

SERVICE MANUAL



MITSUBISHI DIESEL ENGINE D04FR-TAA

for KOBELCO CONSTRUCTION MACHINERY CO.,LTD.

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INTRODUCTION

This service manual describes the specifications, maintenance and service procedures for Mitsubishi diesel engines.

To maintain the performance of the engine for many years and to ensure safe operation, it is important to use the engine correctly and conduct regular inspection and maintenance, and also to take necessary measures which involves the disassembly, inspection, repair and reassembly of the engine and engine parts.

Read this manual carefully and understand the work procedures fully before disassembling, inspecting, repairing or reassembling the engine.

The contents of the manual are based on the engine models that are being produced at the time of publication. Due to improvements made thereafter, the actual engine that you work on may differ partially from the one described in this manual.

How to use this manual

This service manual consists of several Groups, which are arranged so as to allow you to make reference quickly to specifications, maintenance standards, adjustment procedures and service procedures including methods for disassembly, inspection, repair and reassembly of the Mitsubishi Diesel Engine (standard model for land use).

A short summary describing the content of each Group is given in the General Contents page, and there is also a detailed table of contents at the beginning of each Group.

Regarding the procedures for operation and periodical maintenance of the engine, refer to the Operation and Maintenance Manual. For information on the engine components and ordering of service parts, refer to the Parts Catalogue. Structure and function of the engine are described in the relevant training manuals.

Methods of presentation

- (1) Index numbers allotted to parts in exploded views are not only a call-out of part names listed in the text but also an indication of the sequence of disassembly.
- (2) Inspections to be conducted during disassembly process are indicated in boxes in the relevant exploded views.
- (3) Maintenance standards required for inspection and repair works are indicated in the appropriate positions in the text. They are also collectively indicated in Group 2, the General Contents group.
- (4) Fasteners to be tightened in “wet” condition, or with engine oil applied, are identified by [Wet] placed after tightening torque values. If no such indication is suffixed, the fastener should be tightened in “dry” condition, or without lubricating with engine oil.
- (5) In this manual, important safety or other cautionary instructions are emphasized with the following marks headed.

DANGER

Indicates an immediately hazardous situation which, if not avoided, will result in death or serious injury.

WARNING

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

CAUTION

Indicates an immediately hazardous situation which, if not avoided, may result in minor or moderate injury.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, can result in property damage.

Note:

Emphasizes important matter, or indicates information useful for operation or maintenance of the engine.

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Terms used in this manual

Nominal

means the rated (design) size or magnitude of a part to be measured.

Standard

means the quantitative requirement for dimension of a part, clearance between parts and performance. This is given in a form of tolerance. Therefore, the values shown are not in agreement with the design values.

Limit

means that, if this value is reached, the part must be repaired or replaced with a new part.

Abbreviations

- BTDC: Before Top Dead Center
- ATDC: After Top Dead Center
- BBDC: Before Bottom Dead Center
- ABDC: After Bottom Dead Center
- TIR: Total Indicated Runout
- API: American Petroleum Institute
- ASTM: American Society for Testing and Materials
- JIS: Japanese Industrial Standards
- LLC: Long Life Coolant
- MIL: Military Specifications and Standards (U.S.A)
- MSDS: Material Safety Data Sheet
- SAE: Society of Automotive Engineers (U.S.A)

Units of measurement

Measurements are based on the International System of Units (SI), and their converted metric values are indicated in parentheses { }. For metric conversion, the following rates are used.

- Pressure: 1 MPa = 10.197 kgf/cm²
- Torque: 1 N·m = 0.10197 kgf·m
- Force: 1 N = 0.10197 kgf
- Horsepower: 1 kW = 1.341 HP = 1.3596 PS
- Meter of mercury: 1 kPa = 0.7 cmHg
- Meter of water: 1 kPa = 10.197 cmH₂O (cmAq)
- Rotational speed: 1 min⁻¹ = 1 rpm

Safety Cautions

⚠ WARNING

Fire and explosion

Keep flames away

Store fuel and engine oil in a well ventilated designated area.

Make sure that the caps of fuel and engine oil containers are tightly closed.



Do not use flames, do not smoke, and do not work near a heater or other fire hazard where fuel or oil is handled or when cleaning solvent is being used for washing parts.

Wipe off spilled fuel, oil and LLC immediately and thoroughly. Spilled fuel, oil and LLC may ignite and cause a fire.

Keep surrounding area tidy and clean

Do not leave combustible or explosive materials, such as fuel, engine oil and LLC, near the engine. Such substances can cause fire or explosion.

Remove dust, dirt and other foreign materials accumulated on the engine and surrounding parts thoroughly. Such materials can cause fire or the engine to overheat. In particular, clean the top surface of the battery thoroughly. Dust can cause a short-circuit.

Always operate the engine at a position at least 1 m [3.28 ft.] away from buildings and other equipment to prevent possible fire caused by engine heat.

Care about fuel, oil and exhaust gas leakage

If any fuel, oil or exhaust gas leakage is found, immediately take corrective measures to stop it.

Such leakages, if left uncorrected, can cause fuel or engine oil to reach hot engine surfaces or hot exhaust gas to contact flammable materials, possibly leading to personal injury and/or damage to equipment.

Use explosion-proof lighting apparatus

When inspecting fuel, engine oil, coolant, battery electrolyte, etc., use a flameproof light. An ordinary light, if accidentally broken, may ignite and cause an explosion.

Prevent electrical wires from short-circuiting

Avoid inspecting or servicing the electrical system with the ground cable connected to the battery. Otherwise, a fire could result from short-circuiting. Be sure to disconnect the battery cable from the negative (-) terminal before beginning with the work procedure.

Short-circuits, possibly resulting in fire, may be caused by a loose terminal or damaged cable/wire. Inspect the terminals, cables and wires, and repair or replace the faulty parts before beginning with the service procedure.

Keep fire extinguishers and first-aid kit handy

Keep fire extinguishers handy, and become familiar with their usage.

Keep a first-aid kit at the designated place where it is easily accessible by anyone at any time.

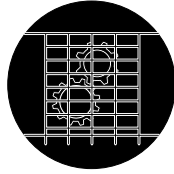


Establish response procedures to follow in the event of fire or accident. Provide an emergency evacuation route, contact points, and means of communication in case of emergency.

Stay clear of all rotating and moving parts

Install protective covers on rotating parts

Make sure the protective covers for engine rotating parts are properly installed as intended. Repair loose or damaged protective covers as necessary.



Never remove the covers guarding personnel from rotating parts, when the engine is operating.

When combining the engine with the engine-driven machine or radiator, always provide a cover on every exposed moving part such as driving belt and coupling. Never remove protective covers.

Ensure safety of neighboring people before starting engine

Before starting the engine, ensure that there is nobody in the neighborhood and that no tools are left on or near the engine. Verbally notify people around the engine or in the work area when starting the engine.

When the starter device is posted with a sign that prohibits startup operation, do not operate the engine.

Stay clear of moving parts during engine running

Do not approach rotating or sliding parts of the engine when the engine is in operation.

Keep objects likely to be caught by rotating parts away from such parts. If any part of the clothing or outfitting is caught by a rotating part, serious bodily injuries could result.



Lockout and Tagout

Be sure to lockout and tagout before starting inspection and maintenance.

Lockout and tagout are effective methods of cutting off machines and equipment from energy sources.

To accomplish the lockout/tagout, remove the starter switch key, set the battery switch to OFF and attach a "Do Not Run" or similar caution tag to the starter switch. The starter switch key must be kept by the person who performs inspection and maintenance during the work. In the case of pneumatic starting type, close the main valve of the air tank and post a tag saying "Do Not Open the Valve" or the like.

Keep engine stopped during servicing

Be sure to stop the engine before proceeding to inspection and service procedure. Never attempt to make adjustments on the engine parts while the engine is running. Rotating parts such as belt can entangle your body and cause serious injuries.

Always restore engine turning tools after use

Do not forget to remove the tools which have been used for turning the engine during inspection or servicing, after the procedure is finished. Remember also that the turning gear must be returned to the operating condition before starting the engine.

Starting the engine with the turning tools inserted or with the turning gear in engagement can lead to not only engine damage but also personal injuries.

⚠ WARNING**Be careful of burns****Do not touch the engine during or immediately after operation**

Do not touch the engine during or immediately after operation to avoid risk of burns.

To conduct maintenance and inspection work, wait until the engine has cooled sufficiently, checking the temperature gauge.

**Slowly and carefully open radiator cap**

Never attempt to open the radiator cap while the engine is running or immediately after the engine stops. Give a sufficient cooling time to the engine coolant before opening the cap.

When opening the radiator cap, slowly turn the cap to release internal pressure. To prevent scalds with steam gushing out, wear thick rubber gloves or cover the cap with a cloth.

Close the radiator cap tightly without fail.

The coolant is very hot and under pressure during engine running or just after the engine stops. If the radiator cap is not closed tightly, steam and hot coolant may gush out and can cause scalds.

Add coolant only after the coolant temperature dropped

Do not add coolant immediately after the engine stops. Wait until the coolant temperature lowers sufficiently to avoid a risk of burns.

⚠ WARNING**Protect ears from noises****Wear ear plugs**

Always wear ear plugs when entering the machine room (engine room). Combustion sound and mechanical noise generated by the engine can cause hearing problems.



⚠ WARNING**Be careful of falling down****Lift engine correctly**

To lift the engine, always use a correct wire rope capable of withstanding the engine weight.

Attach the wire rope to the lifting hangers provided on the engine using a correct sling.

During lifting process, keep the engine in a well-balanced position by taking the center of gravity of the engine into consideration.

If the wire rope contacts the engine directly, place a cloth or other soft padding to avoid damage to the engine and wire rope.

**Do not climb onto the engine**

Do not climb onto the engine, nor step on any engine parts located on the lateral sides.

To work on parts located on the upper section of engine, use a ladder, stool, etc., that is firmly secured.

Climbing on the engine may not only damage engine parts but also cause parts to fall off and result in personal injuries.

⚠ CAUTION**Be careful of handling fuel, engine oil and LLC****Use only specified fuel, engine oil and long-life coolant (LLC)**

Use only the fuel, oil and LLC specified in this manual, and handle them carefully.

Use of any other fuel, oil or LLC, or improper handling may cause various engine problems and malfunctions. Obtain the Material Safety Data Sheets (MSDS) issued by the fuel, oil and LLC suppliers, and follow the directions in the MSDSs for proper handling.

Handle LLC (long life coolant) carefully

When handling LLC, always wear rubber gloves and protective face mask. If LLC or cooling water containing LLC comes into contact with your skin or eyes, or if it is swallowed, you would suffer from inflammation, irritation or poisoning.

Should LLC be accidentally swallowed, induce vomiting immediately and seek medical attention. Should LLC enter your eyes, flush them immediately with plenty of water and seek medical attention. If LLC splashes onto your skin or clothing, wash it away immediately with plenty of water.

Keep flames away from LLC. The LLC can catch flames, causing a fire.

Coolant containing LLC is a hazardous material. Do not dispose of it in unauthorized manner. Abide by the applicable law and regulations when discarding drained coolant.

Proper disposal of waste oil and coolant (LLC)

Do not discharge waste engine oil or coolant into sewerage, river, lake or other similar places. Such a way of disposal is strictly prohibited by laws and regulations.

Dispose of waste oil, coolant and other environmentally hazardous waste in accordance with the applicable law and regulations, or consult a Mitsubishi dealer.

CAUTION**Service battery****Handle the battery correctly**

- Never use flames or allow sparks to generate near the battery. The battery releases flammable hydrogen gas and oxygen gas. Any flames or sparks in the vicinity could cause an explosion.
- Do not use the battery the fluid level of which is lowered below the lower limit line. Sustained use of the battery could result in an explosion.
- Do not short the battery terminals with a tool or other metal object.
- When disconnecting battery cables, always remove the cable from the negative (-) terminal first. When reconnecting the cables, attach the cable to the positive (+) terminal first.
- Charge the battery in a well-ventilated area, with all filling hole plugs removed.
- Make sure the cable clamps are securely installed on the battery terminals. A loose cable clamp can cause sparks that may result in an explosion.
- Before servicing electrical components or conducting electric welding, set the battery switch to the [Open/OFF] position or disconnect the cable from the negative (-) battery terminal to cut off the electrical current.
- Electrolyte (battery fluid) contains dilute sulfuric acid. Careless handling of the battery can lead to the loss of sight and/or skin burns. Also, keep the battery fluid off the mouth.
- Wear protective goggles and rubber gloves when working with the battery (when adding water, charging, etc.).
- If electrolyte is spilled onto the skin or clothing, immediately wash it away with lots of water. Use soap to thoroughly clean.
- The battery fluid can cause blindness if splashing into eyes. If it gets into eyes, immediately flush it away with plenty of clean fresh water, and seek immediate medical attention.
- If the battery fluid is accidentally swallowed, gargle with plenty of water, then drink lots of water, and seek immediate medical attention.

**CAUTION****When abnormality occurs****Stop overheated engine after cooling run**

Even if the engine comes to overheat, do not stop the engine immediately. Abrupt stopping of an overheated engine can cause the coolant temperature to rise, resulting in seized engine parts. If the engine comes to overheat, run the engine at low idling speed (cooling operation), and stop the engine after the coolant temperature lowers sufficiently.

Do not add coolant immediately after stopping the engine. Adding coolant to a hot engine can cause the cylinder heads to crack due to sudden change in temperature. Add coolant little by little after the engine cools down to room temperature.

Avoid immediate restart after abnormal stop

If the engine stops abnormally, do not restart the engine immediately. If the engine stops with an alarm, check and remedy the cause of the problem before restarting. Sustained use of the engine without any remedy could result in serious engine problems.

Avoid continuous engine operation with too low oil pressure

If an abnormal engine oil pressure drop is indicated, stop the engine immediately, and inspect the lubrication system to locate the cause. Continuous engine operation with low oil pressure may cause bearings and other parts to seize.

Stop the engine immediately if the fan belt breaks

If the fan belt breaks, stop the engine immediately. Continuous engine operation with the broken fan belt could cause the engine to overheat and thereby the coolant to boil into steam, which may gush out from the reserve tank or radiator, and cause personal injuries.



Other cautions

Modification of engine prohibited

Unauthorized modification of the engine will void the manufacturer's warranty.

Modification of the engine may not only cause engine damage but also produce personal injuries.

Pre-operational check and periodic inspection/maintenance

Be sure to perform the pre-operational checks and periodic inspection/maintenance as described in this manual.

Neglecting the pre-operational check or periodic inspection/maintenance can arouse various engine troubles such as damage to parts, eventually leading to serious accidents.

Break-in operation

A new engine needs to be broken in for the first 50 hours of operation. During this period, do not subject the engine to heavy loads.

Operating a new engine under high loads or severe conditions during the break-in period can shorten the service life of the engine.

Warming-up operation

After starting the engine, run the engine at low idling speeds for 5 to 10 minutes for warming-up. Start the work after this operation is completed.

Warm-up operation circulates the lubricant through the engine. Therefore, individual engine parts are well lubricated before they are subjected to heavy loads. This is very important for longer service life, high-performance and economical operation.

Do not conduct warm-up operation for a longer time than necessary. Prolonged warm-up operation causes carbon build-up in the cylinders that leads to incomplete combustion.

Avoid engine operations in a overload condition

If the engine is considered to be in an overloaded condition which is identified by too much black smoke, etc., immediately reduce the load on the engine such that the correct output and load conditions may be achieved.

Overloading the engine causes not only high fuel consumption but also excessive carbon deposits inside the engine. Excessive carbon deposits can cause various engine problems and shorten the service life of the en-

gine remarkably.

Cooling operation before stopping engine

Always conduct the cooling operation (low speed idling) for 5 to 6 minutes before stopping the engine.

Abruptly stopping the engine immediately after high-load operation can cause partial overheating and shorten the service life of the engine.

During cooling operation, check the engine for abnormalities.

Protection of engine against water entry

Do not allow rainwater, etc. to enter the engine through the air inlet or exhaust openings.

Do not wash the engine while it is operating. Cleaning fluid (water) can be sucked into the engine.

Starting the engine with water inside the combustion chambers can cause the water hammer action which may result in internal engine damage and serious accidents.

Maintenance of air cleaner or pre-cleaner

The major cause of abnormal wear on engine parts is dust entering with intake air. Worn parts produce many problems such as an increase of oil consumption, decrease of output, and starting difficulties. For effective removal of dust from intake air, conduct maintenance of the air cleaner according to the following instructions.

- Do not conduct maintenance of the air cleaner/pre-cleaner while the engine is operating. Engine operation without the air cleaner/pre-cleaner in place allows foreign matters to enter the turbocharger, causing it to damage seriously.
- Remove the air cleaner/pre-cleaner slowly to prevent dust accumulated on the element from falling off. After removing the air cleaner or pre-cleaner, immediately cover the opening (inlet port in case of air cleaner; port in body in case of pre-cleaner) with plastic sheet or similar means to prevent dust from entering the engine.
- Air cleaners equipped with a dust indicator will issue an alarm if the element gets clogged. Service the cleaner as soon as possible if an alarm is issued.

Observe safety rules at work site

Observe the safety rules established at your workplace when operating and maintaining the engine.

Do not operate the engine if you are feeling ill.

Operation of the engine with reduced awareness may cause improper operation that could result in accidents.

In such a case, inform your supervisor of your condition.

When working in a team of two or more people, use specified hand signals to communicate among workers.

Work clothing and protective gear

Wear a hardhat, face shield, safety shoes, dust mask, gloves and other protective gear as needed.

When handling compressed air, wear safety goggles, hardhat, gloves and other necessary protective gear.

Works without wearing proper protective gear could result in serious injuries.

Use of tools optimum for each work

Always keep in mind to select most appropriate tools for the work to be performed and use them correctly. If tools are damaged, replace with new tools.

Avoidance of prolonged time of starter operation

Do not operate the starter for more than 10 seconds at a time even if the engine does not start. Wait for at least 30 seconds before next engine cranking.

Continuous operation of the starter will drain the battery power and cause the starter to seize.

Do not turn off battery switch during operation

If the battery switch is turned OFF when the engine is running, not only various meters will stop working but also the alternator may have its diode and transistor deteriorated.

Cautionary instructions for transporting engine

When transporting the engine on a truck, consider the engine weight, width and height to ensure safety. Abide by road traffic law, road vehicles act, vehicle restriction ordinance and other pertinent laws.

Avoid continuous engine operation in a low load condition

Do not operate the engine continuously for more than 10 minutes at a load of less than 30%. Engine operation in a low load condition increases the emission of unburned fuel. Therefore, a prolonged time of engine operation in a low load condition increases the quantity of unburned fuel adhering to engine parts, provoking the possibility of engine malfunctioning and shortening the service life of the engine.

Ventilation of engine room

Always keep the engine room well ventilated. Insufficient amount of intake air causes the operating temperature to rise, resulting in poor output and lowered performance.

It is highly recommended to calculate the required amount of air supply to the engine and install an adequate ventilation system before installing the engine.

Avoid contact with high-pressured fuel

Should fuel leak from a fuel injection pipe, do not touch the spouting fuel directly.

Fuel in the fuel injection pipes is under high pressure. If high-pressured fuel contacts your skin, it penetrates through the skin and may result in gangrene.

⚠ CAUTION

About warning labels

Maintenance of warning labels

Make sure all warning/caution labels are legible.

Clean or replace the warning/caution labels when the description and/or illustration are not clear to read.

For cleaning the warning/caution labels, use a cloth, water and soap. Do not use cleaning solvents, gasoline or other chemicals to prevent the letters from getting blurred or the adhesion from being weakened.

Replace damaged or fractured labels with new ones.

If any engine part on which a warning label is attached is replaced with a new one, attach a new identical warning label to the new part.



Warning labels

GENERAL CONTENTS

Group Name	Contents	Group No.
General	External view System flow diagrams Engine serial number location Main specifications Tips on disassembling and reassembling	1
Service data	Maintenance service data Tightening torque table	2
Service tools	Special tools	3
Determination of overhaul	Determining overhaul timing Testing compression pressure	4
Disassembly of basic engine	Disassembling and inspecting cylinder head and valve mechanism Disassembling and inspecting flywheel Disassembling and inspecting gear case, timing gear and camshaft Disassembling and inspection crankcase, crankshaft and piston	5
Inspection and repair of basic engine	Inspecting and repairing cylinder head and valve mechanism Inspecting and repairing flywheel Inspecting and repairing timing gear and camshaft Inspecting and repairing piston, connecting rod, crankshaft and crankcase	6
Reassembly of basic engine	Reassembling piston, connecting rod, crankshaft and crankcase Reassembling timing gear and camshaft Reassembling flywheel Reassembling cylinder head and valve mechanism	7
Fuel system	Environment of fuel system service Removing fuel system Disassembling and inspecting fuel pump Disassembling and inspecting common rail Installing fuel system	8
Lubrication system	Removing and inspecting lubrication system Disassembling, inspecting and reassembling lubrication system Installing lubrication system	9
Cooling system	Removing cooling system Inspecting cooling system Installing cooling system	10
Inlet and exhaust system	Removing inlet and exhaust system Disassembling, inspecting and reassembling inlet and exhaust system Installing inlet and exhaust system	11
Electrical system	Removing electrical system Disassembling, inspecting and reassembling electrical system Installing electrical system	12
Adjustment and operation	Adjusting engine Break-in operation Performance test (JIS standard)	13

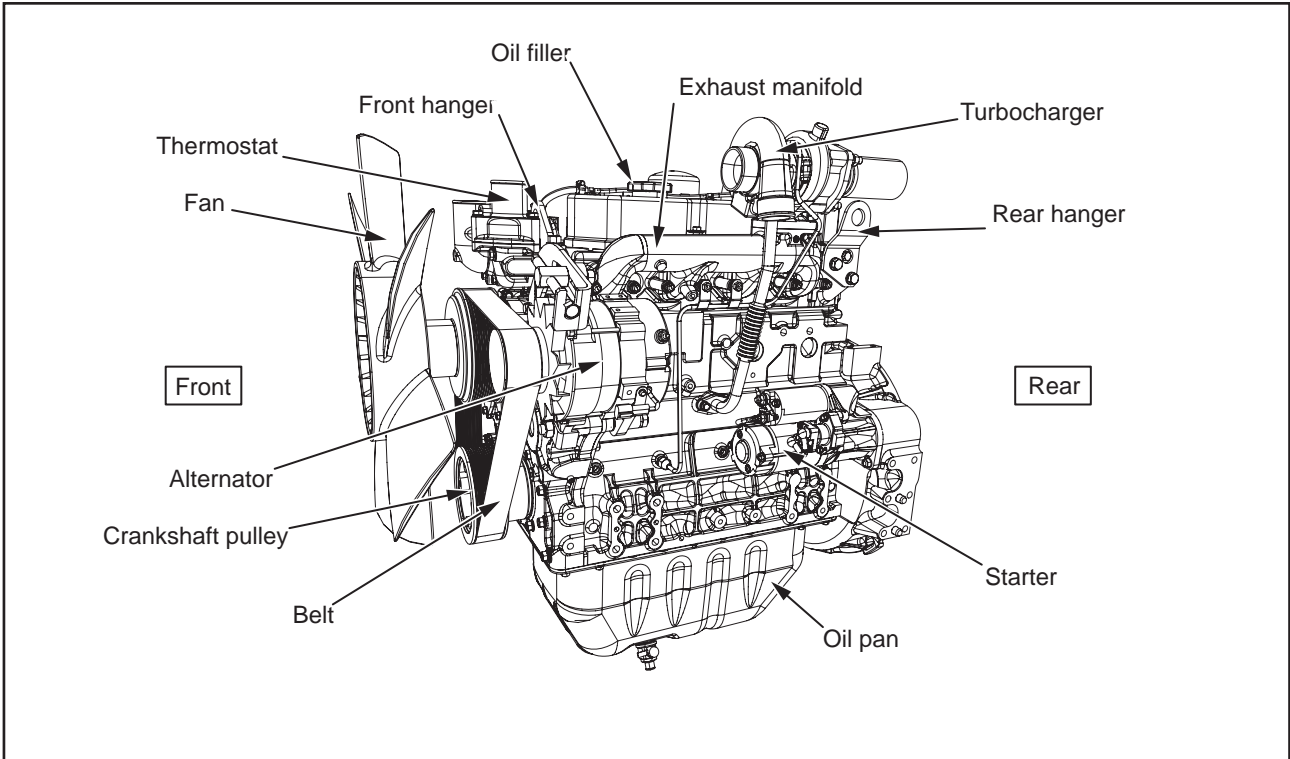
GENERAL CONTENTS

Group Name	Contents	Group No.
Troubleshooting	Troubleshooting by diagnosis codes Scan tester (32G91-00800, main unit: 32G91-00811, interconnect cable: 32G91-00812) Scan tester (32G91-00600) Diagnosis code cross reference Troubleshooting reference chart Inspecting sensors Inspecting wiring	14

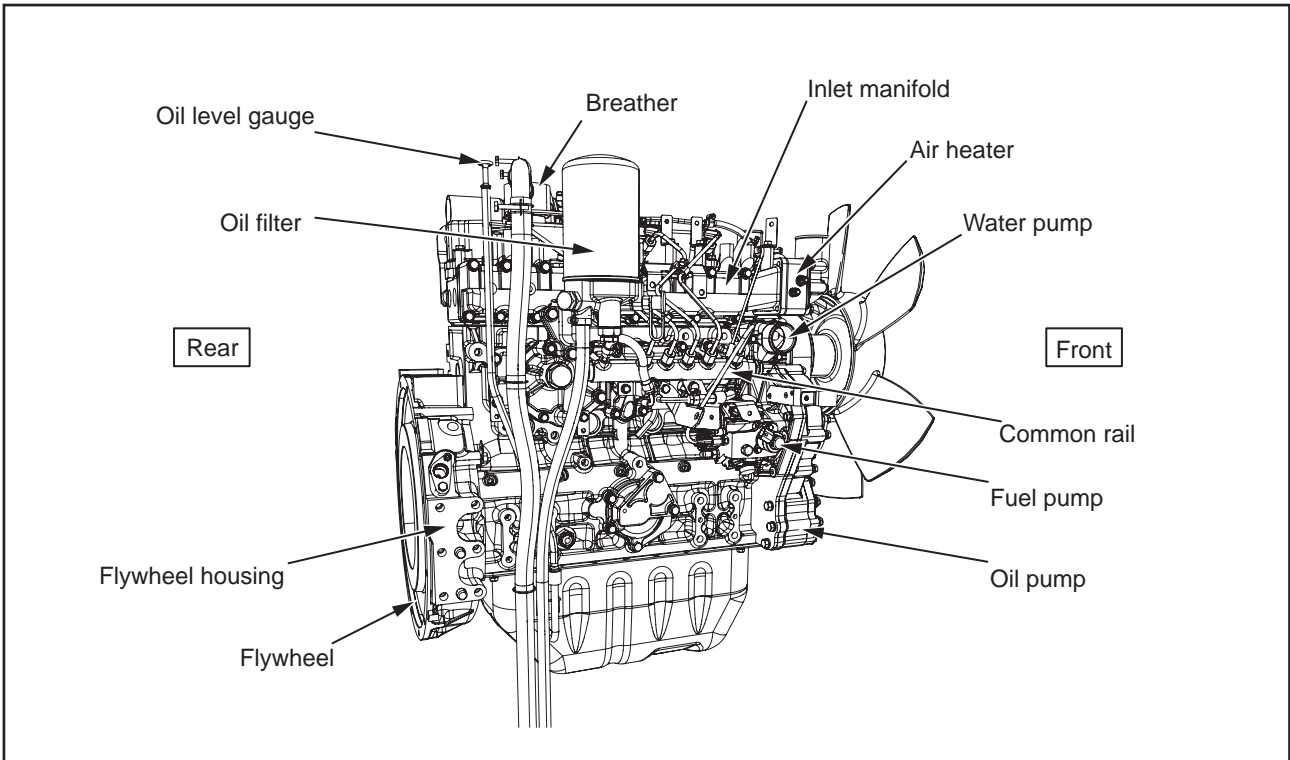
GENERAL

1. External view	1-2
2. System flow diagrams	1-3
2.1 Fuel system - flow diagram	1-3
2.2 Lubrication system - flow diagram	1-3
2.3 Cooling system - flow diagram.....	1-4
2.4 Inlet and exhaust system - flow diagram..	1-4
2.5 Electrical system - wiring diagram	1-5
3. Engine serial number location	1-6
4. Main specifications	1-7
5. Tips on disassembling and reassembling	1-10
5.1 Disassembling.....	1-10
5.2 Reassembling	1-10

1. External view



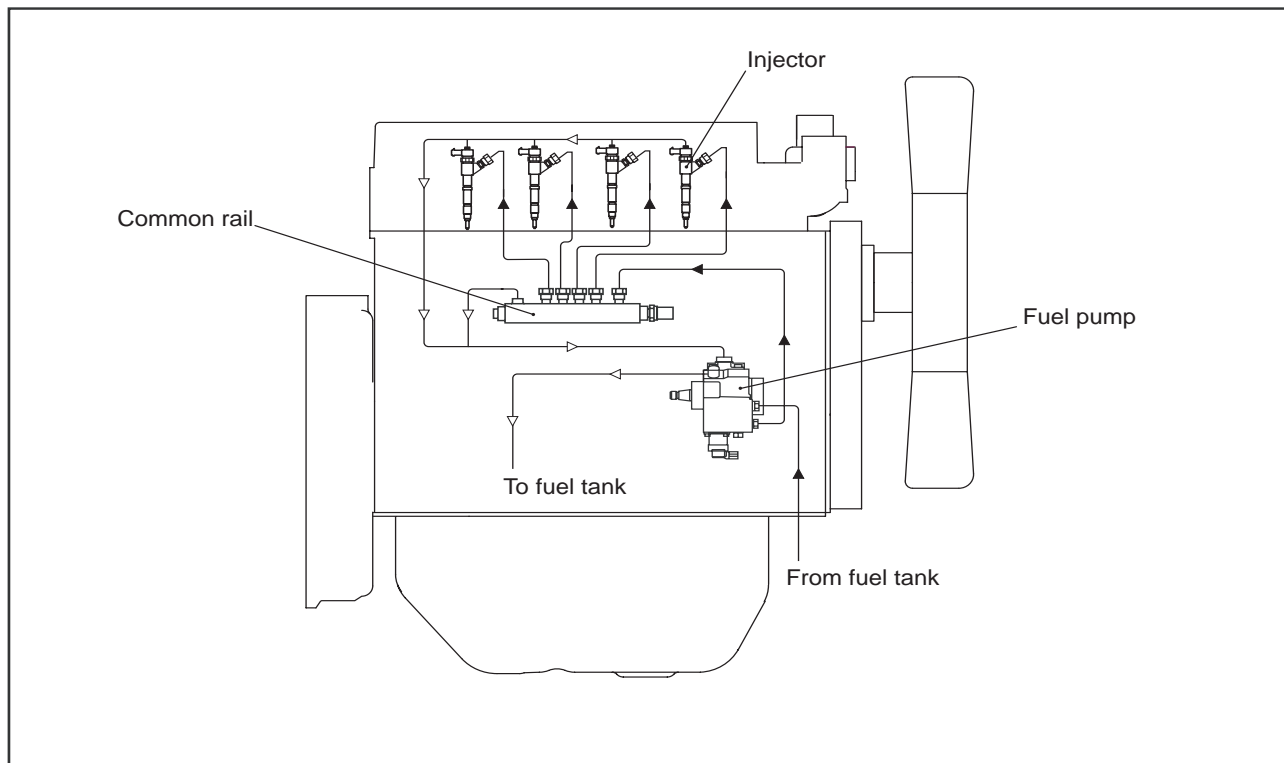
Engine left view



Engine right view

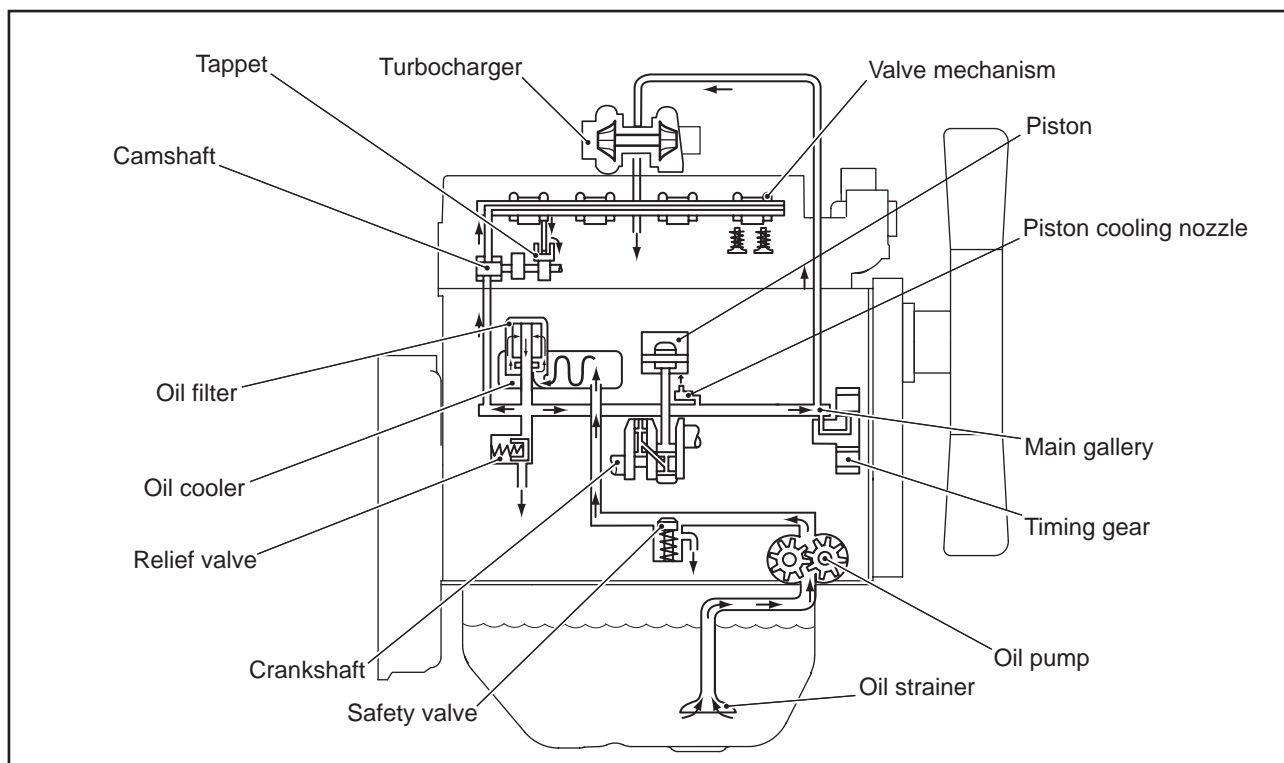
2. System flow diagrams

2.1 Fuel system - flow diagram



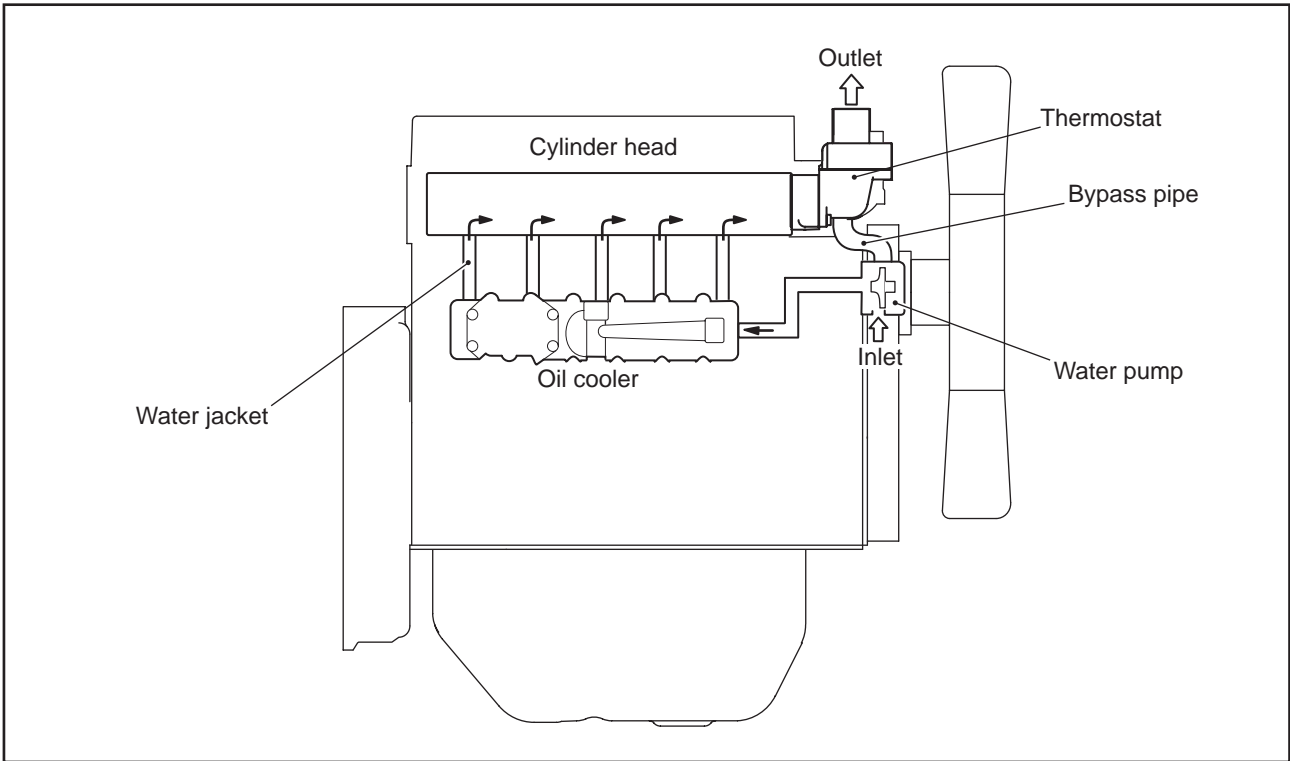
Fuel system - flow diagram

2.2 Lubrication system - flow diagram



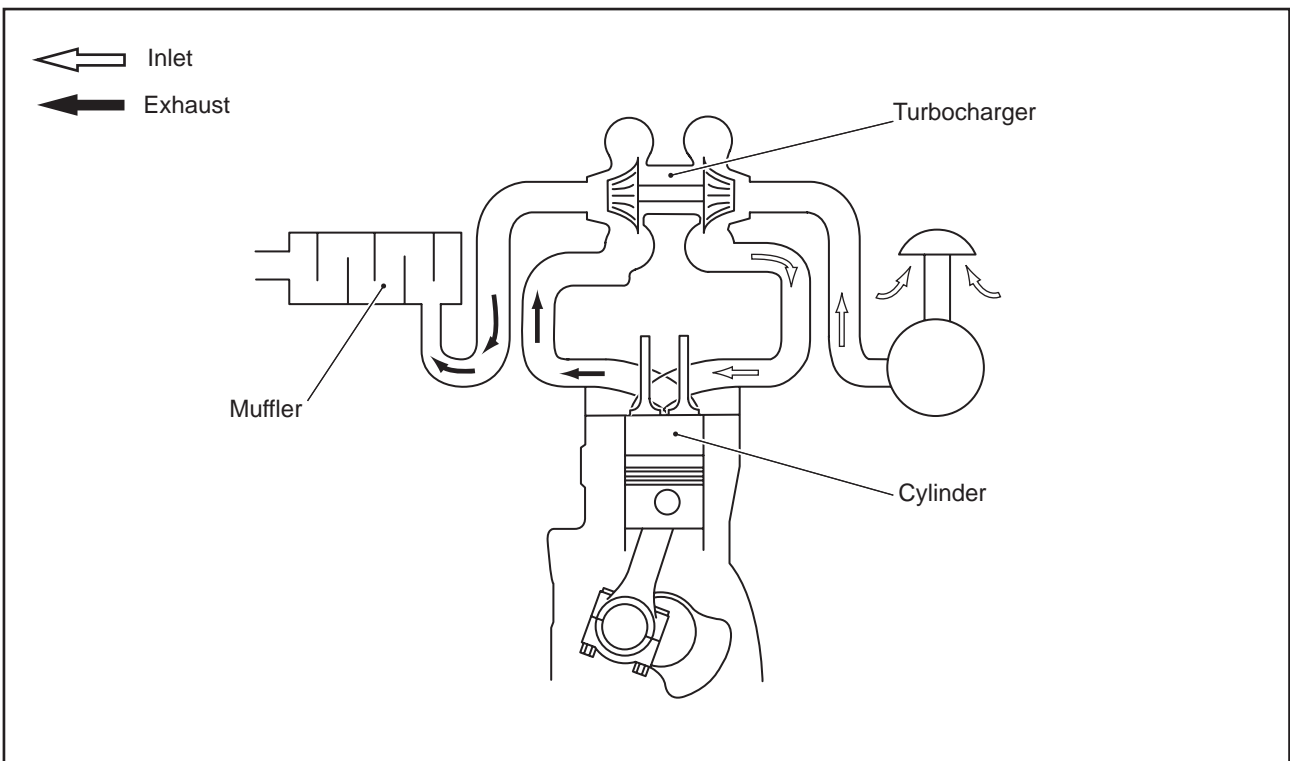
Lubrication system - flow diagram

2.3 Cooling system - flow diagram



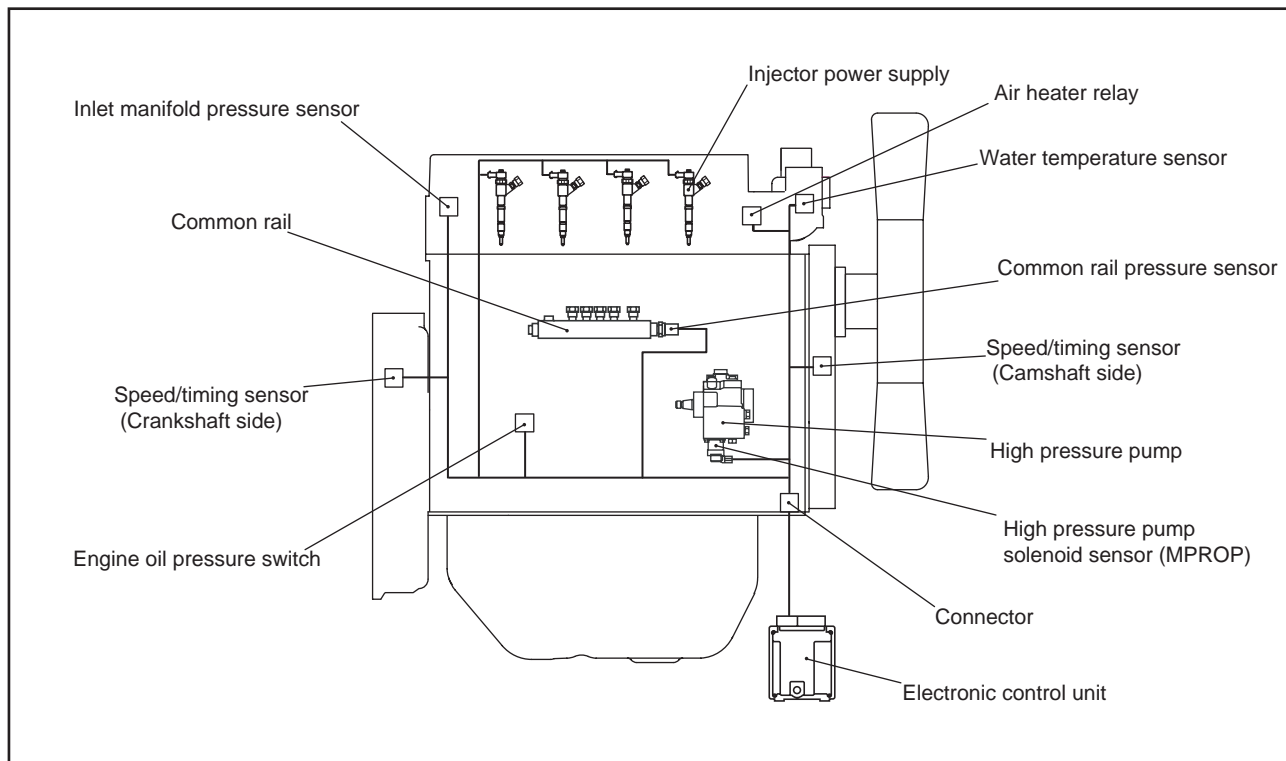
Cooling system - flow diagram

2.4 Inlet and exhaust system - flow diagram



Inlet and exhaust system - flow diagram

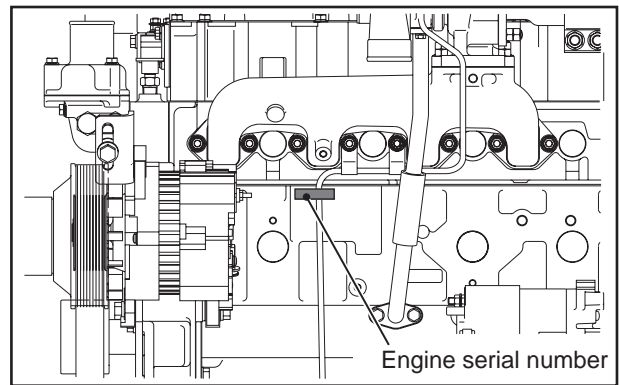
2.5 Electrical system - wiring diagram



Electrical system - wiring diagram

3. Engine serial number location

The engine serial number is stamped on the side of the crankcase.



Stamp location of engine serial number

4. Main specifications

Table 1-1 Main specifications (1 / 3)

Engine model		D04FR-TAA		
Main specification	Type		Water cooled, 4 cycle diesel engine, turbocharged	
	No. of cylinders - arrangement		4 cylinder in-line	
	Combustion system		Direct injection	
	Valve mechanism		Overhead	
	Cylinder bore × stroke		102 × 130 mm [4.02 × 5.12 in.]	
	Displacement		4.249 L [259 cu. in.]	
	Compression ratio		17.8	
	Fuel		Diesel fuel	
	Firing order		1-3-4-2	
	Direction of rotation		Counterclockwise when viewed from flywheel side	
	Dimensions (varies depending on the specifications)	Length	911 mm [35.87 in.]	
		Width	719 mm [28.3 in.]	
Height		940 mm [37.0 in.]		
Dry weight		Approx. 395 kg [870.8 lbs]		
Basic engine	Cylinder sleeve	Type	Dry	
	Piston ring	Number of rings	Compression rings: 2	
			Oil ring (w/expander): 1	
	Valve timing (when warm)	Inlet valve	Open	BTDC 15°
			Close	ABDC 45°
		Exhaust valve	Open	BBDC 49°
			Close	ATDC 15°
	Internal EGR valve timing	Exhaust valve	Open	ATDC 21°
			Close	BBDC 55°
	Starting system		Starter	
Starting aid system		Air heater		
Fuel system	Type		Common rail fuel injection system	
	Model number		CP1H	
	Manufacturer		Bosch Corporation	

Table 1-1 Main specifications (2 / 3)

Engine model		D04FR-TAA	
Lubrication system	Lubricating method		Forced circulation type (pressure feed by oil pump)
	Engine oil	Standard	API classification CF-4 or above class
		Engine oil capacity	Engine total: approx. 17.5 L [4.62 US gallons]
	Oil pump	Type	Gear type oil pump
		Delivery capacity	40 L [10.57 US gallons]/min (at pump rotation of 1800 min ⁻¹)
	Relief valve	Type	Piston valve type
		Valve opening pressure	0.35 ± 0.05 MPa { 3.5 ± 0.5 kgf/cm ² } [50 ± 7 psi]
	Oil cooler	Type	Water-cooled, multi-plate type
Oil filter	Type	Cartridge type paper element	
Safety valve	Opening pressure	1.1 MPa { 11 kgf/cm ² } [157 psi]	
Cooling system	Cooling method		Water-cooled, forced circulation
	Coolant capacity (Engine water jacket)		6 L [1.6 US gallons] approx.
	Water pump	Type	Centrifugal
		Discharge capacity	133 L [35 US gallons]/min (at pump rotation of 1800 min ⁻¹)
	Water pump pulley	Speed ratio	Varies depending on the specifications
	Fan belt	Type	Ribbed belt
	Fan	Type	ø600 mm [23.62 in.]
Thermostat	Type	Wax type	
	Valve opening temperature	71 ± 2°C [160 ± 3.6°F]	
Inlet and exhaust system	Turbocharger	Model number	TD04HL
		Qty	1
Control system	ECU (Electronic Control Unit)	Model number	EDC16UC40
		Manufacturer	Bosch Corporation

Table 1-1 Main specifications (3 / 3)

Engine model		D04FR-TAA		
Electrical system	Starter	Manufacturer	Nikko Electric Industry	
		Type	0-24000-0188	
		Pinion meshing type	Pinion shift	
		Output	24V - 5kW	
		Qty	1	
		Ring gear and pinion ratio	10/127	
		No-load characteristics	Voltage	23V
			Current	85A or below
			Speed	3300 min ⁻¹ or more
		Load characteristics	Voltage	9V
			Current	1400A or below
			Torque	88.26 N·m {9.0 kgf·m} [65 lbf·ft] or above
		Minimum operating voltage	16V or below	
	Minimum holding voltage	8V or below		
	Alternator	Manufacturer	Nikko Electric Industry	
		Model number	0-35000-4838	
		Output	24V - 50A	
		Rated speed	5000 min ⁻¹	
		Direction of rotation	Clockwise when viewed from pulley side	
		Drive system	PK type, V ribbed, 12 ribs	
Ground system		One conductor (-) side		
Regulated voltage		28.5V ± 1V		
Temperature range tolerance		-30 to +100°C [-22 to +212°F]		
Air heater		Type	Electric heater	
	Capacity	2.1kW		
Heater relay	Fuse capacity	127A		

5. Tips on disassembling and reassembling

This service manual specifies the recommended procedures to be followed when servicing Mitsubishi engines. The manual also specifies the special tools that are required for the work, and the basic safety precautions to follow when working.

Note that this manual does not exhaustively cover potential hazards that could occur during maintenance, inspection and service work of engine.

When working on an engine, follow the relevant directions given in this manual and observe the following instructions:

5.1 Disassembling

- (1) Use correct tools and instruments. Serious injury or damage to the engine will result from using the wrong tools and instruments.
- (2) Use an overhaul stand or work bench if necessary, and follow the disassembling procedures described in this manual.
- (3) Keep the engine parts in order of removal to prevent losing them.
- (4) Pay attention to assembling marks. Put your marks on the parts, if necessary, to ensure correct reassembling.
- (5) Carefully check each part for defects during disassembling or cleaning. Do not miss symptoms which can not be detected after disassembling or cleaning.
- (6) When lifting or carrying heavy parts, exercise utmost caution to ensure safety. Pay attention to balance of heavy parts when handling. (Get help, and use jacks, chain blocks and guide bolts as necessary.)

5.2 Reassembling

- (1) Wash all engine parts, except such parts as oil seals, O-rings and rubber sheets, in cleaning oil and dry them with compressed air.
- (2) Use correct tools and instruments.
- (3) Use only high-quality lubricating oils and greases of appropriate types. Be sure to apply oil, grease or adhesive to the part wherever specified.
- (4) Use a torque wrench to tighten parts correctly when their tightening torques are specified.
Refer to "Tightening torque table."
- (5) Replace all gaskets and packings with new ones unless specified otherwise. Apply adhesive if necessary. Use only the proper amount of adhesive.

SERVICE DATA

1. Maintenance service data	2-2
1.1 General	2-2
1.2 Basic engine	2-3
1.3 Lubrication system	2-7
1.4 Cooling system	2-7
1.5 Inlet and exhaust system	2-7
1.6 Electrical system	2-7
2. Tightening torque table	2-8
2.1 Major bolts and nuts tightening torque.....	2-8
2.1.1 Basic engine.....	2-8
2.1.2 Fuel system.....	2-9
2.1.3 Lubrication system	2-9
2.1.4 Cooling system.....	2-10
2.1.5 Inlet and exhaust system	2-11
2.1.6 Electrical system	2-11
2.1.7 Sensors and ECU	2-11
2.2 Standard bolt and nut tightening torque.....	2-12
2.3 Standard eyebolt tightening torque.....	2-13
2.4 Standard union nut tightening torque.....	2-13



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1. Maintenance service data

1.1 General

Table 2-1 Maintenance service data table - General

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark
Maximum rotation speed		2240 min ⁻¹	± 10 min ⁻¹		
Minimum rotation speed		1015 min ⁻¹	± 20 min ⁻¹		
Compression pressure (at 300 min ⁻¹)		2.9 MPa { 30 kgf/cm ² } [427 psi]		2.6 MPa { 27 kgf/cm ² } { [384 psi] }	When oil and water temperatures at 20 to 30°C [68 to 86 °F]
Lubricating oil pressure	Rated speed	0.2 to 0.4 MPa { 2 to 4 kgf/cm ² } [28.4 to 56.9 psi]		0.15 MPa { 1.5 kgf/cm ² } [21.3 psi]	Oil temperature at 70 to 90 °C [158 to 194 °F]
	Low idling	0.1 MPa { 1 kgf/cm ² } [14.2 psi]		0.05 MPa { 0.5 kgf/cm ² } [7.1 psi]	
Valve timing	Inlet	Open	BTDC 15°		±3° (crank angle)
		Close	ABDC 45°		
	Exhaust	Open	BBDC 49°		
		Close	ATDC 15°		
Internal EGR valve timing	Exhaust	Open	ATDC 21°		
		Close	BBDC 55°		
Valve clearance (when cold)	Inlet		0.25 [0.0098]		
	Exhaust		0.40 [0.0157]		
Fan belt deflection			7 to 9 [0.276 to 0.354]		Deflection when the belt forcefully pressed with a thumb New fan belt standard value 4 to 6 [0.158 to 0.236]

1.2 Basic engine

Table 2-2 Maintenance service data table - Basic engine (1 / 4)

Unit: mm [in.]

Inspection point		Nominal	Standard	Limit	Remark	
Crankcase	Flatness of top surface		0.05 [0.0020] or less	0.20 [0.008]	Reface minimum as possible. Total grinding thickness of crankcase top and cylinder head bottom is 0.2 [0.008] max.	
Cylinder sleeve	Inside diameter	∅ 102 [4.02]	102.010 to 102.045 [4.0161 to 4.0175]	102.700 [4.0433]	If limit (102.200 [4.0236]) is exceeded, use oversize sleeve, and hone to +0.010 to +0.045 [0.0004 to 0.0018].	
	Circularity		0.01 [0.0004] or less			
	Cylindricity		0.015 [0.0006] or less		Use oversize piston and piston ring.	
Main bearing	Clearance between main bearing and crank journal		0.050 to 0.118 [0.0020 to 0.0046]	0.200 [0.0079]	If the measured value exceeds the standard and is less than the limit, replace bearing. If the limit is exceeded, grind the crank journal, and use undersize bearing.	
	Width of thrust journals (Thrust clearance)		0.100 to 0.264 [0.0039 to 0.0104]	(0.300 [0.0118])	Replace thrust plate. The limit value means a play in the direction of thrust.	
Tappet hole	Inside diameter	∅ 22 [0.87]	22.000 to 22.021 [0.8661 to 0.8670]	22.100 [0.8701]	Repair limit: 102.200 [4.0236]	
	Clearance between tappet and tappet hole		0.035 to 0.086 [0.0014 to 0.0034]	0.120 [0.0047]	Replace tappet if diameter of tappet hole is +0.10 [0.0039] or less.	
Camshaft bushing	Clearance between bushing and camshaft journal	Front	0.04 to 0.09 [0.0016 to 0.0035]	0.15 [0.0059]	Replace bushing. (Ream if necessary.)	
		Middle				
		Rear	0.04 to 0.119 [0.0016 to 0.0047]	0.15 [0.0059]		
Cylinder head	Distortion of bottom surface		0.05 [0.0020] or less	0.20 [0.008]	Reface minimum as possible. Total grinding thickness of crankcase top and cylinder head bottom is 0.2 [0.008] max.	
	Compressed thickness of gasket	1.7 [0.07]	±0.05 [0.0020]			
Valve and valve guide	Valve stem outside diameter	Inlet	7.940 to 7.955 [0.3126 to 0.3132]	7.900 [0.3110]		
		Exhaust	7.920 to 7.940 [0.3118 to 0.3126]	7.850 [0.3091]		
	Clearance between valve stem and guide	Inlet		0.055 to 0.085 [0.0022 to 0.0033]	0.150 [0.0059]	
		Exhaust		0.070 to 0.105 [0.0028 to 0.0041]	0.200 [0.0079]	
Valve guide mounting dimension	17 [0.669]	17.2 to 17.4 [0.6772 to 0.6850]				

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