YANMAR

SERVICE MANUAL

INDUSTRIAL ENGINES

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

SERVICE MANUAL

INDUSTRIAL ENGINES

TNV Series

SERVICE MANUAL

INDUSTRIAL ENGINE

YPES-MC

YANMAR

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YANMAR CO., LTD.

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.

⚠ WARNING

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.

⚠ 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.

⚠ WARNING

High-Pressure Hazard!

- Avoid skin contact with the high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.
- Never check for a fuel leak with your hands. Always use a piece of wood or cardboard. Have your authorized YANMAR industrial engine dealer or distributor repair the damage.
- Failure to comply could result in death or serious injury.

Section 4

GENERAL SERVICE INFORMATION

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.

Acceleration Sensor (YANMAR Standard)

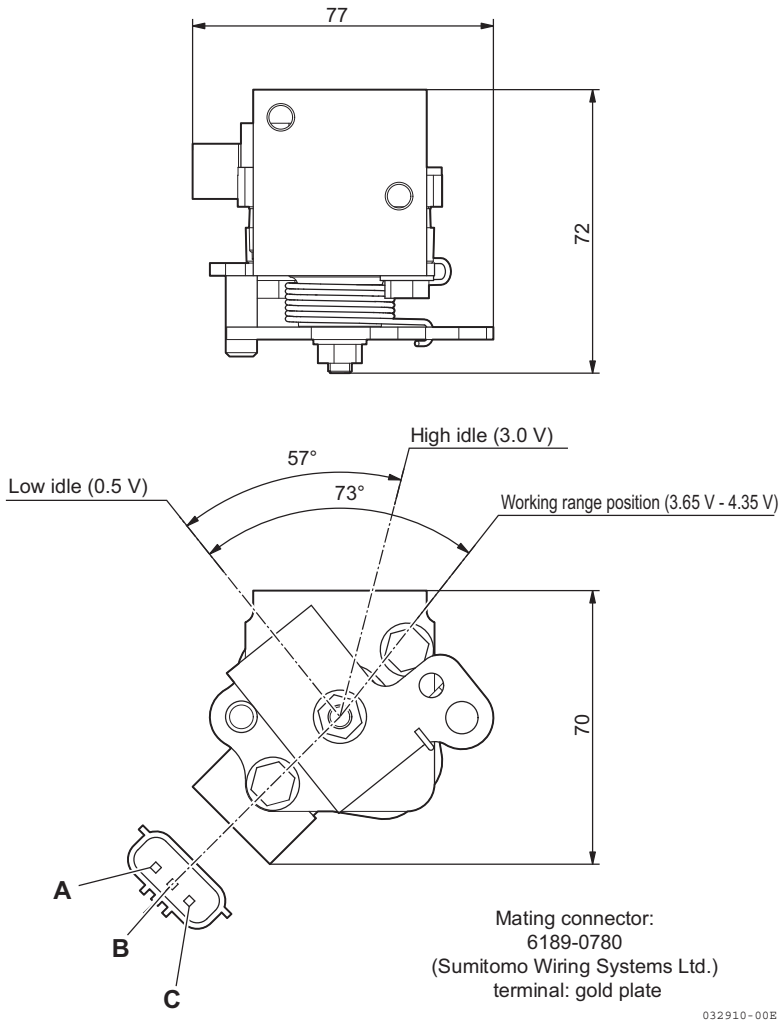


Figure 4-18

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

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

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
cm³	cubic centimeter
cm³/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/cm²	kilogram force per square centimeter
kgf/m	kilogram force per meter
km	kilometers
kPa	kilopascal
kW	kilowatt
L	liter
L/hr	liter per hour
lb	pound
lbf	pound force
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

5. Warm up the engine by running it for five minutes and check for any engine 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 oil **(Figure 5-3, (3))** as needed until the level is between the upper and lower lines shown on the dipstick **(Figure 5-3, (1))**.

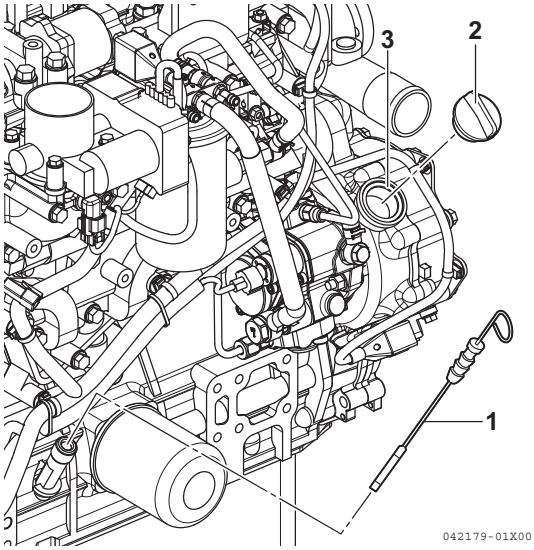


Figure 5-3

9. Reinstall the oil filler cap **(Figure 5-3, (2))**. If any engine oil is spilled, wipe it away with a clean cloth.

■ 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 **(Figure 5-4, (A)**, **(B)** and **(C))**. 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.

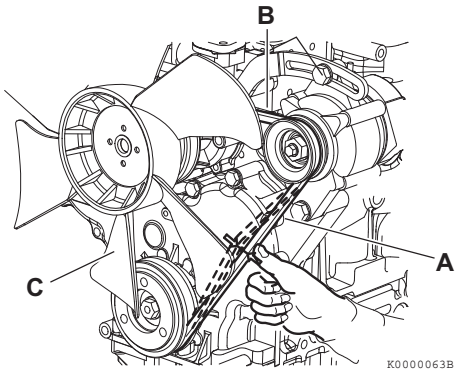


Figure 5-4

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

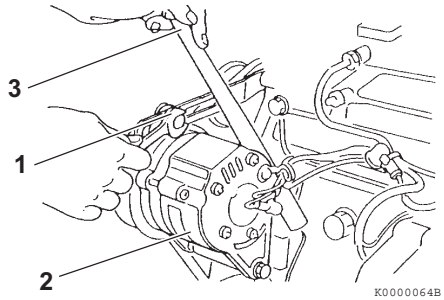


Figure 5-5

13. Open the fuel cock **(Figure 5-14, (3))**.
14. Prime the fuel system. *See Priming the Fuel System on page 4-24.*

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.

Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation.

- **Drain, flush and refill cooling system with new coolant**
- **Adjust intake/exhaust valve clearance**

■ Drain, flush and refill cooling system with new 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.**

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 6-33.*
		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 6-33.*
		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 6-36.*
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 6-36*

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 6-52.*
	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			

CYLINDER HEAD

Cylinder Head Components

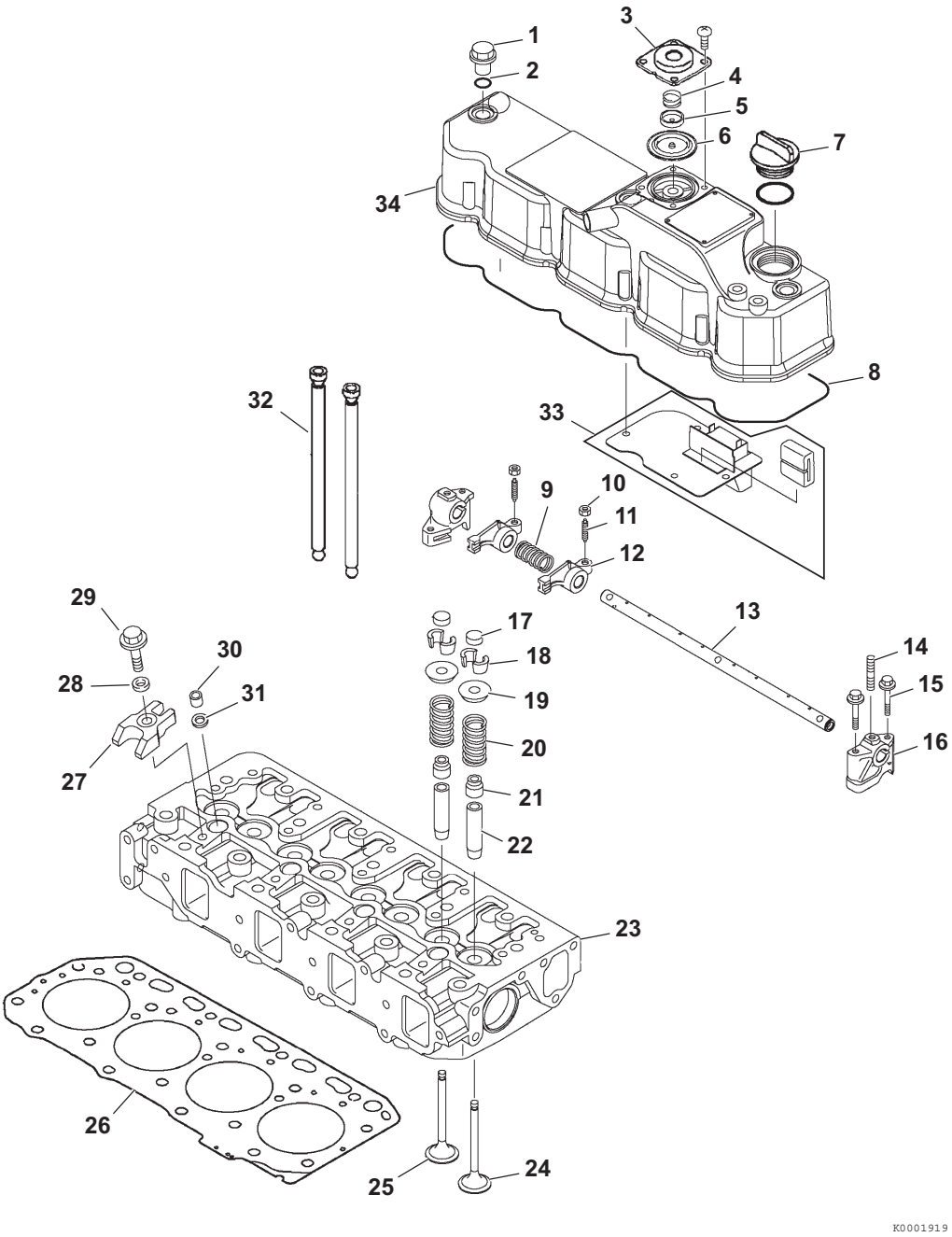


Figure 6-1

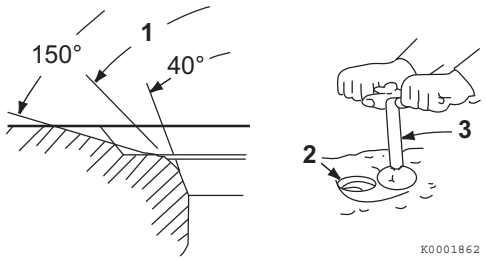


Figure 6-24

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 **(Figure 6-24, (1))** 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 6-25)**. *See Valve Spring on page 6-6 for the service limit.*

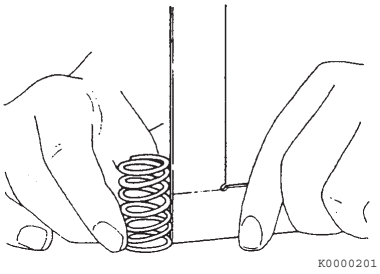


Figure 6-25

Free length

Use a caliper to measure the length of the spring **(Figure 6-26)**. *See Valve Spring on page 6-6 for the service limit.*

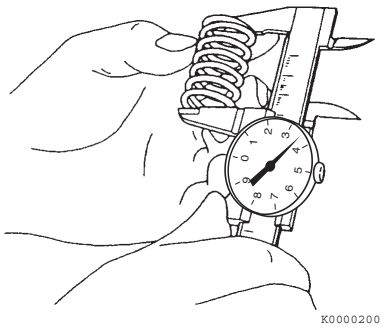


Figure 6-26

■ Measuring idler gear-to-crankshaft gear backlash

1. Install a dial indicator as shown in **Figure 6-44**.

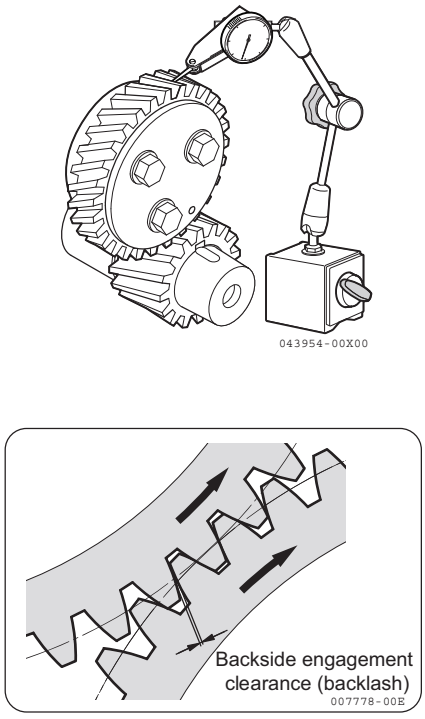


Figure 6-44

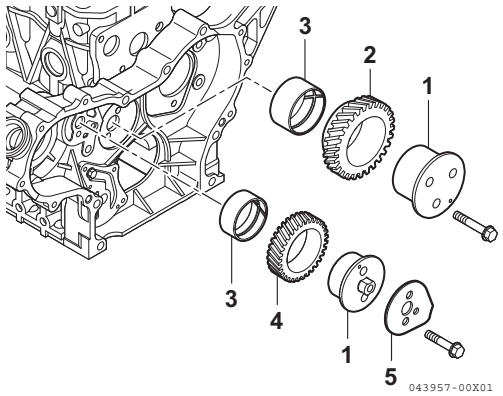
2. Rotate the idler gear back and forth to check the idler gear-to-crankshaft gear backlash. The total indicator reading is the backlash. Record the measurement.

■ 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 **(Figure 6-45, (1))**. Remove the idler gear shaft, idler gear **(Figure 6-45, (2))** and bushing **(Figure 6-45, (3)).**



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

Figure 6-45

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 6-46.*
4. Remove the pump drive gear using a gear puller.

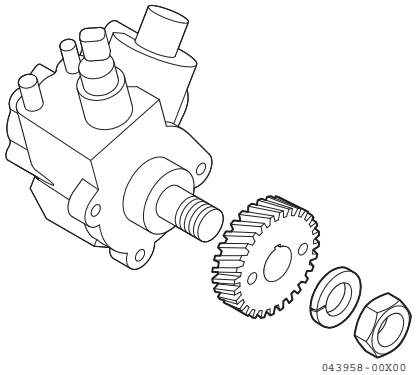


Figure 6-46

■ Inspection of tappets

1. Inspect the tappet contact surfaces for abnormal wear **(Figure 6-74, (1))**. Normal wear will be even as shown in **(Figure 6-74, (2)).** Slight surface defects can be corrected using an oilstone.

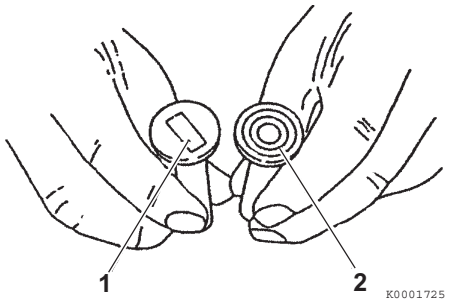


Figure 6-74

2. Measure the outside diameter of the tappet stem **(Figure 6-75, (1))**. *See Tappet on page 6-14 for the service limit.*

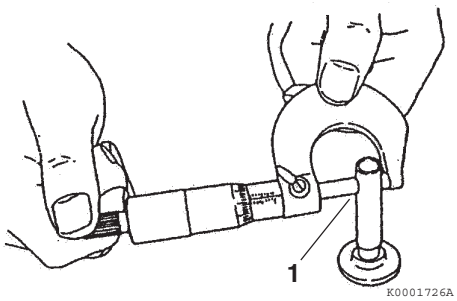


Figure 6-75

3. Measure the tappet bores in the cylinder block. *See Tappet on page 6-14 for the service limit.*

■ Inspection of crankshaft

1. Place the crankshaft end journals **(Figure 6-76, (4))** on V-blocks.
2. Place a dial indicator **(Figure 6-76, (3))** on a center main bearing surface.

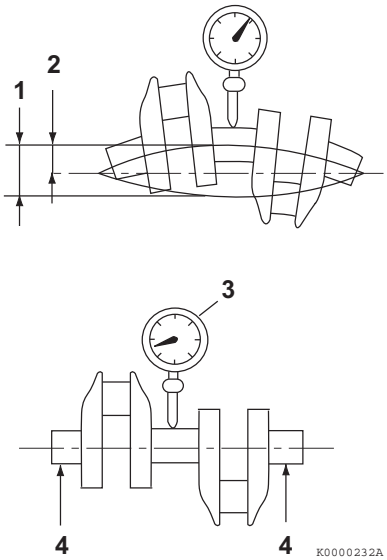
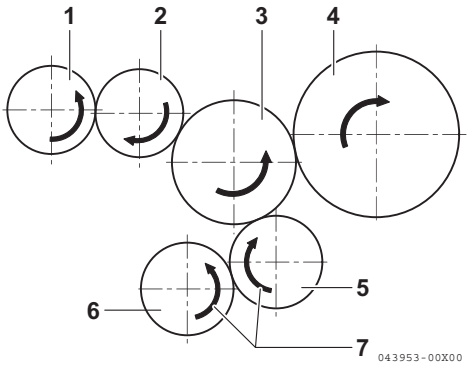


Figure 6-76

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 **(Figure 6-77, (2))** and main bearing journal **(Figure 6-77, (1))**. *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.

■ Installation of timing gears

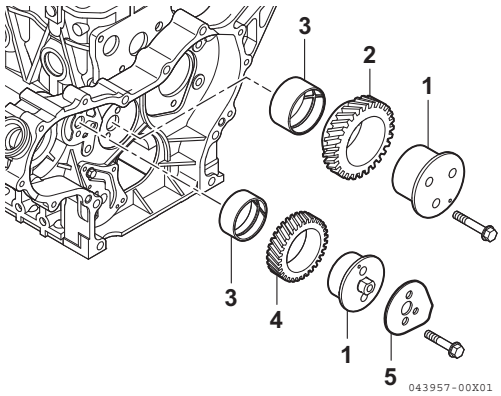
1. Set the No. 1 piston to top dead center.
2. Rotate the camshaft until the mark **(Figure 6-99, (C))** is approximately at the 9 o'clock position**.**



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

Figure 6-99

3. Lubricate the idler gear **(Figure 6-100, (2))**, bushing **(Figure 6-100, (3))** and idler gear shaft **(Figure 6-100, (1))** with clean engine oil.



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

Figure 6-100

4. Align the timing gears as shown in **(Figure 6-99)**.
5. Reinstall the idler gear and idler gear shaft. Be sure the oil hole in the bushing is facing toward the top of the engine.
6. Ensure all three timing marks on idle gear A and two timing marks on idle gear B **(Figure 6-99, (A, B, C))** are aligned**.**
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 **(Figure 6-101, (1))**. Be sure to circle the bolt holes.
2. Reinstall and tighten the gear case cover bolts.

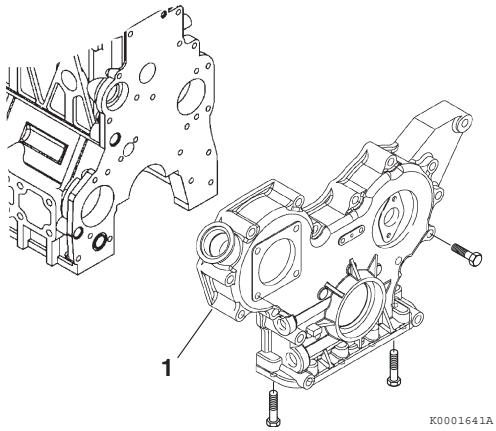


Figure 6-101

3. Reinstall the crankshaft pulley.

NOTICE

Use the crankshaft pulley installation tool **(Figure 6-102, (3))** when reinstalling the pulley **(Figure 6-102, (1))**. The tool will guide the pulley hub and protect the front seal ***(Figure 6-102,*** **(2))** from damage.

■ 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.

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

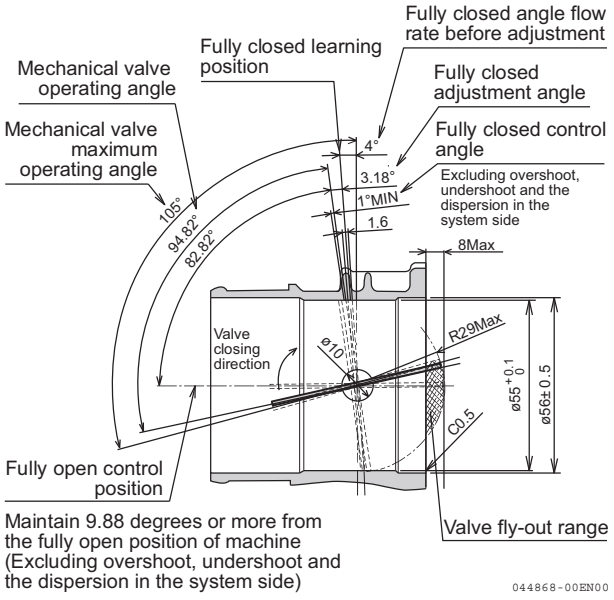


Figure 6-111

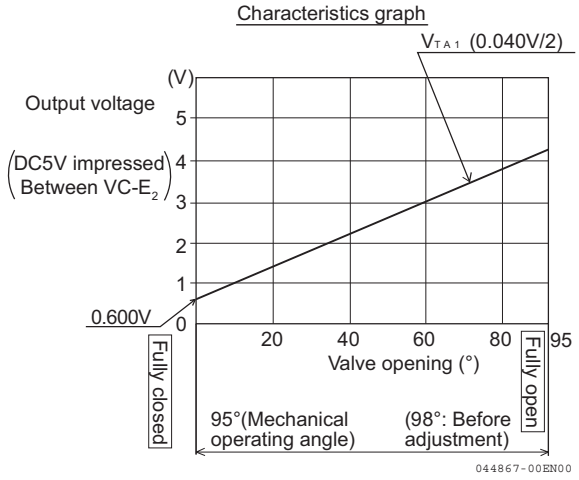


Figure 6-112

2- Press the pipe against the bearing surface by hand and loosen the cap nut while holding the pipe using a tool.

3- While pressing and holding the pipe 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 injector with an aspirator or the like and cover them with a vinyl bag.

6. Removal of high-pressure pipe (2) (Supply pump - common rail)

1- Clean around the cap nuts on both the pump and rail sides, using a brush or aspirator.

2- Press the pipe against the bearing surface by hand and loosen the cap nut while holding the pipe using a tool.

3- While pressing and holding the pipe 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.

7. Removal of common rail
Remove the 2 pieces of M8 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	22.6 - 28.4 N·m (2.3 - 2.9 kgf·m)

2. Reassembly of high-pressure pipe (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 leaks.

1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.

2- Temporarily tighten the cap nuts (both the injector and rail sides) while pressing and fixing the seat portions.

3- Tighten the cap nuts to specification.

Tightening torque for cap nut (injector side)	26.5 - 31.4 N·m (2.7 - 3.2 kgf·m)
Tightening torque for cap nut (rail side)	29.4 - 34.3 N·m (3.0 - 3.5 kgf·m)

3. Reassembly of high-pressure pipe (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 leaks.

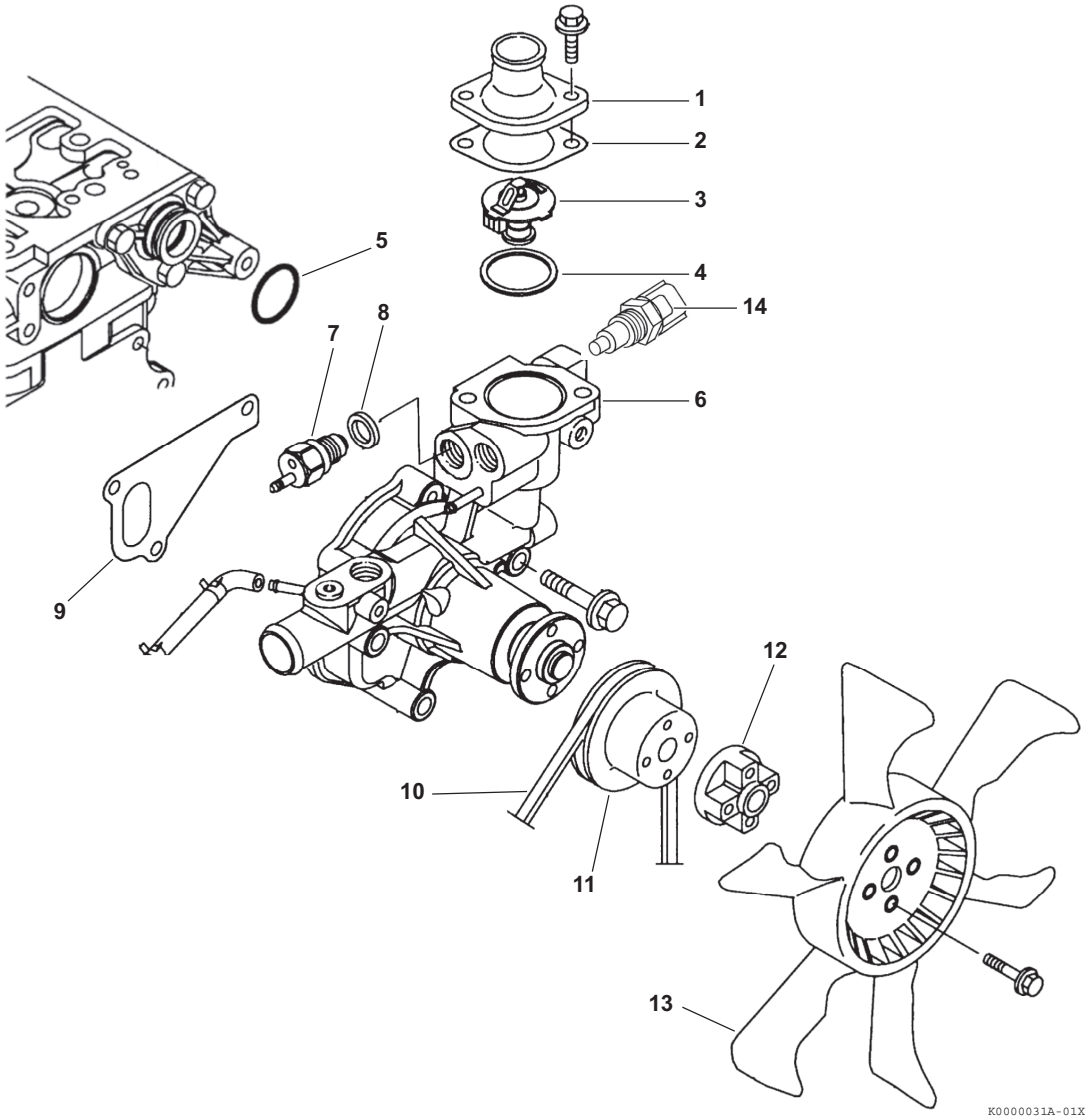
1- Before reinstalling the high-pressure pipe, apply fuel to the cap nut thread portion.

2- Temporarily tighten the cap nuts (both the pump and rail sides) while pressing and fixing the seat portions.

3- Tighten the cap nuts to specification.

Tightening torque for cap nut (rail side)	29.4 - 34.3 N·m (3.0 - 3.5 kgf·m)
Tightening torque for cap nut (pump side)	29.4 - 34.3 N·m (3.0 - 3.5 kgf·m)

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

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*.

■ Check rotor shaft clearance

Determine the rotor shaft clearance. Measure the outside diameter of the rotor shaft **(Figure 9-17, (1))** and the bore diameter in the gear case housing **(Figure 9-17, (2))**.

Calculate the difference between the two measurements to determine the clearance.

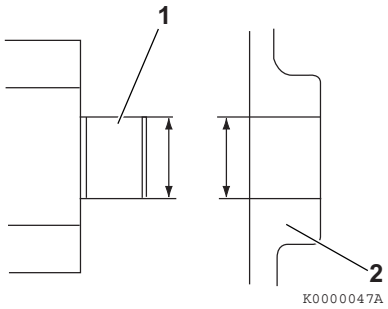


Figure 9-17

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 **(Figure 9-18, (1))** on the end of the outer rotor must face away from the gear case housing **(Figure 9-18, (2))**.

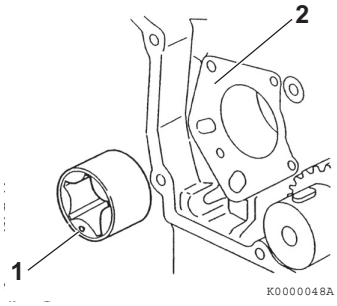


Figure 9-18

3. Reinstall the oil pump assembly **(Figure 9-19, (1))** into the gear case housing **(Figure 9-19, 2)**. Tighten the bolts to specified torque.

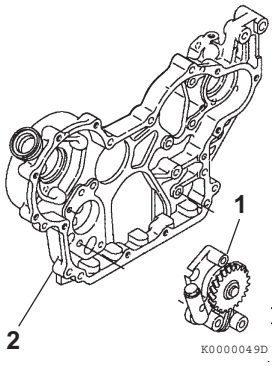


Figure 9-19

4. Reinstall the gear case cover and crankshaft pulley. *See Installation of gear case cover on page 6-65.*
5. Reinstall the engine coolant pump V-pulley **(Figure 9-20, (1))**, spacer **(Figure 9-20, (2))**, engine cooling fan **(Figure 9-20, (3))** and engine cooling fan guard (if equipped).

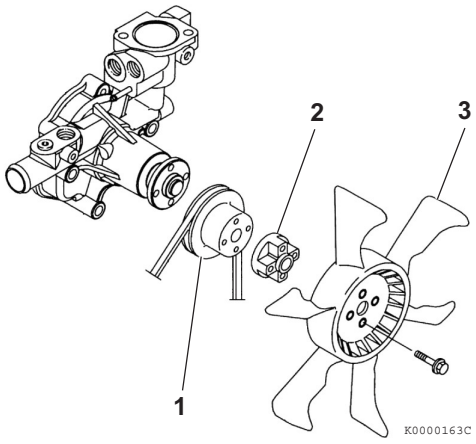


Figure 9-20

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 5-9*.

Theory of Operation

Normally aspirated engines produce horsepower that is limited by the atmospheric pressure of the induction air. The turbocharger is an exhaust gas pressure driven device that adds to the atmospheric pressure, resulting in a boost in pressure at the combustion chambers. This substantially increases the amount of fuel that can be injected into the combustion chambers, while maintaining the proper fuel-to-air ratio. A slight parasitic loss is imposed on the engine because of added back pressure in the exhaust system. That loss is offset by horsepower gains. The net result is substantially increased overall horsepower over normally aspirated engines.

The turbocharger consists of two main components:

- Turbine
- Compressor

■ 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

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.

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.

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.

Waste Gate Modulation

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.

■ Waste gate control

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.

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)

Reassembly of Starter Motor

1. Apply the appropriate starter bendix grease (obtain locally) to the pinion shaft. Reassemble the pinion shaft **(Figure 11-27, (5))**, pinion clutch assembly **(Figure 11-27, (1))**, return spring **(Figure 11-27, (4))** and pinion stop **(Figure 11-27, (3))**. Reinstall the retaining ring **(Figure 11-27, (2))** in the groove in the pinion shaft. Slide the piston stop over the retaining ring.

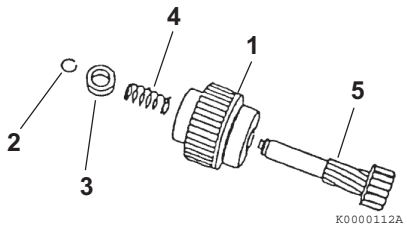


Figure 11-27

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 **(Figure 11-28, (1))**. Reassemble the torsion spring **(Figure 11-28, (2))**, shift lever and dust cover(s) **(Figure 11-28, (3))**, plunger **(Figure 11-28, 4)** and magnetic switch assembly **(Figure 11-28, (5))**.

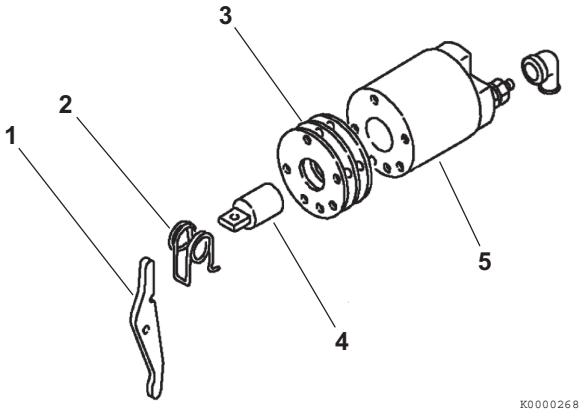


Figure 11-28

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)**.

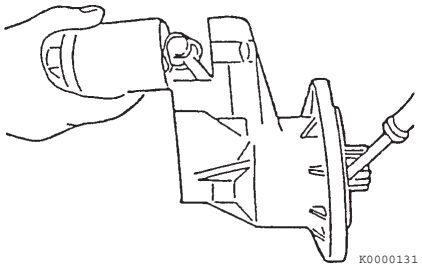
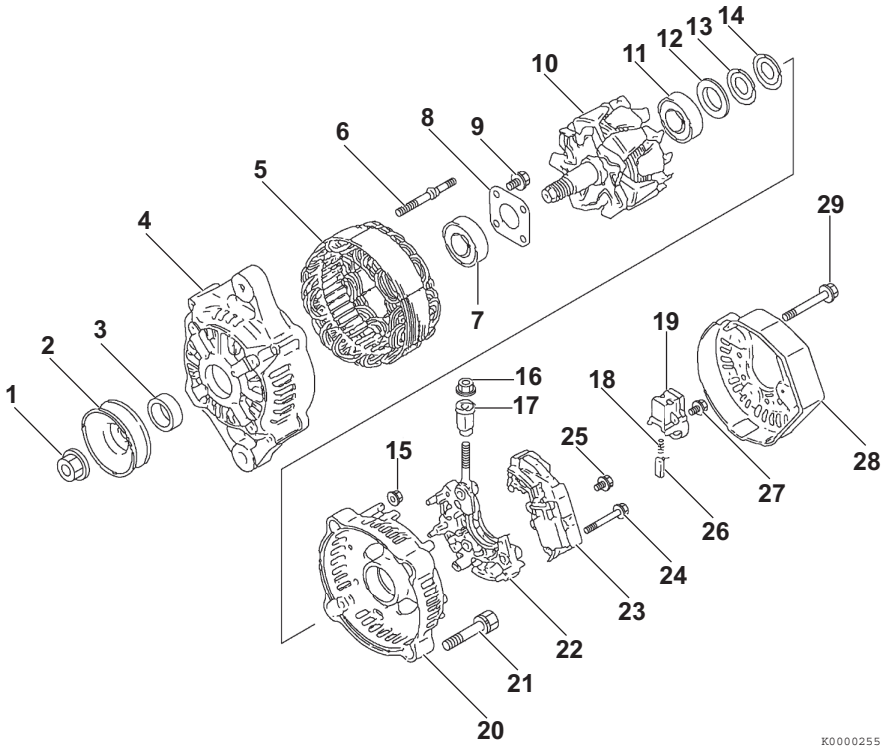


Figure 11-29

6. Secure the magnetic switch assembly to the gear housing using the two M6 bolts.

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

DYNAMO STANDARD OUTPUT

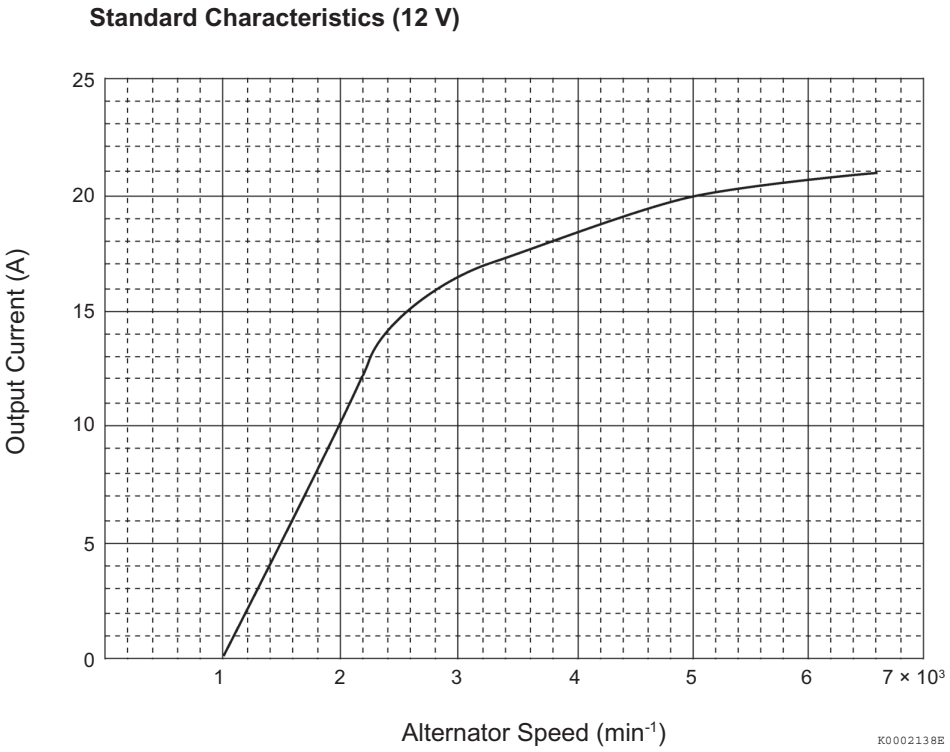


Figure 12-22

■ Outline of Diesel Particulate Filter (DPF)

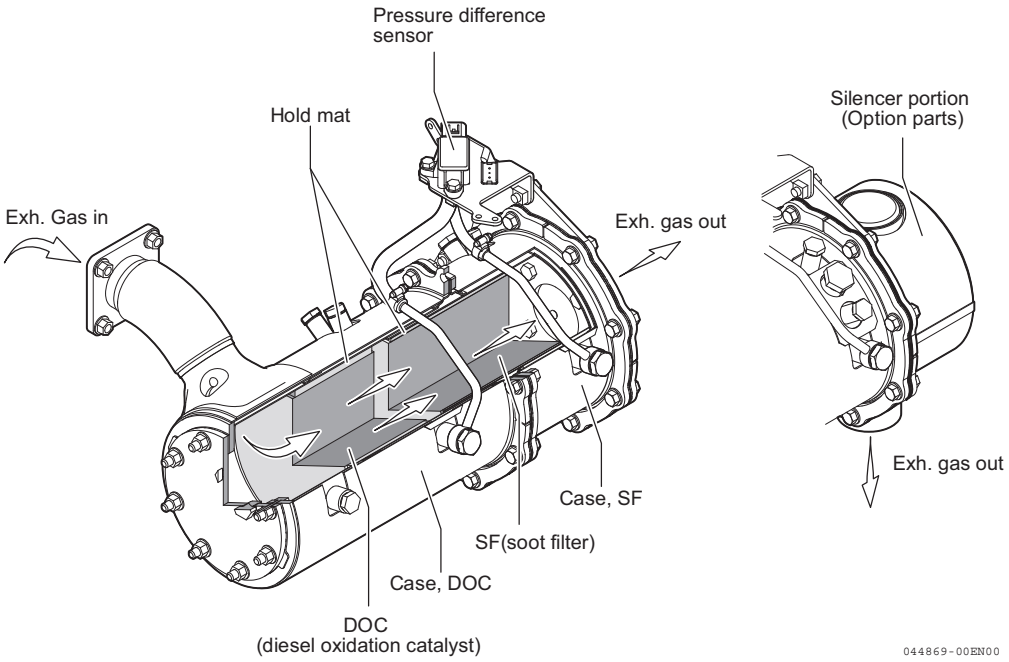


Figure 13-2

■ DPF service

DOC: Maintenance-free parts
Replacement only, every 9000 hrs of operation

SF: Maintenance is required parts
Perform the cleaning every 3000 hrs of operation

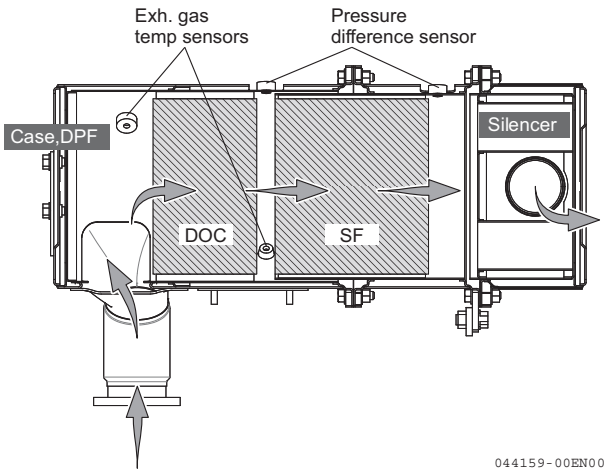


Figure 13-3

Item	Engine type	Emission warranty (Useful life)	Periodic maintenance interval	
			Replacement	Clean
DOC	19 - 37 kW	5000 hrs or 7 years, whichever comes first.	Every 9000 hrs of operation	N/A
	³ 37 kW	8000 hrs or 10 years, whichever comes first		
SF	19 - 37 kW	5000 hrs or 7 years, whichever comes first	Every 9000 hrs of operation	Every 3000 hrs of operation
	³ 37 kW	8000 hrs or 10 years, whichever comes first		

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.