

DX55W

Shop Manual

K1038983BE

Serial Number 7118 and Up

DOOSAN reserves the right to improve our products in a continuing process to provide the best possible product to the market place. These improvements can be implemented at any time with no obligation to change materials on previously sold products. It is recommended that consumers periodically contact their distributors for recent documentation on purchased equipment.

This documentation may include attachments and optional equipment that is 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.

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Safety

Wheel Excavator Safety

Edition 1

MEMO

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MEMO

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 ultimately 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
DX55W	5001 and Up

TO THE OPERATOR OF A EXCAVATOR



DANGER

Unsafe use of the excavator could lead to serious injury or death. Operating procedures, maintenance and equipment practices or traveling or shipping methods that do not follow the safety guidelines on the following pages could cause serious, potentially fatal injuries or extensive damage to the machine or nearby property.

Please respect the importance of taking responsibility for your own safety, and that of other people who may be affected by your actions.

The safety information on the following pages is organized into the following sections:

1. "Location of Safety Labels" on page 1-11
2. "Summary of Safety Precautions for Lifting in Working Mode" on page 1-12
3. "Unauthorized Modifications" on page 1-13
4. "General Hazard Information" on page 1-13
5. "Before Starting Engine" on page 1-23
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WARNING

Improper operation and maintenance of this machine can be hazardous and could result in serious injury or death.

Operator and maintenance personnel should read this manual thoroughly before beginning operation or maintenance.

Keep this manual in the storage compartment to the rear of the operator's seat, and have all personnel involved in working on the machine read the manual periodically.

Some actions involved in operation and maintenance of the machine can cause a serious accident, if they are not done in a manner described in this manual.

The procedures and precautions given in this manual apply only to intended uses of the machine.

If you use your machine for any unintended uses that are not specifically prohibited, you must be sure that it is safe for any others. In no event should you or others engage in prohibited uses or actions as described in this manual.

DOOSAN delivers machines that comply with all applicable regulations and standards of the country to which it has been sent. If this machine has been purchased in another country or purchased from someone in another country, it may lack certain safety devices and specifications that are necessary for use in your country. If there is any question about whether your product complies with the applicable standards and regulations of your country, consult *DOOSAN* or your *DOOSAN* distributor before operating the machine.

SAFETY ALERT SYMBOL

Be Prepared - Get to Know All Operating and Safety Instructions.

This is the Safety Alert Symbol. Wherever it appears in this manual or on safety signs on the machine you should be alert to the potential for personal injury or accidents. Always observe safety precautions and follow recommended procedures.

Learn the Signal Words Used with the Safety Alert Symbol

The words "CAUTION" "WARNING" and "DANGER" used throughout this manual and on decals on the machine indicate degree of risk of hazards or unsafe practices. All three degrees of risk indicate that safety is involved. Observe precautions indicated whenever you see the Safety Alert "Triangle" no matter which signal word appears next to the "Exclamation Point" symbol.

CAUTION

This word is used on safety messages and safety labels and indicates potential threat of a hazardous situation that, if not avoided, could result in minor or moderate injury. It may also be used to alert against a generally unsafe practice.

WARNING

This word is used on safety messages and safety labels and indicates potential threat of a hazardous situation that, if not avoided, could result in serious injury or death. It may also be used to alert against highly unsafe practice.

DANGER

This word is used on safety messages and safety labels and indicates an imminent hazard of a situation that, if not avoided, is very likely to cause death or extremely serious injury. It may also be used to alert against equipment that may detonate or explode if handled or treated carelessly.

Safety precautions are described in SAFETY from page -11 on.

DOOSAN cannot predict every circumstance that might involve a potential hazard in operation and maintenance. Therefore the safety messages in this manual and on the machine may not include all possible safety precautions. If any procedures or actions not specifically recommended or allowed in this manual are used, you must be sure that you and others can do such procedures and actions safely and without damaging the machine. If you are unsure about the safety of any procedures, contact a *DOOSAN* distributor.

GENERAL SAFETY ESSENTIALS

Accessory Applications

The excavator has been primarily designed for moving earth with a bucket. For use as a grapple or for other object handling, contact *DOOSAN* for proper installation and application. Lifting-work applications (unless restricted or prohibited by local regulations) are permitted in approved lift configuration, to rated capacity only, with no side-loading. DO NOT use the machine for activities for which it was not intended. DO NOT use the bucket for lifting work, unless lift slings are used in the approved configuration.

Use of an accessory hydraulic hammer (breaker), work in rough terrain, demolition applications or other hazardous operation may require installation of additional protective structures to safeguard the operator.

Lifting Capacity Rating Configuration

Lifting capacity ratings that are printed at the end of this safety section are based on the machine being level, on a firm supporting surface, with hooks and slings attached in approved configuration. Loads must be balanced and supported evenly. Use tag lines to keep the load steady if wind conditions and large surface area are a problem. Work crew hand signals, individual tasks and safe procedures should all be universally understood before the lift is made.

IMPORTANT

Before using the excavator to make lifts check municipal and regional regulations or statutes that could apply. Governing ordinances may require that all heavy lifting be done with single purpose equipment specifically designed for making lifts, or other local restrictions may apply. Making heavy lifts with a general purpose excavator that can be used for digging, loading, grading or other work may be expressly forbidden by a regional injunction or other legal prohibition. Always follow all of the other instructions, guidelines and restrictions for Safe Lifting in the Operation and Maintenance Manuals.

LOCATION OF SAFETY LABELS

Location of safety labels (decals) can vary from unit to unit. Refer to appropriate Operation and Maintenance Manual, and parts manual for your unit.

Always replace damaged or faded decals.

SUMMARY OF SAFETY PRECAUTIONS FOR LIFTING IN WORKING MODE



DANGER

Unsafe use of the excavator while making rated lifts could cause serious, potentially fatal injuries or extensive damage to the machine or nearby property. Do not let anyone operate the machine unless they've been properly trained and understand the information in the Operation and Maintenance Manual.

To lift safely while in Working Mode, the following items must be evaluated by the operator and the work site crew.

- Condition of ground support.
- Excavator configuration and attachments.
- Weight, lifting height and lifting radius.
- Safe rigging of the load.
- Proper handling of the suspended load.

Tag lines on opposite sides of the load can be very helpful in keeping a suspended load secure, if they are anchored safely to control points on the ground.



WARNING

NEVER wrap a tag line around your hands or body.

NEVER rely on tag lines or make rated lifts when wind gusts are more than 48.3 km/h (30 MPH). Be prepared for any wind gust when working with loads that have a large surface area.

Always engage the "Working Mode" control on the Instrument Panel before using the excavator for lifting work.



WARNING

If you need more information or have any questions or concerns about safe operating procedures or working the excavator correctly in a particular application or in the specific conditions of your individual operating environment, please consult your local **DOOSAN** representative.

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.

Inside Operator's Cabin

When entering the operator's cabin, always remove all mud and oil from the soles of your shoes. If you operate the travel pedal with mud or oil stuck to your shoes, your foot may slip and this may cause a serious accident.

After using the ashtray, make sure that any matches or cigarettes are properly extinguished, and be sure to close the ashtray. If the ashtray is left open, there is a danger of fire.

Do not stick suction pads to the window glass. Suction pads act as a lens and may cause fire.

Do not leave lighters laying around the operator's cabin. If the temperature inside the operator's cabin becomes high, there is a danger that lighter may explode.

Do not use cellular telephones inside the operator's cabin when driving or operating the machine. There is a danger that this may lead to an unexpected accident.

Never bring any dangerous objects such as flammable or explosive items into the operator's cabin.

To ensure safety, do not use the radio or music headphones when operating the machine. There is a danger that this may lead to a serious accident.

When operating the machine, do not put your hands or head out of the window.

When standing up from the operator's seat, always place safety lock lever securely in the "LOCK" position. If you accidentally touch the work equipment levers when they are not locked, the machine may suddenly move and cause serious injury or damage.

When leaving the machine, lower the work equipment completely to the ground, set safety lock lever to the "LOCK" position and shut down engine. Use the key to lock all the equipment. Always remove key and take it with you.

Clothing and Personal Protective Items

Secure long hair, and avoid loose clothing and jewelry. These items have the tendency to catch on controls or protrude into parts and cause serious injury or death.

Do not wear oily clothes. They are highly flammable.

Full eye protection, a hard hat, safety shoes and gloves may be required at the work site.

While working on the machine, never use inadequate tools. They could break or slip, causing injury, or they may not adequately perform intended functions.



Figure 1

Breathing Masks, Ear Protection May Be Required

Do not forget that some risks to your health may not be immediately apparent. Exhaust gases and noise pollution may not be visible, but these hazards can cause disabling or permanent injuries.

NOTE: *The equivalent continuous A-weighted sound pressure level at the workstation for this machine is given in the operation manual.*

Measurement is obtained on a dynamic machine following the procedures and cabin conditions as described in ISO 6396.

NOTE: *The guaranteed sound power level emitted by the machinery for this machine is given in the operation manual.*

Measurement is obtained on a dynamic machine with the procedures as described in 2000/14/EC.

Vibration Level Information

Hands/Arms: The weighted root mean square acceleration to which the hands/arms are subjected, is less than 2.5 m/s^2 .

Whole body: The weighted root mean square acceleration to which the whole body is subjected, is less than 0.5 m/s^2 .

Measurements are obtained on a representative machine, using measuring procedures as described in the following standard: ISO 2631/1, ISO 5349, and SAE J1166.

Recommendations for Limiting Vibrations

1. Select the right machine, equipment and attachments for a particular application.
2. Replace any damaged seat by a *DOOSAN* genuine part. Keep the seat maintained and adjusted.
 - Adjust the seat and suspension for the weight and size of the operator.
 - Inspect and maintain the suspension and adjustment mechanisms of the seat regularly.
3. Check that machine is properly maintained.
 - Tire pressure, brakes, steering, linkages, etc.
4. Steer, brake, accelerate, shift gears, move the attachments and load the attachments smoothly.
5. Adjust the machine speed and travel path to reduce the vibration level.
 - Slow down if it is necessary when traveling through rough terrain.
 - When driving machine, avoid obstacles and excessive rough terrain.
6. Keep the machine on terrain where working and traveling conditions are good.
 - Remove any large rocks or obstacles.
 - Fill any ditches and holes.
 - Provide machines for and schedule time to maintain good terrain conditions.
7. Travel over longer distance (e.g. on public roads) at adjusted (medium) speed.
 - Always adjust the speed to prevent bouncing.

Mounting and Dismounting

Before getting on or off the machine, if there is any oil, grease, or mud on the handrails, steps, wipe it off immediately. Always keep these parts clean. Repair any damage and tighten any loose bolts.

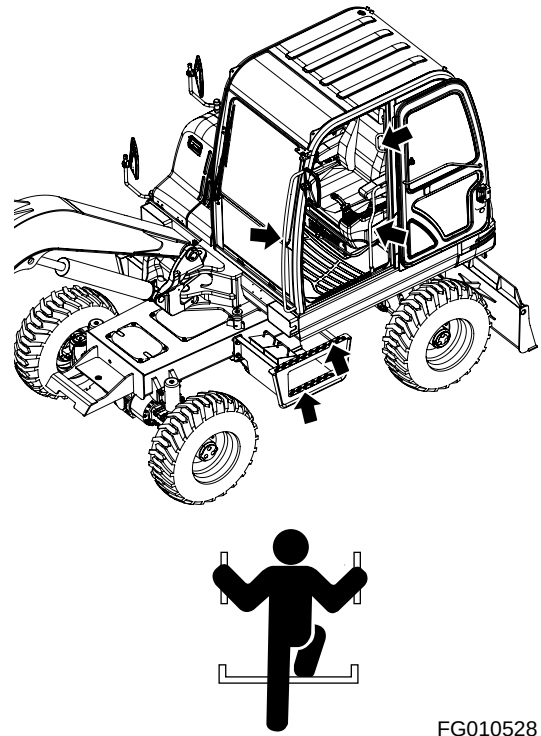
Never jump on or off the machine. In particular, never get on or off a moving machine. These actions may lead to serious injury.

When getting on or off the machine, always face the machine, and maintain three-point contact (both feet and one hand or one foot and both hands) with the handrails and steps to ensure that you support yourself securely.

Never hold any control levers when getting on or off the machine.

Apply the door lock securely. If you grip the handrail inside the door when moving on top of the steps, and the door lock is not applied securely, the door may move and cause you to fall.

Use the points marked by arrows in the diagram when getting on or off the machine.



FG010528

Figure 2

Fuel, Oil and Hydraulic Fluid Fire Hazards

Fuel, oil and antifreeze will catch fire if it is brought close to a flame. Fuel is particularly flammable and can be hazardous.

Always strictly observe the following.

Add fuel, oil, antifreeze and hydraulic fluid to the machine only in a well ventilated area. The machine must be parked with controls, lights and switches turned "OFF". The engine must be "OFF" and any flames, glowing embers, auxiliary heating units or spark causing equipment must be extinguished, turned "OFF" and/or kept well clear of the machine.

Static electricity can produce dangerous sparks at the fuel filling nozzle. In very cold, dry weather or other conditions that could produce a static discharge, keep the tip of the fuel nozzle in constant contact with the neck of the fuel filling nozzle, to provide a ground.

Keep fuel and other fluid reservoir caps tight and do not start the engine until caps have been secured.

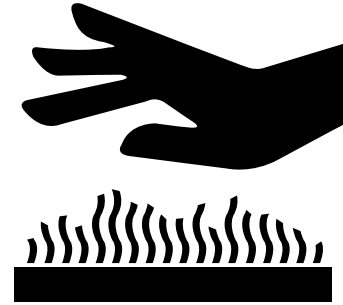


ARO1050S

Figure 3

Precautions When Handling Fluids at High Temperature

Immediately after operations are stopped, the coolant, engine oil, and hydraulic oil are at highest temperatures and the radiator and hydraulic tank are still under pressure. Attempting to remove cap, drain the oil or coolant, or replace the filters may lead to serious burns. Always wait for the temperature to go down, and follow the specified procedures when carrying out these operations.



HAOA050L

Figure 4

To prevent hot coolant from spurting out, shut down engine, wait for the coolant to cool, then loosen the cap slowly to relieve the pressure.

To prevent hot oil from spurting out, shut down engine, wait for the oil to cool, then loosen the cap slowly to relieve the pressure.



HAOA060L

Figure 5

Asbestos Dust Hazard Prevention

Asbestos dust can be HAZARDOUS to your health if it is inhaled. Materials containing asbestos fiber can be present on work site. Breathing air that contains asbestos fiber can ultimately cause serious or fatal lung damage. To prevent lung damage from asbestos fiber, observe following precautions:

- Use a respirator that is approved for use in an asbestos-laden atmosphere.
- Never use compressed air for cleaning.
- Use water for cleaning to keep down the dust.
- Work on the machine or component with the wind at your back whenever possible.
- Always observe any regulations related to the work site and working environment.



ARO1770L

Figure 6

Injury from Work Equipment

Do not enter or put your hand, arm or any other part of your body between movable parts, such as between the work equipment and cylinders, or between the machine and work equipment.

If the control levers are operated, the clearance between the machine and the work equipment will change and this may lead to serious damage or personal injury.

If going between movable parts is necessary, always position and secure the work equipment so it cannot move.



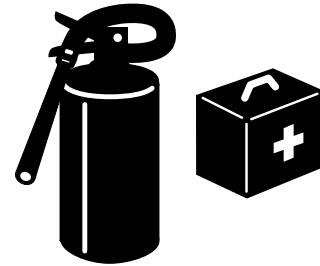
HDO1010L

Figure 7

Fire Extinguisher and First Aid Kit

As a precaution if any injury or fire should occur, always do the following.

- Be sure that fire extinguishers have been provided and read the labels to ensure that you know how to use them. It is recommended that an appropriately sized (2.27 kg [5 lb] or larger) multipurpose "A/B/C" fire extinguisher be mounted in the cabin. Check and service the fire extinguisher at regular intervals and make sure that all work site crew members are adequately trained in its use.
- Provide a first aid kit in the storage compartment and keep another at the work site. Check the kit periodically and make any additions if necessary.
- Know what to do in case of injury from fire.
- Keep emergency numbers for doctor, ambulance service, hospital and fire department near your telephone.



HDO1009L

Figure 8

If the machine catches fire, it may lead to serious personal injury or death. If a fire occurs during operation, escape from the machine as follows:

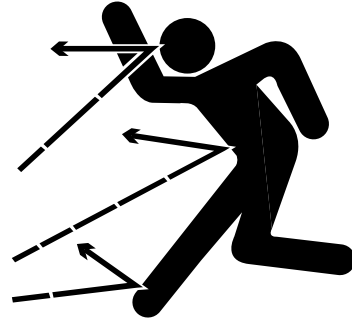
- Turn the starter switch to the "O" (OFF) position and shut down engine.
- If there is time, use the fire extinguisher to put out as much of the fire as possible.
- Use the handrails and steps to escape from the machine.

The above is the basic method for escaping from the machine, but changing the method may be necessary according to the conditions, so carry out practice drills at the work site.

Protection from Falling or Flying Objects

On work sites where there is a danger that falling or flying objects may hit the operator's cabin select a guard to match the operating conditions to protect the operator.

Working in mines, tunnels, deep pits or on loose or wet surfaces could produce danger of falling rock or hazardous flying objects. Additional protection for the operator's cabin could be required in the form of a FOPS (Falling Object Protective Structure) or window guards.



HAOA110L

Figure 9

Never attempt to alter or modify any protective structure reinforcement system, by drilling holes, welding, remounting or relocating fasteners. Any serious impact or damage to the system requires a complete integrity reevaluation. Reinstallation, recertification and/or replacement of the system may be necessary.

Contact your *DOOSAN* distributor for available safety guards and/or recommendations to prevent danger of getting hit by objects that could strike the operator's cabin. Make sure that all other work site crew members are kept well away from the excavator and safe from possible hazards.

For breaker operation, install a front guard and apply a laminated coating sheet to the front glass. Contact your *DOOSAN* distributor for recommendations.

When carrying out demolition or cutting operation, install a front guard and top guard, and apply a laminated coating sheet to the front glass.

When working in mines or quarries where there is a danger of falling rock, install FOPS (Falling Objects Protective Structure) and apply a laminated coating sheet to the front glass.

If any glass on the machine is broken, replace it with new glass immediately.



HAOA100L

Figure 10

Attachment Precautions

Option kits are available through your dealer. Contact *DOOSAN* for information on available one-way (single-acting) and two-way (double-acting) piping / valving / auxiliary control kits. Because *DOOSAN* cannot anticipate, identify or test all the attachments that owners may wish to install on their machines, please contact *DOOSAN* for authorization and approval of attachments, and their compatibility with optional kits.

Accumulator

The pilot control system is equipped with an accumulator. For a brief period of time after the engine has been shut down, the accumulator will store a pressure charge that may enable hydraulic controls to be activated. Activation of any controls may enable the selected function to operate under force of gravity.

When performing maintenance on the pilot control system, the hydraulic pressure in the system must be released as described.

The accumulator is charged with high-pressure nitrogen gas, so it is extremely dangerous if it is handled in the wrong way. Always observe the following precautions:

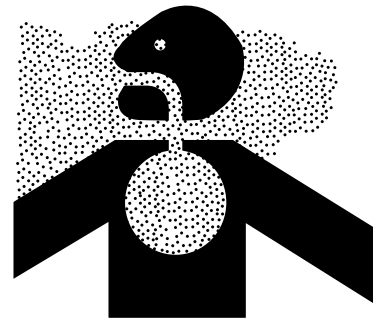
- Do not drill or make any holes in the accumulator or expose it to any flames, fire or heat source.
- Do not weld on the accumulator, or try attaching anything to it.
- When carrying out disassembly or maintenance of the accumulator, or when disposing of the accumulator, the charged gas must be properly released. Contact your *DOOSAN* distributor.
- Wear safety goggles and protective gloves when working on an accumulator. Hydraulic oil under pressure can penetrate the skin and cause serious injuries.

Indoor Ventilation

Engine exhaust gases can cause fatal accidents, and unconsciousness, loss of alertness, judgment and motor control and serious injury.

Make sure there is adequate ventilation before starting the engine in any enclosed area.

You should also be aware of open windows, doors or ductwork where exhaust may be carried, or blown by the wind, exposing others to danger.



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Figure 11

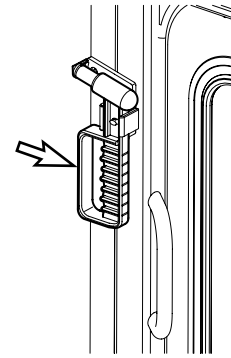
Emergency Glass Breaking Tool

This machine is equipped with a glass breaking tool. It is located on the upper left side of the operator's cabin. This tool can be used in case of an emergency that requires the breaking of glass to exit from the operator's cabin. Grip the handle firmly and use the sharp point to break the glass.



WARNING

Protect your eyes when breaking the glass.



FG010533

Figure 12

BEFORE STARTING ENGINE

Work Site Precautions

Before starting operations, thoroughly check the area for any unusual conditions that could be dangerous.

Check the terrain and condition of the ground at the work site, and determine the best and safest method of operation.

Make sure the ground surface is as hard and horizontal as possible before carrying out operations. If there is a lot of dust and sand on the work site, spray water before starting operations.

If you need to operate on a street, protect pedestrians and cars by designating a person for work site traffic duty or by erecting fences and posting "No Entry" signs around the work site.

Erect fences, post "No Entry" signs, and take other steps to prevent people from coming close to or entering the work site. If people come close to a moving machine, they may be hit or caught by the machine, and this may lead to serious personal injury or death.

Waterlines, gas lines, phone lines and high-voltage electrical lines may be buried under the work site. Contact each utility and identify their locations. Be careful not to damage or cut any of these lines.

Check the condition of the riverbed, and the depth and flow of the water before operating in water or crossing a river. NEVER work in water that is more than the permissible water depth.

Any object in vicinity of boom could represent a potential hazard, or cause the operator to react suddenly and cause an accident. Use a spotter or signal person when working near bridges, phone lines, work site scaffolds, or other obstructions.

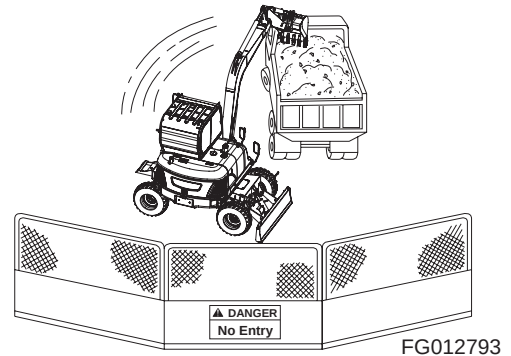


Figure 13

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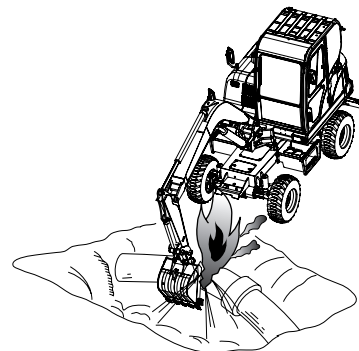


Figure 14

FG010530

Minimum levels of insurance coverage, work permits or certification, physical barriers around the work site or restricted hours of operation may be mandated by governing authorities. There may also be regulations, guidelines, standards or restrictions on equipment that may have to be followed for local requirements. There may also be regulations related to performing certain kinds of work. If there is any question about whether your machine and work site complies with the applicable standards and regulations, contact your local authorities and agencies.

Avoid entering soft ground. It will be difficult for the machine to escape.

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.

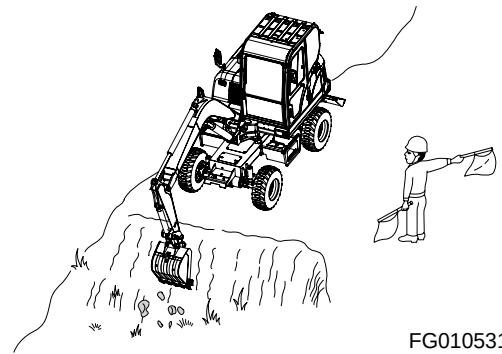


Figure 15

FG010531

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, fuel, and hydraulic tank oil levels, 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 safety lever is in "LOCKED" position.

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

Engine Starting

Walk around your machine before getting in the operator's cabin. Look for evidence of leaking fluid, loose fasteners, misaligned assemblies or any other indications of possible equipment hazard.

All equipment covers and machinery safety guards must be in place, to protect against injury while the machine is being operated.

Look around the work site area for potential hazards, people or property that could be at risk while operation is in progress.

NEVER start the engine if there is any indication that maintenance or service work is in progress, or if a warning tag is attached to controls in the cabin.

A machine that has not been used recently, or is being operated in extremely cold temperatures, could require a warm-up or maintenance service before start-up.

Check gauges and monitor displays for normal operation before starting the engine. Listen for unusual noises and remain alert for other potentially hazardous conditions at the start of the work cycle.

Do not short-circuit the starting motor to start the engine. This is not only dangerous, but may also damage the machine.

When starting the engine, sound the horn as an alert.

Start and operate the machine only while seated.

Before Operating Machine

If checks are not carried out properly after starting the engine, it may result in a delay in discovering abnormalities in the machine, and this may lead to personal injury or damage to the machine.

Carry out the checks in an open area where there are no obstructions. Do not let anyone near the machine when carrying out the checks.

- Check the operating condition of the equipment, and the movement of the bucket, arm, boom, travel, and swing systems.
- Check the machine for any abnormal noise, vibration, heat, smell, or abnormality with the gauges. Check also for leakage of air, oil, and fuel.
- If any abnormality is found, repair the problem immediately. If the machine is used without repairing the problems, it may lead to unexpected injury or failure.
- Clear all personnel from directly around machine and from the area.
- Clear all obstacles from the machine's path. Beware of hazards.
- Be sure that all windows are clean. Secure the doors and the windows in the open position or in the shut position.
- Adjust the rearview mirrors for best visibility close to the machine. Make sure that horn, the travel alarm (if equipped), and all other warning devices are working properly.
- Fasten the seat belt securely.
- Warm up the engine and hydraulic oil before operating machine.
- Before moving the machine, check undercarriage position. The normal travel position is with dozer to the rear the cabin. When the undercarriage is in the reversed position, the travel controls must be operated in opposite directions.

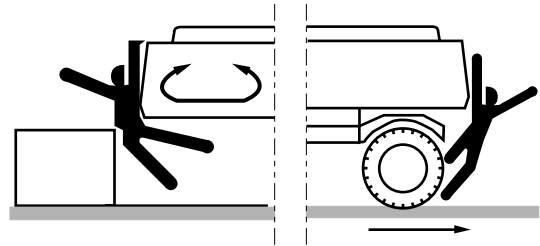
MACHINE OPERATION

When Swinging or Changing Direction of Travel

Before operating the machine or the work equipment, always observe the following precautions to prevent serious injury or death.

- Start and operate the machine only while seated.
- When changing travel direction from forward to reverse or from reverse to forward, reduce speed early and stop the machine before changing travel direction.
- Sound the horn to warn people in the area.
- Check that there is no one in the area around the machine. There are blind spots behind the machine, so if necessary, swing the upper structure to check that there is no one behind the machine before traveling in reverse.
- When operating in areas that may be hazardous or have poor visibility, designate a person to direct work site traffic.
- Ensure that no unauthorized person can come within the turning radius or direction of travel.

Be sure to observe the above precautions even if a travel alarm or mirrors are installed.



HGB1014L-1

Figure 16

Travel Precautions

Never turn the starting switch to the "O" (OFF) position when traveling. It is dangerous if the engine stops while the machine is traveling. It will be impossible to operate the steering.

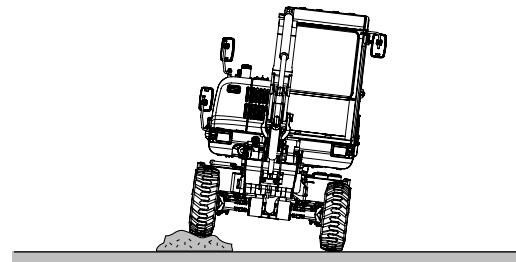
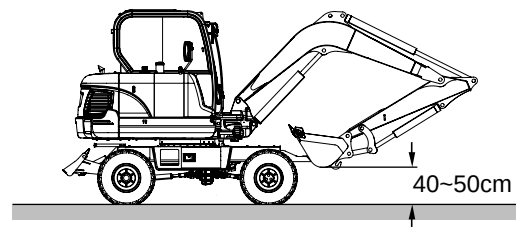
Attachment control levers should not be operated while traveling.

Do not change selected travel mode (FAST/SLOW) while traveling.

Fold in work equipment so the outer end of the boom is as close to the machine as possible, and is 40 - 50 cm (16 - 20 in) aboveground.

Never travel over obstacles or slopes that will cause the machine to tilt severely. Travel around any slope or obstacle that causes the machine to tilt 10 degrees or more to the right or left, or 30 degrees or more from front to rear.

Do not operate the steering suddenly. The work equipment may hit the ground and cause the machine to lose its balance, and this may damage the machine or structures in the area.



FG011196

Figure 17

When traveling on rough ground, travel at low speed, and avoid sudden changes in direction.

Always keep to the permissible water depth. Permissible water depth is to the centerline of the axles.

When traveling over bridges or structures on private land, check first that bridge or structure can withstand the weight of the machine. When traveling on public roads, check with the local authorities and follow their instructions.

Traveling on Slopes

Never jump onto a machine that is running away to stop it. There is a danger of serious injury.

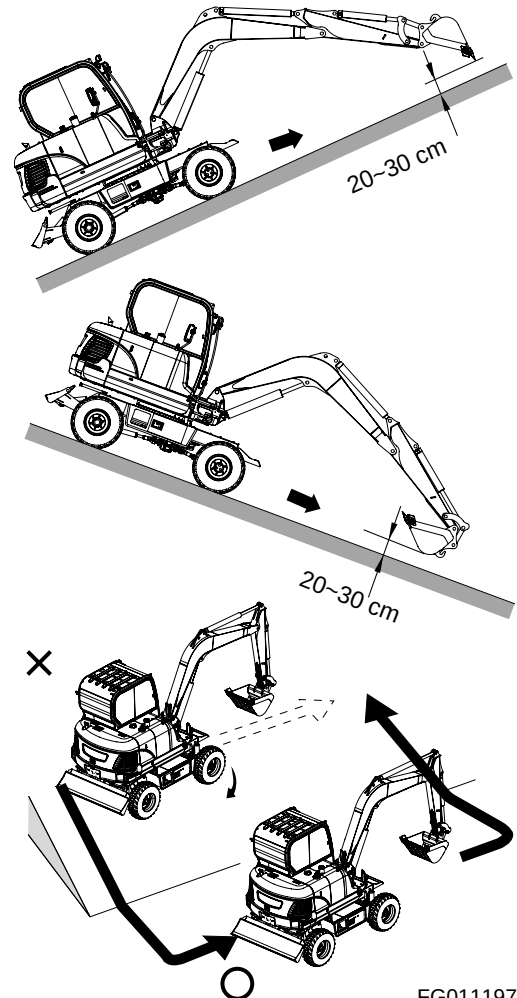
Traveling on slopes could result in the machine tipping over or slipping.

On hills, banks or slopes, carry the bucket approximately 20 - 30 cm (8 - 12 in) above the ground. In case of an emergency, quickly lower the bucket to the ground to help stop the machine.

Do not travel on grass, fallen leaves, or wet steel plates. Even slight slopes may cause the machine to slip to the side, so travel at low speed and make sure that machine is always traveling directly up or down the slope.

Avoid changing travel direction on a slope. This could result in tipping or sideslipping of the machine.

When possible, operate the machine up slopes and downslopes. Avoid operating the machine across the slope, when possible.



FG011197

Figure 18

Prohibited Operations

Do not dig the work face under an overhang. This may cause the overhang to collapse and fall on top of the machine.

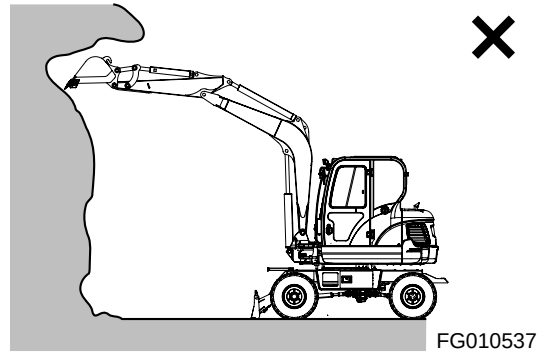


Figure 19

Do not carry out deep digging under the front of the machine. The ground under the machine may collapse and cause the machine to fall.

Working heavy loads over loose, soft ground or uneven, broken terrain can cause dangerous side load conditions and possible tip over and injury. Travel without a load or a balanced load may also be hazardous.

Never rely on lift jacks or other inadequate supports when work is being done. Block tires fore and aft to prevent any movement.

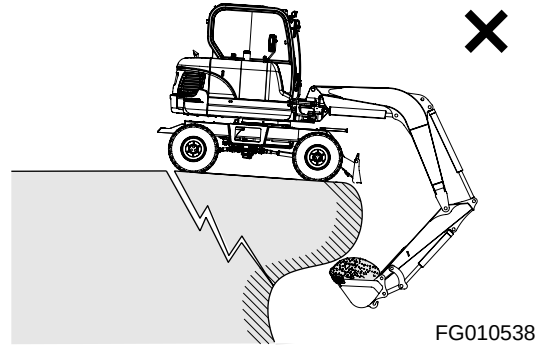


Figure 20

When using the machine, to prevent accidents caused by damage to the work equipment and overturning because of an excessive load, do not use the machine in excess of its ability (in terms of the maximum load and stability determined by the structure of the machine).

When working at the edge of an excavation or on a road shoulder, the machine could tip over, possibly resulting in serious injury or death. Investigate the configuration and ground conditions of the work site beforehand to prevent the machine from falling and to prevent the ground, stockpiles, or banks from collapsing.

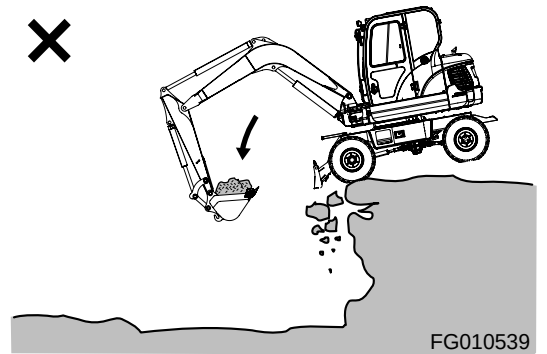


Figure 21

Precautions for Operation

Be careful not to mistakenly travel too close to the edge of a cliff.

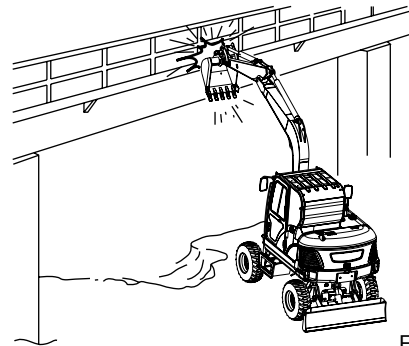
Use the machine only for its main purpose. Using it for other purposes will cause failures.

To ensure a good view, always do the following:

- When working in dark areas, attach working lights and front lights to the machine. If necessary, set up lighting at the work site.
- Stop operations when the visibility is poor, such as in fog, mist, snow, and rain. Wait for the visibility to improve to a level which causes no problems for the operation.

To avoid hitting the work equipment, always do the following:

- When working in tunnels, on bridges, under electrical wires, or when parking the machine or carrying out other operations in places with limited height, be careful not to hit the bucket or other parts.
- To prevent collisions, operate the machine at a safe speed when working in confined spaces, indoors, or in crowded areas.
- Do not pass the bucket over the heads of workers or over the operator's cabin of dump truck.



FG010540

Figure 22

Avoid High-voltage Cables

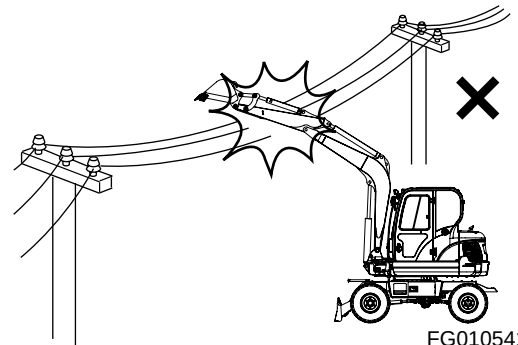
Serious injury or death can result from contact or proximity to high-voltage electrical lines. The bucket does not have to make physical contact with power lines for current to be transmitted.

Use a spotter and hand signals to stay away from power lines not clearly visible to the operator.

Voltage	Minimum Safe Distance
6.6 kV	3 m (9' 10")
33.0 kV	4 m (13' 1")
66.0 kV	5 m (16' 5")
154.0 kV	8 m (26' 3")
275.0 kV	10 m (32' 10")

Use these minimum distances as a guideline only. Depending upon the voltage in the line and atmospheric conditions, strong current shocks can occur with the boom or bucket as faraway as 4 - 6 m (13 - 20 ft.) from the power line. Very high voltage and rainy weather could further decrease that safety margin.

NOTE: Before starting any operation near power lines (either aboveground or buried cable type), you should always contact the power utility company directly and work out a safety plan with them.



FG010541

Figure 23

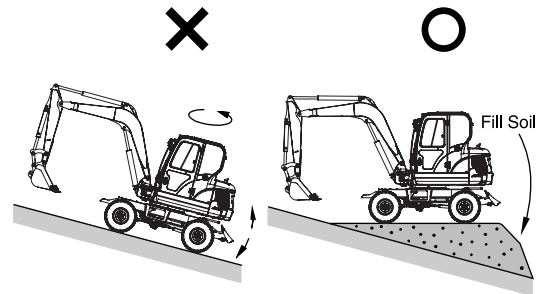
Operations on Slopes

When working on slopes, there is a danger that machine may lose its balance and turn over, when swinging, or when work equipment is operated. Always carry out these operations carefully.

Do not swing the work equipment from the uphill side to the downhill side when the bucket is loaded. This operation is dangerous.

If the machine has to be used on a slope, pile the soil to make a platform that will keep the machine as horizontal as possible.

In addition, lower the bucket as far as possible, keep it pulled into the front, and keep the swing speed as low as possible.



FG010649

Figure 24

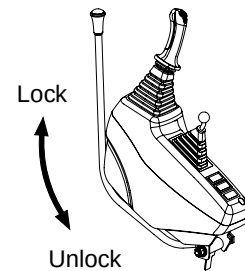
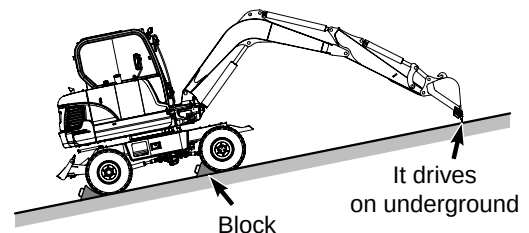
Parking Machine

Avoid making sudden stops, or parking the machine wherever it happens to be at the end of the workday. Plan so the excavator will be on firm, level ground away from traffic and away from high walls, cliff edges and any area of potential water accumulation or runoff. If parking on inclines is unavoidable, block the wheels to prevent movement. Lower the bucket or other working attachment completely to the ground, or to an overnight support saddle. There should be no possibility of unintended or accidental movement.

When parking on public roads, provide fences, signs, flags, or lights, and put up any other necessary signs to ensure that passing traffic can see the machine clearly. Park the machine so the machine, flags, and fences do not obstruct traffic.

After the front attachment has been lowered to an overnight storage position and all switches and operating controls are in the "OFF" position, the safety lock lever must be set to the "LOCKED" position. This will disable all pilot circuit control functions.

Always close the door of the operator's cabin.

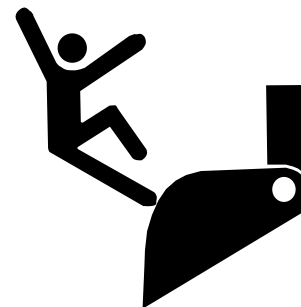


FG010621

Figure 25

Never Let Anyone Ride on Attachment

Never let anyone ride on any work attachment, such as the bucket, crusher, grapple, or clamshell (grab bucket). There is a danger of the person falling and suffering serious injury.



ARO1310L

Figure 26

MAINTENANCE

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.



FG012202

Figure 27

Clean Before Inspection or Maintenance

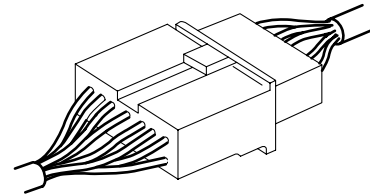
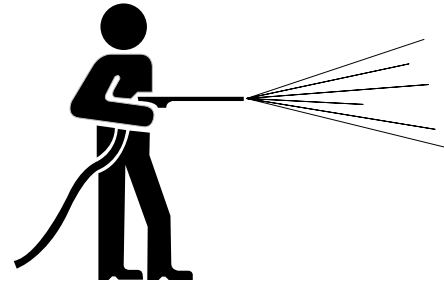
Clean the machine before carrying out inspection and maintenance. This prevents dirt from getting into the machine and ensures safety during maintenance.

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). 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.

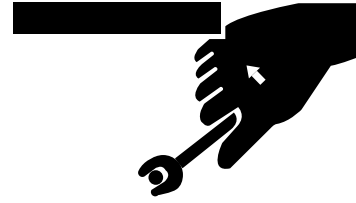


ARO1330L

Figure 28

Proper Tools

Use only tools suited to the task. Using damaged, low quality, faulty, or makeshift tools could cause personal injury. There is a danger that pieces from, chisels with crushed heads, or hammers, may get into your eyes and cause blindness.



HDO1037L

Figure 29

Use of Lighting

When checking fuel, oil, battery electrolyte, or window washing fluid, always use lighting with antiexplosion specifications. If such lighting equipment is not used, there is a danger of an explosion.

If work is carried out in dark places without using lighting, it may lead to injury, so always use proper lighting.

Even if the place is dark, never use a lighter or flame instead of lighting. There is a danger of fire. There is also danger that battery gas may catch fire and cause an explosion.



HDO1040L

Figure 30

Fire Prevention and Explosion Prevention

All fuels, most lubricants and some coolant mixtures are flammable. Leaking fuel or fuel that is spilled onto hot surfaces or onto electrical components can cause a fire.

Store all fuels and all lubricants in properly marked containers and away from all unauthorized persons.

Store oily rags and other flammable material in a protective container.

Do not smoke while you refuel the machine or while you are in a refueling area.

Do not smoke in battery charging areas or in areas the contain flammable material.

Clean all electrical connections and tighten all electrical connections. Check the electrical wires daily for wires that are loose or frayed. Tighten all loose electrical wires before you operate the machine. Repair all frayed electrical wires before you operate the machine.

Remove all flammable materials before they accumulate on the machine.



HDO1015I

Figure 31

Do not weld on pipes or on tubes that contain flammable fluids. Do not flame cut on pipes or on tubes that contain flammable fluids. Before you weld on pipes or on tubes or before you flame cut on pipes or on tubes, clean the pipes or tubes thoroughly with a nonflammable solvent.

Burn Prevention

When checking the radiator coolant level, shut down engine, let the engine and radiator cool down, then check the coolant recovery tank. If the coolant level in the coolant recovery tank is near the upper limit, there is enough coolant in the radiator.

Loosen the radiator cap gradually to release the internal pressure before removing the radiator cap.

If the coolant level in the coolant recovery tank is below the lower limit, add coolant.

Cooling system conditioner contains alkali. Alkali can cause personal injury. Do not allow alkali to contact the skin, the eyes, or the mouth.

Allow cooling system components to cool before you drain the cooling system.

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

Remove hydraulic tank filter plug only after the engine has been stopped. Make sure that hydraulic tank filter plug is cool before you remove it with your bare hand. Remove hydraulic tank filter plug slowly to relieve pressure.

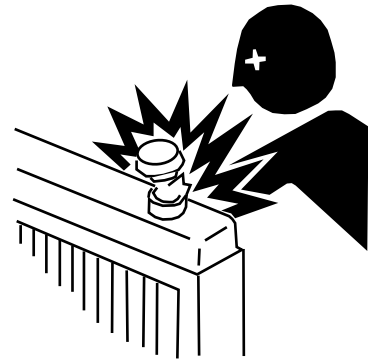
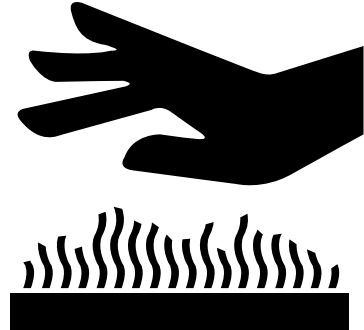
Relieve all pressure in the hydraulic oil system, in the fuel system, or in the cooling system before you disconnect any lines, fittings, or related items.

Batteries give off flammable fumes that can explode.

Do not smoke while you are checking the battery's electrolyte levels.

Electrolyte is an acid. Electrolyte can cause personal injury. Do not allow electrolyte to contact the skin or the eyes.

Always wear protective glasses when you work on batteries.



HAAE1980

Figure 32

Welding Repairs



CAUTION

When you connect or disconnect connectors between ECU and Engine or connector between ECU and the machine, always disconnect the source power to protect damage of the ECU.

If you don't observe this procedure, the ECU would be damaged or the engine would operate abnormally.

When carrying out welding repairs, carry out the welding in a properly equipped place. The welding should be performed by a qualified worker. During welding operations, there is the danger of, generation of gas, fire, or electric shock, so never let an unqualified worker do welding.

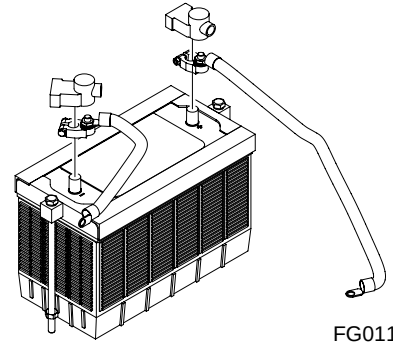
The qualified welder must do the following:

- To prevent explosion of the battery, disconnect the battery terminals and remove battery.
- To prevent generation of gas, remove paint from the location of the weld.
- If hydraulic equipment, piping or places close to them are heated, a flammable gas or mist will be generated and there is a danger of it catching fire. To avoid this, never subject these places to heat.
- Do not weld on pipes or on tubes that contain flammable fluids. Do not flame cut on pipes or on tubes that contain flammable fluids. Before you weld on pipes or on tubes or before you flame cut on pipes or on tubes, clean the pipes or tubes thoroughly with a nonflammable solvent.
- If heat is applied directly to rubber hoses or piping under pressure, they may suddenly break, so cover them with a fireproof covering.
- Wear protective clothing.
- Make sure there is good ventilation.
- Remove all flammable objects and provide a fire extinguisher.

Treatment for Electrical Welding to the Body Structure

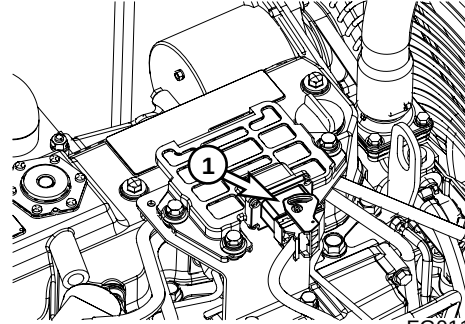
To prevent damage to ECU by electrical welding, please observe the following procedures:

1. Open the door of the battery cover.
2. Detach the cover after loosening the bolts on the cover.
3. Detach the positive and negative terminal cables from the battery.
4. Open the engine hood.
5. Detach the connector (1) from the ECU that is installed at the engine.
6. Proceed with welding.
7. After welding, carefully reassemble the connector.
8. Connect the battery terminal cables.
9. Reassemble the cover over the battery.
10. Close the cover of the battery cover.



FG011198

Figure 33



FG011199

Figure 34

Warning for Counterweight and Front Attachment Removal

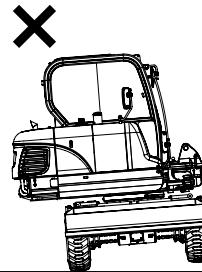
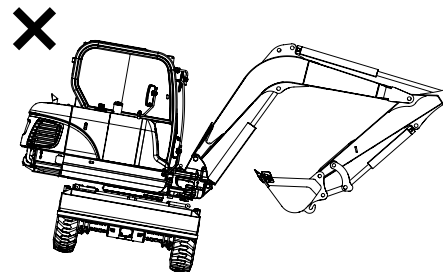


DANGER

DOOSAN warns any user, that removal of the counterweight from the machine, front attachment or any other part, may affect the stability of the machine. This could cause unexpected movement, resulting in death or serious injuries. *DOOSAN* is not liable for any misuse.

Never remove counterweight or front attachment unless the upper structure is in-line with the lower structure.

Never rotate the upper structure once the counterweight or front attachment has been removed.



FG010548

Figure 35

Precautions for Removal, Installation, and Storage of Attachments

Before starting removal and installation of attachments, decide on the team leader.

Do not allow anyone except the authorized workers close to the machine or attachment.

Place attachments that have been removed from the machine in a safe place so they do not fall. Put up a fence around the attachments and take other measures to prevent unauthorized persons from entering.



HDO1041L

Figure 36

Precautions When Working on Machine

When carrying out maintenance operations on the machine, keep area around your feet clean and tidy to prevent falls. Always do the following:

- Do not spill oil or grease.
- Do not leave tools laying about.
- Watch your step when walking.

Never jump down from the machine. When getting on or off the machine, use the steps and handrails, and maintain a three-point contact (both feet and one hand or both hands and one foot) to support yourself securely.

If the job requires it, wear protective clothing.



ARO1380L

Figure 37

Prevention of Crushing and Cutting

You should always have at least two people working together if the engine must be run during service. One person needs to remain in the operator's seat, ready to work the controls or stop the machine and shut off the engine.

Unless you are instructed otherwise, never attempt adjustments while the machine is moving or while the engine is running.

Stay clear of all rotating parts and moving parts.

Keep objects away from moving fan blades. The fan blades will throw objects and the fan blades can cut objects.

Do not use a wire rope cable that is kinked or flayed. Wear gloves when you handle a wire rope cable.

When you strike a retainer pin, the retainer pin might fly out. The loose retainer pin can injure personnel. Make sure that area is clear of people when you strike a retainer pin. To avoid injury to your eyes, wear protective glasses when you strike a retainer pin.

Supports and Blocking for Work Equipment

Do not allow weight or equipment loads to remain suspended.

Lower everything to the ground before leaving the operator's seat.

Do not use hollow, cracked or unsteady wobbling supports.

Do not work under any equipment supported only by a lifting jack.



HDO1042L

Figure 38

Action When Abnormality Is Found During Inspection

If any abnormality is found during inspection, always carry out repairs. In particular, if the machine is used when there are still problems with the brake or work equipment systems, it may lead to serious injury.

If necessary depending on the type of failure, please contact your *DOOSAN* distributor for repairs.

Precautions with High-pressure Lines, Tubes and Hoses

When inspecting or replacing high-pressure piping or hoses, check to verify that pressure has been released from the circuit. Failure to release the pressure may lead to serious injury. Always do the following:

- Wear protective glasses and leather gloves.
- Fluid leaks from hydraulic hoses or pressurized components can be difficult to see but pressurized oil has enough force to pierce the skin and cause serious injury. Always use a piece of wood or cardboard to check for suspected hydraulic leaks. Never use your hands or expose your fingers.
- Do not bend high-pressure lines. Do not strike high-pressure lines. Do not install lines, tubes or hoses that are bent or damaged.
- Make sure that all clamps, guards and heat shields are installed correctly to prevent vibration, rubbing against other parts, and excessive heat during operation.
 - If any of the following conditions are found, replace the part:
 - Damage or leakage from hose end.
 - Wear, damage, cutting of covering, or exposure of strengthening wire layer.
 - Cover portion is swollen in places.
 - There is twisting or crushing at movable parts of hose.
 - Foreign material is embedded in the covering.
 - Hose end is deformed.

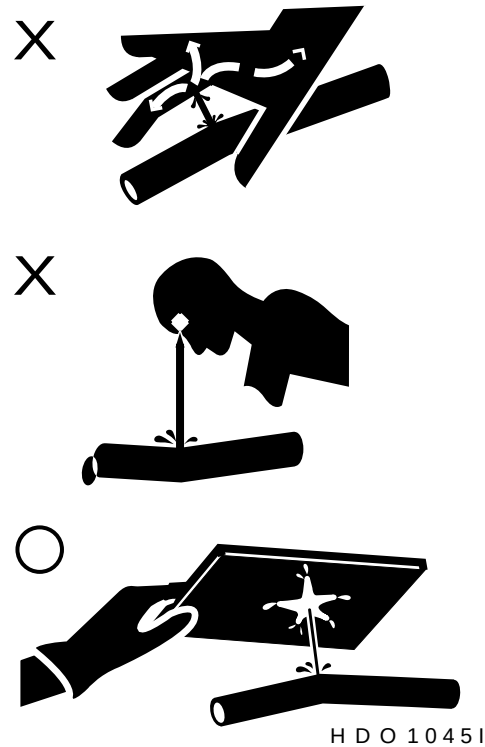


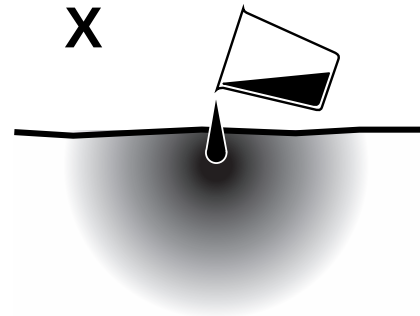
Figure 39

Waste Materials

Physical contact with used motor oil may pose a health risk. Wipe oil from your hands promptly and wash off any remaining residue.

Used motor oil is an environmental contaminant and may only be disposed of at approved collection facilities. To prevent pollution of the environment, always do the following:

- Never dump waste oil in a sewer system, rivers, etc.
- Always put oil drained from your machine in containers. Never drain oil directly onto the ground.
- Obey appropriate laws and regulations when disposing of harmful materials such as oil, fuel, solvent, filters, and batteries.



HAOA470L

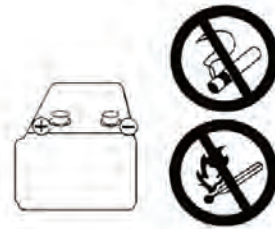
Figure 40

BATTERY

Battery Hazard Prevention

Battery electrolyte contains diluted sulfuric acid and batteries generate hydrogen gas. Hydrogen gas is highly explosive, and mistakes in handling them can cause serious injury or fire. To prevent problems, always do the following:

- Do not smoke or bring any flame near the battery.
- When working with batteries, ALWAYS wear safety glasses and rubber gloves.
- If you spill battery electrolyte on yourself or your clothes, immediately flush the area with water.
- If battery electrolyte gets into your eyes, flush them immediately with large quantities of water and see a doctor at once.
- If you accidentally drink battery electrolyte, drink a large quantity of water or milk, raw egg or vegetable oil. Call a doctor or poison prevention center immediately.
- When cleaning the top surface of the battery, wipe it with a clean, damp cloth. Never use gasoline, thinner, or any other organic solvent or detergent.
- Tighten the battery caps securely.
- If the battery electrolyte is frozen, do not charge the battery or start the engine with power from another source. There is a danger that battery may catch fire.
- When charging the battery or starting with power from another source, let the battery electrolyte melt and check that there is no leakage of battery electrolyte before starting the operation.
- Always remove battery from the machine before charging.



HAAE2100

Figure 41

Boost Starting or Charging Engine Batteries

If any mistake is made in the method of connecting the booster cables, it may cause an explosion or fire. Always do the following:

- Turn off all electrical equipment before connecting leads to the battery. This includes electrical switches on the battery charger or boost starting equipment.
- When boost starting from another machine or vehicle do not allow the two machines to touch. Wear safety glasses or goggles while required battery connections are made.
- Connect positive cable first when installing cables and disconnect the negative cable first when removing them. The final cable connection, at the metal frame of the machine being charged or boost started, should be as faraway from the batteries as possible.

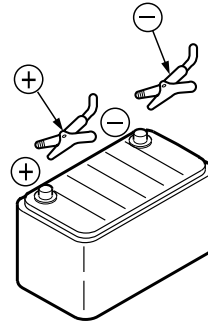


Figure 42

HAOA310L

TOWING

Precautions When Towing

If any mistake is made in the method of selecting or inspecting the towing wire or in the method of towing, it may lead to serious personal injury. Always do the following:

- Always use the method of towing given in this Operation and Maintenance Manual. Do not use any other method.
- Use leather gloves when handling the wire rope.
- When carrying out the preparation work for towing with two or more workers, determine the signals to use and follow these signals correctly.
- If there is a problem with the engine, or a failure in the brake system, the machine will not start. Contact your *DOOSAN* distributor.
- Never go between the towing machine and the towed machine during the towing operation.
- It is dangerous to carry out towing on slopes, so select a place where the slope is gradual. If there is no place where the slope is gradual, carry out operations to reduce the angle of the slope before starting the towing operation.
- When towing a problem machine, always use a wire rope with a sufficient towing capacity.
- Do not use a frayed, kinked rope or a rope with any loss of diameter.
- Do not use the lightweight towing hook for towing another machine.
- Between machine and wire rope the thick piece of cloth put in and prevent the damage of equipment and wire rope.
- Towing speed must be below 10.0 km/h (6.21 MPH) and towing distance must not exceed 5.0 km (3.11 mile). When towing distance is over 5.0 km (3.11 mile) use a trailer.

SHIPPING AND TRANSPORTATION

Obey State and Local Over-the-Road Regulations

Check state and local restrictions regarding weight, width and length of a load before making any other preparation for transport.

The hauling vehicle, trailer and load must all be in compliance with local regulations governing the intended shipping route.

Partial disassembly or teardown of the excavator may be necessary to meet travel restrictions or particular conditions at the work site. See the Shop Manual for information on partial disassembly.

Refer to the Transportation and Shipping section of this Operation and Maintenance Manual for information on loading, unloading and towing.

LIFTING WITH SLING



WARNING!

Improper lifting can allow load to shift and cause injury or damage.

1. Refer to Specification section of Operation and Maintenance Manual for information on weight and dimensions.
2. Use properly rated cables and slings for lifting.
3. Position machine for a level lift.
4. Lifting cables should have a long enough length to prevent contact with the machine. Spreader bars may be required.

If spreader bars are used, be sure that cables are properly secured to them and that the angle of the cables is factored into the lift strength.

Specifications

Specification for DX55W

Edition 1

MEMO

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Specification for DX55W

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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 ultimately 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
DX55W	7118 and Up

GENERAL DESCRIPTION

The excavator has three main component sections:

- The Upper Turntable
- The Lower Undercarriage and Chassis Frames
- The Excavator Front-end Attachment

The following illustration identifies main components and their locations. (See Figure 1 on page -8.)

COMPONENT LOCATIONS

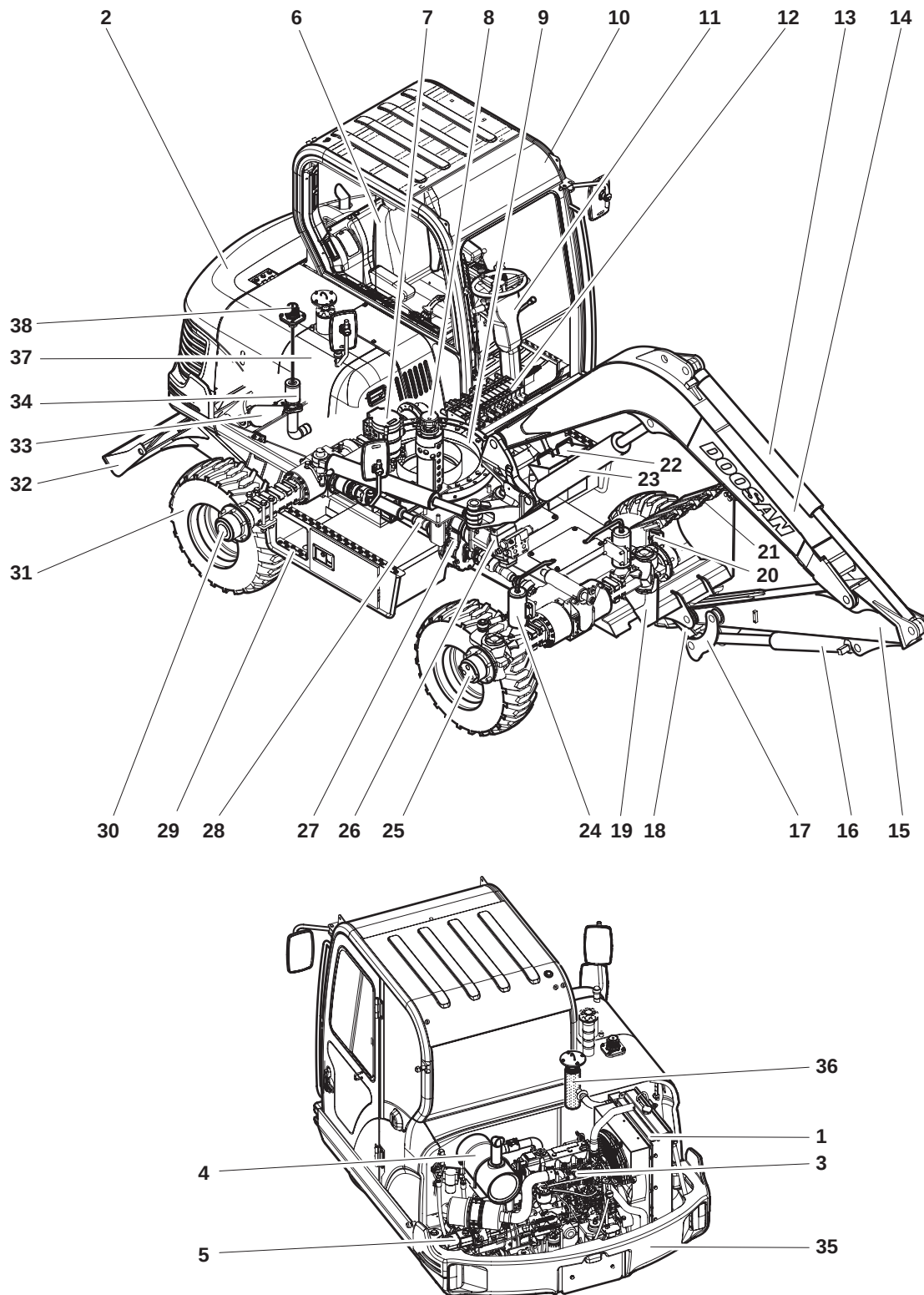


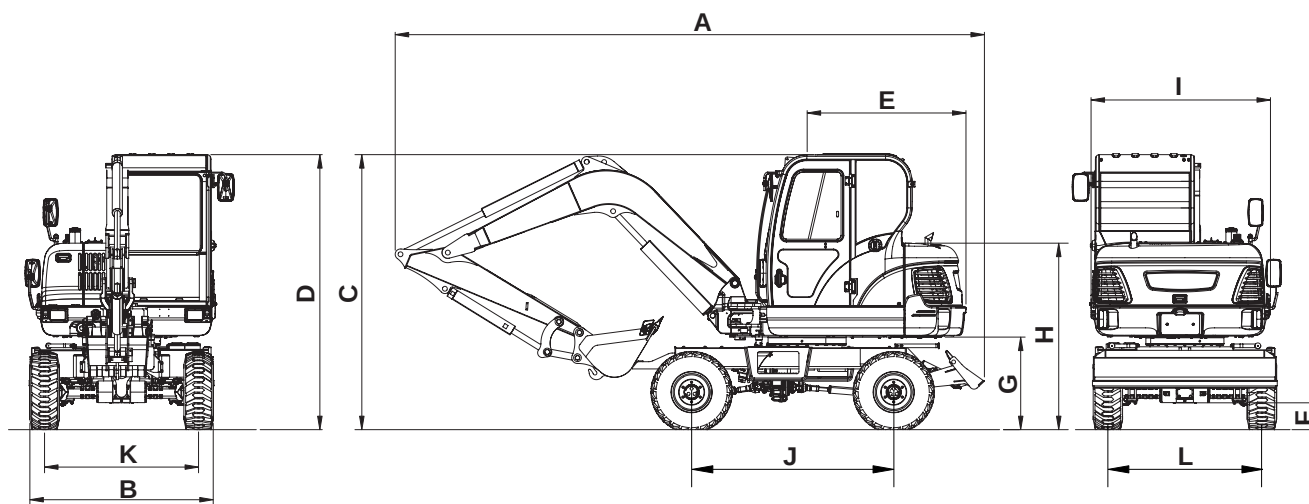
Figure 1

FG024451

Reference Number	Description
1	Radiator and Oil Tank
2	Engine Cover
3	Engine
4	Muffler
5	Main Pump
6	Seat
7	Swing Motor
8	Swivel Joint
9	Swing Bearing
10	Cabin
11	Steering Column
12	Control Valve
13	Arm Cylinder
14	Boom
15	Arm
16	Bucket Cylinder
17	Guide Link
18	Push Link
19	Bucket

Reference Number	Description
20	Side Cutter
21	Tooth Point
22	Wheel Chocks
23	Boom Cylinder
24	Ram Cylinder
25	Front Axle
26	Travel Motor
27	Transmission
28	Driveshaft
29	Step
30	Rear Axle
31	Tire
32	Dozer Blade
33	Dozer Cylinder
34	Suction Filter
35	Counterweight
36	Return Filter
37	Fuel Tank
38	Air Breather

GENERAL DIMENSIONS



FG010567

Figure 2

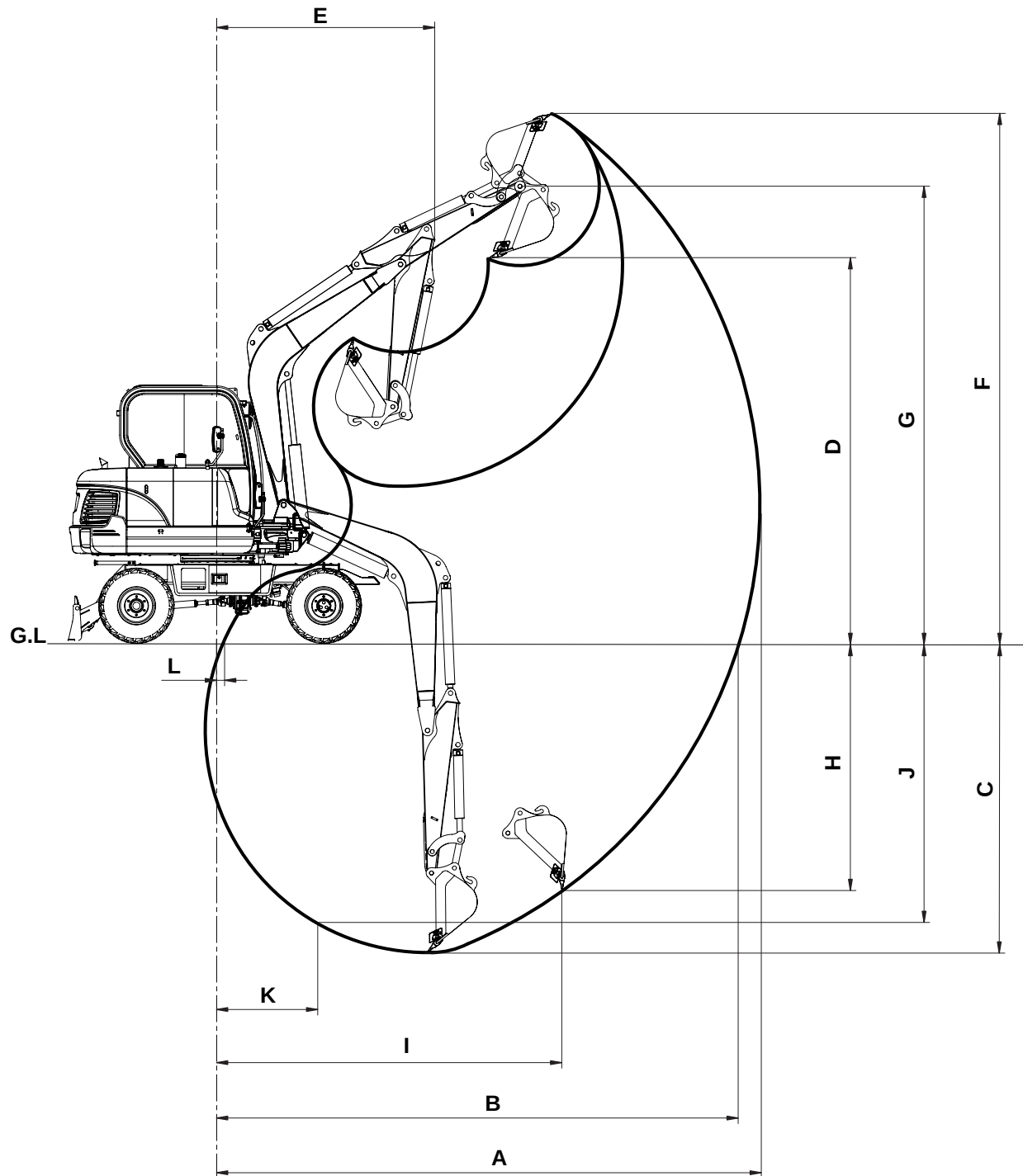
No.	Description	Dimension	
		3.0 m (9' 10") Boom	
		1.6 m (5' 3") Arm	
A	Shipping Length	6,120 mm	20' 1"
B	Shipping Width	1,920 mm	6' 4"
C	Shipping Height	2,855 mm	9' 4"
D	Height Over Cab	2,855 mm	9' 4"
E	Counter Weight Swing Clearance	1,650 mm	5' 5"
F	Ground Clearance	280 mm	11"
G	Frame Clearance	980 mm	3' 3"
H	Engine Cover Height	1,935 mm	6' 4"
I	Upper Housing Width	1,850 mm	6' 1"
J	Wheel Base	2,100 mm	6' 11"
K,L	Tread Width	1,600 mm	5' 3"

WORKING RANGE



WARNING!

The actual value for "Digging Reach," depends on the stability and support provided by ground conditions. Digging too far underneath the excavator when soil conditions are wet, loose or unstable can collapse ground support, which could cause injury and/or equipment damage.

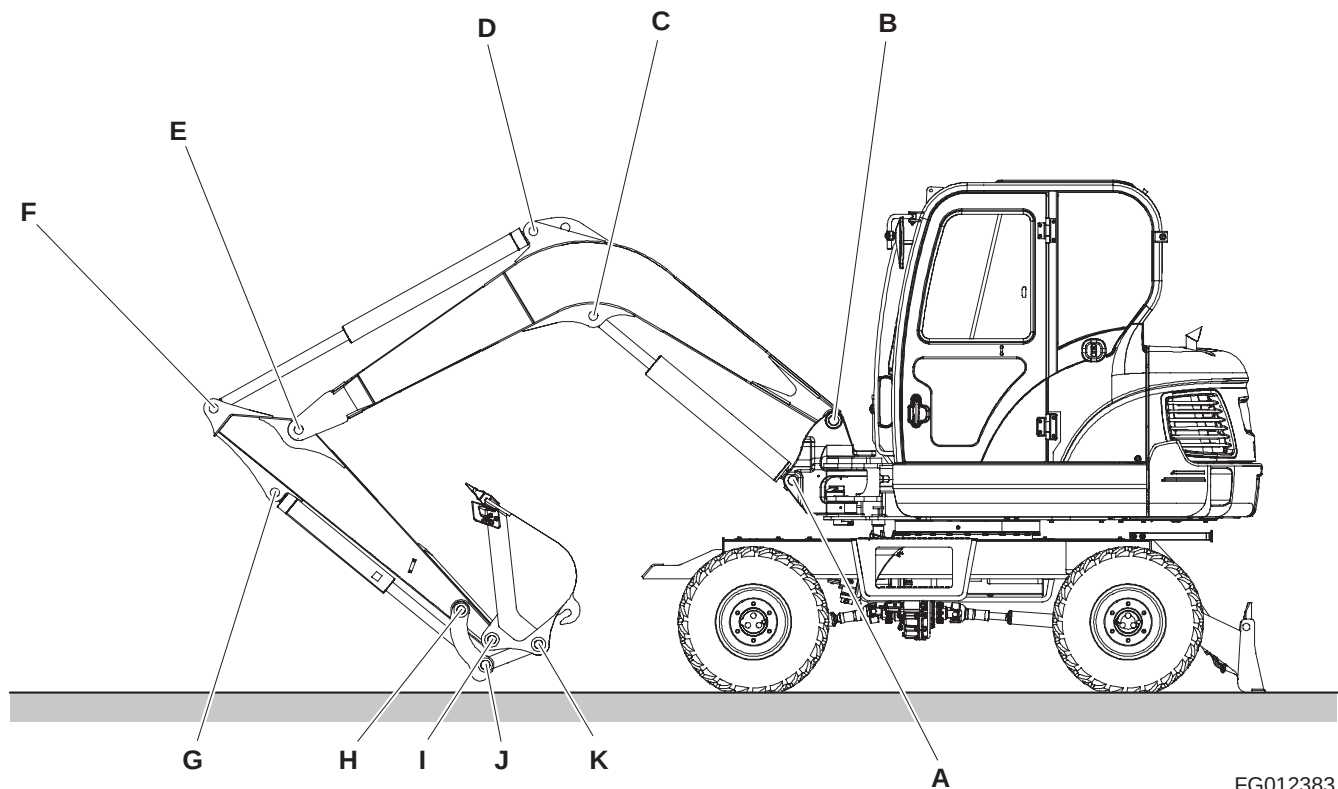


FG012795

Figure 3

No.	Description	Dimension	
		3.0 m (9' 10") Boom	
		1.6 m (5' 3") Arm	1.9 m (6' 3") Arm
A	Max. Digging Reach	6,110 mm (20' 1")	6,400 mm (21')
B	Max. Digging Reach (Ground)	5,980 mm (19' 4")	6,190 mm (20' 4")
C	Max. Digging Depth	3,495 mm (11' 6")	3,795 mm (12' 5")
D	Max. Dump Height	4,265 mm (14')	4,455 mm (14' 7")
E	Min. Swing Radius	1,980 mm (6' 6")	1,990 mm (6' 6")
F	Max. Digging Height	5,980 mm (19' 7")	6,170 mm (20' 3")
G	Max. Bucket Pin Height	5,150 mm (16' 11")	5,340 mm (17' 6")
H	Max. Vertical Wall Depth	2,805 mm (9' 2")	3,115 mm (10' 3")
I	Max. Radius Vertical	3,875 mm (12' 9")	3,930 mm (12' 11")
J	Max. Depth to 8ft Line	3,105 mm (10' 2")	3,445 mm (11' 4")
K	Min. Radius 8ft Line	1,020 mm (3' 4")	1,010 mm (3' 4")
L	Min. Digging Reach	90 mm (4")	-235 mm (9")

FRONT PIN SIZE



FG012383

Figure 4

Mounting Pin	Diameter, mm (Inches)	Length, mm (Inches)
A	50 mm (1.97 in)	205 mm (8.07 in)
B	55 mm (2.17 in)	357 mm (14.06 in)
C	50 mm (1.97 in)	206 mm (8.11 in)
D	50 mm (1.97 in)	152 mm (5.98 in)
E	50 mm (1.97 in)	287 mm (11.3 in)
F	50 mm (1.97 in)	152 mm (5.98 in)
G	50 mm (1.97 in)	152 mm (5.98 in)
H	45 mm (1.77 in)	286 mm (11.26 in)
I	45 mm (1.77 in)	285 mm (11.25 in)
J	50 mm (1.97 in)	286 mm (11.26 in)
K	45 mm (1.77 in)	285 mm (11.25 in)

HYDRAULIC CYLINDERS

	Boom	Arm	Bucket	Dozer	Chocking	Boom Swing
Quantity	1	1	1	1	2	1
Bore	110 mm (4.33")	85 mm (3.34")	80 mm (3.15")	110 mm (4.33")	75 mm (2.95")	95 mm (3.74")
Stroke	712 mm (2' 4")	873 mm (2' 10")	600 mm (2')	160 mm (6.3")	100 mm (3.94")	558 mm (1' 10")
Rod Dia.	60 mm (2.36")	55 mm (2.17")	50 mm (1.97")	60 mm (2.36")	75 mm (2.95")	50 mm (1.97")
Closed Length	1,105 mm (3' 8")	1,295 mm (4' 3")	925 mm (3')	502 mm (1' 8")	260 mm (10.24")	898 mm (2' 9")
Retract.Cushion	X	O	X	X	X	X
Extend.Cushion	O	O	X	X	X	X
Maker	Tongyang	Tongyang	Tongyang	Tongyang	Tongyang	Tongyang

GENERAL SPECIFICATIONS

Weight		
Shipping Weight	Single Tire	5,550 kg (12,236 lb)
	Twin Tire	5,910 kg (13,029 lb)
Count Weight		233 kg (514 lb)
Upper Turntable Weight		2,588 kg (5,706 lb)
Lower (Include Swing Bearing) Weight		1,965 kg (4,332 lb)
Operating Weight		Add weight of full fuel tank and operator.
Major Component Weight	Boom 258 kg (569 lb)	
	Boom Cylinder 68 kg (150 lb)	
	Arm 120 kg (264 lb)	
	Arm Cylinder 59 kg (130 lb)	
	Bucket (Standard) 140 kg (309 lb)	
	Bucket Cylinder 41 kg (90 lb)	
	Dozer 196 kg (432 lb)	
	Dozer Cylinder 35 kg (77 lb)	
	Boom Swing Cylinder 47 kg (104 lb)	
Digging Force		
Bucket Cylinder		35.7 KN or 3.6 ton SAE (8,020 lb•f)
Arm Cylinder		25.6 KN or 2.6 ton SAE (5,760 lb•f)
Fuel Tank Capacity		120 liters (31.7 U.S. gal)
Hydraulic System Capacity		72 liters (19.0 U.S. gal)
Bucket Heaped Capacity Range	[SAE] 0.175 m ³ (0.23 yd ³)	
	[CECE] 0.15 m ³ (0.20 yd ³)	
		IMPORTANT: Refer to the Load Weight, Bucket and Arm Length Compatibility Table for information on which bucket sizes may be used safely with which arm length, for load material weight.
Travel Dimension		
Ground Clearance		280 mm (11")
Wheel Base		2,100 mm (6' 11")
Dozer Blade (Width x Height)	Single Tire	1,920 mm x 500 mm (6' 4" x 1' 8")
	Twin Tire	2,290 mm x 500 mm (7' 6" x 1' 8")
Tire Size	Single Tire	12 - 16.5 - 12 PR
	Twin Tire	8.25 - 15 - 14 PR
Transport Dimensions:		
Overall Length		6,120 mm (20' 1")
Overall Width	Single Tire	1,920 mm (6' 4")
	Twin Tire	2,290 mm (7' 6")
Overall Height		2,855 mm (9' 4")
Transport Loading Ramp Allowable Slope		15°
		CAUTION: Refer to Transport Maximum Procedure for Safe Shipping Instructions.

SP002580
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SYSTEM COMPONENT SPECIFICATIONS

DRIVE SYSTEM	
Propeller Shaft (Front and Rear) Max. Allowable Torque Max. Joint Angle Max. Rotating Speed	373.5 kg•m (2,702 ft lb) 20.5° 5,000 rpm
Tire and Wheel; Standard Type Tire spec: Rim spec: Disc Offset Type Tire spec: Rim spec:	Single 12 - 16.5 - 12PR 9.75 x 16.5 35 mm (1.4 in) Twin (Optional) 8.25 - 15 - 14PR 6.5 x 16.5
SWING MECHANISM	
Swing Reduction Gear Drive Type Reduction Ratio Max. Output Speed Max. Output Torque	2-Stage Planetary Gear 22.7 56.2 rpm 158.7 kg•m (1,145 ft lb)
Pinion Gear (Built in Reduction Gear) Type Gear P.C.D No. of Teeth Module	Spur Gear Dia 98 mm (4.86 in) 14 7
Swing Bearing Type Gear P.C.D No. of Teeth Ball Dia. Race O.D. Race Height Static Load Capacity Weight	Ball Bearing, Internal Gear Dia 630 mm (24.8 in) 90 Dia 22.225 mm (0.875 in) Dia 811 mm (31.9 in) 75 mm (2.95 in) 180,000 kg (396,832 lb) 96 kg (212 lb)
Swing Performance Max Swing Speed Max Swing Torque	8.7 rpm 1,020 kg•m (7,378 ft lb)

Parking Brake Control Type Brake Torque Brake Release Pressure	Pilot Pressure, Mechanical 300 kg•m (2,167 ft lb) 20.4 ~ 65.3 kg/cm ² (290 ~ 929 psi)
Swing Safety Lock Type	Manual Pin Locking
Motor Accessory Brake Time Delayer	3.7 ± 1.2 Sec.
BRAKE SYSTEM	
Accumulator Nitrogen Charge Pressure Volume	25 kg/cm ² (363 psi) 0.32 Liter (0.34 qt)
Service Brake Valve Max Output Pressure	28.5 ± 3.0 kg/cm ² (405 ± 42.7 psi)
System and Pressure System Service Brake Pressure Brake Distance	Full Hydraulic, Dual Line 28.5 kg/cm ² (405 psi) 6.76 m (22' 2") at 24 km/h (15 MPH)
STEERING SYSTEM	
Steering Cylinder (Built-in Front Axle) Area Stroke Maximum Pressure	2,827 mm (4.38 in ²) 89.6 mm (3.52 in) 150.0 kg/cm ² (2,134 psi)
CHOCKING SYSTEM	
Chocking Valve Maximum Working Pressure Check Valve Cracking Pressure	300 kg/cm ² (4,267 psi) 2.0 kg/cm ² (28.4 psi)
Oscillating Angle	± 5°

ENGINE PERFORMANCE CURVES (PER DIN 6270 STANDARD)

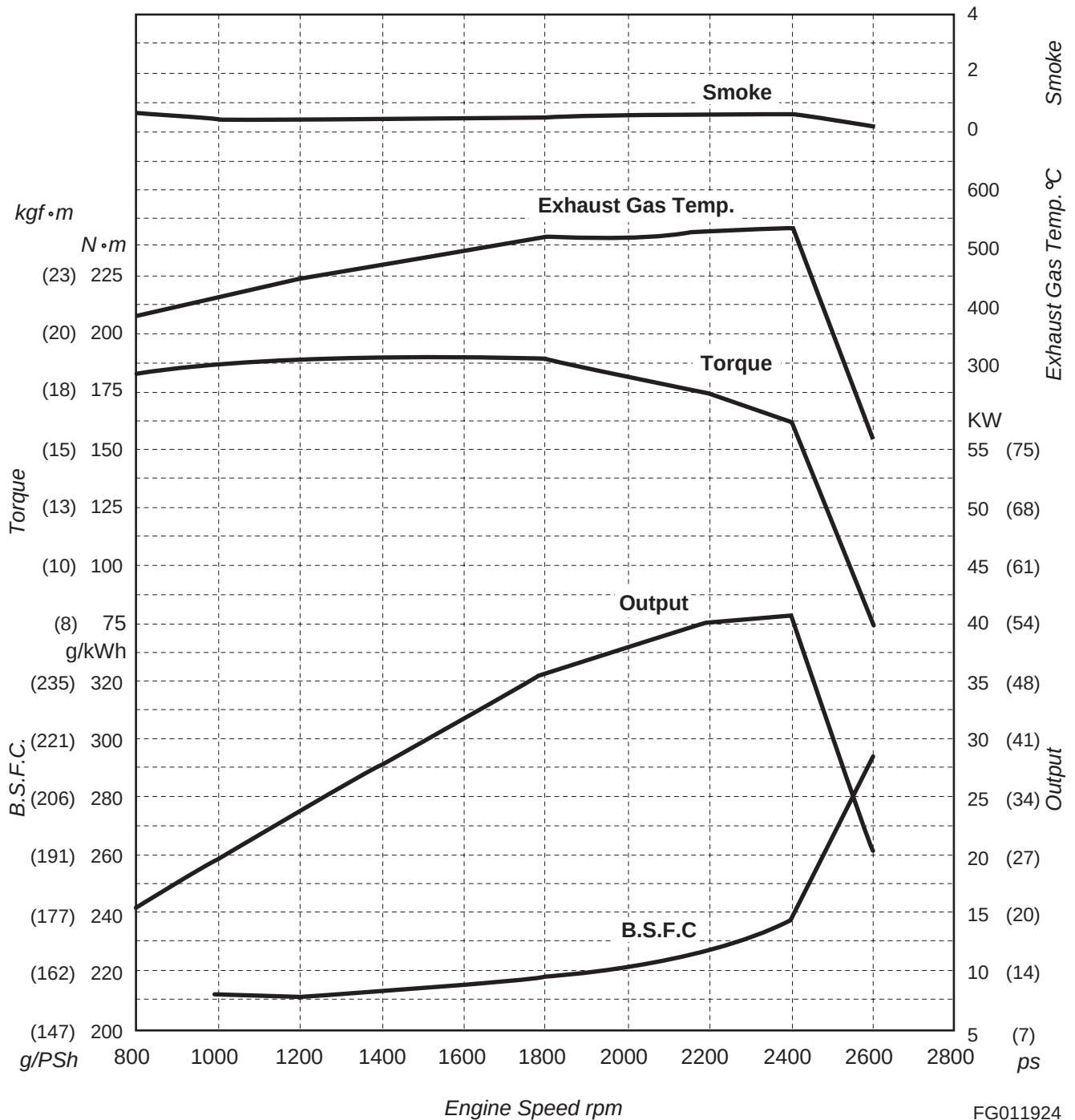


Figure 5

FG011924

Condition	Specification
Engine Model	4TNV98-E
Barometric Pressure	750 mmHg (25° C (77°F))
Cooling Fan	ø 458, 7-Blade, Blower
Alternator	12V x 60A
Air Cleaner	Installed
Muffler	Installed

Performance Standard	KS-R1004
Power	55.5 ps @ 2,400 rpm (54.7 hp @ 2,400 rpm)
Max. Torque	21.0 kg•m @ 1,550 rpm (151.6 ft lb @ 1,550 rpm)
Fuel Consumption (Rated)	181 g/ps•h (6.38 oz/hp•h)

APPROXIMATE WEIGHT OF WORKLOAD MATERIALS

IMPORTANT

Weights are approximations of estimated average volume and mass. Exposure to rain, snow or ground water; settling or compaction due to overhead weight, chemical or industrial processing or changes due to thermal or chemical transformations could all increase the value of weights listed in the table.

Material	Low Weight or Density 1,100 kg/m ³ (1,850 lb/yd ³), or Less	Medium Weight or Density 1,600 kg/m ³ (2,700 lb/yd ³), or Less	High Weight or Density 2,000 kg/m ³ (3,370 lb/yd ³), or Less
Charcoal	401 kg/m ³ (695 lb/yd ³)	-----	-----
Coke, blast furnace size	433 kg/m ³ (729 lb/yd ³)	-----	-----
Coke, foundry size	449 kg/m ³ (756 lb/yd ³)	-----	-----
Coal, bituminous slack, piled	801 kg/m ³ (1,350 lb/yd ³)	-----	-----
Coal, bituminous r. of m., piled	881 kg/m ³ (1,485 lb/yd ³)	-----	-----
Coal, anthracite	897 kg/m ³ (1,512 lb/yd ³)	-----	-----
Clay, DRY, in broken lumps	1,009 kg/m ³ (1,701 lb/yd ³)	-----	-----
Clay, DAMP, natural bed	-----	1,746 kg/m ³ (2,943 lb/yd ³)	-----
Cement, Portland, DRY granular	-----	1,506 kg/m ³ (2,583 lb/yd ³)	-----
Cement, Portland, DRY clinkers	-----	1,362 kg/m ³ (2,295 lb/yd ³)	-----
Dolomite, crushed	-----	1,522 kg/m ³ (2,565 lb/yd ³)	-----
Earth, loamy, DRY, loose	-----	1,202 kg/m ³ (2,025 lb/yd ³)	-----
Earth, DRY, packed	-----	1,522 kg/m ³ (2,565 lb/yd ³)	-----

Material	Low Weight or Density 1,100 kg/m³ (1,850 lb/yd³), or Less	Medium Weight or Density 1,600 kg/m³ (2,700 lb/yd³), or Less	High Weight or Density 2,000 kg/m³ (3,370 lb/yd³), or Less
Earth, WET, muddy	-----	-----	1,762 kg/m ³ (2,970 lb/yd ³)
Gypsum, calcined, (heated, powder)	961 kg/m ³ (1,620 lb/yd ³)	-----	-----
Gypsum, crushed to 3 inch size	-----	1,522 kg/m ³ (2,565 lb/yd ³)	-----
Gravel, DRY, packed fragments	-----	-----	1,810 kg/m ³ (3,051 lb/yd ³)
Gravel, WET, packed fragments	-----	-----	1,922 kg/m ³ (3,240 lb/yd ³)
Limestone, graded above 2	-----	1,282 kg/m ³ (2,160 lb/yd ³)	-----
Limestone, graded 1-1/2 or 2	-----	1,362 kg/m ³ (2,295 lb/yd ³)	-----
Limestone, crushed	-----	1,522 kg/m ³ (2,565 lb/yd ³)	-----
Limestone, fine	-----	-----	1,602 kg/m ³ (2,705 lb/yd ³)
Phosphate, rock	-----	1,282 kg/m ³ (2,160 lb/yd ³)	-----
Salt	929 kg/m ³ (1,566 lb/yd ³)	-----	-----
Snow, light density	529 kg/m ³ (891 lb/yd ³)	-----	-----
Sand, DRY, loose	-----	1,522 kg/m ³ (2,565 lb/yd ³)	-----
Sand, WET, packed	-----	-----	1,922 kg/m ³ (3,240 lb/yd ³)
Shale, broken	-----	1,362 kg/m ³ (2,295 lb/yd ³)	-----
Sulphur, broken	529 kg/m ³ (1,620 lb/yd ³)	-----	-----

PERFORMANCE TESTS AND STANDARDS

1. Main Relief Pressure : 230 kg/cm² (3,271 psi)
2. Actuator Speeds

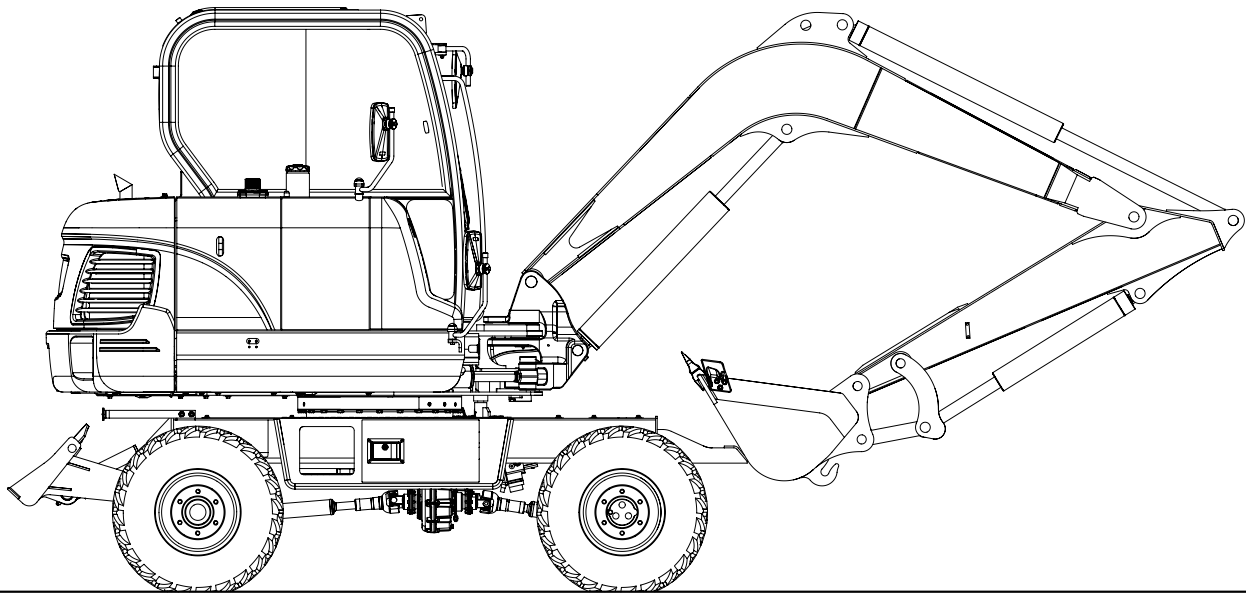
Operation		Unit	Standard Mode
Boom	Up	seconds	2.2 ± 0.3
	Down	seconds	2.1 ± 0.3
Arm	Dump	seconds	2.2 ± 0.3
	Crowd	seconds	2.7 ± 0.3
Bucket	Dump	seconds	2.3 ± 0.3
	Crowd	seconds	3.5 ± 0.3
Dozer	Up	seconds	2.6 ± 0.3
	Down	seconds	2.9 ± 0.3
B/Swing	R→L	seconds	7.2 ± 0.5
	L→R	seconds	6.0 ± 0.5
Swing (3 Revolutions)		seconds	20.9 ± 1.0
Propeller Shaft	High	rpm (min.)	2,580 ± 50
	Low	rpm (min.)	930 ± 30
Travel Speed		Km/h	30 ± 4
Braking Distance		m	6.67/24Km/h

EXCAVATOR PERFORMANCE STANDARDS

Evaluation of equipment performance and operating condition can be made by running the excavator through a series of different tests, and recording results with a stop watch and tape measure.

Compare results of performance tests against the specifications and standards that follow, which are for equipment in new or renewed condition.

Test Conditions



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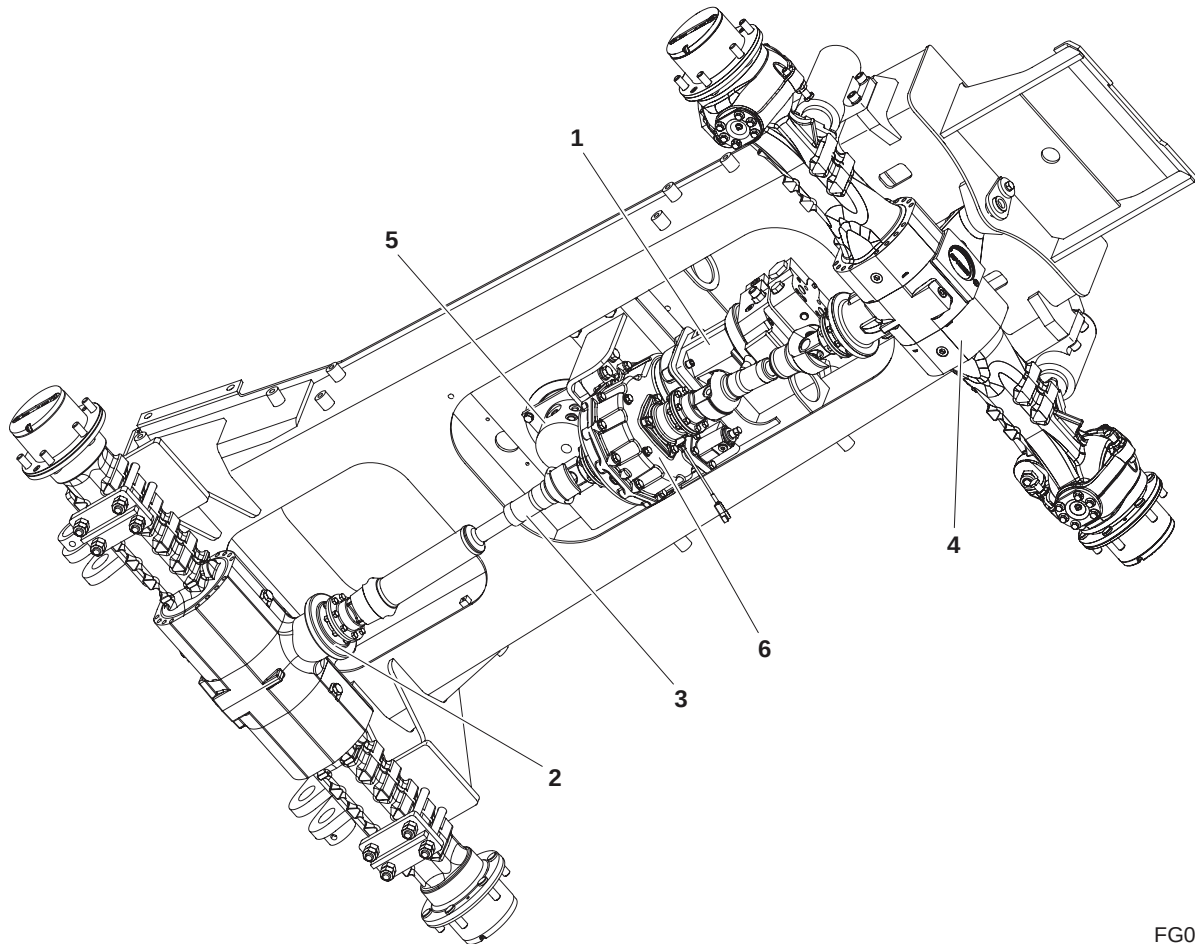
Figure 6 Travel

1. All tests should be performed on a flat, level, firm supporting ground surface.
2. All recommended, applicable maintenance and adjustment service should be completed before testing.
3. Hydraulic fluid and engine oil should be of appropriate viscosity for ambient weather conditions. Warm up hydraulic oil to standard operating temperature, between 45° - 55°C (112° - 135°F).
4. Run all tests with the engine speed control set to maximum rpm.
5. Travel speed tests should also be repeated at both high and low speed.

Travel Speed Tests

Travel Mode	Speed
High Speed (III)	30 km/h (18.6 MPH)
Low Speed (II)	10 km/h (6.21 MPH)

1. Block up all wheels securely.
2. Check that rpm at drive shaft is above;
2,580 $\pm$ 50 rpm at high speed.
930 $\pm$ 30 rpm at low speed.



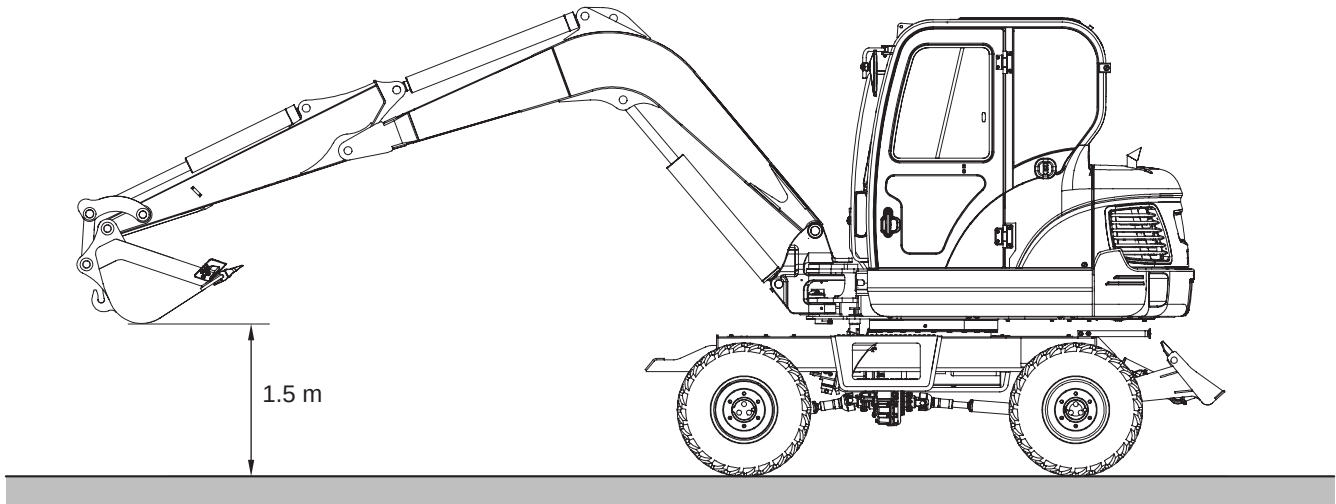
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Figure 7

1	Travel Motor
2	Rear Axle
3	Propeller Shaft
4	Front Axle
5	Swivel Joint
6	Transmission

Swing Speed and Deceleration Force Test

Swing Speed Test



FG012796

Figure 8

Extend the bucket cylinder completely and retract the arm cylinder, as shown in Figure 8, to test swing speed. The lowest point of the bucket will be approximately 1.5 m (4' 11") 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 20.9 second.

Swing Deceleration Force Test

With the boom, arm and bucket in the same position as for the swing speed test, rotate the turntable so that 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 9.

Record how far the turntable drifts past the stop point, measuring the distance between paint marks. Maximum distance should be less than 222 mm (47-1/4").

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

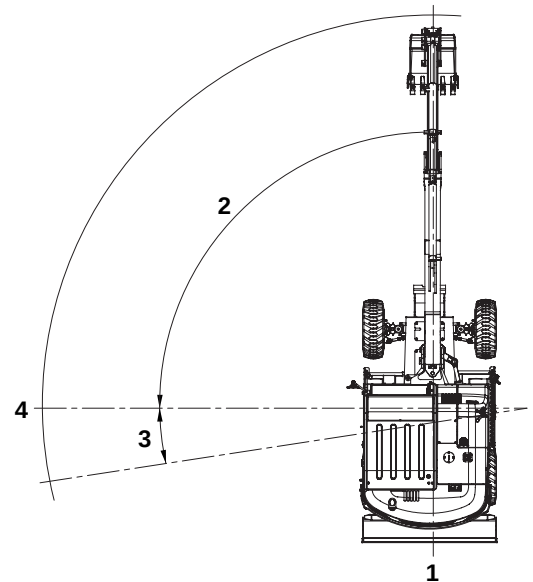


Figure 9

Cylinder Performance Tests

NOTE: All tests are performed with standard boom, arm and bucket configuration. The bucket should be empty.

Boom Cylinders Test

The starting points for the test are with the boom and arm extended away from the excavator, and the bucket curled inward. The arm cylinder should be fully retracted; boom and bucket cylinders must be extended. Test movement in both directions, several times, and average results.

Arm Cylinder Test

Start with the boom up and the arm cylinder fully retracted. Test movement in both directions several times, between the "crowd" and "dump" positions, and average the results of tests.

Bucket Cylinder Test

Start with the boom up and the teeth of the bucket hanging vertically, 500 mm (1.5' - 2') above the ground. Dump and crowd the bucket several times, and average results.

Measurement in Seconds

Operation	Standard Mode
Boom Up	2.2 ± 0.3
Boom Down	2.1 ± 0.3
Arm Dump	2.2 ± 0.3
Arm Crowd	2.7 ± 0.3
Bucket Dump	2.3 ± 0.3
Bucket Crowd	3.5 ± 0.3

Hydraulic Cylinder Natural Drop Test

To check boom and arm cylinder tightness against the specified performance standard for new cylinders, put a full load of dirt in the bucket and move the attachment cylinders so that the arm cylinder is extended 20 - 50 mm (1" - 2") and boom cylinders are retracted the same amount, 20 - 50 mm (1" - 2"). The top of the bucket should be approximately 2 m (6" - 7") off the ground.

Turn off the engine and measure cylinder drop after 5 minutes. Maximum cylinder drops are as follows: bucket and blade 10mm(0.39"), boom 15mm(0.59"), arm 30mm(1.18").

General Maintenance

General Maintenance Procedures

Edition 1

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General Maintenance Procedures

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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 ultimately 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

WELDING PRECAUTIONS AND GUIDELINES

IMPORTANT

To avoid accidents, personal injury and the possibility of causing damage to the machine or to components, welding must only be performed by properly trained and qualified personnel, who possess the correct certification (when required) for the specific welding fabrication or specialized repair being performed.

WARNING!

Structural elements of the machine may be built from a variety of steels. These could contain unique alloys or may have been heat treated to obtain particular strength characteristics. It is extremely important that welding repairs on these types of steel are performed with the proper procedures and equipment. If repairs are performed incorrectly, structural weakening or other damage to the machine (that is not always readily visible) could be caused. Always consult *DOOSAN* After Sales Service before welding on integral components (loader arm, frames, car body, track frames, turntable, attachment, etc.) of the machine. It is possible that some types of structurally critical repairs may require Magnetic Particle or Liquid Penetrant testing, to make sure there are no hidden cracks or damage, before the machine can be returned to service.

CAUTION!

Always perform welding procedures with the proper safety equipment on hand. Adequate ventilation and a dry work area are absolutely essential. Keep a fire extinguisher nearby and always wear protective clothing and the recommended type of eye protection.

 CAUTION!

Observe the following safety precautions:

1. Use extra caution and adequate safety shielding when welding near fuel and oil tanks, batteries, hydraulic piping lines or other fire hazards.
 2. Never weld when the engine is running. Battery cables must be disconnected before the welding procedure is started.
 3. Never weld on a wet or damp surface. The presence of moisture causes hydrogen embrittlement and structural weakening of the weld.
 4. If welding procedures are being performed near cylinder rods, operator's cabin window areas or any other assemblies that could be damaged by weld spatters, use adequate shielding protection in front of the assembly.
 5. During equipment setup, always attach ground cables directly to the area or component being welded to prevent arcing through bearings, bushings, or spacers.
 6. Always use correct welding rods for the type of weld being performed and observe recommended precautions and time constraints. AWS Class E7018 welding rods for low alloy to medium carbon steel must be used within two hours after removal from a freshly opened container. Class E11018G welding rods for T-1 and other higher strength steel must be used within 1/2 hour.
-

HYDRAULIC SYSTEM - GENERAL PRECAUTIONS

Always maintain oil level in the system at recommended levels. Assemblies that operate under heavy loads, at high speed, with extremely precise dimensional tolerances between moving parts - pistons and cylinders, or shoes and swash plates, for example - can be severely damaged if oil supply runs dry.

Assemblies can be run dry and damaged severely in a very short time when piping or hoses are disconnected to repair leaks and/or replace damaged components. Hoses that are inadvertently switched during disassembly (inlet for outlet and vice versa), air introduced into the system or assemblies that are low on oil due to neglect or careless maintenance, could all produce sufficient fluid loss to cause damage.

When starting the engine (particularly after long layoff or storage intervals), make sure that all hydraulic controls and operating

circuits are in neutral, or "OFF." That will prevent pumps or other components that may be temporarily oil starved from being run under a load.

Replacement of any hydraulic system component could require thorough cleaning, flushing, and some amount of prefilling with fresh, clean oil if the protective seal on replacement parts has obviously been broken or if seal integrity may have been compromised. When protective seals are removed before installation and reassembly, inspect all replacement parts carefully, before they are installed. If the replacement part is bone dry (with no trace of factory prelube) or has been contaminated by dirt or by questionable oils, flushing and prefilling with clean hydraulic fluid is recommended.

Vibration, irregular or difficult movement or unusual noise from any part of the hydraulic system could be an indication of air in the system (and many other types of problems). As a general precaution (and to help minimize the risk of potential long-term damage), allow the engine to run at no-load idle speed immediately after initial start-up. Hydraulic fluid will circulate, releasing any air that may have been trapped in the system before load demands are imposed.

A daily walk-around prestart equipment safety inspection, including a quick visual scan for any exterior evidence of leaking hydraulic fluid, can help extend the service life of system components.

IMPORTANT

Hydraulic system operating conditions (repetitive cycling, heavy work loads, fluid circulating under high-pressure) make it extremely critical that dust, grit or any other type of contamination be kept out of the system. Observe fluid and filter change maintenance interval recommendations and always preclean any exterior surface of the system before it is exposed to air. For example, the reservoir fill cap and neck area, hoses that have to be disassembled, and the covers and external surfaces of filter canisters should all be cleaned before disassembly.

MAINTENANCE SERVICE AND REPAIR PROCEDURE

General Precautions

Fluid level and condition should always be checked whenever any other type of maintenance service or repair is being performed.

NOTE: *If the unit is being used in an extreme temperature environment (in sub-freezing climates or in high temperature, high humidity tropical conditions), frequent purging of moisture condensation from the hydraulic reservoir drain tap should be a regular and frequent part of the operating routine. In more moderate, temperate climates, draining reservoir sediment and moisture may not be required more than once or twice every few months.*

Inspect drained oil and used filters for signs of abnormal coloring or visible fluid contamination at every oil change. Abrasive grit or dust particles will cause discoloration and darkening of the fluid. Visible accumulations of dirt or grit could be an indication that filter elements are overloaded (and will require more frequent replacement) or that disintegrating bearings or other component failures in the hydraulic circuit may be imminent or have already occurred. Open the drain plugs on the main pump casings and check and compare drain oil in the pumps. Look for evidence of grit or metallic particles.

Vibration or unusual noise during operation could be an indication of air leaking into the circuit (Refer to the appropriate Troubleshooting section for component or unit for procedures.), or it may be evidence of a defective pump. The gear type pilot pump could be defective, causing low pilot pressure, or a main pump broken shoe or piston could be responsible.

NOTE: *If equipped, indicated operating pressure, as shown on the multidisplay digital gauge on the Instrument Panel ("F-Pump" and "R-Pump") will be reduced as a result of a mechanical problem inside the pump. However, pressure loss could also be due to cavitation or air leakage, or other faults in the hydraulic system.*

Check the exterior case drain oil in the main pumps. If no metallic particles are found, make sure there is no air in the system. Unbolt and remove the tank return drain line from the top part of the swing motor, both travel motors and each main pump. If there is air in any one of the drain lines, carefully prefill the assembly before bolting together the drain line piping connections. Run the system at low rpm.

HYDRAULIC SYSTEM CLEANLINESS AND OIL LEAKS

Maintenance Precautions for Hydraulic System Service

Whenever maintenance, repairs or any other type of troubleshooting or service is being performed, it's important to remember that the hydraulic system - including both the interior and exterior surfaces of assemblies, and every drop of operating fluid - must be protected from contamination.

Dust and other foreign contaminants are major contributors to premature wear in hydraulic circuits. The narrow tolerances, rapidly moving parts and high operating pressures of the system require that fluid be kept as clean as possible. The performance and dependability of the machine (and the service life of individual components) can be noticeably reduced if proper precautions are not observed:

- Use a safe, noncombustible, evaporative type, low-residue solvent and thoroughly clean exterior surfaces of assemblies before any part of the circuit is opened up or disassembled.

NOTE: *It's just as important to clean the cap and reservoir top before routine fluid changes or quick checks as it is before major repairs. (Accumulated dirt attracts moisture, oil and other fluids - and more dirt.)*

- Keep dismantled parts covered during disassembly. Use clean caps, plugs or tape to protect the disconnected openings of flanges, manifolds and piping.
- Do not allow cleaning solvents or other fluids to mix with the oil in the system. Use clean oil to flush any traces of solvent or other residue before reassembly.
- If metal or rubber fragments are found in the system, flush and replace all fluid in the system and troubleshoot the circuit to identify the source of contamination.

IMPORTANT

Make sure that cleaning solvents will be compatible with rubber materials used in the hydraulic system. Many petroleum based compounds can cause swelling, softening, or other deterioration of system sealing elements, such as O-rings, caps and other seals.

Oil Leakage Precautions

Oil that is visibly seeping from joints or seals should always serve as a "red flag" alarm.

Leaks must alert the machine operator and maintenance crew that air, water and dirt have an open, free passageway through which to enter the circuit. Harsh, corrosive salt air, freezing and thawing condensation cycles and working environments that are full of fine dust are especially hazardous. Clogging of valve spools or external piping (especially pilot circuit piping) can gradually diminish or very suddenly put a complete stop to normal hydraulic function. You can prevent having to make these types of repairs by following recommended assembly procedures:

1. Use new O-rings and oil seals whenever hydraulic assemblies are rebuilt.
2. Prepare joint surfaces before assembly by checking alignment and flatness. Clean and repair corrosion or any other damage.
3. Follow bolt torque recommendations and all other assembly requirements.

NOTE: Grease lip seals before assembly.

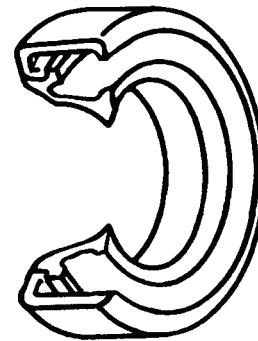


Figure 1

0565A

CLEANING AND INSPECTION

General Guidelines

All parts must be clean to permit an effective inspection. During assembly, it is very important that no dirt or foreign material enters unit being assembled. Even minute particles can cause malfunction of close fitting parts such as thrust bearing, matched parts, etc.



WARNING!

Care should be exercised to avoid inhalation of vapors, exposure to skin and creating fire hazards when using solvent type cleaners.

1. Clean all metal parts thoroughly using a suitable cleaning fluid. It is recommended that parts be immersed in cleaning fluid and moved up and down slowly until all oils, lubricants, and/or foreign materials are dissolved and parts are thoroughly clean.
2. For bearings that can be removed, soak them in a suitable cleaning fluid for a minute or two, then remove bearings from cleaning fluid and strike flat against a block of wood to dislodge solidified particles of lubricant. Immerse again in cleaning fluid to flush out particles. Repeat above operation until bearings are thoroughly clean. To dry bearings, use moisture-free compressed air. Be careful to direct air stream across bearing to avoid spinning bearings that are not lubricated. **DO NOT SPIN BEARINGS WHEN DRYING**; bearings may be rotated slowly by hand to facilitate drying process.
3. Carefully inspect all bearing rollers, cages and cups for wear, chipping or nicks to determine condition. Do not replace a bearing cone or cup individually without replacing mating cup or cone at the same time. After inspection, dip bearings in light weight oil and wrap in clean lintless cloth or paper to protect them until installation.

For those bearings that are to be inspected in place; inspect bearings for roughness of rotation, scoring, pitting, cracked or chipped races. If any of these defects are found, replace bearings. Also, inspect defective bearing housing and/or shaft for grooved, galled or burred conditions that indicate bearing has been turning in its housing or on its shaft.

4. It is more economical to replace oil seals, O-rings, sealing rings, gaskets and retaining rings when unit is disassembled than waiting for premature failures; refer to latest Micro Fiche and/or Parts Book for replacement items. Be extremely careful when installing sealing members, to avoid cutting or scratching. Curling under of

any seal lip will seriously impair its efficiency. Apply a thin coat of Loctite #120 to outer diameter, of metal casing, on oil seals to assure an oil tight fit into retainer. Use extreme care not to get Loctite on lips of oil seals. If this happens, that portion of the seal will become brittle and allow leakage.

When replacing lip type seals, make sure spring loaded side is towards oil to be sealed.

5. If available, use magna-flux or similar process for checking for cracks that are not visible to the eye. Examine teeth on all gears carefully for wear, pitting, chipping, nicks, cracks or scores. Replace all gears showing cracks or spots where case hardening has worn through. Small nicks may be removed with suitable hone. Inspect shafts and quills to make certain they have not been sprung, bent, or splines twisted, and that shafts are true.

NOTE: *Spline wear is not considered detrimental except where it affects tightness of splined parts.*

Inspect thrust washers for distortion, scores, burs, and wear. Replace thrust washer if defective or worn.

6. Inspect bores and bearing surfaces of cast parts and machined surfaces for scratches, wear, grooves and dirt. Remove any scratches and burrs with crocus cloth. Remove foreign material. Replace any parts that are deeply grooved or scratched which would affect their operation.

Bearing Inspection

The conditions of the bearing are vital to the smooth and efficient operation of the machinery. When any component containing bearings is disassembled, always carefully examine the condition of the bearings and all of its components for wear and damage.

Once the bearing is removed, clean all parts thoroughly using a suitable cleaning solution. If the bearing is excessively dirty soak the bearing assembly in a light solution and move the bearing around until all lubricants and or foreign materials are dissolved and the parts are thoroughly clean.

When drying bearings, moisture free compressed air can be used. Be careful not to direct the air in a direction which will force the bearing to dry spin while not being properly lubricated.

After the bearings have been cleaned and dried, carefully inspect all bearing rollers, cages and cups for wear, chipping or nicks. If the bearing cannot be removed and is to be inspected in place, check for roughness of rotation, scoring, pitting, cracked or chipped races. If any of these defects are found replace the whole bearing assembly. NEVER replace the 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 that the bearing has been turning in its housing or on its shaft.

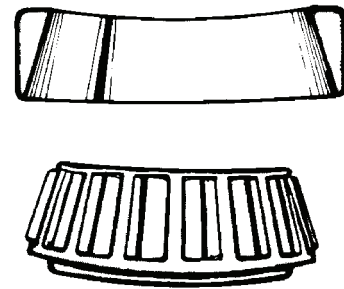
If available, use magna-flux or similar process for checking for cracks that are not visible to the naked eye.

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.

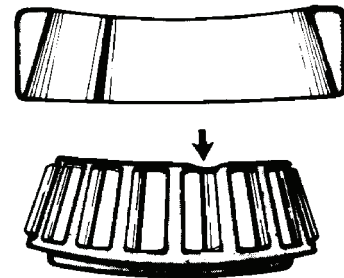


HASA620S

Figure 2

Bent Cage

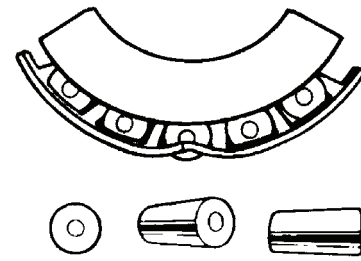
Cage damage due to improper handling or tool usage.



HASA460S

Figure 3

Replace bearing.



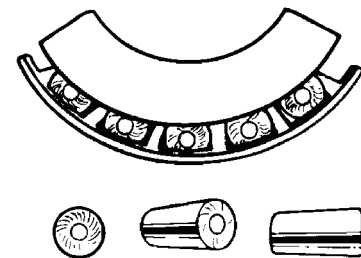
HASA470S

Figure 4

Galling

Metal smears on roller ends due to overhear, lubricant failure or overload.

Replace bearing - check seals and check for proper lubrication.



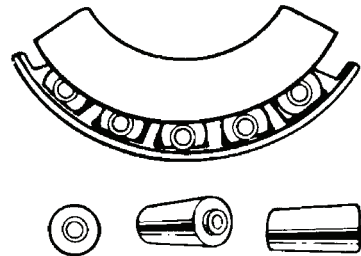
HASA480S

Figure 5

Abrasive Step Wear

Pattern on roller ends caused by fine abrasives.

Clean all parts and housings, check all parts and housings, check seals and bearings and replace if leaking, rough or noisy.



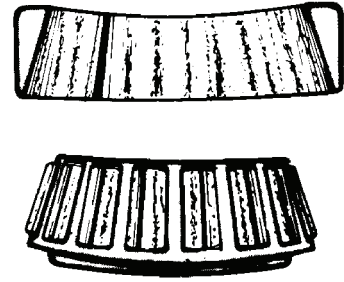
HASA490S

Figure 6

Etching

Bearing surfaces appear gray or grayish black in color with related etching away of material usually at roller spacing.

Replace bearings - check seals and check for proper lubrication.



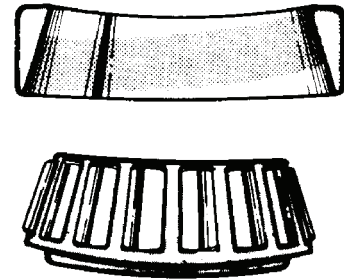
HASA500S

Figure 7

Misalignment

Outer race misalignment due to foreign object.

Clean related parts and replace bearing. Make sure races are properly seated.



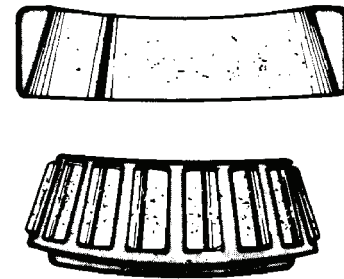
HASA510S

Figure 8

Indentations

Surface depressions on race and rollers caused by hard particles of foreign materials.

Clean all parts and housings, check seals and replace bearings if rough or noisy.



HASA520S

Figure 9

Fatigue Spalling

Flaking of surface metal resulting from fatigue.

Replace bearing - clean all related parts.

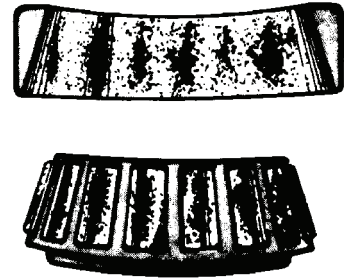


Figure 10

HASA530S

Brinelling

Surface indentations in raceway caused by rollers either under impact loading or vibration while the bearing is not rotating.

Replace bearing if rough or noisy.

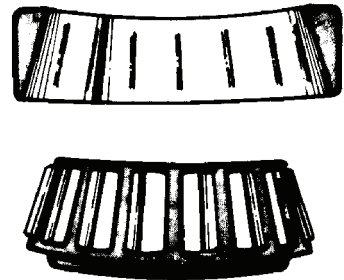


Figure 11

HASA540S

Cage Wear

Wear around outside diameter of cage and roller pockets caused by abrasive material and inefficient lubrication.

Replace bearings - check seals.

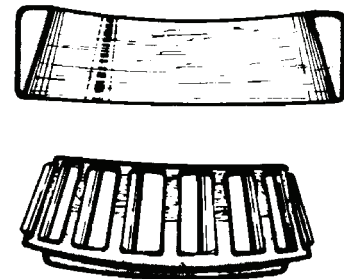


Figure 12

HASA550S

Abrasive Roller Wear

Pattern on races and rollers caused by fine abrasives.

Clean all parts and housings, check seals and bearings and replace if leaking, rough or noisy.

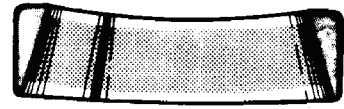


Figure 13

HASA560S

Cracked Inner Race

Race cracked due to improper fit, cocking or poor bearing seat.

Replace all parts and housings, check seals and bearings and replace if leaking.

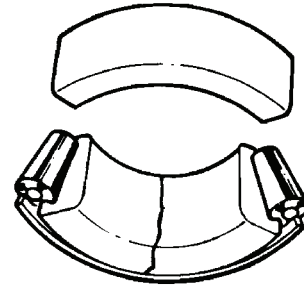


Figure 14

HASA570S

Smears

Smearing of metal due to slippage caused by poor fitting, lubrication, overheating, overloads or handling damage.

Replace bearings, clean related parts and check for proper fit and lubrication.

Replace shaft if damaged.

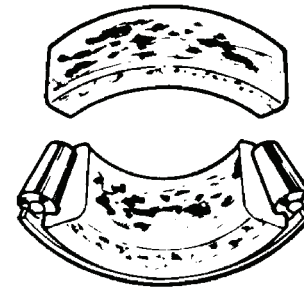


Figure 15

HASA580S

Fretting

Corrosion set up by small relative movement of parts with no lubrication.

Replace bearing. Clean all related parts. Check seals and check for proper lubrication.

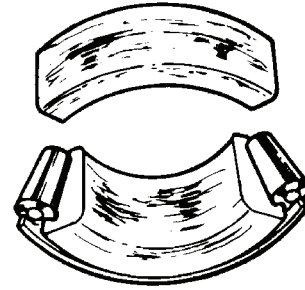


Figure 16

HASA590S

Heat Discoloration

Heat discoloration can range from faint yellow to dark blue resulting from overload or incorrect lubrication.

Excessive heat can cause softening of races or rollers.

To check for loss of temper on races or rollers, a simple file test may be made. A file drawn over a tempered part will grab and cut metal, whereas a file drawn over a hard part will glide readily with no metal cutting.

Replace bearing if over heating damage is indicated. Check seals and other related parts for damage.

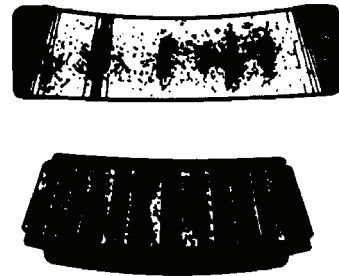


Figure 17

HASA600S

Stain Discoloration

Discoloration can range from light brown to black caused by incorrect lubrication or moisture.

if the stain can be removed by light polishing or if no evidence of overheating is visible, the bearing can be reused.

Check seals and other related parts for damage.

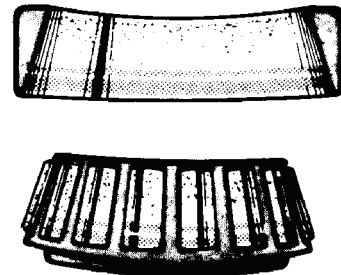


Figure 18

HASA610S

Standard Torques

Edition 1

MEMO

Table of Contents

Standard Torques

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MEMO

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 ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

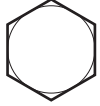
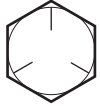
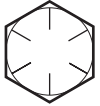
MODEL	SERIAL NUMBER RANGE
ALL MODELS	ALL RANGES

TORQUE VALUES FOR STANDARD METRIC FASTENERS

NOTE: The units for the torque values are kg•m (ft lb).

Dia. x Pitch (mm)	Grade										
	3.6 (4A)	4.6 (4D)	4.8 (4S)	5.6 (5D)	5.8 (5S)	6.6 (6D)	6.8 (6S)	6.9 (6G)	8.8 (8G)	10.9 (10K)	12.9 (12K)
M5 x Std.	0.15 (1.08)	0.16 (1.15)	0.25 (1.80)	0.22 (1.59)	0.31 (2.24)	0.28 (2.02)	0.43 (3.11)	0.48 (3.47)	0.50 (3.61)	0.75 (5.42)	0.90 (6.50)
M6 x Std.	0.28 (2.02)	0.30 (2.16)	0.45 (3.25)	0.40 (2.89)	0.55 (3.97)	0.47 (3.39)	0.77 (5.56)	0.85 (6.14)	0.90 (6.50)	1.25 (9.04)	1.50 (10.84)
M7 x Std.	0.43 (3.11)	0.46 (3.32)	0.70 (5.06)	0.63 (4.55)	0.83 (6.00)	0.78 (5.64)	1.20 (8.67)	1.30 (9.40)	1.40 (10.12)	1.95 (14.10)	2.35 (16.99)
M8 x Std.	0.70 (5.06)	0.75 (5.42)	1.10 (7.95)	1.00 (7.23)	1.40 (10.12)	1.25 (9.04)	1.90 (13.74)	2.10 (15.18)	2.20 (15.91)	3.10 (22.42)	3.80 (27.48)
M8 x 1	0.73 (5.28)	0.80 (5.78)	1.20 (8.67)	1.00 (7.23)	1.50 (10.84)	1.35 (9.76)	2.10 (15.18)	2.30 (16.63)	2.40 (17.35)	3.35 (24.23)	4.10 (29.65)
M10 x Std.	1.35 (9.76)	1.40 (10.12)	2.20 (15.91)	1.90 (13.74)	2.70 (19.52)	2.35 (19.99)	3.70 (26.76)	4.20 (30.37)	4.40 (31.18)	6.20 (44.84)	7.20 (52.07)
M10 x 1.25	1.50 (10.84)	1.60 (11.57)	2.50 (18.08)	2.10 (15.18)	3.10 (22.42)	2.80 (20.25)	4.30 (31.10)	4.90 (35.44)	5.00 (36.16)	7.00 (50.63)	8.40 (60.75)
M12 x Std.	2.40 (17.35)	2.50 (18.08)	3.70 (26.76)	3.30 (23.86)	4.70 (33.99)	4.20 (30.37)	6.30 (45.56)	7.20 (52.07)	7.50 (54.24)	10.50 (75.94)	12.50 (90.41)
M12 x 1.25	2.55 (18.44)	2.70 (19.52)	4.00 (28.93)	3.50 (25.31)	5.00 (36.16)	4.50 (32.54)	6.80 (49.18)	7.70 (55.69)	8.00 (57.86)	11.20 (81.00)	13.40 (96.92)
M14 x Std.	3.70 (26.76)	3.90 (28.20)	6.00 (43.23)	5.20 (37.61)	7.50 (54.24)	7.00 (50.63)	10.00 (72.33)	11.50 (83.17)	12.00 (86.79)	17.00 (122.96)	20.00 (144.66)
M14 x 1.5	4.10 (29.65)	4.30 (31.10)	6.60 (47.73)	5.70 (41.22)	8.30 (60.03)	7.50 (54.24)	11.10 (80.28)	12.50 (90.41)	13.00 (94.02)	18.50 (11.26)	22.00 (158.12)
M16 x Std.	5.60 (40.50)	6.00 (43.39)	9.00 (65.09)	8.00 (57.86)	11.50 (83.17)	10.50 (75.94)	15.50 (112.11)	17.90 (129.47)	18.50 (133.81)	26.00 (188.05)	31.00 (224.22)
M16 x 1.5	6.20 (44.84)	6.50 (47.01)	9.70 (70.16)	8.60 (62.20)	12.50 (90.41)	11.30 (81.73)	17.00 (122.96)	19.50 (141.04)	20.00 (144.66)	28.00 (202.52)	35.50 (256.77)
M18 x Std.	7.80 (56.41)	8.30 (60.03)	12.50 (90.41)	11.00 (79.56)	16.00 (115.72)	14.50 (104.87)	21.00 (151.89)	27.50 (198.90)	28.50 (206.14)	41.00 (296.55)	43.00 (311.01)
M18 x 1.5	9.10 (65.82)	9.50 (68.71)	14.40 (104.15)	12.50 (90.41)	18.50 (133.81)	16.70 (120.79)	24.50 (177.20)	27.50 (198.90)	28.50 (206.14)	41.00 (296.55)	49.00 (354.41)
M20 x Std.	11.50 (83.17)	12.00 (86.79)	18.00 (130.19)	16.00 (115.72)	22.00 (159.12)	19.00 (137.42)	31.50 (227.83)	35.00 (253.15)	36.00 (260.38)	51.00 (368.88)	60.00 (433.98)
M20 x 1.5	12.80 (92.58)	13.50 (97.64)	20.50 (148.27)	18.00 (130.19)	25.00 (180.82)	22.50 (162.74)	35.00 (253.15)	39.50 (285.70)	41.00 (296.55)	58.00 (419.51)	68.00 (491.84)
M22 x Std.	15.50 (112.11)	16.00 (115.72)	24.50 (177.20)	21.00 (151.89)	30.00 (216.99)	26.00 (188.05)	42.00 (303.78)	46.00 (332.71)	49.00 (354.41)	67.00 (484.61)	75.00 (542.47)
M22 x 1.5	17.00 (122.96)	18.50 (133.81)	28.00 (202.52)	24.00 (173.59)	34.00 (245.92)	29.00 (209.75)	47.00 (339.95)	52.00 (44.76)	56.00 (405.04)	75.00 (542.47)	85.00 (614.80)
M24 x Std.	20.50 (148.27)	21.50 (155.50)	33.00 (238.68)	27.00 (195.29)	40.00 (289.32)	34.00 (245.92)	55.00 (397.81)	58.00 (419.51)	63.00 (455.67)	82.00 (593.10)	92.00 (655.43)
M24 x 2.0	23.00 (166.35)	35.00 (253.15)	37.00 (267.62)	31.00 (224.22)	45.00 (325.48)	38.00 (202.52)	61.00 (441.21)	67.00 (484.61)	74.00 (535.24)	93.00 (672.66)	103.00 (744.99)

TORQUE VALUES FOR STANDARD U.S. FASTENERS

Type	S.A.E. Grade	Description	Bolt Head Marking
1	1 OR 2	WILL HAVE NO MARKINGS IN THE CENTER OF THE HEAD. Low or Medium Carbon Steel Not Heat Treated.	
5	5	WILL HAVE THREE RADIAL LINES. Quenched and Tempered Medium Carbon Steel.	
8	8	WILL HAVE 6 RADIAL LINES. Quenched and Tempered Special Carbon or Alloy Steel.	

Recommended torque, in foot pounds, for all Standard Application Nuts and Bolts, provided:

1. All thread surfaces are clean and lubricated with SAE-30 engine oil. (See Note.)
2. Joints are rigid, that is, no gaskets or compressible materials are used.
3. When reusing nuts or bolts, use minimum torque values.

NOTE: *Multiply the standard torque by:*

- | | |
|------|--|
| 0.65 | When finished jam nuts are used. |
| 0.70 | When Molykote, white lead or similar mixtures are used as lubricants. |
| 0.75 | When Parkerized bolts or nuts are used. |
| 0.85 | When cadmium plated bolts or nuts and zinc bolts w/waxed zinc nuts are used. |
| 0.90 | When hardened surfaces are used under the nut or bolt head. |

NOTE: *When reusing bolts and nuts in service, use minimum torque values.*

The following General Torque Values must be used in all cases where **SPECIAL TORQUE VALUES** are not given.

NOTE: <i>Torque values listed throughout this manual are lubricated (wet) threads; values should be increased 1/3 for nonlubricated (dry) threads.</i>				
Thread Size	Heat Treated Material Grade 5 and Grade 8			
	Grade 5 (3 Radial Dashes On Head)		Grade 8 (6 Radial Dashes On Head)	
	Foot Pounds (ft lb)	Newton Meter (Nm)	Foot Pounds (ft lb)	Newton Meter (Nm)
1/4" - 20	6	8	9	12
1/4" - 28	7	9	11	15
5/16" - 18	13	18	18	24
5/16" - 24	15	20	21	28
3/8" - 16	24	33	34	46
3/8" - 24	27	37	38	52
7/16" - 14	38	52	54	73
7/16" - 20	42	57	60	81
1/2" - 13	58	79	82	111
1/2" - 20	65	88	90	122
9/16" - 12	84	114	120	163
9/16" - 18	93	126	132	179
5/8" - 11	115	156	165	224
5/8" - 18	130	176	185	251
3/4" - 10	205	278	290	393
3/4" - 16	240	312	320	434
7/8" - 9	305	414	455	617
7/8" - 14	334	454	515	698
1" - 8	455	617	695	942
1" - 14	510	691	785	1064
1 1/8" - 7	610	827	990	1342
1 1/8" - 12	685	929	1110	1505
1 1/4" - 7	860	1166	1400	1898
1 1/4" - 12	955	1295	1550	2102
1 3/8" - 6	1130	1532	1830	2481
1 3/8" - 12	1290	1749	2085	2827
1 1/2" - 6	1400	2034	2430	3295
1 1/2" - 12	1690	2291	2730	3701
1 3/4" - 5	2370	3213	3810	5166
2" - 4 1/2	3550	4813	5760	7810

NOTE: *If any bolts and nuts are found loose or at values less than what the chart states, it is recommended that the loose bolt and/or nut be replaced with a new one.*

TYPE 8 PHOSPHATE COATED HARDWARE

This chart provides tightening torque for general purpose applications using original equipment standard hardware as listed in the Parts Manual for the machine involved. **DO NOT SUBSTITUTE.** In most cases, original equipment standard hardware is defined as Type 8, coarse thread bolts and nuts and thru hardened flat washers (Rockwell "C" 38 - 45), all phosphate coated and assembled without supplemental lubrication (as received) condition.

The torques shown below also apply to the following:

1. Phosphate coated bolts used in tapped holes in steel or gray iron.
2. Phosphate coated bolts used with phosphate coated prevailing torque nuts (nuts with distorted threads or plastic inserts).
3. Phosphate coated bolts used with copper plated weld nuts.

Markings on bolt heads or nuts indicate material grade **ONLY** and are **NOT** to be used to determine required torque.

Nominal Thread Diameter	Standard Torque $\pm 10\%$	
	Kilogram Meter (kg•m)	Foot Pounds (ft lb)
1/4"	1.1	8
5/16"	2.2	16
3/8"	3.9	28
7/16"	6.2	45
1/2"	9.7	70
9/16"	13.8	100
5/8"	19.4	140
3/4"	33.2	240
7/8"	53.9	390
1"	80.2	580
1 - 1/8"	113.4	820
1 - 1/4"	160.4	1160
1 - 3/8"	210.2	1520
1 - 1/2"	279.4	2020
1 - 3/4"	347.1	2510
2	522.8	3780

TORQUE VALUES FOR HOSE CLAMPS

The following chart provides the tightening torques for hose clamps used in all rubber applications (radiator, air cleaner, operating lever boots, hydraulic system, etc.).

Clamp Type And Size	Torque			
	Radiator, Air Cleaner, Boots, Etc.		Hydraulic System	
	Kilogram Meter (kg•m)	Inch Pounds (in lb)	Kilogram Meter (kg•m)	Inch Pounds (in lb)
"T" Bolt (Any Diameter)	0.68 - 0.72	59 - 63	-----	-----
Worm Drive - Under 44 mm (1-3/4 in) Open Diameter	0.2 - 0.3	20 - 30	0.5 - 0.6	40 - 50
Worm Drive - Over 44 mm (1-3/4 in) Open Diameter	0.5 - 0.6	40 - 50	-----	-----
Worm Drive - All "Ultra-Tite"	0.6 - 0.7	50 - 60	0.5 - 0.6	40 - 50

TORQUE VALUES FOR SPLIT FLANGES

The following chart provides the tightening torques for split flange connections used in hydraulic systems. Split flanges and fitting shoulders should fit squarely. Install all bolts, finger tight and then torque evenly.

NOTE: *Over torquing bolts will damage the flanges and/or bolts, which may cause leakage.*

Flange Size (*)	Bolt Size	Bolt Torque	
		Kilogram Meter (kg•m)	Foot Pounds (ft lb)
1/2"	5/16"	2.1 - 2.5	15 - 18
3/4"	3/8"	3.0 - 3.7	22 - 27
1"	3/8"	3.7 - 4.8	27 - 35
1 - 1/4"	7/16"	4.8 - 6.2	35 - 45
1 - 1/2"	1/2"	6.4 - 8.0	46 - 58
2"	1/2"	7.6 - 9.0	55 - 65
2 - 1/2"	1/2"	10.9 - 12.6	79 - 91
3"	5/8"	19.1 - 20.7	138 - 150
3 - 1/2"	5/8"	16.2 - 18.4	117 - 133

(*) - Inside diameter of flange on end of hydraulic tube or hose fitting.

NOTE: *Values stated in chart are for Standard Pressure Series (Code 61) Split Flanges.*

TORQUE WRENCH EXTENSION TOOLS

Very large diameter, high grade fasteners (nuts, bolts, cap screws, etc.) require a great deal of turning force to achieve recommended tightening torque values.

Common problems that could occur as a result are:

- Recommended torque exceeds the measuring capacity of the torque wrench.
- Specialized sockets do not fit the adapter on the front end (nose) of the torque wrench.
- Generating adequate force on the back end (handle) of the wrench is difficult or impossible.
- Restricted access or an obstruction may make use of the torque wrench impossible.
- A unique application requires fabrication of an adapter or other special extension.

Most standard torque wrenches can be adapted to suit any one of the proceeding needs or situations, if the right extension tool is used or fabricated.

Torque Multiplication

A wrench extension tool can be used to increase the tightening force on a high capacity nut or bolt.

For example, doubling the distance between the bolt and the back (handle) end of the torque wrench doubles the tightening force on the bolt. It also halves the indicated reading on the scale or dial of the torque wrench. To accurately adjust or convert indicated scale or dial readings, use the following formula:

$I = A \times T / A + B$ where:

I = Indicated force shown on the torque wrench scale or dial.

T = Tightening force applied to the nut or bolt (actual Torque).

A = Length of the torque wrench (between the center of the nut or bolt and the center of the handle).

B = Length of the extension.

As an example, if a 12" extension is added to a 12" torque wrench, and the indicated torque on the dial reads "150 ft lb," the real force applied to the bolt is 300 ft lb:

$$I = \frac{A \times T}{A + B} = \frac{12 \times 300}{12 + 12} = \frac{3600}{24} = 150$$

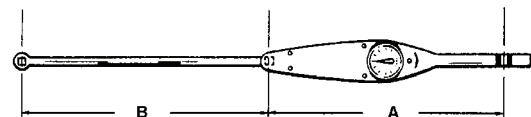


Figure 1

0552A

NOTE: *The formula assumes that there is no added deflection or "give" in the joint between the extension and torque wrench. Readings may also be inaccurate:*

- If the extension itself absorbs some of the tightening force and starts to bend or bow out.
- If an extension has to be fabricated that is not perfectly straight (for example, an extension made to go around an obstruction, to allow access to a difficult to tighten fastener), the materials and methods used must be solid enough to transmit full tightening torque.

Other Uses for Torque Wrench Extension Tools

Torque wrench extensions are sometimes made up for reasons other than increasing leverage on a fastener.

For example, a torque wrench and extension can be used to measure adjustment "tightness" of a linkage or assembly. Specially fabricated extensions can be used to make very precise checks of the force required to engage or disengage a clutch mechanism, release a spring-applied brake assembly, or "take up" free play in most any movable linkage.

Once the value of the adjustment force is established, repeated checks at regular intervals can help to monitor and maintain peak operating efficiency. These types of adjustment checks are especially useful if physical measurements of linkage travel are difficult to make or will not provide the needed degree of precision and accuracy.

To allow the assembly or mechanism to accept a torque wrench, welding a nut or other adapter on the end of a linkage shaft or other leverage point will allow turning the shaft or assembly manually.

Tightening Torque Specifications (Metric)

(For coated threads, prelubricated assemblies.)



CAUTION!

Disassembly, overhaul and replacement of components on the machine, installation of new or replacement parts and/or other service-related maintenance may require the use of thread or flange sealing assembly compound.

Use the information on this page as a general guide in selecting specific formulas that will meet the particular requirements of individual assembly installations. *DOOSAN* does not specifically endorse a specific manufacturer or brand name but the following table of "Loctite" applications is included for which cross-references to other makers' products should also be widely available.

IMPORTANT

Use primer "T" or "N" for all cold weather assembly of fastener adhesives, with Thread locker sealers 222, 242/243, 262, 271, 272, or 277.

I. "Loctite" Fastener Adhesives

Product	Application	Color	Removal	Breakaway Cure Strength (in lb) of Sealer Alone
222	Low strength for 6 mm (1/4") or smaller fasteners.	Purple	Hand tools	45
242 or 243	Medium strength for 6 mm (1/4") and larger fasteners.	Blue	Hand tools	80
262	High strength for high grade fasteners subject to shock, stress and vibration.	Red	Heat/260°C (500°F) Remove HOT (NO solvent)	160
271	Extra high strength for fine thread fasteners up to 25 mm (1") diameter.	Red	Heat/260°C (500°F) Remove HOT	160
272	High temperature/high strength for hostile environments to 232°C (450°F).	Red	Heat/316°C (600°F) Remove HOT	180
277	Extra high strength for coarse thread fasteners 25 mm (1") diameter and larger.	Red	Heat/260°C (500°F) Remove HOT	210

II. "Loctite" Pipe Thread Sealant

Product	Application	Color	Removal	Required Setup
545	"No-filler/nonclog" formula for high-pressure hydraulic systems. Over application will not restrict or foul system components.	Purple	Hand tools	4 Hours (or 1/2 hour with Locquic "T" Primer)
656	Solvent resistant, higher viscosity tapered thread sealer.	White	Hand tools	4 Hours (or 1/2 hour with Locquic "T" Primer)

III. "Loctite" gasket/flange sealer

Product	Application	Color	Notes
518	Gasket eliminator specifically made for aluminum flanges/surfaces. For hydraulic systems to 34,475 kPa (5,000 psi).	Red	Use Locquic "N" primer for fast (1/2 - 4 hours) setup. Unprimed setup 4 - 24 hours.
504	Low-pressure/wide-gap gasket eliminator compound. Fills gaps to 0.0012 mm (0.030"), cures to rigid seal.	Orange	Use Locquic "N" primer for faster (1/2 - 4 hours) setup. Unprimed setup 4 - 24 hours.
515	General purpose, fast setup, flexible-cure gasket eliminator. For nonrigid assemblies subject to shock, vibration or deflection.	Purple	Use Locquic "N" primer for faster (1/4 - 2 hours) setup. Unprimed setup 1 - 12 hours.

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.

Upper Structure

Cabin

Edition 1

MEMO

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Cabin

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MEMO

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 ultimately 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
DX55W	5001 and Up

REMOVAL

CAUTION

Avoid disassembling cabin if there are strong wind gusts, which could catch large surface area of cabin shell and push it sideways during lift.

1. Park on firm and level ground.
2. Lower front attachment (bucket) to ground.
3. Shut down engine.
4. Set safety lever on "RELEASED" position.
5. Turn starter switch to "I" (ON) position.

WARNING

If engine must be run while performing maintenance, use extreme care. Always have one person in the cabin at all times. Never leave the cabin with the engine running.

6. Fully stroke work levers (joysticks) in all directions to relieve pressure from accumulators.
7. Set safety lever on "LOCK" position.
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Hang maintenance warning tag on controls.
10. Disconnect the battery cable from the negative (-) battery terminal.
11. Prepare cabin shell for removal by disconnecting wiring connectors for :
 - A. Main harness.
 - B. Left stand harness.
 - C. Right stand harness.
 - D. Harness passing next to the air conditioner box.

NOTE: *Control console wiring harnesses and hydraulic piping lines that pass through the floor of the cabin do not need to be disassembled.*

NOTE: *If unit is equipped with a cabin protective structure (for forestry, or hazardous working conditions), it must be removed.*

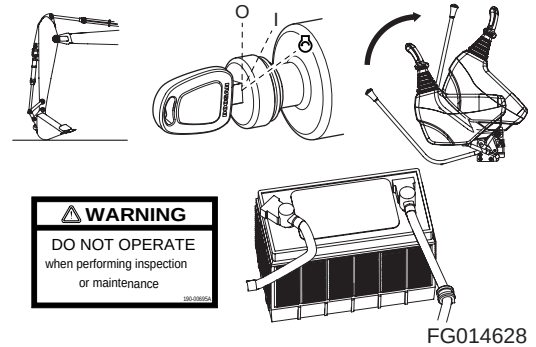


Figure 1

12. Remove floor mat.

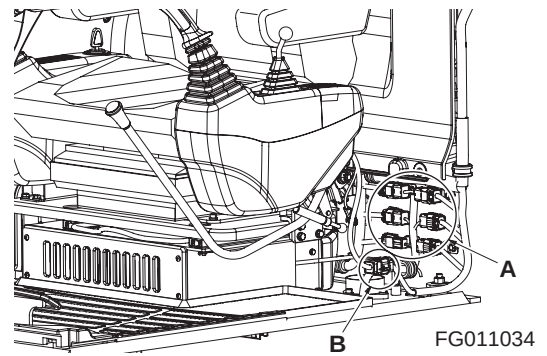


Figure 2

13. First, separate the main harness connector (A, Figure 2). Separate the left stand harness (B, Figure 2) and right stand harness (C, Figure 3). After separating the air conditioner box cover (E, Figure 4) and air conditioner filter (F, Figure 5) under the seat, separate the harness passing next to the air conditioner box (D, Figure 6)

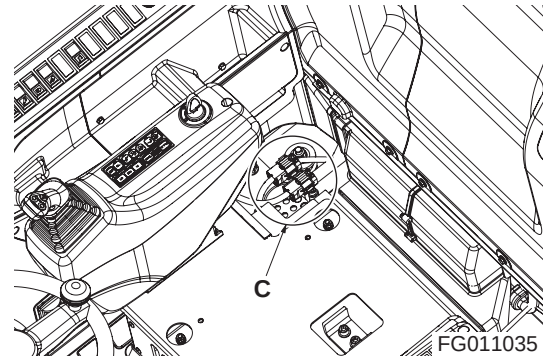


Figure 3

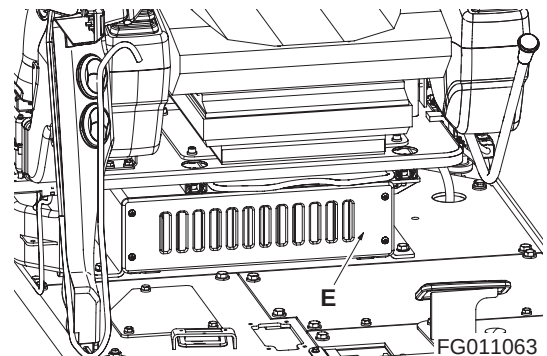


Figure 4

14. Disconnect washer hose located at floor plate bottom.

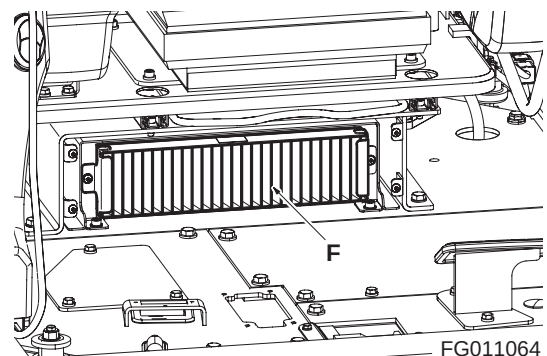


Figure 5

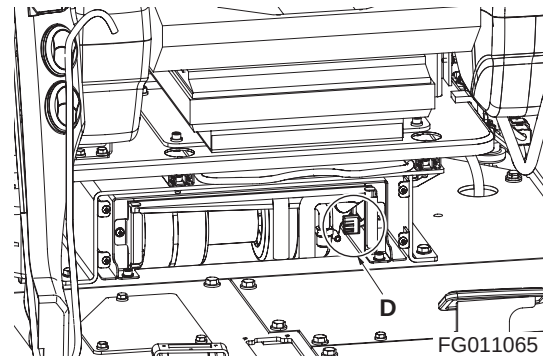


Figure 6

15. Remove four mounting nuts and washers from four corners of cabin floor (Figure 7).

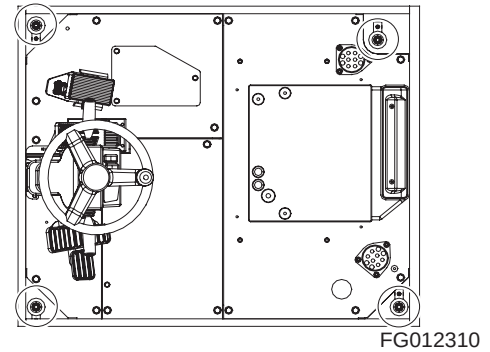


Figure 7

16. Using a suitable lifting device, attach slings to three lift points on top of cabin (Figure 8).

NOTE: Cabin Weights approximately 290 kg (639 lb)

17. Lift cabin approximately 25 - 50 mm (1" - 2") above deck. Check that all electrical connections have been disconnected and all other items unbolted.
18. Continue lifting with the assist crane to remove the cabin shell. Lower the shell to a prepared safe blocking support.

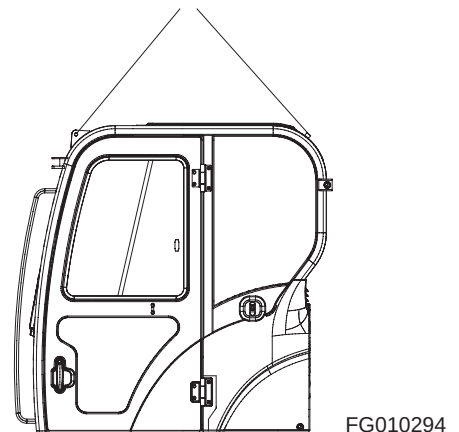


Figure 8

INSTALLATION

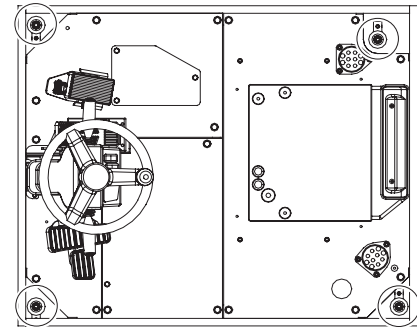
1. Using a suitable lifting device, attach slings to three lift points on top of cabin (Figure 8).

NOTE: Cabin weights approximately 290 kg (639 lb).

2. Lower cabin into position on cabin floor.
3. Install four mounting nuts and washers from four corners of cabin floor (Figure 9).

NOTE: Mounting nut torque 20.2 kg•m (198 N•m, 146 lbf ft).

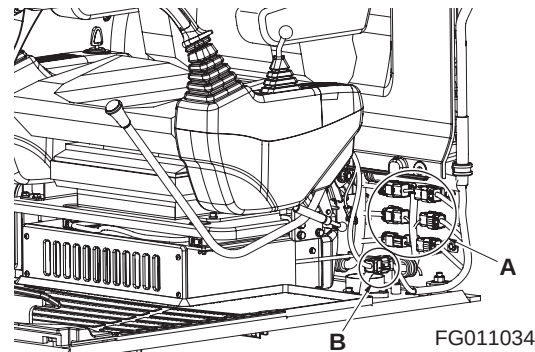
4. Once cabin is mounted to floor, unhook lifting device.



FG012310

Figure 9

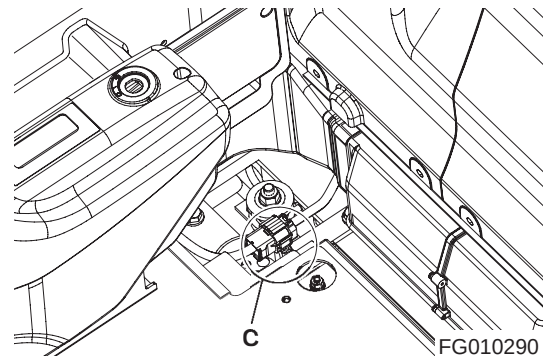
5. Connect the main harness, the harness of stand of both ends and the harness passing next to the air conditioner box in that order (A ~ D, Figure 10 ~ Figure 12).



FG011034

Figure 10

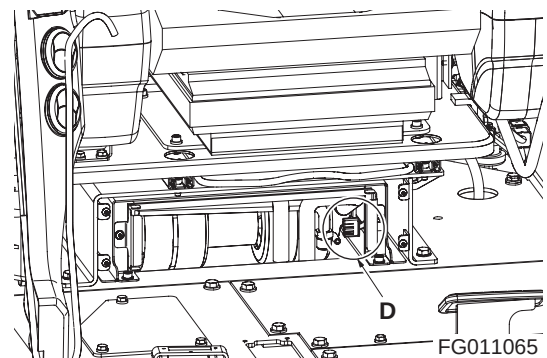
6. Assemble the air conditioner filter and air conditioner box cover.
7. Connect washer hose located at floor plate bottom.



FG010290

Figure 11

8. Install floor mat.
9. Connect negative (-) battery cable leading to frame from battery.



FG011065

Figure 12

Counterweight

Edition 1

MEMO

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Counterweight

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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 ultimately 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
DX55W	5001 and Up

GENERAL

Warning for Counterweight and Front Attachment Removal



DANGER!

DOOSAN warns any user, that the removal of the counterweight from the machine, front attachment or any other part, may affect the stability of the machine. This could cause unexpected movement, resulting in death or serious injuries. **DOOSAN** is not liable for any misuse.

Never remove the counterweight or front attachment unless the upper structure is in-line with the lower structure.

Never rotate the upper structure once the counterweight or front attachment has been removed.

Before any attempt is made to begin removal or installation of the counterweight, the excavator must be parked on a firm and level supporting surface, with no sloping surfaces or soft or muddy ground in the area where the assist lift crane will be working. Position all accessories in the overnight storage position.



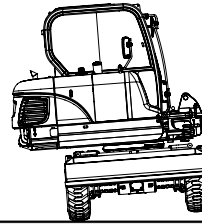
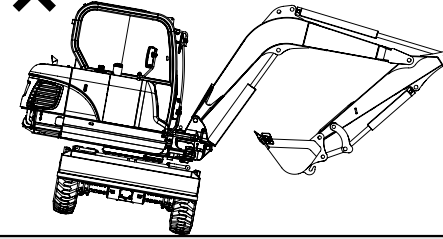
WARNING!

The weight of counterweight is given in the following table. Use only rated and approved slings and hardware when removal or installation lifts are being made. Lifting slings, shackles and all other hardware must be rigged safely. An assist crane that is rated above weight capacity is required.

Model	Weight of Counterweight
DX55W	233 kg (514 lb)

Responsibility should be assigned to one person to be in charge of the lifting crew, and to verify that required safe lifting precautions have been taken before each part of this procedure has been started.

All members of the working crew should know and understand the signals that will be used between the lifting leader, the assist crane operator and the remainder of the work crew.



FG010548

Figure 1

WARNING!

If the turntable deck has been unbalanced by removal of weight from one end only, traveling the excavator, swinging the turntable, movement over bumps or sloping and uneven surfaces could cause loss of control and possible accidents or injuries.

To maintain stability the counterweight should be removed whenever the front attachment is taken off the machine.

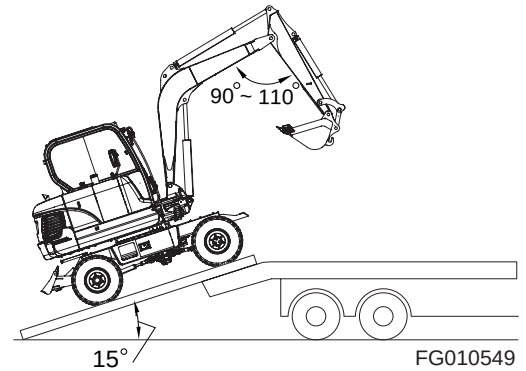


Figure 2

When loading an excavator (either track or wheeled type) on a trailer for transport after the front attachment has been removed, always go backwards up the loading ramp. The counterweight end of the deck has to get on the trailer first, while the cabin is still going up the ramp (Figure 2).

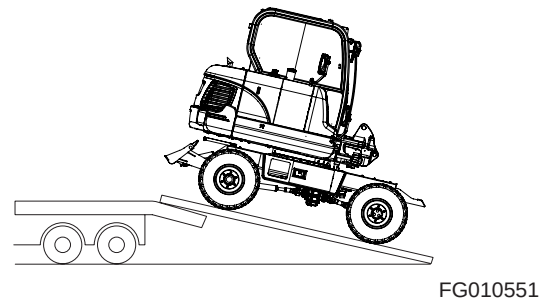


Figure 3

REMOVAL

1. Park on firm and level ground.
2. Lower front attachment (bucket) to the ground.
3. Shut down engine.
4. Set safety lever on "RELEASED" position.
5. Turn starter switch to "I" (ON) position.



WARNING!

If engine must be run while performing maintenance, use extreme care. Always have one person in the cabin at all times. Never leave the cabin with the engine running.

6. Fully stroke work levers (joysticks) in all directions to relieve any pressure from accumulators.
7. Set safety lever on "LOCK" position.
8. Turn key to "O" (OFF) position and remove from starter switch.
9. Hang maintenance warning tag on controls.
10. Disconnect the battery cable from the negative (-) battery terminal.
11. Open the engine compartment cover.

12. Remove two rear lamps (1, Figure 5) from counterweight.
13. Install two lifting eyes in lifting holes (3, Figure 6).
14. Using a suitable lifting device capable of handling a heavy load, partially support counterweight (2, Figure 6) before loosening three bolts (4). Stop lifting with assist crane as soon as lifting slings are taut.
15. Remove three bolts (4, Figure 6) and washers (5) from counterweight (2).

NOTE: Heat bolts if necessary, to free them.

16. When bolts (4, Figure 6) and washers (5) have been removed, lift counterweight (2) a very short distance above support frame (6) and stop. Check slings and make sure counterweight is being supported evenly.

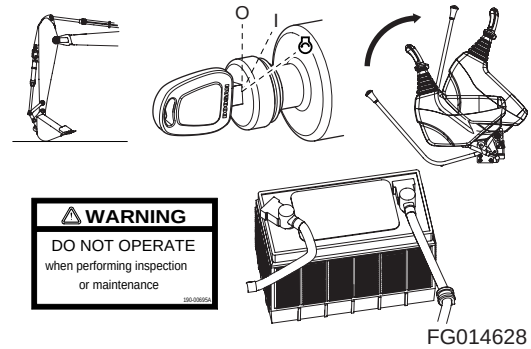


Figure 4

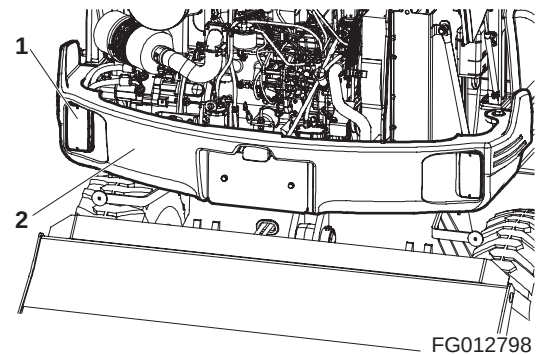


Figure 5

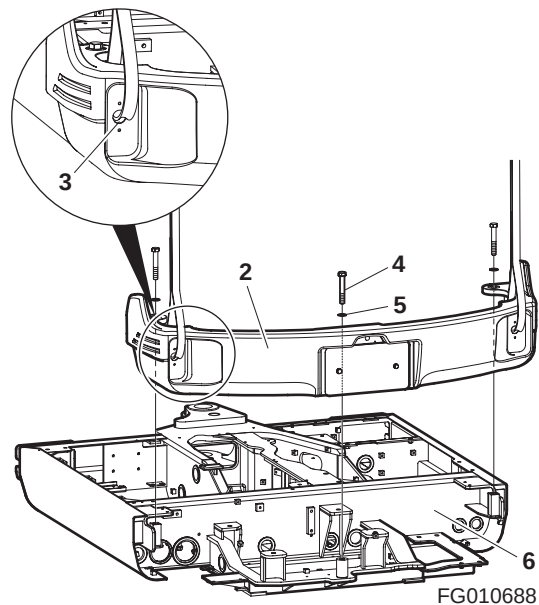


Figure 6

INSTALLATION

1. Using suitable lifting device capable of handling a heavy load, raise counterweight (2, Figure 7) into position just above support frame (6) leaving counterweight suspended. Verify that counterweight is level and even.

NOTE: Leave counterweight (2, Figure 7) suspended 3 mm (0.12") above support frame (6) until all three mounting bolts (4) are started in counterweight mounting holes.

2. Slide washers (5, Figure 7) onto bolts (4). Apply Loctite #262 to mounting bolt threads.
3. Install *three* bolts (4, Figure 7) with washers (5) into counterweight until washers contact support frame. Fully lower counterweight onto support frame and finish tightening bolts.

NOTE: Torque bolts (4, Figure 7) to values shown in following table.

Model	Bolt Torque
DX55W	55 kg•m (398 ft lb)

4. Remove lifting device from counterweight holes (3, Figure 7).
5. Install two rear ramps (1, Figure 5) in the holes (3).
6. Close the engine compartment cover.
7. Connect negative (-) battery cable to battery.

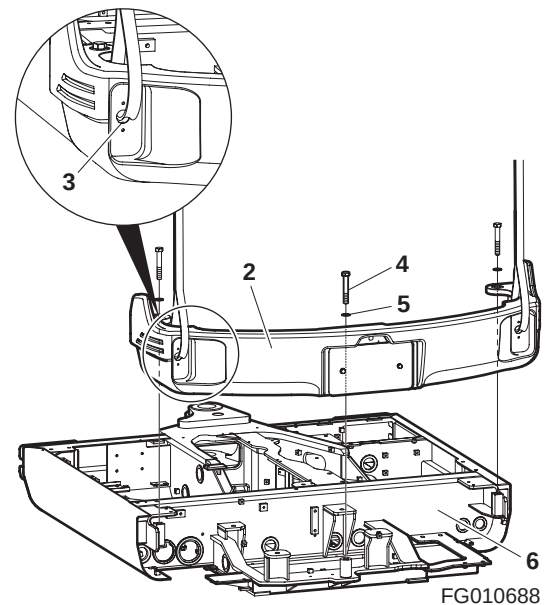


Figure 7

Fuel Tank

Edition 1

MEMO

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SAFETY PRECAUTIONS



CAUTION!

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

Use lifting and hoisting equipment capable of safely handling load.

Remember, that ultimately 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
DX55W	5001 and Up

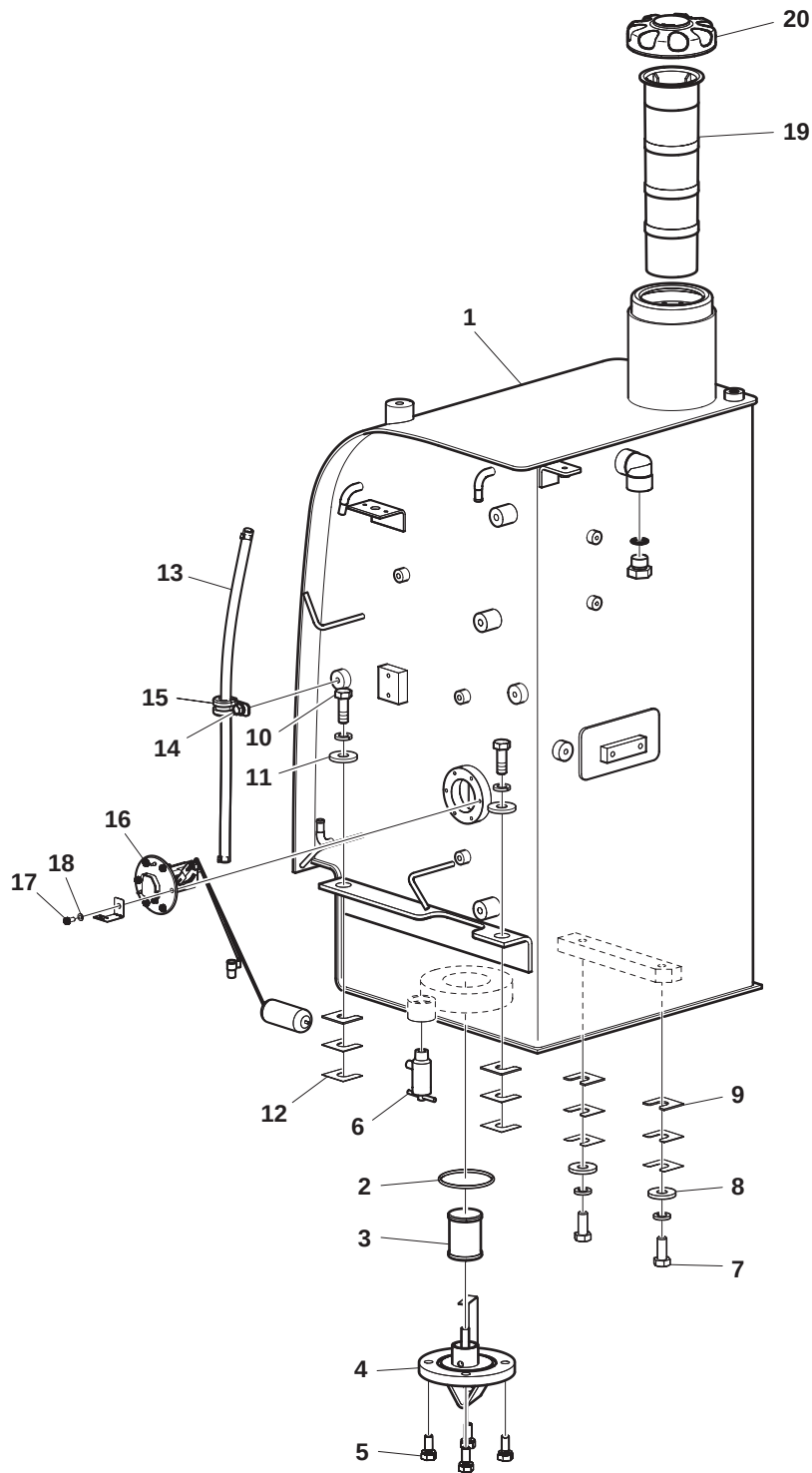
GENERAL DESCRIPTION



WARNING

Engine fuel is highly flammable and potentially explosive. To prevent possible injury and/or damage to equipment, extinguish or move to a safe distance all potential fire hazards.

Parts List



FG010689

Figure 1

Reference Number	Description
1	Fuel Tank
2	O-ring
3	Fuel Filter
4	Cover
5	Set Bolt
6	Drain Valve
7	Bolt
8	Washer
9	Shim
10	Bolt

Reference Number	Description
11	Washer
12	Shim
13	Level Gauge
14	Bolt
15	Clip
16	Fuel Sender
17	Bolt
18	Spring Washer
19	Fuel Strainer
20	Cap

Specifications

Fuel tank capacity is 120 liters (31.7 U.S. gal).

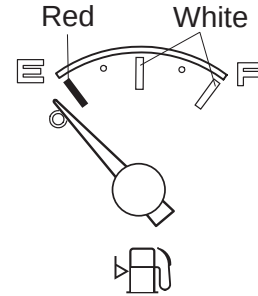
REMOVAL

1. Show remaing fuel quantity in tank

White Range : Indicates a normal fuel quantity.

Red Range : Indicates that the fuel level is low. When the needle indicates this range, add fuel immediately.

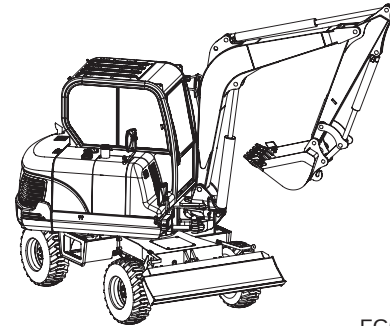
NOTE: *If possible, work excavator until available fuel supply in tank has been run down as far as possible.*



BNO0590L

Figure 2

2. Park on firmly and level ground. Swing turntable approximately 145° with counterclockwise direction to locate the drain valve of a fuel tank to the space beside the left step. See Figure 3.



FG014627

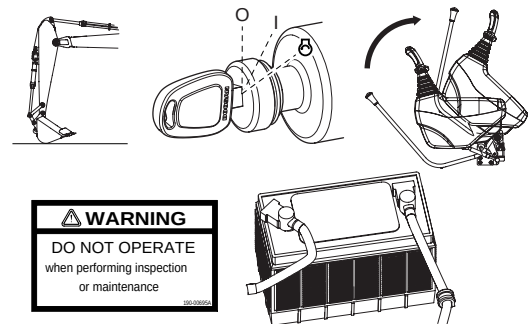
Figure 3

3. Lower front attachment (bucket) to ground.
4. Shut down engine.
5. Set safety lever on "RELEASED" position.
6. Turn starter switch to "I" (ON) position.



WARNING!

If engine must be run while performing maintenance, use extreme care. Always have one person in the cabin at all times. Never leave the cabin with the engine running.



FG014628

Figure 4

7. Fully stroke work levers (joysticks) in all directions to relieve any pressure from accumulators.
8. Set safety lever on "LOCK" position.
9. Turn key to "O" (OFF) position and remove from starter switch.
10. Hang maintenance warning tag on controls.
11. Disconnect negative (-) battery cable leading to frame from battery.

12. Clean area around fuel tank fill cap (1, Figure 5). Open fuel cap.

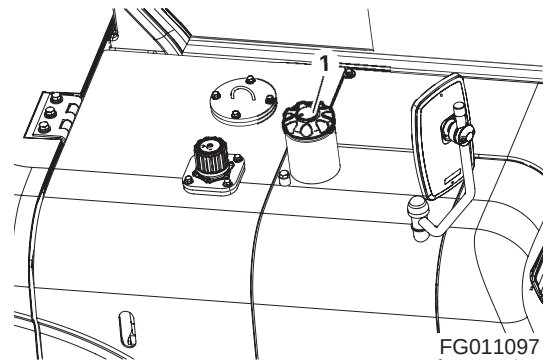
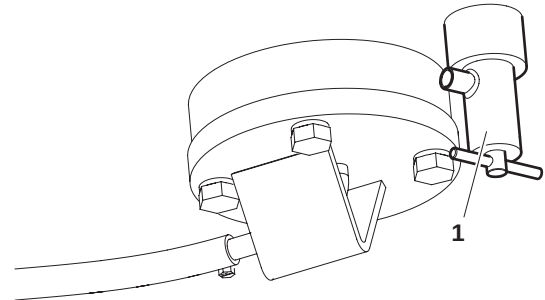


Figure 5

13. Place a large enough container under fuel tank to collect remaining fuel. Open drain valve (1, Figure 6) at bottom of tank and drain.

NOTE: Fuel tank capacity is 120 liters (31.7 U.S. gal).



FG010691

Figure 6

14. Tag and disconnect fuel supply line (1, Figure 7) and fuel return line (2) from fuel tank (3) and carefully drain remaining fuel from lines.
15. Remove clamp (4, Figure 7) holding fuel return line (2) to tank (1).

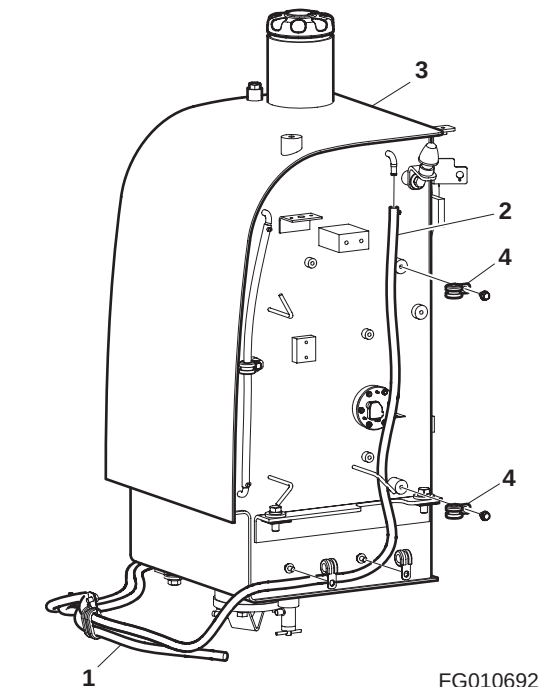
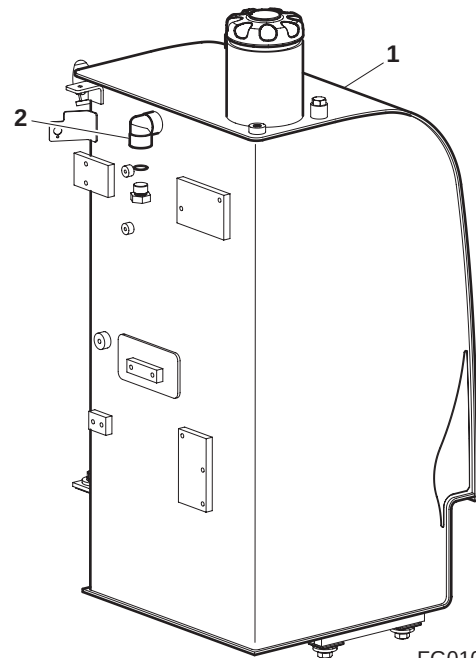


Figure 7

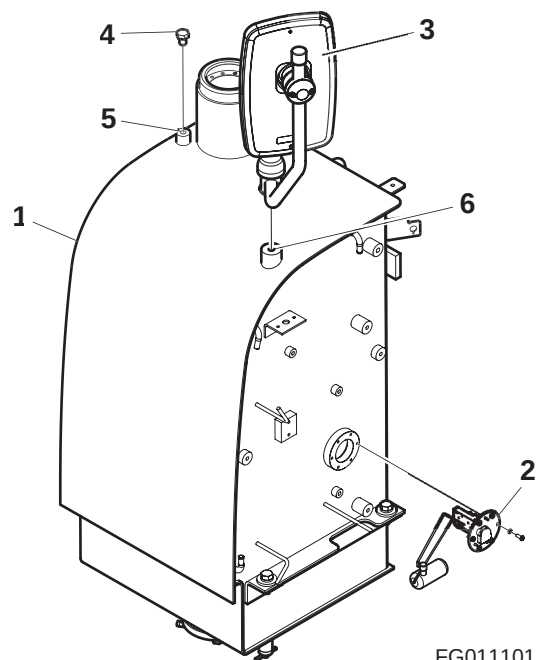
16. If equipped, remove components from fuel filler pump port (2, Figure 8) on side of fuel tank (1).



FG010693

Figure 8

17. Tag and disconnect wires leading to fuel sender (2, Figure 9) on side of fuel tank (1).
18. Remove the mirror (3, Figure 9) and hex head bolt (4, Figure 9) on the fuel tank.



FG011101

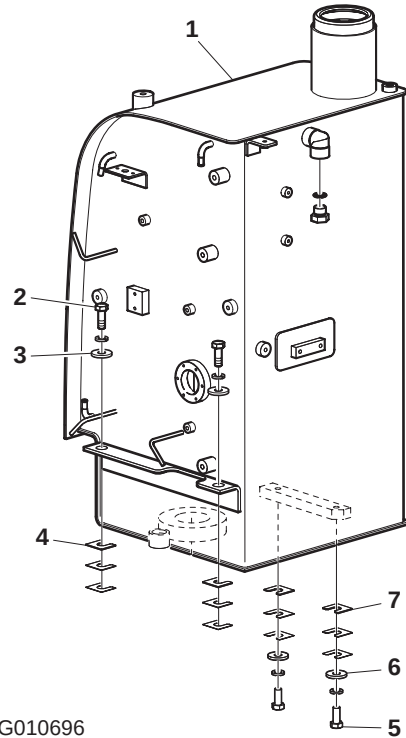
Figure 9

19. Install two 12 mm eyebolts in threaded holes (5 and 6, Figure 9). Using a suitable lifting device, sling eyebolts.
20. Remove four bolts (2,5) and spacers (3, 6 Figure 10) holding tank (1) to frame. Lift tank 25 mm (1") and make sure it is balanced. Make sure that there are no other electrical wires or hoses connected to tank. Completely remove tank after inspection.

NOTE: *The clear level gauge on the side of the tank is easily damaged. Be careful of obstacles and wind gusts.*

21. Remove shims (4, 7 Figure 10).

NOTE: *If tank is to be reused note position and amount of shims used for each mounting bolt location.*

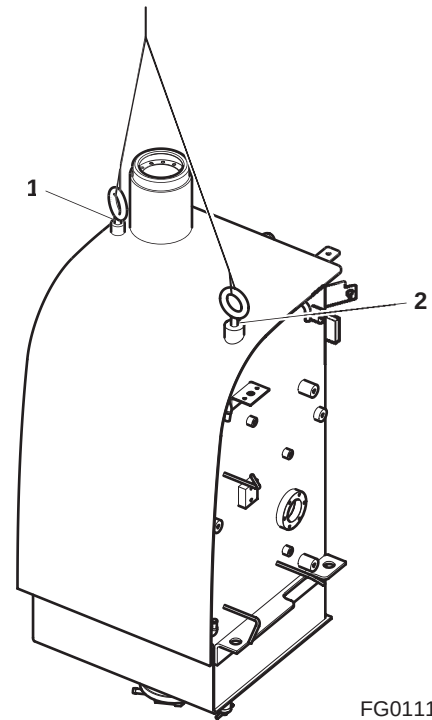


FG010696

Figure 10

INSTALLATION

1. Install two 12 mm eyebolts in threaded holes (1 and 2, Figure 11). Using a suitable lifting device, sling eyebolts.



FG011102

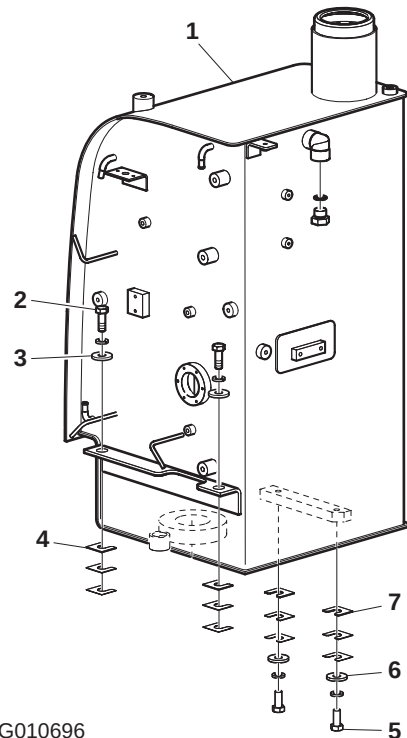
Figure 11

2. Set fuel tank (1, Figure 11) into position. Install four bolts (2, 5) and spacers (3, 6) finger tight, to secure tank to frame.

NOTE: *The clear level gauge on the side of the tank is easily damaged. Be careful of obstacles and wind gusts.*

3. Install shims (4, 7 Figure 11) as needed to prevent tank (1) from rocking or stress from mounting bolts (2, 5).
4. Tighten mounting bolts (2, 5 Figure 11) after shims are installed.

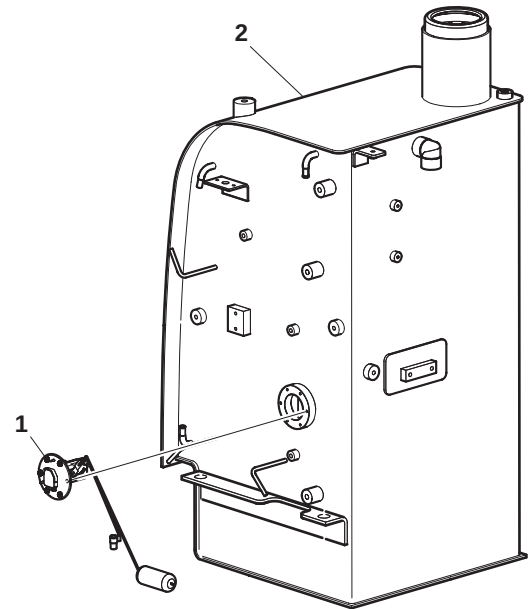
NOTE: *Bolt torque is 11 kg•m (79.6 ft lb).*



FG010696

Figure 12

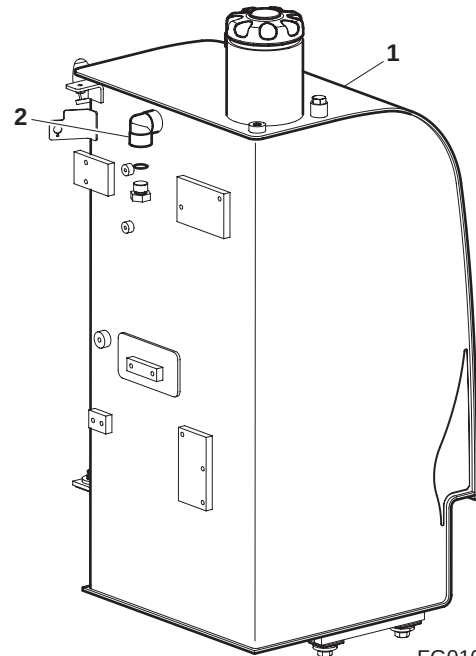
5. Connect wires as tagged to fuel sender (1, Figure 13) on side of fuel tank (2).



FG010695

Figure 13

6. If equipped, connect components to fuel filler pump port (2, Figure 14) on side of fuel tank (1).



FG010693

Figure 14

7. Connect as tagged, fuel supply line (1, Figure 15) and fuel return line (2) to fuel tank (3).
8. Install clamp (4, Figure 15) to hold fuel return line (2) to tank (1).

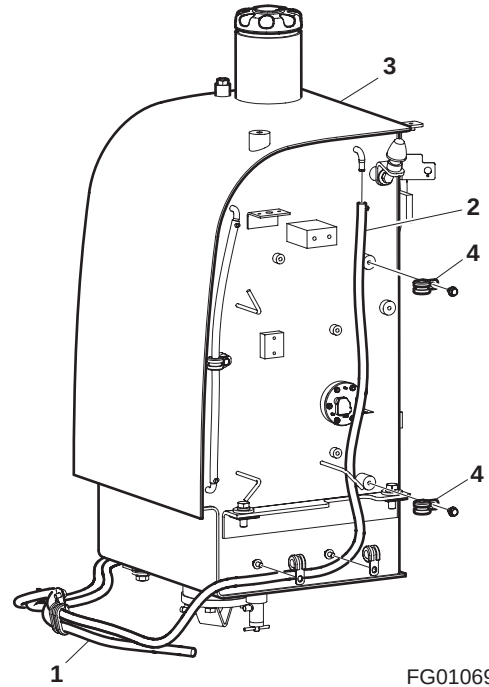


Figure 15

FG010692

9. Make sure fuel tank drain valve (1, Figure 16) on bottom of tank is closed.
10. Fill fuel tank and check for signs of leaks. Correct any problems found.
11. Connect negative (-) battery cable to battery.

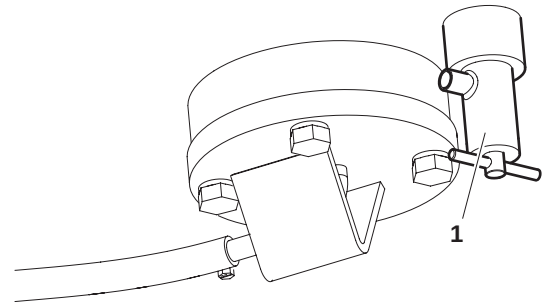


Figure 16

FG010691

PRIMING THE FUEL SYSTEM

If engine does not start, the fuel system may need priming. Prime the fuel system using the following procedure:

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

Fuel Transfer Pump

Edition 1

MEMO

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Fuel Transfer Pump

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MEMO

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 ultimately 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
DX55W	5001 and Up

GENERAL DESCRIPTION

Theory of Operation

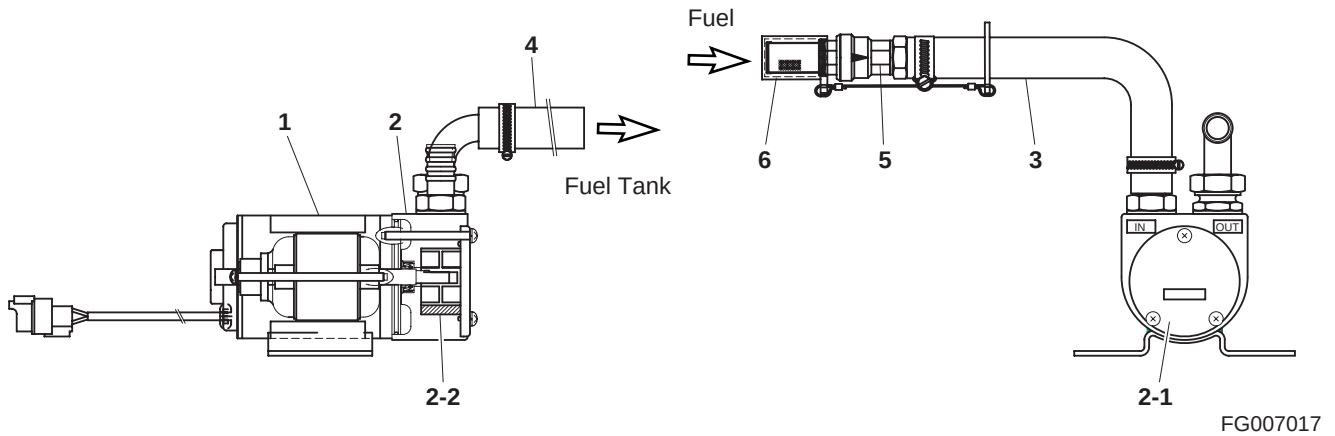


Figure 1

Reference Number	Description
1	Motor
2	Pump
2-1	Pump Cover
2-2	Rotor and Vane

Reference Number	Description
3	Inlet Hose
4	Outlet Hose
5	Check Valve
6	Strainer Cap

The fuel pump consists of a motor, pump, switch, and hose assembly.

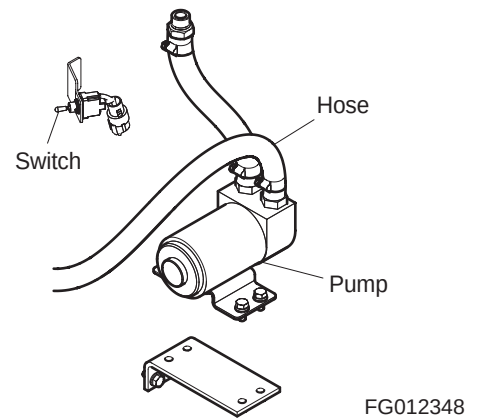


Figure 2

TROUBLESHOOTING

On some pumps the ON-OFF switch is installed separately at a remote location.

A thermal limiter, built into the motor, will automatically shut off power if motor is overheating to protect it from being damaged.

NOTE: *OPEN TEMP: $150 \pm 5^{\circ}\text{C}$ ($302 \pm 41^{\circ}\text{F}$). After circuit is automatically shut off due to overheating the pump will stop running. When temperature drops below 143°C (289°F) the circuit will reactivate allowing the pump to restart.*

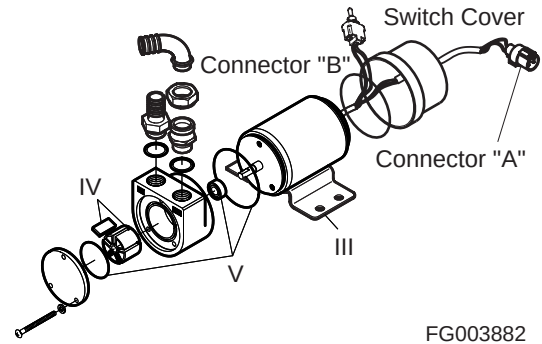


Figure 3 WITH TOGGLE SWITCH

Check resistance at connectors "A." If reading is zero, or very close to zero, the motor is bad and must be replaced.

On units equipped with a toggle switch, check the resistance through the toggle switch, while the switch is in the "ON" position. If continuity is not present, the switch is bad. Be sure to check resistance through the motor.

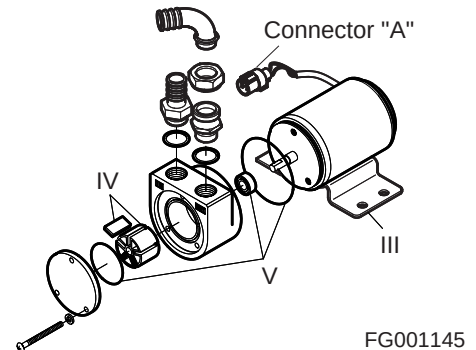
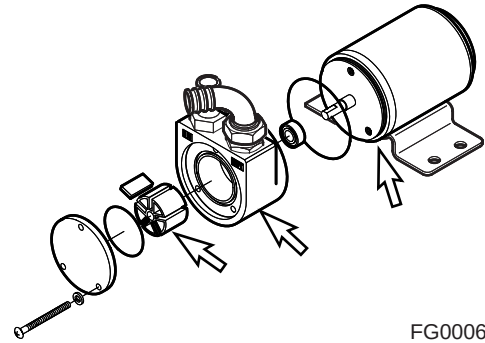


Figure 4 WITHOUT TOGGLE SWITCH

REPLACEMENT OF ROTOR AND VANE

If dirt or other foreign materials enter the pump during operation, it can become lodged between the rotor and/or vanes and generate heat which can cause the pump damage.

Remove the pump cover and check the rotor and vane. If any pump parts or components become lost, damaged or inoperable, immediately replace them with new ones.

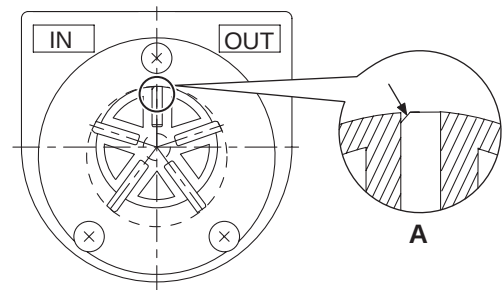


FG000670

Figure 5 WITHOUT TOGGLE SWITCH

Insert vane, with the circled edge of vane facing in the counterclockwise direction. (Detail A)

Insert a new O-ring during reassembly of pump cover.



FG003883

Figure 6

REPLACEMENT OF REAR COVER

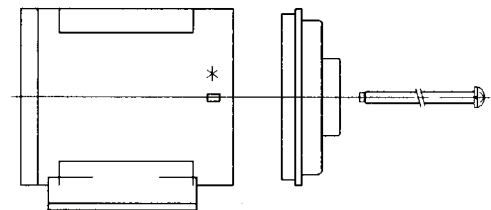
Brush assembly and a thermal limiter are installed in the rear cover. If you find any damage, replace them with new ones.

Remove the switch cover and screw (M5 x L95) from the rear cover.

Remove cover.

At reassembly of rear cover, widen the space of the brush and insert it to the armature. Then fit the hole of screw in the housing.

Be careful when installing the screw. The cover screw may be attracted by the motor magnet.



HAAG0330

Figure 7

REPLACEMENT OF ARMATURE

You can replace only the armature in case motor was damaged by a short circuit.

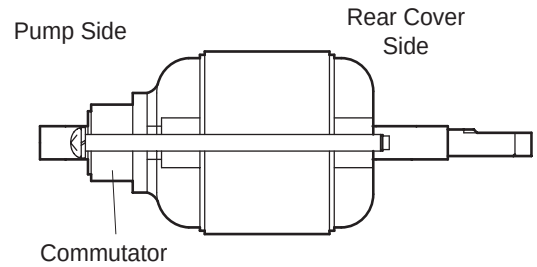
Remove the switch cover and rear cover, than remove the armature from the housing.

Remove the pump cover and remove the rotor and vane.

Insert a new armature into the housing.

Refer to "Replacement of Rear Cover" on page 1-9, for installation of the rear cover.

Fit the rotor into the shaft flute of the armature. Insert vane to the rotor being careful of the direction. Refer to "Replacement of Rotor and Vane" on page 1-9.



FG001146

Figure 8

Swing Bearing

Edition 1

MEMO

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Swing Bearing

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MEMO

SAFETY PRECAUTIONS



CAUTION!

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Remember, that ultimately 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
DX55W	5001 and Up

SWING BEARING MAINTENANCE

Operating Recommendation

The service life of the swing bearing may be extended if a conscious, daily effort is made to equalize usage over both ends of the excavator. If the excavator is used in the same operating configuration day in and day out (for example, with the travel motors always under the counterweight, or with the attachment over one side of the machine more than the other), the bearing's service life could be reduced. Taking a few minutes in the middle of each work shift to reposition the excavator, to work the opposite end of the bearing, will provide a payoff in terms of more even, gradual rate of wear and extended service life.

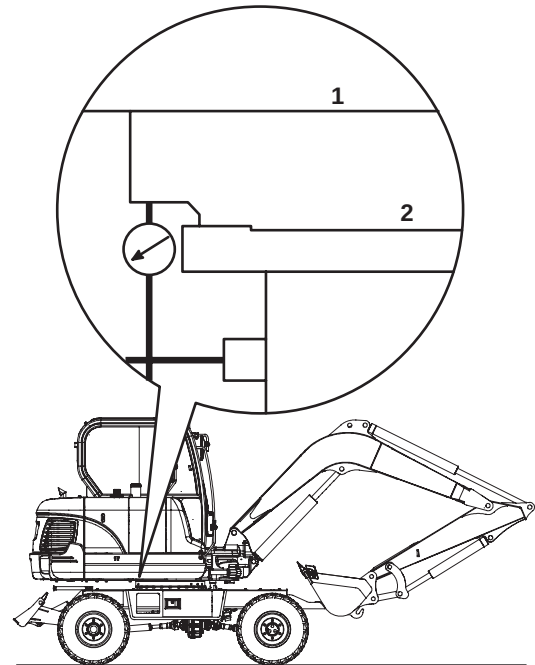
Measuring Swing Bearing Axial Play

Periodic, regular checks of bearing displacement should be made at least twice a year. Use a dial indicator. Push the attachment against the ground to lift the excavator off the ground and take measurements at 4 points, 90° apart, around the circumference of the bearing (Figure 1).

Record and keep all measurements. Play in the bearing should increase minimally from one inspection to the next. Eventually, however, as the bearing begins to approach the limit of its service life, clearance increases become much more pronounced and the actual measured play in the bearing could exceed twice the value that was measured when the machine was new.

Measuring Bearing Lateral Play

When vertical checks are made, the side to side play in the bearing can be checked by fully retracting the arm and bucket cylinders and extending the tip of the bucket as far forward as it will go. With the excavator parked on a flat, level surface and the bucket tip just off the ground, push against the bucket sideways to take up all of the lateral clearance in the bearing. (Less than 100 lb of force should be required to move the bucket over all the way.) Check lateral play in both directions and record the values. When the bearing is beginning to approach the end of its service life, measured lateral clearance should start to show larger and larger increases.



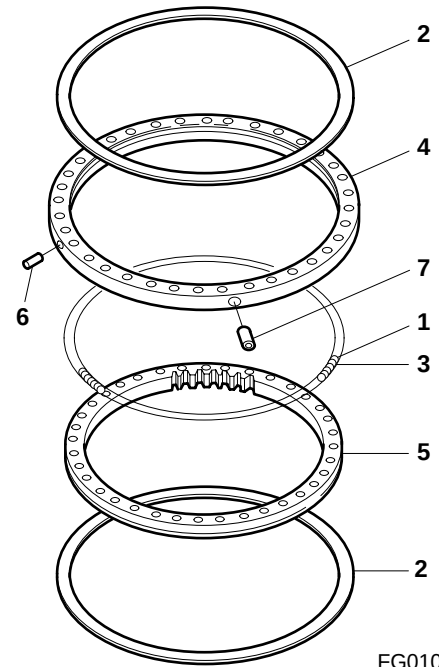
FG012349

Figure 1

Swing Bearing Basic Operation

The swing bearing, which connects the upper structure with the lower structure, consists of a inner ring, outer ring and ball bearings. During swing movement, power from the swing motor is transferred to the pinion by planetary gears connected to gears on the inner ring, which is fixed in the undercarriage. Ball bearings turn the outer ring.

Reference Number	Description
1	Ball
2	Seal
3	Retainer
4	Outer Ring
5	Inner Ring
6	Tapered Pin
7	Plug

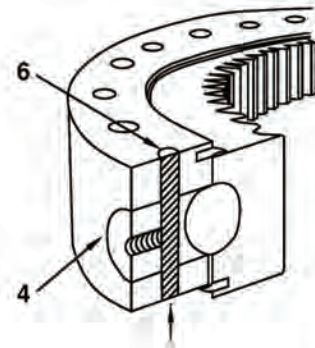


FG010699

Figure 2

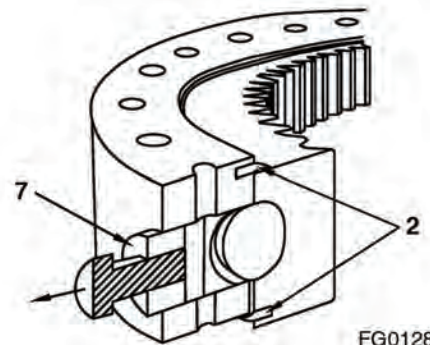
Rebuilding Swing Bearing

1. Remove tip of tapered pin (6, Figure 3) using grinder and tap lightly to remove debris.
2. Remove plug (7, Figure 4) using a M10 x 1.25 bolt.



FG012799

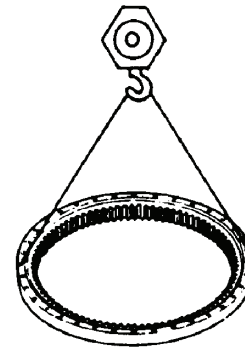
Figure 3



FG012800

Figure 4

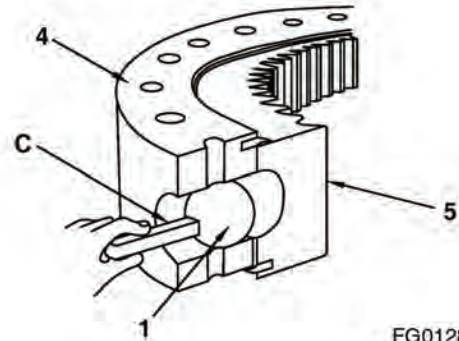
3. Lift outer ring and check that inner ring can move freely.
See Figure 5, if not, replace seal (2, Figure 4).



1588A

Figure 5

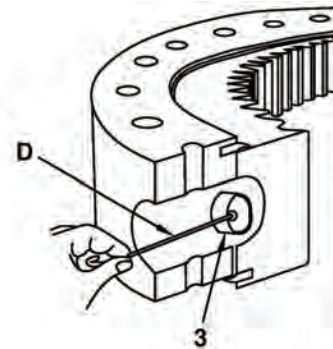
4. Turn inner ring and use magnet bar (C, Figure 6) to remove steel balls (1).



FG012801

Figure 6

5. Turn inner ring and use wire (D, Figure 7) to remove retainers (3).



FG012802

Figure 7

Lower Structure and Chassis

Ram Lock Valve

Edition 1

MEMO

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Ram Lock Valve

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MEMO

SAFETY PRECAUTIONS



CAUTION

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

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

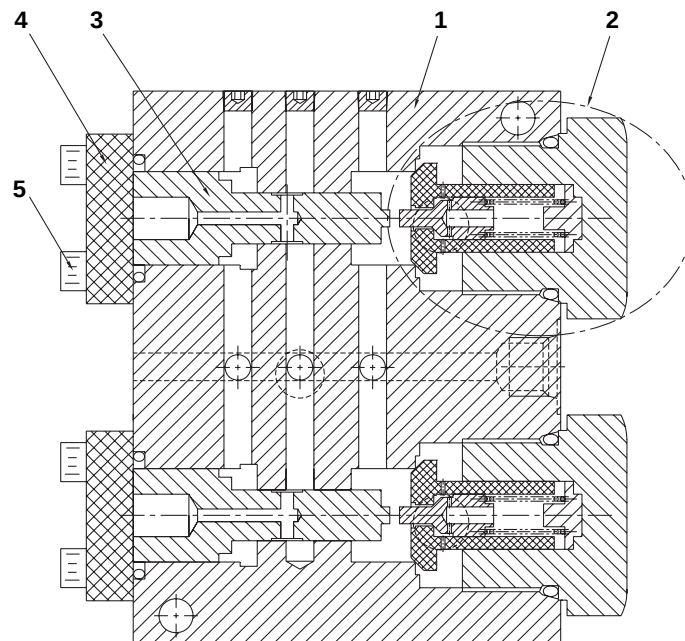
Remember, that ultimately safety is your own responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

SECTIONAL DRAWING AND PART NAMES



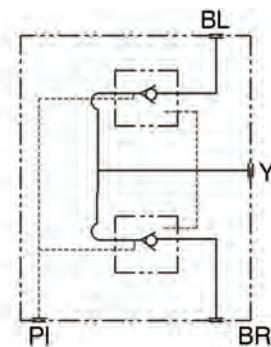
FG007630

Figure 1

Reference Number	Description
1	Body
2	Cartridge Ass'y
3	Plunger

Reference Number	Description
4	Cover Plate
5	Bolt

HYDRAULIC CIRCUIT



FG007631

Figure 2

OPERATIONAL PRINCIPLE

In Case of No Pilot Pressure at PI Port

The hydraulic oil from the BR port and the BL port cannot flow to the Y port as the check valves block the oil passage.

In Case of Pilot Pressure (Approx. 20 kg·cm²) at PI Port

The pressure at the P port opens each check valve to make the hydraulic oil from the BR port and BL port flow to the Y port.

(BR → Y, BL → Y)

DISASSEMBLY AND ASSEMBLY

General Cautions

It is the principle that the manufacturer carry out disassembly and assembly of this valve. In case you inevitably need to disassemble or assemble the valve elsewhere, please observe the following cautions.

1. This chocking valve is precisely processed and the gaps among each part are extremely tiny. Thus, disassembly and assembly should be performed very carefully so any foreign material such as dust or sand cannot intrude into the valve.
2. For disassembly, you should start disassembly after fully understanding the structure of this chocking valve with structural drawings and reference drawings.
3. When you need to leave the disassembled parts of this chocking valve unassembled for a while, be sure to apply rust prevent oil to the parts and seal them to prevent rusting.
4. Do not hit or treat any part of the product roughly even in case disassembly and assembly is not performed smoothly.
5. After disassembly, attach ID tags to each part for accurate assembly.
6. It is recommended to use new O-rings for replacement, and be sure not to damage one during assembly. (Apply a small portion of grease on the parts for smooth assembly.)
7. Fasten bolts with the specified standard torque.
8. Be careful not to damage or scratch the O-ring contacting parts of this valve for preventing oil leakage.

Assembly and Disassembly of Chocking Valve

1. Assemble the main poppet, the pilot poppet, the spring and the spring seat in order. Insert the sub-assembly to the block and fasten the hexa-head plug.

Hexa-head (41 mm) plug fastening torque : 7.0 kg•m

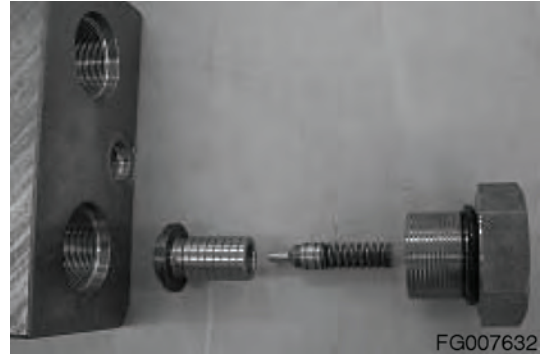


Figure 3

2. Insert each of the two plungers to each of the holes of the block.

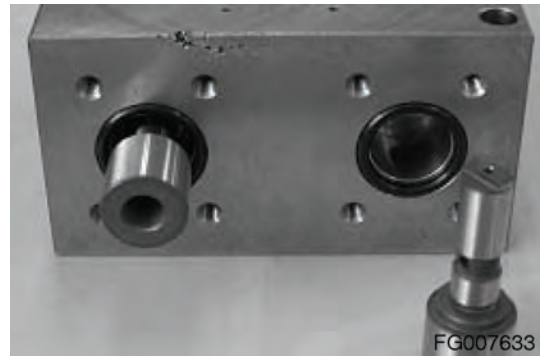


Figure 4

3. Mount the O-rings to the block and fasten the plate with bolts.

A. O-ring: 1B-P24

B. Wrench bolt (5 mm) fastening torque : 1.2 kg•m

NOTE: Follow the reverse procedure for disassembly.

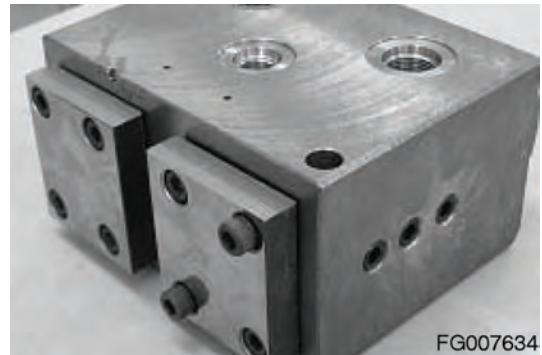
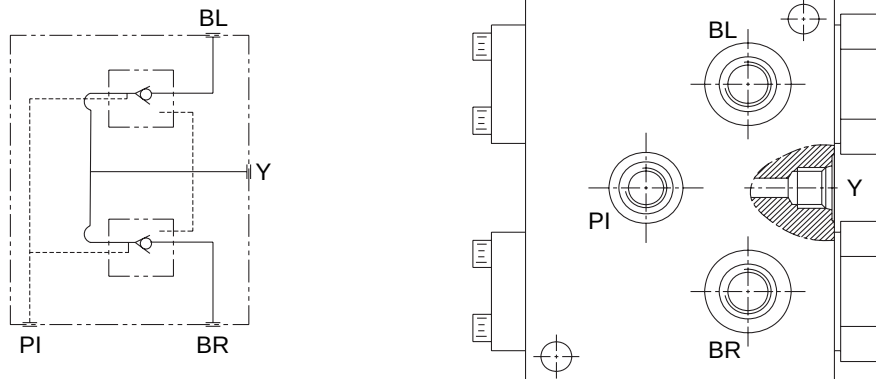


Figure 5

PERFORMANCE TEST

Carry out performance tests as follows based on the operational principle of this valve (refer to #3 "Operational Test").



FG007635

Figure 6

Oil Leakage Test

NOTE: The PI port should be opened.

1. Apply pressure of $350 \text{ kg}\cdot\text{cm}^2$ to the BR port.
2. Oil leakage amount from the Y Port should be less than $1\text{cc}/\text{min}$.
3. Apply pressure of $350 \text{ kg}\cdot\text{cm}^2$ to the BL port.
4. Oil leakage amount from the Y Port should be less than $1\text{cc}/\text{min}$.

Operational Test

1. Apply pressure of $350 \text{ kg}\cdot\text{cm}^2$ to the BR port.
2. When gradually increasing the pressure at the PI port, the hydraulic oil should flow out to the Y port at pressure of $19 \text{ kg}\cdot\text{cm}^2$ or less.
3. Apply pressure of $350 \text{ kg}\cdot\text{cm}^2$ to the BL port.
4. When gradually increasing the pressure at the PI port, the hydraulic oil should flow out to the Y port at pressure of $19 \text{ kg}\cdot\text{cm}^2$ or less.

Front Axle

Edition 1

MEMO

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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 ultimately 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
DX55W	7118 and Up

INTRODUCTION

The efficiency and continued operation of mechanical units depend on constant, correct maintenance and also on efficient repair work, should there be a break-down or malfunction. The instructions contained in this manual have been based on a complete overhaul of the unit. However, it is up to the mechanic to decide whether or not it is necessary to assemble only individual components, when partial repair work is needed. The manual provides a quick and sure guide which, with the use of photographs and diagrams illustrating the various phases of the operations, allows accurate work to be performed.

All the information needed for correct disassembly, checks and assembly of each individual component is set out below. In order to remove the differential unit from the vehicle, the manuals provided by the vehicle manufacturer should be consulted. In describing the following operations it is presumed that the unit has already been removed from the vehicle.

IMPORTANT

In order to facilitate work and protect both working surfaces and operators, it is advisable to use proper equipment such as: trestles or supporting benches, plastic or copper hammers, appropriate levers, pullers and specific spanners or wrenches.

Before going on to disassemble the parts and drain the oil, it is best to thoroughly clean the unit, removing any encrusted or accumulated grease.

Introductory Remarks

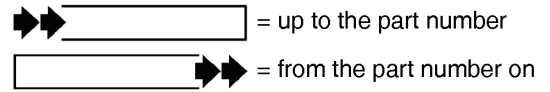
All the disassembled mechanical units should be thoroughly cleaned with appropriate products and restored or replaced if damage, wear, cracking or seizing have occurred.

In particular, thoroughly check the condition of all moving parts (bearings, gears, crown wheel and pinion, shafts) and sealing parts (O-rings, oil shields) which are subject to major stress and wear. In any case, it is advisable to replace the seals every time a component is overhauled or repaired. During assembly, the sealing rings must be lubricated on the sealing edge. In the case of the crown wheel and pinion, replacement of one component requires the replacement of the other one. During assembly, the prescribed pre-loading, backlash and torque of parts must be maintained.

Classification

This manual classifies units according to part numbers. For a correct interpretation, classification is indicated as follows:

When no classification is given, disassembly and assembly operations are the same for all versions.



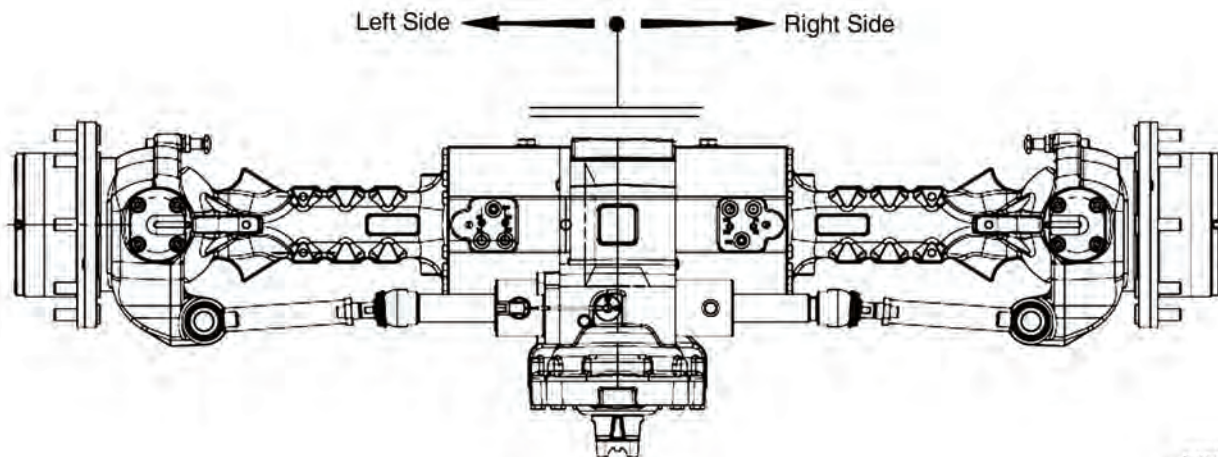
FG024140

Figure 1

Specific Equipment and Spare Parts

The drawings of all specific tools required for maintenance and repair work can be found at the end of this manual; spare parts may be ordered either from the vehicle manufacturer or directly from the Service Centers or Authorized Distributors of DANA ITALIA S.p.A.

DEFINITION OF VIEWPOINTS

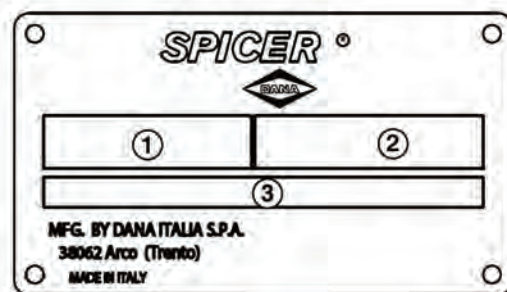


FG023822

Figure 2

DATA PLATE

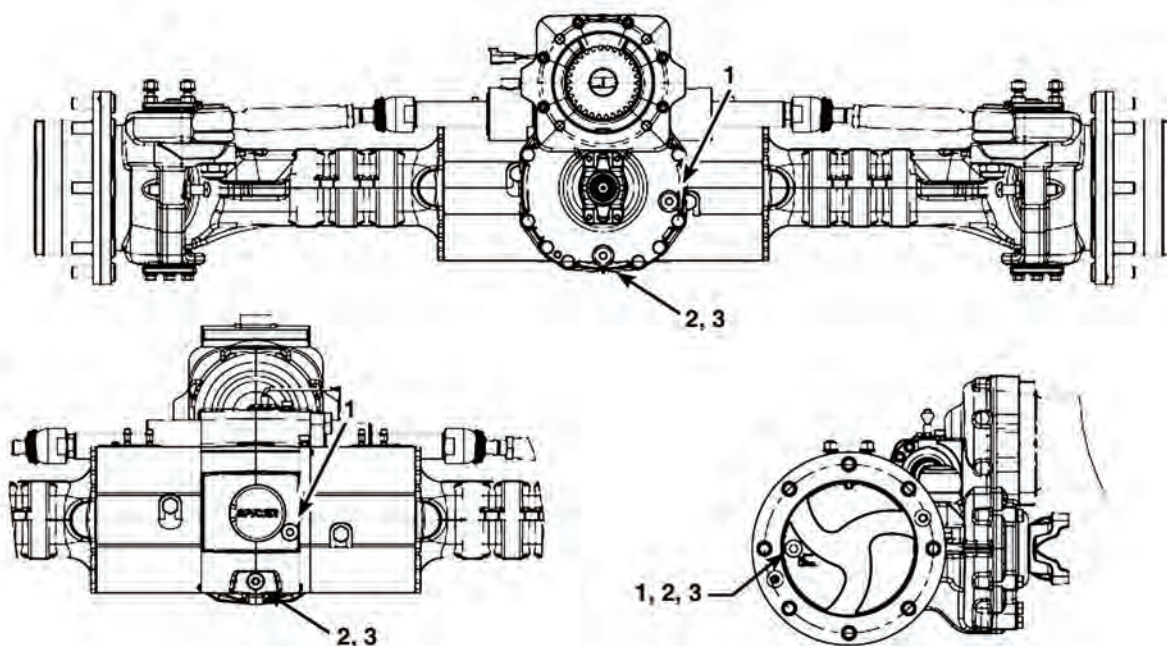
Reference Number	Description
1	Type and Model Unit - Modification Index
2	Serial Number
3	Lubricant



FG023823

Figure 3

MAINTENANCE POINTS



FG023824

Figure 4

Reference Number	Description
1	Oil Filling Plug
2	Oil Draining Plug

Reference Number	Description
3	Check Level Plug

MAINTENANCE INTERVALS

Operation		Frequency	Lubricants	
Check Levels	Differential	Monthly	- SAE85W90 (API GL4 - MIL L-2105) With additives for oil-bath brakes0. - SAE85W90 (API GL5 - MIL L-2105-B) With additives for oil-bath brakes, for units pre-senting hypoid crown wheel and pinion and/or self-locking differential gear.	
	Planetary Reduction	Every 200 hours		
Oil Change	Differential	Every 800 hours*		
	Planetary Reduction	Every 1,000 hours*		
	Self-locking Differential Gear	Every 700 hours* ^v		
* Initially after 100 working hours.				
^v When it starts sounding noisy.				
Operation	Member	Conditions	Frequency	Lubricants
Greasing	Articulations	Normal Work	Monthly	Molikote
		Awkward Work	Weekly	

ADJUSTMENT AND CHECKS

Unit	Operation	Frequency	Service Brake Circuit
Negative Brake	Adjustment	Every 1,000 hours*	Only for mineral oil use e.g. ATF Dexron II. Make sure that master cylinder seals are suitable for mineral oil.
Service Brake	Adjustment	Every 500 hours	
Wheel Nuts	Tightening	Every 200 hours	
* Initially after 100 working hours			

SCREW-LOCKING, SEALING AND LUBRICATING MATERIALS

1. Locking, sealing and lubricating materials referred to in this manual are the same used in the shop-floor.
2. The table below gives an account of the typical application of each single material, in order to facilitate replacement with similar products marketed by different brand names with different trade marks.

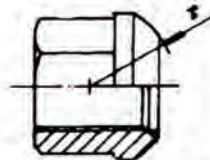
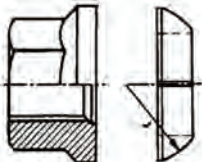
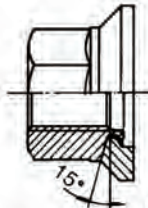
Denomination	Application
Loctite 242	Anaerobic product apt to prevent the loosening of screws, nuts and plugs. Used for medium-strength locking. Before using it, completely remove any lubricant by using the specific activator.
Loctite 243	The oleocompatible alternative to 242. Does not require the activation of lubricated surfaces.
Loctite 270	Anaerobic product for very-high strength locking of screws and nuts. Before using it, completely remove any lubricant by using the specific activator. To remove parts, it may be necessary to heat them at 80°C approx.
Loctite 275	Anaerobic product suitable for high-strength locking and sealing of large threaded parts, bolts and stud bolts, for pipe sealing and for protecting parts against tampering; suitable for sealing coupling surfaces with a max. Diametrical clearance of 0.25 mm.
Loctite 510	Anaerobic product for the hermetic sealing of flanged units and screw holes communicating with fluids. Can seal clearances between flanges up to 0.2 mm.
Loctite 577	Quick anaerobic sealant for sealing threaded portions of conical or cylindrical unions up to M80. Before using it, remove any lubricant with the specific activator. After polymerisation, disassembly may result rather difficult, so heating may be necessary for larger diameters.
Loctite 638	Anaerobic adhesive for fast and high-strength gluing of cylindrical metal joints (hub on shaft). Can glue together parts with clearance ranging between 0.1 and 0.25 mm.
Loctite 648	Anaerobic adhesive for fast and medium-strength gluing of cylindrical metal joints (hub on shaft). Can glue together parts with radial clearance below 0.1 mm.
(AREXONS) Repositionable Jointing Compound for Seals	Solvent-cased sealing compound for elastic seals, drying through evaporation. Used for sealing the outer diameter of sealing rings for rotating shafts with outer metal reinforcement.
Silicone	Semi-fluid adhesive material used for sealing and filling and to protect components from environmental and physical elements. Polymerises with non-corrosive dampness.
(Tecno Lube/101) Silicone-based Grease	Highly adhesive synthetic grease, with silicone compounds added. Applied to adjustment screws with hole communicating with oil-type fluids. Used when frequent adjusting is required.
Molikote (Dow Corning)	Lubricating compound containing molybdenum disulphide, used to lubricate articulation pins and to prevent sticking and oxidation of parts that are not lubricated on a regular basis.
(Lithium-based) Grease	Applied to bearings, sliding parts and used to lubricate seals or parts during assembly.

NOTES ON SAFETY PRECAUTIONS

1. During all operations described in this manual, the axle should be fastened onto a trestle, while the other parts mentioned should rest on supporting benches.
2. When removing one of the arms, an anti-tilting safety trestle should be placed under the other arm.
3. When working on an arm that is fitted on the machine, make sure that the supporting trestles are correctly positioned and that the machine is locked lengthways.
4. Do not admit any other person inside the work area; mark off the area, hang warning signs and remove the ignition key from the machine.
5. Use only clean, quality tools; discard all worn, damaged, low-quality or improvised wrenches and tools. Ensure that all dynamometric wrenches have been checked and calibrated.
6. Always wear gloves and non-slip rubber shoes when performing repair work.
7. Should you stain a surface with oil, remove marks straight away.
8. Dispose of all lubricants, seals, rags and solvents once work has been completed. Treat them as special waste and dispose of them according to the relative law provisions obtaining in the country where the axles are being overhauled.
9. Make sure that only weak solvents are used for cleaning purposes; avoid using turpentine, dilutants and toluol-, xylol-based or similar solvents; use light solvents such as Kerosene, mineral spirits or water-based, environment friendly solvents.
10. For the sake of clarity, the parts that do not normally need to be removed have not been reproduced in some of the diagrams.
11. The terms RIGHT and LEFT in this manual refer to the position of the operator facing the axle from the side opposite the drive.
12. After repair work has been completed, accurately touch up any coated part that may have been damaged.

Wheel Nuts Tightening Torques

Recommended from Rim's O.E.M. with Reference to the Quality of the Rim's Material.

Wheel Nuts Characteristic	Wheel Stud Thread	Recommended Wheel Nuts Torque		Nut Fixing's Solution
		Rim Material Quality		
		St 37	**St 52	
Wheel nuts with integrate spherical collar	M18 x 1.5	330 Nm	460 Nm	 FG024426
	M20 x 1.5	490 Nm	630 Nm	
	M22 x 1.5	630 Nm	740 Nm	
Flat collar wheel nuts with separate spherical lock washer	M18 x 1.5	270 Nm	360 Nm	 FG024427
	M20 x 1.5	360 Nm	450 Nm	
	M22 x 1.5	460 Nm	550 Nm	
Wheel nuts with integrate seat captive washer	M18 x 1.5	260 Nm	360 Nm	 FG024428
	M20 x 1.5	350 Nm	500 Nm	
	M22 x 1.5	450 Nm	650 Nm	
The wheel nuts tightening torque is not related only on nut and stud caratcteristic (diameter, thread pitch dimension, material), to have the correct torque, must be considered also the rim's quality material.				
** Rim's material st 52 is recommended by dana on axles application, it is the optimum for our nut and stud fixing coupling.				

The Dana Official Tightening Torque Table, that is Incluede on Each Maintenance Service Manual, Show the Torque Figure Related to the Bolt Characteristic Only.

Dana Official Tightening Torque Table		
Nut Material Quality 8.8 & 10.9	Stud Material Quality 10.9	*Allow Tight Torque Nm
M18 x 1.5	M18 x 1.5	442 : 489
M20 x 1.5	M20 x 1.5	613 : 677
M22 x 1.5	M22 x 1.5	822 : 908
*The torque figure on nut and stud coupling must be related on stud material quality (for dana axle is 10.9 only).		

CONVERSION TABLE

Units of Pressure

Units of Weight						Units of Torque					
	N	daN	kN	kg	lbs		Nm	daNm	kNm	kg•m	lb in
1 N	1	0.1	0.001	0.102	0.225	1 Nm	1	0.1	0.001	0.102	8.854
1 daN	10	1	0.01	0.02	2.25	1 daNm	10	1	0.01	1.02	88.54
1 kN	1000	100	1	102	225	1 kNm	1000	100	1	102	8854
1 kg	9.81	0.981	0.00981	1	2.205	1 kg•m	9.81	0.981	0.00981	1	86.8
						1 lb in	0.1129	0.01129	0.0001129	0.01152	1

TIGHTENING TORQUES

Unit: Nm

Size of Bolt		Type of Bolt					
		8.8		10.9		12.9	
		Normal	Normal + Loctite 270	Normal	Normal + Loctite 270	Normal	Normal + Loctite 270
Coarse Pitch	M6 x 1	9.5 - 10.5	10.5 - 11.5	14.3 - 15.7	15.2 - 16.8	16.2 - 17.8	18.1 - 20.0
	M8 x 1.25	23.8 - 26.2	25.6 - 28.4	34.2 - 37.8	36.7 - 40.5	39.0 - 43.0	43.7 - 48.3
	M10 x 1.5	48 - 53	52 - 58	68 - 75	73 - 81	80 - 88	88 - 97
	M12 x 1.75	82 - 91	90 - 100	116 - 128	126 - 139	139 - 153	152 - 168
	M14 x 2	129 - 143	143 - 158	182 - 202	200 - 221	221 - 244	238 - 263
	M16 x 2	200 - 221	219 - 242	283 - 312	309 - 341	337 - 373	371 - 410
	M18 x 2.5	276 - 305	299 - 331	390 - 431	428 - 473	466 - 515	509 - 562
	M20 x 2.5	390 - 431	428 - 473	553 - 611	603 - 667	660 - 730	722 - 798
	M22 x 2.5	523 - 578	575 - 635	746 - 824	817 - 903	893 - 987	974 - 1076
	M24 x 3	675 - 746	732 - 809	950 - 1050	1040 - 1150	1140 - 1260	1240 - 1370
	M27 x 3	998 - 1103	1088 - 1202	1411 - 1559	1539 - 1701	1710 - 1890	1838 - 2032
	M30 x 3.5	1378 - 1523	1473 - 1628	1914 - 2115	2085 - 2305	2280 - 2520	2494 - 2757
Fine Pitch	M8 x 1	25.7 - 28.3	27.5 - 30.5	36.2 - 39.8	40 - 44	42.8 - 47.2	47.5 - 52.5
	M10 x 1.25	49.4 - 54.6	55.2 - 61.0	71.5 - 78.5	78 - 86	86 - 94	93 - 103
	M12 x 1.25	90 - 100	98 - 109	128 - 142	139 - 154	152 - 168	166 - 184
	M12 x 1.5	86 - 95	94 - 104	120 - 132	133 - 147	143 - 158	159 - 175
	M14 x 1.5	143 - 158	157 - 173	200 - 222	219 - 242	238 - 263	261 - 289
	M16 x 1.5	214 - 236	233 - 257	302 - 334	333 - 368	361 - 399	394 - 436
	M18 x 1.5	312 - 345	342 - 378	442 - 489	485 - 536	527 - 583	580 - 641
	M20 x 1.5	437 - 483	475 - 525	613 - 677	674 - 745	736 - 814	808 - 893
	M22 x 1.5	581 - 642	637 - 704	822 - 908	903 - 998	998 - 1103	1078 - 1191
	M24 x 2	741 - 819	808 - 893	1045 - 1155	1140 - 1260	1235 - 1365	1363 - 1507
	M27 x 2	1083 - 1197	1178 - 1302	1520 - 1680	1672 - 1848	1834 - 2027	2000 - 2210
	M30 x 2	1511 - 1670	1648 - 1822	2138 - 2363	2332 - 2577	2565 - 2835	2788 - 3082

THE PLANETARY REDUCTION AND THE COMPLETE STEERING CASE



Figure 5

FG023825

Disassembling

1. Remove the securing screws (23) from the planetary carrier cover (25).

Disconnect the steering bars from the steering case (14).

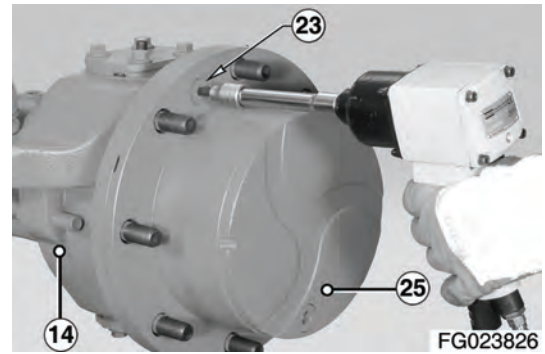


Figure 6

2. Disjoint the planetary carrier cover (25) from the steering case by alternatively forcing a screwdriver into the appropriate slots.

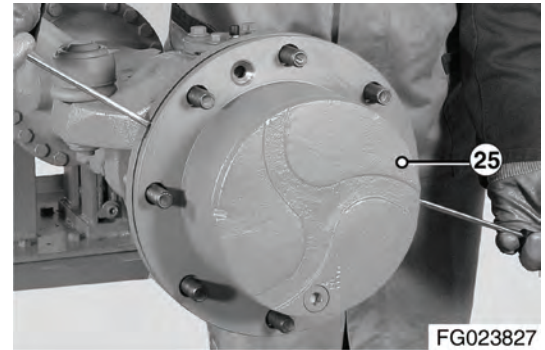


Figure 7

3. Remove the complete planetary carrier cover (25).

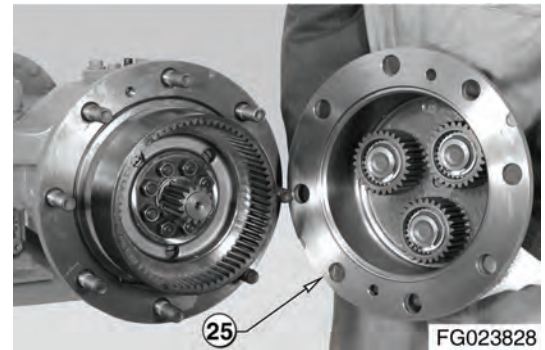


Figure 8

4. Remove the safety spring rings (28) of the planetary gears (27).



Figure 9

5. Remove the planetary gears (27).

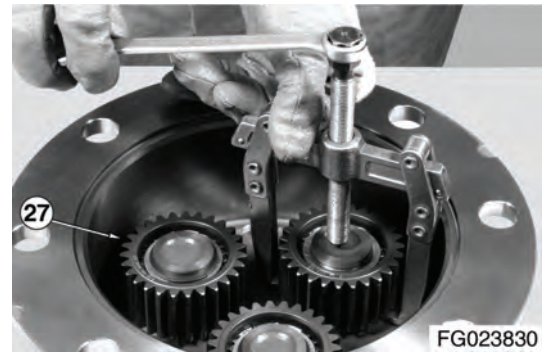


Figure 10

NOTE: Note down direction of assembly of planetary gears.

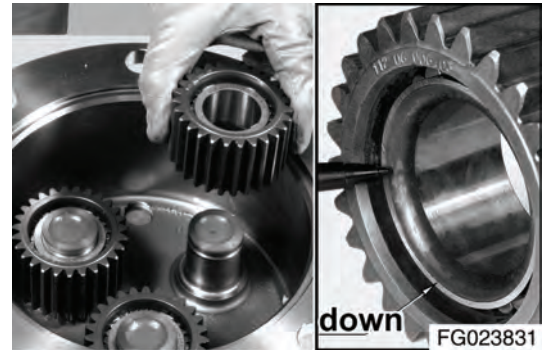


Figure 11

6. Remove the snap ring (30).

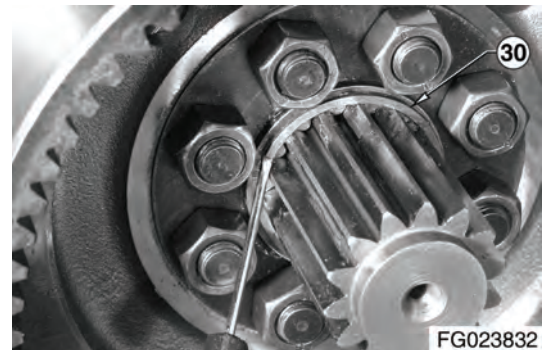


Figure 12

7. Unloose and remove the tightening nuts (32) from the crown flange (35).

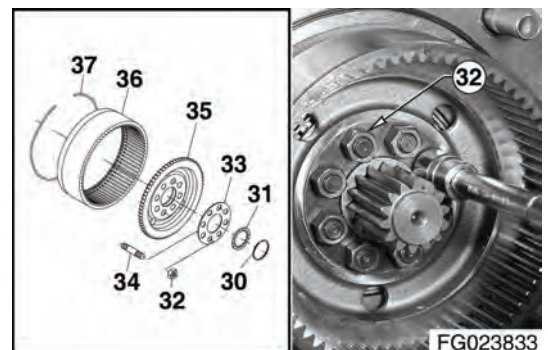


Figure 13

8. Remove the shim washer (31).

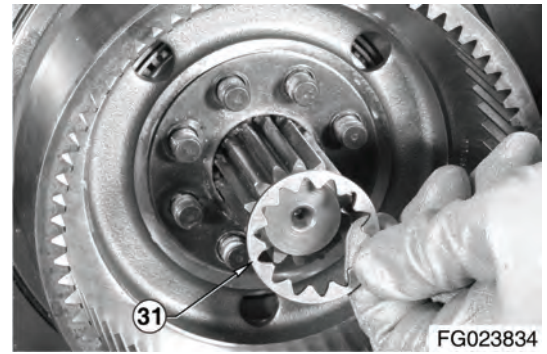


Figure 14

9. Remove the safety flange (33).

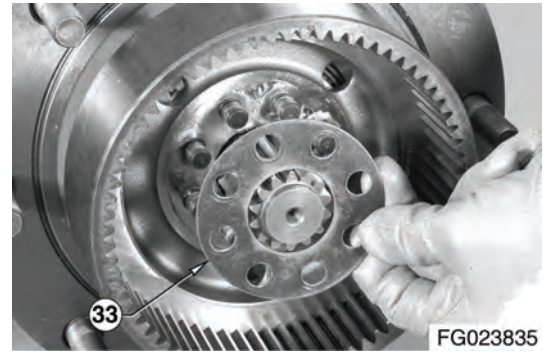


Figure 15

10. Using a puller, remove the complete crown flange (35) by acting on the stud bolts.

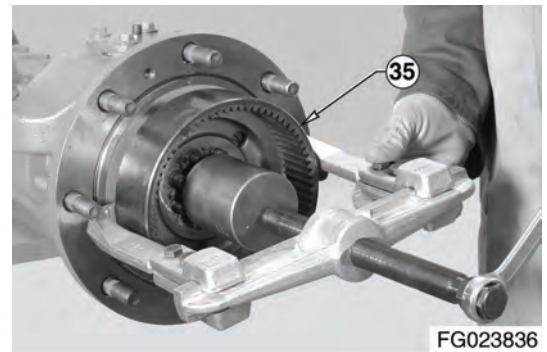


Figure 16

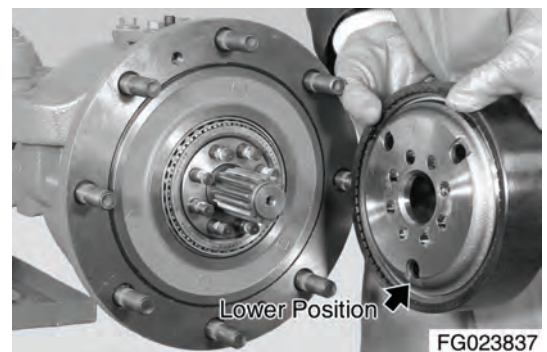


Figure 17

11. Partially extract the hub (41) using a plastic hammer.

NOTE: *Alternately hammer on several equidistant points.*

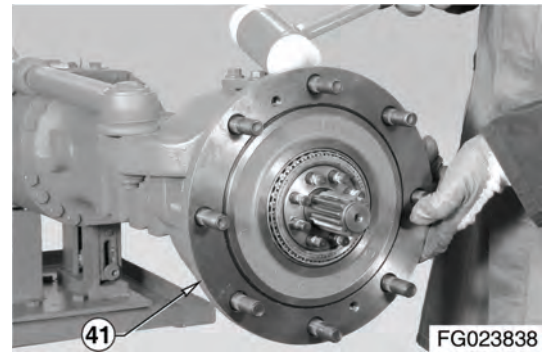


Figure 18

12. Remove the external bearing (38).

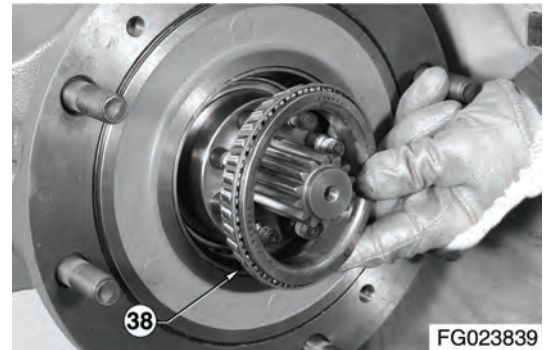


Figure 19

13. By hand remove the complete hub (41).

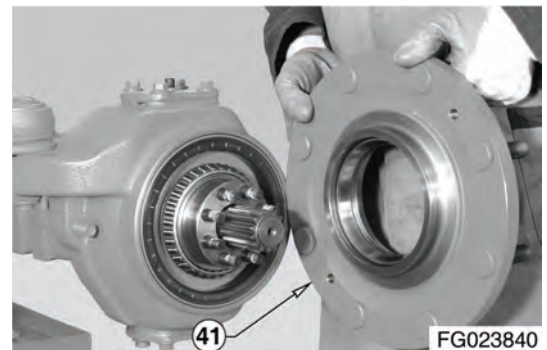


Figure 20

14. Remove the external thrust blocks of bearings, using a pindriver.

NOTE: *Hammer in an alternate sequence to prevent crawling and deformation of the thrust blocks.*

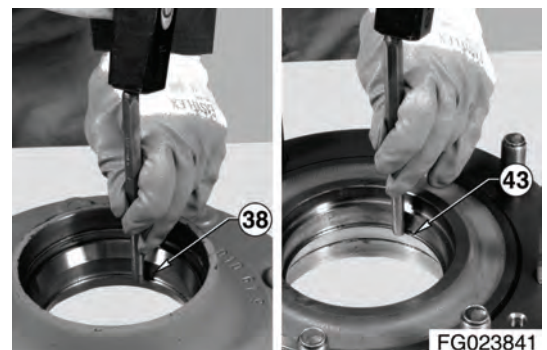


Figure 21

15. Remove the sealing ring from the steering case (44).
Pay due attention not to damage the seat of bearing.

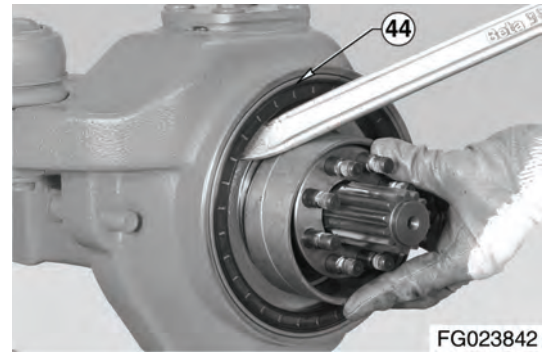


Figure 22

16. Note the measure of the screw of lock steering case.

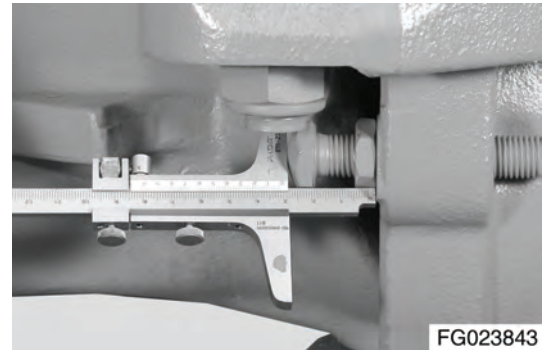


Figure 23

17. Loose the lockscrew and insert it to allow the passage of tool.

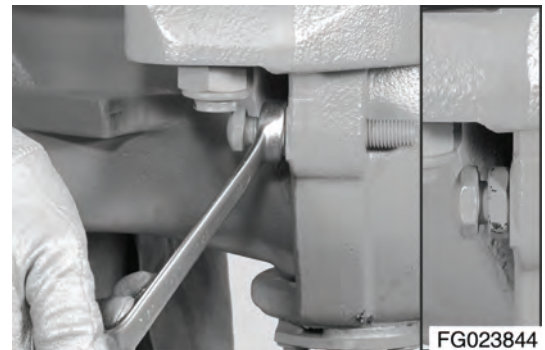


Figure 24

18. Remove the nuts that lock the articulation pins.

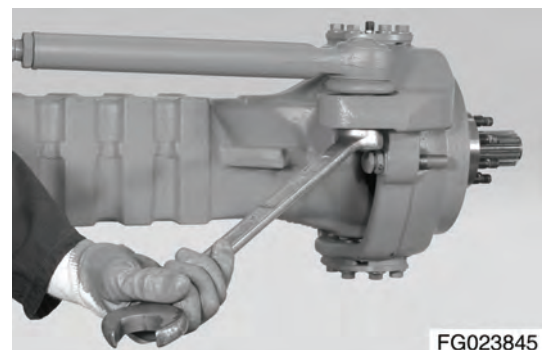


Figure 25

19. Disconnect the tapered pins of the articulation from the steering case (14) by means of a puller.

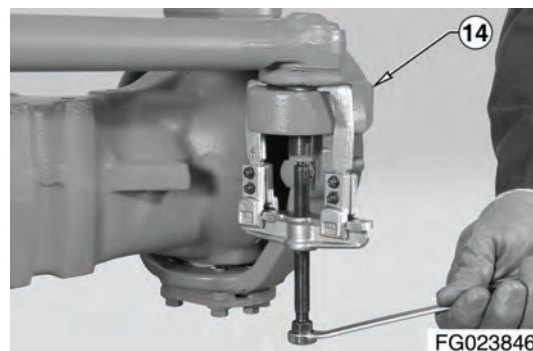


Figure 26

20. Unloose and remove the fitting screws (19) from the bottom articulation pin (20).

NOTE: *Screws cannot be re-used.*

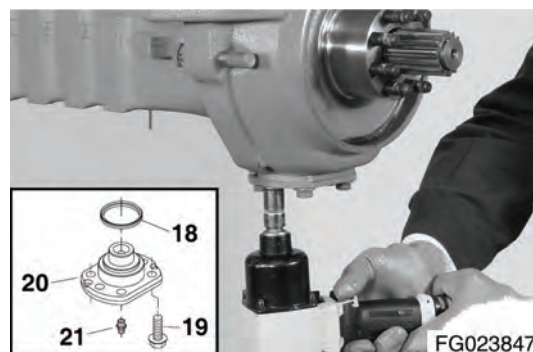


Figure 27

21. Remove the bottom articulation pin (18) complete with front sealing ring (20).

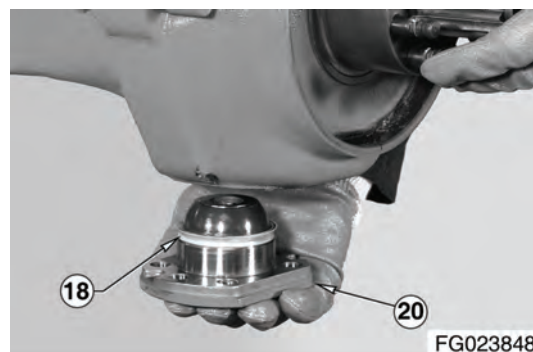


Figure 28

22. Unloose and remove the fitting screws (13) from the top articulation pin (10).

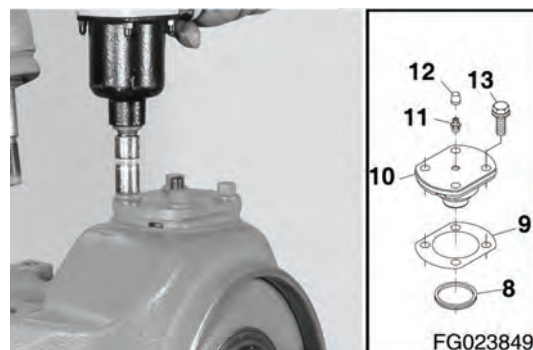


Figure 29

23. Using two levers, remove the top articulation pin (10) complete with front seal (8).

Pay attention not to damage the surfaces.

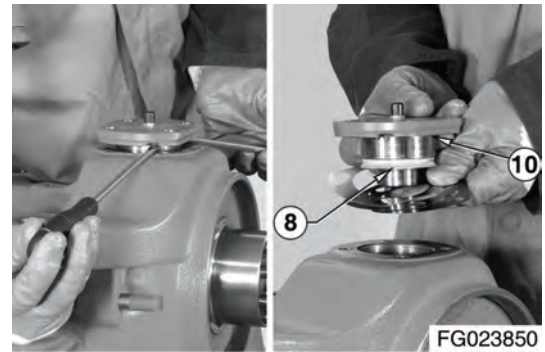


Figure 30

24. Remove the complete steering case (14).

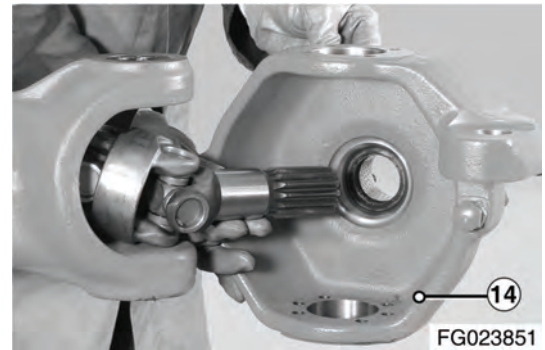


Figure 31

25. Use a puller to remove the sealing ring from the steering case (14).

NOTE: Note down the orientation of sealing ring (5).

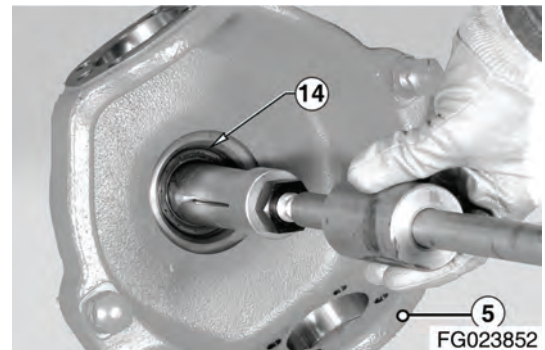


Figure 32

26. Remove the bushing (6) from the steering case (14).

NOTE: *Note down the orientation of bushing.*

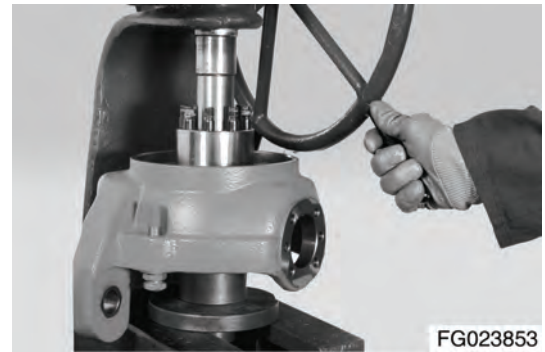


Figure 33

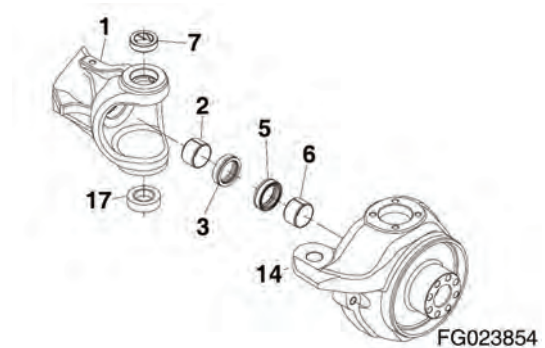


Figure 34

27. Remove the u-joint (4).

NOTE: *To remove the u-joint use, if necessary, a plastic hammer or a lever.*



Figure 35

28. Using a puller for inner parts, remove the top bush (7) and the bottom ball-bush (17).

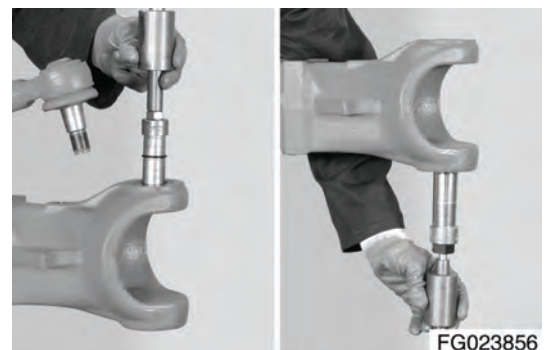


Figure 36

29. Remove the articulation pins (10) (20) and the front sealing rings (8) (18).

NOTE: Note down the side for assembly.

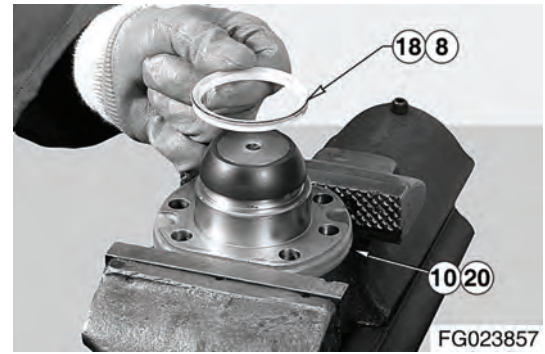


Figure 37

30. If the ball cover (17) needs replacing, remove it from the bottom articulation pin (20).

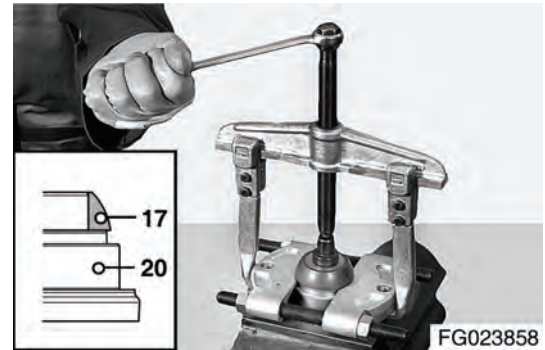


Figure 38

31. Remove seal ring (3) and the bushing (2) from the arm (1).

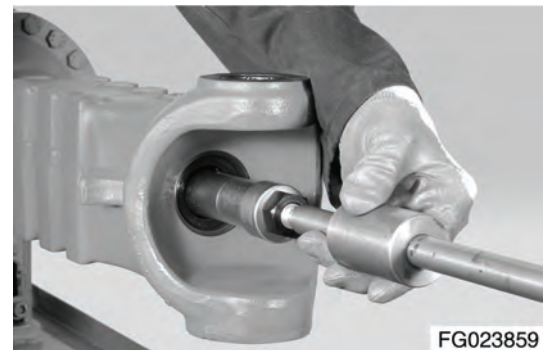
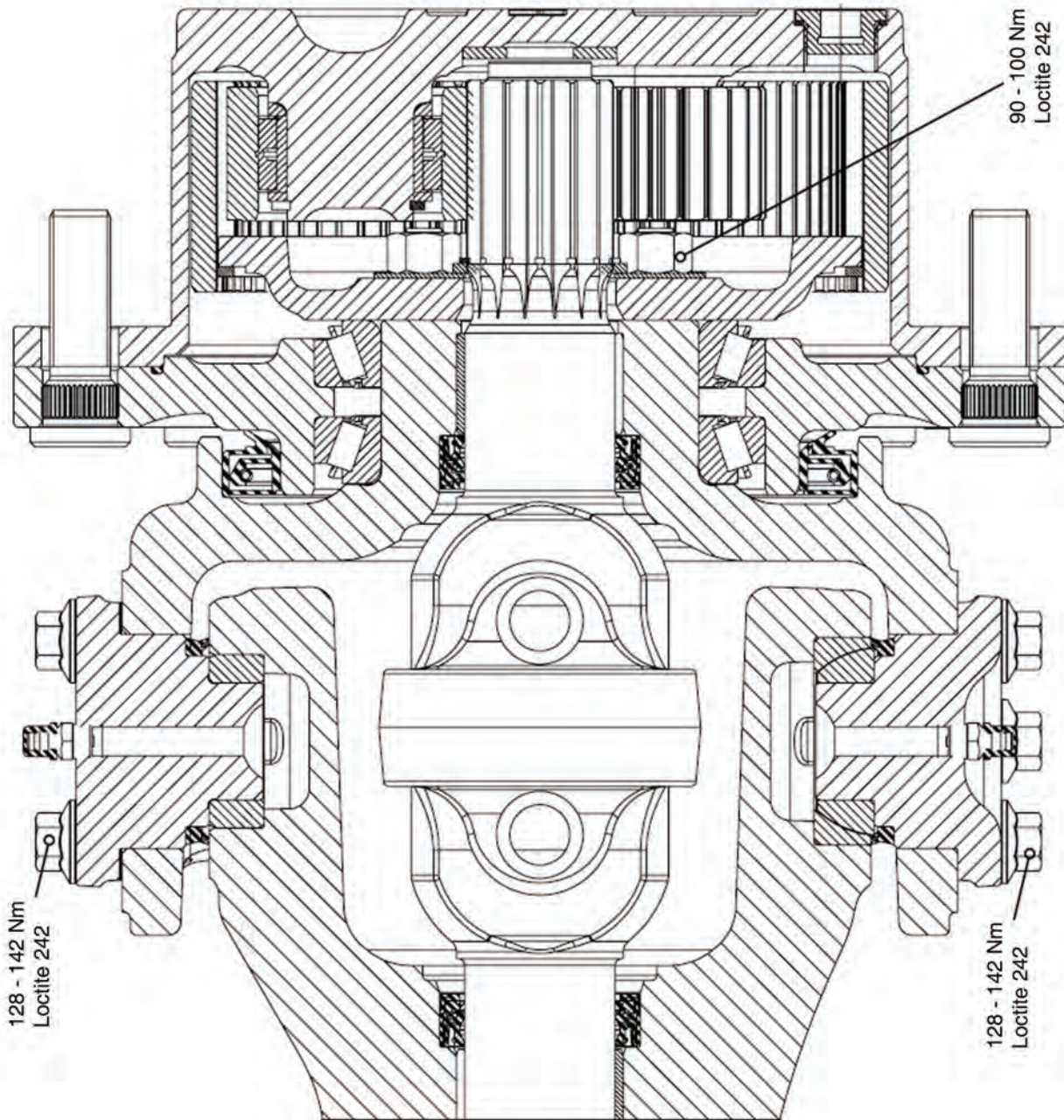


Figure 39



Figure 40

Assembling



FG023861

Figure 41

- Continuous rolling torque without planetary gear cover 7 - 20 Nm
- Preload steering case 40 - 80 Nm

1. Lubricate the bushing (6) and the seat of the steering case (14).

Install the bushing (6), using tool T1.

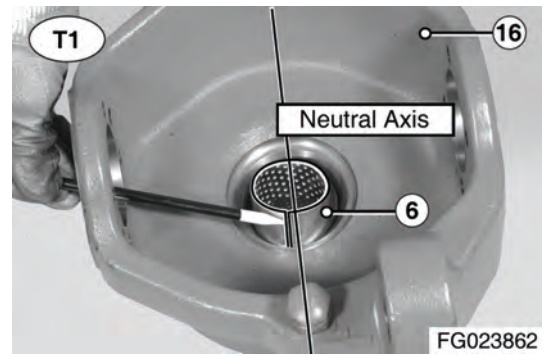


Figure 42

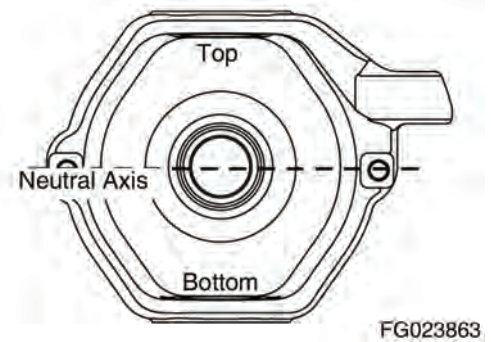


Figure 43

2. Lubricate the outer surface of the sealing ring (5); fit them into their seat using tool T2.

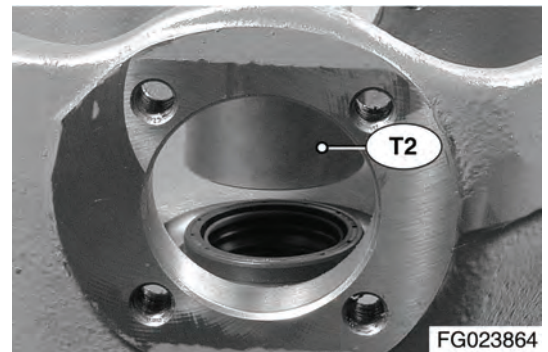


Figure 44

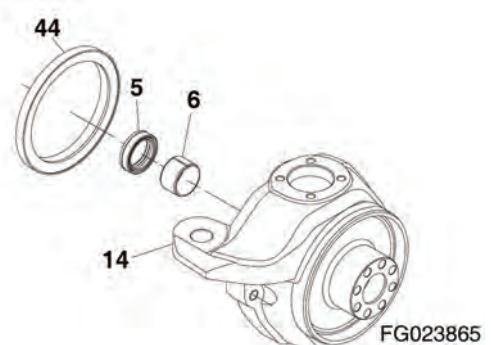


Figure 45

3. Using special tool T3 apply a repositionable jointing compound for seals to the outer surface of the sealing ring (44). Position the sealing ring (44) in the steering case (14).

NOTE: Check that the ring (44) is correctly oriented.

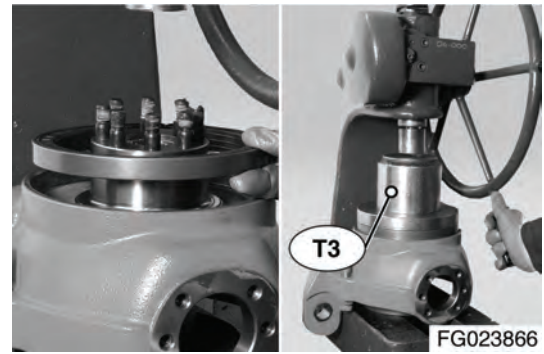


Figure 46

4. If the bottom articulation pin (17) has been extracted, position the pin under a press and fit the ball cover (20).

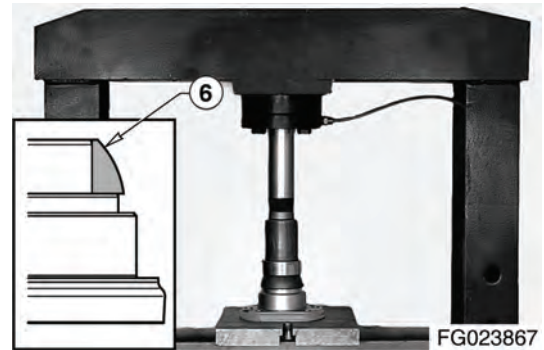


Figure 47

5. Fit the front sealing rings (18) (8) onto the articulation pins (4) and (6).

NOTE: Carefully check that the rings are properly oriented (18) (8).

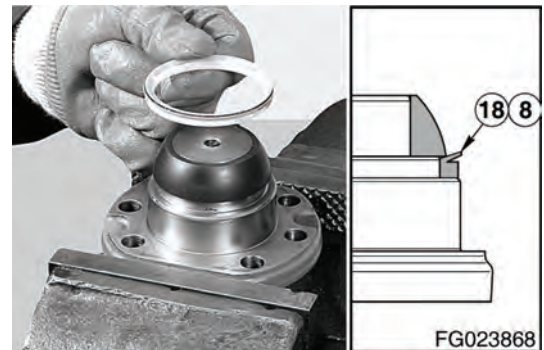


Figure 48

6. Lubricate the top bush (7) or the bottom ball bush (17) and fit them into the fulcrum holes of the arm.

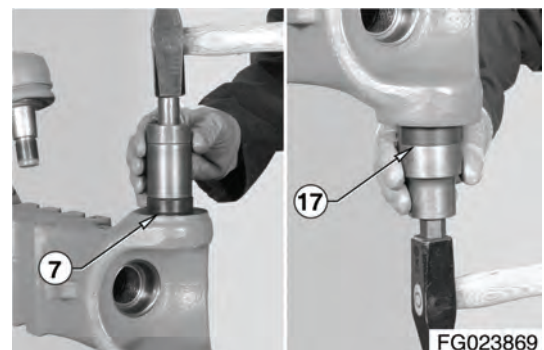


Figure 49

7. Lubricate the bushing (2) and the seat of the steering case (1).

Install the bushing (2), using tool T1.

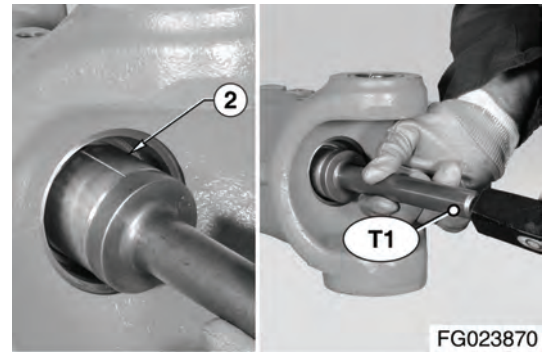


Figure 50

8. Lubricate and fit the sealing ring (3) onto tool T4; install the rings into the arm.



CAUTION

Pay particular attention to the direction of assembly of the rings.

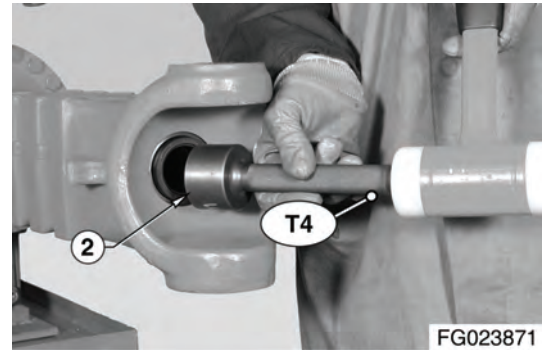


Figure 51

9. Insert the u-joint (4).

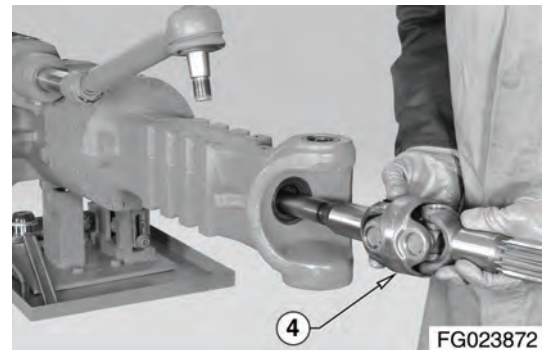


Figure 52

10. Lubricate the terminal of the u-joint (4) and install the steering case (14).

Pay due attention not to damage the dust cover rings and the sealing rings.

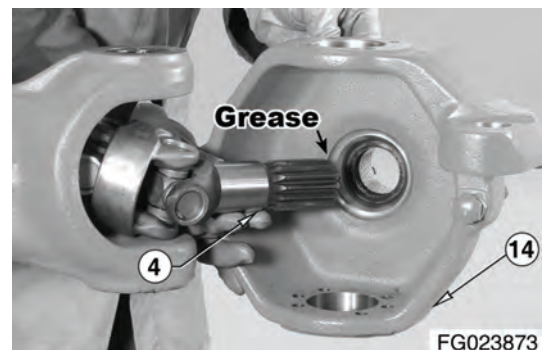


Figure 53

11. Prepare a series of shims (9) of 0.4 up to 0.7 mm.
To be assembled under the upper pin (10).

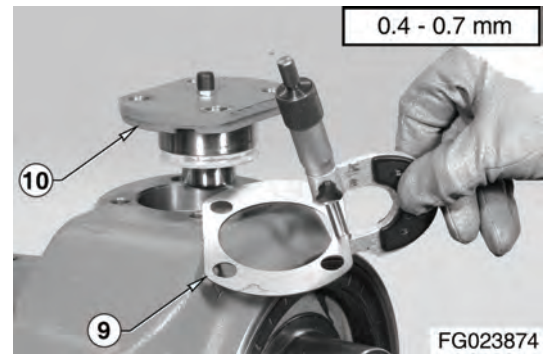


Figure 54

12. Lubricate and install the unit in the steering case.



Figure 55

13. Lubricate the steering case.

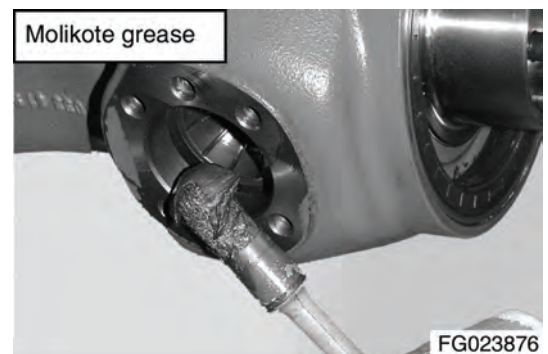


Figure 56

14. Fit the unit (20) in the steering case (14). Position the screws (19) and tightly tighten.

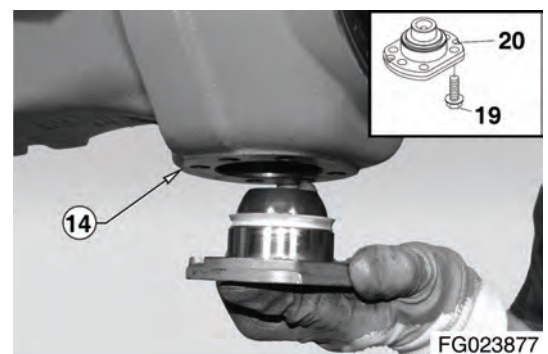


Figure 57

15. Tighten the new fitting screws (13) of top articulation pins in sequence using the cross tightening method.

- Torque wrench setting: 128 - 142 Nm

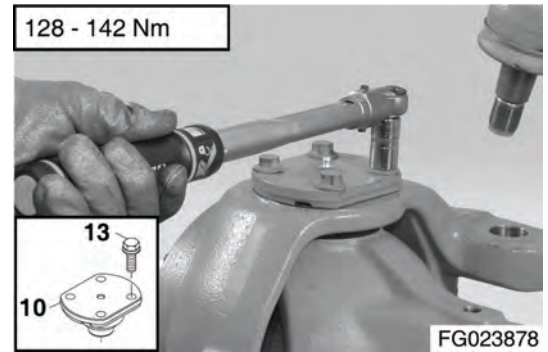


Figure 58

16. Tighten the new fitting screws (19) of bottom articulation pins in sequence using the cross tightening method.

- Torque wrench setting: 128 - 142 Nm

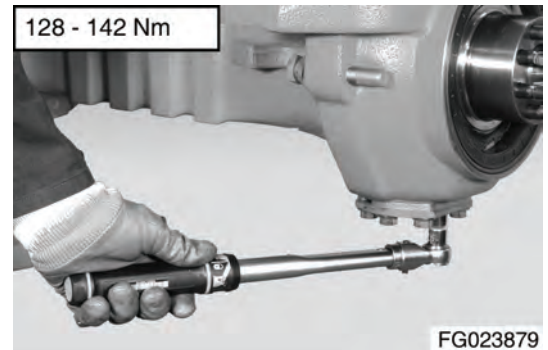


Figure 59

17. Check by means of a lever that there is no vertical gap.

In case there is any gap, determine the width and reduce it by removing shims.

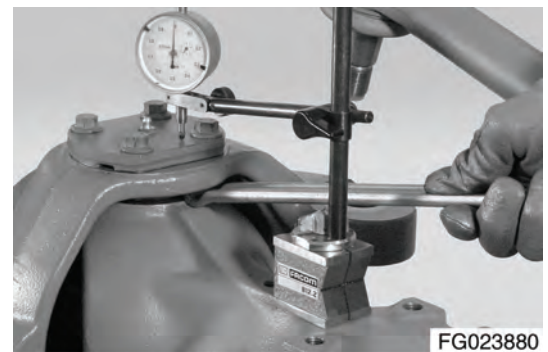


Figure 60

18. Check the torque of the pins, which has to be between 40 and 80 Nm. If the preliminary measured value is too high, the shims have to be increased.

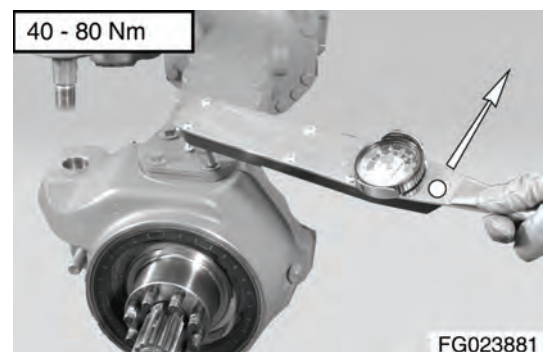


Figure 61

19. Look for the position of the notch regarding the safety cotter pin hole when the nut is finally locked max 300 Nm.

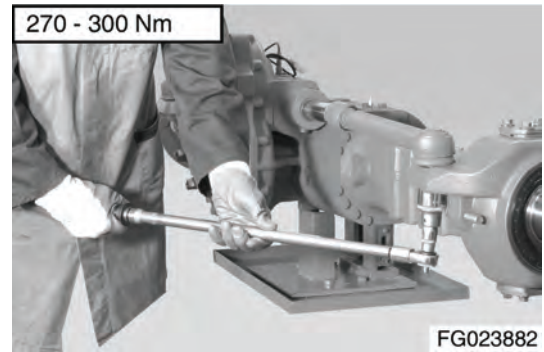


Figure 62

20. Bring the lockscrew to the quote at the measure previously survey.

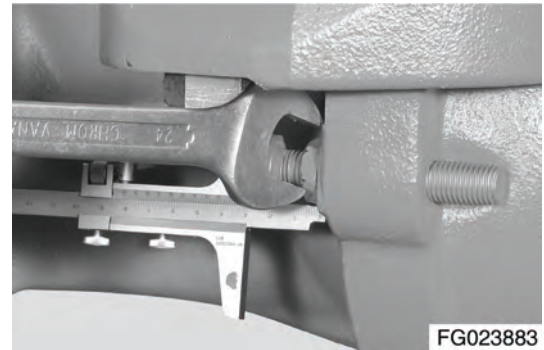


Figure 63

21. Position the lower part of tool T5 and the thrust block of the external bearing (38).

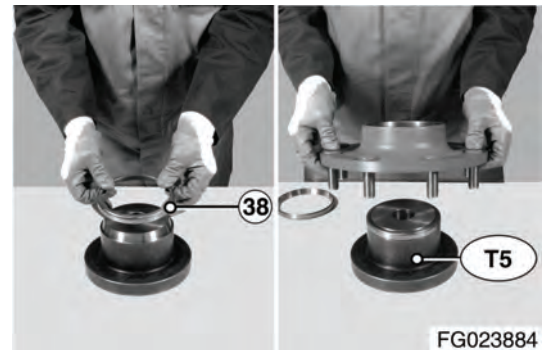


Figure 64

22. Lubricate the seats of the bearings and position the hub (41) on tool T5; position the thrust block of the internal bearing (43).

NOTE: Check that the thrust block is correctly oriented.

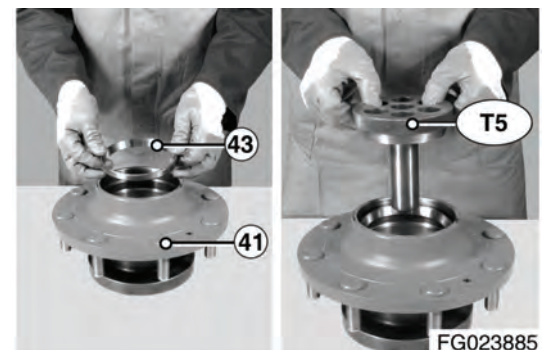


Figure 65

23. Install the external bearing (38).

NOTE: Move the bearing to the limit stop by hammering lightly all around the edge.

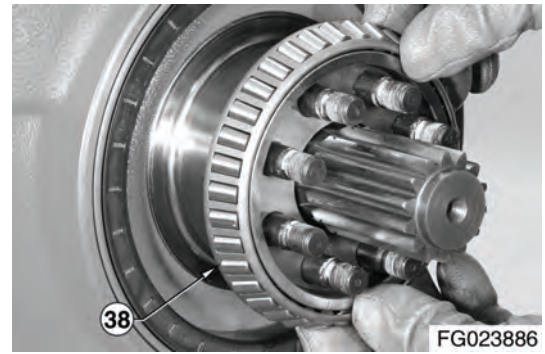


Figure 66

24. Install the wheel hub (41).

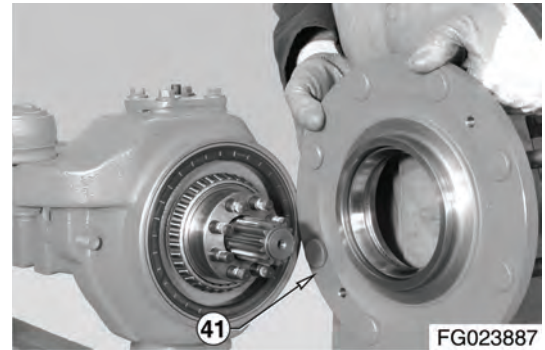


Figure 67

25. Install the crown wheel (36).

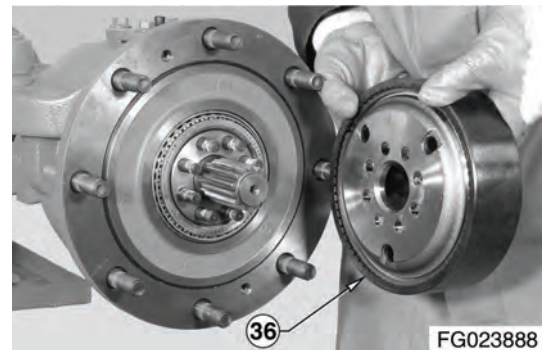


Figure 68

26. Fit the complete crown flange (36).

NOTE: In order to fasten the flange (36), use a plastic hammer and alternately hammer on several equidistant points.

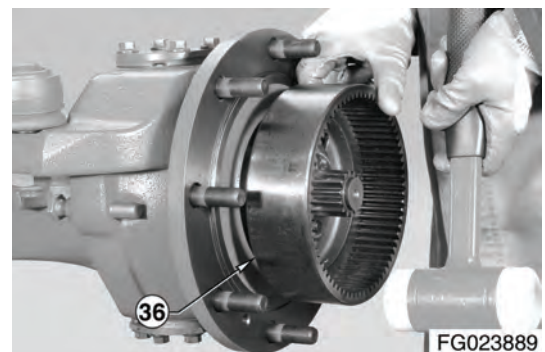


Figure 69

27. Install the security flange (33).

Using tecno lube/101, grease the surface of the safety flange (33) that touches the crown wheel.

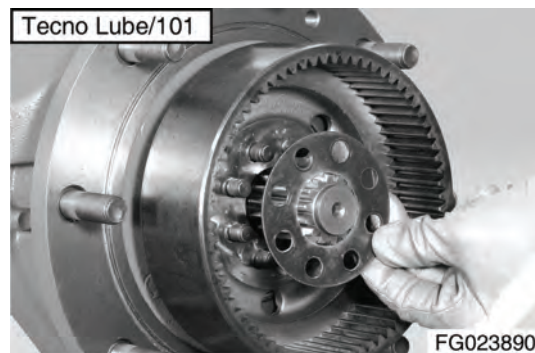


Figure 70

28. Coat the nuts (23) with Loctite 242 and screw them.

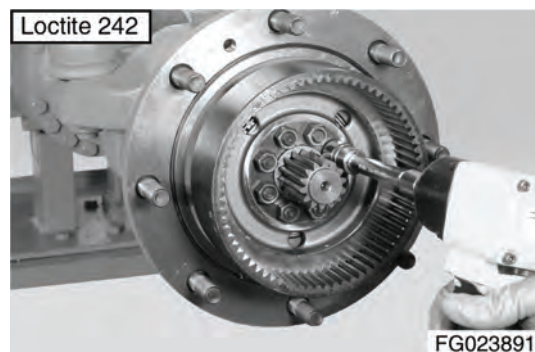


Figure 71

29. Tighten nuts (32) in two stages, using the criss-cross method.

- Initial torque wrench setting: 90 Nm
- Final torque wrench setting: 100 Nm

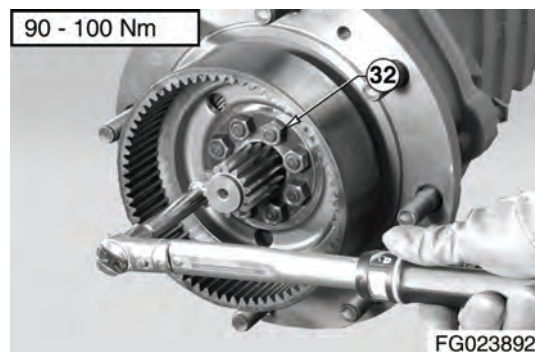


Figure 72

30. Install the distance piece (31).

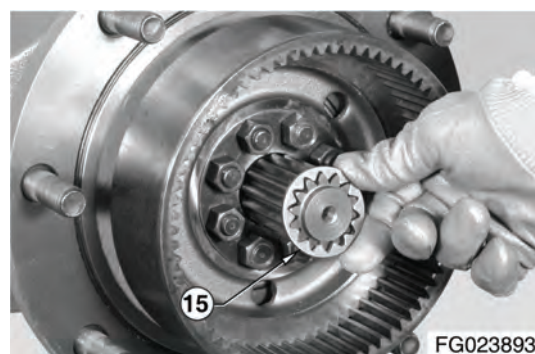


Figure 73

31. Install the snap ring (31).

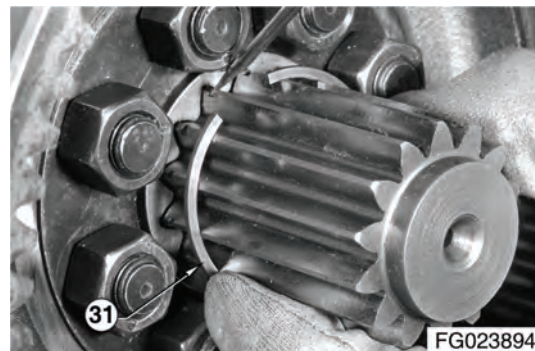


Figure 74

32. Check the continuous rolling torque on the hub.

- Torque: 7 - 20 Nm

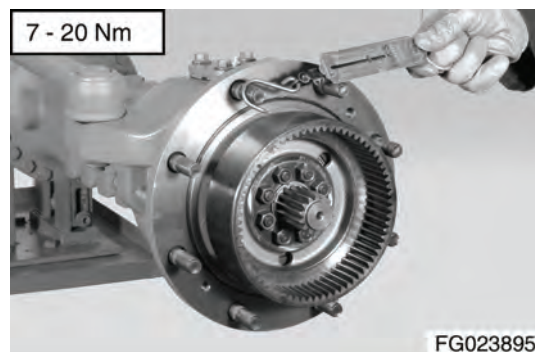


Figure 75



CAUTION

Pay particular attention to the direction of assembly of the rings.

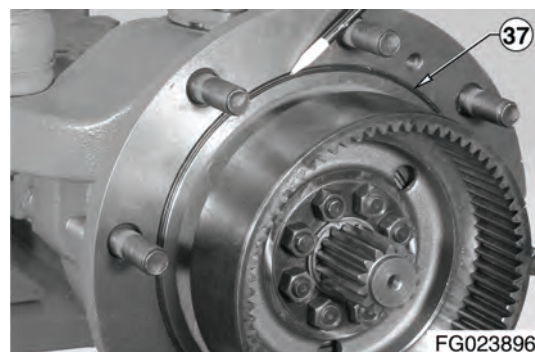


Figure 76

33. Fit the planetary gear (27) onto the planetary gear cover (25).



CAUTION

The jointed portion of the internal ring of the bearings must face the bottom of the pin.

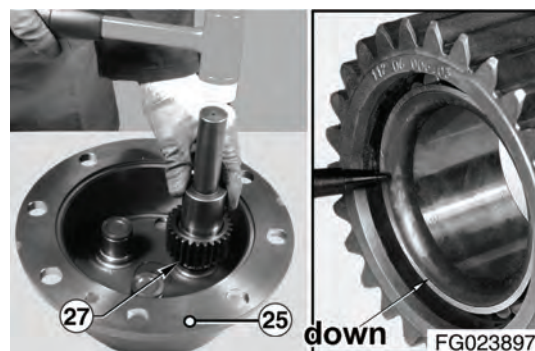


Figure 77

34. Lock into position the planetary gears (16) with the snap rings (15).



Figure 78

35. Fit the planetary gear cover (18) onto the wheel hub (4).



Figure 79

- Torque wrench: 40 - 50 Nm

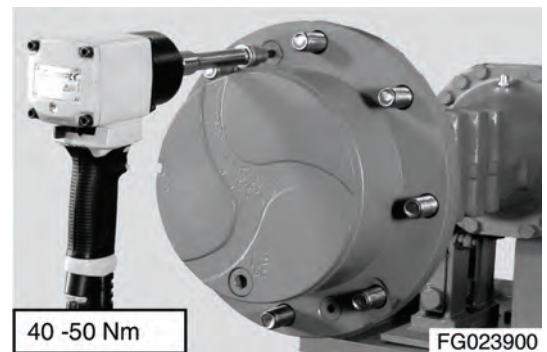
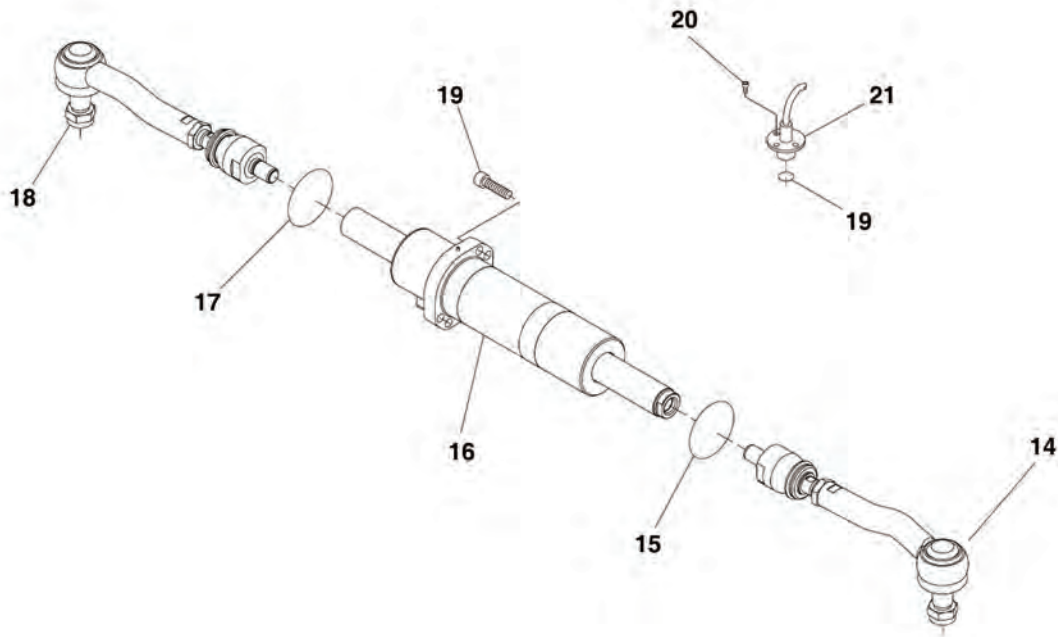


Figure 80

STEERING CYLINDER

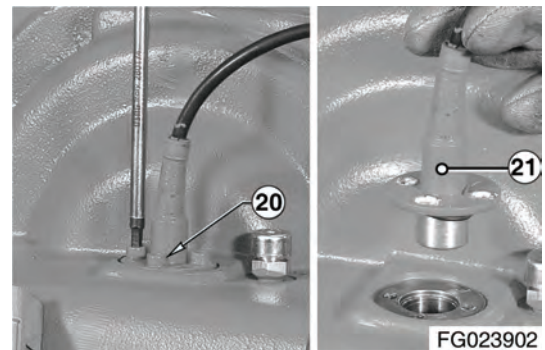
Disassembling



FG023901

Figure 81

1. Remove the centring sensor (21) of the steering piston.



FG023902

Figure 82

2. Remove the nuts (18) that lock the articulation pins (14).

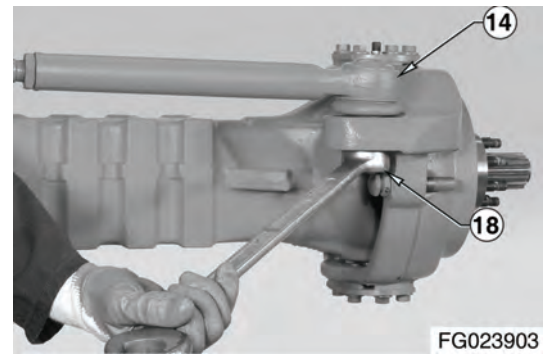


Figure 83

3. Disconnect the tapered pins of the articulation (14) from the steering case by means of a puller.

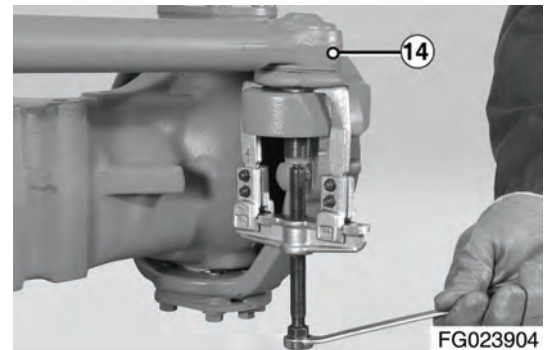


Figure 84

4. If the connection of the steering bars includes a safety collar, raise the border.



Figure 85

5. Disconnect left and right steering bars from the piston.

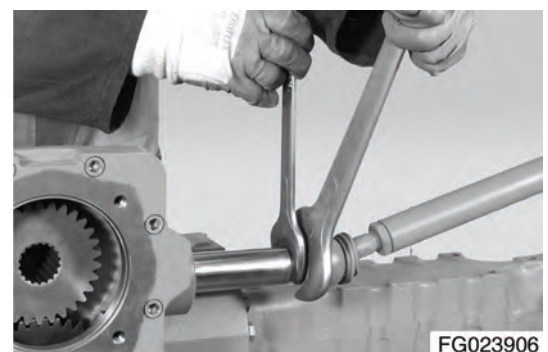


Figure 86

6. Remove the securing screws (19) from the steering cylinder (16).

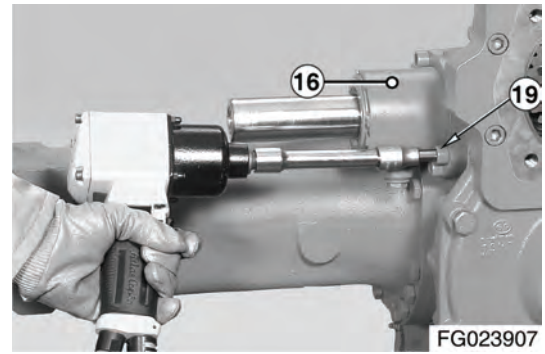


Figure 87

7. Extract the cylinder (16) using a plastic hammer.

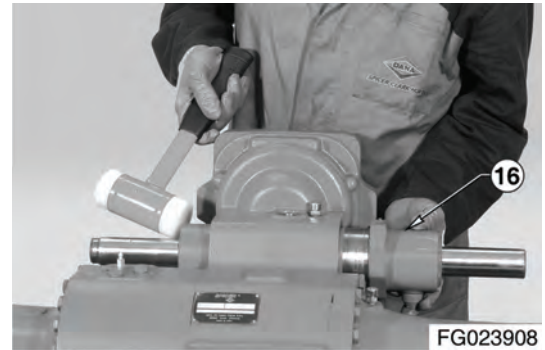
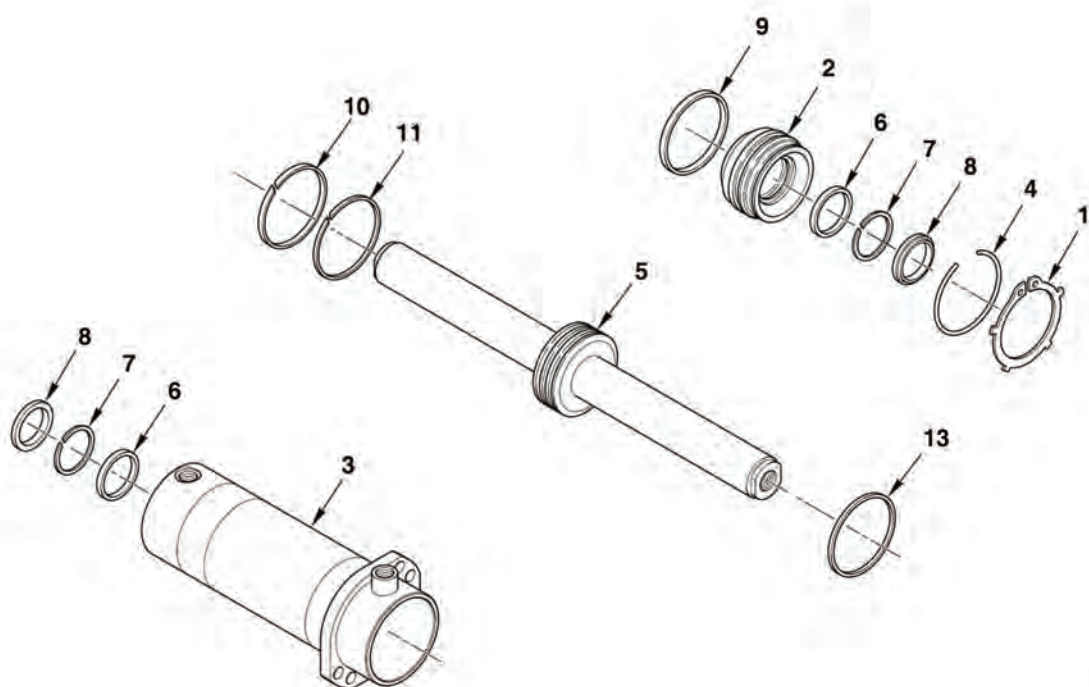


Figure 88

Assembling



FG023909

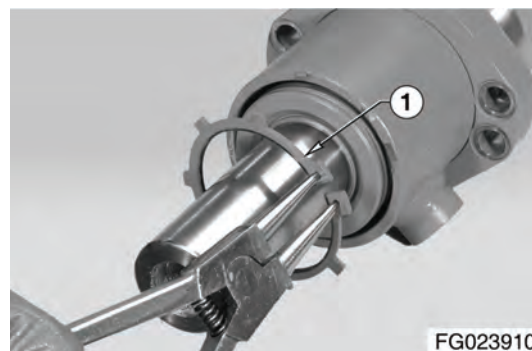
Figure 89



CAUTION

Before attempting to disassemble the unit, drain the oil in the cylinder chambers completely.

1. Using a screwdriver, remove the snap ring (1) of the cylinder head.

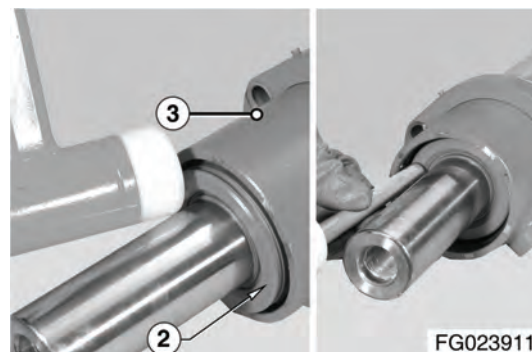


FG023910

Figure 90

2. Lightly tap the cylinder head (2) with a plastic hammer so as to push it inside the cylinder (3).

NOTE: Insert the cylinder head so it is flush with the cylinder.



FG023911

Figure 91

3. Using a punch, force the stop ring (4) located inside the cylinder (3) and extract ring using a screwdriver.

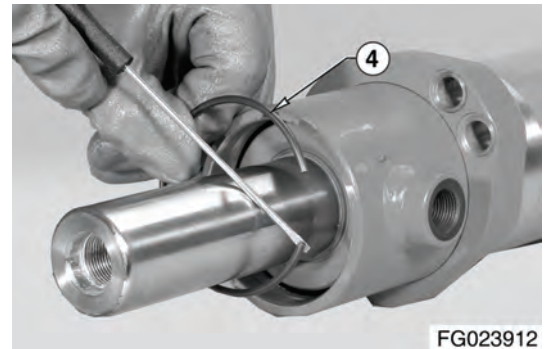


Figure 92

4. Take the cylinder unit a part by extracting the head first, followed by the piston.

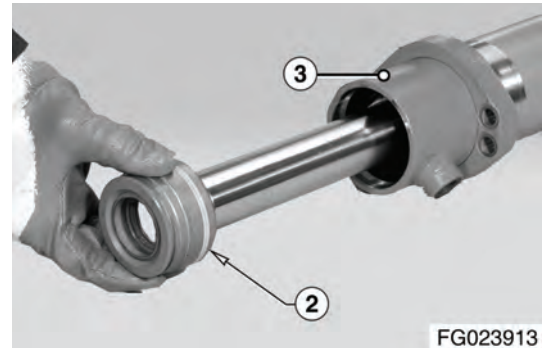


Figure 93



CAUTION

Note down direction of installation of piston whose seal ring is oriented towards cylinder head.



Figure 94

5. Remove all seals, anti-extrusion rings and scraper rings from head (2), cylinder (3) and piston (5).

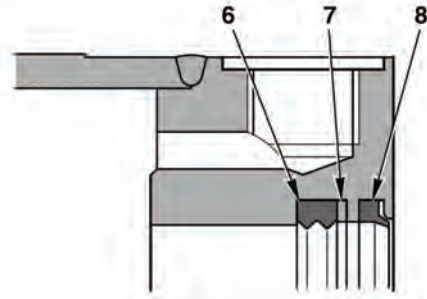
NOTE: All seals must be replaced every time the unit is disassembled.

Particular attention must be paid not to damage the seats of both seals and piston slide.



Figure 95

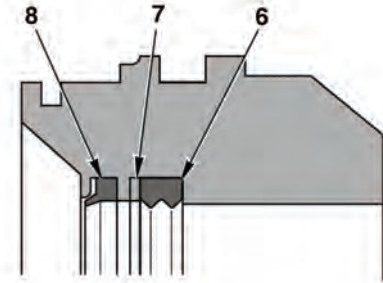
6. Grease and install the piston rod seal ring (6), rod wiper (8) and back up washer (7) into cylinder (3).



FG023916

Figure 96

7. Grease and install the piston rod seal ring (6), rod wiper (8) and anti-extrusion ring (7) into the head (2).



FG023917

Figure 97

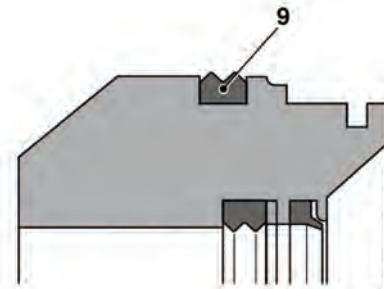
8. Fit seal (9) on the outside of the head (2).



CAUTION

To ease installation, grease the outer surface of the piston.

Do not roll the seal (9).



FG023918

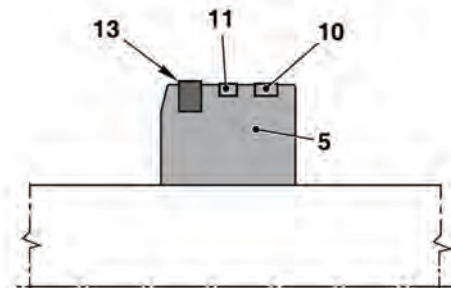
Figure 98

9. Prepare piston (5) by fitting it with magnetic ring (11) anti-extrusion ring (10) and piston seal (13).



CAUTION

To ease installation, lubricate with grease.



FG023919

Figure 99

10. Centre the shaft on the cylinder (3) so that it fits into the piston (5).

NOTE: Apply a little grease to seals and cylinder.

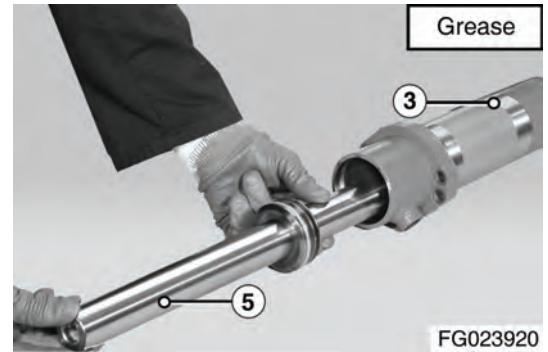


Figure 100

11. Push the piston (5) into the cylinder for 100 mm using a plastic hammer.

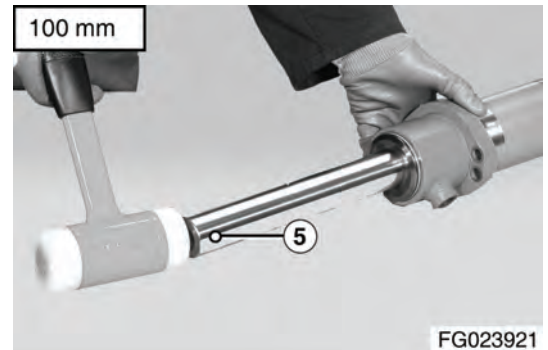


Figure 101

12. Apply grease to head (5) seals, fit the head onto the piston and push it into the cylinder (3) using a plastic hammer.

NOTE: Insert the head as to line it up with the edge of the cylinder.

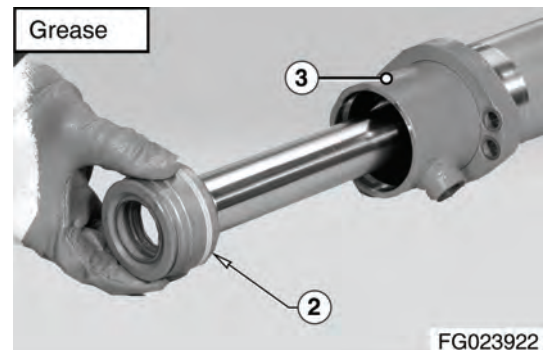


Figure 102

13. Introduce the stop ring (4) and ensure that it sets in the seat of cylinder (3).

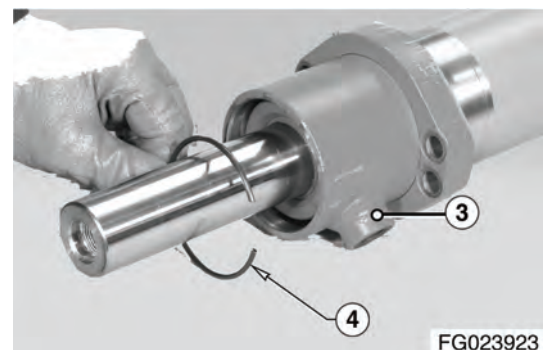


Figure 103



CAUTION

To insert the heading not to go beyond with the ring of gasket the hole of feeding because it could be cut.

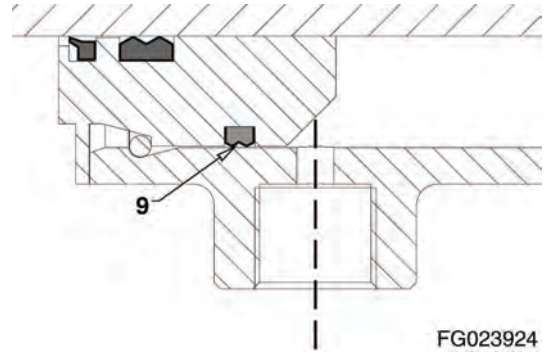


Figure 104

FG023924

14. Using two screwdrivers or levers, force the head until it is seated against the stop ring (4).

Fit the snap ring (1) on the head (2).



CAUTION

Make sure that the snap ring (1) is securely fastened in its seat.

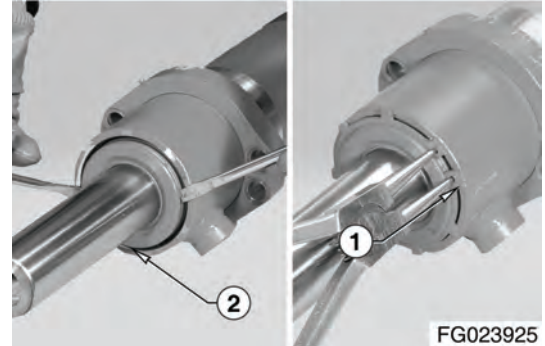


Figure 105

FG023925

If necessary, force it into its seat using a drift and a hammer.

15. Renew at each reassembly.

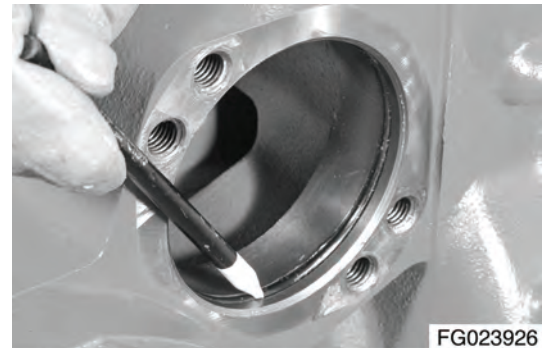


Figure 106

FG023926

16. Check that the O-rings (17) (15) of the axle unit are in good condition; lubricate the seats of the seals and fit the steering cylinder (3).

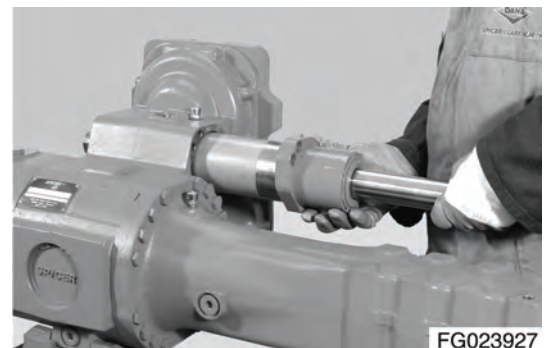


Figure 107

FG023927

17. Lock the cylinder by cross-tightening the screws (3).

- Torque wrench setting: 116 - 128 Nm

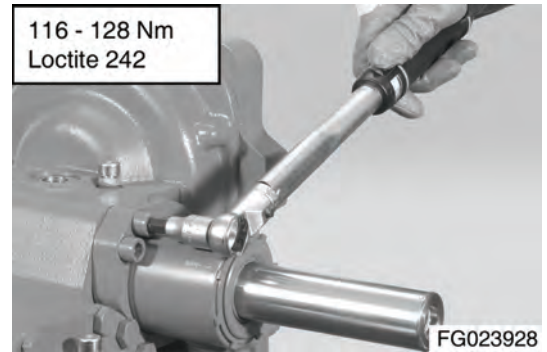


Figure 108

18. Apply Loctite 242 to the thread and connect the steering bars by screwing the terminals onto the piston stem.

- Torque wrench setting: 240 - 270 Nm

NOTE: Versions with coupling require that the rim of the articulation is riveted onto the surfaces of the piston stem.



Figure 109

19. Insert the pins (18) in the steering case and lock into position using a torque wrench setting of 270 - 300 Nm.

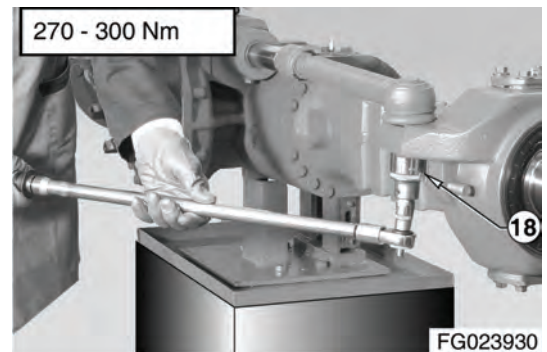


Figure 110

20. Install the proximity (21) for checking piston centring (if applicable) and tighten the screws (20).

- Torque wrench setting: 5 ± 8 Nm

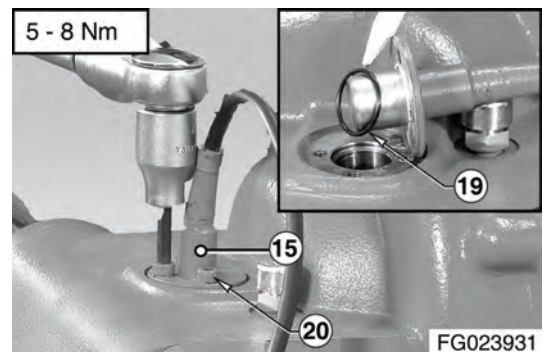


Figure 111



CAUTION

Eliminate the action of the negative brake, if fitted.

21. Apply tools T6 to the hubs and lock them.
Using a level "B", check that tools are perfectly flat and parallel to each other.

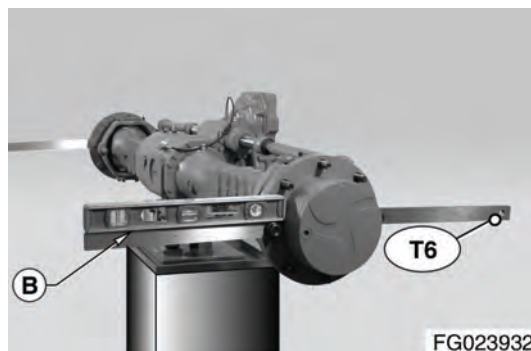


Figure 112

22. Connect the sensor (21) to the inspection device according to either diagram.

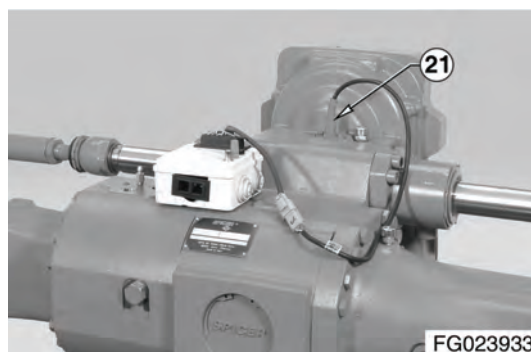


Figure 113

23. Standard version.

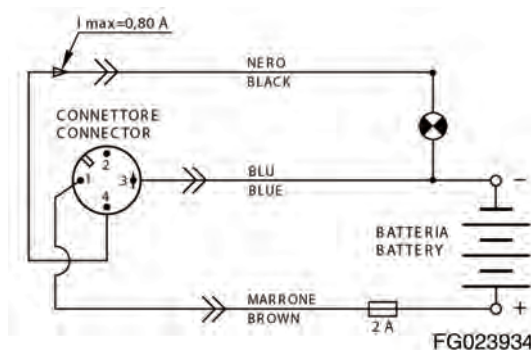


Figure 114

24. Optional version.

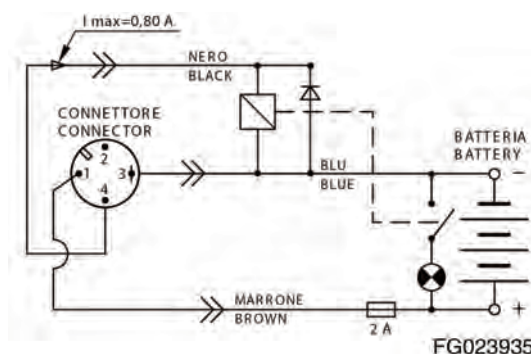


Figure 115

25. Centre the piston by slowly moving it first in one direction then in the other and position it half way on the stroke, which is determined by the switching on and off of the signal lamp of the inspection device in the reversal stage.

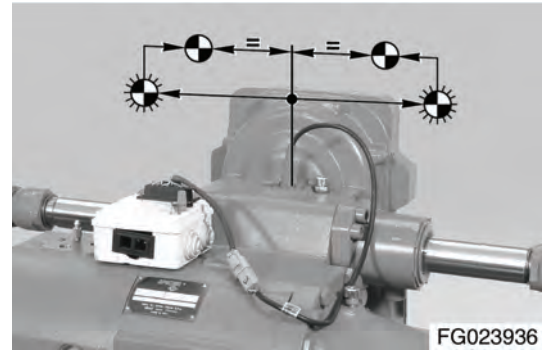


Figure 116

26. Inspect jut "C" on one side of the piston and note down the size for checking later adjustments.

NOTE: *If cylinders come without a sensor, the centring of the piston must be carried out on the basis of the maximum stroke.*

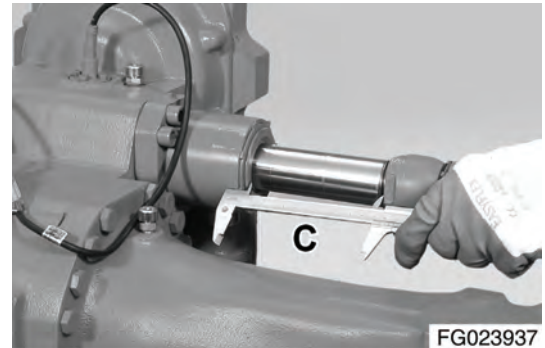


Figure 117

27. Without moving the piston, check front and rear size at the edge of tools T6.

- Max. difference: 0.6 - 0.7 mm

NOTE: *In order to check the rear size, rotate the bevel pinion and check that tools T6 are flat.*

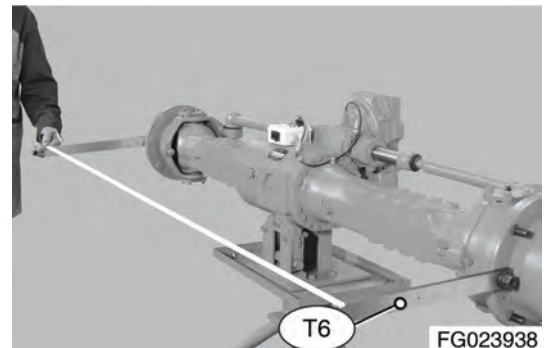


Figure 118

28. If necessary, adjust convergency without moving the centring of the piston and adjust the length of the steering bars (14).

NOTE: *With a half turn of screw, the front size is reduced by about 3 mm, whereas the rear one is increased by about 3 mm.*

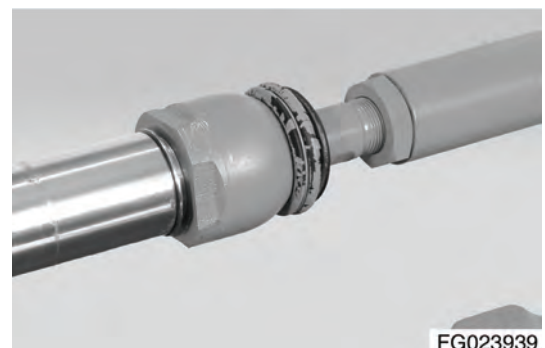


Figure 119

29. Unloose the nuts and screw them onto the ball-and-socket joints.



Figure 120

30. Hold the articulations still and rotate the ball-and-socket joints.

Once the convergency has been adjusted, lock the nuts.

- Torque wrench setting for nuts: 240 - 270 Nm

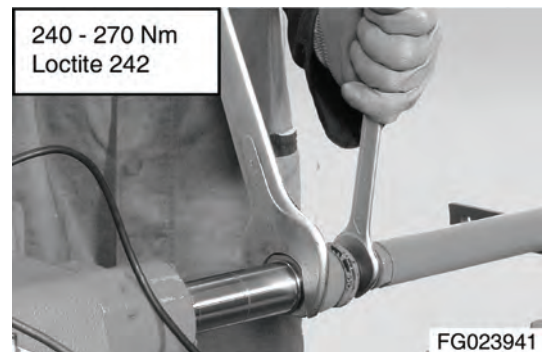
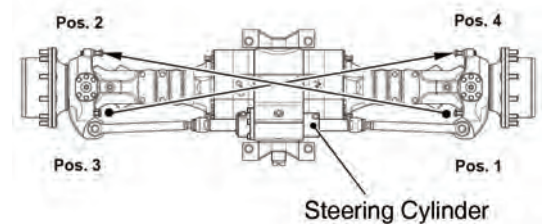


Figure 121

Adjusting the Steering Angle

NOTE: Perform the same operations on both sides (see diagram). Loosen the nut of one of the adjusting screws on cylinder side.



FG023942

Figure 122

31. Adjust the jutting portion of the screw according to data shown in the table.

Lock into the position with nut tightened to max 148 Nm.

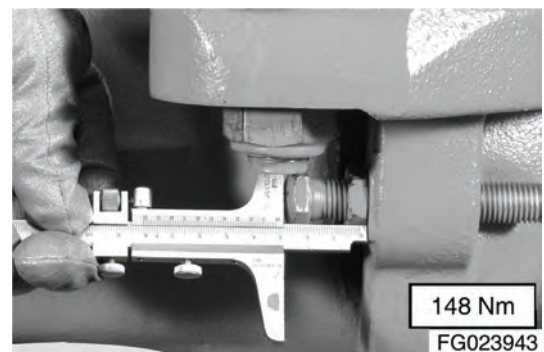


Figure 123

32. Perform one full steering operation until the adjusted screw leans against the arm stop.

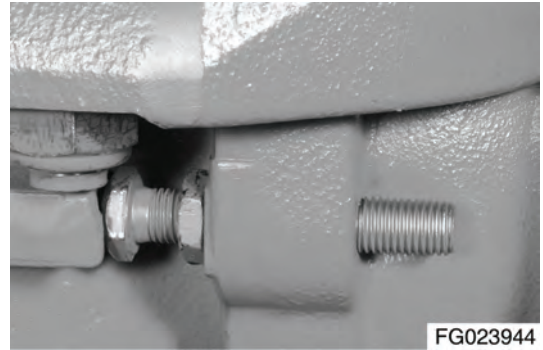


Figure 124

33. As you hold the adjusted screw in position against the arm stop, adjust the screw opposite, on non-cylinder side, until it leans against the arm stop.

IMPORTANT

The screws must lean against the respective arm stops all at the same time.

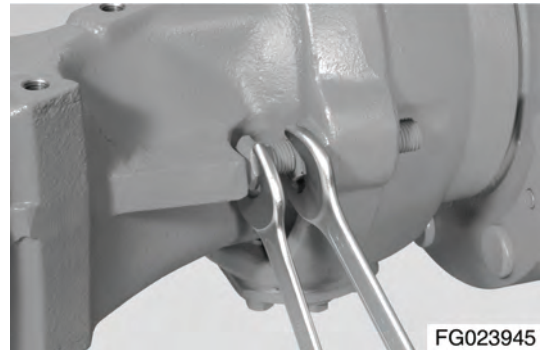


Figure 125

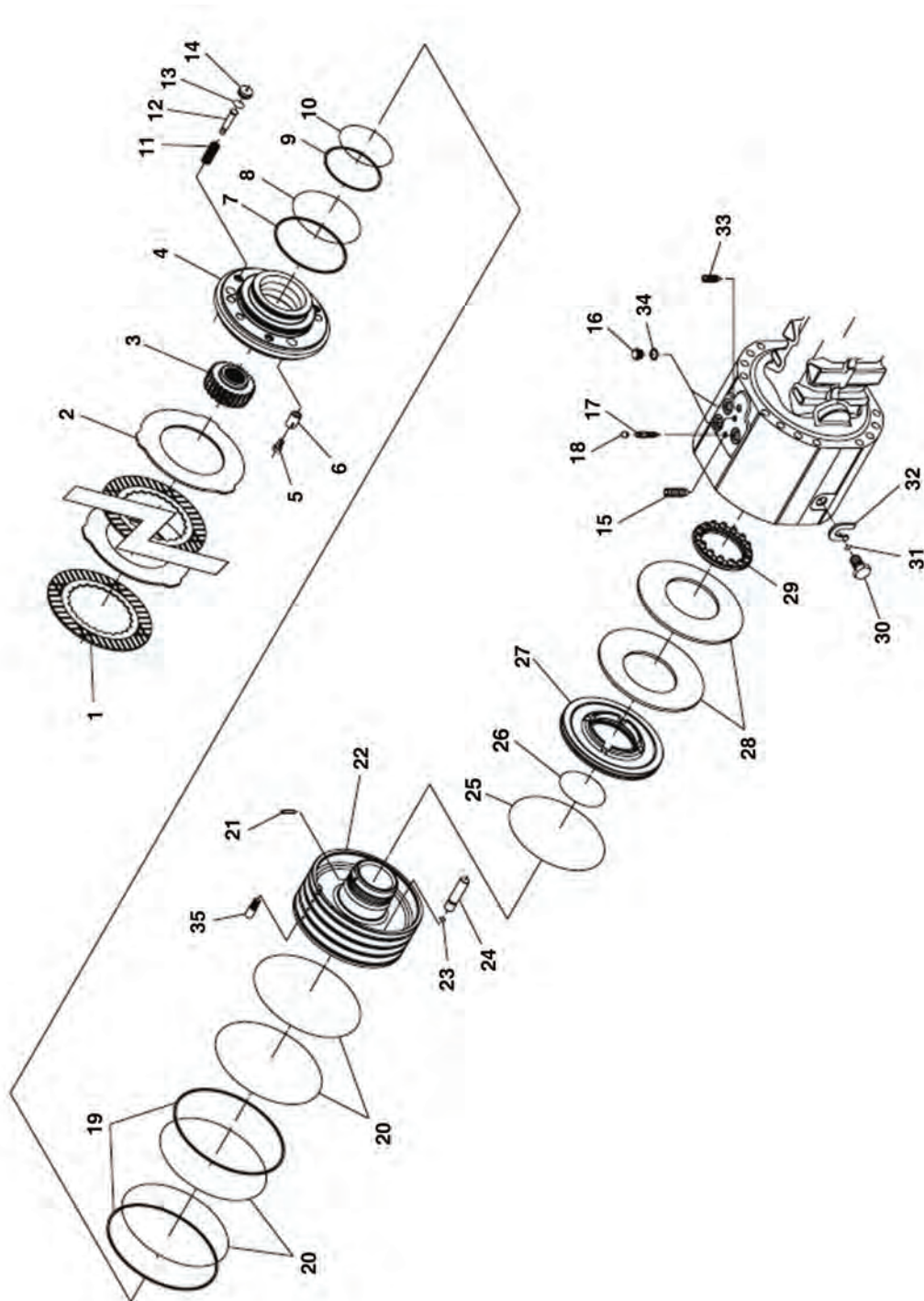
Requested steering angle: value α	25°	27°	30°	32°	35°	36°	40°	42	45
Steering cases versions based on max. steering angle.	Value W = Adjustment of the steering stop screw, steering cylinder side (mm).								
35° max angle.	551	51.2	45.4	35.0					
45° max angle.			57.4		47.0	44.7	35.8	31.2	24.6

IMPORTANT

The screws must lean against the respective arm stops all at the same time.

BRAKE

Disassembling



FG023947

Figure 126

1. Connect an external pump to the union piece "P1" of the negative brake and introduce a pressure of 15 ± 30 bar to eliminate the pressure of the Belleville washers.



CAUTION

Perform all operations on both arms.

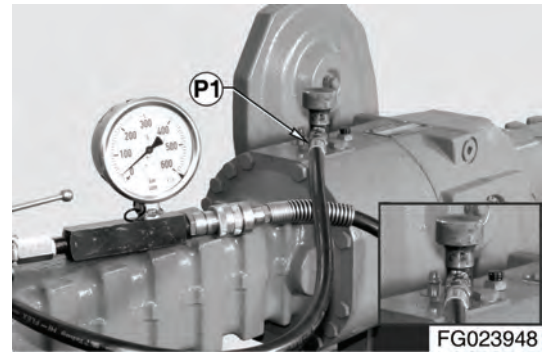


Figure 127

2. Loosen the unlocking screws (30) and remove both stop washers (32).

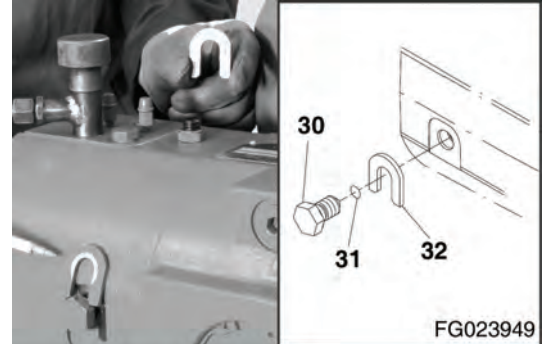


Figure 128

3. Insert block screws to end stroke and release pression.

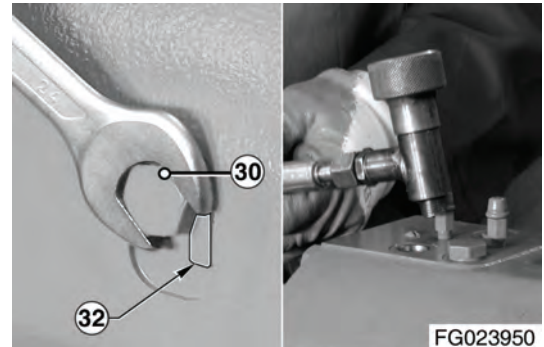


Figure 129

4. Sling the arm to be removed and connect it to a hoist, remove screws.

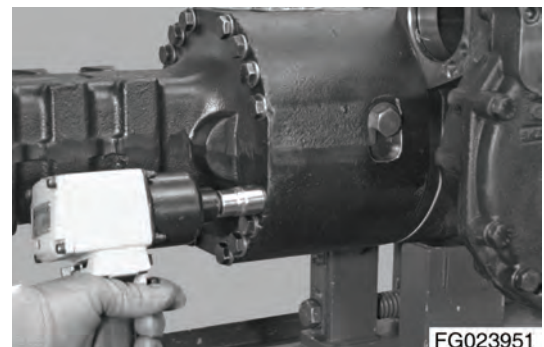


Figure 130

5. Take off the arm and lay it down vertically.

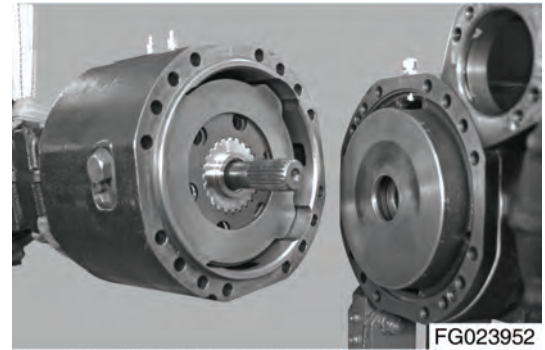


Figure 131

6. Remove the brake discs one after the other (2).

NOTE: *If they are not to be substituted, do not mix up the sequence.*

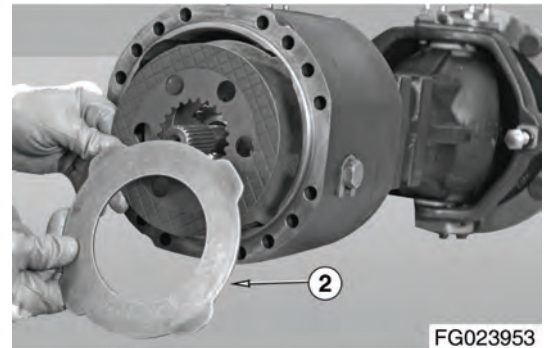


Figure 132

7. Remove the flange (3) complete with the discs.

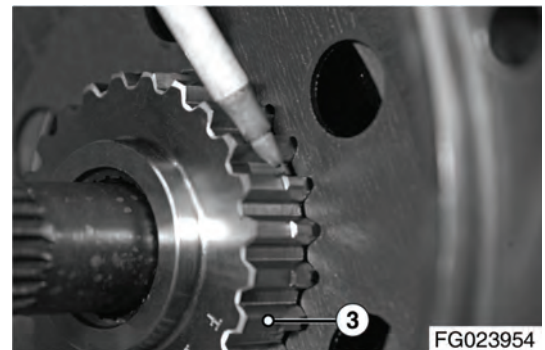


Figure 133

8. In order to keep the disc springs of the negative brake preloaded, screw down the screws with washers to the end stop.



Figure 134

9. Remove the negative brake locking screws (30).

Always exchange the O-ring (31).

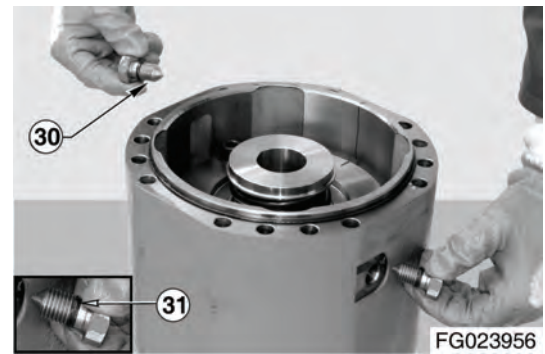


Figure 135

10. Loosen the before installed provisional screws in the same sequence and same measure.



Figure 136

11. Remove the negative brake locking screws (30).

Always exchange the O-ring (31).

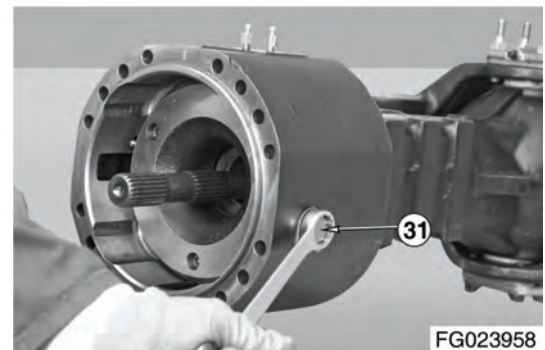


Figure 137

12. Pull out brake piston assembly module (22).

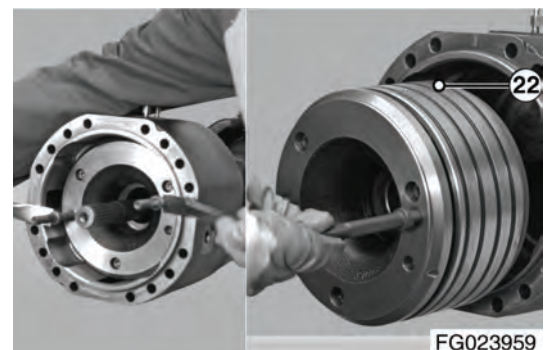


Figure 138



CAUTION

Check locking screw (33) of the brake piston module.

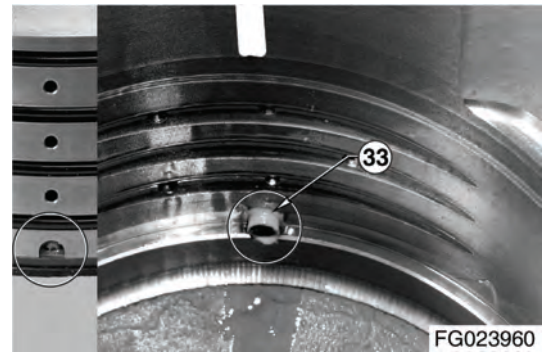


Figure 139

13. Turn upside down the brake module and with a pin driver remove the locking pin of the slotted nut.

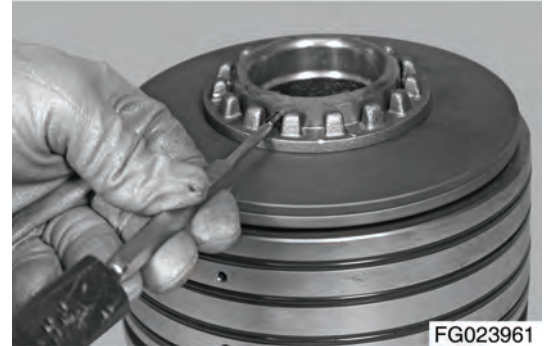


Figure 140

14. Sign the position of the slotted nut.



Figure 141

15. Bring the piston group below a press, compress the cup springs and loosen the metal ring.

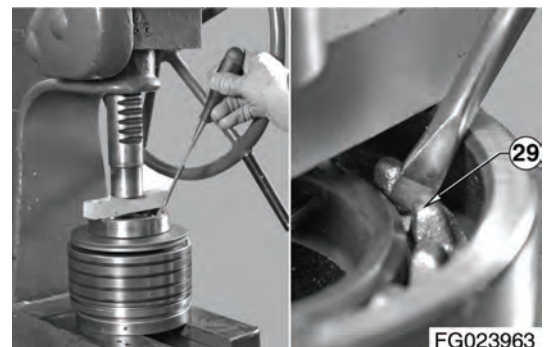


Figure 142

16. Remove nut (29).

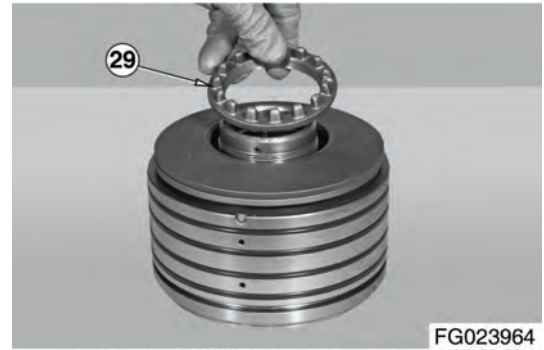


Figure 143

17. Remove the disc springs (28).



Figure 144

18. Applying air pressure, remove the piston (27) of the negative brake.

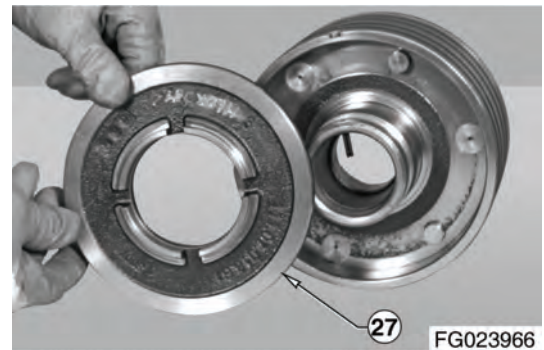


Figure 145

19. Using a new screw remove the pressure seal caps.



Figure 146

20. Remove the reversal springs (11).

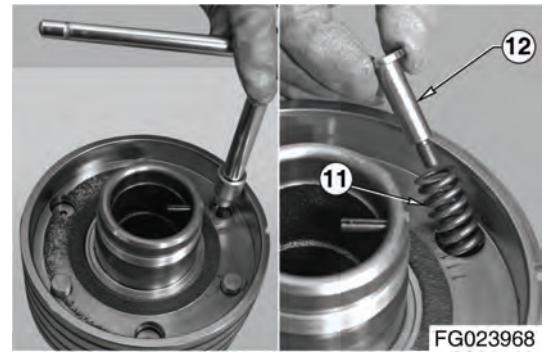


Figure 147

21. Remove the adjusting screws (5).

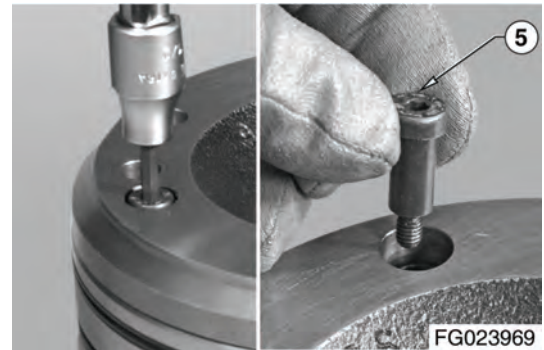


Figure 148

22. Remove the service brake piston (4).



Figure 149

23. Remove the three bolts (24).



Figure 150

24. Remove the O-Rings and the anti-extrusions rings from the service brake, the negative brake piston and from the piston.

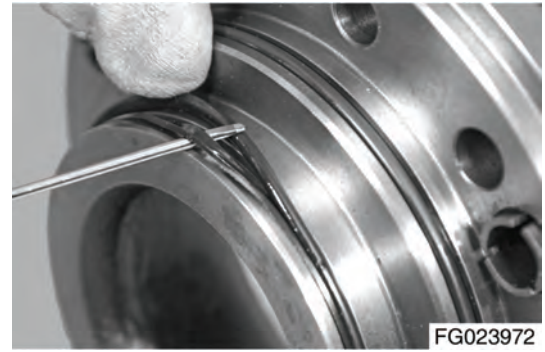


Figure 151

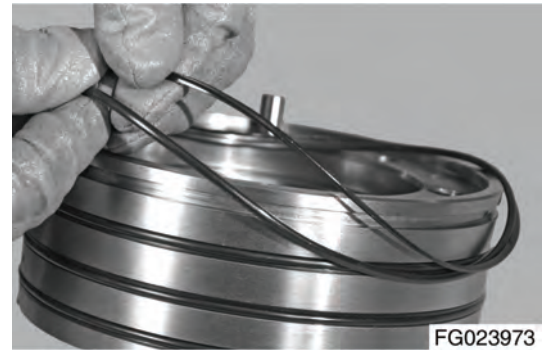
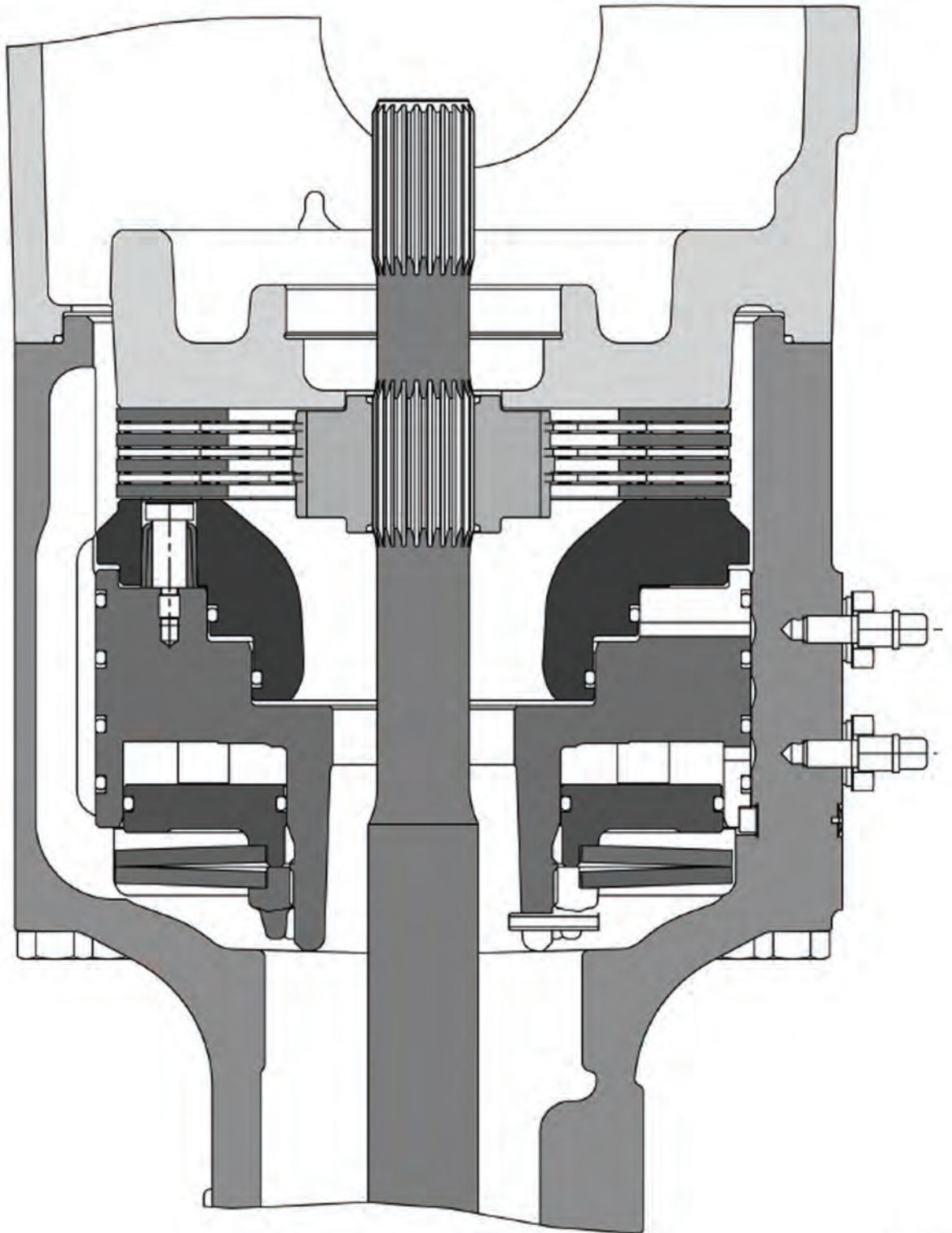


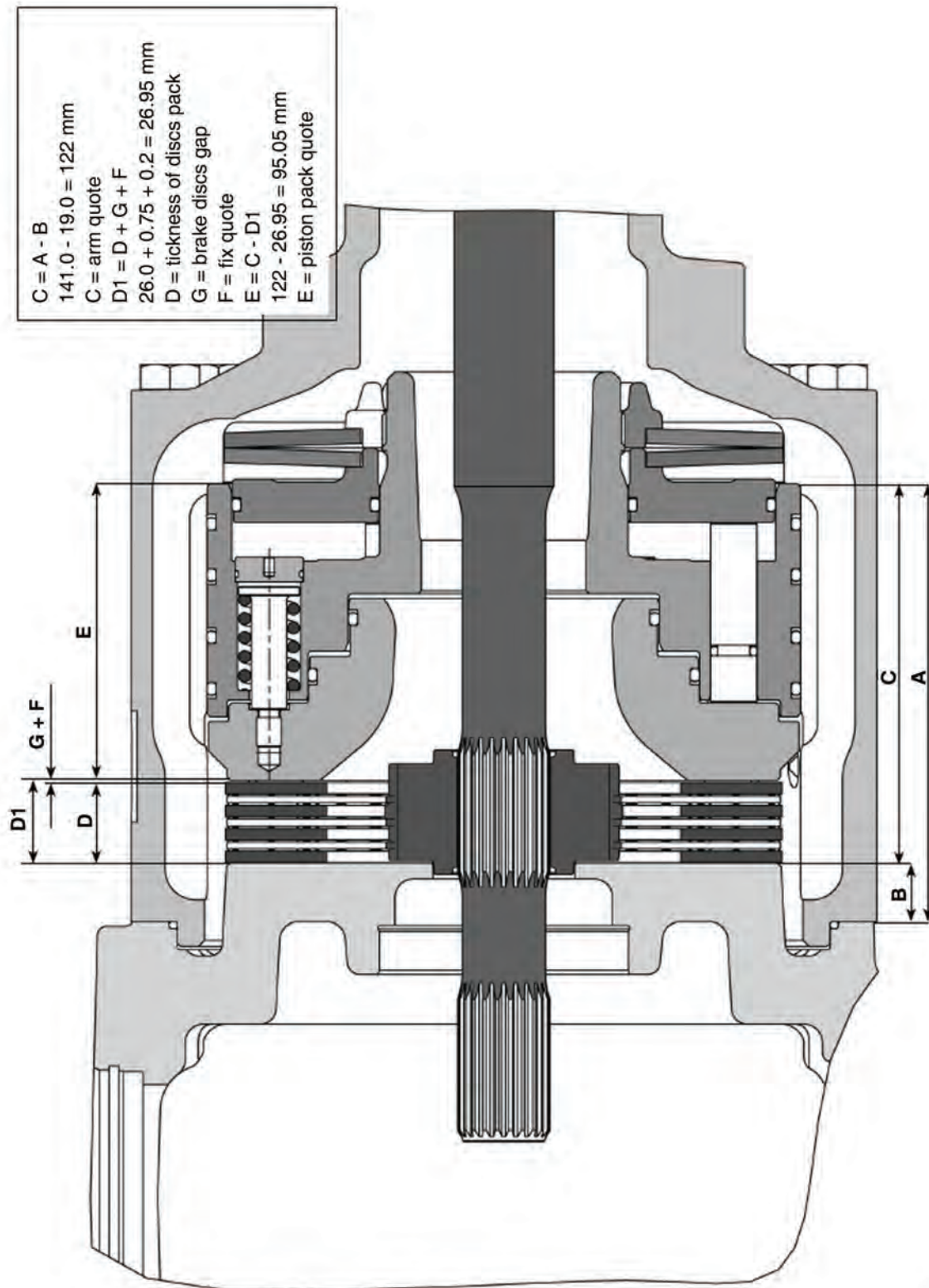
Figure 152

Assembling



FG023974

Figure 153



FG023975

Figure 154

1. Zero the centesimal calibre between the support plane and the centring arm.

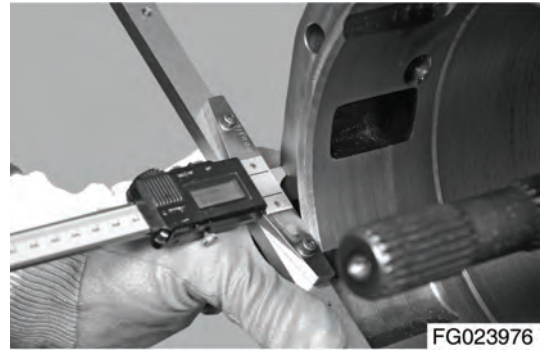


Figure 155

2. Then measure the distance between the arm support plane and the piston pack stop.

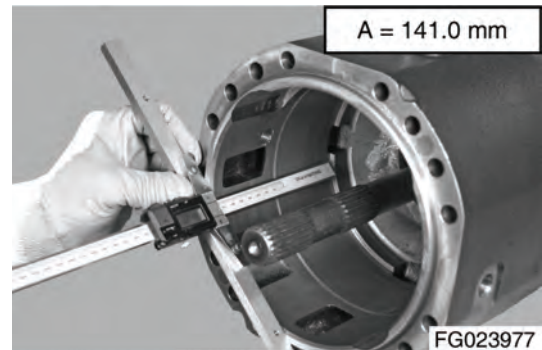


Figure 156

3. Measure the distance between the disk support plane and the arm support plane.

Subtract the value B from the value A to obtain the effective dimension of the arm containing the brake disks and the piston pack.

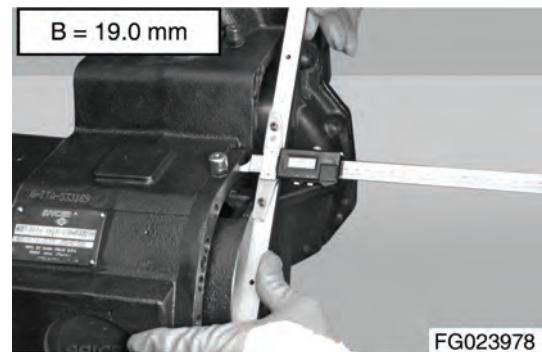


Figure 157

4. Bring the disk pack beneath a press, load with 1,000 kg, then measure the dimension D.

Add the play G and the fixed value F (equal to 0.2 mm) to the value D.

NOTE: Do not take into account the thickness between the press piston and the disks.

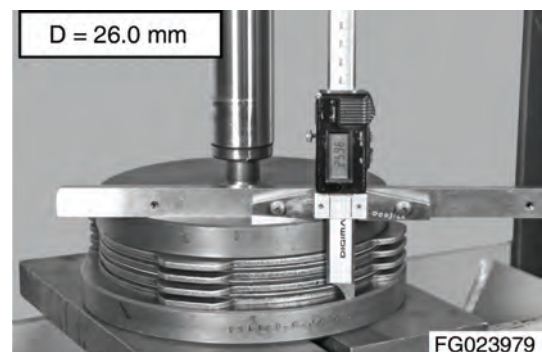


Figure 158

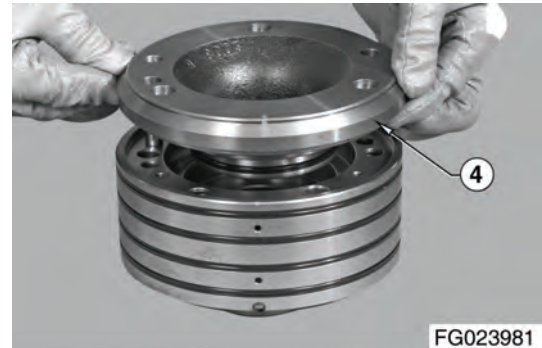
5. To determine the value of the piston pack, subtract value C from value D1.

$C = A - B$
 $141,0 - 19,0 = 122 \text{ mm}$
C= arm quote
 $D1 = D + G + F$
 $26,0 + 0,75 + 0,2 = 26,95 \text{ mm}$
D= tickness of discs pack
G= brake discs gap
F= fix quote
 $E = C - D1$
 $122 - 26,95 = 95,05 \text{ mm}$
E = piston pack quote

FG023980

Figure 159

6. Insert the service brake piston (4) hammering alternately with a plastic hammer.



FG023981

Figure 160

7. Insert the bolts (24).



FG023971

Figure 161

8. Turn upside down and insert the negative brake piston (27).



FG023982

Figure 162



CAUTION

To determine the level "E" the slotted nut has to be operated without spring mounted.



Figure 163

NOTE: To define the level "E" adjust the slotted nut always to the smaller value by driving to the closer notch.

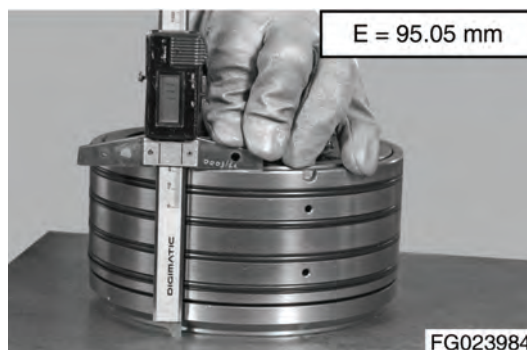


Figure 164

- Before removing the slotted nut in order to insert the springs, note down the distance "H" from the plane to the tooth near the pin.

NOTE: Sign.

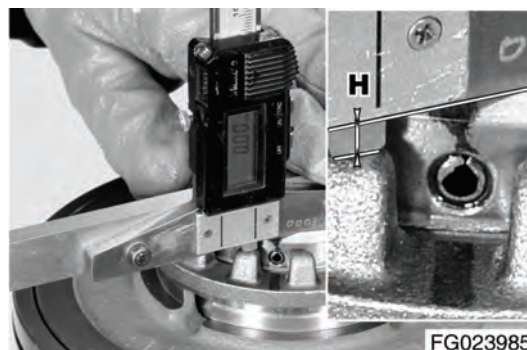


Figure 165

- Remove the service brake piston (4).

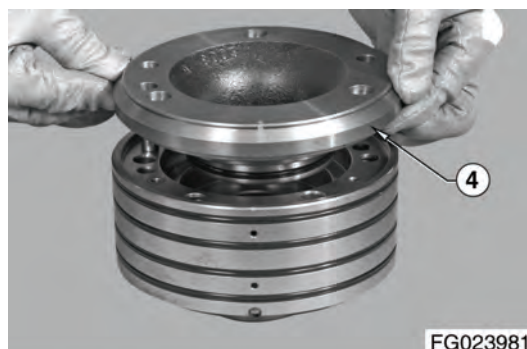


Figure 166

11. Insert the stroke automatic regulation springs (6); place them in line with the piston (4).

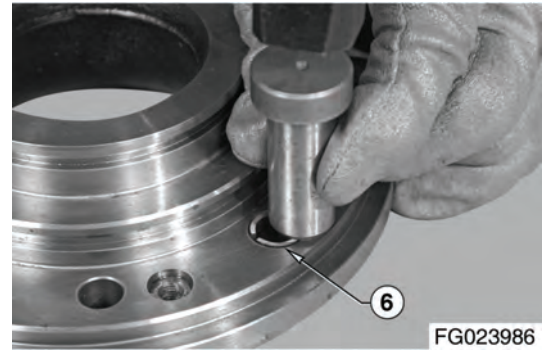


Figure 167

12. Complete the O-rings and anti-extrusion rings on all pistons.



CAUTION

The O-rings always have to be assembled from the pressure facing side.



Figure 168



Figure 169

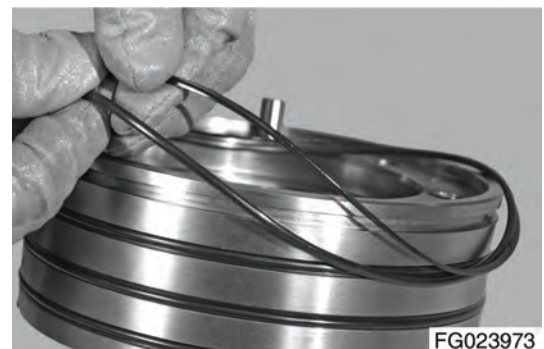


Figure 170

13. Insert the service brake piston (4) hammering alternately with a plastic hammer.

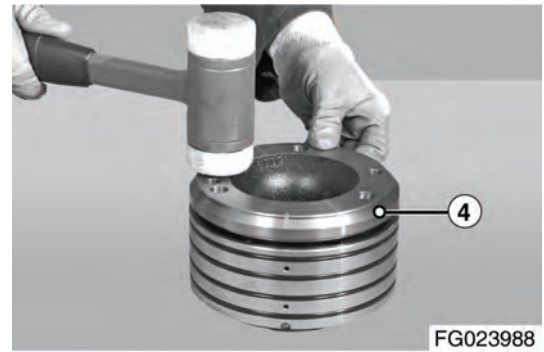


Figure 171

14. Fit the adjusting screws (5).
Apply Loctite 242 to the thread.
- Torque wrench setting: 5 - 7 Nm

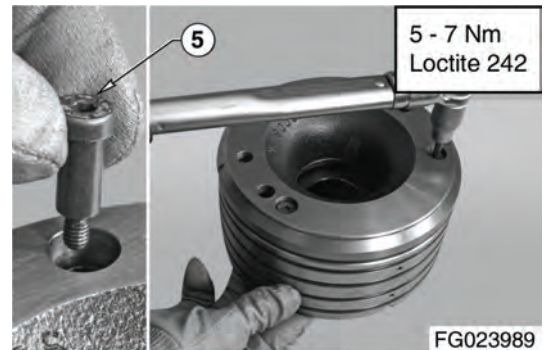


Figure 172

15. Fit the reversal springs (11) on the piston (4).
Apply Loctite 242 to the thread of the adjustment screw.
- Torque wrench setting: 10 - 15 Nm

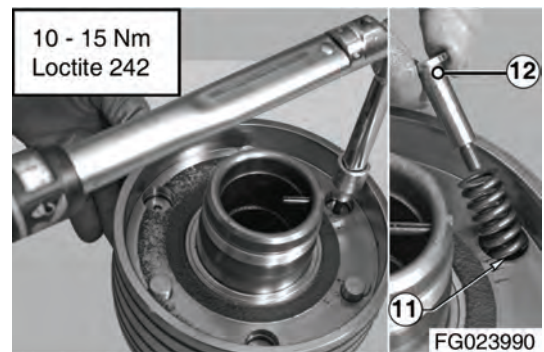


Figure 173

16. Insert the stroke end seal caps.000

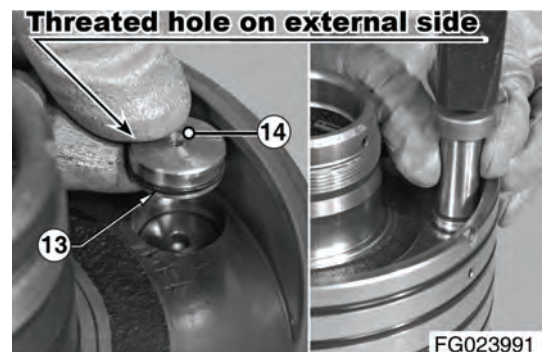


Figure 174

17. Insert the negative brake piston (27).

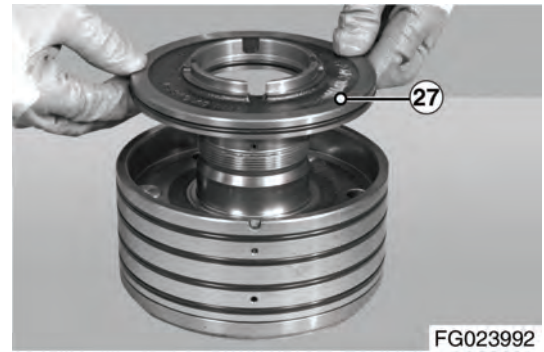


Figure 175

18. Insert the disc springs in the right position (28).



Figure 176

19. Insert at the bottom the piston of the negative brake (27) and screw up the slotted nut (29).

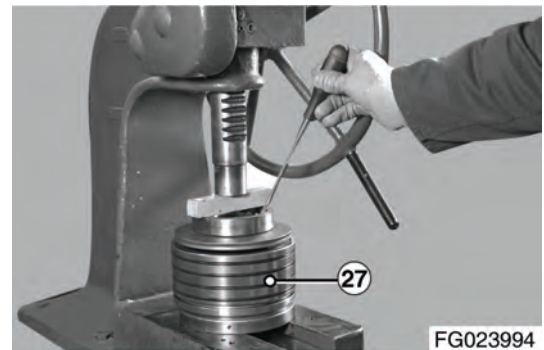


Figure 177

20. Screw down the slotted nut to the earlier determined position.

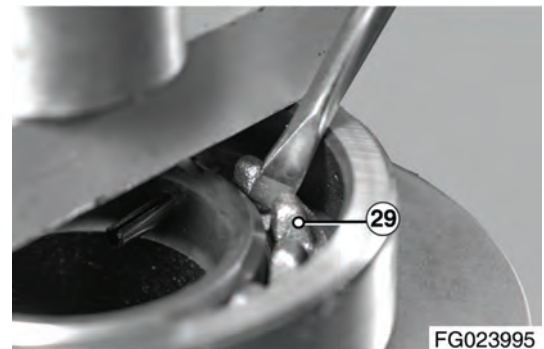


Figure 178

21. Check the earlier measured distance "H" from the plane to the tooth next to the pin.

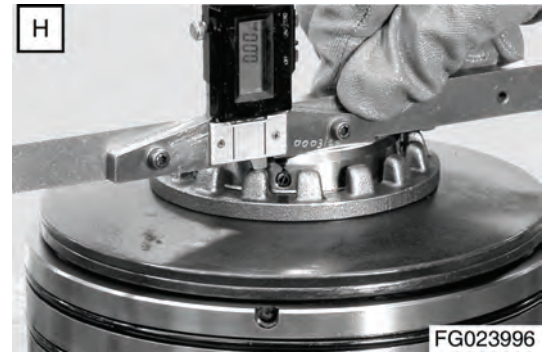


Figure 179

22. Alternately tighten with a torque wrench setting of max. 45.



Figure 180

23. Put the pin in locking (21) position.



Figure 181



CAUTION

Check locking screw (33) of the brake piston module.

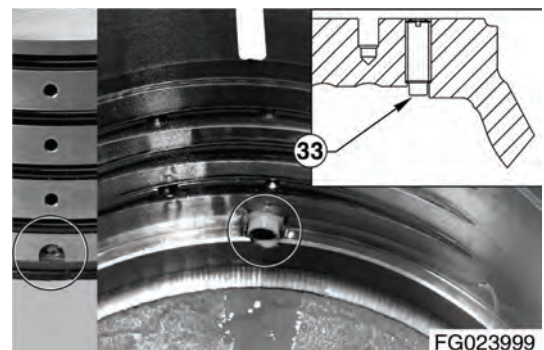


Figure 182

24. Insert the brake modul facing the input holes to the top.

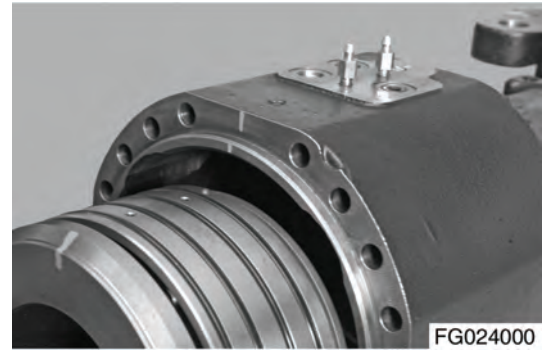


Figure 183

25. Insert the piston to the end stop by alternating light strokes and remove the screws.

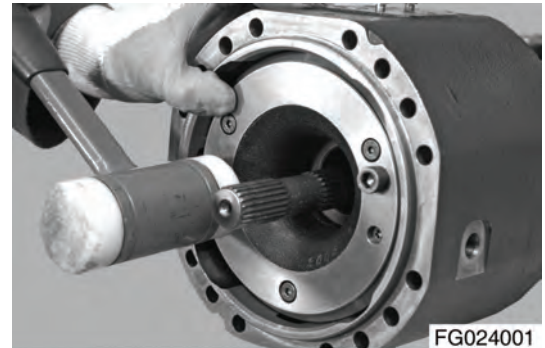


Figure 184

26. Insert the negative brake unlocking screw (30) up to the end stop.

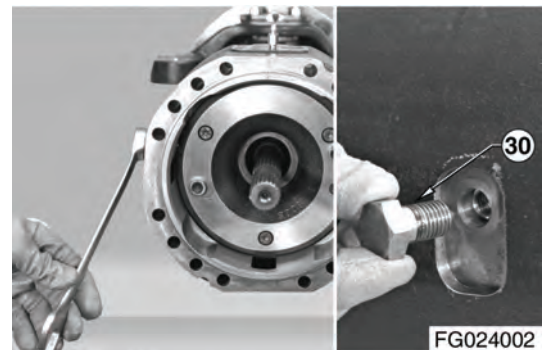


Figure 185

27. Remove the two auxiliary screws.

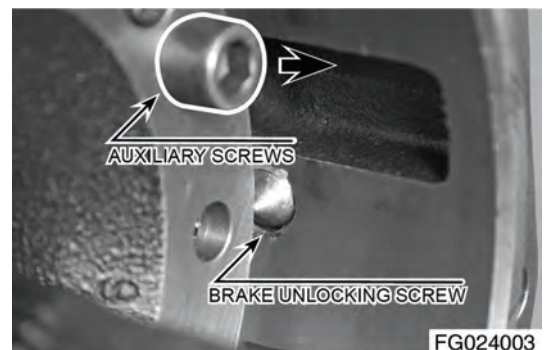


Figure 186

28. Insert the brake discs (1) (2) in the right sequence.

NOTE: *The first brake disc to be inserted must be of friction material.*

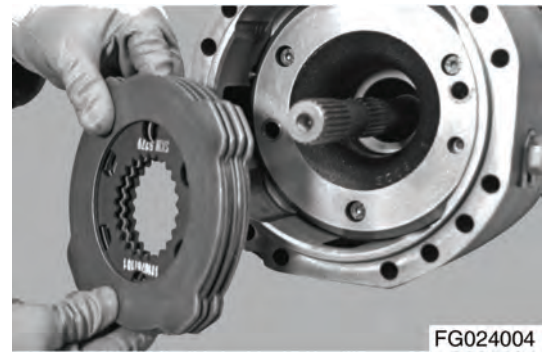


Figure 187

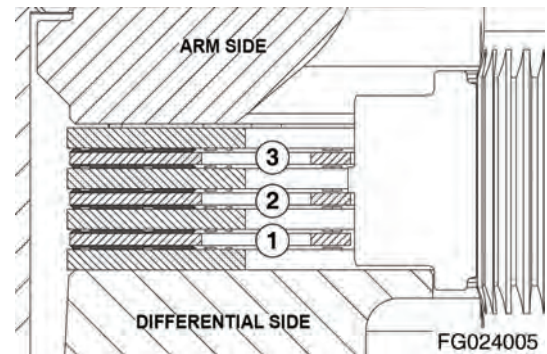


Figure 188

29. Install the flange (3) on the arm.

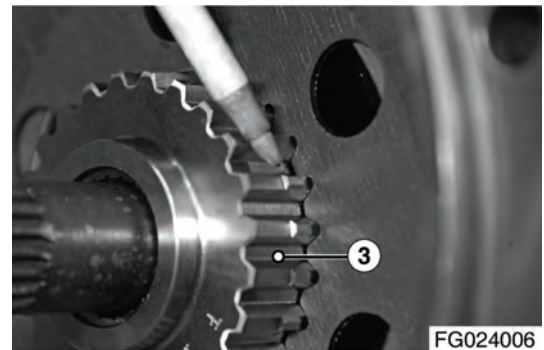


Figure 189

30. Insert the brake discs (1) (2) in the right sequence.

NOTE: *The last brake disc to be inserted must be of metal material.*

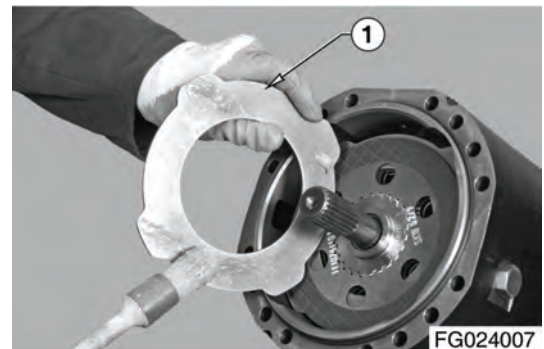


Figure 190

31. Insert the screws and tighten them alternately.

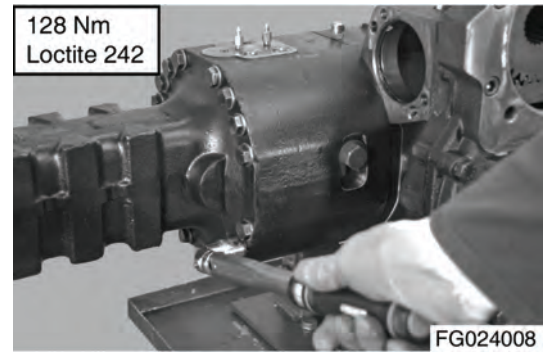


Figure 191

32. Remove the negative brake locking screws (30).
Fit the special tool T7 into the seat of the manual release of the screws, insert a comparator and pre-load it with 1 mm.

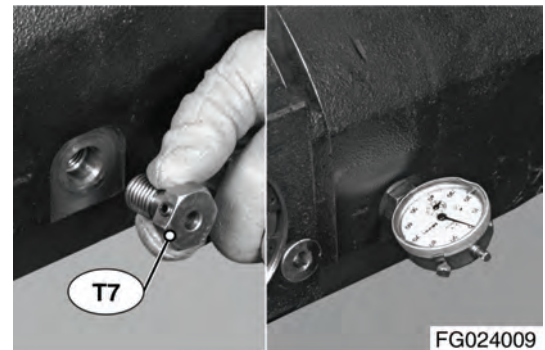


Figure 192

33. Introduce a pressure of max. 25 bar.

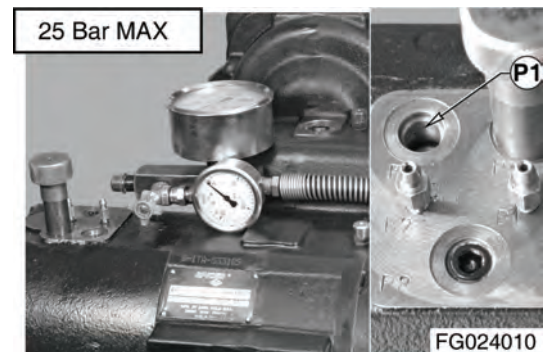


Figure 193

34. Once the pressure is inserted into the circuit the comparator must give a measurement equal to play X (0.75 mm).

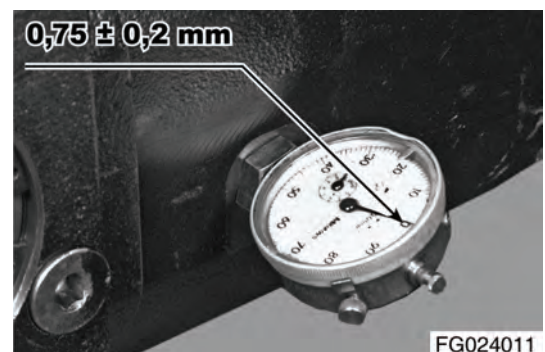


Figure 194

35. Insert the two "U"-shaped shims and tighten the screws with a torque wrench setting of 95 - 115 Nm.

NOTE: *The position of the negative brake is unlocked.*

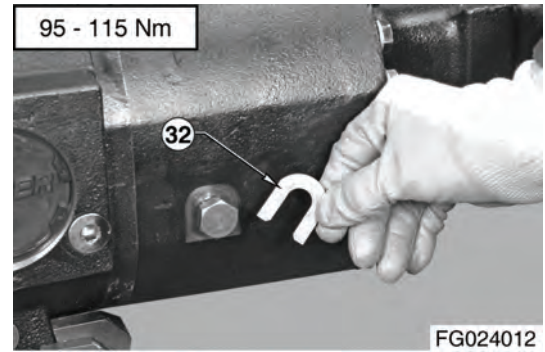


Figure 195

36. Check the flatness of the arms and finally lock the arms with the screws (4) and the washer (5) using the crosstightening method.

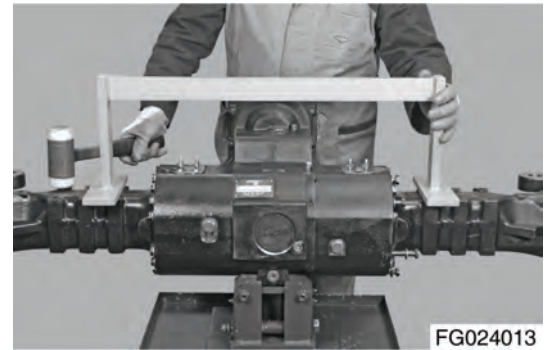
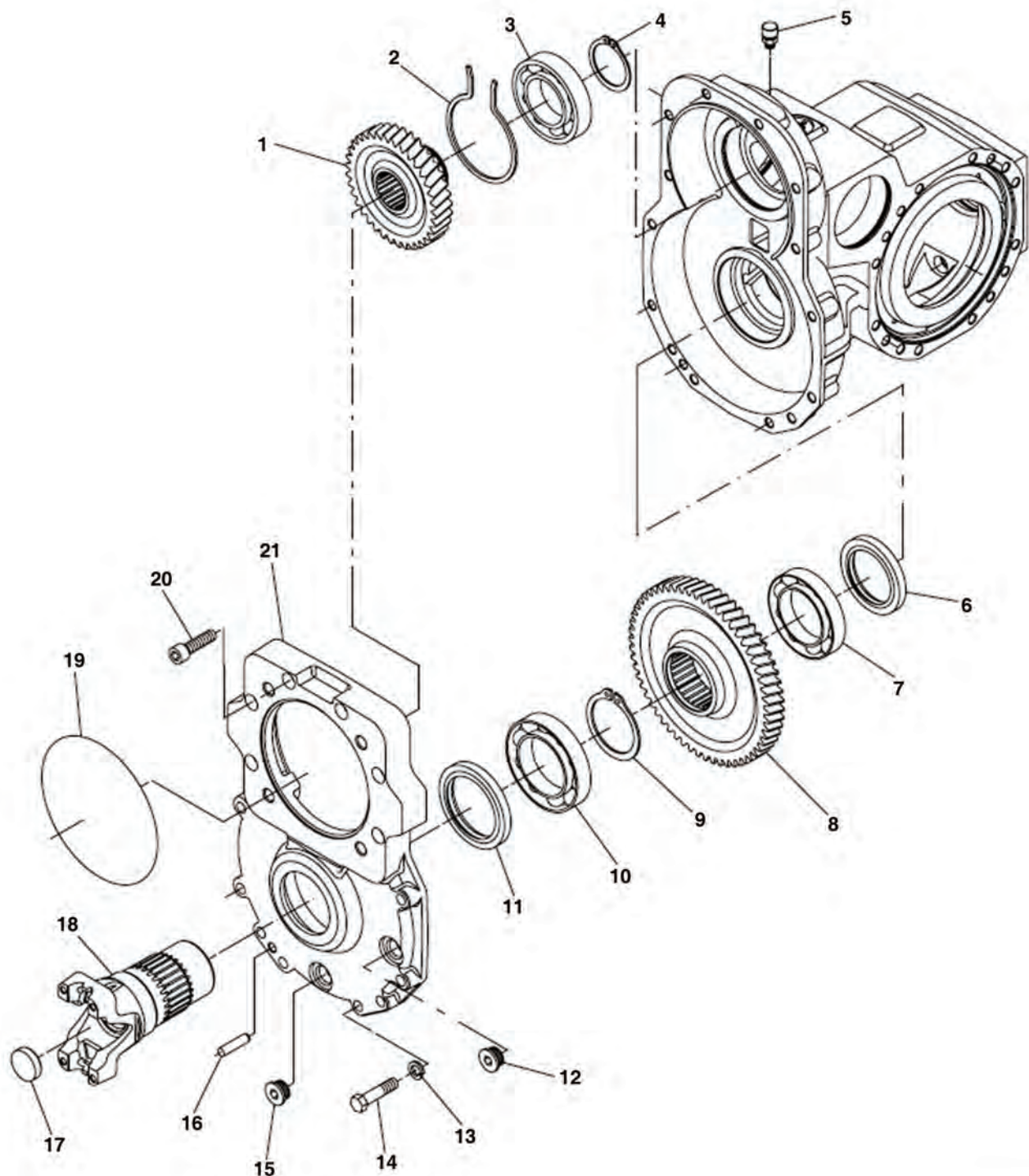


Figure 196

FLANGED REDUCTION GEAR 603 TYPE



FG024014

Figure 197

Disassembling

1. Remove screws (14) (20) of the drive side flange cover.

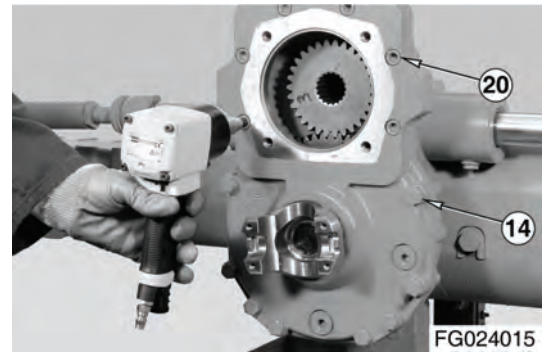


Figure 198

2. Take off the drive side flange cover (21).

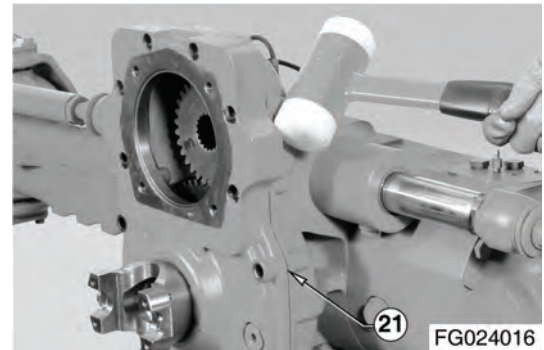


Figure 199

3. Place two levers into the appropriate slots.

NOTE: Look out not to damage the surfaces.

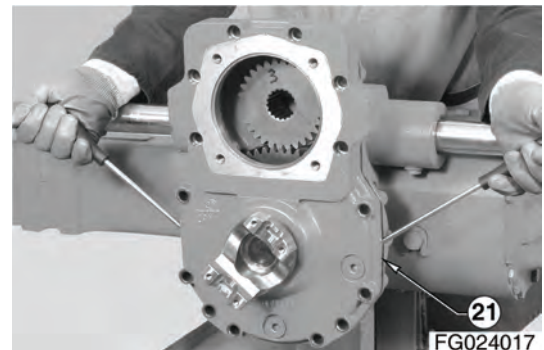


Figure 200

4. Lift off the cover (21).

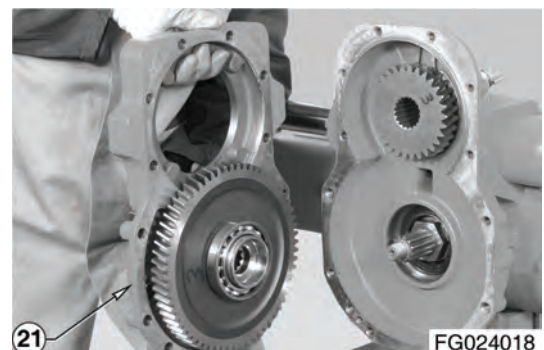


Figure 201

5. To remove the drive side shaft (1), hook off the snap ring (2).

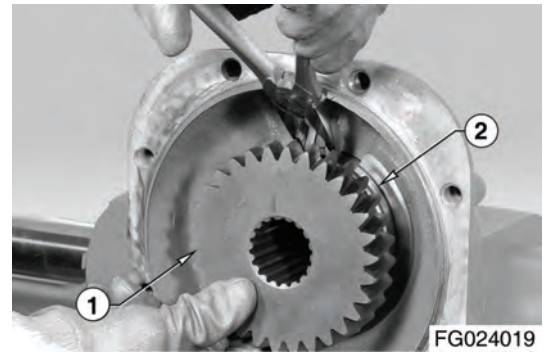


Figure 202

6. Using two levers, remove the drive side shaft (1).

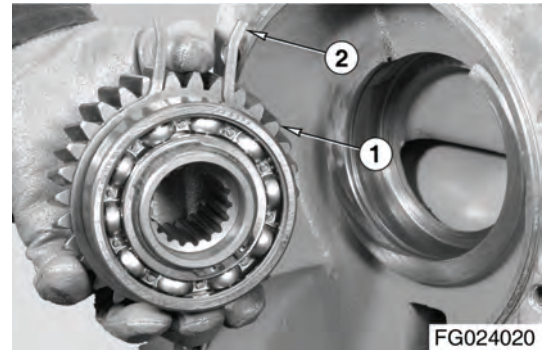


Figure 203

7. Using two levers, remove the flange sealing ring (6).

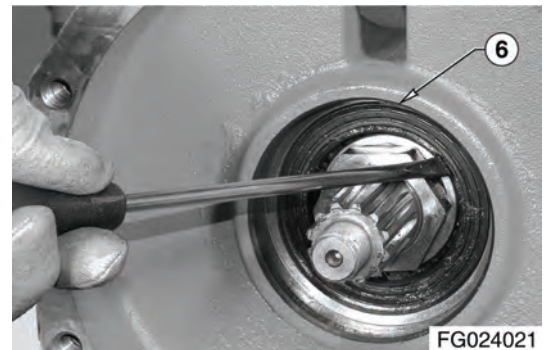


Figure 204

8. Remove the snap ring (4).



Figure 205

9. With a puller, remove the bearing (3) from the input shaft (1).

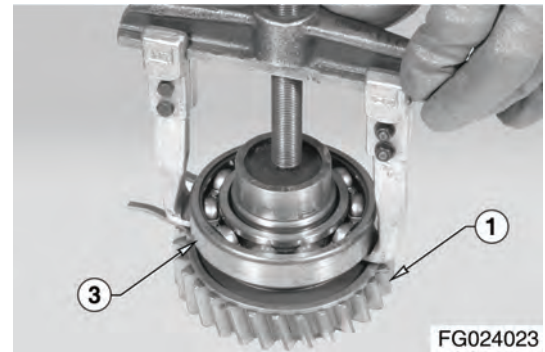


Figure 206



Figure 207

10. With a puller, remove the bearing (7) from the lower shaft (8).



Figure 208

11. Remove the secondary gear wheel (8) using two levers.



Figure 209

12. Remove the snap ring (9).



Figure 210

13. Remove the flange (18) by means of a plastic hammer.

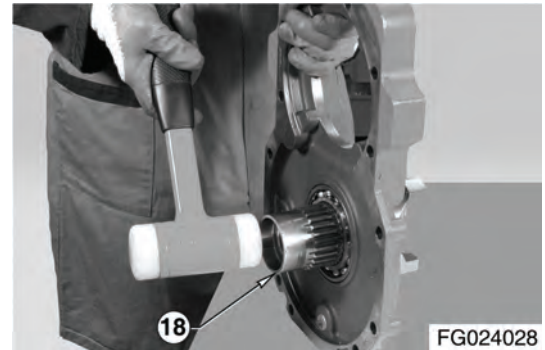


Figure 211

14. Remove the internal bearing (10).

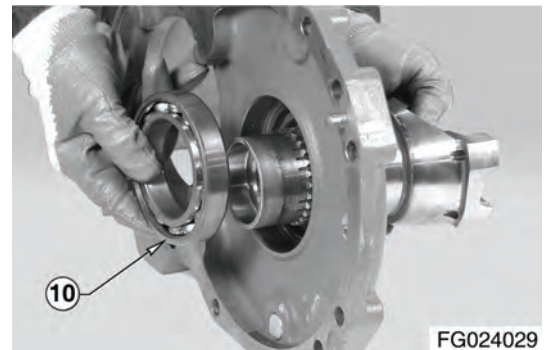
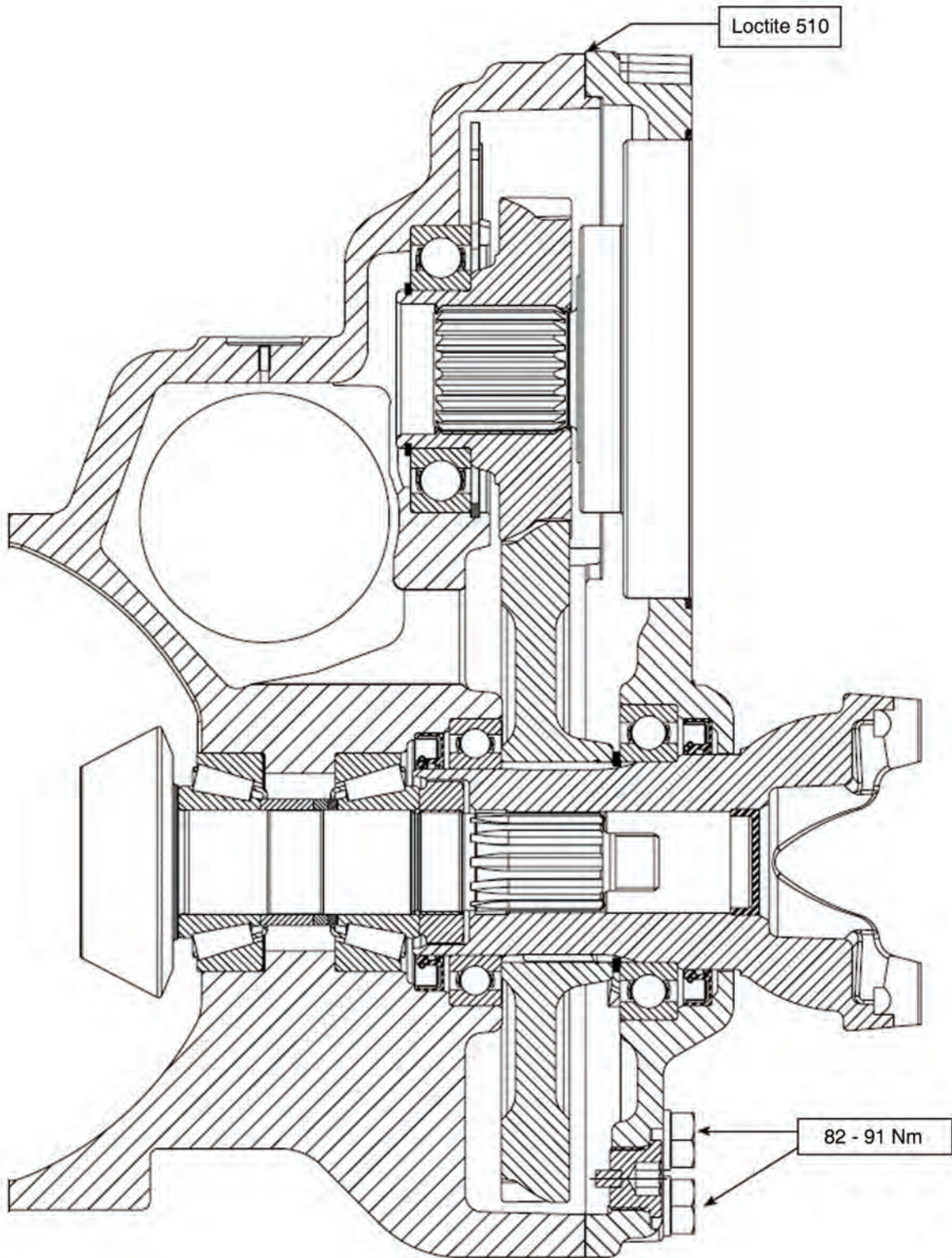


Figure 212

15. Pull out the cup of the sealing ring (11) by using drift.



Figure 213



FG024031

Figure 214

Assembling

1. Insert the sealing ring (6) with a special tool T8.

NOTE: *Bring the sealing ring just to the end stop, apply grease to the sealing lips.*

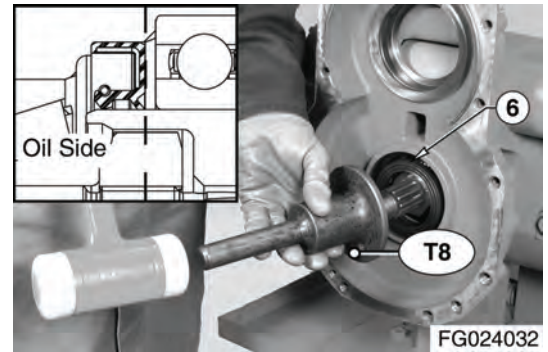


Figure 215

2. Insert the sealing ring (11) with special tool T9.

NOTE: *Bring the sealing ring just to the end stop, apply grease to the sealing lips.*

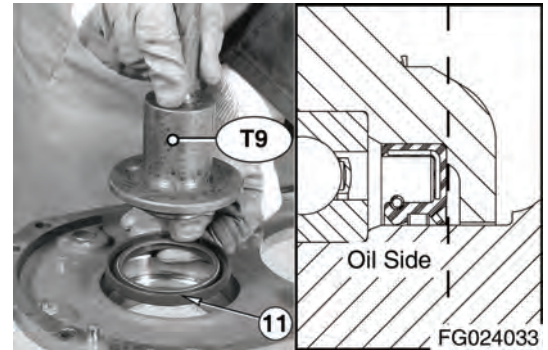


Figure 216

3. Fit the flange (18) and fasten it.

For keying the flange (18), use a plastic hammer if necessary.

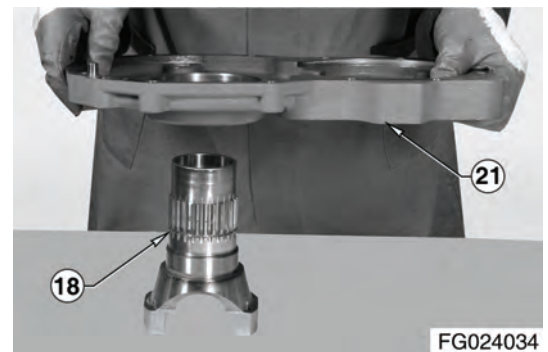


Figure 217

4. Insert the bearing (10).

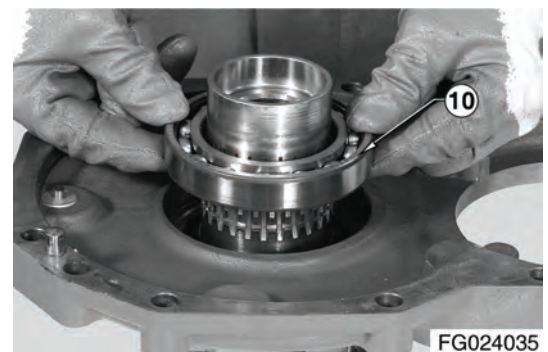
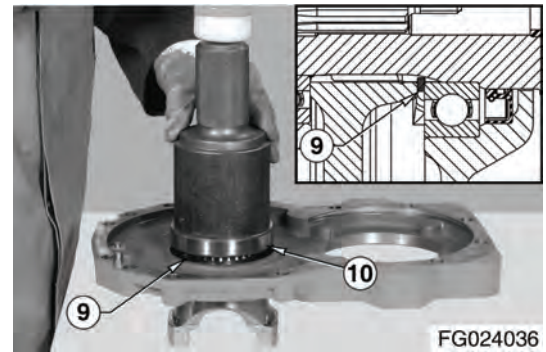
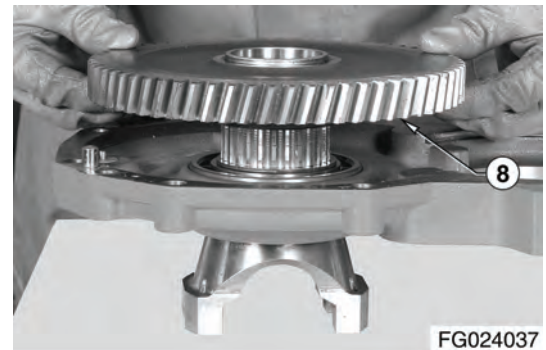


Figure 218

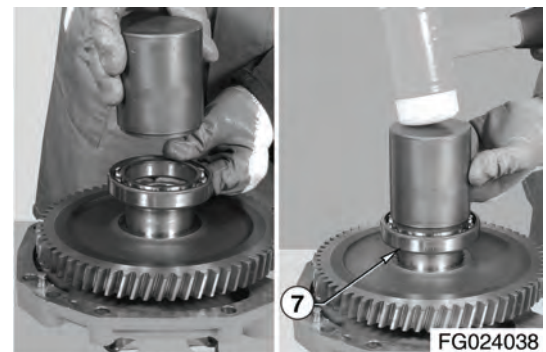
5. Using a normal tool insert the bearing (10) and snap ring (9).



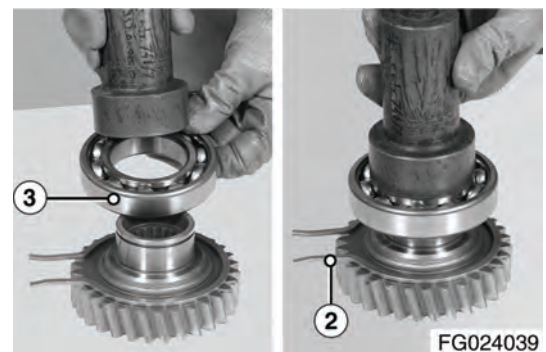
6. Install the secondary gear wheel (8) with a plastic hammer.



7. Using a normal tool insert the bearing (7).



8. Insert the snap ring (2) and using a normal tool insert the bearing (3).



9. Fix the bearing with the snap ring (4).



Figure 223

10. Install the drive side shaft (1) with a plastic hammer.

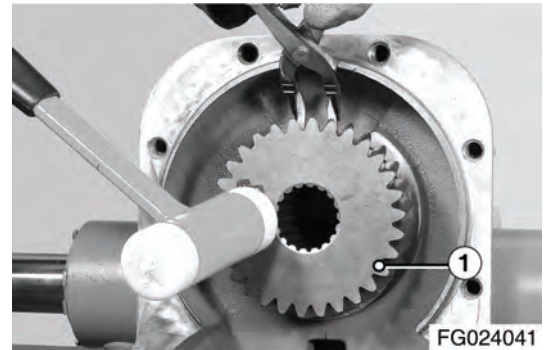


Figure 224

11. Install drive side flange cover, apply Loctite 510 to the short screws.

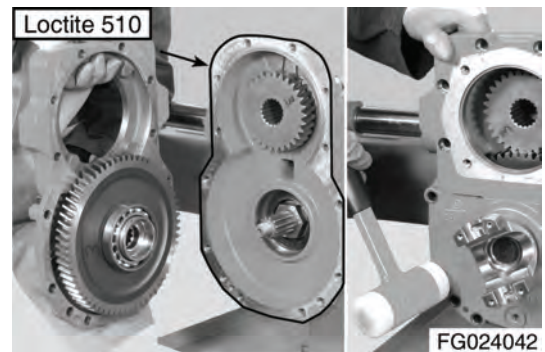


Figure 225

12. Tighten screws with a torque wrench setting of 82 - 91 Nm.

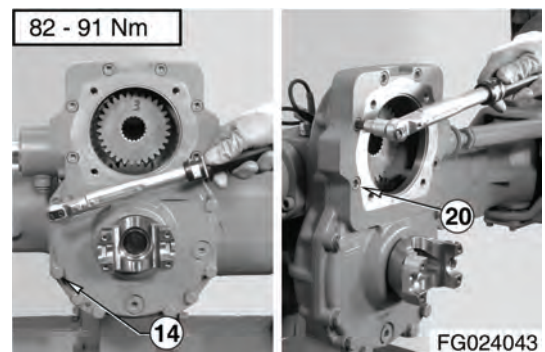
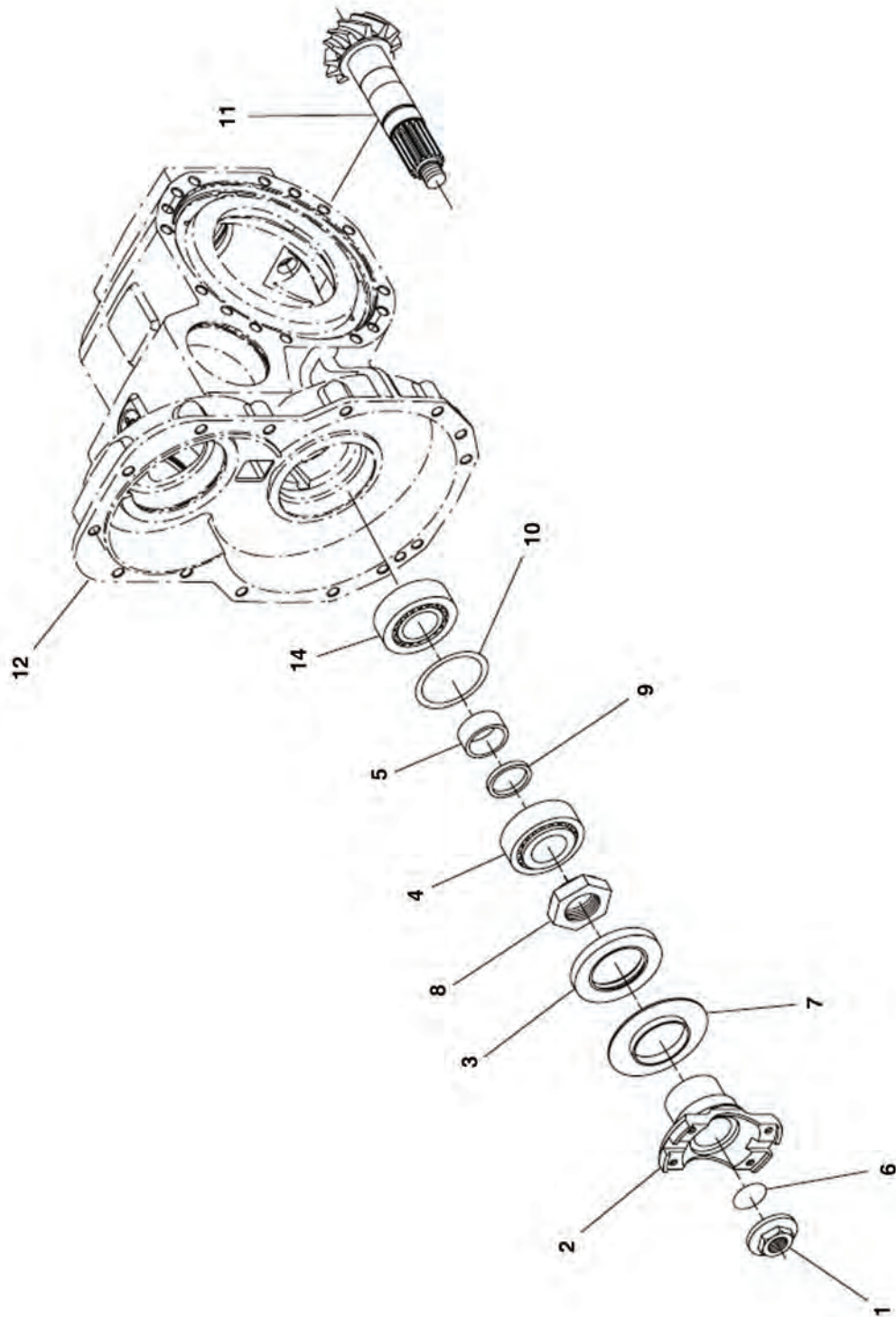


Figure 226

BEVEL PINION



FG024044

Figure 227

Disassembling

1. Position tool T10, so as to avoid pinion rotation.
Unloose and remove the nut (1); also remove the O-ring (6).

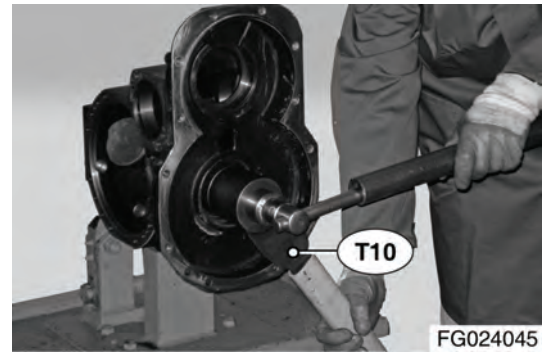


Figure 228

2. Remove the pinion (11), shims and distance piece.

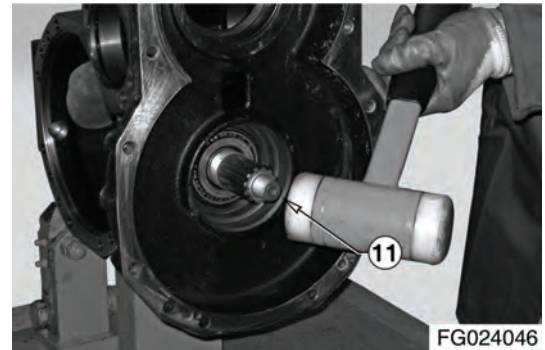


Figure 229

3. Refer and keep to the positions marked during disassembly.

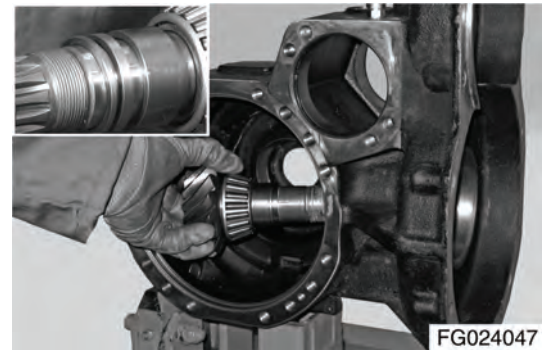


Figure 230

4. Using a puller and a press, remove the inner bearing (4) from the pinion (11).

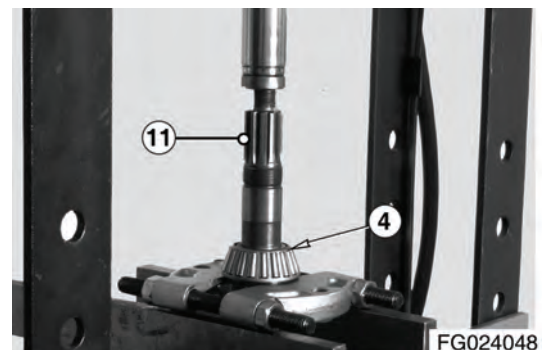


Figure 231

5. Remove the thrust block of the external bearing (14).

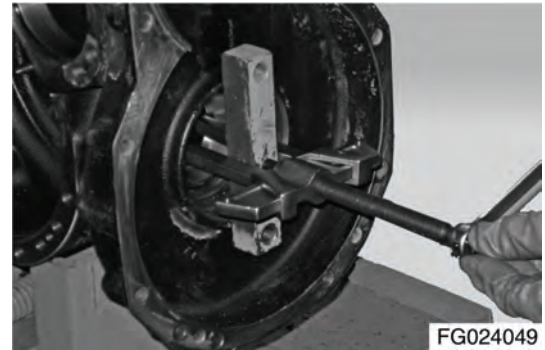


Figure 232

6. Insert a drift in the appropriate holes.

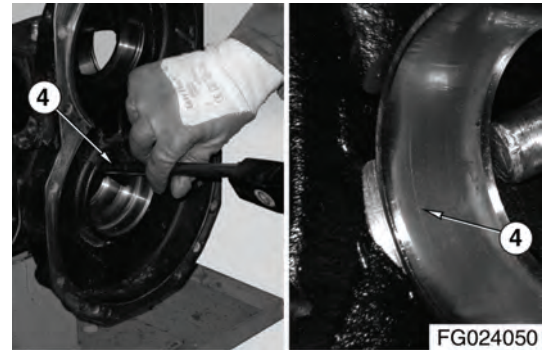


Figure 233

7. Remove the thrust block of the internal bearing (4) as well as the shim washers (10) (S).



Figure 234

8. Remove the snap ring (15).

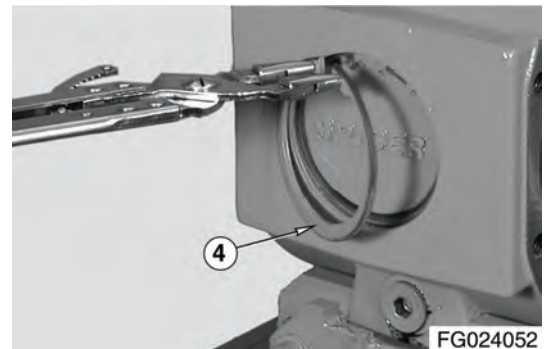
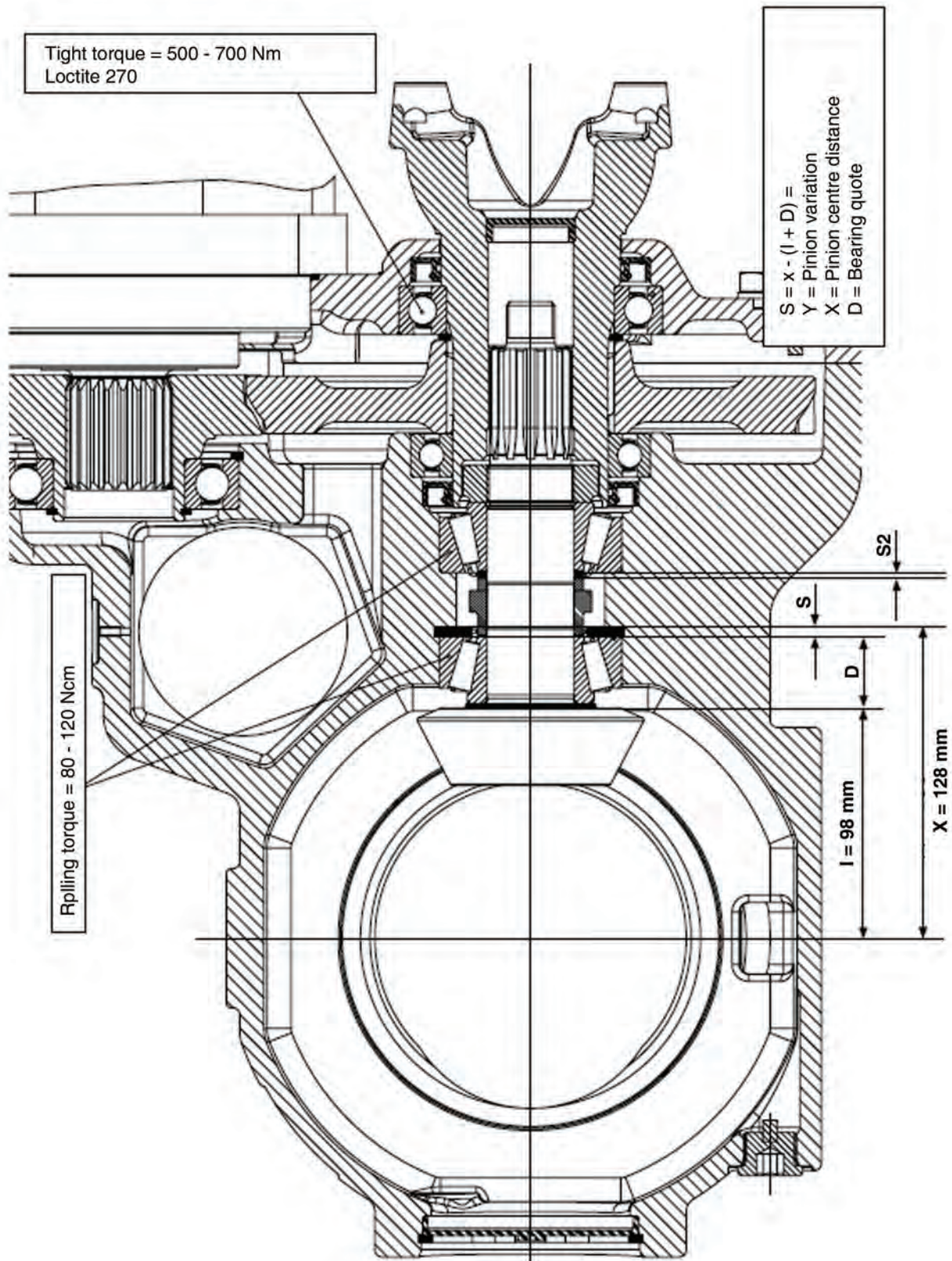


Figure 235

9. Remove the cap (14).



Figure 236



FG024054

Figure 237

Assembling

Calculating Pinion Centre Distance

1. Using a faceplate, reset a centesimal comparator "DG" on a calibrated block (whose known thickness is 30 mm).
Preload the comparator by about 3 mm.

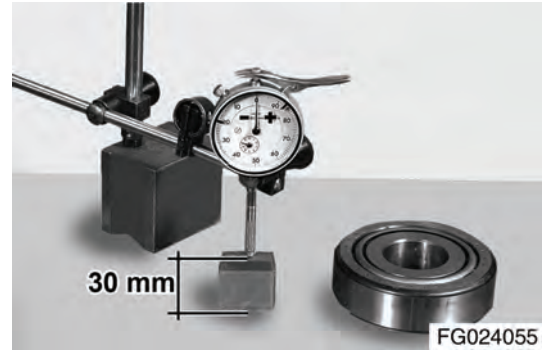


Figure 238

2. Bring inner bearing (4), complete with thrust block, under comparator "DG".

CAUTION

Press the thrust block centrally and carry out several measurements by rotating the thrust block.

- Example: $30 - 0.55 = 29.45 = "D"$.

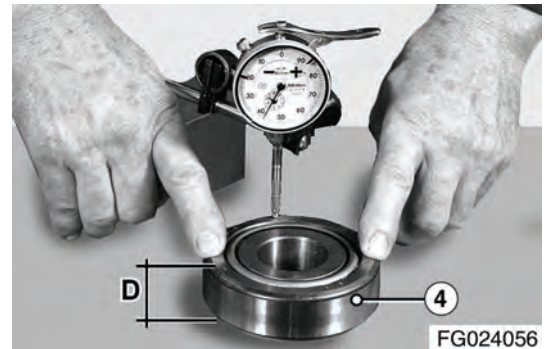


Figure 239

3. Check nominal dimension "I" as marked on the pinion. Add up to or subtract from "I" the variation indicated as "Y" to obtain the actual centre distance "I".

- Example: $I = INT \pm "Y" = 98 - 0.1 = 97.9 \text{ mm}$

NOTE: C61 = Match part number.

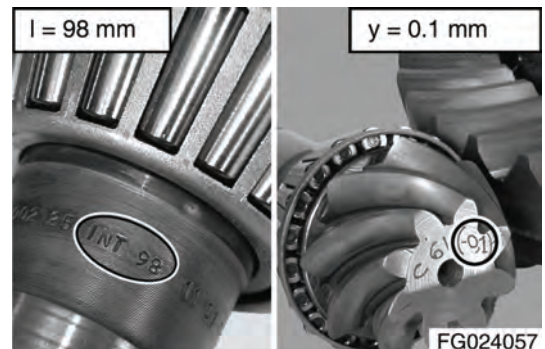


Figure 240

C61 = bevel gear set matching number

(-0.1) = Y variation from the theoretical I = 98

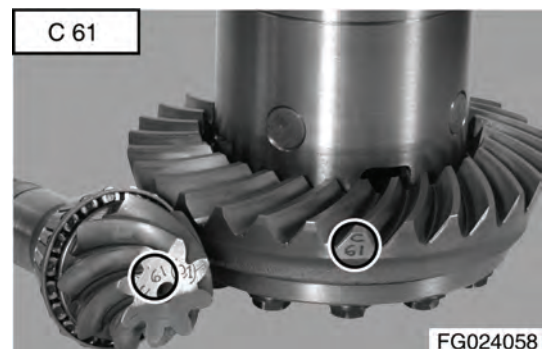


Figure 241

4. Calculate shims "S" for insertion under the thrust block of the inner bearing using the following formula:

- $S = X - (I + D)$ where: X = fixed dimension
I = actual pinion centre distance
D = Total bearing thickness
- Example: $S = 128 - (97.9 + 29.45) = 0,65 \text{ mm}$



Figure 242

5. Using special tool T11.
Insert the thrust block of the bearings (4) and shims (10).

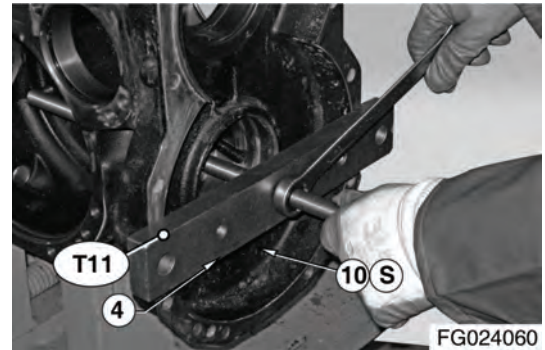


Figure 243

NOTE: Before starting the next stage, make sure that the thrust block has been completely inserted into its seat.

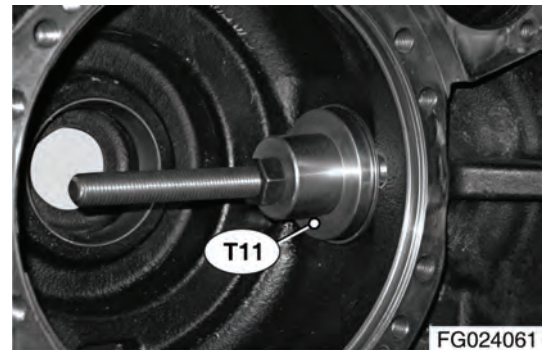


Figure 244

6. Using special tool T11.
Insert the thrust block of the bearings (4) and shims (10).

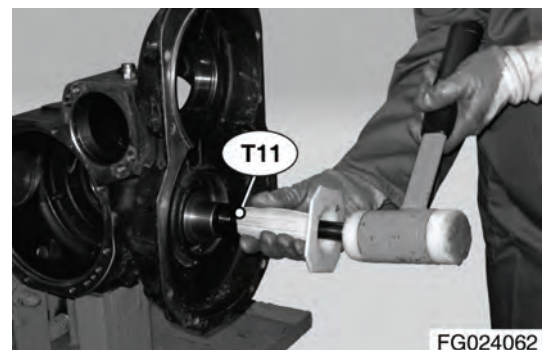
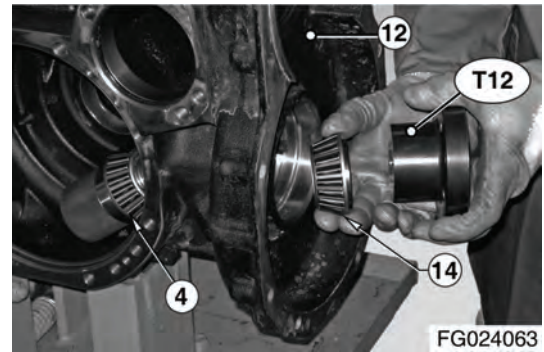


Figure 245

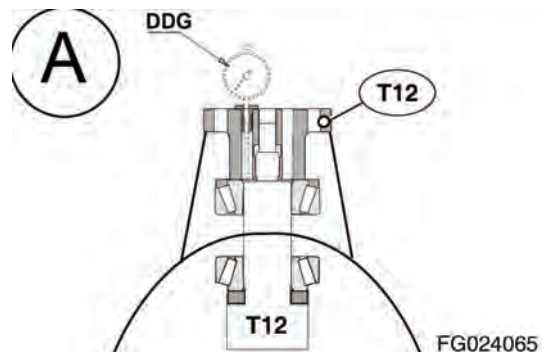
Calculating Pinion Bearings Rolling Torque

1. Introduce tool T12 complete with bearings (4) and (14) into the main body (12); tighten by hand until a rolling torque is definitely obtained.



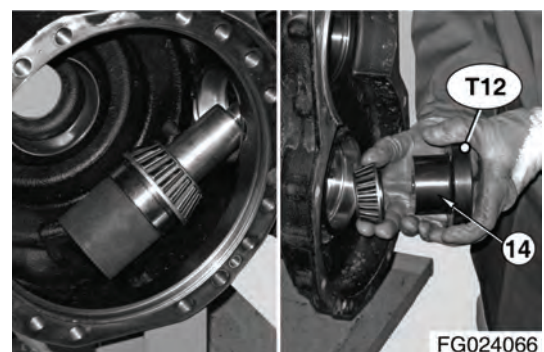
2. Introduce the tracer of a depth comparator "DDG" into either side hole of tool T12.

Reset the comparator with a preload of about 3 mm.



3. Remove the comparator and take out tool T12 and bearing kits from the main body.

Reinstall every part, also introducing a distance piece between bearings (4) and (14). Tighten the entire pack by hand.



4. Assemble on top of the tool T12 and between the two bearings the shim (5) and the largest calibrated shim (9).



Figure 250

5. Measure the difference H using a dial gauge DDG.
- E.g. $H = A - B = 2.93 \text{ mm}$

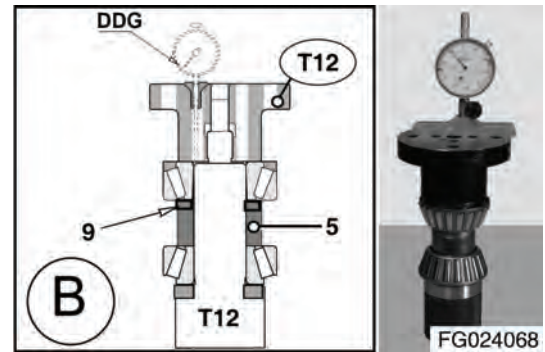


Figure 251

6. Calculate the shim S2 to be inserted.
- E.g. $S2 = H + X1 = 3.01 \text{ mm}$
 - Where $X1 = \text{fixed value to obtain} = 0.07...0.08 \text{ mm}$



Figure 252

7. Heat the bearing to 100°C and assemble it to the pinion shaft.



Figure 253

8. Fit the pinion (11), shim "S2" (10) and distance piece (5) (9) in the main body (12).

NOTE: *The finer shims must be placed in- between the thicker ones.*

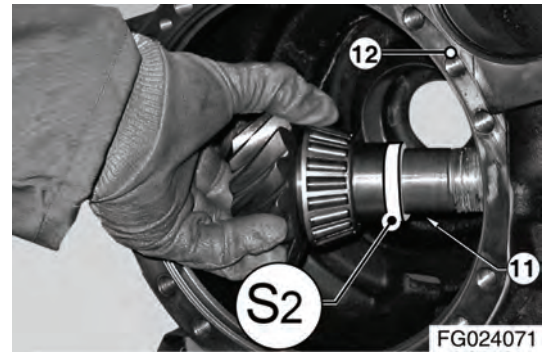


Figure 254

9. Heat the external bearing (14) to a temperature of about 100°C and fit it on to the pinion (11) so as to complete the pack as shown in the figure.

NOTE: *Lightly lubricate bearing with SAE 85W90 oil.*

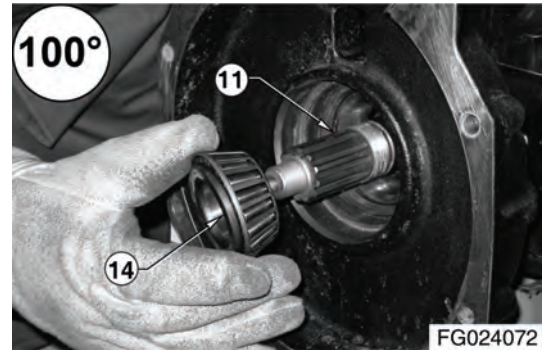


Figure 255

10. Apply Loctite 270 to the thread of the ring nut (8) and screw the nut onto the pinion.

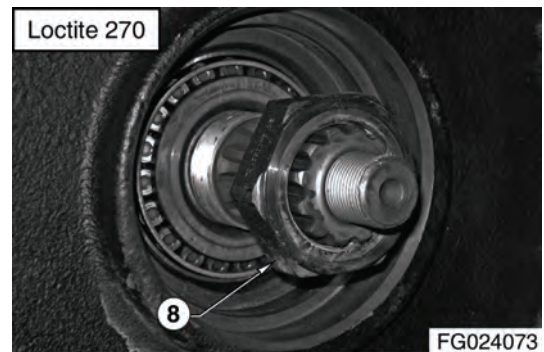


Figure 256

11. Apply onto the pinion (11) the bar-hold and with the help of a torque metre, check the torque of the pinion (11).

- Torque: 500 - 700 Nm



CAUTION

If torque exceeds the maximum value, then the size of shim "S1" (4) between the bearing (9) and the distance piece (3) needs to be increased.

If torque does not reach the set value, increase the torque setting of the ring nut (10) in different stages to obtain a maximum value of 500 Nm.

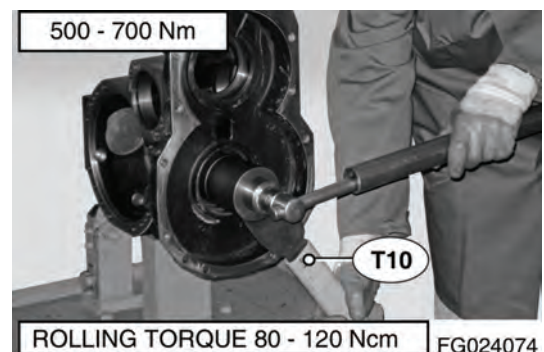


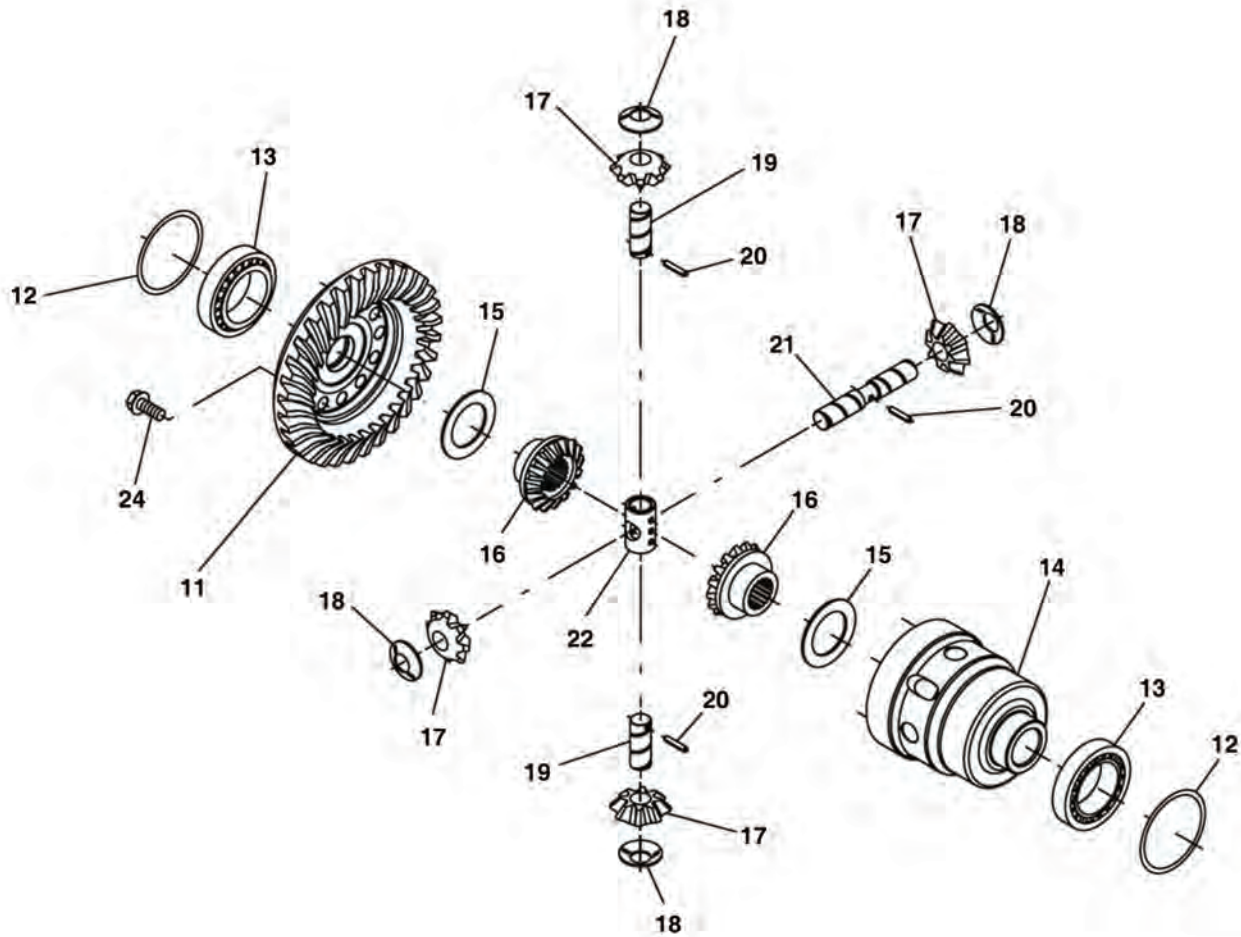
Figure 257



CAUTION

If torque does not reach the minimum value, then the size of shim "S1" (4) needs to be reduced.

DIFFERENTIAL: NORMAL DIFFERENTIAL UNIT



FG024075

Figure 258

Disassembling

1. Connect an external pump to the union piece "P1" of the negative brake and introduce a pressure of 15 ± 30 bar to eliminate the pressure of the belleville washers.

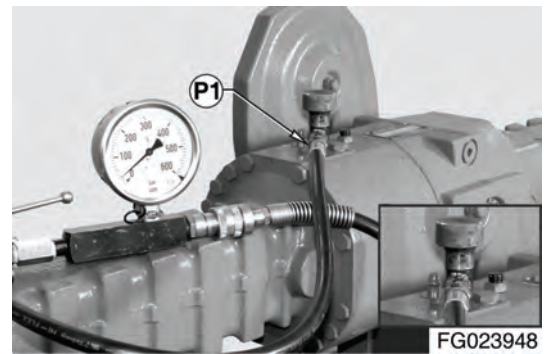


Figure 259

2. Loosen the unlocking screws (30) and remove both stop washers (32).

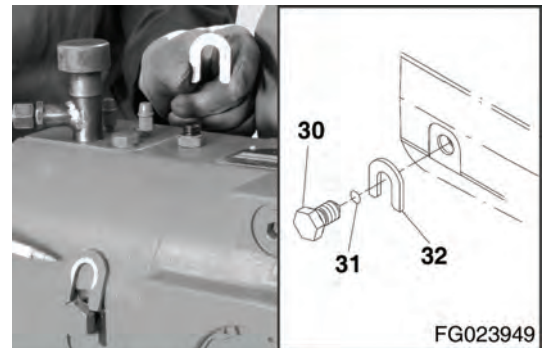


Figure 260

3. Insert block screws to end stroke and release pression.

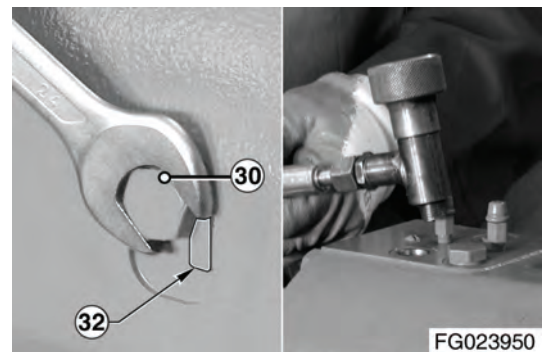


Figure 261

4. Remove the brake side arm and the brake discs pack.
Sling the arm to be removed and connect it to a hoist, remove screws of the crown wheel side arm.
Remove the arm together with the pack of the braking disks. Place the arm on a bench.

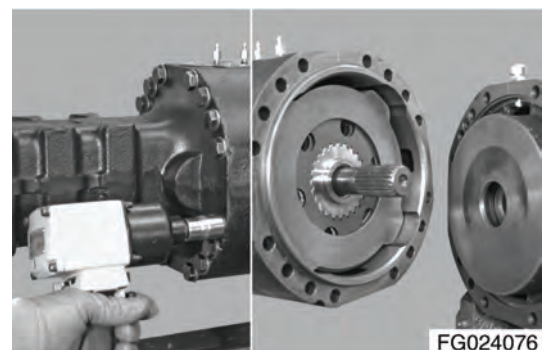


Figure 262

5. Remove the fitting screws from the middle cover.

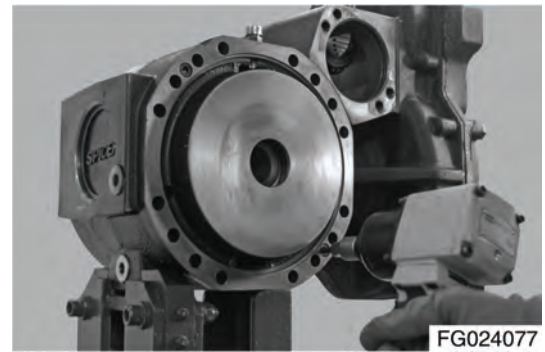


Figure 263

6. Insert a screw-driver in the opposing slots then force and remove the middle cover.

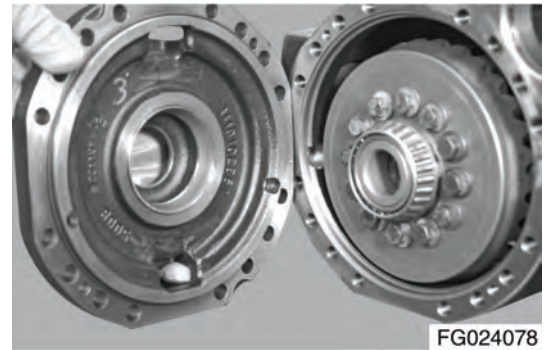


Figure 264

7. If the bearings need replacing (13), extract the external thrust blocks of the bearings (13) from middle cover and central body.

NOTE: *Accurately check the O-ring.*

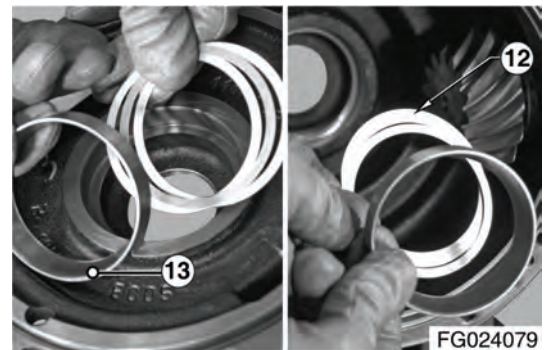


Figure 265

8. Pull out the differential (14).

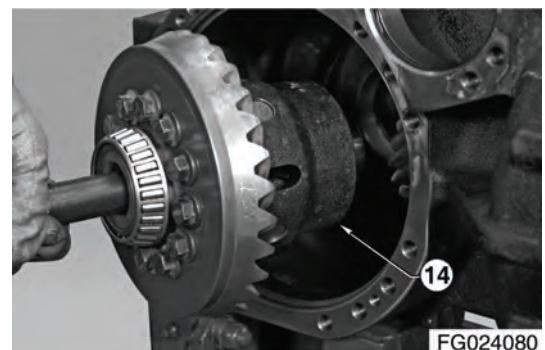


Figure 266

9. If the bearing need replacing, extract the bearing (13) from the differential carrier.

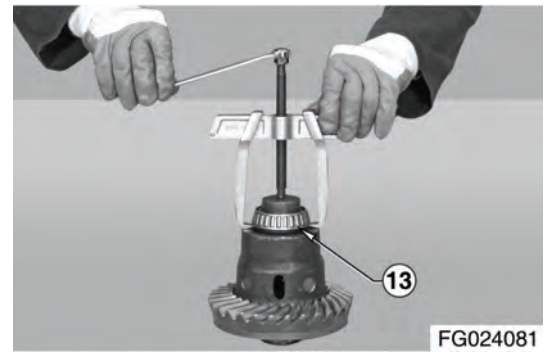


Figure 267

10. Remove fixing screws (24) of the crown wheel; exchange each time when removed.

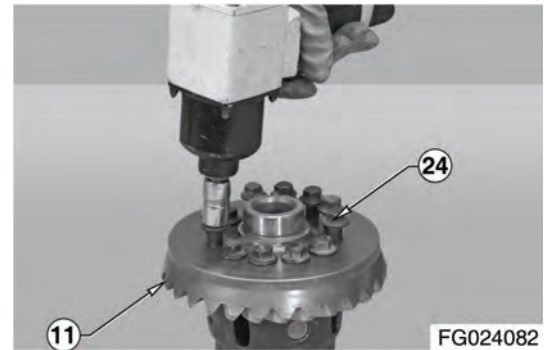


Figure 268

11. Extract the crown wheel (11).

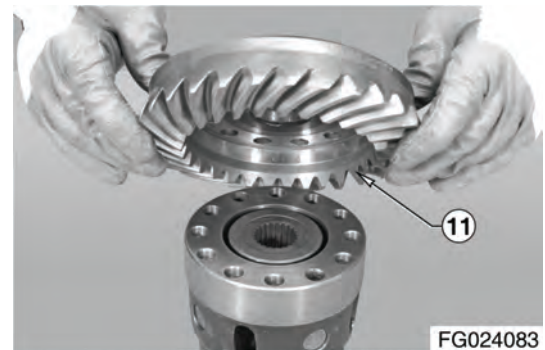


Figure 269

12. Remove the shim washer (15).



Figure 270

13. Remove the planetary gear (16).

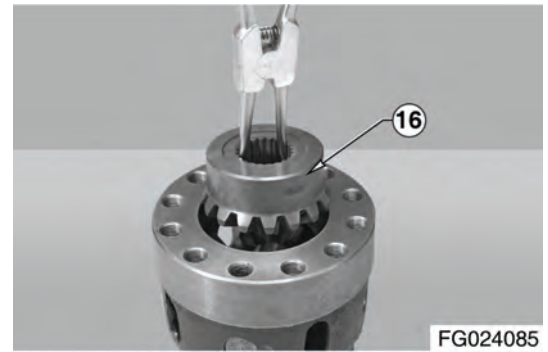


Figure 271

14. Remove the three spider blocking pins (20) by using a pin driver.

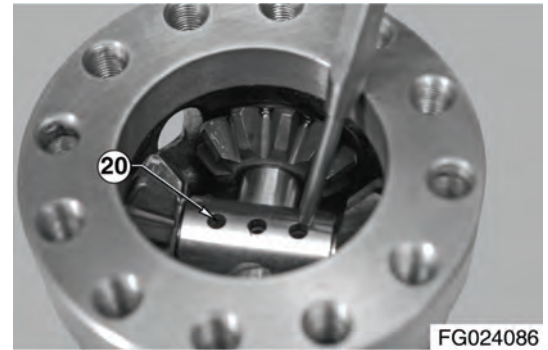


Figure 272

15. Move the two opposite mounted short bolts (19) to the outside of the box using the same pin driver.

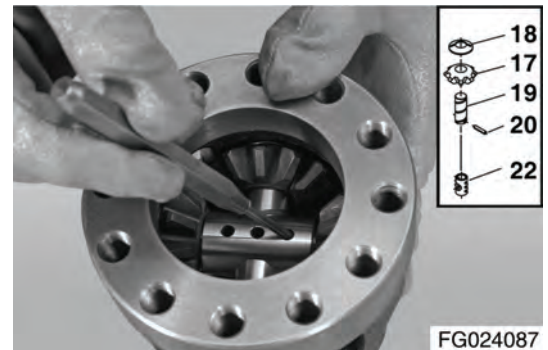


Figure 273

16. Drive out the long bolt (21) and pull out the spider (22) from the centre.

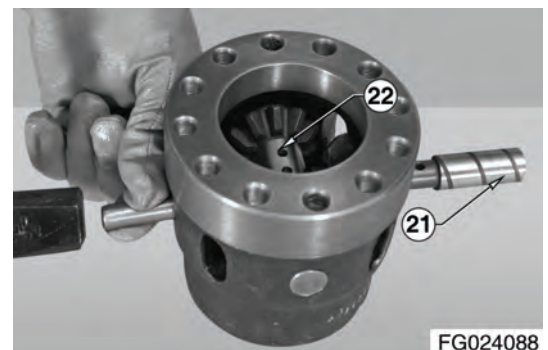


Figure 274

17. Remove the two half bolts (19), spherical washers and satellite wheels.

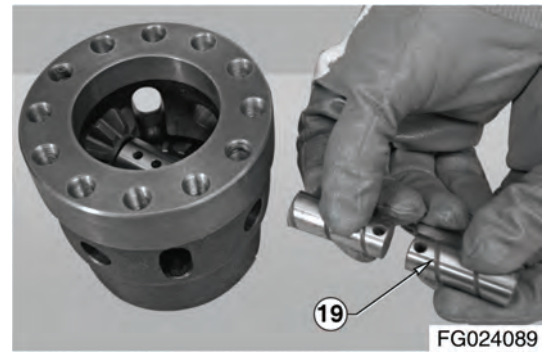


Figure 275

18. Remove long bolt, spherical washers (18) and satellite wheels (17).

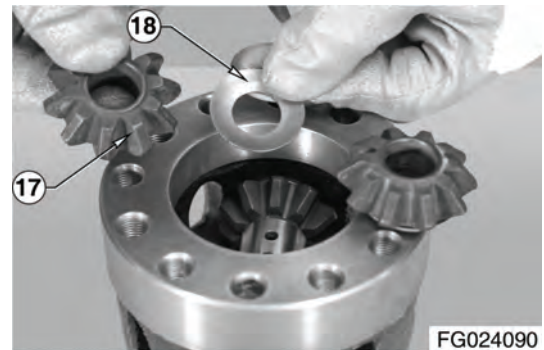


Figure 276

19. Pull out the spider (22) from the centre.



Figure 277

20. Remove the planetary gear (16).

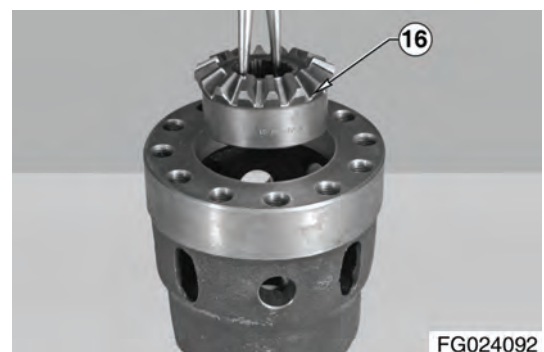


Figure 278

21. Remove the shim washer (15).

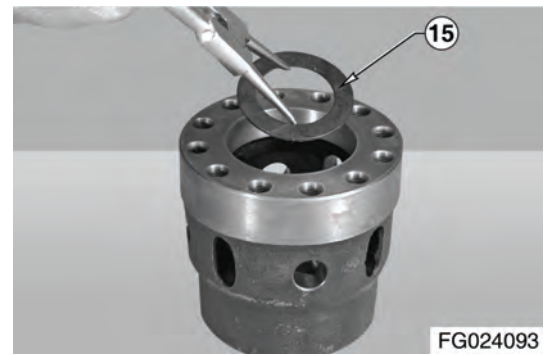
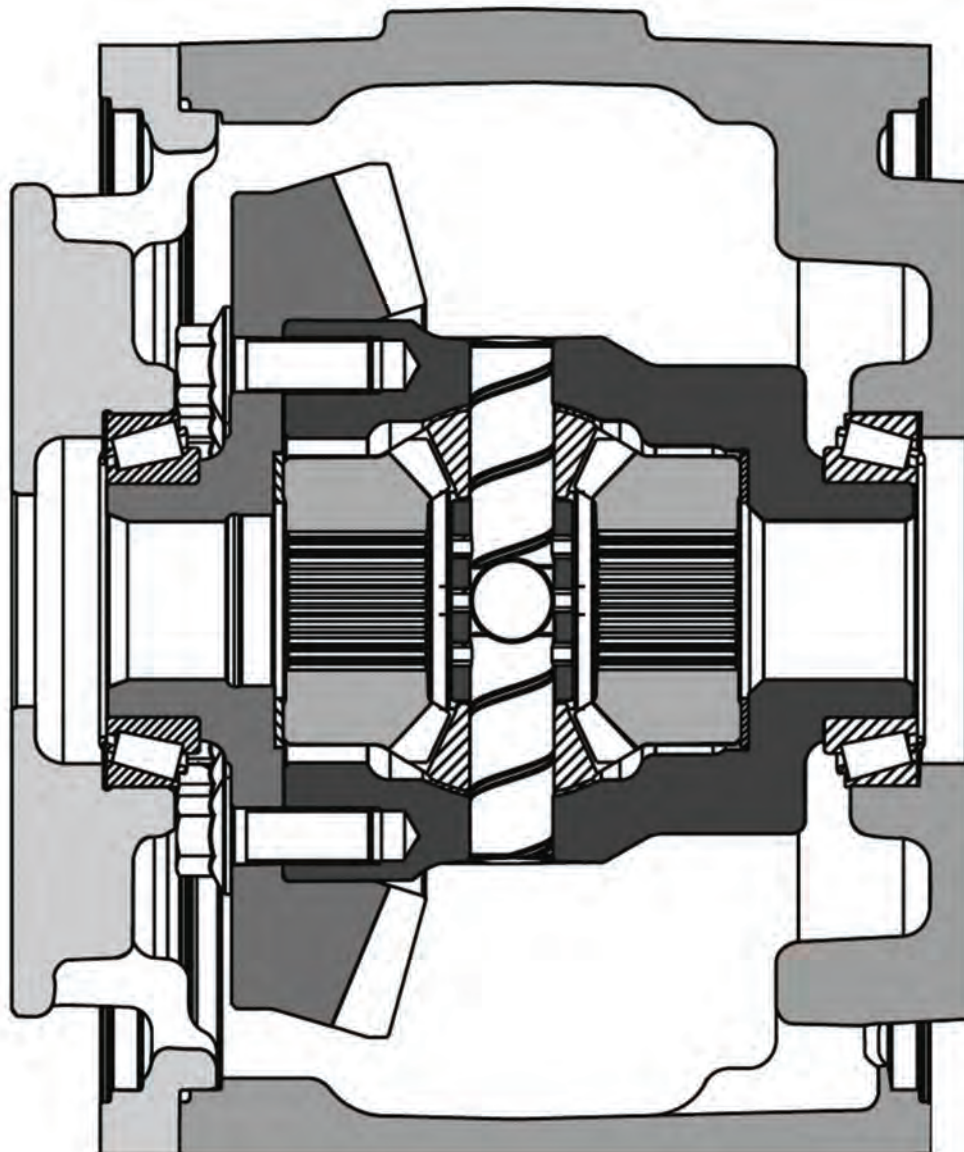


Figure 279



FG024094

Figure 280

Assembling

1. Lubricate and insert washer (15) and planetary wheel (16).

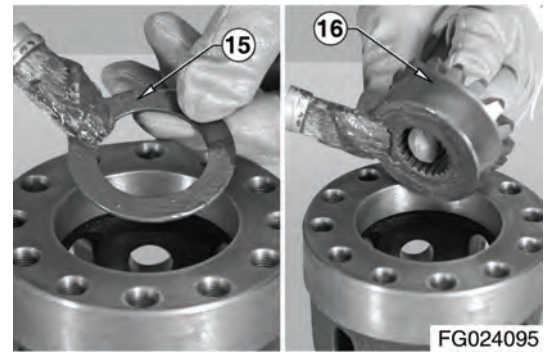


Figure 281

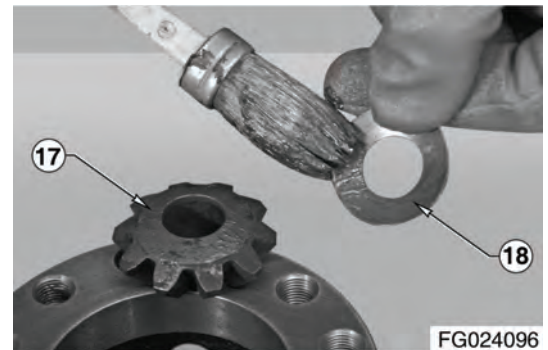


Figure 282

2. Partially insert the long bolt (21), satellite wheels (17) and spherical washers (21).

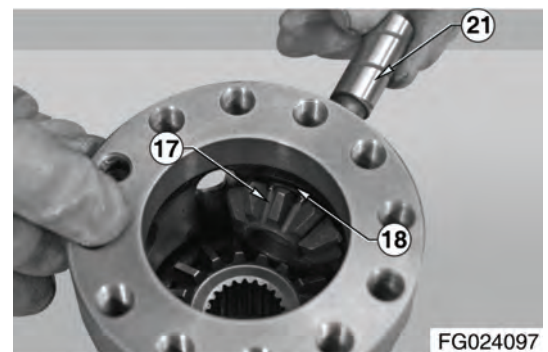


Figure 283

3. Insert the two half bolts (19), spherical washers (18) and satellite wheels (17).

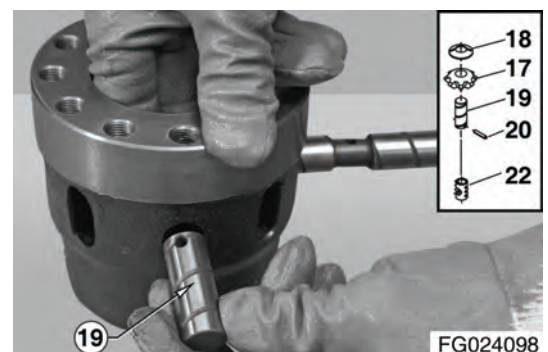


Figure 284

4. Insert spider (22) and completely insert the long bolt (21).

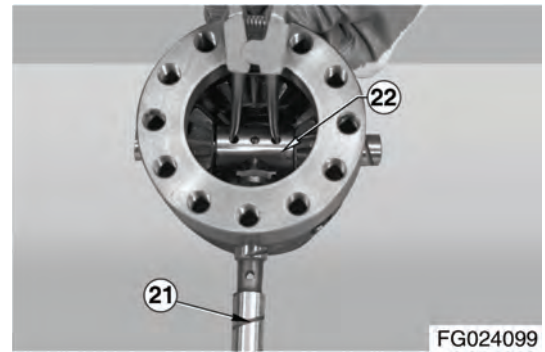


Figure 285

5. Insert completely the bolts (19).

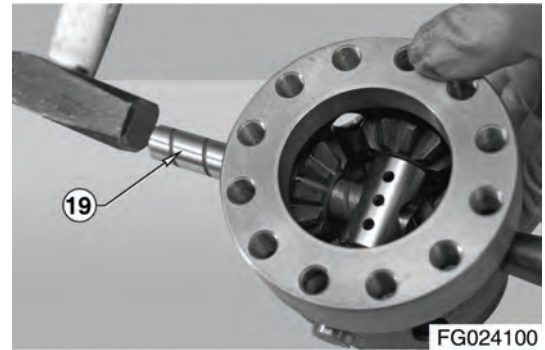


Figure 286

6. Centre the pin holes and insert the 3V pins (20).

NOTE: Check the free rotation of the satellite wheels on the bolts.

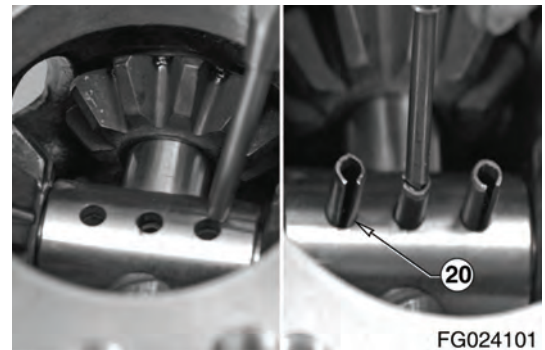


Figure 287

7. Lubricate wheel (16).

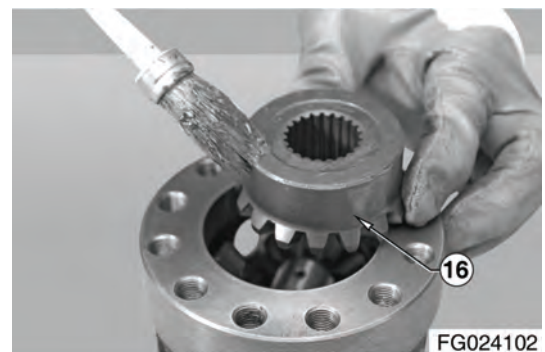


Figure 288

8. Insert planetary gear wheel (16)

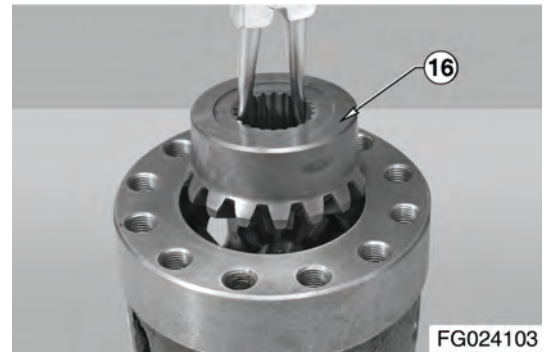


Figure 289

9. Position the shim washer (15) on the crown (11).

NOTE: *In order to hold the shim washer (15) in position, apply grease to it.*



Figure 290

10. Position the crown (11) on the differential carrier and lock it with screws (24) applied with Loctite 270.

NOTE: *Secure the screws using the cross-tightening method.*

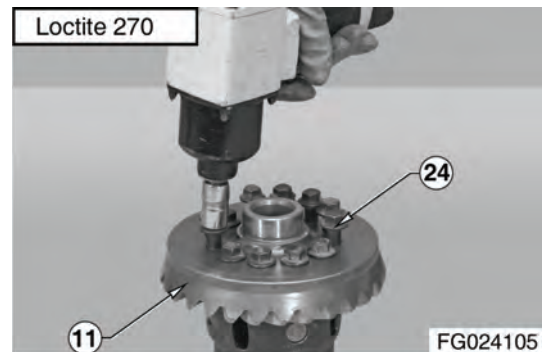


Figure 291

11. Tighten screws with a torque wrench: see table.

NOTE: *Always use new screws to fix the crown wheel. In case the screws are not thread locking pretreated, use Loctite 270.*



Figure 292

12. Assemble the bearing (13).

NOTE: Heat the bearing to 100°C before assembling.

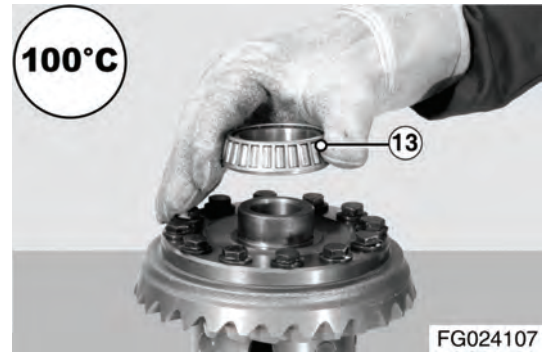


Figure 293

13. If the bearings are replaced, insert the external thrust blocks in the middle cover and in the central body.



Figure 294

14. Position the differential unit in the central body with the help of a bar and fit the middle cover.

NOTE: Thoroughly check the state of the O-ring and make sure that the cover is fitted with the oil discharge in the lower position.



Figure 295

15. Lock the middle cover with screws.

- Torque wrench setting for screw: 23.8 ± 26.2 Nm

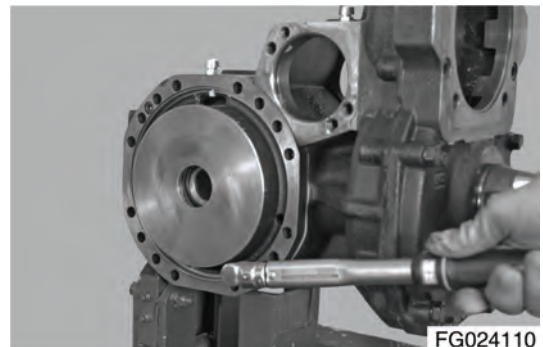


Figure 296

16. Check that the positioning of the sealing ring on the arm is intact; install the complete arm. Lock it into position using two facing screws and washers.

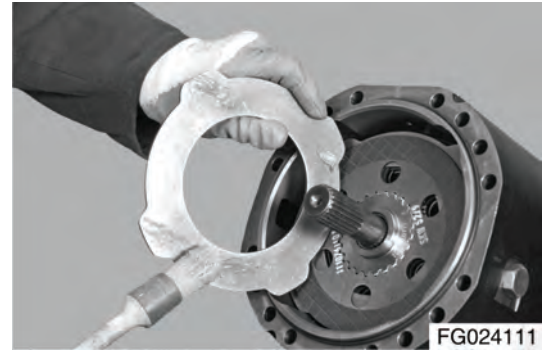
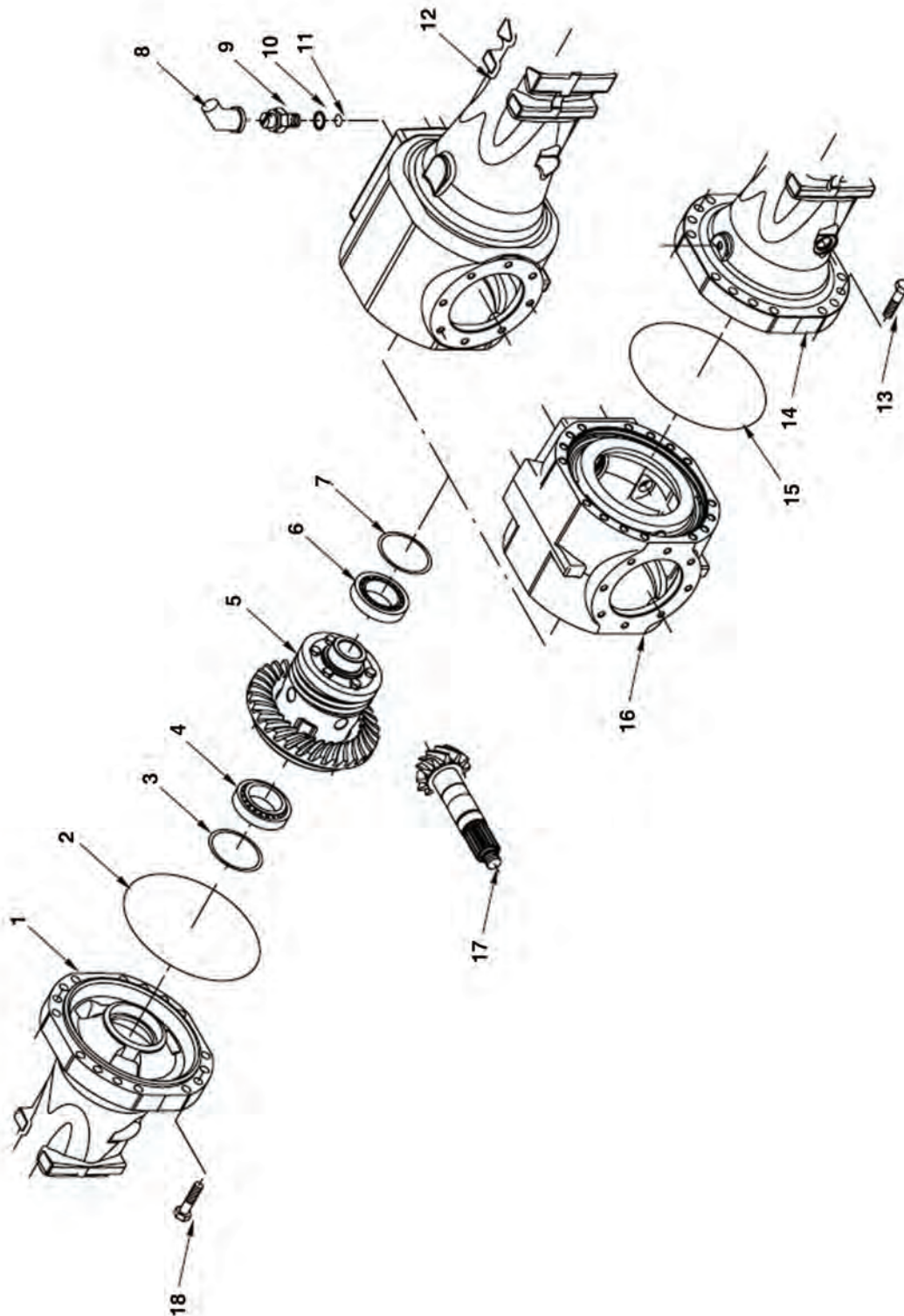


Figure 297

FG024111

RING AND PINION ADJUSTING



FG024112

Figure 298

Setting of the Crown Wheel and Pinion

1. Insert the thrust block of the bearing (6) opposite side of the crown wheel shims (Sb) (7) of an initial thickness of about 0.8 mm.

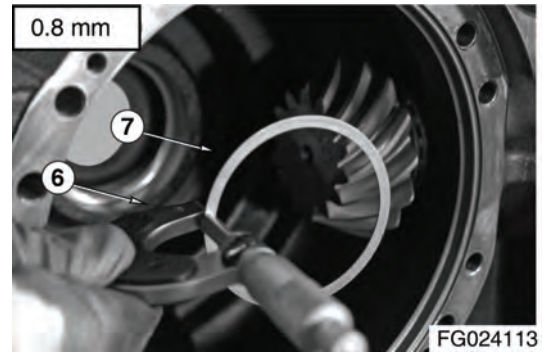


Figure 299

2. Insert the thrust block (6) and the shims (Sb) (7) into the arm.

NOTE: Check to be at end of stroke.

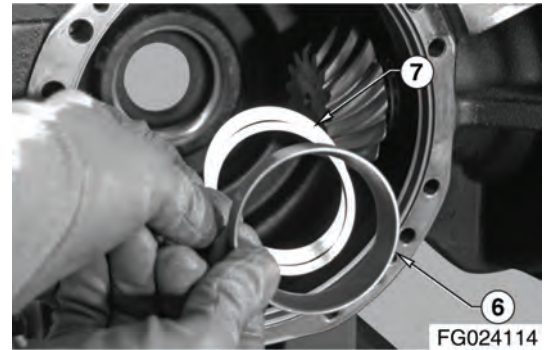


Figure 300

Setting of the Crown Wheel and Pinion

1. Insert thrust block (4) of the bearing shims (Sc) (3) of an initial thickness of about 0.75 mm.

Insert the thrust block and the shims into the arm.

NOTE: Check to be at end of stroke.

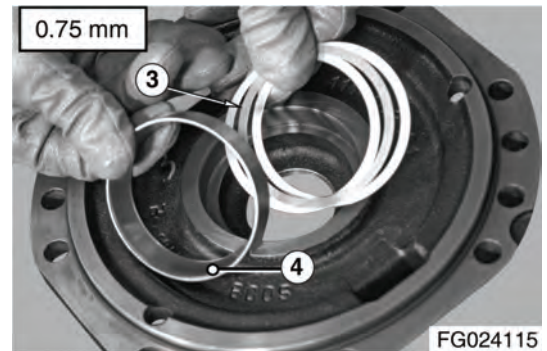


Figure 301

2. Insert complete differential (5).



CAUTION

Do not damage the seat of the O-Ring with the gearwheel.

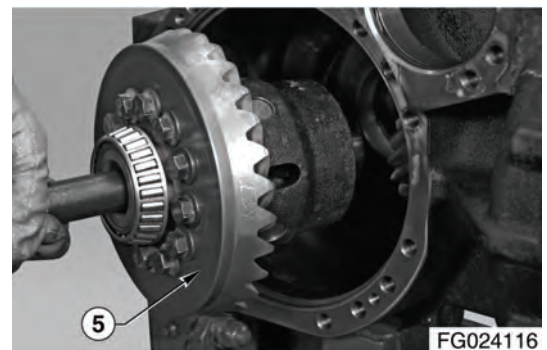


Figure 302

3. Check the O-Ring (2) and grease.

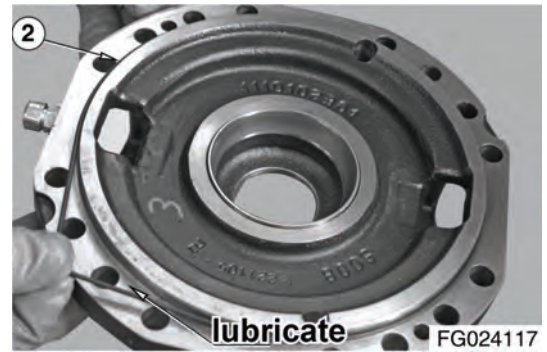


Figure 303

4. Lock the middle cover (5) with screws (4).
 - Torque wrench setting for screw: 23.8 ± 26.2 Nm

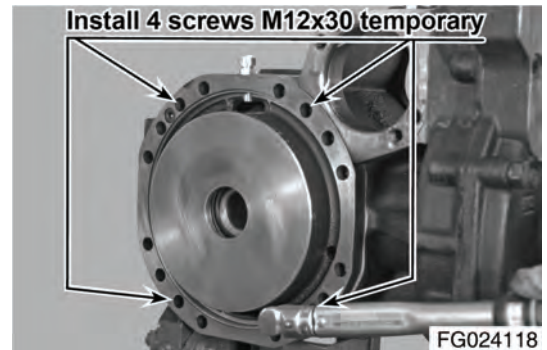


Figure 304

5. Apply torque meter TM to pinion nut and check that torque will increase by 40 - 60 Nm as a result of differential bearing preload.
 - Example: pinion torque: 80 - 120 Nm
 - Pinion + differential torque: 120 - 180 Nm

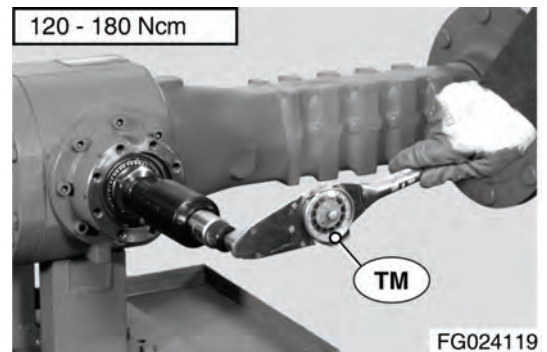


Figure 305

6. Position comparator on the centre of one of the crown teeth, preset it to 1 mm and reset it to zero.
Manually move the crown in both directions to check the existing clearance between pinion and crown.
 - Gap = 0.13 - 0.20 mm

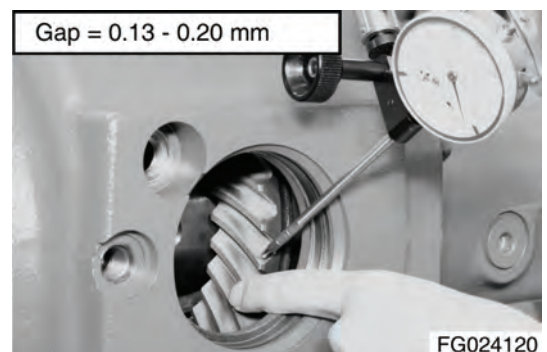


Figure 306

- $+Sc(3) - Sb(7) = \text{reduction gap ring and pinion}$

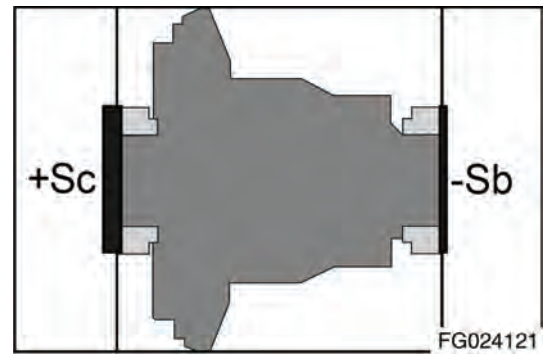


Figure 307

- $-Sc(3) + Sb(7) = \text{increase gap ring and pinion}$

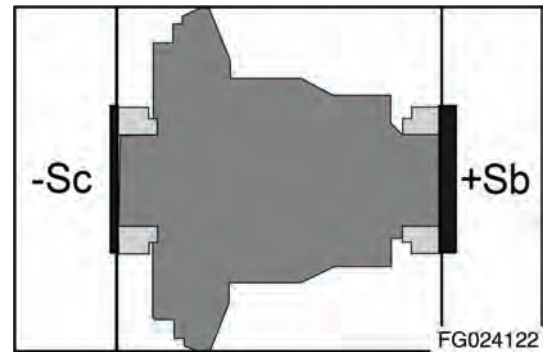


Figure 308

7. Install the crown wheel side arm (1) without half-axle.

NOTE: *To check the torque of the differential, neither of both half-axes must be installed.*

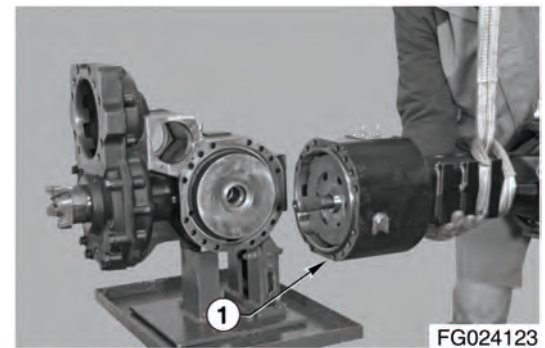


Figure 309

8. Temporarily insert all screws of the arm (18).

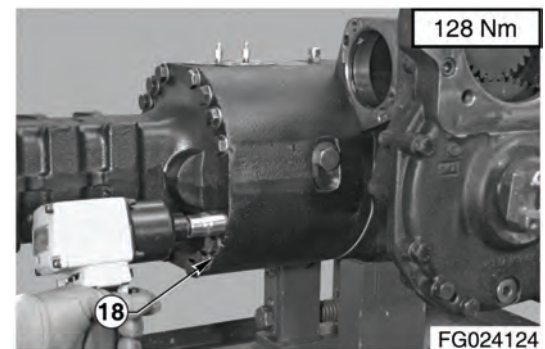


Figure 310

9. Check the flatness of the arms; then lock the arms into their final position, using screws adequately coated with Loctite 242.

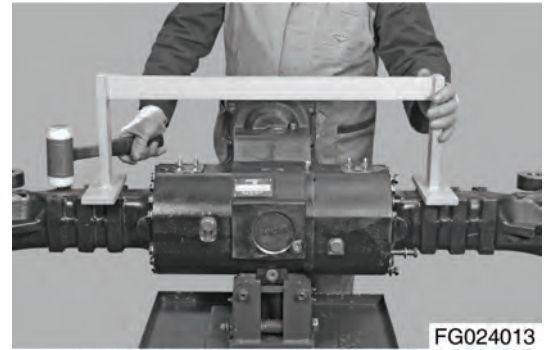


Figure 311

- Torque wrench setting: 128 Nm

NOTE: *Tighten using the criss-cross method.*

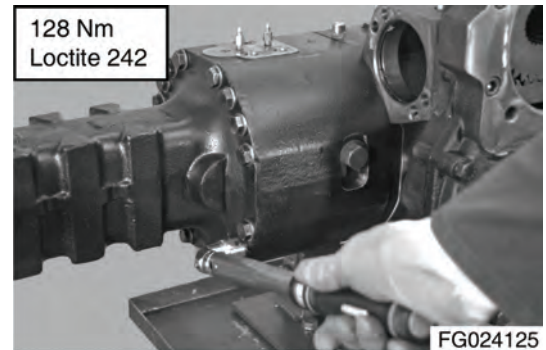


Figure 312

10. Using a driver, fit the cap and position it in its seat with the snap ring.

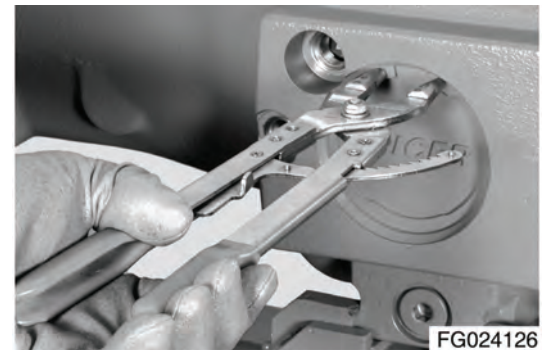


Figure 313

Rear Axle

Edition 1

MEMO

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Rear Axle

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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 ultimately 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
DX55W	7118 and Up

INTRODUCTION

The efficiency and continued operation of mechanical units depend on constant, correct maintenance and also on efficient repair work, should there be a break-down or malfunction. The instructions contained in this manual have been based on a complete overhaul of the unit. However, it is up to the mechanic to decide whether or not it is necessary to assemble only individual components, when partial repair work is needed.

The manual provides a quick and sure guide which, with the use of photographs and diagrams illustrating the various phases of the operations, allows accurate work to be performed. All the information needed for correct disassembly, checks and assembly of each individual component is set out below. In order to remove the differential unit from the vehicle, the manuals provided by the vehicle manufacturer should be consulted. In describing the following operations it is presumed that the unit has already been removed from the vehicle.

IMPORTANT

In order to facilitate work and protect both working surfaces and operators, it is advisable to use proper equipment such as: trestles or supporting benches, plastic or copper hammers, appropriate levers, pullers and specific spanners or wrenches.

Before going on to disassemble the parts and drain the oil, it is best to thoroughly clean the unit, removing any encrusted or accumulated grease.

Introductory Remarks

All the disassembled mechanical units should be thoroughly cleaned with appropriate products and restored or replaced if damage, wear, cracking or seizing have occurred. In particular, thoroughly check the condition of all moving parts (bearings, gears, crown wheel and pinion, shafts) and sealing parts (O-rings, oil shields) which are subject to major stress and wear. In any case, it is advisable to replace the seals every time a component is overhauled or repaired. During assembly, the sealing rings must be lubricated on the sealing edge.

In the case of the crown wheel and pinion, replacement of one component requires the replacement of the other one. During assembly, the prescribed pre-loading, backlash and torque of parts must be maintained.

Classification

This manual classifies units according to part numbers. For a correct interpretation, classification is indicated as follows:

When no classification is given, disassembly and assembly operations are the same for all versions.

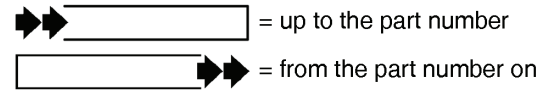


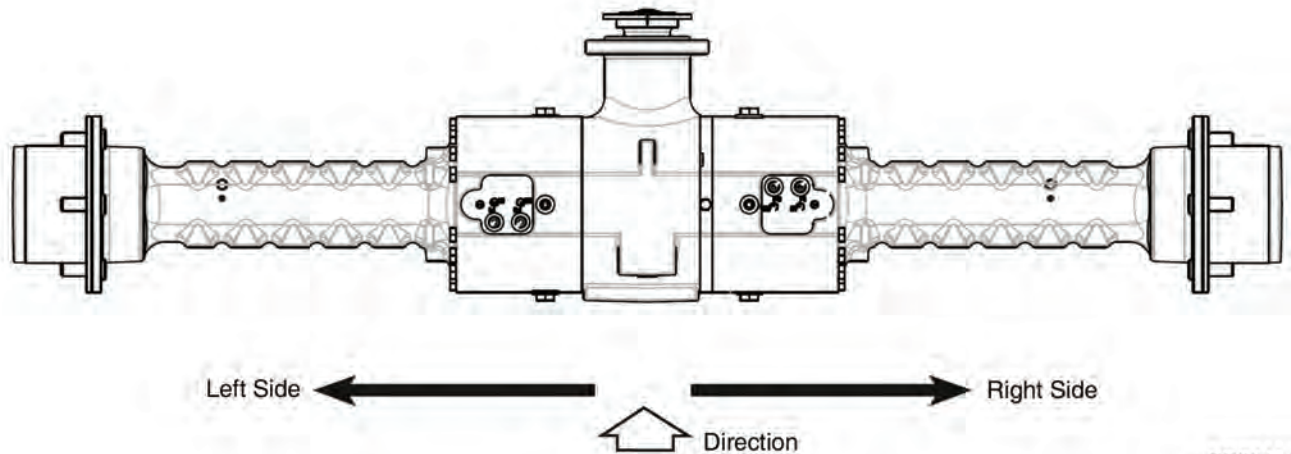
Figure 1

FG024140

Specific Equipment and Spare parts

The drawings of all specific tools required for maintenance and repair work can be found at the end of this manual; spare parts may be ordered either from the vehicle manufacturer or directly from the Service Centers or Authorized Distributors of SPICER.

DEFINITION OF VIEWPOINTS

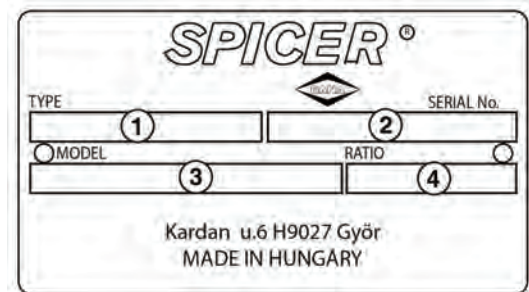


FG024142

Figure 2

DATA PLATE

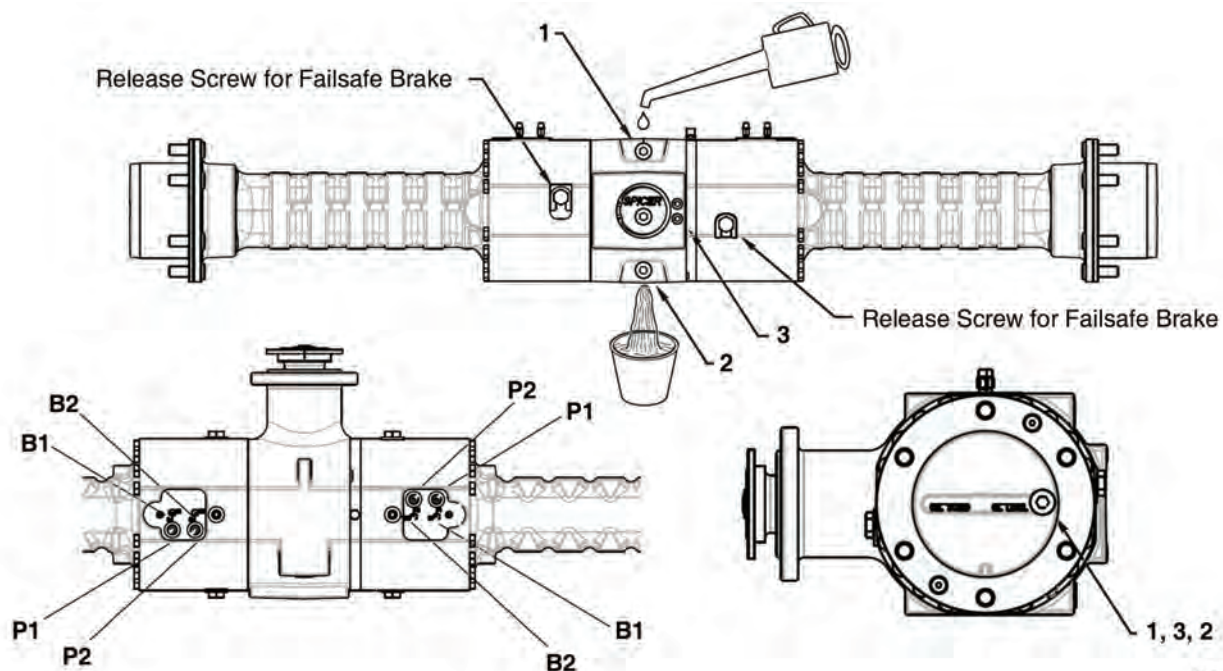
Reference Number	Description
1	Unit Type
2	Serial Number
3	Model Type
4	Reduction Ratio



FG024141

Figure 3

MAINTENANCE POINTS



FG024143

Figure 4

Reference Number	Description
1	Oil Filling Plug
2	Oil Draining Plug

Reference Number	Description
3	Check Level Plug

P1 - Connector for failsafe brake working pressure 15/30 bar

P2 - Connector for hydraulic operated disk brakes oil immersed max 80 bar

B1/B2 - Bleeding screw for brakes

MAINTENANCE INTERVALS

Operation		Frequency	Lubricants	
Check Levels	Differential	Monthly	- SAE85W90 (API GL4 - MIL L-2105) - With additives for oil-bath brakes.	
	Planetary Reduction	Every 200 hours		
Oil Change	Differential Std. LS or 100%	Every 1,000/1,200 hours*		
	Planetary Reduction	Every 1,000/1,200 hours*		
	Planetary Reduction W/brakes	Every 1,000/1,200hours*		
Recommended to set axle's oil changes according to the machine maintenance intervals: If working in heavy conditions half intervals should be used * Initially after 100 working hours.				
Operation	Member	Conditions	Frequency	Lubricants
Greasing	Steering/Suspension Articulation	Normal Work	Every 50 hours	Molikote
		Awkward Work	Every 200 hours	

ADJUSTMENT AND CHECKS

Unit	Operation	Frequency	Service Brake Circuit
Negative Brake	Adjustment	Every 1,000 hours*	Only for mineral oil use e.g. ATF Dexron II. Make sure that master cylinder seals are suitable for mineral oil.
Service Brake	Adjustment	Every 500 hours	
Wheel Nuts	Tightening	Every 200 hours	
* Initially after 100 working hours ** Initially after 10 working hours			

SCREW-LOCKING, SEALING AND LUBRICATING MATERIALS

1. Locking, sealing and lubricating materials referred to in this manual are the same used in the shop-floor.
2. The table below gives an account of the typical application of each single material, in order to facilitate replacement with similar products marketed by different brand names with different trade marks.

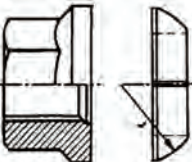
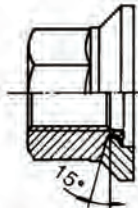
Denomination	Application
Loctite 242	Anaerobic product apt to prevent the loosening of screws, nuts and plugs. Used for medium-strength locking. Before using it, completely remove any lubricant by using the specific activator.
Loctite 243	The oleocompatible alternative to 242. Does not require the activation of lubricated surfaces.
Loctite 270	Anaerobic product for very-high strength locking of screws and nuts. Before using it, completely remove any lubricant by using the specific activator. To remove parts, it may be necessary to heat them at 80°C approx.
Loctite 275	Anaerobic product suitable for high-strength locking and sealing of large threaded parts, bolts and stud bolts, for pipe sealing and for protecting parts against tampering; suitable for sealing coupling surfaces with a max. Diametrical clearance of 0.25 mm.
Loctite 510	Anaerobic product for the hermetic sealing of flanged units and screw holes communicating with fluids. Can seal clearances between flanges up to 0.2 mm.
Loctite 577	Quick anaerobic sealant for sealing threaded portions of conical or cylindrical unions up to M80. Before using it, remove any lubricant with the specific activator. After polymerisation, disassembly may result rather difficult, so heating may be necessary for larger diameters.
Loctite 638	Anaerobic adhesive for fast and high-strength gluing of cylindrical metal joints (hub on shaft). Can glue together parts with clearance ranging between 0.1 and 0.25 mm.
Loctite 648	Anaerobic adhesive for fast and medium-strength gluing of cylindrical metal joints (hub on shaft). Can glue together parts with radial clearance below 0.1 mm.
(AREXONS) Repositionable Jointing Compound for Seals	Solvent-cased sealing compound for elastic seals, drying through evaporation. Used for sealing the outer diameter of sealing rings for rotating shafts with outer metal reinforcement.
Silicone	Semi-fluid adhesive material used for sealing and filling and to protect components from environmental and physical elements. Polymerises with non-corrosive dampness.
(Tecno Lube/101) Silicone-based Grease	Highly adhesive synthetic grease, with silicone compounds added. Applied to adjustment screws with hole communicating with oil-type fluids. Used when frequent adjusting is required.
Molikote (Dow Corning)	Lubricating compound containing molybdenum disulphide, used to lubricate articulation pins and to prevent sticking and oxidation of parts that are not lubricated on a regular basis.
(Lithium-based) Grease	Applied to bearings, sliding parts and used to lubricate seals or parts during assembly.

NOTES ON SAFETY PRECAUTIONS

1. During all operations described in this manual, the axle should be fastened onto a trestle, while the other parts mentioned should rest on supporting benches.
2. When removing one of the arms, an anti-tilting safety trestle should be placed under the other arm.
3. When working on an arm that is fitted on the machine, make sure that the supporting trestles are correctly positioned and that the machine is locked lengthways.
4. Do not admit any other person inside the work area; mark off the area, hang warning signs and remove the ignition key from the machine.
5. Use only clean, quality tools; discard all worn, damaged, low-quality or improvised wrenches and tools. Ensure that all dynamometric wrenches have been checked and calibrated.
6. Always wear gloves and non-slip rubber shoes when performing repair work.
7. Should you stain a surface with oil, remove marks straight away.
8. Dispose of all lubricants, seals, rags and solvents once work has been completed. Treat them as special waste and dispose of them according to the relative law provisions obtaining in the country where the axles are being overhauled.
9. Make sure that only weak solvents are used for cleaning purposes; avoid using turpentine, dilutants and toluol-, xylol-based or similar solvents; use light solvents such as Kerosene, mineral spirits or water-based, environment friendly solvents.
10. For the sake of clarity, the parts that do not normally need to be removed have not been reproduced in some of the diagrams.
11. The terms RIGHT and LEFT in this manual refer to the position of the operator facing the axle from the side opposite the drive.
12. After repair work has been completed, accurately touch up any coated part that may have been damaged.

Wheel Nuts Tightening Torques

Recommended from Rim's O.E.M. with Reference to the Quality of the Rim's Material.

Wheel Nuts Characteristic	Wheel Stud Thread	Recommended Wheel Nuts Torque		Nut Fixing's Solution
		Rim Material Quality		
		St 37	**St 52	
Wheel nuts with integrate spherical collar	M18 x 1.5	330 Nm	460 Nm	 FG024426
	M20 x 1.5	490 Nm	630 Nm	
	M22 x 1.5	630 Nm	740 Nm	
Flat collar wheel nuts with separate spherical lock washer	M18 x 1.5	270 Nm	360 Nm	 FG024427
	M20 x 1.5	360 Nm	450 Nm	
	M22 x 1.5	460 Nm	550 Nm	
Wheel nuts with integrate seat captive washer	M18 x 1.5	260 Nm	360 Nm	 FG024428
	M20 x 1.5	350 Nm	500 Nm	
	M22 x 1.5	450 Nm	650 Nm	
The wheel nuts tightening torque is not related only on nut and stud caratteristic (diameter, thread pitch dimension, material), to have the correct torque, must be considered also the rim's quality material.				
** Rim's material st 52 is recommended by dana on axles application, it is the optimum for our nut and stud fixing coupling.				

The Dana Official Tightening Torque Table, that is Incluede on Each Maintenance Service Manual, Show the Torque Figure Related to the Bolt Characteristic Only.

Dana Official Tightening Torque Table		
Nut Material Quality 8.8 & 10.9	Stud Material Quality 10.9	*Allow Tight Torque Nm
M18 x 1.5	M18 x 1.5	442 : 489
M20 x 1.5	M20 x 1.5	613 : 677
M22 x 1.5	M22 x 1.5	822 : 908
*The torque image on nut and stud coupling must be related on stud material quality (for dana axle is 10.9 only).		

CONVERSION TABLE

Units of Pressure

Units of Weight						Units of Torque					
	N	daN	kN	kg	lbs		Nm	daNm	kNm	kg•m	lb in
1 N	1	0.1	0.001	0.102	0.225	1 Nm	1	0.1	0.001	0.102	8.854
1 daN	10	1	0.01	0.02	2.25	1 daNm	10	1	0.01	1.02	88.54
1 kN	1000	100	1	102	225	1 kNm	1000	100	1	102	8854
1 kg	9.81	0.981	0.00981	1	2.205	1 kg•m	9.81	0.981	0.00981	1	86.8
						1 lb in	0.1129	0.01129	0.0001129	0.01152	1

TIGHTENING TORQUES

Unit: Nm

Size of Bolt		Type of Bolt					
		8.8		10.9		12.9	
		Normal	Normal + Loctite 270	Normal	Normal + Loctite 270	Normal	Normal + Loctite 270
Coarse Pitch	M6 x 1	9.5 - 10.5	10.5 - 11.5	14.3 - 15.7	15.2 - 16.8	16.2 - 17.8	18.1 - 20.0
	M8 x 1.25	23.8 - 26.2	25.6 - 28.4	34.2 - 37.8	36.7 - 40.5	39.0 - 43.0	43.7 - 48.3
	M10 x 1.5	48 - 53	52 - 58	68 - 75	73 - 81	80 - 88	88 - 97
	M12 x 1.75	82 - 91	90 - 100	116 - 128	126 - 139	139 - 153	152 - 168
	M14 x 2	129 - 143	143 - 158	182 - 202	200 - 221	221 - 244	238 - 263
	M16 x 2	200 - 221	219 - 242	283 - 312	309 - 341	337 - 373	371 - 410
	M18 x 2.5	276 - 305	299 - 331	390 - 431	428 - 473	466 - 515	509 - 562
	M20 x 2.5	390 - 431	428 - 473	553 - 611	603 - 667	660 - 730	722 - 798
	M22 x 2.5	523 - 578	575 - 635	746 - 824	817 - 903	893 - 987	974 - 1076
	M24 x 3	675 - 746	732 - 809	950 - 1050	1040 - 1150	1140 - 1260	1240 - 1370
	M27 x 3	998 - 1103	1088 - 1202	1411 - 1559	1539 - 1701	1710 - 1890	1838 - 2032
	M30 x 3.5	1378 - 1523	1473 - 1628	1914 - 2115	2085 - 2305	2280 - 2520	2494 - 2757
Fine Pitch	M8 x 1	25.7 - 28.3	27.5 - 30.5	36.2 - 39.8	40 - 44	42.8 - 47.2	47.5 - 52.5
	M10 x 1.25	49.4 - 54.6	55.2 - 61.0	71.5 - 78.5	78 - 86	86 - 94	93 - 103
	M12 x 1.25	90 - 100	98 - 109	128 - 142	139 - 154	152 - 168	166 - 184
	M12 x 1.5	86 - 95	94 - 104	120 - 132	133 - 147	143 - 158	159 - 175
	M14 x 1.5	143 - 158	157 - 173	200 - 222	219 - 242	238 - 263	261 - 289
	M16 x 1.5	214 - 236	233 - 257	302 - 334	333 - 368	361 - 399	394 - 436
	M18 x 1.5	312 - 345	342 - 378	442 - 489	485 - 536	527 - 583	580 - 641
	M20 x 1.5	437 - 483	475 - 525	613 - 677	674 - 745	736 - 814	808 - 893
	M22 x 1.5	581 - 642	637 - 704	822 - 908	903 - 998	998 - 1103	1078 - 1191
	M24 x 2	741 - 819	808 - 893	1045 - 1155	1140 - 1260	1235 - 1365	1363 - 1507
	M27 x 2	1083 - 1197	1178 - 1302	1520 - 1680	1672 - 1848	1834 - 2027	2000 - 2210
	M30 x 2	1511 - 1670	1648 - 1822	2138 - 2363	2332 - 2577	2565 - 2835	2788 - 3082

THE PLANETARY REDUCTION AND THE COMPLETE STEERING CASE

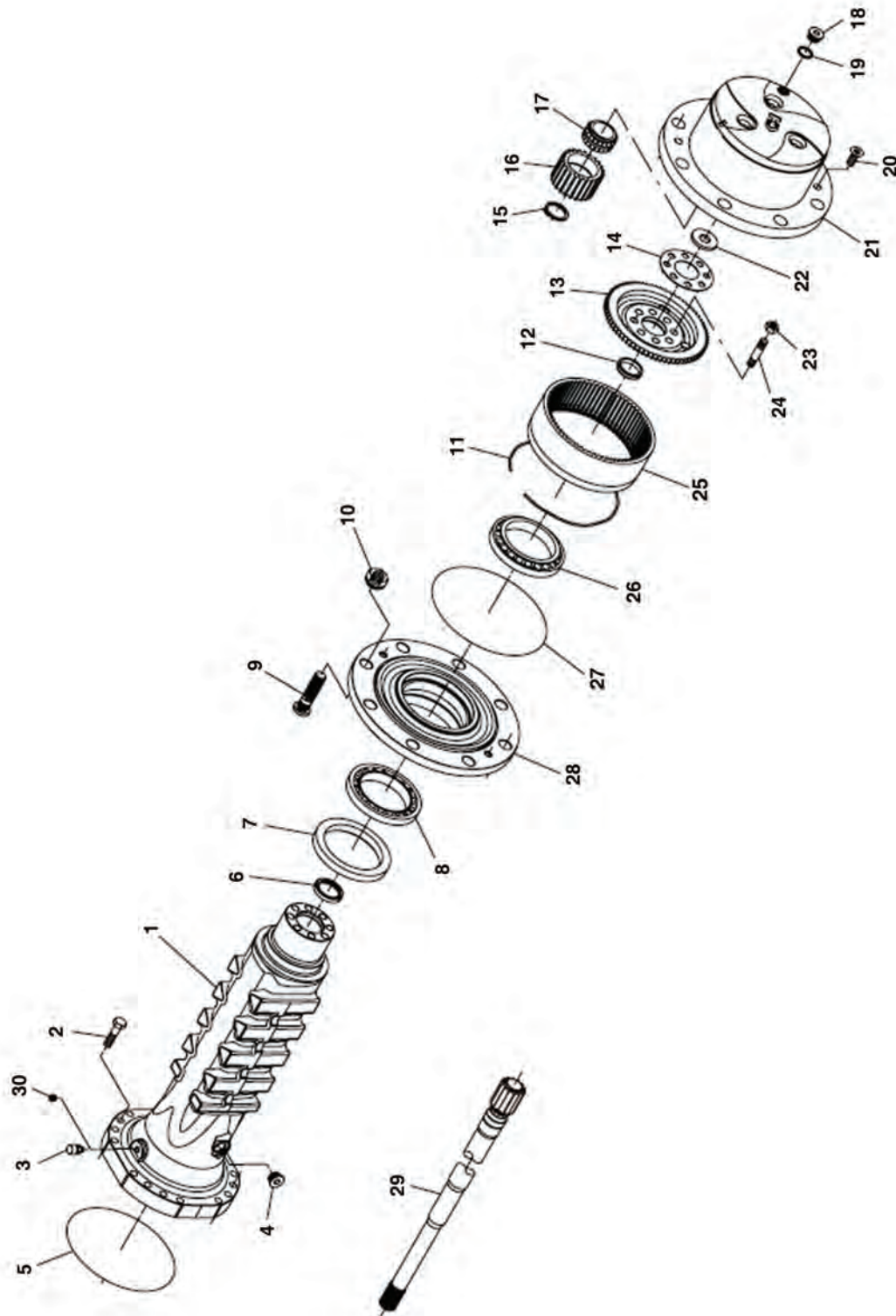


Figure 5

FG024146

Disassembling

1. Remove the locking screws (20) of planetary cover (21).

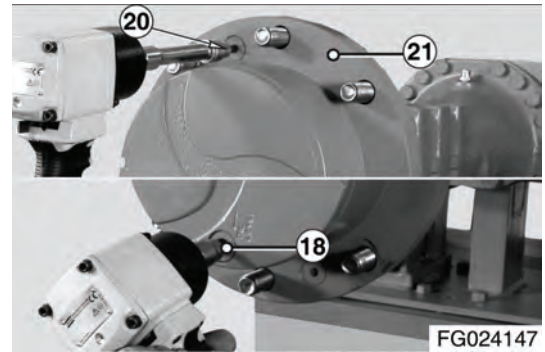


Figure 6

2. Using two screwdrivers or two levers inserted in the slots provided, pry the planetary cover (21) away from the wheel hub.

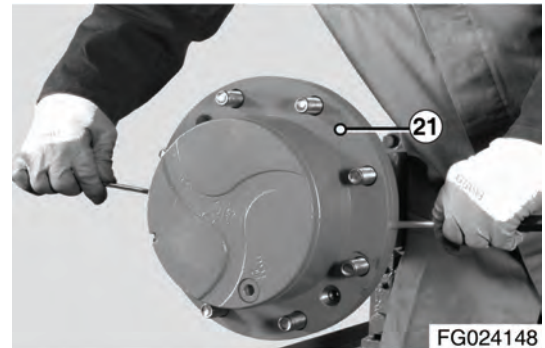


Figure 7

3. Remove the cover (21).



Figure 8

4. Remove the axle half shaft (29).

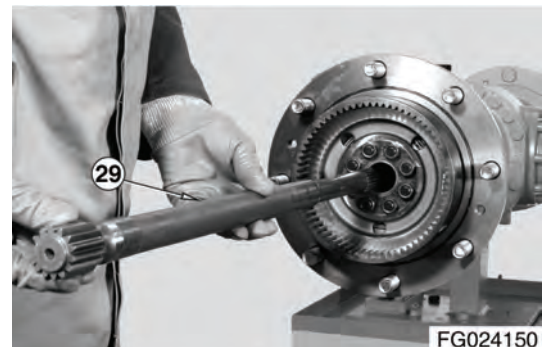


Figure 9

5. Loosen the nuts (23) and remove them.

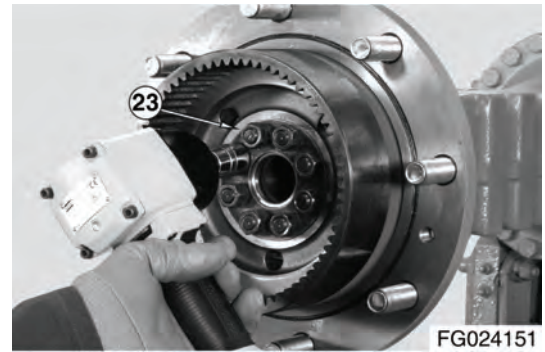


Figure 10

6. Loosen the nuts (23) and remove them.

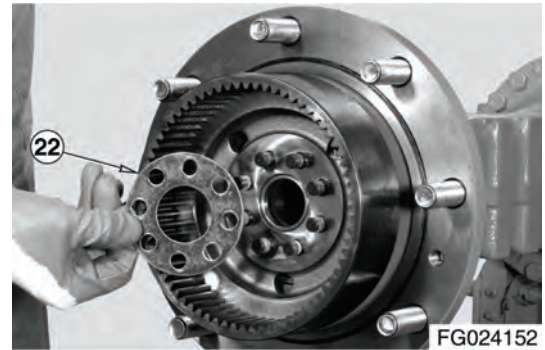


Figure 11

7. Using an extractor and applying a counter pressure to the screws (24), disengage the crown wheel (25) from the hub (28).

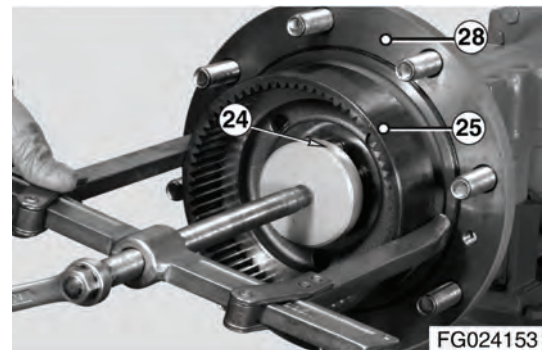


Figure 12

8. Remove the crown (25).

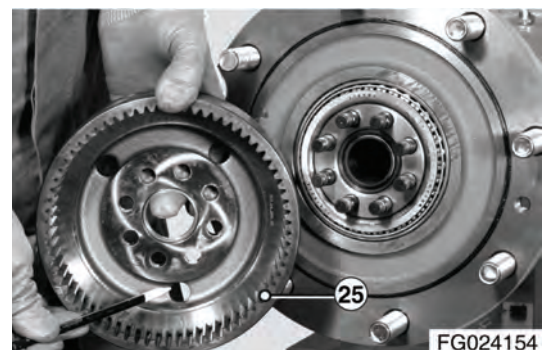


Figure 13

9. With the help of a hammer, shift the hub (28) and the external.

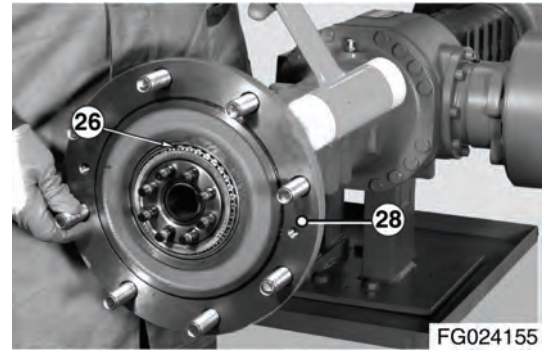


Figure 14

10. Extract the external bearing (26).

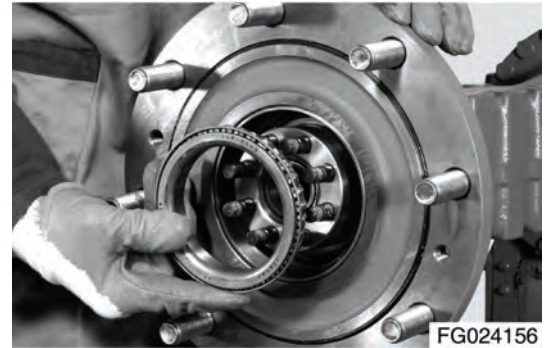


Figure 15

11. Remove the internal bearing (8) and the hub (28).

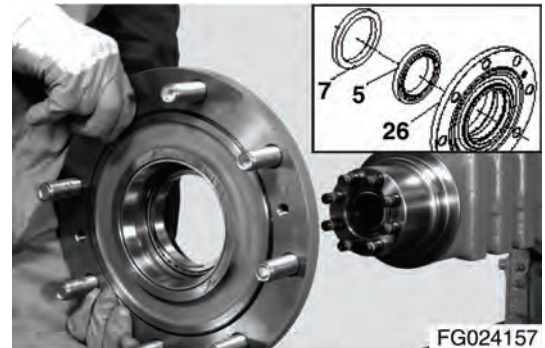


Figure 16

12. Using an extractor, remove the seal ring (6).

NOTE: Note down the direction of assembly of snap ring.

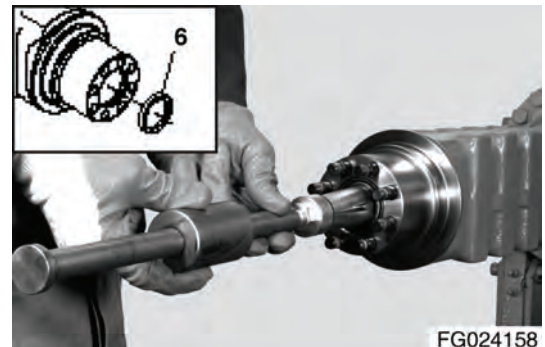


Figure 17

13. Remove the safety spring rings (15) of the planetary gears (17).

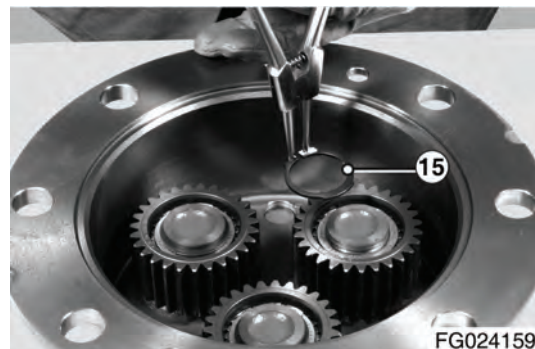


Figure 18

14. Remove the planetary gears (17).

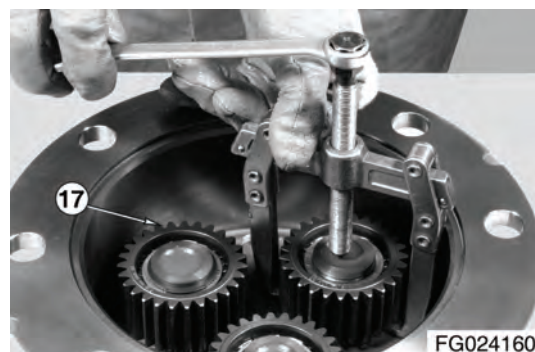


Figure 19

NOTE: Note down direction of assembly of planetary gears.



Figure 20

15. Remove the seal ring (7) from the hub (28).

NOTE: Note down direction of assembly.



CAUTION

The seal ring may not be reused.



Figure 21

16. Remove the internal bearing (8) and sealing ring (7).

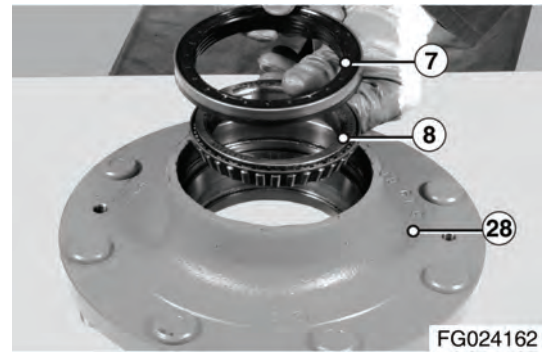


Figure 22

17. Remove the external thrust blocks of bearings, using a pindriver.

NOTE: *Hammer in an alternate sequence to prevent crawling and deformation of the thrust blocks.*

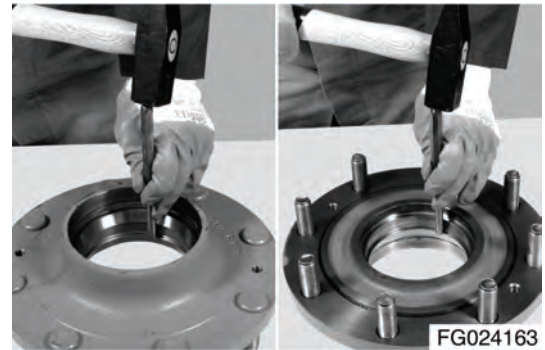


Figure 23

Assembling

1. Position the lower part of tool T1 and the thrust block of the external bearing (26).

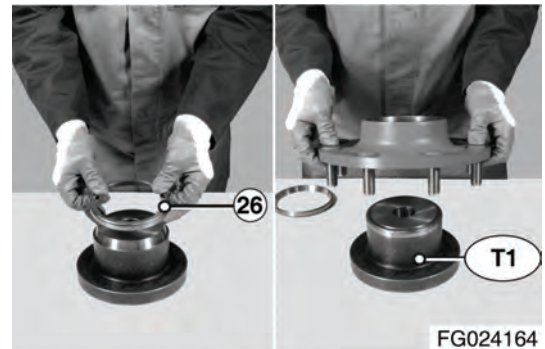


Figure 24

2. Lubricate the seats of the bearings and position the hub (28) on tool T1; position the thrust block of the internal bearing (7).

NOTE: *Check that the thrust block is correctly oriented.*

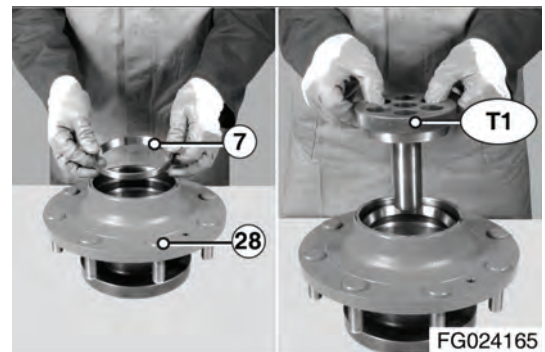


Figure 25

3. Fit the bearing (8) and seal ring (7) into the internal thrust block.

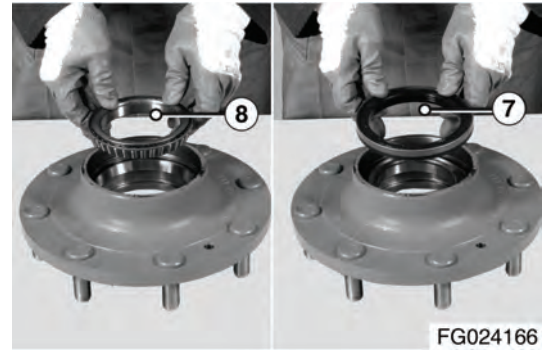


Figure 26

4. Using special tool T2 apply a repositionable jointing compound for seals to the outer surface of the sealing ring (7). Position the sealing ring (7) in the hub (28).

NOTE: Check that the ring (7) is correctly oriented.

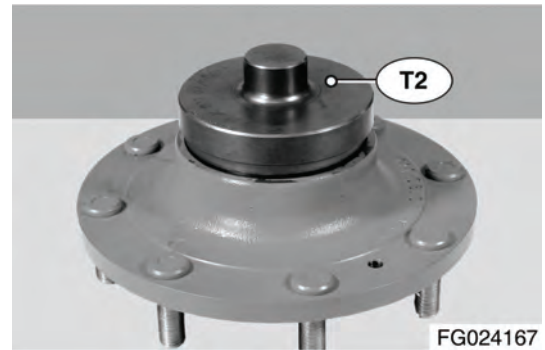


Figure 27

5. Fit the planetary gear (16) onto the planetary gear cover (21).



CAUTION

The jointed portion of the internal ring of the bearings must face the bottom of the pin.

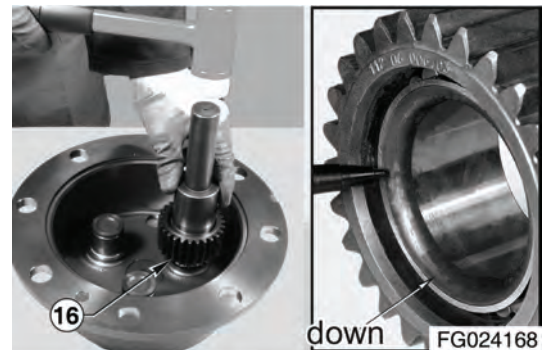


Figure 28

6. Lock into position the planetary gears (16) with the snap rings (15).



Figure 29

7. Lubricate and fit the sealing ring (6) onto tool T3; install the rings into the arm.

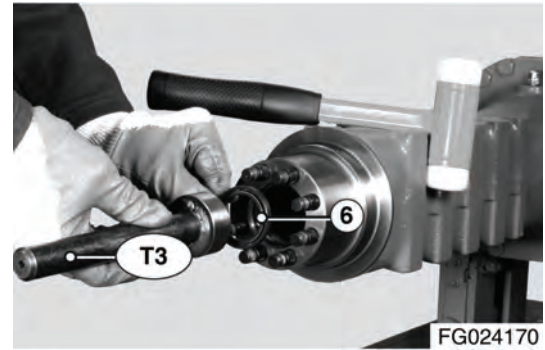


Figure 30



CAUTION

Pay particular attention to the direction of assembly of the rings.

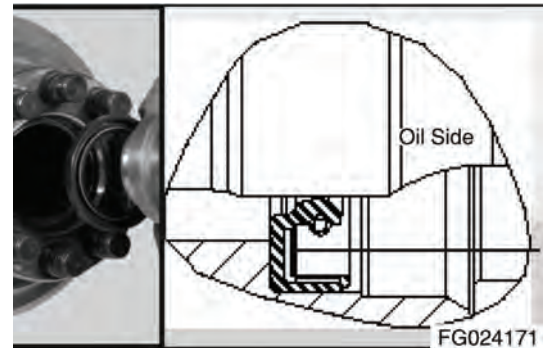


Figure 31

8. Install the wheel hub.



Figure 32

9. Install the external bearing (26).

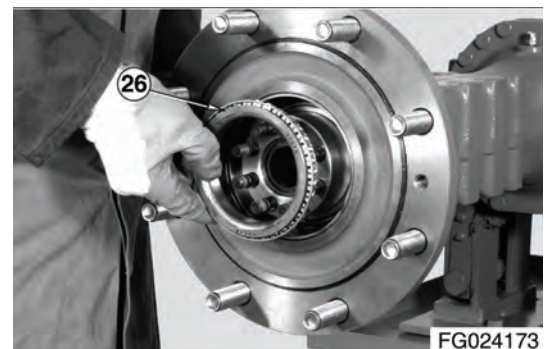


Figure 33

NOTE: Move the bearing to the limit stop by hammering lightly all around the edge.

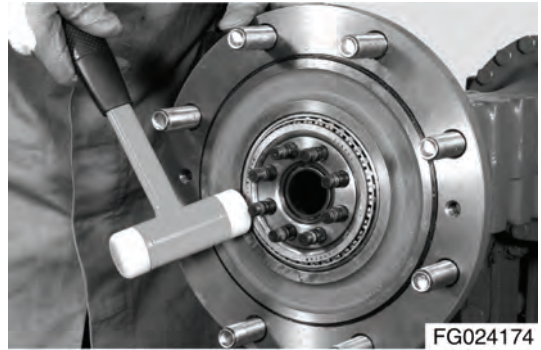


Figure 34

10. Install the crown wheel (25).

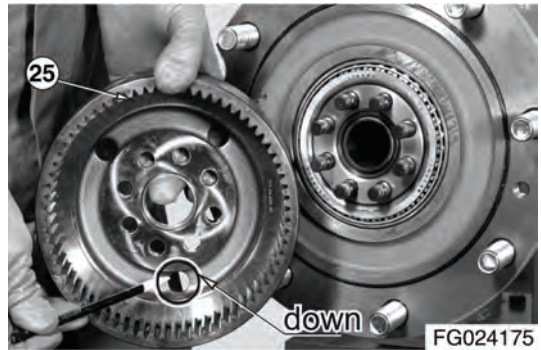


Figure 35

11. Fit the complete crown flange (25).

NOTE: In order to fasten the flange (25), use a plastic hammer and alternately hammer on several equidistant points.

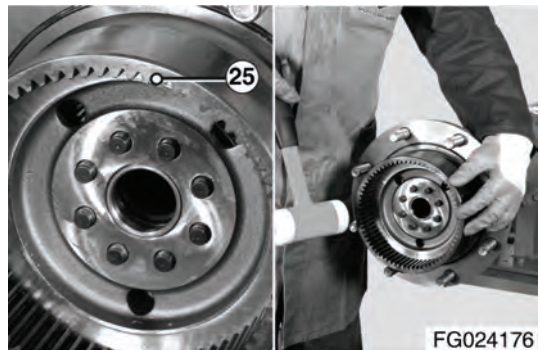


Figure 36

12. Install the security flange (14).

Using tecno lube/101, grease the surface of the safety flange (14) that touches the crown wheel.

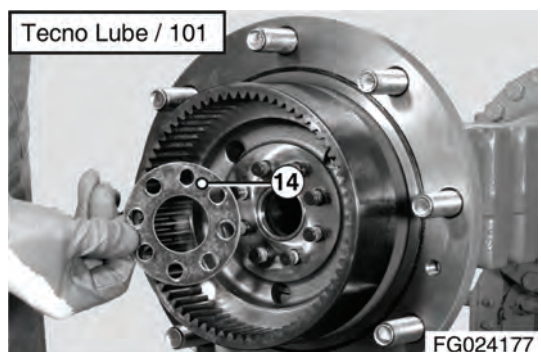


Figure 37

13. Coat the nuts (23) with Loctite 242 and screw them.

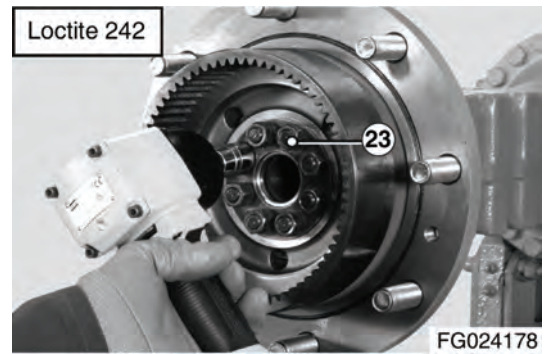


Figure 38

14. Tighten nuts (23) in two stages, using the criss-cross method.
- Initial torque wrench setting: 90 Nm
 - Final torque wrench setting: 100 Nm

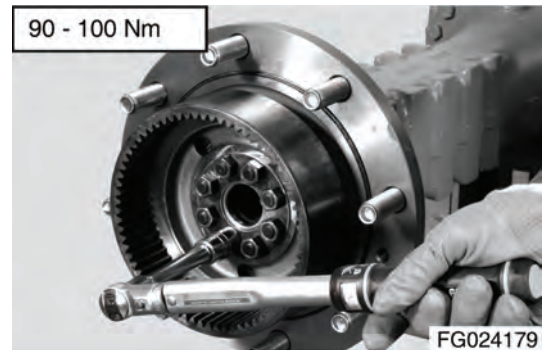


Figure 39

15. Check the continuous rolling torque on the hub.
- Torque 7 - 20 Nm.

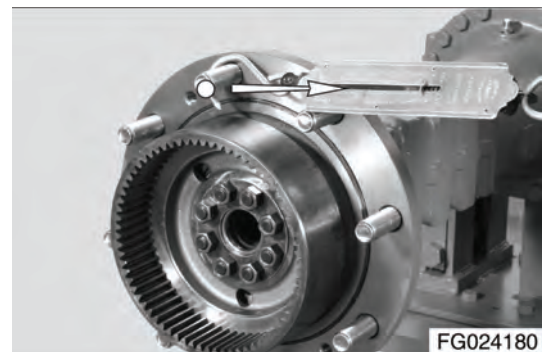


Figure 40



CAUTION

Check the condition and position of the O-ring (27).

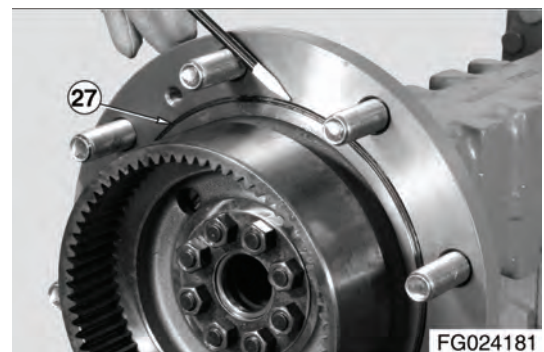


Figure 41

16. Install the axle shaft (29), making sure that it is properly inserted into braking disks and differential unit.

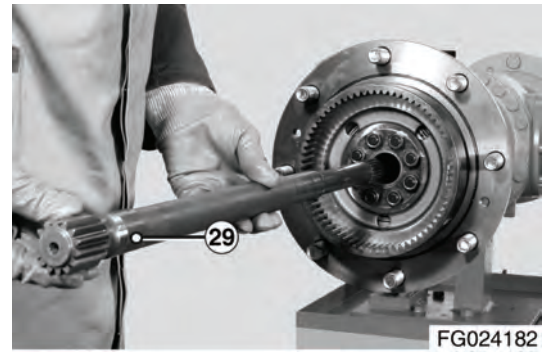


Figure 42

17. Fit the planetary gear cover (18) onto the wheel hub (4).

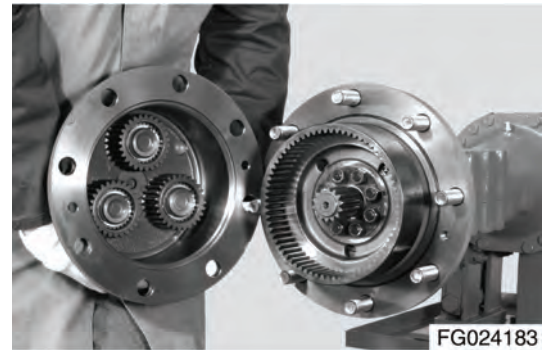


Figure 43

- Torque wrench: 20 - 25 Nm

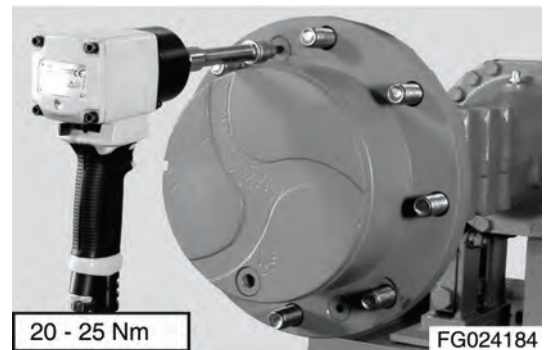
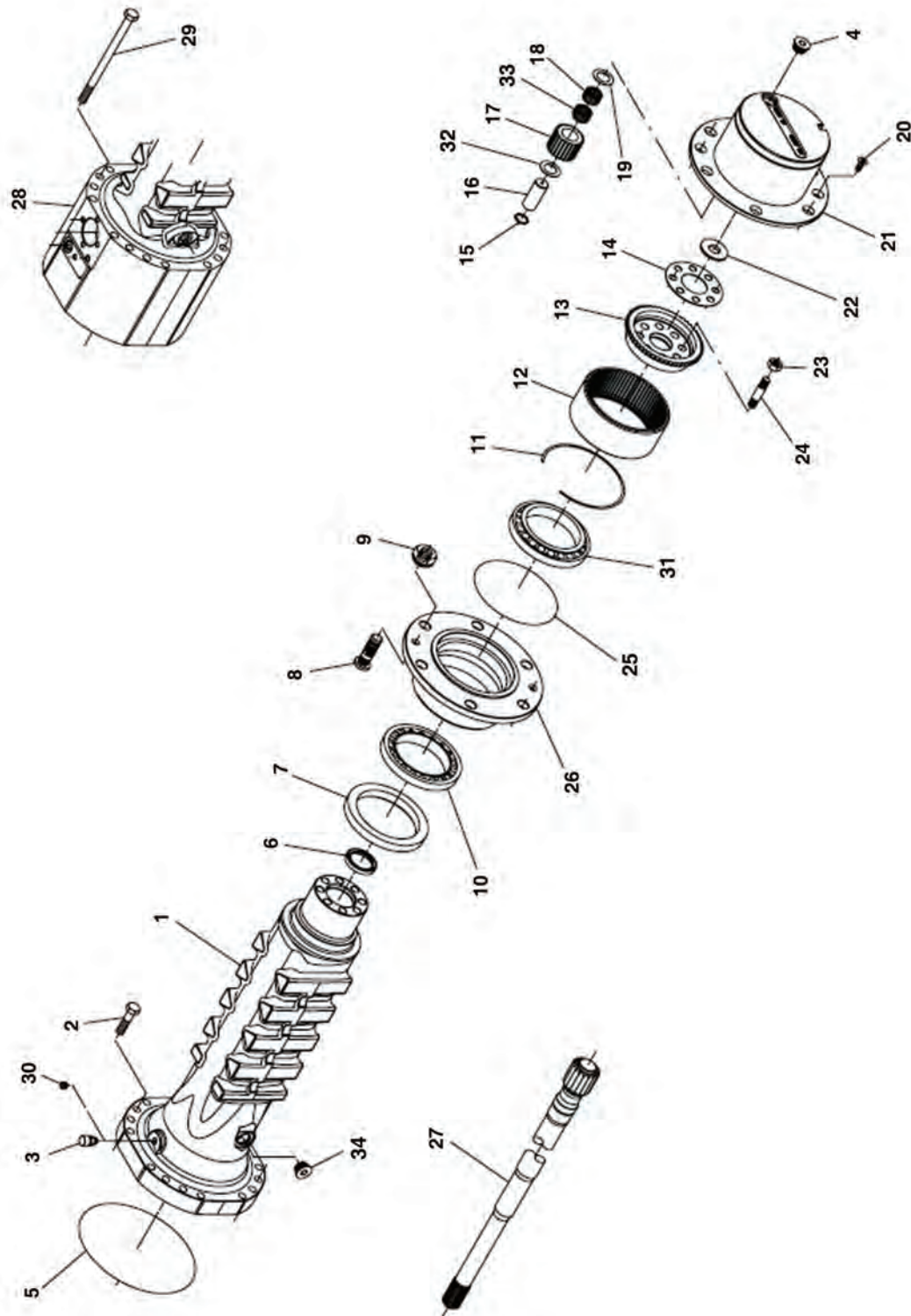


Figure 44

Assembly Diagram



FG024185

Figure 45

Disassembling



CAUTION

Perform all operations on both arms.

1. Remove the oil-level plug (4).
2. Remove the securing screws (20) from the spider cover (21).
3. Disjoin the spider cover (21) from the hub (26) by alternatively forcing a screwdriver into the appropriate slots.
4. Remove the complete planetary carrier cover (21).

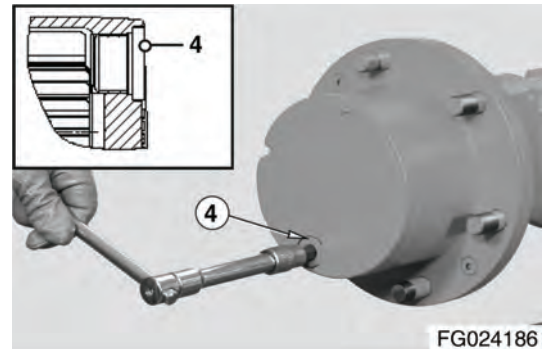


Figure 46

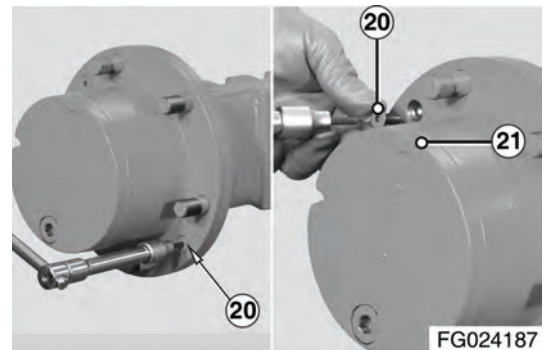


Figure 47

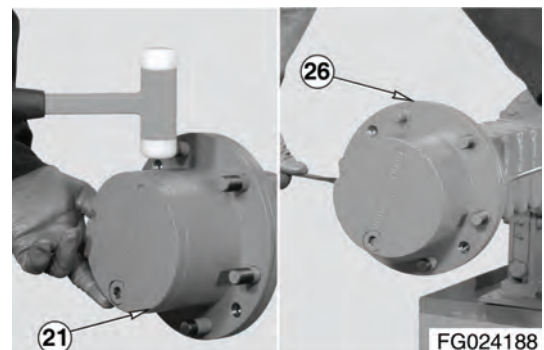


Figure 48

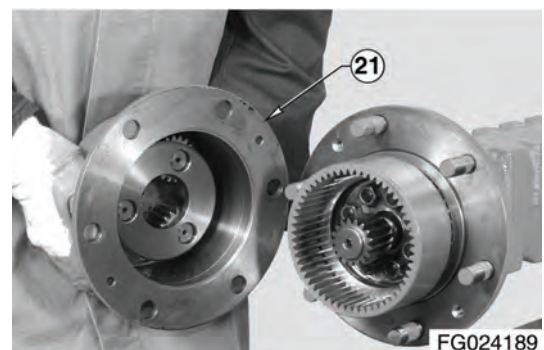


Figure 49

5. Remove the complete axle-shaft (27).

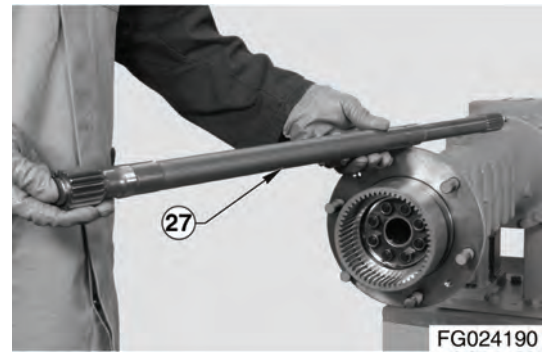


Figure 50

6. Unloose and remove the tightening nuts (23) from the crown flange (13).

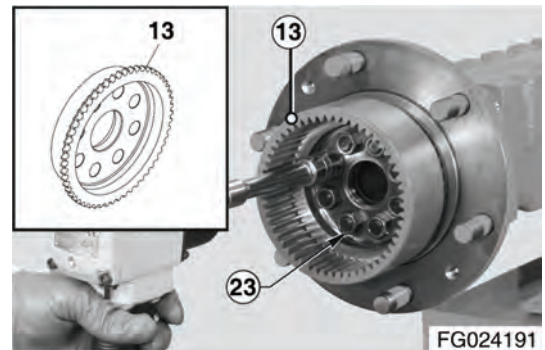


Figure 51

7. Remove the safety flange (14).

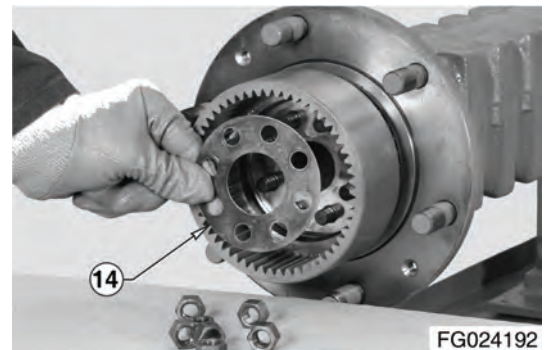


Figure 52

8. Remove the crown (12).

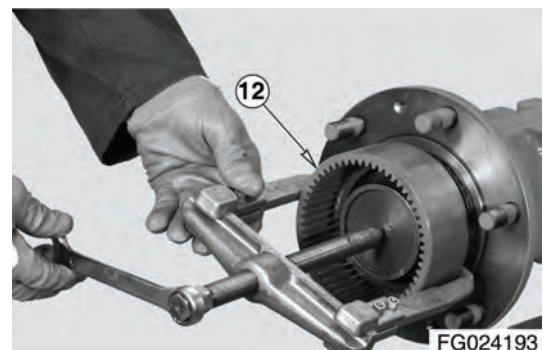


Figure 53

9. Partially extract the hub (26) using a plastic hammer.

NOTE: *Alternately hammer on several equidistant points.*

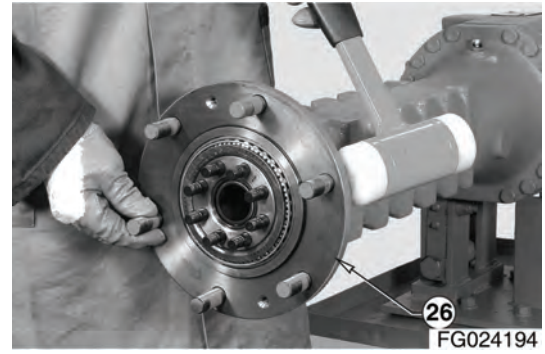


Figure 54

10. Remove the external bearing (31).

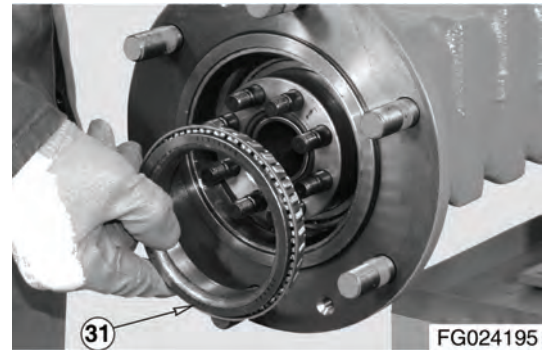


Figure 55

11. By hand remove complete hub (26).

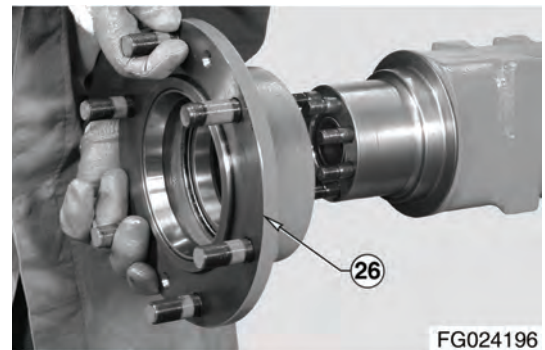


Figure 56

12. Using an extractor, remove the seal ring (6).

NOTE: *Note down the direction of assembly of snap ring.*

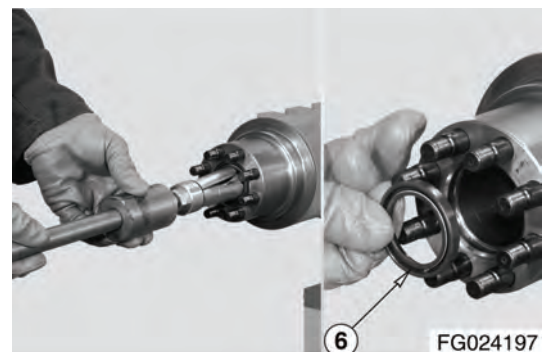


Figure 57

13. Remove snap ring (15).

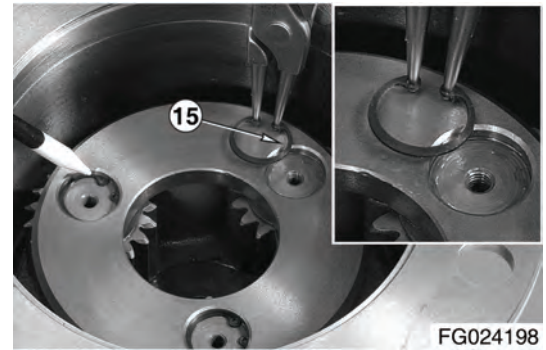


Figure 58

14. Using a screw M6 remove all bolts (16).

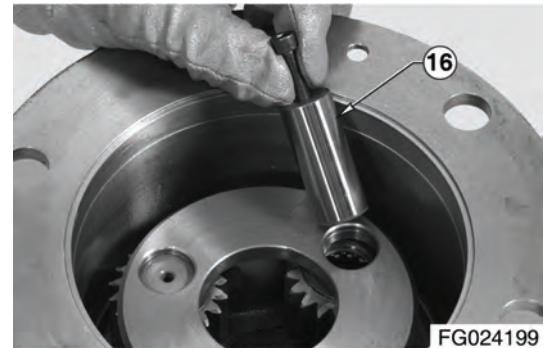


Figure 59

15. Positioning the planet wheel gear (17) in center of the spider cover and remove.

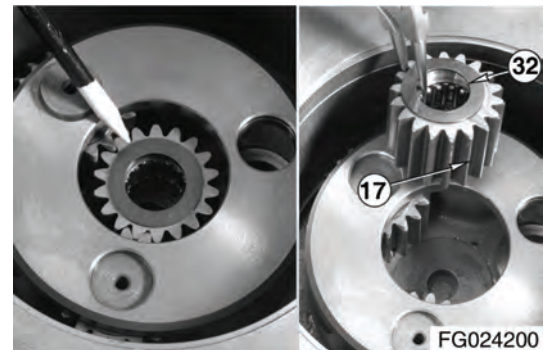


Figure 60

16. Remove the sealing ring (7) from the hub (26).

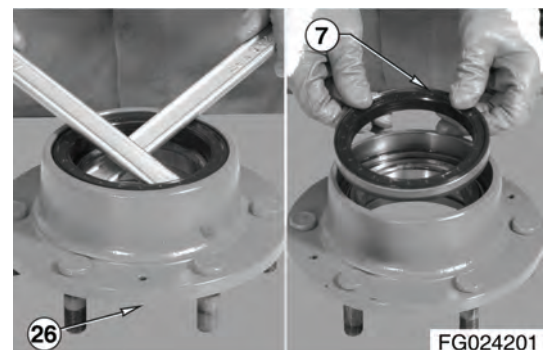


Figure 61

17. Remove the internal bearing (10).

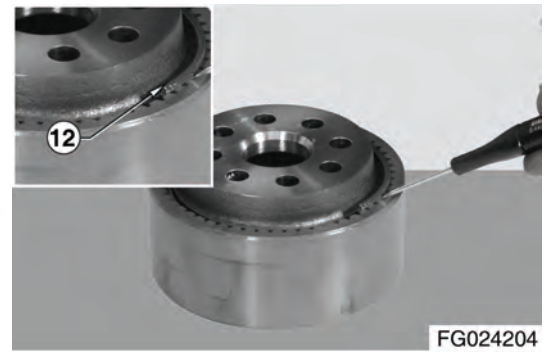


Figure 62

18. Remove the thrust blocks (10) (31) from the bearings and forcing a pin-driver into the appropriate slots on the hub.

NOTE: *Hammer in an alternate way so as to avoid crawling or deformation of the thrust blocks.*



Figure 63

19. Remove the snap ring (12) from the crown (13).

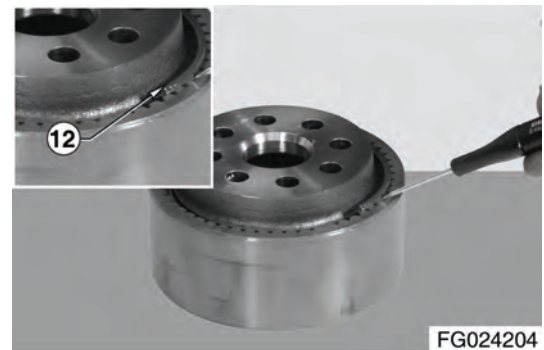


Figure 64

20. Remove the crown flange (13).

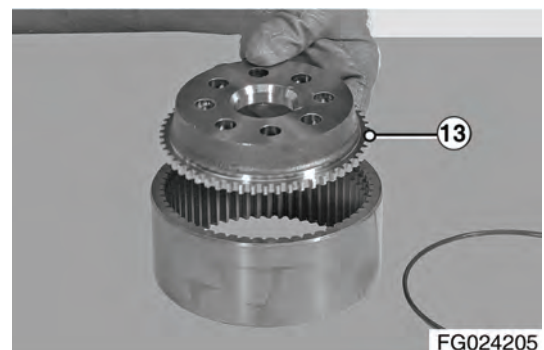


Figure 65

Assembling

1. Lubricate and fit the sealing ring (6) onto tool T3; install the rings into the arm.

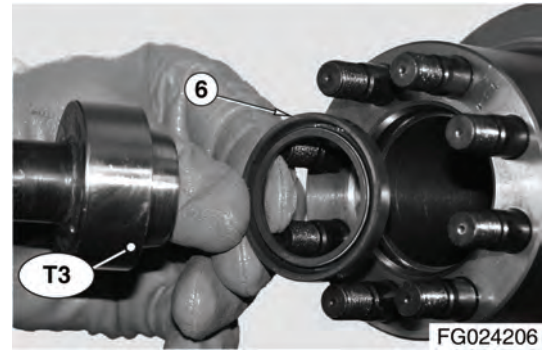


Figure 66



CAUTION

Pay particular attention to the direction of assembly of the rings.

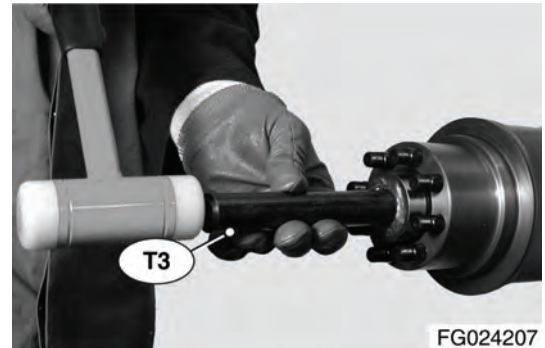


Figure 67

2. Position the lower part of tool T1 and the thrust block of the external bearing (31).

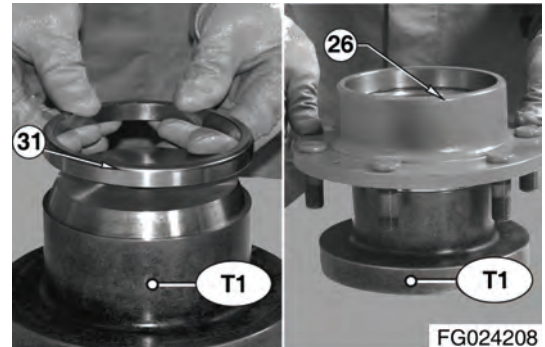


Figure 68

3. Lubricate the seats of the bearings and position the hub on tool T1; position the thrust block of the internal bearing (10).

NOTE: Check that the thrust block is correctly oriented.

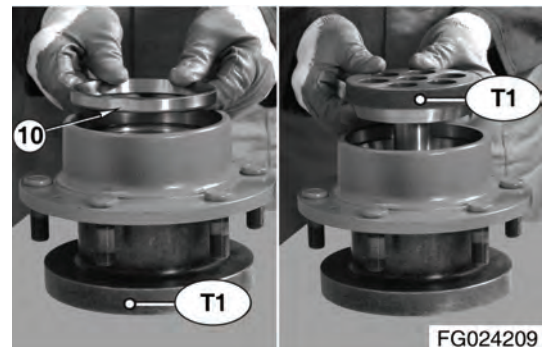


Figure 69

4. Fit the bearing (10) into the internal thrust block.

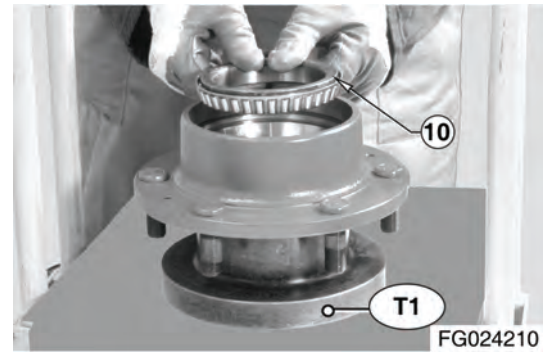


Figure 70

5. Using special tool T2 apply a repositionable jointing compound for seals to the outer surface of the sealing ring (7). Position the sealing ring (7) in the hub (26).

NOTE: Check that the ring (7) is correctly oriented.

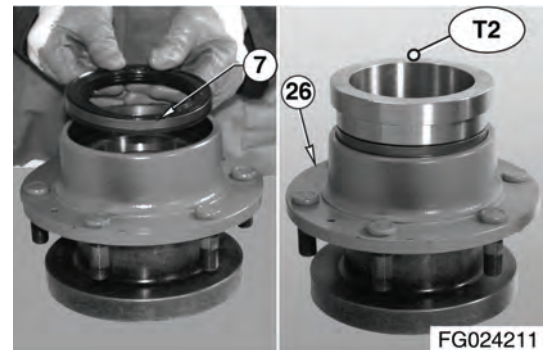


Figure 71

6. Install the wheel hub (26).

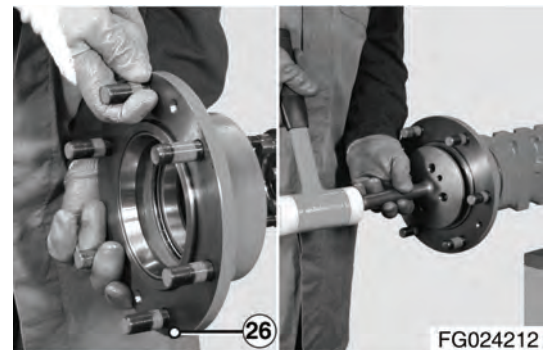


Figure 72

7. Install the external bearing (31).

NOTE: Move the bearing to the limit stop by hammering lightly all around the edge.

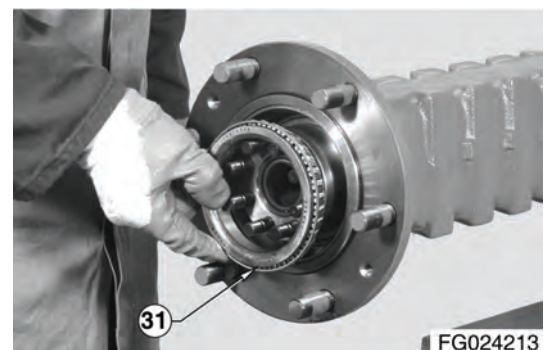


Figure 73

8. Install the crown wheel (12).

Insert the snap ring (11) in order to fix the flange (13) in the crown (12).

NOTE: Carefully check that ring (11) is properly inserted in the slot of the crown (12).

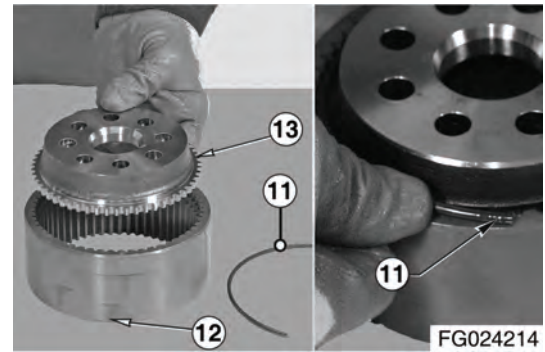


Figure 74

9. Fit the complete crown flange.

NOTE: In order to fasten the flange, use a plastic hammer and alternately hammer on several equidistant points.

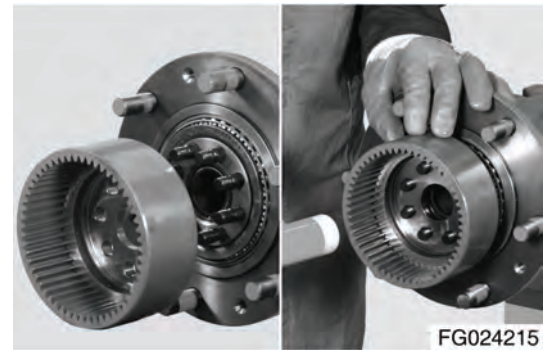


Figure 75

10. Install the security flange (14).

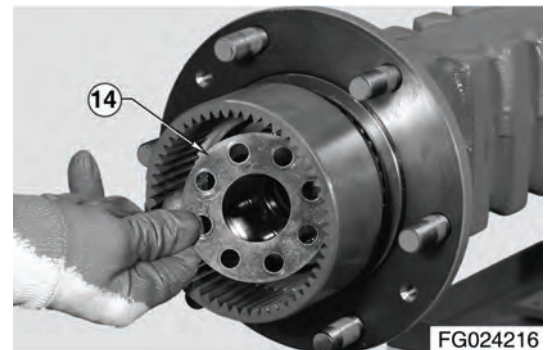


Figure 76

11. Coat the nuts (23) with Loctite 242 and screw them.

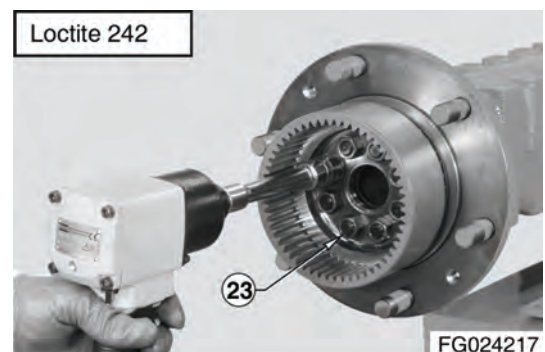


Figure 77

12. Tighten nuts (23) in two stages, using the criss-cross method.
 - Initial torque wrench setting: 90 Nm
 - Final torque wrench setting: 100 Nm

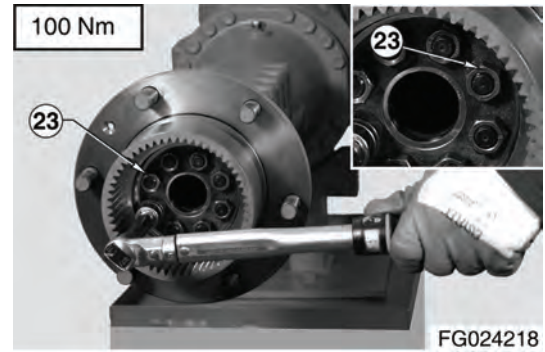


Figure 78

13. Check the continuous rolling torque on the hub.
 - Torque: 7 - 20 Nm

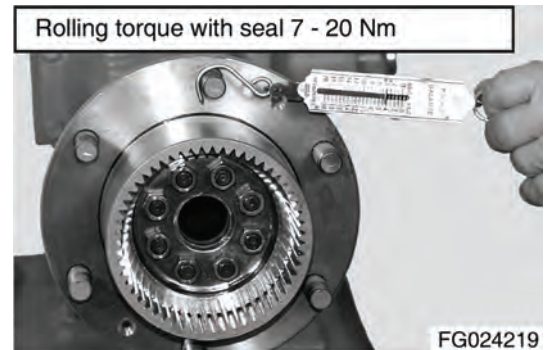


Figure 79

14. Install the axle shaft (27), making sure that it is properly inserted into braking disks and differential unit.

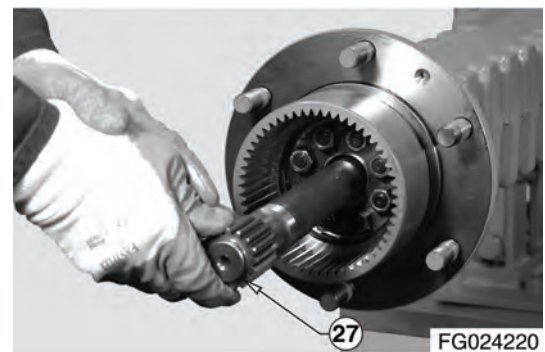


Figure 80



CAUTION

Check the condition and position of the O-ring (25).

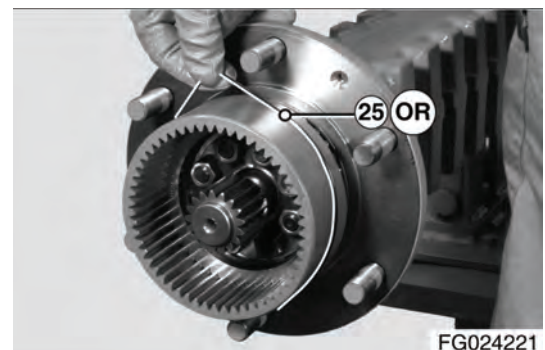


Figure 81

15. Install the spherical washer (19).

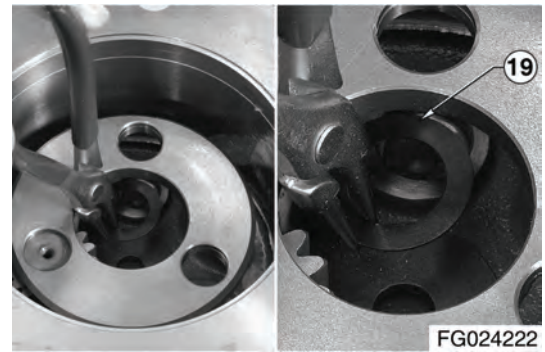


Figure 82

16. Install planetary gears complete with roller bearing (17).

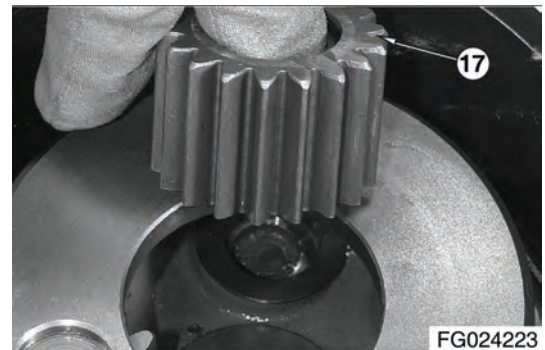


Figure 83

17. Install the others friction washers.

NOTE: *Two friction washers for every planetary gear.*

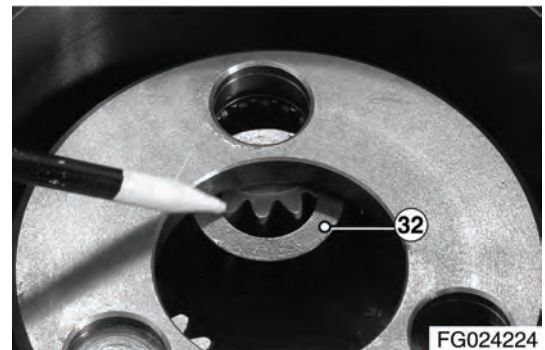


Figure 84

18. Check the concentricity of the planetary gear, the seat and friction washers. Using a screw M6 install the pin (16).

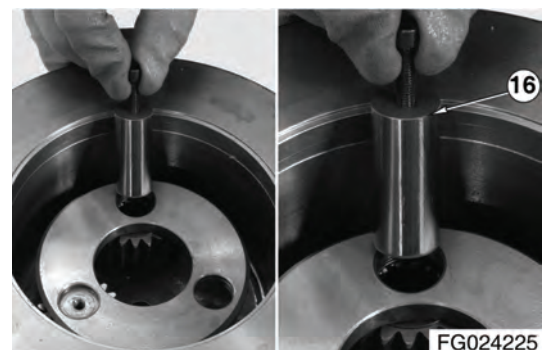


Figure 85

19. Carefully check that pin is completely inserted and install the snap rings (15).

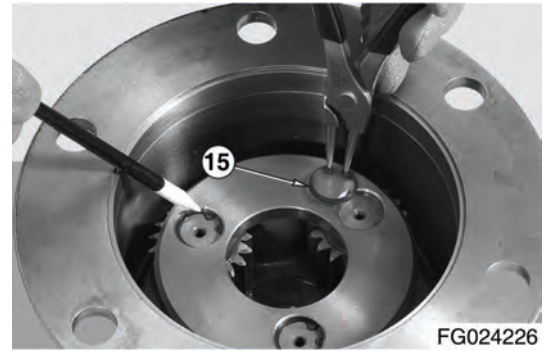


Figure 86

20. Fit the planetary gear cover (21) onto the wheel hub (26).
 - Torque wrench: 20 - 25 Nm

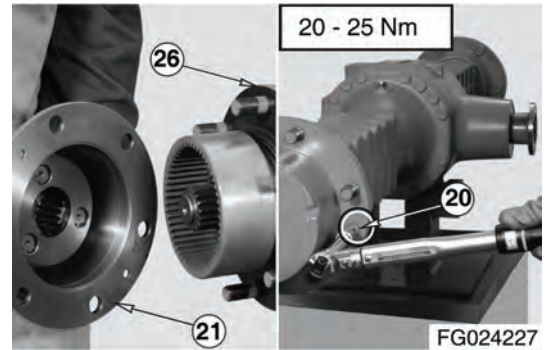
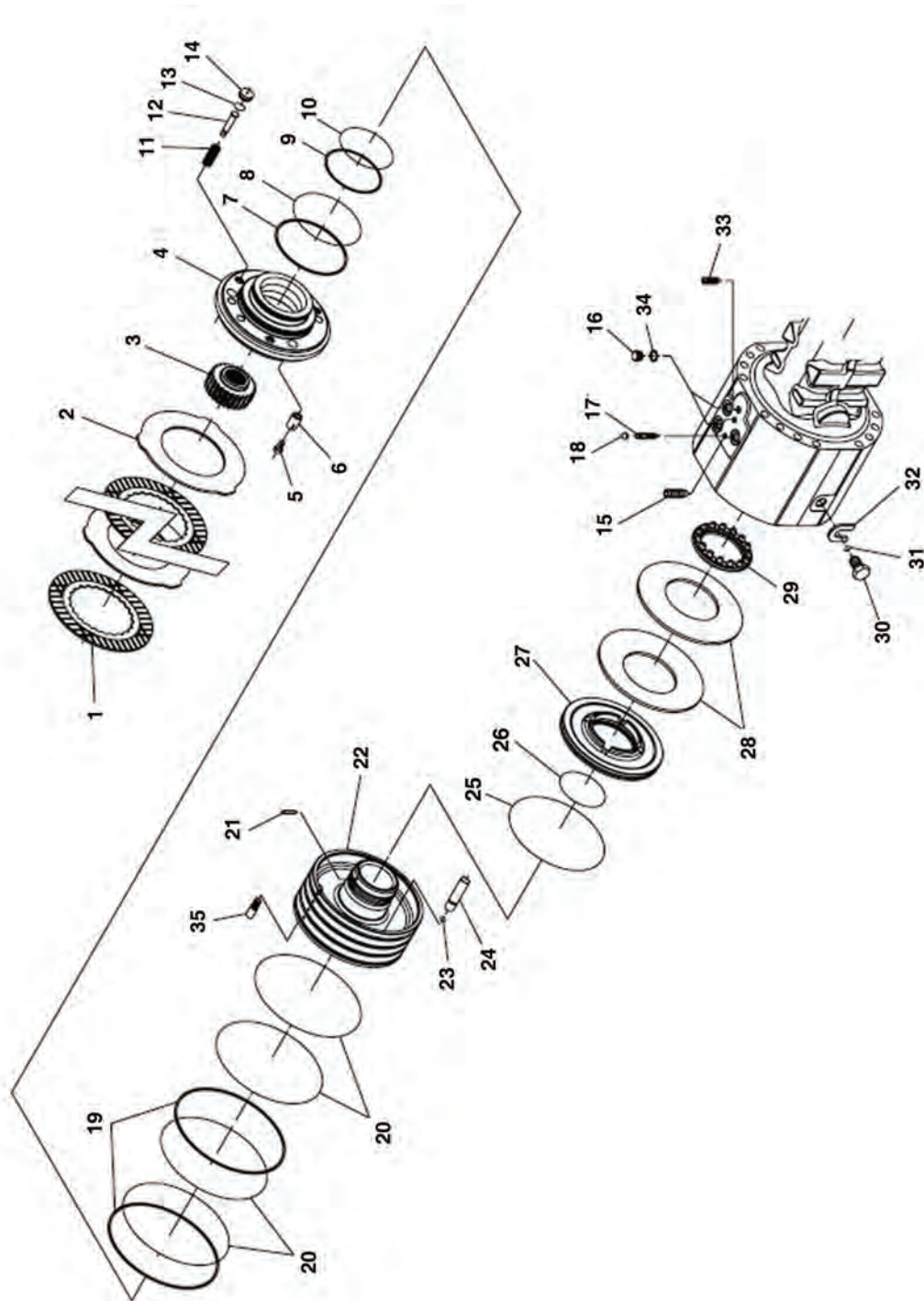


Figure 87

SERVICE AND NEGATIVE BRAKE

Assembly Diagram



FG024228

Figure 88

Disassembling

1. Connect an external pump to the union piece "P1" of the negative brake and introduce a pressure of 15 ± 30 bar to eliminate the pressure of the belleville washers.



CAUTION

Perform all operations on both arms.

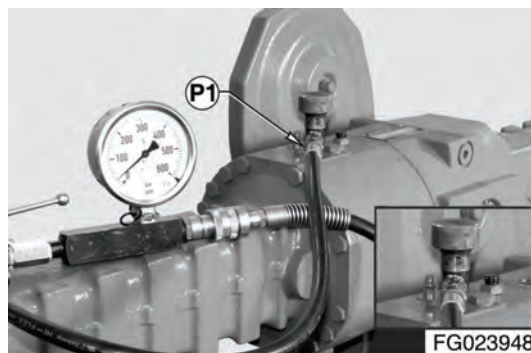


Figure 89

2. Loosen the unlocking screws (30) and remove both stop washers (32).

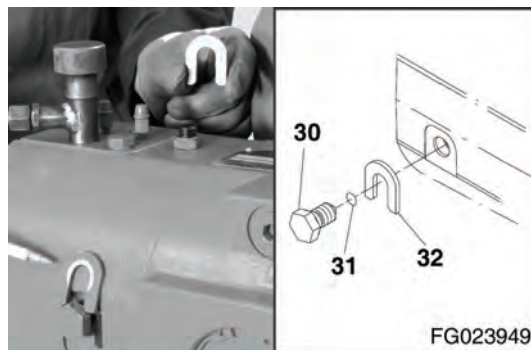


Figure 90

3. Insert block screws to end stroke and release pression.

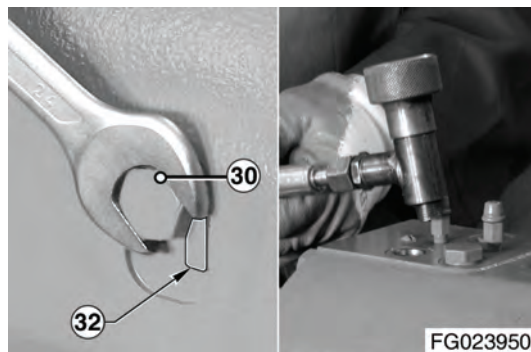


Figure 91

4. Sling the arm to be removed and connect it to a hoist, remove screws.

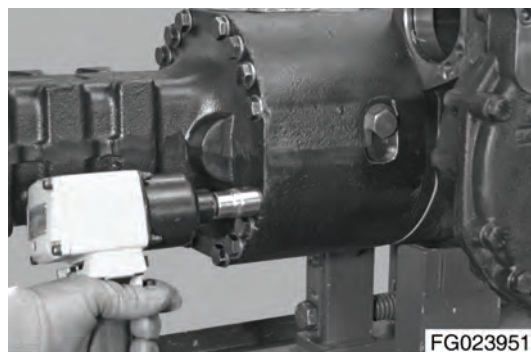


Figure 92

5. Take off the arm and lay it down vertically.

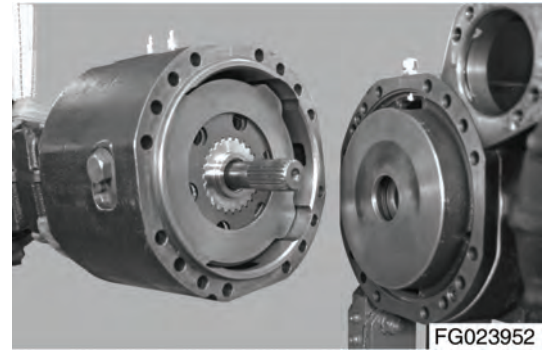


Figure 93

6. Remove the brake discs one after the other (2).

NOTE: *If they are not to be substituted, do not mix up the sequence.*

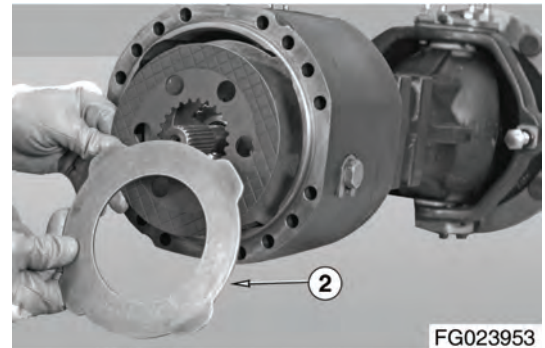


Figure 94

7. Remove the flange (3) complete with the discs.

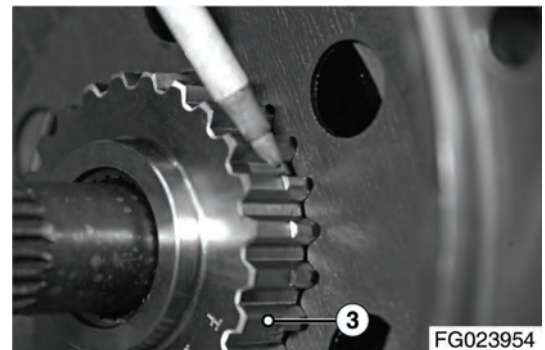


Figure 95

8. In order to keep the disc springs of the negative brake preloaded, screw down the screws with washers to the end stop.



Figure 96

9. Remove the negative brake locking screws (30).

Always exchange the O-ring (31).

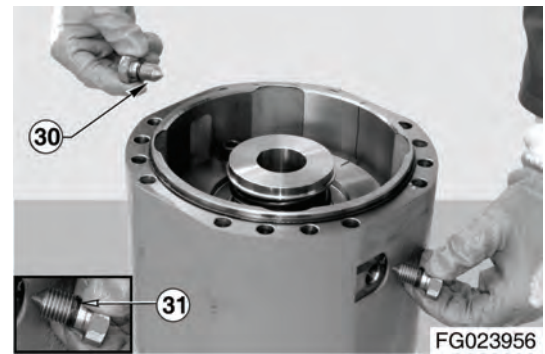


Figure 97

10. Loosen the before installed provisional screws in the same sequence and same measure.



Figure 98

11. Remove the negative brake locking screws (30). Always exchange the O-ring (31).

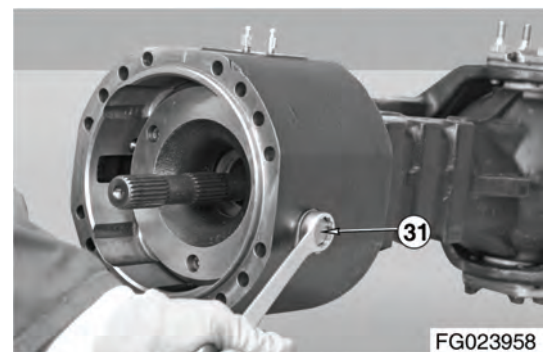


Figure 99

12. Pull out brake piston assembly module (22).

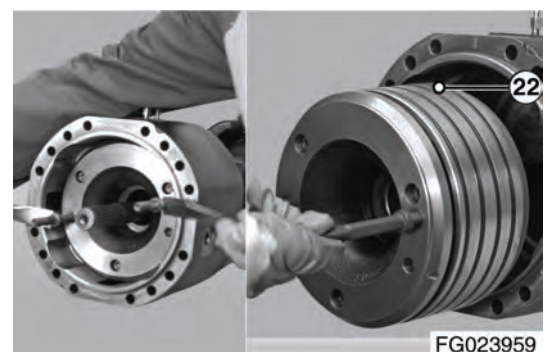


Figure 100



CAUTION

Check locking screw (33) of the brake piston module.

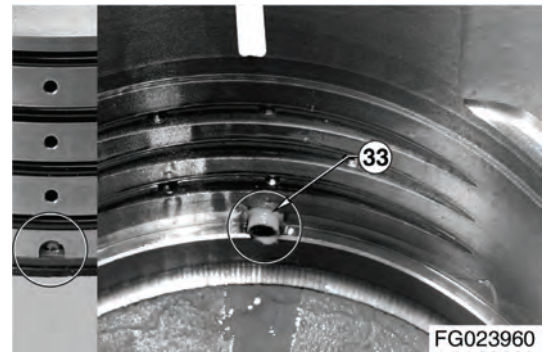


Figure 101

13. Turn upside down the brake module and with a pin driver remove the locking pin of the slotted nut.

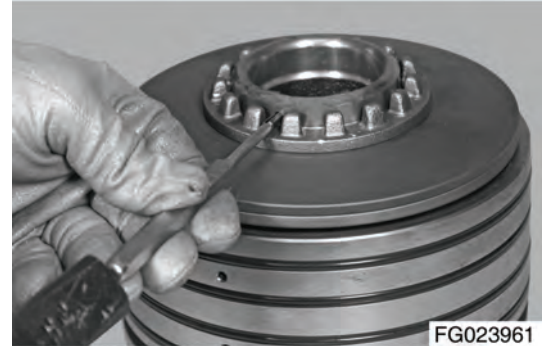


Figure 102

14. Sign the position of the slotted nut.



Figure 103

15. Bring the piston group below a press, compress the cup springs and loosen the metal ring.

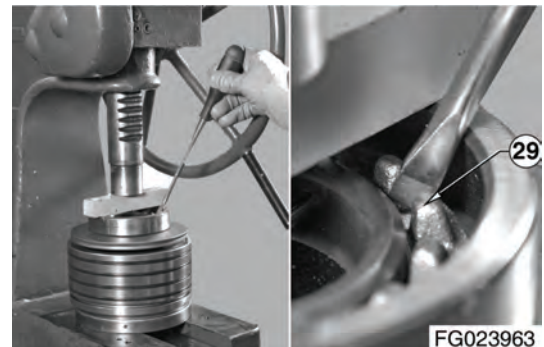


Figure 104

16. Remove nut (29).

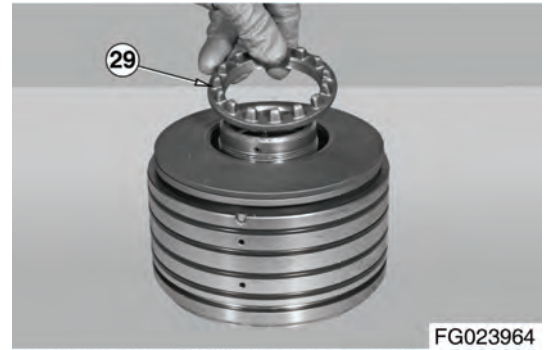


Figure 105

17. Remove the disc springs (28).



Figure 106

18. Applying air pressure, remove the piston (27) of the negative brake.

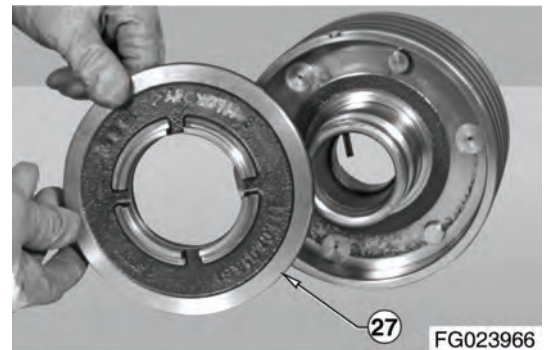


Figure 107

19. Using a new screw remove the pressure seal caps.



Figure 108

20. Remove the reversal springs (11).

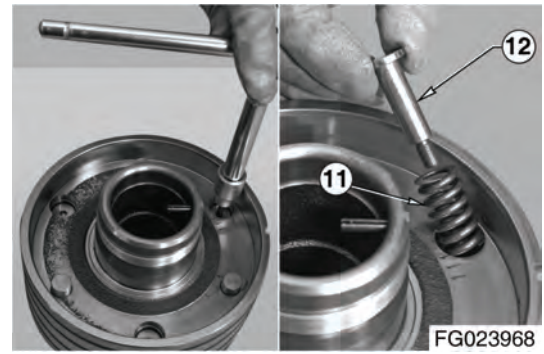


Figure 109

21. Remove the adjusting screws (5).

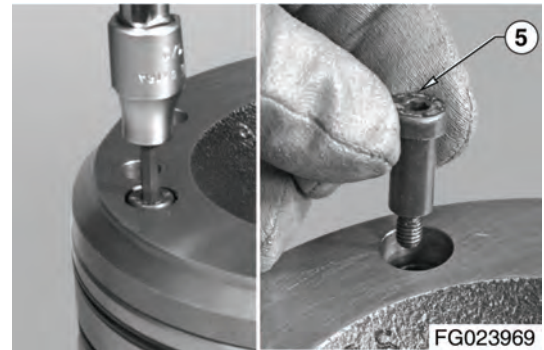


Figure 110

22. Remove the service brake piston (4).



Figure 111

23. Remove the three bolts (24).



Figure 112

24. Remove the O-Rings and the anti-extrusions rings from the service brake, the negative brake piston and from the piston.

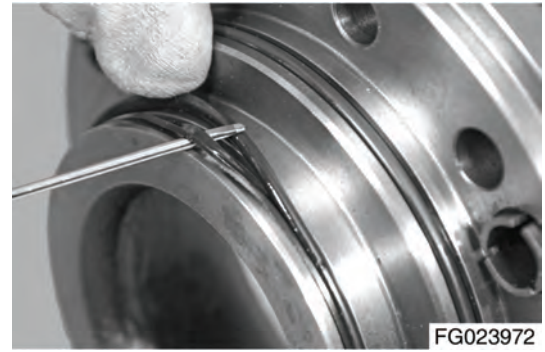
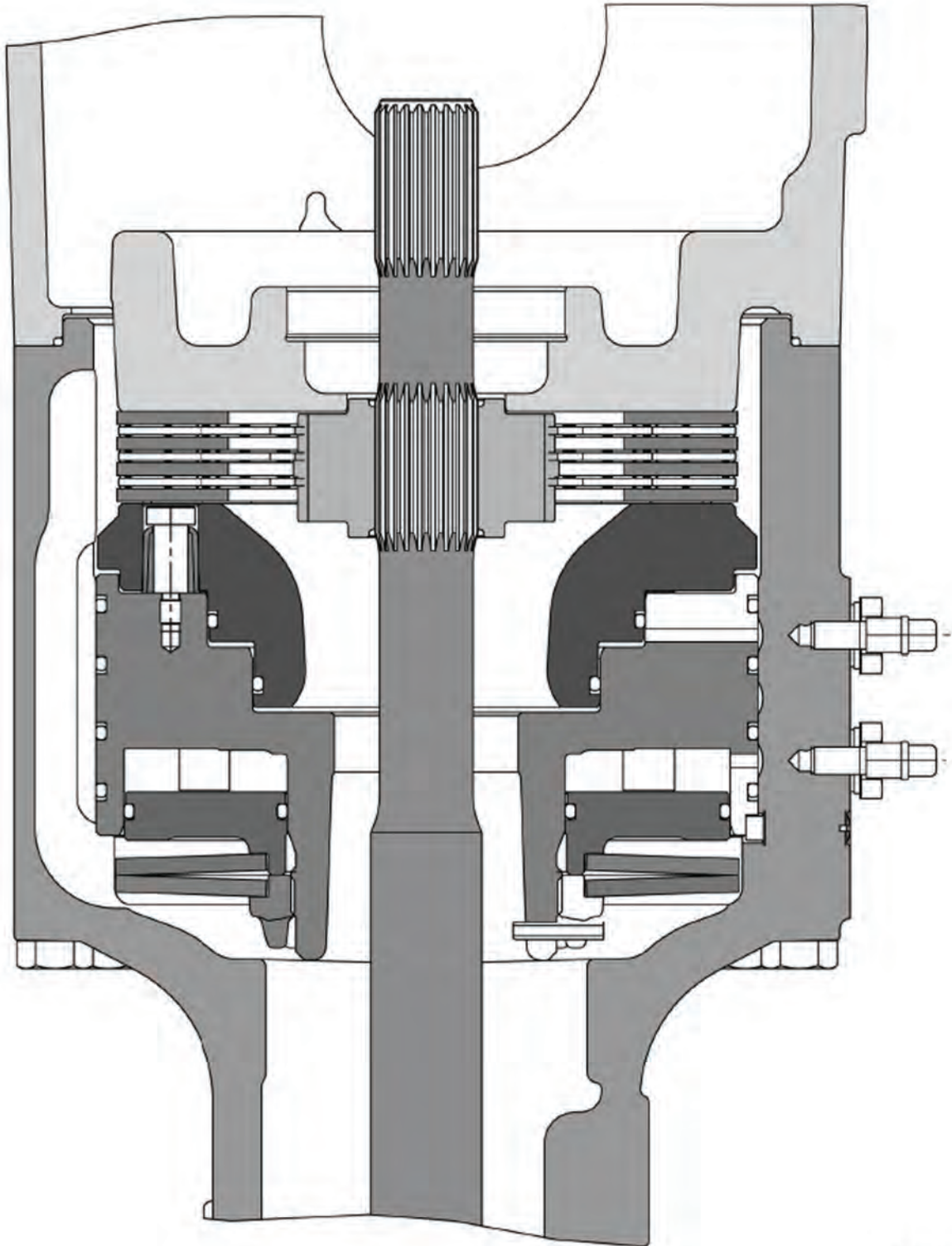


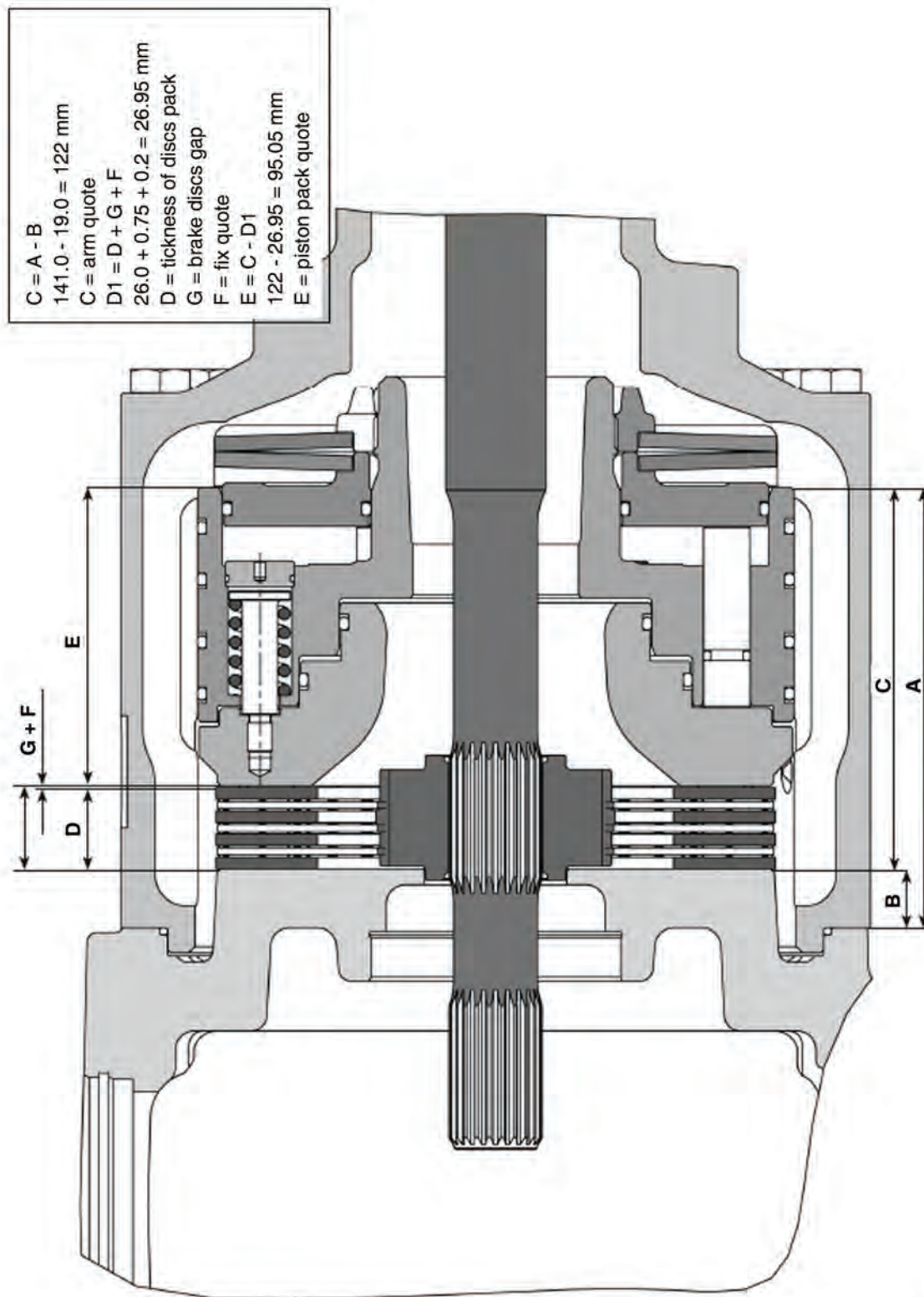
Figure 113

Assembling



FG024229

Figure 114



FG024230

Figure 115

1. Zero the centesimal calibre between the support plane and the centring arm.

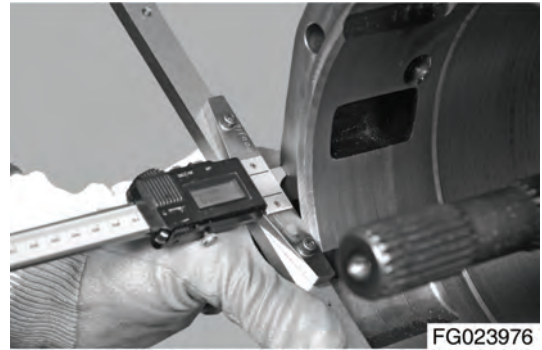


Figure 116

2. Then measure the distance between the arm support plane and the piston pack stop.

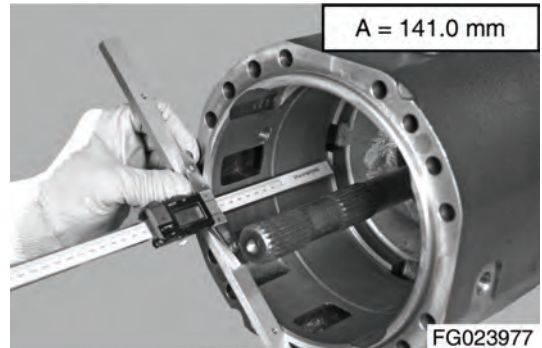


Figure 117

3. Measure the distance between the disk support plane and the arm support plane.

Subtract the value "B" from the value "A" to obtain the effective dimension "C" of the arm containing the brake disks and the piston pack.

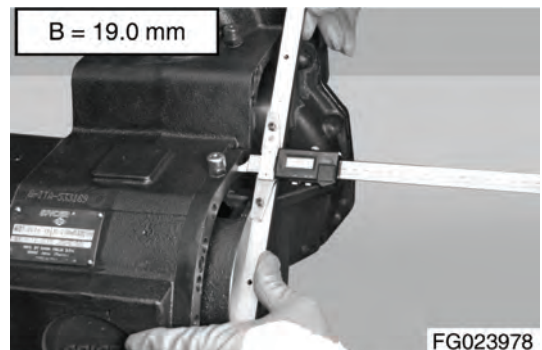


Figure 118

4. Bring the disk pack beneath a press, load with 1000 Kg, then measure the dimension "D".

Add the play "G" and the fixed value "F" (equal to 0.2 mm) to the value "D".

NOTE: Do not take into account the thickness between the press piston and the disks.

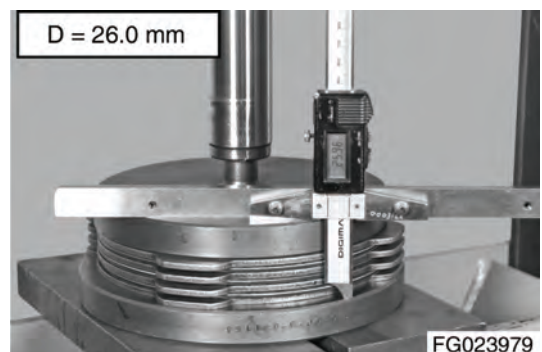


Figure 119

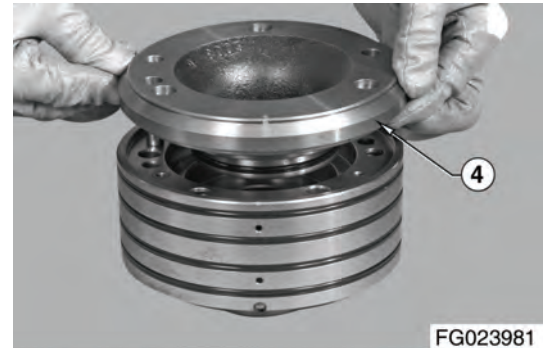
5. To determine the value "E" of the piston pack, subtract value "C" from value "D".

$C = A - B$
 $141,0 - 19,0 = 122 \text{ mm}$
C= arm quote
 $D1 = D + G + F$
 $26,0 + 0,75 + 0,2 = 26,95 \text{ mm}$
D= tickness of discs pack
G= brake discs gap
F= fix quote
 $E = C - D1$
 $122 - 26,95 = 95,05 \text{ mm}$
E = piston pack quote

FG023980

Figure 120

6. Insert the service brake piston (4) hammering alternately with a plastic hammer.



FG023981

Figure 121

7. Insert the bolts (24).



FG023971

Figure 122

8. Turn upside down and insert the negative brake piston (27).



FG023982

Figure 123



CAUTION

To determine the level "E" the slotted nut has to be operated without spring mounted.



Figure 124

NOTE: To define the level "E" adjust the slotted nut always to the smaller value by driving to the closer notch.

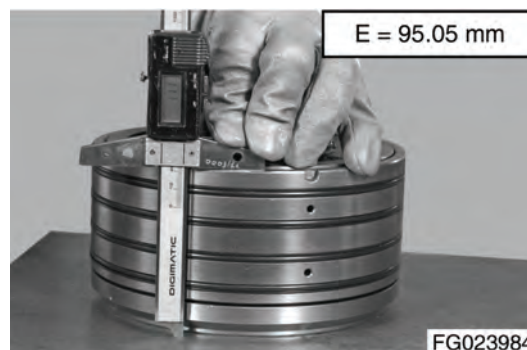


Figure 125

9. Before removing the slotted nut in order to insert the springs, note down the distance "H" from the plane to the tooth near the pin.

NOTE: Sign.

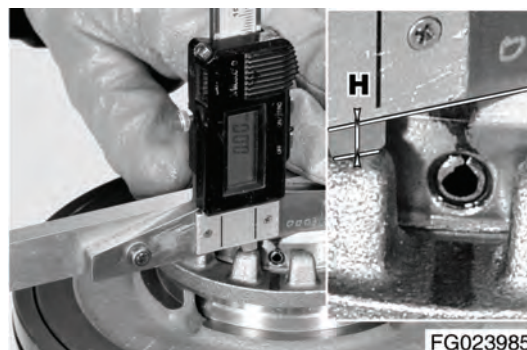


Figure 126

10. Remove the service brake piston (4).

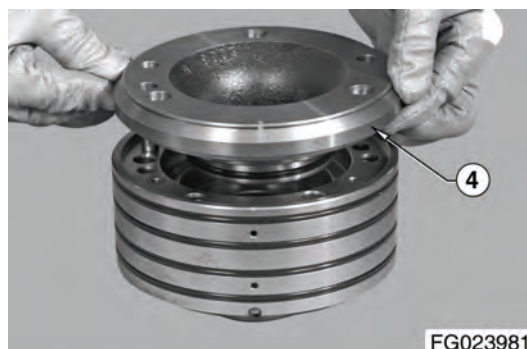


Figure 127

11. Insert the stroke automatic regulation springs (6); place them in line with the piston (4).

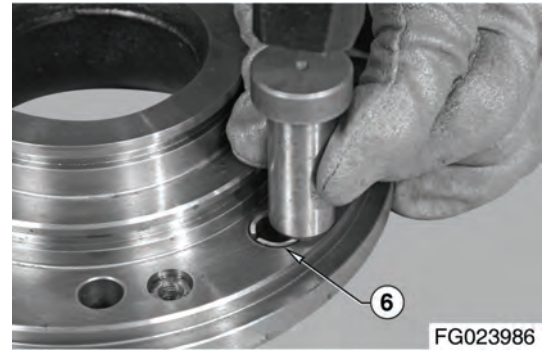


Figure 128

12. Complete the O-rings and anti-extrusion rings on all pistons.



CAUTION

The O-rings always have to be assembled from the pressure facing side.



Figure 129

13. Insert the service brake piston (4) hammering alternately with a plastic hammer.

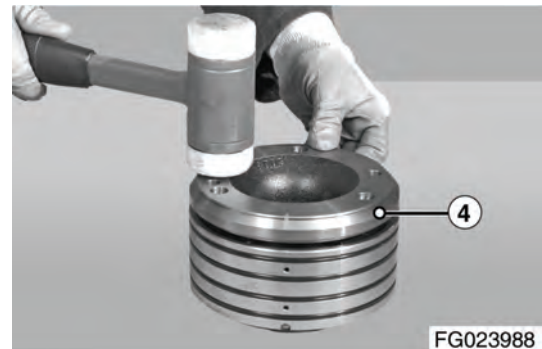


Figure 130

14. Fit the adjusting screws (5).
Apply Loctite 242 to the thread.
 - Torque wrench setting: 5 - 7 Nm.

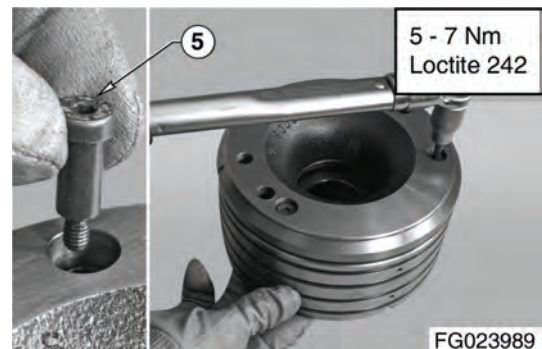


Figure 131

15. Fit the reversal springs (11) on the piston (4).
Apply Loctite 242 to the thread of the adjustment screw.
 - Tighten with torque wrench setting of 10 - 15 Nm

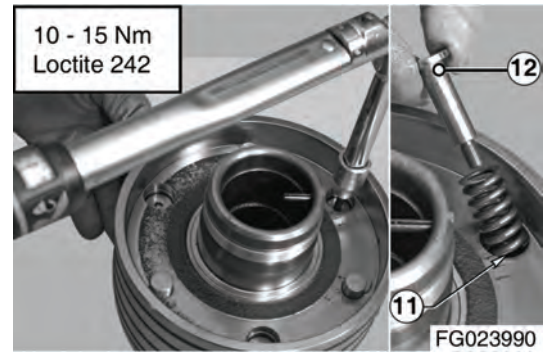


Figure 132

16. Insert the stroke end seal caps.

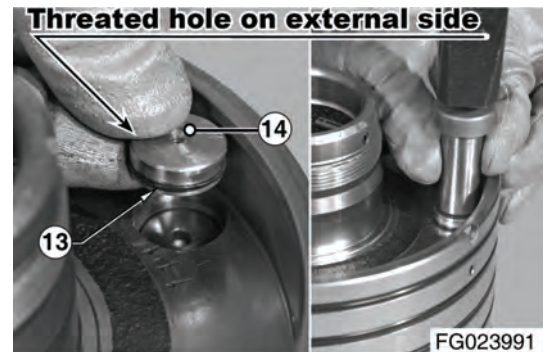


Figure 133

17. Insert the negative brake piston (27).

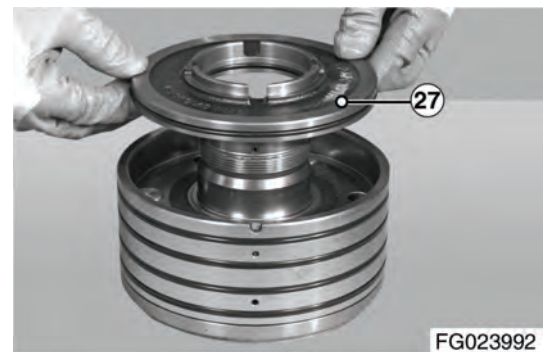


Figure 134

18. Insert the disc springs in the right position (28).



Figure 135

19. Insert at the bottom the piston of the negative brake (27) and screw up the slotted nut (29).

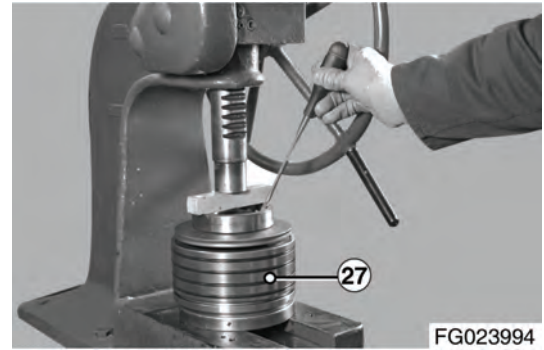


Figure 136

20. Screw down the slotted nut to the earlier determined position.

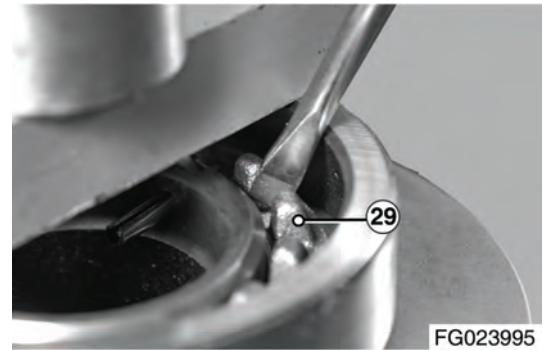


Figure 137

21. Check the earlier measured distance "H" from the plane to the tooth next to the pin.



Figure 138

22. Alternately tighten with a torque wrench setting of max. 45



Figure 139

23. Put the pin in locking (21) position.



Figure 140



CAUTION

Check locking screw (33) of the brake piston module.

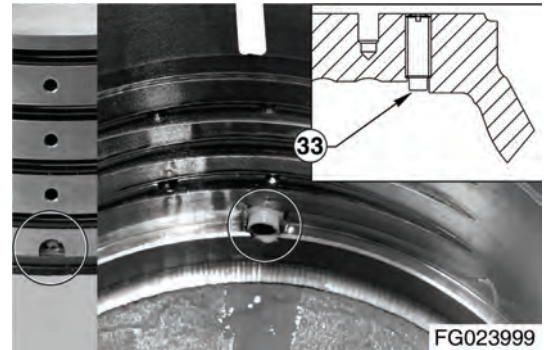


Figure 141

24. Insert the brake modul facing the input holes to the top.

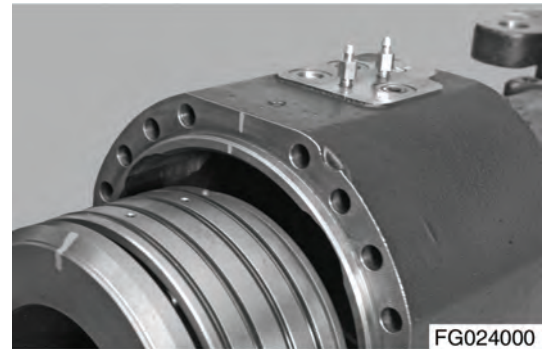


Figure 142

25. Insert the piston to the end stop by alternating light strokes and remove the screws.

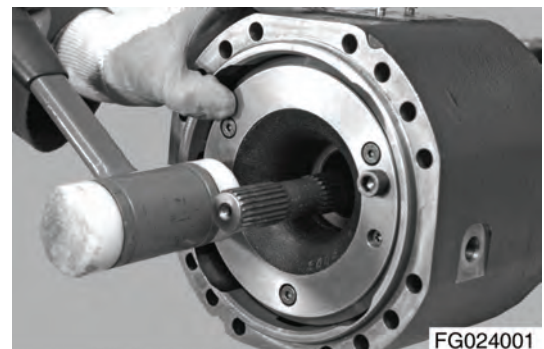


Figure 143

26. Insert the negative brake unlocking screw (30) up to the end stop.

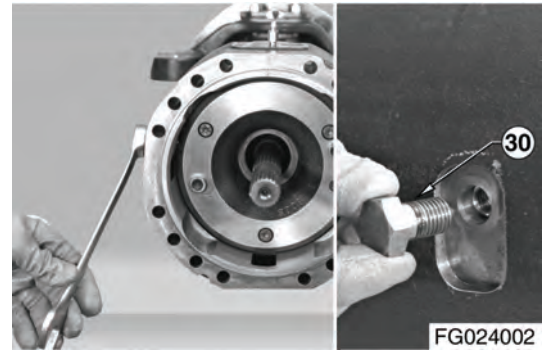


Figure 144

27. Remove the two auxiliary screws.

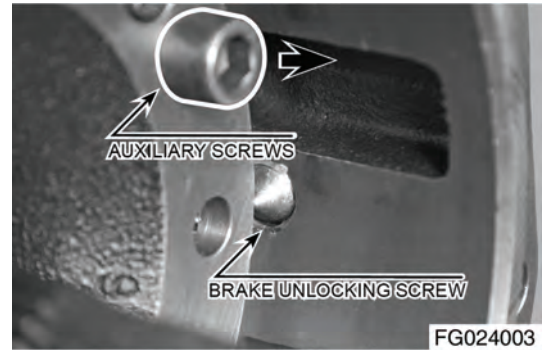


Figure 145

28. Insert the brake discs (1) (2) in the right sequence.

NOTE: *The first brake disc to be inserted must be of friction material.*

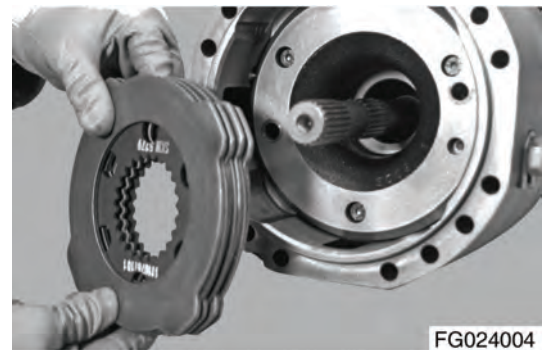


Figure 146

29. Install the flange (3) on the arm.

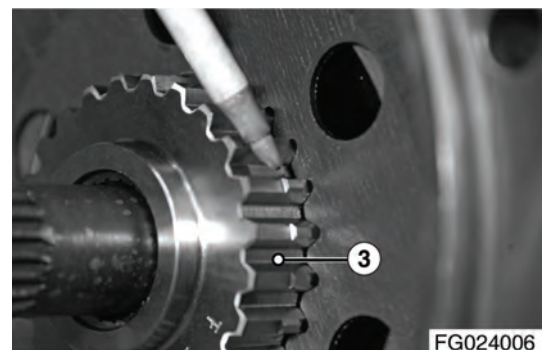


Figure 147

30. Insert the brake discs (1) (2) in the right sequence.

NOTE: *The last brake disc to be inserted must be of metal material.*

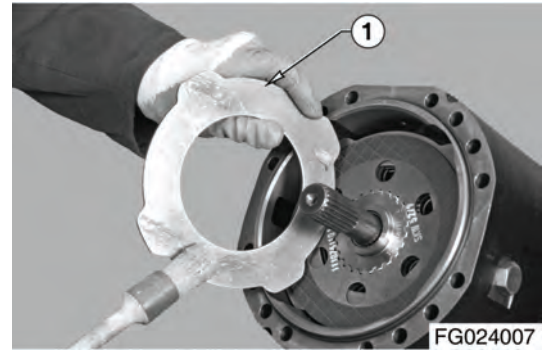


Figure 148

31. Insert the screws and tighten them alternately.

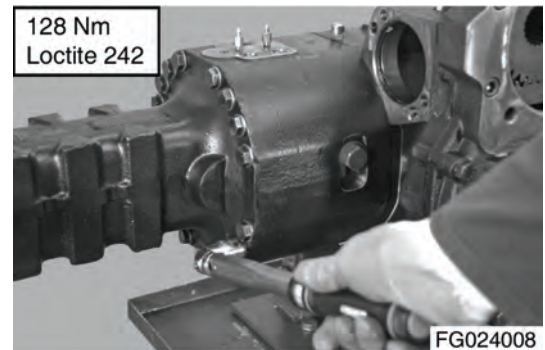


Figure 149

32. Remove the negative brake locking screws (30).

Fit the special tool T4 into the seat of the manual release of the screws, insert a comparator and pre-load it with 1 mm.

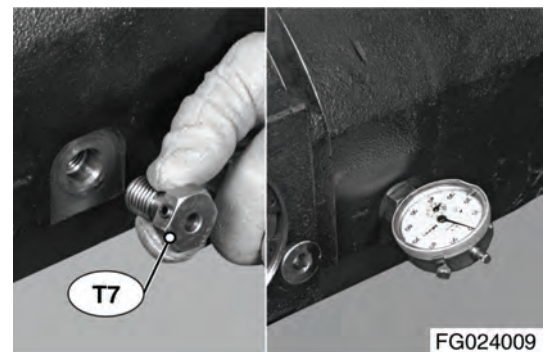


Figure 150

33. Introduce a pressure of max. 25 bar.

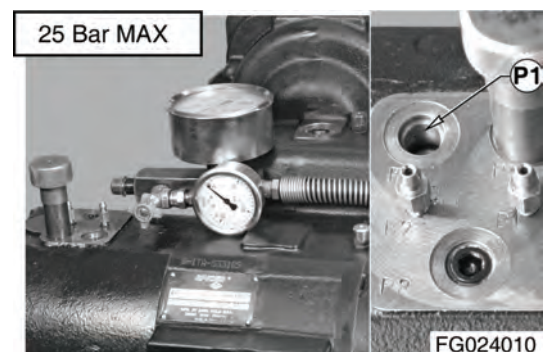


Figure 151

34. Once the pressure is inserted into the circuit the comparator must give a measurement equal to play X (0.75 mm).

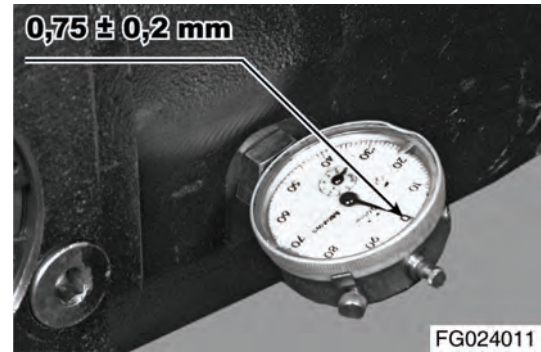


Figure 152

35. Insert the two "U" shaped shims and tighten the screws with a torque wrench setting of 95 - 115 Nm.

NOTE: The position of the negative brake is unlocked.

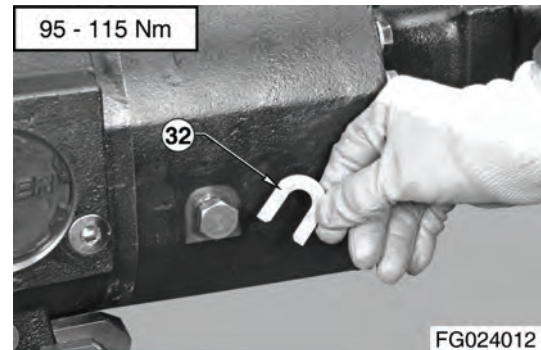


Figure 153

36. Check the flatness of the arms and finally lock the arms with the screws (4) and the washer (5) using the crosstightening method.

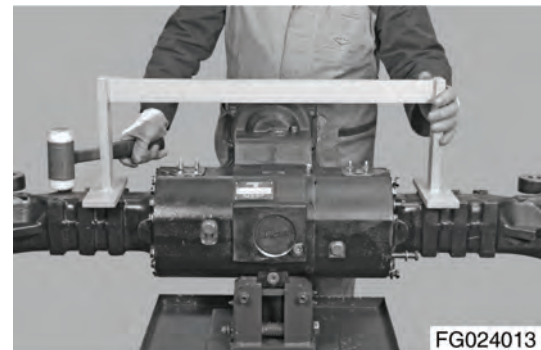
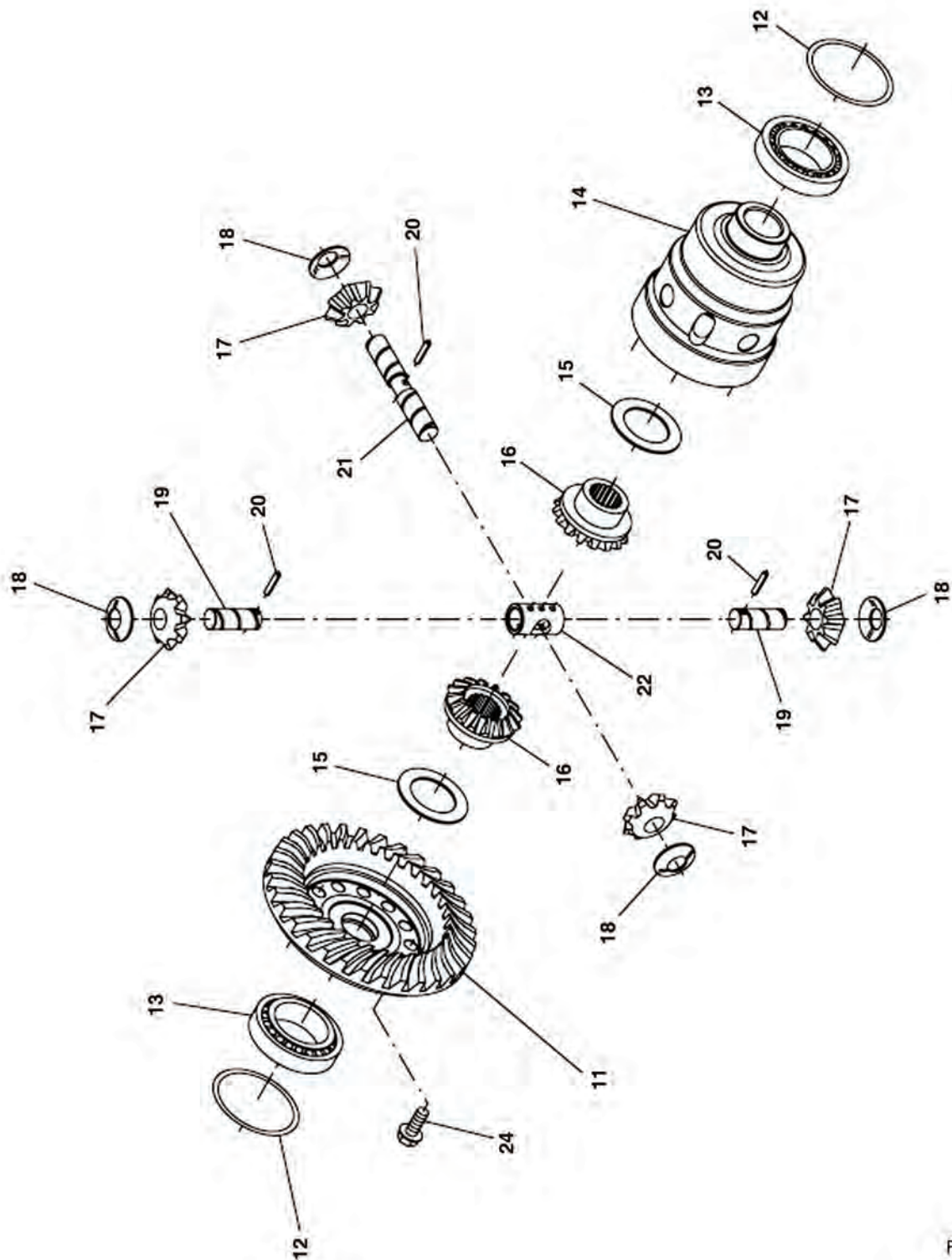


Figure 154

NORMAL DIFFERENTIAL

Assembly Diagram



FG024231

Figure 155

Disassembling

1. Connect an external pump to the union piece "P1" of the negative brake and introduce a pressure of 15 ± 30 bar to eliminate the pressure of the belleville washers.

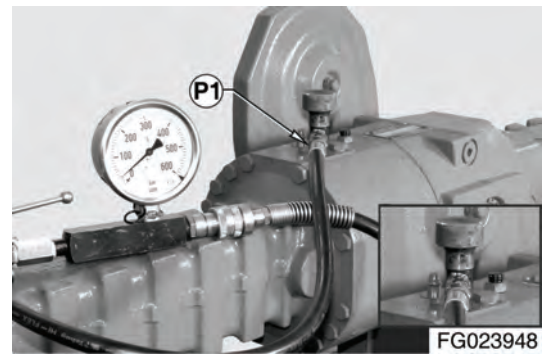


Figure 156

2. Loosen the unlocking screws (30) and remove both stop washers (32).

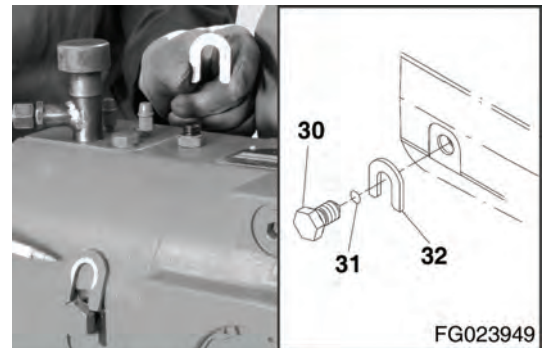


Figure 157

3. Insert block screws to end stroke and release pression.

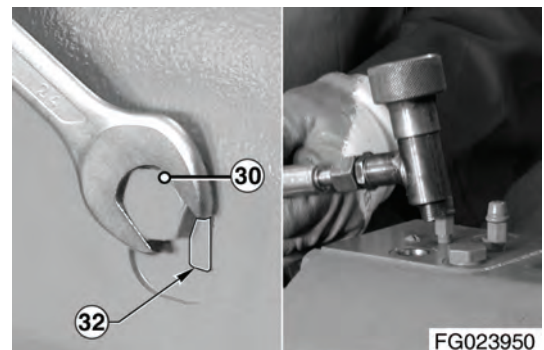


Figure 158

4. Remove the brake side arm and the brake discs pack.
Sling the arm to be removed and connect it to a hoist, remove screws of the crown wheel side arm.
Remove the arm together with the pack of the braking disks.
Place the arm on a bench.

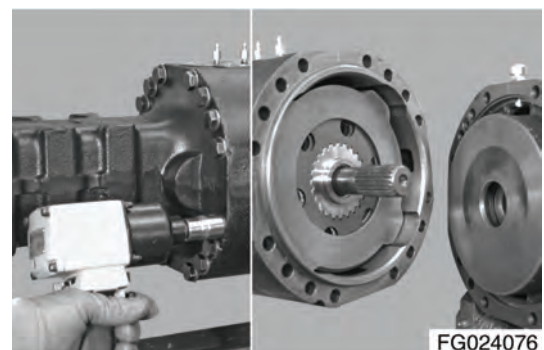


Figure 159

5. Remove the fitting screws from the middle cover.

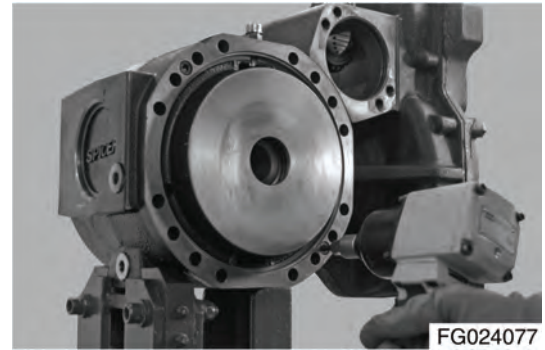


Figure 160

6. Insert a screw-driver in the opposing slots then force and remove the middle cover.

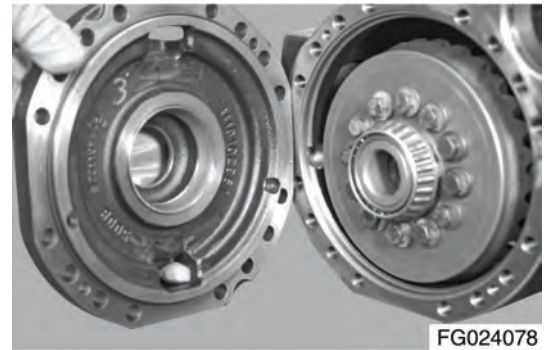


Figure 161

7. If the bearings need replacing (13), extract the external thrust blocks of the bearings (13) from middle cover and central body.

NOTE: *Accurately check the O-ring.*

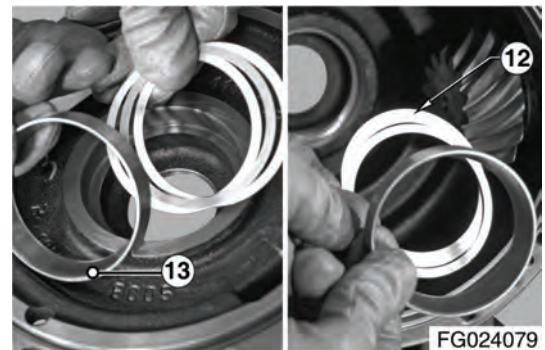


Figure 162

8. Pull out the differential (14).

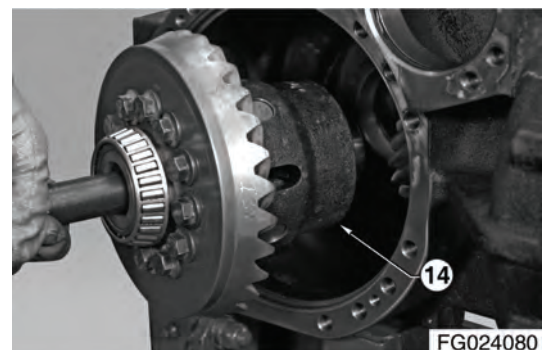


Figure 163

9. If the bearing need replacing, extract the bearing (13) from the differential carrier.

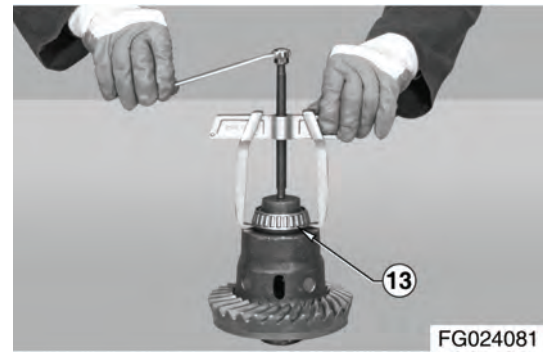


Figure 164

10. Remove fixing screws (24) of the crown wheel (11); exchange each time when removed.

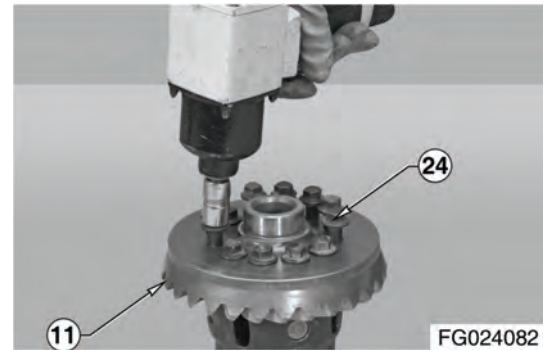


Figure 165

11. Extract the crown wheel (11).

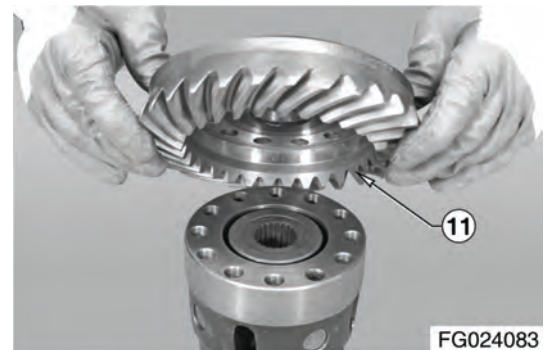


Figure 166

12. Remove the shim washer (15)



Figure 167

13. Remove the planetary gear (16).

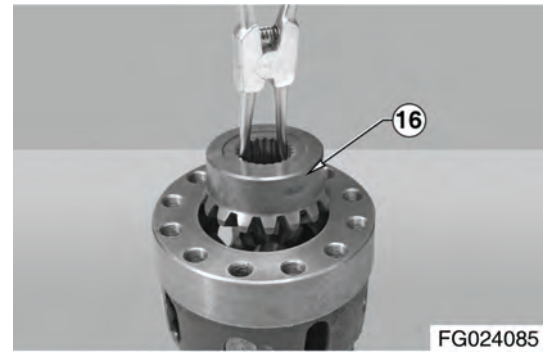


Figure 168

14. Remove the three spider blocking pins (20) by using a pin driver.

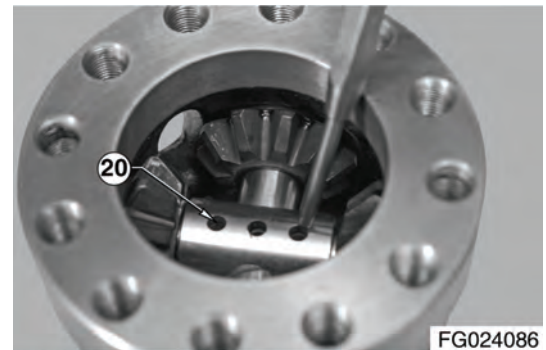


Figure 169

15. Move the two opposite mounted short bolts (19) to the outside of the box using the same pin driver.

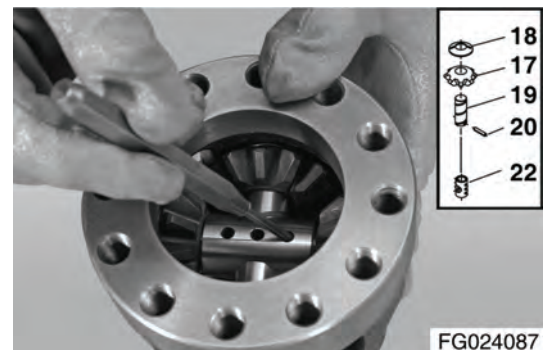


Figure 170

16. Drive out the long bolt (21) and pull out the spider (22) from the centre.

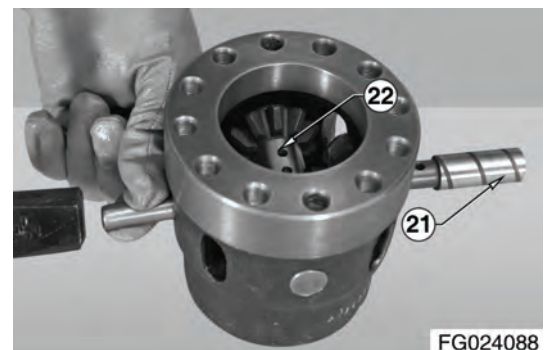


Figure 171

17. Remove the two half bolts (19), spherical washers and satellite wheels.

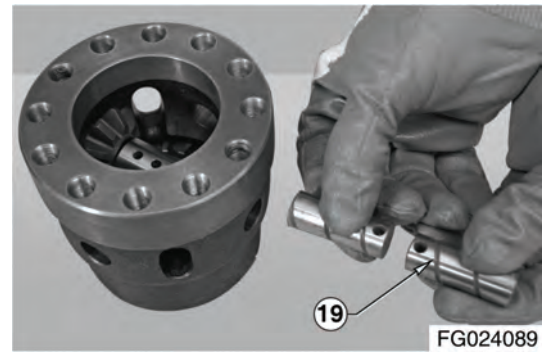


Figure 172

18. Remove long bolt, spherical washers (18) and satellite wheels (17).

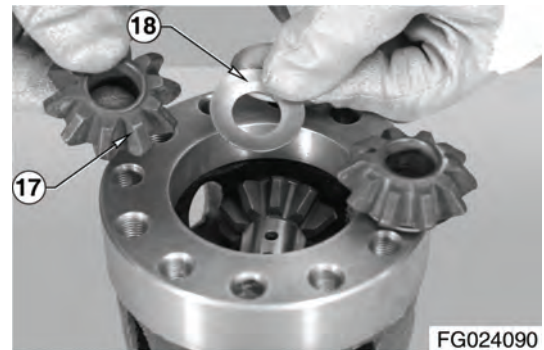


Figure 173

19. Pull out the spider (22) from the centre.



Figure 174

20. Remove the planetary gear (16).

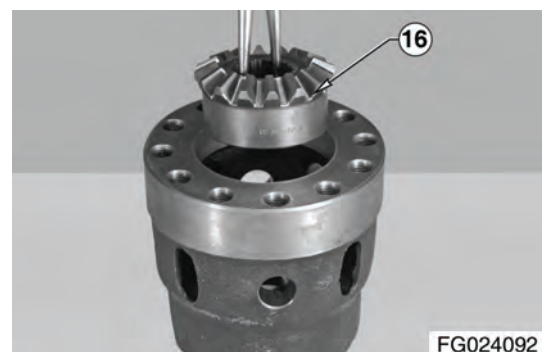


Figure 175

21. Remove the shim washer (15).

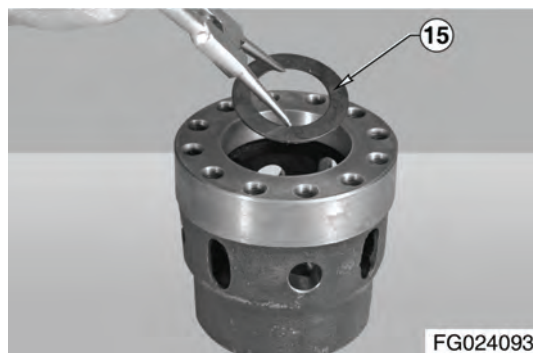


Figure 176

Assembling

1. Lubricate and insert washer (15) and planetary wheel (16).

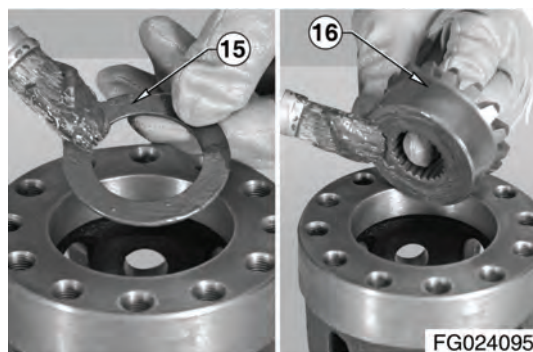


Figure 177

2. Partially insert the long bolt (21), satellite wheels (17) and spherical washers (21).

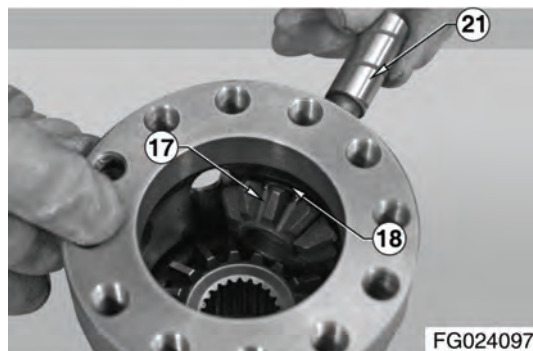


Figure 178

3. Insert the two half bolts (19), spherical washers (18) and satellite wheels (17).

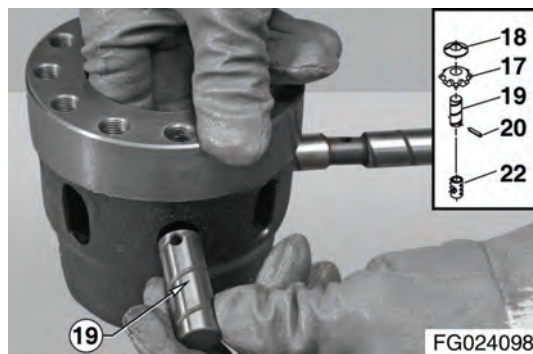


Figure 179

4. Insert spider (22) and completely insert the long bolt (21).

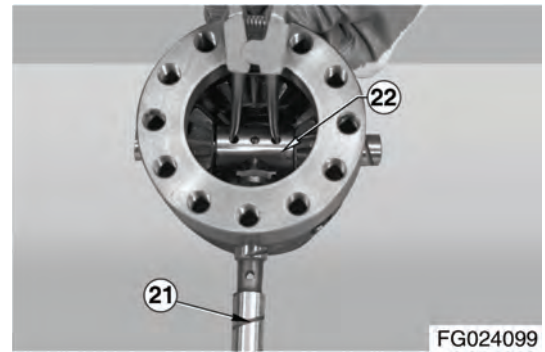


Figure 180

5. Insert completely the bolts (19).

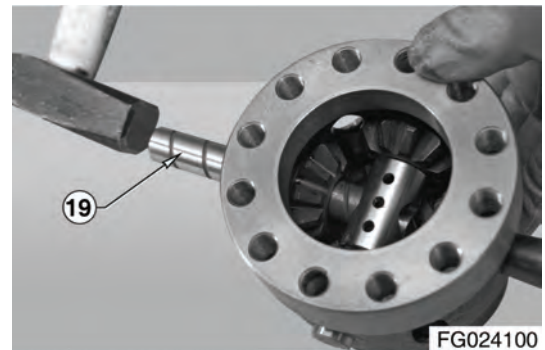


Figure 181

6. Centre the pin holes and insert the 3V pins (20).

NOTE: Check the free rotation of the satellite wheels on the bolts.

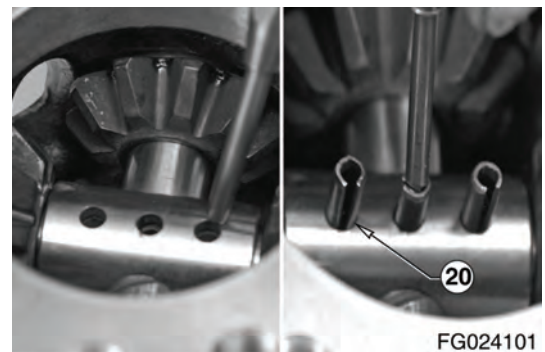


Figure 182

7. Lubricate wheel (16).



Figure 183

8. Insert planetary gear wheel (16).

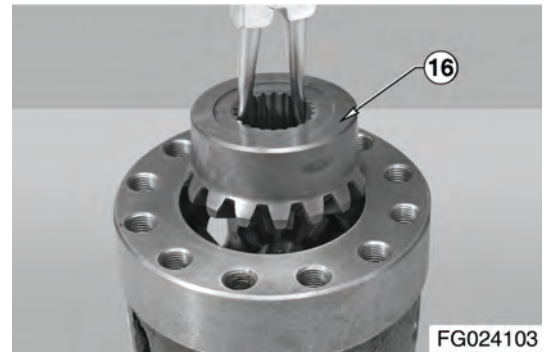


Figure 184

9. Position the shim washer (15) on the crown (11).

NOTE: *In order to hold the shim washer (15) in position, apply grease to it.*



Figure 185

10. Position the crown (11) on the differential carrier and lock it with screws (24) applied with Loctite 270.

NOTE: *Secure the screws using the cross-tightening method.*

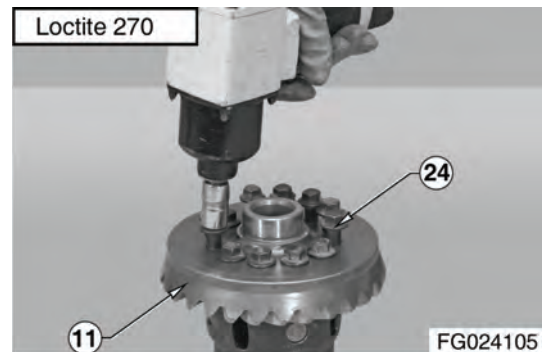


Figure 186

11. Tighten screws with a torque wrench: see table.

NOTE: *Always use new screws to fix the crown wheel. In case the screws are not thread locking pretreated, use Loctite 270.*

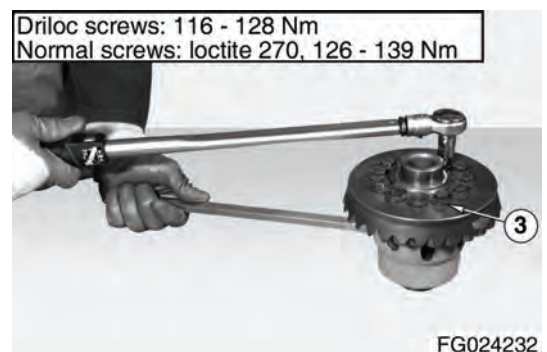


Figure 187

12. Assemble the bearing (13).

NOTE: Heat the bearing to 100 °C before assembling.

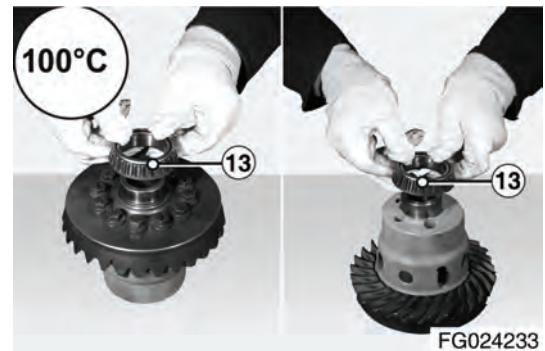


Figure 188

13. If the bearings are replaced, insert the external thrust blocks in the middle cover and in the central body.



Figure 189

14. Position the differential unit in the central body with the help of a bar and fit the middle cover.

NOTE: Thoroughly check the state of the O-ring and make sure that the cover is fitted with the oil discharge in the lower position.



Figure 190

15. Lock the middle cover with screws.

- Torque wrench setting for screw: 23.8 ± 26.2 Nm

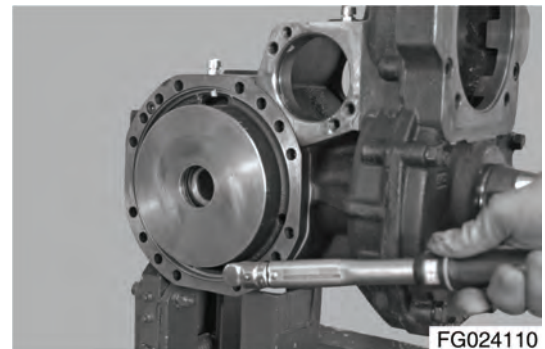


Figure 191

16. Check that the positioning of the sealing ring on the arm is intact; install the complete arm. Lock it into position using two facing screws and washers.

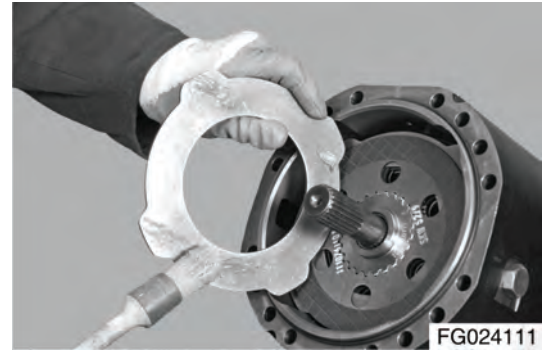


Figure 192

RING AND PINION ADJUSTING

Assembly Diagram

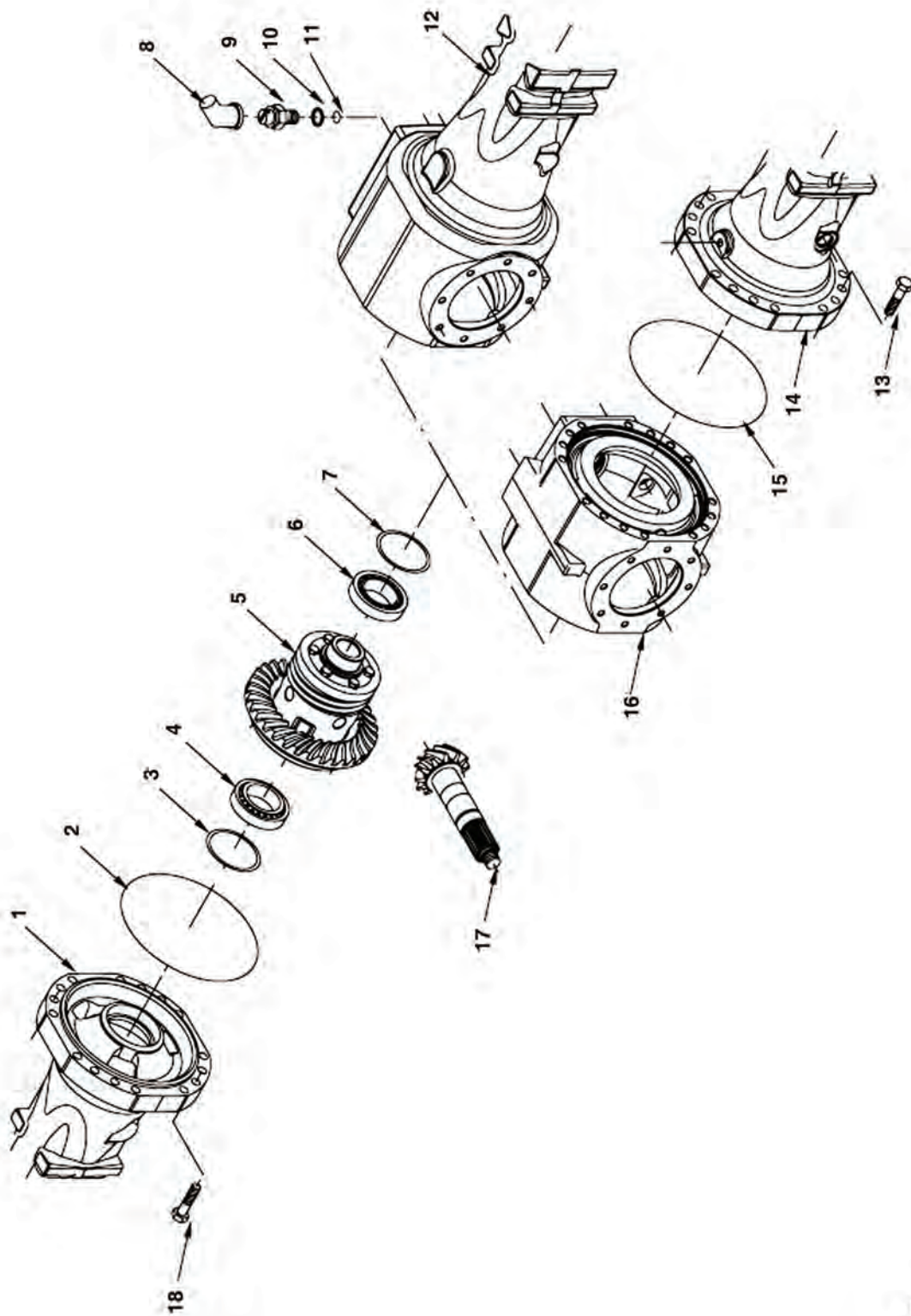


Figure 193

FG024234

Adjust

1. Setting of the crown wheel and pinion

Insert the thrust block of the bearing (6) opposite side of the crown wheel shims (Sb) (7) of an initial thickness of about 0.8 mm.

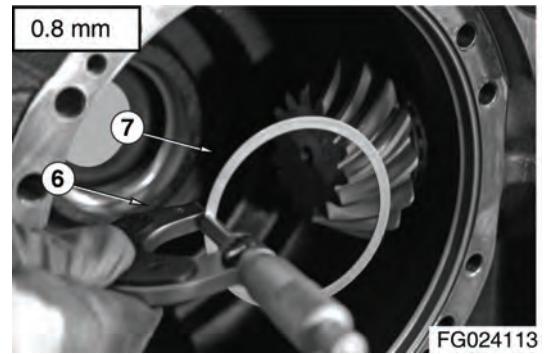


Figure 193

2. Insert the thrust block (6) and the shims (Sb) (7) into the arm.

NOTE: Check to be at end of stroke.

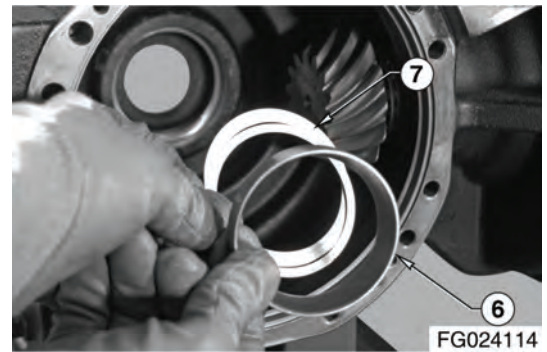


Figure 194

3. Setting of the crown wheel and pinion

Insert thrust block (4) of the bearing shims (Sc) (3) of an initial thickness of about 0.75 mm.

Insert the thrust block and the shims into the arm.

NOTE: Check to be at end of stroke.

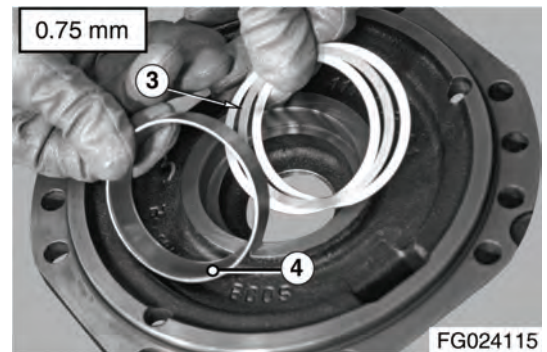


Figure 195

4. Insert complete differential (5).



CAUTION

Do not damage the seat of the O-Ring with the gearwheel.

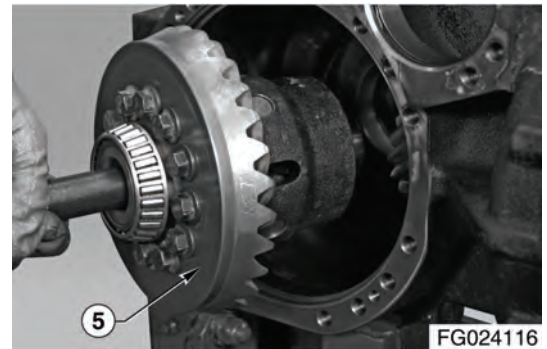


Figure 196

5. Check the O-Ring (2) and grease.

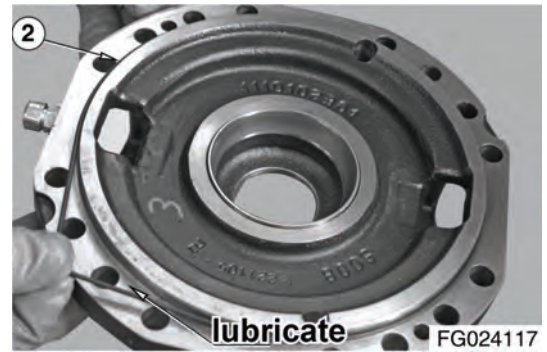


Figure 197

6. Lock the middle cover (5) with screws (4).
- Torque wrench setting for screw: 23.8 ± 26.2 Nm

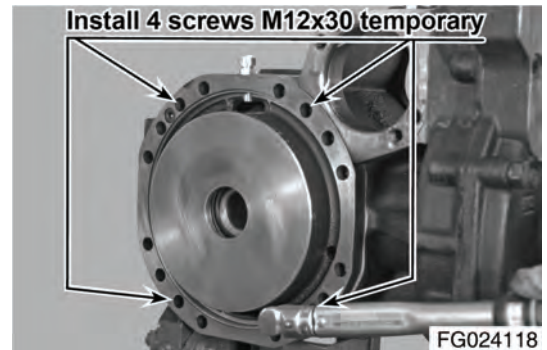


Figure 198

7. Apply torque meter TM to pinion nut and check that torque will increase by 40 - 60 Nm as a result of differential bearing preload.
- Example: pinion torque: 80 - 120 Nm
 - Pinion + differential torque: 120 - 180 Nm

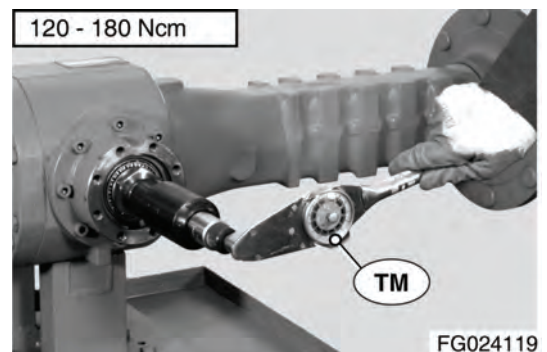


Figure 199

8. Position comparator on the centre of one of the crown teeth, preset it to 1 mm and reset it to zero.
- Manually move the crown in both directions to check the existing clearance between pinion and crown.
- Gap= 0.13 ± 0.20 mm

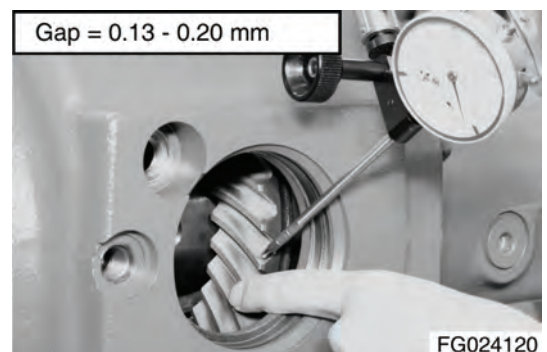


Figure 200

9. Install the crown wheel side arm (1) without half-axle.

NOTE: *To check the torque of the differential, neither of both half axles must be installed.*

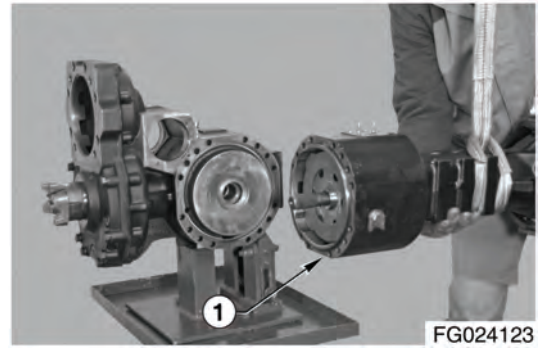


Figure 201

10. Temporarily insert all screws of the arm (18).

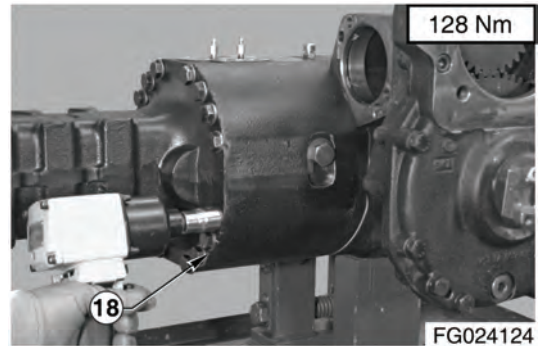


Figure 202

11. Check the flatness of the arms; then lock the arms into their final position, using screws adequately coated with Loctite 242.

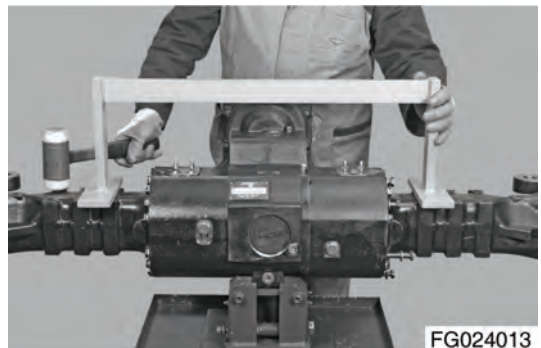


Figure 203

12. Tighten using the criss-cross method.
- Torque wrench setting: 128 Nm

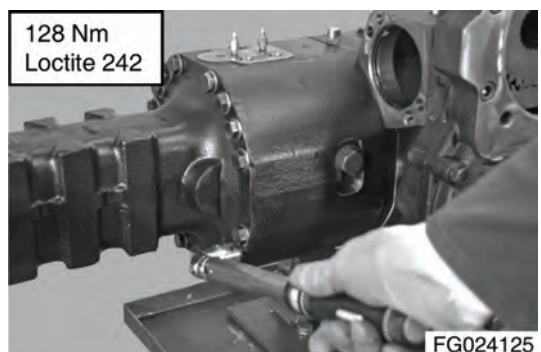


Figure 204

13. Using a driver, fit the cap and position it in its seat with the snap ring.

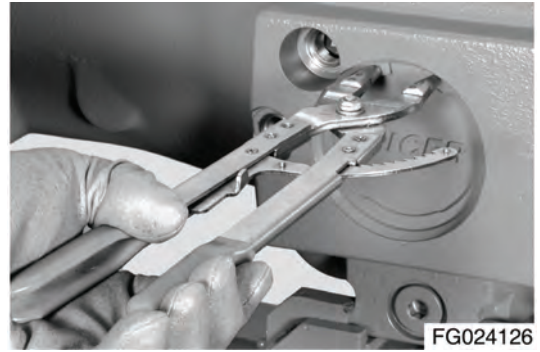
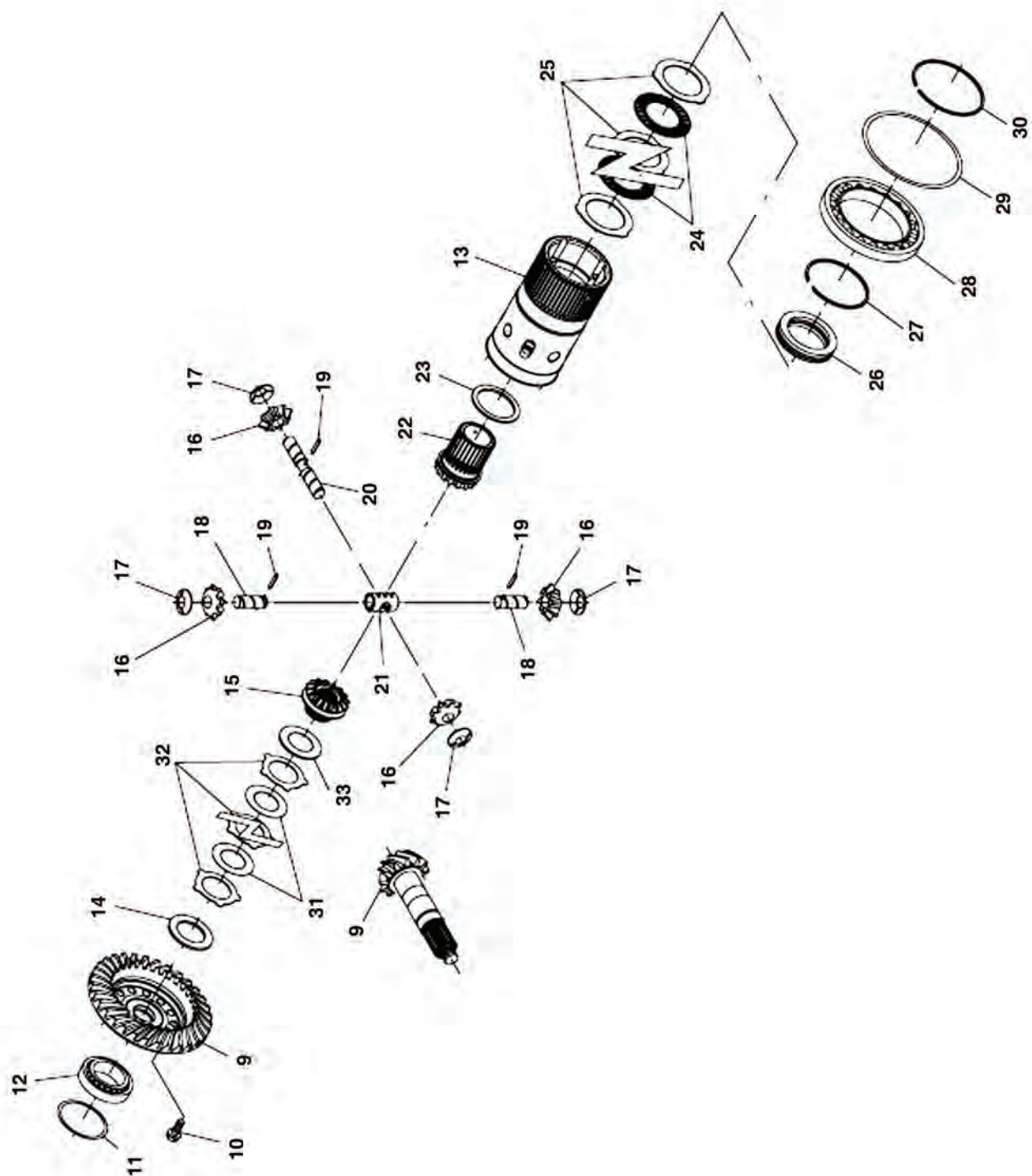


Figure 205

PRELOADED LIMITED SLIP DIFFERENTIAL



FG024235

Figure 206

Disassembling

1. If the bearing (12) has to be replaced, remove two retaining screws (10) from the crown and, using an extractor, remove the crown bearing (9).

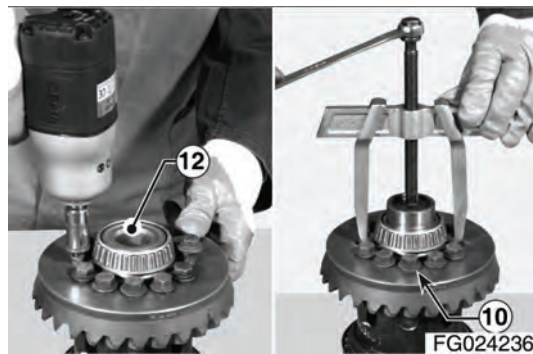


Figure 207

2. If the bearing need replacing, extract the bearing (28) from the differential carrier.



Figure 208

3. Remove the snap ring (27)



Figure 209

4. Remove the trust block (26). Remove the thrust bearing (26).

Remove the trust block (26).

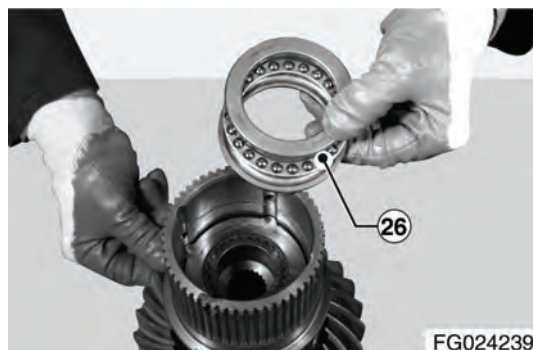


Figure 210

5. Remove the hydraulic block discs (24) (25) one after the other.



Figure 211

6. Remove fixing screws (10) of the crown wheel (9); exchange each time when removed. Extract the crown wheel (9). Remove the shim washer (14).

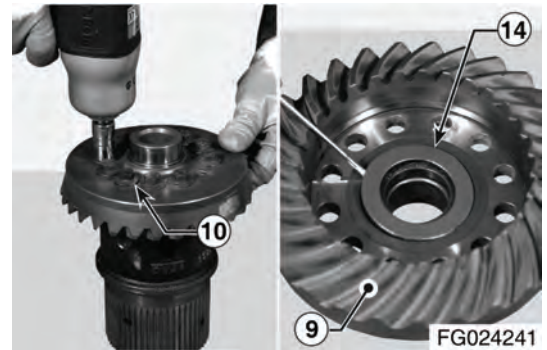


Figure 212

7. Remove the planetary gear (15) and the whole friction assembly concerned.

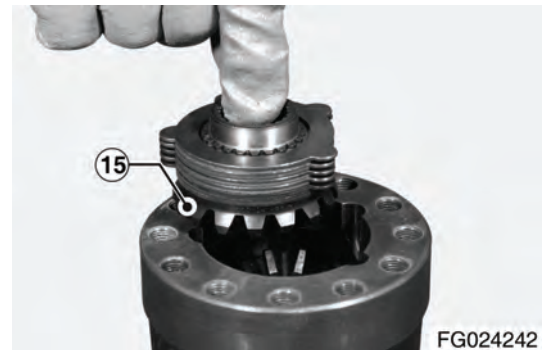


Figure 213

8. Remove the three spider blocking pins (19) by using a pin driver. Move the two opposite mounted short bolts (18) to the outside of the box using the same pin driver.

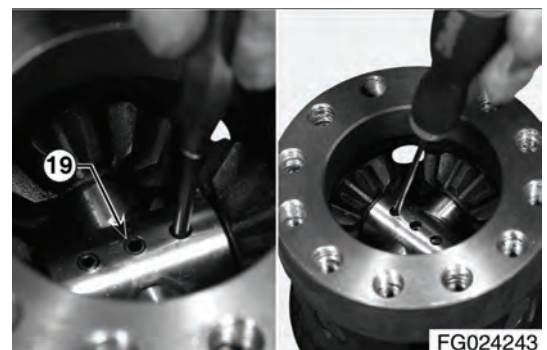


Figure 214

9. Remove the bolts with the help of a drift (20).

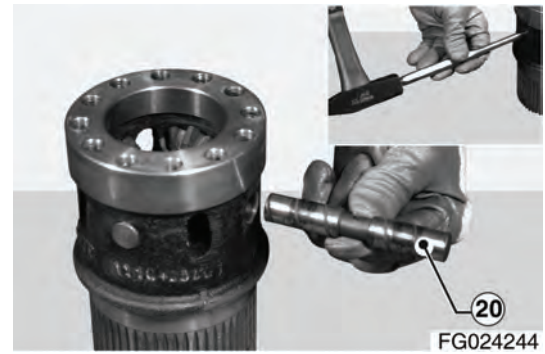


Figure 215

10. Remove the two half bolts (18), spherical washers (17) and satellite wheels (16).

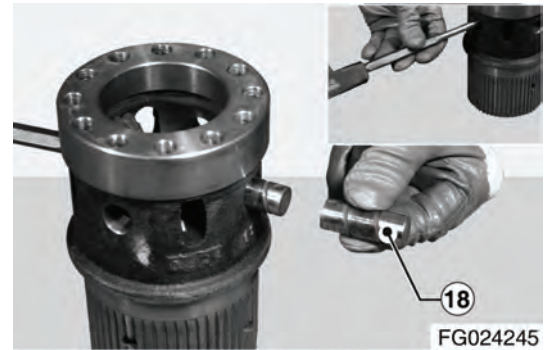


Figure 216

11. Remove the cross bolts (21).

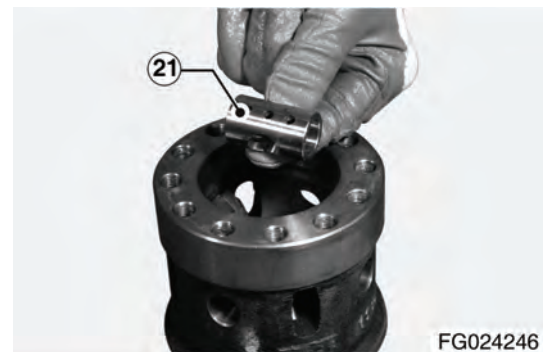


Figure 217

Assembling

1. Remove the central gearwheel (22) with washer (23).

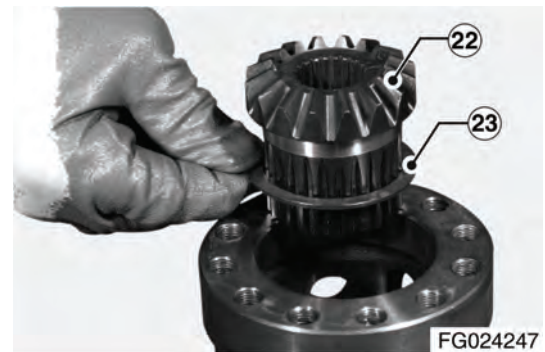


Figure 218

2. Lubricate and insert washer (23) and planetary wheel (22).

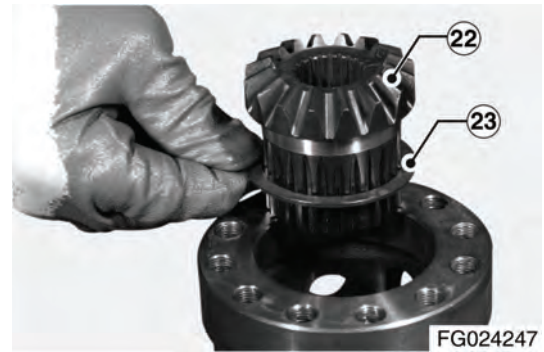


Figure 219

3. Insert the two half bolts (18), spherical washers (17) and satellite wheels (16).

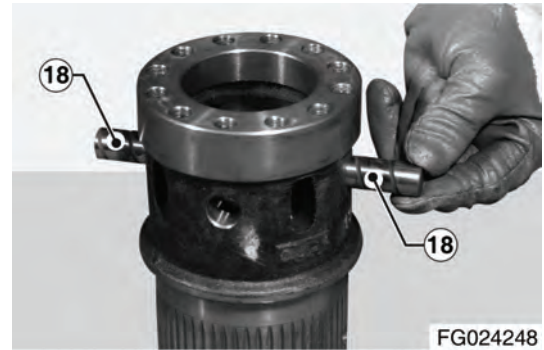


Figure 220

4. Partially insert the long bolt (20), satellite wheels (16) and spherical washers (17).

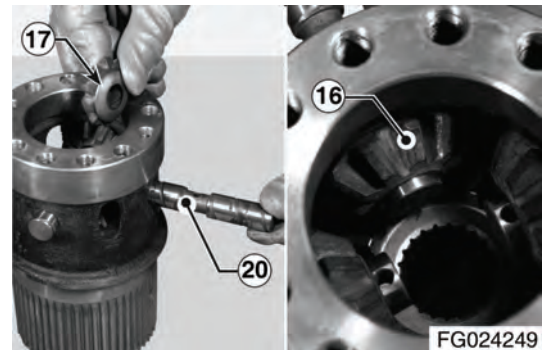


Figure 221

5. Place the planetary (16) and the spherical washer (17) in the box and fix with a fake T5 pin of suitable diameter.

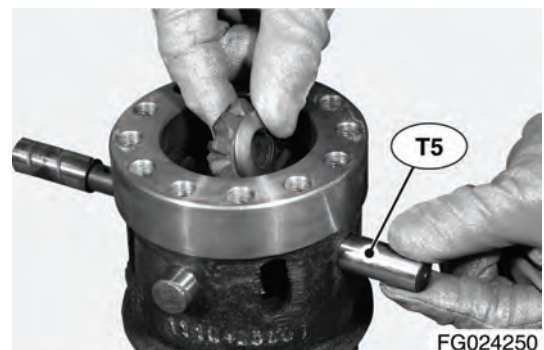


Figure 222

6. Insert the crossbolt (21) in the correct position.

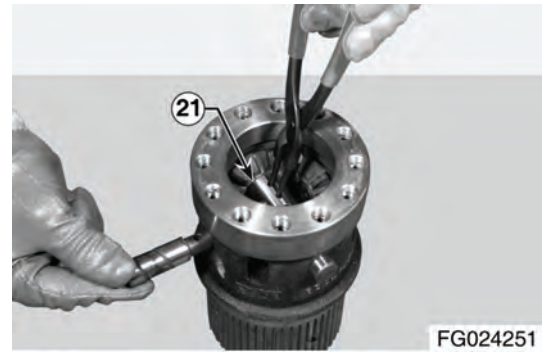


Figure 223

7. Satellite wheels (16), spherical washers (17) and completely insert the long bolt (20).

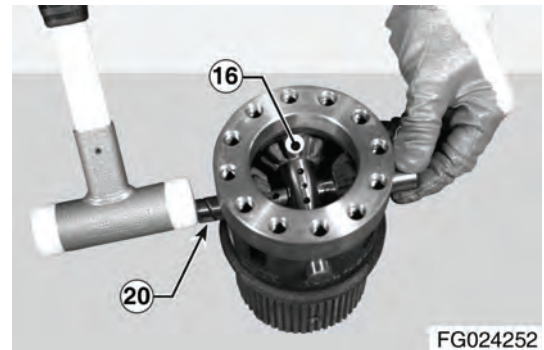


Figure 224

8. Bring the pin holes in line with the help of a pin-driver.
Insert pins (19) to end of stroke.

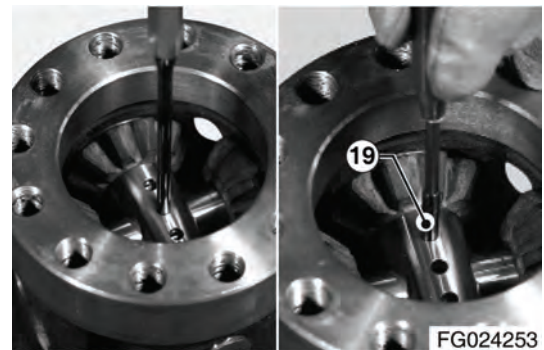


Figure 225

9. Insert and substitute, if necessary, the discs of the differential lock (24) (25).



CAUTION

First and last disc have to be of steel (25).



Figure 226

10. Install the thrust block with maximum internal diameter. Position the bearing (26) in the differential unit. Install the thrust block with minimum internal diameter.

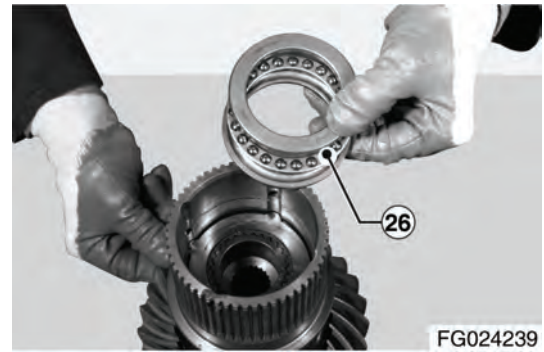


Figure 227

11. Insert the snap ring (27)

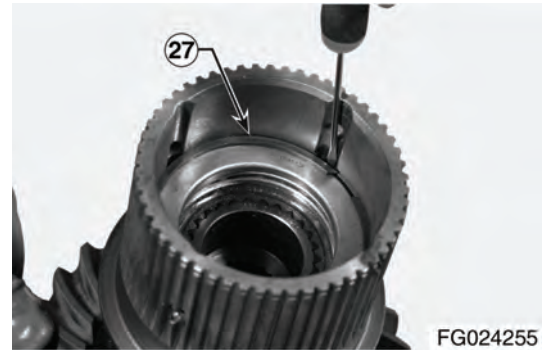


Figure 228



CAUTION

As to ring (33), the side without notches must face outwards.

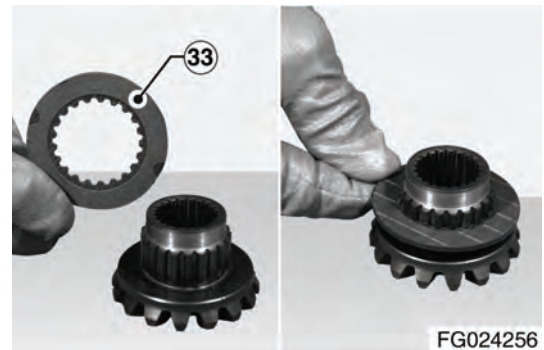


Figure 229

12. 35% friction unit composition

Friction discs with increased shim (33), steel discs (32) and friction discs (31) alternated, end disc (32).



Figure 230

13. Place a friction unit and planetary gear (22) into the half-box (13).

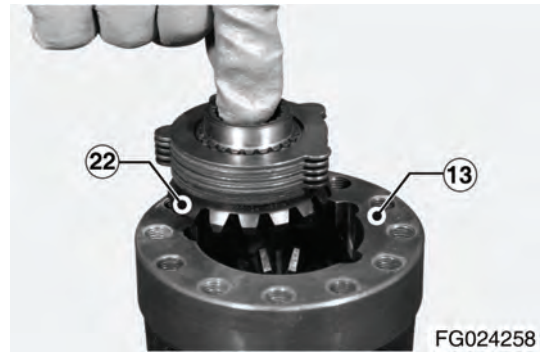


Figure 231

14. Position the shim washer (14) on the crown (9).

NOTE: In order to hold the shim washer (14) in position, apply grease to it. Install the crown wheel (9).

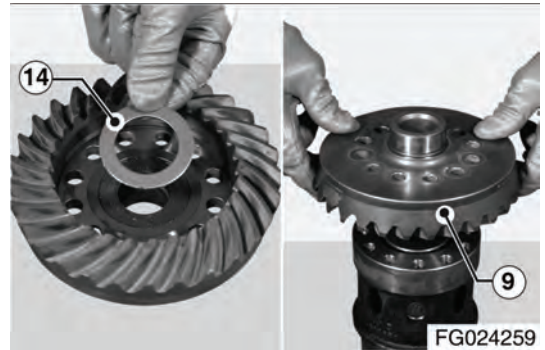


Figure 232

15. Mount the gear ring (9) and fasten it to the differential box with screws (10).



CAUTION

Use only new screws pre-treated with locking adhesive DANA approved.

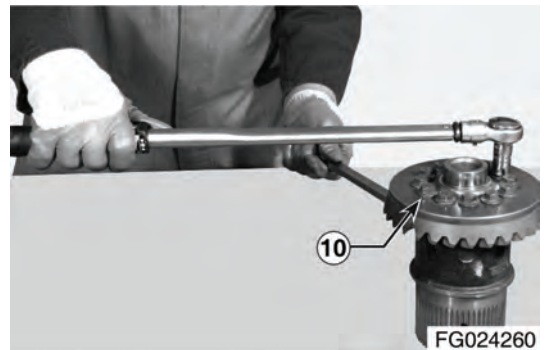


Figure 233

16. Heat the bearings (12) (28) at 100° and Insert them on the differential.

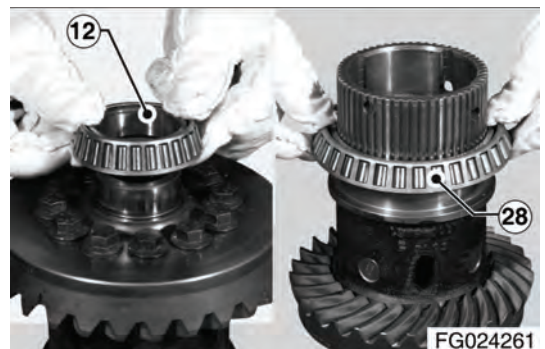


Figure 234

BEVEL PINION

Assembly Diagram

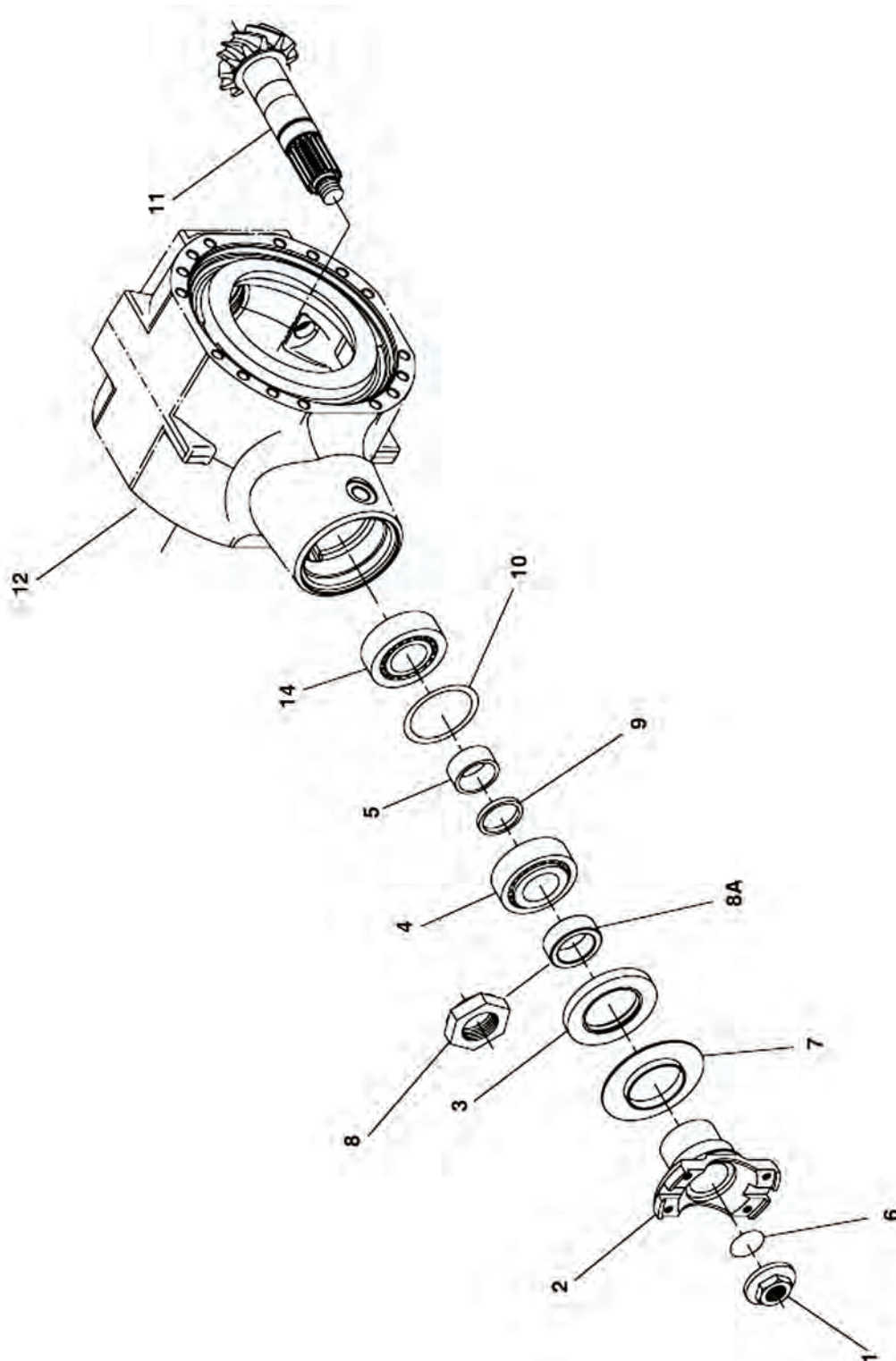


Figure 235

FG024262

Disassembling

1. Make positional marks across nut (1) and pinion (11) tang; If disassembly is awkward, heat the check nut (1) of the flange (2) at 80°C.

NOTE: *Heating is meant to unloose the setting of Loctite on the nut (1).*

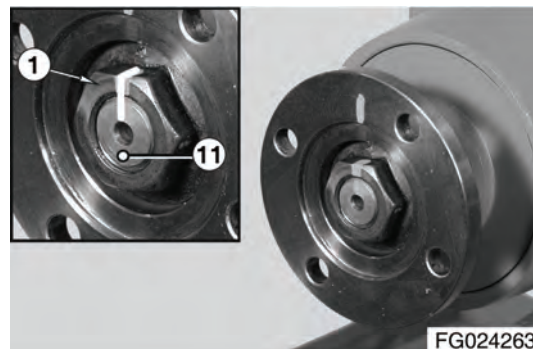


Figure 235

2. Position tool T6, so as to avoid pinion rotation.
Unloose and remove the nut (1); also remove the O-ring (6).



Figure 236

3. Remove the flange (2) complete with guard (7) by means of a puller.

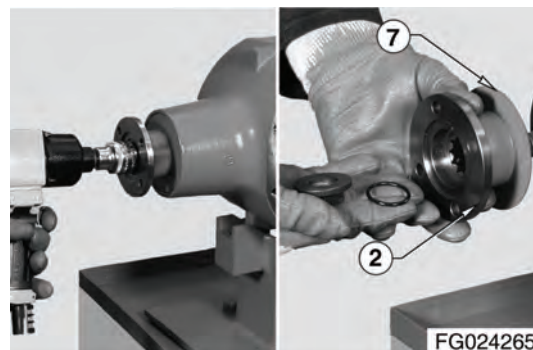


Figure 237

4. Remove the sealing ring (3).

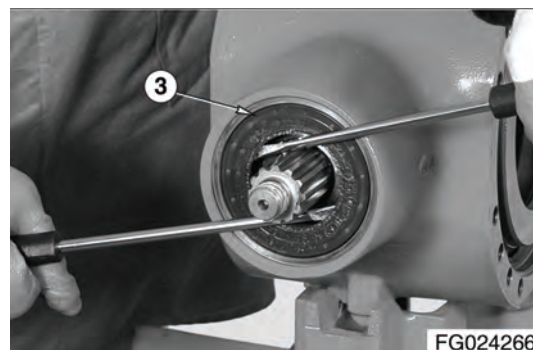


Figure 238

5. Remove the sealing ring (3) and spacer (8A).

NOTE: *sealing rings (3) must be replaced each time the unit is disassembled.*

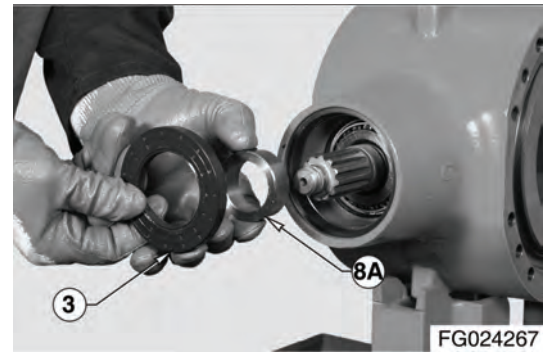


Figure 239

6. Remove the pinion (11), shims and distance piece.

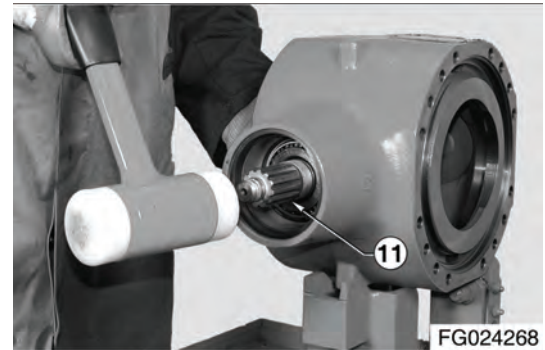


Figure 240

7. Refer and keep to the positions marked during disassembly.

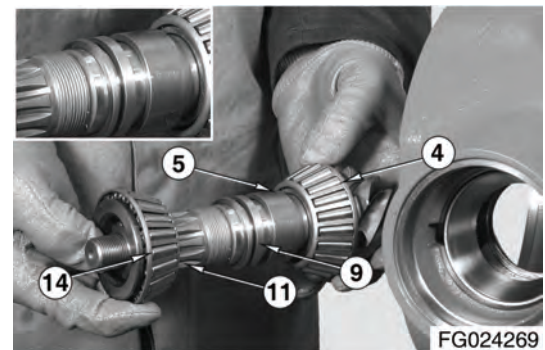


Figure 241

8. Using a puller and a press, remove the inner bearing (4) from the pinion (11).

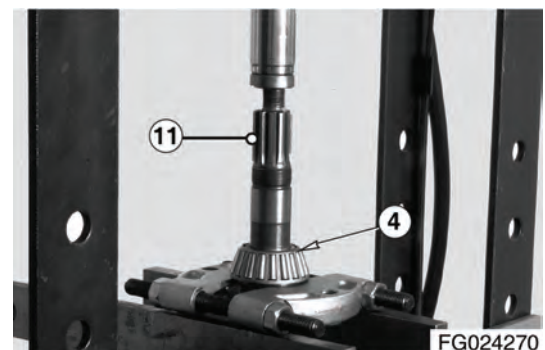


Figure 242

9. Remove the thrust block of the external bearing (14).

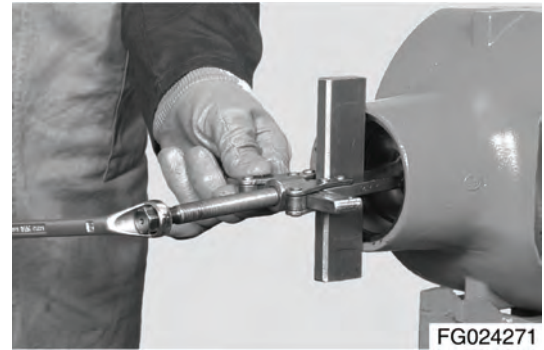


Figure 243

10. Insert a drift in the appropriate holes.

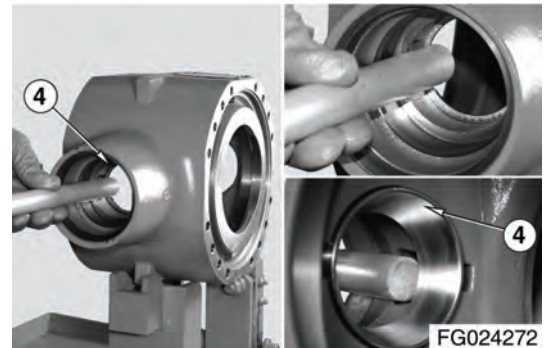


Figure 244

11. Remove the thrust block of the internal bearing (4) as well as the shim washers (10) (S).



Figure 245

12. Remove the snap ring (15). Remove the cap (14).

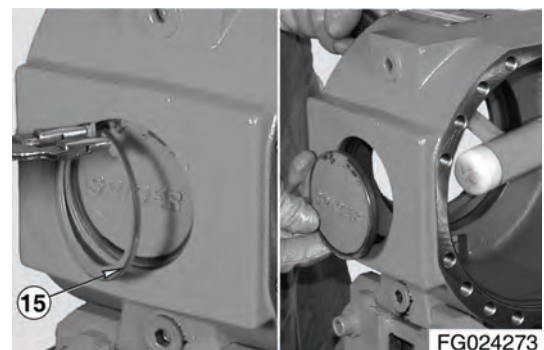


Figure 246

Assembling

1. Calculating pinion centre distance

Using a faceplate, reset a centesimal comparator "DG" on a calibrated block (whose known thickness is 30 mm).

Preload the comparator by about 3 mm.

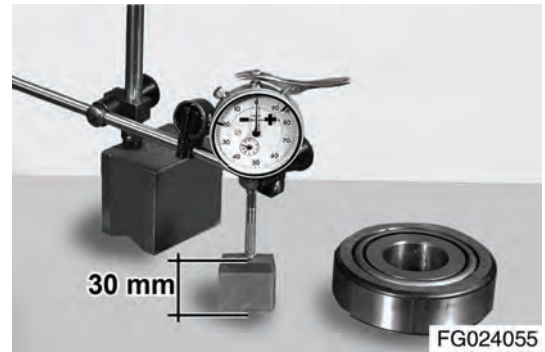


Figure 247

2. Bring inner bearing (4), complete with thrust block, under comparator "DG".



CAUTION

Press the thrust block centrally and carry out several measurements by rotating the thrust block.

- Example: $30 - 0.55 = 29.45 = "D"$.

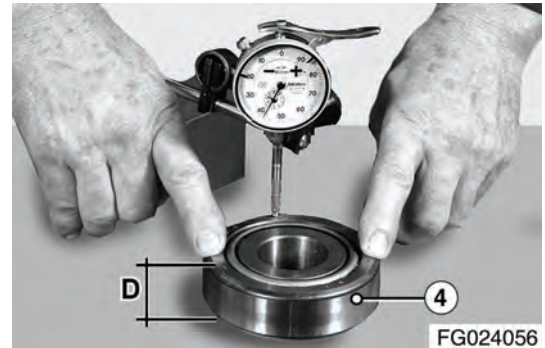


Figure 248

3. Check nominal dimension "I" as marked on the pinion. Add up to or subtract from "I" the variation indicated as "Y" to obtain the actual centre distance "I".

- Example: $I = INT \pm Y = 98 - 0.1 = 97.9 \text{ mm}$

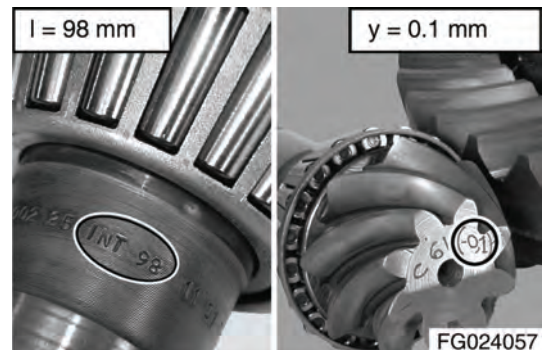


Figure 249

4. Calculate shims "S" for insertion under the thrust block of the inner bearing using the following formula:

- $S = X - (I + D)$ where:
 X = fixed dimension = actual pinion centre distance
 D = Total bearing thickness;
- Example: $S = 128 - (97.9 + 29.45) = 0.65 \text{ mm}$



Figure 250

5. Using special tool T7.

Partially insert the thrust block of the bearings (4) and shims (10).

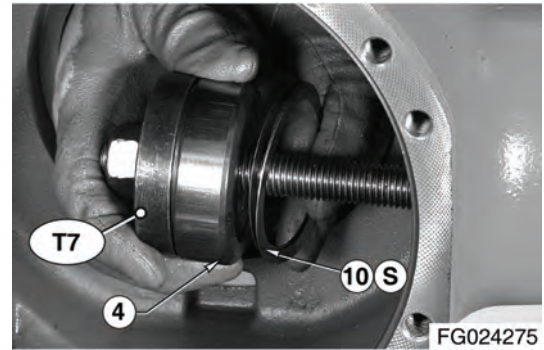


Figure 251

6. Connect the tension rod to the press and move the thrust block of bearings (4) (14) into the seats.

Disconnect the press and remove the tension rod.

NOTE: Before starting the next stage, make sure that the thrust block has been completely inserted into its seat.

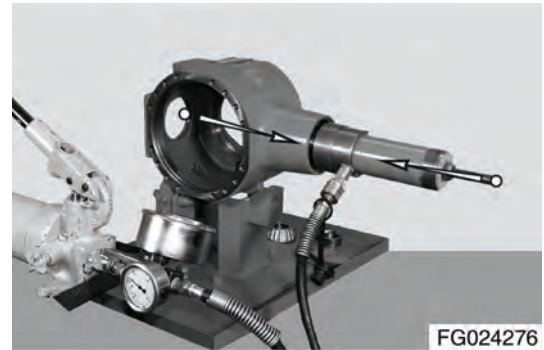


Figure 252

7. Calculating pinion bearings rolling torque

Introduce tool T8 complete with bearings (4) and (14) into the main body (12); tighten by hand until a rolling torque is definitely obtained.

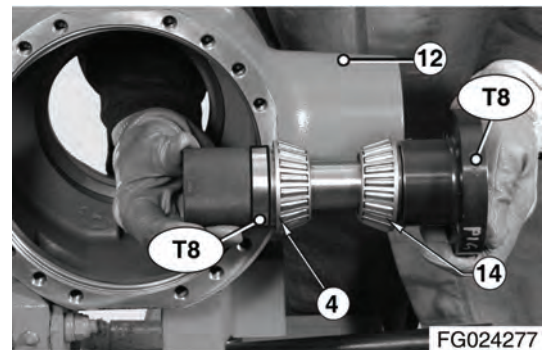


Figure 253

8. Introduce the tracer of a depth comparator "DDG" into either side hole of tool T8.

Reset the comparator with a preload of about 3 mm.

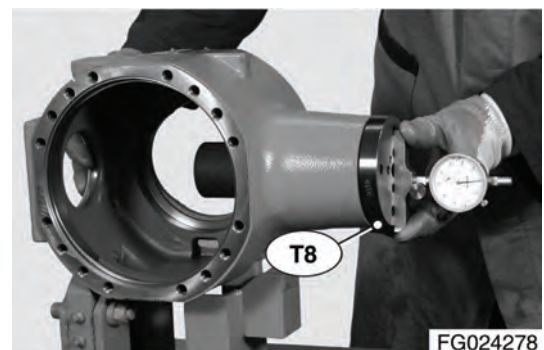


Figure 254

9. Remove the comparator and take out tool and bearing kits from the main body.

Reinstall every part, also introducing a distance piece between bearings (4) and (14). Tighten the entire pack by hand.

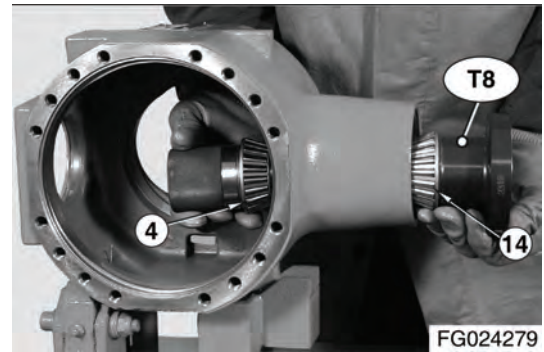


Figure 255

10. Assemble on top of the tool T8 and between the two bearings the shim (5) and the largest calibrated shim (9).



Figure 256

11. Measure the difference H using a dial gauge DDG

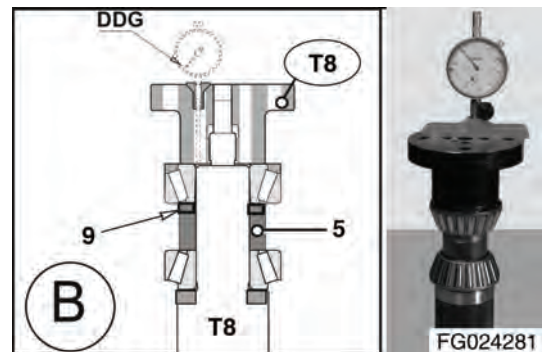


Figure 257

12. Calculate the shim S2 to be inserted.
 - E.g. $S2 = H + X = 3.01 \text{ mm}$
where X = fixed value to obtain = 0.07...0.08 mm



Figure 258

13. Fit the pinion (11), shim "S1" (10) and distance piece (5) (9) in the main body (12).

NOTE: *The finer shims must be placed in- between the thicker ones.*

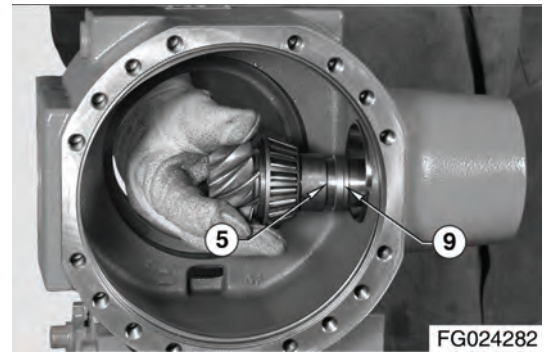


Figure 259

14. Heat the external bearing (14) to a temperature of about 100°C and fit it on to the pinion (11) so as to complete the pack as shown in the figure.

NOTE: *Lightly lubricate bearing with SAE85W90 oil.*

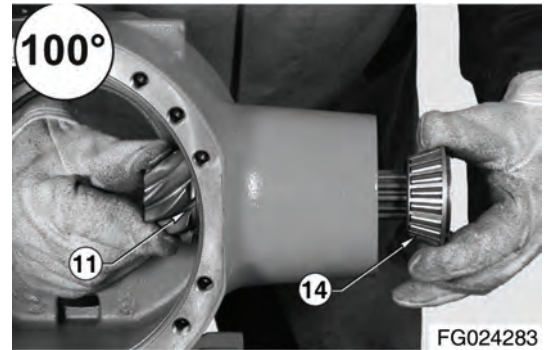


Figure 260

15. Insert the spacer (8A)

NOTE: *Check the using of the friction washers.*

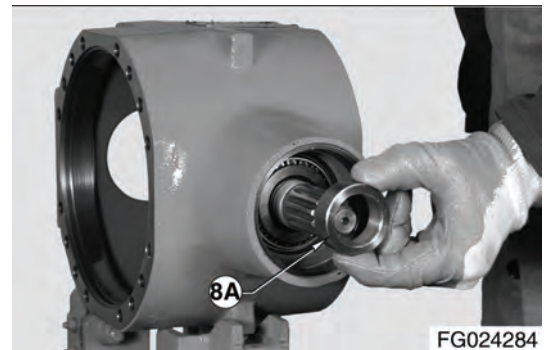


Figure 261

16. Install the flange (2) onto the pinion (11) without sealing ring.

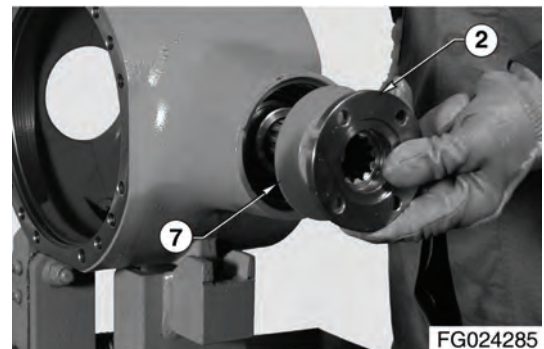


Figure 262

17. Install the nut (1) without Loctite 270.

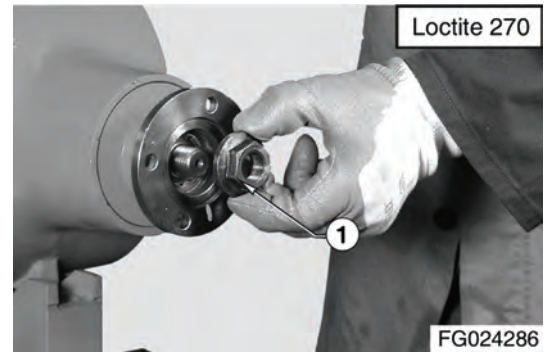


Figure 263

18. Lock the wrench T6, rotate the pinion using a dynamometric wrench, up to a minimum required torque setting of 260 - 300 Nm.

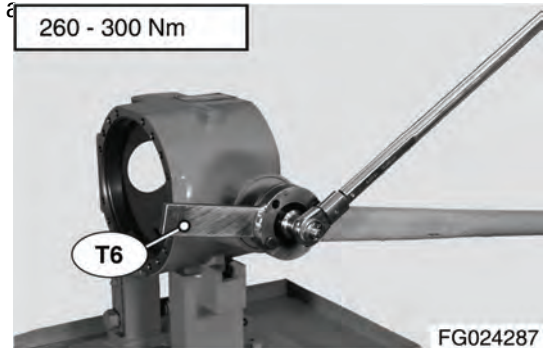


Figure 264

19. Apply onto the pinion (1) the bar-hold and with the help of a torque metre, check the torque of the pinion (1).

- Torque: 80 - 120 Nm



CAUTION

If torque exceeds the maximum value, then the size of shim "S1" (4) between the bearing (9) and the distance piece (3) needs to be increased. If torque does not reach the set value, increase the torque setting of the ring nut (10) in different stages to obtain a maximum value of 500 Nm.



CAUTION

If torque does not reach the minimum value, then the size of shim "S1" (4) needs to be reduced. When calculating the increase or decrease in size of shim "S1", bear in mind that a variation of shim of 0.01 mm corresponds to a variation of 60 Nm in the torque of the pinion (1).

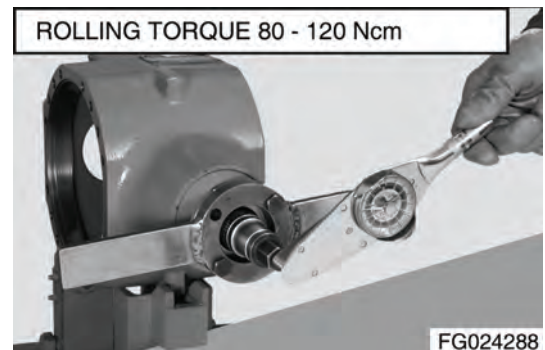


Figure 265

20. Make positional marks across nut (1) and pinion (11) tang; then remove nut and flange (2)

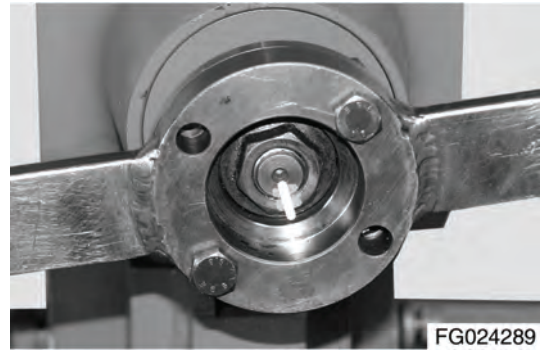


Figure 266

21. Apply Arexons rubber cement to the outer surface of the new seal ring (3) and fit ring in the main body (12) using driver T9.

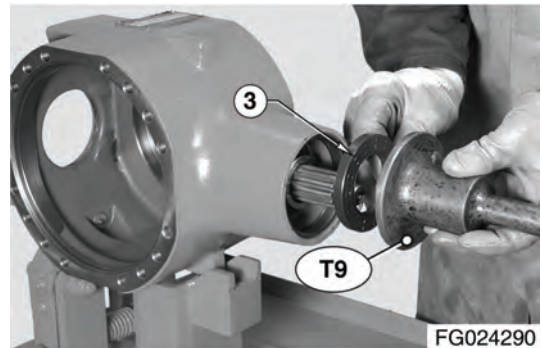


Figure 267

22. Oil seal ring lips and install flange (2).
Mount O-ring (6) and apply Loctite 270 to pinion tang; tighten nut (1).

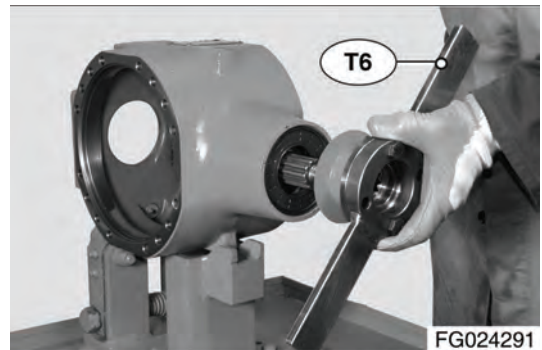


Figure 268

23. Tighten the nut until the match marks made at stage "a" line up.

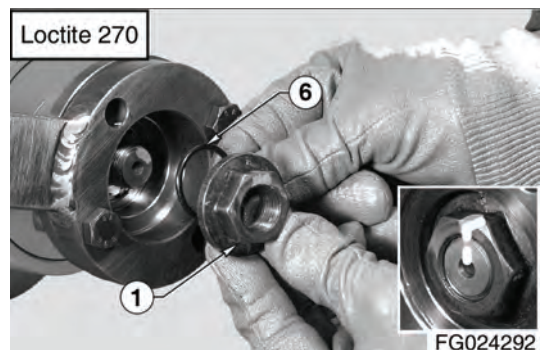


Figure 269

Engine and Drivetrain

Engine

Edition 1

MEMO

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MEMO

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 ultimately 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
DX55W	5001 and Up

SAFETY

Safety Precautions

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 1

DANGER

Explosion Hazard!

Keep the area around the battery well-ventilated. While the engine is running or the battery is charging, hydrogen gas is produced which can be easily ignited.

Keep sparks, open flame and any other form of ignition away while the engine is running or battery is charging.

Failure to comply will result in death or serious injury.



HAOA311P

Figure 2

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 3



DANGER

Fire And Explosion Hazard!

Only use the key switch to start the engine.

Never jump-start the engine. Sparks caused by shorting the battery to the starter terminals may cause a fire or explosion.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 4



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

If the unit has an electric fuel pump, when you prime the fuel system, turn the key switch to the ON position for 10 to 15 seconds to allow the electric fuel pump to prime the system.

If the unit has a mechanical fuel pump, when you prime the fuel system, operate the fuel priming lever of the mechanical fuel pump several times until the fuel filter cup is filled with fuel.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 5



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 6



DANGER

Fire And Explosion Hazard!

Diesel fuel is extremely flammable and explosive under certain conditions.

Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.

Never place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 7



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



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Never use diesel fuel as a cleaning agent.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 11



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 12



WARNING

Sever Hazard!

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

Wear tight-fitting clothing and keep your hair short or tie it back while the engine is running.

Remove all jewelry before you operate or service the machine.

Never start the engine in gear. Sudden movement of the engine and / or machine could cause death or serious personal injury.

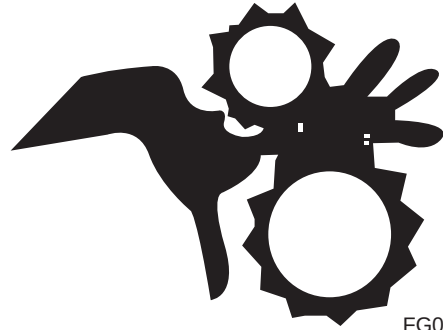
Never operate the engine without the guards in place.

Before you start the engine make sure that all bystanders are clear of the area.

Keep children and pets away while the engine is operating.

Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.

Failure to comply could result in death or serious injury.



FG009148

Figure 13



WARNING

Exhaust Hazard!

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

Never block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.

Make sure that all connections are tightened to specifications after repair is made to the exhaust system.

Failure to comply could result in death or serious injury.



ARO1770L

Figure 14



WARNING

Alcohol And Drug Hazard!

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

Never operate the engine when you are feeling ill.

Failure to comply could result in death or serious injury.



FG009149

Figure 15



WARNING

Exposure Hazard!

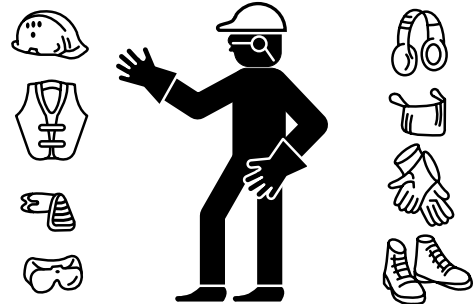
Wear personal protective equipment such as gloves, work shoes, eye and hearing protection as required by the task at hand.

Never wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing when you are working near moving / rotating parts such as the cooling fan, flywheel or PTO shaft.

Always tie back long hair when you are working near moving / rotating parts such as a cooling fan, flywheel, or PTO shaft.

Never operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the alert signals.

Failure to comply could result in death or serious injury.



HAOA020L

Figure 16



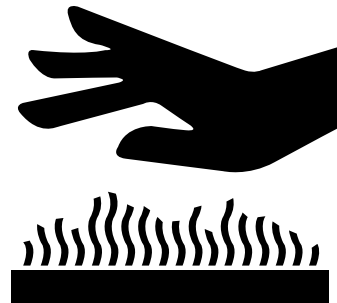
WARNING

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 17

WARNING

Burn Hazard!

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

Failure to comply could result in death or serious injury.



FG008465

Figure 18

WARNING

High-pressure Hazard!

Avoid skin contact with the high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.

Never check for a fuel leak with your hands. Always use a piece of wood or cardboard. Consult authorized DOOSAN dealer or distributor if you have any questions or require more information.

Failure to comply could result in death or serious injury.



FG009150

Figure 19

WARNING

Shock Hazard!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.



FG009151

Figure 20



WARNING

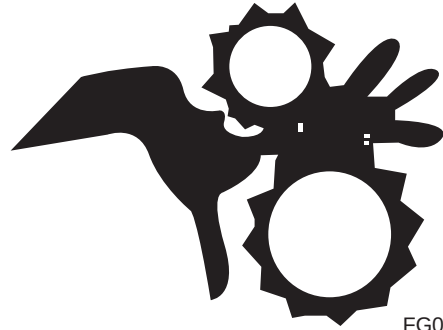
Entanglement Hazard!

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 21

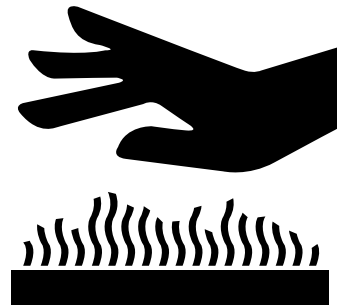


WARNING

Burn Hazard!

Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.

Failure to comply could result in death or serious injury.



HAOA050L

Figure 22



WARNING

Sudden Movement Hazard!

Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.

Failure to comply could result in death or serious injury.

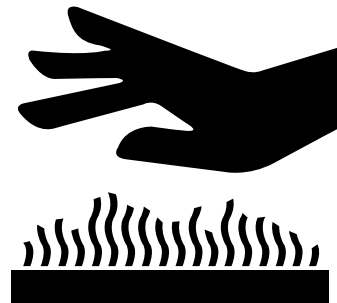


WARNING

Burn Hazard!

Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, 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.



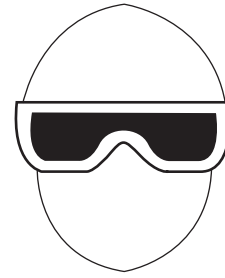
HAOA050L

Figure 23



WARNING

To prevent possible eye injury, always wear SAFETY GLASSES while servicing the engine.



FG009152

Figure 24



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 25



WARNING

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



WARNING

Never inject fuel toward you. Since the fuel is injected at high pressure from the nozzle, it may penetrate the skin, resulting in injury.

Never inject fuel toward a fire source. Atomized fuel is highly flammable and may cause a fire or burn skin.

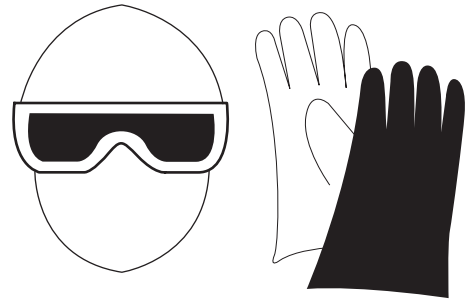


CAUTION

Coolant Hazard!

Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

Failure to comply may result in minor or moderate injury.



FG009154

Figure 26

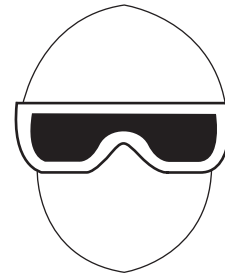


CAUTION

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 27



CAUTION

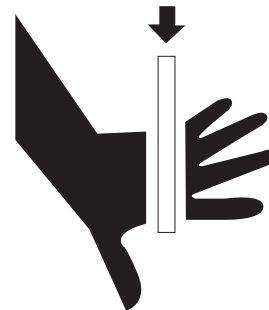
Be sure to secure the engine solidly to prevent injury or damage to parts due to the engine falling during work on the engine.



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 28



CAUTION

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



CAUTION

Only use diesel fuels recommended by *DOOSAN* for the best engine performance, to prevent engine damage and to comply with EPA / ARB warranty requirements.

Only use clean diesel fuel.

Never remove the primary strainer (if equipped) from the fuel tank filler port. If removed, dirt and debris could get into the fuel system causing it to clog.



CAUTION

Never attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the machine and shorten its life. If adjustment is ever required, contact your authorized *DOOSAN* dealer or distributor.



CAUTION

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



CAUTION

Never hold the key in the START position for longer than 15 seconds or the starter motor will overheat.



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

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

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

Avoid operating in extremely dusty conditions.

Avoid operating in the presence of chemical gases or fumes.

Avoid operating in a corrosive atmosphere such as salt water spray.

Never install the engine in a floodplain unless proper precautions are taken to avoid being subject to a flood.

Never expose the engine to the rain.



CAUTION

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

The standard range of ambient temperatures for the normal operation of 4TNV98-E engine is from +5°F (-15°C) to +113°F (+45°C).

If the ambient temperature exceeds +113°F (+45°C) the engine may overheat and cause the engine oil to break down.

If the ambient temperature is below +5°F (-15°C) the engine will be hard to start and the engine oil may not flow easily.

Contact your authorized *DOOSAN* dealer or distributor if the engine will be operated outside of this standard temperature range.



CAUTION

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



CAUTION

If any indicator illuminates during engine operation, stop the engine immediately. Determine the cause and repair the problem before you continue to operate the engine.



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

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 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.

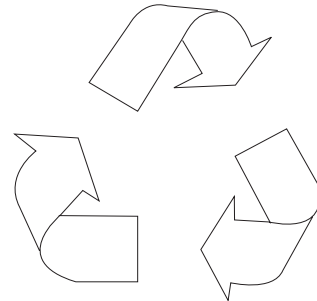
Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.



CAUTION

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



FG009156

Figure 29



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 attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the fuel injection quantity control.

Failure to comply may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may affect the warranty coverage of your engine.



CAUTION

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



CAUTION

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



CAUTION

Never attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the machine and shorten its life. If the idle speed limit screws require adjustment, consult authorized *DOOSAN* dealer or distributor.



CAUTION

The tightening torque in the standard Torque Chart (see General Service Information section) should be applied only to the bolts with a "7" head, (JIS strength classification : 7T)

Apply 60% torque to bolts that are not listed.

Apply 80% torque when tightened to aluminum alloy.



Figure 30

FG009157



CAUTION

If any indicator fails to illuminate when the key switch is in the ON position, see your authorized *DOOSAN* dealer or distributor for service before operating the engine.



CAUTION

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

Consult your authorized *DOOSAN* dealer or distributor for assistance when checking items marked with a ●.



CAUTION

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

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



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.



CAUTION

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



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.



CAUTION

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



CAUTION

Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.



CAUTION

The starter motor can be damaged if operated continuously longer than 10 seconds while performing the no-load test.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



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.



CAUTION

Do not use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated on the wiring diagram. The starter motor will malfunction or break down if the resistance is higher than the specified value.



CAUTION

The starter motor is water-proofed according to JIS D 0203, R2 which protects the motor from rain or general cleaning. Do not use high-pressure wash or submerge the starter motor in water.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

Never attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.

Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use genuine replacement parts.



CAUTION

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



CAUTION

Each pressure adjusting shim removed or added changes the pressure threshold by approximately 275 psi (1.9 MPa, 19 kgf/cm²). Adding adjusting shims increases the threshold pressure.

Removing adjusting shims reduces the pressure threshold.



CAUTION

Do not rotate the crankshaft with the injection pump removed.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

Never remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

Never attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they can be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.



CAUTION

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

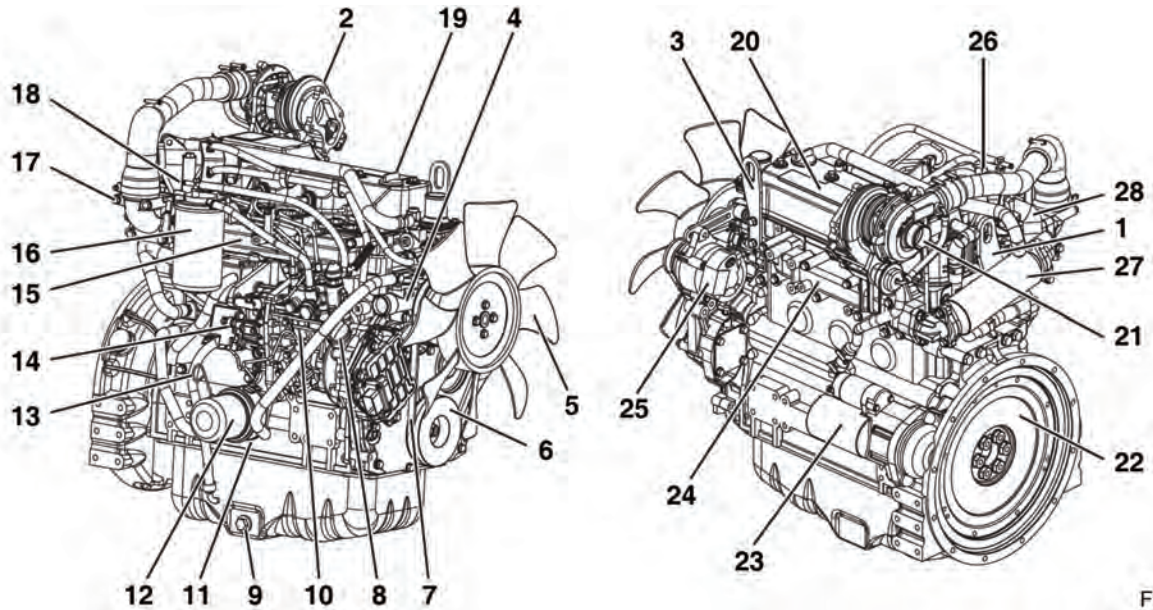


CAUTION

Allow the engine to warm-up for at least five minutes and the idle speed of the engine to return to normal before engaging the transmission or any PTOs. Engaging the transmission or PTO at an elevated engine speed could result in an unexpected movement of the equipment.

GENERAL SERVICE INFORMATION

Component Identification



FG010622

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

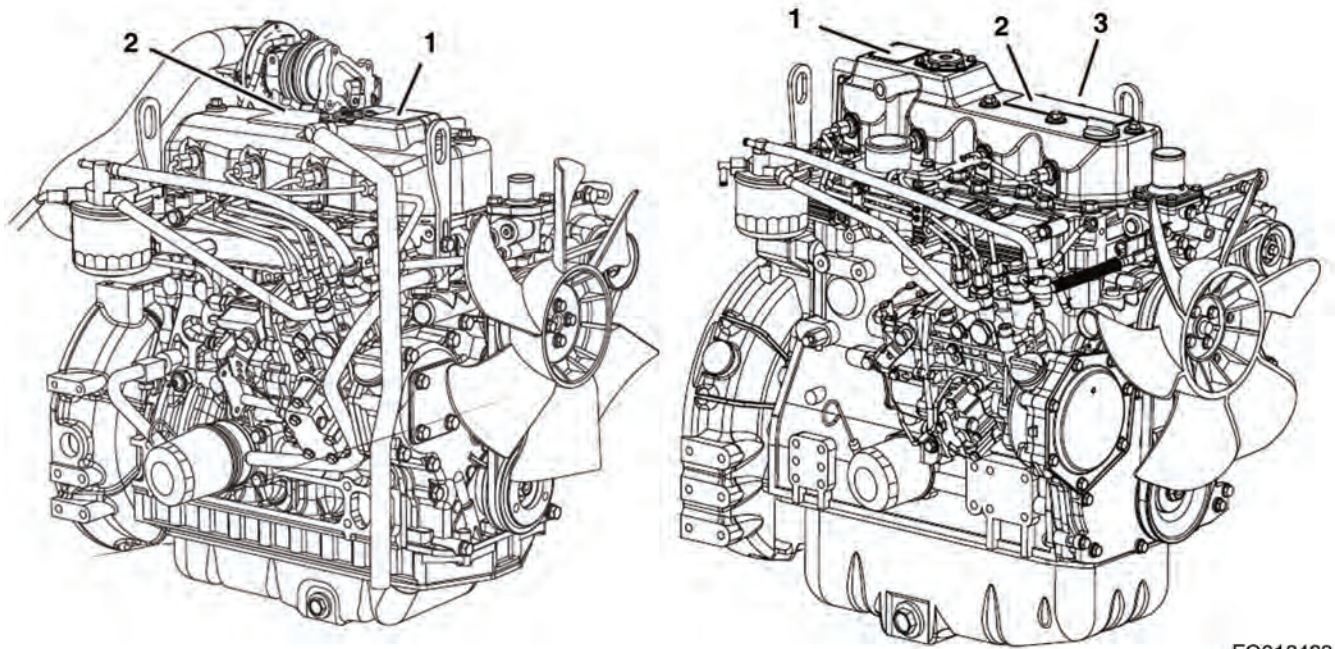
* Only applies to 4TNV84T-Z, 4TNV98T-Z and this machine is not installed turbocharger.

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

*** Not standard on all direct injection models.

**** Only applies to 4TNV84T-Z, 4TNV98T-Z and this machine is not installed EGR cooler

Location of Labels



FG012433

Figure 32

Model	Engine Nameplate	EPA.ARB Certification Label	97/68/EC Emission Control Label
4TNV98-E	On the top of the locker arm cover(flywheel end) (Figure 32 right, 1)	On the top of the locker arm cover(Center) (Figure 32 right, 2)	On the top of the locker arm cover(fan end) (Figure 32 right, 3)

Function Of Major Engine Components

Components	Functions
Air Cleaner	The air cleaner prevents airborne contaminants from entering the engine. Since the air cleaner is application specific, it must be carefully selected by an application engineer. Periodic replacement of the air cleaner filter element is necessary. See "Periodic Maintenance Schedule" on page -65. for the replacement frequency.
Alternator	The alternator is driven by a V-belt which is powered by the crankshaft V-pulley. The alternator supplies electricity to the engine systems and charges the battery while the engine is running.
Dipstick (Engine Oil)	The engine oil dipstick is used to determine the amount of engine oil in the crankcase.
Electric Fuel Pump	The electric fuel pump makes sure there is a constant supply of diesel fuel to the fuel injection pump. The electric fuel pump is electro-magnetic and runs on 12 VDC. It must be installed on every application. This is standard equipment with every engine.
Engine Oil Filter	The engine oil filter removes contaminants and sediments from the engine oil. Periodic replacement of the engine oil filter is necessary. See "Periodic Maintenance Schedule" on page -65. for the replacement frequency.
Engine Oil Cooler (If Equipped)	The engine oil cooler helps to keep the engine oil cool. Engine coolant from the cooling system is circulated through an adapter at the base of the engine oil filter assembly and then returned to the coolant pump inlet.
Fuel Filter	The fuel filter removes contaminants and sediments from the diesel fuel. Periodic replacement of the fuel filter is necessary. See "Periodic Maintenance Schedule" on page -65. for the replacement frequency. Please note that the word "diesel" is implied throughout this manual when the word "fuel" is used.
Fuel Filter / Water Separator	The fuel filter / water separator removes contaminants, sediments and water from the diesel fuel going to the fuel filter. This is a required component of the fuel system. This is standard equipment with every engine. The separator is installed between the fuel tank and the electric fuel pump. Periodically drain the water from the fuel filter / water separator.
Fuel Tank	The fuel tank is a reservoir that holds diesel fuel. When the fuel leaves the fuel tank it goes to the fuel filter / water separator. Next the fuel is pumped to the fuel filter by the electric fuel pump. Then the fuel goes to the fuel injection pump. Since the fuel is used to keep the fuel injection pump cool and lubricated, more fuel than necessary enters the injection pump. When the injection pump pressure reaches a preset value, a relief valve allows the excess fuel to be returned back to the fuel tank. The fuel tank is a required engine component.
Side and Top Filler Port (Engine Oil)	You can fill the crankcase with engine oil from either the side or the top filler port depending upon which one is most convenient.
Starter Motor	The starter motor is powered by the battery. When you turn the key switch in the operator's console to the START position, the starter motor engages with the ring gear installed on the flywheel and starts the flywheel in motion.

Main Electronic Control Components and Features

Component/Feature		Description
Engine controller (E-ECU)		Adjusts the rack position of the fuel injection pump depending on the speed command signal from the accelerator sensor, thus regulating the engine speed and power. The engine controller also regulates the opening of the EGR valve depending on the engine speed and power. It serves as the master station for the following components/control features.
Electronic governor (Eco-governor)		Consists of the engine speed sensor, rack actuator, etc., and is directly connected to the fuel injection pump in order to regulate the rack position of the fuel injection pump depending on the signals communicated with the EECU.
Fuel injection pump (for Eco-governor)		Is of single plunger type and equipped with a CSD solenoid valve that allows the fuel injection timing to advance and the injection quantity to increase, thereby improving the cold start performance of the engine.
EGR valve		Controls the exhaust gas recirculation flow rate depending on the engine speed/load signals from the EECU. It is installed on the top of the exhaust manifold.
Accelerator sensor		Unlike mechanical governors, the Eco-governor has no governor lever. The accelerator sensor serves as the governor lever to provide the speed command signal (voltage signal) to the E-ECU for engine speed control. It is installed in the operator cabin of the driven machine. Constant speed engines for e.g. generator use do not require accelerator sensors because the engine speed can be shifted via a switch on the operator's console.
	Optional	CAN communication capability is available as an option.
Fault indicator		Is installed on the operator's console. If a fault occurs in the E-ECU or Eco-governor, the fault indicator flashes alerting the operator to a fault. The number of flashes and/or the flashing pattern vary depending on the type or source of the fault, enabling quick-fix.
	Optional	
Engine diagnosis tool		Allows the operator to troubleshoot the cause of a problem based on detailed information regarding the problem occurring in the E-ECU or Eco-governor. This tool can also be used for data maintenance tasks including programming and mapping.
	Option for service	
Engine coolant temperature sensor		Allows the CSD and ERG to be controlled in engine cold-start conditions.
Glow plugs Air heater	Optional	When the key switch is turned to the ON position, the glow plugs/air heater are/is energized for up to 15 seconds (glow plugs) or up to 23 seconds (air heater). The duration of energization depends on the engine coolant temperature. The HEAT indicator is on during energization. When the indicator goes out, turn the key switch to the START position to start the engine.
After heater	Optional	In extreme cold start conditions, the after heater is energized for up to 80 seconds or until the coolant temperature reaches 10°C after the engine has started, in order to help ensure the engine continues to run without stall.This option is not available for glow plug engines.

Component/Feature		Description
Droop control	Standard with VM series	Reduces the engine speed by a certain percentage from no load to full (rated) load in steady state operation. The same percentage droop is maintained even when the load increases at any no-load speed.
Isochronous control	Standard with CL series Optional with VM series	Offers a constant engine speed from no load to full load. The engine speed does not decrease even when the load increases at any no-load speed.
Low-idling speed up		Increases the low-idling speed to up to 1000 rpm depending on the engine coolant temperature. When the coolant temperature reaches a predetermined value, this feature returns the engine speed to the normal low idle setting, thus reducing the warm-up time.
High-idling speed down	Optional	Decreases the high-idling speed depending on the engine coolant temperature. When the coolant temperature falls to a predetermined value, this feature returns the engine speed to the normal high idle setting, thus minimizing the emission of white smoke at low temperatures.
Auto deceleration	Optional	Brings the running engine in low idle mode automatically when the accelerator pedal is not operated for a predetermined period of time. When the pedal is operated, i.e., the accelerator sensor is activated, the low idle mode is cancelled.

Function of Cooling System Components

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

Diesel Fuel

Diesel Fuel Specifications

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

Diesel Fuel Specification	Location
No. 2-D, No. 1-D, ASTM D975-94	USA
EN590:96	European Union
ISO 8217 DMX	International
BS 2869-A1 or A2	United Kingdom
JIS K2204 Grade No. 2	Japan
KSM-2610	Korea
GB252	China

Additional Technical Fuel Requirements

The fuel cetane number should be equal to 45 or higher.

The sulfur content must not exceed 0.5% by volume. Less than 0.05% is preferred.

For electronically controlled engine 4TNV98-E, it is mandatory to use fuel that does not contain 0.05% or more sulfur content.

In general, using a high sulfur fuel may possible result in corrosion inside the cylinder.

Bio-Diesel fuels. "Bio-Diesel Fuels" on page 1-38.

Never mix kerosene, used engine oil, or residual fuels with the diesel fuel.

The water and sediment in the fuel should not exceed 0.05% by volume.

Keep the fuel tank and fuel-handling equipment clean at all times.

Poor quality fuel can reduce engine performance and / or cause engine damage.

Fuel additives are not recommended. Some fuel additives may cause poor engine performance. Consult your *DOOSAN* representative for more information.

The ash content must not exceed 0.01% by volume.

The carbon residue content must not exceed 0.35% by volume. Less than 0.1% is preferred.

The total aromatics content should not exceed 35% by volume. Less than 30% is preferred.

The PAH (polycyclic aromatic hydrocarbons) content should be below 10% by volume.

The metal content of Na, Mg, Si, and Al should be equal to or lower than 1 mass ppm. (Test analysis method JPI-5S-44-95)

Lubricity: The wear mark of WS1.4 should be Max. 0.018 in (460 µm) at HFRR test.

Bio-Diesel Fuels

In Europe and in the United States, as well as some other countries, non-mineral oil based fuel resources such as RME (Rapeseed Methyl Ester) and SOME (Soybean Methyl Ester), collectively known as FAME (Fatty Acid Methyl Esters), are being used as extenders for mineral oil derived diesel fuels.

DOOSAN approves the use of bio-diesel fuels that do not exceed a blend of 5% (by volume) of FAME with 95% (by volume) of approved mineral oil derived diesel fuel. Such bio-diesel fuels are known in the marketplace as B5 diesel fuels.

These B5 diesel fuels must meet certain requirements.

The bio-fuels must meet the minimum specifications for the country in which they are used.

1. In Europe, bio-diesel fuels must comply with the European Standard EN14214.
2. In the United States, bio-diesel fuels must comply with the American Standard ASTM D-6751.

Bio-fuels should be purchased only from recognized and authorized diesel fuel suppliers

Precautions and concerns regarding the use of bio-fuels:

1. Free methanol in FAME may result in corrosion of aluminum and zinc FIE components.
2. Free water in FAME may result in plugging of fuel filters and increased bacterial growth.
3. High viscosity at low temperatures may result in fuel delivery problems, injection pump seizures, and poor injection nozzle spray atomization.
4. FAME may have adverse effects on some elastomers (seal materials) and may result in fuel leakage and dilution of the engine lubricating oil.
5. Even bio-diesel fuels that comply with a suitable standard as delivered, will require additional care and attention to maintain the quality of the fuel in the equipment or other fuel tanks. It is important to maintain a supply of clean, fresh fuel. Regular flushing of the fuel system, and / or fuel storage containers, may be necessary.
6. The use of bio-diesel fuels that do not comply with the standards as agreed to by the diesel engine manufacturers and the diesel fuel injection equipment manufacturers, or bio-diesel fuels that have degraded as per the precautions and concerns above, may affect the warranty coverage of your engine.

Filling The Fuel Tank



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

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

Never refuel with the engine running.

Wipe up all spills immediately.

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

Never overfill the fuel tank.

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

Failure to comply will result in death or serious injury.



HDO1015I

Figure 33



DANGER

Fire And Explosion Hazard!

Diesel fuel is extremely flammable and explosive under certain conditions.

Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.

Never place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 34



CAUTION

Only use diesel fuels recommended by *DOOSAN* for the best engine performance, to prevent engine damage and to comply with EPA / ARB warranty requirements.

Only use clean diesel fuel.

Never remove the primary strainer (if equipped) from the fuel tank filler port. If removed, dirt and debris could get into the fuel system causing it to clog.

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.

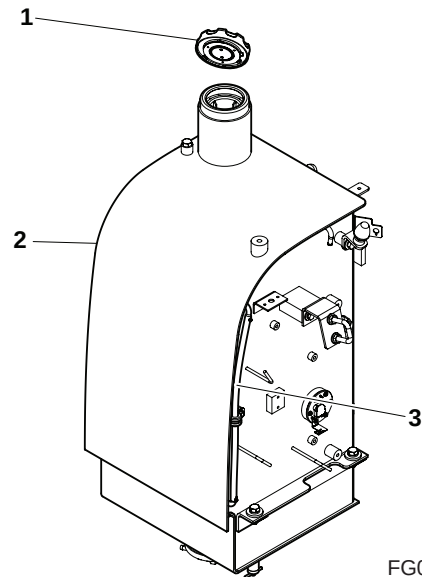
Failure to comply will result in death or serious injury.

1. Clean the area around the fuel cap (1, Figure 36).
2. Remove the fuel cap (1, Figure 36) from the fuel tank (2, Figure 36).
3. Observe the fuel level sight gauge (3, Figure 36) and stop fueling when the gauge shows the fuel tank is full. NEVER overfill the fuel tank.
4. Replace the fuel cap (1, Figure 36) and hand tighten. Over-tightening the fuel cap will damage it.



HDO1015I

Figure 35



FG012227

Figure 36

Priming the Fuel System

The fuel system needs to be primed under certain conditions:

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

To prime the fuel system:

1. Turn the key to the ON position for 10 - 15 seconds. This will allow the electric fuel pump t80o prime the fuel system.
2. Never use the starter motor to crank the engine in order to prime the fuel system. This may cause the starter motor to overheat and damage the coils, pinion and / or ring gear.

Engine Oil



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 engine 4TNV98-E)
- 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).

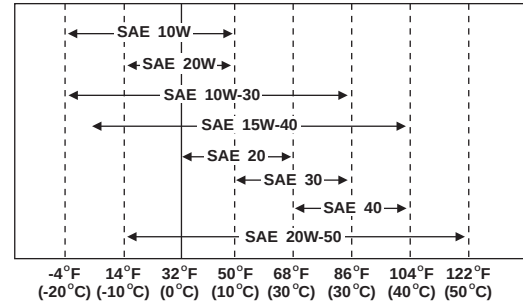
DOOSAN does not recommend the use of engine oil "additives."

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 (HCl), ASTM D4739 (HCl).

Engine Oil Viscosity

Select the appropriate engine oil viscosity based on the ambient temperature and use the SAE Service Grade Viscosity Chart in Figure 37.



FG008849

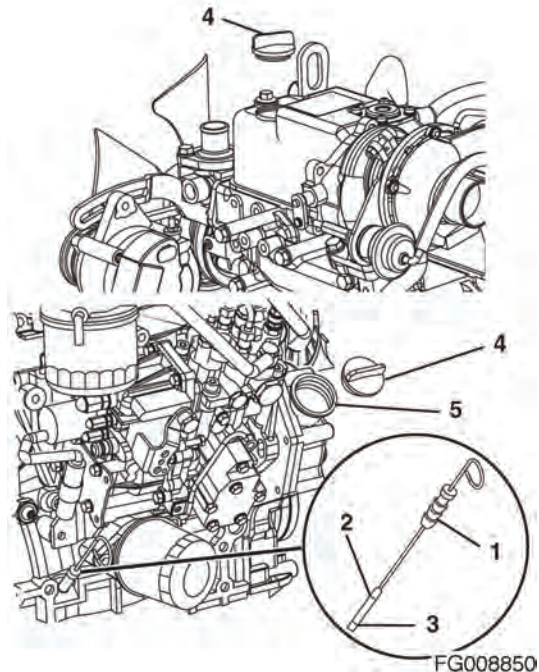
Figure 37

Checking Engine Oil

1. Make sure the engine is level.
2. Remove the dipstick (1, Figure 38) and wipe it with clean cloth.
3. Fully reinsert the dipstick.
4. Remove the dipstick. The oil level should be between the upper (2, Figure 38) and lower (3, Figure 38) lines on the dipstick.
5. Fully reinsert the dipstick.

Adding Engine Oil

1. Make sure the engine is level.
2. Remove the oil cap (4, Figure 38).
3. Add the indicated amount of engine oil at the top or the side engine oil filler port (5, Figure 38).
4. Wait three minutes and check the oil level.
5. Add more oil if necessary.
6. Reinstall the oil cap (4, Figure 38) and hand-tighten. Over-tightening may damage the cap.



FG008850

Figure 38

Engine Coolant



WARNING

Exhaust Hazard!

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

Never block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.

Make sure that all connections are tightened to specifications after repair is made to the exhaust system.

Failure to comply could result in death or serious injury.



WARNING

Burn Hazard!

Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.

Failure to comply could result in death or serious injury.



CAUTION

Coolant Hazard!

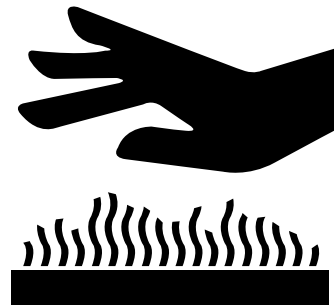
Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

Failure to comply may result in minor or moderate injury.



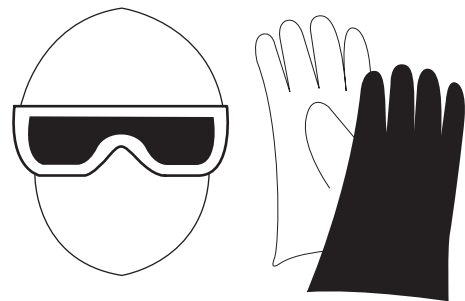
ARO1770L

Figure 39



HAOA050L

Figure 40



FG009154

Figure 41



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.

Engine Coolant Specifications

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

Additional Technical Coolant Specifications:

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

Alternative Engine Coolant

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

NOTE: *ALWAYS use a mix of coolant and water. NEVER use water only.*

Mix the coolant and water per the mixing instructions on the coolant container.

Water quality is important to coolant performance. DOOSAN recommends that soft, distilled, or demineralized water be used to mix with coolants.

NEVER mix extended or long life coolants and conventional (green) coolants.

NEVER mix different types and / or colors of extended life coolants.

Replace the coolant every 2000 engine hours or once a year.

Filling Radiator with Engine Coolant

Fill the radiator and reserve tank as follows. This procedure is for filling the radiator for the first time or refilling it after it is flushed. Note that a typical radiator is illustrated (Figure 42).

1. Check to be sure the radiator drain plug is installed and tightened or the drain cock (1, Figure 42) is closed. Also make sure the coolant drain plug (1, Figure 43) in the cylinder block is closed or the oil coolant hoses (1, Figure 44) are installed at the oil cooler.
2. Remove the radiator cap (2, Figure 42) by turning it counter-clockwise about 1/3 of a turn.
3. Pour the engine coolant slowly into the radiator until it is even with the lip of the engine coolant filler port. Make sure that air bubbles do not develop as you fill the radiator.
4. Reinstall the radiator cap (2, Figure 42). Align the tabs on the back side of the radiator cap with the notches on the engine coolant filler port. Press down and turn the cap clockwise about 1/3 of a turn.
5. Remove the cap on the reserve tank (3, Figure 42), and fill it to the LOW (COLD) mark (4, Figure 42) with engine coolant. Reinstall the cap.
6. Check the hose (5, Figure 42) that connects the reserve tank (3, Figure 42) to the radiator. Be sure it is securely connected and there are no cracks or damage. If the hose is damaged, the engine coolant will leak out instead of going into the reserve tank.
7. Run the engine until it is at operating temperature. Check the level of engine coolant in the reserve tank. When the engine is running and the engine coolant is at normal temperature, the coolant level in the tank should be at the FULL (HOT) mark (6, Figure 42). If the engine coolant is not at the FULL (HOT) mark (6, Figure 42), add additional engine coolant to the reserve tank to bring the level to the FULL (HOT) mark.

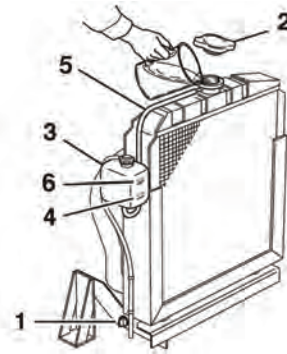


Figure 42

FG008851

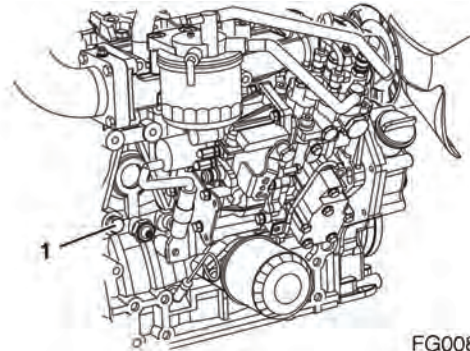


Figure 43

FG008852

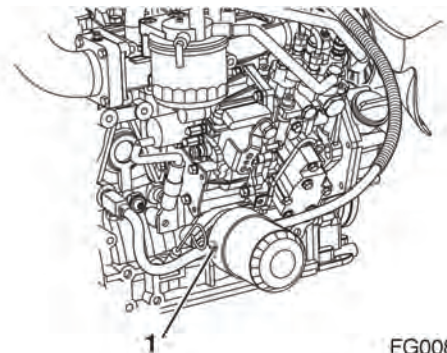


Figure 44

FG008853

Principal Engine Specifications

4TNV98-E

Engine Model		4TNV98-E							
Version		CL		VM					
Type		Vertical, 4-cycle water-cooled diesel engine							
Combustion System		Direct Injection							
Aspiration		Natural aspiration							
No. of Cylinders		4							
Bore x Stroke		98 x 110 mm							
Displacement		3.319 L							
Continuous Rated Output	min ⁻¹								
	kW								
	PS								
Max. Rated Output (Net)	min ⁻¹				2100	2200	2300	2400	2500
	kW				36.8	38.2	39.7	41.6	43.0
	PS				50.0	52.0	54.0	56.5	58.5
High Idling	min ⁻¹				2,250 ± 25	2,350 ± 25	2,450 ± 25	2,550 ± 25	2,650 ± 25
Engine Weight (Dry) *with Flywheel Housing				240 kg					
PTO Position		Flywheel End							
Direction of Rotation		Counterclockwise Viewed From the Flywheel End							
Governor		Electronic governor (All-speed governor)							
Cooling System		Liquid-Cooled with Radiator							
Lubricating System		Forced Lubrication with Trochoid Pump							
Normal Oil Pressure	Rated Engine Speed	0.29 - 0.39 (3.0 - 4.0) MPa							
	Low Idle Speed	0.06 (0.6) MPa							
Starting System		Electric Starting (Starter Motor : DC12V (2.3 kW)***							
Charging system		Alternator (DC12V/ 40A)***							
Recommended Battery Capacity		: 12V-64Ah***r (5h rating)							
Starting aid device		Air heater (12VDC/500w)							
Dimensions (L x W x H)*		719 x 540 x 721 mm							
Engine Oil Pan Capacity**		10.2 L / 5.7 L (Dipstick Upper Limit / Lower Limit)							
Engine Coolant Capacity		4.2 L Engine Only							
Standard Cooling Fan		Resin F type pusher fan - ø410(Al) x 6							
Crank Vpulley dia./ Fan V-pulley dia.		ø130/ ø130mm							

* Engine specifications without radiator.

** Engine oil capacity for a "deep standard" oil pan. Refer to the operation manual provided by the driven machine manufacturer for the actual engine oil capacity of your machine.

*** May vary depending on the application.

Engine Service Standards

Inspection Item		Standard	Limit	Reference page
Intake / Exhaust Valve Clearance		0.006 - 0.010 in. (0.15 - 0.25 mm)	-	See "Measuring And Adjusting Valve Clearance" on page -123.
Fuel Injection Timing	See "Checking And Adjusting Fuel Injection Timing" on page -185.			
Fuel Injection Pressure	See "Test and Adjustment Specifications" on page -170.			
Compression Pressure at 250 rpm (250 min ⁻¹)		483 - 513 psi (3.33 - 3.53 MPa; 34 - 36 kgf / cm ²)	384 - 414 psi (2.65 - 2.85 MPa; 27 - 29 kgf / cm ²)	See "Troubleshooting By Measuring Compression Pressure" on page -259.
Deviation Between Cylinders		29 - 43 psi (0.2 - 0.3 MPa; 2 - 3 kgf/cm ²)	-	-
Oil Pressure Switch Operating Pressure		5.8 - 8.8 psi (0.04 - 0.06 MPa; 0.4 - 0.6 kgf / cm ²)	-	-
Thermostat		Valve Opening Temperature	Full Opening Lift Temperature	See "Thermostat" on page -203.
	Standard	157°F - 163°F (70°C - 73°C)	0.32 in (8 mm) or above 185°F (85°C)	
	Option	176°F - 183°F (80°C - 84°C)	0.39 in (10 mm) or above 203°F (95°C)	
Coolant Temperature Switch		225°F - 235°F (107°C - 113°C)	-	See "Temperature Switch" on page -202.

Tightening Torques For Standard Bolts And Nuts

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



CAUTION

The tightening torque in the standard Torque Chart(see General Service Information section) should be applied only to the bolts with a "7" head,(JIS strength classification:7T)

Apply 60% torque to bolts that are not listed.

Apply 80% torque when tightened to aluminum alloy.



FG009157

Figure 45

Item	Nominal Thread Diameter x Pitch	Tightening Torque	Remarks
Hexagon Bolt (7T) and Nut	M6 x 1.0 mm	7 - 9 ft-lb (87 - 104 in.-lb, 9.8 -11.8 N•m, 1.0 -1.2 kgf•m)	Use 80% of the value at left when the tightening part is aluminum. Use 60% of the value at left for 4T bolts and lock nuts.
	M8 x 1.25 mm	17 - 21 ft-lb (200 - 251 in.-lb, 22.6 - 28.4 N•m, 2.3 - 2.9 kgf•m)	
	M10 x 1.5 mm	33 - 40 ft-lb (44.1 - 53.9 N•m, 4.5 - 5.5 kgf•m)	
	M12 x 1.75 mm	58 - 72 ft-lb (78.4 - 98.0 N•m, 8.0 - 10 kgf•m)	
	M14 x 1.5 mm	94 - 108 ft-lb (127.5 - 147.1 N•m, 13 - 15 kgf•m)	
	M16 x 1.5 mm	159 - 174 ft-lb (215.7- 235.4 N•m, 22 - 24 kgf•m)	
PT PLug	1/8 mm	7 ft-lb (87 in.-lb, 9.8 N•m, 1.0 kgf•m)	-
	1/4 mm	14 ft-lb (173 in.-lb, 19.6 N•m, 2.0 kgf•m)	
	3/8 mm	22 ft-lb (29.4 N•m, 3.0 kgf•m)	
	1/2 mm	43 ft-lb (58.8 N•m, 6.0 kgf•m)	

Item	Nominal Thread Diameter	x Pitch	Tightening Torque	Remarks
Pipe Joint Bolt	M8		9 - 12 ft-lb (112 - 148 in.-lb, 12.7 - 16.7 N•m, 1.3 - 1.7 kgf•m)	-
	M10		14 - 19 ft-lb (173 - 225 in.-lb, 19.6 - 18.734 N•m, 2.0 - 3.5 kgf•m)	
	M12		18 - 25 ft-lb (24.5 - 34.3 N•m, 2.5 - 3.5 kgf•m)	
	M14		29 - 36 ft-lb (39.2 - 49.0 N•m, 4.0 - 5.0 kgf•m)	
	M16		36 - 43 ft-lb (49.0 - 58.8 N•m, 5.0 - 6.0 kgf•m)	

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

PERIODIC MAINTENANCE

Before You Begin Servicing



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.



DANGER

Fire And Explosion Hazard!

Only use the key switch to start the engine.

Never jump-start the engine. Sparks caused by shorting the battery to the starter terminals may cause a fire or explosion.

Failure to comply will result in death or serious injury.



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.



HAOA311P

Figure 46



HDO1015I

Figure 47



HAOA060L

Figure 48



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



DANGER

Fire And Explosion Hazard!

Diesel fuel is extremely flammable and explosive under certain conditions.

Be sure to place the diesel fuel container on the ground when transferring the diesel fuel from the pump to the container. Hold the hose nozzle firmly against the side of the container while filling it. This prevents static electricity buildup which could cause sparks and ignite fuel vapors.

Never place diesel fuel or other flammable material such as oil, hay or dried grass close to the engine during engine operation or shortly after shutdown.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 52



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Never use diesel fuel as a cleaning agent.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 53



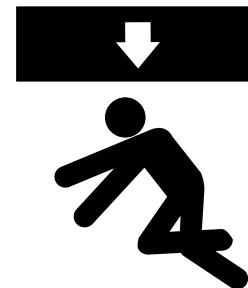
DANGER

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 54



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 55



DANGER

Fire And Explosion Hazard!

Diesel fuel is extremely flammable and explosive under certain conditions.

Place an approved container under the air bleed port when you prime the fuel system. Never use a shop rag to catch the fuel. Wipe up any spills immediately. ALWAYS close the air bleed port after you complete priming the system.

Wear eye protection. The fuel system is under pressure and fuel could spray out when you open the air bleed port.

If the unit has an electric fuel pump, turn the key switch to the ON position for 10 to 15 seconds, or until the fuel coming out of the air bleed port is free of bubbles, to allow the electric fuel pump to prime the system.

If the unit has a mechanical fuel pump, operate the fuel priming pump several times until the fuel coming out of the air bleed port is free of bubbles.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 56



WARNING

Exhaust Hazard!

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

Never block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.

Make sure that all connections are tightened to specifications after repair is made to the exhaust system.

Failure to comply could result in death or serious injury.



WARNING

Sever Hazard!

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

Wear tight-fitting clothing and keep your hair short or tie it back while the engine is running.

Remove all jewelry before you operate or service the machine.

Never start the engine in gear. Sudden movement of the engine and / or machine could cause death or serious personal injury.

Never operate the engine without the guards in place.

Before you start the engine make sure that all bystanders are clear of the area.

Keep children and pets away while the engine is operating.

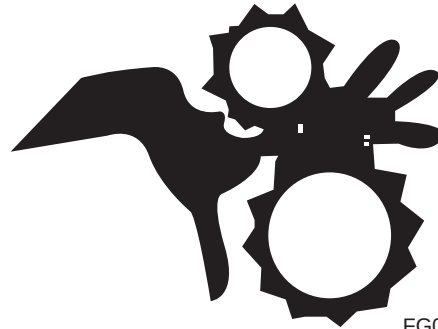
Check before starting the engine that any tools or shop rags used during maintenance have been removed from the area.

Failure to comply could result in death or serious injury.



ARO1770L

Figure 57



FG009148

Figure 58



WARNING

Sudden Movement Hazard!

Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.

Failure to comply could result in death or serious injury.



WARNING

Burn Hazard!

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

Failure to comply could result in death or serious injury.



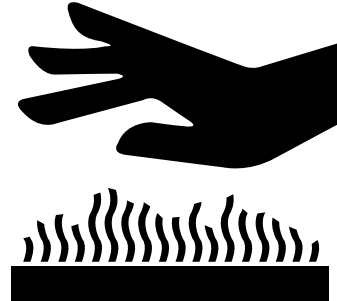
WARNING

Alcohol And Drug Hazard!

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

Never operate the engine when you are feeling ill.

Failure to comply could result in death or serious injury.



HAOA050L

Figure 59



FG009149

Figure 60



WARNING

Exposure Hazard!

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

Never wear jewelry, unbuttoned cuffs, ties or loose-fitting clothing when you are working near moving / rotating parts such as the cooling fan, flywheel or PTO shaft.

Always tie back long hair when you are working near moving / rotating parts such as a cooling fan, flywheel, or PTO shaft.

Never operate the engine while wearing a headset to listen to music or radio because it will be difficult to hear the alert signals.

Failure to comply could result in death or serious injury.

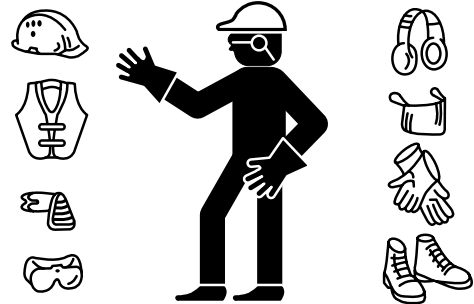


Figure 61



WARNING

Burn Hazard!

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

Failure to comply could result in death or serious injury.



Figure 62

FG008465



WARNING

High-pressure Hazard!

Avoid skin contact with the high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.

Never check for a fuel leak with your hands. Always use a piece of wood or cardboard. Consult authorized DOOSAN dealer or distributor if you have any questions or require more information.

Failure to comply could result in death or serious injury.



Figure 63

FG009150



WARNING

Shock Hazard!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.



FG009151

Figure 64



WARNING

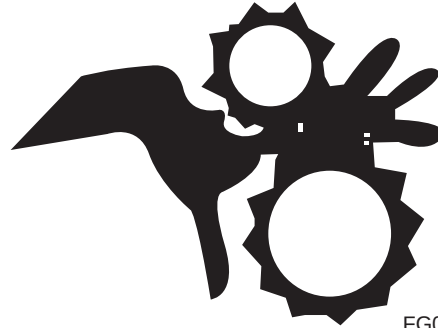
Entanglement Hazard!

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 65



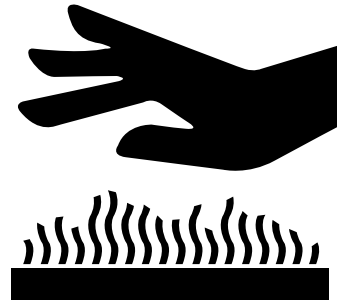
WARNING

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 66

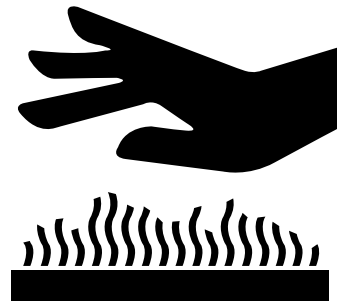


WARNING

Burn Hazard!

Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.

Failure to comply could result in death or serious injury.



HAOA050L

Figure 67

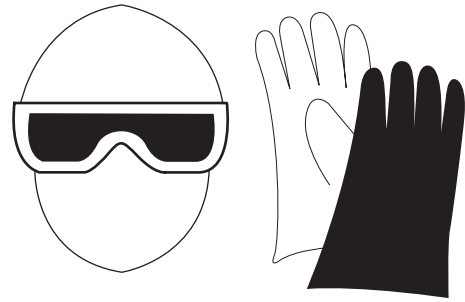


CAUTION

Coolant Hazard!

Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

Failure to comply may result in minor or moderate injury.



FG009154

Figure 68

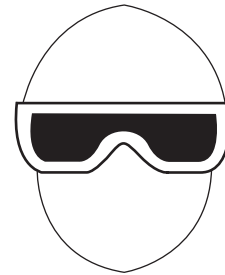


CAUTION

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 69



CAUTION

Only use diesel fuels recommended by *DOOSAN* for the best engine performance, to prevent engine damage and to comply with EPA / ARB warranty requirements.

Only use clean diesel fuel.

Never remove the primary strainer (if equipped) from the fuel tank filler port. If removed, dirt and debris could get into the fuel system causing it to clog.



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

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 attempt to modify the engine's design or safety features such as defeating the engine speed limit control or the diesel fuel injection quantity control.

Modifications may impair the engine's safety and performance characteristics and shorten the engine's life. Any alterations to this engine may void its warranty. Be sure to use genuine replacement parts.



CAUTION

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

Avoid operating in extremely dusty conditions.

Avoid operating in the presence of chemical gases or fumes.

Avoid operating in a corrosive atmosphere such as salt water spray.

Never install the engine in a floodplain unless proper precautions are taken to avoid being subject to a flood.

Never expose the engine to the rain.



CAUTION

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

The standard range of ambient temperatures for the normal operation of 4TNV98-E engines is from +5°F (-15°C) to +113°F (+45°C).

If the ambient temperature exceeds +113°F (+45°C) the engine may overheat and cause the engine oil to break down.

If the ambient temperature is below +5°F (-15°C) the engine will be hard to start and the engine oil may not flow easily.

Contact your authorized *DOOSAN* dealer or distributor if the engine will be operated outside of this standard temperature range.



CAUTION

Never hold the key in the START position for longer than 15 seconds or the starter motor will overheat.



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 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

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.



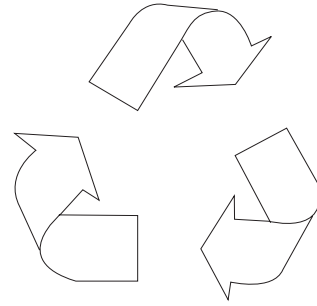
CAUTION

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 70



CAUTION

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



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

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



CAUTION

Never attempt to adjust the low or high idle speed limit screw. This may impair the safety and performance of the machine and shorten its life. If the idle speed limit screws require adjustment, see your authorized *DOOSAN* dealer or distributor.



CAUTION

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

Consult your authorized *DOOSAN* dealer or distributor for assistance when checking items marked with a *.



CAUTION

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

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



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.



CAUTION

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

Introduction

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

The Importance of Periodic Maintenance

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

Performing Periodic Maintenance



Exhaust Hazard!

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

Never block windows, vents, or other means of ventilation if the engine is operating in an enclosed area. All internal combustion engines create carbon monoxide gas during operation. Accumulation of this gas within an enclosure could cause illness or even death.

Make sure that all connections are tightened to specifications after repair is made to the exhaust system.

Failure to comply could result in death or serious injury.

Perform periodic maintenance procedures in an open, level area free from traffic. If possible, perform the procedures indoors to prevent environmental conditions, such as rain, wind, or snow, from damaging the machine.

Genuine Replacement Parts

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

Required EPA / ARB Maintenance - USA Only

To maintain optimum engine performance and compliance with the Environmental Protection Agency (EPA) Regulations Non-road Engines and the California Air Resources Board (ARB, California), it is essential that you follow the See "Periodic Maintenance Schedule" on page -65. and See "Periodic Maintenance Procedures" on page -67.



ARO1770L

Figure 71

EPA / ARB Installation Requirements -USA Only

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

Maximum Exhaust Gas Restriction shall be:

4TNV98 : 2.22 psi (15.3 kPa; 1560 mm Aq) or less

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

Periodic Maintenance Schedule

Daily and periodic maintenance is important to keep the engine in good operating condition. The following is a summary of maintenance items by periodic maintenance intervals. Periodic maintenance intervals vary depending on engine application, loads, diesel fuel and engine oil used and are hard to establish definitively. The following should be treated only as a general guideline.



CAUTION

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

Consult your authorized *DOOSAN* dealer or distributor for assistance when checking items marked with a •.

System	Check Item	Daily	Periodic Maintenance Interval					
			Every 50 hours	Every 250 hours	Every 500 hours	Every 1000 hours	Every 1500 hours	Every 2000 hours
Cooling System	Check and Refill Engine Coolant	C						
	Check and Clean Radiator Fins		C					
	Check and Adjust Cooling Fan V-Belt		C 1st time	C 2nd and after				
	Drain, Flush and Refill Cooling System with New Coolant							R or every year whichever comes first
Cylinder Head	Adjust Intake / Exhaust Valve Clearance					D		
	Lap Intake / Exhaust Valve Seats. If necessary							D
Electrical Equipment	Check Indicators	C						
	Check Battery		C					
Engine Oil	Check Engine Oil Level	C						
	Drain and Fill Engine Oil		R 1st time	R 2st time				
	Replace Engine Oil Filter		R 1st time		R 2nd and after			
Emission Control Warranty	Inspect, Clean and Test Fuel Injectors						D	
	Inspect, Clean and Test EGR Valve.						D	
	Inspect Crankcase Breather System						D	
Fuel	Check and Refill Fuel Tank Level	C						
	Drain Fuel Tank			C				
	Drain Fuel Filter / Water Separator		C					
	Check Fuel Filter / Water Separator	C						
	Clean Fuel Filter / Water Separator				C			
	Replace Fuel Filter		R 1st time		R 2nd and after			
Hoses	Replace Fuel System and Cooling System Hoses							D or every 2 years
Intake and Exhaust	Clean or Replace Air Cleaner Element		C		R			
Complete Engine	Overall Visual Check Daily	C						

C : Check R : Replace D : Contact your authorized DOOSAN dealer or distributor

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

Periodic Maintenance Procedures

After Initial 50 Hours of Operation

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

- Replace Engine Oil and Engine Oil Filter
- Check and Adjust Cooling Fan V-Belt
- Replace Fuel Filter

Replace Engine Oil and Engine Oil Filter

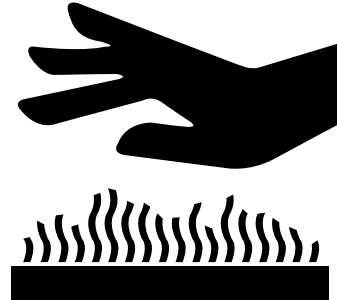


Burn Hazard!

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 72



Sudden Movement Hazard!

Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.

Failure to comply could result in death or serious injury.



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

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.

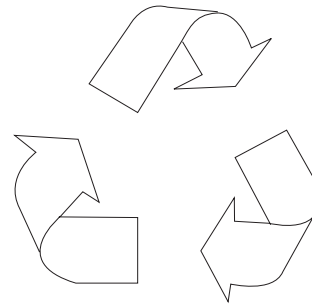
Failure to follow these procedures may seriously harm the environment.

The engine oil in a new engine becomes contaminated from the initial break-in of internal parts. It is very important that the initial oil and filter change is performed as scheduled.

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

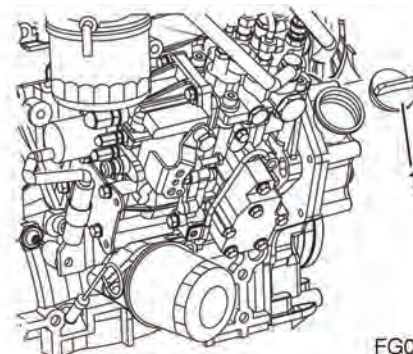
Drain the engine oil as follows:

1. Make sure the engine is level.
2. Start the engine and bring it up to operating temperature.
3. Stop the engine.
4. Remove one of the oil filler caps (4) (1, Figure 74, Figure 75) to vent the engine crankcase and allow the engine oil to drain more easily.
5. Position a container under the engine to collect waste oil.
6. Remove the oil drain plug (1, Figure 76) from the engine oil pan. Allow oil to drain.
7. After all oil has been drained from the engine, reinstall the oil drain plug (1, Figure 76) and tighten to 14 -17 ft•lb (19.6 -23.5 N•m; 2.0 -2.4 kgf•m).
8. Dispose of used oil properly.



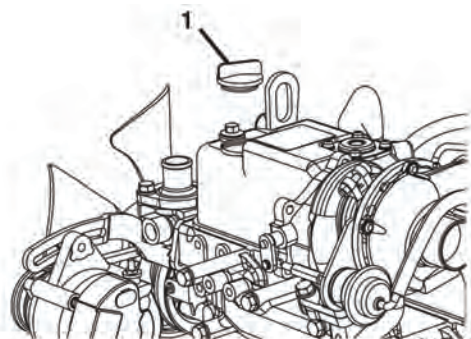
FG009156

Figure 73



FG008854

Figure 74



FG008855

Figure 75

Remove the engine oil filter as follows:

1. Turn the engine oil filter (2, Figure 76) counterclockwise (3, Figure 76) using a filter wrench.
2. Clean the engine oil filter mounting face.
3. Lightly coat the gasket on the new oil filter with engine oil. Install the new engine oil filter manually by turning it clockwise (4, Figure 76) until it contacts the mounting surface. Tighten an additional 3/4 of a turn using the filter wrench.
4. Add new engine oil to the engine as specified in Adding Engine Oil on page 4-14.



CAUTION

Never overfill the engine with engine oil.

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

5. Warm up the engine by running it for five minutes and check for any engine oil leaks.
6. After engine is warm, shut it off and let it sit for 10 minutes.
7. Recheck the engine oil level.
8. Add engine oil (5, Figure 77) as needed until the level is between the upper (2, Figure 77) and lower lines (3, Figure 77) shown on the dipstick (1, Figure 77).
9. Reinstall the oil filler cap (4, Figure 77). If any engine oil is spilled, wipe it away with a clean cloth.

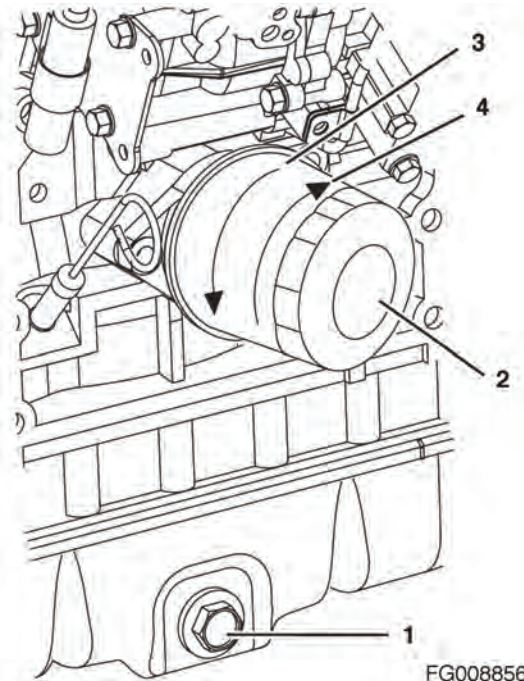


Figure 76

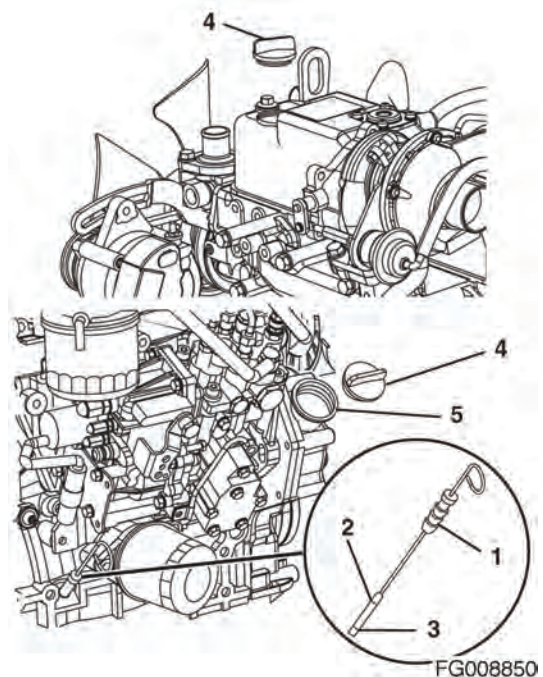


Figure 77

Check and Adjust Cooling Fan V-Belt

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

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

1. Press the V-belt down with your thumb with a force of approximately 22 ft•lb (98 N•m; 10 kgf) to check the deflection. There are three positions to check for V-belt tension (A, B and C, Figure 78). You can check the tension at whichever position is the most accessible. The proper deflection of a used V-belt at each position is:

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

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

2. If necessary, adjust the V-belt tension. Loosen the adjusting bolt (1, Figure 79) and move the alternator (2, Figure 79) with a pry bar (3, Figure 79) to tighten the V-belt to the desired tension. Then tighten the adjusting bolt.

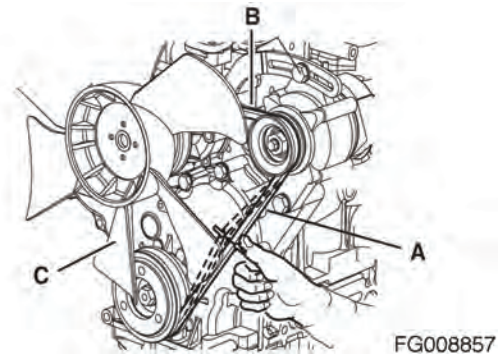


Figure 78

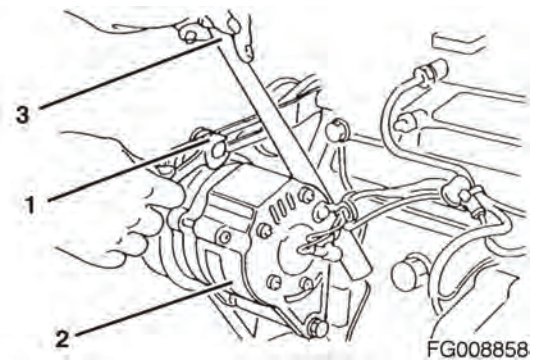


Figure 79

3. Tighten the V-belt to the proper tension. There must be clearance (1, Figure 80) between the V-belt and the bottom of the pulley groove. If there is no clearance (2, Figure 80) between the V-belt and the bottom of the pulley groove, replace the V-belt.
4. Check the V-belt for cracks, oil or wear. If any of these conditions exist, replace the V-belt.
5. Install the new V-belt. Refer to the table for proper tension.

Used V-Belt Tension		
A	B	C
5/16 - 7/16 in. (8 - 12 mm)	3/16 - 5/16 in. (5 - 8 mm)	1/4 - 7/16 in. (7 - 11 mm)

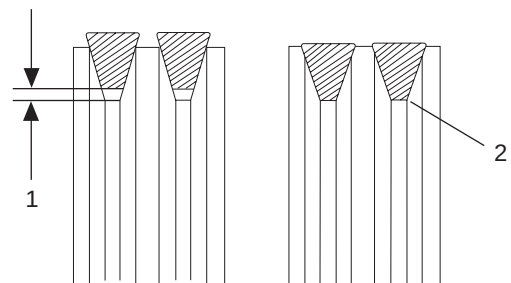


Figure 80

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

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

Replace Fuel Filter



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

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

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

Wipe up any spills immediately.

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

Failure to comply will result in death or serious injury.



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.



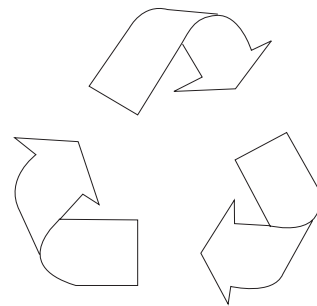
CAUTION

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

Replace the fuel filter at specified intervals to prevent contaminants from adversely affecting the diesel fuel flow.

1. Stop the engine and allow it to cool.
2. Close the fuel cock of the fuel filter / water separator.
3. Remove the fuel filter with a filter wrench, turning it to the left (1, Figure 83). When removing the fuel filter, carefully hold it to prevent the fuel from spilling. Wipe up all spilled fuel.
4. Clean the filter mounting surface and apply a small amount of diesel fuel to the gasket of the new fuel filter.
5. Install the new fuel filter. Turn to the right (2, Figure 83) and hand-tighten it only until it comes in contact with the mounting surface. Tighten to 14 - 17 ft•lb (19.6 - 23.5 N•m; 2.0 - 2.4 kgf•m) or one additional turn using the filter wrench.
6. Open the fuel cock of the fuel filter / water separator.
7. Prime the fuel system. See "Priming the Fuel System" on page -40.
8. Check for leaks.

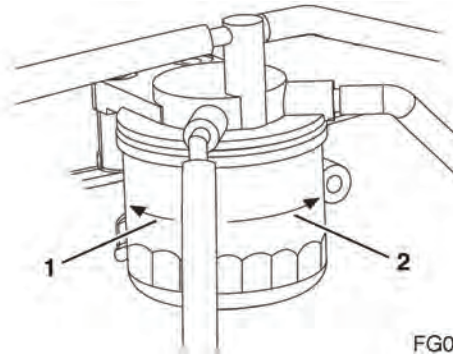


Figure 83

FG008867

Every 50 Hours of Operation

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

- Drain Fuel Filter / Water Separator
- Check Battery
- Clean Air Cleaner Element

Drain Fuel Filter / Water Separator



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.



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

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



HDO1015I

Figure 84



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.

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

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

Drain the fuel filter / water separator as follows:

1. Position an approved container under the fuel filter / water separator (1, Figure 86) to collect the contaminants.
2. Close (2, Figure 86) the fuel cock (3, Figure 86).
3. Loosen the drain cock (4, Figure 86) at the bottom of the fuel filter / water separator. Drain any water collected inside.
4. Hand-tighten the drain cock.

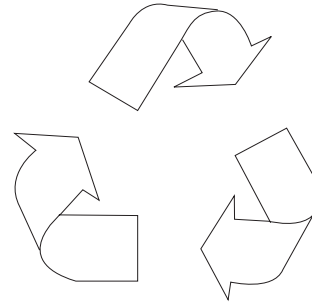


CAUTION

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

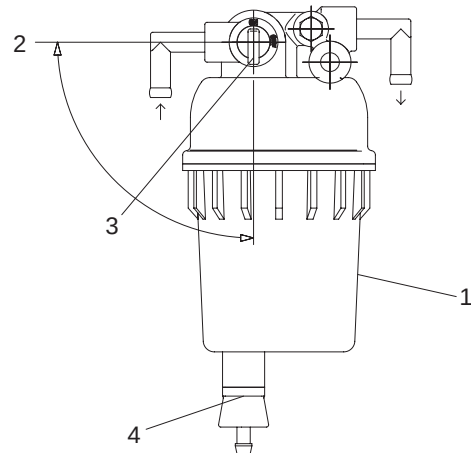
Be sure to tighten the air vent screw after the water has drained out.

5. Open the fuel cock (3, Figure 86).
6. Be sure to prime the diesel fuel system when you are finished. Priming the Fuel System on page 4-12.
7. Check for leaks.



FG009156

Figure 85



FG012380

Figure 86



WARNING

Battery electrolyte contains sulfuric acid and can quickly burn the skin and eat holes in clothing. If you spill acid on yourself, immediately flush the area with water.

Battery acid could cause blindness if splashed into the eyes. If acid gets into the eyes, flush them immediately with large quantities of water and see a doctor at once.

If you accidentally drink acid, drink a large quantity of water or milk, beaten egg or vegetable oil. Call a doctor or poison prevention center immediately.

When working with batteries, always wear safety glasses or goggles.

Battery generates hydrogen gas, so there is a danger of an explosion. Do not bring lighted cigarettes near the battery, or do anything that will cause sparks.

Before working with batteries, shut down engine and turn the starter switch to the "O" (OFF) position.

Avoid short-circuiting the battery terminals through accidental contact with metallic objects, such as tool.

When removing or installing, check which is the positive (+) terminal and negative (-) terminal.

When removing the battery, first disconnect the negative (-) terminal. When installing the battery, first connect the positive (+) terminal.

If the terminals are loose, there is a danger that defective contact may generate sparks that will cause an explosion. When installing the terminals, install them tightly.

Batteries in Cold Weather

In colder weather a greater drain is placed on the batteries when they are used for the preheat cycle and when starting a cold engine. Battery performance decreases as the temperature gets lower.

In extremely cold weather, remove batteries at night and move them to a warm location. This will help to keep them at a higher power level.

Inspection of Battery Electrolyte Level

This machine has two maintenance free battery. It never requires the addition to water.

When the charge indicator becomes transparent, it means low electrolyte state because of the leakage or charging system error. Determine the cause of problem and replace the battery immediately.

Check Charging State

Check charging state through the charging indicator.

- GREEN: Sufficiently charged.
- BLACK: Insufficient charged.
- TRANSPARENT: Replace battery.

Check the Battery Terminals

Be certain that battery is held securely in its compartment. Clean the battery terminals and the battery cable connectors. A solution of baking soda and water will neutralize acid on the battery surface, terminals, and cable connectors. Petroleum jelly or grease can be applied to the connectors to help prevent corrosion.

Battery Replacement

When the charging indicator indicates transparency state, replace the battery.

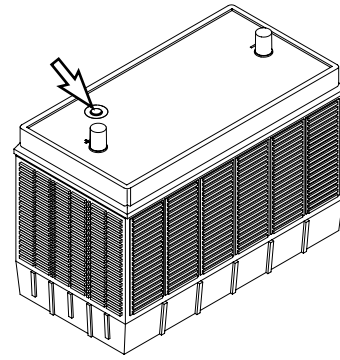


Figure 87

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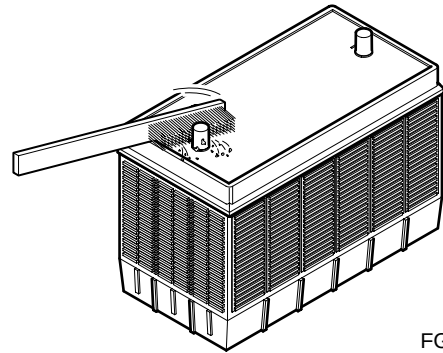


Figure 88

FG010162

Clean Air Cleaner Element

Note that a typical air cleaner is shown in Figure 89 and Figure 91 for illustrative purposes only.

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

1. Unlatch and remove the air cleaner cover (1, Figure 89).
2. Remove the element (2, Figure 89) (outer element if equipped with two elements).

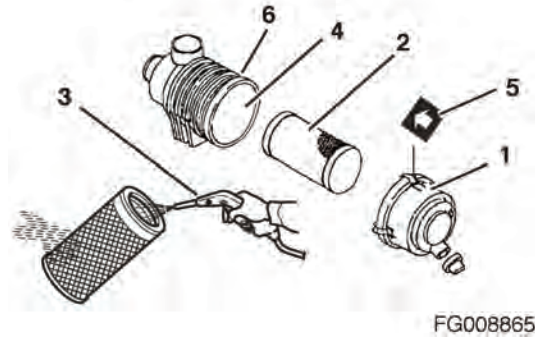


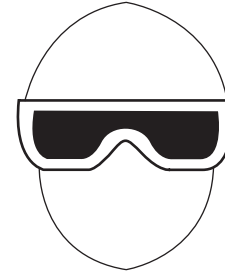
Figure 89

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

3. Blow air (3, Figure 89) 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 91) 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 89).
9. Reinstall the air cleaner cover making sure you match the arrow (5, Figure 89) on the cover with the arrow on the case (6, Figure 89).
10. Latch the air cleaner cover to the case.

Figure 90

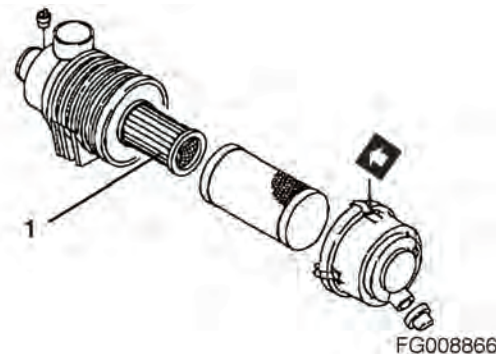


Figure 91

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.

Every 250 Hours of Operation

Perform the following maintenance every 250 hours of operation.

- Drain Fuel Tank
- Replace Engine Oil
- Check and Clean Radiator Fins
- Check and Adjust Cooling Fan V-Belt

Drain Fuel Tank



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

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

Never use a shop rag to catch the fuel. Vapors from the rag are flammable and explosive. Wipe up any spills immediately.

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

Failure to comply will result in death or serious injury.



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.

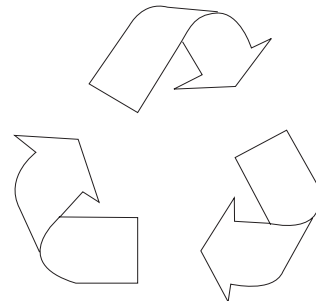
Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.



HDO1015I

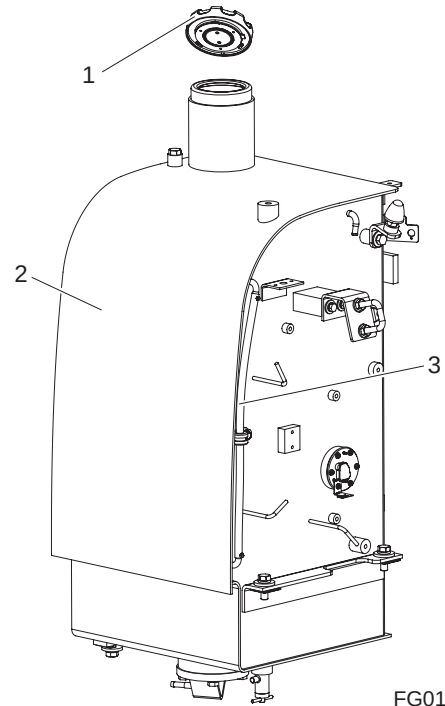
Figure 92



FG009156

Figure 93

1. Position an approved container under the diesel fuel tank (1, Figure 94) to collect the contaminants.
2. Remove the fuel cap (3, Figure 94).
3. Remove the drain plug (2, Figure 94) of the fuel tank to drain the contaminants (water, dirt, etc.) from the bottom of the tank.
4. Drain the tank until clean diesel fuel with no water and dirt flows out. Reinstall and tighten the drain plug firmly.
5. Reinstall the fuel cap.
6. Check for leaks.



FG012435

Figure 94



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

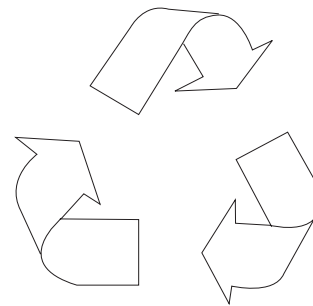
Always be environmentally responsible.

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

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

Failure to follow these procedures may seriously harm the environment.

Change the engine oil every 250 hours of operation after the initial change at 50 hours. Replace the engine oil filter at the same time. See "Replace Engine Oil and Engine Oil Filter" on page -67.



FG009156

Figure 95

Check and Clean Radiator Fins



CAUTION

FLYING OBJECT HAZARD!

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

Failure to comply may result in minor or moderate injury.

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

Note that a typical radiator is shown in Figure 97 for illustrative purposes only.

- Blow off dirt and dust from fins and radiator with 28 psi (0.19 MPa; 2 kgf/cm²) or less of compressed air (1, Figure 97). Be careful not to damage the fins with the compressed air.
- If there is a large amount of contamination on the fins, apply detergent, thoroughly clean and rinse with tap water.

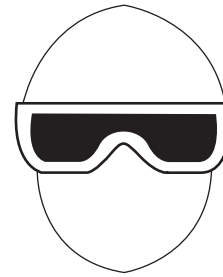


CAUTION

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

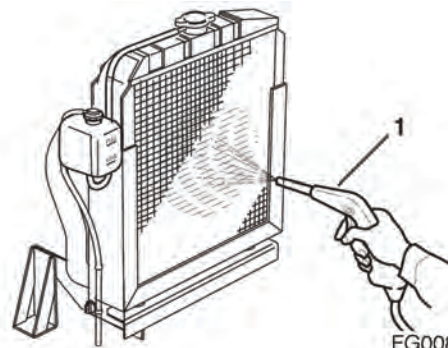
Check and Adjust Cooling Fan V-Belt

Check and adjust the cooling fan V-belt every 250 hours of operation after the initial 50 hour V-belt maintenance. See "Check and Adjust Cooling Fan V-Belt" on page -81.



FG009152

Figure 96



FG008863

Figure 97

Every 500 Hours of Operation

Perform the following maintenance every 500 hours of operation.

- Replace Air Cleaner Element
- Replace Fuel Filter
- Clean Fuel Filter / Water Separator
- Replace Engine Oil Filter

Replace Air Cleaner Element



CAUTION

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

Replace the air cleaner element (2, Figure 89) every 500 hours even if it is not damaged or dirty.

When replacing the element, clean the inside of the air cleaner case (4, Figure 89).

If the air cleaner is equipped with a double element,

only remove and replace the inner element (1, Figure 91) if the engine lacks power or the dust indicator actuates (if equipped). This is in addition to replacing the outer element.

Replace Fuel Filter



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

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

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

Wipe up any spills immediately.

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

Failure to comply will result in death or serious injury.



HDO10151

Figure 98



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

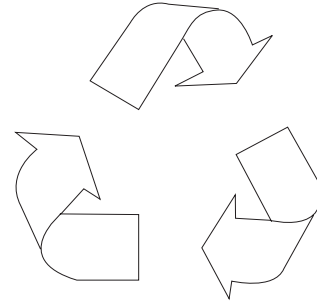
Always be environmentally responsible.

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.

Change the fuel filter every 500hours of operation after initial change at 50 hours. See "Replace Fuel Filter" on page -71.



FG009156

Figure 99



DANGER

Fire And Explosion Hazard!

Diesel fuel is flammable and explosive under certain conditions.

Never use diesel fuel as a cleaning agent.

Failure to comply will result in death or serious injury.



HDO1015I

Figure 100



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 101



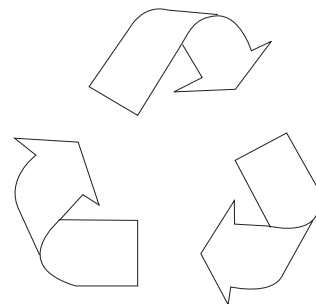
CAUTION

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 102

Periodically clean the fuel filter / water separator element and inside cup.

1. Position an approved container under the cup (1, Figure 103) of the fuel filter / water separator to collect the contaminants.
2. Close (2, Figure 103) the fuel cock (3, Figure 103).
3. Loosen the drain cock (4, Figure 103) and drain the contaminants. See "Drain Fuel Filter / Water Separator" on page -73.
4. Turn the retaining ring (5, Figure 103) to the left (10, Figure 103) and remove the cup (6, Figure 103). If equipped, disconnect the sensor wire (7, Figure 103) from the cup before removing the cup.
5. Carefully hold the cup to prevent fuel from spilling. If you spill any fuel, clean up the spill completely.
6. Remove the float ring (8, Figure 103) from the cup. Pour the contaminants into the container and dispose of it properly.
7. Clean the element (9, Figure 103) and inside cup. Replace the element if it is damaged.
8. Install the element and O-ring in the bracket.
9. Position the float ring in the cup.
10. Check the condition of the cup O-ring. Replace if necessary.
11. Install the cup to the bracket by tightening the retaining ring to the right (6, Figure 103) to a torque of 11 -15 ft•lb (15 -20 N•m; 1.5 -2.0 kg•m).
12. Close the drain cock. Reconnect the sensor wire if equipped.
13. Open the fuel cock (3, Figure 103).
14. Prime the fuel system. See "Priming the Fuel System" on page -40.
15. Check for leaks.

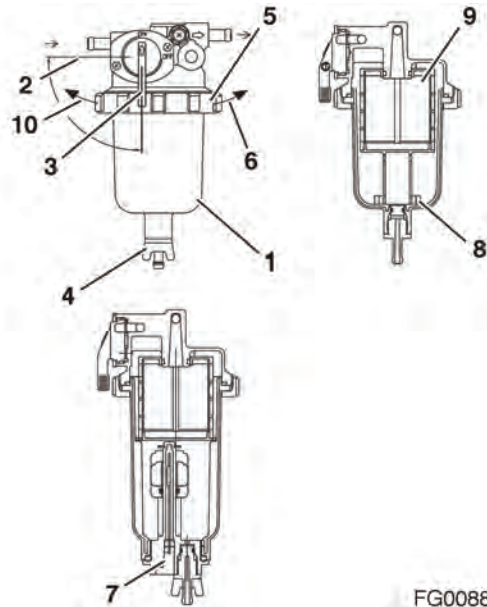


Figure 103

FG008868

Replace Engine Oil Filter



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.

Change the engine oil filter every 500 hours of operation after the initial at 50 hours.

Replace the engine oil at the same time. See "Replace Engine Oil and Engine Oil Filter" on page -67.

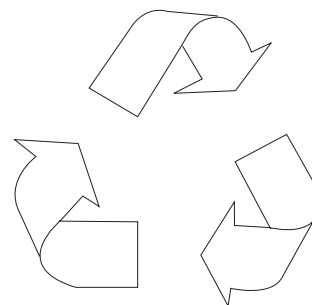


Figure 104

FG009156

Every 1000 Hours of Operation

Perform the following maintenance every 1000 hours of operation.

- Adjust Intake / Exhaust Valve Clearance

Adjust Intake / Exhaust Valve Clearance

Proper adjustment is necessary to maintain the correct timing for opening and closing the valves. Improper adjustment will cause the engine to run noisily, resulting in poor engine performance and engine damage. See "Intake / Exhaust Valve and Guide" on page -95.

Every 1500 Hours of Operation

Perform the following maintenance every 1500 hours of operation.

- Inspect, Clean and Test Fuel Injectors
- Inspect, Clean and Test EGR Valve 4TNV98-E
- Inspect Crankcase Breather System

Inspect, Clean and Test Fuel Injectors



High-pressure Hazard!

Avoid skin contact with the high-pressure diesel fuel spray caused by a fuel system leak such as a broken fuel injection line. High-pressure fuel can penetrate your skin and result in serious injury. If you are exposed to high-pressure fuel spray, obtain prompt medical treatment.

Never check for a fuel leak with your hands. Always use a piece of wood or cardboard. Consult authorized **DOOSAN** dealer or distributor if have any questions or required more information.

Failure to comply could result in death or serious injury.

Proper operation of the fuel injectors is required to obtain the optimum injection pattern for full engine performance. The EPA / ARB requires that the fuel injectors are inspected, cleaned and tested every 1500 hours. See "Testing of Fuel Injectors" on page -190.

This procedure is considered normal maintenance and is performed at the owner's expense.

Inspect, Clean and Test EGR Valve 4TNV98-E

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

To prevent the valve from deteriorating in exhaust gas recirculation performance due to carbon accumulation, inspect, clean and test the valve at least every 1500 hours.

Consult your local **DOOSAN** dealer for this service.



Figure 105

FG009150

Inspect Crankcase Breather System

Proper operation of the crankcase breather system is required to maintain the emission requirements of the engine. The EPA / ARB requires that the crankcase breather system is inspected every 1500 hours.

There are three different crankcase breather systems used on the TNV engines. Only the non-turbo TNV engines crankcase breather system requires periodic maintenance.

The non-turbo TNV engines use a crankcase breather system that has a spring-backed diaphragm (2, Figure 106) in the valve cover (2, Figure 106). When the crankcase pressure reaches a predetermined value, the diaphragm opens a passage that allows crankcase fumes to be routed to the intake manifold.

To inspect the diaphragm and spring (3, Figure 106):

1. Remove the bolts retaining the diaphragm cover (4, Figure 106).
2. Remove the diaphragm cover, spring, diaphragm plate (5, Figure 106) and diaphragm.
3. Inspect the diaphragm for tears. Inspect the spring for distortion. Replace components if necessary.
4. Reinstall the diaphragm, diaphragm plate, spring and diaphragm cover. Tighten the diaphragm bolts to specified torque.

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

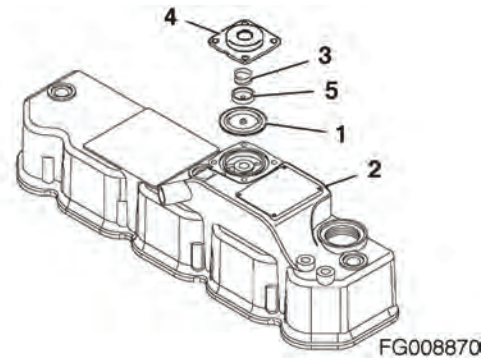


Figure 106

Every 2000 Hours of operation

Perform the following maintenance every 2000 hours of operation.

- Drain, Flush and Refill Cooling System With New Coolant
- Check and Replace Fuel Hoses and Engine Coolant Hoses
- Lap the Intake and Exhaust Valves

Drain, Flush and Refill Cooling System With New Coolant

DANGER

Scald Hazard!

Never Remove the radiator cap if the engine is hot. Steam and hot engine coolant will spurt out and seriously burn you. Allow the engine to cool down before you attempt to remove the radiator cap.

Tighten the radiator cap securely after you check the radiator. Steam can spurt out during engine operation if the cap is loose.

Always check the level of the engine coolant by observing the reserve tank.

Failure to comply will result in death or serious injury.



HAOA060L

Figure 107

WARNING

Burn Hazard!

Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.

Failure to comply could result in death or serious injury.



HAOA050L

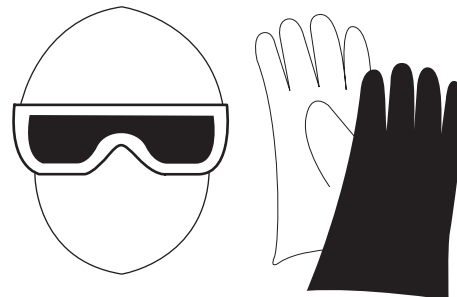
Figure 108

CAUTION

Coolant Hazard!

Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

Failure to comply may result in minor or moderate injury.



FG009154

Figure 109

CAUTION

Always be environmentally responsible.

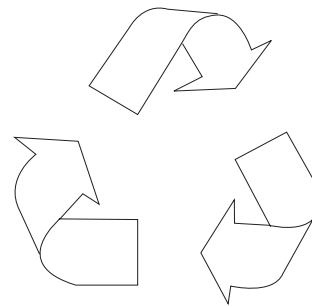
Follow the guidelines of the EPA or other governmental agencies for the proper disposal of hazardous materials such as engine oil, diesel fuel and engine coolant. Consult the local authorities or reclamation facility.

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.

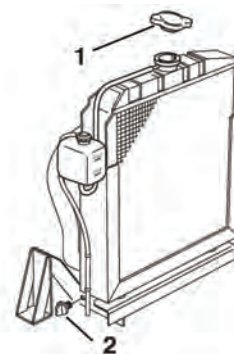
Engine coolant contaminated with rust or scale reduces the cooling effect. Even when extended life engine coolant is properly mixed, the engine coolant gets contaminated as its ingredients deteriorate. Drain, flush and refill the cooling system with new coolant every 1000 hours or once a year, whichever comes first.

1. Allow engine and coolant to cool.
2. Remove the radiator cap (1, Figure 111).
3. Remove the drain plug or open the drain cock (2, Figure 111) at the lower portion of the radiator and drain the engine coolant.



FG009156

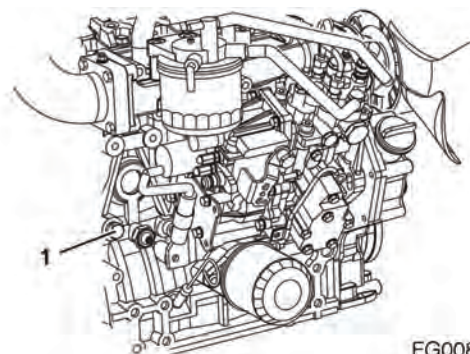
Figure 110



FG008869

Figure 111

4. Drain the coolant from the engine block.
 - On models not equipped with an oil cooler, remove the coolant drain plug (1, Figure 112) from the engine block.



FG008852

Figure 112

- On models equipped with an oil cooler, remove the coolant hose (1, Figure 113) at the oil cooler.

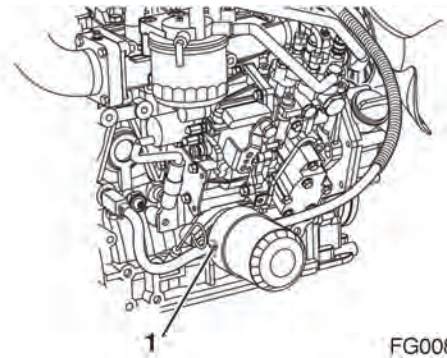


Figure 113

FG008853

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.

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.

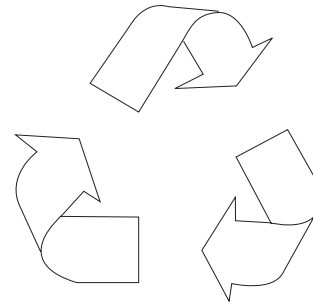


Figure 114

FG009156

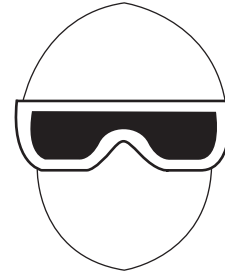
ENGINE

Before You Begin Servicing



WARNING

To prevent possible eye injury, always wear SAFETY GLASSES while servicing the engine.



FG009152

Figure 115



WARNING

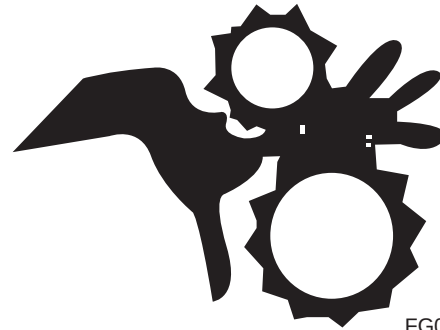
ENTANGLEMENT HAZARD!

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 116



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 117

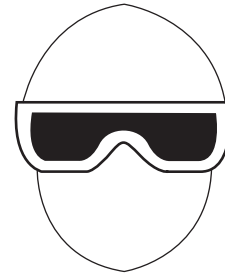


CAUTION

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 118



CAUTION

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



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

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

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.



CAUTION

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



CAUTION

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

Introduction

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

Cylinder Head Specifications

Adjustment Specifications

Valve Clearance	Valve Bridge Clearance (4-Valve Head Only)
0.006 - 0.010 in. (0.15 - 0.25 mm)	0

Cylinder Head

Inspection Item			Standard	Limit	Reference Page
Combustion Surface Distortion (Flatness)			0.0020 in. (0.05 mm) or less	0.0059 in. (0.15 mm)	See "Valve Recession" on page -115.
Valve Recession	Intake		0.0142 - 0.0220 in. (0.36 - 0.56 mm)	0.0315 in. (0.8 mm)	
	Exhaust		0.0138 - 0.0217 in. (0.35 - 0.55 mm)	0.0315 in. (0.8 mm)	
Valve Seat (2-Valve, 4-Valve)	Seat Angle	Intake	120°	-	See "Valve Face and Valve Seat" on page -116.
		Exhaust	90°	-	
	Seat Correction Angle		40°, 150°	-	

Intake / Exhaust Valve and Guide

Inspection Item		Standard	Limit	Reference Page
Intake	Guide Inside Diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.2787 in. (7.08 mm)	
	Valve Stem Outside Diameter	0.2734 - 0.2740 in. (6.945 - 6.960 mm)	0.2717 in. (6.90 mm)	
	Valve Stem Bend	0.0016 - 0.0028 in. (0.040 - 0.070 mm)	0.0067 in. (0.17 mm)	
Exhaust	Guide Inside Diameter	0.2756 - 0.2762 in. (7.000 - 7.015 mm)	0.2787 in. (7.08 mm)	
	Valve Stem Outside Diameter	0.2732 - 0.2738 in. (6.940 - 6.955 mm)	0.2717 in. (6.90 mm)	
	Valve Stem Bend	0.0018 - 0.0030 in. (0.045 - 0.075 mm)	0.0067 in. (0.17 mm)	
Valve Guide Projection From Cylinder Head		0.3819 - 0.3937 in. (9.70 - 10.00 mm)	-	See "Inspection of Cylinder Head" on page -114.
Valve Guide Installation Method		Cold-fitted	-	
Valve Stem Seal Protection from Cylinder Head				
4 Valves		0.460 - 0.472 in. (11.7 - 12.0 mm)	-	See "Inspection of Cylinder Head" on page -114.

Push Rod

Inspection Item	Standard	Limit	Reference Page
Push Rod Bend	Less than 0.0012 in. (0.03 mm)	0.0012 in. (0.03 mm)	See "Push Rod Bend" on page -112.

Valve Spring

Inspection Item	Standard	Limit	Reference Page
Free Length	1.5630 in. (39.7 mm)	1.5433 in. (39.2 mm)	See "Inspection of Valve Springs" on page -116.
Squareness	-	0.0551 in. (1.4 mm)	

Rocker Arm and Shaft

Inspection Item	Standard	Limit	Reference Page
Arm Shaft Hole Diameter	0.7283 - 0.7291 in. (18.500 - 18.520 mm)	0.7311 in. (18.57 mm)	See "Inspection of Rocker Arm Assembly" on page -113.
Shaft Outside Diameter	0.7272 - 0.7280 in. (18.470 - 18.490 mm)	0.7260 in. (18.44 mm)	
Oil Clearance	0.0004 - 0.0020 in. (0.010 - 0.050 mm)	0.0051 in. (0.13 mm)	

Camshaft And Timing Gear Train Specifications

Camshaft

Inspection Item		Standard	Limit	Reference Page
End Play		0.0020 - 0.0079 in. (0.05 - 0.20 mm)	0.0118 in. (0.030 mm)	See "Removal of Camshaft" on page -133.
Bend (1/2 the dial gauge reading)		0 - 0.0008 in. (0 - 0.02 mm)	0.0020 in. (0.05 mm)	See "Inspection of Camshaft" on page -144..
Cam Lobe Height		1.7087 - 1.7165 in. (43.400 - 43.600 mm)	1.6988 in. (50.650 mm)	
Shaft Outside Diameter/ Bearing Inside Diameter				
Gear End	Bushing Inside Diameter	1.9681 - 1.9707 in. (49.990 - 50.055 mm)	1.9736 in. (50.130 mm)	See "Inspection of Camshaft" on page -144.
	Camshaft Outside Diameter	1.9655 - 1.9665 in. (49.925 - 49.950 mm)	1.7673 in. (49.890 mm)	
	Oil Clearance	0.0016 - 0.0051 in. (0.040 - 0.130 mm)	0.0094 in. (0.240 mm)	
Intermediate	Bore Inside Diameter	1.9685 - 1.9695 in. (50.000 - 50.025 mm)	1.9724 in. (50.100 mm)	
	Camshaft Outside Diameter	1.9650 - 1.9659 in. (49.910 - 49.935 mm)	1.9636 in. (49.875 mm)	
	Oil Clearance	0.0026 - 0.0045 in. (0.065 - 0.115 mm)	0.0089 in. (0.225 mm)	
Flywheel End	Bore Inside	1.9685 - 1.9695 in. (50.000 - 50.025 mm)	1.9724 in. (50.100 mm)	
	Camshaft Outside Diameter	1.9655 - 1.9665 in. (49.925 - 49.950 mm)	1.7673 in. (49.890 mm)	
	Oil Clearance	0.0020 - 0.0039 in. (0.050 - 0.100 mm)	0.0083 in. (0.210 mm)	

Idler Gear Shaft and Bushing

Inspection Item	Standard	Limit	Reference Page
Shaft Outside Diameter	1.8091 - 1.8100 in. (45.950 - 45.975 mm)	1.8071 in. (45.900 mm)	See "Inspection of Idler Gear and Shaft" on page -145.
Bushing Inside Diameter	1.8110 - 4.8120 in. (46.000 - 46.025 mm)	1.8140 in. (46.075 mm)	
Oil Clearance	0.0010 - 0.0030 in. (0.025 - 0.075 mm)	0.0069 in. (0.175 mm)	

Timing Gear Backlash

Inspection Item	Standard	Limit	Reference Page
Crank Gear, Cam Gear, Idler Gear, Fuel Injection Pump Gear and PTO Gear	0.0031 - 0.0055 in. (0.08 - 0.14 mm)	0.0063 in. (0.16 mm)	See "Checking Timing Gear Backlash" on page -130.
Lubricating Oil Pump Gear	0.0035 - 0.0059 in. (0.09 - 0.15 mm)	0.0067 in. (0.17 mm)	
Balancer Drive Gear	0.0047 - 0.0071 in. (0.12 - 0.18 mm)	0.0079 in. (0.20 mm)	

Crankshaft and Piston Specifications

Crankshaft

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

Inspection Item		Standard	Limit	Reference Page
Bend (1/2 the dial gauge reading)		-	0.0008 in. (0.02 mm)	See "Inspection of Crankshaft" on page -143.
Connecting Rod Journals	Journal Outside Diameter	2.2816 - 2.2820 in. (57.952 - 57.962 mm)	2.2796 in. (57.902 mm)	
	Bearing Inside Diameter	2.2835 - 2.2845 in. (58.000 - 58.026 mm)	-	
	Bearing Insert Thickness	0.0587 - 0.0591 in. (1.492 - 1.500 mm)	-	
	Oil Clearance	0.0015 - 0.0029 in. (0.038 - 0.074 mm)	0.0059 in. (0.150 mm)	
Main Bearing Journal	Journal Outside Diameter	2.5572 - 2.5576 in. (64.952 - 64.962 mm)	2.5552 in. (64.902 mm)	
	Bearing Inside Diameter	2.5590 - 2.5598 in. (65.000 - 65.020 mm)	-	
	Bearing Insert Thickness	0.0785 - 0.0791 in. (1.995 - 2.010 mm)	-	
	Oil Clearance	0.0015 - 0.0027 in. (0.038 - 0.068 mm)	0.0059 in. (0.150 mm)	

Thrust Bearing

Inspection Item	Standard	Limit	Reference Page
Crankshaft End Play	0.0051 - 0.0091 in. (0.13 - 0.23 mm)	0.0110 in. (0.28 mm)	See "Removal of Crankshaft" on page -137.

Piston

Inspection Item		Standard	Limit	Reference Page
Piston Outside Diameter (Measure at 90° to the Piston Pin.)		3.8555 - 3.8567 in. (97.930 - 97.960 mm)	3.8541 in. (97.895 mm)	See "Inspection of Pistons, Piston Rings and Wrist Pin" on page -140.
Piston Diameter Measure Location (Upward From the Bottom of the Piston.)		0.8661 in. (22 mm)	-	
Piston Pin	Hole Inside Diameter	1.1811 - 1.1815 in. (30.000 - 30.009 mm)	1.1826 in. (30.039 mm)	
	Pin Outside Diameter	1.1807 - 1.1811 in. (29.989 - 30.000 mm)	1.1795 in. (29.959 mm)	
	Oil Clearance	0.0000 - 0.0008 in. (0.000 - 0.020 mm)	0.0031 in. (0.080 mm)	

Piston Ring

Inspection Item		Standard	Limit	Reference Page
Top Ring	Ring Groove Width	0.0803 - 0.0811 in. (2.040 - 2.060 mm)	-	See "Inspection of Pistons, Piston Rings and Wrist Pin" on page -140.
	Ring Width	0.0764 - 0.0772 in. (1.940 - 1.960 mm)	0.0756 in. (1.920 mm)	
	Side Clearance	0.0031 - 0.0047 in. (0.080 - 0.120 mm)	-	
	End Gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0213 in. (0.540 mm)	
Second Ring	Ring Groove Width	0.819 - 0.0825 in. (2.080 - 2.095 mm)	0.0864 in. (2.195 mm)	
	Ring Width	0.0776 - 0.0783 in. (1.970 - 1.990 mm)	0.0768 in. (1.950 mm)	
	Side clearance	0.0035 - 0.0049 in. (0.090 - 0.125 mm)	0.0096 in. (0.245 mm)	
	End Gap	0.017 - 0.0256 in. (0.450 - 0.650 mm)	0.0287 in. (0.730 mm)	
Oil Ring	Ring Groove Width	0.1187 - 0.1193 in. (3.015 - 3.030 mm)	0.1232 in. (3.130 mm)	
	Ring Width	0.1169 - 0.1177 in. (2.970 - 2.990 mm)	0.1161 in. (2.950 mm)	
	Side Clearance	0.0010 - 0.0024 in. (0.025 - 0.060 mm)	0.0071 in. (0.180 mm)	
	End Gap	0.0098 - 0.0177 in. (0.250 - 0.450 mm)	0.0217 in. (0.550 mm)	

Connecting Rod

Connecting Rod Small End

Inspection Item	Standard	Limit	Reference Page
Wrist Pin Bushing Inside Diameter	1.1821 - 1.1826 in. (30.025 - 30.038 mm)	1.1838 in. (30.068mm)	See "Inspection of Connecting Rod" on page -142.
Wrist Pin Outside Diameter	1.1806 - 1.1811 in. (29.987 - 30.000 mm)	1.1795 in. (29.959 mm)	
Oil Clearance	0.0010 - 0.0020 in. (0.025 - 0.51 mm)	0.0043 in. (0.109 mm)	

Connecting Rod Big End

Inspection Item	Standard	Limit	Reference Page
Side Clearance	0.0079 - 0.0157 in. (0.20 - 0.40 mm)	-	See "Inspection of Connecting Rod" on page -142.

Tappet

Inspection Item	Standard	Limit	Reference Page
Tappet Bore (Block) Inside Diameter	0.4724 - 0.4731 in. (12.000 - 12.018 mm)	0.4739 in. (12.038 mm)	See "Inspection of Tappets" on page -142.
Tappet Stem Outside Diameter	0.4715 - 0.4720 in. (11.975 - 11.990 mm)	0.4707 in. (11.955 mm)	
Oil Clearance	0.004 - 0.0017 in. (0.010 - 0.043 mm)	0.0033 in. (0.083 mm)	

Cylinder Block Specifications**Cylinder Block**

Inspection Item		Standard	Limit	Reference Page
Cylinder Inside Diameter		3.8583 - 3.8594 in. (98.000 - 98.030 mm)	3.8634 in. (98.130 mm)	See “Inspection of Cylinder Block” on page -140.
Cylinder Bore	Roundness	0.0004 in. (0.01 mm) or less	0.0012 in. (0.03 mm)	
	Taper			

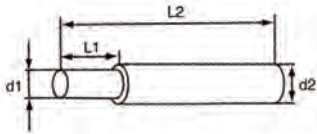
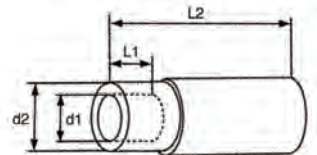
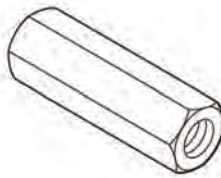
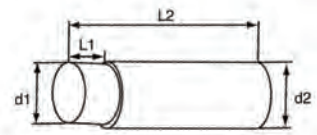
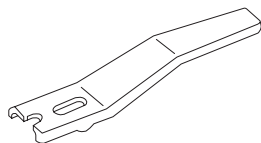
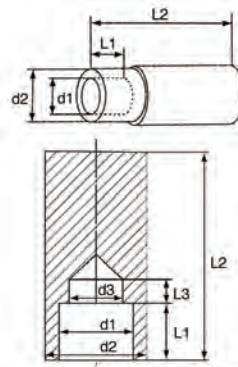
Special Torque Chart

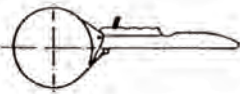
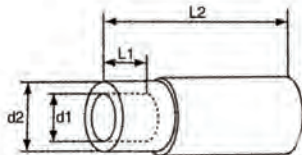
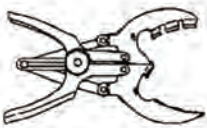
Torque for Bolts and Nuts

Component	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

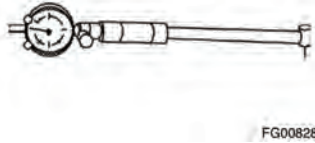
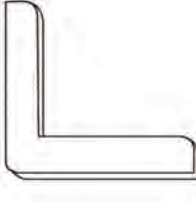
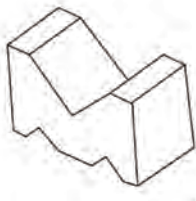
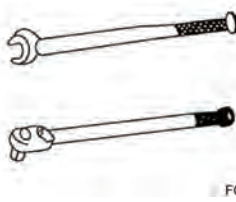
See "Tightening Torques For Standard Bolts And Nuts" on page -48.

Special Service Tools

No.	Illustration	Tool name	Applicable model and tool size														
1	 FG008269	Valve Guide Tool (For Removing Valve Guide)	<table><tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr><tr><td>4TNV98</td><td>0.787 in. (20 mm)</td><td>2.953 in. (75 mm)</td><td>0.256 in. (6.5 mm)</td><td>0.394 in. (10 mm)</td></tr></table> FG010215	Model	L1	L2	d1	d2	4TNV98	0.787 in. (20 mm)	2.953 in. (75 mm)	0.256 in. (6.5 mm)	0.394 in. (10 mm)				
Model	L1	L2	d1	d2													
4TNV98	0.787 in. (20 mm)	2.953 in. (75 mm)	0.256 in. (6.5 mm)	0.394 in. (10 mm)													
*Locally manufactured																	
2	 FG008270	Valve Guide Tool (For Installing Valve Guide)	<table><tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr><tr><td>4TNV98</td><td>0.276 in. (7 mm)</td><td>2.362 in. (60 mm)</td><td>0.512 in. (13 mm)</td><td>0.630 in. (16 mm)</td></tr></table> FG010216	Model	L1	L2	d1	d2	4TNV98	0.276 in. (7 mm)	2.362 in. (60 mm)	0.512 in. (13 mm)	0.630 in. (16 mm)				
Model	L1	L2	d1	d2													
4TNV98	0.276 in. (7 mm)	2.362 in. (60 mm)	0.512 in. (13 mm)	0.630 in. (16 mm)													
3	 FG008871	Fuel Injector Removal Tool (2-Valve Head)	Part No. 129470-92305														
4	 FG008271	Connecting Rod Bushing Replacer (For Removal/ Installation of Connecting Rod Bushing)	<table><tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr><tr><td>4TNV98</td><td>0.787 in. (20 mm)</td><td>3.937 in. (100 mm)</td><td>1.181 in. (30 mm)</td><td>1.299 in. (33 mm)</td></tr></table> FG010217	Model	L1	L2	d1	d2	4TNV98	0.787 in. (20 mm)	3.937 in. (100 mm)	1.181 in. (30 mm)	1.299 in. (33 mm)				
Model	L1	L2	d1	d2													
4TNV98	0.787 in. (20 mm)	3.937 in. (100 mm)	1.181 in. (30 mm)	1.299 in. (33 mm)													
5	 FG008872	Valve Spring Compressor (For Removal/ Installation of Valve Spring)	Part No. 129100-92630														
6	 FG008273	Installer (for Installing Valve Stem Seal)	<table><tr><th>Model</th><th>d1</th><th>d2</th><th>d3</th><th>L1</th><th>L2</th><th>L3</th></tr><tr><td>4TNV98</td><td>0.598 in. (15.2mm)</td><td>0.827 in. (21mm)</td><td>0.472 in. (12mm)</td><td>0.465 in. (11.8mm)</td><td>2.559 in. (65mm)</td><td>0.157 in. (4mm)</td></tr></table> FG010218	Model	d1	d2	d3	L1	L2	L3	4TNV98	0.598 in. (15.2mm)	0.827 in. (21mm)	0.472 in. (12mm)	0.465 in. (11.8mm)	2.559 in. (65mm)	0.157 in. (4mm)
Model	d1	d2	d3	L1	L2	L3											
4TNV98	0.598 in. (15.2mm)	0.827 in. (21mm)	0.472 in. (12mm)	0.465 in. (11.8mm)	2.559 in. (65mm)	0.157 in. (4mm)											
*Locally manufactured																	

No.	Illustration	Tool name	Applicable model and tool size										
7	 FG008274	Filter Wrench (For Removal / Installation of Engine Oil Filter)	Available Locally										
8	 FG010220	Camshaft Bushing Tool (For Extracting Camshaft Bushing)	<table border="1"><thead><tr><th>Model</th><th>L1</th><th>L2</th><th>d1</th><th>d2</th></tr></thead><tbody><tr><td>4TNV98</td><td>0.709 in. (18 mm)</td><td>2.756 in. (70 mm)</td><td>1.968 in. (50 mm)</td><td>2.087 in. (553 mm)</td></tr></tbody></table> FG010228	Model	L1	L2	d1	d2	4TNV98	0.709 in. (18 mm)	2.756 in. (70 mm)	1.968 in. (50 mm)	2.087 in. (553 mm)
Model	L1	L2	d1	d2									
4TNV98	0.709 in. (18 mm)	2.756 in. (70 mm)	1.968 in. (50 mm)	2.087 in. (553 mm)									
9	 FG008232	Flex-Hone (For Preparation of Cylinder Walls)	<table border="1"><thead><tr><th>Model</th><th>Part No.</th><th>Cylinder Bore</th></tr></thead><tbody><tr><td>4TNV98</td><td>129400-92440</td><td>3.504 - 3.976 in. (89 - 101 mm)</td></tr></tbody></table> FG010229	Model	Part No.	Cylinder Bore	4TNV98	129400-92440	3.504 - 3.976 in. (89 - 101 mm)				
Model	Part No.	Cylinder Bore											
4TNV98	129400-92440	3.504 - 3.976 in. (89 - 101 mm)											
10	 FG008275	Piston Ring Compressor (For Installing Piston)	Part No. 95550-002476 The Piston Insertion Tool is Applicable for 2.362 - 4.921 in. (60 - 125 mm) Diameter Pistons										
11	 FG008276	Piston Ring Expander (For Removal / Installation of Piston Ring)	Available Locally										

No.	Illustration	Tool name		Applicable model and tool size
1	 FG008277	Dial Indicator	Locally Available	Measure shaft bend and end play
2	 FG008278	Test Indicator	Locally Available	Measurements of narrow or deep portions that cannot be measured by dial gauge
3	 FG008279	Magnetic Stand	Locally Available	For holding the dial gauge when measuring
4	 FG008280	Micrometer	Locally Available	For measuring the outside diameters of crankshaft, pistons, piston pins, etc.

No.	Illustration	Tool name		Applicable model and tool size
5	 FG008281	Cylinder Bore Gauge	Locally Available	For measuring the inside diameters of cylinder liners, bearing bores, etc.
6	 FG008282	Calipers	Locally Available	For measuring outside diameters, depth, thickness and width
7	 FG008283	Depth Micrometer	Locally Available	For measuring of valve recession
8	 FG008284	Square	Locally Available	For measuring valve spring inclination and straightness of parts
9	 FG008285	V-Block	Locally Available	For measuring shaft bend
10	 FG008286	Torque Wrench	Locally Available	For tightening nuts and bolts to the specified torque
11	 FG008287	Feeler Gauge	Locally Available	For measuring piston ring gaps, piston ring clearance, and valve adjustment clearance

4-valve Cylinder Head

4-Valve Cylinder Head Components

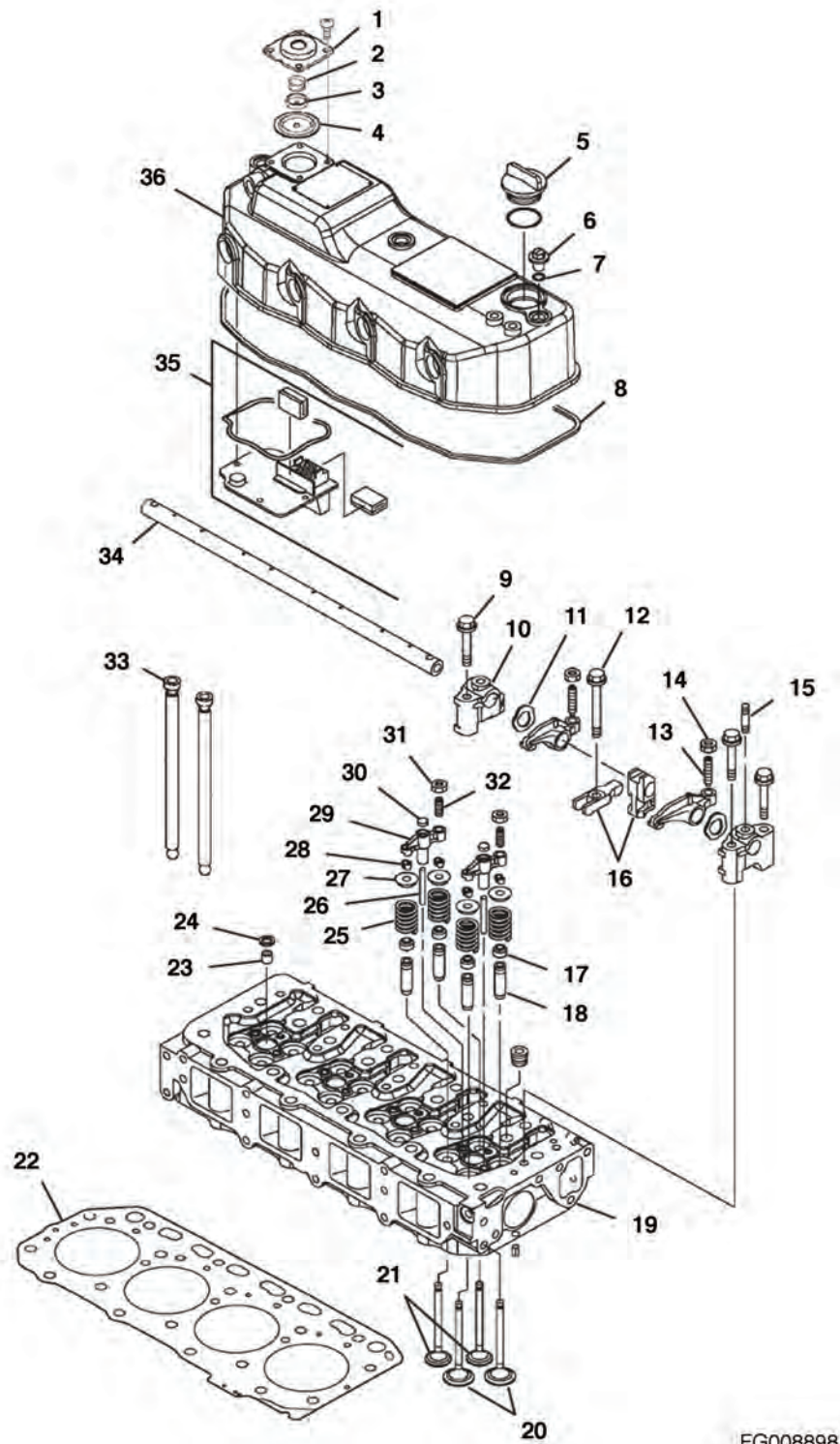


Figure 119

Reference Number	Description
1	Crankcase Breather Cover
2	Diaphragm Spring
3	Diaphragm Cup
4	Crankcase Breather Diaphragm
5	Oil Fill Cap
6	Valve Cover Nut
7	Valve Cover Nut O-Ring
8	Valve Cover Gasket
9	Support Bolt
10	Rocker Arm Shaft Support
11	Wave Washer
12	Fuel Injector Retainer Bolt
13	Valve Adjusting Screw (Primary)
14	Valve Adjusting Screw Lock Nut (Primary)
15	Rocker Arm Shaft Aligning Stud
16	Fuel Injector Retainer
17	Valve Stem Seal
18	Valve Guide
19	Cylinder Head

Reference Number	Description
20	Intake Valve
21	Exhaust Valve
22	Cylinder Head Gasket
23	Fuel Injector Nozzle Protector
24	Fuel Injector Nozzle Seat
25	Valve Spring
26	Valve Bridge Guide
27	Spring Retainer
28	Valve Keepers
29	Valve Bridge
30	Valve Bridge Seat
31	Valve Adjusting Screw Lock Nut (Secondary)
32	Valve Adjusting Screw (Secondary)
33	Push Rod
34	Rocker Arm Shaft
35	Crankcase Breather Components
36	Valve Cover

Disassembly of 4-Valve Cylinder Head

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

1. Drain the coolant from the engine into a suitable container. See "Drain, Flush and Refill Cooling System With New Coolant" on page -89.



CAUTION

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

2. Remove the high pressure fuel injection lines (1, Figure 120). See "Removal of Fuel Injectors" on page -190.



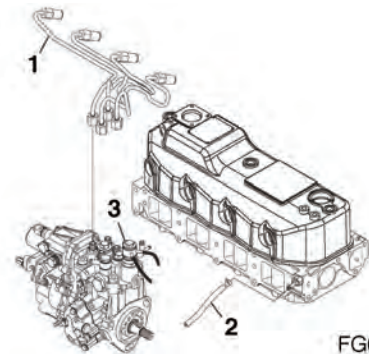
CAUTION

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

3. Disconnect the fuel return hose (2, Figure 120) from the cylinder head.
4. Disconnect the hoses (3, Figure 120) from the cold start device on the fuel injection pump.
This cooling water pipe is not used in electronically controlled engines 4TNV98-E.
Instead, these engines use a solenoid valve and connecting coupler but, when removing the cylinder head only, it is not necessary to remove the connecting coupler.
5. Remove the turbocharger-to-intake manifold hose (1, Figure 121) (if equipped).
6. Disconnect the electrical wire from the intake air heater (12, Figure 121).
7. Remove the intake manifold bolts (11, Figure 121). Remove the intake manifold (10, Figure 121). Discard the intake manifold gasket (9, Figure 121).
8. Disconnect the turbocharger oil supply (2, Figure 121) and the return lines (4, Figure 121) (if equipped).
9. Remove the exhaust manifold bolts (7, Figure 121). Remove the exhaust manifold (6, Figure 121) with the turbocharger attached. Discard the exhaust manifold gasket. (5, Figure 121).

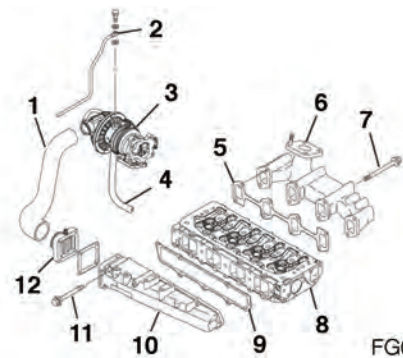
NOTE: *The turbocharger is installed 3TNV84T, 4TNV84T, 4TNV106T model and the engine of this machine has not turbocharger.*

10. Remove the engine coolant pump. See "Disassembly of Engine Coolant Pump" on page -202.



FG008899

Figure 120



FG008918

Figure 121

Removal of Valve Cover

NOTE: The high pressure fuel injection lines and valve cover grommets must be removed prior to removing the valve cover. See "Removal of Fuel Injectors" on page -190.

1. Remove the high-pressure fuel lines.
2. Use a flat-blade screwdriver (Figure 122) to remove the fuel injection line grommets (1, Figure 123) from the valve cover (3, Figure 123) and fuel injectors (2, Figure 123). There is a notch at the 3 o'clock position in the valve cover opening to insert the screwdriver.
3. Remove the valve cover nuts (4, Figure 123).
4. Remove the O-ring (5, Figure 123) on each valve cover nut.
5. Remove the valve cover (3, Figure 123). Discard the valve cover gasket (6, Figure 123).
6. Inspect and clean the crankcase breather assembly. See "Inspect Crankcase Breather System" on page -88.

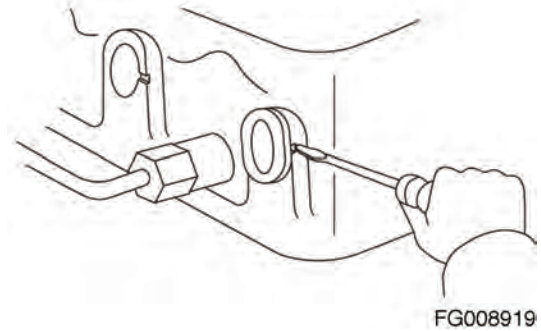


Figure 122

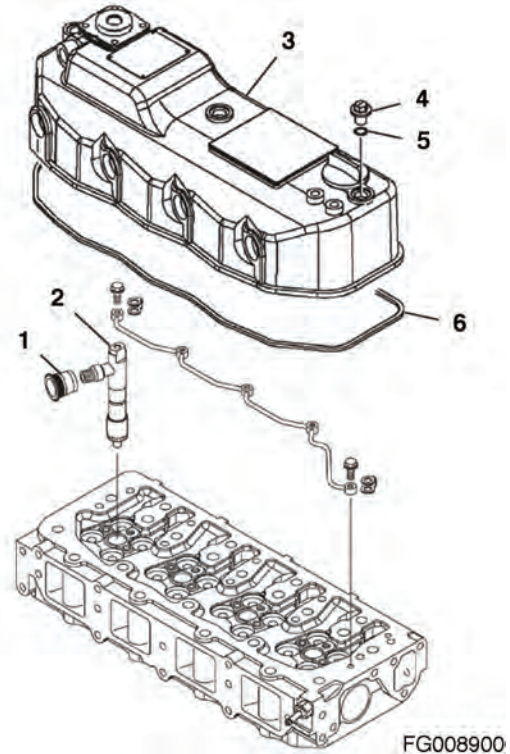


Figure 123

Removal of Rocker Arm Assembly

1. Remove the fuel injectors from the cylinder head. See "Removal of Fuel Injectors" on page -190.
2. Remove the bolts (1, Figure 124) that retain the rocker arm shaft supports to the cylinder head.
3. Remove the rocker arm and shaft assembly from the cylinder head.

NOTE: Identify the push rods and valve bridges so they can be installed in their original locations.

4. Remove the push rods (2, Figure 124).
5. Remove the valve bridge assemblies (3, Figure 124). Remove the seat (4, Figure 124) from each valve bridge.
6. Identify all parts so that they will be reinstalled in their original locations.

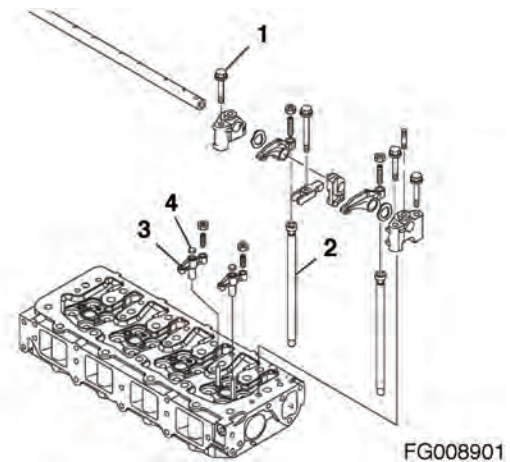


Figure 124

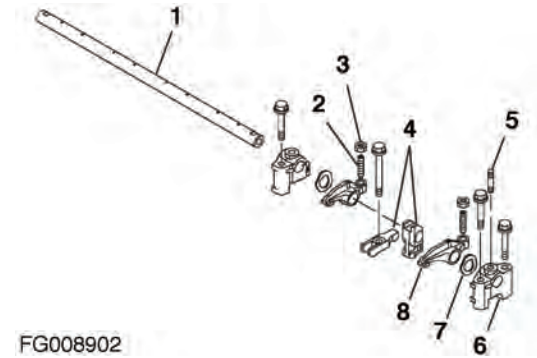
Disassembly of Rocker Arm Assembly

NOTE: Identify the rock arm so they can be reinstalled with the original matching valve and pushrod.

1. Remove the rocker arm shaft alignment studs (5, Figure 125) from the rocker arm shaft supports (6, Figure 125).
2. Slide the supports, wave washers (Figure 125, 7), rocker arms (8, Figure 125), and fuel injector retainers (4, Figure 125) off the rocker shaft (1, Figure 125), leaving these parts in order on the bench surface.

NOTE: Figure 125 shows components for one cylinder. Components for all remaining cylinders are assembled in the same order.

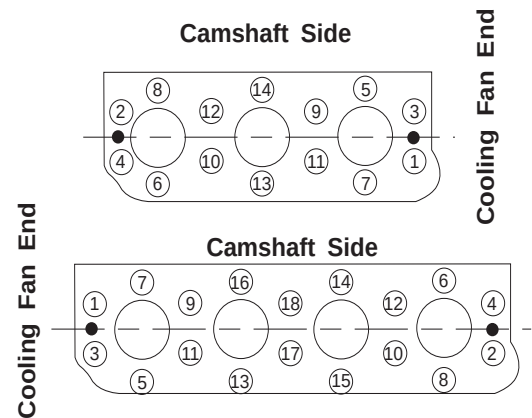
3. Remove the valve adjusting screw (2, Figure 125) and the lock nut (3, Figure 125) from the rocker arms.



FG008902
Figure 125

Removal of Cylinder Head

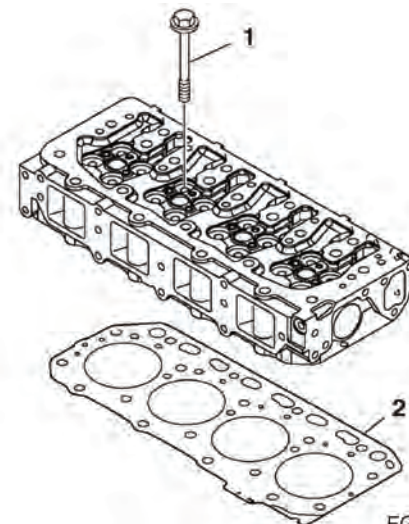
1. Loosen the cylinder head bolts following the sequence shown in Figure 126.



FG008882

Figure 126

2. Remove the cylinder head bolts (1, Figure 127)
3. Lift the cylinder head away from the cylinder block. Discard the cylinder head gasket (2, Figure 127). Place the cylinder head on the work bench to prevent damage to the combustion surface.

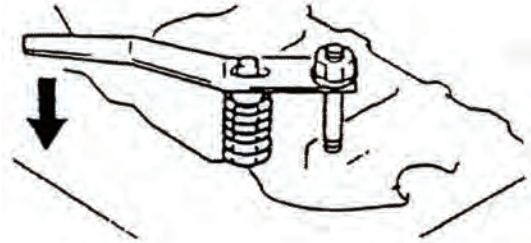


FG008904

Figure 127

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 128).



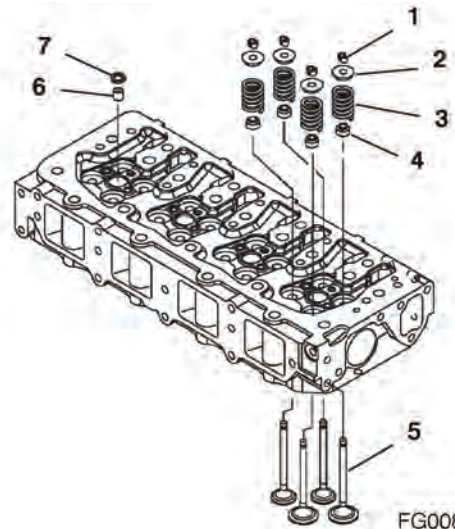
FG008306

Figure 128

3. Remove the valve keepers (1, Figure 129).
4. Slowly release the tension on the valve spring.
5. Remove the spring retainer (2, Figure 129), valve spring (3, Figure 129).
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 129) and the seats (7, Figure 129).
8. Turn the cylinder head so the exhaust port side faces down. Remove the intake and exhaust valves (5, Figure 129) from the cylinder head.
9. Remove the valve stem seals (4, Figure 129).



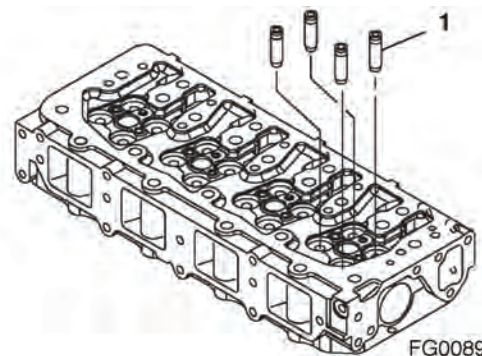
FG008905

Figure 129

Removal of Valve Guides

Note: Removal of the valve guides should be postponed until inspection and measurement procedures have been performed.

1. Using a drift pin and hammer, drive the valve guides (1, Figure 130) out of the cylinder head.



FG008906

Figure 130

Cleaning of Cylinder Head Components

WARNING

Fume / Burn Hazard!

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

Failure to comply could result in death or serious injury.

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



FG009153

Figure 131

Inspection of Cylinder Head Components

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

CAUTION

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

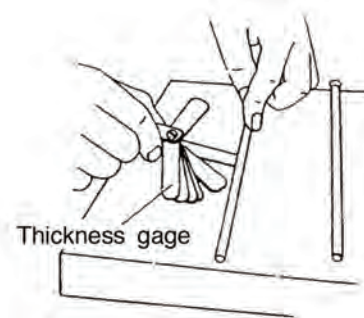
CAUTION

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

Inspection of Push Rods

Push Rod Bend

1. Place the push rods on a flat inspection block or layout bed.
2. Roll the push rods until a gap can be observed between a portion of the push rod and the surface of the block or layout bed.
3. Use a feeler gauge to measure the gap (Figure 132). See "Push Rod" on page -96. for the service limit.



FG008319

Figure 132

Inspection of Rocker Arm Assembly

Rocker Arm Shaft Hole Diameter

Use a telescoping gauge and micrometer to determine if the inside diameter of all the rocker arm support brackets and the rocker arms (Figure 133) are within the specified limits. See "Rocker Arm and Shaft" on page -96. for the service limit.

Inspect the contact areas (1, Figure 133) for excessive wear or damage.

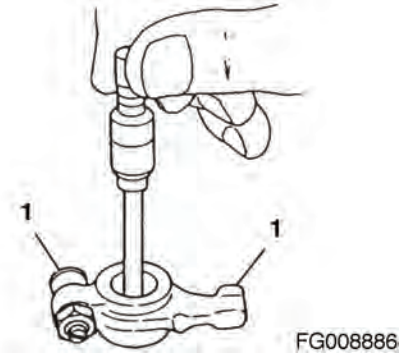


Figure 133

Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm shaft diameter (Figure 134). Measure at each rocker arm location in two directions 90° apart (Figure 134). See "Rocker Arm and Shaft" on page -96. for the service limit.

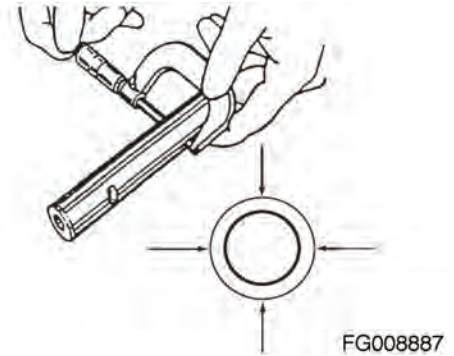


Figure 134

Inspection of Valve Guides

Valve Guide Inside Diameter

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

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

Use a telescoping gauge and micrometer to measure the inside diameter at each end of the valve guide. Measure in three places and 90° apart (Figure 135). See "Intake / Exhaust Valve and Guide" on page -95. for the service limit. Replace the valve guides if not within specification.

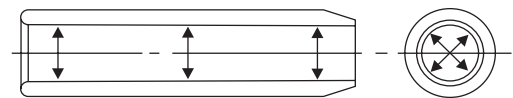


Figure 135

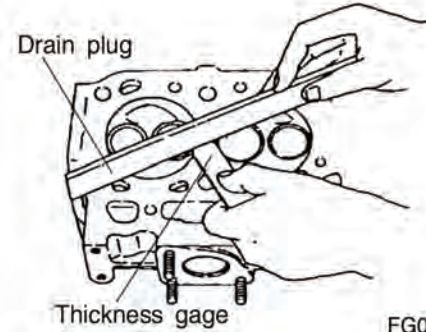
FG008888

Inspection of Cylinder Head

Cylinder Head Distortion

Place the cylinder head flat and inverted (combustion side up) on the bench. Use a straight edge and feeler gauge to measure cylinder head distortion (Figure 136). Measure diagonally and along each side. See "Cylinder Head" on page -95. for the service limit.

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



FG008307

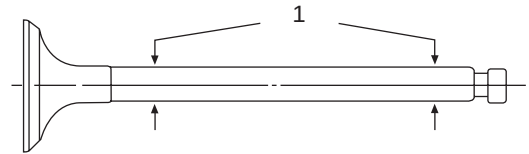
Figure 136

Inspection of Intake and Exhaust Valves

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

Valve Stem Diameter

Use a micrometer to measure the valve stem diameter. Measure the valve stem near the combustion end and near the opposite end (1, Figure 137). See "Intake / Exhaust Valve and Guide" on page -95. for the service limit.

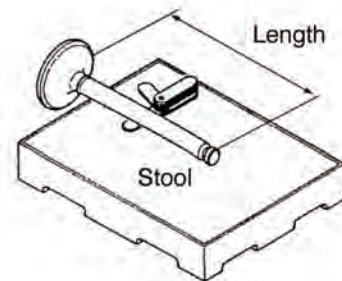


FG008889

Figure 137

Valve Stem Bend

Place the valve stem on a flat inspection block or layout bed. Roll the valve until a gap can be observed between a portion of the valve stem and the surface of the block or bed. Use a feeler gauge to measure the gap (Figure 138). See "Intake / Exhaust Valve and Guide" on page -95. for the service limit.



FG008314

Figure 138

Valve Recession

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

Insert the valves into their original locations and press them down until they are fully seated. Use a depth micrometer (Figure 139) to measure the difference between the cylinder head gasket surface and the combustion surface of each exhaust and intake valve (Figure 140). See "Cylinder Head" on page -95. for the service limit.

NOTE: *2-Valve cylinder head is shown. 4-Valve cylinder head is similar.*

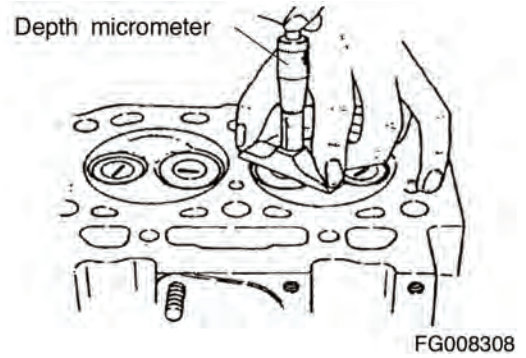


Figure 139

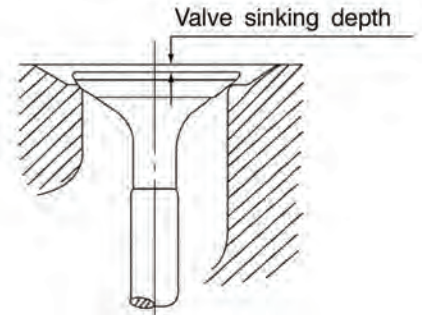


Figure 140

Valve Face and Valve Seat

Always check the clearance between the valve and valve guide before grinding or lapping the valve seats. See "Intake / Exhaust Valve and Guide" on page -95. for the service limit. If the clearance exceeds the limit, replace the valve and/or valve guide to bring the clearance within the limit.

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

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

Coat the valve seat with a thin coat of bluing compound. Install the valve and rotate to distribute bluing onto the valve face. The contact pattern should be approximately centered on the valve face (1, Figure 141) and even in width.

Also visually inspect the valve seat for even contact.

Light cutting can be performed by the use of a hand-operated cutter (Figure 142).

Valve seat diameter can be adjusted by top-grinding with a 150° stone to make the seat diameter smaller, and bottom-grinding using a 40° stone to make the seat diameter larger. Once the seat location has been corrected, grind and lap the seat angle (1, Figure 142) to specification. See "Cylinder Head" on page -95. for specifications.

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

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

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

Inspection of Valve Springs

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

Fractures

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

Corrosion

Check for corrosion of spring material caused by oxidation.

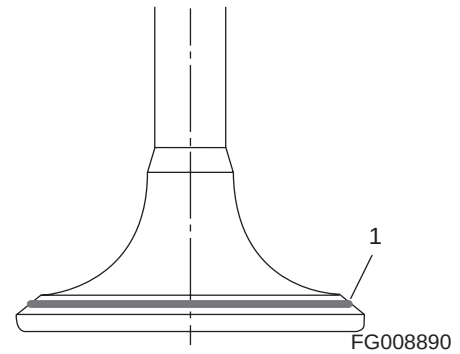


Figure 141

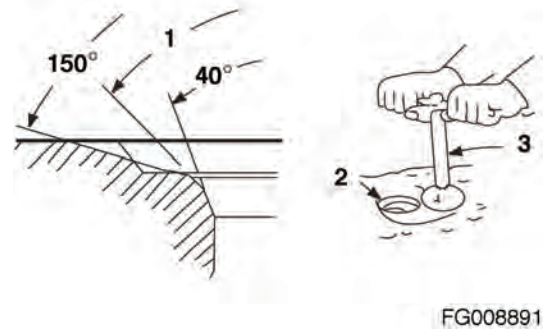
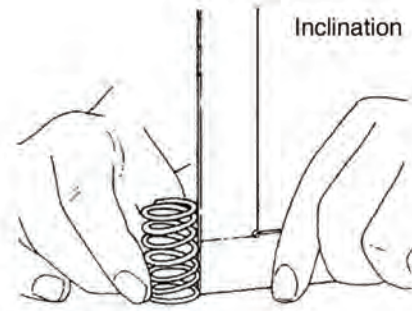


Figure 142

Squareness

Use a flat surface and a square to check each spring for squareness (Figure 143). See "Valve Spring" on page -96. for the service limit.

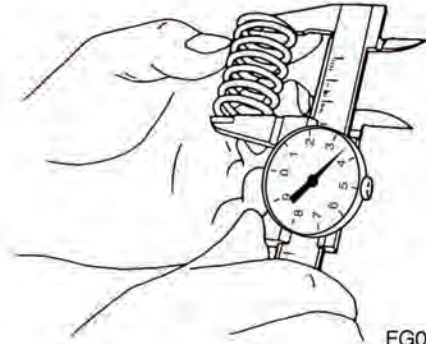


FG008316

Figure 143

Free Length

Use a caliper to measure the length of the spring (Figure 144). See "Valve Spring" on page -96. for the service limit.



FG008892

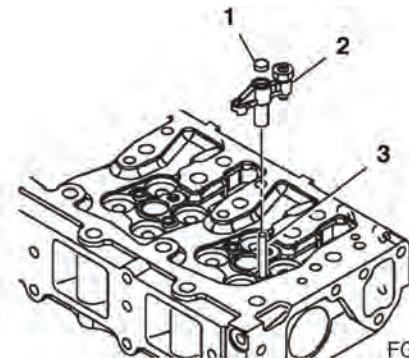
Figure 144

Inspection of Valve Bridges

Visually inspect the contact surface at both ends of the valve bridge (2, Figure 145) for excessive wear or mushrooming.

Remove and inspect the seat (1, Figure 145).

Measure the diameter of the valve bridge guide pin bore in the valve bridge and guide pin (3, Figure 145). See "Rocker Arm and Shaft" on page -96. for the service limit.



FG008907

Figure 145

Reassembly of Cylinder Head

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

IMPORTANT

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

Reassembly of Valve Guides

1. The valve guides are installed into the cylinder head with an extremely tight press fit. Before installing the valve guides, place the valve guides in a freezer for at least twenty minutes. This will cause the valve guides to contract, making it easier to install the valve guides into place.
2. Immediately after removing the valve guides from the freezer, insert the valve guides (1, Figure 146) in their proper positions.

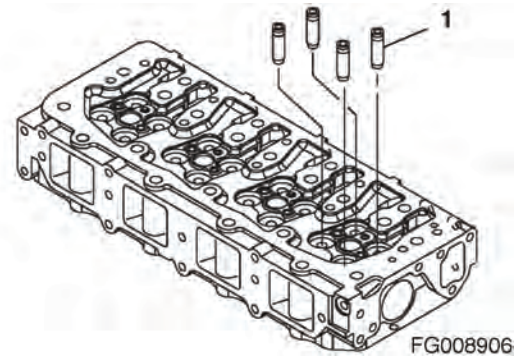


Figure 146

3. Finish installing the valve guides (1, Figure 147) into the cylinder head to the proper height (3, Figure 147) using the valve guide installation tool (2, Figure 147). See "Intake / Exhaust Valve and Guide" on page -95.

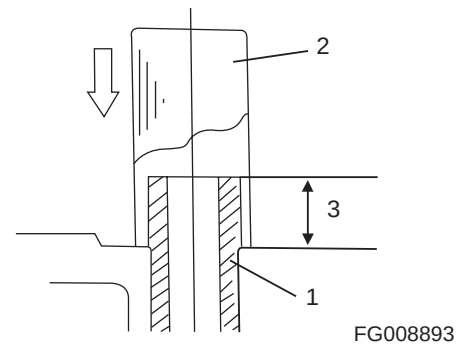


Figure 147

Reassembly of Intake and Exhaust Valves

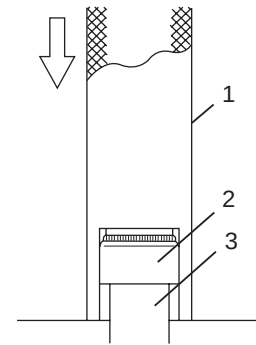
IMPORTANT

When installing valve stem seals, use new ones instead of reusing removed seals.

Exhaust valve and intake valve stem seals are different. They can be distinguished based on the paint marks on the outer side of the seal or the color of the seal spring (Figure 148).

When installing each stem seal, take care to correctly position it.

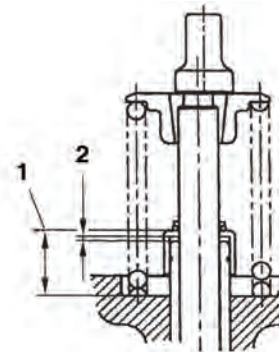
1. Oil the lip of the valve stem seal (2, Figure 148). Using the valve stem seal installation tool (1, Figure 148), install a new valve stem seal on each of the valve guides (3, Figure 148).



FG008894

Figure 148

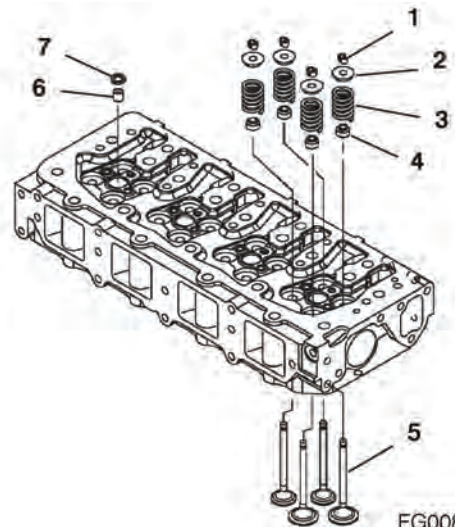
2. Measure the distance (1, Figure 149) from the cylinder head to the valve stem seal to ensure proper clearance (2, Figure 149) between the guide and seal. See "Intake / Exhaust Valve and Guide" on page -95.
3. Place the cylinder head assembly on its exhaust port side.



FG008895

Figure 149

4. Place all the valves (5, Figure 150) in their proper location in the cylinder head.
5. Place the cylinder head on the workbench with the combustion side down. Install the valve spring (3, Figure 150) and spring retainer (2, Figure 150).
6. Using the valve spring compressor tool, compress the valve spring.
7. Insert the valve keepers (1, Figure 150) and slowly release the tension in the valve spring. Repeat the steps on all the remaining valves.



FG008905

Figure 150

Reassembly of Cylinder Head

1. Carefully clean both the combustion surface of the cylinder head and the top surface of the cylinder block. Then place a new cylinder head gasket (2, Figure 151) on the cylinder block.
2. Position the cylinder head on the on the cylinder head gasket.

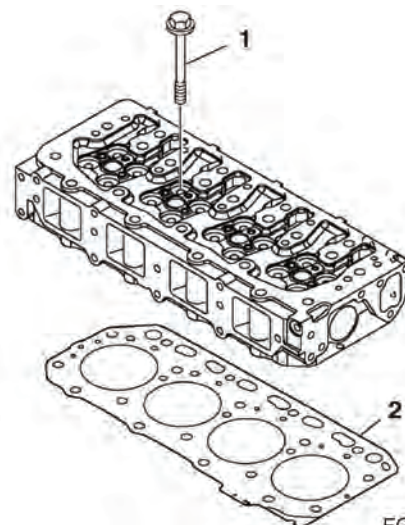


Figure 151

3. Lightly oil the threads of the cylinder head bolts (1, Figure 151). Tighten the bolts to the specified torque in two steps as shown in the chart below. Tighten in the sequence shown in (Figure 152). See "Special Torque Chart" on page -101. for specification.

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

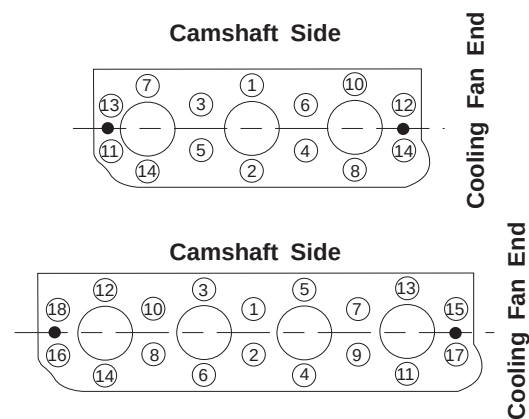


Figure 152

Reassembly of Rocker Arm Assembly

1. Reinstall the valve bridges (3, Figure 153) in their original locations and ensure each seat (4, Figure 153) is in place.
2. Insert the push rods (2, Figure 153) in their original locations.

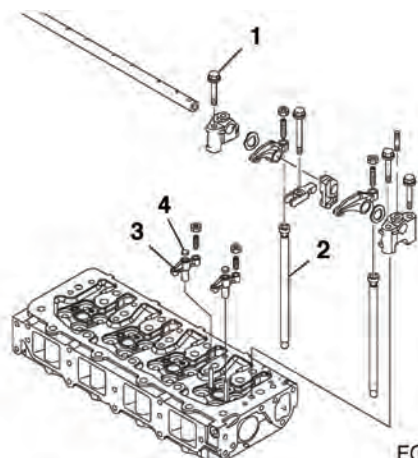


Figure 153

IMPORTANT

The wave washers (2, Figure 154) must be installed with the bow facing the rocker arms (1, Figure 154).

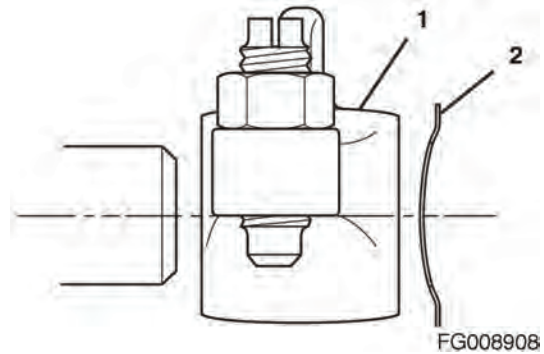


Figure 154

IMPORTANT

Ensure the lubrication holes (1, Figure 155) in the rocker arm shaft are oriented correctly with respect to the rocker arms (2, Figure 155).

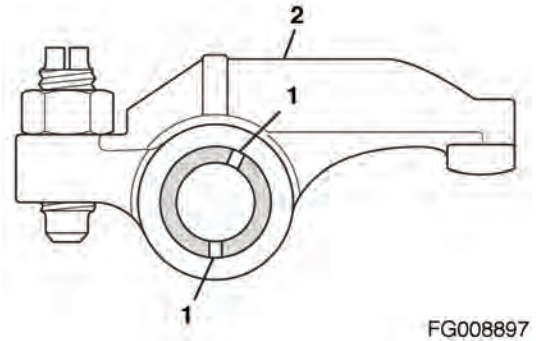


Figure 155

3. Lubricate the rocker arm shaft. Slide the rocker arm supports (6, Figure 156), wave washers (7, Figure 156), rocker arms (8, Figure 156), and fuel injector retainers (4, Figure 156) 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 156) with a hole for the shaft alignment stud (5, Figure 156). Align the hole in the rocker arm shaft and the hole in the rocker arm support bracket. Reinstall the alignment stud.

NOTE: Figure 156 shows components for one cylinder. Components for all remaining cylinders are assembled in the same order.

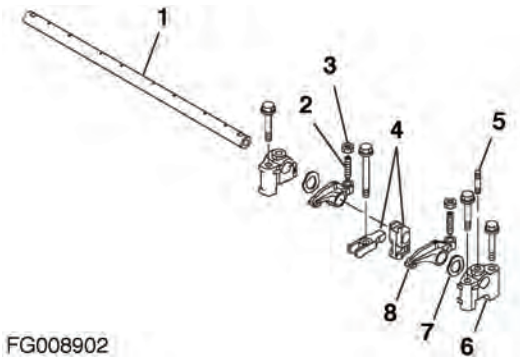


Figure 156

4. Position the rocker arm assembly on a flat surface. Reinstall the alignment studs (5, Figure 156).
5. Place the rocker arm shaft assembly onto the cylinder head.
6. If removed, reinstall the valve adjusting screws (2, Figure 156) and lock nuts (3, Figure 156).
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 -194.

Reassembly of the Valve Cover

1. Lightly grease a new valve cover gasket (6, Figure 157). Place the gasket in the groove of the valve cover (3, Figure 157).
2. Place the valve cover on the cylinder head.
3. Be sure new O-rings (5, Figure 157) are installed on the valve cover nuts. Reinstall and tighten the valve cover nuts (4, Figure 157).
4. Reinstall the fuel injector grommets (1, Figure 157).
5. Reinstall the exhaust manifold using a new gasket. Tighten the bolts to specification.
6. Reinstall the intake manifold using a new gasket. Tighten the bolts to specification.
7. Reconnect the fuel injector return hose and fuel injection pump coolant hoses.
8. Reinstall the high-pressure fuel line grommets into the valve cover.
9. Reinstall the high pressure and fuel return lines. See "Installation of the Fuel Injectors" on page -194.
10. Reinstall the coolant pump. Reassembly of Engine Coolant Pump.
11. Reinstall the alternator. See "Installation of Alternator" on page -245.
12. Reconnect the air intake hose.

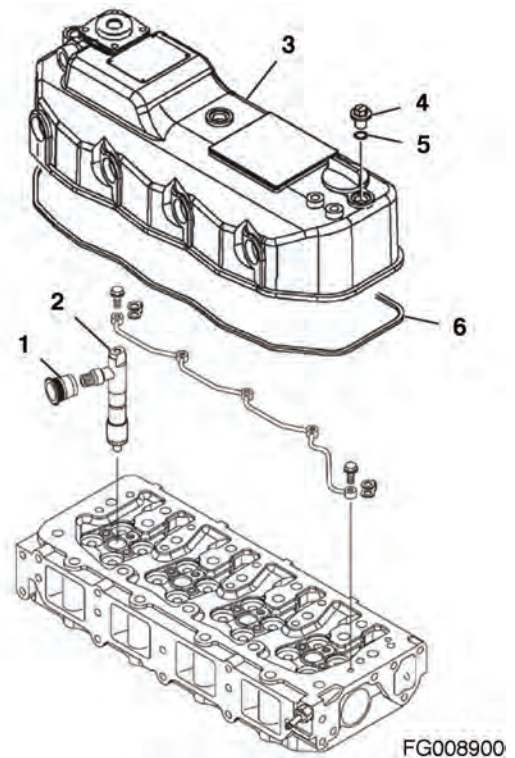


Figure 157

Measuring And Adjusting Valve Clearance

Measure and adjust while the engine is cold.

NOTE: The No. 1 piston position is on the flywheel end of the engine, opposite the radiator. The firing order is 1-3-2 for 3-cylinder engines and 1-3-4-2 for 4-cylinder engines.

3-cylinder engines fire every 240° of crankshaft rotation.

4-cylinder engines fire every 180° of crankshaft rotation.

Valve clearance of both the intake and exhaust valves can be checked with the piston for that cylinder at top dead center (TDC) of the compression stroke. When a piston is at TDC of the compression stroke, both rocker arms will be loose and the cylinder TDC mark on the flywheel will be visible in the timing port of the flywheel housing.

If there is no valve clearance, and the cylinder is at TDC of the compression stroke, extreme wear, or damage to the cylinder head or valves may be possible.

If adjusting each cylinder individually, the cylinder to be adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is nearest to the top deadcenter after turning. Make adjustment for the remaining cylinders in the order of firing by turning the crankshaft each time.

To decrease the number of rotations required to check all cylinders, other cylinders can also be checked as indicated in the chart below.

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

3-Cylinder Engines

Cylinder No.	1		2		3	
Valve	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
No. 1 Cylinder at TDC Compression	o	o	o			o
No. 1 Cylinder at TDC Exhaust				o	o	

4-Cylinder Engines

Cylinder No.	1		2		3		4	
Valve	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
No. 1 Cylinder at TDC Compression	o	o	o			o		
No. 4 Cylinder at TDC Compression				o	o		o	o

4-Valve Cylinder Heads

The 4-valve cylinder head operates two valves with a single rocker arm by employing a valve bridge (1, Figure 158) between the two valves (2, Figure 158). Clearance (4, Figure 158) between the valve bridge and valves must be set before adjusting the clearance (5, Figure 158) between the rocker arm (3, Figure 158) and valve bridge.

1. Remove the valve cover.

NOTE: *If adjusting each cylinder individually, the cylinder to be adjusted first does not have to be the No. 1 cylinder. Select and adjust the cylinder where the piston is nearest to the top dead center after turning, and make adjustment for other cylinders in the order of firing by turning the crankshaft 180° each time.*

2. Rotate the crankshaft clockwise as seen from the coolant pump end, to bring No. 1 piston to TDC on the compression stroke while watching the rocker arm motion and the timing grid on the flywheel. (Position where both the intake and exhaust valves are closed.)
3. Make sure there is clearance (5, Figure 158) between the valve bridge (1, Figure 158) and the rocker arm (3, Figure 158).

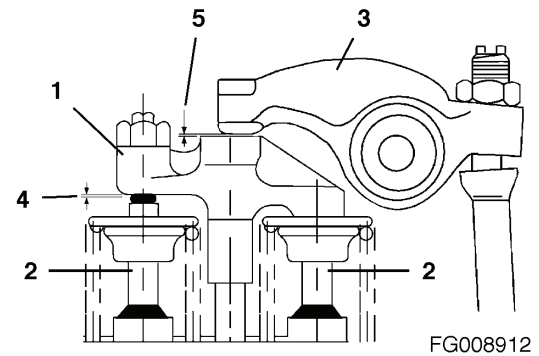


Figure 158

IMPORTANT

Do not loosen or tighten the valve adjusting screw lock nut without holding the valve bridge. Always hold the valve bridge using a wrench to prevent bending of the valve stems.

4. Loosen the valve bridge adjusting screw lock nut (1, Figure 159) while holding the bridge (3, Figure 159) with a wrench (2, Figure 159).

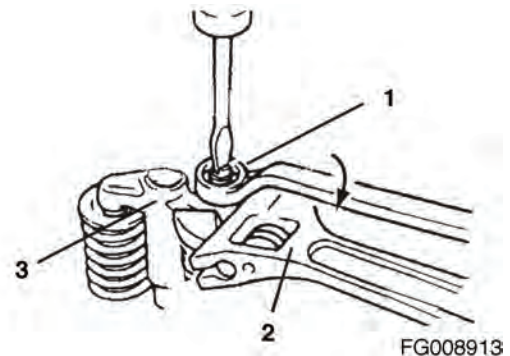


Figure 159

5. To assure the valve bridge contacts the rear valve, apply light, downward (4, Figure 160) finger pressure on the valve bridge (3, Figure 160), and loosen the valve bridge adjusting screw (1, Figure 160), until there is visible clearance (2, Figure 162) between the adjusting screw and the front valve.
6. To assure the valve bridge has equal contact with the front and rear valves, apply light downward (4, Figure 160) pressure on the valve bridge (3, Figure 160), adjust the valve bridge adjusting screw ((1, Figure 160), (1, Figure 162)) so there is zero "0" clearance (2, Figure 162) between the adjusting screw and the front valve.
7. Tighten the lock nut (1, Figure 161), while holding the valve bridge (3, Figure 161) with a wrench (2, Figure 161). Verify that the valve clearance (2, Figure 162) is zero "0".

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

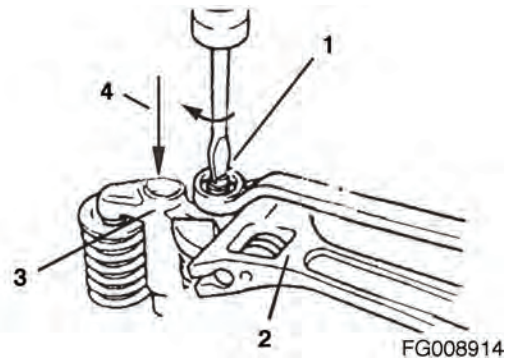


Figure 160

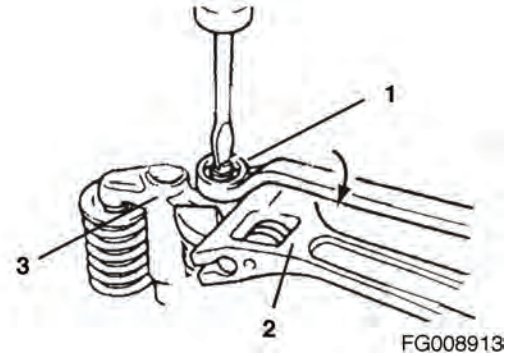


Figure 161

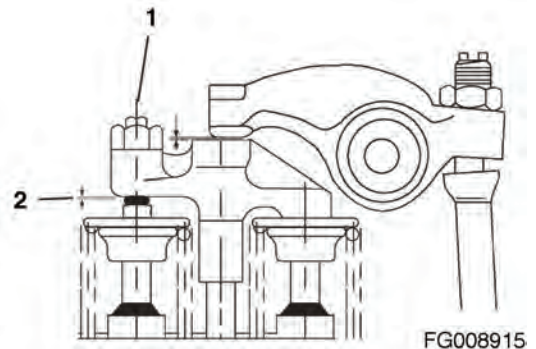


Figure 162

8. To adjust the actual valve clearance between the rocker arm and the valve bridge, insert a feeler gauge (1, Figure 163) of the correct thickness (See "Adjustment Specifications" on page -95.) between the rocker arm (2, Figure 163) and valve bridge (3, Figure 163). Record the results and use this value as an indication of wear.
9. If adjustment is required, proceed to the next step.

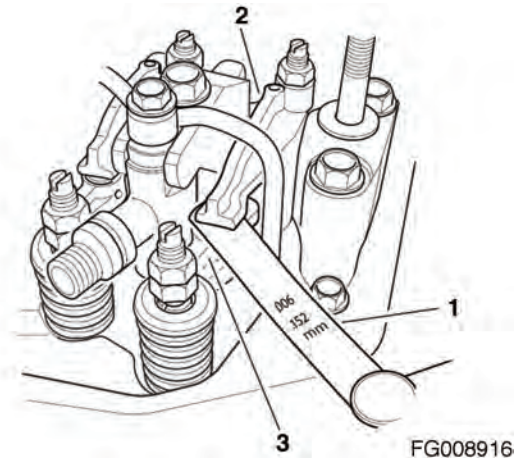


Figure 163

10. Loosen the valve adjusting screw lock nut (5, Figure 164) and valve adjusting screw (4, Figure 164) on the rocker arm (3, Figure 164) and check the clearance gap (2, Figure 164) for evidence of dirt or wear.

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

11. Adjust the valve clearance (2, Figure 164) by turning the adjusting screw (4, Figure 164) until there is a slight "drag" on the feeler gauge when sliding it between the rocker arm and the valve bridge.
12. Hold the adjusting screw (4, Figure 164) while tightening the valve adjusting screw lock nut (5, Figure 164). Recheck the clearance.
13. Apply oil to the contact surface between the adjusting screw and push rod.
14. Rotate the crankshaft to measure and adjust the set of valves. Continue until all valves are measured and adjusted.

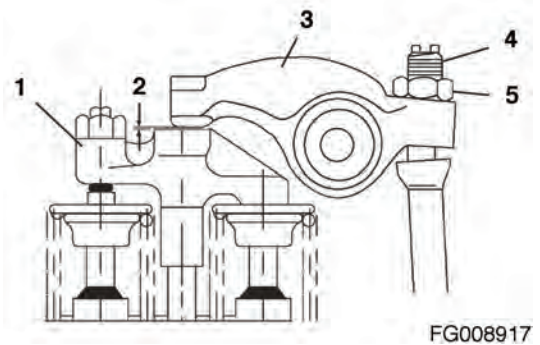
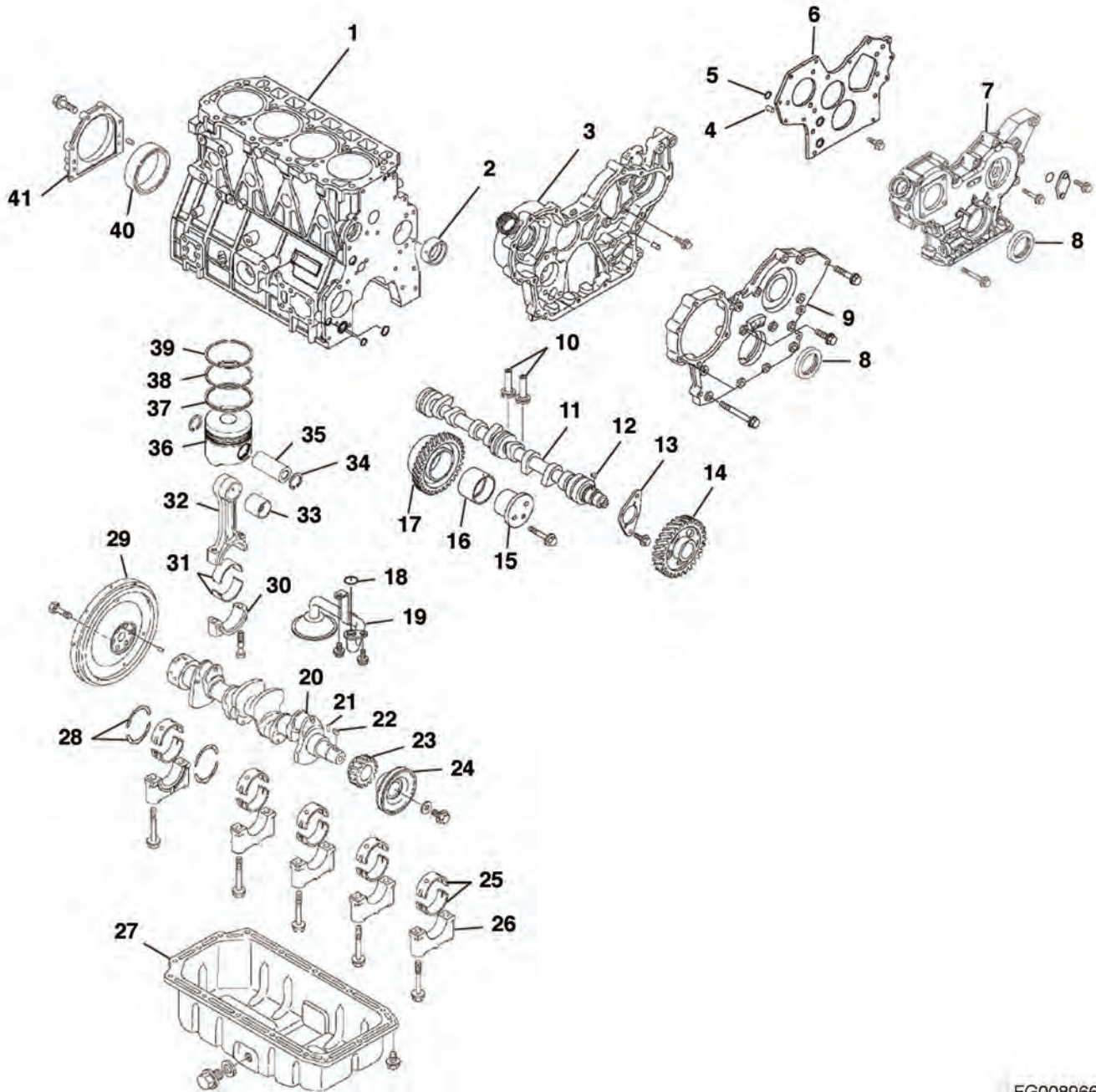


Figure 164

Crankshaft And Camshaft Components



FG008966

Figure 165

Reference Number	Description
1	Cylinder Block
2	Camshaft Bushing
3	Gear Case (4TNV98-E)
4	Dowel (2 used)
5	O-Ring
6	Front Plate (N/A)
7	Gear Case Cover (N/A)
8	Front Crankshaft Seal
9	Gear Case Cover (4TNV98-E)
10	Tappets
11	Camshaft
12	Camshaft Gear Key
13	Camshaft End Plate
14	Camshaft Gear
15	Idler Gear Shaft
16	Idler Gear Bushing
17	Idler Gear
18	Oil Pickup O-Ring
19	Oil Pickup
20	Crankshaft
21	Parallel Pin

Reference Number	Description
22	Crankshaft Gear Key
23	Crankshaft Gear
24	Crankshaft Pulley
25	Main Bearing Inserts
26	Main Bearing Cap
27	Oil Pan
28	Thrust Bearings
29	Flywheel
30	Connecting Rod Cap
31	Connecting Rod Bearing Inserts
32	Connecting Rod
33	Wrist Pin Bushing
34	Circlip
35	Wrist Pin
36	Piston
37	Oil Ring
38	Second Compression Ring
39	Top Compression Ring
40	Crankshaft Rear Seal
41	Crankshaft Rear Seal Housing

Disassembly of Engine

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



CAUTION

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

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

1. Disconnect the battery cables at the battery. Always disconnect the negative (-) cable first.
2. Remove the throttle cable, electrical connections, intake and exhaust system connections, and fuel supply lines from the engine.
3. Remove the alternator. See "Removal of Alternator" on page -240.
4. Drain the engine coolant from the radiator and cylinder block. See "Drain, Flush and Refill Cooling System With New Coolant" on page -89. Remove the cooling system components from the engine.
5. Remove the engine from the machine. Mount the engine to a suitable engine repair stand having adequate weight capacity.



CAUTION

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

6. Clean the engine by washing with solvent, air or steam cleaning. Carefully operate so as to prevent any foreign matter or fluids from entering the engine or any fuel system or electrical components remaining on the engine.
7. Drain the engine oil into a suitable container. Remove the oil filter.
8. Remove the cylinder head. page -106
9. Remove the fuel injection pump from the gear case / front plate only if it must be sent out for repair, or will interfere with other procedures such as "hot tank" cleaning. If the fuel injection pump does not need to be repaired, leaving it mounted to the timing gear case or plate will eliminate the need to re-time it during reassembly. See "Fuel Injection Pump" on page -176.
10. Remove the starter motor. See "Starter Motor" on page -218.

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.

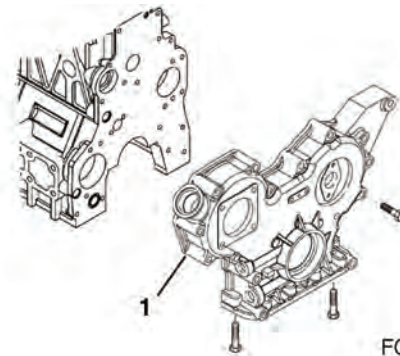
Removal of Timing Gear Case Cover

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 166).



FG008911

Figure 166

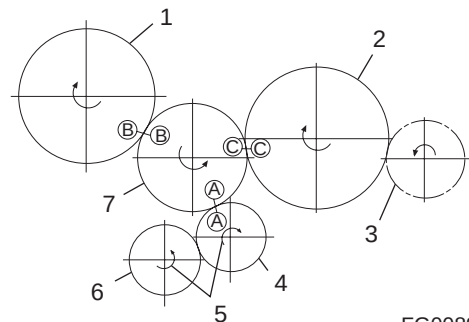
Checking Timing Gear Backlash

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 167). 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



FG008920

Figure 167

Measuring Idler Gear-to-Crankshaft Gear Backlash

1. Install a dial indicator as shown in Figure 168.
2. Rotate the idler gear back and forth to check the idler gear-to-crankshaft gear backlash. The total indicator reading is the backlash. Record the measurement.

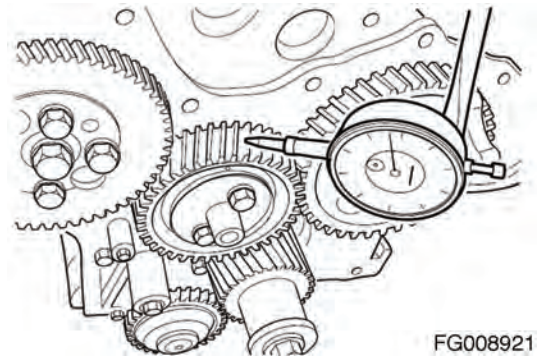


Figure 168

Measuring Idler Gear-to-Camshaft Gear Backlash

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

Removal of Timing Gears

1. Remove the bolts from the idler gear shaft (1, Figure 169). Remove the idler gear shaft, idler gear (2, Figure 169) and bushing (3, Figure 169).
2. Do not remove the crankshaft gear unless it is damaged and requires replacement. If the gear must be removed, remove it using a gear puller.
3. Removal of the camshaft gear requires the camshaft be removed and placed in a press. Do not remove the camshaft gear unless it or the camshaft is damaged and requires replacement. See "Removal of Camshaft" on page -133.

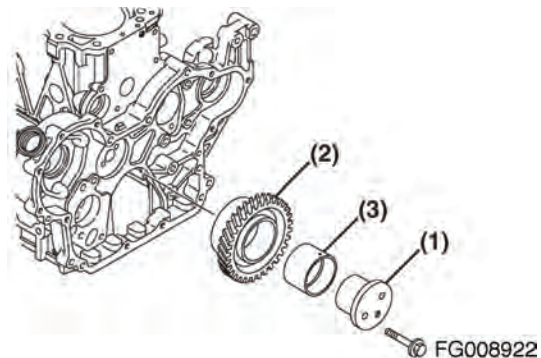


Figure 169

CAUTION

Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.

4. Do not remove the fuel injection pump drive gear unless absolutely necessary to avoid damage to the gear or pump. Do not loosen or remove the four bolts (3, Figure 170) retaining the pump drive gear to the hub. Only remove the nut (1, Figure 170) and washer (2, Figure 170), leaving the hub attached to the gear. Remove the pump drive gear and hub as an assembly using a gear puller.

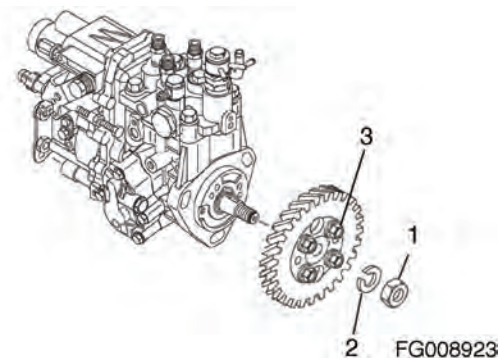


Figure 170

Removal of Oil Pan

1. Invert the engine (oil pan up) on the engine stand.
2. Remove the oil pan (1, Figure 171).

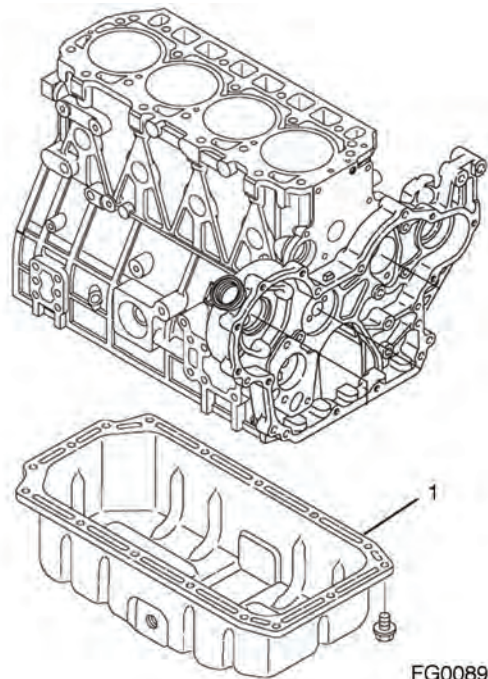


Figure 171

FG008924

3. Remove the oil pickup tube (1, Figure 172) and O-ring (2, Figure 172).

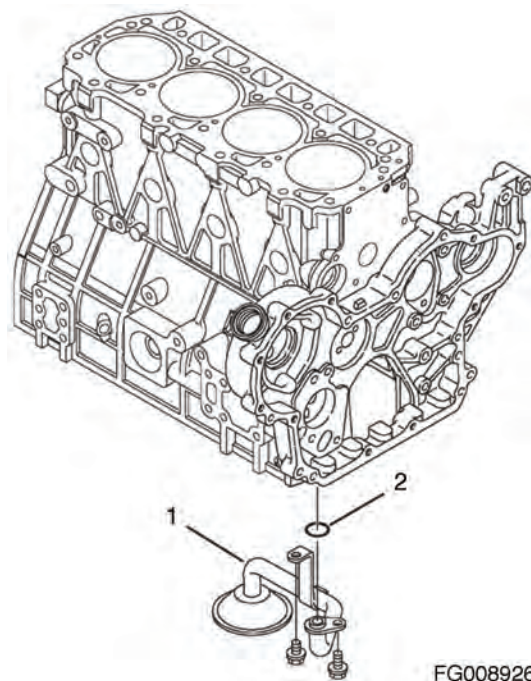


Figure 172

FG008926

Removal of Camshaft

1. Before removing the camshaft, check the camshaft end play.

- Method A: Install a dial indicator (1, Figure 173) on the cylinder block. Move the camshaft (2, Figure 173) back and forth to measure the end play. Record the measurement. See "Camshaft" on page -97. for the service limit.

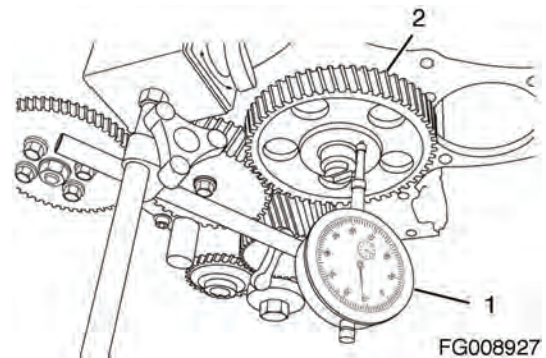


Figure 173

- Method B: Use a feeler gauge to measure the clearance between the thrust plate (1, Figure 174) and front camshaft bearing (2, Figure 174). See "Thrust Bearing" on page -98. for the service limit.

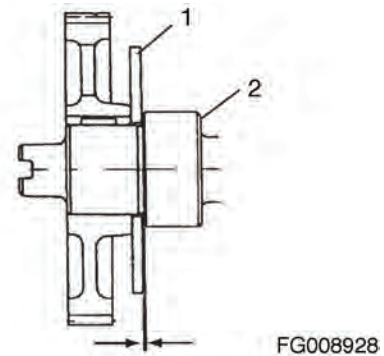


Figure 174

2. Remove the two bolts (3, Figure 175) retaining the camshaft thrust plate (1, Figure 175).
3. Rotate the engine in the engine stand so that gravity causes the tappets (5, Figure 175) to drop away from the camshaft lobes.

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

4. Slowly pull the camshaft (2, Figure 175) assembly out of the engine being careful not to damage the front camshaft bushing.

NOTE: If the engine is not installed on an engine repair fixture, stand the engine upright on the flywheel end mounting flange. Rotate the camshaft at least two turns to bump the tappets out of the way to prevent the tappets from interfering with the removal of the camshaft.

NOTE: The tappets are "mushroom" shaped and must be removed from inside the engine crankcase.

5. Remove the tappets. Mark the tappets so they can be reinstalled in the same location.
6. Remove the camshaft drive gear (4, Figure 175) only if the gear or camshaft require replacement. Use a knife-edge puller and a press to remove the gear. The gear is a shrink-fit and will need to be heated to 356° - 392°F (180° - 200°C) to remove.

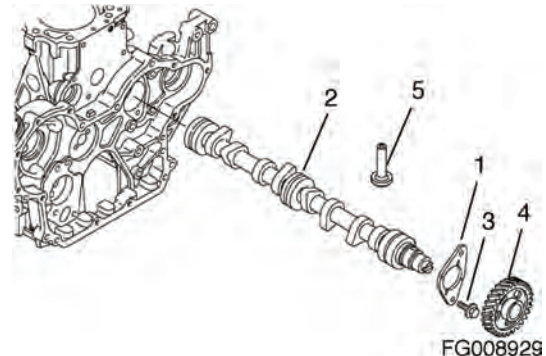


Figure 175

Removal of Gear Case or Front Plate

Note: The camshaft must be removed before the gear case / front plate can be removed. See "Inspection of Camshaft" on page -144.

1. Remove the oil pump.

NOTE: *It is not necessary to remove the fuel injection pump from the gear case / front plate to remove the gear case / front plate. If the fuel injection pump does not need to be repaired, leaving it mounted to the timing gear case / front plate will eliminate the need to re-time it during assembly. See "Fuel Injection Pump" on page -176.*

2. Remove the bolts (4, Figure 176).
3. Remove the gear case (1, Figure 176) or front plate from the cylinder block. Thoroughly clean all old sealant from the mating surfaces.
4. Inspect and measure the camshaft bushing. See "Camshaft" on page -97. for the service limit. If damaged or worn beyond service limits, remove the camshaft bushing (3, Figure 176).
5. Remove two O-rings (2, Figure 176).

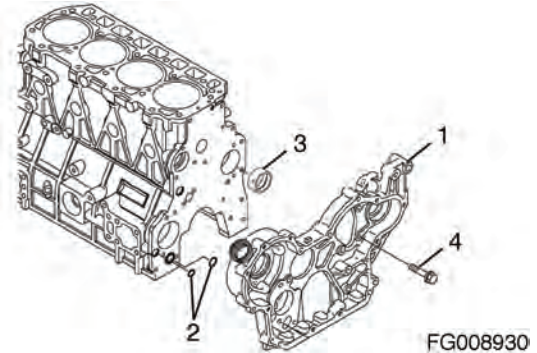


Figure 176

Disassembly of Crankshaft and Piston Components

Removal of Pistons



CAUTION

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

IMPORTANT

Engines with high operating hours may have a ridge near the top of the cylinders that will catch the piston rings and make it impossible to remove the pistons. Use a suitable ridge reamer to remove ridges and carbon prior to removing the pistons.

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

1. Using a feeler gauge, measure the connecting rod side clearance as shown (Figure 177). See "Connecting Rod Big End" on page -99. for the standard limit. If the measurement is out of specification, replace the crankshaft, connecting rod, or both.
2. Measure bearing oil clearance prior to removing the pistons and connecting rods to determine extent of wear. Record the measurements.



FG008336

Figure 177

IMPORTANT

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

- A. Remove the bearing cap. Do not remove the bearing inserts at this time.
- B. Wipe oil from the bearing insert and crankshaft journal surfaces.

- C. Place a piece of PLASTIGAGE (1, Figure 178) along the full width of the bearing insert.

IMPORTANT

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

- D. Reinstall bearing cap and tighten to specification. See "Torque for Bolts and Nuts" on page -101.
- E. Remove bearing cap.
- F. Compare the width of the flattened PLASTIGAGE to the graduation marks on the package (Figure 179, 1). The mark that most closely matches the width of the flattened PLASTIGAGE will indicate the bearing oil clearance.
- G. Repeat with remaining connecting rods.

IMPORTANT

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

3. Use a wooden dowel against the connecting rod and tap the piston / connecting rod assembly out of the cylinder.
4. Mark the cylinder number on the piston and connecting rod.
5. Remove the bearing inserts (2, Figure 180).
6. Remove the compression rings (3, Figure 180) from the piston using a piston ring expander.
7. Remove the oil ring (4, Figure 180) from the piston using a piston ring expander.
8. Remove the circlips (5, Figure 180) from the wrist pin.
9. Remove the wrist pin (6, Figure 180) and connecting rod (8, Figure 180) from the piston (9, Figure 180).
10. Repeat the steps until all pistons are removed and disassembled.

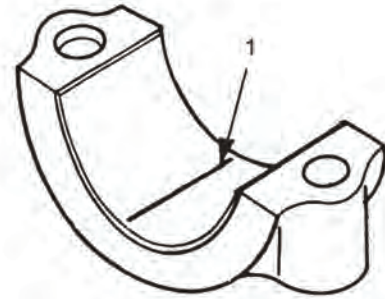


Figure 178

FG008932

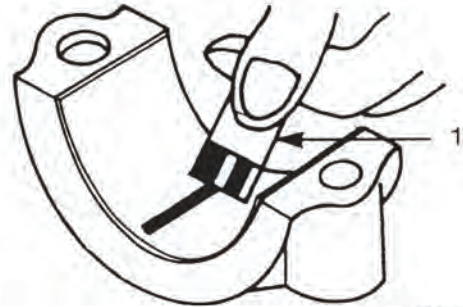


Figure 179

FG008933

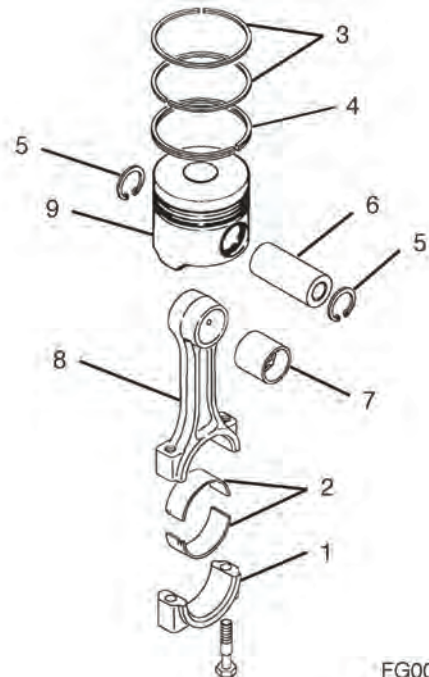


Figure 180

FG008934

Removal of Crankshaft

1. Remove the flywheel (1, Figure 181) from the crankshaft.
2. Remove the bolts from the rear oil seal assembly (2, 3, Figure 181). Remove the assembly from the engine.
3. Before removing the main bearing caps, measure the crankshaft end play. Use either of the following two methods.

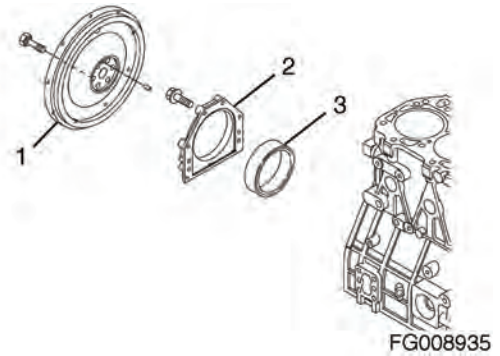


Figure 181

- Method A: Install a dial gauge (1, Figure 182) on the cylinder block. Move the crankshaft (2, Figure 182) in and out to measure the end play. Record the measurement.

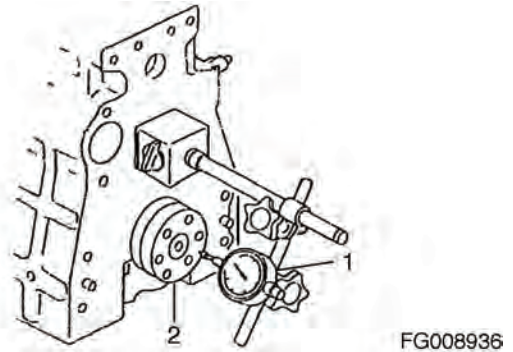


Figure 182

- Method B: Use a feeler gauge to measure the clearance (3, Figure 183) between the thrust bearing (1, Figure 183) and crankshaft (2, Figure 183). Record the measurement. See "Thrust Bearing" on page -98. for the service limit.

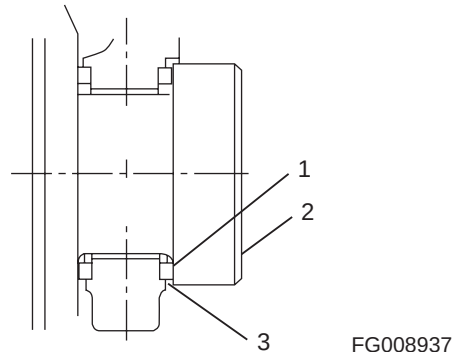


Figure 183

4. Remove the main bearing caps (3, Figure 184). Be sure to note the markings on the main bearing caps, or mark them yourself, so they can be reinstalled in the same order as they were removed. Do not remove the bearing inserts at this time.

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

5. Measure bearing oil clearance prior to removing the crankshaft to determine extent of wear. Record the measurements.

A. Wipe oil from the bearing insert and crankshaft journal surfaces.

B. Place a piece of PLASTIGAGE (1, Figure 185) along the full width of each bearing insert.

IMPORTANT

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

C. Reinstall bearing caps and tighten to specification. See "Special Torque Chart" on page -101.

D. Remove bearing caps.

E. Compare the width of the flattened PLASTIGAGE to the graduation marks on the package (1, Figure 186). The mark that most closely matches the width of the flattened PLASTIGAGE will indicate the bearing oil clearance.

6. Remove the crankshaft from the engine.

7. Remove the bearing inserts (1, Figure 184) and thrust bearings (2, Figure 184).

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

8. If necessary, remove the crankshaft gear (1, Figure 187), parallel pin (2, Figure 187) and key (3, Figure 187). If using a gear puller, be careful not to damage the threads in the end of the crankshaft.

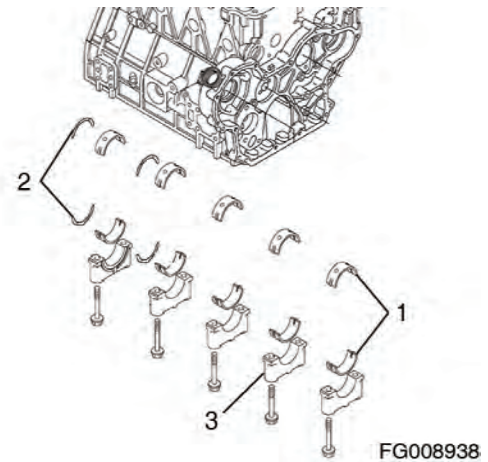


Figure 184

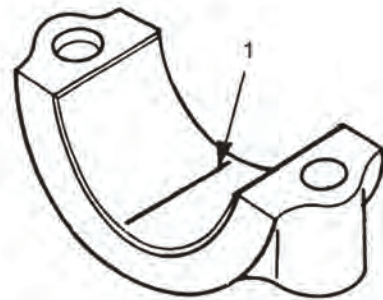


Figure 185

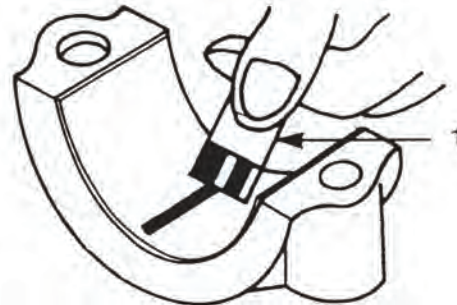


Figure 186

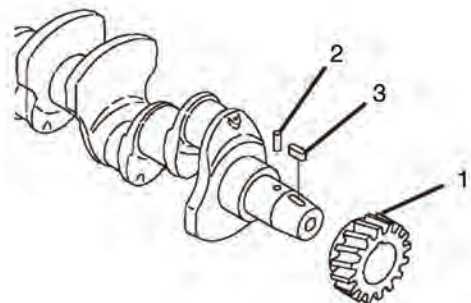


Figure 187

Inspection of Crankshaft and Camshaft Components



WARNING

Fume / Burn Hazard!

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

Failure to comply could result in death or serious injury.

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

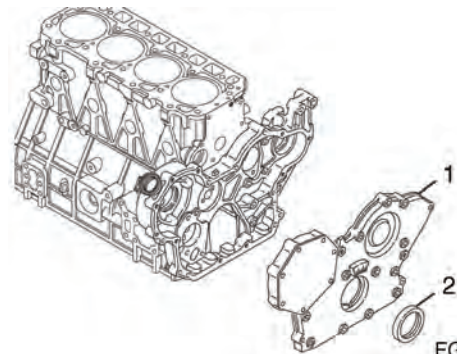


FG009153

Figure 188

Replacement of Crankshaft Oil Seals

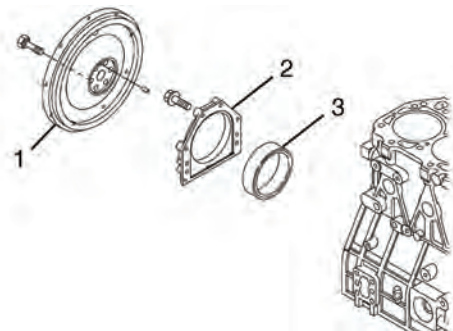
1. Remove the seal (2, Figure 189) from the cover (1, Figure 189).
2. Apply a continuous bead of ThreeBond Liquid Gasket to the outside diameter of a new oil seal (2, Figure 189), and install in the gear case cover. Apply lithium grease to the lip of the seal.



FG008940

Figure 189

3. Remove the rear oil seal (3, Figure 190) from the seal housing (2, Figure 190).
4. Apply a continuous bead of ThreeBond Liquid Gasket to the outside diameter of a new oil seal (2, Figure 190), and install in the housing. Apply lithium grease to the lip of the seal.



FG008935

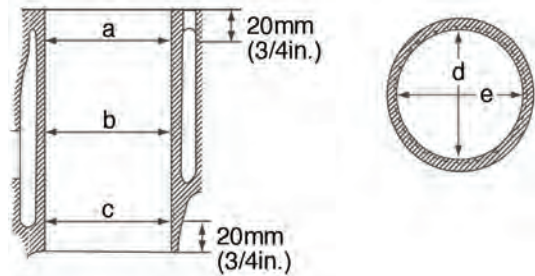
Figure 190

Measure Crankshaft Bearing Oil Clearance

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

Inspection of Cylinder Block

1. Ensure that oil passages are clear and unobstructed.
2. Check for discoloration or evidence of cracks. If a fracture is suspected, use the color check method or the Magnaflux method to determine if the cylinder block is fractured.
3. Inspect cylinders for roundness, taper, or evidence of scoring. Collect and record the measurements. Consider honing, reboring or replacing the cylinder block if the measurements are not within specification.
 - Take measurements at three places (Figure 191) (a, b, c), and in two directions (d and e) in each cylinder.



FG008941

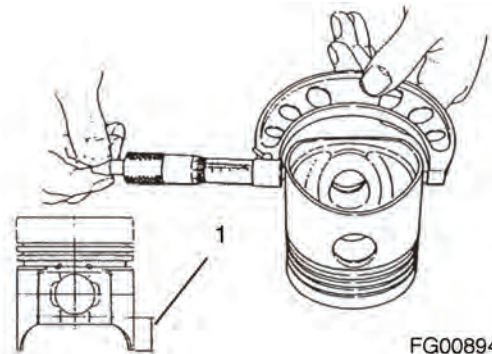
Figure 191

Inspection of Pistons, Piston Rings and Wrist Pin

NOTE: *On an engine with low hours, the pistons, piston rings may be reused if they are found to be within specifications. The pistons and piston rings must be reinstalled in the same cylinders from which they were originally removed.*

On an engine with high hours, the pistons rings should be replaced and the cylinder honed (See "Honing and Boring" on page -145.) or replaced. The piston should be replaced as necessary.

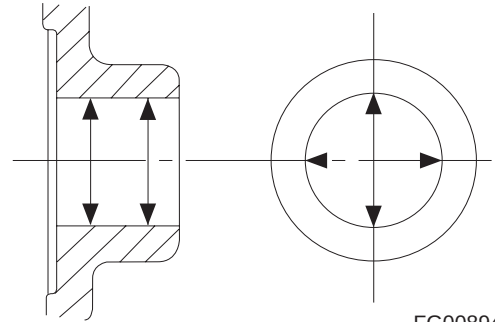
1. Clean piston ring grooves using a piston ring groove cleaning tool. Follow manufacturer's instructions for correct operation.
2. Wash the pistons in an appropriate solvent using a soft brush.
3. Visually inspect each piston for cracks. Pay particular attention to the ring lands between the piston ring grooves.
4. Measure the diameter of the piston skirt at 90° to the wrist pin bore as shown (Figure 192). Measurements must be taken at a specified distance (1, Figure 192) from the bottom of the piston, based on engine model. Record the measurements. See "Piston" on page -98. for specifications.
5. Subtract the piston measurement from the greatest measurement acquired during cylinder inspection (See "Inspection of Cylinder Block" on page -140.) to obtain piston-to-cylinder clearance. Record the measurements. See "Piston" on page -98. for specifications.



FG008942

Figure 192

6. Measure the diameter of the wrist pin bore on both sides of the piston (Figure 193). See "Piston" on page -98. for specifications. Record the measurements.

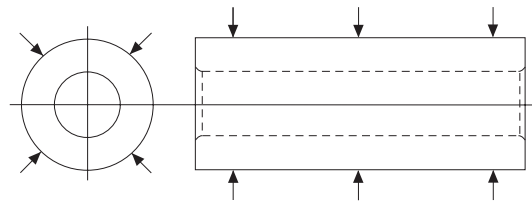


FG008944

Figure 193

7. Measure the outside diameter of the wrist pin in three places and at 90° (Figure 194). See "Piston" on page -98. for specifications. Record the measurements.
8. Using a micrometer, measure the thickness of each piston ring. See "Piston Ring" on page -99. for specifications. Record the measurements.

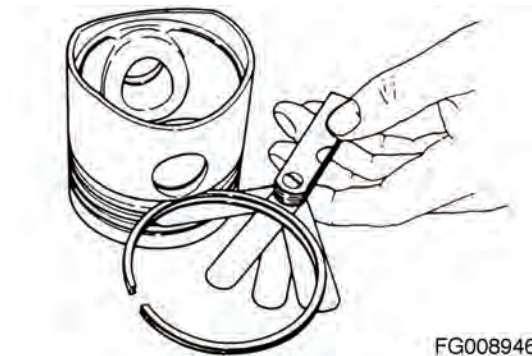
NOTE: *On an engine with low hours, the pistons, piston rings and cylinders may be reused if they are found to be within specifications.*
On an engine with high hours, the pistons rings should be replaced and the cylinder honed (See "Honing and Boring" on page -145.) or replaced.
The piston should be replaced as necessary.



FG008945

Figure 194

9. Place each compression piston ring in the groove as shown (Figure 195). Use a feeler gauge to measure the clearance between the piston ring and the piston ring land. Record the measurements. See "Piston Ring" on page -99. for specifications. Replace the piston if not within specification.

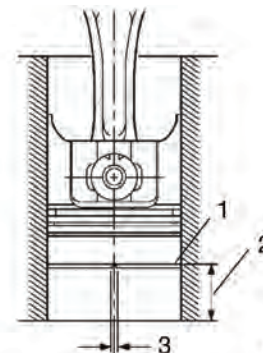


FG008946

Figure 195

10. To measure piston ring end gap, insert each compression piston ring (1, Figure 196), one at a time, into the cylinder. Use a piston with the piston rings removed to slide the ring into the cylinder bore until it is approximately 1.18 in. (30 mm) (2, Figure 196) from the bottom of the bore. Remove the piston. Measure the end gap (3, Figure 196) of each piston ring. Record the measurements. See "Piston Ring" on page -99. for specifications.

NOTE: *Always check the piston ring end gap when installing new piston rings. See "Piston Ring" on page -99. for specifications. Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.*



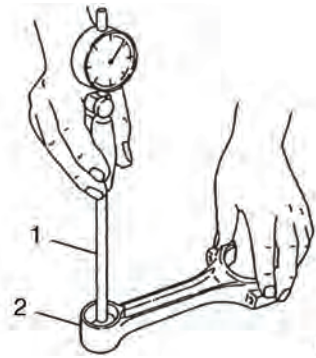
FG008947

Figure 196

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

Inspection of Connecting Rod

1. Measure the wrist pin bushing bore using a bore gauge (1, Figure 197). Replace the bushing if not within specifications. If the bushing has been removed, measure the inside diameter of the connecting rod small end (2, Figure 197). See "Connecting Rod" on page -99. for specifications.
2. Place the connecting rod bearing inserts into the connecting rod and connecting rod cap. Install the rod cap and tighten the bolts to the specified torque.
3. Measure the inside diameter. See "Crankshaft" on page -98. for specifications.

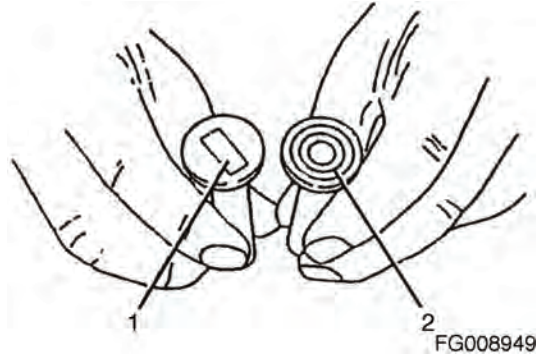


FG008948

Figure 197

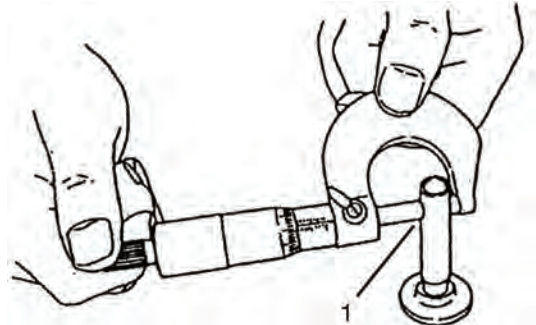
Inspection of Tappets

1. Inspect the tappet contact surfaces for abnormal wear (1, Figure 198). Normal wear will be even as shown in (2, Figure 198). Slight surface defects can be corrected using an oilstone.
2. Measure the outside diameter of the tappet stem (1, Figure 199). See "Tappet" on page -100. for the service limit.
3. Measure the tappet bores in the cylinder block. See "Tappet" on page -100. for the service limit.



FG008949

Figure 198



FG008950

Figure 199

Inspection of Crankshaft

1. Place the crankshaft end journals (4, Figure 200) on V-blocks.
2. Place a dial indicator (3, Figure 200) on a center main bearing surface.
3. Rotate the crankshaft and observe runout. See "Crankshaft" on page -98. for specifications.
4. Use the color check method or Magnaflux to inspect the crankshaft for cracks. Replace the crankshaft if evidence of fractures are found.

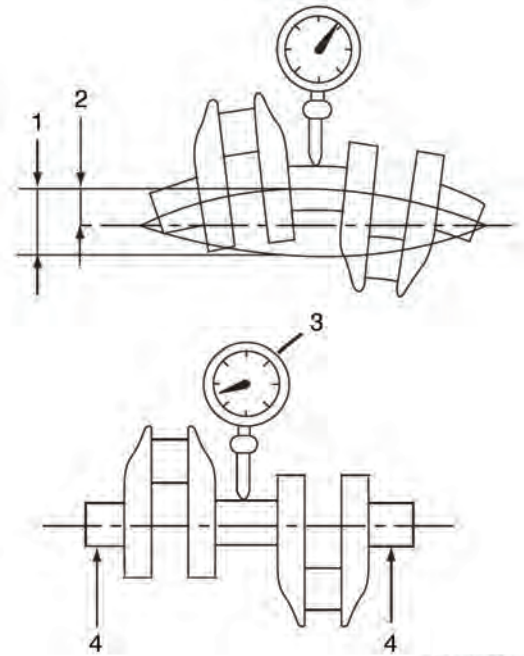


Figure 200

5. Measure the outside diameter of each crankpin (2, Figure 201) and main bearing journal (1, Figure 201). See "Crankshaft" on page -98. for specifications. Take measurements at several places around each bearing surface. If not within specification, grind the journals and install undersize bearings, or replace the crankshaft.

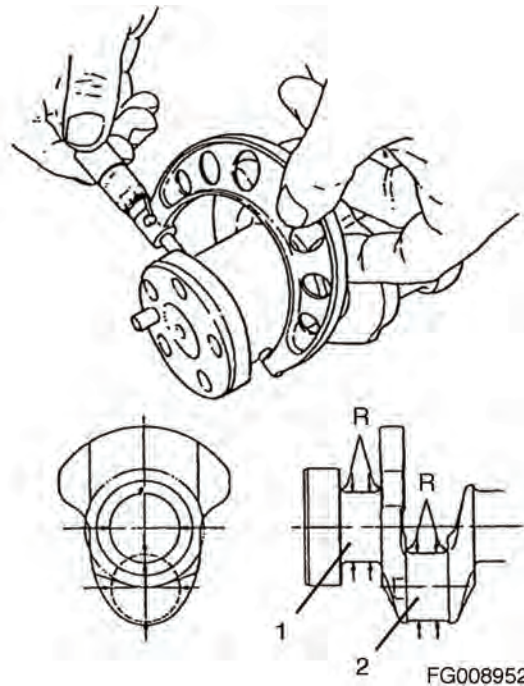
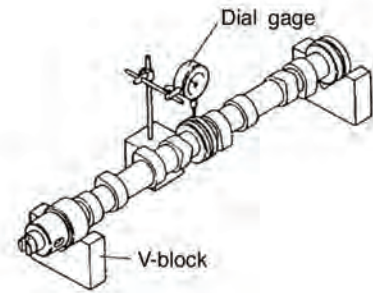


Figure 201

Inspection of Camshaft

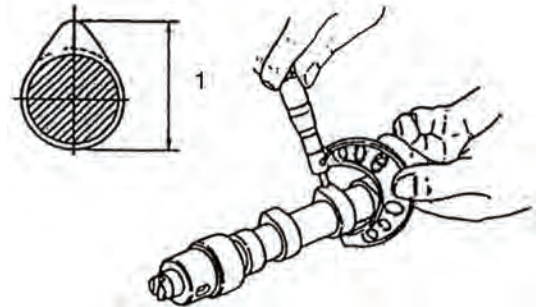
1. Use V-blocks and a dial indicator to check camshaft bend (Figure 202). Place the indicator on the center bearing journal.
2. Rotate the camshaft and observe the runout. See "Camshaft" on page -97. for specifications.



FG008332

Figure 202

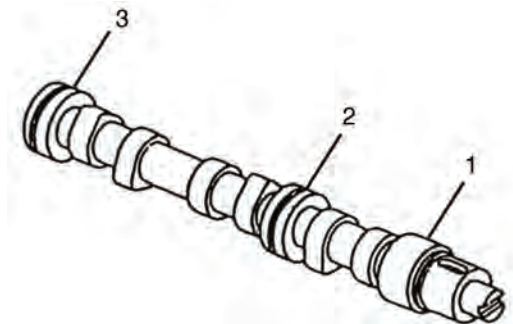
3. Measure the height of each lobe (1, Figure 203) See "Camshaft" on page -97. for specifications.



FG008953

Figure 203

4. Measure the diameter of the gear end (1, Figure 204), intermediate (2, Figure 204) and flywheel end (3, Figure 204) bearing journals. See "Camshaft" on page -97. for specifications.



FG008954

Figure 204

Inspection of Camshaft Bushing and Bores

1. Measure the I.D. of the front bushing and the remaining bores in the cylinder block. See "Camshaft" on page -97. for specifications.
2. If the camshaft bushing is not within specification, replace it using the appropriate service tool. If the remaining bores are not within specification, the cylinder block will require replacement as there are no bearing inserts used.

Inspection of Idler Gear and Shaft

1. Measure the outside diameter (1, Figure 205) of the idler gear shaft (2, Figure 205). See "Idler Gear Shaft and Bushing" on page -97. for specifications.
2. Measure the inside diameter (3, Figure 205) of the idler gear bushing (4, Figure 205) See "Idler Gear Shaft and Bushing" on page -97. for specifications.

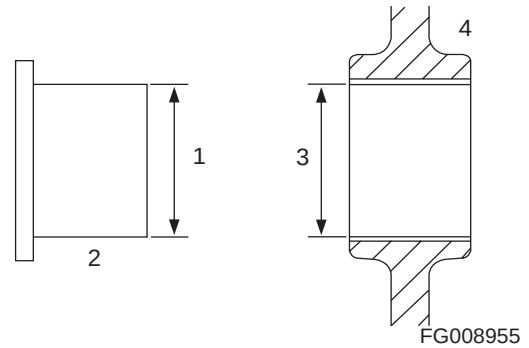


Figure 205

Honing and Boring

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

1. Boring - Significant cylinder damage may be corrected by boring the cylinder to an oversize dimension. Refer to the appropriate parts catalog for available oversize pistons and piston rings.
 - Boring a cylinder should always be done in a properly equipped machine shop.
 - A bored cylinder should always be finished with a hone to properly prepare the cylinder surface so the new piston rings will seat properly.
 - After the cylinder has been bored and honed, install the appropriate oversize pistons and piston rings.
2. Honing - Minor cylinder imperfections may be corrected by using a rigid cylinder hone (1, Figure 206). Be sure not to exceed the maximum cylinder bore specification.

Deglazing - A used cylinder that did not require boring or honing, should always be deglazed with a ball hone (2, Figure 206) before installing new piston rings. This will properly prepare the cylinder surface to allow new piston rings to seat properly.

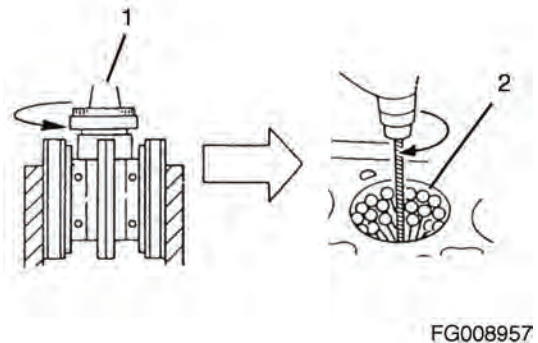


Figure 206

NOTE: When honing a cylinder, with either a ridged hone or a ball hone (1, Figure 207), move the rotating hone up and down in the cylinder bore to accomplish a 30° to 40° crosshatch pattern (Figure 207). This will provide the ideal surface for the proper seating of new piston rings.



CAUTION

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

- Use a 50:50 mixture of diesel fuel and engine oil as a honing fluid.
- Use a 300-grit hone at 300-1200 rpm (Figure 206).

IMPORTANT

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

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

Reassembly of Crankshaft and Piston Components

NOTE: Proceed slowly. Make no forced assemblies unless a pressing operation is called for. All parts must be perfectly clean and lightly lubricated when assembled.

Use new gaskets, seals and O-rings during assembly.

Liberally apply clean engine oil to all internal parts during assembly.

All fasteners should be tightened to a given torque. If a special torque is not provided in the Special Torque Chart on page 6-23, tighten to standard torque specifications. See "Tightening Torques For Standard Bolts And Nuts" on page -48.

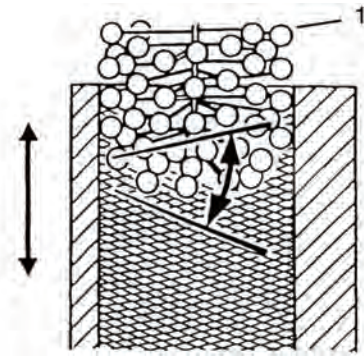


Figure 207

FG008956

Reassembly of Pistons

1. Select the parts needed to reassemble the piston and connecting rod for one cylinder.
2. If removed, install a new wrist pin bushing (7, Figure 208) using a press and the appropriate service tool. Be sure to align the oil holes.
3. Reinstall one circlip (5, Figure 208) into the piston. Ensure the circlip is securely seated in the groove.

IMPORTANT

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

Piston to Connecting Rod Orientation

Orient the piston identification mark stamped on top of the piston on the same side as the rod and cap match marks stamped on the connecting rod.

NOTE: *The actual appearance of the match marks will vary but they will always be in the same locations.*

Reference Number	Description
1	Piston Identification Mark
2	Embossed Mark on Connecting Rod
3	Rod and Cap Match Marks

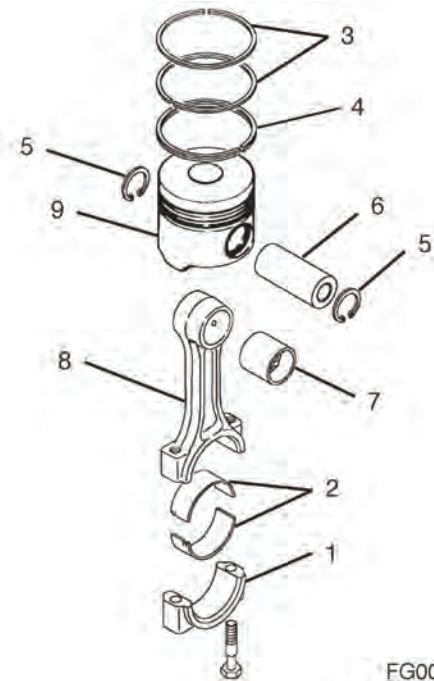


Figure 208

FG008934

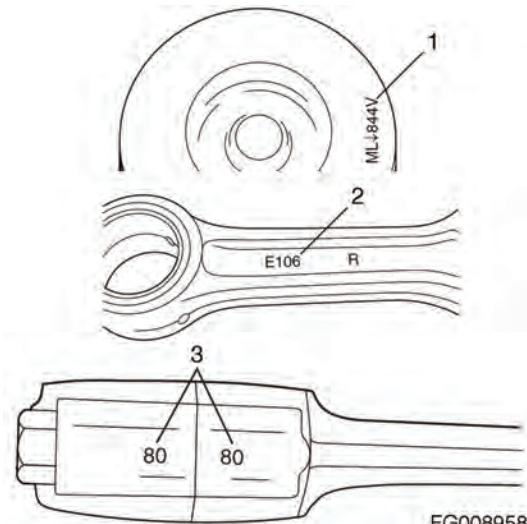


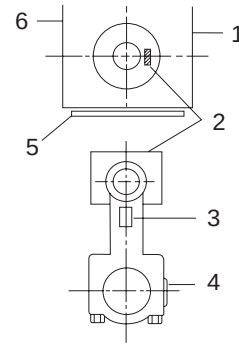
Figure 209

FG008958

Piston Assembly

When correctly assembled, the piston identification mark (2, Figure 210) stamped into the top of the piston will be on the same side of the connecting rod as the match marks (4, Figure 210) stamped into the connecting rod and connecting rod cap.

When installed in the cylinder, the piston identification mark (2, Figure 210) stamped on the top of the piston must face the fuel injection pump side (1, Figure 210) of the engine and the embossed mark on the connecting rod (3, Figure 210) must face the flywheel end (5, Figure 210) of the engine.



FG008960

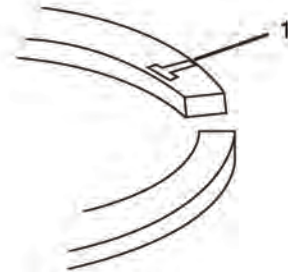
Figure 210

Reference Number	Description
1	Fuel Injection Pump Side of Engine
2	Piston Identification Mark
3	Embossed Mark on Connecting Rod
4	Rod and Cap Match Marks
5	Flywheel End of Engine
6	Camshaft Side of Engine

1. Lubricate and reinstall the wrist pin (3, Figure 208) through the piston and connecting rod.
2. Reinstall the second circlip (4, Figure 208) and ensure it is securely seated in the groove.

NOTE: If installing new piston rings the end gap must be checked and adjusted as necessary. (See page -140) for specifications. Use a piston ring end gap filing tool to adjust the piston ring end gap on new piston rings.

NOTE: Reinstall the top and second piston rings with the stamped "makers mark" (1, Figure 211) facing the top of the piston. The "makers mark" may vary in appearance but will always be located on the top surface of the piston ring adjacent to the piston ring gap. The oil ring and oil ring expander can be installed either side up.



FG008961

Figure 211

IMPORTANT

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

3. Reinstall the oil ring expander (4, Figure 212). Reinstall the oil ring (3, Figure 212) with the end gap at 180° from the expander end gap.
4. Reinstall the second compression ring (2, Figure 212). This ring is identified by its dark color and tapered face profile.
5. Reinstall the top compression ring (1, Figure 212). This ring is identified by its silver color and barrel-shaped face profile.

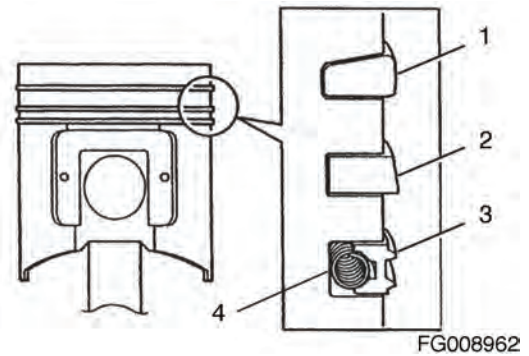


Figure 212

The oil ring expander (4, Figure 212) end gap must be located 180° from the oil ring (3, Figure 212) end gap.

6. Stagger the piston ring end gaps at 120° intervals (1, 2, 3, Figure 212)

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

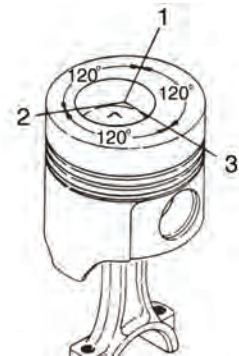


Figure 213

Installation of Crankshaft

1. If removed, reinstall the keys and timing gear on the crankshaft.
2. Reinstall new bearing inserts (1, Figure 214) and thrust bearing (2, Figure 214) in the cylinder block and main bearing caps. Apply a liberal coat of clean engine oil to the bearings and crankshaft journals.
3. Place the crankshaft into the engine.

IMPORTANT

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

4. Reinstall the main bearing caps (3, Figure 214)
5. Apply a light coat of clean engine oil to the bearing cap bolts and tighten the bolts to the specified torque in two stages (1/2 then full torque). See "Special Torque Chart" on page -101. for specifications.
6. Rotate the crankshaft to assure it turns freely.

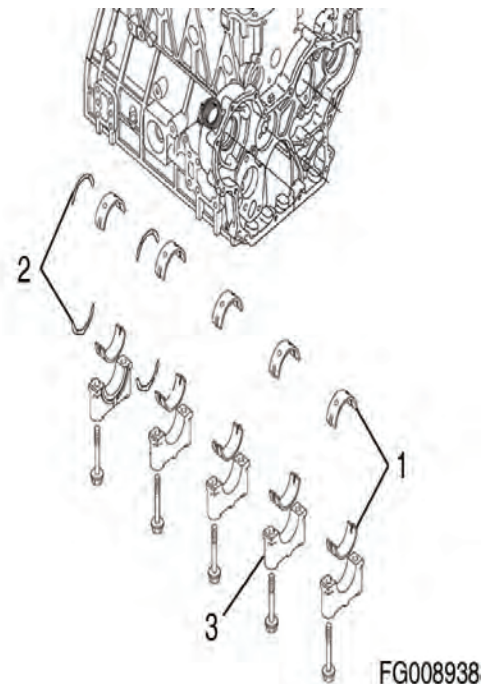


Figure 214

7. Apply threeBond Liquid Gasket to the mounting flange of the seal housing (2, Figure 215)
8. Align the seal housing with the two dowel pins.
9. Reinstall seal housing and seal assembly.
10. Reinstall the flywheel (1, Figure 215) and tighten the bolts to the specified torque. See "Special Torque Chart" on page -101. for specifications.

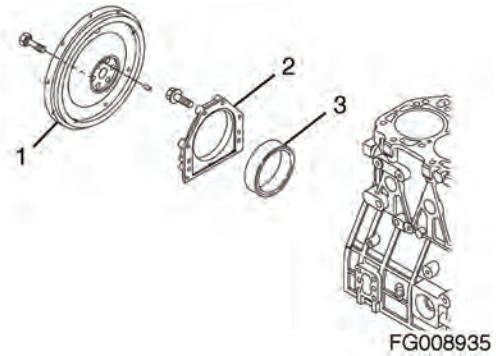


Figure 215

Installation of Pistons

IMPORTANT

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

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

IMPORTANT

Ensure the piston ring gaps are located correctly (Figure 216)

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

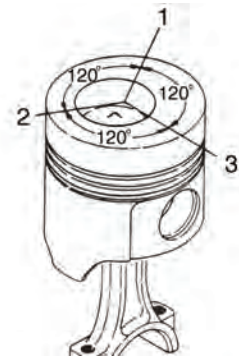


Figure 216

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

IMPORTANT

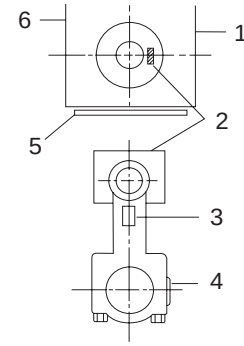
The piston and connecting rod must be installed in the correct orientation. The orientation of the piston to the cylinder is different depending on engine model.

Piston Orientation to Cylinder
Orient the piston identification mark stamped on top of the piston on the fuel injection pump side of the engine

Piston Installation

When correctly assembled, the piston identification mark (2, Figure 217) stamped into the top of the piston will be on the same side of the connecting rod as the match marks (4, Figure 217) stamped into the connecting rod and connecting rod cap.

When installed in the cylinder, the piston identification mark (2, Figure 217) stamped on the top of the piston must face the fuel injection pump side (1, Figure 217) of the engine and the embossed mark on the connecting rod (3, Figure 217) must face the flywheel end (5, Figure 217) of the engine.

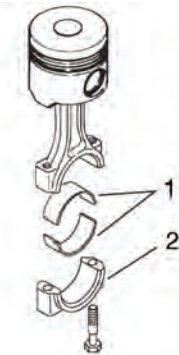


FG008960

Figure 217

Reference Number	Description
1	Fuel Injection Pump Side of Engine
2	Piston Identification Mark
3	Embossed Mark on Connecting Rod
4	Rod and Cap Match Marks
5	Flywheel End of Engine
6	Camshaft Side of Engine

- Reinstall the bearing inserts (1, Figure 218) in the connecting rod and cap.
- Apply a liberal coat of clean engine oil to the bearing inserts and crankshaft journal.
- Apply a light coat of clean engine oil to the rod cap bolts. Reinstall the connecting rod cap (2, Figure 218). Tighten the connecting rod bolts to the specified torque in two stages (1/2 then full torque). See "Special Torque Chart" on page -101. for specifications.
- Reinstall the remaining pistons in their respective cylinders.



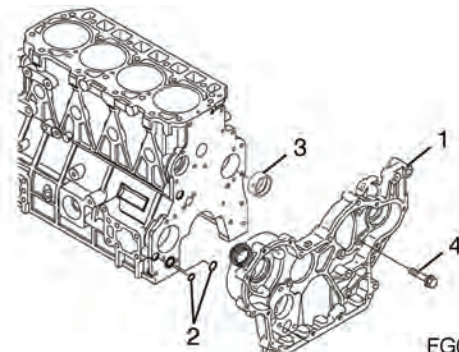
FG008964

Figure 218

Reassembly of Camshaft and Timing Components

Installation of Gear case or Front plate

- If removed, install a new camshaft bushing (3, Figure 219) using the appropriate service tool.
- Apply a continuous bead of threeBond Liquid Gasket to the mounting area of the gear case or front plate. Be sure to circle each bolt hole.
- Install two new O-rings (2, Figure 219) in the cylinder block.
- Reinstall the gear case (1, Figure 218). Tighten the bolts to the specified torque.



FG008930

Figure 219

Installation of Camshaft

NOTE: The gear housing or front plate must be reinstalled prior to installing the camshaft. See "Installation of Gear case or Front plate" on page -151.

1. If removed, reinstall the camshaft end plate (1, Figure 220), key, and timing gear (4, Figure 220) onto the camshaft using a press.

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

2. Rotate the cylinder block so that gravity will keep the tappets (5, Figure 220) in place and out of the way of the camshaft lobes when the camshaft is being reinstalled.

NOTE: If the engine is not installed on an engine repair fixture, stand the engine upright on the flywheel end mounting flange.

NOTE: The tappets are "mushroom" shaped and must be installed from inside the engine crankcase.

3. Lubricate the tappets with clean oil or assembly lube. Reinstall the tappets in their respective locations in the cylinder block. Push the tappets fully into the tappet bores so they will not interfere with the installation of the camshaft.
4. Lubricate the camshaft (2, Figure 220) with clean engine oil or assembly lube. Slowly insert the camshaft through the front of the engine.
5. Reinstall and tighten the cap screws (3, Figure 220).
6. If removed, reinstall the fuel injection pump. Adjust the fuel injection timing the engine after installation. See "Adjusting Fuel Injection Timing" on page -189.

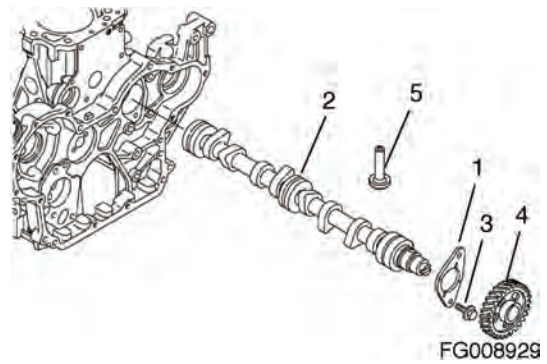
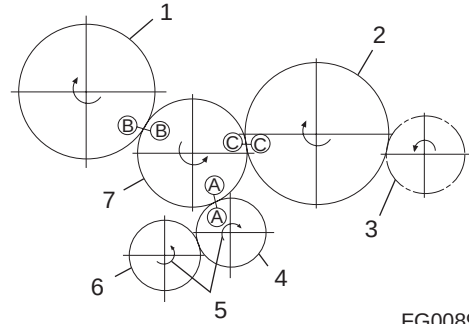


Figure 220

Installation of Timing Gears

1. Set the No. 1 piston to top dead center.
2. Rotate the camshaft until the mark (C, Figure 221) is approximately at the 9 o'clock position.

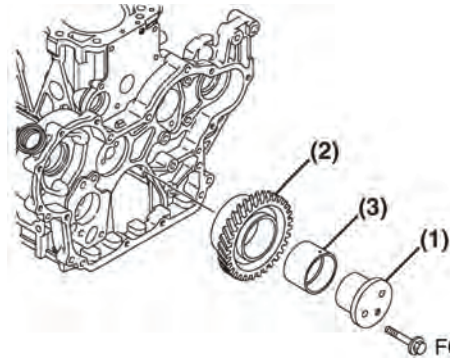
Reference Number	Description
1	Fuel Injection Pump Drive Gear
2	Camshaft Drive Gear
3	Auxiliary Drive Gear (Optional)
4	Crankshaft Drive Gear
5	Direction of Rotation
6	Oil Pump Drive Gear
7	Idler Gear



FG008920

Figure 221

3. Lubricate the idler gear (2, Figure 222), bushing (3, Figure 222) and idler gear shaft (1, Figure 222) with clean engine oil.
4. Align the timing gears as shown in (Figure 221).
5. Reinstall the idler gear and idler gear shaft. Be sure the oil hole in the bushing is facing toward the top of the engine.
6. Ensure all three timing marks (A, B, C, Figure 221) are aligned.
7. When all gears are properly aligned, tighten the idler gear retaining bolts to specified torque. See "Special Torque Chart" on page -101. for specifications.

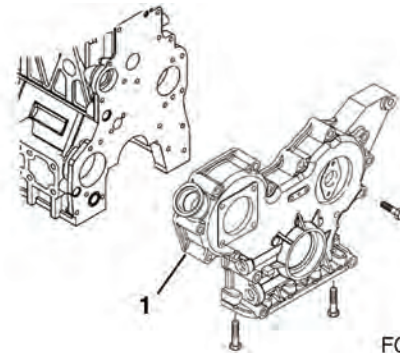


FG008922

Figure 222

Installation of Gear Case Cover

1. Apply a continuous bead of ThreeBond Liquid Gasket to the mounting area of the gear case cover (1, Figure 223). Be sure to circle the bolt holes.
2. Reinstall and tighten the gear case cover bolts.



FG008911

Figure 223

3. Reinstall the crankshaft pulley.

IMPORTANT

Use the crankshaft pulley installation tool (3, Figure 224) when reinstalling the pulley (1, Figure 224). The tool will guide the pulley hub and protect the front seal (2, Figure 224) from damage.v

4. Reinstall the washer and bolt. Tighten the bolt to the specified torque. See "Special Torque Chart" on page -101. for specifications.

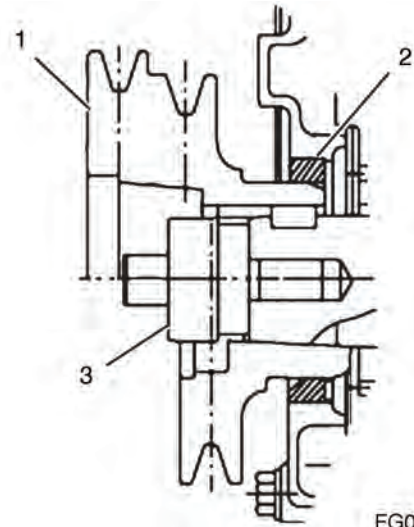


Figure 224

FG008965

Installation of Oil Pan

1. Reinstall the oil pickup tube (1, Figure 225) using a new O-ring (2, Figure 225).

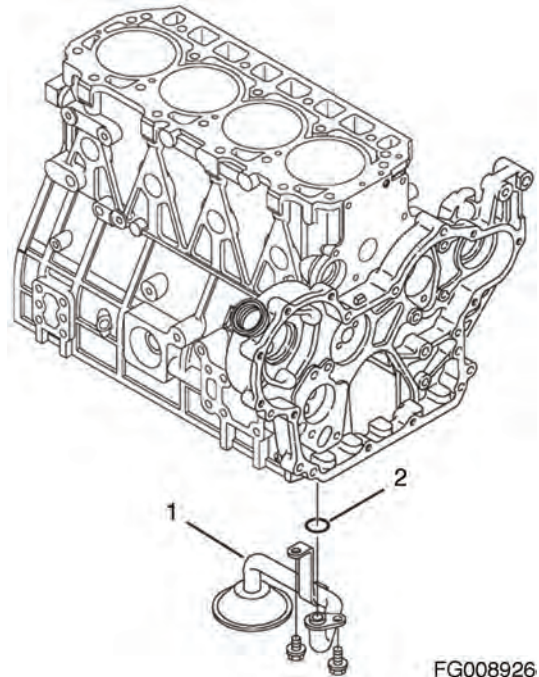


Figure 225

2. Apply a continuous bead of ThreeBond Liquid Gasket to the mounting surface of the oil pan (Figure 226, 1). Be sure to circle each bolt hole.
3. Reinstall the oil pan and tighten the bolts securely.

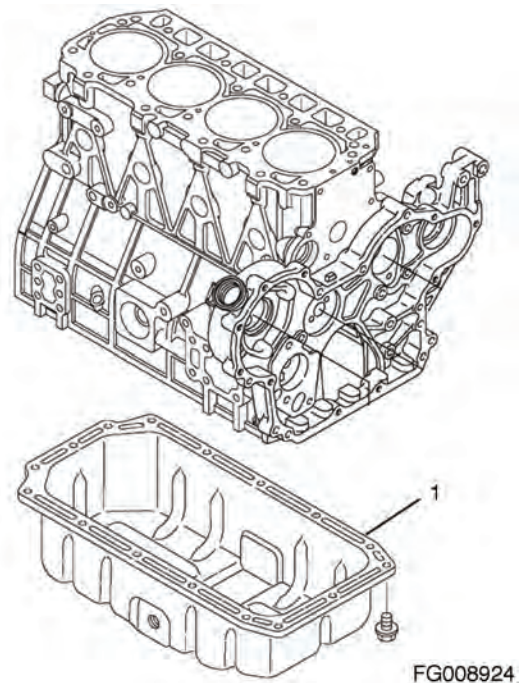


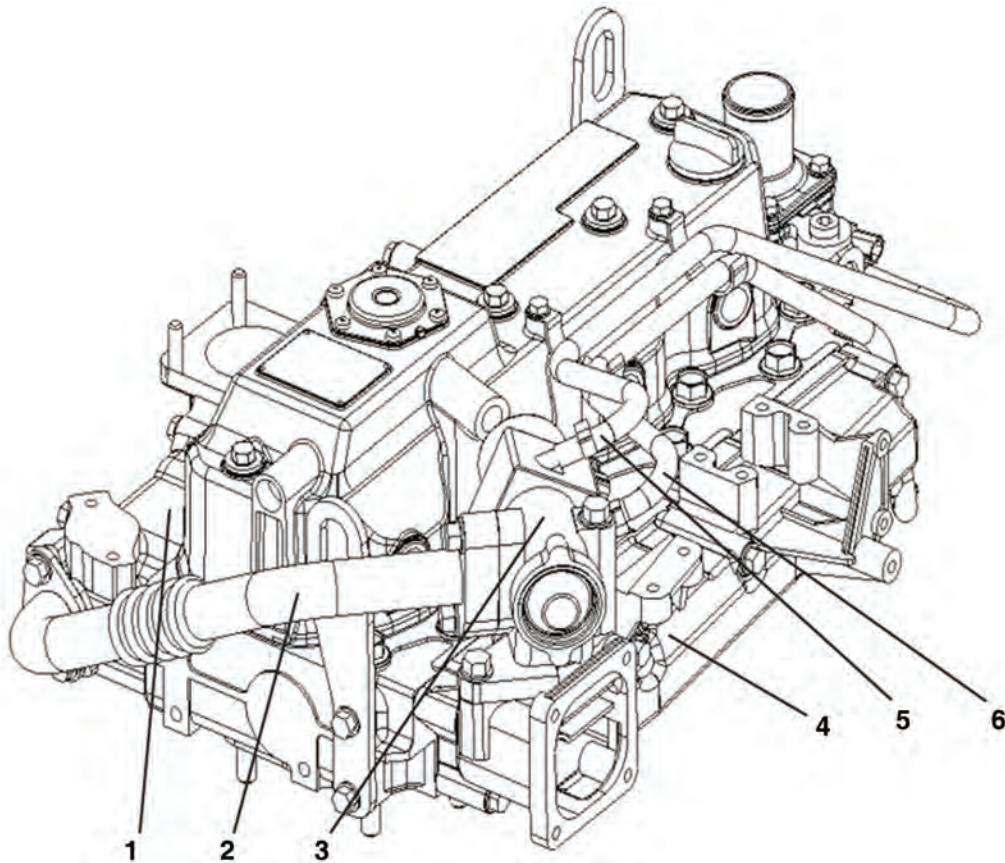
Figure 226

Final Reassembly of Engine

1. Reinstall the starter motor.
2. Reinstall the cylinder head. See "Reassembly of Cylinder Head" on page -120. for the 4-valve cylinder head.
3. Reinstall the engine in the machine.
4. Reconnect the fuel and coolant lines.
5. Reinstall the alternator.
6. Reconnect and adjust the throttle cable.
7. Reconnect all electrical connections.
8. Fill the engine with oil and coolant.
9. Reconnect the battery cables, negative (-) cable last.

EGR System

EGR System



FG012504

Figure 227

Reference Number	Description
1	Exhaust manifold
2	EGR pipe
3	EGR valve

Reference Number	Description
4	Intake manifold
5	Cooling water hose, EGR valve inlet
6	Cooling water hose, EGR valve outlet

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

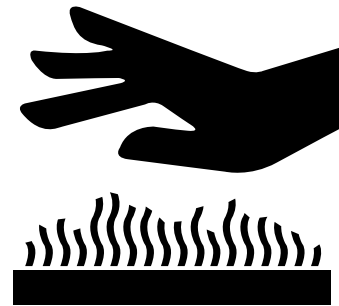
Figure 228

WARNING

Burn Hazard!

Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, 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 229

WARNING

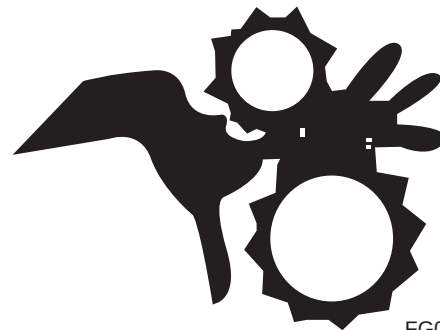
Entanglement Hazard!

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 230



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 231

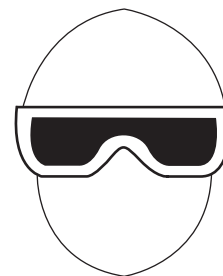


CAUTION

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 232

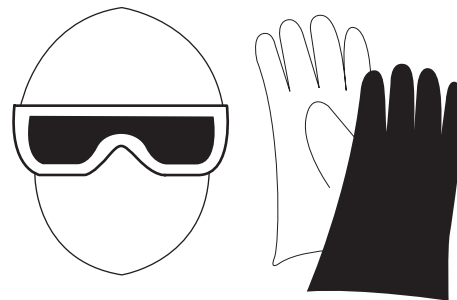


CAUTION

Coolant Hazard!

Wear eye protection and rubber gloves when you handle long life or extended life engine coolant. If contact with the eyes or skin should occur, flush eyes and wash immediately with clean water.

Failure to comply may result in minor or moderate injury.



FG009154

Figure 233



CAUTION

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



CAUTION

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

1. Drain the engine cooling water.
2. Remove the battery cable from the battery's
3. minus (-) terminal.
4. If there is any additional equipment (such as an air cleaner) installed above the EGR valves, remove it in advance.
5. Remove the EGR valve connectors.
6. Disconnect the cooling water inlet and outlet hoses from each EGR valve by loosening the hose clips. When loosening the clips, put waste cloth or the like beneath the hose joints in case water leaks.

4TNV98-E

1. Loosen the nuts in the coupling flanges of the exhaust manifold and the EGR pipe.
2. Loosen the bolts in the coupling flanges of the EGR pipe and EGR valve, and remove the EGR pipe.
3. Remove the EGR valve.

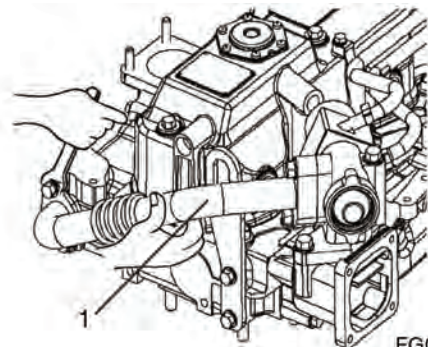


Figure 234

Inspecting/cleaning EGR related components

EGR Valve

Each EGR valve has four built-in coils. The power to each of the four coil is either ON or OFF at any given time. Depending on which coil is ON and which coil is OFF, the step motor rotates to determine the valve lift. The power to each coil is turned ON/OFF by the E-ECU based on the engine speed and fuel injection rate. The resistances of these coils should be as specified below when measured between each pair of pins shown. If any of the actually measured values is beyond the standard range, replace the entire EGR valve assembly.

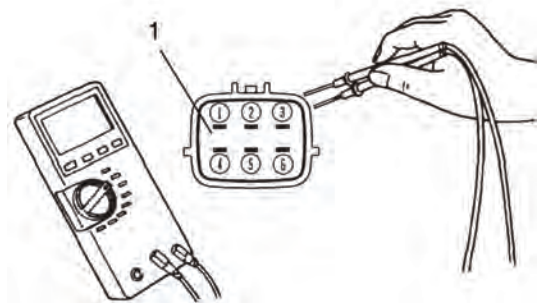


Figure 235 EGR valve connectors

Standard value	
Terminal	Resistance (Ω)
1 - 2	15 $\pm$ 2 at 20°C
2 - 3	
4 - 5	
5 - 6	

NOTE: *The higher the temperature, the higher the coil resistance. Therefore, wait for the EGR valve to return to normal state before measuring the resistances.*

EGR valve operation checks

1. After removing each EGR valve from the engine, connect the valve with the connector.
2. Connect the valve to the battery's minus (-) terminal.
3. Turn on the key switch. (Note that turning on the key switch causes the E-ECU to check whether the valve functions properly by opening and shutting it.)
4. From the exhaust gas inlet, visually check whether the valve operates correctly.

NOTE: *If the EGR valve fails to smoothly operate, replace the entire valve assembly with new one.*

NOTE: *If the EGR valve does not respond at all, check whether there exists a voltage (EGR valve signal) between the connector pins. If the voltage is within the standard range, then replace the entire valve assembly with new one.*

IMPORTANT

Alternatively, you can remove the EGR pipe from the engine and check the valve operation through the gas inlet window, instead of removing the EGR valve from the engine.

Cleaning the EGR valves



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.



Figure 236

FG009153



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.

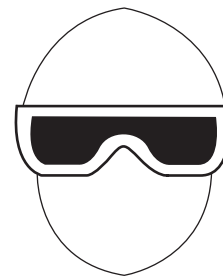


Figure 237

FG009152

The EGR valves must be periodically cleaned every 1500 hours because, as exhaust gas circulates through them for a prolonged time, carbon is deposited on their inner surfaces, possibly deteriorating the EGR ratio.

To remove deposited carbon, use compressed air (0.19MPa(2kg/cm²) or lower). If the valves are heavily fouled, use carbon cleaner, kerosene, or some other liquid capable of removing carbon as well as a soft brush to clean the valves, taking care not to damage their parts.

When cleaning the valves, take extreme care to prevent water, solvent, cleaner, and other liquid from entering into the motor and coupler terminals; otherwise, failure may result.



CAUTION

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

Precautions for installation

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

EGR pipe and other connecting elbows

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



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.

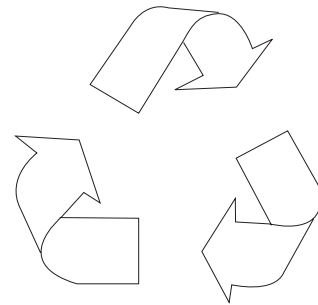
Never dispose of hazardous materials irresponsibly by dumping them into a sewer, on the ground, or into ground water or waterways.

Failure to follow these procedures may seriously harm the environment.

Installing EGR related components/parts

To install these components/parts, reverse the disassembly procedure described above: thus install the EGR valve, EGR pipe, and cooler cooling water hose, exactly in this order.

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



FG009156

Figure 238

FUEL SYSTEM

Before You Begin Servicing



WARNING

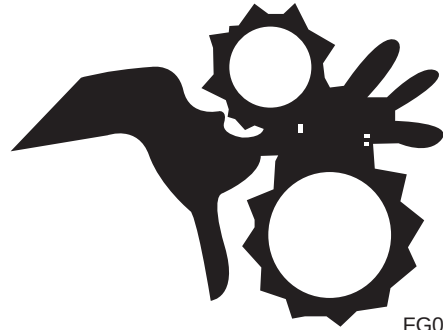
Entanglement Hazard!

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 239



WARNING

Sudden Movement Hazard!

Engaging the transmission or PTO at an elevated engine speed could result in unexpected movement of the equipment.

Failure to comply could result in death or serious injury.



WARNING

Never inject fuel toward you. Since the fuel is injected at high pressure from the nozzle, it may penetrate the skin, resulting in injury.

Never inject fuel toward a fire source. Atomized fuel is highly flammable and may cause a fire or burn skin.



WARNING

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.



Figure 240

FG009153



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.

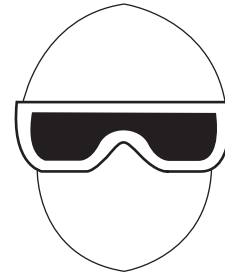


Figure 241

FG009152



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.

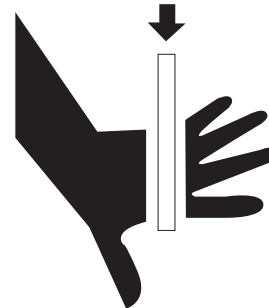


Figure 242

FG009155



CAUTION

Never remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

Never attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they can be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.



CAUTION

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



CAUTION

Allow the engine to warm-up for at least five minutes and the idle speed of the engine to return to normal before engaging the transmission or any PTOs. Engaging the transmission or PTO at an elevated engine speed could result in an unexpected movement of the equipment.



CAUTION

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



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.



CAUTION

Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.



CAUTION

Do not rotate the crankshaft with the injection pump removed.



CAUTION

Each pressure adjusting shim removed or added changes the pressure threshold by approximately 275 psi (1.9 MPa, 19 kgf/cm²). Adding adjusting shims increases the threshold pressure. Removing adjusting shims reduces the pressure threshold.

Introduction

This section of the Service Manual describes the procedures necessary to remove, install, and time the MP fuel injection pump and its associated system components. This fuel injection pump is representative of the fuel injection pumps used on other TNV DI model engines.

Fuel Injection Pump

NOTE: *If the MP fuel injection pump itself requires servicing, it must be taken to an authorized DOOSAN dealer or distributor.*



CAUTION

Never remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

Never attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they can be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.

The following describes the features of the MP fuel injection pump.

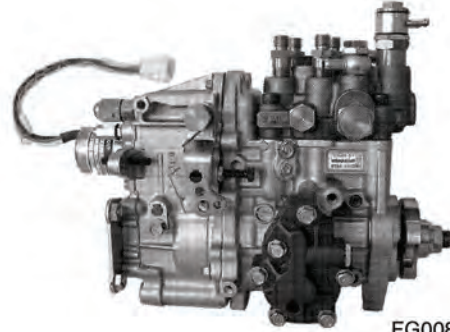
The fuel injection pump is a very important component of the engine. It is capable of making very precise fuel delivery adjustments according to the varied loads applied to the engine.

All of the fuel injection pump components are very precisely machined. It is extremely important to follow good service practices and maintain cleanliness when servicing the fuel injection pump.

The MP "Mono-Plunger" Fuel Injection Pump is a distributor type pump which consists of a single fuel supply plunger, a distributor shaft, a hydraulic head and a pump housing. The hydraulic head has a delivery valve for each cylinder. The fuel injection pump housing contains a governor and an internal camshaft.

The fuel is pressurized by the up and down motion of the camshaft-driven single plunger. It is then distributed to the proper fuel injector by the rotating distributor shaft.

There are two versions and sizes of the MP Fuel Injection Pump. The smaller of the two pumps, the MP2 pump, is used on the 3TNV88 model engines. The larger pump, the MP4 pump, which has a larger single plunger and a more aggressive cam profile, is used on the 4TNV94L -4TNV106T model engines. (in clude 4TNV98-E model engine)



FG008374

Figure 243

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 the 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 the engine when the key is turned off. Therefore, this electronically controlled engine does not have a stop solenoid.

Cold Start Device

The TNV model engines are equipped with a cold start device (CSD).

The cold start device is located in the upper section of the fuel injection pump and is connected to the engine's cooling system.

- The cold start device improves engine starting at lower temperatures. At engine cooling system temperatures below 41°F (5°C), the cold start device advances the fuel injection timing and slightly increases the fuel injection volume.
- For approximately the first 5 minutes of operation, the idle speed of the engine will be slightly elevated.



CAUTION

Allow the engine to warm-up for at least five minutes and the idle speed of the engine to return to normal before engaging the transmission or any PTOs. Engaging the transmission or PTO at an elevated engine speed could result in an unexpected movement of the equipment.

- When the cold start device is activated, you may notice a slight increase in the exhaust smoke of the engine during engine warm-up. Electronically controlled engines 4TNV98-E use a cold start device (CSD) that consists of a fuel injection pump complete with a solenoid valve (1, Figure 244).
- When the engine is started with the cooling water sensor detecting a low water temperature of 10Ae or lower and the E-ECU receives the corresponding signal, then the E-ECU causes the CSD's solenoid valve to increase the injection rate and advance the injection timing.
- . Because of this, the engine speed increases by approximately 75 min-1 while the CSD is operating. When the water temperature becomes 10°C or higher, the CSD is turned off and the engine returns to the normal speed.

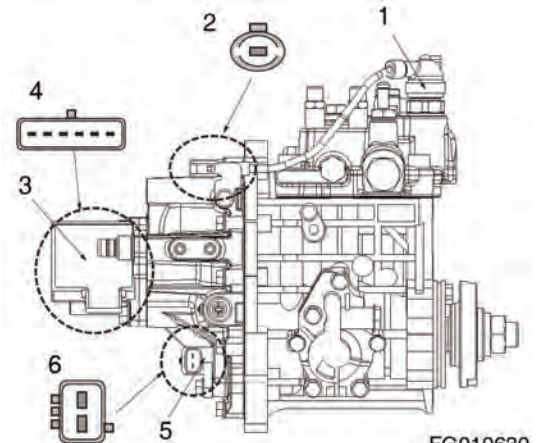


Figure 244

FG010630

Trochoid Fuel Pump

NOTE: *The trochoid fuel pump located on the side of the MP fuel injection pump is not a "fuel supply" pump. The function of this pump is to raise the pressure of the fuel supplied by the electric fuel supply pump to the internal fuel pressure required by the MP fuel injection pump.*

The use of an electric fuel supply pump is required on all TNV model engines with the MP fuel injection pump.

Electronically controlled governor

Electronically controlled engine 4TNV98-Z is quipped with an electronically controlled governor called "Eco Governor". Combined with the rack actuator (3, Figure 244), engine speed sensor (5, Figure 244), and other parts, the electronically controlled governor communicates with the engine controller (E-ECU), whereby the engine speed and fuel injection rate are controlled.

Fuel System Specifications

Special Torque Chart

Component	Tightening Torque	Lubricating Oil Application (Thread Portion and Seat Surface)
Fuel Injector Retainer Bolt	29 ft•lb (39.2 N•m; 4 kgf•m)	Not Applied
Fuel Pump Drive Gear Nut	83 - 91 ft•lb (113 - 123 N•m; 11.5 - 12.5 kgf•m)	Not Applied
High-Pressure Fuel Injection Line Nuts	22 - 25 ft•lb (29 - 34 N•m; 3.0 - 3.5 kgf•m)	Not Applied
Fuel Return Line Bolts	69 - 87 in•lb (7.8 - 9.8 N•m; 0.8 - 1.0 kgf•m)	Not Applied
Fuel Injection Pump Mounting Nuts	17 - 21 ft•lb (23 - 28 N•m; 2.3 - 2.9 kgf•m)	Not Applied
Fuel Injector Nozzle Case Nut	30 - 33 ft•lb (39.2 - 44.1 N•m; 4 - 4.5 kgf•m)	Not Applied
Fuel Injection Pump Plunger Plug	30 - 33 ft•lb (40 - 45 N•m; 4.1 - 4.6 kgf•m)	Not Applied

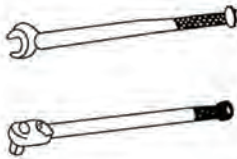
Test and Adjustment Specifications

Engine Class	Injector ID mark*	Fuel Injector Pressure	Fuel Injection Timing
CL VM	V	3133 - 3278 psi (21.6 - 22.6 MPa; 220 - 230 kgf/cm ²)	See "Checking And Adjusting Fuel Injection Timing" on page -185.

NOTE: Fuel injector pressures given are for used parts. New injectors (5 hours operation or less) will read approximately 725 psi (5 MPa; 51 kgf/cm²) higher.

* All DI injectors have 3 letters with the first letter starting with a V or W.

Special Service Tools

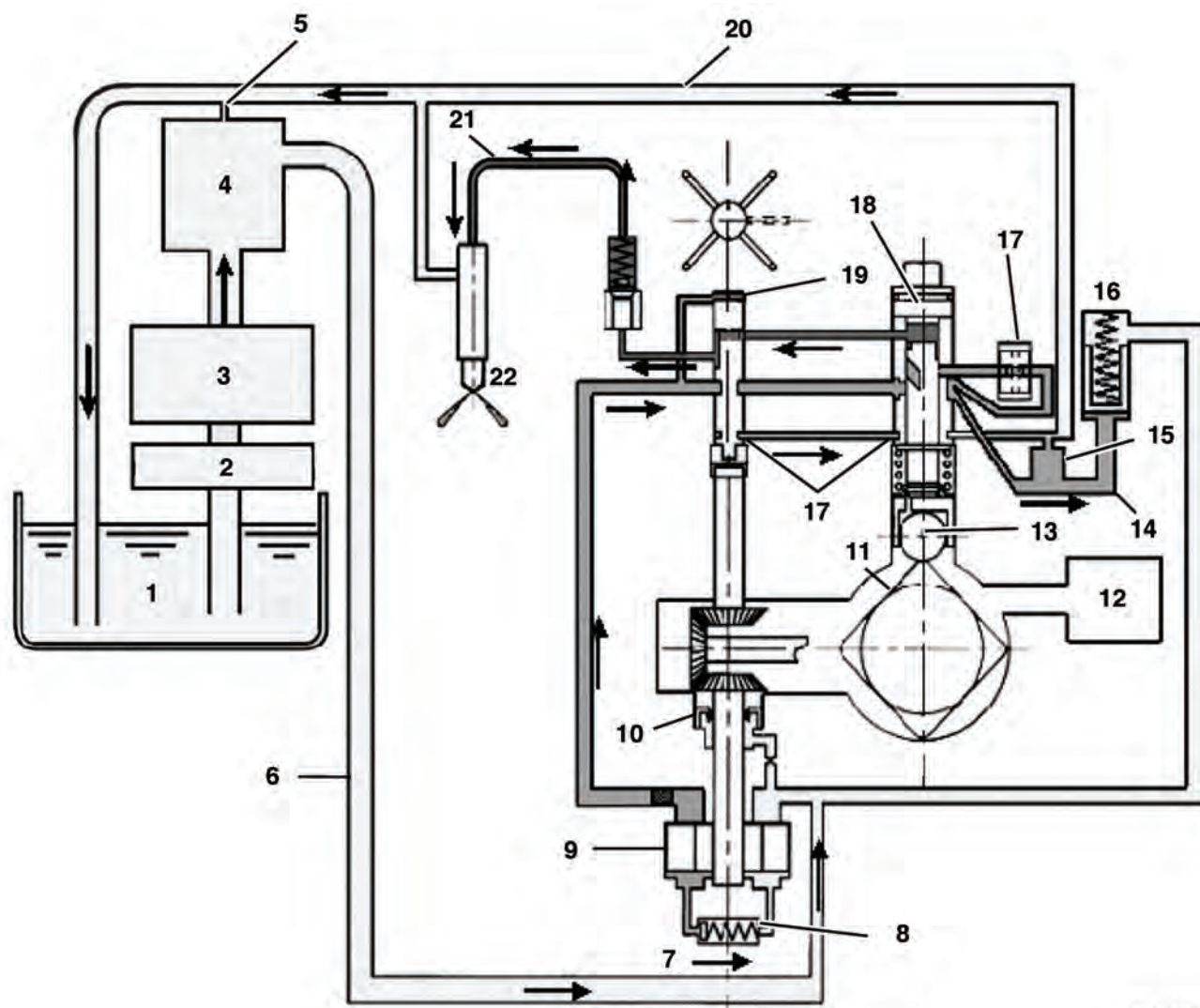
No.	Illustration	Tool name		Application
1		Torque Wrench	Locally Available	For tightening nuts and bolts to the specified torque

Measuring Instruments

No.	Illustration	Instrument Name		Application
1	 FG008971	Fuel Injector Tester	Locally Available	For observing injection spray pattern of fuel injection nozzle and measuring injection pressure
2	 FG008277	Dial Indicator*	Mituotoyo 2050SB - Locally Available	Check and adjust fuel injection timing
		Extension Rod*	Mituotoyo 303613 - Locally Available	
3	 FG008972	Fuel Injection Pump Plunger Adapter*	(M16) 4TNV98 - E Part No. 158090-51841	Mount dial indicator to fuel injection pump
4	 FG008973	Plunger Adapter Clamp	Part No. 23000-013000	Clamps stem of dial indicator in plunger adapter.

* These special service tools may also be available as an "MP Fuel Injection Pump Special Tool Set". Contact your authorized *DOOSAN* dealer or distributor for details.

Fuel System Diagram



FG008974

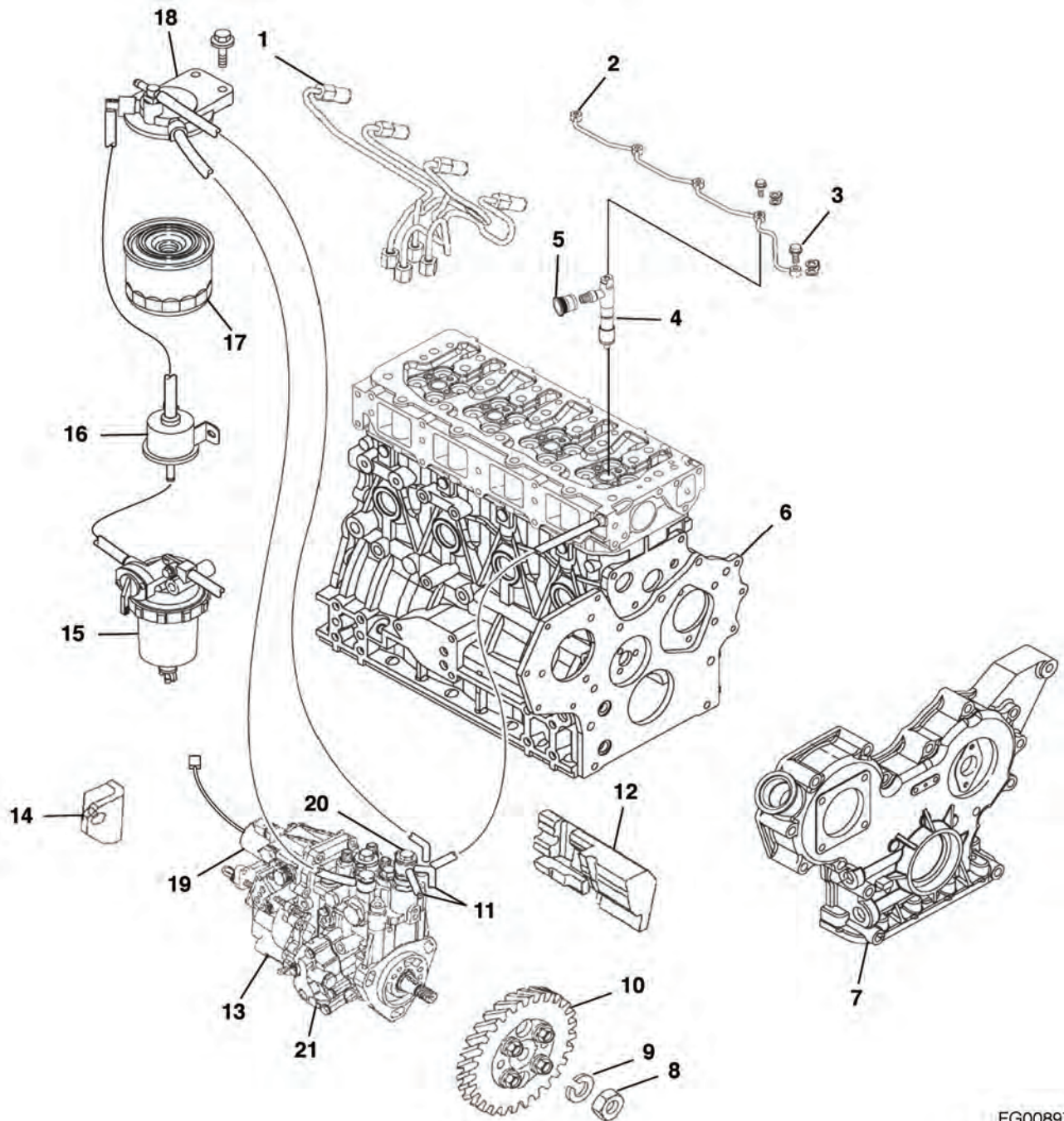
Figure 245

Reference Number	Description
1	Diesel Fuel Tank
2	Fuel Filter / Water Separator
3	Electric Fuel Pump
4	Fuel Filter
5	Air Bleed Orifice
6	Fuel Supply Line
7	Low Pressure Gallery
8	Pressure Control Valve
9	Trochoid Pump
10	Oil Seal
11	Fuel Injection Pump Cam
12	Engine Crankcase

Reference Number	Description
13	Tappet
14	High Pressure Gallery
15	Overflow Orifice
16	Accumulator
17	Timer Piston
18	Mono-Plunger
19	Distributor Shaft
20	Fuel Return Line
21	High-Pressure Fuel Injection Lines
22	Fuel Injector

Fuel System Components

4-Valve Cylinder Head



FG008976

Figure 246

Reference Number	Description
1	High-Pressure Fuel Injection Lines
2	Fuel Return Line
3	Return Line-to-Cylinder Head Bolt
4	Fuel Injector
5	Injection Line Grommet
6	Front Plate or Timing Gear Case
7	Gear Case Cover
8	Fuel Injection Pump Drive Gear Nut
9	Lock Washer
10	Fuel Injection Pump Drive Gear Assembly (DO NOT remove or loosen the four bolts that fasten the injection pump drive gear to the injection pump drive gear hub!)

Reference Number	Description
11	Coolant Lines for Cold Start Device*
12	Fuel Injection Pump Insulator
13	Diesel Fuel Injection Pump
14	Rear Fuel Injection Pump Support
15	Fuel Filter / Water Separator
16	Electric Fuel Supply Pump
17	Fuel Filter
18	Fuel Filter Housing
19	Stop Solenoid*
20	Cold Start Device (CSD)**
21	Trochoid Fuel Pump

* Not used for electronically controlled engines.

** Electronically controlled engines are equipped with a solenoid valve. As shown in the following figure, electronically controlled engines use an electronically controlled governor combined with a solenoid valve (CSD), rack actuator, engine speed sensor, and other parts.

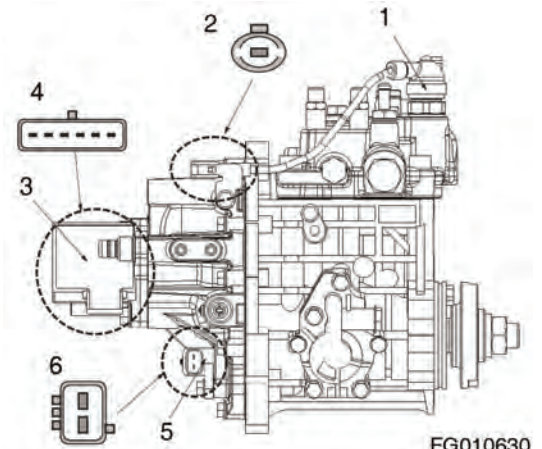


Figure 247

FG010630

Fuel Injection Pump

Removal of Fuel Injection Pump

1. Loosen the cooling fan V-belt.
2. Remove the engine coolant fan guard (if equipped), engine coolant fan (2, Figure 248), spacer (3, Figure 248) if equipped, V-pulley (4, Figure 248) and cooling fan V-belt (1, Figure 248).
3. Close any fuel valves in the fuel supply line.
4. Place a drain pan under the fuel injection pump to catch any spillage.

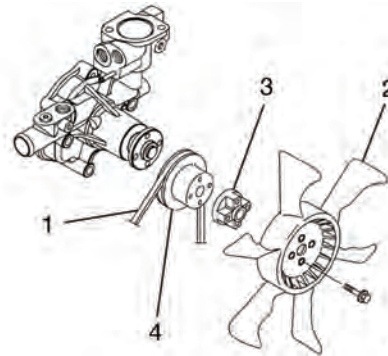


Figure 248

FG008977

5. Remove the high-pressure fuel injection lines as an assembly (1, Figure 249).

NOTE: To prevent "rounding" the fuel line nuts always use a "line" or "flare nut" wrench. When loosening the fuel line nuts, always hold the fuel injection pump delivery valves with a "back up" wrench to prevent loosening of the delivery valves.

6. First loosen the fuel line nuts at the fuel injectors and then at the fuel injection pump.

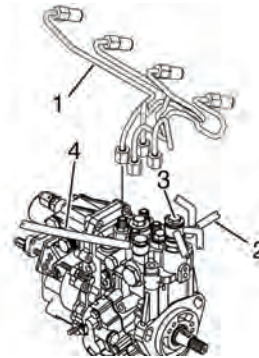


Figure 249

FG008978



CAUTION

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

7. Finish loosening all the fuel line nuts and remove the high-pressure fuel lines as an assembly being careful not to bend any of the fuel lines. Be sure to protect the fuel system from contamination by covering all open connections.
8. Disconnect the coolant lines from the cold start device (3, Figure 249) on the fuel injection pump. Plug the open ends of the lines to minimize leakage and prevent contamination.
This cooling water pipe is not used in electronically controlled engines 4TNV84T-Z, 4TNV98-Z, 4TNV98-E, and 4TNV98T-Z.
9. Disconnect the fuel return lines from the fuel return fitting (2, Figure 249). Plug the open ends of the lines to minimize leakage and prevent contamination.
10. Remove the fuel supply line (4, Figure 249). Plug the open end of the line to minimize leakage and prevent contamination.

11. Remove the throttle cable from the fuel injection pump.
12. Separate the stop solenoid wiring connector (2, Figure 250).

For electronically controlled engines 4TNV84TZ, 4TNV98-Z, 4TNV98-E, and 4TNV98T-Z, remove the solenoid valve connector (2, Figure 249), rack actuator connector (4, Figure 249), and engine speed sensor connector (6, Figure 249).

13. Remove the rear fuel injection pump bracket(s) (1, Figure 250) from the fuel injection pump.

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

14. Disconnect the lube oil line (1, Figure 251) and the clamp (2, Figure 251) from the pump.

IMPORTANT

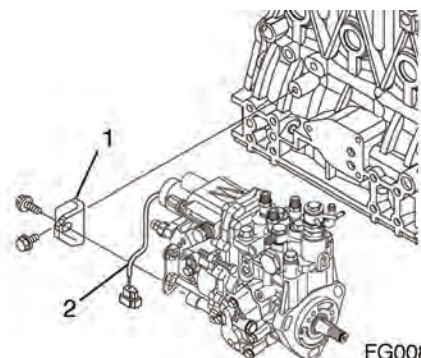
Take care to not damage or bend the oil line. In some applications, it may be preferable to remove the complete oil line assembly from the engine before proceeding.

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

15. Remove the fuel injection pump drive gear cover (1, Figure 252) from the gear case cover (2, Figure 252).

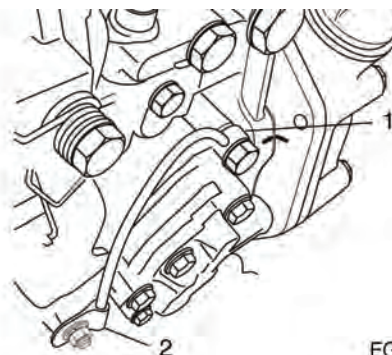
NOTE: The fuel injection pump drive gear cover is secured with an adhesive sealant. Use a gasket scraper to separate the fuel injection pump cover from the gear case cover.

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 -185.) 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.



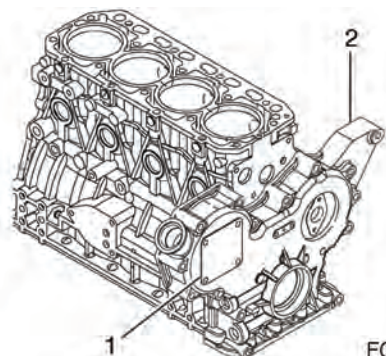
FG008979

Figure 250



FG008980

Figure 251



FG008981

Figure 252



CAUTION

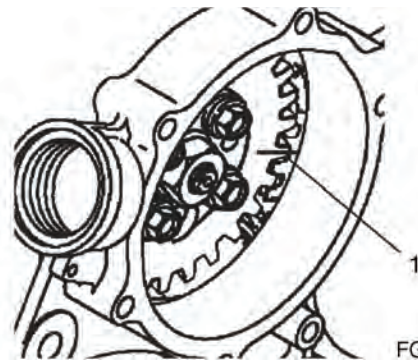
After marking the position of the pump drive gear, do not rotate the engine crankshaft. Rotating the crankshaft will cause the fuel injection pump to become misaligned.

- The idler gear is visible. Make a reference mark (1, Figure 253) across both the fuel injection pump drive gear and the idler gear.



CAUTION

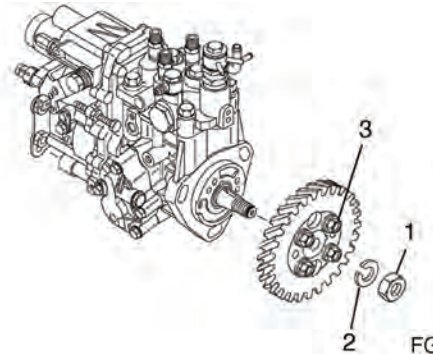
Do not loosen or remove the four bolts retaining the fuel injection pump drive gear to the fuel injection pump hub. Do not disassemble the fuel injection pump drive gear from the hub. Correct fuel injection timing will be very difficult or impossible to achieve.



FG008983

Figure 253

18. Do not loosen or remove the four bolts (3, Figure 254) retaining the pump drive gear to the hub. Only remove the single drive gear nut (1, Figure 254) and washer (2, Figure 254), leaving the hub attached to the gear.
19. Hold the gear train using a large socket wrench on the crankshaft pulley nut. Loosen the fuel injection pump drive gear retaining nut (1, Figure 254) and turn it out to the end of the fuel injection pump shaft.



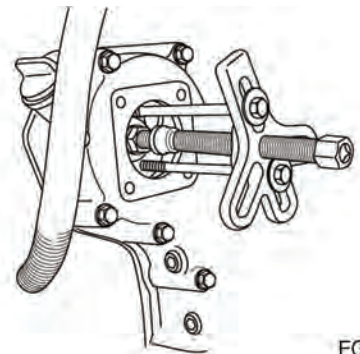
FG008984

Figure 254

20. Remove the pump drive gear and hub as an assembly using an appropriate two-bolt gear puller (Figure 255).

NOTE: On 4TNV98-E model the injection pump drive gear can be removed through the gear case cover opening.

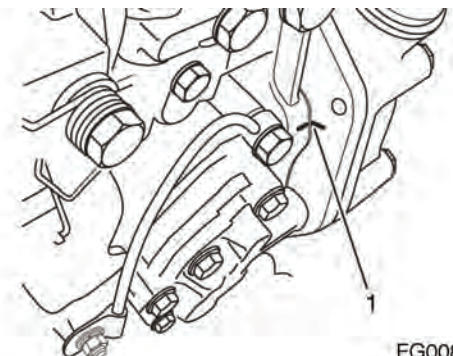
21. Once the fuel injection pump drive gear and hub assembly has "popped" loose from the tapered fuel injection pump drive shaft, carefully remove the drive gear nut (1, Figure 254) and lock washer (2, Figure 254).



FG008985

Figure 255

22. Locate the mark stamped into the upper outside mounting boss of the fuel injection pump. Highlight this mark and make a corresponding mark on the gear case or front plate (1, Figure 256).



FG008986

Figure 256

NOTE: Some model engines may require the intake manifold and fuel injection pump insulator (2, Figure 257) be removed to access the inner fuel injection pump (1, Figure 257) retaining nuts.

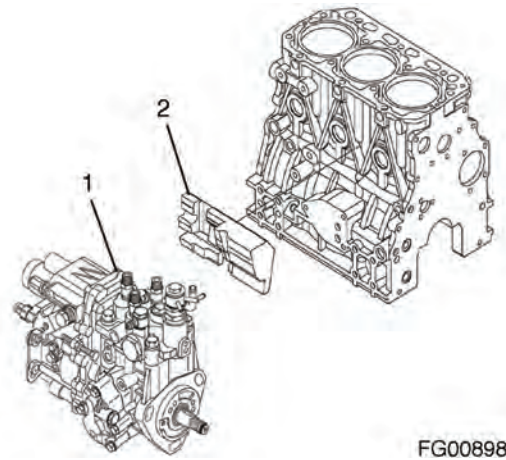


Figure 257

FG008987

23. If required, remove the intake manifold and fuel pump insulator to access the fuel injection pump mounting nuts.

NOTE: The MP4 fuel injection pumps (4TNV98 - E model engine) are fastened to the gear case with four (4) studs and nuts.

24. Remove the fuel injection pump (1, Figure 258). For purposes of future injection timing purposes, record the fuel injection pump timing index number located on the boss on the engine side (back) of the of the fuel injection pump (1, Figure 258).



Figure 258

FG008988



CAUTION

Do not rotate the crankshaft with the injection pump removed.

25. If the fuel injection pump requires servicing, it must be sent to an authorized **DOOSAN** dealer or **distributor** for repair and calibration, or replaced with a new fuel injection pump.



CAUTION

Never remove or attempt to remove the tamper-proof devices from the full-load fuel adjusting screw or the high-speed throttle limit screw on the fuel injection pump and governor assembly. These adjustments have been made at the factory to meet all applicable emissions regulations and then sealed.

Never attempt to make any adjustments to these sealed adjustment screws. If adjustments are required, they can be made only by a qualified fuel injection shop that will ensure the injection pump continues to meet all applicable emissions regulations and then replace the tamper-proof seals.

Installation of Fuel Injection Pump

for electronically controlled engine



WARNING

Replacing the fuel injection pump involves rewriting the fuel injection data in the E-ECU.

Be sure to contact your local **DOOSAN** dealer before replacing the fuel injection pump.

Failure to rewrite the fuel injection data before replacing the fuel injection pump will void the engine warranty.

. Improper use or misuse of the E-ECU may result in death or serious injury due to an abrupt and unexpected increase in engine speed.

IMPORTANT

If installing a new or recalibrated fuel injection pump, locate and record the timing index number located on the pump housing boss on the engine side of the new or recalibrated fuel injection pump (1, Figure 259). This number will be used to calculate and adjust the final fuel injection timing.

NOTE: If either or both of the fuel injection pumps do not have a timing index number, note the injection pump ID (example: XK42) on the injection pump ID label.

If additional assistance is needed in locating the engine timing index number and follow the instructions to locate an authorized **DOOSAN** dealer or distributor for assistance.

NOTE: Treat the timing index number as if it has a decimal point (68 = 6.8).

1. Align the pump drive gear with the idler gear using the reference marks made earlier. (1, Figure 260).

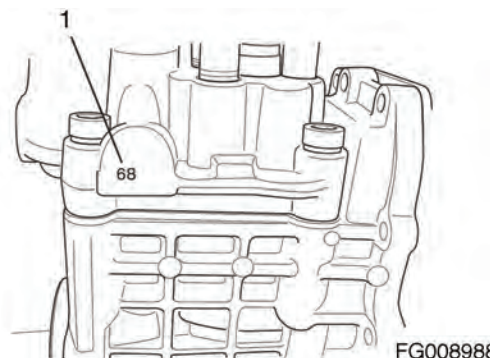


Figure 259

FG008988

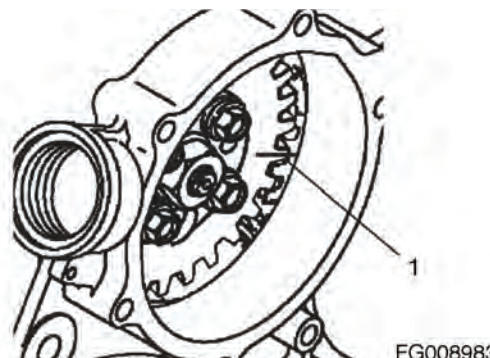
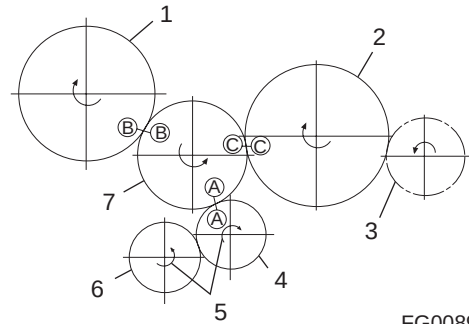


Figure 260

FG008983

2. If installing the fuel injection pump on an engine with the front gear case cover removed, the fuel injection pump drive gear can be aligned with the idler gear by aligning the stamped marks (A, B, C) on the fuel injection pump drive gear, idler gear, and crankshaft drive gear. Ensure all three timing marks (A, B, C, Figure 261) are aligned.

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



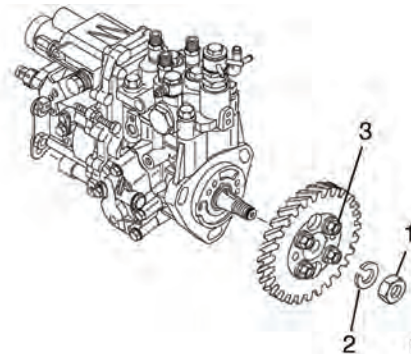
FG008920

Figure 261

3. Install a new O-ring on the pump mounting flange. Apply grease to the O-ring to hold it in place during installation of the injection pump.

NOTE: Ensure the tapered surface of the fuel injection pump shaft is clean and dry.

4. Align the key on the fuel injection pump shaft with the keyway in the fuel injection pump drive gear hub. Reinstall the fuel injection pump into the fuel injection pump drive gear and gear housing. Reinstall the pump retaining nuts finger tight.
5. Reinstall the fuel injection pump drive gear lock washer (2, Figure 262) and nut (1, Figure 262). Do not lubricate the threads of the nut or shaft. Hold the crankshaft pulley bolt with a socket wrench and tighten the drive gear nut to the specified torque. See "Special Torque Chart" on page -170.

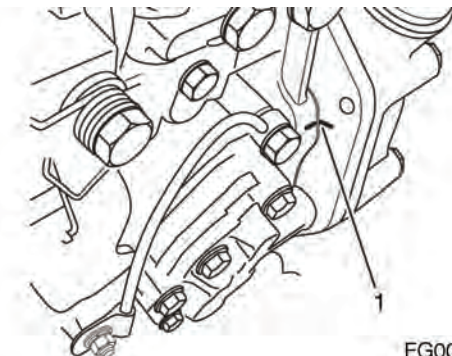


FG008984

Figure 262

If reinstalling the original fuel injection pump:

- Align the reference marks (1, Figure 263) previously made on both the fuel injection pump mounting flange and gear case or front plate.
- Tighten the fuel injection pump retaining nuts to specification. See "Special Torque Chart" on page -170.



FG008986

Figure 263

If installing a new fuel injection pump:

- Reinstall the timing grid sticker, provided with the new fuel injection pump, onto the back of the gear case / front plate (Figure 264). Align the "standard mark" (1, Figure 264) with the reference mark (2, Figure 264) made on the gear case during disassembly.

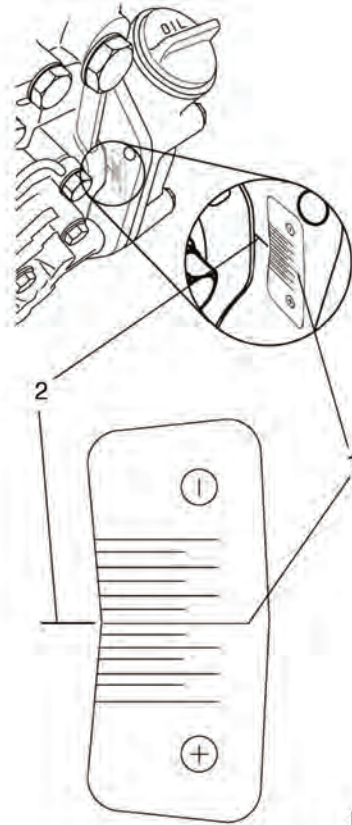


Figure 264

FG008990

- Calculate the difference between the timing index numbers (1, Figure 264) of the fuel injection pump that you removed and the replacement fuel injection pump. See Calculation Example below.

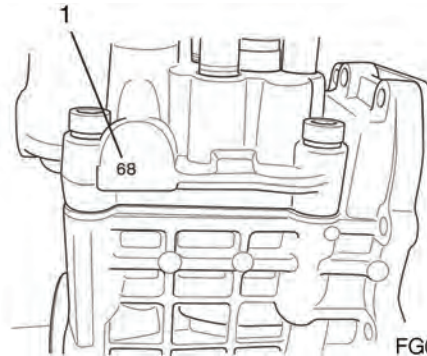


Figure 265

FG008988

Adjusting the fuel injection timing to compensate for the difference in pump timing index numbers:

Calculation Example

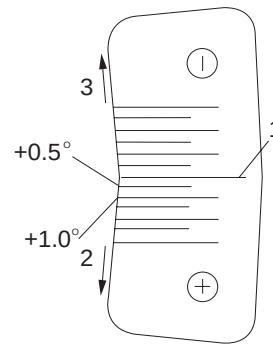
Timing Index Number	
Original injection pump=	6.8
Replacement injection pump=	7.3
Difference=	+0.5

- If the difference between the timing index numbers is a positive number, the fuel injection pump mounting position must be advanced (2, Figure 266) (rotated away from the engine) as compared to the "standard mark" (1, Figure 266) by the calculated positive amount, adjust the fuel injection pump to the calculated value.
- If the difference between the timing index numbers is a negative number, the replacement injection pump must be retarded (3, Figure 266) (rotated toward the engine) by the calculated negative amount.
- Each mark on the timing sticker represents 0.5° timing change.

The above calculated difference indicates that the replacement fuel injection pump is to be installed at +0.5° (advanced) from the "Standard Mark" (1, Figure 266) on the timing sticker.

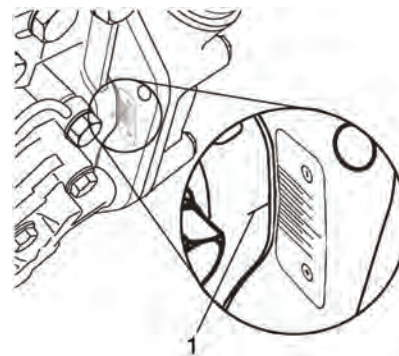
In this case, rotate the top of the fuel injection pump away from the cylinder block until the mark on the outside upper mounting boss (1, Figure 267) of the fuel injection pump aligns with the +0.5° mark on the timing sticker.

Tighten the fuel injection pump mounting nuts to specification. See "Special Torque Chart" on page -170.



FG008991

Figure 266

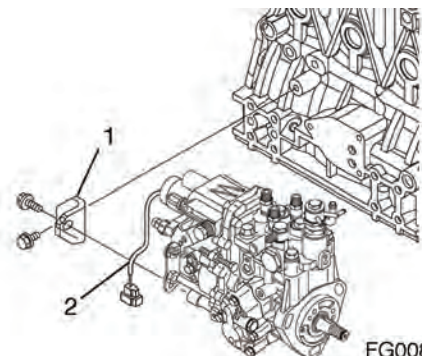


FG008992

Figure 267

6. Reinstall the rear bracket(s) (1, Figure 268) to the fuel injection pump. Tighten the rear support bolts.

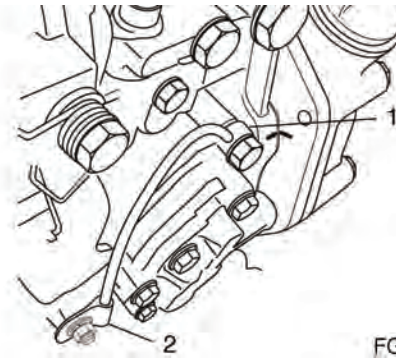
NOTE: Configuration of the fuel injection pump rear brackets may vary depending on the model.



FG008979

Figure 268

7. Reconnect the throttle linkage and the stop solenoid connector (2, Figure 269).
8. Reconnect the lube oil line (1, Figure 269) and clamp (2, Figure 269).
9. Apply ThreeBond Liquid Gasket or equivalent sealant to the sealing surface of the pump cover. Install the pump cover and tighten the cover bolts.
10. Reconnect the fuel return lines, fuel supply line and coolant lines to the fuel injection pump.
11. Reinstall the fuel injection high-pressure lines. Tighten the nuts to specification. See "Special Torque Chart" on page -170.



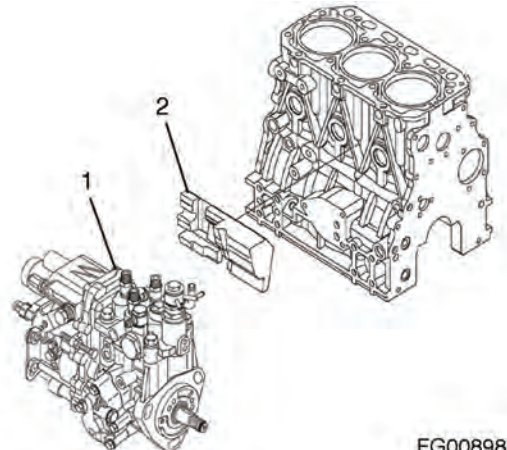
FG008980

Figure 269

IMPORTANT

When reinstalling a new or repaired fuel injection pump, it is important to add engine oil to the fuel injection pump to provide lubrication for initial start-up. Add 5-7 oz (150-200 cc) of clean engine oil to the fuel injection pump at the fill plug located in the upper outside section of the governor housing.

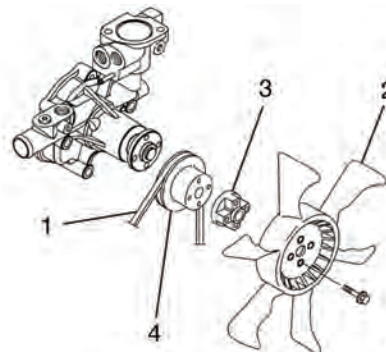
12. If equipped, verify the fuel injection pump insulator (2, Figure 270) is not damaged. Reinstall the insulator and intake manifold if previously removed.



FG008987

Figure 270

13. Reinstall the coolant pump V-pulley (4, Figure 271), spacer (3, Figure 271) (if equipped) and engine coolant fan (2, Figure 271).
14. Reinstall the cooling fan V-belt (1, Figure 271). Adjust it as described in Check and adjust Cooling Fan V-belt on page 5-21.
15. Reinstall the cooling fan guard (if equipped).
16. Prime the fuel system. See "" on page -40.
17. Operate the engine and check for fuel and coolant leaks.



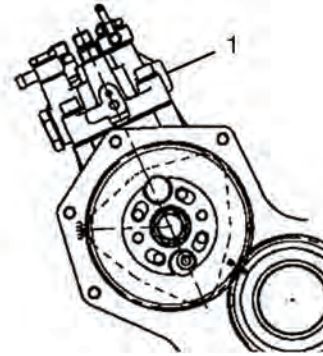
FG008977

Figure 271

Checking And Adjusting Fuel Injection Timing

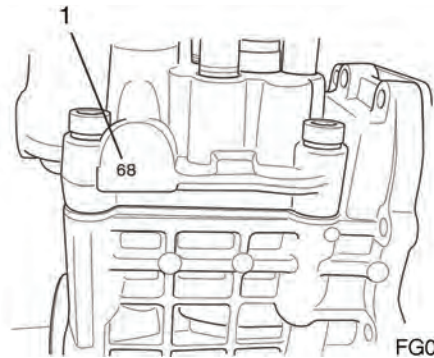
Determining the Fuel Injection Timing Specification

1. Locate and record the fuel injection pump timing index number (1, Figure 273) stamped into the boss on the engine side of the fuel injection pump housing (1, Figure 272). Treat this number as though there is a decimal point between the two digits. i.e. 68 = 6.8



FG008993

Figure 272



FG008988

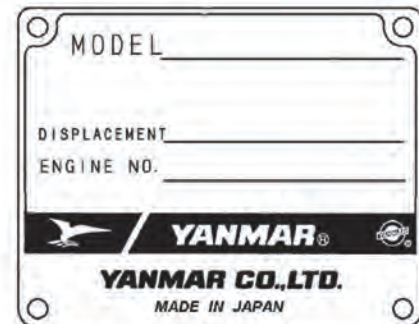
Figure 273

2. The engine model number of this machine is 4TNV98 EPDBW

- The FIR number for this engine is 4.
- (Fuel Injection Pump Timing Index Number X 2) + FIR Number = FIT° (Fuel injection Timing in Degrees)

(6.8 X 2) = 13.6 + 4 = 17.6° Fuel injection Timing

- Record the calculated fuel injection timing specification.



FG010659

Figure 274

Checking Fuel Injection Timing

NOTE: Some fuel may drain from the fuel injection pump during this process. Make provisions to contain any such spillage.

1. Turn off the fuel valve in the fuel supply hose and the fuel return hose.
2. Clamp shut the fuel injection pump fuel return hose leading to fuel filter (1, Figure 275).

IMPORTANT

Clean the top of the fuel injection pump to prevent any contamination when the fuel injection pump plunger plug is removed.

3. Remove the forward fuel injection pump plunger plug (2, Figure 275) on the top of the fuel injection pump.
4. Install a dial indicator adapter and clamp into the pump plunger opening.

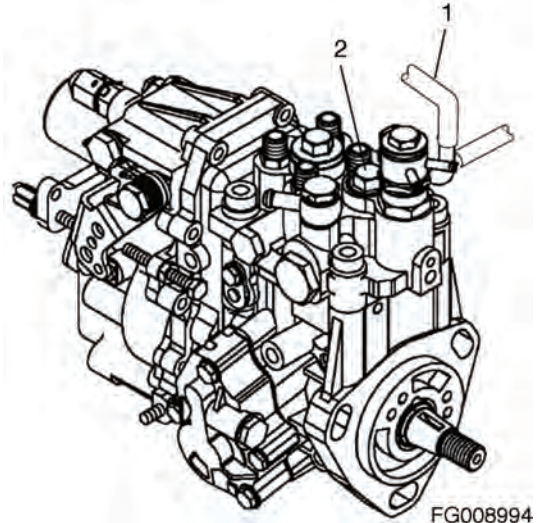


Figure 275

NOTE: Use the M16 adapter used on the MP4 fuel injection pumps and plunger adapter clamp (1, Figure 276).

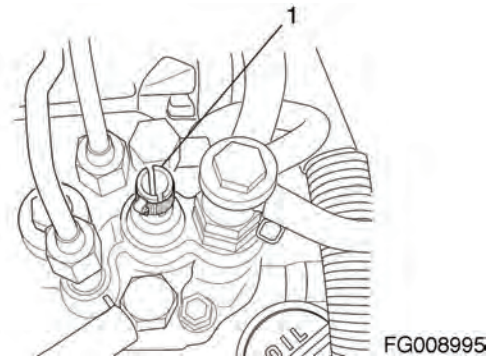


Figure 276

5. Install a dial indicator (1, Figure 277), Mitutoyo or equivalent, with a 30 mm extension, into the adapter. Secure with the plunger adapter clamp (1, Figure 276) at approximately the mid-point of its travel.

NOTE: Note: The following references to the direction-of-rotation are facing the coolant pump end of the engine and are adjusted by turning the crankshaft pulley.

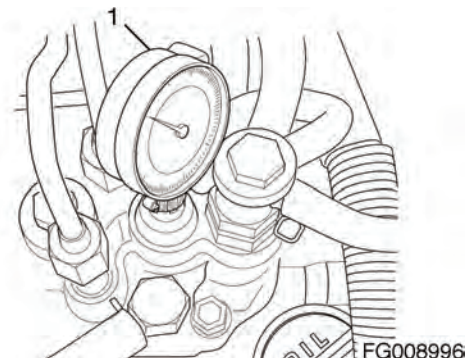


Figure 277

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 278). Rotate the crankshaft until the injection timing marks on the flywheel are visible.

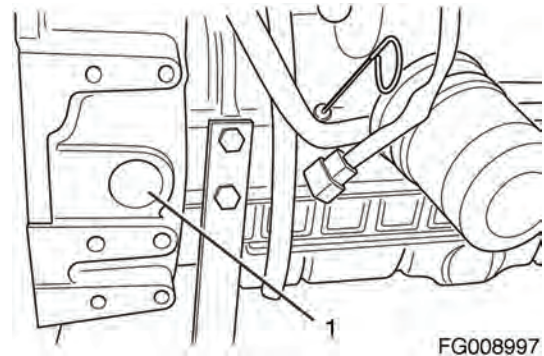


Figure 278

7. Typical flywheel markings are as shown in (1, Figure 279).

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 279 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.

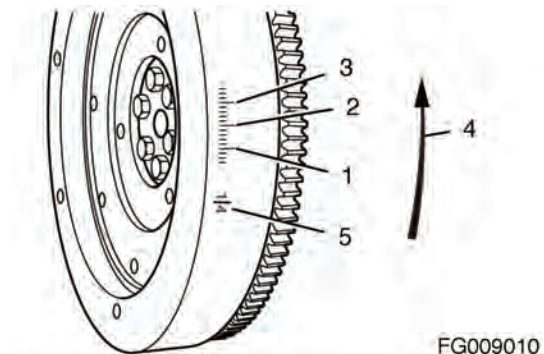


Figure 279

- **EXAMPLE:** If the distance between the two "longer" marks is approximately 2.0 cm and the distance from the TDC mark is approximately 4.0 cm, the answer is approximately 2. This indicates there is 10° (2 x 5°) between the TDC mark and the first "longer" mark on the timing grid. That means the first "longer" mark on the timing grid indicates 10° BTDC, the second "longer" mark indicates 15° BTDC and the third timing mark indicates 20° BTDC. If the answer is 3, that indicates there is 15° (3 x 5°) between the TDC mark and the first "longer" mark and that the first "longer" mark indicates 15° BTDC with the second and third "longer" marks indicating 20° BTDC and 25° BTDC respectively.

8. Highlight the timing reference mark (2, Figure 280) on the flywheel housing or engine back plate (2, Figure 281). Highlight the TDC (Top Dead Center) mark (1, Figure 280) on the flywheel.

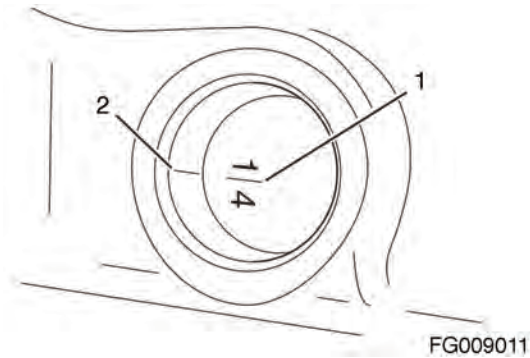


Figure 280

9. Highlight the target timing mark (1, Figure 281) on the flywheel as calculated in Determining the Fuel Injection Timing Specification on page 7-26.
10. Rotate the crankshaft counter-clockwise until the dial indicator shows that the injection pump plunger is at the bottom of its stroke. Rock the crankshaft back and forth slightly to confirm a point where the dial indicator shows no movement. Zero the dial indicator.
11. Slowly rotate the crankshaft clockwise until the dial indicator shows a pump plunger lift of 2.5 mm (0.098 in.).
12. Check the position of the flywheel target timing mark (1, Figure 281) in relation to the timing reference mark (2, Figure 281) on the flywheel housing or engine back plate. If the two marks are aligned, the fuel injection timing is correct. If the marks do not align, the fuel injection timing must be adjusted. See "Adjusting Fuel Injection Timing" on page -189.
13. If the injection timing is correct, remove the dial indicator and adapter. Replace the pump plunger plug and its copper gasket and tighten to specifications. Replace the flywheel inspection port cover. Open the fuel supply valve and remove the clamp from the fuel supply hose and the fuel return hose.
14. Prime the fuel system. Operate the engine and check for leaks.

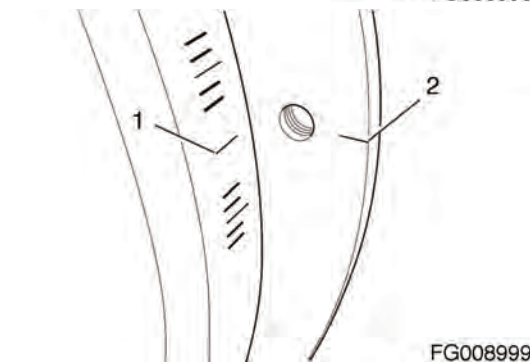
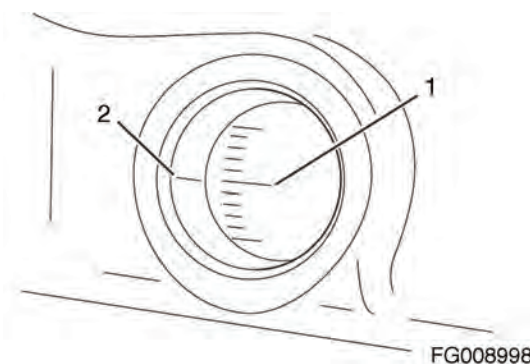


Figure 281

Adjusting Fuel Injection Timing

If the timing marks did not align when performing the Checking Fuel Injection Timing on page 7-27, the following steps must be performed to properly time the engine.

1. Leave the dial indicator installed in the fuel injection pump. Do not disturb the reading on the dial indicator.
2. Rotate the flywheel until the target timing mark (1, Figure 282) and the timing reference mark (2, Figure 282) on the flywheel housing or back plate are aligned.

IMPORTANT

Do not rotate the crankshaft during the remainder of this procedure.

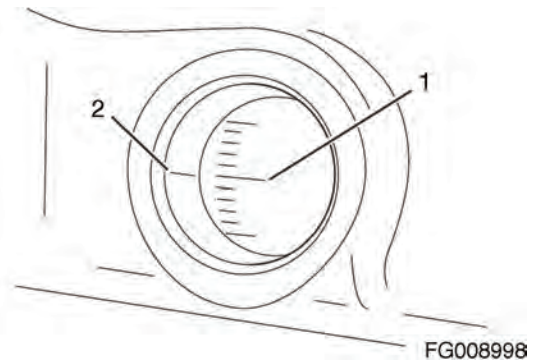


Figure 282

3. Note the reading on the dial indicator (1, Figure 283). If the reading is less than 2.5 mm (0.098 in.), the fuel injection timing is "retarded." If the dial indicator reading is greater than 2.5 mm (0.098 in.), the fuel injection timing is "advanced."

NOTE: Some model engines require the intake manifold and fuel injection pump insulator be removed to access the inner fuel injection pump retaining nuts.

4. Loosen the nuts fastening the fuel injection pump to the gear case or front plate. Loosen the rear bracket(s) on the fuel injection pump.

NOTE: Loosening the high-pressure injection line nuts on the fuel injection pump may make rotating the pump easier.

5. Rotate the fuel injection pump until the dial indicator reads 2.5 mm (0.098 in.).
6. To "advance" the injection timing, rotate the top of the fuel injection pump away from the engine.
7. To "retard" the injection timing, rotate the top of the fuel injection pump toward the engine.
8. When the dial indicator reads 2.5 mm (0.098 in.) of pump plunger lift and the target timing mark on the flywheel aligns with the reference mark on the flywheel housing or engine back plate, the injection timing is correct.
9. Tighten the fuel injection pump mounting nuts and rear bracket(s).
10. Remove the dial indicator and adapter. Replace the plug in the pump plunger opening and tighten it to specification. If removed, install the intake manifold and pump insulator. Tighten the high-pressure injection line nuts to specification. Open the fuel supply valve, remove the clamp from the fuel return line and prime the fuel system. Operate the engine and check it for leaks.

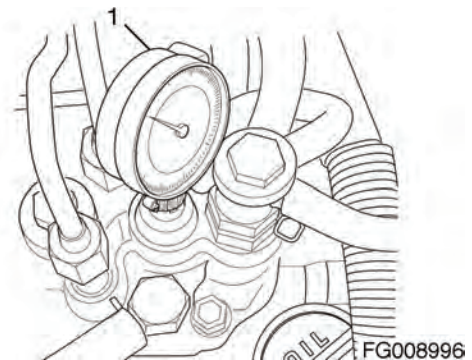


Figure 283

Fuel Injectors

Removal of Fuel Injectors

4-Valve Cylinder Head

1. Close any fuel valves in the fuel supply line.
2. Remove the valve cover.
3. Remove the injector return line (1, Figure 284). Be careful not to bend the line.
4. Remove the fuel injector mounting clamp bolts (2, Figure 284). Lift the injector mounting clamps (3, Figure 284) away from injector.
5. Remove the fuel injector (4, Figure 284) from the cylinder head.

NOTE: *The fuel injectors can be removed by manually pulling them out of the fuel injector wells.*

6. Remove the injector nozzle protector (5, Figure 284) and seat (6, Figure 284) from the cylinder head. Discard both items.
7. Repeat steps to remove the remaining fuel injectors.

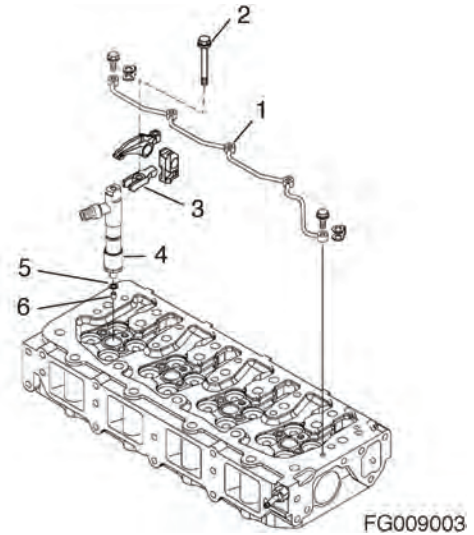


Figure 284

Testing of Fuel Injectors



CAUTION

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

1. Thoroughly clean the fuel injector nozzle using clean diesel fuel and a brass wire brush.
2. Visually inspect the fuel injectors and nozzle protectors for deposits or damage. Clean, repair or replace as necessary.

NOTE: *Test the fuel injector using an injection nozzle tester. Operate the tester following the information provided by the tester manufacturer. Use clean, filtered fuel or FIE calibration fluid for the test.*

3. Using the correct adapter, connect a fuel injector to a nozzle tester. Aim the fuel injector into a suitable container to catch the fuel spray.



CAUTION

Never inject fuel toward you. Since the fuel is injected at high pressure from the nozzle, it may penetrate the skin, resulting in injury.

Never inject fuel toward a fire source. Atomized fuel is highly flammable and may cause a fire or burn skin.



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.

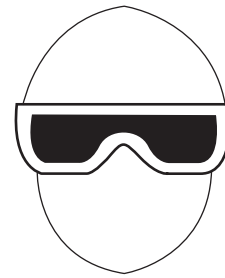
Failure to comply may result in minor or moderate injury.

4. Pump the operating lever of the tester slowly, observing the pressure reading at the point where the fuel injector begins spraying fuel (Figure 286). Figure 291 for injector ID location. See "Fuel System Specifications" on page -170. for correct pressure readings.

NOTE: *The opening pressure of a new fuel injector will be approximately 725 psi (5 MPa; 51 kgf/cm²) higher than one that has been operated for five hours or longer.*

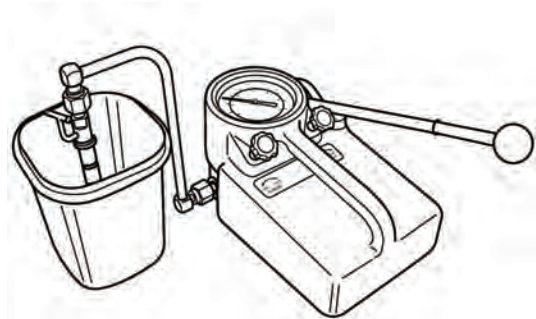
5. Pump the operating lever slowly to hold the pressure steady at a point just below the opening pressure and hold it for 5 seconds. Observe the injector to see that it is sealing properly and is not "dripping". If fuel leaks from the return line fitting, check that the nozzle case nut is tight. Service or replace the injector if fuel continues to leak from either the return line fitting or nozzle.
6. Pump the operating lever more rapidly to repeatedly "pop" the injector and observe the spray pattern. The pattern should be a very fine uniform spray (Figure 287). If a dripping or an uneven pattern is seen (Figure 288), service or replace the injector.

If the fuel injector fails any of these tests, it should be serviced or replaced as necessary. If the pressure is outside specified limits, adjust the pressure. See "Adjusting Fuel Injector Pressure" on page -193.



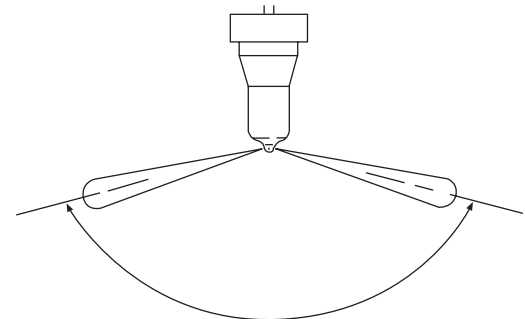
FG009152

Figure 285



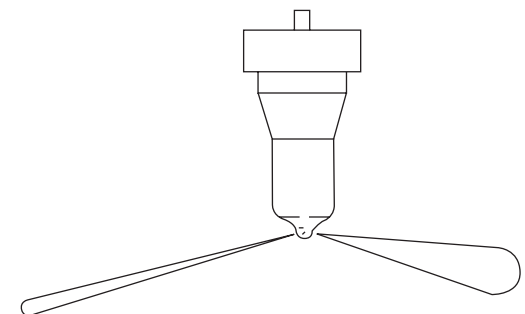
FG008971

Figure 286



FG009004

Figure 287



FG009005

Figure 288

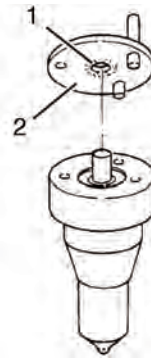
Disassembly and Inspection of Fuel Injectors



CAUTION

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

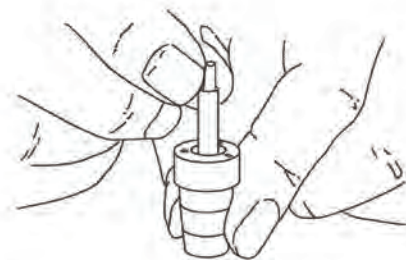
1. Clean carbon from used injectors using clean diesel fuel. Hardened deposits or varnish can be cleaned using a brass wire brush.
2. Place the fuel injector in a soft-jawed vise with the nozzle pointing up.
3. Remove the nozzle case nut.
4. Carefully remove the injector from the vise.
5. Turn the injector over and remove the nozzle body, nozzle valve, valve stop spacer, nozzle spring seat, nozzle spring, and shims.
6. Inspect the sealing surfaces (2, Figure 289) between the valve stop spacer and nozzle body for nicks or scratches. Check the contact area between the valve stop spacer and the nozzle valve (1, Figure 289) for scoring, or pitting. Use a magnifier glass to inspect the area.



FG009007

Figure 289

7. Perform a nozzle valve slide test:
 - A. Wash nozzle body and valve in clean diesel fuel.
 - B. While holding the nozzle body vertical, pull the nozzle valve about 2/3 of the way out (Figure 290).
 - C. Release the valve. It should fall smoothly to its seat by it's own weight.
8. Replace the fuel injector assembly if it fails any inspection.



FG008244

Figure 290

Adjusting Fuel Injector Pressure

The fuel injectors open when pressure reaches a predetermined pressure threshold. They close when the pressure is reduced below that threshold. The pressure threshold can be adjusted by adding or removing shims (3, Figure 291).

Reference Number	Description
1	Fuel Return Passage
2	Injector ID Location
3	Injector Body
4	Pressure Adjusting Shims
5	Spring
6	Spring Seat
7	Valve Stop Spacer
8	Nozzle Valve
9	Nozzle Body
10	Nozzle Case Nut

The injection pressure will change by approximately 275 psi (1.9 MPa; 19 kgf/cm²) for every 0.1 mm (0.004 in.) in shim thickness. See the parts catalog for available shims.

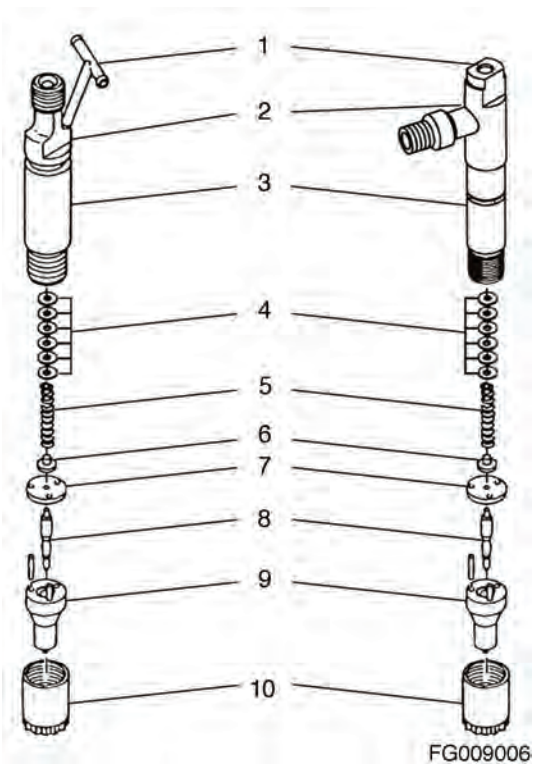


Figure 291

CAUTION

Each pressure adjusting shim removed or added changes the pressure threshold by approximately 275 psi (1.9 MPa, 19 kgf/cm²). Adding adjusting shims increases the threshold pressure. Removing adjusting shims reduces the pressure threshold.

1. Disassemble the fuel injector assembly. See "Disassembly and Inspection of Fuel Injectors" on page -192.
2. Remove or add adjusting shims as needed.
3. Reassemble the fuel injector assembly. "Reassembly of Fuel Injectors" on page 1-194.
4. Retest the fuel injector. See "Testing of Fuel Injectors" on page -190. If the injector cannot be adjusted to the appropriate pressure, discard the fuel injector.

Reassembly of Fuel Injectors

1. Secure the injector in a soft-jawed vise with the nozzle end up.
2. Reinstall the shims, nozzle spring, nozzle spring seat, valve stop spacer, nozzle valve, and nozzle body.
3. Reinstall the nozzle case nut. Tighten it to specification. See "Special Torque Chart" on page -170.

Installation of the Fuel Injectors

4-Valve Cylinder Head

1. Reinsert a new nozzle seat (6, Figure 292) and nozzle protector (5, Figure 292) in the cylinder head for each injector.
2. Reinstall a O-ring on to each injector body.
3. Reinsert each fuel injector (4, Figure 292) into the cylinder head.
4. Reinstall the fuel injector retainers (3, Figure 292) and torque the retaining bolts (2, Figure 292) to specification.
5. Reinstall the fuel injector return line assembly using new gaskets on each side of the injector line screws.
6. Reinstall the fuel high-pressure fuel lines to each injector and tighten the nuts using a "line" or "flare nut" wrench.
7. Prime the fuel system. See "Priming the Fuel System" on page -40.
8. Operate the engine and check for fuel and coolant leaks.

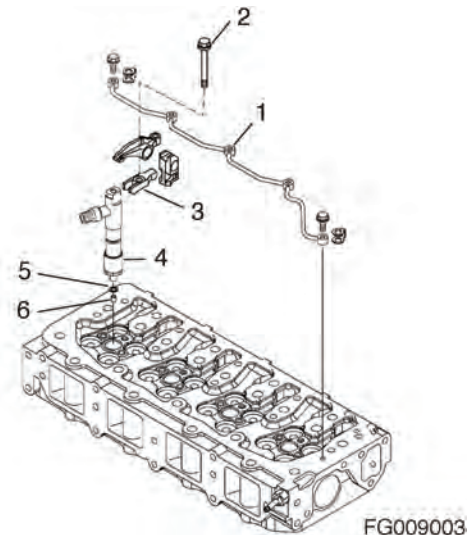


Figure 292

Fuel injection system (for a four-valve cylinder head)

Fuel injection system (for a four-valve cylinder head) The fuel injection system for a four-valve cylinder head is different, not only in the nozzle valve specifications, but also in the nozzle holder specifications. Therefore, it is marked as follows; take care not to install a wrong part when replacing it with new one.

Identifying the fuel injector assembly

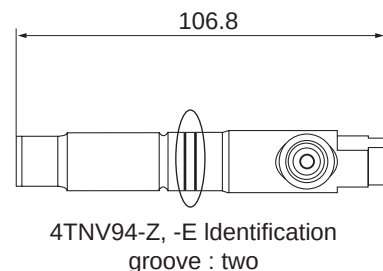


Figure 293

FG010631

COOLING SYSTEM

Before You Begin Servicing



DANGER

Scald Hazard!

Never Remove the radiator cap if the engine is hot. Steam and hot engine coolant will spurt out and seriously burn you. Allow the engine to cool down before you attempt to remove the radiator cap.

Tighten the radiator cap securely after you check the radiator. Steam can spurt out during engine operation if the cap is loose.

Always check the level of the engine coolant by observing the reserve tank.

Failure to comply will result in death or serious injury.



WARNING

Burn Hazard!

Wait until the engine cools before you drain the engine coolant. Hot engine coolant may splash and burn you.

Failure to comply could result in death or serious injury.



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.

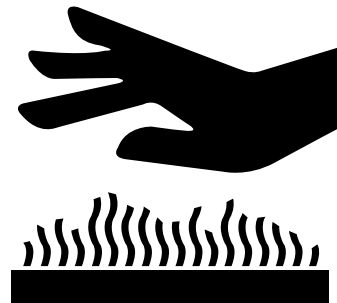
If you must service the engine while it is operating, remove all jewelry, tie back long hair, and keep your hands, other body parts and clothing away from moving / rotating parts.

Failure to comply could result in death or serious injury.



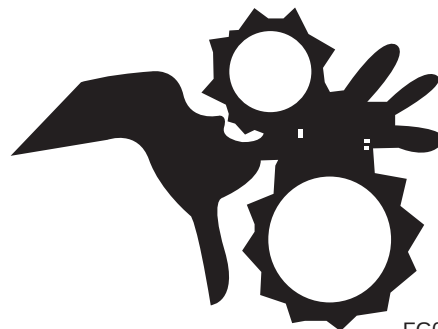
HAOA060L

Figure 294



HAOA050L

Figure 295



FG009148

Figure 296



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 297



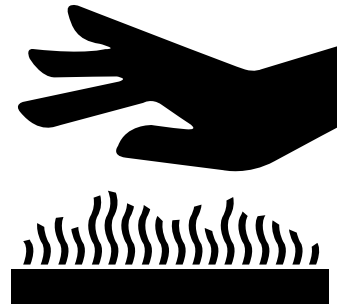
WARNING

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 298

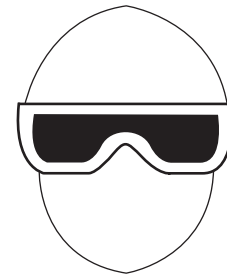


CAUTION

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

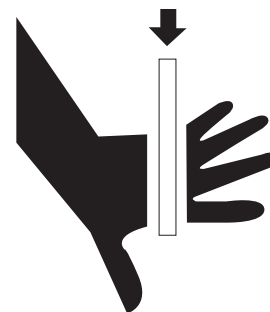
Figure 299



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 300



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

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



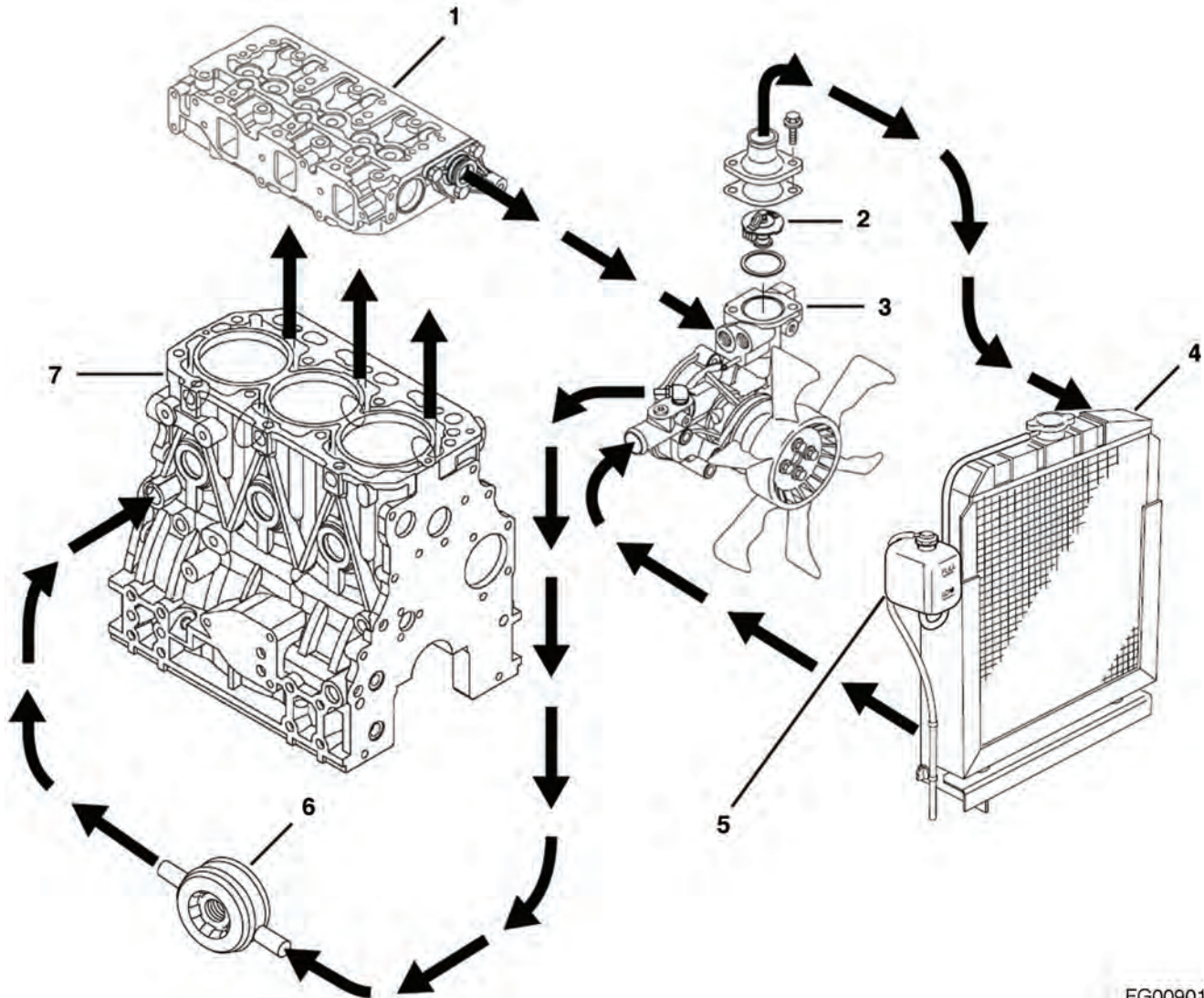
CAUTION

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

Introduction

This section of the Service Manual describes the procedures necessary to service the standard engine coolant pump. This engine coolant pump is representative of the coolant pumps used on other TNV model engines. For specific part detail, see the parts catalog for the engine you are working on.

Cooling System Diagram



FG009012

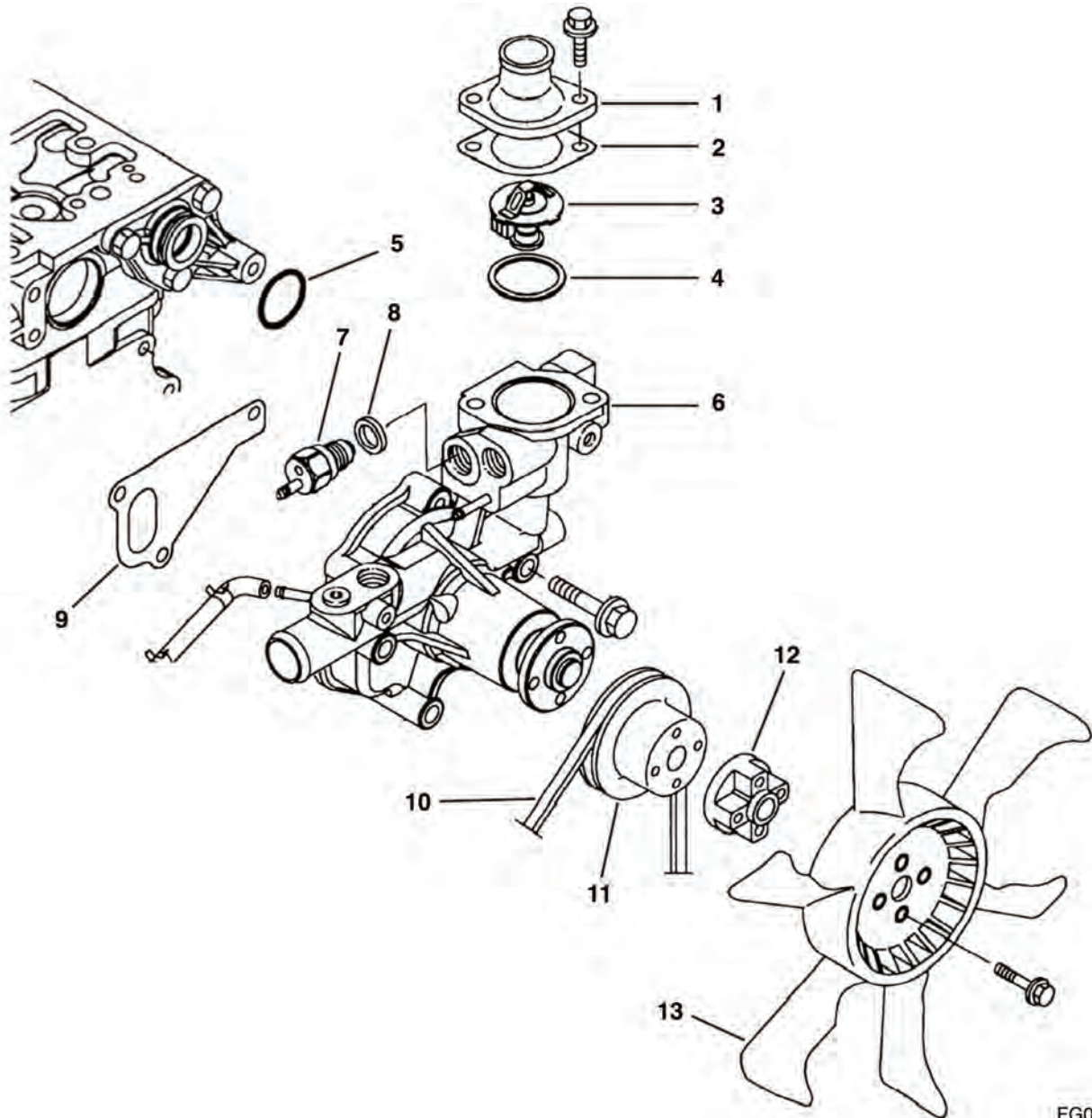
Figure 301

Reference Number	Description
1	Cylinder Head
2	Thermostat
3	Engine Coolant Pump
4	Radiator

Reference Number	Description
5	Coolant Recovery Tank
6	Engine Oil Cooler
7	Cylinder Block

* Not standard on all models.

Engine Coolant Pump Components



FG009013

Figure 302

Reference Number	Description
1	Thermostat Cover
2	Thermostat Cover Gasket
3	Thermostat
4	Thermostat O-Ring
5	Special O-Ring
6	Engine Coolant Pump
7	Temperature Switch

Reference Number	Description
8	Gasket
9	Engine Coolant Pump Gasket
10	V-Belt
11	Engine Coolant Pump V-Pulley
12	Spacer
13	Engine Coolant Fan

Engine Coolant System Check

Check the engine coolant system for leakage.

1. With the radiator properly filled, install a cooling system tester (1, Figure 303).
2. Apply 10.8 -14.8 psi (75 -105 kPa; 0.75 -1.05 kgf/cm²) to the cooling system. If the pressure reading drops, the engine coolant system is leaking. Identify the source of the leak and repair it.

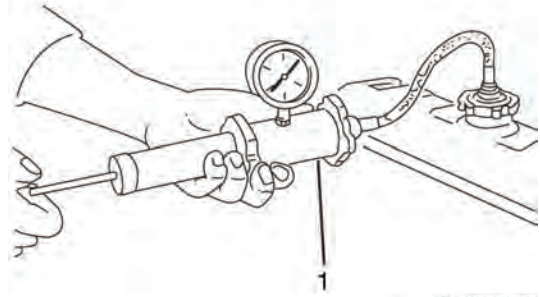


Figure 303

FG009021

Engine Coolant Pump

Removal of Engine Coolant Pump Verify the condition of the engine coolant pump before disassembling it from the engine. Check the engine coolant pump shaft bearing for abnormal noise, sticking, excessive play and water leakage. Replace the coolant pump if any of these conditions are present.



CAUTION

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

IMPORTANT

Make sure the engine and engine coolant are not hot.

1. Before removing the engine coolant pump or thermostat, it will be necessary to drain the engine coolant. Drain the coolant into a clean container if the coolant is to be reused. Otherwise, properly dispose of the coolant.
2. Remove the radiator cap (1, Figure 304).
3. Remove the drain plug or open the drain cock (1, Figure 304) at the lower portion of the radiator and drain the coolant.

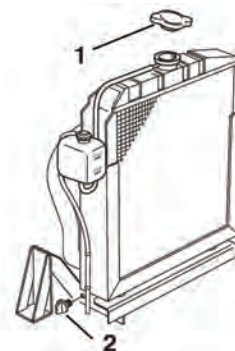


Figure 304

FG008869

4. Drain the coolant from the engine block.
 - On models equipped with an oil cooler, remove the coolant hose (1, Figure 305) at the oil cooler.
 - On models not equipped with an oil cooler, remove the coolant drain plug (1, Figure 306) from the engine block.

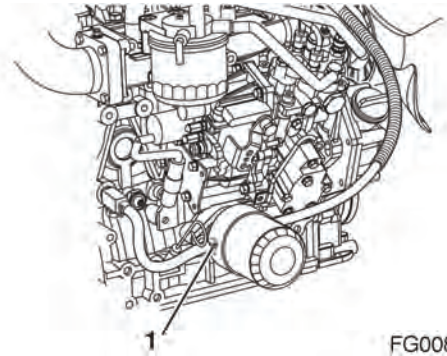


Figure 305

FG008853

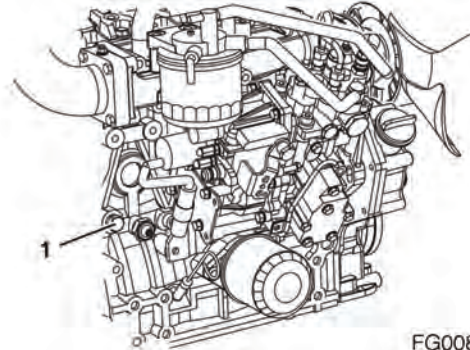


Figure 306

FG008852

5. Loosen the alternator mounting bolts. Loosen and remove the V-belt and rotate the alternator away from the engine and out of the way.



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.

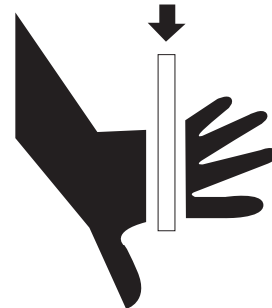


Figure 307

FG009155

6. Remove the engine coolant fan guard (if equipped), engine coolant fan (1, Figure 308), spacer (2, Figure 308) and engine coolant pump V-pulley (3, Figure 308).
7. Disconnect the coolant hoses and the temperature switch lead wire from the engine coolant pump.
8. Remove the engine coolant pump (4, Figure 308). Discard the gasket.

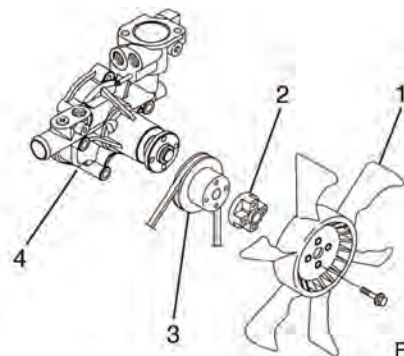


Figure 308

FG009022

Disassembly of Engine Coolant Pump

1. Remove the thermostat cover (1, Figure 309) Discard the gasket.
2. Remove the thermostat (2, Figure 309). Discard the O-ring. Remove the temperature switch (3, Figure 309) and gasket (4, Figure 309). Discard the gasket.

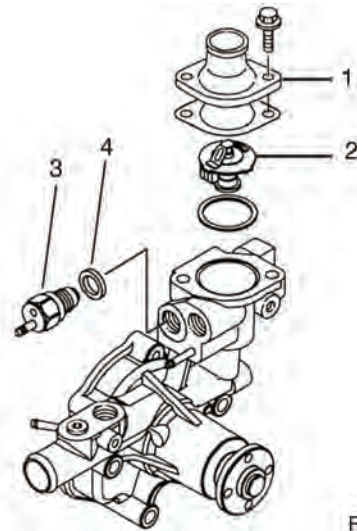


Figure 309

FG009023

Cleaning and Inspection

Temperature Switch

1. Check for proper operation of the temperature switch. Connect a continuity light or ohmmeter to the temperature switch. Connect one lead to the terminal of the switch (1, Figure 310) and the other lead to the metal portion of the switch (2, Figure 310)
2. Place the temperature switch and an accurate thermometer (3, Figure 310) in engine coolant.
3. Slowly increase temperature of the fluid using an external heat source.
4. The temperature switch is operating properly if the continuity light or ohmmeter indicates continuity when the fluid temperature reaches 225°F - 235°F (107°C - 113°C).

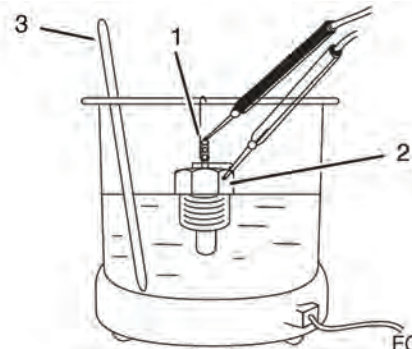


Figure 310

FG009024

Water temperature sensor

1. Inspect the water temperature sensor to make sure that it is properly operating. As shown in the following figure, connect an electric resistor to the coupler of the water temperature sensor (1, Figure 311).
2. Dip the water temperature sensor and an accurate thermometer (2, Figure 311) into the cooling water.
3. Measure the electric resistance value while slowly raising the cooling water temperature using an external heat source.
4. The resistance value at each of the following temperatures is within the permissible range specified, the water temperature sensor is correctly operating.

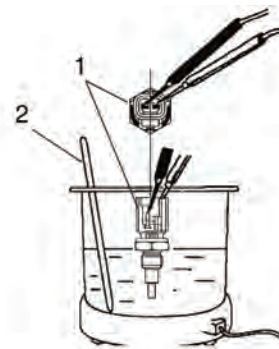


Figure 311

FG010632

Cooling water temperature (°C)	Resistance (kΩ)
20	2.45 ^{+0.14} _{-0.13}
80	0.318 ± 0.008
0.008	(0.1836)

Thermostat

1. Check for proper operation of the thermostat. Place the thermostat (1, Figure 312) and an accurate thermometer (2, Figure 312) in warm water.
2. Slowly increase the temperature of the water using an external heat source.
3. The thermostat is operating properly if it starts to open at the temperature value stamped on the flange of the thermostat, and fully opens as the temperature of the water is increased.

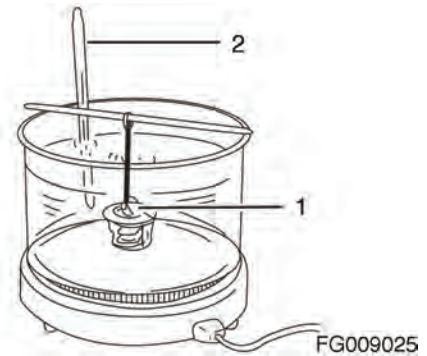


Figure 312

Radiator Cap

1. Check for proper operation of the radiator cap. Install the radiator cap (1, Figure 312) on a cooling system tester.
2. Apply 10.8 - 14.8 psi (75 - 105 kPa; 0.75 - 1.05 kgf/cm²) to the radiator cap. The radiator cap relief valve must open within the specified range.

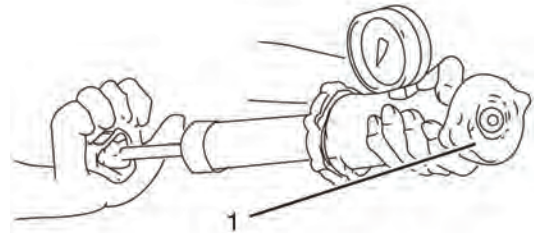


Figure 313

Reassembly of Engine Coolant Pump

1. Reinstall the thermostat (1, Figure 314) and a new O-ring.
2. Reinstall the thermostat cover (2, Figure 314) and a new gasket. Tighten the thermostat cover bolts.
3. Reinstall the temperature switch (3, Figure 314) and a new gasket (4, Figure 314)

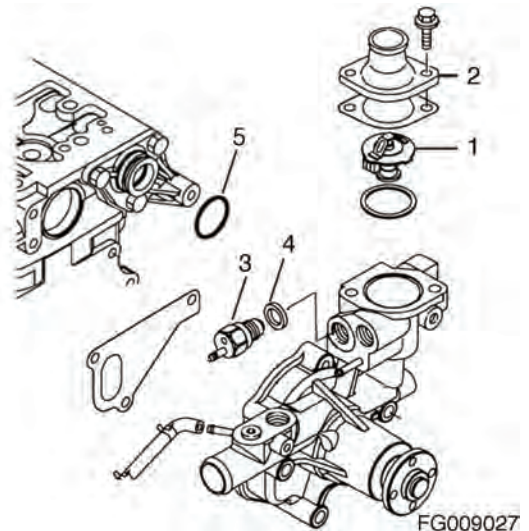


Figure 314

Installation of Engine Coolant Pump

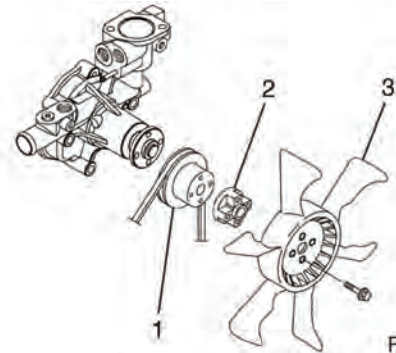
1. Position the engine coolant pump on the engine and install a new gasket. Install a new special O-ring (5, Figure 314) on assembly between the engine coolant pump and the joint.



CAUTION

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

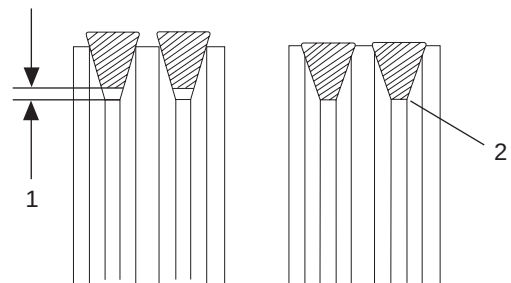
2. Reinstall the engine coolant pump bolts. Tighten the bolts.
3. Inspect and reinstall the coolant hoses and the temperature switch lead wire.
4. Reinstall the engine coolant pump V-pulley (1, Figure 315), spacer (2, Figure 315) engine coolant fan (3, Figure 315) and engine coolant fan guard (if equipped).



FG009028

Figure 315

5. Inspect the condition of the V-belt. There must be clearance (1, Figure 316) between the V-belt and the bottom of the pulley groove. If there is no clearance (2, Figure 316) between the V-belt and the bottom of the pulley groove, replace the V-belt.
6. Reinstall the V-belt. Tighten the V-belt to the proper tension. See "Check and Adjust Cooling Fan V-Belt" on page -81.
7. Reinstall and tighten the drain plug or close the drain cock in the radiator. Reinstall and tighten the engine block drain plug or reconnect the coolant hose at the oil cooler.
8. Fill the radiator and engine with engine coolant. See "Drain, Flush and Refill Cooling System With New Coolant" on page -89.



FG008859

Figure 316



CAUTION

Only use the engine coolant specified. Other engine coolant 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.

LUBRICATION SYSTEM

Before You Begin Servicing



WARNING

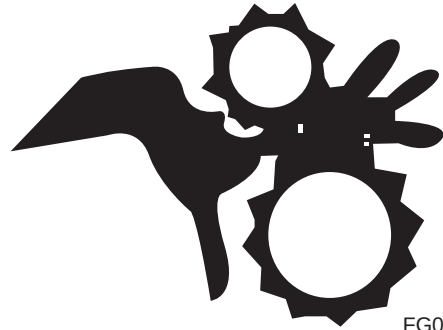
Entanglement Hazard!

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 317

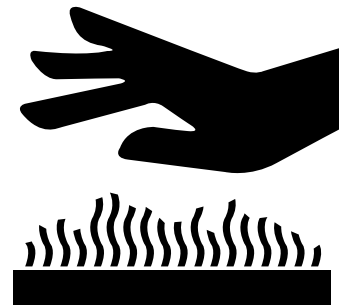


WARNING

Burn Hazard!

Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, 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 318



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 319



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.

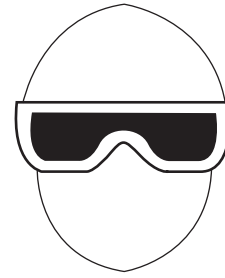


Figure 320

FG009152



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.

Introduction

This section of the Service Manual describes the procedures necessary to service the 4TNV98-Z Trochoid oil pumps.

See "Replace Engine Oil" on page -80. for engine oil and engine oil filter replacement procedures.

Oil Pump Service Information

Engine Oil Pressure

At Rated Engine RPM						At Low Idle Speed
1500 - 1800 min ⁻¹	2000 - 2500 min ⁻¹	2600 min ⁻¹	2700 min ⁻¹	2800 min ⁻¹	2900 - 3000 min ⁻¹	
0.29 - 0.39 MPa (3.0 - 4.0 kgf/cm ²)						0.06 MPa (0.6 kgf/cm ²) or greater

Outer Rotor Outside Clearance

Standard	Limit	Reference Page
0.0039 - 0.0061 in. (0.100 - 0.155 mm)	0.0098 in. (0.25 mm)	Check Outer Rotor Outside Clearance on page 9-14

Outer Rotor Side Clearance

Standard	Limit	Reference Page
0.0020 - 0.0039 in. (0.05 - 0.10 mm)	0.0059 in. (0.15 mm)	Check Outer Rotor Side Clearance on page 9-12

Outer Rotor to Inner Rotor Tip Clearance

Standard	Limit	Reference Page
-	0.0063 in. (0.16 mm)	Outer Rotor to Inner Rotor Tip Clearance on page 9-11

Inner Rotor and Gear Boss Clearance

Item	Parts	Standard Dimension	Standard Clearance	Standard Clearance Limit	Reference Page
Inside Clearance of Inner Rotor	Gear Boss Diameter	2.0886 - 2.0925 in. (53.05 - 53.15 mm)	0.012 - 0.020 in. (0.3 - 0.5 mm)	0.024 in. (0.6 mm)	"Check Rotor Shaft Clearance" on page 1-211
	Rotor Diameter	2.1043 - 2.1083 in. (53.45 - 53.55 mm)			
Inner Rotor Width Across Flat Clearance	Width Across Flat of Gear Boss	1.9468 - 1.9587 in. (49.45 - 49.75 mm)	0.008 - 0.020 in. (0.2 - 0.5 mm)	0.028 in. (0.7 mm)	
	Width Across Flat of Rotor	1.9665 - 1.9705 in. (49.95 - 50.05 mm)			

Rotor Shaft Clearance <Trochoid type>

Inspection Item	Standard	Limit	Reference Page
Gear Case bearing I.D	0.5110 - 0.5126 in. (12.980 - 13.020 mm)	0.5138 in. (13.050 mm)	"Check Rotor Shaft Clearance" on page 1-211
Rotor Shaft O.D.	0.5100 - 0.5104 in. (12.955 - 13.020 mm)	0.5096 in. (12.945 mm)	
Rotor Clearance	0.0006 - 0.0026 in. (0.015 - 0.065 mm)	0.0041 in. (0.105 mm)	

Lubrication System Diagram

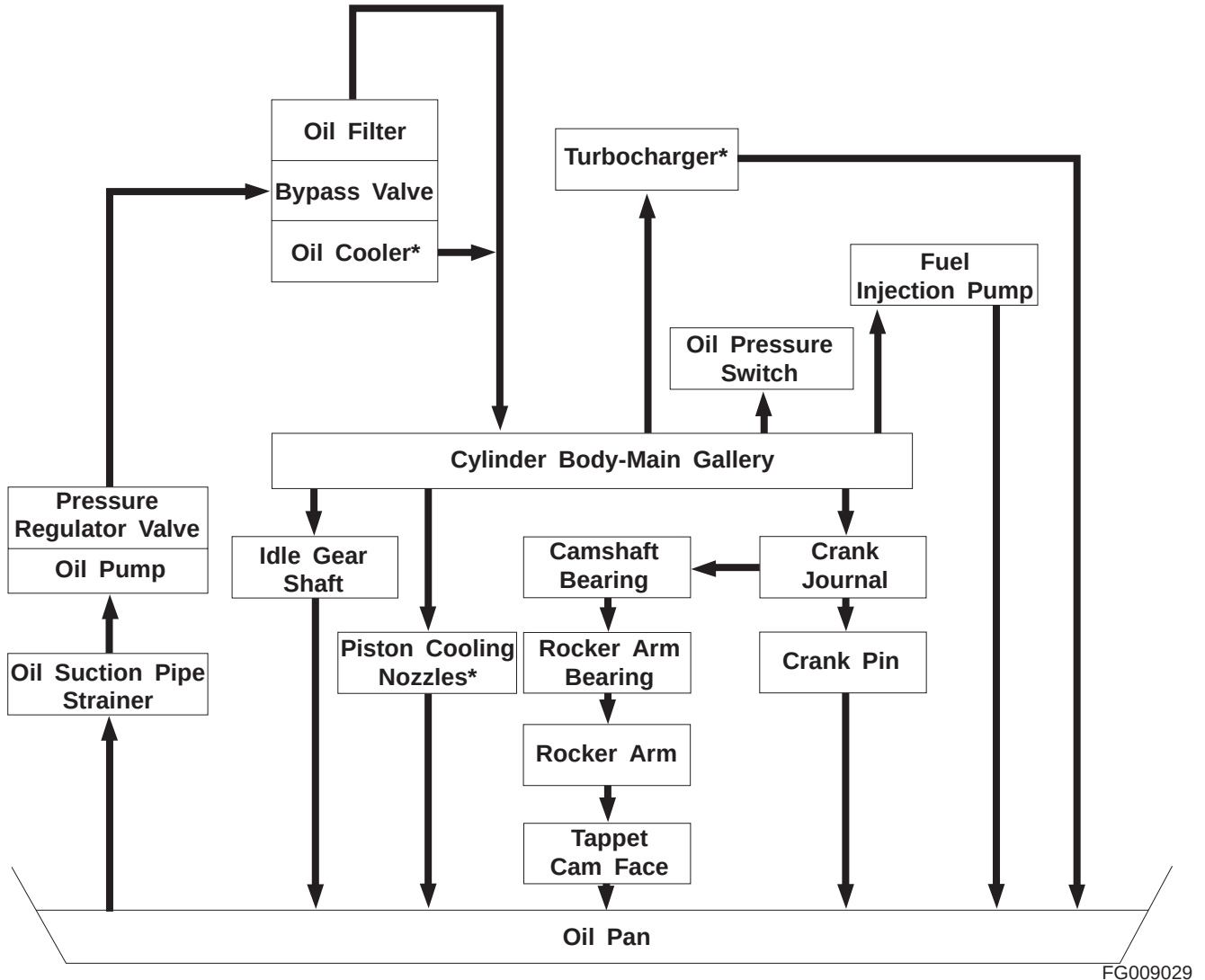


Figure 321

NOTE: Items marked * are not standard equipment on all models.

Checking Engine Oil Pressure

Perform an engine oil pressure check if there is any indication of low oil pressure such as the oil pressure indicator is on or the oil pressure gauge indicates low oil pressure. See "Oil Pump Service Information" on page -207.

1. Disconnect the wire lead from the oil pressure switch or sending unit (1, Figure 322).
2. Remove the oil pressure switch.
3. Install a mechanical oil pressure gauge in the oil pressure switch port.
4. Start the engine:
 - If the mechanical oil pressure test gauge indicates good oil pressure, replace the faulty oil pressure switch or sending unit, or faulty machine oil pressure gauge in instrument panel.
 - If the mechanical oil pressure test gauge indicates low oil pressure, troubleshoot the lubrication system to locate the cause of the low oil pressure.

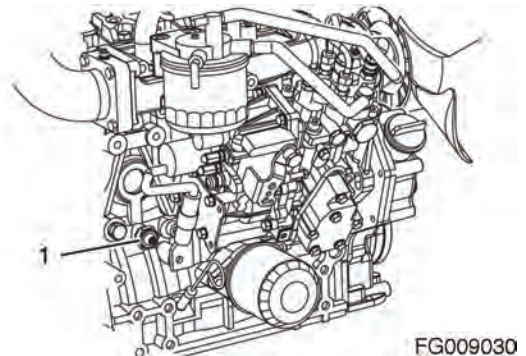


Figure 322

FG009030

Trochoid Oil Pump

Oil Pump Components

The oil pump on these model engines is located in the front gear case and is driven by the same gear train that drives the camshaft and fuel injection pump. You must remove the front gear case cover to gain access to the oil pump.

Reference Number	Description
1	Gear Case Housing
2	Outer Rotor
3	Inner Rotor
4	Cover Plate
5	Drive Gear

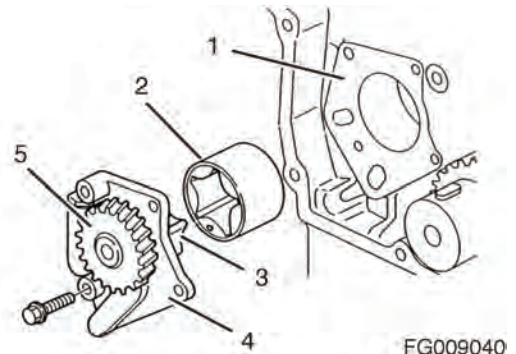


Figure 323

FG009040

Disassembly of Oil Pump



CAUTION

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

Remove the engine cooling fan guard (if equipped), engine cooling fan (3, Figure 324), spacer (2, Figure 324), engine coolant pump V-pulley (1, Figure 324) and V-belt.

1. Remove the crankshaft pulley and the gear case cover.
See Removal of Timing Gear Case Cover on page 6-73.

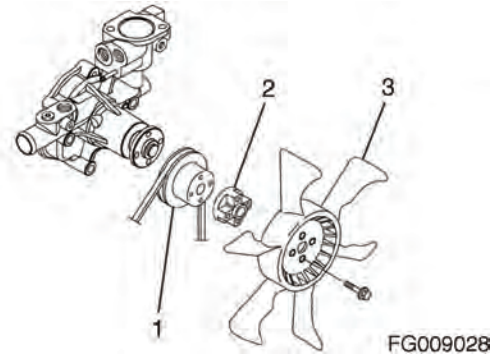


Figure 324

2. Remove the oil pump assembly bolts. Remove the oil pump assembly (1, Figure 325) from the gear case housing (2, Figure 325).

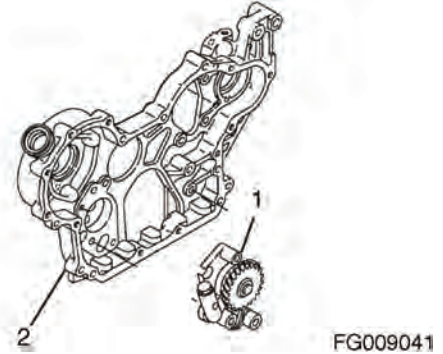


Figure 325

Cleaning and Inspection

Wash the oil pump, oil pressure regulator and oil pump cavity. Inspect for wear or damage. Replace as necessary.



CAUTION

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

Check Outer Rotor Outside Clearance

Determine the outside clearance of the outer rotor. Insert a feeler gauge between the outer rotor (1, Figure 326) and gear case oil pump cavity (2, Figure 326).

Record the measurement(s) and see Check Outer Rotor Outside Clearance on page 9-11 for the service limits.

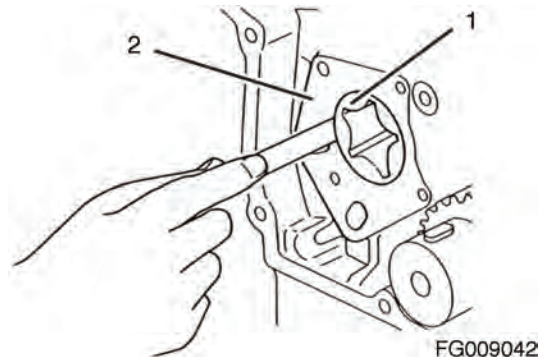


Figure 326

Outer Rotor to Inner Rotor Tip Clearance

Determine the outer rotor to inner rotor tip clearance. Insert a feeler gauge between the top of an inner rotor tooth (1, Figure 327) and the top of an outer rotor tooth (2, Figure 327) and measure the clearance.

Record the measurement(s) and see Outer Rotor to Inner Rotor Tip Clearance on page 9-11 for the service limits.

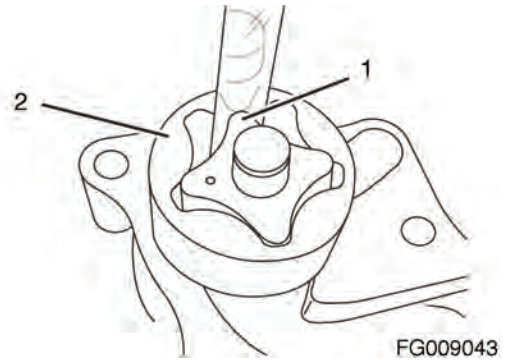


Figure 327

Check Outer Rotor Side Clearance

Determine the side clearance of the outer rotor across the pump cavity. Measure the depression using a depth micrometer (1, Figure 328).

Record the measurement(s) and see Check Outer Rotor Side Clearance on page 9-12 for the service limits.

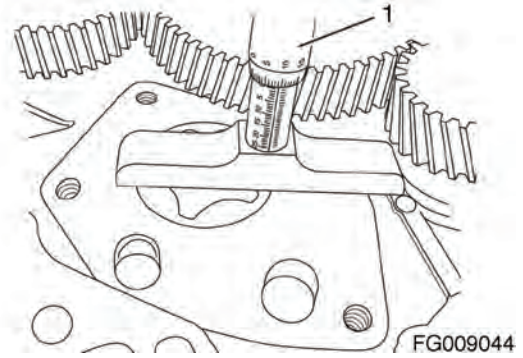


Figure 328

Check Rotor Shaft Clearance

Determine the rotor shaft clearance. Measure the outside diameter of the rotor shaft (1, Figure 329) and the bore diameter in the gear case housing (2, Figure 329).

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

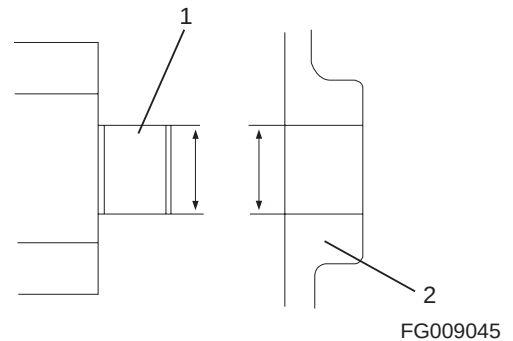


Figure 329

Reassembly of Oil Pump

1. Lubricate the outer rotor and pump bore in the gear case with clean engine oil.
2. Reinstall the outer rotor in the gear case housing. The punch mark (1, Figure 330) on the end of the outer rotor must face away from the gear case housing (2, Figure 330).

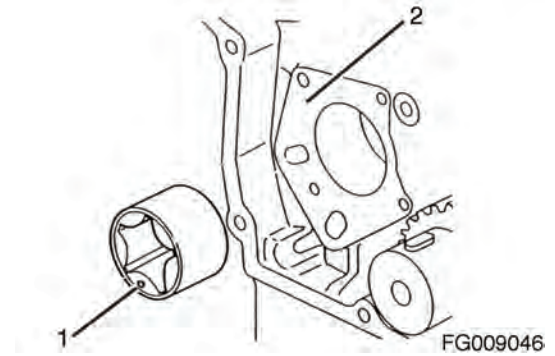


Figure 330

3. Reinstall the oil pump assembly (1, Figure 331) into the gear case housing (2, Figure 331). Tighten the bolts to specified torque.
4. Reinstall the gear case cover and crankshaft pulley. See "Installation of Gear Case Cover" on page -153.

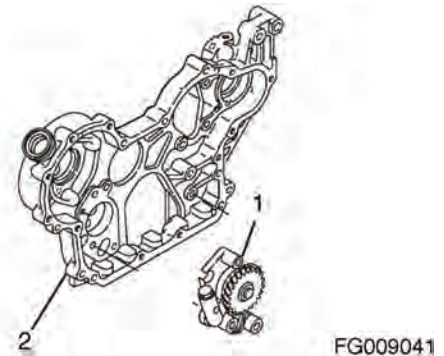


Figure 331

5. Reinstall the engine coolant pump V-pulley (1, Figure 332), spacer (2, Figure 332), engine cooling fan (3, Figure 332) and engine cooling fan guard (if equipped).
6. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in Check and Adjust Cooling Fan V-Belt on page 5-22.

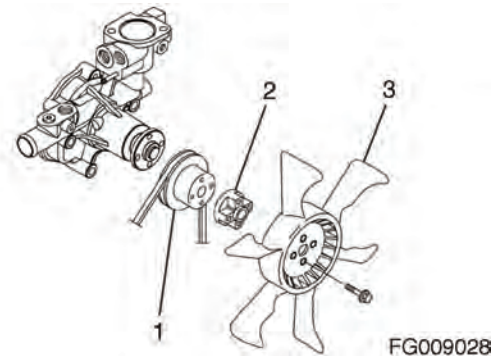


Figure 332

STARTER MOTOR

Before You Begin Servicing



WARNING

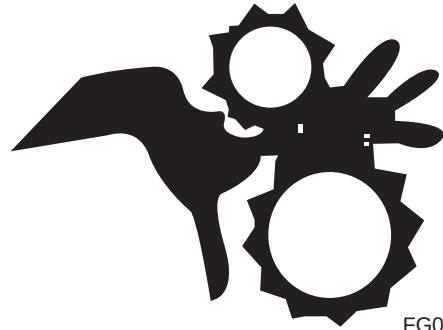
Entanglement Hazard!

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 333



WARNING

Shock Hazard!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.



FG009151

Figure 334



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 335



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.

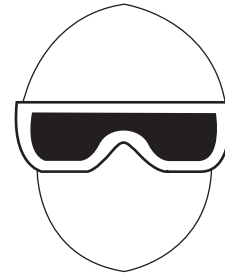


Figure 336

FG009152



CAUTION

The starter motor can be damaged if operated continuously longer than 10 seconds while performing the no-load test.



CAUTION

Make sure that the combined total resistance of the battery cable in both directions between the starter motor and the battery is within the value indicated on the wiring diagram. The starter motor will malfunction or break down if the resistance is higher than the specified value.



CAUTION

The starter motor is water-proofed according to JIS D 0203, R2 which protects the motor from rain or general cleaning. Do not use high-pressure wash or submerge the starter motor in water.



CAUTION

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

Introduction

This section of the Service Manual covers the servicing of the starter motor. Standard equipment on TNV model engine is used in this section to show the service procedures for a representative start motor and it may be different from actual equipment.

Starter Motor Specifications

Nominal Output			3.0 hp (2.3 kW)
Weight			12.1 lb (5.5 kg)
Revolution Direction (As Viewed From Pinion)			Clockwise
Engagement System			Magnetic Shift
No-load	Terminal Voltage / Current		11 V / 140 A max
	Revolution		4100 rpm (min ⁻¹)
	Terminal Voltage / Current		2.5 V / 1050 A max
	Torque		18 ft-lb (24.5 N•m; 2.5 kgf/m) minimum
Clutch System			Overrunning
Pinion Projection Voltage at 212°F (100 °C)			8.6 V max
Pinion DP or Module / Number of Teeth			M3/9
Difference (O-ring, Oil Seal)			Dry (none)
Application			Standard
Brush	Spring Force		7.868 lbf (35 N; 3.6 kgf)
	Height	Standard	0.591 in. (15 mm)
		Limit	0.354 in. (9 mm)
Magnetic Switch	Series Coil Resistance		0.27 W at 68°F (20°C)
	Shunt Coil Resistance		0.60 W at 68°F (20°C)
Commutator	Outside Diameter	Standard	1.437 in. (36.5 mm)
		Limit	1.398 in. (35 mm)
	Run-Out	Standard	0.001 in. (0.03 mm)
		Limit	0.008 in. (0.2 mm)
	Insulation Depth	Standard	0.020 - 0.031 in. (0.5 - 0.8 mm)
		Limit	0.008 in. (0.2 mm)
Armature	Run-Out	Standard	0.001 in. (0.03 mm)
		Limit	0.008 in. (0.02 mm)
Bearing Type	Armature Front	Nominal Number	6903DDU
	Armature Rear		608DDU
	Pinion Front		60004DDU
	Pinion Rear		6904DDU
Pinion Projection Length (Length L)			0.012 - 0.059 in. (0.3 - 1.5 mm)

Starter Motor Troubleshooting

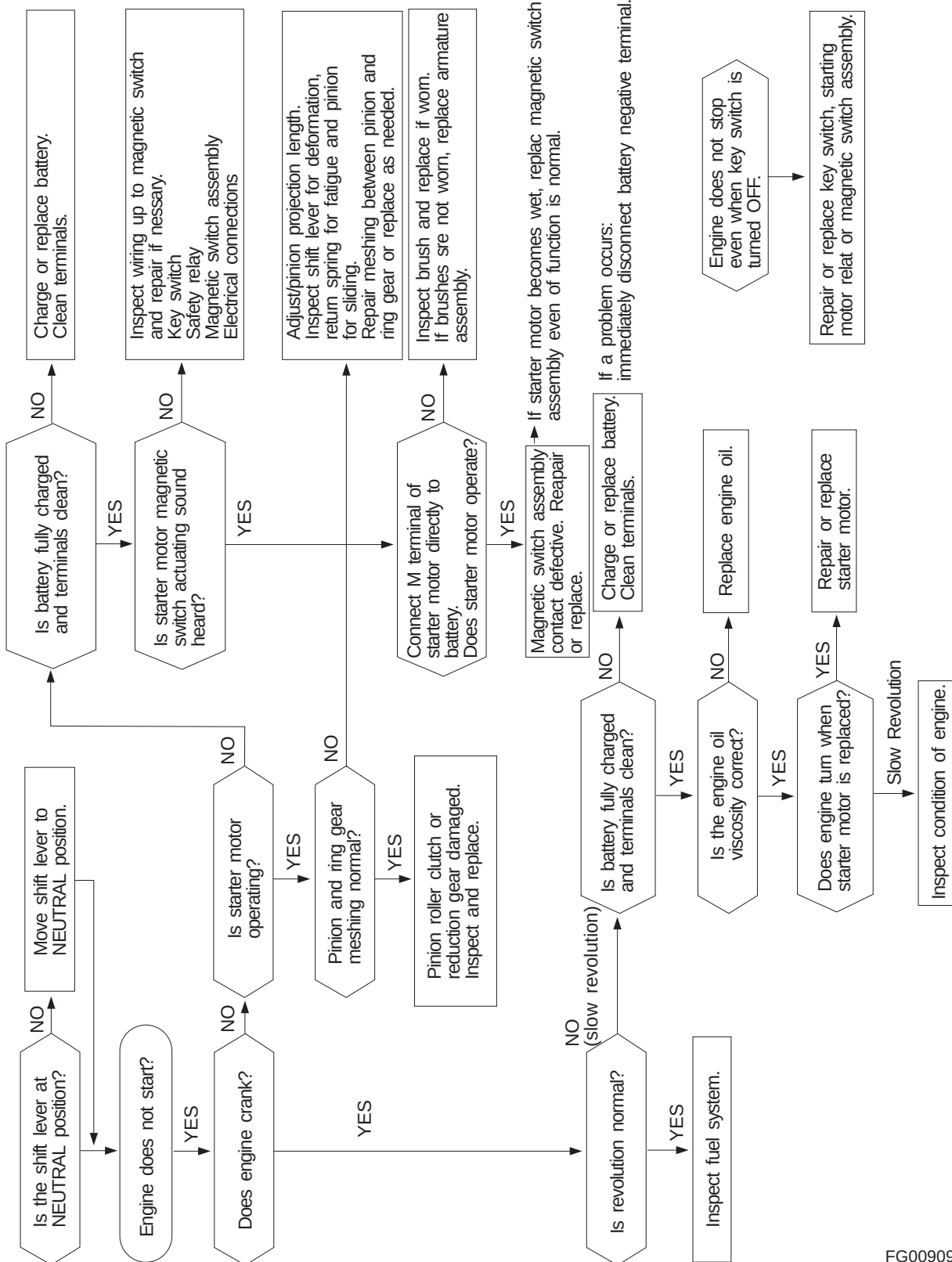
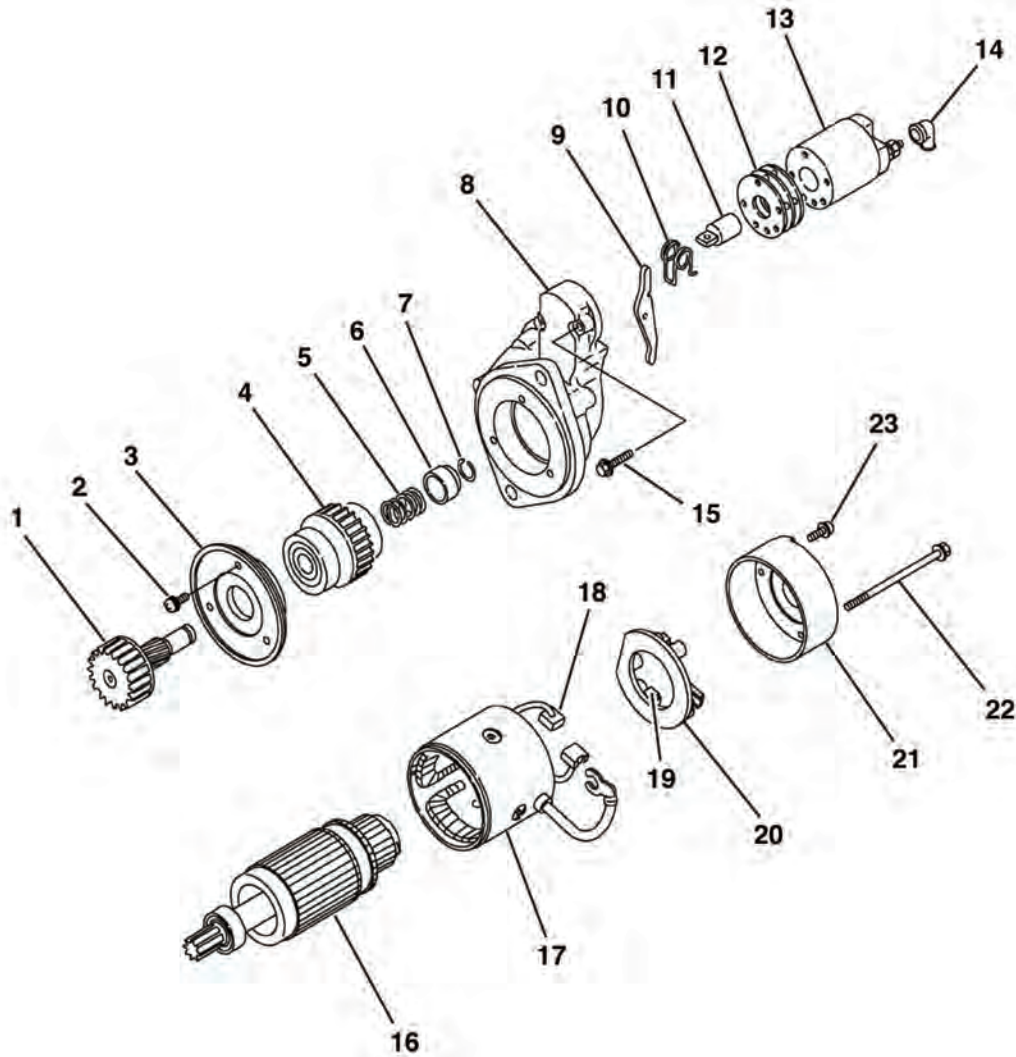


Figure 337

FG009097

Starter Motor Components



FG009061

Figure 338

Reference Number	Description
1	Pinion Shaft
2	M4 Bolts (3 used)
3	Bearing Retainer
4	Pinion Clutch Assembly
5	Return Spring
6	Pinion Stop
7	Retaining Ring
8	Gear Housing
9	Shift Lever
10	Torsion Spring
11	Plunger
12	Dust Covers (Shims)

Reference Number	Description
13	Magnetic Switch Assembly (Solenoid)
14	Cover
15	M6 Bolts (2 used)
16	Armature Assembly
17	Field Coil Assembly
18	Positive (+) Brushes
19	Negative (-) Brushes
20	Brush Holder Assembly
21	Rear Cover
22	M5 Through Bolts (2 used)
23	M4 Bolts (2 used)

Starter Motor



WARNING

Shock Hazard!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. Always keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.

NOTE: While starter motor design varies between models, the basic repair procedures are the same. The following procedures are typical and may differ from the stater being serviced.

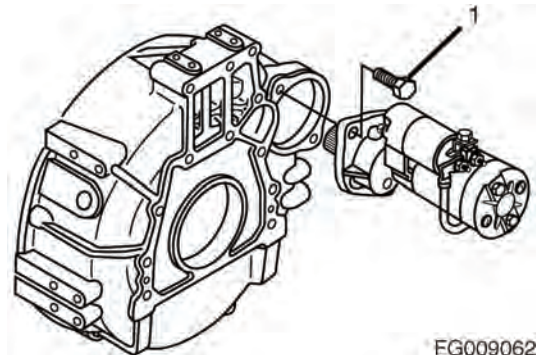


FG009151

Figure 339

Removal of Starter Motor

1. Disconnect the battery cables at the battery, negative (-) cable first.
2. Remove the electrical wires from the magnetic switch assembly.
3. Remove the starter mounting bolts (1, Figure 340). Remove the starter motor from the flywheel housing.

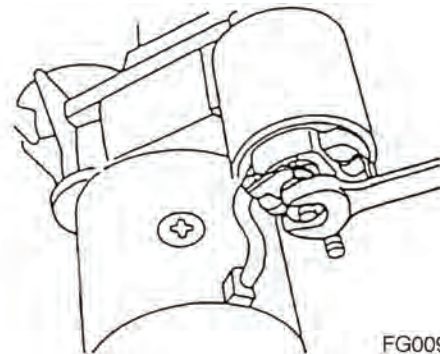


FG009062

Figure 340

Disassembly of Starter Motor

1. Loosen the M8 nut from the magnetic switch (solenoid) assembly (Figure 341). Disconnect the wire from the magnetic switch.



FG009063

Figure 341

2. Remove the two M4 bolts (1, Figure 342) securing the rear cover (2, Figure 342) to the brush holder assembly (3, Figure 342).
3. Remove the two M5 through bolts (4, Figure 342). Separate the rear cover (2, Figure 342), field coil assembly (5, Figure 342) with the armature assembly (6, Figure 342) from the gear housing (7, Figure 342).

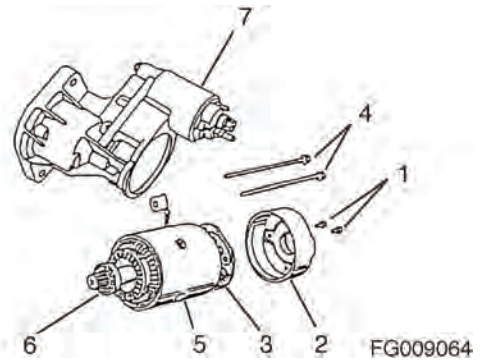


Figure 342

4. Pull the brush springs up using a brush spring puller. On the negative (-) side, bring the brush spring into contact with the side of the brush for lifting from the commutator surface. On the positive (+) side, remove the brush from the brush holder assembly (1, Figure 343).

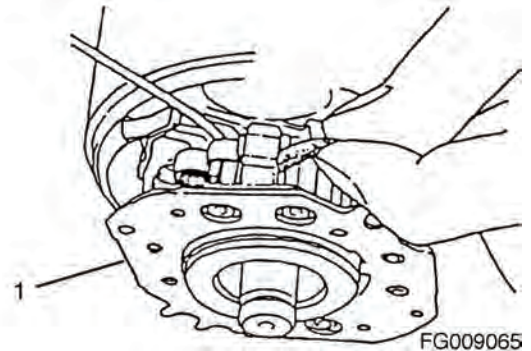


Figure 343

5. Remove the brush holder assembly (1, Figure 344) from the armature assembly (3, Figure 344).
6. Pull the armature assembly (3, Figure 344) out from the field coil assembly (2, Figure 344).

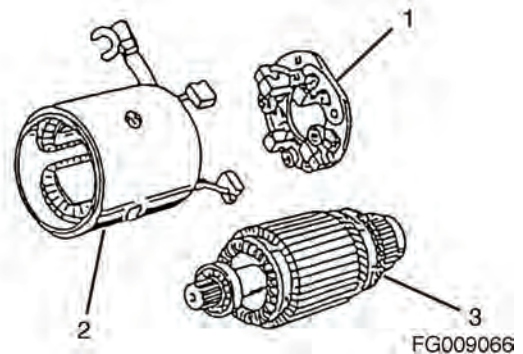


Figure 344

7. Remove the two M6 bolts (1, Figure 345) retaining the magnetic switch assembly (2, Figure 345) to the gear housing. Remove the magnetic switch assembly, dust cover(s) (3, Figure 345) and torsion spring (4, Figure 345) from the gear housing.

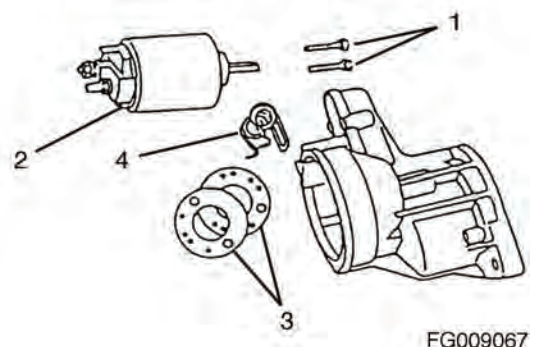


Figure 345

8. Disassemble the dust cover (3, Figure 346) and shift the lever (4, Figure 346) from the gear housing.

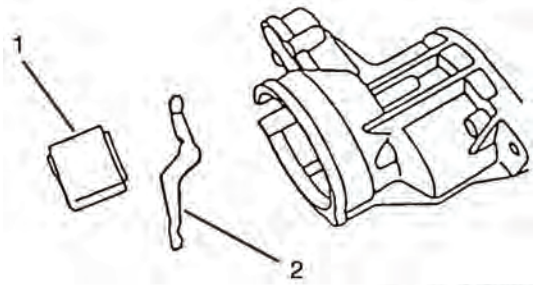


Figure 346

FG009068

9. Remove the three M4 bolts (1, Figure 347) securing the bearing retainer assembly (2, Figure 347) to the gear housing. Remove the bearing retainer assembly from the gear housing.
10. Remove the pinion clutch assembly (3, Figure 347) from the bearing retainer assembly.

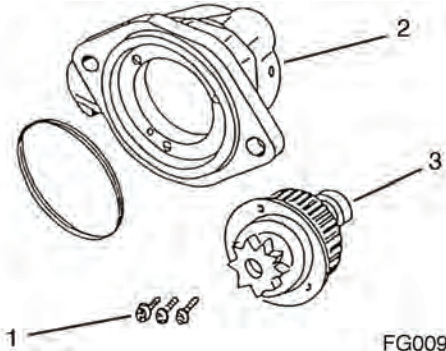


Figure 347

FG009069

11. Using a flat-blade screwdriver, remove the retaining ring (1, Figure 348) from the shaft of the pinion.

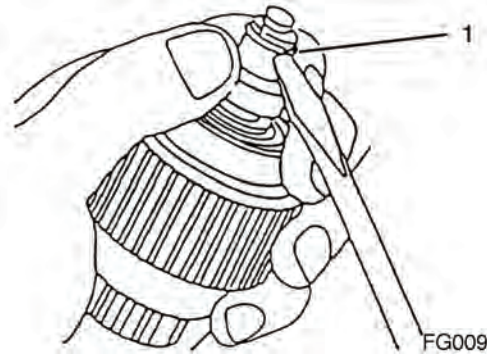


Figure 348

FG009070

12. Disassemble the pinion stop (3, Figure 349), return spring (4, Figure 349), pinion clutch assembly (1, Figure 349), and pinion shaft (5, Figure 349).

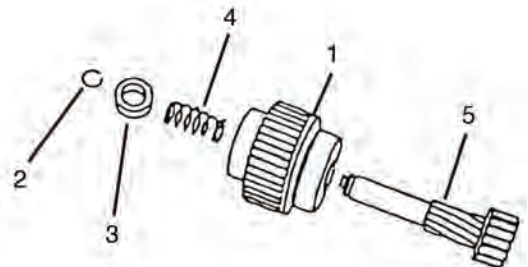


Figure 349

FG009071

Cleaning and Inspection

Armature

Commutator Surface Inspection

if the commutator is rough, polish the surface with a #500 to #600 emery cloth (Figure 350).

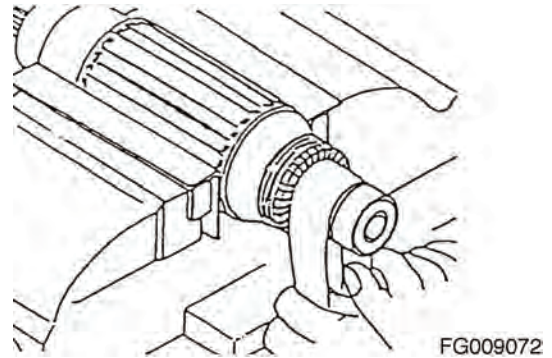


Figure 350

Measure Commutator Outside diameter

Measure Commutator Outside diameter (Figure 351). Replace the armature if the measurement is less than the limit.

See "Starter Motor Specifications" on page -215. for the service limit.

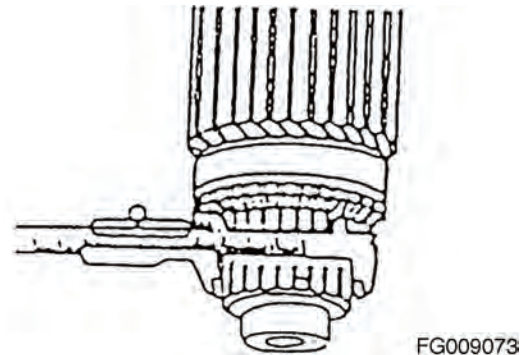


Figure 351

Measure Commutator Insulation Depth

Measure the depth of the insulating material (1, Figure 352) between commutator segments (2, Figure 352). If the depth measures less than the limit, use a hacksaw blade (3, Figure 352) to remove the insulating material until the depth is within the limit.

A normal commutator condition is indicated in (4, Figure 352). An abnormal commutator condition is indicated in (5, Figure 352).

See "Starter Motor Specifications" on page -215. for the service limit.

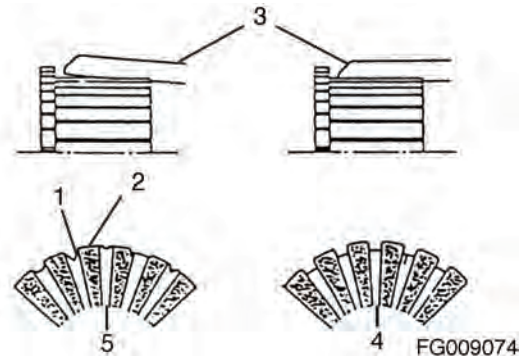
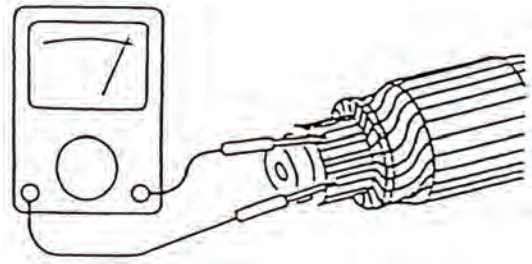


Figure 352

Armature Coil Continuity Test

Check for continuity between the commutator segments using a multimeter (Figure 353). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the armature.



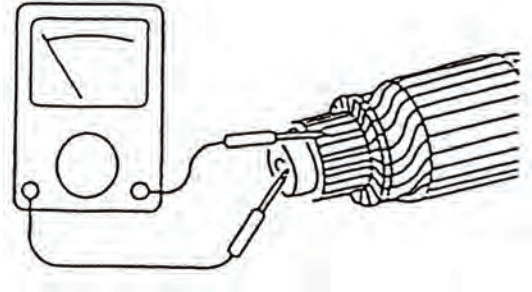
FG009075

Figure 353

Armature Coil Insulation Test

Check for continuity between a commutator segment and the shaft or armature using a multimeter (Figure 354). The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the armature.



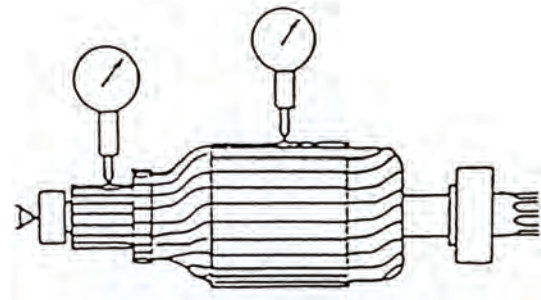
FG009076

Figure 354

Measure Armature and Commutator Run-Outs

Measure the armature core run-out and the commutator run-out using a dial indicator (Figure 355). Replace the armature if either of the measurements is less than the limit.

See "Starter Motor Specifications" on page -215. for the service limit.



FG009077

Figure 355

Field Coil

Field Coil Continuity Test

Check for continuity between the field coil terminals using a multimeter (Figure 356). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the field coil assembly.

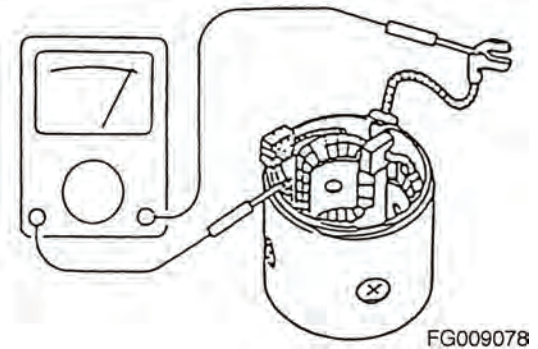


Figure 356

FG009078

Field Coil Insulation Test

Check for continuity between the field coil terminal and the yoke using a multimeter (Figure 357). The multimeter should not indicate continuity.

If the multimeter indicates continuity, replace the field coil assembly.

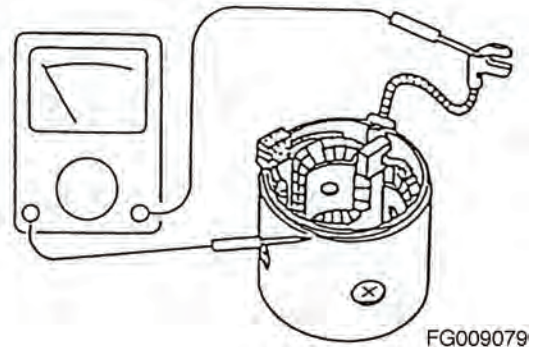


Figure 357

FG009079

Measure Brush Length

Measure the length of the brush (Figure 358). Replace the brush if the length is less than the limit.

See "Starter Motor Specifications" on page -215. for the service limit.

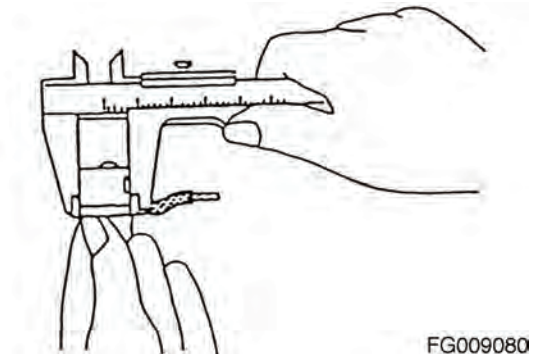


Figure 358

FG009080

Magnetic Switch

If the starter motor becomes wet, replace the magnetic switch even if the magnetic switch assembly function is normal.

Shunt Coil Continuity Test

Check for continuity between the "S" terminal and the switch body using a multimeter (Figure 359). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

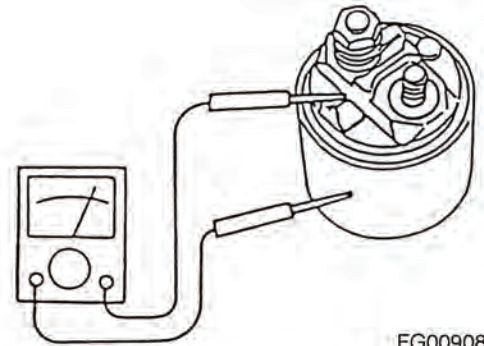


Figure 359

FG009081

Series Coil Continuity Test

Check for continuity between the "S" and "M" terminals using a multimeter (Figure 360). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

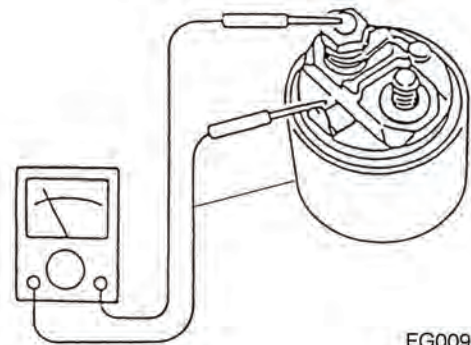


Figure 360

FG009082

Coil Resistance Test

See "Starter Motor Specifications" on page -215. for the service limit.

Contact Continuity Test

Depress the plunger at the bottom of the magnetic switch. Check for continuity between the "B" and "M" terminals using a multimeter (Figure 361). The multimeter should indicate continuity.

If the multimeter does not indicate continuity, replace the magnetic switch.

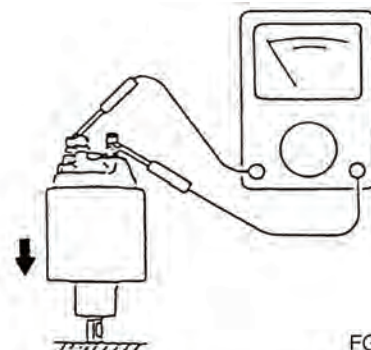


Figure 361

FG009083

Pinion Clutch Assembly

Pinion Clutch Assembly Inspection

Manually rotate the pinion clutch assembly in the drive direction (Figure 362). It should rotate freely in the drive direction and is locked by turning it in the opposite direction. Replace the pinion clutch assembly if the results are different.

Slide the pinion clutch assembly on the shaft. It should slide smoothly on the shaft (Figure 363). Rust, too much grease or damage could prevent the pinion clutch from sliding smoothly. If the pinion clutch assembly does not slide smoothly, clean the shaft and pinion clutch assembly or replace the damaged component.

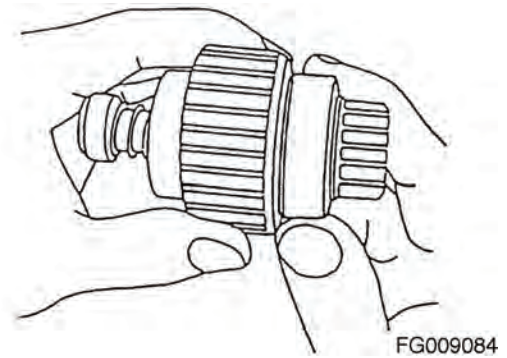


Figure 362

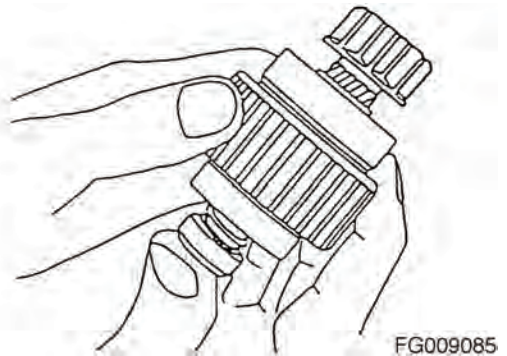


Figure 363

Ball Bearing Inspection

Rotate each ball bearing while holding the pinion clutch assembly (Figure 364). Replace the ball bearing if it does not rotate smoothly or has excessive play.

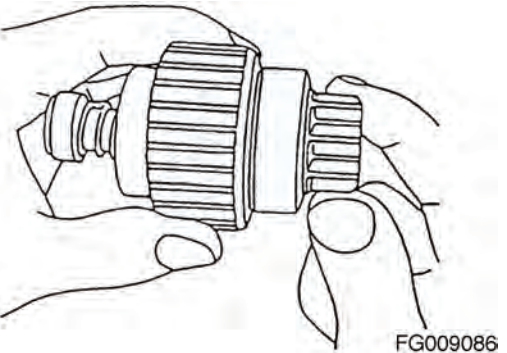
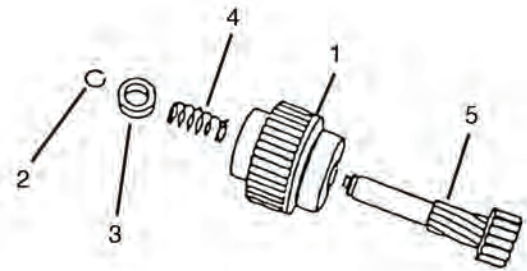


Figure 364

Reassembly of Starter Motor

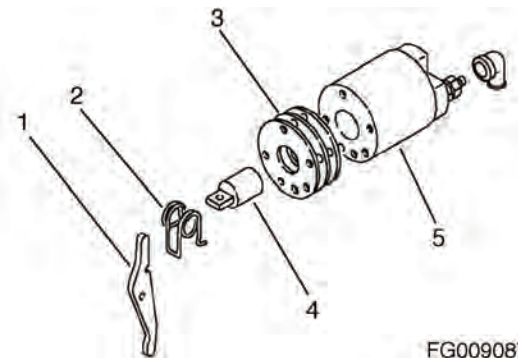
1. Apply appropriate starter bendix grease (obtain locally) to the pinion shaft. Reassemble the pinion shaft (5, Figure 365), pinion clutch assembly (1, Figure 365), return spring (4, Figure 365) and pinion stop (3, Figure 365). Reinstall the retaining ring (2, Figure 365) in the groove in the pinion 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.



FG009071

Figure 365

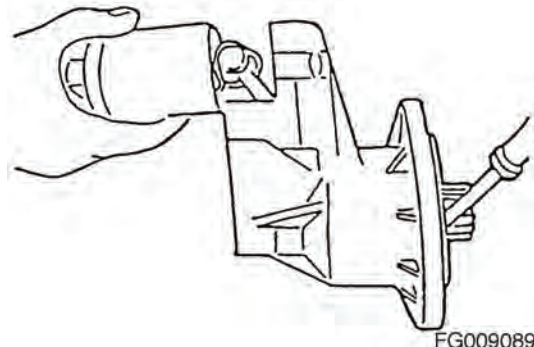
4. Apply a small amount of high temperature lithium grease (obtain locally) to the sliding portions of the shift lever (1, Figure 366). Reassemble the torsion spring (2, Figure 366), shift lever and dust cover(s) (3, Figure 366), plunger (4, Figure 366) and magnetic switch assembly (5, Figure 366).



FG009087

Figure 366

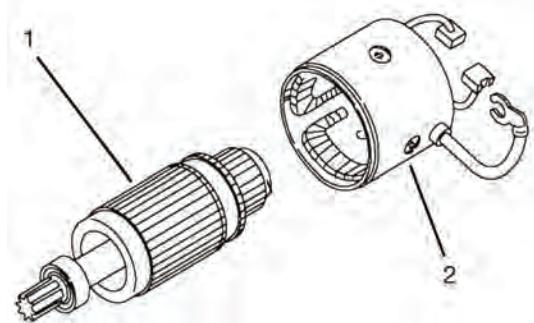
5. Reassemble the magnetic switch assembly to the gear housing. Pry the pinion away from the gear housing to allow installation of the magnetic switch assembly (Figure 367).
6. Secure the magnetic switch assembly to the gear housing using the two M6 bolts.



FG009089

Figure 367

7. Carefully install the armature assembly (1, Figure 368) into the field coil assembly (2, Figure 368).



FG009090

Figure 368

8. Position the brush springs in brush holders (Figure 369). Reinstall the brushes in the brush holders. Reversing the brushes will cause the starter motor to turn backwards.
9. Carefully install the brush holder assembly to the armature assembly.
10. Reinstall the field coil assembly with the armature assembly to the gear housing.
11. Reinstall the rear cover to the brush holder assembly. Securely tighten the two bolts.

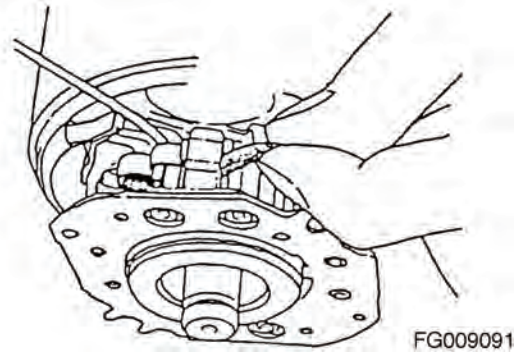


Figure 369

12. Reinstall the two M4 through bolts (Figure 370). Securely tighten the through bolts. Reconnect the wire to the magnetic switch assembly. Tighten the M8 nut. Reinstall the cover over the connection.

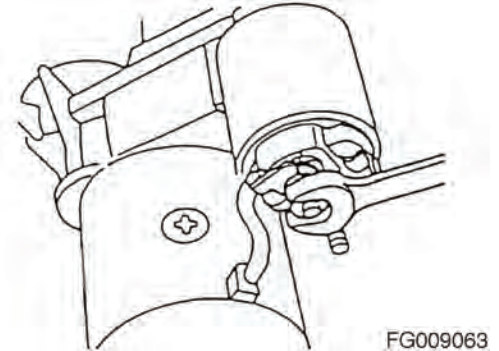
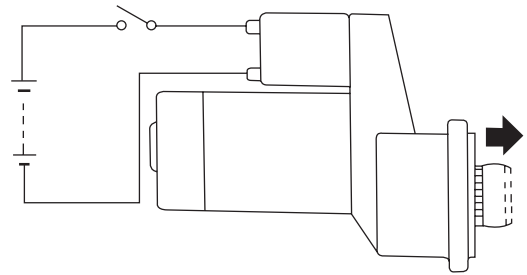


Figure 370

Check Pinion Projection Length

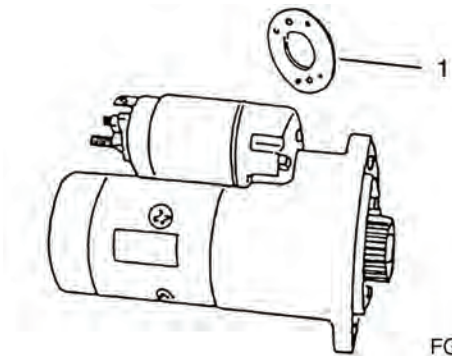
1. Connect the positive (+) lead from a battery to the "S" terminal.
2. Connect the negative (-) lead to the "M" terminal.
3. Lightly pull the pinion away from the gear housing.
4. Turn the switch ON and measure the pinion moving distance L in the thrust direction (Figure 371). Perform this test within 10 seconds. See "Starter Motor Specifications" on page -215. for the service limit.



FG009092

Figure 371

5. If the measured L dimension is outside the standard range, adjust the dust covers to obtain the standard range. Dust cover (1, Figure 372) are available in 0.020 in (0.5 mm) and 0.031 in 0.8 mm) thicknesses.



FG009093

Figure 372

No-Load Test

Test the characteristics of the starter motor by performing a no-load test.

CAUTION

The starter motor can be damaged if operated continuously longer than 10 seconds while performing the no-load test.

1. Secure the starting motor in a vise or other suitable fixture.
2. Connect an ammeter (1, Figure 373) in series between the battery positive (+) terminal (2, Figure 373) and the main positive (+) terminal (3, Figure 373) on the starter motor.

NOTE: *The ammeter and all wire leads used in this test must have a capacity equal to or greater than the amperage draw specification for the starter motor being tested.*

3. Connect a wire lead between the mounting base of the starter motor (4, Figure 373) and the battery negative terminal (5, Figure 373).
4. Connect a voltmeter (7, Figure 373) to the battery negative (-) terminal (5, Figure 373) and the main positive (+) battery terminal (3, Figure 373) on the starter motor.
5. Install a switch (6, Figure 373) in a circuit between the battery positive (+) terminal (2, Figure 373) and the starter magnetic switch (solenoid) terminal (8, Figure 373) on the starter motor.
6. Use a suitable tachometer to monitor the rpm of the starter.
7. Turn the switch to the ON position. Monitor the rpm, amperage draw and voltage. For test specifications, for the appropriate starter motor.

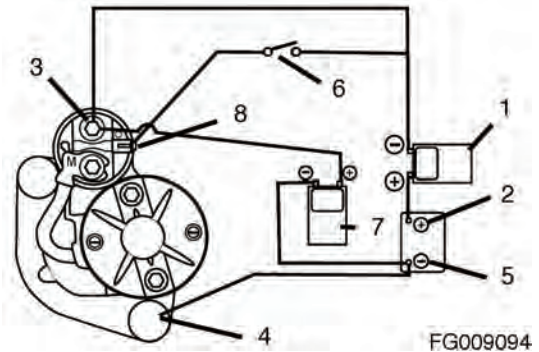


Figure 373

FG009094

Installation of Starter Motor

1. Reinstall the starter motor to the flywheel housing.
2. Reinstall the starter mounting bolts (1, Figure 374). Tighten the bolts to specification. See "Tightening Torques For Standard Bolts And Nuts" on page -48.
3. Reconnect the electrical wires to the magnetic switch assembly (solenoid). Be sure to place the cover over the battery positive (+) cable connection.
4. Reconnect the battery cables at the battery.

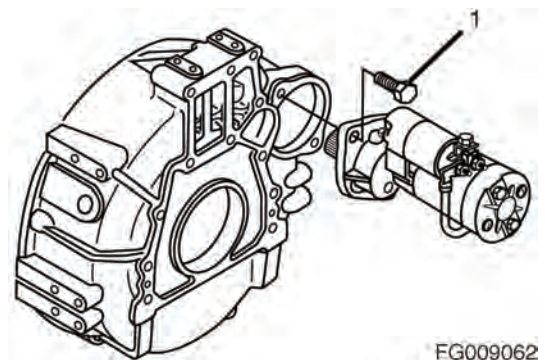


Figure 374

FG009062

ALTERNATOR

Before You Begin Servicing



WARNING

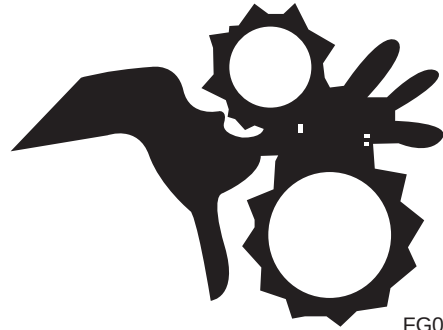
ENTANGLEMENT HAZARD!

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 375



WARNING

SHOCK HAZARD!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. ALWAYS keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.



FG009151

Figure 376

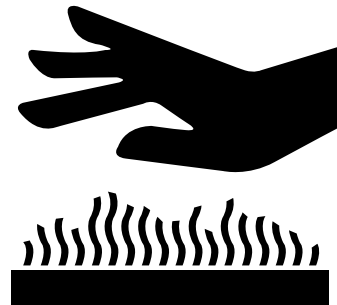


WARNING

BURN HAZARD!

Keep your hands and other body parts away from hot engine surfaces such as the muffler, exhaust pipe, 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 377



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.



Figure 378

FG009153



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.

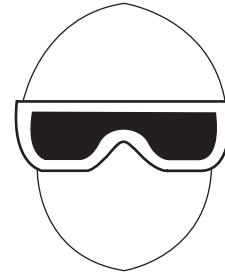


Figure 379

FG009152



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.

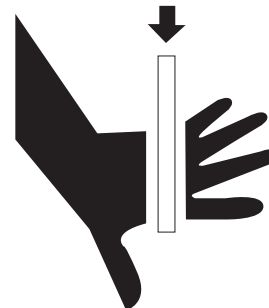


Figure 380

FG009155



CAUTION

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

Read and understand this Operation Manual before you operate or service the machine to ensure that you follow safe operating practices and maintenance procedures.

Machine safety signs and labels are additional reminders for safe operating and maintenance techniques.

See your authorized *DOOSAN* dealer or distributor for additional training.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

Do not use a high-pressure wash directly on the alternator. Water will damage the alternator and result in inadequate charging.

Introduction

This section of the Service Manual describes the servicing of the dynamos and alternators. Standard equipment on TNV model engine is used in this section to show the service procedures for a representative dynamos and alternators and it may be different from actual equipment.

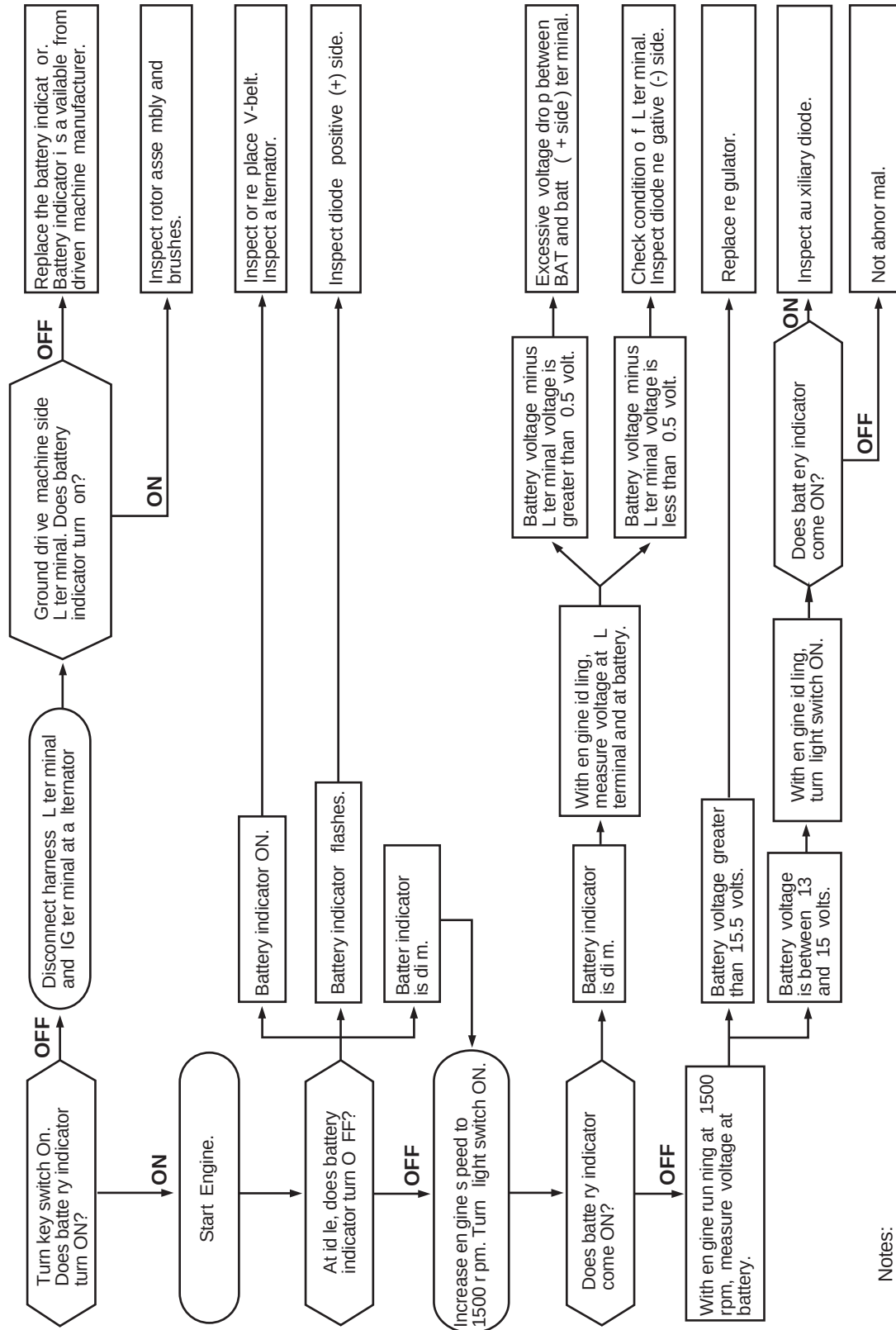
Alternator Specifications

Nominal Output (13.5 Volts Heat)	40 Amps
Weight	6.17 lb (2.8 kg)
Revolution Direction (As Viewed From Pulley)	Clockwise
Rating	Continuous
Battery Voltage	12 Volts
Rated Revolution	5000 rpm (min ⁻¹)
Operating Range	1350 - 18000 rpm (min ⁻¹)
Grounding Characteristics	Negative (-) Side of Circuit
Integrated Regulator	IC Regulator
Outside Diameter of Pulley	2.724 in. (69.2 mm)
Belt Shape	Type A

Dynamo Specifications

Nominal Output (13.5 Volts Heat)		20 Amps
Weight		3.97 lb (1.8 kg)
Revolution Direction (As Viewed From Pulley)		Clockwise
Rating		Continuous
Battery Voltage		12 Volts
Rated Revolution		3500 rpm
Operating Range		1400 - 6600 rpm
Grounding Characteristics		Negative (-) Side of Circuit
Integrated Regulator		IC Regulator
Outside Diameter of Pulley	A-Belt	2.56 in. (65 mm)
	Special M-Belt	2.28 in. (58 mm)
Belt Shape		Type A or Type Special M

Alternator Troubleshooting



Notes:

- 1) Use a fully charged battery
- 2) DC voltmeter: 0 to 30 V, 0.5 class
- 3) The check method is applicable to the bench test

FG009100

Figure 381

Alternator Components

Standard alternator is used in this section to show the service procedures for the representative alternator. For specific part detail, see the Parts Catalog for the engine you are working on.

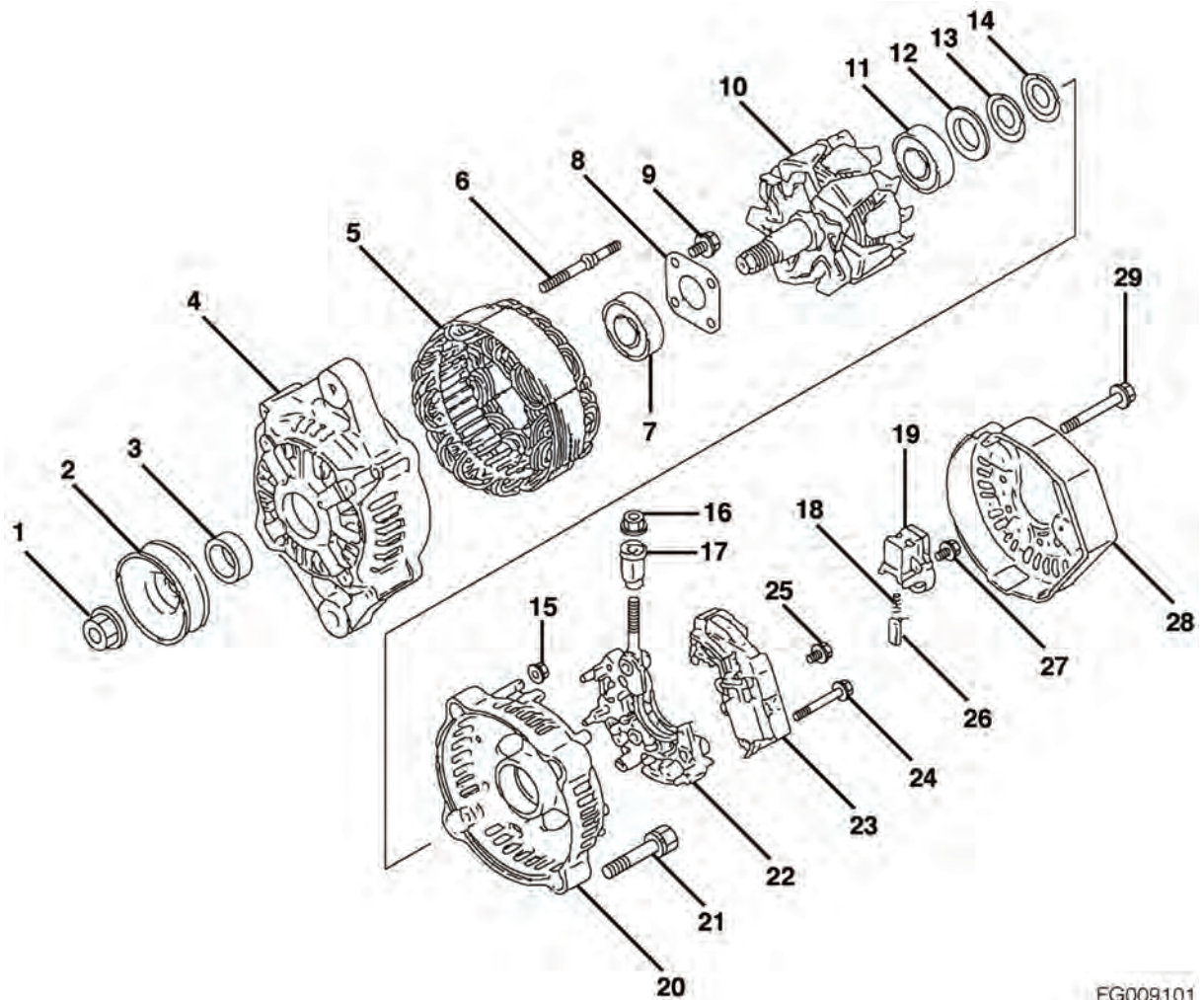


Figure 382

FG009101

Reference Number	Description
1	Nut
2	Pulley
3	Collar
4	Front Frame Housing
5	Stator Assembly
6	Stud (2 used)
7	Front Frame Housing Bearing
8	Bearing Cover
9	Bearing Cover Bolt (4 used)
10	Rotor Assembly
11	Rear Frame Housing Bearing
12	Bearing Cover
13	Thrust Washer
14	Thrust Washer
15	Nut (2 used)

Reference Number	Description
16	Nut
17	Insulation Bushing
18	Spring (2 used)
19	Brush Holder
20	Rear Frame Housing
21	Bolt (2 used)
22	Holder
23	IC Regulator Assembly
24	Bolt (2 used)
25	Bolt
26	Brush (2 used)
27	Bolt
28	Rear Cover
29	Bolt (3 used)

Alternator Wiring Diagram

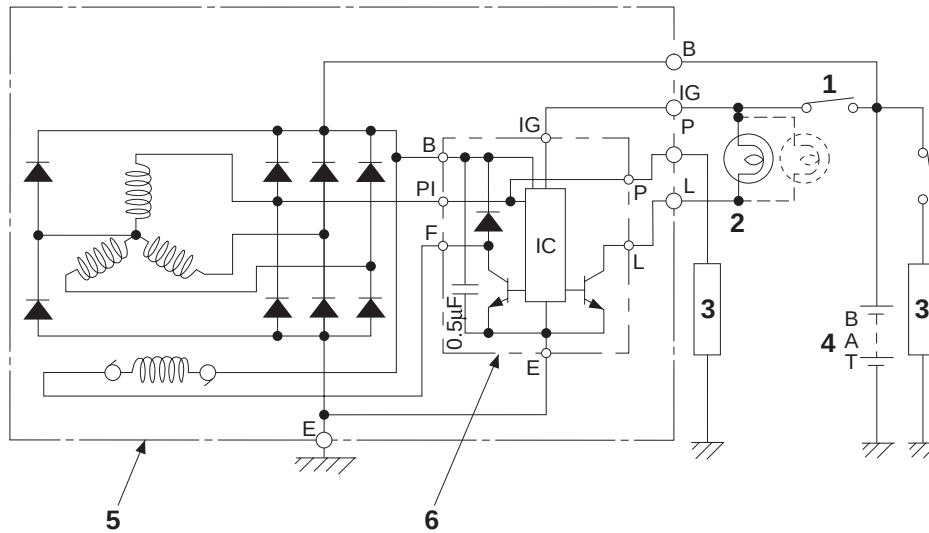


Figure 383

FG009102

Reference Number	Description
1	Key Switch
2	Charge Lamp (3.4 Watts Max.)
3	Load

Reference Number	Description
4	Battery
5	Alternator Assembly
6	IC Regulator Assembly

CAUTION

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

CAUTION

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

CAUTION

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

Alternator Standard Output

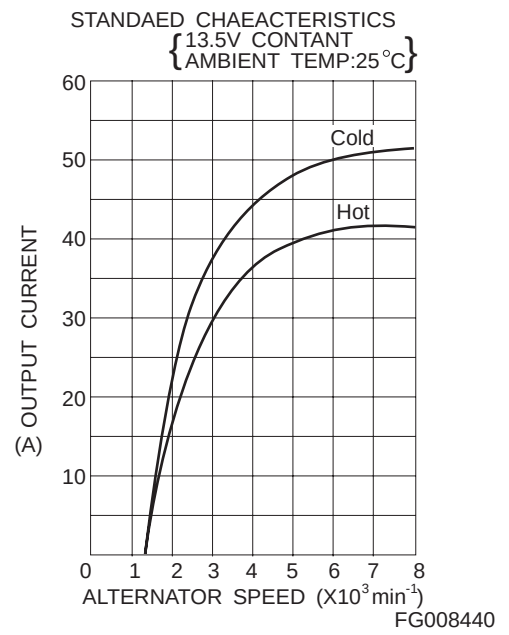


Figure 384

Alternator



WARNING

SHOCK HAZARD!

Turn off the battery switch (if equipped) or disconnect the negative battery cable before servicing the electrical system.

Check the electrical harnesses for cracks, abrasions, and damaged or corroded connectors. ALWAYS keep the connectors and terminals clean.

Failure to comply could result in death or serious injury.



FG009151

Figure 385

Removal of Alternator

1. Disconnect the electrical wires from the alternator.
2. Loosen the V-belt.

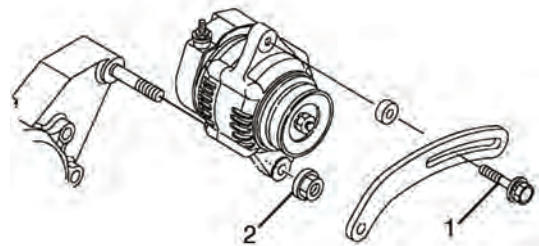


CAUTION

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.

3. Remove the V-belt adjuster from the alternator bolt (1, Figure 386).
4. Remove the nut (2, Figure 386) from the gear case stud. Remove the alternator.



FG009103

Figure 386

Disassembly of Alternator

1. Remove the nut (1, Figure 387) from the shaft of the rotor assembly. Remove the pulley (2, Figure 387).

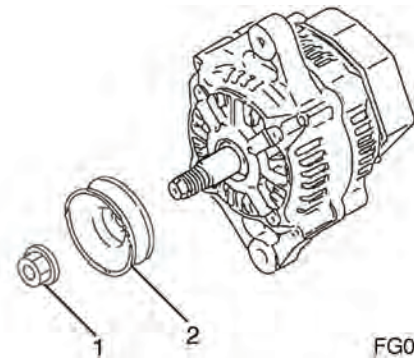


Figure 387

FG009104

2. Remove the three bolts (1, Figure 388) retaining the rear cover (2, Figure 388) to the rear frame assembly.
3. Remove the brush holder (3, Figure 388). Remove the brush springs (4, Figure 388) and brushes (5, Figure 388).

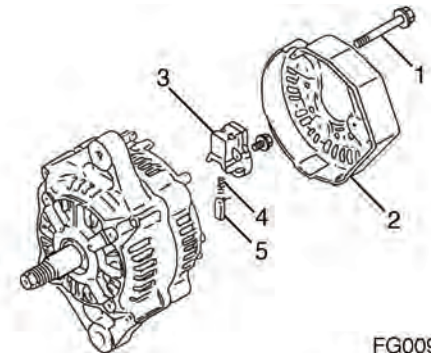


Figure 388

FG009105

4. Remove the bolt retaining the regulator assembly (1, Figure 389) to the holder (2, Figure 389).
5. Remove the bolts retaining the holder (2, Figure 389) to the rear frame housing. Remove the holder.
6. Remove the nut (3, Figure 389) retaining the insulation bushing (4, Figure 389). Remove the insulation bushing.

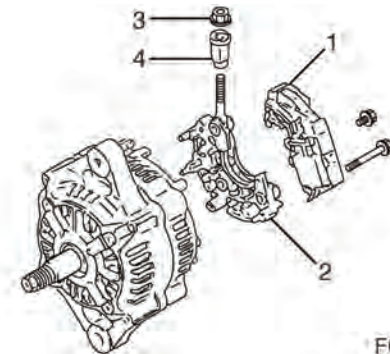


Figure 389

FG009106

7. Remove the two bolts (1, Figure 390) and two nuts (2, Figure 390) securing the rear frame housing to the front frame housing.

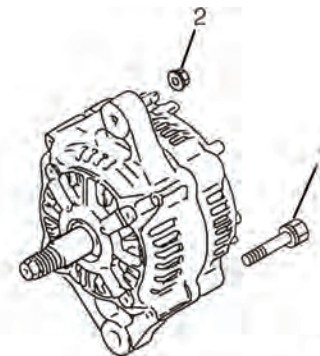
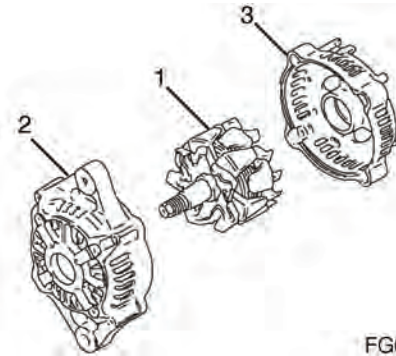


Figure 390

FG009107

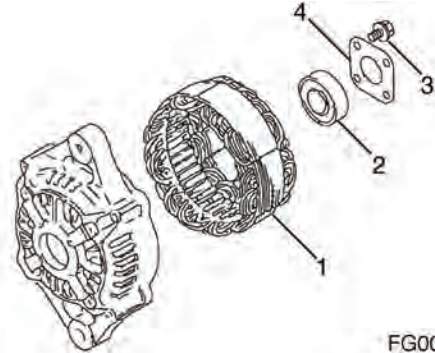
8. Using a press, remove the rotor assembly (1, Figure 391) from the front frame housing (2, Figure 391) and rear frame housing (1, Figure 391).



FG009108

Figure 391

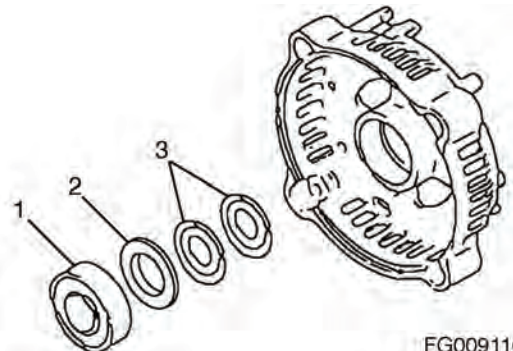
9. Remove the stator assembly (1, Figure 392) from the front frame housing.
10. If it is necessary to replace the bearing (2, Figure 392) in the front frame housing, remove the four bolts (3, Figure 392) securing the plate (4, Figure 392) to the front frame housing. Remove the plate. Use a puller to remove the bearing. Discard the bearing.



FG009109

Figure 392

11. If it is necessary to replace the bearing (1, Figure 393) in the rear frame housing, use a puller to remove. Discard the bearing. Remove the bearing cover (2, Figure 393) and two thrust washers (3, Figure 393).



FG009110

Figure 393

Reassembly of Alternator

1. If removed, reinstall the two trust washers (3, Figure 394) and bearing cover (2, Figure 394) in the rear frame housing. Lubricate the outside diameter of a new bearing (1, Figure 394). Press the bearing into the rear frame housing.

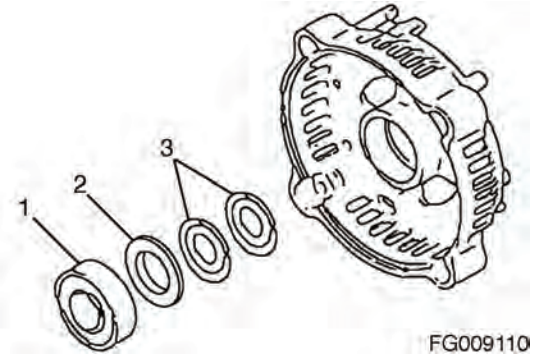


Figure 394

FG009110

2. If removed, lubricate the outside diameter of a new front frame housing bearing. Press the bearing (2, Figure 395) into the front frame housing. Reinstall the plate (4, Figure 395) to the front housing. Tighten the four bolts (3, Figure 395).
3. Position the stator assembly (1, Figure 395) on the front frame housing studs.

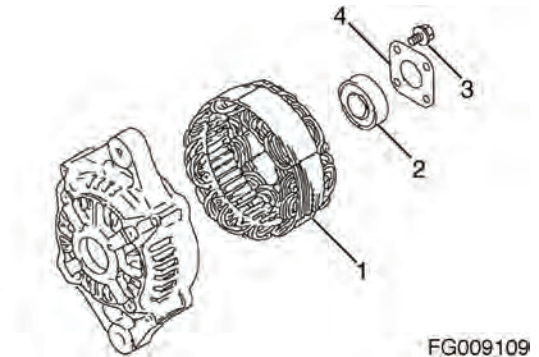


Figure 395

FG009109

4. Lubricate the shaft of the rotor assembly (1, Figure 396). Press the rotor assembly into the front frame housing (2, Figure 396) and rear frame housing (3, Figure 396).

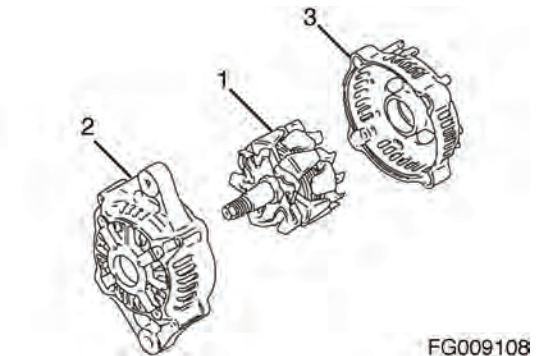


Figure 396

FG009108

5. Align the front frame housing with the rear frame housing. Reinstall the two bolts (1, Figure 397) and two nuts (2, Figure 397).

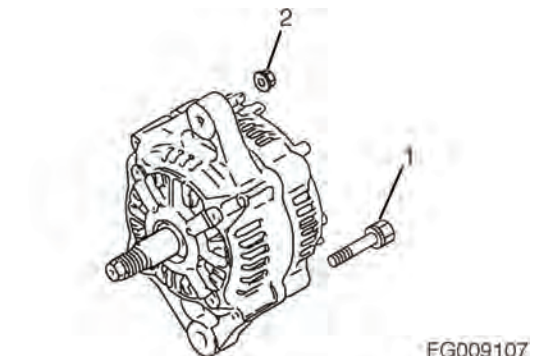
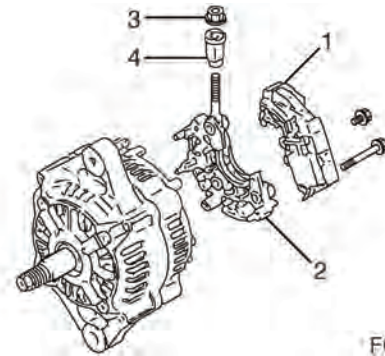


Figure 397

FG009107

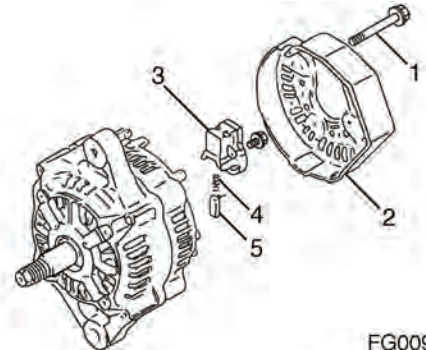
6. Reinstall the insulation bushing (4, Figure 398) and nut (3, Figure 398).
7. Reassemble the regulator assembly (1, Figure 398) to the holder (2, Figure 398).



FG009106

Figure 398

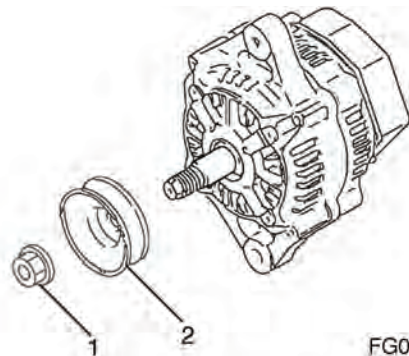
8. Reinstall the brush holder (3, Figure 399), springs (4, Figure 399) and brushes (5, Figure 399).
9. Reattach the regulator assembly and holder to the rear frame housing.
10. Reinstall the rear cover (2, Figure 399) to the rear frame housing with three bolts (1, Figure 399).



FG009105

Figure 399

11. Reassemble the pulley (2, Figure 400) and nut (1, Figure 400) to the shaft of the rotor assembly. Tighten the nut.



FG009104

Figure 400

Installation of Alternator

1. Position the alternator on the gear case. Loosely reinstall the nut (2, Figure 401) on the gear case stud and the V-belt adjuster bolt (1, Figure 401).
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 "Check and Adjust Cooling Fan V-Belt" on page -81.
4. Start the engine. Listen for any unusual sounds from the alternator.

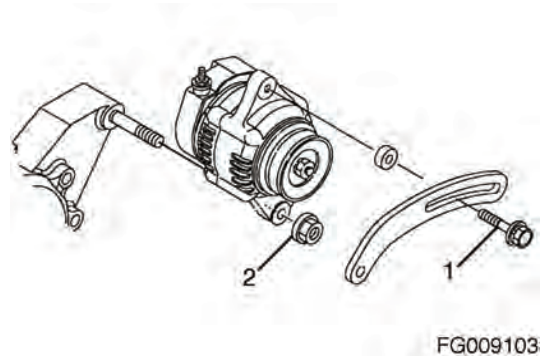


Figure 401



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.

Dynamo Component Location

Standard dynamo is used in this section to show the service procedures for the representative dynamo. For specific part detail, see the Parts Catalog for the engine you are working on.

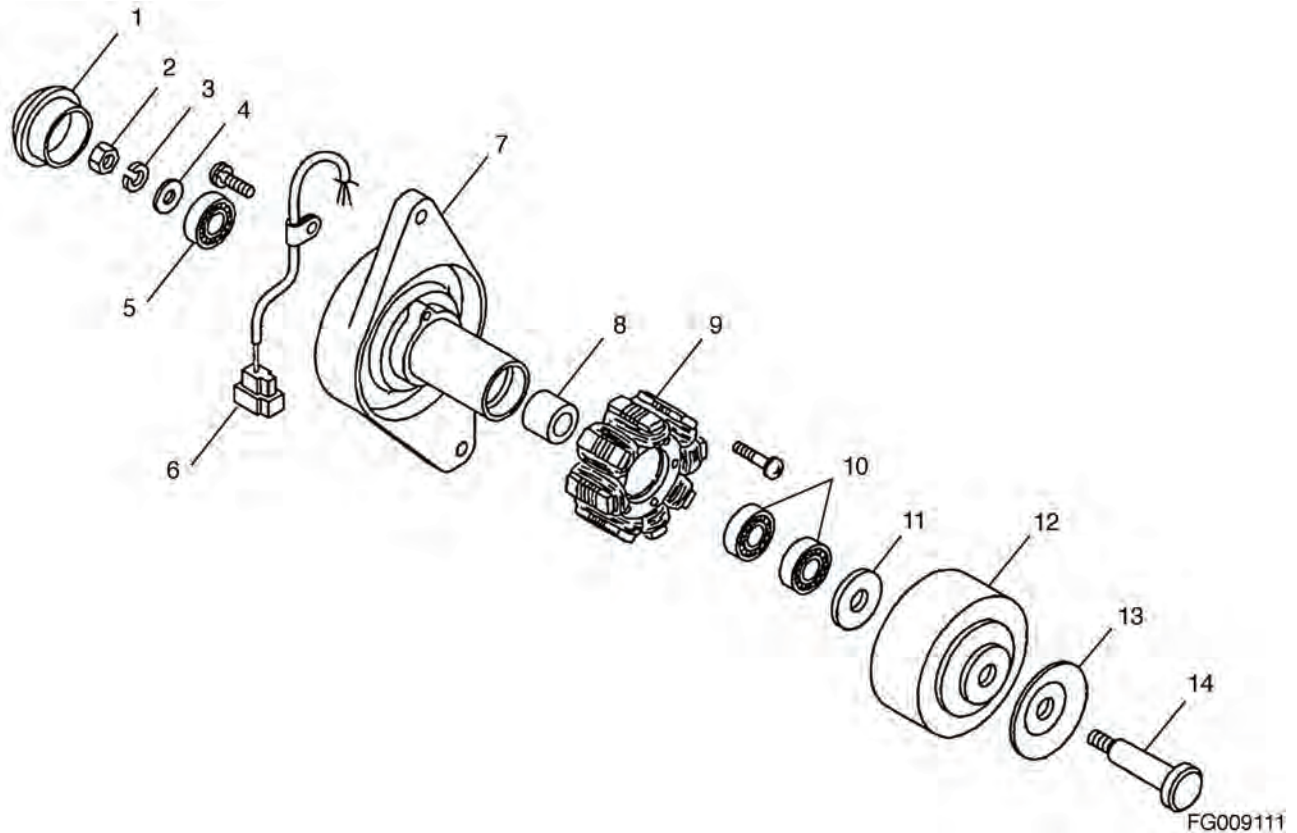


Figure 402

Reference Number	Description
1	Rear Cover
2	Nut
3	Lock Washer
4	Flat Washer
5	Rear Bearing
6	Output Wire and Connector
7	Plate

Reference Number	Description
8	Spacer
9	Stator Assembly
10	Front Bearing (2 used)
11	Flat Washer
12	Flywheel Assembly
13	Pulley Half
14	Through Bolt

Dynamo Wiring Diagram

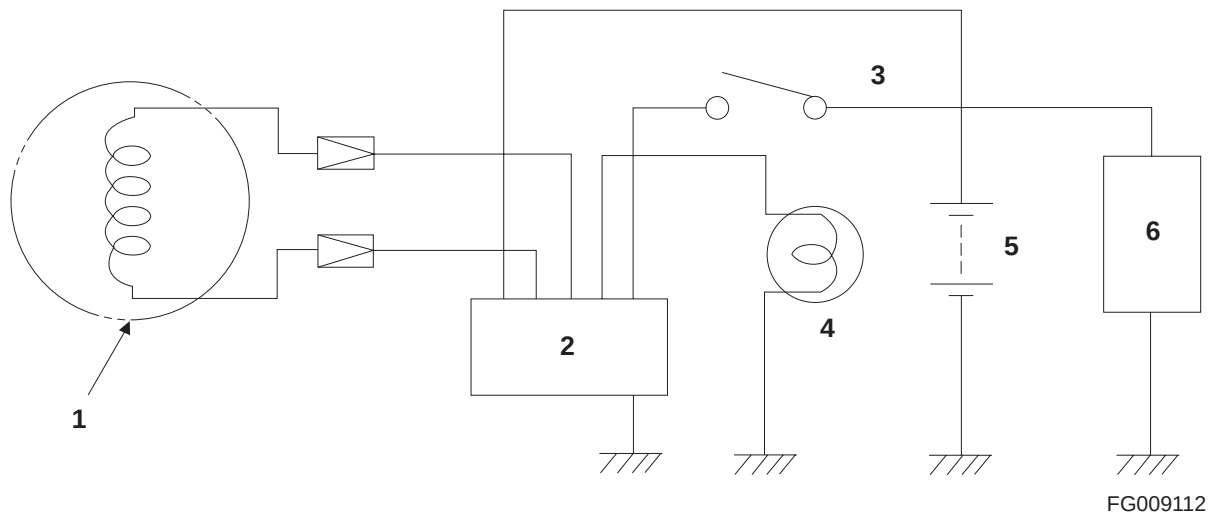


Figure 403

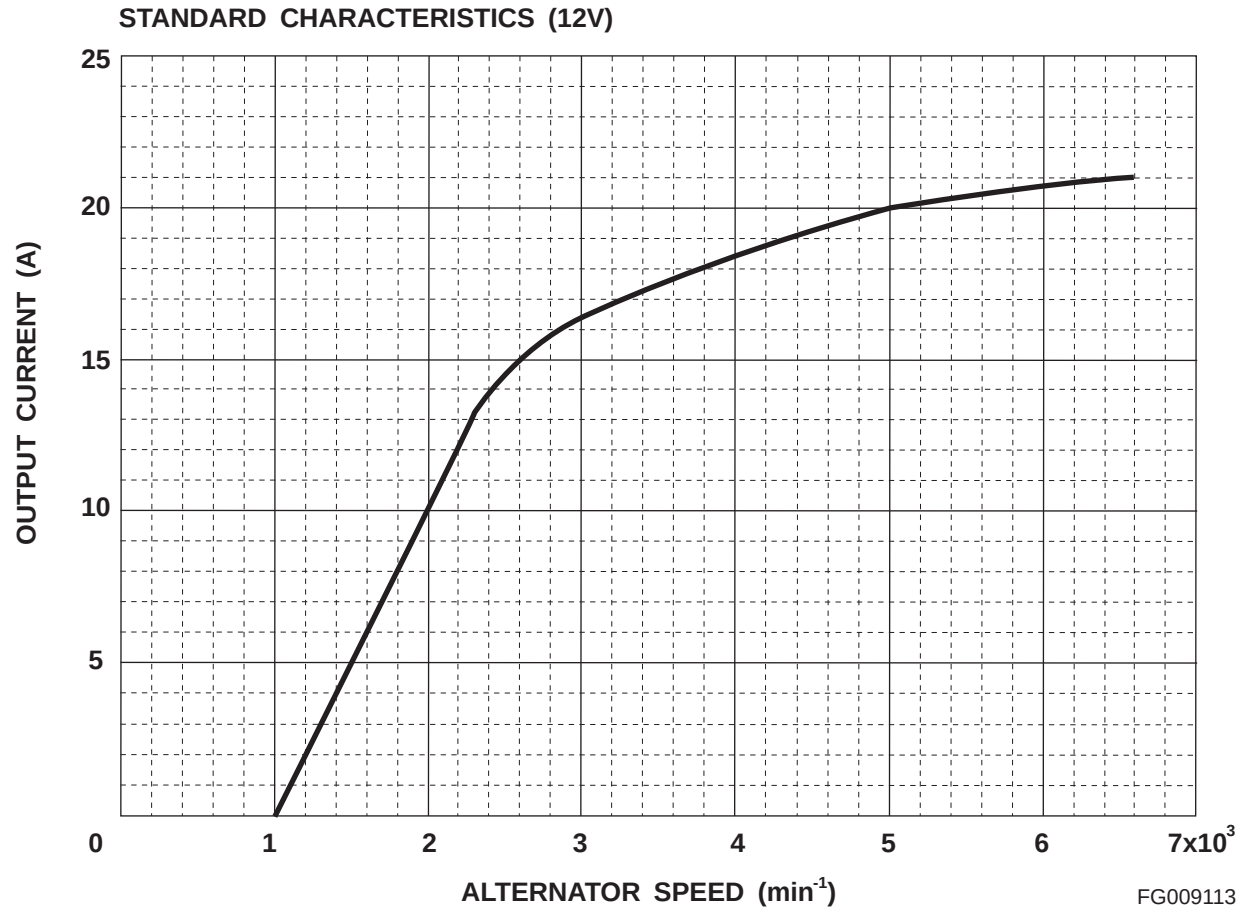
Reference Number	Description
1	Dynamo
2	IC Regulator Assembly
3	Key Switch

Reference Number	Description
4	Charge Lamp (3.4 Watts Max.)
5	Battery
6	Load

Operation Of Dynamo

The dynamo consists of a series of permanent magnets that rotate around a stationary stator coil. The magnets are attached to the flywheel which is rotated via the engine cooling fan drive belt. The resultant output is an AC (alternating current) signal. The AC is converted to DC (direct current) in the IC Regulator. The IC Regulator outputs charging DC current to the battery.

Dynamo Standard Output



Testing of Dynamo

Use a circuit tester or multimeter to perform the following tests.

Testing Stator Coil Continuity

1. Disconnect the dynamo output wire connector.
2. Connect one meter lead to each of the stator wire terminals and read the meter.

NOTE: *The meter reading should indicate continuity. If continuity is not indicated, the windings are open and the stator must be replaced.*

Testing Stator Coil Short-to-Ground

1. Disconnect the dynamo output wire connector.
2. Test continuity between each stator wire terminal and engine ground.

NOTE: *The meter reading should infinity. If the meter reading indicates continuity, the windings are shorted to ground and the stator must be replaced.*

Testing Dynamo Regulated Output

1. Test and record the battery voltage with the engine not running.
2. Start the engine and operate it at normal operating rpm.
3. Again, check the battery voltage with the engine running.

NOTE: *The meter reading with the engine running must be higher than with the engine not running.*

- If results are not correct, test the stator for continuity and shorts to the ground.
- Check the charging system wiring.
- If no problems are found in previous checks, replace the IC regulator.

Dynamo

Removal of Dynamo

1. Disconnect the output wire connector from the dynamo.
2. Loosen the V-belt.

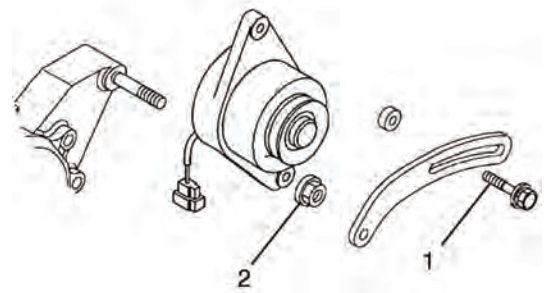


CAUTION

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.

3. Remove the V-belt adjuster from the dynamo bolt (1, Figure 405).
4. Remove the nut (2, Figure 405) from the gear case stud. Remove the dynamo.

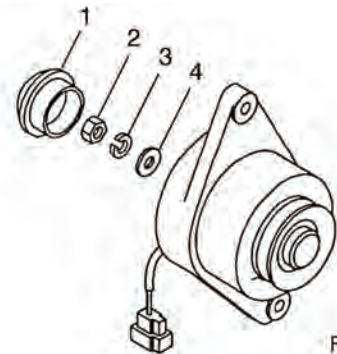


FG009114

Figure 405

Disassembly of Dynamo

1. Remove the rear cover (1, Figure 406).
2. Remove the nut (2, Figure 406), lock washer (3, Figure 406), and flat washer (4, Figure 406).



FG009115

Figure 406

3. Remove the through bolt (1, Figure 407), pulley half (2, Figure 407), flywheel (3, Figure 407), flat washer (4, Figure 407), bearings (5, Figure 407), and spacer (6, Figure 407).

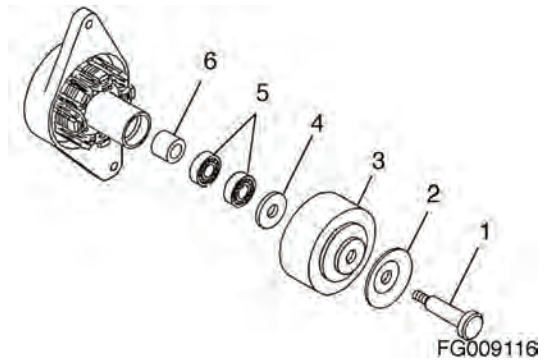


Figure 407

4. Remove the screws (1, Figure 408) and the stator assembly (2, Figure 408).
5. Remove the rear bearing (3, Figure 408).

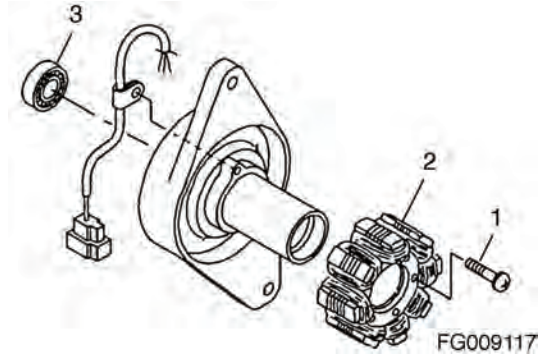


Figure 408

Reassembly of Dynamo

1. Reinstall the rear bearing (3, Figure 409).
2. Reinstall the stator (2, Figure 409) and screws.

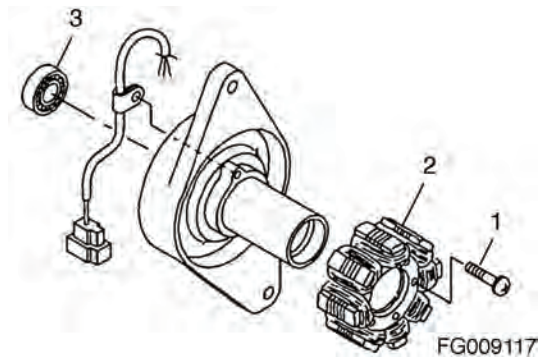


Figure 409

3. Reinstall the front bearings (5, Figure 410) and spacer (6, Figure 410).
4. Reinstall the flat washer (4, Figure 410), flywheel (3, Figure 410), pulley half (2, Figure 410) and through bolt (1, Figure 410).

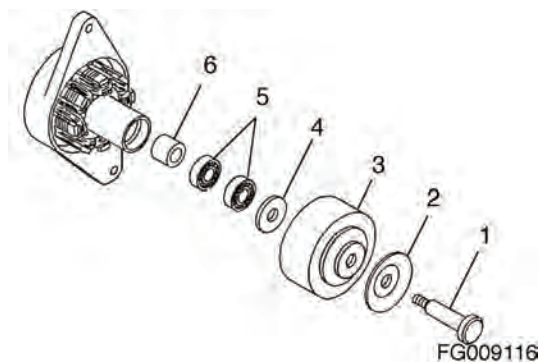
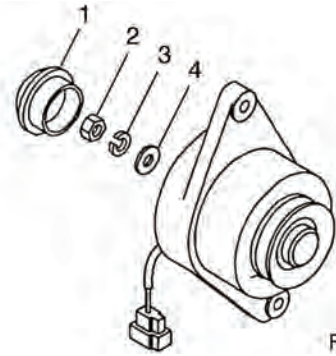


Figure 410

5. Reinstall the flat washer (4, Figure 411), lock washer (3, Figure 411), and nut (2, Figure 411). Tighten the nut to the specified torque.
6. Reinstall the rear cap (1, Figure 411).

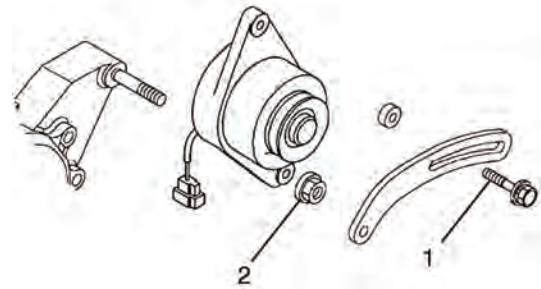


FG009115

Figure 411

Installation of Dynamo

1. Position the dynamo on the gear case. Loosely reinstall the nut (2, Figure 412) on the gear case stud and the V-belt adjuster bolt (1, Figure 412).
2. Reconnect the dynamo output wire connector.
3. Reinstall the V-belt. Tighten the V-belt to the proper tension as described in See "Check and Adjust Cooling Fan V-Belt" on page -70.
4. Start the engine. Listen for any unusual sounds from the alternator.



FG009114

Figure 412



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.

ELECTRIC WIRING

Electric Wiring Precautions

Failure to follow these precautions may result in the failure of an electrical component and the loss of warranty coverage on that item as well as related items. Make sure that all users read and understand these precautions.



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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



CAUTION

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

Electrical Wire Resistance

AWG	Metric Nominal mm ²	Ohms / Foot Resistance
20	0.5	0.009967
18	0.8	0.006340
16	1.25	0.004359
14	2	0.002685
12	3	0.001704
10	5	0.001073
8	8	0.000707
6	15	0.000421
4	20	0.000270
2	30	0.000158
1	40	0.000130
0 (1/0)	50	0.000130
00 (2/0)	60	0.000087
000 (3/0)	85	0.000066
0000 (4/0)	100	0.000051

Wiring voltage drop should not exceed 5% $[0.05] \times 12 \text{ Volts} = 0.6 \text{ Volts}$.

Voltage Drop = Current [Amps] x Length of Wire [Feet] x Resistance per Foot

Example:

Current draw of 100 Amps x 3 feet of 4 AWG wire $100 \text{ Amps} \times 3 \text{ Feet} \times 0.000270 = 0.08 \text{ Volts [Voltage Drop]}$

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 .

Electrical Wire Sizes - Voltage Drop

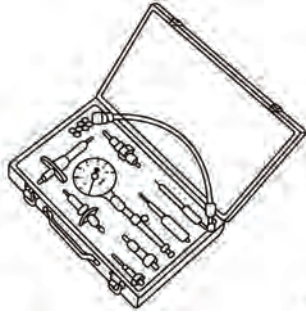
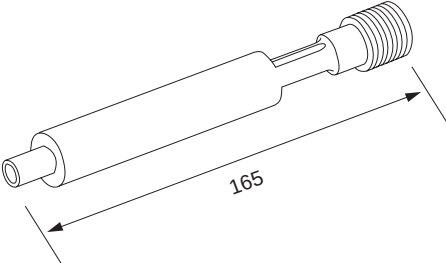
Total current on circuit in amps	Length of conductor from source of current to device and back to source (in feet)																		
	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170
12 Volts	Wire Size (AWG)																		
5	18	16	14	12	12	12	10	10	8	8	8	6	6	6	6	6	6	6	6
10	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
15	12	10	10	8	8	6	6	6	4	4	2	2	2	2	2	1	1	1	1
20	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
25	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
30	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
40	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
50	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				
60	6	4	4	2	2	1	0	2/0	3/0	3/0	4/0	4/0	4/0						
70	6	4	2	2	1	0	2/0	3/0	4/0	4/0									
80	6	4	2	2	1	0	3/0	3/0	4/0	4/0									
90	4	2	2	1	0	2/0	3/0	4/0	4/0										
100	4	2	2	1	0	2/0	3/0	4/0											
24 Volts																			
5	18	18	18	16	16	14	12	12	12	10	10	10	10	10	8	8	8	8	8
10	18	16	14	12	12	10	10	10	8	8	8	6	6	6	6	6	6	6	6
15	16	14	12	12	10	10	8	8	6	6	6	6	6	4	4	4	4	4	2
20	14	12	10	10	10	8	6	6	6	6	4	4	4	4	2	2	2	2	2
25	12	12	10	10	8	6	6	6	4	4	4	4	2	2	2	2	2	2	1
30	12	10	10	8	8	6	6	4	4	4	2	2	2	2	2	1	1	1	1
40	10	10	8	6	6	6	4	4	2	2	2	2	1	1	1	0	0	0	2/0
50	10	8	6	6	6	4	4	2	2	2	1	1	0	0	0	2/0	2/0	2/0	3/0
60	10	8	6	6	4	4	2	2	1	1	0	0	0	2/0	2/0	3/0	3/0	3/0	3/0
70	8	6	6	4	4	2	2	1	1	0	0	2/0	2/0	3/0	3/0	3/0	3/0	4/0	4/0
80	8	6	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	3/0	4/0	4/0	4/0	4/0
90	8	6	4	4	2	2	1	0	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0	4/0	4/0	
100	6	6	4	4	2	2	1	0	2/0	2/0	3/0	3/0	4/0	4/0	4/0				

Conversion Of Awg To European Standards

Conductor Size (AWG)	Conductor Diameter (mm)	Conductor Cross-sectional Area (mm ²)
25	0.455	0.163
24	0.511	0.205
23	0.573	0.259
22	0.644	0.325
21	0.723	0.412
20	0.812	0.519
19	0.992	0.653
18	1.024	0.823
17	1.15	1.04
16	1.29	1.31
15	1.45	1.65
14	1.63	2.08
13	1.83	2.63
12	2.05	3.31
11	2.30	4.15
10	2.59	5.27
9	2.91	6.62
8	3.26	8.35
7	3.67	10.6
6	4.11	13.3
5	4.62	16.8
4	5.19	21.2
3	5.83	26.7
2	6.54	33.6
1	7.35	42.4
0 (1/0)	8.25	53.4
00 (2/0)	9.27	67.5
000 (3/0)	10.40	85.0
0000 (4/0)	11.68	107.2
00000 (5/0)	13.12	135.1
000000 (6/0)	14.73	170.3
1.1 circular mil (CM) @ 0.0005067 mm ²		

TROUBLESHOOTING

Special Service Tools

Compression Gauge Kit	For measuring compression pressure Gauge Set	 FG009118
	Adapter for direct injection 4-valve cylinder head for 4TNV98 - E	 FG009120

Troubleshooting By Measuring Compression Pressure

Compression pressure drop is one of the major causes of increasing blow-by gas (engine oil contamination or increased engine oil consumption as a resultant phenomenon) or starting failure. The compression pressure is affected by the following factors:

1. Degree of clearance between the piston and cylinder
2. Degree of clearance at the intake / exhaust valve seat
3. Gas leak from the nozzle gasket or cylinder head gasket

The pressure will drop due to increased parts wear. Pressure drop reduces the durability of the engine.

A pressure drop may also be caused by a scratched cylinder or piston, dust entrance from the dirty air cleaner element or a worn or broken piston ring. Measure the compression pressure to determine the condition of the engine.

Compression Pressure Measurement Method

1. Warm up the engine.
2. Stop the engine. Remove the high-pressure fuel injection lines as an assembly from the engine. Remove the fuel injector from the cylinder to be measured. See "Removal of Fuel Injectors" on page -190.
3. Remove the valve cover assembly. Remove the fuel injector from the cylinder to be tested. See "Removal of Fuel Injectors" on page -190.
4. Turn off the fuel supply valve in the fuel supply line. Disconnect the fuel injection pump stop solenoid at the connector. This prevents the fuel injection pump from injecting fuel during compression testing.
5. Before installing the compression gauge (1, Figure 413) 2 valve engine, (1, Figure 414) 4 valve engine) adapter, crank the engine with the stop solenoid disconnected for a few seconds to clear the cylinder of any residual fuel.
6. Install a nozzle seat at the tip end of the compression gauge adapter. Install the compression gauge and the compression gauge adapter at the cylinder to be measured.
7. Crank the engine until the compression gauge reading is stabilized.

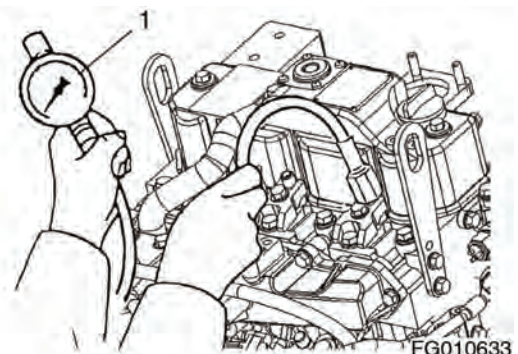


Figure 413

8. After performing the compression check remove the compression gauge and compression gauge adapter from the cylinder.
9. Install the fuel valves. See "Installation of the Fuel Injectors" on page -194. See "Inspection of Valve Guides" on page -113. Then install the valve covers and injection high pressure lines. .
Then connect the stop solenoid..
10. Turn on the fuel supply valve and reconnect the injection pump stop solenoid.
11. Prime the fuel system. Check for leaks. Test the engine.

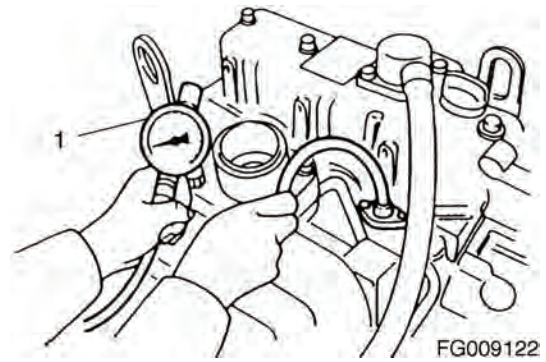


Figure 414

Standard Compression Pressure (Reference Value)

Compression Pressure at 250 rpm (250 min ⁻¹)		Deviation Between Cylinders
Standard	Limit	
483 - 513 psi (3.33 - 3.53 MPa; 34 - 36 kgf/cm ²)	384 - 414 psi (2.65 - 2.85 MPa; 27 - 29 kgf/cm ²)	29 - 43 psi (0.2 - 0.3 MPa; 2 - 3 kgf/cm ²)

Engine Speed and Compression Pressure (Use for Reference)

Engine Speed and Compression Pressure (Use for Reference)

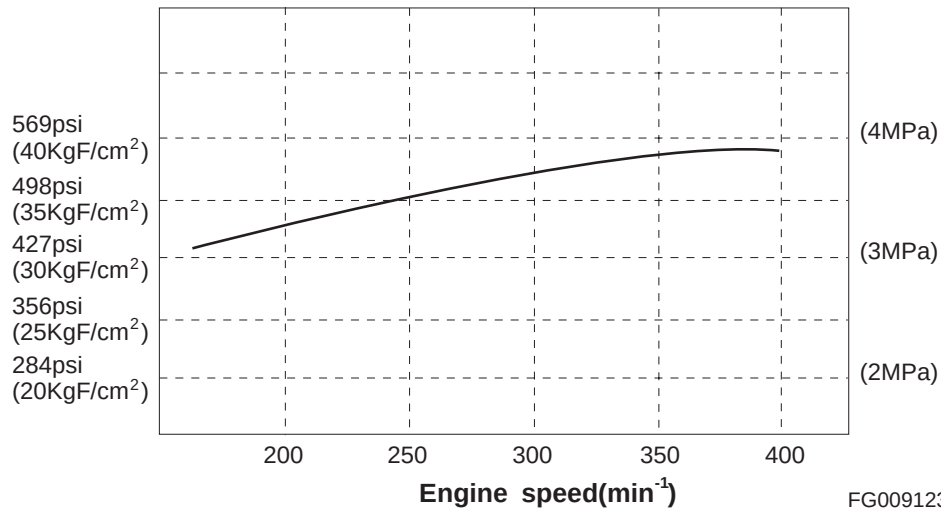


Figure 415

Measured Value and Troubleshooting

When the measured compression pressure is below the limit value, inspect each part by referring to the table below.

No.	Item	Cause	Corrective Action
1	Air Cleaner Element	Clogged element	Clean the element.
		Broken element	Replace the element.
		Defect at element seal portion	
2	Valve Clearance	Excessive or no clearance	Adjust the valve clearance.
3	Valve Timing	Incorrect valve clearance	Adjust the valve clearance.
4	Cylinder Head Gasket	Gas leak from gasket	Replace the gasket.
			Retighten the cylinder head bolts to the specified torque.
5	Intake / Exhaust Valve	Sticking valve	Replace the intake / exhaust valve.
	Valve Seat	Gas leak due to worn valve seat or foreign matter trapped in valve	Lap the valve seat.
6	Piston	Gas leak due to scratching or wear	Perform honing and use an oversized part.
	Piston		
	Cylinder		

Quick Reference Table For Troubleshooting

The following table summarizes the general trouble symptoms and their causes. If any trouble symptom occurs, take corrective action before it becomes a serious problem so as not to shorten the engine service life.

Failure Diagnosis Table

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			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 seconds) after turning off the key	Specific Ecu control functions fail.	Fuses get blown or broken (repeatedly)												
		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	Too much blow-by	Exhaust gas temperature 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 seconds) 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	Revolution speed cannot be changed with accelerator (stays at a constant speed)	Cannot be set to particular speed	Poor acceleration	Does not smoothly return to low speed	Hunting occurs	Hunting occurs	Normal	White	Black	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	White exhaust gas	Black exhaust gas	Too much blow-by	Exhaust gas temperature 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 seconds) after turning off the key	Specific Ecu control functions fail.	Fuses get blown or broken (repeatedly)								
Engine system	Intake/exhaust valves with improper clearances			○		○									○					○					○																Adjust the valve clearances.	See "Measuring And Adjusting Valve Clearance" on page -123							
	Compressed air leaks from a valve seat			●											○		○			○					○		○				○											Lap the valve seat.							
	Intake/exhaust valve seized			○				○						○	○		○			○	○				○					○											Repair or replace the intake/exhaust valves.								
	Cylinder head gasket blown														○					○			○																		Replace the gasket.								
	Piston ring stuck or broken			○				○					○			○				○	○	○			○				○		○	○									Replace the piston rings.								
	Piston ring joint not correctly positioned			○				○								○				○	○							○			○									Apply honing, and use oversized parts.	See "Honing and Boring" on page -145								
	Crank pin metal and bearing seized			○		○							○	○						○	○										○										Repair or replace.								
	Piston ring joint not correctly positioned					○										○					○										○									Correct the joint position.									
	Piston ring reverse-installed															○					○							○			○									Reinstall.									
	Crank pin metal and journal metal worn												○	○	○					○	○				○															Measure and replace.									
	Connecting rod bolt loose																			○	○				○															Tighten with specified torque.									
	Foreign matter in a combustion chamber			○														○			○										○									Disassemble and repair.									
	Gear backlash too large																	○																						Adjust the gear engagement.									
	Intake/exhaust valve guide worn															○					○										○									Measure and replace.									
	Governor not properly adjusted			●		○							○	○	○						○																				Adjust.								
	Intake/exhaust valves with improper opening/closing timings			○													○	○			○								○	○											Adjust the valve clearances.	See "Measuring And Adjusting Valve Clearance" on page -123							
	Engine's mounting loosened or damaged													○	○					●	●																			Repair or replace the faulty part(s).									
Supercharger	Floor fouled														○																○		●								Clean the floor.								
	Waste gate malfunctioning															○															○		●							Disassemble and inspect.									
	Radial metal worn														○					●										○									Disassemble and inspect.										

[illegible]

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		No load	Work load	Smoke color									Work load																									
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	Revolution speed cannot be changed with accelerator (stays at a constant speed)	Cannot be set to particular speed	Poor acceleration	Does not smoothly return to low speed	Hunting occurs	Hunting occurs	Normal	White	Black	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	White exhaust gas	Black exhaust gas	Too much blow-by	Exhaust gas temperature 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 seconds) after turning off the key	Specific Ecu control functions fail.	Fuses get blown or broken (repeatedly)		
Engine stopped or restricted by ECU failure diagnosis function	ECU control function active		○						○	○						●																											This is not a failure. Switch to the normal mode.	Refer to the control manual.
	Water temperature sensor disconnected or short-circuited									○						○																							○				Repair or replace the harness. Replace the water temperature sensor.	
	Accelerator sensor disconnected or short-circuited								○																													○				Repair or replace the harness. Replace the accelerator sensor.		
	Speed sensor signal error				○		○																															○				Repair or replace the harness. Repair or replace the fuel injection pump.		
	Rack position sensor signal error									○			○	○	○	○																					○				Repair or replace the harness. Repair or replace the fuel injection pump.			
	Rack actuator malfunctioning		○				○																														○				Repair or replace the harness. Repair or replace the fuel injection pump.			
	Engine overspeed occurs						○																															○				Check for idle rotations caused by the working machine. Check the speed sensor signal.		
	CAN Communication error									○																												○		○		Repair or replace the harness. Replace the ECU.		
	The EGR valve motor disconnected or short-circuited.										○					○																						○				Repair or replace the harness. Replace the EGR valve.		
	CSD solenoid valve disconnected or short-circuited.			○	○																																		○				Repair or replace the harness. Replace the CSD valve solenoid.	
	Start assist relay disconnected or short-circuited.			○	○																												△						○				Repair or replace the harness. Replace the relay.	
	Main relay cannot be turned off																																					○	○				Replace the relay.	
	Rack actuator relay disconnected or short-circuited		○				?																																○				Repair or replace the harness. Replace the relay.	
	Error detected by ECU self diagnosis		○				?																																○				Replace the ECU.	

Electrical wiring

NOTE: The following wiring diagram is “representative” of a common installation using a TNV engine. The actual installation may be equipped with a variety of electrical components and wiring harnesses. Contact the machine manufacturer for specific information.

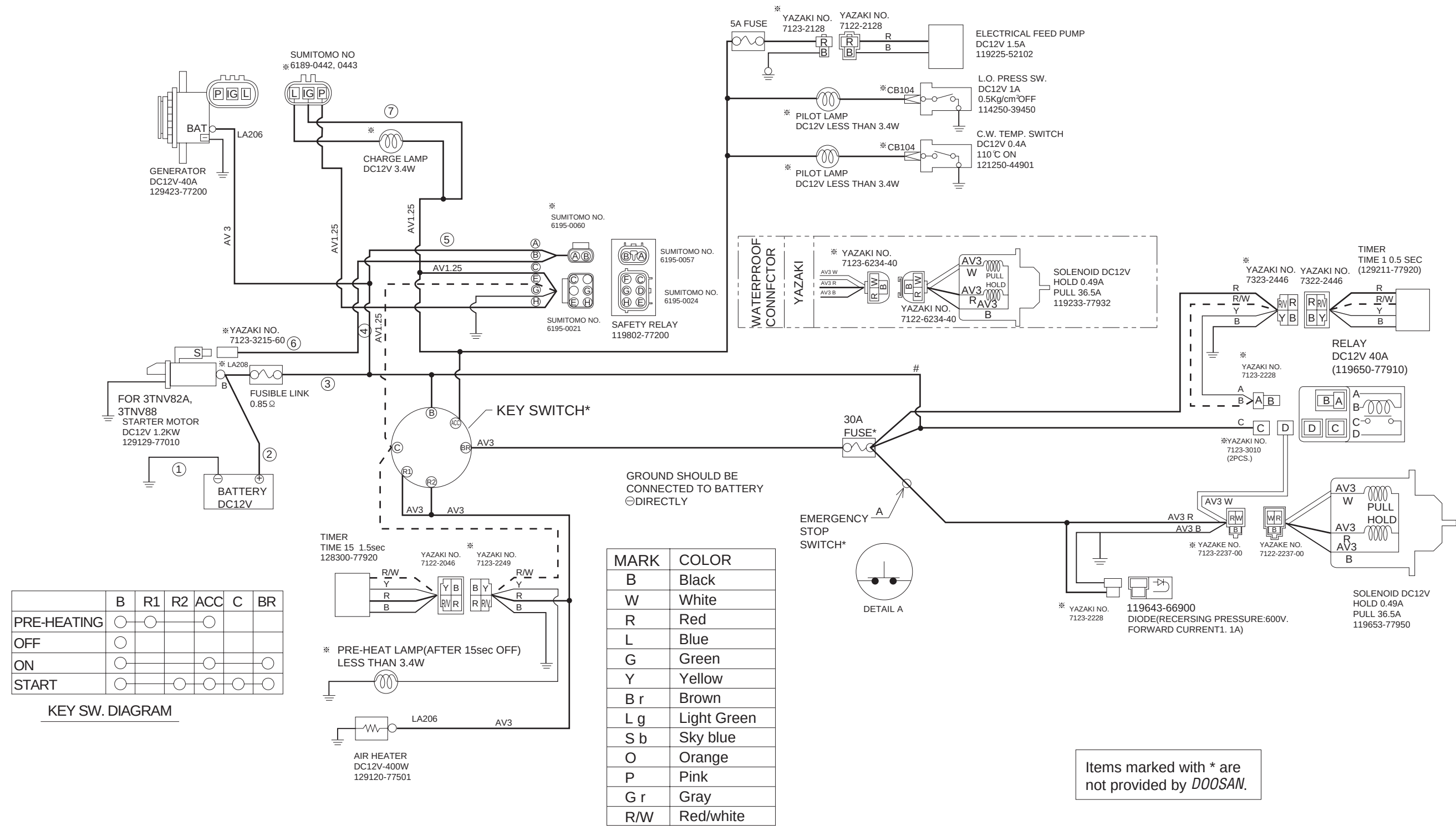


Figure 1

FG012824

Transmission

Edition 1

MEMO

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Transmission

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MEMO

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 ultimately safety is your own personal responsibility.

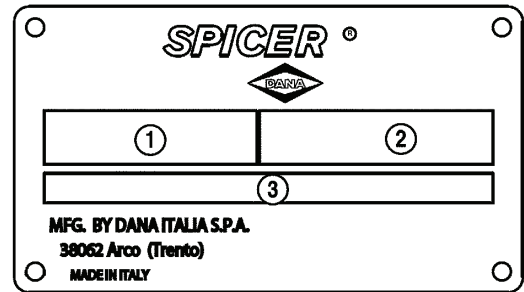
APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

DATA PLATE

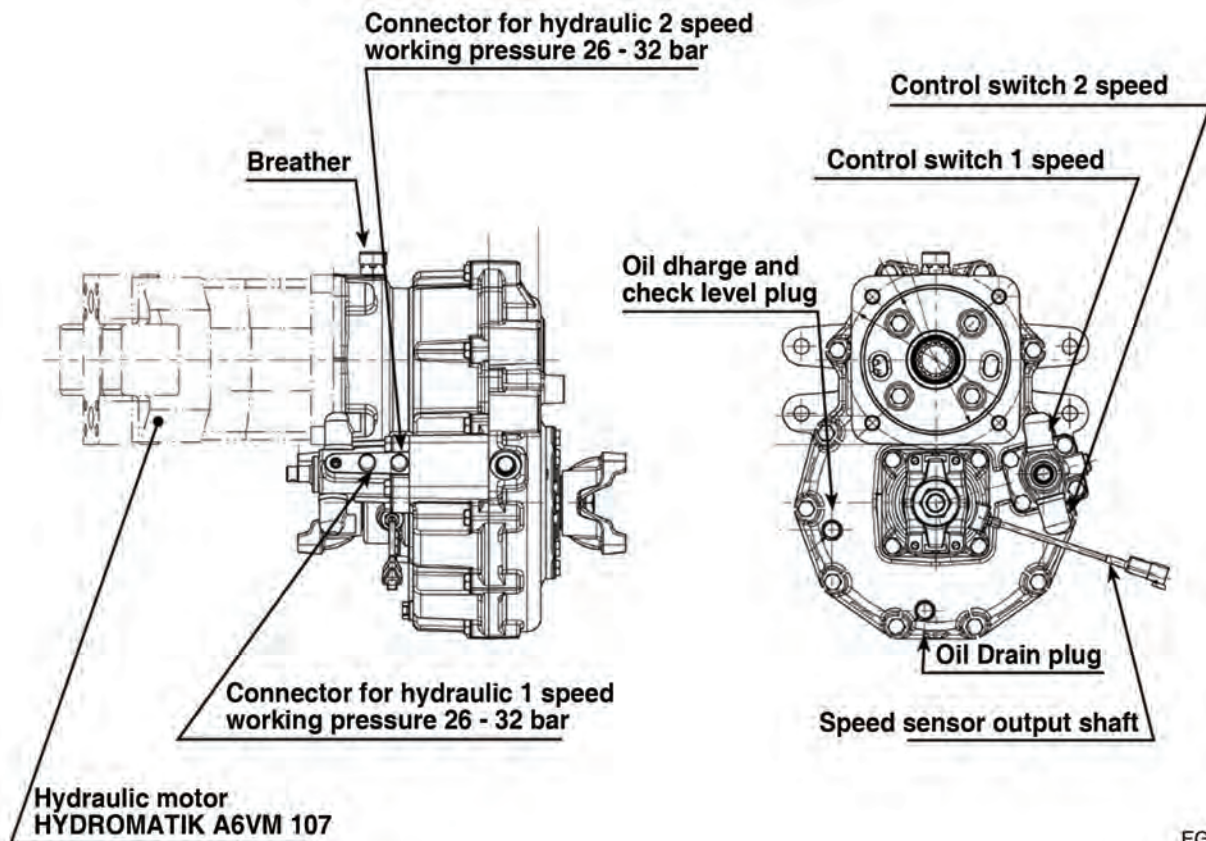
1. Type and model unit - modification index
2. Serial number
3. Lubricant



FG011684

Figure 1

MAINTENANCE POINTS



FG012396

Figure 2

SCREW-LOCKING, SEALING AND LUBRICATING MATERIALS



Locking, sealing and lubricating materials referred to in this manual are the same used in the sop-floor.

The table below gives an account of the typical applications of each single material, in order to facilitate replacement with similar products marketed by different brand names with different trade marks.

Denomination	Application
Loctite 242	Anaerobic product apt to prevent the loosening of screws, nuts and plugs. Used for medium-strength locking. Before using it, completely remove any lubricant by using the specific activator.
Loctite 243	The oleocompatible alternative to 242. Does not require the activation of lubricated surfaces.
Loctite 270	Anaerobic product for very-high strength locking of screws and nuts. Before using it, completely remove any lubricant by using the specific activator. To remove parts, it may be necessary to heat them at 80°C
Loctite 510	Anaerobic product for the hermetic sealing of flanged units and screw holes communicating with fluids. Can seal clearances between flanges up to 0.2 mm.
Silicone	Semi-fluid adhesive material used for sealing and filling and to protect components from environmental and physical elements. Polymerises with non-corrosive dampness.
(TECNO LUBE/101) Silicone-based grease	Highly adhesive synthetic grease, with silicone compounds added. Applied to adjustment screws with hole communicating with oil-type fluids. Used when frequent adjusting is required.
Molikote (DOW CORNING)	Lubricating compound containing molybdenum disulphide, used to lubricate articulation pins and to prevent sticking and oxidation of parts that are not lubricated on a regular basis.

MAINTENANCE INTERVALS AND OIL SPECIFICATION

Operation	Frequency	Lubricants
Check levels	monthly	SAE85W90 API GL
Oil change:	every 1000 hours */**	
* Initially after 150 working hours		
** Clean the sensor reading zone every oil change		

CONVERSION TABLES

Units of pressure : 1 Atm $\cong$ 1 bar $\cong$ 105 Pa $\cong$ 14.4 Psi

Units of weight

	N	daN	kN	kg	lbs
1 N	1	0.1	0.001	0.102	0.225
1 daN	10	1	0.1	1.02	2.25
1 kN	1000	100	1	102	225
1 kg	9.81	0.981	0.00981	1	2.205

Units of weight

	Nm	daNm	kNm	kgm	lb•in
1Nm	1	0.1	0.001	0.102	8.854
1 daNm	10	1	1	102	88.54
1kNm	1000	100	1	102	8854
1 kgm	9.81	0.981	0.00981	1	86.8
1 lb•in	0.1129	0.01129	0.0001129	0.01152	1

TIGHTENING TORQUES

Size of Bolt		Type of Bolt					
		8.8		10.9		12.9	
		Normali	Normali + Loctitw 270	Normali	Normali + Loctitw 270	Normali	Normali + Loctitw 270
Coarse Pitch	M6 X 1	9.5 ~ 10.5	10.5 ~ 11.5	14.3 ~ 15.7	15.2 ~ 16.8	16.2 ~ 17.8	18.1 ~ 20.0
	M8 X 1.25	23.8 ~ 26.2	25.6 ~ 28.4	36.7 ~ 37.8	36.7 ~ 40.5	39.0 ~ 43.0	43.7 ~ 48.3
	M10 X 1.5	48 ~ 53	52 ~ 58	67 ~ 75	73 ~ 81	80 ~ 88	88 ~ 97
	M12 X 1.75	82 ~ 91	90 ~ 100	116 ~ 128	126 ~ 139	139 ~ 153	152 ~ 168
	M14 X2	129 ~ 143	143 ~ 158	182 ~ 202	200 ~ 221	211 ~ 244	238 ~ 263
	M16 X2	200 ~ 221	219 ~ 242	283 ~ 312	309 ~ 341	337 ~ 373	371 ~ 410
	M18 X 2.5	276 ~ 305	299 ~ 331	390 ~ 431	428 ~ 473	466 ~ 515	509 ~ 562
	M20 X 2.5	390 ~ 431	428 ~ 473	553 ~ 611	603 ~ 667	660 ~ 730	722 ~ 798
	M22 X 2.5	523 ~ 578	575 ~ 635	746 ~ 824	817 ~ 903	893 ~ 987	874 ~ 1,076
	M24 X 3	675 ~ 746	950 ~ 1,050	1,040 ~ 1,150	1,140 ~ 1,260	1,140 ~ 1,260	1,240 ~ 1,370
	M27 X 3	1088 ~ 1202	1,088 ~ 1,202	1,411 ~ 1,559	1,539 ~ 1,701	1,710 ~ 1,890	1,838 ~ 2,032
	M30 X 3.5	1378 ~ 1523	1,473 ~ 1,628	1,914 ~ 2,115	2,085 ~ 2,305	2,280 ~ 2,520	2,494 ~ 2,757
Fine Pitch	M8 X 1	25.7 ~ 28.3	27.5 ~ 30.5	36.2 ~ 39.8	40 ~ 44	42.8 ~ 47.2	47.5 ~ 52.5
	M10 X 1.25	49.4 ~ 54.6	55.2 ~ 61	71.5 ~ 78.5	78 ~ 86	86 ~ 94	93 ~ 103
	M12 X 1.25	90 ~ 100	98 ~ 109	128 ~ 142	139 ~ 154	152 ~ 168	166 ~ 184
	M12 X 1.5	86 ~ 95	81 ~ 104	120 ~ 132	133 ~ 147	143 ~ 158	159 ~ 175
	M14 X1.5	143 ~ 158	157 ~ 173	200 ~ 222	219 ~ 242	238 ~ 263	261 ~ 289
	M16 X1.5	214 ~ 236	233 ~ 257	302 ~ 334	333 ~ 368	361 ~ 399	394 ~ 436
	M18 X 1.5	312 ~ 345	342 ~ 378	442 ~ 489	485 ~ 536	527 ~ 583	580 ~ 641
	M20 X 1.5	437 ~ 483	475 ~ 525	613 ~ 677	674 ~ 745	736 ~ 814	808 ~ 893
	M22 X 1.5	581 ~ 642	637 ~ 704	822 ~ 908	903 ~ 998	998 ~ 1,103	1,078 ~ 1,191
	M24 X 2	741 ~ 819	808 ~ 893	1,045 ~ 1,155	1,140 ~ 1,260	1,235 ~ 1,365	1,363 ~ 1,507
	M27 X 2	1,083 ~ 1,197	1,178 ~ 1,302	1,520 ~ 1,680	1,672 ~ 1,848	1,834 ~ 2,027	2,000 ~ 2,210
	M30 X 2	1,511 ~ 1,670	1,648 ~ 1822	2,138 ~ 2363	2,332 ~ 2,577	2,565 ~ 2,835	2,788 ~ 3,082

NOTES ON SAFETY PRECAUTIONS

1. During all operations described in this manual, the axle should be fastened onto a trestle, while the other parts mentioned should rest on supporting benches.
2. When removing one of the arms, an anti-tilting safety trestle should be placed under the other arm.
3. When working on an arm that is fitted on the machine, make sure that the supporting trestles are correctly positioned and that the machine is locked lengthways.
4. Do not admit any other person inside the work area; mark off the area, hang warning signs and remove the ignition key from the machine.
5. Use only clean, quality tools; discard all worn, damaged, low-quality or improvised wrenches and tools. Ensure that all dynamometric wrenches have been checked and calibrated.
6. Always wear gloves and non-slip rubber shoes when performing repair work.
7. Should you stain a surface with oil, remove marks straight away.
8. Dispose of all lubricants, seals, rags and solvents once work has been completed. Treat them as special waste and dispose of them according to the relative law provisions obtaining in the country where the axles are being overhauled.
9. Make sure that only weak solvents are used for cleaning purposes; avoid using turpentine, dilutants and toluol-, xylol-based or similar solvents; use light solvents such as kerosene, mineral spirits or water-based, environment friendly solvents.
10. For the sake of clarity, the parts that do not normally need to be removed have not been reproduced in some of the diagrams.
11. The terms RIGHT and LEFT in this manual refer to the position of the operator facing the axle from the side opposite the drive.
12. After repair work has been completed, accurately touch up any coated part that may have been damaged.

REPLACING COUNTER REVOLUTION SENSOR

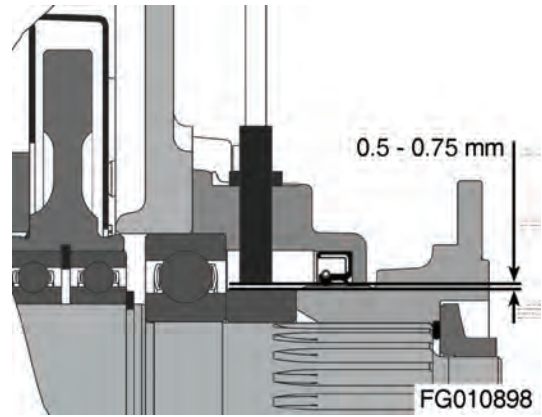


Figure 3

1. Undo the sensor adjuster screw lock nut and the counter-revolution sensor.

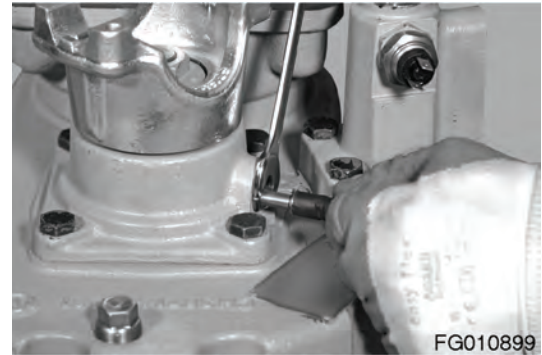


Figure 4

2. Replace the counter-revolution sensor if damaged.

NOTE: Clean the sensor reading zone "A" every oil change and every malfunctioning.

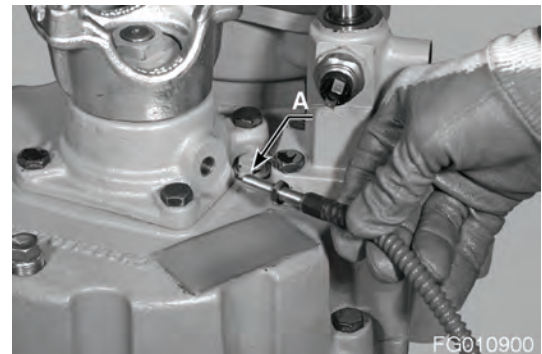


Figure 5

3. Screw the counter-revolution sensor until it contacts the phonic end disk, then loosen the sensor 1/2-3/4 turn.

Tighten the lock nuts completely.

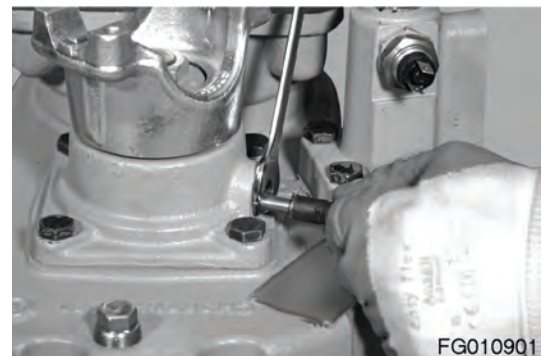
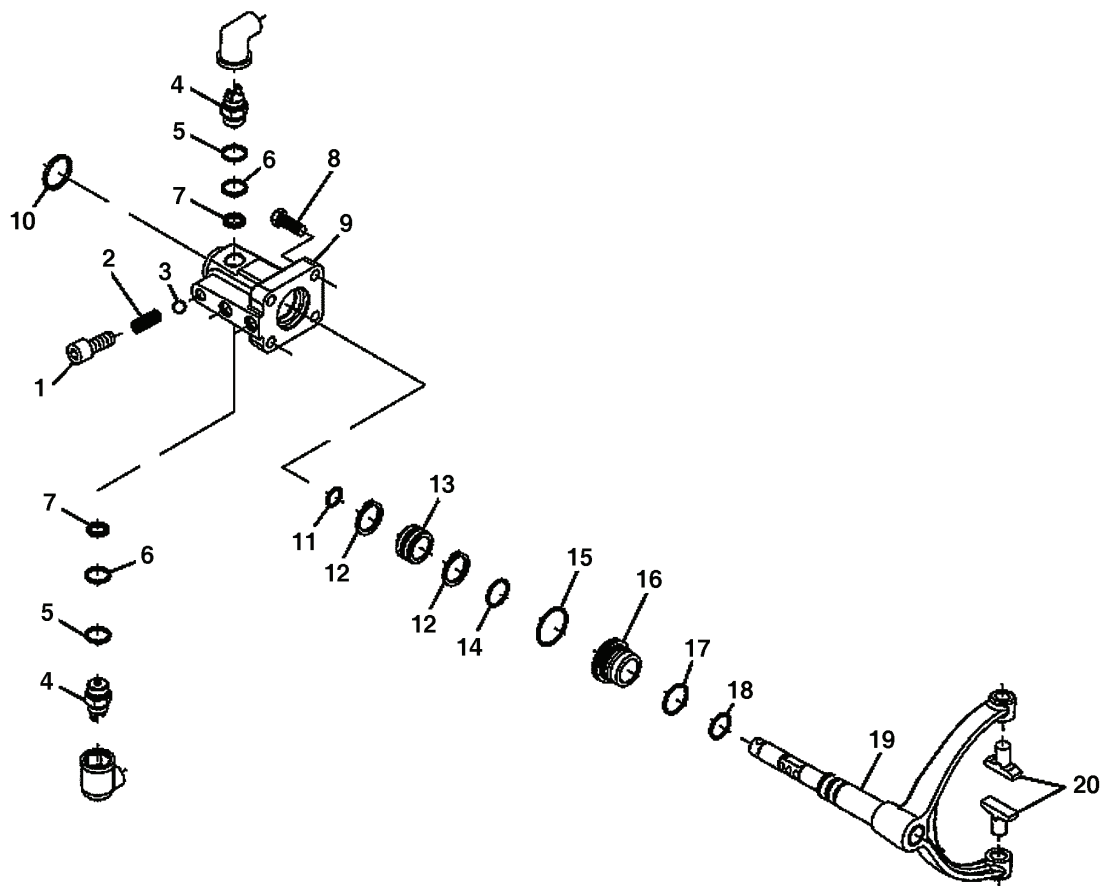


Figure 6

HYDRAULIC GEAR CONTROL

Disassembling



FG011689

Figure 7

Reference Number	Description
1	Grab Bolt
2	Spring
3	Defend Ball
4	Plug
5	O-Ring
6	Seal Washer
7	O-Ring
8	Hexagon Bolt
(	Cylinder
10	Scraper Ring

Reference Number	Description
11	O-Ring
12	Snap Ring
13	Guide Ring
14	O-Ring
15	O-Ring
16	Reduction Bushing
17	O-Ring
18	O-Ring
19	Synchroniser
20	Sliding Pin

1. Remove plug (4), O-ring (5) and (7) and washer (7).

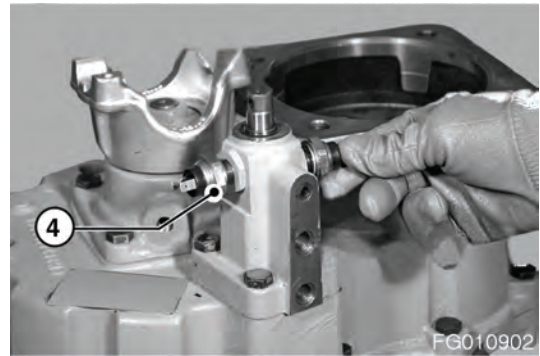


Figure 8

2. Remove the cap (1) from the gear selector.

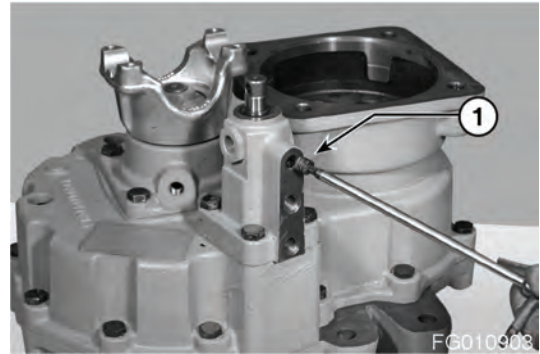


Figure 9

3. Use a magnet to remove the spring (2) from the gear selector.

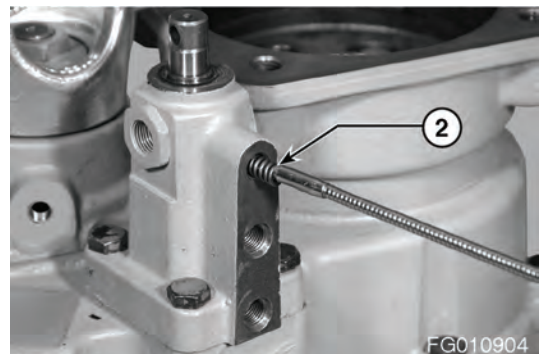


Figure 10

4. Remove the gear selector balls (3).

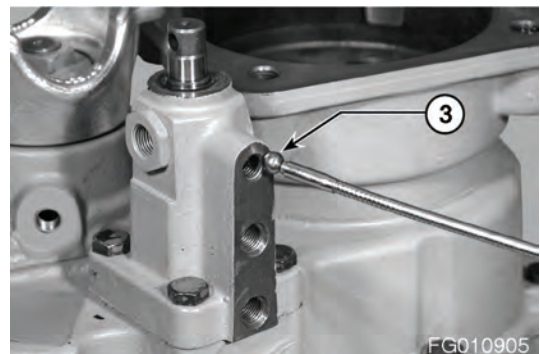


Figure 11

5. Remove hexagon bolts (8) on the gear control cylinder (9).

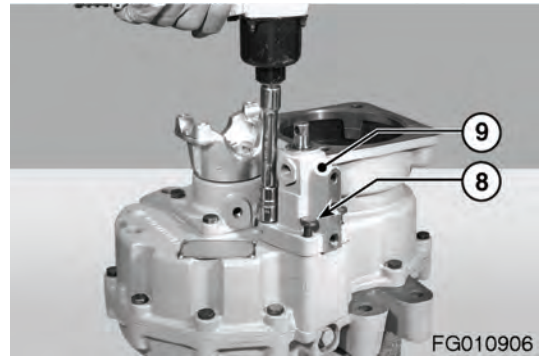


Figure 12

6. Remove the gear control cylinder (9).

NOTE: Carefully remove all residue of LOCTITE from the surfaces.

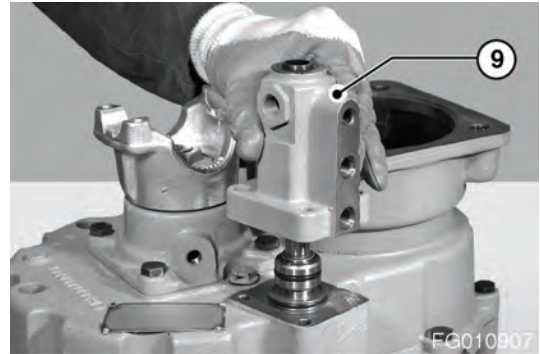


Figure 13

7. Remove the snap ring (12) securing the guide ring (13).

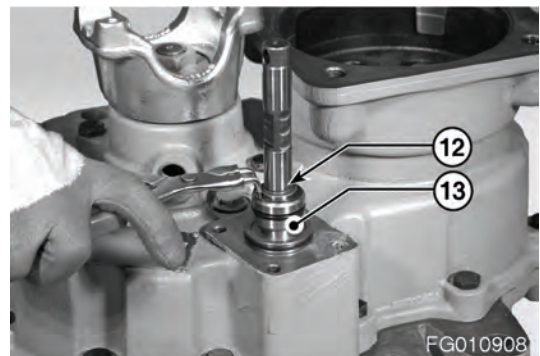


Figure 14

8. Remove the guide ring (13). Complete with seals.



Figure 15

9. Remove the snap ring (12) securing the synchroniser (19).

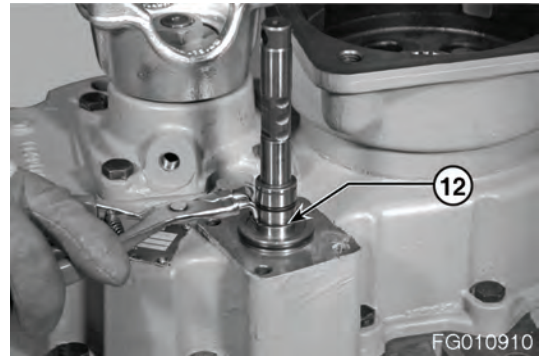


Figure 16

10. Remove the O-ring (15).

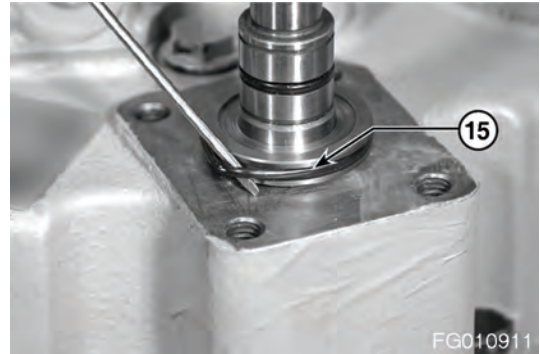


Figure 17

11. Use two levers to remove the bushing (16).

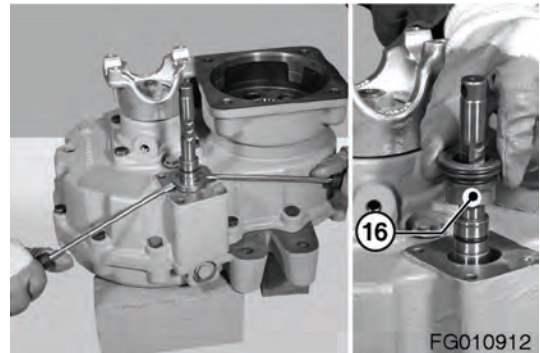


Figure 18

12. Remove the dust scraper ring (10) and the rod's O-ring (11) from the gearshift cylinder (9).

! CAUTION

The O-rings and the dust scraper ring must be replaced every time the unit is disassembled.

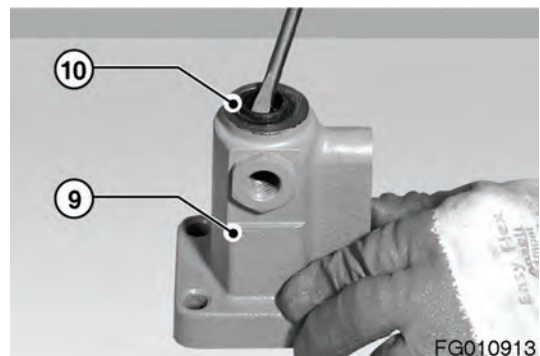
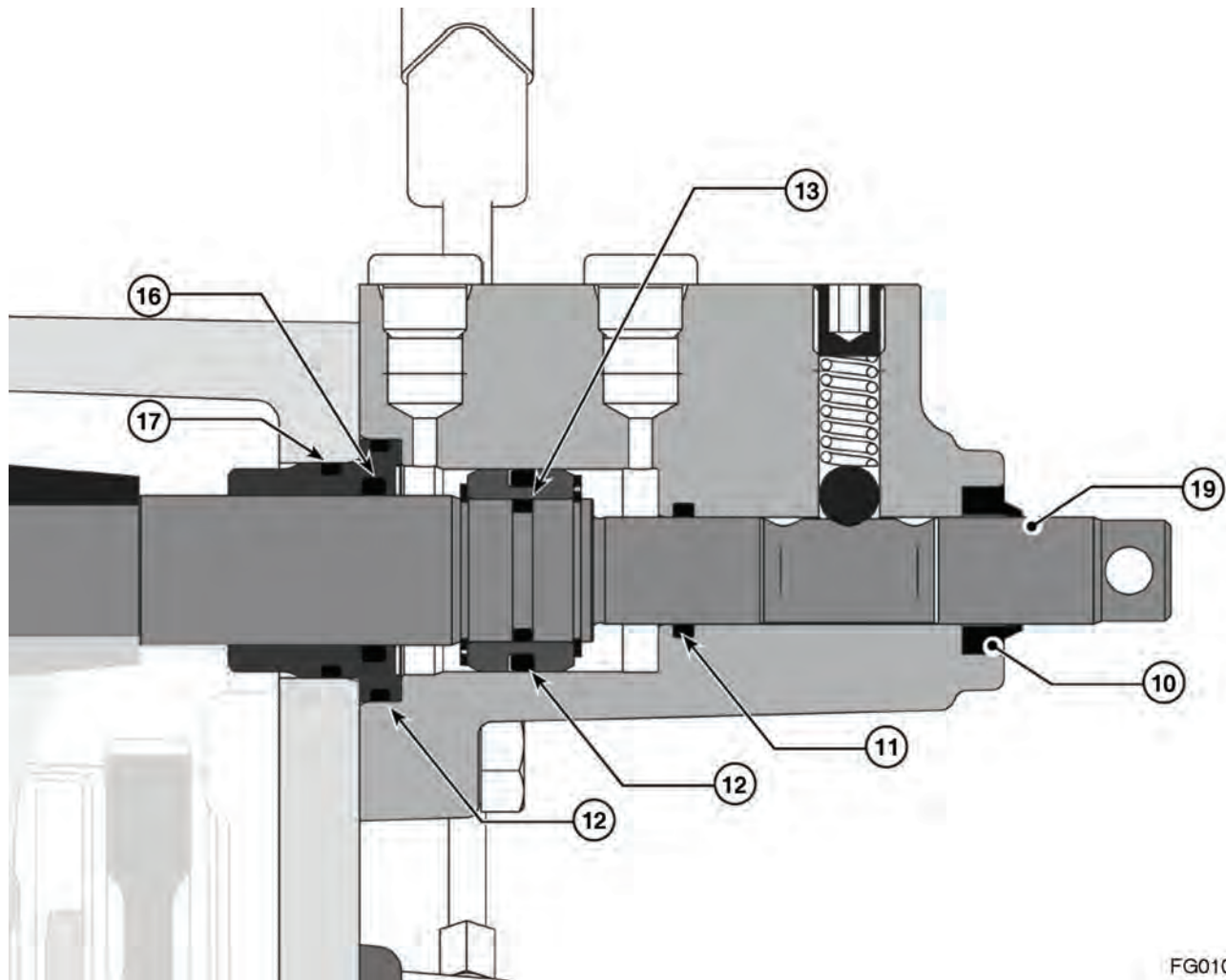


Figure 19

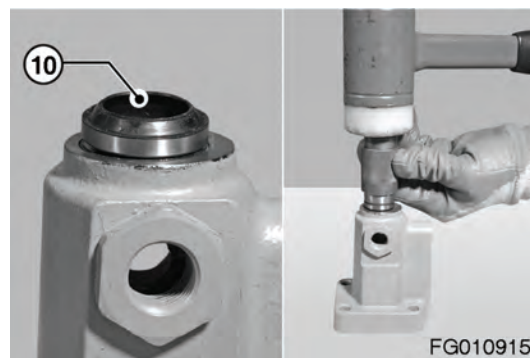
Assembling



FG010914

Figure 20

1. Fit the rod's O-ring (11) and the dust scraper ring (10) into the cylinder.



FG010915

Figure 21

2. Fit the new O-ring (11) on the synchroniser (19).

NOTE: *Lubricate before installing.*

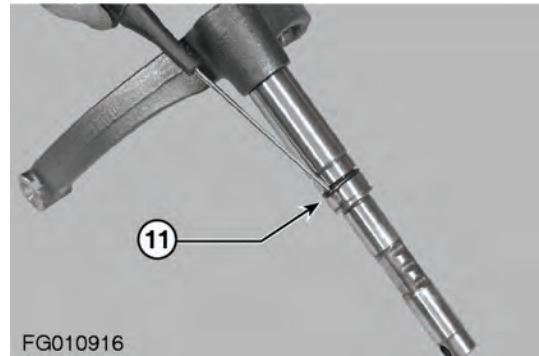


Figure 22

3. Fit the O-rings (15), (17), (18) on the guide bush (16) and lubricate rings.

Fit the bush (16) onto the gear selector rod (19).

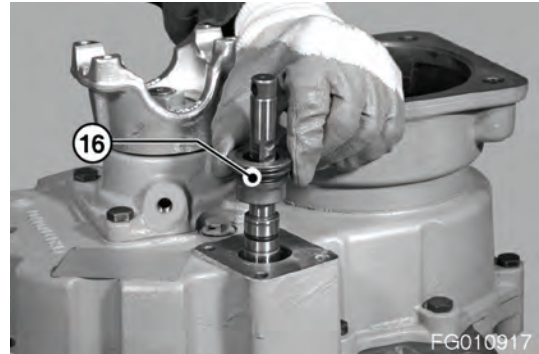


Figure 23

4. Insert the snap ring (12).

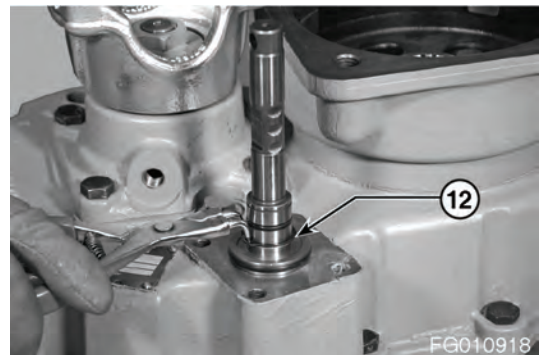


Figure 24

5. Fit the O-rings (11), (14) onto the guide ring (13) and lubricate rings.

Fit the complete guide ring (13) onto the synchroniser (19) and engage it by means of the snap ring (12).

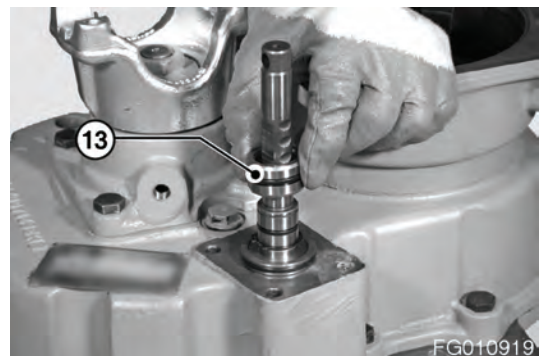


Figure 25

6. Secure the guide ring (13) in position with the snap ring (12).

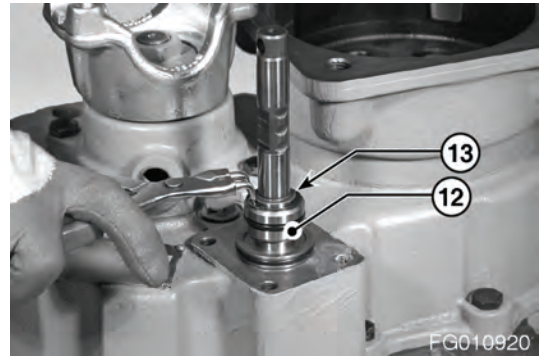


Figure 26

7. Coat the coupling surface of the gearshift cylinder (9) with Loctite 510; fit the cylinder on the gear selector rod (19).

NOTE: *Make sure that the sealant forms a continuous film around the locking holes.*



Figure 27

8. Assembly the hexagon bolts (8), spreading LOCTITE 242 on screws.

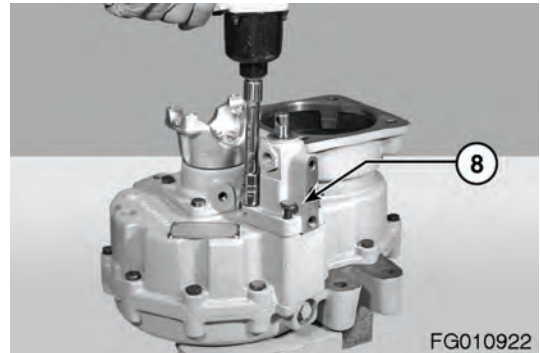


Figure 28

9. Tighten hexagon bolts (8) using a torque wrench setting of 48 - 53 Nm. (35.4 ~ 39.1 ft lb)

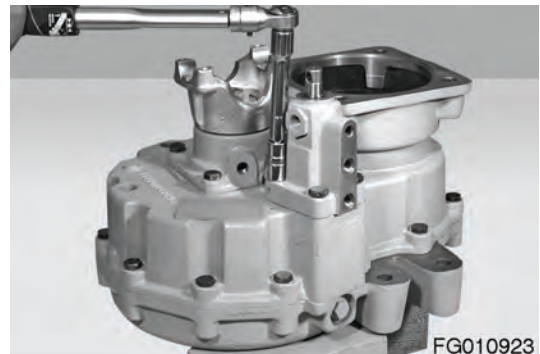


Figure 29

10. Fit the gear selector balls (3).

NOTE: *Lubricate before installing.*

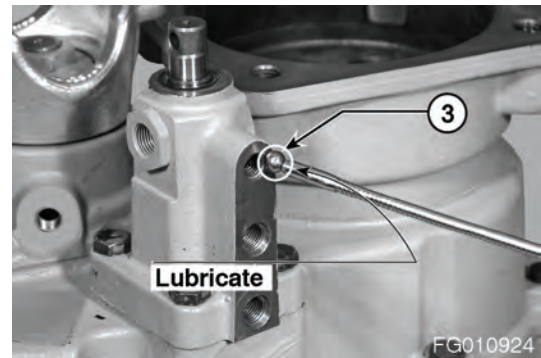


Figure 30

11. Fit the gear selector springs.

NOTE: *Replace the springs (2) if they are weakened or bent.*

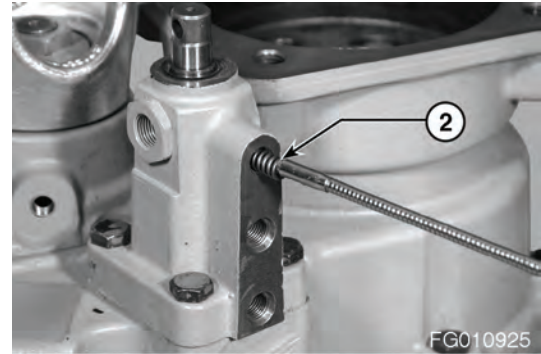


Figure 31

12. Coat the dowel (1) with Loctite 510 and screw it until it is level with the cylinder.

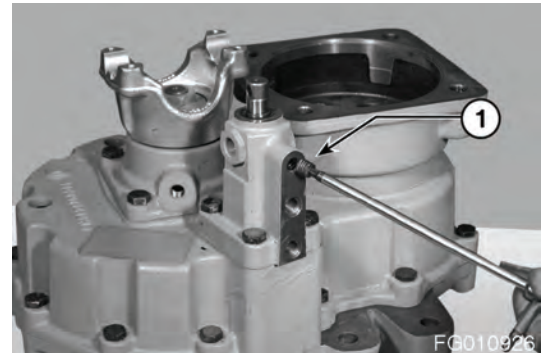


Figure 32

13. Fix the plug (4) with washer (6) and O-ring (5) (7).

Tighten with torque wrench setting of 35 - 50 Nm. (25.8 ~ 36.9 ft lb)

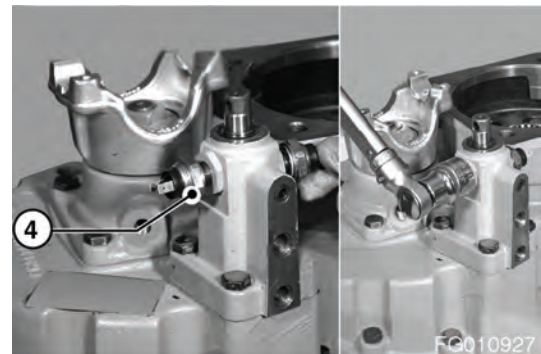


Figure 33

14. Engage the 1-speed and verify with a control device (tester) that the switch 1-speed gives signal and that the switch 2-speed is disabled.

Repeat the operation on the switch 2-speed.

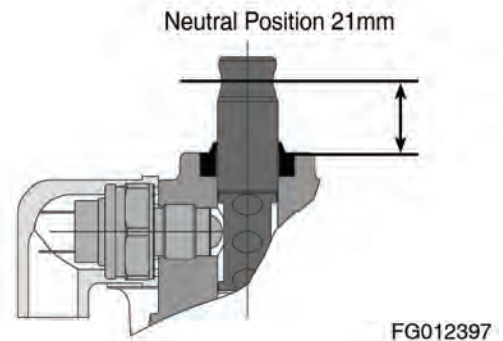
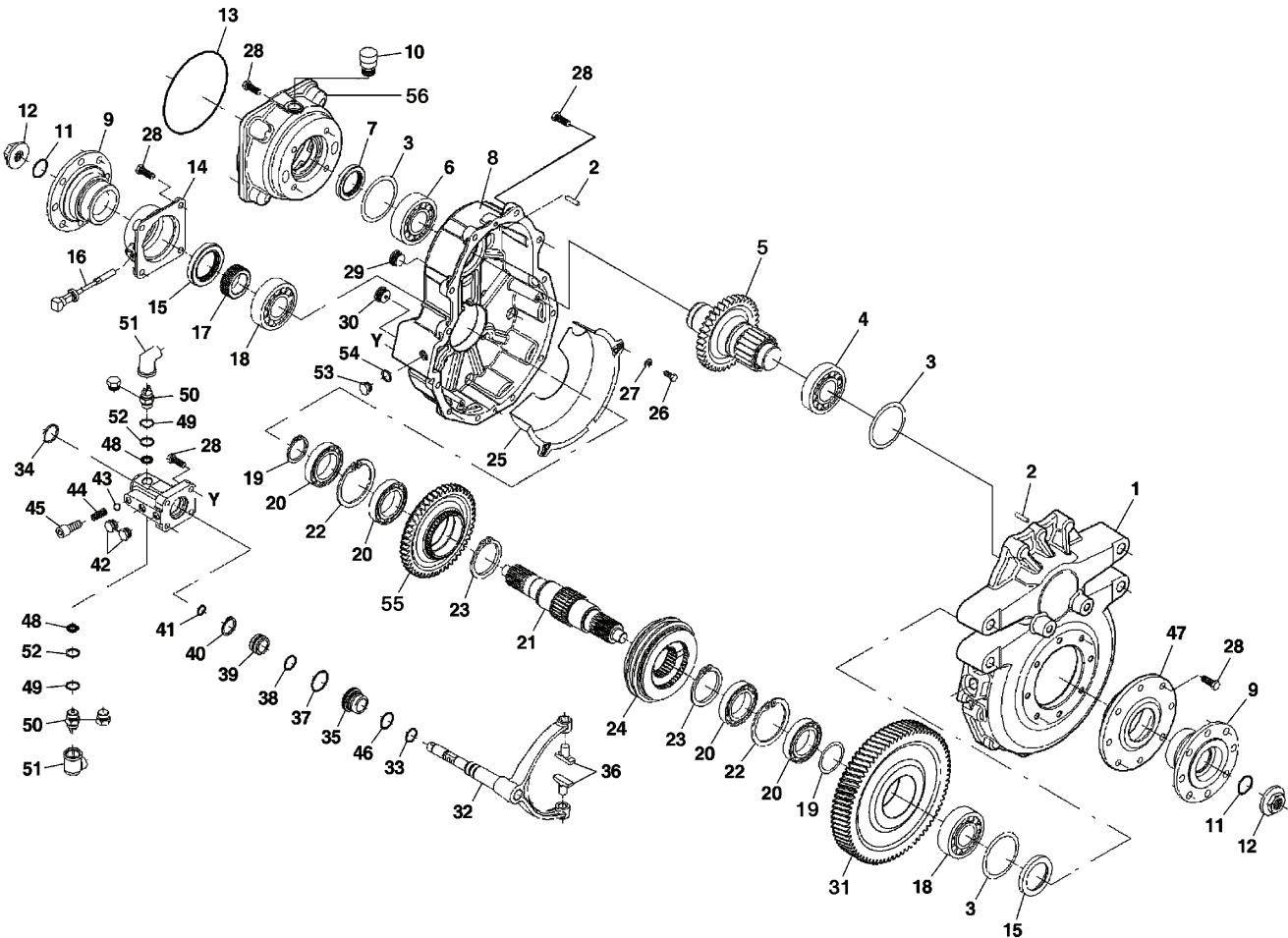


Figure 34

INTEGRATED REDUCTION GEAR 367

Disassembling



FG010897

Figure 35

Reference Number	Description
1	Housing
2	Dowel
3	Shim
4	Ball Bearing
5	Input Shaft
6	Ball Bearing
7	Seal
8	Reduction Gear Cover
9	Flange
10	Vent
11	O-Ring
12	Nut
13	O-Ring
14	Output Cover
15	Seal Ring
16	Electronic Sensor
17	Phonic Wheel
18	Ball Bearing
19	Snap Ring
20	Ball Bearing
21	Output Shaft
22	Snap Ring
23	Snap Ring
24	Synchroniser
25	Baffle Plate
26	Hexagon Bolt
27	Lock Washer
28	Hexagon Bolt

Reference Number	Description
29	Plug
30	Magnet Plug
31	1 Speed Gear
32	Selector Shaft
33	O-Ring
34	Scraper Ring
35	Reduction Bushing
36	Sliding Pin
37	O-Ring
38	O-Ring
39	Guide Ring
40	Snap Ring
41	O-Ring
42	Plug
43	Detend Ball
44	Spring
45	Grub Bolt
46	O-Ring
47	Output Cover
48	O-Ring
49	O-Ring
50	Plug
51	Plug Cap
52	Seal Washer
53	Bolt
54	Washer
55	2 Speed Gear
56	Entrance Cover

1. Remove the gear control cylinder.

For more details, "Hydraulic Gear Control" on page 12

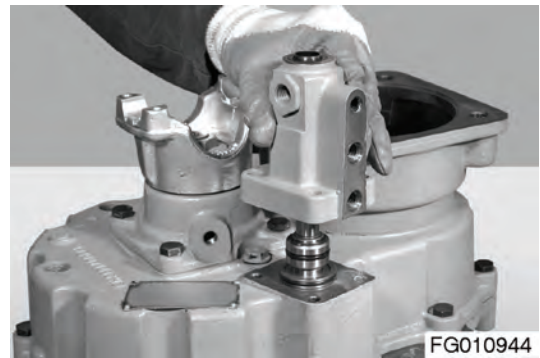


Figure 36

2. Unloose the nut (12) from the flange (9).



Figure 37

3. Remove the nut (12) and O-ring (11) and pull out the flange (9).

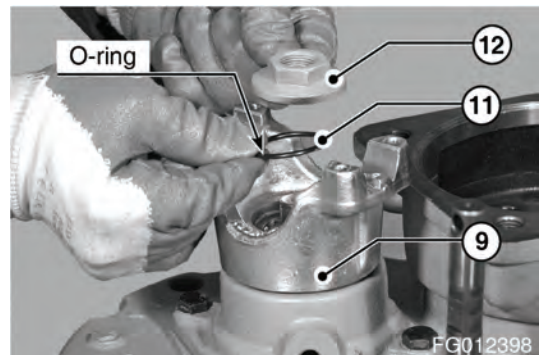


Figure 38

4. Remove the phonic wheel (17).

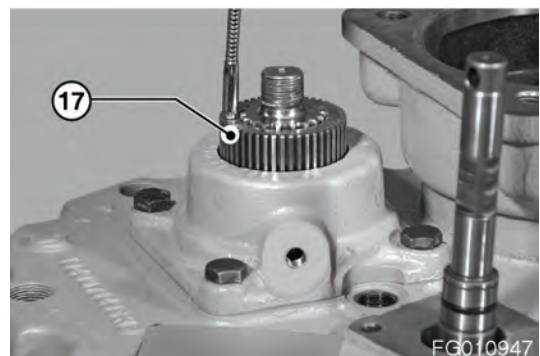


Figure 39

5. Remove hexagon bolts (28) of the cover (8).

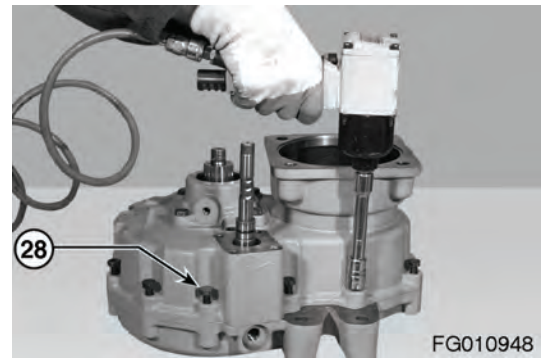


Figure 40

6. Unloose the nut (12) from the flange (9).



Figure 41

7. Remove the nut (12) and O-ring (11) and pull out the flange (9).

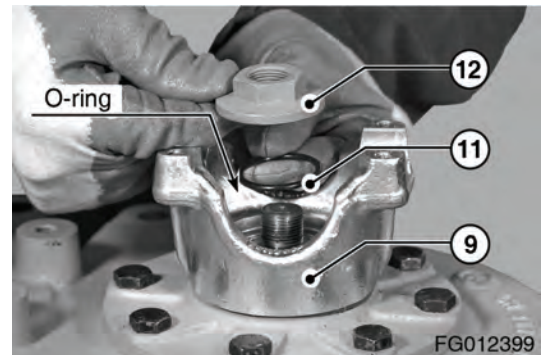


Figure 42

8. Loosen and remove the hexagon bolts (28) of the cover (47).

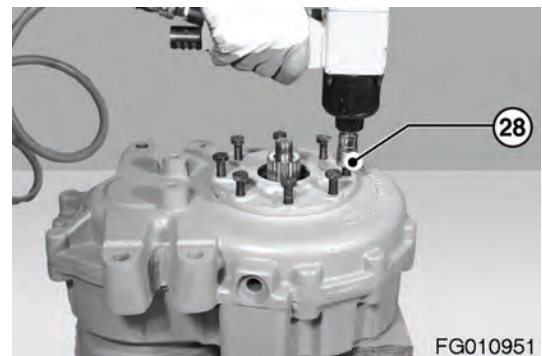


Figure 43

9. Disjoin and remove the cover (47).

NOTE: *Carefully remove all residue of LOCTITE from the surfaces.*

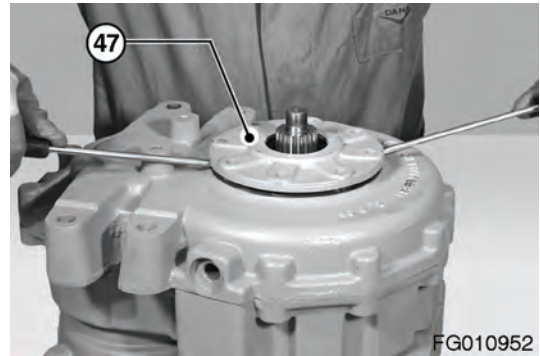


Figure 44

10. Remove seal ring (15).

NOTE: *Note down direction of installation.*

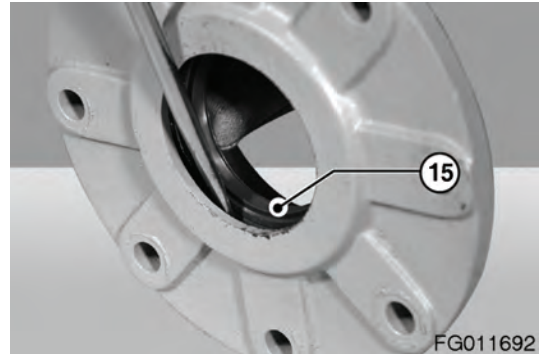


Figure 45

11. Disjoin and remove the housing (1).

NOTE: *Carefully remove all residue of LOCTITE from the surfaces.*

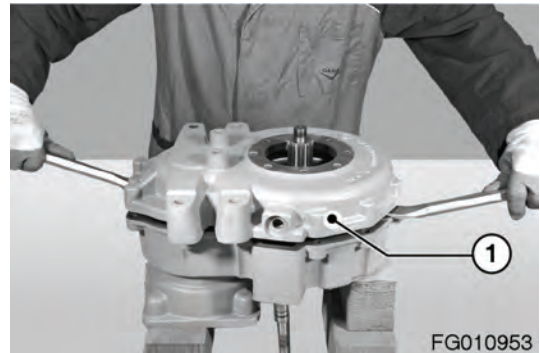


Figure 46

12. Using an internal extractor, remove the bearing (18).



Figure 47

13. Remove gear (31).

NOTE: Note the correct mounting direction.

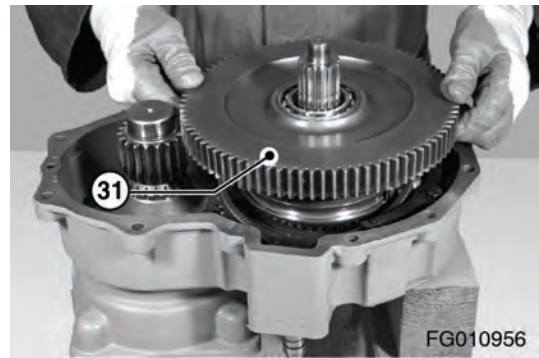


Figure 48

14. Remove the bearing (20) from the gear (31).



Figure 49

15. Remove the snap ring (22).

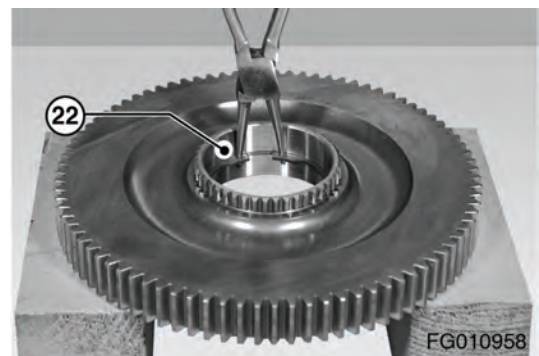


Figure 50

16. Remove the baffle plate (25) and hexagon bolts (26).

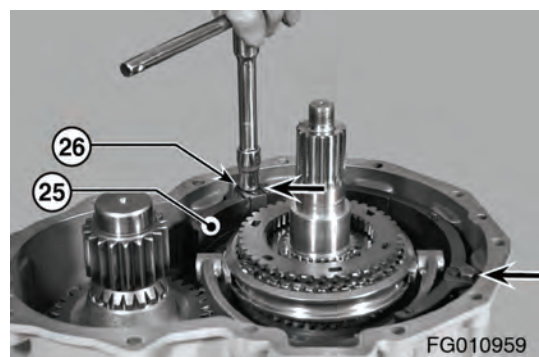


Figure 51

17. Remove the output shaft (21).

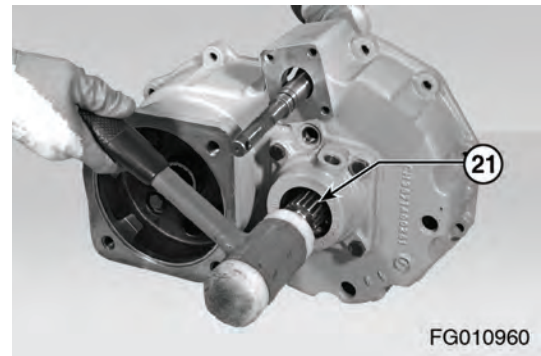


Figure 52

18. Secure the output shaft assembly to a hoist.
Remove the output shaft assembly, complete with yoke and gearbox control rod.



Figure 53

19. Remove the internal baffle plate (25).

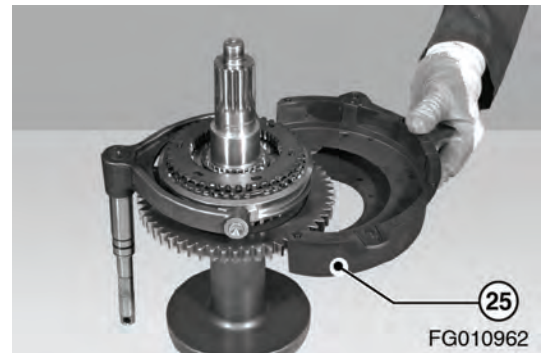


Figure 54

20. Remove yoke and gearbox control rod.
Check the yoke pads for wear.
Replace if worn.

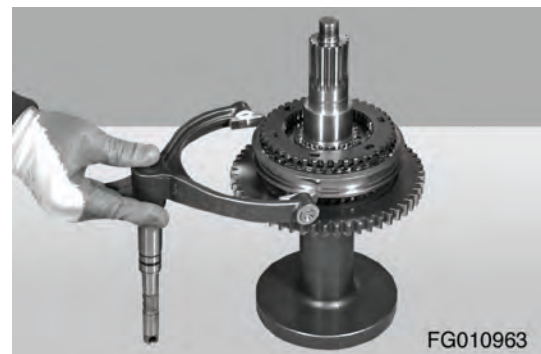


Figure 55

21. Remove the snap ring (23) securing the synchroniser (24).

NOTE: Take care not to bend the snap ring (23).

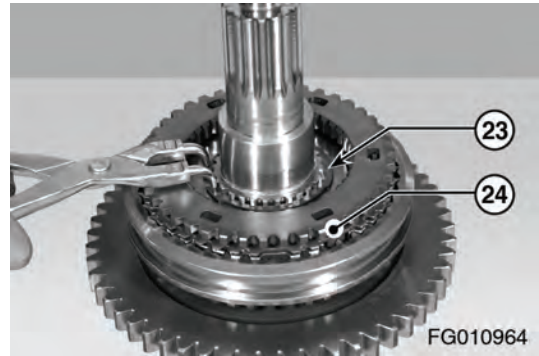


Figure 56

22. Remove the complete synchroniser (24).

NOTE: Note the correct mounting direction.

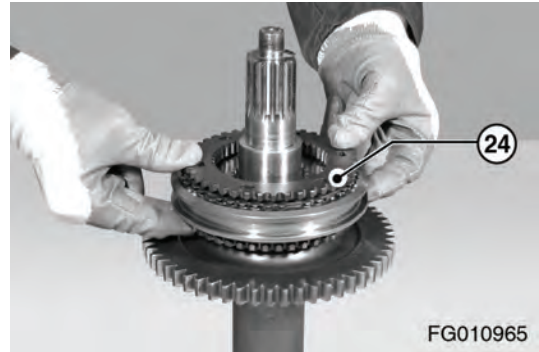


Figure 57

23. Repeat the operation on both sides.

Remove the snap ring (23) securing the gear (55).

NOTE: Take care not to bend the snap ring (23).

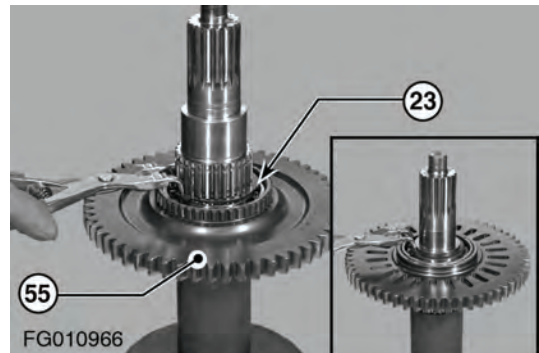


Figure 58

24. Remove gear (55).

NOTE: Note the correct mounting direction.

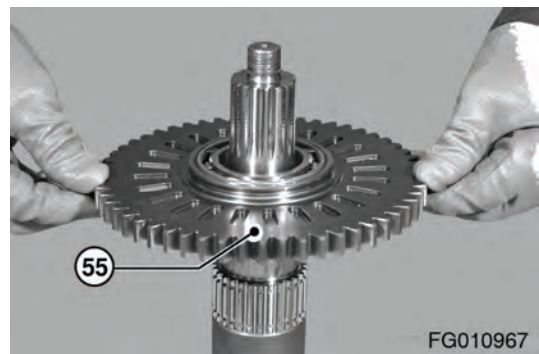


Figure 59

25. Remove the bearings (20) from the gear (55).

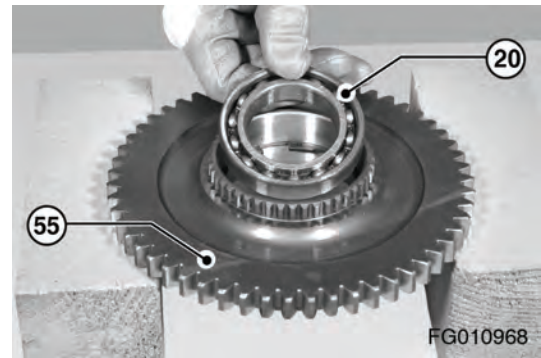


Figure 60

26. Remove the snap ring (22)



Figure 61

27. Remove the input shaft (5).

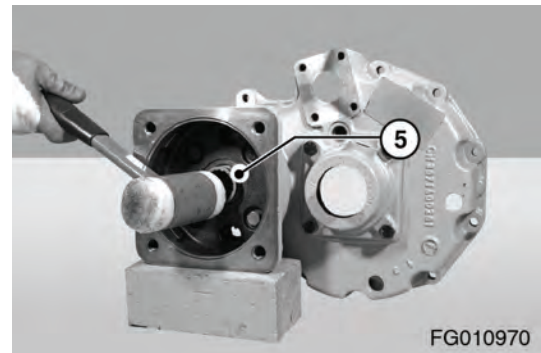


Figure 62

28. INPUT SHAFT

Mark the position between the motion entrance cover (56) and reduction gear cover (8); remove hexagon bolts (28) from the motion entrance cover (56).



Figure 63

29. Remove the cover by fixing the distance shims (3) onto the cover (56) itself.

NOTE: Carefully remove all residue of LOCTITE from the surfaces.

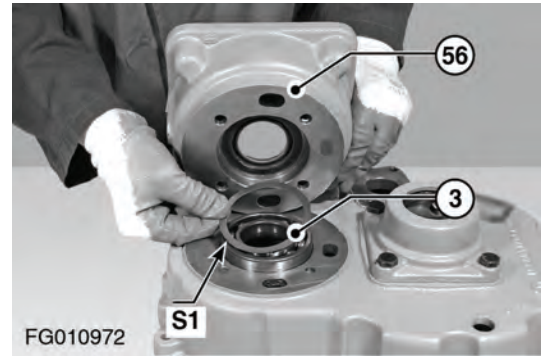


Figure 64

30. Remove seal ring (7).

NOTE: Note down direction of installation.

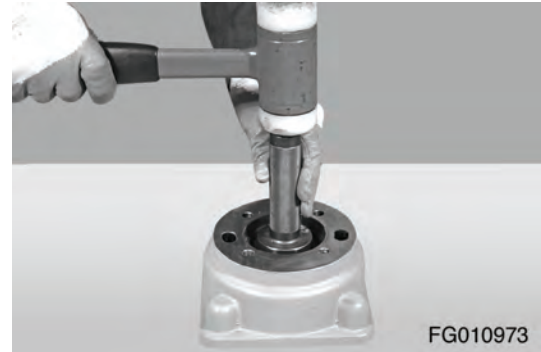


Figure 65

31. Remove the bearing (6) from the cover (8).

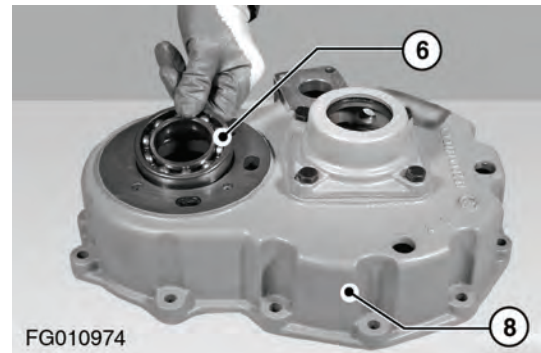


Figure 66

32. Loosen and remove the hexagon bolts (28) of the cover (14).

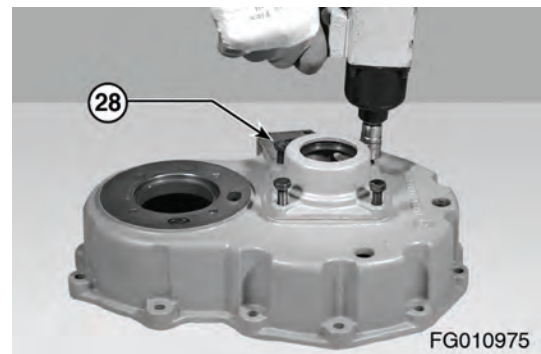


Figure 67

33. Disjoin and remove the cover (14).

NOTE: *Carefully remove all residue of LOCTITE from the surfaces.*

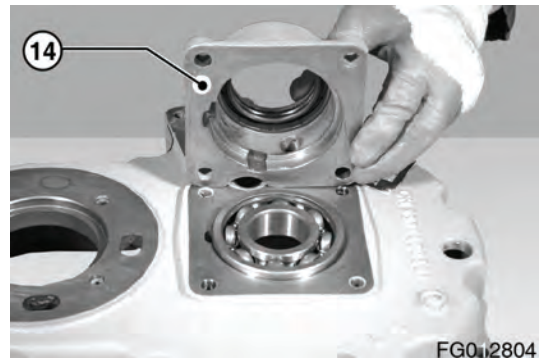


Figure 68

34. Remove the bearing (18) from the cover (8).

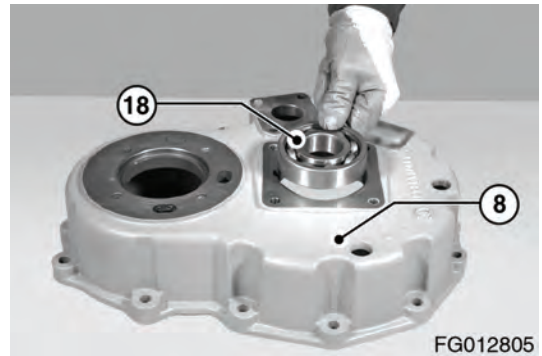


Figure 69

35. Remove seal ring (15).

NOTE: *Note down direction of installation.*

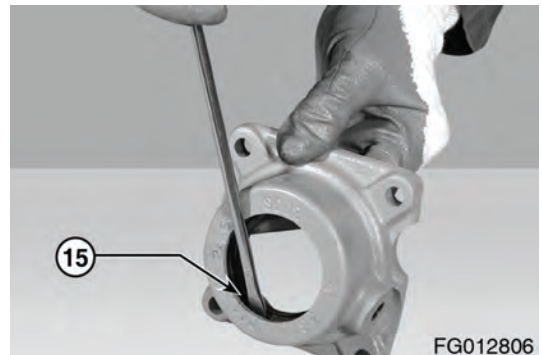
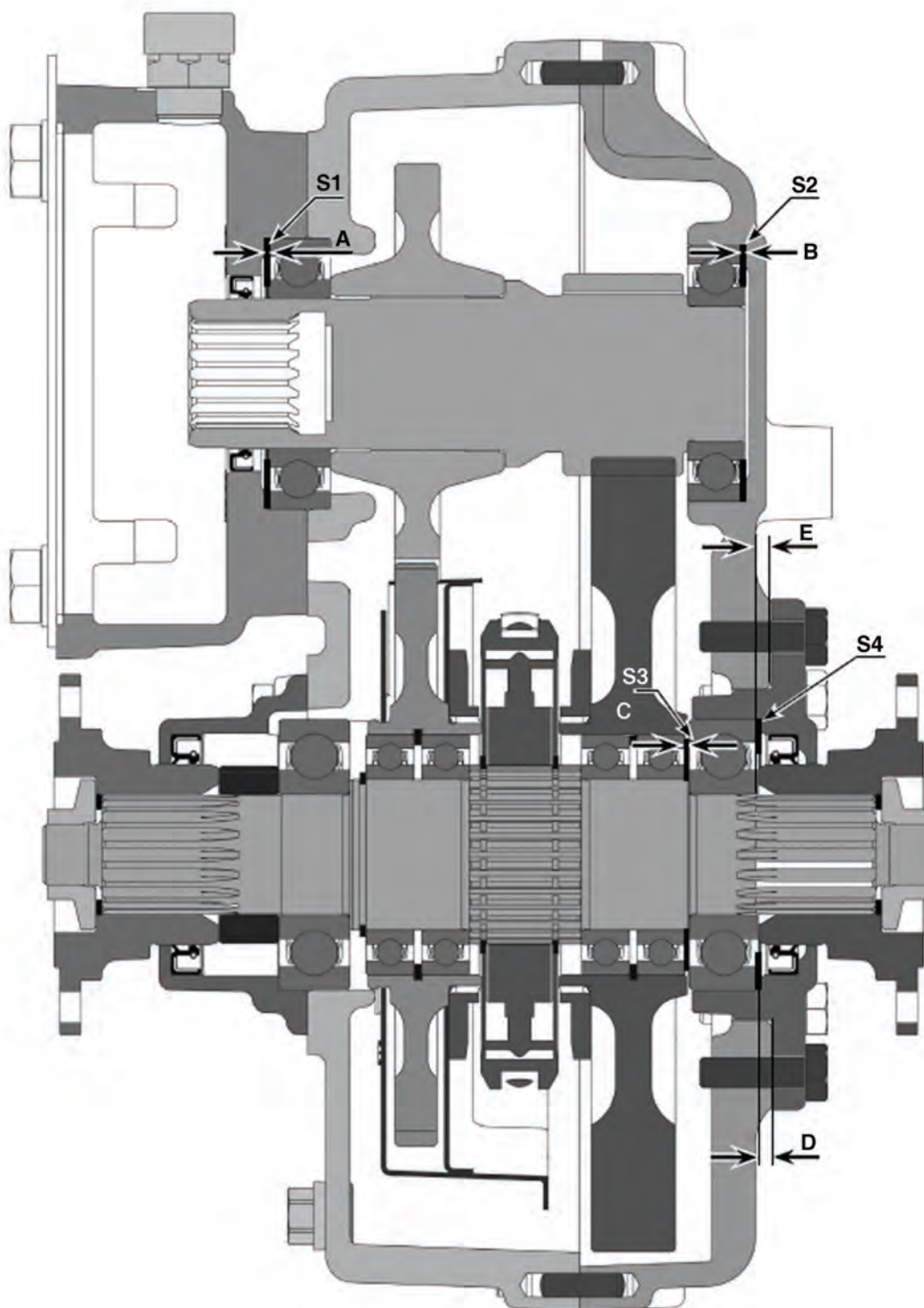


Figure 70

Assembl Clearance



FG010979

Figure 71

Assembling

1. Re-insert the new sealing ring (15) in the output cover (14).

CAUTION

Pay particular attention to the direction of assembly of the rings (7).

Lubricate the lip of the sealing ring with grease.

Lubricate the lip of the sealing ring with grease.

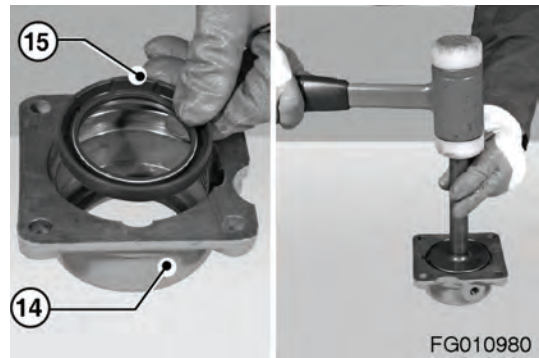


Figure 72

2. Using a normal tool insert the bearing (18).

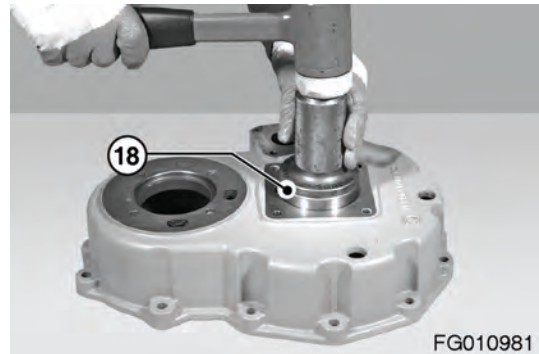


Figure 73

3. Assembly the cover (14) spreading LOCTITE 510 on planes.

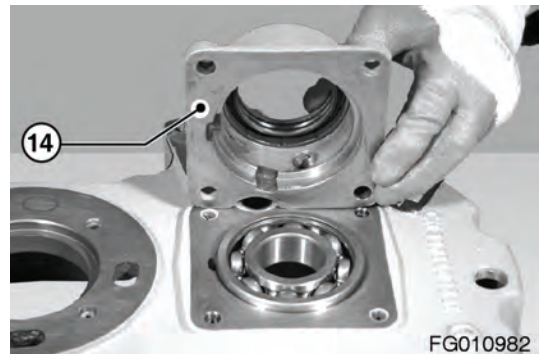


Figure 74

4. Assembly the hexagon bolts (28) spreading LOCTITE 242
Tighten hexagen bolts (28) using a torque wrench setting
of 48 - 53 Nm. (35.4 ~ 39.1 ft lb)

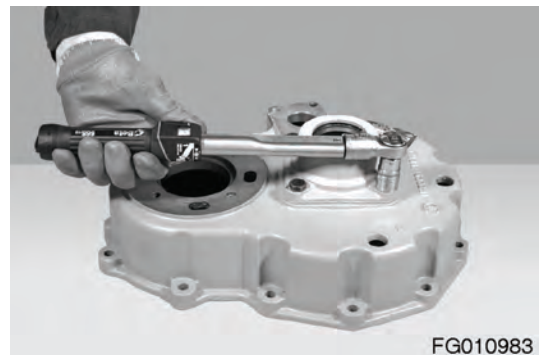


Figure 75

5. Using a normal tool insert the bearing (6).

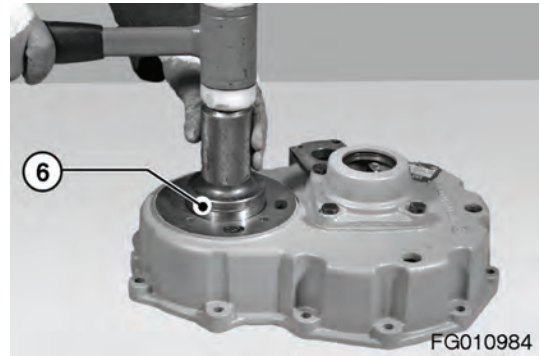


Figure 76

6. Re-insert the new sealing ring (7) in the entrance cover (56).



CAUTION

Pay particular attention to the direction of assembly of the rings (11).

Lubricate the lip of the sealing ring with grease.

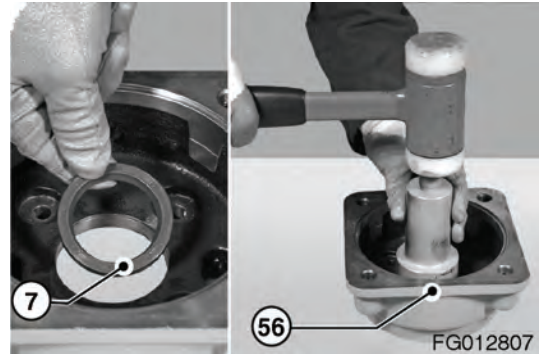


Figure 77

7. Zero the depth gauge between the cover surface and bearing contact surface.

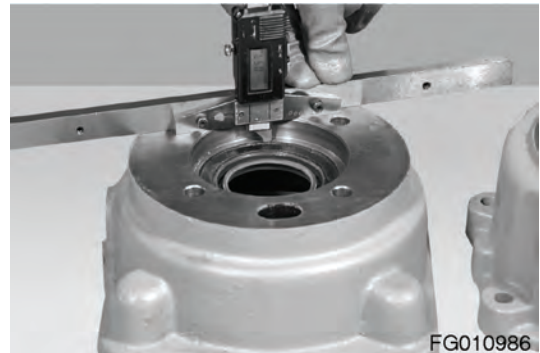


Figure 78

8. Measure distance "A" between the surface and thrust block.

example. $A = 0.50$

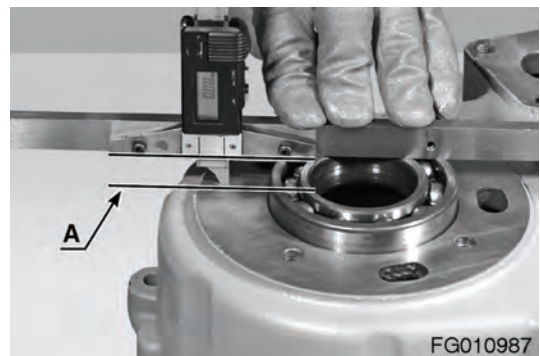


Figure 79

9. Calculate thickness "S" of the shims by using this formula:

$S = A - Y = S$, where Y is the predefined axial backlash.

$Y = \text{backlash} = 0.15 \pm 0.35 \text{ mm}$

Example: $S = A - Y = 0.50 - 0.25 = 0.25 \text{ mm} = S$

Make up the appropriate pack of shims.

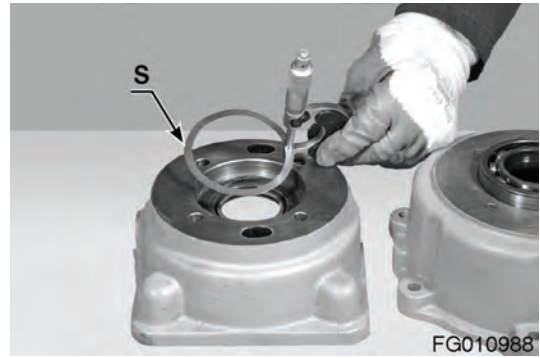


Figure 80

10. Apply LOCTITE 510 to the machined surfaces, Assemble the cover (56) and shims (3).

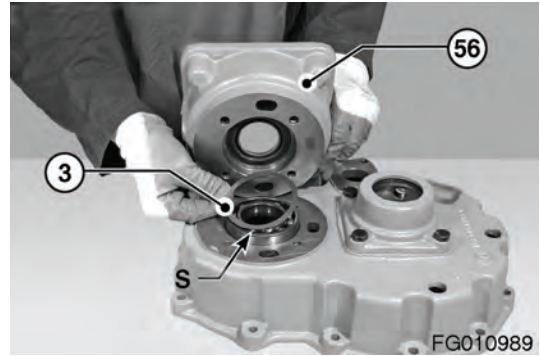


Figure 81

11. Assemble the hexagon bolts (28) spreading LOCTITE 242 Tighten hexagon bolts (28) using a torque wrench setting of 48 - 53 Nm. (35.4 ~ 39.1 ft lb)

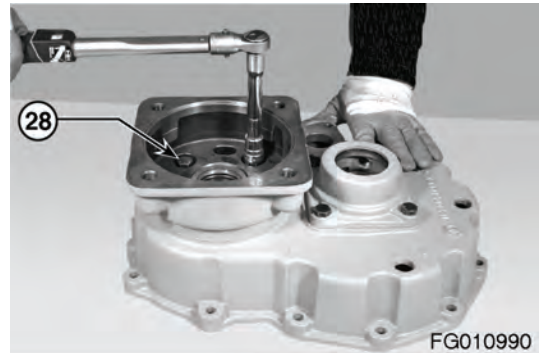


Figure 82

12. Install the input side shaft (5) with a plastic hammer.

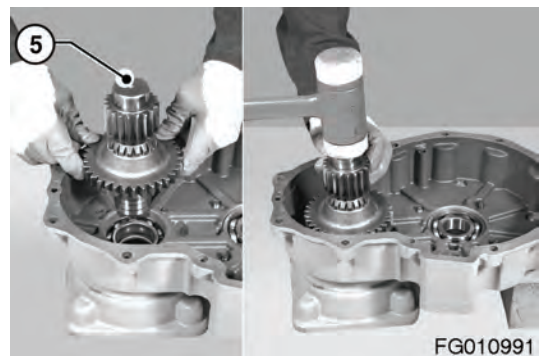


Figure 83

13. Fit the snap ring (19) in the gear (31).

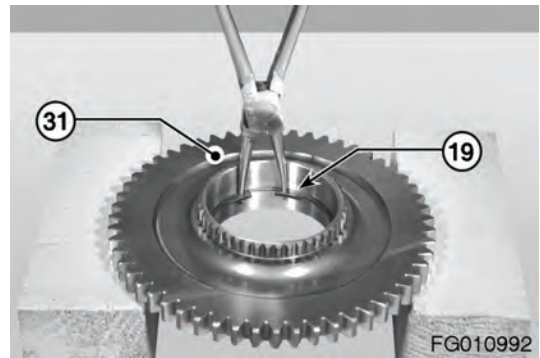


Figure 84

14. Using a pusher of suitable diameter, fit the bearings (20).

NOTE: *Ensure that the bearing is seated securely.*

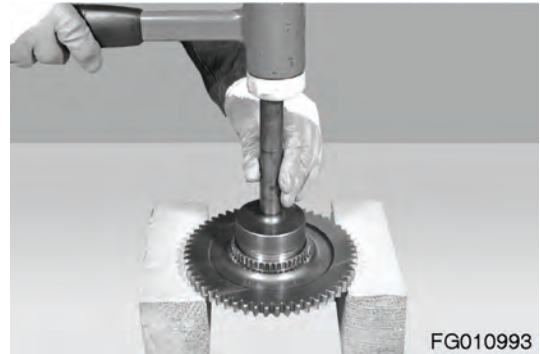


Figure 85

15. Fit gear (55) onto the shaft (21).

NOTE: *Fit as originally mounted, using the markings made previously as reference.*

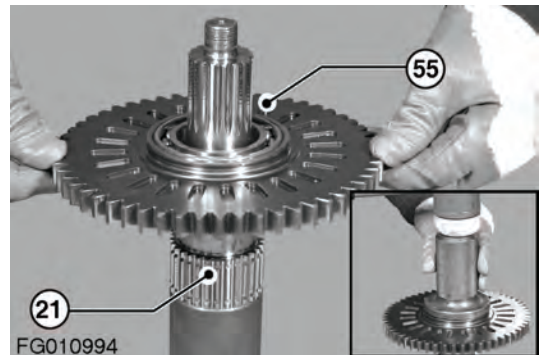


Figure 86

16. Repeat the operation on both sides.

NOTE: *Secure the gear (55) in position with the snap ring (22)(23).*

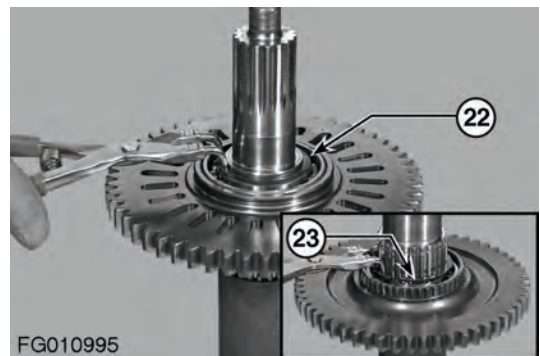


Figure 87

17. Fit the complete synchroniser (24).

NOTE: *Fit as originally mounted, using the markings made previously as reference.*

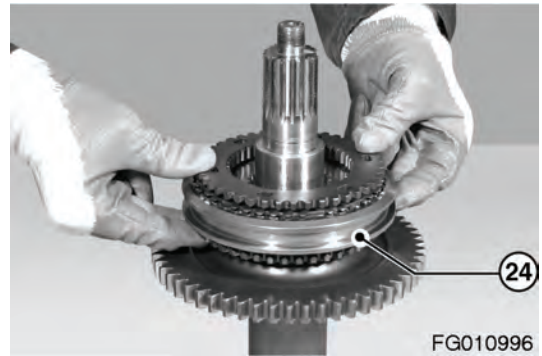


Figure 88

18. Secure the synchroniser (24) in position with the snap ring (23).

NOTE: *Check that the snap ring is seated correctly.*



Figure 89

19. Fit the gear selector yoke in the synchroniser (24).

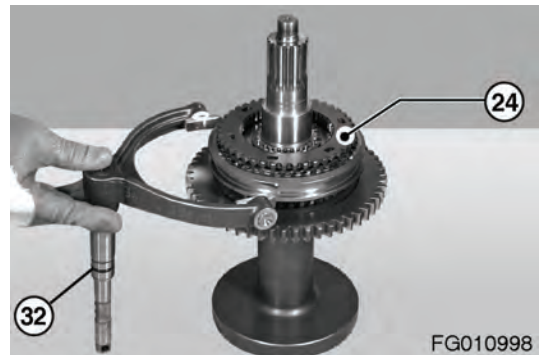


Figure 90

20. Fit the internal baffle plate (25) in position.



Figure 91

21. Secure the output shaft assembly (21) to a hoist.
Install the output shaft assembly (21), complete with yoke and gearbox control rod.

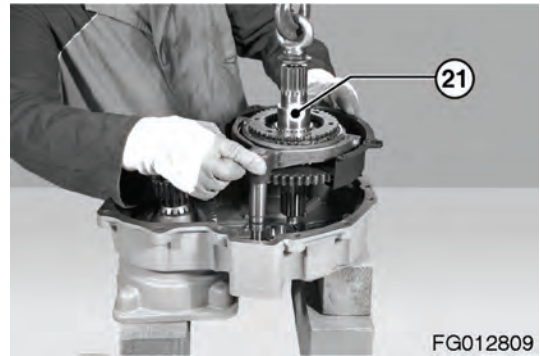


Figure 92

22. Using a plastic hammer, install the output shaft (21).

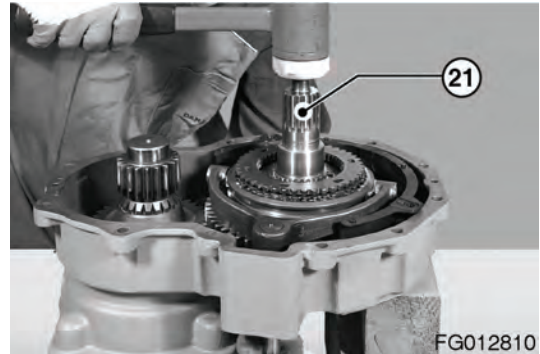


Figure 93

23. Spread Loctite270 on the screws and tighten to a torque of 9.5 - 10.5 Nm. (7.0 ~ 7.7 ft lb)

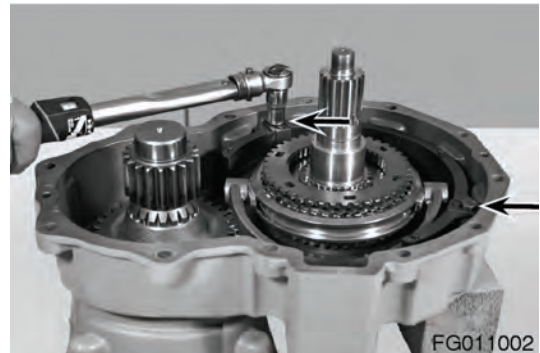


Figure 94

24. Using a pusher of suitable diameter, fit gear (31) onto the shaft (21).

NOTE: *Fit as originally mounted, using the markings made previously as reference.*



Figure 95

25. By hand install the bearing on the input shaft.

Reset a digital depth gauge between cover surface and bearing.

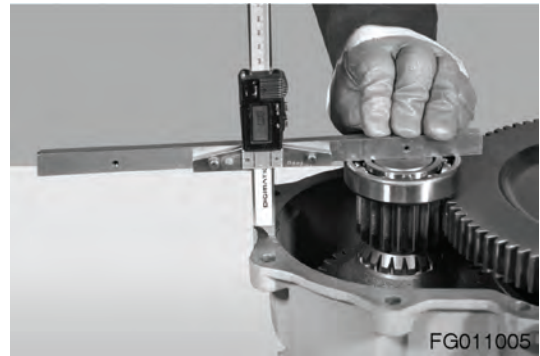


Figure 96

26. Remove the bearing (4) from the input shaft (5).



Figure 97

27. Measure distance "B" between the cover surface and bearing contact surface.

Example: $B = 0.45$

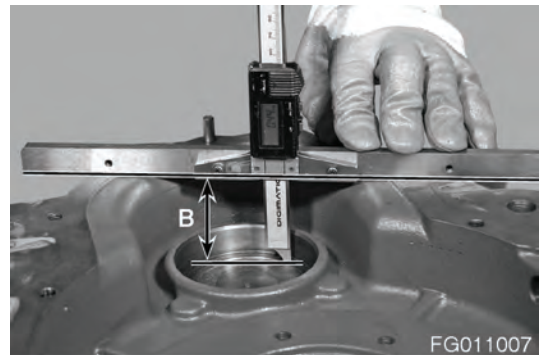


Figure 98

28. Calculate thickness "S2" of the shims by using this formula:

$S2 = B - Y = S2$, where Y is the predefined axial backlash.

$Y = \text{backlash} = 0.15 \pm 0.35 \text{ mm}$

Example: $S2 = B - Y = 0.45 - 0.25 = 0.20 \text{ mm} = S2$

Make up the appropriate pack of shims.

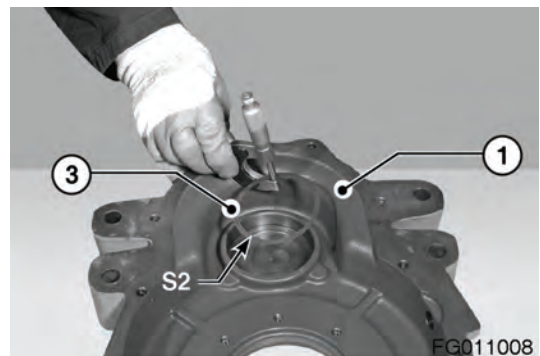


Figure 99

29. Using a normal tool, push the bearing (4) and shims into its seat in the housing (1).

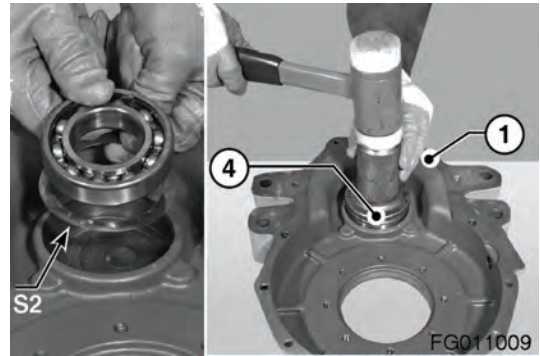


Figure 100

30. Insert dowels (2) .

Apply LOCTITE 510 to the machined surfaces, Fit the cover (1) onto the casing (8) and align the pins (2).

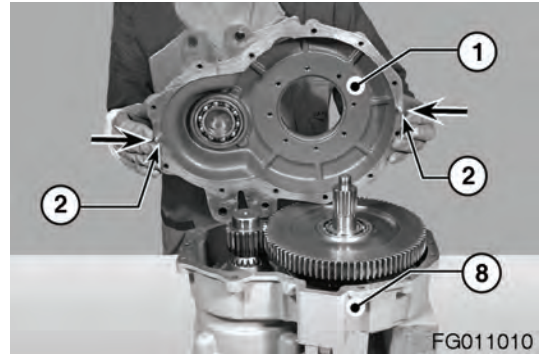


Figure 101

31. Tap the cover (1) gently with a mallet to seat correctly.

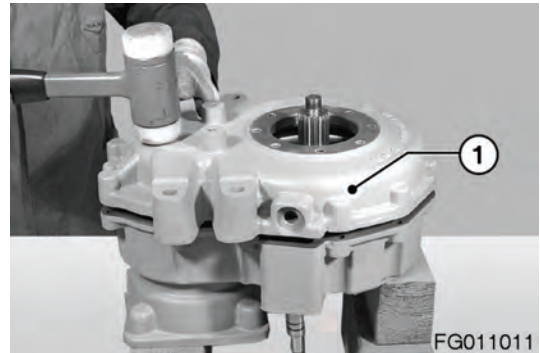


Figure 102

32. Spread Loctite 242 on the hexagon bolts (28).

Secure in position with the hexagon bolt (28), tightening to a torque of 48 - 53 Nm (35.4 ~ 39.1 ft lb)

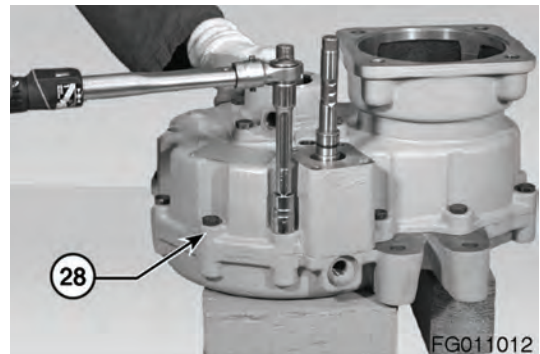


Figure 103

33. Reset a centesimal digital depth gauge between calibrated blocks (whose known thickness is 30 mm.) and output shaft.

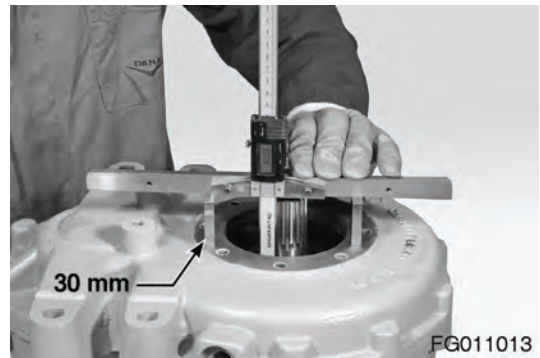


Figure 104

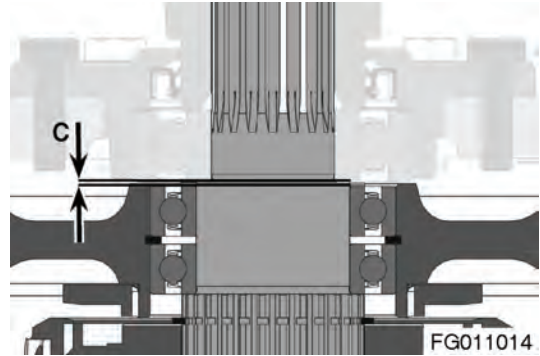


Figure 105

34. Measure distance "C" between the output shaft and bearing thrust block.

Example: $C = 0.45$



Figure 106

35. Calculate thickness "S3" of the shims by using this formula:

$S3 = C - X = S3$, where X is the prede? ned axial backlash.

$X = \text{backlash} = 0.15 \pm 0.35 \text{ mm}$

Example: $S3 = C - X = 0.45 - 0.25 = 0.20 \text{ mm} = S3$

Make up the appropriate pack of shims.

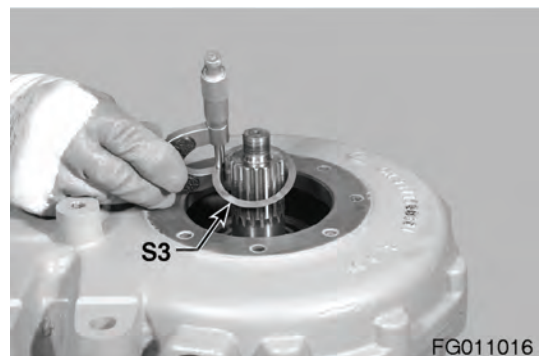


Figure 107

36. Using a pusher of suitable diameter, fit the bearing (18) into output shaft (21).

NOTE: Ensure that the bearing is seated securely.

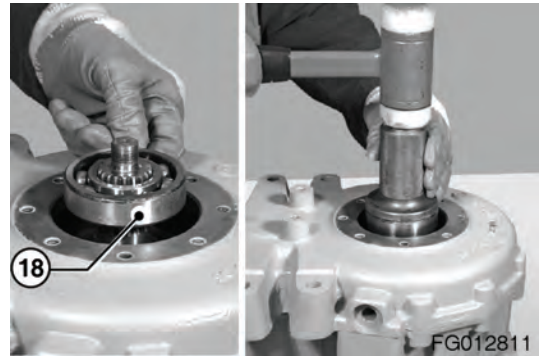


Figure 108

37. Re-insert the new sealing ring (15) in the motion output cover (47).



Pay particular attention to the direction of assembly of the rings (11).

Lubricate the lip of the sealing ring with grease.

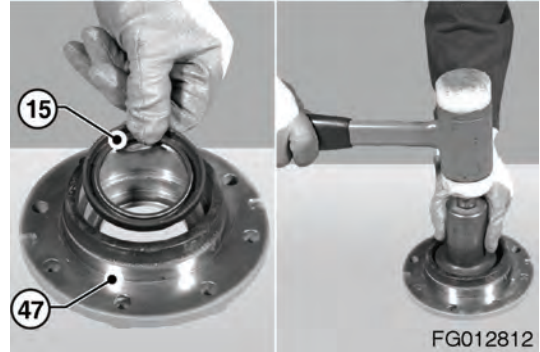


Figure 109

38. Measure distance "D" between cover surface and bearing.

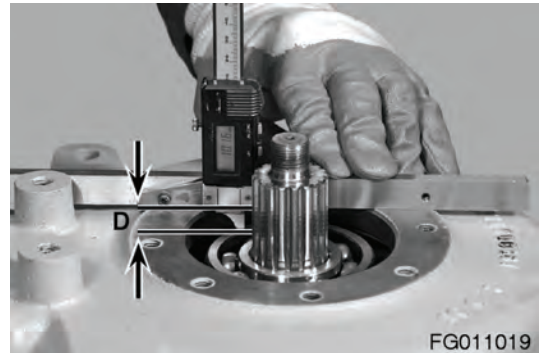


Figure 110

39. Zero the depth gauge between calibrated blocks (whose known thickness is 30 mm.) and bearing seat.

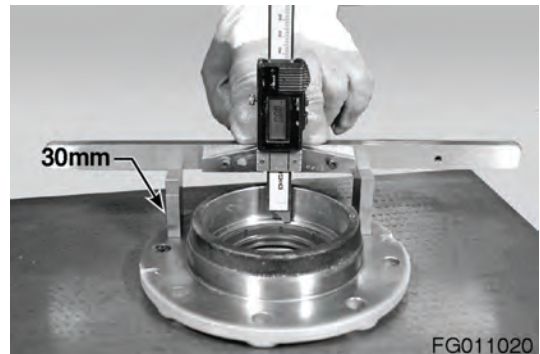


Figure 111

40. Measure dimension "E" on the cover.

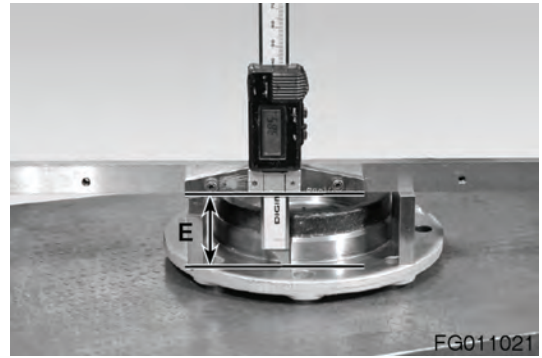


Figure 112

41. Calculate thickness "S4" of the shims by using this formula:

$S4 = (\text{Dimension E} - \text{Dimension D}) - X = S4$, where X is the predefined axial backlash.

$X = \text{backlash} = 0,15 \text{ ? } 0,25 \text{ mm}$

Example: $S4 = (E - D) - X = (3,85 - 3,40) - 0,20 = 0,25 \text{ mm} = S4$

Make up the appropriate pack of shims.

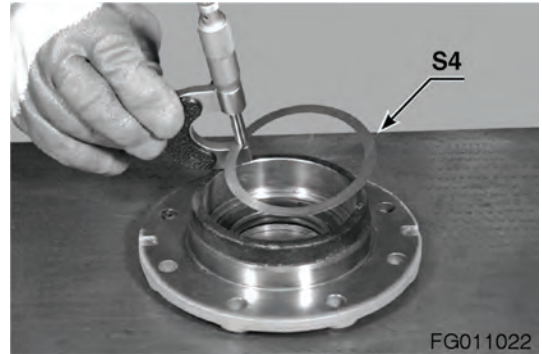


Figure 113

42. Assembly the cover (47) spreading LOCTITE 510 on planes.

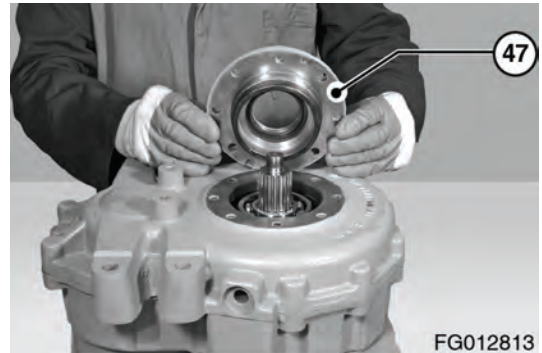


Figure 114

43. Assembly the hexagon bolts (28) spreading LOCTITE 242
Tighten hexagon bolts (28) using a torque wrench setting of 48 - 53 Nm. (35.4 ~ 39.1 ft lb)

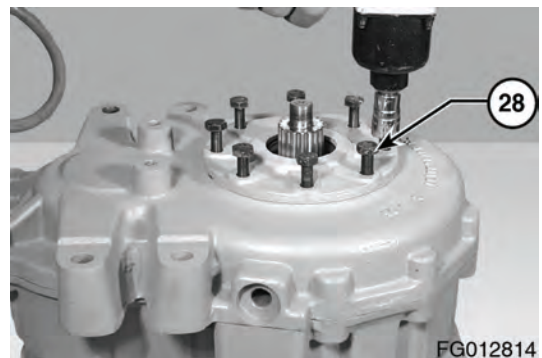


Figure 115

44. Fit the flange (9) on the shaft (21), seating completely.

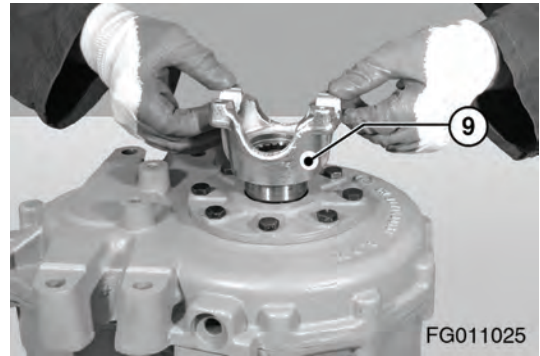


Figure 116

45. Lubricate the O-ring (11) with grease and fit in the flange (9) seating.

Spread with LOCTITE 242 the lock nut (12) and fit.

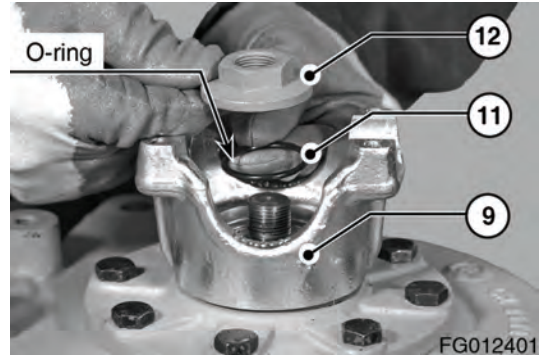


Figure 117

46. Tighten the locknut (12) to a torque of 280 - 310 Nm. (206.5 ~ 228.6 ft lb)

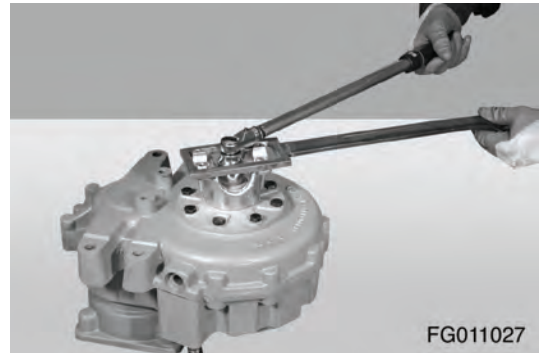


Figure 118

47. Insert the phonic end wheel (17).

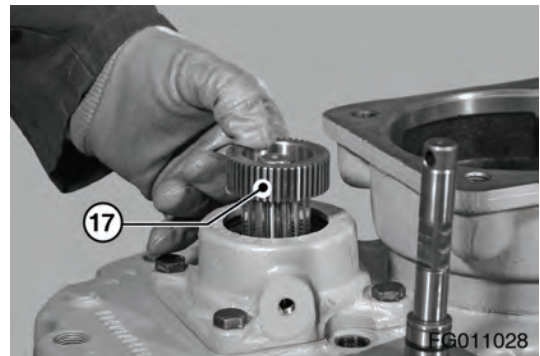


Figure 119

48. Fit the flange (9) on the shaft (21), seating completely.



Figure 120

49. Lubricate the O-ring (11) with grease and fit in the flange (9) seating.

Spread with LOCTITE 242 the lock nut (12) and fit.

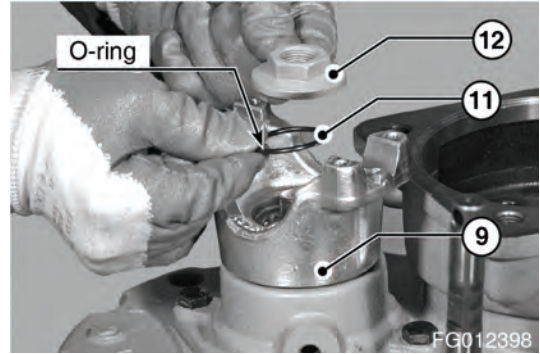


Figure 121

50. Tighten the locknut (12) to a torque of 280 - 310 Nm. (206.5 ~ 228.6 ft lb)

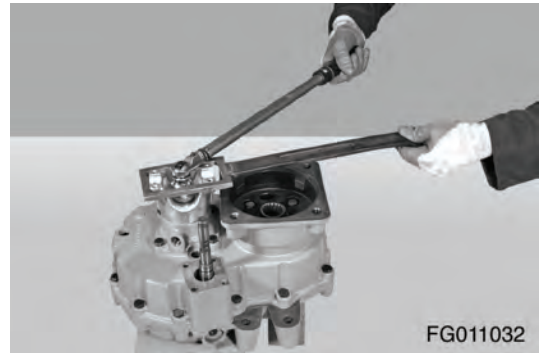


Figure 122

51. Coat the coupling surface of the gearshift cylinder with Loctite 510; fit the cylinder on the gear selector rod.

NOTE: *Make sure that the sealant forms a continuous film around the locking holes.*

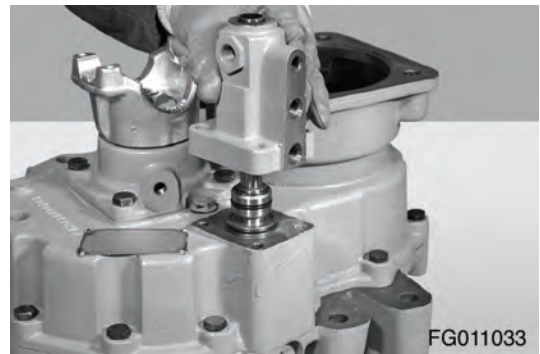


Figure 123

Drive Coupling (Main Pump)

Edition 1

MEMO

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Drive Coupling (Main Pump)

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MEMO

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 ultimately safety is your own responsibility.

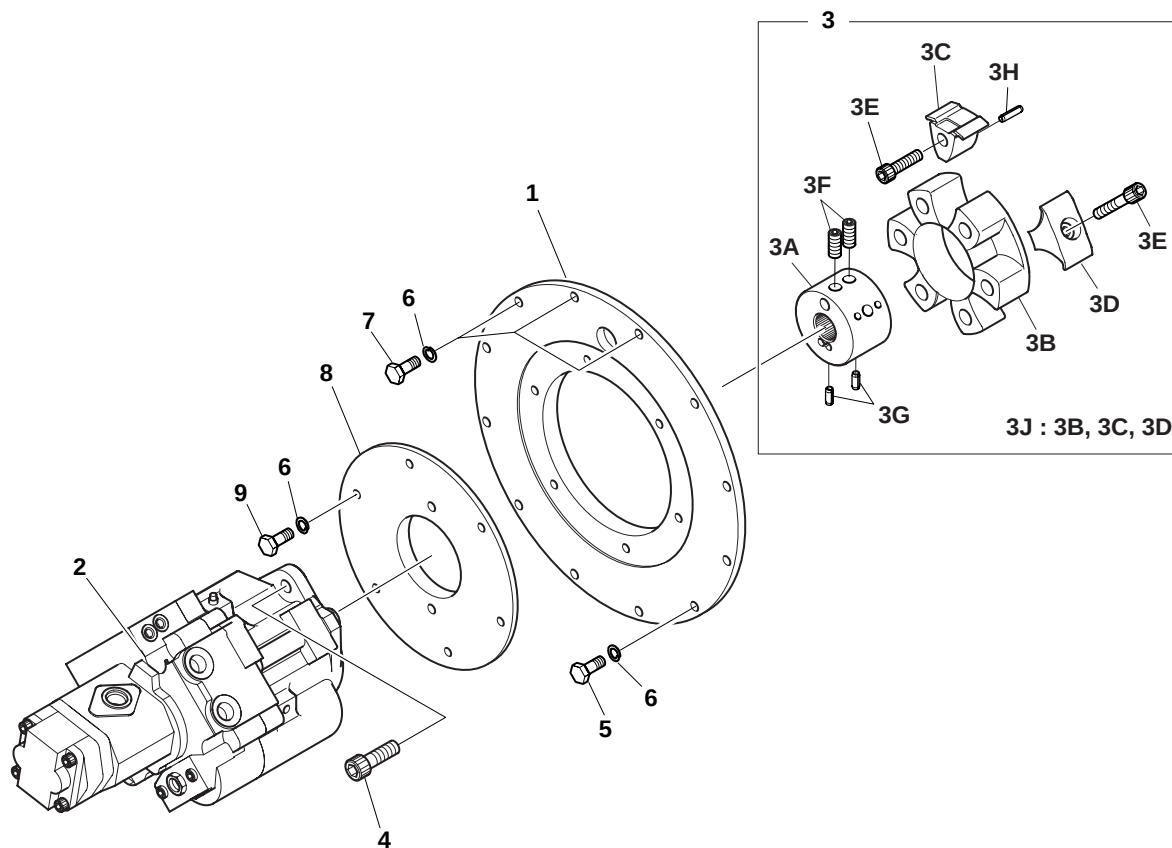
APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55	5001 and Up
DX55W	5001 and Up

DRIVE COUPLING

Figure 1, show typical drive coupling installations.



FG011705

Figure 1

Reference Number	Description
1	Pump Cover
2	Pump
3	Coupling
4	Socket Bolt
5	Spring Washer

Reference Number	Description
6	Bolt
7	Cover
8	Bolt
9	Pump Cover

INSTALLATION OF DRIVE COUPLING

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

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

Installation Procedure

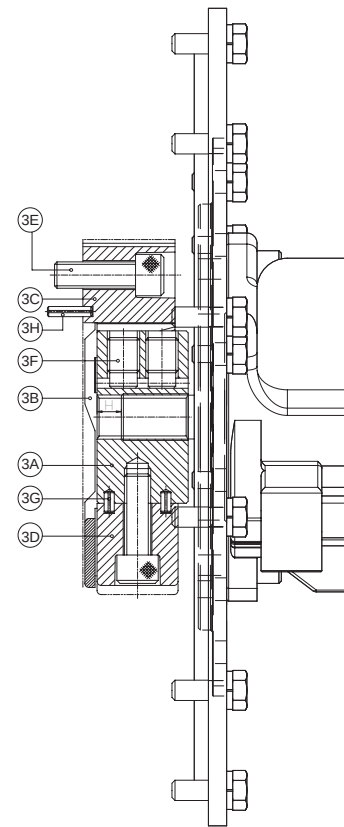
1. Insert the PIN (3G) to the HUB (3A).
2. Assemble the INSERT (3F) on the HUB (3A) using the BOLT (3E).
Decide the location with PIN (3G) during the assembly.
3. Assemble the INSERT (3C) and ELEMENT (3B) to the FLY WHEEL using the BOLT (3E).
Decide the location with PIN (3H) during the assembly.

NOTE: *Because the BOLT (3E) is specially coated, never use bond or white kerosene etc.
Because the ELEMENT (3B) is weak to bond, oil and grease, be careful not to make any contact.*

4. Check whether there is enough 12mm clearance (H) between the end of HUB (3A) and the end of the pump shaft.
Then fixate the PUMP SPLINE with the CLAMPING BOLT.

NOTE: *After painting the LOCTITE on the bolt, assemble with torque 6~6.5kg•m.*

5. Insert 4) Assembly to the above 3) Assembly, and do the final assembly on the FLY WHEEL HOUSING by using the BOLT (9).
6. When tightening the connection BOLT (3E) from the above 2) and 3) article with the connection TORQUE of 13~15kg•m, tightly uniformly by 1 or 2 mounts.



FG014626

Figure 2

Precaution

1. The concentricity of the PUMP (2) and E/G SHAFT must be within 0.3mm.
2. Clean the PUMP FLANGE and SHAFT before installign the PUMP and remove the oil. Then paint the grease on the SPLINE part.
3. PUMP FLANGE connection TORQUE : 6.5kg.m
4. Connection TORQUE of #04 BOLT M12x1.25 for PUMP assembly: 12kg•m
5. Use LOCTITE when assembling the BOLT.

Hydraulics

Hydraulic System Troubleshooting, Testing and Adjustment

Edition 1

MEMO

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Hydraulic System Troubleshooting, Testing and Adjustment

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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.

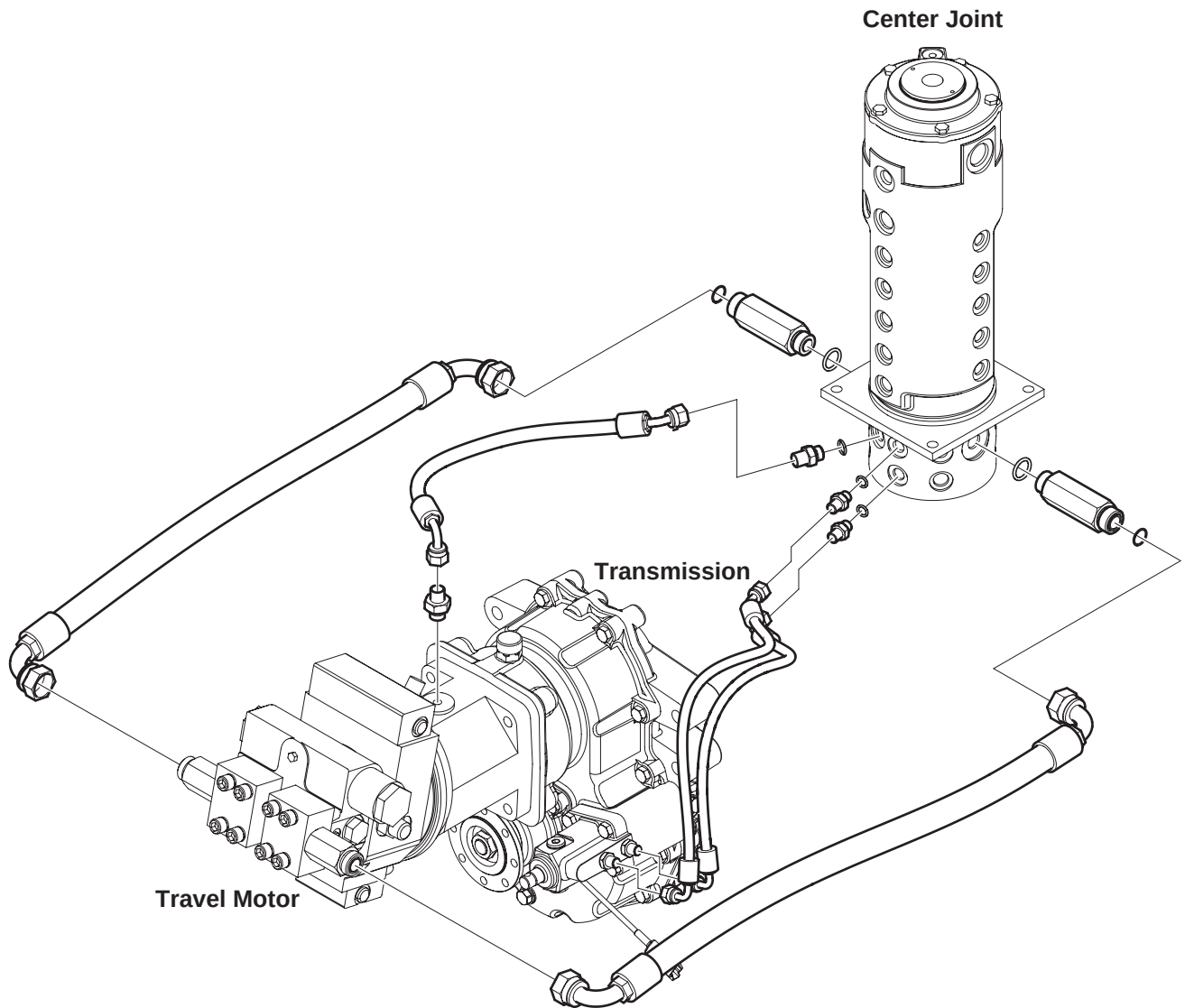
Remember, that ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

HYDRAULIC SYSTEM - GENERAL NOTES



FG012358

Figure 1

The hydraulic system has several improvements over conventional hydraulic systems - including crosssensing total horsepower control - to maximize output efficiency.

Electronic management of hydraulic control valves assists in optimizing the application speed and overall operator control of hydraulic actuators and functions.

HYDRAULIC SCHEMATIC

The hydraulic schematic(s) is available in the "Hydraulic and Electrical Schematic Shop Manual." This manual is a collection of diagrams and schematics for a number of models.

General Notes

When referring to the schematic, refer to the following items:

- As shown in the schematic, the main pump assembly is driven by the engine. Mechanical energy is converted to hydraulic power, generating the required hydraulic flow which drives the system. Main pump assembly is consist of two main pump (1,2 pump) and two gear pump (3 pump, pilot pump).
- Hydraulic output from the 1 pump is transmitted to the right side of the control valve. Output from the 2 pump is transmitted to the valve spools on the left side of the control valve. Hydraulic output from the pilot pump is used to control the pump and to operate pilot and solenoid valves.
- The right half of the hydraulic control valve, supplied by 1 pump in the pump assembly, operates valve spools for right travel, bucket, boom up and arm functions. The amount of oil flow to the actuators at the output end of each of those circuits is regulated through the movement of each individual valve spool.
- The left half of the hydraulic control valve, fed by 2 pump in the pump assembly, has control spools for left travel, option, boom and arm operation.
- Hydraulic output of the 3 pump is transmiassed to the steering valve. When not to steer the vehicle, hydraulic output is transmiassed to confrol valve from the "EL" port of the steering valve and control spools for turning, dozer, boom swing(option) functions.
- Two-stage operation is a feature of boom and arm function. All of these circuits can be operated using the output of only one half of the hydraulic pump assembly (one pump or the other), or – since both halves of the control valve have a spool and available circuit for these functions – the output of both pumps can be combined, allowing higher speed operation. Boom up, arm crowd and dumping functions can operate in any one of the two available power modes – the standard or general duty mode, the high speed/rapid cycling mode.
- Whenever the travel control spools are shifted, output from the main pump assembly passes through the center joint to the axial piston motors driving the wheel.

- The hydraulic reservoir return line and the pilot circuit both have 10 micron full flow filters. The disposable elements in these two canister type filters trap and remove impurities from the oil in the system. An 150 mesh, 105 micron reservoir intake strainer also helps maintain system cleanliness and should be cleaned each time hydraulic fluid is drained and replaced. An oil cooler in the hydraulic system helps maintain the operating temperature of the system at approximately 50°C (122°F).
- The arm cylinder operating circuit includes anticavitation valves which protect the hydraulic system from vacuum that could result from external shocks or other unusual conditions. Boom, Arm, and Bucket cylinder circuit are also protected by overload relief valves. Whenever high-pressure is generated as a result of a shock or overload, excess pressure is dumped to the reservoir return circuit through the relief valve.

OPERATION OF WORKING COMPONENTS

Boom Operating Circuit

The boom operating circuit includes the 1 and 2 main hydraulic pumps (both halves of the main pump assembly), both sides of the control valve and the boom cylinder. The circuit operates in boom down mode through the first shift position and through the second shift position in boom up mode. Overload relief valves set at 245 kg/cm^2 (3,485 psi) protect the hydraulic system from being damaged as a result of overloads or shocks to the boom.

Boom Up Circuit

When you pull the boom control lever backward, the right side pilot valve generates secondary boom up pilot pressure that is transmitted to the right and left sides of the control valve simultaneously. When secondary pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 128 psi), boom control valve spools open and oil from both pumps goes to the boom cylinder.

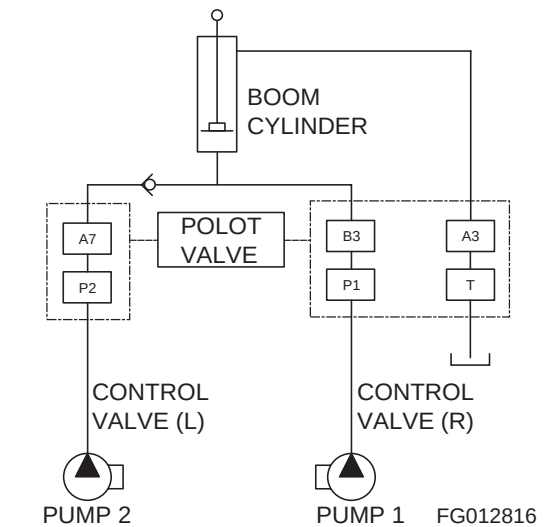


Figure 2

Boom Down Circuit

When the boom control lever is pushed forward, the right side pilot valve generates secondary boom down pilot pressure that is transmitted only to the right side of the control valve. When secondary pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 128 psi), the valve spool on the right side of the control valve opens so that oil from only one half of the pump assembly goes to the boom cylinder for boom lowering.

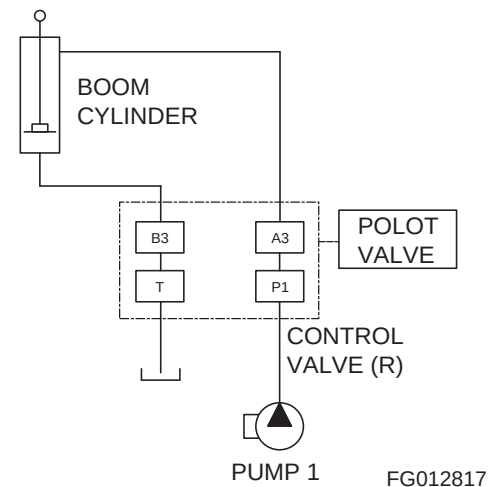


Figure 3

Arm Operating Circuit

The arm operating circuit includes both the 1 and 2 hydraulic main pumps, the control valve, a slow return orifice, and the arm cylinder. The circuit can be operated in the two-stage speed control mode which works through both halves of the control valve and doubles the volume of oil flowing to the cylinder.

Overload relief valves set at 245 kg/cm^2 (3,485 psi) have been installed at the A6 and B6 ports on the left side of the control valve to protect the circuit and system components from possible damage caused by shocks and/or overload pressure. Additional protection - to prevent cavitation of the cylinder - is provided by a make-up valve and reservoir return circuit, which ensures that the volume of oil going to the cylinder will not exceed the volume of oil coming out.

Arm Crowd Circuit

When the arm control lever is put in the crowd mode, the left side pilot valve generates secondary pressure that is transmitted to the right and left sides of the control valve simultaneously.

When secondary pilot pressure reaches 7 - 9 kg/cm^2 (100 - 128 psi), the arm control valve spool on the right and left sides of the control valve opens. Output flow from both halves of the pump assembly is directed to the arm cylinder.

When working in the arm crowd mode, under certain conditions, oil in the cylinder could suddenly be forced out by the weight of the arm and bucket itself. Insufficient oil flow to the cylinder could lead to cavitation in the cylinder and/or surging or irregular movement. This is prevented by a regeneration valve attached to the control valve which maintains the balance between oil flowing into the cylinder and oil flowing out.

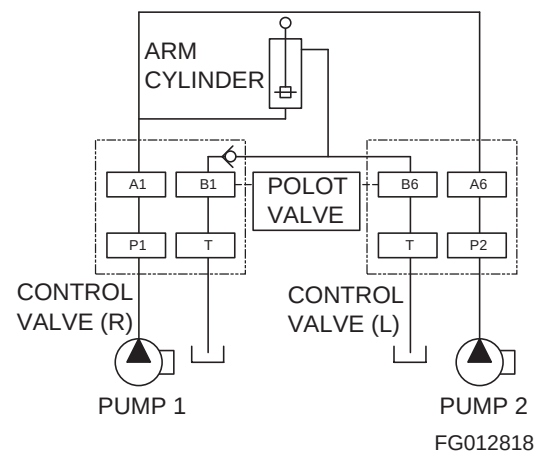


Figure 4

Arm Dump Circuit

When the arm control lever is put in dump mode, the left side pilot valve generates secondary pilot pressure that goes to both halves of the control valve simultaneously.

When pilot pressure reaches 7 - 9 kg/cm^2 (100 - 128 psi), the control spools open on both sides allowing oil from the right and left pumps to flow to the arm cylinder.

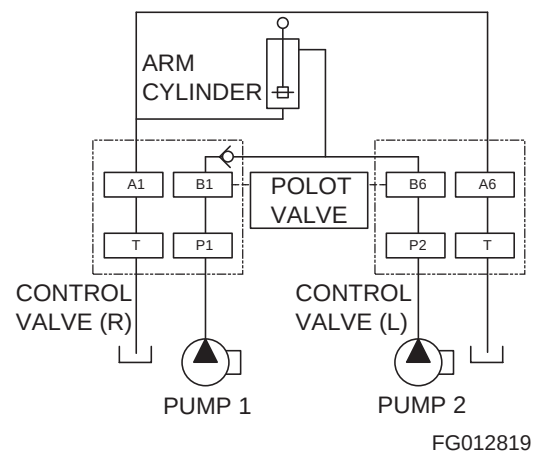


Figure 5

Bucket Operating Circuit

The bucket operating circuit includes the right and left main pumps, the right and left halves of the control valve and the bucket cylinder. 245 kg/cm² (3,485 psi) overload relief valves at A2 and B2 ports of the control valve protect the circuit and its components from damage.

Bucket Crowd Circuit

When the bucket control lever is placed in the crowd position, the bucket control valve spool on the right side of the control valve opens and oil from left main pump flows to the bucket cylinder.

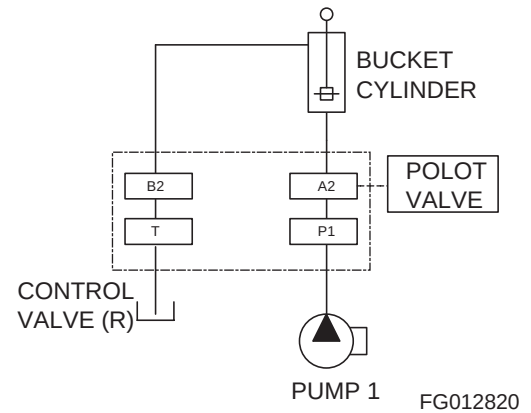


Figure 6

Bucket Dump Circuit

When the bucket control lever is put in the dump mode, the bucket control valve spool in the right half of the control valve opens to supply oil from the left main pump to the cylinder.

Swing Operating Circuit

The swing operating circuit consists of the 3 gear pump in the pump assembly, the left half of the control valve and the swing motor. To keep the upper works from coasting when the swing control is in neutral, a spring device in the control circuit activates a valve to automatically engage a mechanical brake.

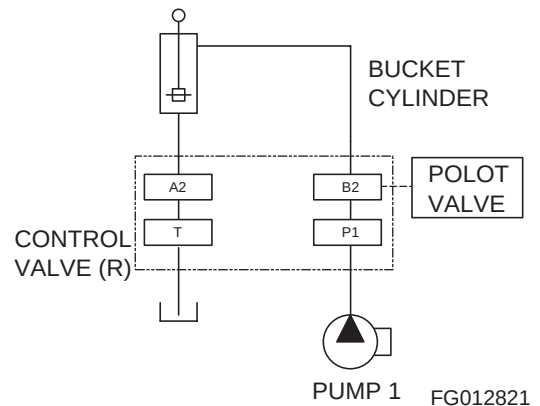
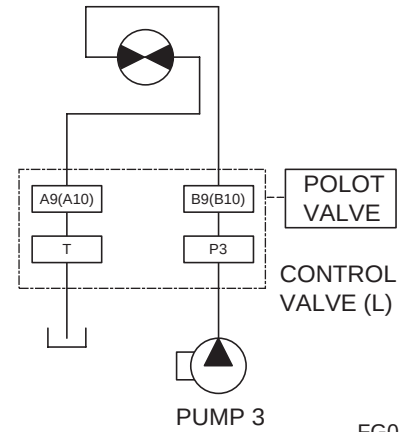


Figure 7

Right Swing Operating Circuit

When the swing control lever is pushed to the right swing position, pilot pressure from the left side pilot valve is directed to the right side pump regulator and right half of the control valve. Output flow from the right pump is then directed through the P3 and B10 ports of the control valve to the swing motor.

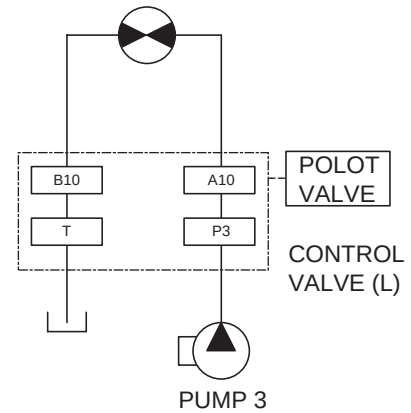


FG012822

Figure 8

Left Swing Operating Circuit

When the swing control lever is pushed to the left swing position, the control valve spool at the left side of the control valve moves in the opposite direction and output flow from the right pump is directed through the P3 and A10 ports of the control valve to the swing motor.



FG012823

Figure 9

Swing Relief Valve and Makeup Valve

Whenever the spool is shifted to the neutral mode during swing operation, the possibility exists that surge pressure in the circuit - caused by inertial momentum of the upper works and correspondingly reduced pressure at the opposite motor port - could produce cavitation in the circuit. To keep that from happening, a 230 kg/cm² (3,270 psi) relief valve is installed in the swing motor and a large-capacity make-up valve is connected to the entrance port of the hydraulic reservoir, helping maintain acceptable pressures on both sides of the circuit.

Drive Operating Circuit

The drive operating circuit is composed of main pump 1, two control valve for drive 1 and drive 2 section, center joint and drive motor.

To prevent overrun and surge pressure that can occur when the device is driving forward/reverse or stopping, there is a counter balance valve on the drive motor.

Forward Circuit

Set the transmission lever to forward and switch to the speed you want to drive, and then the control valve spool of the drive 1 and 2 section will open and the oil will flow from the main pump to the drive motor.

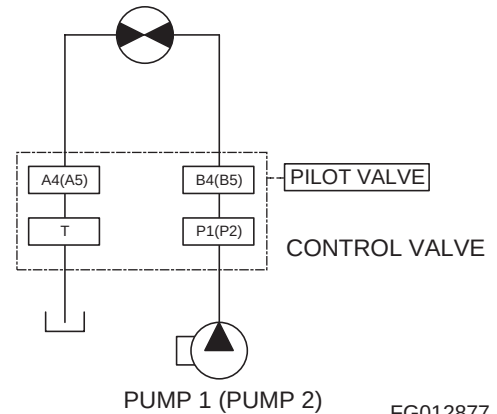


Figure 10

Reverse Circuit

Set the transmission lever to reverse and switch to the speed you want to drive, and then the control valve spool of the drive 1 and 2 section will open and the oil will flow from the main pump to the drive motor.

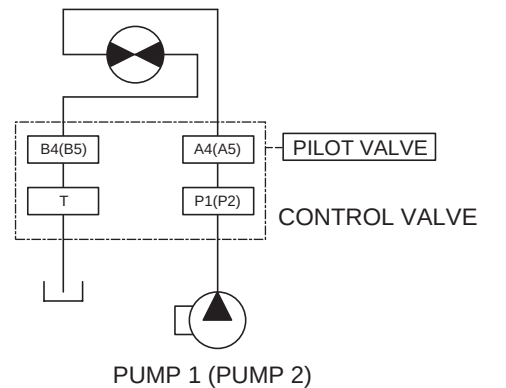


Figure 11

Dozer Operating Circuit

Dozer operating circuit is composed of 3 gear pump of pump assembly, control valve and dozer cylinder.

Dozer Down Circuit

When you push the dozer control lever forward, the dozer control valve spool of the control valve (B8) will open and the oil from 3 pump will flow to the dozer cylinder.

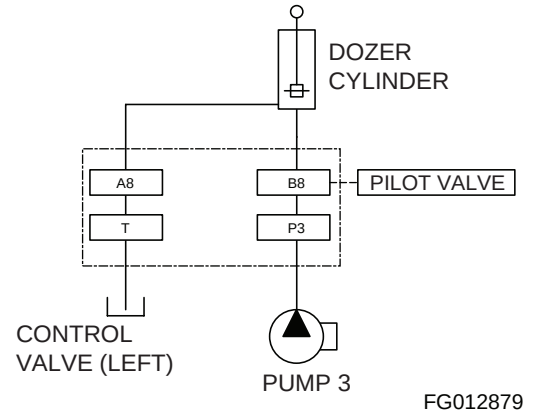


Figure 12

Dozer Up Circuit

When you pull the dozer control lever backward, the dozer control valve spool of the control valve (A8) will open and the oil from 3 pump will flow to the dozer cylinder.

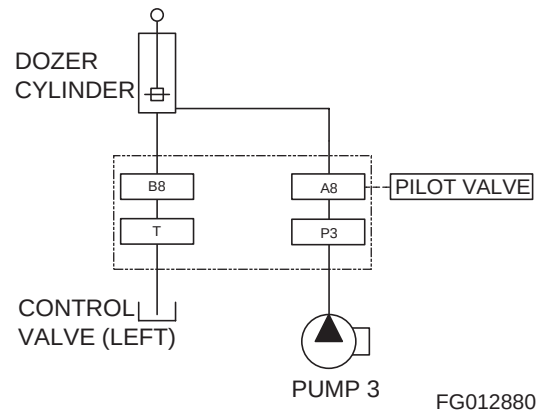


Figure 13

Boom Circle Operating Circuit

The boom circle operating circuit is composed of 3 gear pump of the pump assemble, control valve and boom circle cylinder. 245kg/cm² overload relay valve is installed on the A9 port of the control valve protects the circuit and circuit components from damage.

Right Boom Circle Circuit

When you push the boom circle control lever to the right, the right boom circle control valve spool (A9) of the control valve will open and the oil will flow from the pump to the boom circle cylinder.

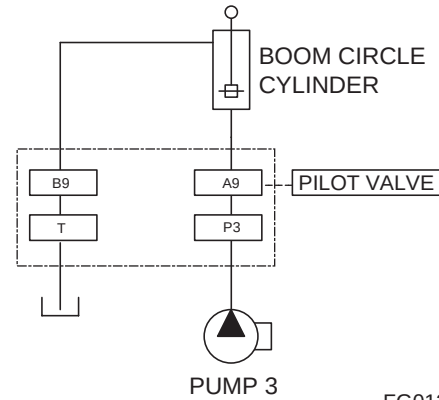


Figure 14

Left Boom Circle Circuit

When you push the boom circle control lever to the left, the boom circle control valve spool (B9) of the control valve will open and the oil will flow from the pump to the boom circle cylinder.

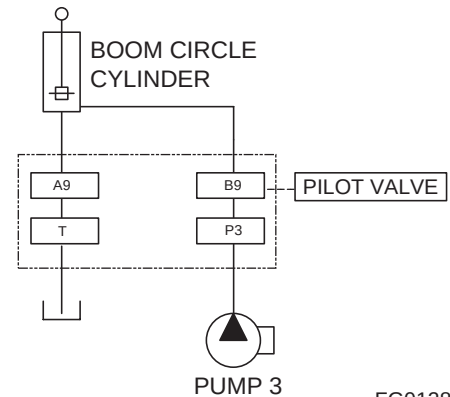


Figure 15

PROCEDURAL TROUBLESHOOTING BASELINE RECOMMENDATIONS

Initial Checks and Tests to Establish Operating Condition of the Excavator

Triage Summary

An excavator that fails to deliver designed performance should be checked for the following:

- Hydraulic flow, first, and.
- Hydraulic pressure, afterwards, in a specified order of priority through different points of the system.

To verify adequate available hydraulic flow, before any other tests are performed through the circuit:

Check engine operation.

- at 2,400 rpm with no load.
- at 2,300 rpm stall load.

If engine rpm drops excessively with a load or fails to surpass rated speed (2,300 rpm), performance problems may be due to inadequate hydraulic flow caused by lagging rotational speed.

NOTE: *Verify actual flow on the excavator against rated performance, with a flow meter.*

If engine tests meet specifications and adequate torque and horsepower are available at the pump drive flex coupling, pull out the electrical tray under the operator's seat to inspect the self-diagnostic display.

If the EPOS trouble code display is clear, check hydraulic functions in the following sequence:

- Pilot pressure.
- Negacon, negative control pressure.
- Main relief pressure (front and rear pump)
- Swing pressure.
- Port relief pressure (individual control functions; boom, arm, bucket, swing, and travel).
- Standard performance tests; cylinder speed, hydraulic motor (travel and swing) speed, cylinder oil tightness "permissible drift" test.

NOTE: *System specification performance tests of individual activator function are determined by flow rate through the component or circuit, not the control*

pressure or system pressure available to the actuator. Poor flow through the individual circuit may indicate that the component is worn beyond tolerance limits, while all other hydraulic functions are adequate.

IMPORTANT

It is suggested that the troubleshooter maintain the testing sequence of the preceding list. Checks and adjustments nearer the middle or the end of the list may depend on adequate functioning of systems tested nearer the top of the list.

PILOT PRESSURE

Adjustment and Testing



This procedure should be done with two people. To reduce the chance of accident or unintended start-up, one person should remain at the operator's control stand while checks and adjustments are made.

Vent hydraulic pressure from the reservoir before breaking the seal on fittings to install two in-line "t-style" adapters and test gauges (60 bar/1,000 psi) at the gear pump outlet port, and at the joystick control valve pilot line.

Start the engine and turn the engine speed control dial to the maximum setting. After the excavator has been operated long enough to reach normal operating temperature, back off the engine control dial to minimum rated rpm speed. With all controls in neutral, make sure the left console control stand is locked in the down (operating) position and check pressure at the gear pump outlet port and at the joystick.

If gear pump pressure is outside the tolerance specified in the table, adjust gear pump relief pressure by loosening the lock nut and turning the set screw in (clockwise) to increase pressure, or turning it out to decrease it.

NOTE: *Be aware that serial number changes and variation in the joystick assemblies used on different excavators could produce slight change in actual performance characteristics. Comparison of part numbers to serial numbers stamped on your assembly may be required, if questions or doubt exists.*

IMPORTANT

Top off the hydraulic fluid reservoir if there is any measurable loss of hydraulic oil during test gauge and adapter fitting installation.

Engine RPM	Pilot Pressure @ Pump	Pilot Pressure - Joystick
Minimum Speed Setting (full left) on Speed Control Dial	33 ± 5 bar (480 ± 3 psi)	33 ± 5 bar (480 ± 3 psi)

SWING SYSTEM TROUBLESHOOTING

Precautions/Initial Checks

1. Stop work. Release all weight or any type of load safely before proceeding. Avoid risking injury or adding to damage.
2. Shut down engine and disengage control functions until initial tests are ready to be made.



WARNING

Prevent possible injury and/or loss of operating control. Stop work and park the excavator at the first indication of:

1. **Equipment breakdown.**
 2. **Inadequate control response.**
 3. **Erratic performance.**
-

Stop the machine, put the boom and arm in the inoperative (overnight park) position and begin by making the fastest, simplest checks first:

- Check oil level.
- Check for overheating, oil leaks, external oil cooler clogging or broken fan belt. Consult service record for prior repair/service work.
- Drain some tank oil to a clean, clear container. Look for metal shavings/grit, cloudiness/water or foam/air bubbles in the oil.
- Check for wobble through the engine/pump flex coupling. Run engine with the pump input hydraulic power control nut turned to the lowest power to check the engine.
- Investigate unusual operating noises or vibration. Check for loose bolts, connections.

Swing Relief Valve Checking and Adjustment

Make a check of operating pressures through the swing relief valve if:

- The swing motor fails to turn.
- Swings in one direction only.
- Swings but continues to coast.
- There is drifting on a slope.

1. Check operation by connecting:

- A. Two 600 bar (8,700 psi) pressure gauges to the inlet and outlet measuring ports on top of the swing motor.

Pressure should be between 260 and 280 bar (3,770 psi and 4,061 psi), with both swing locks engaged. With swing locks released, during full acceleration and deceleration, pressure should approach 270 bar (3,916 psi) in each direction.

- B. Connect a 60 bar (870 psi) pressure gauge at the "SH" port of the hydraulic brake.

Pressure should always stay at or above 4 bar (58 psi) when operating swing, boom or arm.

- C. Connect a 10 bar (145 psi) gauge at the motor makeup valve.

Pressure should stay consistently above 2.5 bar (36 psi). If pressure falls below the recommended minimum level, forceful acceleration of the swing motor could lead to cavitation of the circuit and stalling, slowed rotation, noise and possible damage.

2. If main inlet and outlet pressures were off in the preceding tests in Step 1, adjust swing relief valve pressure.

Following adjustment, repeat the operating pressure tests (with gauges connected to the inlet and outlet test ports on top of the swing motor) and check pressures with the swing locks engaged and released.

If pressure adjustment fails to restore adequate performance, proceed to the Troubleshooting - Swing table.

3. If pressure tests were at recommended levels through the main inlet and outlet ports, and through the "SH" port of the swing brake, the causes of poor swing performance could include a faulty swing motor, drive train overloading or gearbox defect, or a problem in the brake assembly or swing control valve. Proceed to the troubleshooting information in the next procedure.

If pressure through the "SH" port was tested below the minimum 13 bar (189 psi) level, check the shuttle valve in the rear compartment behind cabin. When pressure through the port is at the recommended level, the brake

release valve should disengage the swing brake, allowing the swing motor to rotate the excavator. If pressure adjustment to the valve has been restored but the brake still fails to release, the brake piston or friction plate may be frozen, requiring disassembly of the motor and parts repair/replacement.

4. If pressure tested at the motor makeup valve falls below recommended minimum level, and consequent problems with cavitation, stalling and surging are observed, check the restriction valve. If pressure adjustment to the valve has been restored but if problems with cavitation continues, disassemble the upper swing motor housing and clean or replace assembly components as required.

NOTE: *If all tested pressures are at or above recommended levels, and there are no mechanical problems in the drive train or in the motor/brake assembly, the problem will require further hydraulic troubleshooting. It's also possible that a defective joystick, an intermittent short in an electrical control circuit or a problem in the e-EPOS circuit is causing diminished swing performance. Pull out the e-EPOS indicator panel from underneath the operator's seat and perform the self-diagnosis test. If the display panel reads code "0.2," it is reporting that the swing priority proportional valve is not functioning, except in the minimum "failsafe" mode. Refer to the Electrical section of this book for more information.*

TROUBLESHOOTING – SWING GEARBOX

Problem	Possible Cause	Remedy
Swing motor fails to operate and:		
Three pressure tests at motor, brake or makeup valve show low reading(s).	Swing relief valve defective Brake release valve defective Motor makeup valve defective.	Adjust pressure to recommended range in affected valve. OR Disassemble and clean valve assembly. Replace all valve components that show damage.
All three pressure checks are OK but left travel also fails to run.	Exchange front and rear pump inlet and outlet hoses to test pump function.	If swing and left travel are restored but right travel stops working, replace or repair P1 pump.
All three pressure tests are OK, but machine fails to swing at all.	Brake assembly or motor friction plate failing to release.	Check for binding. Disassemble and repair.
	Pilot (control) pressure low or swing control valve stuck.	Disassemble / Repair pilot pressure swing spool (305) and / or swing control valve.
	Swing motor defective.	Test motor drain rate. Replace / Repair motor.
	Gear train defective.	Refer to "Swing Gear Troubleshooting" procedure.
Swing functions but only at reduced rpm.	Causes listed above could also produce dragging swing, OR hot or wrong oil OR worn-out parts.	Check above list; then replace oil, test motor drain rate and check for "02" reading (e-EPOS self-test).
Left travel speed is also reduced.	Low output at P1 pump or external pilot piping leaks/is clogged.	Clean and repair piping or repair or replace pump P1.
Swing control movement is reversed.	Inlet / outlet piping reversed.	Reset controls or reverse piping.
Machine swings but continues coasting on past stopping point.	Swing control valve spool not centered.	Replace return spring; clean/ repair valve piston and spool.
	Pilot pressure may be outside range.	Disassemble, clean or replace pilot relief valve or pilot valve.
	Swing relief valve may be faulty.	Repair/Replace swing relief valve.
Swing movement is in one direction only.	Check to see that pilot pressure is the same right and left.	If pilot pressure is unequal, clean or repair piping or repair/replace valve.
	Swing control valve spool may be stuck.	Repair/Replace the swing control valve.
	Swing relief valve may be faulty.	Repair/Replace the swing relief valve.
No rotation and:		
Pressure at swing motor inlet increases.	Swing brake not releasing.	Check brake engagement and disengagement; check release pressure.
	Internal damage to gearbox drive train.	Replace broken gears and drive train assemblies.
	Overload.	Reduce load weight.

Problem	Possible Cause	Remedy
Pressure at swing motor inlet shows no increase, and the swing motor is making irregular noises.	Swing motor drive shaft damage.	Replace swing motor.
	Internal damage to gearbox drive train.	Repair/Replace broken or faulty assemblies.
Pressure at swing motor inlet shown no increase, but without irregular noises from the swing motor.	Hydraulic pump or valve problem.	Troubleshoot hydraulic system.
Oil Leakage:		
From drive shaft From bolted connections or other assembled surfaces.	Oil seal damaged Assembly compound (joint sealer) old and not sealing, bolt not tight or flange warped.	Replace oil seal Disassemble and check mating surfaces. Reapply Loctite; torque bolts to specifications.
Excess heat:		
Gearbox casing becomes excessively hot, with or without irregular noise (s), during operation.	Low oil level.	Replace oil; refill to specified level.
	Bearings or gears worn but not completely inoperative.	Repair or replace gearbox.

TROUBLESHOOTING – HYDRAULIC PROBLEMS

Problem	Possible Cause	Remedy
Attachment cylinders, swing and travel motors are all inoperable. Loud noises are heard from main pump assembly.	Main pump(s) malfunction.	Repair or replace.
	Low oil level in hydraulic system.	Refill.
	Main pump inlet (oil supply) piping or hose damaged.	Repair or replace.
Attachment cylinders, swing and travel motors are all inoperable. No usual or loud noises can be heard.	Pilot pump malfunction.	Repair or replace.
	Pilot cutoff solenoid stuck.	Repair or replace.
	Pilot cutoff switch faulty.	Repair or replace.
	Engine/pump flex coupling damaged.	Replace flex coupling.
Sluggish performance of all hydraulic functions – attachment, swing and travel.	Main pump(s) damaged or worn.	Repair or replace.
	Main relief valve pressure off.	Readjust pressure.
	Low oil level in hydraulic system.	Refill.
	Hydraulic reservoir intake strainer clogged.	Clean.
	Pump inlet (supply side) piping or hose allowing air into hydraulic system.	Tighten connection.

Problem	Possible Cause	Remedy
Oil temperature abnormally high.	Oil cooler clogged or air circulation to cooler blocked.	Clean.
	Cooling fan belt tension too loose.	Readjust belt tension.
	Relief valve set too low.	Readjust valve.
	Relief valve in constant use.	Reduce or slow work load or cycling rate.
	Hydraulic oil severely neglected or incorrect for application.	Replace oil.
One circuit in hydraulic system inoperable.	Overload relief valve malfunction.	Readjust or replace.
	Oil leak at makeup valve.	Clean, repair.
	Control valve spool damaged.	Repair or replace.
	Dirt in control valve spool.	Clean or replace.
	Actuator (joystick, foot pedal) damaged or worn.	Repair or replace.
	Internal seal leak in cylinder.	Repair or replace.
	Cylinder rod damaged.	Repair or replace.
	Pilot valve or piping malfunction.	Repair or replace.
	Mechanical linkage frozen, loose or damaged.	Repair or replace.
Travel motors inoperable.	Center joint damaged.	Repair or replace.
	Parking brake not releasing.	Repair or replace.
	Travel motor worn or damaged.	Repair or replace.
	Travel motor pilot piping damaged.	Repair or replace.
Travel motors operate very slowly.	Track tension poorly adjusted Low oil in idlers or rollers.	Readjust tension Refill.
	Travel brake dragging.	Repair.
	Track frame out of alignment, deformed or twisted.	Repair.
Swing motor inoperable.	Swing brake not releasing.	Repair or replace.
	Relief valve malfunction.	Repair or replace.
	Pilot piping damaged.	Repair or replace.
Swing motor operates unevenly.	Swing gear, bearing or mounting loose or worn.	Repair or replace.
	Lubricant worn away, inadequate.	Grease.
	Swing relief valve may be faulty.	Repair/Replace the swing relief valve.

TROUBLESHOOTING – CONTROL VALVE

Check control valve problems only after other hydraulic circuit operational tests have been made. Refer to the "Troubleshooting Baseline Recommendations" procedure. Pump flow, pilot pressure, Negacon pressure, main relief pressure, and port relief pressure should all be checked before starting to work on the control valve. Make sure the hydraulic system is topped up to the required level and free of oil leaks or air in the system that could cause cavitation problems.

Problem	Possible Cause	Remedy
Main relief valve.	Particulate contamination.	Disassemble, clean main poppet.
	Broken or damaged spring.	Replace.
	Adjusting screw loose.	Readjust.
	Main poppet sticking.	Repair/replace.
	Clogged orifice in pilot passage to control valve.	Clean/replace.
Cylinder goes down in spool neutral.	Excessive clearance between casing and spool.	Replace spool or casing.
	Spool does not return to neutral/ sticking spool.	Check secondary pilot pressure.
	Spool does not return to neutral because of dirt or other contaminants.	Clean.
	Broken or damaged spring.	Replace.
	Main relief or port relief not operating properly.	See above.
	Impurities in pilot circuit.	Clean.
Cylinder drops before start at boom up operation.	Rod check valve damaged or clogged.	Clean/replace.
	Poppet sticking.	Clean/replace.
	Broken or damaged spring.	Replace.
Slow operation or response.	Excessive clearance between spool or casing.	Check pilot pressure and/or replace spool or casing.
	Sticking spool.	Clean/replace.
	Broken or damaged spring.	Replace.
	Main or port relief valve damaged.	Check pressure/replace.
Swing priority not operating correctly.	Sticking spool.	Clean/replace.
	Solenoid valve faulty.	Replace.
Boom and arm cylinders do not perform normally in combined operation.	Priority valve faulty or spool sticking.	Check pilot pressure.
	Broken or deformed spring.	Replace.
	Excess clearance between right and left casing and valve spool.	Clean/replace.
	Clogged spool passage.	Clean/replace, replace filter.
Relief valve malfunctions:		

Problem	Possible Cause	Remedy
Pressure does not increase at all.	Main poppet or pilot poppet stuck open.	Clean/replace.
Irregular or uneven pressure.	Poppet seat damaged or pilot piston sticking to main poppet.	Clean/replace.
	Loose lock nut and adjusting screw.	Readjust.
	Components worn out, past wear limits.	Replace.

TROUBLESHOOTING – TRAVEL CONTROL VALVE

Problem	Possible Cause	Remedy
Secondary pressure does not increase.	Low primary pressure.	Check primary pressure.
	Broken spring.	Replace spring.
	Spool sticking.	Clean, repair or replace.
	Excess spool to casing clearance.	Replace spool casing.
	Worn or loose universal joint (handle) subassembly.	Repair or replace U-joint subassembly.
Secondary pressure too high.	Dirt, other interference between valve parts.	Clean, repair or replace.
	Return line pressure too high.	Redirect return line.
Secondary pressure does not hold steady.	Dirt, other interference between valve parts, or worn spool sticking intermittently.	Clean, repair or replace.
	Interference or binding on spool return spring.	Clean, repair or replace.
	Interference, restriction or unsteady pressure in tank return line.	Repair or reroute tank return line.
	Air bubbles in piping (temporary) or air leak.	Vent air, or repair leak.
NOTE: Look for evidence of leaking oil.		

TROUBLESHOOTING – JOYSTICK CONTROL VALVE

Problem	Possible Cause	Remedy
Secondary pressure does not increase.	Low primary pressure.	Check primary pressure.
	Broken spring.	Replace spring.
	Spool sticking.	Clean, repair or replace.
	Excess spool to casing clearance.	Replace spool casing.
	Worn or loose handle subassembly.	Repair or replace handle subassembly.
Secondary pressure too high.	Dirt, other interference between valve parts.	Clean, repair or replace.
	Return line pressure too high.	Redirect return line.
Secondary pressure does not hold steady.	Dirt, other interference between valve parts, or worn spool sticking intermittently.	Clean, repair or replace.
	Interference or binding on spool return spring.	Clean, repair or replace.
	Unsteady pressure in tank return line.	Redirect return line.
	Air bubbles in piping (temporary) or air leak.	Vent air, or repair leak.
NOTE: Look for evidence of leaking oil to help locate damaged seals or gaskets that could be the cause of air leaks.		

Accumulator

Edition 1

MEMO

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Accumulator

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MEMO

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 ultimately 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
DX55W	5001 and Up
DX140W	5001 and Up
DX160W	5001 and Up
DX190W	5001 and Up
DX210W	5001 and Up

GENERAL DESCRIPTION

The accumulator is a gas-charged storage device designed to hold a reserve quantity of hydraulic fluid under pressure. Accumulators are used in hydraulic circuits in much the same way that condensers (or capacitors) are used to collect, store and maintain electrical charge in a circuit.

In a hydraulic circuit, minor variations or lags in pump output that might otherwise cause unsteady or irregular operation are made up from the supply of pressurized oil in the accumulator.

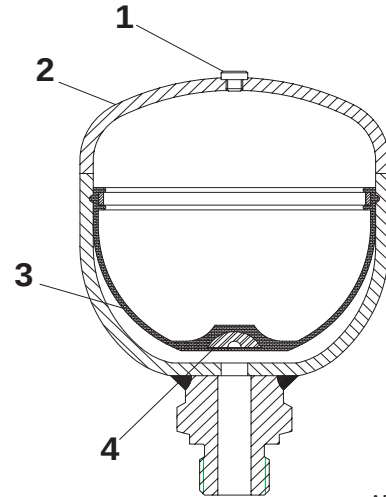
Reference Number	Description
1	Screw Plug
2	Steel Pressure Vessel
3	Diaphragm
4	Fluid Valve

Accumulators are solidly constructed to resist the high operating pressures of the fluids they contain. There are only three main moving parts: a plug at the top allows precharging or expelling gas from the compressible, precharged upper chamber; a valve assembly at the bottom of the accumulator for passing hydraulic fluid in and out, and an elastic diaphragm to separate the two chambers. The flexible diaphragm changes shape to conform to the changing pressures and volumes of the two fluids in the upper and lower chambers.

There are six possible positions the diaphragm can be in and they are as follows:

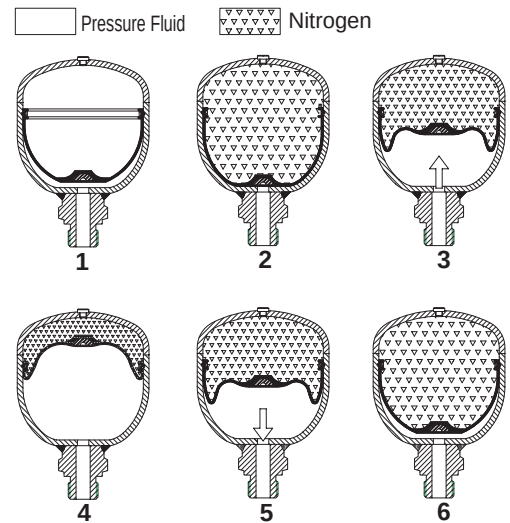
1. With no gas charge in the upper chamber 0 bar (0 psi, empty) and no oil in the bottom 0 bar (0 psi, dry) the elastic diaphragm hangs loosely.
2. When the prepressure charge of gas (usually nitrogen) is introduced through the port at the top of the accumulator, the diaphragm expands to maximum size. The valve button in the center of the diaphragm pushes into the fluid opening in the bottom chamber, sealing off the lower valve. If the pressure of the gas charge exceeds system oil pressure, no fluid enters the accumulator. The button also keeps the diaphragm from protruding into the lower valve opening.

NOTE: Precharge pressure is referred to as the "P1" pressure. The accumulator manufacturer's "P1" rated pressure should be stamped or marked on the accumulator's rating plate. Annual checks of actual precharge pressure should be made by tapping a hydraulic pressure gauge (and 3-way adapter coupling) into the valve on the bottom of the accumulator. When hydraulic fluid is pushed out the lower valve opening by the pressure of the gas charge on the other side of the diaphragm - and there is no counterpressure from system oil - the valve



ARS1790L

Figure 1



ARS1800L

Figure 2

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 condition a minimal amount of oil is stored in the accumulator.

Specifications

Model	Serial Number	System	Charge Pressure	Volume
DX55W	S/N 5001 and Up	Pilot	15 kg/cm ² (213 psi)	320 cc (19.53 in ³)
		Brake	25 kg/cm ² (356 psi)	320 cc (19.53 in ³)
DX140W DX160W DX190W DX210W	S/N 5001 and Up	Pilot	15 kg/cm ² (213 psi)	320 cc (19.53 in ³)
		Brake	30 kg/cm ² (427 psi)	750 cc (45.77 in ³)

Center Joint (Swivel)

Edition 1

MEMO

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Center Joint (Swivel)

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MEMO

SAFETY PRECAUTIONS



CAUTION!

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APPLICABLE MODELS

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

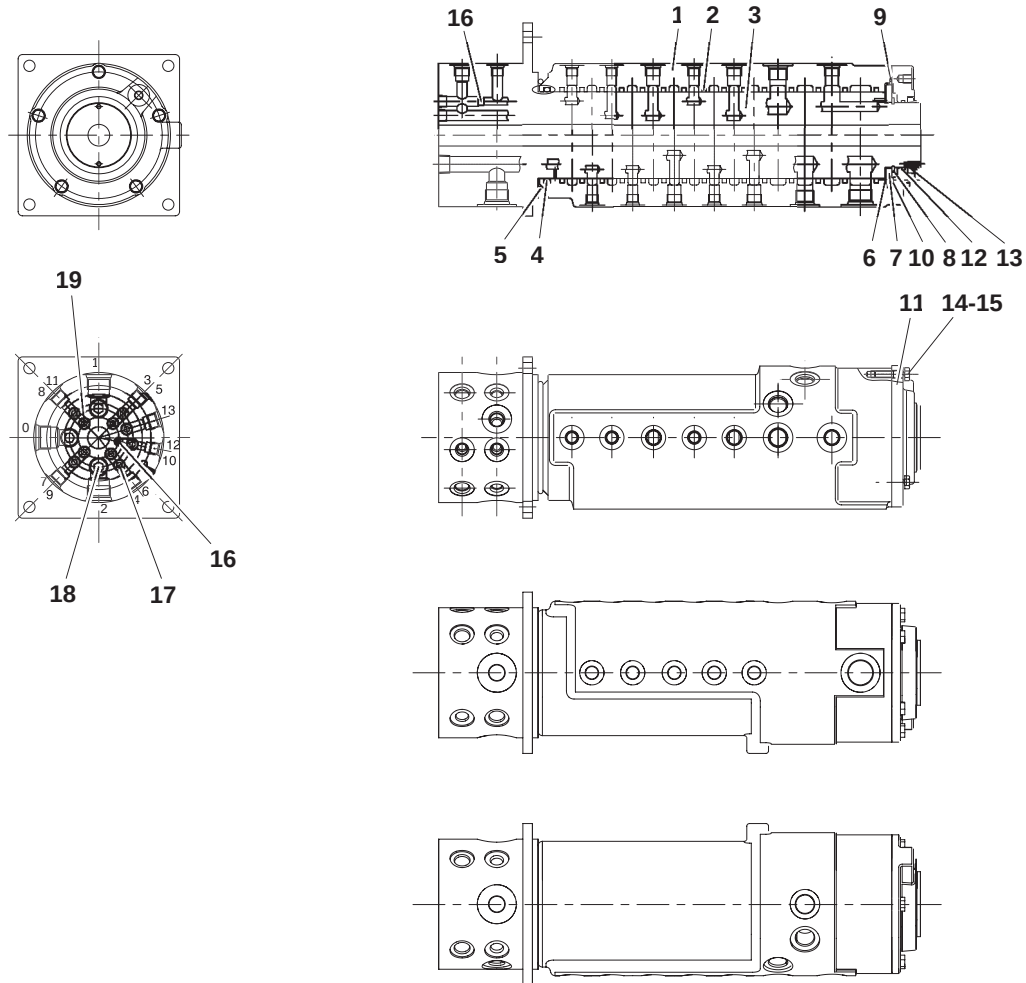
MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

GENERAL DESCRIPTION

The center joint (swivel) is designed to allow hydraulic oil from the upper structure to flow to components in the lower structure.

It is capable of allowing continuous 360° rotation of the upper structure in relationship to the lower structure.

Parts List



FG010701

Figure 1

Reference Number	Description
1	Body
2	Rotary Seal
3	Spindle
4	O-ring
5	O-ring
6	Shim-A
7	Thrust Plate
8	Retaining Ring
9	O-ring
10	Shim-B

Reference Number	Description
11	Cover
12	O-ring
13	Dust Wiper
14	Hex Bolt
15	Spring Washer
16	Socket Plug
17	Socket Plug
18	Socket Plug
19	Socket Plug

TROUBLESHOOTING, TESTING AND ADJUSTMENT

Inspection

The center joint should be checked for evidence of external oil leakage every 2,000 operating hours. Leaking or defective O-rings are an indication that dirt and other contaminants could be getting inside the assembly, which will promote accelerated, abnormal wear and may cause early failure of the assembly.

If internal seals or other sliding surface components are worn and there is internal fluid leakage, complete overhaul and repair or replacement of the center joint may be required.

Testing

To check pressure through the center joint, make up a test kit from the following equipment list:

- 700 bar (10,000 psi) pressure gauge.
- Adapters, connectors, piping and flange block-off plates conforming to those used in high-pressure piping connections of the excavator.
- A high-pressure relief valve with a setting pressure 1.5 times maximum system pressure.
- A stop valve.
- A manually operated, in-line changeover valve.

Install the changeover valve upstream from one of the stem high-pressure ports. Connect the pressure gauge downstream from one of the body ports. Install the stop valve between the changeover valve and the stem of the center joint. Other components should be installed according to the layout in the block diagram. The test kit is used to pressurize the center swivel above normal working pressure and lock in the higher pressure (as the stop valve is closed manually) for a leak down test.

NOTE: The same type of kit can also be made up for the drain port (return line) side of the center joint. Use appropriate piping, connectors, test gauges, etc., and follow the same block diagram general layout (Figure 2).

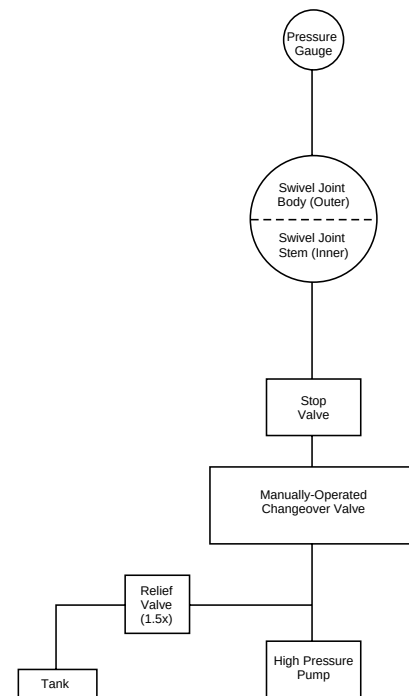


Figure 2

0370

DISASSEMBLY

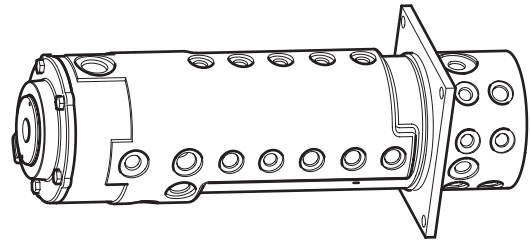
Refer to the assembly drawing of the swivel joint for component references (Figure 1).

IMPORTANT

Do not unbolt the center joint from the lower car body until an adequate number of piping block-off plates are available, for disconnected piping lines. Be sure that system pressure has been vented - including the hydraulic accumulator and tank reserve pressure - before disassembly is started.

1. Remove the Swivel Joint from the Vehicle

Move the Swivel Joint removed from the vehicle to the work table using a crane.

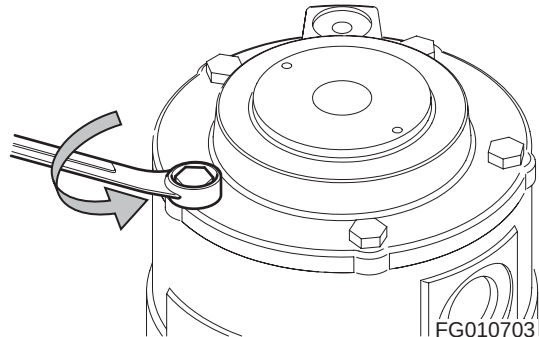


FG010702

Figure 3

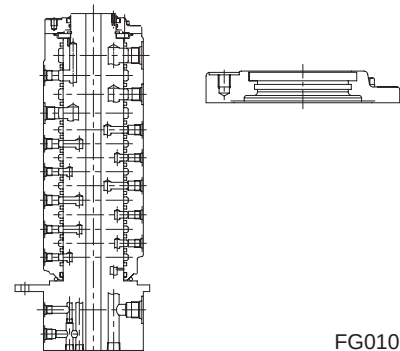
2. Remove Cover

- Remove the bolts and washers using a spanner (wrench) or air impact.
- Remove the cover.



FG010703

Figure 4



FG010704

Figure 5

3. Disassembling the Retainer Ring

Insert an appropriate jig into the Retainer Ring holes, widen the Ring and remove it.

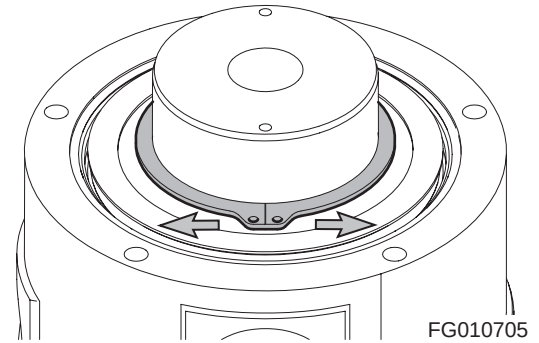
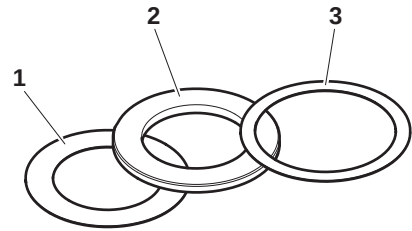


Figure 6

4. Remove Seam-A, Seam-B, and Thrust Plate

- 1) Shim-A
- 2) Thrust Plate
- 3) Shim-B



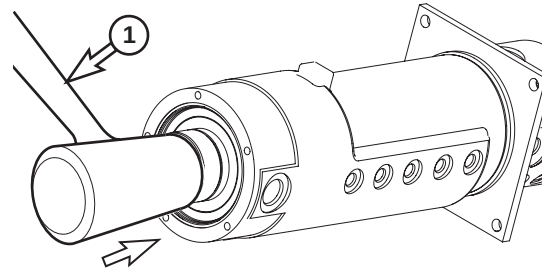
FG010706

Figure 7

5. Disassembling the Spindle and Body

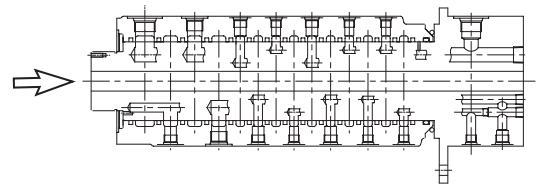
Lay the Cylinder horizontally. Drive the Spindle a little way out using a plastic hammer.

- 1) Plastic Hammer



FG010707

Figure 8



FG010708

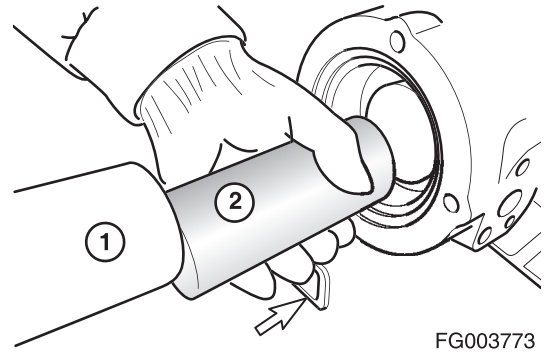
Figure 9

6. Disassembling the Spindle and Body

Place the jig on the Spindle, disassemble the Spindle using a plastic hammer.

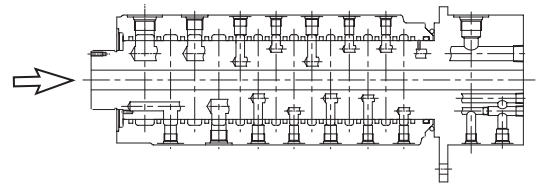
(1, Figure 10) Plastic Hammer

(2, Figure 10) Jig



FG003773

Figure 10



FG010708

Figure 11

7. O- Disassembling the Ring and Seal

Remove the seal in the groove of the Swivel Joint body. Be careful not to damage the O-ring and seal.

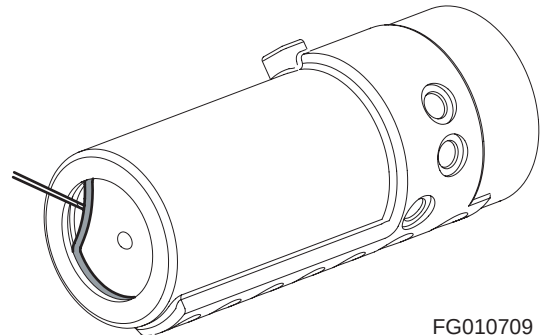


CAUTION!

O-rings and seals should be replaced whenever the assembly is being overhauled or re-assemble.

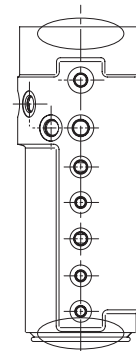
For repair procedures or emergency tear down, use a thin, smooth-edged scraper or spatula with a rounded tip to remove the O-rings or seals, to avoid causing damage to those that can be reused.

The "back-up ring" shown in the assembly drawing (above the swivel joint stem lower seals) should not be overlooked. It is tucked behind the top slip ring, doubled up inside the same groove in the body of the stem.



FG010709

Figure 12



FG010710

Figure 13

8. Body, Spindle, Cover

Be sure to check for any defects such as scratches or dents on the Spindle, Body, and Seals.



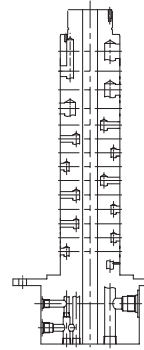
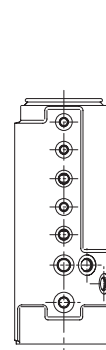
CAUTION!

Be sure to check for any dent-like scratches in the direction of operation.

9. Before reassembling the center swivel, visually inspect ball bearing surfaces for visible signs of wear, damage or discoloration and replace any worn component.

Check clearance between the spindle and thrust plate. Replace any component that shows more than 0.5 mm (0.020") of visible wear.

Clearance between the spindle and body of the center swivel must be tight. Replace or repair either component if there is more than 0.1 mm (0.0039") of measurable wear.



FG010711

Figure 14

REASSEMBLY

1. Prelubricate O-rings with hydraulic oil, white grease or petroleum jelly.



CAUTION!

Apply a very light film of white grease or petroleum jelly to the lower rim of the stem and inner surface of the center swivel body. Apply slow, even-handed pressure, using both hands, to slowly push the stem into the body. Seals may be damaged if the stem is pushed in too quickly.

2. Thoroughly clean all other component surfaces of dirt or grease before reassembly.
3. Reverse disassembly steps for reassembly.
4. Clean threads of fasteners before preapplying Loctite #243 to the threads, and before torquing the thrust plate and cover bolts.
5. Prefill the center swivel with clean hydraulic fluid before reassembly of high-pressure and drain line piping. Clean and prefill piping line ends to reduce the amount of air in the system. Bleed air from the hydraulic system and verify hydraulic tank fluid level before returning the excavator to service.

Cylinders

Edition 1

MEMO

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Cylinders

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MEMO

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.

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APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

GENERAL DESCRIPTION

Two essentially similar types of hydraulic cylinders are used on the excavator. The cylinder that is used to operate the excavator boom or bucket is equipped with a rod stopper, which acts as a cushion only when the cylinder rod is fully retracted (and the bucket is pulled close to the arm). This type of cylinder is shown in the lower drawing.

Arm cylinders have a cushion or stopper for operation in both directions. This type of cylinder is shown in the upper drawing.

Theory of Operation

Reference Number	Description
1	Piston
2	Oil Path A
3	Oil Path B

Cylinder piston rods are extended or retracted by oil flow to the back side of the cylinder (shown as "oil path A") or to the front of the cylinder ("oil path B").

The cylinder rod is extended as oil flow is pumped through the circuit to the back side of the piston. The force (F1) of the piston stroke can be expressed by the formula below, where P = circuit oil pressure and the inside diameter of the cylinder is expressed by B (Figure 1).

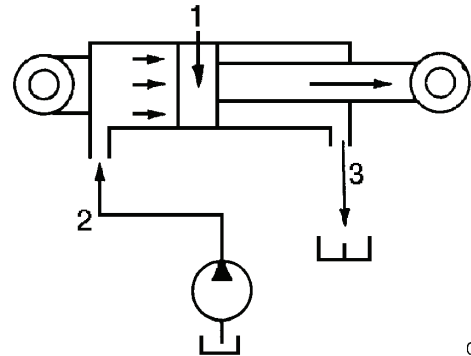
$$F_1 = P \times \frac{\pi B^2}{4}$$

(P: Pressure, p = 3.14, B: Cylinder Inside Diameter)

Reference Number	Description
1	Cylinder Inside Diameter - B
2	Oil Path A
3	Oil Path B
4	Rod Diameter

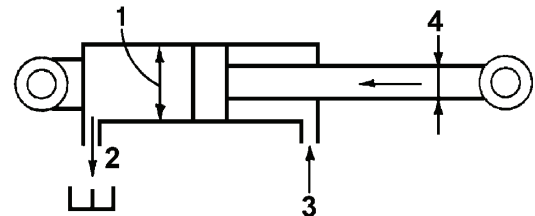
When the cylinder rod is retracted, oil flow through the circuit from the pump to the front side of the cylinder generates a force (F2) that can be expressed by the formula in which the diameter of the piston rod is expressed by R, and the other two terms are the same as in the preceding expression.

$$F_2 = P \times \frac{\pi(B^2 - R^2)}{4}$$



0330

Figure 1



0331

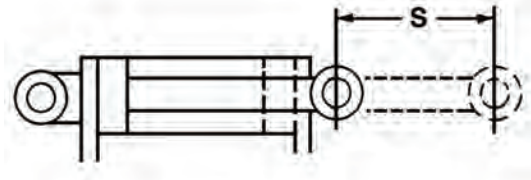
Figure 2

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

Parts List

The following parts list is a partial listing only; for full and complete parts list information, refer to the Hydraulic Equipment Component Parts List

Cross section in Figure 4 shows an arm cylinder.

Cross section in Figure 5 shows a boom cylinder.

The bucket and boom cylinders are identical and differ only in the attached pipes.

Boom Cylinder

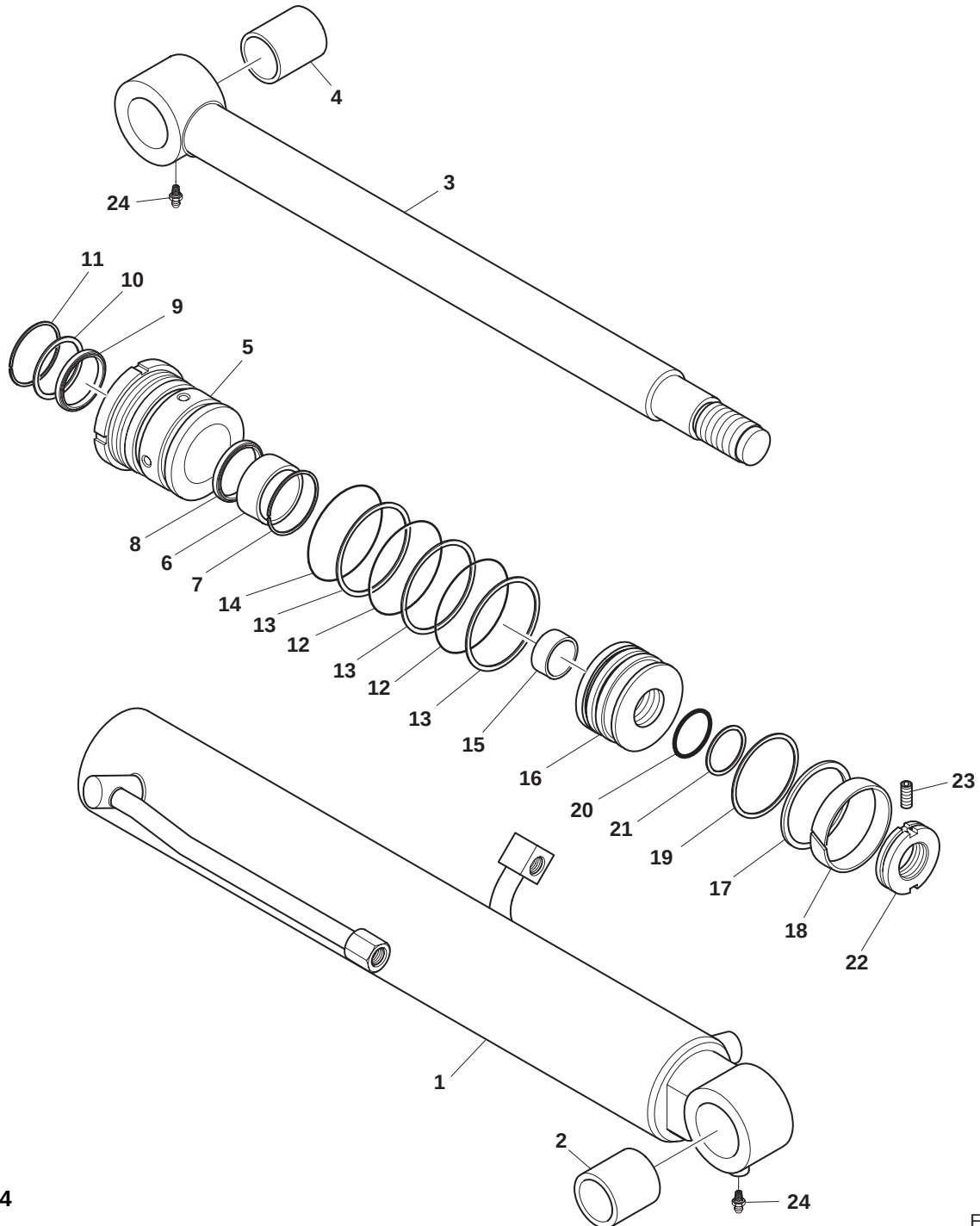


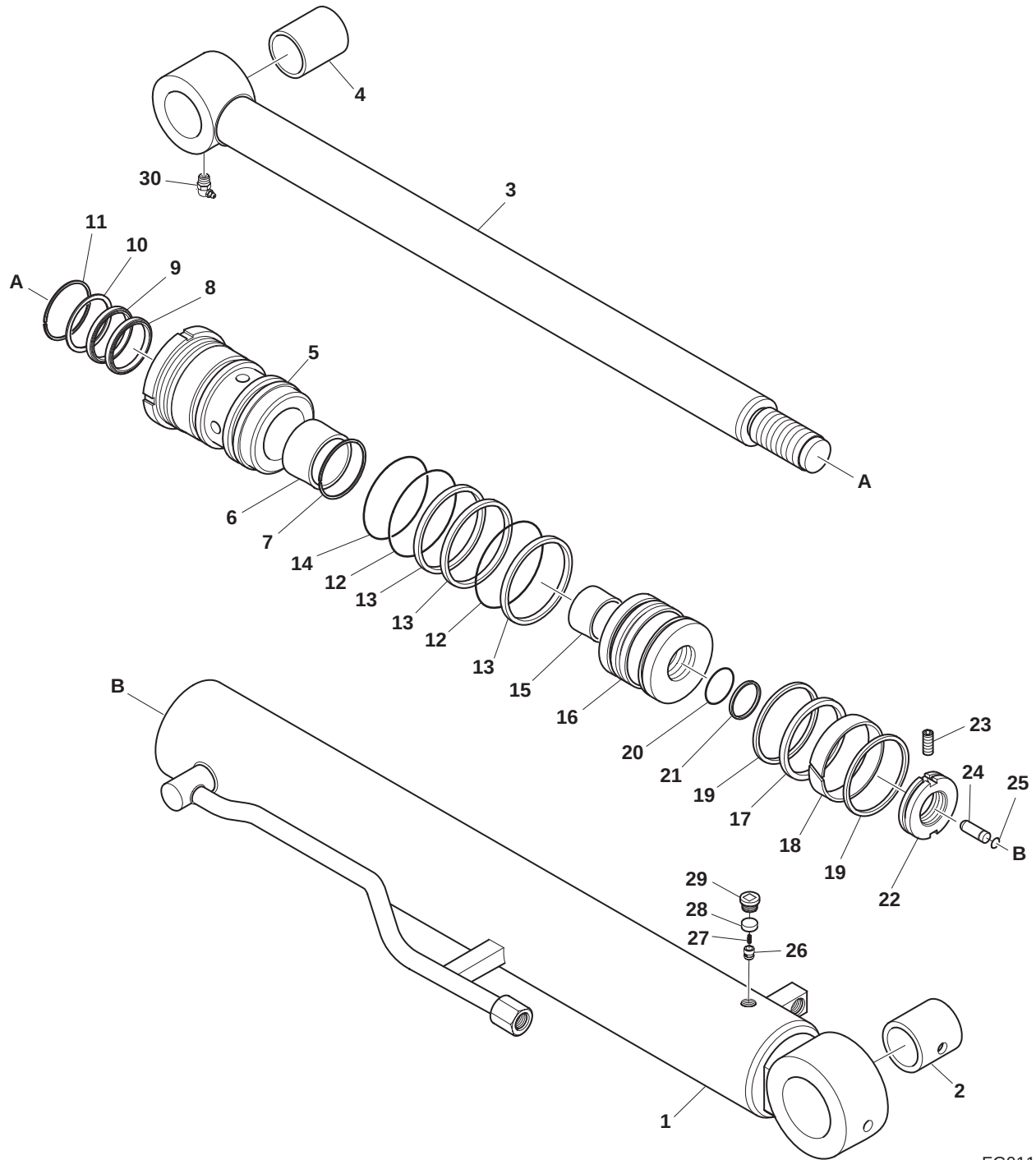
Figure 4

FG011071

Reference Number	Description
1	Tube Ass'y
2	Bush
3	Rod Ass'y
4	Bush
5	Rod Cover
6	DD-bush
7	Ring, Retaining
8	Seal, Buffer
9	U-packing
10	Wiper, Dust
11	Ring, Retaining
12	O-ring

Reference Number	Description
13	Ring, Back Up
14	O-ring
15	Ring, Cushion
16	Piston
17	Ring, Glyd
18	Ring, Wear
19	Ring, Dust
20	O-ring
21	Ring, Back Up
22	Nut, Piston
23	Screw, Set
24	Nipple, Grease

Arm Cylinder



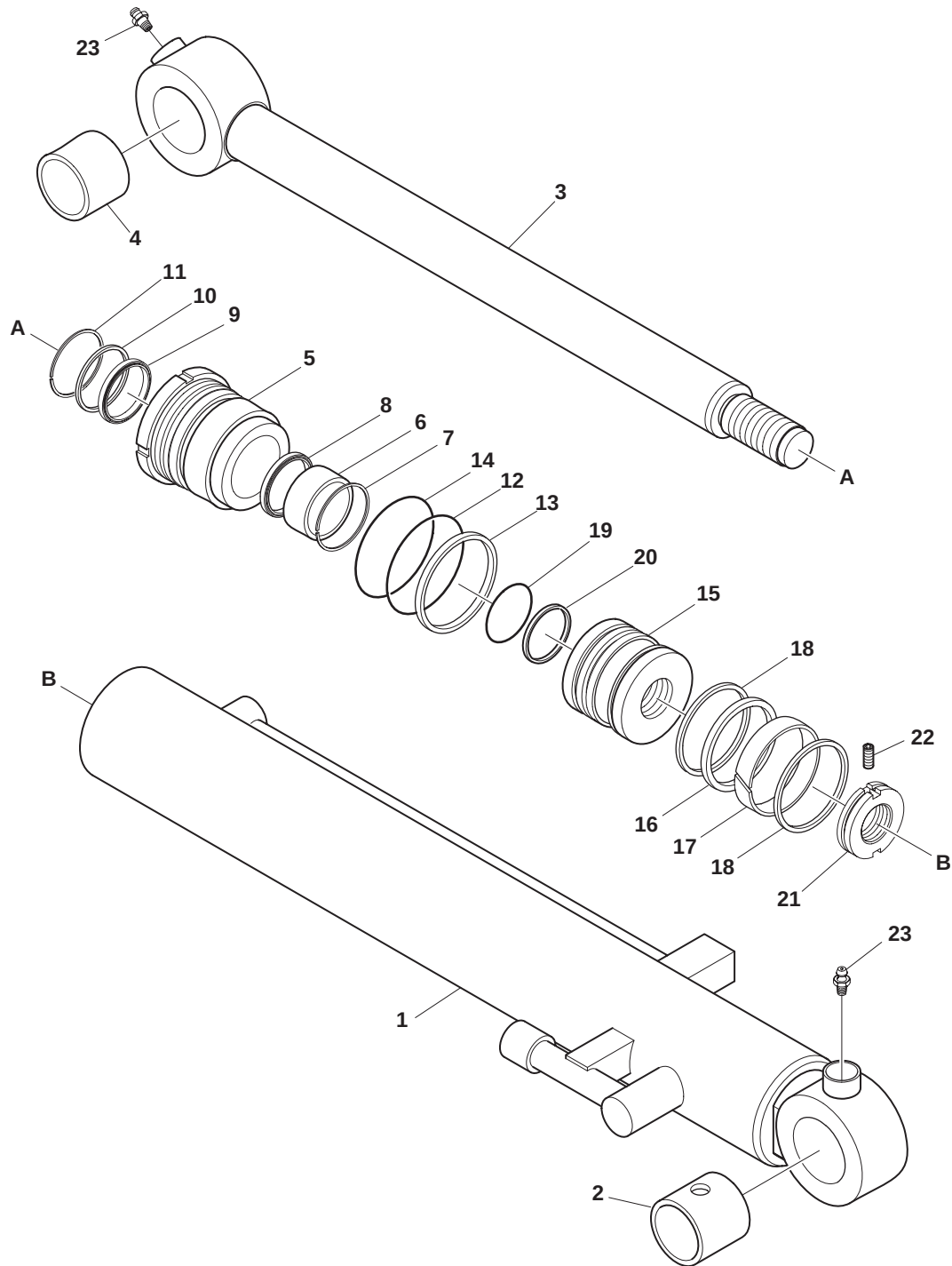
FG011072

Figure 5

Reference Number	Description
1	Tube Ass'y
2	Bush
3	Rod Ass'y
4	Bush
5	Rod Cover
6	DD-bush
7	Ring, Retaining
8	Seal, Buffer
9	U-packing
10	Wiper, Dust
11	Ring, Retaining
12	O-ring
13	Ring, Back Up
14	O-ring
15	Ring, Cushion

Reference Number	Description
16	Piston
17	Ring, Glyd
18	Ring, Wear
19	Ring, Dust
20	O-ring
21	Ring, Back Up
22	Nut, Piston
23	Screw, Set
24	Plunger, Cushion
25	Ring, Stop
26	Valve, Check
27	Spring
28	Support, Spring
29	Plug, Hex Socket
30	Nipple, Grease

Bucket Cylinder



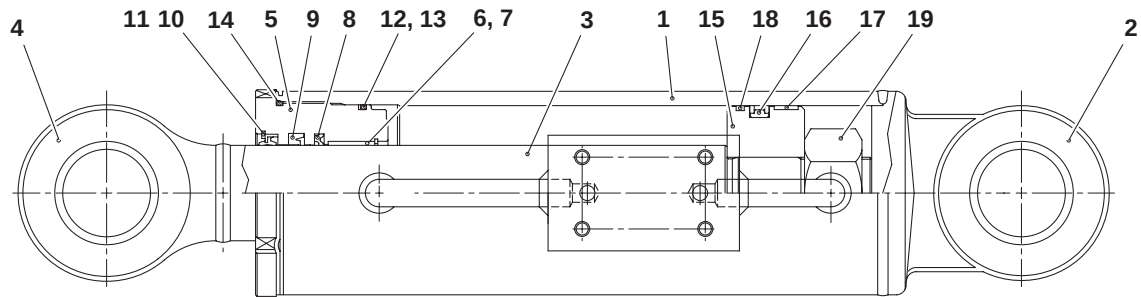
FG011073

Figure 6

Reference Number	Description
1	Tube Ass'y
2	Bush
3	Rod Ass'y
4	Bush
5	Rod Cover
6	DD-bush
7	Ring, Retaining
8	Seal, Buffer
9	U-packing
10	Wiper, Dust
11	Ring, Retaining
12	O-ring

Reference Number	Description
13	Ring, Back Up
14	O-ring
15	Piston
16	Ring, Glyd
17	Ring, Wear
18	Ring, Dust
19	O-ring
20	Ring, Back Up
21	Nut, Piston
22	Screw, Set
23	Nipple, Grease

Dozer Cylinder



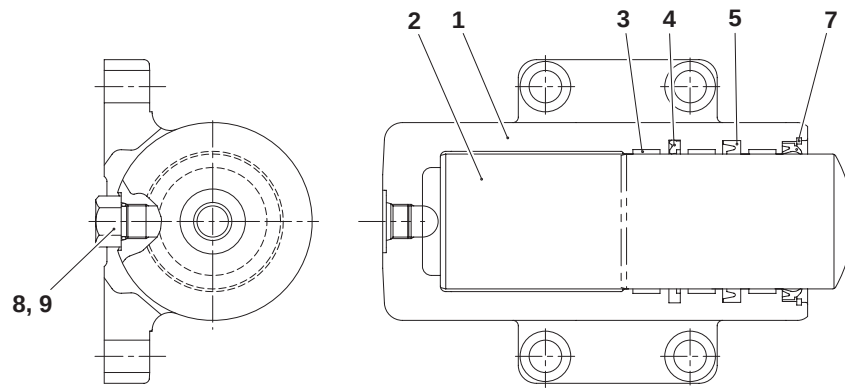
FG011057

Figure 7

Reference Number	Description
1	Tube Assembly
2	Bush
3	Rod Assembly
4	Bush
5	Rod Cover
6	DU-Bush
7	Retaining Ring
8	Buffer Seal
9	U-Packing

Reference Number	Description
10	Dust Wiper
11	Retaining Ring
12	O-Ring
13	Backup Ring
14	O-Ring
15	Piston
16	Wear Ring
17	Slipper Seal
18	Pust Ring
19	Hex Nut

Ram Cylinder



FG011058

Figure 8

Reference Number	Description
1	Body
2	Rod
3	Wear Ring
4	Buffer Seal
5	U-Packing

Reference Number	Description
6	Dust Wiper
7	Retaining Ring
8	Plug-B
9	O-Ring

SPECIAL TOOLS AND MATERIALS

Piston Nut

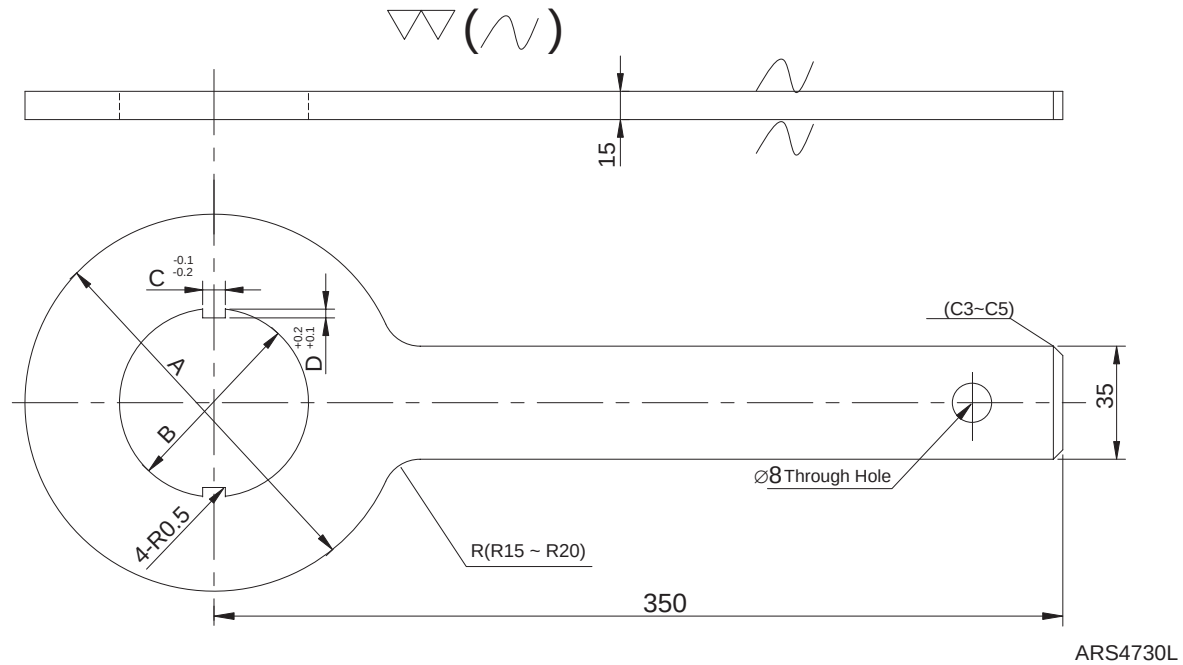


Figure 9

Material SM45C (AISI 1045)

Rockwell Harden from 22 - 27

Oil Quench

MODEL	CYLINDER	øA	øB	C	D	MODEL (CYLINDER)
DX55 DX55W	ARM	110 mm (4.33 in)	69 mm (2.72 in)	12 mm (0.47 in)	5 mm (0.20 in)	
	SWING	100 mm (3.94 in)	58 mm (2.23 in)	12 mm (0.47 in)	5 mm (0.20 in)	
	BUCKET	110 mm (4.33 in)	69 mm (2.72 in)	10 mm (0.39 in)	5 mm (0.20 in)	

Piston Jig

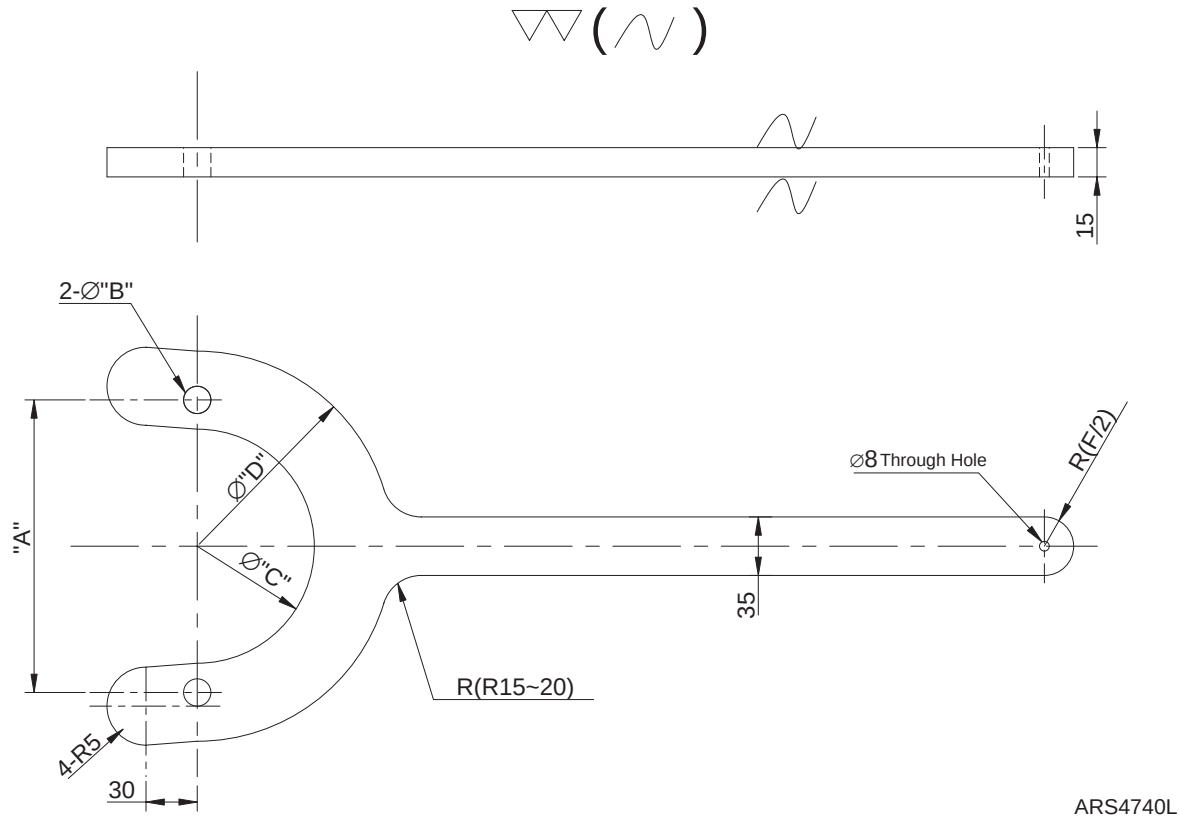


Figure 10

Material SM45C (AISI 1045)

Rockwell Harden from 22 - 27

Oil Quench

MODEL	CYLINDER	A (±0.1)	øB	øC	øD	MODEL (CYLINDER)
DX55 DX55W	ARM	65.0 mm (2.56 in)	11.0 mm (0.43 in)	49.0 mm (1.93 in)	90.0 mm (3.54 in)	
	BOOM	80.0 mm (3.15 in)	11.0 mm (0.43 in)	45.0 mm (1.77 in)	110.0 mm (4.33 in)	
	SWING	58.0 mm (2.28 in)	11.0 mm (0.43 in)	38.0 mm (1.50 in)	80.0 mm (3.15 in)	

Steel Bushing Jig

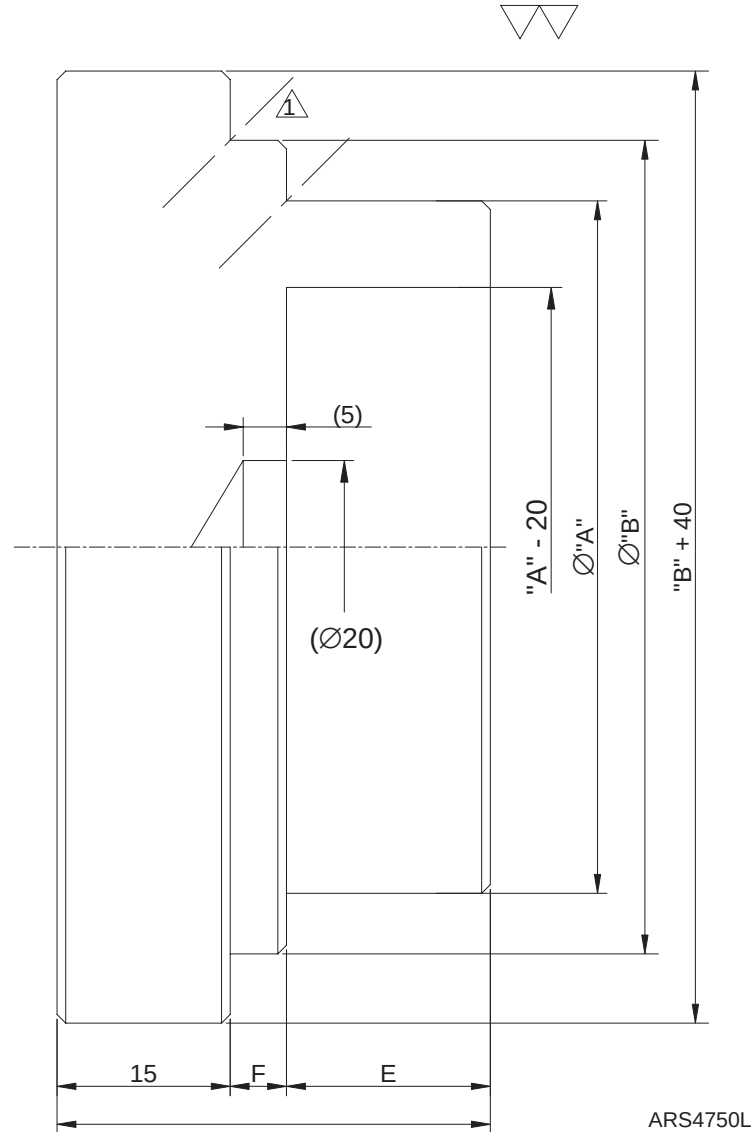


Figure 11

Material: SM45C which is done thermal refining <QT> Hrc 22 - 28

Undefined Chamfer C/R = 0.5 Max.

₁ Place: Finally work to used DNMG Tip <Nose R0.4>

MODEL	CYLINDER	øA-0.05	øB (±0.1)	E	F ₀ ^{+0.05}	Part	MODEL (CYLINDER)
DX55 DX55W	BOOM	50 mm (1.97 in)	65 mm (2.56 in)	30 mm (1.18 in)	-		
	SWING	40 mm (1.58 in)	50 mm (1.97 in)	20 mm (0.79 in)	-		
	DOZER	65 mm (2.56 in)	70 mm (2.76 in)	30 mm (1.18 in)	-		
H/C: Head Cover K/C: Knuckle Cover							

Dust Wiper Jig

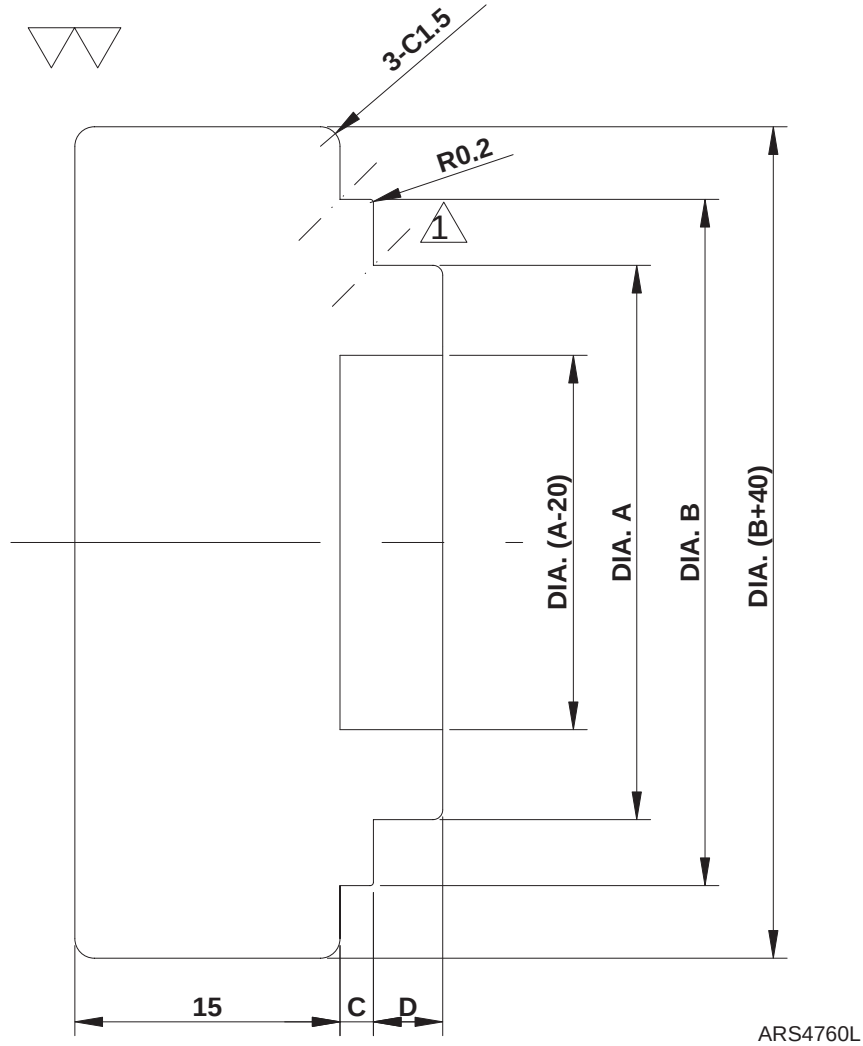


Figure 12

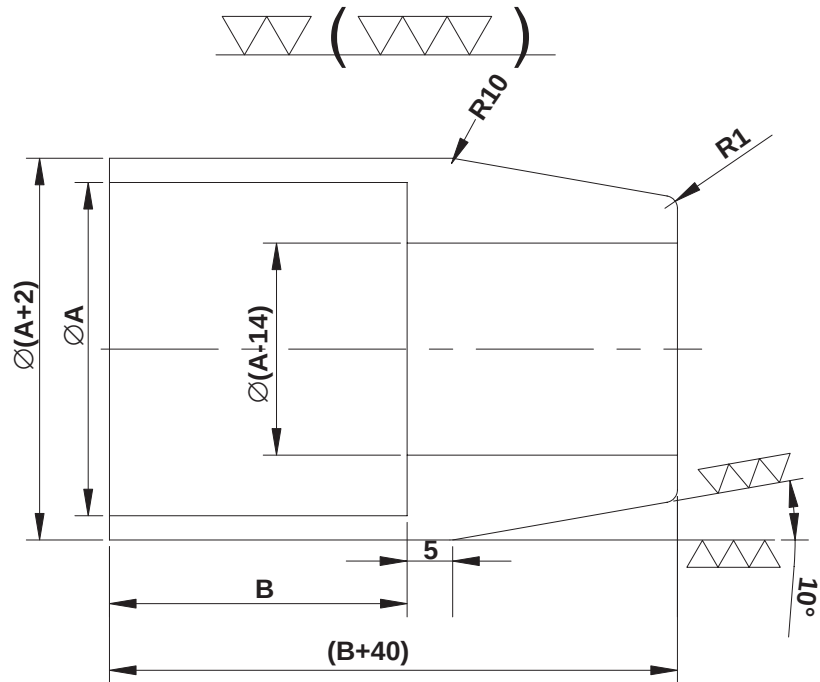
Material: SM45C which is done thermal refining <QT> Hrc 22 - 28

Undefined Chamfer C/R = 0.5 Max.

1 Place: Finally work to used DNMG Tip <Nose R0.4>

MODEL	CYLINDER	øA-0.2	øB-0.2	C ⁰	D	MODEL (CYLINDER)
DX55 DX55W	ARM	55 mm (2.17 in)	69 mm (2.72 in)	5 mm (0.20 in)	6 mm (0.24 in)	
	BOOM	55 mm (2.17 in)	69 mm (2.72 in)	5 mm (0.20 in)	6 mm (0.24 in)	
	BOOM (OP)	55 mm (2.17 in)	69 mm (2.72 in)	5 mm (0.20 in)	6 mm (0.24 in)	
	BUCKET	55 mm (2.17 in)	69 mm (2.72 in)	5 mm (0.20 in)	6 mm (0.24 in)	
	SWING	40 mm (1.58 in)	52 mm (2.05 in)	3.5 mm (0.14 in)	6 mm (0.24 in)	
	DOZER	60 mm (2.36 in)	74 mm (2.91 in)	7 mm (0.28 in)	6 mm (0.24 in)	

Slipper Seal Jig

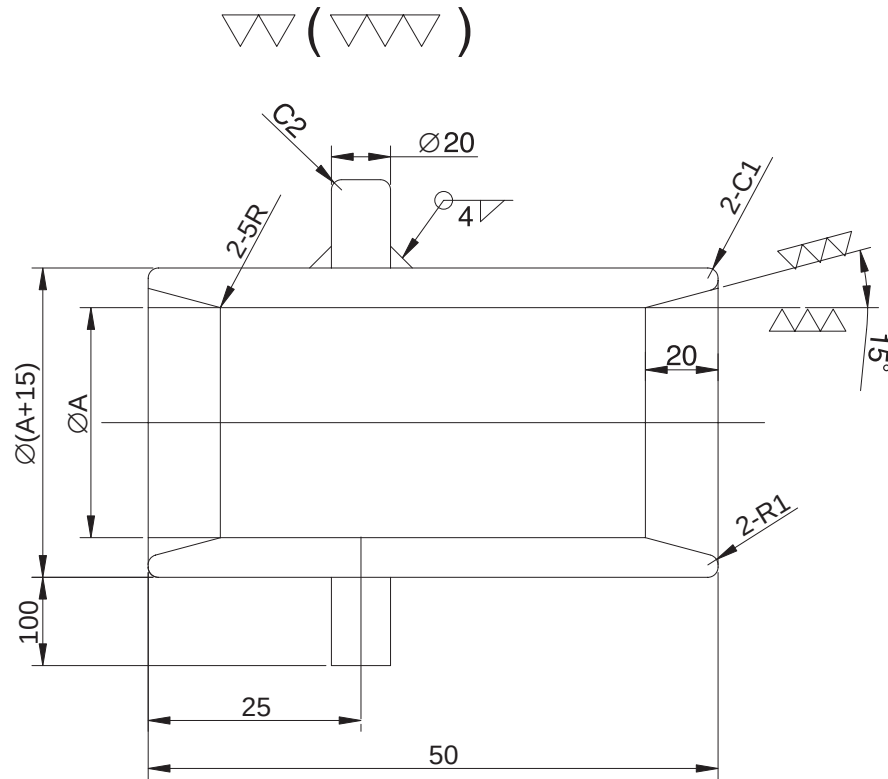


ARS4770L

Figure 13

MODEL	CYLINDER	$\varnothing A_{+0.2}^{+0.1}$	$B_{+0.2}^{+0.1}$	MODEL (CYLINDER)
DX55 DX55W	ARM	90 mm (3.54 in)	27 mm (1.06 in)	
	BOOM	115 mm (4.53 in)	20 mm (0.79 in)	
	DOZER	100 mm (3.94 in)	18 mm (0.71 in)	
P/S: Power Steering				

Slipper Seal Straightening Jig



ARS4780L

Figure 14

MODEL	CYLINDER	$\varnothing A^{+0.2}_{+0.1}$	MODEL (CYLINDER)
DX55 DX55W	ARM	90 mm (3.54 in)	
	BOOM	115 mm (4.53 in)	
	DOZER	100 mm (3.94 in)	
P/S: Power Steering			

DISASSEMBLY



CAUTION

Vent air from the hydraulic system before disconnecting cylinder piping connections. Use the lever on the reservoir, while the engine is running. Discharge the hydraulic accumulator and vent residual tank pressure after the engine is shut off. Pour clean replacement fluid back into the system if excessive fluid is lost.

1. Following removal of cylinder from excavator attachment, support cylinder on some type of sturdy work platform and drain all oil. Rotate cylinder so that piping ports are on top, to allow trapped air to vent.

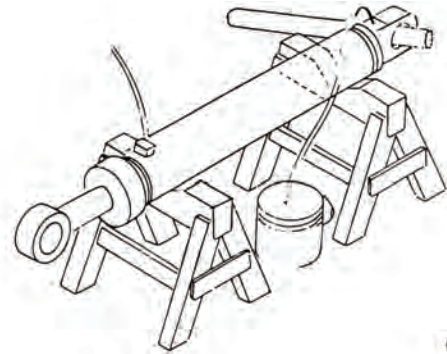


Figure 15

0333

2. Position piston rod so that it is extended approximately one half meter (20").

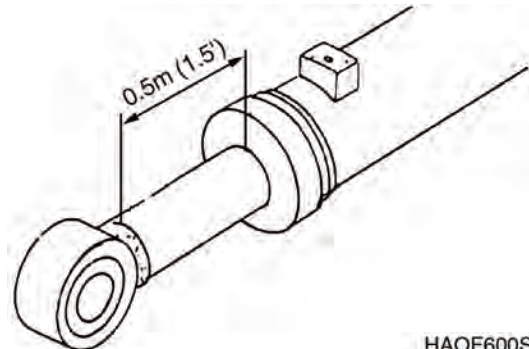


Figure 16

HAOF600S

3. Remove bolts (7) on the end of cylinder.

NOTE: Wrap a cloth or other protective material around piston rod, to avoid possibility of accidentally scratching or scoring rod surface while fasteners are being loosened and removed. Component parts (numbered in parentheses) are keyed to Figure 4.

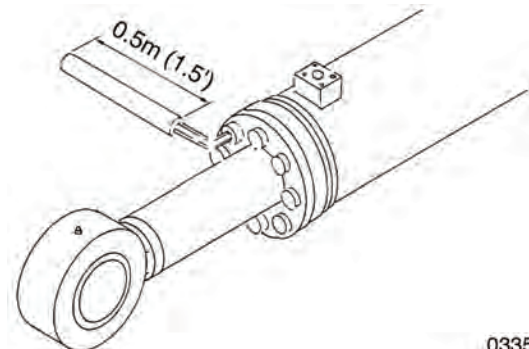
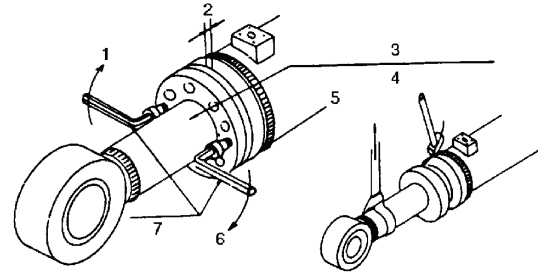


Figure 17

0335

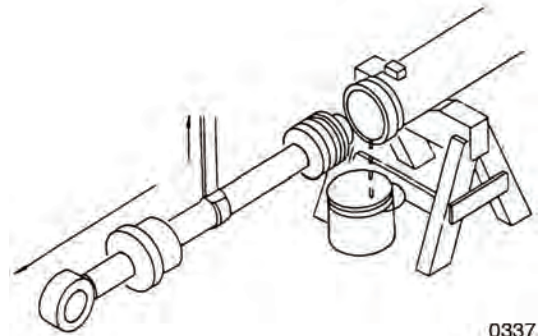
4. Tap two bolts into cover of cylinder head, 180° apart. Tighten them in a staggered, even sequence, to back off piston rod end cover from edge of cylinder wall. Look for adequate clearance between cover and end of cylinder wall before using a plastic or other soft-faced hammer for final disassembly.



HAOF610S

Figure 18

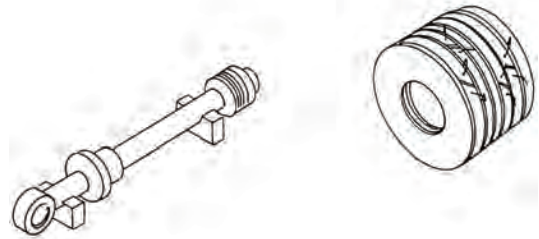
5. Begin withdrawing piston rod assembly, away from cylinder. Attach a lifting support when final 1/3 of rod is still inside barrel of cylinder. Prepare support blocks for piston rod before it has been completely withdrawn.



0337

Figure 19

6. Lower piston rod to support blocks and detach wear ring (outer surface) (18) from end of rod.



HAOF620S

Figure 20

7. Immobilize piston rod by inserting a wooden or other nonscoring, nonmetallic support through end of rod.

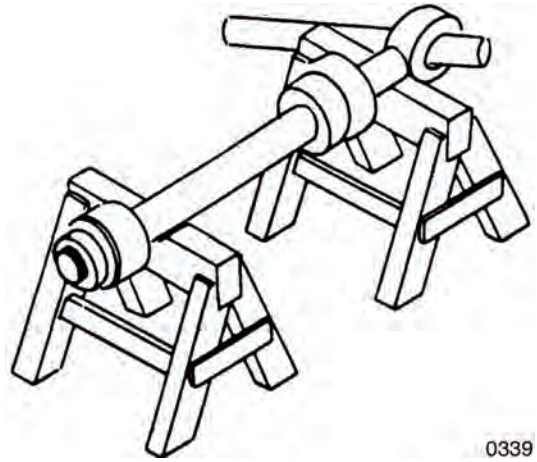


Figure 21

0339

8. Remove set screw by using a socket wrench.

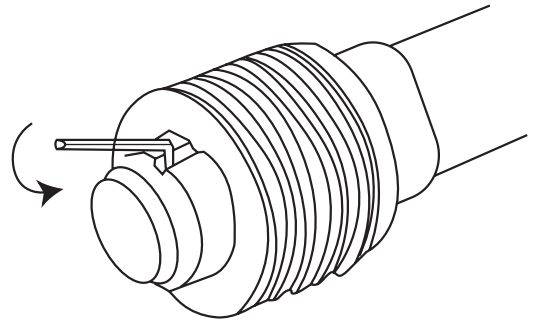


Figure 22

HAOF340L

9. Fabricate or purchase a piston nut removal wrench. (Dimensions are called off at beginning of this procedure. This tool may also be ordered through your local *Doosan* Parts distributor). Remove nut from end of piston.

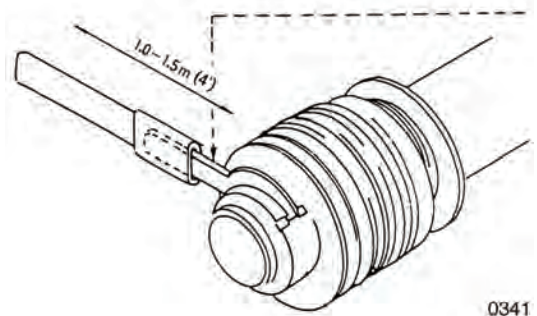


Figure 23

0341

10. Use second piston tool described at beginning of this procedure to separate piston. Detach cushion ring (15), taking care not to damage cushion ring.

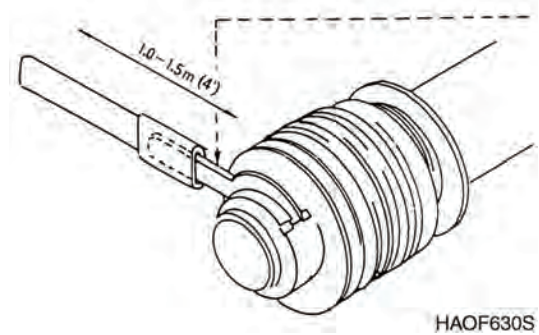


Figure 24

11. Use a plastic hammer to evenly pull off rod cover (9) from end of piston rod. Be careful not to damage rod bushing (6) and dust wiper, U-packing and other seals.

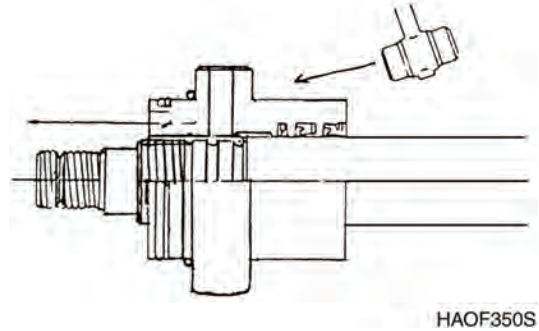


Figure 25

12. Use a dull, rounded-tip tool to pry off O-ring (11) and backup ring (12).

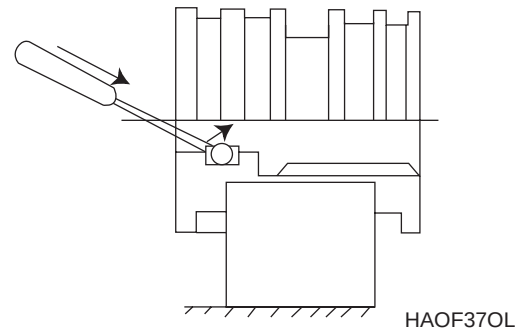


Figure 26

13. Find a screwdriver with an appropriate width tip to facilitate removal of slipper seal (19), wear ring (18) and slide ring (17) from piston (16).

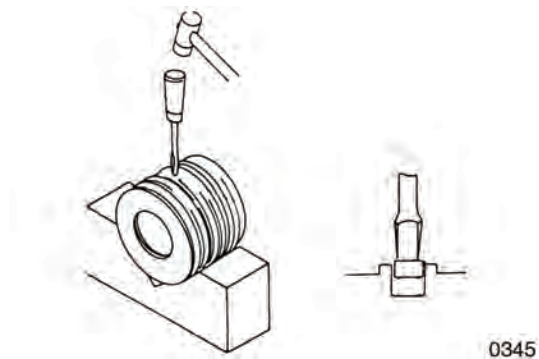


Figure 27

14. Pull off O-ring (20) and backup ring (21) from cylinder head.

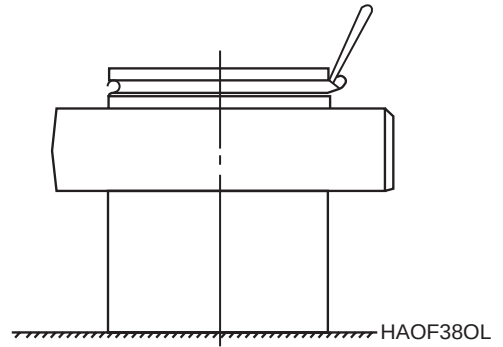


Figure 28

15. During disassembly of cylinder head, be careful not to damage buffer seal (5) and U-packing (4).

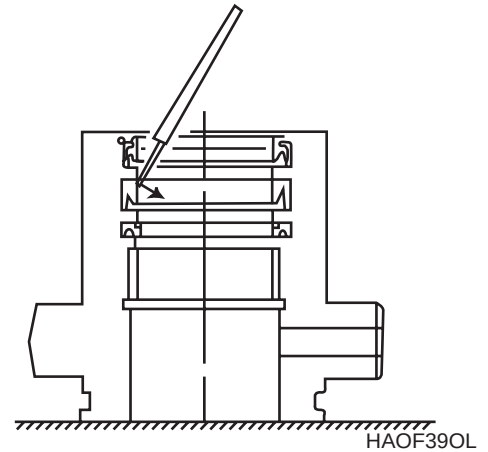


Figure 29

16. Disassemble retaining ring (3) and dust wiper (2). Separate retaining ring (8) and rod bushing (6).

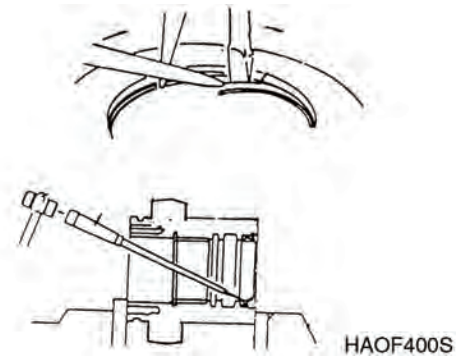


Figure 30

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

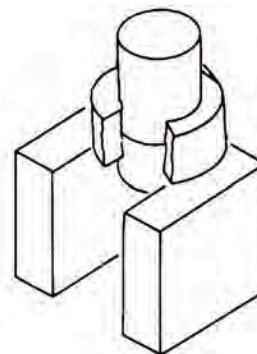


Figure 31

0349

ASSEMBLY

IMPORTANT

Replace any part that shows evidence of damage or excessive wear. Replacement of all O-rings and flexible seals is strongly recommended. Before starting the cylinder assembly procedure, all parts should be thoroughly cleaned and dried, and/or prelubricated with clean hydraulic fluid. Prepare the work area beforehand to maintain cleanliness during the assembly procedure.

NOTE: Assemble subassemblies of cylinder in the following order:

1. Cylinder body
 2. Piston rod
 3. Piston assembly
 4. Cylinder head assembly
1. Assemble pin bushing (1) to piston rod (13) and body of cylinder (14).
 2. Following the assembly of rod cover components, install dust wiper (2) and rod bushing (6) to rod cover (9). Insert retaining rings (3 and 8).

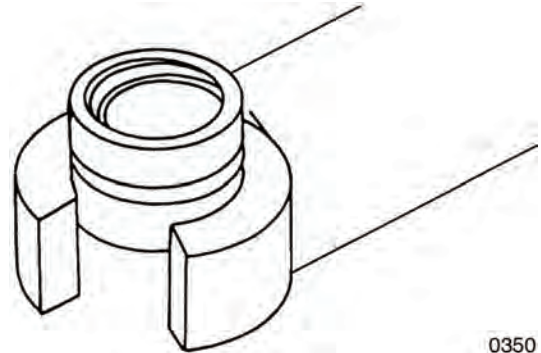


Figure 32

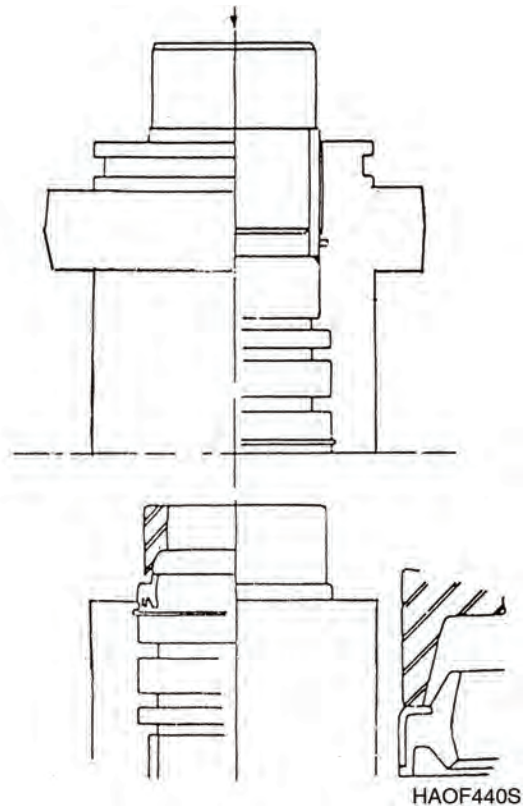


Figure 33

3. Prelubricate O-rings and seals before assembly (Figure 34).

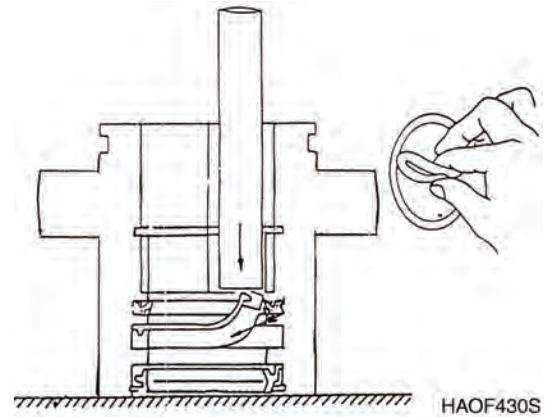


Figure 34

4. Before starting to rebuild piston assembly, heat slipper seal for 5 minutes in an oil bath warmed to 150°-180°C (302°-356°F). Use special slipper seal jig (third item in list of specialized tools at the beginning of this procedure) to attach seal. Cool seal by pushing a retracting jig against seal for several minutes. Apply a strip of clean, see-through sealing tape around slipper seal to keep it free of dust.

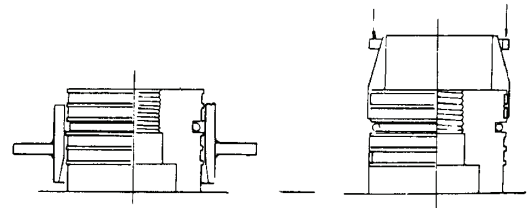


Figure 35

5. Immobilize piston rod on solid support blocks. Assemble O-ring (20) and backup ring (21). Prepare to attach rod cover assembly to piston rod. Push rod cover by tightening piston nut (22).

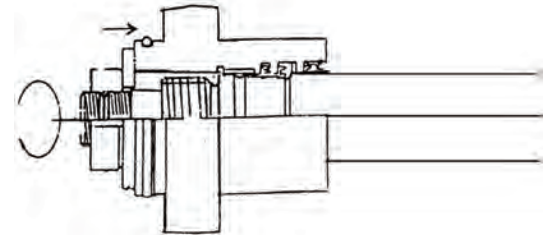


Figure 36

6. Assemble cushion ring (15) and attach piston assembly to piston rod.

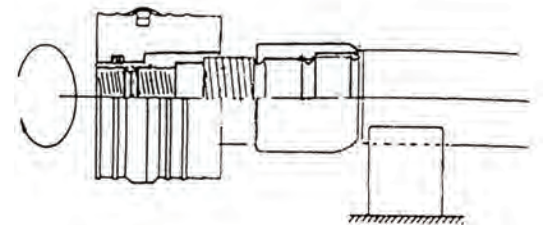
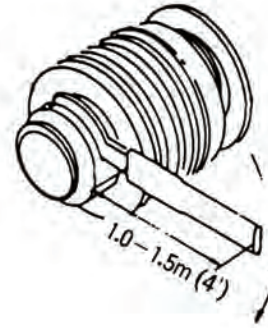


Figure 37

7. Use specially fabricate or factory sourced tool to tighten piston nut (22).

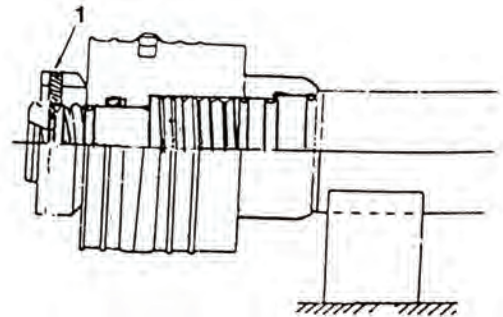


0356

Figure 38

8. Assemble wear ring (18), slide ring (17) and set screw (23) to piston assembly.

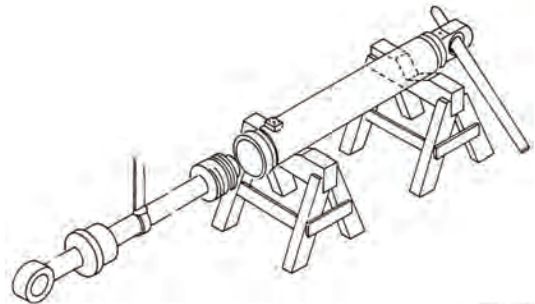
Reference Number	Description
1	Set Screw



HAOF470S

Figure 39

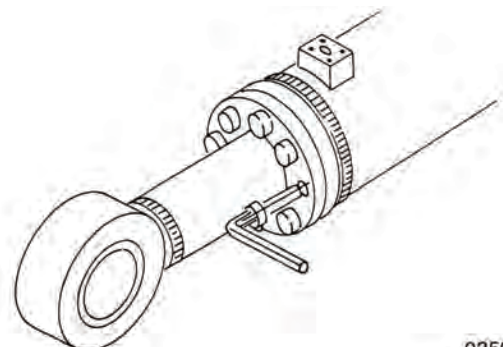
9. Immobilize body of cylinder before assembly.



0358

Figure 40

10. Preapply fastener locking compound (Loctite #242 or #243 or an alternate manufacturer's equivalent product) to all end cover retaining bolts. Wrap a protective cushion around end of rod while tightening fasteners, to prevent possible damage to polished surface of rod, should a wrench slip during retightening.



0359

Figure 41

Main Control Valve

Edition 1

MEMO

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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 ultimately 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
DX55W	5001 and Up

COMPOSITION, FUNCTION AND OPERATION

The control valve is located between pump, cylinder and motor on the oil pressure circuit. Each component within the main control valve operates and controls oil flowing from the main pump. Such control changes operation direction and speed of both cylinder and motor.

Control valve consists of following sections:

1. Arm2 section (Figure 34)
2. Bucket section (Figure 35)
3. Boom1 section (Figure 36)
4. Travel 1 section (Figure 37)
5. Inlet section (Figure 38)
6. Travel 2 section (Figure 39)
7. Rotary section (Figure 40)
8. Arm1 section (Figure 41)
9. Boom 2 / preliminary section (Figure 42)
10. Dozer section (Figure 43)
11. Boom Swing Section (Fig. 38)
12. Turning section (Figure 44)
13. Flue plate section (Figure 46)
14. Tilting section (Optinal) (Figure 47)

Function of Control Valve

1. Control for neutral
Oil discharges from the return port through the center bypass passage within the main control valve.
2. Operation of control valve
Such control changes flow direction of oil in order to operate, stop or change the operating direction of both cylinder and motor. Pump oil is supplied to each section from the enter bypass passage and the parallel passage. Oil returned from each control valve is discharged from the return port through return passage.
3. Drop prevention of operation of cylinder and motor using load check valve
4. Restriction of circuit pressure by relief valve
5. Straight run function
Running moves forward even though operating each working machine of boom, arm, bucket and preliminary during running.

6. Arm reproduction function
Supplies some of returning oil to the cylinder bottom part in Crowd(speed up of cylinder).
7. Arm 2 speed function
If operating the arm cylinder, working oil from the P1 pump side(No.1 section) and the P2 pump side(No.6 section) are mixed by the outside pipe.
8. Boom2 speed function
When performing Lift Up operation on the Boom, working oil in the Boom2 section of the P2 pump group is mixed with Boom1 section through the inside passage of the control valve.
9. Anti-drift valve
An anti-drift plate is installed to reduce natural drop volume in the bottom part of Boom cylinder.
10. Boom right rotation circuit
Poppet with the throttle valve adhered is installed in the parallel passage so that Boom operates in simultaneous operation of Lift Up on boom + Bucket Crowd.
Same as for simultaneous operation of Boom + Arm2.

Operation of Main Section

Arm2

1. For neutral(Figure 16)
Working oil discharging from the pump is returned to the tank through neutral passage. Working oil of both A1 and B1 cylinder port is closed.
2. Crowd operation(Figure 17)
If converting the spool by pressurizing the Pa1 port, flow of the neutral passage is closed and working oil in the neutral passage pushes up the load check valve at both places and flow through "A1".
Working oil of the cylinder port "B1" returns to the tank from the Arm1 section.
3. Crowd operation in simultaneous operation with boom(Figure 18)
Working oil pushes up the load check valve(parallel) with throttle valve and flows through the cylinder port "A1".
4. Dump operation(Figure 19)
Like Crowd operation, return working oil returns to the tank from the cylinder port "A1".

Boom1

1. For neutral(Figure 20)
An anti-drift plate is installed to reduce natural drop volume in the bottom part of cylinder.
2. Move up operation(Figure 21)
Working oil pushes up the Poppet of the anti-drift plate as

well as load check valve and flows through the cylinder port "B3". Return working oil returns to the tank from the cylinder port "A3".

3. Lower down operation(Figure 22)
"Pa3" and "Pi1" port are connected and Lower Down pilot pressure applies to the "Pi1"port.
Operation of the anti-drift plate enables to connect the spring room side of the Poppet to the "DR1" port and make Poppet opening status, and returning passage is obtained.

Travel

1. For neutral(Fig.18)
Working oil discharging from the pump is supplied to Boom1, Bucket, Arm2 from Travel1 and to Rotary, Arm1, Boom2/ preliminary, Dozer, Boom swing, Slew, Flue plate through neutral passage.
2. Move forward(Fig.19)
If converting the spool by pressurizing the Pb4(Pb5) port, working oil is supplied to Travel motor from port "B4(B5)" of the Travel1(Travel2) section
Return working oil from the port "A4(A5)" returns to the tank from the Travel1(Travel2) section.
3. Move backward(Fig.20)
When move backward opposed to forward, if converting the spool by pressurizing the Pa4(Pa5) port, working oil is supplied to Travel motor from port "A4(A5)" of the Travel1(Travel2) section
Return working oil from the port "B4(B5)" returns to the tank from the Travel1(Travel2) section.

Boom2

For Neutral(Figure 25) and Operation(Figure 26), working oil is supplied to Boom1 through inside passage of the control valve(Lift Up Mix).

Arm1

For Neutral(Figure 27), Crowd Operation(Figure 28) and Dump Operation(Figure 29), some of working oil returned from the cylinder port "B6" returns to the tank and the other oil pushes up Poppet for recovery and supplies oil to "A6"(recovery circuit).

Flue plate(Figure 30)

For Neutral(Figure 30), Operation(Figure 31), simultaneous operation of Running and Boom(or Bucket, Arm, Preliminary) enables to operate the flue plate.

Working oil of the P1 pump is supplied to Right run, P2 pump to Left run, and P3 pump to the Boom, Arm, Bucket.

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 and Shuttle valve, Combination No.(14), (15), (16), (17) of Figure 32.

Disassembly of Arm2, Bucket, Travel1, Travel2, Arm1, Boom2/preliminary, Dozer, Turning Section

Take off the cap of Combination No.(3) of Figure 34, Figure 35, Figure 37, Figure 38, Figure 39, Figure 42, Figure 43, Figure 44 by loosening a socket head bolt(13)(hexagonal hole subtense 5mm). Remove spring seat(4), spring(6), spring seat(5) and O-ring(12). Then take out the spool(2) from the valve housing(1). In this manner, also take out the opposite cap(8). 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.

Disassembly of Boom1(Figure 36)

Take off the cap of Combination No.(3) of Figure 36 by loosening a socket head bolt(13)(hexagonal hole subtense 5mm). Remove spring seat(4), spring(6), spring seat(5) and O-ring(13). Then take out the anti-drift valve Assy by loosening a socket head bolt(20)(hexagonal hole subtense 5mm). And take spring seat(4), spring(6), spring seat(5) and O-ring(13).

And to take off the Poppet(15), take out the spacer(17) with M4X0.7 screw. After taking out the spacer(17), take off the Poppet(15), spring(16).

Disassembly of Inlet Section(Figure 38)

Take off the cap(5) of Combination No.(3) of Figure 38 by loosening a socket head bolt(13)(hexagonal hole subtense 5mm). Remove O-ring(4). Then take out the spool(2) from the valve housing(1). In this manner, also take out the opposite cap(3).

Disassembly of Boom2 Section(Figure 40)

Take out the cap of Combination No.(3) of Figure 40 by loosening a socket head bolt(13)(hexagonal subtense 5mm). Remove spring seat(4), spring(6), spring seat(5) and O-ring(12). Then take out the spool(2) from the valve housing(1). In this manner, take out the opposite cap(16) by loosening a socket head bolt(13)(hexagonal subtense 5mm). Remove O-ring(12).

Disassembly of Flue Plate Section(Figure 46)

Take off the cap of Combination No.(3) of Figure 46 (3) by loosening a socket head bolt(13)(hexagonal hole subtense 5mm). Remove spring seat(4), spring(6) and O-ring(5). Then take out the spool(2) from the valve housing(1). In this manner, also take out the opposite cap(8).



CAUTION

Do not disassemble the filter(14) as it is firmly fixed. If disassembling or reassembling it, there is concern to result in poor operation of each working part that the filter may drop or damage and its scraps moves through the oil path.

Take Off of Load Check Poppet Type

By removing a tie-rod, take off load check and plug type before disassembling the valve housing. Types of poppet or plug are as follow:

Arm2 (Figure 34)	: Plug(10)×2, spring(9)×2, Poppet(7), Poppet(8)
Bucket (Figure 35)	: Plug×2(10), spring(9)×2, Poppet(7), Poppet(8)
Boom1 (Figure 36)	: Plug assembly(21)×2, Plug(10)×2, spring(9)×2, Poppet(8)×2
Travel1 (Figure 37)	: Plug(7)
Inlet (Figure 38)	: Plug assembly(7)
Travel2 (Figure 39)	: Plug(7)
Rotary (Fig.35)	: Plug(10), spring(9), Poppet(7)
Arm1 (Figure 41)	: Plug(10), spring(9), Poppet(7), Plug(18), spring(16), Poppet(15)
Boom2/ Preliminary (Figure 42)	: Plug(10), spring(9), Poppet(7)
Dozer (Figure 43)	: Plug(10), spring(9), Poppet(7)
Boom Swing(Fig.3 9)	: Plug(10), spring(9), Poppet(7)
Turning (Figure 44)	: Plug(10), spring(9), Poppet(7)
Flue plate (Figure 46)	: Plug(11)

Disassembly of Valve Housing

Take off the tie-rod((2) by loosening a nut(hexagonal sub tense 8mm), Combination No.(1) of Figure 32. Orderly disassemble the valve housing of each section.

Disassemble parts on the matching surface of each section.

Arm2 (Figure 34)	: No parts
Bucket (Figure 35)	: O-ring(14)
Boom1 (Figure 36)	: O-ring(12)
Travel1 (Figure 37)	: Poppet(12), spring(13), O-ring(11)
Inlet (Figure 38)	: O-ring(7)×2
Travel2 (Figure 39)	: Poppet(12), spring(13), O-ring(11)
Rotary (Fig.35)	: O-ring(14)
Arm1 (Figure 41)	: O-ring(14), O-ring(19), O-ring(21)
Boom2/ Preliminary (Figure 42)	: No parts
Dozer (Figure 43)	: O-ring(14)
Boom Swing(Fig.3 9)	: O-ring(14)
Turning (Figure 44)	: O-ring(14)
Flue plate (Figure 46)	: O-ring(15)

Identify each part disassembled by section so that position to squeeze and insert can be known for reassembly.

CLEANING

Completely clean all parts disassembled with a mineral oil. Place each part on a clean paper or cloth for drying and inspecting with compressed air.

INSPECTION

Inspect for any protruded part, scratched flaw, dented flaw and other defects on the whole surface.

1. Check that the actual groove surface of the valve housing is smooth and that there are scraps, dented point and rust, etc.
2. If there is dented point or defect on the check sheet surface of the valve housing, get away it by wrapping. Be cautious so that wrapping agents not remain within the valve.
3. All the interface and relief parts must lightly move. There should no dirt on all the grooves or passages.
4. When spring is damaged or deformed, replace it.
5. When operation of the relief valve is not good, replace assembly.
6. Replace all seals, wipers and O-rings.

ASSEMBLY

Be cautious of followings when handling O-rings(or seals) for assembly:

1. There should not be defect in forming or groove occurred when handling O-ring.
2. Sufficiently apply grease or working oil etc to the system part of O-ring and O-ring.
3. The O-ring should not be stretched so that warping does not occur.
4. Be careful not to roll the O-ring while squeezing it for insertion. A twisted O-ring can cause an oil leak as it is difficult to return to the original shape after system mounting.

Assembly of Valve Housing

Insert below Poppet, spring into the housing:

Travel1 : Poppet(12), spring(13)
(Figure 37)
Travel2 : Poppet(12), spring(13)
(Figure 39)

Mount O-ring in the matching surface as below on each section:

Arm2 : No O-ring
(Figure 34)
Bucket : O-ring(14)
(Figure 35)
Boom1 : O-ring(12)
(Figure 36)
Travel1 : O-ring(11)
(Figure 37)
Inlet : O-ring(7)×2
(Figure 38)
Travel2 : O-ring(11)
(Figure 39)
Rotary : O-ring(14)
(Figure 40)
Arm1 : O-ring(14), O-ring(19), O-ring(21)
(Figure 41)
Boom2/
Preliminary : No O-ring
(Figure 42)
Dozer : O-ring(14)
(Figure 43)
Boom : O-ring(14)
Swing
(Fig39)
Turning : O-ring(14)
(Figure 44)
Flue plate : O-ring(15)
(Figure 46)

Then, orderly adhere Inlet housing and valve housing of each section to the tie-rod of Figure 32 Combination No.(1). And firmly tightening nut(2)(hexagonal subtense 8mm) to tie-rod(1).

Tightening torque: 26.5~29.4N•m

Assembly of Arm2, Bucket, Travel1, Travel2, Arm1, Boom2/Preliminary, Dozer, Boom Swing, Turning

Insert spring(6) between spring seat(4), (5) of Figure 34, Figure 35, Figure 36, Figure 39, Figure 41, Figure 42, Figure 43, Figure 44, and insert the spool into the valve housing(1) with same position and direction as before-disassembly, and then mount the cap(3) with the O-ring(12) mounted with a socket head bolt(13)(hexagonal hole subtense 5mm). In this manner, also mount the cap in the opposite side.

And Combination No. of the running socket head bolt becomes (10), While O-ring becomes (9).

Tightening torque: 8.8~10.8N•m

Assembly of Boom1 Section(Figure 36)

Insert spring(6) between spring seat(4), (5) of Figure 36, and insert the spool into valve housing(1) with same position and direction as before-disassembly, and then mount cap(3) with O-ring(13) mounted with a socket head bolt(14)(hexagonal hole subtense 5mm). For the anti-drift side, insert the Poppet(15), spring(16) and then insert the spacer mounting the O-ring(18), Back-up ring(19)(be cautious of the mounting position of O-ring and backup). Then insert the spring(6) between spring seat(4), (5) and insert the spool into the valve housing(1) with same position and direction as before-disassembly, and then mount the(7) anti-drift valve assembly equipped with the O-ring(13) with a socket head bolt(20)(hexagonal hole subtense 5mm).

Tightening torque: 8.8~10.8N•m

Assembly of Inlet Section(Figure 38)

Insert the spool(2)(right & left symmetry) of Figure 38 into valve housing(1) and mount the cap(3) equipped with the O-ring(4) with a socket head bolt(5)(hexagonal hole subtense 5mm). Also mount in this manner in the opposite cap.

Tightening torque: 8.8~10.8N•m

Assembly of Flue Plate(Figure 46)

Insert spring(6) between spring seat(4), (5) of Figure 46, and insert the spool(2) into valve housing(1) with same position and direction as before-disassembly, and then mount cap(3) equipped with O-ring(17) mounted with a socket head bolt(13)(hexagonal hole subtense 5mm).

Tightening torque: 8.8~10.8N•m

Then mount the cap(8) with the filter-A(14) inserted with a socket head bolt(20)(hexagonal hole subtense 5mm) as below.

Inserting of Load Check

Insert following load check, spring, plug(equipped with O-ring).

Arm2 (Figure 34)	: Plug(10)×2, spring(9)×2, Poppet(7), Poppet(8) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Bucket (Figure 35)	: Plug(10)×2, spring(9)×2, Poppet(7), Poppet(8) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Boom1 (Figure 36)	: Plug assembly(21)×2 Plug Tightening torque: 49~53N•m(hexagonal hole subtense 8mm) Plug(10)×2, spring(9)×2, Poppet(8) ×2 Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Travel1 (Figure 37)	: Plug(7) Plug Tightening torque : 30.4~32.4N•m(hexagonal hole subtense 6mm)
Inlet (Figure 38)	: Plug assembly(9) Plug Tightening torque : 14~16N•m(hexagonal hole subtense 5mm)
Travel2 (Figure 39)	: Plug(7) Plug Tightening torque : 30.4~32.4N•m(hexagonal hole subtense 6mm)
Rotary (Figure 40)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque : 30.4~32.4N•m(hexagonal subtense 14mm)
Arm1 (Figure 41)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm) Plug(18), spring(16), Poppet(15) Plug Tightening torque: 28.4~30.4N•m(hexagonal hole subtense 6mm)
Boom2/ Preliminary (Figure 42)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Dozer (Figure 43)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Boom Swing (Fig.39)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Turning (Figure 44)	: Plug(10), spring(9), Poppet(7) Plug Tightening torque: 30.4~32.4N•m(hexagonal subtense 14mm)
Flue plate (Figure 46)	: Plug(11) Plug Tightening torque: 30.4~32.4N•m(hexagonal hole subtense 6mm)

Accessory Adherence

Adhere Relief valve assembly according to Combination No. (15), (16), (17), (18), (19) of Figure 32.

Tightening torque of Relief valve assembly : 69~78N•m

Tightening torque of Shutoff valve assembly : 59~8N•m



CAUTION

Slowly insert the spool straightly to the hole. Poor operation of the spool may occur if inserting the spool when there is non-smooth or irregular feeling by operating the spool manually after inserting the spool.



CAUTION

Recheck that there are possibly not-assembled or not-tightened parts disassembled after completing assembly. If not firmly tightening it, oil may leak due to loose parts. Tightening torque as instructed in this manual shows value of wet status(adherence status of working oil).

RELIEF VALVE

Main Relief Valve(for P1, P2)

Operation of main relief valve

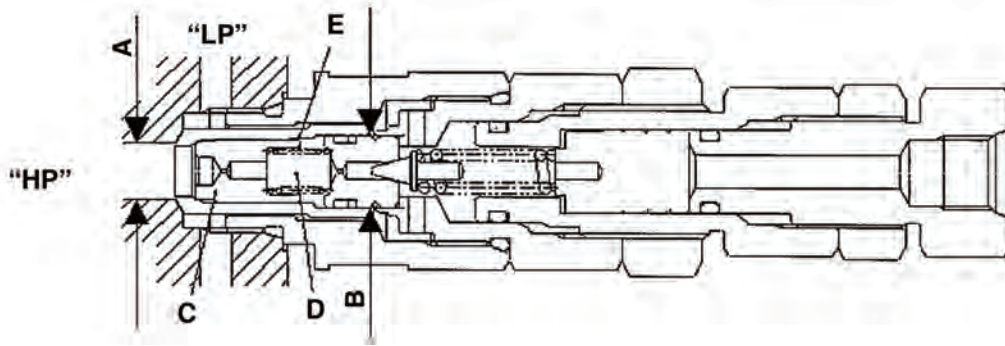


Figure 1

FG011258

1. This relief valve is inserted between the neutral passage "HP" and the low pressure passage "LP", and oil become full in the inside space(D) through the throttle hole of the main Poppet(C). Also the sleeve(E) and main Poppet(C) are firmly seated due to difference of the area.

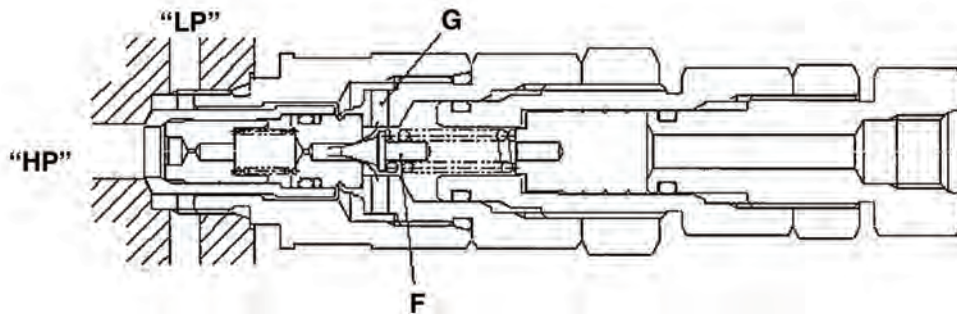
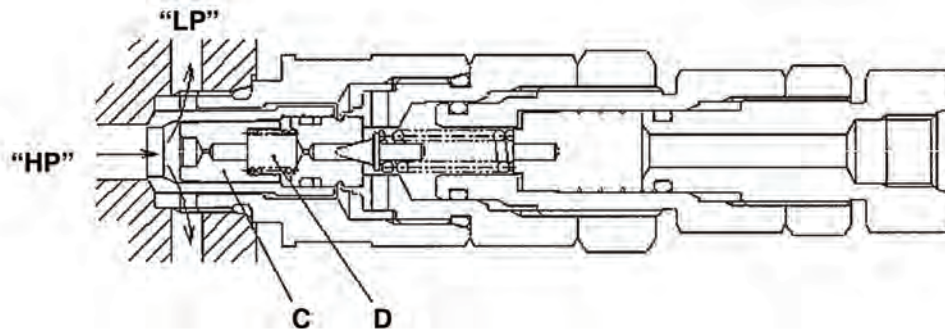


Figure 2

FG011259

2. If pressure of the neutral passage "HP" reaching to force of the pilot spring, the Pilot Poppet(F) is open. Oil flows around Poppet and is delivered to the low pressure passage "LP" through a hole(G).



FG011260

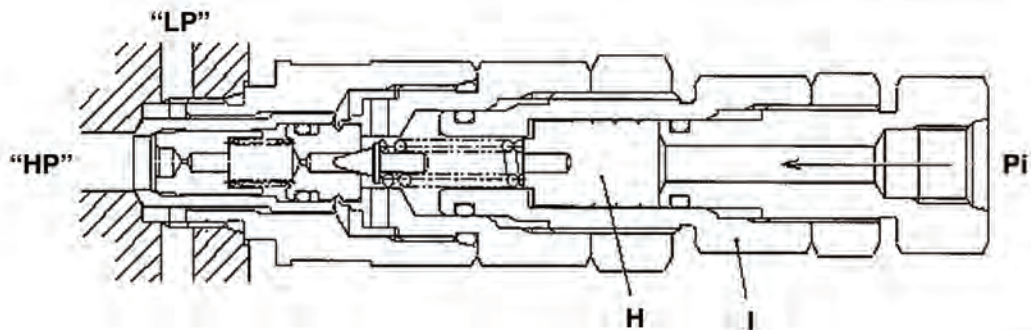
Figure 3

3. As Pilot Poppet(F) is open, pressure of the inside space is reduced. As the main Poppet(C) is open, oil of "HP" flows to direct passage "LP".

*** Booster operation**

If applying pressure to the Pilot port, "Pi", the piston(H) is moved to the set position by Plug(I).

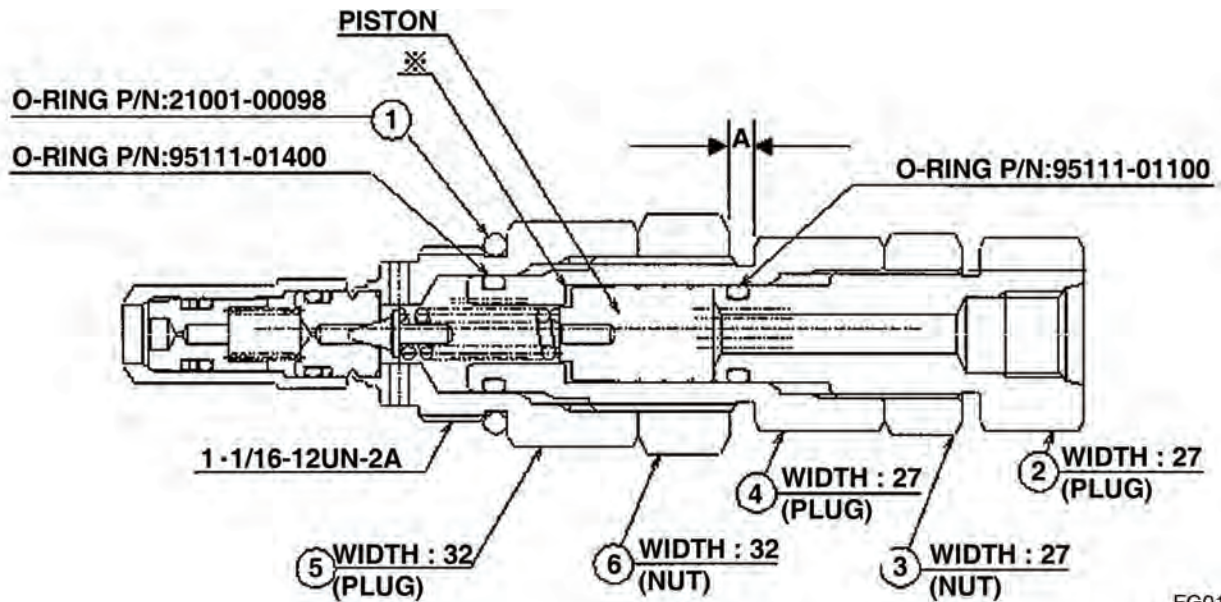
Accordingly pilot spring force rises and so pressure of "HP" increases.



FG011261

Figure 4

Hint for disassembly and assembly of main relief valve



FG011262

Figure 5

1. Disassembly

For the original product, replace assembly.

When replacing, take off O-ring by loosening plug(5: hexagonal subtense 32) with a spanner, etc.



CAUTION

Do not disassemble the relief valve as set pressure changes.

2. Assembly

Properly check that there are no scraps, primer pieces, etc around plug(2), (4), nut(3) and insert a new O-ring(1).

After properly clean the relief mounting part of the valve housing, mount the relief valve and then tighten plug(5: hexagon subtense 32) to tightening torque of 49~59N•m.

If disassembling plugs, assemble them according to "Hint for disassembly and assembly of main relief valve" on page 1-22).



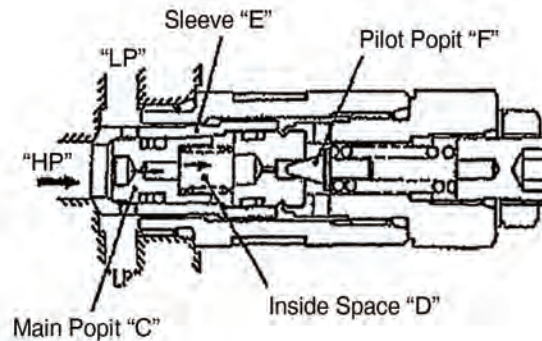
CAUTION

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

Main Relief Valve(P3)

Operation

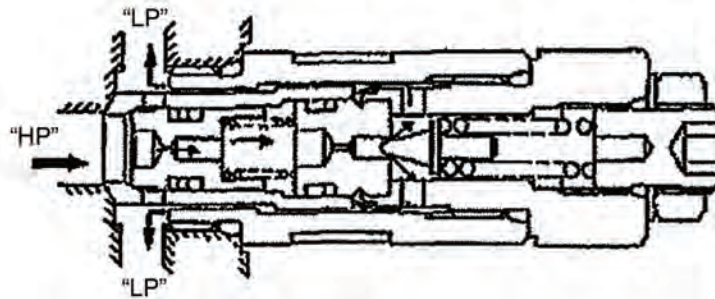
The main relief valve is laid between neutral passage "HP" and low pressure passage "LP" and operates as follow:



FG011263

Figure 6

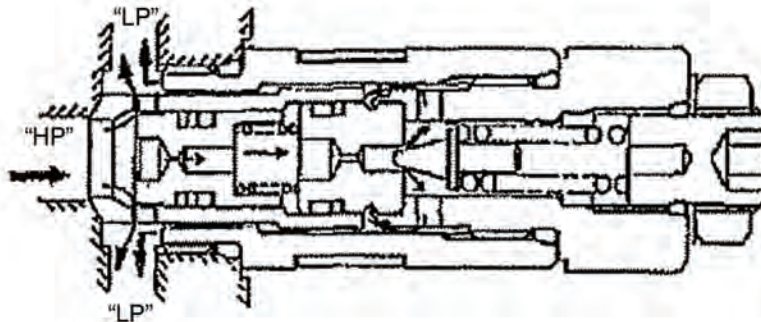
1. Oil fills the inside space "D" room through the throttle hole of the main Poppet "C" and the main Poppet "C" and sleeve "E" are firmly seated due to difference of the area.



FG010410

Figure 7

2. If pressure of the "HP" reaching to force of the pilot spring to be set, the Pilot Poppet(F) is open. Oil flows around Poppet and is delivered to the low pressure passage "LP" through a hole.

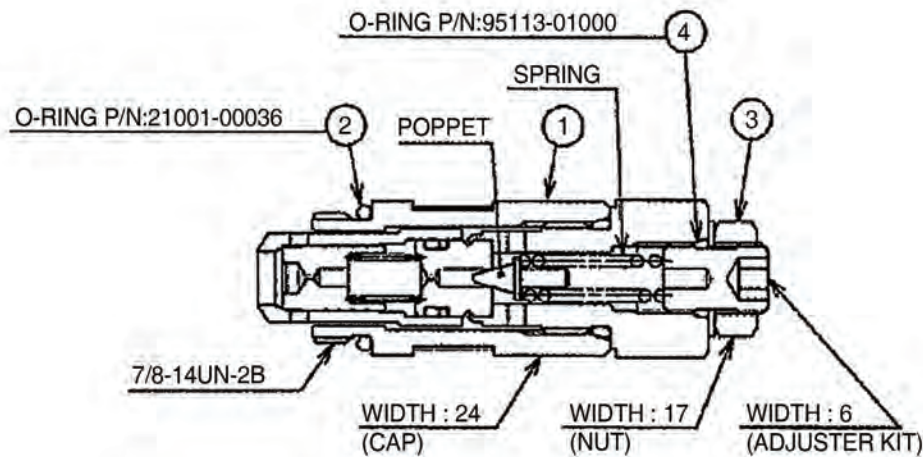


FG011264

Figure 8

3. The Pilot Poppet "F" opens and so oil flows from "HP" to "D" room through the throttle hole of the main Poppet "C". By this, pressure difference generates between "HP" and "D" room, and so the main Poppet "C" opens and oil of the "HP" directly flows into "LP".

Hint for disassembly and assembly of main relief valve



FG011265

Figure 9

1. Disassembly

For the original product, replace assembly.

When replacing, loosen the cap(1: hexagonal subsize24) with a spanner, etc and take off the O-ring(2, Figure 9).

If oil leaks from the adjuster part(3, Figure 9), loosen the adjuster part and replace the O-ring(4, Figure 9).



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 9) screw part. and insert a new O-ring(2, Figure 9).

After properly cleaning the relief mounting part of the valve housing, mount the relief valve and then tighten cam(1, Figure 9) <1: hexagon subsize 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 1-24).



CAUTION

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

Overload Relief Valve

Overload relief valve

1. This relief valve is inserted between the cylinder port "HP" and the low pressure passage "LP". Oil fulfills the inside space(G) through a hole of the piston(C). the sleeve(K) and the main port(D) are firmly seated by which it applies to other area of(A), (B).

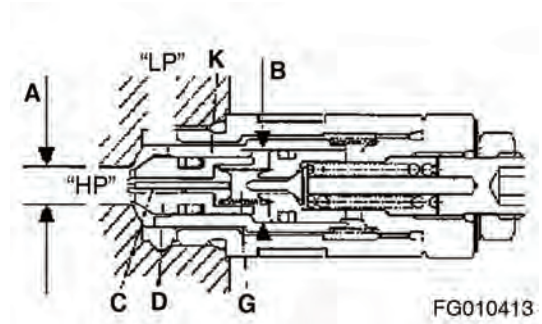


Figure 10

2. If pressure of the "HP", a cylinder port reaches to force of the pilot spring to be set, the Pilot Poppet(E) is open. Oil flows around Poppet and is delivered to the low pressure passage "LP" through a hole(H).

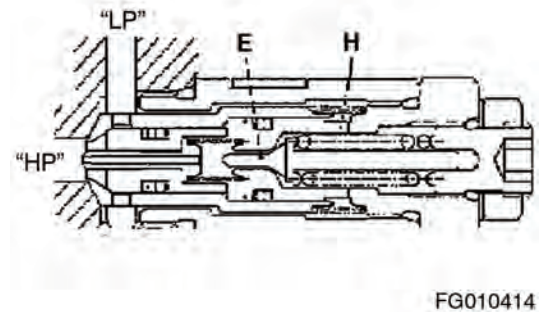


Figure 11

3. If the Poppet(E) opens, oil flows through the throttle hole(I) of the piston(C) and so pressure difference generates at the rear of the passage, "HP" and the piston(C). The Poppet(E) is seated due to movement of the piston(C).

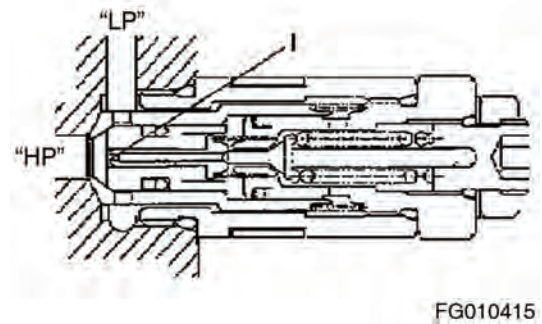


Figure 12

4. Oil flows from the passage "HP" to the rear side of the Poppet(D) only between circular pole of both Poppet(D) and piston(C) only by tightening(F) and so pressure difference becomes large. Accordingly Poppet(D) opens and so oil flows to the direct passage "LP".

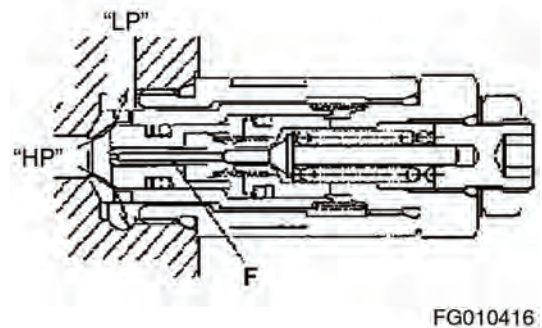


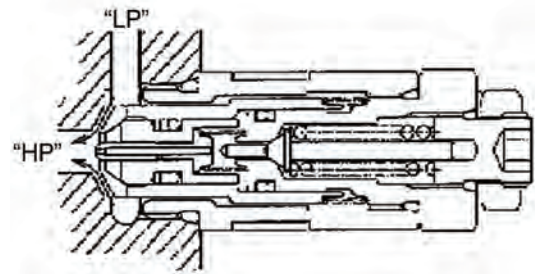
Figure 13

Suction operation

The anti-void unit is equipped with In the cylinder port "HP", which supplies oil when cavitation occurs.

When pressure of the cylinder port "HP" is lower than "LP" in the low pressure side, the sleeve(K) opens by difference in the area between <A> and .

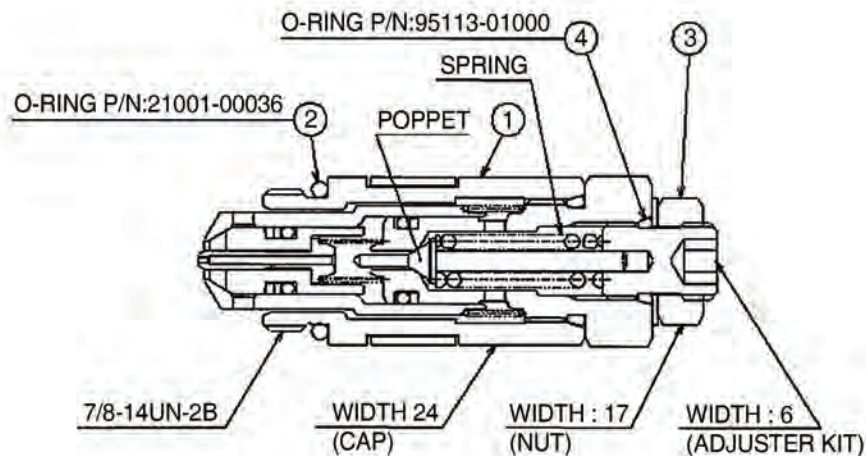
Oil flows from than "LP" in the low pressure side to the cylinder port "HP" and prevents cavitation.



FG010417

Figure 14

Hint for disassembly and assembly of overload relief valve



FG011266

Figure 15

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 15).

If oil leaks from the adjuster part(3, Figure 15), loosen the adjuster part and replace the O-ring(4, Figure 15).



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 cam(1) screw part, and insert a new O-ring(2).

After properly clean the relief mounting part of the valve housing, mount the relief valve and then tighten cam(1: hexagon subtese 23) to tightening torque of 69~78N•m.

If disassembling the adjuster kits, assemble the screw part according to "Hint for disassembly and assembly of overload relief valve" on page 1-24).



CAUTION

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

Pressure Adjustment of Relief Valve

Main relief valve(P1, P2 rise type)

1. Adhere a correct pressure gauge to the inlet circuit.
2. Operate the pump in the rated rotation number.
3. Convert the spool of the control valve and then reads value of the pressure gauge in the end of the cylinder stroke.



CAUTION

An actuator spool, whose set pressure of the overload relief valve is higher than the set pressure of the main relief valve, must be replaced.

4. H/P set(Step 1)
 - Tighten and insert the Plug(2) until the piston will touch with the section of Plug(4)(* subsidiary). In this case, the tightening torque of Plug(2) should be less than 19.6N•m. However, when tightening and inserting the Plug(2), be cautious so that Plug(4) should not rotate together(P.12, ss:A, Length more than 4mm).
 - Tighten and pressurize the Plug(4).
(Slowly tighten Plug(4) while seeing the pressure gauge: 28.4MPa/rotation of plug.)
 - After setting pressure, lock with a hex nut(6).
5. L/P set(Step 2)
 - Loosely adjust the Plug(2) in the H/P set. If loosening the Plug(2), the piston moves to the right and so weight of the spring is reduced: 21.3MPa/rotation of plug rises.
 - After setting pressure, lock with a hex nut(3).
6. Increase pressure again and then check that it becomes specified pressure.

Main relief valve(P3)

1. Read value of the pressure gauge in the end of the cylinder stroke by replacing the spool of the control valve as 1).
2. Turn adjuster clockwise until required pressure will be obtained.
17.7MPa/rotation of adjuster rises.
3. When reaching to the specified pressure, press the adjuster so that it should not rotate and tighten the lock nut.
Tightening torque: 27.5~31.4N•m
4. Increase pressure again and then check that it becomes specified pressure.

Overload relief valve



CAUTION

If set pressure is higher than main relief valve, do not adjust the overload relief valve but replace both relief valve and assembly whose setting is completed.

1. Read value of the pressure gauge in the end of the cylinder stroke by replacing the spool of the control valve as 1).
2. Turn adjuster clockwise until required pressure will be obtained.
28.4Mpa/rotation of adjuster rises.
3. When reaching to the specified pressure, press the adjuster so that it should not rotate and tighten the lock nut.
Tightening torque: 27.5~31.4N•m
4. Increase pressure again and then check that it becomes specified pressure.

MOUNTING

1. Be careful so that force will not be unnecessarily applied to pipe.
2. Tighten all mounting bolts to the same torque.
3. Take care as welding work near the valve may cause seal, etc by excessive heat or sputter,
4. Always perform handling to prevent damage of each part until piping for prevention of scraps ingress.

OPERATION

1. Check that the oil pressure circuit or working oil is clean and that there is no outside leakage by slowly increasing pressure(manually operate a working machine in the low idle).
2. Use oil whose aniline point is 82~113°C as pneumatic working oil.
3. Do increase pressure of the relief valve over the specified set pressure.
4. Maintain the set pressure difference of both main relief valve and overload relief valve is over 3.0Mpa.
5. After fully perform preheat operation(warming-up), perform actual work. Especially for starting to operate the machine when working oil temperature or valve temperature is low, care should be taken of following points for preventing a stick of heat shock:
 - A. Evenly increase temperature of each part by operation so that working oil circulates within each actuator without consecutively and suddenly operating the main relief valve or the overload relief valve.
 - B. Do not suddenly perform mistake operation or complex operation when temperature is low as they may result in heat generation.

SPECIFICATIONS OF CONTROL VALVE

1. Rated flow: 70L/min
2. Max pressure: 24.5MPa
3. Allowable discharge pressure: Surge pressure: 1.5MPa or less
Normal pressure: 0.34MPa
4. Scope of usable fluid temperature : -20~80°C
Spontaneous temperature 100°C
5. Adjustable scope of relief valve pressure
Main relief valve
 - P1, P2 : 22.6MPa at 50L/min
 - P3 : 20.6MPa at 30L/minOverload relief valve:
 - A2, B2, A3, B3, A7, B7, A8, B8, A10, B10, A11 :
24.0MPa at 20L/min
 - A6, B6 : 11.8MPa at 20L/min

FAILURE AND TROUBLESHOOTING

Overall Control Valve

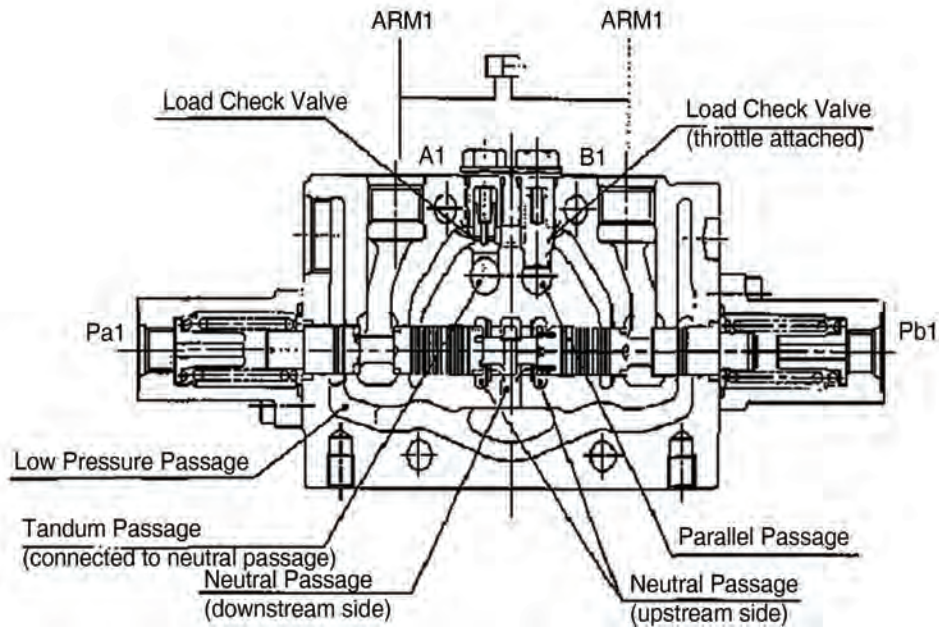
Failure	Possible Cause	Troubleshooting
Spool not subject to stroke	1. Fluid temperature abnormally rises	Remove the part that disturbs oil flow in the pipe.
	2. Working oil dirty	Change working oil and wash circuits.
	3. Pipe port joint too loose	Check torque.
	4. Valve housing is twisted by mounting	Check after loosening mounting bolt.
	5. Pressure too high	Adhere the pressure gauge to the pump port and the cylinder port.
	6. Spool bent	Replace with valve assembly.
	7. Damage of return spring	Replace damaged parts.
	8. Spring or cap turns aside	Loosen cap and take off the core and then tighten.
	9. Temperature distribution within valve not equal	Warm up the whole circuit.
	10. Scraps clogged within valve	Remove scraps(flashing).
	11. Pilot pressure insufficient	Check Pilot valve and Pilot relief pressure
Failing to maintain load	1. Oil leak from cylinder	Check the cylinder room part.
	2. Oil bypassed in the spool	Check possible spool damage.
	3. Oil leak from overload relief valve	Clean some of valve housing seat or relief valve seat
	4. Oil leak from anti-relief valve	Disassemble the anti-relief valve and clean the seat part of each part. When the seat part is damaged, replace Poppet or wrap around Poppet and the seat part. As both spool and sleeve are parts for relief, replace them at the same time.
Load dropped when changing position of spool from Neutral to Lift Up	1. Scraps are laid in the load check part.	Disassemble and clean the check valve.
	2. Poppet or seat part of the check valve damaged	Replace Poppet or wrap around Poppet and the seat part.

Relief Valve

Failure	Possible Cause	Troubleshooting
Pressure not rise	1. Main Poppet sleeve or pilot Poppet stuck open, or scraps are laid between valve seat parts	Replace relief valve
Instable relief pressure	1. Pilot Poppet seat damaged	
	2. Piston or main Poppet is stuck	
Abnormal relief pressure	1. Seat part worn by scraps	Set pressure again and then tighten lock nut to specified torque
	2. Lock nut and adjuster loosened	
Oil leak	1. Damage of relief valve part	Replace relief valve
	2. Each part stuck by scraps	Replace O-ring on the adjuster or the mounting part.
	3. O-ring worn	

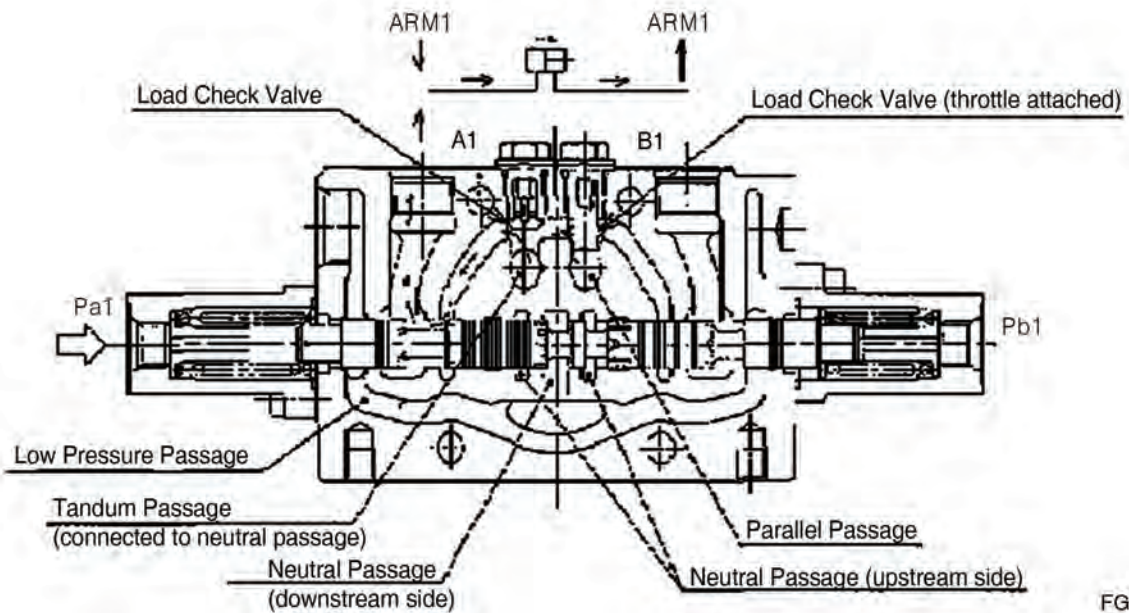
Overall Pneumatic System

Failure	Possible Cause	Troubleshooting
Pneumatic system fails or not operate	1. Failure of pump	Check pressure or replace pump
	2. Failure of relief valve	Replace relief valve
	3. Failure of cylinder, etc	Repair or replace
	4. Pump load pressure too large	Check circuit pressure
	5. Valve torn	Replace with valve assembly
	6. Spool not subject to stroke	Check movement of spool
	7. Oil surface of tank tool low	Supply working oil
	8. Filter clogged among circuit	Clean or replace filter
	9. Circuit pipe tightened	Check pipe



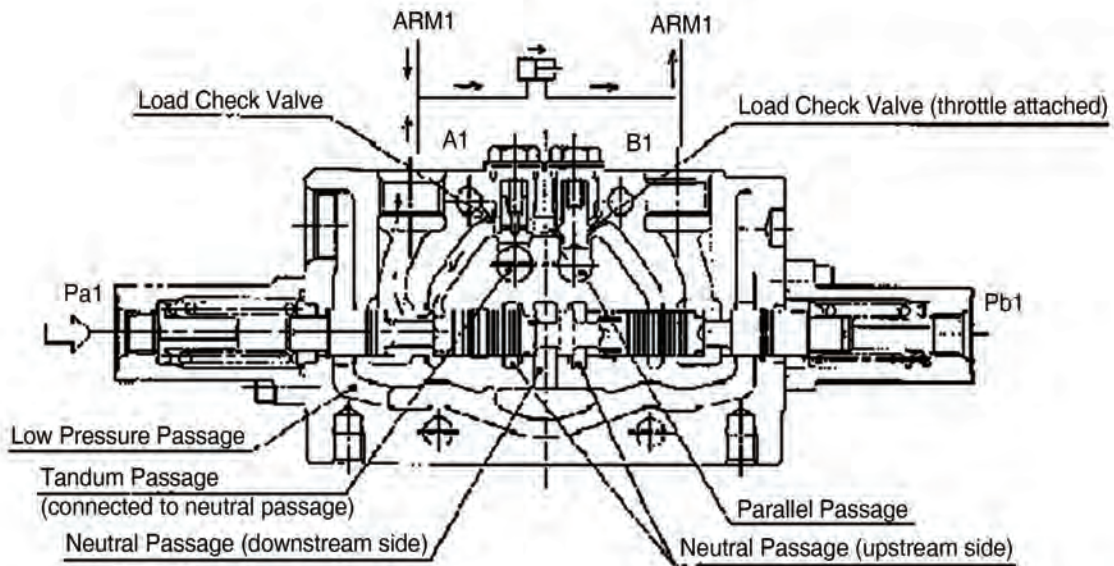
FG011267

Figure 16 Arm2 Neutral



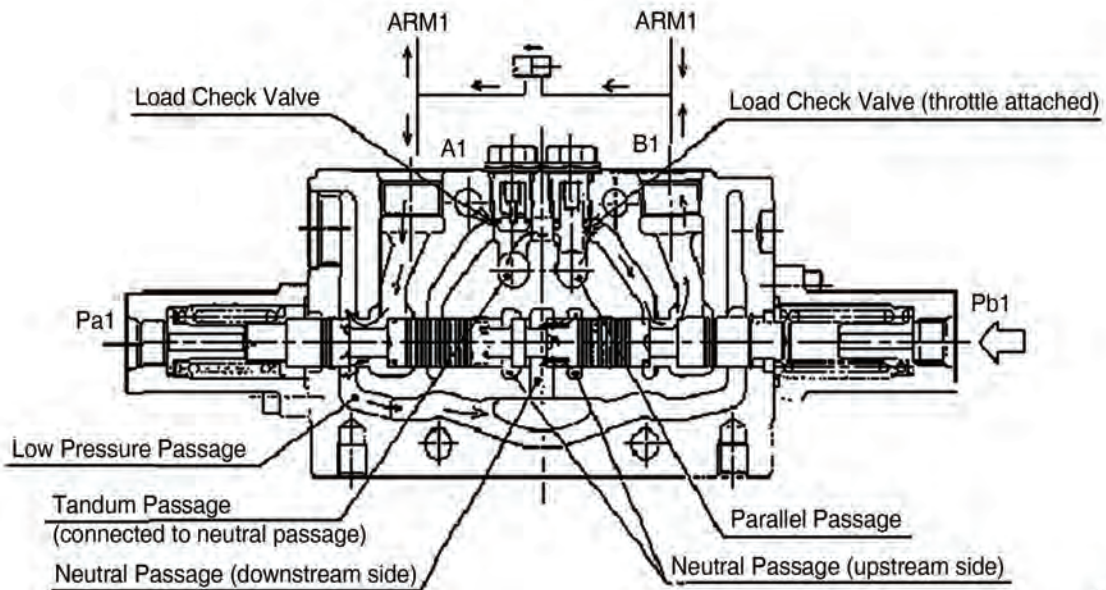
FG011268

Figure 17 Arm2 Crowd



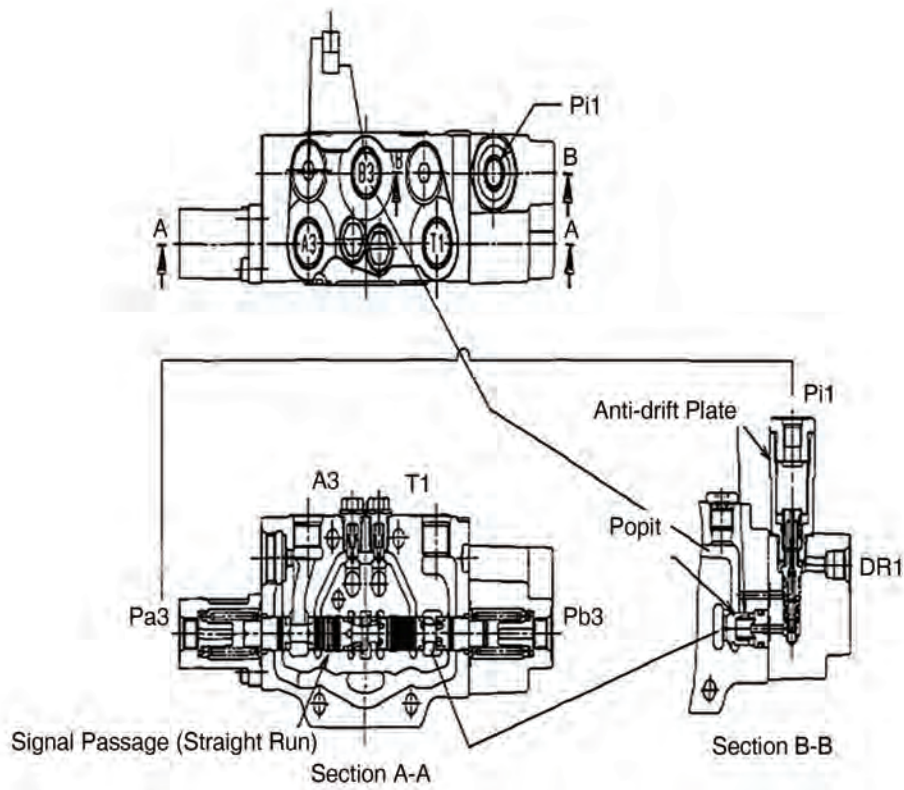
FG011269

Figure 18 Arm2 Crowd(simultaneous Operation with BOOM)



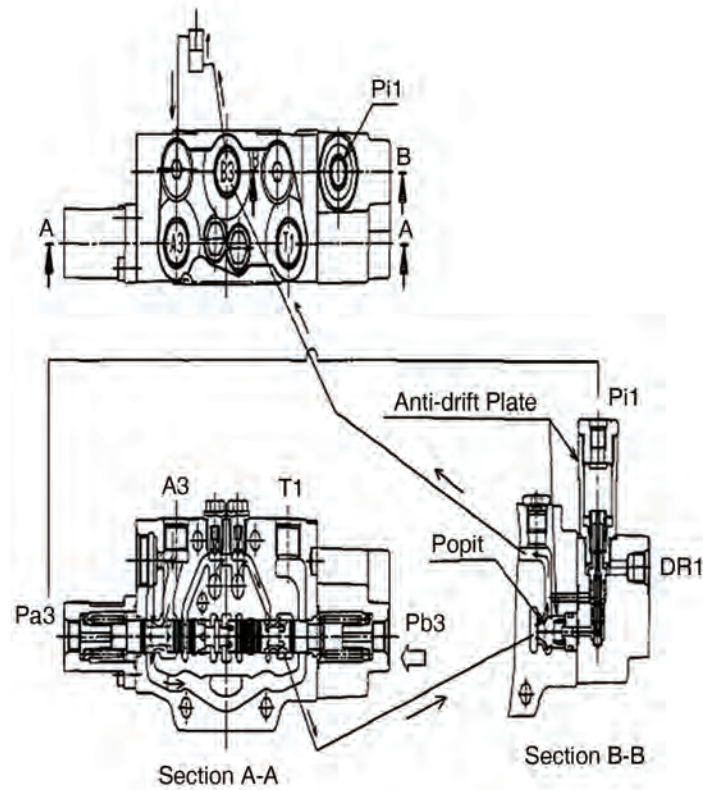
FG011270

Figure 19 Arm2 Dump



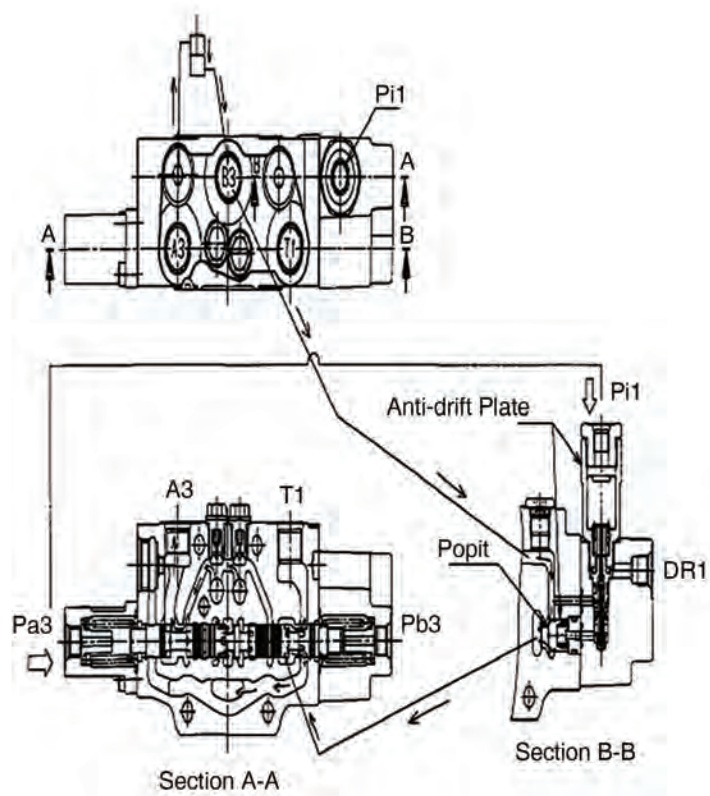
FG011271

Figure 20 Boom1 Neutral



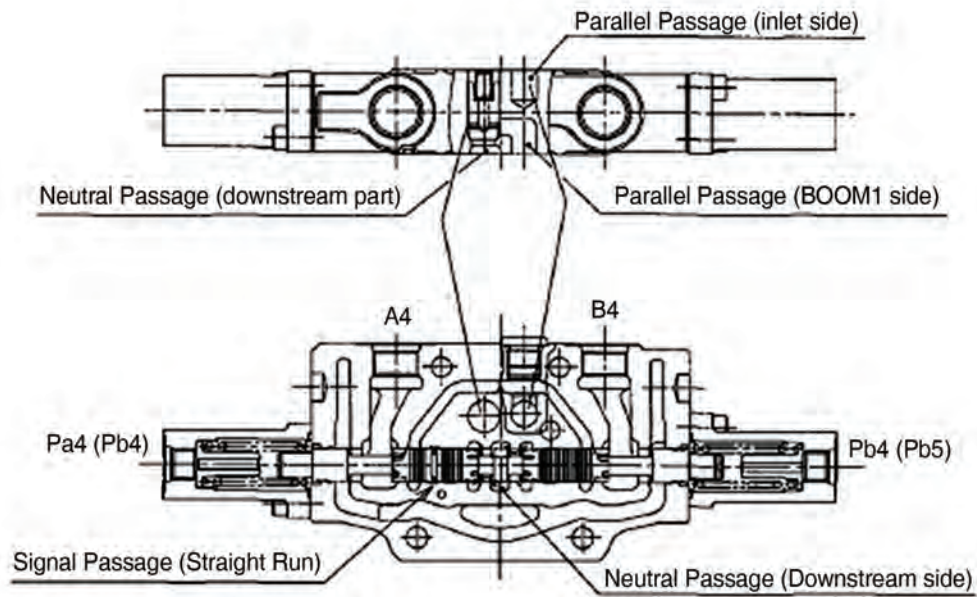
FG011272

Figure 21 Boom1 Lift Up



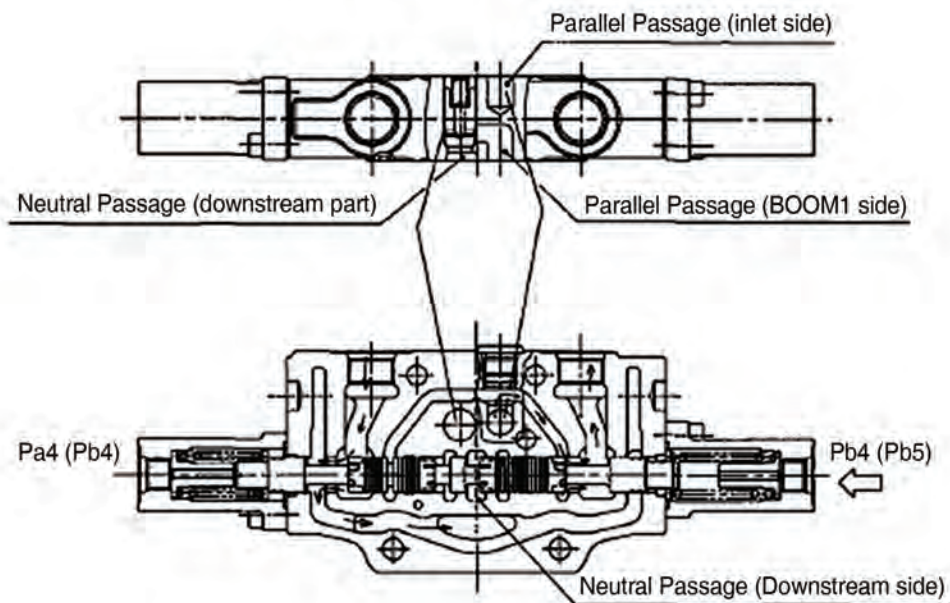
FG011273

Figure 22 Boom1 Lower Down



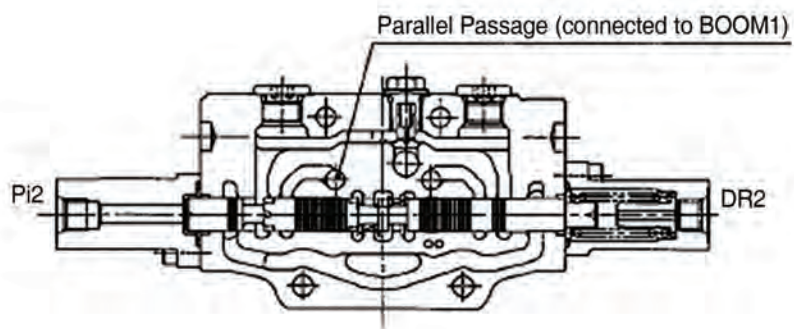
FG011274

Figure 23 Travel - R Neutral



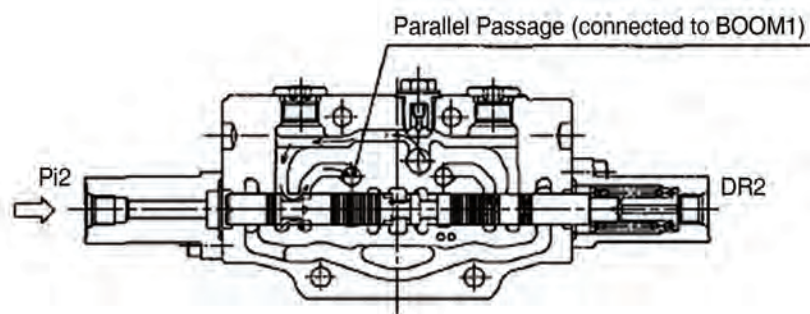
FG011275

Figure 24 Travel - R Pb4



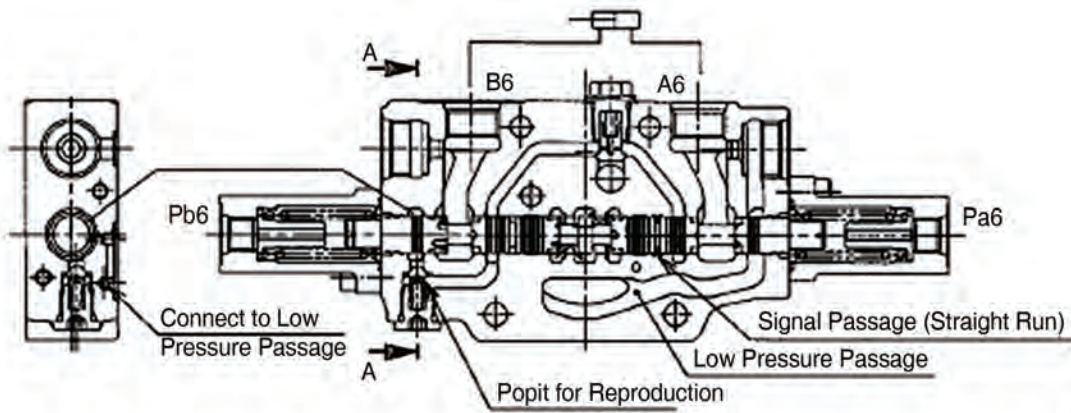
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Figure 25 Boom2 Neutral



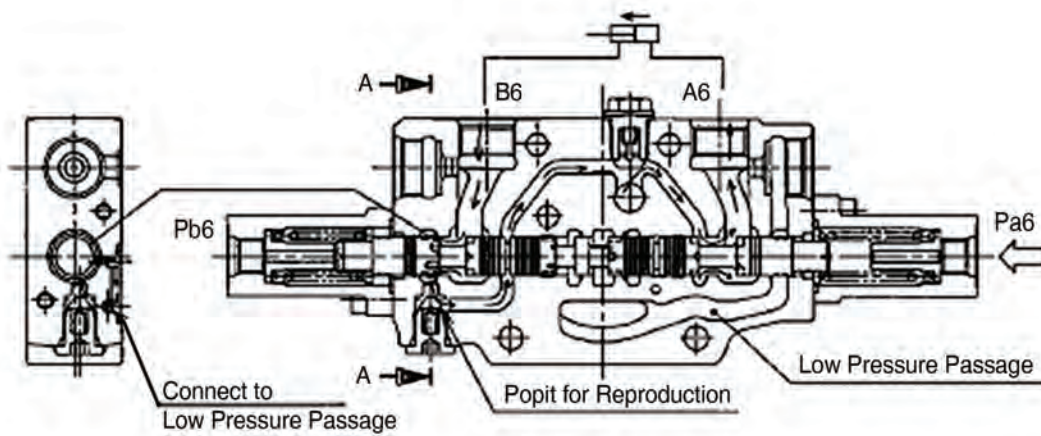
FG011277

Figure 26 Boom2 Lift Up Joint



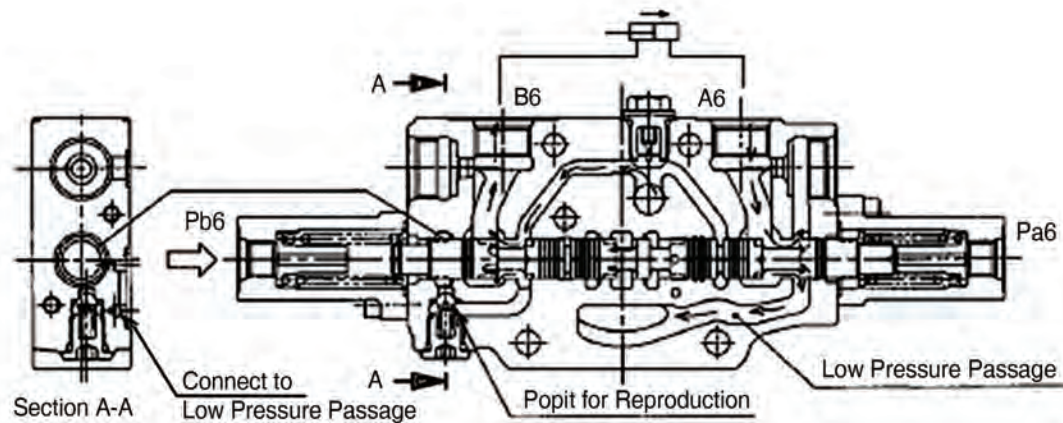
FG011278

Figure 27 Arm1(Reproduction Circuit)



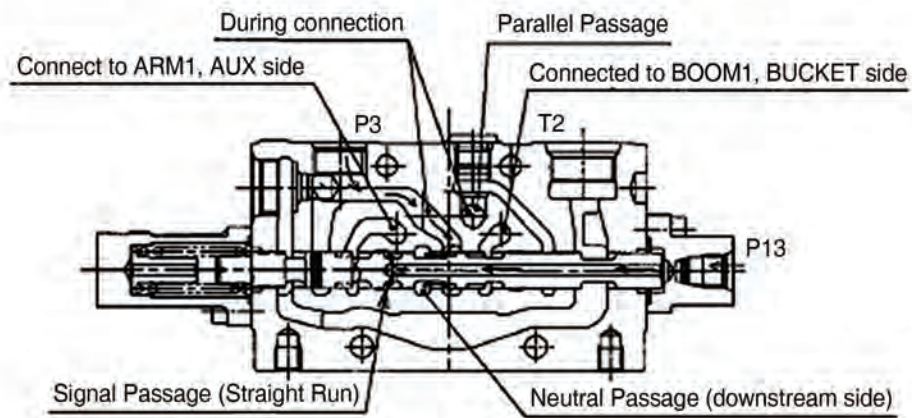
FG011279

Figure 28 Arm1(reproduction Circuit)



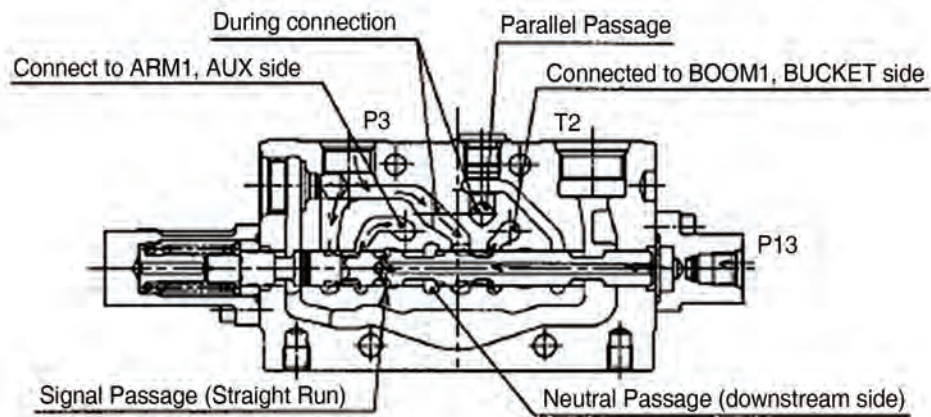
FG011280

Figure 29 Arm1(reproduction Circuit) dump



FG011281

Figure 30 Straight Travel Neutral



FG011282

Figure 31 Straight Travel Operation

Control Valve (Standard)

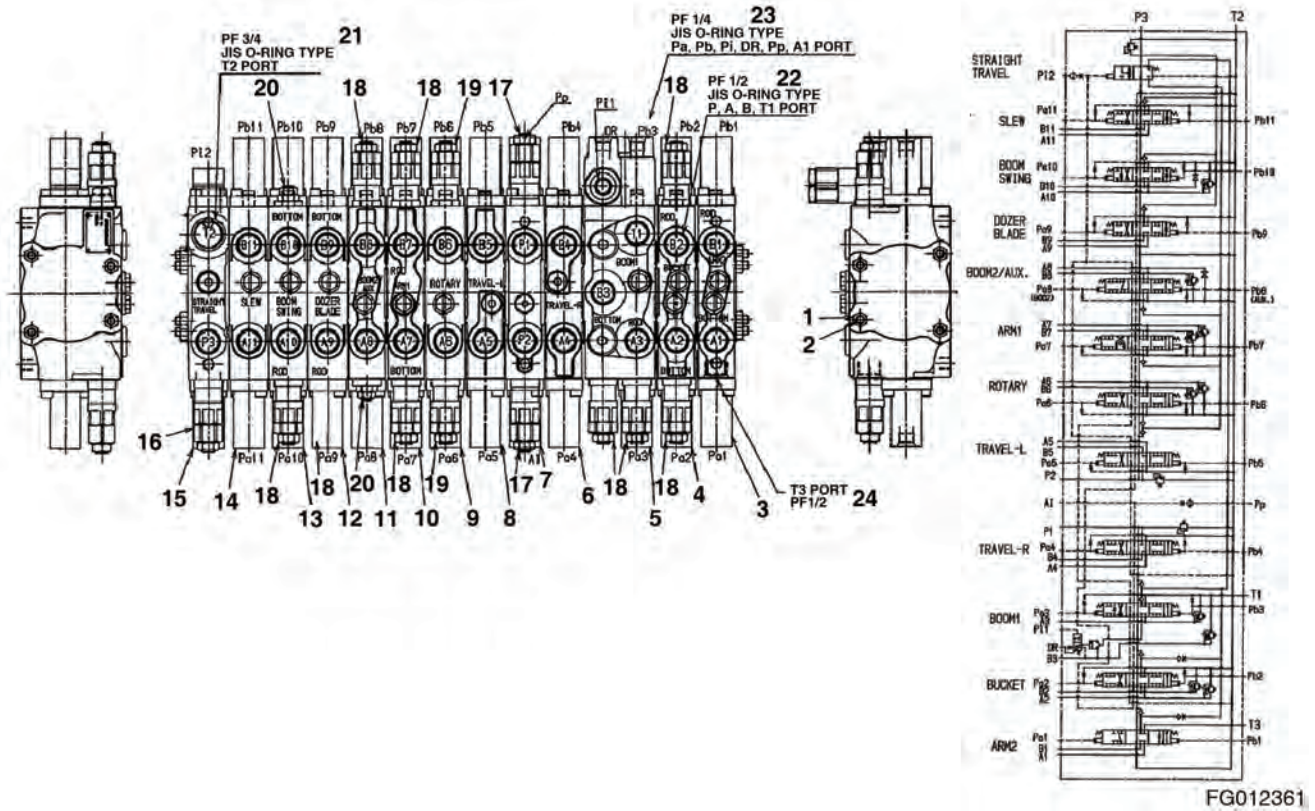


Figure 32

Reference Number	Description
1	Nut
2	Tie-Roo
3	Spool Section Assembly
4	Spool Section Assembly
5	Spool Section Assembly
6	Spool Section Assembly
7	Spacer Section Assembly
8	Spool Section Assembly
9	Spool Section Assembly
10	Spool Section Assembly
11	Spool Section Assembly
12	Spool Section Assembly

Reference Number	Description
13	Spool Section Assembly
14	Spool Section Assembly
15	Spool Section Assembly
16	Relief Valve Assembly
17	Relief Valve Assembly
18	Relief Valve Assembly
19	Relief Valve Assembly
20	Shutoff Valve Assembly
21	Shipping Plug
22	Shipping Plug
23	Shipping Plug
24	Shipping Plug

Control Valve (Option)

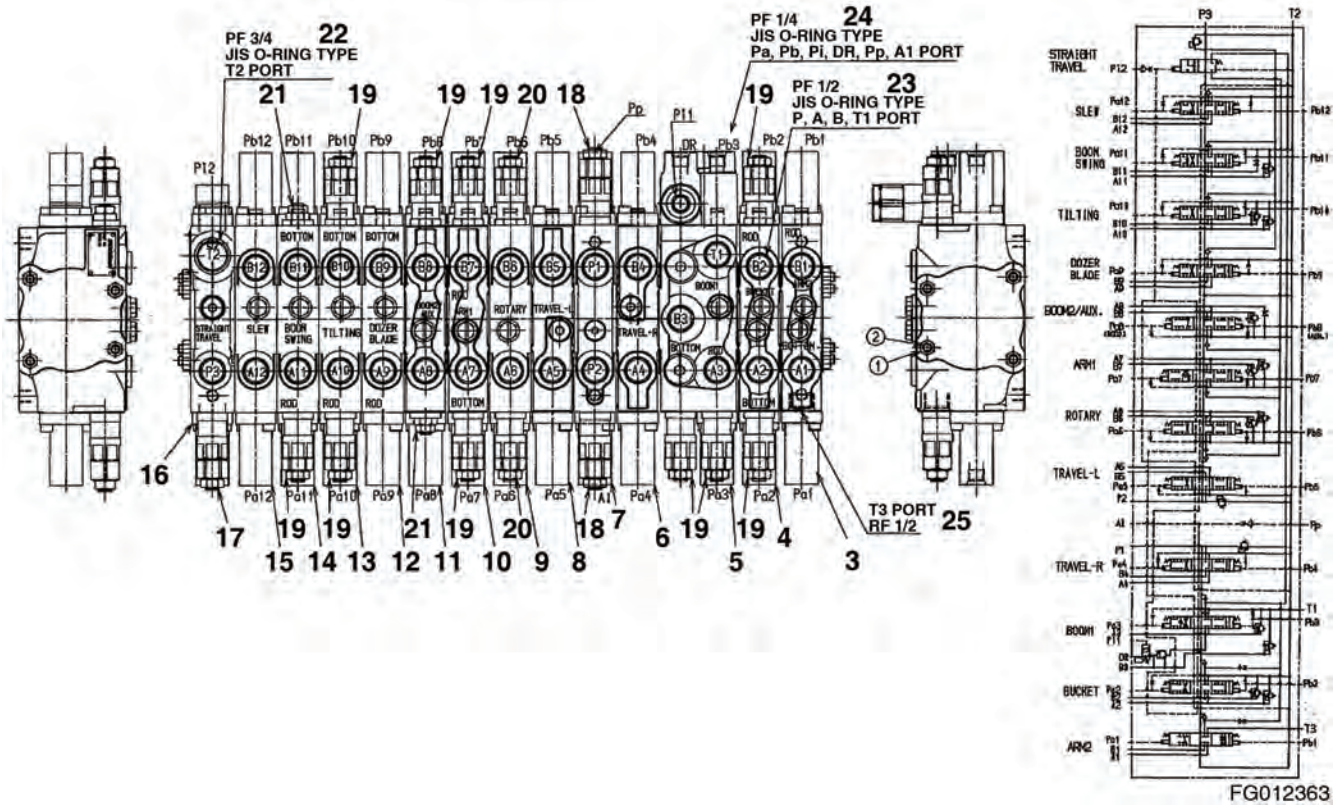
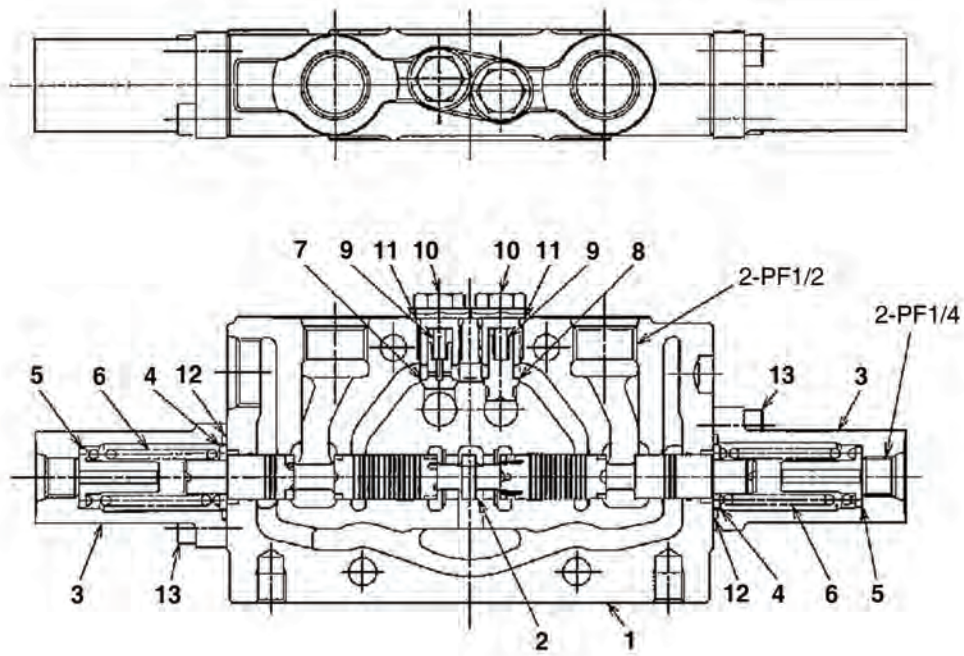


Figure 33

Reference Number	Description
1	Nut
2	Tie-Roo
3	Spool Section Assembly
4	Spool Section Assembly
5	Spool Section Assembly
6	Spool Section Assembly
7	Spacer Section Assembly
8	Spool Section Assembly
9	Spool Section Assembly
10	Spool Section Assembly
11	Spool Section Assembly
12	Spool Section Assembly
13	Spool Section Assembly

Reference Number	Description
14	Spool Section Assembly
15	Spool Section Assembly
16	Spool Section Assembly
17	Relief Valve Assembly
18	Relief Valve Assembly
19	Relief Valve Assembly
20	Relief Valve Assembly
21	Shutoff Valve Assembly
22	Shipping Plug
23	Shipping Plug
24	Shipping Plug
25	Shipping Plug

Arm2 Section



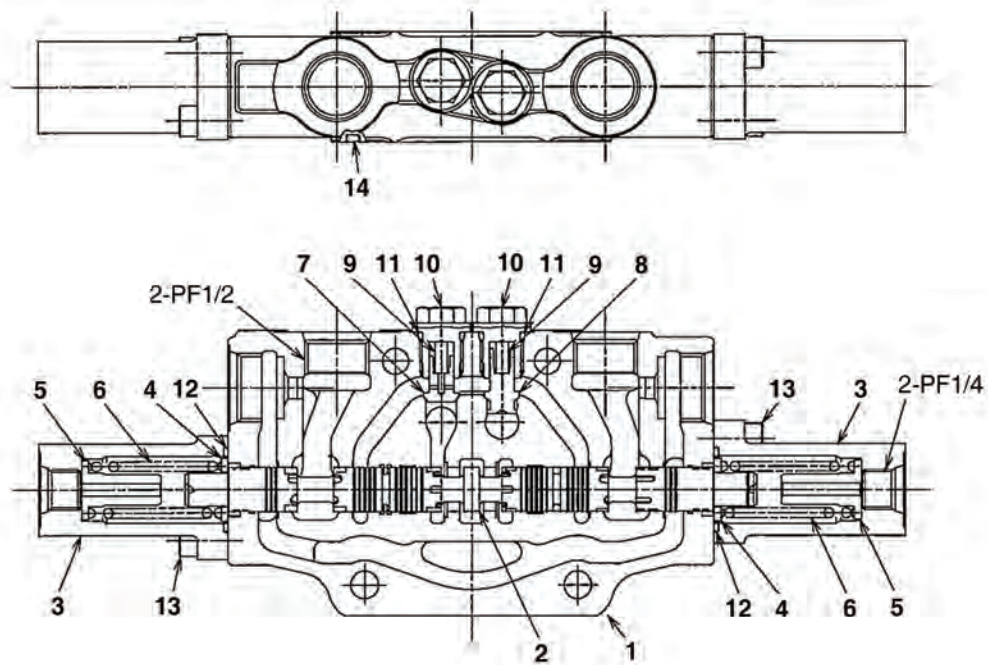
FG010477

Figure 34

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

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

Bucket Section



FG010478

Figure 35

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

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

Boom1 Section

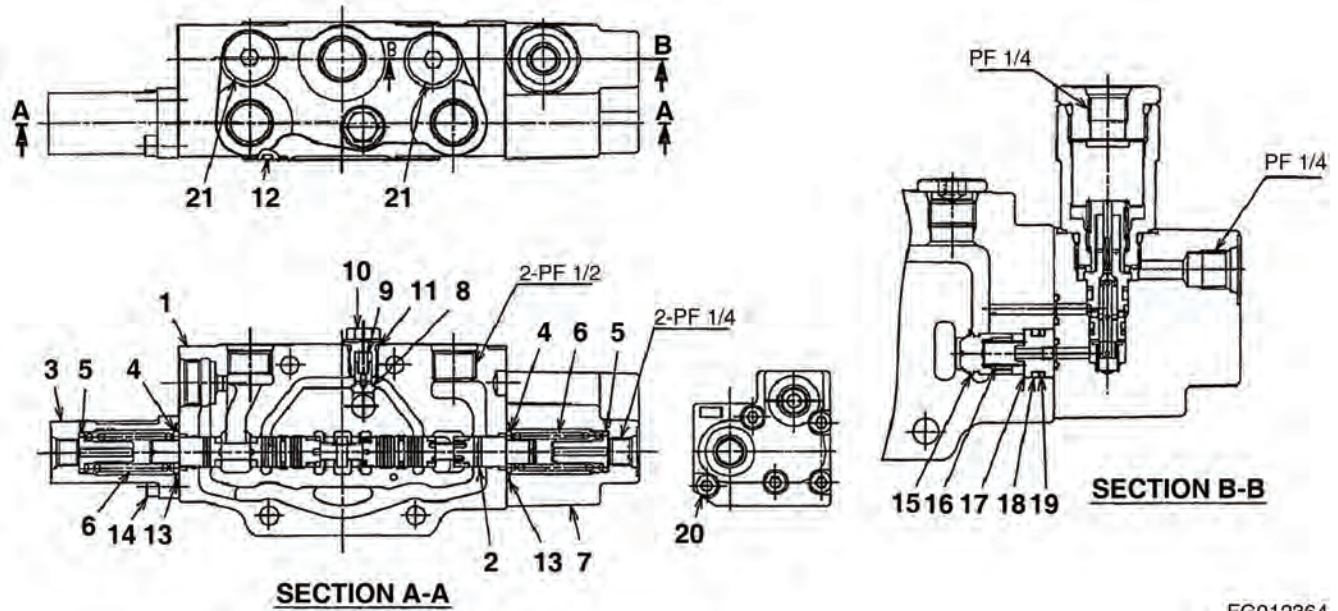


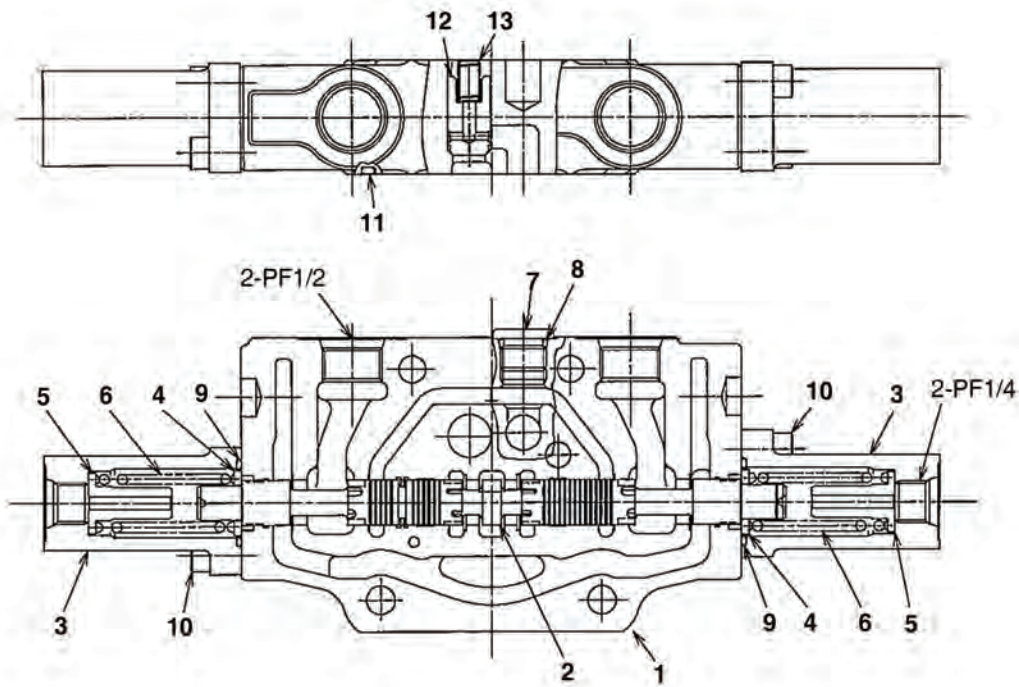
Figure 36

FG012364

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap
4	Spring Seat
5	Spring Seat
6	Spring
7	Anti-Drift Valve Ass'y
8	Poppet
9	Spring
10	Plug
11	O-Ring

Reference Number	Description
12	O-Ring
13	O-Ring
14	Socet Head Bolt
15	Poppet
16	Spring
17	Spacer
18	O-Ring
19	Backup Ring
20	Socet Head Bolt
21	Plug Ass'y

Travel Section



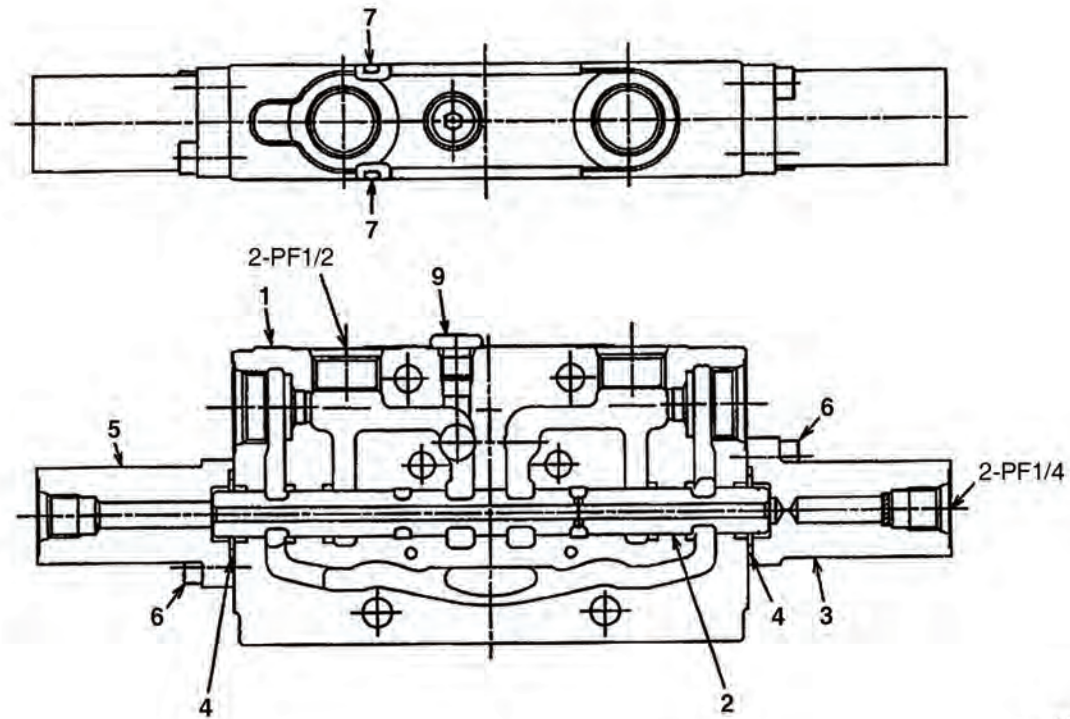
FG010480

Figure 37

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

Inlet Section



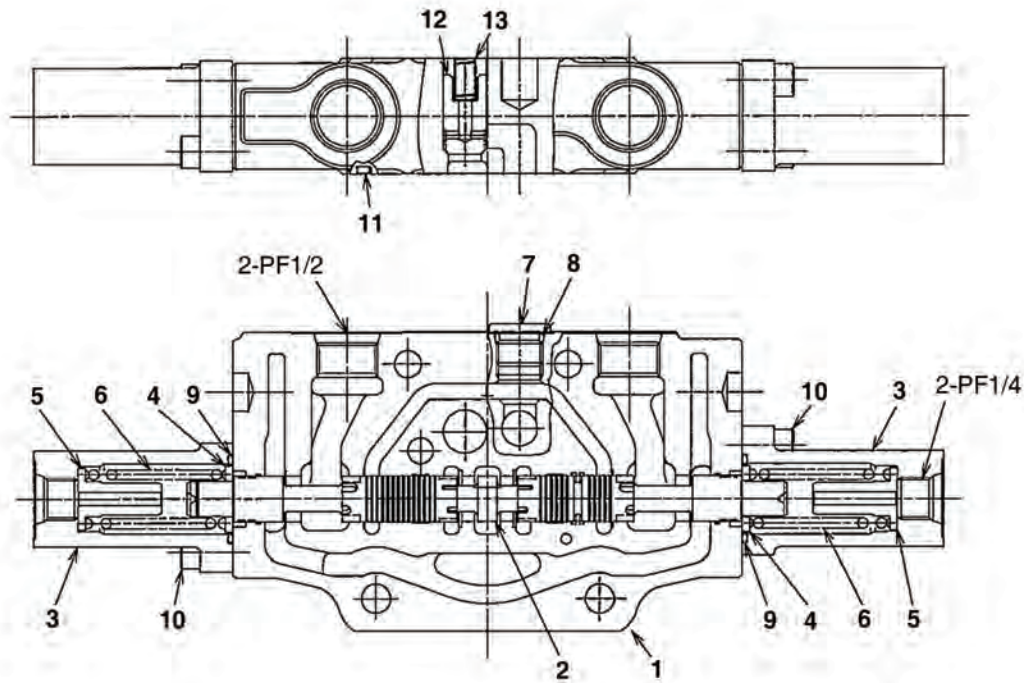
FG011763

Figure 38

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap Kit
4	O-Ring
5	Cap

Reference Number	Description
6	Socket Head Bolt
7	Plug Ass'y
8	O-Ring
9	Plug Ass'y

Travel2 Section



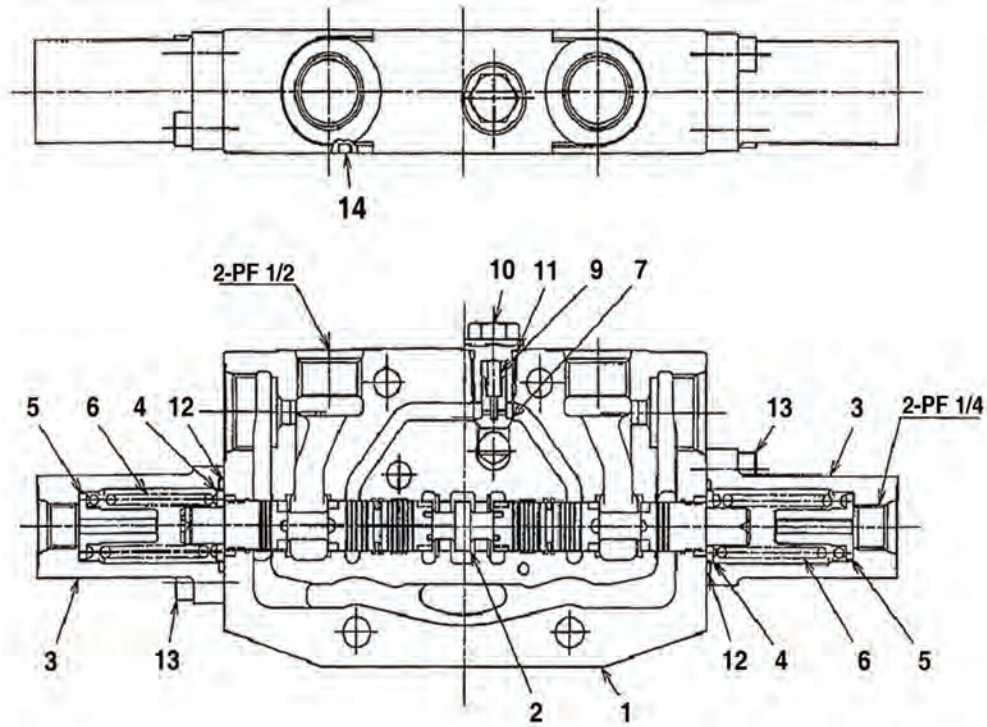
FG010482

Figure 39

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

Rotary Section



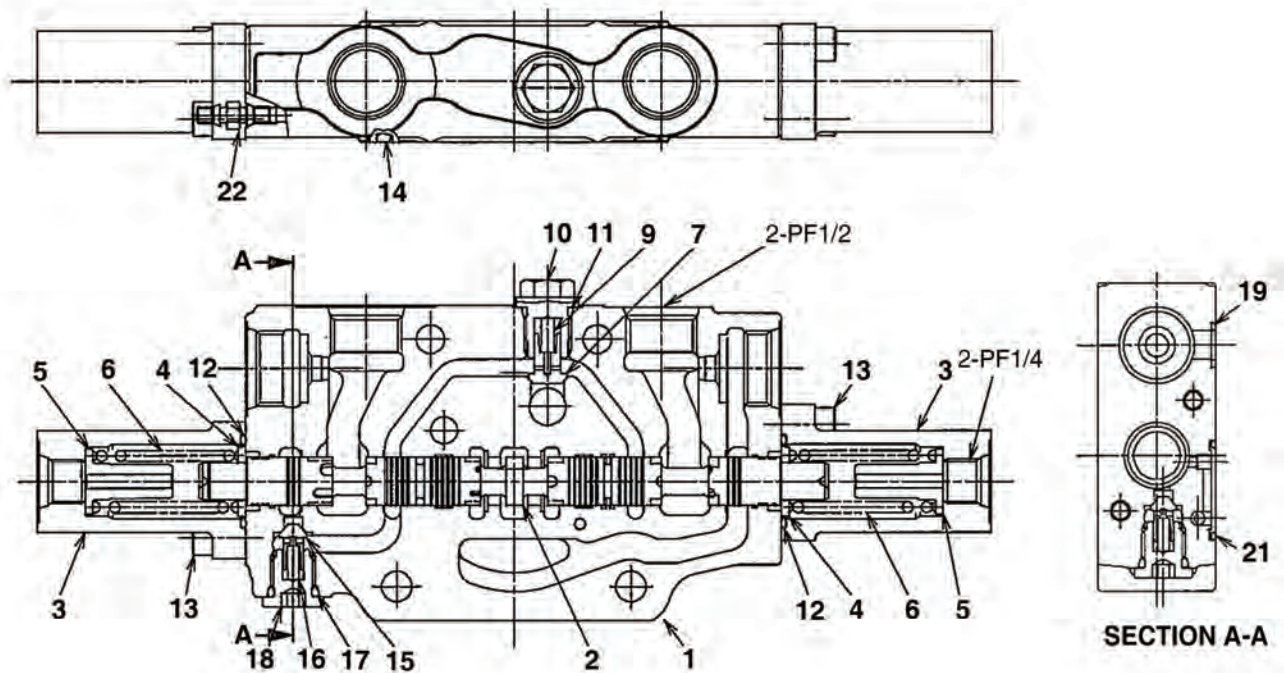
FG012365

Figure 40

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap
4	Spring Seat
5	Spring Seat
6	Spring
7	Poppet
8	-

Reference Number	Description
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt
14	O-Ring

Arm1 Section



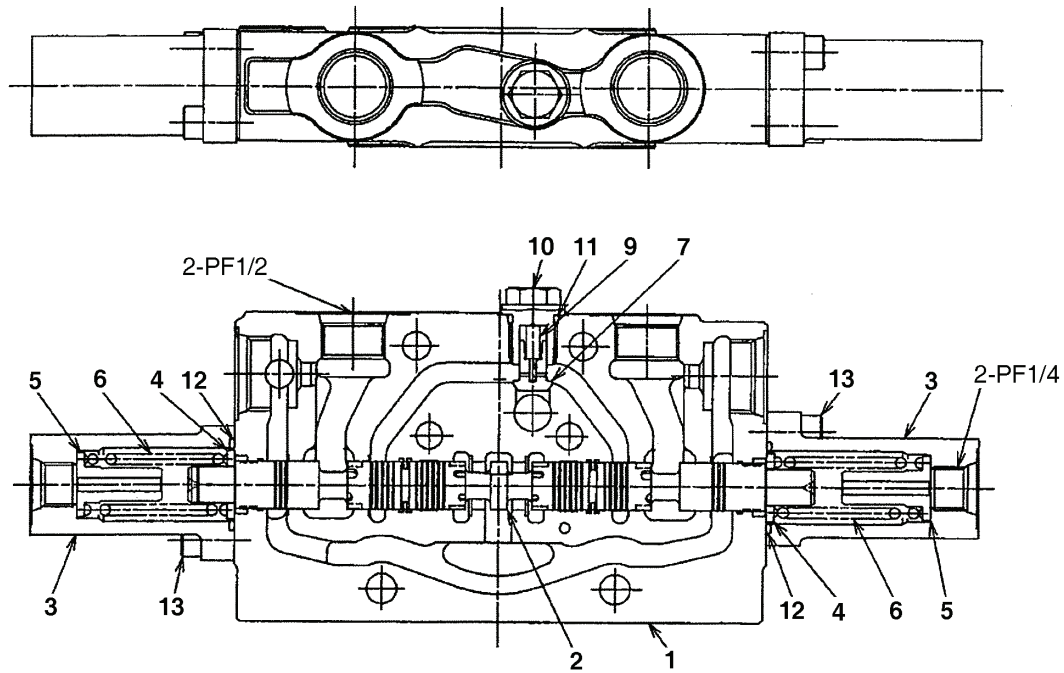
FG010484

Figure 41

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap
4	Spring Seat
5	Spring Seat
6	Spring
7	Poppet
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring

Reference Number	Description
13	Socket Head Bolt
14	O-Ring
15	Poppet
16	Spring
17	O-Ring
18	Plug
19	O-Ring
20	-
21	O-Ring
22	Plug

Boom2/Preliminary Section



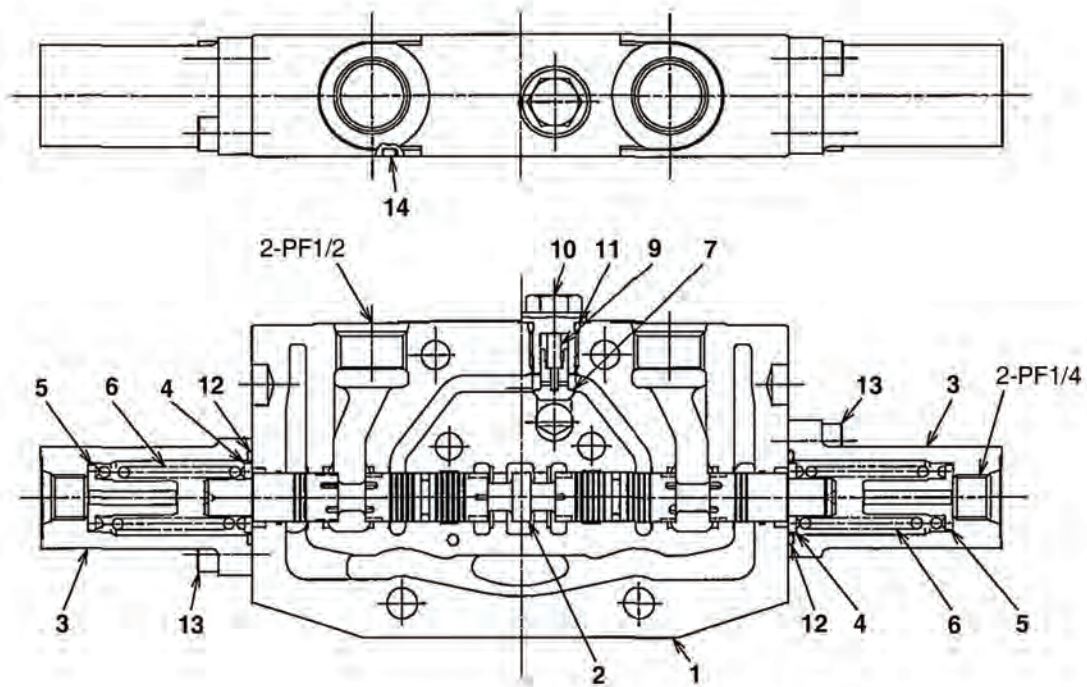
FG010485

Figure 42

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

Reference Number	Description
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt

Dozer Section



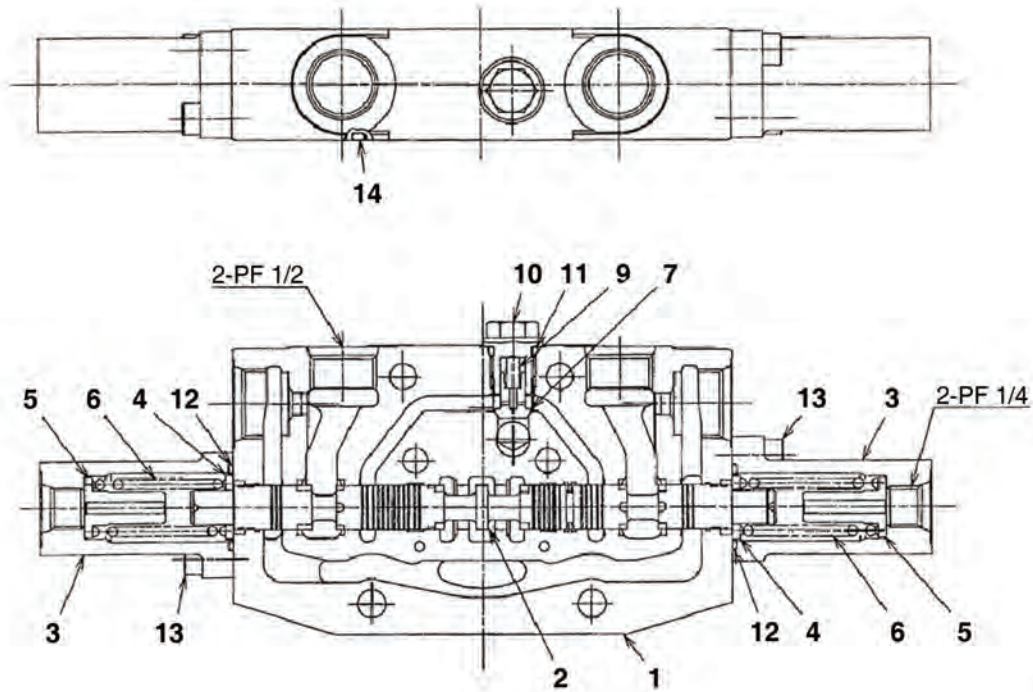
FG010486

Figure 43

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

Reference Number	Description
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt
14	O-Ring

Boom Swing Section



FG012366

Figure 44

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

Reference Number	Description
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt
14	O-Ring

Turning Section

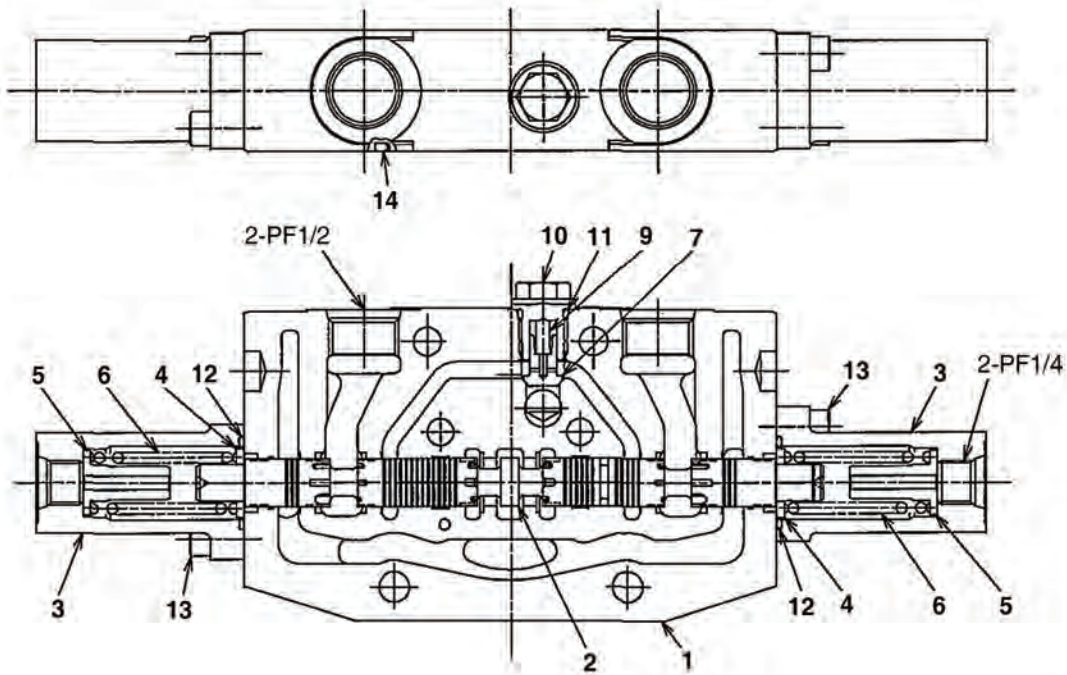


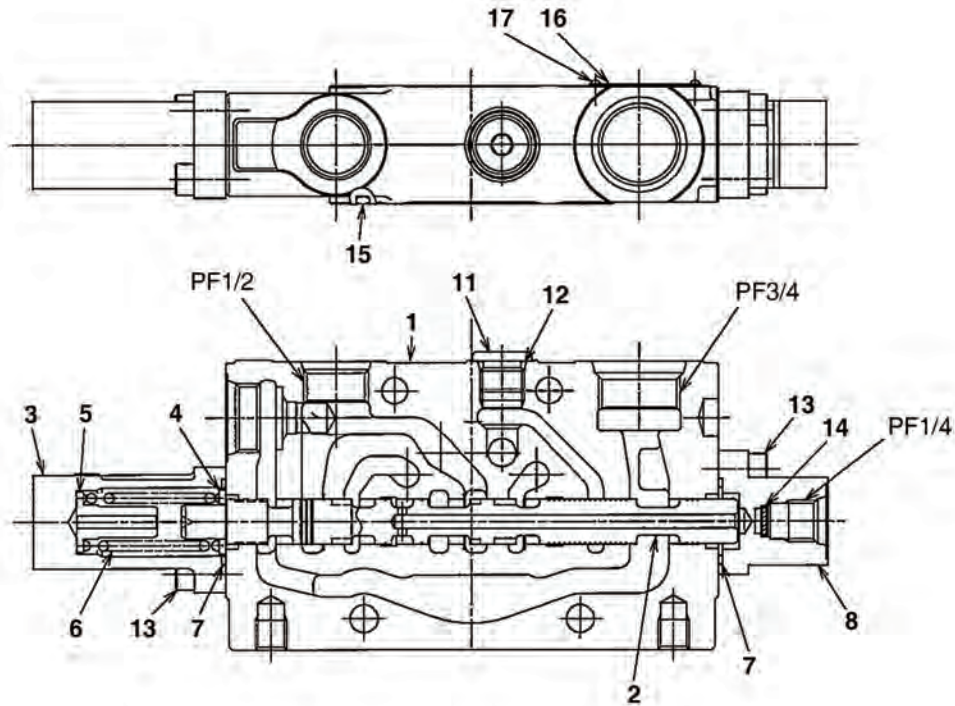
Figure 45

FG010487

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

Reference Number	Description
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt
14	O-Ring

Straight Travel Section



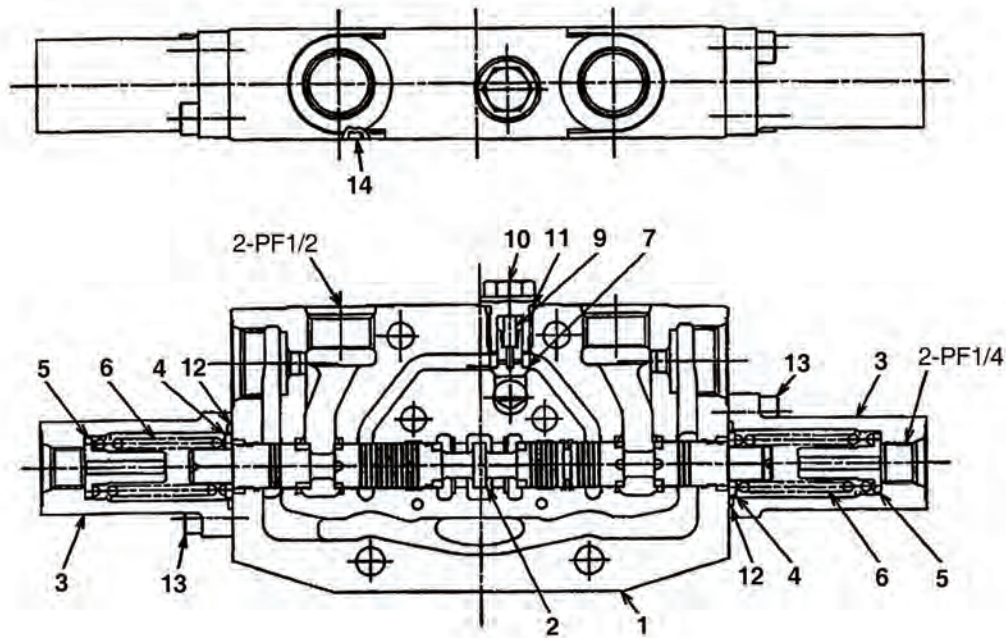
FG010488

Figure 46

Reference Number	Description
1	Valve Housing
2	Spool
3	Cap
4	Spring Seat
5	Spring Seat
6	Spring
7	O-Ring
8	Cap
9	-

Reference Number	Description
10	-
11	Plug
12	O-Ring
13	Socket Head Bolt
14	Filter-A
15	O-Ring
16	Name-Plate
17	Screw

Tilting Section (Optional)



FG011764

Figure 47

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

Reference Number	Description
8	-
9	Spring
10	Plug
11	O-Ring
12	O-Ring
13	Socket Head Bolt
14	O-Ring

Swing Motor

Edition 1

MEMO

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MEMO

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
DX55	5001 and Up
DX55W	5001 and Up

OVERVIEW

Features

This motor unit consists of a compact planetary reduction gear and a hydraulic motor.

The well balanced hydraulic design ensures the stable functioning over a long time and provides a good mechanical efficiency and volumetric efficiency.

The construction is designed simple with high-pressure relief valves, makeup valves and other functional components incorporated in the motor.

The small, lightweight and compact design ensures the sufficient durability under severe operating conditions.

The reduction gear is lubricated by the motor drain (motor hydraulic fluid) to eliminate a need to replace the gear oil.

Specifications

Total displacement	59.2 cm ³ /rev
Motor displacement	26.1 cm ³ /rev
Reduction ratio	1/22.7 (Planetary two-stage)
Mass	50 kg



CAUTION

To use biodegradation hydraulic fluid, please contact us.

DESCRIPTION OF FUNCTIONS AND OPERATION

Swash Plate Motor

Refer to Figure 1 Motor Construction.

The cylinder block incorporates nine pistons. The end face of the cylinder block is in contact with the valve plate having two woodruff ports B and C (distributing valve to change over between high and low-pressures).

<Principle of generating torque>

When high-pressure oil (Pressure P) is introduced to the B port, the inclined surface is pushed by a force of "F = P x A, A: piston sectional area" per piston and the piston receives a reaction force from the inclined surface. The piston that is restricted in the moving direction by the cylinder block because of the reaction force generates a rotating force. The total of rotating force by the reaction force of the high-pressure side pistons works on the cylinder block. The generated rotating force is transmitted as a torque to the shaft by way of the spline to turn the shaft.

On the other hand, if the high-pressure oil is introduced to the C port, the opposite rotation is caused.

The output torque and the revolution are calculated as follows:

© Output torque (T)

$$T = \frac{P \times D \times i \times \eta_m \times \eta_g}{2 \times \pi \times 100}$$

© Revolution (N)

$$N = \frac{Q \times 1000 \times \eta_v}{D \times i}$$

D: Displacement (cm³/rev)

P: Effective drive pressure (MPa)

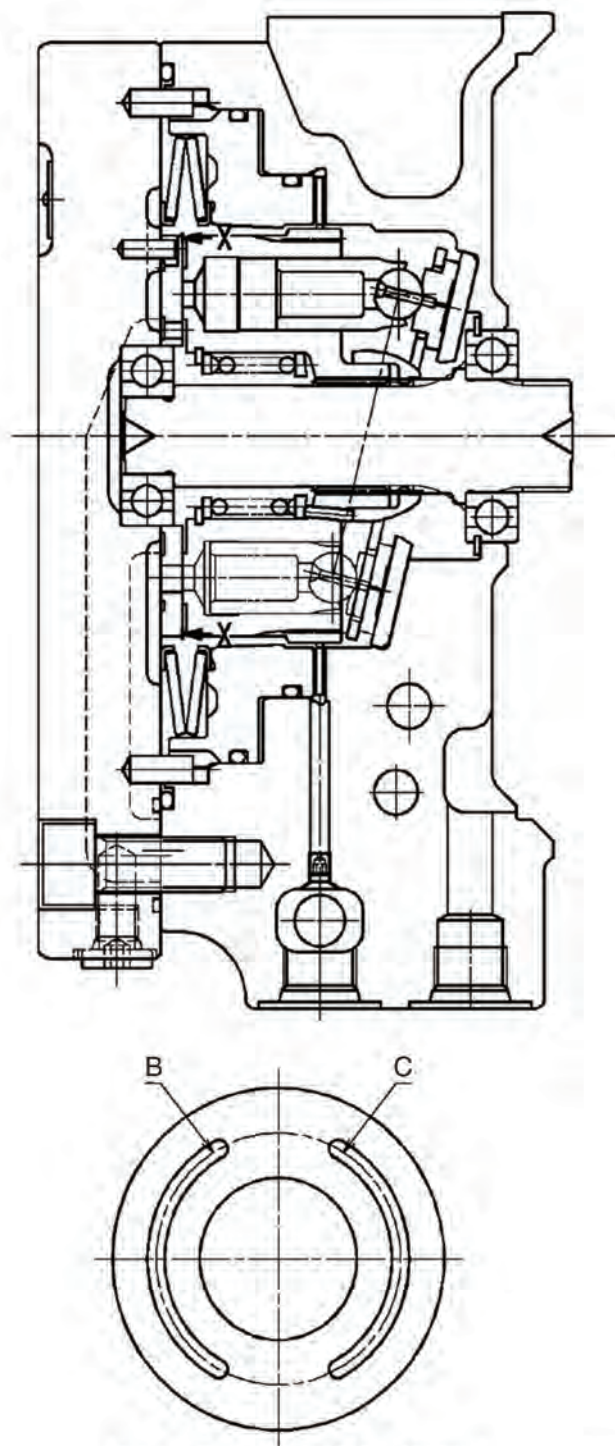
Q: Inflow (lpm)

η_m : Mechanical efficiency (motor) (%X10⁻²)

η_v : Volumetric efficiency (motor) (%X10⁻²)

i: Speed ratio of reduction gear

η_g : Efficiency of reduction gear (%X10⁻²)



View X-X of Valve Plate (Outline)

FG007325

Figure 1 Motor Construction

Parking Brake (for the parking brake spec. only)

The parking brake is of wet type multiplate construction of hydraulic release type and has a shaft lock mechanism that changes between ON and OFF of the brake by external signal pressures.

Parking brake ON

Refer to Figure 2 Construction.

When the hydraulic pressure for brake release is shut, the disk coupled to the periphery of the cylinder block by way of spline is pushed by spring force against brake piston (pinned to case so it will not rotate) and cylinder block and case are secured by frictional force. Thus shaft is locked.

Parking brake OFF

Refer to Figure 3 Construction.

When brake release pressure is introduced to brake cylinder chamber (C) by way of "PB" port ("PG" port for parking brake spec.), brake piston is operated by release pressure in opposition to spring force to eliminate force of friction with disk, thus allowing shaft to rotate freely.

Hydraulic timer (for hydraulic timer spec. only)

Refer to Figure 4 Construction.

The hydraulic timer is provided to prevent dragging of parking brake during braking. It has a role to secure a delay time to keep parking brake unapplied while hydraulic dynamic brake is absorbing swing inertia energy.

The delay time is set by controlling flow rate by throttling oil discharged from cylinder chamber using an orifice.

When control valve is returned to neutral from motor rotating state, valve changeover pressure "SH," interlock with control valve changeover signal, becomes a low-pressure and valve is moved by spring to position shown in figure and brake cylinder chamber is connected to drain by way of valve. (In this state, rotating energy of upper body is converted to thermal energy and absorbed by hydraulic dynamic braking action by way of cross relief overload relief valve.) While oil in brake cylinder chamber A tries to move in direction to push disk by spring force being exerted on brake piston, since oil discharged from brake cylinder chamber is controlled in flow rate by orifice in valve unit, brake piston will not come in contact with disk and no braking force will be produced until preset time passes.

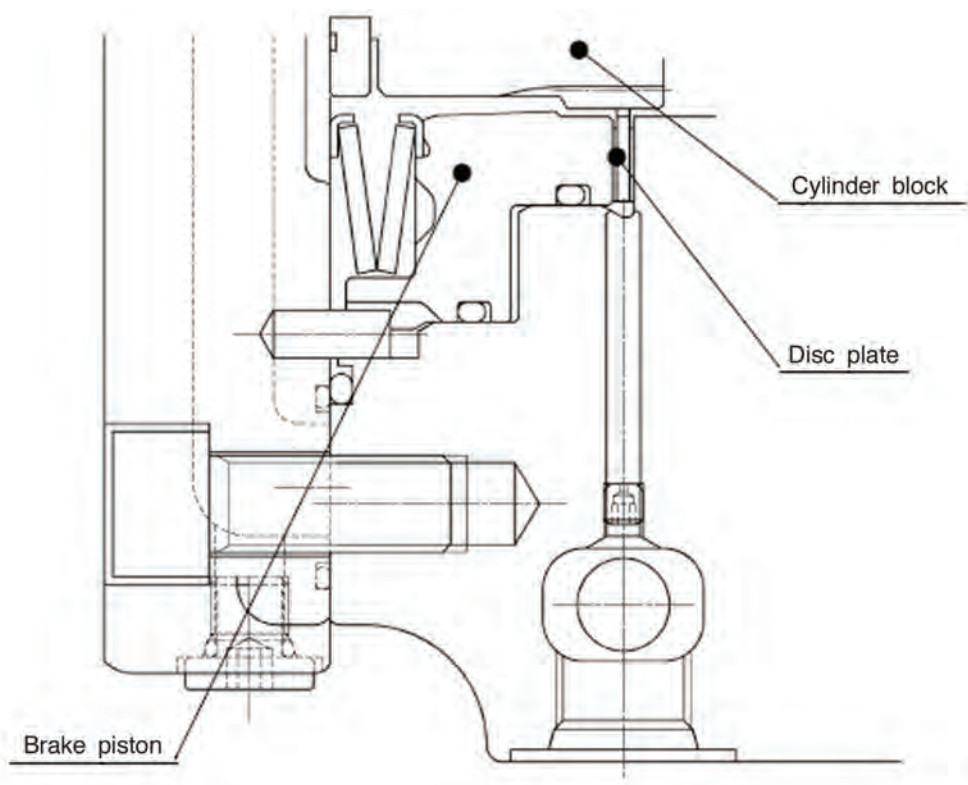


Figure 2 "PB" (Brake Releasing Pressure) OFF

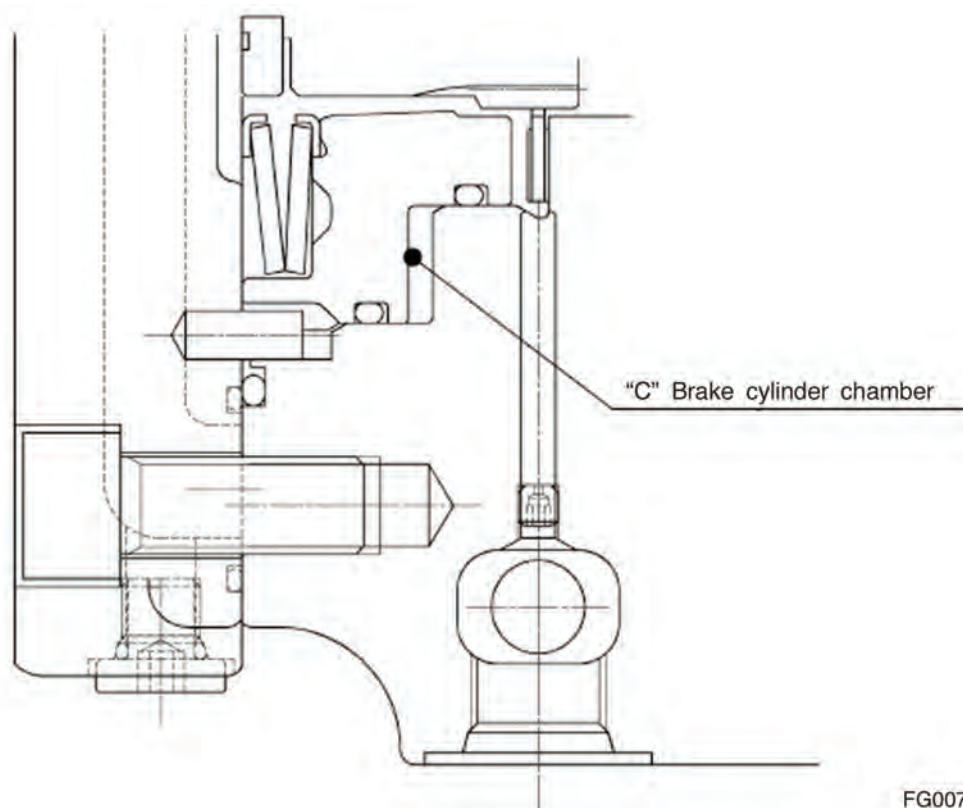
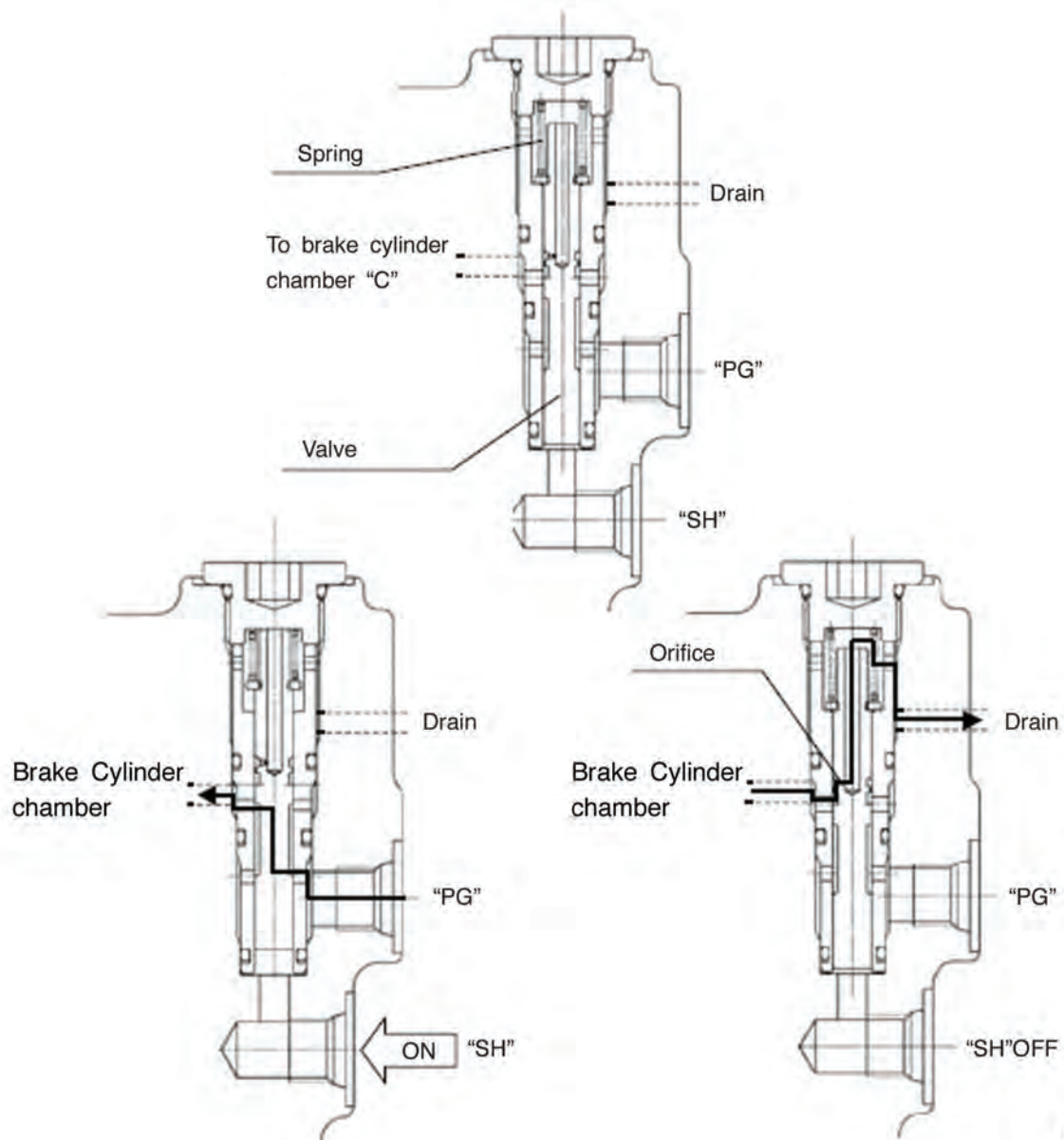


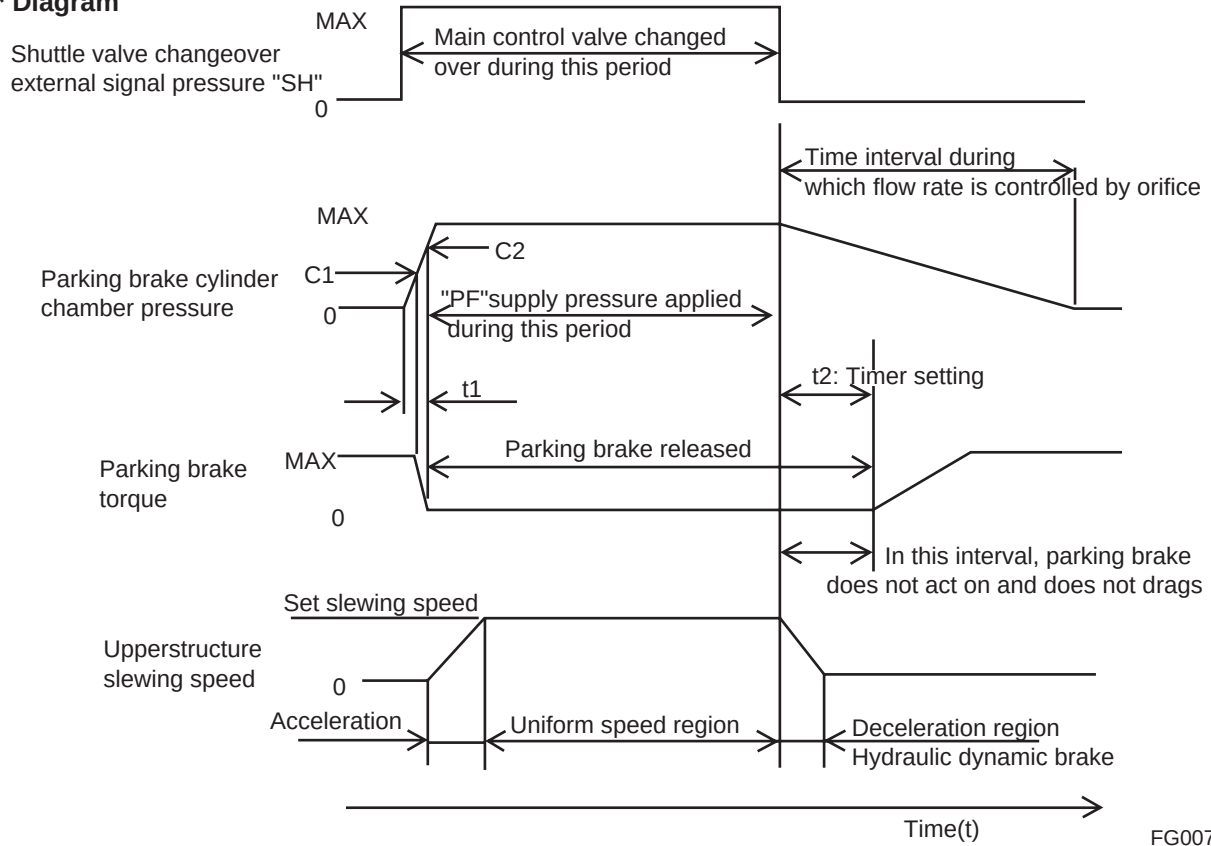
Figure 3 "PB" (Brake Releasing Pressure) ON



FG007328

Figure 4 The above function is explained by diagram as follows.

*** Diagram**



FG007329

Principle of Operation of Relief Valve

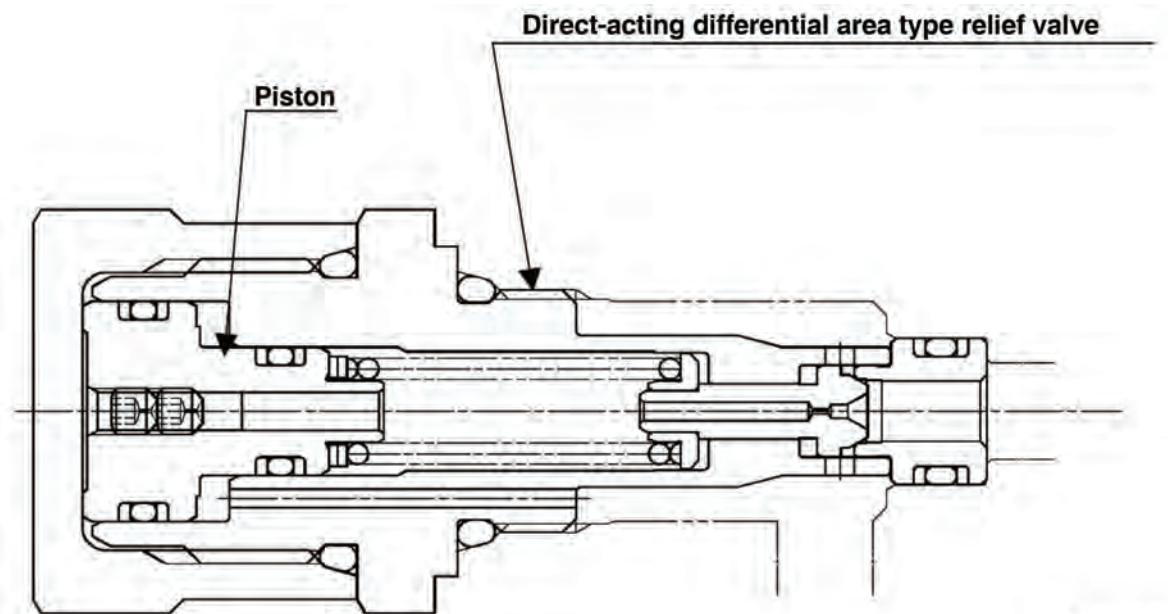
The relief valves determine drive force and brake force for hydraulic shovel swing and are installed in main port A and B lines. The circuit is configured to return relief valve return oil to counterpart main low-pressure line.

A shock less function is also incorporated to reduce shock produced at start of both acceleration and deceleration.

The construction of relief valve, as shown in Figure 5, consists of;

1. A direct acting differential area type relief valve
2. A shock less piston

The installation of a shock less type relief valve helps reduce shock and stress produced in strength members.



FG011242

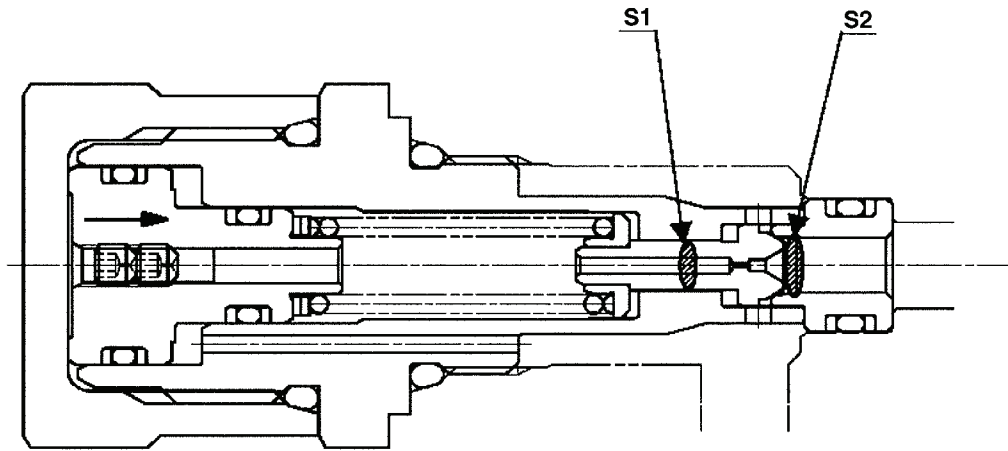
Figure 5 Construction of Relief Valve

The relief valve operates in two stages as follows.

1. First stage: Refer to Figure 6

At the start of operation, spring force is getting stronger while piston is moving and to maintain the spring chamber at a low pressure Accordingly the pressure ramp-up smoothly.

Thus, the pressure receiving area of the poppet becomes the poppet seat area (S1), a considerably larger area than the pressure receiving area (S1 . S2) at the specified relief setting. For this reason, the relief operating pressure is kept at a low pressure until the piston completes its movement.

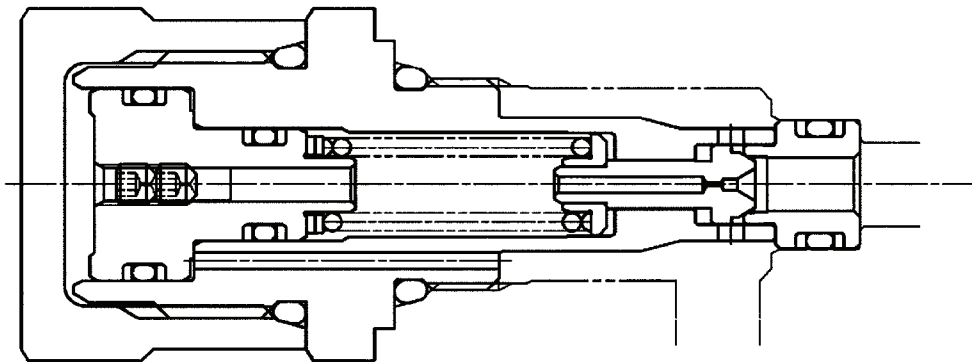


FG011122

Figure 6 Operation of Relief Valve in First Stage

2. Second stage: Refer to Figure 7

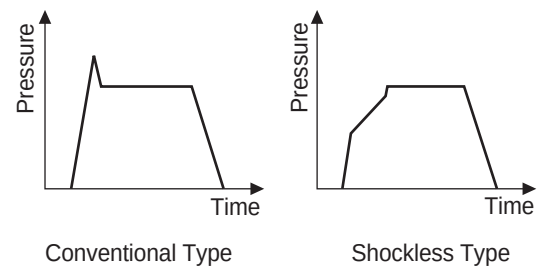
When shockless piston completes its movement, pressure inside spring chamber increases to make pressures before and after poppet equal. Then relief valve operates at specified set pressure.



FG011123

Figure 7 Operation of Relief Valve in Second Stage

Figure 8 shows pressure waveforms of conventional type and shockless type.



FG012300

Figure 8 Comparison of pressure Waveforms

Makeup Valve

The makeup valve has following two functions.

One is to prevent cavitation produced by overrun of piston motor to prevent overrun of upper body. When motor is turned by inertia of upper body to cause pumping action, which then causes motor revolution to rise above revolution equivalent to amount of oil supplied to motor, amount of oil equivalent to shortage is supplied to motor main circuit by way of makeup valve from outside to prevent occurrence of vacuum inside circuit.

The other is a function to add amount of motor drain and valve leak by way of makeup valve to prevent vacuum inside circuit to provide braking capability in normal circuit status when a closed circuit is formed between control valve and motor as when braking.

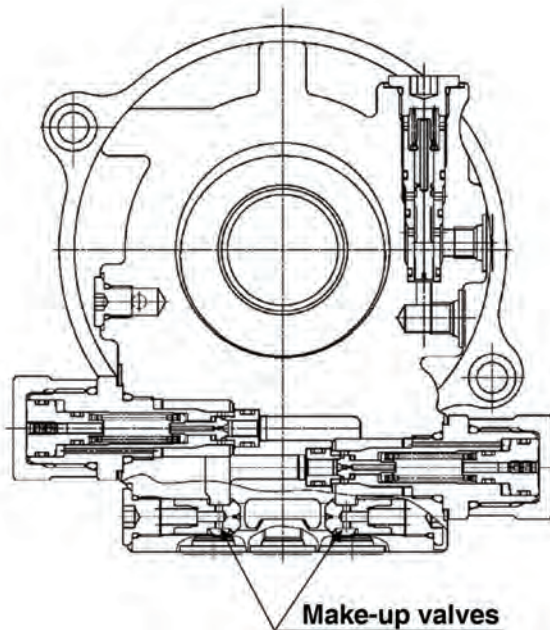


Figure 9

FG011247

Reduction Gear (Planetary two-stage)

Refer to cross-section.

The motor shaft (1, Figure 10) is coupled to drive gear (2, Figure 10) by way of a spline. The drive force of hydraulic motor is transmitted from drive gear (2, Figure 10) to engaged planetary gear (3, Figure 10). The planetary gear (3, Figure 10) is meshed with ring gear of reduction gear housing (4, Figure 10). Thus, while rotating, it revolves around ring gear. The planetary gear (3, Figure 10) is held by holder (5, Figure 10) by way of bearing and holder transmits revolving motion of planetary gear (3, Figure 10) to sun gear (5, Figure 10) coupled by way of spline. The sun gear (3, Figure 10) meshes with planetary gear (7, Figure 10) and as with first stage, transmits rotary motion to planetary gear (7, Figure 10). Since planetary gear (7, Figure 10) is meshed with ring gear of housing (4, Figure 10), it revolves while rotating. Since planetary gear (7, Figure 10) is held by holder (8, Figure 10) by way of bearing, holder (8, Figure 10) transmits revolving motion of planetary gear (7, Figure 10) to pinion shaft (9, Figure 10) coupled by way of spline.

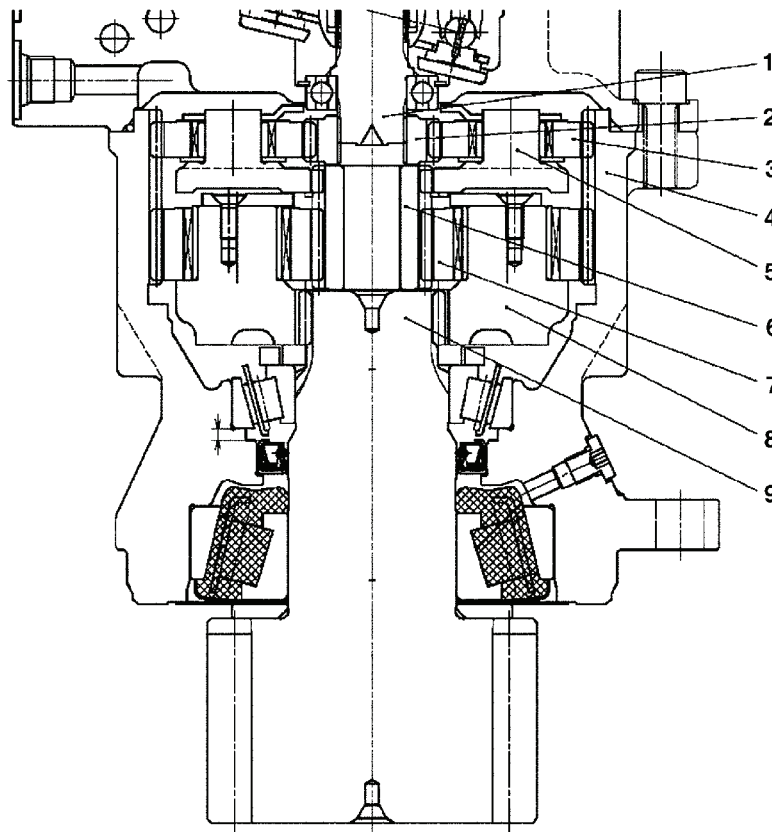


Figure 10

FG011126

PRECAUTIONS FOR HANDLING

Inspection

Before installing piston motor, make sure that;

1. No part has been damaged during transportation. No part is missing.
2. All tightened parts are not loose.
3. All ports are completely sealed and no foreign material has entered piston motor.

Rotating Direction

The relation between oil flow direction and rotating direction is as described in following table.

Oil Inflow Port	Oil Outflow Port	Rotating Direction (when viewed from motor output shaft end)
A	B	Clockwise
B	A	Counterclockwise

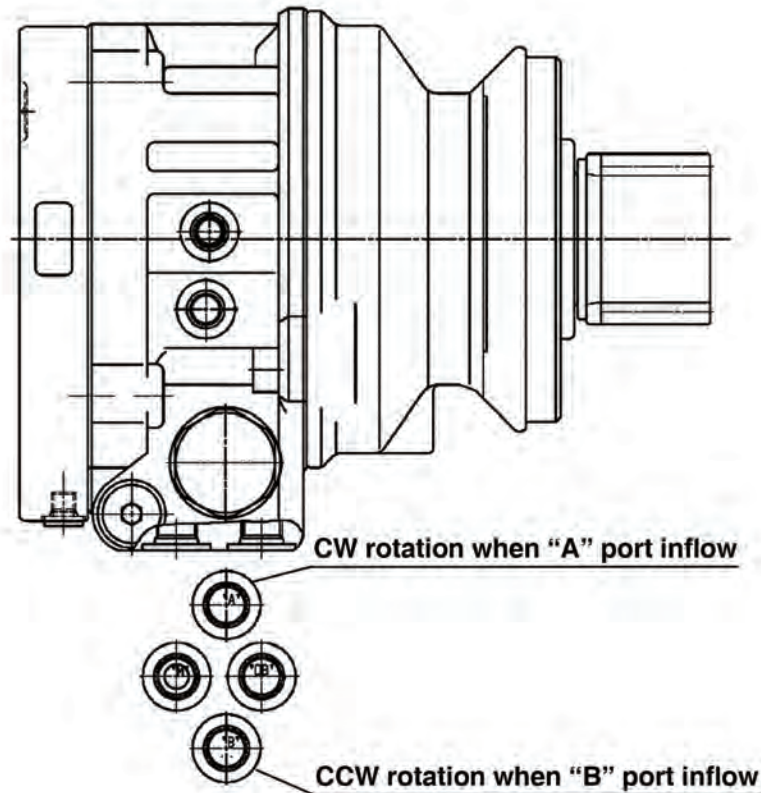


Figure 11

FG011248

Hydraulic Fluid

Optimum hydraulic fluid

Hydraulic fluid is an important element that has roles of both transmitting power and lubricating various parts of hydraulic equipment. The setting and handling of hydraulic fluid has most critical influence on performance and service life of hydraulic equipment.

The hydraulic fluid that is commonly used is high grade lubricating oil having excellent lubricity, oxidation stability, corrosion resistance and anti emulsification. It also must not erode packings and seals.

Different types of hydraulic fluids must not be mixed.

Hydraulic fluid: Oil equivalent to ISO VG46



CAUTION

To use biodegradation hydraulic fluid, please contact us.

Viscosity range

	Viscosity (cSt)	Equivalent Oil Temperature (SUPER HYDRO 46 LW)
Recommended range	25 - 100	22 - 55°C
Practical range	15 - 200	10 - 80°C

For start up at low temperature, conduct warming up under no load.

Oil temperature range:

- Oil temperature in use -20°C to +90°C, momentary max. temperature 100°C
- However, total hours at 90 to 100°C to be less than 100 hours.

Filter

The piston motor consists of very precise components and designed with a minimum clearance between components and therefore is very sensitive to contaminants (such as sludge, iron particles, ground dust, polished dust and other dust and dirt). The drop in performance of piston motor and wear of sliding members can mostly be prevented by minimizing contamination level.

Accordingly, to keep hydraulic fluid in hydraulic system clean. And to use piston motor as reliable hydraulic equipment over a long time without a need of repair and inspection, a suitable filter must be installed to maintain and control contamination level to better than NAS Class 9 level.

A filter to use must be capable of filtering a grain size 10μ (rated) or smaller and be installed in a suitable place on discharge side of hydraulic pump or on return side of piston motor. Also, filter must be equipped with an indicator that enables checking state of clogging of filter from outside and a relief valve to bypass oil flow according to degree of clogging.

A recommended contamination level of hydraulic fluid is NAS Class 9 or better.

Installation and Piping

Installation

Install swing motor unit on machine.

Piping

1. Before assembly, be sure to acid clean pipes to completely remove scales, etc. from inside pipes.
2. During piping work, exercise care so foreign material will not enter piston motor case through ports.
3. After completion of piping, conduct sufficient flushing.
4. Lay drain piping so internal pressure of piston motor case becomes lower than 0.1 MPa in normal state.
5. Return drain piping directly to tank independently.

Piston motor: Normal 0.1 MPa max.

Drain pressure inside case: Momentary max. 0.3 MPa max.

6. It is necessary to keep piston motor case filled with oil for lubrication. The drain piping must be returned to tank at a step higher than piston motor.

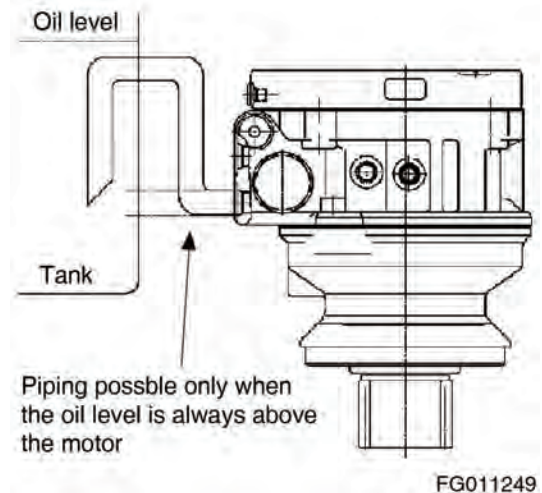


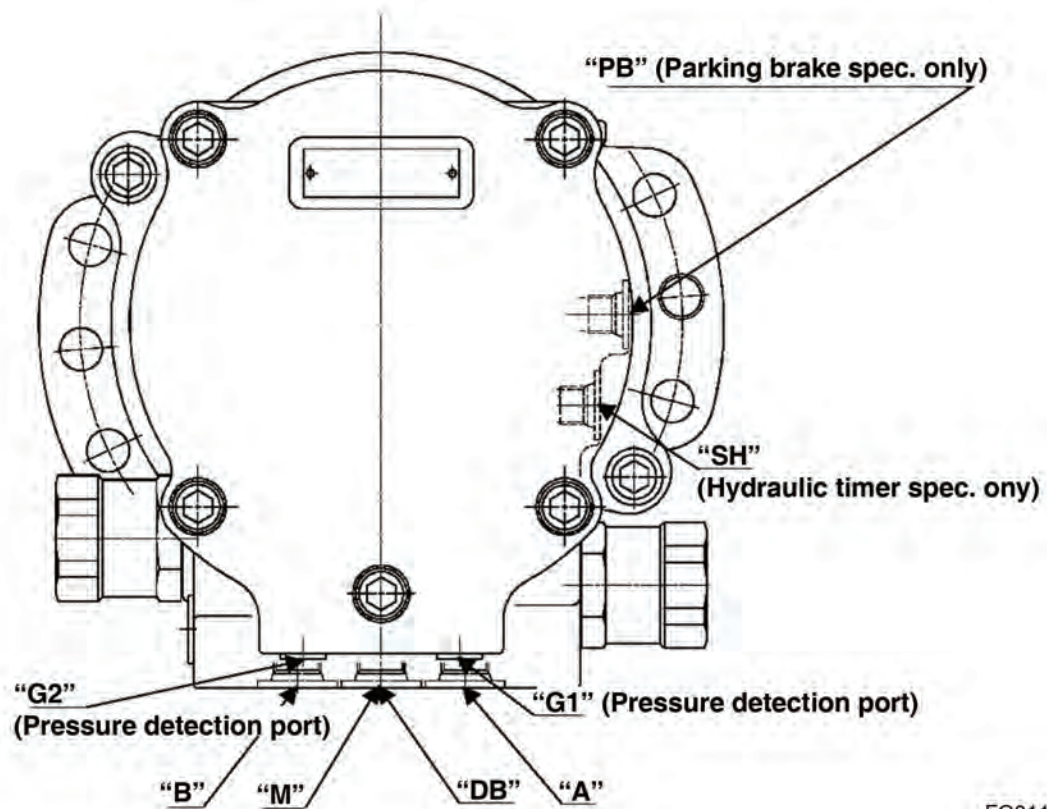
Figure 12

Check Before and After Operation

1. Before start up, fill piston motor case with clean hydraulic fluid.
2. Bleed air from every part of piping.
3. First run motor at low speed and check for abnormal noise and vibration. Then increase speed to specified revolution and apply a load.
4. When piston motor has started up, check to see if;
 - A. Oil is not leaking.
 - B. The revolution and rotating direction are correct.
 - C. The oil temperature has risen abnormally high.
 - D. The piston motor case temperature has risen abnormally high.
 - E. Abnormal noise or vibration is present.
 - F. There are any other problems.

Pressure Detection Port Location

The pressure detection ports are located as shown in Figure 13



FG011250

Figure 13 Pressure Detection Ports

PERIODIC INSPECTION AND REPLACEMENT INTERVALS

Hydraulic Fluid

The hydraulic fluid, when clean at beginning, becomes contaminated over a long time of use of piston motor as it contains sludge and other deposits in circuits and tank. Then when such contaminated hydraulic fluid flows in circuits, it becomes a cause of damage to piston motor. The hydraulic fluid itself also deteriorates gradually and as lubricity drops, wear of sliding parts progresses.

Therefore, a preferable treatment is to conduct periodic inspection of hydraulic fluid and replace it according to level of deterioration. However, it is usually difficult to quantitatively determine level of contamination or deterioration of hydraulic fluid on site. To help determine such a level, a guide is presented (the table below) by which you can visually judge quality of hydraulic fluid.

A recommended timing of replacing hydraulic fluid is after about first 500 hours of operation.

When replacing hydraulic fluid, be sure to wash inside of tank and flush piping because deteriorated hydraulic fluid and deposits such as sludge and water are mixed in circuits and tank. This helps prevent functional failure of piston motor and shortening of service life.

Visual judgment (Take fluid from tank into a test tube and compare it with new

Appearance	Odor	State	Action
Transparent (No color change)	Good	Good	Use as it is
Transparent (Small black spots)	Good	Mixture of foreign material	Use after filtering
Changed to milky white	Good	Mixture of water	Replace oil
Changed to black	Malodor	Oxidized/deteriorated	Replace oil

Filter

When element becomes clogged, filtering performance drops and filter loses its filtering capability. Therefore, it needs to be checked periodically.

Check filter after first 50 hours of use, then every 250 hours thereafter. When indicator indicates that element is clogged, replace it with a new one. If a filter having no differential pressure indicator is used, it is recommended that element be replaced after first 50 hours of use, then every 250 hours thereafter.

Please note that when hydraulic fluid has been replaced with new one, element must also be replaced.

TROUBLESHOOTING

If a problem occurs when motor runs in reverse direction, refer to following troubleshooting table to investigate cause and take corrective action.

Motor Function

Problem	Probable Cause	Corrective Action
I. The motor will not run	1. Equipment other than piston motor, valves (incorporated in motor) and reduction gear has failed.	Check to see if oil at specified pressure is present at inlet of motor, then check each piece of equipment and repair any defective one.
	2. The pressurized oil leaks because of abnormal wear of motor sliding area.	Replace abnormally worn part. Completely wash all parts, remove any scratches and burrs from surface, then reassemble them while taking care to prevent foreign material.
	3. Operational failure because of damage to a major part of motor. If this is case, motor produces abnormal noise.	Disassemble motor and replace damaged part. Completely wash all parts, then reassemble them while taking care to prevent foreign material.
	4. Operational failure because of damage to a major part of reduction gear. If this is case, reduction gear produces abnormal noise.	Disassemble reduction gear and replace damaged part. Completely wash all parts, then reassemble them while taking care to prevent foreign material.
	5. An overload is applied to motor to actuate relief valve.	Check load and run motor under a load suitable for relief set pressure.
II. The motor revolution is too low.	1. The oil in rated amount is not supplied to motor because of a troubled hydraulic pump, pressure control valve, etc. to cause a drop in revolution.	Check to see if oil is supplied to inlet of motor in rated amount, then check and repair if necessary each piece of equipment.
	2. The motor's volumetric efficiency has dropped to cause a drop in revolution.	Disassemble motor and check sliding area for abnormal wear. Repair worn area or replace worn part.
III. The motor revolution fluctuates excessively.	1. Because of wear of motor sliding area, a large amount of high-pressure oil is leaking through drain port, causing revolution to drop considerably with consequent large revolution fluctuation. The revolution will also fluctuate because of wear of bearing.	Disassemble motor and replace abnormally worn part. Completely wash all parts, then reassemble them while taking care to prevent foreign material.

Problem	Probable Cause	Corrective Action
IV. Oil leak.	1. Oil is leaking because of a broken oil seal or O-ring.	Replace broken oil seal or O-ring with a new one. When inserting a new oil seal, exercise sufficient care to prevent damage to lip. Note that maximum safe working temperature of oil seal and O-ring is 80°C. If temperature of hydraulic fluid will rise above 80°C, take such measures as placing a cooler in hydraulic circuit.
	2. Due to a cause of I.2 or III.1, motor case is exposed to a pressure to cause oil seal to be broken, causing oil leak. • Oil seal Pressure resistance: 0.3 MPa. (Momentary max.) Normal pressure: 0.1 MPa max.	Repair motor as explained in "I. 2" and "III. 1" and replace oil seal with a new one. When inserting a new oil seal, exercise sufficient care to prevent damage to lip.
	3. The back pressure has risen because of a cause of clogging of drain piping by foreign material or a too small, too long piping to cause oil seal to be broken, causing oil leak. • Oil seal Pressure resistance: 0.3 MPa. (Momentary max.) Normal pressure: 0.1MPa max.	Remove clogging of drain piping. Check piping system and reduce piping resistance. By above corrective action, ensure that a pressure over 0.3 MPa will not be applied to oil seal, then replace oil seal with a new one. When inserting a new oil seal, exercise sufficient care to prevent damage to lip.
V. Excessive abnormal noise, rotation fluctuation and pressure fluctuation because of cavitation.	1. The amount of drain has increased because of a drop in motor efficiency.	Take corrective action as explained in "II. 2" and "III. 1".
	2. The makeup valve failed to operate properly.	Take corrective action referring to "I. 3" in Valve troubleshooting.
	3. The makeup valve supply pressure or supply oil amount is not sufficient.	Check oil pressure and amount to makeup valve and if not correct, set them to specified levels.

Motor - Incorporated Valve Function

Problem	Probable Cause	Corrective Action
I. The motor will not run or its rotating speed is too slow.	1. Equipment other than piston motor, valves (incorporated in motor) and reduction gear has failed.	Check to see if oil at specified pressure is present at inlet of valve, then check each piece of equipment and repair any defective one.
	2. The amount of internal leak increased because O-ring in relief valve was cut.	Replace O-ring or backup ring with a new one.
	3. The amount of leak increased because of poor sealing of valve or piston area.	Either repair damaged area or replace piston and rear cover with new ones.
	4. The seat of makeup valve is faulty or valve itself failed. A. Foreign matter is present. B. The sliding surface of check valve is rough or damaged. C. The spring is broken.	1) Remove foreign material completely, repair any damaged part, completely wash all parts, then reassemble them. If damage is too deep causing a large amount of leak, replace valve. 2) Correct sliding surface or replace valve with a new one. 3) Replace broken spring. When replacing spring, remove foreign material completely, repair any damaged part, wash all parts completely, then reassemble them. If damage is too deep causing a large amount of leak, replace valve.
	5. The seat of relief valve is faulty. A. Foreign matter is present. B. The spring is broken.	1) Remove foreign material completely, repair any damaged part, completely wash all parts, then reassemble them. If damage is too deep causing a large amount of leak, replace valve. 2) Replace relief valve assembly.
	6. The cracking pressure of relief valve has dropped. A. The spring has settled. B. The poppet orifice is clogged.	1) Replace relief valve assembly. 2) Wash orifice with treated oil and reassemble it.

Problem	Probable Cause	Corrective Action
II. The motor will not stop or it is too slow to come to a stop.	1. The seat of makeup valve is faulty or valve itself failed. A. Foreign matter is present. B. The sliding surface of check valve is rough or damaged. C. The spring is broken.	1) Remove foreign material completely, repair any damaged part, completely wash all parts, then reassemble them. If damage is too deep causing a large amount of leak, replace valve. 2) Correct sliding surface or replace valve with a new one. 3) Replace broken spring. When replacing spring, remove foreign material completely, repair any damaged part, wash all parts completely, then reassemble them. If damage is too deep causing a large amount of leak, replace valve.
	2. The seat of relief valve is faulty. A. Foreign matter is present. B. The spring is broken.	1) Remove foreign material completely, repair any damaged part, completely wash all parts, then reassemble them. If damage is too deep causing a large amount of leak, replace valve. 2) Replace relief valve assembly.
	3. The cracking pressure of relief valve has dropped. A. 1) The spring has settled. B. 2) The poppet orifice is clogged.	1) Replace relief valve assembly. 2) Wash orifice with treated oil and reassemble it.
	4. The amount of leak has increased. A. 1) The amount of internal leak increased because O-ring in valve was cut. B. 2) The amount of leak increased because of poor sealing of valve and piston area.	1) Take corrective action referring to I.2 and 3. 2) Replace relief valve assembly.

Problem	Probable Cause	Corrective Action
III. Abnormal noise is heard.	1. The makeup valve failed. A. Foreign matter is present. B. 2)The spring is broken.	2) Replace broken spring. When replacing spring, remove foreign material completely, repair any damaged part, wash all parts completely, then reassemble them. If damage is too deep causing a large amount of leak, replace valve.
	2. The oil supply pressure or amount to makeup valve is not sufficient.	Check oil pressure and amount to makeup valve and if not correct, set them to correct levels.
	3. The relief set pressure has changed and valve is resonating with other relief valves.	Readjust set pressure of relief valve.
IV. Shock is too large when the swing motion comes to a stop.	1. The shock less function does not work. A. Foreign matter is present. B. No pressurized oil is supplied to piston chamber. C. The O-ring is broken.	Replace the relief valve.
	2. The relief set pressure has risen.	Replace the relief valve.
	3. The relief valve does not operate. A. Foreign matter is present.	Remove foreign material completely, repair any damaged part, completely wash all parts, then reassemble them. If damage is too deep causing a large amount of leak, replace valve.

Parking Brake and Hydraulic Timer Function

(*Parking brake and hydrlic timer spec. only)

Problem	Probable Cause	Corrective Action
I. The motor will not run. →The parking brake will not be released.	1. The release pressure "PB"("PG") or the valve changeover signal pressure "SH" (*hydraulic timer spec. only) is not present. Or the supply pressure is too low (not at the specified level). Accordingly, the brake piston will not operate or the timer valve will not change over.	Adjust "PB"("PG") or "SH" pressure to specified level.
	2. The motor drain pressure is too high for valve to operate.	Measure motor drain pressure and check and repair if necessary drain circuit for clogging. If amount of motor drain is too much, check and repair motor.
	3. The timer valve will not change over. (*Hydraulic timer spec. only) A. The sliding part of the valve body or the valve is worn or damaged to cause an operational failure. B. Foreign matter is present on the sliding part of the valve body or the valve to cause an operational failure. C. The spring is broken.	Check the parts and correct damage. If the sliding part is damaged excessively, replace it with a new one. Wash the sliding part and remove foreign matter. Replace the spring.
	4. The brake piston will not operate. A. The O-ring in brake piston is worn excessively or cut to cause pressurized oil to leak. B. The sliding part of brake piston is worn or damaged to cause a piston operational failure. C. Foreign matter is present on piston sliding part to cause an operational failure.	Replace O-ring with a new one. Check parts and correct damage. If sliding part is damaged excessively, replace it with a new one. Wash sliding part and remove foreign material.

Problem	Probable Cause	Corrective Action
II. The parking brake force is weak. No brake force is produced.	1. The disk friction material is worn.	Replace disk with a new one.
	2. The spring in piston has settled.	Replace spring with a new one.
	3. The sliding part of brake piston is faulty or stuck or disk friction surface has deteriorated.	Correct sliding part. If damaged excessively, replace it with a new one. Note that disk friction material surface cannot be corrected.
	4. The timer valve does not change over and the cylinder chamber is not depressurized. (*Hydraulic timer spec. only) A. The spring of the valve has settled. B. (*Hydraulic timer spec. only) The signal pressure "SH" is present or the back pressure of the signal system is too high. C. Others Same as 1) to 3) in I. 3.	1) Replace the spring with a new one. 2) Check the pressure of the "SH" signal system. If the back pressure is too high, take necessary action to reduce it to the specified level. 3) Others Same as 1) to 3) in I. 3.
	5. The orifice or filter is clogged and cylinder chamber is not depressurized.	Wash or replace filter or orifice.
III> The parking brake drags or produces abnormal noise, vibration, shock, other problems or abnormal heat.	1. The release pressure "PB"("PG") is too low and brake piston is rubbing against disk.	Adjust "PB"("PG") supply pressure to specified level.
	2. The O-ring in brake piston is worn excessively or cut to cause pressure in cylinder chamber to drop.	Replace O-ring with a new one.
	3. The causes of timer valve operational failure are the same as those of 1) to 3) in II. 4	
	4. The hydraulic timer is faulty. (*Hydraulic timer spec. only) The timer set time is too short and the parking brake acts as a dynamic brake. A. The orifice is not set properly. B. The valve seat is faulty. C. Foreign matter is present on the seat. D. The spring has settled or is damaged.	1) Disassemble and check the timer. Then assemble the orifice properly. 2) If the seat surface is damaged excessively, correct or replace it. 3) Wash the parts to remove foreign matter. 4) Replace the spring with a new one.

SERVICE MANUAL

Disassembly Procedure

Precautions before disassembly

1. Remove dirt and dust adhering to outside.
2. Discharge all hydraulic fluid in piston motor case and port oil passage.
3. Use a clean, dust free work area. Handle parts with care to prevent dirt and dust from adhering.
4. Do not over disassemble.

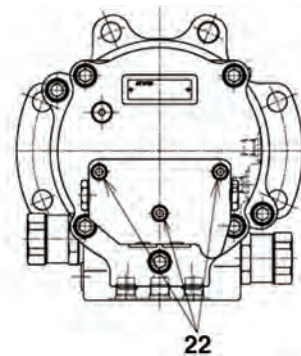
Disassembly

Disassemble parts by following procedure.

Removing anti swing back valve

NOTE: *The steps marked by apply to anti swing back valve spec. only.*

Remove socket head bolts (22, Figure 14).

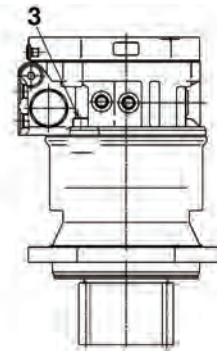


FG011131

Figure 14

Separate motor and reduction gear

Secure motor assembly in a vice and remove socket head bolt (3, Figure 15).



FG011132

Figure 15

Disassembling motor

1. Secure motor assembly in a vice.
Remove socket head bolts (2-27, Figure 16) and separate cover (2-21, Figure 17).



CAUTION

When separating cover (2-21, Figure 17), be careful not to drop valve plate (2-24, Figure 25).

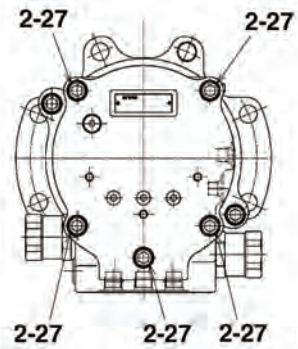


Figure 16

FG011133

2. Remove valve plate (2-24, Figure 17) and pin (2-23, Figure 18).

NOTE: The valve plate (2-24, Figure 17) may remain on motor side.

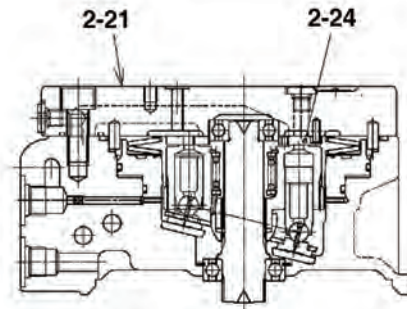


Figure 17

FG011134

3. Remove bearing (2-22, Figure 19). Remove O-ring (2-26, Figure 19).

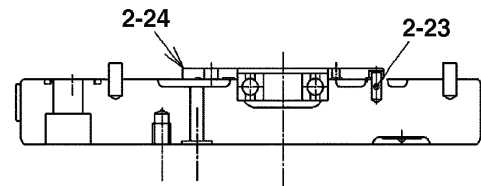


Figure 18

FG007431

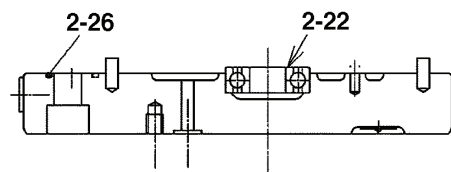
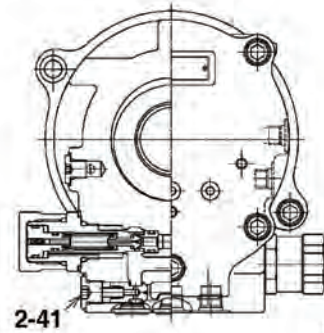


Figure 19

FG007343

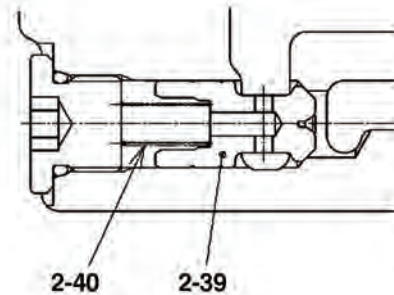
4. Disassemble check valve.
 - A. Loosen to remove plug (2-41, Figure 20).



FG011135

Figure 20

- B. Remove spring (2-40, Figure 21) and check valve (2-39, Figure 21).



FG011136

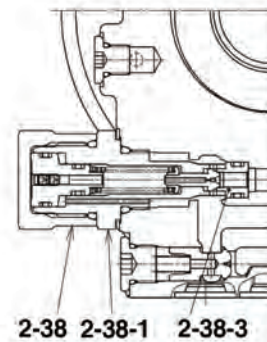
Figure 21

5. Remove relief valve.
 - A. Loosen the relief housing (2-38-1, Figure 22) to remove relief valve assembly (2-38, Figure 22).
 - B. Remove the poppet seat (2-38-3, Figure 22) (The poppet seat (2-38-3, Figure 22) remain in the case.)



CAUTION

Do not disassemble relief valve assembly (2-38, Figure 22) because it is a functional component.



FG011137

Figure 22

6. Remove valve plate (2-24, Figure 23), pin (2-25, Figure 23) and O-ring (2-20, Figure 23).

NOTE: The valve seat (2-24, Figure 23) may remain on cover side.

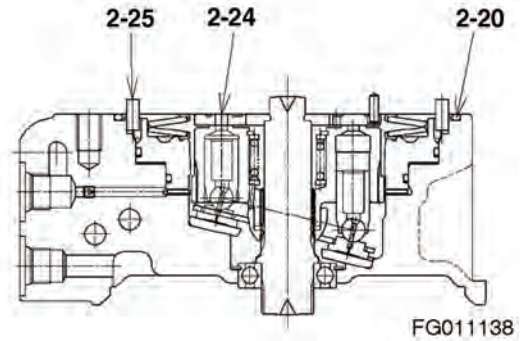


Figure 23

7. Remove disk spring assembly (2-19, Figure 24) and spring seat (2-18, Figure 24), and utilizing gage port of case (2-1, Figure 51), remove parking brake piston (2-15, Figure 24).

(The plug is mounted on gage port.)

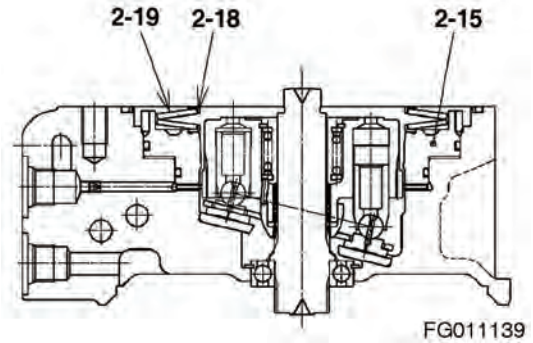


Figure 24



CAUTION

The piston may be ejected by air pressure. Exercise sufficient care during removal. At beginning of work, set a lower air pressure and adjust it while checking piston for ejection.

Be sure to remove brake piston before disassembling parking brake timer. (If it is disassembled first, there is a possibility that it cannot be removed.)

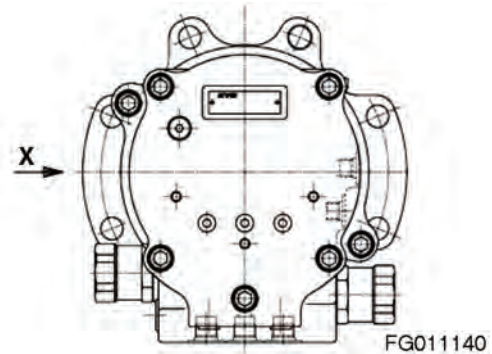


Figure 25

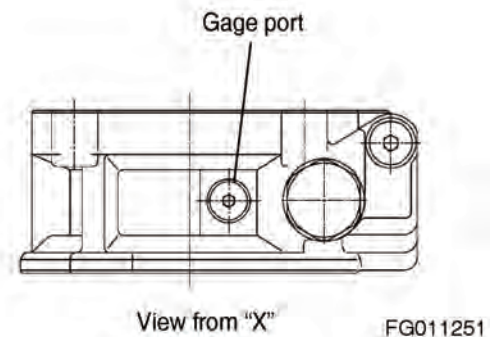


Figure 26

8. Remove cylinder block and other associated parts.

Reference Number	Description
2-5	Cylinder block
2-6	Collar
2-7	Spring
2-8	Washer
2-9	Snap ring
2-10	Pin
2-11	Retainer holder
2-12	Retainer plate
2-13	Piston assembly
2-14	Disk

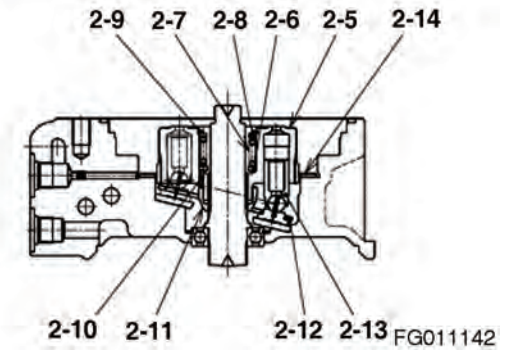
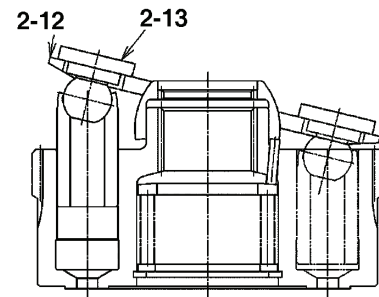


Figure 27

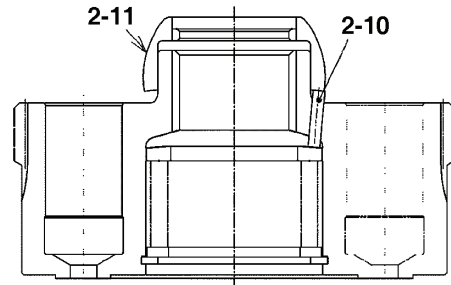
9. Remove retainer plate (2-12, Figure 28) and piston assembly (2-13, Figure 28).



FG007352

Figure 28

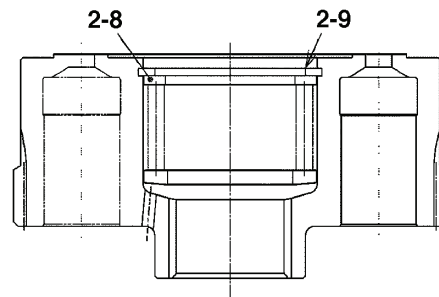
10. Remove pin (2-10, Figure 29) and retainer holder (2-11, Figure 29).



FG007353

Figure 29

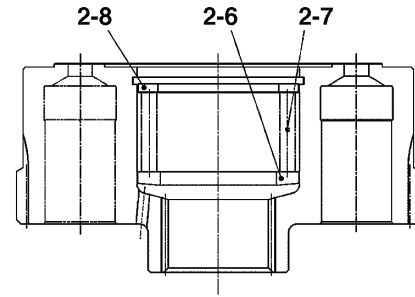
11. While pushing washer (2-8, Figure 30), remove retaining ring (2-9, Figure 30).



FG007354

Figure 30

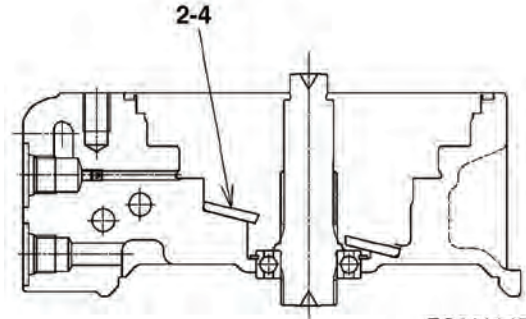
12. Remove collar (2-6, Figure 31), spring (2-7, Figure 31) and washer (2-8, Figure 31).



FG007355

Figure 31

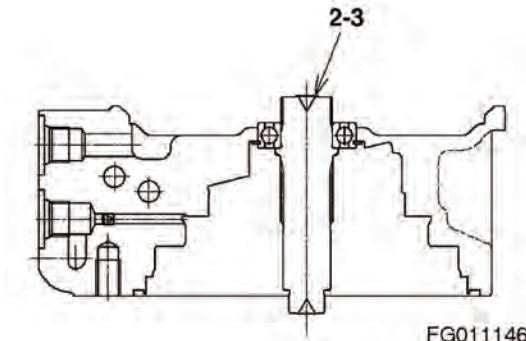
13. Remove thrust plate (2-4, Figure 32).



FG011145

Figure 32

14. Lightly strike end of shaft (2-3, Figure 33) with a plastic hammer to move shaft.



FG011146

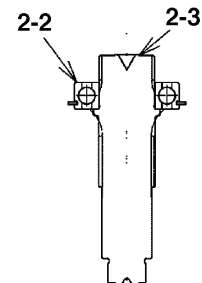
Figure 33

15. Disassemble bearing (2-2, Figure 34) and ball bearing (2-3, Figure 34).



CAUTION

The disassembled bearings must not be used.



FG007358

Figure 34

16. Disassemble the timer valve.

- A. Remove the plug (2-37, Figure 35)

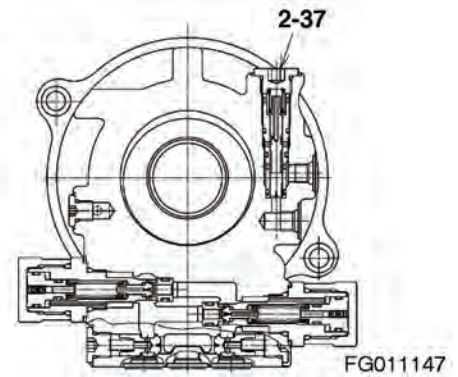


Figure 35

- B. Remove the spring (2-35, Figure 36), the washer (2-34, Figure 36) and the spool (2-29-5, Figure 36).
C. Remove the sleeve (2-29-1, Figure 36).

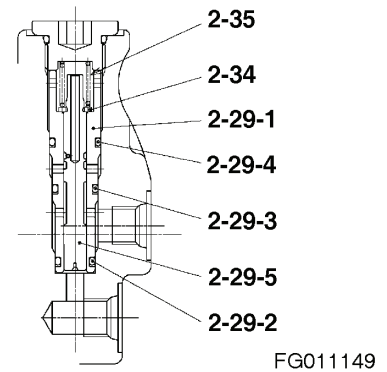


Figure 36

Disassembling reduction gear

1. Remove following parts.

Reference Number	Description
1-37	O-ring
1-24	Thrust plate
1-25	Drive gear
1-23	Planetary gear
1-22	Needle bearing
1-21	Inner race
1-20	Thrust washer
1-19	Holder

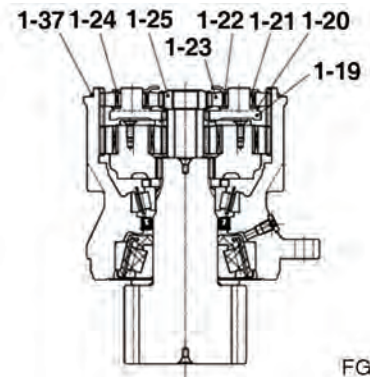


Figure 37

FG011150

2. Remove sun gear (1-17, Figure 38).

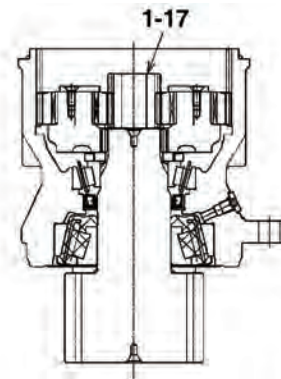


Figure 38

FG011151

3. Remove holder (1-11, Figure 75) and other associated parts.

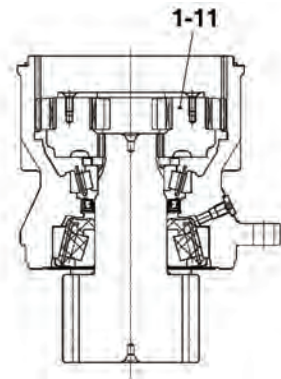


Figure 39

FG011152

4. Secure holder (1-11, Figure 75) in a vice and loosen screw (1-16, Figure 40) to remove thrust plate (1-15, Figure 40).

NOTE: The screw is hard to remove because Loctite was used during assembly. To facilitate removal of screw, warm screw with a drier.

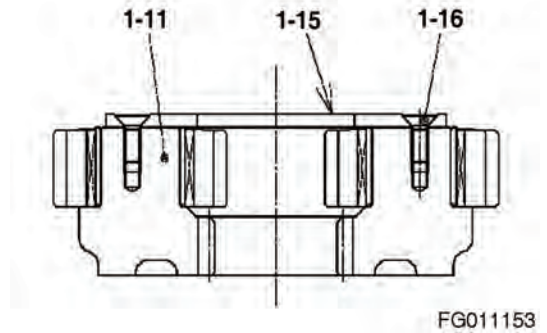


Figure 40

5. Remove following parts.

Reference Number	Description
1-14	Planetary gear
1-13	Needle bearing
1-12	Inner race

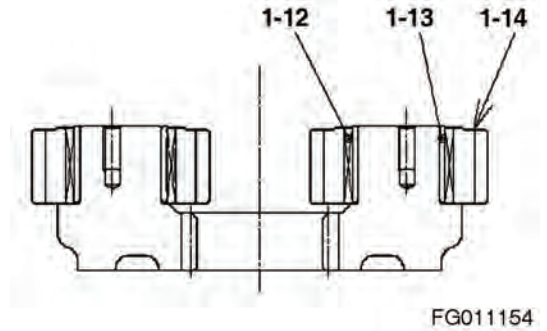


Figure 41

6. Remove following parts.

Reference Number	Description
1-10	Collar
1-9	Plate

NOTE: When replacing taper roller bearings (1-6, Figure 45) and (1-8, Figure 42), collar (1-3) and plate (1-4), they are to be replaced by body assembly.

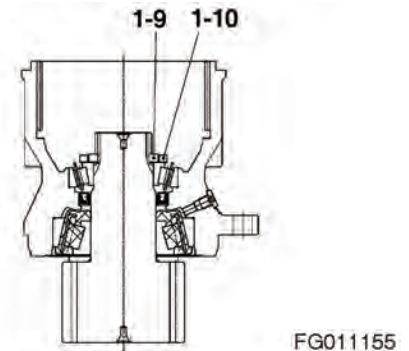


Figure 42

7. Remove pinion shaft (1-2, Figure 43).



CAUTION

When removing shaft, be careful not to drop it. If it is hard to remove, lightly strike it with a plastic hammer.

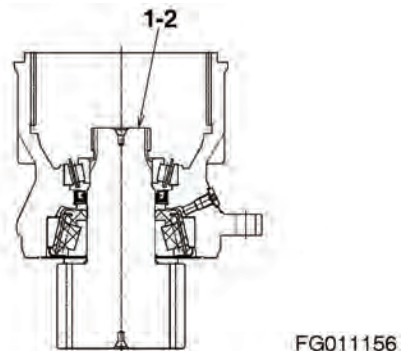


Figure 43

8. Remove inner race of taper roller bearing (1-8, Figure 42).

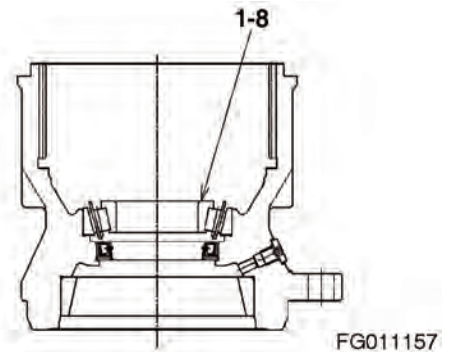


Figure 44

9. Break oil seal (1-7, Figure 44) to remove it.



CAUTION

The removed oil seal must not be used again.
When removing it, exercise care to prevent damage to
outer races of taper roller bearings (1-8, Figure 42) and
(1-6, Figure 45).

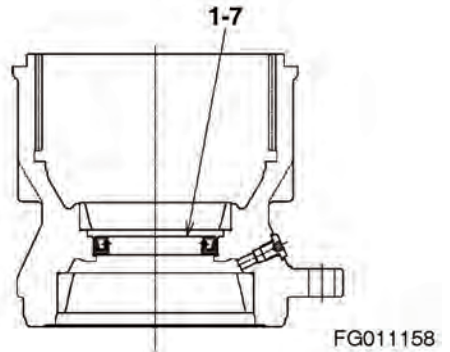


Figure 45

10. Remove outer race of taper roller bearing (1-8, Figure 42) and plug (1-35, Figure 46).

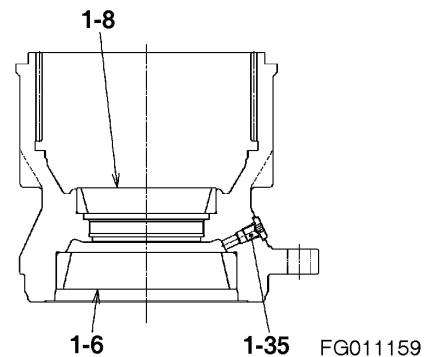


Figure 46

Assembly Procedure

Precautions for assembly

1. Wash all parts with treated oil and blow oil completely.
2. Be sure that washed parts are free of dust and other foreign material. Handle them with care so they will not be dented or damaged.
3. Always replace seals, bearings and pins with new ones.
4. Tighten all tightening areas to specified torque.
5. Apply grease to oil seals and O-rings in advance. (In particular, oil seal lips must be oiled.)
6. Many small parts are used. Exercise care so as not to lose them (such as dropping them in holes).

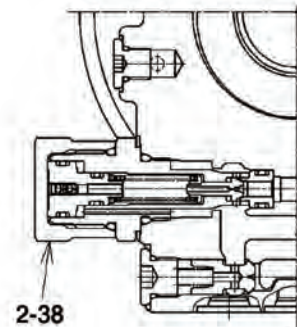
Assembly

Assemble parts by following procedure.

Assembling motor

1. Install relief valve assembly (2- 38, Figure 47).

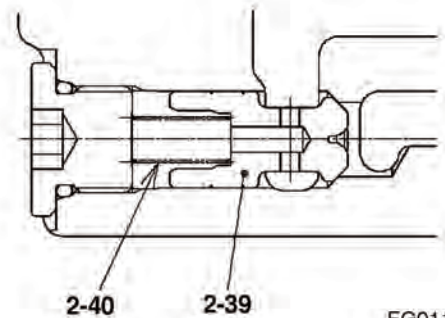
Tightening torque: 157 ± 10 Nm. (115.8 ± 7.4 ft•lb)



FG011160

Figure 47

2. Assemble check valve (2-39, Figure 48) and spring (2-40, Figure 48).



FG011161

Figure 48

3. Install plug (2-41, Figure 49).

Tightening torque: 39.2 ± 2.0 Nm (28.9 ± 1.5 ft•lb)

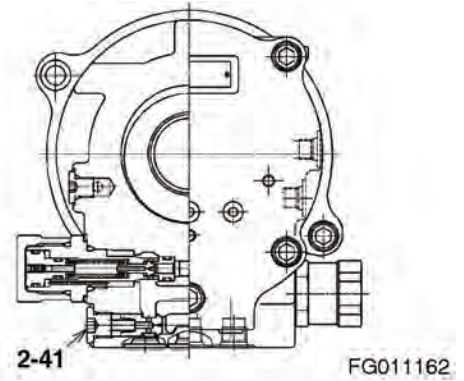


Figure 49

4. * With timer valve type
Install the O-ring (2-29-2-4, Figure 50) on the sleeve (2-29-1, Figure 50).

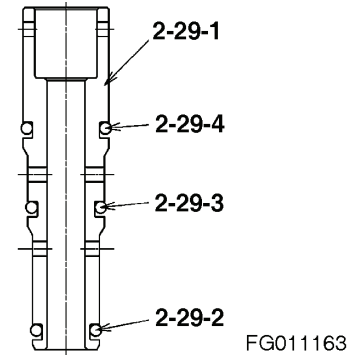


Figure 50

5. * With timer valve type
Assemble the sleeve (2-29-1, Figure 50) in the case (2-1, Figure 51) and set the spool (2-29-5, Figure 51), the washer (2-34, Figure 51) and the spring (2-35, Figure 51) in the hole of the sleeve.
6. Install plug (2-37, Figure 51).
Tightening torque: 84 ± 5 Nm (60.0 ± 3.7 ft•lb)

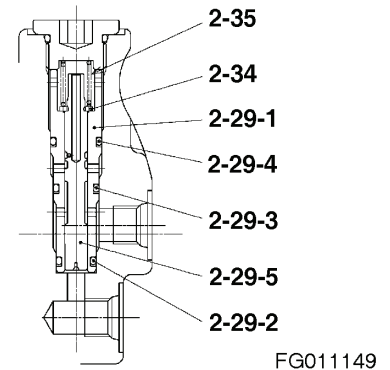


Figure 51

7. Assemble collar (2-6, Figure 52), spring (2-7, Figure 52) and washer (2-8, Figure 52) in cylinder block (2-5, Figure 52).



CAUTION

Be sure to assemble collar (2-6, Figure 52) in correct direction.

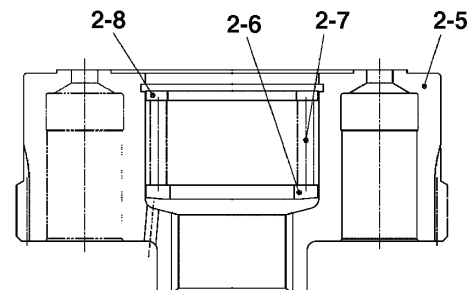
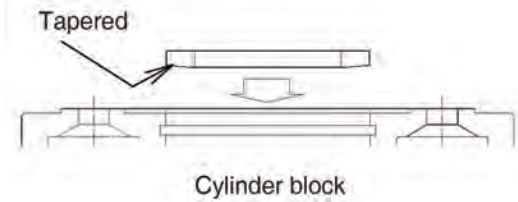


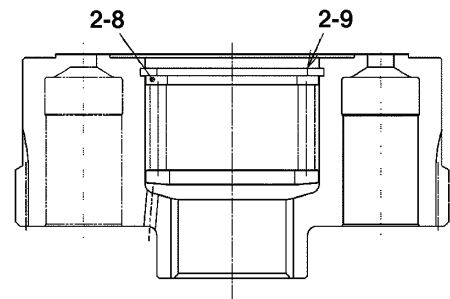
Figure 52



FG012301

Figure 53

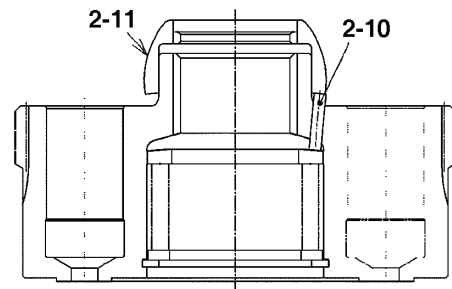
8. While pushing washer (2-8, Figure 54), assemble retaining ring (2-9, Figure 54).



FG007354

Figure 54

9. Apply grease to pin (2-10, Figure 55) and assemble it in cylinder block (2-5, Figure 52).
10. Assemble retainer holder (2-11, Figure 55).



FG007353

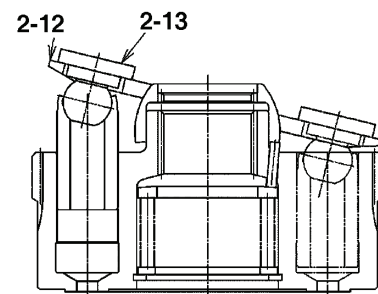
Figure 55

11. Set piston assembly (2-13, Figure 56) on retainer plate (2-12, Figure 56) and assemble it in cylinder block (2-5, Figure 52).



CAUTION

Apply an ample amount of hydraulic fluid to sliding part before assembly.



FG007352

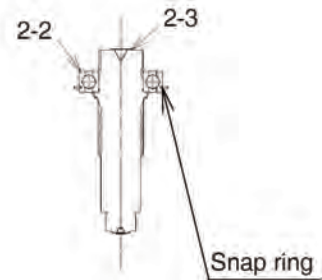
Figure 56

12. Press fit ball bearing (2-2, Figure 57) on shaft (2-3, Figure 57).



CAUTION

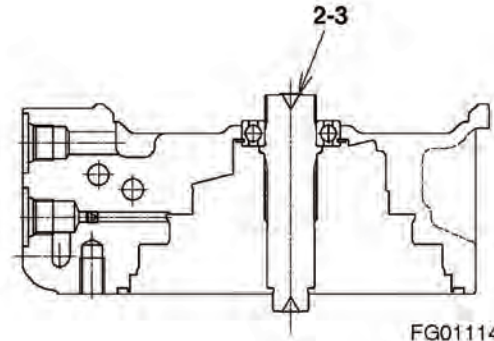
Press Fit ball bearing (2-2, Figure 57) with attached retaining ring facing as shown in figure.



FG007393

Figure 57

13. Press fit shaft (2-3, Figure 58) and ball bearing (2-2, Figure 57) in case (2-1).



FG011146

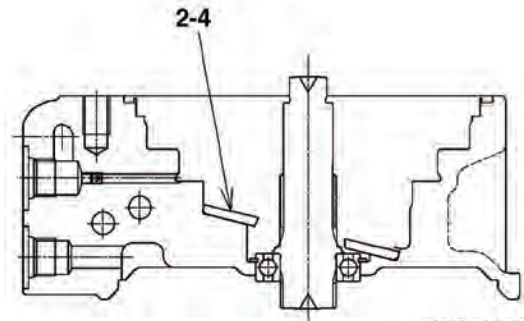
Figure 58

14. Apply grease to back of thrust plate (2-14, Figure 61) and assemble it.



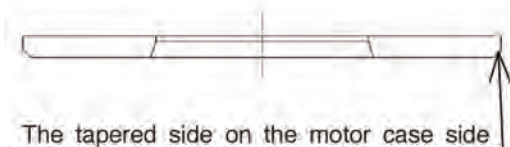
CAUTION

The thrust plate must be assembled in correct direction.



FG011145

Figure 59



FG007395

Figure 60

15. Assemble cylinder block (2-5, Figure 61) and other associated parts.



CAUTION

During assembly, be sure that pin (2-10, Figure 61) will not come out.

*2: The disk (2-14, Figure 61) is assembled only for parking brake spec. only.

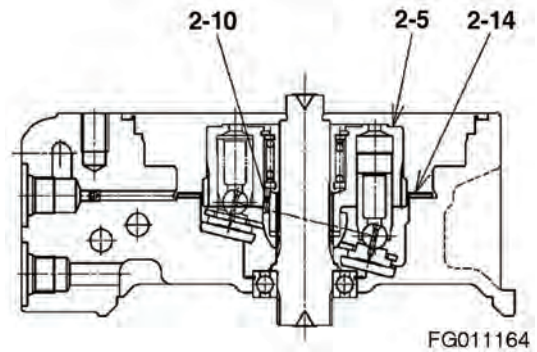


Figure 61

16. * With parking brake type
Apply grease to O-ring (2-16, Figure 62) and O-ring (2-17, Figure 62) and assemble them on brake piston (2-15, Figure 62).
17. * With parking brake type
While paying attention to location of hole of pin (2-25, Figure 68), assemble brake piston (2-15, Figure 63) in case (2-1, Figure 51).

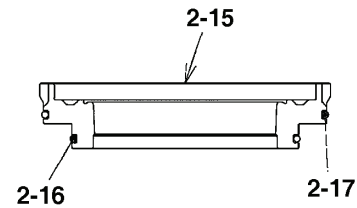


Figure 62

18. * With parking brake type
Assemble spring seat (2-19, Figure 63) and disk spring assembly (2-18, Figure 63) in correct direction. Pay attention to orientation

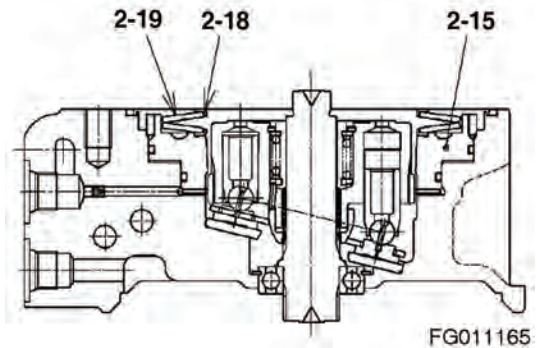


Figure 63

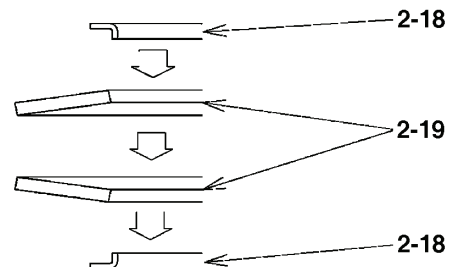


Figure 64

19. Apply grease to O-ring (2-20, Figure 65) and assemble it in case (2-1, Figure 51).

Check to see if pin (2-25, Figure 65) can be assembled in brake piston and case hole. If not, remove brake piston (2-15, Figure 63) and reorient it, then reassemble. (*2 Parking brake spec. only)



CAUTION

Assemble pin (2-25, Figure 65) while being attached on cover.

20. Apply grease to O-ring (2-26, Figure 66) and pin (2-25, Figure 66), then assemble them in cover (2-21, Figure 66).
Press fit ball bearing (2-22, Figure 66).

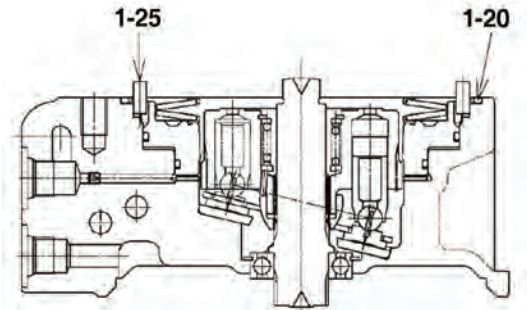


Figure 65

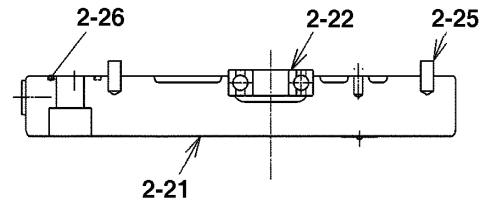


Figure 66

21. Install pin (2-23, Figure 67), then install valve plate (2-24, Figure 67).

To prevent falling, apply grease to back side.

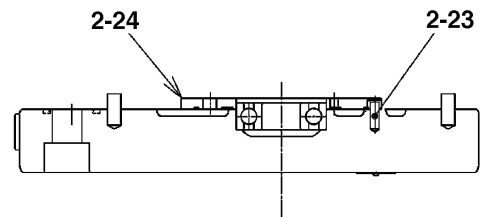


Figure 67

22. While paying attention to location of pin (2-25, Figure 68), install cover (2-21, Figure 68) and other associated parts to case (2-1, Figure 51).



CAUTION

Exercise care so pin (2-25, Figure 68) and valve plate (2-24, Figure 68) will not fall.

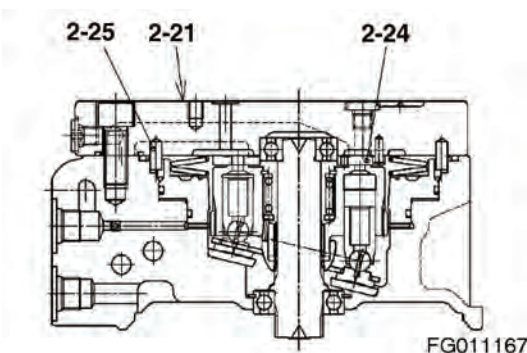


Figure 68

23. Loosely tighten socket head bolts (2-27, Figure 69), then using a torque wrench, tighten them to specified torque.

Tightening torque: $128 \pm 7 \text{ Nm}$ ($94.4 \pm 5.2 \text{ ft}\cdot\text{lb}$)

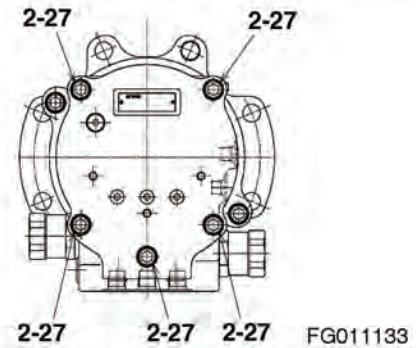


Figure 69

Assembling reduction gear

1. Press fit oil seal (1-7, Figure 71).



CAUTION

Before press fit, apply grease to oil seal mounting area of housing and periphery of oil seal.

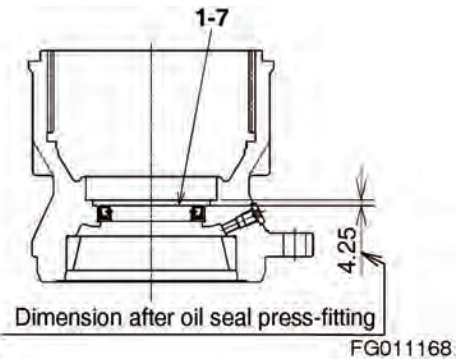


Figure 70

2. Press fit taper roller bearing (1-8, Figure 74) and install plug (1-35, Figure 71).

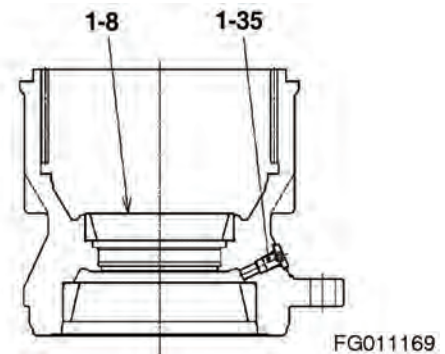


Figure 71

3. Apply grease to inner race of taper roller bearing (1-6, Figure 69) assembled on pinion shaft (1-2, Figure 72).

Grease : Shell Alvania Grease

Volume : $62 \sim 72 \text{ cm}^3$ (About 52 ~ 60g)

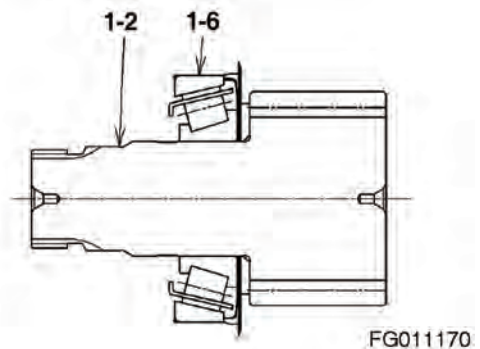


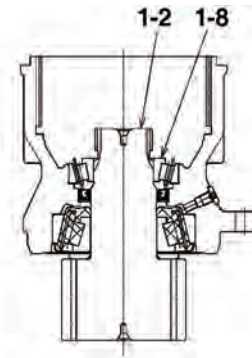
Figure 72

4. Install pinion shaft (1-2, Figure 73) and other associated parts. Install taper roller bearing inner race (1-8, Figure 74).



CAUTION

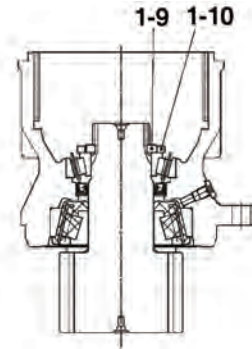
Before assembling pinion shaft (1-2, Figure 73), etc. apply grease to lip of oil seal (1-7, Figure 73).



FG011171

Figure 73

5. Install collar (1-10, Figure 75) and plate (1-9, Figure 74).

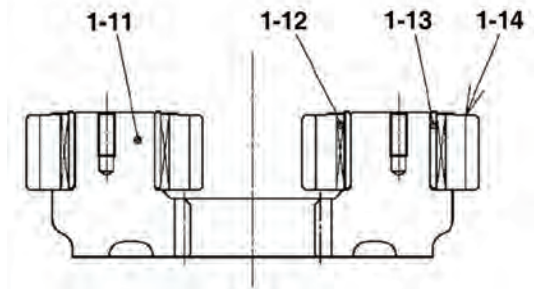


FG011173

Figure 74

6. Install following parts on holder (1-11, Figure 75):

Reference Number	Description
1-12	Inner race
1-13	Needle bearing
1-14	Planetary gear



FG011172

Figure 75

7. Install following parts on holder (1-11, Figure 76):

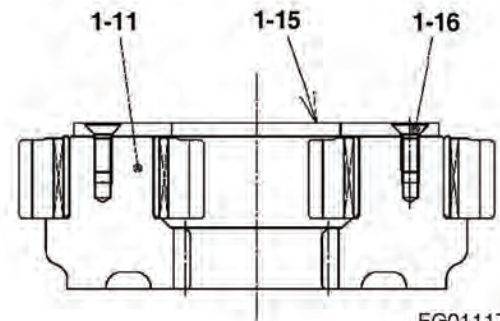
Reference Number	Description
1-15	Thrust plate
1-16	Screw



CAUTION

Apply Loctite 242 to screw before tightening it.

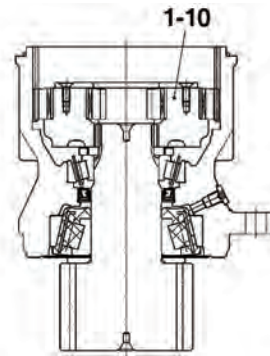
Tightening torque: 3.92 ± 0.49 Nm (2.89 ± 0.36 ft•lb)



FG011174

Figure 76

8. Install holder (1-10, Figure 77) and other associated parts.



FG011175

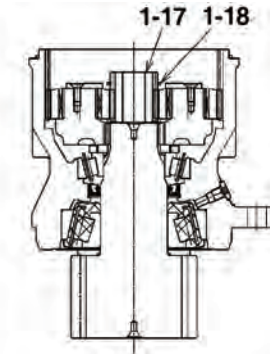
Figure 77

9. Install sun gear (1-17, Figure 78).



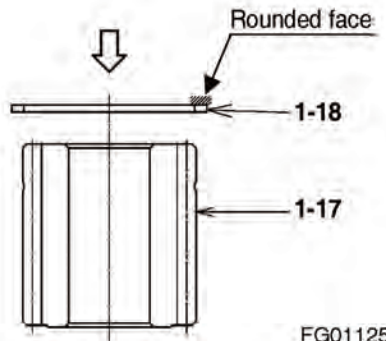
CAUTION

Install sun gear (1-17) with snap ring (1-18) facing as shown in figure.



FG011176

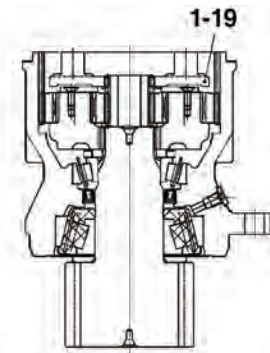
Figure 78



FG011254

Figure 79 Assemble direction of the snap ring

10. Install holder (1-19, Figure 81).



FG011178

Figure 80

11. Install following parts.

Reference Number	Description
1-20	Thrust washer
1-21	Inner race
1-22	Needle bearing
1-23	Planetary gear
1-25	Drive gear
1-24	Thrust plate
1-37	O-ring

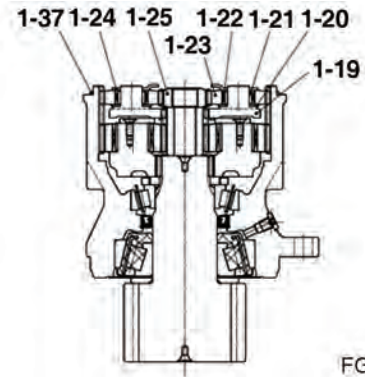


Figure 81



CAUTION

Selection for thrust plate (1-24).

When any consisting parts of reduction unit are changed, select and install thrust plate corresponding to measured value "E" referring to below table.

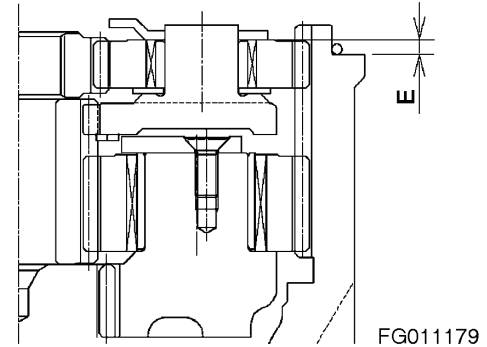


Figure 82

E dimension (measured value)	less than 6.6	6.6 - 7.2	more than 7.2
Part No. of thrust plate 1-23 (Plate thickness)	B0841-23020 (3.2 mm)	B0841-23019 (2.8 mm)	B0841-23018 (2.3 mm)

Assembling whole motor assembly

- Place reduction gear assembly on motor assembly and loosely tighten socket head bolt (3, Figure 83), then tighten it to specified torque.

Tightening torque: 128 ± 7 Nm (94.4 ± 5.2 ft•lb)

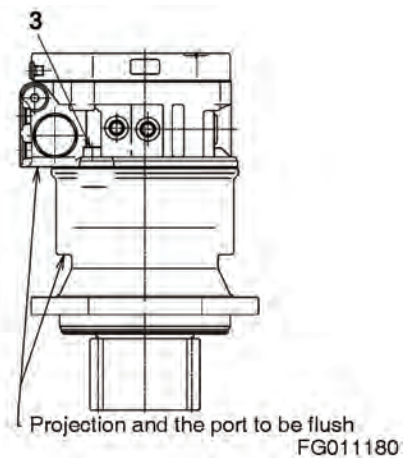


Figure 83

Service Criteria

Replace parts referring to following table.

Motor

Part Name	Service Criteria
(2-13) Piston assembly	The sliding parts are scratched deeply or sliding surface has become rough. The clearance between piston and cylinder block bore is too large. Upper limit of diameter clearance: 0.04 mm. The piston shoe ball is loose excessively. Max. clearance (movement): 0.4 mm
(2-4) Thrust plate (2-11) Retainer holder (2-12) Retainer plate (2-24) Valve plate {(2-15) Brake piston}}	The sliding parts are scratched deeply or sliding surface has become rough. ← {*2 Parking brake spec. only}
(2-5) Cylinder block	The sliding parts are scratched deeply or sliding surface has become rough. The meshing surface is worn excessively or cut.
(2-14) Disk	The disk (friction material) is scratched deeply or peeled. The meshing surface is worn excessively or cut.
(2-2), (2-22) Ball bearings	The rolling contact surface has been flaked or peeled. The rolling contact surface is dented. Bearing rotation produces abnormality (abnormal noise, irregular rotation).
(2-7) Spring	The spring is broken or deformed excessively.
(2-20), (2-26), (2-42), (2-44), (2-46) O-rings {(2-16), (2-17)}	Damage that is likely to cause oil leak, damage that is likely to deteriorate sealing or permanent deformation is noticed. ← {*2 Parking brake spec. only}

Reduction gear

Part Name	Service Criteria
(1-2) Pinion shaft	The gear tooth surface is damaged excessively, worn or flaked.
(1-4), (1-5) Plates	The plate is damaged or worn excessively.
(1-6), (1-8) Taper roller bearings	The roller or race is damaged excessively, dented or flaked. The rotation produces abnormal noise or is not smooth. * To replace bearings, replace body assembly.
(1-7) Oil seal	The lip is damaged, deformed or worn excessively. The lip is hardened.
(1-1) Housing (1-11), (1-19) Holders (1-25) Drive gear (1-17) Sun gear	The gear tooth surface is damaged excessively, worn or flaked. *To replace housing, replace body assembly.

Part Name	Service Criteria
(1-12), (1-21) Inner races	The rolling contact surface of needle bearings is damaged excessively or worn or flaked.
(1-13), (1-22) Needle bearings	The surface of needle bearings is damaged excessively or worn or flaked.
(1-14), (1-23) Planetary gears	The gear tooth surface is excessively damaged, worn or flaked. The rolling contact surface in contact with needle bearing is excessively damaged, worn or flaked.
(1-15), (1-24) Thrust plates	The sliding surface is excessively damaged, worn or seized.

Valve

Part Name	Service Criteria
(2-38-14) Piston (2-1) Case	The sliding surface is damaged deeply or rough. The clearance between piston and case hole is large. Upper limit of diameter clearance: 0.04 mm
(2-40) Spring {(2-35) Spring}	The spring is broken or deformed excessively. ← {*3: Hydraulic timer spec. only}
(2-41), (2-38-6) Plugs (2-39) Check valve (2-38-8, 9, 10, 11), (2-42) O-rings (2-38-12, 13) Backup rings {(2-29-2, 3, 4), (2-36) O-rings, (2-37) Plug}	Damage that is likely to cause oil leak, damage that is likely to deteriorate sealing or permanent deformation is noticed. ← {*3: Hydraulic timer spec. only}

Others

Part Name	Service Criteria
Other plugs and O-rings	Damage that is likely to cause oil leak, damage that is likely to deteriorate sealing or permanent deformation is noticed.

Travel Motor

Edition 1

MEMO

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MEMO

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.

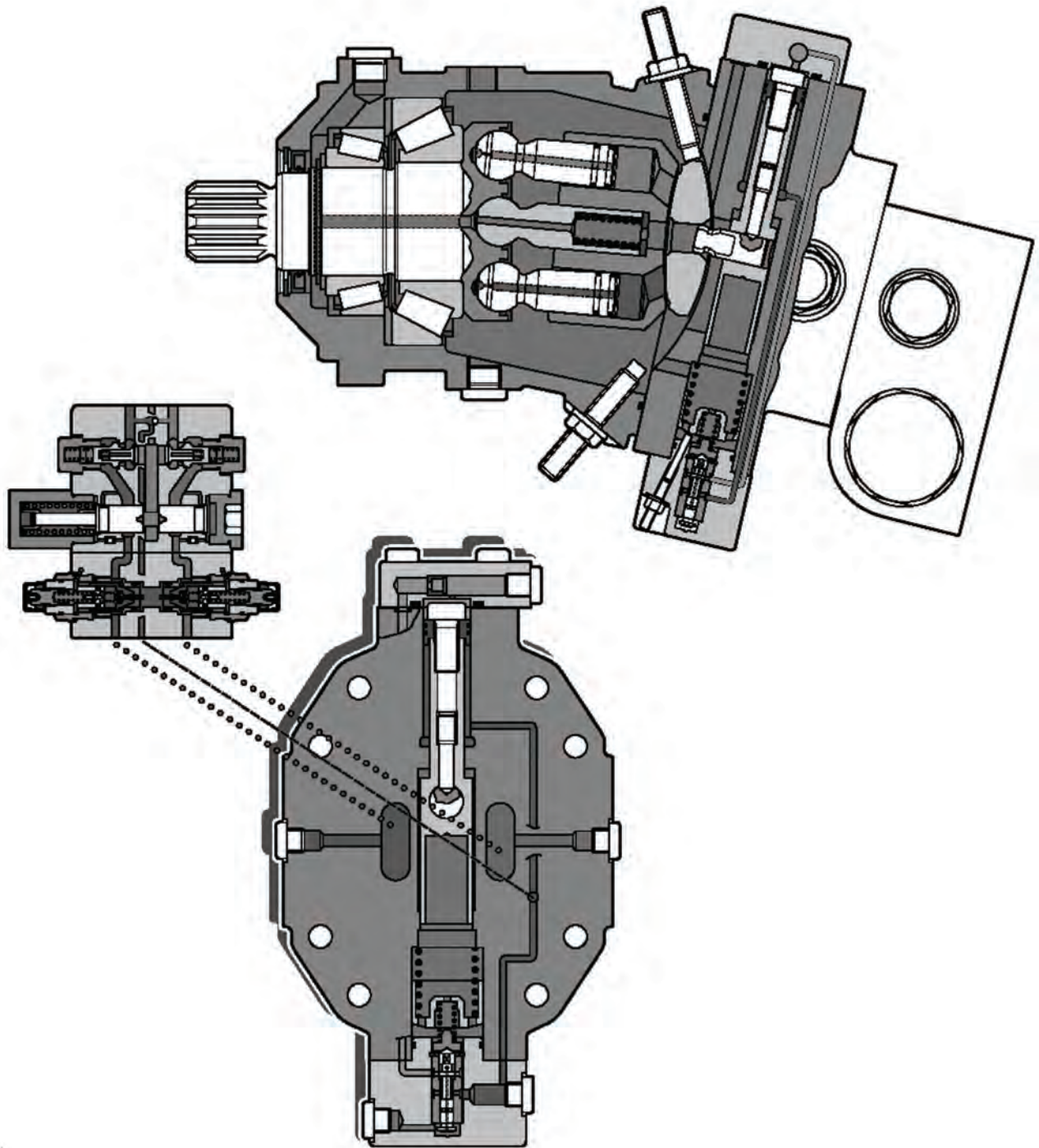
Use lifting and hoisting equipment capable of safely handling load.

Remember, that ultimately 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
DX55W	5001 and Up
DX140W	5001 and Up
DX160W	5001 and Up
DX190W	5001 and Up
DX210W	5001 and Up



FG002964

Figure 1

GENERAL REPAIR GUIDELINES

CAUTION!

Observe the following notices when carrying out repair work at hydraulic aggregates.

1. Close all ports of the hydraulic aggregates.



Figure 2

HB7M3002

2. Replace all seals.
Use only original Hydromatik spare parts.

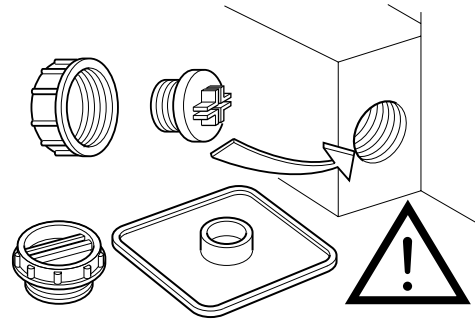


Figure 3

HB7M3003

3. Check all seal and sliding surfaces for wear.

CAUTION!

Rework of sealing area f. ex. with abrasive paper can damage surface.

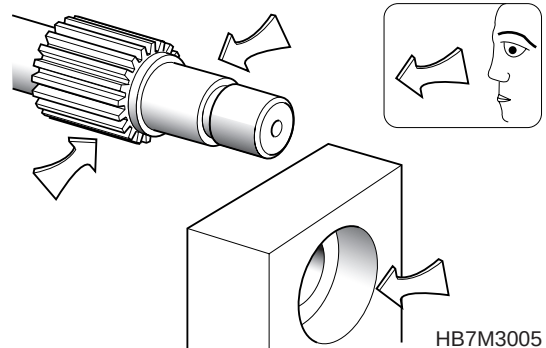


Figure 5

HB7M3005

4. Fill up hydraulic aggregates with hydraulic oil before start-up.

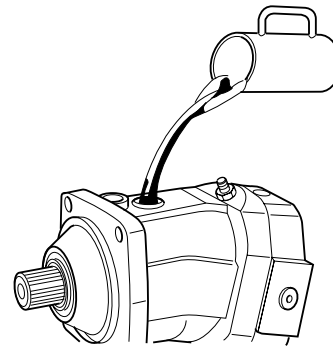


Figure 6

HB7M3006

SEAL KITS AND SUB-ASSEMBLIES

1. Seal Kit for Drive Shaft.

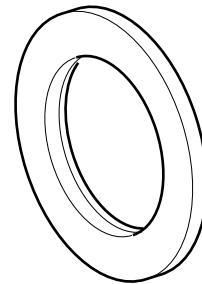


Figure 7

HB7M3007

2. External Seal Kit

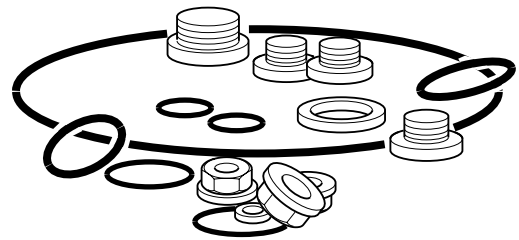


Figure 8

HB7M3008

3. Housing

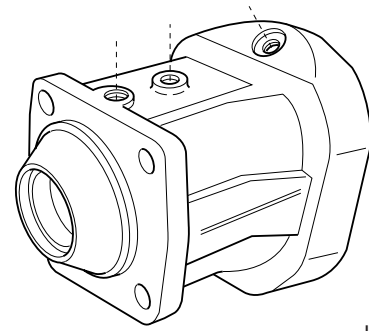


Figure 9

HB7M3009

4. Complete Rotary Group

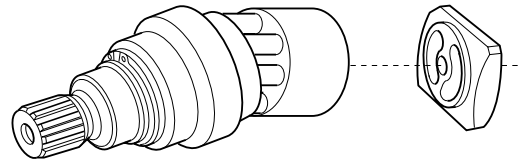


Figure 10

HB7M3010

5. Port Plate with Control Piston

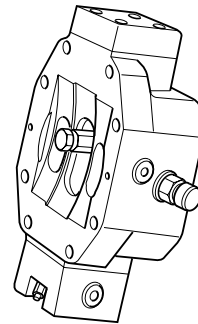


Figure 11

HB7M3011

6. Counter-balance Valve

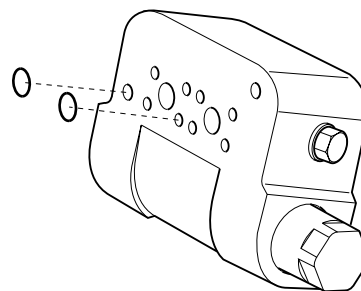


Figure 12

HB7M3012

7. Relief Valve / Make up Check Valve

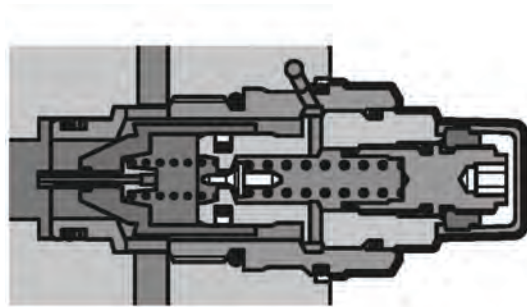


Figure 13

Replace Seal Nut

1. Replace seal nut.
First measure and record setting height.

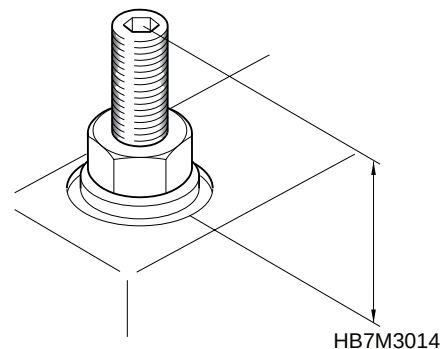


Figure 14

2. When tightening, counterhold setting screw, then check setting height.

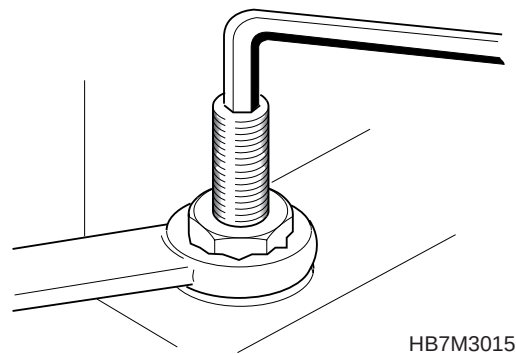
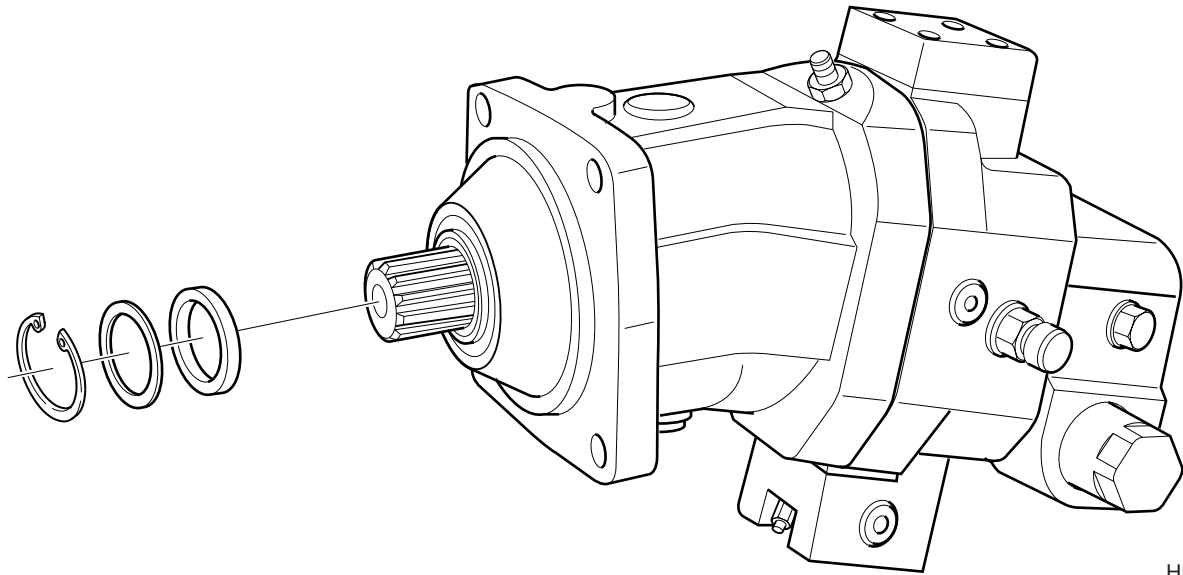


Figure 15

DISASSEMBLY

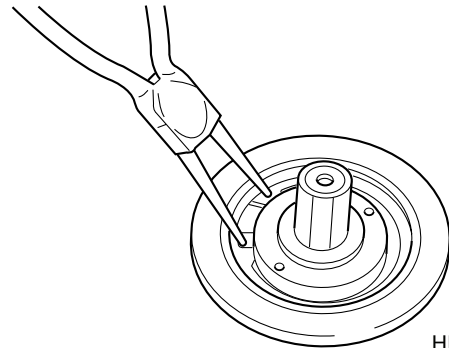
Sealing the Drive Shaft



HB7M3016

Figure 16

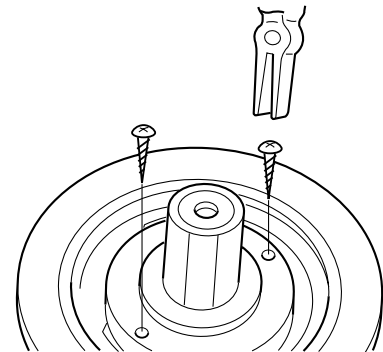
1. Protecting the drive shaft.
Remove retaining ring and shim.



HB7M3017

Figure 17

2. Screw in sheet metal screw into the holes fitted with rubber.
Pull out seal with pliers.



HB7M3018

Figure 18

3. Press in shaft seal and shim with bush to stop.



CAUTION!

Pay attention to pressing depth



CAUTION!

Mark for pressing depth.

Assemble retaining ring.

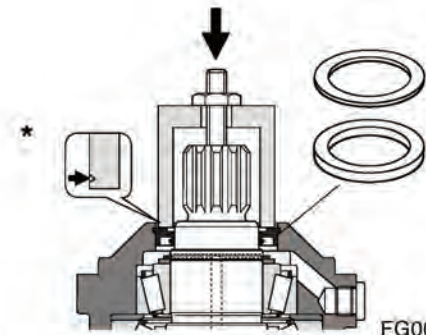
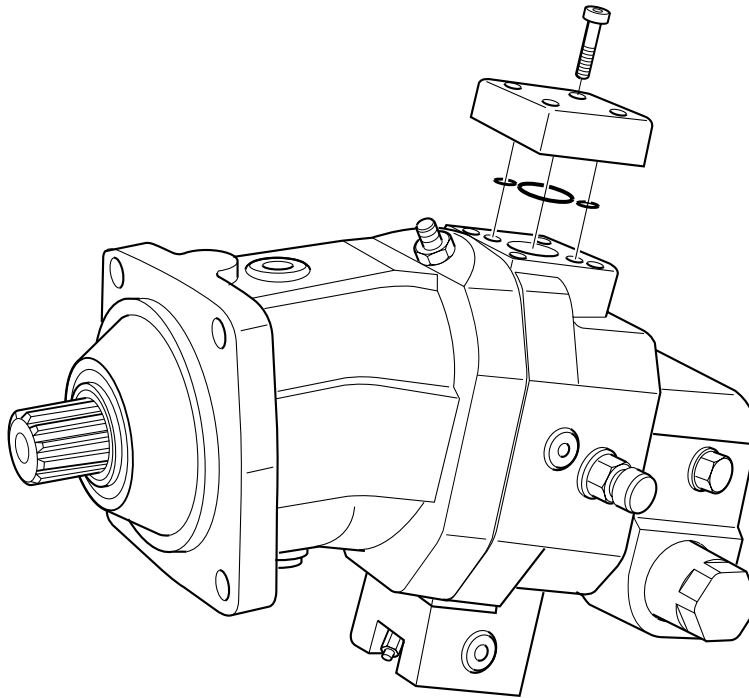


Figure 19

FG002982

Seal of the Control Parts



HB7M3020

Figure 20

4. Disassembly position:
Remove cover pos. 1

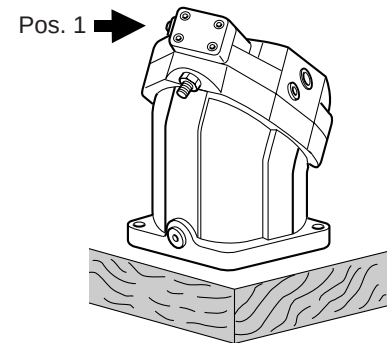


Figure 21

FG007441

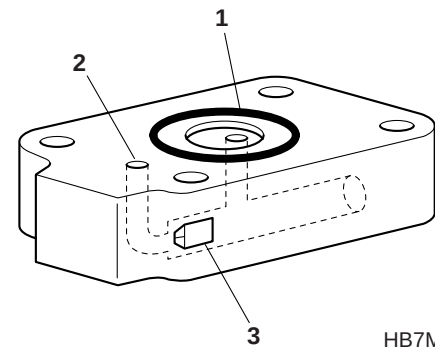
Reference Number	Description
1	O-ring
2	Input Flow of Oil Control
3	Throttle Pin



CAUTION!

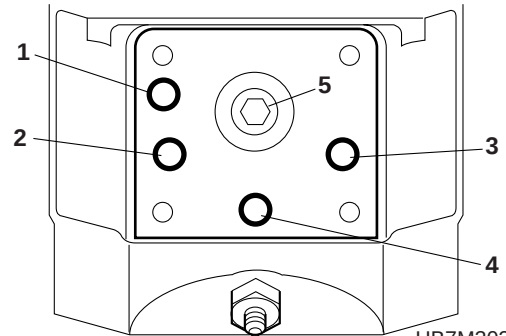
Installation position differs according to the control components

Reference Number	Description
1	Input Flow of Oil Control
2	High Pressure / Low Pressure
3	High Pressure / Low Pressure
4	Leakage Oil
5	Control Piston



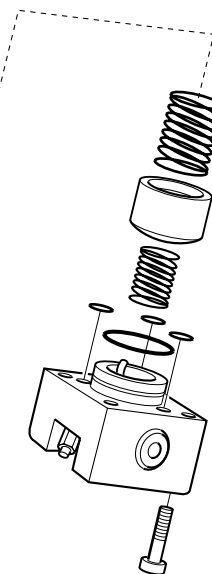
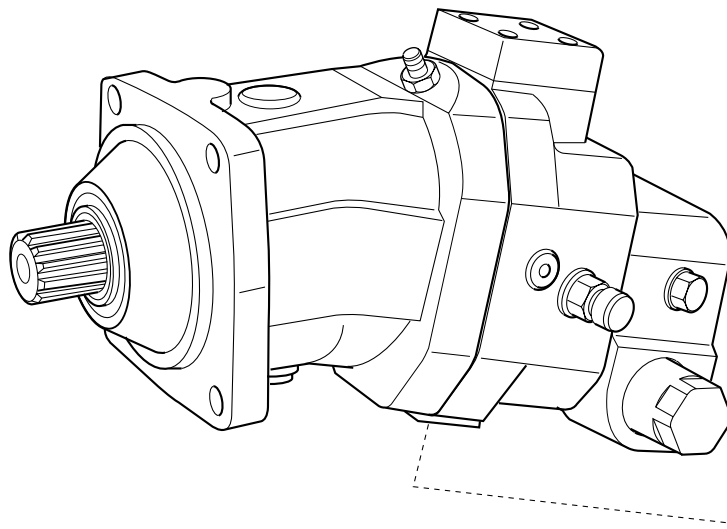
HB7M3022

Figure 22



HB7M3023

Figure 23



HB7M3024

Figure 24

5. Disassembly position: Remove cover pos. 2.



CAUTION!

Attention! Spring load.

Dimension x : Note dimension (begin of regulation).

Reference Number	Description
1	Check of O-ring

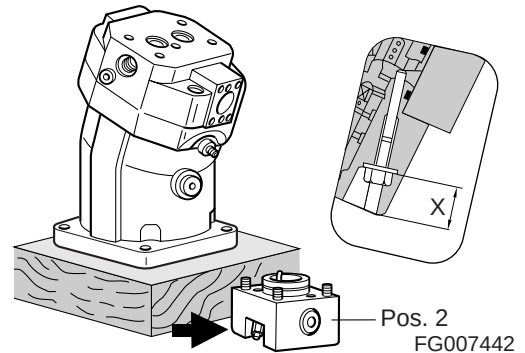
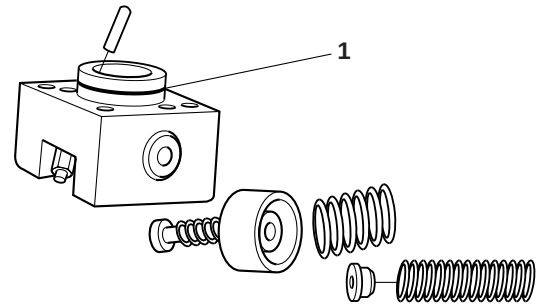


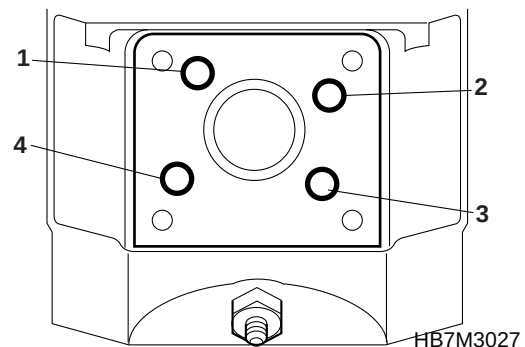
Figure 25



HB7M3026

Figure 26

Reference Number	Description
1	O-ring / High Pressure - Small Control Piston Side
2	O-ring / Control Pressure
3	O-ring / High Pressure - Check Valve
4	O-ring / High Pressure - Check Valve

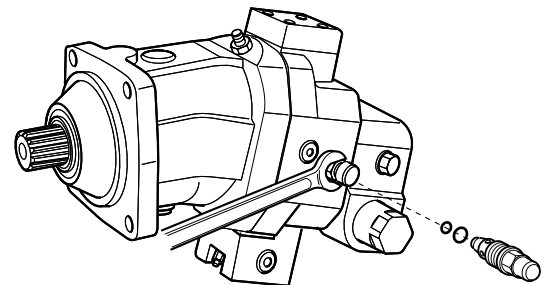


HB7M3027

Figure 27

Seal of the Relief Valve / Counter-balance Valve

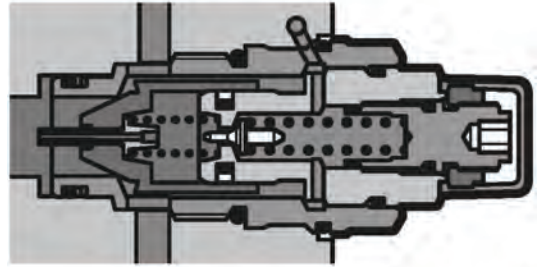
1. Remove relief valve.



HB7M3028

Figure 28

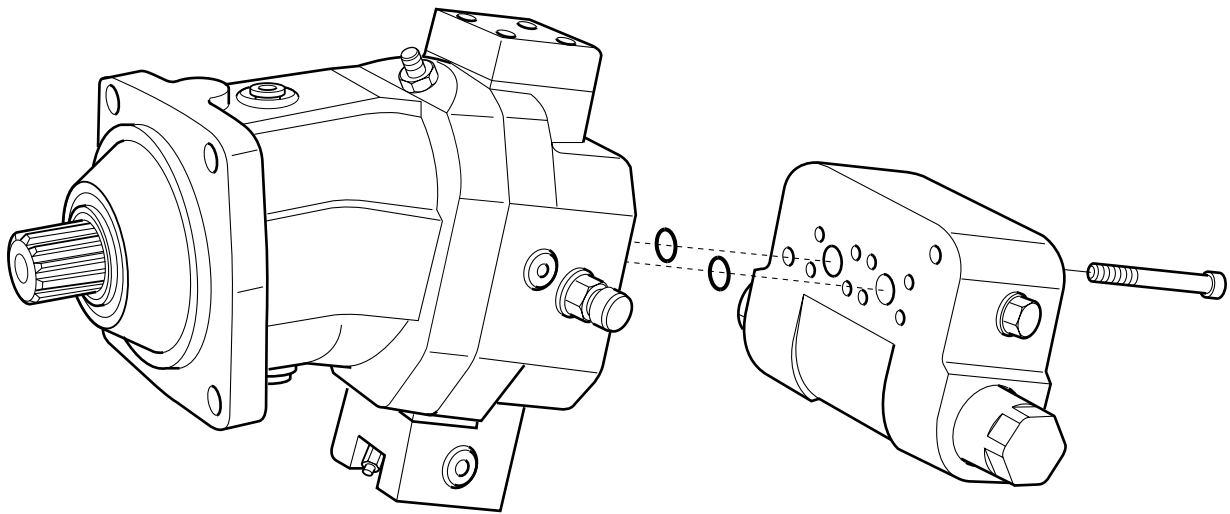
2. Inspect!
O-ring



FG002992

Figure 29

3. Remove counter-balance valve Inspect!
O-ring

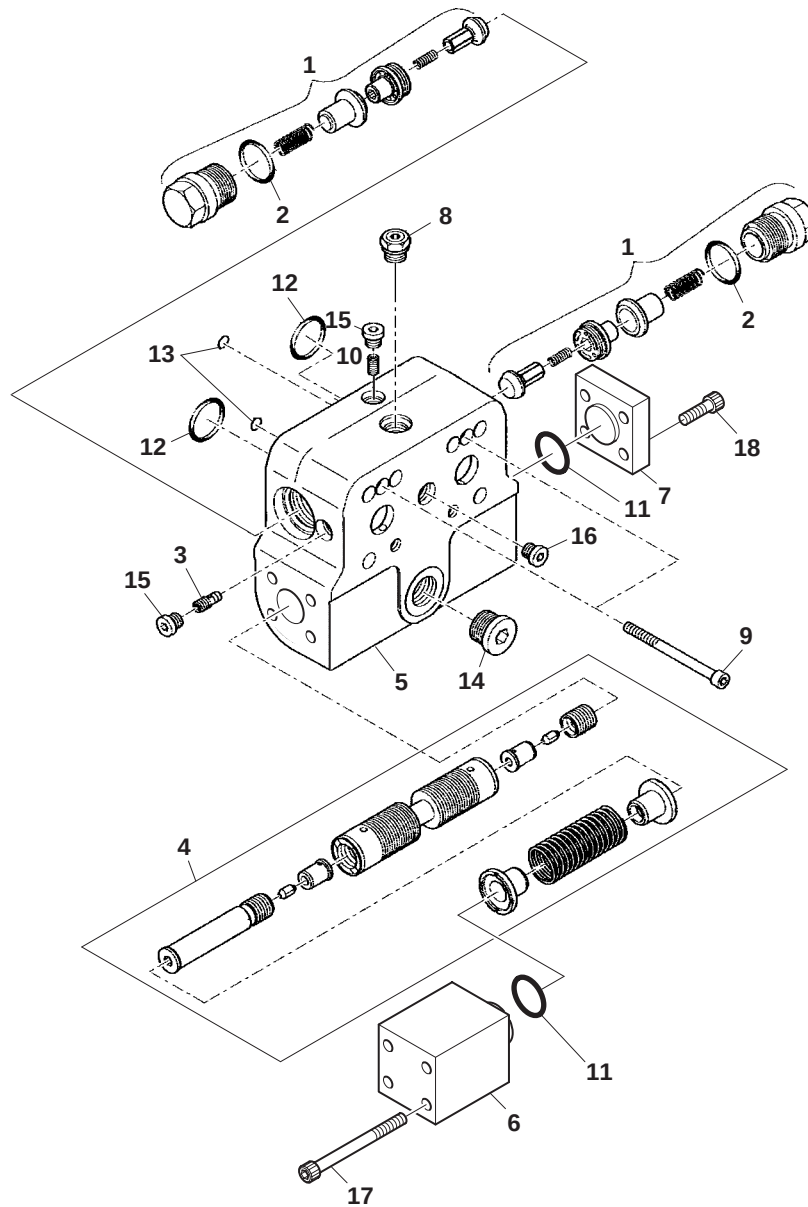


HB7M3030

Figure 30

Spare Parts List

Counter-balance Valve



FG008821

Figure 31

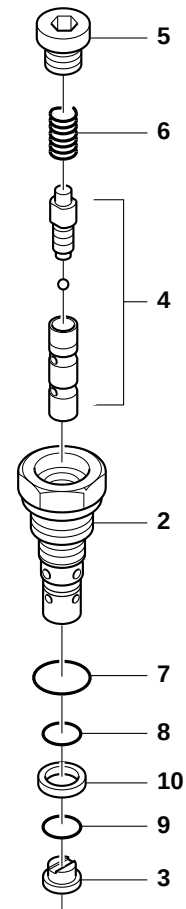
Reference Number	Description
1	Valve
2	O-ring
3	Shuttle Valve
4	Brake Valve
5	Housing
6	Cover
7	Cover
8	Plug
9	Socket Bolt

Reference Number	Description
10	Plug
11	O-ring
12	O-ring
13	O-ring
14	Plug
15	Plug
16	Screw
17	Socket Bolt
18	Socket Bolt

Brake Release Valve (Pos.50)

- These parts are not available separately.

Reference Number	Description
2	Guide
3	Sleeve
4	Spool
5	Screw plug
6	Spring
7	O-ring
8	O-ring
9	O-ring
10	Thrust Ring



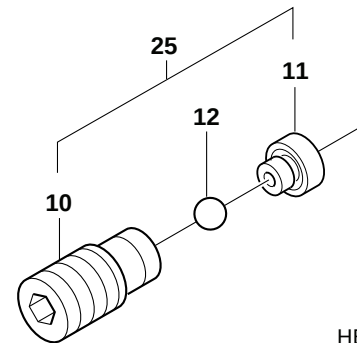
HB7M3032

Figure 32

Shuttle Valve (Pos.25)

- These parts are not available separately.

Reference Number	Description
10	Valve Seat
11	Valve Seat
12	Ball



HB7M3033

Figure 33

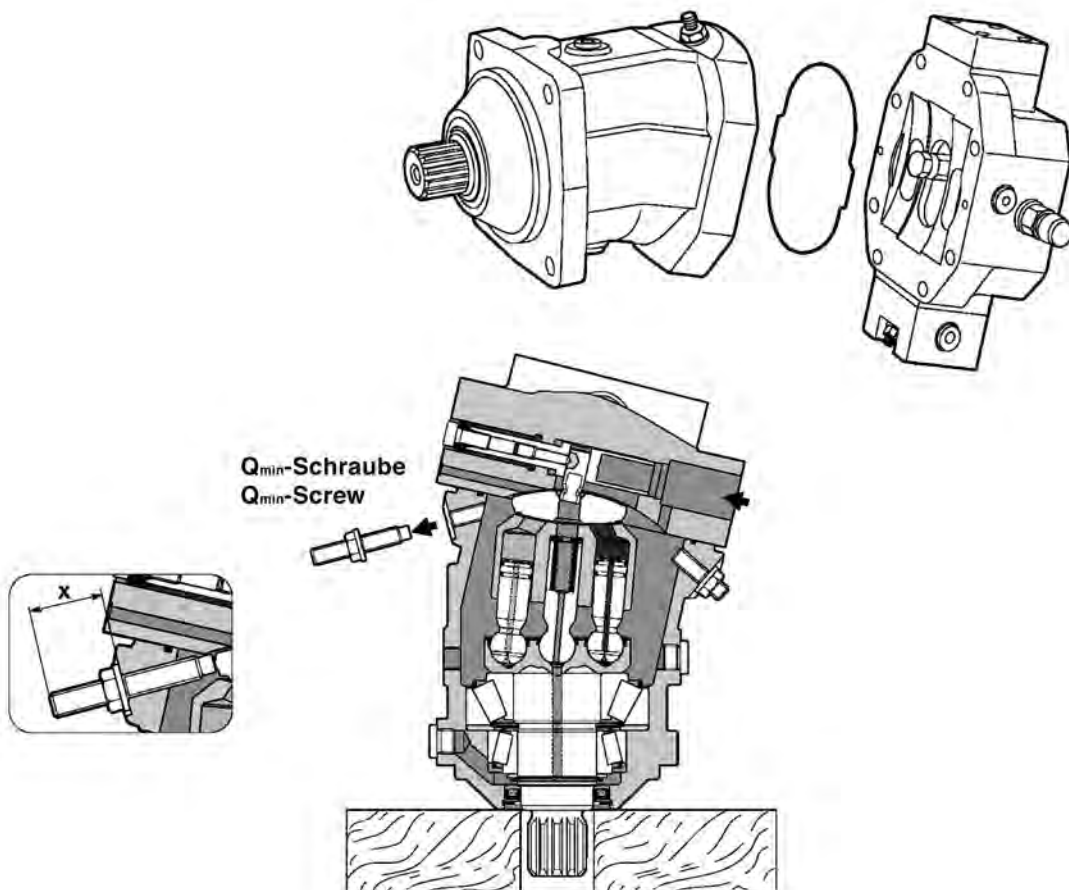
Diassembly of the Port Plate

1. Note dimension x.
Remove Qmin-screw.
Swivel rotary group to zero position.



For diassembly of the port plate, swivel always rotary group to zero position.

Piston rings to hang out of the cylinder boring.



FG002997

Figure 34

2. Port plate
Mark position. Loosen screws.
Removal

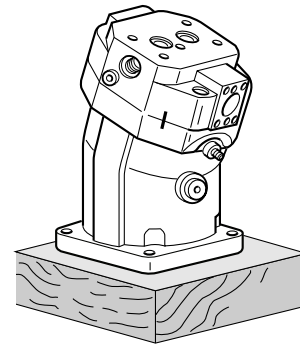


Figure 35

HB7M3035

3. Check O-ring.



Stick new O-ring with some grease.

Do not swivel rotary group.

Piston rings to hang out from the cylinder boring.

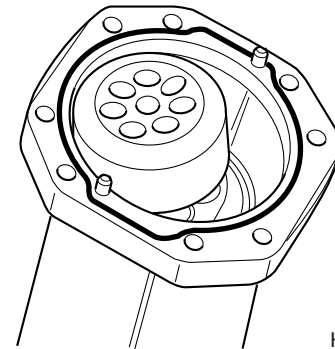


Figure 36

HB7M3036

Remove of the Positioning Piston

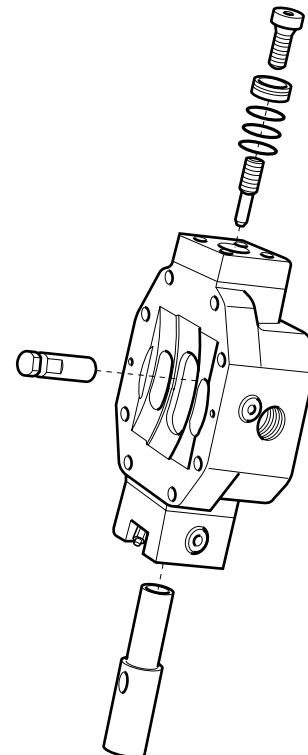


Figure 37

HB7M3037

1. Loosen fixing screw.
Use only socket wrench.

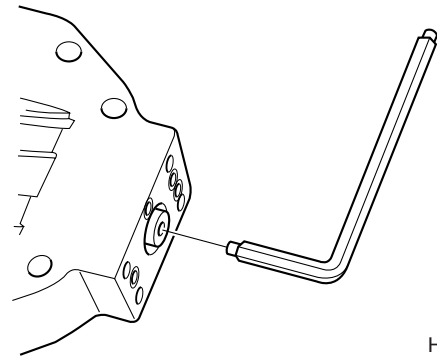


Figure 38

HB7M3038

2. Remove piston with piston ring

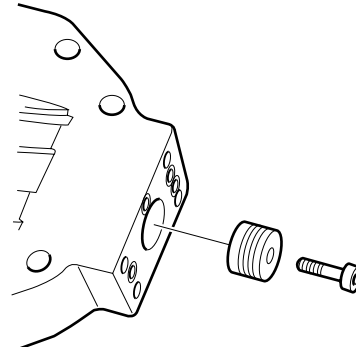


Figure 39

HB7M3039

3. Warm up fixation screw * for positioning plug
via boring (screw glued - to turn out).

! CAUTION!

Use new screw.

Precote coating.

Note tightening torque!

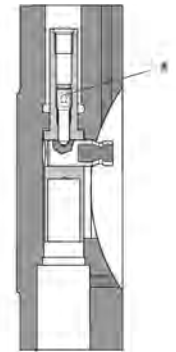


Figure 40

FG003023

! CAUTION!

Stick control lens in sliding surface with grease.

Assembly in reversal order.

Mount port plate.

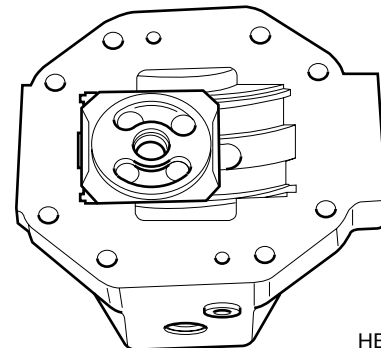


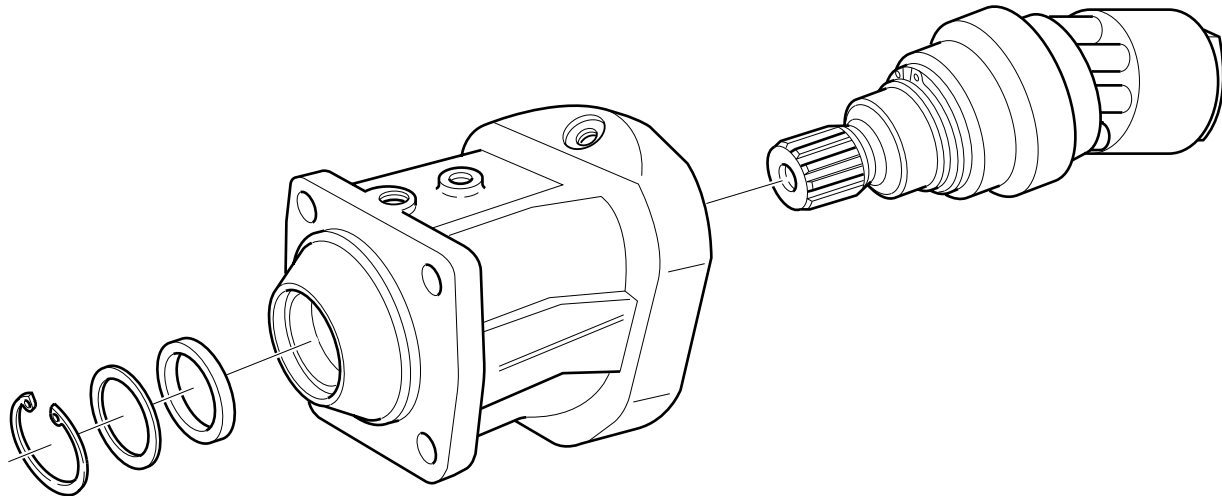
Figure 41

HB7M3041

! CAUTION!

Rotary group vertical.

Remove Rotary Group

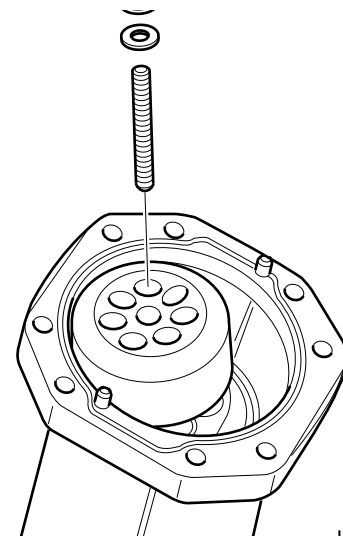


HB7M3042

Figure 42

1. Screw in threaded pin into center pin.
Fix the cylinder with disc and locknut.

Size	28	: M4 x 58 mm
	55	: M5 x 71 mm
	80	: M6 x 82 mm
	107	: M6 x 92 mm
	140	: M8 x 105 mm
	160	: M8 x 105 mm
	200	: M8 x 109 mm



HB7M3043

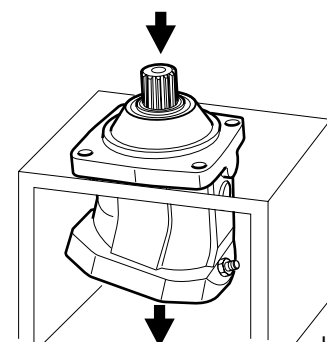
Figure 43

2. Press out rotary group!



CAUTION!

If the bearings are used again
do not hit on the drive shaft.



HB7M3044

Figure 44

3. Complete rotary group

Exchanging of the Rotary Group



Setting of hydraulic part necessary.

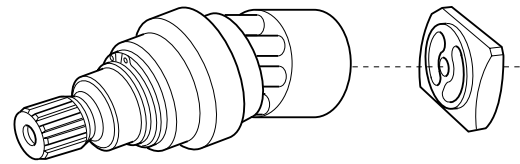


Figure 45

HB7M3010

1. Rotary group
 - A. Mechanical part: Adjust drive shaft with bearing.
 - B. Hydraulic part:



Adjustment necessary.

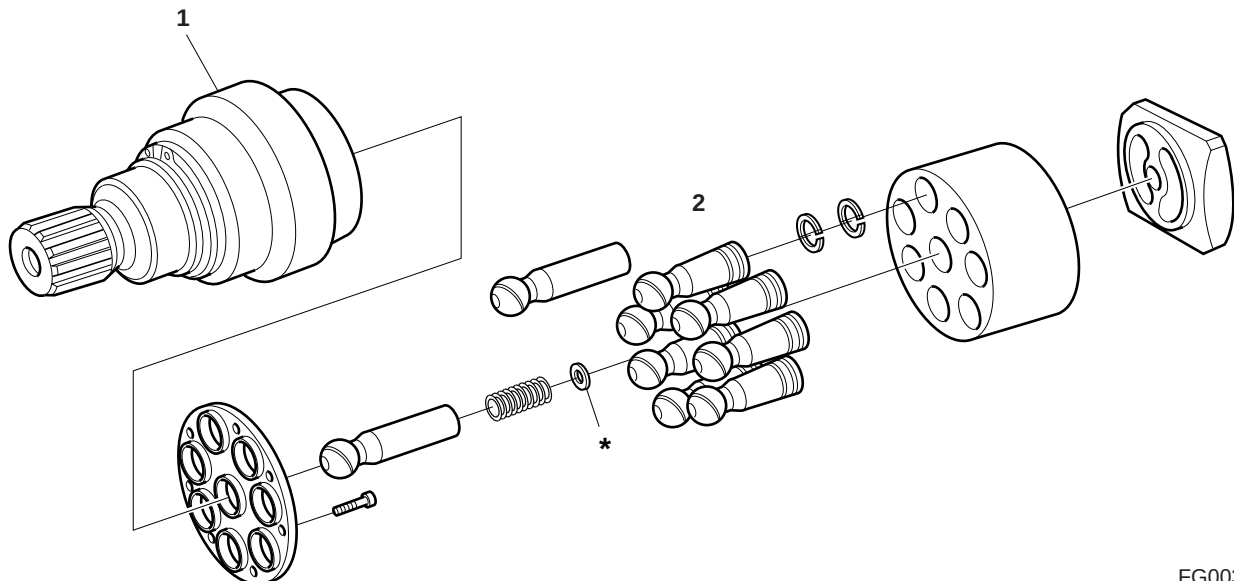


Figure 46

FG003029

2. Remove fixing screw (cylinder).
Remove cylinder.

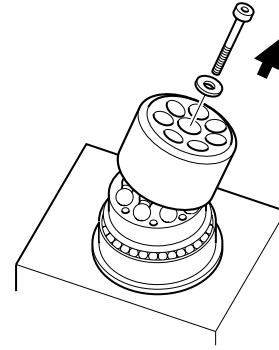


Figure 47

HB7M3047

3. Disassemble retaining plate.



CAUTION!

Screws are glued.

Use Torx-tools.

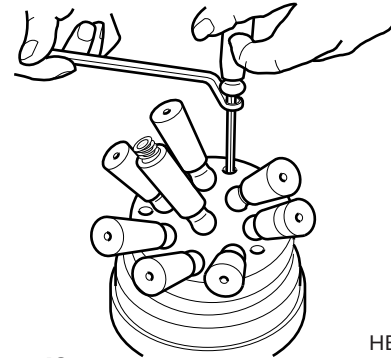


Figure 48

HB7M3048

Inspection Notes

1. Free of corrosion, erosion or fretting; no damage to splines or keyways.

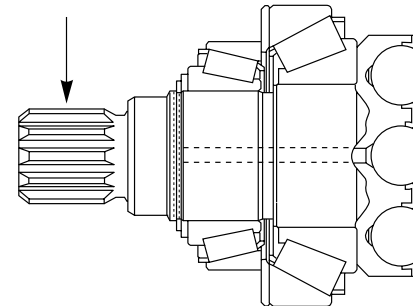


Figure 49

HB7M3049

2. Pistons
No scoring and no pittings.

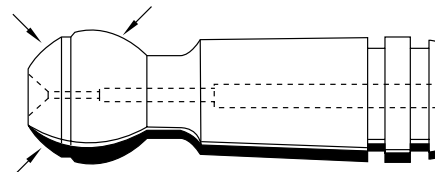


Figure 50

HB7M3050

3. Center pin
No scoring and no pittings.

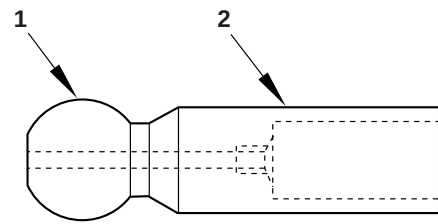


Figure 51

HB7M3051

4. Retaining plate
No scoring and no evidence of wear

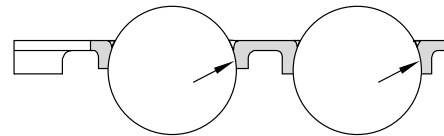


Figure 52

HB7M3052

5. Cylinder block / control lens
- A. Bores free of scoring, no evidence of wear.
 - B. Faces smooth and even, free of cracks and scoring.

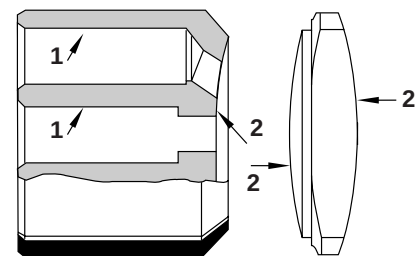


Figure 53

HB7M3053

6. Control housing Sliding surface and side guides free of scoring and no wear.

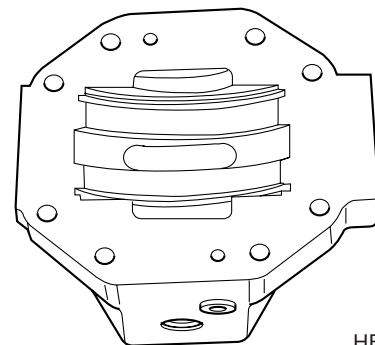
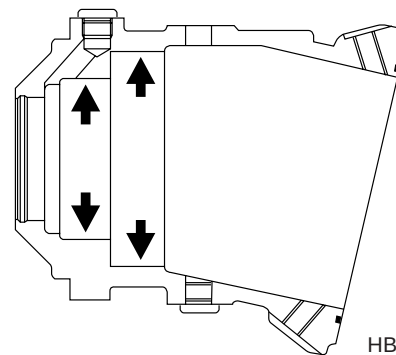


Figure 54

HB7M3054

7. Visual check:
Bearing areas free of scoring and no evidence of wear.



HB7M3055

Figure 55

ASSEMBLY

Rotary Group Assembly

1. Rotary group completely assembled ready for assembly.

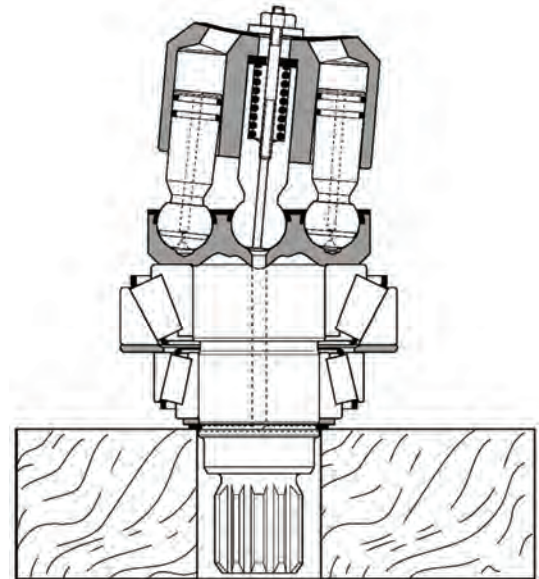


Figure 56

FG003039

2. Place assembly sleeve.

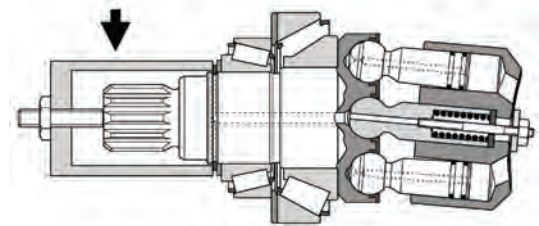


Figure 57

FG003040

3. Warm up housing to 80° C.

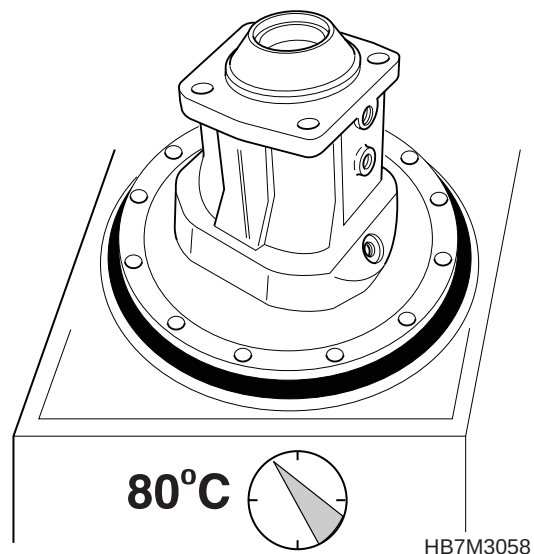


Figure 58

4. Insert rotary group into housing to seat position.

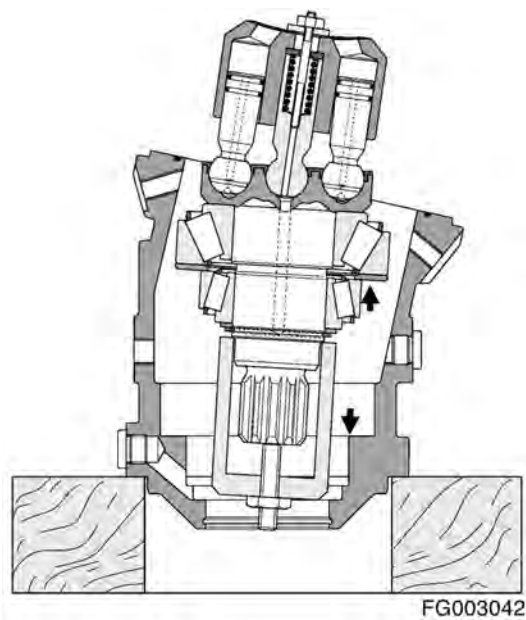


Figure 59

5. Fix zero position of cylinder with Qmax-screw.
 - A. Disassemble cylinder fixing screw.
 - B. Insert O-ring.

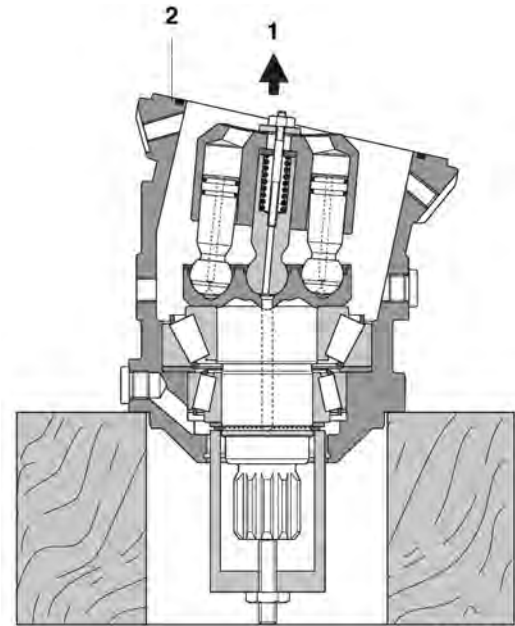


Figure 60

FG003043

Rotary Group Adjustment (See Service Information)

1. Determine cylinder swivel range to max. angle with screw.

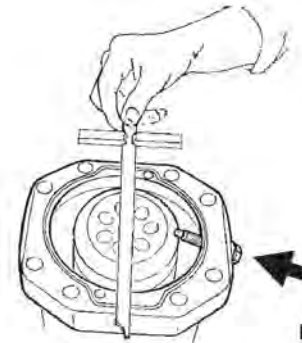


Figure 61

FG003044

2. * Disc

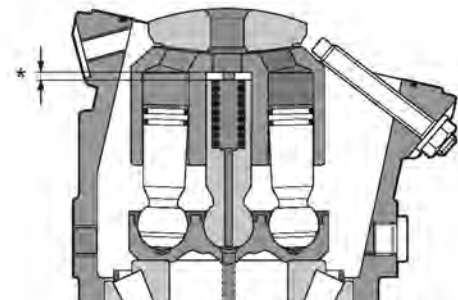
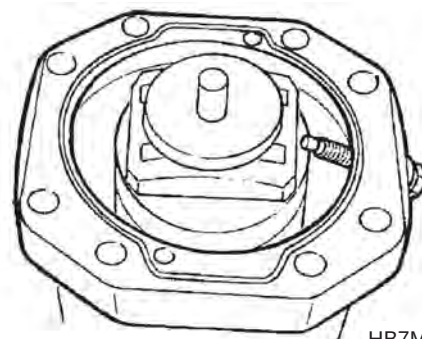


Figure 62

FG003045

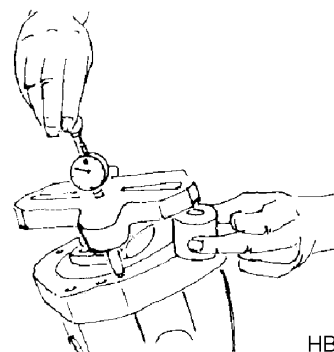
3. Place centering disc.



HB7M3063

Figure 63

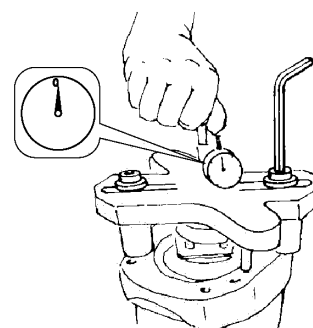
4. Mount measuring device.



HB7M3064

Figure 64

5. Check dimension X.



HB7M3065

Figure 65

Assembly of the Port Plate

1. Assemble port plate.

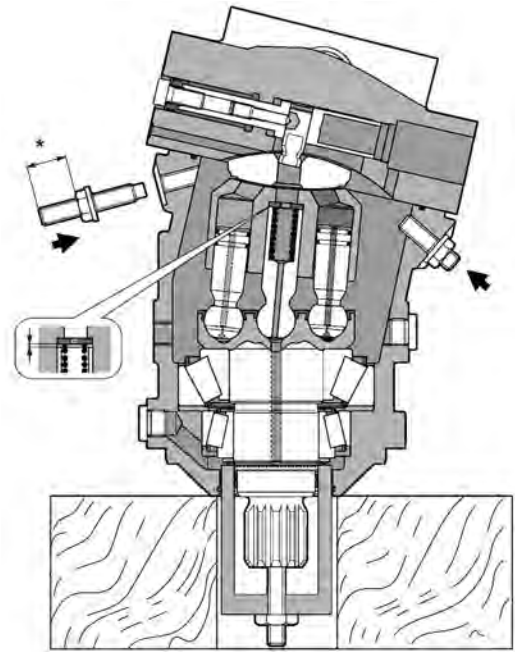


CAUTION!

Take care of assembly design.

Tighten fixing screws with torque.

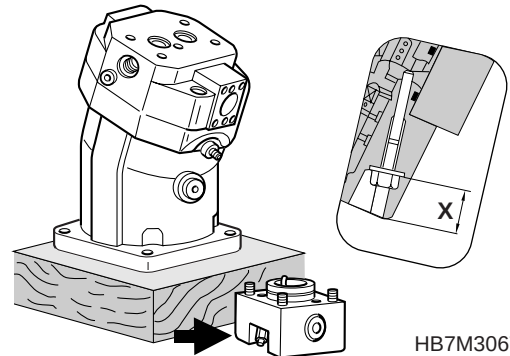
2. Set Qmin -screw to dimension*.
3. Assemble plug.
4. Remove assembly sleeve.



FG003049

Figure 66

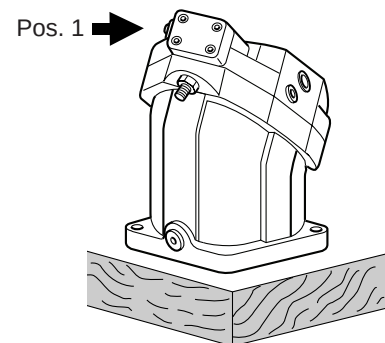
5. Assemble control components.
Assemble cover.



HB7M3067

Figure 67

6. Assemble cover.



FG007441

Figure 68

7. Assemble shaft seal, disc and safety ring.
Press-in with assembly sleeve.



CAUTION!

Take care of press-in depth.

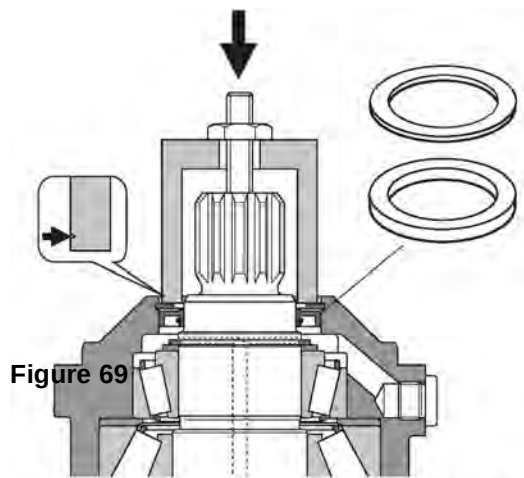
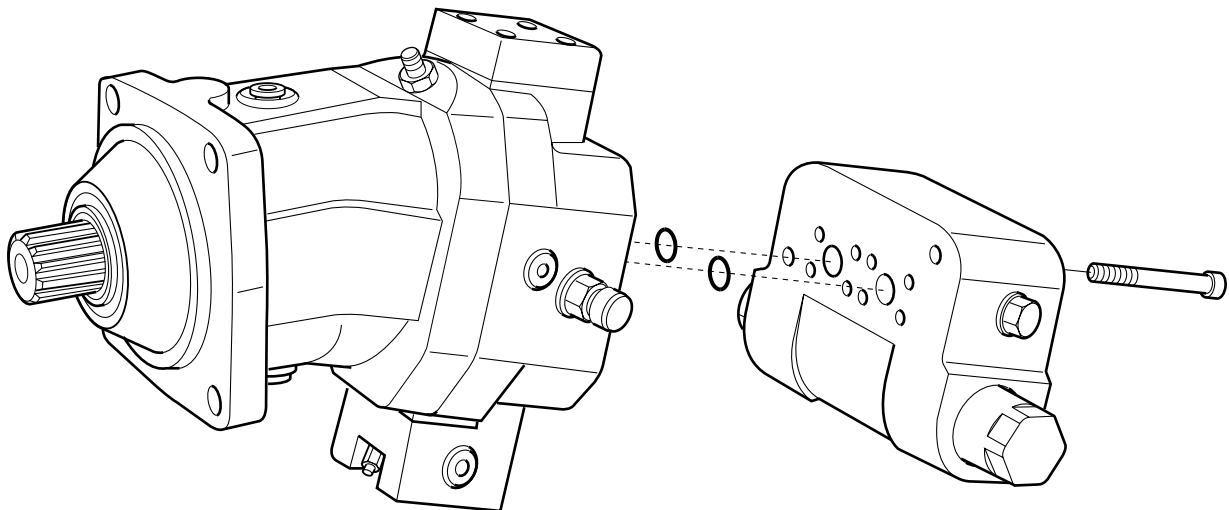


Figure 69

FG003052

Figure 69

8. Assemble counter-balance valve



HB7M3030

Figure 70

TIGHTENING TORQUES

Shaft Bolts

(Metric ISO Standard Thread)

The values for tightening torques shown in the table are valid only for shaft bolts with metric ISO- standard threads and head support surface dimensions in accordance with DIN 912, DIN 931 and DIN 933. These values are also valid only for light or uncoiled, untreated surface as well as for use only with torque-indicating wrenches and force limiting tools.	Thread Size	Strength Classes		
		8.8	10.9	12.9
		Tightening Torque (lb.ft)		
	M 3	0.8	1.2	1.4
	M 4	2.1	3.0	3.6
	M 5	4.4	6.3	7.4
	M 6	7.4	10.3	12.5
	M 8	18.4	25.8	30.2
	M10	36.1	50.9	61.2
	M12	63.4	88.4	106.9
	M14	99.5	140.0	169.5
	M16	154.8	217.4	261.6
	M18	213.7	298.5	357.4
	M 20	302.2	427.5	508.5
	M 22	405.4	574.9	685.4
	M 24	523.5	737.0	884.4
	M 27	773.9	1105.5	1326.6
	M 30	1068.7	1474.0	1768.8

Locking Screws VSTI

(Metric ISO fine thread)

Thread Size	Designation		Tightening Torque (lb.ft)
M 8 x 1	VS.TI 8 x 1	-ED/SA	= 4
M 10 x 1	VSTI 10 x1	-ED	= 7
M 12 x 1.5	VSTI 12 x 1.5	-ED	= 15
M 14 x 1.5	VSTI 14 x 1.5	-ED	= 22
M 16 x 1.5	VSTI 16 x 1.5	-ED/SA	= 22
M 18 x 1.5	VSTI 18 x 1.5	-ED/SA	= 29
M 20 x 1.5	VSTI 20 x 1.5	-ED/SA	= 37
M 22 x 1.5	VSTI 22 x 1.5	-ED	= 44
M 26 x 1.5	VSTI 16 x 1.5	-ED/SA	= 51
M 27 x 2	VSTI 27 x 2	-ED	= 66
M 30 x 1.5	VSTI 30 x 1.5	-ED/SA	= 74
M 33 x 2	VSTI 33 x 2	-ED/SA	= 88
M 42 x 2	VSTI 42 x 2	-ED/SA	= 147
M 48 x 2	VSTI 48 x 2	-ED	= 220

Seal-Lock Nuts

(Metric ISO-Standard Thread)

The values for tightening torques shown in the table are valid only for seal-lock nuts of the strength class 8.8 and with metric ISO-standard thread.	Thread Size	Strength Classes		
		8.8	10.9	12.9
		Tightening Torque (lb.ft)		
	M 6	7.4		
	M 8	16.2		
	M 10	29.5		
	M 12	50.9		
	M 14	81.1		
	M 16	125.3		

Cross-slotted Lens Head Screws DIN 7985

(Metric ISO- Standard Thread)

The values for tightening torques shown in the table are valid only for cross-slotted lens head screws DIN 7985 of the strength class 8.8 and with metric ISO-standard thread.	Thread Size	Strength Classes		
		8.8	10.9	12.9
		Tightening Torque (lb.ft)		
	M 3	0.8		
	M 4	2.1		
	M 5	4.4		
	M 6	7.4		
	M 8	18.4		
	M10	36.1		

Steering Valve

Edition 1

MEMO

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Steering Valve

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MEMO

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 ultimately safety is your own personal responsibility.

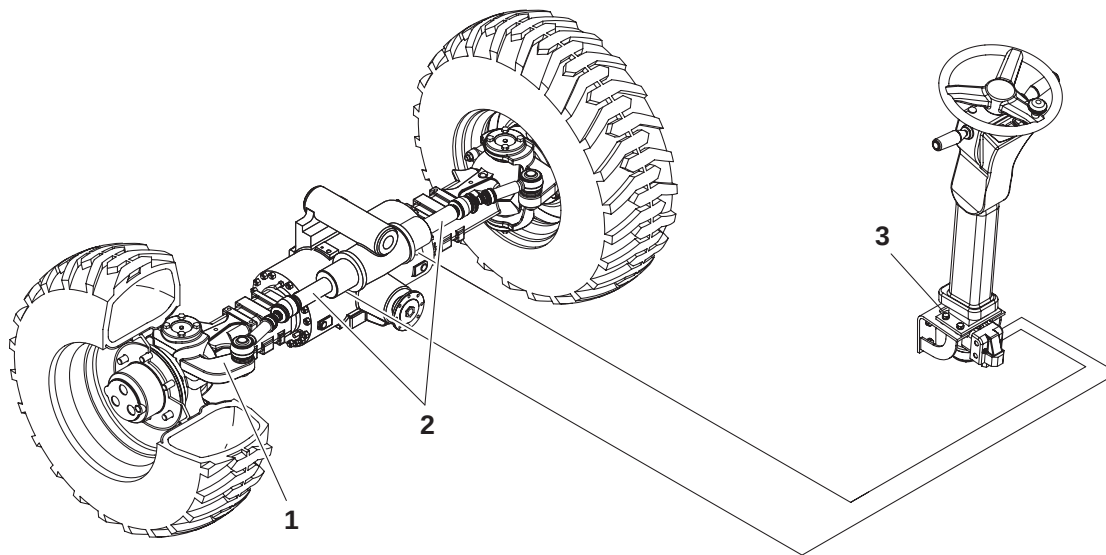
APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

GENERAL DESCRIPTION

Turning the steering wheel causes hydraulic oil to be sent from the steering gear type pump to the steering valve which directs oil to the steering cylinders.

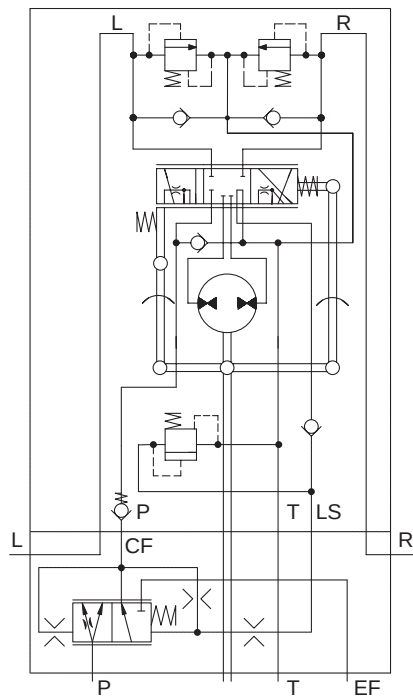


FG012368

Figure 1

Reference Number	Description
1	Knuckle Arm
2	Steering Cylinder

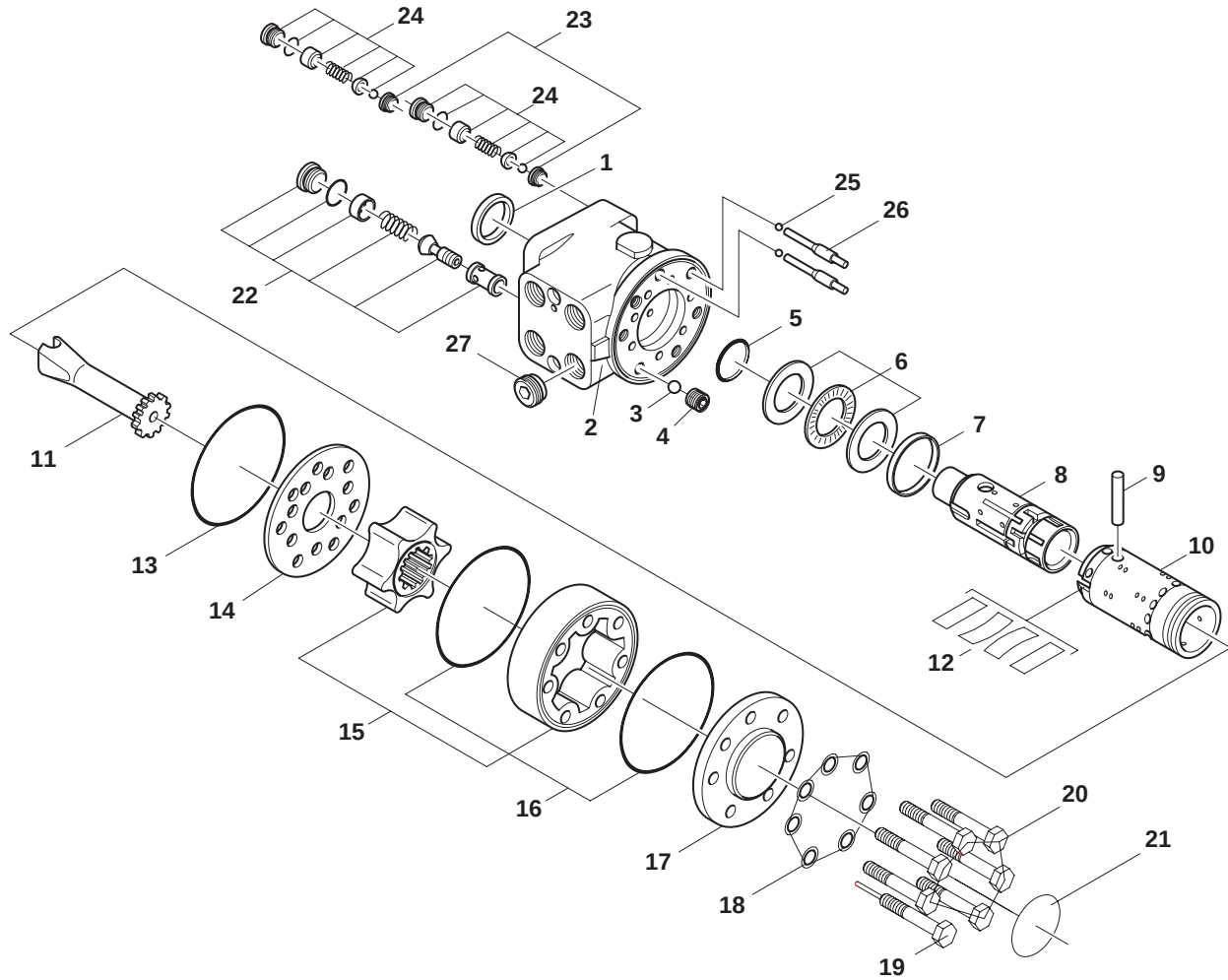
Reference Number	Description
3	Steering Valve



FG011069

Figure 2

OSPC/OLSA

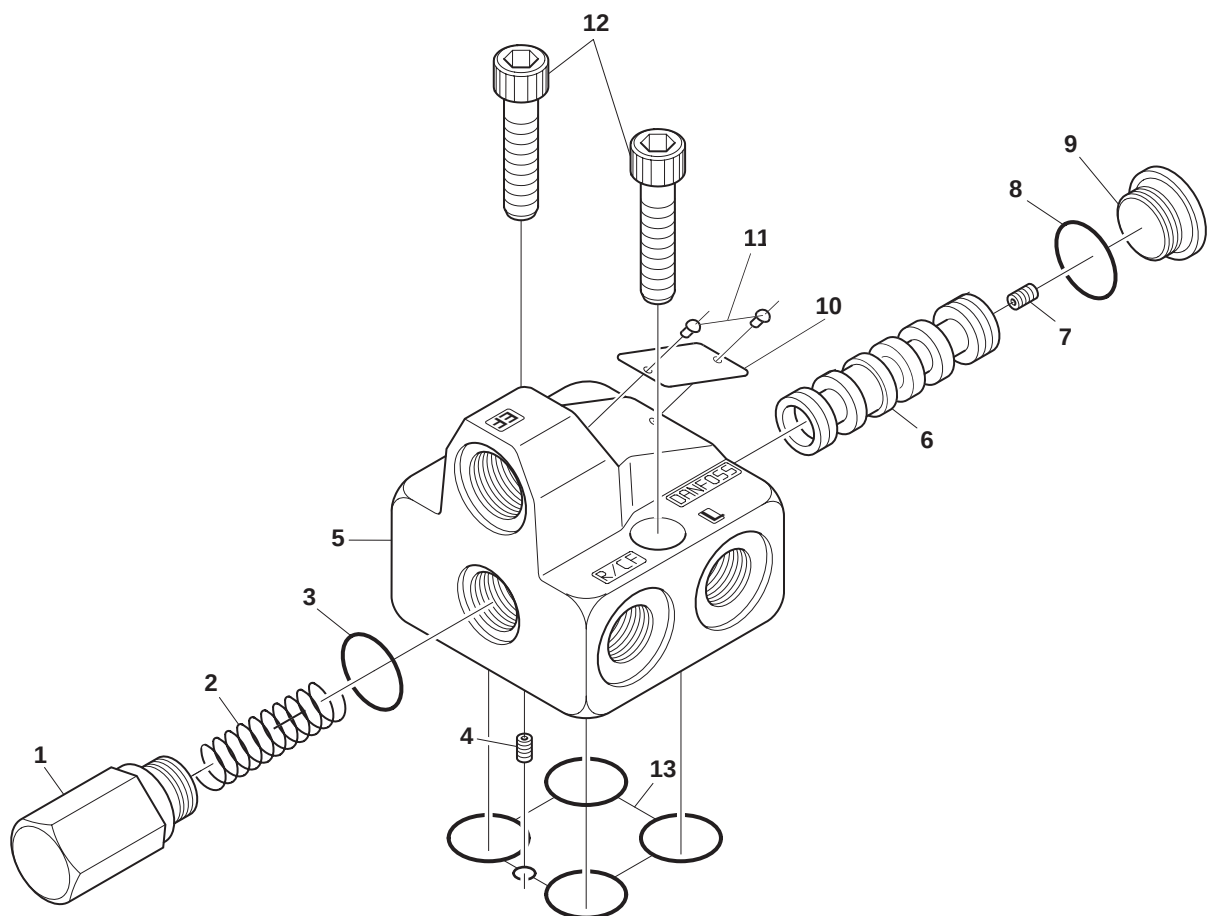


FG010720

Figure 3

Reference Number	Description
1	Dust Seal Ring
2	Housing
3	Ball
4	Thread Bushing
5	O-ring
6	Bearing Assembly
7	Ring
8	Spool
9	Cross Pin
10	Sleeve
11	Cardan Shaft
12	Set of Springs
13	O-ring
14	Distributor Plate

Reference Number	Description
15	Gearwheel Set
16	O-ring
17	End Cover
18	Washer
19	Screw with Pin
20	Screw
21	Name Plate
22	Pilot Relief Valve
23	Spring Wire
24	Shock Valve
25	Ball
26	Bushing with Pin
27	Check Valve



FG010721

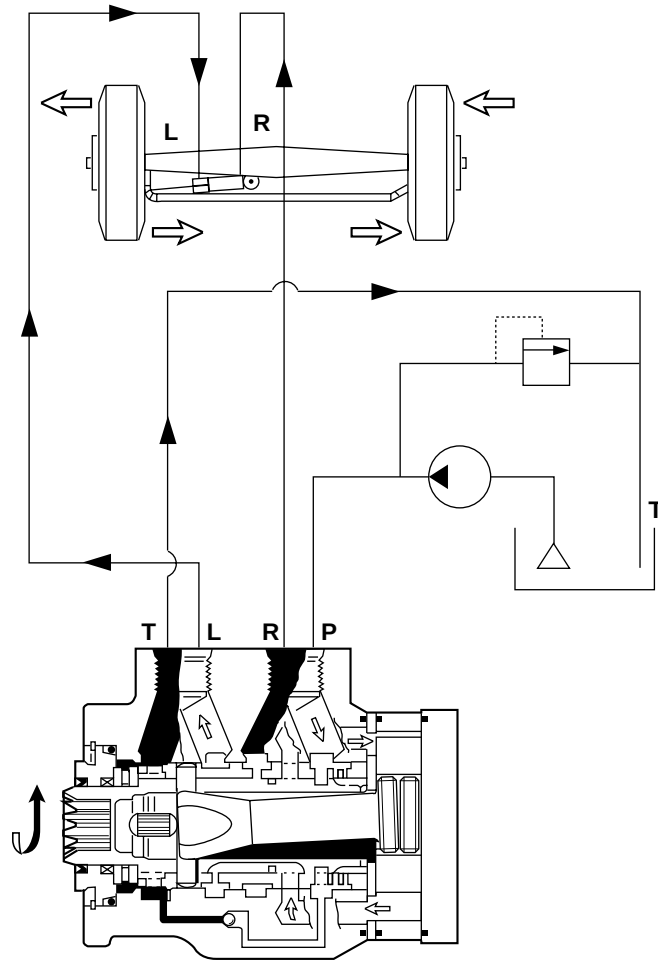
Figure 4

Reference Number	Description
1	Plug
2	Spring
3	Set of Seals
4	Orifice
5	Housing
6	Spool
7	Orifice

Reference Number	Description
8	Plug
9	O-ring
10	Name Plate
11	Drive Screw
12	Screw
13	O-ring Bag

Theory of Operation

The steering valve, which directs hydraulic oil from the pump to the steering cylinder, is comprised of a housing, control sleeve, control spool and drive. Turning the steering wheel counterclockwise causes oil to flow to the steering cylinder L. Return oil goes through passage R to passage T. Oil supplied to the rotor turns the rotor and transmits oil to the control sleeve through the drive or spring. Turning the wheel clockwise sends oil through passage R, while return oil passes from L of the cylinder to passage T. With the steering wheel in a neutral position, oil returns to the tank through passages P and T.



2815

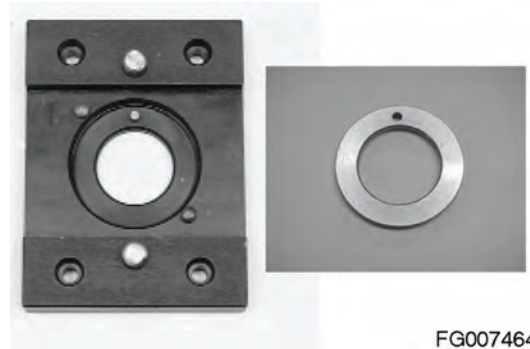
Figure 5

TOOLS

1. Holding tool + guide-ring

Code no.: SJ 150-9000-2.

Best.nr.: SJ 150-9000-16.



FG007464

Figure 6

2. Assembly tool for O-ring and kin-ring / Roto Glyd

Code no.: SJ 150-9000-11.

Best.nr.: SJ 150N4014-1.



FG007465

Figure 7

3. Assembly tool for lip seal.

Code no. SJ 150-9000-17.



FG007466

Figure 8

4. Assembly tool for cardan shaft.

Code no. SJ 150-9000-3.



FG007467

Figure 9

5. Assembly tool for dust seal.

Code no. SJ 150-9000-22.



Figure 10

6. Torque wrench 0-7 daNm.

13 mm socket spanner.

6, 8 and 12 mm hexagon sockets.

12 mm screwdriver.

2 mm screwdriver.

13 mm ring spanner.

6, 8 and 12 mm hexagon socket spanners.

Plastic hammer.

Tweezers.

The tools named under point F are not available from Danfoss.

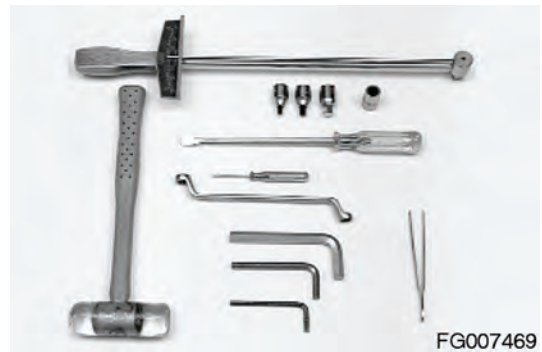
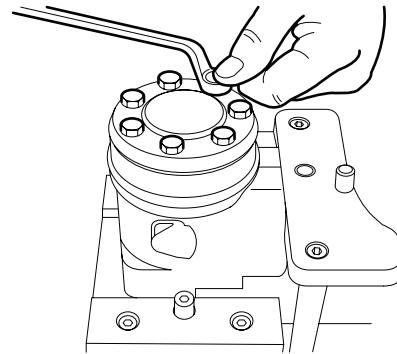


Figure 11

DISASSEMBLY

1. Dismantle steering column from steering unit and place the steering unit in the holding tool.

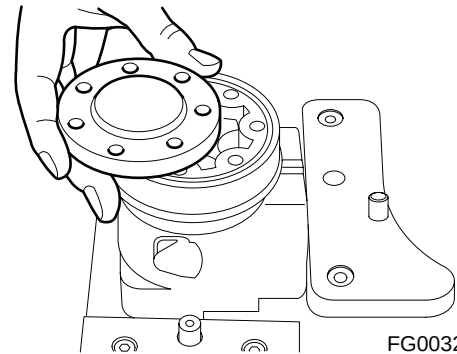
Screw out the screws in the end cover (6-off plus one special screw).



FG003286

Figure 12

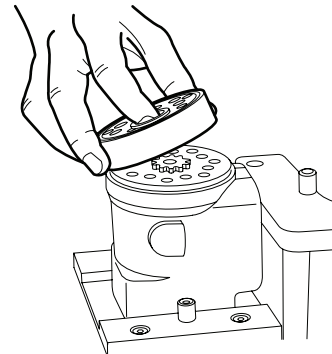
2. Remove the end cover, sideways.



FG003287

Figure 13

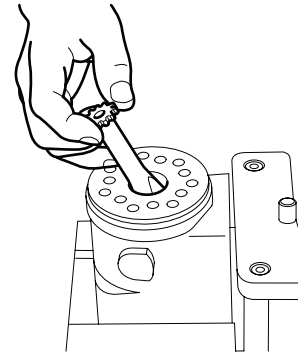
3. Lift the gearwheel set (with spacer if fitted) off the unit.
Take out the two o-rings.



FG003288

Figure 14

4. Remove cardan shaft.



FG003289

Figure 15

5. Remove distributor plate.

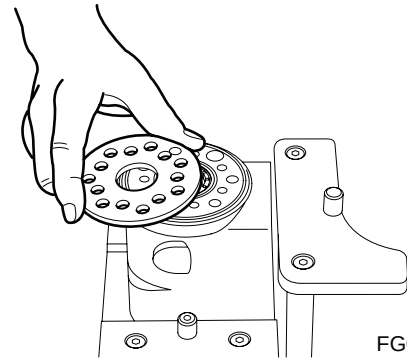


Figure 16

FG003290

6. Screw out the threaded bush over the check valve.

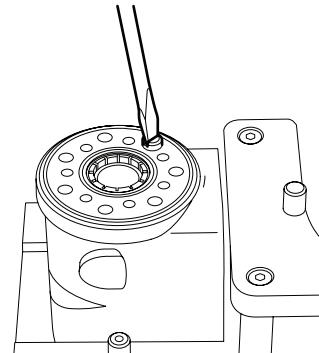


Figure 17

FG003291

7. Remove O-ring.

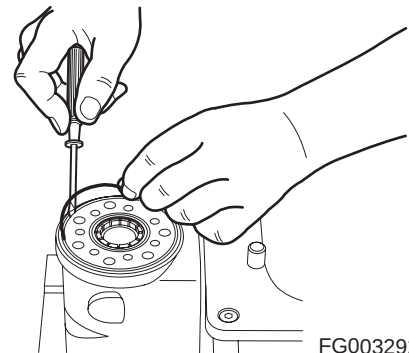


Figure 18

FG003292

8. OSPB; OSPB LS; OSPBX LS: Shake out the check valve ball (8 mm).

OSPC; OSPC LS; OSPC LSR: Shake out the check valve ball and suction valve pins and balls.



CAUTION!

On some pins in the OSPC there are two springs (See **Figure 3 on page -8**). See also spare parts list for OSPC HN.21.UA.52. Replace this pins prior to the reassembly!

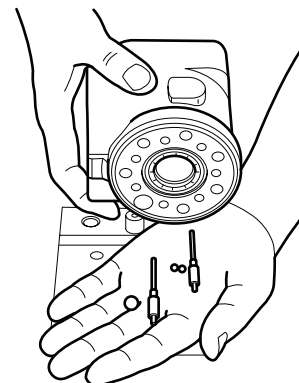


Figure 19

FG003293

9. Take care to keep the cross pin in the sleeve and spool horizontal. The pin can be seen through the open end of the spool. Press the spool inwards and the sleeve, ring, bearing races and needle bearing will be pushed out of the housing together.

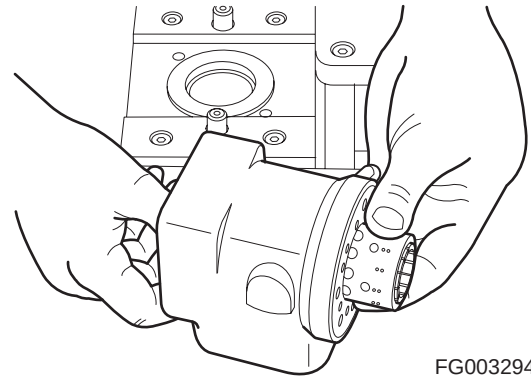


Figure 20

FG003294

10. Take ring, bearing races and needle bearing from sleeve and spool. The outer (thin) bearing race can sometimes stick in the housing, therefore check that it has come out.

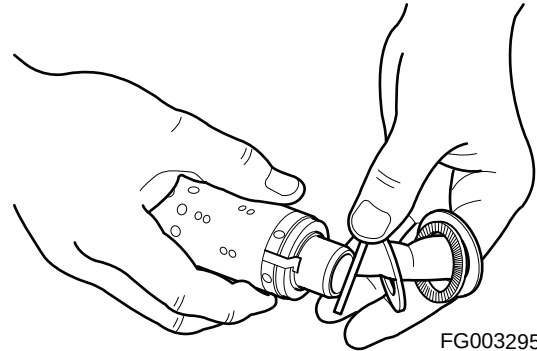


Figure 21

FG003295

11. Press out the cross pin. Use the special screw from the end cover.

Note next point/paragraph!

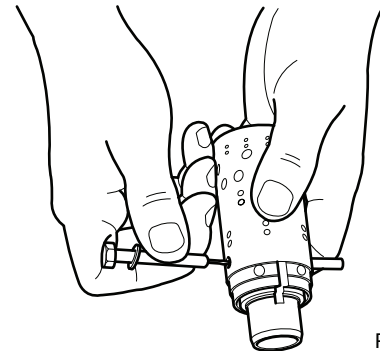


Figure 22

FG003296

12. OSPB CN and OSPC CN

A small mark has been made with a pumice stone on both spool and sleeve close to one of the slots for the neutral position springs (see drawing).

If the mark is not visible, remember to leave a mark of your own on sleeve and spool before the neutral position springs are dismantled.

For OSPF both marks should be placed opposite each other!

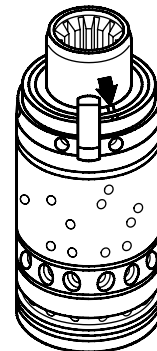


Figure 23 CN

FG003297



Figure 24 OSPF

13. Carefully press the spool out of the sleeve.

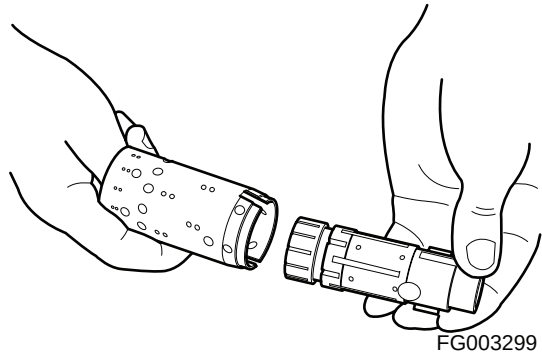


Figure 25

14. Press the neutral position springs out of their slots in the spool.

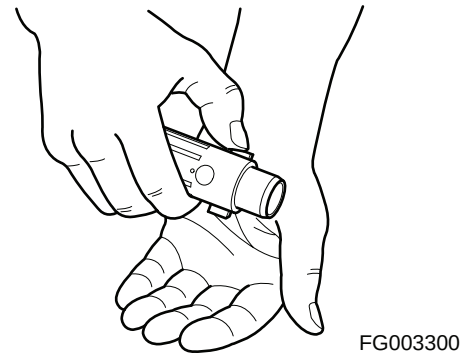


Figure 26

15. Remove dust seal and O-ring/kin-ring/Roto Glyd.

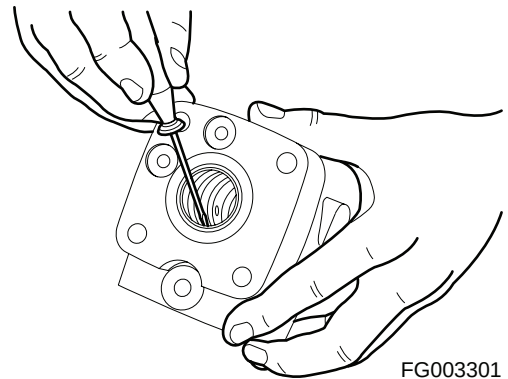


Figure 27

Dismantling the Shock Valves for OSPC/ OSPC LS

1. Remove plugs from shock valves using a 6 mm hexagon socket spanner.

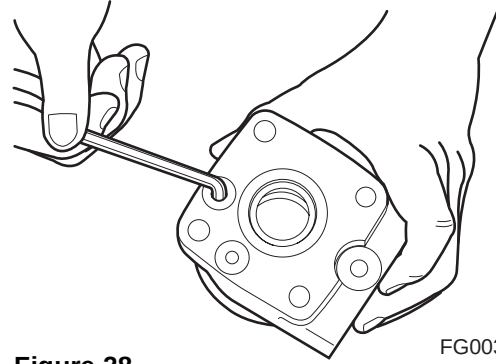


Figure 28

FG003302

2. Remove seal washers (2-off).

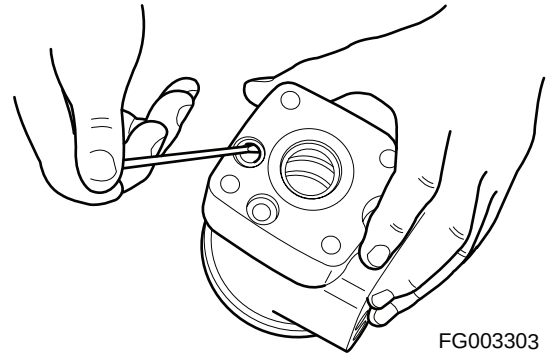


Figure 29

FG003303

3. Unscrew the setting screws using a 6 mm hexagon socket spanner.

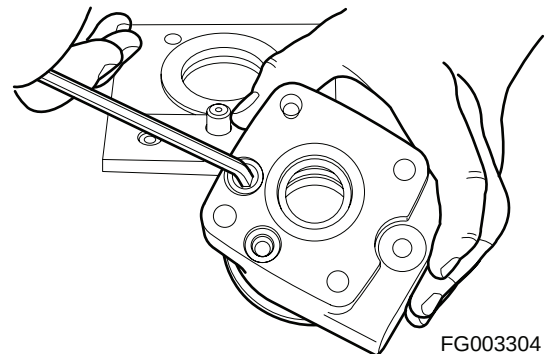


Figure 30

FG003304

4. Shake out the two springs and two valve balls into your hand. The valve seats are bonded into the housing and cannot be removed.

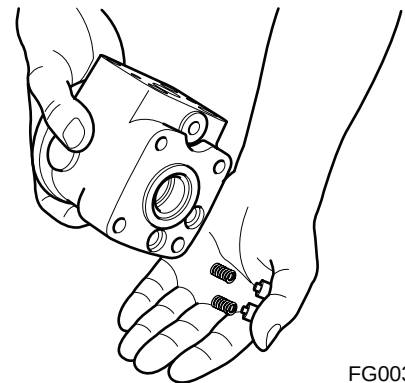
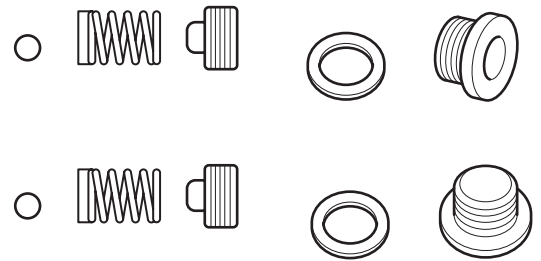


Figure 31

FG003305

5. The shock valves are now dismantled.

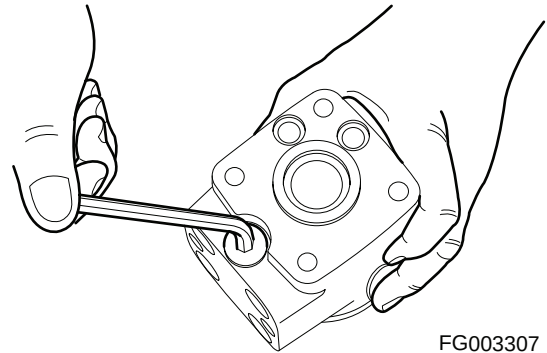


FG007473

Figure 32

Dismantling the Pressure Relief Valve for OSPC

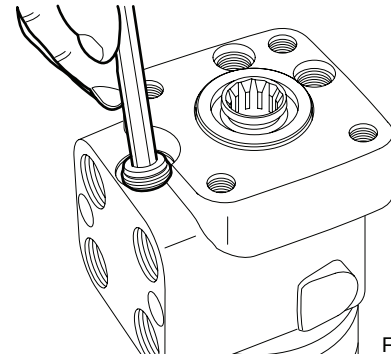
1. Screw out the plug using an 8 mm hexagon socket spanner.
Remove seal washers.



FG003307

Figure 33

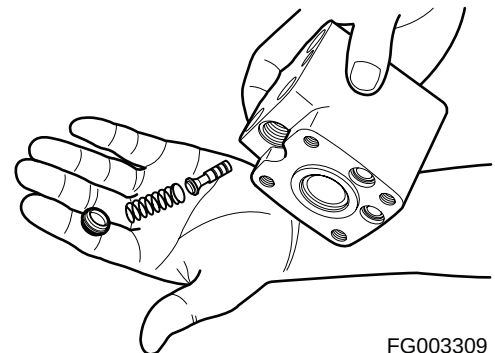
2. Unscrew the setting screw using an 8 mm hexagon socket spanner.



FG003308

Figure 34

3. Shake out spring and piston. The valve seat is bonded into the housing and cannot be removed.



FG003309

Figure 35

4. The pressure relief valve is now dismantled.

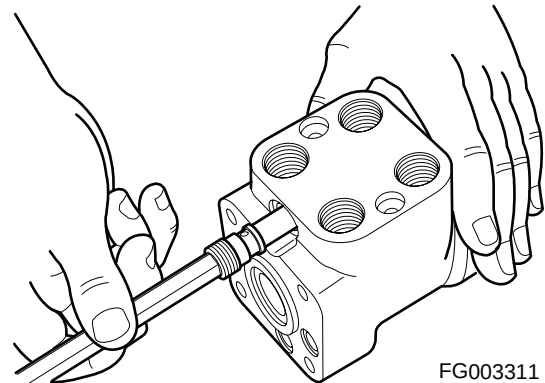


FG003310

Figure 36

Dismantling the Pressure Relief Valve (cartridge) for OSPC LS/OSPC LSR

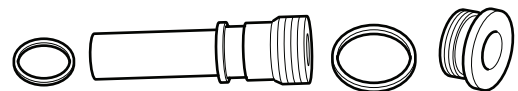
1. Screw out the pressure relief valve using and 8 mm hexagon socket spanner. Remove the seal ring. If the valve is defective it must be replaced (see OSPC spare parts list, HN.21.UA.52).



FG003311

Figure 37

2. The pressure relief valve is now dismantled.



FG003312

Figure 38

ASSEMBLY

1. Place the two flat neutral position springs in the slot.
2. Place the curved springs between the flat ones and press them into place.

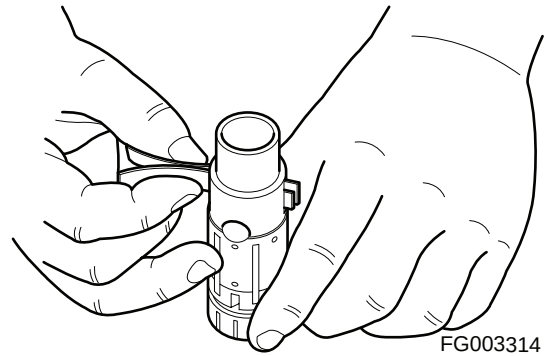


Figure 41

FG003314



Figure 42

FG003315

3. Line up the spring set.

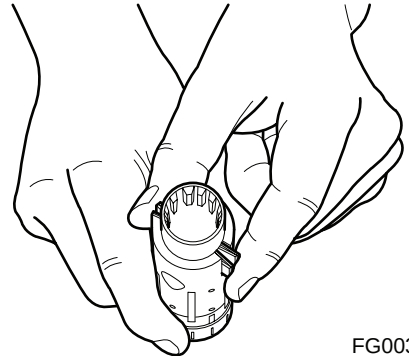


Figure 43

FG003316

4. Guide the spool into the sleeve. Make sure that spool and sleeve for OSPB LS, OSPBX LS, OSPC LS, OSPC LSR and OSPF are placed correctly in relation to each other (See page -12).

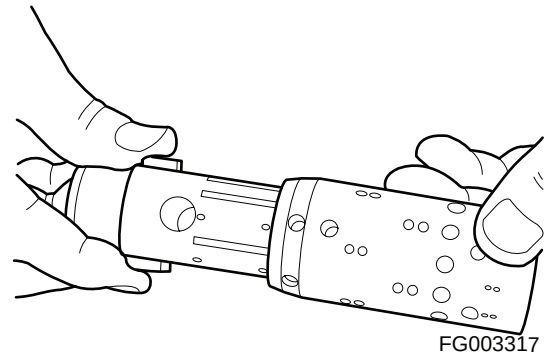


Figure 44

FG003317

5. Assemble spool and sleeve.



CAUTION!

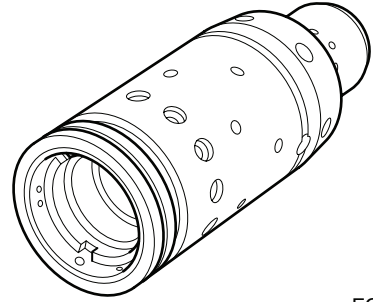
OSPB LS, OSPBX LS, OSPC LS, OSPC LSR and OSPF

When assembling spool and sleeve only one of two possible ways of positioning the spring slots is correct.

There are three slots in the spool and three holes in the sleeve in the end of the spool/sleeve opposite to the end with spring slots. Place the slots and holes opposite each other so that parts of the holes in the sleeve are visible through the slots in the spool.

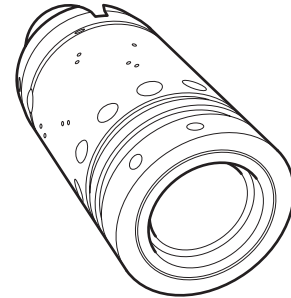
OSPB CN and OSPC CN

Assemble the spool/sleeve and make sure the marks on spool and sleeve are opposite each other (see drawing page 10).



FG003318

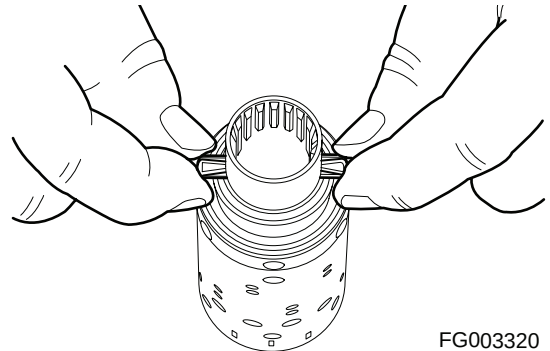
Figure 45



FG003319

Figure 46

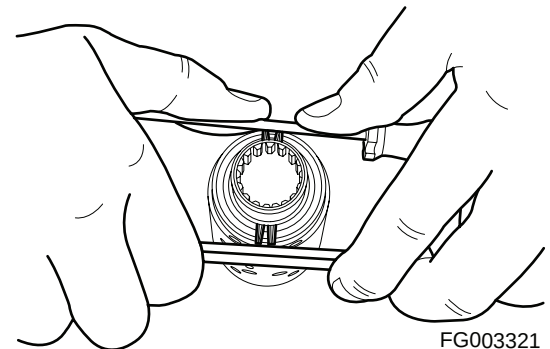
6. Press the springs together and push the neutral position springs into place in the sleeve.



FG003320

Figure 47

7. Line up the springs and center them.



FG003321

Figure 48

8. Guide the ring down over the sleeve.



CAUTION!

The ring should be able to move - free of the springs.

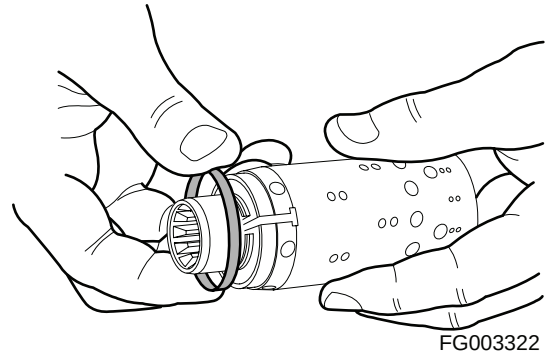


Figure 49

FG003322

9. Fit the cross pin into the spool/sleeve.

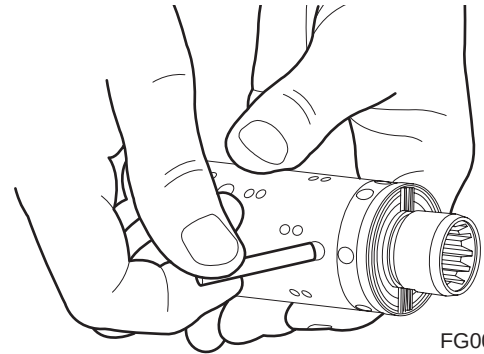


Figure 50

FG003323

10. Fit bearing races and needle bearing as shown on below drawing.

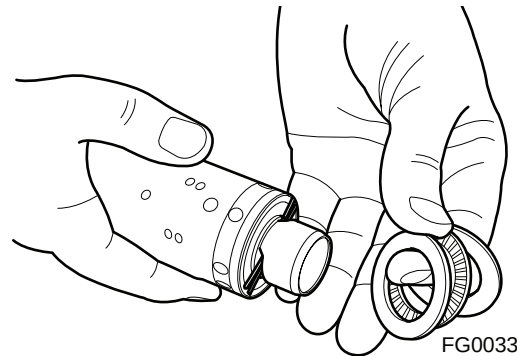


Figure 51

FG003324

Assembly Pattern for Standard Bearing

Reference Number	Description
1	Outer Bearing Race
2	Needle bearing
3	Inner Bearing Race
4	Spool
5	Sleeve

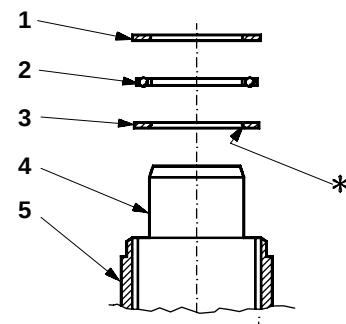


Figure 52

FG003325

Assembly Pattern for Double Bearing

Reference Number	Description
1	Washer For Axial Bearing
2	Outer Needle bearing
3	Outer Bearing Race
4	Spool
5	Sleeve
6	Inner Needle bearing
7	Inner Bearing Race

* The inside chamfer on the inner bearing race must face the inner spool.

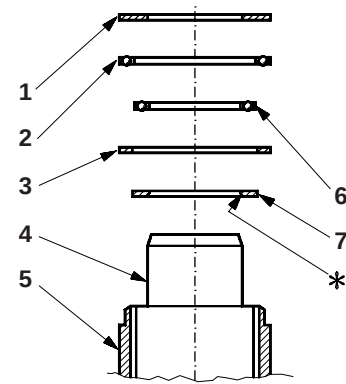


Figure 53

FG003326

Installation Instructions for O-ring/Kin-ring /Roto Glyd

1. Turn the steering unit until the bore is horizontal. Guide the outer part of the assembly tool into the bore for the spool/sleeve.

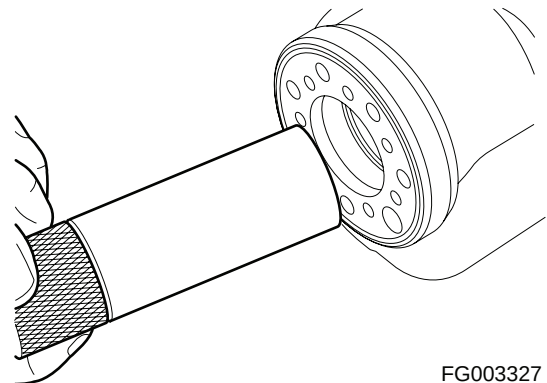


Figure 54

FG003327

2. Grease O-ring and king-ring/roto glyd with hydraulic oil and place them on the tool.

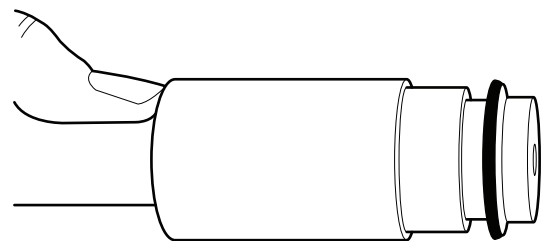


Figure 55

FG003328

3. Hold the outer part of the assembly tool in the bottom of the steering unit housing and guide the inner part of the tool right to the bottom.

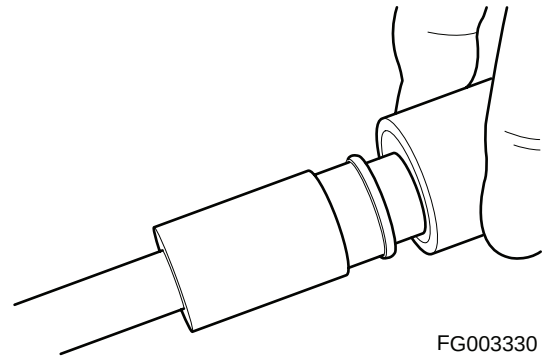


Figure 56

FG003330

4. Press and turn the O-ring/kin-ring into position in the housing.

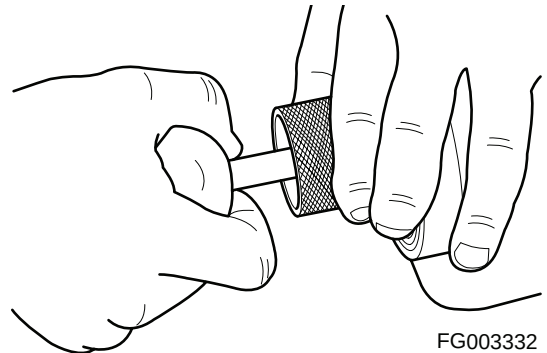


Figure 57

FG003332

5. Draw the inner and outer parts of the assembly tool out of the steering unit bore, leaving the guide from the inner part in the bore.

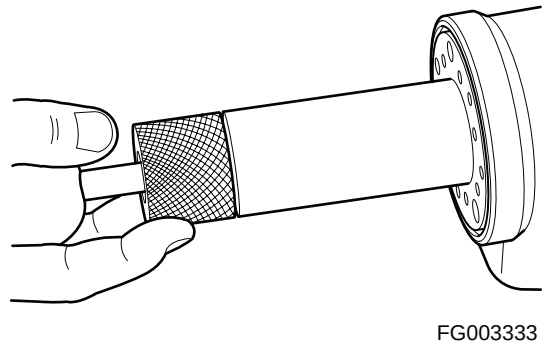


Figure 58

FG003333

Installation Instructions for Lip Seal

1. Lubricate the lip seal with hydraulic oil and place it on the assembly tool.

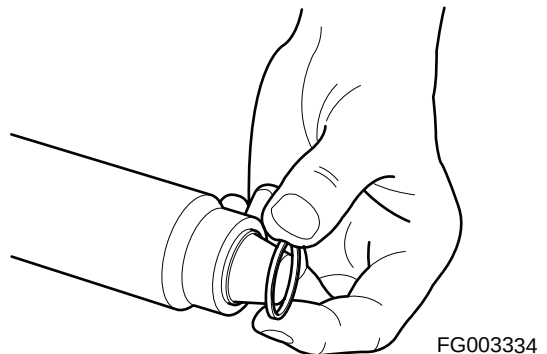


Figure 59

FG003334

2. Guide the assembly tool right to the bottom.

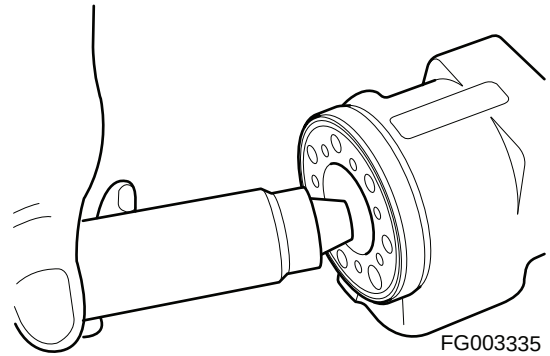


Figure 60

3. Press and turn the lip seal into place in the housing.

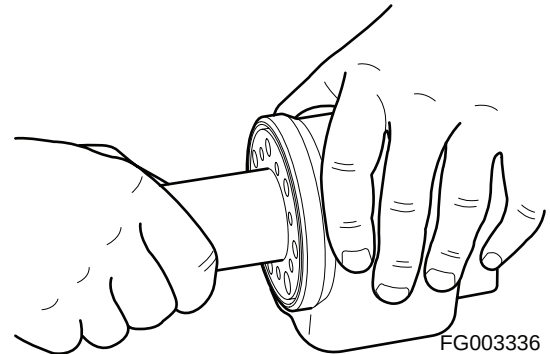


Figure 61

4. With a light turning movement, guide the spool and sleeve into the bore.



CAUTION!

Fit the spool set holding the cross pin horizontal.

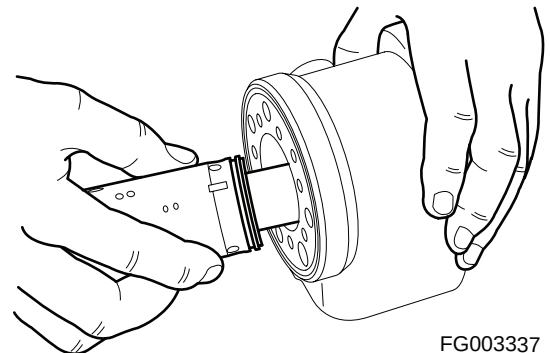


Figure 62

5. The spool set will push out the assembly tool guide. The O-ring and kin-ring/roto Glyd are now in position.

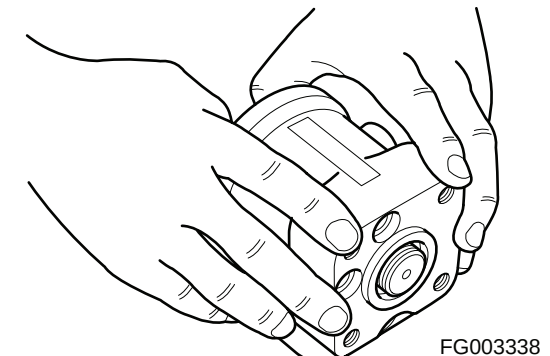


Figure 63

6. Turn the steering unit until the bore is vertical again. Put the check valve ball into the hole indicated by the arrow.

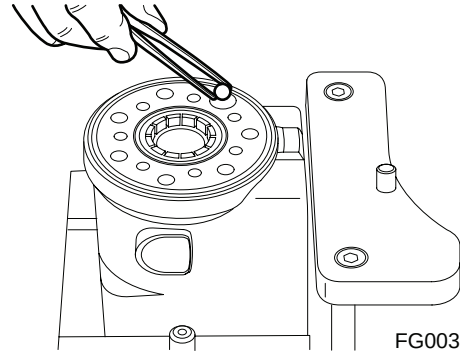


Figure 64

FG003339

7. Screw the threaded bush lightly into the check valve bore. The top of the bush must lie just below the surface of the housing.

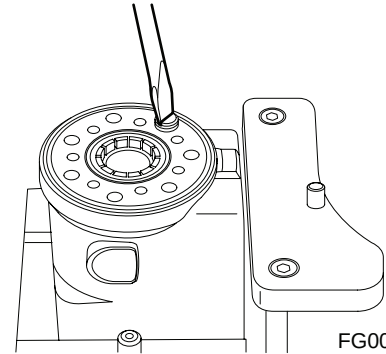


Figure 65

FG003340

8. Place a ball in the two holes indicated by the arrows.

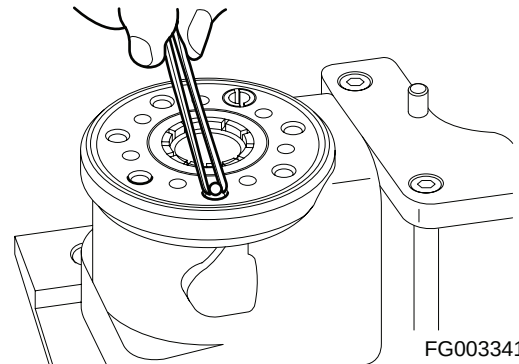


Figure 66

FG003341

9. Place a new pin in the same two holes.

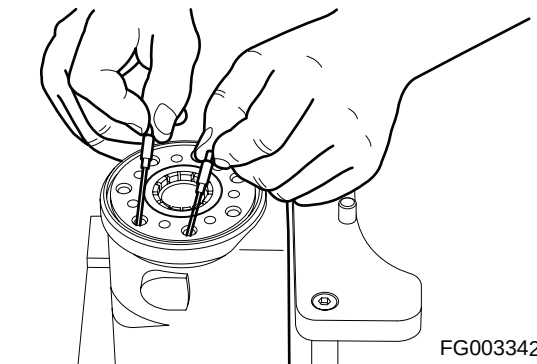


Figure 67

FG003342

10. In some cases a spring has to be fitted (see page 4 pos. 38) on the pin before it is placed in the housing. (See OSPC spare parts list, HN.21.UA.52).

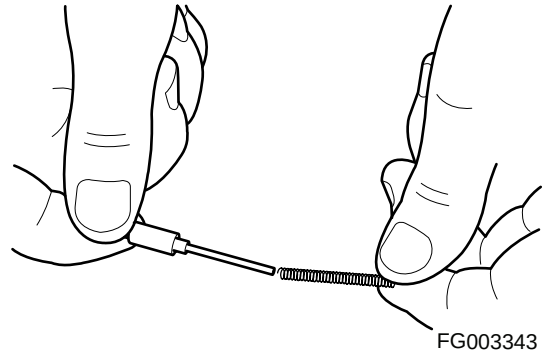


Figure 68

11. Grease the O-ring with mineral oil approx. viscosity 500 mm²/s at 20°C.

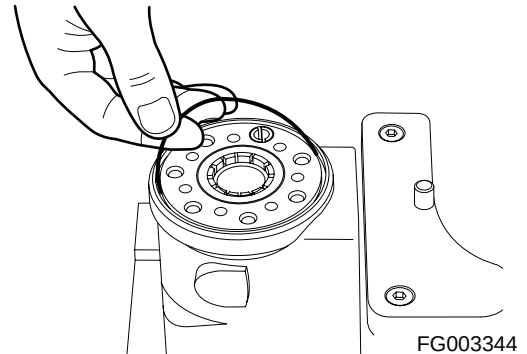


Figure 69

12. Place the distributor plate so that the channel holes match the holes in the housing.

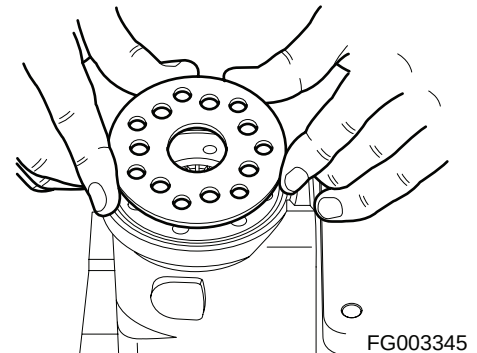


Figure 70

13. Guide the cardan shaft down into the bore so that the slot is parallel with the connection flange.

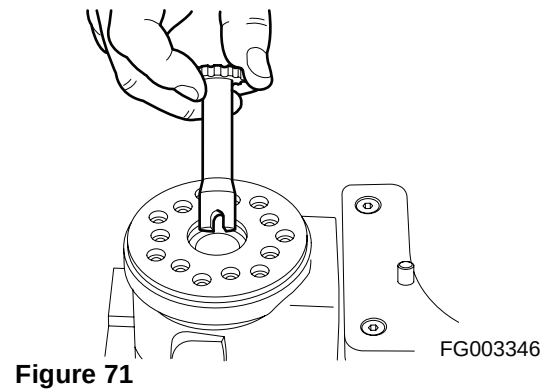


Figure 71

14. Place the cardan shaft as shown - so that it is held in position by the mounting fork.

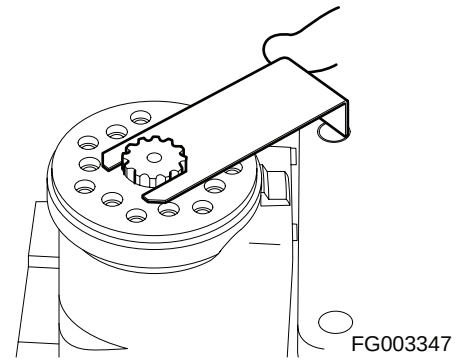


Figure 72

15. Grease the two o-rings with mineral oil approx. viscosity 500 mm²/s at 20°C and place them in the two grooves in the gear rim. Fit the gearwheel and rim on the cardan shaft.

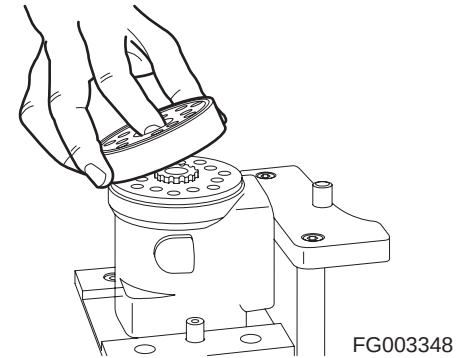


Figure 73



CAUTION!

Fit the gearwheel (rotor) and cardan shaft so that a tooth base in the rotor is positioned in relation to the shaft slot as shown. Turn the gear rim so that the seven trough holes match the holes in the housing.

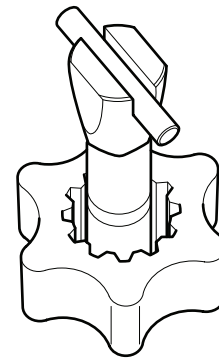


Figure 74

16. Fit the spacer, if any.

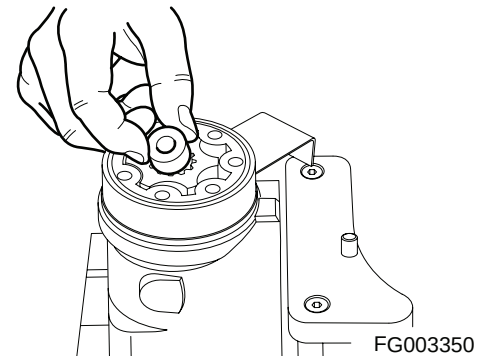


Figure 75

17. Place the end cover in position.

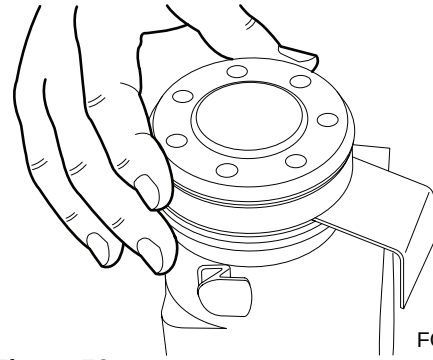


Figure 76

FG003351

18. Fit the special screw with washer and place it in the hole shown.

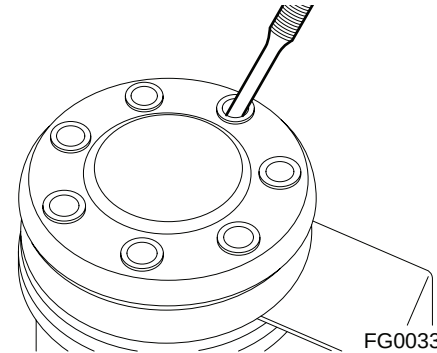


Figure 77

FG003352

19. Fit the six screws with washers and insert them. Cross-tighten all the screws and the rolled pin with a torque of 3.0 ± 0.6 daNm. The OSPB, OSPB LS and OSPBX LS can now be function tested.

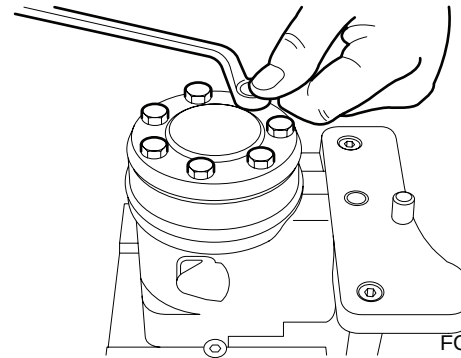


Figure 78

FG003353

Assembly of the Pressure Relief Valve for OSPC

1. Fit the piston.

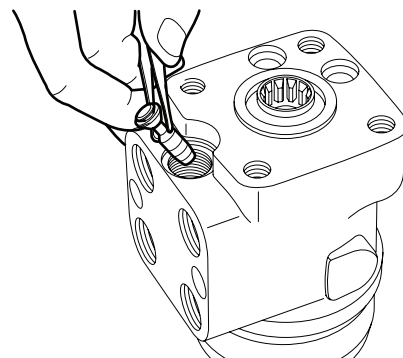
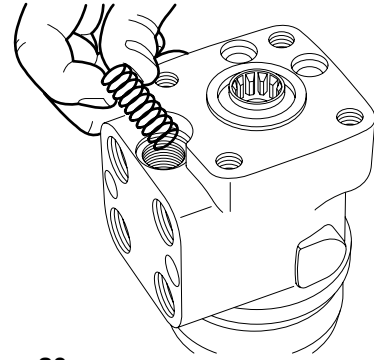


Figure 79

FG003354

2. Fit the spring.

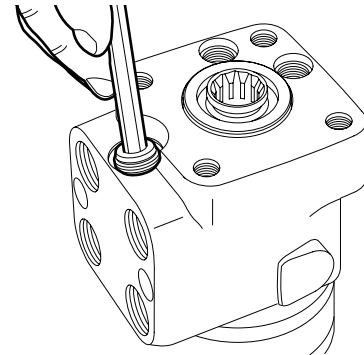


FG003355

Figure 80

3. Screw in the setting screw with an 8 mm hexagon socket spanner.

Make the pressure setting on a panel or the vehicle.

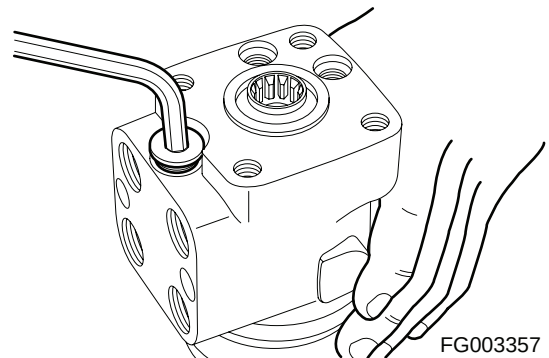


FG003356

Figure 81

4. Screw plug with dust seal into the housing using an 8 mm hexagon socket spanner.

Tightening torque: 5 +/-1 daNm.

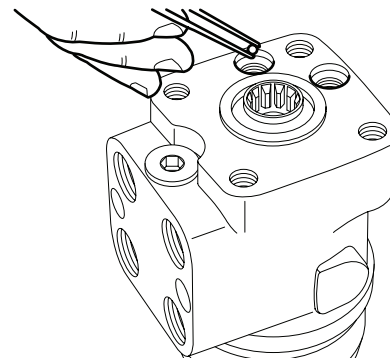


FG003357

Figure 82

Assembly of the Shock Valves for OSPC/ OSPC LS/OSPC LSR

1. Put a ball in the two holes indicated by the arrows.



FG003358

Figure 83

2. Place springs and valve cones over the two balls.



CAUTION!

The blue spring applies to setting range 90-180 bar.
The untreated spring applies to setting range 170-260 bar. (See OSPC spare parts list HN.21.UA.52).

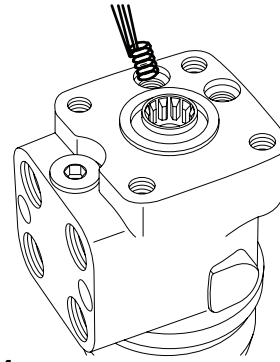


Figure 84

FG003359

3. Screw in the two setting screws using a 6 mm hexagon socket spanner. Make the pressure setting on a panel or the vehicle. (See OSPC spare parts list HN.21.UA.52).

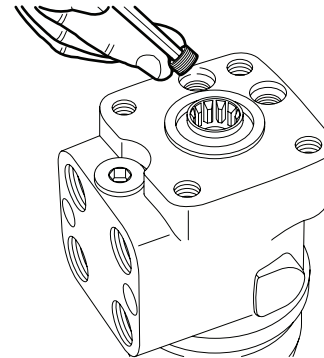


Figure 85

FG003360

4. Screw plug with seal ring into the two shock valves and tighten them with a torque of 3 +1 daNm using a 6 mm hexagon socket spanner.

Steering unit type OSPB, OSPB LS, OSPBX LS, OSPC, OSPC LS or OSPC LSR is now assembled.

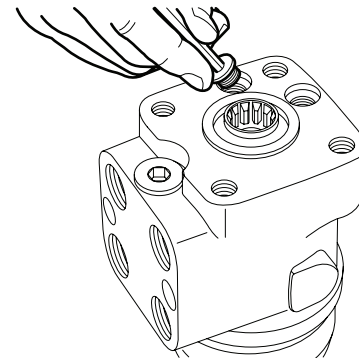


Figure 86

FG003360-1

5. Place the dust seal ring in the housing. With the OSPC, OSPC LS and OSPC LSR the dust seal ring must be placed only after the pressure relief valve and shock valves have been fitted.

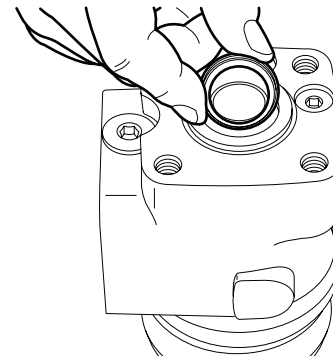


Figure 87

FG003475

6. Fit the dust seal ring in the housing using special tool SJ 150-9000-22 and a plastic hammer.

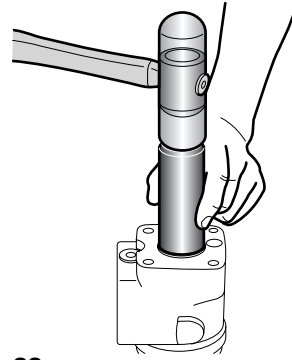


Figure 88

FG003476

7. Press the plastic plugs into the connection ports. Do not use a hammer!

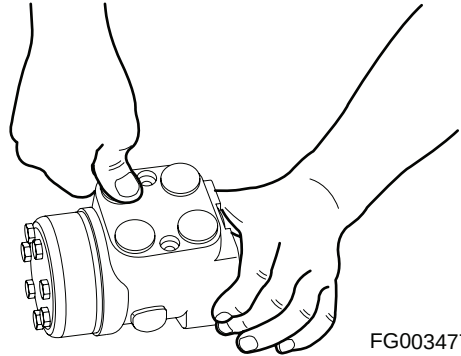


Figure 89

FG003477

Hydraulic Connections

Reference Number	Description
L	Left Port
R	Right Port
T	Tank
P	Pump

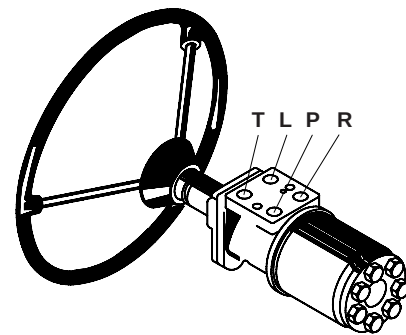


Figure 90

FG003478

Max. Tightening Torque

Screwed Connection	Max. Tightening Torque daNm (lbf in)			
	With Cutting Edge	With Copper Washer	With Aluminium Washer	With O-Ring
G 1/4	4(350)	2(180)	3(270)	
G 3/8	6(530)	2(180)	5(440)	
G 1/2	10(900)	3(270)	8(700)	
7/16-20 UNF		2(180)		
3/4-16 UNF		6(530)		
M12 x 1.5	4(350)	2(180)	3(270)	2(180)
M18 x 1.5	7(620)	2(180)	5(440)	5(440)
M22 x 1.5	10(900)	3(270)	8(700)	7(620)

Remote Control Valve (Work Lever / Joystick)

Edition 1

MEMO

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Remote Control Valve (Work Lever / Joystick)

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MEMO

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.

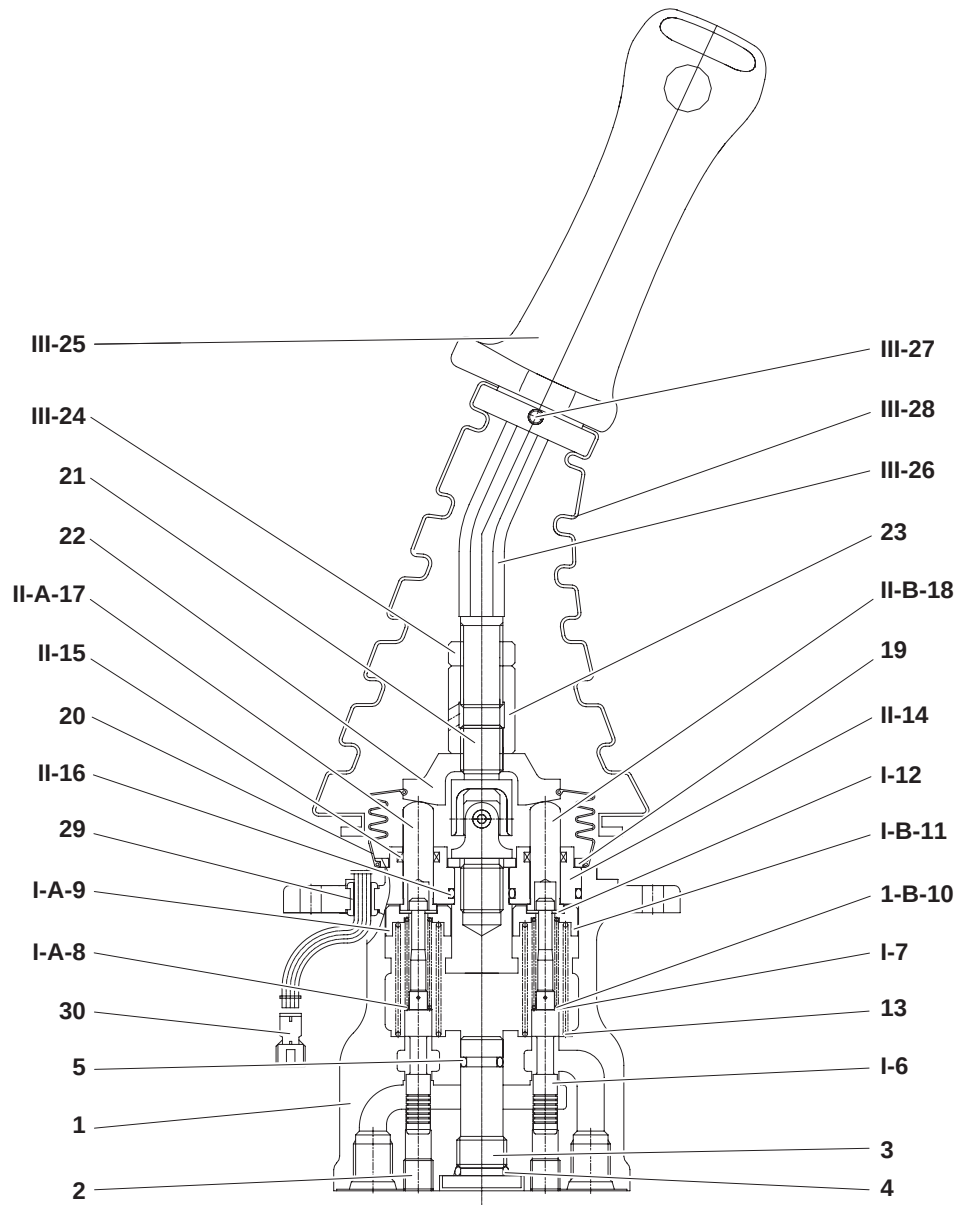
Remember that ultimate. safety is your own responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55	5001 and Up
DX55W	5001 and Up

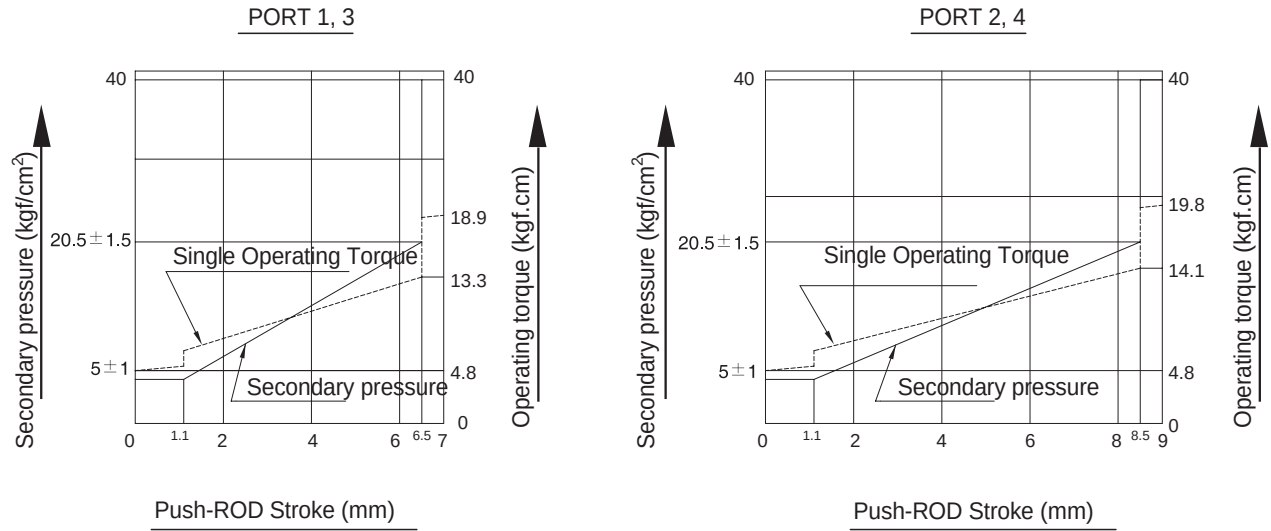
STRUCTURE DIAGRAM



FG010350

Figure 1

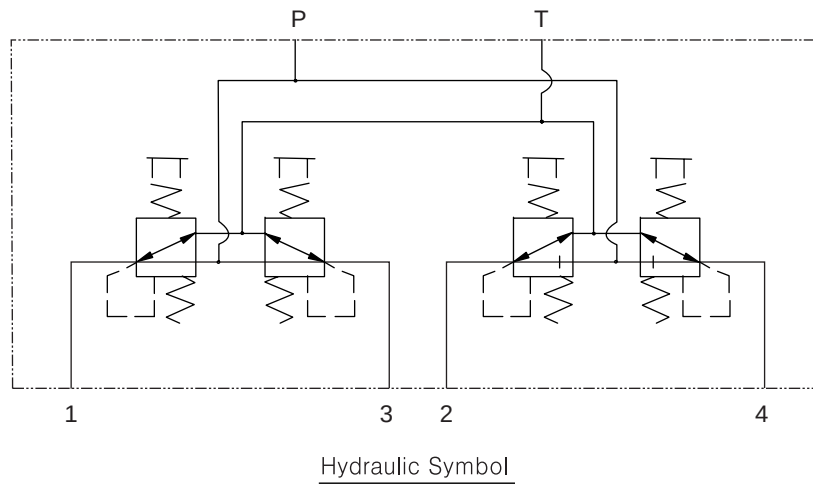
PERFORMANCE SPECIFICATION



FG011412

Figure 2

HYDRAULIC PRESSURE CIRCUIT DIAGRAM



FG011413

Figure 3

PARTS LIST

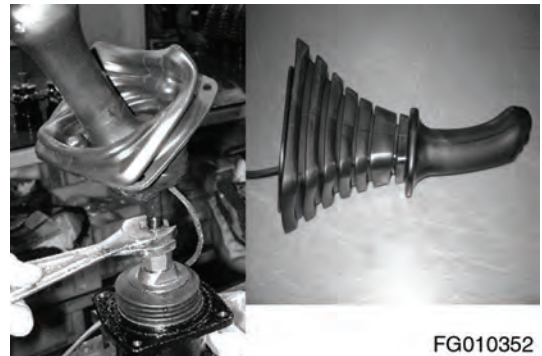
No.	Part Name	Standard	Material	Q'TY	RSP
1	Case			1	O
2	Plug	PT 1/8	SCM440	4	O
3	Plug	PF 3/8		1	O
4	O-Ring	P14	N,B,R	1	X
5	O-Ring	P10A	N,B,R	1	X
I-A	Spool Kit	Port 1, 3			O
I-B	Spool Kit	Port 2, 4			O
I-6	Spool			4	X
I-7	Shim			AR	X
I-A-8	Spring	Port 1, 3		2	X
I-A-9	Spring Seat	Port 1, 3		2	X
I-A-10	Spring	Port 2, 4		2	X
I-A-11	Spring Seat	Port 2, 4		2	X
I-12	Stopper			4 set	X
13	Spring			4	O
II-A	Plug Kit	Port 1, 3			O
II-B	Plug Kit	Port 2, 4			O
II-14	Plug			4	X
II-15	Rod Seal	10×16×4.5	N.B.R	4	X
II-16	O-Ring	4D-P20	FKM	4	X
II-A-17	Push Rod	Port 1, 3			X
II-A-18	Push Rod	Port 2, 4			X
19	Plate			1	O
20	Boot			1	O
21	Joint Ass'y			1	O
22	Swash Plate			1	O
23	Hex Nut			1	O
III	Handle Kit	LH			O
III	Handle Kit	RH			O
III-24	Nut			1	X
III-25	Handle Ass'y	LH		1 set	X
III-25	Handle Ass'y	RH		1 set	X
III-26	Handle Bar			1	X
III-27	Spring Pin			1	X
III-28	Bellows			1	X
29	Bushing			1	O
30	Connector Ass'y			1 set	O
IV	Seal Kit	4,5, II-15, II-16			O

DISASSEMBLY AND ASSEMBLY TOOL

Part no.	Tool	Specification	Remarks
21	Driver	- type	
29	Driver	- type	Small size
22	Spanner	27 mm	
22	Spanner	22 mm	
III-26	Spanner	13 mm	

DISASSEMBLY METHOD

1. Separate the HANDLE KIT (III) from the HEX NUT (23).



2. Separate the BOOT (20) from the SWASH PLATE (22).



3. Separate the HEX NUT (23) from the SWASH PLATE (22), and remove the SHAWH PLATE (22).



Figure 6

4. Separate the JOINT ASSØY (11) from the BODY (1).

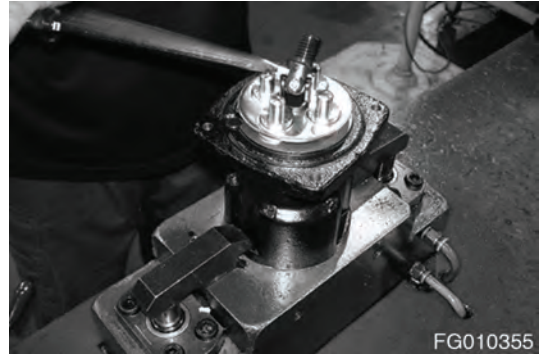


Figure 7

5. Remove the PLATE (19) and separate the PLUG KIT ((II-A, II-B) from the BODY (1).



Figure 8

6. Separate the BUSHING (29) from the BODY (1).

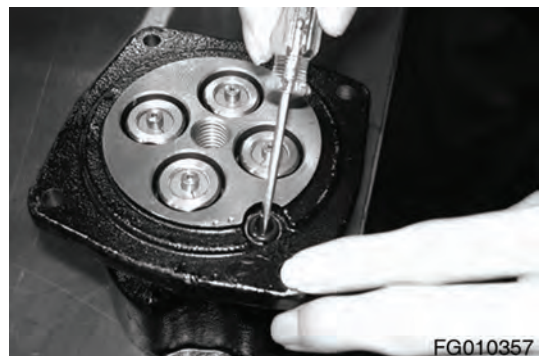


Figure 9

7. Separate the SPOOL KIT (I-A, I-B) from the BODY (1).

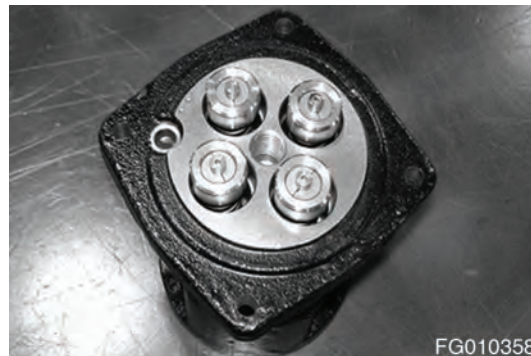


Figure 10



Figure 11

8. Separate SPRING (13) from the BODY (1).

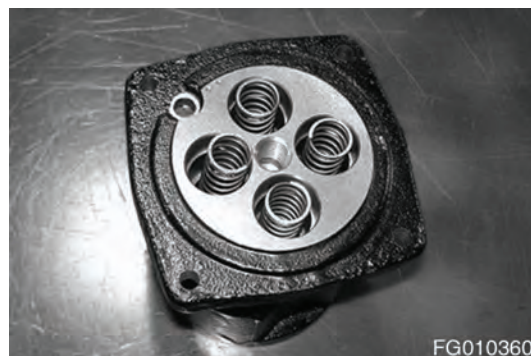


Figure 12

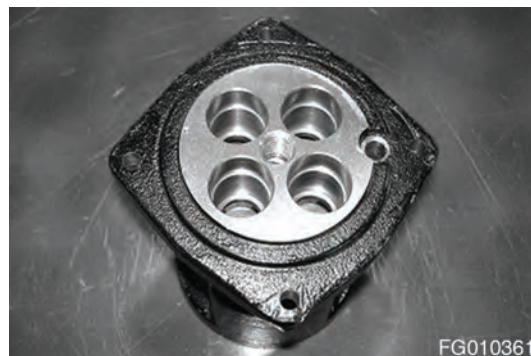


Figure 13

ASSEMBLY METHOD

1. Assemble the SPRING (13) to the BODY (1).

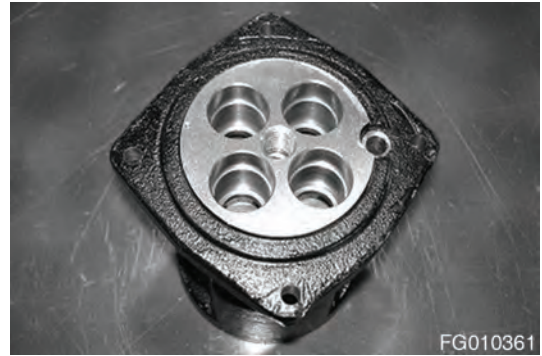


Figure 14

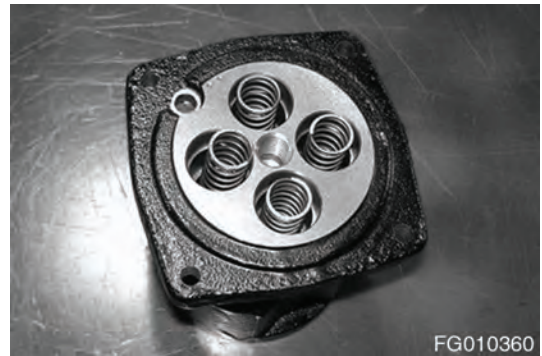


Figure 15

2. Assemble the SPOOL KIT (I-A, I-B).

Assembly order

SPOOL KIT(I-A) : SPOOL(I-6) SHIM(I-7) → SPRING(I-A-8) → SPRING SEAT(I-A-9) → STOPPER(I-12)

SPOOL KIT(I-B) : SPOOL(I-6) SHIM(I-7) → SPRING(I-B-10) → SPRING SEAT(I-B-11) → STOPPER(I-12)

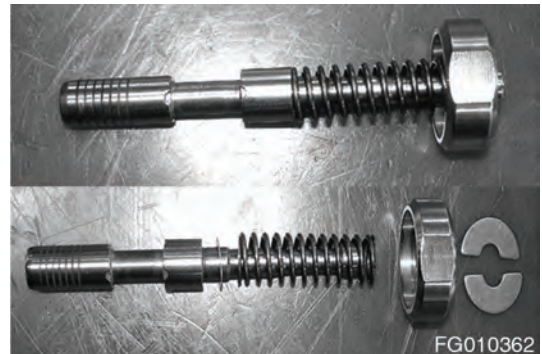


Figure 16

3. Assemble the SPOOL KIT (I-A, I-B) BODY (1).

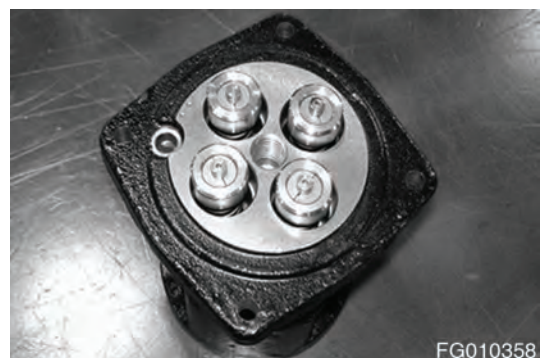


Figure 17

4. Install the BUSHING (29) on the BODY (1).

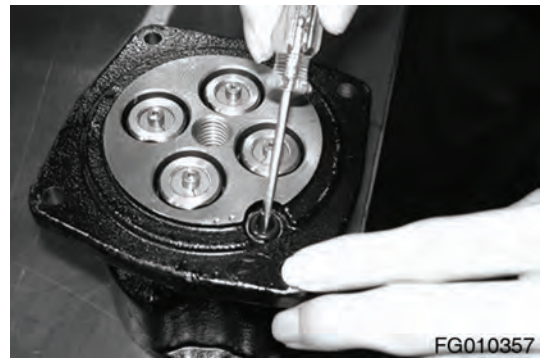


Figure 18



Figure 19

5. Assemble the PLUG KIT (II-A, II-B).

Assembly order

PLUG KIT(II-A) : PLUG(II-14) → PUSH ROD(II-A-17)

PLUG KIT(II-B) : PLUG(II-14) → PUSH ROD(II-B-18)



Figure 20



Figure 21

6. Install the PLUG KIT (II-A, II-B) on the BODY (1).



Figure 22

7. Install the PLATE (19).



Figure 23

8. Assemble the BODY (1) to the JOINT Ass'y (21).

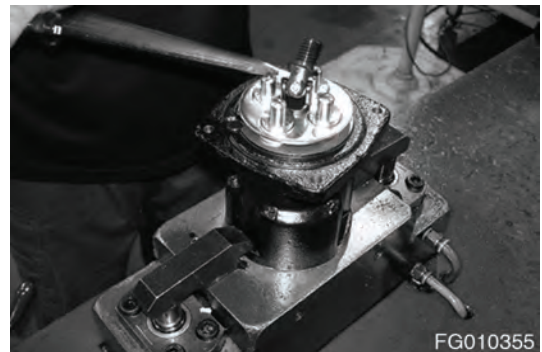


Figure 24

9. Apply enough grease on the PUSH ROD and JOINT Ass'y part.



Figure 25

10. Insert the SWASH PLATE (22) and assemble the HEX NUT (23).



Figure 26

11. Use the spanner to fixate the HEX NUT (23) firmly to the BODY (1).

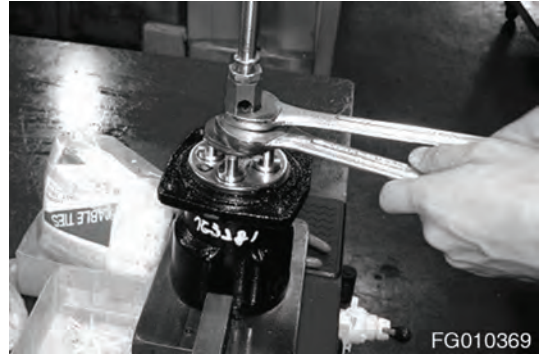


Figure 27

12. Install the BOOT (20) on the SWASH PLATE (22).



Figure 28

13. Assemble the HANDLE KIT (III) to the HEX NUT (23).
Insert the wire in the BUSHING (29).

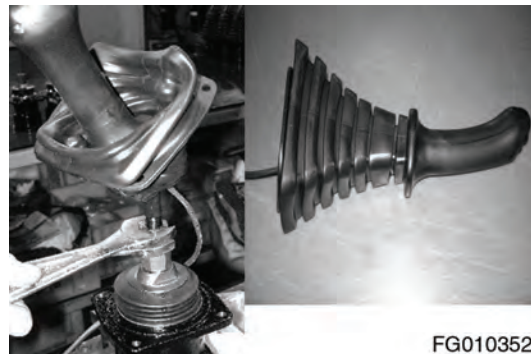


Figure 29



Figure 30

Dozer Valve

Edition 1

MEMO

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Dozer Valve

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MEMO

SAFETY PRECAUTIONS



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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.

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APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55	5001 and Up
DX55W	5001 and Up

STRUCTURE DIAGRAM

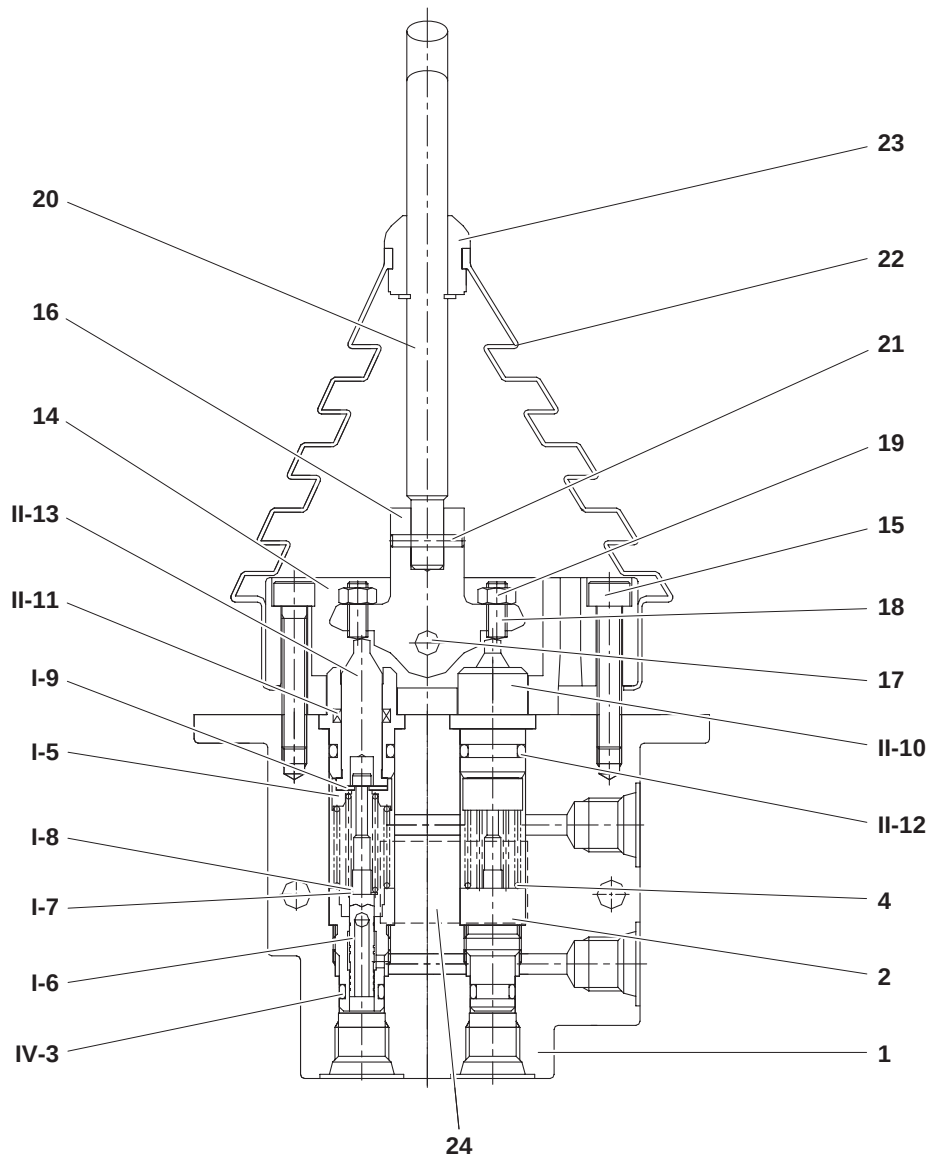


Figure 1

FG010372

PERFORMANCE SPECIFICATION

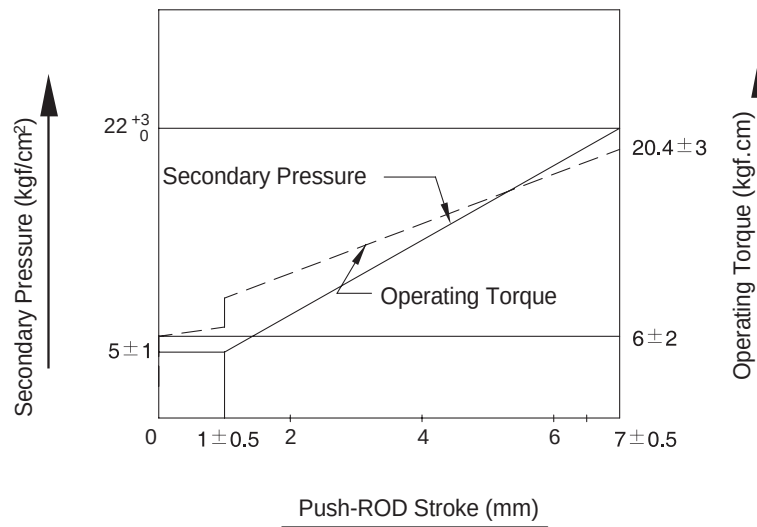


Figure 2

FG011414

HYDRAULIC PRESSURE CIRCUIT DIAGRAM

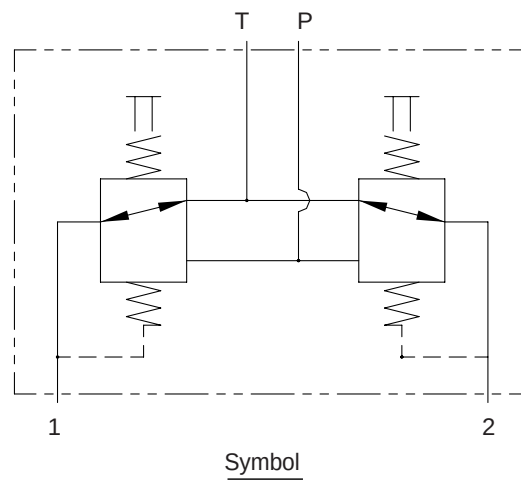


Figure 3

FG011415

PARTS LIST

No.	Part Name	Standard	Material	Q'TY
1	Body			1
2	Plug			2
IV-3	O-ring	P8	N.B.R	2
4	Spring			2
I	Spool Kit			
I-5	Spring Sea			2
I-6	Spool			2
I-7	Spring Sea			2
I-8	Spring			2
I-9	Stopper			2set
II	Plug Kit			
II-10	Plug			2
II-11	Rod Seal	DYR 10	N.B.R	2
II-12	O-ring	P14	N.B.R	2
II-13	Push Rod			2
14	Cover			1
15	Wrench Bolt	M6×35L	SCM440	2
16	Guide			1
17	Pin			1
18	Socket Bolt	M5×15L		2
19	Nut	M5	SCM440	2
20	Lever			1
21	Spring Pin	ø3×18L		1
22	Boot			1
23	Bushing			1
24	Name Plate			1
III	Seal Kit	III-3 II-11, 12		

DISASSEMBLY AND ASSEMBLY TOOL

Part no.	Tool	Specification	Remarks
15	Torque wrench	L35 mm	150 Kg/cm ²
17	L wrench	10 mm	
18	L wrench	15 mm	
19	Spanner	8 mm	

DISASSEMBLY

1. Separate the BOOT (22).

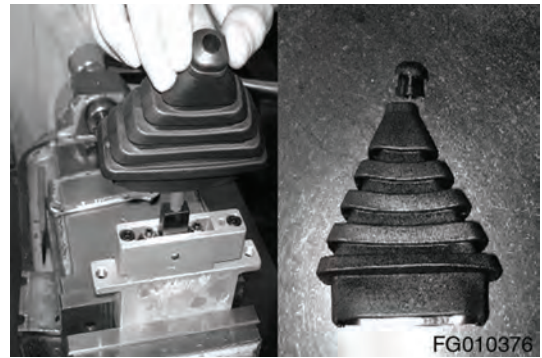


Figure 4

2. Remove the PIN (17) and separate the LEVER (20).

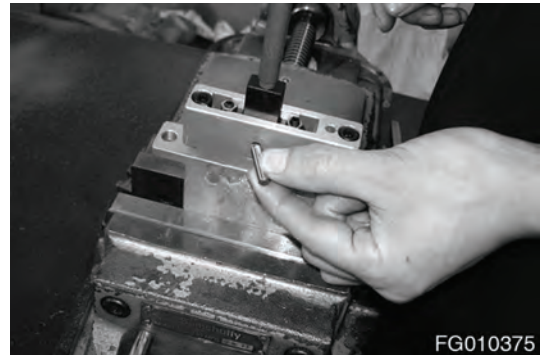


Figure 5

3. Loosen the fixated WRENCH BOLT (15) and separate the COVER (14).

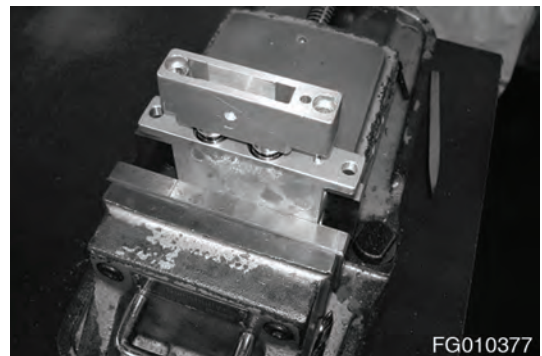


Figure 6

4. Separate the PLUG KIT (II) from the BODY (1).

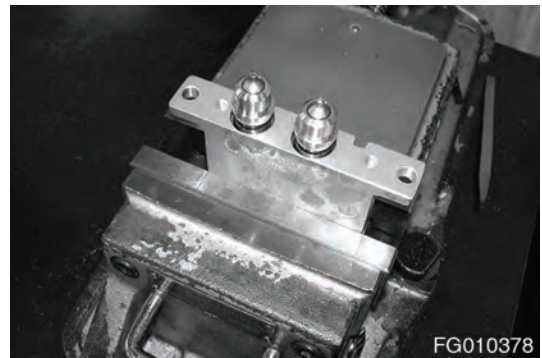


Figure 7

5. Separate the SPOOL KIT (I) from the BODY (1).



Figure 8

6. Separate the SPRING (4) from the BODY (1).



Figure 9

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

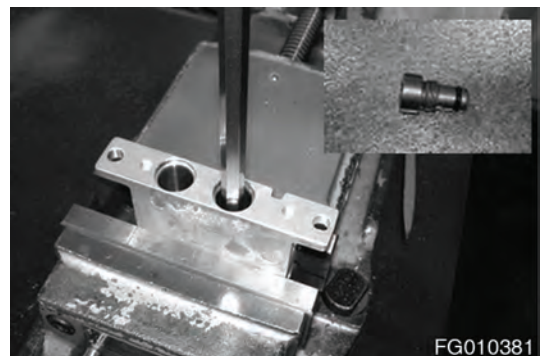


Figure 10

ASSEMBLY METHOD

1. Assemble the PLUG (2) to the BODY (1).

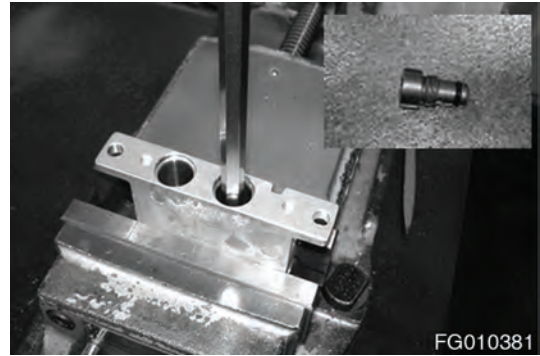


Figure 11

2. Assemble the SPRING (4) to the BODY (1).

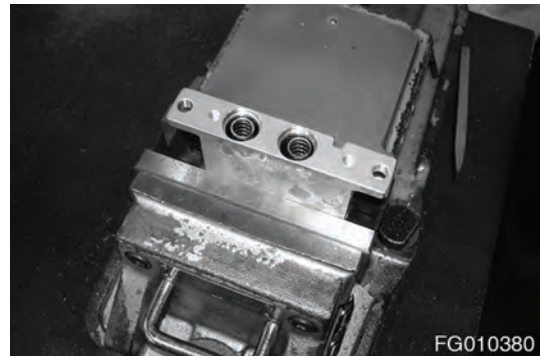


Figure 12

3. Assemble the SPOOL KIT (I).
Assemble SPRING SEAT (I-5), SPRING (I-8), SPRING SEAT (I-5) STOPPER (I-9) to SPOOL (I-6) in this order.

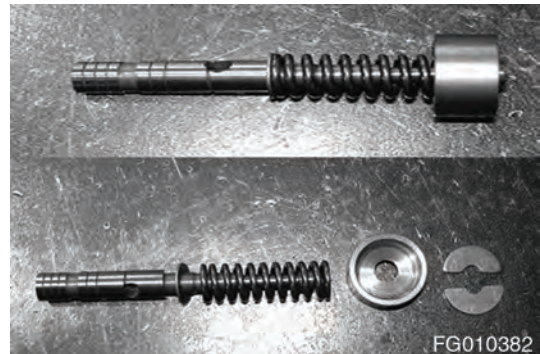


Figure 13

4. Assemble the SPOOL KIT (I) to the BODY (1).

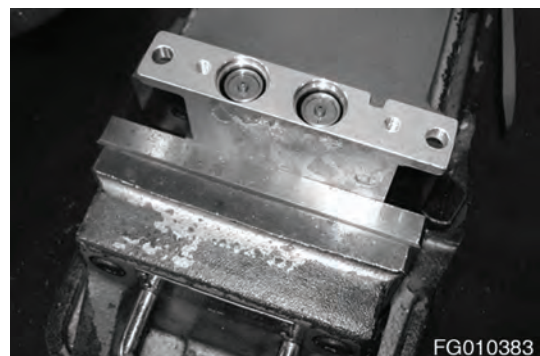


Figure 14

5. Assemble the PLUG KIT (II).
Assemble the ROD SEAL(II-11), O-RING(II-12) and PUSH
ROD(II-13) to the PLUG (II-10) in this order.



Figure 15



Figure 16

6. Assemble the PLUG KIT (II) to the BODY (1).

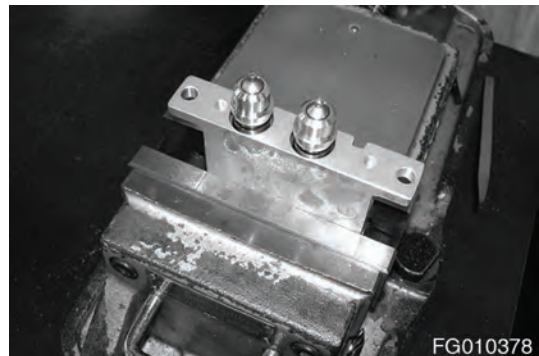


Figure 17

7. Assemble the COVER (14) to the BODY (1).

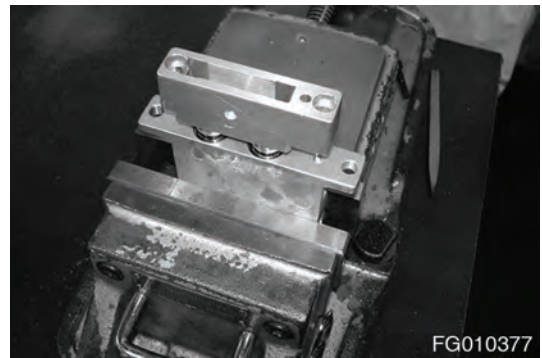


Figure 18

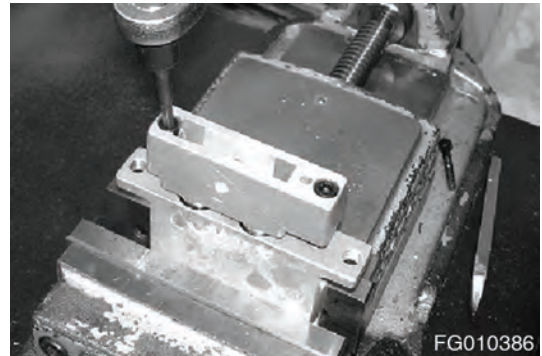


Figure 19

8. After assembling the LEVER20 (20) and GUIDE (16), then install it on the BODY (1) and fixate the assemble with the PIN (17).

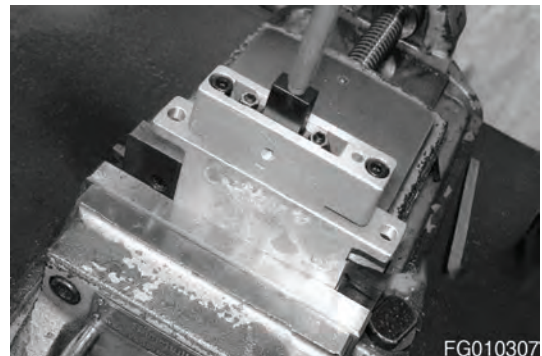


Figure 20



Figure 21

9. Adjust the gap between the GUIDE (16) and PUSH ROD (II-13).

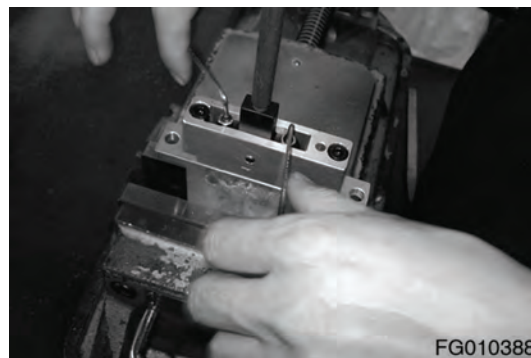


Figure 22

10. Assemble the BOOT (22).

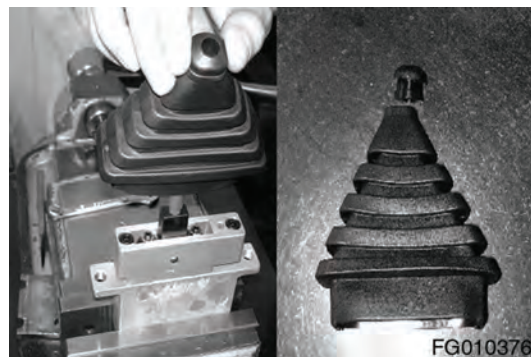


Figure 23

Accelerator Pedal Valve (Hydraulic)

Edition 1

MEMO

Table of Contents

Accelerator Pedal Valve (Hydraulic)

Safety Precautions	5
Applicable Models	5
Structure	6
Parts List.....	6
Performance Curve	7
Hydraulics Symbol.....	7
Disassembly & Assembly Tools.....	7
Disassembly	8
Assembly	9

MEMO

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.

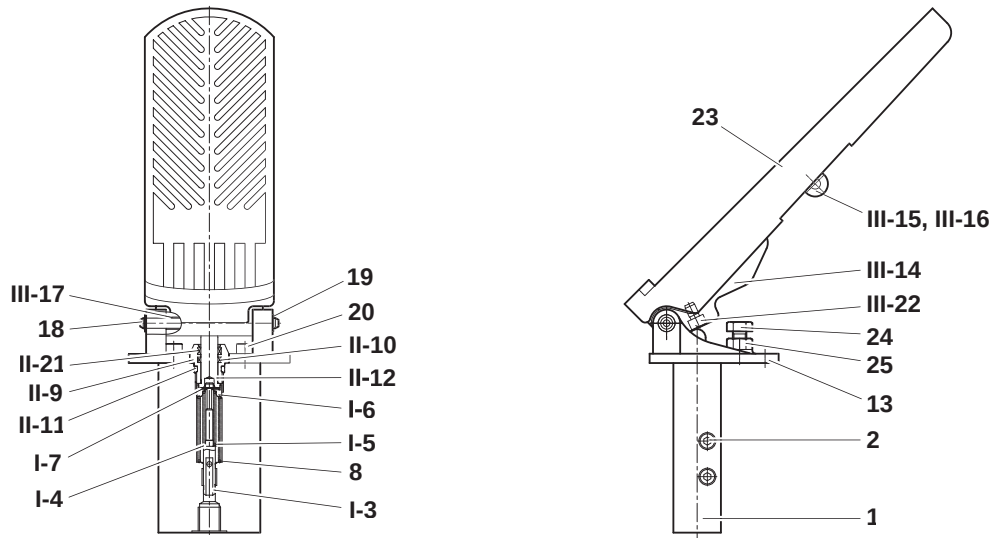
Remember, that ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	

STRUCTURE



FG011193

Figure 1

PARTS LIST

No.	Part Name	Standard	Material	Q'ty
1	Body			1
2	Plug			2
I	Spool Kit			
I-3	Spool			1
I-4	Spring Seat			1
I-5	Spring			1
I-6	Spring Seat			1
I-7	Stopper			1 set
8	Spring			1
II	Plug Kit			
II-9	Plug			1
II-10	Seal	DYR10	N.B.R	1
II-11	O-ring	P14	N.B.R	1
II-12	Push Rod			1
13				
III				
III-14				
III-15				
III-16				
III-17				
18				
19				
20				
III-21				

PERFORMANCE CURVE

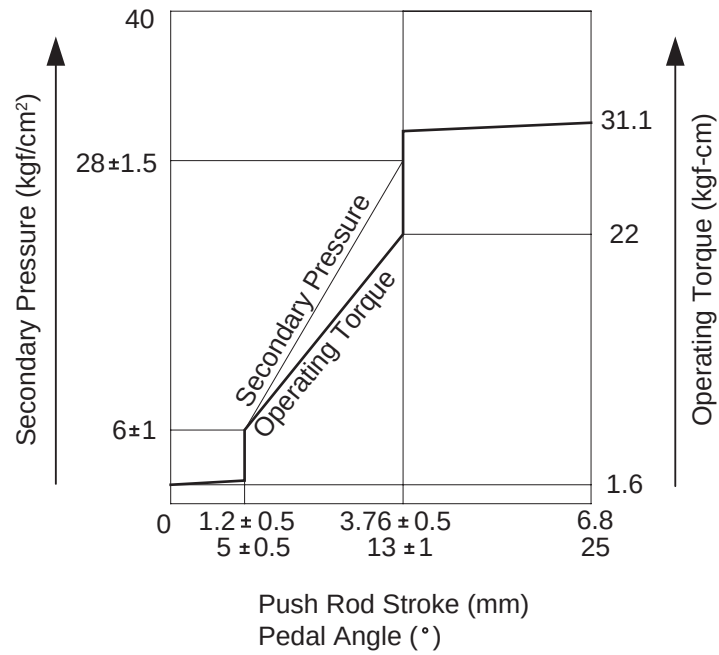


Figure 2

FG012370

HYDRAULICS SYMBOL

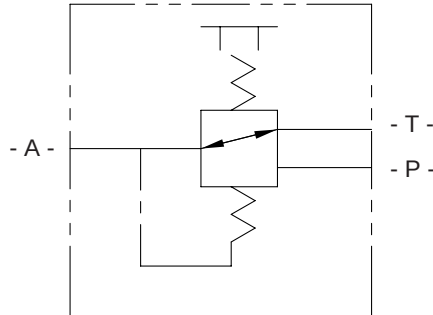


Figure 3

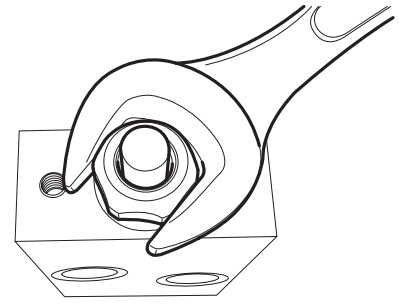
FG007508

DISASSEMBLY & ASSEMBLY TOOLS

NO.	Tool	Standard	Remark
2	L Wrench	5 mm	
II-9	Spanner	21mm	

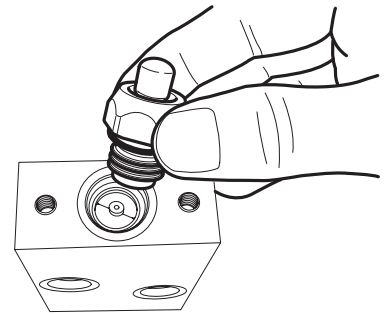
DISASSEMBLY

1. Disassemble plug kit (II) from the body (1).



FG007509

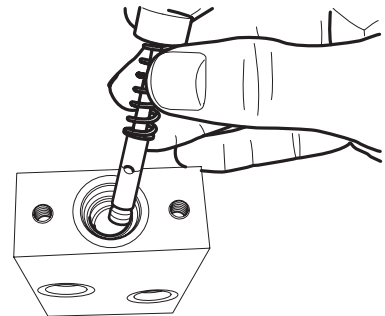
Figure 4



FG007510

Figure 5

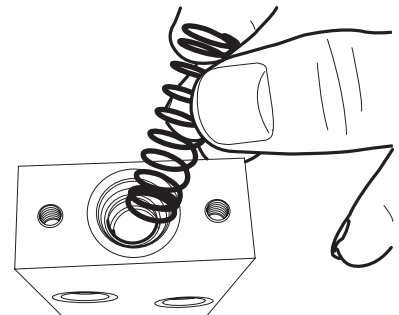
2. Disassemble spool kit (I) from the body (1).



FG007511

Figure 6

3. Disassemble spring (8) from the body (1).

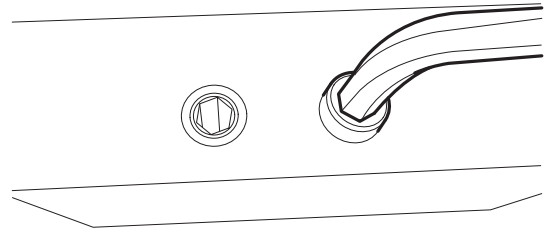


FG007512

Figure 7

ASSEMBLY

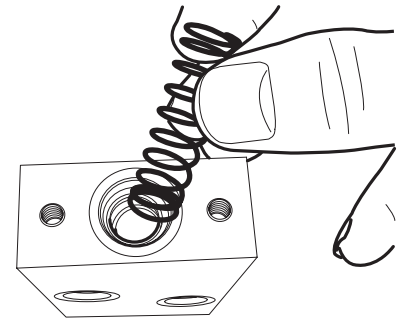
1. Assemble plug (2) in the body (1).



FG007513

Figure 8

2. Assemble spring (8) in the body (1).



FG007512

Figure 9

3. Assemble spool kit (I).

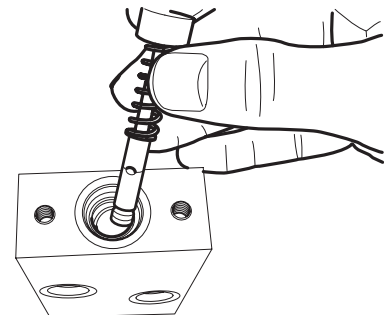
Assemble spring seat (I-4), spring (I-5), spring seat (I-6) and stopper (I-7) at spool (I-3) in the order.



FG007514

Figure 10

4. Assemble spool kit (I) in the body (1).



FG007511

Figure 11

5. Assemble plug kit (II)

Assemble seal (II-10), dust seal (II-13), O-ring (II-11), push rod (II-12) in plug (II-9) in the order.



Figure 12

6. Assemble plug kit (II) in the body (1).

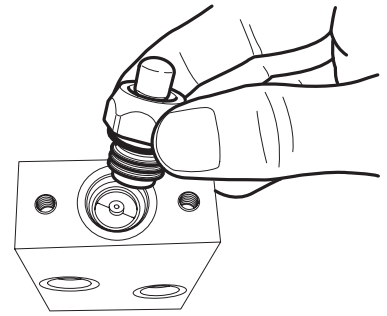


Figure 13

FG007510

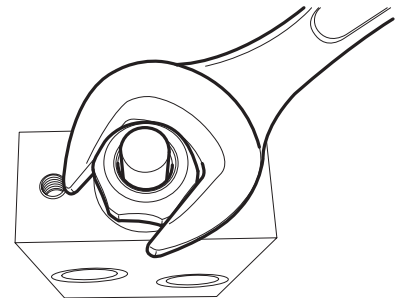


Figure 14

FG007509

Service Brake Pedal Valve

Edition 1

MEMO

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Service Brake Pedal Valve

Safety Precautions	5
Applicable Models	5
Functions of Brake Pedal	6
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Internal Structure.....	7
Operation Principles	9
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Reassembly	10
Reassembly of the Lower Part	10
Reassembly of the Upper Part	12
Assembly of Pedal Plate	15

MEMO

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.

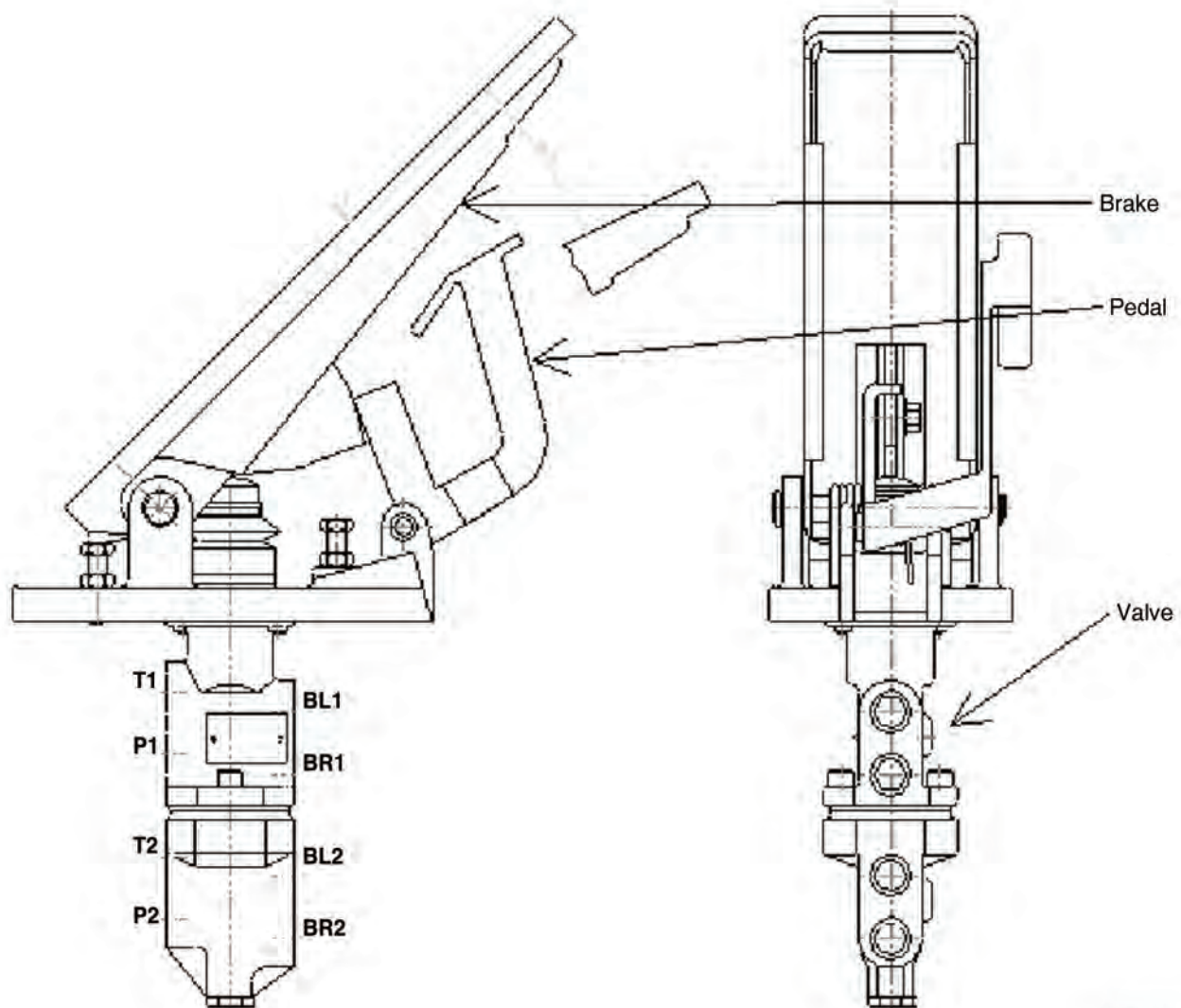
Remember, that ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

FUNCTIONS OF BRAKE PEDAL



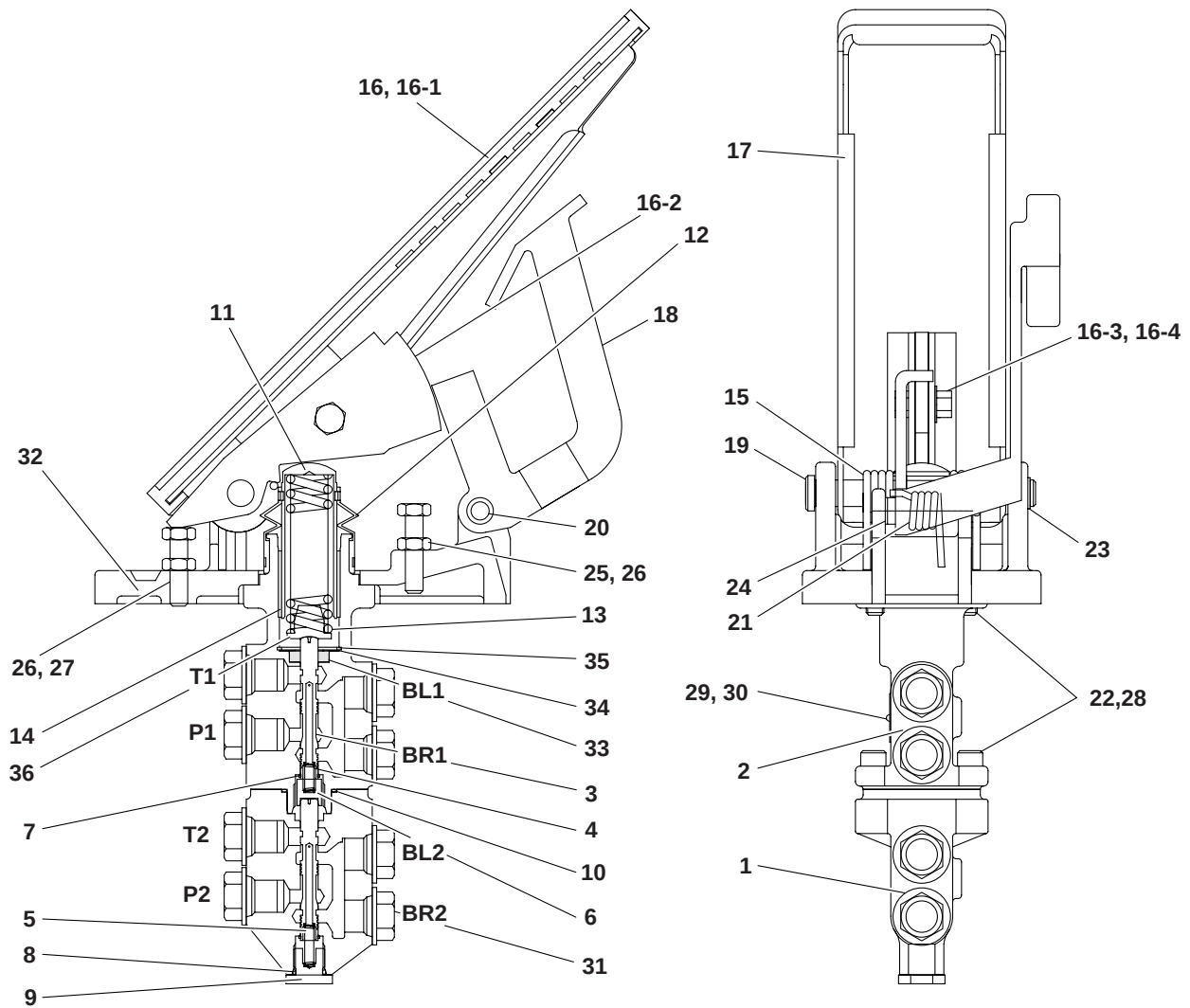
FG007747

Figure 1

This wheel type valve is designed for heavy-duty brake pedal valve of driving excavator used at construction sites. It is hydraulic operated (see the following for operation principles) and contains an operation brake function to fix pedal with ratch while the machine stops.

INTERNAL STRUCTURE AND OPERATION PRINCIPLES

Internal Structure



FG011075

Figure 2

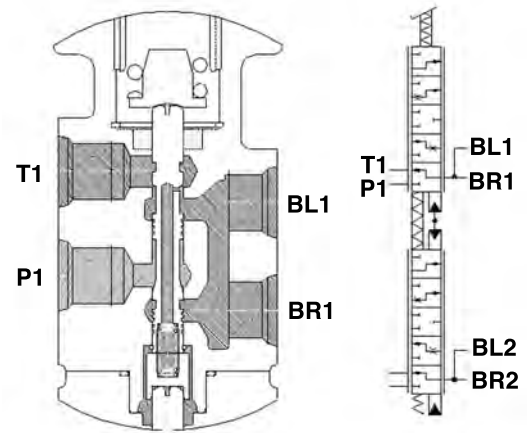
Reference Number	Description
1	Lower part
2	Upper Part
3	Spool
4	Upper Spring
5	Lower Spring
6	Spring Guide
7	Retaining Ring
8	O-ring
9	Plug
10	O-ring
11	Holder
12	Rubber Cover
13	Main Spring
14	DU Bush
15	Drive Bearing
16	Pedal Assembly
16-1	Pedal
16-2	Lock Plate
16-3	Hexagon Bolt (M8X20)
16-4	Plat Washer

Reference Number	Description
17	
18	Latch
19	Rock Pin 1 (Pedal
20	Rock Pin 2 (Ratch)
21	Torsion Spring (Latch)
22	SH Bolt
23	C-type Retaining Ring
24	E-ring
25	Hexagon Bolt
26	Hexagon Nut
27	Hexagon Bolt
28	Spring Washer
29	Name Plate
30	Drive Screw
31	Port Plug
32	Pedal Plate
33	Oil Seal
34	Plat Washer
35	C-type Retaining Ring
36	Spring Retainer

Operation Principles

Brake valve is a reducing valve. Pressure to main pressure (P port) flows in the valve and reduced set pressure flows to the axle brake via the brake port (BR port) to stop the machine.

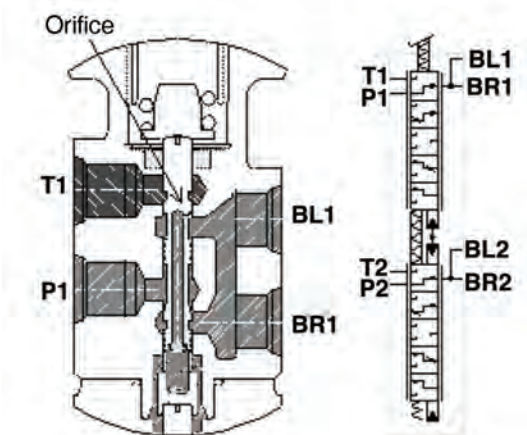
1. In Neutral Position
 - A. P port spool (3) blocks main pressure to P1 port.
 - B. T and BR ports are connected, which is the tank pressure.



FG003649

Figure 3

2. During Operation
 - A. Operation of pedal causes action of main spring (13) and spool (3). The load of spring (13) generates pressure B port seating pressure.
 - B. P and BR ports are connected and pressure is generated, which moves to orifice to act pilot pressure to the floor of spool (3).
 - C. If pilot pressure is higher than pressure set to spring (13), spool (3) moves up and pressure decreases.
 - D. If pilot pressure is lower than pressure set to spring (13), spool (3) moves down to close T port and pressure increases.
 - E. Operation angle of pedal changes load of spring (13) and thus the second pressure of BR port.



FG007748

Figure 4

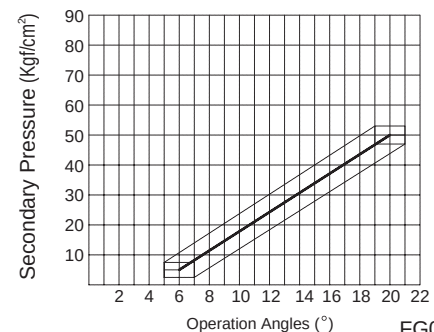
Refer to the Curve

P1, P2 ports: Supply pressure

T1, T2 ports: Tank port

BR1, BR2 ports: Brake supply port

BL1, BL2 ports: Brake pressure sensor location



FG012373

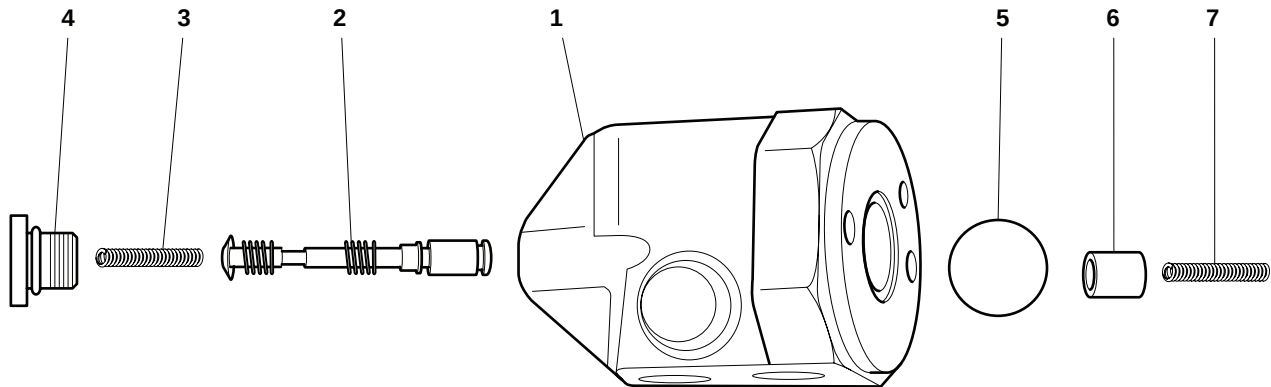
Figure 5

DISASSEMBLY

Disassembly shall be made in the reverse order of reassembly.

REASSEMBLY

Reassembly of the Lower Part



FG003651

Figure 6

Reference Number	Description
1	Lower Part
2	Spool
3	Lower Spring
4	Plug

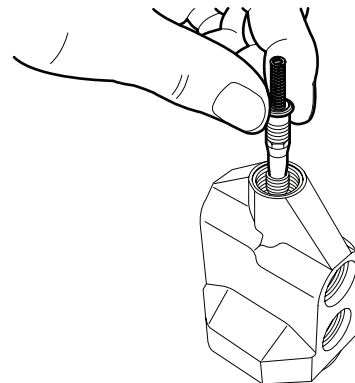
Reference Number	Description
5	O-ring
6	Spring Guide
7	Upper Spring

1. Insert spool (2) and lower spring (3) in lower part (1).



CAUTION!

Take care to prevent dust or foreign substances entering into valves after washing.

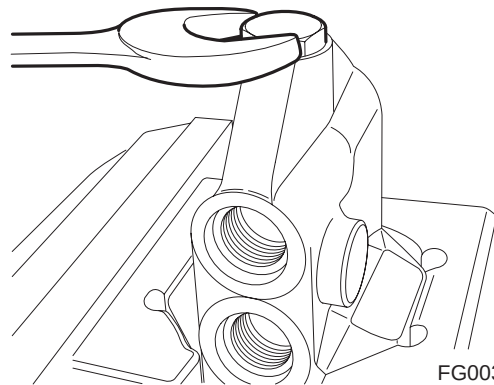


FG003652

Figure 7

2. Install plug (4) on lower part (1).

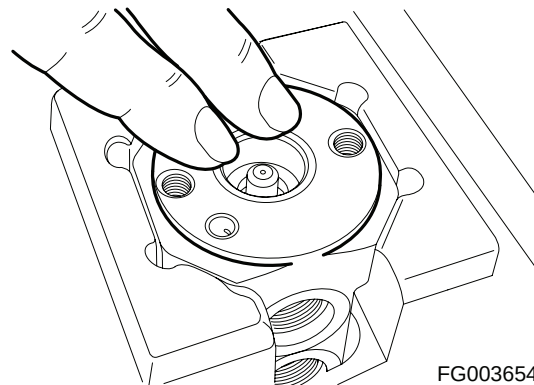
Tools : 19 mm spanner (Tightening torque: 1400 ~ 1650 kgf•m)



FG003653

Figure 8

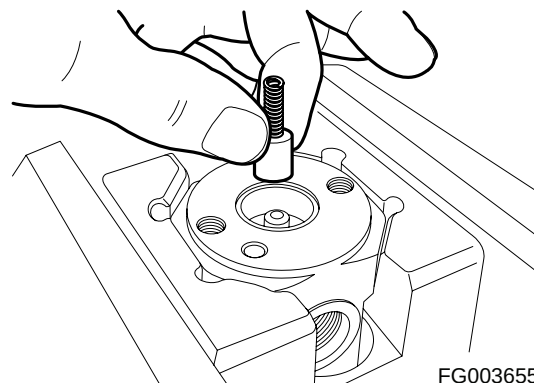
3. Install O-ring (5).



FG003654

Figure 9

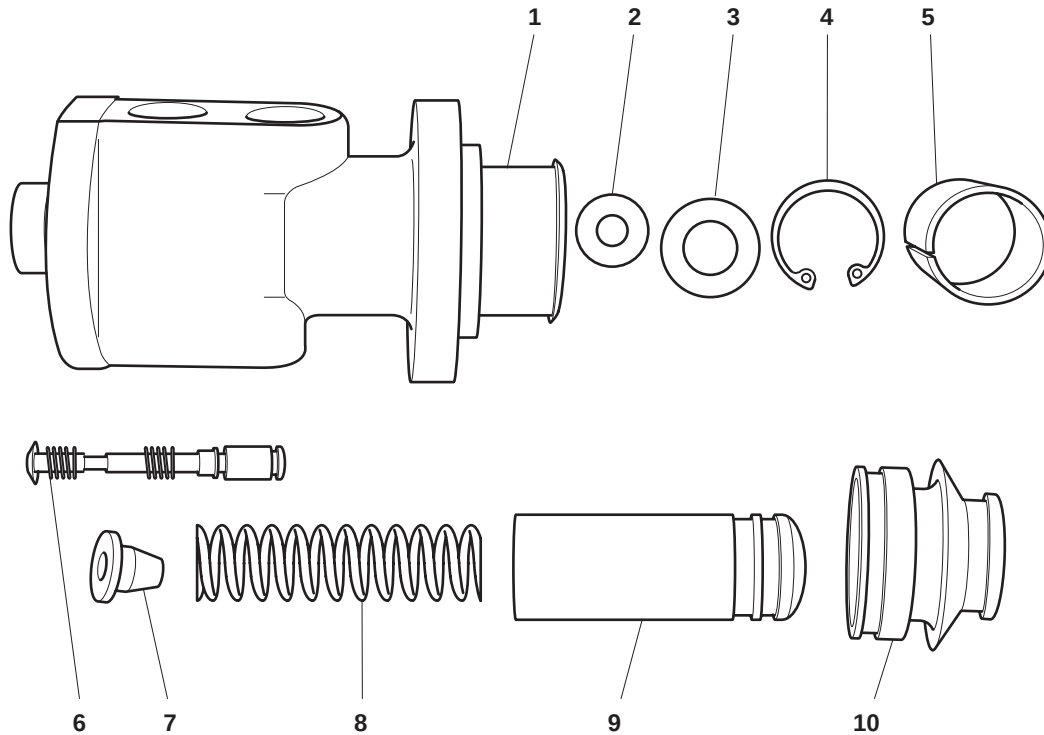
4. Install spring guide (6) and upper spring (7).



FG003655

Figure 10

Reassembly of the Upper Part



FG003656

Reference Number	Description
1	Upper Part
2	Oil Seal
3	Plain Washer
4	Retaining Ring
5	Drive Bearing

Reference Number	Description
6	Spool
7	Spring Retainer
8	Main Spring
9	Holder
10	Rubber Cover

1. Install oil seal (2), plain washer (3), retaining ring (4), and drive bearing on upper part (1).

Tools: Drive bearing jig and snap ring plier.



Use a jig to press and push bearing.

Never remove the dry bearing.

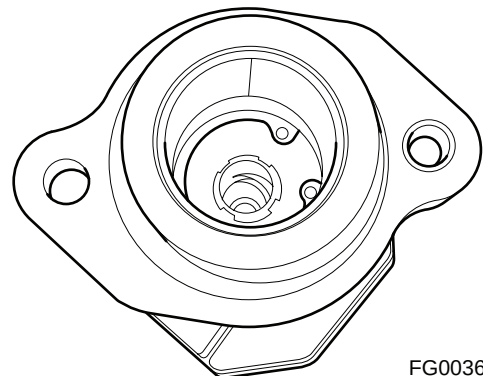


Figure 11

FG003657

2. Insert spool into the upper part.



CAUTION!

Take care to prevent dust or foreign substances entering into valves after washing.

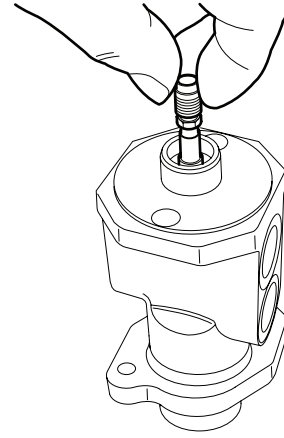


Figure 12

FG003658

3. Assemble the upper and lower parts.



CAUTION!

Do not forget to install O-ring.

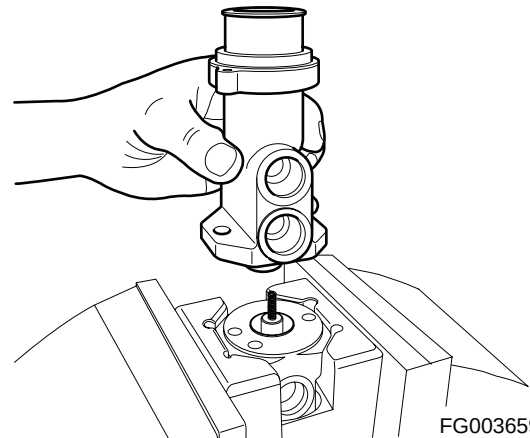


Figure 13

FG003659

4. Connection of the upper and lower parts
6 mm torque wrench (Tightening torque: 250 ~ 300 kgf·m)

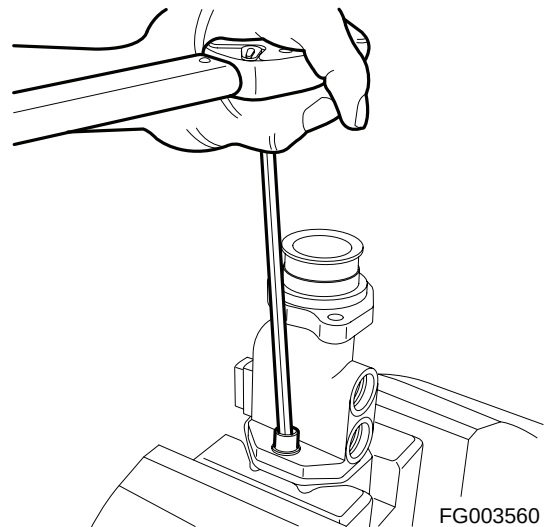


Figure 14

FG003660

5. Assemble spring retainer (7) and main spring (8).

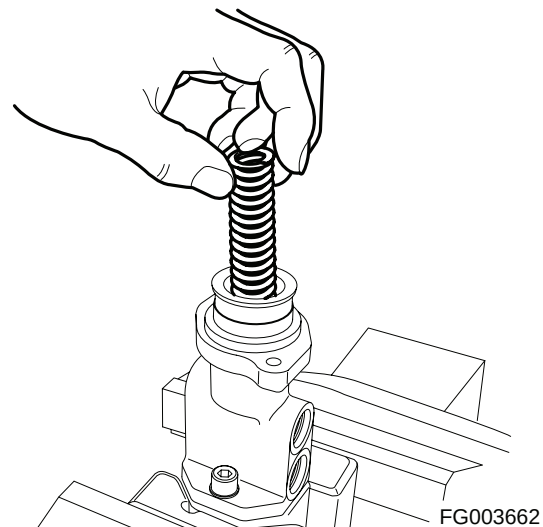


Figure 15

6. Install holder (9).

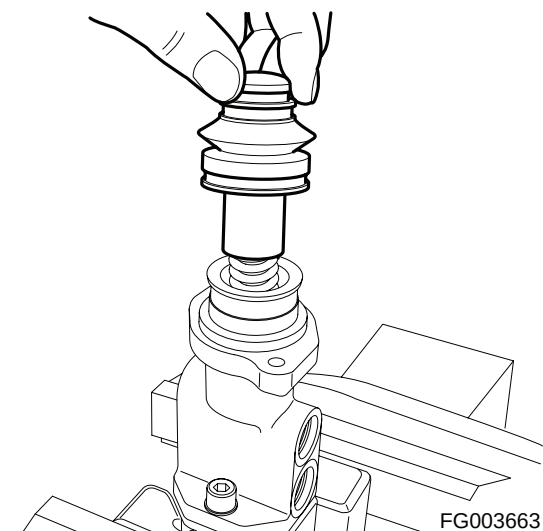


Figure 16

7. Install rubber cover (10).

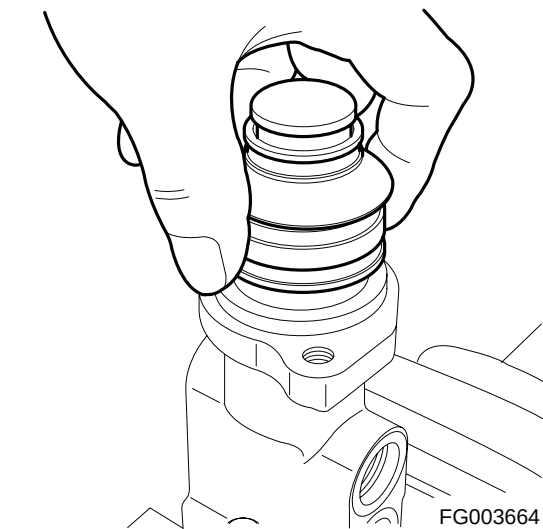
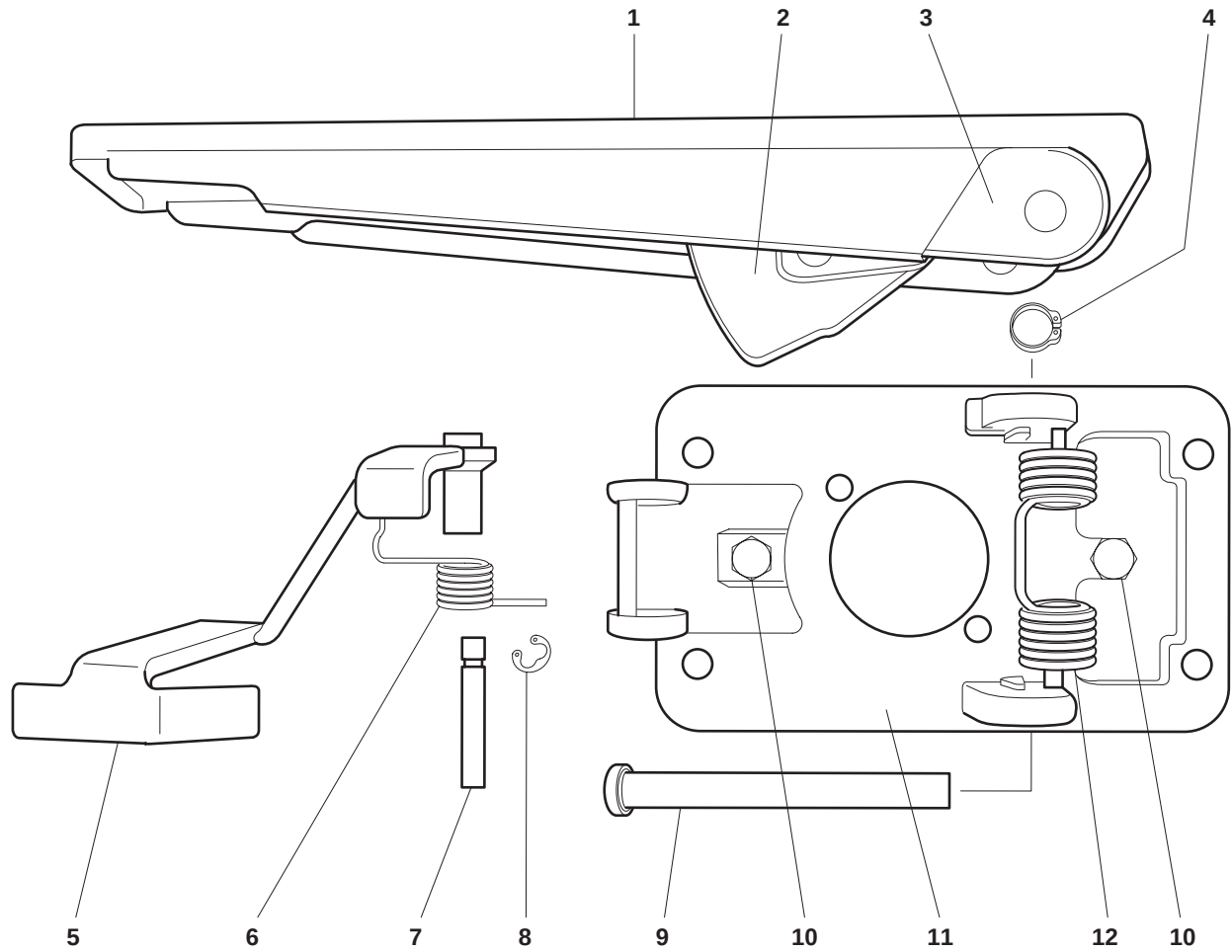


Figure 17

Assembly of Pedal Plate



FG003665

Figure 18

Reference Number	Description
1	Rubber Pedal
2	Lock Plate
3	Pedal
4	Retaining Ring
5	Ratch
6	Ratch Spring

Reference Number	Description
7	Ratch Lock Pin
8	Retaining Ring
9	Pedal Lock Pin
10	Hexagon Bolt
11	Pedal Plate
12	Double Torsion Spring

1. Install pedal plate.

Tools: 6 mm torque wrench (Tightening torque: 250 ~ 300 kgf•m)

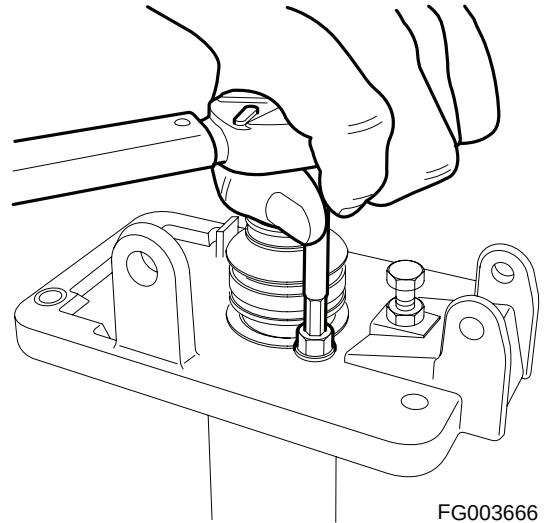


Figure 19

FG003666

2. Use a $\varnothing 12$ round rod to place pedal elements (2, 3) and double torsion spring (11) on pedal plate (12) and use a hammer to push the round rod into lock pin (9).

Tools: $\varnothing 12$ round rod and plastic hammer

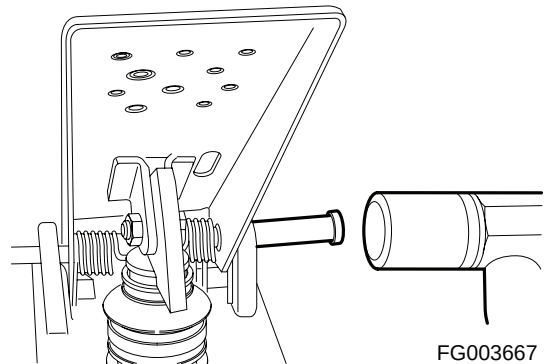


Figure 20

FG003667

3. Install the lock pin retaining ring at the end of lock pin (9).

Tools: Shaft snap ring flyer



CAUTION!

When removing lock pin, remove the retaining ring first.

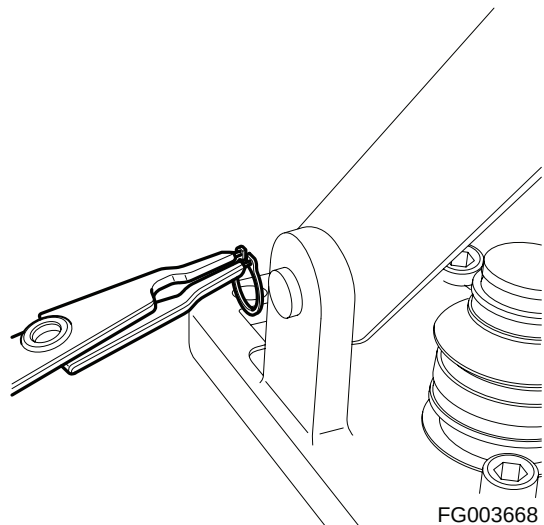


Figure 21

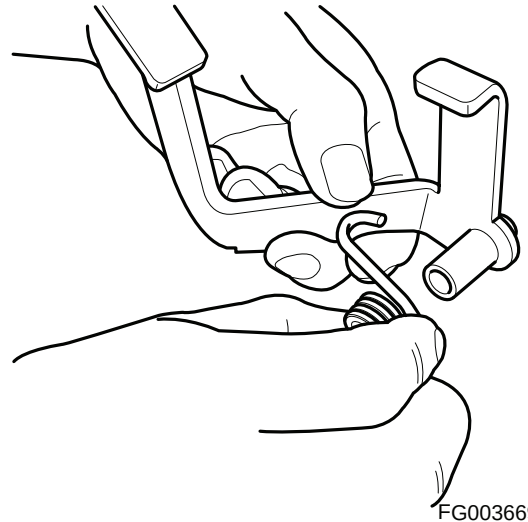
FG003668

4. Install ratch spring (6) on ratch (5).



CAUTION!

Apply grease to the inside of ratch spring.



FG003669

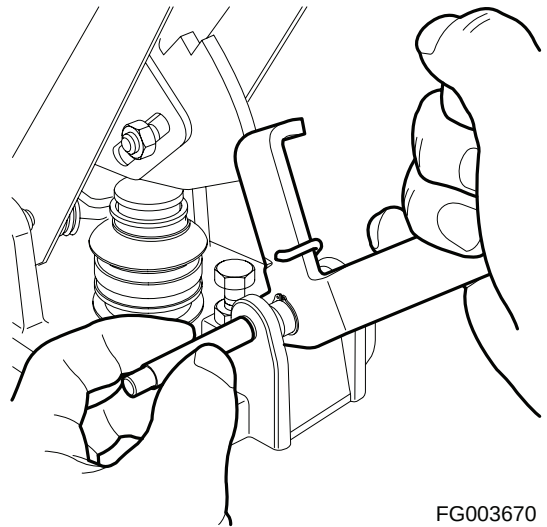
Figure 22

5. Use ratch lock pin (7) to install the ratch assembly in pedal plate (11).



CAUTION!

When removing lock pin, remove the retaining ring first. (Damage to pedal plate)

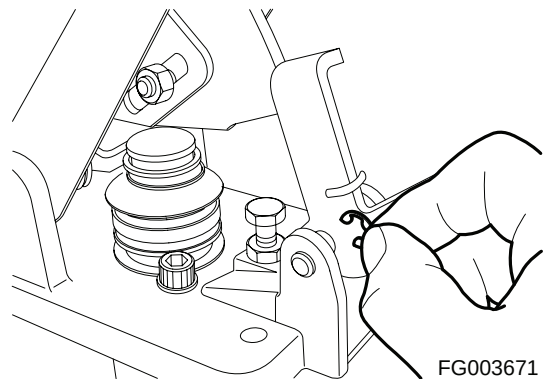


FG003670

Figure 23

6. Install retaining ring.

Tool: Driver



FG003671

Figure 24

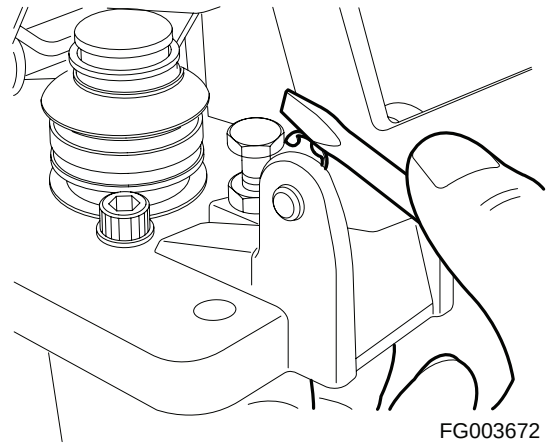


Figure 25

FG003672

7. Apply grease to the area of lock plate (2) which ratch contacts.

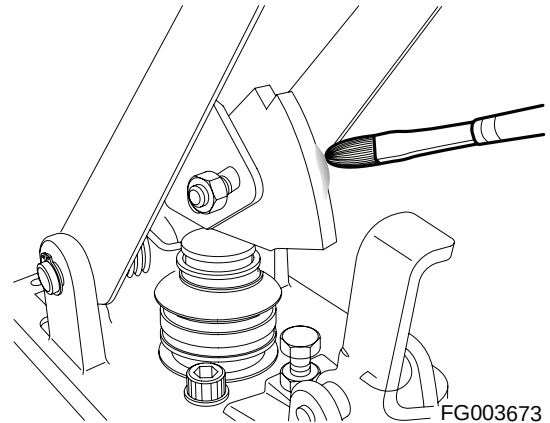


Figure 26

FG003673

8. Use a driver to install rubber pedal (1) on the pedal assembly.

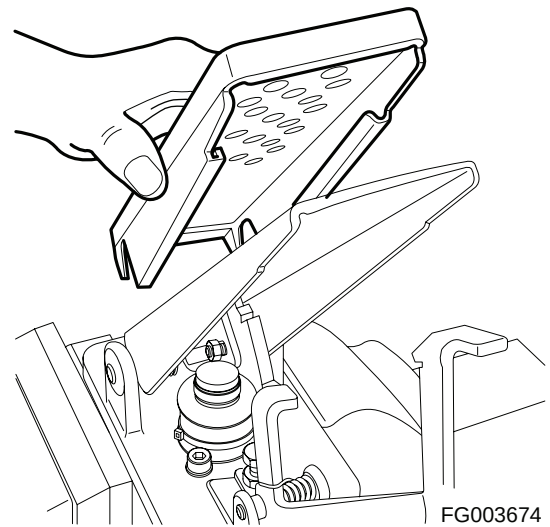


Figure 27

FG003674

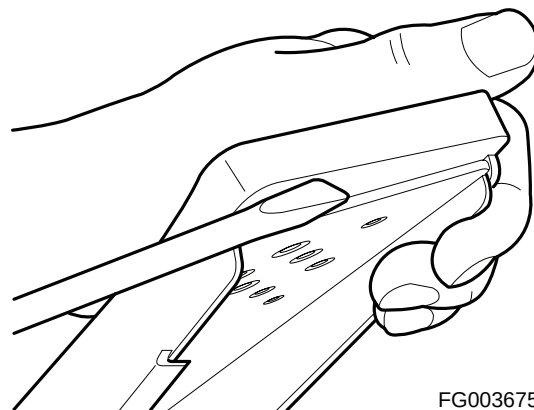


Figure 28

FG003675

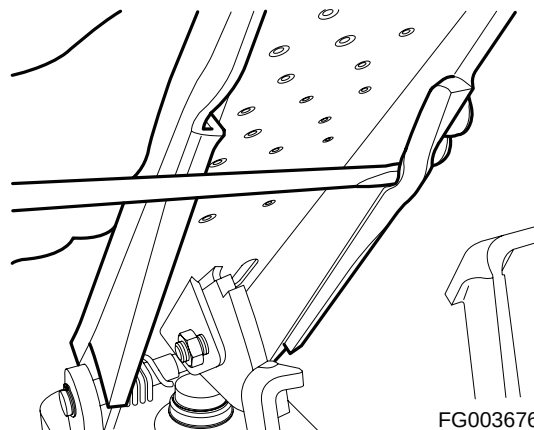


Figure 29

FG003676

9. Install pedal angle adjustment bolt (10).
Tool: 13 mm spanner (tightening torque: 200 kgf•m)

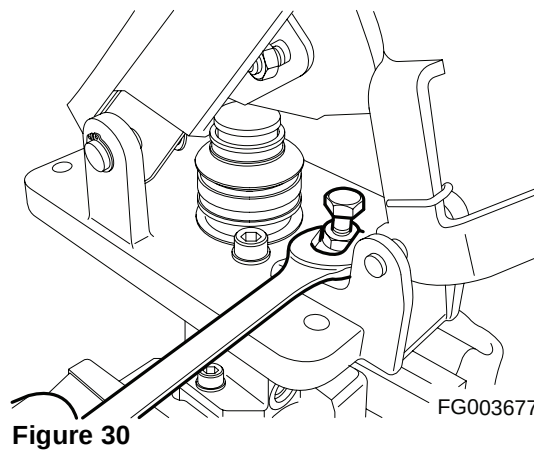


Figure 30

FG003677

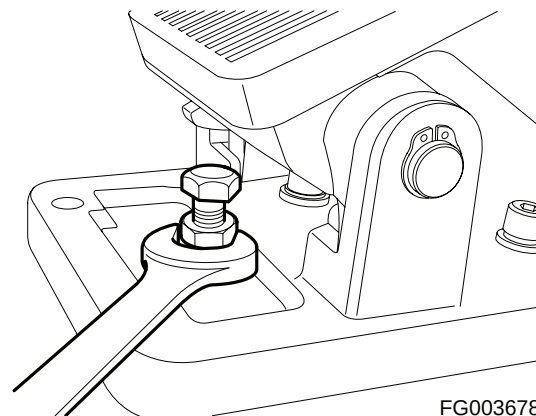


Figure 31

FG003678

Hydraulic Schematic (DX55W)

Edition 1

MEMO

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Hydraulic Schematic (DX55W)

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MEMO

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 ultimately 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
DX55W	5001 and Up

DX55W

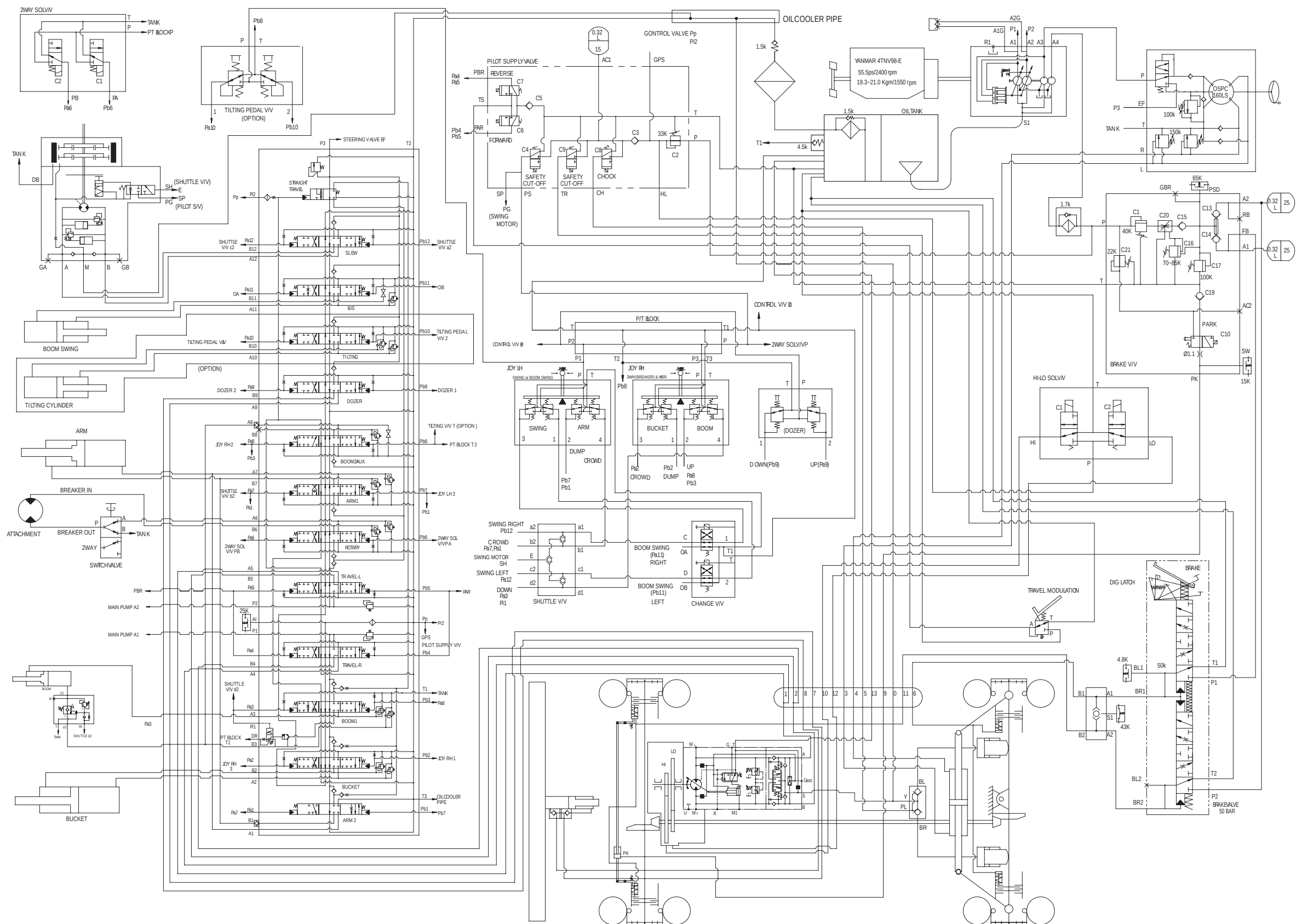


Figure 1

FG012375

Electrical System

Electrical System

Edition 1

MEMO

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SAFETY PRECAUTIONS



CAUTION

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APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

OVERVIEW

The electrical system for this equipment is DC 12 volts. The rated voltage for all electric components is 12 volts. The system contains one 12 volts battery and a three phase AC generator with a rectifier. The electric wiring used in the system is easily identifiable by the insulator color. The color symbols used in the electric system are listed in the following chart.

Electrical Wire Color

Symbol	Color
W	White
G	Green
Or	Orange
B	Black
L	Blue
Lg	Light Green
R	Red
Gr	Gray
P	Pink
Y	Yellow
Br	Brown
V	Violet

NOTE: *RW: Red wire with White stripe*
R - Base Color, W - Stripe Color

NOTE: *0.85G: Nominal sectional area of wire core less insulator = 0.85 mm²*

ELECTRICAL SUPPLY SYSTEM

The electric power circuit supplies electric current to each electric component. It consists of battery, starter switch fusible link and fuse box.

The negative terminal of battery is grounded to negative body.

Even when starter switch (5) is in "OFF" position, electric current is supplied to following components through battery (1) → fusible link (3) → fuse (6).

1. Cab light, fuel pump switch, No. 5 terminal of car stereo for back up and No. 1 terminal of hour meter.
2. B terminal of starter switch, No. 22 terminal of A/C panel for back up.
3. Headlight, turn signal light, illumination light and hazard switch.
4. No.34 terminal of ECU (Engine control unit).

When the starter switch is in the ON and START positions, the current flows from the battery (1) → fusible link (3) → fuse box (6) → starter switch (5) "B" terminal / "BR" terminal → battery relay (2) → 'B' terminal which activates the coil of the battery relay and the electric supply system is energized.

When the battery relay's contacts are connected, the current flows from the circuit breaker (4) → fuse box (6) and all electric devices can be operated.

While the engine is not running, the battery supplies the electric power for all electric components. Once the engine is started, the power is supplied from the alternator (7).

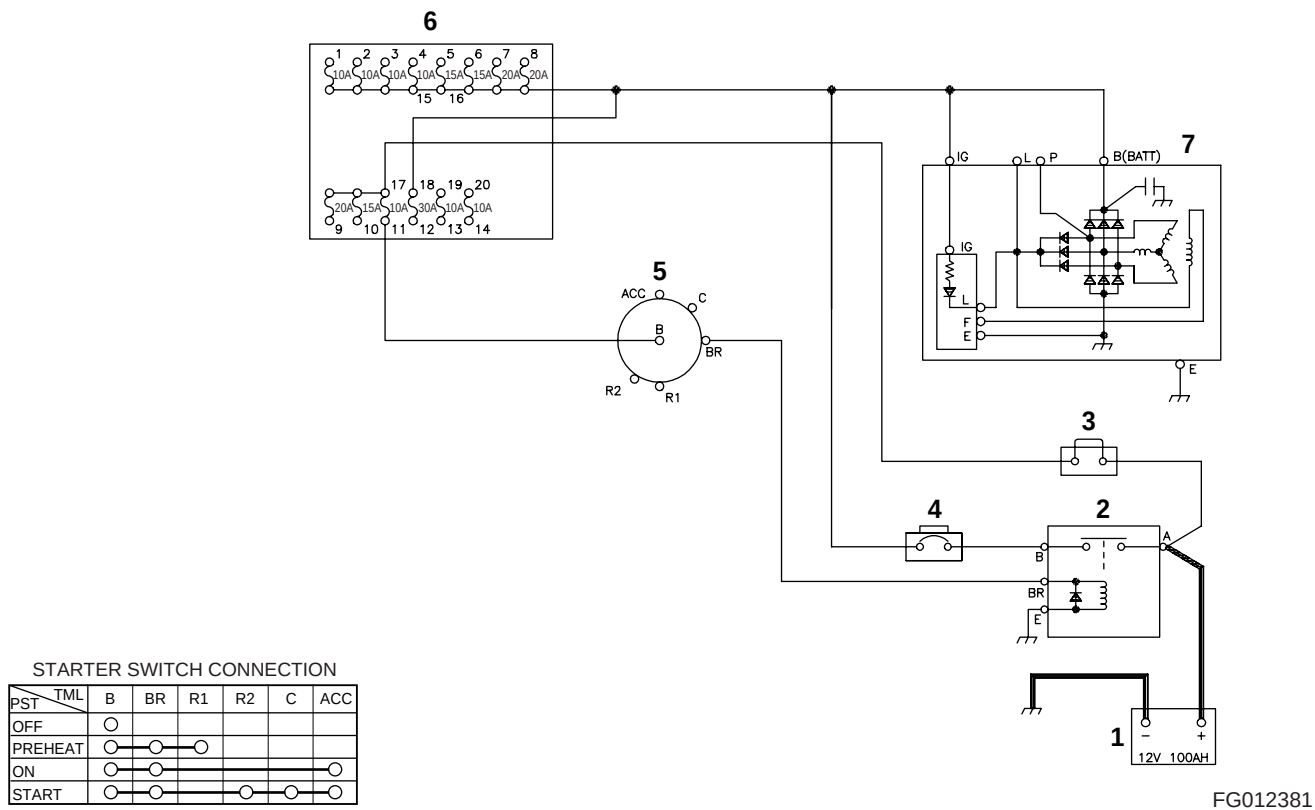


Figure 1

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

ENGINE STARTING

Start Operation

When the starter switch (6) is turned to the ON position, the ECU (9) performs rack self diagnostics directly.

At this time, the starter relay prevents the starter motor from starting until the diagnostics is completed.

When the starter switch (6) is turned to the START position, the contacts in the starter relay (11) are closed by the current flow from battery (1) → fusible link (3) → "B" terminal of starter switch (6) → "C" terminal → "86" terminal of the starter relay (11) → "85" terminal → "20" terminal of ECU (5) → ground.

When the contact point of "86" and "85" of starter relay (11) are connected, the pinion gear of the starter (12) is pushed forward and makes contact with the ring gear of the flywheel and the internal contacts of the starter are connected.

The current flows from the battery (1) → "A" terminal of battery relay (2) – "B" terminal → "B" terminal of starter (12). The starter motor is rotated and the engine is started.

if the neutral signal (14) is not inputted to the "24" terminal of Engine control unit(9), the starter wil not be started. The starter is only started when the travel signal is in the neutral state.

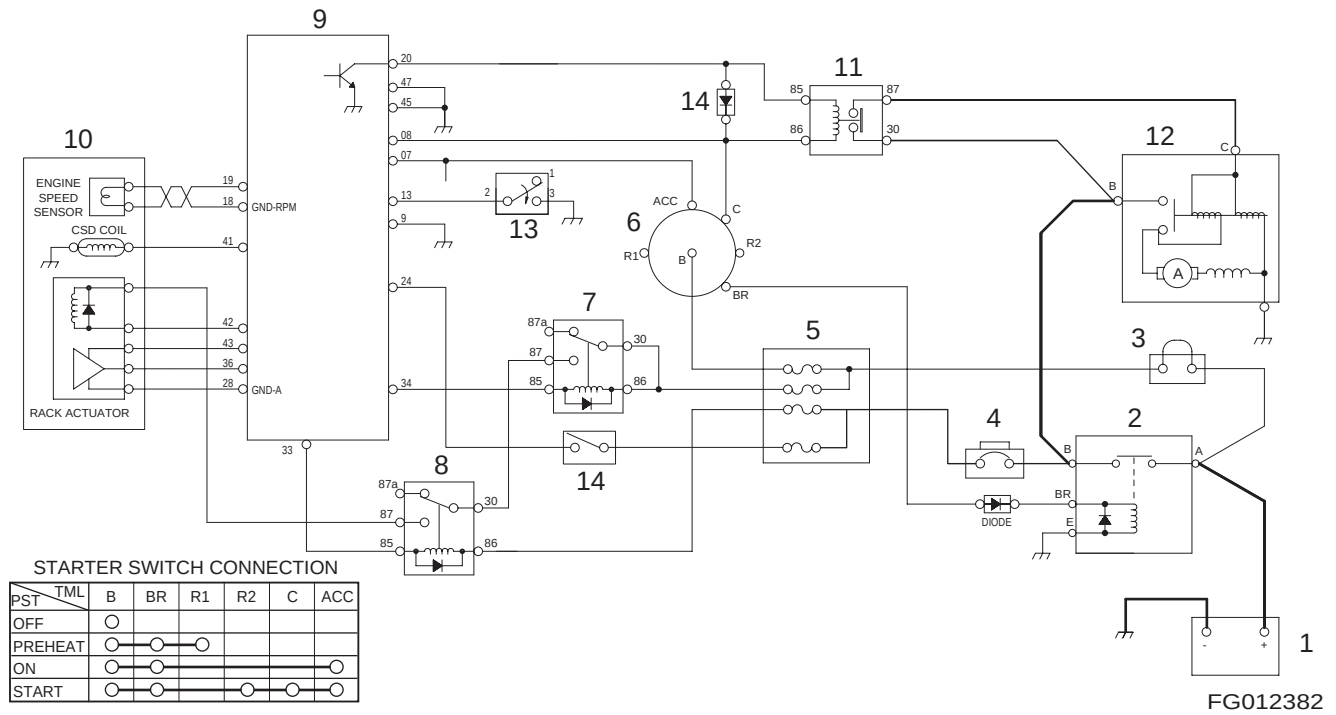


Figure 2 STARTER CIRCUIT

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Starter Switch
7	Main Relay
8	Rack Actuator Relay

Reference Number	Description
9	Engine Control Unit
10	Fuel Injection Pump
11	Starter Relay
12	Starter
13	Engine Emergency Stop Switch
14	Combination Switch (Neutral position)

After Start

when the engine speed goes over 675 rpm, the connection between "20" and "ground" terminals of ECU (9) and the connection between "30" and "87" terminals of starter relay (11) are opened.

As a result the rotation of the starter (12) is stopped.

Once the engine is running, the starter (12) will not operate even if the starter switch (6) is moved to the start position, preventing possible damage to the starter.

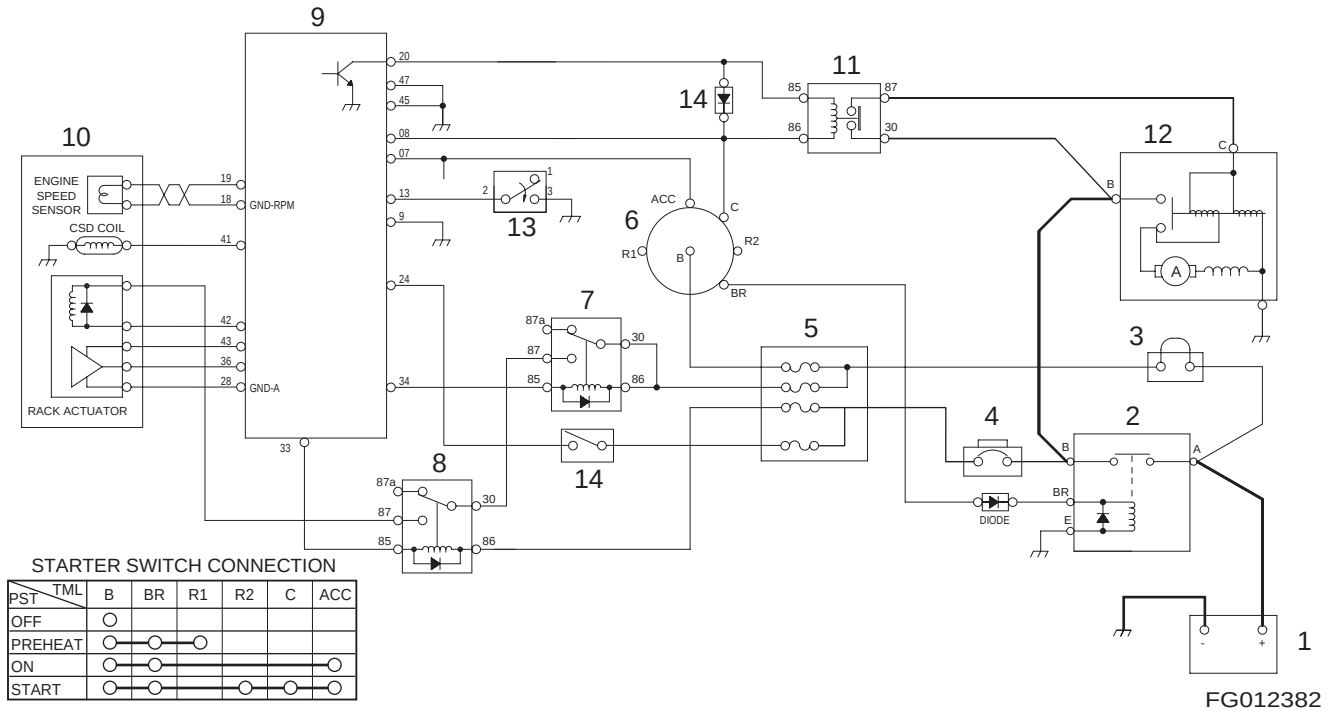


Figure 3 START CIRCUIT

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Starter Switch
7	Main Relay
8	Rack Actuator Relay

Reference Number	Description
9	Engine Control Unit
10	Fuel Injection Pump
11	Starter Relay
12	Starter
13	Engine Emergency Stop Switch
14	Combination Switch (Neutral position)

ENGINE PREHEATING SYSTEM

An air heater (12) is installed in the intake manifold of the engine.

When the starter switch (6) is turned "ON" position, the current flows from the battery (1) → fusible link (3) → fuse box (5) → "B" terminal of starter switch (6) → "ACC" terminal of starter switch → "7" terminal of ECU (9)

At this time, the ECU(9) senses the temperature of engine coolant by coolant temperature sensor(13)

After sensing the temperature of engine coolant, ECU controls the preheat relay (11) and current flows from the "44" terminal of engine controller (9) → "86" terminal of preheat relay (11) → "85" terminal of preheat relay (11) → ground. This current flow causes the coil in preheat relay (11) to be activated, closing contacts.

When the contacts of the preheat relay (11) are closed, the heating coils of the air heater (12) is heated by current flowing from battery (1) → battery relay(2) → fusible link (3) → preheat relay(11) → air heater(12) → ground.

The duration of heating cycle depends on the temperature of engine coolant. The preheat indicator light in the instrument panel(15) will turn "ON" during preheating cycle. The longer the preheating period, the lower the temperature of coolant is.

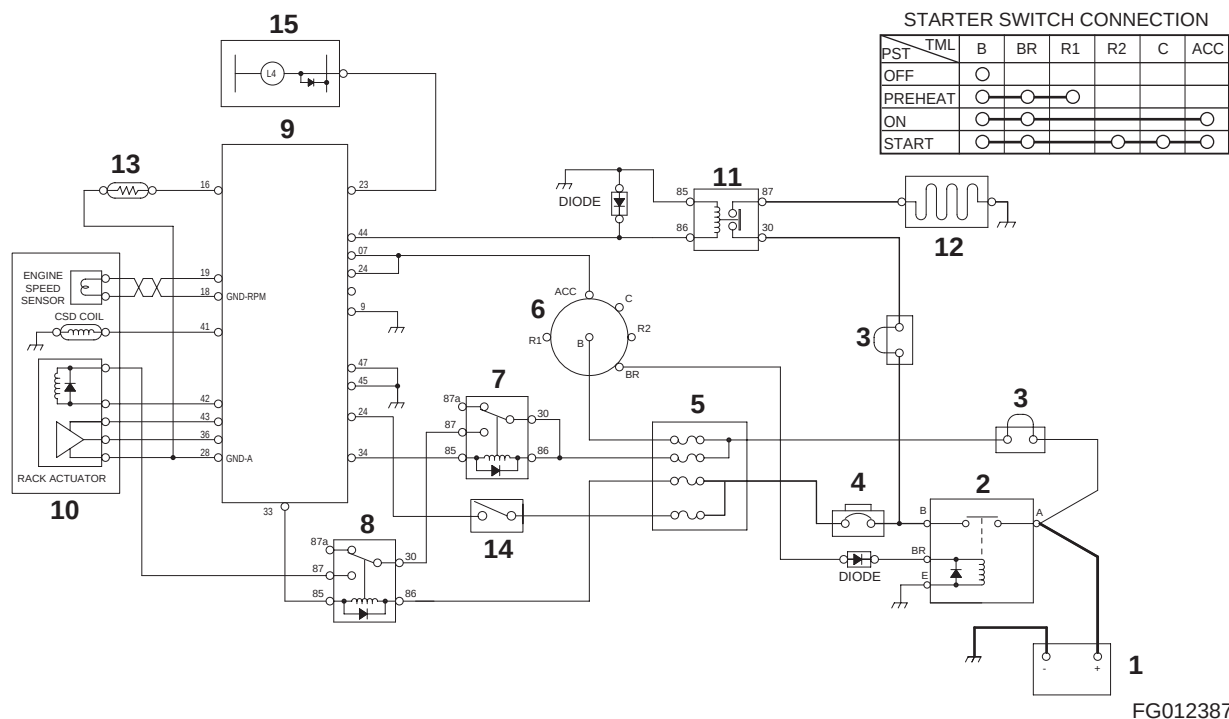


Figure 4 ENGINE PREHEAT CIRCUIT

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Starter Switch
7	Main Relay
8	Rack Actuator Relay

Reference Number	Description
9	Engine Control Unit
10	Fuel Injection Pump
11	Preheat Relay
12	Air Heater
13	Engine Coolant Temperature Sensor
14	Combination Switch (Neutral)
15	Instrument Panel

ENGINE STOP

When the starter switch (6) is turned "ON" position, the ECU (9) is activated.

The ECU (9) controls the rack actuator in the fuel injection pump (10) to control the fuel deliver rate.

When the start switch (6) is turned "OFF" position, the ECU(9) stops supplying power to the rack actuator relay (8). As a result, the power supplying from rack actuator relay (8) to fuel injection pump (10) stops. This stops fuel from being injected into the engine, thus stopping the engine.

In the event that the engine can not be shut down using the starter switch (6), an emergency stop switch (13) is provided to shut down engine.

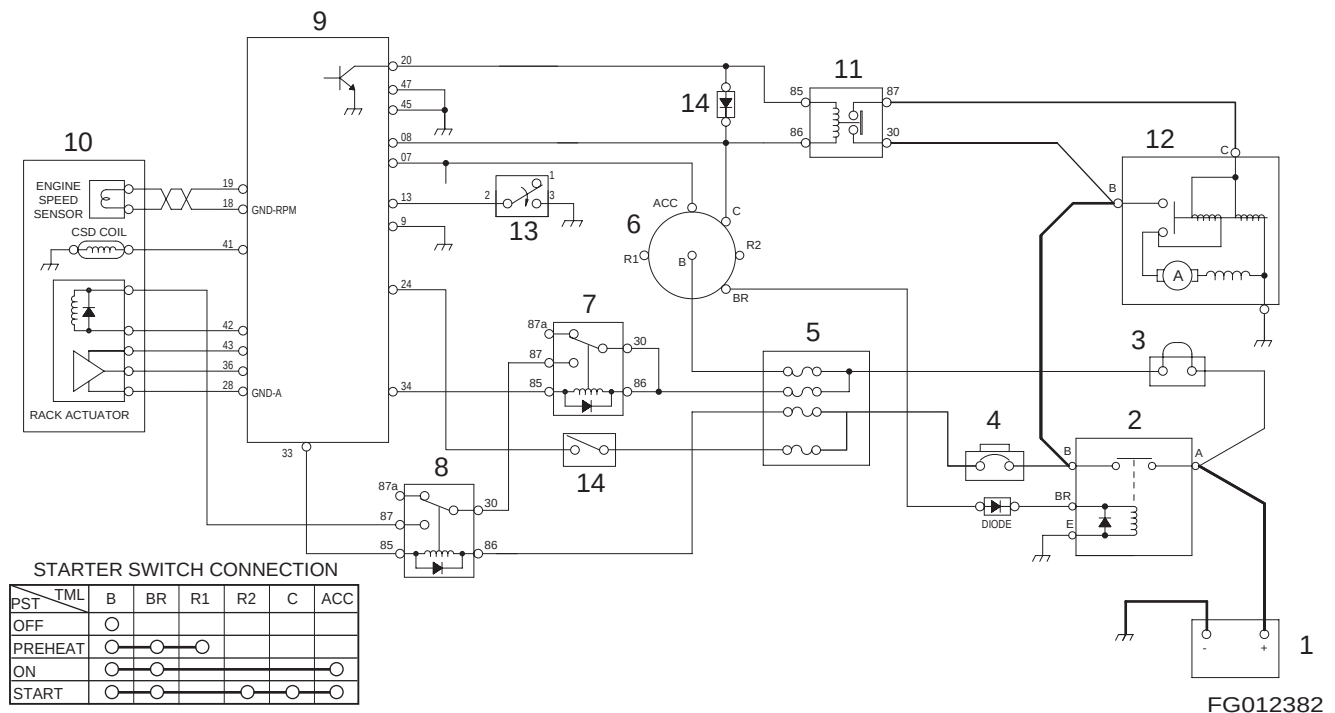


Figure 5 ENGINE STOP CIRCUIT

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Starter Switch
7	Main Relay

Reference Number	Description
8	Rack Actuator Relay
9	Engine Control Unit
10	Fuel Injection Pump
11	Starter Relay
12	Starter
13	Engine Emergency Stop Switch
14	Combination Switch (Neutral)

CHARGING SYSTEM

When the starter switch (4) is turned "ON" position, an initial excited current flows to the field coil of alternator (6) through the battery (1), battery relay (2) and circuit breaker (5).

When the engine is started from this condition the alternator (6) starts charging.

The current flows from the "B" terminal of alternator (6) → circuit breaker (5) → battery relay (2) → battery(1).

The alternator also supplies electric current to other electric components.

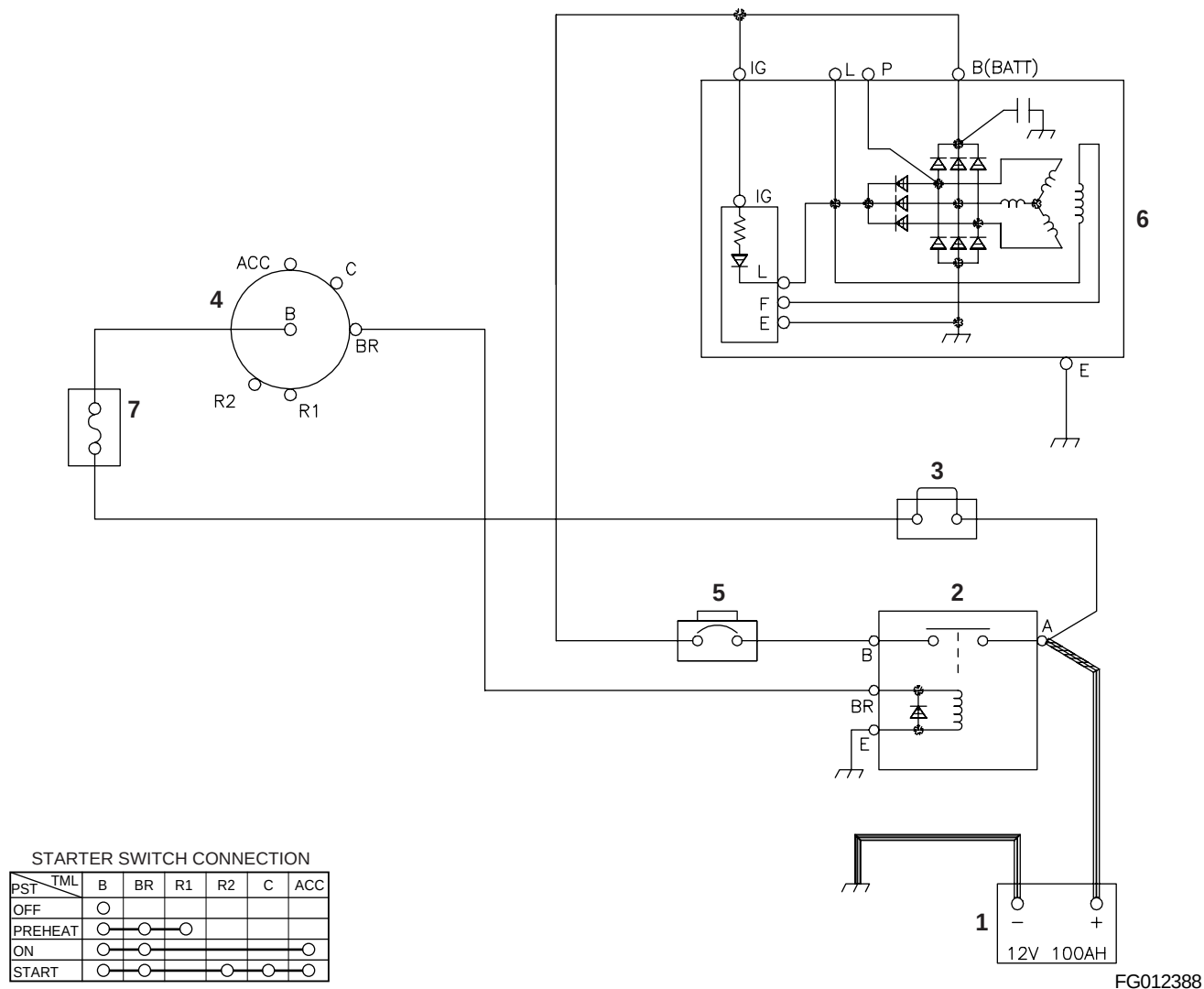


Figure 6 CHARGING CIRCUIT

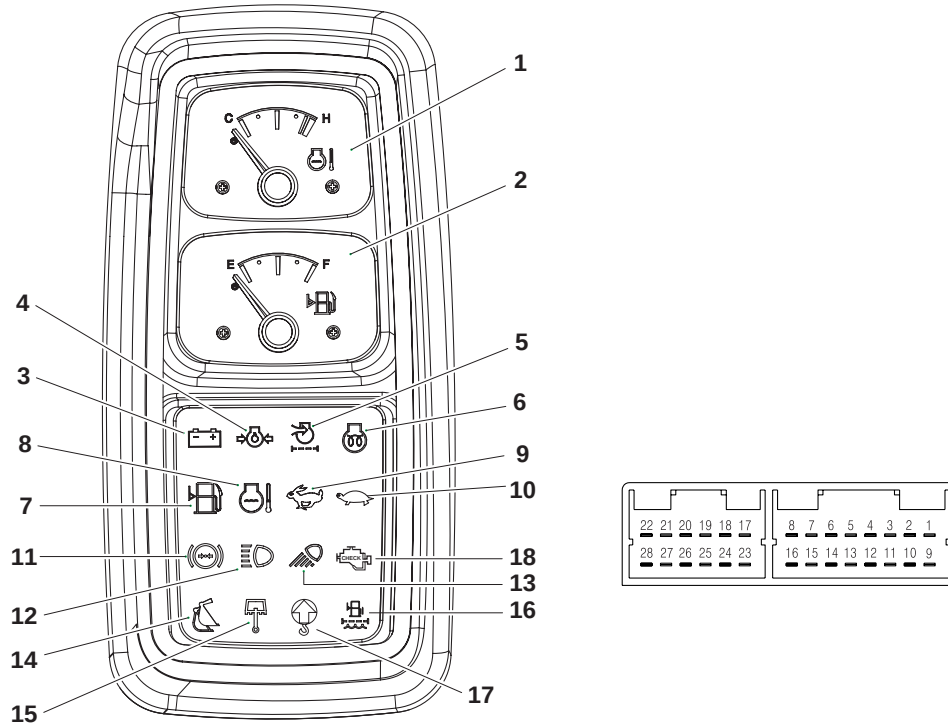
Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Starter Switch

Reference Number	Description
5	Circuit Breaker
6	Alternator
7	Fuse Box

INSTRUMENT SYSTEM

Instrument Panel

The instrument system displays the equipment conditions and warning signals onto the instrument panel by processing the information gathered from the various sensors throughout the equipment.



FG012389

Figure 7

Reference Number	Description
1	Engine Coolant Temperature Gauge
2	Fuel Gauge
3	Charge Warning Light
4	Engine Oil Pressure Warning Light
5	Air Cleaner Clogging Warning Light
6	Preheat Indicator Light
7	Fuel Level Warning Light
8	Engine Coolant Temperature Warning Light

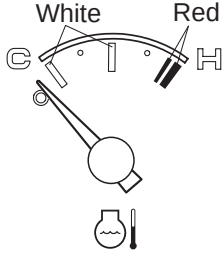
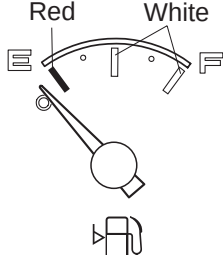
Reference Number	Description
9	High Travel Speed Indicator Light
10	Low Travel Speed Indicator Light
11	Brake Oil Pressure Warning Light
12	High Beam Indicator Light
13	Work Light Indicator Light
14	Quick Clamp Indicator Light
15	Boom Swing Indicator Light
16	Water In Fuel Warning Light
17	Over Load Warning Light
18	Engine Check Warning Light

Function Check

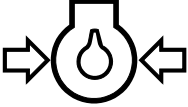
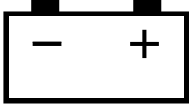
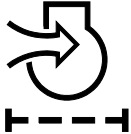
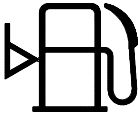
When the starter switch is turned to the "ON" position, all indicator lights and warning lights will be lit for 2 seconds and the warning buzzer will sound. If there is any light that does not go on during the function check, replace or repair.

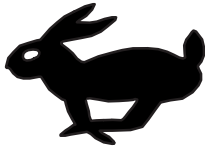
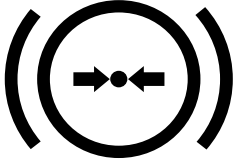
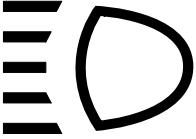
OPERATION

Gauge

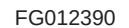
Function	Display	Sensor Specification	
		Input Terminal	Input Specification
Engine Coolant Temperature	 AXO0280L	2	50°C - Over 188.2Ω 67°C - 102Ω 105°C - 32Ω 125°C - below 19.8Ω
Fuel Quantity	 AXO0290L	3	Empty - Over 90Ω 1/2 - 38Ω Full - below 10Ω

Warning Lights

Description	Symbol	Input Terminal	Operation	Remarks
Engine Oil Pressure	 HAOA620L	9	Lights up when oil pressure drops below 0.5 kg/cm ² .	After starting engine, if engine oil pressure is insufficient after 8 seconds, a warning buzzer will sound.
Charging	 HAOA610L	8	Lights up when not charging. ("L" terminal output of alternator drops below 5V)	Under normal condition, it will light up before engine start up and shut off once engine is running.
Air Cleaner	 FG000053	6	Lights up when air cleaner is clogged.	
Preheating		15	It lights during preheating and turns "OFF" after completion of preheating.	
Engine Coolant Temperature	 HAOD350L	10	Lights up when coolant temperature increase over 100°C.	
Fuel Exhausted	 FG000057	7	When fuel is almost exhausted.	

Description	Symbol	Input Terminal	Operation	Remarks
High Speed	 FG010190	16	Lights up when the high speed is selected.	
Low Speed	 FG010191	17	Lights up when the high speed is selected.	
Brake Oil Pressure	 HA002024	12	Lights up when the brake oil pressure switch turns ON.	
High Beam	 HA002023	22	Lights up when the high beams are turned ON.	
Work Light	 HB402003	18	Lights up when the work lamp switch turns ON.	
Water in Fuel	 FG010520	11	Lights up when water quantity is increased in the water separator.	

Description	Symbol	Input Terminal	Operation	Remarks
Quick Clamp	 FG010192	14	Lights up when the quick clamp switch turns "ON".	
Engine Check	 FG000045	20	It lights in case of failure in engine system.	
Overload warning	 FG000253	13	Warning buzzer also starts when boom pressure voltage is about 1.9 while overload warning switch is "ON".	

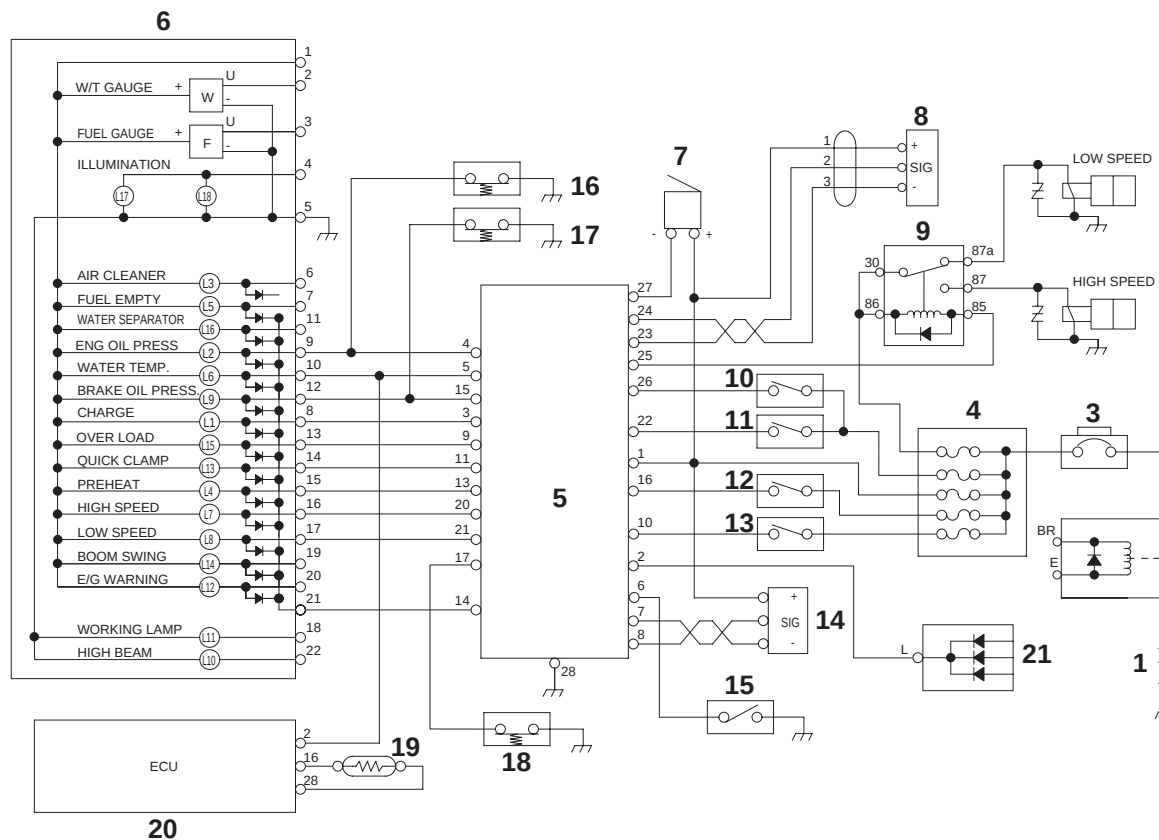


Electrical System
Page 22

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Fuse Box
6	Instrument Panel
7	Control Unit
8	Engine Coolant Temperature Sensor
9	Fuel Sensor
10	Engine Oil Pressure Switch

Reference Number	Description
11	Water In Fuel Warning Switch
12	Air Cleaner Indicator
13	Light Switch
14	Brake Oil Pressure Switch
15	Combination Switch (High Beam)
16	Boom Swing Switch
17	Boom Swing Relay
18	Work Light Switch
19	Work Light Relay
20	Work Light
21	Ecu (Enging Control Unit)

Control Unit Circuit



FG012392

Figure 9

Reference Number	Description
1	Battery
2	Battery Relay
3	Circuit Breaker
4	Fuse Box
5	Control Unit
6	Instrument Panel
7	Pilot Buzzer
8	Transmission Speed Sensor
9	High Speed Relay
10	Combination Switch (Neutral)
11	Combination Switch (High Speed)

Reference Number	Description
12	Combination Switch (F&r)
13	Quick Clamp Select Switch
14	Pressure Sensor (Overload Warning)
15	Overload Warning Switch
16	Engine Oil Pressure Switch
17	Brake Oil Pressure Switch
18	Parking Pressure Switch
19	Engine Coolant Temperature Sensor
20	Ecu (Enging Control Unit)
21	Alternator

Performance Specification

No	Input		Output
1	Starter switch "ON"		All warning lights and warning buzzer are turned on and turned off after approximately 2 seconds.
2	Starter switch "ON"	Quick clamp switch "ON"	"L13" and pilot buzzer turned on
3	Starter switch "ON" and Alternator "L" terminal	6.5 ± 1V Below	"L1" turned on
4		6.5 ± 1V Over	"L1" turned off
5	Alternator "L" terminal 6.5 ± 1V over state	Engine oil pressure switch "ON"	"L2" turned on and pilot buzzer will be turned on after approximately 8 seconds.
6		Engine coolant temperature : 110°C over	Pilot buzzer will be turned on immediately
7		Overload warning switch "ON" and Pressuresensor voltage : 1.9 ± 0.1V over	"L15" and pilot buzzer turned on
8		Overload warning switch "ON" and Pressuresensor voltage : 1.9 ^{+0.1V} _{-0.2V} below	"L15" and pilot buzzer turned off
9		Brake oil pressure switch "ON"	"L9" and pilot buzzer turned on
10		Parking pressure switch "ON" and Combination switch (F&R) "ON"	Pilot buzzer turned off

Performance Specification

No	Input			Output	
	Combination switch		Transmission speed sensor	High speed relay	Indicator
	High speed	Neutral			
1	ON	ON	None output	ON	"L7" ON
2	OFF	ON	None output	ON	"L8" ON

Engine Control System

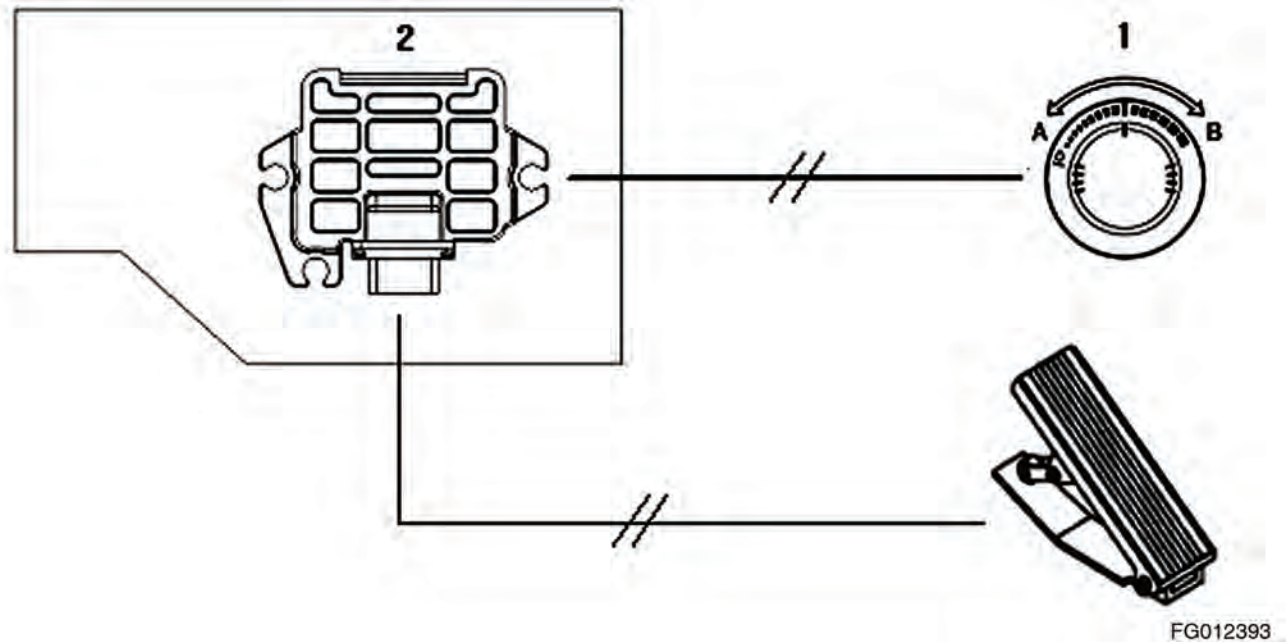


Figure 10

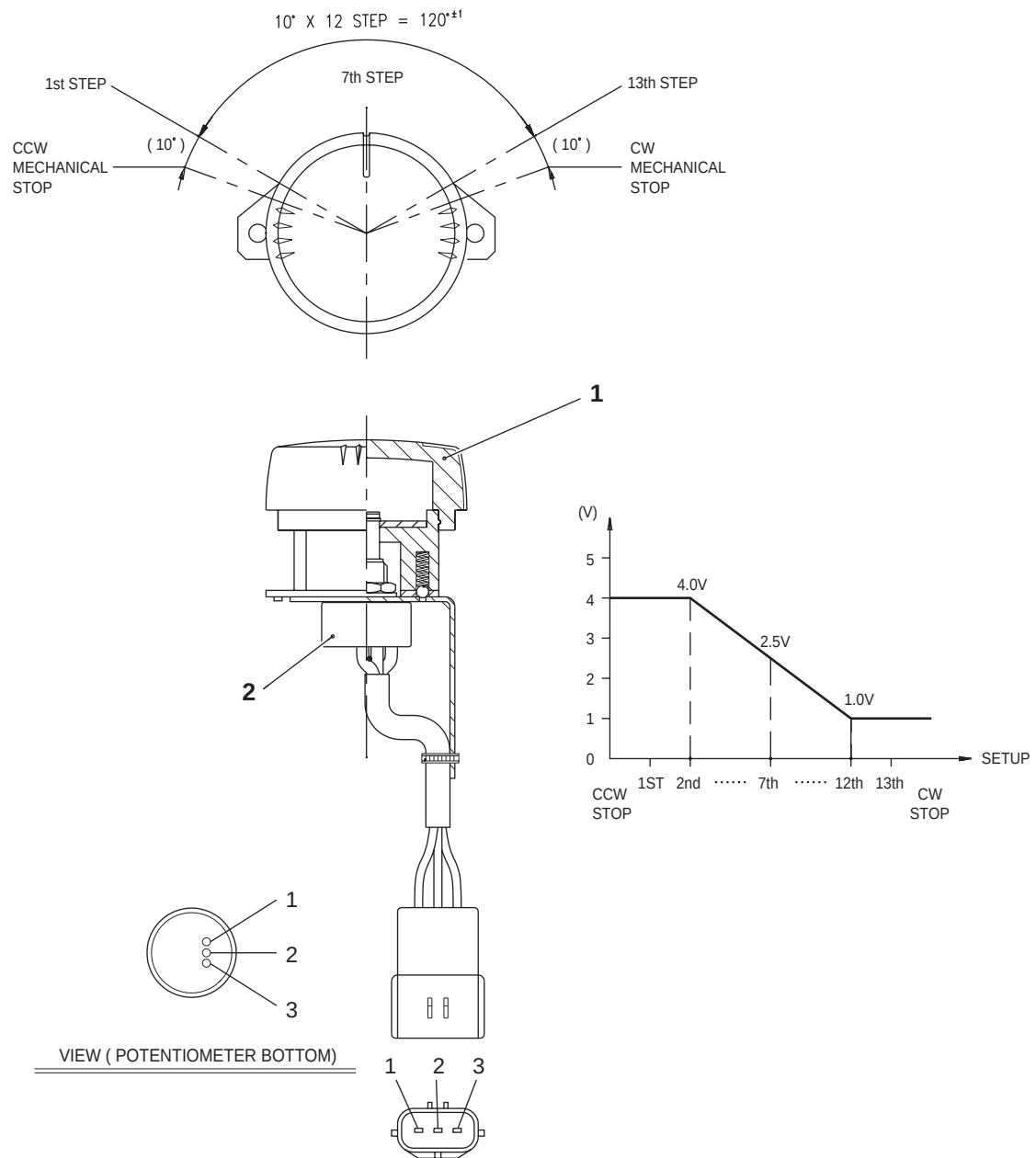
Reference Number	Description
1	Engine Control Dial
2	ECU (Engine Control Unit)

Reference Number	Description
3	Acceleration Pedal

When the engine control dial is moved the output voltage changes according to the dial or acceleration pedal position.

According to the command of control dial or acceleration pedal, the quantity of fuel injection is adjusted.

ENGINE CONTROL DIAL



HDA6033L

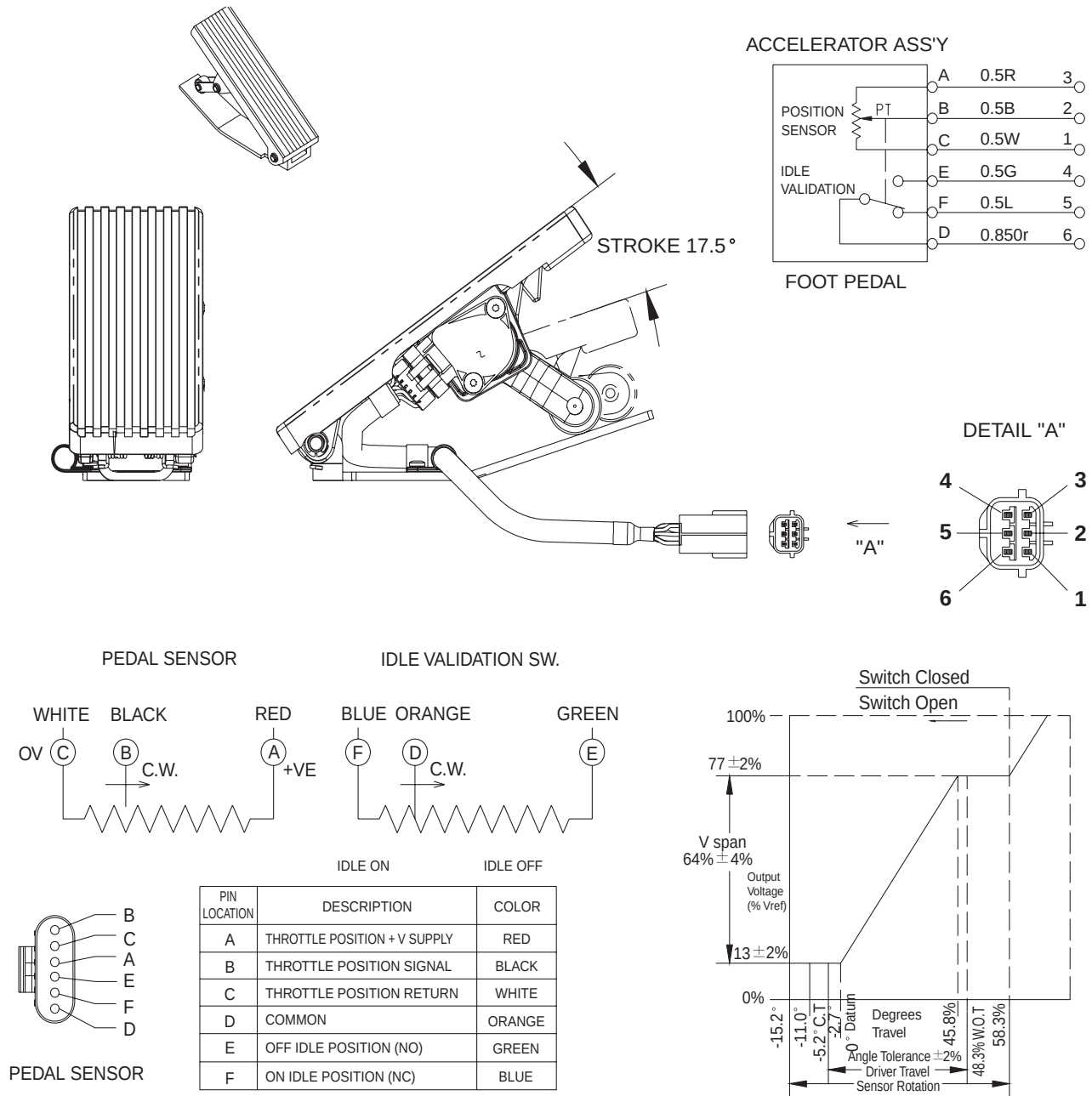
Figure 11

Reference Number	Description
1	Knob

Reference Number	Description
2	Potentiometer (Variable Resistor)

The engine control dial has a built in potentiometer. When the control knob is moved the output voltage (through 2 and 3 terminals) will vary from 5V supplied from the engine throttle controller as shown in the graph.

Acceleration Pedal

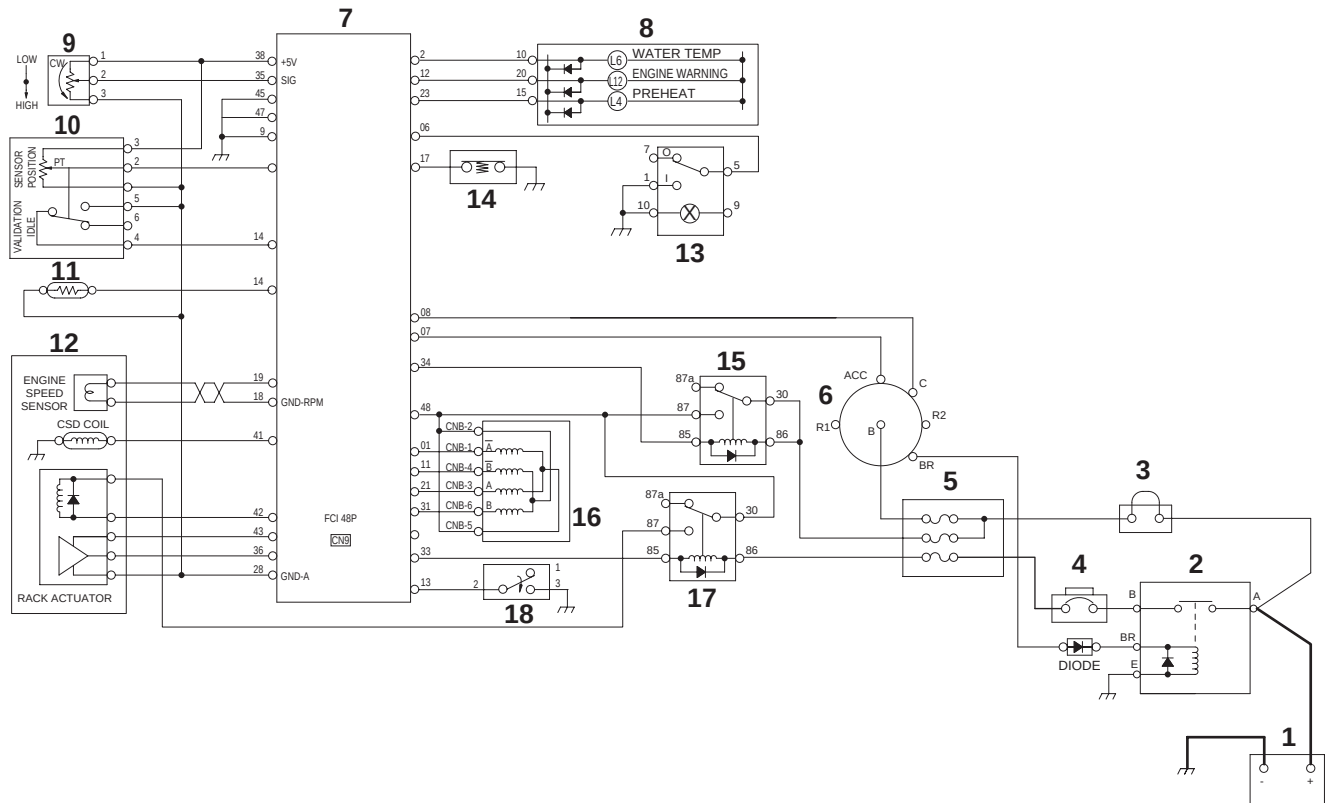


FG007794

Figure 12

The acceleration pedal has a built in potentiometer. When the acceleration pedal is pressed output voltage (through "2 and 1" terminals) will vary from the 5V supplied from engine controller as shown in the graph.

Engine Control Circuit Diagram



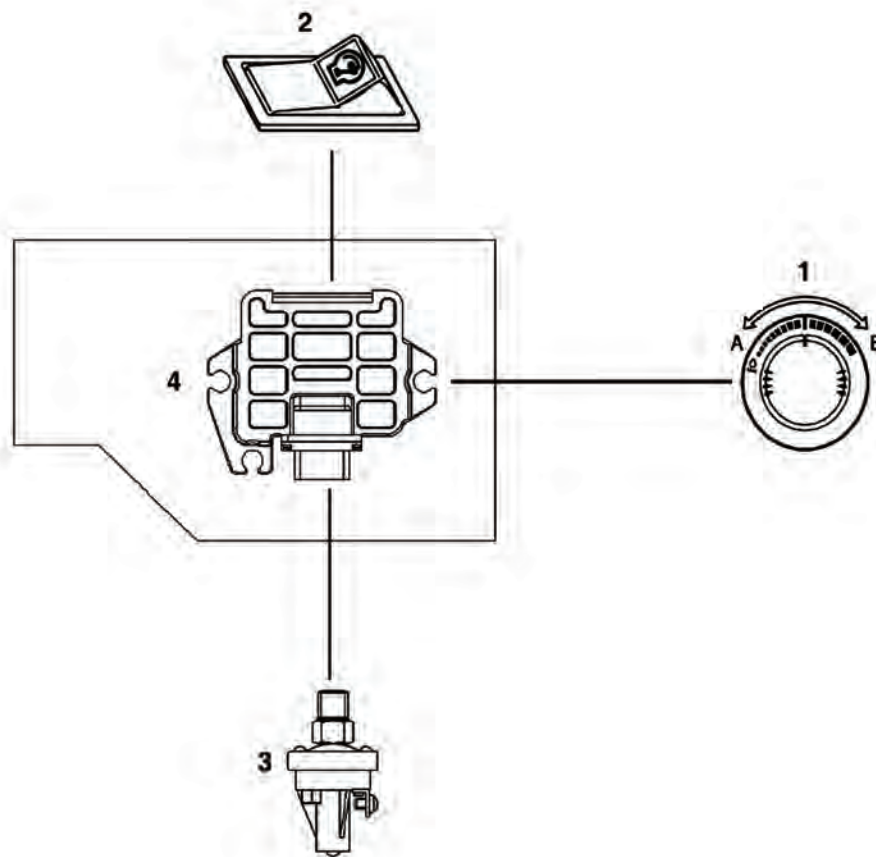
FG012394

Figure 13

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	Engine Control Dial

Reference Number	Description
10	Accelerator Pedal
11	Coolant Temperature Sensor
12	Fuel Injection Pump
13	Auto Idle Selector Switch
14	Auto Idle Pressure Switch
15	Ecu Relay
16	Exhaust Gas Recirculation Valve
17	Rack Actuator Relay
18	Emergency Engine Stop Switch

Automatic Deceleration Control (Auto Idle Control)



FG011495

Figure 14

Reference Number	Description
1	Engine Control Dial
2	Auto Idle Select Switch

Reference Number	Description
3	Auto Idle Pressure Switch
4	ECU (Engine Control Unit)

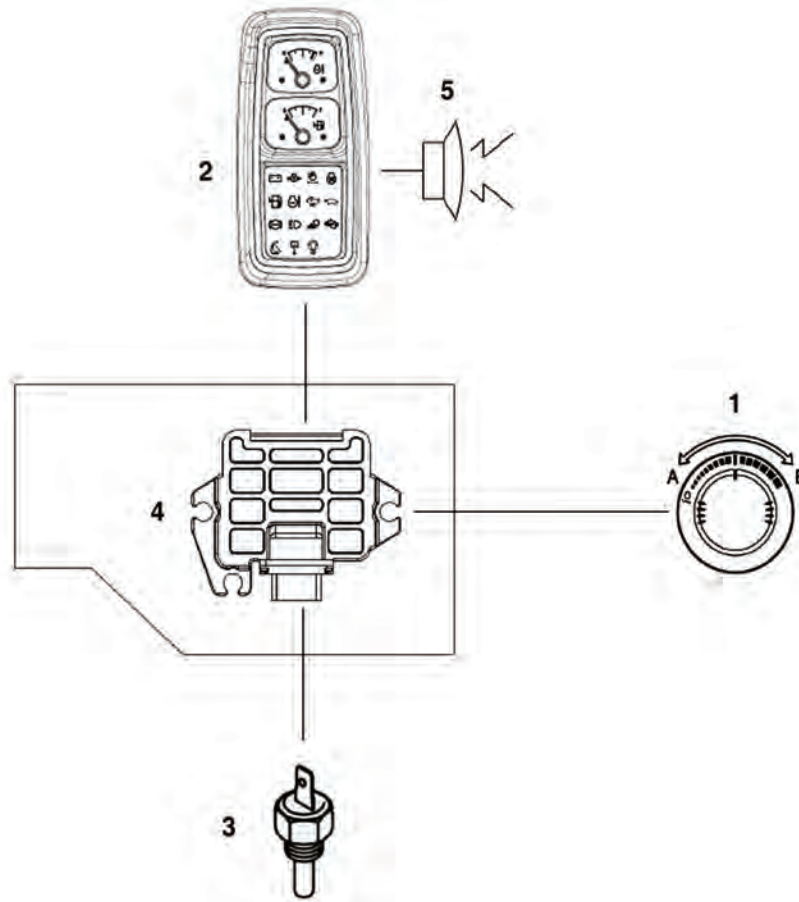
If the machine is idling without the controls being operated or is waiting for a dump truck the engine speed is automatically lowered. Once the controls are operated and work is being started the machine will be restored to the previous settings. As a result, noise and fuel consumption will be reduced. This function can be selected or cancelled through the Auto idle selector switch on the instrument panel.

The initial setting at start-up is with switch in the select position. Approximately 4 seconds after this function is selected, if all work levers are in the neutral position, the ECU compares the automatic reduction signal with the signal set by engine control dial. The lower of the two signal is selected, the ECU sends a signal to the ECU to control the engine speed.

The neutral status of the machine is detected by the pressure switch in the control valve.

When the work levers are in the neutral position, the switch is in the "ON" position.

Engine Overheat Protection System



FG011502

Figure 15

Reference Number	Description
1	Engine Control Dial
2	Instrument Panel
3	Engine Coolant Temperature Sensor

Reference Number	Description
4	ECU (Engine Control Unit)
5	Pilot Buzzer

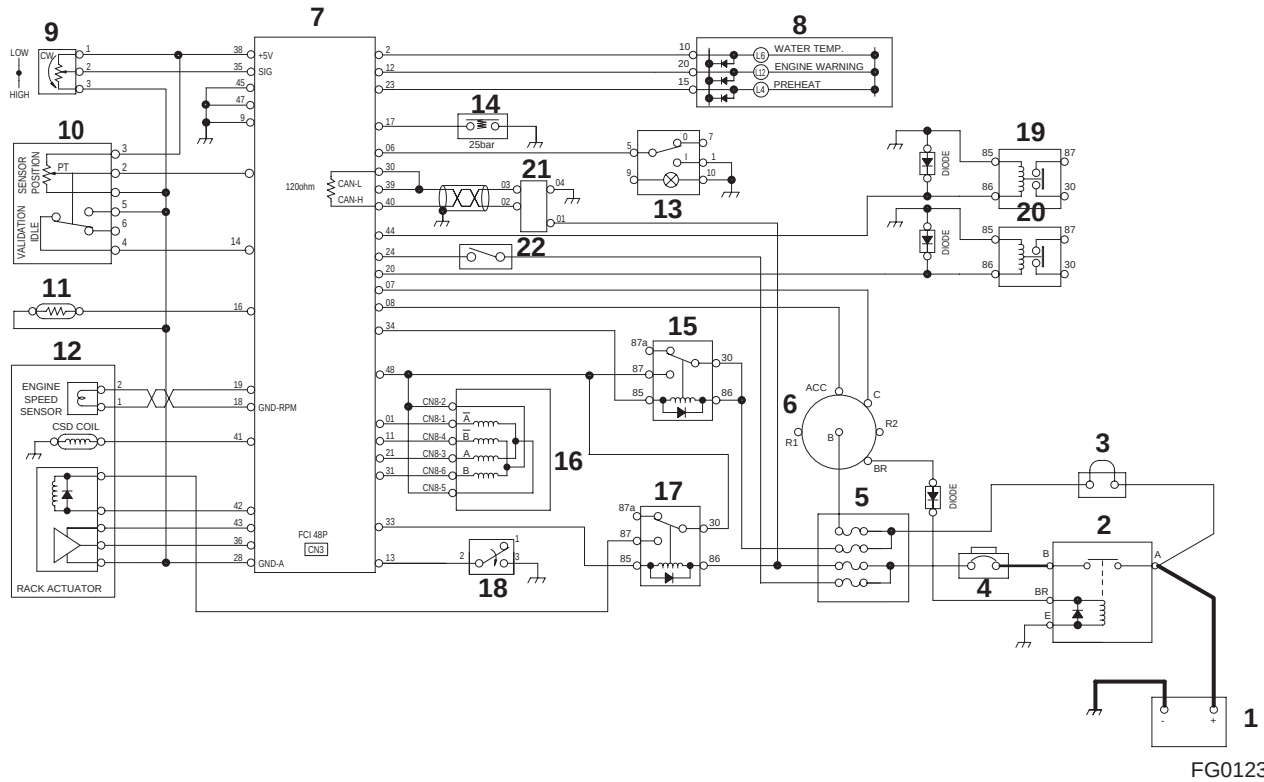
The ECU detects engine coolant temperature from the sensor mounted in the coolant line.

When the engine coolant temperature increases to over 110°C, the overheat warning light in the instrument panel will be turned on and the pilot buzzer sounds simultaneously.

At this time the engine speed is set a low speed by the ECU.

When coolant temperature falls below 105°C, normal operation will resume.

Engine Control Unit



FG012395

Figure 16

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	Engine Control Dial
10	Accelerator Pedal
11	Coolant Temperature Sensor

Reference Number	Description
12	Fuel Injection Pump
13	Auto Idle Selector Switch
14	Auto Idle Pressure Switch
15	Ecu Relay
16	Exhaust Gas Recirculation Valve
17	Rack Actuator Relay
18	Emergency Engine Stop Switch
19	Preheat Relay
20	Starter Relay
21	Can Check Connector
22	Combination Switch (Neutral)

Control Failure Detection

The E-ECU performs various self-diagnostics.

Diagnostic items are divided into "Always enable", "Default to enable" and "Default to disable" in the table.

Diagnostic list

No	Item	Failure detection conditions	Operation when failure occurs	Action/condition for recovery	Category	Number of flashes
1	Coolant temperature sensor failure	Sensor voltage is 4.8V or more, or 0.2V or less.	Engine runs with a coolant temperature of 30°C	Correct failure.	Always enable	4
2	Accelerator sensor failure	Sensor voltage is 4.6V or more, or 0.2V or less.	[Without optional backup accelerator sensor] Engine runs at 1500min ⁻¹ . (Option can change) [With optional backup accelerator sensor] Select backup accelerator sensor : No limitation Backup accelerator sensor failure : Engine runs at 1500min ⁻¹ . (Option can change)	Correct failure.	Default to disable	5
3	Speed sensor failure	Engine start signal (E8) is on, but the engine speed is zero. Engine speed decreases by 480 min ⁻¹ or more in 40 ms	[With optional backup speed sensor] Backup speed sensor becomes active ; speed is limited to 1800 min ⁻¹ . (Option can change) Backup speed sensor failed : Engine stops. [Without optional backup speed sensor] Engine stops.	Turn key off.	Always enable	6
4	Rack position sensor failure	Correlation between rack actuator output and rack position exceeds threshold upper limit by 0.32 sec. or more. Correlation between rack actuator output and rack position exceeds threshold upper limit by 0.16 sec. or more.	Engine runs with limited output and speed. (Rack position control is inactive and speed control is active).	Turn key off.	Always enable	7
5	Rack actuator failure	Rack actuator current is too high. Rack actuator current is too low. Engine accelerates with minimum rack actuator output Engine stalls while rack position sensor is failed.	Engine stops.	Turn key off.	Always enable	8
6	Over speed	Ldling engine speed exceeds high idling speed plus 600 min ⁻¹ .	Engine stops.	Turn key off.	Always enable	9

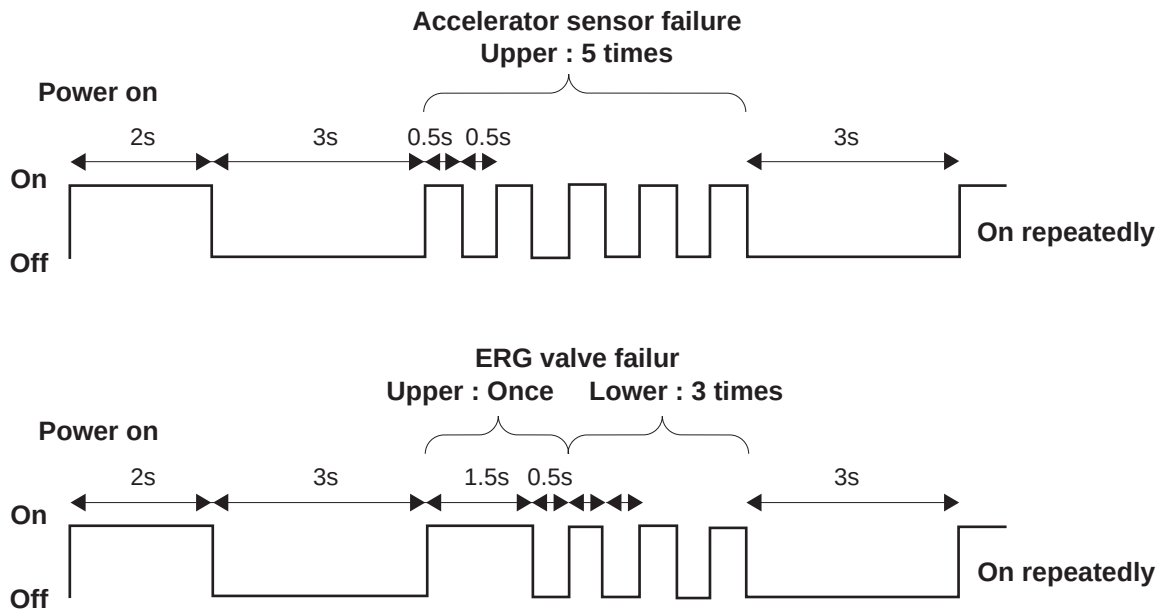
No	Item	Failure detection conditions	Operation when failure occurs	Action/condition for recovery	Category	Number of flashes
7	Backup speed sensor failure	Engine start signal (E8) is on, but the engine speed is zero.	Engine continues to run while main speed sensor is used. Backup speed sensor failed : Engine stops.	Turn key off.	Default to disable	1-1
		Engine speed decreases by 480 min ⁻¹ or more in 40ms.				
8	CAN communication failure	CAN communication packets cannot be received.	Last value is retained. Backup sensor becomes active.	Correct failure.	Default to disable	1-2
9	EGR valve failure	Low status is detected even through port is off.	Engine runs with limited output (92%) and speed (1800min ⁻¹)	Turn key off.	Default to disable	1-3
		High status is detected even through port is on.				
10	CSD solenoid valve failure	High status is detected even through port is off.	Engine continues to run with port being off.	Turn key off.	Always enable	1-4
		Low status is detected even through port is on.				
11	Air heater relay failure	High status is detected even through port is off.	Engine runs with air heater relay being off.	Turn key off.	Default to disable	1-5
		Low status is detected even through port is on.				
12	Main relay failure	Power is not shut off even though main relay is off.	Engine runs normally.	Correct failure. Or turn key off.	Default to disable	1-6
13	Rack actuator relay failure	Low status is detected even through port is off.	Engine stops.	Turn key off.	Always enable	1-7
		High status is detected even through port is on.				
14	Backup accelerator sensor failure	Sensor voltage is 4.6V or more, or 0.2V or less.	Engine continues to run while main accelerator sensor is used. Main accelerator sensor failure : Engine runs at 1500min ⁻¹ . (Option can change)	Correct failure.	Default to disable	1-8
15	Atmospheric pressure sensor failure		Atmospheric pressure compensation is canceled.	Turn key off.	Default to disable	1-9
16	Oil pressure switch failure	Oil pressure switch fails to turn on when engine is off.	Engine runs normally. (Option can change)	Turn key off.	Default to disable	2-1
17	Charge switch failure	Charge switch fails to turn on when engine is off.	Engine runs normally.	Turn key off.	Default to disable	2-2
18	Power supply voltage abnormal	E-ECU supply voltage exceeds 10.0V.	Engine runs normally.	Correct failure.	Always enable	2-3
		E-ECU supply voltage exceeds 16.0V.				

No	Item	Failure detection conditions	Operation when failure occurs	Action/condition for recovery	Category	Number of flashes
19	Sensor failure 5V	Monitoring voltage is approx. 0 V.	Engine runs normally.	Turn key off.	Always enable	2-4
		Monitoring voltage is 4.5 V or less.				
		Monitoring voltage is 5.5 V or more.				
20	E-ECU overheat alarm	E-ECU temperature exceeds 105°C. Alarm is canceled when E-ECU temperature decreases to 100°C. (option can change)	Engine runs normally. (Option can change)	Correct failure.	Default to disable	2-5
21	Oil pressure low	Oil pressure switch fails to turn off when engine is running.	Engine runs normally. (Option can change)	Correct failure.	Default to disable	3-1
22	Charge failure	Charge switch fails to turn off when engine is running.	Engine runs normally.	Turn key off.	Default to disable	3-2
23	Coolant temperature abnormal	Coolant temperature switch turns on.	Engine runs normally. (Option can change)	Turn key off.	Default to disable	3-3
24	Air cleaner blockage alarm	Air cleaner switch turns on.	Engine runs normally. (Option can change)	Turn key off.	Default to disable	3-4
25	Oily water separator alarm	Oily water separator switch turns on.	Engine runs normally. (Option can change)	Turn key off.	Default to disable	3-5
26	Coolant temperature high alarm	Coolant temperature is 115°C or higher. alarm is canceled when Coolant temperature decreases to 110°C. (Option can change)	Engine runs normally.	Correct failure.	Default to disable	3-6
27	E-ECU failure [ROM error]	Flash ROM suffers checksum error.	Engine stops.	Turn key off.	Always enable	4-1
28	E-ECU failure [EEPROM error]	Reading /Writing fails.	Engine runs normally.	Turn key off.	Always enable	4-1
		EEPROM suffers checksum error.				
29	E-ECU failure [EEPROM failure]	E-ECU fails to communicate with sub CPU.	Engine runs normally.	Turn key off.	Always enable	4-1
30	E-ECU failure [Mapping error]	Map format is invalid.	Engine stops.	Turn key off.	Always enable	4-1
31	E-ECU failure [E-ECU temperature sensor failure]	Sensor voltage is 4.6V or more, or 1.0V or less.	Engine runs normally.	Correct failure.	Always enable	4-1

Flashing Patterns of Engine Check Lamp

When detecting these failures, the E-ECU (Engine control unit) flashes the engine check lamp to alert the operator to the occurrence of failure conditions. The engine check lamp will illuminate for 2 sec. when the E-ECU is power on. This allows checking if the E-ECU is supplied with power normally.

Flashing patterns of the engine check lamp are shown in Figure 17. When accelerator sensor failure (flashing 5 time) and EGR valve failure (flashing 1-3 times) occur, the engine check lamp flashes as shown in Figure 17. When two or more failures have occurred simultaneously, the engine check lamp indicates all the failures in order of increasing number of flashes cyclically.



FG011504

Figure 17 Flashing patterns of the engine check

FUEL INJECTION PUMP

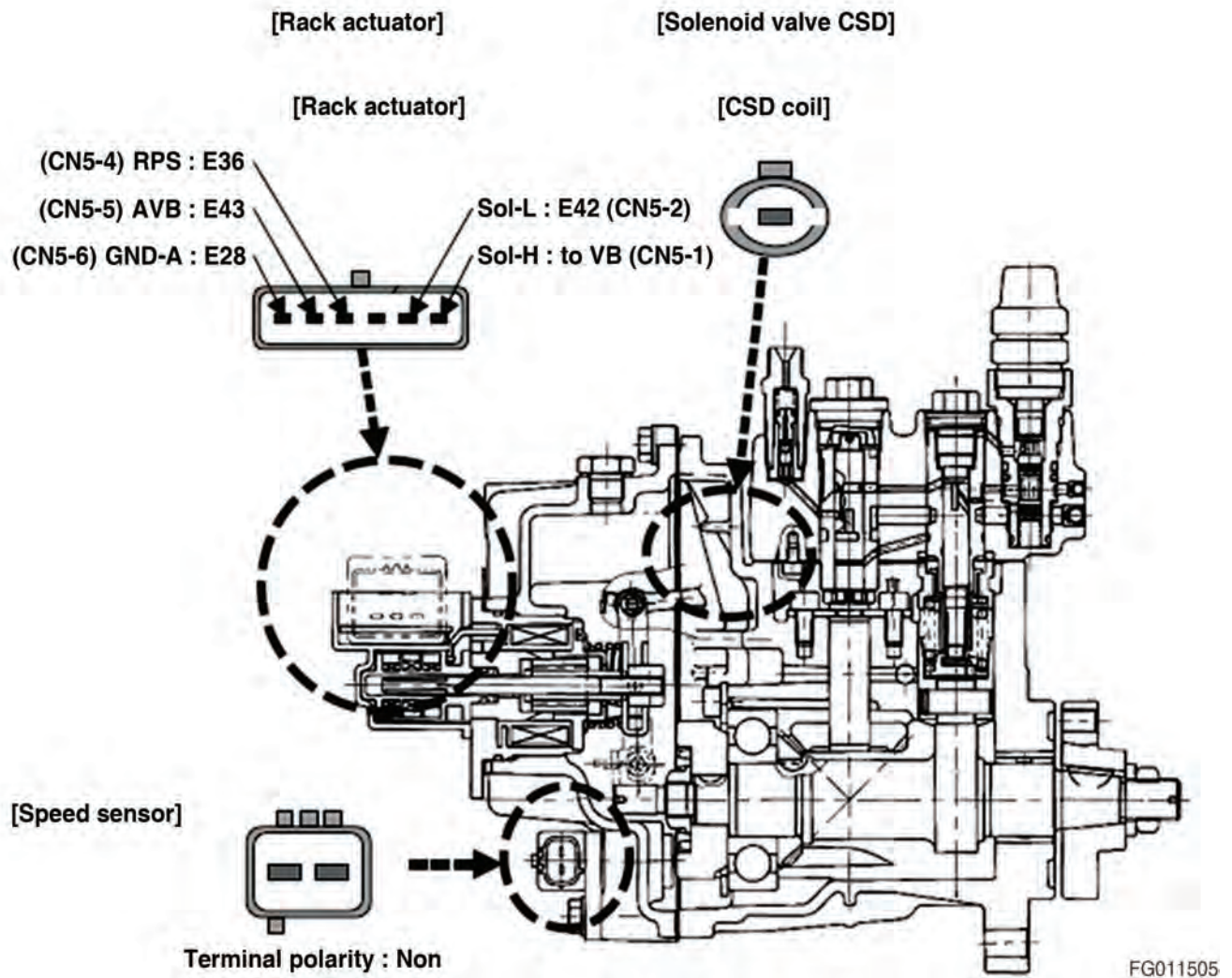
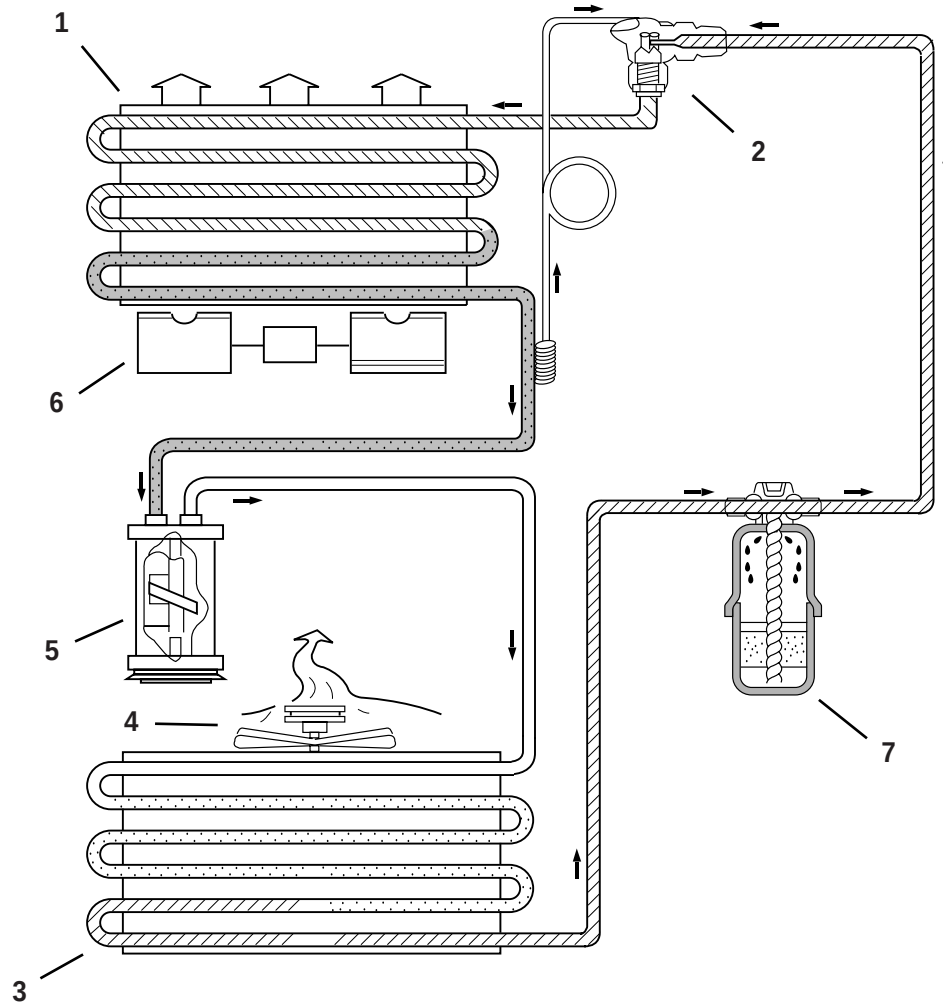


Figure 18



REFRIGERANT CIRCULATION



HBOI020L

Figure 20

Reference Number	Description
1	Evaporator
2	Expansion Valve
3	Condenser
4	Condenser Fan

Reference Number	Description
5	Compressor
6	Blower Fan
7	Receiver Dryer

Shading	Temperature	Refrigerant State
	High	High-pressure Gas
	High	High-pressure Liquid
	Low	Low-pressure Liquid
	High	High-pressure Gas/Liquid
	Low	Low-pressure Gas

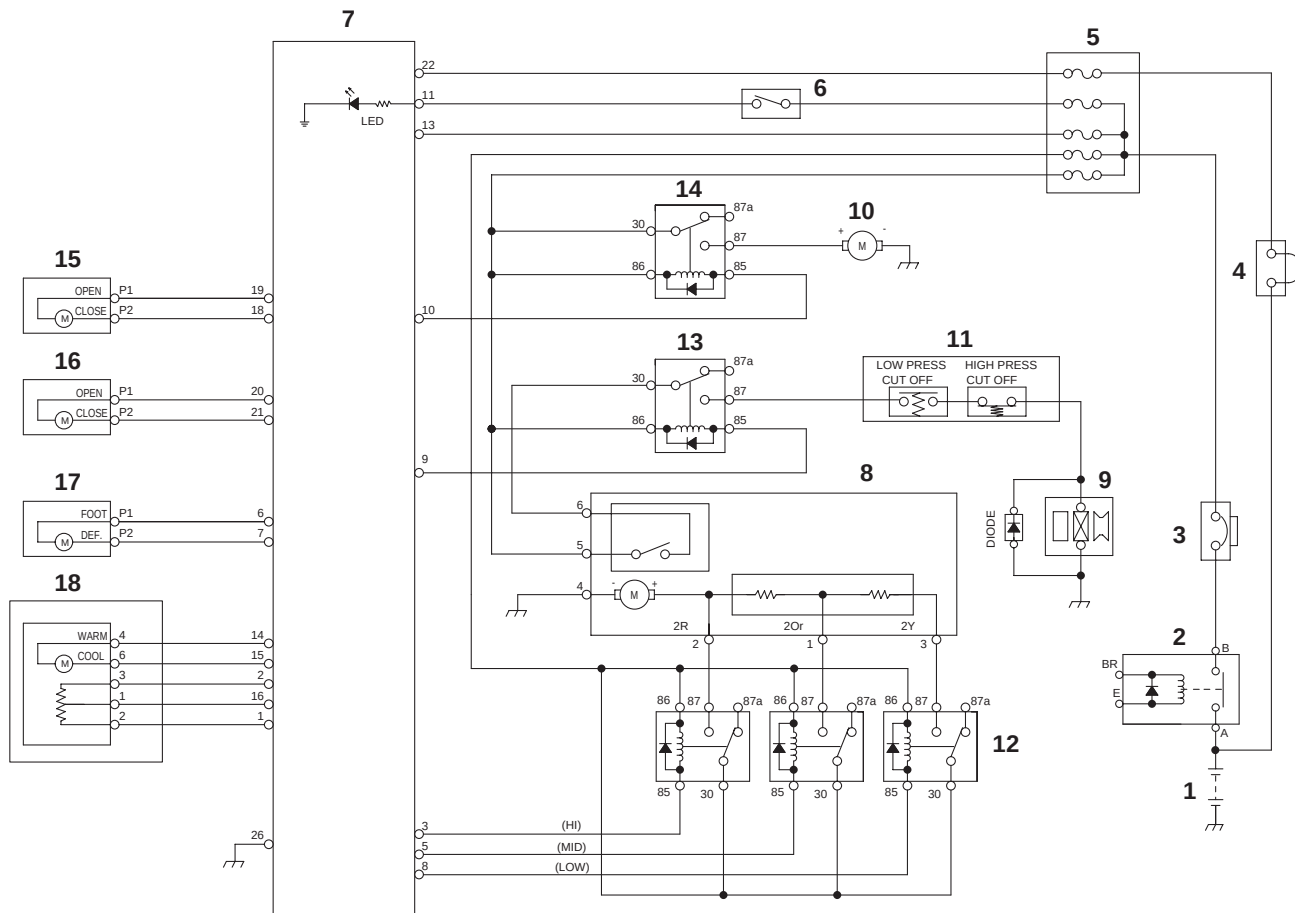
- Refrigerant (R134a) is compressed to approximately 15 kg/cm² (210 psi) within the compressor.
- The compressed refrigerant flows into the condenser at high temperature (approximately 80°C (176°F)).
- The refrigerant in the condenser is cooled to approximately 60° by the condenser fan. At this time the refrigerant changes from the gas to the liquid state, even though the temperature has only been reduced 20°C (68°F). (From 80° - 60°C (176° - 140°F)).
- The refrigerant in its liquid form is injected into the evaporator through the expansion valve. At this time the pressure is reduced by approximately 2 kg/cm² (28 psi) and the temperature is also reduced. As a result, the refrigerant absorbs the heat from the air surrounding the evaporator creating a cooling effect and changes from the gas to the liquid state.
- The refrigerant once again flows into the compressor in the gaseous state and the process is repeated.



CAUTION

Refrigerant gas is pressurized and sealed in the air-conditioning system. Special precautions are required for the proper recharging or release of refrigerant. Release of refrigerant into the atmosphere is strictly regulated by law. Make sure that you are in compliance with all mandated federal, state and municipality requirements, before starting any service or repair of the air conditioner. Refrigerant gas used in the system must meet or exceed specifications for R134a refrigerant, or any subsequently issued environmentally mandated standard.

Air-conditioning System Circuit Diagram



FG010308

Figure 21

Reference Number	Description
1	Battery
2	Battery relay
3	Fusible link
4	Circuit breaker
5	Fuse box
6	Light switch
7	AC panel
8	AC unit
9	Compressor

Reference Number	Description
10	Condenser fan
11	Receiver dryer
12	Blower relay
13	Compressor relay
14	Condenser fan relay
15	Air flow control motor (A)
16	Air flow control motor (B)
17	Air flow control motor (C)
18	Coolant flow control valve

Air Flow Control

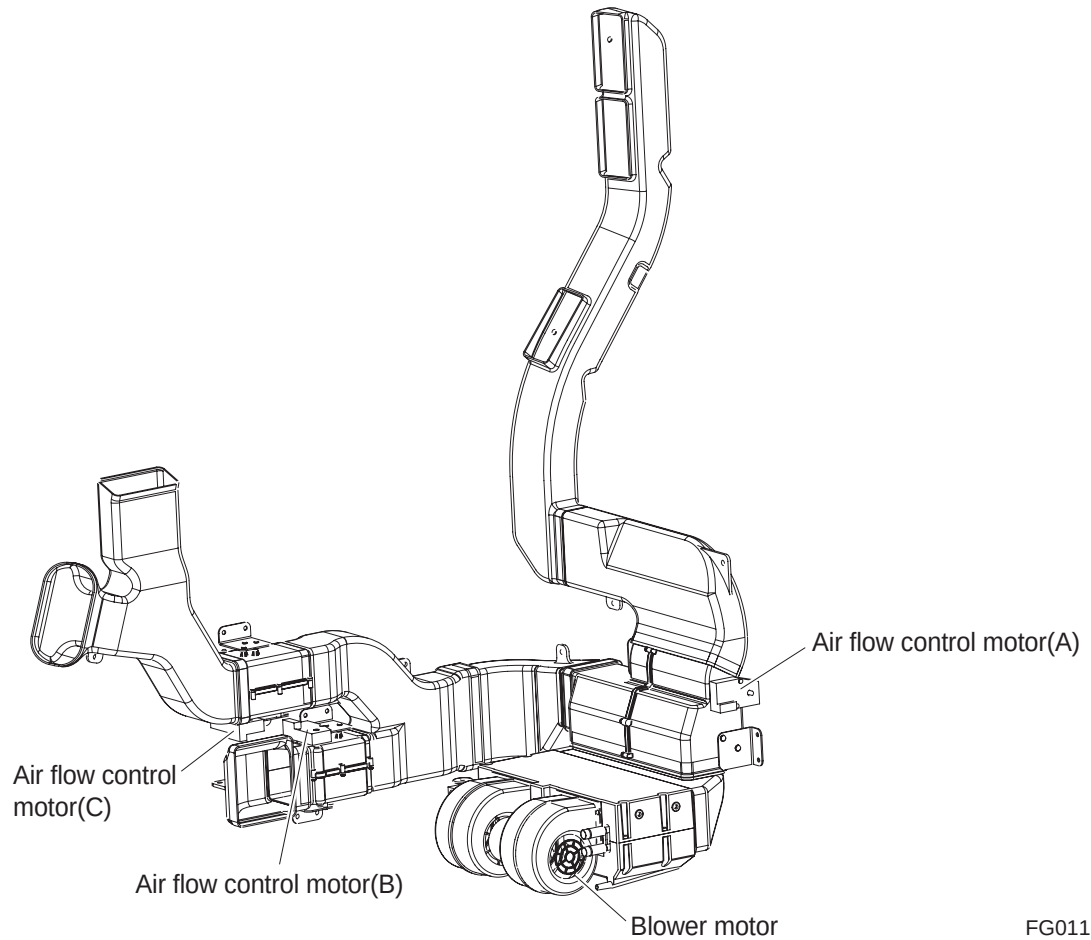


Figure 22

FG011507

	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

Air Flow Control Motor

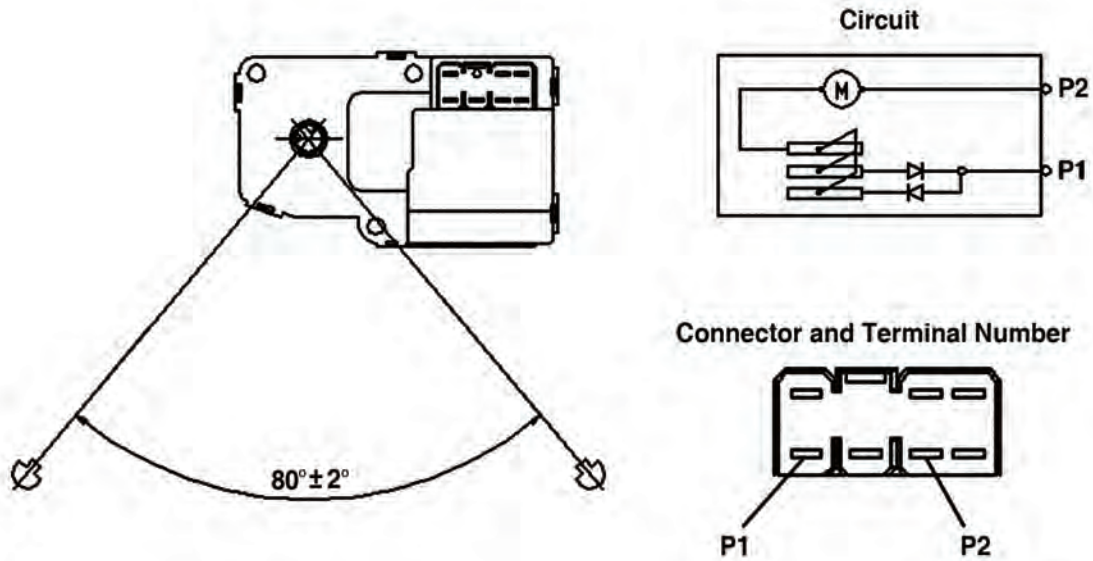


Figure 23

FG011509

Blower Motor

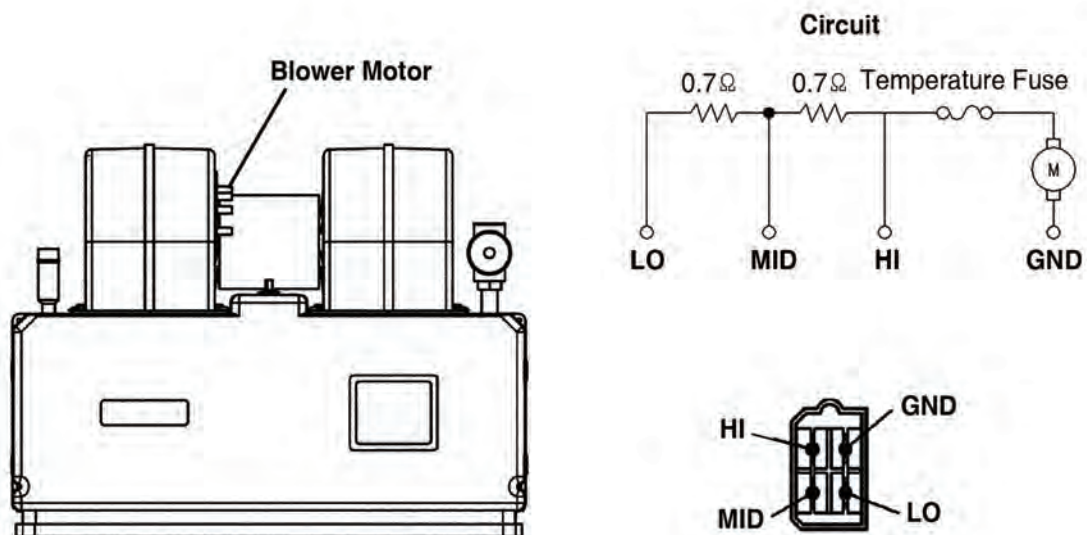


Figure 24

FG010673

Coolant Flow Control Valve

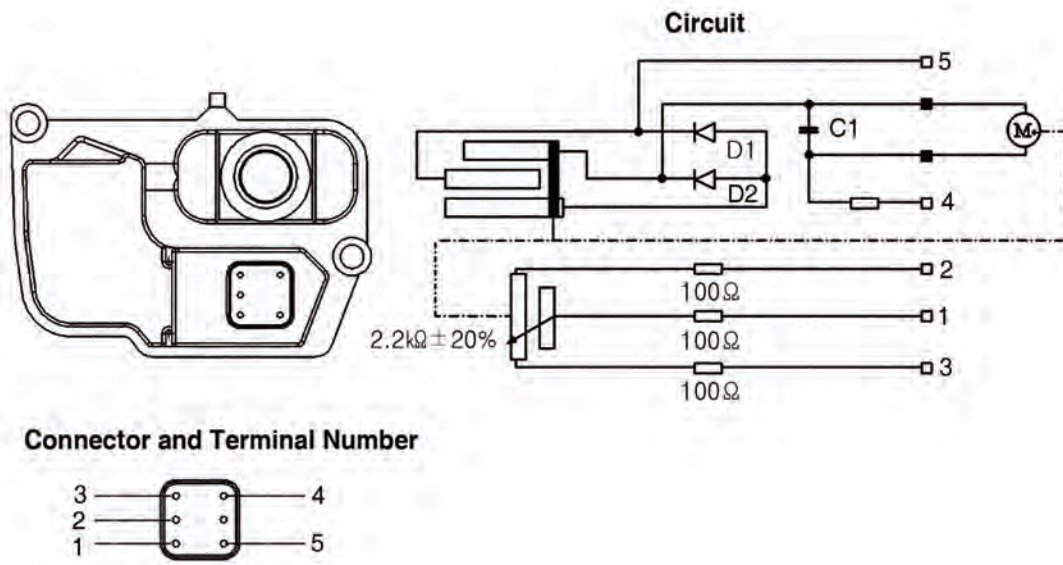


Figure 25

FG011511

Temperature Level Control And Display

step	LED 1	LED 2	LED 3	LED 4	LED 5	LED 6	LED 7	Position Sensor Voltage	Remark
0	Green	Green	Green	Green	Green	Green	Green	4.50V $\pm$ 0.2	MAX. COOL
1	Green	Green	Green	Green	Green	Green	Green	4.33V $\pm$ 0.2	
2	Green	Green	Green	Green	Green	Green	Green	4.15V $\pm$ 0.2	
3	Red	Green	Green	Green	Green	Green	Green	3.98V $\pm$ 0.2	
4	Red	Green	Green	Green	Green	Green	Green	3.80V $\pm$ 0.2	
5	Red	Green	Green	Green	Green	Green	Green	3.63V $\pm$ 0.2	
6	Red	Red	Green	Green	Green	Green	Green	3.46V $\pm$ 0.2	
7	Red	Red	Green	Green	Green	Green	Green	3.28V $\pm$ 0.2	
8	Red	Red	Green	Green	Green	Green	Green	3.11V $\pm$ 0.2	
9	Red	Red	Red	Green	Green	Green	Green	2.93V $\pm$ 0.2	
10	Red	Red	Red	Green	Green	Green	Green	2.76V $\pm$ 0.2	
11	Red	Red	Red	Green	Green	Green	Green	2.59V $\pm$ 0.2	
12	Red	Red	Red	Red	Green	Green	Green	2.41V $\pm$ 0.2	
13	Red	Red	Red	Red	Green	Green	Green	2.24V $\pm$ 0.2	
14	Red	Red	Red	Red	Green	Green	Green	2.07V $\pm$ 0.2	
15	Red	Red	Red	Red	Red	Green	Green	1.89V $\pm$ 0.2	
16	Red	Red	Red	Red	Red	Green	Green	1.72V $\pm$ 0.2	
17	Red	Red	Red	Red	Red	Green	Green	1.54V $\pm$ 0.2	
18	Red	Red	Red	Red	Red	Red	Green	1.37V $\pm$ 0.2	
19	Red	Red	Red	Red	Red	Red	Green	1.20V $\pm$ 0.2	
20	Red	Red	Red	Red	Red	Red	Green	1.02V $\pm$ 0.2	
21	Red	Red	Red	Red	Red	Red	Red	0.85V $\pm$ 0.2	
22	Red	Red	Red	Red	Red	Red	Red	0.67V $\pm$ 0.2	
23	Red	Red	Red	Red	Red	Red	Red	0.50V $\pm$ 0.2	MAX. HOT

REFRIGERANT SYSTEM REPAIRS



CAUTION

Always wear protective glasses and gloves when handling refrigerant. If refrigerant comes in contact with the skin or eyes, immediately flush with clean, running water and consult a physician.

Select a clean and well-ventilated area to work.

The refrigerant container is under high-pressure and should be stored below 40°C (104°F). Be careful not to drop the container from a high location

The contents are under high-pressure and should not be used with compressed air or near an open flame.

Refrigerant Safe Handling Procedures

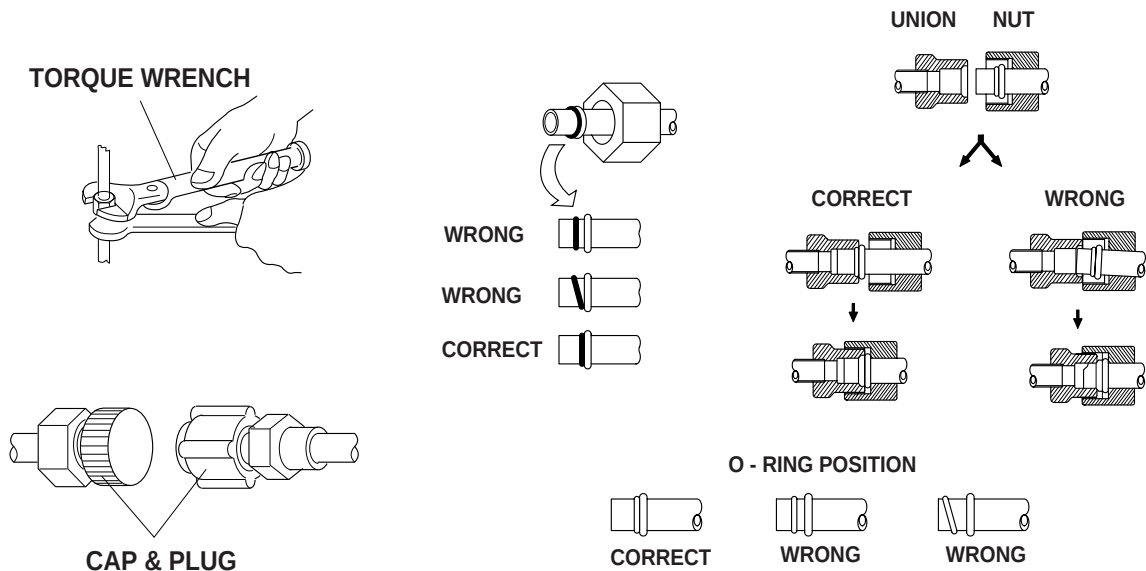


Figure 26

HDA6066L

The following procedures should be observed for safe handling of refrigerant during vacuum and charging process.

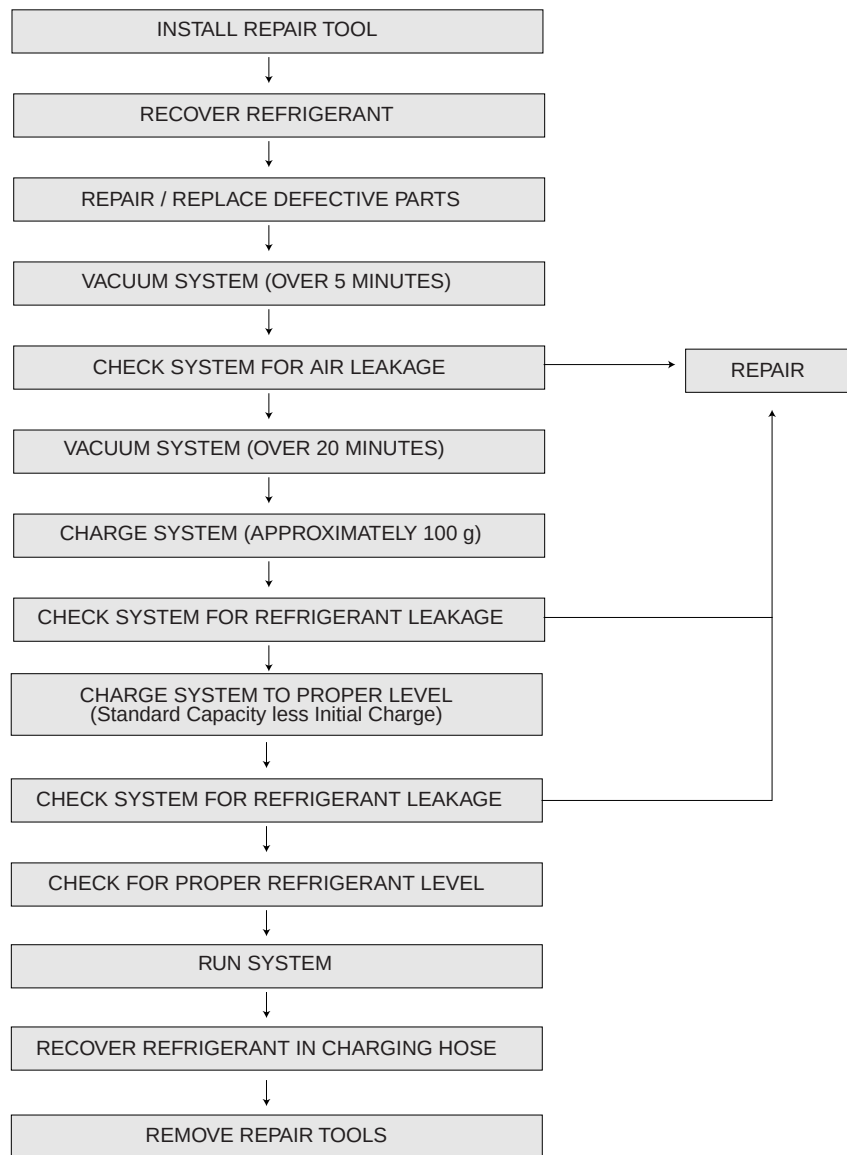
1. Use an approved recovery / charging device which can safely perform vacuum and charge work simultaneously.
2. The new refrigerant has improved cooling characteristics than the old type and care should be used not to overcharge the system.

3. Do not over tighten connections when working on refrigerant system.
4. The new refrigerant system standards require new tools, equipment and parts. Do not attempt to use equipment use in servicing the old refrigerant system.
5. The new refrigerant oil (PAG type) has a high moisture absorption characteristic. When the refrigerant system vacuum seal has been broken, immediately plug up all openings to prevent moisture from entering into the system.
6. When joining unions which use O-ring seals, lightly coat O-rings with refrigerant oil. Be careful not to drip oil on the threads of the nut.
7. Be certain the O-rings are seated properly on the refrigerant line lip. Always use new O-rings when reassembling parts. Do not reuse old O-rings.
8. Use a vacuum pump to evacuate refrigerant system of air.
9. When charging the refrigerant system with the engine running, do not open the high-pressure valve on the manifold gauge as the reverse flow of high-pressure refrigerant will rupture the hose.
10. When releasing the high-pressure hose after completing the charging process, quickly disconnect the hose to minimize refrigerant released to the air.

Repair and Replacement Procedure

1. Work Procedure;
 - A. Before repairing or replacing any refrigerant components first, return all refrigerant oil to the compressor and perform recovery procedures.
2. Operating Condition;
 - A. Run engine at maximum engine speed.
 - B. Select "HI" blower fan speed and select A/C switch to "ON."
 - C. Set the temperature control switch for maximum cooling and leave running for approximately 20 minutes.

NOTE: *The manifold gauge dial pointer can vary depending on the outdoor temperatures.*



HDA6067L

Figure 27

Refrigerant Recovery

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

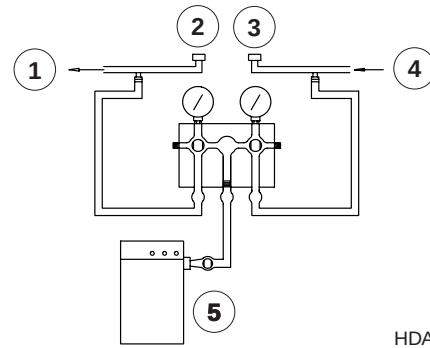
1. Attach the manifold gauges and the refrigerant recovery unit to the refrigerant lines as shown.

NOTE: Be careful not to switch the connections for the low and high-pressure valves.

2. Open the high-pressure valve slowly to release the refrigerant to the recovery unit.

NOTE: Open the valve slowly, while checking to see that refrigerant is not leaking out.

3. When the manifold gauge dial falls below 3.5 kg/cm² (50 psi), slowly open the low-pressure valve.
4. Open both the high and low-pressure valves slowly until the manifold gauge dials indicates 0 kg/cm² (0 psi).



HDA6067L

Figure 28

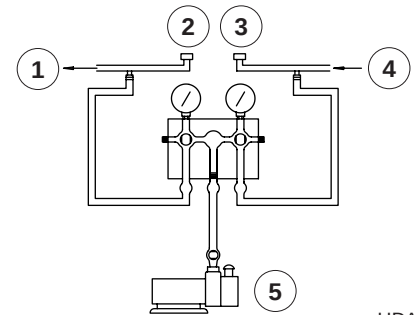
Vacuumping Refrigerant System

Reference Number	Description
1	To Compressor
2	Low-pressure Side
3	High-pressure Side
4	From Receiver
5	Vacuum Pump

1. Vacuuming Procedure;

NOTE: When the A/C system has been exposed to the air, it must be vacuumed out. Perform vacuum process for 30 minutes for complete moisture and air evacuation.

- A. Attach the manifold gauges and vacuum pump to the refrigerant system as shown.
- B. Turn on the vacuum pump and open both valves.
- C. When the low-pressure gauge shows approximately 710 mmHg, close both valves and turn off vacuum pump.



HDA6068L

Figure 29

2. Check system for vacuum leak;

Allow system to sit for 10 minutes and check whether the system is holding the pressure. If the pressure has dropped, it must be repaired before proceeding to the next step.

3. Vacuuming Procedure;

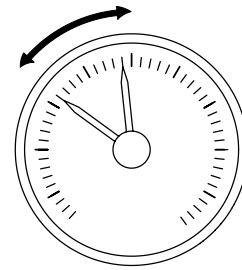
If the system is holding the pressure and it has not changed for 10 minutes, vacuum out the system for an additional 20 minutes.

- A. Turn on the vacuum pump and slowly open both valves.
- B. Allow vacuum pump to run for additional 20 minutes until the low-pressure gauge dial reads approximately 750 mmHg.
- C. Close both valves and stop the vacuum pump.

4. Installation of Refrigerant Container

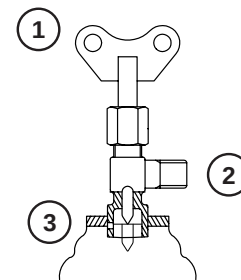
Reference Number	Description
1	Handle
2	Hose Connection
3	Mounting Disk

- A. Before mounting valve on the container, make sure the handle is in the counter clockwise most position, with the puncture pin retracted and the mounting disk is in the raised position.
- B. Attach the manifold gauge center hose to the valve assembly.
- C. Turn the disc in the clockwise direction and securely mount valve onto refrigerant container.
- D. Turn the valve handle in the clockwise direction and puncture the container seal with the pin.
- E. Once the can has been punctured, turn the handle in the counter clockwise direction so the refrigerant can flow into the manifold gauge center hose. At this time, do not open the low and high-pressure valves of the manifold gauge.
- F. Press the manifold gauge low side valve to eliminate the trapped air in the hose.



HDA6069L

Figure 30



HDA6070L

Figure 31

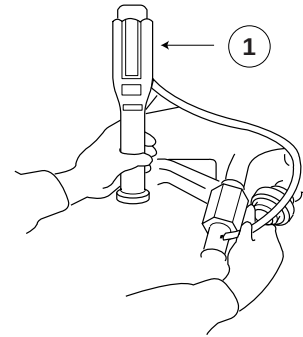
Leakage Check

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/cm² (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 32



WARNING

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.

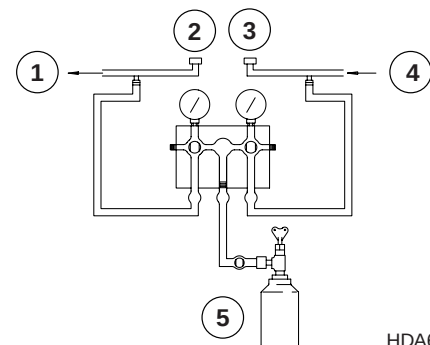
NOTE: First charge the refrigerant system with 100 g (3.5 ounces) of refrigerant with the engine off. Then using the manifold gauges as a guide fully charge the system with the engine running.

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 33

3. If refrigerant does not flow freely into system, try starting engine first before operating air conditioner.
 - Temperature control switch setting: Maximum Cooling.
Blower Speed Setting: Hi (3 step).
Engine Speed: 1,300 - 1,500 rpm.



WARNING

When charging refrigerant system with the engine running;

- **Always keep refrigerant supply container in the upright position.**
- **Never open the high side pressure valve.**

-
4. Open the manifold gauge low side valve and charge system to standard capacity.

Gauge Dial	Standard Reading
High Side Gauge	13 - 20 kg/cm ² (185 - 285 psi)
Low Side Gauge	1.5 - 3.5 kg/cm ² (21 - 49 psi)

NOTE: *These standards are for outside temperatures between 30° - 35°C (86° - 95°F). The gauge readings may vary for extreme temperature conditions.*



WARNING

-
- **When outside temperature is low, warm the refrigerant supply container with warm water not exceeding 40°C (104°F). Do not allow water to come in contact with the charging adapter valve handle.**
 - **When outside temperature is high, cool off refrigerant supply container and condenser to aid the refrigerant charging process.**

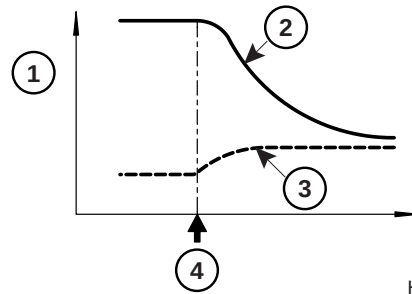
-
5. Close low-pressure side valve.
 6. Shut off engine and close refrigerant supply container adapter valve. Disconnect manifold gauge hoses from vehicle.

Inspecting System for Leakage

After completing charging procedures, clean all joints and connections with a clean dry cloth. Using a refrigerant leak detecting device or soapy water, inspect system for leaks starting from the high-pressure side.

NOTE: When the refrigerant circulation has been stopped the high-pressure will start to decrease and the low-pressure will start to increase until they are equalized. Starting the inspection from the high side will result in a accurate test.

Reference Number	Description
1	Pressure
2	High-pressure
3	Low-pressure
4	Compressor Stop



HDA6073L

Figure 34

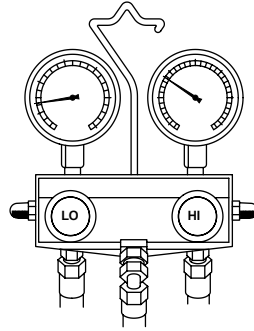
Inspection Procedure

- High-pressure Side.
Compressor outlet → condenser inlet → receiver dryer inlet → air conditioner unit inlet
- Low pressure side.
Compressor inlet → air conditioner unit outlet
- Compressor.
Compressor shaft area, bolt hole area and magnetic clutch area.
- Receiver dryer.
Pressure switch and plug area.
- Connection valve area.
Inspect all valve areas.
Verify all valves are capped to prevent leaking.
Check for foreign material inside of valve cap.
- Interior of air conditioner unit.
After stopping engine, insert detector probe into drain hose. (Leave inserted for 10 seconds minimum.)

NOTE: When inspecting leakage from the air conditioner unit, perform the inspection in a well ventilated area.

TROUBLESHOOTING

Refrigerant Pressure Check



HDA6074L

Figure 35

1. Open all doors and windows.
2. Install manifold gauge set.
3. Start engine and maintain engine speed at 1,800 - 2,000 rpm.
4. Check high / low-pressure of refrigerant.

1	High-pressure: 8 - 10.0 kg/cm² (114 - 142 psi) Low-pressure: Approximately 1.0 kg/cm² (14 psi)		
Possible Cause: Low Refrigerant Level			
Step	Inspection Item		Remedy
1	Check for traces of refrigerant oil.	Yes	Reassemble using correct tightening torque.
		No	Go to next step.
2	Using a leak detection device or soapy water check for refrigerant leakage at all major components and joints.	Yes	Repair leaking component.
		No	Recharge system to correct pressure.

2	High-pressure: Over 23 kg/cm² (327 psi) Low-pressure: Approximately 2.5 - 3.0 kg/cm² (36 - 43 psi)		
Possible Cause: Overcharge, Frost on condenser			
Step	Inspection Item		Remedy
1	Check for condenser pin damage or contamination.	Yes	Clean, repair or replace condenser.
		No	Refrigerant overcharge.

3	High-pressure: Approximately 20 - 25 kg/cm² (285 - 356 psi) Low-pressure: Approximately 2.5 - 3.5 kg/cm² (36 - 50 psi)
Possible Cause: Air in system.	
1. Recover any remaining refrigerant. 2. Vacuum out system. 3. Recharge system.	
NOTE: If the system has been exposed to the air for a long period of time, replace the receiver dryer.	

4	High-pressure: Over 6.0 kg/cm ² (85 psi) Low-pressure: Approximately 760 mmHg (Negative Pressure)		
Possible Cause: Refrigerant does not circulate			
Step	Inspection Item		Remedy
1	1. Connect manifold gauge and start engine. 2. Turn on air conditioner. 3. Set blower switch to "HIGH" position. 4. Turn air conditioner "OFF" and wait 10 minutes.	Yes	Moisture in system, replace receiver dryer.
	5. Recheck high / low-pressure readings. High-pressure: 13 - 19 kg/cm ² (185 - 270 psi) Low-pressure: 1.5 - 3.3 kg/cm ² (21.3 - 46.9 psi)	No	Contaminated system, replace expansion valve. (Replace evaporator core assembly.)

5	High-pressure: Over 6.0 - 18 kg/cm² (85 - 256 psi) Low-pressure: 500 mmHg (Negative Pressure) - Dial indicator needle unstable.
Possible Cause: Moisture in system has iced up the expansion valve.	
NOTE: When the absorbed moisture freezes the pressure readings may look normal. Careful readings should be made to determine whether pressure is in normal range.	
1. Recover any remaining refrigerant. 2. Vacuum out system. 3. Recharge system.	
NOTE: If the system has been exposed to the air for a long period of time, replace the receiver dryer.	

6	High-pressure: Over 22 - 23 kg/cm² (313 - 327 psi) Low-pressure: 2.5 kg/cm² (36 psi)			
Possible Cause: Refrigerant pressure problem due to defective expansion valve or temperature sensor.				
Step	Inspection Item		Remedy	
1	Inspect whether the temperature sensor is installed properly.		Yes	Replace expansion valve.
			No	Exchange duct sensor.

7	High-pressure: Over 7.0 - 11 kg/cm² (100 - 156 psi) Low-pressure: 4.0 - 6.0 kg/cm² (57 - 85 psi)
Possible Cause: Low refrigerant pressure due to poor compressor compression	
Inspect and replace compressor if necessary.	

Electrical Schematic (DX55W)

Edition 1

MEMO

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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 ultimately 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
DX55W	5001 and Up

DX55W

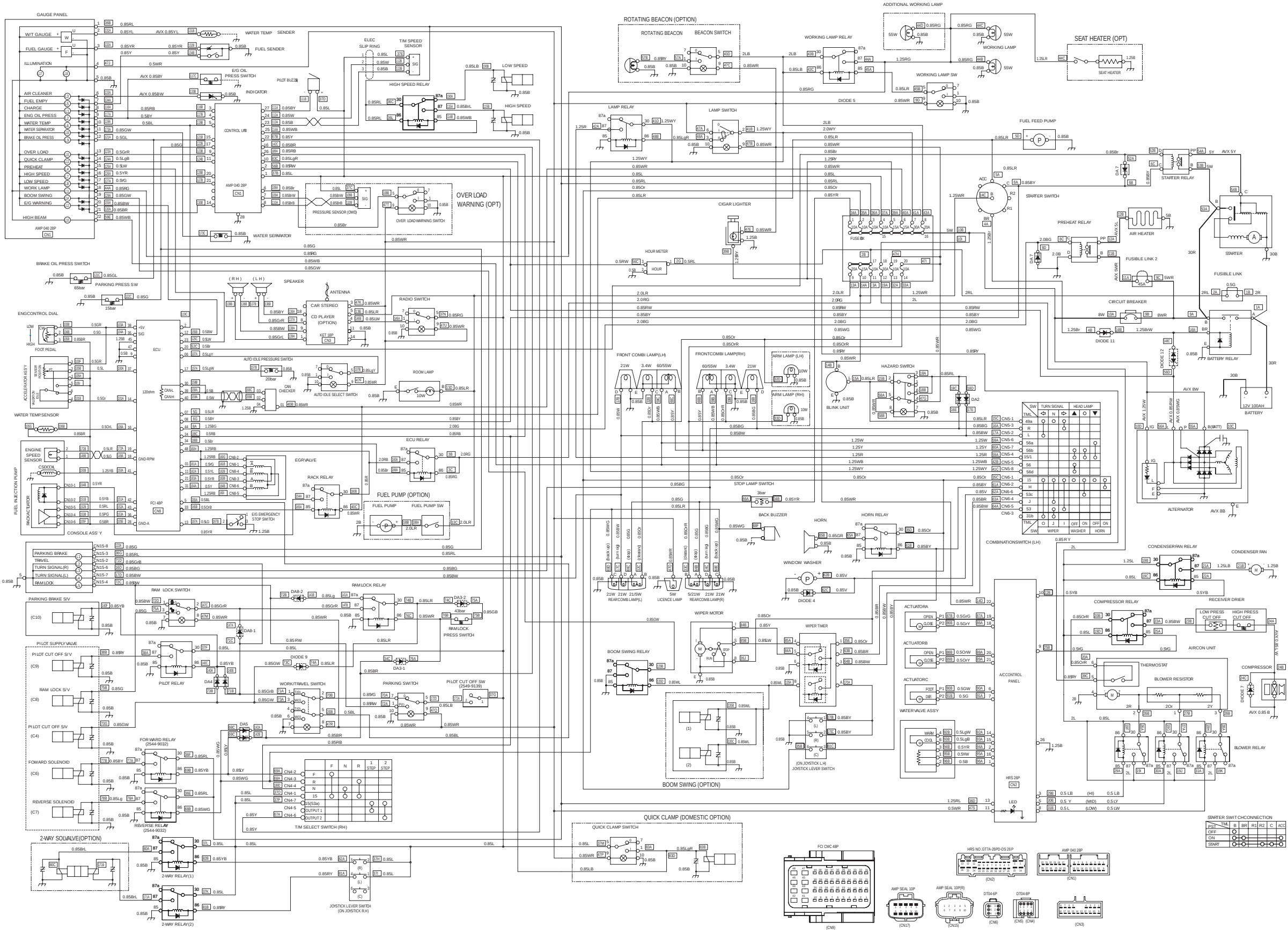


Figure 1

Attachments

Boom and Arm

Edition 1

MEMO

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Boom and Arm

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SAFETY PRECAUTIONS



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APPLICABLE MODELS

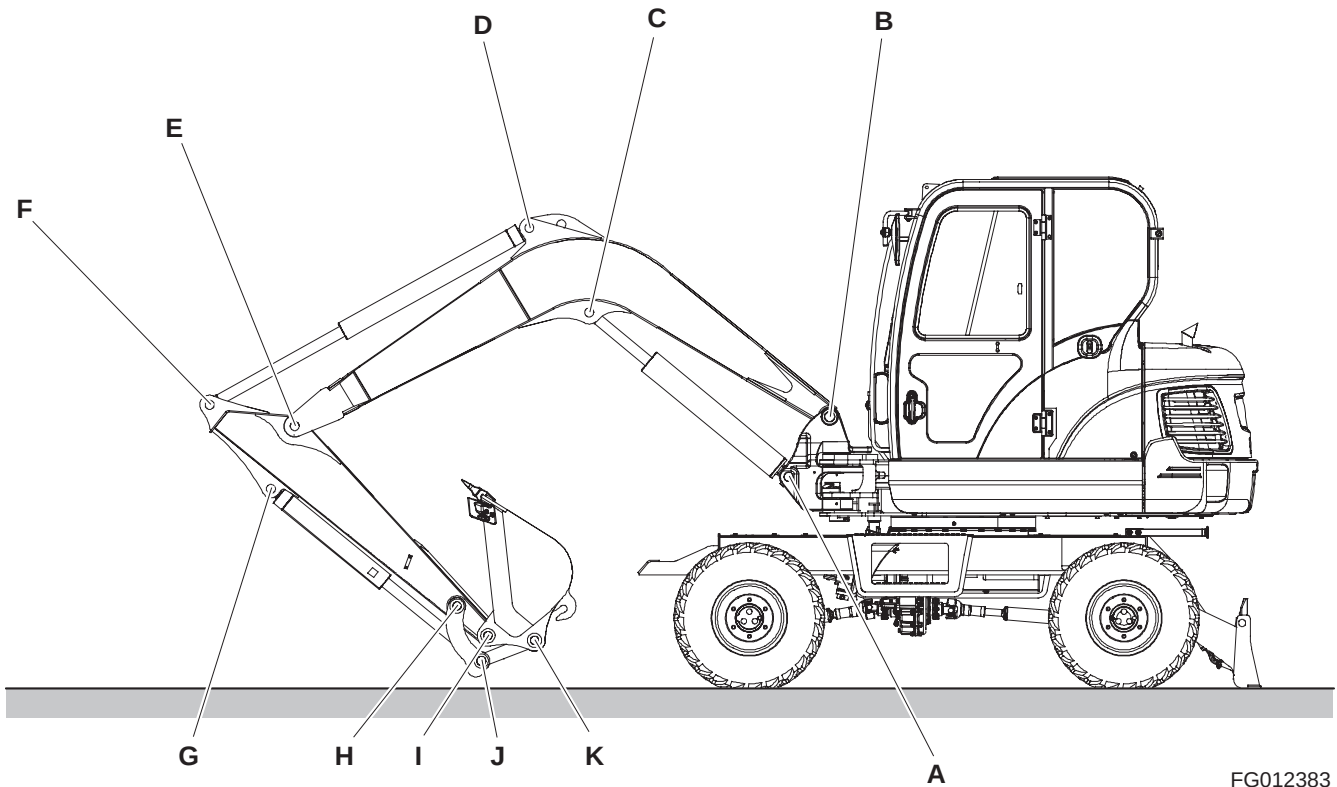
The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX55W	5001 and Up

FRONT ATTACHMENT PIN SPECIFICATIONS

The table below has a complete listing of dimensional specifications for all mounting pins used on the front attachment.

NOTE: *Some mounting pins must be drilled and tapped for lubrication fittings and piping, or may have other required specifications. Consult DOOSAN After Sales Service for information on wear tolerances and replacement limits for mounting pins.*



FG012383

Figure 1

Mark	Measuring Part	Diameter, mm (Inches)						Remedy
		Size		Tolerance		Stanard Clearance	Clearance Limit	
		Diameter	Length	Pin	Hole			
A	Boom Cylinder Head	50 mm (1.97 in)	205 mm (8.07 in)	-0.05	+0.294	0.294 ~ 0.364	1.5	Replace
				-0.07	+0.244			
B	Boom Foot	55 mm (2.17 in)	357 mm (14.06 in)	-0.05	+0.294	0.294 ~ 0.364	1.5	
				-0.07	+0.244			
C	Boom Center	50 mm (1.97 in)	206 mm (8.11 in)	-0.04	+0.294	0.284 ~ 0.384	1.5	
				-0.09	+0.244			
D	Boom End	50 mm (1.97 in)	287 mm (11.30 in)	-0.04	+0.294	0.284 ~ 0.385	1.5	
				-0.09	+0.244			
E	Arm Cylinder Head	50 mm (1.97 in)	152 mm (5.98 in)	-0.04	+0.294	0.284 ~ 0.386	1.5	
				-0.09	+0.244			
F	Arm Cylinder Rod	50 mm (1.97 in)	152 mm (5.98 in)	-0.04	+0.294	0.284 ~ 0.387	1.5	
				-0.09	+0.244			
G	Bucket Cylinder Head	50 mm (1.97 in)	152 mm (5.98 in)	-0.04	+0.294	0.284 ~ 0.388	1.5	
				-0.09	+0.244			
H	Arm Link	45 mm (1.77 in)	286 mm (11.26 in)	-0.05	+0.294	0.294 ~ 0.364	1.5	
				-0.07	+0.244			
I	Arm End	45 mm (1.77 in)	285 mm (11.22 in)	-0.04	+0.294	0.284 ~ 0.388	1.5	
				-0.09	+0.244			
J	Bucket Cylinder Rod	50 mm (1.97 in)	286 mm (11.26 in)	-0.05	+0.294	0.294 ~ 0.364	1.5	
				-0.07	+0.244			
K	Push Link to Bucket	45 mm (1.77 in)	285 mm (11.22 in)	-0.04	+0.294	0.284 ~ 0.388	1.5	
				-0.09	+0.244			

FRONT ATTACHMENT - REMOVAL AND INSTALLATION



DANGER!

DOOSAN warns any user, that the removal of the counterweight from the machine, front attachment or any other part, may affect the stability of the machine. This could cause unexpected movement, resulting in death or serious injuries. *DOOSAN* is not liable for any misuse.

Never remove the counterweight or front attachment unless the upper structure is in-line with the lower structure.

Never rotate the upper structure once the counterweight or front attachment has been removed.

IMPORTANT

Always break down the front attachment by removing outermost sections first - the bucket before the arm, the arm before the boom. Reinstallation of the attachment should begin with the boom and end with the bucket.

Refer to the appropriate Bucket section for its removal and installation procedure before going onto the initial step of the front attachment removal or installation procedure.

Arm Removal Procedure



WARNING!

This procedure is only intended for routine removal or replacement of the attachment, while working under normal, safe operating conditions. In the event of a major structural collapse of some part of the attachment, an accident or complete loss of attachment hydraulic function, **DO NOT** proceed with attachment disassembly unless you are completely sure of what you are doing. Please call your local *DOOSAN* distributor or *DOOSAN* After Sales Service for assistance. **DO NOT** allow personnel to stand underneath a weakened or only partially supported attachment section. Keep clear of hydraulic lines that may have fluid escaping at high-pressure - it can cause severe or even fatal injuries.

Complete the bucket end removal procedure by pulling out the two bucket linkage pins and the bucket cylinder mounting pin, on the arm. Use an assist crane or hoist to lift the cylinder and relieve weight on mounting pins.

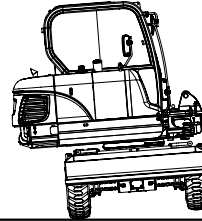


Figure 2

FG010548

Park the excavator away from obstructions and all traffic on clear, flat, level ground. Extend the arm cylinder and crowd the arm into the boom. Partially retract the boom cylinder so that the boom is stretched out in front of the excavator, as low to the ground as possible, with the arm crowded under the boom.

The tip of the arm point should be lowered to secure blocking that will safely support the weight of the arm. Place the blocking directly in front of the excavator and make sure that it will not be unbalanced with an initial weight load that is all to one end, under the arm point.

Shut off the engine and release hydraulic system pressure - move any of the control levers with the engine off to release pressure built up in the accumulator. Manually vent residual hydraulic pressure in the tank by moving the lever near the cap, on top of the reservoir.

 WARNING!

Secure the swing lock and tag and lock out controls in the operator's cabin to keep anyone from moving or inadvertently starting the engine. Restrict access to the work site while sections of the attachment are in the air, or while they are being supported by the assist crane. The safe lifting capacity of the assist crane or hoist that is used must exceed the weight of the heaviest section of the attachment, the boom (approximately 258 kg [570 lb], not including the weight of accessories or fixtures).

Before beginning the disassembly of attachment mounting pins, disconnect the arm cylinder hydraulic hose couplings and put a clean plug in the end of each one. Use any and all reasonable precautions necessary to avoid introducing dirt or other contaminants into the hydraulic system. Wipe down coupling points before disconnecting hydraulic lines and use evaporative type solvent spray cleaner. Tag and mark hoses for reassembly, if necessary.

Place a sling under the arm cylinder (the cylinder used to extend and retract the attachment arm, pinned to the top of the boom). Lift the sling so that the weight load on the rod end of the arm cylinder (pinned to the ears on the inner end of the arm) is released. Prepare blocking under the arm that will securely support the weight of the arm and arm cylinder.



CAUTION!

To make sure that the polished surfaces of cylinder rod ends will not suffer accidental damage during disassembly or removal procedures, wrap exposed rod surfaces (especially those of boom cylinders) with a protective covering material. Immediately following disassembly and removal, cylinder rods should always be fully retracted. This eases handling problems and also avoids possible damage.

Remove retainers on the end of the mounting pin for the arm cylinder rod end. Use the assist crane to relieve the weight load and withdraw the pin. Lower the arm down to the blocking support for any continued disassembly procedures.

Boom Removal Procedure

NOTE: *Boom removal may be simplified if the shell of the operator's cabin is taken off the turntable deck first. Refer to the Operator's Cabin Removal procedure before continuing, if both components are to be removed from the excavator.*

After the bucket, arm and arm cylinder have been removed, lower the end of the boom to a stable, secure blocking support.

Attach the assist crane sling to the body of either boom cylinder, break the mounting pin connection to the boom by tapping through the pin from the same side of the boom and repeat for the opposite cylinder.

Release hydraulic pressure and disconnect line couplings as previously outlined in the Arm Removal Procedure, observing the same precautions.

Disconnect wiring for work light assemblies and any other accessory lines or connections. Locate the sling of the assist crane near the center of gravity, optimum lift point for the boom, and use the crane to take pressure off the boom foot pin. Drive out the pin after disassembling retainers and carefully lift away the boom.



WARNING!

Traveling the excavator, swinging the turntable or movement over bumps or sloping, uneven surfaces could all produce loss of control and possible accidents or injuries, if the turntable deck has been unbalanced by removal of weight from one end only.

To maintain stability, the counterweight should be removed whenever the front attachment is taken off the machine.

INSTALLATION

Arm Installation Procedure

Reattach the base of the arm cylinder to the mounting point on top of the boom.



Before assembling the front attachment, make sure that the individual boom, arm and bucket sections are all compatible and can be used safely for work intended. Refer to the General Safety Pages, Lift Ratings, Working Range Diagrams and Weights of Materials sections in the Operation and Maintenance Manual. Consult your dealer or DOOSAN After Sales Service for more information if you have any questions or require more information.

Begin with the arm securely supported on blocking in front of the excavator. Pregrease the mounting pin for the rod end of the arm cylinder and push it through the ears on the end of the arm. Attach a sling around that mounting pin and lift the arm with an assist crane until it is in position for the boom-arm pin connection to be made.

Relieve hydraulic pressure from all points of the system before any hydraulic lines are opened, then carefully assemble hydraulic connections to the arm cylinder.

Remove the sling from around the rod end arm cylinder pin, withdraw the pin and lift the body of the arm cylinder to re-pin the mounting connection.

Boom Installation Procedure

Before reassembling the attachment, make sure to inspect all bushings and pivot points of each section. To avoid damaging the seats, bushings should never be hammered or chiseled out of their seats.

Installation is otherwise a reversal of the removal procedures.

START-UP PROCEDURES

Once the boom has been serviced, it should be lubricated as outlined in the initial start-up procedures of the operation manual. Refer to the appropriate operation and maintenance manual for unit.

Bucket

Edition 1

MEMO

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MEMO

SAFETY PRECAUTIONS



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APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX55	5001 and Up
DX55W	5001 and Up

BUCKET TOOTH INSPECTION AND REPLACEMENT

There are several different types of attachment methods for replaceable bucket teeth. Some of the most common types are shown in the following drawings.



WARNING

Due to the possibility of flying metal objects, always wear safety helmet, protective gloves and eye protection when changing bucket teeth.

Curl the bucket upwards and place the round rear surface of the bucket firmly on the ground. Shut the engine off and lock out the hydraulic controls before working on the bucket.

NOTE: *These instructions are only for DOOSAN OEM buckets. If you are using other manufacturers buckets, refer to their specific instructions.*

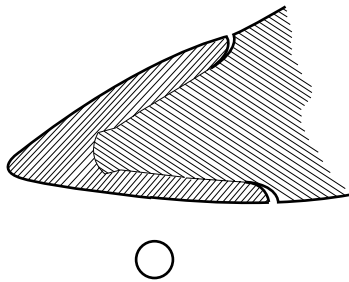
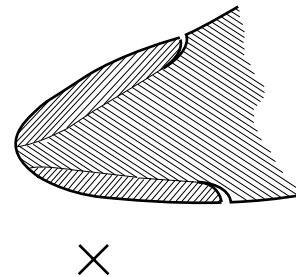


Figure 1



FG010467

1. On a routine basis, inspect bucket teeth to make sure that tooth wear or breakage has not developed. Do not allow replaceable bucket teeth to wear down to a point that bucket adapter is exposed. See Figure 1.
2. To replace a tooth, use a hammer (1, Figure 2) and punch (2, Figure 2) to drive locking pin (4, Figure 3) and locking rubber (3, Figure 3) out of tooth adapter.
3. Once worn tooth has been removed, use a putty knife to scrape adapter as clean as possible.
4. Slide new tooth into position and insert lock washer.
5. Insert locking pin into tooth and with a hammer, drive pin in until lock washer seats in locking groove.

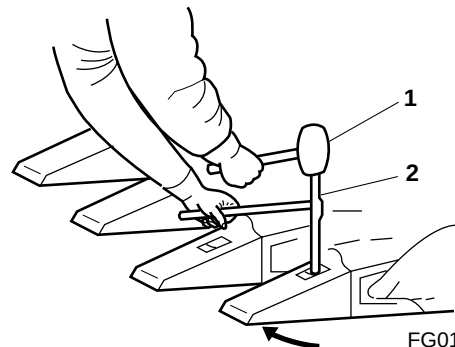
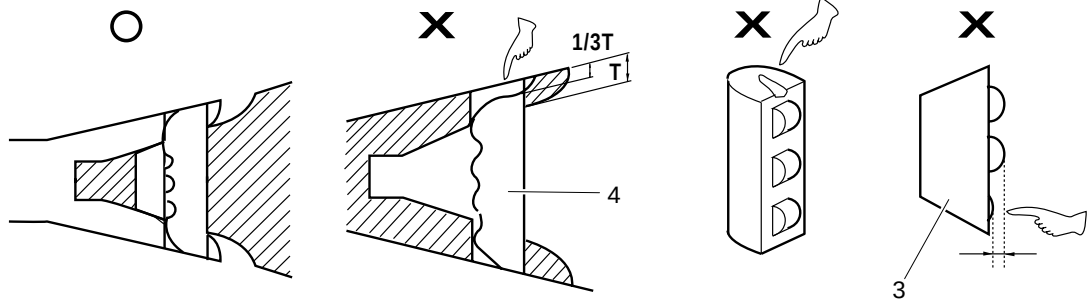


Figure 2

FG010527

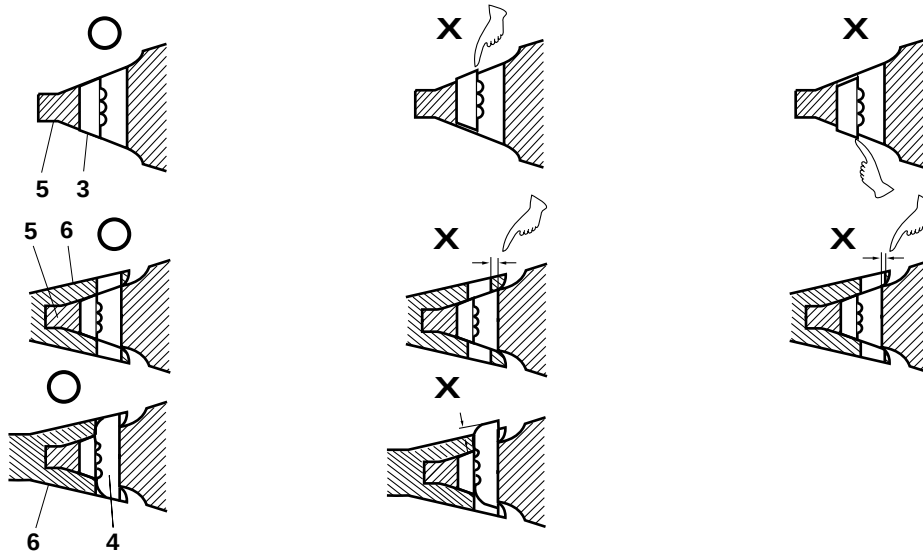


FG012221

Figure 3

Inspect locking pin assembly and replace it if the following conditions exist:

1. The locking pin is too short when both surfaces are aligned.
2. The rubber has been torn and bosses of the steel balls are liable to slip off.
3. Pressing steel ball causes the boss to go inside.



HFO3043I

Figure 4

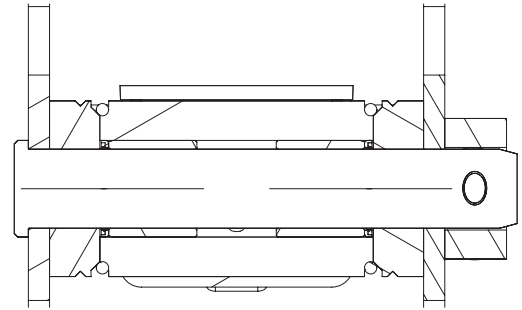
BUCKET O-RING REPLACEMENT



WARNING

Due to possibility of flying metal objects, always wear safety helmet, protective gloves and eye protection when changing pins.

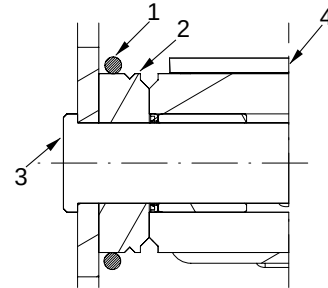
1. Inspect bucket O-rings on a routine basis. If worn or damaged, replacement is necessary.



FG012378

Figure 5

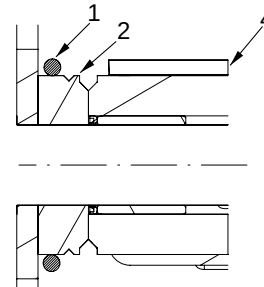
2. Roll old O-ring (1, Figure 6) onto boss (2) around bucket pin (3). Remove bucket pin and move arm or bucket link (4) out of way.



FG011218

Figure 6

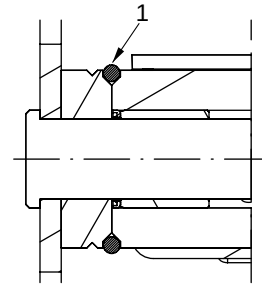
3. Remove old O-ring and temporarily install new O-ring (1, Figure 7) onto bucket boss (2). Make sure that O-ring groove on both bucket link (4) and boss have been cleaned.
4. Realign arm or link with bucket pinhole and insert bucket pin (3, Figure 6).



FG011219

Figure 7

5. Roll new O-ring (1, Figure 8) into O-ring groove.



FG011220

Figure 8

BUCKET ATTACHMENT, REMOVAL AND REVERSAL

Detaching the Bucket

Park the excavator away from obstructions on clear, flat, level ground. Lower the bucket carefully to preassembled blocking on the ground. Brace the bucket so that there is no load weight on the pin connecting the bucket and arm. Disassemble the fasteners on the end of the bucket pin and pull out the pin.

If the pin sticks and resists normal withdrawal, there may be a load on it. Raise and lower the arm slightly until the unstressed pin position is located.



WARNING

Use care pulling out the pin to avoid damaging the dust seals on either end of the arm.

When the pin has been withdrawn, move the operating joystick slightly to take weight off the remaining link pin. Disassemble the link pin end retainers and pull out the pin.

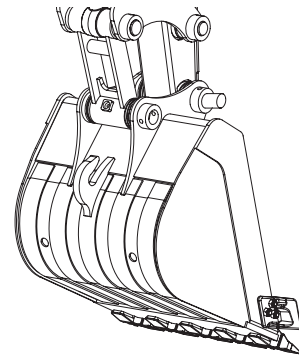
Lift the arm away from the bucket so that the bucket can be carried away or another end attachment can be put on the excavator.

Attaching the Bucket

Carefully inspect all parts before reassembling the bucket linkage. Look for cracks or any other evidence of physical damage and replace any seal or O-ring that is not in like-new condition. Prelube linkage pins before assembly.

Use an old cylinder rod, a long breaker bar or a similar, relatively thin diameter support bar for making the first (temporary) pin connection, between the bucket and arm. If the support bar is straight, the arm can be raised and the bucket will hang level, allowing direct insertion of the bucket ear-attachment linkage pin.

When the link pin has been installed, withdraw the temporary support rod from the bucket pin holes, lower and raise the arm and boom and install the bucket pin.



FG010394

Figure 9



WARNING

When making linkage alignments, never insert fingers into pin holes. The attachment or bucket could shift position and cause a severe injury. Match holes by visually lining them up. Use the sharp tipped, soft point of a pencil or a similar tool to check for high spots or irregularities.

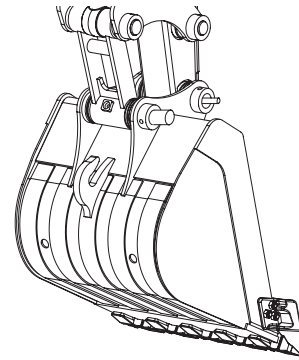
Reversing the Bucket

Follow instructions for "Detaching the Bucket" and remove both the bucket and link pins. Rotate the bucket 180° to change bucket configuration. This procedure is greatly simplified if some type of rotating or swiveling support can be used, on the ground underneath the bucket. Follow instructions for "Bucket Attachment" to replace pins.



WARNING

Bucket curl and dump levers must be used in opposite directions, after the bucket has been reversed.



FG010395

Figure 10