CX15B
CX18B
Series 2
Mini Excavator

SERVICE MANUAL

Part number 84533370B
English
May 2014

CASE
CONSTRUCTION

Contents

INTRODUCTION

Foreword - Important notice regarding equipment servicing

All repair and maintenance work listed in this manual must be carried out only by qualified dealership personnel, strictly complying with the instructions given, and using, whenever possible, the special tools.

Anyone who performs repair and maintenance operations without complying with the procedures provided herein shall be responsible for any subsequent damages.

The manufacturer and all the organizations of its distribution chain, including - without limitation - national, regional, or local dealers, reject any responsibility for damages caused by parts and/or components not approved by the manufacturer, including those used for the servicing or repair of the product manufactured or marketed by the manufacturer. In any case, no warranty is given or attributed on the product manufactured or marketed by the manufacturer in case of damages caused by parts and/or components not approved by the manufacturer.

The information in this manual is up-to-date at the date of the publication. It is the policy of the manufacturer for continuous improvement. Some information could not be updated due to modifications of a technical or commercial type, or changes to the laws and regulations of different countries.

In case of questions, refer to your CASE CONSTRUCTION Sales and Service Networks.

Safety rules

Personal safety

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible death or injury.

Throughout this manual you will find the signal words DANGER, WARNING, and CAUTION followed by special instructions. These precautions are intended for the personal safety of you and those working with you.

Read and understand all the safety messages in this manual before you operate or service the machine.

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

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

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

FAILURE TO FOLLOW DANGER, WARNING, AND CAUTION MESSAGES COULD RESULT IN DEATH OR SERIOUS INJURY.

Machine safety

NOTICE: *Notice indicates a situation that, if not avoided, could result in machine or property damage.*

Throughout this manual you will find the signal word Notice followed by special instructions to prevent machine or property damage. The word Notice is used to address practices not related to personal safety.

Information

NOTE: *Note indicates additional information that clarifies steps, procedures, or other information in this manual.*

Throughout this manual you will find the word Note followed by additional information about a step, procedure, or other information in the manual. The word Note is not intended to address personal safety or property damage.

Personal safety

NOTICE: *The proper and safe lubrication and maintenance for this machine, recommended by Manufacturer, are outlined in the OPERATOR'S MANUAL for the machine.*
Improper performance of lubrication or maintenance procedures are dangerous and could result in injury or death. Read and understand the MANUAL before performing any lubrication or maintenance.

The serviceman or mechanic may be unfamiliar with many of the systems on this machine. This makes a careful use of the systems very important when performing maintenance operations. Sound knowledge of the system and or components is important before the removal or disassembly of any component.

Because of the size of some of the machine components, the serviceman or mechanic should check the weights noted in this manual. Use proper lifting procedures when removing any components. Weight of components table is shown in this section.

The following is a list of basic precautions that must always be observed.

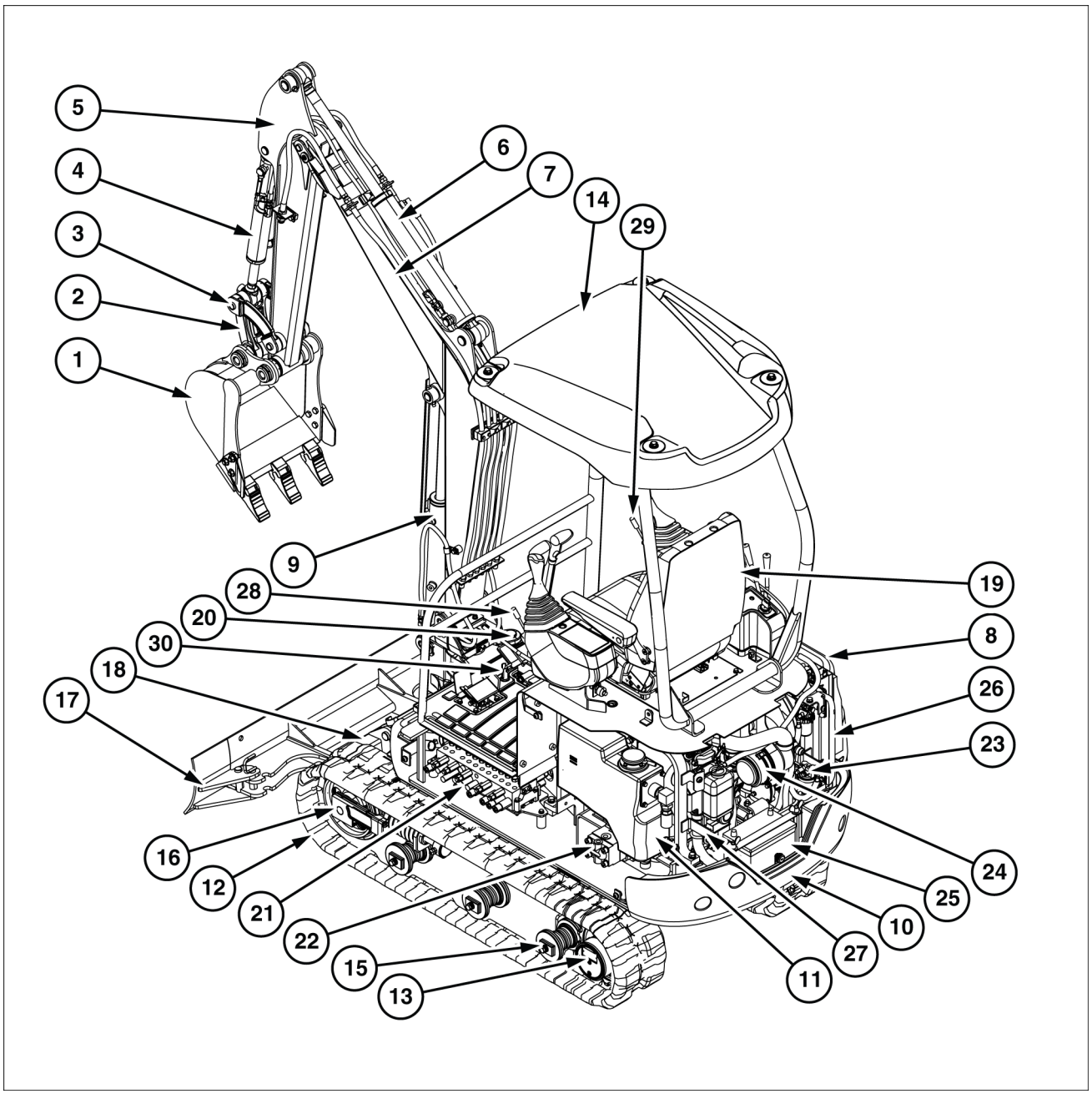
1. Read and understand all Warning plates and decals on the machine before Operating, Maintaining or Repairing this machine.
2. Always wear protective glasses and protective shoes when working around machines. In particular, wear protective glasses when using hammers, punches or drifts on any part of the machine or attachments. Use welders gloves, hood/goggles, apron and the protective clothing appropriate to the welding job being performed. Do not wear loose fitting or torn clothing. Remove all rings from fingers, loose jewellery, confine long hair and loose clothing before working on this machinery.
3. Disconnect the battery and hang a "Maintenance in Progress" tag in the operator's seat. Remove starter key.
4. If possible, make all repairs with the machine parked on a level and firm surface. Block the machine so it does not roll while working on or under the machine. Hang a "Maintenance in Progress" tag in the operator's seat.
5. Do not work on any machine that is supported only by lift, jacks or a hoist. Always use blocks or stops for the jack before carrying out any disassembly operation.

NOTICE: *Do not operate this machine unless you have read and understood all instructions contained in this manual. Improper machine operation is dangerous and could result in injury or death.*

6. Relieve all pressure in air, oil or water systems before any lines, fittings or related items are disconnected or removed. Always make sure all raised components are blocked correctly and be alert for possible pressure when disconnecting any device from a system under pressure.
7. Lower the bucket, dozer or other attachments to the ground before performing any work on the machine. If this cannot be done, make sure the bucket, blade or other attachment is blocked correctly to prevent it from dropping unexpectedly.
8. Use steps and grab handles when mounting or dismounting a machine. Remove any debris or mud from steps, walkways or work platforms before using them. Always face the machine when using steps, ladders and walkways. When it is not possible to use the designed access system, provide ladders, scaffolds, or work, platforms to perform safe repair operations.
9. To avoid back injury, use a hoist when lifting components which weigh 20 kg (44.09 lb) or more. Make sure all chains, hooks, slings, etc., are in good condition and are the correct capacity. Be sure hooks are positioned correctly. Lifting eyes are not to be side loaded during a lifting operation.
10. To avoid burns, be alert for hot parts and surfaces immediately after stopping the machine such as hot fluids in lines, tubes and compartment covers.
11. Be careful when removing cover plates. Gradually back off the last two capscrews or nuts located at opposite ends of the cover or device and carefully pry the cover loose to relieve any spring or other pressure, before removing the last two capscrews or nuts completely.
12. Be careful when removing filler caps, breathers and plugs on the machine. Hold a rag over the cap or plug to prevent being sprayed or splashed by liquids under pressure. Danger is even greater if the machine has just been stopped, as liquids might be boiling hot.
13. Always use the proper tools that are in good condition and that are suited for the job at hand. Be sure you understand how to use them before performing any service work.
14. Reinstall all clamps with the same spare part number. Do not use clamps of inferior quality if replacement is necessary.

15. Repairs which require welding should be performed only with the benefit of the appropriate reference information and by personnel adequately trained and skilled in welding procedures. Determine the type of metal being welded and select the correct welding procedure and electrodes, rods or wires to provide a metal weld strength at least equivalent to that of the parent metal. Make sure to disconnect the battery before any welding operation is performed.
16. Do not damage wiring during removal operations. Reinstall the wiring so it is not damaged nor will be damaged in operation of the machine by contacting sharp corners, or by rubbing against some object or hot surface. Do not connect wiring to a line containing fluid.
17. Be sure all protective devices, including guards and shields, are properly installed and functioning correctly before starting a repair. If a guard or shield must be removed to perform the repair work, use extra caution and replace the guard or shield after repair is complete.
18. Performing maintenance and repair operations while the bucket is lifted is dangerous, because there is the possibility of a device falling. Do not fail to lower such device and place the bucket to the ground before starting the operation.
19. Loose or dirty fuel, lubrication and hydraulic systems, pipes and hoses may cause fires. Do not bend or strike high-pressure lines, do not install bent or damaged lines. Inspect lines, tubes and hoses carefully. Do not check for leaks with your hands. Very small (pinhole) leaks can result in a high velocity oil jet that will be invisible close to the hose.
    This oil can penetrate the skin and cause personal injury. Use card-board or paper to locate pinhole leaks.
20. Tighten connections to the correct torque. Make sure that all protections against burns, the clamps and the operator's protective devices are correctly installed in order to prevent excessive heat, vibrations or rubbing against other parts during operation. Shields that protect against oil spray onto hot exhaust components in event of a line, tube or seal failure must be installed correctly.
21. Do not operate a machine if any rotating part is damaged or contacts any other part during operation. Any high speed rotating component that has been damaged or altered should be checked for balance before reusing.
22. Be careful when servicing or separating the tracks. Chips can fly when removing or installing a track pin. Wear safety glasses and long sleeve protective clothing. Tracks can unroll very quickly when separated. Keep away from front and rear of machine. The machine can move unexpectedly when both tracks (crawlers) are disengaged from the sprockets. Block the machine to prevent it from moving.

Part identification



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1. Bucket
2. Link rod
3. Lever
4. Bucket cylinder
5. Arm
6. Arm cylinder
7. Boom
8. Fuel tank
9. Boom cylinder
10. Counterweight
11. Hydraulic oil tank
12. Crawler
13. Travel motor
14. Canopy
15. Lower roller
16. Idler adjuster
17. Dozer
18. Dozer cylinder
19. Operator’s seat
20. Swing cylinder
21. Control valve
22. Pump
23. Engine
24. Air filter
25. Battery
26. Radiator
27. Muffler
28. Left-hand safety lever
29. Right-hand safety lever (only on models with canopy)
30. Upper structure slewing locking pin

SERVICE MANUAL

Engine

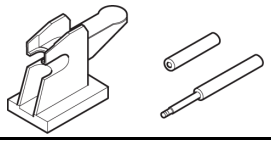
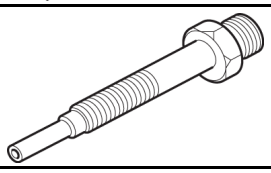
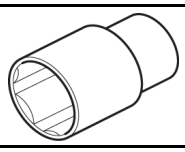
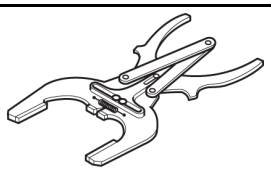
CX15B
CX18B

Engine - General specification

Model				L3E-31KBSA
Main data	Type			In-line, water cooled, 4-cycle diesel engine
	Number of cylinders.			3
	Combustion type			Swirl chamber type
	Valve mechanism			Overhead valve type
	Cylinder bore x stroke			**76 mm** (**2.99 in**) x **70 mm** (**2.76 in**)
	Total displacement			**0.952 l** (**0.25 US gal**)
	Compression ratio			23: 1
	Fuel			Diesel oil (EN590)
	Order of ignition			1-3-2
	Rotating direction			Counterclockwise as viewed from flywheel side
	Dry weight			**71 kg** (**156.53 lb**)
Main components	Piston ring	Number		Compression ring: 2 Oil rings (with expander): 1
	Valve timing (when warm)	Intake valve	Open	BTDC 18°
			Close	ABDC 46°
		Exhaust valve	Open	BBDC 46°
			Close	ATDC 18°
	Starting system			Centrifugal mass start
Fuel system	Fuel injection pump	Type		Bosch NC
		Manufacturer		DENSO CORPORATION
		Piston diameter		ø **5.5 mm** (**0.22 in**)
		Cam lift		**6 mm** (**0.24 in**)
	Governor	Speed governing type		Centrifugal weight system
	Fuel injection nozzle	Type		Nozzle
		Manufacturer		DENSO CORPORATION
		Spray angle		15°
		Valve opening pressure		**13.73 MPa** (**1991.54 psi**)
	Fuel filter	Type		Paper filter element
	Fuel pump	Type		Solenoid fuel pump (compact type)
		Discharge rate		**0.4 l** (**0.11 US gal**)/min or higher (at **12 V** - **1.5 A**)

Engine Model			L3E
Lubrication system	Lubrication system		Pressure feed, full flow filter system
	Engine oil	Specification	Class CD or above oil (API service classification)
		(Engine total) capacity	**3.6 l** (**0.95 US gal**)
	Oil pump	Type	Gear type (internal and external teeth engagement), built into the gear case
		Flow	**3 l** (**0.79 US gal**) l/ **1 min** (**1 min**) or more (at **1000 RPM**)
	Relief valve	Type	Piston valve
		Valve opening pressure	**0.261 - 0.319 MPa** (**37.86 - 46.27 psi**) (**1000 RPM**)
	Oil filter	Type	Paper filter element
Cooling system	Cooling system		Forced-feed circulation type
	Coolant capacity (main engine components)		**1.8 l** (**0.48 US gal**)
	Water pump	Type	Centrifugal volute type
		Discharge rate	**50 l** (**13.21 US gal**) / **1 min** (at pump rotation of **4500 RPM**)
	Thermostat	Type	Wax pellet
		Valve opening pressure	**75 - 78 °C** (**167 - 172 °F**)
	Cooling fan	Type	Push type
		Number of blades/outer diameter	5 equally spaced blades/ **310 mm** (**12.2 in**)
Inlet system	Air cleaner	Type	Paper filter element
Electric	Voltage - polarity		**12 V** - negative (-) ground
	Starter motor	Type	M001T68381
		Manufacturer	Mitsubishi Electric Corporation
		Pinion engagement type	With reduction
		Output	**12 V** - **1.7 kW** (**2.31 Hp**)
		Number	1
		Pinion/ring gear ratio	14/106
	Alternator	Type number	A007TA0171B
		Type	Three-phase current generator, integral with IC regulator
		Manufacturer	Mitsubishi Electric Corporation
		Output	**12 V** - **40 A**
		Rated voltage generating speed	**5000 RPM** (at **13.5 V**, **37 A**, when hot)
		Regulator adjusting voltage	**14.4 - 15 V** (**14 - 15 V**)
	Glow plug	Type	Sheathed
		Rated voltage - current	**11 V** - **8.5 - 10.5 A** (**8.5 - 10.5 A**) (**6 s** duration)
	Stop solenoid	Working voltage	**12 V**
		Insulation resistance	**100 Ω** (**100 Ω**) or higher measured with **500 V** cc (normal temperature, normal relative humidity)
		Stroke	**13 - 14 mm** (**0.51 - 0.55 in**)
		Ambient temperature for use	**-40 - 120 °C** (**-40 - 248.00 °F**)

Engine - Special tools

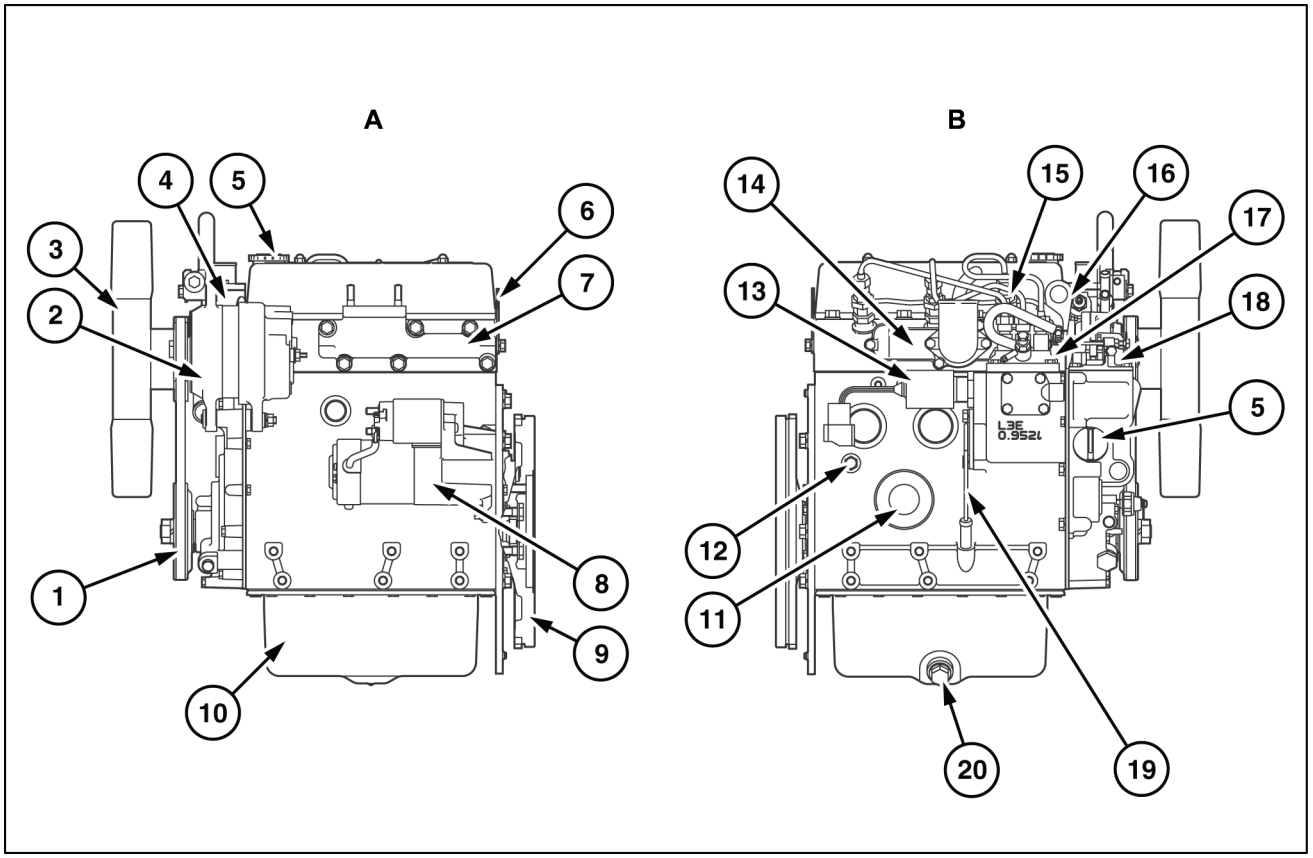
Name	Shape	Function
Piston pin setting tool.		For pulling out and press fitting piston pins.
Compression gauge adapter.		For measuring compression.
Oil pressure switch key **(26)**.		For removing and installing oil pressure switch.
Piston ring pliers.		Range applicable for removing and installing piston rings: **60 - 95 mm** (**2.36 - 3.74 in**)

Engine - General specification

Engine model		L3E-31KBSA	
Type		Water-cooled, 4-stroke engine with swirl chamber	
No. of cylinders - Bore x stroke		3 - **76 mm** (**2.99 in**) x **70 mm** (**2.76 in**)	
Total displacement		**952 ml** (**32.2 US fl oz**)	
Compression ratio		23:1	
Rated output		**11.2 kW** (**15 Hp**) at **2100 RPM**	
Maximum torque		**53.5 N·m** (**39.5 lb ft**) at **1800 RPM**	
Minimum RPM		**1350 - 1410 RPM**	
Maximum RPM		**2250 - 2300 RPM**	
Rated fuel consumption		**270 - 280 g/kWh**	
Allowable tilting angles		Continuous, 25° in all directions	
Rotating direction		Counterclockwise as viewed from flywheel side	
Order of ignition		1-3-2-1	
Fuel injection pressure		**13.7 MPa** (**1987 psi**)	
Valve action		Open	Close
	Intake valve	Before T.D.C. 18°	After B.D.C. 46°
	Exhaust valve	Before B.D.C. 46°	After T.D.C. 18°
Thermostat action		**75 - 78 °C** (**167 - 172 °F**)	
Lubrication oil pressure		**0.29 MPa** (**42 psi**) at **1000 RPM**	
Dimensions L x D x H		**478 mm** (**18.82 in**) x **400 mm** (**15.75 in**) x **532 mm** (**20.94 in**)	
Dry weight		**71 kg** (**157 lb**)	
Injection governor		Mechanical centrifugal governor (all speed types)	
Fuel filter		Paper filter element	
Lubrication system		Forced lubrication with trochoid pump	
Cooling system		Coolant/Radiator	
Starter motor capacity		**12 V** x **1.7 kW** (**2.31 Hp**)	
Battery capacity		**12 V** x **45 A**	
Starting aid		Glow plug (DC **11 V** - **9.5 A**)	
Cooling water capacity: maximum/engine		**3.7 l** (**0.98 US gal**)/ **1.8 l** (**0.48 US gal**)	
Engine oil volume: maximum/real		**3.6 l** (**0.95 US gal**)/ **2.2 l** (**0.58 US gal**)	

Engine - Component identification

Main components



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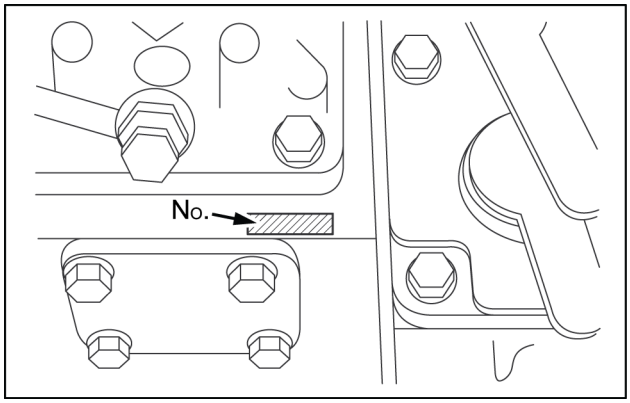
A. Left side view
B. Right side view
1. Belt
2. Alternator
3. Fan
4. Thermostat
5. Oil filler
6. Eyebolt
7. Exhaust manifold
8. Starter motor
9. Flywheel
10. Oil pan
11. Oil filter
12. Water drain plug
13. Stop solenoid
14. Intake manifold
15. Fuel injection nozzle
16. Eyebolt
17. Fuel injection pump
18. Water pump
19. Engine oil dipstick
20. Oil drain plug

Engine serial number

The engine serial number (No.) is stamped on the injection pump mount (upper side of tie rod cover) of the cylinder block.



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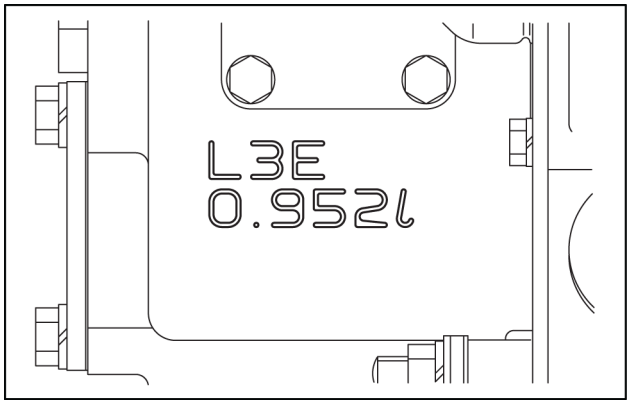
Engine model and total displacement

The engine type and displacement are stamped on the side of the injection pump mount of the cylinder block.



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Engine - Service instruction

Break-in operation

After the engine is overhauled, couple the engine to the dynamometer, and run the engine for break-in operation and inspection.

Starting up

Before starting the engine, check the level of coolant, engine oil and fuel.

Bleed air from the fuel system and cooling system.

Stop fuel supply and start the engine with the starter motor for about **10 s** to lubricate the engine.

Move the control lever slightly in the fuel increase direction (but not to the “full injection” position), and then turn the starter switch key to the “START” position to start the engine.

After the engine is started, adjust the control lever to let the engine operate at a minimum no-load speed (low idle speed).

Turn the starter switch key to the “OFF” position and make sure that the engine is stopped.

Inspecting engine condition after starting up

During the break-in operation, check the following. If any abnormality is found, stop the engine, investigate the cause, and take appropriate measures.

The oil pressure must be within the specified value.

The coolant temperature must be within the specified value.

The engine must be free from any leakages such as oil, coolant and fuel. Pay special attention to oil leakage from the fitting face of turbocharger lube oil pipe.

Check for an abnormal noise.

NOTE: *Knocking noise will disappear as the coolant temperature rises.*

Check for the colour of smoke and odours.

Break-in operation time

The relationship between the load in break-in operation and the operation time is as shown below.

Break-in operation time				
	Engine speed		Load	Duration
1.	Low rotation speed	**600 - 900 RPM**	No load	**5 min**
2.	Medium rotation speed	**1000 - 1200 RPM**	No load	**5 min**
3.	High rotation speed	**1400 RPM** to rated rotation speed	No load	**10 min**
4.	Rotation speed		25%	**10 min**
5.			50%	**10 min**
6.			75%	**30 min**
7.			100%	**20 min**

NOTICE: *The table above is provided solely for reference purpose. Run the engine at appropriate speed and load for the break-in operation of your engine. Be sure to perform break-in operation after overhaul or installation.*

Inspection and adjustment after break-in operation

Valve clearance adjustment.

Ignition timing inspection.

Exterior bolt and nut tightness check.

Performance test (standard jis)

The following describes the procedures specified in “Earth moving machinery - Engines - Part 1: Test code of net power (**JIS D0006-1**)” and “Earth moving machinery - Engines - Part 2: Standard format of specifications and testing methods of diesel engines (**JIS D0006-2**)”.

Other test items may be required in some applications. All test results should be evaluated comprehensively in order to determine the engine performance.

Engine equipment condition

The engine must be equipped with standard auxiliary devices such as cooling fan, air cleaner and alternator.

Test items and purposes

Operation load test

Conduct this test to evaluate the engine output, torque, fuel consumption rate and governor performance under various load conditions.

Continuous load test

Operate the engine continuously for **10 h** at 90% load (continuous load application) of nominal net brake power while the engine speed is maintained at revolutions corresponding to the nominal brake power. In this test, evaluate the fuel consumption rate and operating condition, and confirm that the engine is capable of continuous operation.

Low idle test

Conduct this test to confirm that the engine can operate stably at the specified low idle speed.

Other inspections

Check for gas, coolant an oil leaks, anomalousodours and hunting. Make adjustment as needed.

Engine output adjustment

Diesel engine output is affected by atmospheric pressure, temperature and humidity. Therefore, correction calculations must be performed to obtain the value of engine output under the standard atmospheric conditions.

Standard atmospheric conditions:

Base temperature: **25 °C** (**77 °F**)

Total pressure: **100 kPa** (**15 psi**)

Dry pressure: **99 kPa** (**14 psi**)

Calculation of corrected power

Multiply the measured braking power or braking torque value for the diesel engine correction coefficient.

If the applicable range of the correction formula is exceeded, indicate the corrected values and record the test conditions on the test record.

<table>
<tr><td colspan="2">Calculation output = Correction factor (α_c) x measured brake power</td></tr>
<tr><td colspan="2">Atmospheric conditions during test
Temperature (T): 10 °C (50 °F)≤ (T) ≤(40 °C (104 °F))
Dry atmospheric pressure (P_d): 80 kPa (12 psi) ≤ (P_d) ≤ 110 kPa (16 psi)
$\alpha_c = (f_a)^{fm}$ f_a :atmospheric factor f_m : engine factor
Range of correction equation use
The range of correction factor (α_c) is as follows: $0.9 \le \alpha_c \le 1.1$</td></tr>
<tr><td>Calculation of correction factor (f_a)
Natural aspiration engine and engine with mechanically driven air charger
$f_a = (99/P_d) \cdot (T/298)^{0.7}$

Turbocharged engine without air cooler or with air-to-air cooler
$f_a = (99/P_d)^{0.7} \cdot (T/298)^{1.2}$

Turbocharged engine with air-to-liquid cooler
$f_a = (99/P_d)^{0.7} \cdot (T/298)^{0.7}$</td><td>Calculation of engine factor (f_m)
$f_m = 0.036\ q_c - 1.14$
q_c : corrected fuel supply volume
$q_c = \frac{q}{r}$
$q = \frac{(z) \times (\text{Fuel flow rate g/s})}{(\text{Stroke volume l}) \times (\text{Engine speed RPM})}$
z= 120000 (4-cycle engine)
r: ratio between turbocharger pressure or air cooling outlet and atmospheric pressure (r=1 for natural suction engine)
Applicable range of engine factor (f_m)
$37.2 \le q_c$: ≤ 65 mg (0.023 oz)/(l x cycle)
$q_c \le$ 37.2 mg (0.0 oz)/(l x cycle): $f_m = 0.2$ (constant)
65 mg (0.023 oz)/(l x cycle) ≤ q_c : $f_m = 1.2$ (constant)</td></tr>
</table>

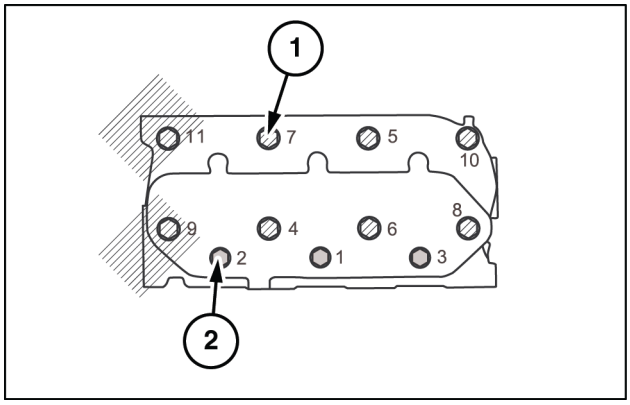
Engine - Adjust

Inspection and adjustment of valve clearance

Preparation for valve clearance adjustment

1. Inspect and adjust the valve clearance when the engine is cold.
2. Slightly loosen the cylinder head screws (1 main screw) and (2 secondary screws) and tighten them to the specified torque in the order shown in the figure (following the numbers).

NOTE: *Be careful that the tightening torque of cylinder head bolts is different between main bolts and sub bolts.*
Screws **(1)** = tightening torque **73.5 - 83.4 N·m** (**54.2 - 61.5 lb ft**)
Screws **(2)** = tightening torque **19.6 - 29.4 N·m** (**14.5 - 21.7 lb ft**)



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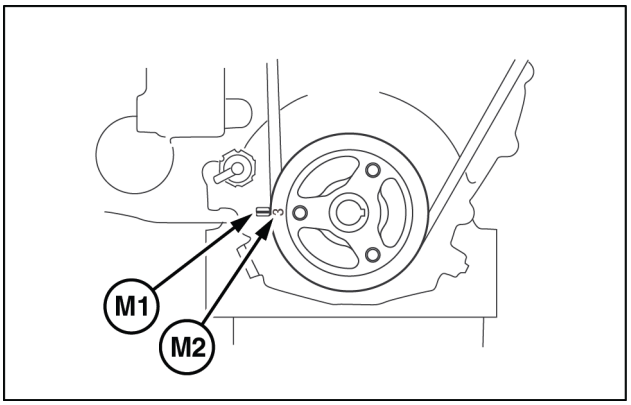
Valve clearance check

1. Set cylinder No. 1 to the top dead center in compression stroke.
   This position is where the TDC mark **(M2)** on the crankshaft pulley aligns with the mark on the gear case **(M1)**.

NOTE: *The compression top is where the rocker arm does not move when the crankshaft is rotated in the forward and backward direction by both 20° approximately.*
If the rocker arm moves, it is the top dead center in exhaust stroke. Rotate the crankshaft another full turn to set the No. 1 cylinder to the top dead center in compression stroke.
Order of ignition: 1-3-2
Turning angle: 240°



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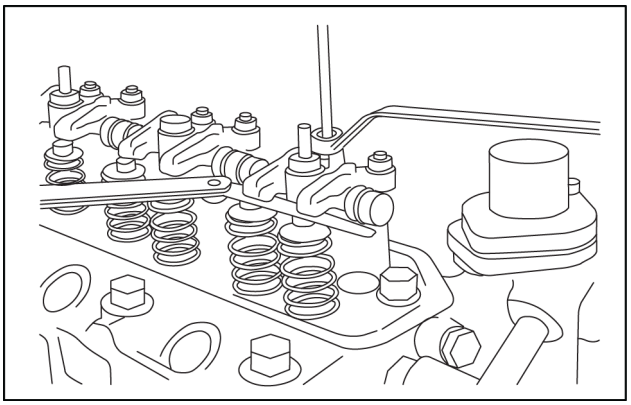
2. Start adjusting the valve clearance from the No. 1 cylinder and adjust the valve clearance of other cylinders according to the ignition order.

NOTE: *To set the next cylinder to the compression top after adjustment of No. 1 cylinder, rotate the crankshaft in the forward direction (clockwise toward the timing gear case) by the angle corresponding to the number of cylinders.*

3. Insert a thickness gauge between the rocker arm and bridge cap. Turn the adjusting screw while measuring the clearance, and adjust the clearance so that the thickness gauge can move with slight stiffness.

4. After adjustment, tighten the lock nut firmly. Then, check the clearance again.



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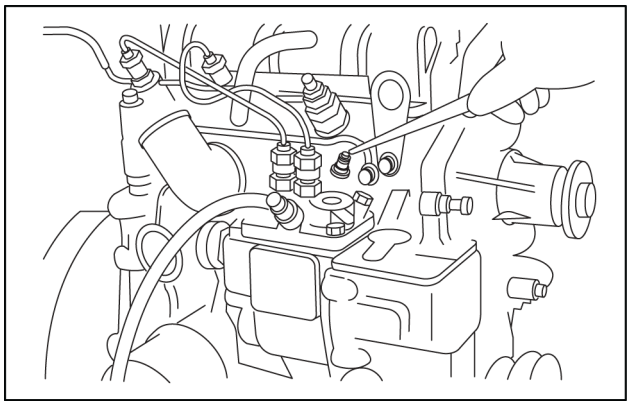
Item		Standard
Valve clearance	Inlet	**0.25 mm** (**0.010 in**)
	Drain	**0.25 mm** (**0.010 in**)

Inspecting fuel injection timing

NOTICE: *To prevent the outflow of fuel, stop the fuel supply before removing the delivery valve.*

1. The fuel injection timing varies with the output, speed and other engine specifications. Be sure to check the engine's specification sheet.
2. Remove the No. 1 fuel injection pipe.
3. Remove the No. 1 delivery valve of the fuel injection pump, and install the holder.



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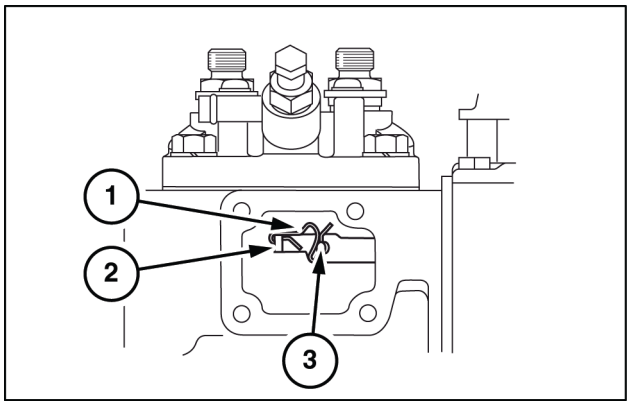
4. Remove the cover.
5. Remove the clip **(1)** and disconnect the rod **(2)** from the control crosspiece **(3)**.
6. Place the control crosspiece **(3)** in medium position with respect to the operating stroke.
7. Feed fuel from the fuel hose and check that the fuel flows out from the delivery holder.
8. Rotate the crankshaft forward (clockwise). The fuel injection timing is the moment when the fuel stops flowing from the delivery valve holder outlet.



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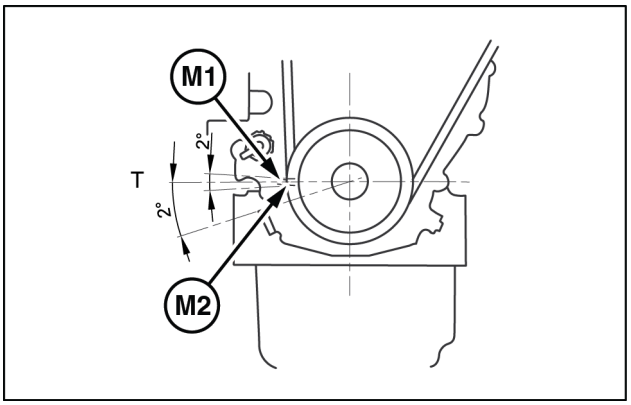
Adjusting fuel injection timing

1. Check that the fuel injection timing (T) meets the specified fuel injection timing at the position where the injection timing mark **(M2)** on the crank pulley is aligned with the mark **(M1)** on the gear case.
2. If the fuel injection timing does not meet the specified value, increase or decrease the thickness of the fuel injection pump adjusting shim to adjust the timing.

NOTE: *A change in thickness of the shim by* ***0.1 mm*** *(****0.004 in****) results in a change in the fuel injection timing by approximately 1°.*
There are nine kinds of shims from ***0.2 - 1.0 mm*** *(****0.01 - 0.04 in****).*



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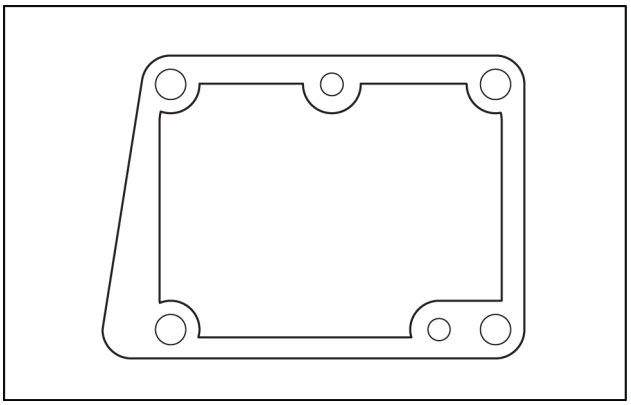
Adjusting value	Standard value ± 1.5°

With the delivery valve installed, check the fuel in ejection timing as follows:

1. Remove the tie rod cover and disconnect the tie rod from the control rack.
2. Set the control rack to the medium position in the operating range and then remove the No. 1 fuel injection pipe on the nozzle side.
3. When the crankshaft is gradually rotated, fuel begins to swell at the tip of the pipe. This timing is the fuel injection timing. In this case, the timing is delayed by 1° as compared to the normal fuel injection timing.



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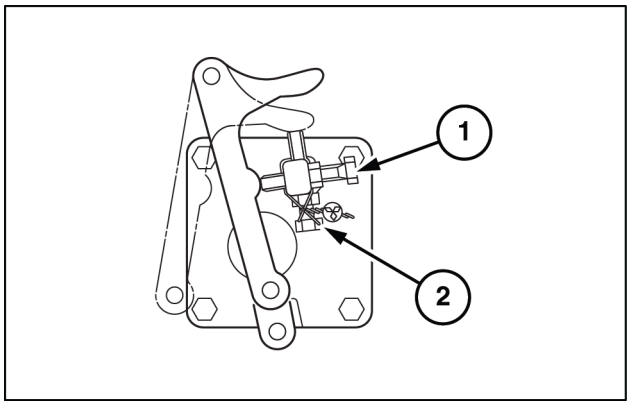
RPM check and adjustment

NOTICE: *The minimum no-load speed (low idle speed) and the maximum no-load speed (high idle speed) of each engine have been checked on test bench and then their setting bolts have been sealed at the factory. Only the service shops designated by Mitsubishi are authorized to perform checking and adjusting of these settings.*
Be sure to seal all the external stoppers in the same manner as they were sealed at the factory if adjustments have been made on the governor.
Whether the seals are intact or not has important effect on the validity of claims under warranty. Be sure to seal all of the specified locations.
When inspecting and adjusting the governor, be prepared to operate the engine stop lever manually in anticipation of engine overrunning.



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Adjust speed after engine preheating (coolant temperature of **60 °C** (**140 °F**) or higher).

1. To adjust the engine speed, remove the cooling fan and pay attention to the rotating part.
2. During engine operation for speed adjustment, check for leakages of gas, water, oil and fuel.
3. Adjust the high idling speed with the high-speed set bolt **(2)**. Note that the high-speed set bolt **(2)** is sealed at the factory before shipment. Do not make an adjustment unless absolutely necessary. Do not remove the torque spring set from the front plate unless necessary.
4. Adjust the engine low idling speed with the low idle set bolt **(1)**.
5. Do not remove the sealing cap to adjust the torque spring set.
6. After adjustment, perform an acceleration and deceleration test to check for hunting and smoke condition.

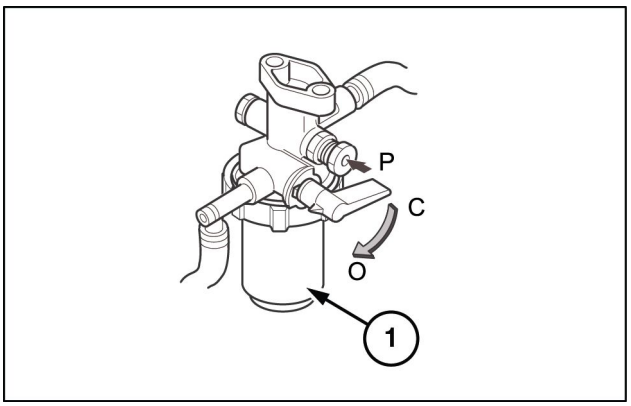
Bleeding fuel system

NOTICE: *Completely wipe off any spilled fuel from air vent screws with a cloth or the like, as spilled fuel can cause a fire.*

Bleeding of the fuel system must be carried out closest to the fuel tank: bleed the fuel filter first, then the injection pump.

Air bleeding from fuel filter

1. Deliver fuel by solenoid pump.
2. Place the cock of the fuel filter in the “OPEN” position (O).
3. Press (P) and hold the button until the filter body cup **(1)** is filled with fuel.
4. Stop the fuel supply.



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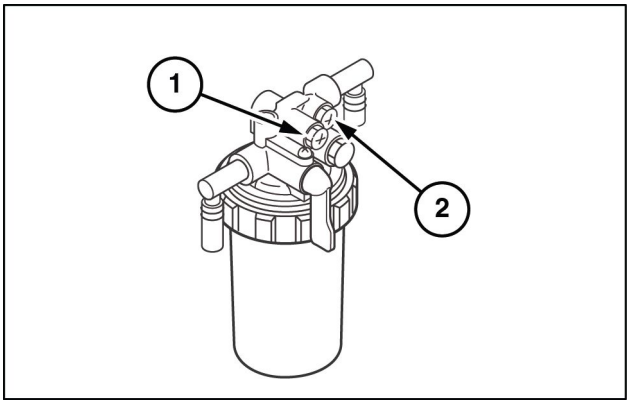
Air bleeding from water separator

1. Loosen the water separator’s bleed plug for fuel supply **(1)**.
2. Deliver fuel by solenoid pump.
3. Tighten air bleed plug for fuel inlet when the fuel flow from the air bleed plug becomes free of bubbles.
4. Loosen air bleed plug for fuel outlet **(2)**.
5. Tighten air bleed plug for fuel outlet when the fuel flow from the air bleed plug becomes free of bubbles.
6. Stop the fuel supply.



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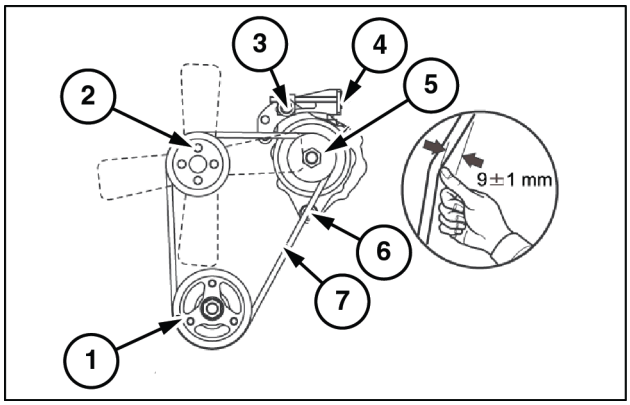
Belt tension adjustment

1. Loosen the adjusting screw **(4)** and the screw **(6)**. Loop the belt **(7)** around the water pump pulley **(2)**, the alternator pulley **(5)** and the crankshaft pulley **(1)**.
2. Adjust the adjusting screw **(4)** so that the belt **(7)** tension meets the specified value.



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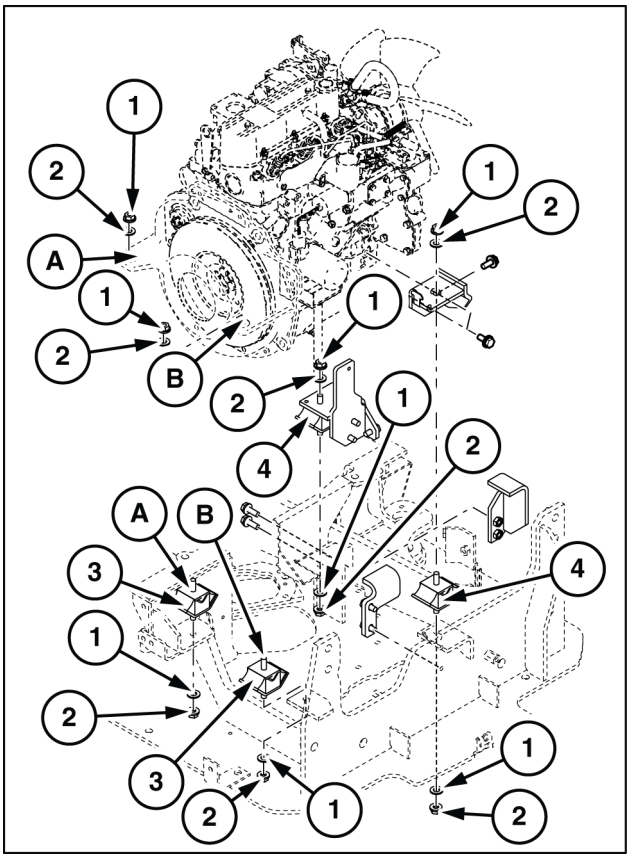
Belt deflection (with push force of approximately **44 - 54 N·m** (**32 - 40 lb ft**)	Approximately **10 mm** (**0.39 in**)

Engine - Remove

1. Remove the side guard and the engine guard.
2. Remove the battery.
3. Remove the counterweight.
4. Remove the air filter.
5. Remove the exhaust gas muffler.
6. Remove the radiator.
7. Remove the pump or disconnect the hoses connected to the pump.
8. Disconnect the hoses of the fuel system.
9. Disconnect any hose connected to the engine.
10. Disconnect the cable of the starter motor (M-1).
11. Disconnect the connector from the generator (E-2).
12. Disconnect the terminals for the water temperature sensor (SW-5) and oil pressure switch (SW-6).
13. Disconnect the terminal of the glow plugs (E-8).
14. Disconnect the terminal of the ground cable (H-6).
15. Loosen and remove the nuts **(1)** with the relevant washers **(2)** fastening the engine **(5)** to the rubber supports **(3)** and **(4)**.
16. Pass a steel wire or rope through the two lifting eyes, located on the top of the engine and lift the engine. Engine weight: approximately **71 kg** (**157 lb**).



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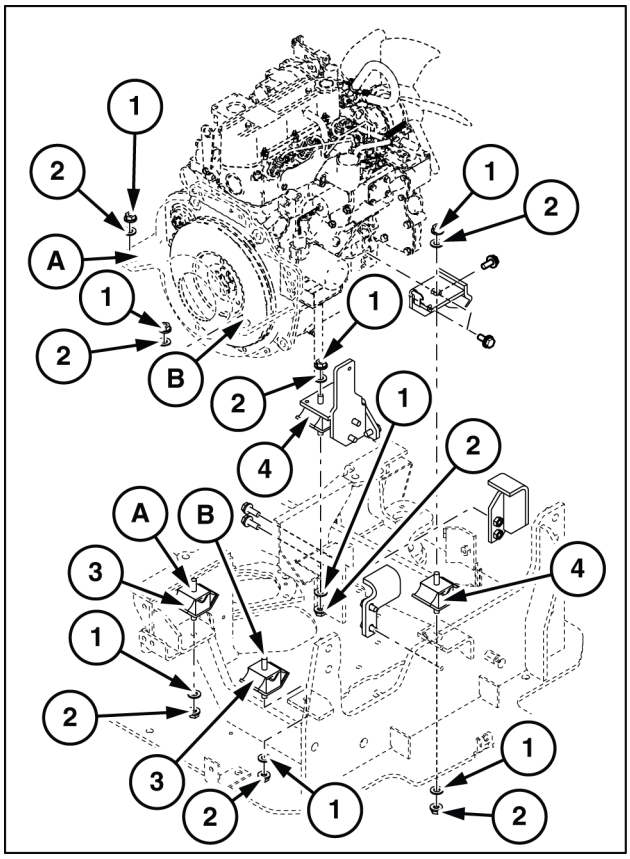
Engine - Install

Install the engine in reverse order of the removal.
Tightening torque of nuts **(1)**= **34 N·m** (**25 lb ft**)



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Engine - Overhaul

Determining overhaul timing

In most cases, the engine should be overhauled when the compression pressure of the engine becomes low. An increase in engine oil consumption and blow-by gas are also considered to evaluate the engine condition. Besides, also symptoms such as a decrease in output, an increase in fuel consumption, a decrease in oil pressure, difficulty in starting the engine and an increase in noise are also considered to evaluate an overhaul, although these symptoms are often influenced by other causes, and are not always useful to evaluate the overhaul timing. Decreased compression pressure shows a variety of symptoms and engine conditions, thus making it difficult to accurately determine when the engine needs an overhaul. The following shows typical problems caused by reduced compression pressure.

1. Decreased output power
2. Increased fuel consumption
3. Increased engine oil consumption
4. Increased blow-by gas through the breather due to worn cylinder liners and piston rings (Visually check the blow-by amount)
5. Increased gas leakage due to poor seating of inlet and exhaust valves
6. Difficulty in starting
7. Increased noise from engine parts
8. Abnormal exhaust colour after warm-up operation

The engine can exhibit these conditions in various combinations. Some of these problems are directly caused by worn engine parts, while others are not. Phenomena described in items **(2)** and **(6)** will result from improper fuel injection volume, fuel injection timing, worn plunger, faulty nozzles and also faulty electrical devices such as battery and starter motor. The most valid reason to overhaul an engine is a decrease in compression pressure due to worn cylinder liners and pistons, as described in item **(4)**. In addition to this item, it is reasonable to take other problems into consideration for making the total judgment.