YANMAR

SERVICE MANUAL

INDUSTRIAL ENGINE

3TNV88C
3TNV86CT
4TNV88C
4TNV86CT
4TNV98C
4TNV98CT

California Proposition 65 Warning
Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects, and other reproductive harm.

California Proposition 65 Warning
Battery posts, terminals, and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer and reproductive harm. Wash hands after handling.

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:

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

When exporting or providing YANMAR products to non-residents, please comply with the security trade control laws and regulations of Japan and other relevant countries.

SERVICE MANUAL	MODEL	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT, 4TNV98C, 4TNV98CT
	CODE	0BTN4-EN0025

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Section 1

INTRODUCTION

This Service Manual describes the service procedures for the TNV series engines have common rail injection system. These engines are certified by the U.S. EPA, California ARB and/or the 97/68/EC Directive for industrial use.

Please use this manual for accurate, quick and safe servicing of the engine. Since the directions in this manual are for a typical engine, some specifications and components may be different from your engine. Refer to the documentation supplied by the optional equipment manufacturer for specific service instructions.

For the replacement of some parts and troubleshooting for the TNV series engines, the YANMAR Diagnostics Tool called SMARTASSIST-Direct is required. In addition, please read both Troubleshooting Manual and SMARTASSIST-Direct Operation Manual.

YANMAR products are continuously undergoing improvement. This Service Manual might not address possible field modifications to the equipment. Contact an authorized YANMAR industrial engine dealer or distributor for answers to any questions relating to field modifications.

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Section 2

YANMAR WARRANTIES

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YANMAR LIMITED WARRANTY

What is Covered by this Warranty?

YANMAR warrants to the original retail purchaser that a new YANMAR TNV series industrial engine will be free from defects in material and/or workmanship for the duration of the warranty period.

Note: YANMAR engines may be equipped with external components including, but not limited to: wiring harnesses, electrical devices, control panels, radiators, air filters, fuel filters, and/or exhaust systems that are supplied and/or installed by manufacturers other than YANMAR. For warranty information on such external components, please contact the machine or component manufacturer directly.

This warranty is provided in lieu of all other warranties, express or implied. YANMAR specifically disclaims any implied warranties of merchantability or fitness for a particular purpose, except where such disclaimer is prohibited by law. If such disclaimer is prohibited by law, then implied warranties shall be limited in duration to the life of the express warranty.

How Long is the Warranty Period?

The YANMAR standard limited warranty period runs for a period of **twenty-four (24) months or two-thousand (2000) engine operation hours**, whichever occurs first. An extended limited warranty of thirty-six (36) months or three thousand (3000) engine operating hours, whichever occurs first, is provided for these specific parts only: the cylinder block, cylinder head, crankshaft forging, connecting rods, flywheel, flywheel housing, camshaft, timing gear, and gear case. The warranty period for both the standard limited warranty and the extended limited warranty (by duration or operation hours) begins on the date of delivery to the original retail purchaser and is valid only until the applicable warranted duration has passed or the operation hours are exceeded, whichever comes first.

What the Engine Owner must Do:

If you believe your YANMAR engine has experienced a failure due to a defect in material and/or workmanship, you must contact an authorized YANMAR industrial engine dealer or distributor within thirty (30) days of discovering the failure. You must provide proof of ownership of the engine, proof of the date of the engine purchase and delivery, and documentation of the engine operation hours. Acceptable forms of proof of delivery date include, but are not limited to: the original warranty registration or sales receipts or other documents maintained in the ordinary course of business by YANMAR dealers and/or distributors, indicating the date of delivery of the YANMAR product to the original retail purchaser. This information is necessary to establish whether the YANMAR product is still within the warranty period. Thus, YANMAR strongly recommends you register your engine as soon as possible after purchase in order to facilitate any future warranty matters.

You are responsible for the transportation of the engine to and from the repair location as designated by YANMAR.

YANMAR limited warranty - continued

To Locate an Authorized YANMAR Industrial Engine Dealer or Distributor:

You can locate your nearest authorized YANMAR industrial engine dealer or distributor by visiting the YANMAR CO., LTD. website at:

https://www.yanmar.com/global/ (The English language page will be displayed.)

- “Click” on “Dealer Locator” in the website heading to view the “Dealer Locator” menu.
- Choose the Country from the pull down menu.
- Choose the Product Category from the pull down menu.
- “Click” on “Search” to browse YANMAR dealer or distributor.

You may also contact YANMAR by clicking on “Contact” icon in the website heading and typing in your question or comment.

What YANMAR will Do:

YANMAR warrants to the original retail purchaser of a new YANMAR engine that YANMAR will make such repairs and/or replacements at YANMAR’s option, of any part(s) of the YANMAR product covered by this warranty found to be defective in material and/or workmanship. Such repairs and/or replacements will be made at a location designated by YANMAR at no cost to the purchaser for parts or labor.

What is not Covered by this Warranty?

This warranty does not cover parts affected by or damaged by any reason other than defective materials or workmanship including, but not limited to, accident, misuse, abuse, “Acts of God,” neglect, improper installation, improper maintenance, improper storage, the use of unsuitable attachments or parts, the use of contaminated fuels, the use of diesel fuels, engine lubricating oil, or engine coolant other than those recommended in your YANMAR Operation Manual, unauthorized alterations or modifications, ordinary wear and tear, and rust or corrosion. This warranty does not cover the cost of parts and/or labor required to perform normal/scheduled maintenance on your YANMAR engine. This warranty does not cover consumable parts such as, but not limited to, filters, belts, hoses, diesel fuels, engine lubricating oil and cleaning fluids. This warranty does not cover the cost of shipping the product to or from the warranty repair facility.

YANMAR limited warranty - continued

Warranty Limitations:

The foregoing is YANMAR's only obligation to you and your exclusive remedy for breach of warranty. Failure to follow the requirements for submitting a claim under this warranty may result in a waiver of all claims for damages and other relief. **In no event shall YANMAR or any authorized industrial engine dealer or distributor be liable for incidental, special or consequential damages.** Such consequential damages may include, but not be limited to, loss of revenue, loan payments, cost of rental of substitute equipment, insurance coverage, storage, lodging, transportation, fuel, mileage, and telephone costs. The limitations in this warranty apply regardless of whether your claims are based on breach of contract, tort (including negligence and strict liability) or any other theory. Any action arising hereunder must be brought within one (1) year after the cause of action accrues or it shall be barred. Some states and countries do not allow certain limitations on warranties or for breach of warranties. **This warranty gives you specific legal rights, and you may also have other rights which vary from state to state and country to country.** Limitations set forth in this paragraph shall not apply to the extent that they are prohibited by law.

Warranty Modifications:

Except as modified in writing and signed by the parties, this warranty is and shall remain the complete and exclusive agreement between the parties with respect to warranties, superseding all prior agreements, written and oral, and all other communications between the parties relating to warranties. **No person or entity is authorized to give any other warranty or to assume any other obligation on behalf of YANMAR, either orally or in writing.**

Questions:

If you have any questions or concerns regarding this warranty, please call or write to the nearest authorized YANMAR industrial engine dealer or distributor or other authorized facility.

EMISSION SYSTEM WARRANTY

YANMAR CO., LTD. LIMITED EMISSION CONTROL SYSTEM WARRANTY - USA ONLY

Your Warranty Rights and Obligations:

■ California

The California Air Resources Board (CARB), the Environmental Protection Agency (EPA) and YANMAR Co., Ltd. hereafter referred to as YANMAR, are pleased to explain the **emission control system warranty** on your industrial compression-ignition engine. In California, model year 2000 or later off-road compression-ignition engines must be designed, built and equipped to meet the state's stringent anti-smog standards. In all states, 1998 and later non-road compression-ignition engines must be designed, built and equipped to meet the United States EPA emissions standards. YANMAR warrants the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel injection system, Electronic Control Unit, Exhaust Gas Recirculation (EGR) system, after treatment system (DPF) and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, YANMAR will repair your non-road compression-ignition engine at no charge to you including diagnosis, parts and labor.

Manufacturer's Warranty Period:

The model year 1998 or later certified and labeled non-road compression-ignition engines are warranted for the periods listed below. If any emission-related part on your engine is found to be defective during the applicable warranty period, the part will be replaced by YANMAR.

If your engine is certified as	And its maximum power is	And its rated speed is	Then its warranty period is
Variable speed or constant speed	$kW < 19$	Any speed	1,500 hours or two (2) years whichever comes first. In the absence of a device to measure the hours of use, the engine has a warranty period of two (2) years.
Constant speed	$19 \leq kW < 37$	3,000 rpm or higher	1,500 hours or two (2) years whichever comes first. In the absence of a device to measure the hours of use, the engine has a warranty period of two (2) years.
Constant speed	$19 \leq kW < 37$	Less than 3,000 rpm	3,000 hours or five (5) years whichever comes first. In the absence of a device to measure the hours of use, the engine has a warranty period of five (5) years.
Variable speed	$19 \leq kW < 37$	Any speed	3,000 hours or five (5) years whichever comes first. In the absence of a device to measure the hours of use, the engine has a warranty period of five (5) years.
Variable speed or constant speed	$kW \geq 37$	Any speed	3,000 hours or five (5) years whichever comes first. In the absence of a device to measure the hours of use, the engine has a warranty period of five (5) years.

Limited emission control system warranty - USA only - continued

Warranty Coverage:

This warranty is transferable to each subsequent purchaser for the duration of the warranty period. Repair or replacement of any warranted part will be performed at an authorized YANMAR industrial engine dealer or distributor.

Warranted parts not scheduled for replacement as required maintenance in the operation manual shall be warranted for the warranty period. Warranted parts scheduled for replacement as required maintenance in the operation manual are warranted for the period of time prior to the first scheduled replacement. Any part repaired or replaced under warranty shall be warranted for the remaining warranty period.

During the warranty period, YANMAR is liable for damages to other engine components caused by the failure of any warranted part during the warranty period.

Any replacement part which is functionally identical to the original equipment part in all respects may be used in the maintenance or repair of your engine, and shall not reduce YANMAR's warranty obligations. Add-on or modified parts that are not exempted may not be used. The use of any non-exempted add-on or modified parts shall be grounds for disallowing a warranty.

Warranted Parts:

This warranty covers engine components that are a part of the emission control system of the engine as delivered by YANMAR to the original retail purchaser. Such components may include the following:

- Fuel injection system
- Electronic control system
- Cold start enrichment system
- Intake manifold and intake throttle valve
- Turbocharger systems
- Exhaust manifold and exhaust throttle valve
- EGR system
- Positive crankcase ventilation system
- After treatment system (Diesel Particulate Filter)
- Hoses, belts, connectors and assemblies associated with emission control systems

Since emissions-related parts may vary slightly between models, certain models may not contain all of these parts and other models may contain the functional equivalents.

Limited emission control system warranty - USA only - continued

Exclusions:

Failures other than those arising from defects in material and/or workmanship are not covered by this warranty. The warranty does not extend to the following: malfunctions caused by abuse, misuse, improper adjustment, modification, alteration, tampering, disconnection, improper or inadequate maintenance or use of non-recommended fuels and lubricating oils; accident-caused damage, and replacement of expendable items made in connection with scheduled maintenance. YANMAR disclaims any responsibility for incidental or consequential damages such as loss of time, inconvenience, loss of use of equipment/engine or commercial loss.

Owner's Warranty Responsibilities:

As the engine owner, you are responsible for the performance of the required maintenance listed in your owner's manual. YANMAR recommends that you retain all documentation, including receipts, covering maintenance on your non-road compression-ignition engine, but YANMAR cannot deny warranty solely for the lack of receipts, or for your failure to ensure the performance of all scheduled maintenance.

YANMAR may deny your warranty coverage of your non-road compression-ignition engine if a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with applicable emissions requirements.

You are responsible for initiating the warranty process. You must present your engine to a YANMAR dealer as soon as a problem exists. The warranty repairs should be completed by the dealer as expeditiously as possible. If you have any questions regarding your warranty rights and responsibilities, or would like information on the nearest YANMAR dealer or authorized service center, you should contact YANMAR America Corporation.

Website: https://www.yanmar.com
E-mail: CS_support@yanmar.com
Toll free telephone number: 1-800-872-2867, 1-855-416-7091

Section 3

SAFETY

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SAFETY STATEMENTS

YANMAR is concerned for your safety and your machine's condition. Safety statements are one of the primary ways to call your attention to the potential hazards associated with YANMAR TNV engine operation. 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 engine. Keep the labels from becoming dirty or torn and replace them if they are lost or damaged. Also, if you need to replace a part that has a label attached to it, make sure you order the new part and label 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

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

WARNING

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

CAUTION

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

NOTICE

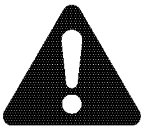
NOTICE indicates a situation which can cause damage to the machine, personal property and/or the environment or cause the equipment to operate improperly.

SAFETY PRECAUTIONS

During Operation and Maintenance

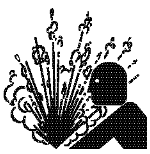
⚠ DANGER

High-Pressure Hazard!



- This engine uses a high-pressure common rail system. For disassembly of the high-pressure parts (e.g. the high-pressure pipe) in particular, be sure to wait approximately 10 to 15 minutes before performing disassembly.
- Do not loosen the high-pressure pipe while the engine is running, even in low idle. This is dangerous because fuel under high-pressure will blow out.
- Failure to comply will result in death or serious injury.

Scald Hazard!



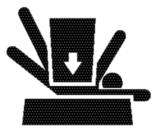
- Never remove the radiator cap if the engine is hot. Steam and hot engine coolant will spurt out and seriously burn you. Allow the engine to cool down before you attempt to remove the radiator cap.
- Tighten the radiator cap securely after you check the radiator. Steam can spurt out during engine operation if the cap is loose.
- Always check the level of the engine coolant by observing the reserve tank.
- Failure to comply will result in death or serious injury.

⚠ DANGER

Explosion Hazard!

- Keep the area around the battery well-ventilated. While the engine is running or the battery is charging, hydrogen gas is produced which can be easily ignited.
- Keep sparks, open flame and any other form of ignition away while the engine is running or battery is charging.
- Never check the remaining battery charge by shorting out the terminals. This will result in a spark and may cause an explosion or fire. Use a hydrometer to check the remaining battery charge.
- If the electrolyte is frozen, slowly warm the battery before you recharge it.
- Failure to comply will result in death or serious injury.

Crush Hazard!



- When you need to transport an engine for repair, have a helper assist you to attach it to a hoist and load it on a truck.
- Never stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you, causing death or serious injury.
- Failure to comply will result in death or serious injury.

⚠ DANGER

Fire and Explosion Hazard!

- Diesel fuel is flammable and explosive under certain conditions.

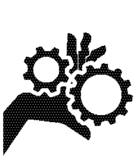
- When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.
- Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.
- Wipe up any spills immediately.
- Wear eye protection. The fuel system is under pressure and fuel could spray out when you remove any fuel system component.
- Only use the key switch to start the engine.
- Never jump-start the engine (by shorting the battery terminal and the starter terminal). This will result in a spark and may cause a fire or explosion.
- This is an electric feed pump. When you prime the fuel system, turn the key switch to the ON position for 10 to 15 seconds. Air inside the fuel will bleed automatically.
- Only fill the fuel tank with diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine.
- Never refuel with the engine running.
- Keep sparks, open flames or any other form of ignition (match, cigarette, static electric source) well away when refueling.
- Never overfill the fuel tank.
- Fill the fuel tank. Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

⚠ DANGER (Continued)

- Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.
- Never place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.
- Before you operate the engine, check for fuel leaks. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of engine operation, whichever comes first.
- Never remove the fuel cap with the engine running.
- Never use diesel fuel as a cleaning agent.
- Failure to comply will result in death or serious injury.

⚠WARNING

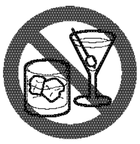
Sever Hazard!



- Keep hands and other body parts away from moving/rotating parts such as the cooling fan, flywheel or PTO shaft.

- Wear tight-fitting clothing and keep your hair short or tie it back while the engine is running.
- Remove all jewelry before you operate or service the machine.
- Never start the engine in gear. Sudden movement of the engine and/or machine could cause death or serious personal injury.
- Never operate the engine without the guards in place.
- Before you start the engine make sure that all bystanders are clear of the area.
- Keep children and pets away while the engine is operating.
- Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.
- Failure to comply could result in death or serious injury.

Alcohol and Drug Hazard!

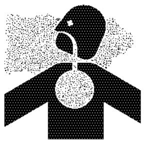


- Never operate the engine while you are under the influence of alcohol or drugs.

- Never operate the engine when you are feeling ill.
- Failure to comply could result in death or serious injury.

⚠WARNING

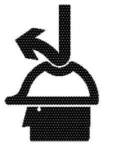
Exhaust Hazard!



- Never operate the engine in an enclosed area such as a garage, tunnel, underground room, manhole or ship's hold without proper ventilation.

- 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 could cause illness or even death.
- Make sure that all connections are tightened to specifications after repair is made to the exhaust system.
- Failure to comply could result in death or serious injury.

Exposure Hazard!

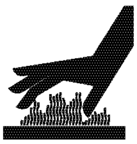


- Wear personal protective equipment such as gloves, work shoes, eye and hearing protection as required by the task at hand.

- Never wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing when you are working near moving/rotating parts such as the cooling fan, flywheel or PTO shaft.
- Always tie back long hair when you are working near moving/rotating parts such as a cooling fan, flywheel, or PTO shaft.
- Never operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the alert signals.
- Failure to comply could result in death or serious injury.

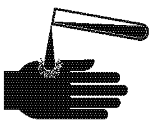
⚠ WARNING

Burn Hazard!



- If you must drain the engine oil while it is still hot, stay clear of the hot engine oil to avoid being burned.
- Always wear eye protection.
- Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.
- Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could seriously burn you.
- Failure to comply could result in death or serious injury.

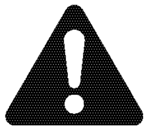
Burn Hazard!



- Batteries contain sulfuric acid. Never allow battery fluid to come in contact with clothing, skin or eyes. Severe burns could result. Always wear safety goggles and protective clothing when servicing the battery. If battery fluid contacts the eyes and/or skin, immediately flush the affected area with a large amount of clean water and obtain prompt medical treatment.
- Failure to comply could result in death or serious injury.

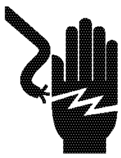
⚠ WARNING

High-Pressure Hazard!



- While the engine is running or right after the engine has stopped, there is still high-pressure fuel left in the fuel piping system. When you need to disassemble the fuel system, wait for 10 to 15 minutes after stopping the engine.
- If fuel is spraying out or leaking from broken fuel system such as high-pressure fuel injection lines, it may be in high-pressure. Avoid skin contact. 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.
- Disassembling or repairing the fuel system shall be done by professionals such as the authorized YANMAR distributor or dealer.
- Failure to comply could result in death or serious injury.

Shock Hazard!



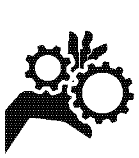
- Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.
- Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.
- Failure to comply could result in death or serious injury.

Sudden Movement Hazard!

- Before engaging the transmission or PTO, warm up the engine for at least 5 minutes and then set the speed back to normal. Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.
- Failure to comply could result in death or serious injury.

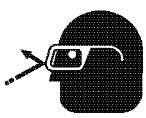
⚠ WARNING

Entanglement Hazard!



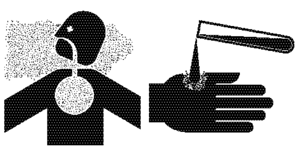
- Stop the engine before you begin to service it.

- Never leave the key in the key switch when you are servicing the engine. Someone may accidentally start the engine and not realize you are servicing it. This could result in a serious injury.
- If you must service the engine while it is operating, remove all jewelry, tie back long hair, and keep your hands, other body parts and clothing away from moving/rotating parts.
- Failure to comply could result in death or serious injury.



To prevent possible eye injury, always wear safety glasses while servicing the engine.

Fume/Burn Hazard!



- Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.
- Failure to comply could result in death or serious injury.

Never apply over 40 psi (2.8 kgf/cm^2) to the waste gate actuator.

- Never inject fuel toward you. Since the fuel is injected at high-pressure from the nozzle, it may penetrate the skin, resulting in injury.
- Never inject fuel toward a fire source. Atomized fuel is highly flammable and may cause a fire or burn skin.

⚠ WARNING

Precaution regarding the ECU (Engine Controller)

- Never use the ECU for purposes that are not intended by YANMAR; such as using unauthorized ECU, writing unauthorized data to ECU, leaving it broken, or removing sensors and actuators. Doing so could result in the violation of emission control regulations and will void the product warranty.
- Improper use or misuse of the ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.

- Be sure to use the ECU in conjunction with the engines whose models or serial numbers are specified by YANMAR.
  Other ECU/engine combinations than specified will void the engine warranty.
- Improper use or misuse of the ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.

- When replacing the fuel injector, you need to rewrite the fuel injection quantity adjustment data in the ECU. You will need YANMAR's genuine SMARTASSIST-DIRECT (SA-D) for rewriting the data. Always contact the authorized YANMAR dealer that handles the SA-D. ECU that does not have the proper fuel injection quantity adjustment data written will void the engine warranty.
- Improper use or misuse of the ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.

- When replacing the ECU, it is necessary to transfer the data from the old ECU to the new ECU using SMARTASSIST-DIRECT (SA-D). Contact your authorized YANMAR dealer who can handle SMARTASSIST-DIRECT (SA-D).
  If the data is not correctly transfered to the new ECU, the engine performance can not be ensured.
- Improper use or misuse of the ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.

⚠ CAUTION

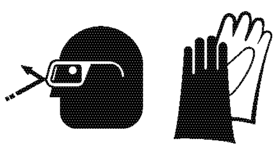
DPF Regeneration

During reset regeneration, post-injection is used and fuel is burned directly inside the DPF (burned by chemical reaction inside the DOC). Through this heat, regeneration occurs inside the SF, but the combustion increases the temperature of the exhaust gas to close to 600 °C (1112 °F). Stay away from the exhaust gas. Extremely hot exhaust gas may burn you. Be careful that neither people nor flammable materials are near the exhaust gas outlet. Never operate the engine in an enclosed area without proper ventilation.

Observe the following conditions when performing stationary regeneration.

- Never operate the engine in an enclosed area. Accumulation of gas may cause carbon monoxide poisoning.
- Regeneration causes the exhaust gas temperature to increase. To prevent fire, make sure that there are no flammable materials around the exhaust gas outlet.
- Never touch the exhaust pipe. The temperature of the exhaust gas can be extremely high. Never stand near or around the exhaust gas outlet.

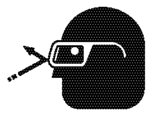
Engine Coolant Hazard!



- Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.
- Failure to comply may result in minor or moderate injury.

⚠ CAUTION

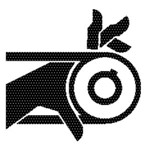
Flying Object Hazard!



- 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.
- Failure to comply may result in minor or moderate injury.

Be sure to secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.

Pinch Hazard!



Carefully rotate the alternator toward the cylinder block while loosening the V-belt. Failure to comply may result in minor or moderate injury.

If any oil pump component clearance exceeds its limit, the oil pump must be replaced as an assembly.

NOTICE

Diesel Fuel

- Poor quality fuel can reduce engine performance and cause damage. Only use diesel fuels recommended by YANMAR for the best engine performance. The recommended fuel complies with the U.S. EPA and ARB protection guidelines.
- The common rail system installed as this engine's fuel injection device is very high in pressure and sprays fuel into the cylinder. If any impurities or water mixes into the fuel, the sliding parts of the fuel system causes friction and may degrade the engine's exhaust gas property durability. Only use clean diesel fuel.
- Keep the fuel tank and fuel-handling equipment clean at all times. Be careful not to let any contaminants or even dust from the outside into the filler port when supplying fuel.
- Never remove the primary strainer (if equipped) from the fuel tank filler port. If removed, dirt and debris could get into the fuel system causing it to clog.

Engine Lubricating Oil

- Only use the engine lubricating oil specified. Other oils may affect warranty coverage, cause internal engine components to seize and/or shorten engine life.
- Prevent dirt and debris from contaminating the engine lubricating oil. Carefully clean the oil cap/dipstick and the surrounding area before you remove the cap.
- Never mix different types of engine lubricating oil. This may adversely affect the lubricating properties of the engine oil.
- Always keep the oil level between the upper and lower lines on the oil cap/dipstick.
- Never overfill the engine with engine lubricating oil. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.

NOTICE

Engine Coolant

- 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 radiator 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.

Inspecting and Starting

If any problem is noted during the visual check, the necessary corrective action should be taken before you operate the engine.

Never hold the key in the START position for longer than 15 seconds.
Take a pause of at least 30 seconds until the restart.
The starter motor may overheat and cause damage.

If the engine fails to start:
Wait until the engine comes to a complete stop before you attempt to start it again. Engaging the starter while the engine is still rotating will result in damage to the starter and flywheel.

Never use an engine starting aid such as ether. Engine damage will result.

Never engage the starter motor while the engine is running. This may damage the starter motor pinion and/or ring gear.

NOTICE

Engine Break-in Period

New engine break-in:

- On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper engine oil pressure, diesel fuel leaks, engine oil leaks, engine coolant leaks, and for proper operation of the indicators and/or gauges.
- During the first hour of operation, vary the engine speed and the load on the engine. Short periods of maximum engine speed and load are desirable. Avoid prolonged operation at minimum or maximum engine speeds and loads for the next four to five hours.
- During the break-in period, carefully observe the engine oil pressure and engine temperature.
- During the break-in period, check the engine oil and engine coolant levels frequently.

Make sure the engine is installed on a level surface. If a continuously running engine is installed at an angle greater than (30°) in any direction or if an engine runs for short periods of time (less than three minutes) at an angle greater than (35°) in any direction, engine oil may enter the combustion chamber causing excessive engine speed and white exhaust smoke. This may cause serious engine damage.

Alarm System

If there is a problem with the engine and/or its control components, the engine failure lamp comes on and indicates the status. If the engine failure lamp illuminates during engine operation, stop the engine immediately. Do not keep running the engine while the engine failure lamp is on. It will not only void the engine warranty, but could result in a serious malfunction of or damage to the engine. Determine the cause and repair the problem before you continue to operate the engine.

The illustrations and descriptions of optional equipment in this manual, such as the operator's console, are for a typical engine installation. Refer to the documentation supplied by the optional equipment manufacturer for specific operation and maintenance instructions.

NOTICE

Environment Conditions for Operation

Observe the following environmental operating conditions to maintain engine performance and avoid premature engine wear:

- Avoid operating in extremely dusty conditions.
- Avoid operating in the presence of chemical gases or fumes.
- Avoid operating in a corrosive atmosphere such as salt water spray.
- If the ambient temperature exceeds +45 °C (+113 °F) or falls below -15 °C (+5 °F), there are possibilities of:
  - If the ambient temperature exceeds +45 °C (+113 °F), engine lubricating oil degrades due to the overheating of the engine.
  - If the ambient temperature falls below -15 °C (+5 °F), parts degrade and shortens its life due to the hardening of the rubber parts.

    If you need to use it in the above temperatures, please change to applicable parts and specification.
- Further, for engines with turbochargers, be aware that leaving them idling or working in low load in an environment with ambient temperature below -15 °C (+5 °F) may freeze the intake pipe. If this continues, load-operate the engine every three hours to prevent freezing.

- When the engine is operated in dusty conditions, clean the air cleaner element more frequently.
- Never operate the engine with the air cleaner element(s) removed. This may allow foreign material to enter the engine and damage it.

The maximum air intake restriction, in terms of differential pressure measurement, must not exceed 0.90 psi (6.23 kPa; 635 mmAq). Clean or replace the air cleaner element if the air intake restriction exceeds the above mentioned value.

NOTICE

Engine Stop

For maximum engine life, YANMAR recommends that when shutting the engine down, you allow the engine to idle, without load, for five minutes. This will allow the engine components that operate at high temperatures, such as the turbocharger (if equipped) and exhaust system, to cool slightly before the engine itself is shut down.

Battery and Electrical Equipment

Always keep the battery in a best charged state. Electronic controlled engines may not be able to start.

Use a specialized battery charger to recharge a battery with a voltage of 8 volts or less. Booster starting a battery with a voltage of 8 volts or less will generate an abnormally high voltage and destroy electrical equipment.

When unavoidably using a rapid charger to recharge, do not insert and turn the starter key to ON position while the battery is being charged. Avoid using a charger equipped with a boost function (cell start support) to start the engine. The ECU may be damaged by applied excessive voltage.

Removing the battery cables or the battery while the engine is operating may cause damage to the current limiter depending on the electrical equipment being used. This situation could cause loss of control of output voltage. The continuous high voltage of 23 - 24 volts (for 5000 min^{-1} (rpm) dynamo) will damage the current limiter and other electrical equipment.

Reversing the battery cable connections at the battery or on the engine will destroy the SCR diode in the current limiter. This will cause the charging system to malfunction and may cause damage to the electrical harnesses.

Do not remove the positive (+) battery cable from alternator terminal B while the engine is operating. Damage to the alternator will result.

NOTICE

Do not turn the battery switch OFF while the engine is operating. Damage to the alternator will result.

Do not reverse the positive (+) and negative (-) ends of the battery cable. The alternator diode and stator coil will be damaged.

When the battery indicator goes out, it should not come on again. The battery indicator only comes on during operation if the alternator fails. However, if an LED is used in the battery indicator, the LED will shine faintly during normal operation.

Using a non-specified V-belt will cause inadequate charging and shorten the belt life. Use the specified belt.

Agricultural or other chemicals, especially those with a high sulfur content, can adhere to the IC regulator. This will corrode the conductor and result in battery over-charging (boiling) and charging malfunctions. Consult YANMAR before using the equipment in such an environment or the warranty is voided.

ECU (Engine Controller)

- Do not plug or unplug the ECU for a period of at least 60 seconds after power to the unit has been turned on or off.
- Do not touch connector pins of the ECU with bare hands. Doing so may result in corrosion of the connector pins and/or damage to the internal circuits of the ECU due to static electricity.
- Do not force a measuring probe into the female coupler. Doing so may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Take care to prevent water from entering the couplers when plugging or unplugging the connector. Water inside the couplers may cause corrosion, resulting in malfunction of the ECU.
- Avoid plugging/unplugging the connector more than approx. 10 times.
  Frequent plugging/unplugging of the connector may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Do not use the ECU that has ever suffered drop impact.

NOTICE

High-Pressure Cleaning

Protect the air cleaner, turbocharger (if equipped) and electric components from damage when you use steam or high-pressure water to clean the engine.

Never use high-pressure water or compressed air at greater than 28 psi (193 kPa; 19686 mmAq) or a wire brush to clean the radiator fins. Radiator fins damage easily.

- Do not use a high-pressure cleaner directly on the alternator. Water will damage the alternator and result in inadequate charging.
- The starter motor is water-proofed according to JIS D 0203, R2 which protects the motor from rain or general cleaning. Do not use high-pressure cleaner or submerse the starter motor in water.
- Avoid using high-pressure cleaner for electronic or electric devices installed in, on or around the engine, including the E-ECU, relays and harness couplers.

Otherwise such devices may suffer malfunction due to water ingress into them.

Periodic Maintenance

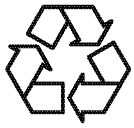
Establish a periodic maintenance plan according to the engine application and make sure you perform the required periodic maintenance at intervals indicated. Failure to follow these guidelines will impair the engine's safety and performance characteristics, shorten the engine's life and may affect the warranty coverage on your engine.

Periodic maintenance prevents unexpected downtime, reduces the number of accidents due to poor machine performance and helps extend the life of the engine.

NOTICE

The tightening torque in the *Standard Torque Chart in the Periodic Maintenance Section of this manual* should be applied only to the bolts with a "7" head. (JIS strength classification: 7T)

- Apply 60 % torque to bolts that are not listed.
- Apply 80 % torque when tightened to aluminum alloy.



- Always be environmentally responsible.

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

- Never attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.
- Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use YANMAR genuine replacement parts.

If the oil pump must be replaced, replace it as an assembly only. Do not replace individual components.

If the engine coolant pump must be replaced, replace the engine coolant pump as an assembly only. Do not attempt to repair the engine coolant pump or replace individual components.

NOTICE

Use a new special O-ring between the engine coolant pump and the joint. Be sure to use the special O-ring for each engine model. Although the O-ring dimensions are the same as a commercially available O-ring, the material is different.

Remove or install the high-pressure fuel injection lines as an assembly whenever possible. Disassembling the high-pressure fuel injection lines from the retainers or bending any of the fuel lines will make it difficult to reinstall the fuel lines.

After marking the position of the pump drive gear, do not rotate the engine crankshaft. Rotating the crankshaft will cause the fuel supply pump to become misaligned.

Avoid damage to the turbocharger or the engine. Do not spray blower cleaning fluid or water too quickly.

Use short strokes from a spray bottle to inject blower cleaning fluid or water into the turbocharger.

Spraying too much cleaning fluid or water, or spraying too quickly will damage the turbocharger.

Do not allow any material to fall into the oil lines or the oil inlet and outlet ports of the turbocharger.

If the waste gate valve does not meet specifications, replace the turbocharger or have it repaired by a qualified repair facility.

Do not short-circuit the charging system between alternator terminals IG and L. Damage to the alternator will result.

Do not connect a load between alternator terminals L and E. Damage to the alternator will result.

Do not operate the engine if the alternator is producing unusual sounds. Damage to the alternator will result.

NOTICE

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated in the *Battery Cable Resistance chart* in the *Electric Wiring Section* of this manual. The starter motor will malfunction and fail if the resistance is higher than the specified value.

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

Keep the piston pin parts, piston assemblies, and connecting rod assemblies together to be returned to the same position during the reassembly process. Label the parts using an appropriate method.

Do not allow the honing tool to operate in one position for any length of time. Damage to the cylinder wall will occur. Keep the tool in constant up-and-down motion.

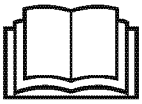
Any part which is found defective as a result of inspection or any part whose measured value does not satisfy the standard or limit must be replaced.

Any part determined to not meet the service standard or limit before the next service, as determined from the state of current rate of wear, should be replaced even though the part currently meets the service standard limit.

Never use a steel wire brush to clean fuel injectors. Damage to the nozzle and other components is likely to result.

NOTICE

Operating the Engine or the Attachment



- Never permit anyone to operate the engine or driven machine without proper training.

- Read and understand this Operation Manual before you operate or service the machine to ensure that you follow safe operating practices and maintenance procedures.
- Machine safety signs and labels are additional reminders for safe operating and maintenance techniques.

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Section 4

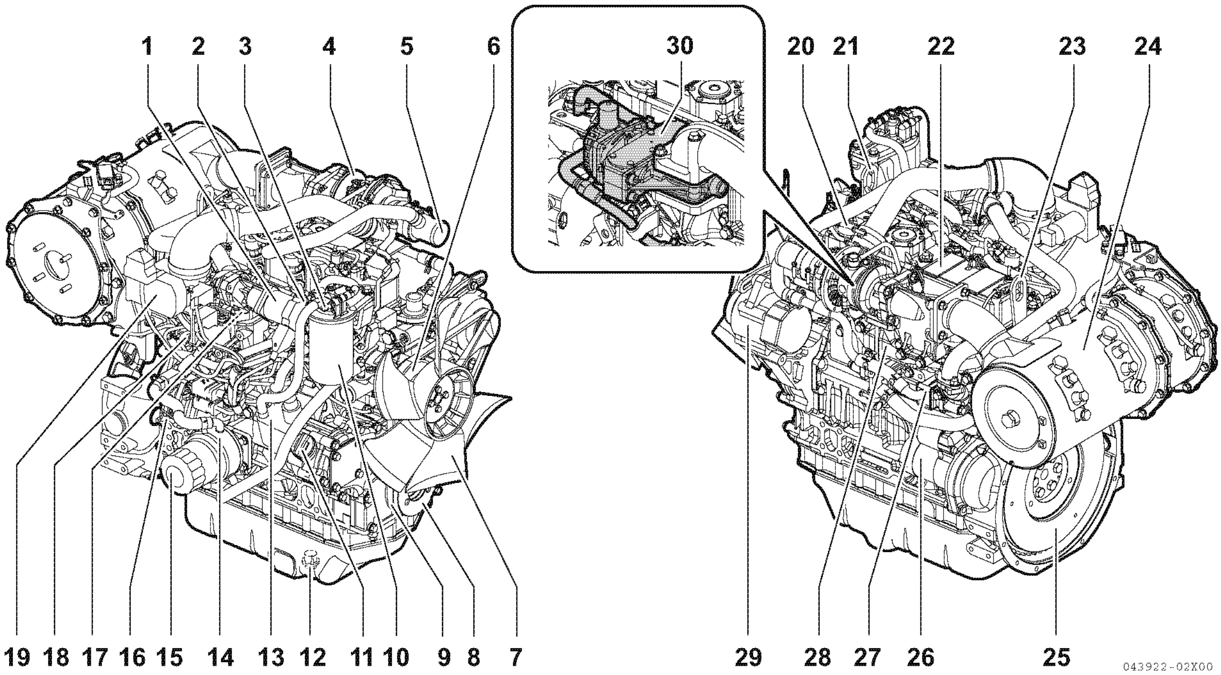
GENERAL SERVICE INFORMATION

Page

COMPONENT IDENTIFICATION

■ 3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT

Figure 4-1 shows where the major engine components are located.



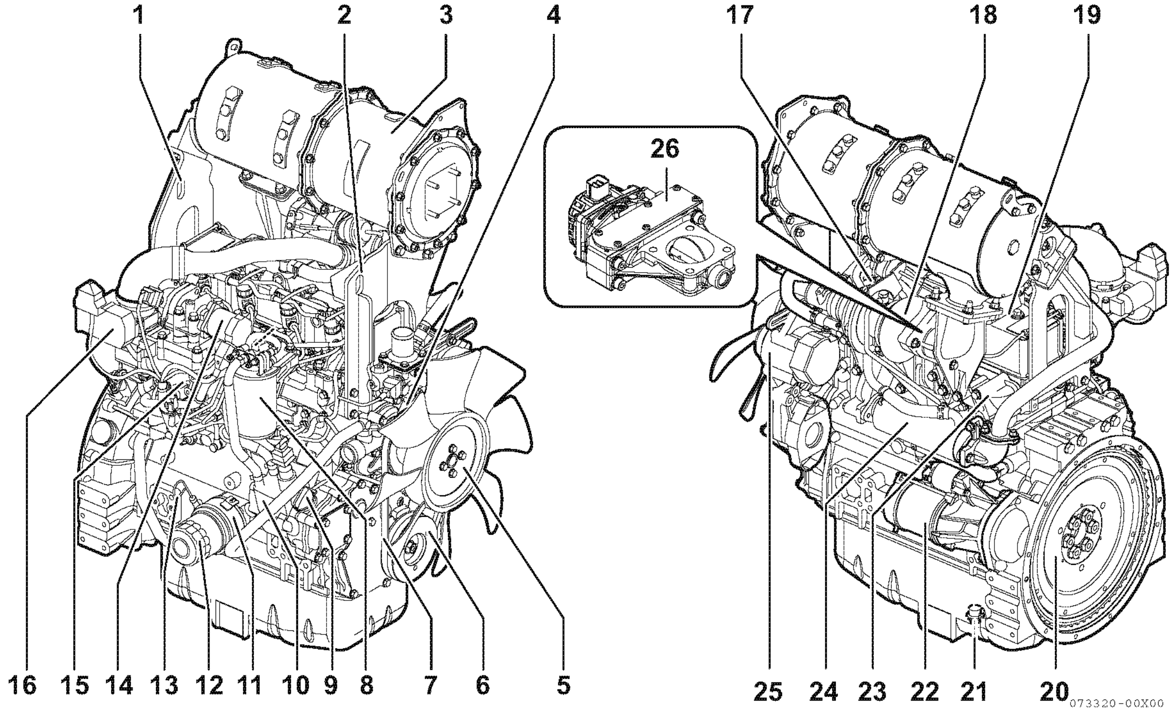
1 – EGR valve
2 – Fuel inlet
3 – Fuel return to fuel tank
4 – Turbocharger*1
5 – Air intake port (from air cleaner)
6 – Engine coolant pump
7 – Engine cooling fan
8 – Crankshaft V-pulley
9 – V-belt
10 – Fuel filter
11 – Side filler port (engine oil)
12 – Drain plug (engine oil)*2
13 – Supply pump
14 – Engine oil cooler*3
15 – Engine oil filter
16 – Dipstick (engine oil)
17 – Intake manifold
18 – Common rail
19 – Intake throttle valve
20 – Top filler port (engine oil)
21 – Lifting eye (engine cooling fan end)
22 – Cylinder head cover
23 – Lifting eye (flywheel end)
24 – Diesel Particulate Filter
25 – Flywheel
26 – Starter motor
27 – EGR cooler
28 – Exhaust manifold
29 – Alternator
30 – Exhaust throttle*4

Figure 4-1

**1: Only applies to 3TNV86CT and 4TNV86CT.*
**2: The engine oil drain plug location may vary based on oil pan options.*
**3: This may not be equipped to some of the engines.*
**4: This may be equipped to some of the engines.*

■ 4TNV98C, 4TNV98CT

Figure 4-2 shows where the major engine components are located.



1 – Lifting eye (flywheel end)
2 – Lifting eye (engine cooling fan end)
3 – Diesel Particulate Filter
4 – Engine coolant pump
5 – Engine cooling fan
6 – Crankshaft V-pulley
7 – V-belt
8 – Fuel filter
9 – Side filler port (engine oil)
10 – Supply pump
11 – Engine oil cooler
12 – Engine oil filter
13 – Dipstick (engine oil)
14 – EGR valve
15 – Common rail
16 – Intake throttle valve
17 – Top filler port (engine oil)
18 – Turbocharger*1
19 – Cylinder head cover
20 – Flywheel
21 – Drain plug (engine oil)*2
22 – Starter motor
23 – Exhaust manifold
24 – EGR cooler
25 – Alternator
26 – Exhaust throttle*3

Figure 4-2

**1: Only applies to 4TNV98CT.*
**2: Engine oil drain plug location may vary based on oil pan options.*
**3: This may be equipped to some of the engines.*

LOCATION OF LABELS

Figure 4-3 and **Figure 4-4** shows the location of engine labels and regulatory labels on YANMAR TNV series engines.

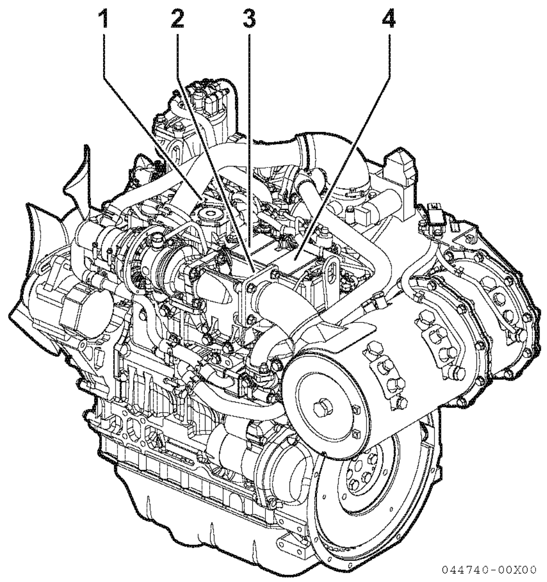


Figure 4-3

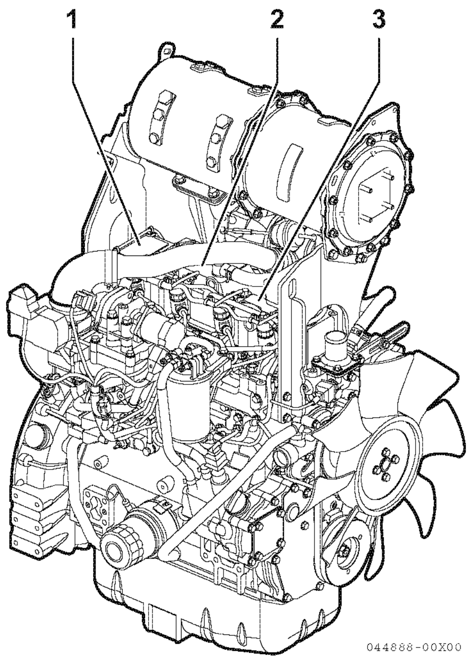
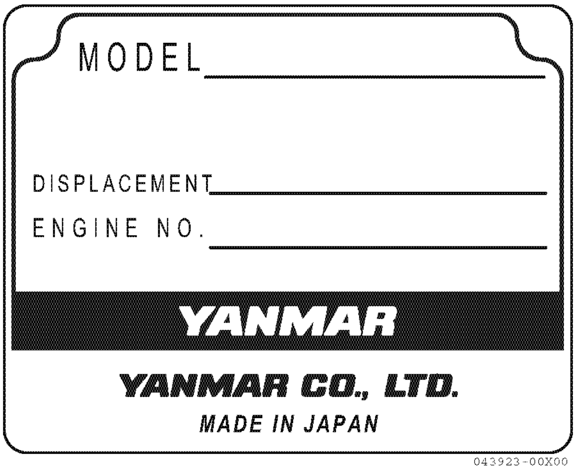


Figure 4-4

■ Location of labels/nameplates on common rail system engine

Model	Engine nameplate	EPA/ARB certification label	97/68/EC emission control label
3TNV88C, 3TNV86CT	On the top of the cylinder head cover (cooling fan end) (1, **Figure 4-3**)	On the top of the cylinder head cover (flywheel end) (4, **Figure 4-3**)	On the exhaust side of the cylinder head cover (near the flywheel) (2, **Figure 4-3**)
4TNV88C, 4TNV86CT	On the top of the cylinder head cover (cooling fan end) (1, **Figure 4-3**)	On the top of the cylinder head cover (flywheel end) (4, **Figure 4-3**)	On the top of the cylinder head cover (center) (3, **Figure 4-3**)
4TNV98C, 4TNV98CT	On the top of the cylinder head cover (flywheel end) (1, **Figure 4-4**)	On the top of the cylinder head cover (center) (2, **Figure 4-4**)	On the top of the cylinder head cover (fan end) (3, **Figure 4-4**)

Engine Nameplate (Typical)



EMISSION CONTROL REGULATIONS

EPA/ARB Regulations - USA Only

YANMAR TNV engines meet Environmental Protection Agency (EPA) (U. S. Federal) emission control standards as well as the California Air Resources Board (ARB, California) regulations. Only engines that conform to ARB regulations can be sold in the State of California.

Refer to the specific EPA/ARB installation *(page 5-4)* and maintenance *(page 5-4)* in the *Periodic Maintenance Schedule* section of this manual. Also refer to the *Emission System Warranty on page 2-6*.

EMISSION CONTROL LABELS

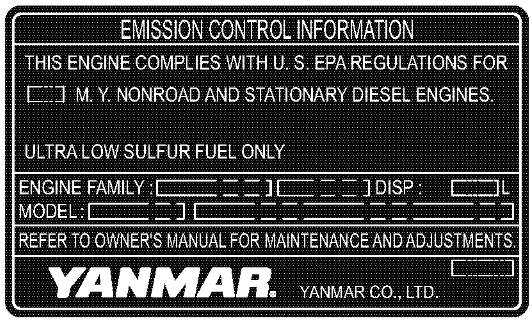
Since emission control regulations are being issued on a global basis, it is necessary to identify which regulations a particular engine complies with. We have listed several different types of labels you might find on your engine.

EPA/ARB labels (Typical)

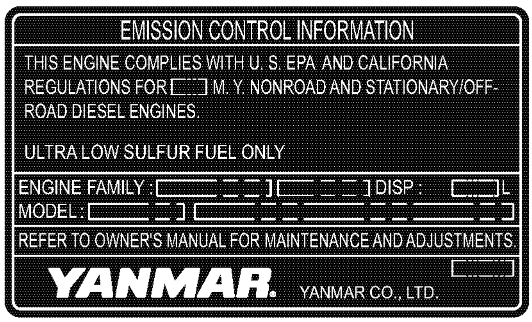
EPA: United States Environmental Protection Agency

ARB: California Air Resources Board

■ EPA



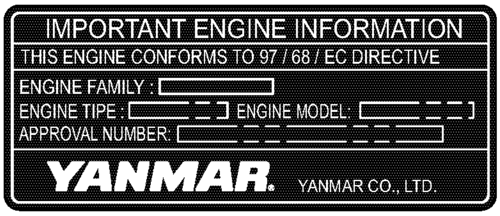
■ EPA and ARB



The 97/68/EC Directive Certified Engines

The engines described in this manual have been certified by the 97/68/EC Directive.

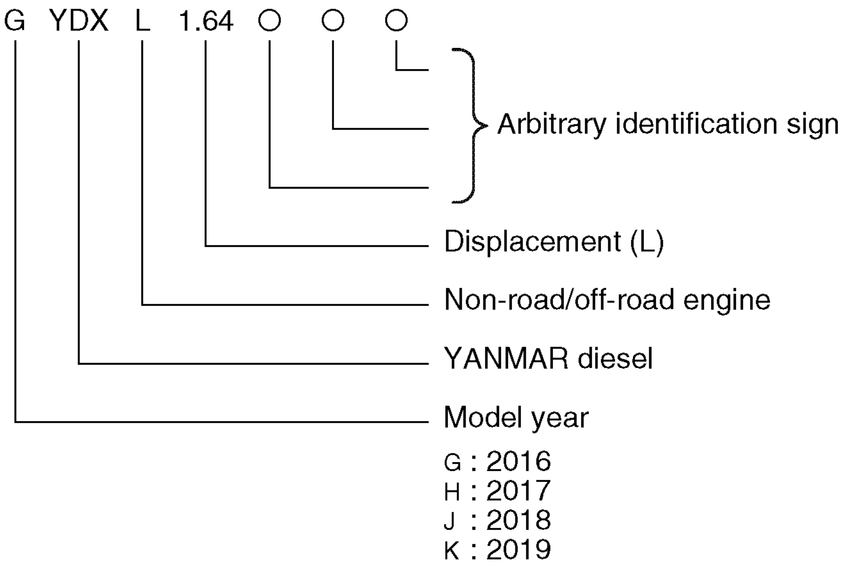
To identify the engines that meet this certification, the 97/68/EC emission control label is affixed on the engines.



ENGINE FAMILY

The EPA/ARB labels and the 97/68/EC label all have an Engine Family field.
The following is an explanation of the Engine Family designation:

The example of the EPA/ARB label indication is shown below. An indication is different for the 97/68/EC Directive Certified Labels.



FUNCTION OF MAJOR ENGINE COMPONENTS

Components	Functions
Air cleaner	The air cleaner prevents airborne contaminants from entering the engine. Since the air cleaner is application specific, it must be carefully selected by an application engineer. It is not part of the basic engine package as shipped from the YANMAR factory. Periodic replacement of the air cleaner filter element is necessary. *See the Periodic Maintenance Schedule on page 5-5* for the replacement frequency.
Alternator	The alternator is driven by a V-belt which is powered by the crankshaft V-pulley. The alternator supplies electricity to the engine systems and charges the battery while the engine is running.
Dipstick (engine lubricating oil)	The engine lubricating oil dipstick is used to determine the amount of engine lubricating oil in the crankcase.
Electric fuel feed pump	The fuel pump force-feeds fuel from the fuel tank to the supply pump. The DI engine uses the electric type, and the solenoid valve runs on 12 V (DC). When sending fuel to the fuel system, by keeping the key of the key switch in the ON position for 10 to 15 seconds, the air is automatically bled.
Engine lubricating oil filter	The engine lubricating oil filter removes contaminants and sediments from the engine lubricating oil. Periodic replacement of the engine lubricating oil filter is necessary. *See the Periodic Maintenance Schedule on page 5-5* for the replacement frequency.
Engine lubricating oil cooler	The engine lubricating oil cooler helps to keep the engine lubricating oil cool. Engine coolant from the cooling system is circulated through an adapter at the base of the engine lubricating oil filter assembly and then returned to the coolant pump inlet. This may not be equipped to some of the engines.
Fuel filter	The fuel filter removes contaminants and sediments from the diesel fuel. Periodic replacement of the fuel filter is necessary. See the *Periodic Maintenance Schedule on page 5-5* for the replacement frequency. Please note that the word “diesel” is implied throughout this manual when the word “fuel” is used.
Water separator	The water separator removes contaminants, sediment and water from diesel fuel going to the fuel filter. The separator is installed between the fuel tank and the fuel filter. Periodically replace the internal filter element and drain water.
Fuel tank	The fuel tank is a reservoir that holds diesel fuel. When fuel leaves the fuel tank it goes to the water separator. Next, fuel is pumped to the fuel filter by the electric feed pump. Next the fuel goes into the supply pump. The fuel pressurized in the supply pump is fed to the rail, but excess fuel returns to the fuel tank. The fuel tank is a required engine component.
Fuel cooler Optional	This helps to keep the fuel cool. The cooler is equipped to the returning circuit to the fuel tank.
Side and top filler port (engine lubricating oil)	You can fill the crankcase with engine oil from either the side or the top filler port depending upon which one is most convenient.
Starter motor	The starter motor is powered by the battery. When you turn the key switch in the operator’s console to the START position, the starter motor engages with the ring gear installed on the flywheel and starts the flywheel in motion.
Turbocharger (only applies to 3TNV86CT, 4TNV86CT, 4TNV98CT)	The turbocharger pressurizes the air coming into the engine. It is driven by a turbine that is energized by exhaust gas.

FUNCTION OF COOLING SYSTEM COMPONENTS

Components	Functions
Cooling system	The TNV engine is liquid-cooled by means of a cooling system. The cooling system consists of a radiator, radiator cap, engine cooling fan, engine coolant pump, thermostat, and reserve tank. Note that all cooling system components are required for proper engine operation. Since some of the components are application specific, they must be carefully selected by an application engineer. The application specific items are not part of the basic engine package as shipped from the YANMAR factory.
• Engine cooling fan	The engine cooling fan is driven by a V-belt which is powered by the crankshaft V-pulley. The purpose of the engine cooling fan is to circulate air through the radiator.
• Engine coolant pump	The engine coolant pump circulates the engine coolant through the cylinder block and the cylinder head and returns the engine coolant to the radiator.
• Radiator	The radiator acts as a heat exchanger. As the engine coolant circulates through the cylinder block it absorbs heat. The heat in the engine coolant is dissipated in the radiator. As the engine cooling fan circulates air through the radiator, the heat is transferred to the air.
• Radiator cap	The radiator cap controls the cooling system pressure. The cooling system is pressurized to raise the boiling point of the engine coolant. As the engine coolant temperature rises, the system pressure and the coolant volume increases. When the pressure reaches a preset value, the release valve in the radiator cap opens and the excess engine coolant flows into the reserve tank. As the engine coolant temperature is reduced, the system pressure and volume is reduced and the vacuum valve in the radiator cap opens allowing the engine coolant to flow from the reserve tank back into the radiator.
• Reserve tank	The reserve tank contains the overflow of engine coolant from the radiator. If you need to add engine coolant to the system, add it to the reserve tank; not the radiator.
• Thermostat	A thermostat is placed in the cooling system to prevent the engine coolant from circulating into the radiator until the engine coolant temperature reaches a preset temperature. When the engine is cold, no engine coolant flows through the radiator. Once the engine reaches its operating temperature, the thermostat opens and allows the engine coolant to flow through the radiator. By letting the engine warm up as quickly as possible, the thermostat reduces engine wear, deposits and emissions.

MAIN ELECTRONIC CONTROL COMPONENTS AND FEATURES

Component/feature	Description
Engine controller (ECU)	To be precise, it is an abbreviation for Engine Electronic Control Unit: E-ECU. By controlling the fuel injection timing, injection volume, injection pressure, and number of injection in accordance with the target speed indication entered from the accelerator sensor, the controller adjusts the engine speed and power. Depending on the above-mentioned speed and power, the controller controls the EGR opening. Also, the controller acts as the key station of the application function.
Fuel pump (supply pump)	The fuel pump supplies fuel to the common rail.
Common rail	The common rail stores the compressed high-pressure fuel from the supply pump and distributes fuel to the injector in each cylinder.
Fuel injector	The Fuel Injectors the high-pressure fuel from the rail to the engine combustion room after receiving a signal from the ECU in the most appropriate injection timing, injection volume, injection ratio, number of injection and spray condition.
EGR valve	Controls the exhaust gas recirculation flow rate depending on the engine speed/load signals from the ECU. It is installed on the top of the exhaust manifold.
Diesel Particulate Filter (DPF)	The Diesel Particulate Filter (DPF) consists of the diesel oxidation catalyst (DOC) and the soot filter (SF). It is a device to prevent the discharge of particulate matter (PM) by breaking down the hazardous constituent with the DOC and collecting the PM in the exhaust gas with the SF.
Intake throttle valve	The intake throttle adjusts the amount of intake air in the engine and controls the exhaust temperature to assist the DPF regeneration.
Exhaust throttle valve Optional	The exhaust throttle adjusts the back pressure of the exhaust gas by the valve attached to the discharge port area of the exhaust manifold. This controls the exhaust temperature and assists the DPF regeneration.
Accelerator sensor (machine setting)	Unlike mechanical governors, the electronically controlled common rail system has no governor lever. In stead, the accelerator sensor is required to set the engine target speed. The ECU determines the target speed by catching the size of voltage from the accelerator sensor. The accelerator sensor is located in the machine operator part. Specification only for constant speed engines such as those for electric generator do not require accelerator sensors because the engine speed can be shifted via a panel switch.
Optional	CAN communication capability is available as an option.

Component/feature		Description
Engine failure lamp	Optional	The failure lamp is installed on the operator's console and ECU displays the occurrence of failures to inform the operator of the initial diagnosis of failures when an error is detected in the ECU or the electronic control system. The display pattern varies depending on the machine.
SMARTASSIST-DIRECT (SA-D)	Option for service	Allows the operator to troubleshoot the cause of a problem based on detailed information regarding the defects occurring in the ECU internal control information. The SMARTASSIST-DIRECT can also be used for data maintenance tasks including ECU internal programming, mapping and adjustment values. For more details, *see Troubleshooting of Electronic Control System on page 13-16*.
Engine coolant temperature sensor		Allows the fuel injection volume and ERG to be controlled in engine cold-start conditions.
On-glow control (preheat)		At cold start, when the key switch is set to the ON position, the system automatically energizes the glow plug relay and keeps it energized for particular amount of time depending on the engine coolant temperature. (Maximum 15 seconds) The preheat indicator lights up while the relay is being energized. When the indicator goes out, turn the key switch to the "START" position to start the engine.
Droop control	Standard with VM series	Reduces the engine speed by a certain percentage from no load to full (rated) load in steady state operation. The same percentage droop is maintained even when the load increases at any no-load speed.
Isochronous control	Standard with CL series Optional with VM series	Offers a constant engine speed from no load to full load. The engine speed does not decrease even when the load increases at any no-load speed.
Low-idling speed up		When the temperature of the engine cooling water is as low 10 °C or below, raise the low idle speed to 1000 min^{-1} or more to boost the engine warm-up. When the cooling water temperature reaches the set value, it will return to the original low idle speed. This feature is not required for engines with low idle speed of 1000 min^{-1} or higher.
T/C protection control at low temperature		When starting at low temperature, if the temperature of the cooling water at the time when the engine start is complete is -15 °C (5 °F) or lower, limit the high idle speed to 1500 min^{-1} for ten seconds from the point when the engine start is complete, in order to prevent seizure of the turbocharger. The control of accelerator operation to lower the high idle speed to below 1500 min^{-1} after the ten seconds will be canceled.
High idle speed down at low temperature	Optional	When setting this function to an engine with a rated speed of 2300 min^{-1} or higher, if the temperature is -30 °C (-22 °F) or lower, the high-idling speed is lowered by about 150 min^{-1}, and shortens the time for blue-white smoke to disappear. Operating the accelerator to a speed lower than the low-temperature high-idling speed limit when the engine coolant temperature is 30 °C (86 °F) or higher will release the said control.
Auto deceleration	Optional	Brings the running engine in low idle mode automatically when the accelerator pedal is not operated for a predetermined period of time. When the pedal is operated, i.e., the accelerator sensor is activated, the low idle mode is cancelled.

INSTALLATION POSITION OF SENSORS

Do not unnecessarily touch the sensor coupler portion with your bare hands.
The sensor may be damaged due to static electricity.

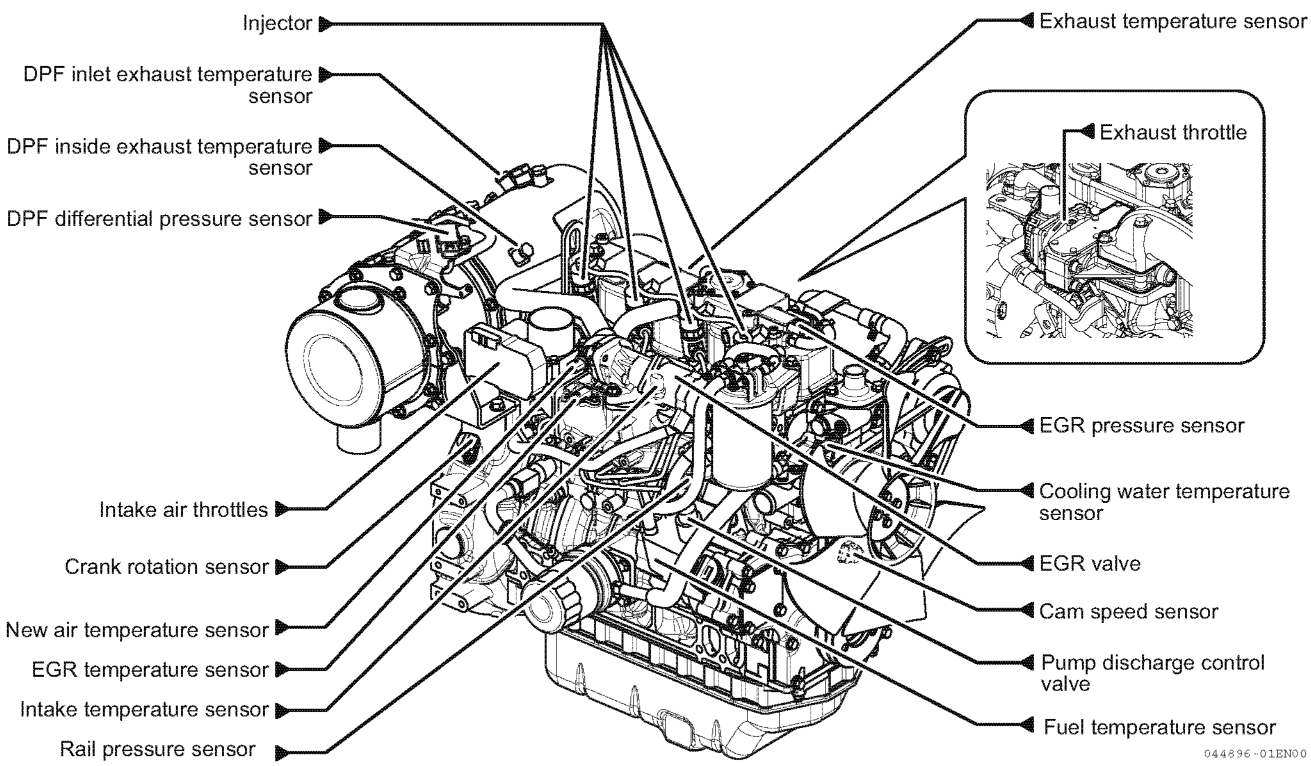


Figure 4-5

Crank Rotation Sensor

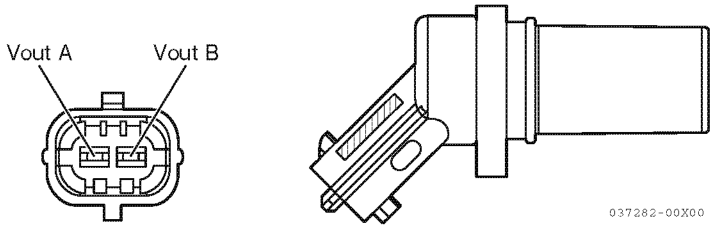


Figure 4-6

Part No.	129A00-21710
Sensor installation tightening torque	8 ± 2 N•m

Cam Speed Sensor

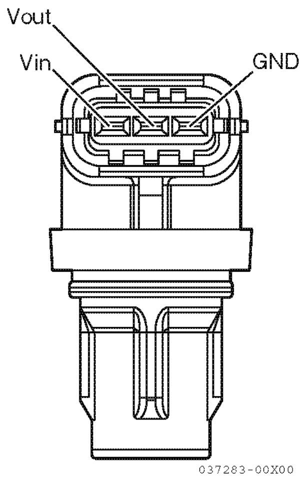


Figure 4-7

Part No.	129A00-14710
Sensor installation tightening torque	8 ± 0.5 N•m

New Air Temperature Sensor

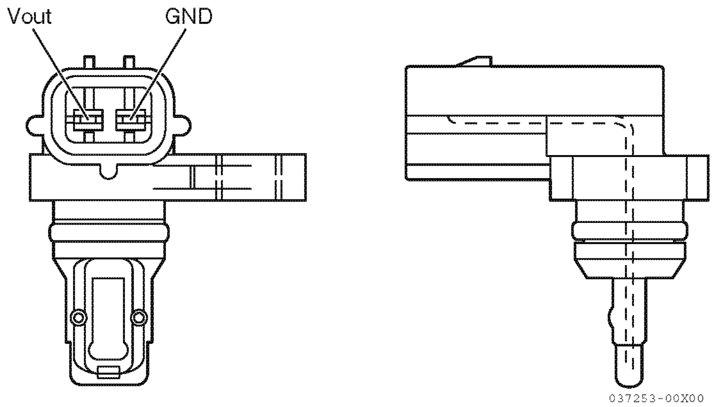


Figure 4-8

Part No.		129A00-12711
Sensor installation tightening torque	With turbocharger	7.0 ± 1.4 N•m
	Without turbocharger	3.5 ± 0.5 N•m

EGR Temperature Sensor

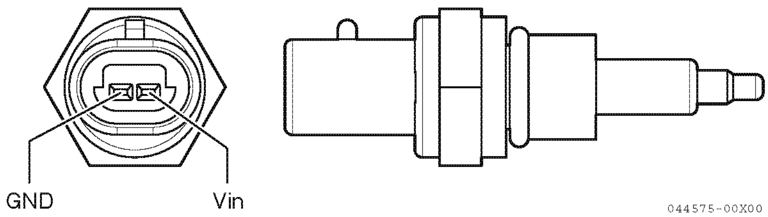


Figure 4-9

Part No.	129A00-13751
Sensor installation tightening torque	14 ± 3 N•m

Intake Temperature Sensor

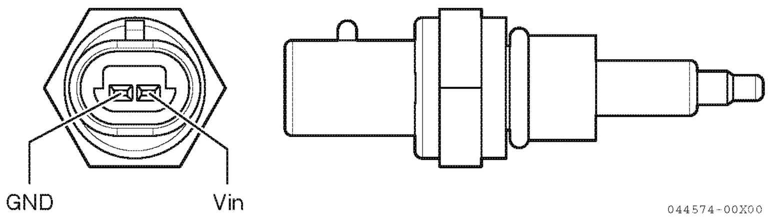


Figure 4-10

Part No.	129A00-12720
Sensor installation tightening torque	14 ± 3 N•m

Fuel Temperature Sensor (equipped on supply pump)

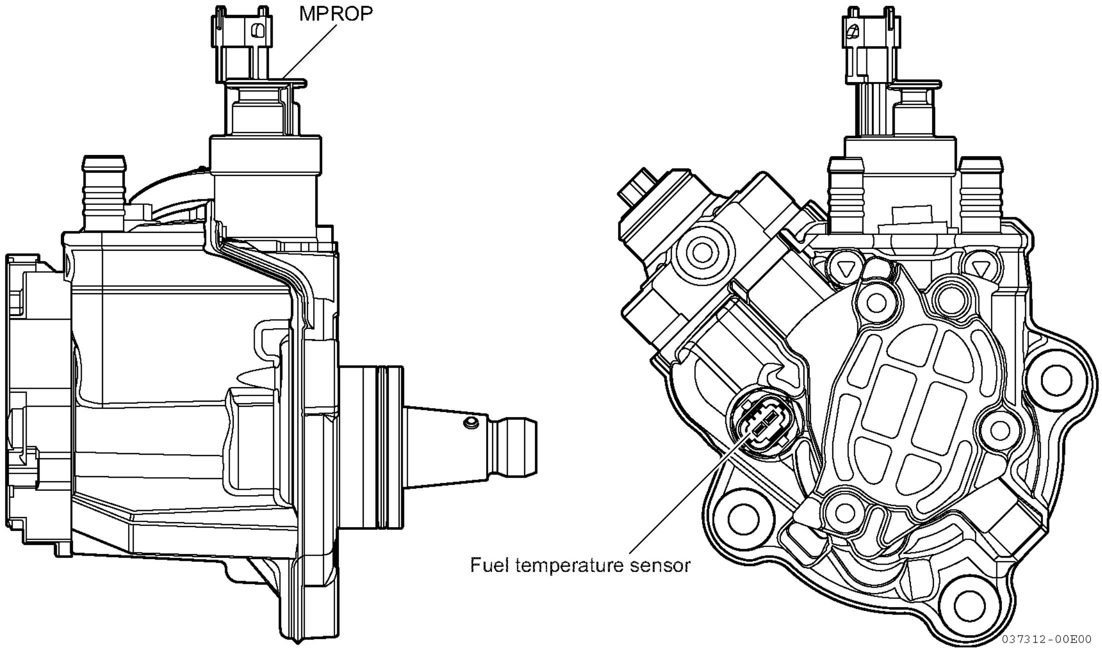


Figure 4-11

Part No.	129A00-51200
Sensor installation tightening torque	28 ± 2 N•m

Cooling Water Temperature Sensor

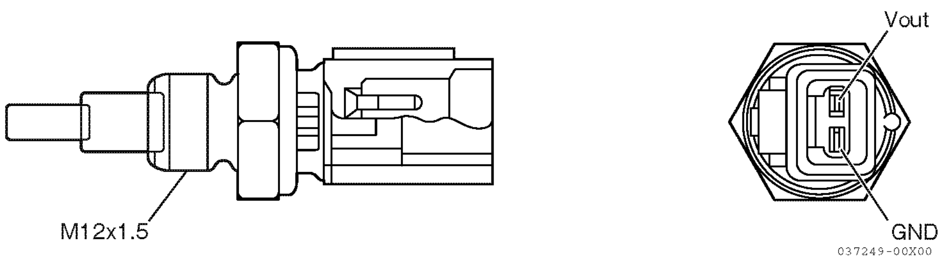


Figure 4-12

Part No.	129927-44900
Sensor installation tightening torque	22 ± 2 N•m

Exhaust Temperature Sensor

Diesel Particulate Filter (DPF) Inside/Inlet Temperature Sensor

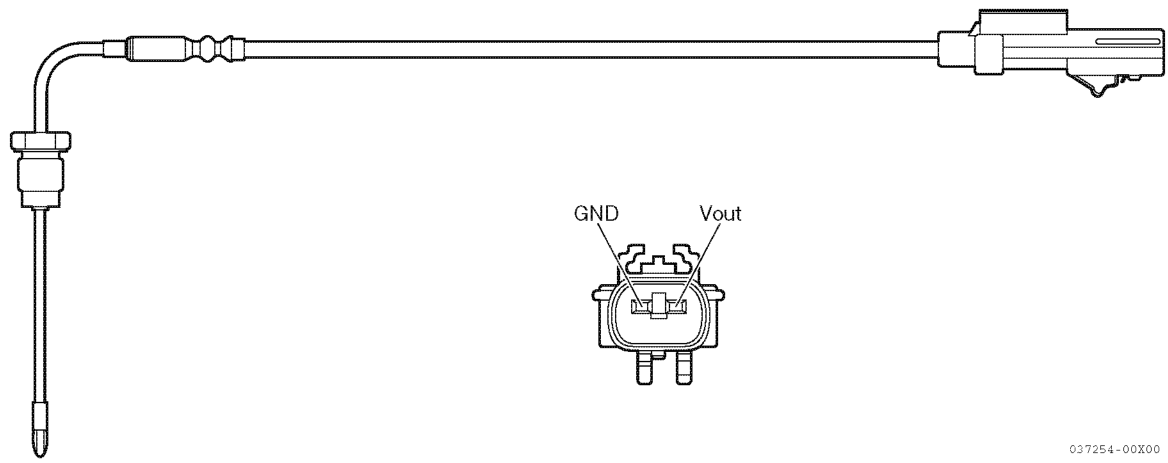


Figure 4-13

	Exhaust temperature sensor	DPF inside exhaust temperature sensor	DPF inlet exhaust temperature sensor
Part No.	129A00-13760 (Main)	129C00-13950 (Main)	129C00-13940 (Main)
Sensor installation tightening torque	32.5 ± 7.5 N•m	40 ± 5 N•m	40 ± 5 N•m
Safety precaution	Do not lift the DPF by holding the sensor part.		

Note: The parts numbers for the sensors are different depending on the engine model. Refer to the parts catalog for the correct parts number when replacing.

Rail Pressure Sensor

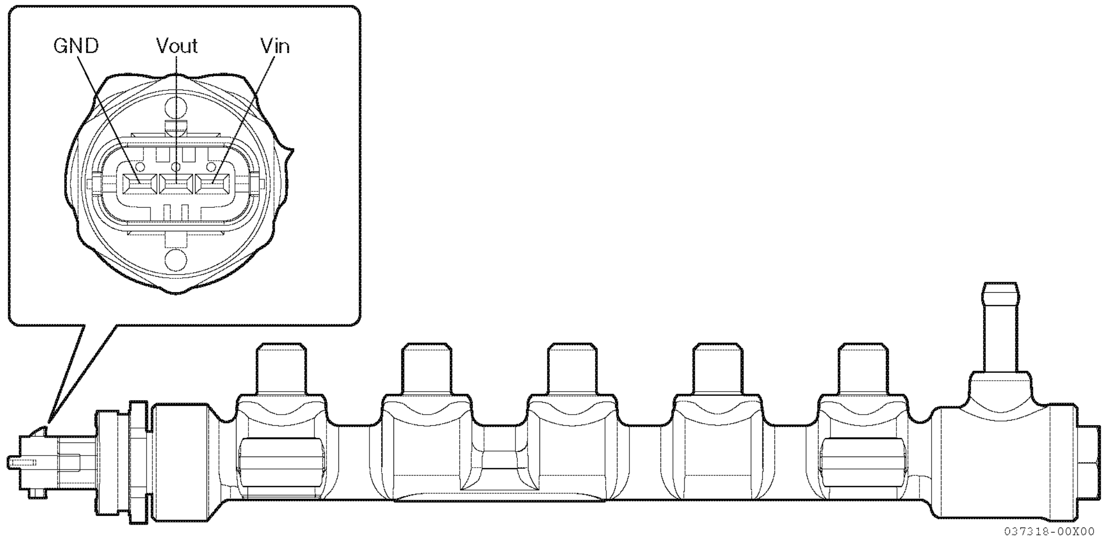


Figure 4-14

Part No.	129A00-57100
Sensor installation tightening torque	95 ± 5 N•m

EGR Pressure Sensor

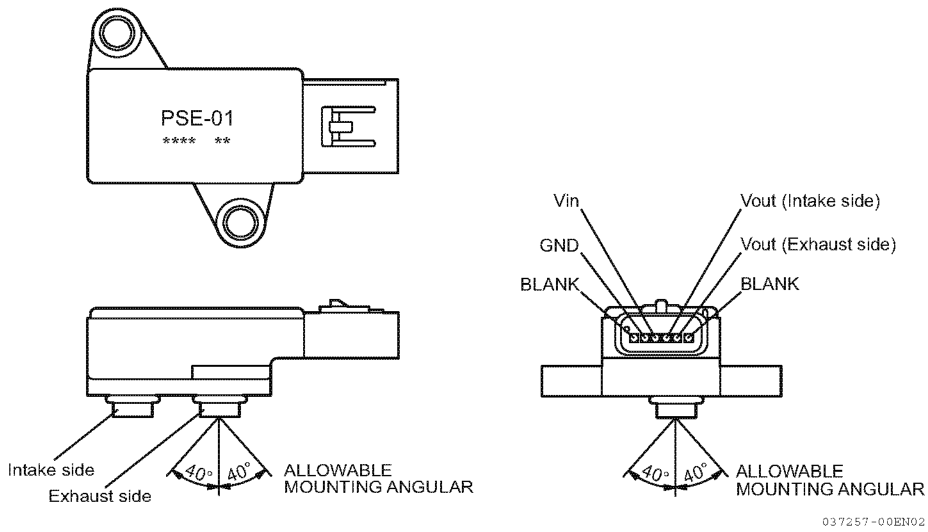


Figure 4-15

Part No.	129A00-12703
Sensor installation tightening torque	7 ± 1.4 N·m

Diesel Particulate Filter (DPF) Differential Pressure Sensor

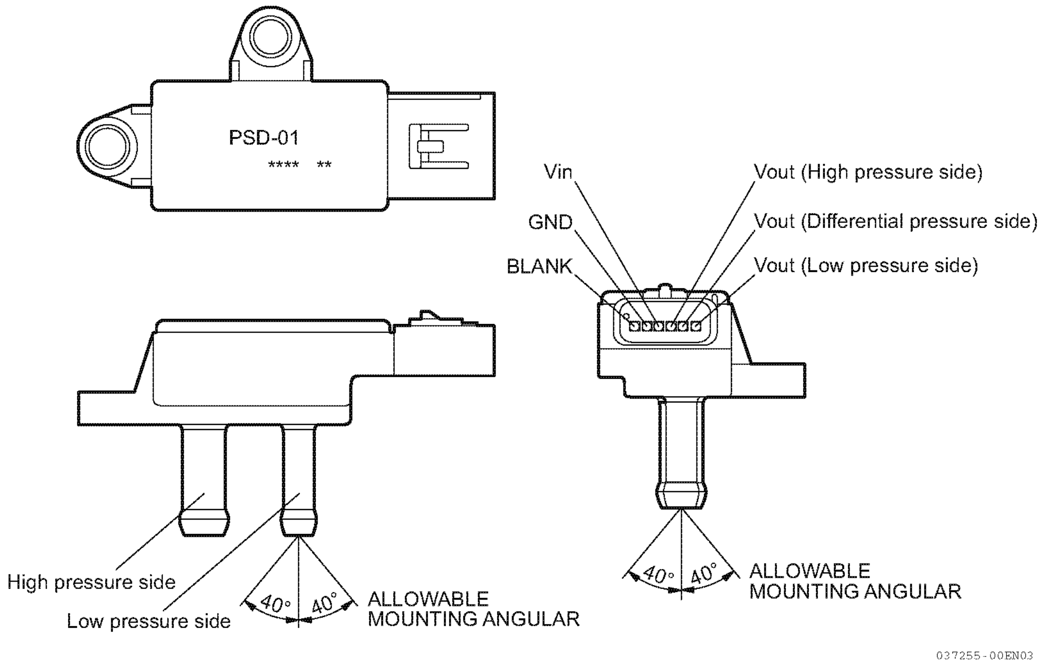
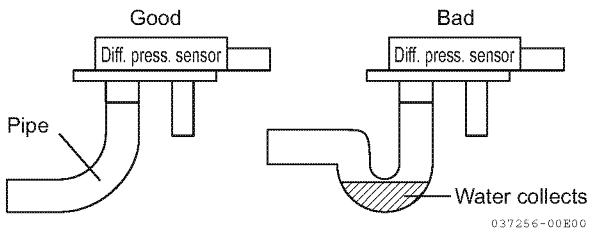


Figure 4-16

Part No.	129A00-17702
Sensor installation tightening torque	7 ± 1.4 N·m
Safety precaution	If you install a pipe to the DPF differential pressure sensor, do not install it as shown in the below figure. If water collects, the pressure cannot be detected.  Differential pressure sensor pipe installation (example)

EGR Valve

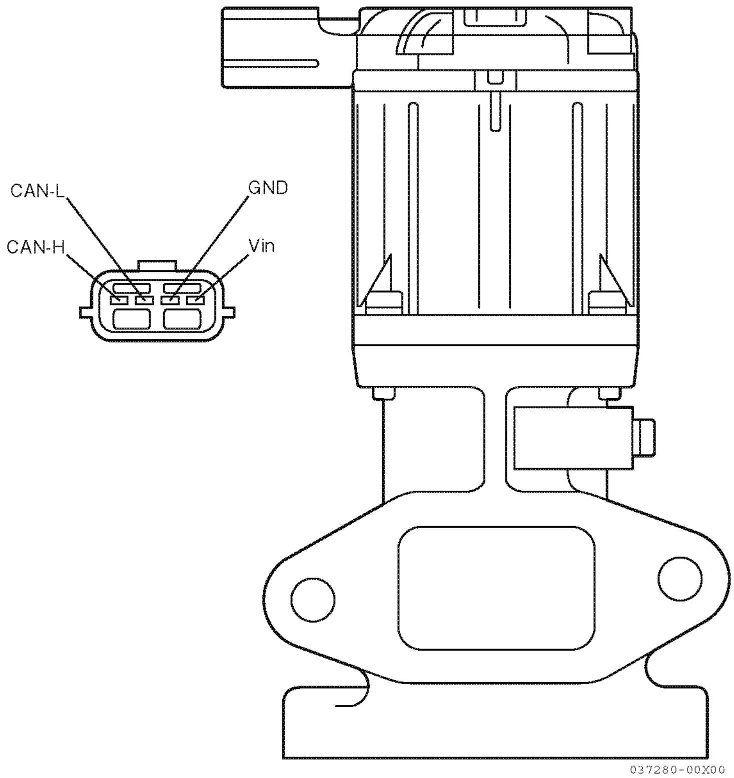


Figure 4-17

	3TNV88C, 3TNV86T	4TNV88C, 4TNV86CT	4TNV98C, 4TNV98CT
Part No.	129A00-13901	129C00-13901	129E00-13901

Intake Air Throttles

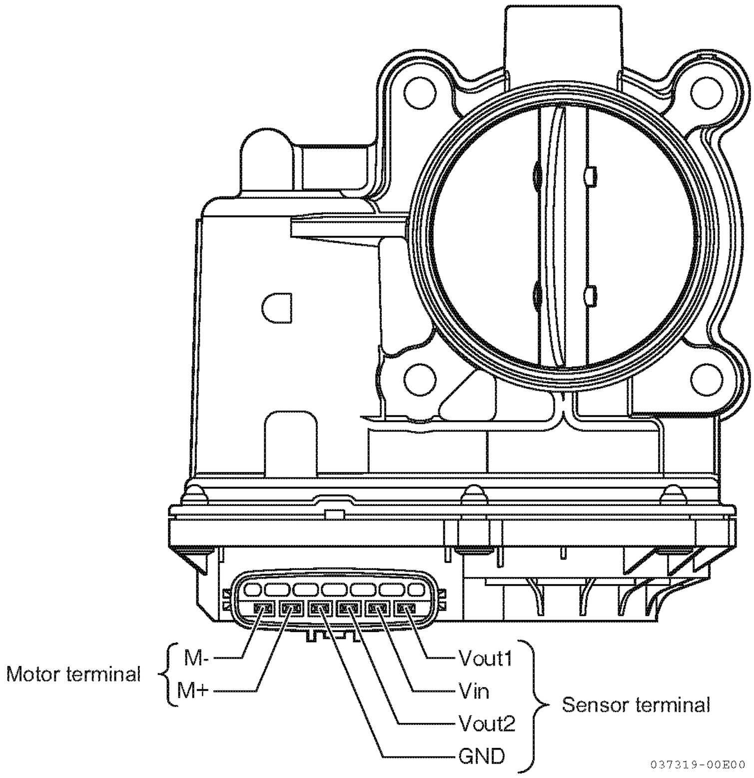


Figure 4-18

Part No.	129A00-12900
Sensor installation tightening torque	9.0 ± 1.8 N·m
Safety precaution	Be sure to read the precautions before handling the intake throttle.

Exhaust Air Throttles

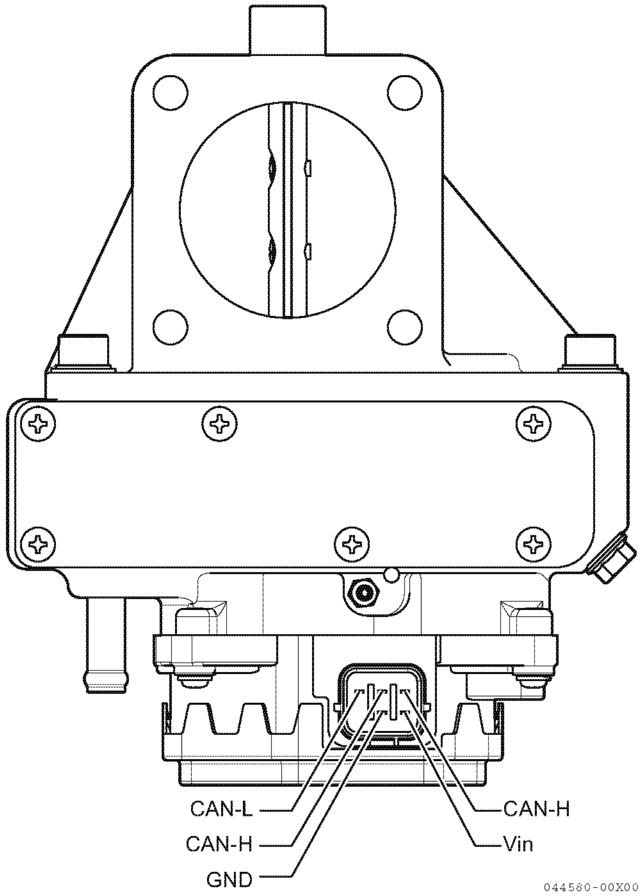


Figure 4-19

Part No.	129C00-13501
Mating part connector	Yazaki Corporation: 7283-1968-30
Water resistance	JIS D0203 S2 equivalent
Sensor installation tightening torque	25.5 ± 2.9 N·m
Safety precaution	• Do not use throttles that have been dropped. • Do not expose to excessive impact or load. • Do not touch moving parts. Do not forcefully retain moving parts.

Acceleration Sensor (YANMAR Standard)

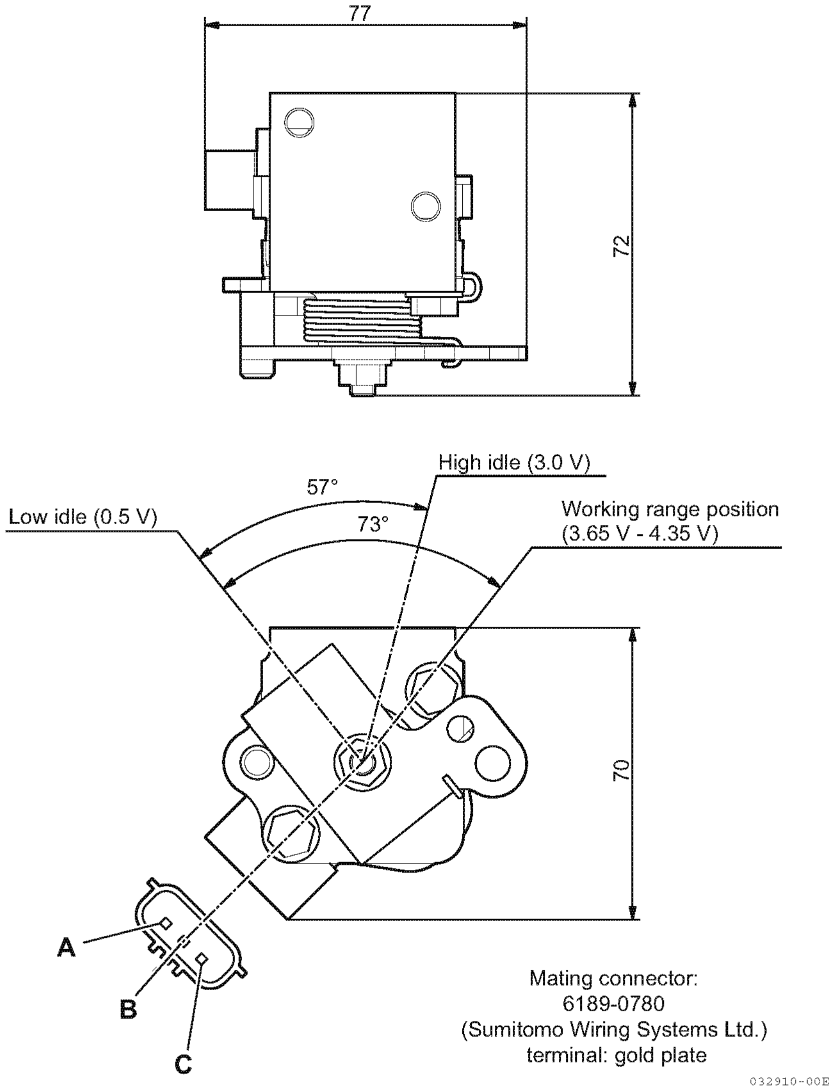


Figure 4-20

Terminal	Wire
A	GND GND-A
B	OUTPUT APS
C	INPUT AVCC

Rated voltage	DC 5 V ± 0.01 V
Part No.	129938-77800
Total resistance (sensor unit)	5 ± 1.5 kΩ

DIESEL FUEL

Diesel Fuel Specifications

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

Diesel fuel specification	Location
ASTM D975 **No. 1D S15** **No. 2D S15**	USA
EN590:96	European Union
ISO 8217 DMX	International
BS 2869-A1 or A2	United Kingdom
JIS K2204 Grade No. 2	Japan
KSM-2610	Korea
GB252	China

■ Additional technical fuel requirements

- When operating the engine in cold districts or high altitudes, the fuel cetane number should be equal to 45 or higher.
- **The sulfur content must not exceed 15 ppm by volume. A higher sulfur content fuel may cause sulfuric acid corrosion in the cylinders of the engines. Especially in U.S.A. and Canada, Ultra Low Sulfur fuel must be used.**
- Use the fuel that can be used where the temperature is 12 °C (53.6 °F) lower than the expected lowest temperature to prevent the fuel from freezing.
- Biodiesel fuels. *See Biodiesel fuels on page 4-23*.
- Water and sediment in the fuel should not exceed 0.05 % by volume.
- 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.
- Metal content of Mg, Si, and Al should be equal to or lower than 1 mass ppm. (Test analysis method JPI-5S-44-95)
- The diesel fuel should be free from Zn and Na.
- Lubricity: Wear mark of WS1.4 should be Max. 0.018 in. (460 μm) at HFRR test.

■ Precautions and concerns regarding the use of diesel fuel

- Never use kerosene.
- Never mix kerosene or used engine oil with the diesel fuel.
- Never use residual fuels that cause diesel fuel filter clogging and carbon deposits on the nozzles.
- Never use fuels stored for long time in a drum can or the like.
- Never use fuels purchased from unauthorized dealer.
- Fuel additives are not recommended. Some fuel additives may cause poor engine performance. Consult your YANMAR representative for more information.

■ Biodiesel fuels

1. General Description of Biodiesel

(a) Biodiesel is a renewable, oxygenated fuel made from agricultural and renewable resources such as soybeans or rapeseeds. Biodiesel is a fuel comprised of methyl or ethyl ester-based oxygenates of long chain fatty acids derived from the transesterification of vegetable oils, animal fats, and cooking oils. It contains no petroleum-based diesel fuel but can be blended at any level with petroleum-based diesel fuel. In case it is not blended with petroleum-based diesel fuel such biodiesel is referred to as “B100”, which means that it consists of 100 % (pure) biodiesel. However, most common biodiesel is blended with conventional (petroleum-based) diesel fuel. The percentage of the blend can be identified by its name. For example, B7 consisting of 7 % biodiesel and 93 % conventional petroleum-based diesel fuel and B20 consisting 20 % biodiesel and 80 % conventional diesel fuel. Raw pressed vegetable oils are not considered to be biodiesel.

(b) Advantages of Biodiesel:

- Biodiesel produces less visible smoke and a lower amount of particulate matter.
- Biodiesel is biodegradable and nontoxic.
- Biodiesel is safer than conventional diesel fuel because of its higher flash point.

Following the increased interest in the reduction of emissions and the reduction of the use of petroleum distillate based fuels; many governments and regulating bodies encourage the use of biodiesel.

(c) Disadvantages of Biodiesel:

Concentrations that are higher than 7 % of biodiesel (higher than B7) can have an adverse affect on the engine's performance, its integrity and/or durability. The risk of problems occurring in the engine increases as the level of biodiesel blend increases. The following negative affects are exemplary and typical for the usage of high concentrated biodiesel blends:

- Biodiesel can accelerate the oxidation of Aluminum, Brass, Bronze, Copper and Zinc.
- Biodiesel damages, and finally seeps through certain seals, gaskets, hoses, glues and plastics.
- Certain natural rubbers, nitride and butyl rubbers will become harder and more brittle as degradation proceeds when used with biodiesel.
- The deteriorated biodiesel creates deposits in the engines.
- Due to its natural characteristic, biodiesel will decrease the engine output by approximately 2 percent (in case of B20) comparing to conventional (petroleum-based) diesel fuel.
- The fuel consumption ratio will increase by approximately 3 percent (in case of B 20) comparing to conventional diesel fuel.

2. Approved Engines

All of the following engine series of YANMAR can be operated with biodiesel with concentrations up to B20. In case of using biodiesel fuel up to B7 concentrations, no special preparations etc. have to be made and the original operating conditions and service intervals as stated in the operating manuals apply. In case of running below indicated engines with biodiesel concentrations above B7 up to B20, the required operating conditions (see below No. 4) have to be observed.

The following listed engines can be run with B20 biodiesel:

- 3TNM68, 3TNM72, 2TNV70, 3TNV70 and 3TNV76
- 3TNV82A, 3TNV84, 3TNV84T, 3TNV88, 4TNV84, 4TNV84T, 4TNV88, 4TNV94L 4TNV98 and 4TNV98T
- 4TNV106 and 4TNV106T
- 4TNE92, 4TNE94L and 4TNE98 for forklift application
- 3TNM74F, 3TNV74F and 3TNV80F
- 3TNV88F
- 3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT, 4TNV98C and 4TNV98CT High-Pressure Common Rail
- 4TNV94CHT High-Pressure Common Rail

3. Approved Fuel

In case of using biodiesel (only concentrations up to B20) such fuel should comply with the below recommended standards. However, raw pressed vegetable oils are not considered to be biodiesel and are not acceptable for use as fuel in any concentration in YANMAR engines.

(a) EN14214 (European standard) and/or ASTM D-6751 (American standard).
In North America, biodiesel and biodiesel blends must be purchased from the BQ-9000 accredited producers and BQ-9000 certified distributors.

(b) All applicable engines can be operated with biodiesel fuels with concentration levels up to B20 (20 % bio-fuel blend). (However in Japan, the legally allowed maximum concentration for on-road applications is B5.)

If the concentration is B7 (7 %) or lower, the fuel can be used for all of the YANMAR's industrial engines, and does not require any special preparations or operating conditions. However, please strictly follow the standard operating conditions included in the manual.

4. Conditions for the Operation with Biodiesel (above B7 through B20)

When operating your applicable YANMAR engine (No. 2) with biodiesel blends concentrated above B7, we seriously recommend observing the following operation, service and maintenance conditions:

(a) The original service interval of the below stated services as indicated in the respective YANMAR engine standard operation manual, the application manual and the service manual should be halved (please refer to your own manuals for the each service interval):

- Replacement interval of the engine lubricating oil filter, engine lubricating oil and the fuel filter.
- Cleaning interval of the water separator
- Drain interval of the fuel tank.

(b) It is required to inspect and clean the fuel injector every 1000 operating hours.

It is strongly recommended to replace the fuel hoses after 2000 operating hours or 2 years whichever comes first same as conventional diesel fuel used.

(c) Replacement of the following parts before using the recommended biodiesel:
(only for the operation with biodiesel above B10 through B20)

- O-ring for the water separator of common rail type engines

(d) Please use only biodiesel fuel that is appropriate to the intended operation environment of the engines. This especially applies if the operating ambient temperature falls below 0 degree centigrade.

(e) In particular, operation with biodiesel requires daily maintenance as follows:

1. Please daily check the engine oil level. If the oil level rises above the oil level of the previous day, the engine oil needs to be immediately replaced.
2. Please daily check the water level of the water separator. If the water level rises above the "max" indicator, an immediate drain of the water separator is required.

(f) Biodiesel blends up to B20 can only be used for a limited time of up to 3 months of the date of biodiesel manufacture. Therefore biodiesel needs to be used at latest within 2 months from the time of filling the tank or within 3 months from the time of production by the fuel supplier, whichever comes first.

(g) Before a long-term storage without operating the engine, the biodiesel needs to be drained out completely and the engine has to be run for 30 minutes with conventional diesel fuel as indicated in your operation manual.

The summary of difference for operation condition by blends and models which is mentioned above are as follows.

Blends	Service interval	Parts exchange	Model
- B7	Same as standard	Not required	All YANMAR industrial models
B8 - B10	Half of standard	Not required	TNV Tier3 & Tier4
B11 - B20	Half of standard	Required (only O-rings)	TNV Tier4 CR model

Standard: Same as Operation and Service manual
CR: Common Rail Engine

■ Kit component for B20 (TNV Tier4 CR)

Water separator
(Replacement of the O-rings only)

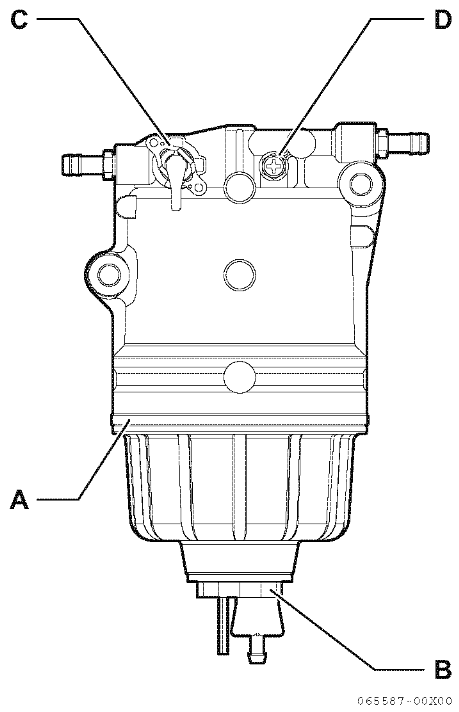


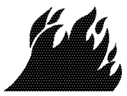
Figure 4-21

A	24326-001000 (G100)
B	24316-000070 (P7)
C	24316-000110 (P11) Valve lever
D	24316-000060 (P6) Air plug

Filling The Fuel Tank

⚠ DANGER

Fire and Explosion Hazard!



- **Diesel fuel is flammable and explosive under certain conditions.**

- **Only fill the fuel tank with diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine.**
- **Never refuel with the engine running.**
- **Wipe up all spills immediately.**
- **Keep sparks, open flames or any other form of ignition (match, cigarette, static electric source) well away when refueling.**
- **Never overfill the fuel tank.**
- **Fill the fuel tank. Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.**
- **Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.**
- **Never place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.**
- **Before you operate the engine, check for fuel leaks. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of engine operation, whichever comes first.**
- **Failure to comply will result in death or serious injury.**

NOTICE

- Poor quality fuel can reduce engine performance and cause damage. Only use diesel fuels recommended by YANMAR for the best engine performance. The recommended fuel complies with the U.S. EPA and ARB protection guidelines.
- The common rail system installed as this engine's fuel injection device is very high in pressure and sprays fuel into the cylinder. If any impurities or water mixes into the fuel, the sliding parts of the fuel system causes friction and may degrade the engine's exhaust gas property durability. Only use clean diesel fuel.
- Keep the fuel tank and fuel-handling equipment clean at all times. Be careful not to let any contaminants or even dust from the outside into the filler port when supplying fuel.
- Never remove the primary strainer (if equipped) from the fuel tank filler port. If removed, dirt and debris could get into the fuel system causing it to clog.

Note that a typical fuel tank is shown. The fuel tank on your equipment may be different.

1. Clean the area around the fuel cap (1, **Figure 4-22**).
2. Remove the fuel cap from the fuel tank (2, **Figure 4-22**).
3. Observe the fuel level sight gauge (3, **Figure 4-22**) and stop filling when gauge shows fuel tank is full. Never overfill the fuel tank.
4. Replace the fuel cap (1, **Figure 4-22**), hand tighten. Over tightening the fuel cap will damage it.

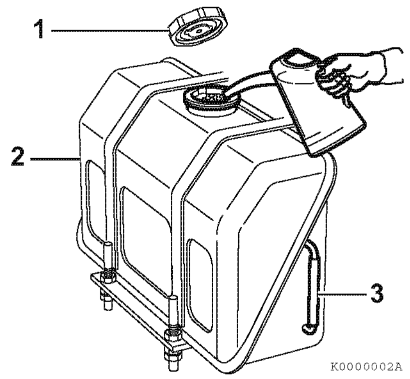


Figure 4-22

NOTICE

Check the fuel level gauge in the fuel tank daily and ensure that the engine does not run out of fuel.Seizure to the supply pump may occur.

Priming the Fuel System

DANGER

Fire and Explosion Hazard!

- **Diesel fuel is flammable and explosive under certain conditions.**

- **If the unit has an electric fuel pump, when you prime the fuel system, turn the key switch to the ON position for 10 to 15 seconds to allow the electric fuel pump to prime the system.**
- **Never open the air vent valve while the fuel system is being primed. The fuel filter has an internal air bleed port.**
- **Failure to comply will result in death or serious injury.**

The fuel system needs to be primed under certain conditions:

- Before starting the engine for the first time.
- After running out of fuel and fuel has been added to the fuel tank.
- After fuel system maintenance such as changing the fuel filter and draining the fuel filter/water separator, or replacing a fuel system component.

To prime the fuel system:

1. Turn the key to the ON position for 10 to 15 seconds. This will allow the electric fuel pump to prime the fuel system.
2. Never use the starter motor to crank the engine in order to prime the fuel system. This may cause the starter motor to overheat and damage the coils, pinion and/or ring gear.

NOTICE

Be sure to perform priming. If air is mixed to the fuel, seizure to the supply pump and the injector may result.

ENGINE LUBRICATING OIL

NOTICE

- Only use the engine lubricating oil specified. Other engine lubricating oils may affect warranty coverage, cause internal engine components to seize and/or shorten engine life.
- Prevent dirt and debris from contaminating the engine lubricating oil. Carefully clean the oil cap/dipstick and the surrounding area before you remove the cap.
- Never mix different types of engine lubricating oil. This may adversely affect the lubricating properties of the engine lubricating oil.
- Never overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.

Engine Lubricating Oil Specifications

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

■ Service categories

- API service categories CJ-4
- ACEA service categories E6
- JASO service category DH-2

■ Definitions

- API classification (American Petroleum Institute)
- ACEA classification (Association des Constructeurs Européens d'Automobilies)
- JASO (Japanese Automobile Standards Organization)

NOTICE

- Be sure the engine lubricating oil, engine lubricating oil storage containers, and engine lubricating oil filling equipment are free of sediments and water.
- Change the engine lubricating oil at every 500 hours or 1 year. However, change interval has different standard dependent on the application or engine lubricating oil capacity. Refer to the operation manual provided by the driven machine manufacturer for the actual engine lubricating oil change interval.
- Select the oil viscosity based on the ambient temperature where the engine is being operated. See the SAE service grade viscosity chart (**Figure 4-23**).
- YANMAR does not recommend the use of engine lubricating oil "additives."
- Never mix different brands of lubricating oils.
- Never use synthetic oil.

■ Additional technical engine lubricating oil requirements:

The engine lubricating oil must be changed when the Total Base Number (TBN) has been reduced to 1.0 mgKOH/g. TBN (mgKOH/g) test method; JIS K-201-5.2-2 (HCl), ASTM D4739 (HCl).

Engine Lubricating Oil Viscosity

Select the appropriate engine oil viscosity based on the ambient temperature and use the SAE service grade viscosity chart in **Figure 4-23**.

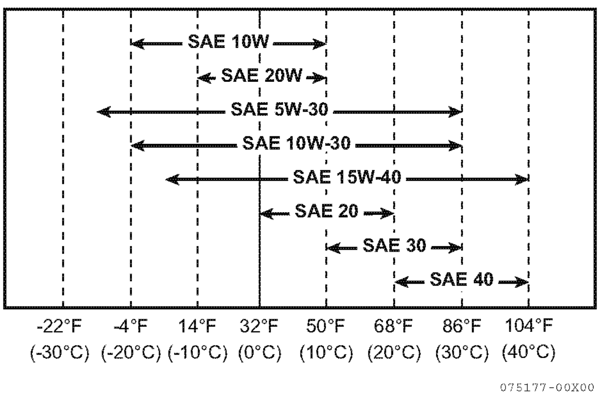


Figure 4-23

Checking Engine Lubricating Oil

1. Make sure engine is level.
2. Remove dipstick (1, **Figure 4-24**) and wipe with clean cloth.
3. Fully reinsert dipstick.
4. Remove dipstick. The oil level should be between upper (2, **Figure 4-24**) and lower (3, **Figure 4-24**) lines on the dipstick.
5. Fully reinsert dipstick.

Adding Engine Lubricating Oil

1. Make sure engine is level.
2. Remove oil cap (4, **Figure 4-24**).
3. Add indicated amount of engine oil at the top or side engine oil filler port (5, **Figure 4-24**).
4. Wait three minutes and check oil level.
5. Add more oil if necessary.
6. Reinstall oil cap (4, **Figure 4-24**) and hand-tighten. Over-tightening may damage the cap.

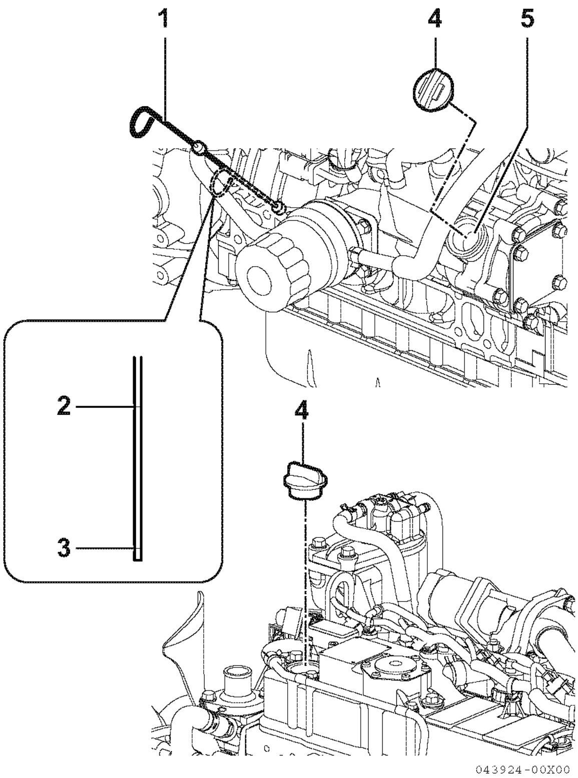


Figure 4-24

Engine Oil Capacity (Typical)

These are the engine oil capacities associated with a “Deep Standard” oil pan. Oil capacity will vary dependent upon which optional oil pan is used. Refer to the operation manual provided by the driven machine manufacturer for the actual engine oil capacity of your machine.

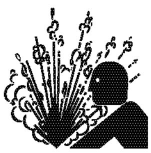
The following are the engine oil capacities for various YANMAR TNV engines.

Engine model	Dipstick upper limit/lower limit
3TNV88C, 3TNV86CT	7.1/4.1 qt (6.7/3.9 L)
4TNV88C, 4TNV86CT	7.8/4.2 qt (7.4/4.0 L)
4TNV98C, 4TNV98CT	11.1/6.3 qt (10.5/6.0 L)

ENGINE COOLANT

⚠ DANGER

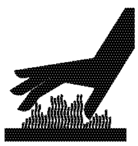
Scald Hazard!



- **Never remove the radiator cap if the engine is hot. Steam and hot engine coolant will spurt out and seriously burn you. Allow the engine to cool down before you attempt to remove the radiator cap.**
- **Tighten the radiator cap securely after you check the radiator. Steam can spurt out during engine operation if the cap is loose.**
- **Always check the level of the engine coolant by observing the reserve tank.**
- **Failure to comply will result in death or serious injury.**

⚠ WARNING

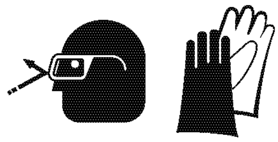
Burn Hazard!



- **If you drain the engine oil while it is still hot, stay clear of the hot engine oil to avoid being burned. Always wear eye protection when you handle the engine coolant.**
- **Failure to comply could result in death or serious injury.**

⚠ CAUTION

Engine Coolant Hazard!



- **Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.**
- **Failure to comply may result in minor or moderate injury.**

NOTICE

- Only use the engine coolant specified. Other engine coolants may affect warranty coverage, cause an internal buildup of rust and scale and/or shorten engine life.
- Prevent dirt and debris from contaminating the engine coolant. Carefully clean the radiator 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.

Engine Coolant Specifications

Use a Long Life Coolant (LLC) or an Extended Life Coolant (ELC) that meets or exceeds the following guidelines and specifications.

- ASTM D6210, D4985 (US)
- JIS K-2234 (Japan)
- SAE J814C, J1941, J1034 or J2036 (International)

■ Alternative engine coolant

If an Extended or Long Life Coolant is not available, alternatively, you may use an ethylene glycol or propylene glycol based conventional coolant (green).

NOTICE

- Always use a mix of coolant and water. Never use water only.
- Mix coolant and water per the mixing instructions on the coolant container.
- Water quality is important to coolant performance. YANMAR recommends that soft, distilled or demineralized water be used to mix with coolants.
- Never mix extended or long life coolants and conventional (green) coolants.
- Never mix different types and/or colors of extended life coolants.
- Replace the coolant every 2000 engine hours or 2 years.

Filling Radiator with Engine Coolant

Fill the radiator and reserve tank as follows. This procedure is for filling the radiator for the first time or refilling it after it is flushed. Note that a typical radiator is illustrated.

1. Check to be sure the radiator drain plug is installed and tightened or the drain valve (1, **Figure 4-25**) is closed. Also make sure the coolant hoses (1, **Figure 4-26**) are installed at the oil cooler.

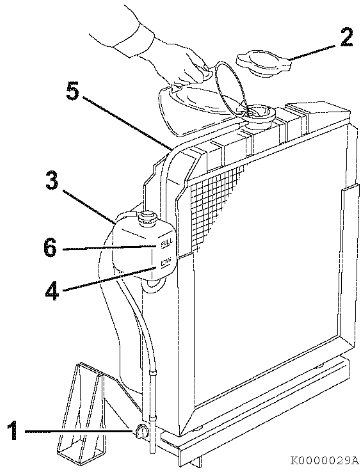


Figure 4-25

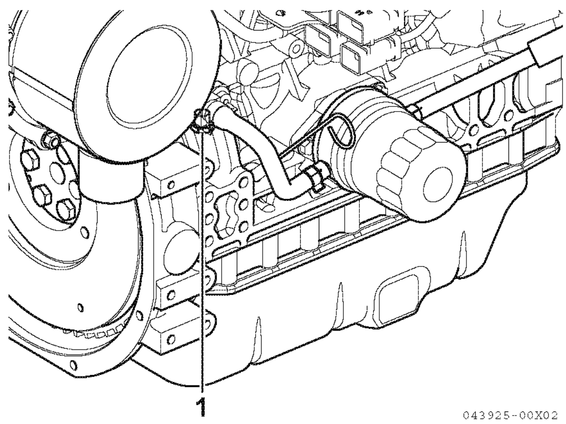


Figure 4-26

2. Remove the radiator cap (2, **Figure 4-25**) by turning it counterclockwise about 1/3 of a turn.
3. Pour the engine coolant slowly into the radiator until it is even with the lip of the engine coolant filler port. Make sure that air bubbles do not develop as you fill the radiator.
4. Reinstall the radiator cap (2, **Figure 4-25**). Align the tabs on the back side of the radiator cap with the notches on the engine coolant filler port. Press down and turn the cap clockwise about 1/3 of a turn.
5. Remove the cap of the reserve tank (3, **Figure 4-25**), and fill it to the LOW (COLD) mark (4, **Figure 4-25**) with engine coolant. Reinstall the cap.
6. Check the hose (5, **Figure 4-25**) that connects the reserve tank (3, **Figure 4-25**) to the radiator. Be sure it is securely connected and there are no cracks or damage. If the hose is damaged, engine coolant will leak out instead of going into the reserve tank.
7. Run the engine until it reaches operating temperature. Check the level of engine coolant in the reserve tank. When the engine is running and the engine coolant is at normal temperature, the coolant level in the reserve tank should be at or neat the FULL (HOT) mark (6, **Figure 4-25**). If the coolant is not at the FULL (HOT) mark, add coolant to the reserve tank to bring the coolant level to the FULL (HOT) mark.

Daily Check of the Cooling System

1. Check the level of engine coolant in the reserve tank. When the engine is cold, the coolant level in the tank should be at or slightly above the LOW (COLD) mark (4, **Figure 4-25**) on the coolant reserve tank.

   If the coolant level is at the FULL (HOT) mark (6, **Figure 4-25**) when the engine is cold, the coolant will expand when it becomes hot and possibly spray out of the overflow hose.
2. Add additional engine coolant to the reserve tank if necessary.
3. Check the radiator hoses for cracks, abrasions, cuts or other damage. Replace as necessary.

Engine Coolant Capacity (Typical)

Capacities listed are for the engine only without a radiator. Refer to the operation manual provided by the driven machine manufacturer for actual engine coolant capacity on your machine.

The following are the engine coolant capacities for various YANMAR TNV engines.

Engine model	Engine coolant capacity
3TNV88C, 3TNV86CT	2.1 qt (2.0 L)
4TNV88C, 4TNV86CT	2.9 qt (2.7 L)
4TNV98C, 4TNV98CT	4.4 qt (4.2 L)

SPECIFICATIONS

Description of Model Number

3 TNV 86 C T - 0 00

- 00 — Customer code
- 0 — Rated RPM
- T — Turbocharged (No symbol indicates naturally aspirated)
- C — Common rail system (EPA Tier4 certified)
- 86 — Cylinder bore (mm)
- TNV — Engine series
- 3 — No. of cylinders

Engine General Specifications

Type	Vertical in-line, water cooled, 4-cycle diesel engine
Fuel injection system	Common rail system
Starting system	Electric starting
Cooling system	Radiator
Lubricating system	Forced lubrication with trochoid pump
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end

Note:

- *The information described in Principal Engine Specifications is for a “standard” engine. To obtain the information for the engine installed in your driven machine, please refer to the manual provided by the driven machine manufacturer.*
- *Engine rating conditions are as follows (SAE J1349, ISO 3046/1):*
  - *Atmospheric condition: Room temperature 77 °F (25 °C), atmospheric pressure 29.53 in. Hg (100 kPa, 750 mm Hg), relative humidity 30 %*
  - *Fuel temperature at fuel injector pump inlet: 104 °F (40 °C)*
  - *Fuel feeding pressure: 20 ± 10 kPa (net) after engine break-in has been performed with the cooling fan, air cleaner and muffler installed to the engine.*
  - *With cooling fan, air cleaner, muffler: YANMAR standard*
  - *After the engine break-in period. Output allowable deviation: ± 3 %*
  - *1 PS = 0.7355 kW*
  - *1 hp SAE (Society of Automotive Engineers) = 0.7457 kW*

PRINCIPAL ENGINE SPECIFICATIONS

3TNV88C

Engine model	3TNV88C
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Naturally aspiration
No. of cylinders	3
Bore × stroke	88 × 90 mm
Displacement	1.642 L
Max. rated output (Gross)	3000 min^{-1}
	27.5 kW
	37.4 PS
High idling	3150 ± 25 min^{-1}
Engine weight (Dry)	188 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.34 - 0.54 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 1.7 kW)
	Alternator (12 V - 55 A)
	Recommended battery capacity: 12 V 413CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	6.7/3.9 L Dipstick upper limit/lower limit)
Engine coolant capacity	2.0 L (Engine only)
Standard cooling fan	ø335 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø110/ø110 mm
Top clearance	0.73 ± 0.06 mm

3TNV86CT

Engine model	3TNV86CT
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Turbocharged
No. of cylinders	3
Bore × stroke	86 × 90 mm
Displacement	1.568 L
Max. rated output (Gross)	3000 min^{-1}
	32.4 kW
	44.1 PS
High idling	3150 ± 25 min^{-1}
Engine weight (Dry)	200 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.34 - 0.54 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 1.7 kW)
	Alternator (12 V - 55 A)
	Recommended battery capacity: 12 V 413CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	6.7/3.9 L Dipstick upper limit/lower limit)
Engine coolant capacity	2.0 L (Engine only)
Standard cooling fan	ø350 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø110/ø110 mm
Top clearance	0.73 ± 0.06 mm

4TNV88C

Engine model	4TNV88C
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Naturally aspiration
No. of cylinders	4
Bore × stroke	88 × 90 mm
Displacement	2.189 L
Max. rated output (Gross)	3000 min^{-1}
	35.5 kW
	48.3 PS
High idling	3150 ± 25 min^{-1}
Engine weight (Dry)	220 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.32 - 0.47 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 1.7 kW)
	Alternator (12 V - 55 A)
	Recommended battery capacity: 12 V 622CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	7.4/4.0 L Dipstick upper limit/lower limit)
Engine coolant capacity	2.7 L (Engine only)
Standard cooling fan	ø370 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø110/ø110 mm
Top clearance	0.73 ± 0.06 mm

4TNV86CT

Engine model	4TNV86CT
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Turbocharged
No. of cylinders	4
Bore × stroke	86 × 90 mm
Displacement	2.090 L
Max. rated output (Gross)	3000 min^{-1}
	44.0 kW
	59.8 PS
High idling	3150 ± 25 min^{-1}
Engine weight (Dry)	225 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.36 - 0.51 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 1.7 kW)
	Alternator (12 V - 55 A)
	Recommended battery capacity: 12 V 622CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	7.4/4.0 L Dipstick upper limit/lower limit)
Engine coolant capacity	2.7 L (Engine only)
Standard cooling fan	ø370 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø110/ø110 mm
Top clearance	0.73 ± 0.06 mm

4TNV98C

Engine model	4TNV98C
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Naturally aspiration
No. of cylinders	4
Bore × stroke	98 × 110 mm
Displacement	3.319 L
Max. rated output (Gross)	2500 min^{-1}
	51.7 kW
	70.3 PS
High idling	2650 ± 25 min^{-1}
Engine weight (Dry)	280 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.29 - 0.39 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 3.0 kW)
	Alternator (DC12 V - 55 A)
	Recommended battery capacity: 12 V 799CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	10.5/6.0 L Dipstick upper limit/lower limit)
Engine coolant capacity	4.2 L (Engine only)
Standard cooling fan	ø430 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø130/ø130 mm
Top clearance	0.793 ± 0.063 mm

4TNV98CT

Engine model	4TNV98CT
Version	VM
Type	Vertical in-line diesel engine (Common rail system)
Combustion system	Direct injection
Aspiration	Turbocharged
No. of cylinders	4
Bore × stroke	94 × 110 mm
Displacement	3.053 L
Max. rated output (Gross)	2500 min^{-1}
	53.7 kW
	73.0 PS
High idling	2650 ± 25 min^{-1}
Engine weight (Dry)	291 kg
PTO position	Flywheel end
Direction of rotation	Counterclockwise viewed from flywheel end
Cooling system	Liquid-cooled with radiator
Lubricating system	Forced lubrication with trochoid pump
Normal oil pressure at rated engine speed	0.29 - 0.39 MPa
Normal oil pressure at low idle speed	0.06 MPa
Starting system	Electric starting (Starter motor: DC 12 V - 3.0 kW)
	Alternator (DC12 V - 55 A)
	Recommended battery capacity: 12 V 799CCA
Dimensions (L × W × H)	Depend on DPF layout
Engine oil pan capacity	10.5/6.0 L Dipstick upper limit/lower limit)
Engine coolant capacity	4.2 L (Engine only)
Standard cooling fan	ø430 pusher
Crank V-pulley dia./ fan V-pulley dia.	ø130/ø130 mm
Top clearance	0.793 ± 0.071 mm

Set Output Listed by Rotation

Model	Displacement	Gross output (kW)									
		2000	2100	2200	2300	2400	2500	2600	2700	2800	3000
3TNV88C	1.642	–	–	–	–	21.8	22.8	23.7	24.6	25.5	27.5
3TNV86CT	1.568	–	–	–	–	–	27.4	28.5	–	31.0	32.4
4TNV88C	2.189	24.2	25.4	26.7	27.9	29.1	30.5	31.7	33.0	34.3	35.5
4TNV86CT	2.091	–	–	–	–	35.5	36.6	37.9	39.5	41.1	44.0
4TNV98C	3.318	42.4	44.3	46.2	48.1	49.9	51.7	–	–	–	–
4TNV98CT	3.318	51.6	53.7	53.7	53.7	53.7	53.7	–	–	–	–

ENGINE SERVICE STANDARDS

<table>
<tr><th colspan="2">Inspection item</th><th>Standard</th><th>Limit</th><th>Reference page</th></tr>
<tr><td>Intake/exhaust valve clearance</td><td>All models</td><td>0.006 - 0.010 in.
(0.15 - 0.25 mm)</td><td>–</td><td>See Measuring and Adjusting Valve Clearance on page 6-39</td></tr>
<tr><td rowspan="3">Compression pressure at 250 min^{-1} (rpm)</td><td>3TNV88C, 4TNV88C</td><td>455 - 485 psi
(3.14 - 3.34 MPa;
32 - 34 kgf/cm^2)</td><td>355 - 385 psi
(2.45 - 2.65 MPa;
25 - 27 kgf/cm^2)</td><td rowspan="3">–</td></tr>
<tr><td>3TNV86CT, 4TNV86CT</td><td>411 - 441 psi
(2.84 - 3.04 MPa;
29 - 31 kgf/cm^2)</td><td>340 - 370 psi
(2.35 - 2.55 MPa;
24 - 26 kgf/cm^2)</td></tr>
<tr><td>4TNV98C, 4TNV98CT</td><td>483 - 513 psi
(3.33 - 3.53 MPa;
34 - 36 kgf/cm^2)</td><td>384 - 414 psi
(2.65 - 2.85 MPa;
27 - 29 kgf/cm^2)</td></tr>
<tr><td>Deviation between cylinders</td><td>All models</td><td>29 - 43 psi
(0.2 - 0.3 MPa;
2 - 3 kgf/cm^2)</td><td>–</td><td>–</td></tr>
<tr><td colspan="2">Oil pressure switch operating pressure</td><td>5.8 - 8.8 psi
(0.04 - 0.06 MPa;
0.4 - 0.6 kgf/cm^2)</td><td>–</td><td>–</td></tr>
<tr><td rowspan="3">Thermostat</td><td></td><td>Valve opening temperature</td><td>Full opening lift temperature</td><td rowspan="3">See Thermostat on page 8-9</td></tr>
<tr><td>All models</td><td>157 °F - 163 °F
(70 °C - 73 °C)</td><td>0.32 in. (8 mm) or above
185 °F (85 °C)</td></tr>
<tr><td>All models option</td><td>176 °F - 183 °F
(80 °C - 84 °C)</td><td>0.39 in. (10 mm) or above
203 °F (95 °C)</td></tr>
<tr><td colspan="2">Coolant temperature switch</td><td>225 °F - 235 °F
(107 °C - 113 °C)</td><td>–</td><td>See Temperature switch on page 8-8</td></tr>
</table>

TIGHTENING TORQUES FOR STANDARD BOLTS AND NUTS

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

NOTICE

The tightening torque in the *Standard Torque Chart (see General Service Information section)* should be applied only to the bolts with a “7” head. (JIS strength classification: 7T)

- Apply 60 % torque to bolts that are not listed.
- Apply 80 % torque when tightened to aluminum alloy.

Item	Nominal thread diameter × pitch	Tightening torque	Remarks
Hexagon bolt (7T) and nut	M6 × 1.0 mm	7 - 9 ft-lb (87 -104 in.-lb, 9.8 -11.8 N·m, 1.0 -1.2 kgf·m)	Use 80 % of the value at left when the tightening part is aluminum. Use 60 % of the value at left for 4T bolts and lock nuts.
	M8 × 1.25 mm	17 - 21 ft-lb (200 - 251 in.-lb, 22.6 - 28.4 N·m, 2.3 - 2.9 kgf·m)	
	M10 × 1.5 mm	33 - 40 ft-lb (44.1 - 53.9 N·m, 4.5 - 5.5 kgf·m)	
	M12 × 1.75 mm	58 - 72 ft-lb (78.4 - 98.0 N·m, 8.0 - 10 kgf·m)	
	M14 × 1.5 mm	94 - 108 ft-lb (127.5 - 147.1 N·m, 13 - 15 kgf·m)	
	M16 × 1.5 mm	159 - 174 ft-lb (215.7- 235.4 N·m, 22 - 24 kgf·m)	
PT plug	1/8	7 ft-lb (87 in.-lb, 9.8 N·m, 1.0 kgf·m)	–
	1/4	14 ft-lb (173 in.-lb, 19.6 N·m, 2.0 kgf·m)	
	3/8	22 ft-lb (29.4 N·m, 3.0 kgf·m)	
	1/2	43 ft-lb (58.8 N·m, 6.0 kgf·m)	
Pipe joint bolt	M8	9 - 12 ft-lb (112 - 148 in.-lb, 12.7 - 16.7 N·m, 1.3 - 1.7 kgf·m)	–
	M10	14 - 19 ft-lb (173 - 225 in.-lb, 19.6 - 25.4 N·m, 2.0 - 2.5 kgf·m)	
	M12	18 - 25 ft-lb (24.5 - 34.3 N·m, 2.5 - 3.5 kgf·m)	
	M14	29 - 36 ft-lb (39.2 - 49.0 N·m, 4.0 - 5.0 kgf·m)	
	M16	36 - 43 ft-lb (49.0 - 58.8 N·m, 5.0 - 6.0 kgf·m)	

Note: Torque values shown in this manual are for clean, non-lubricated fasteners unless otherwise specified.

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
BDC	bottom dead center
BTDC	before top dead center
°C	degree Celsius
CARB	California Air Resources Board
CCA	cold cranking amp
cfm	cubic feet per minute
cm	centimeter
cm^3	cubic centimeter
cm^3/min	cubic centimeter per minute
cu in.	cubic inch
D	diameter
DC	direct current
DI	direct injection
DVA	direct volt adapter
EPA	Environmental Protection Agency
ESG	electronic speed governor
°F	degree Fahrenheit
fl oz	fluid ounce (U.S.)
fl oz/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
gal/min	gallon (U.S.) per minute
GL	gear lubricant
hp	horsepower (U.S.)
hr	hour
I.D.	inside diameter
ID	identification
IDI	indirect injection
in.	inch
in.Aq	inches Aqueous (water)
in.Hg	inches Mercury
in.-lb	inch pound
j	joule
JASO	Japanese Automobile Standards Organization
k	kelvin
kg	kilogram
kgf/cm^2	kilogram force per square centimeter
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lbf	pound force
m	meter
mL	milliliter
mm	millimeter
mmAq	millimeter Aqueous (water)
MPa	megapascal
mV	millivolt
N	newton
N·m	newton meter
No.	number
O.D.	outside diameter
oz	ounce
Pa	pascal
PS	horsepower (metric)
psi	pound per square inch
qt	quart (U.S.)
R	radius
rpm	revolutions per minute
SAE	Society of Automotive Engineers
sec.	second
t	short ton 2000 lb
TBN	total base number
TDC	top dead center
V	volt
VAC	volt alternating current
VDC	volt direct current
W	watt

■ Symbols

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

UNIT CONVERSIONS

■ Unit prefixes

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

■ Units of length

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

■ Units of volume

gal (U.S.)	×	3.78540	= L
qt (U.S.)	×	0.94635	= L
cu in.	×	0.01639	= L
cu in.	×	16.38700	= mL
fl oz (U.S.)	×	0.02957	= L
fl oz (U.S.)	×	29.57000	= mL
cm^3	×	1.00000	= mL
cm^3	×	0.03382	= fl oz (U.S.)

■ Units of mass

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

■ Units of force

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

■ Units of torque

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

■ Units of pressure

psi	×	0.0689	= bar
psi	×	6.8950	= kPa
psi	×	0.0703	= kg/cm^2
bar	×	14.5030	= psi
bar	×	100.0000	= kPa
bar	×	29.5300	= inHg (60 °F)
kPa	×	0.1450	= psi
kPa	×	0.0100	= bar
kPa	×	0.0102	= kg/cm^2
kg/cm^2	×	98.0700	= psi
kg/cm^2	×	0.9807	= bar
kg/cm^2	×	14.2200	= kPa
in.Hg (60°)	×	0.0333	= bar
in.Hg (60°)	×	3.3770	= kPa
in.Hg (60°)	×	0.0344	= kg/cm^2
mmAq	×	0.0394	= in.Aq

■ Units of power

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

■ Units of temperature

°F = (1.8 × °C) + 32

°C = 0.556 × (°F - 32)

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Section 5

PERIODIC MAINTENANCE

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety section on page 3-1*.

INTRODUCTION

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

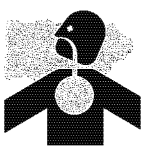
The Importance of Periodic Maintenance

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

Performing Periodic Maintenance

⚠ WARNING

Exhaust Hazard!



- **Never operate the engine in an enclosed area such as a garage, tunnel, underground room, manhole or ship's hold without proper ventilation.**
- **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 could cause illness or even death.**
- **Make sure that all connections are tightened to specifications after repair is made to the exhaust system.**
- **Failure to comply could result in death or serious injury.**

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 machine.

YANMAR Replacement Parts

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

Required EPA/ARB Maintenance USA Only

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulations Non-Road Engines and the California Air Resources Board (ARB, California), it is essential that you follow the *Periodic Maintenance Schedule on page 5-5* and *Periodic Maintenance Procedures on page 5-7*.

EPA/ARB Installation Requirements USA Only

The following are the installation requirements for the EPA/ARB. Unless these requirements are met, the exhaust gas emissions will not be within the limits specified by the EPA and ARB.

■ Maximum exhaust gas restriction shall be:

Initial upper limit	12.7 kPa (1300 mmAq)
Cleaning upper limit	45 kPa (4590 mmAq)

Maximum air intake restriction shall be 0.90 psi (6.23 kPa; 635 mmAq) or less. Clean or replace the air cleaner element if the air intake restriction exceeds the above mentioned value.

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.

NOTICE

Establish a periodic maintenance plan according to the engine application and make sure you perform the required periodic maintenance at the intervals indicated. Failure to follow these guidelines will impair the engine's safety and performance characteristics, shorten the engine's life and may affect the warranty coverage on your engine. *See YANMAR Limited Warranty in Warranty Section.*

The TNV series engines may inject fuel after general combustion for the purpose of self-regeneration of the DPF. This fuel may enter the oil pan through the cylinder and dilute the engine oil.
Check the oil level daily. If it is above the upper limit of the dipstick, change the oil regardless of the replacement intervals.

Add the new oil if the oil level is below lower mark on the dipstick to keep the oil level between upper and lower mark, even if it is remaining the change interval.

For the items marked with ●, the specialized knowledge and skill are particularly required. Have your authorized YANMAR dealer or distributor perform maintenance according to this manual.

○: Check ◇: Replace ●: Have your authorized YANMAR dealer or distributor perform checking and cleaning

System	Check item	Daily	Periodic maintenance interval						
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours	Every 3000 hours
Cooling system	Check and refill engine coolant	○							
	Check and clean radiator fins			○					
	Check and adjust cooling fan V-belt		○ (1st time)	○ (2nd and after)					
	Change coolant							◇ or every 2 years*1	
Cylinder head	Check and adjust intake/exhaust valve clearance					●			
	Lap intake/exhaust valve seats (if required)							●	
Electrical equipment	Check indicators	○							
	Check battery		○						

○: Check ◇: Replace ●: Have your authorized YANMAR dealer or distributor perform checking and cleaning

System	Check item	Daily	Periodic maintenance interval						
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours	Every 3000 hours
Engine lubricating oil	Check engine lubricating oil level	○							
	Drain and fill engine lubricating oil				◇ or every 1 year*2				
	Replace engine lubricating oil filter								
Emission control warranty	Inspect turbocharger (blower wash as necessary)								●
	Inspect, clean and test EGR valve (except for engines with turbochargers)								●
	Clean EGR cooler (clean to blow water/air passages)								●
	Inspect crankcase breather system						●		
	Check and clean of DPF soot filter *3								
	Inspect and test intake throttle valve								●
	Inspect and test exhaust throttle valve *4								●
Fuel	Check and refill fuel tank level	○							
	Drain fuel tank			○					
	Drain water separator		○						
	Check fuel filter, water separator	○							
	Replace fuel filter, water separator element				◇				
	Check and clean injector								○
Hoses	Replace fuel system and cooling system hoses							◇ or every 2 years*1	
Intake and exhaust	Clean or replace air cleaner element			○	◇				
Complete engine	Overall visual check daily	○							

**1: Whichever occurs first.*

**2: Differ depending on the application or engine oil capacity.*
If the engine is equipped with a shallow type oil sump, the maintenance interval should be every 250 hours regardless of the implement.

**3: If your engine is equipped with DPF cleaning alarm, clean the DPF when the alarm lamp comes on.*
If your engine is not equipped with DPF cleaning alarm, clean the DPF on 6000 hours of operation.

**4: If your engine is equipped with exhaust throttle valve.*

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

PERIODIC MAINTENANCE PROCEDURES

After Initial 50 Hours of Operation

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

- **Check and adjust cooling fan V-belt**

⚠ WARNING

Sudden Movement Hazard!

- **Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.**
- **Failure to comply could result in death or serious injury.**

■ Check and adjust cooling fan V-belt

The V-belt will slip if it does not have the proper tension. This will prevent the alternator from generating sufficient power. Also, the engine will overheat due to the engine coolant pump pulley slipping.

Check and adjust the V-belt tension (deflection) as follows:

1. Press the V-belt down with your thumb with a force of approximately 22 ft-lb (98 N·m; 10 kgf) to check the deflection.

   There are three positions to check for V-belt tension (A, B and C, **Figure 5-1**). You can check the tension at whichever position is the most accessible. The proper deflection of a used V-belt at each position is:

Used V-belt tension		
A	B	C
3/8 - 1/2 in. (10 - 14 mm)	1/4 - 3/8 in. (7 - 10 mm)	5/16 - 1/2 in. (9 - 13 mm)

Note: A "Used V-belt" refers to a V-belt which has been used on a running engine for five minutes or more.

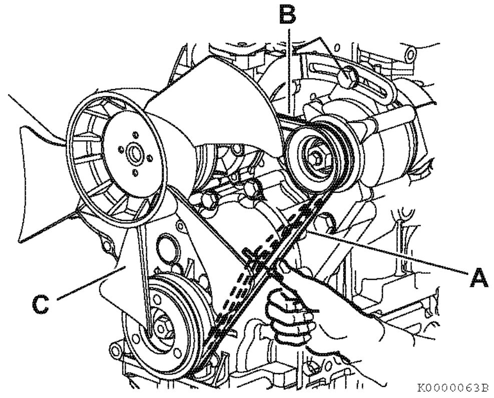


Figure 5-1

2. If necessary, adjust the V-belt tension.
   - **Manual type**

     Loosen the adjusting bolt (1, **Figure 5-2**) and the other related bolts and/or nuts, then move the alternator (2, **Figure 5-2**) with a pry bar (3, **Figure 5-2**) to tighten the V-belt to the desired tension. Then tighten the adjusting bolts and/or nuts.

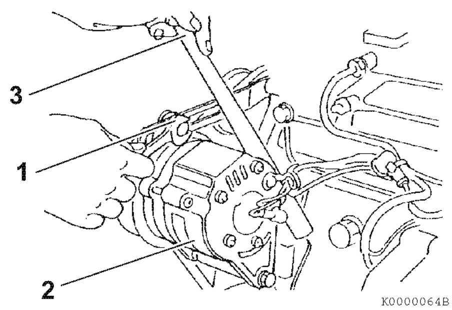


Figure 5-2

   - **Jack type**

     1- Loosen the attaching nut (1, **Figure 5-3**) under the alternator, belt adjuster mounting bolt (2, **Figure 5-3**), and belt adjuster tightening bolt (3, **Figure 5-3**).

     2- Loosen the adjuster bolt lock nut (4, **Figure 5-3**) and adjust the tension by turning the adjuster bolt (5, **Figure 5-3**). (Turn the adjuster bolt clock wise to stretch the belt.)

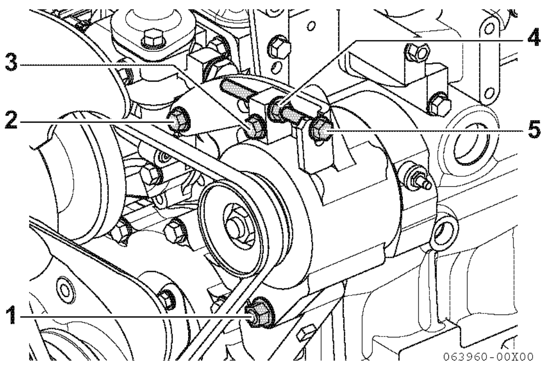


Figure 5-3

3- After adjusting with the adjuster bolt (5, **Figure 5-3**), in the following order, tighten the tightening bolt (3, **Figure 5-3**), belt adjuster mounting bolt (2, **Figure 5-3**), attaching nut (1, **Figure 5-3**), and then the lock nut (4, **Figure 5-3**) at last.

3. Tighten the V-belt to the proper tension. There must be clearance (1, **Figure 5-4**) between the V-belt and the bottom of the pulley groove. If there is no clearance (2, **Figure 5-4**) between the V-belt and the bottom of the pulley groove, replace the V-belt.

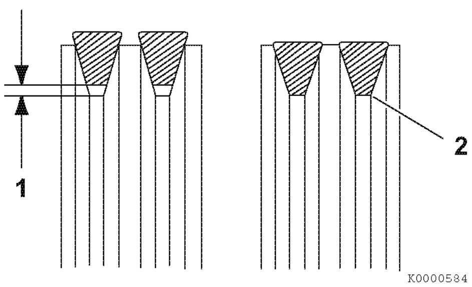


Figure 5-4

4. Check the V-belt for cracks, oil or wear. If any of these conditions exist, replace the V-belt.
5. Install the new V-belt. Refer to the table for proper tension.

New V-belt tension		
A	B	C
5/16 - 7/16 in. (8 - 12 mm)	3/16 - 5/16 in. (5 - 8 mm)	1/4 - 7/16 in. (7 - 11 mm)

6. After adjusting, run the engine for 5 minutes or more. Check the tension again using the specifications for a used V-belt.

Used V-belt tension		
A	B	C
3/8 - 1/2 in. (10 - 14 mm)	1/4 - 3/8 in. (7 - 10 mm)	5/16 - 1/2 in. (9 - 13 mm)

Every 50 Hours of Operation

After you complete the initial 50 hour maintenance procedures, perform the following procedures every 50 hours thereafter.

- **Drain water separator**
- **Check battery**

■ Drain water separator

⚠ DANGER

Fire and Explosion Hazard!

- **Diesel fuel is flammable and explosive under certain conditions.**

- **When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.**
- **Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.**
- **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.**
- **Failure to comply will result in death or serious injury.**

NOTICE

If the water separator is positioned higher than the fuel level in the fuel tank, water may not drip out when the water separator drain valve is opened. If this happens, turn the air vent screw on the top of the water separator 2 - 3 turns counterclockwise.

Be sure to tighten the air vent screw after the water has drained out.

NOTICE

- Be sure to perform periodic maintenance in a clean environment free from dust.

- Always be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Drain the water separator whenever there are contaminants, such as water, collected in the bottom of the cup. Never wait until the scheduled periodic maintenance if contaminants are discovered.

The cup of the separator is made from semi-transparent material. In the cup is a red colored float ring. The float ring will rise to the surface of the water to show how much needs to be drained. Also, some optional water separators are equipped with a sensor to detect the amount of contaminants. This sensor sends a signal to an indicator to alert the operator.

Drain the water separator as follows:

1. Position an approved container under the water separator (1, **Figure 5-5**) to collect the contaminants.

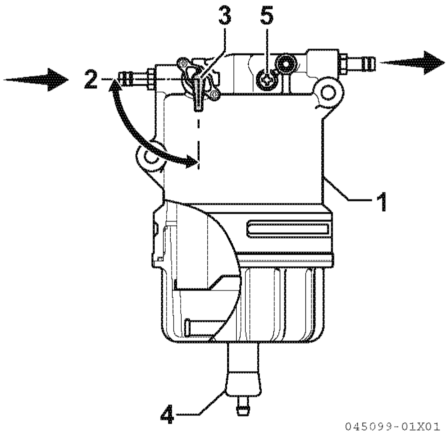


Figure 5-5

2. Close the fuel valve (3, **Figure 5-5**) by turning it to (2, **Figure 5-5**) position.
3. Open the drain valve (4, **Figure 5-5**) at the bottom of the water separator. Drain any water collected inside. If no water comes out, loosen the air vent screw (5, **Figure 5-5**) at the top of the water separator by turning it counterclockwise 2 - 3 turns.
4. If still no water comes out, open the fuel valve (3, **Figure 5-5**).
5. After draining the water separator, hand-tighten the drain valve.

Tightening torque	0.7 - 1.4 ft·lb (1 - 2 N·m; 0.1 - 0.2 kgf·m)

6. Be sure to tighten the air vent screw if it is loosened.
7. Open the fuel valve.
8. Be sure to prime the diesel fuel system. *See Priming the Fuel System on page 4-28.*
9. Check for fuel leaks.

■ Check battery

⚠ DANGER

Explosion Hazard!

- **Never check the remaining battery charge by shorting out the terminals. This will result in a spark and may cause an explosion or fire. Use a hydrometer to check the remaining battery charge.**
- **If the electrolyte is frozen, slowly warm the battery before you recharge it.**
- **Failure to comply will result in death or serious injury.**

⚠ WARNING

Burn Hazard!

- **Batteries contain sulfuric acid. Never allow battery fluid to come in contact with clothing, skin or eyes. Severe burns could result. Always wear safety goggles and protective clothing when servicing the battery. If battery fluid contacts the eyes and/or skin, immediately flush the affected area with a large amount of clean water and obtain prompt medical treatment.**
- **Failure to comply could result in death or serious injury.**

NOTICE

- Always be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

- When the amount of fluid nears the lower limit (3, **Figure 5-6**), fill with distilled water (2, **Figure 5-6**) so it is at the upper limit (1, **Figure 5-6**). If operation continues with insufficient battery fluid, the battery life is shortened, and the battery may overheat and explode. During the summer, check the fluid level more often than specified.

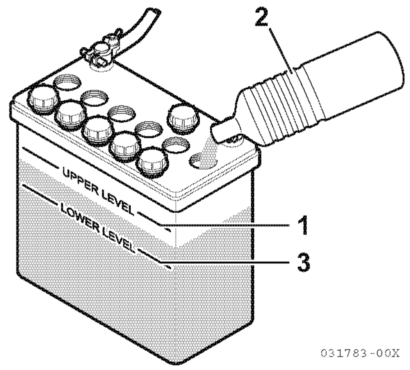


Figure 5-6

- If the engine cranking speed is so slow that the engine does not start, recharge the battery. Use a specialized battery charger to recharge the battery with a voltage of 8 volts or less. Charging the battery by booster even with a voltage of 8 volts or less will generate an abnormally high voltage and destroy electrical equipment. When unavoidably using a rapid charger to recharge, do not insert and turn the starter key to ON position while the battery is being charged. Avoid using a charger equipped with a boost function (cell start support) to start the engine. The ECU may be damaged by applied excessive voltage.
- If the engine still will not start after charging, have your authorized YANMAR industrial engine dealer or distributor check the battery and the engine's starting system.
- If operating the machine where the ambient temperature could drop to 5 °F (-15 °C) or less, remove the battery from the machine at the end of the day. Store the battery in a warm place until the next use. This will help start the engine easily at low ambient temperatures.

Every 250 Hours of Operation

Perform the following maintenance every 250 hours of operation.

- **Drain fuel tank**
- **Check and clean radiator fins**
- **Check and adjust cooling fan V-belt**
- **Clean air cleaner element**

■ Drain fuel tank

⚠ DANGER

Fire and Explosion Hazard!

- **Diesel fuel is flammable and explosive under certain conditions.**
- **When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.**
- **Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.**
- **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.**
- **Failure to comply will result in death or serious injury.**

NOTICE

- Always be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Note that a typical fuel tank is illustrated.

1. Position an approved container under the diesel fuel tank (1, **Figure 5-7**) to collect the contaminates.
2. Remove the fuel cap (3, **Figure 5-7**).
3. Remove the drain plug (2, **Figure 5-7**) of the fuel tank to drain the contaminates (water, dirt, etc.) from the bottom of the tank.

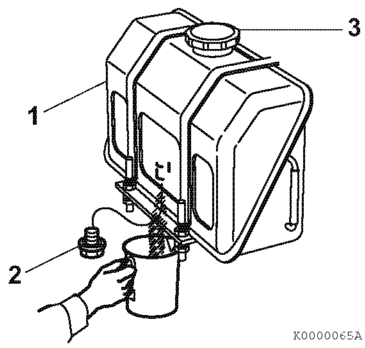


Figure 5-7

4. Drain the tank until clean diesel fuel with no water and dirt flows out. Reinstall and tighten the drain plug firmly.
5. Reinstall the fuel cap.
6. Check for leaks.

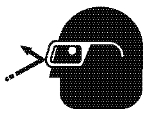
NOTICE

Be sure to perform priming. If air is mixed to the fuel, seizure to the supply pump and the injector may result.

■ Check and clean radiator fins

⚠ CAUTION

Flying Object 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.**
- **Failure to comply may result in minor or moderate injury.**

Dirt and dust adhering to the radiator fins reduce the cooling performance, causing overheating. Make it a rule to check the radiator fins daily and clean as needed.

Note that a typical radiator is shown in **Figure 5-8** for illustrative purposes only.

- Blow off dirt and dust from fins and radiator with 28 psi (0.19 MPa; 2 kgf/cm^2) or less of compressed air (1, **Figure 5-8**). Be careful not to damage the fins with the compressed air.
- If there is a large amount of contamination on the fins, apply detergent, thoroughly clean and rinse with tap water.

NOTICE

Never use high-pressure water or compressed air at greater than 28 psi (193 kPa; 19 686 mmAq) or a wire brush to clean the radiator fins. Radiator fins damage easily.

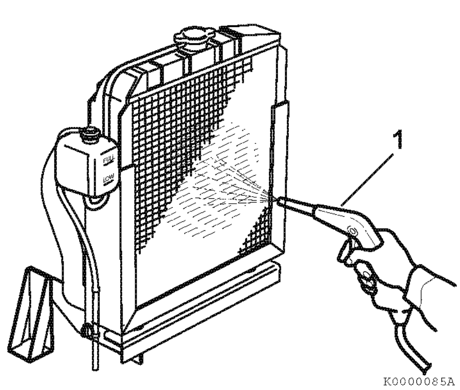


Figure 5-8

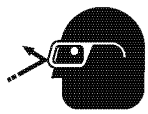
■ Check and adjust cooling fan V-belt

Check and adjust the cooling fan V-belt every 250 hours of operation after the initial 50 hour V-belt maintenance. *See Check and adjust cooling fan V-belt on page 5-7.*

■ Clean air cleaner element

⚠ CAUTION

Flying Object 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.**
- **Failure to comply may result in minor or moderate injury.**

Note that a typical air cleaner is shown in **Figure 5-9** and **Figure 5-10** for illustrative purposes only.

The engine performance is adversely affected when the air cleaner element is clogged with dust. Be sure to clean the air filter element periodically.

1. Unlatch and remove the air cleaner cover **(Figure 5-9, (1))**.

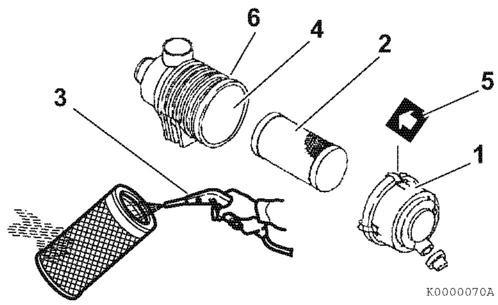


Figure 5-9

2. Remove the element (2, **Figure 5-9**) (outer element if equipped with two elements).
3. Blow air (3, **Figure 5-9**) through the element from the inside out using 42 - 71 psi (0.29 - 0.49 MPa; 3.0 - 5.0 kgf/cm^2) compressed air to remove the particulates. Use the lowest possible air pressure to remove the dust without damaging the element.

4. If the air cleaner is equipped with a double element, only remove and replace the inner element (1, **Figure 5-10**) *if the engine lacks power or the dust indicator actuates (if equipped).*

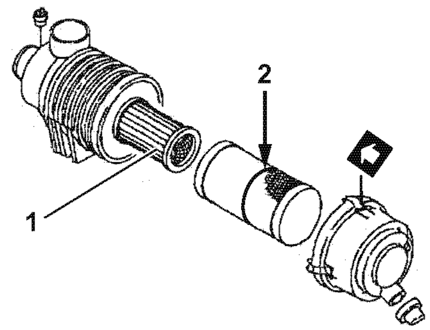


Figure 5-10

5. The inner element should not be removed when cleaning or replacing the outer element. The inner element is used to prevent dust from entering the engine while servicing the outer element.
6. Replace the element with a new one if the element is damaged, excessively dirty or oily.
7. Clean inside of the air cleaner cover.
8. Install the element into the air cleaner case (4, **Figure 5-9**).

   *Note: If there is a red line (2, **Figure 5-10**) in the outer element, reinsert the element until the overlap position of red line and end face of the air cleaner case.*

9. Reinstall the air cleaner cover making sure you match the arrow (5, **Figure 5-9**) on the cover with the arrow on the case (6, **Figure 5-9**).
10. Latch the air cleaner cover to the case.

NOTICE

- When the engine is operated in dusty conditions, clean the air cleaner element more frequently.
- Never operate the engine with the air cleaner element(s) removed. This may allow foreign material to enter the engine and damage it.

Every 500 Hours of Operation

Perform the following maintenance every 500 hours of operation.

- **Replace air cleaner element**
- **Replace fuel filter**
- **Replace water separator element**
- **Replace engine lubricating oil and oil filter**
  *** Differ depending on the application, engine model or engine oil capacity**

■ Replace air cleaner element

NOTICE

The maximum air intake restriction, in terms of differential pressure measurement, must not exceed 0.90 psi (6.23 kPa; 635 mmAq). Clean or replace the air cleaner element if the air intake restriction exceeds the above mentioned value.

Replace the air cleaner element (2, **Figure 5-9**) every 500 hours even if it is not damaged or dirty.

When replacing the element, clean the inside of the air cleaner case (4, **Figure 5-9**).

If the air cleaner is equipped with a double element, *only remove and replace the inner element (1, **Figure 5-10**) if the engine lacks power or the dust indicator actuates (if equipped).* This is in addition to replacing the outer element.

■ Replace fuel filter

⚠ DANGER

Fire and Explosion Hazard!

- **Diesel fuel is flammable and explosive under certain conditions.**

- **When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.**
- **Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.**
- **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.**
- **Failure to comply will result in death or serious injury.**

NOTICE

- Always be environmentally responsible.

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Replace the fuel filter every 500 hours of operation to prevent contaminants from adversely affecting the diesel fuel flow.

1. Stop the engine and allow it to cool.
2. Close the fuel valve of the water separator.
3. Remove the fuel filter with a filter wrench, turning it to the left (1, **Figure 5-11**). When removing the fuel filter, carefully hold it to prevent the fuel from spilling. Wipe up all spilled fuel.

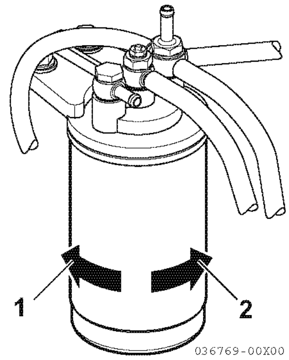


Figure 5-11

4. Clean the filter mounting surface and apply a small amount of diesel fuel to the gasket of the new fuel filter.
5. Install the new fuel filter. Turn to the right (2, **Figure 5-11**) and hand-tighten it only until it comes in contact with the mounting surface. Tighten to 20 - 24 N·m (2.0 - 2.4 kgf·m) or one additional turn using the filter wrench.

Applicable fuel filter Part No.	129A00-55800

** Consult the operation manual for the driven machine for applicability of the dust proof filter.*

6. Open the fuel valve of the fuel filter/water separator.
7. Prime the fuel system. *See Priming the Fuel System on page 4-28.*
8. Check for leaks.

NOTICE

Be sure to perform priming the engine before starting. If air is mixed to the fuel, seizure to the supply pump and the injector may result.

■ Replace water separator element

⚠ DANGER

Fire and Explosion Hazard!

- **Diesel fuel is flammable and explosive under certain conditions.**

- **Never use diesel fuel as a cleaning agent.**
- **When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.**
- **Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive.**
- **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.**
- **Failure to comply will result in death or serious injury.**

NOTICE

- Always be environmentally responsible.

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Replace the water separator element every 500 hours of operation.

1. Position an approved container under the cup (1, **Figure 5-12**) of the water separator to collect the contaminants.

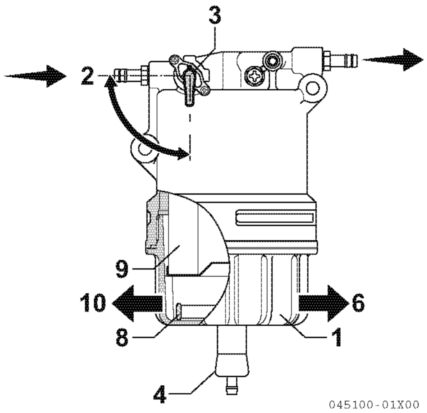


Figure 5-12

2. Close the fuel valve (3, **Figure 5-12**) by turning it to (2, **Figure 5-12**) position.
3. Loosen the drain valve (4, **Figure 5-12**) and remove the fuel oil and mixed substance. *See Drain water separator on page 5-8.*
4. Turn the cup (1, **Figure 5-12**) to the left (10, **Figure 5-12**) and remove from the bracket. If it comes with a drain sensor, remove the cable in advance.
5. While removing the cup, the element (9, **Figure 5-12**) may come off together. Carefully remove the cup to prevent fuel from spilling. If you spill any fuel, clean up the spill completely.
6. Remove the float ring (8, **Figure 5-12**) from the cup. If it comes with a drain sensor, there is not float ring. Move the drain inside the cup to the specified container, and dispose with a predetermined method.
7. Remove the element from the bracket.
8. Clean the cup inside with new diesel fuel oil.

Applicable element Part No.	129A00-55730

9. Check the O-ring of the cup. Replace it if necessary.

10. Place a float ring inside the cup, and attach the O-ring and the new element in the cup.
11. Attach the bracket in the cup. Turn to the right (6, **Figure 5-12**) with a torque of 27 to 33 N·m (2.8 to 3.4 kgf·m). Always tighten with your hand.
12. Close the drain valve. Reconnect the sensor wire if equipped.
13. Open the fuel valve (3, **Figure 5-12**).
14. Prime the fuel system. See *Priming the Fuel System on page 4-28*.

NOTICE

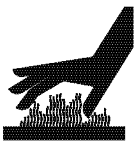
Be sure to perform priming. If air is mixed to the fuel, seizure to the supply pump and the injector may result.

15. Check for leaks.

■ Replace engine lubricating oil and oil filter

⚠ WARNING

Burn Hazard!

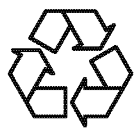


- **If you must drain the engine lubricating oil while it is still hot, stay clear of the hot engine lubricating oil to avoid being burned.**
- **Always wear eye protection.**
- **Failure to comply could result in death or serious injury.**

NOTICE

- Only use the engine lubricating oil specified. Other oils may affect warranty coverage, cause internal engine components to seize and/or shorten engine life.
- Prevent dirt and debris from contaminating the engine lubricating oil. Carefully clean the oil cap/dipstick and the surrounding area before you remove the cap.
- Never mix different types of engine lubricating oil. This may adversely affect the lubricating properties of the engine lubricating oil.
- Never overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.

NOTICE



- Always be environmentally responsible.

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Change the engine lubricating oil every 500 hours or 1 year of operation. Replace the engine oil filter at the same time.

If the engine is equipped with a shallow type oil sump, the maintenance interval for the engine lubricating oil and filter should be every 250 hours regardless of the implement.

Drain the engine lubricating oil as follows:

1. Make sure the engine is level.
2. Start the engine and bring it up to operating temperature.
3. Stop the engine.
4. Remove one of the oil filler caps (1 or 2, **Figure 5-13**) to vent the engine crankcase and allow the engine lubricating oil to drain more easily.
5. Position a container under the engine to collect waste oil.

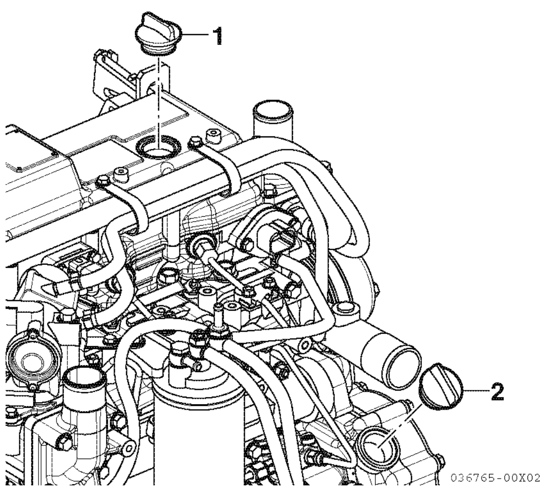


Figure 5-13

Note: The oil drain plug may be in another location if an optional oil pan is used.

6. Remove the oil drain plug (1, **Figure 5-14**) from the engine oil pan. Allow lubricating oil to drain.
7. After all lubricating oil has been drained from the engine, reinstall the oil drain plug (1, **Figure 5-14**) and tighten to 39.8 - 47.0 ft·lb (53.9 - 63.7 N·m; 5.5 - 6.5 kgf·m).
8. Dispose of used oil properly.

Remove the engine oil filter as follows:

1. Turn the engine oil filter (2, **Figure 5-14**) counterclockwise (3, **Figure 5-14**) using a filter wrench.

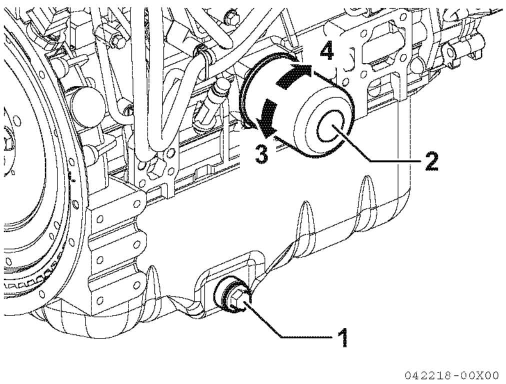


Figure 5-14

2. Clean the engine oil filter mounting face.
3. Lightly coat the gasket on the new oil filter with engine lubricating oil. Install the new engine oil filter manually by turning it clockwise (4, **Figure 5-14**) until it contacts the mounting surface. Tighten to 14 - 17 ft-lb (19.6 - 23.5 N·m; 2.0 - 2.4 kgf·m) or one additional turn using the filter wrench.

Engine oil filter Part No.	
Size*[1]	**Part No.**
80 × 80L	129150-35153
80 × 100L	119005-35151

**1: The applicable engine filter size varies depending on the engine model. Install the filter of the same size as currently installed.*

4. Add new engine lubricating oil to the engine as specified in *Adding Engine Lubricating Oil on page 4-30.*

NOTICE

- Never overfill the engine with engine lubricating oil.
- Always keep the oil level between the upper and lower lines on the oil cap/dipstick.

5. Warm up the engine by running it for five minutes and check for any engine lubricating oil leaks.
6. After engine is warm, shut it off and let it sit for 10 minutes.
7. Recheck the engine oil level.
8. Add engine lubricating oil to engine oil filter port (3, **Figure 5-15**) as needed until the level is between the upper and lower lines shown on the dipstick (1, **Figure 5-15**).

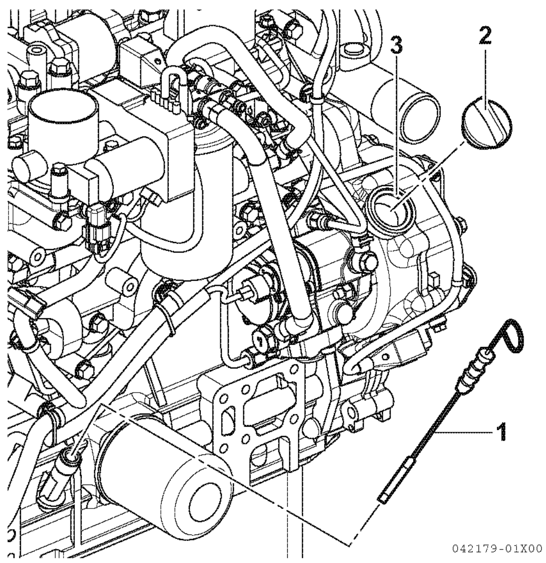


Figure 5-15

9. Reinstall the oil filler cap (2, **Figure 5-15**). If any engine lubricating oil is spilled, wipe it away with a clean cloth.

Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation.

- **Check and adjust intake/exhaust valve clearance (if required)**

■ Check and adjust intake/exhaust valve clearance

For the check method of intake/exhaust valve clearance, *see Measuring and Adjusting Valve Clearance on page 6-39*. For the standard values and limit values, *see Cylinder Head Specifications on page 6-4*.

To maintain the correct timing for opening and closing the intake/exhaust valves, it is necessary to adjust the intake/exhaust valve clearance in proper procedure. Improper adjustment increases the engine noise, and causes poor performance and engine damage. *See Intake/Exhaust Valve and Guide on page 6-5.*

Every 1500 Hours of Operation

Perform the following maintenance every 1500 hours of operation.

- **Inspect crankcase breather system**

■ Inspect crankcase breather system

Proper operation of the crankcase breather system (intake air circulation) that relieve the pressure fluctuation in the crank chamber and sucks back the blow-by gas. is required for maintaining the emission requirements of the engine. The EPA/ARB requires that you have the crankcase breather system inspected every 1500 hours.

As shown below, for engines without turbochargers, when the diaphragm (2, **Figure 5-16**) attached to the cylinder head cover (1, **Figure 5-16**) via the spring (4, **Figure 5-16**) opens with a certain pressure where the pressure of the crank case connected to the breather baffle (7, **Figure 5-16**) attached to the baffle plate (6, **Figure 5-16**) becomes high, the breather system of the TNV engine reduces the blow-by gas into the intake manifold (9, **Figure 5-16**) via the breather pipe (8, **Figure 5-16**).

For turbocharged engines, blow-by gas is returned before the turbocharger because the air pressure of the intake manifold side becomes very high. (See **Figure 5-17**)

Naturally aspirated engine

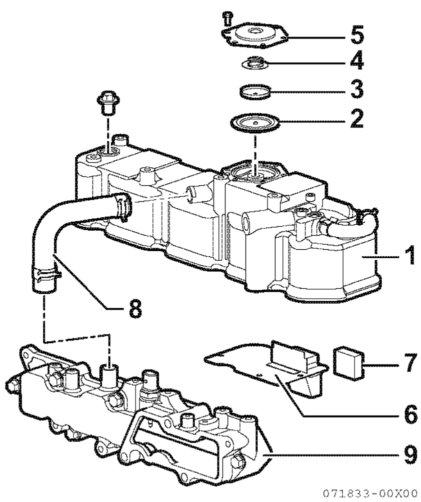


Figure 5-16

Turbocharged engine

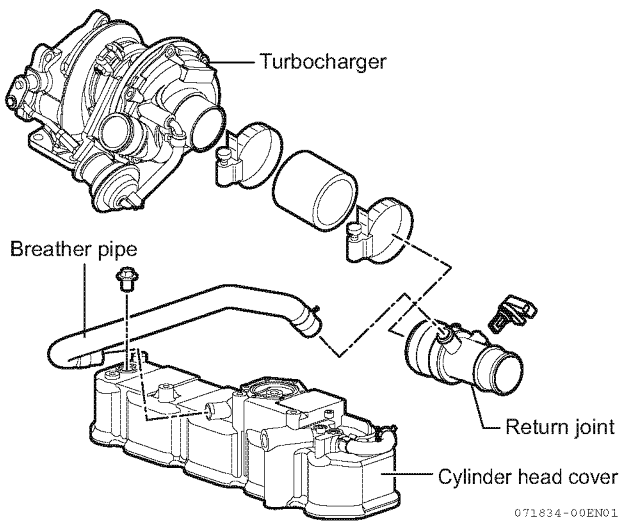


Figure 5-17

To inspect the diaphragm and spring:

1. Remove the bolts retaining the diaphragm cover (5, **Figure 5-16**).
2. Remove the diaphragm cover, spring, center plate (3, **Figure 5-16**) and diaphragm.
3. Check to see if there are no damage to the diaphragm. Replace as necessary. Further, remove the breather hose to make sure there are no sediments inside the hose, and clean if necessary.
4. Reinstall the diaphragm, center plate, spring, and diaphragm cover. Tighten the retainer bolt (M5 x 10) with a predetermined torque.

Failure of the diaphragm and/or spring will cause the loss of pressure control and allow an excessive amount of crankcase fumes to be routed to the intake manifold. This could result in excessive deposits in the intake system, high engine exhaust smoke levels, excessive engine oil consumption, and/or engine run-on due to the burning of the engine oil.

Every 2000 Hours of Operation

Perform the following maintenance every 2000 hours of operation.

- **Check and replace fuel hoses and engine coolant hoses**
- **Lap the intake and exhaust valves (if required)**
- **Change engine coolant**

■ Check and replace fuel hoses and engine coolant hoses

Regularly check the fuel system and engine coolant system hoses. If they are cracked or degraded, replace them. Replace the hoses at least every two years.

■ Lap the intake and exhaust valves

Adjustment is necessary to maintain proper contact of the valves and seats. For lapping of the intake and exhaust valves, *see Inspection of Intake and Exhaust Valves on page 6-32.*

■ Change engine coolant

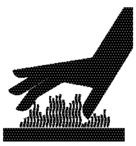
⚠ DANGER

Scald Hazard!

- **Never remove the radiator cap if the engine is hot. Steam and hot engine coolant will spurt out and seriously burn you. Allow the engine to cool down before you attempt to remove the radiator cap.**
- **Tighten the radiator cap securely after you check the radiator. Steam can spurt out during engine operation if the cap is loose.**
- **Always check the level of the engine coolant by observing the reserve tank.**
- **Failure to comply will result in death or serious injury.**

⚠ WARNING

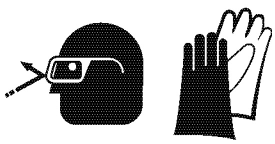
Burn Hazard!



- **Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.**
- **Failure to comply could result in death or serious injury.**

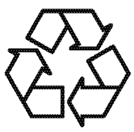
⚠ CAUTION

Engine Coolant Hazard!



- **Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.**
- **Failure to comply may result in minor or moderate injury.**

NOTICE



- Always be environmentally responsible.
- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Engine coolant contaminated with rust or scale reduces the cooling effect. Even when extended life engine coolant is properly mixed, the engine coolant gets contaminated as its ingredients deteriorate. Drain, flush and refill the cooling system with new engine coolant every 2000 hours or 2 years, whichever comes first.

1. Allow engine and coolant to cool.
2. Remove the radiator cap (1, **Figure 5-18**).
3. Remove the drain plug or open the drain valve (2, **Figure 5-18**) at the lower portion of the radiator and drain the engine coolant.

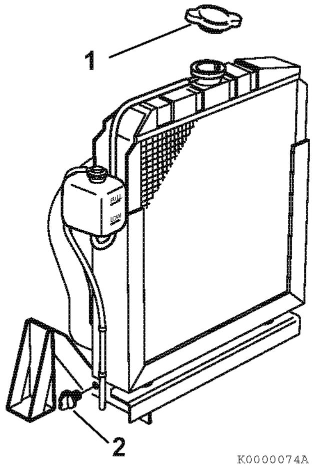


Figure 5-18

4. Drain the engine coolant from the engine block.
   - Remove the coolant hose (1, **Figure 5-19**) from the oil cooler if your machine is equipped with an oil cooler.

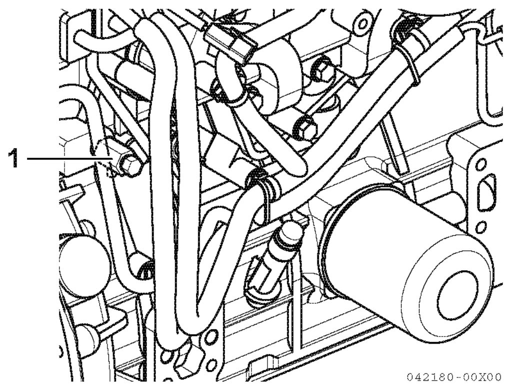


Figure 5-19

5. After draining the engine coolant, reinstall and tighten the drain plug or close the drain valve in the radiator. Reinstall and tighten the engine block drain plug or reconnect the coolant hose at the oil cooler if your machine is equipped with an oil cooler.
6. Fill radiator and engine with engine coolant. *See Filling Radiator with Engine Coolant on page 4-32.*

Every 3000 Hours of Operation

Perform the following maintenance every 3000 hours of operation.

- **Inspect turbocharger (blower wash as necessary) 3TNV86CT, 4TNV86CT, 4TNV98CT**
- **Inspect, clean and test EGR valve (except for engines with turbochargers)**
- **Clean EGR cooler (water side/exhaust passage blower)**
- **Inspect and test intake throttle valve**
- **Inspect and test exhaust throttle valve (optional)**
- **Check and clean injector**

■ Inspect turbocharger (blower wash as necessary)

3TNV86CT, 4TNV86CT, 4TNV98CT

Turbocharger service is required by the EPA/ARB every 3000 hours. Your authorized YANMAR industrial engine dealer or distributor will inspect and blower wash the unit if necessary. If you notice that the engine seems sluggish or the exhaust color is abnormal never wait until the next periodic interval. For cleaning and inspection of the turbocharger, *see Cleaning Procedure on page 10-12* and *Periodic Inspection on page 10-9*.

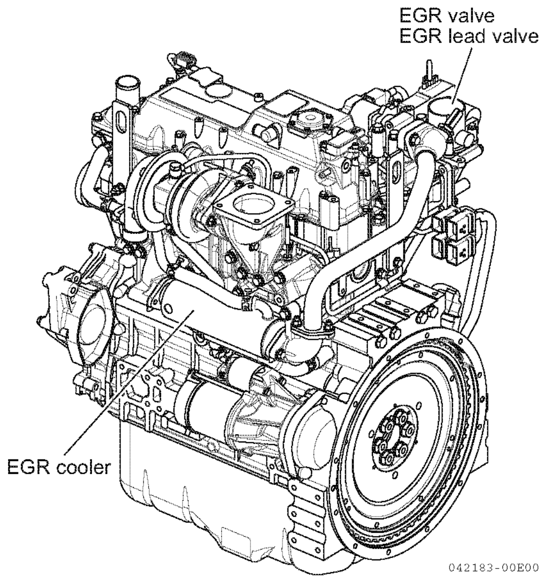


Figure 5-20

■ Inspect, clean and test EGR valve (except for engines with turbochargers)

The EGR valve is a key component for cleaning exhaust gas.

To prevent the valve from deteriorating in exhaust gas recirculation performance due to carbon accumulation, inspect, clean and test the valve at least every 3000 hours. For cleaning and inspection of the EGR valve, *see Cleaning the EGR valves on page 6-71*.

■ Clean EGR cooler (water side/exhaust passage blower)

The EGR cooler is apt to be contaminated with rust and scale that deteriorate the cooling performance. Carbon accumulation in the exhaust gas passage of the cooler hinders circulation of exhaust gas, resulting in deterioration in exhaust gas cleanup performance.

To prevent such a problem, clean the cooler at least every 3000 hours.

For cleaning of the EGR cooler, *see Clean EGR Cooler on page 6-72*.

■ Inspect and test intake throttle valve

The intake throttle can affect the exhaust gas treatment performance. Therefore periodic maintenance of the intake throttle is required every 3000 hours of operation. For operational inspection of the intake throttle valve, *see Intake Throttle on page 6-74*.

■ Check the operation of exhaust throttle valve (optional)

Because the exhaust gas property depends on the exhaust throttle, operation check is required every 300 hours. For more information on checking the operation of the exhaust throttle valve, *see Exhaust Throttle on page 6-75*.

■ Check and clean injector

Check the injector tip. Clean the injector tip with a soft brush or replace it if necessary.

At 6000 Hours of Operation

Perform the following maintenance on 6000 hours of operation.

- **Check and clean of DPF soot filter**

■ Check and clean of DPF soot filter

If your engine is equipped with DPF cleaning alarm, clean the DPF when the alarm lamp comes on.
If your engine is not equipped with DPF cleaning alarm, clean the DPF on 6000 hours of operation.

For cleaning of the DPF soot filter, contact YANMAR.
Japan: Power System Operations Division
Overseas: RHQ

Section 6

ENGINE

Page

BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual describes servicing of the engine.

CYLINDER HEAD SPECIFICATIONS

Adjustment Specifications

Model	Valve clearance
All models	0.006 - 0.010 in. (0.15 - 0.25 mm)

Cylinder Head

<table>
<tr><th colspan="3">Inspection item</th><th>Standard</th><th>Limit</th><th>Reference page</th></tr>
<tr><td colspan="3">Combustion surface distortion (flatness)</td><td>0.0020 in.
(0.05 mm) or less</td><td>0.0059 in.
(0.15 mm)</td><td rowspan="5">See Valve recession on page 6-33.</td></tr>
<tr><td rowspan="4">Valve recession</td><td rowspan="2">3TNV88C, 3TNV86CT,
4TNV88C, 4TNV86CT</td><td>Intake</td><td>0.0118 - 0.0197 in.
(0.30 - 0.50 mm)</td><td>0.0315 in.
(0.8 mm)</td></tr>
<tr><td>Exhaust</td><td>0.0118 - 0.0197 in.
(0.30 - 0.50 mm)</td><td>0.0315 in.
(0.8 mm)</td></tr>
<tr><td rowspan="2">4TNV98C, 4TNV98CT</td><td>Intake</td><td>0.0142 - 0.0220 in.
(0.36 - 0.56 mm)</td><td>0.0315 in.
(0.8 mm)</td></tr>
<tr><td>Exhaust</td><td>0.0138 - 0.0217 in.
(0.35 - 0.55 mm)</td><td>0.0315 in.
(0.8 mm)</td></tr>
<tr><td rowspan="3">Valve seat</td><td rowspan="2">Seat angle</td><td>Intake</td><td>120°</td><td>–</td><td rowspan="3">See Valve face and valve seat on page 6-33.</td></tr>
<tr><td>Exhaust</td><td>90°</td><td>–</td></tr>
<tr><td colspan="2">Seat correction angle</td><td>40°, 150°</td><td>–</td></tr>
</table>

Intake/Exhaust Valve and Guide

Inspection item			Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88, 4TNV86CT	Intake	Guide inside diameter	0.3154 - 0.3159 in. (8.010 - 8.025 mm)	0.3189 in. (8.10 mm)	*See Inspection of Valve Guides on page 6-32.*
		Valve stem outside diameter	0.3132 - 0.3140 in. (7.955 - 7.975 mm)	0.3110 in. (7.90 mm)	
		Valve stem bend	0.0014 - 0.0028 in. (0.035 - 0.070 mm)	0.0071 in. (0.18 mm)	
	Exhaust	Guide inside diameter	0.3156 - 0.3161 in. (8.015 - 8.030 mm)	0.3189 in. (8.10 mm)	
		Valve stem outside diameter	0.3132 -.3134 in. (7.955 - 7.960 mm)	0.3110 in. (7.90 mm)	
		Valve stem bend	0.0018 - 0.0030 in. (0.045 - 0.075 mm)	0.0071 in. (0.18 mm)	
4TNV98C, 4TNV98CT	Intake	Guide inside diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.2787 in. (7.08 mm)	*See Inspection of Valve Guides on page 6-32.*
		Valve stem outside diameter	0.2734 - 0.2740 in. (6.945 - 6.960 mm)	0.2717 in. (6.90 mm)	
		Oil clearance	0.0016 - 0.0028 in. (0.040 - 0.070 mm)	0.0067 in. (0.17 mm)	
	Exhaust	Guide inside diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.2787 in. (7.08 mm)	
		Valve stem outside diameter	0.2732 - 0.2738 in. (6.940 - 6.955 mm)	0.2717 in. (6.90 mm)	
		Valve stem bend	0.0018 - 0.0030 in. (0.045 - 0.075 mm)	0.0067 in. (0.17 mm)	
Valve guide projection from cylinder head		3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT, 4TNV98C, 4TNV98CT	0.5791 - 0.5905 in. (14.71 - 15.00 mm)	–	*See Reassembly of valve guides on page 6-35.*
Valve guide installation method			Cold-fitted	–	
Valve stem seal projection from cylinder head		3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT, 4TNV98C, 4TNV98CT	0.736 - 0.748 in. (18.7 - 19.0 mm)	–	*See Reassembly of intake and exhaust valves on page 6-35*

Push Rod

Inspection item	Standard	Limit	Reference page
Push rod bend - all models	Less than 0.0012 in. (0.03 mm)	0.0012 in. (0.03 mm)	*See Push rod bend on page 6-31.*

Rocker Arm and Shaft

Model	Inspection item	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Arm shaft hole diameter	0.6299 - 0.6307 in. (16.000 - 16.020 mm)	0.6327 in. (16.07 mm)	*See Inspection of Rocker Arm Assembly on page 6-31.*
	Shaft outside diameter	0.6286 - 0.6293 in. (15.966 - 15.984 mm)	0.6276 in. (15.94 mm)	
	Oil clearance	0.0006 - 0.0021 in. (0.016 - 0.054 mm)	0.0051 in. (0.13 mm)	
4TNV98, 4TNV98CT	Arm shaft hole diameter	0.7283 - 0.7291 in. (18.500 - 18.520 mm)	0.7311 in. (18.57 mm)	
	Shaft outside diameter	0.7272 - 0.7280 in. (18.470 - 18.490 mm)	0.7260 in. (18.44 mm)	
	Oil clearance	0.0004 - 0.0020 in. (0.010 - 0.050 mm)	0.0051 in. (0.13 mm)	

Valve Spring

Inspection item	Model	Standard	Limit	Reference page
Free length	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	1.6535 in. (42.0 mm)	1.6339 in. (41.5 mm)	*See Inspection of Valve Springs on page 6-34.*
	4TNV98C, 4TNV98CT	1.8701 in. (47.5 mm)	1.8504 in. (47.0 mm)	
Squareness	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	–	0.0551 in. (1.4 mm)	
	4TNV98C, 4TNV98CT	–	0.0472 in. (1.2 mm)	

CAMSHAFT AND TIMING GEAR TRAIN SPECIFICATIONS

Camshaft

Inspection item			Standard	Limit	Reference page
End play			0.0020 - 0.0079 in. (0.05 - 0.20 mm)	0.0118 in. (0.030 mm)	*See Removal of camshaft on page 6-45.*
Bend (1/2 the dial gauge reading)			0 - 0.0008 in. (0 - 0.02 mm)	0.0020 in. (0.05 mm)	*See Inspection of camshaft on page 6-54.*
Cam lobe height		3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	1.5197 - 1.5276 in. (38.600 - 38.800 mm)	1.5098 in. (38.350 mm)	
		4TNV98C, 4TNV98CT	1.6707 - 1.6758 in. (42.435 - 42.565 mm)	1.6608 in. (42.185 mm)	
Shaft outside diameter/bearing inside diameter					
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Gear end	Bushing inside diameter	1.7713 - 1.7738 in. (44.990 - 45.055 mm)	1.7768 in. (45.130 mm)	*See Inspection of camshaft on page 6-54.*
		Camshaft outside diameter	1.7687 - 1.7697 in. (44.925 - 44.950 mm)	1.7673 in. (44.890 mm)	
		Oil clearance	0.0016 - 0.0051 in. (0.040 - 0.130 mm)	0.0094 in. (0.240 mm)	
	Intermediate	Bore inside diameter	1.7716 - 1.7726 in. (45.000 - 45.025 mm)	1.7756 in. (45.100 mm)	
		Camshaft outside diameter	1.7681 - 1.7691 in. (44.910 - 44.935 mm)	1.7667 in. (44.875 mm)	
		Oil clearance	0.0026 - 0.0045 in. (0.065 - 0.115 mm)	0.0089 in. (0.225 mm)	
	Flywheel end	Bore inside diameter	1.7716 - 1.7726 in. (45.000 - 45.025 mm)	1.7756 in. (45.100 mm)	
		Camshaft outside diameter	1.7687 - 1.7697 in. (44.925 - 44.950 mm)	1.7673 in. (44.890 mm)	
		Oil clearance	0.0020 - 0.0039 in. (0.050 - 0.100 mm)	0.0083 in. (0.210 mm)	
4TNV98C, 4TNV98CT	Gear end	Bushing inside diameter	1.9681 - 1.9707 in. (49.990 - 50.055 mm)	1.9736 in. (50.130 mm)	*See Inspection of camshaft on page 6-54.*
		Camshaft outside diameter	1.9655 - 1.9665 in. (49.925 - 49.950 mm)	1.9642 in. (49.890 mm)	
		Oil clearance	0.0016 - 0.0051 in. (0.040 - 0.130 mm)	0.0094 in. (0.240 mm)	
	Intermediate	Bore inside diameter	1.9685 - 1.9695 in. (50.000 - 50.025 mm)	1.9724 in. (50.100 mm)	
		Camshaft outside diameter	1.9650 - 1.9659 in. (49.910 - 49.935 mm)	1.9636 in. (49.875 mm)	
		Oil clearance	0.0026 - 0.0045 in. (0.065 - 0.115 mm)	0.0089 in. (0.225 mm)	
	Flywheel end	Bore inside diameter	1.9685 - 1.9695 in. (50.000 - 50.025 mm)	1.9724 in. (50.100 mm)	
		Camshaft outside diameter	1.9655 - 1.9665 in. (49.925 - 49.950 mm)	1.9642 in. (49.890 mm)	
		Oil clearance	0.0020 - 0.0039 in. (0.050 - 0.100 mm)	0.0083 in. (0.210 mm)	

Idler Gear Shaft and Bushing

Model	Inspection item		Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Idler gear A	Shaft outside diameter	1.8091 - 1.8100 in. (45.950 - 45.975 mm)	1.8071 in. (45.900 mm)	
		Bushing inside diameter	1.8110 - 1.8120 in. (46.000 - 46.025 mm)	1.8140 in. (46.075 mm)	
		Oil clearance	0.0010 - 0.0030 in. (0.025 - 0.075 mm)	0.0068 in. (0.175 mm)	
	Idler gear B	Shaft outside diameter	1.6909 - 1.6919 in. (42.950 - 42.975 mm)	1.6890 in. (42.900 mm)	
		Bushing inside diameter	1.6929 - 1.6939 in. (43.000 - 43.025 mm)	1.6959 in. (43.075 mm)	
		Oil clearance	0.0010 - 0.0030 in. (0.025 - 0.075 mm)	0.0068 in. (0.175 mm)	
4TNV98C, 4TNV98CT	Idler gear A	Shaft outside diameter	1.8091 - 1.8100 in. (45.950 - 45.975 mm)	1.8071 in. (45.900 mm)	
		Bushing inside diameter	1.8110 - 1.8120 in. (46.000 - 46.025 mm)	1.8140 in. (46.075 mm)	
		Oil clearance	0.0010 - 0.0030 in. (0.025 - 0.075 mm)	0.0068 in. (0.175 mm)	
	Idler gear B	Shaft outside diameter	1.8091 - 1.8100 in. (45.950 - 45.975 mm)	1.8071 in. (45.900 mm)	
		Bushing inside diameter	1.8110 - 1.8120 in. (46.000 - 46.025 mm)	1.8140 in. (46.075 mm)	
		Oil clearance	0.0010 - 0.0030 in. (0.025 - 0.075 mm)	0.0068 in. (0.175 mm)	

Timing Gear Backlash

Model	Inspection item	Standard	Limit	Reference page
All models	Crank gear, cam gear, idler gear, fuel injection pump gear and PTO gear	0.0031 - 0.0055 in. (0.08 - 0.14 mm)	0.0063 in. (0.16 mm)	*See Checking timing gear backlash on page 6-43.*

CRANKSHAFT AND PISTON SPECIFICATIONS

Crankshaft

Note: Check appropriate parts catalog for various sizes of replacement main bearing inserts.

Inspection item			Standard	Limit	Reference page
Bend (1/2 the dial gauge reading)			–	0.0008 in. (0.02 mm)	*See Inspection of crankshaft on page 6-54.*
Connecting rod journals	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Journal outside diameter	1.8879 - 1.8883 in. (47.952 - 47.962 mm)	1.8859 in. (47.902 mm)	
		Bearing inside diameter	1.8898 - 1.8909 in. (48.000 - 48.026 mm)	–	
		Bearing insert thickness	0.0587 - 0.0591 in. (1.492 - 1.500 mm)	–	
		Oil clearance	0.0015 - 0.0029 in. (0.038 - 0.074 mm)	0.0059 in. (0.150 mm)	
	4TNV98C, 4TNV98CT	Journal outside diameter	2.2816 - 2.2820 in. (57.952 - 57.962 mm)	2.2796 in. (57.902 mm)	
		Bearing inside diameter	2.2835 - 2.2845 in. (58.000 - 58.026 mm)	–	
		Bearing insert thickness	0.0587 - 0.0591 in. (1.492 - 1.500 mm)	–	
		Oil clearance	0.0015 - 0.0029 in. (0.038 - 0.074 mm)	0.0059 in. (0.150 mm)	
Main bearing journal	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Journal outside diameter	1.9666 -1.9670 in. (49.952 - 49.962 mm)	1.9646 in. (49.902 mm)	*See Inspection of crankshaft on page 6-54.*
		Bearing inside diameter	1.9685 - 1.9693 in. (50.000 - 50.020 mm)	–	
		Bearing insert thickness	0.0785 - 0.0791 in. (1.995 - 2.010 mm)	–	
		Oil clearance	0.0015 - 0.0027 in. (0.038 - 0.068 mm)	0.0059 in. (0.150 mm)	
	4TNV98C, 4TNV98CT	Journal outside diameter	2.5572 - 2.5576 in. (64.952 - 64.962 mm)	2.5552 in. (64.902 mm)	
		Bearing inside diameter	2.5590 - 2.5598 in. (65.000 - 65.020 mm)	–	
		Bearing insert thickness	0.0785 - 0.0791 in. (1.995 - 2.010 mm)	–	
		Oil clearance	0.0015 - 0.0027 in. (0.038 - 0.068 mm)	0.0059 in. (0.150 mm)	

Thrust Bearing

Inspection item	Standard	Limit	Reference page
Crankshaft end play - all models	0.0051 - 0.0091 in. (0.13 - 0.23 mm)	0.0110 in. (0.28 mm)	*See Removal of crankshaft on page 6-48.*

Piston

<table>
<tr><th colspan="3">Inspection item</th><th>Standard</th><th>Limit</th><th>Reference page</th></tr>
<tr><td colspan="2" rowspan="3">Piston outside diameter
(Measure at 90° to the piston pin)</td><td>3TNV88C, 4TNV88C</td><td>3.4622 - 3.4634 in.
(87.940 - 87.970 mm)</td><td>3.4604 in.
(87.895 mm)</td><td rowspan="5">See Inspection of pistons, piston rings and wrist pin on page 6-51.</td></tr>
<tr><td>3TNV86CT, 4TNV86CT</td><td>3.3835 - 3.3846 in.
(85.940 - 85.970 mm)</td><td>3.3817 in.
(85.895 mm)</td></tr>
<tr><td>4TNV98C, 4TNV98CT</td><td>3.8559 - 3.8563 in.
(97.940 - 97.950 mm)</td><td>3.8545 in.
(97.905 mm)</td></tr>
<tr><td colspan="2" rowspan="2">Piston diameter measure location
(Upward from the bottom of the piston)</td><td>3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT</td><td>0.9449 in.
(24 mm)</td><td>–</td></tr>
<tr><td>4TNV98C, 4TNV98CT</td><td>0.8661 in.
(22 mm)</td><td>–</td></tr>
<tr><td rowspan="6">Piston pin</td><td rowspan="3">3TNV88C,
3TNV86CT,
4TNV88C,
4TNV86CT</td><td>Hole inside diameter</td><td>1.0236 - 1.0240 in.
(26.000 - 26.009 mm)</td><td>1.0252 in.
(26.039 mm)</td><td rowspan="6">See Inspection of pistons, piston rings and wrist pin on page 6-51.</td></tr>
<tr><td>Pin outside diameter</td><td>1.0234 - 1.0236 in.
(25.995 - 26.000 mm)</td><td>1.0222 in.
(25.965 mm)</td></tr>
<tr><td>Oil clearance</td><td>0.0000 - 0.0006 in.
(0.000 - 0.014 mm)</td><td>0.0029 in.
(0.074 mm)</td></tr>
<tr><td rowspan="3">4TNV98C,
4TNV98CT</td><td>Hole inside diameter</td><td>1.1811 - 1.1815 in.
(30.000 - 30.009 mm)</td><td>1.1826 in.
(30.039 mm)</td></tr>
<tr><td>Pin outside diameter</td><td>1.1809 - 1.1811 in.
(29.995 - 30.000 mm)</td><td>1.1797 in.
(29.965 mm)</td></tr>
<tr><td>Oil clearance</td><td>0.0000 - 0.0006 in.
(0.000 - 0.014 mm)</td><td>0.0029 in.
(0.074 mm)</td></tr>
</table>

Piston Ring

Model	Inspection item		Standard	Limit	Reference page
3TNV86CT, 4TNV86CT	Top ring	Ring groove width	0.0813 - 0.0819 in. (2.065 - 2.080 mm)	–	*See Inspection of pistons, piston rings and wrist pin on page 6-51.*
		Ring width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
		Side clearance	0.0030 - 0.0043 in. (0.075 - 0.110 mm)	–	
		End gap	0.0079 - 0.0157 in. (0.200 - 0.400 mm)	0.0193 in. (0.490 mm)	
	Second ring	Ring groove width	0.0801 - 0.0807 in. (2.035 - 2.050 mm)	0.0846 in. (2.150 mm)	
		Ring width	0.0768 - 0.0776 in. (1.950 - 1.970 mm)	0.0760 in. (1.930 mm)	
		Side gap	0.0018 - 0.0039 in. (0.045 - 0.100 mm)	0.0079 in. (0.200 mm)	
		End gap	0.0118 - 0.0197 in. (0.30 - 0.50 mm)	0.0232 in. (0.590 mm)	
	Oil ring	Ring groove width	0.1581 - 0.1587 in. (4.015 - 4.030 mm)	0.1626 in. (4.130 mm)	
		Ring width	0.1563 - 0.1571 in. (3.970 - 3.990 mm)	0.01555 in. (3.950 mm)	
		Side clearance	0.0010 - 0.0024 in. (0.025 - 0.060 mm)	0.0071 in. (0.180 mm)	
		End gap	0.0079 - 0.0157 in. (0.200 - 0.400 mm)	0.0193 in. (0.490 mm)	

(Piston ring cont.)

Model	Inspection item		Standard	Limit	Reference page
3TNV88C, 4TNV88C	Top ring	Ring groove width	0.0807 - 0.0817 in. (2.050 - 2.075 mm)	–	*See Inspection of pistons, piston rings and wrist pin on page 6-51.*
		Ring width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
		Side clearance	0.0028 - 0.0041 in. (0.070 - 0.105 mm)	–	
		End gap	0.0079 - 0.157 in. (0.200 -.0400 mm)	0.0193 in. (0.490 mm)	
	Second ring	Ring groove width	0.0797 - 0.0803 in. (2.025 - 2.040 mm)	0.0843 in. (2.140 mm)	
		Ring width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
		Side clearance	0.0014 - 0.0028 in. (0.035 - 0.070 mm)	0.0075 in. (0.190 mm)	
		End gap	0.0079 - 0.0157 in. (0.20 - 0.40 mm)	0.0193 in. (0.490 mm)	
	Oil ring	Ring groove width	0.1581 - 0.1587 in. (4.015 - 4.030 mm)	0.1626 in. (4.130 mm)	
		Ring width	0.1563 -.1571 in. (3.970 - 3.990 mm)	0.1555 in. (3.950 mm)	
		Side clearance	0.0010 - 0.0024 in. (0.025 - 0.060 mm)	0.0071 in. (0.180 mm)	
		End gap	0.0079 - 0.0157 in. (0.200 - 0.400 mm)	0.0193 in. (0.490 mm)	

(Piston ring cont.)

Model	Inspection item		Standard	Limit	Reference page
4TNV98C, 4TNV98CT	Top ring	Ring groove width	0.0803 - 0.0811 in. (2.040 - 2.060 mm)	–	*See Inspection of pistons, piston rings and wrist pin on page 6-51.*
		Ring width	0.0764 - 0.0772 in. (1.940 - 1.960 mm)	0.0756 in. (1.920 mm)	
		Side clearance	0.0031 - 0.0047 in. (0.080 - 0.120 mm)	–	
		End gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0213 in. (0.540 mm)	
	Second ring	Ring groove width	0.0819 - 0.0825 in. (2.080 - 2.095 mm)	0.0864 in. (2.195 mm)	
		Ring width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
		Side clearance	0.0035 - 0.0049 in. (0.090 - 0.125 mm)	0.0096 in. (0.245 mm)	
		End gap	0.0177 - 0.0256 in. (0.450 - 0.650 mm)	0.0287 in. (0.730 mm)	
	Oil ring	Ring groove width	0.1187 - 0.1193 in. (3.015 - 3.030 mm)	0.1232 in. (3.130 mm)	
		Ring width	0.1169 - 0.1177 in. (2.970 - 2.990 mm)	0.1161 in. (2.950 mm)	
		Side clearance	0.0010 - 0.0024 in. (0.025 - 0.060 mm)	0.0071 in. (0.180 mm)	
		End gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0217 in. (0.550 mm)	

Connecting Rod

■ Connecting rod small end

Model	Inspection item	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Wrist pin bushing inside diameter	1.0234 - 1.0251 in. (26.025 - 26.038 mm)	1.0263 in. (26.068 mm)	*See Inspection of connecting rod on page 6-53.*
	Wrist pin outside diameter	1.0234 - 1.0236 in. (25.995 - 26.000 mm)	1.0223 in. (25.967 mm)	
	Oil clearance	0.0010 - 0.0017 in. (0.025 - 0.043 mm)	0.0040 in. (0.101 mm)	
4TNV98C, 4TNC98CT	Wrist pin bushing inside diameter	1.1821 - 1.1826 in. (30.025 - 30.038 mm)	1.1838 in. (30.068 mm)	
	Wrist pin outside diameter	1.1809 - 1.1811 in. (29.995 - 30.000 mm)	1.1797 in. (29.965 mm)	
	Oil clearance	0.0010 - 0.0017 in. (0.025 - 0.043 mm)	0.0040 in. (0.101 mm)	

■ Connecting rod big end

Inspection item	Standard	Limit	Reference page
Side clearance - all models	0.0079 - 0.0157 in. (0.20 - 0.40 mm)	–	*See Inspection of connecting rod on page 6-53.*

Note: See Special Torque Chart on page 6-16 for other specifications.

Tappet

Model	Inspection item	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Tappet bore (block) inside diameter	0.4724 - 0.4734 in. (12.000 - 12.025 mm)	0.4742 in. (12.045 mm)	*See Inspection of tappets on page 6-53.*
	Tappet stem outside diameter	0.4715 - 0.4720 in. (11.975 - 11.990 mm)	0.4707 in. (11.955 mm)	
	Oil clearance	0.0004 - 0.0020 in. (0.010 - 0.050 mm)	0.0035 in. (0.090 mm)	
4TNV98C, 4TNV98CT	Tappet bore (block) inside diameter	0.4724 - 0.4731 in. (12.000 - 12.018 mm)	0.4739 in. (12.038 mm)	
	Tappet stem outside diameter	0.4715 - 0.4720 in. (11.975 - 11.990 mm)	0.4707 in. (11.955 mm)	
	Oil clearance	0.0004 - 0.0017 in. (0.010 - 0.043 mm)	0.0033 in. (0.083 mm)	

CYLINDER BLOCK SPECIFICATIONS

Cylinder Block

Inspection item	Model	Standard	Limit	Reference page
Cylinder inside diameter	3TNV88C - 4TNV88C	3.4646 - 3.4657 in. (88.000 - 88.030 mm)	3.4724 in. (88.200 mm)	*See Inspection of cylinder block on page 6-51.*
	3TNV86CT, 4TNV86CT	3.3858 - 3.3870 in. (86.000 - 86.030 mm)	3.3937 in. (86.200 mm)	
	4TNV98C, 4TNV98CT	3.8583 - 3.8594 in. (98.000 - 98.030 mm)	3.8634 in. (98.130 mm)	
Cylinder bore	Roundness	0.0004 in. (0.01 mm) or less	0.0012 in. (0.03 mm)	
	Taper			

SPECIAL TORQUE CHART

Torque for Bolts and Nuts

Component	Model	Thread diameter and pitch	Torque	Lubricating oil application (Thread portion and seat surface)
Cylinder head bolt	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M10 × 1.25 mm	68 - 72 ft·lb (92.0 - 98.0 N·m; 9.4 - 10.0 kgf·m)	Applied
	4TNV98C, 4TNV98CT	M11 × 1.25 mm	76 - 83 ft·lb (103.1 - 112.9 N·m; 10.5 - 11.5 kgf·m)	
Connecting rod bolt	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M9 × 1.0 mm	33 - 36 ft·lb (44.1 - 49.0 N·m; 4.5 - 5.0 kgf·m)	Applied
	4TNV98C, 4TNV98CT	M10 × 1.0 mm	40 - 43 ft·lb (53.9 - 58.8 N·m; 5.5 - 6.0 kgf·m)	
Flywheel bolt	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M10 × 1.25 mm	61 - 65 ft·lb (83.3 - 88.2 N·m; 8.5 - 9.0 kgf·m)	Applied
	4TNV98C, 4TNV98CT	M14 × 1.5 mm	137 - 152 ft·lb (186.2 - 205.8 N·m; 19 - 21 kgf·m)	
Main bearing cap bolt	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M12 × 1.5 mm	70.8 - 73.8 ft·lb (96.0 - 100 N·m; 9.8 - 10.2 kgf·m)	Applied
	4TNV98C, 4TNV98CT	M11 × 1.25 mm	80 - 87 ft·lb (108.1 - 117.9 N·m; 11.0 - 12.0 kgf·m)	
Crankshaft pulley bolt	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M14 × 1.5 mm	Cast metal (FC300) 62 - 69 ft·lb (83.3 - 93.1 N·m; 8.5 - 9.5 kgf·m)	Applied
			Steel metal (S45C) 83 - 91 ft·lb (112.7 - 122.7 N·m; 11.5 - 12.5 kgf·m)	
	4TNV98C, 4TNV98CT	M14 × 1.5 mm	80 - 94 ft·lb (107.9 - 127.5 N·m; 11.0 - 13.0 kgf·m)	

(Torque for bolts and nuts cont.)

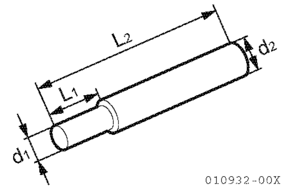
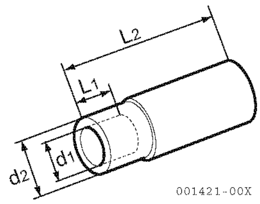
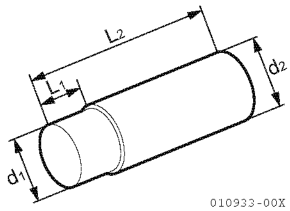
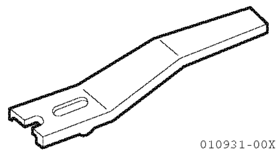
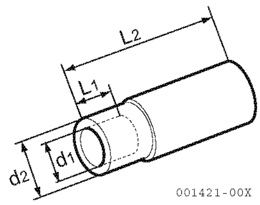
Component	Model	Thread diameter and pitch	Torque	Lubricating oil application (Thread portion and seat surface)
Fuel injector retainer bolt	All models	M8 × 1.25 mm	18 - 21 ft·lb (24.4 - 28.4 N·m; 2.5 - 2.9 kgf·m)	Not applied
Supply pump drive gear nut	All models	M18 × 1.5 mm	55 - 63 ft·lb (75 - 85 N·m; 7.7 - 8.7 kgf·m)	Not applied
High-pressure fuel line nut	All models	M12 × 1.5 mm Common rai	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)	Not applied
		M12 × 1.5 mm Injector	19.5 - 25.3 ft·lb (26.5 - 34.3 N·m; 2.7 - 3.5 kgf·m)	
		M16 × 1.0 mm Supply pump	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)	
Crank rotation sensor	All models	M6 × 1.0 mm	4.4 - 7.4 ft·lb (6.0 - 10.0 N·m; 0.6 - 1.0 kgf·m)	Not applied
Cam speed sensor	All models	M6 × 1.0 mm	5.5 - 6.3 ft·lb (7.5 - 8.5 N·m; 0.75 - 0.85 kgf·m)	Not applied
Pipe, EGR valve	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	M8 × 1.25 mm	14.0 - 18.2 ft·lb (18.9 - 24.7 N·m; 1.9 - 2.5 kgf·m)	Not applied
	4TNV98C, 4TNV98CT	M10 × 1.5 mm	43.3 - 47.0 ft·lb (58.7 - 63.7 N·m; 6.0 - 6.5 kgf·m)	Not applied
New air temperature sensor	3TNV88C, 4TNV88C, 4TNV98C	M6 × 1.0 mm	4.1 - 6.2 ft·lb (5.6 - 8.4 N·m; 0.57 - 0.86 kgf·m)	Not applied
	3TNV86CT, 4TNV86CT, 4TNV98CT		2.2 - 3.0 ft·lb (3.0 - 4.0 N·m; 0.31 - 0.41 kgf·m)	
Intake temperature sensor	All models	M14 × 1.5 mm	8.1 - 12.5 ft·lb (11.0 - 17.0 N·m; 1.1 - 1.7 kgf·m)	Not applied

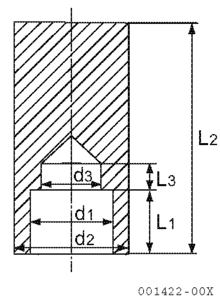
(Torque for bolts and nuts cont.)

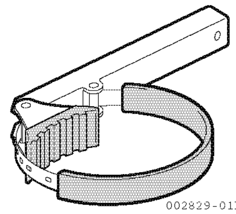
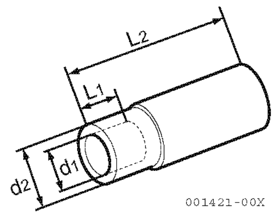
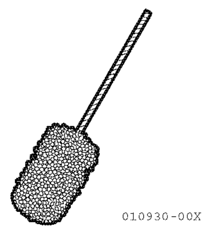
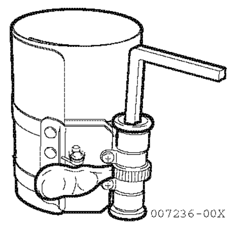
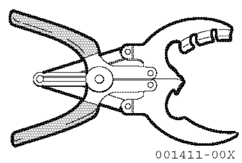
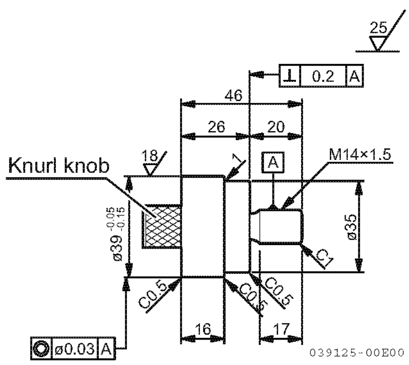
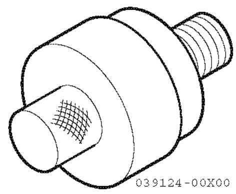
Component	Model	Thread diameter and pitch	Torque	Lubricating oil application (Thread portion and seat surface)
Exhaust temperature sensor	All models	M12 × 1.25 mm	18.4 - 29.5 ft·lb (25.0 - 40.0 N·m; 2.5 - 4.1 kgf·m)	Not applied
DPF inlet temperature sensor	All models	M14 × 1.5 mm	33.2 - 40.6 ft·lb (45.0 - 55.0 N·m; 4.6 - 5.6 kgf·m)	Not applied
DPF inside temperature sensor	All models	M12 × 1.25 mm	33.2 - 40.6 ft·lb (45.0 - 55.0 N·m; 4.6 - 5.6 kgf·m)	Not applied
DPF differential pressure sensor	All models	M6 × 1.0 mm	4.1 - 6.2 ft·lb (5.6 - 8.4 N·m; 0.57 - 0.86 kgf·m)	Not applied
Bolt, DPF differential pressure sensor pipe joint	All models	M12 × 1.25 mm	18.1 - 25.3 ft·lb (24.5 - 34.3 N·m; 2.5 - 3.5 kgf·m)	Burning prevention medicine
Knob, cylinder head cover	4TNV98C, 4TNV98CT	M8 × 1.5 mm	8.9 - 11.0 ft·lb (12.0 - 15.0 N·m; 1.2 - 1.5 kgf·m)	Not applied
Glow plug	All models	M10 × 1.25 mm	11.1 - 14.8 ft·lb (15 - 20 N·m; 1.53 - 2.04 kgf·m)	Not applied
Glow connector nut	All models	M4 × 0.7 mm	0.7 - 1.1 ft·lb (1 - 1.5 N·m; 0.1 - 0.15 kgf·m)	Not applied
Piston cooling nozzle banjo bolt	3TNV86CT, 4TNV86CT, 4TNV98CT	M8 × 1.25 mm	9.4 - 12.3 ft·lb (12.7 - 16.7 N·m; 1.3 - 1.7 kgf·m)	Not applied

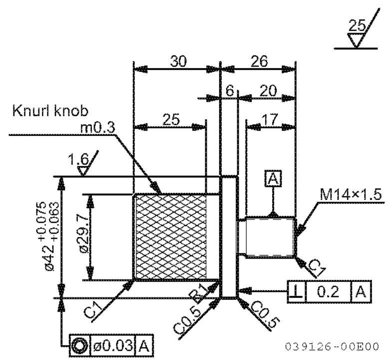
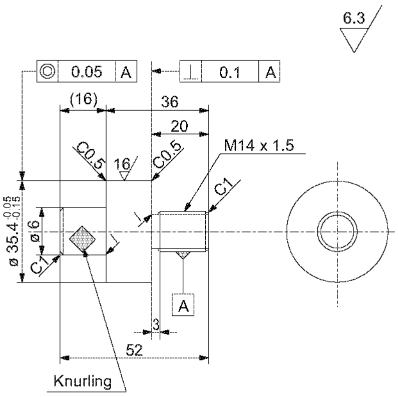
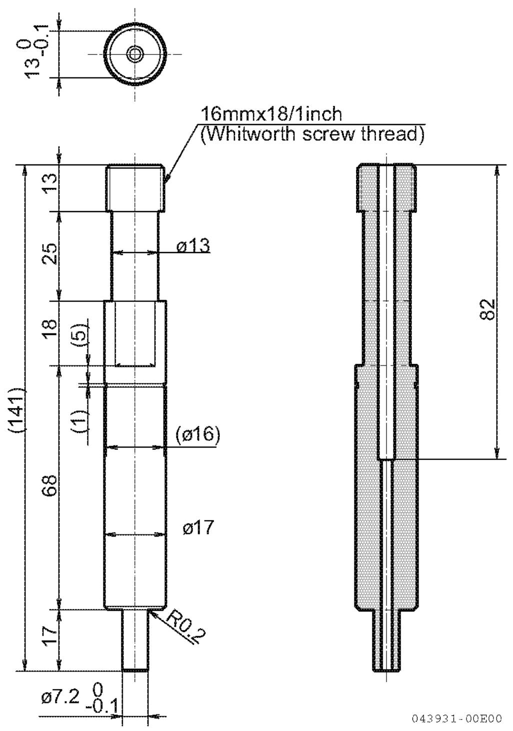
Note: See Tightening Torques for Standard Bolts and Nuts on page 4-43 for standard hardware torque values.

SPECIAL SERVICE TOOLS

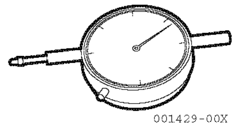
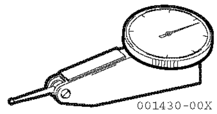
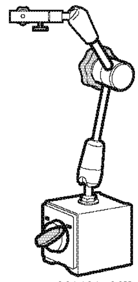
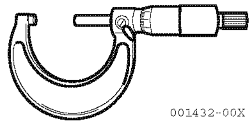
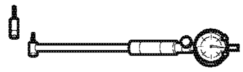
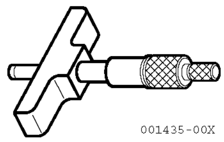
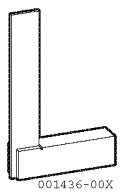
<table>
<tr><th>No.</th><th>Tool name</th><th>Applicable model and tool size</th><th>Illustration</th></tr>
<tr><td>1</td><td>Valve guide tool (for removing valve guide)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr>
<tr><td>All models</td><td>0.787 in. (20 mm)</td><td>2.953 in. (75 mm)</td><td>0.295 in. (7.5 mm)</td><td>0.433 in. (11 mm)</td></tr>
</table>
Locally manufactured</td><td>
</td></tr>
<tr><td>2</td><td>Valve guide tool (for installing valve guide)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr>
<tr><td>All models</td><td>0.591 in. (15 mm)</td><td>2.559 in. (65 mm)</td><td>0.551 in. (14 mm)</td><td>0.787 in. (20 mm)</td></tr>
</table>
Locally manufactured</td><td>
</td></tr>
<tr><td>3</td><td>Connecting rod bushing replacer (for removal/ installation of connecting rod bushing)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr>
<tr><td>3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT</td><td>0.787 in. (20 mm)</td><td>3.937 in. (100 mm)</td><td>1.024 in. (26 mm)</td><td>1.142 in. (29 mm)</td></tr>
<tr><td>4TNV98C, 4TNV98CT</td><td>0.787 in. (20 mm)</td><td>3.937 in. (100 mm)</td><td>1.181 in. (30 mm)</td><td>1.299 in. (33 mm)</td></tr>
</table>
Locally manufactured</td><td>
</td></tr>
<tr><td>4</td><td>Valve spring compressor (for removal/ installation of valve spring)</td><td>YANMAR Part No. 129100-92630</td><td>
</td></tr>
<tr><td>5</td><td>Stem seal installer (for installing valve stem seal)</td><td>
<table>
<tr><th>Model</th><th>d1</th><th>d2</th><th>d3</th><th>L1</th><th>L2</th><th>L3</th></tr>
<tr><td>All models</td><td>0.638 in. (16.2 mm)</td><td>0.866 in. (22 mm)</td><td>0.531 in. (13.5 mm)</td><td>0.740 in. (18.8 mm)</td><td>2.559 in. (65 mm)</td><td>0.157 in. (4 mm)</td></tr>
</table>
Locally manufactured</td><td>

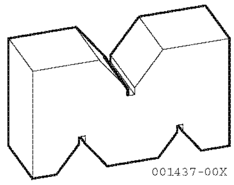
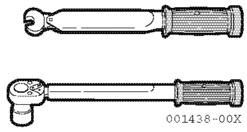
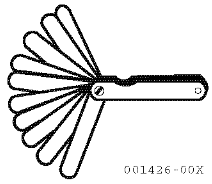

</td></tr>
</table>

<table>
<tr><th>No.</th><th>Tool name</th><th>Applicable model and tool size</th><th>Illustration</th></tr>
<tr><td>6</td><td>Filter wrench
(for removal/
installation of
engine oil filter)</td><td>Available locally</td><td></td></tr>
<tr><td>7</td><td>Camshaft
bushing tool
(for extracting
camshaft
bushing)</td><td>
<table>
<tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr>
<tr><td>3TNV88C,
3TNV86CT,
4TNV88,
4TNV86CT</td><td>0.709 in.
(18 mm)</td><td>2.756 in.
(70 mm)</td><td>1.772 in.
(45 mm)</td><td>1.890 in.
(48 mm)</td></tr>
<tr><td>4TNV98C,
4TNV98CT</td><td>0.709 in.
(18 mm)</td><td>2.756 in.
(70 mm)</td><td>1.968 in.
(50 mm)</td><td>2.087 in.
(53 mm)</td></tr>
</table>
Locally manufactured</td><td></td></tr>
<tr><td>8</td><td>Flex-hone
(for preparation
of cylinder
walls)</td><td>
<table>
<tr><th>Model</th><th>YANMAR Part No.</th><th>Cylinder bore</th></tr>
<tr><td>3TNV88C,
3TNV86CT,
4TNV88,
4TNV86CT</td><td>129400-92430</td><td>3.268 - 3.740 in.
(83 - 95 mm)</td></tr>
<tr><td>4TNV98C,
4TNV98CT</td><td>129400-92440</td><td>3.504 - 3.976 in.
(89 - 101 mm)</td></tr>
</table></td><td></td></tr>
<tr><td>9</td><td>Piston ring
compressor
(for installing
piston)</td><td>YANMAR Part No. 95550-002476
The piston insertion tool is applicable for
2.362 - 4.921 in. (60 - 125 mm) diameter pistons</td><td></td></tr>
<tr><td>10</td><td>Piston ring
expander
(for removal/
installation of
piston ring)</td><td>Available locally</td><td></td></tr>
<tr><td>11</td><td>Crankshaft
pulley installing
tool
(for taper pilot)</td><td>Locally manufactured
(4TNV98C, 4TNV98CT
series)
</td><td></td></tr>
</table>

No.	Tool name	Applicable model and tool size		Illustration
12	Crankshaft pulley installing tool (for straight pilot)	Locally manufactured (4TNV98C, 4TNV98CT series)		
13	Pulley installing tool	3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT			
14	Compression gauge adapter (129A00-92950)			

MEASURING INSTRUMENTS

No.	Instrument name		Application	Illustration
1	Dial Indicator	Locally available	Measure shaft bend and end play.	
2	Test indicator	Locally available	Measurements of narrow or deep portions that cannot be measured by dial gauge.	
3	Magnetic stand	Locally available	For holding the dial gauge when measuring.	
4	Micrometer	Locally available	For measuring the outside diameters of crankshaft, pistons, piston pins, etc.	
5	Cylinder bore gauge	Locally available	For measuring the inside diameters of cylinder liners, bearing bores, etc.	
6	Calipers	Locally available	For measuring outside diameters, depth, thickness and width.	
7	Depth micrometer	Locally available	For measuring of valve recession.	
8	Square	Locally available	For measuring valve spring inclination and straightness of parts.	

No.	Instrument name		Application	Illustration
9	V-block	Locally available	For measuring shaft bend.	
10	Torque wrench	Locally available	For tightening nuts and bolts to the specified torque.	
11	Feeler gauge	Locally available	For measuring piston ring gaps, piston ring clearance, and valve adjustment clearance.	

CYLINDER HEAD

Cylinder Head Components

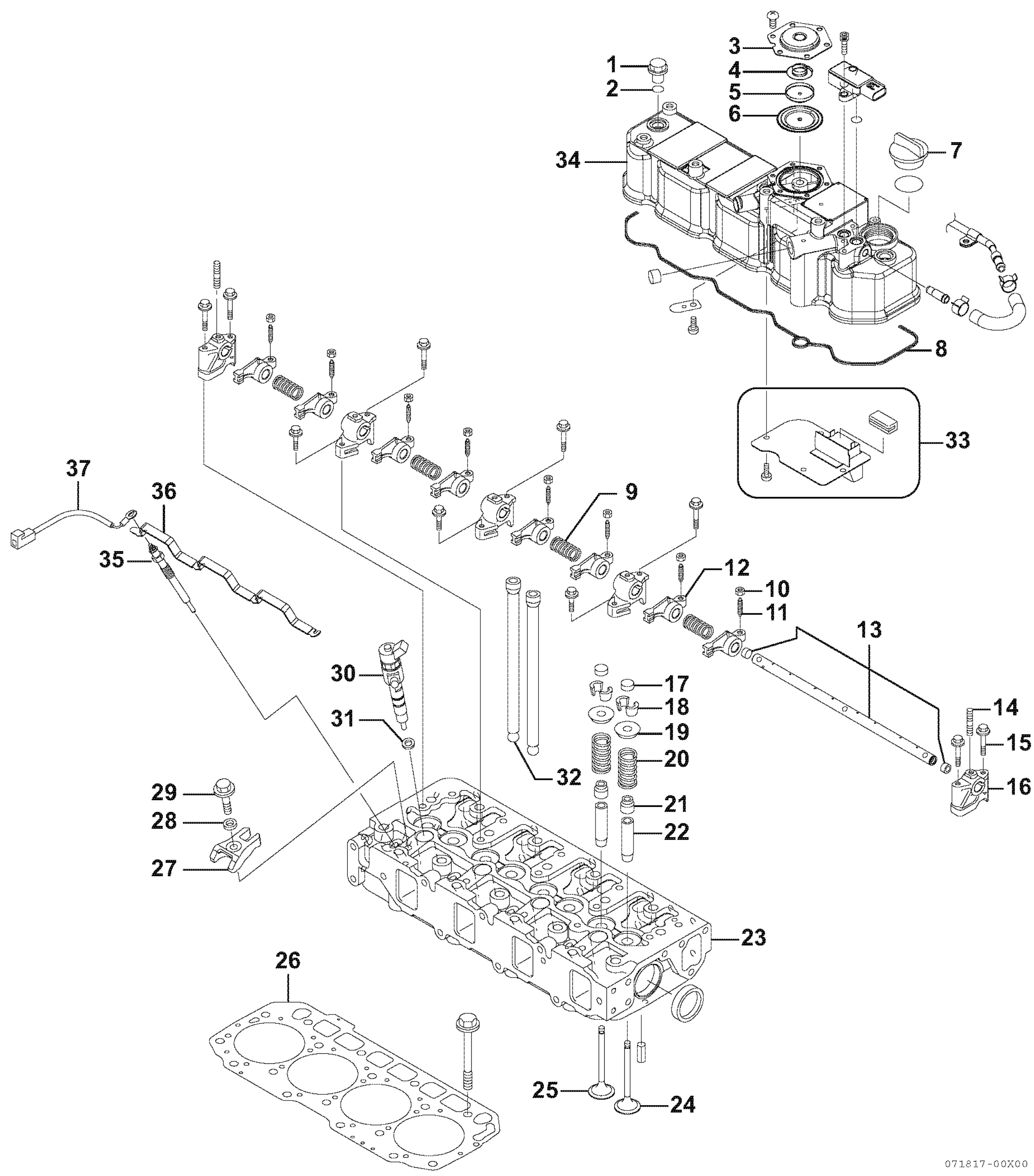


Figure 6-1

1 – Cylinder head cover knob
2 – Cylinder head cover knob O-ring
3 – Crankcase breather cover
4 – Diaphragm spring
5 – Diaphragm plate
6 – Breather diaphragm
7 – Oil fill cap
8 – Cylinder head cover packing
9 – Rocker arm shaft spring
10 – Valve adjusting screw lock nut
11 – Valve adjusting screw
12 – Rocker arm
13 – Rocker arm shaft
14 – Rocker arm shaft aligning stud
15 – Support bolt
16 – Rocker arm shaft support
17 – Valve cap
18 – Valve stem cotter
19 – Spring retainer
20 – Valve spring
21 – Valve stem seal
22 – Valve guide
23 – Cylinder head
24 – Intake valve
25 – Exhaust valve
26 – Cylinder head gasket
27 – Fuel injector retainer
28 – Washer
29 – Fuel injector retainer bolt
30 – Fuel injector
31 – Fuel injector gasket
32 – Push rod
33 – Crankcase breather components
34 – Cylinder head cover
35 – Glow plug
36 – Glow plug connector
37 – Glow plug wire harness

Disassembly of Cylinder Head

Prepare a clean, flat working surface on a workbench large enough to accommodate the cylinder head assembly. Discard all gaskets, O-rings and seals. Use new gaskets, O-rings and seals on reassembly of the cylinder head.

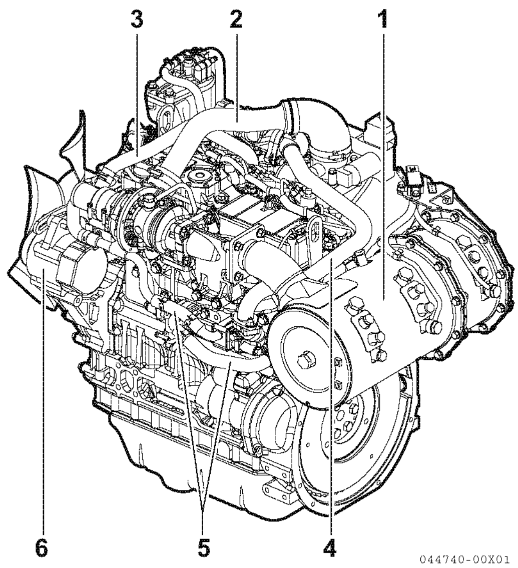
1. Drain the coolant from the engine into a suitable container. *See Change engine coolant on page 5-19.*

NOTICE

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

2. Remove the DPF (1, **Figure 6-2**). *See How to remove the DPF unit on page 13-15.*
3. For models with turbocharger, remove the intake duct (2, **Figure 6-2**) on the cylinder head cover, and also the breather hose (3, **Figure 6-2**).
   For models without turbocharger, remove the breather hose (1, **Figure 6-3**) that connects the intake manifold and the cylinder head cover.
4. Remove electric wirings of the EGR gas temperature sensor (equipped to the EGR valve side end of the EGR pipe), and remove the EGR pipe (4, **Figure 6-2**). Remove the cooling water pipes (both inlet and outlet) (5, **Figure 6-2**) of the EGR cooler. Here, remaining water may spill. Prepare waste cloths or the like under the EGR cooler.
5. Alternator (6, **Figure 6-2**). *See Removal of Alternator on page 12-10.*
6. Remove the electric wirings for the temperature sensor of the coolant, and then remove the cooling fan ans the coolant pump. *See Removal of Engine Coolant Pump on page 8-6.*

DPF flywheel housing-mounted type



DPF Exhaust manifold-mounted type

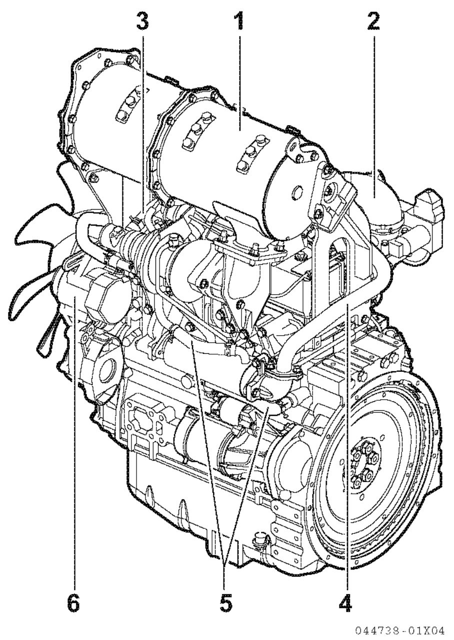


Figure 6-2

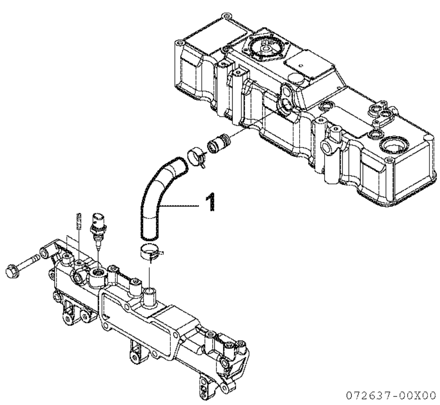


Figure 6-3

7. Remove electric wirings from each of intake throttle (1, **Figure 6-4**), ambient air temperature sensor (2, **Figure 6-4**), and EGR valve (3, **Figure 6-4**).

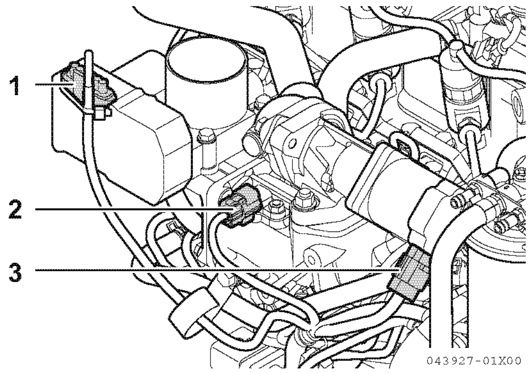


Figure 6-4

8. If the fuel filter assembly (1, **Figure 6-5**) is attached to the intake manifold, either remove the filter bracket by removing the fuel pipe from the fuel filter, or leave the fuel pipe and remove the fuel filter assembly, and put it aside to the engine side.
9. If necessary, remove the intake throttle (2, **Figure 6-5**) on the intake manifold, and the EGR valve (3, **Figure 6-5**) (Dispose all the gaskets.).

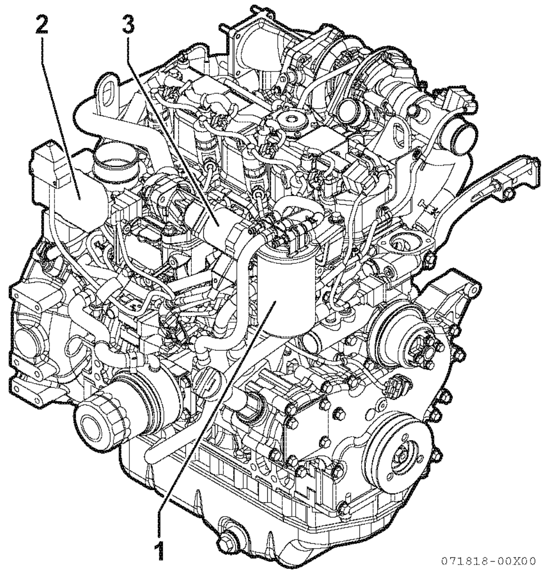


Figure 6-5

10. Remove the high-pressure fuel injection lines (From rail to injector (18, **Figure 6-6**) and from rail to supply pump (19, **Figure 6-6**). *See Removal of Injector on page 7-9.*
11. Remove the wiring coupler of the intake temperature sensor (4, **Figure 6-6**) of the intake manifold (1, **Figure 6-6**). Remove the intake manifold mounting bolts (5, **Figure 6-6**), and the mounting bolt (7, **Figure 6-6**) and nut (8, **Figure 6-6**) of the intake collector (6, **Figure 6-6**).

Remove the intake collector and the intake manifold as a unit, along with the common rail (9, **Figure 6-6**), intake throttle (2, **Figure 6-6**), and EGR valve (3, **Figure 6-6**). Dispose the exhaust manifold gasket (10, **Figure 6-6**). Cover the sheet part of the rail inlet of which the high-pressure pipe is removed with plastic bags after cleaning the part. Also cover the supply pump side too with a plastic bag.

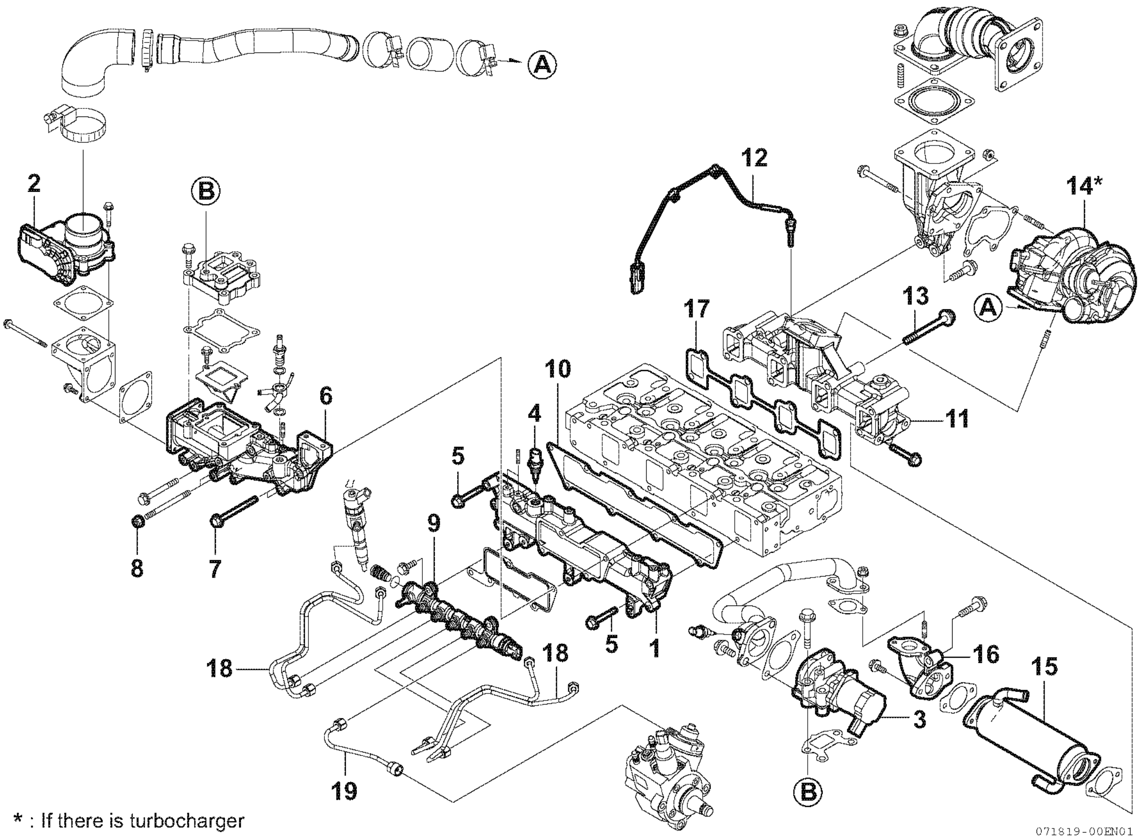


Figure 6-6

12. If there is an exhaust throttle (1, **Figure 6-7**) equipped, remove the electric wirings (2, **Figure 6-7**) from the driven machine side.

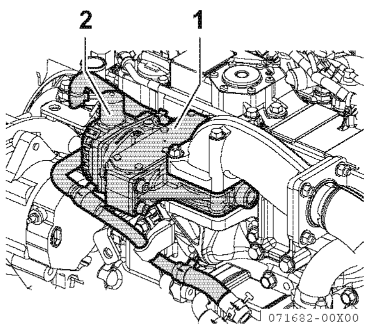


Figure 6-7

13. Remove the exhaust manifold mounting bolts (13, **Figure 6-6**), and then remove the turbocharger (14, **Figure 6-6**) (If there is one.), exhaust throttle (If there is one), EGR cooler (15, **Figure 6-6**), and EGR cooler outlet vent (16, **Figure 6-6**), together with the exhaust manifold. Dispose the exhaust manifold gasket (17, **Figure 6-6**).
14. Remove the injector from the cylinder head. *See Removal of Injector on page 7-9.*

Removing the Glow Plugs

1. Remove the electric wiring harness from the glow plug wire harness (3, **Figure 6-8**), and loosen the nut (4, **Figure 6-8**) from the glow plug (1, **Figure 6-8**) to remove the glow plug connector (2, **Figure 6-8**).
2. Remove the glow plug from the cylinder head.

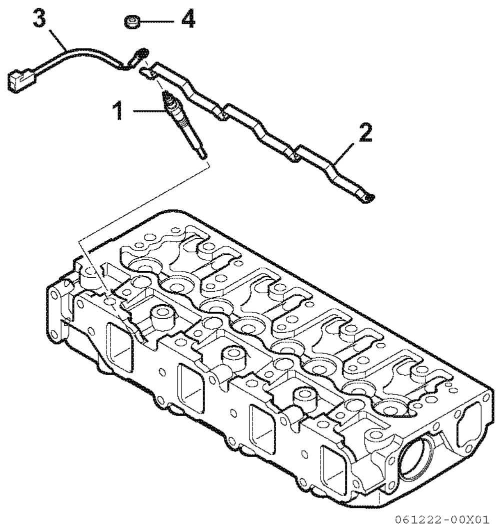


Figure 6-8

Note: Removing the cylinder head from the engine requires that the glow plugs be removed in advance. Failure to remove the glow plugs in advance could result in damages to the glow plugs because their tips are protruding from the cylinder head combustion chamber surface.

Removal of Cylinder Head Cover

1. Disconnect the electrical wire from sensor (3, **Figure 6-9**) on the cylinder head cover.
2. Remove the cylinder head cover knobs (1, **Figure 6-9**).
3. Remove the O-ring (2, **Figure 6-9**) on each cylinder head cover knob.

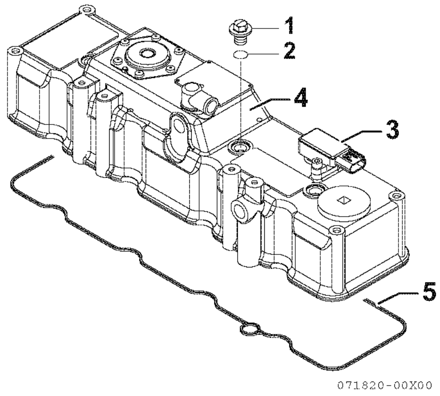


Figure 6-9

4. Remove the cylinder head cover (4, **Figure 6-9**) and the cylinder head cover gasket (5, **Figure 6-9**).

Removal of Rocker Arm Assembly

1. Remove the bolts (1, **Figure 6-10**) that retain the rocker arm shaft supports.
2. Remove the rocker arm shaft assembly from the cylinder head.

   Note: Identify the push rods so they can be reinstalled in their original locations.
3. Remove the push rods and identify for installation.

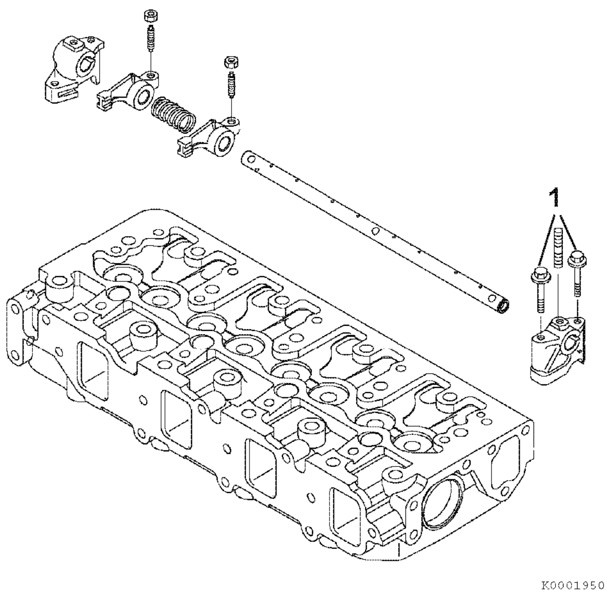


Figure 6-10

Disassembly of Rocker Arm Assembly

1. Remove the rocker arm shaft alignment stud (4, **Figure 6-11**) from support (5, **Figure 6-11**).

   Note: The rocker arm shaft fits tightly in the rocker arm supports. Clamp the support in a padded vise. Twist and pull out on the rocker arm shaft to remove. Reverse this process when you reinstall the rocker arm shaft into the supports.

2. Slide the rocker arm shaft (3, **Figure 6-11**) out of the rocker arm supports (5, **Figure 6-11**), springs (1, **Figure 6-11**), and rocker arms (2, **Figure 6-11**).

   Note: Mark the rocker arms so they can be reinstalled with the original matching valve and pushrod.

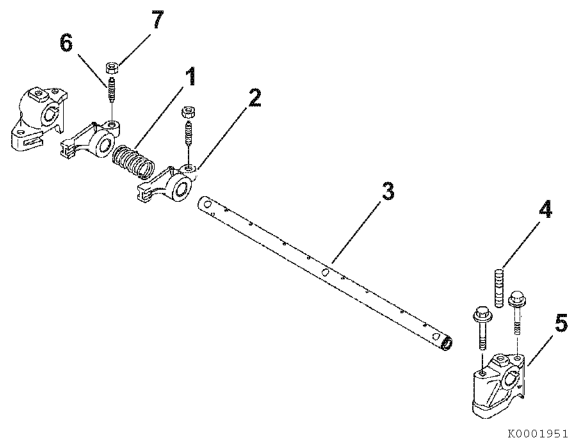
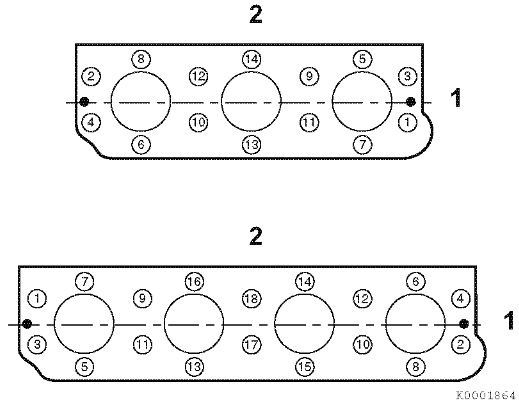


Figure 6-11

3. Remove the valve adjusting screw (6, **Figure 6-11**) and the lock nut (7, **Figure 6-11**) from the rocker arms.

Removal of Cylinder Head

1. Loosen the cylinder head bolts following the sequence shown in (**Figure 6-12**).



1 – Cooling fan end
2 – Camshaft side

Figure 6-12

2. Remove the cylinder head bolts (1, **Figure 6-13**).
3. Lift the cylinder head away from the cylinder block. Discard the cylinder head gasket (2, **Figure 6-13**). Position the cylinder head on the work bench to prevent damage to the combustion surface.

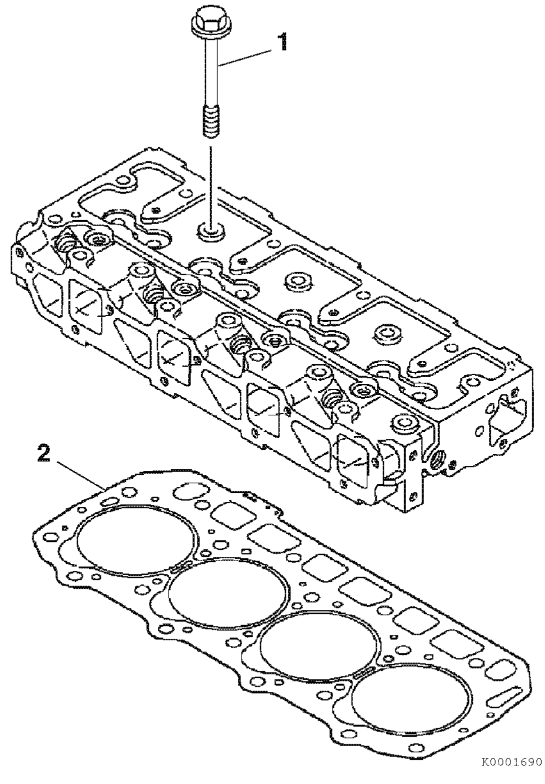


Figure 6-13

Removal of Intake/exhaust Valves

1. Place the cylinder head on the work bench with the combustion side down.
2. Remove the valve cap (1, **Figure 6-15**) and keep with the valve it was installed on.
3. Using the valve spring compressor tool, compress one of the valve springs (**Figure 6-14**).

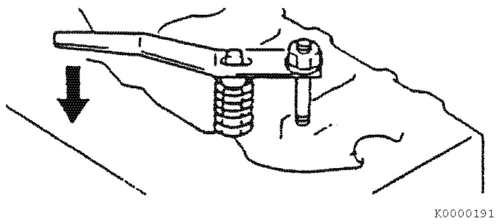


Figure 6-14

4. Remove the valve keepers (2, **Figure 6-15**).
5. Slowly release the tension on the valve spring.
6. Remove the spring retainer (3, **Figure 6-15**) and valve spring (4, **Figure 6-15**).

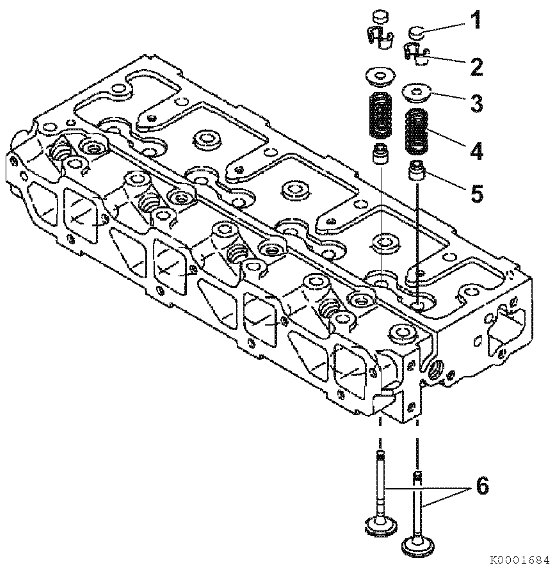


Figure 6-15

7. Repeat the procedure with all remaining valves.

   Note: If the valves are to be reused, identify them so they can be installed in their original location.

8. Turn the cylinder head so the exhaust port side faces down. Remove the intake and exhaust valves (6, **Figure 6-15**) from the cylinder head.
9. Remove the valve stem seals (5, **Figure 6-15**).

Removal of Valve Guides

Note: Removal of the valve guides should be postponed until inspection and measurement procedures have been performed. See Inspection of Valve Guides on page 6-32.

1. If the valve guides were not within specifications, use a drift pin and hammer to drive the valve guides (1, **Figure 6-16**) out of the cylinder head.

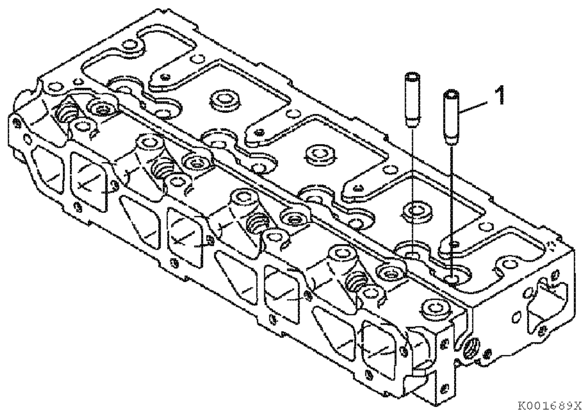
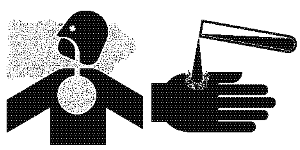


Figure 6-16

Cleaning of Cylinder Head Components

⚠ WARNING

Fume/Burn Hazard!



- **Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.**
- **Failure to comply could result in death or serious injury.**

Thoroughly clean all components using a non-metallic brush and an appropriate solvent. Each part must be free of carbon, metal filings and other debris.

Inspection of Cylinder Head Components

Visually inspect the parts. Replace any parts that are obviously discolored, heavily pitted or otherwise damaged. Discard any parts that do not meet its specified limit.

NOTICE

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

NOTICE

Any part determined to not meet the service standard or limit before the next service, as determined from the state of current rate of wear, should be replaced even though the part currently meets the service standard limit.

Inspection of Push Rods

■ Push rod bend

Determine if the bend of the push rods are within the specified limit.

1. Place the push rods on a flat inspection block or layout bed.
2. Roll the push rods until a gap can be observed between a portion of the push rod and the surface of the block or layout bed.
3. Use a feeler gauge to measure the gap (**Figure 6-17**). *See Push Rod on page 6-6 for the service limit.*

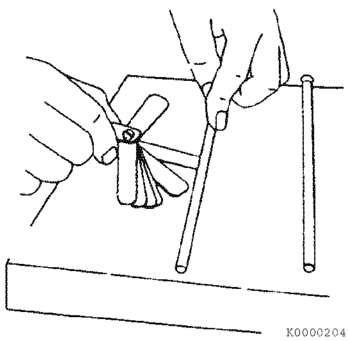


Figure 6-17

Inspection of Rocker Arm Assembly

■ Rocker arm shaft hole diameter

Use a test indicator and micrometer to determine if the inside diameter of all the rocker arm support brackets and the rocker arms (**Figure 6-18**) are within the specified limits. *See Rocker Arm and Shaft on page 6-6 for the service limit.*

Inspect the contact areas (1, **Figure 6-18**) for excessive wear or damage**.**

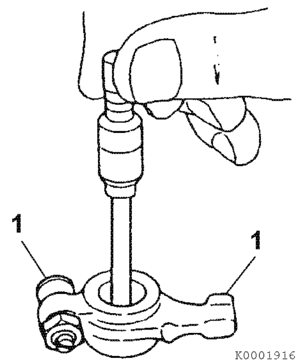


Figure 6-18

■ Rocker arm shaft outside diameter

Use a micrometer to measure the rocker arm shaft diameter. Measure at each rocker arm location in two directions 90° apart (**Figure 6-19**). *See Rocker Arm and Shaft on page 6-6 for the service limit.*

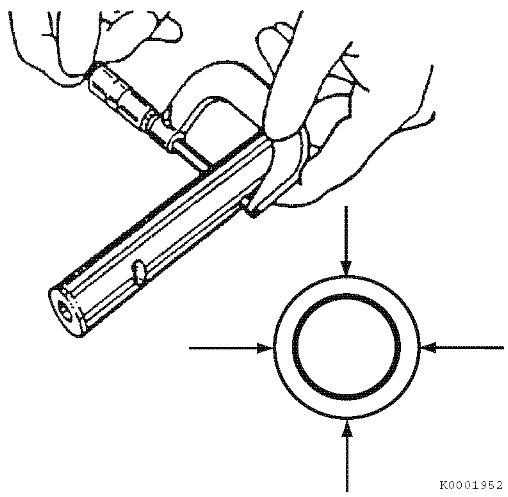


Figure 6-19

Inspection of Valve Guides

Visually inspect the valve guides for distortions, scoring or other damage.

Note: Measure the valve guides while they are installed in the cylinder head.

Use a telescoping gauge and micrometer to measure the inside diameter at each end of the valve guide. Measure in three places and 90° apart (**Figure 6-20**). *See Intake/Exhaust Valve and Guide on page 6-5 for the service limit.* Replace valve guides if not within specification.

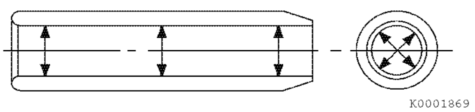


Figure 6-20

Inspection of Cylinder Head

■ Cylinder head distortion

Place the cylinder head flat and inverted (combustion side up) on the bench. Use a straight edge and a feeler gauge to measure cylinder head distortion (**Figure 6-21**). Measure diagonally and along each side. *See Cylinder Head on page 6-4 for the service limit.*

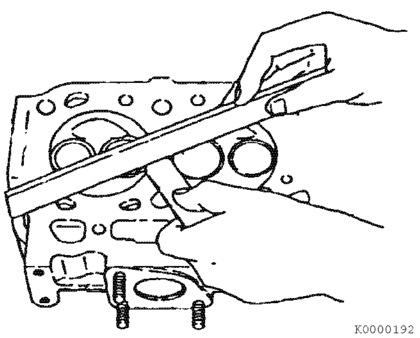


Figure 6-21

If distortion exceeds the service limit, resurface or replace the cylinder head. Remove only enough material to make the cylinder head flat, but do not remove more than 0.008 in. (0.20 mm).

Inspection of Intake and Exhaust Valves

Visually inspect the intake and exhaust valves. Replace any valves that are obviously discolored, heavily pitted or otherwise damaged.

■ Valve stem diameter

Use a micrometer to measure the valve stem diameter. Measure the valve stem near the combustion end and near the opposite end (1, **Figure 6-22**). *See Intake/Exhaust Valve and Guide on page 6-5 for the service limit.*

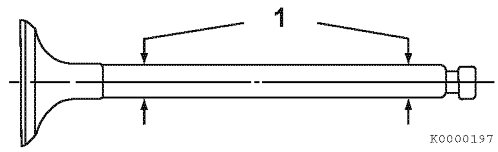


Figure 6-22

■ Valve stem bend

Place the valve stem on a flat inspection block or layout bed. Roll the valve until a gap can be observed between a portion of the valve stem and the surface of the block or bed. Use a feeler gauge to measure the gap (**Figure 6-23**). *See Intake/Exhaust Valve and Guide on page 6-5 for the service limit.*

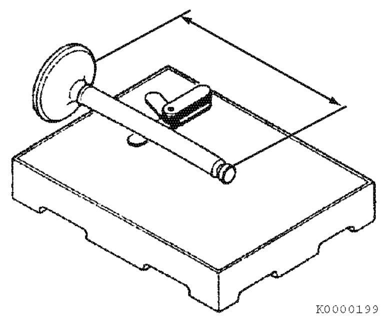


Figure 6-23

■ Valve recession

Note: The valve guides must be installed to perform this check.

Insert the valves into their original locations and press them down until they are fully seated. Use a depth micrometer (**Figure 6-24**) to measure the difference between the cylinder head gasket surface and the combustion surface of each exhaust and intake valve (**Figure 6-25**). *See Cylinder Head on page 6-4 for the service limit.*

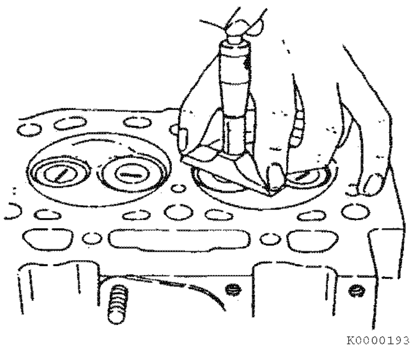


Figure 6-24

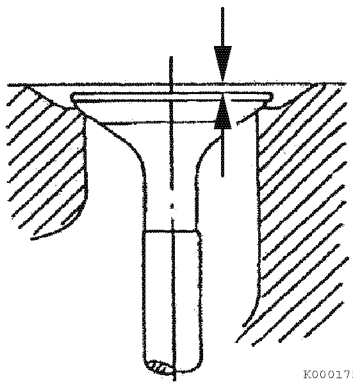


Figure 6-25

■ Valve face and valve seat

Always check the clearance between the valve and valve guide before grinding or lapping the valve seats. *See Intake/Exhaust Valve and Guide on page 6-5 for the service limit.* If the clearance exceeds the limit, replace the valve and/or valve guide to bring the clearance within the limit.

Roughness or burrs will cause poor seating of a valve. Visually inspect the seating surfaces of each valve and valve seat to determine if lapping or grinding is needed.

Visually inspect all valve faces and valve seats for pitting, distortion, cracking, or evidence of overheating. Usually the valves and the valve seats can be lapped or ground to return them to serviceable condition. Severely worn or damaged components will require replacement.

Coat the valve seat with a thin coat of bluing compound. Install the valve and rotate it to distribute bluing onto the valve face. The contact pattern should be approximately centered on the valve face (1, **Figure 6-26**) and even in width.

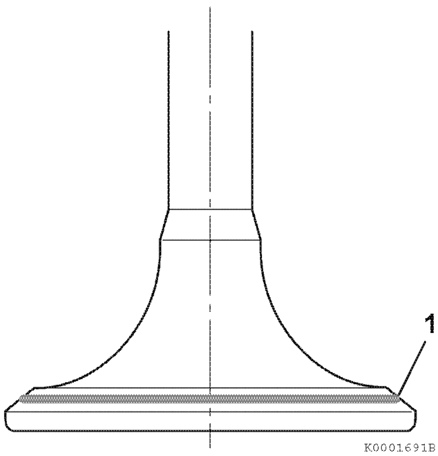


Figure 6-26

Also visually inspect the valve seat for even contact.

Light cutting can be performed by the use of a hand-operated cutter (3, **Figure 6-27**).

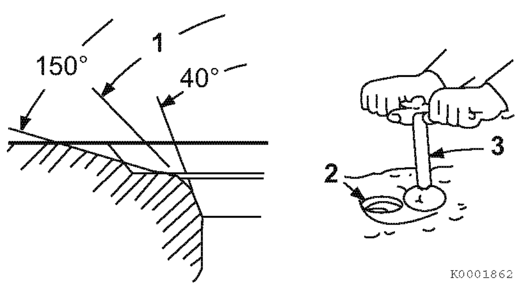


Figure 6-27

The valve seat diameter can be adjusted by top-grinding with a 150° stone to make the seat diameter smaller, and bottom-grinding using a 40° stone to make the seat diameter larger. Once the seat location has been corrected, grind and lap the seat angle (1, **Figure 6-27**) to specification. *See Cylinder Head on page 6-4 for specifications.*

Grind the valve face and/or valve seat only enough to return them to serviceable condition. Grinding is needed if the valve and the valve seat do not contact correctly. Check the recession after grinding.

If the valve or seat require grinding, lap the valve after grinding. Lap the valve face to the valve seat using a mixture of valve lapping compound and engine oil.

Be sure to thoroughly wash all parts to remove all grinding powder or compound.

Inspection of Valve Springs

Inspect the valve springs. If damage or corrosion is seen, or if measurements exceed the specified limits, replace the springs.

■ Fractures

Check for fractures on the inside and outside portions of the springs. If the valve spring is fractured, replace the valve spring.

■ Corrosion

Check for corrosion of the spring material caused by oxidation.

■ Squareness

Use a flat surface and a square to check each spring for squareness (**Figure 6-28**). *See Valve Spring on page 6-6 for the service limit.*

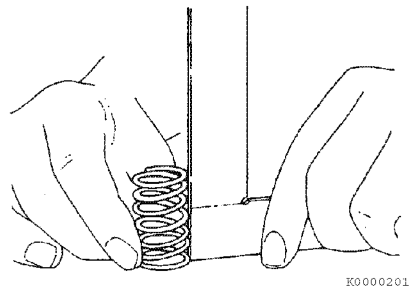


Figure 6-28

■ Free length

Use a caliper to measure the length of the spring (**Figure 6-29**). *See Valve Spring on page 6-6 for the service limit.*

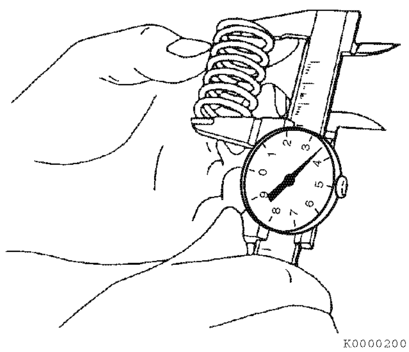


Figure 6-29

Reassembly of Cylinder Head

Use new gaskets, O-rings and seals for the reassembly of the cylinder head.

NOTICE

Liberally oil all components during reassembly to prevent premature wear or damage.

■ Reassembly of valve guides

1. The valve guides are installed into the cylinder head with an extremely tight press fit. Before installing the valve guides, place the valve guides in a freezer for at least twenty minutes This will cause the valve guides to contract, making it easier to install the valve guides into place.
2. Immediately after removing the valve guides from the freezer, insert the valve guides (1, **Figure 6-30**) in their proper positions.

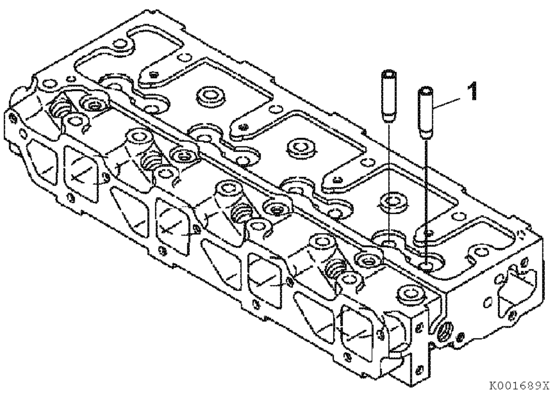


Figure 6-30

3. Finish installing the valve guides (1, **Figure 6-31**) into the cylinder head to the proper height (3, **Figure 6-31**) using the valve guide installation tool (2, **Figure 6-31**). *See Intake/Exhaust Valve and Guide on page 6-5.*

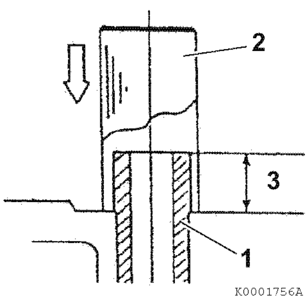


Figure 6-31

■ Reassembly of intake and exhaust valves

NOTICE

Always install new valve stem seals. The exhaust valve stem seals are different than the intake valve stem seals and can be identified by either the paint marks on the outside of the seals or by the color of the seal spring (4, **Figure 6-33**). Ensure they are installed in the correct locations.

Engine model	Marking	
	Intake	Exhaust
All models	None	White (Paint on outside of seal)

1. Oil the lip of the valve stem seal (2, **Figure 6-32**). Using the valve stem seal installation tool (1, **Figure 6-32**), install a new valve stem seal on each of the valve guides (3, **Figure 6-32**).

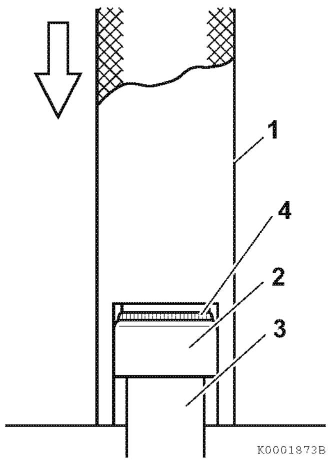


Figure 6-32

2. Measure the distance (1, **Figure 6-33**) from the cylinder head to valve stem seal to ensure proper clearance (2, **Figure 6-33**) between the guide and the seal. *See Intake/Exhaust Valve and Guide on page 6-5.*

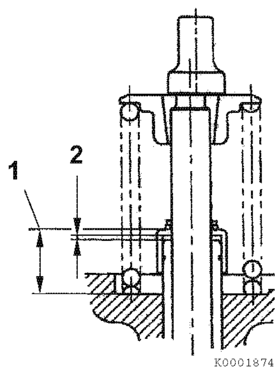


Figure 6-33

3. Place the cylinder head assembly on its exhaust port side.
4. Place all the valves (6, **Figure 6-34**) in their proper location in the cylinder head.

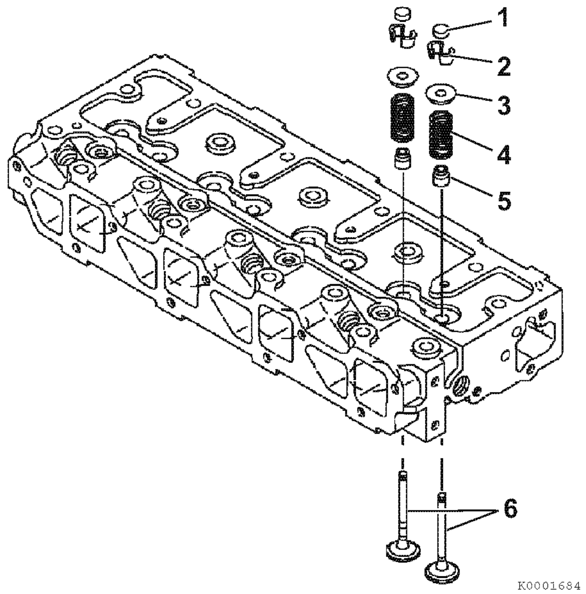


Figure 6-34

5. Place the cylinder head on the workbench with the combustion side down to install the valve springs. Install the valve spring (4, **Figure 6-34**) and the spring retainer (5, **Figure 6-34**).
6. Using the valve spring compressor tool, compress the valve spring.
7. Insert the valve keepers (2, **Figure 6-34**) and slowly release the tension on the valve spring. Install the valve cap (1, **Figure 6-34**). Repeat the steps on all the remaining valves.

■ Reassembly of cylinder head

1. Carefully clean both the combustion surface of the cylinder head and the top surface of the cylinder block. Then place a new cylinder head gasket (2, **Figure 6-35**) on the cylinder block.
2. Position the cylinder head on the cylinder head gasket.

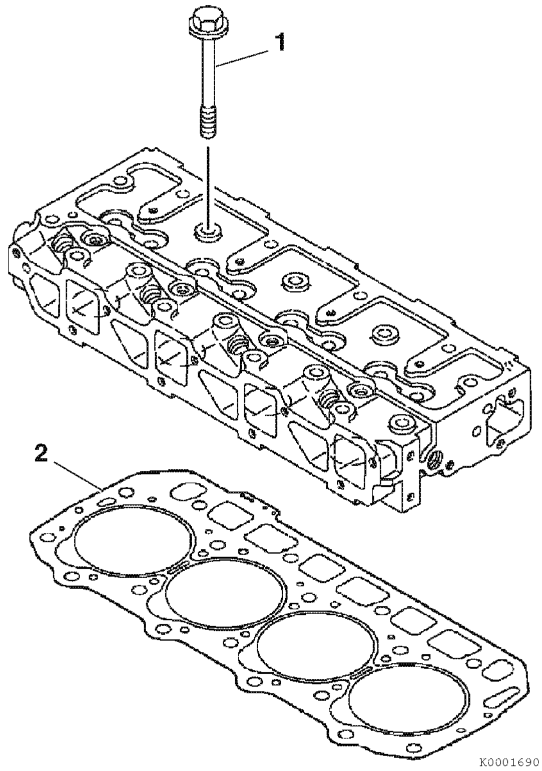
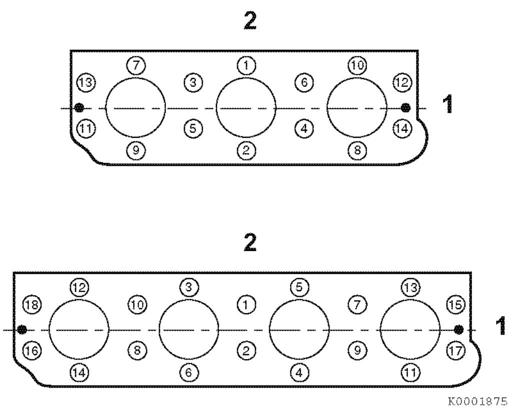


Figure 6-35

3. Lightly oil the threads of the cylinder head bolts (1, **Figure 6-35**). Tighten the bolts to the specified torque in two steps as shown in the chart below. Tighten in the sequence shown in (**Figure 6-36**). *See Special Torque Chart on page 6-16 for specification.*

First step	1/2 of final torque
Second step	Final torque

4. Insert the push rods in their respective positions.



1 – Fan end
2 – Camshaft side

Figure 6-36

■ Reassembly of rocker arm reassembly

NOTICE

Ensure the lubrication holes (1, **Figure 6-37**) in the rocker arm shaft are oriented correctly with respect to the rocker arms (2, **Figure 6-37**).

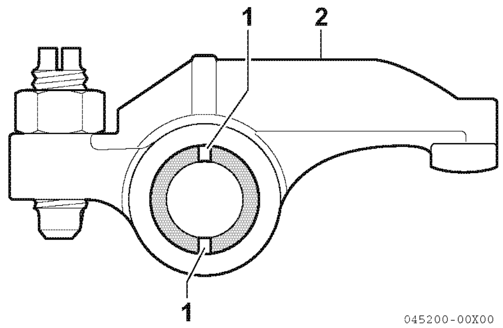


Figure 6-37

1. Lubricate the rocker arm shaft.
   Slide the rocker arm supports (5, **Figure 6-38**), springs (1, **Figure 6-38**) and rocker arms (2, **Figure 6-38**) onto the shaft.

   Note:
   - *The rocker arm shaft fits tightly in the rocker arm supports. Clamp the support in a padded vise. Twist and push on the rocker arm shaft to reinstall.*
   - *To properly align the rocker arm shaft with the rocker arm shaft supports, first reinstall a rocker arm support (5, **Figure 6-38**) having a hole for the shaft alignment stud (4, **Figure 6-38**). Align the hole in the rocker arm shaft and the hole in the rocker arm support. Reinstall the alignment stud.*

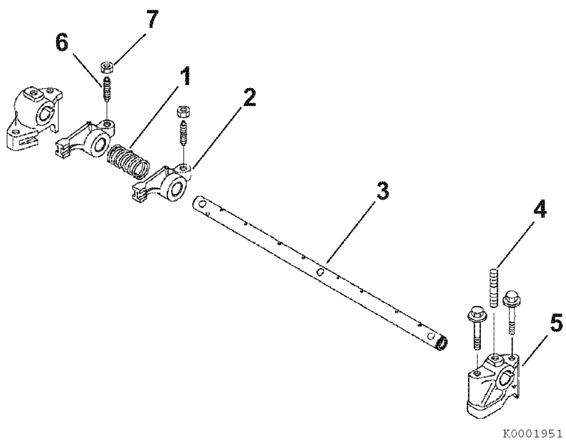


Figure 6-38

*Note: **Figure 6-38** shows components for one cylinder. Components for all remaining cylinders are assembled in the same order.*

2. Place the rocker arm shaft assembly onto the cylinder head.
3. If removed, reinstall the valve adjusting screws (6, **Figure 6-38**) and the lock the nuts (7, **Figure 6-38**).
4. Align the push rods with their respective rocker arms.
5. Reinstall and tighten the rocker arm shaft retaining bolts (M10 × 65) to the specified torque.
6. Tighten the rocker arm shaft alignment studs.
7. Adjust the valve clearance. *See Measuring and Adjusting Valve Clearance on page 6-39.*

■ Assembling the parts around the cylinder head

1. Attaching the glow plug
   Install the glow plug (1, **Figure 6-39**) and tighten with the specified torque.

Glow plug (M10) tightening torque	11.1 - 14.8 ft·lb (15 - 20 N·m; 1.5 - 2.0 kgf·m)

   Attach the glow plug connector (2, **Figure 6-39**) and glow plug harness (3, **Figure 6-39**) to the glow plug with a specified torque.

M4 nut tightening torque	0.7 - 1.1 ft·lb (1 - 1.5 N·m; 0.1 - 0.2 kgf·m)

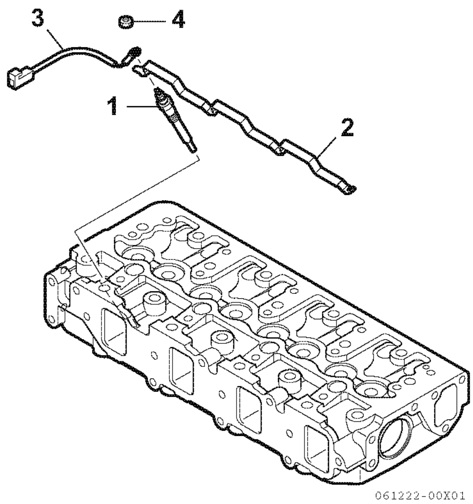


Figure 6-39

2. Attaching the injector
   Attach the injector. *See Reassembly of injector on page 7-10.*

3. Attaching the exhaust manifold
Reinstall the exhaust manifold using a new gasket (17, **Figure 6-6**). Here, attach the EGR cooler, the EGR cooler outlet vent, a turbocharger (if there is one), and an exhaust throttle (if there is one), as a unit to the cylinder head. Tighten it with specified torque.

Tightening torque for M10 (10.9T) bolts and nuts	59.3 - 60.4 ft·lb (80.3 - 81.8 N·m; 8.2 - 8.3 kgf·m)

Connect the cooling water pipes (both inlet and outlet) of the EGR cooler.

4. Attaching the intake manifold
Attach the exhaust manifold and intake collector as a unit using a new gasket (10, **Figure 6-6**). Here, attach the intake collector with the EGR valve and the intake throttle in a attached state, and attach the intake manifold with the common rail in a connected state. Tighten it with specified torque. If the EGR valve and the intake throttle were removed, attach them to the intake collector. Replace the gasket with a new one.

Tightening torque for M6 bolts	7.2 - 8.7 ft·lb (9.8 - 11.8 N·m; 1.0 - 1.2 kgf·m)
Tightening torque for M8 bolts and nuts	16.7 - 21.0 ft·lb (22.6 - 28.4 N·m; 2.3 - 2.9 kgf·m)
Tightening torque for M10 bolts	32.5 - 39.8 ft·lb (44.1 - 53.9 N·m; 4.5 - 5.5 kgf·m

5. Installing the high-pressure fuel injection lines
Install the high-pressure piles and fuel return lines from injector to common rail and from supply pump to common rail. *See Reassembly of Common Rail on page 7-12.*

⚠ CAUTION

For high-pressure fuel injection line, use a new one. If you reuse it, the displacement of the working face may occur, causing the fuel to leak.

6. Attaching the EGR pipe
Attach the EGR pipe (4, **Figure 6-2**). Replace the gasket with a new one on both ends.
7. Connecting the electric wiring
Connect the coupler of the removed electric wirings.
   - Intake temperature sensor
   - Exhaust temperature sensor
   - Exhaust throttle (if equipped)
   - EGR valve
   - EGR gas temperature sensor
   - Intake throttle
   - Ambient temperature sensor
   - Glow plug wire harness
8. Attaching the coolant pump
Attach the coolant pump. *See Reassembly of Engine Coolant Pump on page 8-9.*
Connect the electric wirings of the coolant pump temperature sensor.
9. Attaching the cylinder head cover
Apply grease to a new cylinder head cover packing (2, **Figure 6-40**) and insert the packing to the cylinder head cover groove (1, **Figure 6-40**). Place the cylinder head cover on the cylinder head. Tighten the cylinder head cover with a mounting knob (3, **Figure 6-40**). Here, replace the O-ring with a new one (4, **Figure 6-40**). Connect the electric wirings of the pressure sensor (5, **Figure 6-40**).
For turbocharged engines, attach the removed intake duct (2, **Figure 6-2**) and the breather hose (3, **Figure 6-2**). For models without turbocharger, attach the breather hose (1, **Figure 6-3**).

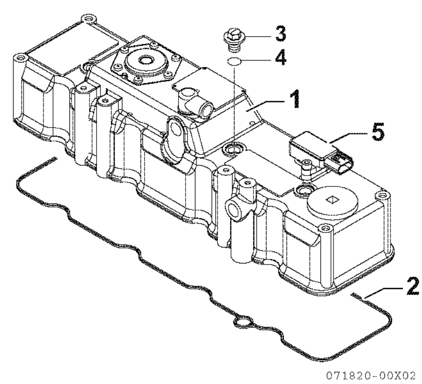


Figure 6-40

10. Installing the alternator
Install the alternator. *See Installation of Alternator on page 12-14.*
11. Attaching the fuel filter assembly
If the fuel filter assembly was removed, attach it to the intake manifold.
12. Installing the DPF
Install the DPF. *See How to reattach the DPF on page 13-17.*

MEASURING AND ADJUSTING VALVE CLEARANCE

Measure and adjust while the engine is cold.

Note:

- *The No. 1 piston position is on the flywheel end of the engine, opposite the radiator. The firing order is 1-3-2 for 3-cylinder engines and 1-3-4-2 for 4-cylinder engines.*
- *3-cylinder engines fire every 240° of crankshaft rotation.*
- *4-cylinder engines fire every 180° of crankshaft rotation.*
- *Valve clearance of both the intake and exhaust valves can be checked with the piston for that cylinder at top dead center (TDC) of the compression stroke. When a piston is at TDC of the compression stroke, both rocker arms will be loose and the cylinder TDC mark on the flywheel will be visible in the timing port of the flywheel housing.*
- *If there is no valve clearance, and the cylinder is at TDC of the compression stroke, extreme wear, or damage to the cylinder head or valves may be possible.*
- *If adjusting each cylinder individually, the cylinder to be adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is nearest to the top dead center after turning. Make adjustment for the remaining cylinders in the order of firing by turning the crankshaft each time.*
- *To decrease the number of rotations required to check all cylinders, other cylinders can also be checked as indicated in the chart below.*

Example: On a 3-cylinder engine, with the No. 1 piston at TDC on the compression stroke (both valves closed), the valves indicated on the top line of the chart can be adjusted without rotating the crankshaft. To adjust the remaining two valves, rotate the crankshaft until the No. 1 piston is at TDC on the exhaust stroke (exhaust valve only open).

■ 3-cylinder engines

Cylinder No.	1		2		3	
Valve	**Intake**	**Exhaust**	**Intake**	**Exhaust**	**Intake**	**Exhaust**
No. 1 cylinder at TDC compression	●	●	●			●
No. 1 cylinder at TDC exhaust				●	●	

■ 4-cylinder engines

Cylinder No.	1		2		3		4	
Valve	**Intake**	**Exhaust**	**Intake**	**Exhaust**	**Intake**	**Exhaust**	**Intake**	**Exhaust**
No. 1 cylinder at TDC compression	●	●	●			●		
No. 4 cylinder at TDC compression				●	●		●	●

1. Remove the cylinder head cover. *See Removal of Cylinder Head Cover on page 6-28.*

   Note: If adjusting each cylinder individually, the cylinder to be adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is nearest to the top dead center after turning, and make adjustment for other cylinders in the order of firing by turning the crankshaft.

2. Rotate the crankshaft clockwise as seen from the coolant pump end, to bring No. 1 piston to TDC on the compression stroke while watching the rocker arm motion and timing grid on the flywheel. (Position where both the intake and exhaust valves are closed.)
3. Insert a feeler gauge (1, **Figure 6-41**) between the rocker arm and valve cap, and record the measured valve clearance. (Use the data for estimating the wear.)

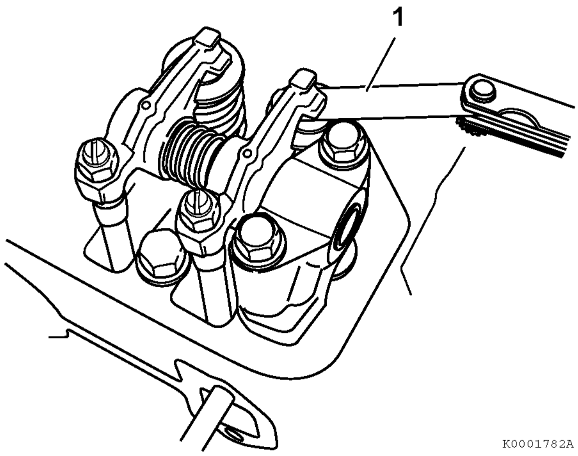


Figure 6-41

4. If adjustment is required, proceed to the next step.
5. Loosen the valve adjusting screw lock nut (1, **Figure 6-42**) and valve adjusting screw (2, **Figure 6-42**) on the rocker arm and check the valve for inclination of the valve cap, entrance of dirt, or wear.

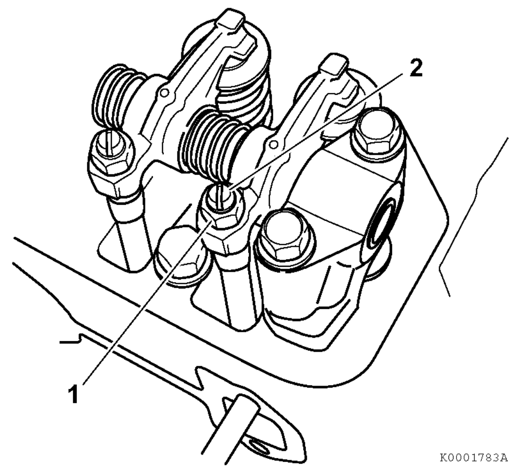


Figure 6-42

6. Insert a feeler gauge of the correct thickness (1, **Figure 6-43**) *(seeAdjustment Specifications on page 6-4)* between the rocker arm and valve cap. Turn the valve adjustment screw to adjust the valve clearance so there is a slight "drag" on the feeler gauge when sliding it between the rocker arm and the valve cap. Hold the adjusting screw while tightening the valve adjusting screw lock nut (1, **Figure 6-42**). Recheck the clearance.

   Note: There is a tendency for the clearance to decrease slightly when the lock nut is tightened. It is suggested that you make the initial clearance adjustment slightly on the "loose" side before tightening the lock nut.

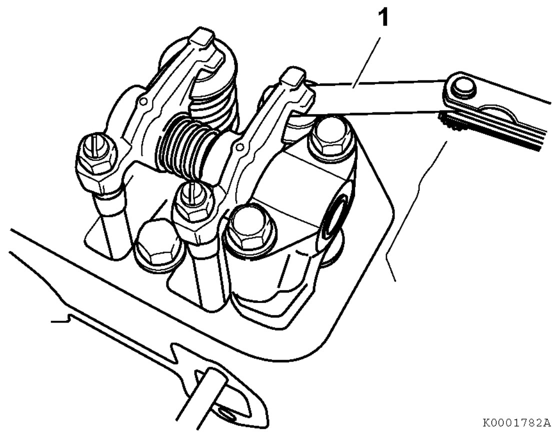


Figure 6-43

7. Apply oil to the contact surface between the adjusting screw and push rod.
8. Rotate the crankshaft. Measure and adjust the valves on the next cylinder. Continue until all the valves have been measured and adjusted.

CRANKSHAFT AND CAMSHAFT COMPONENTS

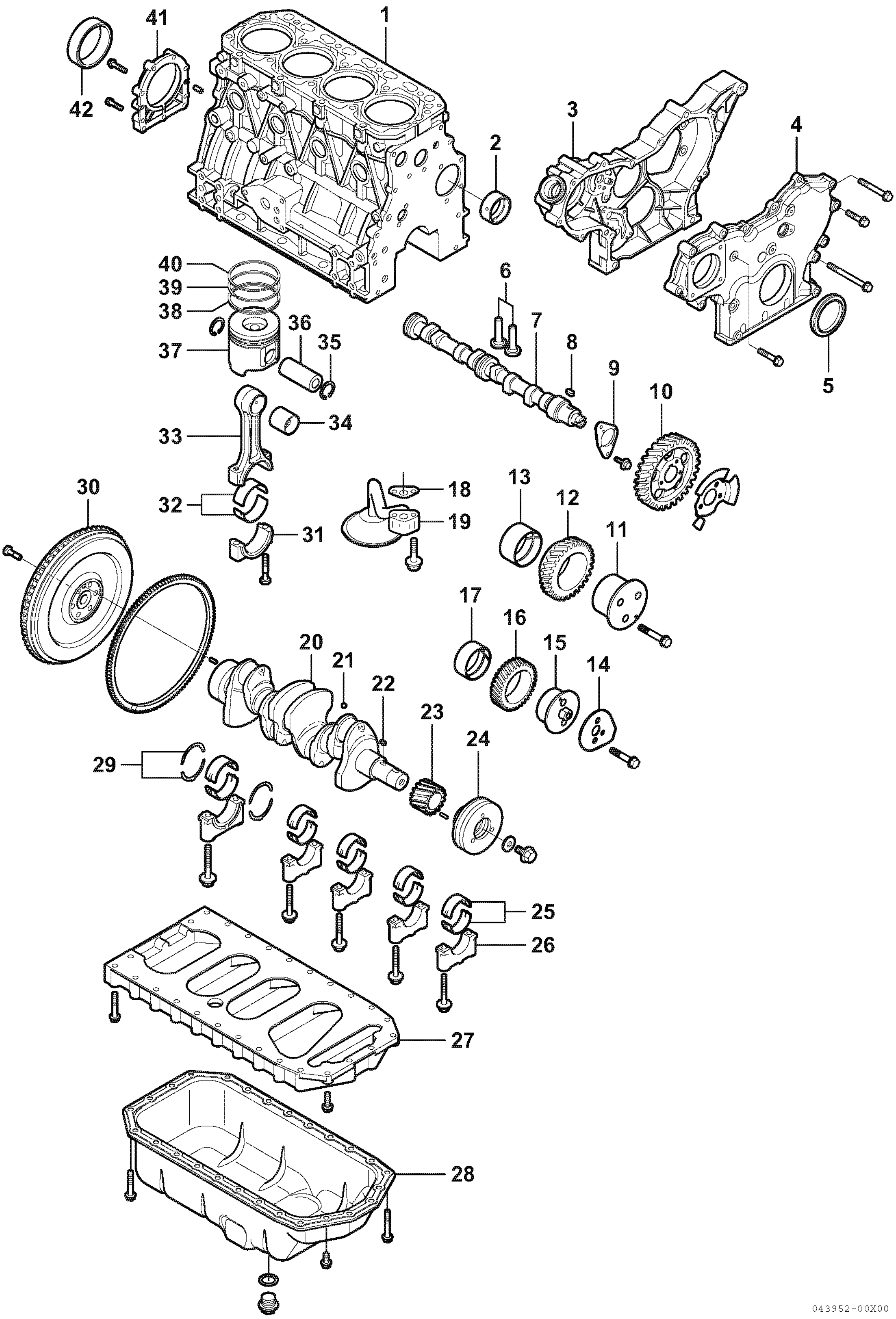


Figure 6-44

1 – Cylinder block
2 – Camshaft bushing
3 – Gear case
4 – Gear case cover
5 – Front crankshaft seal
6 – Tappets
7 – Camshaft
8 – Camshaft gear key
9 – Camshaft end plate
10 – Camshaft gear
11 – Idler gear shaft (A)
12 – Idler gear (A)
13 – Idler gear bushing (A)
14 – Idler gear plate (B)
15 – Idler gear shaft (B)
16 – Idler gear (B)
17 – Idler gear bushing (B)
18 – Oil pickup gasket
19 – Oil pickup
20 – Crankshaft
21 – ball
22 – Crankshaft gear key
23 – Crankshaft gear
24 – Crankshaft pulley
25 – Main bearing inserts
26 – Main bearing cap
27 – Oil pan spacer
28 – Oil pan
29 – Thrust bearings
30 – Flywheel
31 – Connecting rod cap
32 – Connecting rod bearing inserts
33 – Connecting rod
34 – Wrist pin bushing
35 – Circlip
36 – Wrist pin
37 – Piston
38 – Oil ring
39 – Second compression ring
40 – Top compression ring
41 – Crankshaft rear seal housing
42 – Crankshaft rear seal

Disassembly of Engine

Prepare a clean, flat working surface on a workbench large enough to accommodate the engine components. Discard all used gaskets, O-rings and seals. Use new gaskets, O-rings and seals on reassembly of engine.

NOTICE

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

If the engine will be completely disassembled, the following preliminary steps should be performed:

1. Disconnect the battery cables at the battery. Always disconnect the negative (-) cable first.
2. Remove the throttle cable, electrical connections, intake and exhaust system connections, and fuel supply lines from the engine.
3. Remove the alternator. *See Removal of Alternator on page 12-10.*
4. Drain the engine coolant from the radiator and cylinder block. *See Change engine coolant on page 5-19.* Remove the cooling system components from the engine.
5. Remove the engine from the machine. Mount the engine to a suitable engine repair stand having adequate weight capacity.

   NOTICE

   Be sure to secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.

6. Clean the engine by washing with solvent, air or steam cleaning. Carefully operate so as to prevent any foreign matter or fluids from entering the engine or any fuel system or electrical components remaining on the engine.
7. Drain the engine oil into a suitable container. Remove the oil filter.
8. Remove the cylinder head. *See Cylinder Head on page 6-24.*
9. Remove fuel supply pump if necessary. *See Removal of Supply Pump on page 7-13 if necessary.*
10. Remove the starter motor. *See Removal of Starter Motor on page 11-8.*

Disassembly of Camshaft and Timing Components

Discard all gaskets, O-rings and seals. Use new gaskets, O-rings and seals on reassembly of the camshaft and timing components.

■ Removal of timing gear case cover

1. Remove the bolt and washer retaining the crankshaft pulley.

NOTICE

Use care not to damage the threads in the end of the crankshaft when removing the crankshaft pulley.

2. Remove the crankshaft pulley using a gear puller.
3. Remove the bolts that retain the gear case cover to the cylinder block and oil pan.
4. Remove the gear case cover (1, **Figure 6-45**).

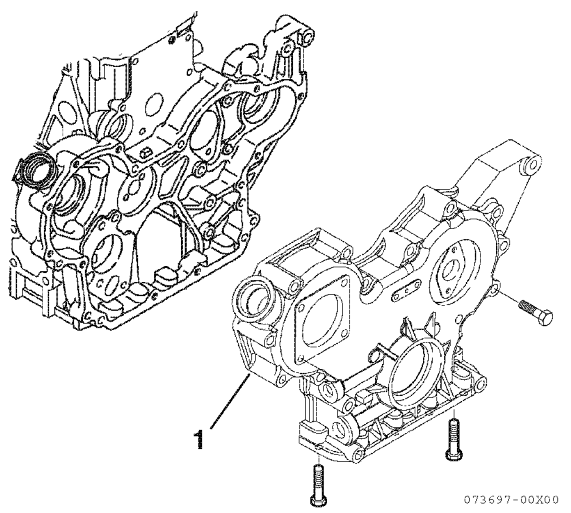


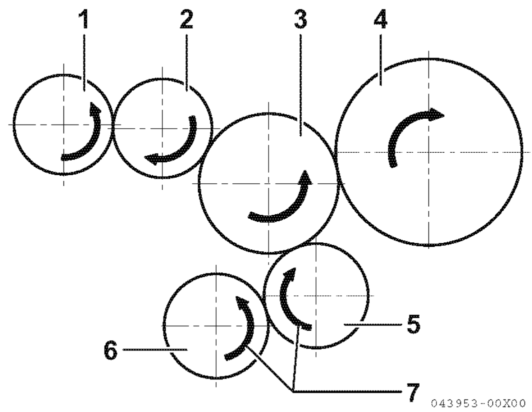
Figure 6-45

■ Checking timing gear backlash

Prior to removing the timing gears, measure the gear backlash and determine the gear wear.

Check the backlash between each pair of mating gears (**Figure 6-46**). If not within specification, replace both mating gears. *See Timing Gear Backlash on page 6-8 for service limits.*

Note: Do not allow the gear being checked to move axially as excess end play could cause a false reading.



1 – Supply pump gear
2 – Idler gear (B)
3 – Idler gear (A)
4 – Camshaft gear
5 – Crankshaft gear
6 – Lubricating oil pump gear
7 – Direction of rotation

Figure 6-46

■ Measuring idler gear-to-crankshaft gear backlash

1. Install a dial indicator as shown in **Figure 6-47**.

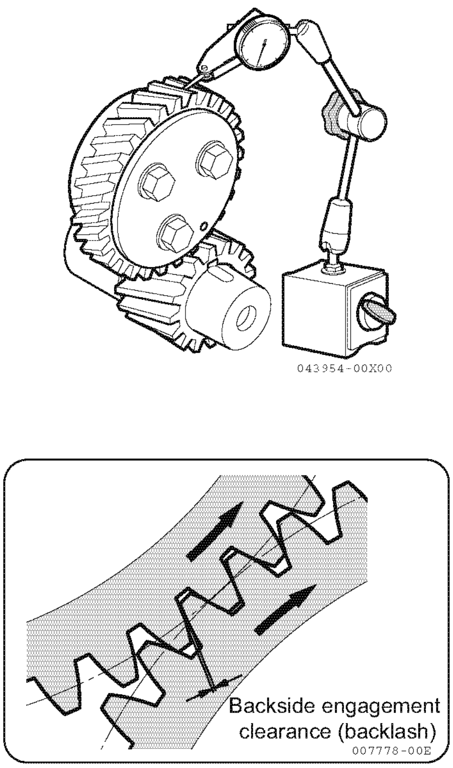


Figure 6-47

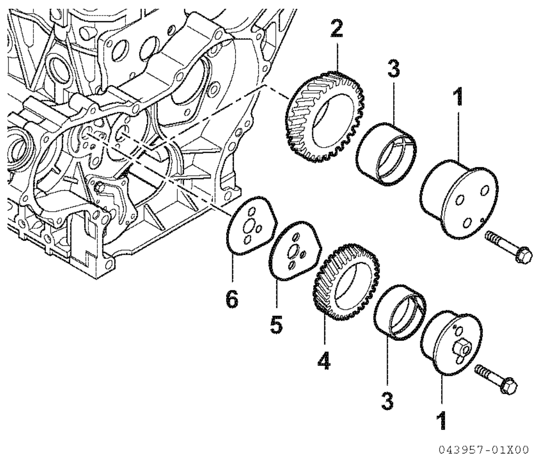
2. Rotate the idler gear back and forth to check the idler gear-to-crankshaft gear backlash. The total indicator reading is the backlash. Record the measurement.

■ Measuring idler gear-to-camshaft gear backlash

1. Drive a small wooden wedge between the crankshaft gear and idler gear to prevent the idler gear from rotating.
2. Install the dial indicator to read the camshaft gear backlash. Rotate the camshaft drive gear against the idler gear to measure the backlash. Record the measurement.
3. Check the idler gear-to-fuel injection pump drive gear backlash in the same manner as the camshaft drive gear. Record the measurement.

■ Removal of timing gears

1. Remove the bolts from the idler gear shaft (1, **Figure 6-48**). Remove the idler gear shaft, idler gear (2, **Figure 6-48**) and bushing (3, **Figure 6-48**).



1 – Idler gear shaft
2 – Idler gear (B)
3 – Idler gear bushing
4 – Idler gear (A)
5 – Plate, idle shaft
6 – Packing

Figure 6-48

2. Do not remove the crankshaft gear unless it is damaged and requires replacement. If the gear must be removed, remove it using a gear puller.
3. Removal of the camshaft gear requires the camshaft be removed and placed in a press. Do not remove the camshaft gear unless it or the camshaft is damaged and requires replacement. *See Removal of camshaft on page 6-45.*
4. Remove the supply pump drive gear using a gear puller.

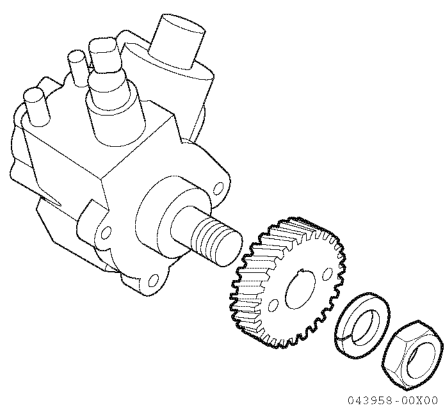


Figure 6-49

■ Removal of oil pan

1. Invert the engine (oil pan up) on the engine stand.
2. Remove the oil pan (1, **Figure 6-50**).

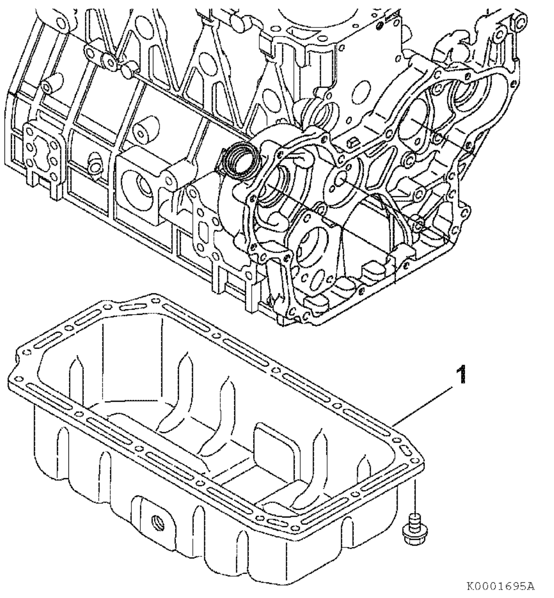


Figure 6-50

3. Remove the oil pickup tube (1, **Figure 6-51**) and O-ring (2, **Figure 6-51**).

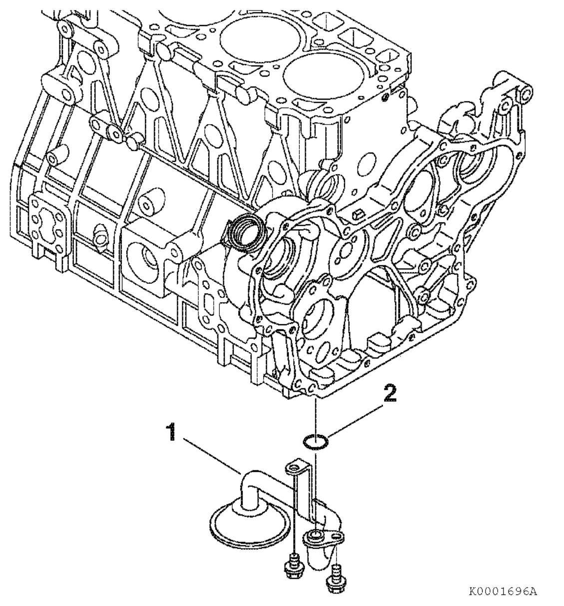


Figure 6-51

■ Removal of camshaft

1. Before removing the camshaft, check the camshaft end play.
   - **Method A:** Install a dial indicator (1, **Figure 6-52**) on the cylinder block. Move the camshaft (2, **Figure 6-52**) back and forth to measure the end play. Record the measurement. *See Camshaft on page 6-7 for the service limit.*

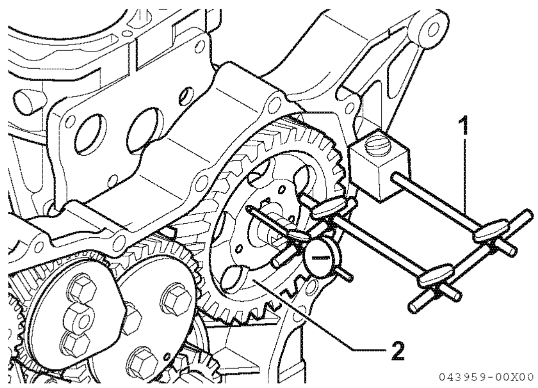


Figure 6-52

   - **Method B:** Use a feeler gauge to measure the clearance between the thrust plate (1, **Figure 6-53**) and front camshaft bearing (2, **Figure 6-53**). *See Thrust Bearing on page 6-10 for the service limit.*

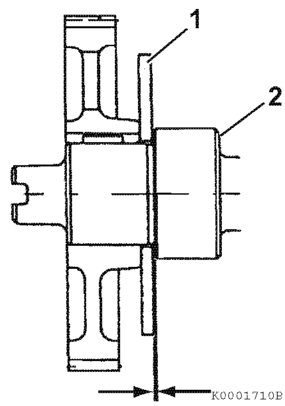


Figure 6-53

2. Remove the two bolts (3, **Figure 6-54**) retaining the camshaft thrust plate (1, **Figure 6-54**).

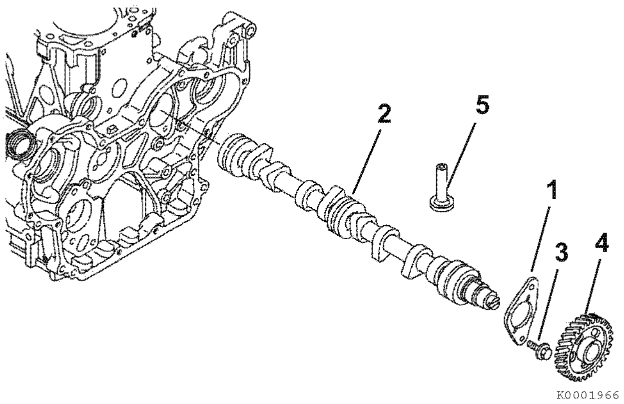


Figure 6-54

3. Rotate the engine in the engine stand so that gravity causes the tappets (5, **Figure 6-54**) to drop away from the camshaft lobes.

   Note: *Rotate the camshaft at least two turns to "bump" any sticking tappets away from the camshaft.*

4. Slowly pull the camshaft (2, **Figure 6-54**) assembly out of the engine being careful not to damage the front camshaft bushing.

   Note:

   - *If the engine is not installed on an engine repair fixture, stand the engine upright on the flywheel end mounting flange. Rotate the camshaft at least two turns to bump the tappets out of the way to prevent the tappets from interfering with the removal of the camshaft.*
   - *The tappets are "mushroom" shaped and must be removed from inside the engine crankcase.*

5. Remove the tappets. Mark the tappets so they can be reinstalled in the same location.
6. Remove the camshaft drive gear (4, **Figure 6-54**) only if the gear or camshaft require replacement. Use a knife-edge puller and a press to remove the gear. The gear is a shrink-fit and will need to be heated to 356 - 392 °F (180 - 200 °C) to remove.

■ Removal of gear case or front plate

Note: *The camshaft must be removed before the gear case can be removed. See Inspection of camshaft on page 6-54.*

1. Remove the oil pump.

Note: *It is not necessary to remove the fuel supply pump from the gear case to remove the gear case. If the fuel supply pump does not need to be repaired, leaving it mounted to the timing gear case will eliminate the need to re-time it during assembly. See Removal of Supply Pump on page 7-13.*

2. Remove the bolts (5, **Figure 6-55**).
3. Remove the gear case (1, **Figure 6-55**) from the cylinder block. Thoroughly clean all old sealant from the mating surfaces.
4. Inspect and measure the camshaft bushing. *See Camshaft on page 6-7 for the service limit.* If damaged or worn beyond service limits, remove the camshaft bushing (3, **Figure 6-55**).
5. **4TNV98C, 4TNV98CT:** Remove two O-rings (P20 and P14) (2, **Figure 6-55**) and two pins (4, **Figure 6-55**).

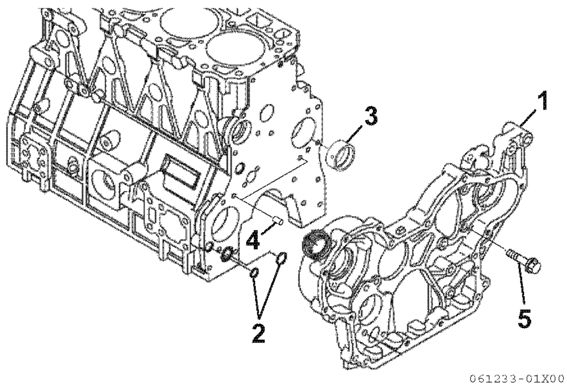


Figure 6-55

6. **3TNV88C - 4TNV86CT:** Remove two O-rings (2, **Figure 6-56**) and two dowels (4, **Figure 6-56**).

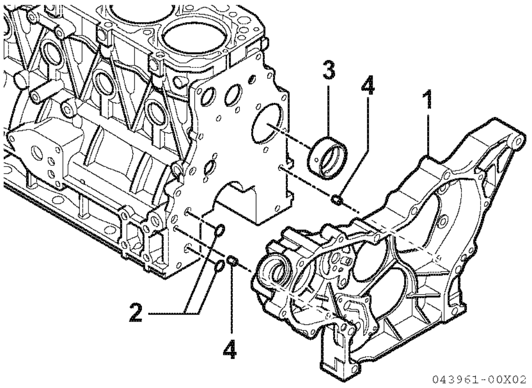


Figure 6-56

Disassembly of Crankshaft and Piston Components

■ Removal of pistons

NOTICE

Keep the piston pin parts, piston assemblies, and connecting rod assemblies together to be returned to the same position during the reassembly process. Label the parts using an appropriate method.

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 the pistons.

Note: *Pistons can fall from cylinder block if the engine is inverted. Rotate the engine so the connecting rods are horizontal before removing the connecting rod caps.*

1. Using a feeler gauge, measure the connecting rod side clearance as shown (**Figure 6-57**). *See Connecting Rod on page 6-14 for the standard limit.* If the measurement is out of specification, replace the crankshaft, connecting rod, or both.

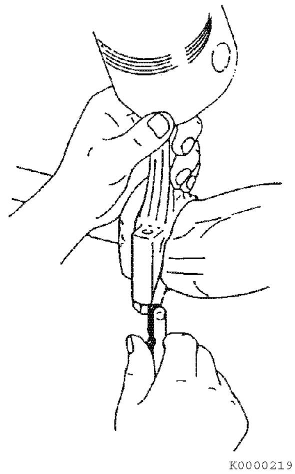


Figure 6-57

2. Measure bearing oil clearance prior to removing the pistons and connecting rods to determine extent of wear. Record the measurements.

NOTICE

Mark the connecting rod caps and connecting rods so the caps and connecting rods stay together.

1- Remove the bearing cap. Do not remove the bearing inserts at this time.
2- Wipe oil from the bearing insert and crankshaft journal surfaces.
3- Place a piece of PLASTIGAGE® (1, **Figure 6-58**) along the full width of the bearing insert.

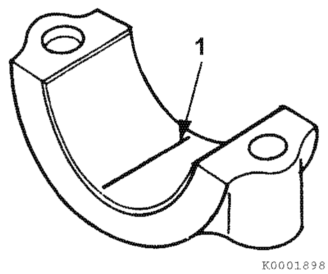


Figure 6-58

NOTICE

Do not rotate the crankshaft when using PLASTIGAGE. A false reading may result.

4- Reinstall bearing cap and tighten to specification. *See Special Torque Chart on page 6-16.*

5- Remove bearing cap.

6- Compare the width of the flattened PLASTIGAGE to the graduation marks on the package (1, **Figure 6-59**). The mark that most closely matches the width of the flattened PLASTIGAGE will indicate the bearing oil clearance.

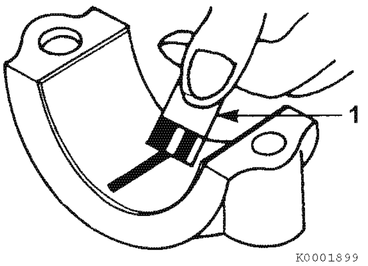


Figure 6-59

7- Repeat with remaining connecting rods.

NOTICE

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

3. Use a wooden dowel against the connecting rod and tap the piston/connecting rod assembly out of the cylinder.
4. Mark the cylinder number on the piston and connecting rod.
5. Remove the bearing inserts (2, **Figure 6-60**).
6. Remove the compression rings (3, **Figure 6-60**) from the piston using a piston ring expander.
7. Remove the oil ring (4, **Figure 6-60**) from the piston using a piston ring expander.

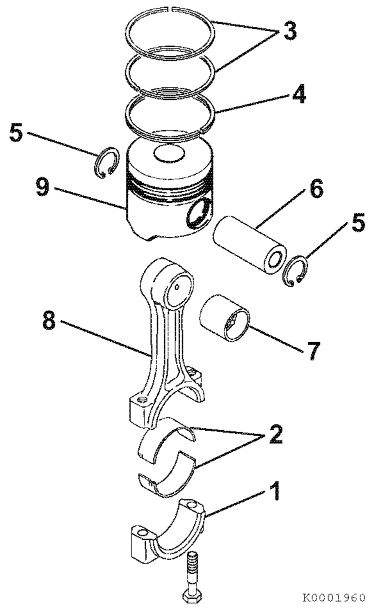


Figure 6-60

8. Remove the circlips (5, **Figure 6-60**) from the wrist pin.
9. Remove the wrist pin (6, **Figure 6-60**) and connecting rod (8, **Figure 6-60**) from the piston (9, **Figure 6-60**).
10. Repeat the steps until all pistons are removed and dissembled.

■ Removal of crankshaft

1. Remove the flywheel (1, **Figure 6-61**) from the crankshaft.
2. Remove the bolts from the rear oil seal assembly (2, 3, **Figure 6-61**). Remove the assembly from the engine.

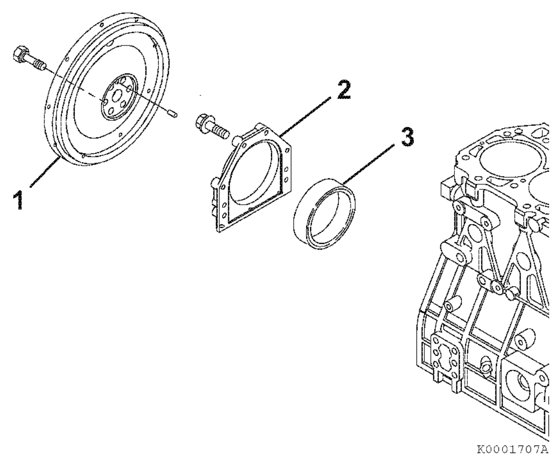


Figure 6-61

3. Before removing the main bearing caps, measure the crankshaft end play. Use either of the following two methods.
   - **Method A:** Install a dial gauge (1, **Figure 6-62**) on the cylinder block. Move the crankshaft (2, **Figure 6-62**) in and out to measure the end play. Record the measurement.

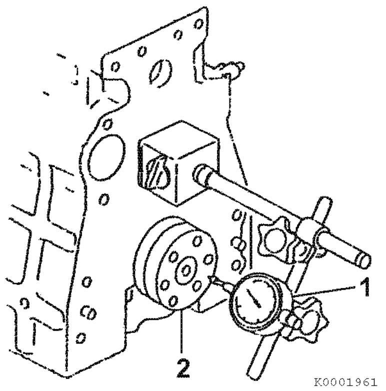


Figure 6-62

   - **Method B:** Use a feeler gauge to measure the clearance (3, **Figure 6-63**) between the thrust bearing (1, **Figure 6-63**) and crankshaft (2, **Figure 6-63**). Record the measurement. *See Thrust Bearing on page 6-10 for the service limit.*

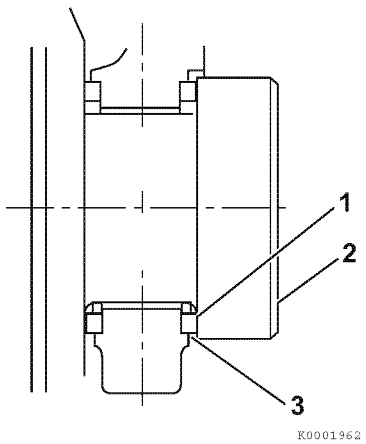


Figure 6-63

4. Remove the main bearing caps (3, **Figure 6-64**). Be sure to note the markings on the main bearing caps, or mark them yourself, so they can be reinstalled in the same order as they were removed. Do not remove the bearing inserts at this time.

Note: The "arrows" on the main bearing caps point to the flywheel end of the engine.

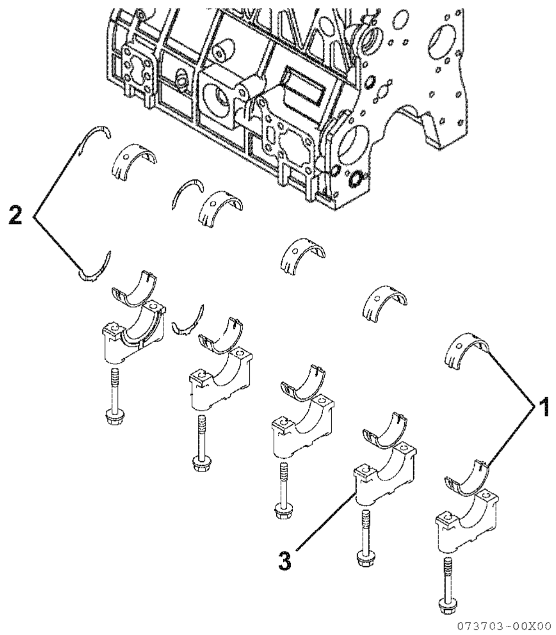


Figure 6-64

5. Measure bearing oil clearance prior to removing the crankshaft to determine extent of wear. Record the measurements.
   1- Wipe oil from the bearing insert and crankshaft journal surfaces.
   2- Place a piece of PLASTIGAGE (1, **Figure 6-65**) along the full width of each bearing insert.

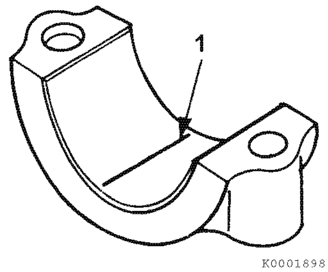


Figure 6-65

NOTICE

Do not rotate the crankshaft when using PLASTIGAGE. A false reading may result.

3- Reinstall bearing caps and tighten to specification. *See Special Torque Chart on page 6-16.*

4- Remove bearing caps.

5- Compare the width of the flattened PLASTIGAGE to the graduation marks on the package (1, **Figure 6-66**). The mark that most closely matches the width of the flattened PLASTIGAGE will indicate the bearing oil clearance.

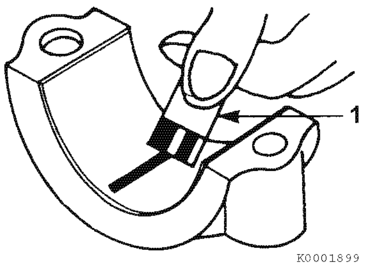


Figure 6-66

6. Remove the crankshaft from the engine.
7. Remove the bearing inserts (1, **Figure 6-64**) and thrust bearings (2, **Figure 6-64**).

   Note: Do not remove the crankshaft gear unless the gear or crankshaft are damaged and require replacement.

8. If necessary, remove the crankshaft gear (1, **Figure 6-67**) parallel pin (2, **Figure 6-67**) and key (3, **Figure 6-67**). If using a gear puller, be careful not to damage the threads in the end of the crankshaft.

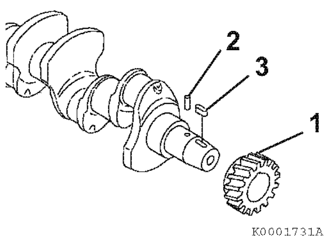
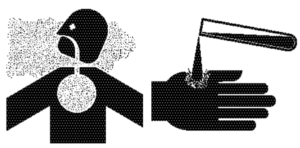


Figure 6-67

Inspection of Crankshaft and Camshaft Components

⚠ WARNING

Fume/Burn Hazard!



- **Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.**
- **Failure to comply could result in death or serious injury.**

Thoroughly clean all components using a brush and appropriate solvent. Each part must be free of carbon, gasket material, metal filings and other debris.

■ Replacement of crankshaft oil seals

1. Remove the seal (2, **Figure 6-68**) from the cover (1, **Figure 6-68**).
2. Apply a continuous bead of ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the outside diameter of a new oil seal (2, **Figure 6-68**), and install in the gear case cover. Apply lithium grease to the lip of the seal.

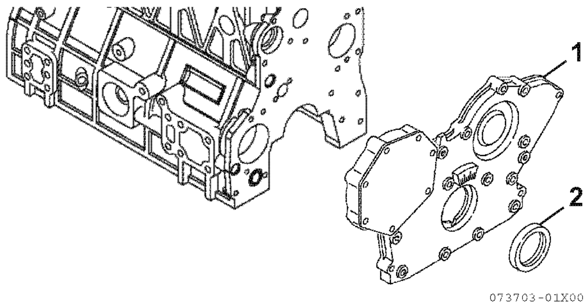


Figure 6-68

3. Remove the rear oil seal (3, **Figure 6-69**) from the seal housing (2, **Figure 6-69**).
4. Apply a continuous bead of ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the outside diameter of a new oil seal (2, **Figure 6-69**), and install in the housing. Apply lithium grease to the lip of the seal.

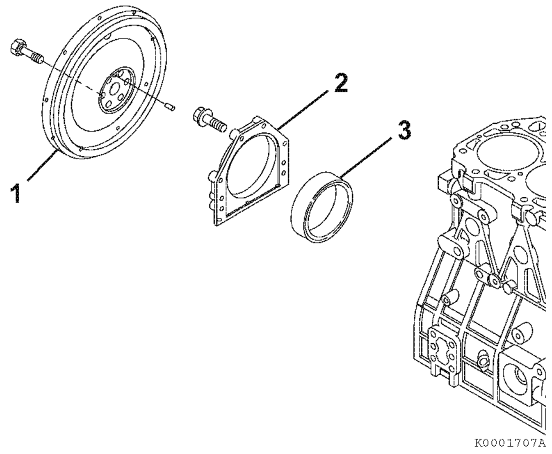


Figure 6-69

■ Measure crankshaft bearing oil clearance

Oil clearance should be checked during disassembly to determine the extent of wear, and during assembly to ensure long engine life. The same procedure is done for both connecting rods and main bearings.

■ Inspection of cylinder block

1. Ensure that oil passages are clear and unobstructed.
2. Check for discoloration or evidence of cracks. If a fracture is suspected, use the color check method or the Magnaflux method to determine if the cylinder block is fractured.
3. Inspect cylinders for roundness, taper, or evidence of scoring. Collect and record the measurements. Consider honing, reboring or replacing the cylinder block if the measurements are not within specification.
   - Take measurements at three places (**Figure 6-70**) (a, b, c), and in two directions (d and e) in each cylinder.

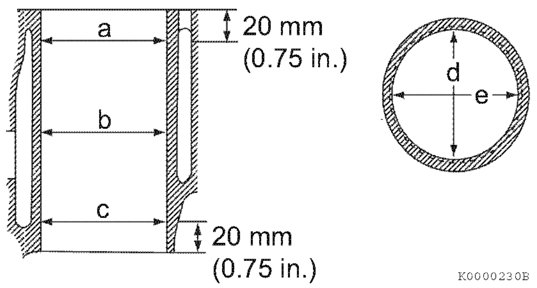


Figure 6-70

■ Inspection of pistons, piston rings and wrist pin

Note:

- *On an engine with low hours, the pistons, piston rings may be reused if they are found to be within specifications. The pistons and piston rings must be reinstalled in the same cylinders from which they were originally removed.*
- *On an engine with high hours, the pistons rings should be replaced and the cylinder honed (See Honing and Boring on page 6-56) or replaced. The piston should be replaced as necessary.*

1. Clean piston ring grooves using a piston ring groove cleaning tool. Follow manufacturer's instructions for correct operation.
2. Wash the pistons in an appropriate solvent using a soft brush.
3. Visually inspect each piston for cracks. Pay particular attention to the ring lands between the piston ring grooves.
4. Measure the diameter of the piston skirt at 90° to the wrist pin bore as shown (**Figure 6-71**). Measurements must be taken at a specified distance (1, **Figure 6-71**) from the bottom of the piston, based on engine model. Record the measurements. *See Piston on page 6-10 for specifications.*

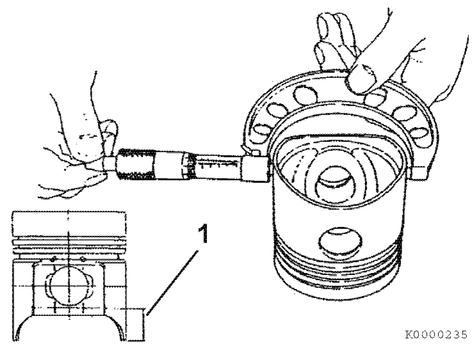


Figure 6-71

5. Subtract the piston measurement from the greatest measurement acquired during cylinder inspection *(seeInspection of cylinder block on page 6-51)* to obtain piston-to-cylinder clearance. Record the measurements. *See Piston on page 6-10 for specifications.*

6. Measure the diameter of the wrist pin bore on both sides of the piston (**Figure 6-72**). *See Piston on page 6-10 for specifications.* Record the measurements.

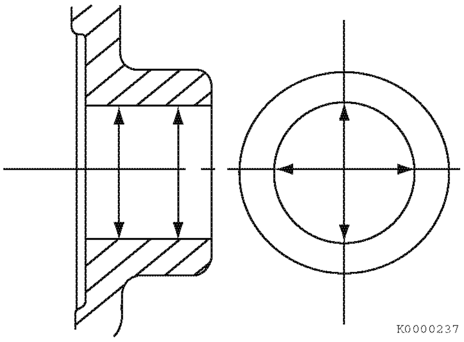


Figure 6-72

7. Measure the outside diameter of the wrist pin in three places and at 90° (**Figure 6-73**). *See Piston on page 6-10 for specifications.* Record the measurements.

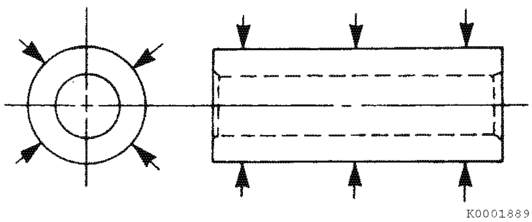


Figure 6-73

8. Using a micrometer, measure the thickness of each piston ring. *See Piston on page 6-10 for specifications.* Record the measurements.

   Note:
   - *On an engine with low hours, the pistons, piston rings and cylinders may be reused if they are found to be within specifications.*
   - *On an engine with high hours, the pistons rings should be replaced and the cylinder honed (seeHoning and Boring on page 6-56) or replaced. The piston should be replaced as necessary.*

9. Place each compression piston ring in the groove as shown (**Figure 6-74**). Use a feeler gauge to measure the clearance between the piston ring and the piston ring land. Record the measurements. *See Piston Ring on page 6-11 for specifications.* Replace the piston if not within specification.

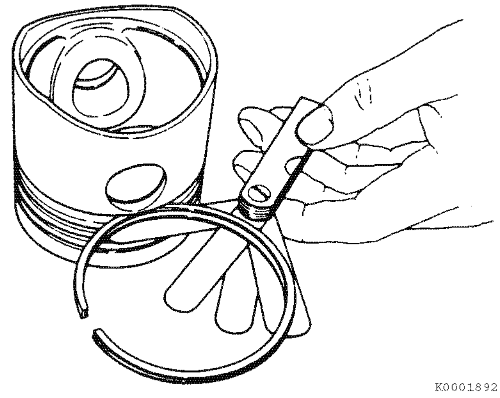


Figure 6-74

10. To measure piston ring end gap, insert each compression piston ring (1, **Figure 6-75**), one at a time, into the cylinder. Use a piston with the piston rings removed to slide the ring into the cylinder bore until it is approximately 1.18 in. (30 mm) (2, **Figure 6-75**) from the bottom of the bore. Remove the piston. Measure the end gap (3, **Figure 6-75**) of each piston ring. Record the measurements. *See Piston Ring on page 6-11 for specifications.*

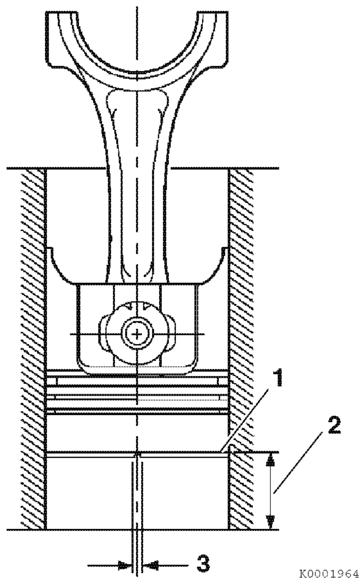


Figure 6-75

Note: Always check the piston ring end gap when installing new piston rings. See Piston Ring on page 6-11 for specifications. Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.

11. Repeat the above steps for each cylinder and piston assembly.

■ Inspection of connecting rod

1. Measure the wrist pin bushing bore using a bore gauge (1, **Figure 6-76**). Replace the bushing if not within specifications. If the bushing has been removed, measure the inside diameter of the connecting rod small end (2, **Figure 6-76**). *See Connecting Rod on page 6-14 for specifications.*

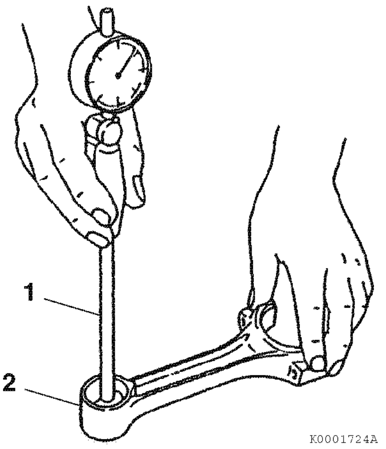


Figure 6-76

2. Place the connecting rod bearing inserts into the connecting rod and connecting rod cap. Install the rod cap and tighten the bolts to the specified torque.
3. Measure the inside diameter. *See Crankshaft on page 6-9 for specifications.*

■ Inspection of tappets

1. Inspect the tappet contact surfaces for abnormal wear (1, **Figure 6-77**). Normal wear will be even as shown in (2, **Figure 6-77**). Slight surface defects can be corrected using an oilstone.

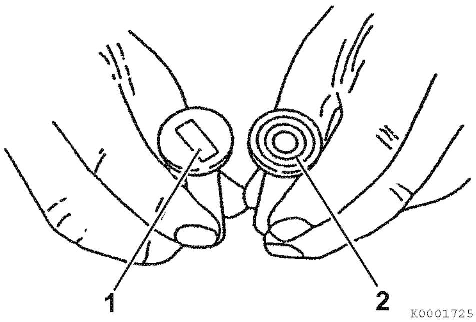


Figure 6-77

2. Measure the outside diameter of the tappet stem (1, **Figure 6-78**). *See Tappet on page 6-14 for the service limit.*

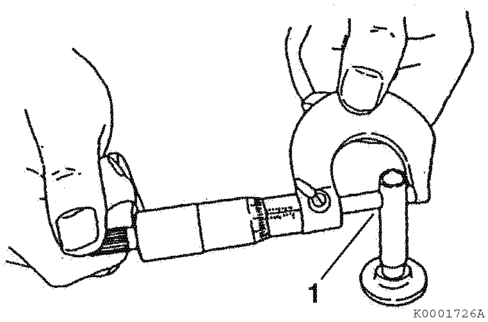


Figure 6-78

3. From the head side of the below illustration, use the cylinder gauge (1, **Figure 6-79**) to measure the tappet bore. Limit values are noted *Tappet on page 6-14*.

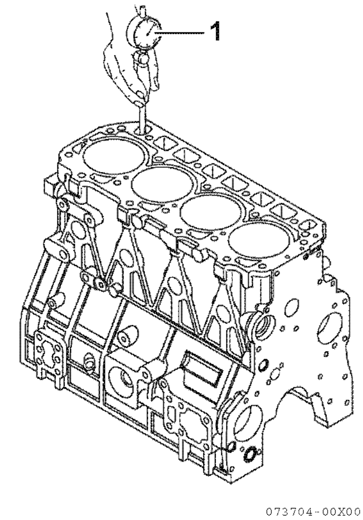


Figure 6-79

■ Inspection of crankshaft

1. Place the crankshaft end journals (4, **Figure 6-80**) on V-blocks.
2. Place a dial indicator (3, **Figure 6-80**) on a center main bearing surface.

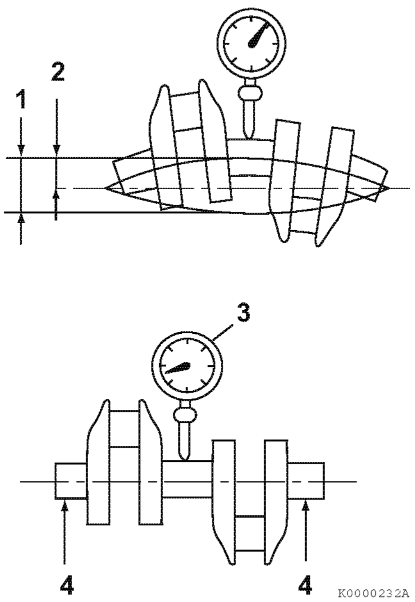


Figure 6-80

3. Rotate the crankshaft and observe runout. *See Crankshaft on page 6-9 for specifications.*
4. Use the color check method or Magnaflux® to inspect the crankshaft for cracks. Replace the crankshaft if evidence of fractures are found.
5. Measure the outside diameter of each crankpin (2, **Figure 6-81**) and main bearing journal (1, **Figure 6-81**). *See Crankshaft on page 6-9 for specifications.* Take measurements at several places around each bearing surface. If not within specification, grind the journals and install undersize bearings, or replace the crankshaft.

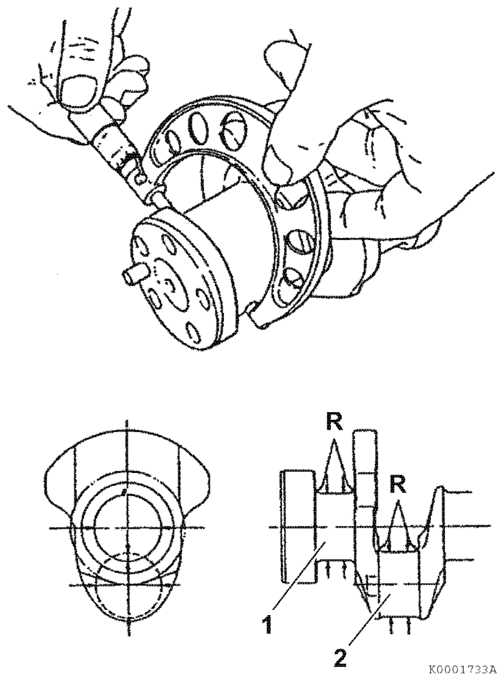


Figure 6-81

■ Inspection of camshaft

1. Use V-blocks and a dial indicator to check camshaft bend (**Figure 6-82**). Place the indicator on the center bearing journal.

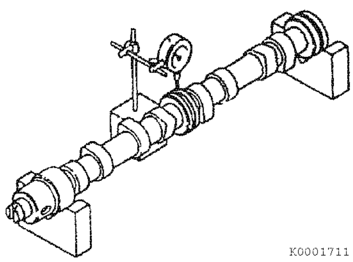


Figure 6-82

2. Rotate the camshaft and observe the runout. *See Camshaft on page 6-7 for specifications.*
3. Measure the height of each lobe (1, **Figure 6-83**). *See Camshaft on page 6-7 for specifications.*

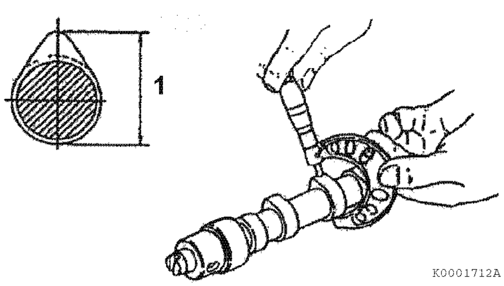


Figure 6-83

4. Measure the diameter of the gear end (1, **Figure 6-84**), intermediate (2, **Figure 6-84**), and flywheel end (3, **Figure 6-84**) bearing journals. *See Camshaft on page 6-7 for specifications.*

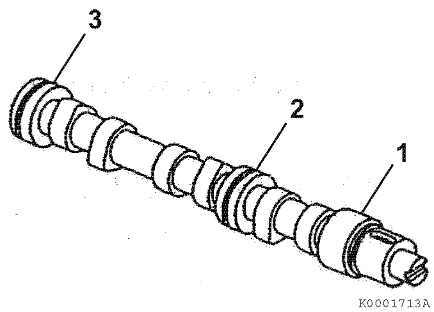


Figure 6-84

■ Inspection of camshaft bushing and bores

1. Measure the I.D. of the front bushing and the remaining bores in the cylinder block. *See Camshaft on page 6-7 for specifications.*
2. If the camshaft bushing is not within specification, replace it using the appropriate service tool. If the remaining bores are not within specification, the cylinder block will require replacement as there are no bearing inserts used.

■ Inspection of idler gear and shaft

1. Measure the outside diameter (1, **Figure 6-85**) of the idler gear shaft (2, **Figure 6-85**). *See Idler Gear Shaft and Bushing on page 6-8 for specifications.*
2. Measure the inside diameter (3, **Figure 6-85**) of the idler gear bushing (4, **Figure 6-85**). *See Idler Gear Shaft and Bushing on page 6-8 for specifications.*

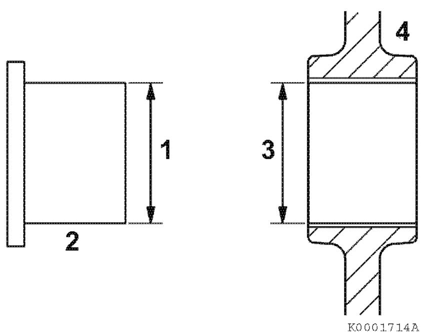


Figure 6-85

■ Inspection of flywheel

1. Check for crack and wear on the flywheel friction surface, and replace it if there is damage.
2. Check the ring gear tooth surface and replace the ring gear if there is damage or excessive wear.
   - Removal of ring gear
     Bring a rod into contact with the ring gear, and remove the gear while evenly hitting the circumference with a hammer.

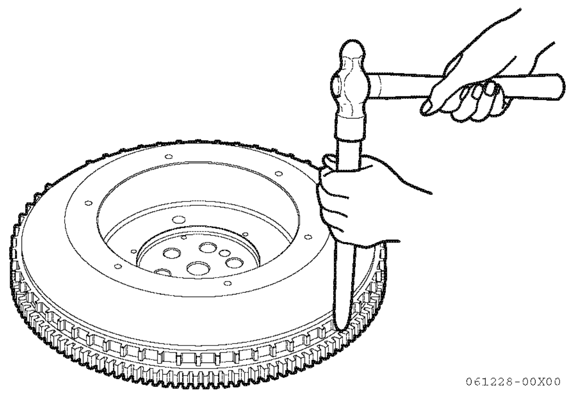


Figure 6-86

   - Evenly heat a new ring gear with a gas burner (approximately 200 °C (392 °F)), quickly install the ring gear with the chamfered side of the tooth surface facing the block side. Completely and closely contact the ring gear and the flywheel.

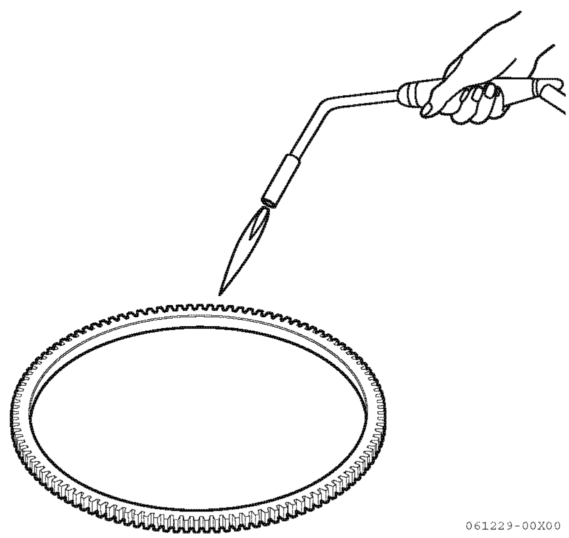


Figure 6-87

Honing and Boring

Pistons must move freely in the cylinders while maintaining adequate compression and oil sealing. If the cylinder walls are scuffed, scored, out-of-round, or tapered beyond specifications, rebore and hone to restore cylinders to usable condition. Slight imperfections can be corrected by honing alone.

1. **Boring** - Significant cylinder damage may be corrected by boring the cylinder to an oversize dimension. Refer to the appropriate parts catalog for available oversize pistons and piston rings.
   - Boring a cylinder should always be done in a properly equipped machine shop.
   - A bored cylinder should always be finished with a hone to properly prepare the cylinder surface so the new piston rings will seat properly.
   - After the cylinder has been bored and honed, install the appropriate oversize pistons and piston rings.
2. **Honing** - Minor cylinder imperfections may be corrected by using a rigid cylinder hone (1, **Figure 6-89**). Be sure not to exceed the maximum cylinder bore specification.

   Deglazing - A used cylinder that did not require boring or honing, should always be deglazed with a ball hone (2, **Figure 6-89**) before installing new piston rings. This will properly prepare the cylinder surface to allow new piston rings to seat properly.

Note: *When honing a cylinder, with either a ridged hone or a ball hone (1, **Figure 6-88**), move the rotating hone up and down in the cylinder bore to accomplish a 30° to 40° crosshatch pattern (**Figure 6-88**). This will provide the ideal surface for the proper seating of new piston rings.*

NOTICE

Do not allow the honing tool to operate in one position for any length of time. Damage to the cylinder wall will occur. Keep the tool in constant up-and-down motion.

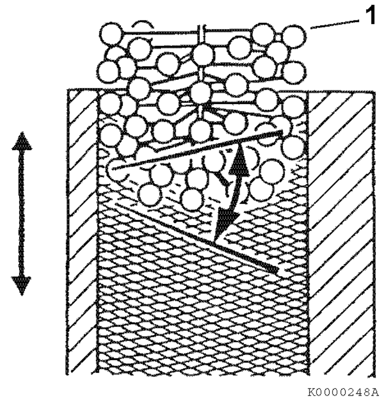


Figure 6-88

- Use a 50:50 mixture of diesel fuel and engine oil as a honing fluid.
- Use a 300-grit hone at 300 - 1200 min^{-1} (rpm). (**Figure 6-89**)

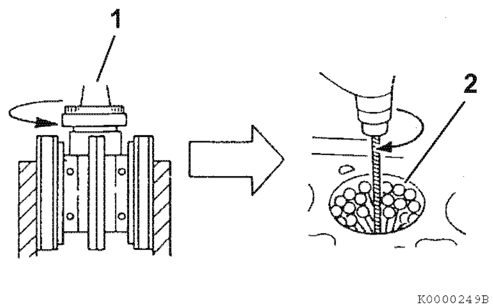


Figure 6-89

NOTICE

Solvents will not adequately remove honing residue, resulting in premature piston and ring wear. Always wash cylinders using hot, soapy water.

- When honing is completed, wash the cylinder block with hot water and soap. The cylinder wall is adequately cleaned when a white rag wiped in cylinder comes out clean. Use brushes to clean all passages and crevices. Rinse with hot water and dry with compressed air. Apply clean engine oil to all steel surfaces to prevent rusting.

Reassembly of Crankshaft and Piston Components

Note:

- *Proceed slowly. Make no forced assemblies unless a pressing operation is called for. All parts must be perfectly clean and lightly lubricated when assembled.*
- *Use new gaskets, seals and O-rings during assembly.*
- *Liberally apply clean engine oil to all internal parts during assembly.*
- *All fasteners should be tightened to a given torque. If a special torque is not provided in the Special Torque Chart on page 6-16, tighten to standard torque specifications. See Tightening Torques for Standard Bolts and Nuts on page 4-43.*

■ Reassembly of pistons

1. Select the parts needed to reassemble the piston and connecting rod for one cylinder.
2. If removed, install a new wrist pin bushing (7, **Figure 6-90**) using a press and the appropriate service tool. Be sure to align the oil holes.

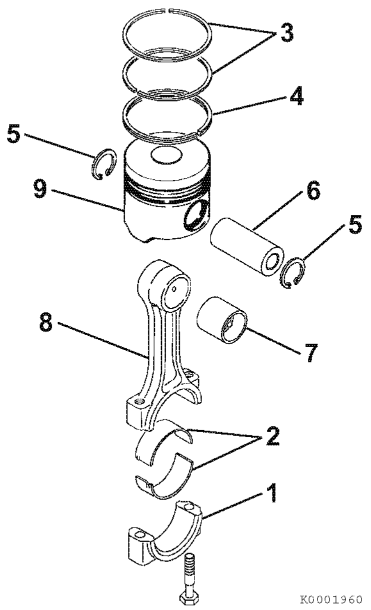


Figure 6-90

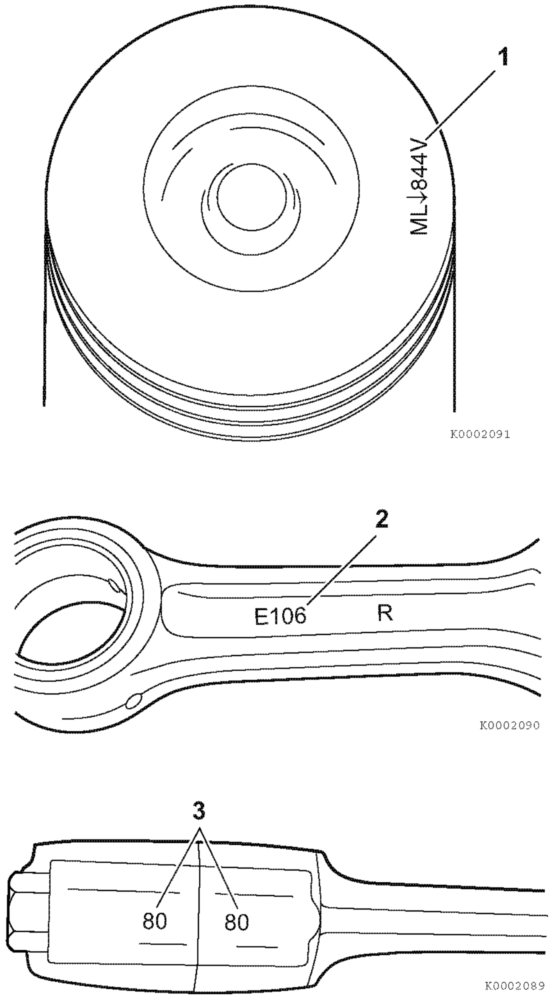
3. Reinstall one circlip (5, **Figure 6-90**) into the piston. Ensure the circlip is securely seated in the groove.

NOTICE

The piston and connecting rod must be assembled together in the correct orientation. The orientation of the piston and connecting rod are different depending on engine model.

Piston to connecting rod orientation - by model
Orient the piston identification mark stamped on top of the piston on the same side as the rod and cap match marks stamped on the connecting rod.

Note: *The actual appearance of the match marks on the piston and connecting rod may vary, but they will always be in the same locations.*



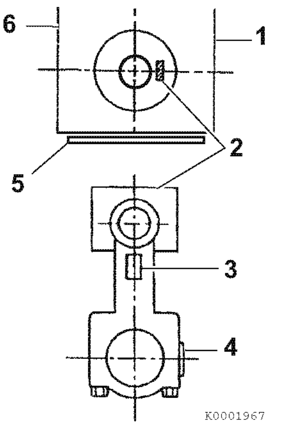
1 – Piston identification mark
2 – Embossed mark on connecting rod
3 – Rod and cap match marks

Figure 6-91

Piston assembly - all TNV models

When correctly assembled, the piston identification mark (2, **Figure 6-92**) stamped into the top of the piston will be on the same side of the connecting rod as the match marks (4, **Figure 6-92**) stamped into the connecting rod and connecting rod cap.

When installed in the cylinder, the piston identification mark (2, **Figure 6-92**) stamped on the top of the piston must face the fuel injection pump side (1, **Figure 6-92**) of the engine and the embossed mark on the connecting rod (3, **Figure 6-92**) must face the flywheel end (5, **Figure 6-92**) of the engine.



1 – Fuel injection pump side of engine
2 – Piston identification mark
3 – Embossed mark on connecting rod
4 – Rod and cap match marks
5 – Flywheel end of engine
6 – Camshaft side of engine

Figure 6-92

4. Lubricate and reinstall the wrist pin (6, **Figure 6-93**) through the piston and connecting rod.
5. Reinstall the second circlip (5, **Figure 6-93**) and ensure it is securely seated in the groove.

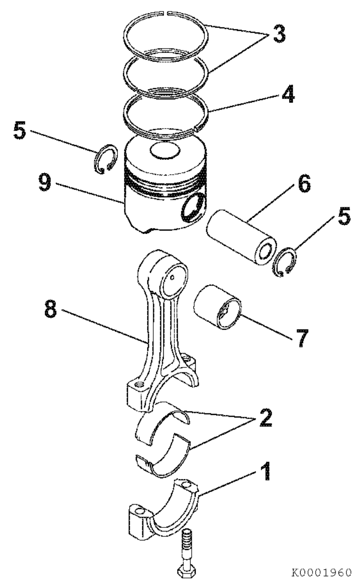


Figure 6-93

Note:

- *If installing new piston rings the end gap must be checked and adjusted as necessary. See Inspection of pistons, piston rings and wrist pin on page 6-51 for specifications. Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.*
- *Reinstall the top and second piston rings with the stamped "makers mark" (1,* ***Figure 6-94****) facing the top of the piston. The "makers mark" may vary in appearance but will always be located on the top surface of the piston ring adjacent to the piston ring gap. The oil ring and oil ring expander can be installed either side up.*

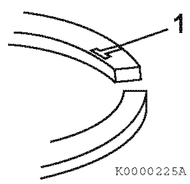


Figure 6-94

NOTICE

Always use a piston ring installation tool (expander) when installing piston rings. Never attempt to install piston rings by hand.

6. Reinstall the oil ring expander (4, **Figure 6-95**). Reinstall the oil ring (3, **Figure 6-95**) with the end gap at 180° from the expander end gap.

7. Reinstall the second compression ring (2, **Figure 6-95**). This ring is identified by its dark color and tapered face profile.
8. Reinstall the top compression ring (1, **Figure 6-95**). This ring is identified by its silver color and barrel-shaped face profile.

NOTICE

The oil ring coil expander (4, **Figure 6-95**) end gap must be located 180° from the oil ring (3, **Figure 6-95**) end gap.

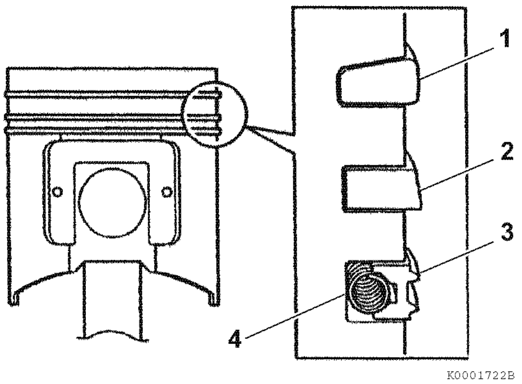
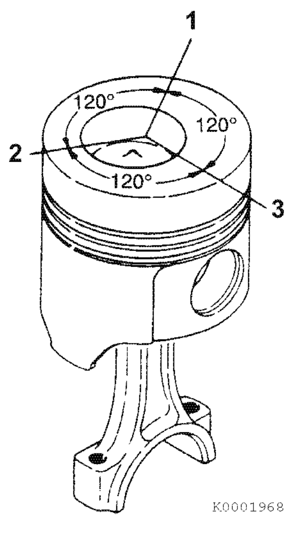


Figure 6-95

9. Stagger the piston ring end gaps at 120° intervals (1, 2, 3, **Figure 6-96**). Do not position the top piston ring end gap in line with the wrist pin.



1 – Top compression ring end gap
2 – Second compression ring end gap
3 – Oil ring end gap

Figure 6-96

■ Installation of crankshaft

1. If removed, reinstall the keys and timing gear on the crankshaft.
2. Reinstall new bearing inserts (1, **Figure 6-97**) and thrust bearing (2, **Figure 6-97**) in the cylinder block and main bearing caps. Apply a liberal coat of clean engine oil to the bearings and crankshaft journals.
3. Place the crankshaft into the engine.

NOTICE

The main bearing caps are numbered and have arrows for proper positioning. The No. 1 cap is at the flywheel end. The arrows point toward the flywheel end of the engine.

4. Reinstall the main bearing caps (3, **Figure 6-97**).
5. Apply a light coat of clean engine oil to the bearing cap bolts and tighten the bolts to the specified torque in two stages (1/2 then full torque). *See Special Torque Chart on page 6-16 for specifications.*

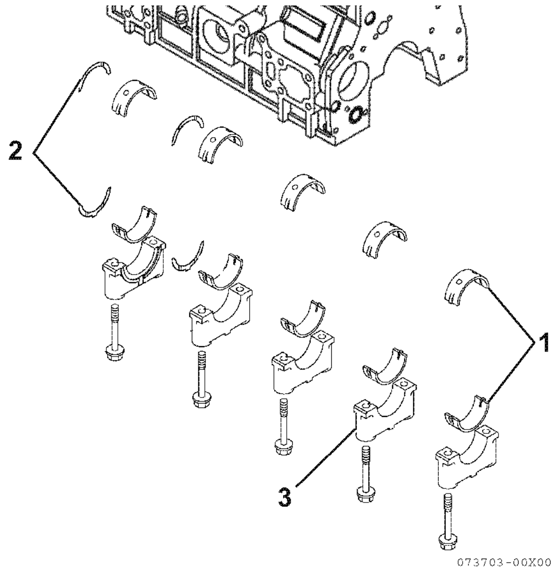


Figure 6-97

6. Rotate the crankshaft to assure it turns freely.
7. Apply ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the mounting flange of the seal housing (2, **Figure 6-98**).
8. Align the seal housing with the two dowel pins.
9. Reinstall seal housing and seal assembly.

10. Reinstall the flywheel (1, **Figure 6-98**) and tighten the bolts to the specified torque. *See Special Torque Chart on page 6-16 for specifications.*

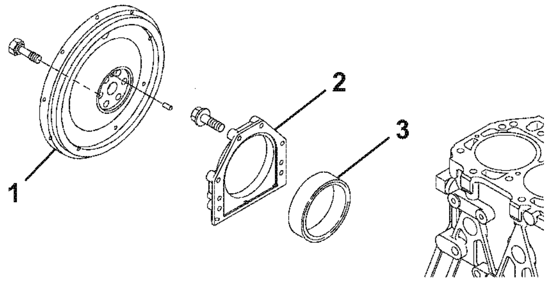


Figure 6-98

■ Installation of pistons

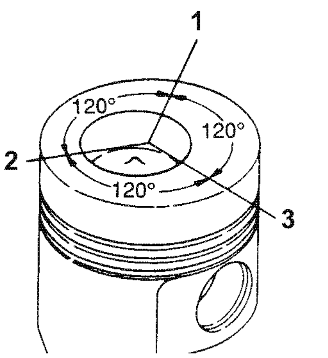
NOTICE

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

1. Lubricate the piston, piston rings, and cylinder with clean engine oil or assembly lubricant.
2. Rotate the crankshaft so the crankpin for the piston being installed is near bottom dead center.

NOTICE

Ensure the piston ring gaps are located correctly (**Figure 6-99**).



1 – Top compression ring end gap
2 – Second compression ring end gap
3 – Oil ring end gap

Figure 6-99

3. Using a piston ring compressor, compress the piston rings.

NOTICE

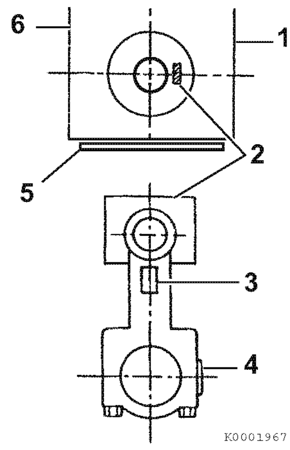
The piston and connecting rod must be installed in the correct orientation.

Piston orientation to cylinder	
All TNV models	Orient the piston identification mark stamped on top of the piston on the fuel injection pump side of the engine

Piston installation - all TNV models

When correctly assembled, the piston identification mark (2, **Figure 6-100**) stamped into the top of the piston will be on the same side of the connecting rod as the match marks (4, **Figure 6-100**) stamped into the connecting rod and connecting rod cap.

When installed in the cylinder, the piston identification mark (2, **Figure 6-100**) stamped on the top of the piston must face the fuel injection pump side (1, **Figure 6-100**) of the engine and the embossed mark on the connecting rod (3, **Figure 6-100**) must face the flywheel end (5, **Figure 6-100**) of the engine.



1 – Fuel injection pump side of engine
2 – Piston identification mark
3 – Embossed mark on connecting rod
4 – Rod and cap match marks
5 – Flywheel end of engine
6 – Camshaft side of engine

Figure 6-100

4. Reinstall the bearing inserts (1, **Figure 6-101**) in the connecting rod and cap.
5. Apply a liberal coat of clean engine oil to the bearing inserts and crankshaft journal.
6. Apply a light coat of clean engine oil to the rod cap bolts. Reinstall the connecting rod cap (2, **Figure 6-101**). Tighten the connecting rod bolts to the specified torque in two stages (1/2 then full torque). *See Special Torque Chart on page 6-16 for specifications.*

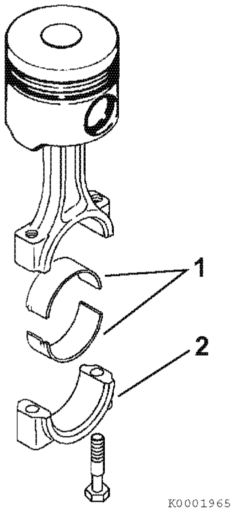


Figure 6-101

7. Reinstall the remaining pistons in their respective cylinders.

Reassembly of Camshaft and Timing Components

■ Installation of gear case

1. If removed, install a new camshaft bushing (3, **Figure 6-102** and **Figure 6-103**) using the appropriate service tool.
2. Apply a continuous bead of ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the mounting area of the gear case. Be sure to circle each bolt hole.
3. **4TNV98C, 4TNV98CT:** Install two new O-rings (P14 and P20) (2, **Figure 6-102**) and two pins (4, **Figure 6-102)** in the cylinder block.

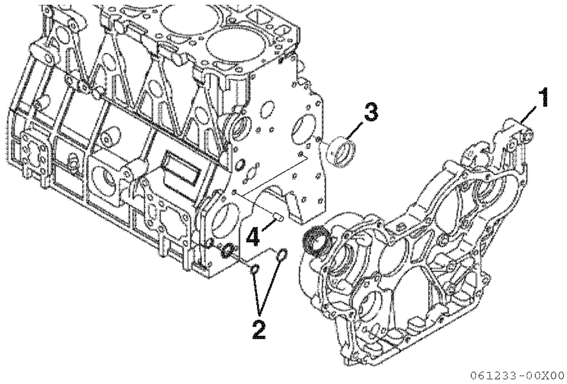


Figure 6-102

4. **3TNV88C - 4TNV86CT:** Reinstall the dowels (4, **Figure 6-103**) and two new O-rings (2, **Figure 6-103**).

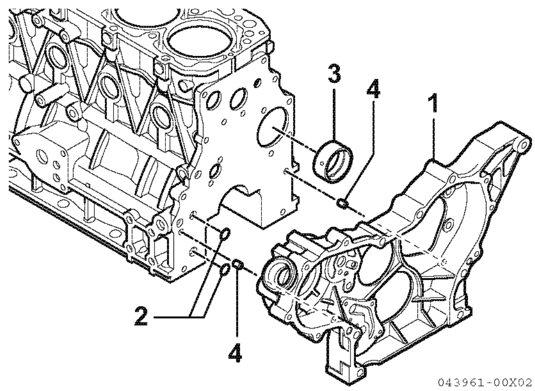


Figure 6-103

5. Reinstall the gear case (1, **Figure 6-102**) or front plate (1, **Figure 6-103**). Tighten the bolts to the specified torque.

■ Installation of camshaft

Note: The gear housing or front plate must be reinstalled prior to installing the camshaft. See Installation of gear case on page 6-61.

1. If removed, reinstall the camshaft end plate (1, **Figure 6-104**), key, and timing gear (4, **Figure 6-104**) onto the camshaft using a press.

   Note: Heat the gear to 356 - 392 °F (180 - 200 °C) and press onto the end of the camshaft.

2. Rotate the cylinder block so that gravity will keep the tappets (5, **Figure 6-104**) in place and out of the way of the camshaft lobes when the camshaft is being reinstalled.

   Note:
   - *If the engine is not installed on an engine repair fixture, stand the engine upright on the flywheel end mounting flange.*
   - *The tappets are “mushroom” shaped and must be installed from inside the engine crankcase.*

3. Lubricate the tappets with clean oil or assembly lube. Reinstall the tappets in their respective locations in the cylinder block. Push the tappets fully into the tappet bores so they will not interfere with the installation of the camshaft.
4. Lubricate the camshaft (2, **Figure 6-104**) with clean engine oil or assembly lube. Slowly insert the camshaft through the front of the engine.
5. Reinstall and tighten the cap screws (3, **Figure 6-104**).

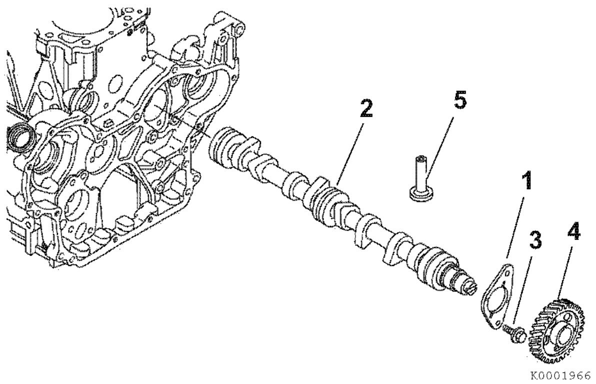
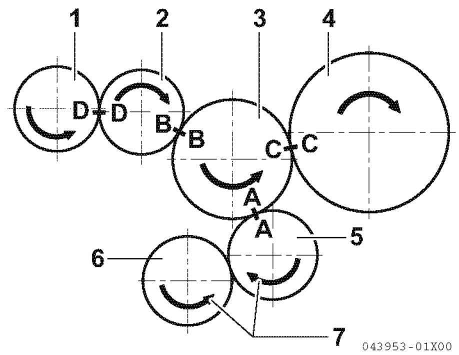


Figure 6-104

■ Installation of timing gears

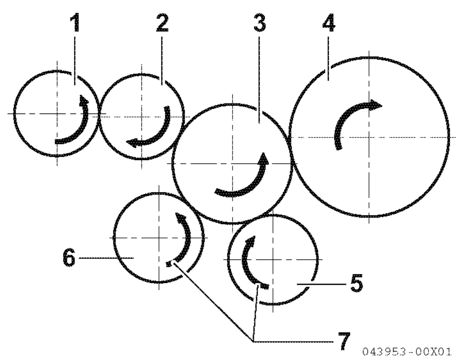
1. Set the piston of gear case side cylinder (cylinder No. 3 for three-cylinder engine, cylinder No. 4 for four-cylinder engine) to the top dead center position.
2. Rotate the camshaft until the mark (C, **Figure 6-105**) is approximately at the 9 o’clock position.



1 – Supply pump gear
2 – Idler gear (B)
3 – Idler gear (A)
4 – Camshaft gear
5 – Crankshaft gear
6 – Lubricating oil pump gear
7 – Direction of rotation

Figure 6-105

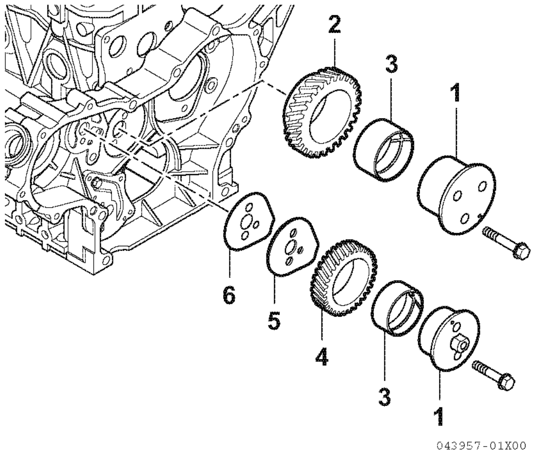
Figure 6-105 shows a gear train of 3TNV88C-4TNV86CT, the lubricating oil pump gear is driven from the crankshaft gear. For 4TNV98C/4TNV98CT, it is driven from the idler gear (A) as shown in the **Figure 6-106**.



1 – Supply pump gear
2 – Idler gear (B)
3 – Idler gear (A)
4 – Camshaft gear
5 – Crankshaft gear
6 – Lubricating oil pump gear
7 – Direction of rotation

Figure 6-106

3. Lubricate the idler gear (A) (2, **Figure 6-107**), bushing (3, **Figure 6-107**) and idler gear shaft (1, **Figure 6-107**) with clean engine oil.



1 – Idler gear shaft
2 – Idler gear (A)
3 – Idler gear bushing
4 – Idler gear (B)
5 – Plate, idle shaft
6 – Packing

Figure 6-107

4. Align the timing gears as shown in (**Figure 6-105**).
5. Install the idler gear (A), idler gear shaft, and idler gear bushing while aligning the timing marks A and C. At this time, direct the punch mark on the idler gear shaft end surface to the upper part of the engine.
6. While aligning the timing marks B and D of the idler gear (B), install the idler gear (B), idler gear shaft, and idler gear bushing**.**
7. When all gears are properly aligned, tighten the idler gear retaining bolts to specified torque. *See Special Torque Chart on page 6-16 for specifications.*

■ Installation of gear case cover

1. Apply a continuous bead of ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the mounting area of the gear case cover (1, **Figure 6-108**). Be sure to circle the bolt holes.
2. Reinstall and tighten the gear case cover bolts.

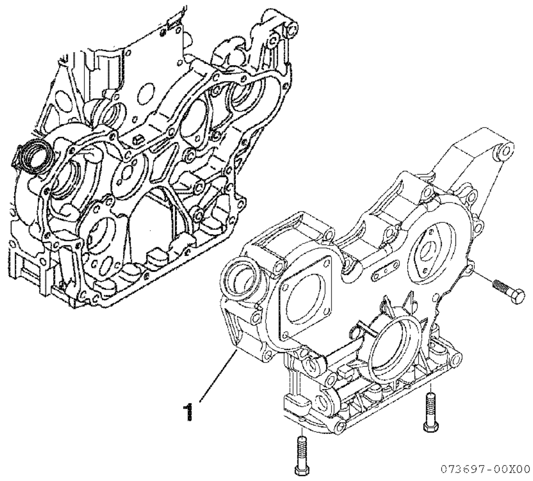


Figure 6-108

3. Reinstall the crankshaft pulley.

NOTICE

Use the crankshaft pulley installation tool (3, **Figure 6-109**) when reinstalling the pulley (1, **Figure 6-109**). The tool will guide the pulley hub and protect the front seal (2, **Figure 6-109**) from damage.

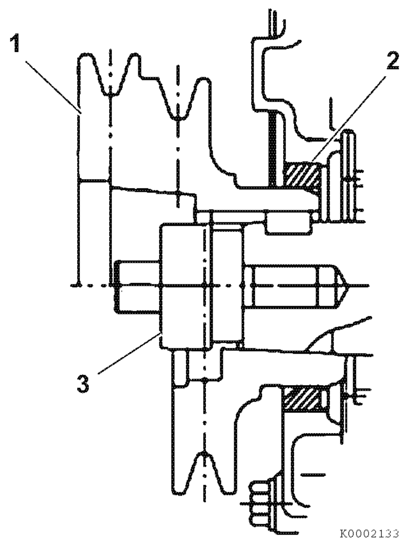


Figure 6-109

4. Reinstall the washer and bolt. Tighten the bolt to the specified torque. *See Special Torque Chart on page 6-16 for specifications.*

■ Installation of oil pan

1. Reinstall the oil pickup tube (1, **Figure 6-110**) using a new O-ring (2, **Figure 6-110**).

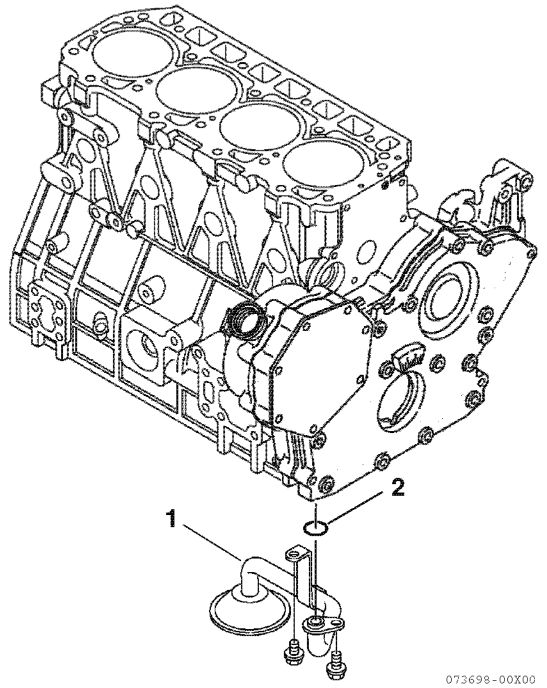


Figure 6-110

2. Apply a continuous bead of ThreeBond Liquid Gasket No. 1207F, YANMAR Part No. 977770-1207F to the mounting surface of the oil pan (1, **Figure 6-111**). Be sure to circle each bolt hole.
3. Reinstall the oil pan and tighten the bolts securely.

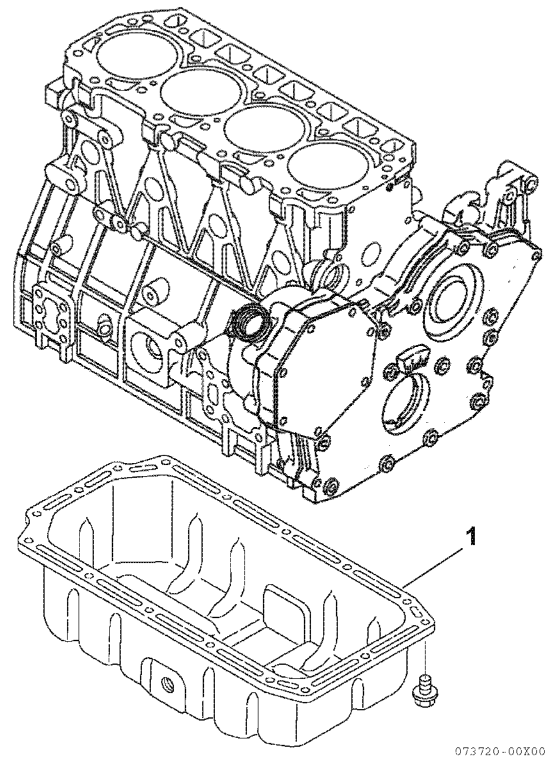


Figure 6-111

Final Reassembly of Engine

1. Reinstall the starter motor.
2. Reinstall the cylinder head. *See Reassembly of cylinder head on page 6-36.*
3. Reinstall the engine in the machine.
4. Reconnect the fuel and coolant lines.
5. Reinstall the alternator.
6. Reconnect all electrical connections.
7. Fill the engine with oil and coolant.
8. Reconnect the battery cables, negative (-) cable last.

EGR SYSTEM

EGR (Exhaust Gas Recirculation) is a technology which has been widely used for automotive diesel engines. EGR lowers the combustion temperature by introducing a part of exhaust gas into the intake air and reduces NOx which is a composition subject to emission control regulations. By applying this EGR technology, we can now comply with emission control regulations in each country, including the emission control regulation Tier4 of the Environmental Protection Agency (EPA).

Figure 6-112 shows the schematic diagram of the equipment. There is an appropriate value for the circulating exhaust gas volume (EGR rate), and it is controlled by the EGR valve which is installed between the intake and exhaust flow. EGR valves are driven by DC motors and they adjust the EGR rate according to the appropriate opening indicated by the ECU based on engine speed or load conditions.

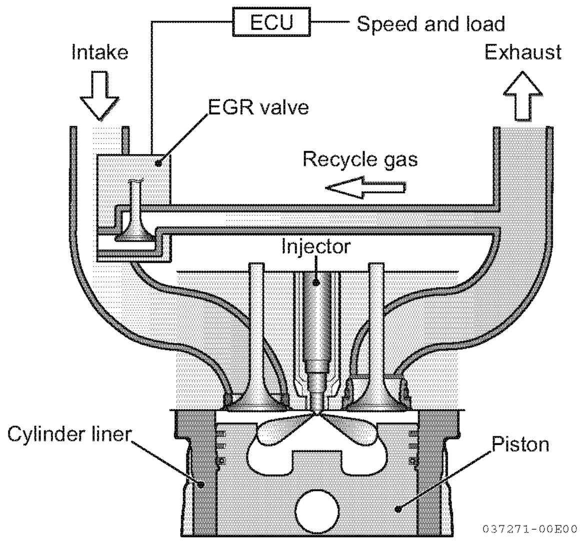
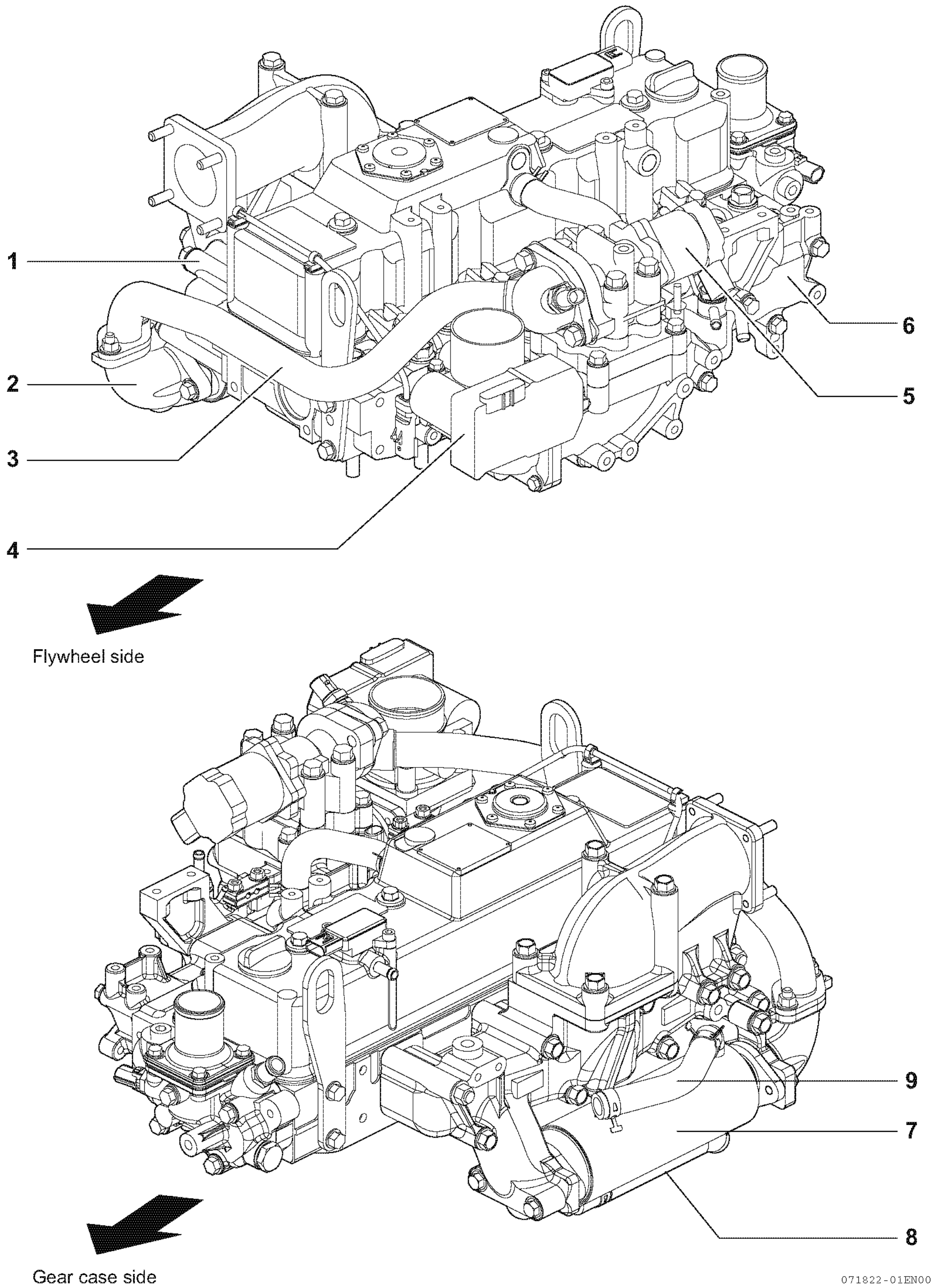


Figure 6-112

EGR System Configuration

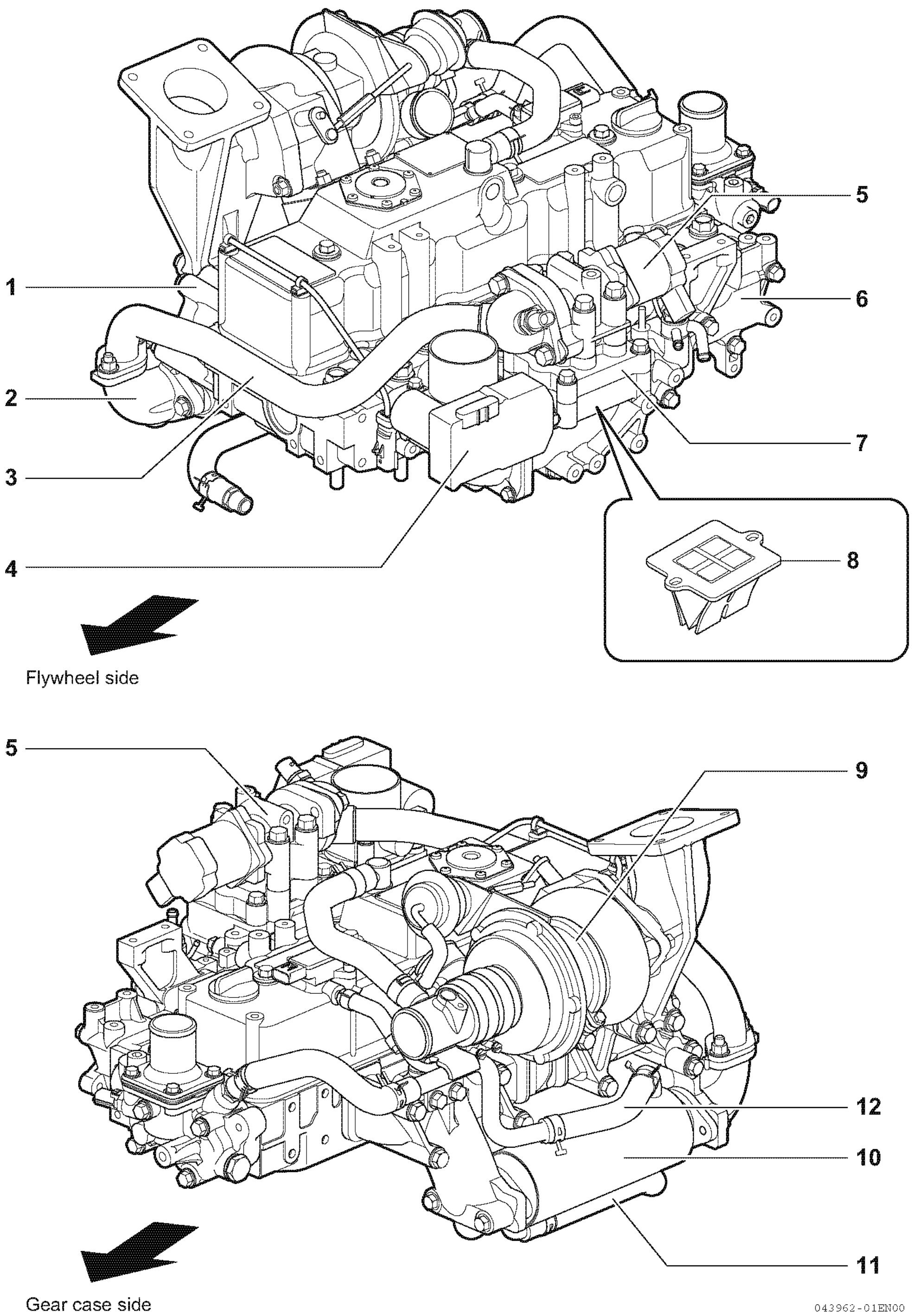
■ Engine without turbocharger



1 – Exhaust manifold
2 – EGR cooler outlet vent
3 – EGR pipe
4 – Intake throttle valve
5 – EGR valve
6 – Intake manifold
7 – EGR cooler
8 – EGR cooler inlet side coolant hose
9 – EGR cooler outlet side coolant hose

Figure 6-113

■ Engine with turbocharger



1 – Exhaust manifold
2 – EGR cooler outlet vent
3 – EGR pipe
4 – Intake throttle valve
5 – EGR valve
6 – Intake manifold
7 – EGR valve spacer
8 – EGR lead valve*1
9 – Turbocharger
10 – EGR cooler
11 – EGR cooler inlet side coolant hose
12 – EGR cooler outlet side coolant hose

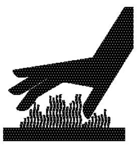
Figure 6-114

**1: Only for engines with turbocharger.*

Disassembly of EGR System

⚠ WARNING

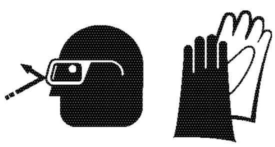
Burn Hazard!



- **Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could seriously burn you.**
- **Failure to comply could result in death or serious injury.**

⚠ CAUTION

Coolant Hazard!



- **Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.**
- **Failure to comply may result in minor or moderate injury.**

Disassembling procedure of each components will be described for maintenance and parts replacement of the EGR system.

■ EGR valve

1. If there is any additional equipment (such as an air cleaner) installed above the EGR valves, remove it in advance.
2. Remove the connector from the EGR valve (1, **Figure 6-115**). (Leave the connector attached when checking or cleaning the EGR valve.)
3. Loosen the flange nut (4, **Figure 6-115**) that mount the EGR cooler outlet vent (2, **Figure 6-115**) and the EGR pipe (3, **Figure 6-115**).
4. Loosen the flange bolt (5, **Figure 6-115**) that mount the EGR pipe and EGR valve (1, **Figure 6-115**), and remove the EGR pipe.
5. Loosen the EGR valve mounting bolt (6, **Figure 6-115**), and remove the EGR valve.

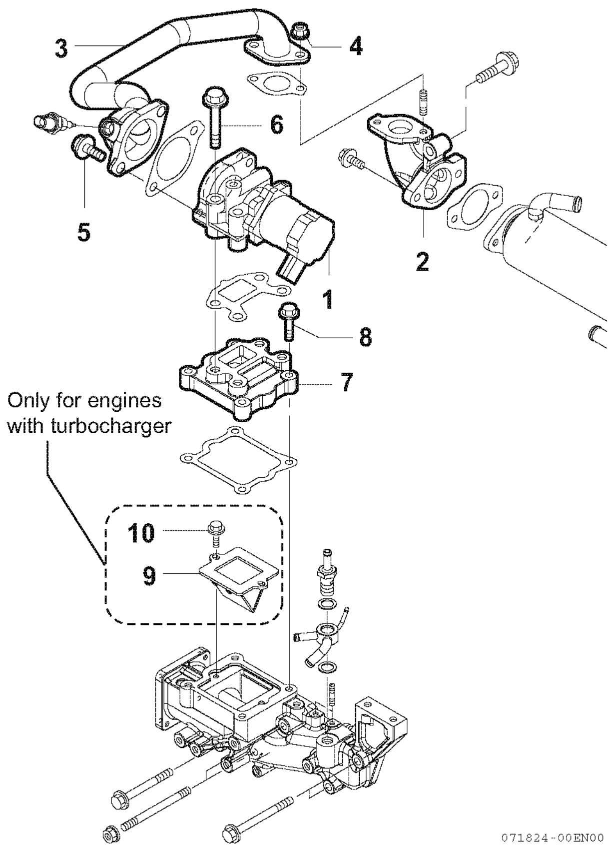


Figure 6-115

NOTICE

When it is necessary to replace an EGR valve, be sure to replace the entire EGR valve assembly. Neither attempt to disassemble and repair the EGR valve, nor replace its individual components.

NOTICE

A steel gasket is used to the joint section of the EGR system devices with the parts.
When reinstalling the EGR system devices and parts, always use new and specified one.

■ Lead valve (only for engines with turbocharger)

1. After removing the EGR valve, loosen the bolt (8, **Figure 6-115**) mounting the EGR lead valve spacer (7, **Figure 6-115**), and remove the spacer.
2. Loosen the bolt (10, **Figure 6-115**) mounting the EGR lead valve (9, **Figure 6-115**), and remove the lead valve.

■ EGR cooler

When removing the EGR cooler for cleaning, inspections of the EGR valve should be done at the same time (every 3000 hours), so carry on after removing the EGR valve.

1. Drain the engine coolant. (How to drain the engine coolant is described in *Change engine coolant on page 5-19*)
2. Disconnect the coolant inlet (2, **Figure 6-116**) and outlet hoses (3, **Figure 6-116**) from the EGR cooler (1, **Figure 6-116**) by loosening the hose clips. When loosening the clips, put a waste cloth or the like beneath the hose joints in case water leaks.
3. Loosen the bolt (5, **Figure 6-116**) fixing the EGR cooler outlet vent (4, **Figure 6-116**) to the cylinder block, and the bolt (7, **Figure 6-116**) fixing the EGR cooler to the exhaust manifold (6, **Figure 6-116**), then remove the EGR cooler along with the vent.

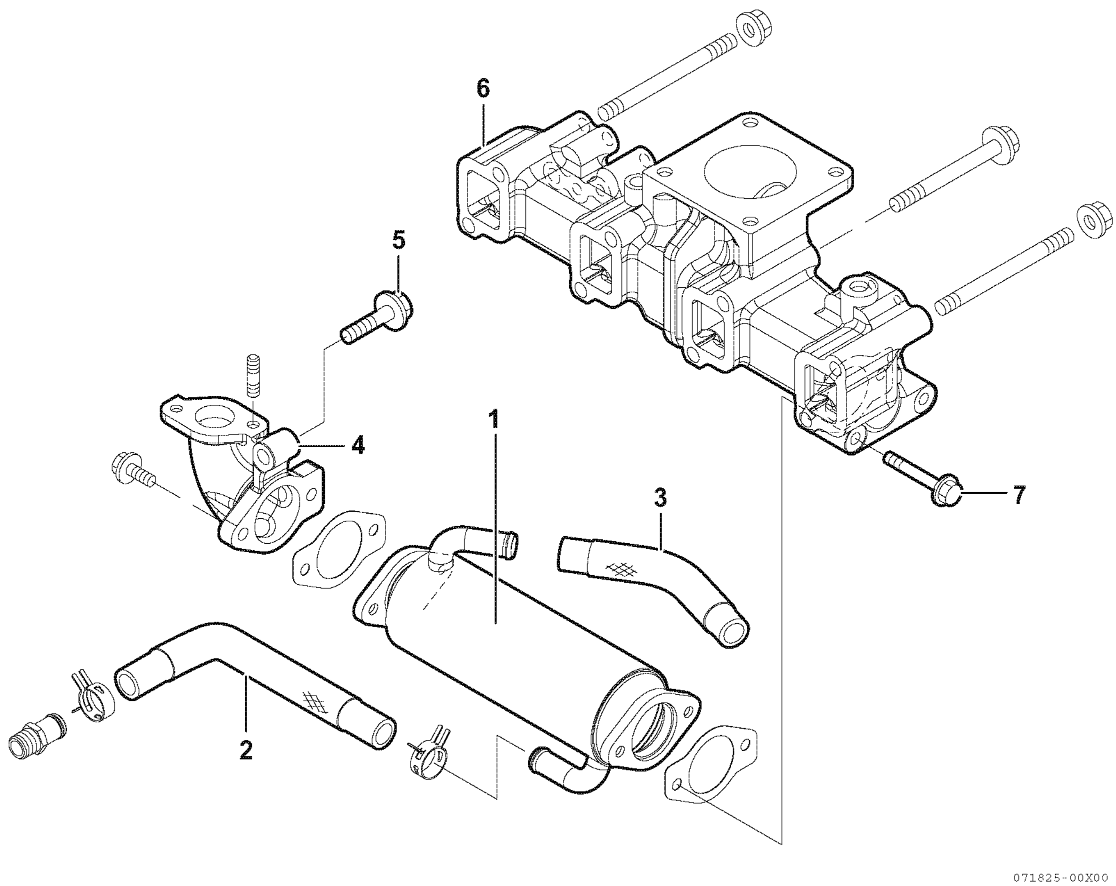
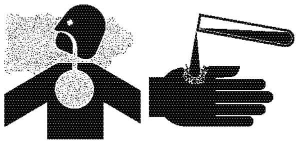


Figure 6-116

Check, Clean, and Test EGR Valve

⚠ WARNING

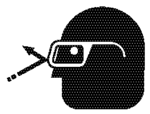
Fume/Burn Hazard!



- **Always read and follow safety related precautions found on containers of hazardous substances like parts cleaners, primers, sealants and sealant removers.**
- **Failure to comply could result in death or serious injury.**

⚠ CAUTION

Flying Object 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.**
- **Failure to comply may result in minor or moderate injury.**

Because the EGR valve is in a closed state when the engine key switch is off, in order to check, clean, and test the valve, connect the interface box to forcibly send signal from the ECU to fully open the EGR valve by SMARTASSIST-DIRECT (SA-D), as shown in **Figure 6-117**.

Therefore, when removing the EGR valve from the engine, leave the harness in a connected state.
If it is difficult to remove with the harness connected, disconnect the harness once, and then reconnect it after removing the EGR valve.

■ EGR active control

First connect the interface box to the engine harness via the connector cable, and then turn on SMARTASSIST-DIRECT (SA-D). Force open the EGR valve, and clean the vale.

- Before forcibly activating the EGR, check for errors that affect the fully closing process of the EGR. How to check: Press “Defect Display” and “Current Defect”. If the error is displayed, go to (1). If no error is displayed, go to (2).

(1)

- Select “Diagnostic Codes” and select “Defect History”
- Press “All Clear” button
- Error information is cleared from the “Defect History”

(2)

- Select “Diagnosis Tests” and select “Active Control”
- Press “Execute” button from “EGR Valve Opening Control”
- Enter the user ID and password
- When “EGR Valve Opening Control” is displayed, enter “106” in “Desired” and press “Set”
- Active control starts if no error is found

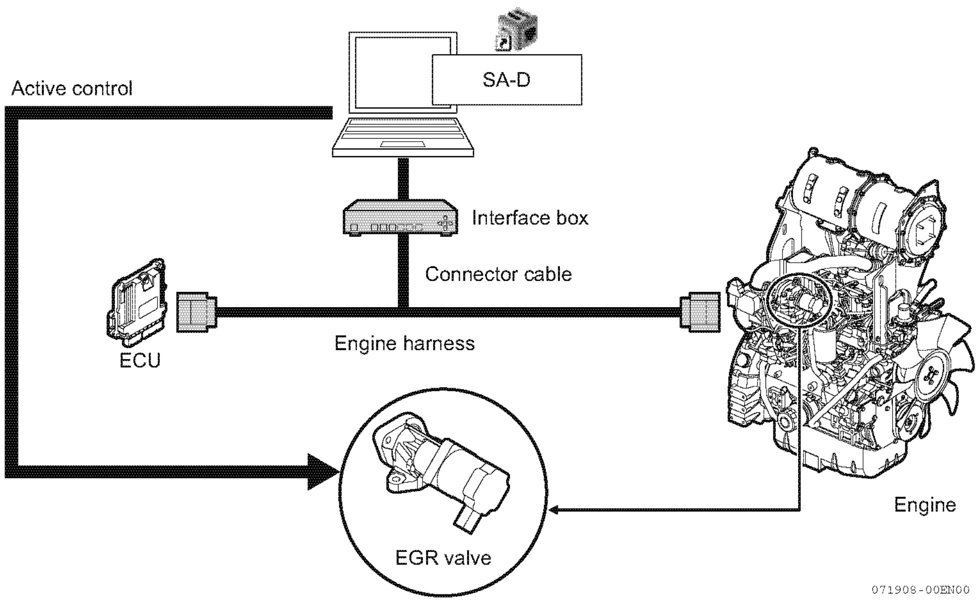


Figure 6-117

- Check that the desired value on the screen indicates the set target value. EGR valve opening control lamp comes on.

NOTICE

Do not end the SA-D while cleaning the EGR.

For details on how to operate the EGR Active Control, refer to the SMARTASSIST-DIRECT (SA-D) Operation Manual.

■ Cleaning the EGR valves

Cleaning the EGR valves only apply for engines without turbochargers. If the engine comes with a turbocharger, this cleaning is not necessary.

Clean the EGR valve every 3000 hours of operation to prevent carbon deposits. This leads to deterioration of EGR performance. Blow the carbon deposits with the compressed air (0.19 MPa (2 kg/cm^2) or less). Use a soft brush with carbon cleaner or kerosene to clean the EGR valve if the EGR valve is excessively dirty. Be sure to remove all carbon deposits. (**Figure 6-118**)

In this case, the motor portion and the coupler terminals should not be exposed to solvent or cleaner. This may result in a malfunction.

If the carbon deposits can not be removed by a brush, be sure to replace the entire EGR valve assembly.

Remove the remaining carbon deposits by blowing the compressed air. (**Figure 6-118**)

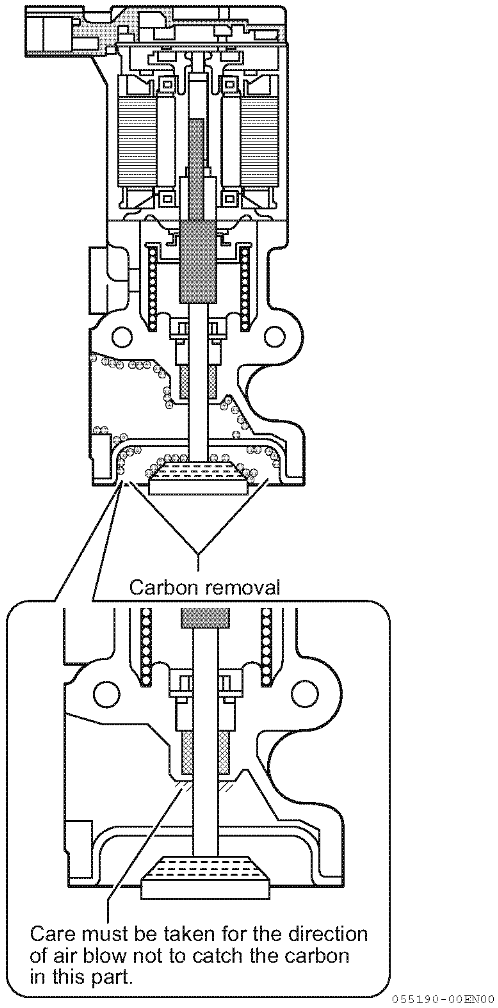


Figure 6-118

■ Exit the EGR active control

You can exit the EGR Active Control from the SMARTASSIST-DIRECT screen.

- Press the “Stop” button from “EGR Valve Opening Control”.
- EGR valve opening control lamp goes off and EGR Active Control exits.

■ Precautions for cleaning

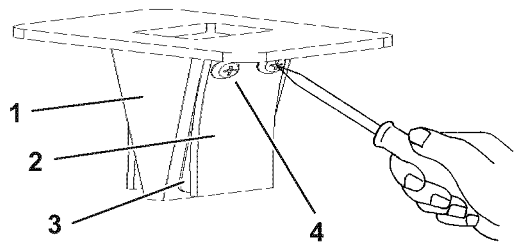
- Do not disassemble the EGR valve.
- Do not use wash fluid.
- Do not use a hard brush made of metal.
- Clean entire circumference of the valve and the valve seat, and blow with the compressed air.
- Do not put your fingers into the valve portion.

Clean EGR Lead Valves (only for engines with turbocharger)

It is not mandatory to clean the EGR lead valve, but if you do, follow the below steps.

Similarly to the EGR valves, the lead valves must be periodically cleaned every 3000 hours because, as exhaust gas circulates through them for a prolonged time, carbon is deposited on their inner surfaces, possibly deteriorating the EGR ratio.

To remove carbon deposited inside the lead valves, disassemble and clean them.



1 – Case
2 – Stopper
3 – Valve
4 – Machine screw

Figure 6-119

To remove deposited carbon, use carbon cleaner, kerosene, or some other liquid capable of removing carbon as well as a soft brush or cloth to clean the valves, taking care not to damage their parts.

Upon completion of carbon removal, wipe off water and liquid, make sure that the case, valve, and stopper are free of foreign matter, and then reinstall the valve and related parts.

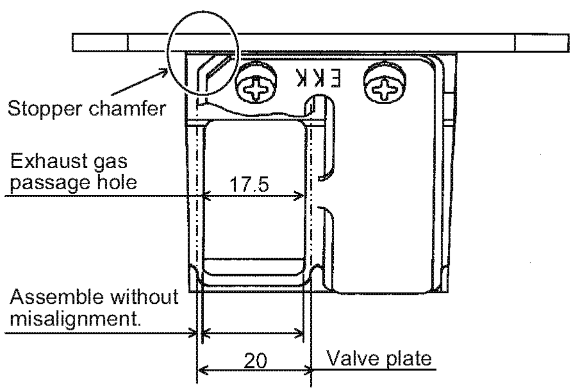


Figure 6-120

Precautions for Installation

1. The valve and stopper must be installed in their specific orientations. As shown in the figure above, install the valve and stopper so that they are located on the left-hand side of the lead valve.
2. Install the valve by tightening the machine screw while ensuring that it is evenly positioned inside the case window.
3. The machine screw must be tightened with torque of 1.37 ± 0.2 N·m (14 ± 2 kgf·cm).
4. After tightening the machine screw, mark it with a marker to indicate that it has already been tightened.

Clean EGR Cooler

The EGR cooler must be periodically cleaned every 3000 hours because the exhaust gas passage is subject to carbon deposition and the cooling water transit portion to scale deposition and these depositions gradually deteriorate the cooling of recirculated gas, thus resulting in higher gas temperatures and lower effective circulation amounts (EGR ratio).

To remove deposited carbon from the gas passage, use compressed air (0.19 MPa (2 kg/cm^2) or lower). Then dip the gas passage in carbon cleaner, kerosene, or some other liquid capable of removing carbon; leave it dry and blow it with compressed air again.

To clean the water transit portion, dip it in a solution of descaling detergent diluted with water and wash it.

EGR Pipe and Other Connecting Elbows

The exhaust gas passage is subject to carbon deposition when used over time. To remove deposited carbon from the gas passage, use compressed air (0.19 MPa (2 kg/cm^2) or lower). If the exhaust gas passage is heavily fouled, clean it by dipping it in carbon cleaner, kerosene, or some other liquid capable of removing carbon.

NOTICE

- Always be environmentally responsible.

- Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.
- Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.
- Failure to follow these procedures may seriously harm the environment.

Installing EGR Related Components/Parts

To assemble the EGR related units, install the following components/parts, by reversing the disassembly procedure described above: lead valve (only for engines with turbocharger), spacer, EGR valve, EGR pipe, EGR cooler, EGR cooler outlet vent, EGR cooler coolant hose, exactly in this order.

The EGR system uses steel gaskets at the joints between its components/parts. When you remove the system's components/parts and reinstall them, replace the steel gaskets between them with new correct ones.

INTAKE THROTTLE

The intake throttle is a device that controls the amount of the engine air intake. The TNV series engines use it for the combustion of soot collected inside the DPF. The intake throttle is driven by the DC motor. The ECU controls the appropriate degree of opening of the throttle depending on the engine speed and load conditions. Accordingly, the engine takes in the minimum required amount of air to increase the exhaust temperature and burn soot inside the DPF.

Check the operation performance of the intake throttle very 3000 hours of operation. It is necessary to connect SMARTASSIST-DIRECT for the EGR valve cleaning. For details, refer to the SMARTASSIST-DIRECT Operation Manual.

Precautions for Handling the Intake Throttle

- Do not use a throttle after you have dropped it. Even if it appears okay on the outside, it may have internal damage.
- Do not apply excessive impact or load to the throttle.
- Do not touch the stop screw part, as it has already been adjusted.
- Prevent any foreign matter including oil, dust, and water droplets from entering the air passage part.
- Do not remove the sensor cover installation rivet.
- Consider static electricity and prevent static electric charge of the human body when handling the throttle.
- Do not touch the sensor cover terminal directly.
- Do not touch the throttle valve with your hands when the throttle is energized.
  Your hands may get pinched in the valve and get injured.
- Do not check operation with the installation surface of the throttle unit pointing down, as the valve protrudes from the installation surface.
- Prevent water and foreign matter from entering the connector connection part.

Characteristics of the intake throttle

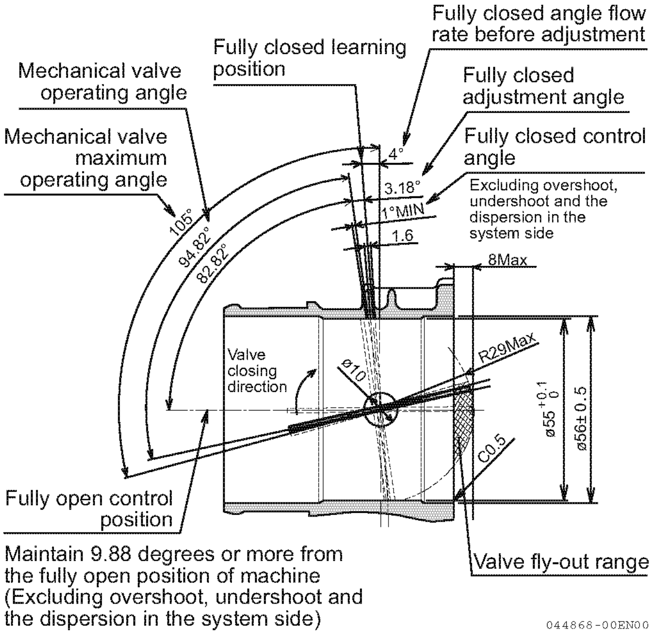


Figure 6-121

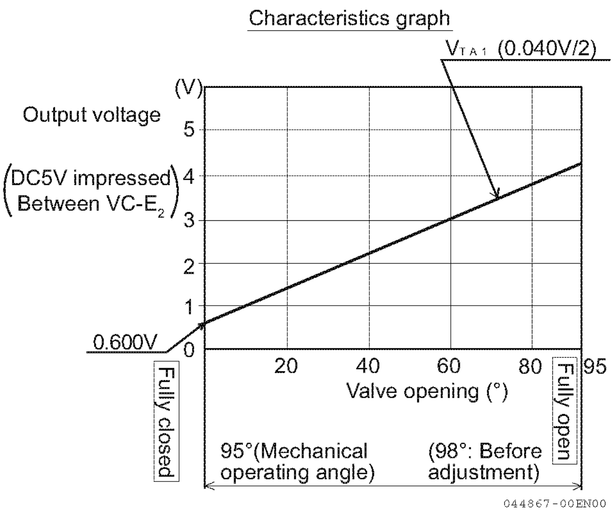


Figure 6-122

EXHAUST THROTTLE

The exhaust throttle adjusts the back pressure of the exhaust gas by the valve attached to the discharge port passage area of the exhaust manifold. This controls the exhaust temperature and assists the DPF regeneration. Exhaust throttle valve is driven by DC motors and it controls the valve according to the appropriate opening indicated by the ECU based on engine speed or fuel injection volume. Exhaust throttle valve is in a fully opened state during normal operation. (**Figure 6-123, Figure 6-124**)

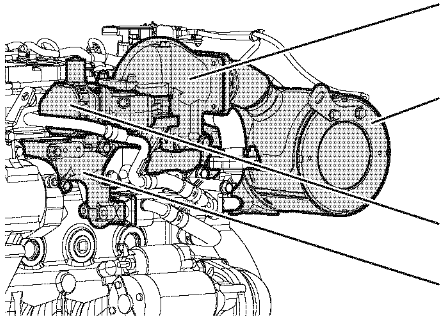


Figure 6-123

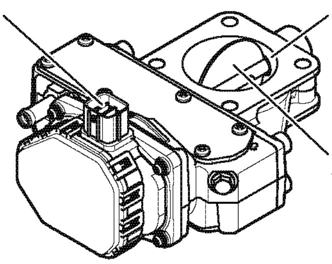


Figure 6-124

Checking the Operation of Exhaust Throttle

Check the operation of the exhaust throttle every 3000 hours. If an exhaust pipe is attached above the exhaust throttle (attached parts may vary among models), remove it before inspecting so that the exhaust throttle valve is exposed for inspection.

Connect and check the operation of the engine diagnosis tool, SMARTASSIST-DIRECT in the same manner as EGR valve active control. For operation procedures refer to the SMARTASSIST-DIRECT operating manual.

If valve operation is affected due to the exhaust passage contamination, clean the passage according to the following procedures:

1. Remove the connector of the electric signal.
2. Remove the exhaust throttle from the exhaust manifold. Make sure you do not damage the connector, flange surface, and valve when removing.
   A hose for cooling is attached to the exhaust throttle. If it is necessary to remove the hose for cleaning, put a waste cloth or the like beneath the pipings in case coolant spills.
3. Remove deposits from the exhaust passage and valve using an air blower, waste cloth, plastic scraper, or the like.
   Do not use an air blower or a high-pressure and high-temperature injection cleaning from a short distance, or do not immerse valves in cleaning fluids.
4. Do not disassemble the exhaust throttle body.
5. When installing the exhaust throttle, replace the gasket of the inlet and outlet sides with new ones.

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Section 7

FUEL SYSTEM

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety section on page 3-1*.

SYSTEM STRUCTURE

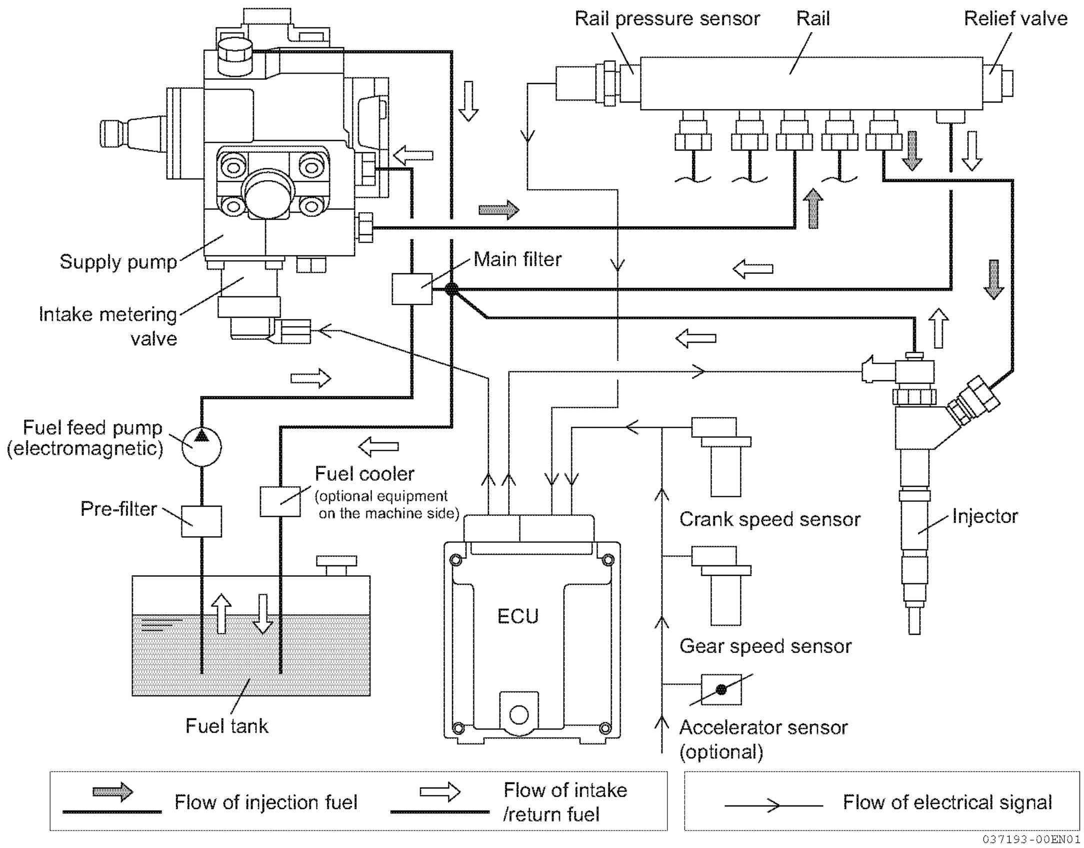


Figure 7-1

■ Supply pump

The fuel passes the pre-filter and is pressure-fed by a fuel feed pump to the main filter, then it arrives at the supply pump. The ECU controls the opening of the intake metering valve and adjusts the fuel intake volume so that the rail pressure is at the target value. The fuel pressurized in the supply pump is fed to the rail.

■ Rail

The pressure of maximum 160 MPa is accumulated in the rail. The rail pressure sensor is equipped with the rail and it sends information to the ECU. In the case of abnormal increase in the rail pressure, the mechanical relief valve (pressure limiter valve) opens to prevent the pressure increase (injection valve opening pressure; 205 $^{-100}$ MPa).

■ Injector

The ECU controls the injector to maintain optimum injection volume and injection timing, and injects the high-pressure fuel accumulated in the rail into the cylinder.

Each injector has its unique correction data to optimize the injection volume. The correction data can be found on the top of the injectors. The correction data is written to the ECU, and the ECU corrects the injection volume based on the correction data. Therefore, it is necessary to write the correction data to the ECU when the injector or ECU is replaced. For details, refer to the SMARTASSIST-DIRECT (SA-D) Operation Manual. Never touch the electric wiring with your hands when the key switch is in the “ON” position. High-voltage current flows in the injector.

■ Crank rotation sensor and gear speed sensor

The crank rotation sensor is equipped on the flywheel side and the gear speed sensor is equipped on the gear side. Based on these 2 sensor outputs, the ECU recognizes the engine speed and each piston position.

■ ECU

Based on the information from each sensor, ECU determines optimum injection volume, injection timing and rail pressure, and controls the intake metering valve of the supply pump and injector. It also monitors the occurrence of system abnormality at all times. If an abnormality is detected, it notifies the operator and controls the safe running condition of the system.

FUEL SYSTEM SPECIFICATIONS

Torque Chart for Major Bolts and Nuts

Component	Thread diameter and pitch	Tightening torque	Lubricating oil application (Thread portion and seat surface)
Fuel injector retainer bolt	M8 × 1.25 mm	18.0 - 20.9 ft·lb (24.4 - 28.4 N·m; 2.5 - 2.9 kgf·m)	Not applied
Supply pump drive gear nut	M18 × 1.5 mm	55.3 - 62.7 ft·lb (75 - 85 N·m; 7.6 - 8.7 kgf·m)	Not applied
Fuel high-pressure pipe nut	M12 × 1.5 mm (Rail)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)	Not applied
	M12 × 1.5 mm (Injector)	19.5 - 23.2 ft·lb (26.5 - 31.4 N·m; 2.7 - 3.2 kgf·m)	Not applied
	M16 × 1.0 mm (Supply pump)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)	Not applied
Ball joint bolt	M8	9.4 - 12.3 ft·lb (12.7 - 16.7 N·m; 1.3 - 1.7 kgf·m)	Not applied
	M10	14.5 - 18.7 ft·lb (19.6 - 25.4 N·m; 2.0 - 2.6 kgf·m)	Not applied
	M12	18.1 - 25.3 ft·lb (24.5 - 34.3 N·m; 2.5 - 3.5 kgf·m)	Not applied
	M14	28.9 - 36.1 ft·lb (39.2 - 49.0 N·m; 4.0 - 5.0 kgf·m)	Not applied
	M16	36.1 - 43.4 ft·lb (49.0 - 58.8 N·m; 5.0 - 6.0 kgf·m)	Not applied
Hexagon bolt (7T) and nut	M6 × 1.0 mm	7.2 - 8.7 ft·lb (9.8 - 11.8 N·m; 1.0 - 1.2 kgf·m)	• Apply 80 % torque when tightened to aluminum alloy. • Apply 60 % torque for 4T and check nut.
	M8 × 1.25 mm	16.6 - 20.9 ft·lb (22.6 - 28.4 N·m; 2.3 - 2.9 kgf·m)	
	M10 × 1.5 mm	32.5 - 39.8 ft·lb (44.1 - 53.9 N·m; 4.5 - 5.5 kgf·m)	
	M12 × 1.75 mm	57.8 - 72.3 ft·lb (78.4 - 98 N·m; 8.0 - 10.0 kgf·m)	

FUEL SYSTEM DIAGRAM

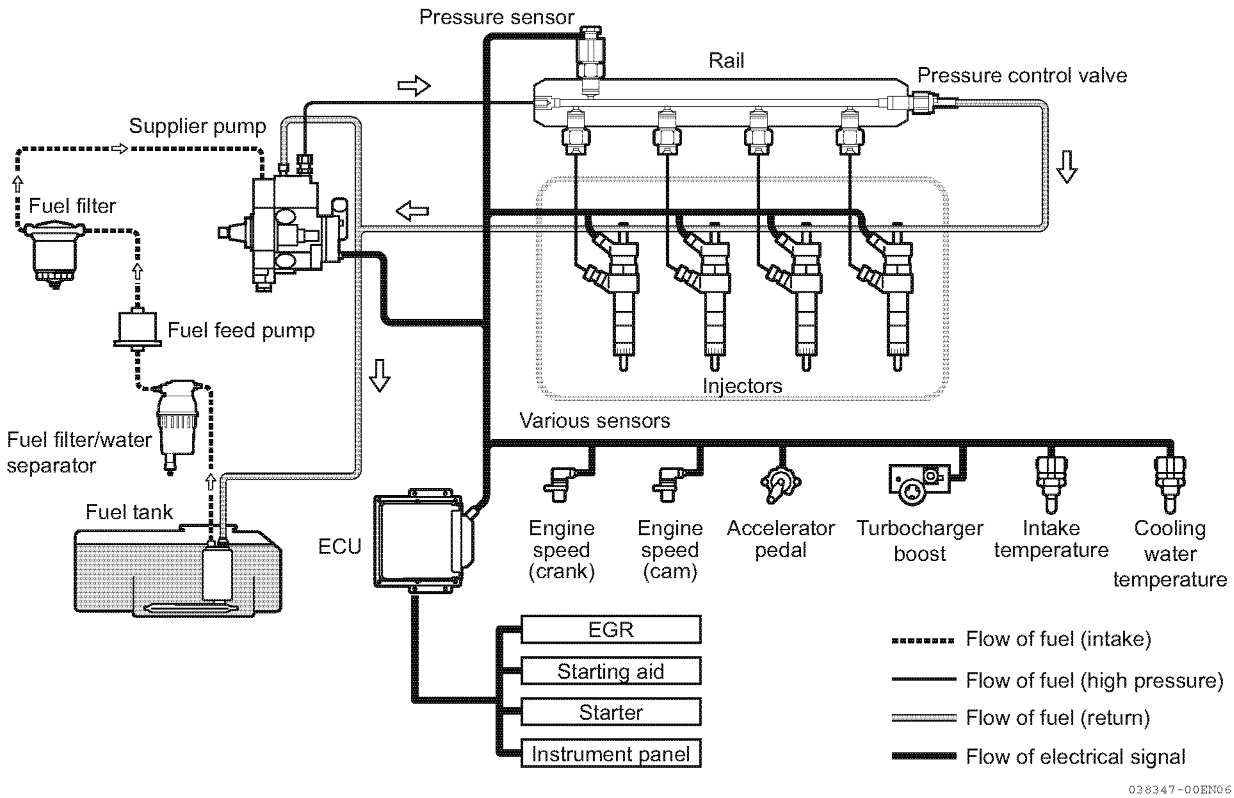
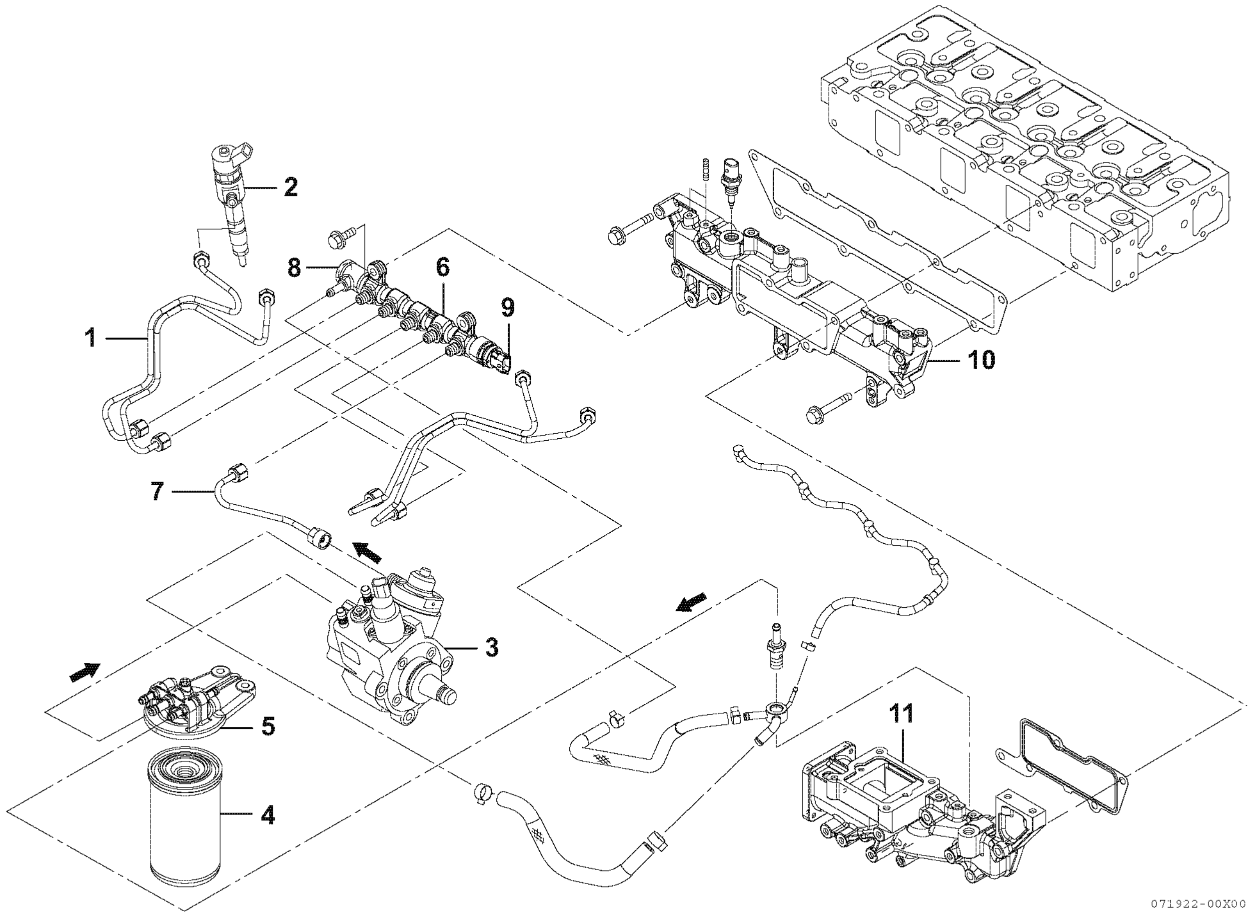


Figure 7-2

FUEL SYSTEM COMPONENTS



1 – High-pressure fuel injection lines (Common rail - Injector)
2 – Fuel injector
3 – Supply pump
4 – Fuel filter
5 – Fuel filter bracket
6 – Common rail
7 – High-pressure fuel injection lines (Supply pump - Common rail)
8 – Pressure limiter valve
9 – Pressure sensor
10 – Intake manifold
11 – Collector

Figure 7-3

Removal of Injector

1. If there is any additional equipment such as a intake duct (for engines with turbocharger) or electric wiring stay above the injectors, remove it in advance.
2. Remove the coupler (1, **Figure 7-4**) from the upper part of the injectors and place them aside.

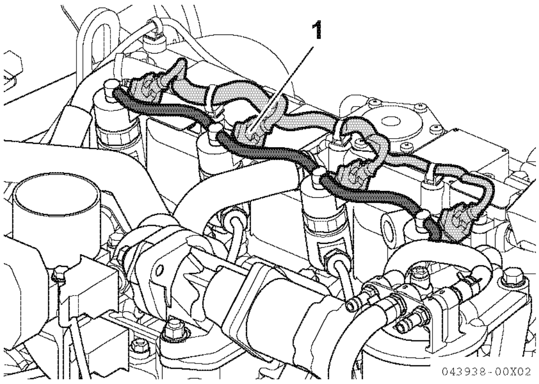


Figure 7-4

3. Remove the fuel return hose (1, **Figure 7-5**) from the injector. Pull out the fuel return hose connector (back leak rail connector) (2, **Figure 7-6**) vertically while fully pressing the retaining ring (clip) (1, **Figure 7-6**) attached on the top of the injector in the direction of the arrow A (**Figure 7-6**). Do not hold the hose. This may damage the hose. Do not reuse the removed clips.

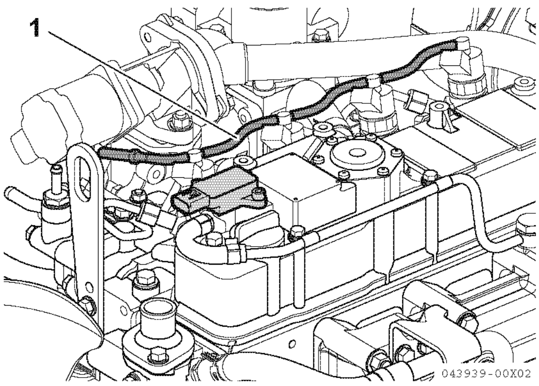


Figure 7-5

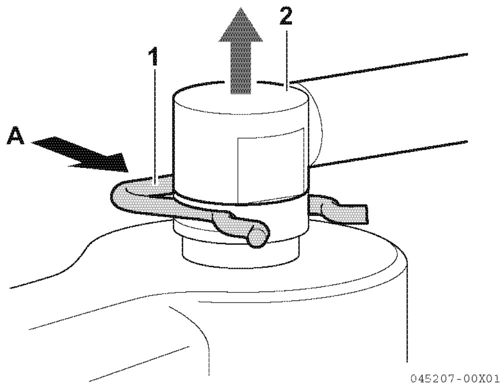


Figure 7-6

4. Removing the high-pressure fuel injection lines (Injector - Common rail)
   1- Clean around the cap nuts on both the injector and rail sides, using a brush or aspirator. (**Figure 7-7**)

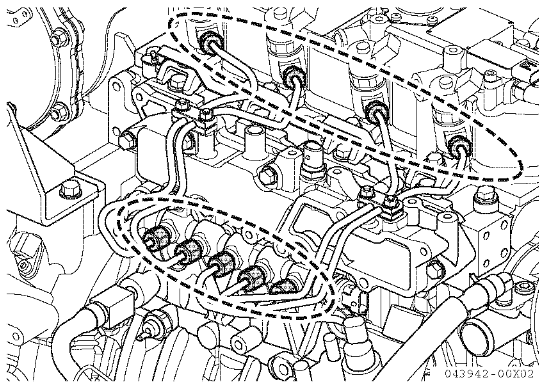


Figure 7-7

   2- Loosen the cap nut (4, **Figure 7-8**) of the high-pressure pipe (2, **Figure 7-8**) on the injector side. Here, loosen the cap nut held with a spanner (1, **Figure 7-8**) or the like to prevent the inlet connector (3, **Figure 7-8**) from rotating together.

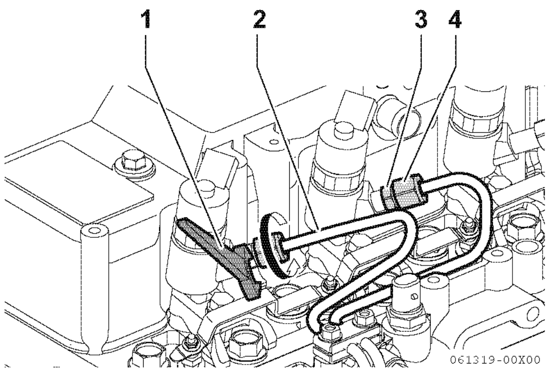


Figure 7-8

3- Loosen the cap nut (1, **Figure 7-7**) of the high-pressure pipe on the common rail side in the same manner.

4- Loosen and remove the cap nut by hand while pushing the high-pressure pipe on both injector side and rail side against the mounting surfaces.

5- Remove the high-pressure pipe.

6- Cover the sheet part of the high-pressure pipe on the injector side of which the high-pressure pipe is removed with plastic bags after cleaning the part using a vacuum or the like.

5. Loosen the injector fixture retainer bolt (1, **Figure 7-9**) (M8), and remove the retainer (2, **Figure 7-9**).
6. Remove the injector (3, **Figure 7-9**) and injector seats (gaskets) (4, **Figure 7-9**).

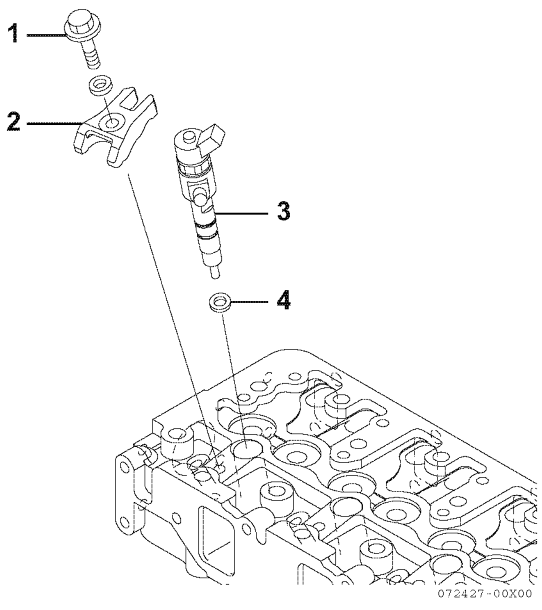


Figure 7-9

NOTICE

- Do not reuse the injector seats (gaskets).
- Separate the injectors by each cylinder (mark them).
- Clean the removed injectors and cover them with a vinyl bag.
- Never disassemble the injector. If you change the injector to the new one must be changed with whole injector.

Reassembly of injector

1. Reassembly of injector
   Insert the injector into the head by using the new injector seat (gasket).

NOTICE

- If you reuse the injector, be sure to reinstall it to the original cylinder.
- When replacing the injector, replace it in the assembly.
- If you replace the injector, it is required to write the correction value of each injector to E-ECU.
- If rewriting is not correctly done, the engine performance cannot be guaranteed.
- Rewrite the correction value using SMARTASSIST-DIRECT (SA-D).
- The correction value is written on the injector.

2. Reassembly of injector fixture retainer

   1- Reinstall the injector fixture retainer. Temporarily tighten the bolt by hand at this time.

3. Reassembly of high-pressure fuel injection lines (Injector - Common rail)

CAUTION

For high-pressure pipe, use a new one. If you reuse it, the displacement of the working face may occur, causing the fuel to leak.

1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.

2- Temporarily tighten the clamp of the high-pressure pipe.

3- Be sure to fit and fix the high-pressure pipe on the injector side to the sheet part by hand, and temporarily tighten the cap nut by hand.

4- Next, securely fit the high-pressure pipe on the rail side to the sheet part by hand, and temporarily tighten the cap nut so as to rotate smoothly by hand.

5- Fully tighten the clamp.

4. Tighten the injector fixture retainer bolt to specification.

Tightening torque for M8 bolts	18.0 - 20.9 ft·lb (24.4 - 28.4 N·m; 2.5 - 2.9 kgf·m)

5. Tighten the cap nut of the high-pressure pipe with a predetermined torque while holding the inlet connector on the injector side using a spanner or the like.
6. Tighten the cap nut of the high-pressure pipe on the rail side with a predetermined torque.

Tightening torque for cap nuts (injector side)	19.5 - 23.2 ft·lb (26.5 - 31.4 N·m; 2.7 - 3.2 kgf·m)
Tightening torque for cap nuts (rail side)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)

7. Reinstall the fuel return pipe.
   Push the connector vertically with the retaining ring (clip) of the injector pushed in the direction of arrow A. Here, apply diesel oil to the O-ring at the mounting area of the connector to prevent it from being worn. (Do not use lubricating oil since it contains metal composition such as zinc.)

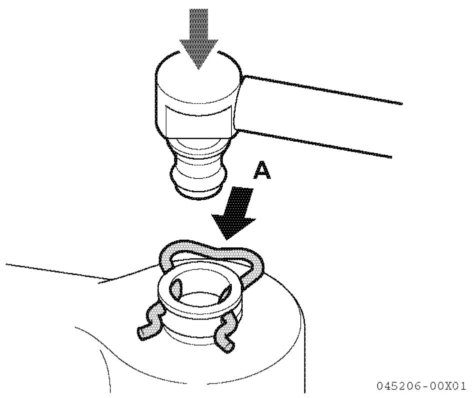


Figure 7-10

8. Reinstall the injector wiring coupler.

NOTICE

- If you replace the injector, it is required to write the correction value of each injector to E-ECU.
- If rewriting is not correctly done, the engine performance cannot be guaranteed.
- Rewrite the correction value using YANMAR Diagnostic Tool, SMARTASSIST-DIRECT (SA-D).
- The correction value is written on the injector.
- If the correction value of the injector is not correctly written, not only the engine performance cannot be guaranteed, but the engine may also not comply with emission control regulations.

Removal of Common Rail

1. Removal of high-pressure fuel injection lines
   The procedure for removal of high-pressure pipe between the injector and common rail is as the same procedure as removal of injectors. However, it is not necessary to remove the wiring coupler above the injectors and the fuel return line when removing the common rail. Follow the same procedure to remove the high-pressure fuel injection line between the common rail and the supply pump.
2. Remove the leak piping (2, **Figure 7-11**) from the pressure limiter (1, **Figure 7-11**).

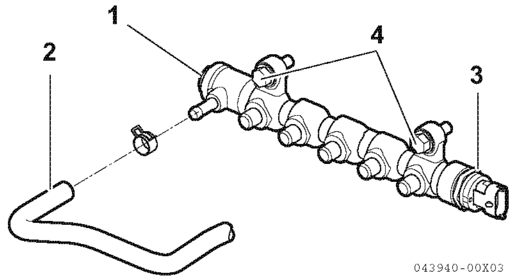


Figure 7-11

3. Remove the wiring coupler of the pressure sensor (3, **Figure 7-11**).
4. Removal of common rail
   Remove the 2 pieces of M8 (4, **Figure 7-11**) bolts that attach the common rail, and remove the rail body.

NOTICE

- Loosen the bolts while securely holding the rail body by hand not to drop it.
- Hold the rail body without touching the sensors.

Reassembly of Common Rail

1. Reassembly of common rail body
   Temporarily tighten the 2 pieces of M8 bolts by hand while securely holding the common rail body by hand. Then, tighten the bolts to specification.

Tightening torque for M8 bolts	16.7 - 20.9 ft·lb (22.6 - 28.4 N·m; 2.3 - 2.9 kgf·m)

2. Installing the high-pressure fuel injection lines (1) (Common rail - injector)

⚠ CAUTION

For high-pressure pipe, use a new one. If you reuse it, the displacement of the working face may occur, causing the fuel to leak.

1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.
2- Temporarily tighten the clamp of the high-pressure pipe.
3- Be sure to fit and fix the high-pressure pipe on the injector side to the sheet part by hand, and temporarily tighten the cap nut by hand.
4- Next, securely fit the high-pressure pipe on the rail side to the sheet part by hand, and temporarily tighten the cap nut so as to rotate smoothly by hand.
5- Fully tighten the clamp.
6- While holding the inlet connector of the injector side using a spanner or other tool, tighten the cap nut to the specified torque.
7- Finally tighten the cap nut of the rail side to the specified torque.

Tightening torque for cap nut (injector side)	19.5 - 23.2 ft·lb (26.5 - 31.4 N·m; 2.7 - 3.2 kgf·m)
Tightening torque for cap nut (rail side)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)

3. Installing the high-pressure fuel injection lines (2) (Supply pump - common rail)

⚠ CAUTION

For high-pressure pipe, use a new one. If you reuse it, the displacement of the working face may occur, causing the fuel to leak.

1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.
2- Next, securely fit the high-pressure pipe both on the pump side and rail side to the sheet part by hand, and temporarily tighten the cap nut so as to rotate smoothly by hand.
3- Tighten the cap nuts to specification.

Tightening torque for cap nut (rail side)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)
Tightening torque for cap nut (pump side)	

4. Reinstall the leak piping from the pressure limiter.

NOTICE

Do not reuse the gaskets.

5. Reinstall the wiring coupler of the pressure sensor.
6. Replace attached parts of the rail
   Spare parts for the rail pressure sensor (1, **Figure 7-12**) and the pressure limiting valve (2, **Figure 7-12**) are available for replacement. See the below table for the part number and the tightening torque.

Part name	Part No.	Tightening torque
Rail pressure sensor	129A00-57100	66.4 - 73.8 ft·lb (90 - 100 N·m; 9.2 - 10.2 kgf·m)
Pressure limiting valve (with O-ring)	129A00-57200	70.1 - 77.4 ft·lb (95 - 105 N·m; 9.7 - 10.7 kgf·m)
O-ring for pressure limiting valve	129A00-57210	–

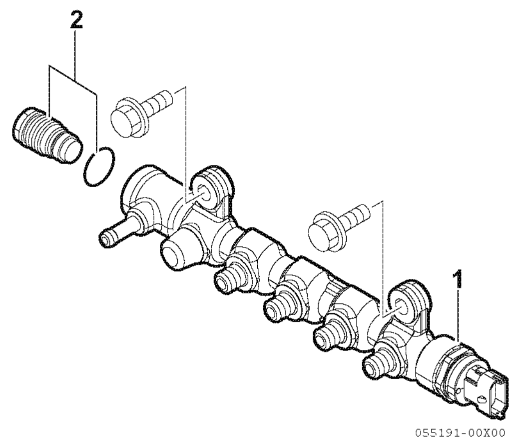


Figure 7-12

Removal of Supply Pump

1. Remove the wiring coupler of the fuel pressure sensor.
2. Remove the wiring coupler of the suction control valve (SCV).
3. Remove the fuel supply pipe (supply pump inlet) from the fuel filter (supply pump intake).

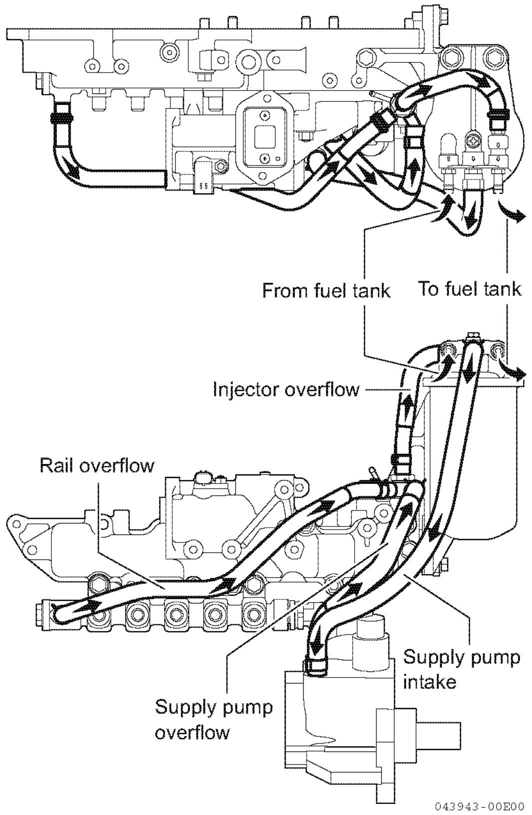


Figure 7-13

NOTICE

The fuel in the pipe may possibly spill at this time. Prepare a fuel container before its removal.

4. Remove the fuel return pipe (supply pump outlet) to the fuel filter (supply pump overflow).
5. Remove the return pipes from the common rail and injector (rail overflow and injector overflow).

NOTICE

Do not reuse either gasket.

6. Remove the fuel filter together with the mounting base from the engine as required.
7. Removal of high-pressure pipe (Supply pump - common rail)
   1- Clean around the cap nuts on both the pump and rail sides, using a brush or aspirator.
   2- While pressing and holding the pipes of the rail and pump sides respectively against the bearing surface by hand, loosen the cap nut using a tool.
   3- After that, while pressing the pipes of the rail and pump sides respectively against the bearing surface by hand, loosen and remove the cap nut by hand.
   4- Remove the high-pressure pipe.
   5- Clean the removed seat portions of the rail inlet with an aspirator or the like and cover them with a vinyl bag.
8. Remove the supply pump cover (drive gear) of the gear case.
9. Remove the supply pump drive gear nut (M18).

NOTICE

Be sure to put an alignment mark between the supply pump drive gear and the idle gear. Do not rotate the crankshaft of the engine after putting the mark.

10. Extract the supply pump drive gear by using the gear extraction tool.

NOTICE

Be sure to use the gear extraction tool.

11. Remove the supply pump nut (M8 - 3 pieces), and remove the supply pump.

NOTICE

- Never disassemble the supply pump.
- If you change the supply pump to the new one must be changed with whole pump.

Reassembly of Supply Pump

1. Reassembly of supply pump body
   Align the position of the supply pump drive shaft key (pin) to the drive gear position, and reinstall the supply pump to the gear case.

   Reinstall the supply pump with the 3 pieces of M8 nuts.

NOTICE

Be sure to apply oil to the O-ring at the time of installation so that is does not roll up.

Tightening torque for M8 nuts	16.7 - 20.9 ft·lb 22.6 - 28.4 N·m (2.3 - 2.9 kgf·m)

2. With the special M18 nuts, reinstall the supply pump drive gear to the supply pump drive shaft.

Tightening torque for M18 nut	55.3 - 62.7 ft·lb 75 - 85 N·m (7.7 - 8.7 kgf·m)

NOTICE

Make sure that the alignment mark with the idle gear is not misaligned.

NOTICE

Make sure that painting does not get into the coupler while reinstalling the coupler.

3. Reinstall the supply pump cover

Tightening torque for M8 bolts	16.7 - 20.9 ft·lb 22.6 - 28.4 N·m (2.3 - 2.9 kgf·m)

4. Reassembly of high-pressure pipe
   (Supply pump - common rail)

⚠ CAUTION

For high-pressure pipe, use a new one. If you reuse it, the displacement of the working face may occur, causing the fuel leaks.

1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.

2- Securely seat and fix the pipes of the pump and rail sides respectively on the seat part by hand, and temporarily tighten the cap nut so as to rotate smoothly by hand.

3- Tighten the cap nuts to specification.

Tightening torque for cap nuts (rail side)	21.7 - 25.3 ft·lb (29.4 - 34.3 N·m; 3.0 - 3.5 kgf·m)
Tightening torque for cap nuts (pump side)	

5. Reinstall the fuel filter (M10 - 2 pieces).

Tightening torque for M10 bolts	25.8 - 31.7 ft·lb 35 - 43 N·m (3.6 - 4.4 kgf·m)

6. Reinstall the common rail and the return pipe from the injector.
7. Reinstall the return pipe from the supply pump.
8. Reinstall the fuel supply pipe (supply pump inlet) from the fuel filter.
9. Reinstall the wiring coupler of the fuel temperature sensor.
10. Reinstall the wiring coupler of the SCV.

NOTICE

Be sure to perform priming the engine before starting. If air is mixed to the fuel, seizure to the supply pump and the injector may result.

11. Replace attached parts of the supply pump
    Spare parts for the fuel temperature sensor (1, **Figure 7-14**) and the fuel metering valve (suction control valve) (2, **Figure 7-14**) are available for replacement. See the below table for the part number and the tightening torque.

Part name	Part No.	Tightening torque
Fuel temperature sensor (with gasket)	129A00-51200	19.2 - 22.1 ft·lb (26 - 30 N·m; 2.7 - 3.1 kgf·m)
Fuel metering valve (suction control valve) (with seal ring and O-ring)	129A00-51100	2.2 - 3.0 ft·lb (3.0 - 4.0 N·m; 0.31 - 0.41 kgf·m)
Fuel metering valve seal ring	129A00-51110	–
Fuel metering valve O-ring	129A00-51120	–
Fuel metering valve fixing bolt	129A00-51130	–

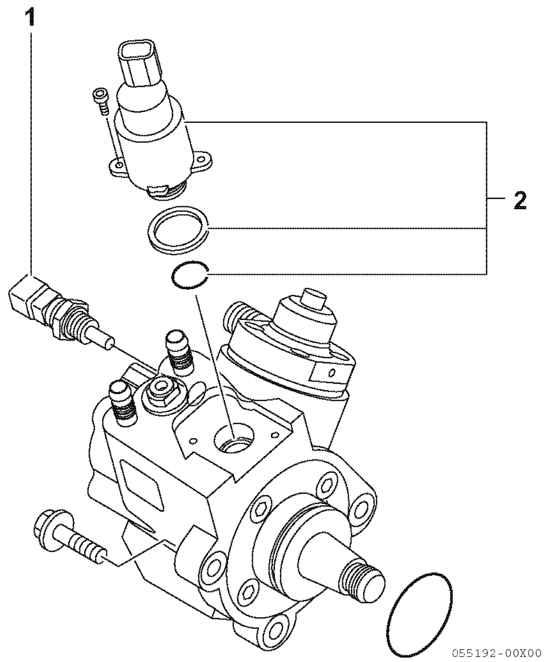


Figure 7-14

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Section 8

COOLING SYSTEM

Page

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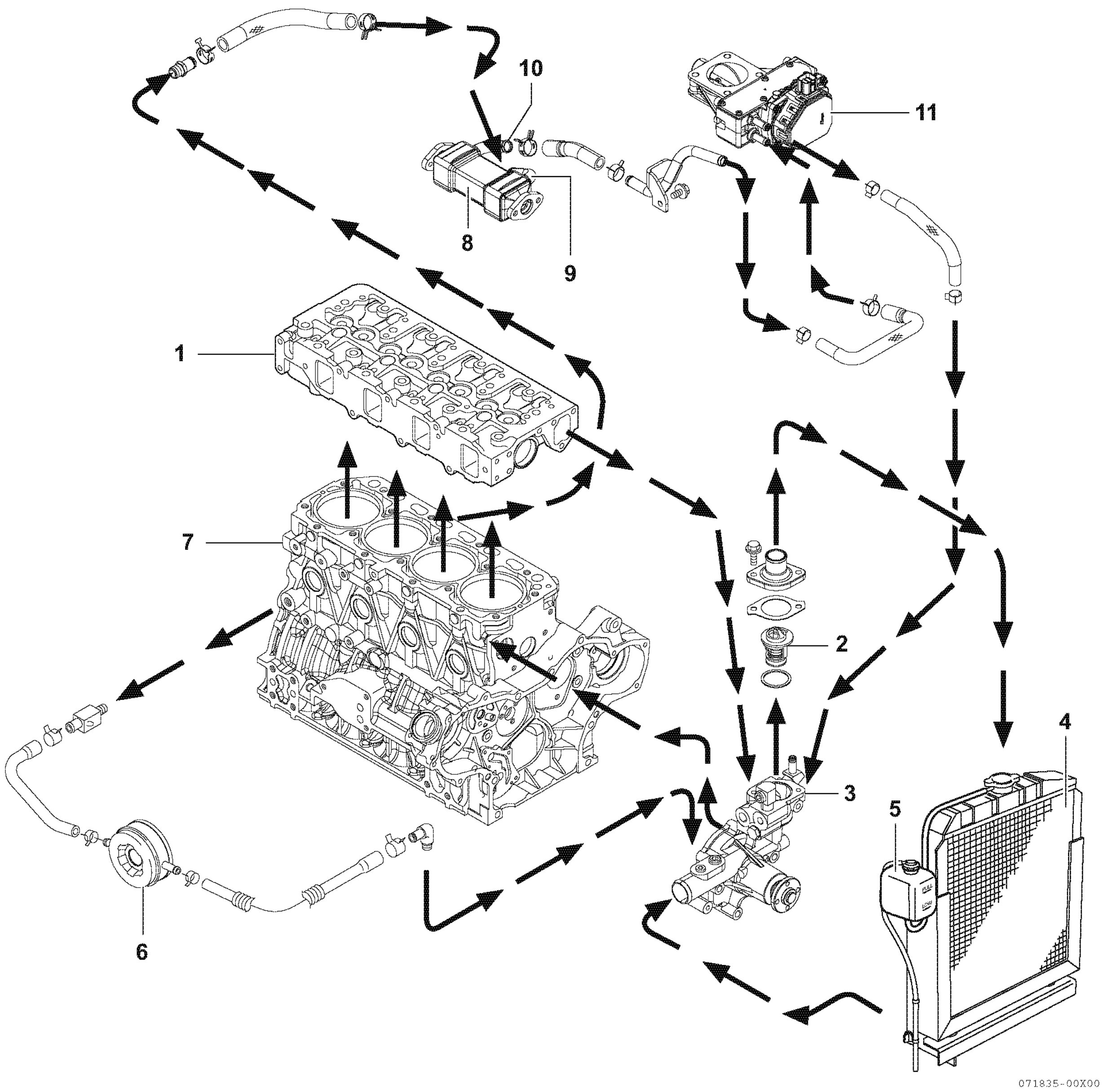
BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual describes the procedures necessary to service the TNV engine coolant pump. This engine coolant pump is representative of the coolant pumps used on other TNV model engines. For specific part detail, see the parts catalog for the engine you are working on.

COOLING SYSTEM DIAGRAM

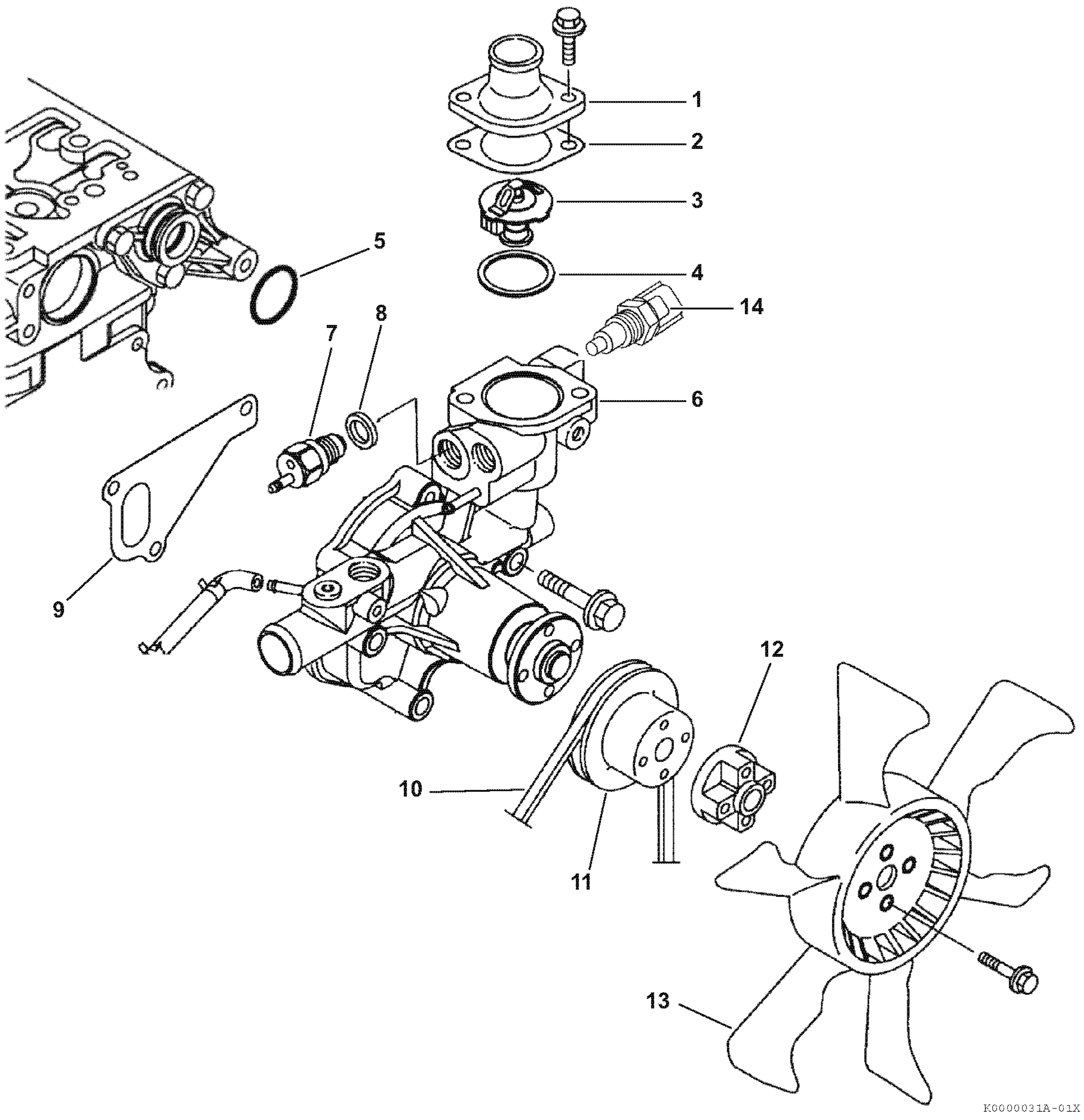


1 – Cylinder head
2 – Thermostat
3 – Engine coolant pump
4 – Radiator
5 – Coolant recovery tank
6 – Engine oil cooler*1
7 – Cylinder block
8 – EGR cooler
9 – EGR cooler inlet side hose
10 – EGR cooler outlet side hose
11 – Exhaust throttle*2

Figure 8-1

**1: Not standard on all models.*
**2: Equipped to some of the engines.*

ENGINE COOLANT PUMP COMPONENTS



1 – Thermostat cover
2 – Thermostat cover gasket
3 – Thermostat
4 – Thermostat O-ring
5 – Special O-ring
6 – Engine coolant pump
7 – Temperature switch
8 – Gasket
9 – Engine coolant pump gasket
10 – V-belt
11 – Engine coolant pump V-pulley
12 – Spacer
13 – Engine coolant fan
14 – Water temperature sensor (Electronically controlled engine)

Figure 8-2

ENGINE COOLANT SYSTEM CHECK

Check the engine coolant system for leakage.

1. With the radiator properly filled, install a cooling system tester (1, **Figure 8-3**).
2. Apply 10.8 - 14.8 psi (75 - 105 kPa; 0.75 - 1.05 kgf/cm^2) to the cooling system. If the pressure reading drops, the engine coolant system is leaking. Identify the source of the leak and repair it.

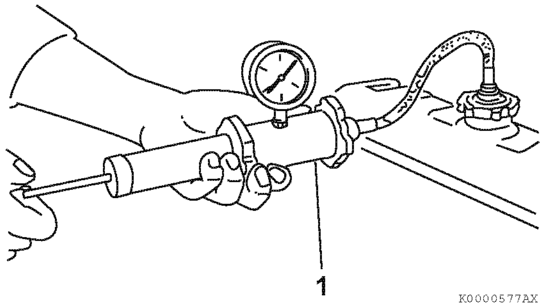


Figure 8-3

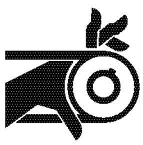
ENGINE COOLANT PUMP

Removal of Engine Coolant Pump

Verify the condition of the engine coolant pump before disassembling it from the engine. Check the engine coolant pump shaft bearing for abnormal noise, sticking, excessive play and water leakage. Replace the coolant pump if any of these conditions are present.

⚠ CAUTION

Pinch Hazard!



Carefully rotate the alternator toward the cylinder block while loosening the V-belt. Failure to comply may result in minor or moderate injury.

NOTICE

If the engine coolant pump must be replaced, replace the engine coolant pump as an assembly only. Do not attempt to repair the engine coolant pump or replace individual components.

NOTICE

Make sure the engine and engine coolant are not hot.

---

1. Before removing the engine coolant pump or thermostat, it will be necessary to drain the engine coolant. Drain the coolant into a clean container if the coolant is to be reused. Otherwise, properly dispose of the coolant.
2. Remove the radiator cap (1, **Figure 8-4**).
3. Remove the drain plug or open the drain valve (2, **Figure 8-4**)) at the lower portion of the radiator and drain the coolant.

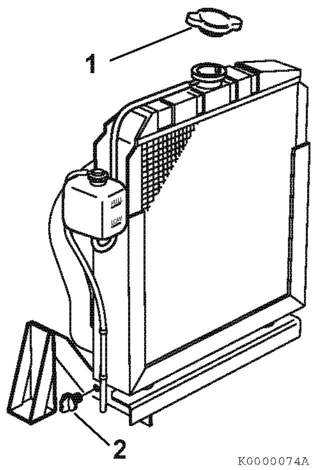


Figure 8-4

4. Drain the coolant from the engine block.
   - On models equipped with an oil cooler, remove the coolant hose (1, **Figure 8-5**) at the oil cooler.

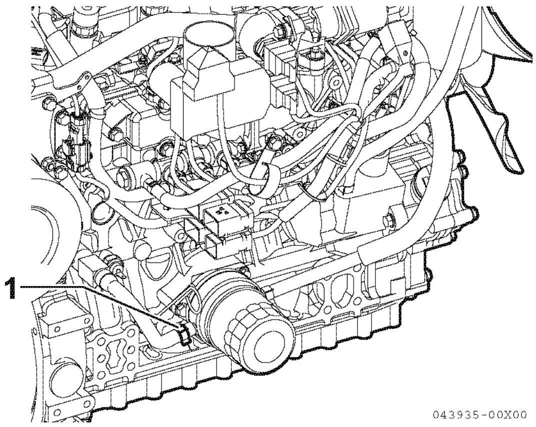


Figure 8-5

   - On models not equipped with an oil cooler, remove the coolant drain plug (1, **Figure 8-6**) from the engine block.

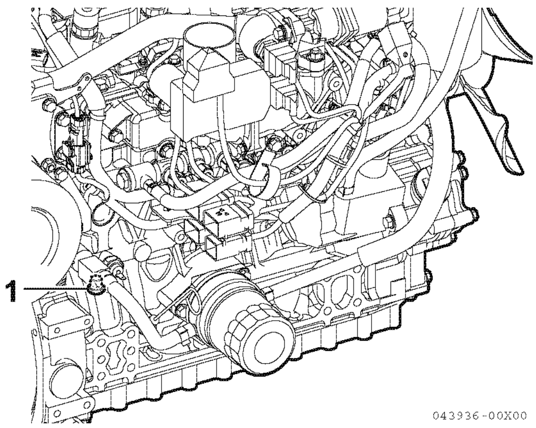


Figure 8-6

5. Loosen the alternator mounting bolts. Loosen and remove the V-belt and rotate the alternator away from the engine and out of the way.
6. Remove the engine coolant fan guard (if equipped), engine coolant fan (1, **Figure 8-7**), spacer (2, **Figure 8-7**) and engine coolant pump V-pulley (3, **Figure 8-7**).

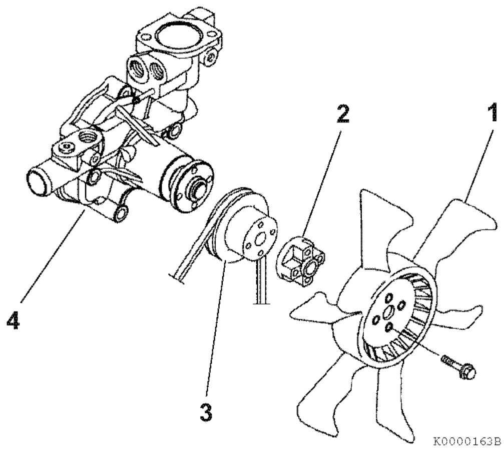


Figure 8-7

7. Disconnect the coolant hoses and the temperature switch lead wire from the engine coolant pump.
8. Remove the engine coolant pump (4, **Figure 8-7**). Discard the gasket.

Disassembly of Engine Coolant Pump

1. Remove the thermostat cover (1, **Figure 8-8**). Discard the gasket.

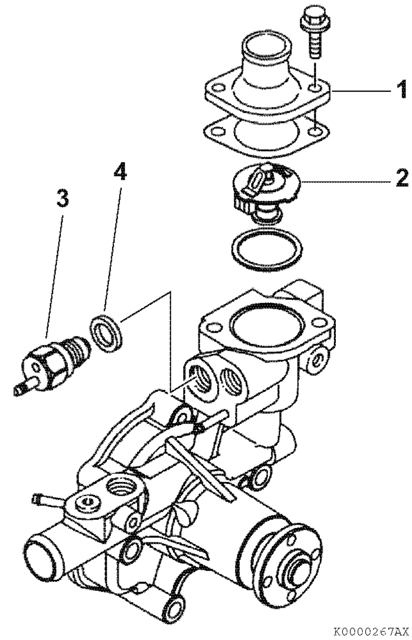


Figure 8-8

2. Remove the thermostat (2, **Figure 8-8**). Discard the O-ring. Remove the temperature switch (3, **Figure 8-8**) and gasket (4, **Figure 8-8**). Discard the gasket.

Cleaning and Inspection

■ Temperature switch

1. Check for proper operation of the temperature switch. Connect a continuity light or ohmmeter to the temperature switch. Connect one lead to the terminal of the switch (1, **Figure 8-9**) and the other lead to the metal portion of the switch (2, **Figure 8-9**).

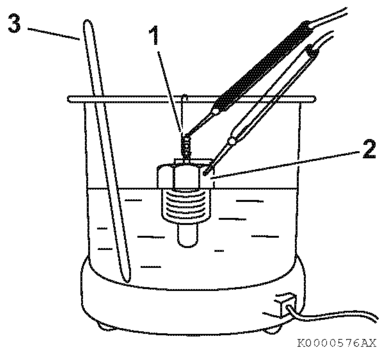


Figure 8-9

2. Place the temperature switch and an accurate thermometer (3, **Figure 8-9**) in engine coolant.
3. Slowly increase temperature of the fluid using an external heat source.
4. The temperature switch is operating properly if the continuity light or ohmmeter indicates continuity when the fluid temperature reaches 225 °F - 235 °F (107 °C - 113 °C).

■ Water temperature sensor

1. Inspect the water temperature sensor to make sure that it is properly operating. As shown in the following figure, connect an electric resistor to the coupler of the water temperature sensor (1, **Figure 8-10**).

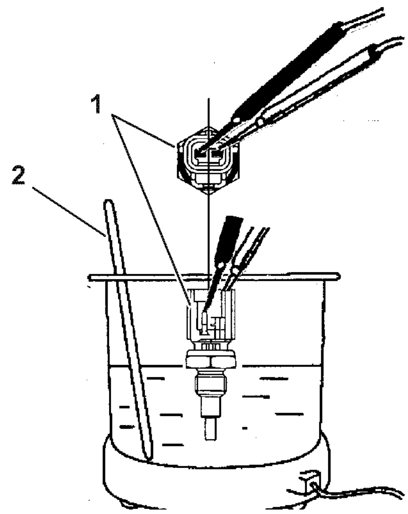


Figure 8-10

2. Dip the water temperature sensor and an accurate thermometer (2, **Figure 8-10**) into the cooling water.
3. Measure the electric resistance value while slowly raising the cooling water temperature using an external heat source.
4. The resistance value at each of the following temperatures is within the permissible range specified, the water temperature sensor is correctly operating.

Cooling water temperature (°C)	Resistance (kΩ)
20	$2.45^{+0.14}_{-0.13}$
80	0.318 ± 0.008
100	(0.1836)

■ Thermostat

1. Check for proper operation of the thermostat. Place the thermostat (1, **Figure 8-11**) and an accurate thermometer (2, **Figure 8-11**) in warm water.

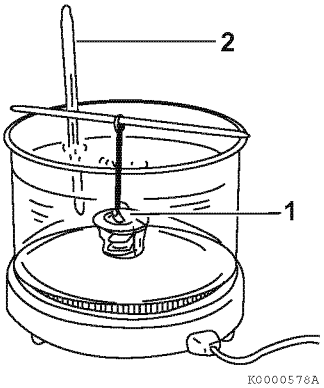


Figure 8-11

2. Slowly increase the temperature of the water using an external heat source.
3. The thermostat is operating properly if it starts to open at the temperature value stamped on the flange of the thermostat, and fully opens as the temperature of the water is increased.

■ Radiator cap

1. Check for proper operation of the radiator cap. Install the radiator cap (1, **Figure 8-12**) on a cooling system tester.

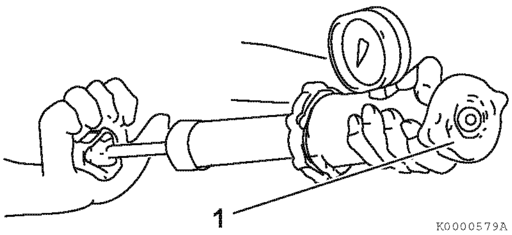


Figure 8-12

2. Apply 10.8 - 14.8 psi (75 - 105 kPa; 0.75 - 1.05 kgf/cm^2) to the radiator cap. The radiator cap relief valve must open within the specified range.

Reassembly of Engine Coolant Pump

1. Reinstall the thermostat (1, **Figure 8-13**) and a new O-ring.

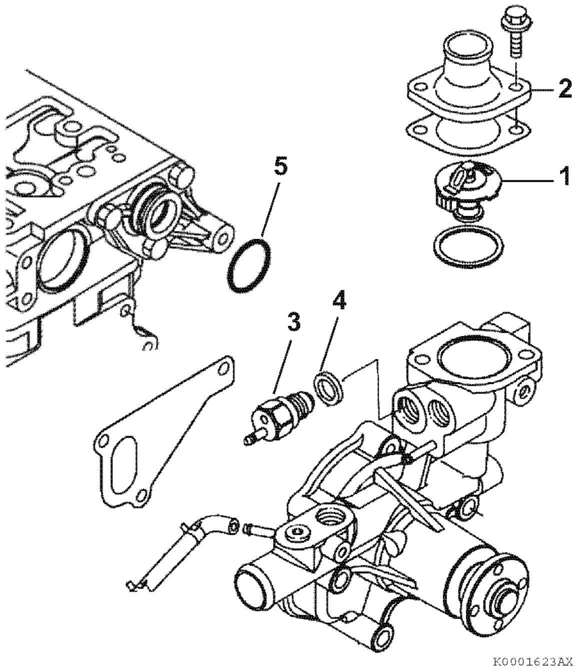


Figure 8-13

2. Reinstall the thermostat cover (2, **Figure 8-13**) and a new gasket. Tighten the thermostat cover bolts.
3. Reinstall the temperature switch (3, **Figure 8-13**) and a new gasket (4, **Figure 8-13**).

Installation of Engine Coolant Pump

1. Position the engine coolant pump on the engine and install a new gasket. Install a new special O-ring (5, **Figure 8-13**) on assembly between the engine coolant pump and the joint.

NOTICE

Use a new special O-ring between the engine coolant pump and the joint. Be sure to use the special O-ring for each engine model. Although the O-ring dimensions are the same as a commercially available O-ring, the material is different.

2. Reinstall the engine coolant pump bolts. Tighten the bolts.
3. Inspect and reinstall the coolant hoses and the temperature switch lead wire.
4. Reinstall the engine coolant pump V-pulley (1, **Figure 8-14**), spacer (2, **Figure 8-14**) engine coolant fan (3, **Figure 8-14**) and engine coolant fan guard (if equipped).

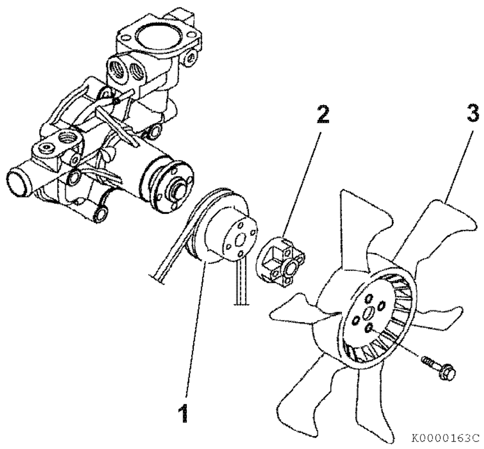


Figure 8-14

5. Inspect the condition of the V-belt. There must be clearance (1, **Figure 8-15**) between the V-belt and the bottom of the pulley groove. If there is no clearance (2, **Figure 8-15**) between the V-belt and the bottom of the pulley groove, replace the V-belt.

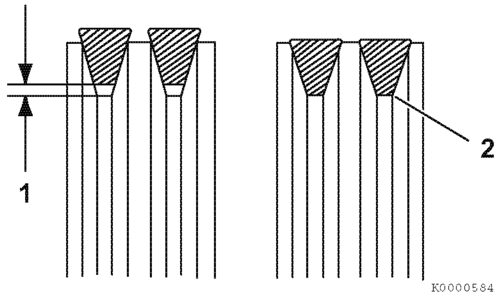


Figure 8-15

6. Reinstall the V-belt. Tighten the V-belt to the proper tension. *See Check and adjust cooling fan V-belt on page 5-12.*
7. Reinstall and tighten the drain plug or close the drain valve in the radiator. Reinstall and tighten the engine block drain plug or reconnect the coolant hose at the oil cooler.
8. Fill the radiator and engine with engine coolant. *See Change engine coolant on page 5-19.*

NOTICE

- Only use the engine coolant specified. Other engine coolants may affect warranty coverage, cause an internal buildup of rust and scale and/or shorten engine life.
- Prevent dirt and debris from contaminating the engine coolant. Carefully clean the radiator 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.

Section 9

LUBRICATION SYSTEM

Page

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual describes the procedures necessary to service the 3TNV88C to 4TNV86CT and 4TNV98C/4TNV98CT Trochoid oil pumps.

See Replace engine lubricating oil and oil filter on page 5-16 for engine oil and engine oil filter replacement procedures.

OIL PUMP SERVICE INFORMATION

■ Engine lubricating oil pressure

<table>
<tr><th rowspan="2">Model</th><th colspan="6">At rated engine RPM</th><th rowspan="2">At low idle speed</th></tr>
<tr><th>1500 - 1800 min^{-1}</th><th>2000 - 2500 min^{-1}</th><th>2600 min^{-1}</th><th>2700 min^{-1}</th><th>2800 min^{-1}</th><th>2900 - 3000 min^{-1}</th></tr>
<tr><td>3TNV88C</td><td>0.29 - 0.44 MPa
(3.0 - 4.5 kgf/cm^2)</td><td colspan="4">0.34 - 0.49 MPa
(3.5 - 5.0 kgf/cm^2)</td><td>0.39 - 0.54 MPa
(4.0 - 5.5 kgf/cm^2)</td><td rowspan="5">0.06 MPa
(0.6 kgf/cm^2)
or greater</td></tr>
<tr><td>4TNV88C</td><td>0.29 - 0.44 MPa
(3.0 - 4.5 kgf/cm^2)</td><td colspan="5">0.32 - 0.47 MPa
(3.3 - 4.8 kgf/cm^2)</td></tr>
<tr><td>3TNV86CT</td><td>0.29 - 0.44 MPa
(3.0 - 4.5 kgf/cm^2)</td><td colspan="2">0.34 - 0.49 MPa
(3.5 - 5.0 kgf/cm^2)</td><td colspan="3">0.39 - 0.54 MPa
(4.0 - 5.5 kgf/cm^2)</td></tr>
<tr><td>4TNV86CT</td><td>0.29 - 0.44 MPa
(3.0 - 4.5 kgf/cm^2)</td><td colspan="5">0.36 - 0.51 MPa
(3.7 - 5.2 kgf/cm^2)</td></tr>
<tr><td>4TNV98C,
4TNV98CT</td><td colspan="6">0.29 - 0.39 MPa
(3.0 - 4.0 kgf/cm^2)</td></tr>
</table>

■ Outer rotor outside clearance

Model	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	0.0035 - 0.0059 in. (0.09 - 0.15 mm)	0.0098 in. (0.25 mm)	*Check outer rotor outside clearance on page 9-8*
4TNV98C, 4TNV98CT	0.0039 - 0.0061 in. (0.100 - 0.155 mm)	0.0098 in. (0.25 mm)	*Check outer rotor outside clearance on page 9-11*

■ Outer rotor side clearance

Model	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	0.0020 - 0.0035 in. (0.05 - 0.09 mm)	0.0059 in. (0.15 mm)	*Check outer rotor side clearance on page 9-9*
4TNV98C, 4TNV98CT	0.0020 - 0.0039 in. (0.05 - 0.10 mm)	0.0059 in. (0.15 mm)	*Check outer rotor side clearance on page 9-11*

■ Outer rotor to inner rotor tip clearance

Model	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	–	0.0063 in. (0.16 mm)	*Outer rotor to inner rotor tip clearance on page 9-8*
4TNV98C, 4TNV98CT	–	0.0063 in. (0.16 mm)	*Outer rotor to inner rotor tip clearance on page 9-11*

■ Rotor shaft clearance

Model	Inspection item	Standard	Limit	Reference page
3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT	Plate bearing I.D.	0.3945 - 0.3952 in. (10.020 - 10.038 mm)	0.3962 in. (10.063 mm)	*Check rotor shaft clearance on page 9-9*
	Rotor shaft O.D.	0.3928 - 0.3932 in. (9.978 - 9.987 mm)	0.3922 in. (9.963 mm)	
	Rotor clearance	0.0013 - 0.0024 in. (0.033 - 0.060 mm)	0.0039 in. (0.100 mm)	
4TNV98C, 4TNV98CT	Gear case bearing I.D.	0.5110 - 0.5126 in. (12.980 - 13.020 mm)	0.5138 in. (13.050 mm)	*Check rotor shaft clearance on page 9-12*
	Rotor shaft O.D.	0.5100 - 0.5104 in. (12.955 - 12.965 mm)	0.5096 in. (12.945 mm)	
	Rotor clearance	0.0006 - 0.0026 in. (0.015 - 0.065 mm)	0.0041 in. (0.105 mm)	

LUBRICATION SYSTEM DIAGRAM

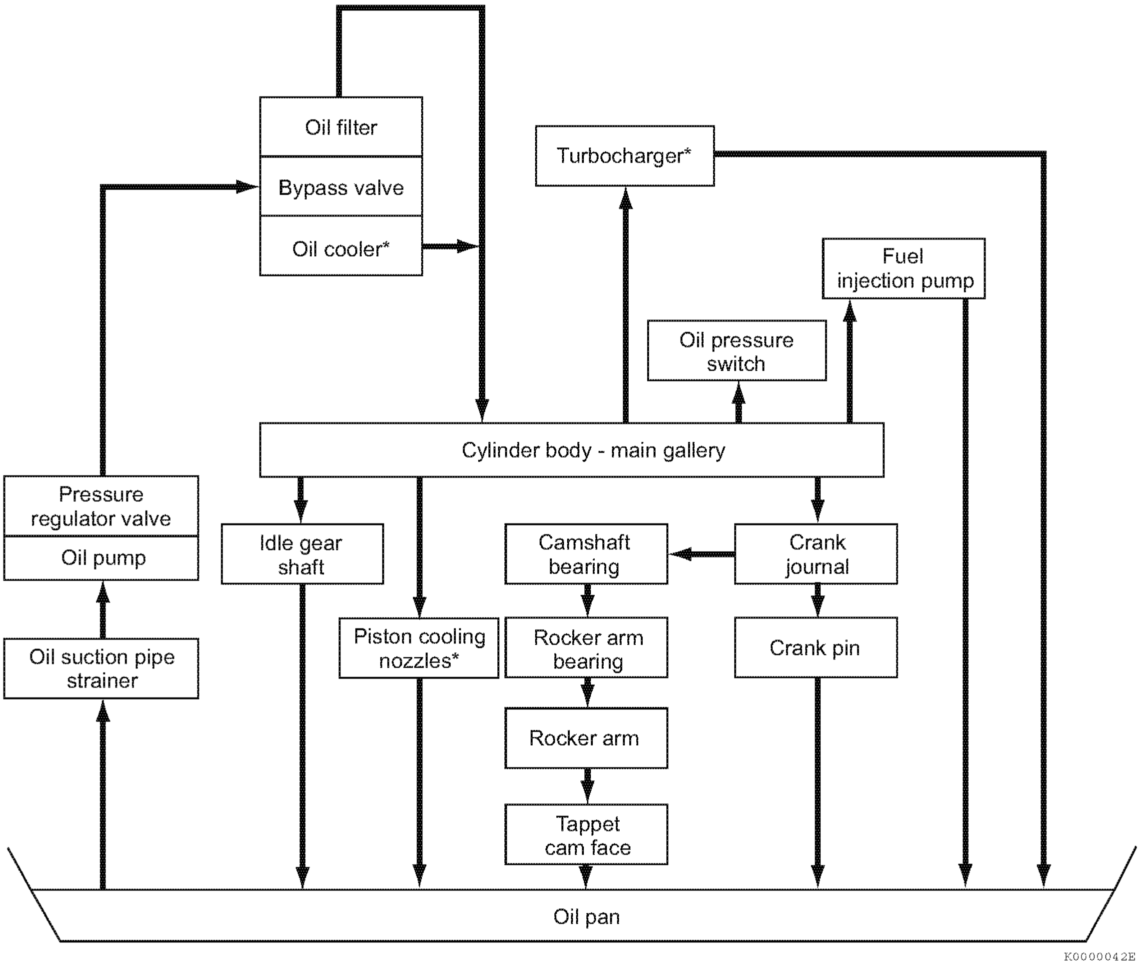


Figure 9-1

Note: Items marked are not standard equipment on all models.*

CHECKING ENGINE LUBRICATING OIL PRESSURE

Perform an engine oil pressure check if there is any indication of low oil pressure such as the oil pressure indicator is on or the oil pressure gauge indicates low oil pressure. *See Engine lubricating oil pressure on page 9-4.*

1. Disconnect the wire lead from the oil pressure switch or sending unit (1, **Figure 9-2**).

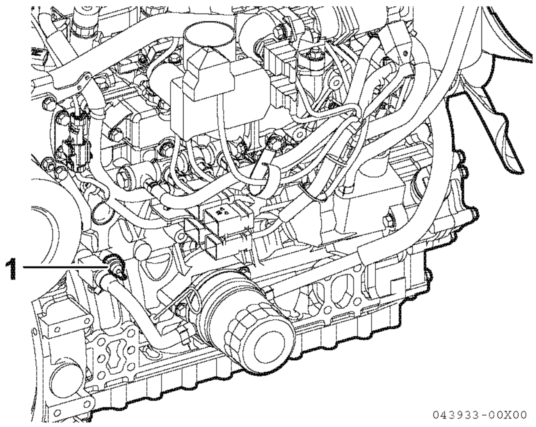


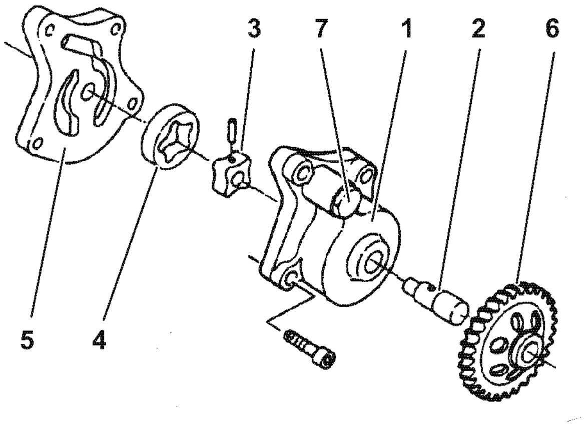
Figure 9-2

2. Remove the oil pressure switch.
3. Install a mechanical oil pressure gauge in the oil pressure switch port.
4. Start the engine:
   - If the mechanical oil pressure test gauge indicates good oil pressure, replace the faulty oil pressure switch or sending unit, or faulty machine oil pressure gauge in instrument panel.
   - If the mechanical oil pressure test gauge indicates low oil pressure, troubleshoot the lubrication system to locate the cause of the low oil pressure. *See Failure Diagnostic List on page 15-9.* Repair as necessary.

OIL PUMP COMPONENTS

3TNV88C, 3TNV86CT, 4TNV88C, 4TNV86CT

The oil pump on these model engines is located in the front gear case and is driven by the same gear train that drives the camshaft and fuel injection pump. You must remove the front gear case cover to gain access to the oil pump.



1 – Body
2 – Shaft
3 – Inner rotor
4 – Outer rotor
5 – Cover
6 – Drive gear
7 – Pressure regulator valve

Figure 9-3

Disassembly of Oil Pump

NOTICE

If the oil pump must be replaced, replace it as an assembly only. Do not replace individual components.

1. Remove the cooling water fan guard (if equipped), cooling fan (3, **Figure 9-4**), spacer (2, **Figure 9-4**), cooling water pump V-pulley (1, **Figure 9-4**), and V-belt.

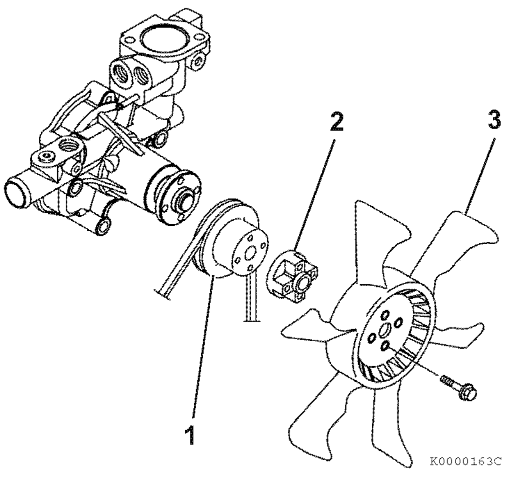


Figure 9-4

2. Remove the crank shaft pulley and gear case cover. See*Removal of timing gear case cover on page 6-43*.
3. Remove the lubricating oil pump assembly mounting bolts. Remove the lubricating oil pump assembly (1, **Figure 9-5**) from the gear case flange (2, **Figure 9-5**).
4. You can remove by hand the lubricating oil pump cover (3, **Figure 9-5**) and outer rotor (4, **Figure 9-3**).

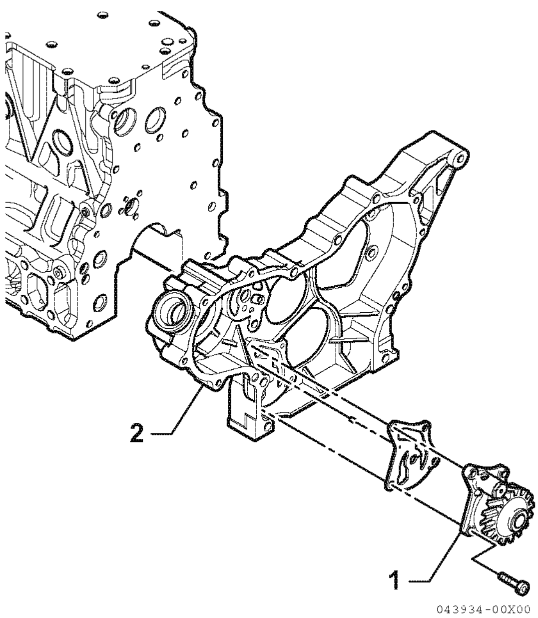


Figure 9-5

Cleaning and Inspection

Clean the lubricating oil pump, pressure regulator valve (7, **Figure 9-3**), and rotor inserting portion. Check the parts for wear or flaw. Replace the parts with new ones as needed.

NOTICE

- Never overfill the engine with engine oil.
- Always keep the oil level between the upper and lower lines on the oil cap/dipstick.

■ Check outer rotor outside clearance

Inspect the outside diameter clearance of the outer rotor. To inspect this, insert a feeler gauge between the outer rotor (1, **Figure 9-6**) and the lubricating oil pump body (2, **Figure 9-6**).

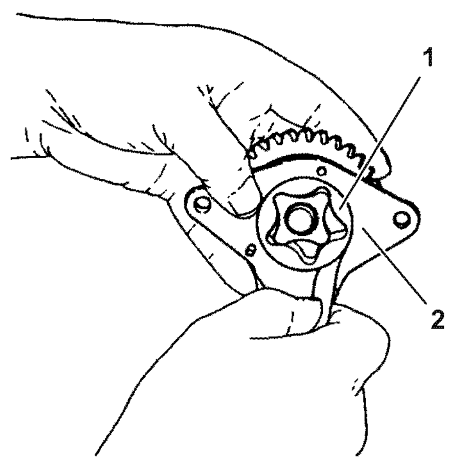


Figure 9-6

Record the measurement(s) and see Outer rotor outside clearance on page 9-4 for the service limits.

■ Outer rotor to inner rotor tip clearance

Inspect the tip clearance between the outer and inner rotors. To inspect this, insert a feeler gauge between the inner rotor tooth tip (1, **Figure 9-7**) and the outer rotor tooth tip (2, **Figure 9-7**), and measure the clearance.

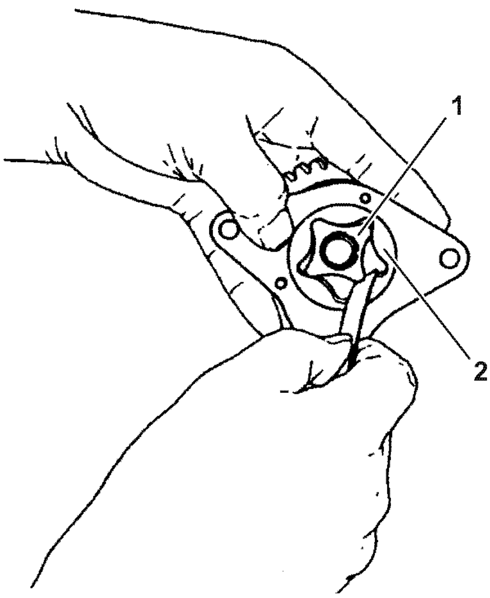


Figure 9-7

Record the measurement(s) and see Outer rotor to inner rotor tip clearance on page 9-4 for the service limits.

■ Check outer rotor side clearance

Inspect the side clearance between the lubricating oil pump body and the outer rotor. To measure the side clearance, use a straight edge and feeler gauge (as shown in **Figure 9-8**) or a depth micrometer.

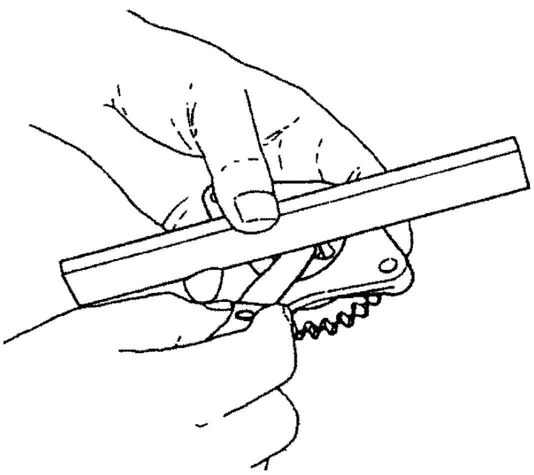


Figure 9-8

Record the measurement(s) and seeOuter rotor outside clearance on page 9-4 for the service limits.

■ Check rotor shaft clearance

Inspect the rotor shaft clearance. Measure the outside diameter of the rotor shaft (1, **Figure 9-9**) and the inside diameter of the cover.

Determine the clearance by subtracting the outside diameter of the rotor from the inside diameter of the cover.

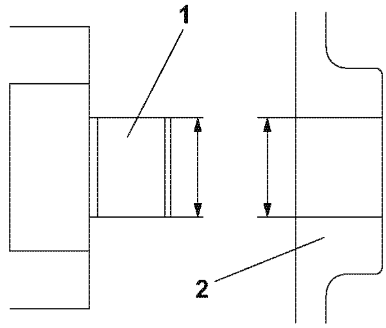


Figure 9-9

Record the measurement(s) and see Rotor shaft clearance on page 9-5 for the service limits.

Reassembly of Oil Pump

1. Apply clean lubricating oil to the lubricating oil pump body and inner rotor assembly as well as to the outer rotor.
2. Insert the outer rotor into the lubricating oil pump body and inner rotor assembly and install the cover.
3. Replace the packing with new one.
4. Install the lubricating oil pump assembly to the gear case by tightening the bolts with the specified torque.
5. Install the gear case cover. For more information, See Installation of gear case cover on page 6-63.
6. Install the crank shaft pulley.
7. Install the cooling water pump V-pulley (1, **Figure 9-10**), spacer (2, **Figure 9-10**), cooling water fan (3, **Figure 9-10**), and fan guard (if equipped).

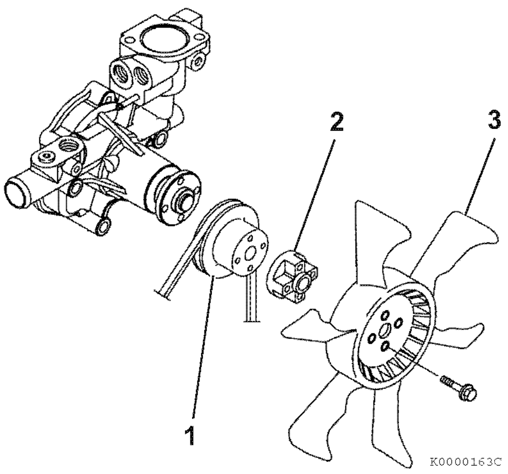
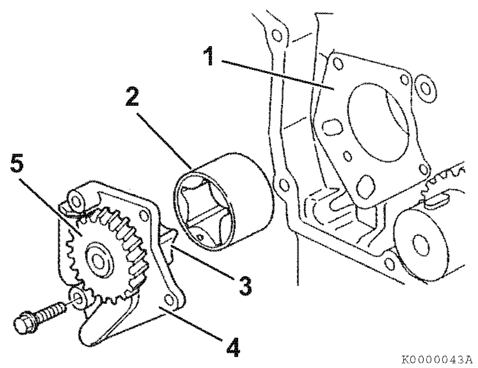


Figure 9-10

8. Install the V-belt. Adjust the belt to uniform tensile strength in accordance with the instructions given in *Check and adjust cooling fan V-belt on page 5-7*.

4TNV98C, 4TNV98CT (Trochoid Oil Pump)

The oil pump on these model engines is located in the front gear case and is driven by the same gear train that drives the camshaft and fuel injection pump. You must remove the front gear case cover to gain access to the oil pump.



1 – Gear case housing
2 – Outer rotor
3 – Inner rotor
4 – Cover plate
5 – Drive gear

Figure 9-11

Disassembly of Oil Pump

NOTICE

If the oil pump must be replaced, replace it as an assembly only. Do not replace individual components.

Remove the engine cooling fan guard (if equipped), engine cooling fan (3, **Figure 9-12**), spacer (2, **Figure 9-12**), engine coolant pump V-pulley (1, **Figure 9-12**) and V-belt.

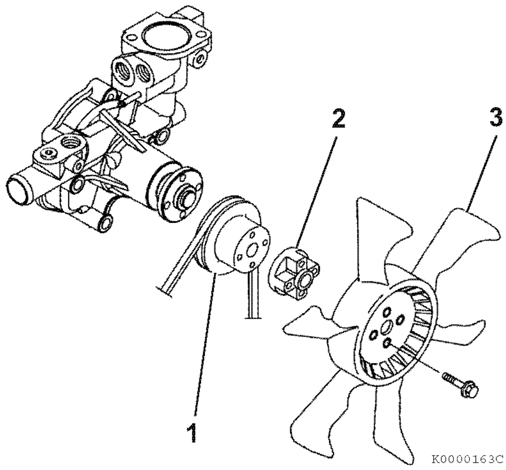


Figure 9-12

1. Remove the crankshaft pulley and the gear case cover. *See Removal of timing gear case cover on page 6-43.*
2. Remove the oil pump assembly bolts. Remove the oil pump assembly (1, **Figure 9-13**) from the gear case housing (2, **Figure 9-13**).

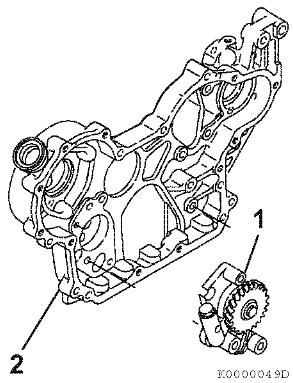


Figure 9-13

Cleaning and Inspection

Wash the oil pump, oil pressure regulator and oil pump cavity. Inspect for wear or damage. Replace as necessary.

NOTICE

If any oil pump component clearance exceeds its limit, the oil pump must be replaced as an assembly.

■ Check outer rotor outside clearance

Determine the outside clearance of the outer rotor. Insert a feeler gauge between the outer rotor (1, **Figure 9-14**) and gear case oil pump cavity (2, **Figure 9-14**).

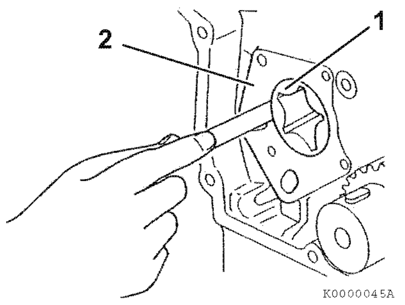


Figure 9-14

Record the measurement(s) and see Check outer rotor outside clearance on page 9-8 for the service limits.

■ Outer rotor to inner rotor tip clearance

Determine the outer rotor to inner rotor tip clearance. Insert a feeler gauge between the top of an inner rotor tooth (1, **Figure 9-15**) and the top of an outer rotor tooth (2, **Figure 9-15**) and measure the clearance.

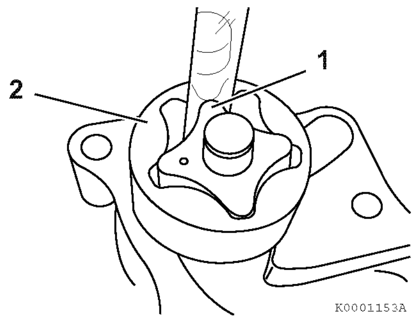


Figure 9-15

Record the measurement(s) and see Outer rotor to inner rotor tip clearance on page 9-4 for the service limits.

■ Check outer rotor side clearance

Determine the side clearance of the outer rotor across the pump cavity. Measure the depression using a depth micrometer (1, **Figure 9-16**).

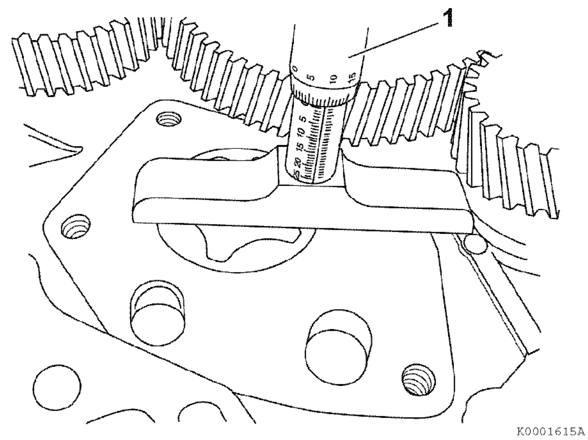


Figure 9-16

Record the measurement(s) and see Check outer rotor outside clearance on page 9-8 for the service limits.

■ Check rotor shaft clearance

Determine the rotor shaft clearance. Measure the outside diameter of the rotor shaft (1, **Figure 9-17**) and the bore diameter in the gear case housing (2, **Figure 9-17**).

Calculate the difference between the two measurements to determine the clearance.

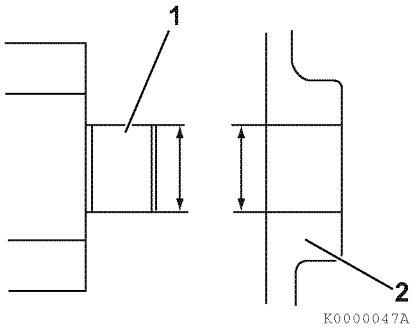


Figure 9-17

Record the measurement(s) and see Rotor shaft clearance on page 9-5 for the service limits.

Reassembly of Oil Pump

1. Lubricate the outer rotor and pump bore in the gear case with clean engine oil.
2. Reinstall the outer rotor in the gear case housing. The punch mark (1, **Figure 9-18**) on the end of the outer rotor must face away from the gear case housing (2, **Figure 9-18**).

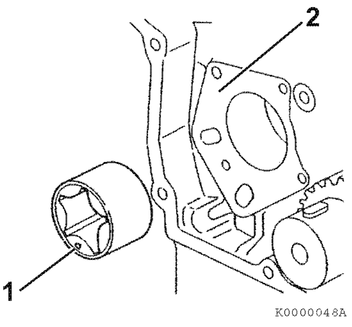


Figure 9-18

3. Reinstall the oil pump assembly (1, **Figure 9-19**) into the gear case housing (2, **Figure 9-19**). Tighten the bolts to specified torque.

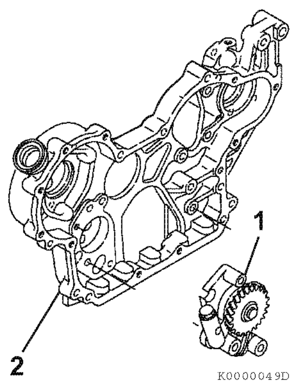


Figure 9-19

4. Reinstall the gear case cover and crankshaft pulley. *See Installation of gear case cover on page 6-63.*
5. Reinstall the engine coolant pump V-pulley (1, **Figure 9-20**), spacer (2, **Figure 9-20**), engine cooling fan (3, **Figure 9-20**) and engine cooling fan guard (if equipped).

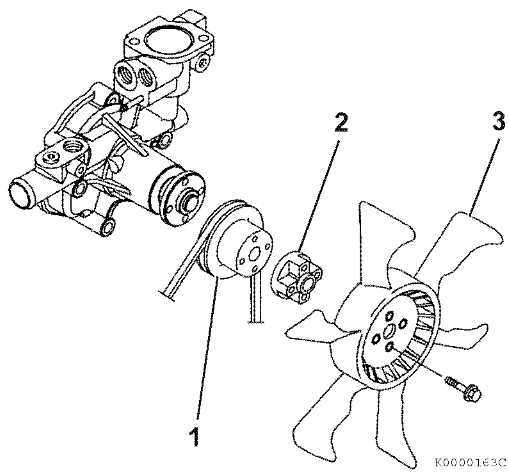


Figure 9-20

6. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in*Check and adjust cooling fan V-belt on page 5-7.*

Section 10

TURBOCHARGER

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual describes the servicing of the RHF3, RHF4 and RHF5 model turbochargers.

SPECIFICATIONS

Turbocharger Service Information

Applicable engine model (application)	3TNV86CT	4TNV86CT	4TNV98CT
Turbocharger model	RHF3	RHF4	RHF5
Turbocharger specification	Standard (w/waste gate)		
Turbine type	Radial flow		
Blower (compressor) type	Centrifugal		
Lubrication	External lubrication		
Maximum continuous allowable speed	250,000	190,000	180,000
Maximum continuous allowable gas inlet temperature	750 °F (399 °C)		
Weight (Dry)	5.4 lb (24 N; 2.4 kgf)	5.7 lb (25 N; 2.6 kgf)	10.3 lb (46 N; 4.7 kgf)

Note: VM application is provided with the waste gate.

TROUBLESHOOTING

The following troubleshooting procedures apply to problems identified as turbocharger related. Consider all other troubleshooting possibilities before cleaning or removing the turbocharger.

■ Excessive exhaust smoke

Cause	Corrective action
Clogged air cleaner element	Clean or replace the air cleaner element
Blocked air intake port	Correct the condition
Leak from a joint in intake line	Correct the condition

Cause	Corrective action
Compressor impeller dirty	Wash the impeller blades.
Deposit of impurities in oil sticking on the turbine side seal portion to make turbine revolution heavy	Repair the turbocharger. Send to a qualified repair facility.
Sticking bearing: • Insufficient lubrication or clogged lubrication piping • Excessively high oil temperature • Unbalanced rotating part • Insufficient warming up or sudden stop from loaded operation (no-load operation)	 • Repair turbocharger. Send to qualified repair facility. • Inspect the lubricating oil line for problem. Correct the condition and replace lubricating oil. • Repair the turbocharger. Send to a qualified repair facility. • Improper operation of the machine. Refer to the Inspection and repair of each engine part
Contact or breakdown of turbine wheel or blower vane: • Excessive revolution • Excessive exhaust temperature rise • Foreign matter within turbocharger • Worn bearing • Incorrect assembly of turbocharger	 • Inspection and repair of each engine part • Inspection and repair of each engine part • Clean the air cleaner and engine compartment. Repair the turbocharger. Send to a qualified repair facility. • Repair the turbocharger. Send to a qualified repair facility. • Repair the turbocharger. Send to a qualified repair facility.

Cause	Corrective action
Exhaust system gas leak prior to the turbocharger. Condition will decrease turbocharger revolutions.	Inspect the exhaust system for leaks. Correct the condition.
Deformed or clogged exhaust pipe. Condition will decrease turbocharger revolutions.	Correct the condition.

■ Generates white smoke

Cause	Corrective action
Clogged or deformed oil return pipe causing oil flow to the blower on the turbine side	Correct the condition
Excessive bearing wear causing abnormal wear or damage of the seal ring	Repair the turbocharger. Send to a qualified repair facility.

■ Sudden oil decrease

Cause	Corrective action
Excessive bearing wear causing abnormal wear or damage of the seal ring	Repair turbocharger. Send to qualified repair facility.

■ Decrease in output

Cause	Corrective action
Gas leak from any part in exhaust piping	Correct the condition
Air leak from discharge side of blower	Correct the condition
Clogged air cleaner element	Clean or replace the air cleaner element
Damaged turbocharger	Repair the turbocharger. Send to a qualified repair facility

■ Poor (slow) response (starting) of turbocharger

Cause	Corrective action
Hard carbon deposit on the turbine side (wheel sealing portion) causing abnormal revolution of the turbine shaft	Repair the turbocharger. Send to a qualified repair facility
Incomplete combustion	Correct the condition

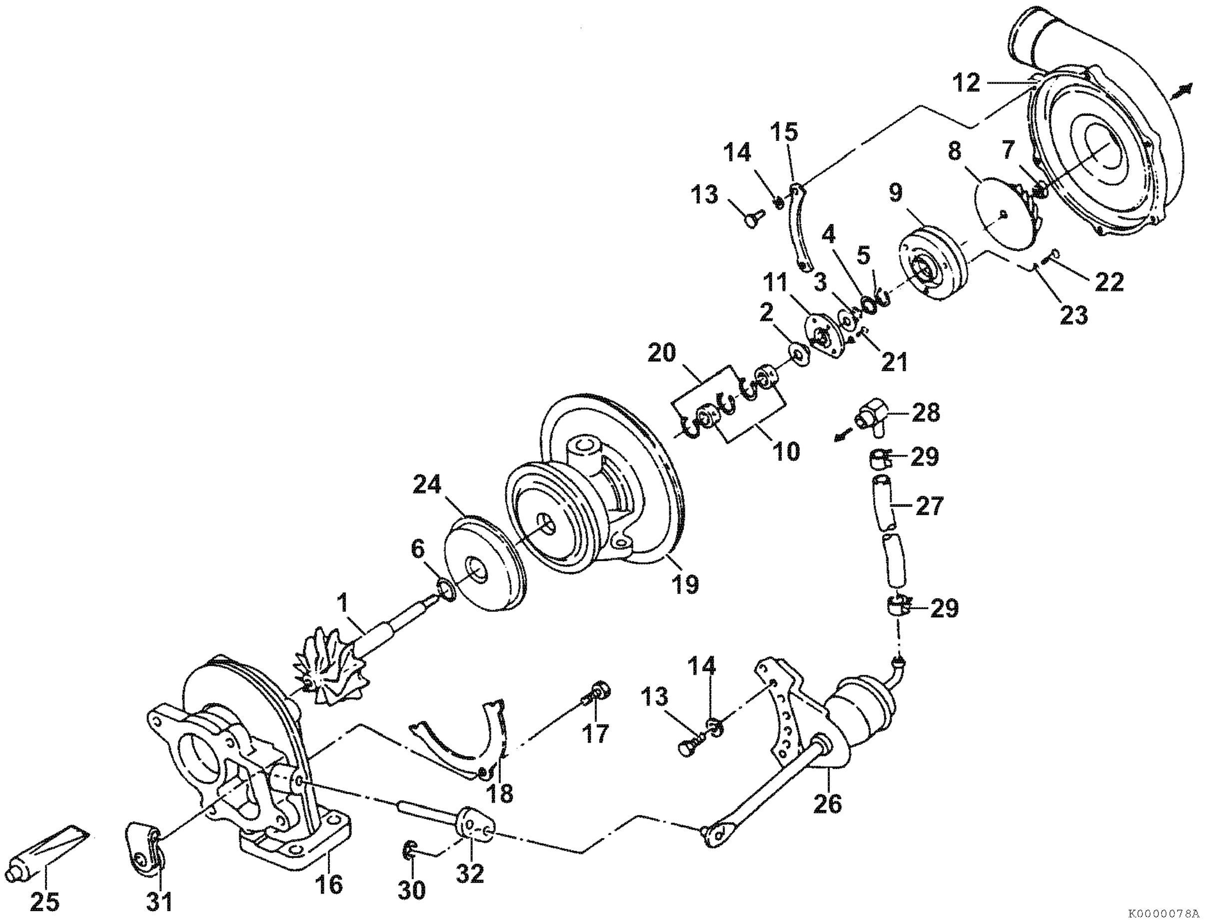
■ Abnormal sound or vibration

Cause	Corrective action
Excessively narrowed gas path due to clogged nozzle in the turbine wheel chamber or reverse flow of blower discharge in acceleration (generally called surging)	Repair the turbocharger. Send to a qualified repair facility
Contact rotating part	Repair the turbocharger. Send to a qualified repair facility

Cause	Corrective action
Loosened intake, exhaust or oil pipe connection with the turbocharger	Correct the condition
Damaged bearing, contact between rotating part and adjacent part, or chipping of the turbine wheel or blower vane due to foreign matter within the turbocharger	Repair the turbocharger. Send to a qualified repair facility
Unbalanced rotating part	Repair the turbocharger. Send to a qualified repair facility

TURBOCHARGER COMPONENTS

Note: The following illustration is provided for informational purposes only. YANMAR does not offer individual service parts for turbochargers. If the turbocharger is worn or damaged, it should be replaced or repaired by a qualified repair facility.



1 – Turbine shaft
2 – Thrust bearing
3 – Oil thrower
4 – Seal ring
5 – Seal ring
6 – Seal ring (Turbine side)
7 – Lock nut
8 – Impeller
9 – Seal plate
10 – Journal bearing
11 – Thrust bearing
12 – Compressor housing
13 – Flanged bolt
14 – Spring washer
15 – Clamp
16 – Turbine housing
17 – Bolt
18 – Lock plate
19 – Bearing housing
20 – Retaining ring
21 – Bolt
22 – Bolt
23 – Lock washer
24 – Heat protector
25 – Liquid gasket
26 – Waste gate actuator
27 – Hose
28 – Adapter
29 – Clip
30 – Retaining ring
31 – Waste gate valve
32 – Link plate

Figure 10-1

TURBOCHARGER COMPONENT FUNCTIONS

Engines achieve the most efficient combustion at a certain air-fuel ratio. Although the amount of fuel injection can be increased, the amount of air that can be introduced into the cylinder is limited.
The turbocharger rotates the turbine using the pressure from engine exhaust gas, drives the compressor, and pressurize the intake air. Therefore the pressure inside the combustion chamber increases, thereby substantially increasing the amount of fuel that can be injected into the combustion chambers, while maintaining the proper air-fuel ratio to improve engine output property.

Structure of Turbocharger

Structure of the turbocharger is shown in **Figure 10-2**.
The turbocharger consists of two main components: Turbine, and compressor.

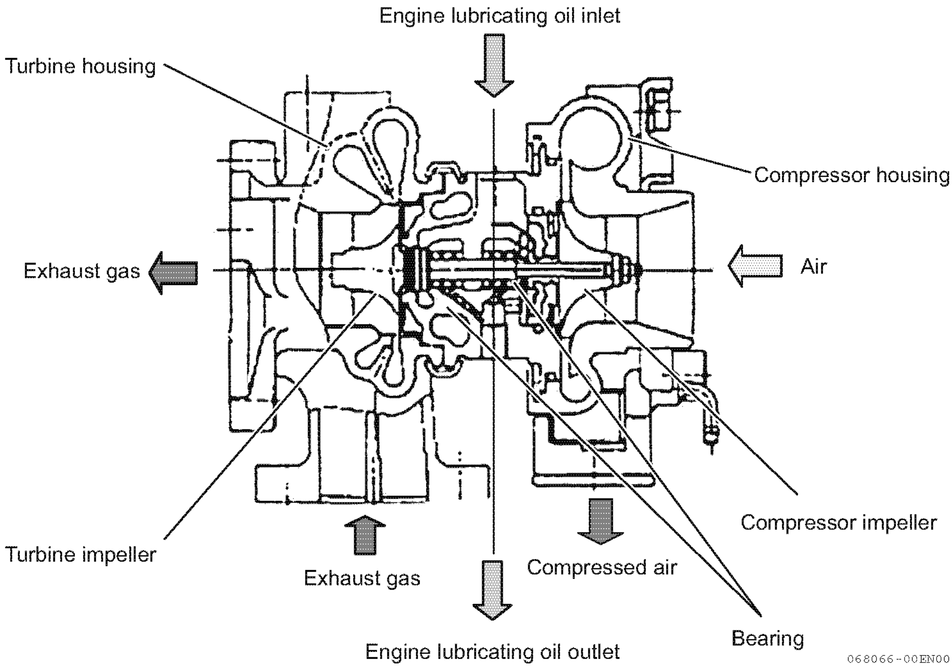


Figure 10-2

■ Turbine

The turbine is driven by exhaust gas pressure from the engine and is coupled to a shaft on the compressor side of the turbocharger.

Exhaust gas velocity is accelerated at the nozzle portion in the turbine housing where the cross-sectional area is reduced. As exhaust passes over the turbine impeller at high linear velocity, the turbine shaft is rotated at proportionally high rpm.

■ Compressor

The compressor is driven by a shaft on the turbine side of the turbocharger and increases the induction air pressure at the intake manifold.

The compressor impeller draws induction air into the turbocharger, compresses it and directs it into the engine at high-pressure.

A seal ring and heat insulating plate thermally isolate heat energy, at the turbine side, from the bearings and the induction air, at the compressor side.

■ Bearings

1. Thrust bearing

   A thrust force is continuously imposed on the turbine shaft during engine operation. A thrust bearing prevents the shaft from moving laterally under this thrust force.

2. Radial bearing

   A floating radial bearing moves with the turbine shaft as oil films form on the inside and outside bearing surfaces. The bearing slipping speed is slower than the turbine shaft speed, resulting in higher dynamic stability and reduced mechanical noise.

3. Lubrication

   The oil pump delivers oil from the engine to the turbocharger for cooling and lubrication of the bearings. As oil leaves the turbocharger, it is returned to the engine.

■ Compressor side sealing mechanism

A seal ring and a seal plate form a double wall structure at the rear of the compressor impeller. The seal ring and seal plate prevent Intake air and oil leakage.

Role of Waste Gate

Excessive boost pressure that cannot be accommodated by the engine can damage the turbocharger. The waste gate is a component that monitors intake boost pressure on the compressor side and diverts exhaust gases around the turbocharger turbine. The amount of exhaust gas diverted is varied to limit turbine rpm and maintain the intake pressure equal to, or less than the specified maximum level. This improves the response to load variation in the low to medium rpm range and minimizes black smoke.

A mechanical pressure sensor in the outlet of the compressor side of the turbocharger opens and closes the waste gate to maintain the specified intake pressure at the intake manifold.

PERIODIC INSPECTION

Visual Inspection

1. Check for indications of oil leaks at the oil inlet and outlet lines. Repair or replace the oil lines as needed.
2. Inspect the air inlet connection to the turbocharger's turbine side for cracks or broken hardware. Repair or replace the connection as needed.
3. Inspect the exhaust outlet connection to the turbocharger's compressor side for cracks or broken hardware. Repair or replace the connection as needed.

Inspection of Rotor Rotation

1. With the engine cool and not operating, manually rotate the rotor. Smooth rotation is normal. Any catching or resistance to rotation is an indication of abnormal operation. Replace the turbocharger or have it repaired by a qualified repair facility.
2. Start the engine.
3. After the engine reaches normal operating temperature, place a stethoscope firmly against the turbocharger case.
4. Increase the rpm gradually. A high-pitched sound, occurring at intervals of two or three seconds, is an indication of abnormal operation. Replace the turbocharger or have it repaired by a qualified repair facility.

Checking Rotor Play

To inspect the play (side gap, run-out) of the rotor, the turbocharger must be removed. Refer to the next article for attaching and removing the turbocharger. If the measured value does not meet the following specifications, replace the turbocharger assembly or have it repaired by a qualified repair facility.

in. (mm)

Rotor play	Standard dimension		Wear limit	
	RHF4	RHF5	RHF4	RHF5
End play	0.0010 - 0.0033 (0.026 - 0.084)	0.0011 - 0.0024 (0.03 - 0.06)	0.0035 (0.09)	0.0035 (0.09)
Run-out	0.0031 - 0.0051 (0.08 - 0.13)	0.0031 - 0.0051 (0.08 - 0.13)	0.0063 (0.16)	0.0067 (0.17)

■ To check rotor end play:

1. Set up a dial indicator as shown (**Figure 10-3**).
2. Manually move the rotor end-to-end while observing indicated readings. Replace the turbocharger if end play measurements are outside specified limits. *See table above.*

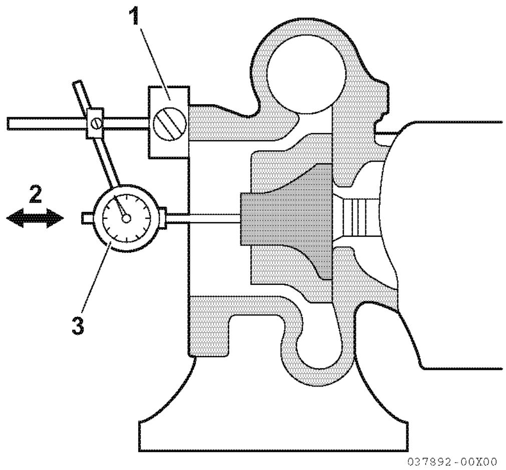


Figure 10-3

■ To check rotor run-out:

1. Set up a dial indicator as shown (**Figure 10-4**).
2. Manually rotate the rotor while observing indicated limits. Replace the turbocharger if run-out measurements are outside specified limits. *See table above.*

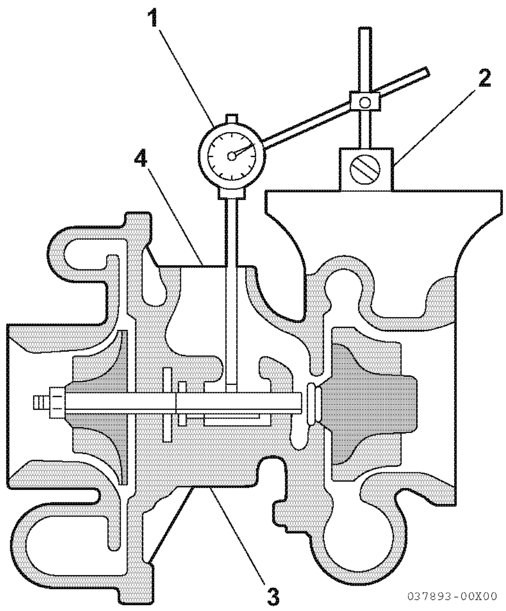


Figure 10-4

Waste Gate Valve Test

Before reinstalling the turbocharger, verify the operation of the waste gate valve. Poor waste gate operation will adversely affect the engine performance.

⚠ WARNING

Never apply over 40 psi (2.8 kgf/cm²) to the waste gate actuator.

NOTICE

If the waste gate valve does not meet specifications, replace the turbocharger or have it repaired by a qualified repair facility.

1. Connect a hand-operated air pump to the waste gate actuator pipe (1, **Figure 10-5**). The pump should be equipped with a 30 psi (0.21 MPa; 2.21 kgf/cm²) pressure gauge (2, **Figure 10-5**), and a pressure release valve to release any pressure pumped into the system. (Similar pumps are used to check for leaks in marine gear cases.)

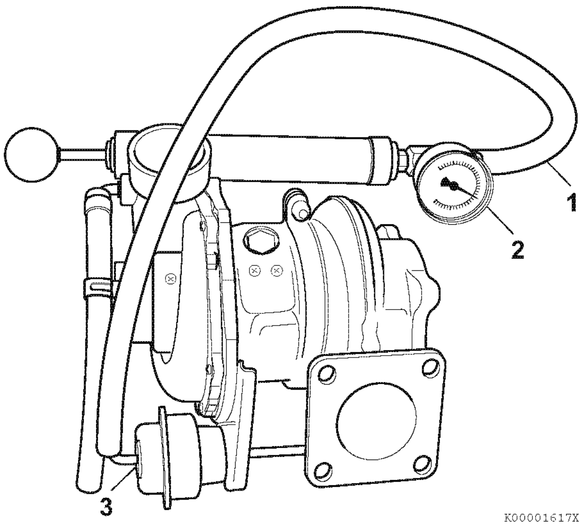


Figure 10-5

2. Apply 17 psi (0.12 MPa; 1.2 kgf/cm²) to the waste gate actuator (3, **Figure 10-5**) circuit. Observe if the waste gate valve fully opens. If the waste gate valve does not fully open, replace the turbocharger or have it repaired by a qualified repair facility.

Waste Gate Actuator Leak Test

Allow the pressure, 17 psi (0.12 MPa; 1.2 kgf/cm²) to remain in the circuit for one minute. After one minute, observe the pressure reading.

- If the pressure reading is equal to or greater than 15.9 psi (0.11 MPa; 1.1 kgf/cm²), the waste gate actuator is not leaking and is operating properly.
- If the pressure gauge shows less than 15.9 psi (0.11 MPa; 1.1 kgf/cm²), air is leaking at the waste gate actuator. Replace the turbocharger or have it repaired by a qualified repair facility.

REMOVAL AND INSTALLATION OF TURBOCHARGER

Removal of Turbocharger

1. Shut down the engine and allow the turbocharger to cool. Remove the exhaust outlet connection from the turbocharger housing.
2. Remove the air inlet connection from the turbocharger housing.

NOTICE

Do not allow any material to fall into the oil lines or the oil inlet and outlet ports of the turbocharger.

3. Remove the inlet and outlet oil lines from the turbocharger. Plug the lines and ports with tape to prevent contamination. Discard the sealing washers and O-rings. Inspect the oil lines and replace if damaged.
4. Remove the turbocharger mounting nuts from the mounting studs. Lift the turbocharger from the engine and place it on a clean, level working surface.
5. Discard the turbocharger exhaust manifold gasket.

Installation of Turbocharger

1. Pour 2 oz (60 cc) of clean engine oil in the oil inlet port at the top of the turbocharger. Rotate the compressor wheel to ensure the shaft bearings are lubricated.
2. Flush the oil lines to ensure that they are free of containments.
3. Put a new turbocharger exhaust manifold gasket in place and reinstall turbocharger on the exhaust manifold.
4. Apply anti-seize compound to the turbocharger mounting studs.
5. Reinstall the mounting nuts. Torque the nuts to the specified torque.
6. Install new sealing washers and O-rings and reinstall the inlet and outlet oil lines to the turbocharger.

NOTICE

Do not allow any material to fall into the oil lines or the oil inlet and outlet ports of the turbocharger.

7. Reinstall the air inlet connection to the turbocharger turbine housing.
8. Reinstall the exhaust connection to the turbocharger compressor housing.

CLEANING PROCEDURE

Note: Inspection, cleaning and repair of the internal turbocharger components must be performed by a qualified repair facility.

The cleaning procedure described in this section is intended to clean the impeller on the compressor only if the engine loses rpm, seems sluggish or has insufficient boost pressure. The process does not require disassembling any portion of the turbocharger.

Since cleaning is quick and easy, perform this procedure before considering replacement.

1. Start the engine and allow it to reach the normal operating temperature.

NOTICE

Avoid damage to the turbocharger or the engine. Do not spray blow clean fluid or water too quickly.

Use short strokes from a spray bottle to inject blow clean fluid or water into the turbocharger.

Spraying too much blow clean fluid or water, or spraying too quickly will damage the turbocharger.

2. While the engine is operating at normal load (75 - 80 % of maximum), slowly and evenly spray 2 - 3 oz (60 - 90 cc) of blow clean fluid over a period of ten to fifteen seconds into the air inlet (**Figure 10-6**).

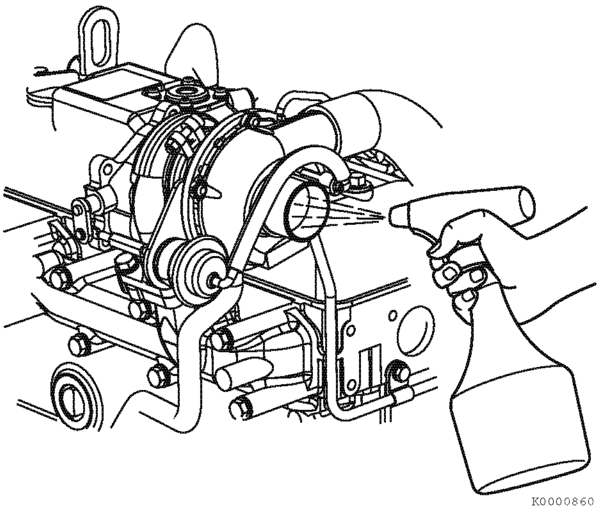


Figure 10-6

3. Continue to operate the engine under the same load for three to four minutes.
4. While the engine is still operating at normal load (75 - 80 % of maximum), slowly and evenly spray 2 - 3 oz (60 - 90 cc) of clean water over a period of ten to fifteen seconds into the air inlet.
5. Continue to operate the engine under the same load for at least ten minutes to completely dry the air intake system and turbocharger.
6. Test the engine performance. If engine performance has not improved, repeat steps 2 through 6. If the engine performance does not improve after executing the cleaning process three times, replace the turbocharger or have it repaired by a qualified repair facility.

Section 11

STARTER MOTOR

Page

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual covers the servicing of the starter motor. YANMAR Part No. 129900-77010 is typical equipment on 4TNV98C model engines and is used in this section to show the service procedures for a representative starter motor. For specific part detail, see the *YANMAR Parts Catalog* for the engine you are working on.

STARTER MOTOR INFORMATION

3TNV88C to 4TNV86CT - Standard and Optional

YANMAR Part No.	Mfg.	Mfg. Part No.	Specification	No load			Loaded			
				Terminal voltage	Amperage draw	min^{-1} (rpm)	Terminal voltage	Amperage draw	Torque	min^{-1} (rpm)
129129-77010	Denso	228000-0251	DC 12 V-1.6 HP (1.2 kW)	11.5	90 A maximum	3000	8	280 maximum	87 in.-lb (9.81 N·m; 1.0 kgf·m)	900
129407-77010	Denso	228000-3732	DC 12 V-1.9 HP (1.4 kW)	11.5	90 A maximum	3000	8.5	350 maximum	117 in.-lb (13.2 N·m; 1.4 kgf·m)	1000
129608-77010	Hitachi	S114-817A	DC 12 V-1.9 HP (1.4 kW)	11	90 A maximum	2700	8.4	250 maximum	74 in.-lb (8.3 N·m; 0.9 kgf·m)	1000
129242-77010	Hitachi	S114-883	DC 12 V-2.3 HP (1.7 kW)	11	90 A maximum	2300	8	370 maximum	134 in.-lb (15.1 N·m; 1.5 kgf·m)	880
129136-77011	Hitachi	S13-332	DC 12 V-3.1 HP (2.3 kW)	11	140 A maximum	4100	7.7	400 maximum	97 in.-lb (11.0 N·m; 1.1 kgf·m)	1400

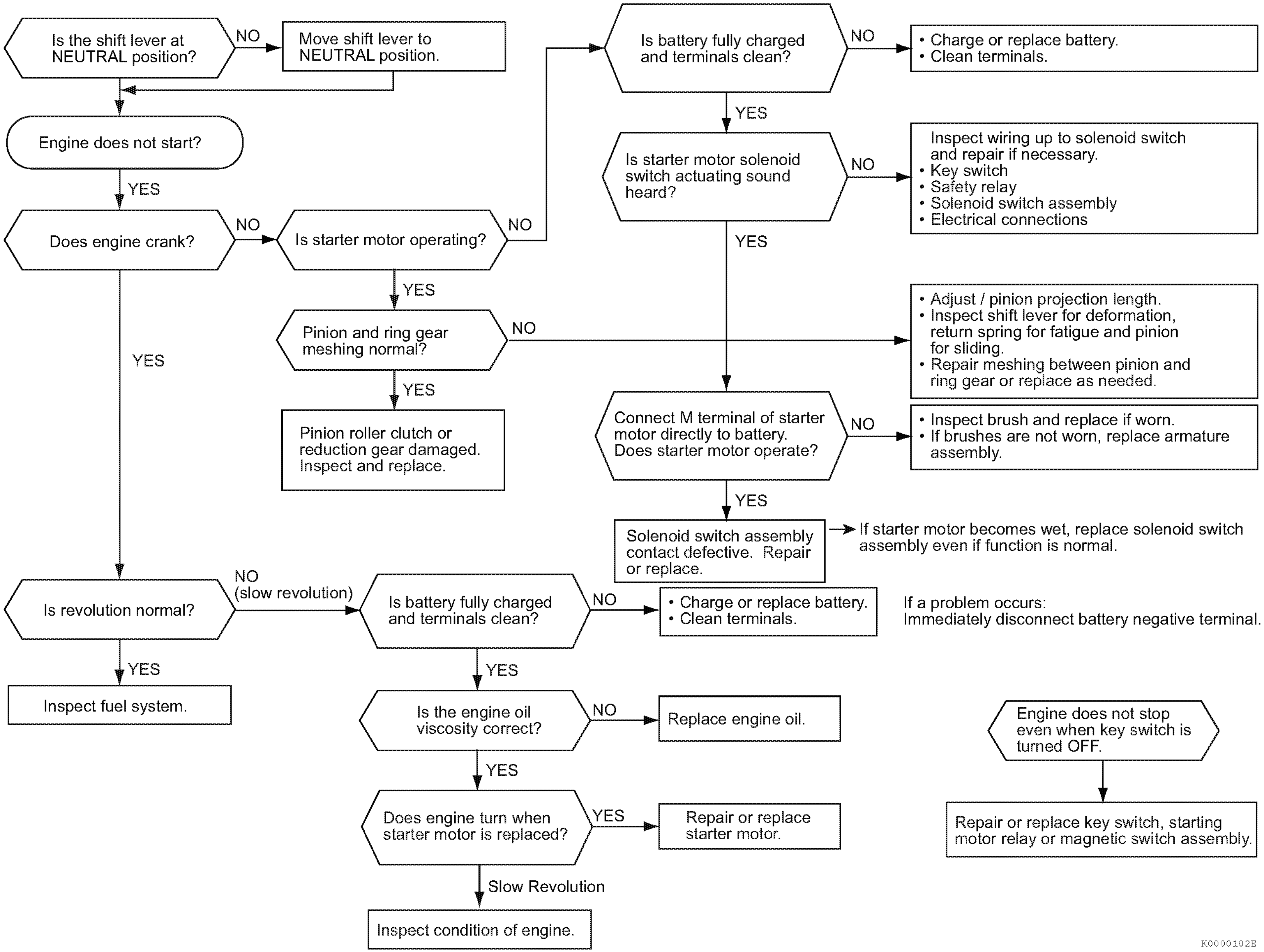
4TNV98C and 4TNV98CT - Standard and Optional

YANMAR Part No.	Mfg.	Mfg. Part No.	Specification	No load			Loaded			
				Terminal voltage	Amperage draw	min^{-1} (rpm)	Terminal voltage	Amperage draw	Torque	min^{-1} (rpm)
129900-77010	Hitachi	S13-204	DC 12 V-3.1 hp (2.3 kW)	11	140 A maximum	4100	7.7	400 maximum	97 in.-lb (11.0 N·m; 1.1 kgf·m)	1400
129940-77011	Hitachi	S14-102	DC 12 V-4.0 hp (3.0 kW)	12	160 A maximum	3600	10.85	300 maximum	60 in.-lb (6.9 N·m; 0.7 kgf·m)	2000

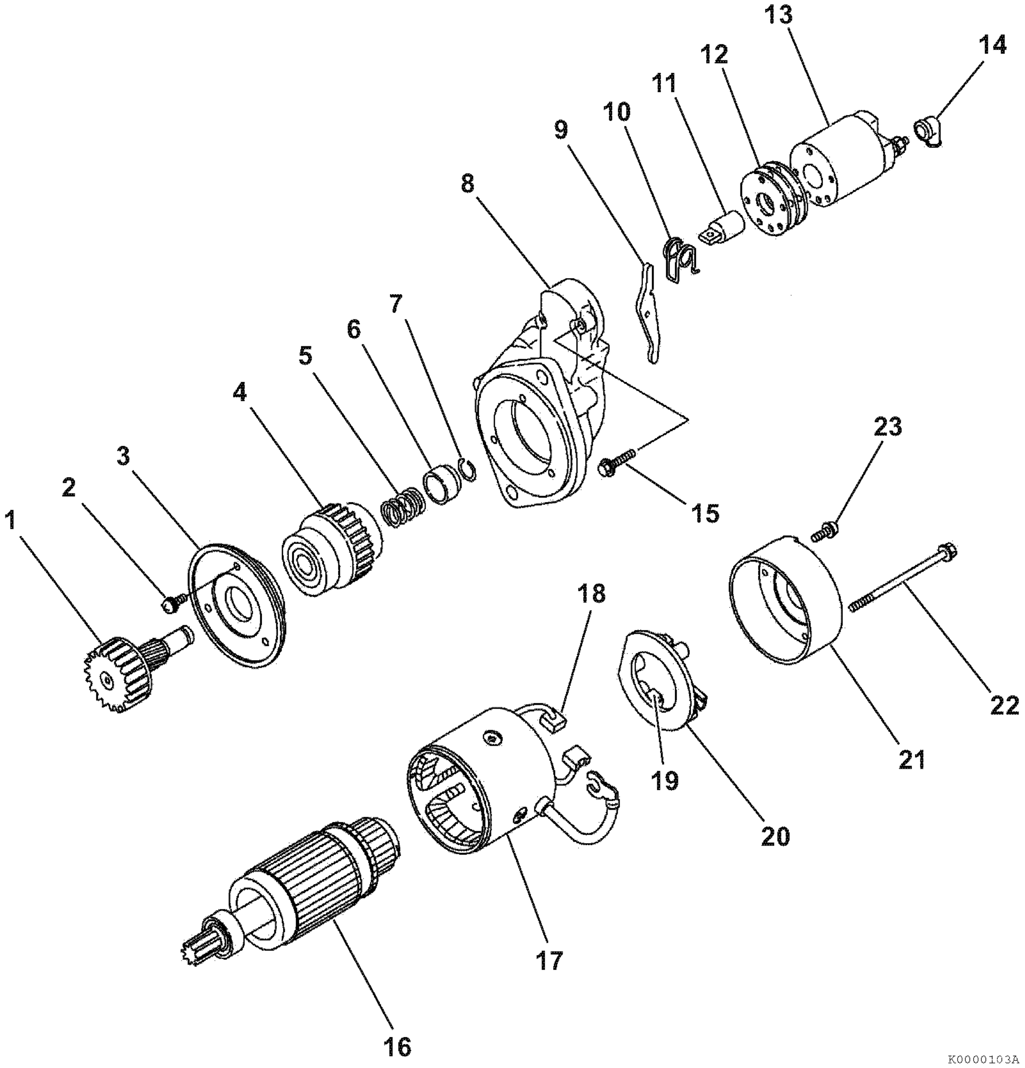
STARTER MOTOR SPECIFICATIONS

YANMAR Part No.			129900-77010
Nominal output			3.0 HP (2.3 kW)
Weight			12.1 lb (5.5 kg)
Revolution direction (as viewed from pinion)			Clockwise
Engagement system			Magnetic shift
No-load	Terminal voltage/current		11 V/140 A max
	Revolution		4100 min^{-1} (rpm)
Loaded	Terminal voltage/current		2.5 V/1050 A maximum
	Torque		18 ft-lb (24.5 N·m; 2.5 kgf·m) minimum
Clutch system			Overrunning
Pinion projection voltage at 212 °F (100 °C)			8.6 V maximum
Pinion DP or module/number of teeth			M3/9
Difference (O-ring, oil seal)			Dry (none)
Application			Standard
Brush	Spring force		7.868 lbf (35 N; 3.6 kgf)
	Height	Standard	0.591 in. (15 mm)
		Limit	0.354 in. (9 mm)
Magnetic switch	Series coil resistance		0.27 W at 68 °F (20 °C)
	Shunt coil resistance		0.60 W at 68 °F (20 °C)
Commutator	Outside diameter	Standard	1.437 in. (36.5 mm)
		Limit	1.398 in. (35 mm)
	Run-out	Standard	0.001 in. (0.03 mm)
		Limit	0.008 in. (0.2 mm)
	Insulation depth	Standard	0.020 - 0.031 in. (0.5 - 0.8 mm)
		Limit	0.008 in. (0.2 mm)
Armature	Run-out	Standard	0.001 in. (0.03 mm)
		Limit	0.008 in. (0.02 mm)
Bearing type	Armature front	Nominal No.	6903DDU
	Armature rear		608DDU
	Pinion front		60004DDU
	Pinion rear		6904DDU
Pinion projection length (length L)			0.012 - 0.059 in. (0.3 - 1.5 mm)

STARTER MOTOR TROUBLESHOOTING



STARTER MOTOR COMPONENTS



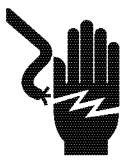
1 – Pinion shaft
2 – M4 bolts (3 used)
3 – Bearing retainer
4 – Pinion clutch assembly
5 – Return spring
6 – Pinion stop
7 – Retaining ring
8 – Gear housing
9 – Shift lever
10 – Torsion spring
11 – Plunger
12 – Dust covers (shims)
13 – Magnetic switch assembly (solenoid)
14 – Cover
15 – M6 bolts (2 used)
16 – Armature assembly
17 – Field coil assembly
18 – Positive (+) brushes
19 – Negative (-) brushes
20 – Brush holder assembly
21 – Rear cover
22 – M5 through bolts (2 used)
23 – M4 bolts (2 used)

Figure 11-1

STARTER MOTOR

⚠ WARNING

Shock Hazard!



- **Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.**
- **Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.**
- **Failure to comply could result in death or serious injury.**

Note: While starter motor design varies between models, the basic repair procedures are the same. The following procedures are typical and may differ from the stater being serviced.

Removal of Starter Motor

1. Disconnect the battery cables at the battery, negative (-) cable first.
2. Remove the electrical wires from the magnetic switch assembly.
3. Remove the starter mounting bolts (1, **Figure 11-2**). Remove the starter motor from the flywheel housing.

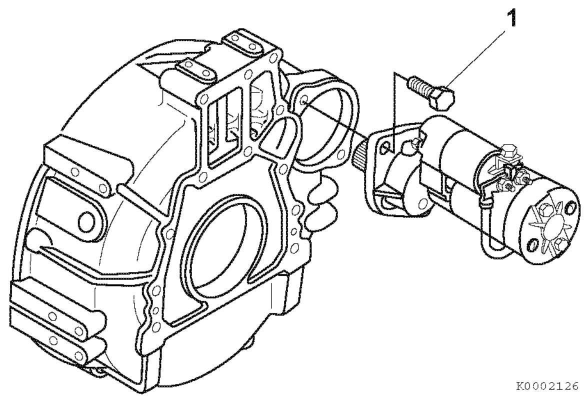


Figure 11-2

Disassembly of Starter Motor

1. Loosen the M8 nut from the magnetic switch (solenoid) assembly (**Figure 11-3**). Disconnect the wire from the magnetic switch.

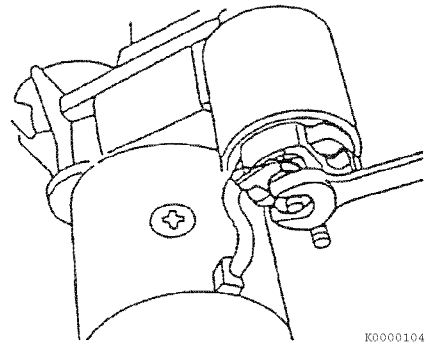


Figure 11-3

2. Remove the two M4 bolts (1, **Figure 11-4**) securing the rear cover (2, **Figure 11-4**) to the brush holder assembly (3, **Figure 11-4**).

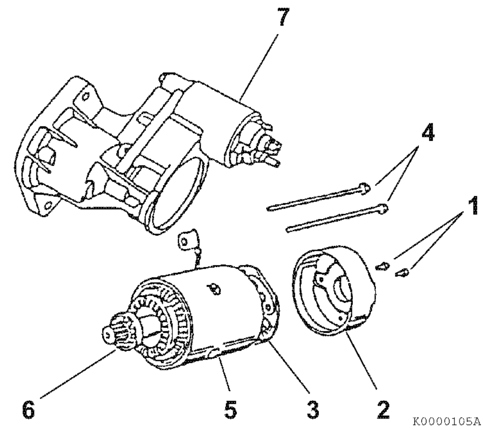


Figure 11-4

3. Remove the two M5 through bolts (4, **Figure 11-4**). Separate the rear cover (2, **Figure 11-4**), field coil assembly (5, **Figure 11-4**) with the armature assembly (6, **Figure 11-4**) from the gear housing (7, **Figure 11-4**).
4. Pull the brush springs up using a brush spring puller. On the negative (-) side, bring the brush spring into contact with the side of the brush for lifting from the commutator surface. On the positive (+) side, remove the brush from the brush holder assembly (1, **Figure 11-5**).

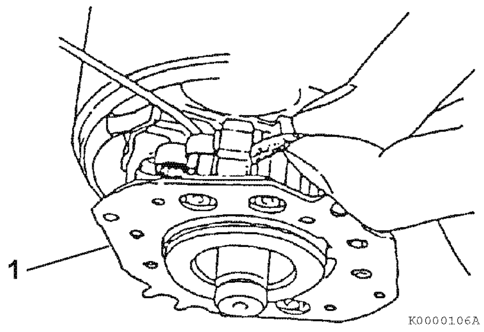


Figure 11-5

5. Remove the brush holder assembly (1, **Figure 11-6**) from the armature assembly (3, **Figure 11-6**).

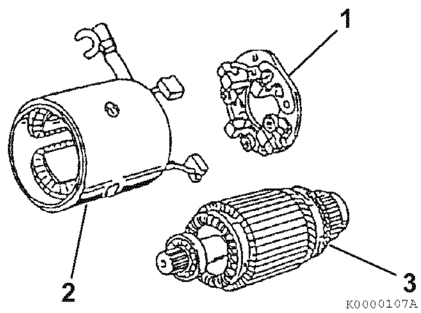


Figure 11-6

6. Pull the armature assembly (3, **Figure 11-6**) out from the field coil assembly (2, **Figure 11-6**).
7. Remove the two M6 bolts (1, **Figure 11-7**) retaining the magnetic switch assembly (2, **Figure 11-7**) to the gear housing. Remove the magnetic switch assembly, dust cover(s) (3, **Figure 11-7**) and torsion spring (4, **Figure 11-7**) from the gear housing.

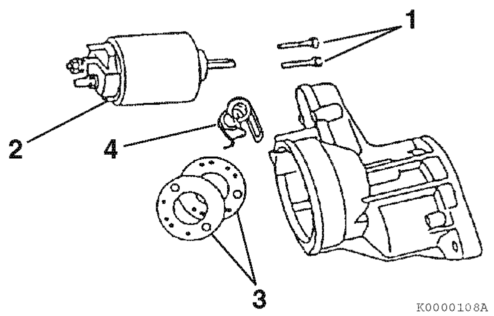


Figure 11-7

8. Disassemble the dust cover (3, **Figure 11-8**) and shift the lever (4, **Figure 11-8**) from the gear housing.

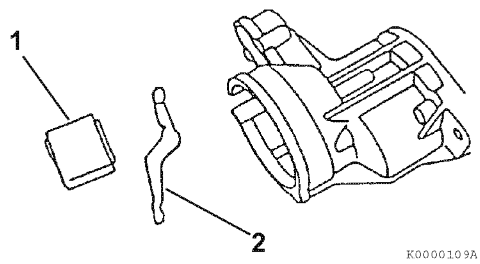


Figure 11-8

9. Remove the three M4 bolts (1, **Figure 11-9**) securing the bearing retainer assembly (2, **Figure 11-9**) to the gear housing. Remove the bearing retainer assembly from the gear housing.

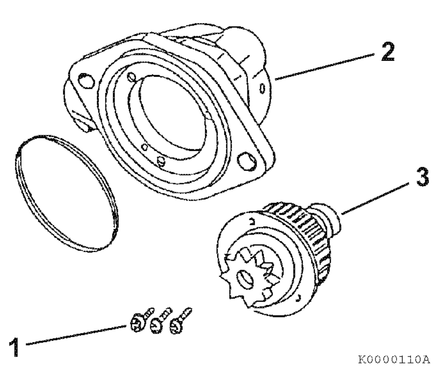


Figure 11-9

10. Remove the pinion clutch assembly (3, **Figure 11-9**) from the bearing retainer assembly.
11. Using a flat-blade screwdriver, remove the retaining ring (1, **Figure 11-10**) from the shaft of the pinion.

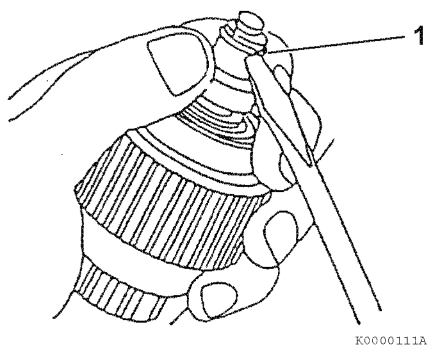


Figure 11-10

12. Disassemble the pinion stop (3, **Figure 11-11**), return spring (4, **Figure 11-11**), pinion clutch assembly (1, **Figure 11-11**), and pinion shaft (5, **Figure 11-11**).

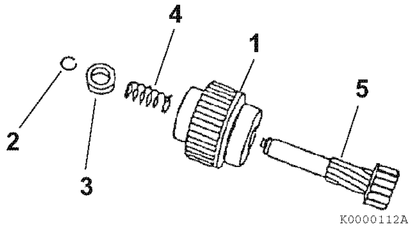


Figure 11-11

Cleaning and Inspection

■ Armature

Commutator surface inspection

If the commutator surface is rough, polish the surface with a #500 to #600 emery cloth (**Figure 11-12**).

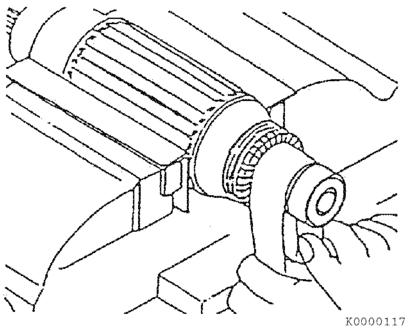


Figure 11-12

Measure commutator outside diameter

Measure the commutator outside diameter (**Figure 11-13**). Replace the armature if the measurement is less than the limit.

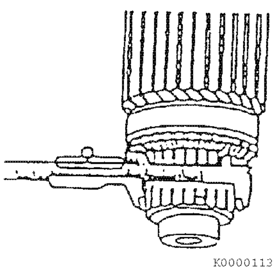


Figure 11-13

See Starter Motor Specifications on page 11-5 for the service limit.

Measure commutator insulation depth

Measure the depth of the insulating material (1, **Figure 11-14**) between commutator segments (2, **Figure 11-14**). If the depth measures less than the limit, use a hacksaw blade (3, **Figure 11-14**) to remove the insulating material until the depth is within the limit.

A normal commutator condition is indicated in (4, **Figure 11-14**). An abnormal commutator condition is indicated in (5, **Figure 11-14**).

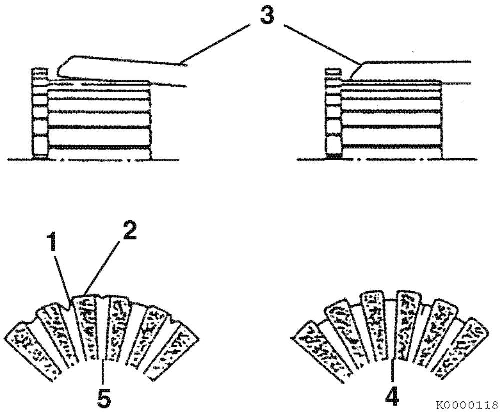


Figure 11-14

See Starter Motor Specifications on page 11-5 for the service limit.

Armature coil continuity test

Check for continuity between the commutator segments using a multimeter (**Figure 11-15**). The multimeter should indicate continuity.

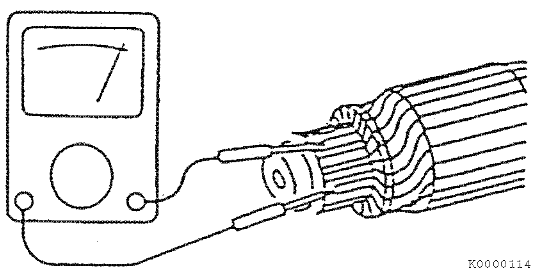


Figure 11-15

If the multimeter does not indicate continuity, replace the armature.

Armature coil insulation test

Check for continuity between a commutator segment and the shaft or armature using a multimeter (**Figure 11-16**). The multimeter should not indicate continuity.

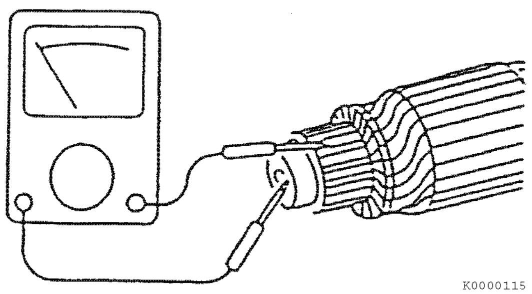


Figure 11-16

If the multimeter indicates continuity, replace the armature.

Measure armature and commutator run-outs

Measure the armature core run-out and the commutator run-out using a dial indicator (**Figure 11-17**). Replace the armature if either of the measurements is less than the limit.

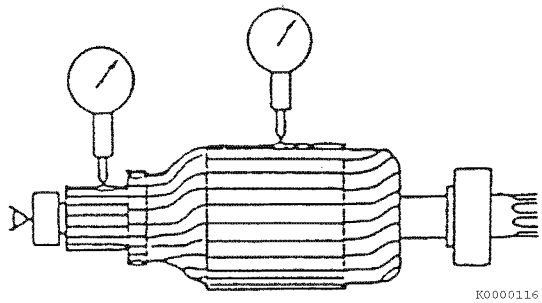


Figure 11-17

See Starter Motor Specifications on page 11-5 for the service limit.

■ Field coil

Field coil continuity test

Check for continuity between the field coil terminals using a multimeter (**Figure 11-18**). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the field coil assembly.

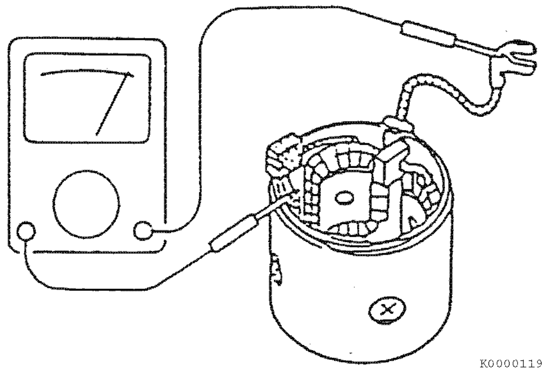


Figure 11-18

Field coil insulation test

Check for continuity between the field coil terminal and the yoke using a multimeter (**Figure 11-19**). The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the field coil assembly.

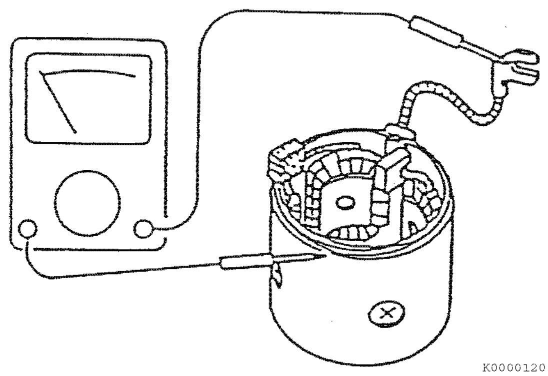


Figure 11-19

Measure brush length

Measure the length of the brush (**Figure 11-20**). Replace the brush if the length is less than the limit.

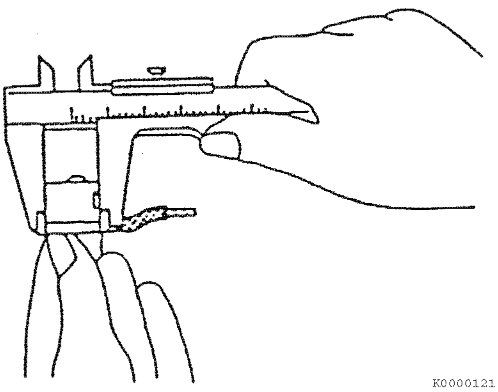


Figure 11-20

See Starter Motor Specifications on page 11-5 for the service limit.

■ Magnetic switch

If the starter motor becomes wet, replace the magnetic switch even if the magnetic switch assembly function is normal.

Shunt coil continuity test

Check for continuity between the “S” terminal and the switch body using a multimeter (**Figure 11-21**). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

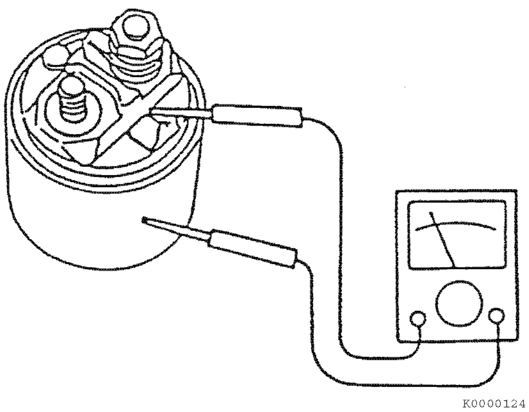


Figure 11-21

Series coil continuity test

Check for continuity between the “S” and “M” terminals using a multimeter (**Figure 11-22**). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

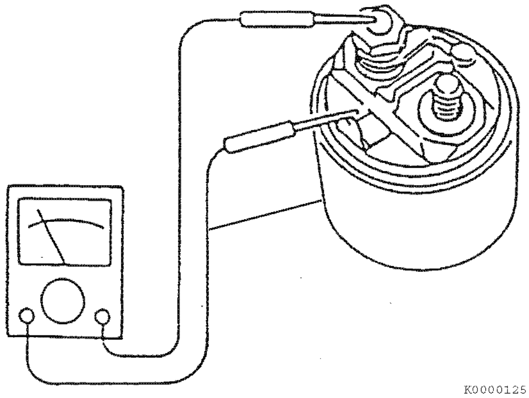


Figure 11-22

Coil resistance test

See Starter Motor Specifications on page 11-5 for the service limit.

Contact continuity test

Depress the plunger at the bottom of the magnetic switch. Check for continuity between the “B” and “M” terminals using a multimeter (**Figure 11-23**). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

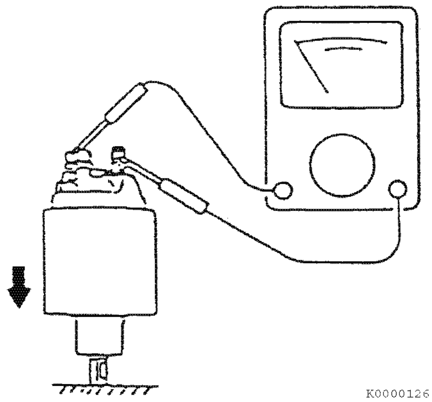


Figure 11-23

■ Pinion clutch assembly

Pinion clutch assembly inspection

Manually rotate the pinion clutch assembly in the drive direction (**Figure 11-24**). It should rotate freely in the drive direction and is locked by turning it in the opposite direction. Replace the pinion clutch assembly if the results are different.

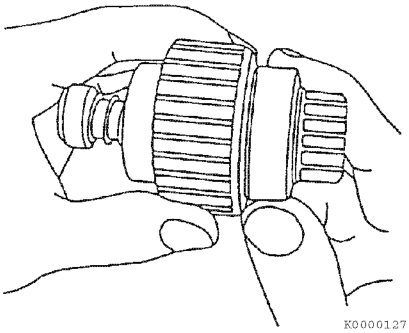


Figure 11-24

Slide the pinion clutch assembly on the shaft. It should slide smoothly on the shaft (**Figure 11-25**). Rust, too much grease or damage could prevent the pinion clutch from sliding smoothly. If the pinion clutch assembly does not slide smoothly, clean the shaft and pinion clutch assembly or replace the damaged component.

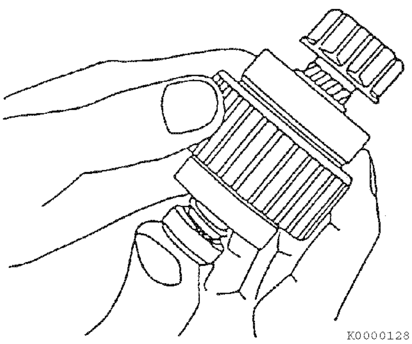


Figure 11-25

Ball bearing inspection

Rotate each ball bearing while holding the pinion clutch assembly (**Figure 11-26**). Replace the ball bearing if it does not rotate smoothly or has excessive play.

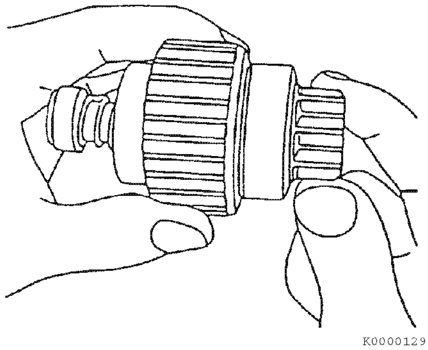


Figure 11-26

Reassembly of Starter Motor

1. Apply the appropriate starter bendix grease (obtain locally) to the pinion shaft. Reassemble the pinion shaft (5, **Figure 11-27**), pinion clutch assembly (1, **Figure 11-27**), return spring (4, **Figure 11-27**) and pinion stop (3, **Figure 11-27**). Reinstall the retaining ring (2, **Figure 11-27**) in the groove in the pinion shaft. Slide the piston stop over the retaining ring.

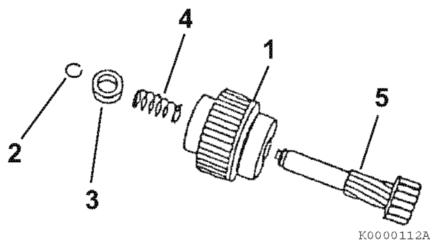


Figure 11-27

2. Reinstall the pinion clutch assembly into the bearing retainer assembly.
3. Reinstall the bearing retainer assembly and pinion assembly to the gear housing. Reinstall and tighten the three M4 bolts.
4. Apply a small amount of high temperature lithium grease (obtain locally) to the sliding portions of the shift lever (1, **Figure 11-28**). Reassemble the torsion spring (2, **Figure 11-28**), shift lever and dust cover(s) (3, **Figure 11-28**), plunger (4, **Figure 11-28**)) and magnetic switch assembly (5, **Figure 11-28**).

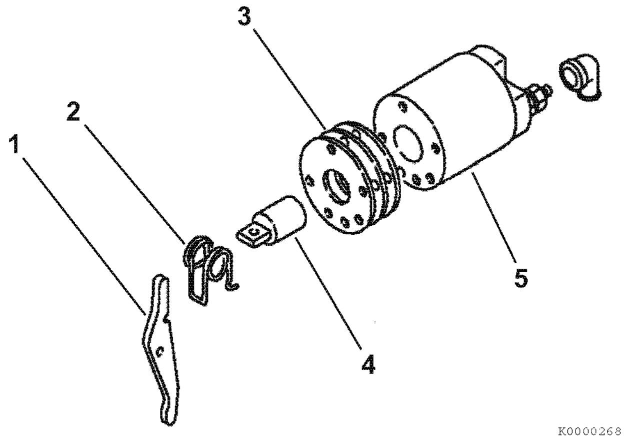


Figure 11-28

5. Reassemble the magnetic switch assembly to the gear housing. Pry the pinion away from the gear housing to allow installation of the magnetic switch assembly (**Figure 11-29**).

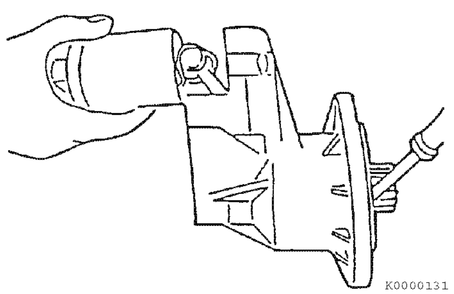


Figure 11-29

6. Secure the magnetic switch assembly to the gear housing using the two M6 bolts.
7. Carefully install the armature assembly (1, **Figure 11-30**) into the field coil assembly (2, **Figure 11-30**).

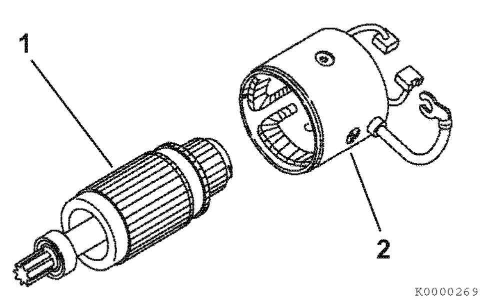


Figure 11-30

8. Position the brush springs in brush holders (**Figure 11-31**). Reinstall the brushes in the brush holders. Reversing the brushes will cause the starter motor to turn backwards.

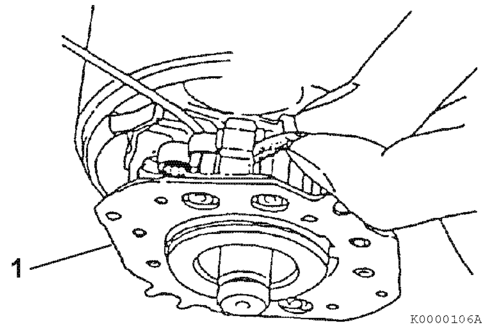


Figure 11-31

9. Carefully install the brush holder assembly to the armature assembly.
10. Reinstall the field coil assembly with the armature assembly to the gear housing.
11. Reinstall the rear cover to the brush holder assembly. Securely tighten the two bolts.
12. Reinstall the two M4 through bolts (**Figure 11-32**). Securely tighten the through bolts. Reconnect the wire to the magnetic switch assembly. Tighten the M8 nut. Reinstall the cover over the connection.

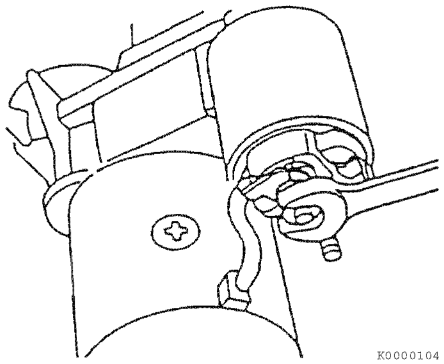


Figure 11-32

Check Pinion Projection Length

1. Connect the positive (+) lead from a battery to the “S” terminal.
2. Connect the negative (-) lead to the “M” terminal.
3. Lightly pull the pinion away from the gear housing.
4. Turn the switch ON and measure the pinion moving distance L in the thrust direction (**Figure 11-33**). Perform this test within 10 seconds. *See Starter Motor Specifications on page 11-5 for the service limit.*

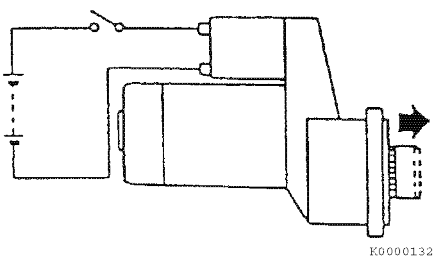


Figure 11-33

5. If the measured L dimension is outside the standard range, adjust the dust covers to obtain the standard range. Dust covers (1, **Figure 11-34**) are available in 0.020 in. (0.5 mm) and 0.031 in. (0.8 mm) thicknesses.

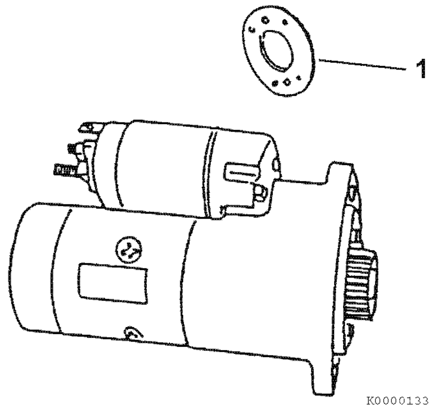


Figure 11-34

No-Load Test

Test the characteristics of the starter motor by performing a no-load test.

NOTICE

The starter motor can be damaged if operated continuously longer than 10 seconds while performing the no-load test.

1. Secure the starting motor in a vise or other suitable fixture.
2. Connect an ammeter (1, **Figure 11-35**) in series between the battery positive (+) terminal (2, **Figure 11-35**) and the main positive (+) terminal (3, **Figure 11-35**) on the starter motor.

   Note: The ammeter and all wire leads used in this test must have a capacity equal to or greater than the amperage draw specification for the starter motor being tested.

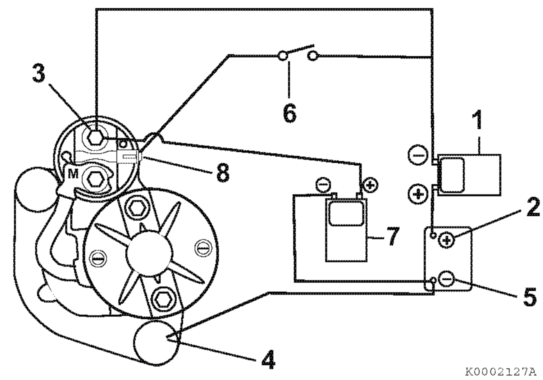


Figure 11-35

3. Connect a wire lead between the mounting base of the starter motor (4, **Figure 11-35**) and the battery negative terminal (5, **Figure 11-35**).
4. Connect a voltmeter (7, **Figure 11-35**) to the battery negative (-) terminal (5, **Figure 11-35**) and the main positive (+) battery terminal (3, **Figure 11-35**) on the starter motor.

5. Install a switch (6, **Figure 11-35**) in a circuit between the battery positive (+) terminal (2, **Figure 11-35**) and the starter magnetic switch (solenoid) terminal (8, **Figure 11-35**) on the starter motor.
6. Use a suitable tachometer to monitor the rpm of the starter.
7. Turn the switch to the ON position. Monitor the rpm, amperage draw and voltage. For test specifications, *see 3TNV88C to 4TNV86CT - Standard and Optional and 4TNV98C and 4TNV98CT - Standard and Optional on page 11-4 for the appropriate starter motor.*

Installation of Starter Motor

1. Reinstall the starter motor to the flywheel housing.
2. Reinstall the starter mounting bolts (1, **Figure 11-36**). Tighten the bolts to specification. *See Tightening Torques for Standard Bolts and Nuts on page 4-43.*

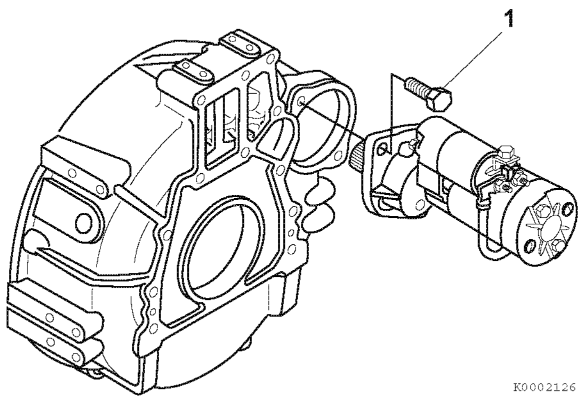


Figure 11-36

3. Reconnect the electrical wires to the magnetic switch assembly (solenoid). Be sure to place the cover over the battery positive (+) cable connection.
4. Reconnect the battery cables at the battery.

Section 12

ALTERNATOR

Page

BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety* section on page *3-1*.

INTRODUCTION

This section of the Service Manual describes the servicing of the dynamos and alternators. YANMAR Part No. 129423-77200 alternator is used in this section to show the service procedures for the representative alternator. YANMAR Part No. 171301-77201 dynamo is used in this section to show the service procedures for the representative dynamo. For specific part detail, see the *Parts Catalog* for the engine you are working on.

DYNAMO AND ALTERNATOR INFORMATION

3TNV88C to 4TNV98CT - Standard and Optional Dynamos

YANMAR Part No.	Mfg.	Mfg. Part No.	Specification
171301-77201	Kokusan	GP8138	DC 12 V - 15 A
119910-77200	Kokusan	GP9191	DC 12 V - 20 A

3TNV88C to 4TNV98CT - Standard and Optional Alternators

YANMAR Part No.	Mfg.	Mfg. Part No.	Specification
119620-77201	Denso	100211-4531	DC 12 V - 40 A
129423-77200	Denso	101211-1170	DC 12 V - 40 A with pulse
129961-77200	Denso	101211-2591	DC 12 V - 55 A
119626-77210	Denso	101211-2951	DC 12 V - 55 A with pulse

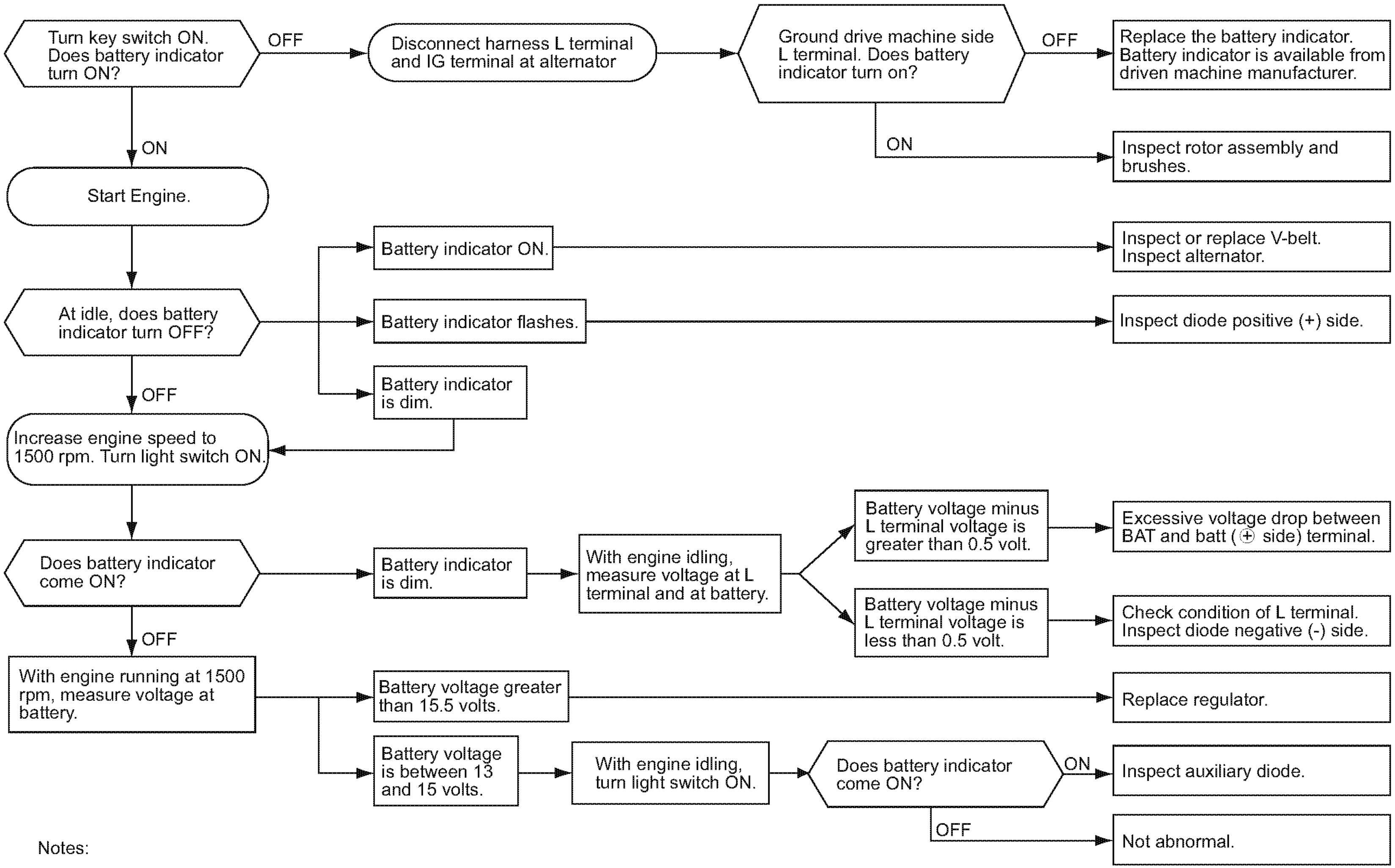
ALTERNATOR SPECIFICATIONS

YANMAR Part No.	129423-77200
Nominal output (13.5 volts heat)	40 A
Weight	6.17 lb (2.8 kg)
Revolution direction (as viewed from pulley)	Clockwise
Rating	Continuous
Battery voltage	12 V
Rated revolution	5000 min^{-1} (rpm)
Operating range	1350 - 18000 min^{-1} (rpm)
Grounding characteristics	Negative (-) side of circuit
Integrated regulator	IC regulator
Outside diameter of pulley	2.724 in. (69.2 mm)
Belt shape	Type A

DYNAMO SPECIFICATIONS

YANMAR Part No.		119910-77200
Nominal output		20 A
Weight		3.97 lb (1.8 kg)
Revolution direction (as viewed from pulley)		Clockwise
Rating		Continuous
Battery voltage		12 V
Rated revolution		3500 min^{-1} (rpm)
Operating range		1400 - 6600 min^{-1} (rpm)
Grounding characteristics		Negative (-) side of circuit
Regulator		Current limiter (YANMAR Part No. 119653-77710)
Outside diameter of pulley	A-belt	2.56 in. (65 mm)
	Special M-belt	2.28 in. (58 mm)
Belt shape		Type A or type special M

ALTERNATOR TROUBLESHOOTING

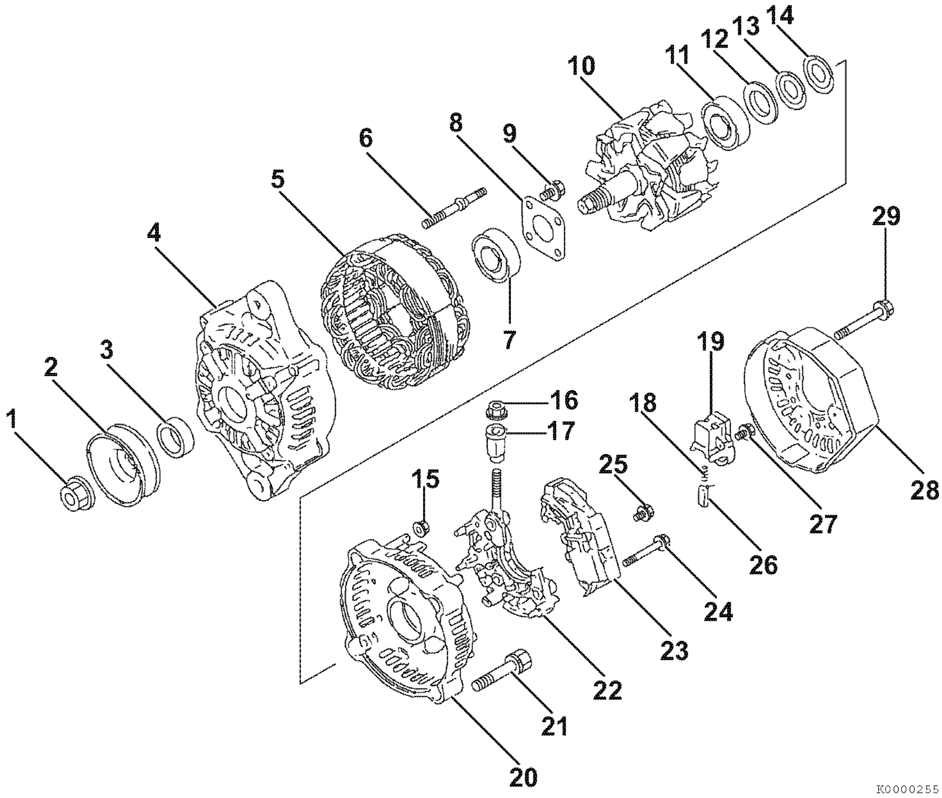


Notes:

1. Use a fully charged battery
2. DC voltmeter: 0 to 30 V, 0.5 class
3. The check method is also applicable to the bench test

ALTERNATOR COMPONENTS

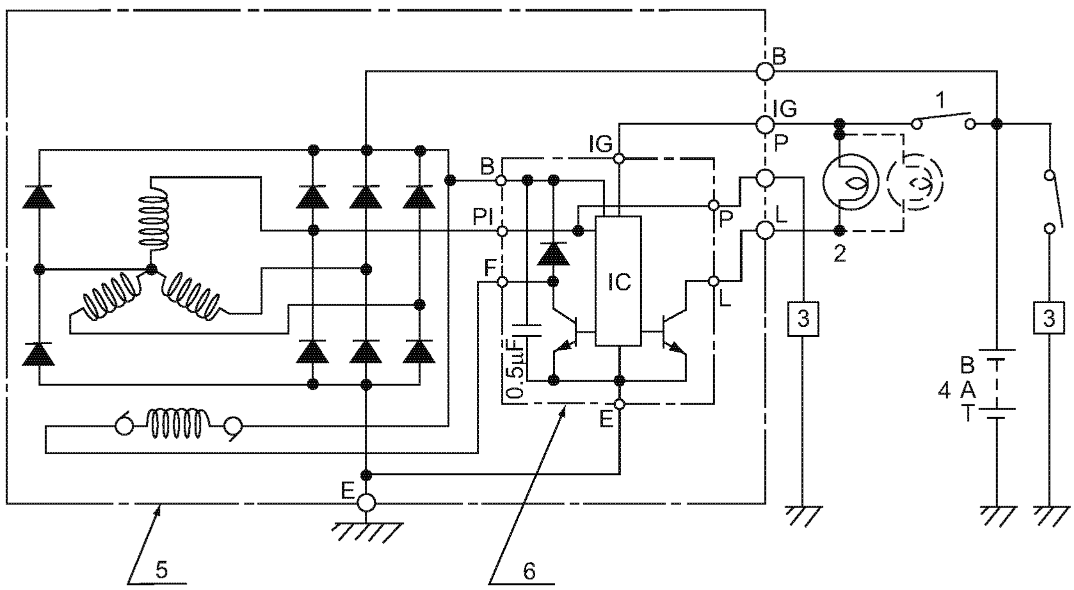
YANMAR Part No. 129423-77200 alternator is used in this section to show the service procedures for the representative alternator. For specific part detail, see the *Parts Catalog* for the engine you are working on.



1 – Nut
2 – Pulley
3 – Collar
4 – Front frame housing
5 – Stator assembly
6 – Stud (2 used)
7 – Front frame housing bearing
8 – Bearing cover
9 – Bearing cover bolt (4 used)
10 – Rotor assembly
11 – Rear frame housing bearing
12 – Bearing cover
13 – Thrust washer
14 – Thrust washer
15 – Nut (2 used)
16 – Nut
17 – Insulation bushing
18 – Spring (2 used)
19 – Brush holder
20 – Rear frame housing
21 – Bolt (2 used)
22 – Holder
23 – IC regulator assembly
24 – Bolt (2 used)
25 – Bolt
26 – Brush (2 used)
27 – Bolt
28 – Rear cover
29 – Bolt (3 used)

Figure 12-1

ALTERNATOR WIRING DIAGRAM



1 – Key switch
2 – Charge lamp (3.4 watts maximum)
3 – Load
4 – Battery
5 – Alternator assembly
6 – IC regulator assembly

Figure 12-2

NOTICE

Do not short-circuit the charging system between alternator terminals IG and L. Damage to the alternator will result.

NOTICE

Do not connect a load between alternator terminals L and E. Damage to the alternator will result.

NOTICE

Do not remove the positive (+) battery cable from alternator terminal B while the engine is operating. Damage to the alternator will result.

ALTERNATOR STANDARD OUTPUT

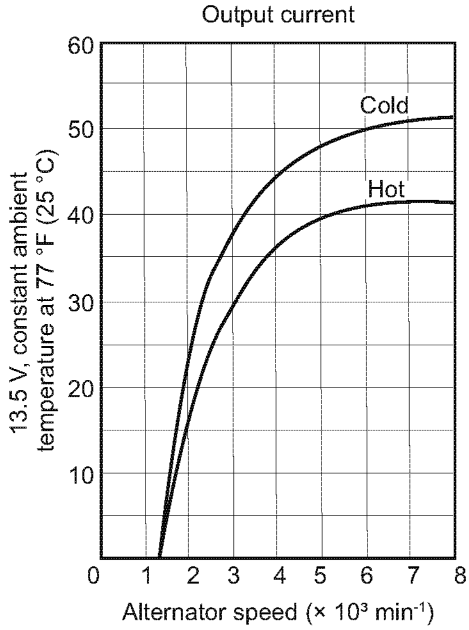


Figure 12-3

ALTERNATOR

⚠ WARNING

Shock Hazard!

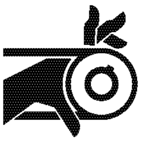
- **Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.**

- **Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.**
- **Failure to comply could result in death or serious injury.**

Removal of Alternator

⚠ CAUTION

Pinch Hazard!



Carefully rotate the alternator toward the cylinder block while loosening the V-belt. Failure to comply may result in minor or moderate injury.

1. Disconnect the electrical wires from the alternator.
   - **Manual type**

     1- Loosen the alternator mounting nut (1, **Figure 12-4**) and belt adjuster mounting bolt (2, **Figure 12-4**), and remove the V-belt adjuster bolt (3, **Figure 12-4**) from the belt adjuster to loosen the V-belt.
     Here, do not loose the spacer (4, **Figure 12-4**).

     2- Remove the alternator mounting nut, and remove the alternator.

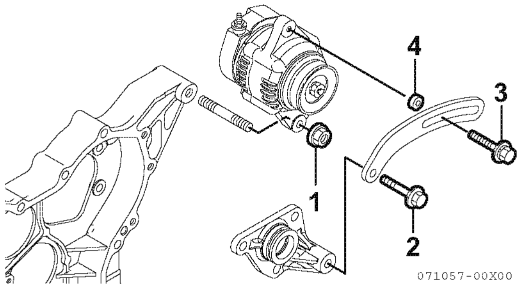


Figure 12-4

   - **Jack type**

     1- Loosen the adjuster bolt lock nut (1, **Figure 12-5**) adjusting the tension and the belt adjuster mounting bolt (2, **Figure 12-5**), and loosen the adjuster bolt (3, **Figure 12-5**) to a certain degree.

     2- Loosen the mounting nut (4, **Figure 12-5**) at the bottom of the alternator. Remove the tightening bolt (5, **Figure 12-5**) from the alternator, and loosen the V-belt.
     Here, do not loose the spacer (6, **Figure 12-5**).

     3- Remove the alternator mounting nut (4, **Figure 12-5**), and remove the alternator.

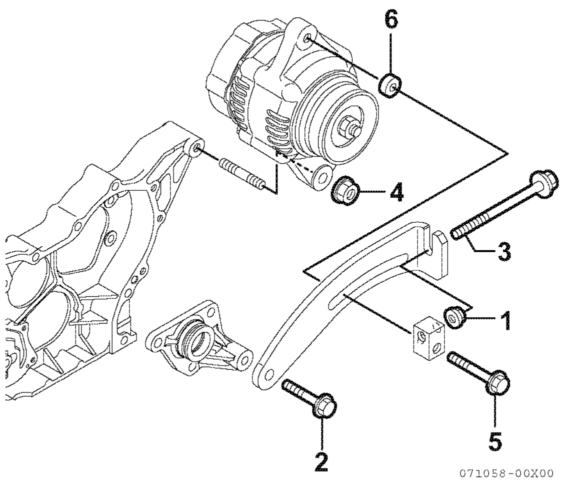


Figure 12-5

Disassembly of Alternator

1. Remove the nut (1, **Figure 12-6**) from the shaft of the rotor assembly. Remove the pulley (2, **Figure 12-6**).

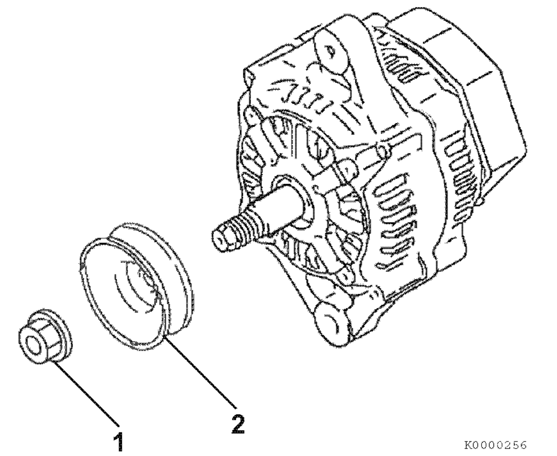


Figure 12-6

2. Remove the three bolts (1, **Figure 12-7**) retaining the rear cover (2, **Figure 12-7**) to the rear frame assembly.

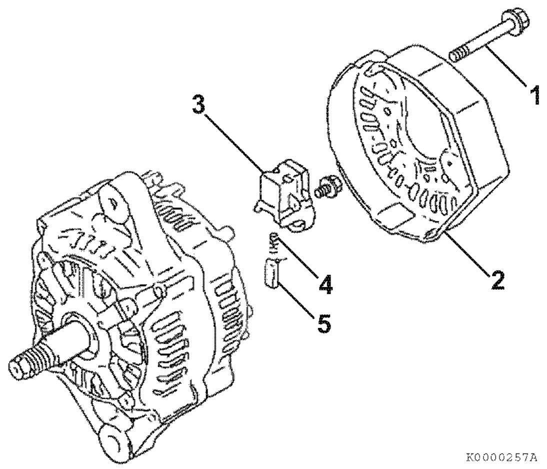


Figure 12-7

3. Remove the brush holder (3, **Figure 12-7**). Remove the brush springs (4, **Figure 12-7**) and brushes (5, **Figure 12-7**).
4. Remove the bolt retaining the regulator assembly (1, **Figure 12-8**) to the holder (2, **Figure 12-8**).

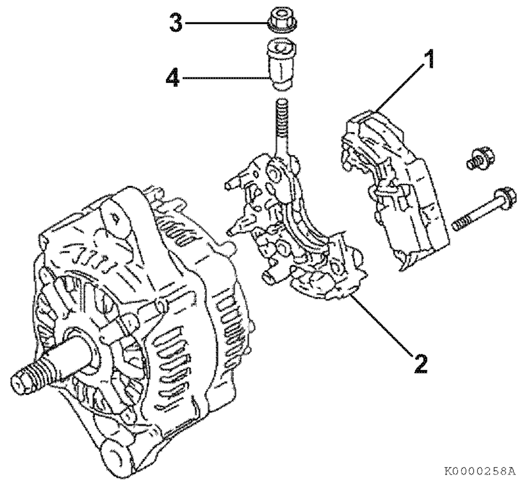


Figure 12-8

5. Remove the bolts retaining the holder (2, **Figure 12-8**) to the rear frame housing. Remove the holder.
6. Remove the nut (3, **Figure 12-8**) retaining the insulation bushing (4, **Figure 12-8**). Remove the insulation bushing.
7. Remove the two bolts (1, **Figure 12-9**) and two nuts (2, **Figure 12-9**) securing the rear frame housing to the front frame housing.

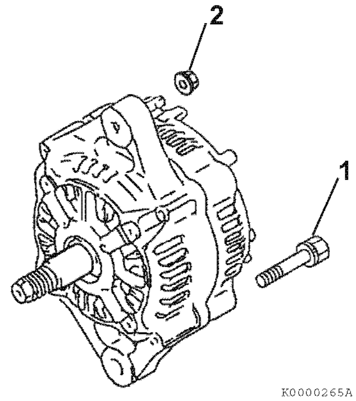


Figure 12-9

8. Using a press, remove the rotor assembly (1, **Figure 12-10**) from the front frame housing (2, **Figure 12-10**) and rear frame housing (3, **Figure 12-10**).

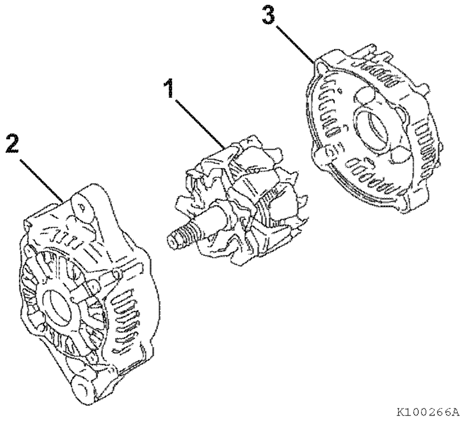


Figure 12-10

9. Remove the stator assembly (1, **Figure 12-11**) from the front frame housing.

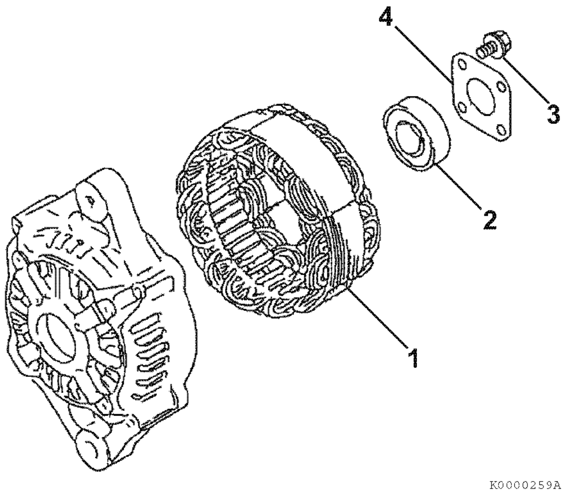


Figure 12-11

10. If it is necessary to replace the bearing (2, **Figure 12-11**) in the front frame housing, remove the four bolts (3, **Figure 12-11**) securing the plate (4, **Figure 12-11**) to the front frame housing. Remove the plate. Use a puller to remove the bearing. Discard the bearing.

11. If it is necessary to replace the bearing (1, **Figure 12-12**) in the rear frame housing, use a puller to remove. Discard the bearing. Remove the bearing cover (2, **Figure 12-12**) and two thrust washers (3, **Figure 12-12**).

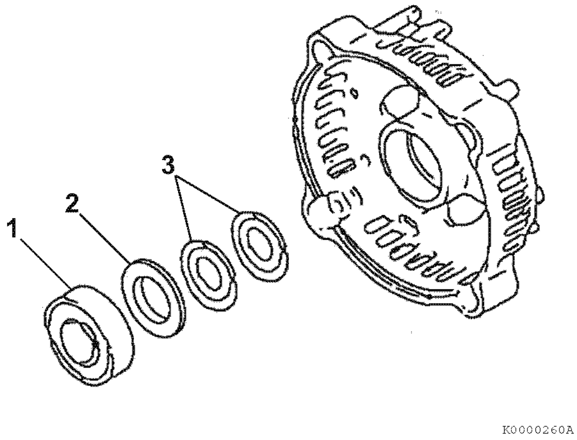


Figure 12-12

Reassembly of Alternator

1. If removed, reinstall the two trust washers (3, **Figure 12-13**) and bearing cover (2, **Figure 12-13**) in the rear frame housing. Lubricate the outside diameter of a new bearing (1, **Figure 12-13**). Press the bearing into the rear frame housing.

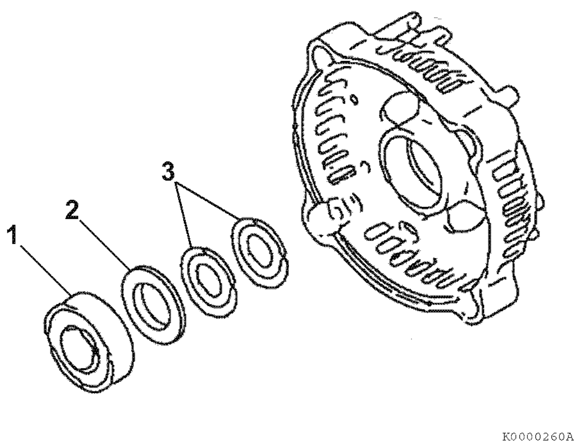


Figure 12-13

2. If removed, lubricate the outside diameter of a new front frame housing bearing. Press the bearing (2, **Figure 12-14**) into the front frame housing. Reinstall the plate (4, **Figure 12-14**) to the front housing. Tighten the four bolts (3, **Figure 12-14**).

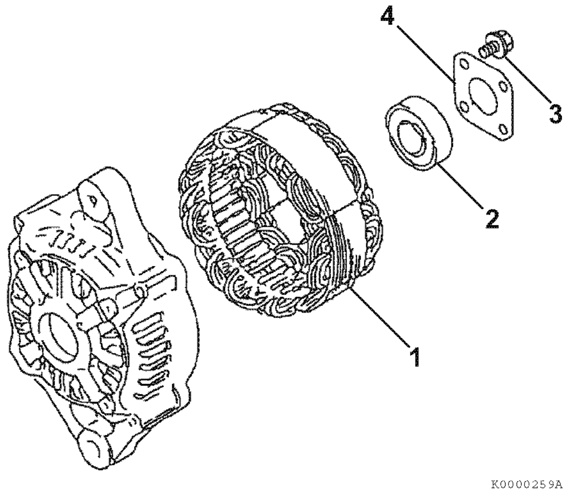


Figure 12-14

3. Position the stator assembly (1, **Figure 12-14**) on the front frame housing studs.
4. Lubricate the shaft of the rotor assembly (1, **Figure 12-15**). Press the rotor assembly into the front frame housing (2, **Figure 12-15**) and rear frame housing (3, **Figure 12-15**).

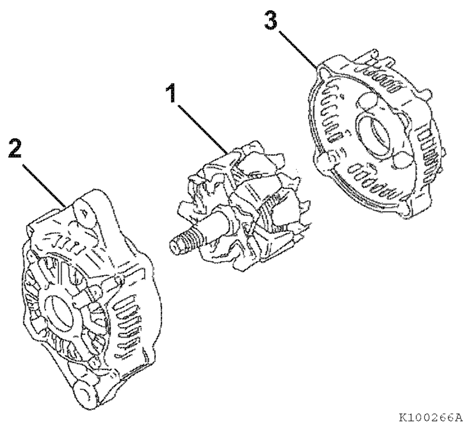


Figure 12-15

5. Align the front frame housing with the rear frame housing. Reinstall the two bolts (1, **Figure 12-16**) and two nuts (2, **Figure 12-16**).

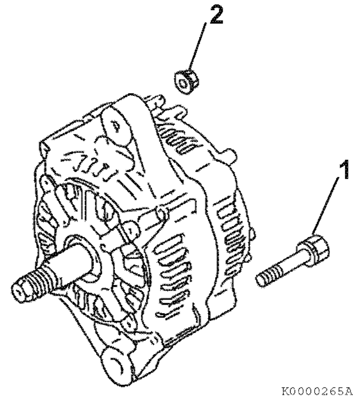


Figure 12-16

6. Reinstall the insulation bushing (4, **Figure 12-17**) and nut (3, **Figure 12-17**).

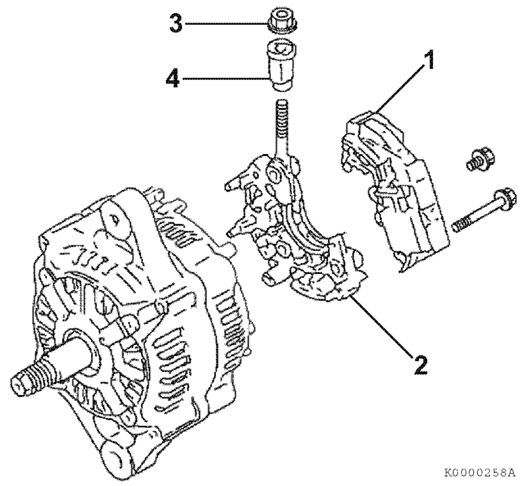


Figure 12-17

7. Reassemble the regulator assembly (1, **Figure 12-17**) to the holder (2, **Figure 12-17**).
8. Reinstall the brush holder **(Figure 12-18, (3))**, springs **(Figure 12-18, (4))** and brushes **(Figure 12-18, (5))**.

9. Reattach the regulator assembly and holder to the rear frame housing.

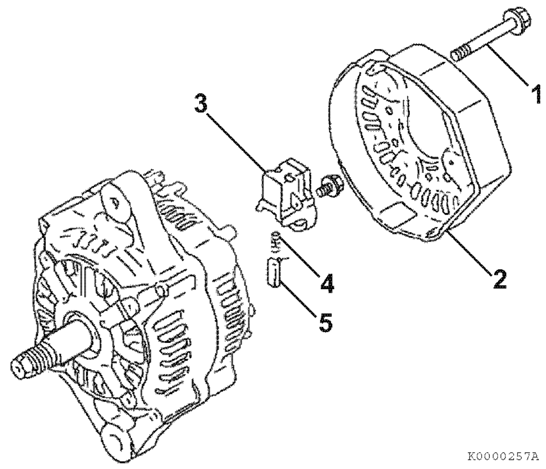


Figure 12-18

10. Reinstall the rear cover (2, **Figure 12-18**) to the rear frame housing with three bolts (1, **Figure 12-18**).
11. Reassemble the pulley (2, **Figure 12-19**) and nut (1, **Figure 12-19**) to the shaft of the rotor assembly. Tighten the nut.

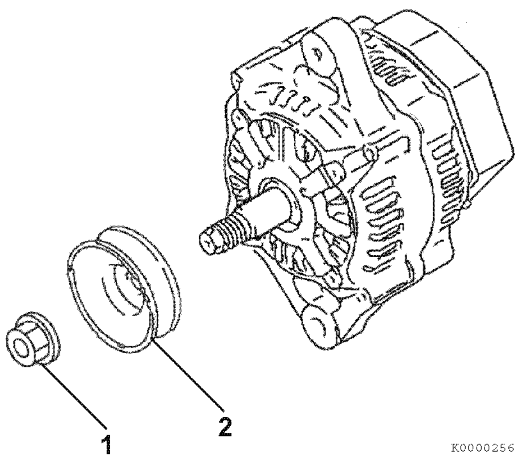


Figure 12-19

Installation of Alternator

1. Install the alternator.
   - **Manual type**
     1- Insert the stud bolt of the gear case to the alternator, and temporarily tighten the alternator mounting nut (1, **Figure 12-20**).
     2- With the belt adjuster mounting bolt (2, **Figure 12-20**) temporarily tightened, temporarily tighten the V-belt adjuster bolt (3, **Figure 12-20**) to the alternator.

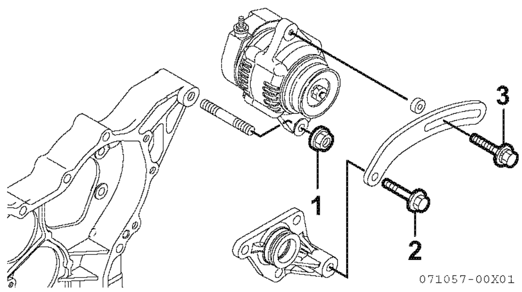


Figure 12-20

   - **Jack type**
     1- Insert the stud bolt of the gear case to the alternator, and temporarily tighten the alternator mounting nut (1, **Figure 12-21**).
     2- With the belt adjuster mounting bolt (2, **Figure 12-21**) temporarily tightened, temporarily tighten the belt adjuster tightening bolt (3, **Figure 12-21**).

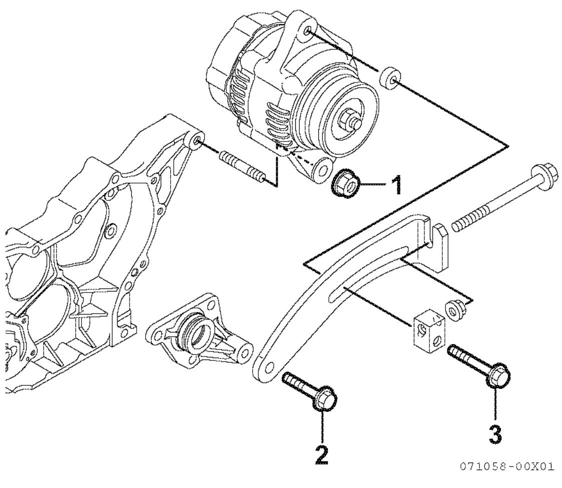


Figure 12-21

2. Reconnect the electrical wires to the alternator. Tighten the nuts to 15 - 20 in.-lb (1.7 - 2.3 N·m; 17 - 23 kgf·m).
3. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in *Check and adjust cooling fan V-belt on page 5-7.*
4. Start the engine. Listen for any unusual sounds from the alternator.

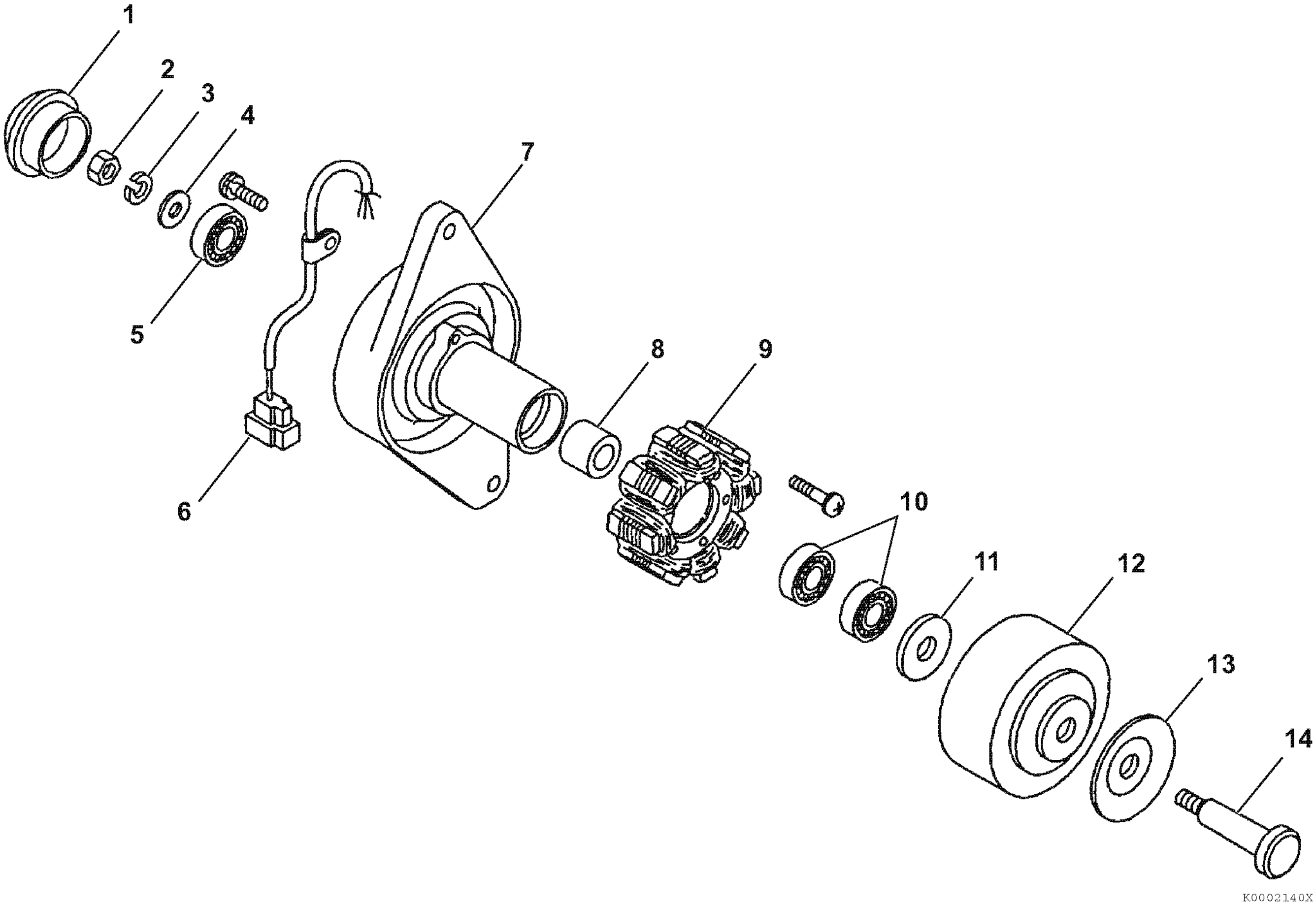
NOTICE

Do not operate the engine if the alternator is producing unusual sounds. Damage to the alternator will result.

5. Verify that the charge indicator is ON while the engine is operating. If the charge indicator is not ON, repair the problem before operating the engine.

DYNAMO COMPONENT LOCATION

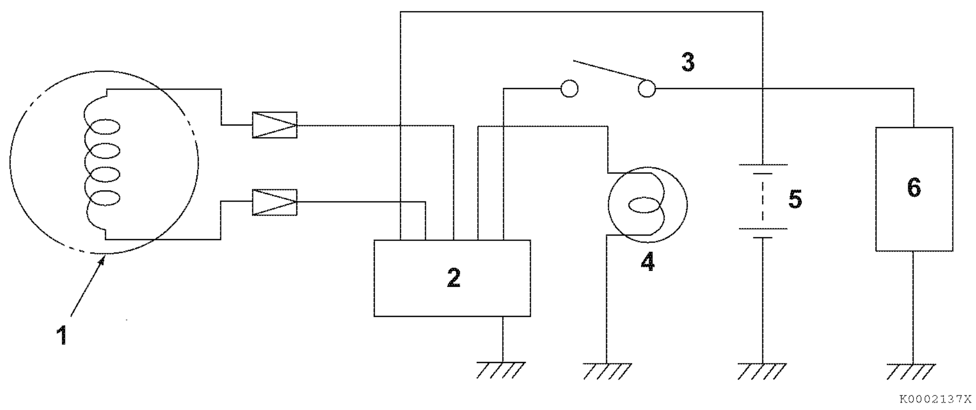
YANMAR Part No. 171301-77201 dynamo is used in this section to show the service procedures for the representative dynamo. For specific part detail, see the *Parts Catalog* for the engine you are working on.



1 – Rear cover
2 – Nut
3 – Lock washer
4 – Flat washer
5 – Rear bearing
6 – Output wire and connector
7 – Plate
8 – Spacer
9 – Stator assembly
10 – Front bearing (2 used)
11 – Flat washer
12 – Flywheel assembly
13 – Pulley half
14 – Through bolt

Figure 12-22

DYNAMO WIRING DIAGRAM



1 – Dynamo
2 – Current limiter
3 – Key switch
4 – Charge lamp (3.4 watts maximum)
5 – Battery
6 – Load

Figure 12-23

OPERATION OF DYNAMO

The dynamo consists of a series of permanent magnets that rotate around a stationary stator coil. The magnets are attached to the flywheel which is rotated via the engine cooling fan drive belt. The resultant output is an AC (alternating current) signal. The AC is converted to DC (direct current) by the current limiter. The current limiter outputs charging DC current to the battery.

DYNAMO STANDARD OUTPUT

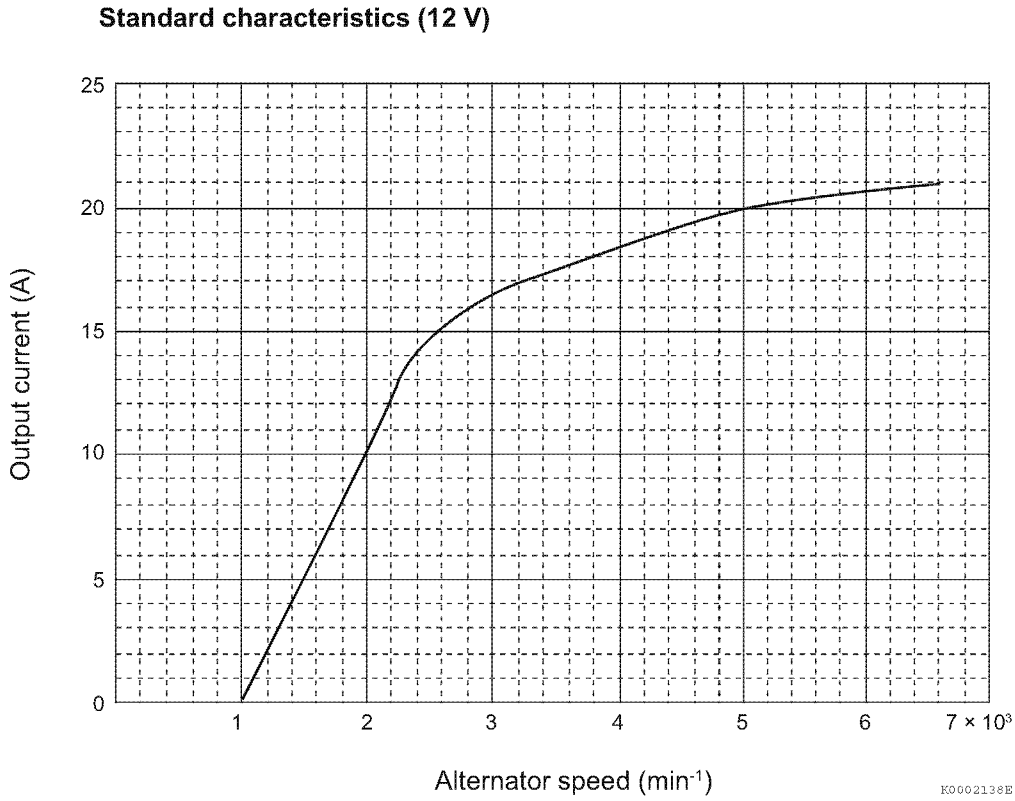


Figure 12-24

TESTING OF DYNAMO

Use a circuit tester or multimeter to perform the following tests.

Testing Stator Coil Continuity

1. Disconnect the dynamo output wire connector.
2. Connect one meter lead to each of the stator wire terminals and read the meter.

Results: The meter reading should indicate continuity. If continuity is not indicated, the windings are open and the stator must be replaced.

Testing Stator Coil Short-to-Ground

1. Disconnect the dynamo output wire connector.
2. Test continuity between each stator wire terminal and engine ground.

Results: The meter reading should infinity. If the meter reading indicates continuity, the windings are shorted to ground and the stator must be replaced.

Testing Dynamo Regulated Output

1. Test and record the battery voltage with the engine not running.
2. Start the engine and operate it at normal operating rpm.
3. Again, check the battery voltage with the engine running.

Results: The meter reading with the engine running must be higher than with the engine not running.

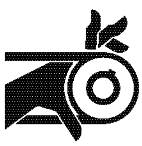
- If results are not correct, test the stator for continuity and shorts to the ground.
- Check the charging system wiring.
- If no problems are found in previous checks, replace the IC regulator.

DYNAMO

Removal of Dynamo

⚠ CAUTION

Pinch Hazard!



Carefully rotate the alternator toward the cylinder block while loosening the V-belt. Failure to comply may result in minor or moderate injury.

1. Disconnect the output wire connector from the dynamo.
2. Loosen the V-belt.
3. Remove the V-belt adjuster from the dynamo bolt (1, **Figure 12-25**).
4. Remove the nut (2, **Figure 12-25**) from the gear case stud. Remove the dynamo.

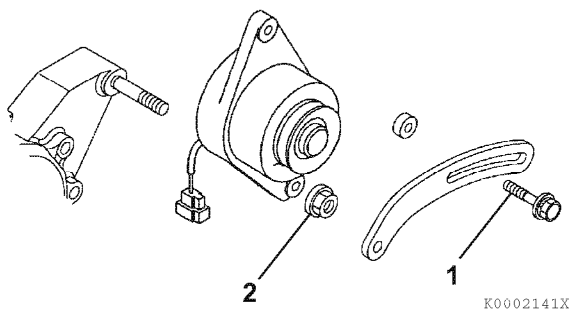


Figure 12-25

Disassembly of Dynamo

1. Remove the rear cover (1, **Figure 12-26**).
2. Remove the nut (1, **Figure 12-26**), lock washer (3, **Figure 12-26**), and flat washer (4, **Figure 12-26**).

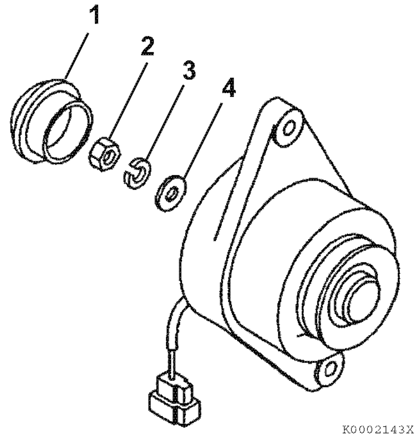


Figure 12-26

3. Remove the through bolt (1, **Figure 12-27**), pulley half (2, **Figure 12-27**), flywheel (3, **Figure 12-27**), flat washer (4, **Figure 12-27**), bearings (5, **Figure 12-27**), and spacer (6, **Figure 12-27**).

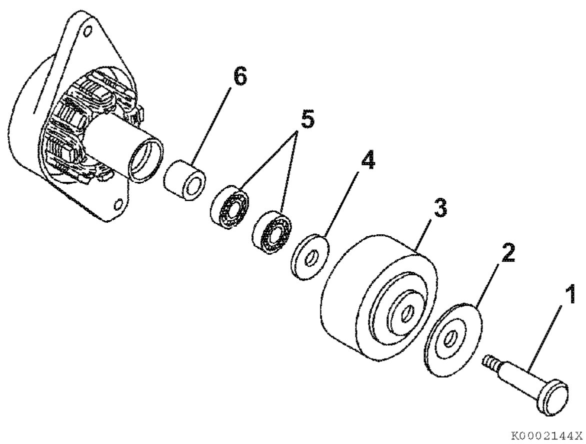


Figure 12-27

4. Remove the screws (1, **Figure 12-28**) and the stator assembly (2, **Figure 12-28**).
5. Remove the rear bearing (3, **Figure 12-28**).

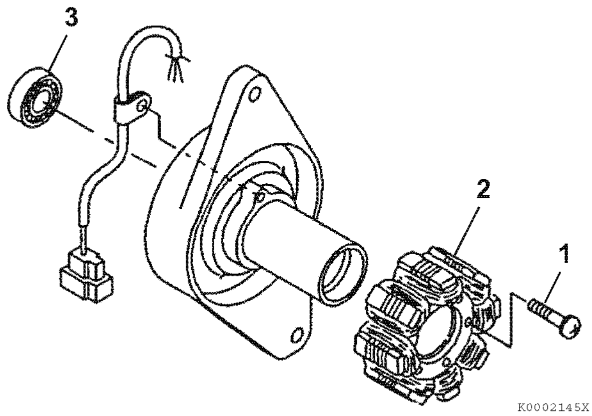


Figure 12-28

Reassembly of Dynamo

1. Reinstall the rear bearing (3, **Figure 12-29**).
2. Reinstall the stator (2, **Figure 12-29**) and screws.

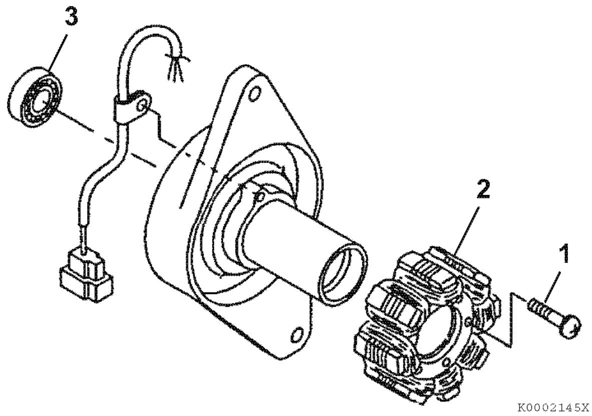


Figure 12-29

3. Reinstall the front bearings (5, **Figure 12-30**) and spacer (6, **Figure 12-30**).
4. Reinstall the flat washer (4, **Figure 12-30**), flywheel (3, **Figure 12-30**), pulley half (2, **Figure 12-30**), and through bolt (1, **Figure 12-30**).

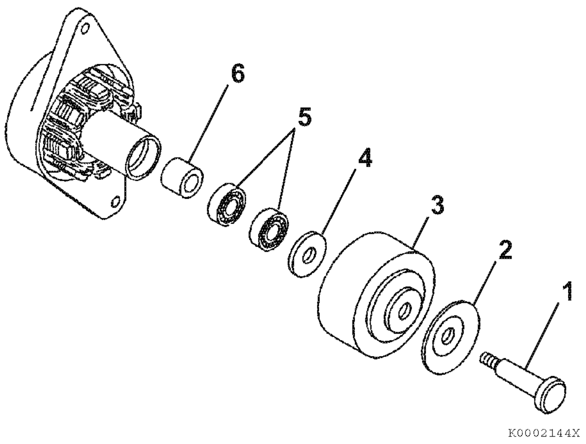


Figure 12-30

5. Reinstall the flat washer (4, **Figure 12-31**), lock washer (3, **Figure 12-31**), and nut (2, **Figure 12-31**). Tighten the nut to the specified torque.
6. Reinstall the rear cap (1, **Figure 12-31**).

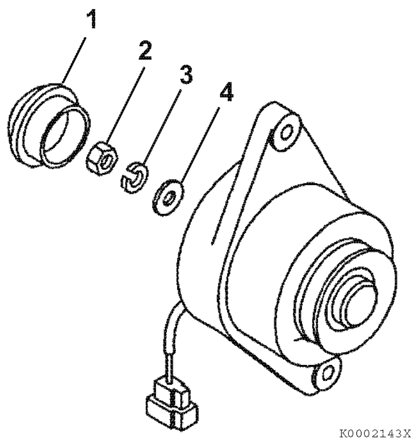


Figure 12-31

Installation of Dynamo

1. Position the dynamo on the gear case. Loosely reinstall the nut (2, **Figure 12-32**) on the gear case stud and the V-belt adjuster bolt (1, **Figure 12-31**).

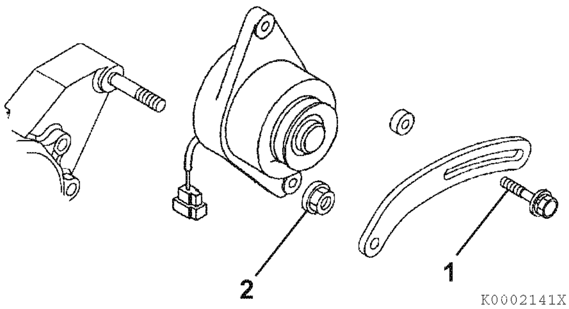


Figure 12-32

2. Reconnect the dynamo output wire connector.
3. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in *Check and adjust cooling fan V-belt on page 5-7*.
4. Start the engine. Listen for any unusual sounds from the alternator.

NOTICE

Do not operate the engine if the alternator is producing unusual sounds. Damage to the alternator will result.

5. Verify that the charge indicator is ON while the engine is operating. If the charge indicator is not ON, repair the problem before operating the engine.

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Section 13

ELECTRONIC CONTROL SYSTEM

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BEFORE YOU BEGIN SERVICING

Before performing any service procedures within this section, read the following safety information and review the *Safety section on page 3-1*.

INTRODUCTION

None of the components of the electronic control system can be individually repaired. When any component is faulty and needs repair, the entire assembly must be replaced.

SYSTEM STRUCTURE

YANMAR TNV engines come with the following systems:

- Common rail system as shown in the **Figure 7-1** on page *7-4*.
- Exhaust Gas Recirculation (EGR) system that controls the exhaust gas recirculation flow rate depending on the engine load and speed.
- System that controls the Diesel Particulate Filter (DPF) condition (for clogging), and controls the DPF regeneration by controlling the intake throttle.

Figure 13-1 illustrates the outline of the electronic control system.

Features of the electronic engine control system include:

- Engine speed control schemes
  Droop control/Isochronous control/Low-idling speed up/High-idling speed down/Auto deceleration
- Starting aid
  Auto preheating/After heating
- Engine failure detection
- CAN communication with the control system of the driven machine
- Other

These functions are described in *Main Electronic Control Components and Features on page 4-10*. However components and features vary depending on the driven machine. For details, refer to the operation manual provided by the driven machine manufacturer for these functions.

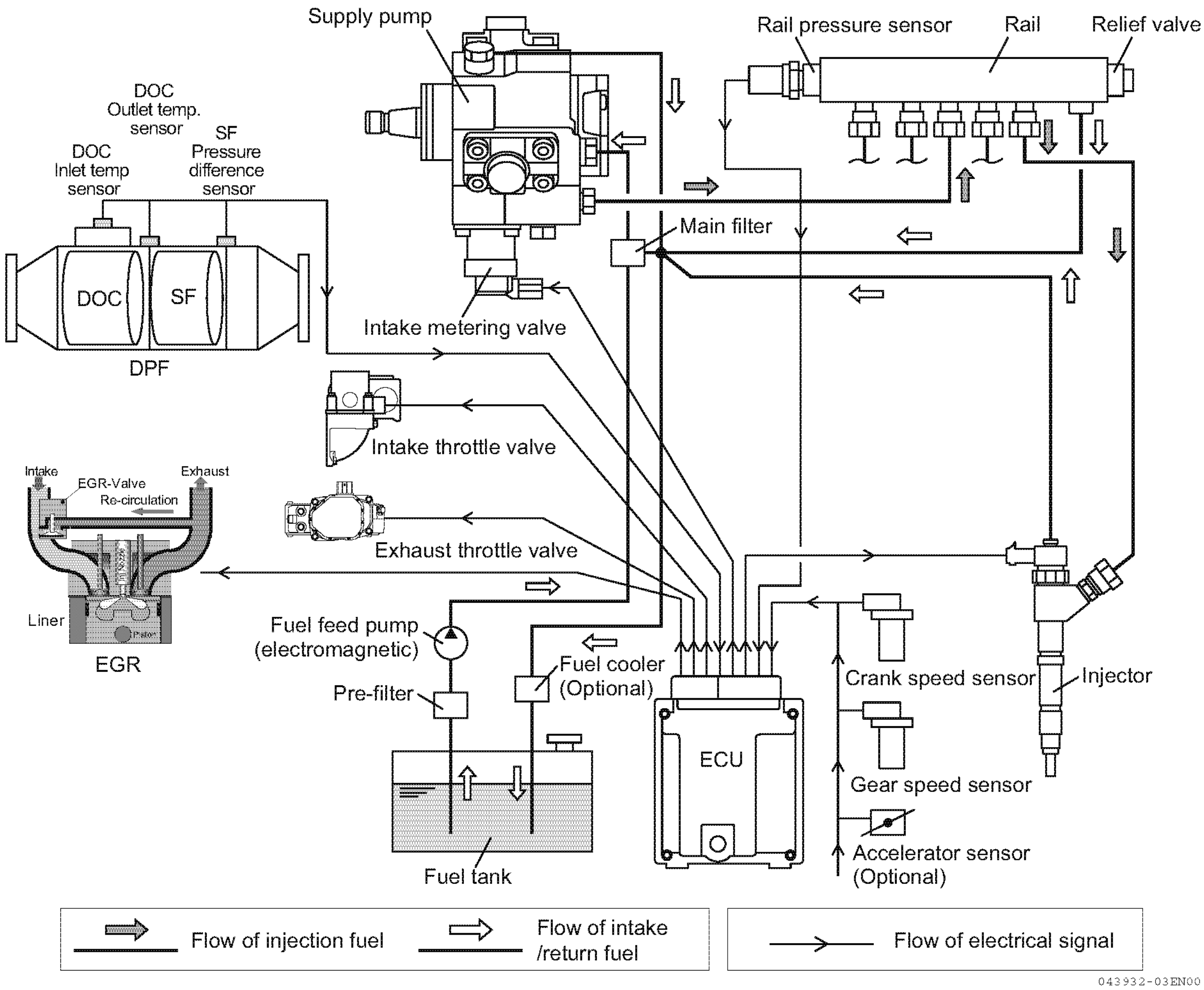


Figure 13-1

Diesel Particulate Filter (DPF)

The DPF consists of the Diesel Oxidation Catalyst (DOC) and the Soot Filter (SF), held by a case that sends the exhaust gas to the DOC and the SF. (**Figure 13-2**)

The role of the DPF is to prevent the discharge of PM by breaking down the hazardous constituents with the DOC and collecting the PM with the SF. The PM clogs the SF if left there and the engine performance decreases, so a means of regeneration is required. YANMAR engines use a continuous regeneration method. While continuing the operation, the DPF collects the PM and is regenerated at the same time. To perform the regeneration, the PM collected in the SF is combusted with NO_2 generated in the DOC and O_2 in the exhaust gas. At the same time, the DOC purifies the exhaust gas elements such as HC and CO into H_2O and CO_2.

Apart from the PM, ash also collects in the SF. This comes mostly from metallic components in the additives to the lubricating oil. Part of the lubricating oil is burnt in the high temperature combustion chamber and exhausted along with the combustion gas. In that case, metallic components are collected together with the PM in the SF. However, because the amount of ash is very little compared to the PM, it does not clog the SF immediately. Because ash is a metallic component, it cannot be combusted in the DPF for treatment like the PM. Therefore, ash is over-accumulated in the SF over a long period of time. This increases the pressure loss and has adverse effects on the engine. In this case, maintenance must be performed to remove the SF with the accumulated ash from the DPF. YANMAR recommends to do this maintenance once every 6000 operating hours.

Be sure to use the specified fuel and lubricating oil so that the DPF can fulfill its function. For fuel, use diesel fuel (ultra-low sulfur) with a sulfur mass of 15 ppm or lower. If you use a fuel other than the specified, performance of the catalyst contained in the DOC deteriorates rapidly due to sulfur. Because of this, the DPF cannot develop its regeneration capabilities and PM accumulates easier. This leads to increased fuel consumption and a deterioration of general engine receptiveness caused by decreased engine performance and frequent switching to the regeneration mode.

For lubricating oil, use low ash oil. If you use any other than the specified lubricating oil, a large amount of ash is vented through the exhaust and the DPF will clog within a short period of time. This will not only cause the engine output to decrease and the fuel costs to increase, but also makes earlier maintenance of the SF necessary.

Outline of Diesel Particulate Filter (DPF)

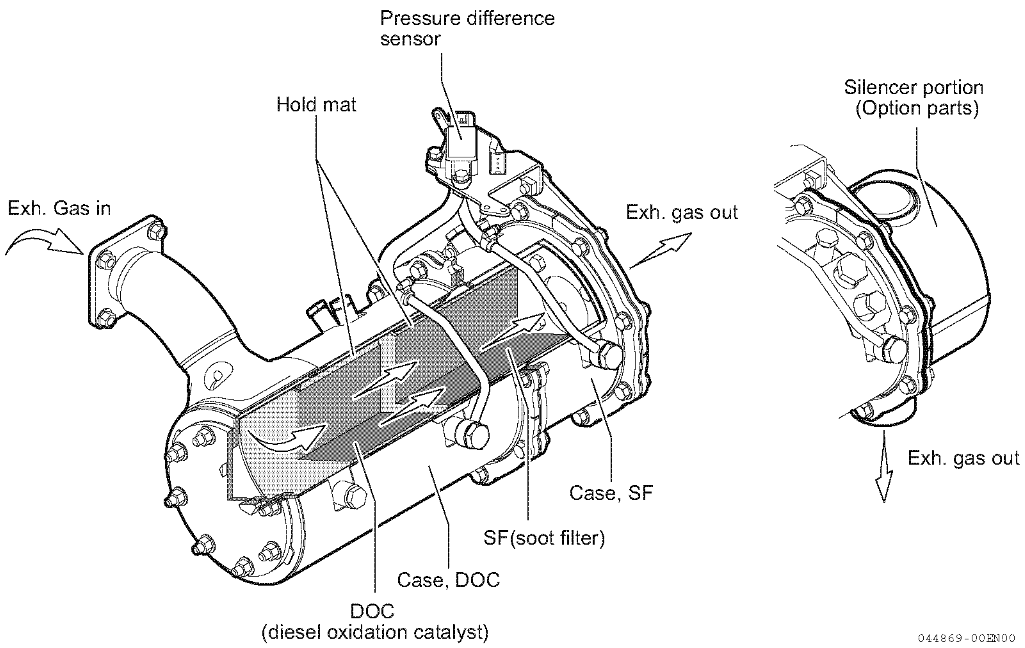


Figure 13-2

■ Overview of Diesel Particulate Filter (DPF) regeneration control

Electrical components such as the DPF differential pressure sensor, temperature sensor, and intake throttle are installed in the DPF. If the DPF cannot perform continuous regeneration due to low load operation, the ECU uses these electrical components to control assisted DPF regeneration (DPF regeneration control) automatically to prevent PM from over-accumulating.

■ Self-regeneration

Regeneration without the use of regeneration assistance devices (normal)

During the operation at high speed or high load, the exhaust temperature rises and PM is continuously combusted and eliminated.

■ Assisted regeneration

Regeneration with the use of assistance devices (e.g. the intake throttle)

When the differential pressure in the SF inlet/outlet in the DPF rises, the differential pressure sensor installed to the DPF detects the increase. The ECU commands the intake throttle to open the throttle according to the detected differential pressure to adjust the amount of engine intake air. The ECU also controls the regeneration by performing after-injection*1 to increase the exhaust temperature. At this time, the EGR valve is closed.

■ Reset regeneration

Regeneration with the combined use of assisted regeneration and post-injection

50 hours after the initial operation, and every 100 hours of operation thereafter, the assisted regeneration and post-injection*1 are automatically used together to control regeneration by increasing the exhaust temperature to burn off and remove PM.

These automatic regenerations can be performed during operation. No special operation is required for the operator. The following conditions may occur due to the characteristics of the DPF system, but they are not malfunctions.

- The engine sound may change due to the adjustment of intake throttle valve and degree of opening of the EGR valve when starting and completing the DPF regeneration.
- White smoke may be discharged from the exhaust pipe right after starting a cold engine or during acceleration.

  This is due to discharge of water vapor. When the exhaust temperature increases, the white smoke disappears. Always perform the DPF regeneration in a well-ventilated and safe location.
- The exhaust gas is purified through the catalyst installed in the DPF, so the smell of the exhaust gas is different from the exhaust gas of a conventional diesel engine.

**1: After-injection and post-injection*
Both of these are functions to inject fuel with a delay following the main injection. However, the post-injection is slightly more delayed than the after-injection. That allows the exhaust temperature to increase to assist DPF regeneration.

⚠ CAUTION

- **During reset regeneration, post-injection is used and fuel is burned directly inside the DPF (burned by chemical reaction inside the DOC). Through this heat, regeneration occurs inside the SF, but the combustion increases the temperature of the exhaust gas to close to 600 °C (1112 °F). Stay away from the exhaust gas. Extremely hot exhaust gas may burn you. Be careful that neither people nor flammable materials are near the exhaust gas outlet.**
- **Post-injection can cause the fuel consumption to increase by a small amount.**
- **Through this genuine YANMAR regeneration method, the dilution of the lubricating oil with fuel caused by the post-injection is kept to a minimum, but some dilution is possible for low-load operation (low temperature exhaust gas) of fork lifters or similar machines. Make sure that you do a daily check of the oil level.**

■ Stationary regeneration

Although the DPF performs the regeneration control, if the operation conditions with idling at no load and low speed/low load operation are frequently repeated, the PM may not be regenerated.
If the ECU determines that performing the stationary regeneration is required at this time, the DPF regeneration request lamp comes on. If the DPF regeneration request lamp comes on, immediately perform the stationary regeneration by performing the following operation. If the operation is continued with the DPF regeneration request lamp being come on, an excessive amount of PM will accumulate. Abnormal combustion of PM may cause fire and damage to the DPF.

■ Operation procedures of stationary regeneration

1. Move to a well-ventilated and safe location.
2. Move the accelerator lever to the lowest position and operate the engine in idling.

Note: *If the DPF regeneration prohibition switch is installed, turn the DPF regeneration prohibition switch to "Regeneration Permitted".*

3. Operate the interlock mechanism including the parking brake and activate the interlock function.

Note: *When the ECU verifies that the interlock mechanism is enabled with the regeneration interlock switch, the DPF regeneration approval lamp starts blinking.*

4. Press the DPF regeneration request switch for 3 seconds (standard) or longer to start the stationary regeneration. (The time required to start the stationary regeneration can be changed. Refer to the operation manual provided by the driven machine manufacturer for the detailed operation.)
   - When the stationary regeneration starts, the engine speed increases gradually to high idle speed. Then the reset regeneration is performed at that operation condition.
   - When the stationary regeneration starts, the DPF regeneration request lamp turns off, the DPF regeneration approval lamp switches from blinking to continuously lit, and the exhaust temperature warning lamp lights up.
   - The stationary regeneration is complete after approximately 25 to 30 minutes.
   - If you want to interrupt the stationary regeneration, perform one of the following operations.
   - Turn the interlock switch to "Regeneration Disabled".
   - Turn the DPF regeneration prohibition switch to "Regeneration Prohibited".
   - Raise the accelerator lever above the lowest position.
   - Turn off the power switch.
5. When the above-mentioned time has elapsed, the engine speed decreases to low idling, the regeneration approval lamp and the exhaust temperature warning lamp turn off, and the stationary regeneration is complete.

■ Precautions for stationary regeneration

- Do not disconnect SMARTASSIST-DIRECT (SA-D) or the computer while performing the stationary regeneration. Check the remaining battery level to avoid the computer from shutting down. Prepare the sufficient battery that can perform the stationary regeneration for at 30 minutes to 1 hour.
- Be sure to check the remaining fuel level to avoid the engine from running out of fuel while performing the stationary regeneration. Stationary regeneration normally takes 25 to 30 minutes to complete. Prepare sufficient fuel that can run the engine for at least 1 hour.
- Make sure that no other failure other than excessive deposits is observed.

■ Recovery regeneration (optional)

The DPF can not be regenerated by the reset regeneration or the stationary regeneration when the excessive PM is accumulated. Therefore, optional recovery regeneration function is available. The recovery regeneration requires longer regeneration time and lower temperature than that of the reset regeneration and the stationary regeneration. However, the function varies depending on the driven machine. For details, refer to the operation manual provided by the driven machine manufacturer for these functions.

■ Precautions for recovery regeneration

- Do not disconnect SMARTASSIST-DIRECT (SA-D) or the computer while performing the recovery regeneration. (Check the remaining battery level. Recovery regeneration takes approximately 4 hour to complete.)
- Be sure to check the remaining fuel level to avoid the engine from running out of fuel. (Recovery regeneration requires sufficient fuel that can run the engine for at least 4 hour.)
- Make sure that no other failure other than excessive deposits is observed.

NOTICE

If DPF is clogged quickly, check the following items.

- Please use the specified fuel. Fuel with a high sulfur content can deteriorate the catalyst performance inside the DOC, resulting in deterioration of DPF regeneration performance and PM accumulation.
- Please use the specified lubricating oil. If lubricating oil contains a large amount of ash, the ash content is vented through the exhaust, causing the DPF to clog quickly.
- Soot accumulates easily due to incomplete combustion as the resistances in the intake/exhaust system increase. Periodically check and clean the air cleaner, EGR valve, and exhaust throttle (if equipped).
- For more information on factors causing black smoke, *see Quick Reference Table for Troubleshooting on page 15-8*.

■ Diesel Particulate Filter (DPF) service

DOC: Maintenance-free parts
Replace every 9000 operation hours.

SF: Parts that require maintenance
If your engine is equipped with DPF cleaning alarm, clean the DPF when the alarm lamp comes on.
If your engine is not equipped with DPF cleaning alarm, clean the DPF on 6000 hours of operation.
For cleaning, contact YANMAR.
Japan: Power System Operations Division
Overseas: RHQ.

Item	Engine type	Emission warranty (Useful life)	Periodic maintenance interval	
			Limit to use	Clean
DOC	19 - 37 kW	5000 hours or 7 years, whichever comes first	9000 hours of operation	N/A
	≥ 37 kW	8000 hours or 10 years, whichever comes first		
SF	19 - 37 kW	5000 hours or 7 years, whichever comes first	9000 hours of operation	With DPF cleaning alarm: when the alarm comes on Without DPF cleaning alarm: on 6000 hours of operation
	≥ 37 kW	8000 hours or 10 years, whichever comes first		

■ Procedures for servicing the Diesel Particulate Filter (DPF)

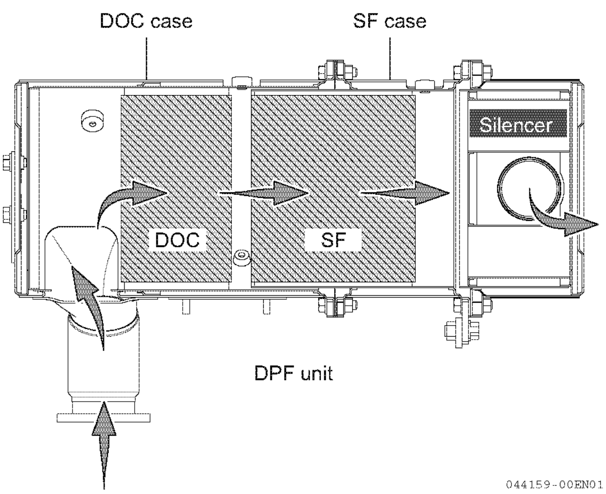


Figure 13-3

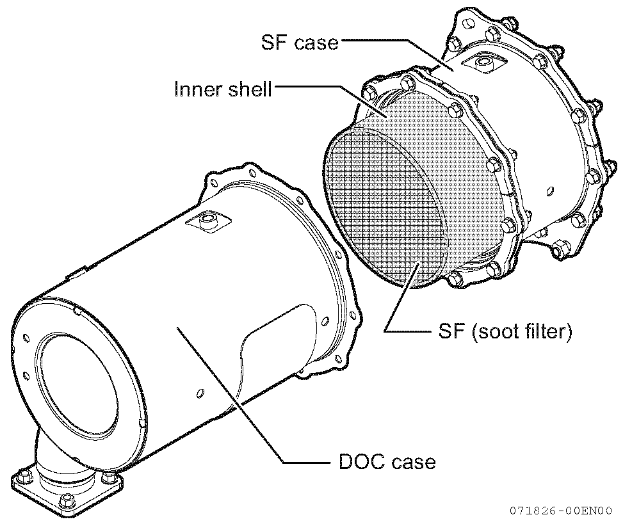


Figure 13-4

1. SF cleaning
Structure of the DFP unit is shown in **Figure 13-3**. In order to clean the SF, it is necessary to remove it as a unit from the DPF as shown in **Figure 13-4**. SF is installed with an inner shell as a unit inside the SF case, and cannot remove the SF alone. In principle, the SF can be removed while the DPF unit is still mounted to the engine, but depending on how the engine is mounted in the driven machine, it may be easier to first remove the removing the DPF unit and then remove the SF. Accordingly, select the procedure taking into account the DPF unit mounting location and how the engine is mounted.
2. DOC replacement
Replacement of the DOC requires replacement of both the catalyst section and case section as a unit, therefore removal of the DPF unit is necessary. (In reality, the DOC is not normally replaced on its own - instead, the whole DPF assembly including SF is usually replaced.)

HOW TO REMOVE AND REATTACH THE DIESEL PARTICULATE FILTER (DPF)

An overview of the Diesel Particulate Filter (DPF) is given in *page 13-5*, however explanations of components in removal, reattachment, and replacement are given in **Figure 13-5** and **Figure 13-6**.

Figure 13-5 shows the whole DPF unit, and broadly speaking, the DPF unit comprises the DPF assembly and the sensor unit. The sensor unit contains an exhaust temperature sensor and exhaust differential pressure sensor.

Figure 13-6 shows the DPF assembly by itself after the sensor unit has been removed, and this comprises the DOC, SF, silencer or outlet flange, and stiffener.

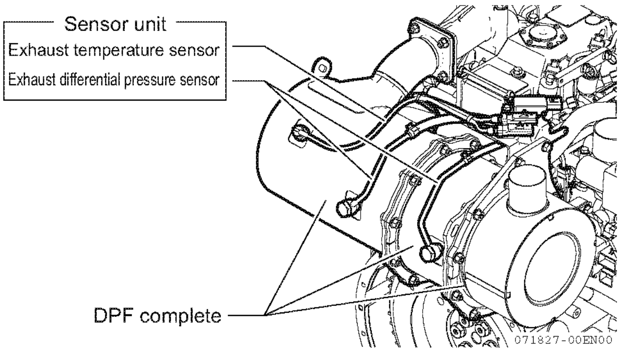


Figure 13-5 DPF unit

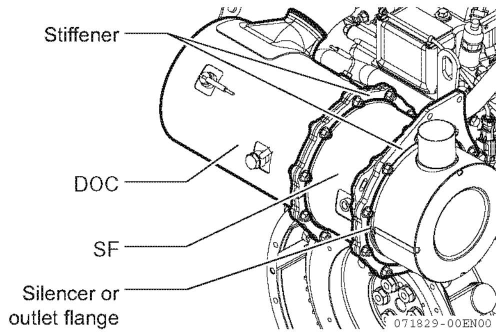


Figure 13-6 DPF assembly

■ How to remove the soot filter (SF) case

When cleaning the SF, it is possible to remove the SF case alone from the DPF unit without removing the DPF unit from the engine. The DPF unit may be mounted either on top of the flywheel housing or on top of the exhaust manifold. Some details may differ, so different procedures are shown below.

DPF flywheel housing-mounted type

1. **Removal of the SF side exhaust pressure hose**
   - Loosen the hose clip (3, **Figure 13-7**) for the hose (2, **Figure 13-7**) connected to the SF side exhaust pressure pipe (1, **Figure 13-7**), and remove from the pipe.

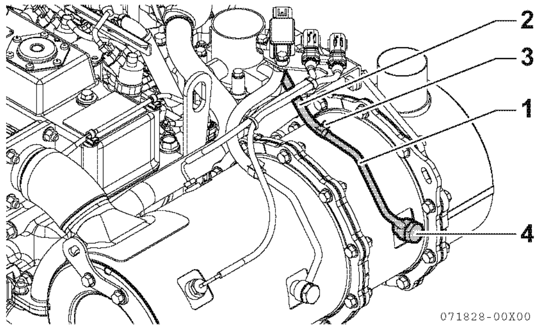


Figure 13-7

NOTICE

- SF cleaning is also possible while the exhaust pressure pipe is attached, therefore it is not necessary to remove the pipe joint bolts (4, **Figure 13-7**).
- When replacing the SF case, remove the pipe joint bolts together with the gasket.

2. **Removal of the sensor bracket**
   - Loosen the sensor bracket (3, **Figure 13-8**) M8 flange bolts (2 pcs.) (4, **Figure 13-8**) that mount the exhaust differential pressure sensor (1, **Figure 13-8**) and the exhaust temperature sensor coupler (2, **Figure 13-8**), and remove.
   - Put the removed sensor bracket on the engine side with the sensor, coupler, hose, harness and other parts connected so that they do not interfere when removing other parts.

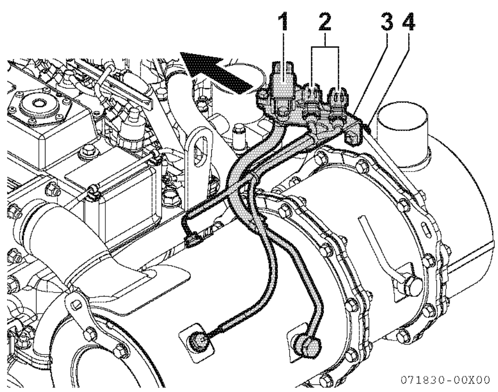


Figure 13-8

3. **Removal of the DPF stay fixing bolts**
   - Remove the silencer (or outlet flange) (1, **Figure 13-9**) side DPF stay (2, **Figure 13-9**) and the M10 bolts (2 pcs.) (3, **Figure 13-9**) that affix the flywheel housing. Leave the stiffener (4, **Figure 13-9**) attached to the DPF stay.

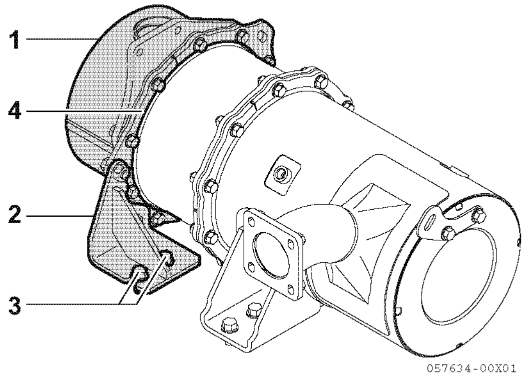


Figure 13-9

4. **Removal of the silencer (or outlet flange)**
   - Remove the M8 bolts and flange nuts (3, **Figure 13-10**) (8 or 10 of each) that fix the silencer (or outlet flange) (1, **Figure 13-10**) and SF case (2, **Figure 13-10**).
   - Remove the stiffeners (4 pcs.) (4, **Figure 13-10**) that hold the mating surface of the silencer and SF case flange while DPF stay is attached to one of the stiffeners, and remove the silencer (or outlet flange). For mounting position of the stiffener, see **Figure 13-11**.

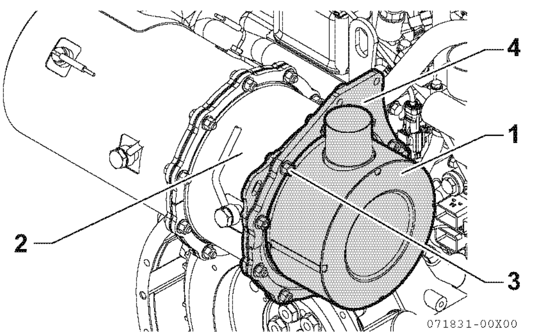
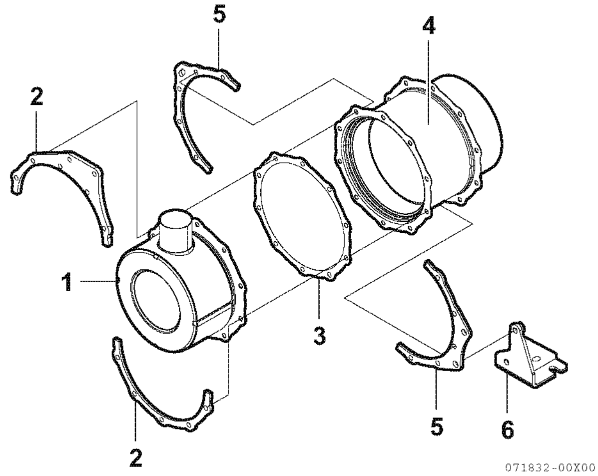


Figure 13-10

NOTICE

Remove the stiffener making note of its position and angle.



1 – Silencer
2 – Stiffener A
3 – DPF gasket
4 – SF case
5 – Stiffener B
6 – DPF stay

Figure 13-11

5. **Removal of the SF case**
   - Remove the M8 bolts and flange nuts (3, **Figure 13-12**) (8 or 10 of each) that fix the SF case (1, **Figure 13-12**) and DOC case (2, **Figure 13-12**).
   - Remove the stiffeners (4 pcs.) (2 pcs. on each side) (4, **Figure 13-12**) that hold the mating surface of the SF case and DOC case flange, and remove the SF and SF case as a unit. Mark the stiffeners so that they can be reassembled in the original position.

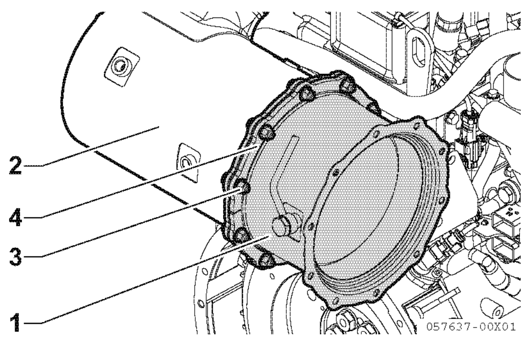


Figure 13-12

This completes the removal of the SF case.

DPF exhaust manifold-mounted type

In principle, the procedure is the same as for the flywheel housing-mounted type, but with the exhaust manifold-mounted type, the sensor bracket has a stiffener between the DOC case and the SF case.

1. **Removal of the SF side exhaust pressure hose**
   - Loosen the hose clip for the hose (2 **Figure 13-13**) connected to the SF side exhaust pressure pipe (1 **Figure 13-13**), and remove from the pipe.

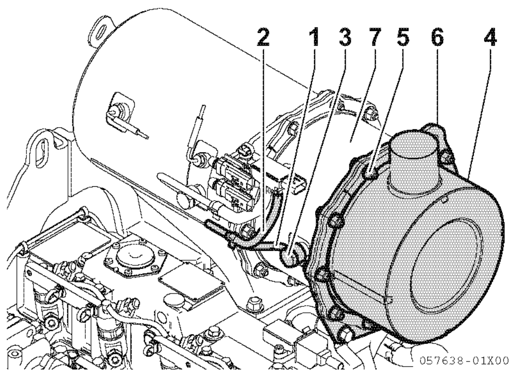


Figure 13-13

NOTICE

- SF cleaning is also possible while the exhaust pressure pipe is attached, therefore it is not necessary to remove the pipe joint bolts (3, **Figure 13-13**).
- When replacing the SF case, remove the pipe joint bolts together with the gasket.

2. **Removal of the sensor bracket**
   - Loosen the sensor bracket (1 **Figure 13-14**) M8 flange bolts (2 pcs.) (2 **Figure 13-14**) that mount the exhaust differential pressure sensor and the exhaust temperature sensor coupler, and remove.
   - The removed bracket holds the sensor, coupler, hose, harness, and other parts so that they do not interfere with the engine when mounted.

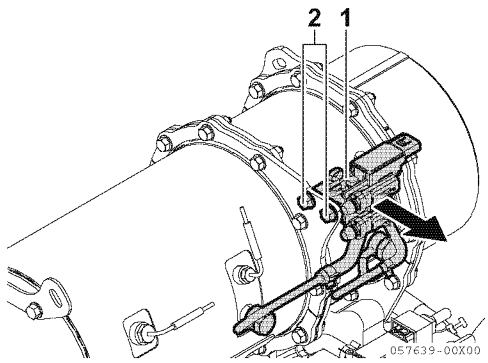


Figure 13-14

3. **Removal of the SF case fixing bolts**
   - Remove the M10 flange bolts (2 pcs.) (3, **Figure 13-15**) and the M10 flange nut (1 pc.) (4, **Figure 13-15**) that fix the PDF stay (2, **Figure 13-15**) and stiffener (1, **Figure 13-15**) mounted on the bottom of the SF case. Depending on the model, the configuration and fixing method of the engine-side stay may differ.

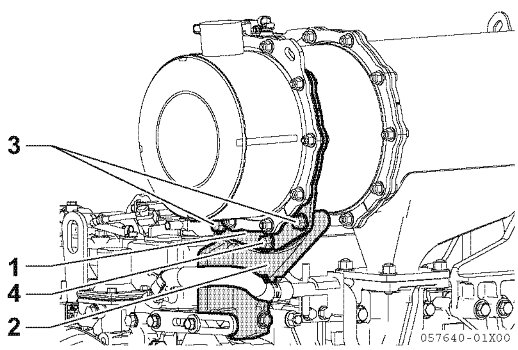


Figure 13-15

4. **Removal of the silencer (or outlet flange)**
   - Remove the M8 bolts and flange nuts (5, **Figure 13-13**) (8 or 10 of each) that fix the silencer (or outlet flange) (4, **Figure 13-13**) and SF case (7, **Figure 13-13**).
   - Remove the stiffeners (4 pcs.) (2 pcs. on each side) (6, **Figure 13-11**) and the silencer (or outlet flange). Mark the stiffeners so that they can be reassembled in the original position.

5. **Removal of the SF case**
   - Remove the M8 bolts and flange nuts (2, **Figure 13-16**) (8 or 10 of each) that fix the SF case (1, **Figure 13-16**) and DOC case (4, **Figure 13-16**).
   - Remove the stiffeners (4 pcs.) (2 pcs. on each side) (3, **Figure 13-16**) that hold the mating surface of the SF case and DOC case flange, and remove the SF and SF case as a unit. Mark the stiffeners so that they can be reassembled in the original position.

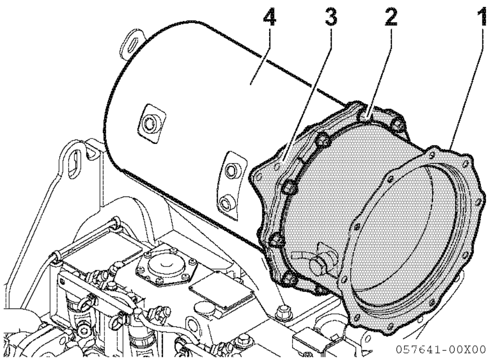


Figure 13-16

This completes the removal of the SF case.

■ How to reattach the SF case

DPF flywheel housing-mounted type

1. **Reassembly of the SF case**
   - For reassembly of the SF case after cleaning, reverse the steps for its removal. Reassemble the SF case onto the DOC. Making note of its position and angle, reattach the stiffener in its original position. (M8 bolts and flange nuts, 8 or 10 of each)
   - Replace the M8 flange bolts and nuts with new ones.
   - Replace the gasket with a new one.
2. **Reattachment of the silencer (or outlet flange)**
   - Install the silencer (or outlet flange), following the same details as for installation of the SF case. Making note of its position and angle, reattach the stiffener in its original position. (M8 bolts and flange nuts, 8 or 10 of each)
   - Replace the M8 flange bolts and nuts with new ones.
   - Replace the gasket with a new one.
3. **Reattachment on the DPF stay**
   - Temporarily fasten the DPF stay (1 **Figure 13-17**) on the silencer (or outlet flange) side to the flywheel housing using M10 flange bolts (2 pcs.) (2 **Figure 13-17**).
   - Before fully tightening, slightly loosen the M10 flange bolts (2 pcs.) (3 **Figure 13-15**) that affix the stiffener (4 **Figure 13-15**) and the DPF stay, and after fully tightening the DPF stay and the flywheel housing bolts, (2 **Figure 13-17**), fully tighten the stiffener bolts (3 **Figure 13-17**).

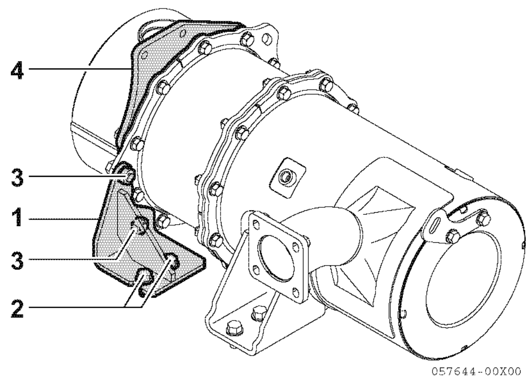


Figure 13-17

4. **Reattachment of the sensor bracket**
   - Reattach the sensor bracket that had been moved to the engine side to the outlet flange side stiffener (4 **Figure 13-17**). (M8 flange bolts (2 pcs.))

5. **Reattachment of the SF side exhaust pressure hose**
   - Replace the exhaust pressure hose with a new one. Insert a new hose into the SF exhaust pressure pipe, and tighten the hose clip. As a guideline, replace the exhaust pressure hose every 3000 hours.
   - At the same time, replace the DOC side exhaust pressure hose with a new one.

M8 bolt tightening torque	26 ± 5 N·m
M10 bolt tightening torque	49 ± 5 N·m

DPF exhaust manifold-mounted type

Details of reattachment of the SF and silencer (or outlet flange) are the same as for the flywheel housing flywheel housing-mounted type. Reattachment on the DPF stay is different to with the flywheel housing-mounted type, therefore follow the procedures below.

1. **Reattachment on the DPF stay**
   - After reattachment of the SF case on the DOC, reattach the silencer (or outlet flange) to the SF case using the stiffener. At this time, align the notches on the bottom of the stiffener (1 **Figure 13-18**) underneath the silencer with the stud bolt in the center of the DPF stay (2 **Figure 13-18**), and reattach the stiffener (M8 bolts and flange nuts, 8 or 10 of each). Make note of the position and angle of the stiffeners (4 pcs.).
   - Replace the M8 flange bolts and nuts with new ones.
   - Replace the gasket with a new one.
   - Next, affix the stiffener (1 **Figure 13-18**) and DPF stay (2 **Figure 13-18**). (M10 bolts (2 pcs.), M10 flange nut (1 pc.))
   - Depending on the model, the configuration and fixing method of the DPF stay may differ.

Repair parts required for reattachment after SF cleaning or replacement are shown on *page 13-20*.

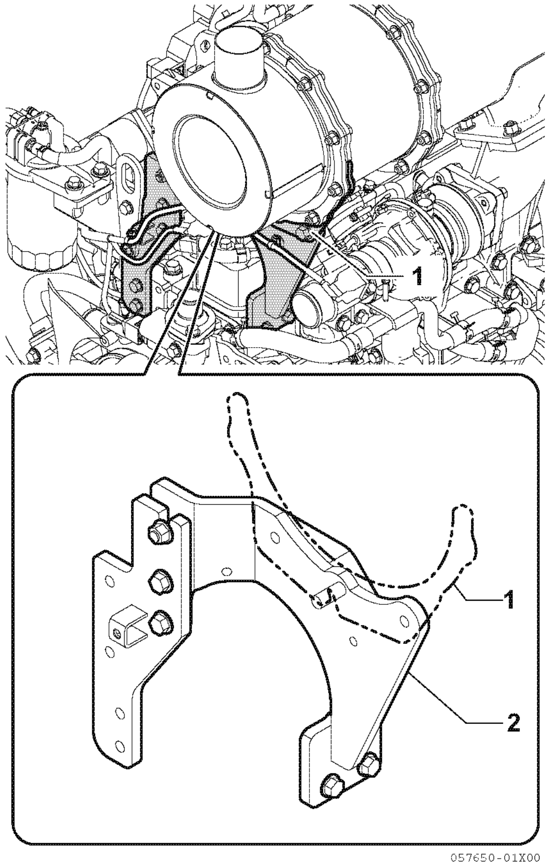


Figure 13-18

M8 bolt tightening torque	26 ± 5 N·m
M10 bolt tightening torque	49 ± 5 N·m

■ How to remove the DPF unit

When replacing the DPF or the DOC alone, removal of the DPF unit is necessary.
(See *page 13-10* for an explanation of the DPF unit and DPF assembly)

DOC cannot be removed alone. It is necessary to replace the DOC case since the DOC is installed as a unit with DOC case.

DPF flywheel housing-mounted type

1. **Removal of the sensor and coupler wiring**
   - Remove the exhaust differential pressure sensor connected to the sensor bracket (1 **Figure 13-19**) and the wiring from the engine or driven machine that is connected to the exhaust temperature sensor couplers (2 pcs.) (2 **Figure 13-19**).

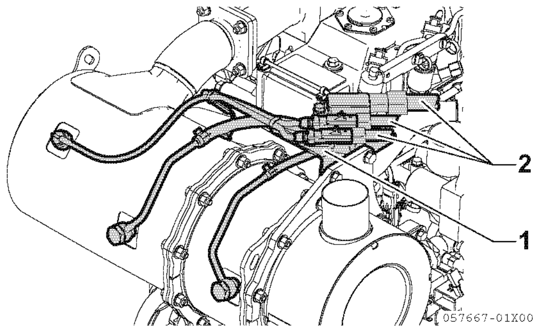


Figure 13-19

2. **Removal of the DPF unit**
   - Remove the 4 M8 flange nuts (1 **Figure 13-20**) on the exhaust manifold flange.
   - Remove the M10 flange bolts (2 pcs. each, total 4 pcs.) (2, 3, **Figure 13-20**) that affix the stays (2 locations) (on the back of the DPF housing), that themselves affixes the DPF.
   - Remove the DPF unit together with the exhaust flange gasket (1 pc.).
   - Leave the stiffener attached to the DPF stay on the silencer (or outlet flange).

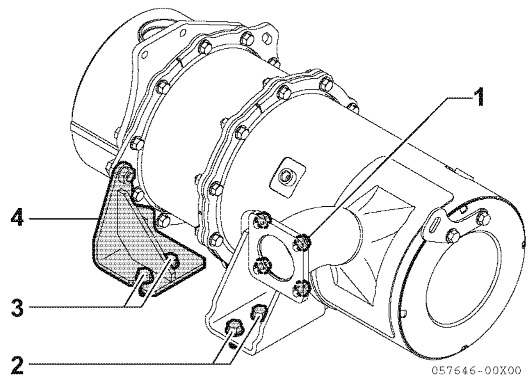


Figure 13-20

NOTICE

Do not lift the sensor or wire harness together wi.th the DPF. The sensor may break.

3. **Removal of the sensor unit**

   When replacing the DPF assembly, the sensor unit is reused, therefore remove this from the DPF unit.

   - **Removal of the exhaust temperature sensor**
     Loosen the band (1 **Figure 13-21**) that fixes the exhaust harness. From two locations on the exhaust temperature sensor, remove the 17 mm bolt from one location (2 **Figure 13-21**) and the 13 mm bolt from the other (3 **Figure 13-21**). Leave the exhaust temperature sensor couplers (2 pcs.) (4 **Figure 13-21**) mounted on the sensor bracket section.

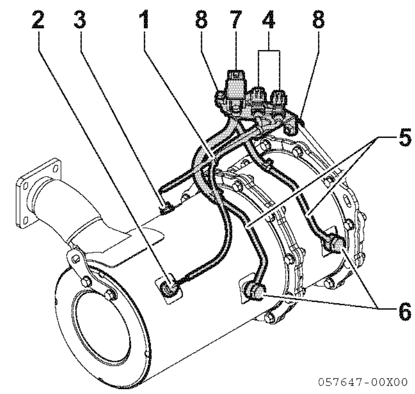


Figure 13-21

- **Removal of the exhaust pressure pipe**
  Remove the M12 pipe joint bolts (2 pcs.) (6 **Figure 13-21**) that affix the exhaust pressure pipe (5 **Figure 13-21**). Leave the exhaust differential pressure sensor (7 **Figure 13-21**) mounted on the sensor bracket section.
- **Removal of the sensor bracket**
  Loosen the M8 flange bolts (2 pcs.) (8 **Figure 13-21**) and remove the sensor bracket. Leave the exhaust differential pressure sensor and the exhaust temperature sensor coupler attached to the sensor bracket.

This makes the DPF unit the DPF assembly, and replacement is possible.

If replacing only the DOC case and leaving the SF case as is, then remove only the sensor unit connected to the DOC case, and leave the sensor bracket fixed to the SF case affixed, together with the sensor coupler. Next, remove the M8 bolts and flange nuts (8 or 10 of each) that affix the SF case and DOC case. This enables replacement of the DOC unit.

DPF exhaust manifold-mounted type

As with the flywheel housing-mounted type, if replacing the DPF assembly or the DOC alone, then removal of the DPF unit is necessary.

1. **Removal of the sensor and coupler wiring**
   - Remove the exhaust differential pressure sensor (2 **Figure 13-22**) connected to the sensor bracket (1 **Figure 13-22**), and the wiring (4 **Figure 13-22**) from the engine or driven machine that is connected to the exhaust temperature sensor couplers (2 pcs.) (3 **Figure 13-22**).

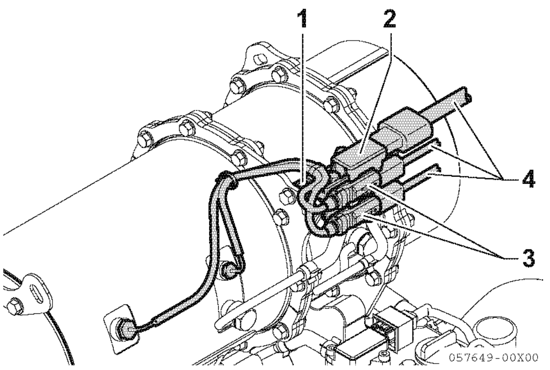


Figure 13-22

2. **Removal of the DPF unit**
   - Remove the fixing bolts (2 pcs.) (2 **Figure 13-23**) and flange nut (3 **Figure 13-23**) from the DPF stay (1 **Figure 13-23**) on the silencer (or outlet flange) side.

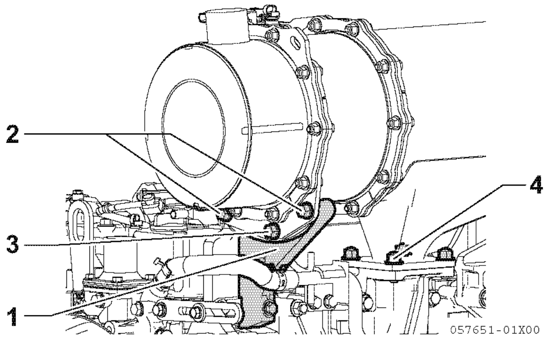


Figure 13-23

   - Remove the DPF stay (1 **Figure 13-24**) fixing bolts (2 pcs.) (2, 3, **Figure 13-24**) on the other side. Stay configuration and numbers of bolts will differ depending on the model, but the method for fixing will be largely the same.
   - Finally, remove the exhaust manifold flange nuts (4 pcs.) (4 **Figure 13-23**), and remove the DOF unit together with the gasket.

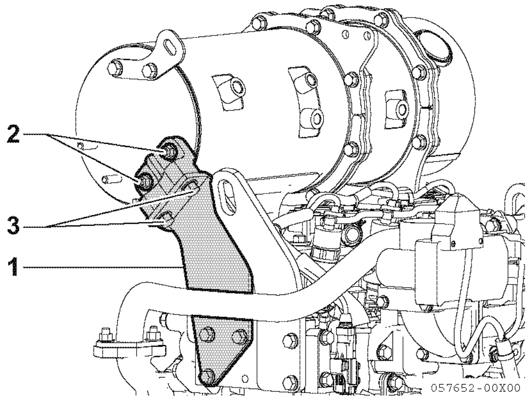


Figure 13-24

NOTICE

Do not lift the sensor or wire harness together with the DPF. The sensor may break.

3. **Removal of the sensor unit**

   When replacing the DPF assembly, the sensor unit is reused, therefore remove this from the DPF unit. The procedure for removal is that same as for the flywheel housing-mounted type. Refer to *page 13-15*.

   This makes the DPF unit the DPF assembly, and replacement is possible.

   If replacing only the DOC case and leaving the SF case as is, then remove only the sensor unit connected to the DOC case, and leave the sensor bracket fixed to the SF case affixed, together with the sensor coupler. Next, remove the M8 bolts and flange nuts (8 or 10 of each) that affix the SF case and DOC case. This enables replacement of the DOC unit.

■ How to reattach the DPF

DPF flywheel housing-mounted type

This procedure shows how to install a new DPF assembly. In principle, the procedure is the reverse of that for removal. First, reattach the removed sensor unit to the DPF assembly.

1. **Reattachment of the exhaust temperature sensor**
   - On two locations on the removed exhaust temperature sensor, attach the 17 mm bolt in one location, and the 13 mm bolt in the other.

Tightening torque	40 ± 5 N·m

   - Tighten the 2 loosened exhaust temperature sensor harness bands.

2. **Reattachment of the exhaust pressure pipe**
   - Reattach the removed exhaust pressure pipe (2 pcs.). At this time, replace the pipe joint bolt, the gasket, and the hose with new ones. As a guideline, replace the exhaust pressure hose every 3000 hours.
   - When tightening the pipe joint bolt, apply anti-seize compound to the threaded sections.

M12 pipe joint bolt tightening torque	29.4 ± 5 N·m

3. **Reattachment of the sensor bracket**
   - Reattach the removed sensor bracket to the SF stiffener. (M8 flange bolts (2 pcs.))

This completes the DPF unit.

Repair parts required for reinstallation of the exhaust differential pressure sensor are shown on *page 13-20*.

4. **Reattachment of the DPF unit**
   - First, slightly loosen the flange bolts (2 pcs.) (2 **Figure 13-25**) that attach the DPF stay (1 **Figure 13-25**) and the stiffener so that these have some play.
   - Replace the exhaust manifold flange gasket with a new one, and attach the DPF unit to the exhaust manifold stud bolt.
   - Temporarily tighten the DPF assembly central stay M10 bolts (2 pcs.) (3 **Figure 13-25**).
   - Seat the exhaust manifold flange (4 **Figure 13-25**) using M8 flange nuts (4 pcs.), and temporarily tighten.
   - Fully tighten the central stay M10 bolts (3 **Figure 13-25**).
   - Fully tighten the flange nuts (4 pcs.) on the exhaust manifold flange.
   - Fully tighten the M10 flange bolts (2 pcs.) (5 **Figure 13-25**) of the DPF stay on the flywheel housing side.
   - Fully tighten the DPF stay M8 flange bolts (2 pcs.) (2 **Figure 13-25**).

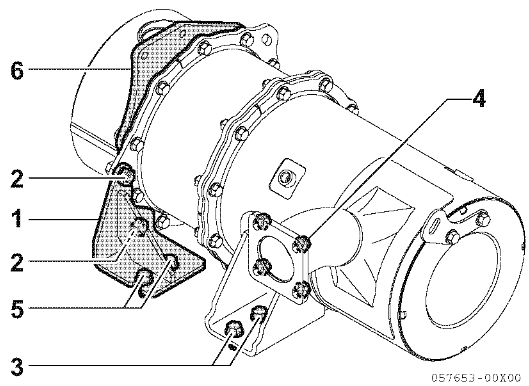


Figure 13-25

M8 bolt tightening torque	26 ± 5 N·m (Lock nut: 16 ± 5 N·m)
M10 bolt tightening torque	49 ± 5 N·m

5. **Driven machine wiring**
   - Connect the exhaust pressure sensor to the sensor bracket and the wiring from the engine or driven machine to the exhaust temperature sensor couplers (2 pcs.).

   This completes reattachment of the DPF unit.

   If only the DOC case has been replaced, then first affix the DOC case and SF case using M8 bolts and nuts (8 or 10 of each), and with the DPF assembly, proceed as above.

   - Replace the M8 flange bolts and nuts with new ones.
   - Replace the gasket with a new one.

Cylinder head-mounted type

If the engine is cylinder head-mounted type, stay configuration and fixing method will differ depending on the engine model. This explains a typical model.

1. **Reattachment of the sensor unit**
   - Reattach the removed sensor unit (exhaust temperature sensor and exhaust differential pressure sensor), and reattach the bracket to the SF stiffener. Up until this point is the same as for the flywheel housing-mounted type, so refer to the details on the previous pages.

Repair parts required for reinstallation of the exhaust differential pressure sensor are shown on *page 13-20*.

2. **Reattachment of the DPF unit**
   - Replace the exhaust manifold flange gasket with a new one, place the DPF unit upon this, and temporarily tighten the flange nuts (4 pcs.) (1 **Figure 13-26**).

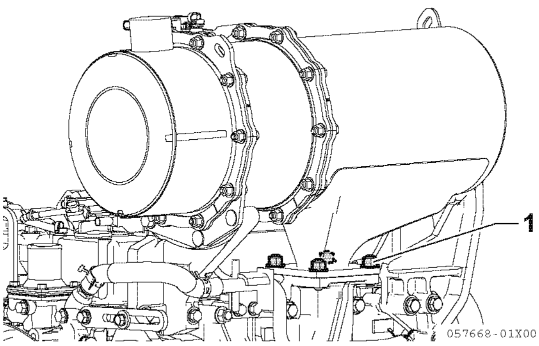


Figure 13-26

- Temporarily tighten the stiffener (1 **Figure 13-27**) and the DPF stay (2 **Figure 13-27**) on the silencer (or outlet flange) side with flange bolts (2 pcs.) (3 **Figure 13-27**) and a flange nut (4 **Figure 13-27**) until it is seated.
- Next, fully tighten the flange nuts on the exhaust manifold flange (4 pcs.) (5 **Figure 13-27**), then fully tighten the DPF stay flange bolts and flange nuts.

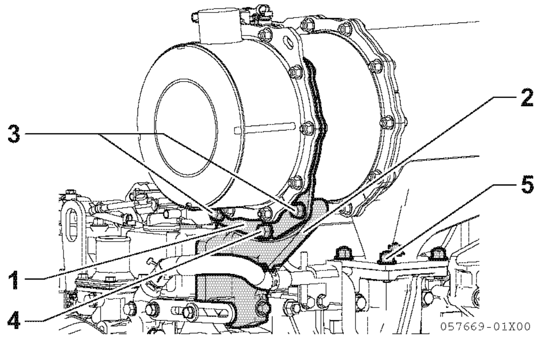


Figure 13-27

- Next, affix the DPF unit to th DPF stay on the flywheel housing side. First, slightly loosen the fixing bolts (2, **Figure 13-28**) of the DPF stay (1, **Figure 13-28**) on the flywheel side in 2 locations so that these have some play. Temporarily tighten the fixing bolts (4, **Figure 13-28**) that fix the DPF unit and stay. Next, temporarily tighten the DPF stay fixing bolts (2 **Figure 13-28**) until it seats, then fully tighten the DPF and stay fixing bolts (4 **Figure 13-28**). Lastly, fully tighten the DPF stay fixing bolts (2 **Figure 13-28**).

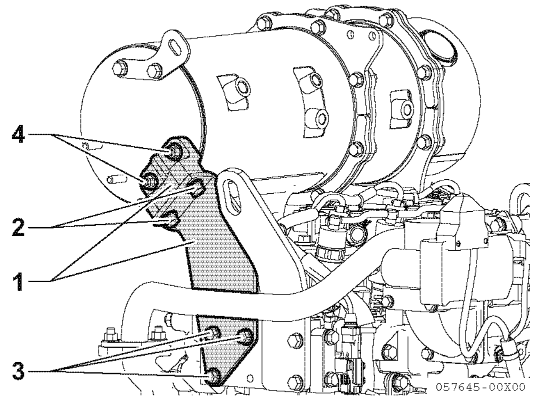


Figure 13-28

M8 bolt tightening torque	26 ± 5 N·m (Lock nut: 16 ± 5 N·m)
M10 bolt tightening torque	49 ± 5 N·m

*Note: In principle, it is not necessary to loosen the fixing bolts (3, **Figure 13-28**) that affix the DPF stay to the engine, however adjust according to conditions.*

3. **Driven machine wiring**

   Connect the exhaust differential pressure sensor to the sensor bracket and the wiring from the engine or driven machine to the exhaust temperature sensor couplers (2 pcs.).

   This completes reattachment of the DPF unit.

   If only the DOC case has been replaced, then first affix the DOC case and SF case using M8 bolts and nuts (8 or 10 of each), and with the DPF assembly, proceed as above.

   - Replace the M8 flange bolts and nuts with new ones.
   - Replace the gasket with a new one.

SF AND DPF MAINTENANCE KIT

The required individual parts are available for SF cleaning and replacement, and for maintenance when replacing the DPF assembly and the DOC, however the kit as below is also available. There are two types - for the DPF housing, and for the differential pressure sensor hose, therefore select in accordance with the engine model and the DPF installation location.

Kit name	Part name		Part code	Engine model name						
				DPF installation location / Remarks	3TNV88C		3TNV86CT		4TNV88C	
					FW side	Exh. M side	FW side	Exh. M side	FW side	Exh. M side
DOC-SF maintenance kit	Exhaust gage flange	Gasket	129930-13201	80 × 80	1	–	1	1	1	–
			128300-13230	102 × 102	–	1	–	–	–	1
		Flange nut	26306-080002	M8	4	–	4	–	4	
			26306-100002	M10	–	4	–	4	–	4
	DPF Stiffener	bolt	129A00-16610	M8 × 28	16	16	16	16	16	16
		Flange nut	26306-080002	M8	16	16	16	16	16	16
		DPF Gasket	129A00-16600	–	2	2	2	2	2	2
			129E00-16600	–	–	–	–	–	–	–
	Kit code				129A00-16900		129A00-16900		129A00-16900	
Differential pressure sensor hose kit	Hose CMP (ø13.5)		129A00-17600	L = 170	1	–	–	–	–	–
			129C00-17600	L = 200	–	–	1	–	1	–
			129A00-17610	L = 90	–	1	–	1	–	1
			129C01-17610	L = 105	–	–	–	–	–	–
	Hose CMP (ø9.8)		129A00-17650	L = 130	1	–	1	–	1	–
			129A00-17670	L = 90	–	1	–	1	–	1
	Pipe joint bolt		129A00-13350	–	2	2	2	2	2	2
	Gasket		129A00-17311	–	4	4	4	4	4	4
	Kit code				129A00-17900	129C01-17900	129C00-17900	129C01-17900	129C00-17900	129C01-17900

Kit name	Part name		Part code	Engine model name						
				DPF installation location / Remarks	4TNV86CT		4TNV98C		4TNV98CT	
					FW side	Exh. M side	FW side	Exh. M side	FW side	Exh. M side
DOC-SF maintenance kit	Exhaust gage flange	Gasket	129930-13201	80 × 80	1	–	1	–	1	–
			128300-13230	102 × 102	–	1		1	–	1
		Flange nut	26306-080002	M8	4	–	4	–	4	–
			26306-100002	M10	–	4	–	4	–	4
	DPF Stiffener	bolt	129A00-16610	M8 × 28	20	20	20	20	20	20
		Flange nut	26306-080002	M8	20	20	20	20	20	20
		DPF Gasket	129A00-16600	–	–	–	–	–	–	–
			129E00-16600	–	2	2	2	2	2	2
	Kit code				129E00-16900		129E00-16900		129E00-16900	
Differential pressure sensor hose kit	Hose CMP (ø13.5)		129A00-17600	L = 170	–	–	–	–	–	–
			129C00-17600	L = 200	1	–	1	–	1	–
			129A00-17610	L = 90	–	–	–	1	–	–
			129C01-17610	L = 105	–	1	–	–	–	1
	Hose CMP (ø9.8)		129A00-17650	L = 130	1	–	1	–	1	–
			129A00-17670	L = 90	–	1	–	1	–	1
	Pipe joint bolt Gasket		129A00-13350	–	2	2	2	2	2	2
			129A00-17311	–	4	4	4	4	4	4
	Kit code				129C00-17900	129E00-17900	129C00-17900	129C01-17900	129C00-17900	129E00-17900

The required individual clamps are available when replacing the wire harnesses and other parts. However the kit as below is also available.

Kit name	Kit code	Part name	Part code	Qty
Harness clamp service kit	129A00-91000	Band clip	129A00-91200	25
		Band	129C00-91200	3
		Band	29621-200000	4
		Band	29621-100000	3
		Connector crop	129A00-91430	5
		Boots	129A00-91450	3

TROUBLESHOOTING OF ELECTRONIC CONTROL SYSTEM

The electronically controlled engine with built-in common rail system is equipped with a engine failure lamp. The following section describes how to detect faults on those engines.

Fault Detection Capability

On the electronically controlled engine, the ECU performs various kinds of self-diagnosis based on the information from the sensor for electronic control and various types of preset engine fault detection sensors. According to the status of each sensor, you can set the operations during a fault (optional). When such a fault is detected, the ECU indicates occurrence of failure.

ECU turns on the engine failure lamp, and the indicator indicates that the fault is detected.

The engine failure lamp comes on for approximately 2 seconds when the key switch is turned on, then goes off. With this lamp, you can check whether the power is supplied to ECU.
The engine failure lamp is located on the panel as shown in (1, **Figure 13-29**).

NOTICE

Shut down the engine if the engine failure lamp comes on. Continuing running the engine with the engine failure lamp being on may result in a serious malfunction of or damage to the engine, and will void the engine warranty.

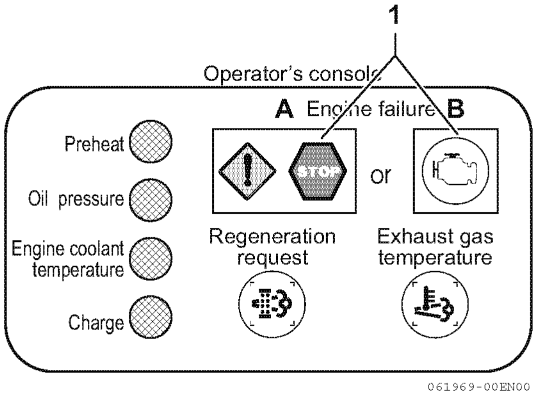


Figure 13-29

Note: This figure is for reference only. The gauges located on the operator's console may vary depending on the machine. Refer to the operation manual provided by the driven machine manufacturer for details.

Figure 13-30 exemplifies flashing patterns of the engine failure lamp.
The engine failure lamp comes on for approximately 2 seconds when the switch is turned on, and goes off while the engine is running. If a fault occurs in ECU, this indicator lamp will come on 3 seconds after the indicator lamp goes off, and the lamp continuously stays on. If a fault occurs while the engine is running, the engine failure lamp comes on at the time of fault occurrence.

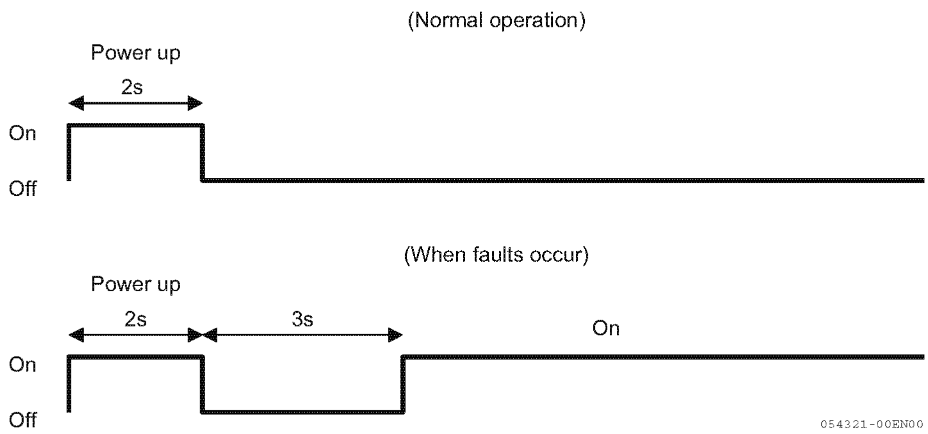


Figure 13-30

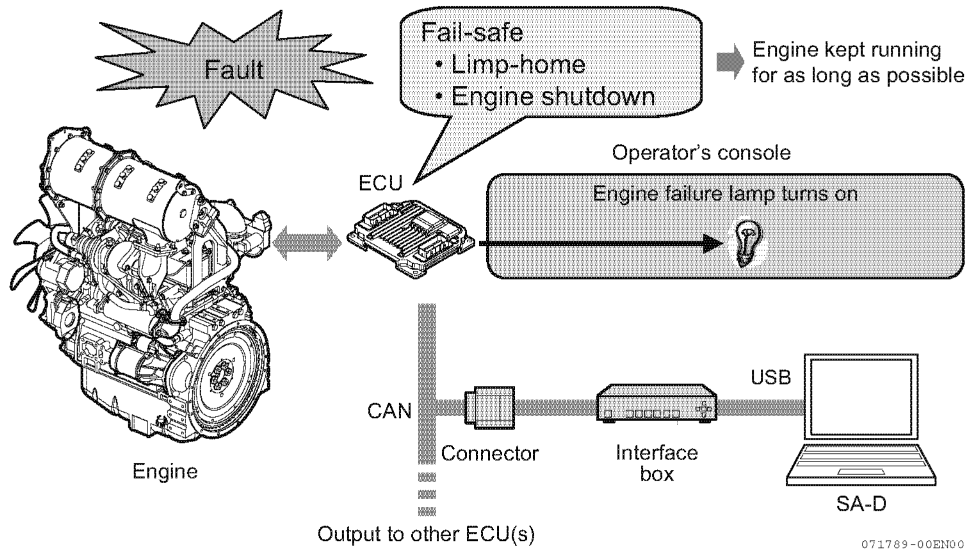


Figure 13-31

NOTICE

If the engine failure lamp comes on, stop the engine immediately and contact your local YANMAR dealer.

As shown in **Figure 13-31**, SMARTASSIST-DIRECT (SA-D), YANMAR genuine diagnosis tool, is required to connect to your engine for fault diagnosis. SA-D allows reviewing detailed fault information, historical fault/alarm logs and freeze frame data. In addition, you can monitor the engine status and perform the fault diagnosis by using SMARTASSIST-DIRECT. Events in the fault/alarm logs can be time stamped.

SMARTASSIST-DIRECT (SA-D)

When the ECU or injectors are replaced, you need to rewrite the individual data inside the ECU.

A special treatment is also necessary when replacing DPF or sensors that affects the electronic control system.

A connector is provided at an end of the harness of the driven machine so that the YANMAR genuine SMMARTASSIST DIRECT (SA-D) can be loaded with data from the ECU. See **Figure 13-32** and **Figure 13-33**.

Contact your authorized YANMAR industrial engine dealer or distributor that can handle SA-D to repair or replace the electronic control parts. Also, refer to the SMARTASSIST-DIRECT operation manual for the detailed operation.

⚠ WARNING

- **Never use the ECU for purposes that are not intended by YANMAR; such as using unauthorized ECU, writing unauthorized data to ECU, leaving it broken, or removing sensors and actuators. Doing so could result in the violation of emission control regulations and will void the product warranty.**
- **Be sure to use the ECU in conjunction with the engines whose models or serial numbers are specified by YANMAR.**
  Other ECU/engine combinations than specified will void the engine warranty.
- **When replacing the fuel injector, you need to rewrite the fuel injection quantity adjustment data in the ECU. When replacing the ECU, you need to export data from the existing ECU to the new ECU. In order to operate as above, you need to connect the YANMAR genuine SA-D. Be sure to contact your authorized YANMAR dealer. ECU that does not have the proper fuel injection quantity adjustment data written, or ECU that does not have the data transferred correctly will void the engine warranty.**
- **You will also need to connect to SA-D for replacing other CR related products, so be sure to contact your authorized YANMAR dealer.**
- **Improper use or misuse of the ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.**

NOTICE

- Do not plug or unplug the ECU for a period of at least 60 seconds after power to the unit has been turned on or off.
- Do not touch connector pins of the ECU with bare hands. Doing so may result in corrosion of the connector pins and/or damage to the internal circuits of the ECU due to static electricity.
- Do not force a measuring probe into the female coupler. Doing so may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Take care to prevent water from entering the couplers when plugging or unplugging the connector. Water inside the couplers may cause corrosion, resulting in malfunction of the ECU.
- Avoid plugging/unplugging the connector more than approx. 10 times.
  Frequent plugging/unplugging of the connector may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Do not use the ECU that has ever suffered drop impact.
- Do not disassemble the ECU terminal.

■ About SA-D use

SA-D is a diagnosis tool that automatically transmits the following information to the YANMAR data server (SMARTASSIST CORE (SA-C)) from the ECU equipped in your driven machine via the Internet.

- Injector, exhaust gas post-treatment equipment, parts replacement information for controllers that are necessary for exhaust gas warranty claims.
- Accumulated operation information required for the reuse of exhaust gas post-treatment equipment.
- Operation history of an engine including fault history, operation time, engine speed, and load ratio.

All the obtained data will be used for the following purposes.

- To prevent improper service in the market
- To provide more accurate and prompt service
- To improve product quality through YANMAR Research and Development

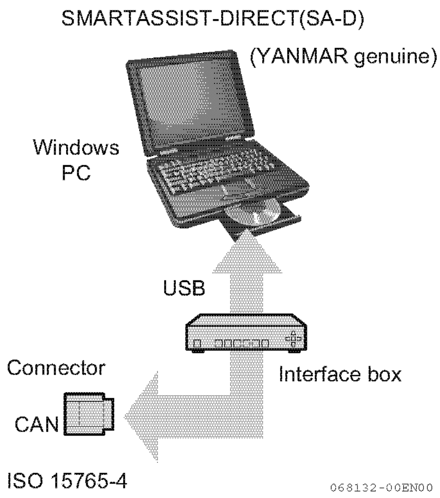


Figure 13-32

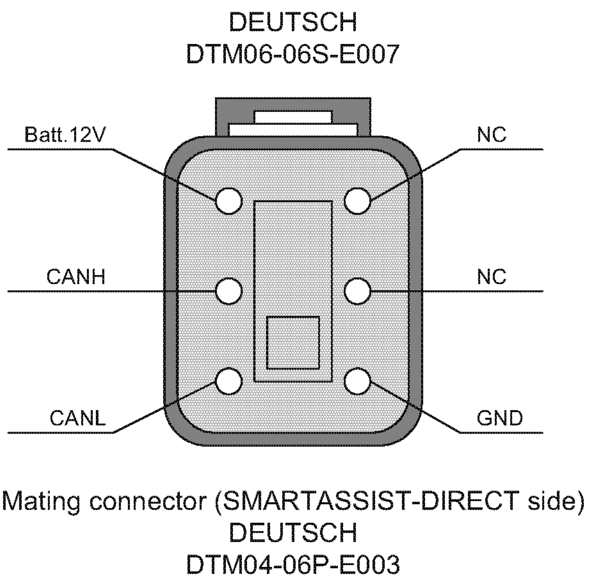


Figure 13-33

REPLACEMENT OF COMPONENTS

If any part for the electronic control system must be repaired or replaced as a result of periodic maintenance or the failure diagnosis conducted using the SMARTASSIST-DIRECT, do not attempt to repair the individual device of the electronic control system. Refer to the separate TROUBLESHOOTING manual, and replace the parts or entire assembly.

■ Processing the DPF regeneration after the parts replacement

The following parts are used for the calculation of the accumulated PM amount. Therefore, when there is a fault in these parts, the accumulated PM amount may be miscalculated. Be sure to perform the DPF regeneration in order to eliminate the calculation error of the accumulated PM amount after replacing parts.

• Injector	• Rail CMP or rail pressure sensor
• Supply pump	• DOC
• EGR valve	• Intake throttle
• ECU	• EGR gas temperature sensor
• EGR pressure sensor	• DPF inlet temperature sensor
• DPF differential pressure sensor	• Intake manifold temperature sensor
• DPF inside temperature sensor	• Fuel temperature sensor
• Exhaust manifold temperature sensor	• Crankshaft rotation sensor
• Cooling water temperature sensor	

1. Start and warm-up the engine until the cooling water temperature is 60 °C or higher, then let it idle.
2. Without optional recovery regeneration function equipped, when the ECU determines that the PM sediment amount is 10 g/L or more, the stationary regeneration request is displayed. Perform the stationary regeneration. For details on regeneration operation, see *Operation procedures of stationary regeneration on page 13-7*.
3. If the stationary regeneration request lamp does not come on (sediment is 10 g/L or less), connect SMARTASSIST-DIRECT (SA-D) and perform stationary regeneration. For operation procedures for stationary regeneration using SA-D, refer to the SMARTASSIST-DIRECT operating manual, 6.5.9 supplementary materials “Active Control”.
4. With optional recovery regeneration function equipped, when the ECU determines that the PM sediment amount is 12 g/L or more, the recovery regeneration request is displayed. Perform recovery regeneration. For details on regeneration operation, see s*Operation procedures of stationary regeneration on page 13-7*.
5. If sediment is 12 g/L or less, then go to the stationary regeneration determination flow.

Procedure to eliminate calculation errors of the accumulated PM amounts when using method C

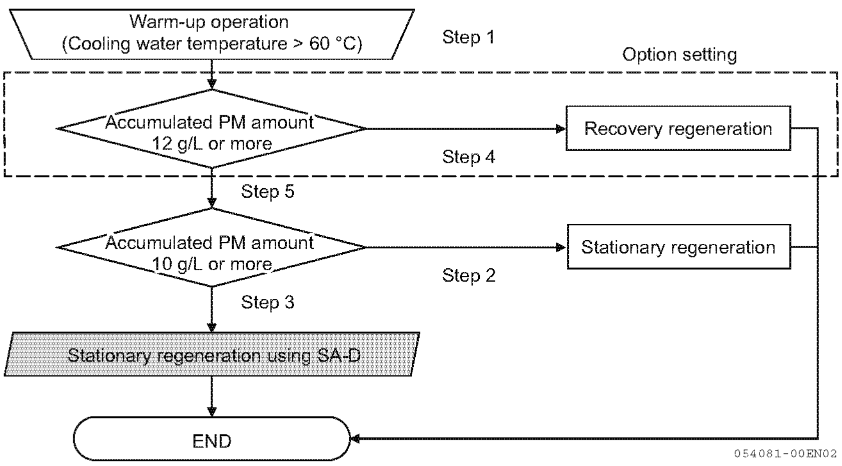


Figure 13-34

Calculation of PM sediment amount in DPF

ECU calculate the PM sediment amount that is accumulated in soot filter (SF) by following 2 methods:

- Method C calculates the difference between the estimated PM sediment amount that is discharged from the engine and the estimated PM sediment amount that is burned inside the SF.
- Method P calculates the PM sediment amount accumulated in the SF from the pressure difference between the inlet and outlet of the SF.

ECU uses the PM sediment amount whichever is greater for regeneration control.

■ Processing after the ECU replacement (when it is impossible to inherit from the old ECU)

When the history data could not be inherited from the old ECU at the time of replacing the ECU, the data for the accumulated Ash*1 amount is reset, accordingly estimate the PM sediment amount from the accumulated Ash using method P, and determine if SF cleaning is necessary.

Procedures for when the history data could not be inherited are shown below.

1. After ECU replacement, the procedure for burning PM by using DPF regeneration (stationary regeneration or stationary regeneration using SA-D, or recovery regeneration when optional recovery regeneration function equipped) is the same as in the previous chapter.
2. If PM sediment is 10 g/L or more, and stationary regeneration is being performed, then after regeneration has completed, connect SMARTASSIST-DIRECT (SA-D) so that this can be used to confirm the PM sediment concentration (P method). If the PM sediment is 10 g/L or less, and the SA-D connected and stationary regeneration performed, then proceed to the next step while leaving this connected.
3. Operate the engine at high idling for 10 minutes or more until the situation has stabilized.
4. After operation has completed, check the ash sediment amount using SA-D. On the SA-D menu screen, select “Diagnosis Test” and then pulse/analog input and output, and confirm the “DPF PM sediment concentration (P method)” data. For operation procedures refer to the SMARTASSIST-DIRECT operating manual, 6.5.10 supplementary materials “Pulse/Analog Input and Output”.
5. When the PM sediment amount (P method) exceeds 5 g/L, clean the soot filter (SF).

**1: Refer to page 13-5 for PM and Ash.*

Procedure to eliminate calculation errors of the accumulated PM amounts when using method C, and to confirm ash sediment amount

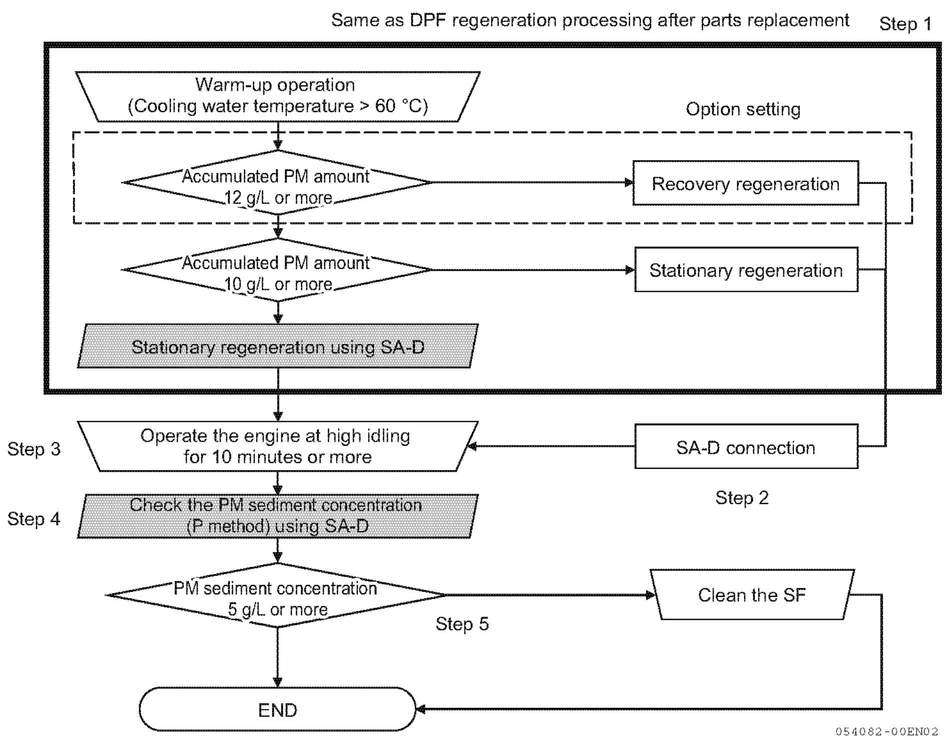


Figure 13-35

■ Required processing at the CR-related parts replacement

Replacement parts	SA-D operation	
	Bosch	
	ECU rewrite	Processing DPF regeneration
ECU	○	○*2
Injector	○	○
DPF	○	○
SF	○	○
DOC	○	○
Rail	○	○
Supply pump	–	○
Other*1	–	○

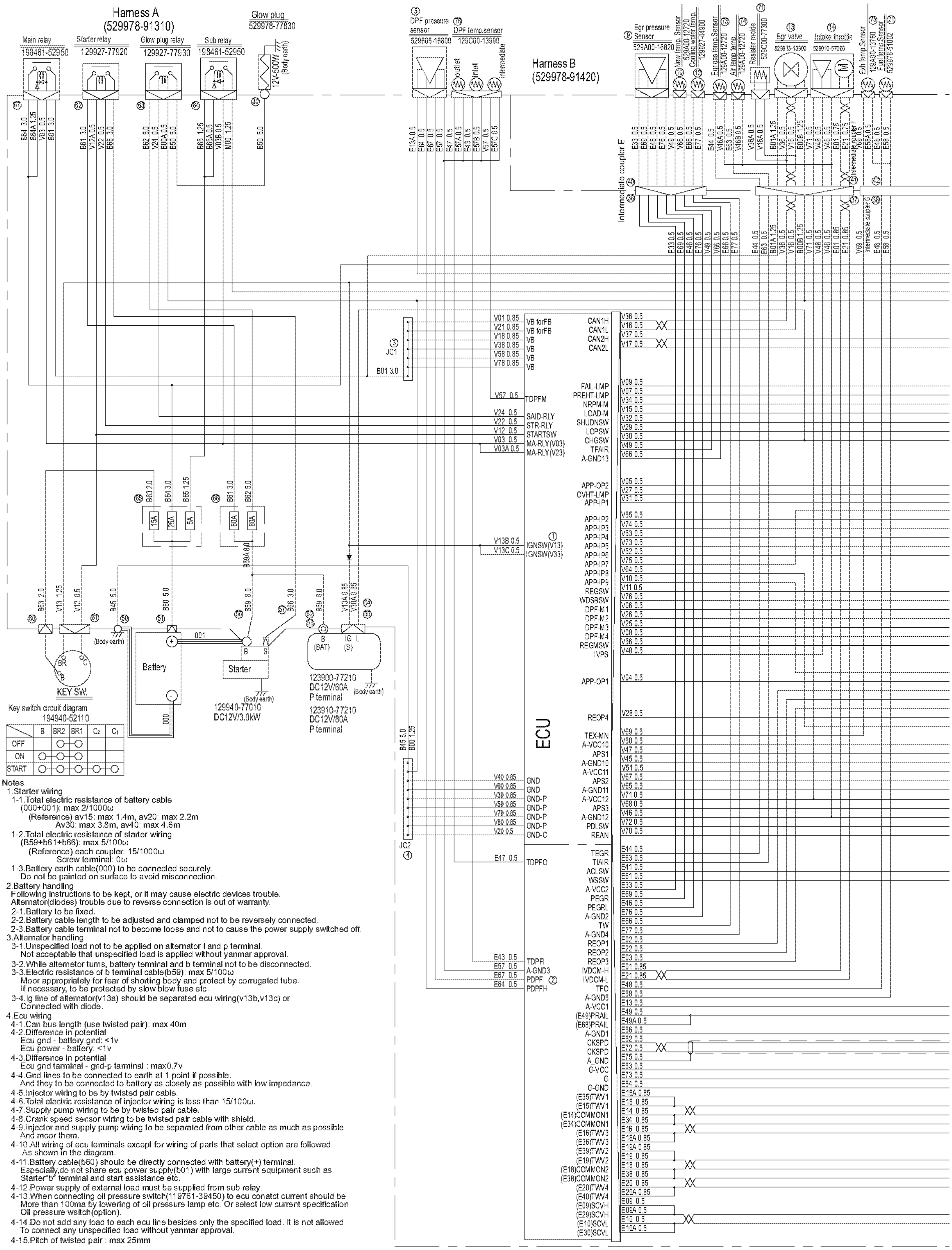
**1: EGR valve, intake throttle, DPF differential pressure sensor, DPF inlet temperature sensor, DPF inside temperature sensor, EGR pressure sensor, intake manifold temperature sensor, EGR gas temperature sensor, exhaust manifold temperature sensor, crankshaft speed sensor, fuel temperature sensor, cooling water temperature sensor.*

**2: When the history data could not be inherited from the old ECU, processing the DPF regeneration is required. Furthermore, it is required to clean the SF when the accumulated amount by method P after the DPF regeneration exceeds 5 g/L.*

NOTICE

- Do not plug or unplug the ECU for a period of at least 60 seconds after power to the unit has been turned on or off.
- Do not touch connector pins of the ECU with bare hands. Doing so may result in corrosion of the connector pins and/or damage to the internal circuits of the ECU due to static electricity.
- Do not force a measuring probe into the female coupler. Doing so may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Take care to prevent water from entering the couplers when plugging or unplugging the connector. Water inside the couplers may cause corrosion, resulting in malfunction of the ECU.
- Avoid plugging/unplugging the connector more than approx. 10 times.
  Frequent plugging/unplugging of the connector may cause contact failure of the connector pins, resulting in malfunction of the ECU.
- Do not use the ECU that has ever suffered drop impact.

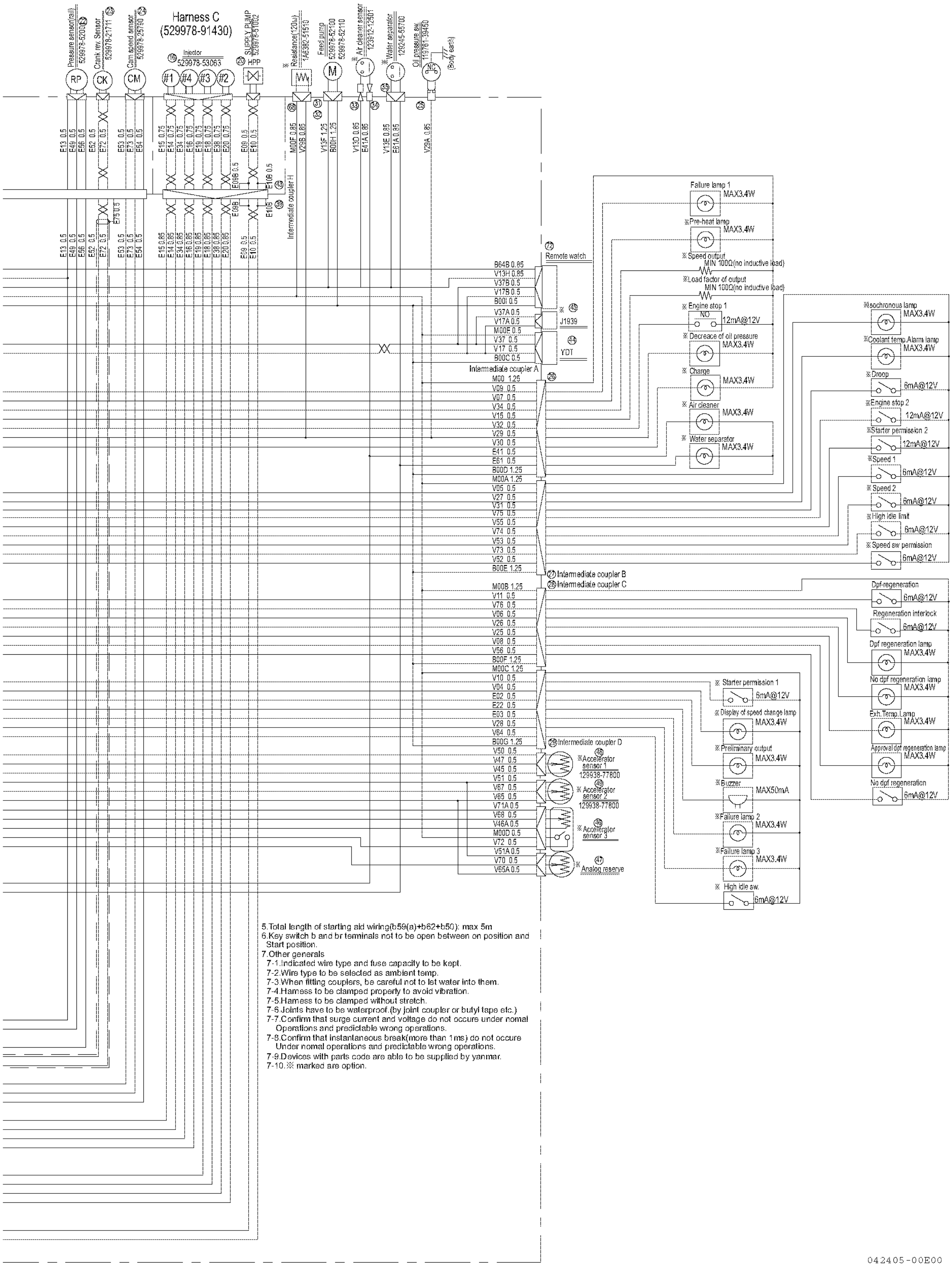
ELECTRONIC CONTROL HARNESS CONNECTIONS



Key switch circuit diagram
194940-52110

	B	BR2	BR1	C2	C1
OFF		O	O		
ON	O	O	O		
START	O	O	O	O	O

Notes
1.Starter wiring
1-1.Total electric resistance of battery cable (000+001): max 2/1000ω
(Reference) av15: max 1.4m, av20: max 2.2m
Av30: max 3.8m, av40: max 4.6m
1-2.Total electric resistance of starter wiring (B59+b61+b66): max 5/100ω
(Reference) each coupler: 15/1000ω
Screw terminal: 0ω
1-3.Battery earth cable(000) to be connected securely.
Do not be painted on surface to avoid misconnection.
2.Battery handling
Following instructions to be kept, or it may cause electric devices trouble.
Alternator(diodes) trouble due to reverse connection is out of warranty.
2-1.Battery to be fixed.
2-2.Battery cable length to be adjusted and clamped not to be reversely connected.
2-3.Battery cable terminal not to become loose and not to cause the power supply switched off.
3.Alternator handling
3-1.Unspecified load not to be applied on alternator l and p terminal.
Not acceptable that unspecified load is applied without yanmar approval.
3-2.While altemetor tums, battery terminal and b terminal not to be disconnected.
3-3.Electric resistance of b teminal cable(b59): max 5/100ω
Moor appropriately for fear of shorting body and protect by corrugated tube.
if necessary, to be protected by slow blow fuse etc.
3-4.Ig line of alternator(v13a) should be separated ecu wiring(v13b,v13c) or
Connected with diode.
4.Ecu wiring
4-1.Can bus length (use twisted pair): max 40m
4-2.Difference in potential
Ecu gnd - battery gnd: <1v
Ecu power - battery: <1v
4-3.Difference in potential
Ecu gnd tarminal - gnd-p taminal : max0.7v
4-4.Gnd lines to be connected to earth at 1 point if possible.
And they to be connected to battery as closely as possible with low impedance.
4-5.Injector wiring to be by twisted pair cable.
4-6.Total electric resistance of injector wiring is less than 15/100ω.
4-7.Supply pump wiring to be by twisted pair cable.
4-8.Crank speed sensor wiring to be twisted pair cable with shield.
4-9.injector and supply pump wiring to be separated from other cable as much as possible
And moor them.
4-10.All wiring of ecu teminals except for wiring of parts that select option are followed
As shown in the diagram.
4-11.Battery cable(b60) should be directly connected with battery(+) terminal.
Especially,do not share ecu power supply(b01) with large current equipment such as
Starter"b" terminal and start assistance etc.
4-12.Power supply of external load must be supplied from sub relay.
4-13.When connecting oil pressure switch(119761-39450) to ecu conatct current should be
More than 100ma by lowering of oil pressure lamp etc. Or select low current specification
Oil pressure wsitch(option).
4-14.Do not add any load to each ecu line besides only the specified load. It is not allowed
To connect any unspecified load without yanmar approval.
4-15.Pitch of twisted pair : max 25mm



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No.	Kind of wire	Cross section	Wire color	Circuit mark	Terminal	Circuit mark	Terminal	Circuit mating tip		Remarks
001	AVS	5.0	R	B60		B60		51	65	
002	AVS	3.0	R	B01		B01		67	3	
003	AVSS	1.25	R			B01A			37	
004	AVSS	0.85	R	V01		V01	Gold	3	1	
005	AVSS	0.85	R	V21		V21	Gold	3	1	
006	AVSS	0.85	R	V18		V18	Gold	3	1	
007	AVSS	0.85	R	V38		V38	Gold	3	1	
008	AVSS	0.85	R	V58		V58	Gold	3	1	
009	AVSS	0.85	R	V78		V78	Gold	3	1	
010	AVSS	2.0	RW	B63		B63		65	60	
011	AVSS	3.0	RY	B64		B64		65	67	
012	AVSS	1.25	RY			B64A			67	
013	AVSS	0.85	RY			B64B			72	
014	AVSS	0.5	G	V03		V03	Gold	67	1	
015	AVSS	0.5	G			V03A	Gold		1	
016	AVSS	0.5	G			V03B			64	
017	AVSS	1.25	Y	B65		B65		65	64	
018	AVSS	0.5	Y			B65A			64	
019	AVSS	1.25	O	V13		V13		61	31	
020	AVSS	0.85	O			V13A			54	
021	AVSS	0.5	O			V13B	Gold		1	
022	AVSS	0.5	O			V13C	Gold		1	
023	AVSS	0.85	O			V13D			33	
024	AVSS	0.85	O			V13E			35	
025	AVSS	1.25	O			V13F			32	
026	AVSS	0.85	O			V13G			55	
027	AVSS	0.85	O			V13H			72	
028	AVSS	0.5	G	V12		V12	Gold	61	1	
029	AVSS	0.5	G			V12A			62	
030	AVS	5.0	B	B45		B45		4	50	
031	AVSS	0.85	B	V40	Gold	V40		1	4	
032	AVSS	0.85	B	V60	Gold	V60		1	4	
033	AVSS	0.85	B	V39	Gold	V39		1	4	
034	AVSS	0.85	B	V59	Gold	V59		1	4	
035	AVSS	0.85	B	V79	Gold	V79		1	4	
036	AVSS	0.85	B	V80	Gold	V80		1	4	
037	AVSS	0.5	B	V20	Gold	V20		1	4	
038	AVSS	1.25	B	B00		B00		4	31	
039	AVSS	0.5	B			B00A			63	
040	AVSS	1.25	B			B00B			37	
041	AVSS	0.5	B			B00C			44	
042	AVSS	1.25	B			B00D			26	
043	AVSS	1.25	B			B00E			27	
044	AVSS	1.25	B			B00F			28	
045	AVSS	1.25	B			B00G			29	
046	AVSS	1.25	B			B00H			32	
047	AVSS	0.5	B			B00I			72	
048	AV	8.0	W	B59		B59		56	52	
049	AV	8.0	W			B59A			66	
050	AV	8.0	W			B59B			53	
051	AVS	3.0	BrY	B61		B61		66	62	
052	AVS	5.0	Br	B62		B62		66	63	
053	AVS	3.0	W	B66		B66		62	57	
054	AVSS	0.5	P	V22	Gold	V22		1	62	
055	AVSS	0.5	LW	V24	Gold	V24		1	63	
056	AVS	5.0	R	B50		B50		30	63	
057	AVSS	1.25	R	M00		M00		64	26	
058	AVSS	1.25	R			M00A			27	
059	AVSS	1.25	R			M00B			28	
060	AVSS	1.25	R			M00C			29	
061	AVSS	0.5	R			M00D			46	
062	AVSS	0.5	R			M00E			44	
063	AVSS	0.85	R			M00F			68	
064	AVSS	0.5	RG	V09	Gold	V09		1	26	
065	AVSS	0.5	L	V07	Gold	V07		1	26	
066	AVSS	0.5	Y	V34	Gold	V34		1	26	
067	AVSS	0.5	G	V15	Gold	V15		1	26	
068	AVSS	0.5	P	V32	Gold	V32		1	26	
069	AVSS	0.5	Br	V29	Gold	V29		1	26	
070	AVSS	0.85	Br			V29A			25	
071	AVSS	0.85	Br			V29B			68	
072	AVSS	0.5	RW	V30	Gold	V30		1	26	
073	AVSS	0.85	RW			V30A			54	
074	AVSS	0.85	RW			V30B			55	
075	AVSS	0.5	L	E41	Gold	E41		2	26	
076	AVSS	0.85	L			E41A			34	
077	AVSS	0.5	GY	E61	Gold	E61		2	26	
078	AVSS	0.85	GY			E61A			35	
079	AVSS	0.5	W	V05	Gold	V05		1	27	
080	AVSS	0.5	RW	V27	Gold	V27		1	27	
081	AVSS	0.5	Br	V31	Gold	V31		1	27	
082	AVSS	0.5	G	V75	Gold	V75		1	27	
083	AVSS	0.5	L	V55	Gold	V55		1	27	
084	AVSS	0.5	Y	V74	Gold	V74		1	27	
085	AVSS	0.5	P	V53	Gold	V53		1	27	
086	AVSS	0.5	LW	V73	Gold	V73		1	27	
087	AVSS	0.5	BrW	V52	Gold	V52		1	27	
088	AVSS	0.5	LW	V11	Gold	V11		1	28	
089	AVSS	0.5	Y	V76	Gold	V76		1	28	
090	AVSS	0.5	Br	V06	Gold	V06		1	28	
091	AVSS	0.5	P	V26	Gold	V26		1	28	
092	AVSS	0.5	W	V25	Gold	V25		1	28	
093	AVSS	0.5	G	V08	Gold	V08		1	28	
094	AVSS	0.5	O	V56	Gold	V56		1	28	
095	AVSS	0.5	W	V10	Gold	V10		1	29	
096	AVSS	0.5	G	V04	Gold	V04		1	29	
097	AVSS	0.5	Br	E02	Gold	E02		2	29	
098	AVSS	0.5	L	E22	Gold	E22		2	29	
099	AVSS	0.5	P	E03	Gold	E03		2	29	
100	AVSS	0.5	Y	V28	Gold	V28		1	29	
101	AVSS	0.5	RW	V64	Gold	V64		1	29	
102	AVSS	0.5	R	E33	Gold	E33		2	36	
103	AVSS	0.5	Y	E69	Gold	E69		2	36	
104	AVSS	0.5	W	E46	Gold	E46		2	36	
105	AVSS	0.5	B	E76	Gold	E76		2	36	
106	AVSS	0.5	P	V49	Gold	V49		1	36	
107	AVSS	0.5	BW	V66	Gold	V66		1	36	

No.	Kind of wire	Cross section	Wire color	Circuit mark	Terminal	Circuit mark	Terminal	Circuit mating tip		Remarks
108	AVSS	0.5	G	E66	Gold	E66		2	36	
109	AVSS	0.5	L	E77	Gold	E77		2	36	
110	AVSS	0.5	P	V36	Gold	V36		1	37	V16 twisted pair
111	AVSS	0.5	L	V16	Gold	V16		1	37	V36 twisted pair
112	AVSS	0.5	R	V71	Gold	V71		1	37	
113	AVSS	0.5	R			V71A			46	
114	AVSS	0.5	G	V48	Gold	V48		1	37	
115	AVSS	0.5	Br	V46	Gold	V46		1	37	
116	AVSS	0.5	Br			V46A			46	
117	AVSS	0.85	Y	E01	Gold	E01		2	37	E21 twisted pair
118	AVSS	0.85	LW	E21	Gold	E21		2	37	E01 twisted pair
119	AVSS	0.5	L	E48	Gold	E48		2	38	
120	AVSS	0.5	BrW	E58	Gold	E58		2	38	
121	AVSS	0.5	R	E13	Gold	E13		2	38	
122	AVSS	0.5	R			E13A	Gold		5	
123	AVSS	0.5	G	E49		E49	Gold	38	2	
124	AVSS	0.5	G			E49A	Gold		2	
125	AVSS	0.5	BW	E56	Gold	E56		2	38	
126	AVSS	0.5	P	E52	Gold	E52		2	38	Shield and twist with e72
127	AVSS	0.5	O	E72	Gold	E72		2	38	Shield and twist with e52
128	AVSS	0.5	B	E75	Gold	E75		2	38	Shield with e52,e72
129	AVSS	0.5	RW	E53	Gold	E53		2	38	
130	AVSS	0.5	L	E73	Gold	E73		2	38	
131	AVSS	0.5	BL	E54	Gold	E54		2	38	
132	AVSS	0.85	WL	E15		E15	Gold	39	2	E14 twisted pair
133	AVSS	0.85	WL			E15A	Gold		2	Connected to e15
134	AVSS	0.85	R	E14	Gold	E14		2	39	E15 twisted pair Connected to e34 and a
135	AVSS	0.85	R	E34	Gold	E34		2	39	E16 twisted pair Connected to e14 and a
136	AVSS	0.85	Y	E16		E16	Gold	39	2	E34 twisted pair
137	AVSS	0.85	Y			E16A	Gold		2	Connected to e16
138	AVSS	0.85	W	E19		E19	Gold	39	2	E18 twisted pair
139	AVSS	0.85	W			E19A	Gold		2	Connected to e19
140	AVSS	0.85	L	E18	Gold	E18		2	39	E19 twisted pair Connected to e38 and a
141	AVSS	0.85	L	E38	Gold	E38		2	39	E20 twisted pair Connected to e18 and a
142	AVSS	0.85	WL	E20		E20	Gold	39	2	E38 twisted pair
143	AVSS	0.85	WL			E20A	Gold		2	Connected to e20
144	AVSS	0.5	Y	E09	Gold	E09		2	39	E10 twisted pair
145	AVSS	0.5	Y			E09A	Gold		2	Connected to e09
146	AVSS	0.5	Y			E09B			39	Connected to e09
147	AVSS	0.5	P	E10	Gold	E10		2	39	E09 twisted pair
148	AVSS	0.5	P			E10A	Gold		2	Connected to e10
149	AVSS	0.5	P			E10B			39	Connected to e10
150	AVSS	0.5	G	E64	Gold	E64	Gold	2	5	
151	AVSS	0.5	L	E67	Gold	E67	Gold	2	5	
152	AVSS	0.5	B	E57	Gold	E57	Gold	2	5	
153	AVSS	0.5	B			E57A			76	
154	AVSS	0.5	B			E57B			76	
155	AVSS	0.5	B			E57C			76	
156	AVSS	0.5	RW	E43	Gold	E43		2	76	
157	AVSS	0.5	Br	V57	Gold	V57		1	76	
158	AVSS	0.5	Y	V37	Gold	V37		1	44	V17 twisted pair
159	AVSS	0.5	Y			V37A			45	Connected to v37
160	AVSS	0.5	Y			V37B			72	Connected to v37
161	AVSS	0.5	L	V17		V17		1	44	V37 twisted pair
162	AVSS	0.5	L			V17A			45	Connected to v17
163	AVSS	0.5	L			V17B			72	Connected to v17
164	AVSS	0.5	R	V50	Gold	V50	Gold	1	48	
165	AVSS	0.5	P	V47	Gold	V47	Gold	1	48	
166	AVSS	0.5	B	V45	Gold	V45	Gold	1	48	
167	AVSS	0.5	LW	V51	Gold	V51	Gold	1	49	
168	AVSS	0.5	LW			V51A	Gold		47	
169	AVSS	0.5	G	V67	Gold	V67	Gold	1	49	
170	AVSS	0.5	Y	V65	Gold	V65	Gold	1	49	
171	AVSS	0.5	Y			V65A	Gold		47	
172	AVSS	0.5	O	V68	Gold	V68		1	46	
173	AVSS	0.5	P	V72	Gold	V72		1	46	
174	AVSS	0.5	L	V70	Gold	V70	Gold	1	47	
175	AVSS	0.5	YG	V69		V69		1	38	
176	AVSS	0.5	RW	E44		E44		2	37	
177	AVSS	0.5	LY	E63		E63		2	37	
178	AVSS	0.5	Y	E47		E47		2	76	
179	AVSSX	0.5	R	E33	Gold	E33		9	40	
180	AVSSX	0.5	Y	E69	Gold	E69		9	40	
181	AVSSX	0.5	W	E46	Gold	E46		9	40	
182	AVSSX	0.5	B	E76	Gold	E76		9	40	
183	AVSSX	0.5	P	V49	Gold	V49		10	40	
184	AVSSX	0.5	BW	V66	Gold	V66		10	40	
185	AVSSX	0.5	G	E66	Gold	E66		12	40	
186	AVSSX	0.5	L	E77	Gold	E77		12	40	
187	AVSSX	1.25	O	B01A		B01A		13	41	
188	AVSSX	0.5	P	V36		V36		13	41	V16 twisted pair

No.	Kind of wire	Cross section	Wire color	Circuit mark	Terminal	Circuit mark	Terminal	Circuit mating tip		Remarks
189	AVSSX	0.5	P			V36A			71	
190	AVSSX	0.5	L	V16		V16		13	41	V36 twisted pair
191	AVSSX	0.5	L			V16A			71	
192	AVSSX	1.25	B	B00B		B00B		13	41	
193	AVSSX	0.5	R	V71	Gold	V71		14	41	
194	AVSSX	0.5	G	V48	Gold	V48		14	41	
195	AVSSX	0.5	Br	V46	Gold	V46		14	41	
196	AVSSX	0.5	Br			V46A	Gold		73	
197	AVSSX	0.5	Br			V46B	Gold		74	
198	AVSSX	0.75	Y	E01		E01		14	41	E21 twisted pair
199	AVSSX	0.75	LW	E21		E21		14	41	E01 twisted pair
200	AVSSX	0.5	L	E48	Gold	E48		21	42	
201	AVSSX	0.5	BrW	E58	Gold	E58		21	42	
202	AVSSX	0.5	BrW			E58A			75	
203	AVSSX	0.5	R	E13	Gold	E13		22	42	
204	AVSSX	0.5	G	E49	Gold	E49		22	42	
205	AVSSX	0.5	BW	E56	Gold	E56		22	42	
206	AVSS	0.5	P	E52		E52		23	42	E72 twisted pair
207	AVSS	0.5	O	E72		E72		23	42	E52 twisted pair
208	AVSSX	0.5	RW	E53		E53		24	42	
209	AVSSX	0.5	L	E73		E73		24	42	
210	AVSSX	0.5	BL	E54		E54		24	42	
211	AVSSX	0.5	YG	V69	Gold	V69		75	42	
212	AVSSX	0.5	RW	E44	Gold	E44		73	41	
213	AVSSX	0.5	LY	E63	Gold	E63		74	41	
214	AVSSX	0.75	WL	E15		E15		16	43	E14 twisted pair
215	AVSSX	0.75	R	E14		E14		16	43	E15 twisted pair
216	AVSSX	0.75	R	E34		E34		16	43	E16 twisted pair
217	AVSSX	0.75	Y	E16		E16		16	43	E34 twisted pair
218	AVSSX	0.75	W	E19		E19		16	43	E18 twisted pair
219	AVSSX	0.75	L	E18		E18		16	43	E19 twisted pair
220	AVSSX	0.75	L	E38		E38		16	43	E20 twisted pair
221	AVSSX	0.75	WL	E20		E20		16	43	E38 twisted pair
222	AVSSX	0.5	Y	E09		E09		20	43	E10 twisted pair
223	AVSSX	0.5	Y			E09B			43	Connected to e09
224	AVSSX	0.5	P	E10		E10		20	43	E09 twisted pair
225	AVSSX	0.5	P			E10B			43	Connected to e10

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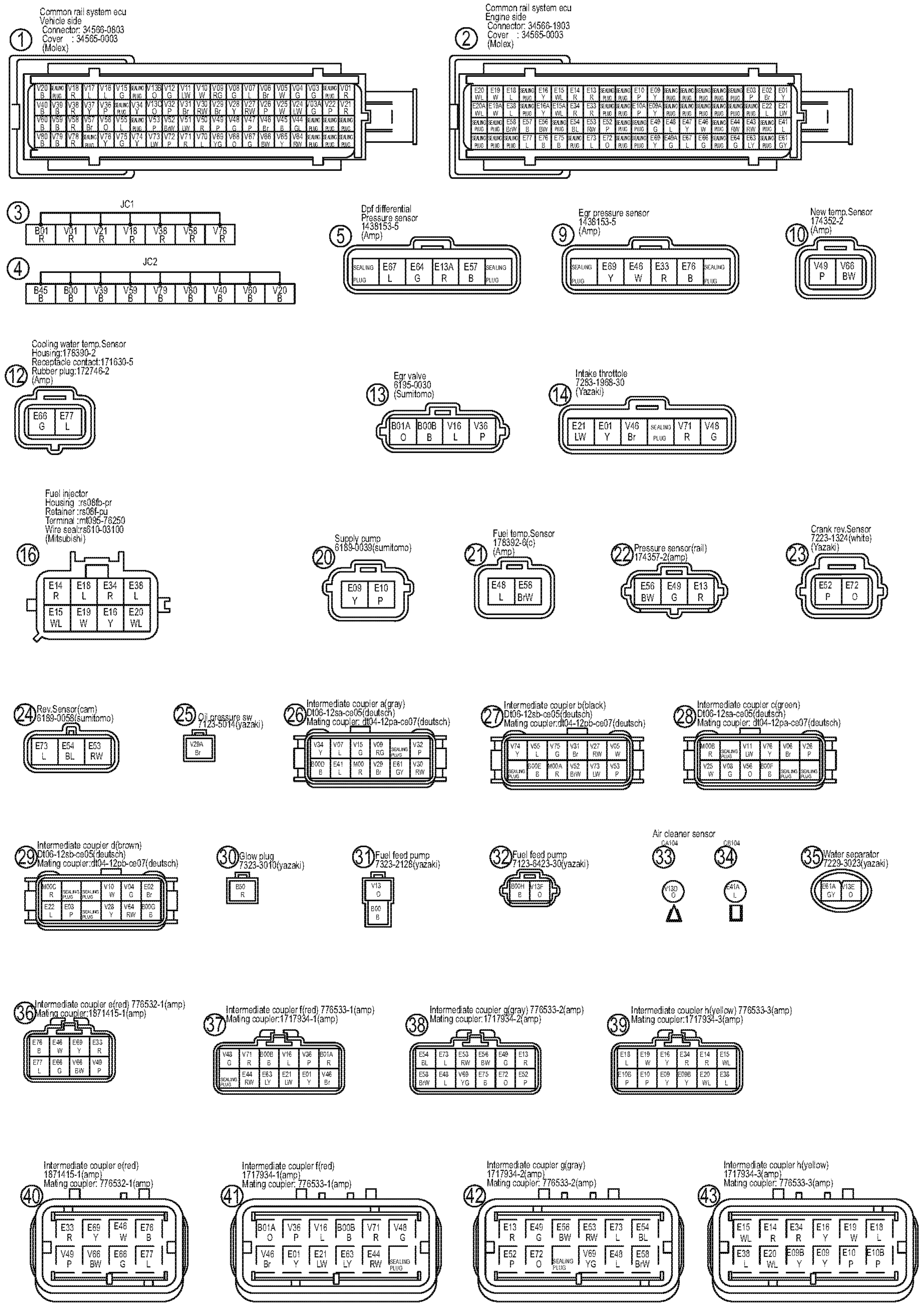
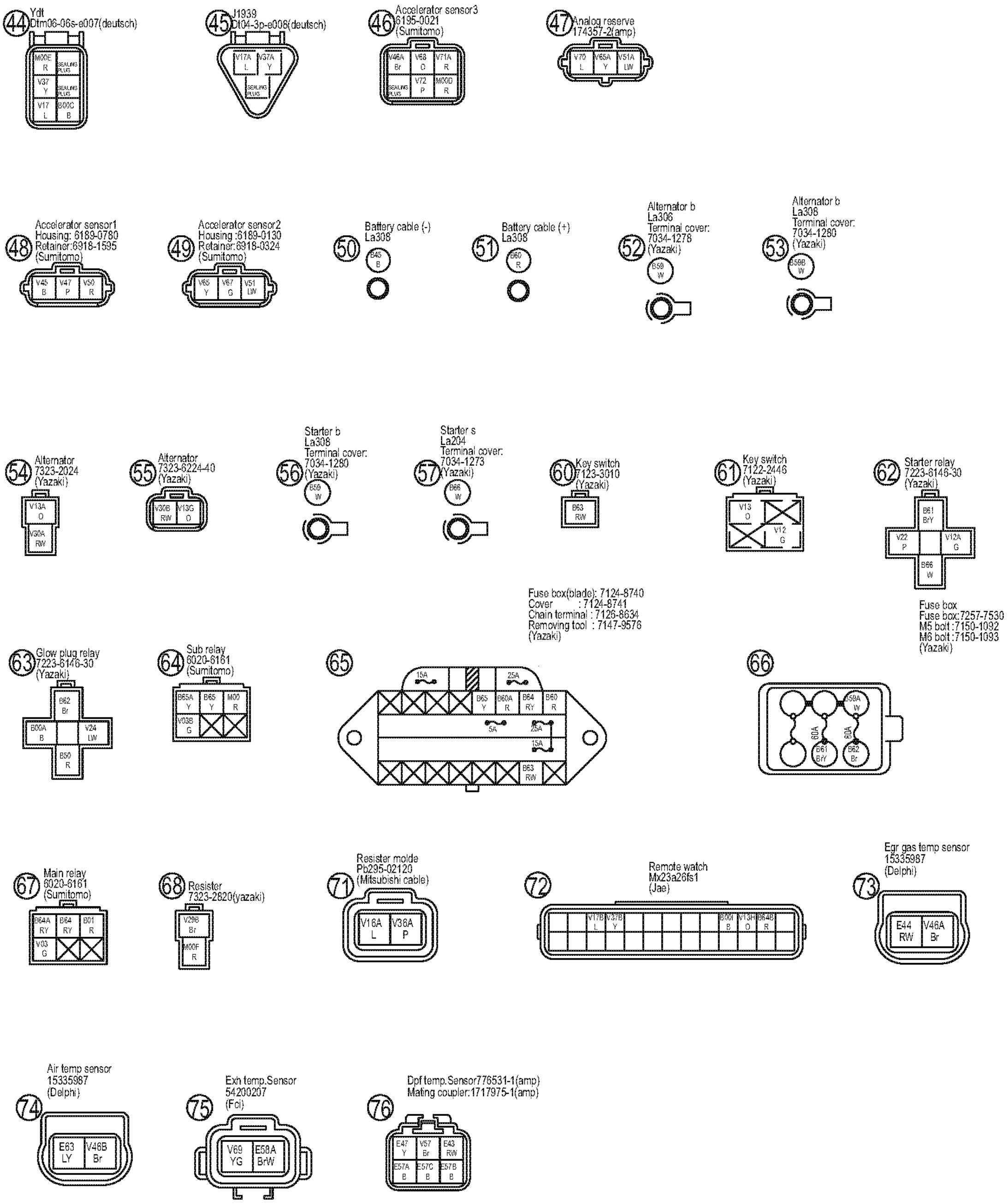


Common rail system ecu
Vehicle side
Connector: 34566-0803
Cover : 34565-0003
(Molex)
Common rail system ecu
Engine side
Connector: 34566-1903
Cover : 34565-0003
(Molex)
JC1
B01 R
V01 R
V21 R
V18 R
V38 R
V58 R
V78 R
JC2
B45 B
B00 B
V39 B
V59 B
V79 B
V80 B
V40 B
V60 B
V20 B
Dpf differential
Pressure sensor
1438153-5
(Amp)
E67 L
E64 G
E13A R
E57 B
Egr pressure sensor
1438153-5
(Amp)
E69 Y
E46 W
E33 R
E76 B
New temp.Sensor
174352-2
(Amp)
V49 P
V66 BW
Cooling water temp.Sensor
Housing:178390-2
Receptacle contact:171630-5
Rubber plug:172746-2
(Amp)
E66 G
E77 L
Egr valve
6195-0030
(Sumitomo)
B01A O
B00B B
V16 L
V36 P
Intake throttole
7283-1968-30
(Yazaki)
E21 LW
E01 Y
V46 Br
V71 R
V48 G
Fuel injector
Housing :rs08fb-pr
Retainer :rs08f-pu
Terminal :mt095-76250
Wire seal:rs610-03100
(Mitsubishi)
E14 R
E18 L
E34 R
E38 L
E15 WL
E19 W
E16 Y
E20 WL
Supply pump
6189-0039(sumitomo)
E09 Y
E10 P
Fuel temp.Sensor
178392-6(c)
(Amp)
E48 L
E58 BrW
Pressure sensor(rail)
174357-2(amp)
E56 BW
E49 G
E13 R
Crank rev.Sensor
7223-1324(white)
(Yazaki)
E52 P
E72 O
Rev.Sensor(cam)
6189-0058(sumitomo)
E73 L
E54 BL
E53 RW
Oil pressure sw
7123-5014(yazaki)
Intermediate coupler a(gray)
Dt06-12sa-ce05(deutsch)
Mating coupler: dt04-12pa-ce07(deutsch)
Intermediate coupler b(black)
Dt06-12sb-ce05(deutsch)
Mating coupler:dt04-12pb-ce07(deutsch)
Intermediate coupler c(green)
Dt06-12sa-ce05(deutsch)
Mating coupler: dt04-12pa-ce07(deutsch)
Intermediate coupler d(brown)
Dt06-12sb-ce05(deutsch)
Mating coupler:dt04-12pb-ce07(deutsch)
Glow plug
7323-3010(yazaki)
Fuel feed pump
7323-2128(yazaki)
Fuel feed pump
7123-6423-30(yazaki)
Air cleaner sensor
Water separator
7229-3023(yazaki)
Intermediate coupler e(red) 776532-1(amp)
Mating coupler:1871415-1(amp)
Intermediate coupler f(red) 776533-1(amp)
Mating coupler:1717934-1(amp)
Intermediate coupler g(gray) 776533-2(amp)
Mating coupler:1717934-2(amp)
Intermediate coupler h(yellow) 776533-3(amp)
Mating coupler:1717934-3(amp)
Intermediate coupler e(red)
1871415-1(amp)
Mating coupler: 776532-1(amp)
E33 R
E69 Y
E46 W
E76 B
V49 P
V66 BW
E66 G
E77 L
Intermediate coupler f(red)
1717934-1(amp)
Mating coupler: 776533-1(amp)
B01A O
V36 P
V16 L
B00B B
V71 R
V48 G
V46 Br
E01 Y
E21 LW
E63 LY
E44 RW
Intermediate coupler g(gray)
1717934-2(amp)
Mating coupler: 776533-2(amp)
E13 R
E49 G
E56 BW
E53 RW
E73 L
E54 BL
E52 P
E72 O
V69 YG
E48 L
E58 BrW
Intermediate coupler h(yellow)
1717934-3(amp)
Mating coupler: 776533-3(amp)
E15 WL
E14 R
E34 R
E16 Y
E19 W
E18 L
E38 L
E20 WL
E09B Y
E09 Y
E10 P
E10B P



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Section 14

ELECTRIC WIRING

Page

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ELECTRIC WIRING PRECAUTIONS

Failure to follow these precautions may result in the failure of an electrical component and the loss of warranty coverage on that item as well as related items. Make sure that all users read and understand these precautions.

NOTICE

Do not reverse the positive (+) and negative (-) ends of the battery cable. The alternator diode and stator coil will be damaged.

NOTICE

When the battery indicator goes out, it should not come on again. The battery indicator only comes on during operation if the alternator fails. However, if an LED is used in the battery indicator, the LED will shine faintly during normal operation.

NOTICE

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated in the *Battery Cable Resistance chart* in the *Electric Wiring Section* of this manual. The starter motor will malfunction and fail if the resistance is higher than the specified value.

NOTICE

Removing the battery cables or the battery while the engine is operating may cause damage to the current limiter depending on the electrical equipment being used. This situation could cause loss of control of output voltage. The continuous high voltage of 23 - 24 V (for 5000 min^{-1} (rpm) dynamo) will damage the current limiter and other electrical equipment.

NOTICE

Reversing the battery cable connections at the battery or on the engine will destroy the SCR diode in the current limiter. This will cause the charging system to malfunction and may cause damage to the electrical harnesses.

ELECTRICAL WIRE RESISTANCE

AWG	Metric nominal mm²	Ohms/foot resistance
20	0.5	0.009967
18	0.8	0.006340
16	1.25	0.004359
14	2	0.002685
12	3	0.001704
10	5	0.001073
8	8	0.000707
6	15	0.000421
4	20	0.000270
2	30	0.000158
1	40	0.000130
0 (1/0)	50	0.000103
00 (2/0)	60	0.000087
000 (3/0)	85	0.000066
0000 (4/0)	100	0.000051

Wiring voltage drop should not exceed 5 % [0.05] × 12 volts = 0.6 volts.

Voltage drop = Current [Amps] × Length of wire [feet] × Resistance per foot Ω

Example:

Current draw of 100 Amps × 3 feet of 4 AWG wire

100 Amps × 3 feet × 0.000270 = 0.08 volts [voltage drop]

BATTERY CABLE RESISTANCE

AWG	mm^2	Maximum total battery cable length (positive cable + negative cable + a*) 12 V starter motor output			
		Less than 2.68 HP (2 kW)		Greater than 2.68 HP (2 kW)	
		m	ft	m	ft
6	15	1.5	4.75	N/A	N/A
4	20	2.3	7.4	N/A	N/A
2	30	3.8	12.6	2.3	7.5
1	40	4.6	15.3	2.8	9.2
0 (1/0)	50	5.9	19.5	3.5	11.6
00 (2/0)	60	7.0	22.8	4.2	13.7
000(3/0)	85	9.3	30.5	5.6	18.3
0000 (4/0)	100	11.9	39.0	7.1	23.4
00000 (5/0)	125	N/A	N/A	8.3	27.3
000000 (6/0)	150	N/A	N/A	10.1	33.3

Note:

- *Total allowable resistance of the complete battery cable circuit (positive cable + negative cable + a*) (a*: Resistance (Ω) of a battery switch or other electrical equipment having high resistance).*
- *For starter motors of less than 2.68 HP (2 kW): the total resistance must be less than 0.002 Ω.*
  For starter motors of greater than 2.68 HP (2 kW): the total resistance must be less than 0.0012 Ω.

ELECTRICAL WIRE SIZES - VOLTAGE DROP

Total current on circuit in amps	Length of conductor from source of current to device and back to source (in feet)																	
	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 v	Wire size (AWG)																		
5	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	4	4	2	2	2	2	2	1	1	1	1
20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
25	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
30	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
40	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
70	6	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0								
80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
90	4	2	2	1	0	2/0	3/0	4/0	4/0										
100	4	2	2	1	0	2/0	3/0	4/0											
24 v																			
5	18	18	18	16	16	14	12	12	12	10	10	10	10	10	8	8	8	8	8
10	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
15	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
20	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
25	12	12	10	10	8	6	6	6	4	4	4	4	2	2	2	2	2	2	1
30	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
40	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
70	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	4/0	4/0
80	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
90	8	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	
100	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				

CONVERSION OF AWG TO EUROPEAN STANDARDS

Conductor size (AWG)	Conductor diameter (mm)	Conductor cross-sectional area (mm^2)
25	0.455	0.163
24	0.511	0.205
23	0.573	0.259
22	0.644	0.325
21	0.723	0.412
20	0.812	0.519
19	0.992	0.653
18	1.024	0.823
17	1.15	1.04
16	1.29	1.31
15	1.45	1.65
14	1.63	2.08
13	1.83	2.63
12	2.05	3.31
11	2.30	4.15
10	2.59	5.27
9	2.91	6.62
8	3.26	8.35
7	3.67	10.6
6	4.11	13.3
5	4.62	16.8
4	5.19	21.2
3	5.83	26.7
2	6.54	33.6
1	7.35	42.4
0 (1/0)	8.25	53.4
00 (2/0)	9.27	67.5
000(3/0)	10.40	85.0
0000 (4/0)	11.68	107.2
00000 (5/0)	13.12	135.1
000000 (6/0)	14.73	170.3
1.1 circular mil (CM) ≈ 0.0005067 mm^2		

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Section 15

FAILURE DIAGNOSIS

Page

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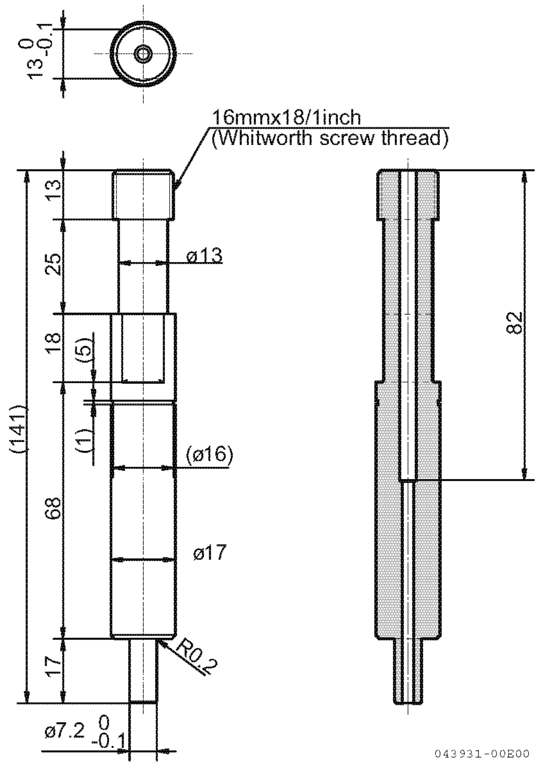
SPECIAL SERVICE TOOLS

Compression gauge	For measuring compression pressure YANMAR Part No.129A00-92950 For detailed dimensions, *refer to Compression gauge adapter (129A00-92950) on page 6-21.*	

TROUBLESHOOTING BY MEASURING COMPRESSION PRESSURE

Decrease in compression pressure is one of the major causes of increased blow-by gas (results in contamination and increased consumption of lubricating oil) and starting problems. The compression pressure is affected by the following factors:

- Size of clearance between the piston and cylinder
- Size of clearance of intake/exhaust valve seats
- Gas leakage from nozzle gasket or cylinder head gasket

The pressure will decrease due to increased parts wear. Pressure decrease reduces the durability of the engine.

Pressure decrease may also be caused by damage to cylinders and pistons. This can occur due to dust entering and wearing the piston rings caused by contamination of the air cleaner element. Measure the compression pressure to determine the condition of the engine.

Compression Pressure Inspection Procedures

1. Warm up the engine.
2. Stop the engine and close the valves of the fuel system.
3. Remove injector harnesses (couplers) (1, **Figure 15-1**) from all cylinders.
4. Remove the fuel return hose (2, **Figure 15-1**) from the injectors. *(See Removal of Injector on page 7-9.)*
5. Remove the high-pressure fuel injection lines (injector to common rail) as an assembly.
6. Loosen the retainer mounting bolts that fix the injector, and remove the retainer.
7. Remove the injector and injector seat (gasket). When removing the injectors, mark the cylinder No.
8. Connect all injectors and rail with a high-pressure pipe in the direction that will not affect the inspection work.
9. Attach the injector harnesses (couplers) to the injectors.
10. Connect the diagnosis tool, SMARTASSIST-DIRECT (SA-D) with the engine key switch in "ON" position, and cut the fuel injection to all cylinders using "Active Control" function.
    For details, see P91 on SMARTASSIST-DIRECT operation manual.
11. Install the specified gauge adapter along with a gasket (129978-11871) at the cylinder to be measured. Fix with a retainer.

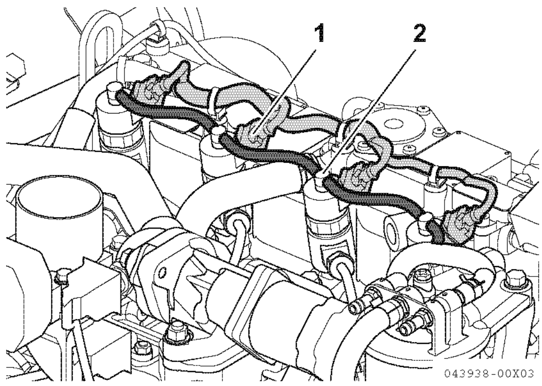


Figure 15-1

12. Attach a compression gauge to the adapter.
13. Crank the engine until the compression gauge reading is stabilized, and measure the compression pressure. (**Figure 15-2**)

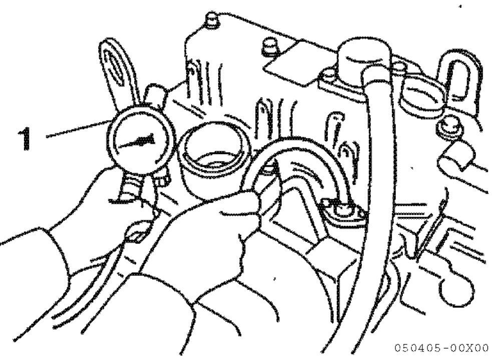


Figure 15-2

14. After checking the compression pressure, turn off the SMARTASSIST-DIRECT active control, communication, and engine key switch.
15. Remove the compression gauge, specified adapter, and injector gasket.

Attaching the Injector

1. Remove the injector from the injector and the high-pressure fuel pipe set next to the engine, and insert to the correct cylinder. Replace the injector gasket to new.
2. Remove the high-pressure fuel pipe from the rail, replace it to new, and connect the rail and injector.
3. Install the fuel return hose and injector harnesses (couplers). For details, *see Reassembly of injector on page 7-10*.
4. Open valves of fuel system.
5. Start the engine and check for fuel leaks.

Standard Compression Pressure (Reference Value)

Engine model	Compression pressure at 250 min^{-1}		Deviation between cylinders
	Standard	Limit	
3TNV88C 3TNV86CT 4TNV88C 4TNV86CT 4TNV98C 4TNV98CT	3.14 - 3.34 MPa (32 - 34 kgf/cm^2)	2.45 - 2.65 MPa (25 - 27 kgf/cm^2)	0.2 - 0.3 MPa (2 - 3 kgf/cm^2)

Engine Speed And Compression Pressure (Use For Reference)

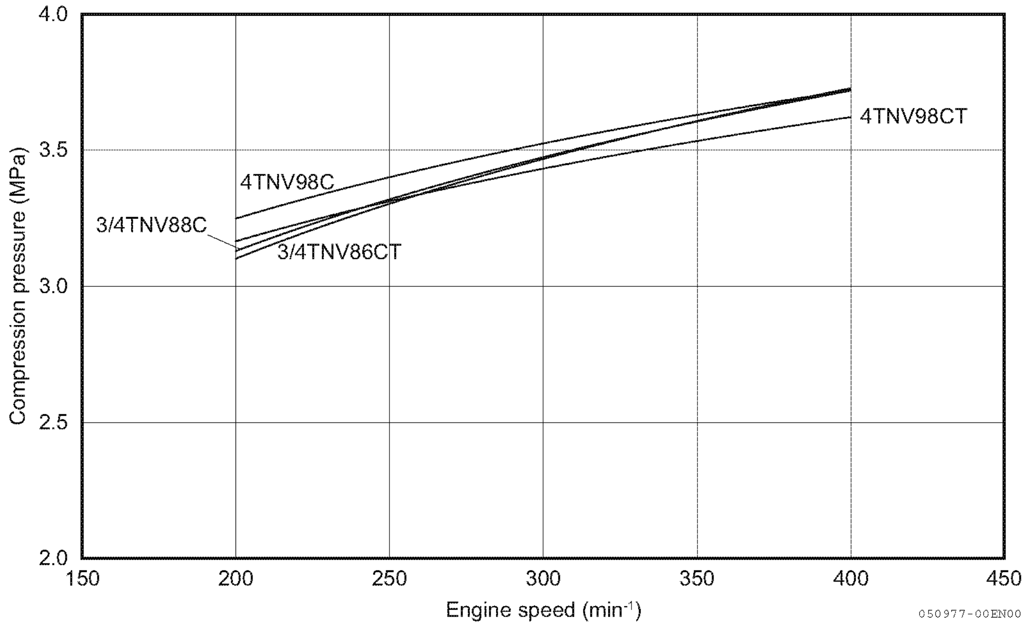


Figure 15-3

MEASURED VALUE AND TROUBLESHOOTING

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective action
1	Air cleaner element	Clogged element	Clean the element.
		Broken element	Replace the element.
		Defect at element seal portion	
2	Valve clearance	Excessive or no clearance	Adjust the valve clearance.
3	Valve timing	Incorrect valve clearance	Adjust the valve clearance.
4	Cylinder head gasket	Gas leak from gasket	Replace the gasket.
			Retighten the cylinder head bolts to the specified torque.
5	Intake/exhaust valve	Sticking valve	Replace the intake/exhaust valve.
	Valve seat	Gas leak due to worn valve seat or foreign matter trapped in valve	Lap the valve seat.
6	Piston	Gas leak due to scratching or wear	Perform honing and use an oversized part.
	Piston ring		
	Cylinder		

QUICK REFERENCE TABLE FOR TROUBLESHOOTING

The following table summarizes the general trouble symptoms and their causes. If any trouble symptom occurs, take corrective action before it becomes a serious problem so as not to shorten the engine service life.

For details of troubleshooting on electronic control (ECU), refer to the SA-D section in Tier 4 Troubleshooting Manual.

Failure Diagnostic List

	Symptoms and conditions of failures	Defective start					Engine stall after start			Defective rotation control						Insufficient engine output			Noise/vibration				Lubricant				Cooling water		Intake		Exhaust				Fuel			Electrics/electronics					Action	Referenced page number
		Starter not rotate		Starter rotates			Exhaust fume				Without load				At work	Exhaust color															At work													
	Cause	ECU indicator lamp not on just after key-on	ECU indicator lamp on just after key-on (2 seconds)	Engine not start (not even initial combustion)	Engine not start (stall after serial combustion)	Engine starts later then ever	None	Little	Much	Speed change by accelerator not available (constant speed)	Specified speed setting not available	Poor acceleration	Return to low speed not smooth	Hunting	Hunting	Normal	White	Black	Knocking noise at combustion too high	Combustion noise uneven	Noise other than combustion from engine	Engine vibration too big	Lubricant consumption too much	Lubricant diluted with fuel	Lubricant mixed with water	Oil pressure too low (oil pressure lamp on)	Overheated (water temperature lamp on)	Water temperature too low	Pressure down (air cleaner lamp on)	Pressure up	White exhaust color	Black exhaust color	Blow-by too much	Exhaust temperature up	Fuel consumption too much	Fuel mixed with water (oil-water separator lamp on)	Fuel filter contaminated too early	Battery charge defect (charge lamp on)	ECU indicator lamp flashing	ECU indicator lamp not on just after key-on (2 seconds)	Prescribed ECU control function not operate	Fuse meltdown, disconnection (repeated)	Action	Referenced page number
Engine system	Intake/exhaust valve clearance incorrect			○			○									○					○								○					○									Valve clearance adjustment	*See Measuring and Adjusting Valve Clearance on page 6-39*
	Compression failure at valve seat			○												○		○			○								○			○	○	○	○								Valve seat facing	*See Valve face and valve seat on page 6-33.*
	Intake/exhaust valve seizure			○					○						○	○		○			○	○		○					○			○	○										Correction or replacement of intake/exhaust valve	*See Removal of Intake/exhaust Valves on page 6-30.*
	Cylinder head gasket blow-out															○									○		○																Gasket replacement	*See Removal of Cylinder Head on page 6-29.*
	Piston ring sticking or breakage			○					○					○			○				○	○	○	○			○				○		○	○									Piston ring replacement	*See Reassembly of pistons on page 6-57.*
	Wear of piston ring, piston or cylinder			○					○								○						○	○							○		○										Horning work and usage of over-sized parts	*See Honing and Boring on page 6-56.*
	Seizure of crank pin metal or bearing parts			○			○							○	○						○	○											○										Repair or replacement	*See Inspection of crankshaft on page 6-54.*
	Closed gap position fault of piston ring						○										○						○										○										Correction of closed gap position	*See Reassembly of pistons on page 6-57.*
	Reverse assembling of piston ring																○						○								○		○										Correction of assembling	*See Reassembly of pistons on page 6-57.*
	Wear of crank pin metal and journal metal													○	○	○					○	○				○																	Measurement and replacement	*See Inspection of crankshaft on page 6-54.*
	Connecting rod bolt loose																				○	○				○																	Tightening at specified torque	*See Torque for Bolts and Nuts on page 6-16.*
	Foreign material entered into combustion chamber			○																	○		○										○										Disassembling and repair	*See Disassembly of Engine on page 6-42.*
	Gear backlash too big																				○																						Gear mesh adjustment	*See Checking timing gear backlash on page 6-43.*
	Wear of intake/exhaust valve guide																○						○										○										Measurement and replacement	*See Inspection of Valve Guides on page 6-32.*
	Open/close timing failure of intake/exhaust valve			○													○	○			○										○	○											Valve clearance adjustment	*See Measuring and Adjusting Valve Clearance on page 6-39.*
	Engine vibration isolating support loose, damage													○	○						○	○																					Repair or replacement of faulty parts	
Turbocharger	Blower contamination																	○														○		○									Floor cleaning	*See Cleaning Procedure on page 10-12.*
	Operation defect of waste gate																	○														○		○									Disassembling and inspection	*See Waste Gate Valve Test on page 10-10.*
	Wear of radial metal																○						○								○												Disassembling and inspection	*See Radial bearing on page 10-8.*

	Symptoms and conditions of failures / Cause	Defective start					Engine stall after start			Defective rotation control						Insufficient engine output			Noise/vibration				Lubricant				Cooling water		Intake		Exhaust				Fuel			Electrics/electronics					Action	Referenced page number
		Starter not rotate		Starter rotates			Exhaust fume				Without load				At work	Exhaust color															At work													
		ECU indicator lamp not on just after key-on	ECU indicator lamp on just after key-on (2 seconds)	Engine not start (not even initial combustion)	Engine not start (stall after serial combustion)	Engine starts later then ever	None	Little	Much	Speed change by accelerator not available (constant speed)	Specified speed setting not available	Poor acceleration	Return to low speed not smooth	Hunting	Hunting	Normal	White	Black	Knocking noise at combustion too high	Combustion noise uneven	Noise other than combustion from engine	Engine vibration too big	Lubricant consumption too much	Lubricant diluted with fuel	Lubricant mixed with water	Oil pressure too low (oil pressure lamp on)	Overheated (water temperature lamp on)	Water temperature too low	Pressure down (air cleaner lamp on)	Pressure up	White exhaust color	Black exhaust color	Blow-by too much	Exhaust temperature up	Fuel consumption too much	Fuel mixed with water (oil-water separator lamp on)	Fuel filter contaminated too early	Battery charge defect (charge lamp on)	ECU indicator lamp flashing	ECU indicator lamp not on just after key-on (2 seconds)	Prescribed ECU control function not operate	Fuse meltdown, disconnection (repeated)		
Cooling water system	Radiator super cooled																											o			o				o								Thermostat replacement	See Disassembly of Engine Coolant Pump on page 8-7.
	Insufficient radiator cooling																	o									o							o									Thermostat replacement or check for fan belt loose	See Disassembly of Engine Coolant Pump on page 8-7 or Check and adjust cooling fan V-belt on page 5-7.
	Insufficient cooling water quantity																	o									o							o									Water leak inspection of cooling water system	See Engine Coolant System Check on page 8-6.
	Water jacket cracks																								o	o	o																Repair or replacement	See Disassembly of Engine Coolant Pump on page 8-7.
	Fan belt elongation																	o									o							o									Adjustment of belt tension	See Check and adjust cooling fan V-belt on page 5-7.
	Thermostat fault																	o									o	o			o												Inspection or replacement	See Disassembly of Engine Coolant Pump on page 8-7.
Lubricant system	Incorrect lubricant			o			o									o							o			o							o										Usage of correct lubricant	See Engine Lubricating Oil Specifications on page 4-29.
	Lubricant system leakage																						o			o																	Repair	See Disassembly of Oil Pump on page 9-7.
	Insufficient discharge rate of trochoid pump																									o																	Inspection and repair	See Disassembly of Oil Pump on page 9-7.
	Lubricant filter clogged																									o							o										Cleaning or replacement	See Replace engine lubricating oil and oil filter on page 5-16.
	Regulator valve fault																									o																	Cleaning, adjustment or replacement	See Disassembly of Oil Pump on page 9-7.
	Insufficient lubricant quantity						o																			o																	Replenishment of correct lubricant	See Adding Engine Lubricating Oil on page 4-30.
	Excess filling into crankcase																						o			o					o												Engine oil check	See Adding Engine Lubricating Oil on page 4-30.
Fuel system	Incorrect fuel															o	o	o		o											o	o				o	o						Usage of correct fuel	See Diesel Fuel Specifications on page 4-23.
	Water entered into fuel system			o	o				o					o	o		o			o											o					o							Drainage of fuel filter	See Drain water separator on page 5-8.
	Fuel filter clogged			o		o	o					o				o																											Cleaning or replacement	See Replace water separator element on page 5-15.
	Air entered into fuel system			o	o		o							o	o	o																											Bleeding	See Priming the Fuel System on page 4-28.
	Fuel pipe clogged, cracked			o			o									o																											Cleaning or replacement	
	Insufficient fuel feeding to fuel supply pump			o	o		o					o				o																											Check of fuel tank cock, fuel filter, fuel pipe, fuel feed pump	
	Priming not available			o																																							Valve in priming pump pinched dust (disassembled cleaning)	See Fuel System Components on page 7-8.
	Strainer at feed pump inlet clogged					o						o				o																											Cleaning of strainer	
	Sealing defect of fuel tank																																			o	o						Check of fuel tank and cap, as well as installation of genuine parts	

	Symptoms and conditions of failures	Defective start					Engine stall after start			Defective rotation control						Insufficient engine output			Noise/vibration				Lubricant				Cooling water		Intake		Exhaust				Fuel			Electrics/electronics					Action	Referenced page number
		Starter not rotate		Starter rotates			Exhaust fume				Without load				At work	Exhaust color															At work													
	Cause	ECU indicator lamp not on just after key-on	ECU indicator lamp on just after key-on (2 seconds)	Engine not start (not even initial combustion)	Engine not start (stall after serial combustion)	Engine starts later then ever	None	Little	Much	Speed change by accelerator not available (constant speed)	Specified speed setting not available	Poor acceleration	Return to low speed not smooth	Hunting	Hunting	Normal	White	Black	Knocking noise at combustion too high	Combustion noise uneven	Noise other than combustion from engine	Engine vibration too big	Lubricant consumption too much	Lubricant diluted with fuel	Lubricant mixed with water	Oil pressure too low (oil pressure lamp on)	Overheated (water temperature lamp on)	Water temperature too low	Pressure down (air cleaner lamp on)	Pressure up	White exhaust color	Black exhaust color	Blow-by too much	Exhaust temperature up	Fuel consumption too much	Fuel mixed with water (oil-water separator lamp on)	Fuel filter contaminated too early	Battery charge defect (charge lamp on)	ECU indicator lamp flashing	ECU indicator lamp not on just after key-on (2 seconds)	Prescribed ECU control function not operate	Fuse meltdown, disconnection (repeated)		
Intake	Air filter clogged								o			o						o		o			o						o			o		o									Cleaning of air filter	*See Clean air cleaner element on page 5-12.*
Intake	Engine operation at high temperature or high land																	o									o		o			o			o								Consideration of matching output reduction with load	
Intake	Exhaust pipe clogged							o				o						o		o												o		o									Cleaning of exhaust pipe	
Electric system	Fuse meltdown, disconnection	o	o				o																																	o		o	Inspection and replacement of fuse Repair or replacement of harness	For harness inspection method, *see Failure Diagnosis on page 15-1.*
Electric system	Starter fault		o	o																																							Repair or replacement of starter	*See Starter Motor on page 11-8.*
Electric system	Alternator fault			o																																		o					Repair or replacement of alternator	*See Removal of Alternator on page 12-10.*
Electric system	Wiring disconnection	o	o	o			o																															o	o	o	o		Repair or replacement of harness disconnection	
Electric system	Wiring short-circuit (insulator broken), electric power load of added device too big	o																																								o	Inspection, repair or replacement of harnesses Review of added devices	
Electric system	Battery voltage descent		o	o																																		-					Inspection and charging of battery	*See Check battery on page 5-10.*
Electric system	Key switch fault, disconnection	o					o																																	o			Repair or replacement of harness Key switch replacement	For harness inspection method, *see Failure Diagnosis on page 15-1.*
Electric system	Instantaneous interruption of key switch				o		o																																				Key switch replacement	
Electric system	Failure, disconnection, short-circuit of starter relay		o																																								Repair or replacement of harness Replacement of starter relay	For harness inspection method, *see Failure Diagnosis on page 15-1.*
Electric system	Main relay fault (Error other than contact sticking that ECU can't detect)	o																																						o			Repair or replacement of harness Replacement of main relay	For harness inspection method, *see Failure Diagnosis on page 15-1.*
Electric system	Actuator relay fault (Error of contact that ECU can't detect)		o	o			o																																				Replacement of actuator relay	
Electric system	The start assist relay may be faulty. (Error of contact that ECU can't detect)			o		o													o												o												Replacement of start assist relay	
Electric system	Accelerator sensor signal error (Error at which level ECU can't detect)										o			o	o					o																							Repair or replacement of accelerator sensor	Monitor the accelerator sensor by the diagnosis tool.
Electric system	Water temperature sensor signal error (Error at which level ECU can't detect)			o		o								o	o				o																								Replacement of water temperature sensor	Monitor the cooling water temperature by the diagnosis tool.
Electric system	Speed sensor signal error (Cause of noise etc. that ECU can't detect)				o	o	o							o	o					o																							Cleaning or replacement of speed sensor Repair or replacement of fuel supply pump	Monitor the engine rotational speed by the diagnosis tool.
Electric system	Rack position sensor signal error (Level that ECU can't detect)					o	o						o	o	o					o																							Repair or replacement of fuel supply pump	Monitor the rack position sensor signal by the diagnosis tool.
Electric system	Operation defect of rack actuator (Level that ECU can't detect)					o	o						o	o	o					o																							Repair or replacement of fuel supply pump	Check the movement of rack actuator by the diagnosis tool.
Electric system	ECU failure lamp disconnected																																							o			Replace the lamp. Repair or replace the harness.	
Electric system	ECU faulty (ECU self diagnosis failure)	o	o								o																													o	o		Replace the ECU.	

	Symptoms and conditions of failures	Defective start					Engine stall after start			Defective rotation control						Insufficient engine output			Noise/vibration				Lubricant				Cooling water		Intake		Exhaust				Fuel			Electrics/electronics					Action	Referenced page number
		Starter not rotate		Starter rotates			Exhaust fume				Without load				At work	Exhaust color															At work														
	Cause	ECU indicator lamp not on just after key-on	ECU indicator lamp on just after key-on (2 seconds)	Engine not start (not even initial combustion)	Engine not start (stall after serial combustion)	Engine starts later then ever	None	Little	Much	Speed change by accelerator not available (constant speed)	Specified speed setting not available	Poor acceleration	Return to low speed not smooth	Hunting	Hunting	Normal	White	Black	Knocking noise at combustion too high	Combustion noise uneven	Noise other than combustion from engine	Engine vibration too big	Lubricant consumption too much	Lubricant diluted with fuel	Lubricant mixed with water	Oil pressure too low (oil pressure lamp on)	Overheated (water temperature lamp on)	Water temperature too low	Pressure down (air cleaner lamp on)	Pressure up	White exhaust color	Black exhaust color	Blow-by too much	Exhaust temperature up	Fuel consumption too much	Fuel mixed with water (oil-water separator lamp on)	Fuel filter contaminated too early	Battery charge defect (charge lamp on)	ECU indicator lamp flashing	ECU indicator lamp not on just after key-on (2 seconds)	Prescribed ECU control function not operate	Fuse meltdown, disconnection (repeated)		
Engine stop or operation limits by ECU failure diagnosis function	ECU control function operating		O							O	O					O																											Not failure Implement regular usage	Check the causes of engine stop or starter restraint by a diagnosis tool.
	Disconnection/short-circuit of water temperature sensor										O					O																							O				Repair or replacement of harness Replacement of water temperature sensor	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Disconnection/short-circuit of accelerator sensor									O																													O				Repair or replacement of harness Replacement of accelerator sensor	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Speed sensor signal error				O		O																																O				Repair or replacement of harness Repair or replacement of fuel supply pump	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Engine over speed						O																																O				Check operating machine's driving. Check speed sensor signal.	
	CAN communication error									O																													O		O		Repair or replacement of harness ECU Replacement	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Disconnection/short-circuit of EGR valve motor										O					O																							O				Repair or replacement of harness Replacement of EGR valve	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Disconnection/short-circuit of start assist relay			O		O																									O								O				Repair or replacement of harness Relay replacement	For harness inspection method, *see Failure Diagnosis on page 15-1.*
	Main relay "OFF" not available																																				O	O				Relay replacement	
	Malfunction by ECU self-diagnosis		O																																				O				ECU Replacement	

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