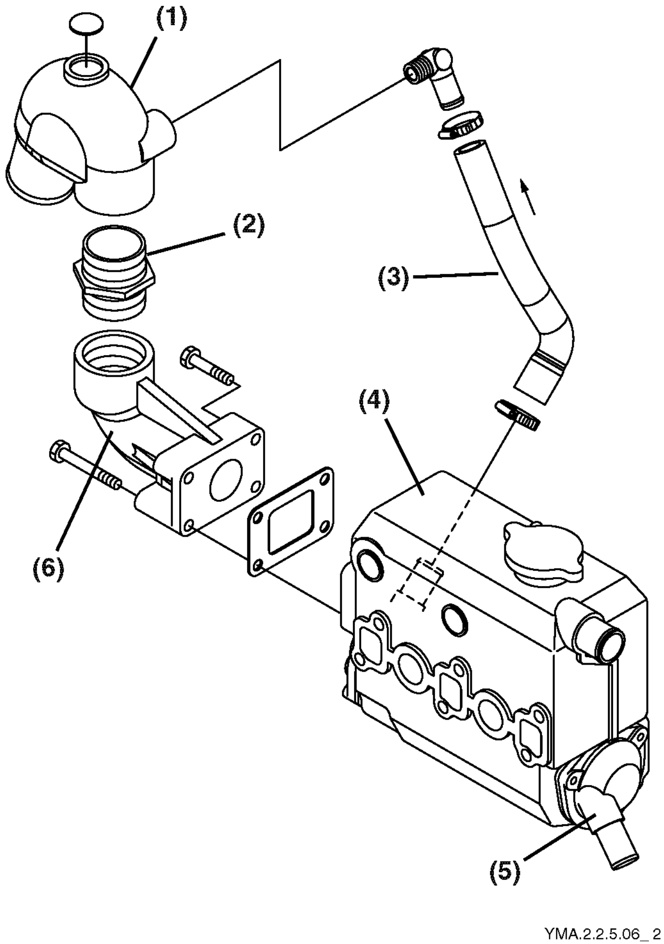


Figure 5-115

1 – **U-Type Mixing Elbow (optional)**
2 – **Joint**
3 – **Seawater Hose**
4 – **Heat Exchanger Assembly**
5 – **Heat Exchanger Unit**
6 – **Exhaust Elbow**

Installing the Heat Exchanger Assembly

Note: Adjust the injection timing and torque the fuel injection pump before installing the heat exchanger assembly. *see Checking the Fuel Injection Timing on page 4-29* and *Removing the Fuel Injection Pump on page 5-87*.

⚠ WARNING

To prevent exhaust leaks, make sure all exhaust system connections are sealed and tightened.

1. Install a new heat exchanger unit gasket, then install the heat exchanger unit onto the heat exchanger assembly (if removed during disassembly).
2. Install new exhaust manifold gaskets onto the cylinder head then install the heat exchanger assembly onto the cylinder head. Tighten all exhaust manifold bolts.

Installing the Cooling System Hoses

1. Install the hose **(Figure 5-116, (8))** between the seawater pump and the heat exchanger unit **(Figure 5-116, (7))** and secure with hose clamps.
2. Install the hose **(Figure 5-116, (10))** between the seawater pump and the seacock inlet and secure with hose clamps (connect hose to seacock after engine is installed in vessel).
3. Install the supply and return hoses **(Figure 5-116, (4) and (6))** between the coolant pump and the heat exchanger assembly and secure with hose clamps.
4. Install the hose **(Figure 5-116, (2))** between the mixing elbow and the heat exchanger assembly and secure with hose clamps.
5. Install all remaining disconnected cooling system hoses after the engine is mounted in the vessel. *see Installing the Engine in the Vessel on page 5-28*.

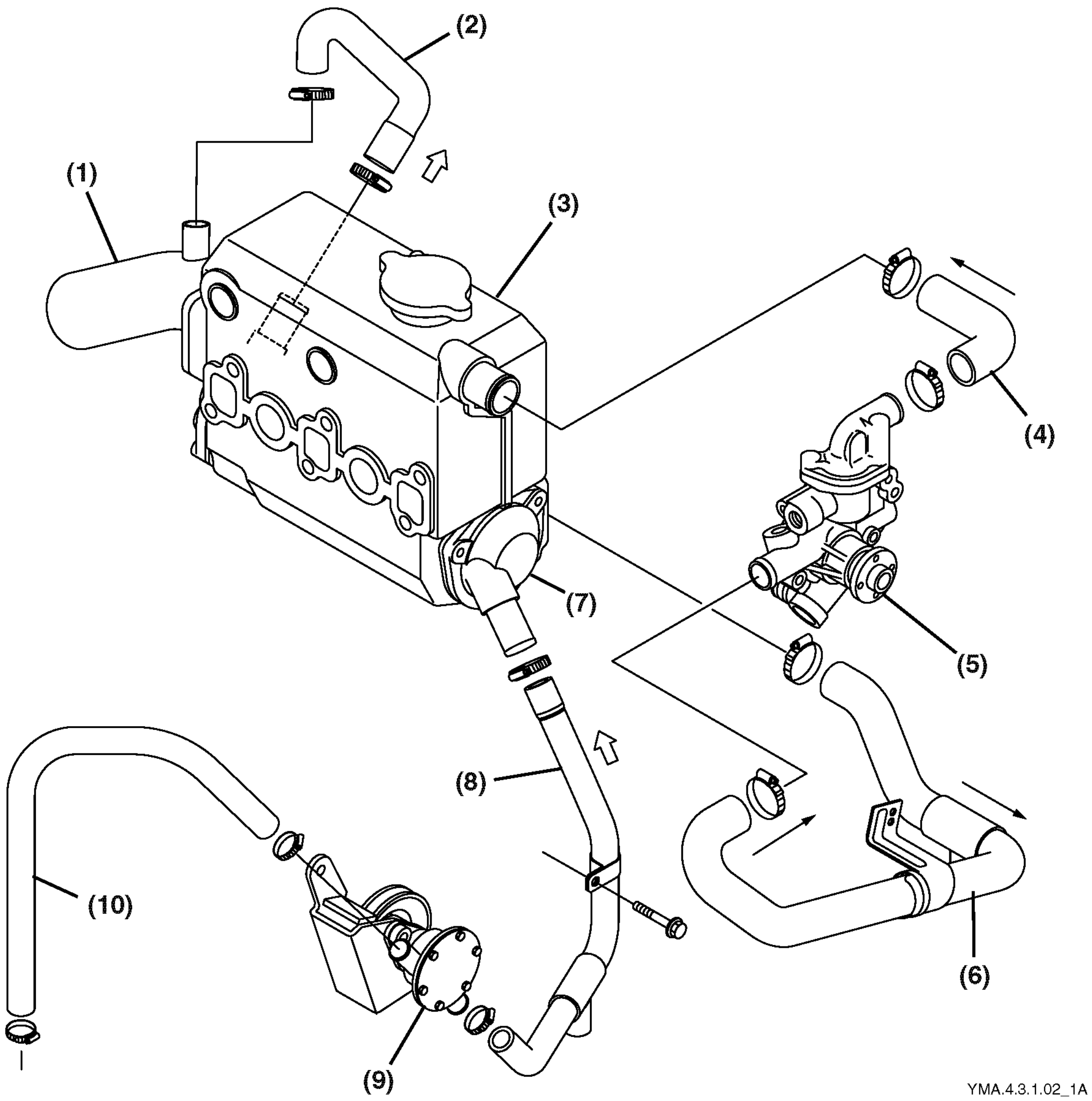


Figure 5-116

1 – Mixing Elbow
2 – Seawater Hose
3 – Heat Exchanger Assembly
4 – Coolant Hose
5 – Coolant Pump
6 – Coolant Hose
7 – Heat Exchanger Unit
8 – Seawater Hose
9 – Seawater Pump
10 – Hose from the Seacock

Filling the Cooling System

1. Open the heat exchanger assembly cap and fill with coolant.

Model	Engine Capacity
3YM30AE(-C) / 3YM30(C)	4.9 L (5.2 qt)
3YM20(C)	4.1 L (4.3 qt)
2YM15(C)	3.0 L (3.2 qt)

2. Fill with coolant until the level in the coolant recovery tank is between the full and low marks.

Coolant Recovery Tank Capacity (full)
0.8 L (0.8 qt)

FUEL SYSTEM

see Fuel System on page 6-1 for additional fuel system and fuel system component specifications and service procedures.

Removing the Fuel Filter and Fuel Lines

⚠ WARNING

Fire Hazard

Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.

Exposure Hazard

Wear eye protection. The fuel system is under pressure and fuel could spray out when you service any fuel system component.

1. Put an approved container under the opening to catch the fuel. Remove the fuel filter to fuel feed pump fuel line **(Figure 5-117, (8))**, fuel filter to fuel injection pump fuel line **(Figure 5-117, (6))** and fuel nozzle to fuel pump engine fuel line.
2. Remove the engine fuel filter **(Figure 5-117, (4))**.

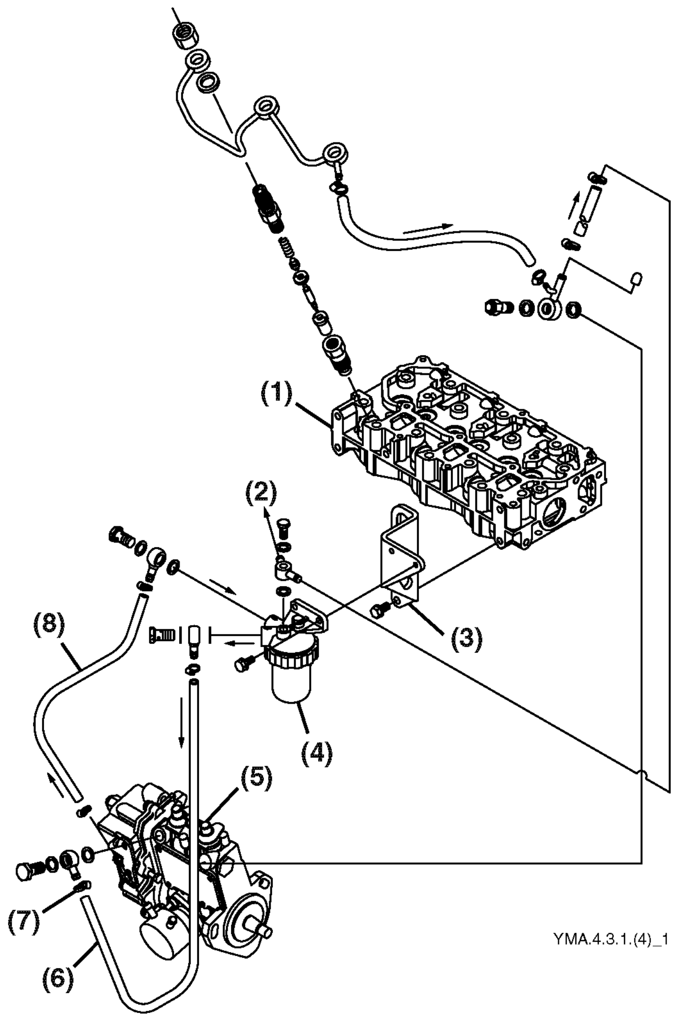


Figure 5-117

1 – Cylinder Head
2 – To Fuel Tank
3 – Bracket
4 – Fuel Filter
5 – Fuel Injection Pump
6 – Fuel Line
7 – Clamp
8 – Fuel Line

Removing the Fuel Injection Lines

1. WARNING! Exposure Hazard. ***Fuel may be under pressure. ALWAYS wear eye protection when servicing fuel system components.***
   Remove the fuel injection line retainer **(Figure 5-118, (1))**.

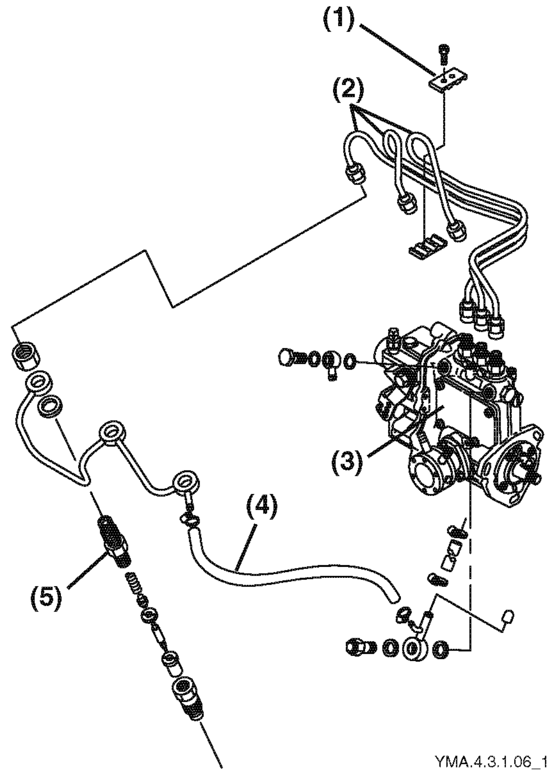


Figure 5-118

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

NOTICE

To prevent rounding of fuel line nuts, use a "line" or "flare nut" wrench. When loosening the cap nut **(Figure 5-119, *(2))***, *hold the return line* **(Figure 5-119, *(3))*** *to prevent it from breaking.*

Remove the cap nuts on both ends of the fuel injection lines.

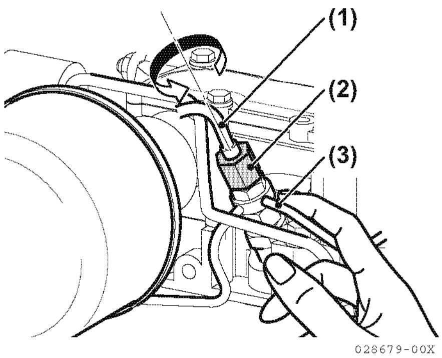


Figure 5-119

1 – Fuel Injection Line
2 – Cap Nut
3 – Fuel Return Line

2. Remove all fuel injection **(Figure 5-118, (2))** and fuel return **(Figure 5-118, (4))** lines.

Removing the Fuel Injection Nozzles

1. Loosen the fuel nozzles **(Figure 5-120, (1))** from the cylinder head **(Figure 5-120, (4))**.
2. Remove the fuel nozzles, nozzle seats **(Figure 5-120, (2))** and nozzle protector **(Figure 5-120, (3))**.

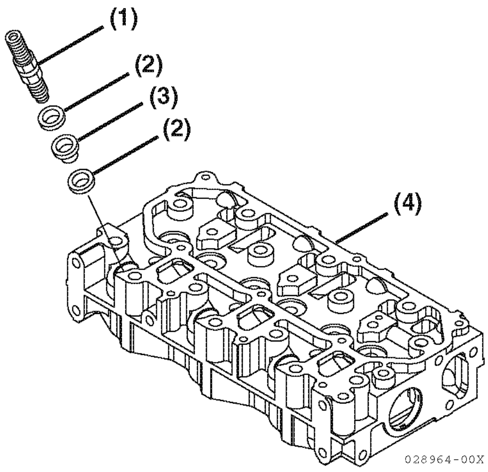


Figure 5-120

1 – Fuel Injection Nozzle
2 – Nozzle Seat
3 – Nozzle Protector
4 – Cylinder Head

Removing the Fuel Injection Pump

1. Remove the drive gear nut **(Figure 5-121, (3))** on fuel pump drive gear and pull out the fuel pump drive gear / flange assembly with an extraction tool.

NOTICE

Do not disassemble the pump drive gear **(Figure 5-121,** ***(4))*** *from the pump flange* **(Figure 5-121,** ***(5))***.

2. Remove the three nuts for the fuel injection pump **(Figure 5-121, (6))**.
3. Remove the pump and O-ring from the gear housing cover **(Figure 5-121, (1))**.

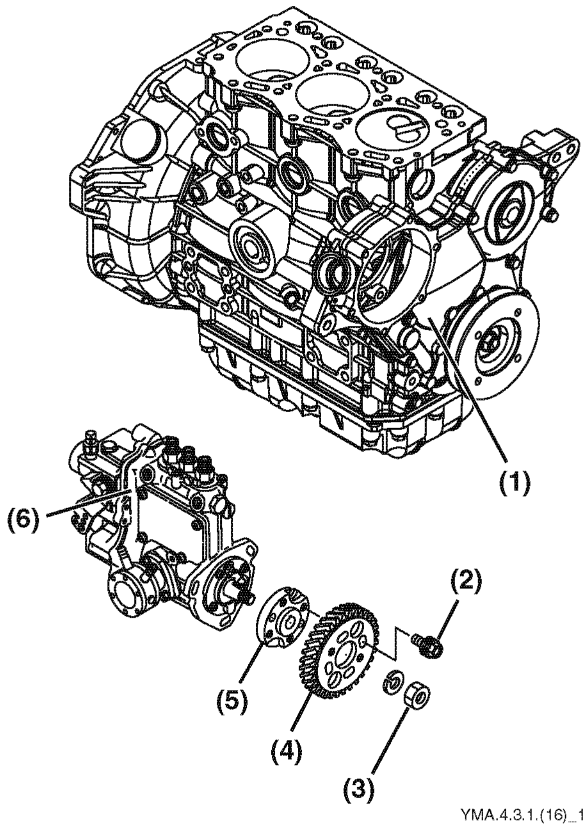


Figure 5-121

1 – Gear Housing Cover
2 – Pump Flange Bolt (do not remove)
3 – Drive Gear Nut
4 – Fuel Pump Drive Gear (do not disassemble)
5 – Fuel Pump Flange (do not disassemble)
6 – Fuel Injection Pump

Installing the Fuel Injection Pump

1. Loosely install the fuel injection pump **(Figure 5-121, (6))** on the gear housing.
2. Adjust the injection timing. *see Checking the Fuel Injection Timing on page 4-29.*
3. Tighten the fuel injection pump bolts.

NOTICE

Do not damage the O-ring between the fuel injection pump and the gear housing.

4. Install the fuel injection pump drive gear **(Figure 5-121, (4))** to the fuel pump camshaft.

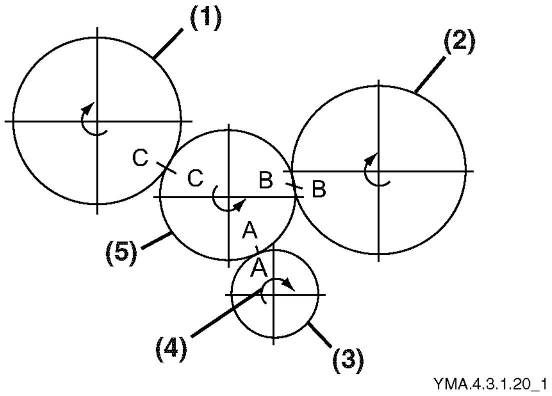


Figure 5-122

1 – Fuel Injection Pump Drive Gear
2 – Camshaft Gear
3 – Crankshaft Gear
4 – Direction of Rotation
5 – Idler Gear

5. Align the **C** mark on the fuel injection pump drive gear to the **C** mark on the idler gear **(Figure 5-122, (5))**.
6. Make sure the drive gear nut is dry and tighten to the specified torque.

Pump Drive Gear Nut Torque
58.9 to 68.7 N•m (43.4 to 50.6 lb-ft)

7. Measure the backlash of the fuel injection pump and drive gear. *see Inspecting the Timing Gears and Measuring Backlash on page 5-52.*

Fuel Injection Pump Drive Gear Backlash
0.06 to 0.12 mm (0.0023 to 0.0047 in.)

Installing the Fuel Injection Nozzles

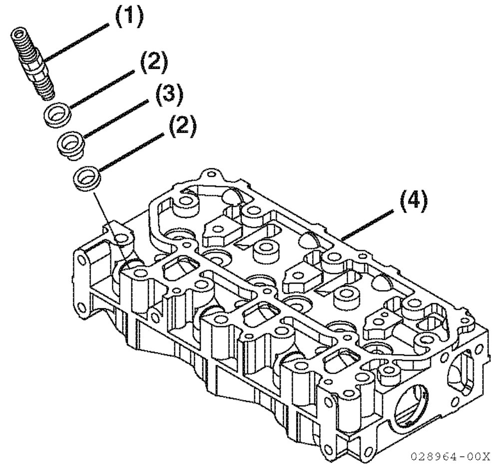


Figure 5-123

1 – Fuel Injection Nozzle
2 – Nozzle Seat
3 – Nozzle Protector
4 – Cylinder Head

1. Replace the fuel nozzle protectors **(Figure 5-123, (3))** and fuel nozzle seats **(Figure 5-123, (2))**.
2. Place the nozzle seat in the cylinder head **(Figure 5-123, (4))**, and the protector on the nozzle tip.
3. Install the fuel injection nozzles **(Figure 5-123, (1))** into the cylinder head.
4. Make sure the bolt is dry and tighten the fuel nozzle retainer bolt to the specified torque.

Fuel Nozzle Retainer Bolt Torque
49.0 to 53.0 N•m (30.1 to 39-0 lb-ft)

Installing the Fuel Injection Lines

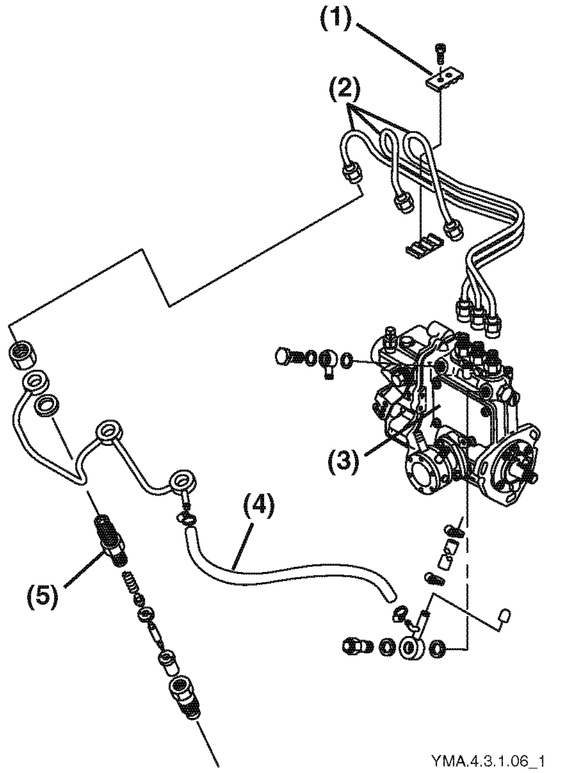


Figure 5-124

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

1. Install and lightly tighten the fuel injection lines **(Figure 5-124, (2))** onto the fuel injection pump **(Figure 5-124, (3))** and then install the fuel injection line retainer **(Figure 5-124, (1))**.
2. Install the fuel injection pump fuel return line **(Figure 5-124, (4))** to the fuel injection nozzles **(Figure 5-124, (5))**.

NOTICE

When tightening the fuel return line to fuel injection nozzles, tighten the nut while holding the return line by hand in order to prevent the line from being damaged.

3. Lightly tighten the fuel injection line joint nuts onto the nozzle. Torque to specified value after adjusting the injection timing. *see Checking the Fuel Injection Timing on page 4-29.*

Fuel Injection Pipe Joint Nut Torque
29.4 to 34.4 N•m (21.6 to 25.3 lb-ft)

Installing the Fuel Filter and Lines

1. Install the fuel filter bracket **(Figure 5-125, (2))** to the cylinder head **(Figure 5-125, (1))**,
2. Install the fuel filter **(Figure 5-125, (3))** to the fuel filter bracket.
3. Install the supply **(Figure 5-125, (7))** and outlet **(Figure 5-125, (5))** fuel lines to the fuel injection pump **(Figure 5-125, (4))**.

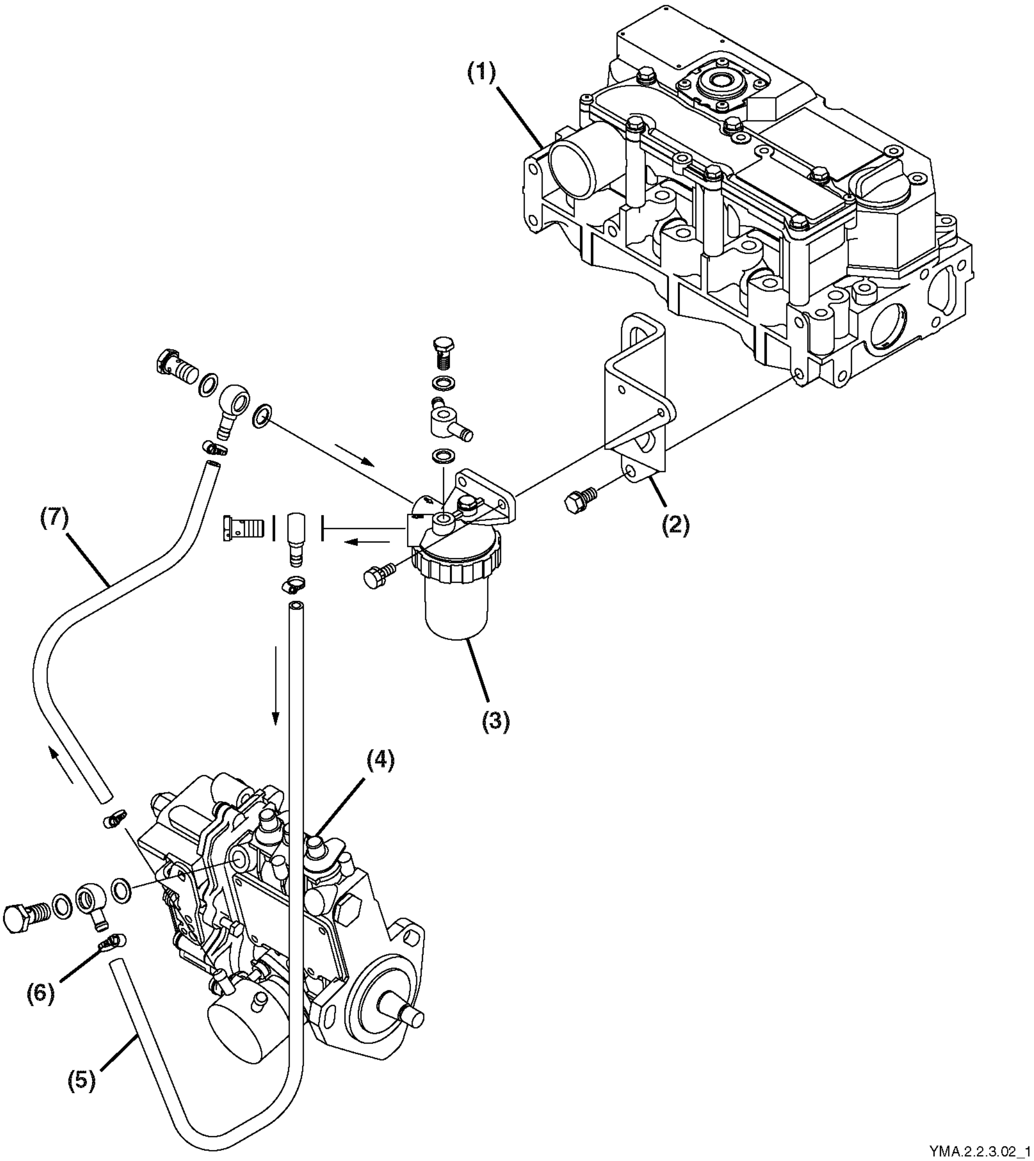


Figure 5-125

1 – Cylinder Head
2 – Fuel Filter Bracket
3 – Fuel Filter
4 – Fuel Injection Pump
5 – Fuel Outlet Line from Fuel Filter
6 – Clamp
7 – Fuel Supply Line to Fuel Filter

BREATHER SYSTEM

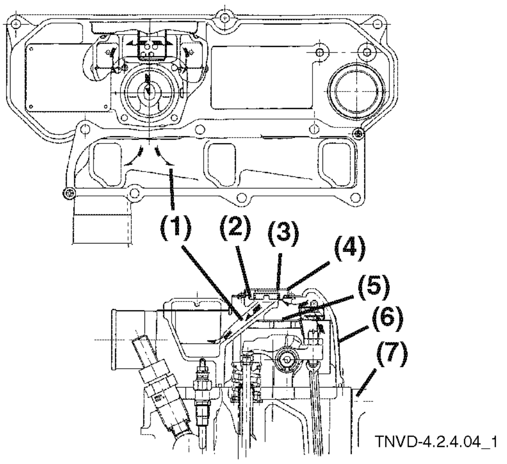


Figure 5-126

1 – Blow-by Gas
2 – Diaphragm
3 – Spring
4 – Diaphragm Cover
5 – Baffle Plate
6 – Rocker Arm Cover
7 – Cylinder Head

Some combustion gases pass through the clearances between the cylinder walls and piston rings and flow into the crankcase. This is called “blow-by gas” **(Figure 5-126, (1))**. Emitting blow-by gas is harmful to the natural environment. Therefore, a blow-by gas reducer is incorporated in the breather system.

When blow-by gas arrives in the cylinder head **(Figure 5-126, (7))** and rocker arm cover **(Figure 5-126, (6))** it mixes with splash oil and becomes an oil-mist. It then moves through the baffle plate **(Figure 5-126, (5))** inside the rocker arm cover and passes through a diaphragm assembly **(Figure 5-126, (2))** to the air intake filter. The blow-by gas is then consumed in the combustion chamber.

Pressure inside the crankcase is controlled by the diaphragm assembly, and a substantial amount of blow-by gas is delivered back to the intake air system.

If the diaphragm is inoperative, crankcase pressure drops and engine damage may occur. When the internal pressure of the crankcase decreases too much, excessive blow-by gas is directed into the intake air system.

This may cause a reduction in engine performance by contaminating the intake valves, causing excessive oil consumption and / or reduced engine compression.

If pressure increases in the crankcase, it may cause leakage of oil seals and / or seeping at the gasket of the oil pan.

A damaged diaphragm causes blow-by to be exhausted through a breather hole on the side of the diaphragm cover **(Figure 5-126, (4))**, and not into in the intake manifold.

Inspecting the Breather Diaphragm

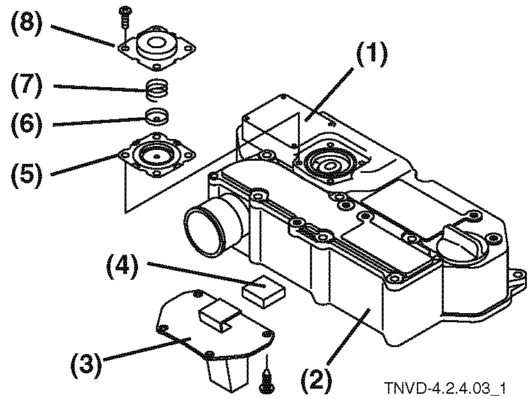


Figure 5-127

1 – Rocker Arm Cover
2 – Intake Manifold
3 – Baffle Plate
4 – Breather Baffle
5 – Diaphragm
6 – Center Plate
7 – Spring
8 – Diaphragm Cover

1. Remove the rocker arm cover **(Figure 5-127, (1))**.
2. Check to make sure the small hole in the diaphragm cover **(Figure 5-127, (8))** is not plugged with oil or other debris.

NOTICE

Do not disassemble the diaphragm **(Figure 5-127, *(5))***.

3. Inspect the diaphragm carefully and correct any suspected problems.

NOTICE

Do not overfill the oil pan. An excessive amount of engine oil will cause the oil to be directed into the combustion chamber, which can lead to oil hammering of the piston. Fill the oil to the upper mark on the engine oil dipstick.

AIR SILENCER

Removing the Air Silencer

1. Remove the air intake hose **(Figure 5-128, (1))** attached to the intake manifold.
2. Remove the air silencer **(Figure 5-128, (3))** from the cylinder head **(Figure 5-128, (2))**.

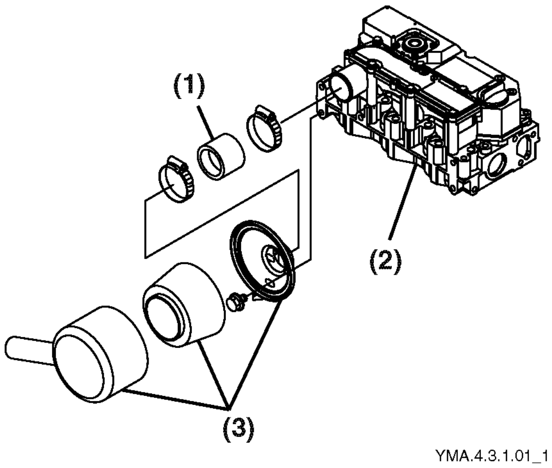


Figure 5-128

1 – Intake Hose
2 – Cylinder Head
3 – Air Silencer

Inspecting Intake System Components

Air enters the air silencer **(Figure 5-128, (3))**, which is mounted on the end of the intake manifold (rocker arm cover). The air flows to the intake manifold and proceeds to each cylinder.

When the inside surface of the intake manifold becomes dirty, air resistance is increased and reduces engine power.

Periodically check the inside of the intake manifold and air silencer for dirt and clean as required.

Ensure that there are no leaks in the induction system connections.

NOTICE

Do not operate the engine with the air silencer removed.

Installing the Air Silencer

1. Install the air intake hose **(Figure 5-128, (1))** to the intake manifold.
2. Install the air silencer **(Figure 5-128, (3))** on the air intake hose.

ALTERNATOR

see Alternator on page 10-1 for additional alternator specifications and service procedures.

Note: 3YM30 installation shown. Other models are similar.

Removing the Alternator

1. Loosen the belt adjuster setscrew **(Figure 5-129, (2))** and push the alternator **(Figure 5-129, (1))** downward.
2. Loosen the V-pulley bolts for the coolant pump.
3. Remove the V-belt **(Figure 5-129, (3))**.
4. Remove the belt adjuster **(Figure 5-129, (4))** from the gear housing.
5. Remove the alternator and bracket **(Figure 5-129, (5))** from the cylinder head.

3YM30

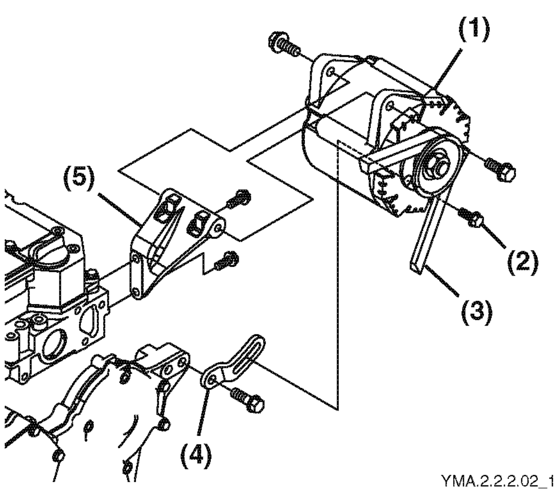


Figure 5-129

1 – Alternator
2 – Setscrew
3 – V-Belt
4 – Belt Adjuster
5 – Bracket

Note: 3YM30 installation shown. Other models are similar.

Installing the Alternator

1. Install the bracket **(Figure 5-129, (5))** on the cylinder head and the belt adjuster **(Figure 5-129, (4))** on the gear housing cover.
2. Install the alternator **(Figure 5-129, (1))**.
3. Adjust V-belt **(Figure 5-129, (3))** tension with the adjuster and tighten the setscrew **(Figure 5-129, (2))**.

STARTER MOTOR

see Starter on page 9-1 for additional starter motor specifications and service procedures.

Removing the Starter Motor

Remove the starter motor **(Figure 5-130, (1))** from the flywheel housing **(Figure 5-130, (2))**.

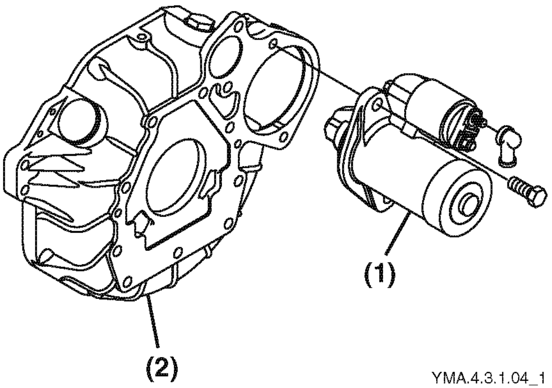


Figure 5-130

1 – Starter Motor
2 – Flywheel Housing

Installing the Starter Motor

Install the starter motor **(Figure 5-130, (1))** on the flywheel housing **(Figure 5-130, (2))**.

MARINE GEAR

See the model-specific marine gear *Service Manual* for additional details on the removal and installation of the marine gear.

Removing the Marine Gear

1. Drain the oil from the marine gear. See the appropriate marine gear manual.
2. Disconnect the marine gear control cables and any related wiring.
3. Remove the bolts from the marine gear housing case flange and remove the marine gear assembly from the engine flywheel housing.

Installing the Marine Gear

1. Install the marine gear to the engine flywheel housing while aligning the input shaft into the damper disk splines. Tighten all marine gear to engine bolts.
2. Fill the marine gear with oil. See the appropriate marine gear manual.
3. Connect the marine gear control cables and any related wiring.

Section 6

FUEL SYSTEM

Page

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SAFETY PRECAUTIONS

Before servicing the fuel system, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, could result in death or serious injury.

Fire/Explosion Hazard

Diesel fuel is flammable and explosive under certain conditions. Never put diesel fuel or other flammable material near the engine during engine operation or shortly after shutdown.

Never use a shop rage to catch the fuel.

Always put an approved fuel container under the opening whenever removing any fuel system component (such as changing the fuel filter). Dispose of waste properly.

Wipe up all spills immediately.

High Pressure Hazard

Avoid skin contact with high-pressure diesel fuel spray cause by a fuel leak such as a broken fuel injection line. High-pressure fuel can penetrate the skin and result in serious injury. If 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.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the fuel injector pump and fuel components used on the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

FUEL INJECTION PUMP

Refer to the YPES-ML *Service Manual* for fuel injection pump disassembly, assembly and adjustment procedures.

Fuel System Diagram

3-Cylinder Engine

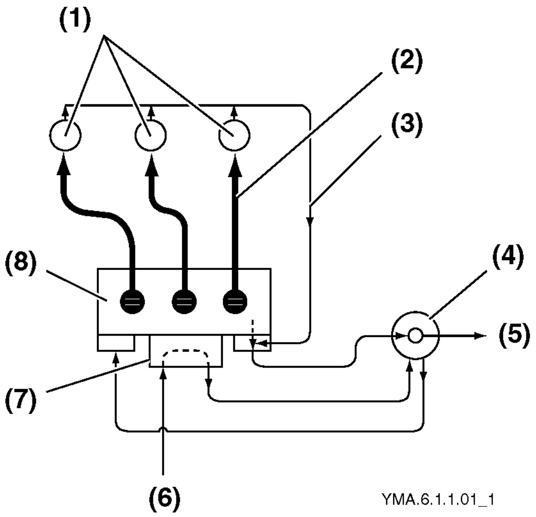

Figure 6-1

1 – Fuel Nozzle
2 – Fuel Injection Line
3 – Fuel Return Line
4 – Fuel Filter
5 – To Fuel Tank
6 – From Fuel Tank
7 – Feed Pump
8 – Fuel Injection Pump

3YM30 Fuel Injection Pump / Governor Views

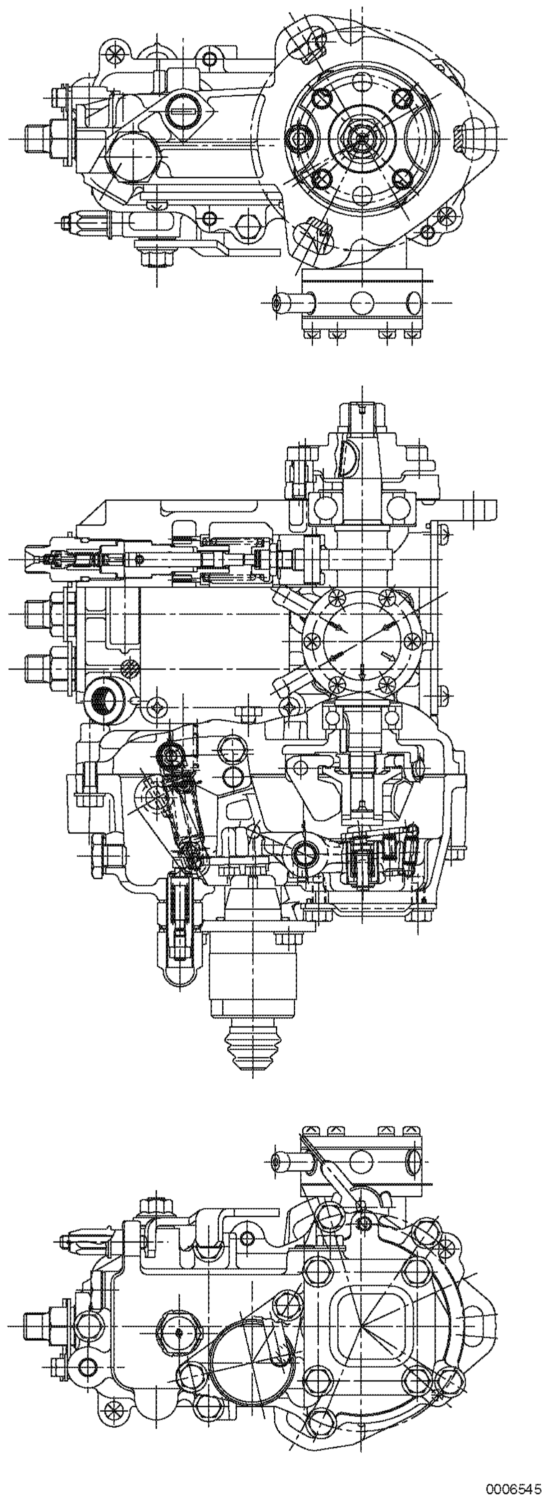

Figure 6-2

Fuel Injection Pump Service and Adjustment Data (3YM30AE)

Part Code (Back Number)			728995-51300 (4Z01)	
Adjustment Specification			Engine Specification	Service Standard
Item	Fuel Valve (valve pressure)		12.3 MPa	17.0 ± 0.3 MPa
	Nozzle Type (ID mark)		NP-DN0PDN158	DN-12SD12
	Fuel Injection Pipe		2 x 320 mm (0.0787 x 12.6 in.)	2 x 600 mm (0.0787 x 23.6 in.)
Injection Adjustment	Starting	Pump Speed N_D	200 min^{-1} (rpm)	200 min^{-1} (rpm)
		Average Injection Volume Q_D	38 ± 5 mm^3/st	39 ± 5 mm^3/st
	Rated Load	Pump Speed N_A	1600 min^{-1} (rpm)	1600 min^{-1} (rpm)
		Injection Volume Q_A	26.5 ± 0.2 mm^3/st	28.2 ± 0.5 mm^3/st
		Variation	± 3%	± 3%
	Torque Rise	Pump Speed N_C	750 min^{-1} (rpm)	750 min^{-1} (rpm)
		Injection Volume Q_C	27.1 ± 0.2 mm^3/st	26.1 ± 0.5 mm^3/st
		Variation	± 5%	± 5%
	High-Idle	Pump Speed N_B	1730 min^{-1} (rpm)	1730 min^{-1} (rpm)
		Injection Volume Q_B	13.3 mm^3/st	4.4 ± 0.5 mm^3/st
	Idle	Pump Speed N_E	400 min^{-1} (rpm)	400 min^{-1} (rpm)
		Injection Volume Q_E	10.0 mm^3/st	3.8 ± 0.5 mm^3/st
Plunger Stroke			7.0 mm (0.2755 in.)	
Plunger Diameter			6 mm (0.2362 in.)	
Retraction Volume of Delivery Valve			23.5 mm (0.9251 in.)	
Pre-stroke			2.5 mm (0.0984 in.)	
Top Clearance			1.0 mm (0.0393 in.)	
Governor Spring		Spring Constant	4.02 N/cm (0.409 kgf/cm)	
		Free Length	41 mm (1.6141 in.)	

Note: [ ] value in brackets is a reference value.

Fuel Injection Pump Service and Adjustment Data (3YM30)

Part Code (Back Number)			728990-51350 (TMR1)	
Adjustment Specification			Engine Specification	Service Standard
Item	Fuel Valve (valve pressure)		12.3 MPa	17.0 ± 0.3 MPa
	Nozzle Type (ID mark)		KCA/DN-PD(12.3)	DN-12SD12
	Fuel Injection Pipe		2 x 320 mm (0.0787 x 12.6 in.)	2 x 600 mm (0.0787 x 23.6 in.)
Injection Adjustment	Starting	Pump Speed N_D	200 min^{-1} (rpm)	200 min^{-1} (rpm)
		Average Injection Volume Q_D	38 ± 5 mm^3/st	40 ± 5 mm^3/st
	Rated Load	Pump Speed N_A	1800 min^{-1} (rpm)	1800 min^{-1} (rpm)
		Injection Volume Q_A	22.2 ± 0.2 mm^3/st	23.4 ± 0.5 mm^3/st
		Variation	± 3%	± 3%
	Torque Rise	Pump Speed N_C	1300 min^{-1} (rpm)	1300 min^{-1} (rpm)
		Injection Volume Q_C	24.5 ± 0.5 mm^3/st	25.4 ± 0.5 mm^3/st
		Variation	± 5%	± 5%
	High-Idle	Pump Speed N_B	1960 min^{-1} (rpm)	1960 min^{-1} (rpm)
		Injection Volume Q_B	[4] mm^3/st	4.8 ± 0.5 mm^3/st
	Idle	Pump Speed N_E	425 min^{-1} (rpm)	400 min^{-1} (rpm)
		Injection Volume Q_E	[4] mm^3/st	4 ± 0.5 mm^3/st
Plunger Stroke			7.0 mm (0.2755 in.)	
Plunger Diameter			6 mm (0.2362 in.)	
Retraction Volume of Delivery Valve			20.1 mm (0.7913 in.)	
Pre-stroke			2.9 mm (0.1141 in.)	
Top Clearance			1.4 mm (0.0551 in.)	
Governor Spring		Spring Constant	4.23 N/cm (0.431kgf/cm)	
		Free Length	42 mm (1.6535 in.)	

Note: [ ] value in brackets is a reference value.

Fuel Injection Pump Service and Adjustment Data (3YM20)

Part Code (Back Number)			728890-51350 (TMM1)	
Adjustment Specification			Engine Specification	Service Standard
Item	Fuel Valve (valve pressure)		12.3 MPa	17.0 ± 0.3 MPa
	Nozzle Type (ID mark)		KCA/DN-PD(12.3)	DN-12SD12
	Fuel Injection Pipe		2 x 320 mm (0.0787 x 12.6 in.)	2 x 600 mm (0.0787 x 23.7 in.)
Injection Adjustment	Starting	Pump Speed N_D	200 min^{-1} (rpm)	200 min^{-1} (rpm)
		Average Injection Volume Q_D	30 ± 5 mm^3/st	27.7 ± 5 mm^3/st
	Rated Load	Pump Speed N_A	1800 min^{-1} (rpm)	1800 min^{-1} (rpm)
		Injection Volume Q_A	15.9 ± 0.2 mm^3/st	15.0 ± 0.5 mm^3/st
		Variation	± 3%	± 3%
	Torque Rise	Pump Speed N_C	1300 min^{-1} (rpm)	1200 min^{-1} (rpm)
		Injection Volume Q_C	17.7 ± 0.2 mm^3/st	18.4 ± 0.5 mm^3/st
		Variation	± 5%	± 5%
	High-Idle	Pump Speed N_B	1945 min^{-1} (rpm)	1945 min^{-1} (rpm)
		Injection Volume Q_B	[6] mm^3/st	2.4 ± 0.5 mm^3/st
	Idle	Pump Speed N_E	425 min^{-1} (rpm)	425 min^{-1} (rpm)
		Injection Volume Q_E	[5] mm^3/st	3.5 ± 0.5 mm^3/st
Plunger Stroke			7.0 mm (0.2755 in.)	
Plunger Diameter			6 mm (0.2362 in.)	
Retraction Volume of Delivery Valve			23.5 mm (0.9251 in.)	
Pre-stroke			2.5 mm (0.0984 in.)	
Top Clearance			1.0 mm (0.3936 in.)	
Governor Spring		Spring Constant	5.54 (0.565)	
		Free Length	42 mm (1.6535 in.)	

Note: [ ] value in brackets is a reference value.

Fuel Injection Pump Service and Adjustment Data (2YM15)

<table>
<tr><td colspan="3">Part Code (Back Number)</td><td colspan="2">728790-51350 (TMG1)</td></tr>
<tr><td colspan="3">Adjustment Specification</td><td>Engine Specification</td><td>Service Standard</td></tr>
<tr><td rowspan="3">Item</td><td colspan="2">Fuel Valve (valve pressure)</td><td>12.3 MPa</td><td>17.0 ± 0.3 MPa</td></tr>
<tr><td colspan="2">Nozzle Type (ID mark)</td><td>KCA/DN-PD(12.3)</td><td>DN-12SD12</td></tr>
<tr><td colspan="2">Fuel Injection Pipe</td><td>2 x 300 mm (0.0787 x 11.8 in.)</td><td>2 x 600 mm (0.0787 x 23.7 in.)</td></tr>
<tr><td rowspan="12">Injection Adjustment</td><td rowspan="2">Starting</td><td>Pump Speed N_D</td><td>200 min^{-1} (rpm)</td><td>200 min^{-1} (rpm)</td></tr>
<tr><td>Average Injection Volume Q_D</td><td>30 ± 3.5 mm^3/st</td><td>32.5 ± 5 mm^3/st</td></tr>
<tr><td rowspan="3">Rated Load</td><td>Pump Speed N_A</td><td>1800 min^{-1} (rpm)</td><td>1800 min^{-1} (rpm)</td></tr>
<tr><td>Injection Volume Q_A</td><td>16.6 ± 0.2 mm^3/st</td><td>15.5 ± 0.5 mm^3/st</td></tr>
<tr><td>Variation</td><td>± 3%</td><td>± 3%</td></tr>
<tr><td rowspan="3">Torque Rise</td><td>Pump Speed N_C</td><td>1300 min^{-1} (rpm)</td><td>1200 min^{-1} (rpm)</td></tr>
<tr><td>Injection Volume Q_C</td><td>18.7 ± 0.2 mm^3/st</td><td>18.6 ± 0.5 mm^3/st</td></tr>
<tr><td>Variation</td><td>± 5%</td><td>± 5%</td></tr>
<tr><td rowspan="2">High-Idle</td><td>Pump Speed N_B</td><td>1925 min^{-1} (rpm)</td><td>1925 min^{-1} (rpm)</td></tr>
<tr><td>Injection Volume Q_B</td><td>[5] mm^3/st</td><td>4.9 ± 0.5 mm^3/st</td></tr>
<tr><td rowspan="2">Idle</td><td>Pump Speed N_E</td><td>425 min^{-1} (rpm)</td><td>425 min^{-1} (rpm)</td></tr>
<tr><td>Injection Volume Q_E</td><td>[5] mm^3/st</td><td>4.5 ± 0.5 mm^3/st</td></tr>
<tr><td colspan="3">Plunger Stroke</td><td colspan="2">7.0 mm (0.2755 in.)</td></tr>
<tr><td colspan="3">Plunger Diameter</td><td colspan="2">6 mm (0.2362 in.)</td></tr>
<tr><td colspan="3">Retraction Volume of Delivery Valve</td><td colspan="2">23.5 mm (0.9251 in.)</td></tr>
<tr><td colspan="3">Pre-stroke</td><td colspan="2">2.5 mm (0.9842 in.</td></tr>
<tr><td colspan="3">Top Clearance</td><td colspan="2">1.0 mm (0.3936 in.)</td></tr>
<tr><td colspan="2" rowspan="2">Governor Spring</td><td>Spring Constant</td><td colspan="2">5.54 N/cm (0.565 kgf/cm)</td></tr>
<tr><td>Free Length</td><td colspan="2">42 mm (1.6535 in.)</td></tr>
</table>

Note: [ ] value in brackets is a reference value.

Fuel Adjustment Procedures

1. Loosen the jam nut **(Figure 6-3, (1))** of the fuel limiter, and turn the adjusting screw **(Figure 6-3, (2))** clockwise until it bottoms out.
2. Tighten the jam nut.

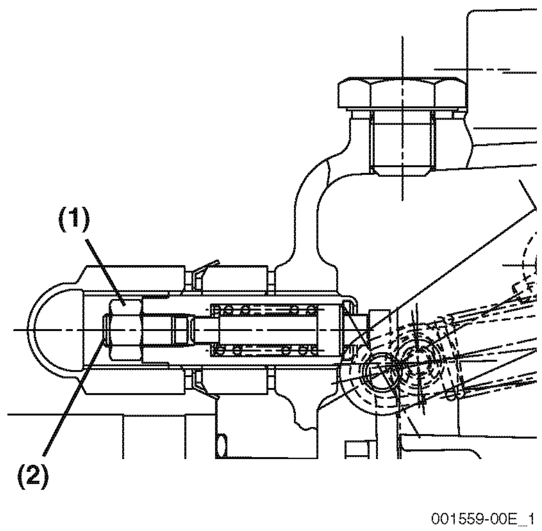

Figure 6-3

1 – Jam Nut
2 – Adjusting Screw

3. Adjust the rack position to Ro (15 mm [0.5905 in.]) **(Figure 6-6, (Ro))** with the fuel limiter, and measure the injection volume **(Figure 6-6, (A))** at the rated speed.
4. If the measured injection volume is out of the standard, readjust the injection volume by turning the adjusting screw.
5. Pull the control lever **(Figure 6-4, (3))** to high idle stop **(Figure 6-4, (2))** at full rack position.
6. Adjust the position of the high idle set bolt **(Figure 6-4, (1))** at high idle speed to achieve the specified injection volume **(Figure 6-6, (B))**.

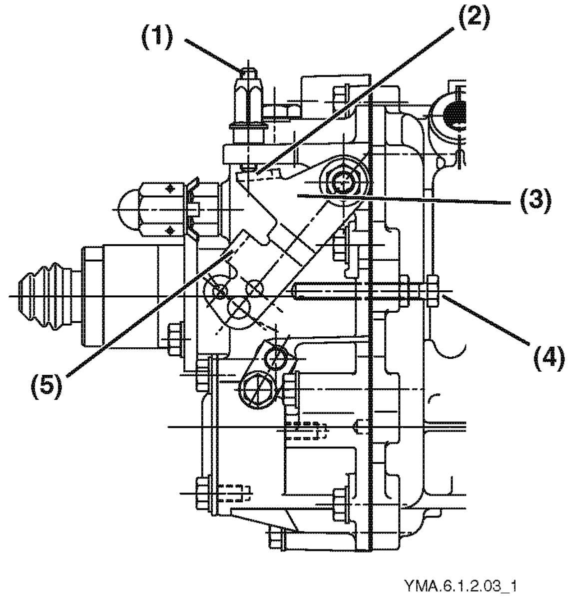

Figure 6-4

1 – High Idle Set Bolt
2 – High Idle Stop
3 – Control Lever
4 – Low Idle Set Bolt
5 – Low Idle Stop

7. Loosen the jam nut **(Figure 6-5, (1))** at the volume adjustment screw **(Figure 6-5, (2))**.
8. Turn the volume adjustment screw to the torque-rise speed to achieve the specified injection volume **(Figure 6-6, (C))**.

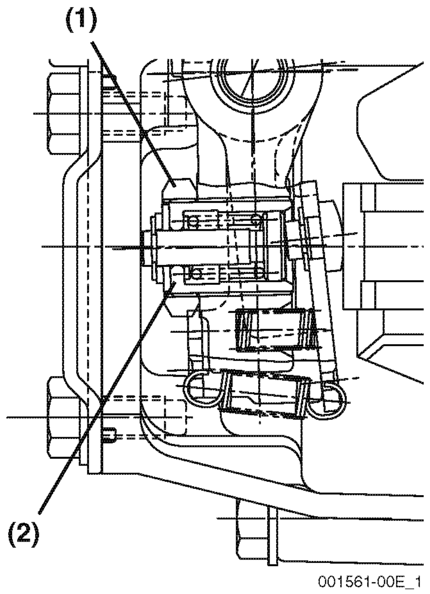

Figure 6-5

1 – Jam Nut
2 – Volume Adjustment Screw

9. Tighten the jam nut **(Figure 6-5, (1))**.
10. Confirm the injection volume **(Figure 6-6, (D))** at starting at the specified speed.
11. Push the control lever to low idle stop **(Figure 6-4, (5))**.
12. Adjust the position of the low idle set bolt **(Figure 6-4, (4))** at low idle speed to achieve the specified injection volume **(Figure 6-6, (E))**.

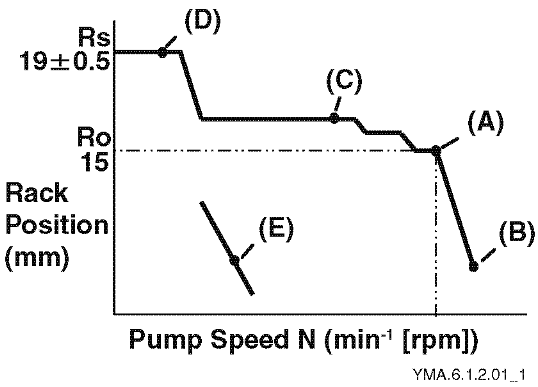

Figure 6-6

Removing the Fuel Injection Pump

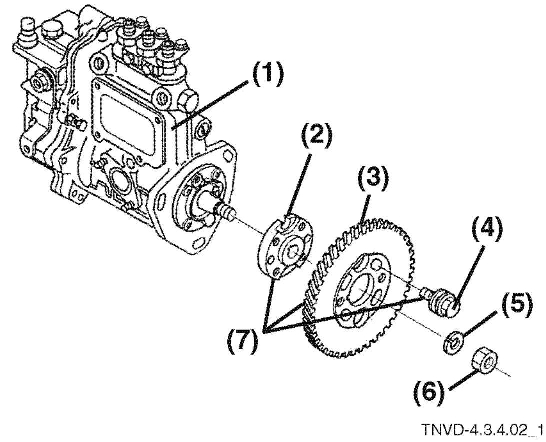

Figure 6-7

1 – Fuel Injection Pump
2 – Flange
3 – Fuel Injection Pump Drive Gear
4 – Flange Bolt
5 – Spring Washer
6 – Pump Drive Gear Nut
7 – Do Not Disassemble

1. Remove the fuel injection lines, fuel lines and the remote control cable. Cover the ends of the fittings and lines to prevent dirt from entering the components.
2. Mark the position of the timing marks on the fuel pump and gear housing.
3. Remove the pump cover from the gear housing.
4. Paint index marks on the fuel injection pump drive gear and the idler gear.
5. Loosen the three fuel injection pump installation nuts.
6. Loosen the fuel injection pump drive gear nut **(Figure 6-7, (6))**.
7. Pull the fuel injection pump drive gear and flange with a gear puller.

NOTICE

Remove the flange **(Figure 6-7, *(2))*** *and fuel injection pump drive gear* **(Figure 6-7, *(3))*** *as an assembly. Do not loosen the flange bolts* **(Figure 6-7, *(4))*.**

8. Remove the pump drive gear nut and washer **(Figure 6-7, (5))**.
9. Remove the fuel injection pump. Leave the pump drive gear mounted in the gear housing.

Installing the Fuel Injection Pump

1. Use a new O-ring on the fuel pump flange **(Figure 6-7, (2))**. Apply grease to the O-ring.
2. Turn the camshaft so that the key of the pump camshaft aligns with the groove of the pump drive gear.
3. Install the fuel injection pump **(Figure 6-7, (1))** into the gear housing. Avoid damaging the O-ring.
4. Confirm that the key of the camshaft aligns with the groove of the drive gear.
5. Assemble the pump drive gear nut **(Figure 6-7, (6))** and washer **(Figure 6-7, (5))** temporarily.
6. Turn the fuel injection pump **(Figure 6-7, (1))** until its marks align with the gear housing marks.
7. Tighten the injection pump installation nuts.
8. Tighten the pump drive gear nut to the specified standard torque (dry).

Pump Drive Gear Nut Torque
58.8 to 68.8 N•m (43.3 to 50.7 lb-in)

9. Check the fuel injection timing. Refer to *Checking the Fuel Injection Timing on page 4-29*.

Troubleshooting the Fuel Injection Pump

A complete repair requires not only the replacement of defective parts, but also the isolation and correction of the cause of the trouble. The cause of the trouble may not necessarily always be in the pump; it may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the problem may be lost. Before removing the pump, go through the following basic points.

Basic Checkpoints:

- Check for leaks throughout the fuel system, from the fuel tank to the nozzle.
- Check the injection timing for all cylinders.
    - Are they correctly adjusted?
    - Are they too fast or too slow?
- Check the nozzle spray pattern.
- Check the fuel delivery system. Loosen the fuel line connection at the injection pump inlet, and test for fuel flow from the fuel feed pump.

Major Faults and Troubleshooting

Fault		Cause	Remedy	Reference
Engine won't start.	Fuel not delivered to injection pump.	No fuel in the fuel tank.	Re-supply	*3-7*
		Fuel tank cock is closed.	Open	*3-7*
		Fuel line system is clogged.	Clean	*4-11*
		Fuel filter element is clogged.	Disassemble and clean, or replace element.	*4-16*
		Air is sucked into the fuel due to defective connections in the lines from the fuel tank to the fuel pump.	Repair	*6-18*
		Defective valve contact of feed pump.	Repair or replace	*6-16*
		Piston spring of feed pump is broken.	Replace	*6-16*
		Inter-spindle or tappets of feed pump are stuck.	Repair or replace	*6-16*
	Fuel delivered to injection pump.	Defective connection of control lever and control cable at the injection pump.	Repair or adjust	*6-4*
		Plunger is worn out or stuck.	Repair or replace	*6-4*
		Delivery valve is stuck.	Repair or replace	*6-4*
		Control rack doesn't move.	Repair or replace	*6-4*
		Injection pump coupling is damaged, or the key is broken.	Replace	*6-4*
	Nozzle doesn't work.	Nozzle valve doesn't open or close normally.	Repair or replace	*4-30*
		Nozzle seat is defective.	Repair or replace	*4-30*
		Case nut is loose.	Inspect and tighten	*4-30*
		Injection nozzle starting pressure is too low.	Adjust	*4-30*
		Nozzle spring is broken.	Replace	*4-30*
		Fuel oil filter is clogged.	Repair or replace	*6-18*
		Excessive oil leaks from the nozzle sliding area.	Replace the nozzle assembly.	*5-88*
	Injection timing is defective.	Injection timing is retarded due to failure of the coupling.	Adjust	*4-29*
		Camshaft is excessively worn.	Replace camshaft	*5-63*
		Roller guide incorrectly adjusted or excessively worn.	Adjust or replace	–
		Plunger is excessively worn.	Replace plunger assembly.	–
Engine starts, but immediately stops.		Fuel line is clogged.	Clean	*4-11*
		Fuel filter is clogged.	Disassemble and clean, or replace the element.	*4-16*
		Loose fuel line connection or line is broken and air is entering the system.	Replace packing repair line.	*6-4*
		Insufficient fuel delivery from the feed pump.	Repair or replace	*6-16*

Fault		Cause	Remedy	Reference
Engine's output is insufficient.	Defective injection timing and other failures.	Knocking sounds caused by improper (too fast) injection timing.	Inspect and adjust	*4-29*
		Engine overheats or emits large amount of smoke due to improper (to slow) injection timing.	Inspect and adjust	*4-29*
		Insufficient fuel delivery from feed pump.	Repair or replace	*6-16*
	Nozzle movements are defective.	Case nut loose.	Inspect and retighten	*4-30*
		Defective injection nozzle performance.	Repair or replace nozzle	*4-30*
		Nozzle spring is broken.	Replace	*4-30*
		Excessive oil leaks from nozzle.	Replace nozzle assembly	*4-30*
	Injection pump is defective.	Maximum delivery limit screw is screwed in too far.	Adjust	*6-9*
		Plunger is worn.	Replace	–
		Injection amount is not uniform.	Adjust	*5-92*
		Injection timings are not even.	Adjust	*4-29*
		The 1st and 2nd levers of the governor and the control rack or the injection pump are improperly lined up.	Repair	*3-67*
		Delivery stopper is loose.	Inspect and retighten	–
		Delivery packing is defective.	Replace packing	–
		Delivery valve seat is defective.	Repair or replace	–
		Delivery spring is broken.	Replace	–
Idling is rough.		Movement of control rack is defective.		
		Stiff plunger movement or sticking.	Repair or replace	–
		Rack and pinion fitting is defective.	Repair	–
		Movement of governor is improper.	Repair	*6-9*
		Delivery stopper is too tight.	Inspect and adjust	–
		Uneven injection volume.	Adjust	*4-29*
		Injection timing is defective.	Adjust	*4-29*
		Plunger is worn and fuel injection adjustment is difficult.	Replace	–
		Governor spring is too weak.	Replace	*6-9*
		Feed pump can't feed oil at low speeds.	Repair or replace	*6-16*
		Fuel supply is insufficient at low speeds due to clogging of fuel filter.	Disassemble and clean, or replace element.	*4-16*
Engine runs at high speeds, but cuts out at low speeds.		The wire or rod of the accelerator is caught.	Inspect and repair	–
		Control rack is caught and can't be moved.	Inspect and repair	*3-67*
Engine doesn't reach maximum speed.		Governor spring is broken or excessively worn.	Replace	*6-9*
		Injection performance or nozzle is poor.	Repair or replace	*4-29*
Loud knocking.		Injection timing is too fast or too slow.	Adjust	*4-29*
		Injection from nozzle is improper. Fuel drips after each injection.	Adjust	*4-29*
		Injection nozzle starting pressure is too high.	Adjust	*4-29*
		Uneven injection.	Adjust	*4-29*
		Engine overheats, or insufficient compression.	Repair	*5-1*

Fault		Cause	Remedy	Reference
Engine exhausts too much smoke.	When exhaust smoke is black:	Injection timing is too fast.	Adjust	*4-29*
		Air volume intake is insufficient.	Inspect and repair	*4-14*
		The amount of injection is uneven.	Adjust	*4-29*
		Injection from nozzle is improper.	Repair or replace	*4-29*
	When exhaust smoke is white:	Injection timing is too slow.	Adjust	*4-29*
		Water is mixed in fuel.	Inspect fuel system, and clean	*4-11*
		Shortage of engine oil in the engine.	Repair	*4-9*
		Engine is overcooled.	Inspect	*5-1*

FUEL FEED PUMP COMPONENTS AND FUNCTIONS

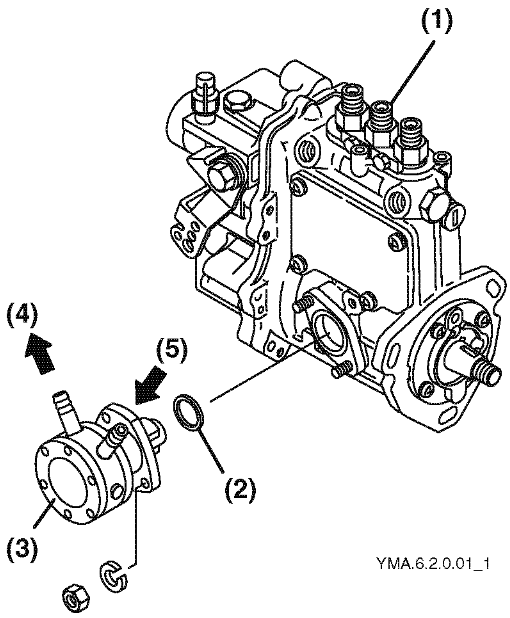

Figure 6-8

1 – Fuel Injection Pump
2 – Packing
3 – Fuel Feed Pump
4 – To Fuel Filter
5 – From Fuel Tank

The fuel feed pump **(Figure 6-8, (3))** feeds fuel from the fuel tank **(Figure 6-8, (5))**, passes it through the fuel filter element and supplies it to the fuel injection pump **(Figure 6-8, (1))**. The fuel feed pump is mounted on the side of the engine and is driven by the (eccentric) cam of the fuel pump camshaft. It is equipped with a manual priming lever so that fuel can be pumped when the engine is stopped.

Fuel Feed Pump Components

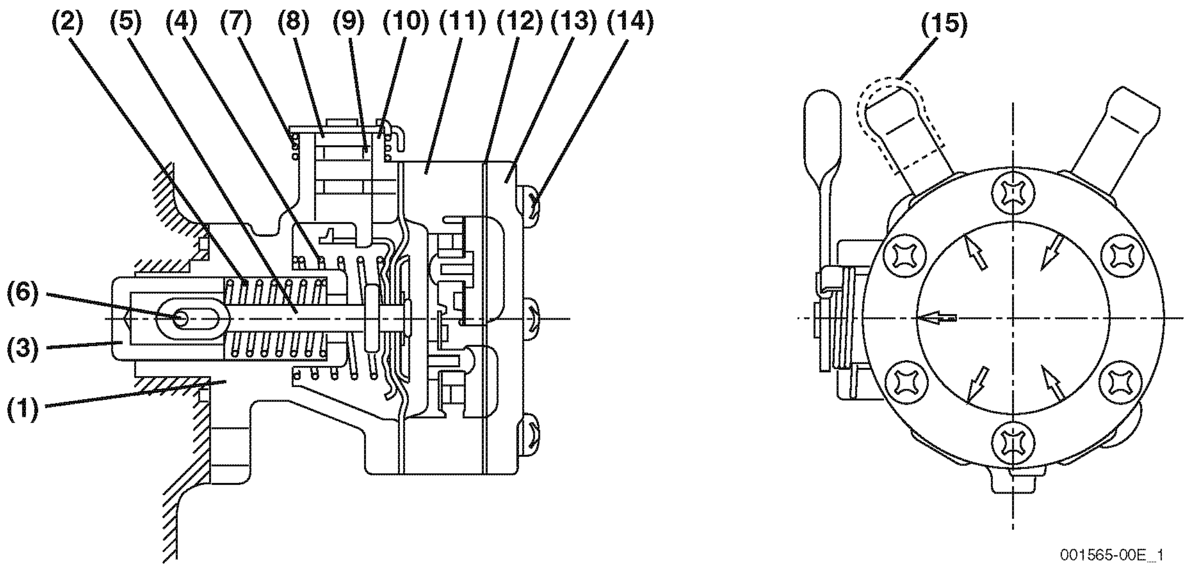

Figure 6-9

1 – Bottom Body
2 – Piston Spring
3 – Piston
4 – Diaphragm Spring
5 – Diaphragm Assembly
6 – Pin
7 – Lever Return Spring
8 – Lever Assembly
9 – O-Ring
10 – Stop Pin
11 – Top Body Assembly
12 – Packing
13 – Cover
14 – Cover Screws
15 – Cap

Fuel Feed Pump Specifications

Head	1 m (39.3699 in.)
Discharge Volume	230 cm^3 / (0.2430 qt) at 1500 min^{-1} (rpm) (cam), discharge pressure of 0.020 MPa (2.9 psi)
Closed Off Pressure	0.029 MPa (4.2060 psi) or more at 400 min^{-1} (rpm) (cam)

Disassembling the Fuel Feed Pump

1. Remove the fuel feed pump mounting nut, and then the fuel feed pump, from the fuel injection pump.
2. Clean the fuel feed pump assembly with clean fuel.
3. Check the orientation of the arrow on the cover **(Figure 6-9, (13))**.
4. Make index marks on the upper body **(Figure 6-9, (11))** and cover.
5. Remove the cover screws **(Figure 6-9, (14))**.
6. Disassemble the cover, upper body and lower body **(Figure 6-9, (1))**.

Inspecting the Fuel Feed Pump

1. Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles.
2. Repair or replace any part that emits air bubbles.

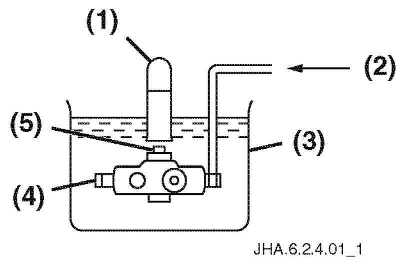

Figure 6-10

1 – Measuring Cylinder
2 – Air Pressure
3 – Container Filled with Light Oil
4 – Blocked
5 – Tappet

3. Attach a vinyl hose to the fuel feed pump intake, keep the pump at the specified depth from the diesel fuel surface, move the priming lever by hand and check for sudden spurts of fuel from the discharge port.
4. If no fuel is evident, inspect the diaphragm and diaphragm spring.
5. Repair / replace as necessary.

Inspecting the Diaphragm

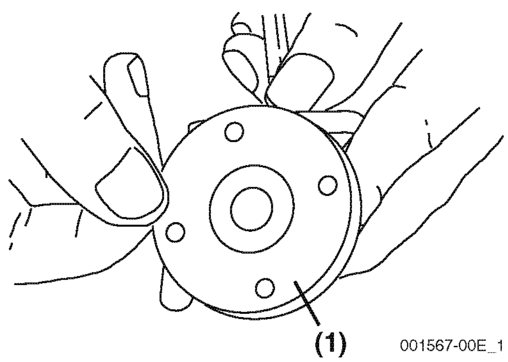

Figure 6-11

1 – Diaphragm

Parts of the diaphragm **(Figure 6-11, (1))** that are repeatedly heated will become thinner or deteriorate over a long period of time. Check the diaphragm and replace if necessary.

Inspecting the Valve

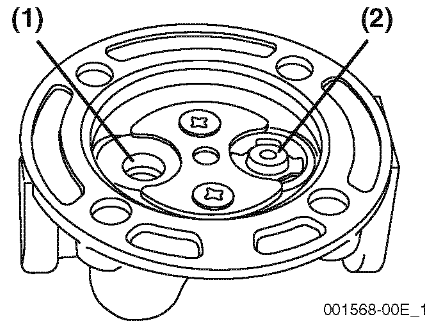

Figure 6-12

1 – Inlet Valve
2 – Outlet Valve

1. Clean the valve seat and valve with compressed air to remove any foreign matter.
2. Inspect the diaphragm spring and piston spring for settling.
3. Inspect the piston for wear.
4. If any component is damaged, replace valve as an assembly.

Assembling the Fuel Feed Pump

1. Clean all parts with diesel fuel and inspect / replace any defective parts.
2. Replace all seals on parts that have been disassembled.
3. Make sure that the intake valve and discharge valve on the upper body are mounted in the proper direction.
4. Replace the valve seal.
5. Install the diaphragm into the body. Make sure the diaphragm mounting holes line up.

NOTICE

Do not force diaphragm into the body.

6. Align the index marks on the upper body of the pump and cover.
7. Tighten the cover screws evenly.

Cover Screw Torque
147 to 245 N•cm (1.3 lb-in.)

FUEL FILTER COMPONENTS AND FUNCTIONS

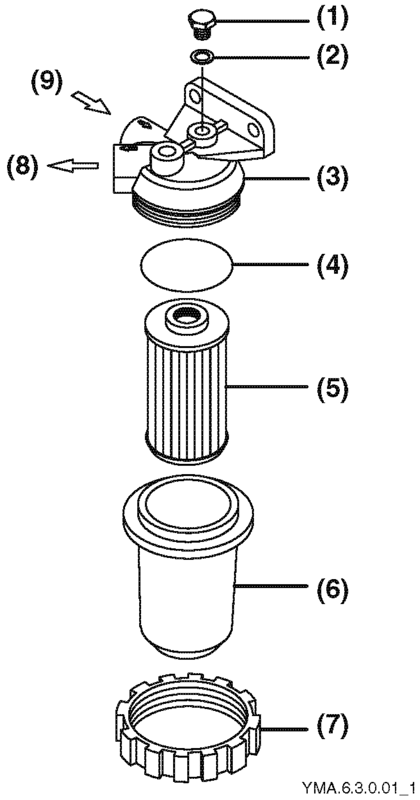

Figure 6-13

1 – Air Bleed Screw
2 – Nylon Gasket
3 – Fuel Filter Body
4 – O-Ring
5 – Element
6 – Filter Cup
7 – Retaining Ring
8 – To Injection Pump
9 – From Feed Pump

The fuel filter is installed between the feed pump and injection pump and removes dirt and impurities from the fuel. The fuel filter incorporates a replaceable filter paper element **(Figure 6-13, (5))**. Fuel from the fuel tank enters the outside of the element and passes through the element under its own pressure.

As it passes through the element, the dirt and impurities in the fuel are filtered out, allowing only clean fuel to enter the interior of the element. The fuel exits from the outlet at the top center of the filter and is sent to the fuel injection pump **(Figure 6-13, (8))**.

Loosen the screw **(Figure 6-13, (1))** installed on the fuel filter body to bleed air from the fuel system.

Fuel Filter Specifications

Filtering Area	333 cm^2 (51.6 cu in.)
Element Material	Cotton Fiber
Filter Mesh	10 to 15 μ

Inspecting the Fuel Filter

- The fuel filter should be inspected according to the periodic maintenance schedule.
- If water and sediment are present in the filter, drain the water and remove all dirt and rust by washing the filter with clean fuel.
- The normal replacement interval for the element is 250 hours, but the element should be replaced whenever it is dirty or damaged.

Section 7

COOLING SYSTEM

Page

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SAFETY PRECAUTIONS

Before servicing the coolant system, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The following safety message has a WARNING level hazard. The safety message describes a hazardous situation which, if not avoided, *could* result in minor or moderate injury.

Coolant Hazard

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

Burn Hazard

Some of the engine surfaces become very hot during operation and shortly after shutdown.

- Keep hands and other body parts away from hot engine surfaces.

Handle hot components with heat resistant gloves.

Never remove the coolant filler cap if the engine is hot. Steam and hot engine coolant will spray out and seriously burn you. Allow the engine to cool down before you attempt to remove the cap.

NOTICE

Indicates a situation which can cause damage to the engine, personal property and / or the environment or cause the equipment to operate improperly.

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 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engine cooling systems.

COOLING SYSTEM

The cooling system is a closed coolant mixture system which is cooled by seawater that is pumped through a heat exchanger **(Figure 7-1, (7))**. The cylinders, cylinder heads and exhaust manifold are cooled with a coolant mixture. The heat exchanger uses pass-through seawater to cool the coolant mixture.

Seawater is pumped in from the sea by the seawater pump **(Figure 7-1, (9))** and goes through the heat exchanger, where it cools the coolant. It then continues on to the mixing elbow **(Figure 7-1, (1))** and is discharged from the vessel with the exhaust gas.

The coolant mixture is circulated by the coolant pump **(Figure 7-1, (5))** through the cylinder jacket to cool the cylinders and the cylinder head. The coolant pump body also serves as a discharge passageway (line) at the cylinder head outlet and is equipped with a thermostat.

The thermostat is closed when the coolant temperature is low immediately after the engine is started, and during low-load operation. The coolant flows through the coolant pump inlet and is circulated inside the engine without passing through the heat exchanger.

When the temperature of the coolant rises, the thermostat opens and the coolant flows through the heat exchanger. It is then cooled by flowing around a series of tubes and baffles. Seawater flows inside the tube and baffle assembly and the heat of the coolant mixture is carried away and discharged through the mixing elbow. The temperature of the coolant mixture is controlled by the thermostat.

Cooling System Components

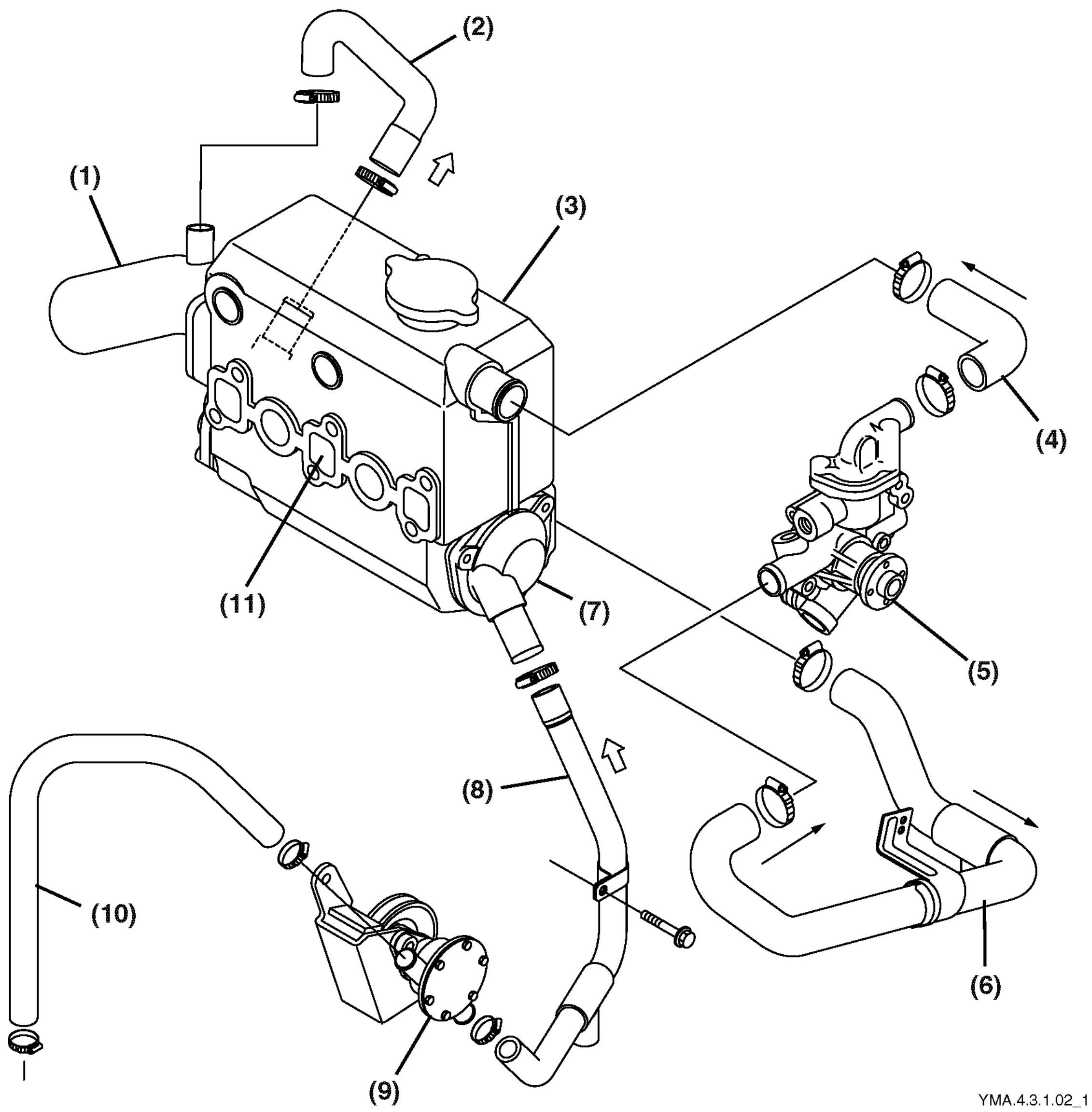


Figure 7-1

1 – Mixing Elbow
2 – Coolant Hose
3 – Coolant Tank
4 – Coolant Hose
5 – Coolant Pump
6 – Coolant Hose
7 – Heat Exchanger
8 – Seawater Hose
9 – Seawater Pump
10 – Hose from the Seacock
11 – Exhaust Manifold

Cooling System Diagram

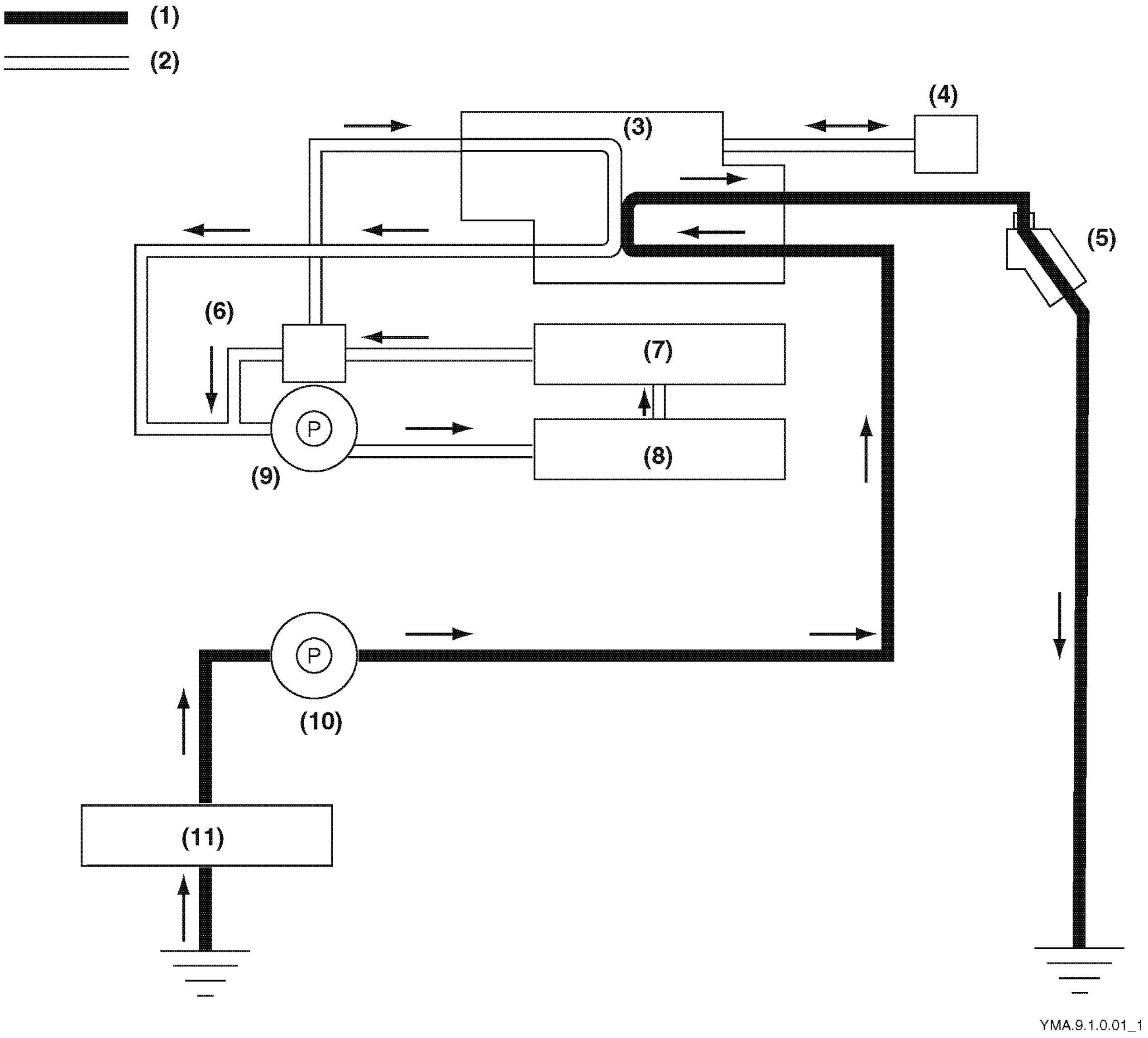


Figure 7-2

1 – Seawater Circuit
2 – Coolant Circuit
3 – Heat Exchanger
4 – Coolant Recovery Tank
5 – Mixing Elbow
6 – Thermostat
7 – Cylinder Head
8 – Cylinder Block
9 – Coolant Pump
10 – Seawater Pump
11 – Seacock

Seawater Pump

The seawater pump **(Figure 7-3, (4))** is driven by a V-belt **(Figure 7-3, (3))**.

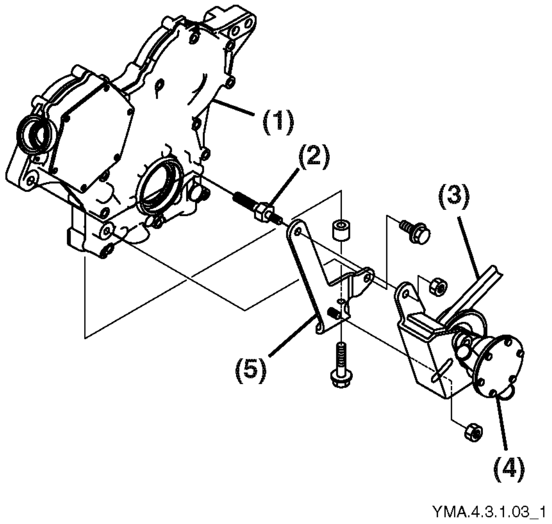


Figure 7-3

1 – Gear Housing Cover
2 – Spacer Bolt
3 – V-Belt
4 – Seawater Pump
5 – Bracket

Seawater Pump Specifications

Seawater Pump Flow
Minimum 1650 L/h (435 gal/hr) at engine speed 3600 min^{-1} (rpm)

Disassembling the Seawater Pump

1. Remove the rubber hose from the seawater pump outlet.
2. Remove the seawater pump assembly from the gear housing cover **(Figure 7-3, (1))**.
3. Remove the seawater pump cover **(Figure 7-4, (3))**.
4. Take the O-ring **(Figure 7-4, (4))** and impeller **(Figure 7-4, (5))** out of the pump.
5. Remove the oil seal **(Figure 7-4, (7))** and the pump shaft **(Figure 7-4, (2))** if necessary.

Inspecting the Seawater Pump

1. Inspect the rubber impeller **(Figure 7-4, (5))**, checking for splitting around the outside edges, and other damage or cracks. *See Checking or Replacing the Seawater Pump Impeller on page 4-24.*
2. Replace components as necessary.
3. Inspect the oil seal **(Figure 7-4, (7))**.
4. Replace if it is damaged or if there was considerable water leakage during operation. When installing the oil seal, coat with grease and insert.

Seawater Pump Leakage
Less than 3 cm^3/h (46 drops/hr)

5. Make sure the ball bearings **(Figure 7-4, (10) and (13))** rotate smoothly.
6. Replace if there is excessive play.

Assembling the Seawater Pump

1. Coat the shaft **(Figure 7-4, (2))** with grease.
2. Assemble the pump shaft, ball bearings **(Figure 7-4, (10),** and **(13))**, retaining ring **(Figure 7-4, (11))**, plate **(Figure 7-4, (9))** and O-ring **(Figure 7-4, (8))**.
3. Install the seal **(Figure 7-4, (7))** into the pump body **(Figure 7-4, (6))**.
4. Install the shaft assembly into the pump body.
5. Install the retaining ring **(Figure 7-4, (14))**.
6. Install the impeller **(Figure 7-4, (5))** on the pump shaft.
7. Install a new O-ring **(Figure 7-4, (4))**, cover **(Figure 7-4, (3))** and pulley **(Figure 7-4, (1))**.

Note: Always replace the O-ring if the cover is removed.

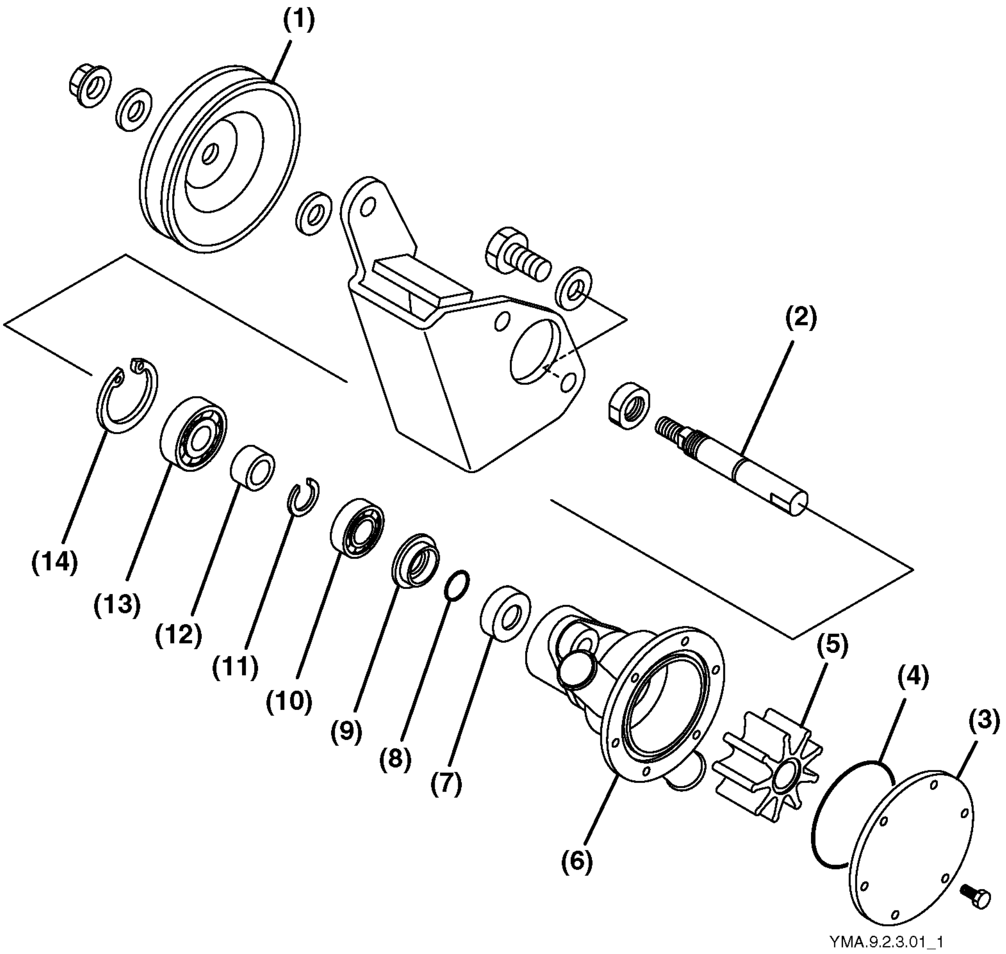


Figure 7-4

1 – V-Pulley
2 – Shaft
3 – Cover
4 – O-Ring
5 – Impeller
6 – Pump Body
7 – Oil Seal
8 – O-Ring
9 – Plate
10 – Ball Bearing
11 – Retaining Ring
12 – Spacer
13 – Ball Bearing
14 – Retaining Ring

Coolant Pump

Coolant Pump Components

The coolant pump is the centrifugal (volute) type, and circulates coolant from the coolant tank through the cylinder block and the cylinder head.

The coolant pump consists of the pump body, an impeller, a pump shaft, a bearing unit and a mechanical seal. The V-pulley on the end of the pump shaft is driven by a V-belt.

The bearing unit installed on the pump shaft uses sealed, grease-lubricated ball bearings and cannot be disassembled.

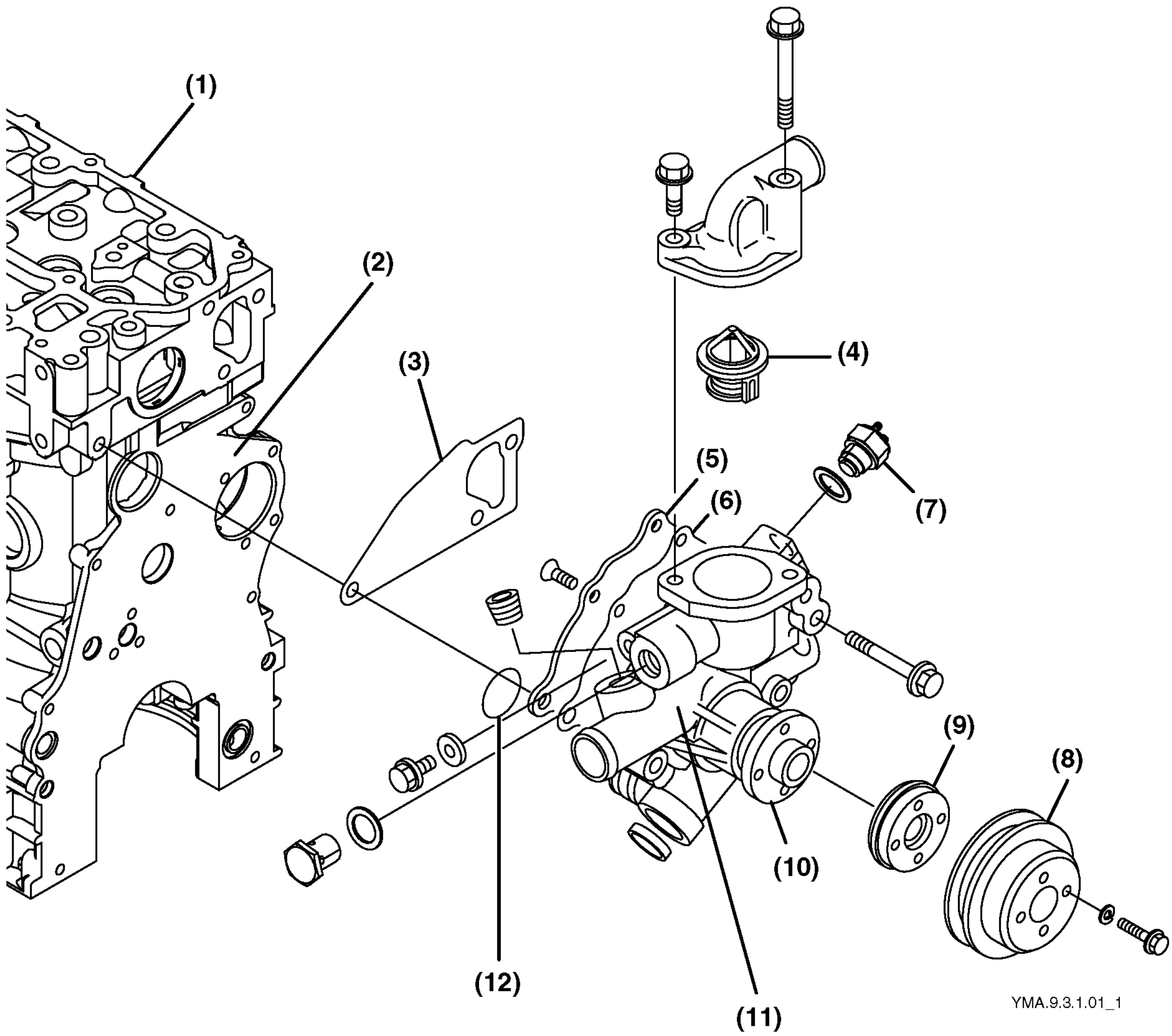


Figure 7-5

1 – Cylinder Head
2 – Cylinder Block
3 – Gasket
4 – Thermostat
5 – Cover
6 – Gasket
7 – Coolant Temperature Switch
8 – V-Pulley
9 – Spacer
10 – Pulley Seat
11 – Coolant Pump
12 – O-Ring (to cylinder block)

Coolant Pump Specifications

Pump Shaft Speed	3860 min^{-1} (rpm) ± 30
Delivery Capacity	66.7 L/min or more (17.6 gal/min.)
Total Head	4 mAq

Removing the Coolant Pump

NOTICE

Never disassemble the coolant pump. Replace when defective.

When removing the coolant pump as an assembly from the cylinder and cylinder head **(Figure 7-5, (1))**, replace the cylinder inlet pipe O-ring **(Figure 7-5, (12))**.

Inspecting the Coolant Pump

Inspect the coolant pump body and flange, and clean off scale and rust. Replace if corroded.

Bearing Unit Inspection

Rotate the impeller. If the rotation is not smooth or an abnormal noise is heard or felt, replace the pump as an assembly.

Impeller Inspection

Check the impeller blades. Replace if damaged, corroded or if the impeller blade is excessively worn due to contact with the pump body.

Coolant and Bypass Lines

Check the holes in the coolant and bypass lines, clean out any dirt or other foreign matter and repair as needed.

Coolant Pump Replacement

Replace the pump as an assembly if there is excessive coolant leakage due to mechanical seal or impeller seal wear.

When the coolant pump body, cylinder inlet flange and / or coolant pump and pump plate are assembled, retighten pump mounting bolts to the specified torque.

Coolant Pump Mounting Bolt Torque
9.3 to 11.3 N•m (9.3 to 8.3 lb-ft)

Measuring the Coolant Pump Clearances

1. Push the impeller all the way toward the pump body and insert a feeler gauge **(Figure 7-6, (1))** diagonally between the impeller and the body to measure the clearance between the two.

Outside Clearance Between Impeller and Body	
Standard	**Limit**
0.3 to 1.1 mm (0.011 to 0.043 in.)	1.5 mm (0.059 in.)

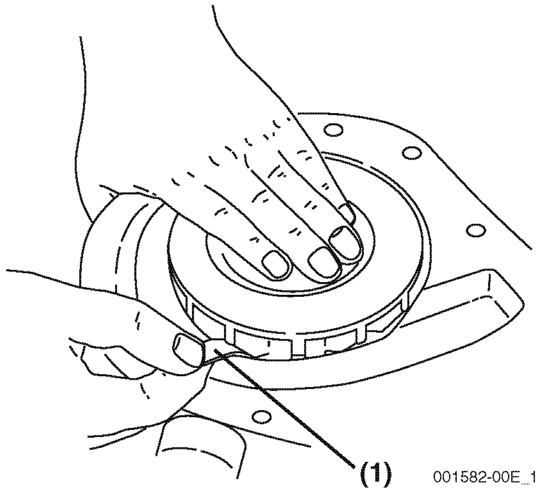


Figure 7-6

1 – Feeler Gauge

2. Place a straightedge **(Figure 7-7, (1))** against the end of the pump body and insert a feeler gauge **(Figure 7-7, (2))** between the impeller and the plate (pump body bracket) to measure the clearance between the two.

Side Clearance Between Impeller and Plate	
Standard	**Limit**
0.5 mm (0.019 in.)	–

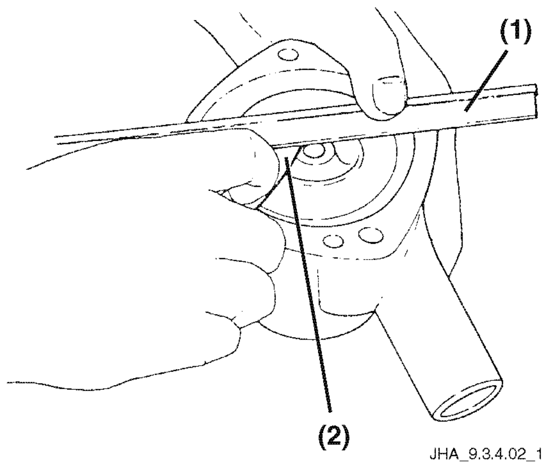


Figure 7-7

1 – Straightedge
2 – Feeler Gauge

HEAT EXCHANGER COMPONENTS AND FUNCTIONS

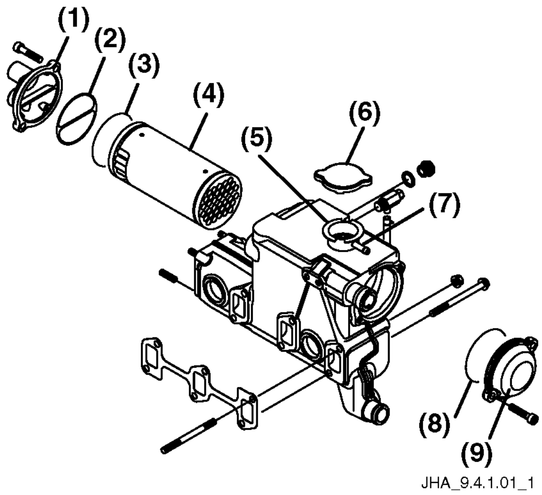


Figure 7-8

1 – **Side Cover**
2 – **Gasket**
3 – **O-Ring**
4 – **Core**
5 – **Filler Neck**
6 – **Pressure Cap**
7 – **Overflow Pipe**
8 – **O-Ring**
9 – **Side Cover**

The heat exchanger uses seawater to cool the engine's internal coolant system. The core **(Figure 7-8, (4))** of the heat exchanger consists of many small diameter tubes held together by baffle plates. Seawater flows through the inside of the tubes, and the baffle plates allow the engine's internal coolant mixture to flow around and between the tubes, transferring the engine heat to the flowing seawater within the tubes.

Reservoir

There is a reservoir above the cooler core which serves as the coolant mixture tank. Exhaust gases move through a manifold inside the reservoir, cooling the exhaust manifold.

Pressure Cap

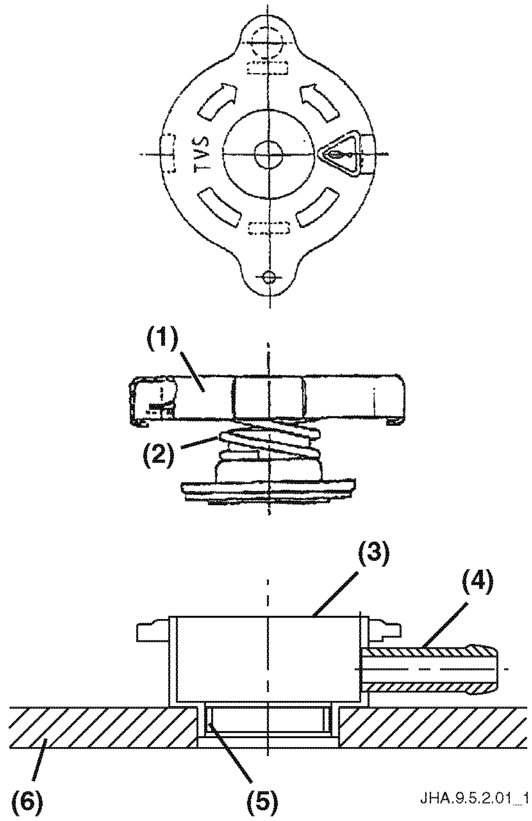


Figure 7-9

1 – **Pressure Cap**
2 – **Pressure Valve Spring**
3 – **Filler Neck**
4 – **Overflow Pipe**
5 – **Copper Tube**
6 – **Heat Exchanger**

Pressure Cap Functions

The pressure valve and the vacuum valve are both sealed when the pressure in the coolant recovery tank is within the specified value of 88 kPa (12.7 psi). When the pressure within the tank exceeds the specified value, it pushes against the pressure valve spring **(Figure 7-9, (2))** and opens, allowing steam to discharge through the overflow pipe **(Figure 7-9, (4))**. When the coolant mixture is cold and the internal pressure drops below the normal value, atmospheric pressure opens the vacuum valve and air is drawn in through the overflow pipe.

The coolant recovery tank prevents the coolant level from dropping due to the discharge of steam when the pressure valve opens.

Action of Pressure Control Valve	
Pressure Valve	Opens at 82 to 109 kPa (11.8 to 15.8 psi)
Vacuum Valve	Opens at 8 kPa (1.1 psi) or less

Inspecting the Pressure Cap

See Inspecting the Pressure Cap on page 4-33.

Disassembling the Heat Exchanger

WARNING! Burn Hazard. ***Avoid contact with hot coolant system components. Wait until the engine has fully cooled to disassemble the heat exchanger.***

1. Remove the covers **(Figure 7-8, (1) and (9))** on both ends of the heat exchanger and take out the cooler core **(Figure 7-8, (4))** and O-rings **(Figure 7-8, (3) and (8))**.

Note: Always replace the O-rings when removing the covers from the heat exchanger.

2. Remove the pressure cap **(Figure 7-8, (6))**.

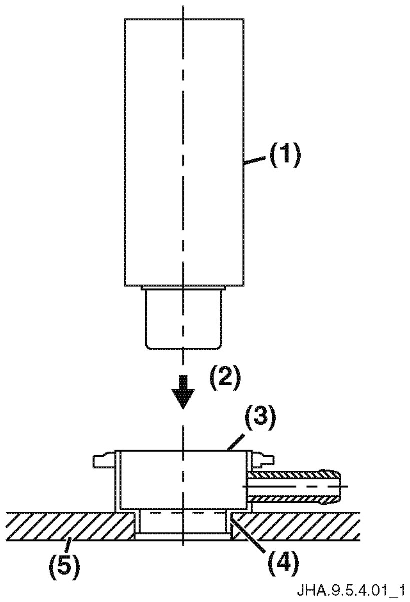
Inspecting the Heat Exchanger

See Inspecting the Heat Exchanger Body on page 4-33.

Replacing the Filler Neck

1. Remove the copper tube **(Figure 7-9, (5))** from the inside of the filler neck **(Figure 7-9, (3))** by tapping the circumference with a special tool 1 **(Figure 7-10, (1))** and mallet.
2. When the filler neck comes free of the heat exchanger **(Figure 7-9, (6))**, avoid damaging the exchanger as you remove it.
3. Clean the mating surfaces of the new filler neck and the heat exchanger.
4. Apply Loctite® T7471 activator (or equivalent) to both the surfaces and let it evaporate.

5. Apply Loctite® 603 or improved Loctite® 601 **(Figure 7-10, (4))** glue or equivalent to the filler neck mating surface and press the filler neck into the heat exchanger with the special tool 1 **(Figure 7-11, (1))**.



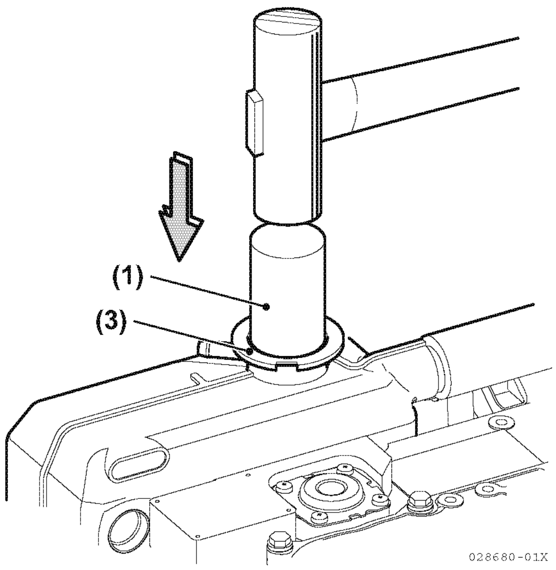


Figure 7-10

1 – Special Tool 1 (Soft Punch)
2 – Press the Filler Neck
3 – Filler Neck
4 – Loctite ® 601
5 – Heat Exchanger

6. Secure the new filler neck to the heat exchanger by pressing the small copper tube **(Figure 7-11, (2))** inside the filler neck with the special tool 2 **(Figure 7-11, (1))**.

NOTICE

The top of this tube should be below the sealing surface of the filler neck. This will allow the pressure cap to seal.

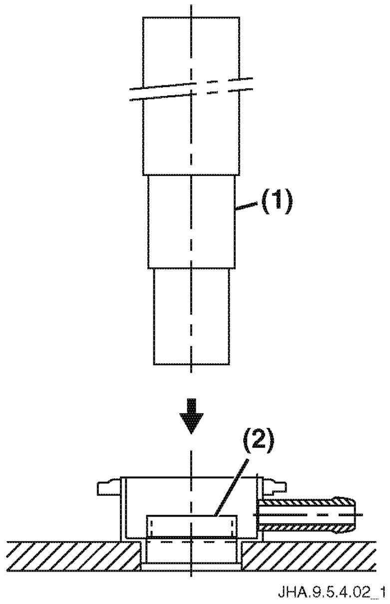


Figure 7-11

1 – Special Tool 2
2 – Copper Tube

7. Install the pressure cap on the filler neck.

Filler Neck Part No.	Copper Tube Part No.
129673-44110	129673-44150

See page *5-18* for special tool 1 and tool 2.

Coolant Recovery Tank Components and Functions

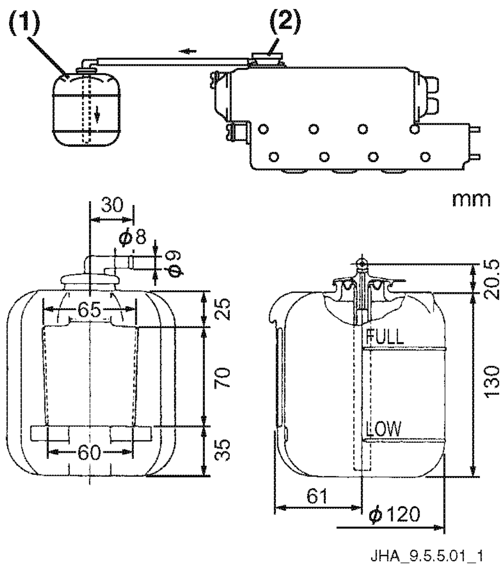


Figure 7-12

1 – Coolant Recovery Tank
2 – Filler Cap

The pressure valve opens to discharge steam when the steam pressure in the coolant tank exceeds
90 kPa (13 psi). The coolant recovery tank **(Figure 7-12, (1))** captures coolant discharged during this process.

The steam discharged into the coolant recovery tank condenses and the coolant level in the coolant recovery tank rises.

When the pressure in the coolant system drops below the normal value, the coolant in the coolant recovery tank is drawn back into the coolant tank to raise the coolant level back to its original level.

The coolant recovery tank allows for long hours of operation without coolant 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 Specifications

Coolant Recovery Tank Capacities	
Overall Capacity	1.3 L (2.7 pt)
Full-scale Position	0.8 L (1.6 pt)
Low-scale Position	0.2 L (0.4 pt)

Installing the Coolant Recovery Tank

The coolant recovery tank is mounted at approximately the same height as the heat exchanger coolant reservoir.

Allowable Difference in Height: 300 mm (11.81 in.) or less

The overflow tube **(Figure 7-13, (1))** should be less than 1000 mm (39.37 in.) long, and mounted so that it does not sag or bend.

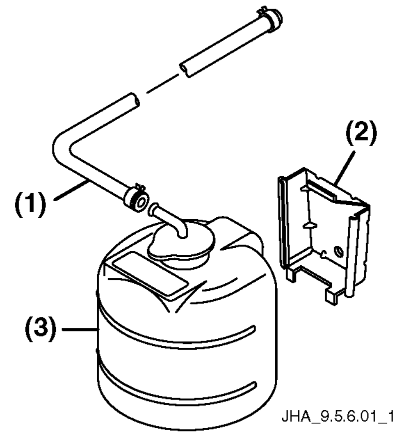


Figure 7-13

1 – Overflow Tube
2 – Mounting Plate
3 – Sub Tank

NOTICE

Make sure that the overflow pipe of the coolant recovery tank is not submerged in bilge water. If the overflow pipe is submerged in bilge, the water in the bilge will be siphoned into the heat exchanger coolant reservoir when the water is being cooled.

Precautions for Using the Coolant Recovery Tank

- Check the coolant recovery tank when the engine is cool and refill with coolant 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.

THERMOSTAT COMPONENTS AND FUNCTIONS

The thermostat **(Figure 7-14, (2))** opens and closes a valve according to changes in the coolant temperature inside the engine. This valve controls the volume of coolant flowing to the heat exchanger from the cylinder head and, in turn, maintains the coolant temperature in the engine at a constant level.

The thermostat is a bottom bypass type. It is connected to the cylinder head outlet line at the top of the coolant pump unit.

The thermostat used in this engine is a wax pellet type, with a solid wax pellet located in a small chamber.

When the coolant temperature rises, the wax melts and increases in volume. This expansion and contraction is used to open and close the valve.

When the coolant temperature exceeds the opening temperature, the thermostat opens and a portion of the coolant is sent to the heat exchanger, where it is cooled by seawater. The other portion flows from the bypass line to the coolant pump intake.

The bypass line is closed off as the thermostat valve opens and is completely closed when the coolant temperature reaches 81.5°C (179°F). When this temperature is reached, the valve lifts 4 mm (0.16 in.), sending all of the coolant to the heat exchanger.

Thermostat Specifications

Opening Temperature	69.5 to 72.5°C (157.1 to 162.5°F)
Full Open Temperature	85°C (185°F)
Valve Lift at Full Open	8 mm (0.3149 in.) or more

Thermostat Components

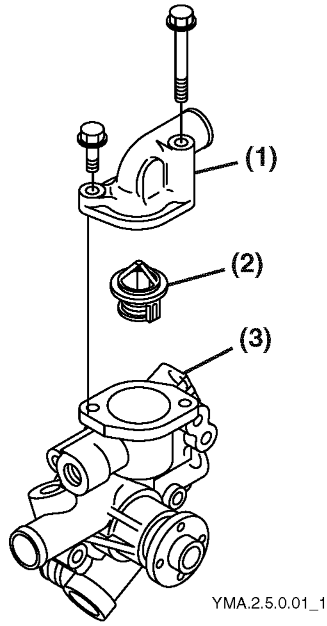


Figure 7-14

1 – Thermostat Cover
2 – Thermostat
3 – Coolant Pump Body

Inspecting the Thermostat

Remove the thermostat cover **(Figure 7-14, (1))** on top of the coolant pump **(Figure 7-14, (3))** and take out the thermostat **(Figure 7-14, (2))**. Clean off scale and rust, inspect, and replace if the characteristics (performance) have changed, or if the spring is broken, deformed or corroded.

See Inspecting the Thermostat on page 4-37.

BILGE PUMP AND STRAINER COMPONENTS AND FUNCTIONS (OPTIONAL)

General Introduction

Name	Bilge Pump
Constant Running Time	10 minutes
Rotation Direction	Right (viewed from the impeller side)
Weight	Pump 1.4 kg (3.0 lb)
Negative Pressure Detector	Diaphragm Type
Temperature	-30° to 80°C (-22° to 176°F)

Exterior

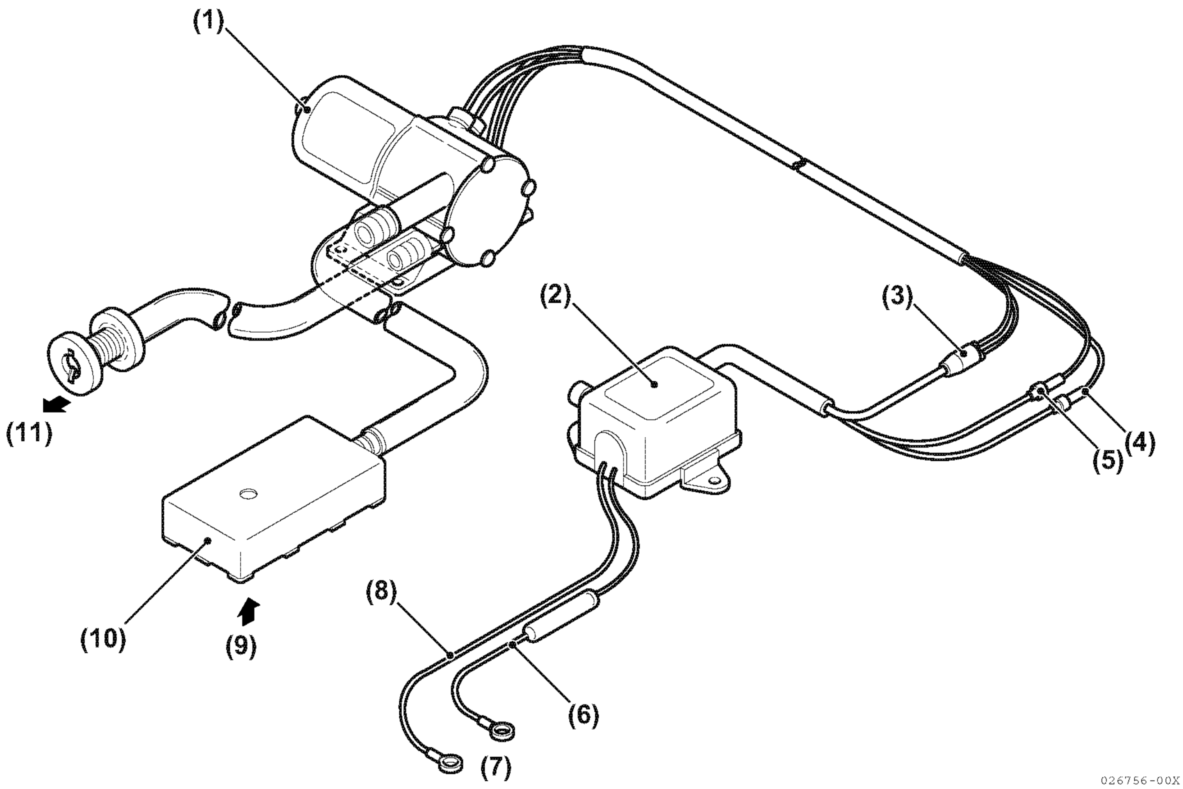


Figure 7-15

1 – Motor Assembly
2 – Controller
3 – Red
4 – White
5 – Black
6 – Red Positive (+)
7 – Battery
8 – White Negative(-)
9 – Oil Inlet
10 – Strainer
11 – Oil Outlet

Pump Dimensions

Length	225 mm (8.8 in.)
Yoke Diameter	61 mm (2.4 in.)
Assembly Hole Diameter	5.3 mm (0.2086 in.)
Assembly Pitch	50 x 90 mm (2.0 x 3.5 in.)

Bilge Pump Characteristics

- Discharge Capacity at 0 m Lift: 20 L (5.2 gal) or more
- Automatic Feed Height: 1 m (3.28 ft) or more (Limits for automatic feed height, new pump in primed condition: Approximately 2 m [6.5 ft])
- Automatic Feed Time: 2 to 5 seconds (limits for automatic feed time, new pump in primed condition: Approximately 1 second)
- Automatic Shut-Off: Air intake causes negative (-) pressure, triggering automatic shut-off

Insulation

- Insulation Resistance: 500V with a megatester when the difference between the continuity point and the body is 1MΩ or more
- Insulation Proof Stress: AC50 between the continuity point and the body, or 60Hz 500V for 1 minute when impressed current leakage is 10mA or less.

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.) (one side of amplitude)
Vibration Frequency	10 to 55 Hz
Sweep Time	90 seconds
Duration	4 hours (each direction)

Precautions for Installing the Bilge Pump

- Attach at a position above the bilge water and away from rain or other water. Attachment should be 50 to 70 cm (19 to 27 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.

NOTICE

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 dry out and its ability to draw water will be diminished. Before using, clean the inside of the pump and prime it. Check to be sure that the pump is operating correctly.
- When changing the engine oil, wait 30 minutes or longer before operating the bilge pump (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).
- If the bilge water freezes, melt the frozen water in the hoses and strainer with a steaming towel before operating the pump. When the pump temperature is low, it will take longer for the pump to drain 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 the bilge, place the appropriate 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 10A at 12VDC and 5A at 24VDC. If too many washers are used, the current draw will trip or blow the 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 modified for showering, the increase in water pressure will overload the motor and cause it to seize.
- Prevent the strainer from turning over and resting on its side.
- Never submerge the pickup strainer in bilge sludge. Position the strainer about 20 cm (0.8 in.) above the sludge. Clear the pump of all sludge before shutting the bilge pump down.
- Ensure that the battery is fully charged with a specific gravity of 1.25 or more.
- Never use gasoline, ester, benzol, battery fluid, liquids at 70°C (158°F) or greater, engine oil or any other type of solvent when installing or operating the bilge pump components.
- 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 into the wires.
- Use the recommended hose. Do no use thin vinyl hose or hose that is not heat-resistant.

Installing the Bilge Pump

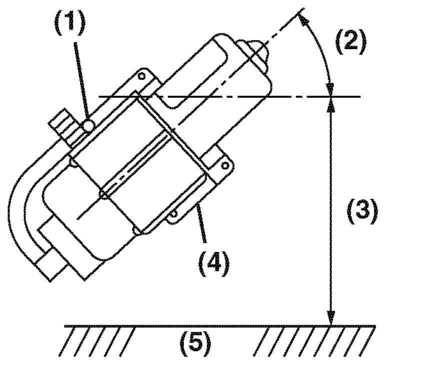


Figure 7-16

1 – Ø5 x 12 Screw, 4 each
2 – 45°
3 – 50 to 70 cm (20 to 28 in.)
4 – Bilge Pump
5 – Bilge

Install the bilge pump with the following considerations in mind:

1. Select a dry place above the bilge water level.
2. Select the location for the bilge pump **(Figure 7-16, (4))**, taking into consideration the length of the switch cable (approximately 3 m [9.8 ft]) and its attachment point in relation to the battery location.
3. Orient the pump at a 45° angle **(Figure 7-16, (2))** with the nozzle facing up, and 50 to 70 cm (20 to 28 in.) **(Figure 7-16, (3))** from the bottom of the boat.

Assembling the Switch

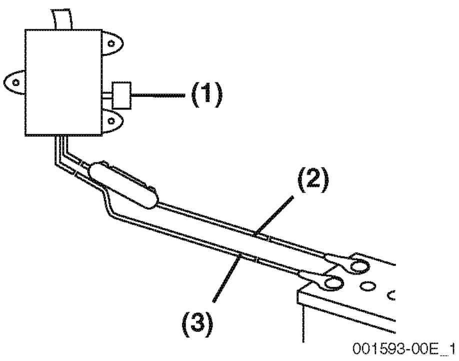


Figure 7-17

1 – Ø5 x 12 Screw, Controller
2 – 2mm^2 AV2wire Red Positive (+)
3 – 2mm^2 AV2wire White Negative (-)

1. Attach the switch in a location that is away from rain water and ensures easy operation.
2. Connect the wiring terminals to the battery.

NOTICE

If the cord will not reach the battery, an extension of no more than 3 m (9.8 ft) equal to AV3cm^2 (0.465 sq. in.) is allowed.

Positioning the Strainer

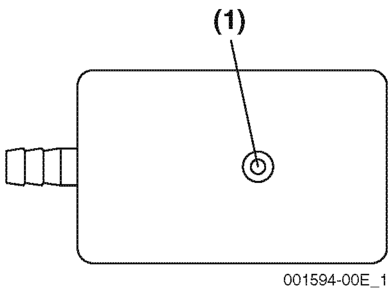


Figure 7-18

1 – Ø4 x 16 Screw

1. Attach the strainer in a location where the greatest amount of water can be collected when the boat is stopped.

Note: It is best to place the strainer as close to the bilge pump as possible where water will collect when the vessel is stopped.

2. Cut the 3 m (9.8 ft) length of hose to 1.2 m to 1.8 m (3.9 to 5.9 ft) and secure, allowing plenty of slack.
3. Test the strainer before securing it to the boat.

Note: The strainer contains a weight and is intended to be used with the weight in place.

Attaching the Delivery Nozzle (Outlet)

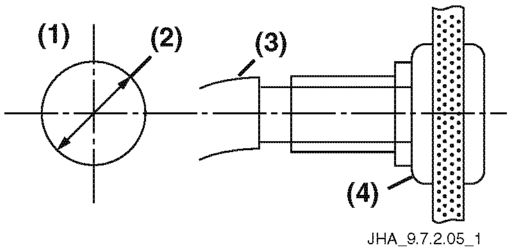


Figure 7-19

1 – Hole
2 – Ø21
3 – Hose
4 – Delivery Nozzle

1. Drill a 21 mm (0.827 in.) hole **(Figure 7-19, (1))** or less for attaching the nozzle **(Figure 7-19, (4))**. The hose **(Figure 7-19, (3))** attached at the nozzle should be 1.8 m (5.9 ft.) in length or less and should reach without any strain.
2. Install the nozzle (outlet) in place and attach on the discharge side of the pump.

Attaching the Hose

1. Attach the hose from the strainer to the pump inlet.
2. Attach the delivery nozzle hose to the pump outlet.
3. Make the hose as short as possible and avoid sharp bends.

Testing Bilge Pump Operation

1. Collect water in the bottom of the boat, and check for any problems with the hose or wiring.
2. Connect the battery.
3. 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.
4. 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.
5. Prime the pump before starting it up again.

Installing the Strainer

After testing bilge pump operation, attach the strainer into place with screws.

NOTICE

Do not damage the bottom of the boat.

Replacing the Bilge Pump Components

1. Remove the impeller plate by taking out the four M4 screws and opening the top of the diaphragm switch.

Note: Screw lock has been applied to the screw. Carefully heat the screw before removal.

2. Clean the inside of the pump.
3. Grease the plate, the impeller and the adjustment film for side gap adjustment.
4. Reassemble the pump by inserting the adjustment shim and then the impeller.

Troubleshooting the Bilge Pump System

Problem	Cause	Remedy
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	Repair / replace as required
	Faulty pump	Repair / replace as required
Pump turns but does not draw up water	Draws up air	Check hose connections. Retighten pump screws.
	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 to 70 cm (19.7 to 27.6 in.) above the bottom of the boat.)
	Pump intake is weak	If intake is still faulty after priming, repair / replace as required.
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.
Water leakage from pump	Water leakage from packing	Retighten pump screws.
	Faulty pump seal	Repair / replace as required
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	Repair / replace as required
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. Repair / replace as required

Section 8

LUBRICATION SYSTEM

Page

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SAFETY PRECAUTIONS

Before servicing the lubrication system, review the *Safety Section on page 2-1*.

NOTICE

Indicates a situation which can cause damage to the machine, personal property, the environment or cause the equipment to operate improperly.

Use only 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 lubrication system used on the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

LUBRICATION COMPONENTS AND FUNCTIONS

The engine oil in the pan is drawn through the strainer and suction tube to the engine oil pump. It is then pumped through passages in the cylinder block, through the oil filter adapter and onto the filter element. After being filtered, it is fed back into the main oil galley of the cylinder block. Oil from the galley flows to the crankshaft journals and lubricates the crank pins.

A portion of the oil is fed to the camshaft bearings and then pumped through passages in the cylinder block and cylinder head to the rocker arm shaft to lubricate the rocker arms and valves.

Pressurized oil also feeds the intermediate gear bearings to lubricate the bearings and respective gears.

Engine oil is fed to the fuel injection pump from the main oil galley through external oil lines.

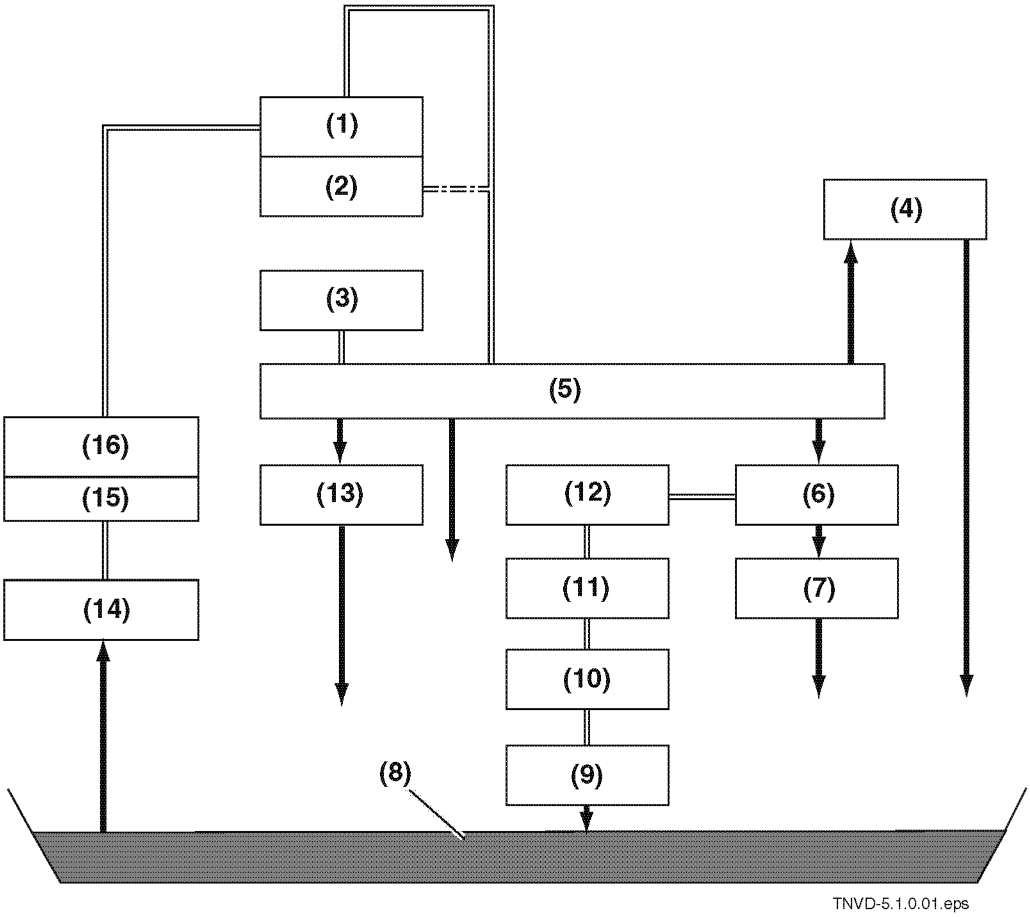

Figure 8-1

1 – Engine Oil Filter
2 – Bypass Valve
3 – Oil Pressure Switch
4 – Fuel Injection Pump
5 – Cylinder Block Main Galley
6 – Crank Journal Bearing
7 – Crank Pin Bearing
8 – Oil Pan
9 – Tappet Cam Face
10 – Rocker Arm
11 – Rocker Arm Bearing
12 – Camshaft Bearing
13 – Intermediate Gear Shaft
14 – Oil Suction Pipe Strainer
15 – Engine Oil Pump
16 – Regulator Valve

Oil Pump Components

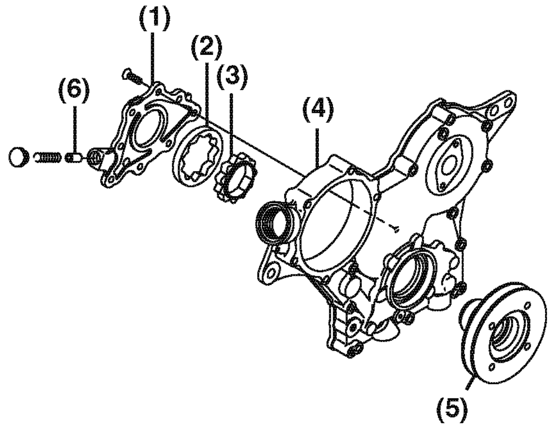

Figure 8-2

1 – Oil Pump Cover
2 – Outer Rotor
3 – Inner Rotor
4 – Gear Housing Cover
5 – Crankshaft Pulley
6 – Control Valve

The trochoid type oil pump is mounted in the gear housing cover, and the inner rotor of the pump is driven by the crankshaft pulley.

Oil flows from the intake filter mounted on the bottom of the oil pan through the cylinder block and engine plate holes to the engine oil filter. The oil pump is equipped with a control valve that controls the oil pressure.

Oil Pump Specifications

Engine Speed	3600 min^{-1} (rpm)	800 min^{-1} (rpm)
Pump Speed	3477 min^{-1} (rpm)	772 min^{-1} (rpm)
Delivery Quantity	19.0 L / minute (5 gal / minute)	8.0 L / minute (2.1 gal / minute)
Delivery Pressure	0.43 MPa (62 psi)	0.049 MPa (7.1 psi)
Oil Temperature	60±5°C (140±5°F)	60±5°C (140±5°F)

Disassembling the Oil Pump

Note: Disassembly is unnecessary unless a problem has been identified.

1. Remove the crankshaft pulley **(Figure 8-2, (5))**.
2. Remove the gear housing cover **(Figure 8-2, (4))**.
3. Remove the oil pump cover **(Figure 8-2, (1))** from the gear housing cover. Do not disassemble the inner / outer rotors **(Figure 8-2, (2) and (3))** and check that the pump rotates smoothly.
4. Remove the pressure control valve **(Figure 8-2, (6))** from the oil pump cover.
5. Wash the control valve.

Inspecting the Oil Pump

1. Check the outside diameter clearance and side clearance of the outer rotor.

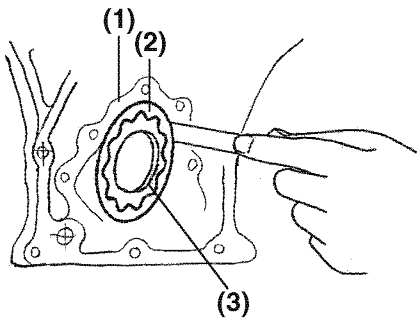

Figure 8-3

1 – Gear Housing
2 – Outer Rotor
3 – Inner Rotor

(a) Insert a feeler gauge between the outer rotor **(Figure 8-3, (2))** and the oil pump cover and measure the outside diameter gap.

(b) Put a straightedge on the end face of the gear housing cover and insert a feeler gauge between rotor and straightedge.

(c) Measure the side gap.

Outside Clearance	
Standard	**Limit**
0.12 to 0.21 mm (0.0047 to 0.0082 in.)	0.30 mm (0.0118 in.)

2. Using a feeler gauge, measure the tip clearance between the outer rotor and inner rotor.

Tip Clearance	
Standard	**Limit**
–	0.16 mm (0.0062 in.)

3. Measure the side clearance of outer rotor:

   Place a square on the pump body and insert a feeler gauge under the square.

Side Clearance	
Standard	**Limit**
0.02 to 0.07mm (0.0007 to 0.0027 in.)	0.12 mm (0.0047 in.)

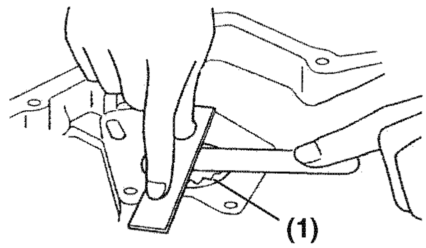

Figure 8-4

1 – Outer Rotor

4. Measure inner rotor pivot pin clearance. Measure the outside diameter of inner rotor pivot pin. Measure the hole diameter of gear housing cover. Calculate the clearance from that difference.

Inspection Item	Standard	Limit
Gear Housing Cover I.D.	46.13 to 46.18 mm (1.8161 to 1.8181 in.)	–
Inner Rotor O.D.	45.98 to 46.00 mm (1.8102 to 1.8110 in.)	–
Rotor Clearance	0.13 to 0.20 mm (0.0051 to 0.0078 in.)	0.25 mm (0.0098 in.)

Assembling the Oil Pump

NOTICE

When replacing the engine oil pump, replace the whole assembly.

1. Apply engine oil to the pump cover bolts.
2. Fasten the pump cover with bolts. Torque the bolts to the specified value.
3. Check that the pump rotates smoothly after installation.

NOTICE

Running the engine when the pump rotation is obstructed may cause the pump gears to overheat and burn.

Pump Cover Bolt Torque
5.9 to 7.9 N•m (4.3 to 5.8 lb-ft.)

Oil Pressure Control Valve

The pressure control valve controls the oil pressure when it leaves the oil filter.

When the oil pressure in the main oil galley exceeds the standard value, the control valve piston opens and bypasses oil back into the oil pan.

Standard Oil Pressure
0.29 to 0.44 MPa (42 to 63 psi)

Oil Filter Components

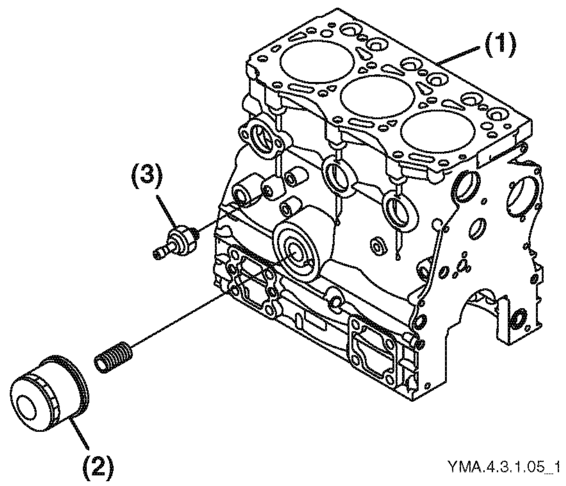

Figure 8-5

1 – Cylinder Block
2 – Engine Oil Filter
3 – Engine Oil Pressure Switch

The oil filter is a full-flow paper element type mounted to the side of the cylinder block. The cartridge-type filter is easy to remove. To prevent engine seizure in the event of filter blockage, a bypass circuit is provided in the oil filter. When the pressure differential before and after the filter element reaches 0.08 to 0.12 MPa (11.6 to 17 psi), the bypass valve inside the filter opens and the unfiltered oil is sent to each part as an emergency measure.

Oil Filter Specifications	
Type	Full Flow Element
Filtration Area	0.10 m^2 (155 sq. in.)
Discharge Volume	30 L / minute (7.9 gal / minute)
Pressure Loss	0.03 to 0.05 MPa (4.3511 to 7.2518 psi)
Bypass Valve Regulating Pressure	0.08 to 0.12 MPa (11.6030 to 17.4050 psi)

Replacing the Oil Filter

See Replacing the Engine Oil Filter Element on page 4-11.

Rotary Waste Oil Pump (Optional)

A rotary waste oil pump is available as an option.

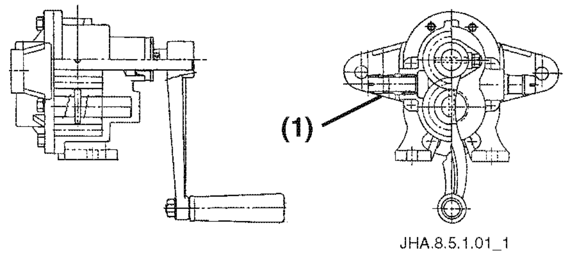

Figure 8-6

1 – Oil Inlet Pipe Outside Diameter 16 mm (0.63 in.)

Rotary Waste Oil Pump Specifications	
Delivery Capacity per One Revolution	0.057 L (0.015 gal)
Delivery Pressure	0.15 MPa (21 psi) or less
Suction Head	Less than 1 m (3.2 ft)
Part No.	124413-39100

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Section 9

STARTER

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SAFETY PRECAUTIONS

Before servicing the starter motor, read the following safety information and review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, could result in death or serious injury.

Shock Hazard

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

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

NOTICE

Indicates a situation which can cause damage to the machine, personal property, the environment or cause the equipment to operate improperly.

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* describes the procedures necessary to service the starter motor used on the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

STARTER COMPONENTS AND FUNCTIONS

The starter motor turns the ring gear, which is installed on the engine flywheel. The pinion gear of the starter overcomes compression pressure and engine friction, and starts the engine.

Starter Specifications

Yanmar Part No.		129608-77010
Hitachi Model No.		S114-817A
Nominal Power Nominal Voltage Rating Direction of Rotation (Looking from the Pinion Side) Number of Pinion Teeth Weight		1.4 kW (1.9 hp) 12 V 30 seconds Clockwise 11 3.0 kg (6.6 lb)
No Load	Terminal Voltage Electric Current Revolutions	11 V 90 A Maximum 2700 min^{-1} (rpm) Minimum
Load	Terminal Voltage Electric Current Torque Revolutions	8.4 V 250 A 8.3 N•m Maximum (6.1 lb-ft) 1000 min^{-1} (rpm) Minimum

Starter Performance Curve

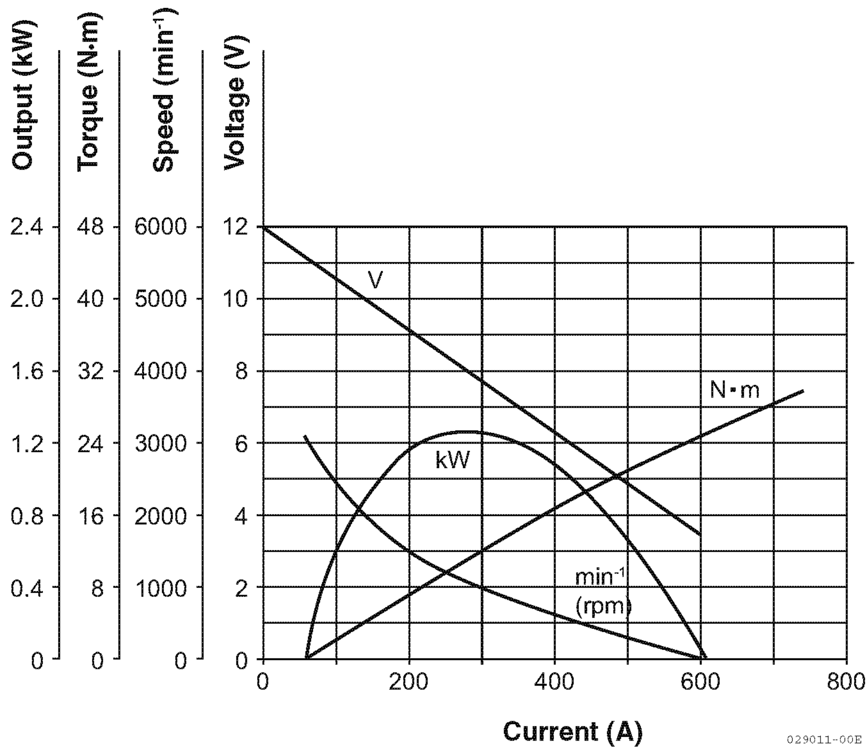

Figure 9-1

Starter Components

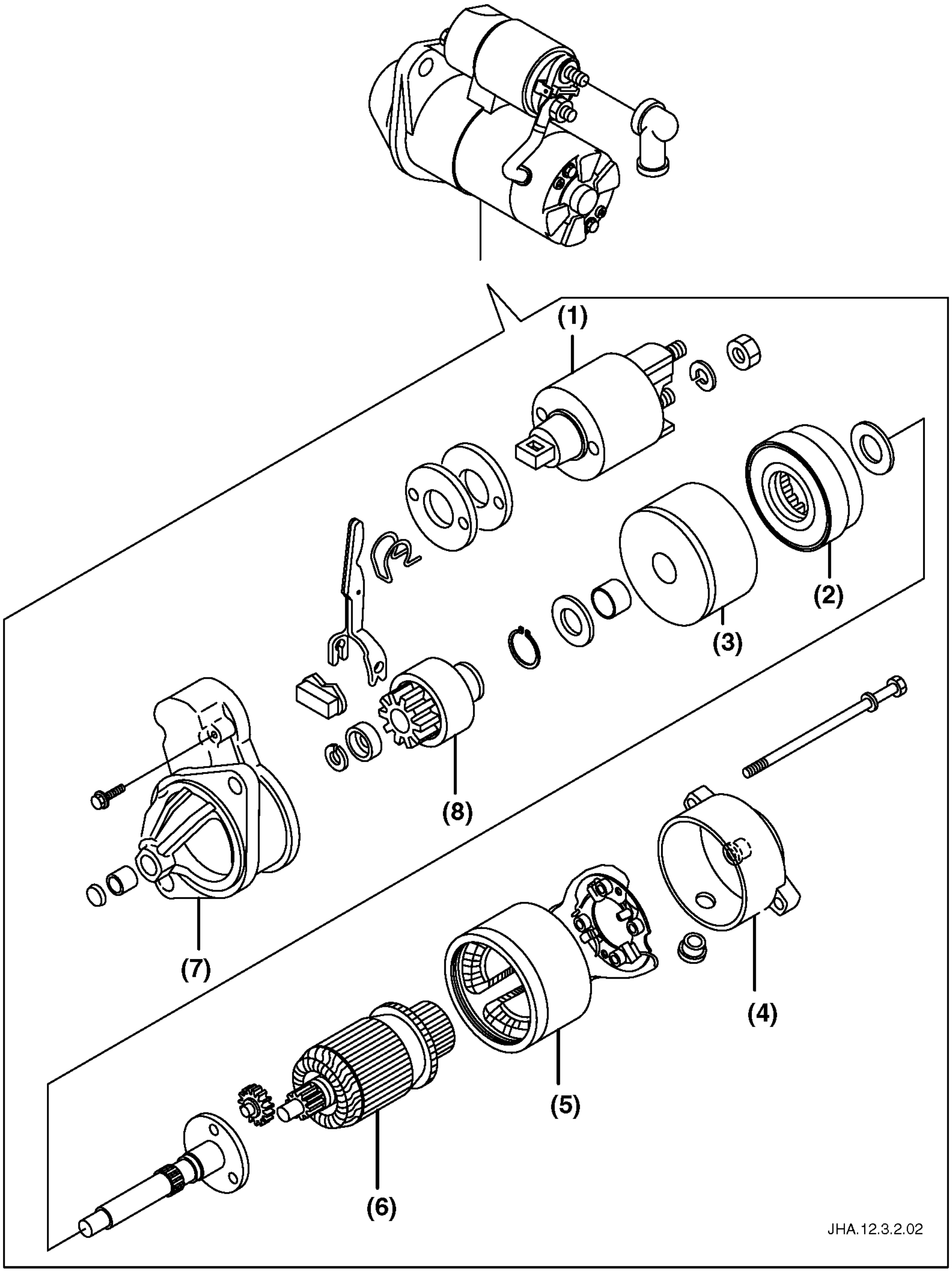

Figure 9-2

1 – Magnetic Switch
2 – Internal Gear
3 – Bracket
4 – Rear Cover
5 – Yoke
6 – Armature
7 – Gear Housing
8 – Pinion

Starter Operations

While the starting switch is held in the ON position, the starter motor spins and the solenoid extends the pinion gear to engage the teeth of the flywheel. This rotates the flywheel of the engine until it starts or the starting switch is released.

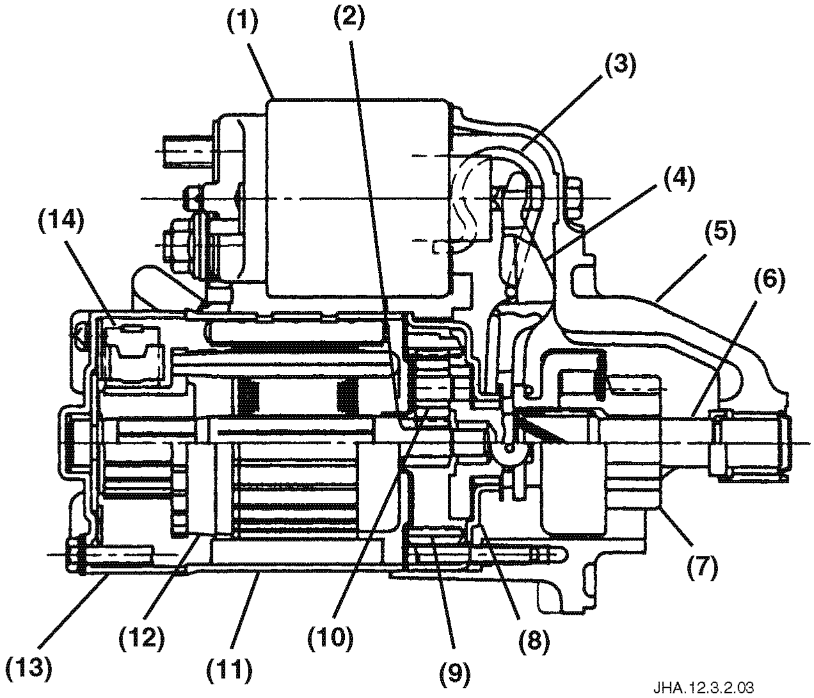

Figure 9-3

1 – Magnetic Switch
2 – Center Bracket (A)
3 – Torsion Spring
4 – Shim Lever
5 – Gear Housing
6 – Pinion Shaft
7 – Pinion
8 – Center Bracket (P)
9 – Internal Gear
10 – Planetary Gear
11 – Yoke
12 – Armature
13 – Rear Cover
14 – Brush

Starter Wiring Diagram

1. When the starting switch **(Figure 9-4, (1))** is engaged, the core of the switch is energized. This extends the contact end of the solenoid to close the circuit between the battery **(Figure 9-4, (4))** and the starter motor **(Figure 9-4, (3))**. As the core extends to close the electrical contacts on one end, the other end of the solenoid core moves a lever that pushes the pinion gear against spring pressure into engagement with the teeth of the flywheel ring gear.
2. When battery power is supplied to the armature of the starter motor, the pinion gear is driven to rotate.
3. When the starting switch is released, the solenoid returns to its normal state. This breaks contact between the armature of the starter motor and the battery. The pinion gear is retracted by return spring pressure.

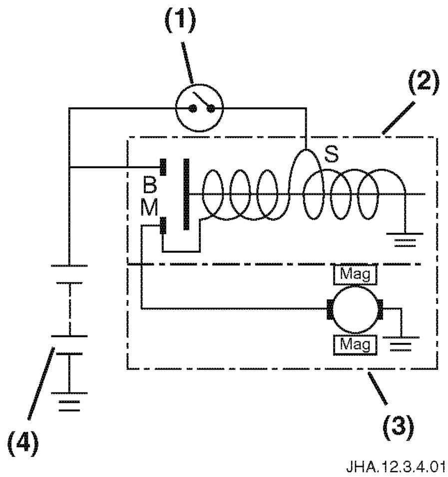

Figure 9-4

1 – Starting Switch
2 – Magnetic Switch
3 – Starter Motor
4 – Battery

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Section 10

ALTERNATOR

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SAFETY PRECAUTIONS

Before servicing the alternator, review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, could result in death or serious injury.

Shock Hazard

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

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

NOTICE

Indicates a situation which can cause damage to the engine, personal property and / or the environment or cause the equipment to operate improperly.

Never turn the battery switch off or disconnect the battery leads from the battery while the engine is operating. Damage to the alternator will result.

Never reverse the positive (+) and negative (-) ends of the battery cable when connecting battery cables. The alternator will be damaged.

Never use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.

Always disconnect the battery cables from the battery when charging the battery.

Never use a high-voltage insulation resistance tester for test.

INTRODUCTION

This section of the *Service Manual* describes the procedures necessary to service the alternator used on the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

ALTERNATOR SPECIFICATIONS

Alternator Components and Functions

The alternator creates electrical energy and charges the battery. It is installed on the cylinder block with brackets and is operated with twin V-belts that are driven by the engine crankshaft. The alternator is equipped with an IC regulator that is designed to deliver a constant voltage throughout a wide range of engine speeds and uses diodes to convert AC to DC.

Inspecting the Alternator

Inspection of V-Pulley

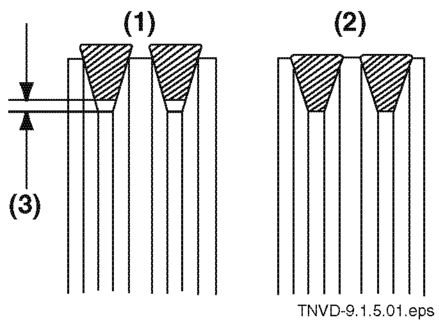


Figure 10-1

1 – Normal
2 – Defect
3 – Clearance

1. Remove the V-belts from the pulley and rotate the alternator by hand. Feel for any roughness or unusual drag and listen for any unusual sounds.
2. Inspect both belts for any cracks, stickiness or visual signs of wear.
3. Check to ensure that there is clearance **(Figure 10-1, (3))** between the inner surface of the belts and the bottom of the pulley grooves.
4. Inspect the belt tension. *See Checking and Adjusting Alternator V-Belt Tension on page 4-13.*
5. Make sure all the connections and terminals on the alternator are tight.
6. Secure all wires from making contact with any moving parts.

Inspecting the Charge Indicator Circuit

1. Move the start switch to the ON position. Confirm that the charge indicator is on.
2. Start the engine. Confirm that the charge indicator goes off.
3. If results differ from the above steps, repair as necessary.

12V / 60A Alternator (Standard 2008 and earlier)

Item	Specification
Yanmar Code	128271-77200
Alternator Model	LR160-741 (Hitachi)
IC Regulator Model	SA-A (Hitachi)
Battery Voltage	12VDC
Nominal Output	12V / 60A
Polarity	Negative (-) Ground
Direction of Rotation (viewed from pulley end)	Clockwise
Weight	4.2 kg (9.2 lb)
Rated Speed	5000 min^{-1} (rpm)
Operating Speed	1050 to 1800 min^{-1} (rpm)
Speed for 13.5V at 20°C (68°F)	1050 min^{-1} (rpm) or less
Output Current for 13.5V	56A or more at 5000 min^{-1} (rpm)
Regulated Voltage	14.4 ± 0.3V at 20°C (68°F), Voltage Gradient -0.01V / °C)

12V / 60A Alternator Components Exploded View

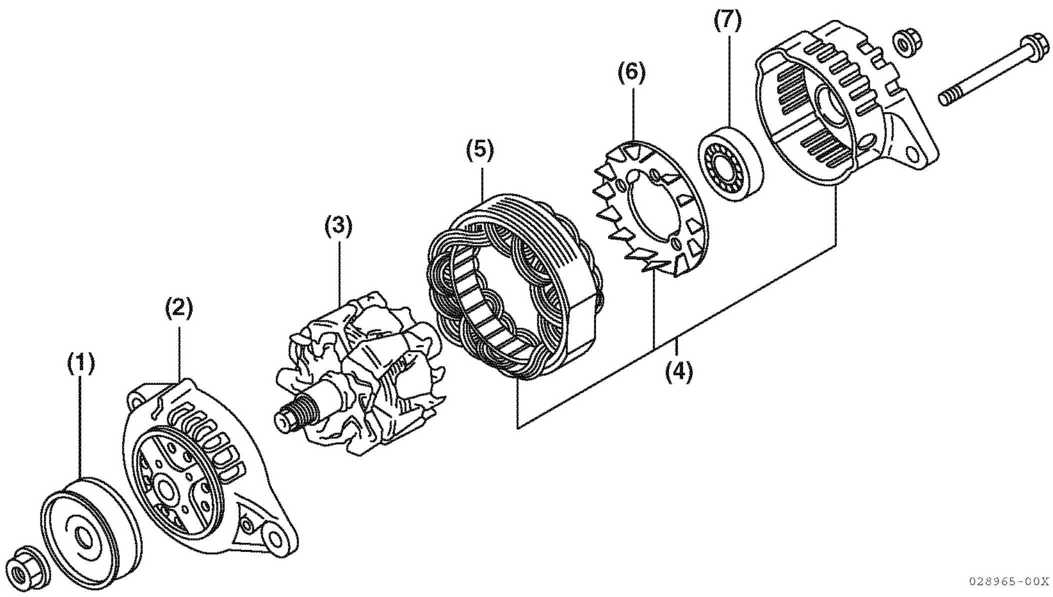


Figure 10-2

1 – Pulley
2 – Front Bracket
3 – Rotor
4 – Rear Bracket Assembly
5 – Stator
6 – Fan
7 – Ball Bearing

12V / 60A Alternator Components Assembly View

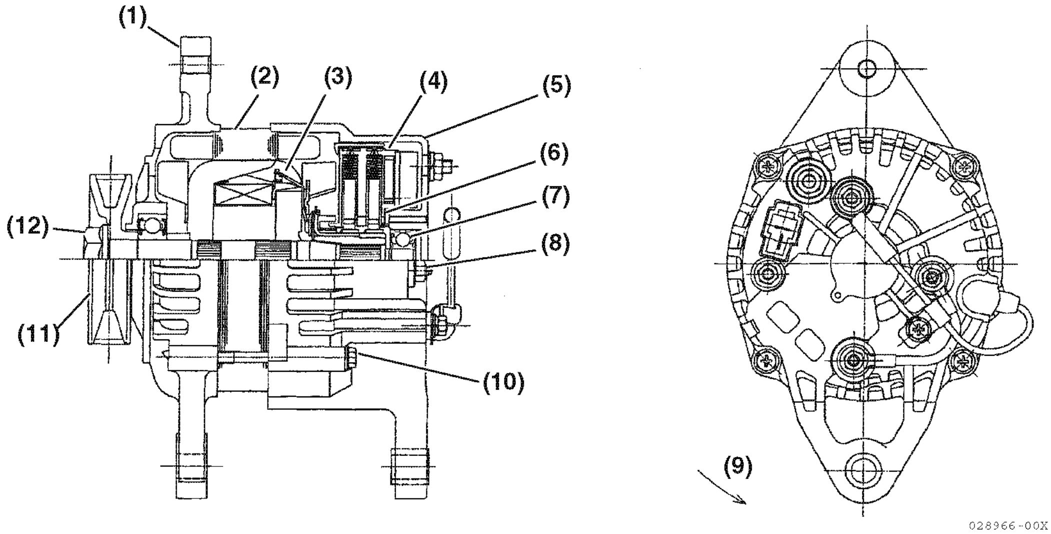


Figure 10-3

1 – Bracket
2 – Stator Assembly
3 – Rotor Assembly
4 – Rectifier Assembly
5 – Bracket
6 – Packing
7 – Ball Bearing
8 – Nut (M5)
9 – Rotation Direction
10 – Through-Bolt
11 – Pulley
12 – Nut

12V / 60A Alternator Schematic

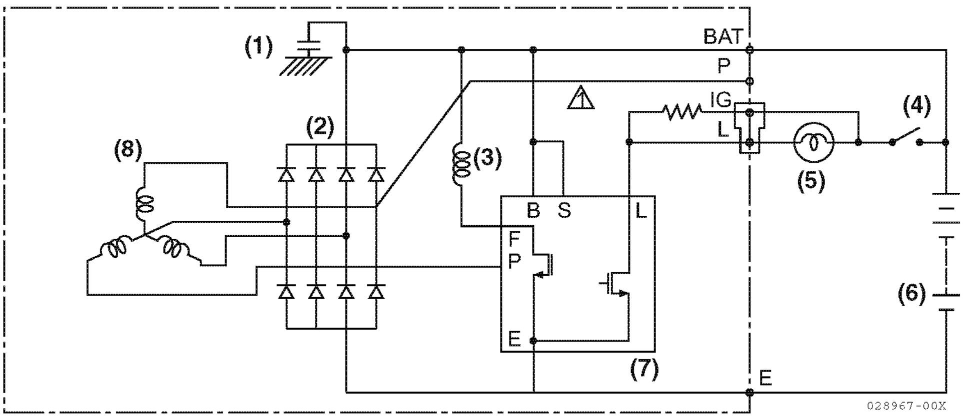


Figure 10-4

1 – Condenser 2.2 µF
2 – Diode
3 – Rotor Coil
4 – Key Switch
5 – Charge Indicator 12V 3.4W
6 – Battery
7 – IC Regulator
8 – Stator Coil

- *Do not incorrectly wire or short-circuit any of the alternator terminals.*
- *Do not attempt to remove wires while the alternator is operating.*
- *Turn the main power switch to OFF when the engine is shut down.*

12V / 60A Alternator Output Curve

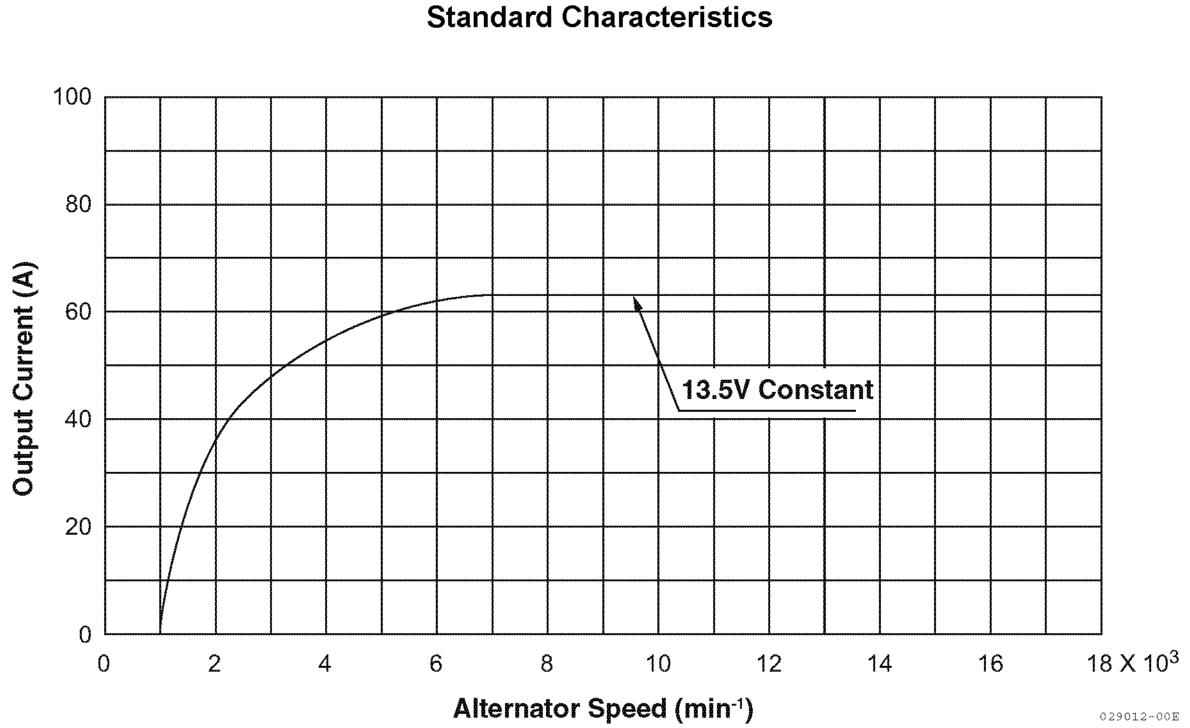


Figure 10-5

12V / 80A Alternator (Standard 2009 and later)

Item	Specification
Yanmar Code	119573-77201
Alternator Model	LR180-03C (Hitachi)
IC Regulator Model	TR1Z-63 (Hitachi)
Battery Voltage	12VDC
Nominal Output	12V / 80A
Polarity	Negative (-) Ground
Direction of Rotation (viewed from pulley end)	Clockwise
Weight	5.4 kg (11.9 lb)
Rated Speed	5000 min^{-1} (rpm)
Operating Speed	1200 to 9000 min^{-1} (rpm)
Speed for 13.5V at 20°C (68°F)	1200 min^{-1} (rpm) or less
Output Current for 13.5V	75A or more at 5000 min^{-1} (rpm)
Regulated Voltage	14.5 ± 0.3V at 20°C (68°F), Voltage Gradient -0.01V / °C

12V / 80A Alternator Components and Assembly

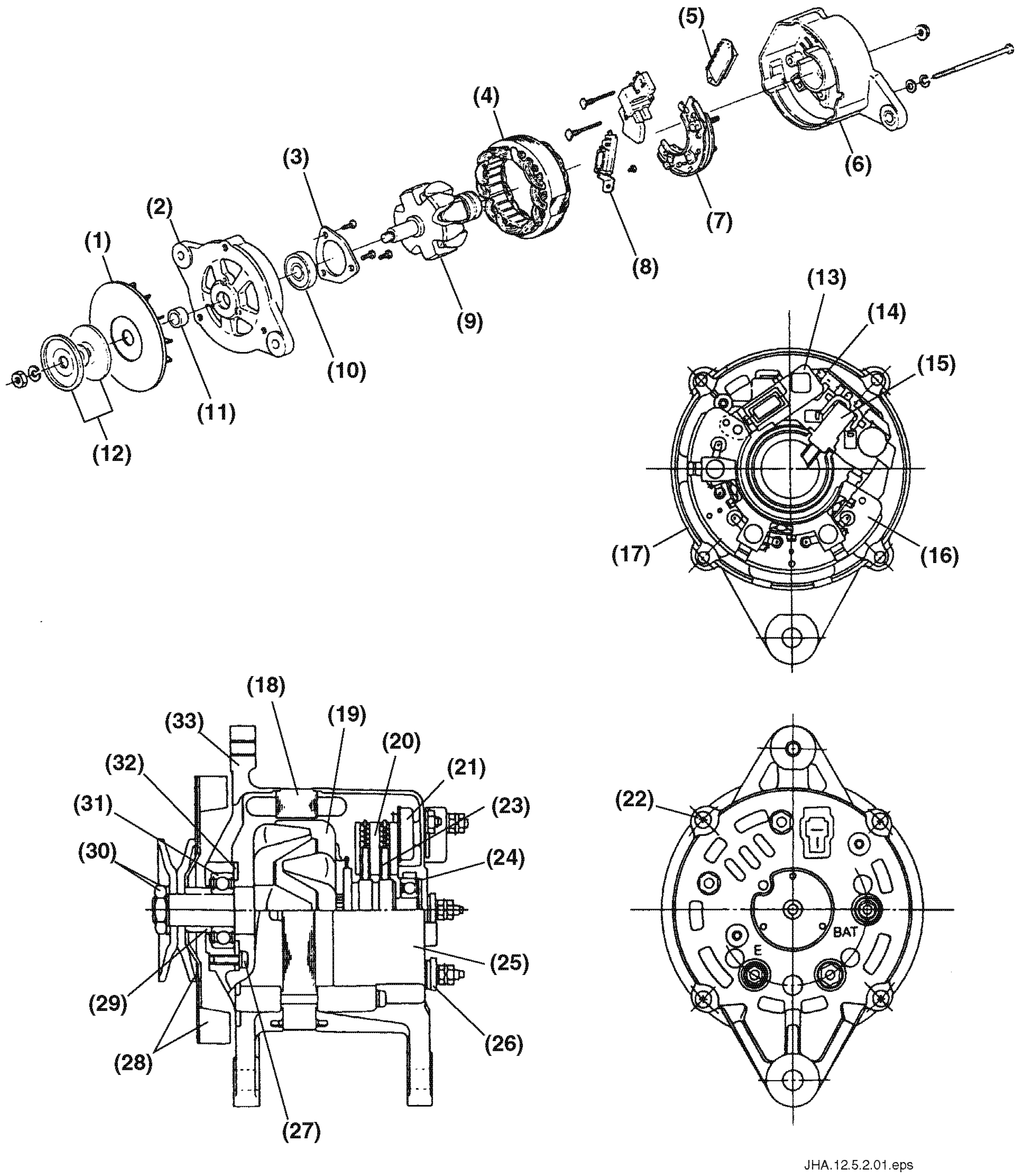


Figure 10-6

1 – Fan
2 – Front Cover
3 – Bearing Retainer
4 – Stator
5 – Brush Regulator Assembly
6 – Rear Cover
7 – Diode
8 – Condenser
9 – Rotor
10 – Ball Bearing
11 – Spacer
12 – Pulley
13 – Capacitor Assembly
14 – Brush Regulator Assembly
15 – Brush Holder
16 – Diode Assembly
17 – Rear Cover Assembly
18 – Stator Assembly
19 – Rotor Assembly
20 – Brush Assembly
21 – IC Regulator Assembly
22 – Through-Bolt
23 – Brush Set
24 – Ball Bearing
25 – Rear Cover
26 – Insulating Bushing
27 – Bolt (M5x0.8x14)
28 – Pulley Assembly
29 – Spacer
30 – Pulley Nut Assembly
31 – Ball Bearing
32 – Bearing Retainer
33 – Front Cover Assembly

12V / 80A Alternator Schematic

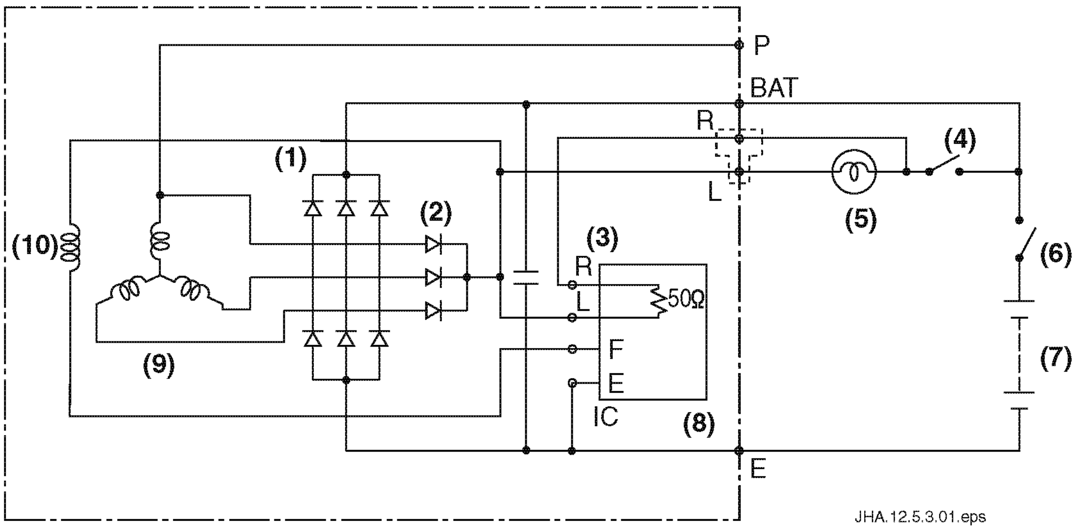


Figure 10-7

1 – Diode
2 – Sub-Diode
3 – Condenser (3.2 µF)
4 – Key Switch
5 – Charge Indicator 12V 3.4W
6 – Battery Switch
7 – Battery
8 – IC Regulator
9 – Stator Coil
10 – Rotor Coil

NOTICE

- *Do not incorrectly wire or short-circuit any of the alternator terminals.*
- *Do not attempt to remove wires while the alternator is operating.*
- *Turn the main power switch to OFF when the engine is shut down.*

12V / 80A Alternator Output Curve

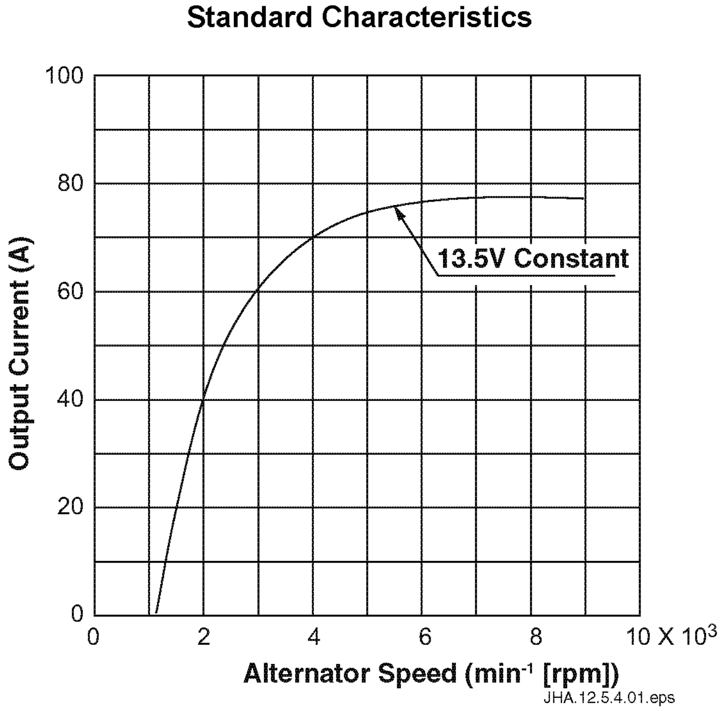


Figure 10-8

12V / 125A Valeo Alternator (from 2013)

SPECIFICATIONS

Model of alternator	SG10S078 (128990-77250)
Model of regulator	YR208 (Valeo)
Battery voltage	12V
Nominal out put	12/125
Direction of rotation	Clockwise
Weight	5.6Kg
Rated speed	6000rpm
Operation speed	1200rpm to 150000rpm
Cut of Speed for: 13,5V 27V	1200 rpm
Output current an 20°C	126A/6000rpm
Regulated voltage	14.55 ±0.15V
Terminal B minus	Body ground
Comments	Standard

CHARACTERISTICS

Standard Alternator - 12 V / 125 A

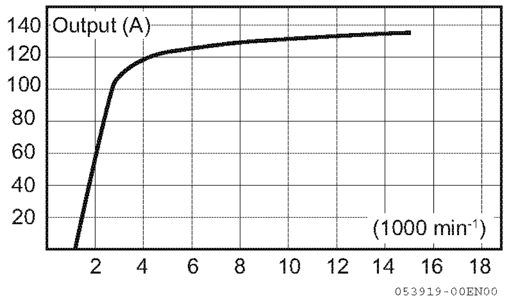


Figure 10-9

CONSTRUCTION

This alternator composed by 7 major parts: The rear cover **(Figure 10-10, (1))**, the regulator **(Figure 10-10, (2))**, the rectifier with bracket **(Figure 10-10, (3))**, the stator, the rotor, the front brackets and the pulley **(Figure 10-10, (5))**.

Yanmar supplies 5 spare parts items only, which are listed below.

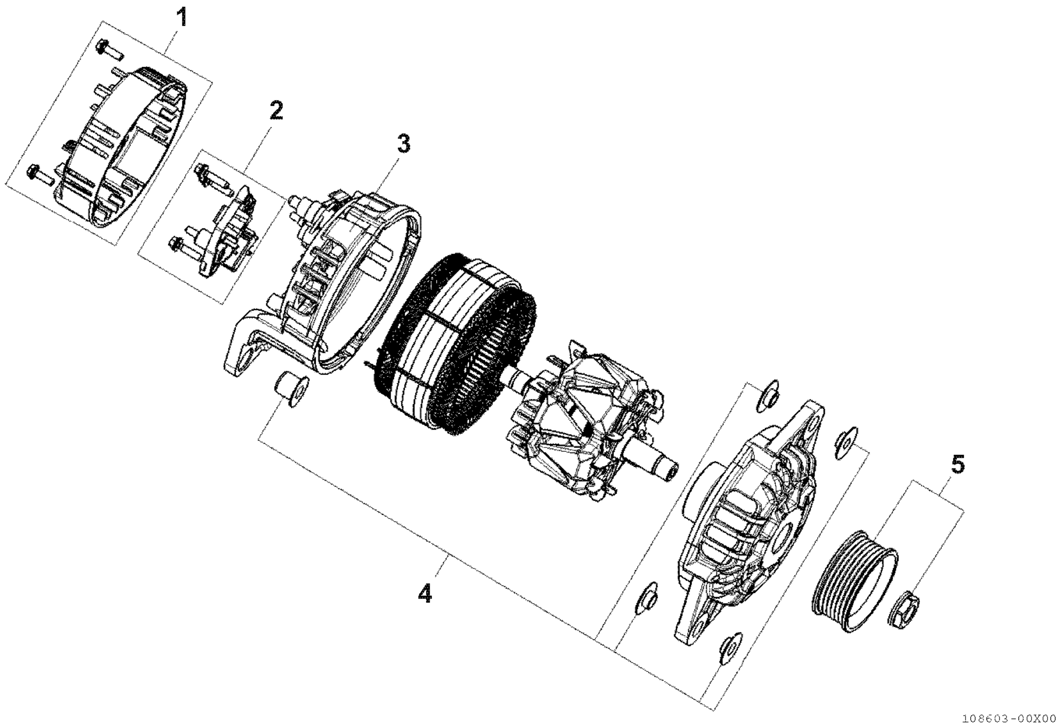


Figure 10-10

Valeo alternator spare parts list	
Yanmar Code	128990-77250
Model	SG10S078
Nominal Output (V/A)	12 / 125
Model of regulator	YR208 (Valeo)
1. Rear cover with screws	128990-77700
2. Regulator with screws	128990-77780
3. Rectifier with bracket	128990-77770
4. Bush Assembly, isolation	-
5. Pulley	128990-77730
Terminal B minus	Body ground
Comments	Standard

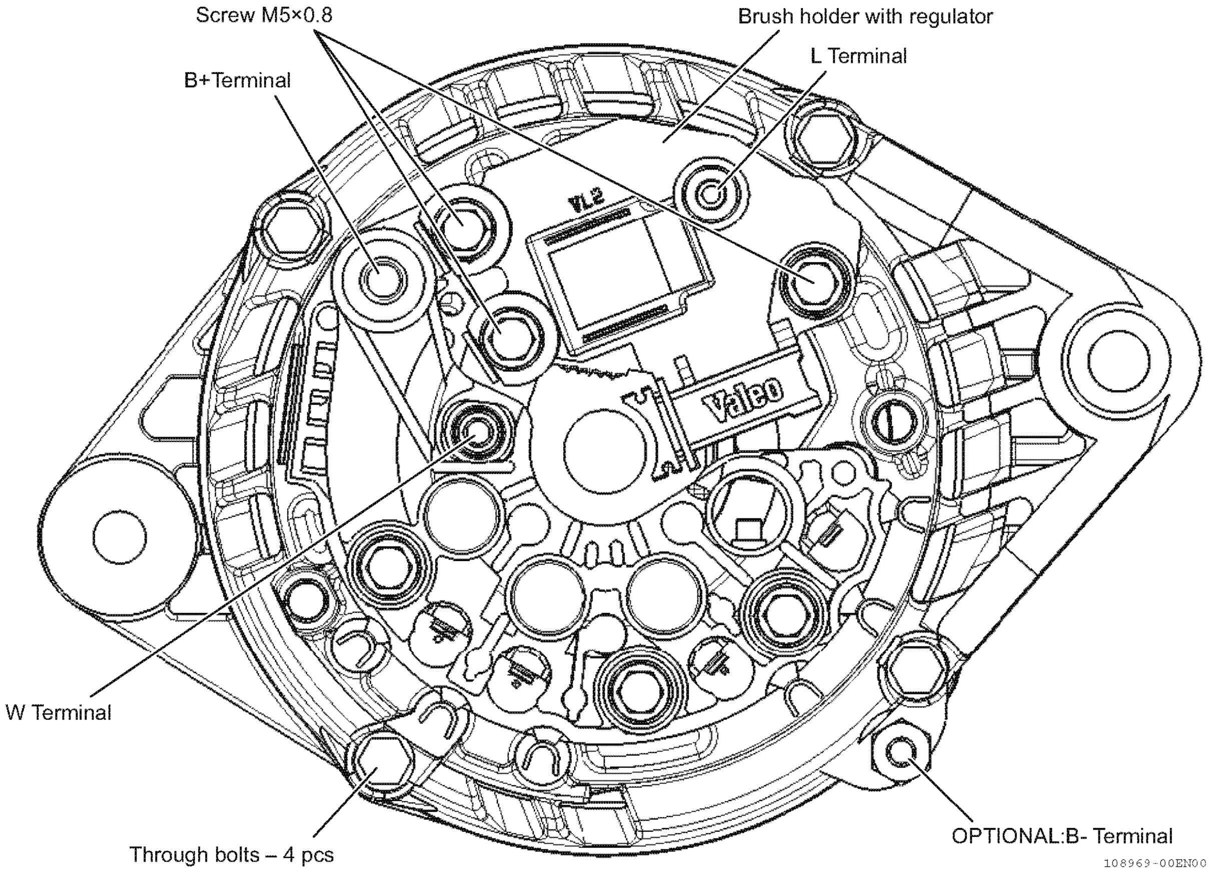


Figure 10-11

ALTERNATOR FUNCTIONING

By the rotation of the rotor, a three phase AC current is generated in stator winding. It must be converted into DC output. This conversion process is referred to as “Rectification” and realized by the rectifier. The wave form of voltage obtained across the output terminal B+

A too high charge in the battery will cut the rotor electrical feeding, while a too low charge will allow its feeding. This “controller” function is supported by the regulator.

128990-77250

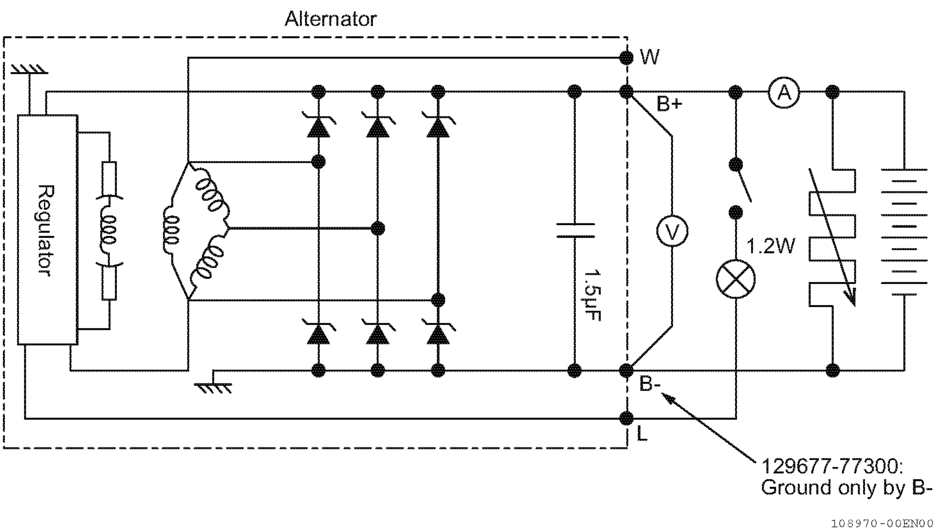


Figure 10-12

ALTERNATOR FUNCTIONING

Charging Failure

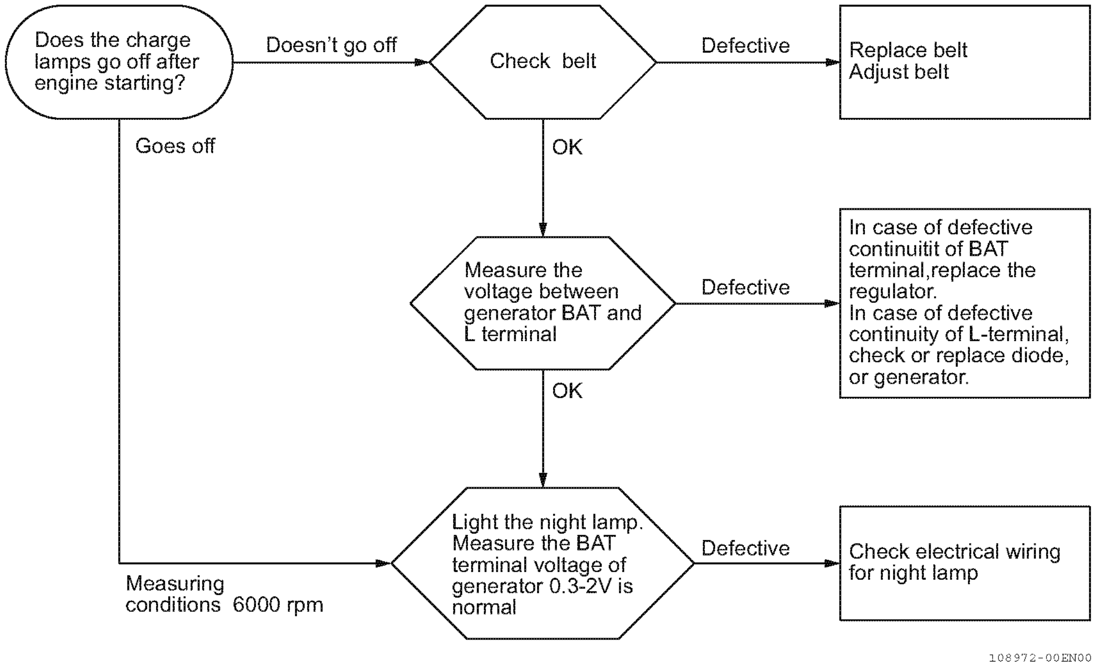


Figure 10-13

Overcharging

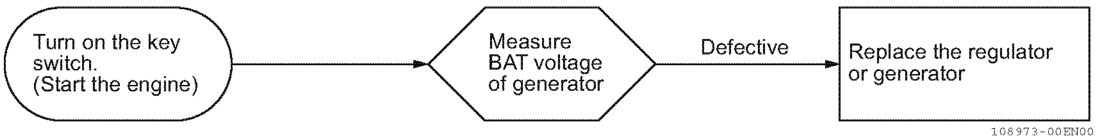


Figure 10-14

Charge Lamp Failure

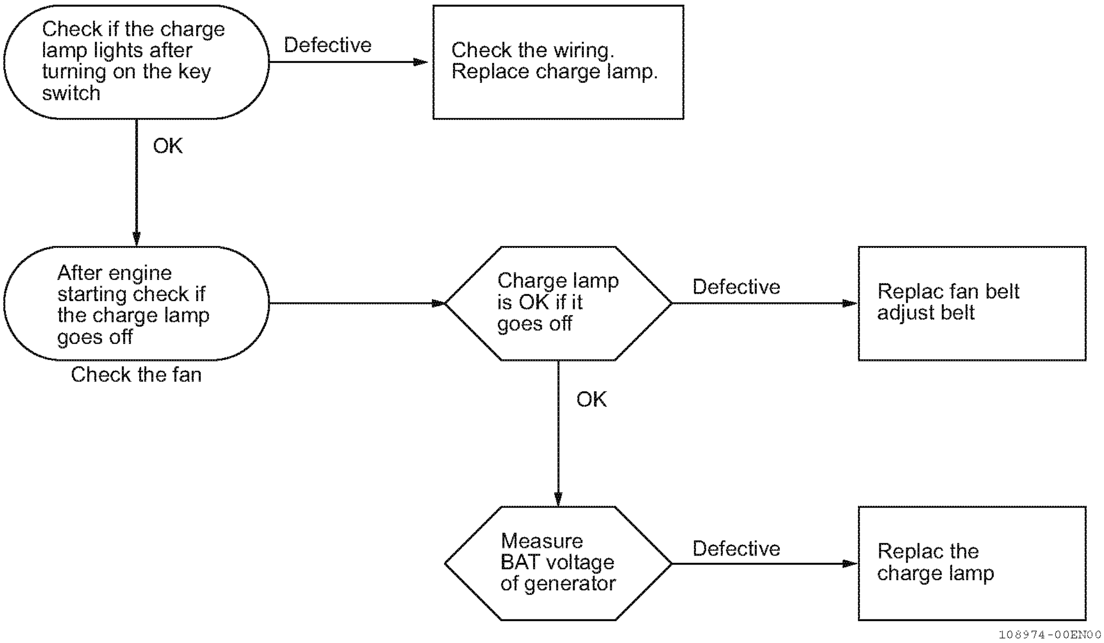


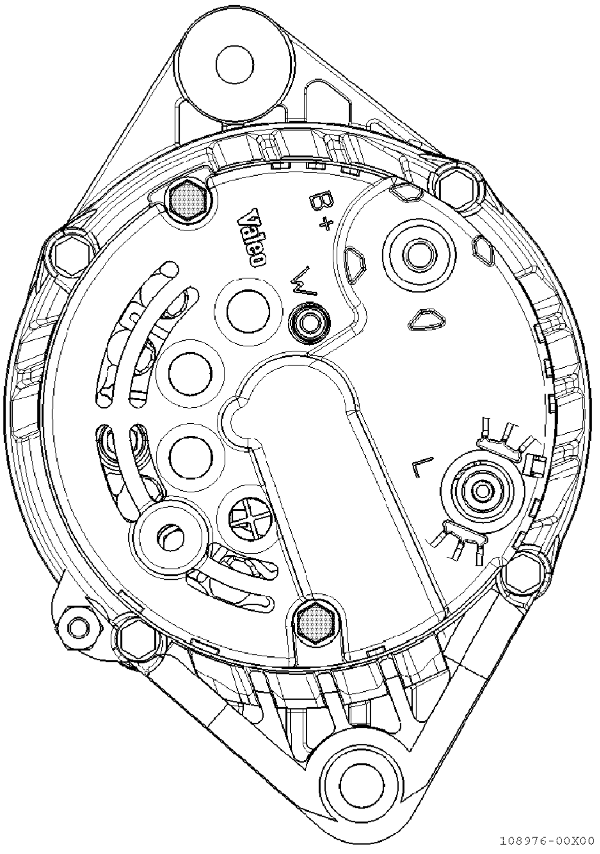
Figure 10-15

HANDLING PRECAUTIONS

- Do ensure that all electrical connections are clean and secured.
- Disconnect all alternator terminals while carrying out welding job on the vehicle.
- Disconnect the battery earth cable before removing the alternator.
- Be careful of the battery's polarity and do not connect the wrong terminals to the wrong cables.
- Do not flash the alternator output leads to check working of alternator assy.
- Do not run the alternator with the battery disconnected.
- Do not disconnect any lead of alternator with the engine in running condition.
- Do not disconnect battery cables while the engine is running.

DISASSEMBLING - SPARE PART REPLACEMENT

1. Cover – unscrew 2 of M5 screws and pull out axially cover.



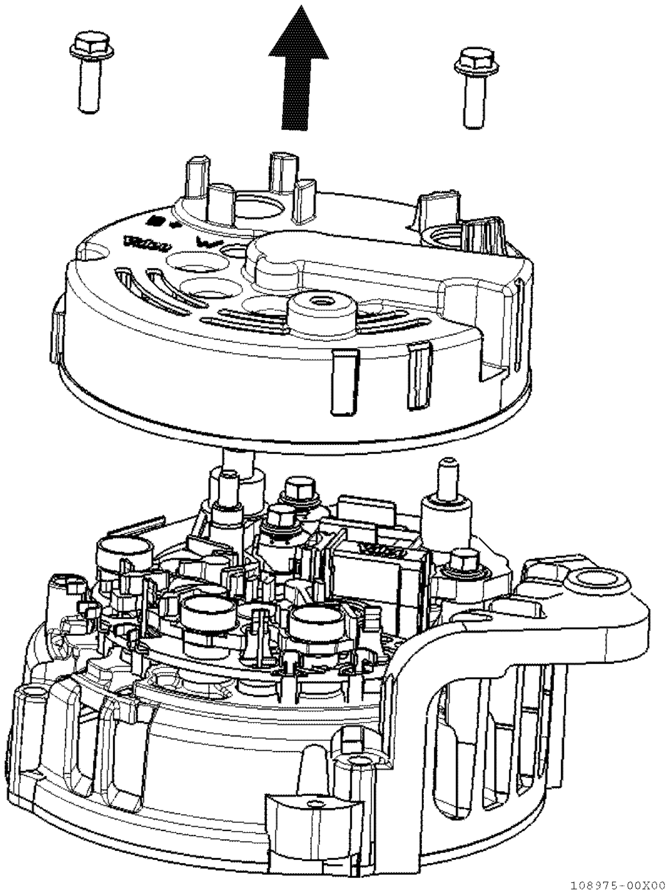


Figure 10-16

2. Regulator - unscrew 3 of M5 screws from regulator.

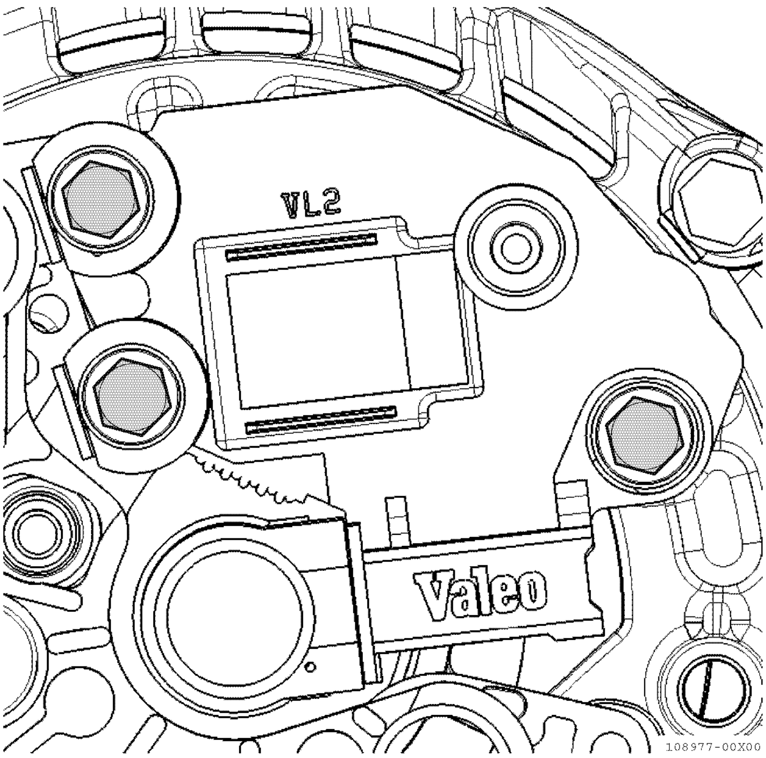


Figure 10-17

3. – remove screws and pull out axially regulator.

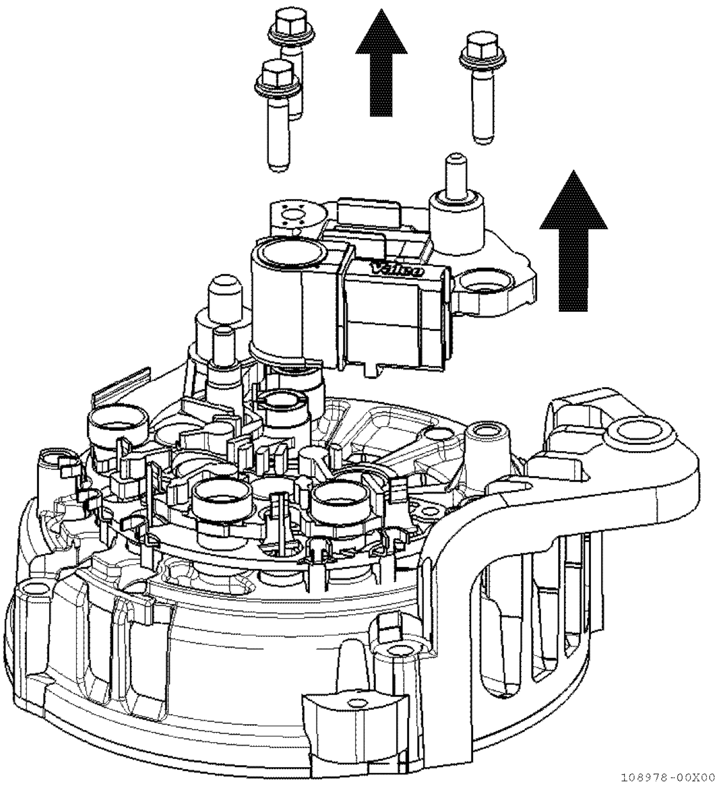
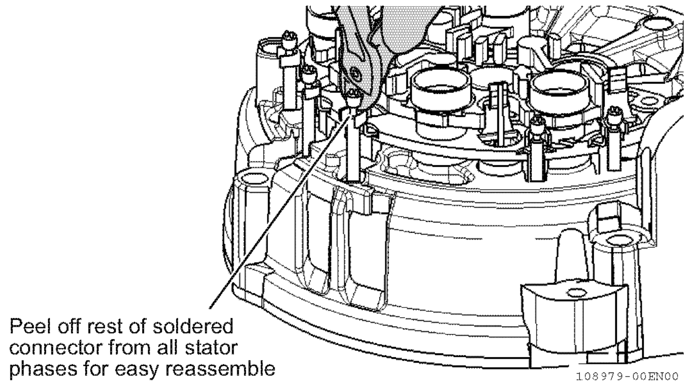


Figure 10-18

4. Rectifier – cut all rectifier connectors with do not damaging stator phases for replacement rear bracket and rectifier assembly.



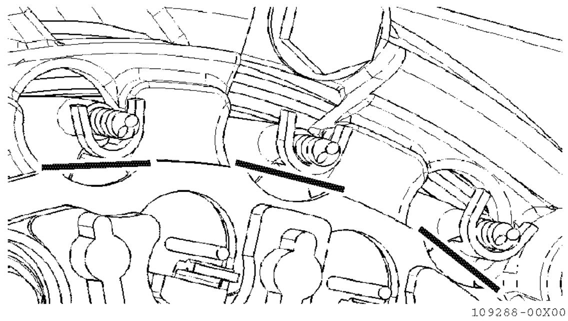


Figure 10-19

5. – unscrew 4 of M5 through bolts which maintain rear bracket assy.

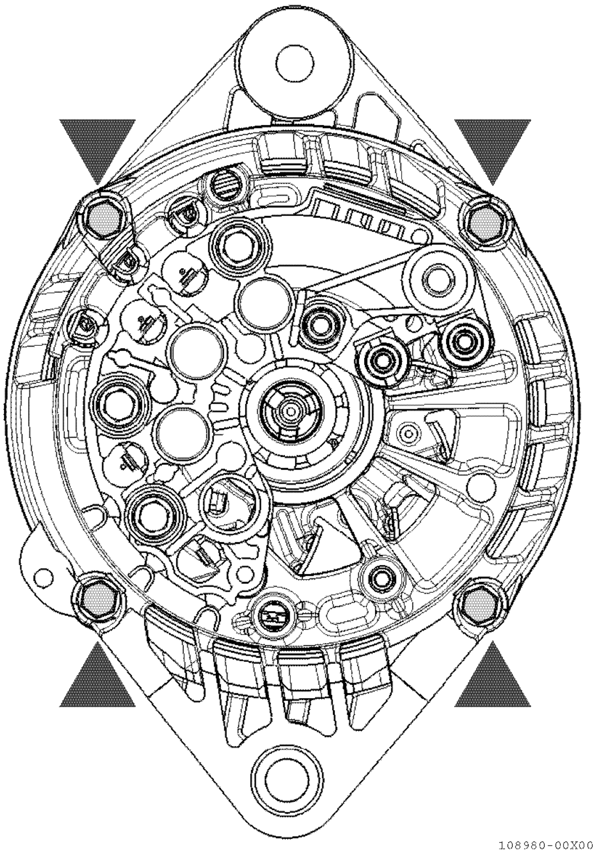


Figure 10-20

6. Remove the through-bolts, and separate the front assembly from the rear assembly.

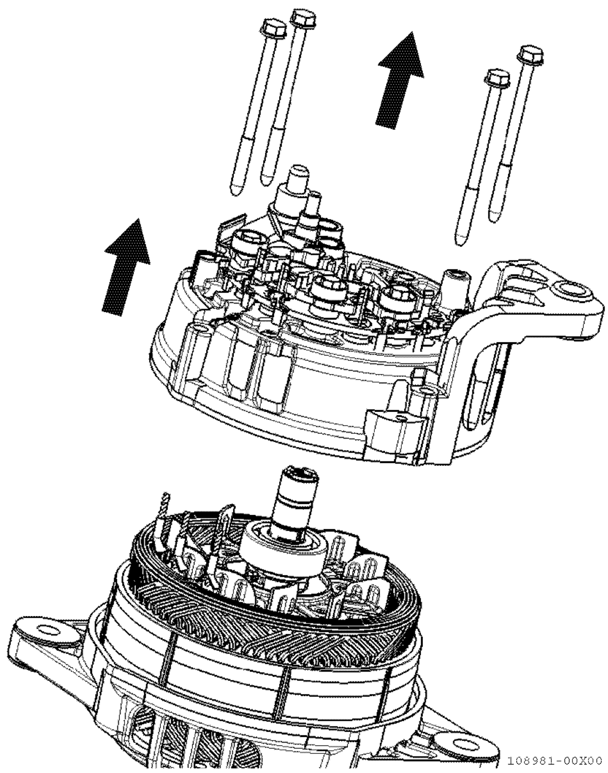


Figure 10-21

7. Bush - lever bushes by slotted screwdriver.

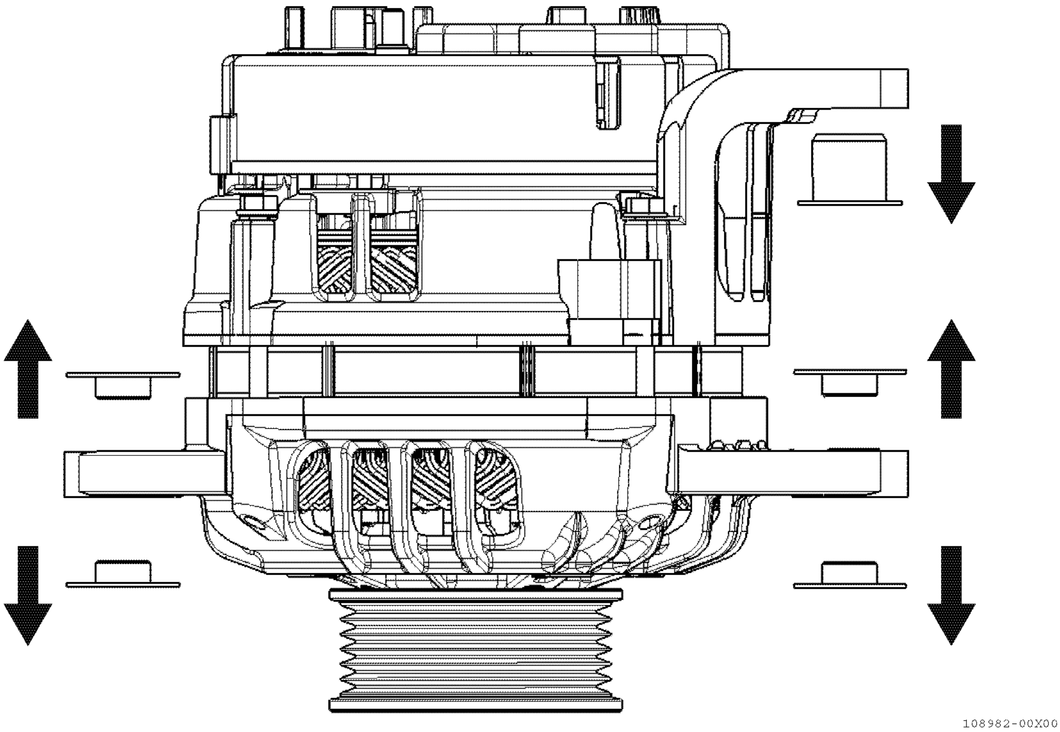


Figure 10-22

8. Pulley – unscrew M16 screw and pullout axially pulley.

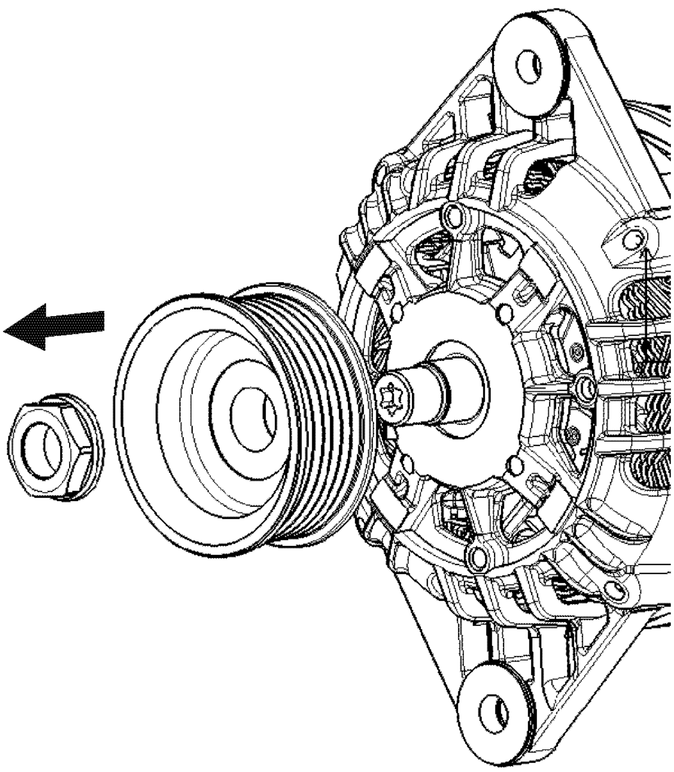


Figure 10-23

INSPECTION AND ADJUSTMENT

Rectifier Diode

- Use the multimeter mass probe (-) to positive terminal and the (+) to the diode connection [P1], [P2], [P3].
- Use the multimeter positive probe (+) to bracket and the (-) to the diode connection [P1], [P2], [P3].
- It should not indicate open circuit : Replace the rectifier assembly if it is open circuit.

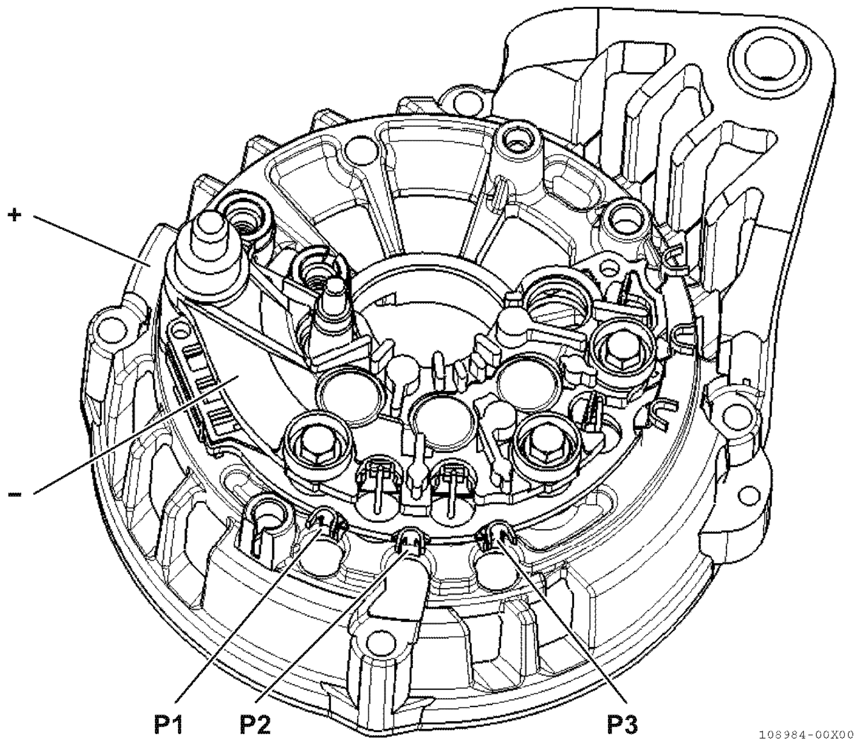


Figure 10-24

REASSEMBLING THE ALTERNATOR - GOES IN OPPOSITE STEPS TO DISASSEMBLE

1. Fix the pulley by M16 nut – make sure that you are using proper tools (key 24 and torx T50) maximum torque allowed it is indicated on drawing (generally 75 to 82 Nm).

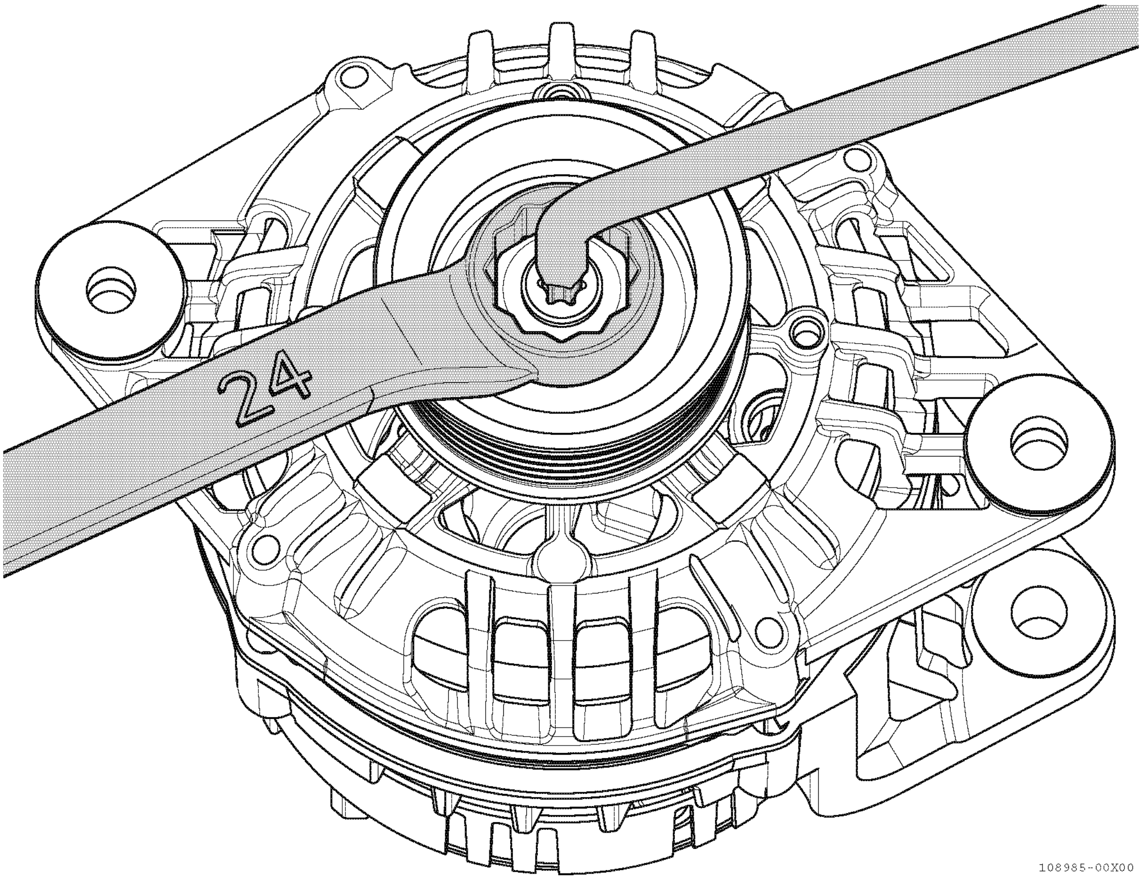


Figure 10-25

2. Rectifier – assemble firstly rear bracket assembled with rectifier and after tighten 4 pieces of M5 screws with torque 5.5 to 7 Nm, according to the cross rule of twist.

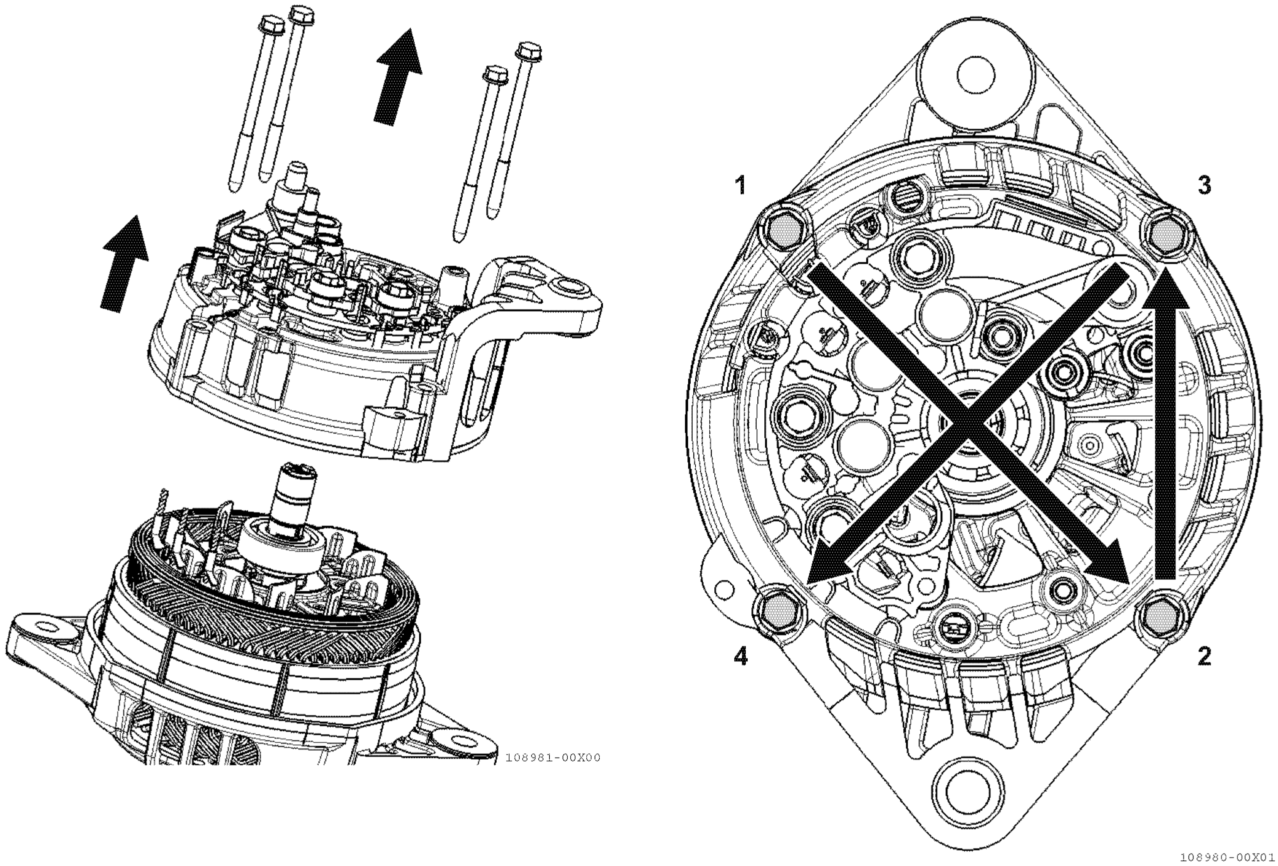


Figure 10-26

3. Regulator – Valeo recommend to replace once disassembled regulator for new one, which originally protect brushes against damage during assembly to alternator. Tightening torque for M5 regulator screws 2 to 3 Nm. After screwing regulator, push down protective cap (3) to release brushes.

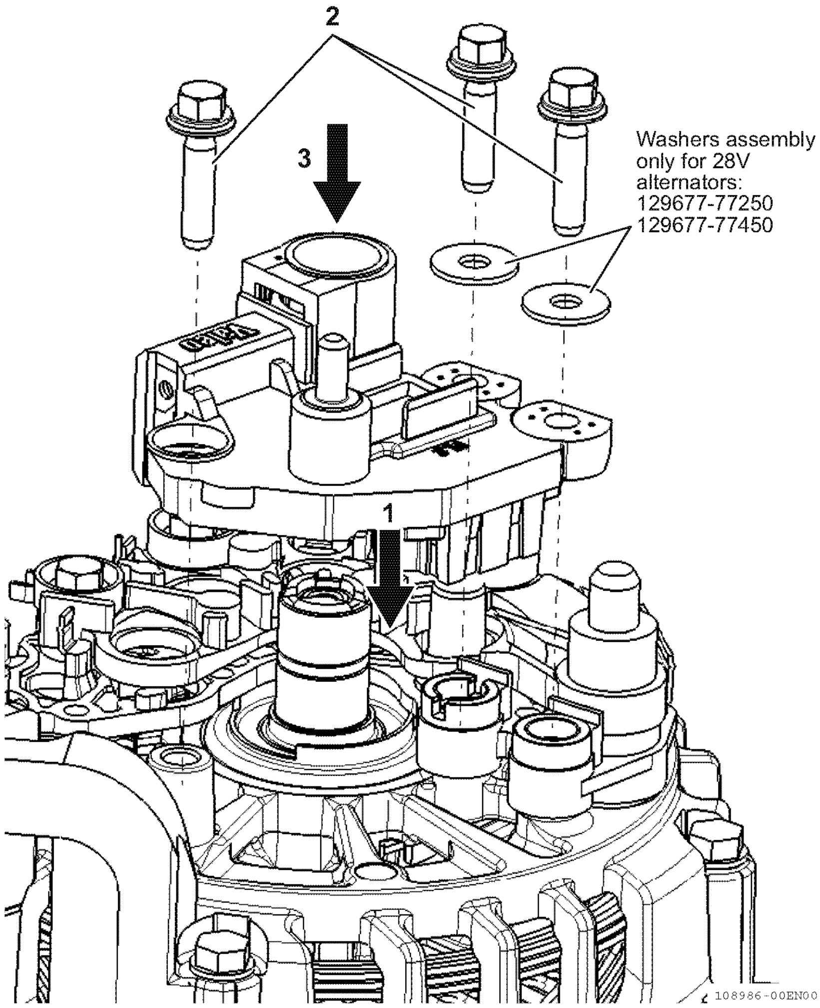


Figure 10-27

4. Cover – assembly axially with screws holes and tighten by M5 screw 2 to 3 Nm.

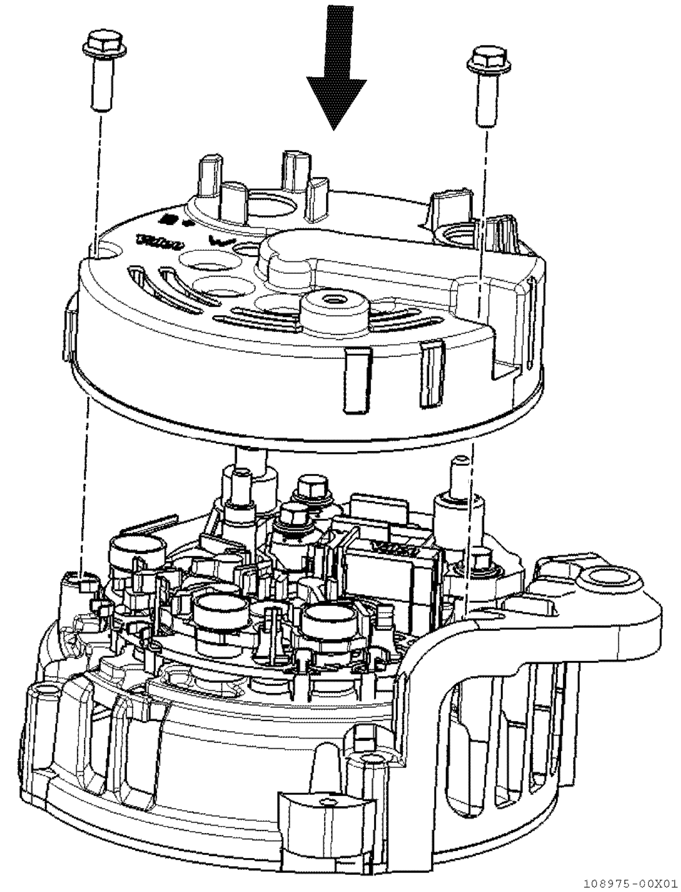


Figure 10-28

5. Bushes – press isolation brushes to alternator bracket by hand or with vise.

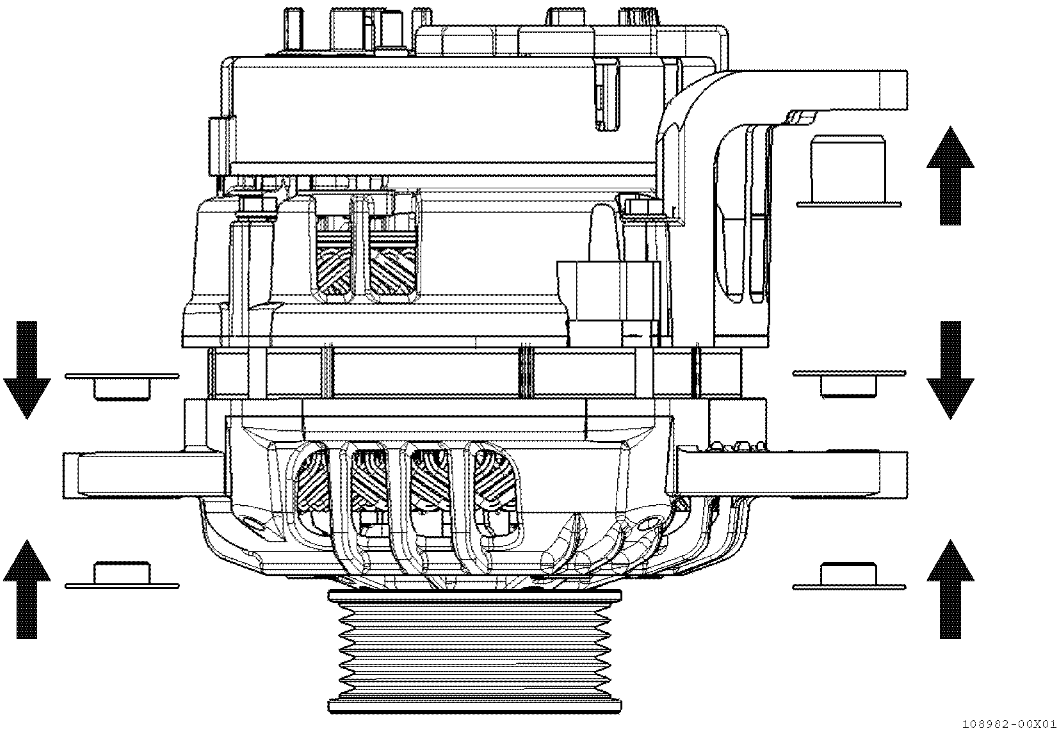


Figure 10-29

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Section 11

ELECTRICAL SYSTEM

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SAFETY PRECAUTIONS

Before servicing the electrical components, review the *Safety Section on page 2-1*.

⚠ WARNING

The safety messages that follow have WARNING level hazards. These safety messages describe a hazardous situation which, if not avoided, could result in death or serious injury.

Shock Hazard

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

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

INTRODUCTION

This section of the *Service Manual* contains assembly information, schematics, wiring diagrams, illustrations and procedures that familiarize and guide service technicians in diagnosing and repairing problems with the electrical systems used on the 3YM30AE, 3YM30, 3YM20 and 2YM15 marine engines.

ELECTRICAL SYSTEM COMPONENTS

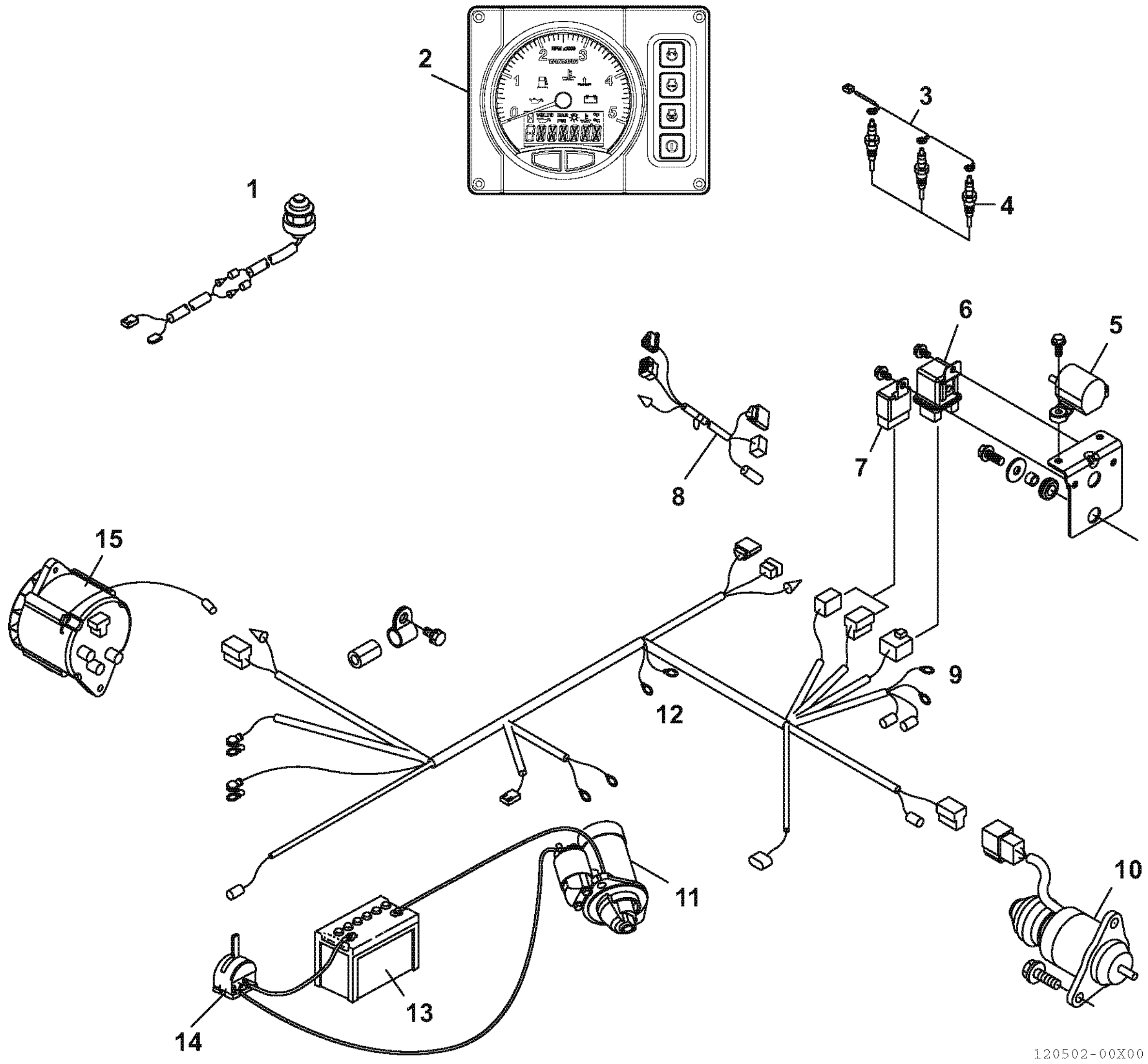

Figure 11-1

1 – Neutral Safety Switch (fitting to marine gear)
2 – B20 Type Instrument Panel
3 – Glow Connector
4 – Glow Plugs
5 – Magnet Relay
6 – Glow Relay
7 – Safety Relay
8 – Wire Harness Extension
9 – Oil Pressure Switch and Coolant Temperature Switch Connectors
10 – Stop Solenoid
11 – Starting Motor
12 – Ground
13 – Battery
14 – Battery Switch
15 – Alternator

WIRING DIAGRAMS

Color Coding	
R	Red
B	Black
W	White
L	Blue
RB	Red / Black
LB	Blue / Black
YW	Yellow / White
YG	Yellow / Green
WL	White / Blue
WG	White / Green
GR	Green / Red
O	Orange
WBr	White / Brown

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)

2YM15, 3YM20, 3YM30, 3YM30AE - B20 Type Instrument Panel

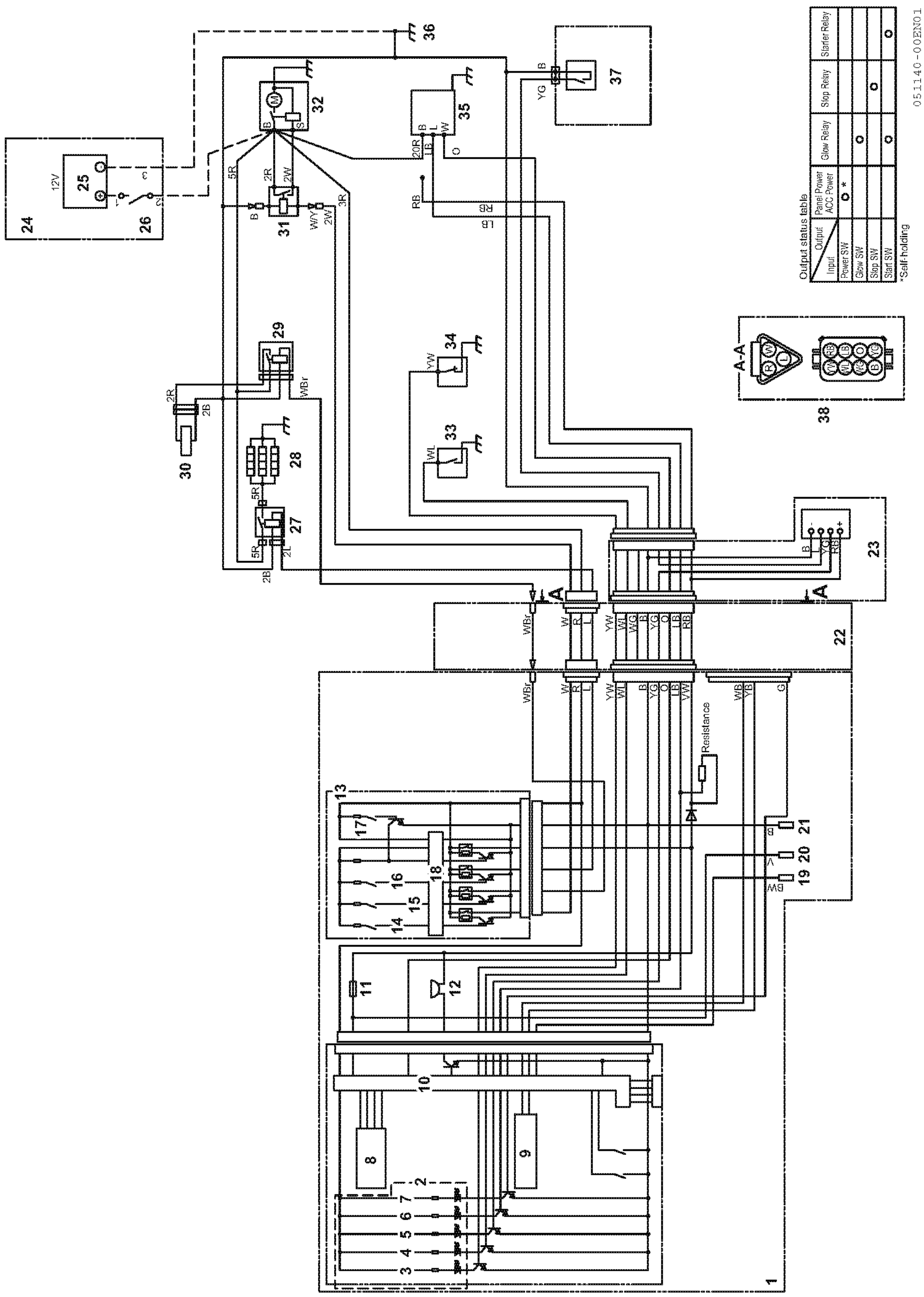

Figure 11-2

1 – Instrument panel B20
2 – Alarm lamps (3 to 7)
3 – Engine oil low pressure indicator
4 – Coolant high temperature Indicator
5 – Water in sail drive seal indicator
6 – Battery low charge indicator
7 – Water in fuel filter indicator
8 – Tachometer
9 – Segmented display
10 – Control unit (tacho gauge)
11 – Fuse 3 A
12 – Buzzer
13 – Switch module (14 to 18)
14 – Start switch
15 – Stop switch
16 – Glow switch
17 – Power switch
18 – Control unit (switch module)
19 – Fuel tank level sensor input
20 – ACC power
21 – ACC GND
22 – Wire harness
23 – Water in sail drive seal sensor amplifier (sail drive only)
24 – Procured by customer
25 – Battery
26 – Battery switch
27 – Relay (glow plug)
28 – Glow plug
29 – Stop relay
30 – Engine stop solenoid
31 – Starter relay
32 – Starter
33 – Coolant temperature switch
34 – Engine oil pressure switch
35 – Alternator
36 – Ground
37 – Water in sail drive seal sensor (sail drive only)
38 – Details of coupler (wire harness, view from A-A)

BATTERY COMPONENTS AND FUNCTIONS

The battery utilizes chemical action to convert chemical energy to electrical energy. This engine uses a lead-acid battery which stores a fixed amount of power that can be used when required. After use, the battery can be recharged and used again.

As shown in **Figure 11-3**, a non-conducting container is filled with dilute sulfuric acid electrolyte. Lead dioxide positive (+) plates **(Figure 11-3, (7))** and lead dioxide negative (-) plates **(Figure 11-3, (5))** separated by separator plates **(Figure 11-3, (6))** are stacked alternately in the electrolyte. The positive (+) and negative (-) plates are connected to their respective terminals **(Figure 11-3, (1))**.

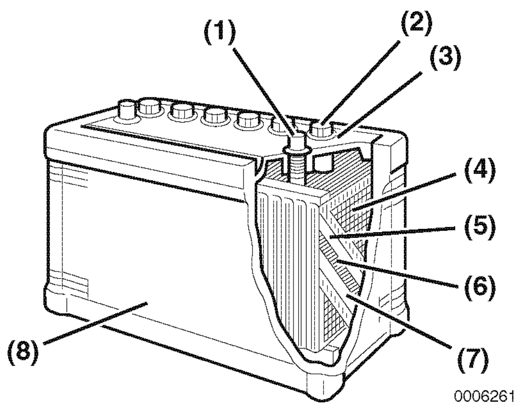

Figure 11-3

1 – **Terminal**
2 – **Filler Cap**
3 – **Cover**
4 – **Glass Mat**
5 – **Negative Plate**
6 – **Separator Plate**
7 – **Positive Plate**
8 – **Battery Case**

Power is removed from the battery by connecting a load across the two terminals.

When the battery is discharging, an electric current flows from the positive (+) plates to the negative (-) plates. When the battery is being charged, electric current is passed through the battery in the opposite direction by an external power source.

Battery Capacity

Battery Capacity (5 hour rating)	12V-64 AH or more (Type 95D31L or equivalent)

Battery Cables

Battery cables should be selected with the correct size and length in mind. As a rule, thick cables are kept to the minimum required length and should be used to connect the battery to the starter.

Using wires other than those specified may cause the following troubles:

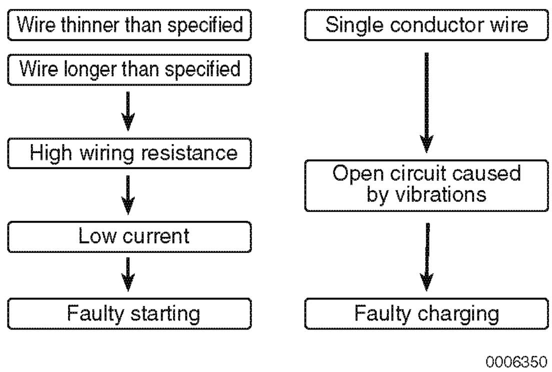

Figure 11-4

The overall length of the wire between the battery positive (+) terminal and the starter (B) terminal, and between the battery negative (-) terminal and the starter (E) terminal, should be determined according to the following table.

Voltage System	Allowable Wiring Voltage Drop	Conductor Cross Section	Allowable Overall Length
12 V	0.2 V or less at 100A	20 sq mm (0.03 sq in.)	Up to 2.5 m (8.2 ft)
		40 sq mm (0.06 sq in.)	Up to 5 m (16.4 ft)

NOTICE

Excessive resistance in the key switch circuit (between the battery and start [S] terminals) can cause improper pinion engagement. To prevent this, follow the wiring diagram carefully.

Inspecting the Battery

The strength of the battery's charge governs the starting performance of the engine. Inspect the battery routinely to ensure dependable starting performance. *See Checking the Battery Electrolyte Level on page 4-19* and *Measuring the Battery Charge on page 4-20.*

Charging the Battery

Charging Methods

There are two methods for charging a battery: normal and rapid. Rapid charging should only be used in emergencies.

Normal Charging

Normal charging should be conducted at a current of 1/10 or less of the indicated battery capacity (10A or less for a 100Ah battery).

Rapid Charging

Rapid charging is conducted over a short period of time at a current of 1/5 to 1/2 of the indicated battery capacity (20A to 50A for a 100Ah battery).

NOTICE

Rapid charging can increase the electrolyte temperature. Exercise care when rapid charging the battery.

Charging Procedure

1. Check the specific gravity and adjust the electrolyte level.
2. Disconnect the battery cables.
3. Connect the red clip of the charger to the positive (+) battery terminal and connect the black clip to the negative (-) terminal.

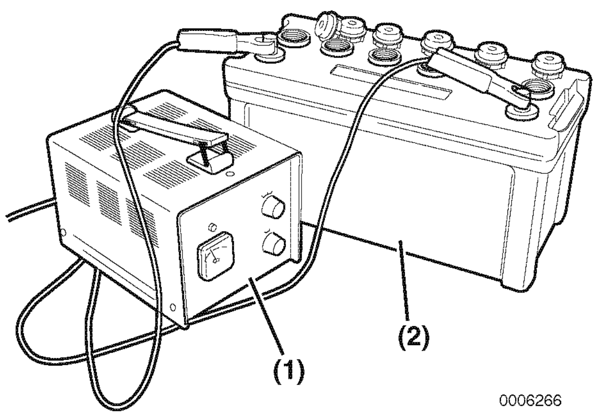

Figure 11-5

1 – Battery Charger
2 – Battery

4. Set the current to 1/10 to 1/5 of the capacity indicated on the outside of the battery **(Figure 11-5, (2))**.
5. Periodically measure the specific gravity during charging to make sure the specific gravity remains at a high fixed value. Also check whether gas is being generated.

Charging Precautions

NOTICE

Since an alternator is used on this engine when charging with a charger, always disconnect the battery cables to prevent damaging the diodes in the alternator.

Disconnect the negative (-) cable first

- Remove the battery caps to vent the gas during charging.
- The electrolyte temperature should not exceed 45°C (113°F) during charging.

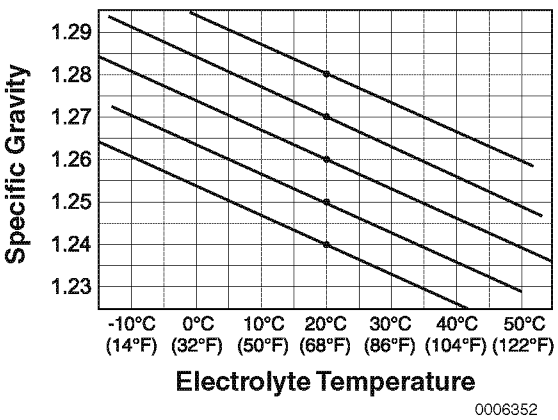

Figure 11-6

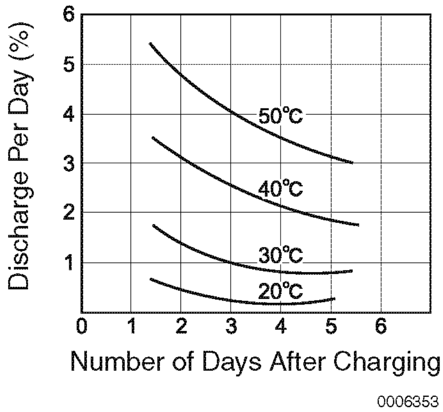

Figure 11-7

If charging with the engine alternator is insufficient because of frequent starts and stops, the battery will rapidly lose power. Charge the battery as soon as possible when it is used under these conditions.

An easy-to-use battery charger is available from Yanmar. Take proper care of the battery by using a battery charger **(Figure 11-8, (1))** and hydrometer.

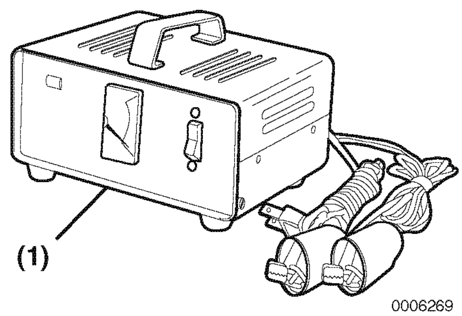

Figure 11-8

1 – **Battery Charger**

When the specific gravity drops to about 1.16, charge the battery up to a specific gravity of 1.26 (24 hours). Before putting the battery in storage for long periods, charge it for about 8 hours.

Precautions for Battery Storage

The life of a battery depends on the way it is handled. After about 2 years, its performance will deteriorate and replacement will be necessary.

A battery will discharge about 0.5% per day when not in use. It must be charged one to two times a month while in storage.

INSTRUMENT PANEL

The 3YM30AE, 3YM30, 3YM20 and 2YM15 use the B20 type panel.

B20 Type Instrument Panel

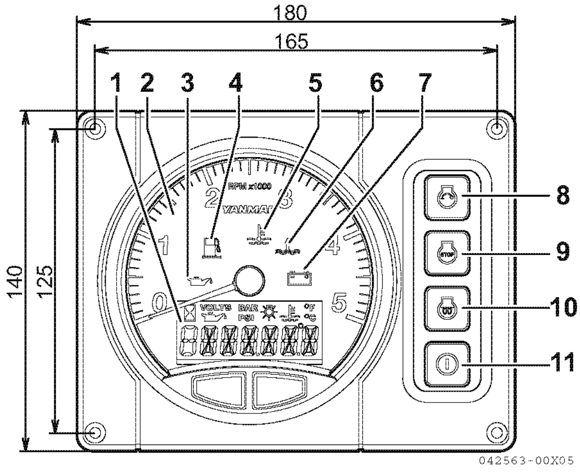

Figure 11-9

1 – LCD
2 – Tachometer
3 – Engine oil low pressure indicator and alarm
4 – This feature is not available on this engine.
5 – Coolant high temperature indicator and alarm
6 – Water in sail drive seal indicator and alarm
7 – Battery low charge indicator
8 – Start switch
9 – Stop switch
10 – Glow switch
11 – Power switch

ALARMS

After engine start, make sure that the warning devices operate correctly and according to “After start” in the below table.

- All alarm lamps turn off. The above check tells you whether the electric circuit for the warning lamps and alarm buzzer operate correctly. If they do not operate correctly, inspection and repair are required. Consult your dealer or distributor for repairs.

Correct operation of the warning devices				
Instrument panel (power switch)	Power ON			
	Immediately	After 2 seconds	After 4 seconds	
	Before start engine			Running
Alarm buzzer	ON			OFF
Charge lamp	ON	ON	ON	OFF
Coolant temperature lamp	ON	ON	OFF	OFF
Engine lubricating oil pressure lamp	ON	ON	ON	OFF
LCD display	Yanmar	Full display	Hourmeter	

WARNING DEVICES

Oil Pressure Switch

The contacts **(Figure 11-10, (2))** of the oil pressure switch are normally closed.

Oil Pressure Switch

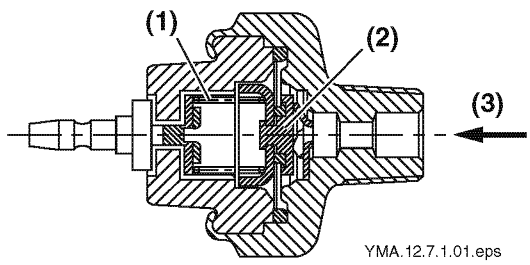

Figure 11-10

1 – **Spring**
2 – **Contacts**
3 – **Oil Pressure**

When the main power switch **(Figure 11-11, (3))** on the instrument panel is in the ON position and the engine is running, oil pressure **(Figure 11-11, (7))** forces the contact points to open.

Oil Pressure Alarm Circuit

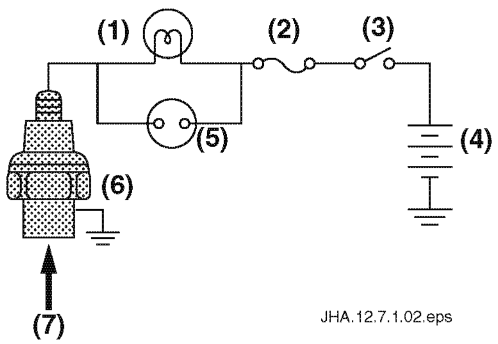

Figure 11-11

1 – **Warning Indicator**
2 – **Fuse**
3 – **Main Power Switch**
4 – **Battery**
5 – **Audible Alarm Buzzer**
6 – **Oil Pressure Switch**
7 – **Oil Pressure**

This opens the circuit to ground and allows the engine to run. When engine oil pressure drops below 0.01 to 0.03 MPa (1.5 to 4.3 psi), the contacts are closed by spring pressure and the warning indicator **(Figure 11-11, (1))** and audible alarm **(Figure 11-11, (5))** are activated.

The oil pressure switch **(Figure 11-12, (3))** is located on the right side of the engine (viewed from flywheel) near the oil filter **(Figure 11-12, (2))**.

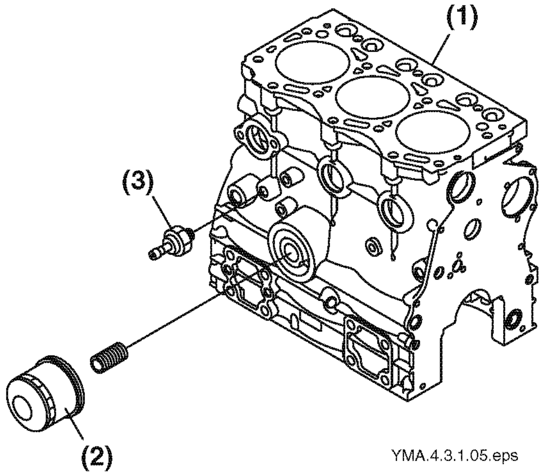

Figure 11-12

1 – Cylinder Block
2 – Oil Filter
3 – Oil Pressure Switch

Oil Pressure Switch Specifications

Rated Voltage	12VDC
Operating Pressure	0.04 to 0.06 MPa (6 to 9 psi)
Indicator Capacity	5 W

Troubleshooting the Oil Pressure Alarm

Problem	Probable Cause	Procedure	Corrective Action
Indicator not illuminated when main switch set to ON	Oil pressure indicator blown out	(1) Visual inspection (2) Indicator not illuminated even when main switch set to ON position and terminals of oil pressure sensor grounded	Replace indicator
	Operation of oil pressure sensor	Indicator illuminated when checked as described in (2) above	Replace oil pressure sensor
Indicator will not go out when 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	Sensor is faulty if abnormal at (1) and (2) above	Replace oil pressure sensor
	Wiring between indicator and oil pressure sensor faulty	Check the wiring harness for continuity or shorts	Repair wiring harness

Coolant Temperature Switch

A coolant temperature indicator **(Figure 11-13, (1))** and an audible alarm buzzer **(Figure 11-13, (5))** are mounted in the instrument panel.

Coolant Temperature Alarm Circuit

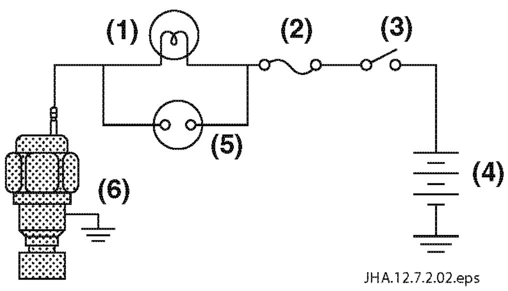

Figure 11-13

1 – Warning Indicator
2 – Fuse
3 – Main Switch
4 – Battery
5 – Alarm Buzzer
6 – Coolant Temperature Switch

The indicator and buzzer are wired to a coolant temperature switch **(Figure 11-14, (1))** that is installed in the coolant pump **(Figure 11-14, (2))**.

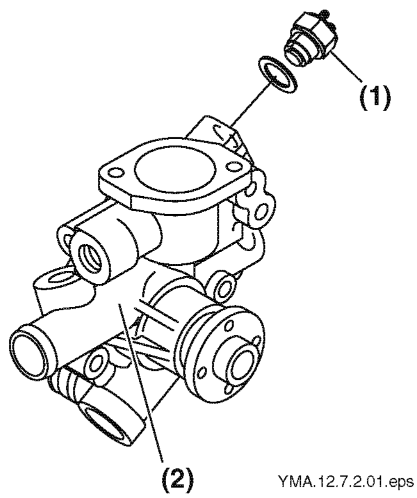

Figure 11-14

1 – Coolant Temperature Switch
2 – Coolant Pump

The switch is normally open (NO). When the coolant temperature rises to a dangerous level, the switch contacts close. This activates the warning indicator and the audible alarm buzzer.

Coolant Temperature Switch Specifications

Operating Temperature	On	93° to 97°C (199° to 206°F)
Electric Capacity		12VDC 1A
Response Time		60 seconds
I.D. Color		Black
Tightening Torque		23.54 to 31.38 N·m (17 to 23 lb-ft)

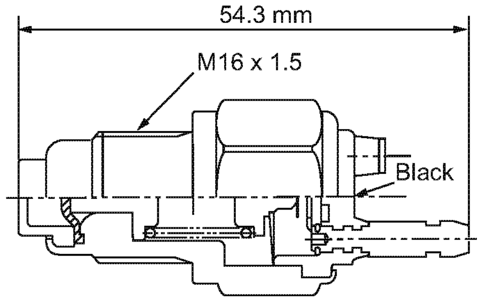

Figure 11-15

GLOW PLUGS

Glow plugs are provided to warm intake air when starting in cold temperatures.

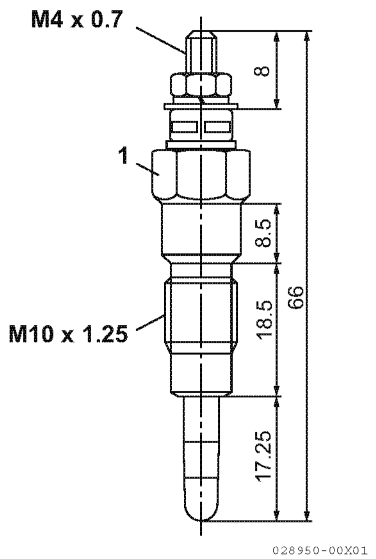

Figure 11-16

1 – **Hexagon 12 mm (0.472 in.) Width Across Flat**

The glow plugs **(Figure 11-17, (2))** are mounted to the cylinder head **(Figure 11-17, (3))** and are operated by the glow plug switch on the instrument panel.

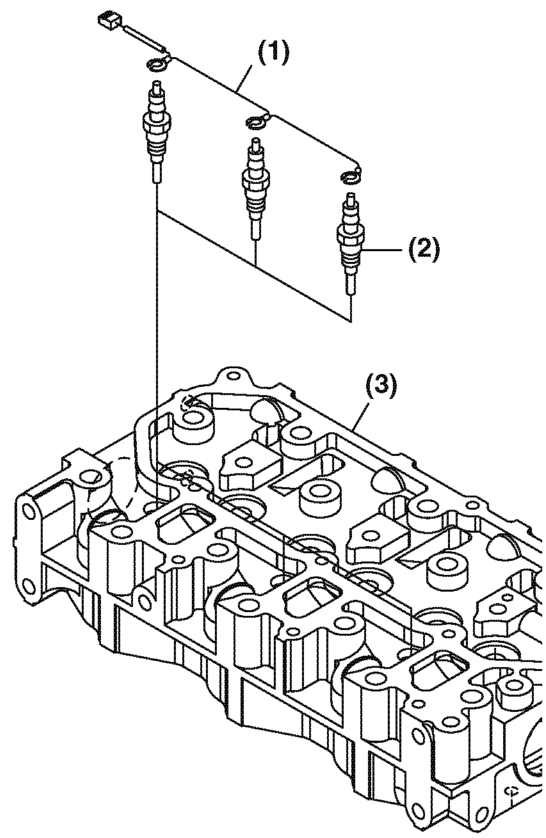

Figure 11-17

1 – **Glow Plug Connectors**
2 – **Glow Plug**
3 – **Cylinder Head**

Glow Plug Specifications

Rated Current	8 to 10 A
Rated Voltage	11VDC

STOP SOLENOID

The electric engine stop device is fitted to the governor. The device is operated by the stop switch on the instrument panel.

The emergency stop button is integrated with the solenoid. When the stop button is pushed, the engine will shut down.

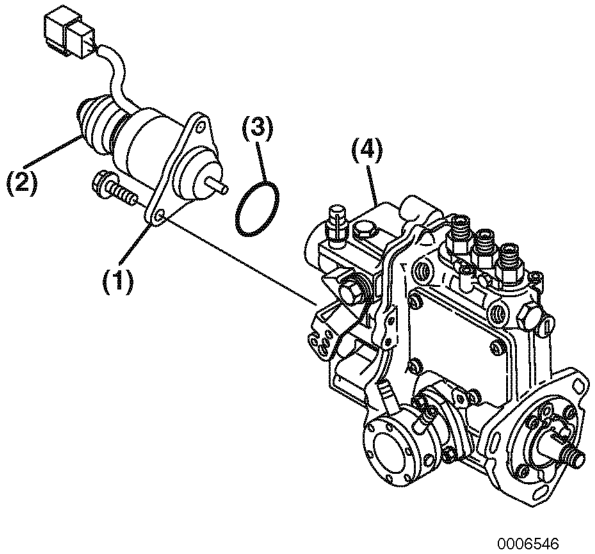

Figure 11-18

1 – Stop Solenoid
2 – Emergency Stop Button
3 – O-Ring
4 – Governor

Section 12

TROUBLESHOOTING

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SAFETY PRECAUTIONS

Before you troubleshoot, perform any troubleshooting procedures and 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

Problem / Symptom	Cause	Action	Reference
Engine Will Not Crank	Discharged battery	Charge / replace battery	See OEM Information
	Blown fuse	Replace fuse	*See Wiring Diagrams on page 11-5, 11-8*
	Defective starter motor	Replace starter motor	*See Starter Motor on page 5-94* *See Starter on page 9-1*
	Loose wiring connections	Tighten connections	*See Wiring Diagrams on page 11-5*
	Faulty connection in starting switch	Repair using sandpaper or replace	*See Starter Wiring Diagram on page 9-7*
	Rough cap movement	Repair using sandpaper and then grease	*See Starter Motor on page 5-94* *See Starter on page 9-1*
	Edges of gear teeth misshapen	Adjust	
	Piston ring sticks	Disassemble and repair or replace	*See Inspecting the Pistons, Piston Pins and Piston Rings on page 5-45*
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 Feed Pump Components and Functions on page 6-15*
	No fuel to cylinders	Clean or replace clogged pre-filter (if equipped)	*See Fuel Filter Components and Functions on page 6-18*
		Clean or replace fuel filter / water separator	
		Replace clogged fine filter	
		Bleed fuel system	
		Check fuel injection pump and replace if necessary	*See Removing the Fuel Injection Pump on page 6-10*
		Check fuel injection nozzle and replace if necessary	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
		Check fuel injection pipes and replace if necessary	*See Fuel System on page 5-85*
	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 Cylinder Head on page 5-29*
	Governor handle is in STOP position	Move governor handle to acceleration position	*See Fuel Adjustment Procedures on page 6-9*
	Low ambient temperature	Install optional glow plug control	–
		Install block heater	–
	Oil viscosity too high	Replace with correct viscosity oil for operating conditions	*See Engine Oil Specifications on page 3-8*

Exhaust Color

Problem / Symptom	Cause	Action	Reference
White Smoke	Cold engine	Allow engine to warm to operating temperature	–
		Defective thermostat, replace	*See Inspecting the Thermostat on page 4-37* *See Thermostat Components and Functions on page 7-16*
	Incorrect fuel	Replace fuel with correct type	*See Diesel Fuel Specifications on page 3-6*
	Incorrect fuel injection nozzle	Test / replace fuel injection nozzle	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
	Injection timing is incorrect	Adjust	*See Checking the Fuel Injection Timing on page 4-29*
White Smoke with Water Vapor	Leaking cylinder head gasket	Repair	*See Cylinder Head on page 5-29* *See Compression Test on page 12-10*
	Cracked cylinder head	Repair as necessary	
	Cracked cylinder		
Blue Smoke	Worn piston rings / cylinders	Repair as necessary	*See Inspecting the Pistons, Piston Pins and Piston Rings on page 5-45* *See Engine Cylinder Block on page 5-68*
Black Smoke Under Load	Clogged air filter	Clean / replace air filter	*See Cleaning Intake Silencer (Air Cleaner) Element on page 4-26*
	Incorrect valve timing	Check / correct camshaft installation	*See Adjusting the Valve Clearance on page 5-39*
	Low injection pressure	Adjust fuel injection nozzle	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
	Defective (leaking) fuel injection nozzle	Test / replace fuel injection nozzle	*See Removing the Fuel Injection Lines on page 5-86*
	Excessive exhaust back pressure	Correct as necessary	–
	Excessive intake suction loss	Correct as necessary	–
	Overloading	Reduce load	–

Vibration - Drive Disengaged

Problem / Symptom	Cause	Action	Reference
Rough at All Engine Speeds	Air in fuel system	Bleed fuel system	*See Fuel Filter Components and Functions on page 6-18*
	Faulty fuel injector	Replace as necessary	*See Fuel System on page 5-85*
	Leaking cylinder head gasket	Replace	*See Cylinder Head on page 5-29* *See Compression Test on page 12-10*
	Damaged intake or exhaust valves	Repair / replace as necessary	*See Inspecting Valve Components on page 5-34*
	Incorrect injection pressure	Check / replace fuel injection nozzle	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
		Check / replace fuel injection pump	*See Major Faults and Troubleshooting on page 6-12*
Vibration Increases with Engine Speed (Sail Drive Models)	Worn or damaged spline shaft	Replace as necessary	*See Sail Drive Service Manual*
Vibration Increases with Engine Speed	Loose parts	Tighten loose parts	–

Vibration - Drive Engaged

Problem / Symptom	Cause	Action	Reference
Rough at All Speeds	Engine and propeller shaft misaligned	Check and adjust	*See Principle Engine Specifications on page 3-34*
	Damaged bearing	Replace	*See Inspecting the Crankshaft and Bearings on page 5-58*
	Excessive backlash of gear	Repair / replace	*See Timing Gear Train on page 5-51*
	Leaking cylinder head gasket	Replace	*See Cylinder Head on page 5-29*
	Bent propeller shaft	Replace as necessary	See OEM information
Rough at Higher Speeds	Bent propeller	Replace as necessary	See OEM information
	Slipping clutch / clutch dog	Repair as necessary	*See Removing the Damper Disk on page 5-74*
	Incorrect injection pressure	Check / replace fuel injection nozzle	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
		Check / replace fuel injection pump	*See Removing the Fuel Injection Pump on page 6-10*

Engine Knocks

Problem / Symptom	Cause	Action	Reference
Excess Fuel Injected	Defective fuel injection nozzle	Check / replace fuel injection nozzle	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
	High fuel injection pressure	Check / replace fuel injection pump	*See Removing the Fuel Injection Pump on page 6-10*
Noise Changes with Engine Load	Incorrect or poor quality fuel	Drain and refill tank	*See Diesel Fuel on page 3-6*
	Worn crankshaft / bearings	Repair / replace as necessary	*See Inspecting the Crankshaft and Bearings on page 5-58*
	Broken piston / rings	Repair / replace as necessary	*See Inspecting the Pistons, Piston Pins and Piston Rings on page 5-45*

Low Power Output

Problem / Symptom	Cause	Action	Reference
Miscellaneous	Clogged intake air filter	Clean / replace	*See Cleaning Intake Silencer (Air Cleaner) Element on page 4-26*
	Leaking cylinder head gasket	Replace	*See Cylinder Head on page 5-29*
	Incorrect propeller	Replace	See OEM Information
	Excessive exhaust backpressure	Remove obstruction	–
Fuel	Plugged fuel filter(s)	Clean / replace as necessary	*See Fuel Filter Components and Functions on page 6-18*
	Faulty fuel feed pump	Replace	*See Fuel Feed Pump Components and Functions on page 6-15*
	Incorrect fuel quality	Replace with correct fuel	*See Diesel Fuel Specifications on page 3-6*
Low Fuel Injection Pressure	Defective fuel injection nozzle	Check / replace	*See Checking the Fuel Injector Spray Pattern on page 4-30* *See Fuel System on page 5-85*
	Worn fuel injection pump	Check / replace	*See Major Faults and Troubleshooting on page 6-12*
	Injection timing is incorrect	Adjust	*See Checking the Fuel Injection Timing on page 4-29*
Coolant	Insufficient coolant	Check / replace coolant pump	*See Engine Coolant on page 3-9* *See Installing the Coolant Pump on page 5-81*
Lubricating Oil Supply	Insufficient lubricating oil supply	Check / replace lubricating oil pump or lubricating oil level	*See Engine Oil Specifications on page 3-8* *See Oil Pump Components on page 8-5*

Problem / Symptom	Cause	Action	Reference
Governor	Damaged bearing	Replace	Contact Yanmar
	Governor link length incorrect	Repair	See OEM information
Low RPM at Wide Open Throttle	Propeller pitch too great	Replace	See OEM information
	Engine overheated	Reduce load / repair cooling system	*See Cooling System on page 5-77*

Engine Overheat

Problem / Symptom	Cause	Action	Reference
Instrument Shows High Temperature	Clogged seawater inlet	Clean	–
	Low coolant level	Fill with coolant / inspect for leak	*See Engine Coolant on page 3-9* *See Cleaning Intake Silencer (Air Cleaner) Element on page 4-26*
	Clogged seawater filter (if equipped)	Clean	–
	Clogged heat exchanger	Clean	*See Removing the Heat Exchanger Assembly, Cooling Hoses and Mixing Elbow on page 5-78*
	Seawater pump worn or damaged	Repair / replace as necessary	*See Removing the Seawater Pump on page 5-80*
	Defective sensor / instrument	Repair as necessary	*See Electrical System Components on page 11-4*
	Defective thermostat	Replace	*See Thermostat Components and Functions on page 7-16*
	Damaged closed coolant pump	Replace	*See Removing the Coolant Pump on page 5-80* *See Installing the Coolant Pump on page 5-81*
	Combustion gas leakage (causes loss of coolant)	Repair as necessary	*See Engine on page 5-1* *See Compression Test on page 12-10*
	Coolant water pump belt slips or pump pulley loose on pump shaft	Repair as necessary	*See Checking and Adjusting Alternator V-Belt Tension on page 4-13*
	Faulty lubricating oil pump	Check and repair / replace	*See Oil Pump Components on page 8-5*
	Over loading	Reduce load	NA

Engine Runs Cold

Problem / Symptom	Cause	Action	Reference
Instrument Shows Low Temperature	Defective sensor / instrument	Repair / replace as necessary	*See Electrical System Components on page 11-4*
	Defective thermostat	Replace	*See Inspecting the Thermostat on page 4-37* *See Thermostat Components and Functions on page 7-16*

Coolant Loss

Problem / Symptom	Cause	Action	Reference
Repeated Low Coolant Level	Defective cylinder head gasket (external leakage)	Replace	*See Cylinder Head on page 5-29*
	External leakage at connection	Repair as necessary	*See Heat Exchanger Body Water Leakage Test on page 4-33* *See Heat Exchanger Components and Functions on page 7-12*
Coolant Forced Out of Coolant Recovery Tank	Turbocharger pressure enters cooling system via leaking charge intercooler	Repair / replace as necessary	*See Coolant Recovery Tank Components and Functions on page 7-15*
White Smoke when Engine is Hot	Crack in cylinder head	Repair / replace as necessary	*See Cylinder Head on page 5-29*
	Leaking cylinder head gasket	Replace	

Lubricating Oil Pressure Low

Problem / Symptom	Cause	Action	Reference
Insufficient Lubricating Oil Supply	Clogged lubricating oil filter	Clean or replace filter element	*See Engine Oil Lubrication System on page 5-69*
	Damaged lubricating oil pump	Repair / replace as necessary	*See Oil Pump Components on page 8-5*
	Loose pressure adjustment valve	Tighten adjustment valve	
	Inadequate viscosity of lubricating oil	Change lubricating oil	*See Engine Oil Specifications on page 3-8*
	Insufficient amount of lubricating oil	Add lubricating oil	*See Checking the Engine Oil Level on page 4-7*
Instrument Faulty	Faulty pressure gauge	Replace	*See Checking Alarm Functions on page 4-8*
	Faulty pressure sensor or connector	Check / replace	*See Checking Alarm Functions on page 4-8* *See Electrical System Components on page 11-4*

Panel Display

Problem / Symptom	Cause	Action	Reference
No Display	Harness connector loose	Repair as necessary	*See Electrical System Components on page 11-4*
	Defective fuse	Replace	*See Wiring Diagrams on page 11-5*

Compression Test

Cylinder compression loss is caused by fuel and air gases escaping from the cylinder as the piston moves up during the compression stroke. It is the leading cause of poor engine starting, oil contamination, increased oil consumption and severely reduced engine performance.

Compression pressure loss can be caused by one or a combination of the following:

- Excessive clearance between piston rings and cylinder walls
- Intake and / or exhaust valves that do not seal on their seats
- A faulty or improperly installed injector nozzle gasket
- A faulty or improperly installed cylinder head gasket
- A crack or other damage in the cylinder head and / or cylinder block

The cylinder compression may also drop due to extended use and wear.

1. Start the engine and allow it warm up.
2. Remove the fuel injection lines and valves from the cylinder being measured.
3. Crank the engine freely before installing the compression gauge.
   - Crank the engine with the stop handle in the STOP position (no injection state).
   - *See Compression Gauge on page 5-23* for the specific compression gauge to use.
4. Install the compression gauge **(Figure 12-1, (1))** in the cylinder to be measured.

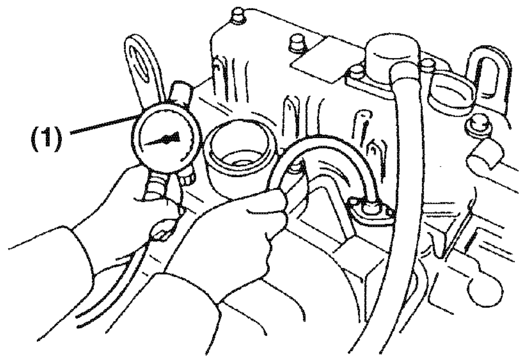

Figure 12-1

1 – Compression Gauge

5. Crank the engine with the starter motor until the compression gauge stabilizes.
6. Read the cylinder compression pressure and compare with the chart below.

Cylinder Compression Specifications

Model	Compression Pressure at 250 min^{-1}		Deviation Among Cylinders
	Standard	Limit	
3YM30AE / 3YM30	3.43 ± 0.1 MPa (497 ± 14 psi)	2.75 ± 0.1 MPa (398 ± 14 psi)	0.2 ± 0.3 MPa (29 ± 43 psi)
3YM20 / 2YM15	3.23 ± 0.1 MPa (468 ± 14 psi)	2.55 ± 0.1 MPa (369 ± 14 psi)	0.2 ± 0.3 MPa (29 ± 43 psi)

Engine Speed and Compression Pressure

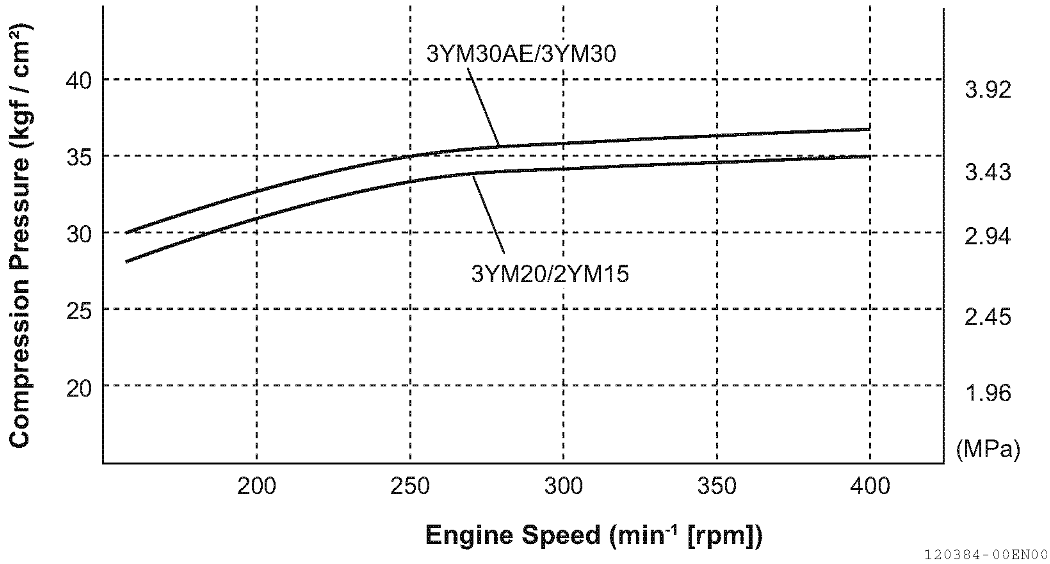

Figure 12-2

Measured Compression Value and Troubleshooting

When compression pressure is below the limit value, inspect each part using the table below.

No.	Item	Cause	Remedy	Reference
1	Air Cleaner Element	Clogged element Broken element Defect at element seal	Clean the element. Replace the element.	–
2	Valve Clearance	Excessive or no clearance	Adjust the valve clearance.	*5-39*
3	Valve Timing	Incorrect valve clearance	Adjust the valve clearance.	*5-39*
4	Cylinder Head Gasket	Gas leak from gasket	Replace the gasket. Retighten the cylinder head bolts to the specified torque.	*5-29*
5	Intake / Exhaust Valve Valve Seat	Gas leak due to worn valve seat or foreign matter Sticking valve	Lap the valve seat. Replace the intake / exhaust valve.	*5-33*
6	Piston Piston Ring Cylinder	Gas leak due to scratching or wear	Perform honing and use an oversized part.	–

AFTER TROUBLESHOOTING OR REPAIR

Check and clear any problems after repairs are complete.

Section 13

SERVICE STANDARDS

Page

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ENGINE

No.	Inspection Item			Standard	Limit	Reference
1	Intake / Exhaust Valve Clearance			0.15 to 0.25 mm (0.0004 to 0.0008 in.)	–	*5-39*
2	V-belt Tension at 98 N (22 lbf)	Between Alternator and Coolant Pump	Used Part	8 to 10 mm (0.0262 to 0.0328 in.)	–	*4-13*
			New Part	6 to 8 mm (0.0196 to 0.0262 in.)	–	
3	Fuel Injection Pressure			12.3 to 13.28 Mpa (1783 to 1926 psi)	–	*4-30*
4	Compression Pressure (at 250 min^{-1})		3YM30AE / 3YM30	3.43 ± 0.1 Mpa (497 ± 14 psi)	2.75 ± 0.1 Mpa (398 ± 14 psi)	*12-10*
			3YM20 / 2YM15	3.23 ± 0.1 Mpa (468 ± 14 psi)	2.55 ± 0.1 Mpa (369 ± 14 psi)	
5	Coolant Capacity	Engine	3YM30AE / 3YM30	4.9 L (5.2 qt)	–	*4-8*
			3YM20	4.1 L (4.3 qt)	–	
			2YM15	3.0 L (3.2 qt)	–	
		Coolant Recovery Tank		0.8 L (0.8 qt)	–	
6	Engine Oil Capacity	3YM30AE / 3YM30 (full) (at 8° rake angle)		2.8 L (2.96 qt)	–	*4-7* *4-8*
		3YM20 (full) (at 8° rake angle)		2.7 L (2.85 qt)	–	
		2YM15 (full) (at 8° rake angle)		2.0 L (2.11 qt)	–	
		Marine Gear KM2P-1		0.3 L (0.31 qt)	–	
		3YM30AE-C / 3YM30C (full) (at 0° rake angle)		2.5 L (2.64 qt)	–	
		3YM20C (full) (at 0° rake angle)		2.4 L (2.53 qt)	–	
		2YM15C (full) (at 0° rake angle)		1.8 L (1.90 qt)	–	
		Sail-Drive SD20 / SD25		2.2 L (2.32 qt)	–	
7	Oil Pressure	At Rated Speed	3YM30AE	0.24 to 0.44 Mpa (35 to 63 psi)	–	–
			3YM30 / 3YM20 / 2YM15	0.29 to 0.44 Mpa (42 to 63 psi)	–	–
		At Low Idle Speed		0.06 Mpa (8.7 psi) or more	–	*8-7*
8	Oil Pressure Switch Operating Pressure			0.05 ± 0.01 Mpa (7.25 ± 1.4 psi)	–	*11-12*
9	Thermostat	Valve Opening Temperature		69.5° to 72.5°C (157° to 162°F)	–	*4-37*
		Full Opening Lift Temperature		8 mm (0.31 in.) or more at 85°C (185°F)	–	
10	Thermo Switch Actuating Temperature		On	93° to 97°C (199° to 206°F)	–	*4-37*

CYLINDER HEAD

Inspection Item			Standard	Limit	Reference
Combustion Surface Distortion			0.05 mm (0.0019 in.) or less	0.15 mm (0.0059 in.)	*5-31*
Valve Sink		Intake Exhaust	0.4 to 0.6 mm (0.0157 to 0.0236 in.)	0.8 mm (0.0314 in.)	*5-32*
Valve Seat	Seat Angle	Intake	120°	–	*5-33*
		Exhaust	90°	–	

INTAKE / EXHAUST VALVE AND GUIDE

Inspection Item		Standard	Limit	Reference
Intake	Guide I.D.	6.000 to 6.012 mm (0.2362 to 0.2366 in.)	6.08 mm (0.2393 in.)	*5-34*
	Valve Stem O.D.	5.960 to 5.975 mm (0.2396 to 0.2352 in.)	5.90 mm (0.2322 in.)	
	Clearance	0.025 to 0.052 mm (0.0009 to 0.0020 in.)	0.16 mm (0.0006 in.)	
Exhaust	Guide I.D.	6.000 to 6.012 mm (0.2362 to 0.2366 in.)	6.08 mm (0.2393 in.)	
	Valve Stem O.D.	5.945 to 5.960 mm (0.2340 to 0.2346 in.)	5.90 mm (0.2322 in.)	
	Clearance	0.040 to 0.067 mm (0.0015 to 0.0026 in.)	0.17 mm (0.0066 in.)	
Valve Guide Projection from Cylinder Head		9.8 to 10.0 mm (0.3858 to 0.3936 in.)	–	*5-35*
Valve Guide Driving In Method		Cold-Fit	–	

VALVE SPRING

Inspection Item	Standard	Limit	Reference
Free Length	37.8 mm (1.4881 in.)	36.3 mm (1.4291 in.)	*5-35*
Inclination	–	1.3 mm (0.0511 in.)	

ROCKER ARM AND SHAFT

Inspection Item	Standard	Limit	Reference
Arm Shaft Hole Diameter	12.000 to 12.020 mm (0.4724 to 0.4732 in.)	12.07 mm (0.4751 in.)	*5-37*
Shaft O.D.	11.966 to 11.984 mm (0.4711 to 0.4718 in.)	11.94 mm (0.4700 in.)	
Clearance	0.016 to 0.054 mm (0.0006 to 0.0021 in.)	0.13 mm (0.0051 in.)	

TAPPET AND PUSH ROD

Inspection item	Standard	Limit	Reference
Tappet O.D.	20.927 to 20.960 mm (0.8238 to 0.8251 in.)	20.907 mm (0.8231 in.)	*5-66*
Tappet Guide Hole I.D. (cylinder block)	21.000 to 21.021 mm (0.8267 to 0.8275 in.)	21.041 mm (0.8283 in.)	
Tappet Oil Clearance	0.040 to 0.094 mm (0.0015 to 0.0037 in.)	0.134 mm (0.0052 in.)	
Push Rod Bend	Less than 0.03 mm (0.0011 in.)	0.03 mm (0.0011 in.)	*5-37*

CAMSHAFT AND GEAR TRAIN

Camshaft

Inspection item		Standard	Limit	Reference
End Play		0.05 to 0.15 mm (0.0019 to 0.0059 in.)	0.25 mm (0.0098 in.)	*5-37*
Bending (1/2 the dial gauge reading)		0.02 mm (0.0007 in.) or less	0.05 mm (0.0019 in.)	*5-65*
Camshaft Lobe Height	3YM30AE / 3YM30	34.135 to 34.265 mm (1.1438 to 1.3490 in.)	33.89 mm (1.3342 in.)	*5-64*
	3YM20 / 2YM15	34.535 to 34.665 mm (1.3596 to 1.3647 in.)	34.29 mm (1.3499 in.)	
Shaft O.D. / Bearing I.D.				
Gear Side	Bushing I.D.	40.000 to 40.075 mm (1.5747 to 1.5777 in.)	40.150 mm (1.5807 in.)	*5-65*
	Camshaft O.D.	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)	
	Clearance	0.040 to 0.135 mm (0.0015 to 0.0053 in.)	0.245 mm (0.0096 in.)	
Intermediate	Bushing I.D.	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)	
	Camshaft O.D.	39.910 to 39.935 mm (1.5712 to 1.5722 in.)	39.875 mm (1.5698 in.)	
	Clearance	0.065 to 0.115 mm (0.0025 to 0.0045 in.)	0.225 mm (0.0088 in.)	
Flywheel Side	Bushing I.D.	40.000 to 40.025 mm (1.5747 to 1.5757 in.)	40.100 mm (1.5787 in.)	
	Camshaft O.D.	39.940 to 39.960 mm (1.5724 to 1.5732 in.)	39.905 mm (1.5710 in.)	
	Clearance	0.04 to 0.085 mm (0.0015 to 0.0083 in.)	0.195 mm (0.0076 in.)	

Idler Gear Shaft and Bushing

Inspection item	Standard	Limit	Reference
Shaft O.D.	36.950 to 36.975 mm (1.4547 to 1.4557 in.)	36.900 mm (1.4527 in.)	*5-53*
Bushing I.D.	37.000 to 37.025 mm (1.4566 to 1.4576 in.)	37.075 mm (1.4596 in.)	
Clearance	0.025 to 0.075 mm (0.0009 to 0.0029 in.)	0.175 mm (0.0068 in.)	

Gear Backlash

Inspection item	Standard	Limit	Reference
Crank Gear, Cam Gear, Idler Gear and Fuel Injection Pump Gear	0.06 to 0.12 mm (0.0023 to 0.0047 in.)	0.14 mm (0.0055 in.)	*5-52*

CYLINDER BLOCK

Inspection item		Standard	Limit	Reference
Cylinder I.D.	3YM30AE	80.000 to 80.030 mm (3.1496 to 3.1508 in.)	80.200 mm (3.1574 in.)	*5-68*
	3YM30	76.000 to 76.030 mm (2.9921 to 2.9932 in.)	76.200 mm (2.9999 in.)	
	3YM20 / 2YM15	70.000 to 70.030 mm (2.7558 to 2.7570 in.)	70.200 mm (2.7637 in.)	
Cylinder Bore	Roundness	0.01 mm (0.0003 in.) or less	0.03 mm (0.0011 in.)	
	Inclination			

Crankshaft

Inspection item		Standard	Limit	Reference
Bending (1/2 the dial gauge reading)		–	0.01 mm (0.0003 in.)	*5-59*
Crank Pin 3YM30AE / 3YM30	Pin O.D.	41.952 to 41.962 mm (1.6516 to 1.6520 in.)	41.902 mm (1.6496 in.)	*5-59*
	I.D.	41.982 to 42.010 mm (1.6528 to 1.6539 in.)	–	
	Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–	
	Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)	
Crank Pin 3YM20 / 2YM15	Pin O.D.	37.952 to 37.962 mm (10.4941 to 1.4945 in.)	37.902 mm (1.4922 in.)	
	Bearing I.D.	37.982 to 38.010 mm (1.4953 to 1.4964 in.)	–	
	Thickness	1.503 to 1.509 mm (0.0591 to 0.0594 in.)	–	
	Clearance	0.020 to 0.058 mm (0.0007 to 0.0022 in.)	0.120 mm (0.0047 in.)	
Crank Journal (selective pairing) All Models	Journal O.D.	46.952 to 46.962 mm (1.8484 to 1.8488 in.)	46.902 mm (1.8465 in.)	
	I.D.	46.982 to 47.002 mm (1.8496 to 1.8504 in.)	–	
	Thickness	2.009 to 2.014 mm (0.0790 to 0.0792 in.)	–	
	Clearance	0.020 to 0.050 mm (0.0007 to 0.0019 in.)	0.120 mm (0.0047 in.)	

Thrust Bearing

Inspection item	Standard	Limit	Reference
Crankshaft End Play	0.111 to 0.250 mm (0.0043 to 0.0098 in.)	0.30 mm (0.0118 in.)	*5-56*

PISTONS AND RINGS

Inspection item		Standard	Limit	Reference
Piston O.D. (Measure in the direction vertical to the piston pin.)	3YM30AE	79.962 to 79.972 mm (3.1481 to 3.1484 in.)	79.917 mm (3.146 in.)	*5-44*
	3YM30	75.965 to 75.975 mm (2.9907 to 2.9911 in.)	75.920 mm (2.9889 in.)	
	3YM20 / 2YM15	69.970 to 69.980 mm (2.7547 to 2.7551 in.)	69.925 mm (2.7529 in.)	
Piston Diameter Measure Position (upward from the bottom end of the piston)	3YM30AE	13 mm (0.5118 in.)	–	
	3YM30 / 3YM20 / 2YM15	22 mm (0.8661 in.)	–	
Clearance Between Piston and Cylinder	3YM30AE	0.038 to 0.058 mm (0.0014 to 0.0022 in.)	–	
	3YM30	0.035 to 0.055 mm (0.0013 to 0.0021 in.)	–	
	3YM20 / 2YM15	0.030 to 0.050 mm (0.0011 to 0.0019 in.)	–	
Piston Pin Hole I.D.		22.000 to 22.009 mm (0.8661 to 0.8664 in.)	22.039 mm (0.8676 in.)	*5-47*
Piston Pin O.D.		21.995 to 22.000 mm (0.8659 to 0.8661 in.)	21.965 mm (0.8647 in.)	
Clearance		0.000 to 0.014 mm (0.0000 to 0.0005 in.)	0.074 mm (0.0029 in.)	

Piston Ring

3YM30AE

Inspection item		Standard	Limit	Reference
Top Ring	Groove Width	2.04 to 2.06 mm (0.0803 to 0.0811 in.)	–	*5-48*
	Ring Width	1.94 to 1.96 mm (0.0763 to 0.0771 in.)	1.92 mm (0.0755 in.)	
	Side Clearance	0.08 to 0.12 mm (0.0031 to 0.0047 in.)	–	
	Ring Gap	0.20 to 0.35 mm (0.0078 to 0.0137 in.)	0.44 mm (0.0173 in.)	
Second Ring	Groove Width	1.54 to 1.56 mm (0.0606 to 0.0614 in.)	1.66 mm (0.0653 in.)	
	Ring Width	1.47 to 1.49 mm (0.0578 to 0.0586 in.)	1.45 mm (0.0570 in.)	
	Side Clearance	0.05 to 0.09 mm (0.0019 to 0.0035 in.)	0.21 mm (0.0082 in.)	
	Ring Gap	0.35 to 0.50 mm (0.0137 to 0.0196 in.)	0.59 mm (0.0232 in.)	
Oil Control Ring	Groove Width	3.010 to 3.025 mm (0.1185 to 0.1190 in.)	3.125 mm (0.1230 in.)	
	Ring Width	2.97 to 2.99 mm (0.1169 to 0.1177 in.)	2.950 mm (0.1161 in.)	
	Side Clearance	0.020 to 0.055 mm (0.0007 to 0.0021 in.)	0.135 mm (0.0053 in.)	
	Ring Gap	0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.49 mm (0.0192 in.)	

3YM30

Inspection item		Standard	Limit	Reference
Top Ring	Groove Width	1.550 to 1.570 mm (0.0610 to 0.0618 in.)	–	*5-48*
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0586 in.)	1.450 mm (0.0570 in.)	
	Side Clearance	0.060 to 0.100 mm (0.0023 to 0.0039 in.)	–	
	Ring Gap	0.15 to 0.30 mm (0.0059 to 0.0118 in.)	0.390 mm (0.0153 in.)	
Second Ring	Groove Width	1.580 to 1.595 mm (0.0622 to 0.0627 in.)	1.695 mm (0.0667 in.)	
	Ring Width	1.430 to 1.450 mm (0.0562 to 0.0570 in.)	1.410 mm (0.0555 in.)	
	Side Clearance	0.013 to 0.165 mm (0.0005 to 0.0164 in.)	0.285 mm (0.0112 in.)	
	Ring Gap	0.18 to 0.33 mm (0.0070 to 0.0129 in.)	0.420 mm (0.0165 in.)	
Oil Control Ring	Groove Width	3.010 to 3.030 mm (0.1185 to 0.1192 in.)	3.130 mm (0.1232 in.)	
	Ring Width	2.970 to 2.990 mm (0.1169 to 0.1177 in.)	2.950 mm (0.1161 in.)	
	Side Clearance	0.020 to 0.060 mm (0.0007 to 0.0023 in.)	0.180 mm (0.0070 in.)	
	Ring Gap	0.20 to 0.45 mm (0.0078 to 0.0177 in.)	0.540 mm (0.0212 in.)	

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Inspection item		Standard	Limit	Reference
Top Ring	Groove Width	1.550 to 1.570 mm (0.610 to 0.0618 in.)	–	*5-48*
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0586 in.)	1.450 mm (0.0570 in.)	
	Side Clearance	0.060 to 0.100 mm (0.0023 to 0.0039 in.)	–	
	Ring Gap	0.15 to 0.30 mm (0.0059 to 0.0118 in.)	0.390 mm (0.0153 in.)	
Second Ring	Groove Width	1.540 to 1.560 mm (0.060 to 0.0614 in.)	1.660 mm (0.0653 in.)	
	Ring Width	1.470 to 1.490 mm (0.0578 to 0.0588 in.)	1.450 mm (0.0570 in.)	
	Side Clearance	0.050 to 0.090 mm (0.0019 to 0.0035 in.)	0.210 mm (0.0082 in.)	
	Ring Gap	0.18 to 0.33 mm (0.0070 to 0.2129 in.)	0.420 mm (0.0165 in.)	
Oil Control Ring	Groove Width	3.010 to 3.030 mm (0.1185 to 0.1192 in.)	3.130 mm (0.1232 in.)	
	Ring Width	2.970 to 3.010 mm (0.1169 to 0.1185 in.)	2.950 mm (0.1161 in.)	
	Side Clearance	0.020 to 0.060 mm (0.0007 to 0.0023 in.)	0.180 mm (0.0070 in.)	
	Ring Gap	0.15 to 0.35 mm (0.0059 to 0.0137 in.)	0.44 mm (0.0173 in.)	

CONNECTING RODS

Rod Big End

Inspection item	Standard	Limit	Reference
Side Clearance	0.20 to 0.40 mm (0.0078 to 0.0157 in.)	0.55 mm (0.0216 in.)	*5-41*

Rod Small End

Item	Standard	Limit	Reference
Bushing I.D.	22.025 to 22.038 mm (0.8671 to 0.8676 in.)	22.068 mm (0.8688 in.)	*5-44*
Pin O.D.	21.991 to 22.000 mm (0.8657 to 0.8661 in.)	21.963 mm (0.8646 in.)	
Clearance	0.025 to 0.047 mm (0.0009 to 0.0018 in.)	0.105 mm (0.0041 in.)	

TROCHOID OIL PUMP

Outer Rotor Clearance

Standard	Limit	Reference
0.12 to 0.21 mm (0.0047 to 0.0082 in.)	0.30 mm (0.0118 in.)	*8-6*

Tip Clearance Between Outer Rotor and Inner Rotor

Standard	Limit	Reference
-	0.16 mm (0.0062 in.)	*8-6*

Outer Rotor Side Clearance

Standard	Limit	Reference
0.02 to 0.07 mm (0.0007 to 0.0027 in.)	0.12 mm (0.0047 in.)	*8-6*

Outside Diameter Clearance of Inner Rotor Pivot Pin

Inspection Item	Standard	Limit	Reference
Gear Housing Cover I.D.	46.13 to 46.18 mm (1.8161 to 1.8181 in.)	–	*8-6*
Inner Rotor O.D.	45.98 to 46.00 mm (1.8102 to 1.8110 in.)	–	
Rotor Clearance	0.13 to 0.20 mm (0.0051 to 0.0078 in.)	0.25 mm (0.0098 in.)	

TIGHTENING TORQUE FOR BOLTS AND NUTS

Main Bolts and Nuts

No.	Name	Thread Diameter x Pitch	Engine Oil Application (Thread Portion and Seat Surface)	Torque
1	Cylinder Head Bolt	M9x1.25	Coat with engine oil	59 to 63 N·m (43.5 to 46.4 lb-ft)
2	Connecting Rod Bolt	M7x1.0	Coat with engine oil	22.6 to 27.5 N·m (16.6 to 20.2 lb-ft)
3	Flywheel Retainer Bolt	M10x1.25	Coat with engine oil	80.4 to 86.4 N·m (59.2 to 63.7 lb-ft)
4	Metal Cap Retainer Bolt	M10x1.25	Coat with engine oil	75.5 to 81.5 N·m (55.6 to 60.1 lb-ft)
5	Crankshaft Pulley Bolt (FC250 pulley)	M10x1.25	Coat with engine oil	83.3 to 93.3 N·m (61.4 to 68.8 lb-ft)
6	Fuel Pump Gear Nut	M12x1.75	Coat with engine oil	58.8 to 68.8 N·m (43.3 to 50.7 lb-ft)
7	Nozzle Fastening Nut	M20x1.5	No engine oil	49 to 53 N·m (36.1 to 39 lb-ft)
8	Fuel Injection Pipe Joint Nut	M12x1.25	No engine oil	29.4 to 34.4 N·m (21.6 to 25.3 lb-ft)
9	Glow Plug	M10x1.25	No engine oil	14.7 to 19.6 N·m (10.8 to 14.4 lb-ft)
10	Governor Weight Support Fastening Nut	M12x1.25	Coat with engine oil	68.7 to 73.7 N·m (50.6 to 54.3 lb-ft)

Standard Bolts and Nuts (Dry)

Name	Screw Diameter x Pitch	Tightening Torque	Remarks
Hexagon Bolt (7T) and Nut	M6x1	9.8 to 11.8 N·m (7.2 to 8.7 lb-ft)	Use 80% of the value at left for aluminum parts. Use 60% of the value at left for 4T bolts and locknuts.
	M8x1.25	22.5 to 28.5 N·m (16.5 to 21.0 lb-ft)	
	M10x1.5	44 to 54 N·m (32.4 to 39.8 lb-ft)	
	M12x1.75	78.2 to 98.2 N·m (57.6 to 72.4 lb-ft)	
PT 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 (21.6 lb-ft)	
	1/2	58.8 N·m (43.3 lb-ft)	
Pipe Joint Bolt	M8	12.7 to 16.7 N·m (9.3 to 12.3 lb-ft)	–
	M10	19.5 to 25.5 N·m (14.3 to 18.8 lb-ft)	
	M12	24.4 to 34.4 N·m (17.9 to 25.3 lb-ft)	
	M14	39.1 to 49.1 N·m (28.8 to 36.2 lb-ft)	
	M16	48.9 to 58.9 N·m (36.0 to 43.4 lb-ft)	

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