DX60R

Shop Manual

K1042957E

Serial Number 50001 and Up

DOOSAN reserves the right to improve its products continuously, delivering the best possible product to the marketplace. These improvements can be implemented at any time with no obligation to change materials previously sold. It is recommended that consumers periodically contact their distributors for most recent documentation on purchased equipment.

This documentation may include attachments and optional equipment not available in your machine's package. Please call your distributor for additional items that you may require.

Illustrations used throughout this manual are used only as a representation of the actual piece of equipment, and may vary from the actual item.

K1042957E Shop Manual

Table of Contents

Track Excavator Safety

UNAUTHORIZED MODIFICATIONS

Any modification made without authorization or written approval from DOOSAN can create a safety hazard, for which the machine owner will be held responsible.

For safety's sake, replace all OEM parts with the correct authorized or genuine DOOSAN part. For example, not taking the time to replace fasteners, bolts or nuts with the correct replacement parts could lead to a condition where the safety of critical assemblies are dangerously compromised.

GENERAL HAZARD INFORMATION

Safety Rules

Only trained and authorized personnel can operate and maintain the machine.

Follow all safety rules, precautions and instructions when operating or performing maintenance on the machine.

Do not operate the machine if you are not feeling well, if you are taking medication that makes you feel sleepy, if you have been drinking, or if you are suffering from emotional problems. These problems will interfere with your sense of judgment in emergencies and may cause accidents.

When working with another operator or with a person on work site traffic duty, be sure that all personnel know the nature of the work and understand all hand signals that are to be used.

Always observe strictly any other rules related to safety.

Safety Features

Be sure that all guards and covers are installed in their proper position. Have guards and covers repaired immediately if damaged.

Be sure that you understand the method of use of safety features such as safety lock lever and the seat belt, and use them properly.

Never remove any safety features. Always keep them in good operating condition.

Failure to use safety features according to the instructions in the Operation and Maintenance Manual could result in serious bodily injury.

Avoid operating your machine too close to the edge of cliffs, overhangs, and deep ditches. The ground may be weak in such areas. If the ground collapses, the machine could fall or tip over resulting in serious injury or death.

Remember that soil after heavy rain, blasting or after earthquakes, is weakened.

Newly laid earth and the soil near ditches is typically loose. It can collapse under the weight of vibration of your machine and cause your machine to tip over.

Install the head guard (FOPS) if working in areas where there is a danger of falling rocks.

Checks Before Starting Engine

Every day before starting the engine for the first time, carry out the following checks. If these checks are not carried out properly, there is a danger of serious injury.

Remove all wood chips, leaves, grass, paper and other flammable materials accumulated in the engine compartment and around the battery. They could cause a fire. Remove any dirt from the window glass, mirrors, handrails, and steps.

Do not leave tools or spare parts laying around in the operator's cabin. The vibration of the machine when traveling or during operations may cause them to fall and damage or break the control levers or switches. They may also get caught in the gap of the control levers and cause the work equipment to malfunction or move dangerously. This may lead to unexpected accidents.

Check the coolant level, fuel level, and hydraulic tank oil level, and check for clogged air cleaner and damage to the electrical wiring.

Adjust the operator's seat to a position where it is easy to operate the machine, and check the seat belt and mounts for damage and wear.

Check the operation of the gauges and the angle of the mirrors, and check that the safety lever is in "LOCKED" position.

If any abnormalities are found in the above checks, carry out repairs immediately.

Warning Tag

Alert others that service or maintenance is being performed and tag operator's cabin controls – and other machine areas if required – with a warning notice. OSHA mandated control lever lockout can be made with any OSHA certified lockout device and a length of chain or cable to keep the safety lever in the fully lowered, nonactive position.

Warning tags, for controls are available from DOOSAN distributors.

FG012195

Figure 29

Clean Before Inspection or Maintenance

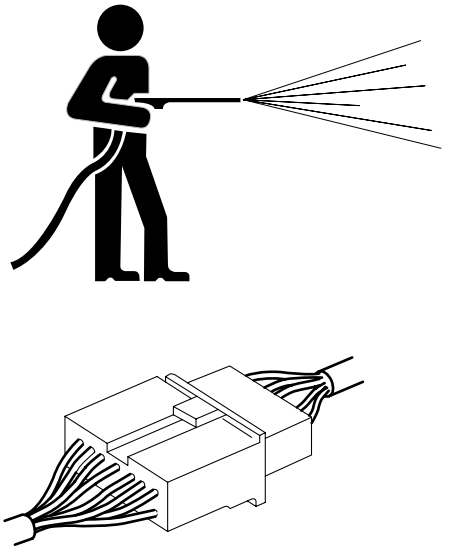
Clean the machine before carrying out inspection and maintenance. This prevents dirt from getting into the machine and ensures safety during maintenance.

If inspection and maintenance are carried out when the machine is dirty, it will become more difficult to locate the problems, and there is a danger that you may get dirt or mud in your eyes or that you may slip and injure yourself.

When washing the machine, do the following:

- Wear shoes with nonslip soles to prevent yourself from slipping and falling on wet places.
- Wear safety glasses and protective clothing when washing the machine with high-pressure steam.
- Take action to prevent touching high-pressure water and cutting your skin or having mud fly into your eyes.
- Do not spray water directly on electrical components (sensors, connector) (1, Figure 30). If water gets into the electrical system, there is a danger that it will cause defective operation and malfunction.

Pick up any tools or hammers that are laying in the workplace, wipe up any grease or oil or any other slippery substances, and clean the area to make it possible to carry out the operation in safety. If the workplace is left untidy, you may trip or slip and suffer injury.



ARO1330L

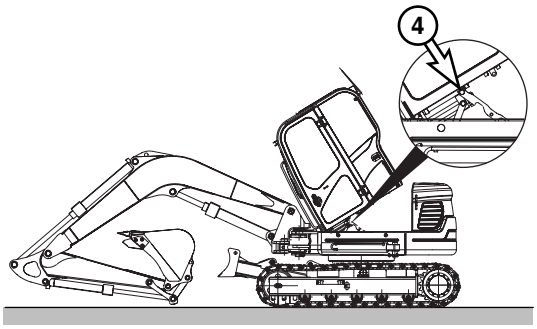
Figure 30

7. When cabin is raised to its proper angle, lower safety bar (4) and secure it to the main frame.

WARNING

Make sure that safety bar is secured before operating.

Do not replace tilting mechanism components with cabin tilted. (This may result in machine damage or personal injuries.)



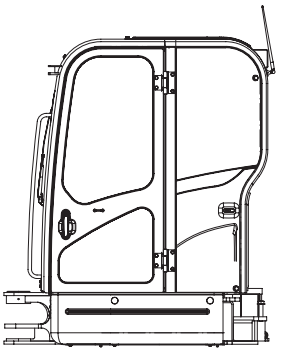
FG012421

Figure 47

8. Follow this procedure in reverse order when finished.

WARNING

1. **Make sure there is nothing between cabin and main frame. This includes tools used for servicing machine or used to raise cabin.**
2. **Watch cabin until it is resting on main frame.**
3. **After releasing safety bar immediately lower cabin. Do not leave cabin raised with safety bar removed.**



FG012422

Figure 48

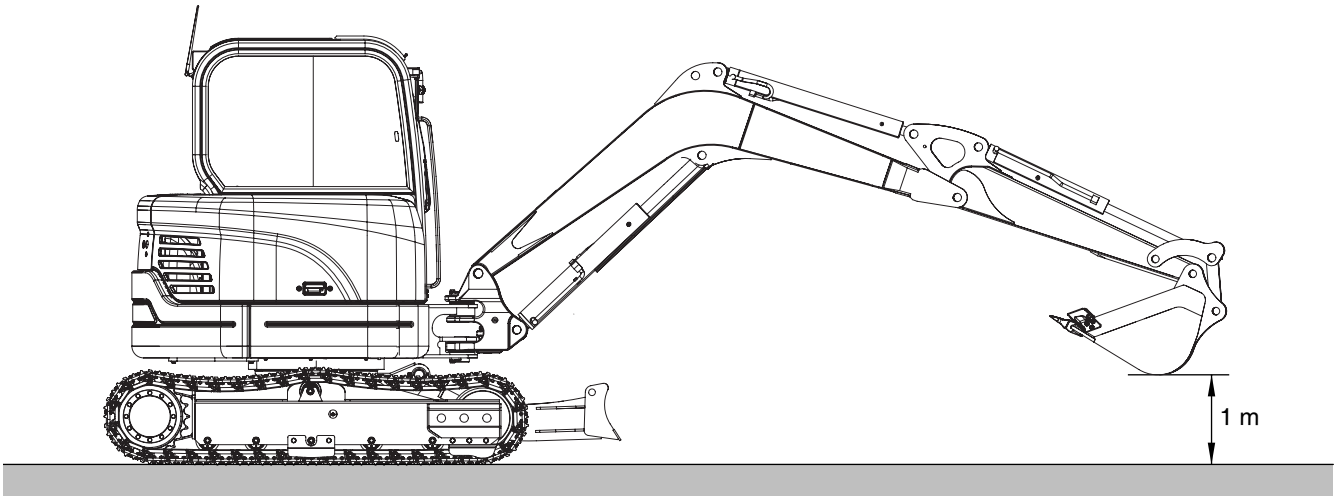
Table of Contents

Specification for DX60R

DIM.	BOOM TYPE	2.9 m (9' 6") BOOM	
	ARM TYPE	1.48 m (4' 10") ARM	1.9 m (6' 3") ARM
	BUCKET TYPE (PCSA / CECE)	0.175 m^3 (0.229 yd^3) / 0.151 m^3 (0.197 yd^3)	
A	Max. Digging Reach	6,130 mm (20' 1")	6,500 mm (21' 4")
B	Max. Digging Reach (Ground)	6,005 mm (19' 8")	6,380 mm (20' 11")
C	Max. Digging Depth	3,725 mm (12' 3")	4,145 mm (13' 7")
D	Max. Loading Height	3,940 mm (12' 11")	4,125 mm (13' 6")
E	Min. Swing Radius	2,415 mm (7' 11")	2,500 mm (8' 2")
F	Max. Digging Height	5,685 mm (18' 8")	5,855 mm (19' 2")
G	Max. Bucket Pin Height	4,830 mm (15' 10")	5,010 mm (16' 5")
H	Max. Vertical Wall Depth	3,095 mm (10' 2")	3,165 mm (10' 5")
I	Max. Radius Vertical	3,870 mm (12' 8")	4,415 mm (14' 6")
J	Max. Depth to 8 ft Line	3,320 mm (10' 11")	3,770 mm (12' 4")
K	Min. Radius 8 ft Line	1,115 mm (3' 8")	1,050 mm (3' 5")
L	Min. Digging Reach	485 mm (1' 7")	0 mm (0' 0")

Swing Speed and Deceleration Force Test

Swing Speed Test



FG013215

Figure 6

Extend the bucket cylinder completely and retract the arm cylinder, as shown in Figure 6, to test swing speed. The lowest point of the bucket will be approximately 1.0 m (3') off the ground.

Use paint marks at the same point on the turntable and undercarriage, or select alternate measuring locations and use a stopwatch to time 3 full 360° rotations. The time required for 3 revolutions should be between 17.4 and 19.4 seconds.

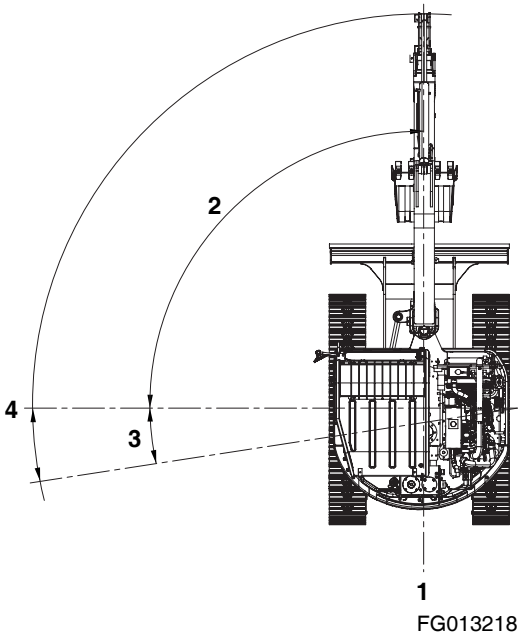
Swing Deceleration Force Test

With the boom, arm and bucket in the same position as for the swing speed test, rotate the turntable so the boom is evenly centered between the side frames, pointing straight ahead. Locate the 90° reference point, perpendicular to the boom. Mark the turntable and undercarriage with paint at the 90° point.

Make several attempts to rotate the turntable exactly 90°, starting from the boom straight ahead position. Engage the swing lever and brake at the 90° point, shown as "swing stop" in Figure 7.

Record how far the turntable drifts past the stop point, measuring the distance between paint marks. Maximum distance should be less than 260 mm (10-1/4").

Reference Number	Description
1	Start Swing
2	90° Swing
3	Swing Force
4	Swing Stop



FG013218

Figure 7

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling the load.

Remember that ultimate safety is your own responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
ALL MODELS	ALL RANGES

bearing alone without replacing the mating cup or the cone at the same time.

After inspection lightly coat the bearing and related parts with oil and wrap in a clean lintless cloth or paper and protect them from moisture and other foreign materials until installation.

It is also important to inspect the bearing housing and/or shaft for grooved, galled or burred conditions that indicate the bearing has been turning in its housing or on its shaft.

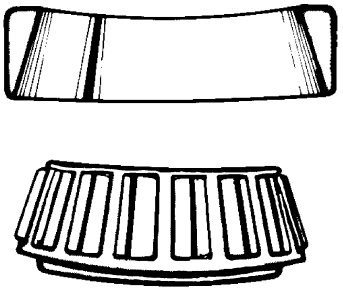
If available, use magna-flux or similar process for checking for cracks that are not visible.

The following illustrations will aid in identifying and diagnosing some of the bearing related problems.

NOTE: *The illustrations will only show tapered roller bearings, but the principles of identifying, diagnosing and remedying the defects are common to all styles and types of bearings.*

Normal Bearing

Smooth even surfaces with no discoloration or marks.

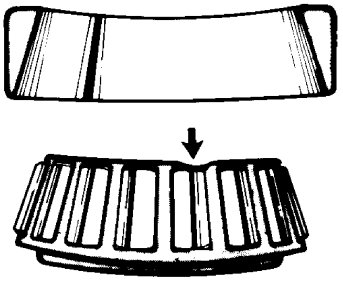


HASA620S

Figure 2

Bent Cage

Cage damage because of improper handling or tool usage.



HASA460S

Figure 3

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling load.

Remember that ultimate safety is your own personal responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
ALL MODELS	ALL RANGES

IV. "Loctite" retaining compounds

Product	Application	Color	Notes
609	For bushings, sleeves, press fit bearings, splines and collars. For gaps to 0.0002 mm (0.005"), temperatures to 121°C (250°F).	Green	Use Locquic "N" primer for increased bond strength and all cold temperature applications.
620	For high temperatures to 232°C (450°F).	Green	Same as 609, above.
680	For high strength bonds and tight clearance gaps, to 0.00008 mm (0.002").	Green	Same as 609, above.

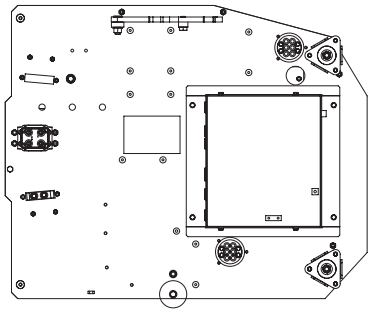
V. "Loctite" Adhesives

Product	Application	Color	Notes
380	Black Max instant adhesive for shock and vibration-resistant bonds.	Black	May take 120 hours to reach full cure strength.
454	Adhesive for porous surfaces.	Clear	Full strength in 24 hours.
480	Increased strength (+50%), shock and vibration-resistant.	Black	Full strength in 24 hours.

12. Tilt up cabin.
    Remove a bolt (Figure 2).
    Disconnect pilot hoses as required.
    Tilt down cabin.

    NOTE: *Please refer to cabin tilting.*

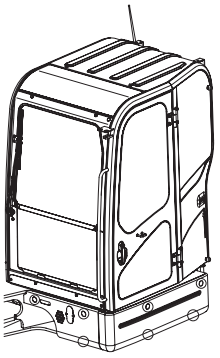
    NOTE: *Be careful about hydraulic oil leak.*



FG013471

Figure 2

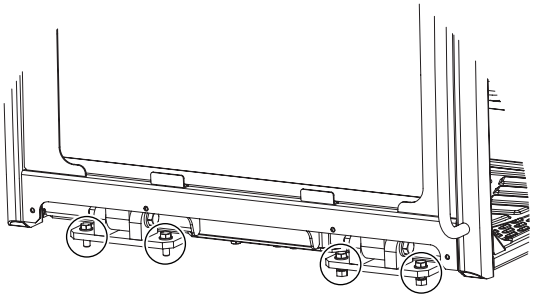
13. Remove seven M8 bolts Then open side cover of main frame (Figure 3).
    Remove front pivot bracket four bolts (M12) and washers outside of cabin (Figure 4).
    Remove two M16 bolts and washers to split tilting lever from main frame (Figure 5).



FG013818

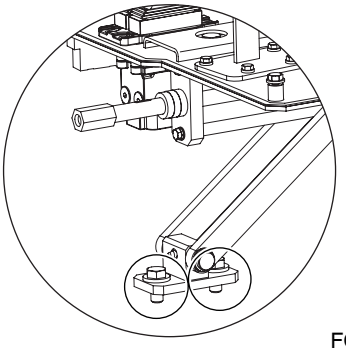
Figure 3

14. Remove floor mat.



FG013823

Figure 4



FG013822

Figure 5

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling the load.

Remember that ultimate safety is your own responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX60R	50001 and Up

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling the load.

Remember that ultimate safety is your own responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX60R	50001 and Up

LOWER ROLLER

Steel Track

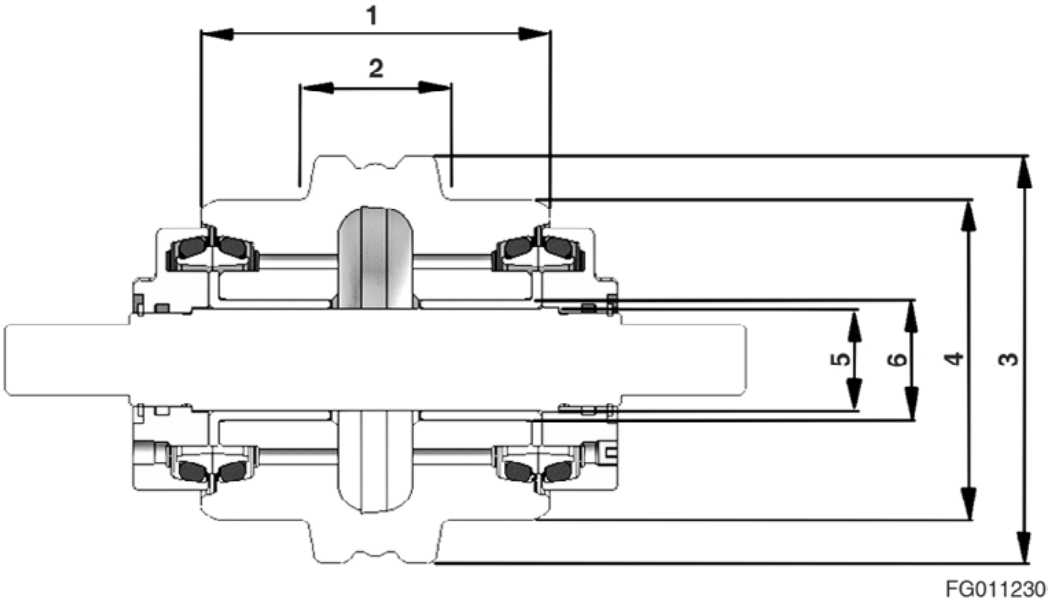
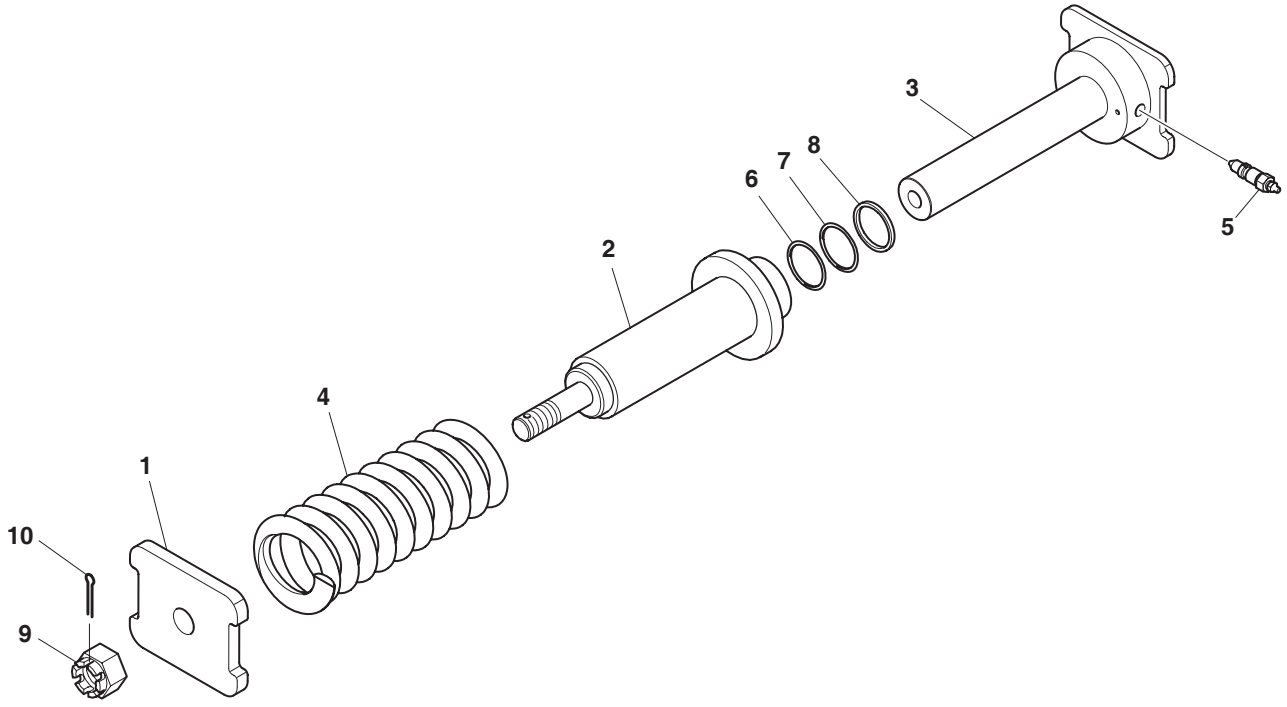


Figure 15

No.	Item	Standard			Limits	Remarks
1	Body Length	120.0 mm (4.72 in)			-	-
2	Flange Width	46.6 mm (1.83 in)			40.6 mm (1.59 in)	Repair
3	Diameter of Flange	140 mm (5.5 in)			-	-
4	Diameter of Link	110 mm (4.33 in)			102 mm (4.02 in)	Repair
5	Shaft-Bushing Clearance	Standard dimension	Tolerance		Standard Clearance	Allowable wear limit
			Shaft	Hole		
		35 mm (1.38 in)	34.95	35.36	Max: 0.44	Undefinable
			34.925	35.22	Min: 0.27	
6	Body-Bushing Press Fit	Standard dimension	Tolerance		Standard Fit	Allowable wear limit
			Bushing	Hole		
		41.15 mm (1.6 in)	41.15	41.18	Max: -0.15	Nonoccurrence
			41.1	41.15	Min: -0.07	

TRACK TENSION ADJUSTING CYLINDER

Parts List



FG013472

Figure 31

Reference Number	Description
1	Flange
2	Cylinder
3	Rod
4	Spring
5	Valve

Reference Number	Description
6	U-packing
7	Back up Ring
8	Dust Ring Nok DSI-50
9	Nut
10	Split Pin

Engine

Edition 1

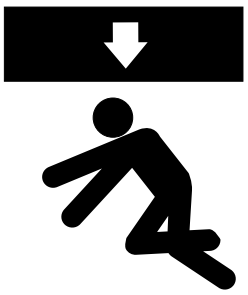
DANGER

Crush Hazard!

When you need to transport an engine for repair, have a helper assist you to attach it to a hoist and load it on a truck.

Never stand under a hoisted engine. If the hoist mechanism fails, the engine will fall on you, causing death or serious injury.

Failure to comply will result in death or serious injury.



HDO1042L

Figure 8

DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Before you operate the engine, check for fuel leaks. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of engine operation, whichever comes first.

Failure to comply will result in death or serious injury.

HDO1015I

Figure 9

DANGER

Explosion Hazard!

Never check the remaining battery charge by shorting out the terminals. This will result in a spark and may cause an explosion or fire. Use a hydrometer to check the remaining battery charge.

If the electrolyte is frozen, slowly warm the battery before you recharge it.

Failure to comply will result in death or serious injury.

HAOA311P

Figure 10

CAUTION

Only use the engine coolant specified. Other engine coolants may affect warranty coverage, cause an internal buildup of rust and scale and / or shorten engine life.

Prevent dirt and debris from contaminating the engine coolant. Carefully clean the radiator cap and the surrounding area before you remove the cap.

Never mix different types of engine coolants. This may adversely affect the properties of the engine coolant.

CAUTION

Never overfill the engine with engine oil.

Always keep the oil level between the upper and lower lines on the oil cap / dipstick.

CAUTION

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

CAUTION

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

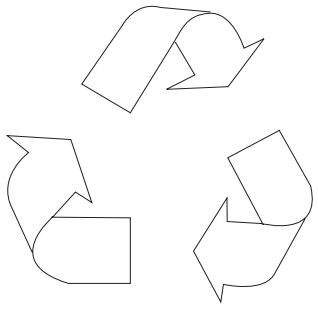
CAUTION

Always be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.



FG009156

Figure 29

GENERAL SERVICE INFORMATION

Component Identification

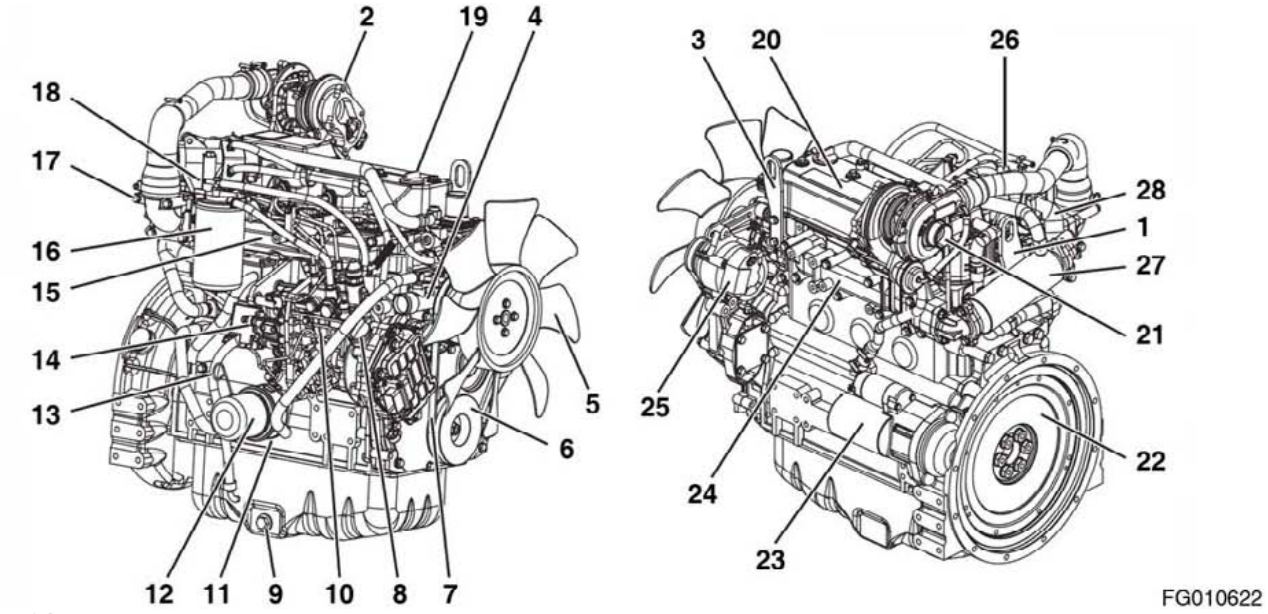


Figure 31

Reference Number	Description
1	Lifting Eye (Flywheel End)
2	Turbocharger*
3	Lifting Eye (Engine Cooling Fan End)
4	Engine Coolant Pump
5	Engine Cooling Fan
6	Crankshaft V-Pulley
7	V-Belt
8	Side Filler Port (Engine Oil)
9	Drain Plug (Engine Oil)**
10	Fuel Injection Pump
11	Engine Oil Cooler***
12	Engine Oil Filter
13	Dipstick (Engine Oil)
14	Eco-Governor

Reference Number	Description
15	Intake Manifold
16	Fuel Filter
17	Fuel Inlet
18	Fuel Return to Fuel Tank
19	Top Filler Port (Engine Oil)
20	Rocker Arm Cover
21	Air Intake Port (From Air Cleaner)
22	Flywheel
23	Starter Motor
24	Exhaust Manifold
25	Alternator
26	EGR valve
27	EGR cooler****
28	EGR pipe

NOTE: ** Only applies to 4TNV98T-Z*

*** Engine oil drain plug location may vary based on oil pan options.*

**** Not standard on all direct injection models.*

***** Only applies to 4TNV98T-Z*

CAUTION

Only use the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and / or shorten engine life.

Prevent dirt and debris from contaminating the engine oil. Carefully clean the oil cap / dipstick and the surrounding area before you remove the cap.

Never mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.

Never overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.

Engine Oil Specifications

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

Service Categories

- API Service Categories CD or higher
  (Grade CF or higher for EGR-equipped engines 4TNV84T-Z, 4TNV98-Z, 4TNV98-E, and 4TNV98T-Z)
- ACEA Service Categories E-3, E-4, and E-5
- JASO Service Category DH-1

Definitions

API Classification (American Petroleum Institute)

- ACEA Classification (Association des Constructeurs Europeens d'Automobilies)
- JASO (Japanese Automobile Standards Organization)

NOTE: *Be sure the engine oil, engine oil storage containers, and engine oil filling equipment are free of sediment and water.*

Change the engine oil after the first 50 hours of operation and then every 250 hours thereafter.

*Select the oil viscosity based on the ambient temperature where the engine is being operated (*Figure 37*).*

DOOSAN does not recommend the use of engine oil "additives".

Additional Technical Engine Oil Requirements:

The engine oil must be changed when the Total Base Number (TBN) has been reduced to 2.0. TBN (mgKOH/g) test method; JIS K-201-5.2-2 (HCI), ASTM D4739 (HCI).

DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Only fill the fuel tank with diesel fuel. Filling the fuel tank with gasoline may result in a fire and will damage the engine.

Never refuel with the engine running.

Wipe up all spills immediately.

Keep sparks, open flames or any other form of ignition (match, cigarette, static electric source) well away when refueling.

Never overfill the fuel tank.

Fill the fuel tank. Store any containers containing fuel in a well-ventilated area, away from any combustibles or sources of ignition.

Failure to comply will result in death or serious injury.

HDO1015I

Figure 49

DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Before you operate the engine, check for fuel leaks. Replace rubberized fuel hoses every two years or every 2000 hours of engine operation, whichever comes first, even if the engine has been out of service. Rubberized fuel lines tend to dry out and become brittle after two years or 2000 hours of engine operation, whichever comes first.

Failure to comply will result in death or serious injury.

HDO1015I

Figure 50

DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Never remove the fuel cap with the engine running.

Failure to comply will result in death or serious injury.

HDO1015I

Figure 51

CAUTION

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

CAUTION

New Engine Break-in:

On the initial engine start-up, allow the engine to idle for approximately 15 minutes while you check for proper engine oil pressure, diesel fuel leaks, engine oil leaks, coolant leaks, and for proper operation of the indicators and / or gauges.

During the first hour of operation, vary the engine speed and the load on the engine. Short periods of maximum engine speed and load are desirable. Avoid prolonged operation at minimum or maximum engine speeds and loads for the next four to five hours.

During the break-in period, carefully observe the engine oil pressure and engine temperature.

During the break-in period, check the engine oil and coolant levels frequently.

CAUTION

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

CAUTION

It is important to perform daily checks.

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

DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

When you remove any fuel system component to perform maintenance (such as changing the fuel filter) place an approved container under the opening to catch the fuel.

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

Wipe up any spills immediately.

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

Failure to comply will result in death or serious injury.

HDO1015I

Figure 81

DANGER

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

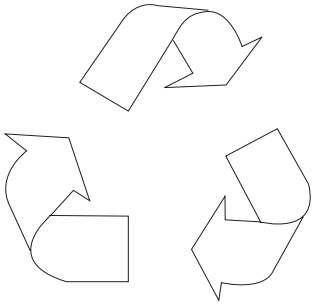
CAUTION

Always be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.



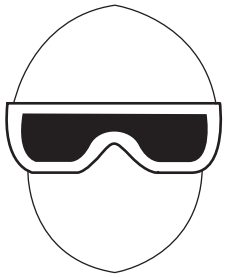
FG009156

Figure 82

CAUTION

FLYING OBJECT HAZARD!

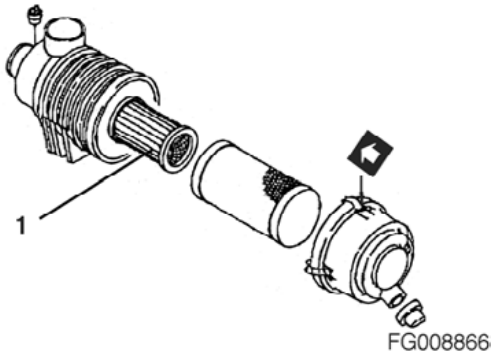
Always wear eye protection when servicing the engine and when using compressed air or high-pressure water. Dust, flying debris, compressed air, pressurized water or steam may injure your eyes.
Failure to comply may result in minor or moderate injury.



FG009152

Figure 99

3. Blow air (3, Figure 98) through the element from the inside out using 42 -71 psi (0.29 -0.49 MPa; 3.0 -5.0 kgf/cm2) compressed air to remove the particulates. Use the lowest possible air pressure to remove the dust without damaging the element.
4. If the air cleaner is equipped with a double element, only remove and replace the inner element (1, Figure 100) if the engine lacks power or the dust indicator actuates (if equipped).
5. The inner element should not be removed when cleaning or replacing the outer element. The inner element is used to prevent dust from entering the engine while servicing the outer element.
6. Replace the element with a new one if the element is damaged, excessively dirty or oily.
7. Clean inside of the air cleaner cover.
8. Install the element into the air cleaner case (4, Figure 98).
9. Reinstall the air cleaner cover making sure you match the arrow (5, Figure 98) on the cover with the arrow on the case (6, Figure 98).
10. Latch the air cleaner cover to the case.



FG008866

Figure 100

CAUTION

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

- On models equipped with an oil cooler, remove the coolant hose (1, Figure 115) at the oil cooler.

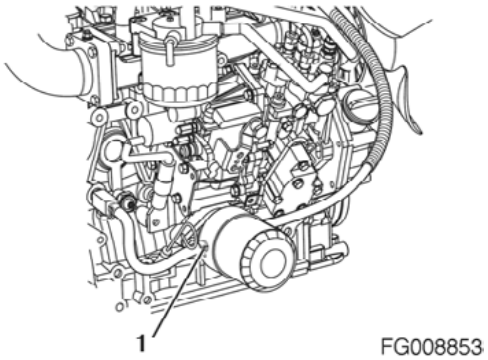


Figure 115

5. After draining the engine coolant, flush the radiator and engine block to remove any rust, scale and contaminants. Then reinstall and tighten the drain plug or close the drain cock in the radiator. Reinstall and tighten the cylinder block drain plug or reconnect the coolant hose at the oil cooler.
6. Fill radiator and engine with engine coolant. See “Filling Radiator with Engine Coolant” on page -45

Check and Replace Fuel Hoses and Engine Coolant Hoses

CAUTION

Always be environmentally responsible.

Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.

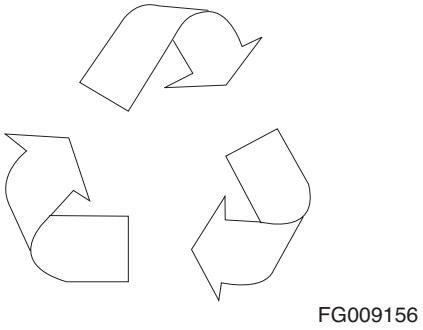


Figure 116

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

Lap the Intake and Exhaust Valves

Adjustment is necessary to maintain proper contact of the valves and seats. See “Inspection of Intake and Exhaust Valves” on page -114

Special Torque Chart

Torque for Bolts and Nuts

Component	Thread Diameter and Pitch	Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Cylinder Head Bolt	M11 x 1.25 mm	76 - 83 ft•lb (103.1 - 112.9 N•m; 8.7 - 9.3 kgf•m)	Applied
Connecting Rod Bolt	M10 x 1.0 mm	40 - 43 ft•lb (53.9 - 58.8 N•m; 5.5 - 6.0 kgf•m)	Applied
Flywheel Bolt	M14 x 1.5 mm	137 - 152 ft•lb (186.2 - 205.8 N•m; 19 - 21 kgf•m)	Applied
Main Bearing Cap Bolt	M11 x 1.25 mm	80 - 87 ft•lb (108.1 - 117.9 N•m; 11.0 - 12.0 kgf•m)	Applied
Crankshaft Pulley Bolt	M14 x 1.5 mm	80 - 94 ft•lb (107.9 - 127.5 N•m; 11.0 - 13.0 kgf•m)	Applied
Fuel Injector Bolt	M8 x 1.25 mm	17 - 21 ft•lb (22.6 - 28.4 N•m; 2.3 - 2.9 kgf•m)	Not Applied
Fuel Pump Drive Gear Nut	M18 x 1.5 mm	83 - 90 ft•lb (113 - 123 N•m; 11.5 - 12.5 kgf•m)	Not Applied
High-Pressure Fuel Lines Bolt	M12 x 1.5 mm	174 - 217 ft•lb (19.6 - 24.5 N•m; 2.0 - 2.5 kgf•m)	Not Applied

See “Tightening Torques for Standard Bolts and Nuts” on page -48

2. Remove the cylinder head bolts (1, Figure 129)
3. Lift the cylinder head away from the cylinder block. Discard the cylinder head gasket (2, Figure 129). Place the cylinder head on the work bench to prevent damage to the combustion surface.

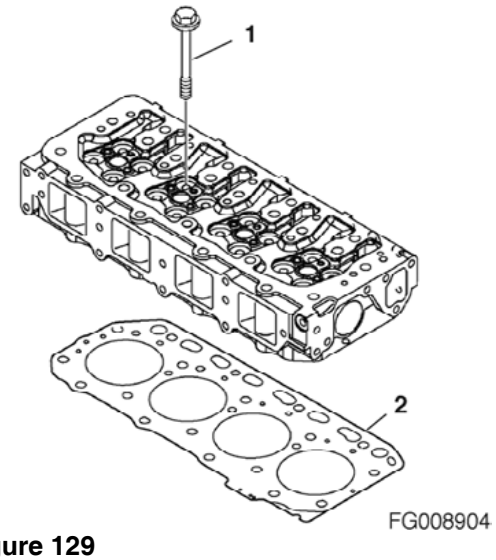


Figure 129

Removal of Intake and Exhaust Valves

1. Place the cylinder head on the work bench with the combustion side down.
2. Using the valve spring compressor tool, compress one of the valve springs (Figure 130).

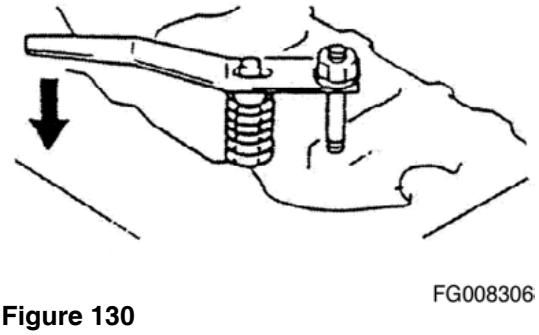


Figure 130

3. Remove the valve keepers (1, Figure 131).
4. Slowly release the tension on the valve spring.
5. Remove the spring retainer (2, Figure 131), valve spring (3, Figure 131).
6. Repeat the procedure with all the remaining valves.

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

7. Remove the injector nozzle protectors (6, Figure 131) and the seats (7, Figure 131).
8. Turn the cylinder head so the exhaust port side faces down. Remove the intake and exhaust valves (5, Figure 131) from the cylinder head.
9. Remove the valve stem seals (4, Figure 131).

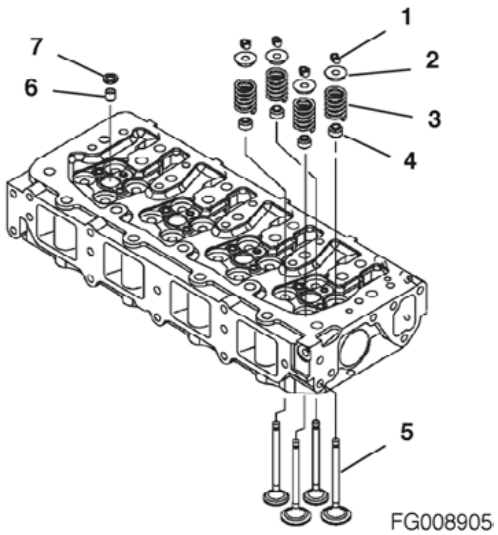


Figure 131

IMPORTANT

The wave washers (2, Figure 156) must be installed with the bow facing the rocker arms (1, Figure 156).

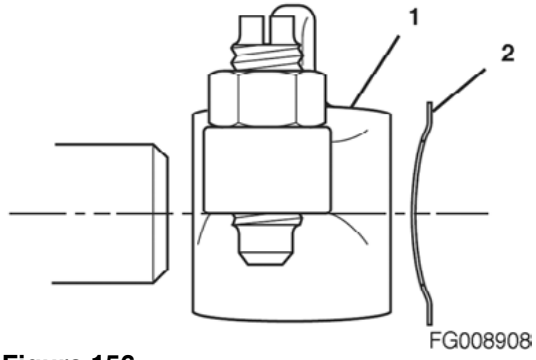


Figure 156

IMPORTANT

Ensure the lubrication holes (1, Figure 157) in the rocker arm shaft are oriented correctly with respect to the rocker arms (2, Figure 157).

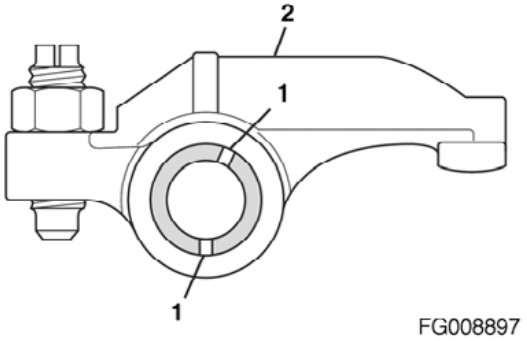


Figure 157

3. Lubricate the rocker arm shaft. Slide the rocker arm supports (6, Figure 158), wave washers (7, Figure 158), rocker arms (8, Figure 158), and fuel injector retainers (4, Figure 158) onto the shaft.

   NOTE: *To properly align the rocker arm shaft with the rocker arm shaft supports, first reinstall one of the end rocker arm supports (6, Figure 158) with a hole for the shaft alignment stud (5, Figure 158). Align the hole in the rocker arm shaft and the hole in the rocker arm support bracket. Reinstall the alignment stud.*

   NOTE: *Figure 158 shows components for one cylinder. Components for all remaining cylinders are assembled in the same order.*

4. Position the rocker arm assembly on a flat surface. Reinstall the alignment studs (5, Figure 158).
5. Place the rocker arm shaft assembly onto the cylinder head.
6. If removed, reinstall the valve adjusting screws (2, Figure 158) and lock nuts (3, Figure 158).
7. Align the push rods with their respective rocker arms.
8. Reinstall and tighten the rocker arm shaft retaining bolts to the specified torque.
9. Tighten the rocker arm shaft alignment studs.
10. Adjust the valve clearance.
11. Reinstall the fuel injectors. See “Installation of the Fuel Injectors” on page -199

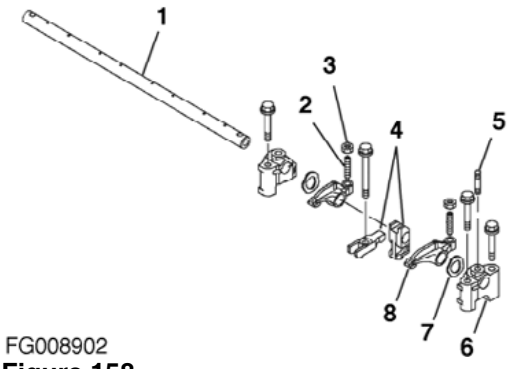


Figure 158

Disassembly of Camshaft and Timing Components

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

Removal of Timing Gear Case Cover

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

IMPORTANT

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

2. Remove the crankshaft pulley using a gear puller.
3. Remove the bolts that retain the gear case cover to the cylinder block and oil pan.
4. Remove the gear case cover (1, Figure 168).

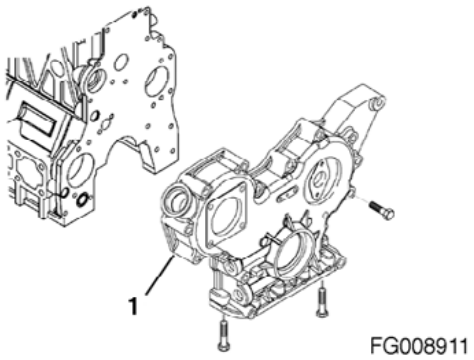


Figure 168

Checking Timing Gear Backlash

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

Check the backlash between each pair of mating gears (Figure 169). If not within specification, replace both mating gears. See "Timing Gear Backlash" on page -97 for service limits.

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

Reference Number	Description
1	Fuel Injection Pump Drive Gear
2	Camshaft Drive Gear
3	Auxiliary Drive Gear (Optional)
4	Crankshaft Drive Gear
5	Direction of Rotation
6	Oil Pump Drive Gear
7	Idler Gear

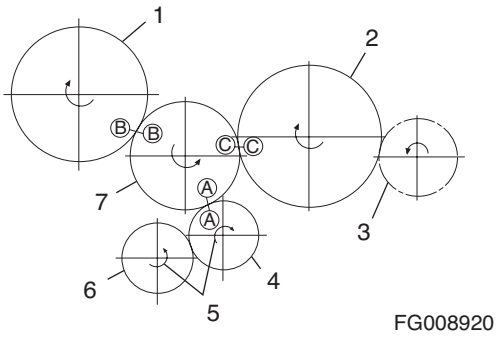


Figure 169

3. Remove the rear oil seal (3, Figure 192) from the seal housing (2, Figure 192).
4. Apply a continuous bead of ThreeBond Liquid Gasket to the outside diameter of a new oil seal (2, Figure 192), and install in the housing. Apply lithium grease to the lip of the seal.

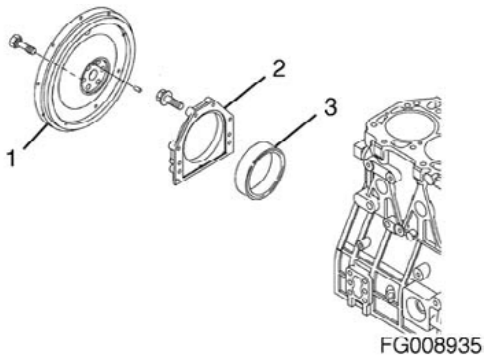


Figure 192

Measure Crankshaft Bearing Oil Clearance

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

3. Reinstall the oil ring expander (4, Figure 214). Reinstall the oil ring (3, Figure 214) with the end gap at 180° from the expander end gap.
4. Reinstall the second compression ring (2, Figure 214). This ring is identified by its dark color and tapered face profile.
5. Reinstall the top compression ring (1, Figure 214). This ring is identified by its silver color and barrel-shaped face profile.

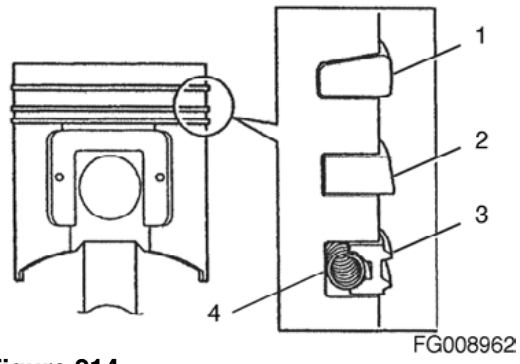


Figure 214

IMPORTANT

The oil ring expander (4, Figure 214) end gap must be located 180° from the oil ring (3, Figure 214) end gap.

6. Stagger the piston ring end gaps at 120° intervals (1, 2, 3, Figure 214)

Reference Number	Description
1	Top Compression Ring End Gap
2	Second Compression Ring End Gap
3	Oil Ring End Gap

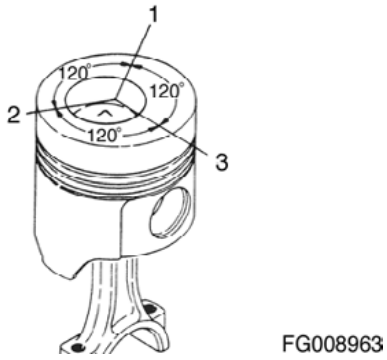


Figure 215

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.

HAOA060L

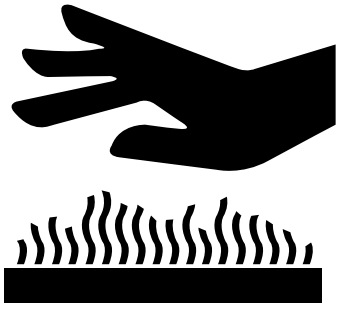
Figure 230

WARNING

Burn Hazard!

Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, turbocharger (if equipped) and engine block during operation and shortly after you shut the engine down. These surfaces are extremely hot while the engine is operating and could seriously burn you.

Failure to comply could result in death or serious injury.



HAOA050L

Figure 231

WARNING

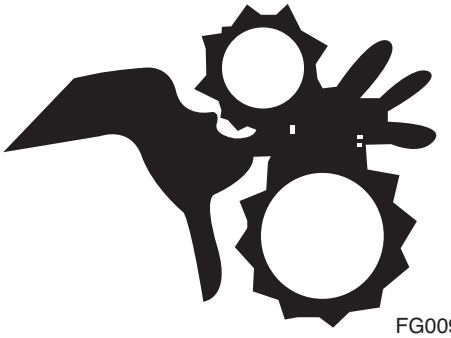
Entanglement Hazard!

Stop the engine before you begin to service it.

Never leave the key in the key switch when you are servicing the engine. Someone may accidentally start the engine and not realize you are servicing it. This could result in a serious injury.

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

Failure to comply could result in death or serious injury.



FG009148

Figure 232

Stop Solenoid

The MP fuel injection pumps are equipped with a stop solenoid that controls the fuel flow inside the fuel injection pump.

With the starter switch in the OFF position, no current flows to the stop solenoid and the solenoid plunger is extended holding the fuel injection pump fuel rack in the "closed" position and not allowing fuel to flow through the injection pump and to the engine.

When the starter switch is turned to the start position, the "pull coil" (36.5 Amp draw / white wire) inside the solenoid is activated and pulls the solenoid plunger into the solenoid. This releases the fuel injection pump fuel rack, allowing fuel to flow through the injection pump and allowing the engine to start and run.

When the starter switch is returned to the ON or RUN position, the "pull coil" no longer receives current and the "hold coil" (0.5 Amp draw / red wire) inside the solenoid is activated. The "hold coil" holds the solenoid plunger in the RUN position, allowing fuel to continue flowing and he engine to continue running.

To stop the engine, the key switch is turned to the OFF position. Current no longer flows to the stop solenoid "hold coil", and the solenoid plunger extends and moves the injection pump fuel rack to the "closed" position, shutting off the fuel flow and stopping the engine.

Failure of the stop solenoid could result in the engine not starting, the engine stopping suddenly, the engine not continuing to run with the key switch returned to the ON or RUN position, or the engine failing to stop when the key switch is turned to the OFF position. Use a multimeter or continuity light to check for 12V at the stop solenoid connector in the correct sequence.

Electronically controlled engines 4TNV84T-Z, 4TNV98-Z, 4TNV98-E, and 4TNV98T-Z are designed so that, when the key is turned on or off, the corresponding signal is sent to the E-ECU.

Thus the E-ECU controls the rack actuator to provide a sufficient injection rate when the engine is started up (the key is turned on) or cut the fuel supply and stop then engine when the key is turned off. Therefore, this electronically controlled engines does not have a stop solenoid.

11. Remove the throttle cable from the fuel injection pump.
12. Separate the stop solenoid wiring connector (2, Figure 252).
13. Remove the rear fuel injection pump bracket(s) (1, Figure 252) from the fuel injection pump.

    NOTE: *Configuration of the fuel injection pump rear brackets may vary depending upon engine model.*

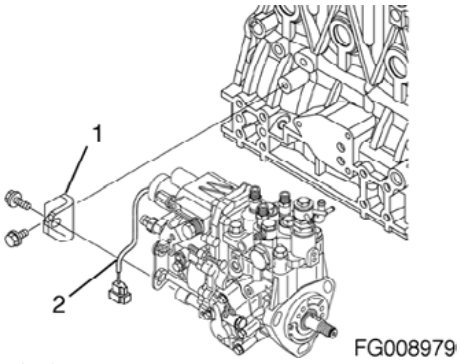


Figure 252

14. Disconnect the lube oil line (1, Figure 253) and the clamp (2, Figure 253) from the pump.

IMPORTANT

Take care to not damage or bend the oil line. In some applications, it may be preferable to remove the complete oil line assembly from the engine before proceeding.

NOTE: *On model 4TNV98-E, the cover is larger and retained by 7 bolts.*

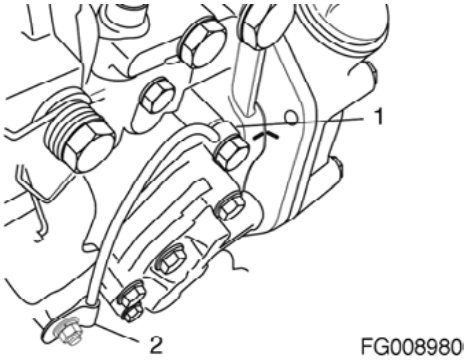


Figure 253

15. Remove the fuel injection pump drive gear cover (1, Figure 254) from the gear case cover (2, Figure 254).

    NOTE: *The fuel injection pump drive gear cover is secured with an adhesive sealant. Use a gasket scraper to separate the fuel injection pump cover from the gear case cover.*

16. To position the fuel injection pump for easier removal and installation, install a dial indicator (See “Checking and Adjusting Fuel Injection Timing” on page -189) into the injection pump plunger opening. Using a wrench on the crankshaft pulley bolt, rotate the crankshaft until the dial indicator shows that injection pump plunger is at the bottom of it's stroke.
17. To aid in reassembly, make reference marks on the fuel injection pump drive gear, and on either the gear case cover or idler gear.

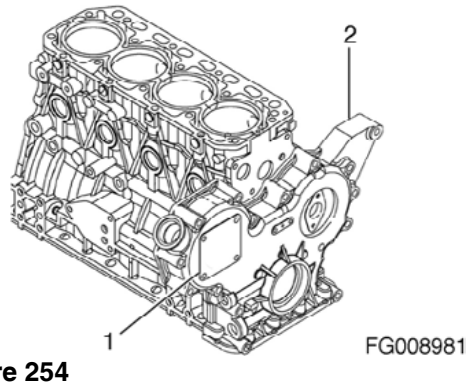


Figure 254

CAUTION

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

6. Using a wrench on the crankshaft pulley bolt, rotate the crankshaft in a clockwise direction while looking through the flywheel inspection port (1, Figure 281). Rotate the crankshaft until the injection timing marks on the flywheel are visible.

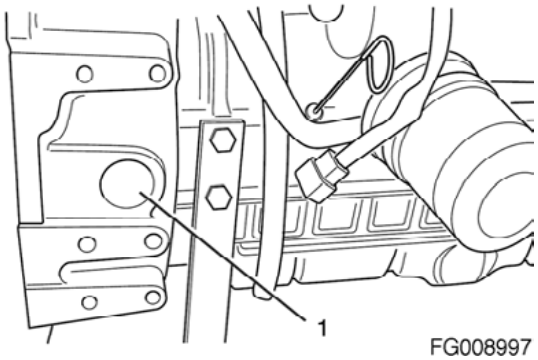


Figure 281

7. Typical flywheel markings are as shown in (1, Figure 282).

   NOTE: *A typical flywheel will have multiple timing grids depending on the number of cylinders. Any grid can be used to check the fuel injection timing.*

   The flywheel shown in Figure 282 is for a "Standard Specification" DI engine. Flywheels used on some "OEM Specific" DI engines may be marked differently. You should contact that specific OEM for information on the identification of the timing marks.

Reference Number	Description
1	10° BTDC (Before Top Dead Center)
2	15° BTDC
3	20° BTDC
4	Direction of Rotation
5	TDC (Top Dead Center)

   NOTE: *The TDC (Top Dead Center) mark can be identified by the cylinder numbers stamped near the TDC mark on the flywheel.*

   If you are uncertain as to the timing degree designation of the timing marks on the flywheel timing grid, you can determine the timing degree designation by measuring the timing grid.

   - First measure the distance between two of the "longer" marks on the timing grid. (They are 5° apart.) Then measure the distance from the TDC mark to the first "longer" mark on the timing grid. Divide that measurement by the distance between the two "longer" marks. The resulting answer will tell you how many degrees there are between the TDC mark and the first "longer" mark.

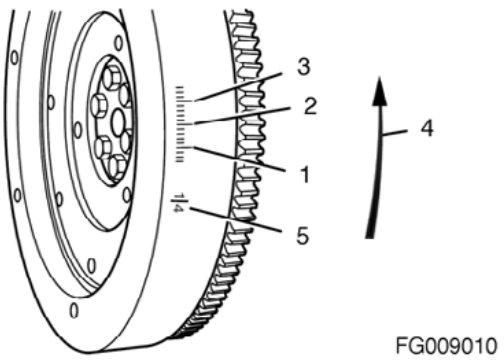


Figure 282

WARNING

Fume / Burn Hazard!

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

Failure to comply could result in death or serious injury.

FG009153

Figure 300

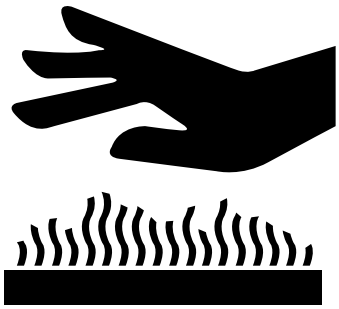
WARNING

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.

Failure to comply could result in death or serious injury.



HAOA050L

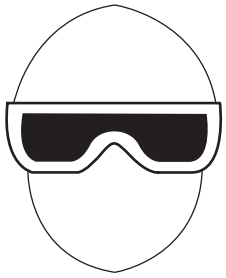
Figure 301

CAUTION

FLYING OBJECT HAZARD!

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

Failure to comply may result in minor or moderate injury.



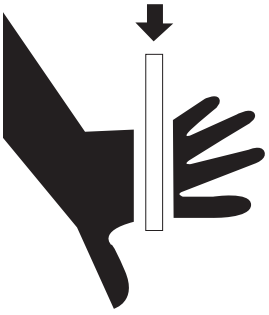
FG009152

Figure 302

CAUTION

Pinch Hazard!

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



FG009155

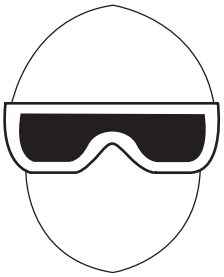
Figure 303

CAUTION

FLYING OBJECT HAZARD!

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

Failure to comply may result in minor or moderate injury.



FG009152

Figure 323

CAUTION

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

CAUTION

Only use the engine oil specified. Other engine oils may affect warranty coverage, cause internal engine components to seize and / or shorten engine life.

Prevent dirt and debris from contaminating the engine oil. Carefully clean the oil cap / dipstick and the surrounding area before you remove the cap.

Never mix different types of engine oil. This may adversely affect the lubricating properties of the engine oil.

Never overfill. Overfilling may result in white exhaust smoke, engine overspeed or internal damage.

CAUTION

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

Starter Motor Troubleshooting

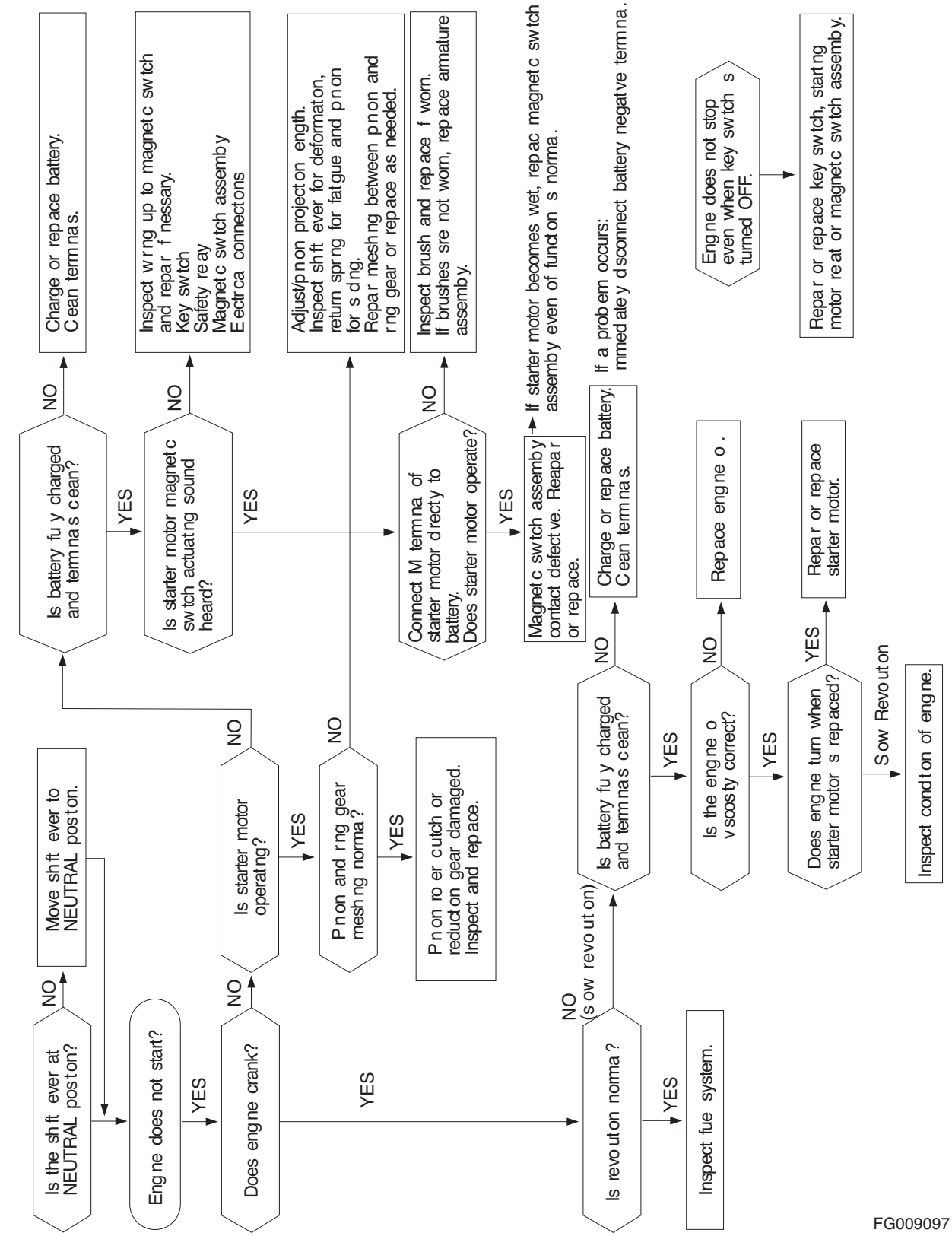


Figure 340

Reassembly of Starter Motor

1. Apply appropriate starter bendix grease (obtain locally) to the pinion shaft. Reassemble the pinion shaft (5, Figure 368), pinion clutch assembly (1, Figure 368), return spring (4, Figure 368) and pinion stop (3, Figure 368). Reinstall the retaining ring (2, Figure 368) in the groove in the pinion shaft. Slide the piston stop over the retaining ring.
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.

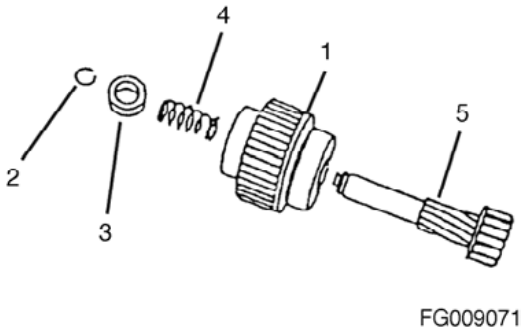


Figure 368

4. Apply a small amount of high temperature lithium grease (obtain locally) to the sliding portions of the shift lever (1, Figure 369). Reassemble the torsion spring (2, Figure 369), shift lever and dust cover(s) (3, Figure 369), plunger (4, Figure 369) and magnetic switch assembly (5, Figure 369).

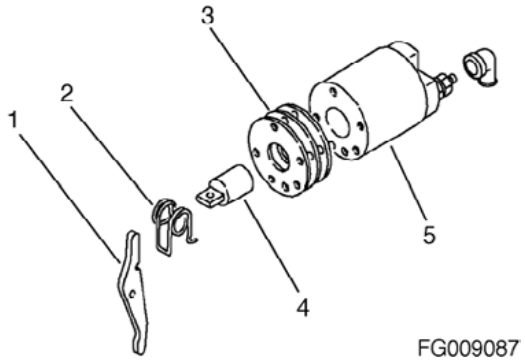


Figure 369

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 370).
6. Secure the magnetic switch assembly to the gear housing using the two M6 bolts.

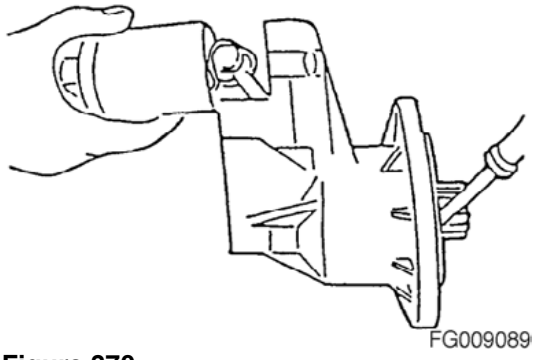


Figure 370

7. Carefully install the armature assembly (1, Figure 371) into the field coil assembly (2, Figure 371).

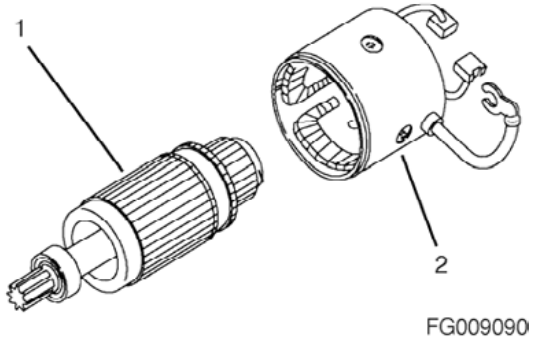
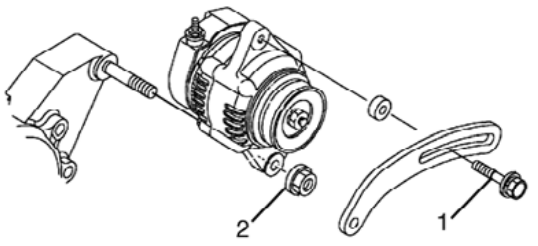


Figure 371

Installation of Alternator

1. Position the alternator on the gear case. Loosely reinstall the nut (2, Figure 404) on the gear case stud and the V-belt adjuster bolt (1, Figure 404).
2. Reconnect the electrical wires to the alternator. Tighten the nuts to 15 - 20 in.-lb (1.7 -2.3 N•m ; 17-23 kgf•m).
3. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in See "" on page -70.
4. Start the engine. Listen for any unusual sounds from the alternator.



FG009103

Figure 404

CAUTION

Do not operate the engine if the alternator is producing unusual sounds.

Damage to the alternator will result.

5. Verify that the charge indicator is ON while the engine is operating. If the charge indicator is not ON, repair the problem before operating the engine.

Battery Cable Resistance

AWG	mm^2	Maximum Total Battery Cable Length (Positive Cable + Negative Cable + a*) 12V Starter Motor Output			
		Less Than 2.68 HP (2 kW)		Greater Than 2.68 HP (2 kW)	
		m	ft	m	ft
6	15	1.5	4.75	N/A	N/A
4	20	2.3	7.4	N/A	N/A
2	30	3.8	12.6	2.3	7.5
1	40	4.6	15.3	2.8	9.2
0 (1/0)	50	5.9	19.5	3.5	11.6
00 (2/0)	60	7.0	22.8	4.2	13.7
000 (3/0)	85	9.3	30.5	5.6	18.3
0000 (4/0)	100	11.9	39	7.1	23.4
00000 (5/0)	125	N/A	N/A	8.3	27.3
000000 (6/0)	150	N/A	N/A	10.1	33.3

NOTE: *Total allowable resistance of the complete battery cable circuit (positive cable + negative cable + a*) (a*: Resistance (Ω) of a battery switch or other electrical equipment having high resistance).*

NOTE: *For starter motors of less than 2.68 HP (2 kW): the total resistance must be less than 0.002 Ω. For starter motors of greater than 2.68 HP (2 kW): the total resistance must be less than 0.0012 Ω.*

	Symptoms and conditions of failure	Starting failure					Engine stall after start up			Speed control error				Engine output low			Noise and vibration				Lubricating oil				Cooling water		Intake air		Exhaust gas				Fuel			Electrical parts						Corrective Action	Referenced page number
		Starter does not rotates		Starter rotates			Smoke			Revolution speed cannot be changed with accelerator (stays at a constant speed)	No load			Work load	Smoke color			High knocking sound at combustion time	Uneven combustion sound	Abnormal sound (other than combustion sound) from engine	Engine vibrates heavily	Too much lubricating oil consumed	Lubricating oil diluted with fuel	Lubricating oil mixed with water	Oil pressure low (oil pressure warning lamp lit)	Overheat (water temperature warning lamp lit)	Water temperature low	Pressure low (air cleaner warning lamp lit)	Pressure high	Work load			Exhaust gas ternperature high	Too much fuel consumed	Fuel mixed with water (oil-water separator warning lamp lit)	Fuel filter fouled shortly	Battery charge error (charge lamp lit)	ECU failure lamp flashes	ECU failure lamp stops flashing immediately (within 2 secinds) after turning off the key	Specific Ecu control functions fail.	Fuses get blown or broken (repeatedly)		
	Possible causes	ECU failure lamp does not go on immediately after turning on the key	ECU failure lamp goes in immediately(within 2 seconds) after turning on the key	Engine does not start up (without initial ignition)	Engine does not start up (it stops immediately after initial ignition)	It takes longer than before to start up engine	None	slight	Remarkable		Cannot be set to particular speed	Poor acceleration	Does not smoothly return to low speed	Hunting occurs	Hunting occurs	Normal	White	Black											White exhaust gas	Black exhaust gas	Too much blow-bye															
Fuel system	Stop solenoid faulty			○				○																																Inspect and replace.	See “Stop Solenoid” on page -171
	Fuel injection pump's injection timing advanced excessively																	○			○									○	○											Inspect and adjust.	
	Fuel injection pump's injection timing advanced excessively																○	○												○	○		○	○								Inspect and adjust.	
	Improper fuel oil															○	○	○		○										○	○				●	●							Use the proper fuel oil.	
	Water flown into the fuel system			○	●				○					○	○		○			○										○					●								Drain the fuel filter.	
	Fuel filter clogged			○		●	○					●				○																										Clean or replace.	
	Air contained in the fuel system			○	●		○							●	●	○																										Bleed.	
	Fuel pipe clogged or cracked			○			○									○																										Clean or replace.	
	Insufficient fuel supply to the fuel injection pump			○	●		○					●				○																										Inspect the fuel tank cock, fuel filter, fuel pipe, and fuel feed pump.	
	Uneven injection by the fuel injection pump													○	○		○	○		○		○								○	○		○									Inspect and adjust.	
	Fuel injected excessively																				○					○			○		○	○	○	○								Inspect and adjust.	
	Fuel injection nozzle spray failure													○	○		○	○		○		○								○	○			○								Inspect and adjust.	
	Priming fails			○																																						Remove dirt caught in the priming pump internal valve (disassemble and clean).	See “Fuel System Components” on page -178
	Feed pump inlet strainer clogged					●					●					○																										Clean the strainer.	
	CSD valve malfunctioning			○		○													●																								Replace the pump. Replace the CSD valve.	
	Fuel tank airtightness deteriorated																																		●	●							Inspect the fuel tank and lid; replace with the genuine parts if necessary.	
Intake/exhaust gas system	Air filter clogged								○			●						○		○			●					○			○		●									Clean the air filter.	
	Engine used at high temperatures or high altitudes																	○								○			○		○				○								Examine the relationship between output reduction and load.	
	Exhaust pipe clogged							●				●						○		○								○			○		●									Clean the exhaust pipe.	

INSTALLATION OF DRIVE COUPLING

Always follow the following installation procedure when installing the drive coupling in the main pump.

NOTE: *Noncompliance with the procedure may cause noise or shortening of life of the drive coupling or the main pump.*

Installation Procedure

1. Assemble the coupling (1, Figure 1) in the engine flywheel with spring washers (2, Figure 1) and bolts (3, Figure 1).

   NOTE: *Apply lock tight to bolts.*

   NOTE: *Tightening torque = 13.8 kg•m*

2. Assemble the pump cover (4, Figure 1) to the fly whell housing with spring washers (5, Figure 1) and bolts (6, Figure 1).

   NOTE: *Check the distance between the coupling and the pump cover to be 9 mm*

   NOTE: *Tightening torque = 6.5 kg•m*

3. Assemble the pump (7, Figure 1) to the pump cover with, spring washers (8, Figure 1) and bolts (10, Figure 1).

   NOTE: *Apply lock tight to bolts.*

   NOTE: *Tightening torque = 9kg•m*

button on the bottom of the diaphragm eventually seals off the lower oil passage. Just after the needle on the gauge reaches its highest point (when there is 0 bar (0 psi) resistance from hydraulic system pressure) pressure on the gauge will drop sharply to zero, as the accumulator is completely emptied of oil and the diaphragm button closes.

Record the highest gauge reading and compare to the "P1" rated precharge pressure on the accumulator manufacturer's data label. Repeat this test at least once a year to verify proper functioning of the accumulator.

3. As hydraulic system pressure overcomes accumulator precharge pressure, the flexible diaphragm begins to retract upward.

4. When system oil is at highest working pressure and the accumulator fills to maximum reserve capacity, the flexible diaphragm is pushed up into the top of the upper chamber.

   The highest working pressure is sometimes referred to as the "P3" pressure and can also be referenced on the manufacturer's data label on the exterior of the accumulator.

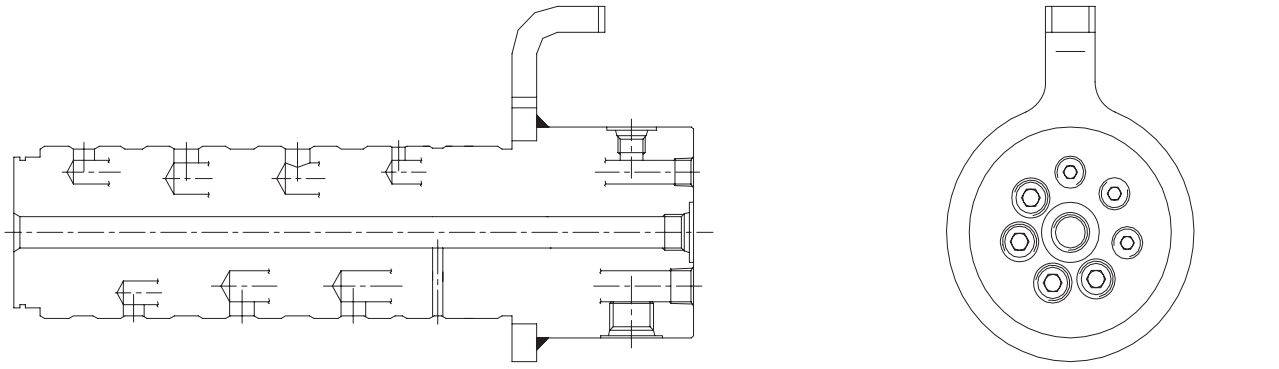
5. If system oil pressure begins to fall off or is momentarily checked or interrupted, the energy stored on the other side of the diaphragm, in the form of compressed gas, pushes oil back out of the lower chamber, maintaining oil pressure of the circuit.

6. With minimal system pressure, an equilibrium point may be reached in which accumulator precharge pressure and hydraulic system oil pressure achieve a rough balance. In this state a minimal amount of oil is stored in the accumulator.

REASSEMBLY

CAUTION

Apply active oil to every funcational (moving) part before assembly to reduce any assembly friction as much as possible.



FG013239

Figure 6

1. Wrap the teflon tape around the PT plug about 6 ~ 10 times.
2. Assemble the PT plug into the washed shaft.

PT 1/4: 6 mm wrench	PT 3/8: 8 mm wrench
Engagement torque: 3 ~ 4 kg•m	Engagement torque: 6 ~ 7 kg•m

3. Assemble the sliper seal and the O-ring into the Hub.
4. Assemble the dust seal (LBH80) into the Hub.

CAUTION

Apply active oil to every funcational (moving) part before assembly to reduce any assembly friction as much as possible.

CAUTION

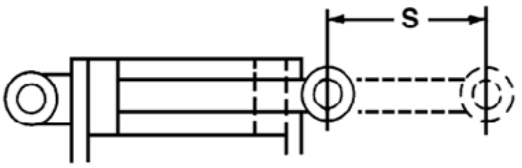
For any sliper seal which is protruded, press it with finger to seat it in its position. Care should be taken when using a driver or a metal tool, which may cause damage to it.

Because the volume of oil needed to lengthen the cylinder rod (Q1) is greater than the volume of oil required to retract the cylinder rod, it takes more time to decrease cylinder stroke length than it does to lengthen it.

$$Q_1 = S \times \frac{\pi(B^2)}{4}$$

$$Q_2 = S \times \frac{\pi(B^2-R^2)}{4}$$

$Q_1 > Q_2$



FG011246

Figure 3

Piston Jig

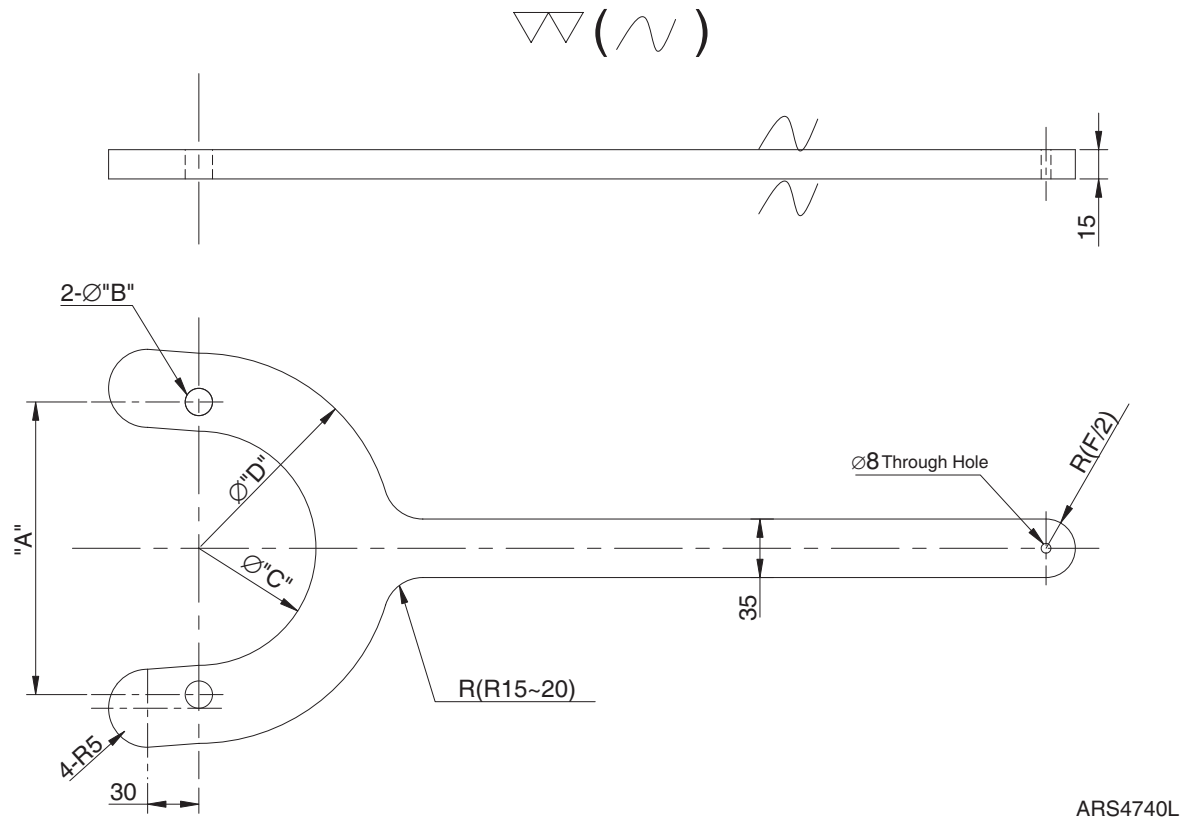


Figure 9

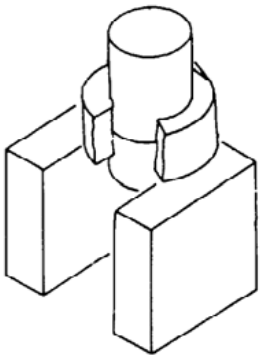
Material SM45C (AISI 1045)

Rockwell Harden from 22 - 27

Oil Quench

Model	Cylinder	øA (mm)	øB (mm)	C (mm)	D (mm)
DX60R	ARM	65.0	12.0	22.0	52.0
	BOOM	80.0	12.0	25.0	55.0
	BUCKET	65.0	12.0	22.0	52.0
	SWING	80.0	12.0	25.0	55.0
DX80R	ARM	75.0	12.0	27.0	60.0
	BOOM	75.0	12.0	27.0	60.0
	BUCKET	60.0	12.0	22.0	52.0
	SWING	80.0	12.0	25.0	55.0
	DOZER	70.0	12.0	25.0	55.0

17. Force out pin bushing (1) from body of cylinder.



0349

Figure 30

SPECIFICATIONS

MODEL	TSM32 (S)CAB-RG250D
Displacement	31.5 cc/rev
Set Pressure of Relief Valve	220 kgf/cm^2
Theoretical Output Torque (Motor)	10.5 kg•m
Rated Flow Rate	38.5 lpm
Brake Torque	14.5 kgf•m
Brake Release Pressure	10 ~ 20 kgf/cm^2
Theoretical Output Torque	205 kgf•m
Gear Ratio	19.464
Weight	49.7 kgf

NOTE: *The theoretical value at the rated pressure, not including mechanical efficiency.*

TSM32 series can be applied from 28.98 cc/rev to 31.5 cc/rev by the change of displacement.

Oil Filling

1. Fill in the casing with oil using the drain port before the operating.

   In the motor, there are many kinds of high-speed sliding surface like bearing, piston, shoe, spherical bush, and etc. So If there isn't enough oil, can make some problem like sticking or breaking in those parts.

2. All the air in the motor and circuit must be removed, otherwise, it will be likely to be causes of imperfect working or a damage of the motor.

Precaution in Starting Operations

1. If the direction of revolution is correct or not.
2. Whether or not there is any leakage of oil from the motor.
3. If the equipment vibrates abnormally or not during operation or when the revolution direction is changed.
4. If the oil temperature rises rapidly in spite of running for a short period of time.
5. Whether the pressure varies to a great extent as compared with the established one.
6. If the piping is fully connected or not.

17. Remove the bearing (4).

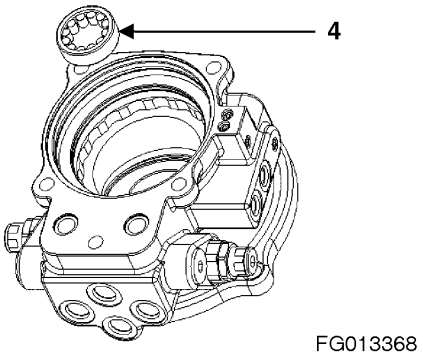


Figure 25

18. Remove the relief valve (44).

CAUTION

Do not disassemble the relief valve assembly because it is a functional component.

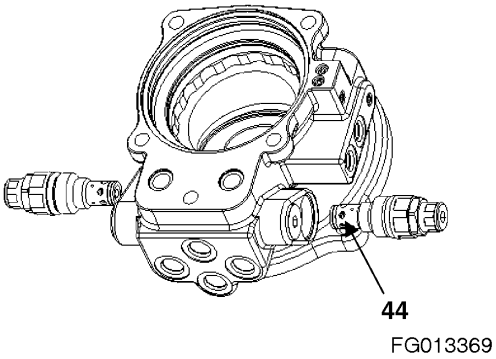


Figure 26

19. Remove the plug (21), the spring (20) and the plunger (19).

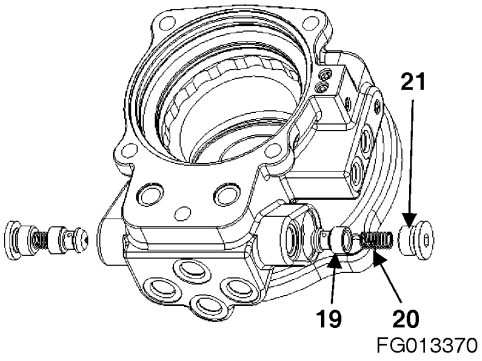


Figure 27

20. Remove the spool (30) and other associated parts.

Reference Number	Description
30	Spool
31	Spring
32	Plunger A assembly
33	Plunger A assembly
34	Plunger A assembly
35	Plunger A assembly
36	Plunger A assembly
37	Plunger A assembly
38	Plug

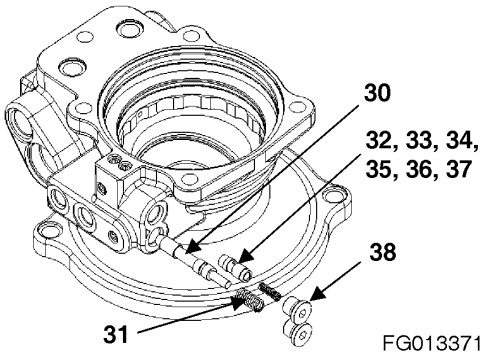


Figure 28

Disassembling is finished, check each component throughly.

Assembly of Reduction Gear

Following are caution to be specially borne in mind.

A. Rework damaged parts and before assembling, prepare all parts to be replaced.

B. Clean all parts and dry with compressed air.

C. Coat the sliding parts and bearing with clean hydraulic oil.

D. Replace oil seal.

1. Place the gear casing (R1) on the work table.

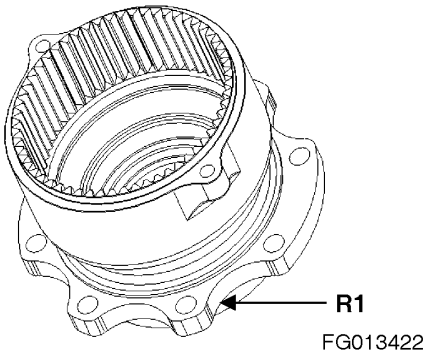


Figure 60

2. Press to insert oil seal (R5) by using pressing jig after spreading grease oil around the outside ring of the oil seal.

   Coat grease oil slightly on the lip surface to prevent any scratch when installing.

   Be sure to check by eye that the oil seal is seated completely after being inserted.

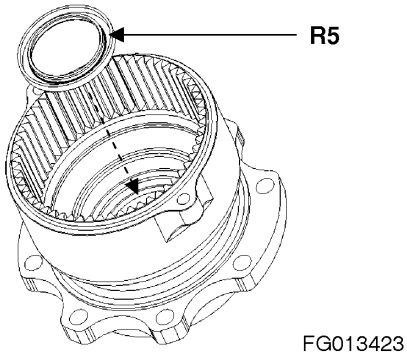


Figure 61

3. Install the bearing cover (R6) and the taper roller bearing (R3) on the pinion shaft (R2).

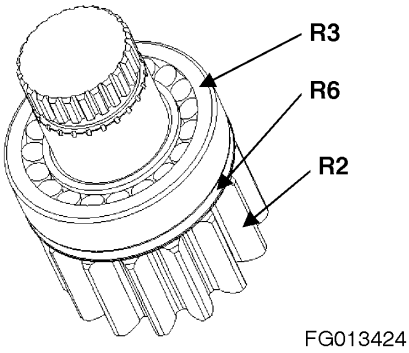


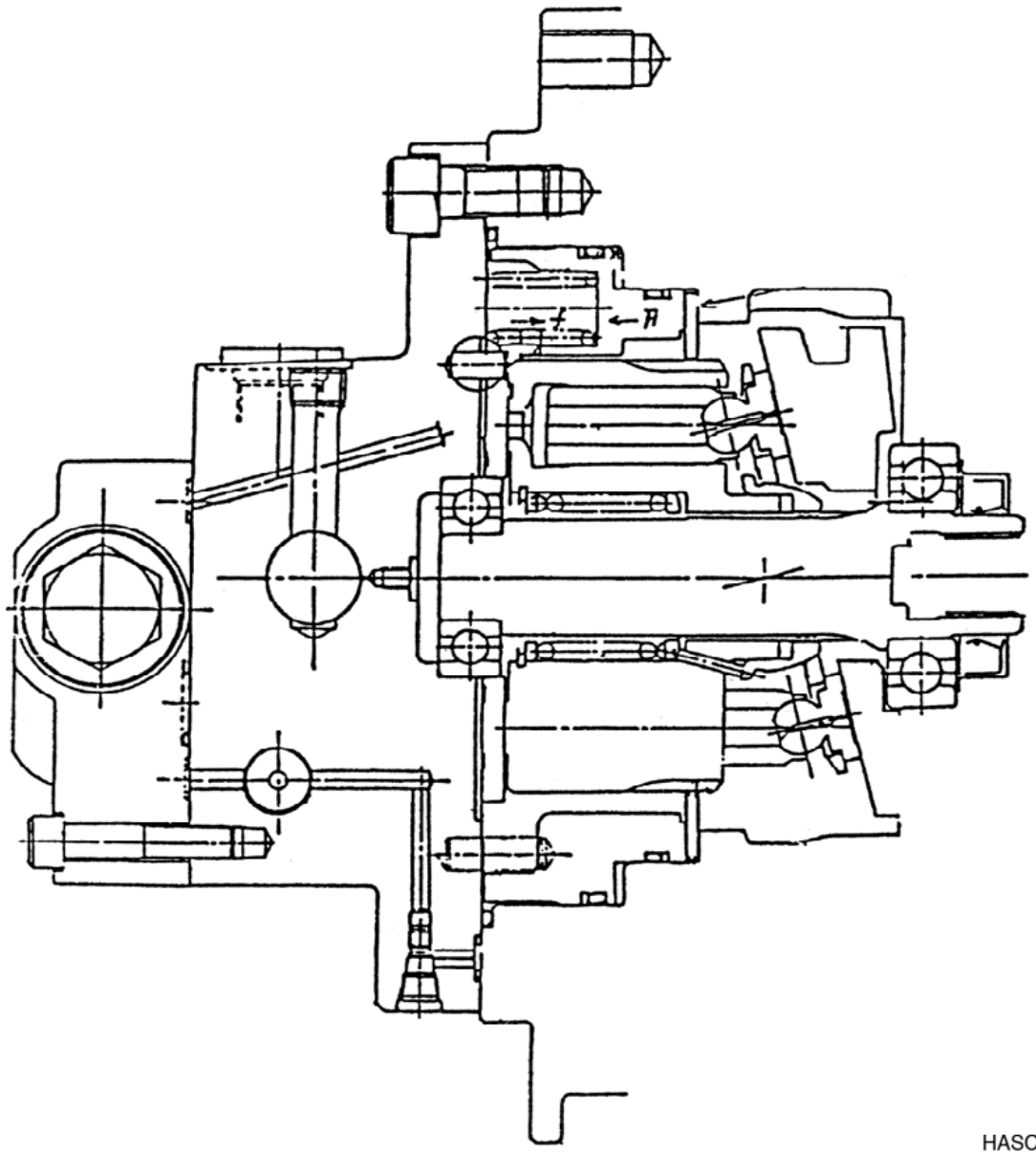
Figure 62

Table of Contents

Travel Motor

Operating Principle of Parking Brake

Parking brake consists of friction board, piston, and spring. Cylinder block and friction board are interconnected through a spool line. Friction board produces friction force by means of spring. Pressurized oil that entered the motor will open the release port of the parking brake and push the spring that presses the friction board, thus releasing the brake. When stopping, the release port of the parking brake will be closed, and pressurized oil inside the brake chamber will drain into the casing, causing spring force to have the brake operate.

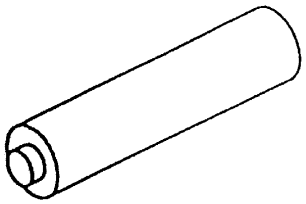


HASC340S

Figure 6

Holder (IIII)

For press fitting oil seal (132) into the oil seal hole the spindle (2).

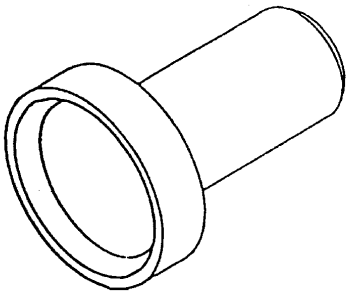


AXS0340S

Figure 15

Holder (IV)

For installing the RV gear assembly on spindle (2).



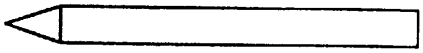
AXS0350S

Figure 16

Steel Rod

For removing ring (18) from hub (1).

For removing ring (265) from rear flange (201).

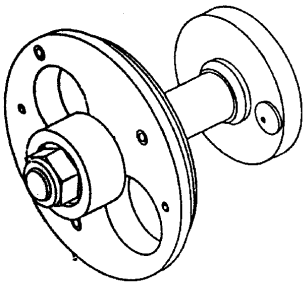


AXS0360S

Figure 17

Bearing Preload Adjuster

For adjusting the preload of ball bearing (21).



AXS0370S

Figure 18

D. Pick the end portion of the ring and pull it out to remove the ring off the groove.

Figure 37

5. Remove cover (8) from hub (1) making use of the cover removable tool.
6. Remove O-ring (29) from cover (8).

NOTE: *O-ring (29) might prevent the cover from sliding out. If it is difficult to lift the cover off, shake the cover loose by tapping on it with a plastic hammer, so that the cover will slide out without cocking.*

NOTE: *Do not reuse O-ring (29) which has been removed.*

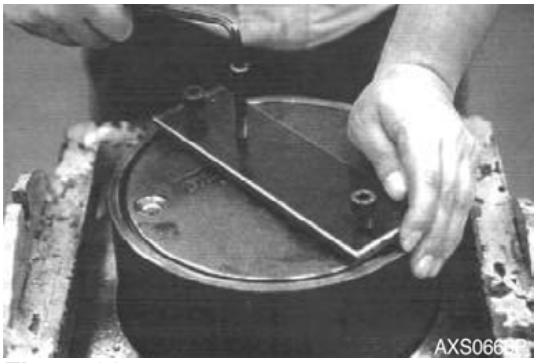


Figure 38

Input Gear Removal

1. Remove retaining ring (24) from shaft (102).

CAUTION

Be careful when removing the retaining ring. You could become injured if tip of the pliers comes out of the retaining ring hole, and the retaining ring jumps out.

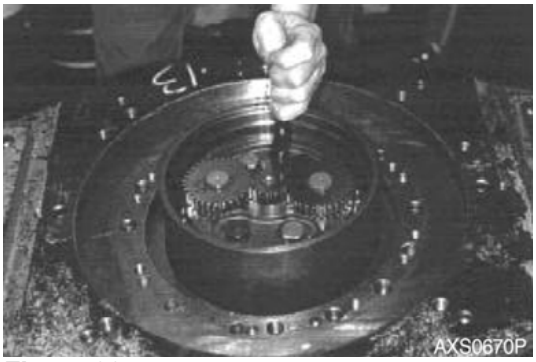


Figure 39

2. Draw out input gear (6) from shaft (102).

Figure 40

4. Remove piston assembly (161,162) by injecting compressed air into the access hole in spindle (2).

CAUTION

Be careful that the abrupt injection of compressed air could cause the piston assembly to pop out. To ensure your safety, hold a protective cover over the piston assembly.

Figure 72

Removing Ball Bearing From Shaft

1. Place retainer (II) on the work bench. Insert shaft (102) into the retainer.
2. Remove ball bearing (149) from shaft (102) by pressing on the shaft end with a press.

   NOTE: *Do not remove ball bearing if it is not be replaced. Do not reuse removed ball bearing.*

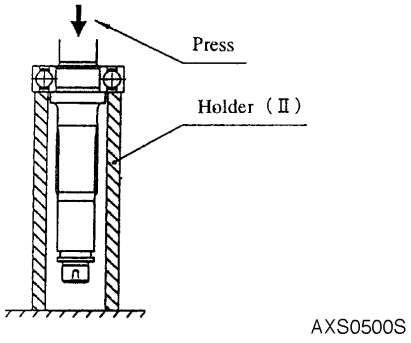


Figure 73

Removing Hold Flange

1. Turn the workbench so the spindle is on top.
2. Fasten the fixture jig to the hub & spindle.

   NOTE: *This clamping is necessary because the hub is sandwiched between the spindle and hold flange. Cramp the spindle and hub securely before removing the hold flange so that the spindle will not fall from the workbench.*

Figure 74

3. Turn the workbench upside down.
4. Remove retaining rings (20) (2 rings) from hold flange (3).

Figure 75

4. Press fit the ball bearing (21) in the hub (1) with an aluminum rod and hammer.

   NOTE: *Be sure to keep it true and square by shining the aluminum rod around and pushing it in just a little at each spot.*

Figure 93

5. Apply oil thinly on the outside circumference of the O-ring of the floating seal (31), and mount the floating seal in the floating seal groove of the hub (1).

   NOTE: *To mount the floating seal, piece the F/S installation tool (I), floating seal and F/S installation tool (II) in that order, and press in until F/S installation tool (II) reaches F/S installation tool (I). Remove the installation tools, and check the inclination of the floating seal surface to make sure it is within 1 mm (0.0394 in).*

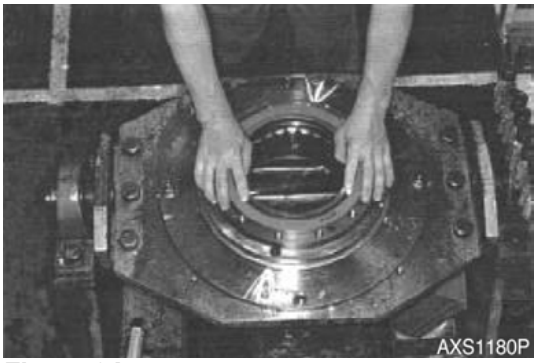


Figure 94

Spindle Assembly

1. Apply oil thinly on the outside circumference of the O-ring of floating seal (31) and mount the floating seal in the floating seal groove of the spindle (2).

   NOTE: *To mount the floating seal, place the F/S installation tool (III), floating seal and F/S installation tool (III) in that orders, and press in until F/S installation tool (II) reaches F/S installation tool (III). Remove the installation tools, and, check the inclination or the surface of the floating seal to make sure it is within 1 mm (0.0394 in).*

Figure 95

2. Fit the outer ring of tapered roller bearing (22) into the spindle (2).

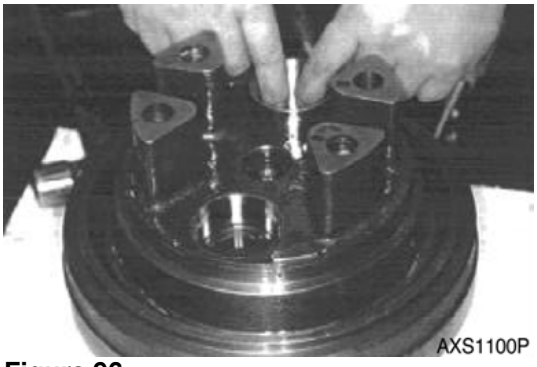


Figure 96

8. Temporarily tighten the plugs (224).

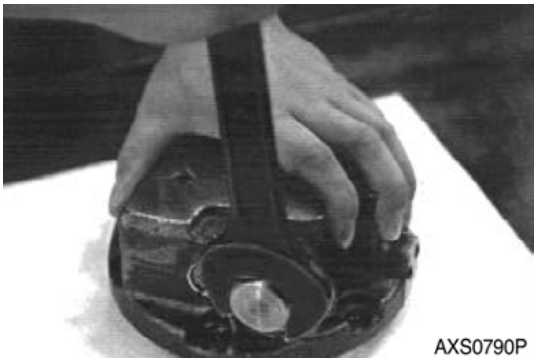


Figure 127

Assembly of Rear Flange Mounted Parts

1. Put rear flange (201) on the workbench, with its inner face up.
2. Insert valve (263) into rear flange (201).

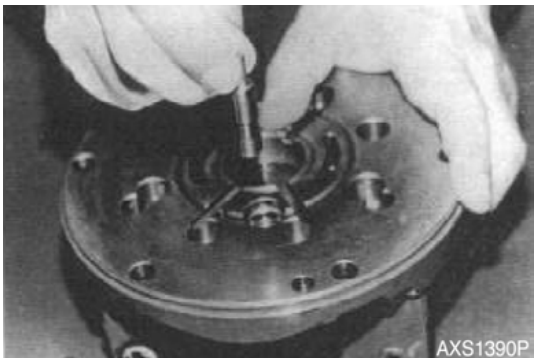


Figure 128

3. Install the spring (266) into the valve (263), and insert the stopper (264) on it.

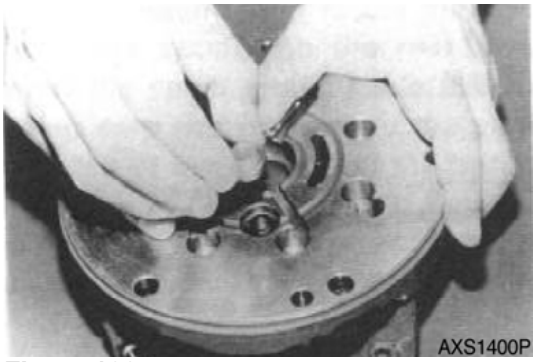


Figure 129

4. Slightly bend a new ring (265) and insert it into the rear flange (201) from the top of stopper (264). Then fit the new ring (265) into the groove of the rear flange (201).

   NOTE: *The ring used must be fitted snugly into the ring groove of the rear flange. Improper insertion of the ring into the ring groove may cause unstable of the valve, thus disassembling high/low speed selection. The ring must be a new one.*

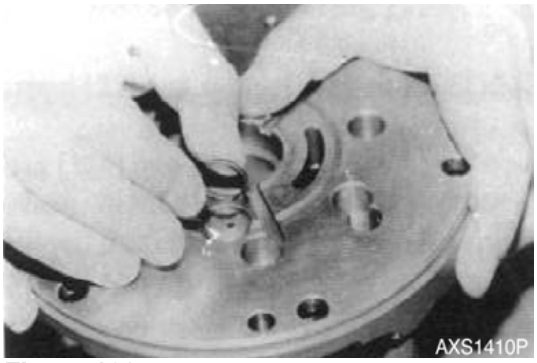
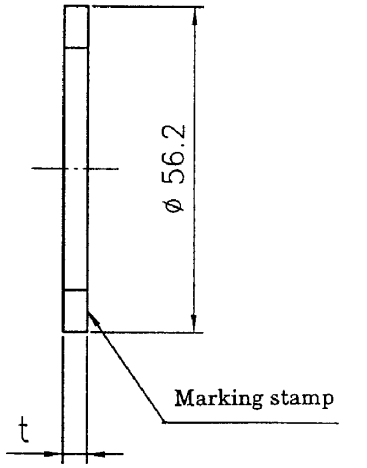


Figure 130

CLEARANCE ADJUSTMENT
PART DIMENSIONS

Part Name	Dimensions	
Retaining ring (20)	Classification symbol	Dimension (T)
	A	1.75 mm < T ≤ 1.80 mm (0.07 in < T ≤ 0.0709 in)
	B	1.80 mm < T ≤ 1.85 mm (0.0709 in < T ≤ 0.0728 in)
	C	1.85 mm < T ≤ 1.90 mm (0.0728 in < T ≤ 0.0748 in)
	D	1.90 mm < T ≤ 1.95 mm (0.0748 in < T ≤ 0.0768 in)
	E	1.95 mm < T ≤ 2.00 mm (0.0768 in < T ≤ 0.0787 in)
	F	2.00 mm < T ≤ 2.05 mm (0.0787 in < T ≤ 0.0807 in)
	G	2.05 mm < T ≤ 2.10 mm (0.0807 in < T ≤ 0.0827 in)
	H	2.10 mm < T ≤ 2.15 mm (0.0827 in < T ≤ 0.0846 in)
	I	2.15 mm < T ≤ 2.20 mm (0.0846 in < T ≤ 0.0866 in)
	J	2.20 mm < T ≤ 2.25 mm (0.0866 in < T ≤ 0.0886 in)
	K	2.25 mm < T ≤ 2.30 mm (0.0886 in < T ≤ 0.0906 in)
	L	2.30 mm < T ≤ 2.35 mm (0.0906 in < T ≤ 0.0925 in)
	M	2.35 mm < T ≤ 2.40 mm (0.0925 in < T ≤ 0.0945 in)
	N	2.40 mm < T ≤ 2.45 mm (0.0945 in < T ≤ 0.0965 in)
	O	2.45 mm < T ≤ 2.50 mm (0.0965 in < T ≤ 0.0984 in)



AXS0540S

NOTE: *56.2 mm (2.21 in)*

DISASSEMBLY

Following care should be taken in disassembly:

Make pressure of the actuator not fulfilled and stop engine. If disassembling with pressure fulfilled, it is dangerous as H/P oil may be discharged or parts may be taken out.

1. Take out air pressure within the tank. If there is pressure within a tank, it is dangerous as oil may be discharged in disassembly.
2. Properly clean around the part disassemble so that foreign material should not enter in the valve.
3. Keep disassembled parts with tags so that position of reassembly can be known.
4. Disassembles seal types (O-ring, backup ring, wiper) should be replaced with new parts.

Disassembly of Accessory

Take off relief valve assembly, Combination No. (15), (16), (17) of Figure 27.

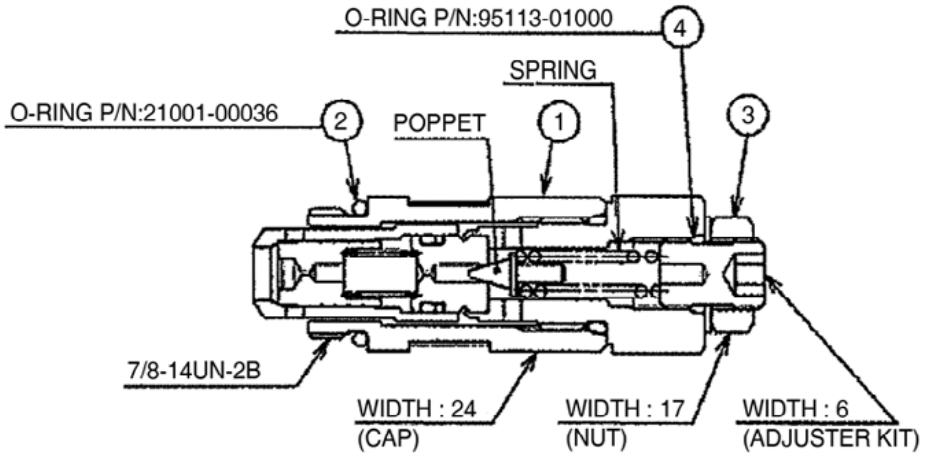
Disassembly of Arm2, Bucket, Right Run, Left Run, Arm1, Dozer, Swing, Boom Swing Section

Take off the cap of Combination No. (3) of Figure 28, Figure 29, Figure 31, Figure 32, Figure 33, Figure 36, Figure 37, Figure 38 by loosening a (13) socket head bolt (hexagonal hole subtense 5mm). Remove (4) spring seat, (6) spring (5) spring seat and (12) O-ring. Then take out the (2) spool from the (1) valve housing. In this manner, also take out the opposite (8) cap. And Combination No. of the running socket head bolt becomes (10), while O-ring becomes (9).

⚠ CAUTION

When taking out the spool, straightly take out it so that stroke trace, scratched flaw, etc should not occur. If they occur, there is concern that flaw may occur in the body hole and that spool may enter in assembly. Entering of spool may result in poor operation. Tags, etc should be adhered for identification so that wrong identification of the actuator should not occur.

Hint for Disassembly and Assembly of Main Relief Valve



FG011265

Figure 4

1. Disassembly

   For the original product, replace assembly.

   When replacing, loosen the cap (1: hexagonal subtense24) with a spanner, etc and take off the O-ring (2, Figure 4).

   If oil leaks from the adjuster part (3, Figure 4), loosen the adjuster part and replace the O-ring (4, Figure 4).

⚠ CAUTION

In disassembling disassembly the adjuster kits, be cautious so that poppet may not be lost by which parts are popped up by spring.

2. Assembly

   Properly check that there are no scraps, primer pieces, etc around cap (1, Figure 4) screw part. and insert a new O-ring (2, Figure 4).

   After properly cleaning the relief mounting part of the valve housing, mount the relief valve and then tighten cam (1, Figure 4) <1: hexagon subtense 24> to tightening torque of 69~78N•m. If disassembling the adjuster kits, properly clean around the screw part and adjust pressure according to “Hint for Disassembly and Assembly of Overload Relief Valve” on page 1-21).

⚠ CAUTION

All tightening torques as directed above are wet status (working oil adherence status).

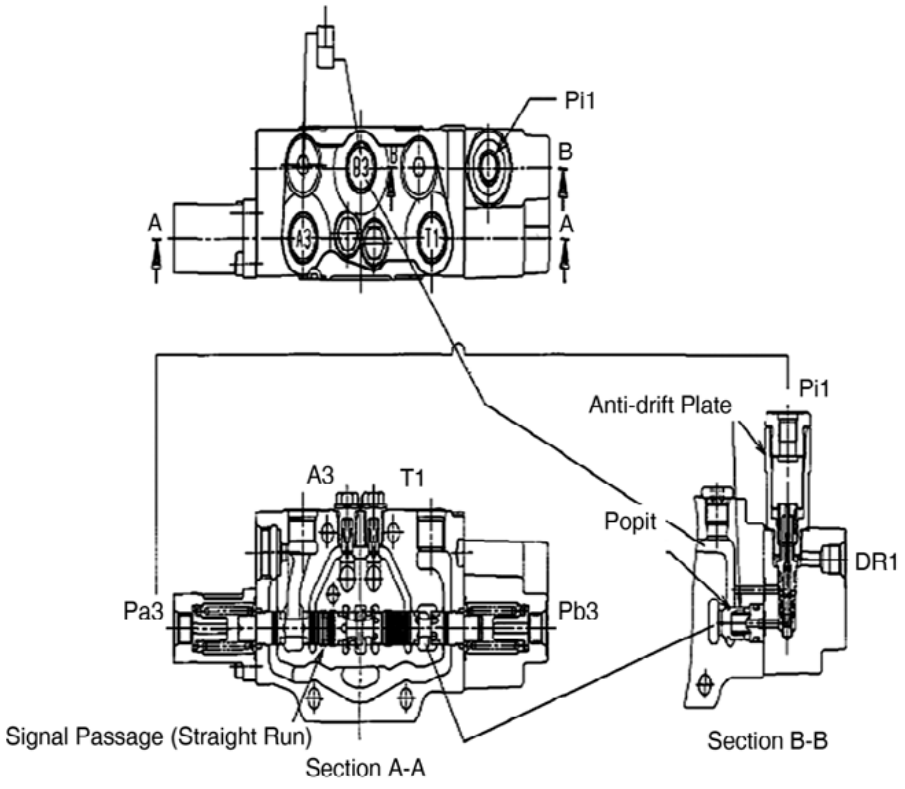


Figure 15 Boom1 Neutral

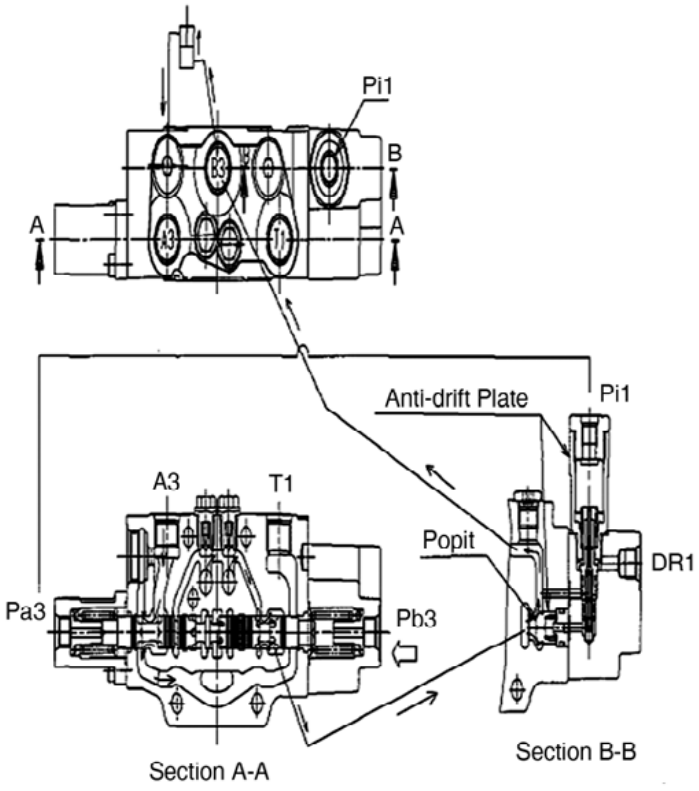
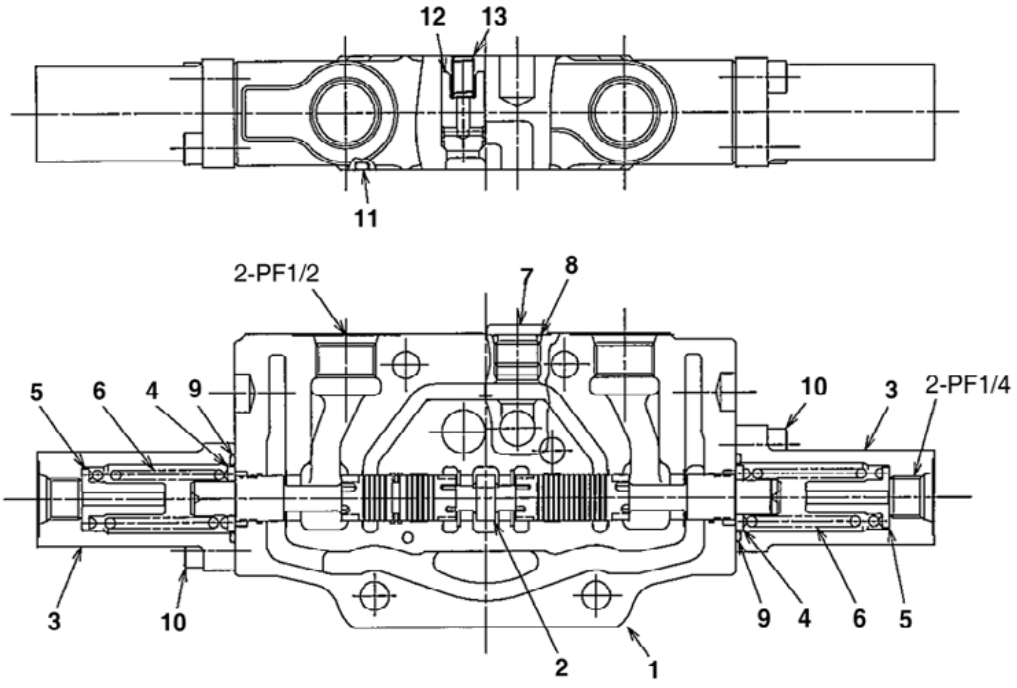


Figure 16 Boom1 Lift Up



FG010480

Figure 31 T-R

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap
4	Spring Seat
5	Spring Seat
6	Spring
7	Plug

Reference Number	Description
8	O-ring
9	O-ring
10	Socket Head Bolt
11	O-ring
12	Poppet
13	Spring

Main Pump

Edition 1

Operation Principle

1. Function of Pump

   - The cylinder block is joined together by a key groove and rotates along with driving axle.
   - The piston is assembled inside cylinder which operates in a reciprocal action along with surface of tilting plate.
   - The piston moves towards direction in which quantity of discharged oil increases, from lower tilting point toward upper tilting point (suction process).
   - While piston strokes are going on from upper tilting point toward lower tilting point, piston moves towards direction in which quantity of discharged oil decreases. The actuator oil is discharged into discharge port (discharge process).
   - The quantity of discharged oil changes according to change in tilt angle of tilting plate (tilting plate).
   - Actuator oil that came into ports of cylinder block is discharged into discharge port of valve plate.
   - The actuator oil that came into outer ports of cylinder block is discharged into discharge port of outer side of valve plate.

Symptoms	Causes	Check	Remedies
Pressure Does Not Increase	The relief valve set pressure is low	Check circuit oil pressure	Adjust relief valve
	Oil Leaking from control valve and actuator	Check the function of the actuators and return line pipes for overheating	Replace control valve and actuator
	Poor pump efficiency	Examine if problem originates from the pump	Replace pump
Overload At Normal Load	Increase in pump output adjustment	Check motor sound and speed	Compare and verify sound of motor and adjust output
	Control system Failure	Check movement of control system and presence of foreign objects	Repair or replace damaged parts
	Mechanical damage (bearing etc.)	Check bearing for cause of abnormal heat and noise	Repair or replace damaged parts
Decreased Revolution Speed At Varying Load	Maximum pressure in relief valve circuit	Check circuit for cause of abnormal vibration • Check pilot line for foreign objects • Check slipping of the control valve due to foreign objects	Replace relief valve. • Remove foreign objects • Repair or replace damaged parts
	Poor control valve performance		
Abnormally High Heat	Increasing pump leakage	Measure the actuator speed	Replace pump
	Mechanical damage (bearing etc.)	Check the source of noise and heat	Replace damaged parts
	Damaged rubbing surfaces	Check the source of abnormal heat	Replace damaged parts
Oil Leakage	Damaged O-rings and packings	Check area around leak and for abnormal pressure	Replace seal
	Damaged oil seals	Check for damage caused by foreign objects and for abnormal pressure	Replace seal
	Worn input axle seal		Replace input axle, seal and pump
	Loose plug	Check area around leak	Tighten and replace seal

Solenoid Valve and Relief Valve

Symptoms	Causes	Check	Remedies
Does Not Operate	Relief valve set pressure is low	Measure circuit pressure	Adjust relief valve
	Damaged or worn spool	Check for damage due to foreign objects	Replace valve
	Foreign objects in spool	Check for presence of foreign objects	Replace valve

Gear Pump Disassembly

1. Using an Allen wrench (6 mm), remove Allen head bolts (M8 x 45, 4 each).

Figure 36

2. Remove side plate, backup ring, oblong cylindrical ring and gear.

Figure 37

3. Remove idle gear.

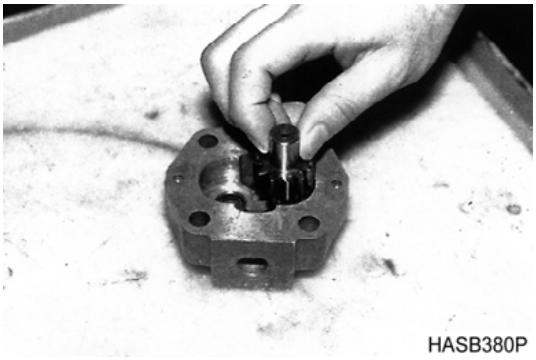


Figure 38

4. Gear pump (GSP2) disassembly
5. Using a wrench (6 mm), remove hex socket bolts (M10 x 90, 4 each).
6. Remove O-rings and filters assembled into the gear pump housing.

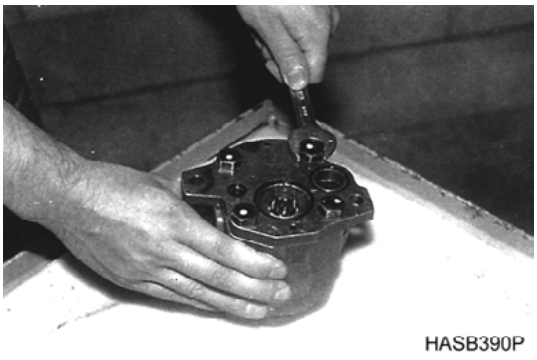


Figure 39

Assembling Control Spring

1. Coat control spring bores with grease before assembling.

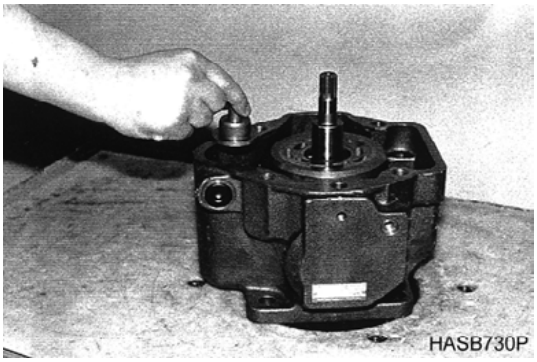


Figure 73

2. Install two springs (both internal and external).

Figure 74

3. Install spring seat and insert control spring.

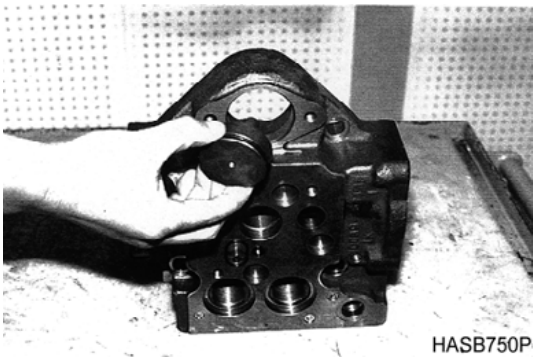


Figure 75

4. Install cover with Allen head bolts.

   NOTE: *Tightening Torque 55 - 69 Nm (5.6 - 7.0 kg•m) 40.5 - 50.5 ft lb)*

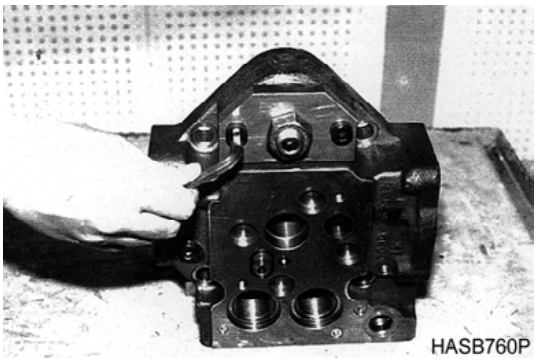


Figure 76

5. Install two aligning pins in the middle housing.

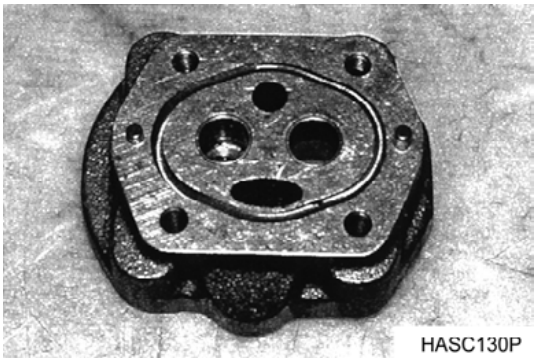


Figure 112

6. Install O-ring into middle housing.

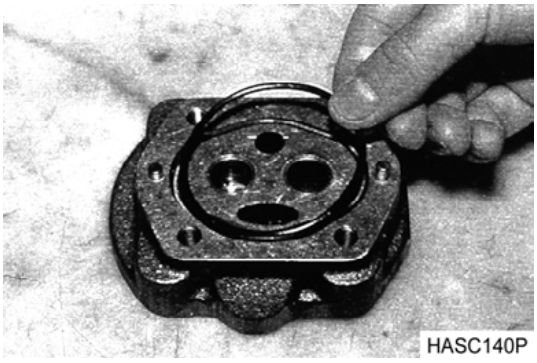


Figure 113

7. Assemble the two middle housings.

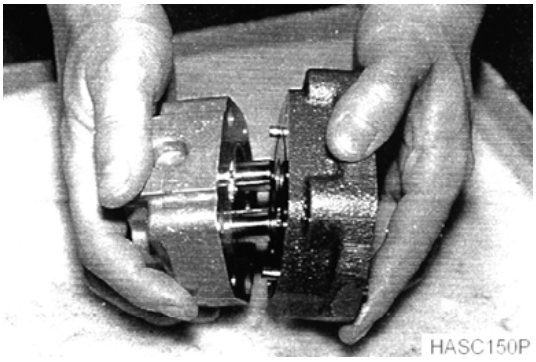


Figure 114

8. Install socket head bolts to secure housing.

   NOTE: *Tightening Torque 29 Nm (3 kg•m) (21.70 ft lb).*

Figure 115

PARTS LIST

No.	Part Name	Standard	Material	Q'TY	Remark	RSP
1	Case			1	J95C1001	O
2	Plug	PT 1/8	SCM440	4	WPT18	O
3	Plug	PF 3/8		1	J95C1002	O
4	O-Ring	P14	N,B,R	1	PO 014	X
5	O-Ring	P10A	N,B,R	1	PO 010A	X
I-A	Spool Kit	Port 1, 3			JA6H6011	O
I-B	Spool Kit	Port 2, 4			JA6H6012	O
I-6	Spool			4	J95C1003	X
I-7	Shim			AR	J95C1004	X
I-A-8	Spring	Port 1, 3		2	J95C1005	X
I-A-9	Spring Seat	Port 1, 3		2	J95C1006	X
I-A-10	Spring	Port 2, 4		2	J96C1008	X
I-A-11	Spring Seat	Port 2, 4		2	J96C1009	X
I-12	Stopper			4 set	J24D2011	X
13	Spring			4	J96C2001	O
II-A	Plug Kit	Port 1, 3			JA7L4013	O
II-B	Plug Kit	Port 2, 4			JA7L4014	O
II-14	Plug			4	JA2M5017A	X
II-15	Rod Seal	10×16×4.5	N.B.R	4	C1-1008	X
II-16	O-Ring	4D-P20	FKM	4	PO 020(F)	X
II-A-17	Push Rod	Port 1, 3			J95C1009	X
II-B-18	Push Rod	Port 2, 4			J96C1001	X
19	Plate			1	JA1G1002	O
20	Boot			1	J97A5018	O
21	Joint Ass'y			1	J95C1012	O
22	Swash Plate			1	J97A5016	O
23	Hex Nut			1	J95C1014	O
III	Handle Kit	LH			JA7L4015	O
III	Handle Kit	RH			JA7L4016	O
III-24	Nut			1	HNM14	X
III-25	Handle Ass'y	LH		1 set	JA2M5010	X
III-25	Handle Ass'y	RH		1 set	JA2M5011	X
III-26	Handle Bar			1	JA7L4001	X
III-27	Spring Pin			1	SP0528	X
III-28	Bellows			1	JA2M5012	X
29	Bushing			1	JA1G1003	O
30	Connector Ass'y			1 set	JA2M5013	O
IV	Seal Kit	4,5, II-15, II-16			JA7L4017	O

Dozer Valve

Edition 1

7. Separate the PLUG (2) from the BODY (1).

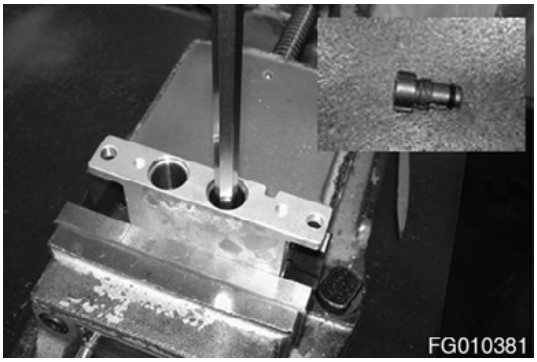


Figure 10

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling the load.

Remember that ultimate safety is your own responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX60R	50001 and Up

Assembly

Preparation

1. Prepare the tool and parts, and assemble the valve at a location where it is clean and dust free.

General precaution during reassembly

1. It is the same as disassembly.
2. Clean each part and remove any alien particles. Then check whether there are any rough marks and damages. If there are rough marks and damages, remove them with oil stone or exchange the part.
3. In principle, O-ring and dust seal (NHU PACKING) must be exchanged with a new product.
4. When exchanging the O-ring or dust seal (NHU PACKING), be careful not to damage the part. (When assembling the part, apply a small amount of grease on the O-ring so that the part does not come off.)
5. Apply the grease even when assembling a small part so that the part does not come off.
6. Tighten the bolt according to the 'Tightening torque table'. Measure the tightening torque with the torque wrench.
7. Block the port with the plug after the assembly so that alien particles do not get inside.

Assembly

1. Assemble the washer (6), washer (7) and spring (9) to the spool in this order.

Figure 23

2. Put the spring seat (10) on the spool and press down to assemble it.

Figure 24

Table of Contents

Pedal Valve

13. Completd Assembly.

Figure 23

Electrical System

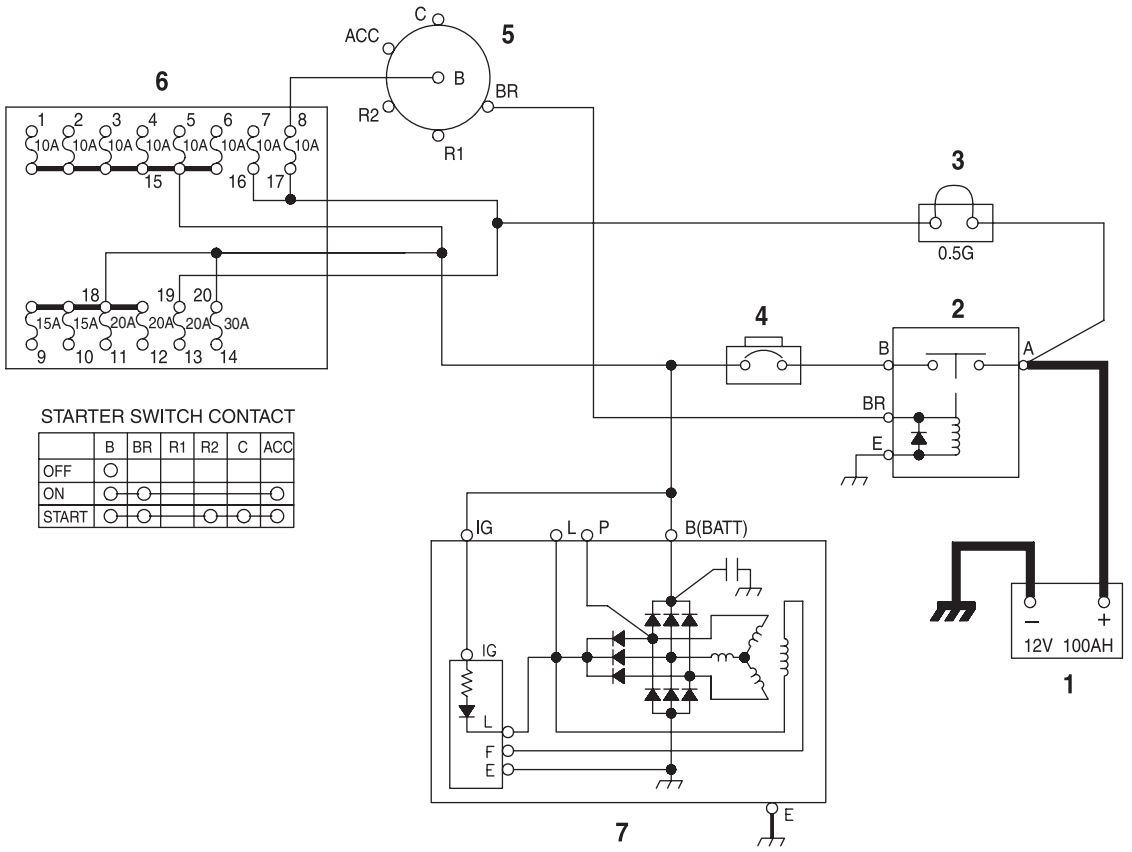


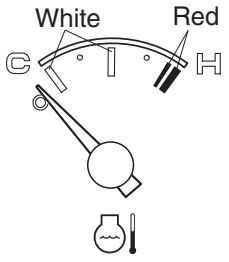
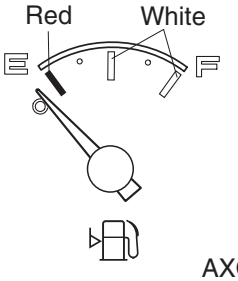
Figure 1 ELECTRIC POWER CIRCUIT DIAGRAM

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker

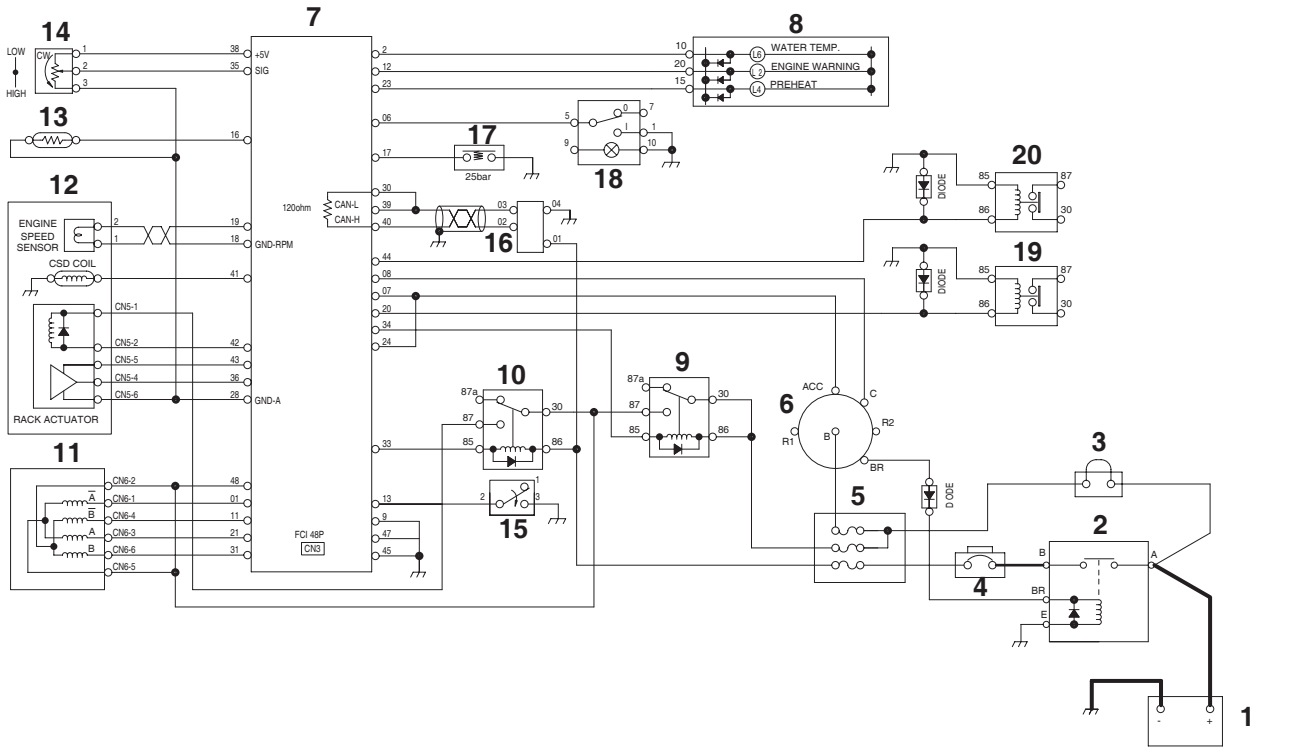
Reference Number	Description
5	Starter Switch
6	Fuse Box
7	Alternator

OPERATION

Gauge

Function	Display	Sensor Specification	
		Input Terminal	Input Specification
Engine Coolant Temperature	 AXO0280L	2	50°C - Over 188.2Ω 67°C - 102Ω 105°C - 32Ω 125°C - below 19.8Ω
Fuel Quantity	 AXO0290L	3	Empty - Over 90Ω 1/2 - 38Ω Full - below 10Ω

Engine Control Unit



FG011503

Figure 17

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Starter Switch
7	ECU (Engine Control Unit)
8	Instrument Panel
9	Main Relay
10	Rack Actuator Relay

Reference Number	Description
11	EGR Valve
12	Fuel Injection Pump
13	Engine Coolant Temperature Sensor
14	Engine Control Dial
15	Engine Emergency Stop Switch
16	CAN check connector
17	Auto Idle Pressure Switch
18	Auto Idle Select Switch
19	Starter Relay
20	Preheat Relay

Air Flow Control

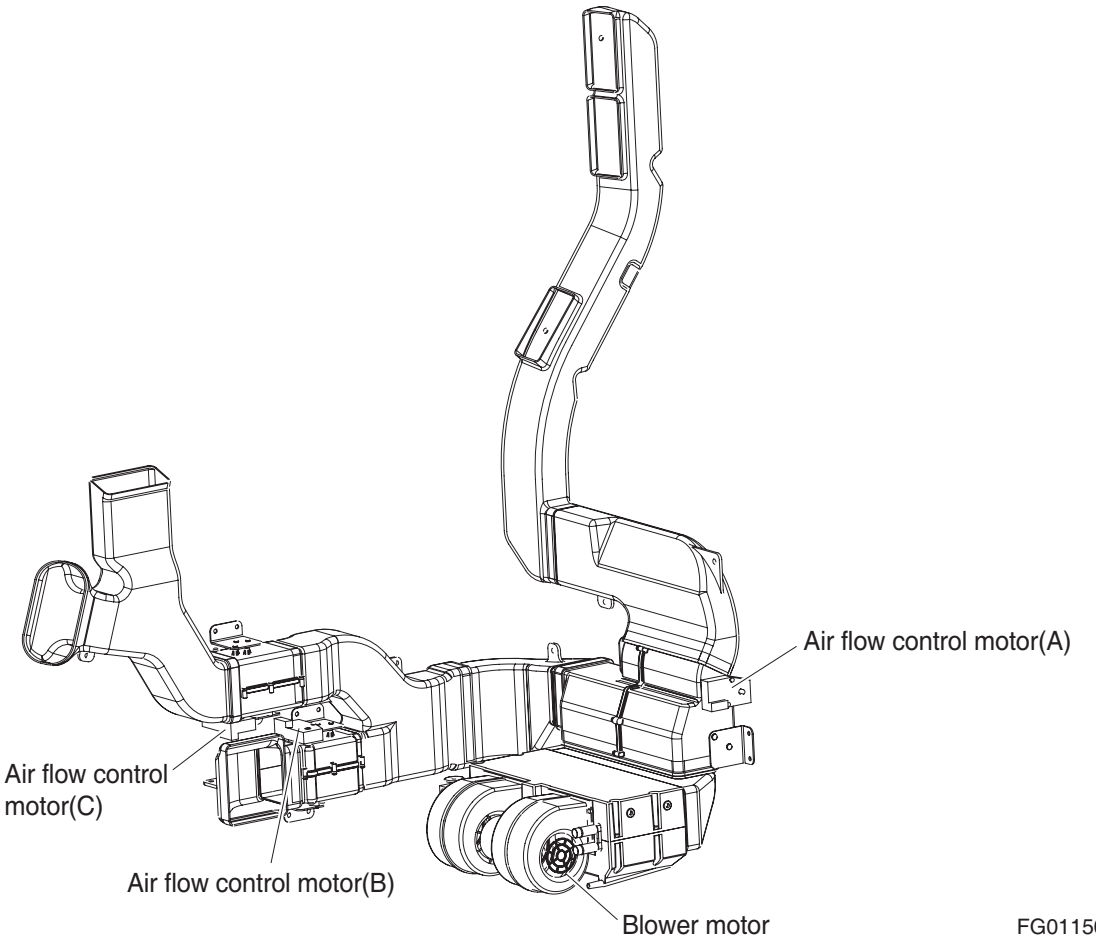


Figure 23

	Air flow control motor (A)	Air flow control motor (B)	Air flow control motor (C)
	Open	Open	Close
	Close	Open	Close
	Close	Open	Open
	Close	Close	Open
	Open	Open	Open

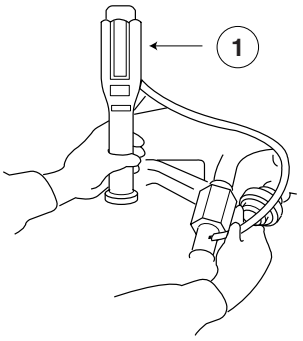
Leakage Check

NOTE: *Perform the leakage check after completing vacuuming process.*

1. After attaching the manifold gauge, open the high side valve.
2. Charge system until the low side gauge dial indicates a pressure of 1 kg/cm^2 (14 psi) and close the high side valve.
3. Using a refrigerant leak detector or soapy water check each joint for leakage.

Reference Number	Description
1	Refrigerant Leak Detection Device

4. If a leak is detected, check for O-ring damage or correct tightening torque and replace or repair as necessary.
5. If no leaks are detected, proceed with the charging process.



HDA6071L

Figure 33

CAUTION

For accurate refrigerant leak detection, perform leak detection procedure in a well-ventilated area.

Refrigerant Charging

1. Perform the vacuuming procedure, vacuum holding and leaking tests as described in the proceeding headings.

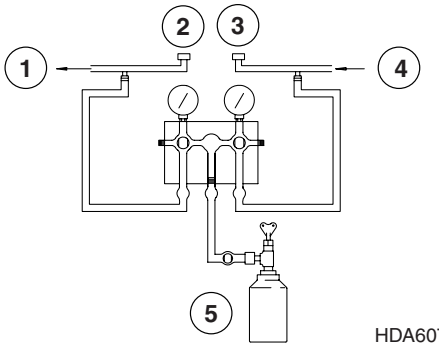
   NOTE: *First charge the refrigerant system with 100 g (3.5 ounces) of refrigerant with the engine off. Then using the manifold gauges as a guide fully charge the system with the engine running.*

   When exchanging refrigerant containers, press the manifold gauge low side valve to eliminate air from the charging hose.

Reference Number	Description
1	To Compressor
2	Low-pressure Side
3	High-pressure Side
4	From Receiver
5	Refrigerant Supply Container

2. Charge the system by opening the manifold gauge low side valve.

   Initial charge amount: 100 g (3.5 ounces).



HDA6072L

Figure 34

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling the load.

Remember that ultimate safety is your own responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX60R	50001 and Up
DX80R	50001 and Up

SAFETY PRECAUTIONS

CAUTION

Follow all safety recommendations and safe shop practices outlined in the front of this manual or those contained within this section.

Always use tools and equipment that are in good working order.

Use lifting and hoisting equipment capable of safely handling load.

Remember that ultimate safety is your own personal responsibility.

APPLICABLE MODELS

The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX60R	50001 and Up