

DOOSAN

K1049551BE
July 2011

EXCAVATOR
**Shop
Manual**

DX140R / DX140LCR

Serial Number 5001 and Up



WARNING

CALIFORNIA PROPOSITION 65 WARNING

Diesel engine exhaust and some of its constituents are known to the state of California to cause cancer, birth defects and other reproductive harm.



WARNING

CALIFORNIA PROPOSITION 65 WARNING

Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. WASH HANDS AFTER HANDLING.

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Shop Manual

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DOOSAN

Product Label

Instructions

**Trim Out The Label Along
The Lines And Insert Into
Pocket On The Binder Spine**

Table of Contents

Safety

Track Excavator Safety.....	SP002281
-----------------------------	----------

Specifications

Specification for DX140LCR	SP002379
----------------------------------	----------

General Maintenance

General Maintenance Procedures	SP000016
Standard Torques	SP000813

Upper Structure

Cabin	SP002282
Counterweight.....	SP001939
Fuel Tank.....	SP001940
Fuel Transfer Pump	SP000021
Swing Bearing.....	SP001856
Swing Reduction Gear.....	SP000921

Lower Structure and Chassis

Track Assembly	SP001941
----------------------	----------

Engine and Drive Train

QSB4.5 Engine	SP001671
Drive Coupling (Main Pump).....	SP001326

Hydraulics

Hydraulic System Troubleshooting, Testing and Adjustment	SP001942
Accumulator.....	SP000028
Center Joint (Swivel).....	SP000029

Cylinders.....	SP000030
Swing Motor.....	SP001943
Travel Moter.....	SP001346
Main Pump.....	SP001945
Main Control Valve	SP001029
Remote Control Valve (Work Lever / Joystick)	SP001646
Travel Control Valve (with Damper).....	SP002262
Solenoid Valve Assembly	SP001944
Breaker EPPR Valve (Opt)	SP000192
Hydraulic Schematic (DX140LCR)	SP002383

Electrical System

Electrical System	SP001949
Electrical Schematic (DX140LCR).....	SP002271

Attachments

Bucket.....	SP000939
-------------	----------

Safety

Track Excavator Safety

Edition 1

MEMO

Table of Contents

Track Excavator Safety

Safety Precautions	5
Applicable Models	5
To the Operator of a Excavator	6
General Safety Essentials	9
Location of Safety Labels	10
Summary of Safety Precautions for Lifting in Digging Mode	11
Unauthorized Modifications	12
General Hazard Information	12
Before Starting Engine	22
Machine Operation	26
Maintenance	34
Battery	43
Towing	45
Shipping and Transportation	46
Lifting With Sling	46

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
DX140LCR	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. "General Safety Essentials" on page 1-9
2. "Location of Safety Labels" on page 1-10
3. "Summary of Safety Precautions for Lifting in Digging Mode" on page 1-11
4. "Unauthorized Modifications" on page 1-12
5. "General Hazard Information" on page 1-12
6. "Before Starting Engine" on page 1-22
7. "Machine Operation" on page 1-26
8. "Maintenance" on page 1-34
9. "Battery" on page 1-43
10. "Towing" on page 1-45
11. "Shipping and Transportation" on page 1-46
12. "Lifting With Sling" on page 1-46



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 Signal Words Used with 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 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 -10 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 DIGGING 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 Digging 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 "Digging 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, completely lower the work equipment 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 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

HAOA020L

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 genuine *DOOSAN* 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 distances (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, or track shoes, wipe it off immediately. Always keep these parts clean. Repair any damage and tighten any loose bolts.

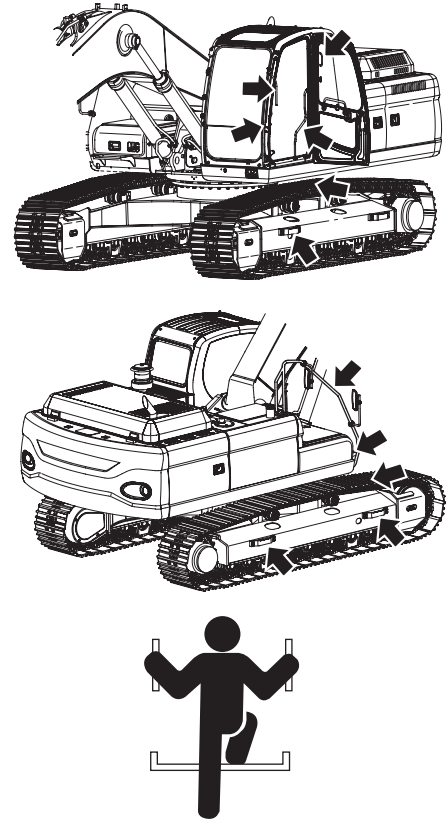
Never jump on or off the machine. In particular, never get on or off a moving machine. These actions may lead to serious injury.

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, steps, and track shoes 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 track shoes, 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.



FG000355

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.



Figure 3

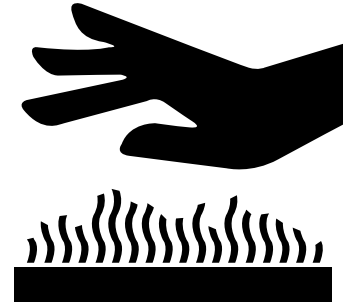
ARO1050S

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 replacing 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.

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.



HAOA050L

Figure 4



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.



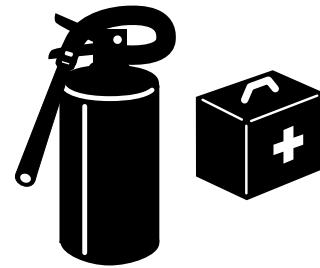
HDO1010L

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:

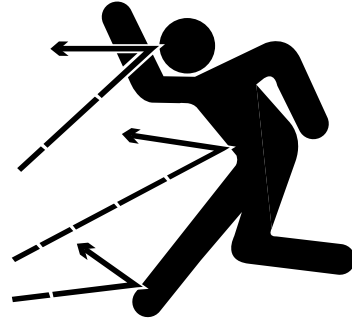
- Turn the starter switch to the "O" (OFF) position and shut down engine.
- If there is time, use the fire extinguisher to put out as much of the fire as possible.
- Use the handrails and steps to escape from the machine.

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 in "Handling of Accumulator" in the Operation and Maintenance Manual.

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.



ARO1770L

Figure 11

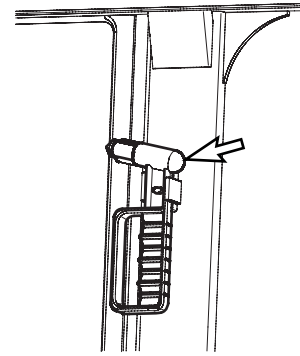
Emergency Exit

This machine is equipped with a glass breaking tool. It is on the upper left pillar of the 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.



FG014380

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.

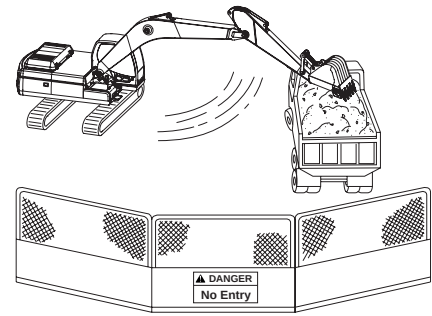
If you need to operate on a street, protect pedestrians and cars by designating a person for work site traffic duty or by erecting fences and posting "No Entry" signs around the work site.

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.

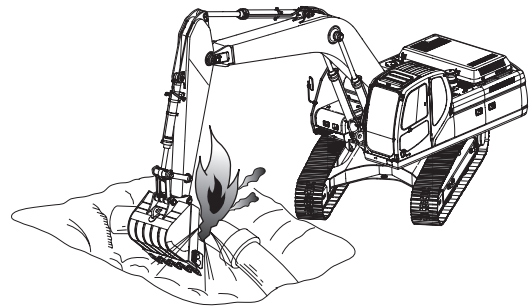
Check the condition of the riverbed, and the depth and flow of the water before operating in water or crossing a river. NEVER work in water that is more than the permissible water depth.

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.



FG000400

Figure 13

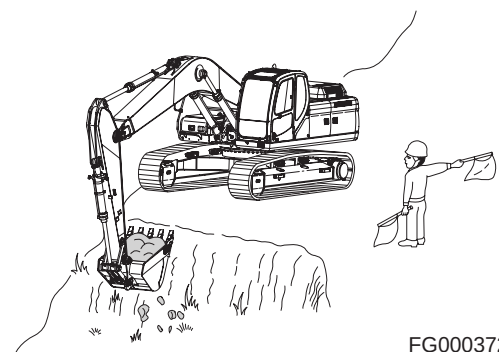


FG000363

Figure 14

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.



FG000372

Figure 15

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

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

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

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

Checks Before Starting Engine

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

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

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

Check the coolant, 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 idler wheels to the front under the cabin and the drive sprockets to the rear. When the undercarriage is in the reversed position, the travel controls must be operated in opposite directions.

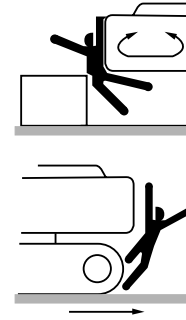
MACHINE OPERATION

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.



HAOA190L

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.

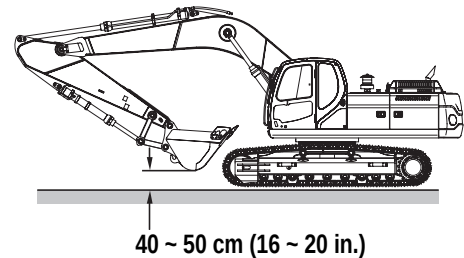
Never travel over obstacles or slopes that will cause the machine to tilt severely. Travel around any slope or obstacle that causes the machine to tilt 10 degrees or more to the right or left, or 30 degrees or more from front to rear.

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.

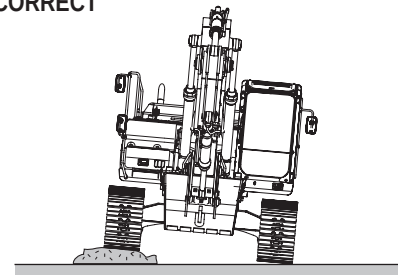
When traveling on rough ground, travel at low speed, and avoid sudden changes in direction.

Always keep to the permissible water depth. Permissible water depth is to the centerline of the upper track rollers.

TRAVEL POSTURE



INCORRECT



FG000349

Figure 17

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.

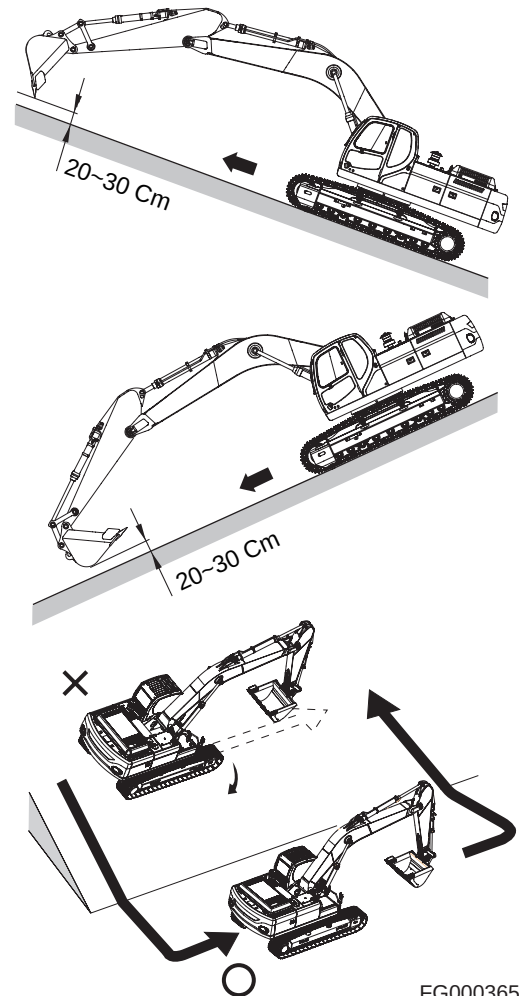
Traveling on slopes could result in the machine tipping over or slipping.

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.



FG000365

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.

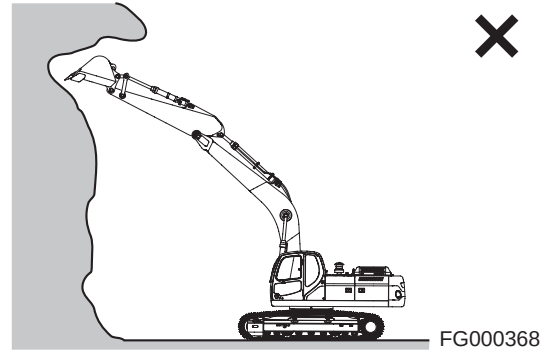


Figure 19

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 tipover 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 tracks fore and aft to prevent any movement.

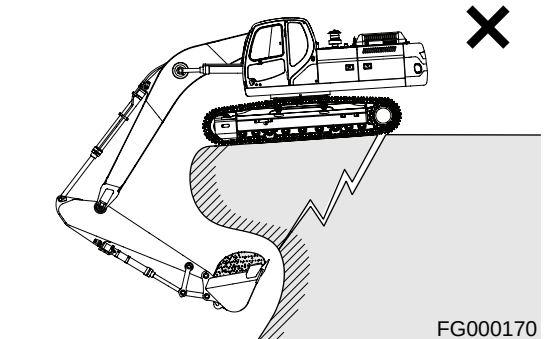


Figure 20

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.

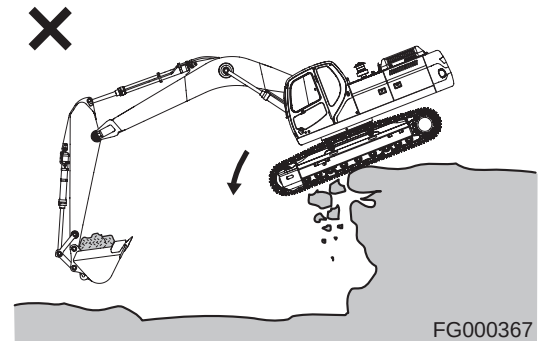


Figure 21

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.



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.

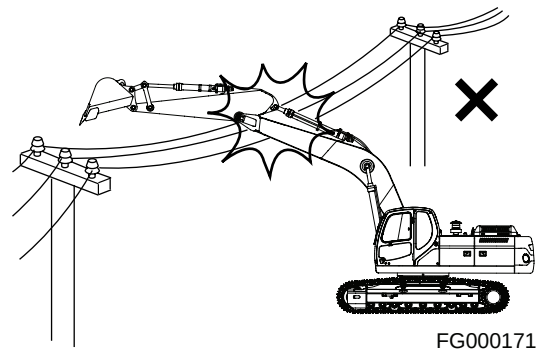


Figure 23

Roll Over Protective Structure (ROPS) When Required by Local Regulations

Global markets may or may not require a Roll Over Protective Structure (ROPS). Always comply with all regional and governmental regulations that apply to your market. The following information is for a ROPS cabin.

General ROPS Guidelines for ROPS Certified Cabins

The operator's cabin is a ROPS certified structure for protecting the seat-belted operator. It absorbs the impact energy of a rollover impact. Do not allow machine weight (mass) to exceed certified value on certification plate. If weight is exceeded, the ROPS structure will not be able to fulfill its safety function.

Do not increase machine weight beyond certified value by modifying machine or by installing attachments on machine. If weight limit of protective equipment is exceeded, protective equipment will not be able to protect operator, and operator may suffer serious injury or death. Always observe the following:

- This machine is equipped with a protective structure. Do not remove protective structure and carry out operations without it.
- Never modify the operator's cabin by welding, grinding, drilling holes or adding attachments unless instructed by *DOOSAN*. Changes to the cabin can cause loss of operator protection from rollover and falling objects, and operator may suffer serious injury or death.
- When protective structure is damaged or deformed by falling objects or by rolling over, its strength will be reduced and it will not be able to properly fulfill its function. In these cases, always contact your *DOOSAN* distributor for advice. Never repair a ROPS cabin.
- Always wear your seat belt when operating machine.

ROPS Certification

This *DOOSAN* excavator has an operator's cabin that meets ROPS requirements. The seat belt must be worn for rollover protection.

The ROPS certification plate (Figure 24) is found on the left side of the cabin on most models. It may vary slightly in its location on some models.

Check the ROPS cabin, mounting, and hardware for damage.

Never modify the ROPS cabin. Replace the cabin and hardware if damaged. See your *DOOSAN* dealer for parts.

ROPS – Roll Over Protective Structure complies with ISO 12117-2:2008.



Figure 24



WARNING

Never modify the operator cabin by welding, grinding, drilling holes or adding attachments unless instructed by *DOOSAN*. Changes to the cabin can cause loss of operator protection from rollover and falling objects, and result in serious injury or death.

Protecting Cabin from Falling Object (Optional)

In a work site where falling objects or flying objects are expected, be sure to install adequate protective devices for covering the cabin.

When using a breaker, be sure to install the front window protection guard (1, Figure 25).

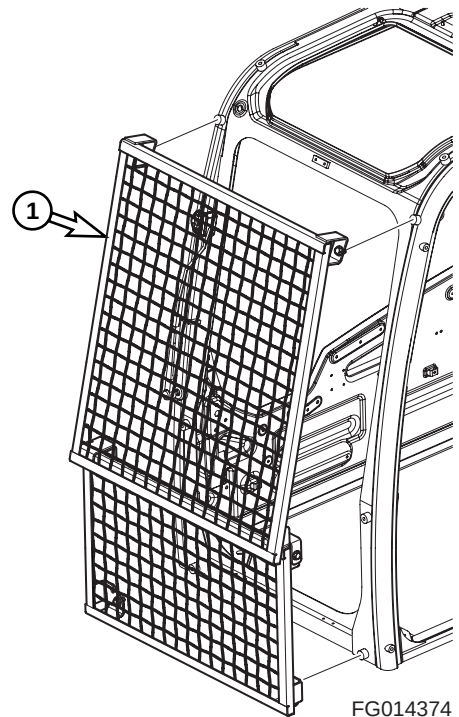


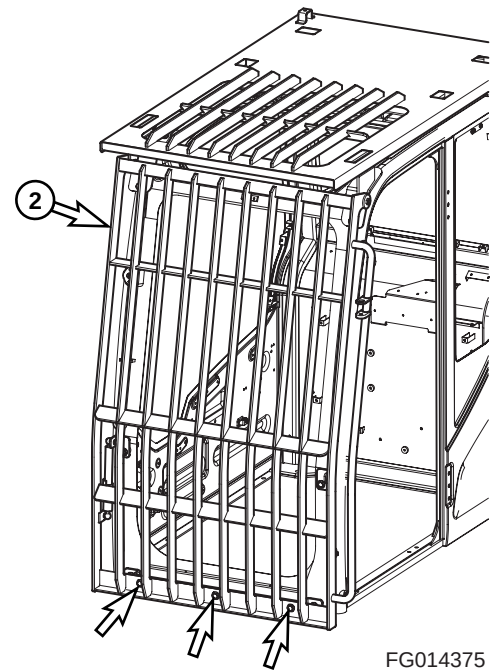
Figure 25

FG014374

In a work site where falling rocks can cause damage and possibly crush personnel, or in a mining operation, be sure to install the falling object protective structure (2, Figure 26).

Be sure to install any other additional protective structures required for work site conditions.

When the falling object protective structure is installed, and the front window needs to be cleaned, loosen the bolts marked with an arrow. Be sure to tighten bolts when done.



FG014375

Figure 26

Operate Carefully on Snow, Ice and in Very Cold Temperatures

In icy cold weather avoid sudden travel movements and stay away from even slight slopes. The machine could skid off to one side very easily.

Snow accumulation could hide or obscure potential hazards. Use care while operating or while using the machine to clear snow.

Warming up the engine for a short period may be necessary, to avoid operating with sluggish or reduced working capacity. The jolting shocks and impact loads caused by bumping or bottoming the boom or attachment are more likely to cause severe stress in very cold temperatures. Reducing work cycle rate and workload may be necessary.

When the temperature rises, frozen road surfaces become soft, and machine travel becomes unstable.

In cold weather, do not touch metal surfaces with your bare hands. If you touch a metal surface in extremely cold weather, your skin may freeze to the metal surface.

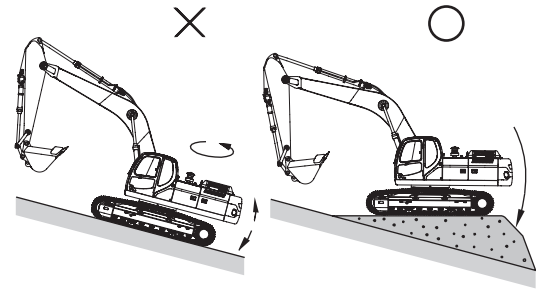
Operations on Slopes

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.



FG000212

Figure 27

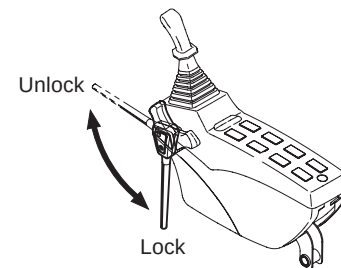
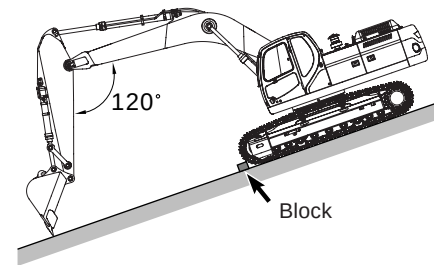
Parking Machine

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 crawler tracks 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.

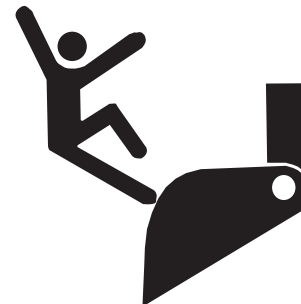


FG000666

Figure 28

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 potential danger of the person falling and suffering serious injury.



ARO1310L

Figure 29

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.



FG012195

Figure 30

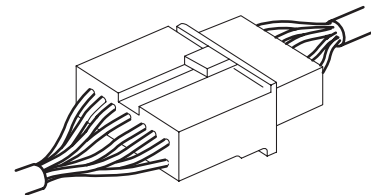
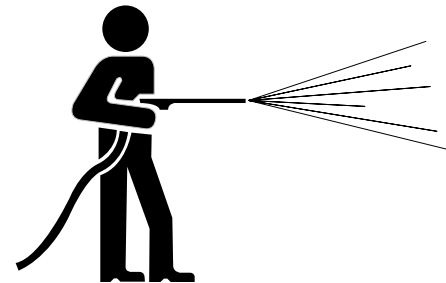
Clean Before Inspection or Maintenance

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

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

When washing the machine, do the following:

- Wear shoes with nonslip soles to prevent yourself from slipping and falling on wet places.
- Wear safety glasses and protective clothing when washing the machine with high-pressure steam.
- Take action to prevent touching high-pressure water and cutting your skin or having mud fly into your eyes.
- Do not spray water directly on electrical components (sensors, connector) (1, Figure 31). If water gets into the electrical system, there is a danger that it will cause defective operation and malfunction.



ARO1330L

Figure 31

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.

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 32

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 33

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 that 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.

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.



HDO1015I

Figure 34

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.

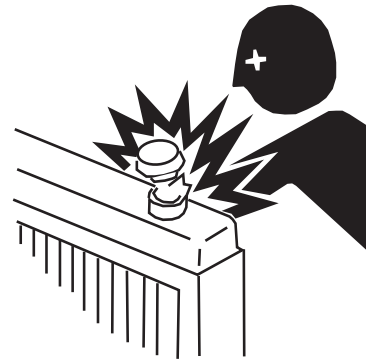
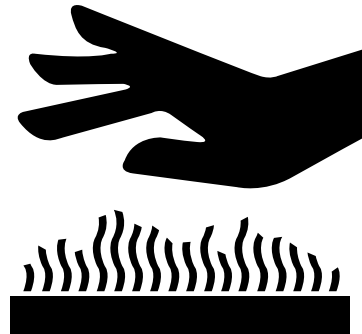
Relieve all pressure in the hydraulic oil system, in the fuel system, or in the cooling system before you disconnect any lines, fittings, or related items.

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 35

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 batteries.
- 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 on Body Structure

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

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

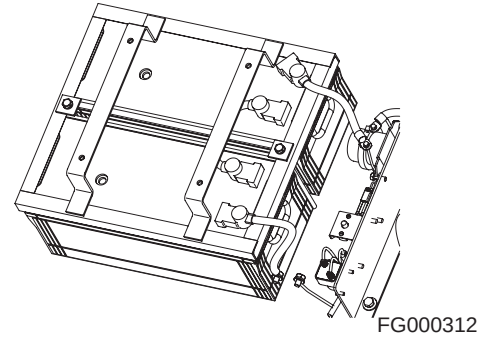


Figure 36

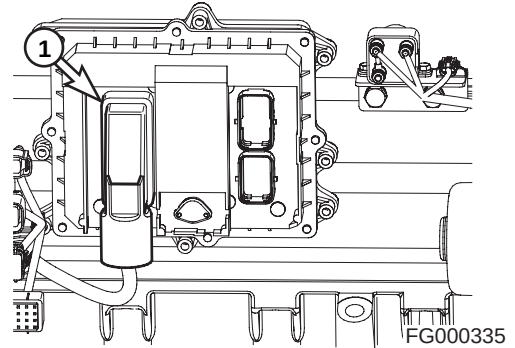


Figure 37

Warning for Counterweight and Front Attachment Removal



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.

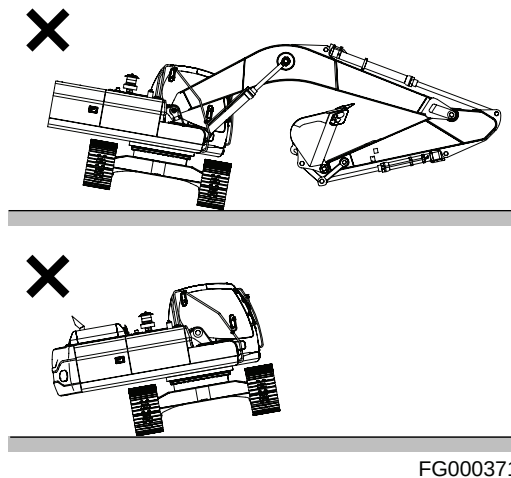


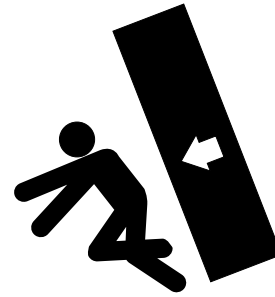
Figure 38

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 39

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.

To prevent injury from slipping or falling, when working on the hood or covers, never use any area except the area equipped with nonslip pads.



ARO1380L

Figure 40

Lock Inspection Covers

When carrying out maintenance with the inspection cover open, lock the cover securely in position with the lock bar.

If maintenance work is carried out with the inspection cover open but not locked, there is a danger that it may suddenly close and cause injury if there is a gust of wind.

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.

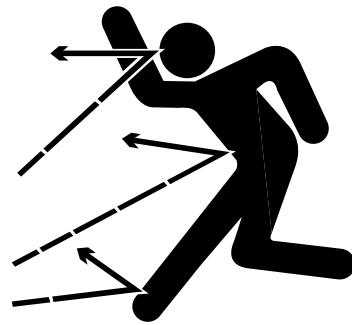
Do not use a wire rope cable that is kinked or frayed. Wear gloves when you handle a wire rope cable.

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.

Track Tension Adjustments Require Caution

Never turn out the track tension grease valve. To release pressure from the crawler frame track tension assembly, you should NEVER attempt to disassemble the track adjuster or attempt to remove grease fitting or valve assembly.

Keep your face and body away from the valve. Refer to the track adjustment procedure in the Operator and Maintenance Manual or Shop Manual.



HAOA110L

Figure 41

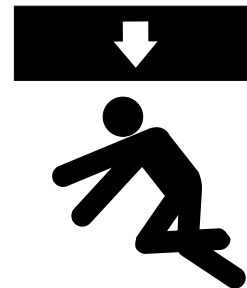
Supports and Blocking for Work Equipment

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 42

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.

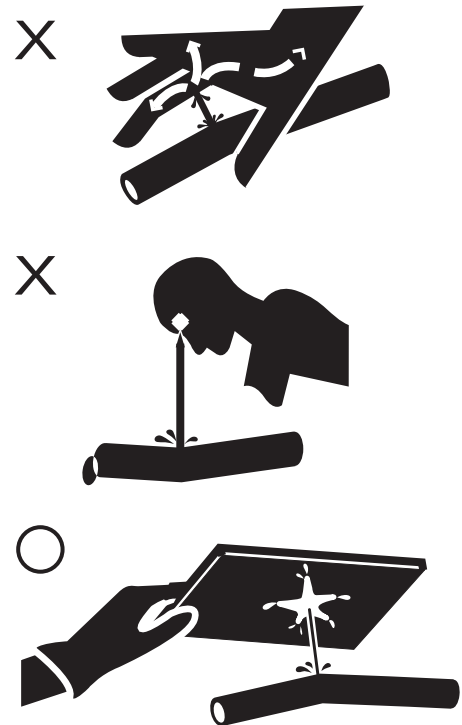
If necessary depending on the type of failure, please contact your DOOSAN distributor for repairs.

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.

NOTE: Refer to "Hose In-service Lifetime Limit (European Standard ISO 8331 and EN982 CEN)" in the Operation and Maintenance Manual, for additional European regulations.



HDO1045I

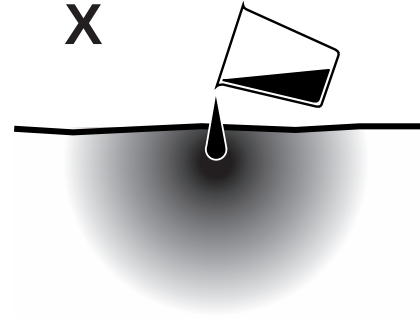
Figure 43

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 44

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.

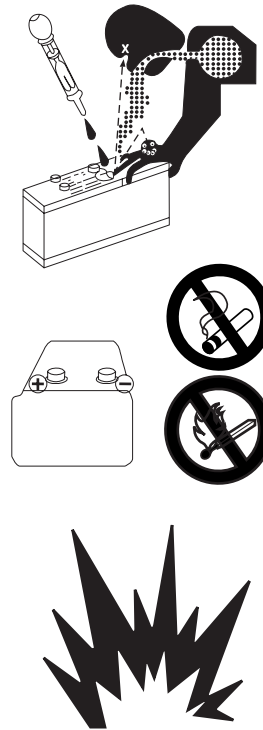


Figure 45

HAAE2100

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.
- 24 volt battery units consisting of two series connected twelve volt batteries have a cable connecting one positive terminal on one of the 12 volt batteries to a negative terminal on the other battery. Booster or charger cable connections must be made between the nonseries connected positive terminals and between the negative terminal of the booster battery and the metal frame of the machine being boosted or charged. Refer to the procedure and illustration in "Starting Engine With a Booster Cable" in the Operation and Maintenance Manual.
- 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.

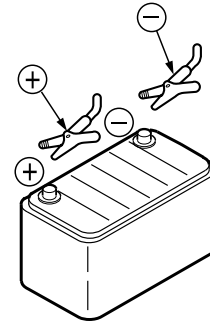


Figure 46

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.
- Always fit the towing rope to the left and right hooks and secure in position.
- If the engine on the problem machine will not start or there is a failure in the brake system, always 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.

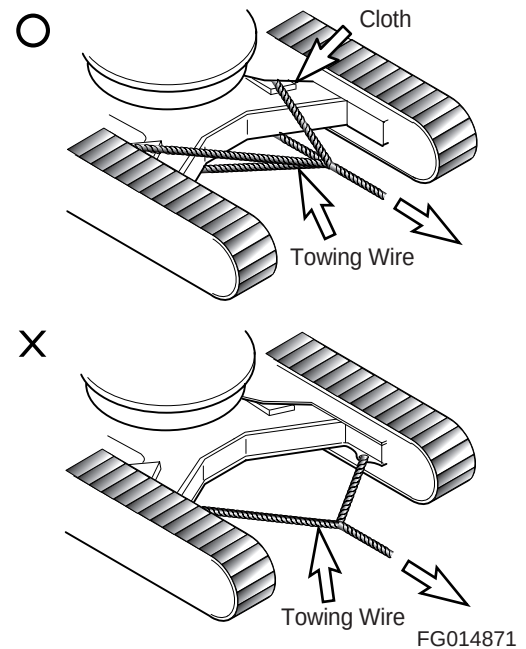


Figure 47

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

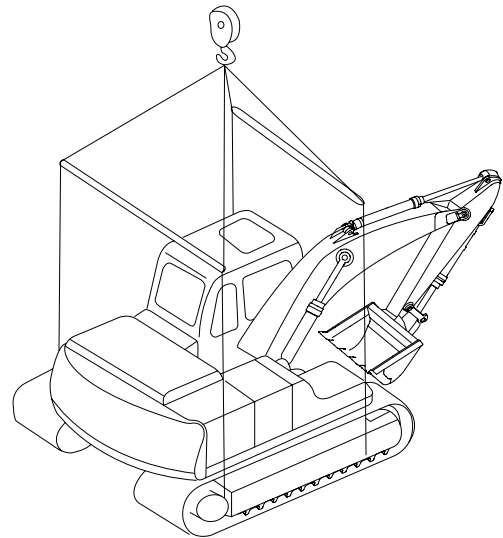


WARNING

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.

NOTE: *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.*



FG016361

Figure 48

Specifications

Specification for DX140LCR

Edition 1

MEMO

Table of Contents

Specification for DX140LCR

Safety Precautions	5
Applicable Models	5
General Description	6
Component Locations.....	6
General Dimensions	8
One - Piece Boom	8
Two - Piece Boom	9
Working Range	10
One - Piece Boom	10
Two - Piece Boom	11
General Specifications.....	12
Engine Performance Curves (Per DIN 6270 Standard)	14
Approximate Weight of Workload Materials.....	16
Performance Tests	18
Excavator Performance Standards.....	19
Test Conditions	19
Travel Speed and Travel Motor Balance (Steering Deviation) Tests	19
Swing Speed and Deceleration Force Test.....	21
Cylinder Performance Tests	23

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
DX140LCR	5001 and Up

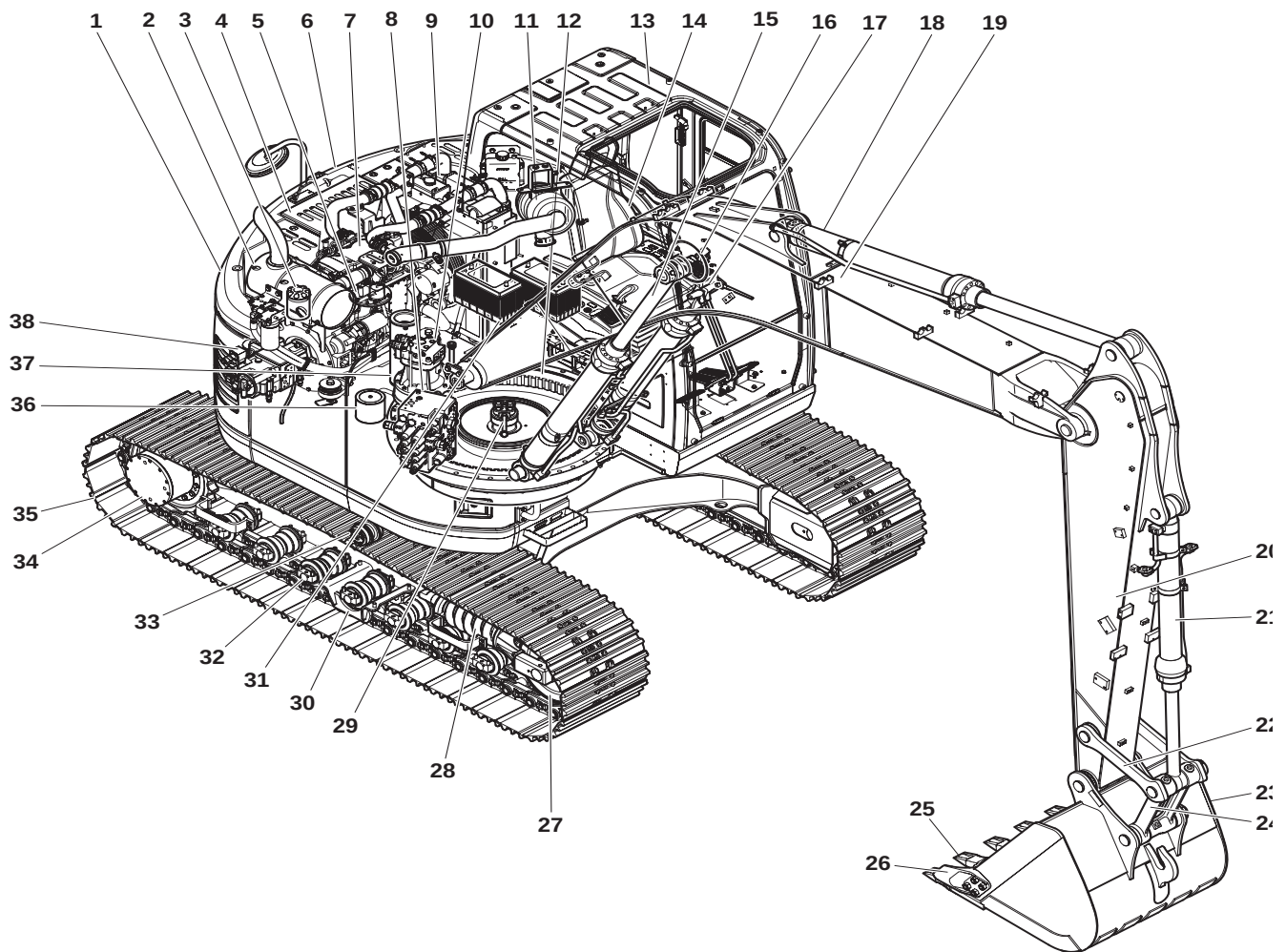
GENERAL DESCRIPTION

The excavator has three main component sections:

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

The following illustration identifies main components and their locations. (See Figure 1 on page -6.)

COMPONENT LOCATIONS



FG014632

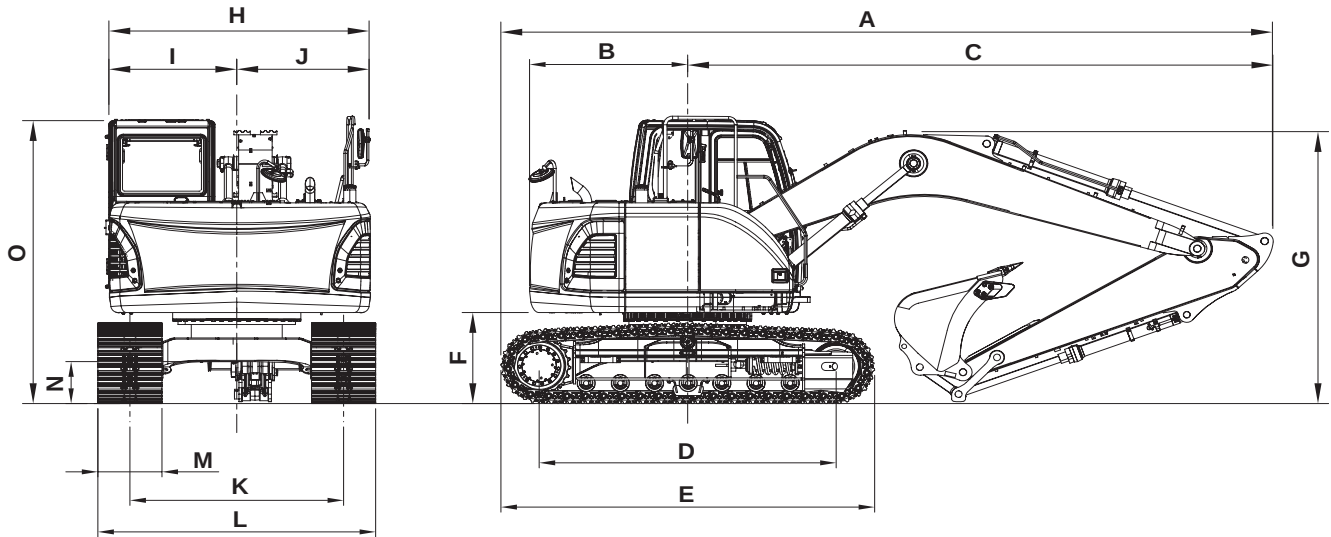
Figure 1

Reference Number	Description
1	Counterweight
2	Muffler
3	Fuel Tank Fill Cap
4	Hood
5	Hydraulic Oil Tank
6	Fuel Tank
7	Engine
8	Control Valves
9	Radiator and Oil Cooler
10	Swing Motor
11	Air Cleaner
12	Swing Bearing
13	Cabin
14	Seat
15	Boom Cylinder
16	Work Lever (Joystick) Controls
17	Travel Lever
18	Arm Cylinder
19	Boom
20	Arm

Reference Number	Description
21	Bucket Cylinder
22	Guide Link
23	Bucket
24	Push Link
25	Tooth Point
26	Side Cutter
27	Idler
28	Track Adjuster
29	Center Joint
30	Track Guide
31	Battery
32	Lower Roller
33	Upper Roller
34	Travel Motor
35	Track Link and Shoe
36	Suction Filter
37	Return Filter
38	Pumps

GENERAL DIMENSIONS

One - Piece Boom



FG014455

Figure 1

DIMENSION	4.6 m (15' 1") One - Piece BOOM		
	2.1 m (6' 11") Arm	2.5 m (8' 2") Arm	3.0 m (9' 10") Arm
A	* 7,240 mm (23' 9") / ** 7,373 mm (24' 2")	* 7,230 mm (23' 9") / ** 7,363 mm (24' 2")	* 7,190 mm (23' 7") / ** 7,323 mm (24')
B	1,480 mm (4' 10")		
C	5,495 mm (18' 0")	5,485 mm (18' 0")	5,445 mm (17' 10")
D	* 2,780 mm (9' 1") / ** 3,035 mm (9' 11")		
E	* 3,490 mm (11' 5") / ** 3,755 mm (12' 4")		
F	895 mm (2' 11")		
G	2,580 mm (8' 5")	2,710 mm (8' 11")	3,090 mm (10' 2")
H	2,440 mm (8' 0")		
I	1,190 mm (3' 11")		
J	1,250 mm (4' 1")		
K	1,990 mm (6' 6")		
L	2,590 mm (8' 6")		
M	600 mm (2' 0")		
N	410 mm (1' 4")		
O	2,795 mm (9' 1")		

* : DX140R

** : DX140LCR

Two - Piece Boom

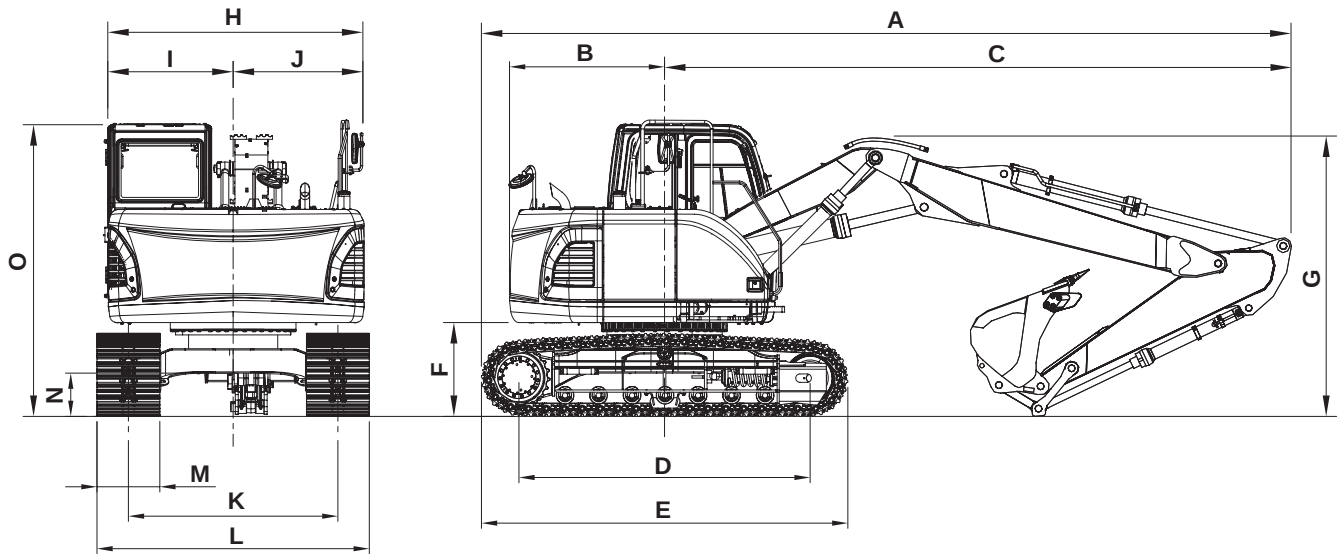


Figure 1

FG015127

DIMENSION	4.98 m (16' 4") Two - Piece BOOM	
	2.1 m (6' 11") Arm	2.5 m (8' 2") Arm
A	* 7,620 mm (25') / ** 7,753 mm (25' 5")	* 7,595 mm (24' 11") / ** 7,728 mm (25' 4")
B	1,480 mm (7' 2")	
C	5,875 mm (19' 3")	5,850 mm (19' 2")
D	* 2,780 mm (9' 1") / ** 3,035 mm (9' 11")	
E	* 3,490 mm (11' 5") / ** 3,755 mm (12' 4")	
F	895 mm (2' 9")	
G	2,830 mm (9' 3")	2,940 mm (9' 8")
H	2,440 mm (8' 0")	
I	1,190 mm (3' 9")	
J	1,250 mm (4' 1")	
K	1,990 mm (6' 6")	
L	2,590 mm (8' 6")	
M	600 mm (2' 0")	
N	410 mm (1' 4")	
O	2,795 mm (9' 1")	

* : DX140R

** : DX140LCR

WORKING RANGE

One - Piece Boom

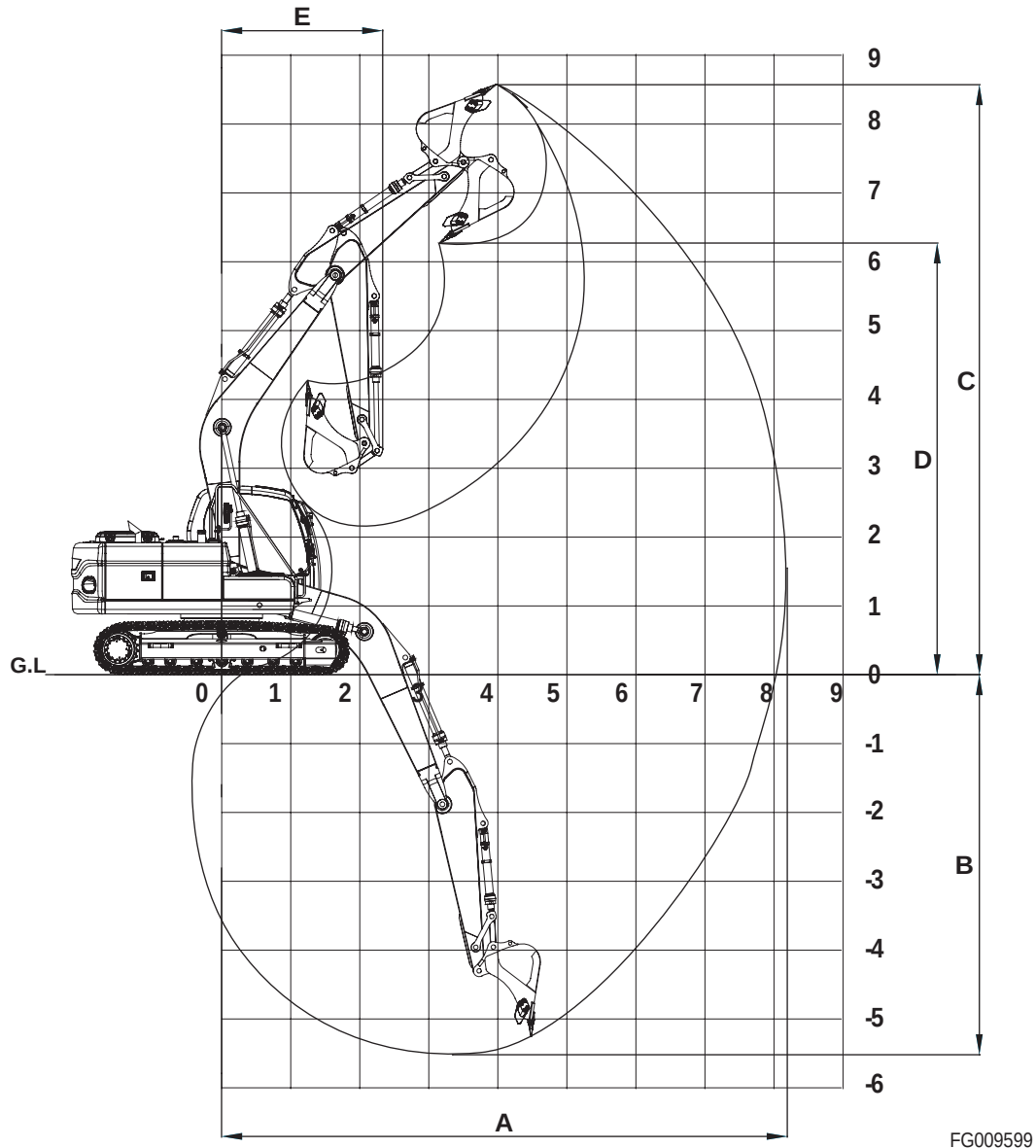
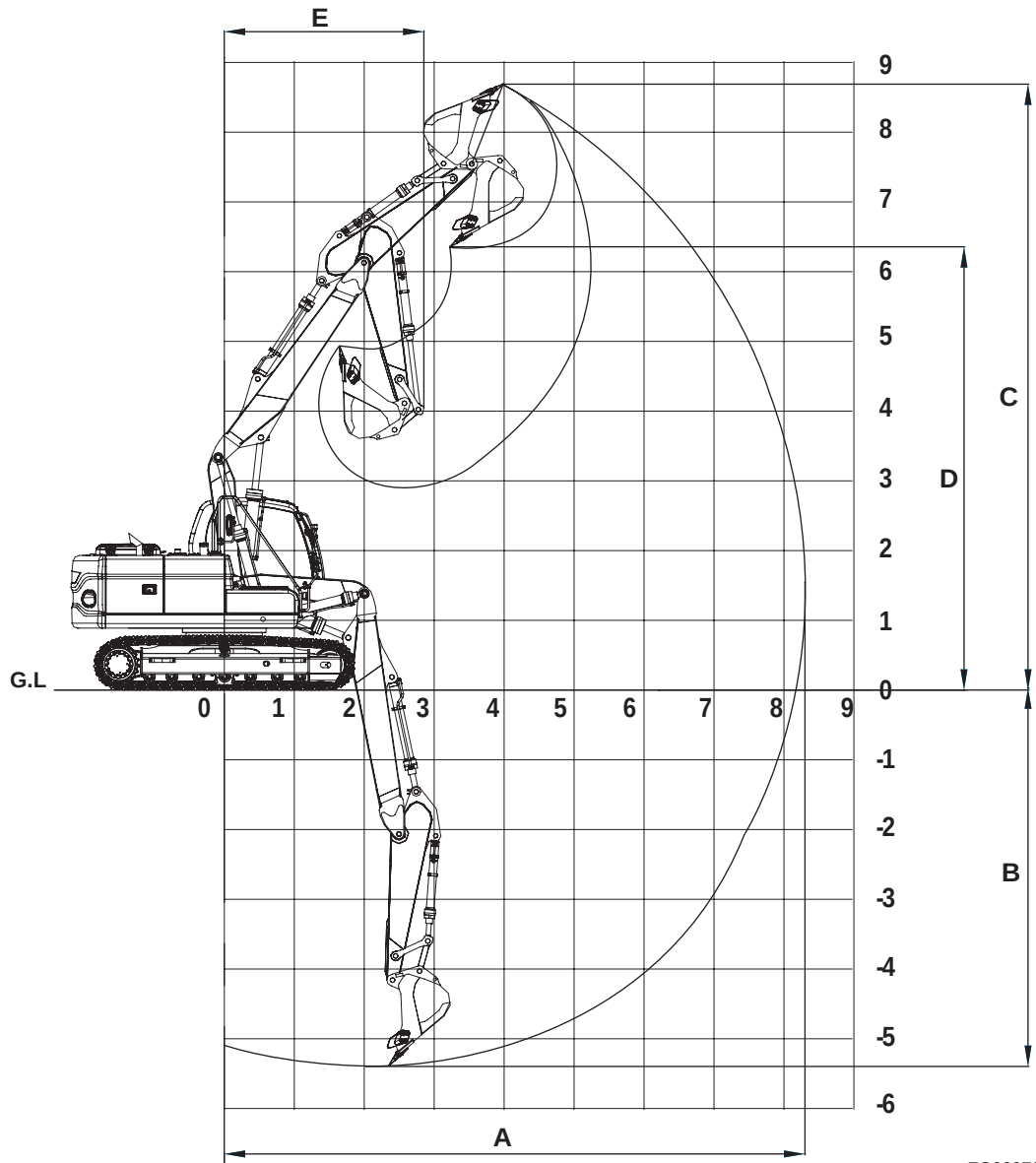


Figure 2

DIM.		4.6 m (15' 1") One - Piece BOOM		
		2.1 m (6' 11") Arm	2.5 m (8' 2") Arm	3.0 m (9' 10") Arm
A	Max. Digging Reach	7,845 mm (25' 9")	8,295 mm (27' 2")	8,675 mm (28' 5")
B	Max. Digging Depth	5,100 mm (16' 9")	5,500 mm (18' 0")	6,000 mm (19' 8")
C	Max. Digging Height	8,795 mm (28' 10")	9,280 mm (30' 5")	9,470 mm (31' 1")
D	Max. Loading Height	6,385 mm (20' 11")	6,840 mm (22' 5")	7,055 mm (23' 2")
E	Min. Swing Radius	1,885 mm (6' 2")	1,995 mm (6' 7")	2,290 mm (7' 6")

Two - Piece Boom



FG009725

Figure 3

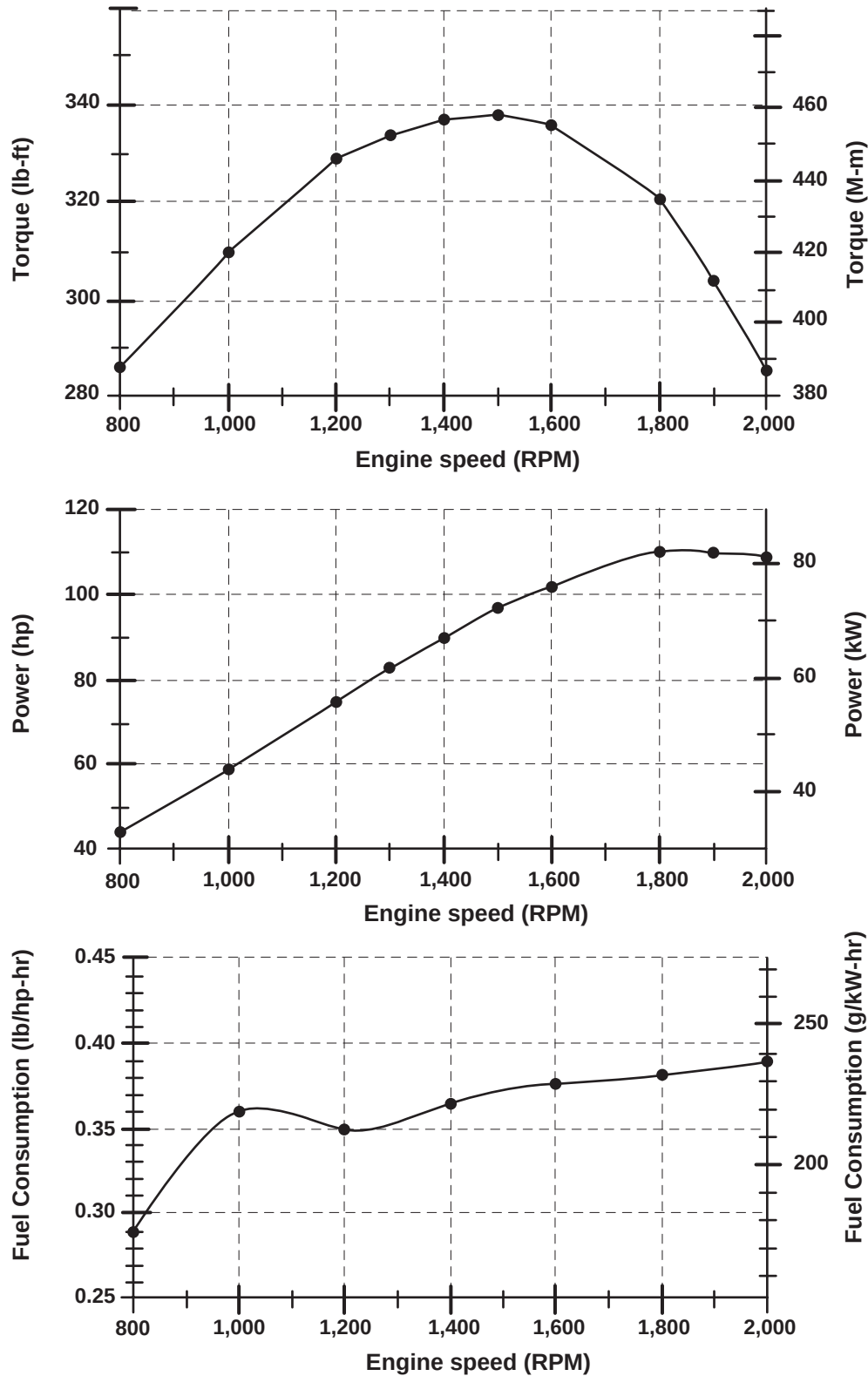
DIM.		4.98 m (16' 4") Two - Piece BOOM	
		2.1 m (6' 11") Arm	2.5 m (8' 2") Arm
A	Max. Digging Reach	8,270 mm (27' 2")	8,720 mm (28' 7")
B	Max. Digging Depth	5,345 mm (17' 6")	5,735 mm (18' 10")
C	Max. Digging Height	8,975 mm (29' 5")	9,445 mm (31' 0")
D	Max. Loading Height	6,605 mm (21' 8")	7,045 mm (23' 1")
E	Min. Swing Radius	2,450 mm (8' 0")	2,500 mm (8' 2")

GENERAL SPECIFICATIONS

Shipping Weight	14.4 metric tons (31,568 lb), includes 10% fuel, 4,600 mm (15' 1") boom, 2,500 mm (8' 2") arm, standard backhoe bucket and standard shoes
Operating Weight	Add weight of full fuel tank and operator
Shipping Weights With Optional Track Shoes	Subtract 210 kg (463 lb) for 500 mm (19.7") shoes
	Add 210 kg (970 lb) for 700 mm (34") shoes
Major Component Weights	Standard Boom 756 kg (1,667 lb)
	Two Piece Boom : 970 kg (2,138 lb)
	2,100 mm (6' 11") Arm 367 kg (809 lb)
	2,500 mm (8' 2") Arm 412 kg (908 lb)
	3,000 mm (9' 10") Arm 450 kg (992 lb)
	Boom Cylinders 122 kg (269 lb) each
	Arm Cylinder 145 kg (320 lb)
	Bucket Cylinder 92 kg (207 lb)
	Counterweight 3,100 kg (6,830 lb)
	Upper Turntable 4,100 kg (9,039 lb)
	Lower - below Swing Bearing LC 5,300 kg (11,685 lb), STD 4,800 kg (10,582 lb)
Digging Forces (At Power Boost):	
Bucket Cylinder	94 KN or 9,600 kg (21,200 lb) - (with either 3,000 mm [9' 10"] or 2,500 mm [8' 2"] or 2,100 mm [6' 11"] arm)
Arm Cylinder	62 KN or 6,300 kg (13,900 lb) with 2,500 mm (8' 5") standard arm
Fuel Tank Capacity	235 liters (62.3 U.S. gal)
Hydraulic System Capacity	131 liters (34.6 U.S. gal)
Hydraulic Reservoir Capacity	93.5 liters (24.7 U.S. gal)
Bucket Heaped Capacity Range	PCSA 0.24 - 0.76 m ³ (0.31 - 0.99 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 weights.
Shoe Type	Triple Grouser
Shoe Width and Optional Sizes	600 mm (23.5") - standard
	700 mm (28") - optional
	500 mm (19.7") - optional
Ground Pressure Ratings:	
Standard 600 mm (23.6") shoe -	0.40 kg/cm ² (5.7 psi)
Optional 700 mm (28.0") shoe -	0.34 kg/cm ² (4.8 psi)
Optional 500 mm (19.7") shoe -	0.43 kg/cm ² (6.8 psi)
Optional Dozer Blade Sizes	2,490 mm (8' 2") with 500 mm (19.7")
	2,590 mm (8' 6") with 600 mm (23.5")
	2,690 mm (8' 10") with 700 mm (28")
Transport Dimensions	
Overall Shipping Length (standard boom and arm)	7,230 mm (23' 9")
Overall Shipping Width (standard shoes)	2,590 mm (8' 6")

Overall Shipping Height (to top of cabin)	2,795 mm (9' 2")
Track Shipping Length	3,750 mm (12' 4")
Transport Trailer Capacity	20 tons (22 short tons), minimum load capacity
Transport Loading Ramp	
Allowable Slope	15° angle CAUTION: Refer to Transport Maximum Procedure for Safe Shipping Instructions.

ENGINE PERFORMANCE CURVES (PER DIN 6270 STANDARD)



FG013093

Figure 4

Condition	Specification
Engine Model	QSB4.5
Barometric Pressure	760 mmHg (20° C (68°F))
Cooling Fan	595 mm, SUCKER (23.4 in)
Alternator	24V x 50A
Air Cleaner	Installed
Muffler	Installed

Performance Standard	DIN 6270
Power	100 ps @ 1,800 rpm (98.5 hp @ 1,800 rpm)
Max. Torque	45.8 kg•m @ 1,400 rpm (338 ft lb @ 1,400 rpm)
Fuel Consumption (Rated)	232 g/kw•hr

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

1. Main Relief Pressure

normal operation: 330 kg/cm³ (4,689 psi)

with "Pressure Up": 350 kg/cm³ (4,970 psi)

2. Actuator Speeds

Operation		Unit	Standard Mode	Power Mode
Boom	Up	sec	3.3 ± 0.4	3.0 ± 0.4
	Down	sec	2.6 ± 0.3	2.6 ± 0.3
Arm	Dump	sec	2.2 ± 0.3	2.0 ± 0.3
	Crowd	sec	2.9 ± 0.4	2.8 ± 0.4
Bucket	Dump	sec	2.3 ± 0.3	2.1 ± 0.3
	Crowd	sec	4.0 ± 0.4	3.8 ± 0.4
Swing (3 Revolutions)		sec	17.6 ± 1.5	16.7 ± 1.5
Jack-up Speed (3 Turns)	High	sec	18.9 ± 1.5	18.0 ± 1.5
	Low	sec	29.8 ± 2.0	28.4 ± 2.0
Travel Speed 20 m (66 ft)	High	sec	16.0 ± 1.0	15.3 ± 1.0
	Low	sec	25.0 ± 1.5	24.0 ± 1.5
Travel Deviation 20 m (66 ft)	High	mm (in)	150 (6)	150 (6)
	Low	mm (in)	150 (6)	150 (6)

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

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°C - 55°C (112°F - 135°F).
4. Run all tests with the engine speed control set to maximum rpm.
5. Repeat tests with Power Mode engine control settings at both Standard Mode (standard work mode) and Power Mode (high speed mode). Travel speed tests should also be repeated at both high and low speed.

Travel Speed and Travel Motor Balance (Steering Deviation) Tests

Speed Test

Prepare the excavator for travel speed tests by extending all hydraulic cylinders - boom, arm and bucket - to the fully extended position, shown in Figure 5.

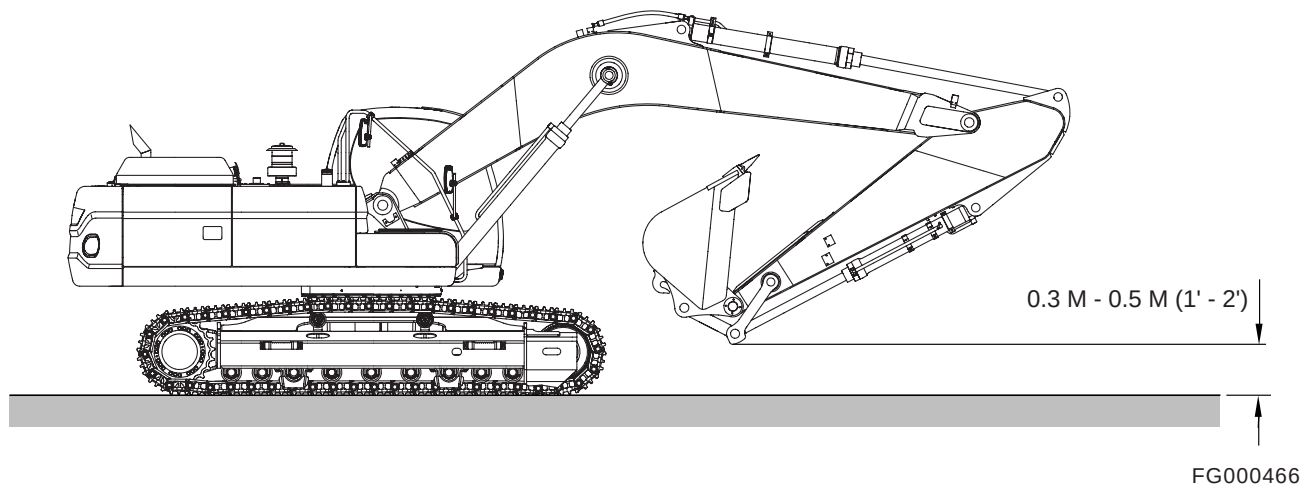


Figure 5

The lowest part of the bucket linkage should be 0.3 - 0.5 m (1' - 2') off the ground.

Mark off a 20 m (65' 7-1/2") test distance, with a 3 - 5 m (10' - 15') run-up area, and a 3 - 5 m (10' - 15', or longer) speed run-off distance.

Travel the excavator back and forth to be sure steering is centered and side frames are parallel with the test course.

Operate both travel levers at the fully engaged position and measure the time it takes to cross 20 m (65' 7-1/2"). Compare measured results against the standard for new machines:

Rate of Travel	Time	
	Standard Mode	Power Mode
High Speed	16.0 ± 1.0 sec	15.3 ± 1.0 sec
Low Speed	25.0 ± 1.5 sec	24.0 ± 1.5 sec

Rotate the turntable 180°. Both tests should be repeated three times. Average all results to obtain a final value.

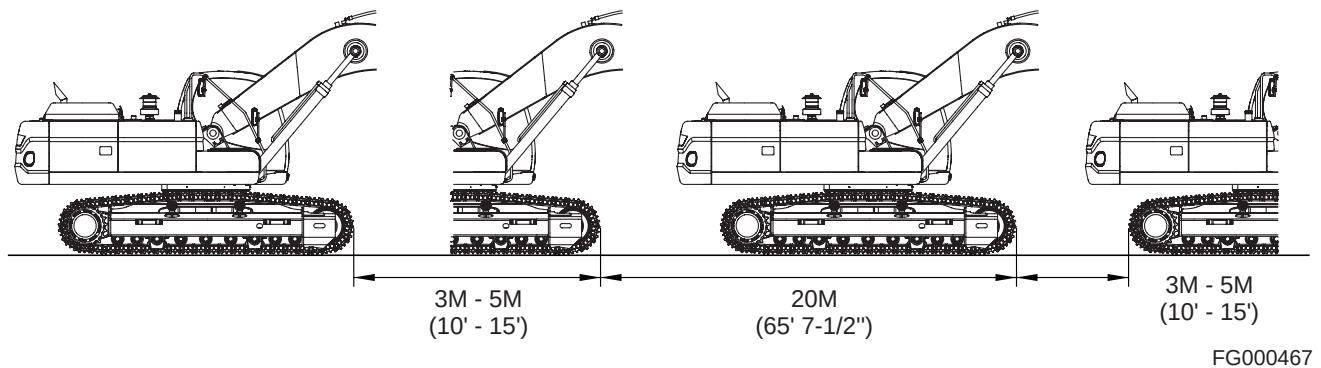


Figure 6

Travel Deviation

To check steering deviation (travel motor balance), use a long tape or rope, or the edge of an undeviating straight road curb or other marker to verify side to side travel motor uniformity.

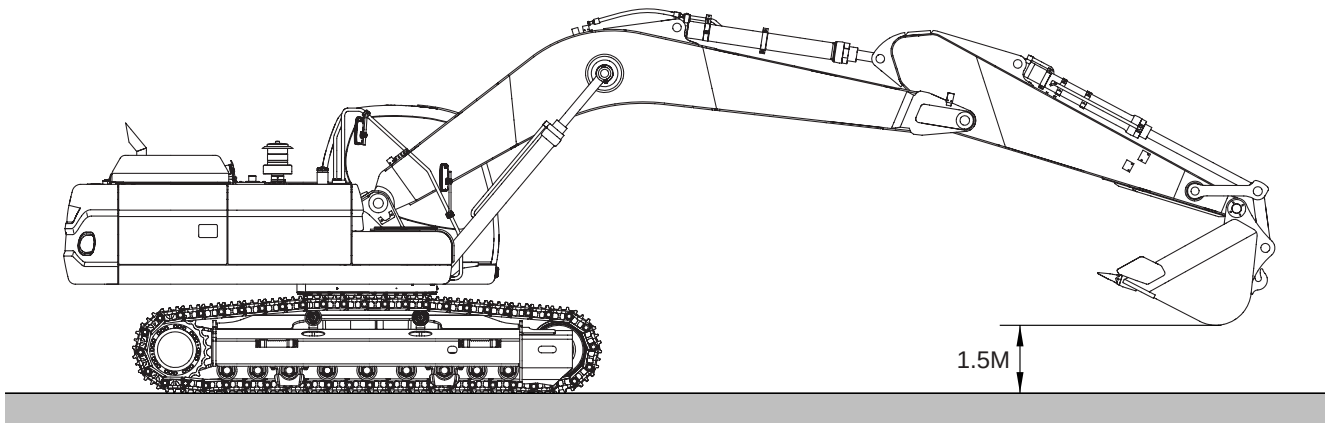
Deviation distance should always be measured at the 20 m (65' 7-1/2") "finish line." Repeat the test in reverse to measure in both directions, with starting point becoming the finish line, and vice versa. (Figure 6)

A greater amount of deviation is allowed with the travel control set for high speed.

Rate of Travel	Max. Distance
High Speed	150 mm (6 in)
Low Speed	150 mm (6 in)

Swing Speed and Deceleration Force Test

Swing Speed Test



FG000468

Figure 7

Extend the bucket cylinder completely and retract the arm cylinder, as shown in Figure 7, to test swing speed. The lowest point of the bucket will be approximately 1.5 m (3') off the ground.

Use paint marks at the same point on the turntable and undercarriage, or select alternate measuring locations and use a stopwatch to time 3 full 360° rotations. The time required for 3 revolutions should be between 16 and 19 seconds in Standard Mode, 15 and 18 seconds in Power Mode.

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 8.

Record how far the turntable drifts past the stop point, measuring the distance between paint marks. Maximum distance should be less than 607 mm (23.9"), in both Power Mode and Standard Mode.

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

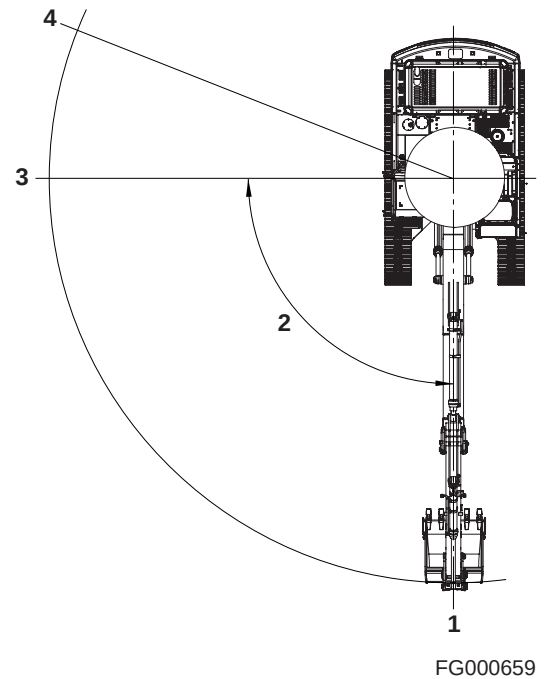


Figure 8

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 for both Standard Mode and Power Mode.

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 both tests, in both standard and extra-duty power modes.

Bucket Cylinder Test

Start with the boom up and the teeth of the bucket hanging vertically, 500 mm (1-1/2' - 2') above the ground. Dump and crowd the bucket several times, and average results, for both standard and extra-duty power modes.

Operation	Standard Mode	Power Mode
Boom Up	2.9 - 3.7 sec	2.6 - 3.4 sec
Boom Down	2.3 - 2.9 sec	2.3 - 2.9 sec
Arm Dump	1.9 - 2.5 sec	1.7 - 2.3 sec
Arm Crowd	2.5 - 3.3 sec	2.4 - 3.2 sec
Bucket Dump	2.0 - 2.6 sec	1.8 - 2.4 sec
Bucket Crowd	3.6 - 4.4 sec	3.4 - 4.2 sec

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.

Shut down engine and measure cylinder drop after 5 minutes. Bucket cylinder should not show more than 40 mm (1.57") change, while the arm and boom cylinders should not fall more than 10 mm (0.39").

Travel Motor Jack-up Test

Test travel motor operation on each side by painting or chalking a mark on one crawler shoe, with a corresponding mark on the travel frame. Use the attachment to jack up one side of the machine and operate the raised travel motor. Record the number of seconds it takes the crawler shoe to make 3 full rotations, during both high speed and low speed operation.

Operation	Standard Mode	Power Mode
High Speed	17.4 - 20.4 sec	16.5 - 19.5 sec
Low Speed	27.8 - 31.8 sec	26.4 - 30.4 sec

General Maintenance

General Maintenance Procedures

Edition 1

MEMO

Table of Contents

General Maintenance Procedures

Safety Precautions.....	5
Applicable Models.....	5
Welding Precautions and Guidelines	6
Hydraulic System - General Precautions	7
Maintenance Service and Repair Procedure	9
General Precautions.....	9
Hydraulic System Cleanliness and Oil Leaks	10
Maintenance Precautions for Hydraulic System Service	10
Oil Leakage Precautions	11
Cleaning and Inspection	12
General Guidelines	12
Bearing inspection	13

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

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.

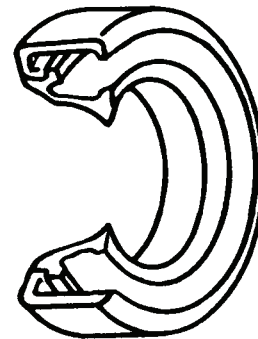


Figure 1

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.

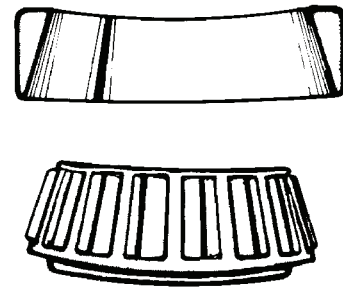
If available, use magna-flux or similar process for checking for cracks that are not visible to the naked eye.

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.

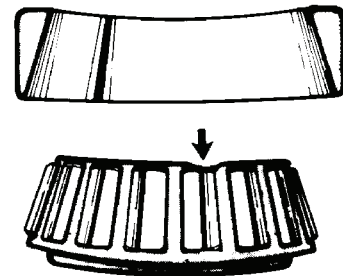


HASA620S

Figure 2

Bent Cage

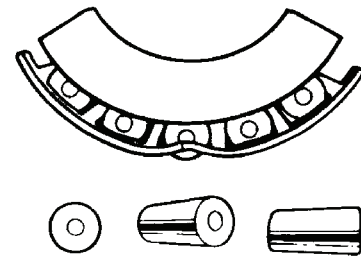
Cage damage due to improper handling or tool usage.



HASA460S

Figure 3

Replace bearing.



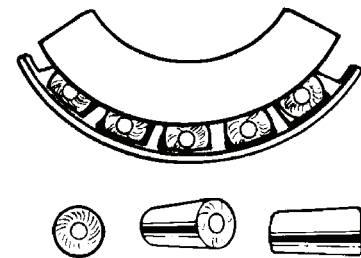
HASA470S

Figure 4

Galling

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

Replace bearing - check seals and check for proper lubrication.



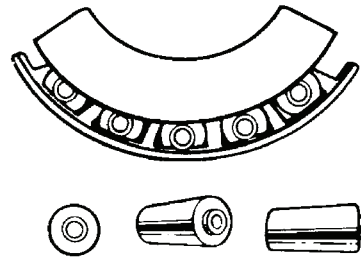
HASA480S

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.



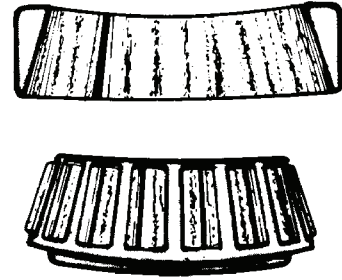
HASA490S

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.



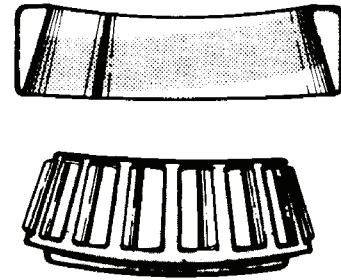
HASA500S

Figure 7

Misalignment

Outer race misalignment due to foreign object.

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



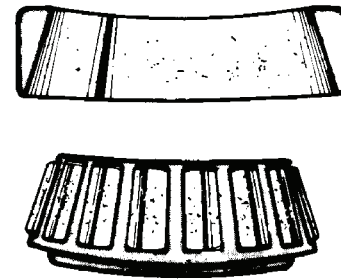
HASA510S

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.



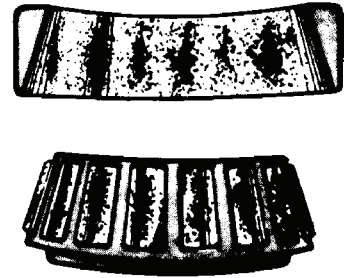
HASA520S

Figure 9

Fatigue Spalling

Flaking of surface metal resulting from fatigue.

Replace bearing - clean all related parts.



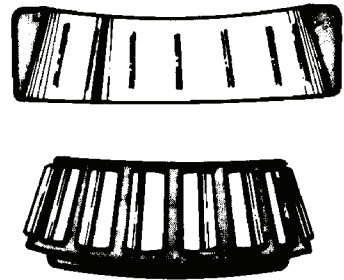
HASA530S

Figure 10

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.



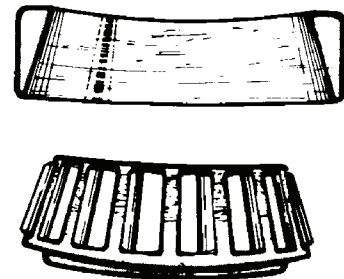
HASA540S

Figure 11

Cage Wear

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

Replace bearings - check seals.



HASA550S

Figure 12

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.

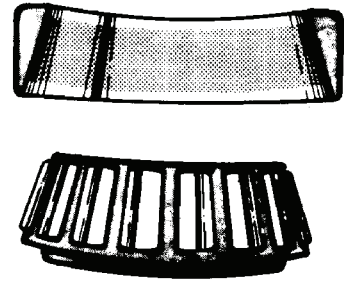


Figure 13

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.

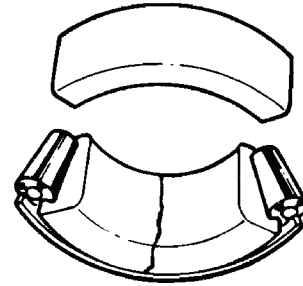


Figure 14

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.

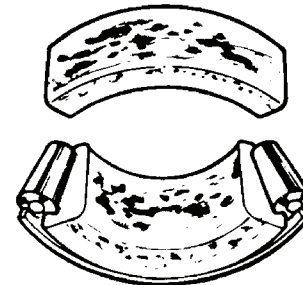


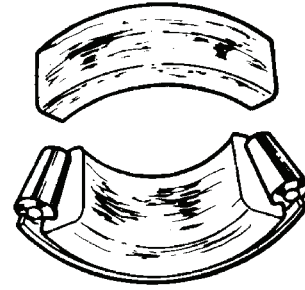
Figure 15

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.



HASA590S

Figure 16

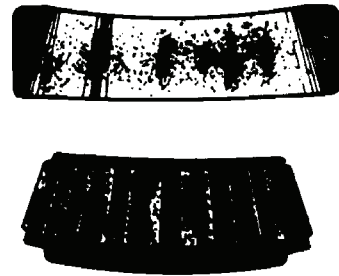
Heat Discoloration

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.



HASA600S

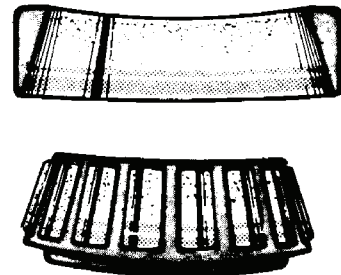
Figure 17

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.



HASA610S

Figure 18

Standard Torques

Edition 1

MEMO

Table of Contents

Standard Torques

Safety Precautions	5
Applicable Models	5
Torque Values for Standard Metric Fasteners.....	6
Torque Values for Standard U.S. Fasteners	7
Type 8 Phosphate Coated Hardware	9
Torque Values for Hose Clamps	10
Torque Values for Split Flanges	11
Torque Wrench Extension Tools	12
Torque Multiplication	12
Other Uses for Torque Wrench Extension Tools.....	13
Tightening Torque Specifications (Metric).....	13

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 (133.81)	22.00 (159.12)
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:

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

NOTE: The formula assumes that there is no added deflection or "give" in the joint between the extension

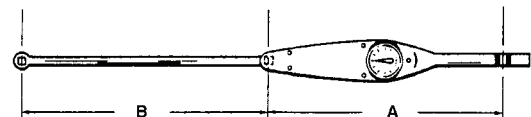


Figure 1

0552A

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

Table of Contents

Cabin

Safety Precautions	5
Applicable Models	5
Cab Identification	6
Roll Over Protective Structure (ROPS) When Required by Local Regulations	6
Removal	8
Installation	12

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
DX140LCR	5001 and Up
DX235LCR	5001 and Up

CAB IDENTIFICATION

Roll Over Protective Structure (ROPS) When Required by Local Regulations

Global markets may or may not require a Roll Over Protective Structure (ROPS). Always comply with all regional and governmental regulations that apply to your market. The following information is for a ROPS cabin.

General ROPS Guidelines for ROPS Certified Cabins

The operator's cabin is a ROPS certified structure for protecting the seat-belted operator. It absorbs the impact energy of a rollover impact. Do not allow machine weight (mass) to exceed certified value on certification plate. If weight is exceeded, the ROPS structure will not be able to fulfill its safety function.

Do not increase machine weight beyond certified value by modifying machine or by installing attachments on machine. If weight limit of protective equipment is exceeded, protective equipment will not be able to protect operator, and operator may suffer serious injury or death. Always observe the following:

- This machine is equipped with a protective structure. Do not remove protective structure and carry out operations without it.
- Never modify the operator's cabin by welding, grinding, drilling holes or adding attachments unless instructed by *DOOSAN*. Changes to the cabin can cause loss of operator protection from rollover and falling objects, and operator may suffer serious injury or death.
- When protective structure is damaged or deformed by falling objects or by rolling over, its strength will be reduced and it will not be able to properly fulfill its function. In these cases, always contact your *DOOSAN* distributor for advice. Never repair a ROPS cabin.
- Always wear your seat belt when operating machine.

ROPS Certification

This *DOOSAN* excavator has an operator's cabin that meets ROPS requirements. The seat belt must be worn for rollover protection.

The ROPS certification plate (Figure 1) is found on the left side of the cabin on most models. It may vary slightly in its location on some models.

Check the ROPS cabin, mounting, and hardware for damage.

Never modify the ROPS cabin. Replace the cabin and hardware if damaged. See your *DOOSAN* dealer for parts.

ROPS – Roll Over Protective Structure complies with ISO 12117-2:2008.



Figure 1



WARNING

Never modify the operator cabin by welding, grinding, drilling holes or adding attachments unless instructed by *DOOSAN*. Changes to the cabin can cause loss of operator protection from rollover and falling objects, and result in serious injury or death.

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. Cabin harness - main harness connections.
 - B. Left / right control stand wiring harness connections.
 - C. Air conditioner harness connections and control duct wiring connection.
 - D. Washer hose connections.
 - E. Cabin floor ground.

NOTE: *Control stand 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.*

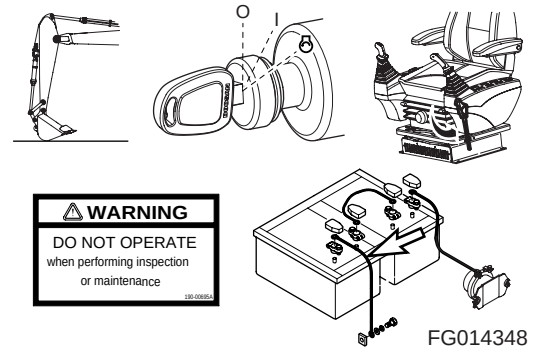


Figure 2

12. Remove floor mat (1, Figure 3).

13. Remove seat (2, Figure 3).

NOTE: Be careful not to damage seat covering.

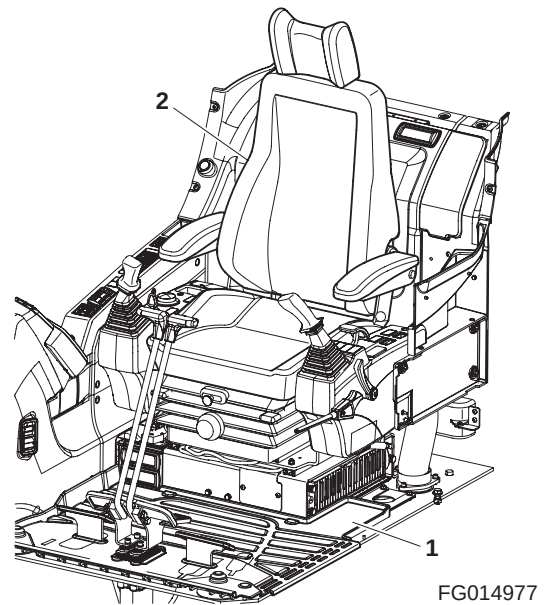


Figure 3

14. Disconnect the cabin main harness connector (1, Figure 4) and remove harness connection mounting bracket from floor.

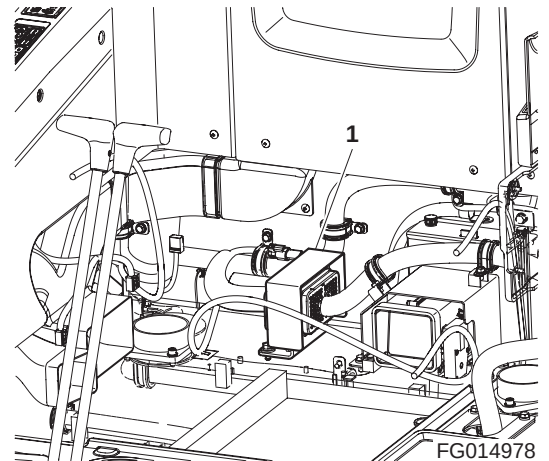


Figure 4

15. Remove joystick hose cover (1 and 2, Figure 5) and disconnect left / right control stand wiring harness connected inside them.

16. Disconnect control duct wiring connectors located on right side and back side of seat.

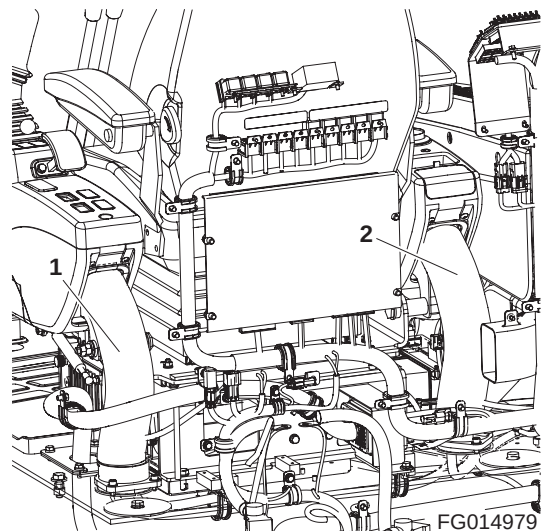


Figure 5

17. Disconnect air conditioner harness connection inside the seat base (1, Figure 6) under seat.

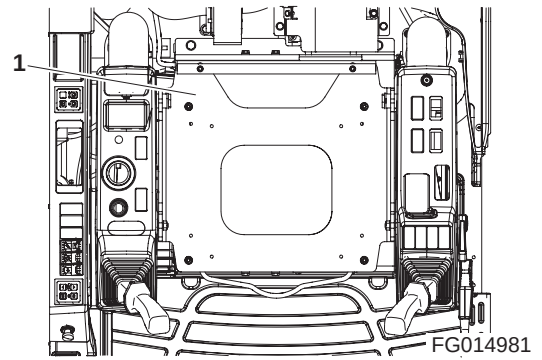


Figure 6

18. Remove air ducts (1 and 2, Figure 7) on right side of cabin from main control duct.

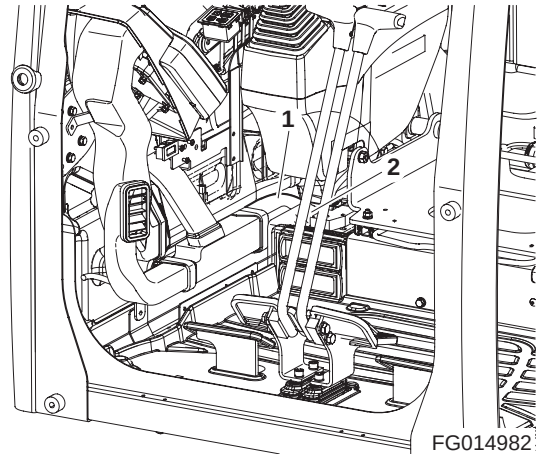


Figure 7

19. Remove rear control duct (1, Figure 8).

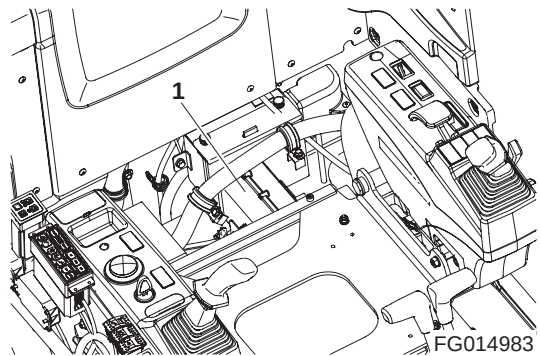


Figure 8

20. Remove washer hose from floor plate.
21. Remove cabin ground.

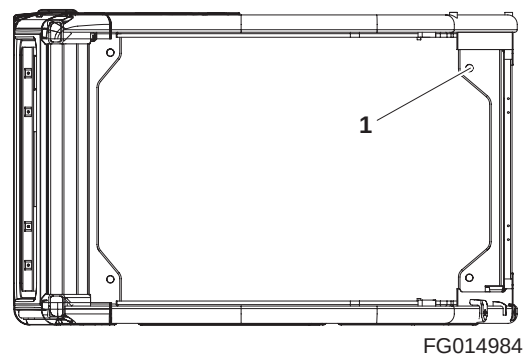


Figure 9

22. Remove cabin inner handle. (1, Figure 10)

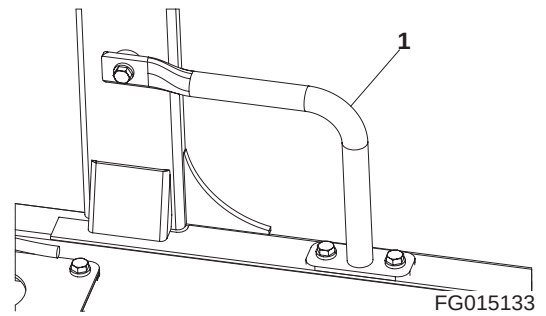


Figure 10

23. Remove bolts and washers (5 sets) from cabin floor (1, Figure 11).
24. Remove four mounting nuts and washers from four corners of cabin floor (1, Figure 9).

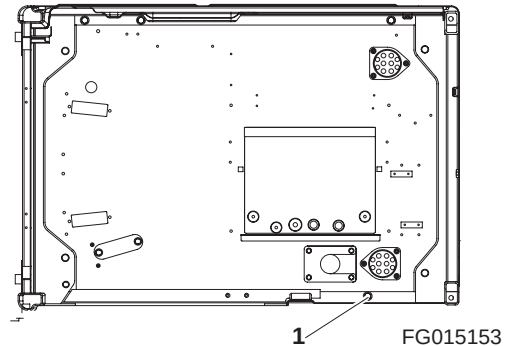


Figure 11

25. Using a suitable lifting device, attach slings to four lift points on top of cabin (Figure 12).

NOTE: Cabin weights approximately 368 kg (811 lb).

26. Lift cabin from 25 - 50 mm (1" - 2") above deck height. Check that all electrical connections have been disconnected and all other items unbolted.
27. Continue lifting to remove cabin shell. Lower the shell to a prepared safe blocking support.

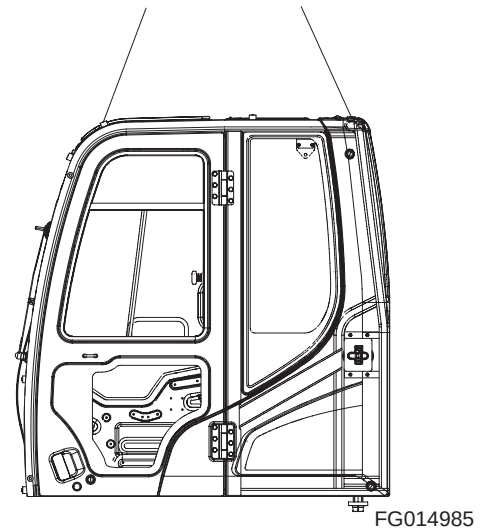


Figure 12

INSTALLATION

1. Using a suitable lifting device, attach slings to four lift points on top of cabin (Figure 12).

NOTE: Cabin weights approximately 368 kg (811 lb).

2. Lower cabin into position on cabin floor.
3. Install four mounting nuts and washers in four corners of cabin floor (1, Figure 13).

NOTE: Mounting nut torque 21 kg•m (205 Nm, 150 ft lb).

4. Install cabin inner handle.
5. Install bolts and washers (5 sets) on the cabin floor.
6. Once cabin is mounted to floor, unhook lifting device.
7. Connect cabin ground.
8. Connect washer hose to floor plate.
9. Install rear control duct (1, Figure 14).

NOTE: Connect harness of control duct.

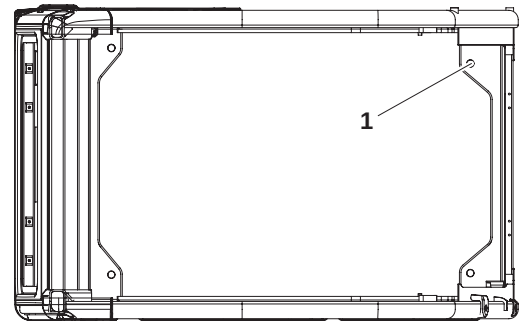


Figure 13

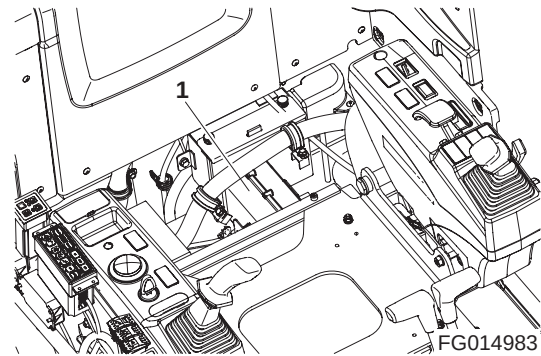


Figure 14

10. Install air ducts (1 and 2, Figure 15) on right side of cabin to main control duct.

NOTE: Connect the harness of main control duct.

11. Connect air conditioner harnesses inside seat base under seat.
12. Install joystick hose cover (1 and 2, Figure 5) and connect left / right control stand wiring harness inside them.

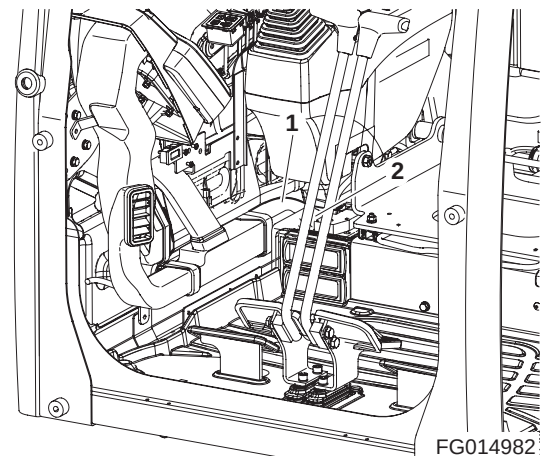


Figure 15

13. Connect cabin main harness at rear side of cabin and install the mounting bracket for harness (1, Figure 16) connection to floor.

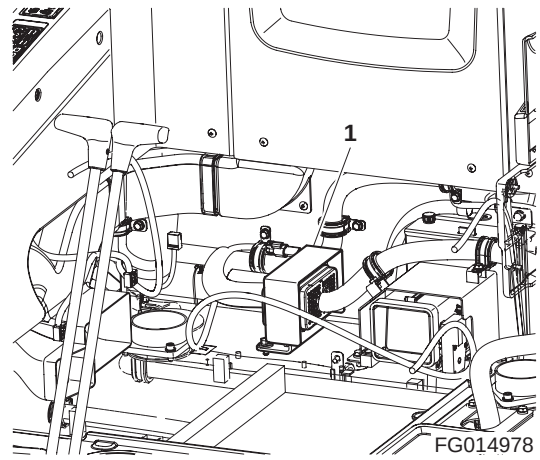


Figure 16

14. Install seat (2, Figure 17).
- NOTE:** *Be careful not to damage seat covering.*
15. Install floor mat (1, Figure 17).
 16. Connect negative battery cable from frame to battery.

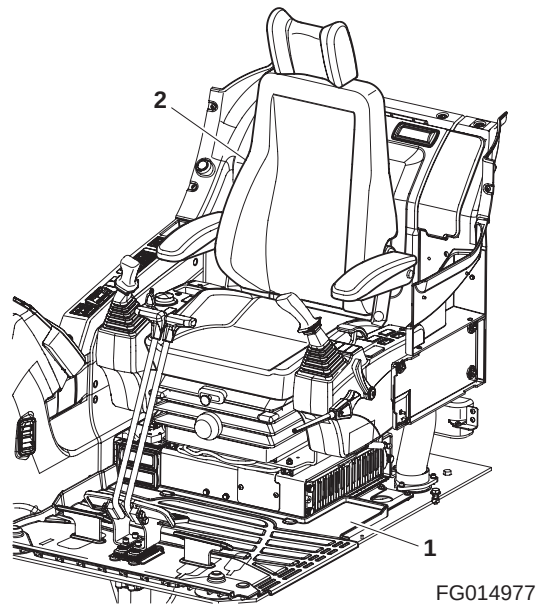


Figure 17

Counterweight

Edition 1

MEMO

Table of Contents

Counterweight

Safety Precautions	5
Applicable Models	5
General	6
Warning for Counterweight and Front Attachment Removal	6
Removal	8
Installation	10

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
DX140LCR	5001 and Up
DX140LC	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up
DX340LC	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
DX140LCR	3,000 kg (6,614 lb)
	3,500 kg (7,716 lb) (Optional)
DX140LC	2,200 kg (4,850 lb)
DX180LC	3,000 kg (6,614 lb)
DX225LC	4,100 kg (9,039 lb)
	5,300 kg (11,685 lb) (Optional)
DX225NLC	4,100 kg (9,039 lb)
	4,700 kg (10,361 lb) (Optional)
DX255LC	4,700 kg (10,361 lb)
DX300LC	5,300 kg (11,685 lb)
	5,900 kg (13,007 lb) (Optional)
DX340LC	6,800 kg (14,991 lb)



Figure 1

FG000371

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.

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.

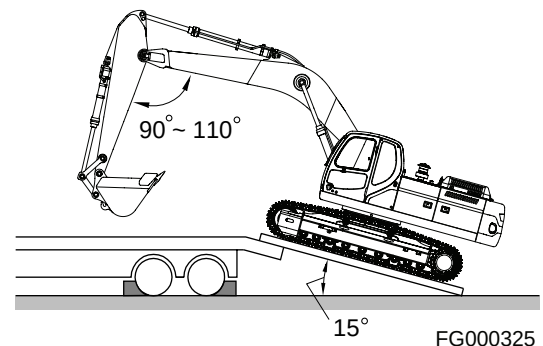


Figure 1

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 1).

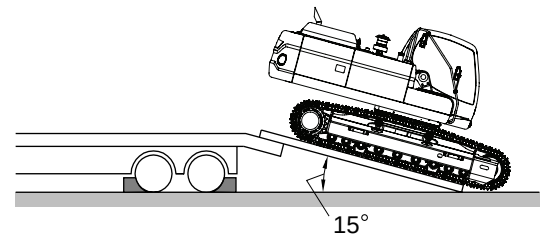


Figure 2

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. Remove engine compartment cover.

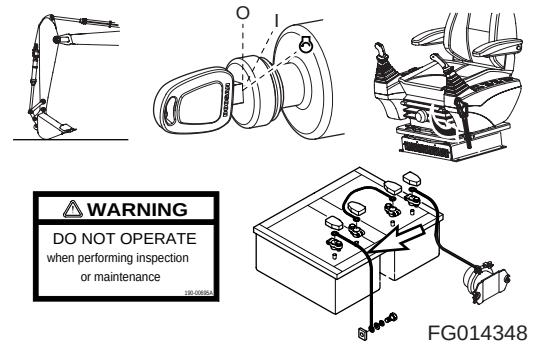


Figure 3

12. Remove two caps (1, Figure 4) from counterweight (2).
13. Install two lifting eyes in lifting holes (3, Figure 4).

Model	Lifting Eye Size
DX140LCR	M30x3.5
DX140LC	M48x5.0
DX180LC	
DX225LC	
DX225NLC	
DX255LC	
DX300LC	
DX340LC	

14. Using a suitable lifting device capable of handling a heavy load, partially support counterweight (2, Figure 4) before loosening four bolts (4). Stop lifting with assist crane as soon as lifting slings are taut.
15. Remove four bolts (4, Figure 4) and washers (5) from counterweight (2).

NOTE: Heat bolts if necessary, to free them.

16. When bolts (4, Figure 4) 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.

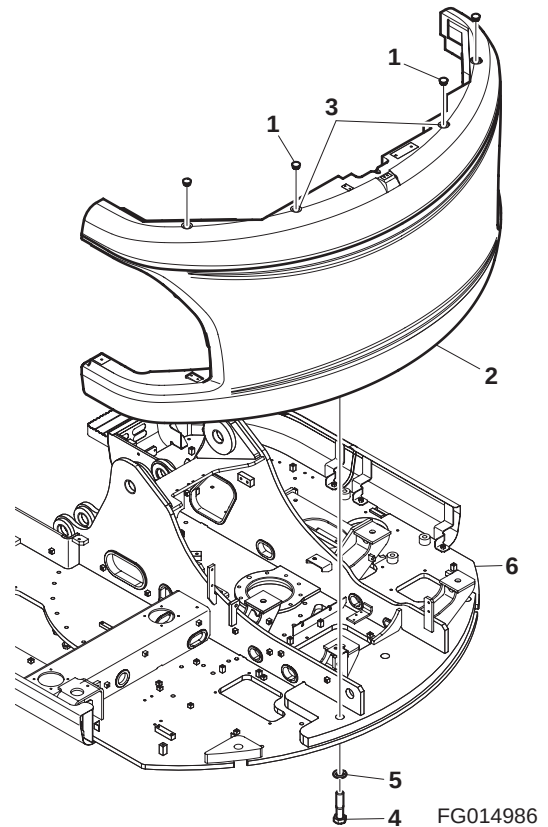


Figure 4

INSTALLATION

1. Using suitable lifting device capable of handling a heavy load, raise counterweight (2, Figure 5) into position just above support frame (6) leaving counterweight suspended. Verify that counterweight is level and even.

NOTE: Leave counterweight (2, Figure 5) suspended 3 mm (0.125") above support frame (6) until all four mounting bolts (4) are started in counterweight mounting holes.

2. Slide washers (5, Figure 5) onto bolts (4). Apply Loctite #242 to mounting bolt threads.
3. Install four bolts (4, Figure 5) 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 5) to values shown in following table.

Model	Bolt Torque
DX140LCR	240 kg•m (1,736 ft lb)
DX140LC	115 kg•m (832 ft lb)
DX180LC	150 kg•m (1,085 ft lb)
DX225LC	
DX225NLC	
DX255LC	
DX300LC	250 kg•m (1,807 ft lb)
DX340LC	

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

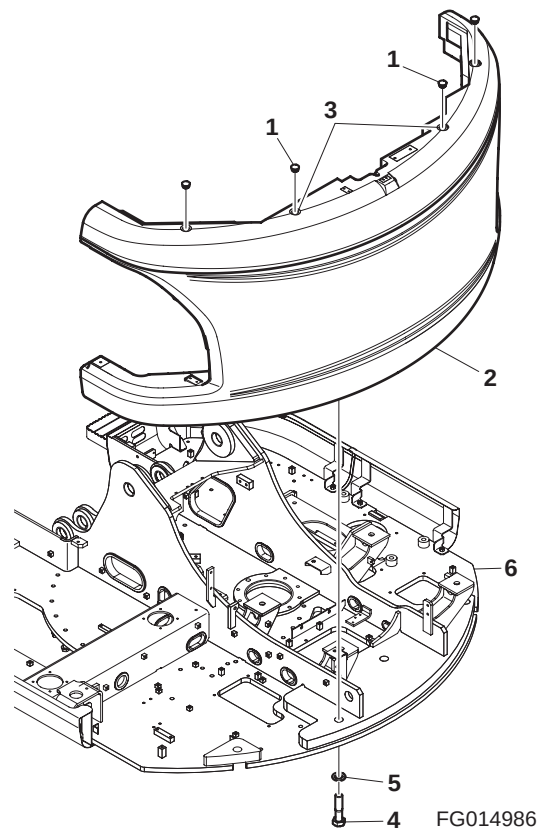


Figure 5

Fuel Tank

Edition 1

MEMO

Table of Contents

Fuel Tank

Safety Precautions	5
Applicable Models	5
General Description	6
Parts List	6
Specifications	7
Removal	8
Installation	12
Start-up Procedures	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
DX140LCR	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

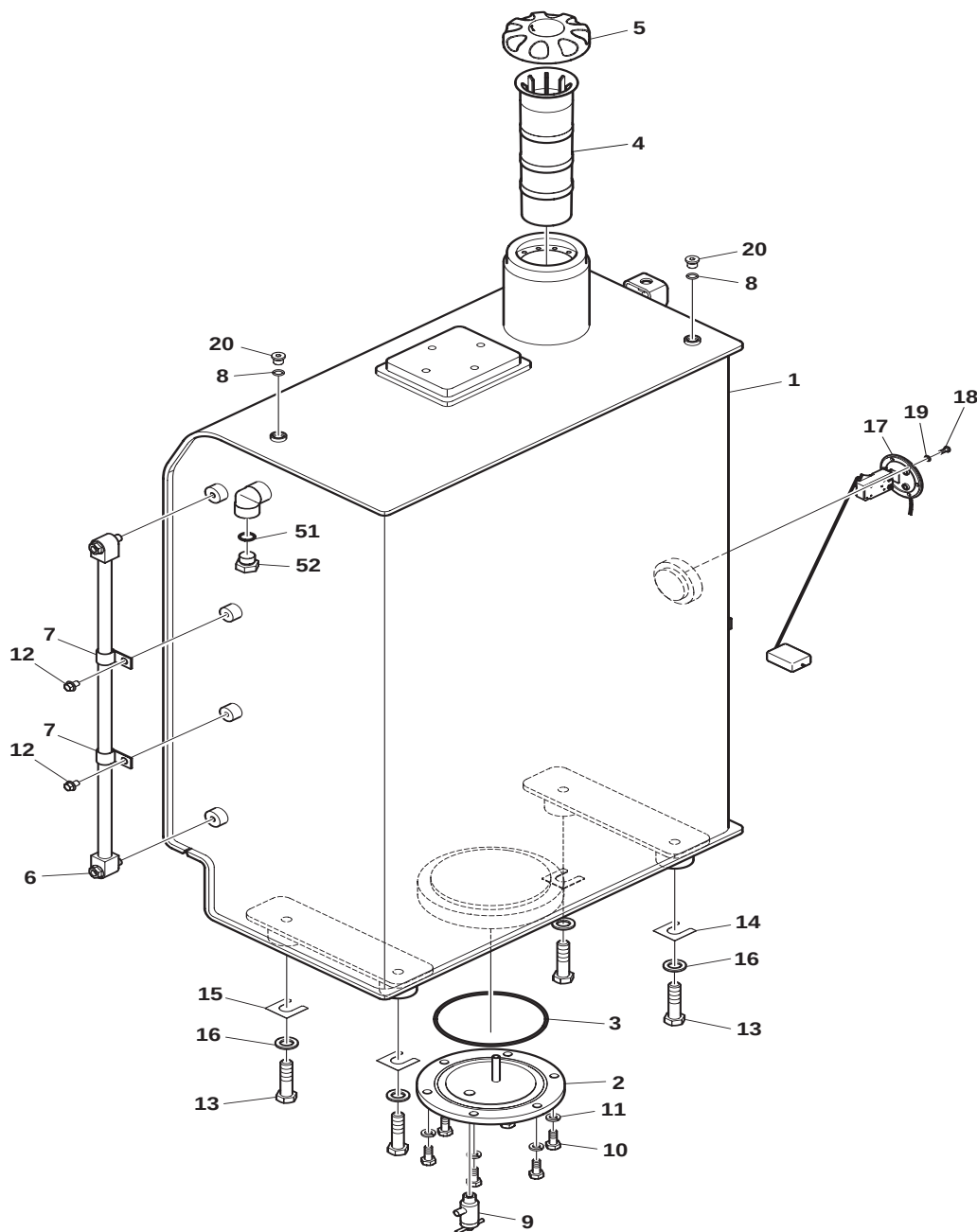


Figure 1

FG014987

Reference Number	Description
1	Fuel Tank
2	Cover
3	O-ring
4	Fuel Strainer
5	Fuel Cap
6	Level Gauge
7	Clip
8	O-ring
9	Drain Valve
10	Bolt
11	Spring Washer
12	Bolt

Reference Number	Description
13	Bolt
14	Shim
15	Shim
16	Spacer
17	Fuel Sender
18	Bolt
19	Spring Washer
20	Plug
51	O-ring
52	Plug

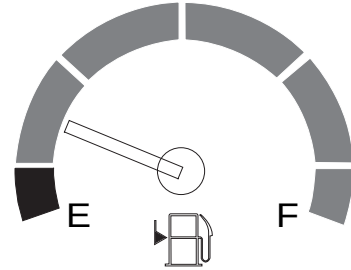
Specifications

Fuel tank capacity is 234 liters (61.8 U.S. gal).

REMOVAL

1. Look at fuel level display (Figure 2) on instrument panel in operator's cabin to see what it displays. The display is divided into ten separated segments, each representing 10 percent of total fuel supply. Also, look at level gauge on side of tank to estimate volume of fuel left in tank.

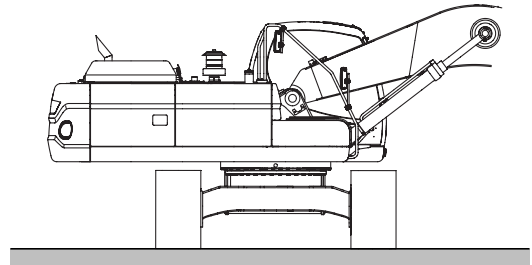
NOTE: *If possible, work excavator until available fuel supply in tank has been run down as far as possible.*



FG014483

Figure 2

2. Park on firm and level ground and swing turntable to approximately a 90° with respect to tracks. See Figure 3.



FG000471

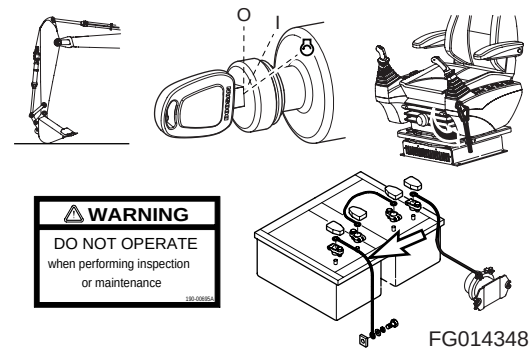
Figure 3

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.

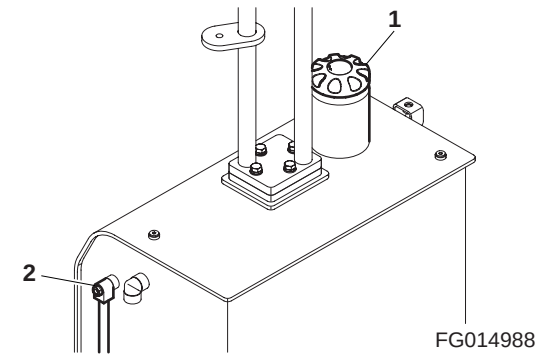


FG014348

Figure 4

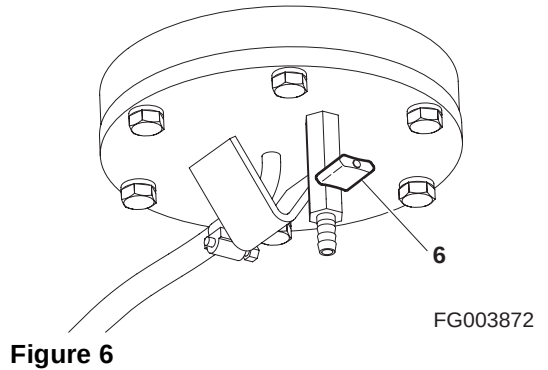
7. Fully stroke work levers (joysticks) in all directions to relieve any pressure from accumulators.
8. Set safety lever on "LOCK" position.
9. Turn key to "O" (OFF) position and remove from starter switch.
10. Hang maintenance warning tag on controls.
11. Disconnect negative (-) battery cable leading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

12. Clean area around fuel tank fill cap (11, Figure 5). Open fuel cap.

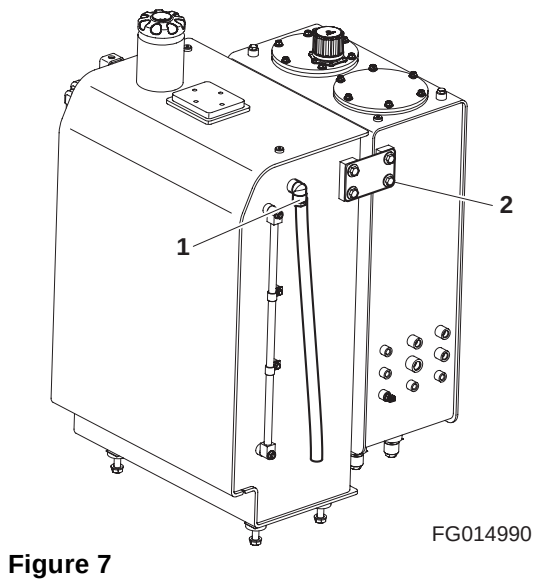


13. Place a large enough container under fuel tank to collect remaining fuel. Open drain valve (6, Figure 6) at bottom of tank and drain.

NOTE: Fuel tank capacity is 234 liters (61.8 U.S. gal).



14. Remove hose (1) from fuel feed pump (optional) (1, Figure 7).
15. Remove bolts of bracket connect with fuel tank (2, Figure 7).



16. Remove fuel hose clamp (1, Figure 8).
17. Remove clamp connecting fuel hose and fuel prefilter (2, Figure 8).

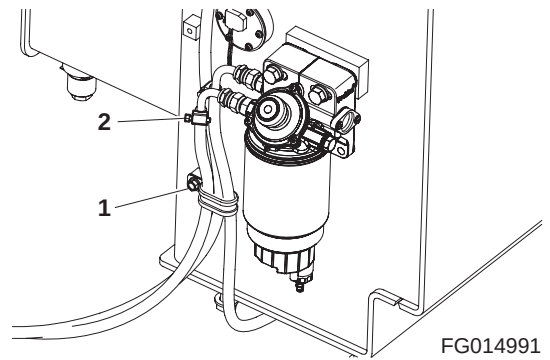


Figure 8

18. Remove prefilter mounting bolt (1, Figure 9).
19. Remove fuel sensor harness connector (2, Figure 9).

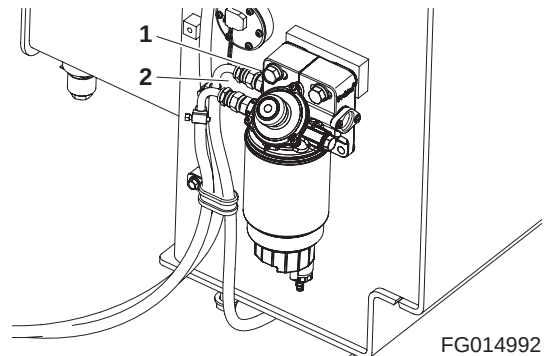


Figure 9

20. Remove engine oil filter bracket bolt (1, Figure 10).
21. Disconnect fuel return hose (2, Figure 10).

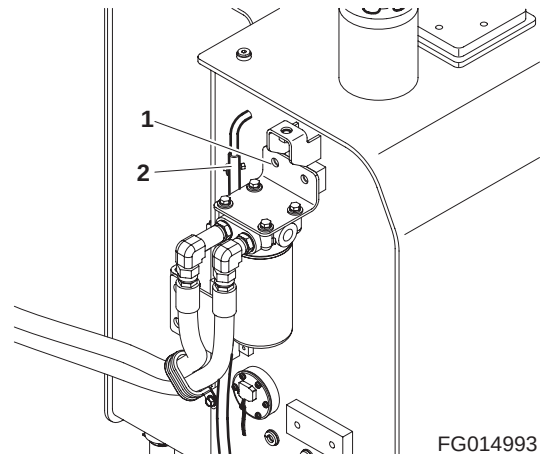


Figure 10

22. Remove bracket tied with oil tank (1, Figure 11).

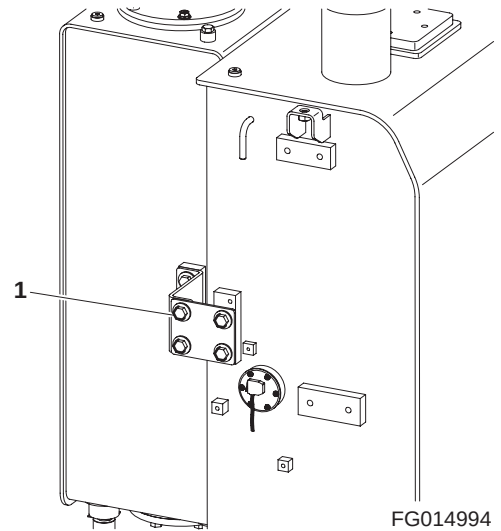


Figure11

23. Install two 12 mm eyebolts in threaded holes (38 and 39, Figure 12). Using a suitable lifting device, sling eyebolts.
24. Remove four bolts (7) and spacers (13, Figure 12) 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.*

25. Remove shims (9, Figure 12).

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

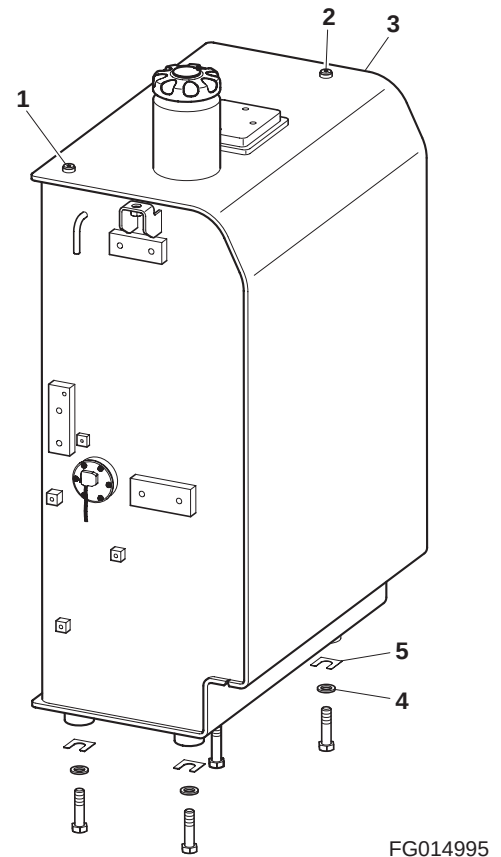


Figure 12

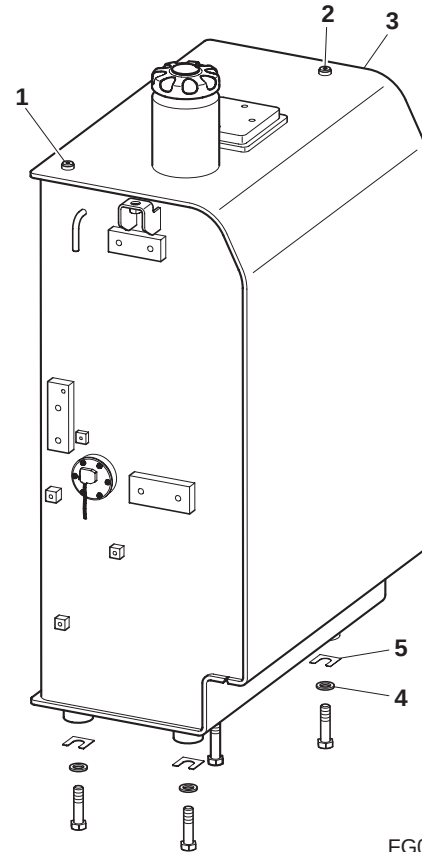
INSTALLATION

1. Install two 12 mm eyebolts in threaded holes (38 and 39, Figure 13). Using a suitable lifting device, sling eyebolts.
2. Set fuel tank (1, Figure 13) into position. Install four bolts (7) and spacers (13) 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 (9, Figure 13) as needed to prevent tank (1) from rocking or stress from mounting bolts (7).
4. Tighten mounting bolts (7, Figure 13) after shims are installed.

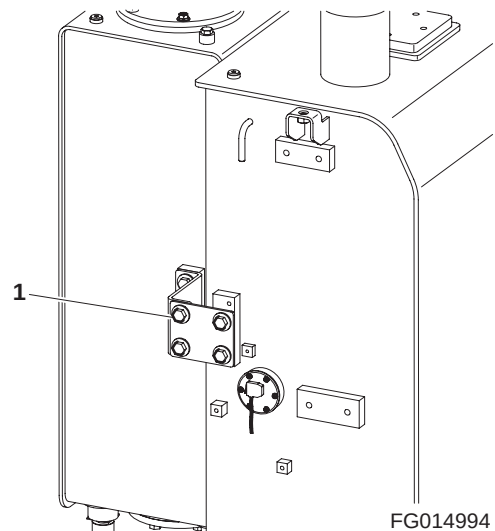
NOTE: *Bolt torque is 27 kg•m (200 ft lb).*



FG014995

Figure 13

5. Install bracket tied with oil tank.



FG014994

Figure 14

6. Install engine oil filter (1, Figure 15).
7. Connect fuel return line (2, Figure 15).

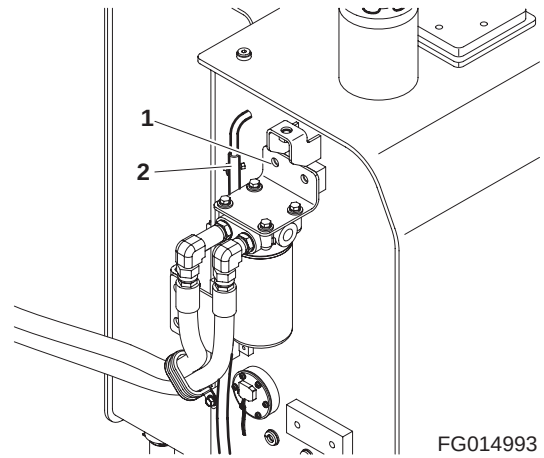


Figure 15

8. Install fuel prefilter (1, Figure 16).
9. Connect fuel sensor harness connector (2, Figure 16).

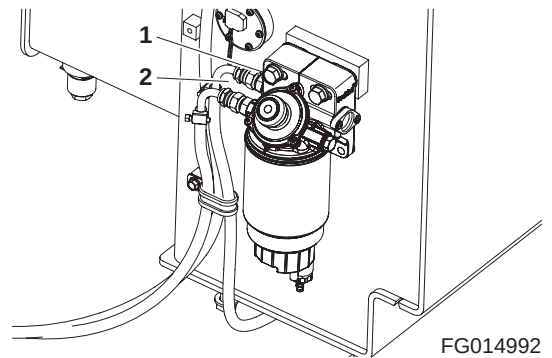


Figure 16

10. Fasten fuel hose clamp (1, Figure 17).
11. Fasten clamp connects fuel hose and prefilter.

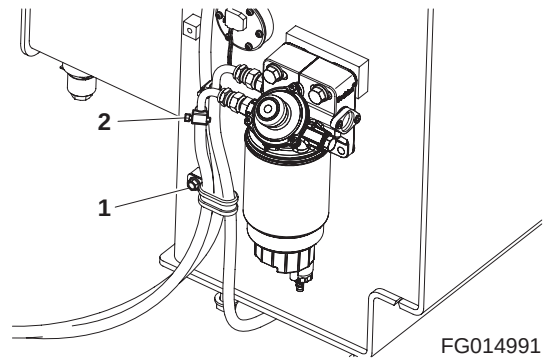
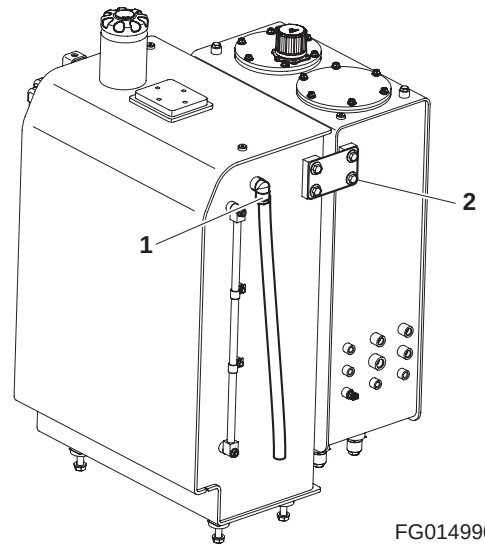


Figure 17

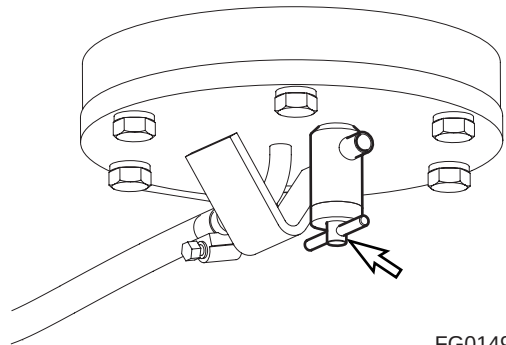
12. Connect fuel filler pump hose (1, Figure 18) (optional).
13. Install bracket tied with oil tank (2, Figure 18).



FG014990

Figure 18

14. Make sure fuel tank drain valve (6, Figure 19) on bottom of tank is closed.
15. Fill fuel tank and check for signs of leaks. Correct any problems found.
16. Connect negative (-) battery cable to battery.



FG014989

Figure 19

START-UP PROCEDURES

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

1. Stop Engine.
2. Open right rear door and then there is fuel filter.

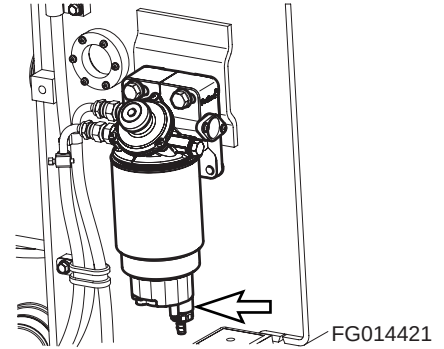


Figure 20

3. Loosen plug (1, Figure 21) on top of fuel filter head.
4. Pump hand operated primer pump (2, Figure 21) by the fuel injection pump. Pump primer until fuel is present at plug hole in fuel filter head.
5. Tighten plug in fuel filter head.
6. Continue to pump primer pump until a strong resistance is felt.
7. Start engine and look for signs of leaks.

Repeat procedure if necessary.

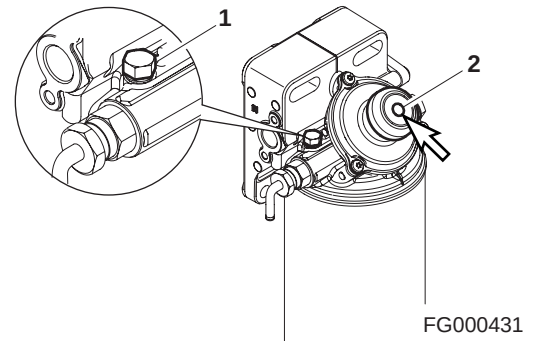


Figure 21

Fuel Transfer Pump

Edition 1

MEMO

Table of Contents

Fuel Transfer Pump

Safety Precautions	5
Applicable Models	5
General Description	6
Theory of Operation	6
Troubleshooting	7
Replacement of Rotor and Vane	7
Replacement of Rear Cover	8
Replacement of Armature	8

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up

GENERAL DESCRIPTION

Theory of Operation

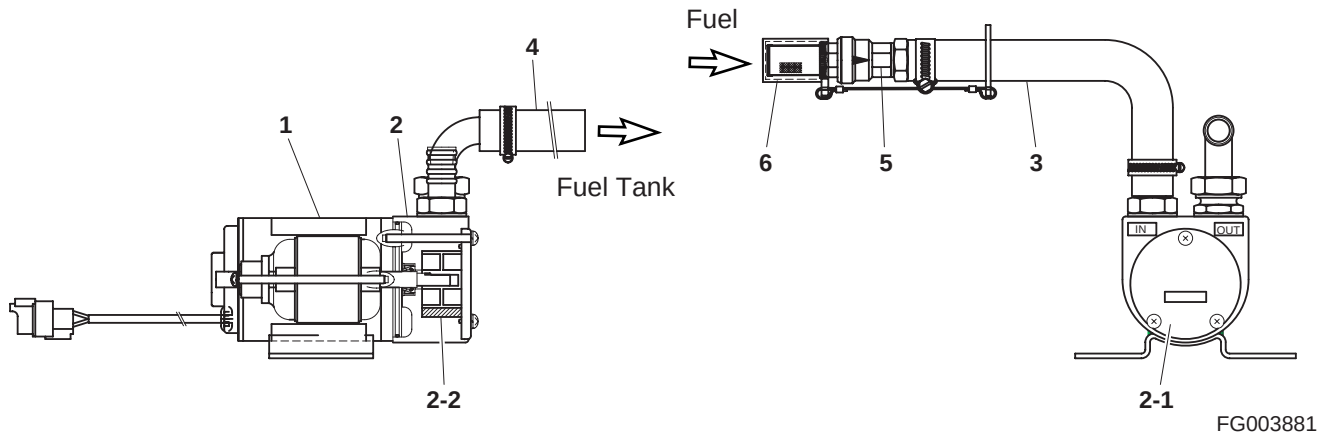


Figure 1

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.

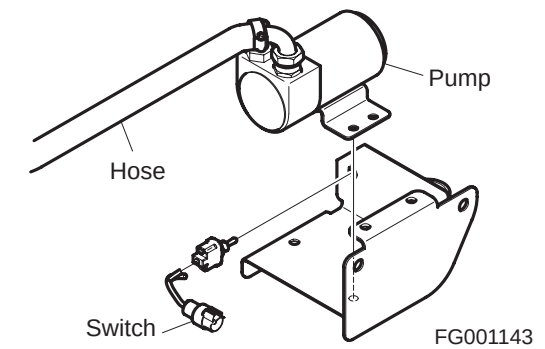


Figure 2

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.*

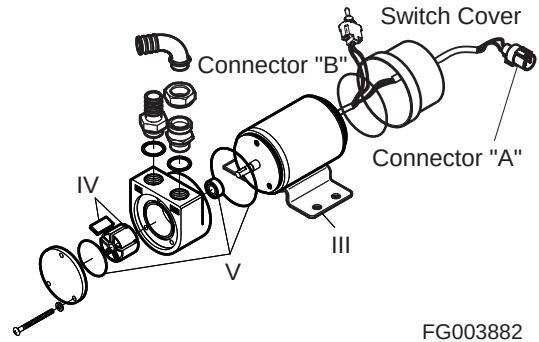


Figure 3 WITH TOGGLE SWITCH

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.

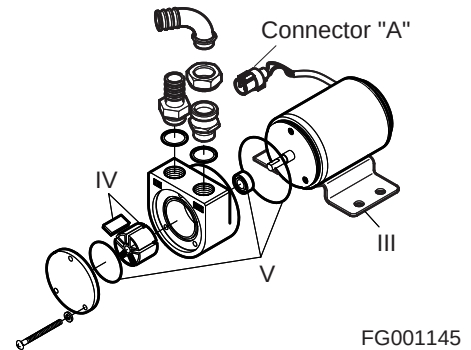


Figure 4 WITHOUT TOGGLE SWITCH

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.

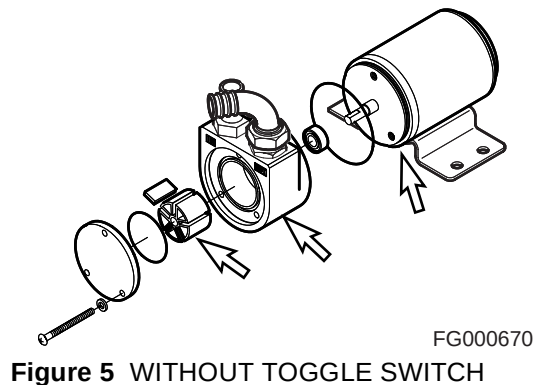
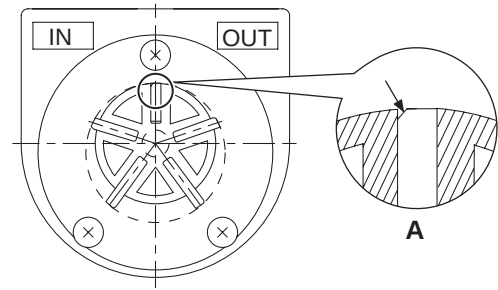


Figure 5 WITHOUT TOGGLE SWITCH

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

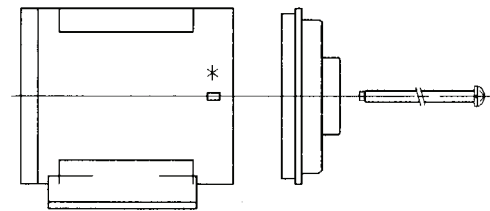
Brush assembly and a thermal limiter are installed in the rear cover. If you find any damage, replace them with new ones.

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.

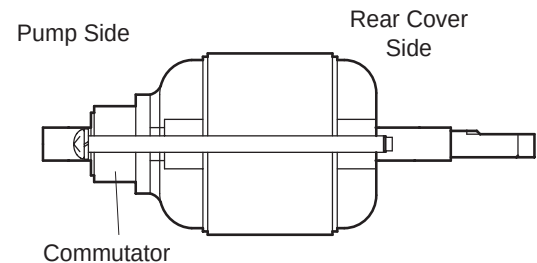
Remove the switch cover and rear cover, then remove the armature from the housing.

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 1-8, 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 1-7.



FG001146

Figure 8

Swing Bearing

Edition 1

MEMO

Table of Contents

Swing Bearing

Safety Precautions	5
Applicable Models	5
Swing Bearing Maintenance	6
Operating Recommendation	6
Measuring Swing Bearing Axial Play	6
Measuring Bearing Lateral Play	6
Swing Bearing Basic Operation	7
Disassembly	7
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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5434 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	7440 and Up
DX340LC	5980 and Up
DX350LC	5980 and Up
DX380LC	5109 and Up
DX420LC	5327 and Up
DX480LC	5221 and Up
DX520LC	5117 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.

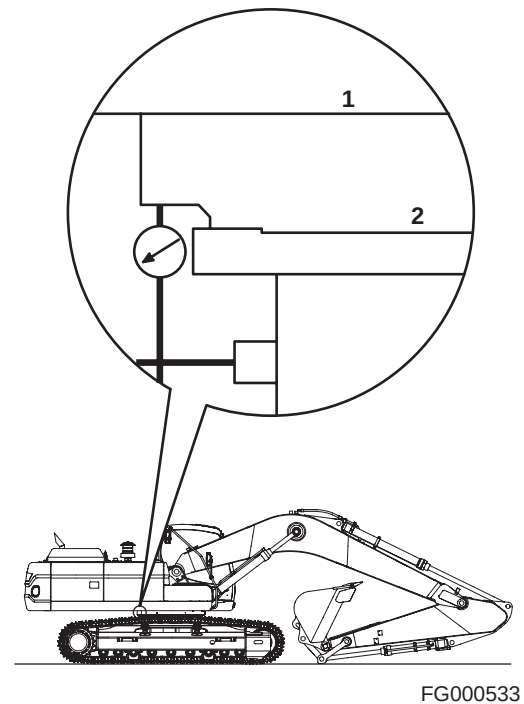


Figure 1

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	Outer Ring
2	Inner Ring
3	Tapered Pin
4	Plug
5	Ball
6	Retainer
7	Seal

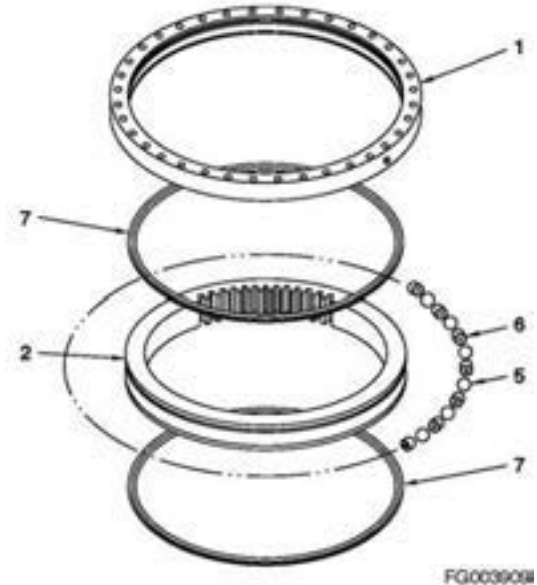


Figure 2

Disassembly

1. Remove tip of tapered pin (3, Figure 3) using grinder and tap lightly to remove debris.

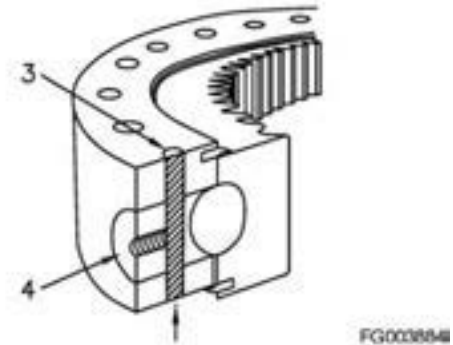


Figure 3

2. Remove plug (4, Figure 4) using a M10 x P 1.5 bolt.

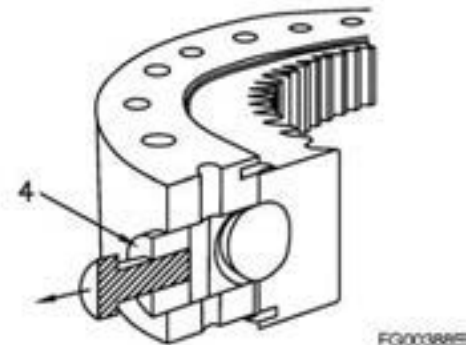
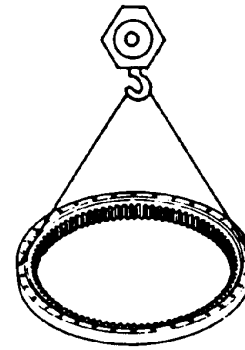


Figure 4

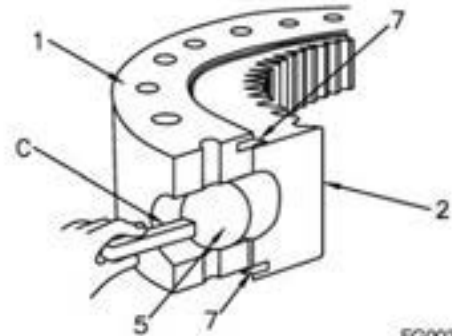
3. Lift outer ring and check that inner ring can move freely.
See Figure 5, if not, replace seal (7, Figure 6).



1588A

Figure 5

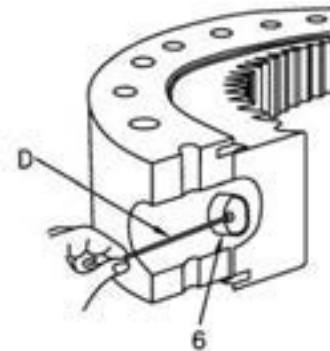
4. Turn inner ring and use magnet bar (C, Figure 6) to remove steel balls (5).



FG003889

Figure 6

5. Turn inner ring and use wire (D, Figure 7) to remove retainers (6).



FG003908

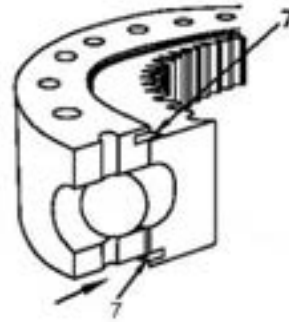
Figure 7

Assembly

1. Clean (degrease) the seal groove for the outer and inner seals (7).

Apply instant glue to seal (7).

Install both seals respectively into position.

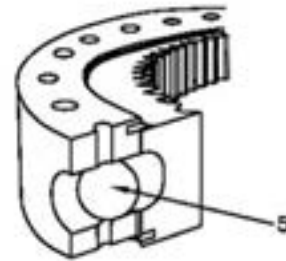


FG005123

Figure 8

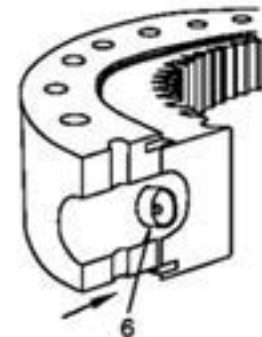
2. Hoist the outer race by crane horizontally and match it with the inner race coaxially.

Rotating the outer race, insert balls (5), support (6) into the plug (4) hole one by one with a round bar.



FG005225

Figure 9



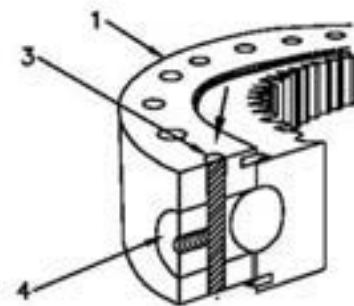
FG005124

Figure 10

3. Top plug (4) into outer race (1) and then, drive pin (3) into the pin hole.

Caulk the head of pin (3) with a punch.

Fill grease through the grease fitting.



FG005125

Figure 11

Swing Reduction Gear

Edition 1

MEMO

Table of Contents

Swing Reduction Gear

Safety Precautions	5
Applicable Models	5
General Description	7
Theory of Operation	7
Reassembly	8
Parts List	8
Shrinkage Fitting of Shaft and Flexible Bearing .	10
Reassembly of Carrier Sub	13
Assembly of the Main	20
Test.....	32
Reassembly of motor.....	35

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 personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX140W	5001 and Up
DX160W	5001 and Up

GENERAL DESCRIPTION

Theory of Operation

The swing motor final drive is a two-stage planetary gearbox with two planet gears, two sun gears and two-stage output reduction. The planetary gear engages the ring gear. The pinion gear is connected to the output shaft and spline.

The final drive reduces swing motor rpm to increase swing motor output torque. The available maximum swing speed provides a fast turning rate for efficient, rapid work cycling with more than adequate power for good acceleration.

REASSEMBLY

Parts List

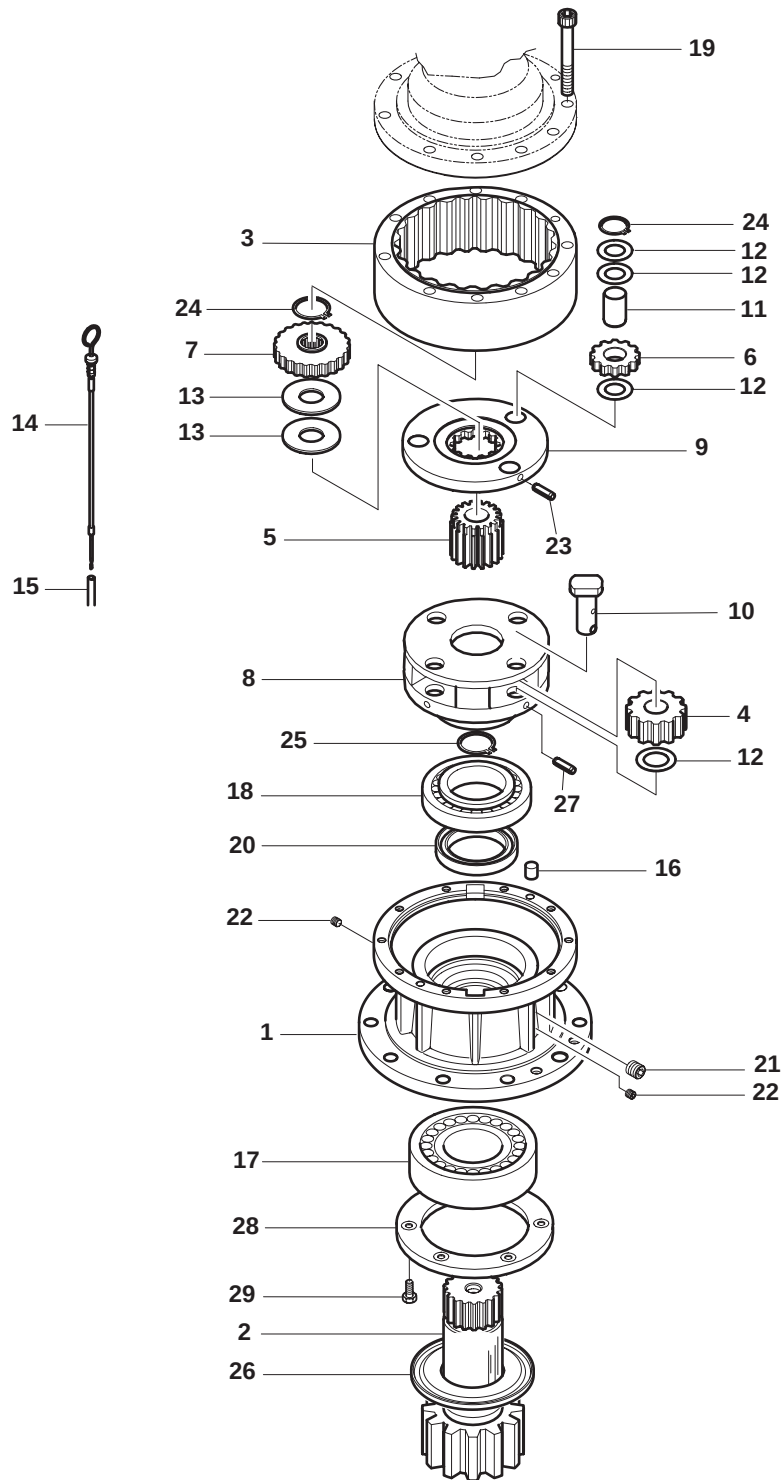


Figure 1

FG005349

Reference Number	Description
1	Casing
2	Driveshaft
3	Ring Gear
4	Planetary Gear
5	Sun Gear 2
6	Planetary Gear
7	Sun Gear 1
8	Carrier 2
9	Carrier 1
10	Pin Assembly
11	Pin Assembly
12	Adjustment Washer
13	Adjustment Washer
14	Level Bar
15	Level Gauge Piping

Reference Number	Description
16	Pin
17	Roller Bearing
18	Roller Bearing
19	Socket Bolt
20	Oil Seal
21	Plug
22	Plug
23	Spring Pin
24	Retainer Ring
25	Retainer Ring
26	Ring
27	Spring Pin
28	Support Plate
29	Screw Bolt

SHRINKAGE FITTING OF SHAFT AND FLEXIBLE BEARING

1. Washing of shaft
Remove fluids like anticorrosive fluid applied to the shaft and use an air conditioner to remove foreign substances.
2. Insert the support plate and the NILOS ring into the prepared shaft as shown in the figure and heat bearings (#22314, 2109-1041) on the heater.



Figure 2



Figure 3



Figure 4

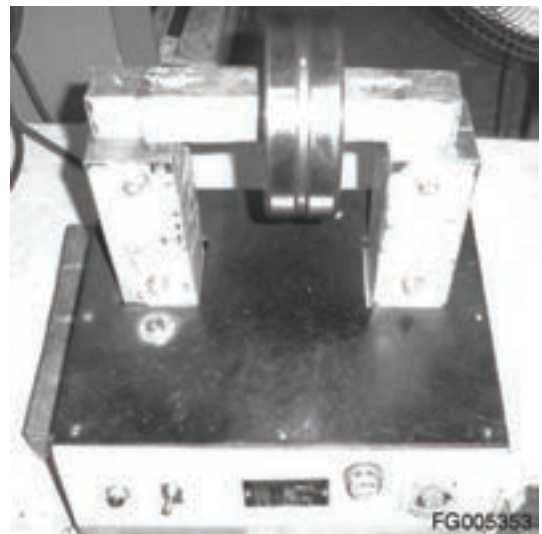


Figure 5

3. When bearing is heated up to 90°C - 100°C, remove it from the heater, hold it with both hands, and insert it into the shaft evenly.

To do so, slowly insert bearing 4-5 mm that it seats itself and then push it strongly to contact the NILOS ring.



CAUTION

Do not heat bearing above 120°C.

4. After assembling the bearing, let it cooled fully in the air for 1 to 2 hours.



Figure 6



Figure 7

REASSEMBLY OF CARRIER SUB

1. Washing of carrier

Put in a steam washer the carrier whose burr is removed completely with corner face-milling and place it on the assembly die after checking if there is not left any foreign substance in it.

2. Washing of planetary gear

Check if planetary gear parts are washed or dented, and put them on the assembly die.

3. Reassembly of carrier #1 assembly

- A. Place the carrier #1 assembly on the assembly jig, insert the thrust washer in it, and fix it to the hole of carrier.



Figure 8



Figure 9

- B. Put a pressure jig on the pin and use a press to insert it.



Figure 10



Figure 11

- C. Place the carrier with the pin being pressed in on the jig vertically, use a hammer to insert the spring pin (Ø6 x 25 liter§), and drain valve it.



Figure 12



Figure 13

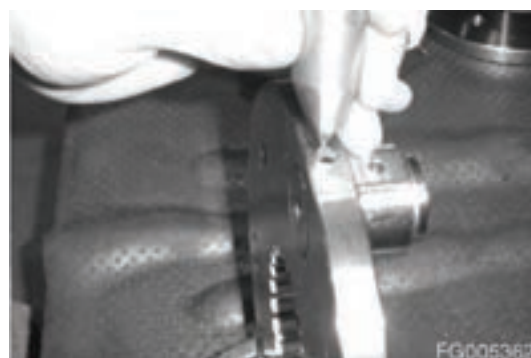


Figure 14



Figure 15

- D. Assemble 2 other parts in the same way.

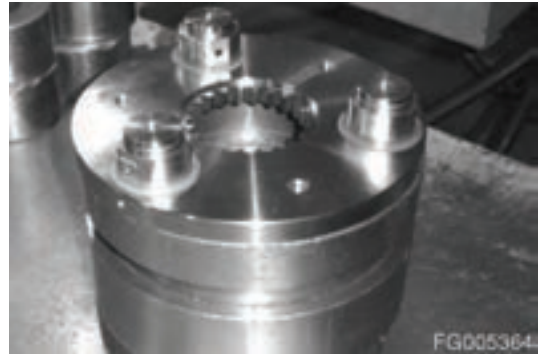


Figure 16

- E. Put the thrust washer (B) in the middle of the carrier with all of pins being pressed in.



Figure 17

- F. Insert planetary gear #1 in 3 pins and put two thrust washers on them as shown in the figure.



Figure 18



Figure 19

- G. Install a retaining ring ($\varnothing 30$, C type, and for shaft) on each and check if gear rotates smooth.



Figure 20



Figure 21

4. Reassembly of carrier #2 assembly

- A. Place the carrier #2 assembly on the assembly die, attach the thrust washer on a side of the planetary gear #2, and insert it in the carrier with the washer facing downward.



CAUTION

The calibers of gear and washer should be fit to holes of the carrier pins.



Figure 22

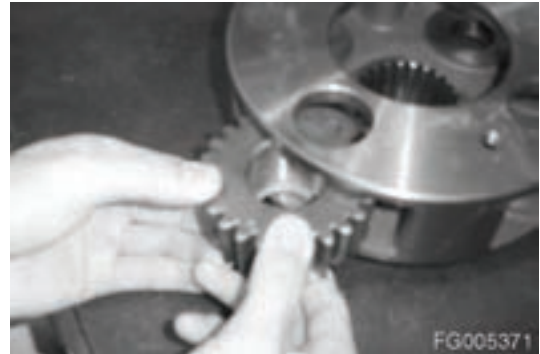


Figure 23



Figure 24

- B. Place the pin #2 assembly on the assembly die that the pinhole of the spring faces the same direction as the carrier shaft, and insert it by pressing with hands or gently knocking with hammer.



Figure 25



Figure 26



Figure 27

- C. After inserting the pin assembly, set the carrier vertically as shown in the figure, insert the spring pin ($\varnothing 6 \times 25$ mm) by gently knocking with hammer, and push it to the end with a jig.



Figure 28



Figure 29



Figure 30

- D. Use a punch to drain valve 2 or 3 places near hole where spring pin is inserted.



Figure 31



Figure 32

- E. Assemble other 3 parts and check if the gear runs smooth.



Figure 33

ASSEMBLY OF THE MAIN

1. Washing of casing and other parts

Wash casing and other parts with steam to remove remaining foreign substance after casting and machining.

- Washing fluid: PK6540 (alkali)
- Concentration : 3-5%
- Temperature: 60 - 70°C

2. Assembly of shaft and bearing

- A. Fix the washed casing on the turnover machine and rotate the turnover machine that the press fitting side of the shaft looks upward.

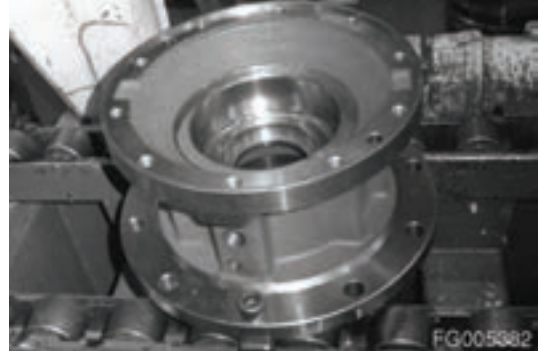


Figure 34

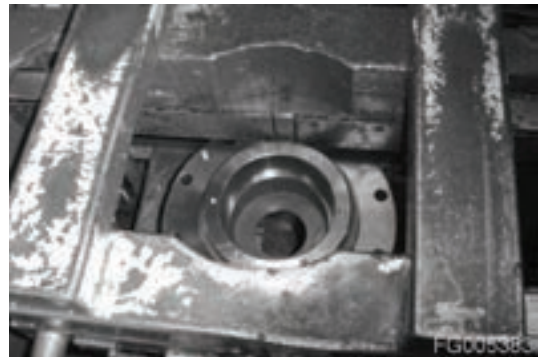


Figure 35

- B. Place the driveshaft assembly where bearing (#22314) is assembled on the case assembly, put a press jig on it, and use press to insert it.



CAUTION

Make sure that bearing is not tilted for correct press fitting before using press.



Figure 36



Figure 37



Figure 38



- C. Remove the bearing press jig, align the support plate with the bolt tap of the case, and install 6 Loctite (#262) applied flat head bolts (M8 x 15 mm) and tighten them with torque wrench (torque :320 kg•cm).



Figure 40

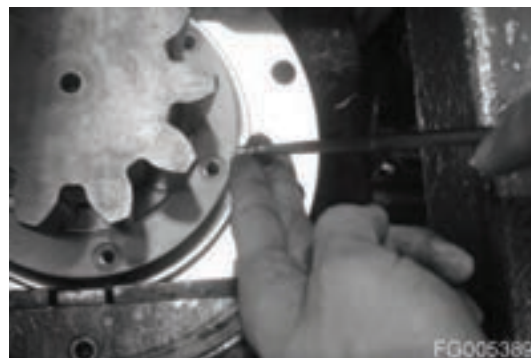


Figure 41

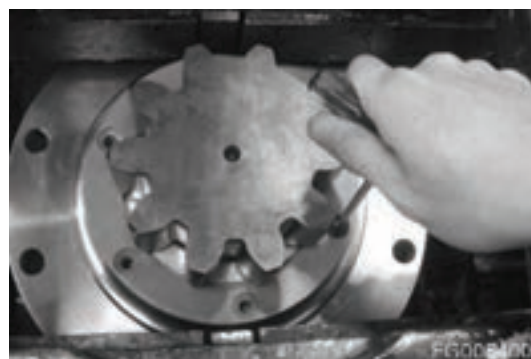


Figure 42

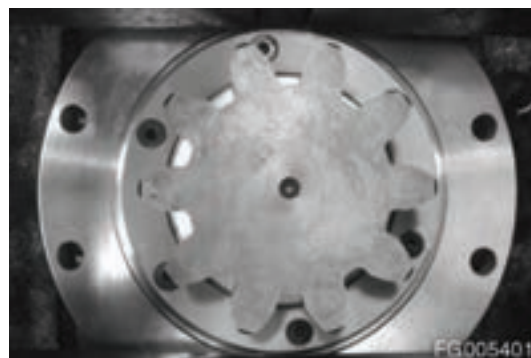


Figure 43

- D. After installing the support plate, rotate the turnover machine that the case is situated as shown in the figure.



Figure 44

- E. Apply grease to the lip of the oil seal (TC70 x 95 x 13, 2180-1254), insert it in the case, adjust it evenly, put jig on it, and use press to fit it. After press fitting, remove the jig and check its fitting state.



Figure 45



Figure 46



Figure 47



Figure 48

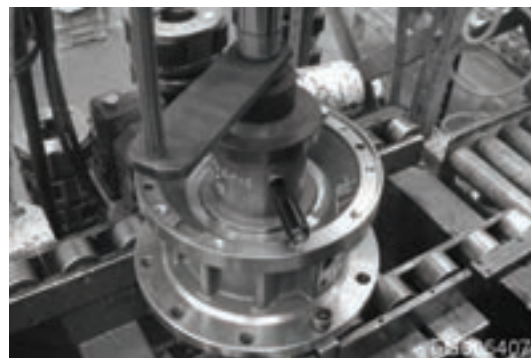


Figure 49



Figure 50

- F. Place bearing (2109-1042, NJ313) evenly, put jig on it, and use press to fit it.



Figure 51



Figure 52

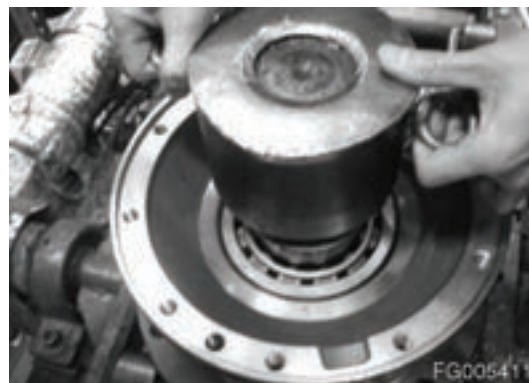


Figure 53



Figure 54

- G. After the assembly of the bearing, fix retaining ring (ø65, shaft ring, C type, S6500650) on the shaft.



Figure 55



- H. Install drain valve on PT3/8 tap of the side of the case.



Figure 57



Figure 58

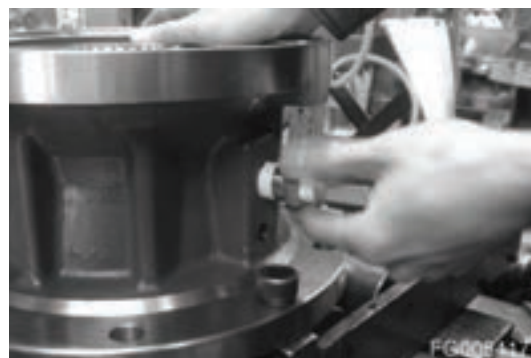


Figure 59

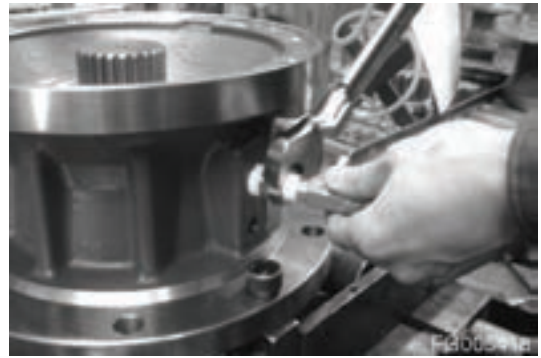


Figure 60

3. Reassembly of ring gear and carrier assembly
 - A. Apply liquid gasket (#1104) to the ring gear assembly parts of the case, lift the ring gear, and insert it with its groove facing downward as shown in figures.



CAUTION

Do not rotate the ring gear after it seats itself.



Figure 61

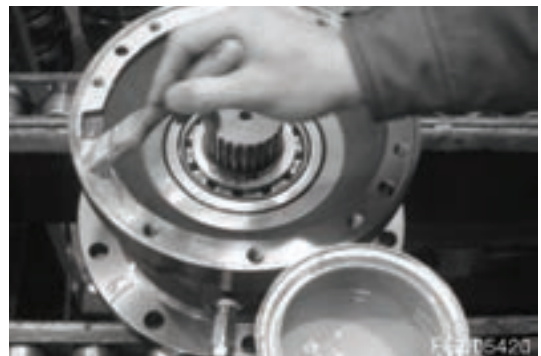


Figure 62



Figure 63



Figure 64

- B. Put lock pins on the assigned 4 places, use jig and hammer to insert them, and install bolts symmetrically.



Figure 65



Figure 66

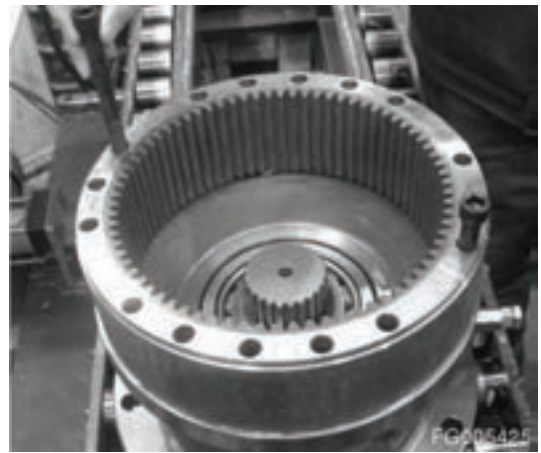


Figure 67



Figure 68

- C. Put the prepared carrier #2 assembly on the ring gear and turn it slowly right and left to have it engaged with gear. Assemble the spool line part of the carrier to the shaft in the same way.

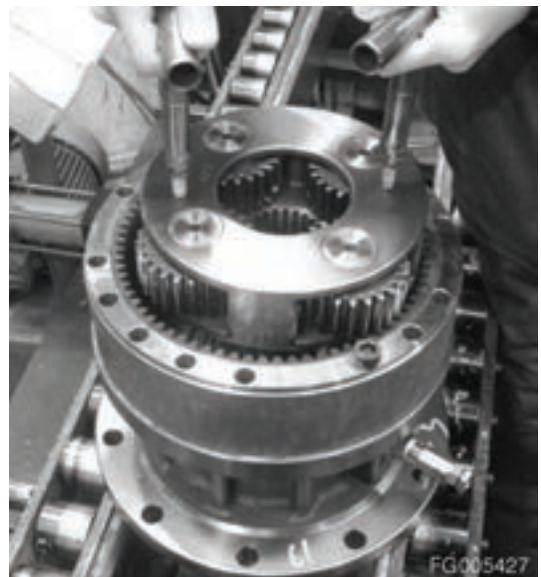


Figure 69



Figure 70

D. Install the sun gear #2 in the way as shown in figures.



Figure 71



Figure 72

- E. Assemble the carrier #1 assembly in the same way as for the carrier #2.



Figure 73



Figure 74

- F. Assemble the sun gear #1.



Figure 75



Figure 76

TEST

1. Pneumatic pressure test

- A. After the reassembly of the carrier and the sun assemblies, loose bolts of the ring gear, place the pneumatic test jig, and tighten 4 bolts again. At this time, make sure that the pressure gauge is set to zero.



Figure 77

- B. Supply air through valve until the pressure gauge points $2 \text{ kg}\cdot\text{cm}^2$ and check if there is any change in the pressure gauge for 3 minutes.
- C. Remove the jig after the pneumatic pressure test.

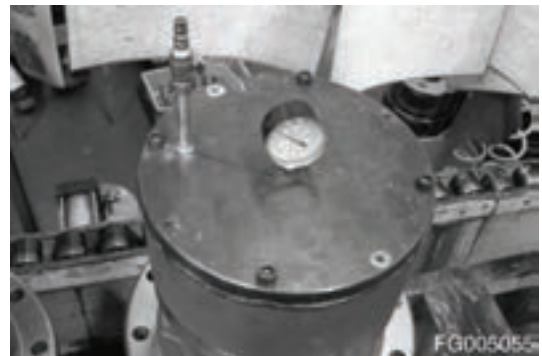


Figure 78

2. Noise and abnormal sound test

- A. After the pneumatic pressure test, fill the reduction gear with gear oil of 1 liter and connect it to test motor.



Figure 79



Figure 80

- B. Start motor in the advance and reverse directions ($1,875 \pm 90$ rpm, no idle) and check any noise or abnormal sound carefully. (Standard noise is 90dB at 30cm away.)



Figure 81

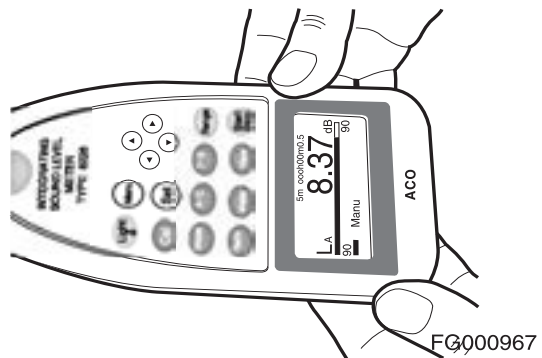


Figure 82

- C. At the end of the test open plug of drain port to remove contaminated gear oil completely and wipe remaining oil on the case surface with cloth.



Figure 83



Figure 84

REASSEMBLY OF MOTOR

1. Reassembly of motor
 - A. Remove retaining bolts of ring gear, wipe the motor assembly cleanly with cloth, and apply fluid gasket (#1104).
 - B. Use hoist to lift the motor, clean reassembled parts, and install retaining ring (ø30, shaft ring, and C type) in the shaft.



Figure 85



Figure 86

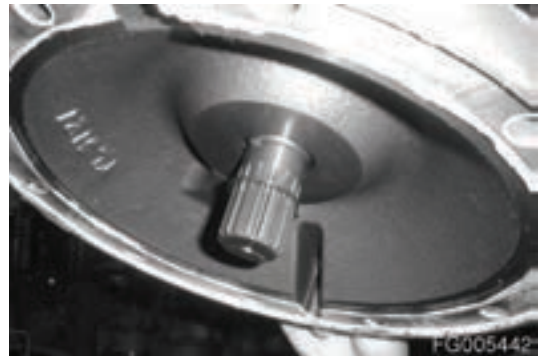


Figure 87

- C. Place the motor carefully on the reduction gear while arranging its direction as shown in figures (with caution not to have flange of the motor contact the applied fluid gasket). Assemble it by slowly turning it right and left that the spool line of the shaft engages with the threads of the sun gear #1.

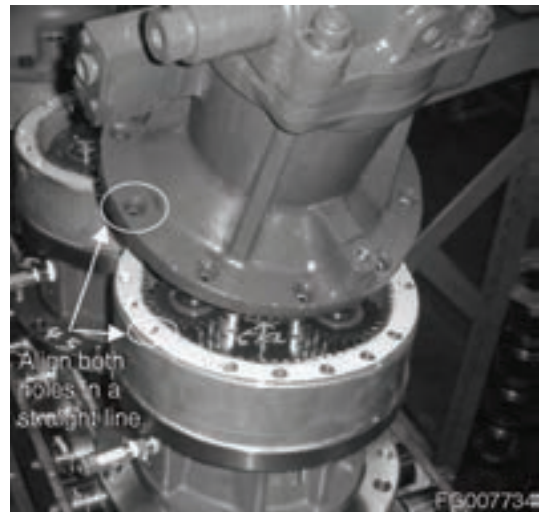


Figure 88



Figure 89

- D. Insert 10 Loctite (#262) applied socket bolts (M12 x 110 mm) in holes and use impact wrench to tighten them (torque : 1,100 kg•cm). After tightening bolts, use torque wrench their tightening torque.

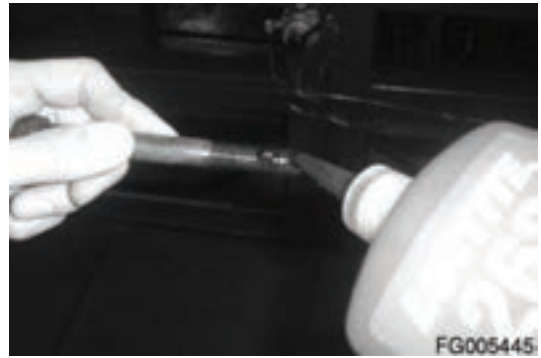


Figure 90

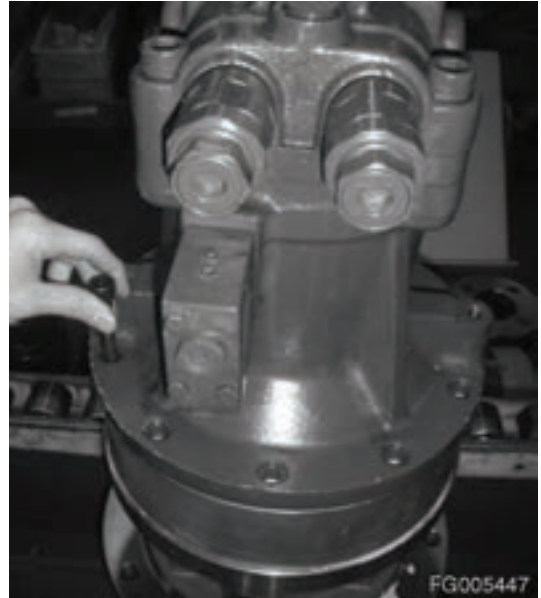


Figure 91

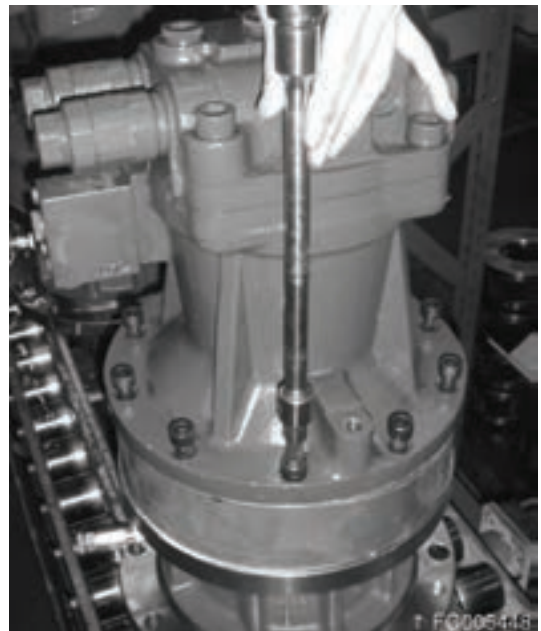


Figure 92

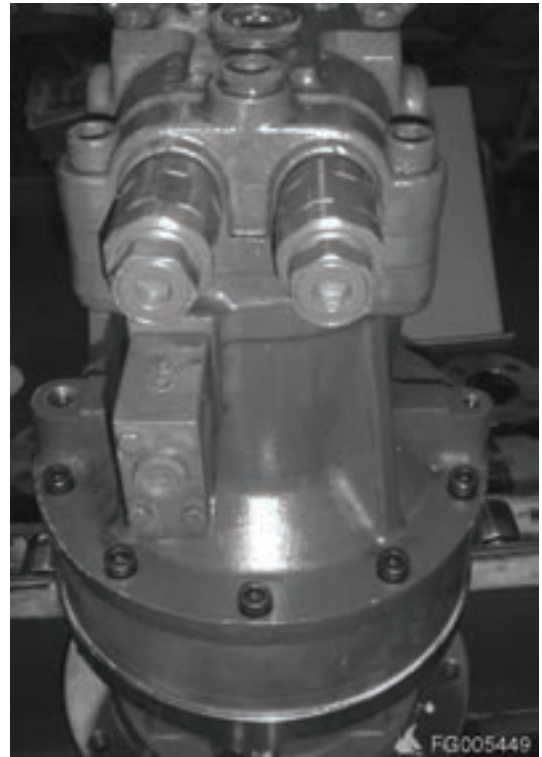


Figure 93

- E. Seal the level gauge port of the motor with teflon tape and use pipe wrench to tighten the level gauge pipe.



CAUTION

Do not insert the level gauge before filling gear oil.



Figure 94

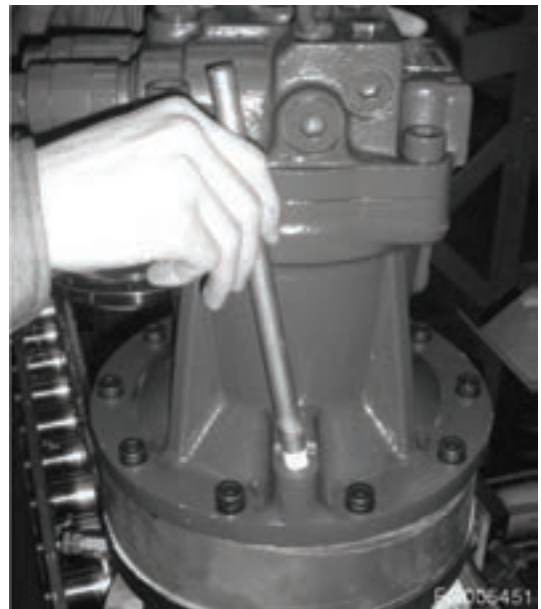


Figure 95



Figure 96

2. Filling of gear oil and grease

- A. Open oil nipple, fill gear oil (EP80W/90) of 2.4 liter, install PT1/2 plug again, insert the level gauge, and check oil level.

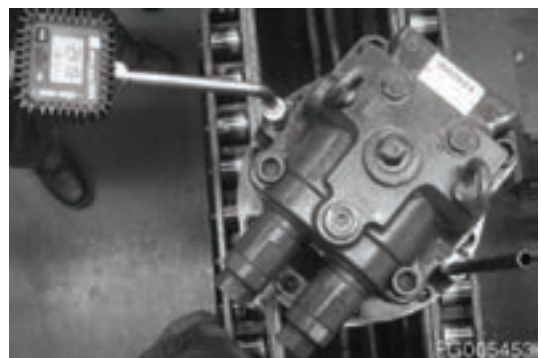


Figure 97

- B. Fill grease through grease fitting until grease is observed through the opposite hole and install PT1/8 plugs at both sides.

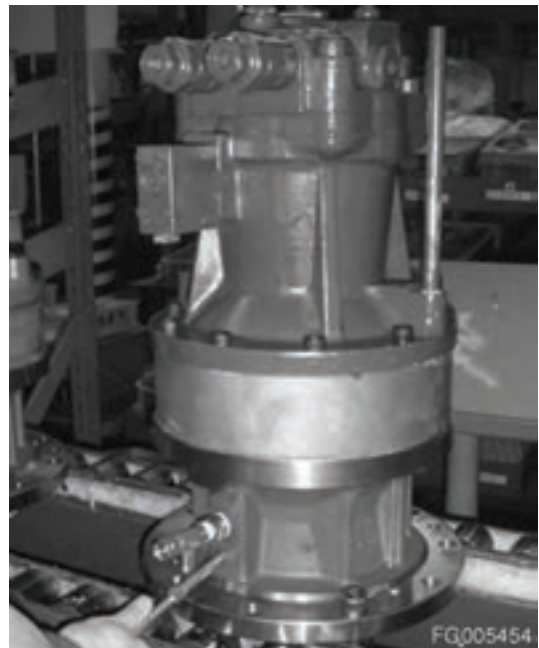


Figure 98



Figure 99

- C. Wipe grease and foreign substance with cloth and check the motor reassembly position again.

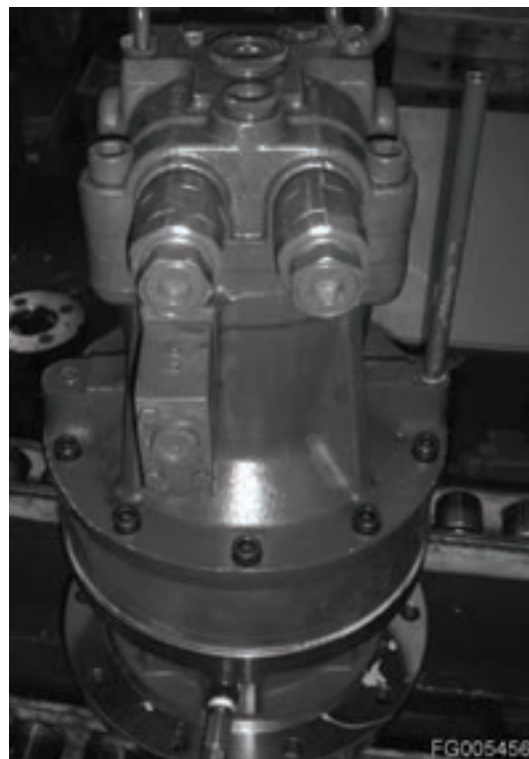


Figure 100

Lower Structure and Chassis

Track Assembly

Edition 1

MEMO

Table of Contents

Track Assembly

Safety Precautions	5
Applicable Models	5
General Description	6
Track Tension	6
Cleaning and Inspection (Wear Limits and Tolerances).....	9
Track Shoe	10
Lower Roller	12
Upper Roller	13
Front Idler	14
Track Shoes and Links	15
Track Removal	15
Track Installation	16
Front Idler	17
Parts List	17
Disassembly of Front Idler.....	18
Reassembly of Front Idler	19
Lower Roller	21
Parts List	21
Lower Roller Removal	22
Lower Roller Disassembly	22
Lower Roller Reassembly	23
Lower Roller Installation	24
Upper Roller	25
Parts List	25
Upper Roller Removal	26
Upper Roller Disassembly	26
Upper Roller Reassembly	28
Track Spring and Track Adjusting Cylinder	29
Parts List	29

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
DX140LCR	5001 and Up

GENERAL DESCRIPTION

The track assembly is composed of the following major components:

1. Track
2. Front Idler Roller
3. Upper Roller
4. Lower Roller
5. Track Spring and Track Adjustment Cylinder

TRACK TENSION



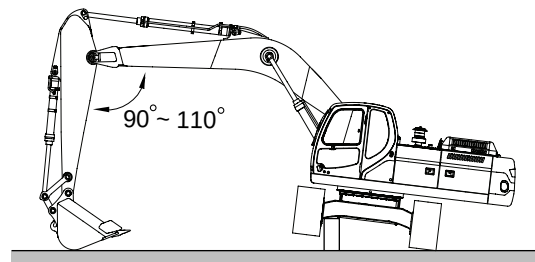
WARNING

Safely measuring track tension requires two people. One person must be in the operator's seat, running the controls to keep one side frame in the air, while the other person makes dimensional checks. Take all necessary precautions to make sure the machine won't move or shift position during service. Warm up the engine to prevent stalls, travel the excavator to an area that provides level, uniform ground support and/or use support blocks when necessary.

The track adjusting mechanism is under very high-pressure. NEVER release pressure too suddenly. The grease cylinder valve should never be backed off more than 1 complete turn from the fully tightened down position. Bleed off pressure slowly and keep your body away from the valve at all times.

Track shoe link pins and bushings wear with normal usage, reducing track tension. Periodic adjustment is necessary to compensate for wear and it may also be required by working conditions.

1. Track tension is checked by jacking up one side of the excavator. See Figure 1. Place blocking under frame while taking measurement.



FG000345

Figure 1

2. Measuring the distance (A, Figure 2) between the bottom of the side frame and the top of the lowest crawler shoe. Recommended tension for operation over most types of terrain is distance "B" on below table.

NOTE: *This measurement can be thrown off if there is too much mud or dirt or other material in the track assembly. Clean off the tracks before checking clearance.*

3. Too little sag in the crawler track (less than clearance distance "C" on below table) can cause excessive component wear. The recommended adjustment can also be too tight causing accelerated stress and wear if ground conditions are wet, marshy or muddy.
4. The increased clearance recommended for muddy, sandy or snowy ground conditions is between distance "D" on below table.

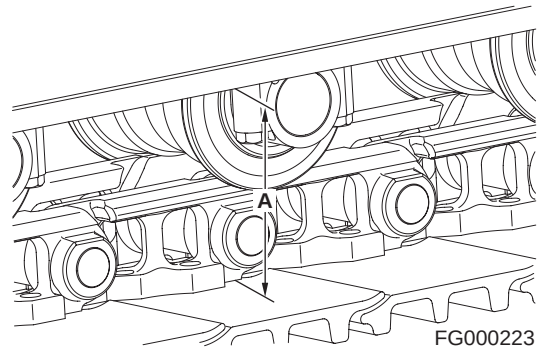


Figure 2

Terrain Type	Distance "A"
	DX140LC
Normal "B"	190 - 210 mm (7.50 - 8.27 in)
Minimum "C"	190 mm (7.50 in)
Muddy, Sandy or Snowy "D"	210 - 240 mm (8.27 - 9.45 in)



WARNING

The track adjusting mechanism is under very high-pressure. **NEVER** release pressure too suddenly. The grease cylinder valve should never be backed off more than 1 complete turn from the fully tightened down position. Bleed off pressure slowly and keep your body away from the valve at all times.

5. Track tension adjustments are made through the grease fitting (1, Figure 3) in the middle of each side frame. Adding grease increases the length of an adjustment cylinder (2). The longer the adjustment cylinder, the greater the pressure on the tension spring pushing the track idler wheel outward.
6. If there is not enough slack or clearance in the tracks and the adjustment is too tight, the idler wheel and adjusting cylinder can be retracted by bleeding off grease through hole in adjustment cylinder (2, Figure 3).

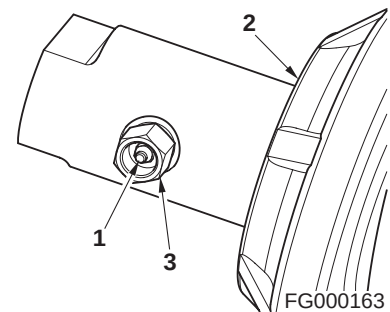


Figure 3

5. Track tension adjustments are made through the grease fitting (1, Figure 3) in the middle of each side frame. Adding grease increases the length of an adjustment cylinder (2). The longer the adjustment cylinder, the greater the pressure on the tension spring pushing the track idler wheel outward.
6. If there is not enough slack or clearance in the tracks and the adjustment is too tight, the idler wheel and adjusting cylinder can be retracted by bleeding off grease through hole in adjustment cylinder (2, Figure 3).

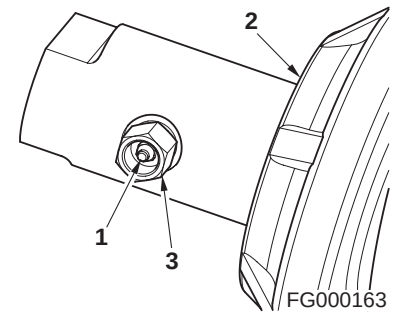


Figure 3

CLEANING AND INSPECTION (WEAR LIMITS AND TOLERANCES)

CAUTION

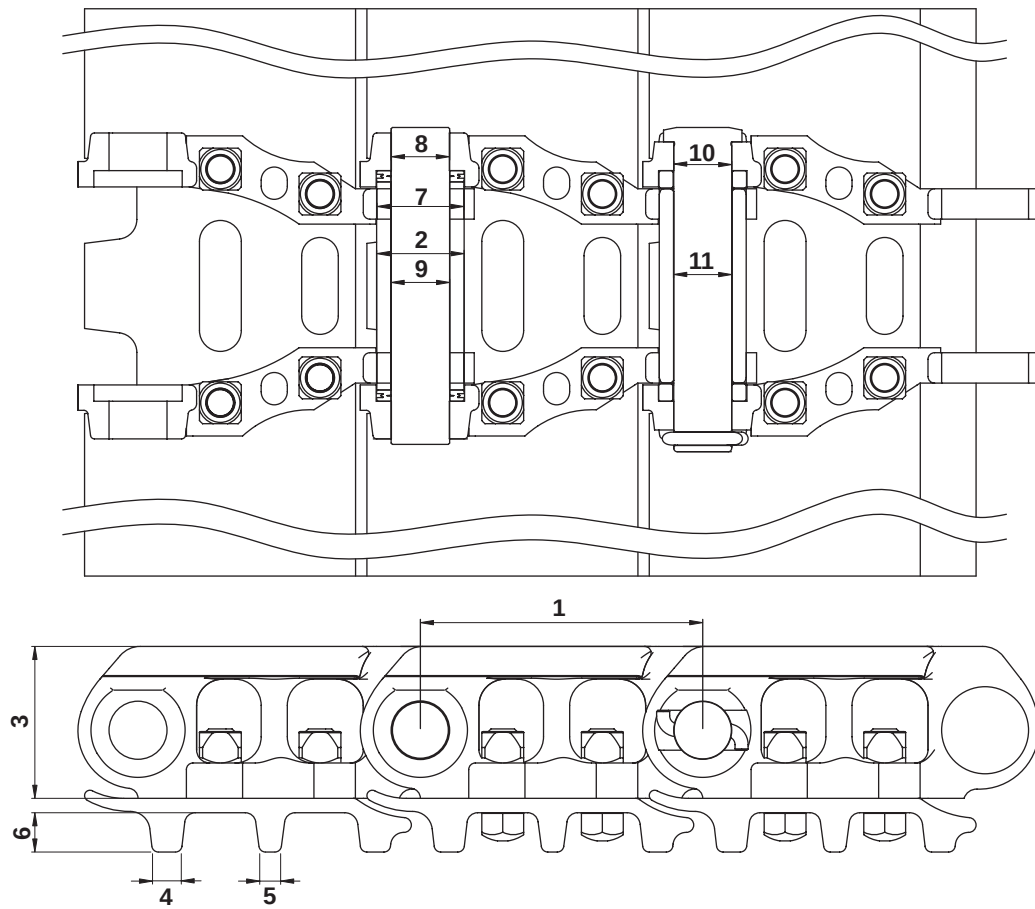
Refer to the "Welding Precautions and Guidelines" information in "General Maintenance Procedures" section for general recommendations and specific safety precautions, before starting any lower travel frame component rebuilding procedure.

The tables that follow provide factory specified dimensional limits (as new condition, recommended service and replacement limit) for lower travel frame components.

Recommended maintenance to renew most listed components requires welding on additional material and grinding off excess. Some components must be replaced before the service limit is exceeded. No maintenance or renewal is possible.

Compare the values in the tables with dimensions and profiles shown in the adjacent figures.

Track Shoe

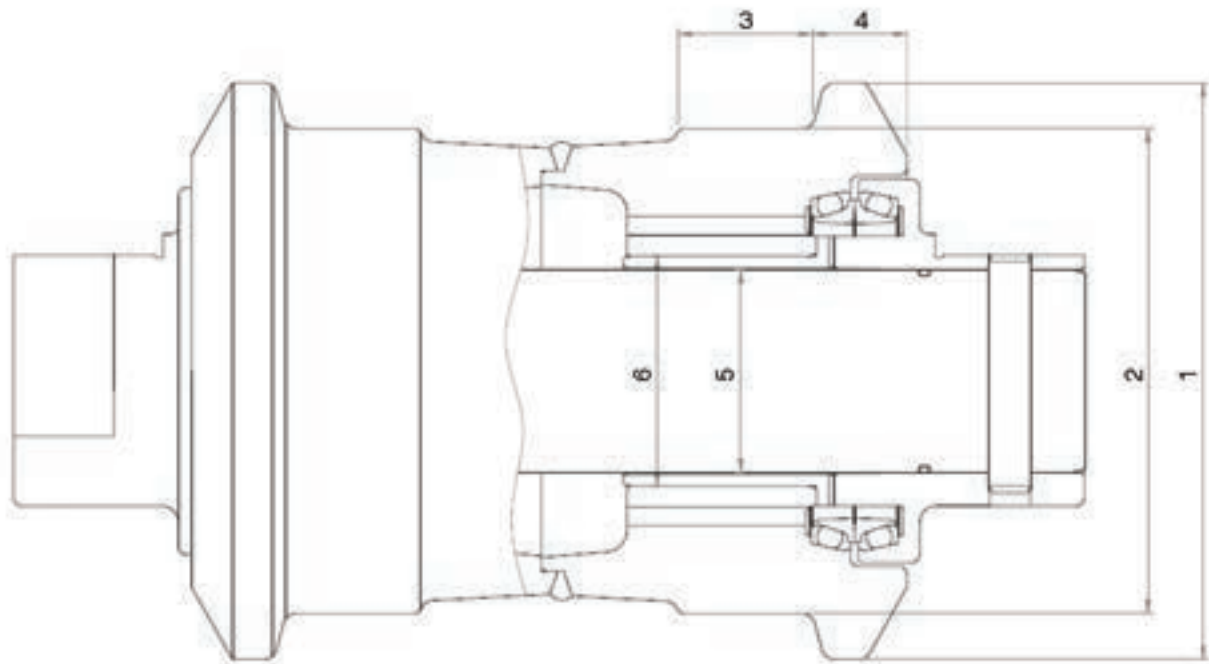


FG003910

Figure 4

No.	Check Item	Standard Dimension	Recommended Limit for Maintenance		Limit for Use (Repair - P or Replace - R)
1	Link Pitch	171.5 mm (6.752")			
2	Bushing Outside Diameter	53.9 mm (2.122")	50 mm (1.969")		47 mm [R] (1.850")
3	Link Height	94.5 mm (3.720")	89 mm (3.504")		85 mm [P] (3.346")
4	Length at Tip	17 mm (0.669")			
5	Length at Tip	11 mm (0.433")			
6	Height	25 mm (0.984")	20 mm (0.787")		18 mm (0.709")
7	Interference between bushing and link	Standard Dimension	Tolerance		Standard Interference
			Shaft	Hole	
		53.9 mm (2.122")	+0.055 +0.045	-0.126 -0.7	0.171 - 0.755
8	Interference between regular pin and link	Standard Dimension	Tolerance		Standard Interference
			Shaft	Hole	
		36.6 mm (1.441")	+0.05 +0	-0.2 -0.25	0.2 - 0.3
9	Clearance between regular pin and bushing	Standard Dimension	Tolerance		Standard Clearance
			Shaft	Hole	
		36.6 mm (1.441")	+0.05 +0	+0.75 +0.35	0.3 - 0.75
10	Interference between master pin and bushing	Standard Dimension	Tolerance		Standard Interference
			Shaft	Hole	
		36.4 mm (1.433")	-0.005 -0.035	+0 -0.05	0.0 - 0.045
11	Clearance between master pin and bushing	Standard Dimension	Tolerance		Standard Clearance
			Shaft	Hole	
		36.4 mm (1.433")	-0.005 -0.035	+0.95 +0.55	0.555 - 0.985

Lower Roller

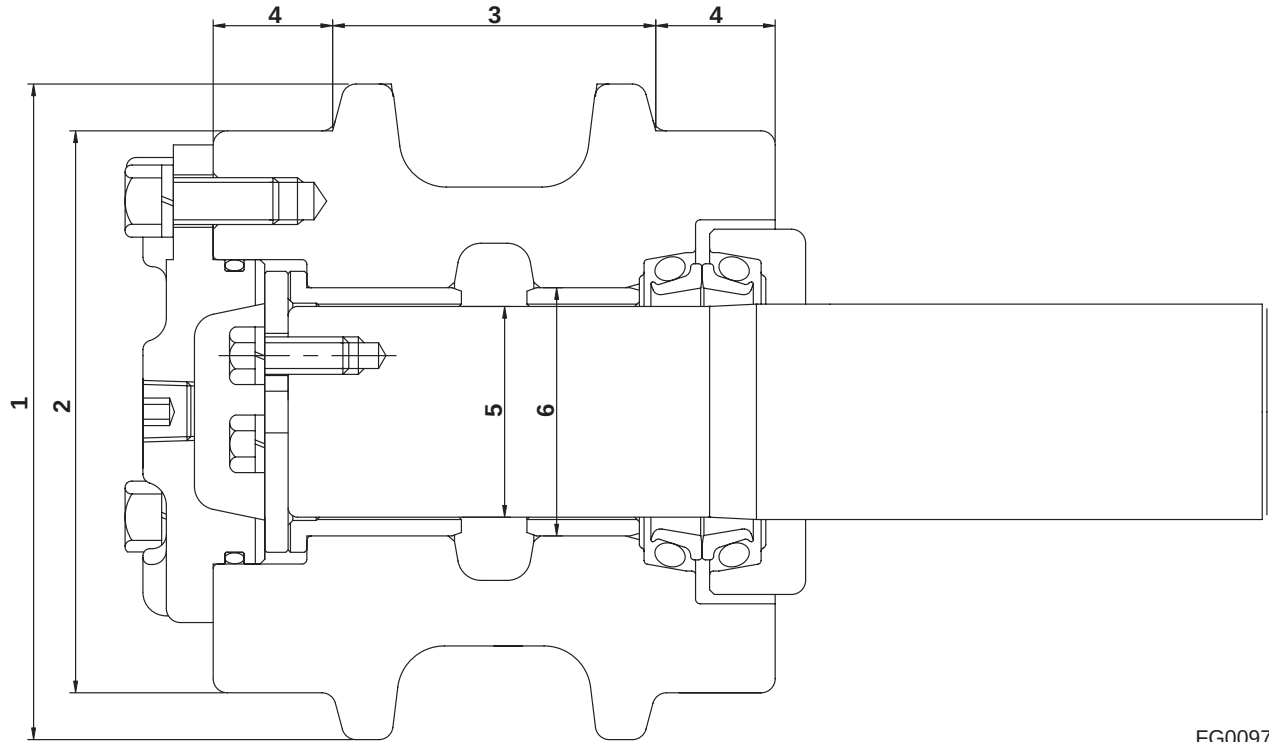


FG007871

Figure 5

No.	Check Item	Standard Dimension		Recommended Limit for Maintenance		Limit for Use (Repair - P or Replace - R)
1	Outside Diameter of Flange	170 mm (6.693")				
2	Outside Diameter of Tread	140 mm (5.512")		128 mm (5.039")		125 mm [P] (4.921")
3	Width of Tread	38.5 mm (1.516")		42 mm (1.654")		44 mm [P] (1.732")
4	Width of Flange	22.5 mm (0.886")				
5	Clearance between shaft and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		50 mm (1.969")	-0.05 -0.08	+0.24 +0.20	+0.32 +0.25	
6	Interference between roller and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		57 mm (2.244")	+0.103 +0.078	+0.03 -0.02	+0.048 +0.123	

Upper Roller

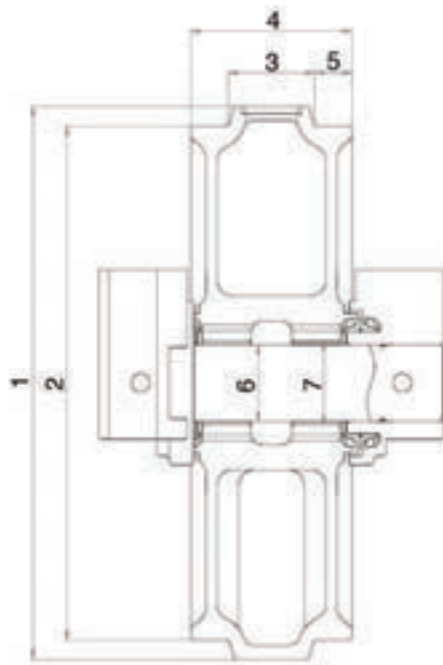


FG009714

Figure 6

No.	Check Item	Standard Dimension		Recommended Limit for Maintenance		Limit for Use (Repair - P or Replace - R)
1	Outside Diameter of flange	140 mm (5.512")				
2	Outside Diameter of Tread	120 mm (4.724")		112 mm (4.409")		
3	Width of Tread	69 mm (2.717")				
4	Width of Tread	25.5 mm (1.004")		29 mm (1.142")		
5	Clearance between shaft and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		46 mm (1.811")	-0.05 -0.08	+0.25 +0.2	+0.33 +0.25	
6	Interference between roller and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		53 mm (2.087")	+0.10 +0.05	+0.03 -0.02	+0.12 +0.02	

Front Idler



FG00785E

Figure 7

No.	Check Item	Standard Dimension		Recommended Limit for Maintenance		Limit for Use (Repair - P or Replace - R)
1	Outside Diameter of flange	489 mm (19.252")				
2	Outside Diameter of Tread	454 mm (17.874")		443 mm (17.441")		440 mm [P] (17.323")
3	Width of Protrusion	68 mm (2.677")				
4	Total Width	135 mm (5.315")				
5	Width of Tread	33.5 mm (1.319")		39 mm (1.535")		41 mm (1.614")
6	Clearance between shaft and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		75 mm (2.953")	0 -0.03	+0.40 +0.35	+0.43 +0.35	
7	Interference between roller and bushing	Standard Dimension	Tolerance		Standard Interference	Repair Limit
			Shaft	Hole		
		85 mm (3.346")	+0.17 +0.13	+0.035 0.0	+0.17 +0.095	

TRACK SHOES AND LINKS

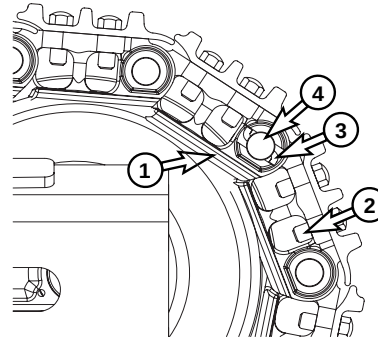
Track Removal

1. Position machine on a smooth level surface with adequate room for forward and reverse travel.
2. Relieve track tension. Refer to "Track Tension" in this section for procedure.
3. Move machine until master link (1, Figure 8) is positioned at approximately 10 o'clock from top position on front idle roller.
4. Remove four nuts and bolts (2, Figure 8) holding shoe to link. Remove enough shoes to make access to lock pin easier.

NOTE: Support track shoes with blocking so that when master pin (4, Figure 8) is removed track will not fall.

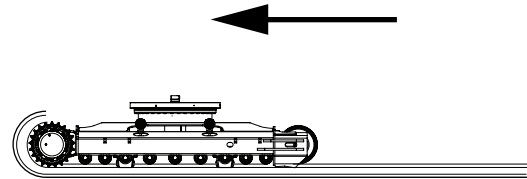
5. Straighten lock pin (3, Figure 8) and remove it from master pin (4). Discard lock pin.
6. Remove master pin from master links.
7. Move unit backward until entire track is laying on ground.

NOTE: Do not drive unit off track.



FG003982

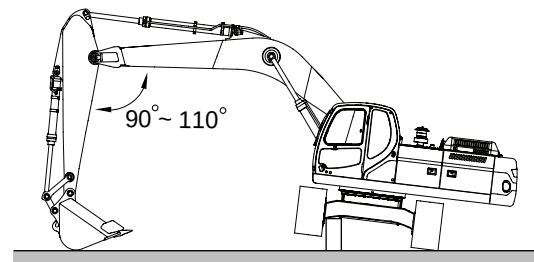
Figure 8



FG003911

Figure 9

8. Rotate upper structure to 90° from track. Use bucket and boom to raise track frame off track.
9. Position blocking under frame.

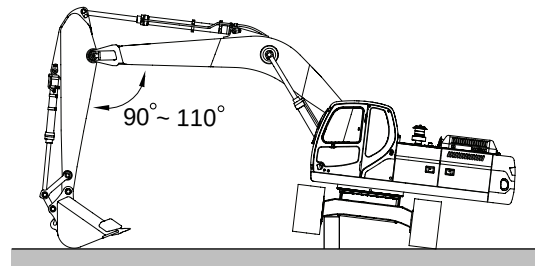


FG000345

Figure 10

Track Installation

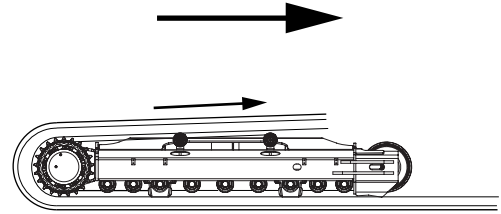
1. Lay rebuilt or new track into position under track frame. End of track should be positioned under drive sprocket.
2. With upper structure at 90° to track frame. Use bucket and boom to raise track frame off blocking.
3. With blocking removed, lower track frame onto track. Make sure all rollers are properly positioned on track.



FG000345

Figure 11

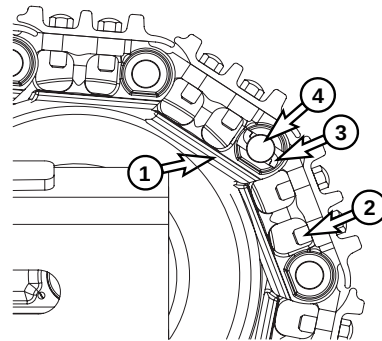
4. Move unit forward while feeding track up over drive sprocket. Continue to pull track back until it engages front idle roller.



FG003912

Figure 12

5. Align master links and install master pin.
6. Insert new lock pin in master pin. Bend end of pin over so it is pointing in opposite direction of other end as shown.
7. Apply track tension. Refer to "Track Tension" in this section for procedure.

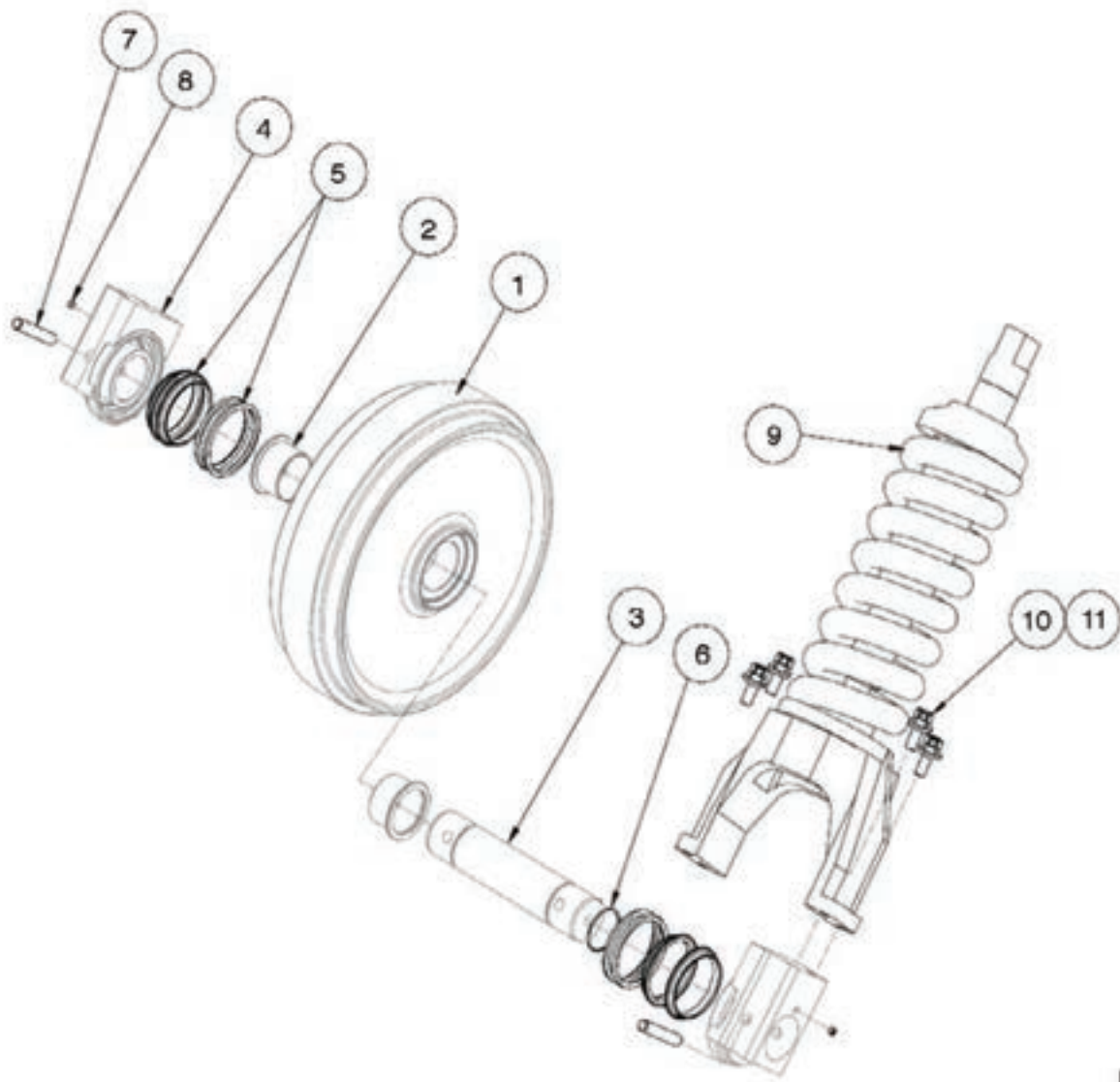


FG003982

Figure 13

FRONT IDLER

Parts List



FG007775

Figure 14

Reference Number	Description
1	Front
2	Bushing
3	Shaft
4	Bearing
5	Floating Seal
6	O-ring

Reference Number	Description
7	Pin
8	Plug
9	Track Spring Assembly
10	Bolt
11	Washer

Disassembly of Front Idler

1. Detach T/Spring assembly from Idler assembly.
Remove 4-M16 bolts and washers (10, 11, Figure 15).
2. Remove the plug (8, Figure 14) from the bearing (4, Figure 14) (using 6mm "L" wrench).

NOTE: About 330cc of oil will be discharged. Prepare an oil cloth or pan to prevent spillage on the ground.

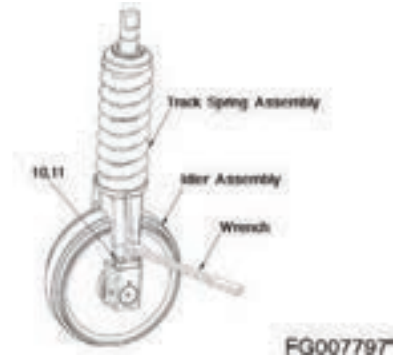


Figure 15

3. Using a hammer and pin-removing tool, remove the pin (7, Figure 16) on one side.
4. Remove the bearing (4, Figure 14) on the side from which the pin (7, Figure 16) has been removed.
5. From the removed bearing (4, Figure 14) and front (1, Figure 14), separate the floating seal (5, Figure 14).
6. From the shaft (3, Figure 14), separate the O-ring (6, Figure 14).

NOTE: If the O-ring is not removed, the bearing sub-assembly on the opposite side will be difficult to separate

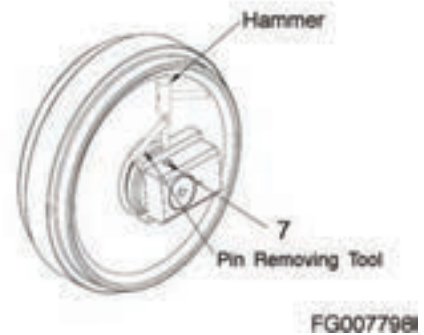


Figure 16

7. Separate the bearing sub-assembly on the opposite side of the front (1, Figure 14).
8. Separate the floating seal (5, Figure 14) from the separated bearing sub-assembly and front (1, Figure 14).
9. Separate the pin (7, Figure 14) from the separated bearing sub-assembly.
10. Separate the shaft (3, Figure 14) from the bearing (4, Figure 14).
11. Separate the O-ring (6, Figure 14) from the shaft (3, Figure 14).

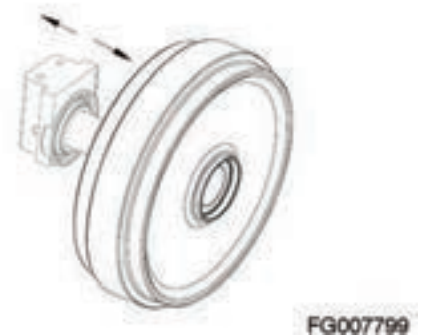


Figure 17

12. Separate the bushing (2, Figure 18) from the front (1, Figure 18).

NOTE: Insert jig 2, and press jig 1 to separate.
Use the hydraulic press for pressing the jig. Be careful of sputtering.

13. Turn the front upside down. Separate the bushing (2, Figure 18) in the same manner as described above (Figure 18).

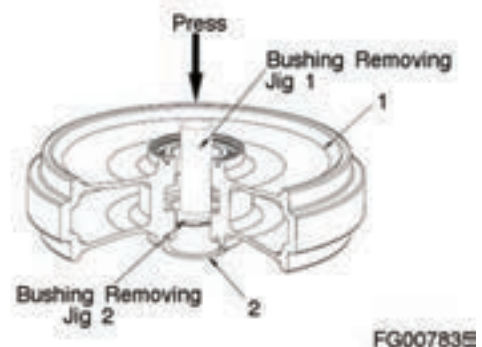


Figure 18

Reassembly of Front Idler

1. Take care that foreign matters do not enter the front part. Wash all parts for assembly.
2. Using the hydraulic press, assemble two bushings (2, Figure 19) at front (1, Figure 19). Use the hydraulic press. Take care to prevent accidents.

NOTE: Apply a volatile lubricant on the bushing surface before insertion.
There must be no dent marks on the flange.

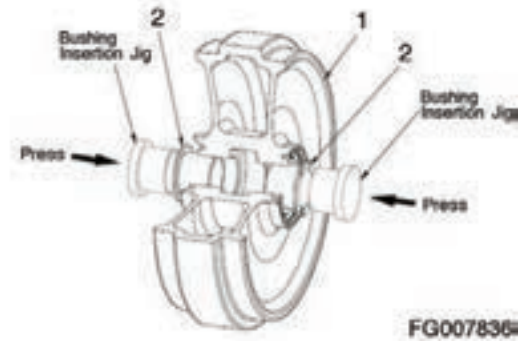


Figure 19

3. Assemble two bearings (4, Figure 20) with the floating seal (5, Figure 20).

In order not to twist the O-ring, use assembling jig to assemble the floating seal, as shown in Figure 20. Check that the floating seal is parallel. Clean up its lapped surface.

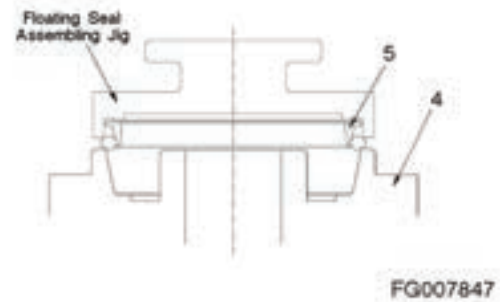


Figure 20

4. On one side of the shaft (3, Figure 21), assemble the O-ring (6, Figure 21) applied with thin oil (Figure 21).
5. Assemble the shaft (3, Figure 21) with the bearing to which floating seal has been attached.
6. Insert pin (7, Figure 21) into the bearing on which the shaft has been assembled.

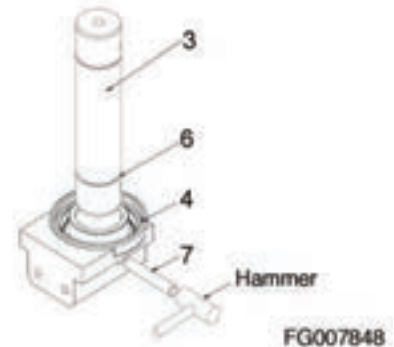


Figure 21

7. Using the assembling jig, assemble floating seal (5, Figure 14) at the front on which bushing has been assembled.
8. Apply oil to the lapped surface of the floating seal (5, Figure 14) which was assembled with the bearing.

NOTE: Use engine oil SAE #30/CD or higher grade.

9. Assemble bearing sub-assembly with the front to which the bushing and floating seal have been assembled (Figure 22).



Figure 22

10. Assemble shaft (3, Figure 14) with O-ring (6, Figure 14). Apply oil to O-ring to prevent damage when assembling bearing.
11. Apply oil to the lapped surface of the floating seal which was assembled with the bearing.
12. Assemble the bearing (4, Figure 23) on which the floating seal has been assembled.
13. Insert pin (7, Figure 23).
14. Rotate front or bearing by 3 rounds to left and right.
15. Assemble plug (8, Figure 23) to the bearing (4, Figure 23) on one side.

NOTE: Use 6mm L wrench to assemble plug, at torque 200kgf•cm

16. Inject oil through the plug hole.

NOTE: Oil quantity: 320cc (10.8 oz) ± 20cc

17. Assemble bearing (4, Figure 23) with plug (8, Figure 23).

NOTE: Use 6mm L wrench to assemble plug, at torque of 200kgf-cm

18. Assemble Idler Assembly with Track Spring assembly (Figure 24).

Assemble bolt and washer (10 and 11, Figure 24).

NOTE: Apply Loctite #243 to the bolt and washer (10 and 11, Figure 24).
Torque: 2700kgf-cm

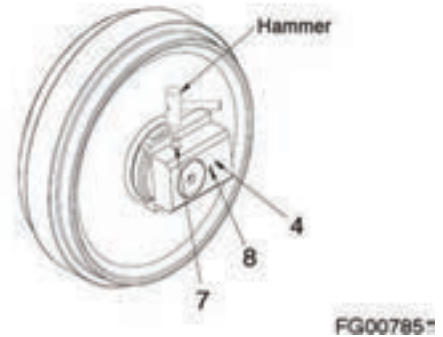


Figure 23

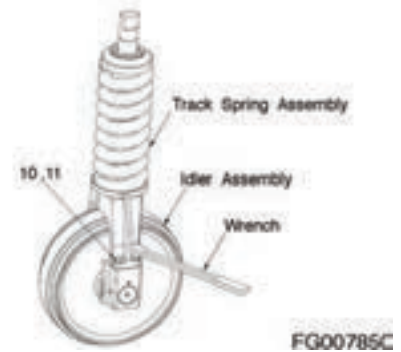


Figure 24

LOWER ROLLER

Parts List

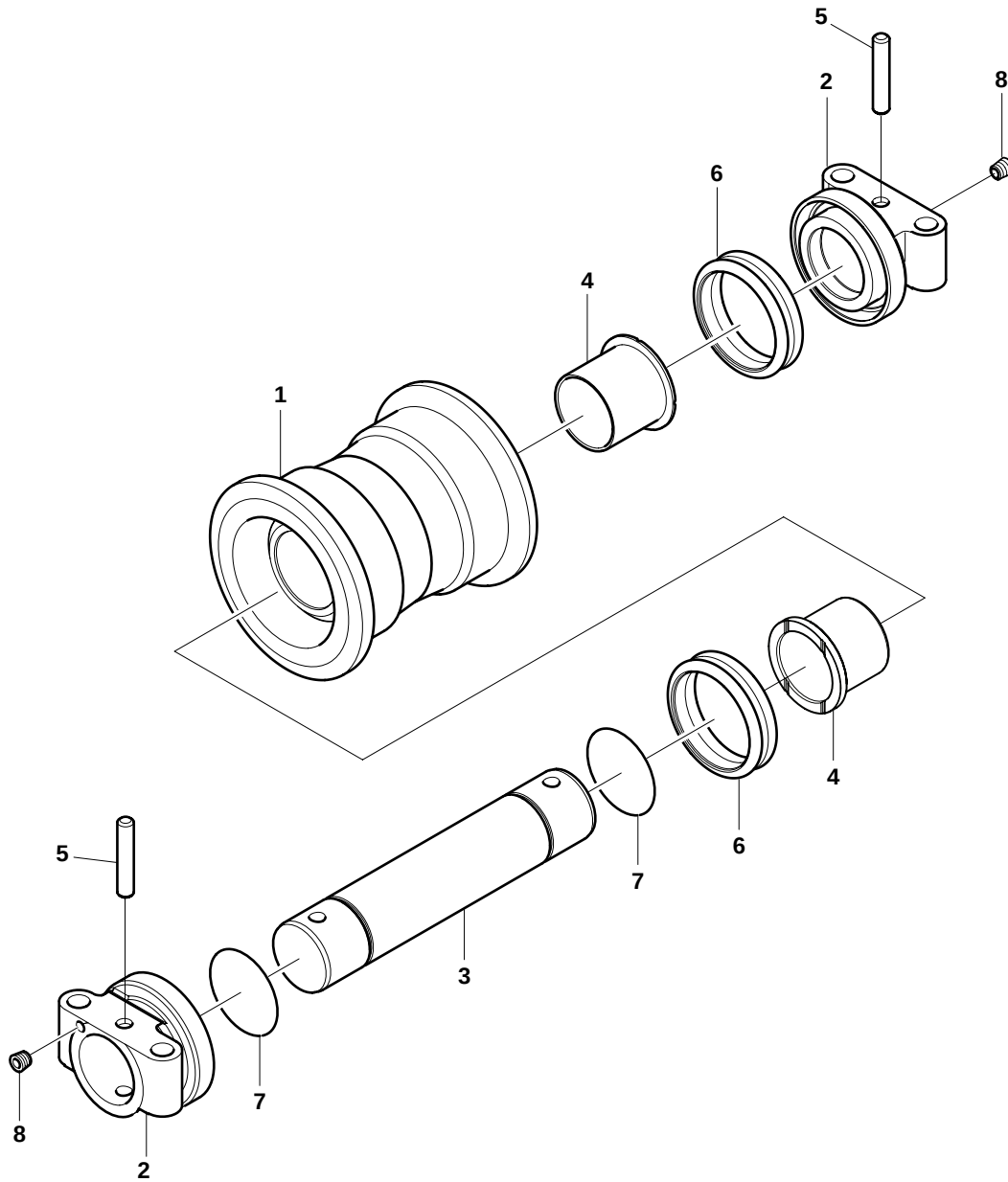


Figure 25

FG000483

Reference Number	Description
1	Roller
2	Collar
3	Shaft
4	Bushing

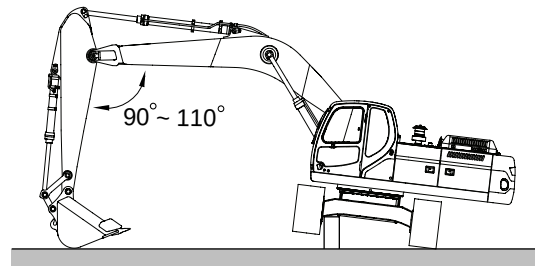
Reference Number	Description
5	Pin
6	Floating Seal
7	O-ring
8	Plug

Lower Roller Removal

1. Relieve track tension. Refer to "Track Tension" in this section for procedure.
2. Swing upper structure at 90° to frame.
3. Using bucket raise track off ground and place blocking under frame.
4. Remove four bolts and lower roller assembly from track frame. There is an alignment pin on each end of lower roller assembly.

NOTE: To gain access to some rollers the link guard may have to be removed. Remove four spring washers and bolts to remove guard.

NOTE: If additional track clearance is required, remove upper rollers before raising track.

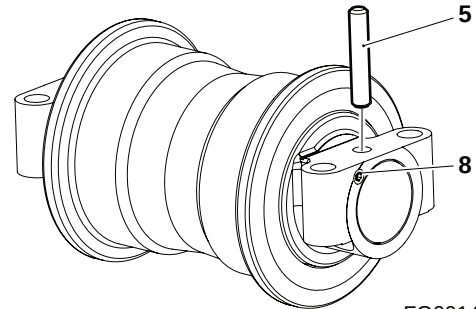


FG000345

Figure 26

Lower Roller Disassembly

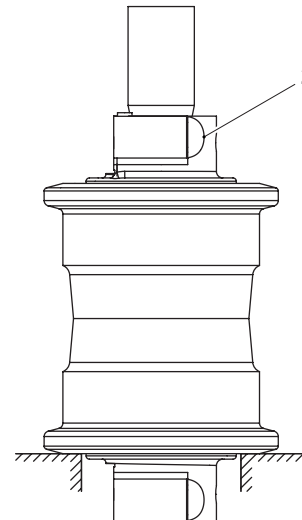
1. Remove plug (8, Figure 27) from the collar and drain oil.
2. Pull the pin (5, Figure 27) from the collar.



FG001489

Figure 27

3. Separate the collar (2, Figure 28) from the axle, using press.



FG001490

Figure 28

4. Detach O-rings (7, Figure 29) from the axle.
5. Separate floating seals (6, Figure 29) from the collar and roller (1).
6. Detach collar (2, Figure 29) and O-rings (7) from the axle, using press.

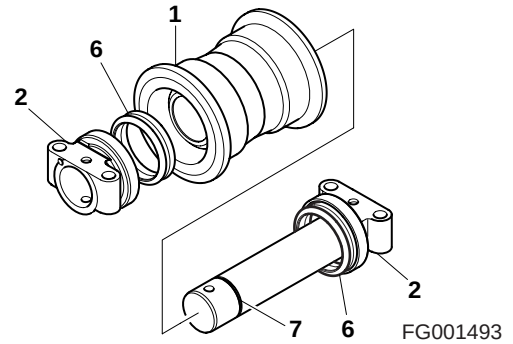


Figure 29

Lower Roller Reassembly

1. Degrease, clean and dry all parts before reassembly. Insert bushing (4, Figure 30) into roller.

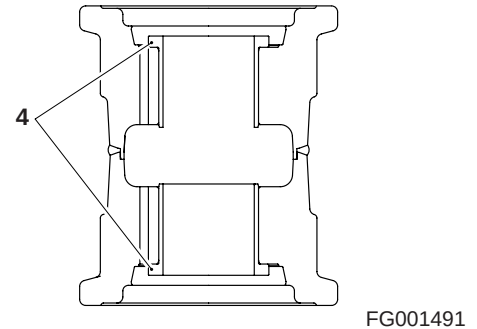


Figure 30

2. Apply grease to the O-rings (7, Figure 30) and insert into axle.
3. Align collar (2, Figure 31) and axle (3) pin holes and pin (5) the collar.

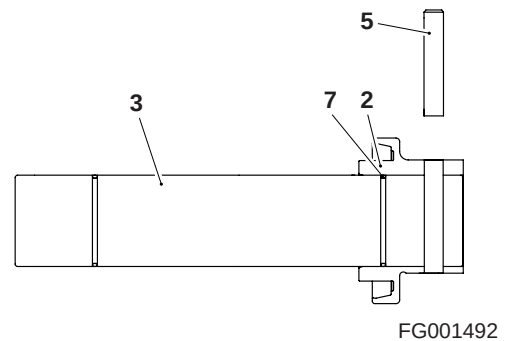


Figure 31

4. Insert floating seals (6, Figure 32) into the roller (1) and collar (2).

NOTE: Apply clean engine oil to the joint side of the floating seal. Apply grease to the floating seal O-ring.

5. Slide the axle inside the roller.

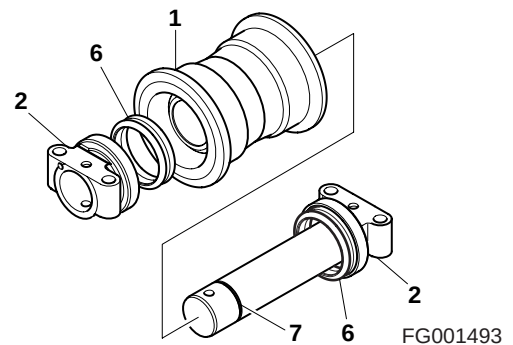


Figure 32

6. Install the collar (2, Figure 33), O-ring (7), and pin (5) on the remaining side.
7. Fill with clean engine oil with approximately 330 cc (11.2 oz).
8. Install plug (8, Figure 33) on the collar.

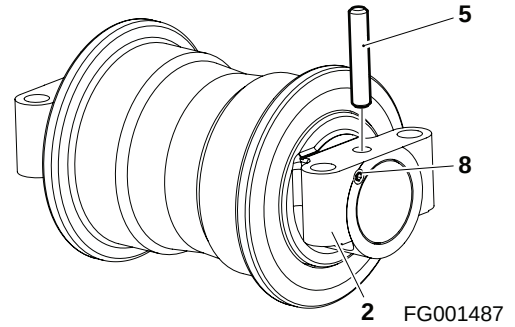


Figure 33

Lower Roller Installation

1. Install four bolts to hold lower roller assembly to track frame.

NOTE: *To gain access to some rollers a link guard may have to be removed. Remove four spring washers and bolts to remove guard.*

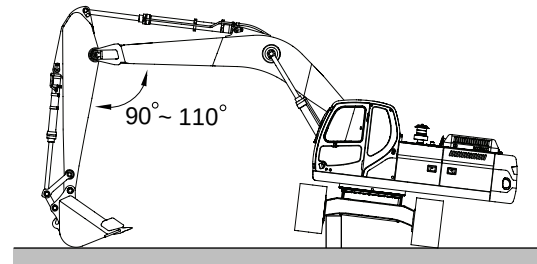
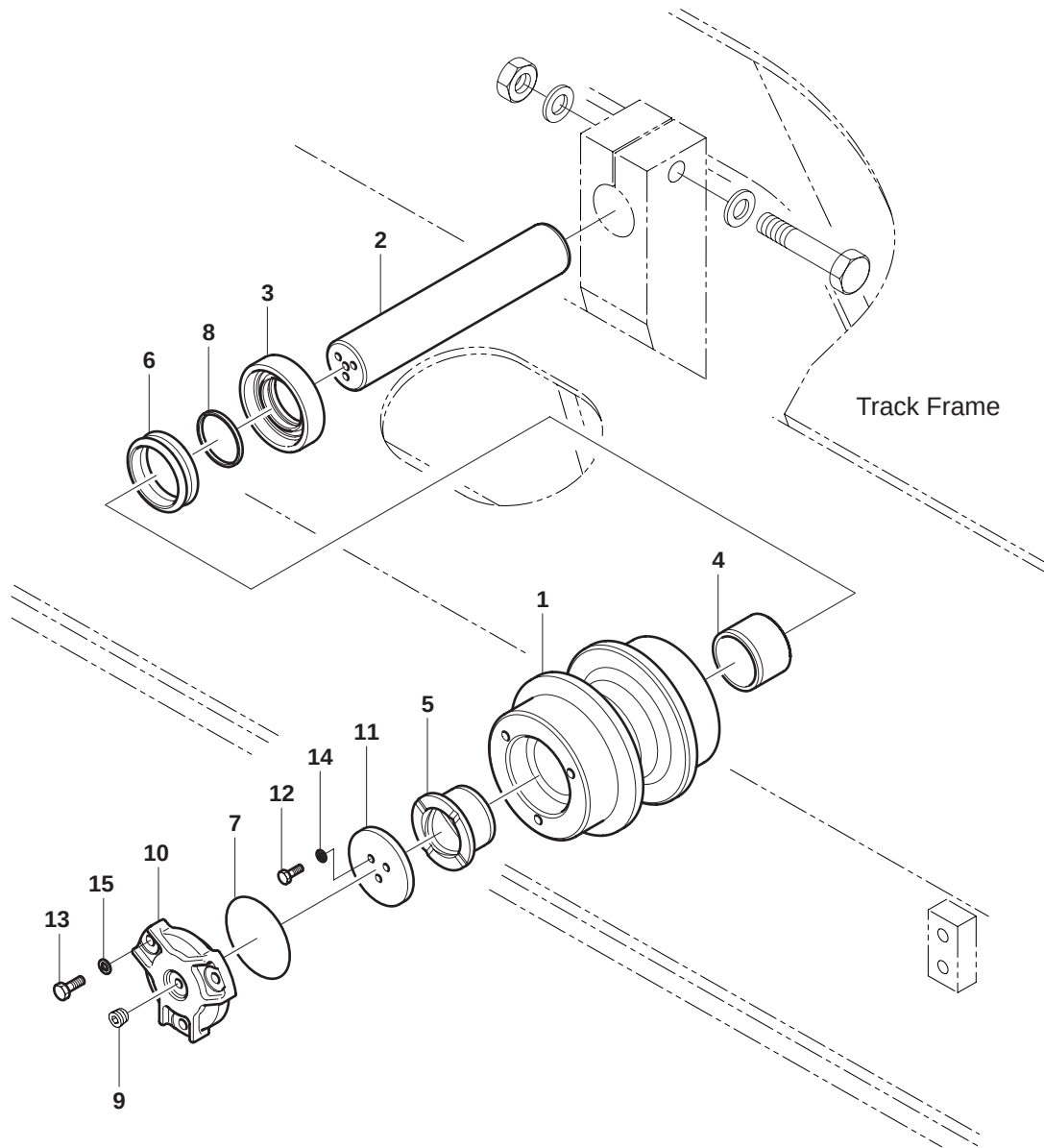


Figure 34

UPPER ROLLER

Parts List



FG001141

Figure 35

Reference Number	Description
1	Roller
2	Shaft
3	Thrust Ring
4	Bushing
5	Bushing
6	Floating Seal
7	O-ring
8	O-ring

Reference Number	Description
9	Plug
10	Cover
11	Washer
12	Bolt
13	Blot
14	Spring Washer
15	Spring Washer

Upper Roller Removal

1. Relieve track tension. This will allow track to be raised so that links clear top of roller.
2. Position a bottle jack on top of track frame and apply pressure to track shoe.
3. Remove mounting hardware holding upper roller assembly to track frame.

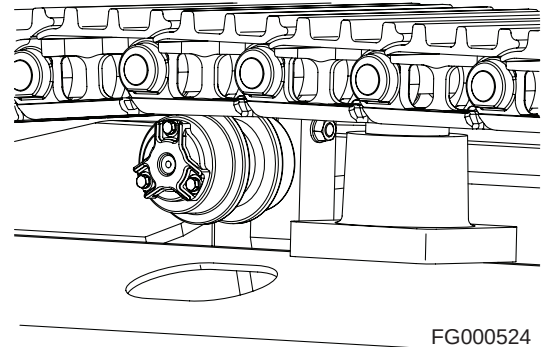
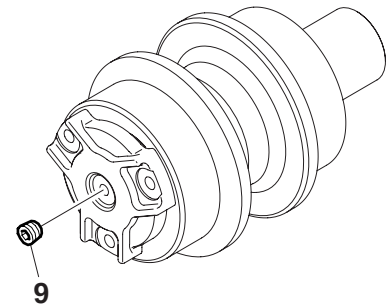


Figure 36

Upper Roller Disassembly

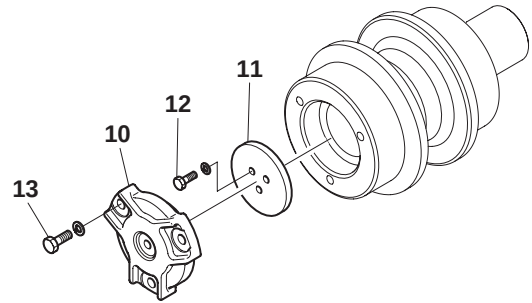
1. Remove the plug (9, Figure 37) from the cover and drain oil.



FG001494

Figure 37

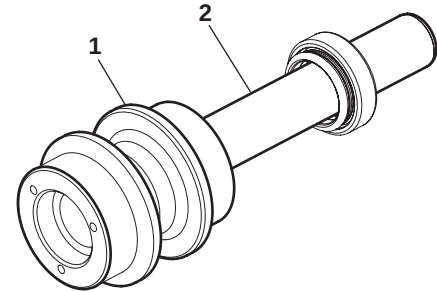
2. Remove the bolts (13, Figure 38) and cover (10). Detach bolts (12) and washer (11).



FG001495

Figure 38

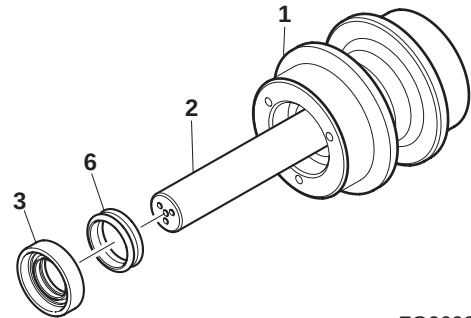
3. Separate the roller (1, Figure 39) from the axle (2).



FG009907

Figure 39

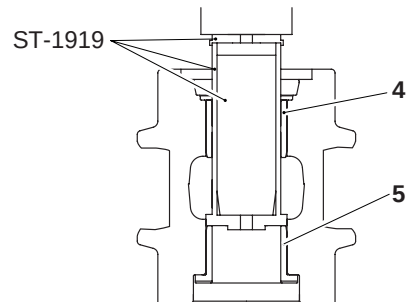
4. Separate the floating seal (6, Figure 40) from the roller.
5. Separate the O-ring (8) and thrust ring (3) from the axle.



FG009908

Figure 40

6. Separate the bushing (4 and 5, Figure 41) from the roller with a press and special tool (ST-1919).

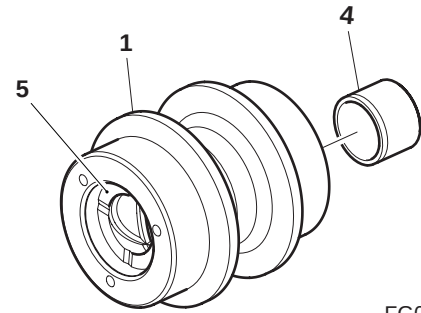


FG009909

Figure 41

Upper Roller Reassembly

1. Degrease, clean and dry all parts before reassembly.
Insert bushing (4 and 5, Figure 42) into the roller (1).



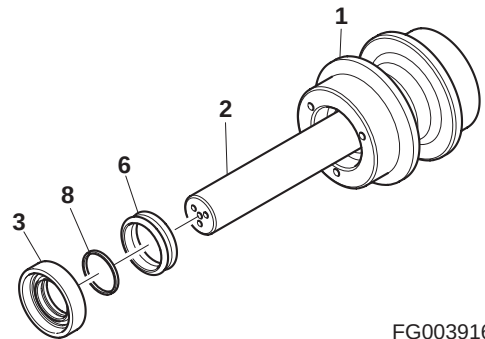
FG003917

Figure 42

2. Insert floating seal (6, Figure 43) into the roller (1) and bushing.

NOTE: Apply clean engine oil to the joint side of the floating seal. Apply grease to the floating seal O-ring.

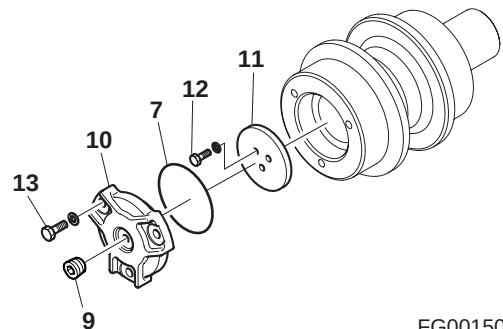
3. Install the axle (2), O-ring (8) and thrust ring (3).



FG003916

Figure 43

4. Install washer (11, Figure 44) and bolt (12).
5. Insert the O-ring (7, Figure 44) to the cover (10). Attach cover (10) and bolt (13) to the roller.
6. Fill with engine oil with 60cc.
7. Tighten plug (9, Figure 44).

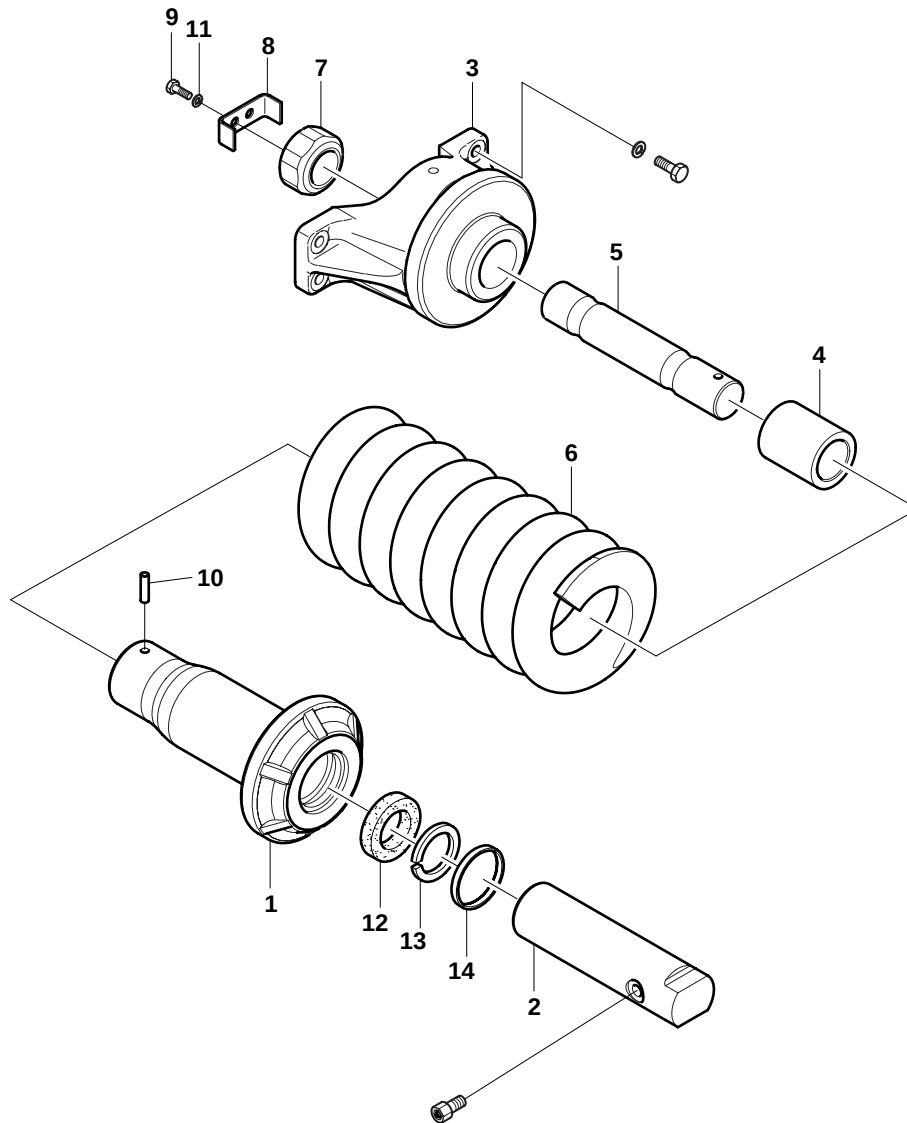


FG001501

Figure 44

TRACK SPRING AND TRACK ADJUSTING CYLINDER

Parts List



FG003918

Figure 45

Reference Number	Description
1	Cylinder
2	Piston Rod
3	Yoke
4	Spacer
5	Shaft
6	Spring
7	Lock Nut

Reference Number	Description
8	Lock Plate
9	Bolt
10	Spring Pin
11	Spring Washer
12	Packing
13	Backup Ring
14	Dust Seal

Engine and Drive Train

QSB4.5 Engine

Edition 1

MEMO

Table of Contents

QSB4.5 Engine

Safety Precautions.....	7
Applicable Models.....	7
QSB4.5 Engine	8
Important Reference Numbers	9
General Information	10
To the Owner and Operator	10
About the Manual.....	10
How to Use the Manual	11
Illustrations.....	11
General Safety Instructions	12
General Repair Instructions	15
General Cleaning Instructions	17
Fuel System	24
Acronyms and Abbreviations	25
Engine Identification	26
Engine Data Plate.....	26
Cummins® Engine Nomenclature	28
Fuel Injection Pump Dataplate.....	28
ECM Data Plate	28
Air Compressor (Not Used)	29
Engine Diagrams	30
Fan Control	35
Water-in-Fuel Sensor.....	36
Idle Shutdown	37
Accelerator Optionals	39
Intermediate Speed Control (ISC)	40
Alternate Droop.....	42
Switchable (Alternate) Torque	43
Multiple Unit Synchronization	44
Hot Shutdown Monitor	45
Automatic Boost Power	46
Fuel Consumption Rate Logger	47
Operating Instructions.....	48

Operating Instructions -Overview	48
General Information.....	48
Normal Starting Procedure	50
Jump Starting	52
Cold Weather Starting	53
Starting Procedure After Extended Shutdown or Oil Change	53
Operating the Engine	53
Engine Operating Range.....	56
Engine Shutdown	57
Electromagnetic Interference (EMI).....	57
Maintenance Guidelines	59
Maintenance Guidelines -Overview.....	59
Tool Requirements	59
Maintenance Schedule	60
Oil Drain Intervals.....	61
Maintenance Procedures at Daily Interval	62
Daily Maintenance Procedures - Overview	62
Air Tanks and Reservoirs	63
Crankcase Breather Tube	63
Fuel-Water Separator	64
Lubricating Oil Level.....	65
Drive Belts	65
Air Cleaner Restriction	67
Air Compressor (Not Used)	68
Charge-Air Cooler	68
Charge-Air Piping	68
Radiator Hoses.....	69
Air Intake Piping	69
Fan, Cooling	70
Coolant Level	71
Maintenance Procedures at 500 Hours or 6 Months.....	72
Maintenance Procedures - Overview	72
Cooling System	72

Fuel Filter (Spin-On Type)	77
Lubricating Oil and Filters	79
Maintenance Procedures at 1,000 Hours or 1 Year	82
Maintenance Procedures - Overview	82
Fan Hub, Belt Driven	83
Maintenance Procedures at 2,000 Hours or 2 Years	84
Air Compressor Discharge Lines (Not Used)	84
Cooling System	86
Vibration Damper, Rubber	91
Vibration Damper, Viscous	91
Overhead Set	92
Alternator	98
Charge-Air Cooler	104
Coolant Thermostat	109
Cooling Fan Belt Tensioner	114
Drive Belt, Cooling Fan	115
Fan Spacer and Pulley	116
Starting Motor	118
System Diagrams	123
General Information	123
Fuel System	124
Lubricating Oil System	126
Cooling System	131
Air Intake System	132
Exhaust System	133
Compressed Air System	135
Service Literature	136
Additional Service Literature	136
Service Literature Ordering Location	136
Cummins Customized Parts Catalog	136
Component Manufacturers Addresses	138
Service Assistance	142

Routine Service and Parts.....	142
Emergency and Technical Service.....	142
Problem Solving	142
Division and Regional Offices - Locations.....	144
Distributors and Branches - United States	146
Distributors and Branches - Canada	159
Distributors and Branches - Australia.....	161
Distributors and Branches - New Zealand.....	164
Regional Offices - International - Locations	165
Distributors - International - Locations.....	169
Troubleshooting Symptoms	195
Troubleshooting Procedures and Techniques.....	195
Troubleshooting Symptoms Charts	195
Maintenance Specifications	245
General Engine	245
Fuel System	246
Lubricating Oil System	247
Cooling System	248
Air Intake System	248
Exhaust System	248
Electrical System.....	249
Cummins/Fleetguard® Filter Specifications	250
Fuel Recommendations and Specifications	251
Lubricating Oil Recommendations and Specifications	253
Coolant Recommendations and Specifications.....	256
Drive Belt Tension	259
Engine Component Torque Values	260
Sealants	260
Cap Screw Markings and Torque Values.....	261
Warranty	264
All Engines United States and Canada Industrial (Off-Highway)	264
All Engines International Industrial (Off-Highway).....	268
California Emission Control System Warranty, Off-Highway.....	271

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.

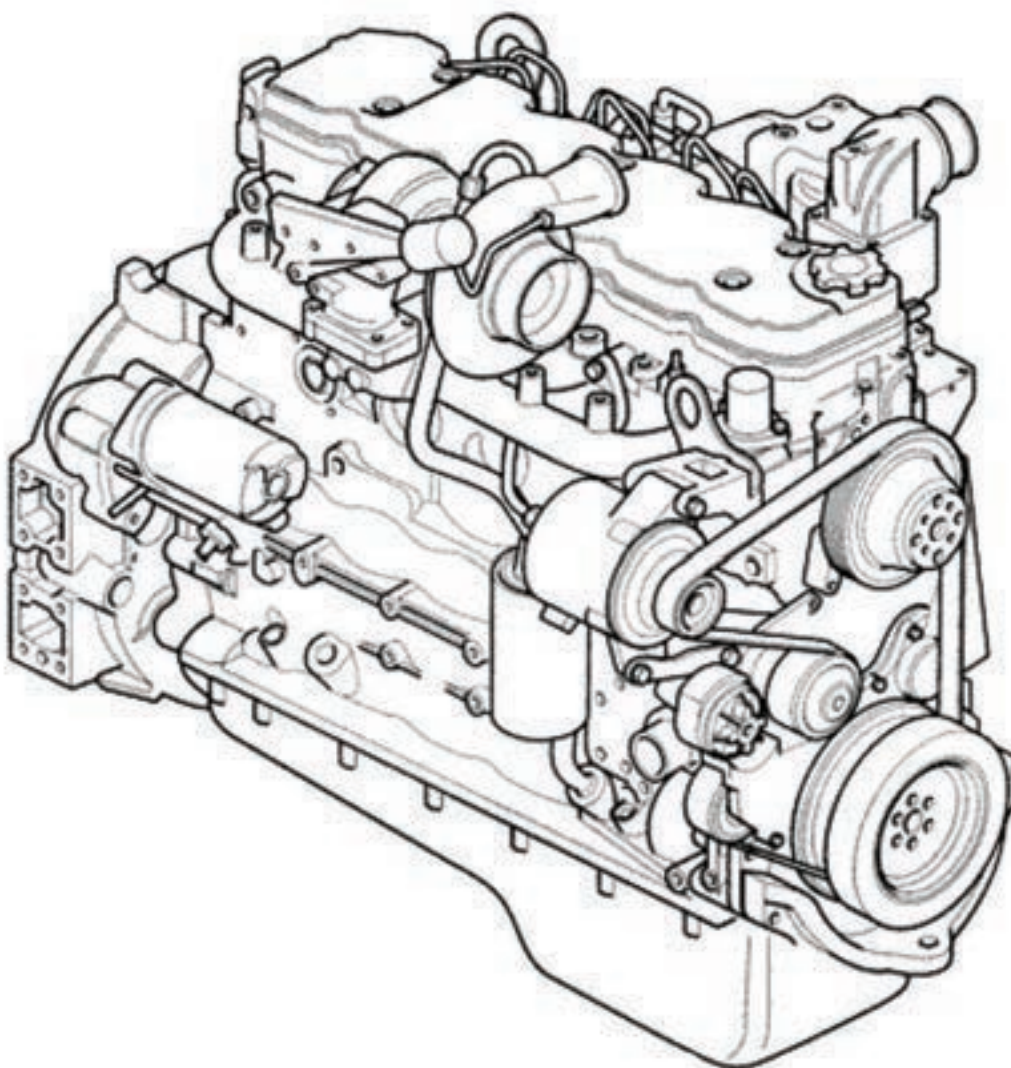
Remember, that ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX140LCR	5001 and Up

QSB4.5 ENGINE



FG013907

Figure 1

Important Reference Numbers

Fill in the part name and number in the blank spaces provided below. This will give you a reference whenever service or maintenance is required.

Part Name		Part Number
Engine Model		QSB4.5
Engine Serial Number (ESN)		
Control Parts List (CPL)		
Fuel Pump Part Number		
Electronic Control Module (ECM)		
Electronic Control Module Serial Numbers (ECM)		
Filter Part Numbers		
Air Cleaner Element		
Lubricating Oil Filter	DOOSAN	
	Cummins	
	Fleetguard	
Fuel Filter; Main	DOOSAN	
	Cummins	
	Fleetguard	
Fuel-Water Separator; Pre	DOOSAN	
	Mannhumel	
Coolant Filter	DOOSAN	
	Cummins	
	Fleetguard	
Crankcase Ventilation	DOOSAN	
	Cummins	
	Fleetguard	
Cummins Particulate Filter		
Governor Control Module (GCM) (if applicable)		
Belt Part Numbers:		
Clutch or Marine Gear (if applicable):		
Model		
Serial Number		
Part Number		
Oil Type		
Sea Water Pump		
Model		
Part Number		

GENERAL INFORMATION

To the Owner and Operator

Preventive maintenance is the easiest and least expensive type of maintenance. Follow the maintenance schedule recommendations outlined in "Maintenance Guidelines" on page-59.

Keep records of regularly scheduled maintenance.

Use the correct fuel, lubricating oil, and coolant in your engine as specified in "Maintenance Specifications" on page-245. Blending engine oil with fuel is prohibited for engines with an aftertreatment system.

Cummins Inc. uses the latest technology and the highest quality components to produce its engines. Cummins Inc. recommends using genuine Cummins new parts and ReCon® exchange parts.

Personnel at Cummins Authorized Repair Locations have been trained to provide expert service and parts support. If you have a problem that cannot be resolved by a Cummins Authorized Repair Location, follow the steps outlined in the "Service Assistance" on page-142.

Product coverage, warranty limitations and owner responsibilities are available in "Warranty" on page-264.



CAUTION!

Disconnect both the positive (+) and negative (-) battery cables from the battery before welding on the vehicle. Attach the welder ground cable no more than 0.61 meters [2 feet] from the part being welded. Do not connect the ground cable of the welder to the ECM cooling plate or ECM. Welding on the engine or engine mounted components is not recommended.

About the Manual

This manual contains information needed to correctly operate and maintain your engine as recommended by Cummins Inc. For additional service literature and ordering locations, refer to "Service Literature" on page-136.

This manual does not cover vehicle, vessel, or equipment maintenance procedures. Consult the original vehicle, vessel, or equipment manufacturer for specific maintenance recommendations.

Both metric and U.S. customary values are listed in this manual. The metric value is listed first, followed by the U.S. customary in brackets.

Numerous illustrations and symbols are used to aid in understanding the meaning of the text. Refer to Symbols in this section for a complete listing of symbols and their definitions.

Each section of the manual is preceded by a Section Contents to aid in locating information.

How to Use the Manual

This manual is organized according to intervals at which maintenance on your engine is to be performed. A maintenance schedule, that states the required intervals and maintenance checks, is located in "Maintenance Guidelines" on page-59. Locate the interval at which you are performing maintenance; then follow the steps given in that section for all the procedures to be performed.

Keep a record of all the checks and inspections made. A maintenance record form is located in "Maintenance Guidelines" on page-59.

Engine troubleshooting procedures for your engine are located in "Troubleshooting Symptoms" on page-195.

Specifications for your engine are located in "Maintenance Specifications" on page-245.

Illustrations

Some of the illustrations throughout this manual are generic and will not look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required and an acceptable or not acceptable condition.

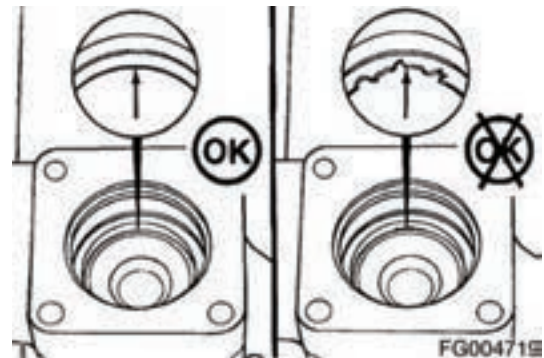


Figure 2

The illustrations are intended to show repair or replacement procedures. The procedure will be the same for all applications, although the illustration can differ.

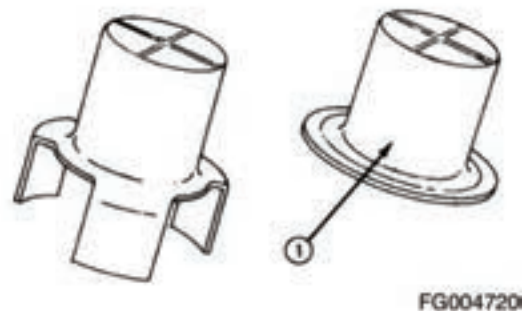


Figure 3

General Safety Instructions

Important Safety Notice



WARNING!

Improper practices, carelessness, or ignoring the warnings can cause burns, cuts, mutilation, asphyxiation or other personal injury or death.

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that must be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Work in an area surrounding the product that is dry, well lit, ventilated, free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- Always wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do not wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work.
Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do Not Operate" tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do not attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before slowly loosening the fill cap to relieve the pressure from the cooling system.
- Always use blocks or proper stands to support the product before performing any service work. Do not work on anything that is supported ONLY by lifting jacks or a hoist.
- Relieve all pressure in the air, oil, fuel, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do not check for pressure leaks with your hand. High-pressure oil or fuel can cause personal injury.

- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (Freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems must be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capturing and recycling refrigerant.
- To reduce the possibility of personal injury, use a hoist or get assistance when lifting components that weigh 23 kg (50 lb) or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. Always use a spreader bar when necessary.
The lifting hooks must not be side-loaded.
- Corrosion inhibitor, a component of SCA and lubricating oil, contains alkali. Do not get the substance in eyes. Avoid prolonged or repeated contact with skin. Do not swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and must be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and must be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To reduce the possibility of burns, be alert for hot parts on products that have just been turned off, and hot fluids in lines, tubes, and compartments.
- Always use tools that are in good condition. Make sure you understand how to use the tools before performing any service work. Use ONLY genuine Cummins or Cummins ReCon® replacement parts.
- Always use the same fastener part number (or equivalent) when replacing fasteners. Do not use a fastener of lesser quality if replacements are necessary.
- Do not perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.

- Liquefied petroleum gas is heavier than air and can accumulate near the floor, in sumps, and low-lying areas.
- Natural gas is lighter than air and can accumulate under hood and awnings.
- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect natural gas and liquefied petroleum gas lines in a well ventilated area.
- Coolant is toxic. If not reused, dispose of in accordance with local environmental regulations.
- California Proposition 65 Warning -Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

General Repair Instructions

General Information

This engine incorporates the latest technology at the time it was manufactured; yet, it is designed to be repaired using normal repair practices performed to quality standards.

- Cummins Inc. does not recommend or authorize any modifications or repairs to engines or components except for those detailed in Cummins Service Information. In particular, unauthorized repair to safety related components can cause personal injury or death. Below is a partial listing of components classified as safety-related:

1. Air Compressor
2. Air Controls
3. Air Shutoff Assemblies
4. Balance Weights
5. Cooling Fan
6. Fan Hub Assembly
7. Fan Mounting Bracket(s)
8. Fan Mounting Capscrews
9. Fan Hub Spindle
10. Flywheel
11. Flywheel Crankshaft Adapter
12. Flywheel Mounting Capscrews
13. Fuel Shutoff Assemblies
14. Fuel Supply Tubes
15. Lifting Brackets
16. Throttle Controls
17. Turbocharger Compressor Casing
18. Turbocharger Oil Drain Line(s)
19. Turbocharger Oil Supply Line(s)
20. Turbocharger Turbine Casing
21. Vibration Damper Mounting Capscrews

- Follow all safety instructions noted in the procedures

Follow the manufacturer's recommendations for cleaning solvents and other substances used during the repair of the engine. Some solvents and used engine oil have been identified by government agencies as toxic or carcinogenic. Avoid excessive breathing, ingestion and contact with such substances. Always use good safety practices with tools and equipment.

- Provide a clean environment and follow the cleaning instructions specified in the procedures
The engine and its components must be kept clean during any repair. Contamination of the engine or components will cause premature wear.
- Perform the inspections specified in the procedures
- Replace all components or assemblies which are damaged or worn beyond the specifications
- Use genuine Cummins new or ReCon[®] service parts and assemblies

The assembly instructions have been written to use again as many components and assemblies as possible.

When it is necessary to replace a component or assembly, the procedure is based on the use of new Cummins or Cummins ReCon[™] components. All of the repair services described in this manual are available from all Cummins Distributors and most Dealer locations.

- Follow the specified disassembly and assembly procedures to reduce the possibility of damage to the components

Complete rebuild instructions are available in the shop manual which can be ordered or purchased from a Cummins Authorized Repair Location.

Welding on a Vehicle with an Electronic Controlled Fuel System



CAUTION!

Disconnect both the positive (+) and negative (-) battery cables from the battery before welding on the vehicle. Attach the welder ground cable no more than 0.61 meters (2 feet) from the part being welded. Do not connect the ground cable of the welder to the ECM cooling plate or ECM. Welding on the engine or engine mounted components is not recommended or damage to the engine or components can result.

General Cleaning Instructions

Definition of Clean

Parts must be free of debris that can contaminate any engine system. This does not necessarily mean they have to appear as new.

Sanding gasket surfaces until the factory machining marks are disturbed adds no value and is often harmful to forming a seal. It is important to maintain surface finish and flatness tolerances to form a quality sealing surface. Gaskets are designed to fill small voids in the specified surface finish.

Sanding gasket surfaces where edge-molded gaskets are used is most often unnecessary. Edge-molded gaskets are those metal carriers with sealing material bonded to the edges of the gasket to seal while the metal portion forms a metal to metal joint for stability. Any of the small amounts of sealing material that can stick to the parts are better removed with a blunt-edged scraper on the spots rather than spending time polishing the whole surface with an air sander or disk.

For those gaskets that do not have the edge molding, nearly all have a material that contains release agents to prevent sticking. Certainly this is not to say that some gaskets are not difficult to remove because the gasket has been in place a long time, has been overheated or the purpose of the release agent has been defeated by the application of some sealant. The object however is just to remove the gasket without damaging the surfaces of the mating parts without contaminating the engine (don't let the little bits fall where they cannot be removed).

Bead blasting piston crowns until the dark stain is removed is unnecessary. All that is required is to remove the carbon build-up above the top ring and in the ring grooves. There is more information on bead blasting and piston cleaning later in this document.

Cummins Inc. does not recommend sanding or grinding the carbon ring at the top of cylinder liners until clean metal is visible. The liner will be ruined and any signs of a problem at the top ring reversal point (like a dust-out) will be destroyed. It is necessary to remove the carbon ring to provide for easier removal of the piston assembly. A medium bristle, high quality, steel wire wheel that is rated above the rpm of the power tool being used will be just as quick and there will be less damage. Yes, one must look carefully for broken wires after the piston is removed but the wires are more visible and can be attracted by a magnet.

Oil on parts that have been removed from the engine will attract dirt in the air. The dirt will adhere to the oil. If possible, leave the old oil on the part until it is ready to be cleaned, inspected and installed, and then clean it off along with any attracted dirt. If the part is cleaned then left exposed it can have to be cleaned again before installation. Make sure parts are lubricated with clean oil before installation.

They do not need to be oiled all over but do need oil between moving parts (or a good lube system priming process conducted before cranking the engine).

Bead blasting parts to remove exterior paint is also usually unnecessary. The part will most likely be painted again so all that needs happen is remove any loose paint.

Abrasive Pads and Abrasive Paper

The keyword here is "abrasive." There is no part of an engine designed to withstand abrasion. That is they are all supposed to lock together or slide across each other. Abrasives and dirt particles will degrade both functions.



WARNING!

Abrasive material must be kept out of or removed from oil passages and parts wear points. Abrasive material in oil passages can cause bearing and bushing failures that can progress to major component damage beyond reuse. This is particularly true of main and rod bearings.

Cummins Inc. does not recommend the use of emery cloth or sand paper on any part of an assembled engine or component including but not limited to removing the carbon ridge from cylinder liners or to clean block decks or counterbores.

Great care must be taken when using abrasive products to clean engine parts, particularly on partially assembled engines. Abrasive cleaning products come in many forms and sizes. All of them contain aluminum oxide particles, silicon carbide, or sand or some other similar hard material. These particles are harder than most of the parts in the engine. Since they are harder, if they are pressed against softer material they will either damage the material or become embedded in it. These materials fall off the holding media as the product is used. If the products are used with power equipment the particles are thrown about the engine. If the particles fall between two moving parts, damage to the moving parts is likely.

If particles that are smaller than the clearance between the parts while they are at rest (engine stopped), but larger than the running clearance then damage will occur when the parts move relative to each other (engine started). While the engine is running and there is oil pressure, particles that are smaller than the bearing clearance are likely to pass between the parts without damage and be trapped in the oil filter. However, particles larger than the bearing clearance QSL9 Engines General Cleaning Instructions Section i - Introduction Page i-9 will remove material from one part and can become embedded in one of the parts. Once embedded in one part it will abrade the other part until contact is no longer being made between the two parts. If the damage sufficiently degrades the oil film, the two parts will come into contact resulting in early wear-out or failure from lack of effective lubrication.

Abrasive particles can fly about during cleaning it is very important to block these particles from entering the engine as much as possible. This is particularly true of lubricating oil ports and oil drilling holes, especially those located downstream of the lubricating oil filters. Plug the holes instead of trying to blow the abrasive particles and debris with compressed air because the debris is often simply blown further into the oil drilling.

All old gasket material must be removed from the parts gasket surfaces. However, it is not necessary to clean and polish the gasket surface until the machining marks are erased. Excessive sanding or buffing can damage the gasket surface. Many newer gaskets are of the edge molded type (a steel carrier with a sealing member bonded to the steel). What little sealing material that can adhere is best removed with a blunt-edged scraper or putty knife. Cleaning gasket surfaces where an edge-molded gasket is used with abrasive pads or paper is usually a waste of time.



WARNING!

Excessive sanding or grinding the carbon ring from the top of the cylinder liners can damage the liner beyond reuse. The surface finish will be damaged and abrasive particles can be forced into the liner material which can cause early cylinder wear-out or piston ring failures.

Tape off or plug all openings to any component interior before using abrasive pads or wire brushes. If really necessary because of time to use a power tool with abrasive pads, tape the oil drillings closed or use plug and clean as much of the surface as possible with the tool but clean around the oil hole/opening by hand so as to prevent contamination of the drilling. Then remove the tape or plug and clean the remaining area carefully and without the tool. DO NOT use compressed air to blow the debris out of oil drilling on an assembled engine! More likely than not, the debris can be blown further into the drilling. Using compressed air is fine if both ends of the drilling are open but that is rarely the case when dealing with an assembled engine.

Gasket Surfaces

The object of cleaning gasket surfaces is to remove any gasket material, not refinish the gasket surface of the part.

Cummins Inc. does not recommend any specific brand of liquid gasket remover. If a liquid gasket remover is used, check the directions to make sure the material being cleaned will not be harmed.

Air powered gasket scrapers can save time but care must be taken to not damage the surface. The angled part of the scraper must be against the gasket surface to prevent the blade from digging into the surface. Using air powered gasket scrapers on parts made of soft materials takes skill and care to prevent damage.

Do not scrape or brush across the gasket surface if at all possible.

Solvent and Acid Cleaning

Several solvent and acid-type cleaners can be used to clean the disassembled engine parts (other than pistons. See Below). Experience has shown that the best results can be obtained using a cleaner that can be heated to 90° to 95° Celsius (180° to 200° Fahrenheit). Kerosene emulsion based cleaners have different temperature specifications, see below. A cleaning tank that provides a constant mixing and filtering of the cleaning solution will give the best results. Cummins Inc. does not recommend any specific cleaners. Always follow the cleaner manufacturer's instructions. Remove all the gasket material, O-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful not to damage any gasket surfaces. When possible, steam clean the parts before putting them in the cleaning tank.



WARNING!

When using solvents, acids, or alkaline materials for cleaning, follow the manufacturers recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Experience has shown that kerosene emulsion based cleaners perform the best to clean pistons. These cleaners should not be heated to temperature in excess of 77°C (170°F). The solution begins to break down at temperatures in excess of 82°C (180°F) and will be less effective.

Do not use solutions composed mainly of chlorinated hydrocarbons with cresols, phenols and/or cresylic components. They often do not do a good job of removing deposits from the ring groove and are costly to dispose of properly.

Solutions with a pH above approximately 9.5 will cause aluminum to turn black; therefore do not use high alkaline solutions.

Chemicals with a pH above 7.0 are considered alkaline and those below 7.0 are acidic. As you move further away from the neutral 7.0, the chemicals become highly alkaline or highly acidic.

Remove all the gasket material, O-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful to not damage any gasket surfaces. When possible use hot high-pressure water or steam clean the parts before putting them in the cleaning tank. Removing the heaviest dirt before placing in the tank will allow the cleaner to work more effectively and the cleaning agent will last longer.

Rinse all the parts in hot water after cleaning. Dry completely with compressed air. Blow the rinse water from all the cap screw holes and the oil drillings.

If the parts are not to be used immediately after cleaning, dip them in a suitable rust proofing compound. The rust proofing compound must be removed from the parts before assembly or installation on the engine.

Steam Cleaning

Steam cleaning can be used to remove all types of dirt that can contaminate the cleaning tank. It is a good method for cleaning the oil drillings and coolant passages



WARNING!

When using a steam cleaner, wear safety glasses or a face shield, and protective clothing. Hot steam can cause serious personal injury.

Do not steam clean the following components:

- Electrical Components
- Wiring Harnesses
- Injectors
- Fuel Pump
- Belts and Hoses
- Bearings (ball or taper roller)
- Electronic Control Module (ECM)
- ECM Connectors

Plastic Bead Cleaning

Cummins Inc. does not recommend the use of glass bead blast or walnut shell media on any engine part. Cummins Inc. recommends using only plastic bead media, Part Number 3822735 or equivalent on any engine part. Never use sand as a blast media to clean engine parts. Glass and walnut shell media when not used to the media manufacturer's recommendations can cause excess dust and can embed in engine parts that can result in premature failure of components through abrasive wear.

Plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the use of plastic beads, the operating pressure and cleaning time.



CAUTION!

Do not use bead blasting cleaning methods on aluminum pistons skirts or the pin bores in any piston, piston skirt or piston crown. Small particles of the media will embed in the aluminum or other soft metal and result in premature wear of the cylinder liner, piston rings, pins and pin bores. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.



CAUTION!

Do not contaminate wash tanks and tank type solvent cleaners with the foreign material and plastic beads. Remove the foreign material and plastic beads with compressed air, hot high-pressure water or steam before placing them in tanks or cleaners. The foreign material and plastic beads can contaminate the tank and any other engine parts cleaned in the tank. Contaminated parts may cause failures from abrasive wear.

Plastic bead blasting media, Part Number 3822735, can be used to clean all piston ring grooves. Do not use any bead blasting media on piston pin bores or aluminum skirts.

Follow the equipment manufacturer's cleaning instructions. Make sure to adjust the air pressure in the blasting machine to the bead manufacturer's recommendations. Turning up the pressure can move material on the part and cause the plastic bead media to wear out more quickly. The following guidelines can be used to adapt to manufacturer's instructions:

1. Bead size: U.S. size Number 16 - 20 for piston cleaning with plastic bead media, Part Number 3822735
2. Operating Pressure - 270 kPa (40 psd) for piston cleaning. Pressure should not cause beads to break.
3. Steam clean or wash the parts with solvent to remove all of the foreign material and plastic beads after cleaning. Rinse with hot water. Dry with compressed air.



CAUTION!

The bead blasting operation must not disturb the metal surface. If the metal surface is disturbed the engine can be damaged due to increased parts clearance or inadequate surface finish on parts that move against other parts.

When cleaning pistons, it is not necessary to remove all the dark stain from the piston. All that is necessary is to remove the carbon on the rim and in the ring grooves. This is best done by directing the blast across the part as opposed to straight at the part. If the machining marks are disturbed by the blasting process, then the pressure is too high or the blast is being held on one spot too long. The blast operation must not disturb the metal surface.

Walnut shell bead blast material is sometimes used to clean ferrous metals (iron and steel). Walnut shell blasting produces a great amount of dust particularly when the pressure of the air pressure on the blasting machine is increased above media manufacturer's recommendation. Cummins Inc. recommends not using walnut shell media to clean engine parts due to the risk media embedment and subsequent contamination of the engine.

Cummins Inc. now recommends glass bead media NOT used to clean any engine parts. Glass media is too easily embedded into the material particularly in soft materials and when air pressures greater than media manufacturer's recommend are used. The glass is an abrasive so when it is in a moving part, that part is abrading all the parts in contact with it. When higher pressures are used the media is broken and forms a dust of a very small size that floats easily in the air. This dust is very hard to control in the shop, particularly if only compressed air (and not hot water) is used to blow the media after it is removed from the blasting cabinet (blowing the part off inside the cabinet may remove large accumulations but never removes all the media).

Bead blasting is best used on stubborn dirt/carbon build-up that has not been removed by first steam/higher pressure washing then washing in a heated wash tank. This is particularly true of pistons. Steam and soak the pistons first then use the plastic bead method to safely remove the carbon remaining in the grooves (instead of running the risk of damaging the surface finish of the groove with a wire wheel or end of a broken piston ring. Make sure the parts are dry and oil free before bead blasting to prevent clogging the return on the blasting machine.

Always direct the bead blaster nozzle "across" rather than directly at the part. This allows the bead to get under the unwanted material. Keep the nozzle moving rather than hold on one place. Keeping the nozzle directed at one-place too long causes the metal to heat up and be moved around. Remember that the spray is not just hitting the dirt or carbon. If the machining marks on the piston groove or rim have been disturbed then there has not been enough movement of the nozzle and/or the air pressure is too high.

Never bead blast valve stems. Tape or use a sleeve to protect the stems during bead blasting. Direct the nozzle across the seat surface and radius rather than straight at them. The object is to remove any carbon build up and continuing to blast to remove the stain is a waste of time.

Fuel System

When servicing any fuel system components, which can be exposed to potential contaminants, prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed. If the surrounding areas are not cleaned, dirt or contaminants can be introduced into the fuel system.

The internal drillings of some injectors are extremely small and susceptible to plugging from contamination. Some fuel injection systems can operate at very high pressures. High pressure fuel can convert simple particles of dirt and rust into a highly abrasive contaminant that can damage the high pressure pumping components and fuel injectors.

Electrical contact cleaner can be used if steam cleaning tools are not available. Use electrical contact cleaner rather than compressed air, to wash dirt and debris away from fuel system fittings. Diesel fuel on exposed fuel system parts attracts airborne contaminants.

Choose lint free towels for fuel system work.

Cap and plug fuel lines, fittings, and ports whenever the fuel system is opened. Rust, dirt, and paint can enter the fuel system whenever a fuel line or other component is loosened or removed from the engine. In many instances, a good practice is to loosen a line or fitting to break the rust and paint loose, and then clean off the loosened material.

When removing fuel lines or fittings from a new or newly-painted engine, make sure to remove loose paint flakes/chips that can be created when a wrench contacts painted line nuts or fittings, or when quick disconnect fittings are removed.

Fuel filters are rated in microns. The word micron is the abbreviation for a micrometer, or one millionth of a meter. The micron rating is the size of the smallest particles that will be captured by the filter media. As a reference, a human hair is 0.003 mm (3/1000 in) in diameter. One micron measures 0.00004 mm (4/100,000 in). The contaminants being filtered out are smaller than can be seen with the human eye, a magnifying glass, or a low powered microscope.

The tools used for fuel system troubleshooting and repair are to be cleaned regularly to avoid contamination. Like fuel system parts, tools that are coated with oil or fuel attract airborne contaminants. Remember the following points regarding your fuel system tools:

- Fuel system tools are to be kept as clean as possible.
- Clean and dry the tools before returning them to the tool box.
- If possible, store fuel system tools in sealed containers.
- Make sure fuel system tools are clean before use.

Acronyms and Abbreviations

The following list contains some of the acronyms and abbreviations used in this manual.

API	American Petroleum Institute	kPa	Kilo Pascal
ASTM	American Society of Testing and Materials	LNG	Liquid Natural Gas
BTU	British Thermal Unit	LTA	Low Temperature After Cooling
°C	Celsius	MPa	Mega Pascal
CARB	California Air Resources Board	mph	Miles Per Hour
C.I.D.	Cubic Inch Displacement	mpq	Miles Per Quart
CNG	Compressed Natural Gas	Nm	Newton-meter
CPL	Control Parts List	NG	Natural Gas
cSt	Centistokes	OEM	Original Equipment Manufacturer
ECM	Electronic Control Module	PID	Parameter Identification Descriptions
EGR	Exhaust Gas Recirculation	ppm	Parts Per Million
EPA	Environmental Protection Agency	psi	Pounds Per Square Inch
°F	Fahrenheit	PTO	Power Takeoff
FMI	Failure Mode Identifier	RGT	Rear Gear Train
GVW	Gross Vehicle Weight	rpm	Revolutions Per Minute
LPG	Liquefied Petroleum Gas	SAE	Society of Automotive Engineers
Hg	Mercury	SCA	Supplemental Coolant Additive
hp	Horsepower	STC	Step Timing Control
H₂O	Water	SID	Subsystem Identification Descriptions
ICM	Ignition Control Module	VS	Variable Speed
km/l	Kilometers per Liter	VSS	Vehicle Speed Sensor

ENGINE IDENTIFICATION

Engine Data Plate

The engine data plate provides important facts about the engine. The engine serial number (ESN) and control parts list (CPL) provide information for service and ordering parts. The engine data plate must not be changed unless approved by Cummins Inc.

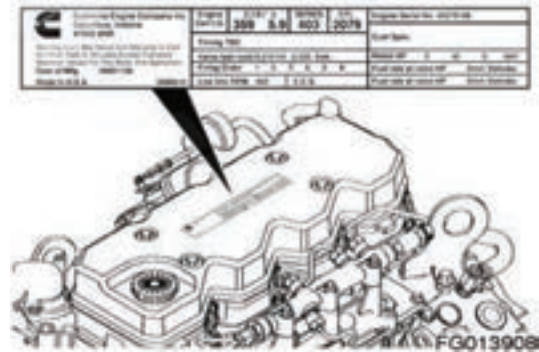


Figure 4

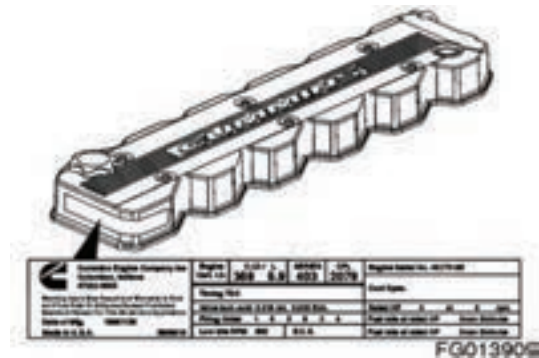
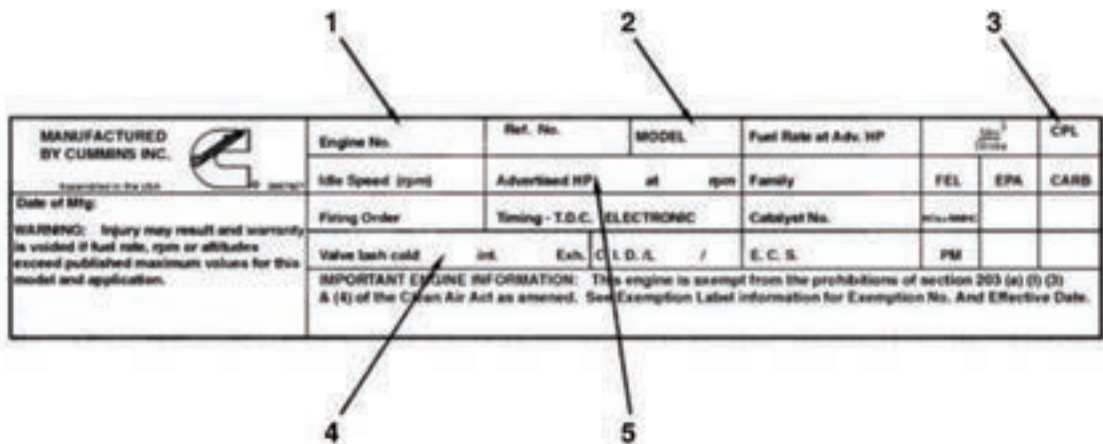


Figure 5



FG013910

Figure 6

Reference Number	Description
1	Engine serial number
2	Engine model information
3	Control parts list (CPL)

Reference Number	Description
4	Valve lash (overhead) setting
5	Horsepower and rpm rating

FG013911

Figure 7

Reference Number	Description
1	Engine serial number
2	Engine model information

Reference Number	Description
3	Horsepower and rpm rating
4	Valve lash (overhead) setting

NOTE: If the engine dataplate (1) is not legible, the engine serial number (2) can be identified on the engine block on top of the lubricating oil cooler housing. Additional engine information is available by reading the ECM dataplate.

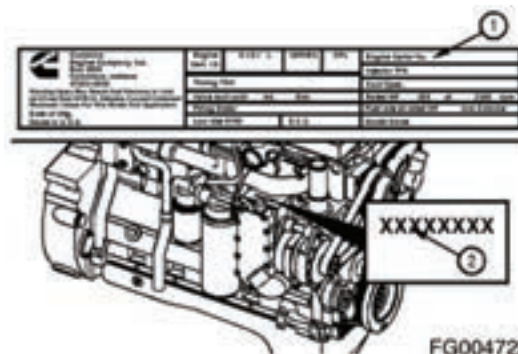
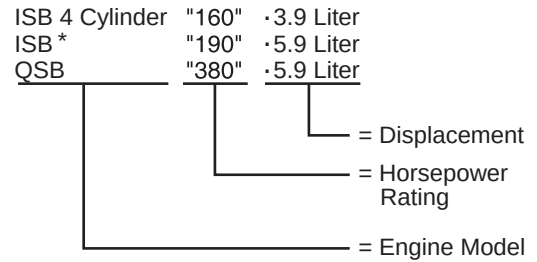


Figure 8

Cummins® Engine Nomenclature

The Cummins® engine nomenclature provides the data as illustrated in the graphic.



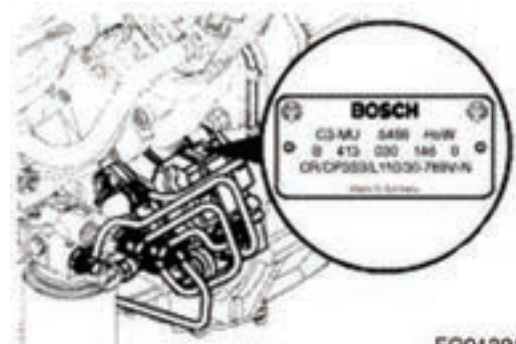
FG013912

Figure 9

Fuel Injection Pump Dataplate

The Bosch® fuel injection pump dataplate is located on the fuel pump. The dataplate contains the following information which assist in servicing or replacement:

- Pump serial number
- Cummins® part number
- Factory code
- Bosch® part number
- Date code



FG013913

Figure 10

ECM Data Plate

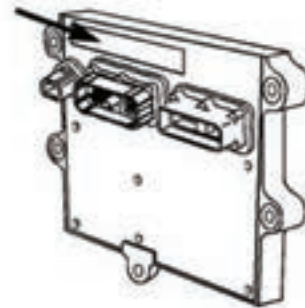
The electronic control module (ECM) dataplate shows information about the ECM and how the ECM was programmed.

The dataplate is located on the ECM.

The following information is available on the ECM dataplate:

- ECM part number (PN)
- ECM serial number (SN)
- ECM date code (DC)
- Engine serial number (ESN)
- ECM Code (identifies the software in the ECM).

NOTE: Have the ECM code for the engine available when communicating with a Cummins® Authorized Repair Location.



FG004726

Figure 11

Air Compressor (Not Used)

NOTE: *Not all engines are equipped with an air compressor.*

The Cummins® branded air compressor dataplate, identified by the Cummins Inc. logo, is typically located on the side of the air compressor. The dataplate contains the following information which assist in servicing or replacement:

- Cummins® part number
- Serial number
- Date code

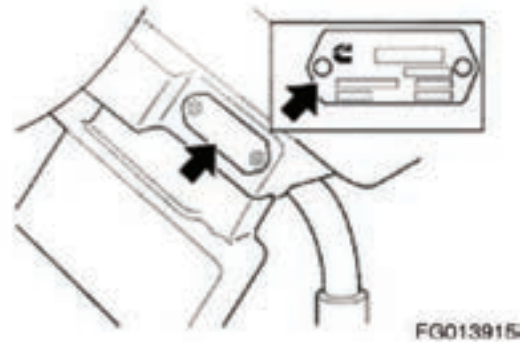


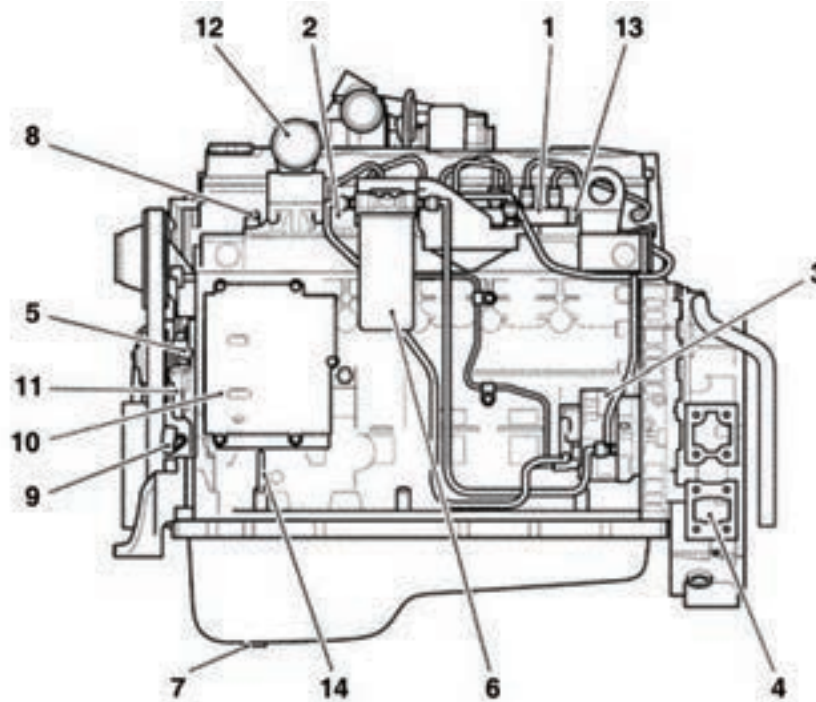
Figure 12

Engine Diagrams

Engine Views

The following illustrations show the locations of the major external engine components, filters, and other service and maintenance points. Some external components will be at different locations for different engine models.

NOTE: *The illustrations are only a reference to show a typical engine.*

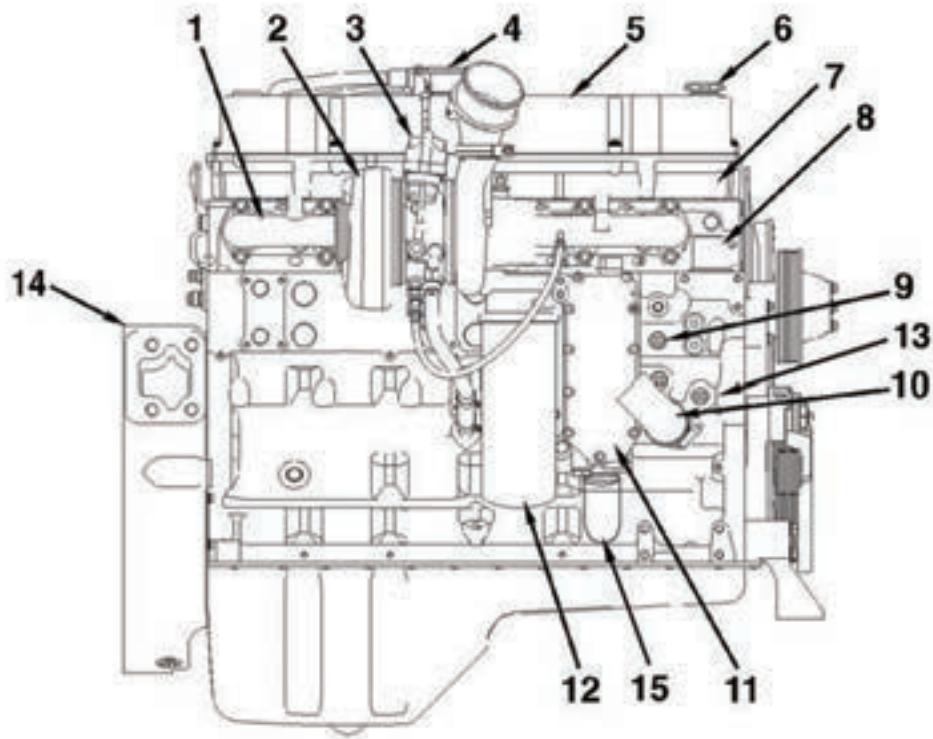


FG013916

Figure 13 QSB4.5 Engine Air Intake Side View

Reference Number	Description
1	Fuel Rail Pressure Sensor
2	Intake Manifold Pressure / Temperature Sensor
3	Air Compressor Coolant Pipes (Not Used)
4	Air Compressor (Not Used)
5	Ambient Air Pressure Sensor
6	Bosch® Fuel Pump
7	Flywheel Housing
8	Fuel Return

Reference Number	Description
9	Fuel Inlet
10	Fuel Filter
11	Oil Pan Drain Plug
12	Dipstick/Oil Level Sensor
13	Electronic Control Module
14	Air Intake Inlet
15	Coolant Outlet
16	Fuel Rail Pressure Relief Valve
17	Fuel Rail

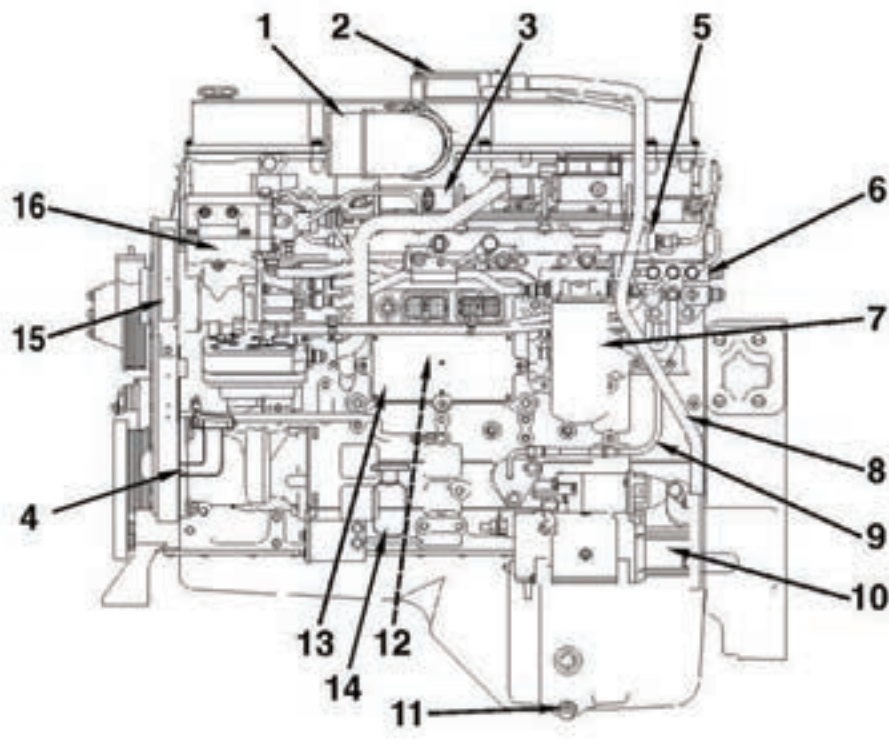


FG004729

Figure 14 QSB4.5 Engine Front View

Reference Number	Description
1	Air Inlet
2	Electronic Control Module
3	Engine Speed Sensor (Camshaft)
4	Engine Speed Sensor (Crankshaft)
5	Fuel Filter
6	Vibration Damper (Optional)

Reference Number	Description
7	Fan or PTO Drive Flange Mounting
8	Starter Mounting Location
9	Coolant Inlet
10	Water Pump
11	Belt Tensioner
12	Alternator
13	Coolant Outlet
14	Coolant Temperature Sensor

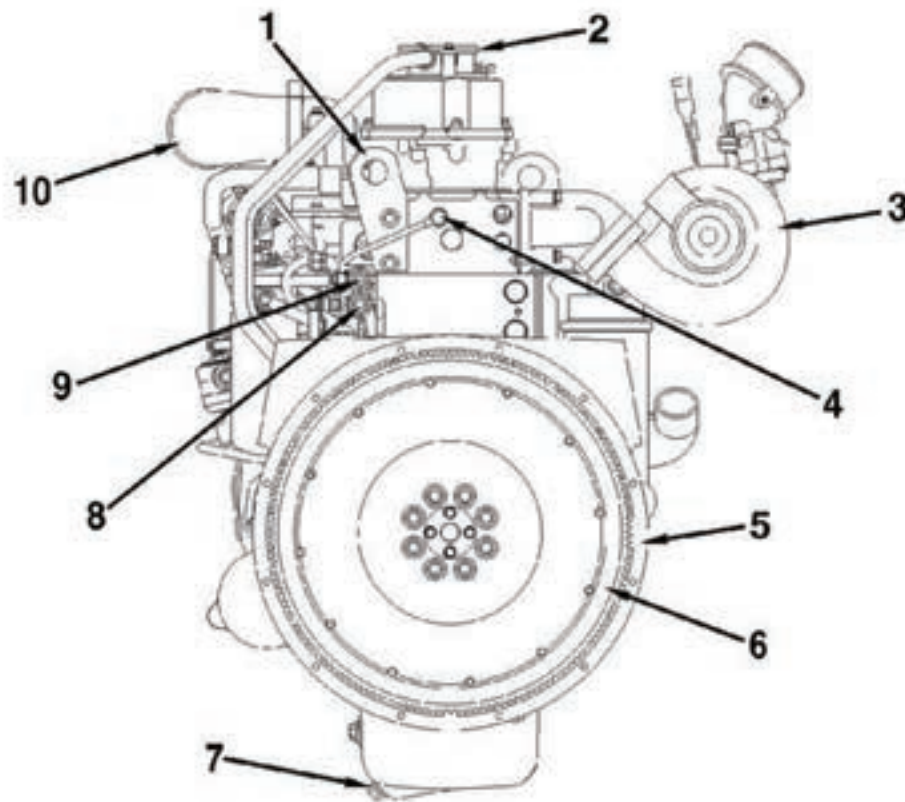


FG004730

Figure 15 QSB4.5 Engine Rear View

Reference Number	Description
1	Rear Engine Lifting Bracket
2	Air Outlet from Turbocharger
3	Air Inlet to Turbocharger
4	Flywheel

Reference Number	Description
5	Flywheel Housing
6	Crankcase Breather Tube
7	Fuel Return Line
8	Engine Lifting Brackets

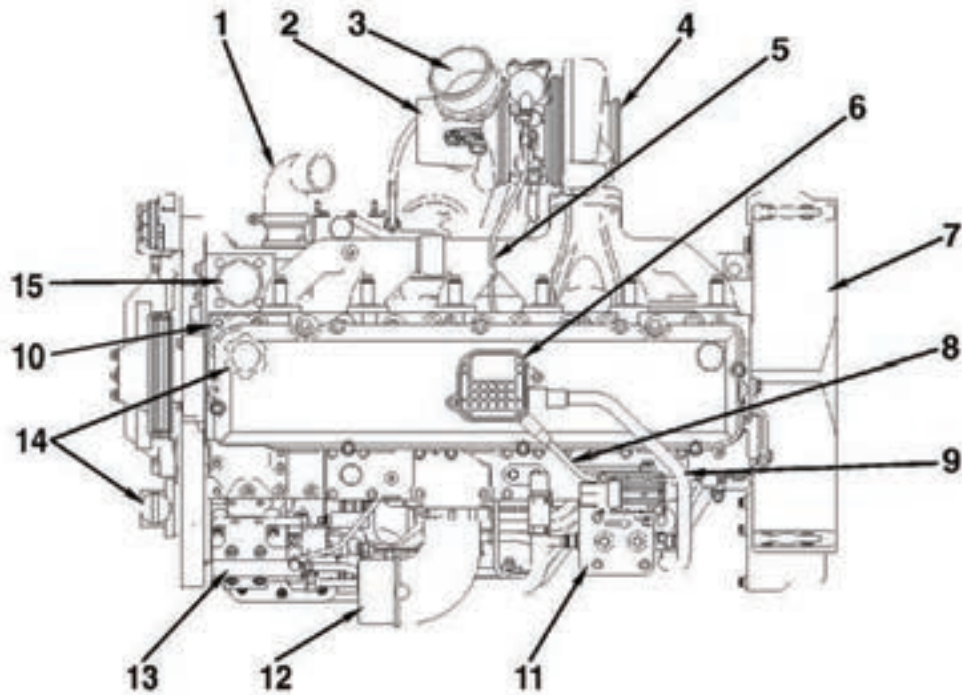


FG004731

Figure 16 QSB4.5 Engine Exhaust Side View

Reference Number	Description
1	Coolant Outlet
2	Alternator
3	Oil Cooler
4	Coolant Inlet
5	Oil Filter

Reference Number	Description
6	Oil Pan Drain Plug
7	Turbocharger Exhaust Outlet
8	Starter
9	Flywheel Housing
10	Turbocharger Compressor Inlet



FG004732

Figure 17 QSB 4.5 Engine Top View

Reference Number	Description
1	Turbocharger Wastegate Actuator
2	Crankcase Breather
3	Air Compressor Coolant Connection
4	Intake Manifold Pressure/temperature Sensor
5	Air Compressor (Not Used)
6	Fuel Rail
7	High-Pressure supply Lines (Pump to Rail)

Reference Number	Description
8	Fuel Rail Pressure Sensor
9	High-Pressure Fuel Lines
10	Oil Fill Cap
11	Tone Wheel
12	Coolant Temperature Sensor
13	Vibration Damper (Optional)
14	Coolant Outlet
15	Exhaust Manifold

Fan Control

Feature Description

Various fan control features are available and while not all aspects of fan control are available on all engines, most (but not all) electronic controlled engines have some Electronic Control Module (ECM) fan control capability.

Fan control capability means that the ECM is able to turn the fan on or off in response to any of the following inputs:

Engine operating conditions (coolant temperature, intake manifold temperature, etc.)

- Control of fan overspeed
- Air conditioner operation
- Manual fan switch
- Engine performance requirements
(Example: engine braking)

NOTE: *Many Industrial engines have fan controls as part of the ECM calibration that can not be adjusted using the service tool.*

Driver Activation/Deactivation

The driver can override the ECM to turn the fan on, using the manual fan switch installed in the cab by the vehicle manufacturer. When the driver places the manual fan switch in the ON position, the fan will be on regardless of other engine operating conditions. When the manual fan switch is in the OFF position, the fan will operate according to engine operating conditions and according to how the fan control parameters are configured.

Interaction with other Features and Parameters

ISB and ISC have a single pin on the ECM that provides Pulse Width Modulation.

This pin can be used to send a kick-down signal to an automatic transmission, in which case it must not be used to operate a variable speed fan.

Disadvantages

Due to heat rejection, the fan on during engine braking feature will appear inconsistent to some vehicle operators (Example: Consider an ISX calibration setting that the fan will engage 15 seconds after engine braking starts. It will be possible for the fan to sometimes come on sooner in response to air intake temperatures, coolant temperatures, or the air conditioner pressure switch).

Water-in-Fuel Sensor

Feature Description

The water-in-fuel sensor protects the fuel system by alerting the vehicle operator that water has accumulated in the fuel filter and this water must be drained. The operator will be warned of a high water condition by a flashing warning lamp on the dash.

The fuel filter removes emulsified and free water from the fuel as it passes through the filter media. The removed water is heavier than fuel and falls to the bottom of the filter canister where it accumulates. The water-in-fuel sensor is installed in the base of

the fuel filter canister. The sensor consists of two metallic probes that sense the electrical conductivity of the surrounding solution. A change in conductivity can be detected when sufficient water accumulates around the probes and displaces the diesel fuel. When this happens the ECM lights the warning light on the dash and Fault Code 418, Water-In-Fuel Indicator High -Maintenance is logged.

Driver Activation/Deactivation

The driver can not activate or deactivate the water-in-fuel sensor feature. This feature can only be activated or deactivated by the Cummins INSITE™ service tool.

Interaction with other Features and Parameters

This feature does not interact with any other feature or parameter.

Idle Shutdown

Feature Description

The idle shutdown feature reduces the amount of fuel burned and increases engine life by shutting down the engine after a period of engine idling with no driver activity.

Before the shutdown will occur a flashing warning lamp will warn the driver of an impending shutdown. The driver can override the shutdown by depressing the service brake, clutch or accelerator pedal during the warning period. This activity will override the idle shutdown. Idle shutdown operates when the engine is in the Power TakeOff (PTO) mode unless a specific load threshold is exceeded. Idle shutdown can be automatically overridden during cold ambient temperatures if equipped with an OEM supplied ambient air temperature sensor.

The following table indicates when manual and automatic overrides are available.

Driver Activation/Deactivation

The driver can not activate or deactivate the idle shutdown feature. This feature can only be activated or deactivated by the Cummins INSITETM service tool.

To override the automatic idle shutdown the driver will need to activate the brake, clutch or accelerator pedal during the 30 second period prior to shutdown. 30 seconds prior to the shutdown a flashing warning lamp will notify the driver that engine shutdown is pending. This action will override idle shutdown. If the override is successful the warning lamp will flash every one half second for two minutes.

Interaction with other Features and Parameters

Idle shutdown can interact with the PTO feature. Idle shutdown can cause the engine to shutdown when in PTO mode. If the idle shutdown percent load threshold is not exceeded the engine will be shutdown.

It is required that this feature be enabled with the ICONTM product and the ambient air temperature override must be disabled.

Disadvantages

The idle shutdown feature will not activate if Fault Code 241 is active.

When stopped in traffic for extended periods the engine will be shutdown.

Visual Aids

The chart below indicates when manual and automatic overrides are available.

	Manual Override	Automatic Override
Below Cold Air Temperature No Yes	No	Yes
Between Cold Air and Intermediate Air Temperature	Yes	No
Between Intermediate Air and Hot Air Temperature	No	Yes
Above Hot Air Temperature Yes No	Yes	No

Accelerator Optionals

Feature Description

This feature allows the user to determine the type of engine governor control. The two types available are the automotive (minimum or maximum) and Variable Speed or All Speed Governor types. The automotive governor provides a constant fueling for a given accelerator position. With the automotive governor selected the engine speed can vary with changes in engine loading for a constant accelerator position.

The Variable Speed governor provides a constant engine speed for a given accelerator position. With the Variable Speed governor selected the engine speed will remain constant with changes in engine loading for a constant accelerator position. The Variable Speed governor is an option. It is best suited for applications where a constant engine speed is desired to perform a desired task where engine or power take-off speed must remain constant.

Driver Activation/Deactivation

The selection of the governor type can be accomplished two ways. If the vehicle is equipped with a cab-mounted switch, the driver can activate this switch to select between the automotive or Variable Speed governor. If the cab switch is not available the INSITE™ service tool can be used to select the desired governor type.

Interaction with other Features and Parameters

This feature does not interact with any other feature or parameter.

Disadvantages

For applications that require a constant engine speed to perform a desired task, the automotive governor will not hold the engine or Power Take-Off speed constant for a given accelerator position.

Intermediate Speed Control (ISC)

Feature Description

Industrial applications use an engine speed control feature called Intermediate Speed Control.

Up to three Intermediate Speed Control Set Speeds (1, 2, or 3) can be selected depending on Original Equipment Manufacturer (OEM) availability. To support this feature, a multi-position switch, or three toggle switches must be installed by the OEM.

Additionally, up to five Variable Intermediate Speed Control Set speeds (1, 2, 3, 4, or 5) can be selected and the operator can select these speeds using an OEM installed accelerator lever.

The Intermediate Speed Control set speeds will interact with the accelerator pedal in one of three different ways (modes A, B and C); the interaction between Intermediate Speed Control set speeds and the accelerator pedal is not adjustable, this interaction is determined by the OEM and built into the ECM calibration.

Mode A - Intermediate Speed Control set speed acts as low speed governor. In this mode, the Intermediate Speed Control set speed becomes the Minimum Engine Speed. The operator can use the accelerator pedal to increase the speed above the Intermediate Speed Control set speed.

Mode B - Intermediate Speed Control set speed acts as high speed governor. In this mode, the Intermediate Speed Control set speed becomes the Maximum Engine Speed. The operator can use the accelerator pedal to control engine speed up to the Intermediate Speed Control set speed.

Mode C -Intermediate Speed Control Constant Speed. In this mode, the Intermediate Speed Control runs at constant speed and accelerator pedal input is ignored.

The three Preset Intermediate Speed Control speeds can be adjusted with an increment or decrement switch and are INSITE™ service tool adjustable, but can not exceed the low or high idle governor engine speed limits.

The five Intermediate Speed Control Variable Speed Control set speeds are not adjustable with the increment or decrement switch, but are adjustable with the INSITE™ service tool.

Only one droop setting is available for all Intermediate Speed Control speeds.

One of the switch inputs can be used as a validation input (if used, the ECM pin for Intermediate Speed Control 3 will be used). If this is the case, the ECM calibration will use the ECM pin used for Intermediate Speed Control 3 as a validation input and only 2 Intermediate Speed Control speeds will be available while the five variable Intermediate Speed Control inputs will not be available.

If more than one Intermediate Speed Control switches is turned ON; the lowest speed turned ON will take priority.

Driver Activation/Deactivation

Using the Intermediate Speed Control Switched Set Speeds

The operator can operate the engine using the Intermediate Speed Control Set Speeds with OEM installed Intermediate Speed Control Switches, or an equivalent OEM installed device. Activating Intermediate Speed Control can or can not cause Accelerator Pedal inputs to be ignored.

Using the Intermediate Speed Control Variable Speed Set Points

The operator can operate the engine using the Intermediate Speed Control Variable Speeds; Intermediate Speed Control Variable Speeds are selected with an Accelerator Lever or an equivalent switching device that is installed by the OEM. This device can contain a potentiometer that sends a variable signal to the ECM. Based on the output of the potentiometer, the engine will be controlled to one of five Intermediate Speed Control Variable Speeds. Refer to the figure below for visual reference. It is recommended that all five speeds be chosen and entered in a sequential order so that as the operator increases the position of the hand throttle, the engine speed will change accordingly.

Interaction with other Features and Parameters

Intermediate Speed Control and Cruise Control can not be active at the same time. If the cruise control on/off switch is on, then Intermediate Speed Control is disabled. If the cruise on/off switch is off then Intermediate Speed Control will remain off until an Intermediate Speed Control switch transitions from off to on.

Remote Throttle and Variable Speed Intermediate Speed Control must not both be used on the same engine.

Disadvantages

Using the service tool, it is not possible to display the interaction between Intermediate Speed Control and the throttle pedal.

Alternate Droop

Feature Description

Alternate Droop allows the droop characteristics to be changed for the automotive (minimum or maximum) and for Variable Speed (VS) governor or All Speed Governor. In general less governor droop (lower percentage) provides a more responsive governor for more precise engine control. More governor droop (higher percentage) provides smoother shifting and smoother mechanical clutch engagement. This feature, depending on Original Equipment Manufacturer (OEM) availability, provides the user the ability to select multiple breakpoint speeds and the droops associated with those speeds by way of an OEM-provided switch.

Driver Activation/Deactivation

Alternate Droop is calibration activated (except for CELECT ϕ Plus), but uses a switch to toggle between the alternate droop settings. Depending on the application the alternate droop switch can be a 2 or 3 position switch. Toggling the switch into the 2nd and 3rd positions will activate the 2nd and 3rd droop settings accordingly.

Interaction with other Features and Parameters

The Vehicle Speed Droop feature uses the droop settings for this feature.

Disadvantages

- Driver complains of low power.
- Driver complains of poor or unexpected throttle reaction.

Visual Aids

Reference Number	Description
1	Torque
2	Engine Speed (RPM)
3	Low Idle Speed
4	Maximum Torque Curve
5	High speed Break Point
6	Normal Droop
7	Alternate Droop
8	Alternate Droop (available)

Switchable (Alternate) Torque

Feature Description

Switchable (Alternate) Torque provides derated torque curves other than the 100 percent torque curve. These torque curves are normally used to help limit the torque output of the engine and helps to protect driveline components such as axles and transmissions and in some cases can help protect the engine from damage.

Driver Activation/Deactivation

The operator can activate or deactivate the alternate torque curves through an OEM supplied switch.

Interaction with other Features and Parameters

None

Disadvantages

Possible operator complaints of low power

Multiple Unit Synchronization

Feature Description

The multi unit synchronization feature allows two or more engines (up to a maximum of 11) to be controlled by a single throttle signal and run at a similar speed (See visual aids section). There are three engine configurations available with this feature: soft-coupled, hard-coupled, and soft-coupled marine.

The soft-coupled configuration has all secondary engines in parallel with each other. The primary engine outputs a throttle signal to all secondary engines. This setup allows all engines to remain running if a secondary engine stops running.

The hard-coupled configuration has the primary and all secondary engines in series with each other (See visual aids section). The primary engine outputs a throttle signal, which is received by the first secondary engine. This secondary engine then outputs the throttle signal to the next secondary engine in the series. This process repeats until the primary engine receives the throttle signal.

The soft-coupled marine configuration has all secondary engines in parallel with each other (See visual aids section). The primary engine outputs a throttle signal on the J1939 datalink to all secondary engines.

Driver Activation/Deactivation

This feature can not be activated or deactivated by the driver except in the case of the soft-coupled marine configuration. In this case, Multi Unit Synchronization is turned on or off by a user activated switch.

Disadvantages

In the hard-coupled configuration, if one engine in the series stops running, then the remaining engines in the circuit will also stop running.

Hot Shutdown Monitor

Feature Description

The Hot Shutdown Monitor will log a fault in the Electronic Control Module (ECM) if the engine is shut down, either by the key switch or by the engine protection feature or other Original Equipment Manufacturer (OEM) devices, while still hot.

The engine is considered hot if the load on the engine is above the hot shutdown minimum load set by Cummins INSITE[®], electronic service tool. Hot shutdown monitor is available on QSB, QSC, QSL9, QSM11, QSX15, QST30, QSK19, QSK45, QSK50, QSK38, QSK78, and QSK60 industrial engines.

The hot shutdown load percent is based on the duty cycle load factor that is determined from engine fueling levels. For example: If the hot shutdown load percent is set at 60 percent, every time the engine is shut down when the calculated engine load is over 60 percent, a hot shutdown fault will be logged.

Driver Activation/Deactivation

There is no operator activation or deactivation for hot shutdown monitor.

Automatic Boost Power

Feature Description

Boost Power is a torque curve that is calibrated for a higher torque/horsepower than the normal engine rating and is available on QSB, QSC, SELECT™ Plus, QSM11, QSX15, QSK19, QSK45, and QSK60 industrial engines. The Electronic Control Module (ECM) will monitor engine speed, intake manifold temperature, and coolant temperature to determine if Boost Power can be activated. If Boost Power is available, the operator can activate Boost Power using a dash-mounted switch. The engine will switch to the higher torque curve or power rating for a limited period of time. The higher torque curve or power rating is calibrated for an intermittent or noncontinuous torque or power rating which is higher than the normal torque or power rating for the engine. Boost power is not available if coolant temperature or intake manifold temperatures are above calibrated thresholds. If engine speed is below a calibrated threshold, then Boost Power will not be time limited.

Automatic Boost Power will provide the operator with enhanced torque or power for a fraction of the operating period. The ECM will monitor engine speed, intake manifold temperature, percent load, and coolant temperature to determine if automatic Boost Power can be activated. If automatic Boost Power is available, the engine will switch to the enhanced torque or power rating for a limited period of time. The Original Equipment Manufacturer (OEM) equipment users manual will document the time periods that automatic Boost Power is available, since it is application specific. Automatic Boost Power is not available if coolant temperature or intake manifold temperatures are above calibrated thresholds. If engine speed or percent load is below a calibrated threshold, automatic Boost Power will not be available. If coolant temperature or intake manifold temperature rise above calibrated threshold, then automatic Boost Power will be deactivated. Automatic Boost Power is available on QSB, QSC, QSM11, and QSX15 industrial engines.

Driver Activation/Deactivation

To activate Boost Power, the operator must turn on a dash-mounted switch. To deactivate Boost Power, the operator must turn the switch off. Boost power will engage if the engine operating conditions are met. There is no operator interaction to activate or deactivate automatic Boost Power.

Interaction with other Features and Parameters

Boost power must be enabled in order to enable automatic Boost Power.

Disadvantages

A possible customer complaint associated with this feature will be intermittent low power.

Boost Power must not engage due to the Boost Power load threshold is set above the highest load experienced during normal engine operation

Fuel Consumption Rate Logger

Feature Description

Fuel Consumption Rate Logger is an industrial feature that monitors fuel usage over the life of the engine. The feature also maintains a bar graph (short term fuel consumption) that displays fuel consumption over the last 40 hours of engine operation. Fuel consumption is measured in Gallons Per Hour (gph).

The feature allows the following to be viewed under the Fuel Consumption Monitor heading with Cummins INSITE™:

Long Term Rate -Cumulative Fuel Economy (Gallons/Hour). The cumulative fuel economy is the fuel economy averaged over the life of the engine.

Long Term Time - Engine Hours Included in the calculation of the Long Term Rate Instantaneous Rate - The instantaneous fuel economy (Gallons/Hour) Short Term Rate - A graphical representation of fuel economy (Gallons/Hour) versus time (Hours). The graphical representation will span up to 40 hours of engine operation and display average fuel economy for each of the last 40 hours of engine operation.

Short Term Hour - Identifies which hour is being monitored in the current 40 hour period represented by the short term rate graphical display. Hour Counter -Shows the minutes elapsed in the current hour being monitored.

If fuel consumption rate monitor is enabled, Cummins INSITE™ will display a bar graph representing fuel consumption for the last 40 hours of engine operation. The graphical display is a bar graph with engine hours on the horizontal axis and fuel consumption on the vertical axis. A maximum of 40 bars representing 40 hours of engine operation will be displayed; each bar represents fuel consumption averaged over one hour of engine operation. The graph will size itself to fit on the screen for easy viewing.

Visual Aids

The Short Term Rate Logger has logged 15 hours of data since the last RESET, currently the engine has run for 32 minutes into the 16th hour of engine operation. The engine has averaged 34.1 L (1 hour) over its life.

OPERATING INSTRUCTIONS

Operating Instructions -Overview



WARNING!

DO NOT OPERATE A DIESEL ENGINE WHERE THERE ARE OR CAN BE COMBUSTIBLE VAPORS. The vapors can be sucked through the air intake system and cause engine acceleration and overspeeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of overspeeding where an engine, due to its application, due to a fuel spill or gas leak. Remember, Cummins has no way of knowing the use you have for your engine. THE EQUIPMENT OWNER AND OPERATOR ARE RESPONSIBLE FOR SAFE OPERATION IN A HOSTILE ENVIRONMENT. CONSULT YOUR CUMMINS AUTHORIZED REPAIR LOCATION FOR FURTHER INFORMATION.



CAUTION!

Do not expose the engine to corrosive chemicals. Corrosive chemicals can damage the engine.

General Information

Correct care of your engine will result in longer life, better performance, and more economical operation.

Follow the daily maintenance checks listed in "Maintenance Guidelines" on page-59.

The new Cummins engine associated with this manual does not require a "break-in" procedure. This section of the manual provides all of the necessary information required for proper engine operation.

Check the oil pressure indicators, temperature indicators, warning lights, and other gauges daily to make sure they are operational.

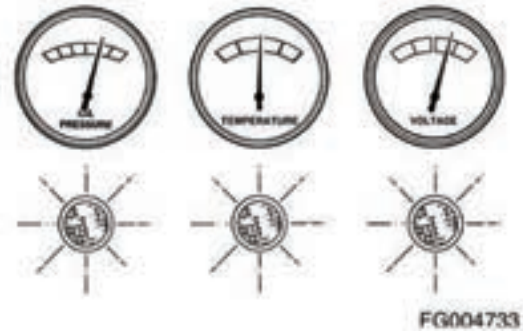


Figure 18

 WARNING!

DO NOT OPERATE A DIESEL ENGINE WHERE THERE ARE OR CAN BE COMBUSTIBLE VAPORS. The vapors can be sucked through the air intake system and cause engine acceleration and overspeeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of overspeeding where an engine, due to its application, due to a fuel spill or gas leak. Remember, Cummins has no way of knowing the use you have for your engine. **THE EQUIPMENT OWNER AND OPERATOR ARE RESPONSIBLE FOR SAFE OPERATION IN A HOSTILE ENVIRONMENT. CONSULT YOUR CUMMINS AUTHORIZED REPAIR LOCATION FOR FURTHER INFORMATION.**

Cummins recommends the installation of an air intake shutoff device or a similar safety device to minimize the risk of overspeeding where an engine, due to the vehicle, vessel or equipment being operated in a combustible environment, such as due to a fuel spill or gas leak.

 CAUTION!

Do not expose the engine to corrosive chemicals. Corrosive chemicals can damage the engine.

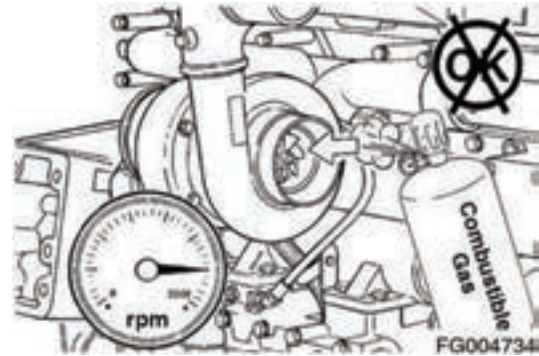


Figure 19

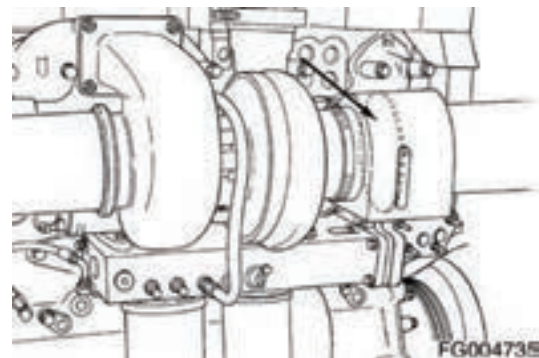


Figure 20

Normal Starting Procedure

General Information



WARNING!

Do not depress the accelerator pedal or move the accelerator lever from the idle position while cranking the engine. This can result in engine overspeed and severe damage to the engine.



CAUTION!

To prevent damage to the starting motor, do not engage the starting motor for more than 30 seconds. Wait 2 minutes between each attempt to start (electrical starting motors only).

NOTE: Engines equipped with air starting motors require a minimum of 480 kPa (70 PSI).

- Disengage the driven unit, or if equipped, put the transmission in neutral.
 - With the accelerator pedal or lever in the idle position, turn the key switch to the ON position, and wait for the WAIT-TO-START lamp to go out; then, turn the key to the START position.
 - If the engine does not start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.
-



CAUTION!

The engine must have adequate oil pressure within 15 seconds after starting. If the WARNING lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut off the engine immediately to avoid engine damage. The low oil pressure troubleshooting procedure is located in "Troubleshooting Symptoms" on page-195.

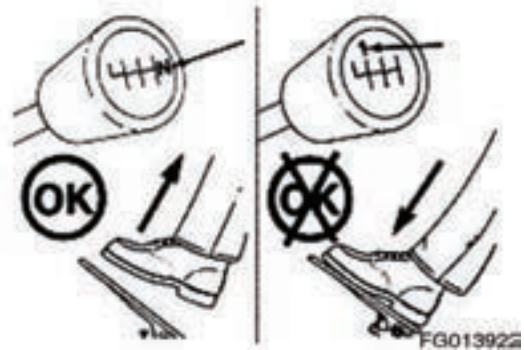


Figure 21

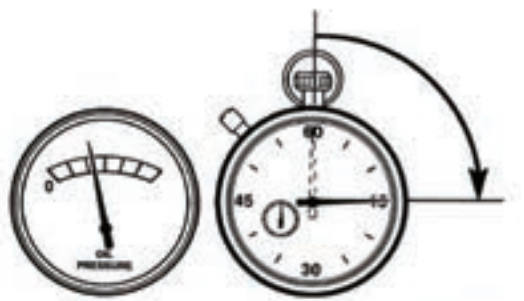


Figure 22

FG004736

Idle the engine 3 to 5 minutes before operating with a load.

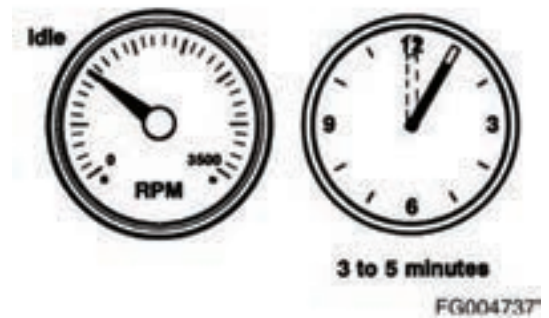


Figure 23

After starting a cold engine, increase the engine speed (rpm) slowly to provide adequate lubrication to the bearings and to allow the oil pressure to stabilize.

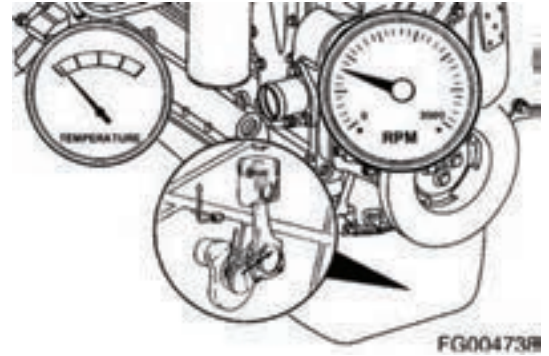


Figure 24

CAUTION!

Do not operate engine at low idle for long periods with engine coolant temperature below the minimum specification in "Maintenance Specifications" on page-245. This can result in the following:

- Fuel Dilution of the lubricating oil
 - Carbon build up in the cylinder
 - Cylinder head valve sticking
 - Reduced performance
-

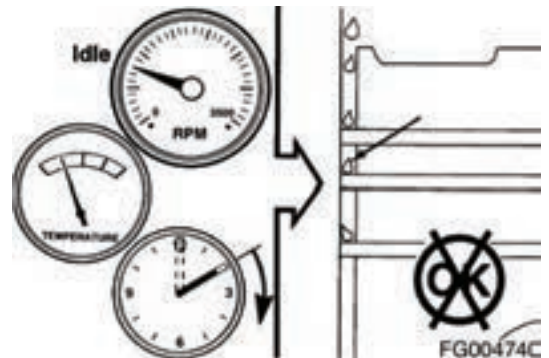


Figure 25

Jump Starting



WARNING!

Batteries can emit explosive gases. To avoid personal injury, always ventilate the compartment before servicing the batteries. To avoid arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



CAUTION!

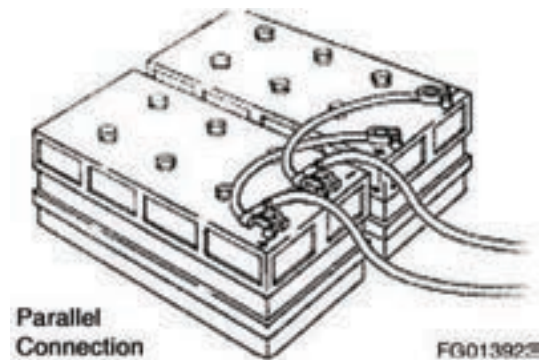
When using jumper cables to start the engine, make sure to connect the cables in parallel: Positive (+) to positive (+) and negative (-) to negative (-). When using an external electrical source to start the engine, turn the disconnect switch to the OFF position. Remove the key before attaching the jumper cables.



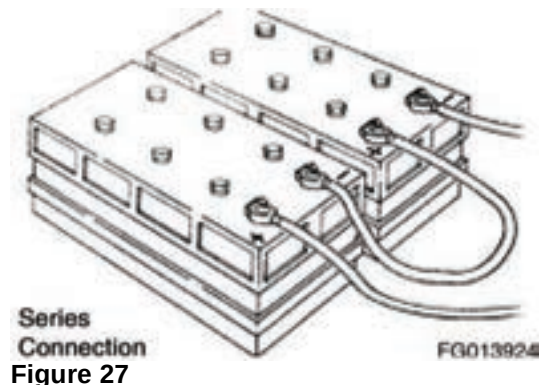
CAUTION!

To avoid damage to engine parts, do not connect jumper starting or battery charging cable to any fuel system or electronic component.

The accompanying illustration shows a typical parallel battery connection. This arrangement doubles the cranking amperage.



This illustration shows a typical series battery connection. This arrangement, positive (+) to negative (-), doubles the voltage.



Cold Weather Starting

Using Starting Aids

Cold weather starting aids are available for your engine. Contact the local Cummins Authorized Repair Location for more information.

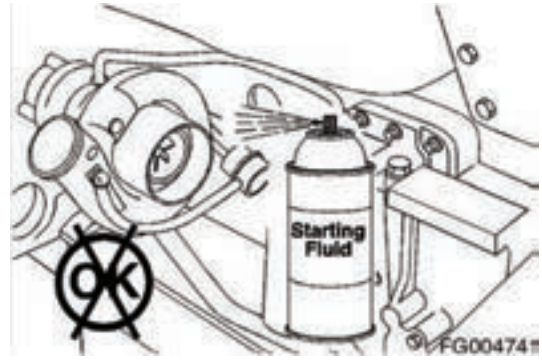


Figure 28

Starting Procedure After Extended Shutdown or Oil Change

General Information

Follow the Normal Starting Procedure in this section. The engine will not start until the minimum cranking oil pressure is detected by the ECM. It can take more cranking time to start the engine after an extended shut down or oil change.

Operating the Engine

Normal

If equipped, monitor the oil pressure and coolant temperature gauges frequently. Refer to Lubricating Oil System specifications and Cooling System specifications, in "Maintenance Specifications" on page-245 for recommended operating pressures and temperatures. Shut off the engine if any pressure or temperature does not meet the specifications.

Continuous operation with engine coolant temperature above or below the engine coolant temperature specifications listed in "Maintenance Specifications" on page-245 can damage the engine.

If an overheating condition starts to occur, reduce the power output of the engine by releasing the accelerator pedal or lever or shifting the transmission to a lower gear, or both, until the temperature returns to the normal operating range. If the engine temperature does not return to normal, shut off the engine, and refer to "Troubleshooting Symptoms" on page-195, or contact a Cummins Authorized Repair Location.

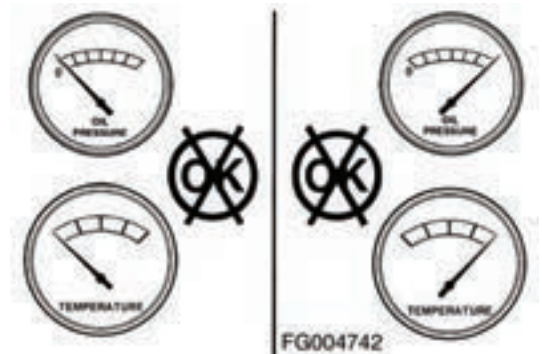


Figure 29

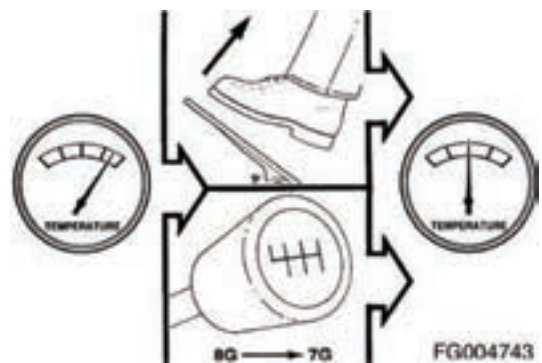
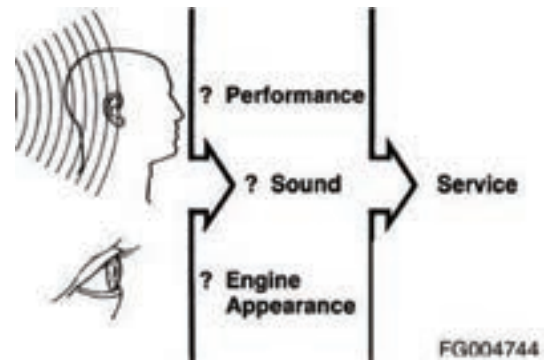


Figure 30

Most failures give an early warning. Look and listen for changes in performance, sound, or engine appearance that can indicate service or engine repair is needed. Some changes to look for are:

- Engine misfires
- Vibration
- Unusual engine noises
- Sudden changes in engine operating temperatures or pressures
- Excessive smoke
- Loss of power
- An increase in oil consumption
- An increase in fuel consumption
- Fuel, oil, or coolant leaks.



Cold Weather

It is possible to operate engines in extremely cold environments if they are properly prepared and maintained. Satisfactory performance of an engine in low ambient temperature conditions requires modification of the engine, surrounding equipment, operating practices and maintenance procedures.

The correct engine coolant lubricating oil and fuels must be used for the cold weather range in which the engine is being operated. Below are the recommendations for these critical engine fluids:

Ambient Temperature

0 to -32°C [32 to -25°F]

Use 50-percent ethylene glycol antifreeze and 50-percent water for the engine coolant mixture.

Refer to "Maintenance Specifications" on page-245 Lubricating Oil recommendations for the correct specifications.

The Diesel fuel must have maximum cloud and pour points 6°C (10°F) lower than the ambient temperature in which the engine operates.

-32 to -54°C [-25 to -65°F]

Use 60-percent ethylene glycol antifreeze and 40-percent water for the engine coolant mixture.

Refer to "Maintenance Specifications" on page-245 Lubricating Oil recommendations for the correct specifications.

The Diesel fuel must have maximum cloud and pour points 6°C (10°F) lower than the ambient temperature in which the engine operates.

The following cold weather operating aids are required for cold weather situations:

Cold Weather Operating Aids										
Temperature	Starting Aid	Coolant Heater	Oil Heater	Under-hood Air	Fuel Heater	Battery Heater	Radiator Shutters	Engine Enclosure	Winter Front	Thermostatic Fan
 50 to 32° F 10 to 0° C										
32 to -10° F 0 to -23° C	↑	↑	↑	↑	↑	↑	↑	↑		↑
-10 to -25° F -23 to -32° C	Required	Required	Required	Required	Required	Required	Required	Required	Required	Required
-25 to -65° F -32 to -54° C	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

* Required dependent upon viscosity/pour point.

FG004745

Figure 32

Engine Operating Range

CAUTION!

Do not operate the engine at full throttle operation below peak torque rpm (refer to engine data plate for peak torque rpm) for more than 30 seconds. Operating the engine at full throttle below peak torque will shorten engine life to overhaul, can cause serious engine damage, and is considered engine abuse.

CAUTION!

Do not operate the engine beyond the maximum engine speed. Operating the engine beyond the maximum engine speed can cause severe engine damage. Use proper operating techniques for the vehicle, vessel, or equipment to prevent engine overspeed. The maximum engine speed specification is listed in "Maintenance Specifications" on page-245.

General Information

CAUTION!

Do not operate the engine at full throttle operation below peak torque rpm (refer to engine dataplate for peak torque rpm) for more than 30 seconds. Operating the engine at full throttle below peak torque will shorten engine life to overhaul, can cause serious engine damage, and is considered engine abuse.

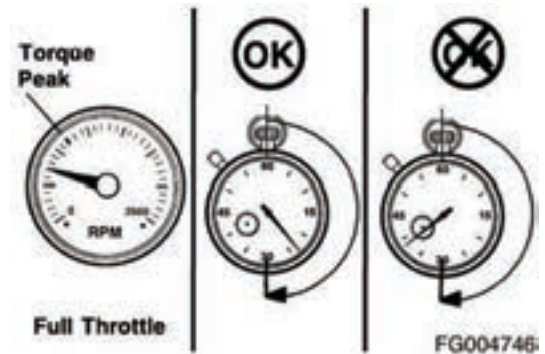


Figure 33

Cummins® engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed. This is consistent with recommended operating practices.

CAUTION!

Do not operate the engine beyond the maximum engine speed. Operating the engine beyond the maximum engine speed can cause severe engine damage. Use proper operating techniques for the vehicle, vessel, or equipment to prevent engine overspeed. The maximum engine speed specification is listed in "Maintenance Specifications" on page-245.

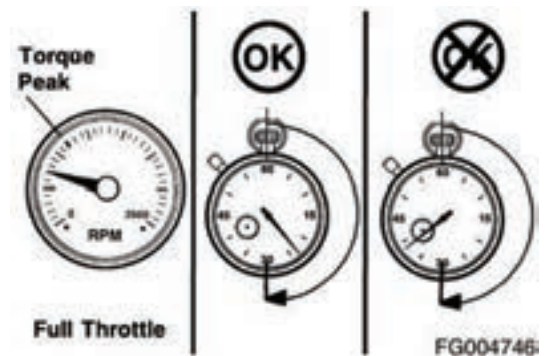


Figure 34

Engine Shutdown

General Information

Allow the engine to idle 3 to 5 minutes before shutting it off after a full-load operation. This allows adequate cool down of pistons, cylinders, bearings, and turbocharger components.

Turn the ignition starter switch to the OFF position. If the engine does not shut down, refer to "Troubleshooting Symptoms" on page-195 in appropriate Operation and Maintenance manual.



Figure 35

Electromagnetic Interference (EMI)

General Information

Some engine applications utilize accessories (CB radios, mobile transmitters, etc.) that generate and use radio frequency energy that, if not installed and used properly, can cause electromagnetic interference (EMI) conditions to exist between the accessory and Cummins electronic controlled fuel system. Cummins is not liable for any performance problems with either the fuel system or the accessory due to EMI.

EMI is not considered by Cummins to be an engine failure and therefore is not warrantable.

System EMI Susceptibility

Your Cummins product has been designed and tested for minimum sensitivity to incoming electromagnetic energy. Testing has shown that there is no engine performance degradation at relatively high energy levels; however, if very high energy levels are encountered, then some noncritical diagnostic fault code logging can occur.

The fuel system EMI susceptibility level will protect your engine from most, if not all, electromagnetic energy-emitting devices that meet the Federal Communications Commission legal requirements.

System EMI Radiation Levels

Your Cummins product has been designed to emit minimum electromagnetic energy.

Electronic components are required to pass various Cummins and industry EMI specifications. Testing has shown that when the engine is properly installed, it will not interfere with onboard communication equipment or with the vehicle's, equipment's, or vessel's ability to meet any applicable EMI standards and regulated specifications.

If an interference condition is observed, follow the suggestions below to reduce the amount of interference:

1. Locate the receiving antenna as far away from the engine and as high as possible.
2. Locate the receiving antenna as far away as possible from all metal obstructions (e.g., exhaust stacks)
3. Consult a representative of the accessory supplier in your area to:
 - Calibrate accurately the device for proper frequency, power output, and sensitivity (both base and remote site devices must be properly calibrated)
 - Obtain antenna reflective energy data measurements to determine the optimum antenna location
 - Obtain optimum antenna type and mounting arrangement for your application
 - Make sure your accessory equipment model is built for maximum filtering to reject incoming electromagnetic noise.

MAINTENANCE GUIDELINES

Maintenance Guidelines -Overview

Cummins Inc. recommends that the engine be maintained according to the Maintenance Schedule in this section.

If the engine is operating in ambient temperatures below -18°C (0°F) or above 38°C (100°F), perform maintenance at shorter intervals. Shorter maintenance intervals are also required if the engine is operated in a dusty environment or if frequent stops are made. Contact your local Cummins Authorized Repair Location for recommended maintenance intervals.

Some of these maintenance procedures require special tools or must be completed by qualified personnel. Contact your local Cummins Authorized Repair Location for detailed information.

If your engine is equipped with a component or accessory not manufactured by Cummins Inc., refer to the component manufacturer's maintenance recommendations.

Use the chart provided in this section as a convenient way to record maintenance performed.

Tool Requirements

General Information

Most of the maintenance operations described in this manual can be performed with common hand tools (metric and S.A.E. wrenches, sockets, and screwdrivers).

The following is a list of special service tools required for some maintenance operations:

Tool Part Number	Description	Used for
ST-1273	Pressure gauge	Measure Intake Manifold Pressure
3400158	Filter Wrench	Oil and Fuel Filters
3824591	Barring tool	Rotate the engine
CC-2800	Refractometer	Check antifreeze concentration and battery specific gravity
3164488	Digital Multimeter	Measure Voltage on electrical equipment
3822525	Belt Tensioner Gauge (click type)	Check belt tension (6 to 12 v-ribbed belts)
3164795	Torque Wrench	Dial type 3/8 drive 0-250 in-lb
3164794	Torque Wrench	Micro-adjust 3/8 drive 10-100 ft-lb
3164797	Torque Wrench	Micro-adjust 1/2 drive 50-250 ft-lb

Contact your nearest Cummins Authorized Repair Location for the required service tools.

Maintenance Schedule

For your convenience, listed below are the section numbers that contain specific instructions for performing the maintenance checks.

Perform maintenance at whichever interval that occurs first. At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled maintenance.

SERVICE ITEM		
Section 3	Air Intake Piping -Inspect	Daily or Refueling
	Engine Lubricating Oil Level -Check/Correct	
	Air Tank and Reservoirs -Drain	
	Crankcase Breather Tube -Inspect	
	Engine Coolant Level -Check/Correct	
	Fuel-Water Separator -Drain	
Section 4	Air Cleaner Restriction -Check/Correct	Every 250 Hours or 3 Months
	Air Compressor Mounting Hardware -Check/Correct	
	Charge-Air Cooler -Check/Correct	
	Charge-Air Piping -Check/Correct	
	Radiator Hoses -Check	
	Air Intake Piping -Inspect	
	Fan, Cooling -Check	
	Coolant Level -Check/Correct	
	Drive Belts -Check/Correct	
Section 5	Engine Coolant -Antifreeze Check	Every 500 Hours or 6 Months
	Fuel Filter (Spin-On Type) -Replace	
	Lubricating Oil and Filters -Change	
Section 6	Cooling Fan Belt Tensioner -Check/Correct	Every 1,000 Hours or 1 Year
	Fan Hub, Belt-Driven -Check/Correct	
Section 7	Air Compressor Discharge Line -Check/Correct	Every 2,000 Hours or 2 Years
	Cooling System -Drain, Flush, and Fill	
	Vibration Damper, Rubber -Check	
	Vibration Damper, Viscous -Check	

SERVICE ITEM		
Section 8	Overhead Set -Adjust	Every 5000 Hours or 4 Years
	1. The lubricating oil and lubricating oil filter interval can be adjusted based on application, fuel consumption, gross vehicle weight, and idle time. See the Oil Drain Intervals in this section.	
	2. Antifreeze check interval is every oil change or 500 hours or 6 months, whichever occurs first. The operator must use a heavy-duty year-round antifreeze that meets the chemical composition of GM6038M. The antifreeze change interval is 2 years or 2000 hours whichever occurs first. Antifreeze is essential for freeze, overheat, and corrosion protection.	
	3. Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical components, exhaust brake, charge air cooler, radiator, air compressor, air cleaner, freon compressor, and fan clutch. Refer to "Component Manufacturers Addresses" on page-138.	

Oil Drain Intervals

See table to determine the maximum recommended oil change and filter change interval in hours or months, whichever comes first.

American Petroleum Institute Classification (API)	European Classification (ACEA)	Engine Rating is 261 Hp (195 kW) or greater	Engine Rating is 260 Hp (194 kW) or less
API CH-4/SJ	ACEA E-5	250 hours or 3 months	500 hours or 6 months
API CF-4/SG	ACEA E-3 and ACEA E-2	125 hours or 6 weeks	250 hours or 3 months
API CD API CE API		Obsolete. Do not	Obsolete. Do
CG-4/SH	ACEA E-1	Use	Not Use

MAINTENANCE PROCEDURES AT DAILY INTERVAL

Daily Maintenance Procedures - Overview

General Information

Preventative maintenance begins with day-to-day awareness of the engine and its system. Before starting the engine, check the oil and coolant levels. Look for:

- Leaks
- Loose or damaged parts
- Worn or damaged belts
- Any change in engine appearance.
- Odor of fuel

Engine Operation Report

The engine must be maintained in top mechanical condition if the operator is to get optimum satisfaction from its use.

The maintenance department needs daily running reports from the operator to make necessary adjustments in the time allocated. The daily running report also helps to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report, along with a practical follow-up action, will eliminate most failures and emergency repairs.

Report to the maintenance department any of the following conditions:

- Low lubricating oil pressure
- Low power
- Power increases or engine surge
- Erratic or no accelerator control or response
- Any warning lights flashing or staying on
- Abnormal water or oil temperature
- Unusual engine noise
- Excessive smoke
- Excessive use of coolant, fuel, or lubricating oil
- Any fuel, coolant, or lubricating oil leaks
- Loose or damaged parts
- Worn or damaged belts

Unusual Engine Noise

During daily maintenance checks, listen for any unusual engine noise that can indicate that service is required.

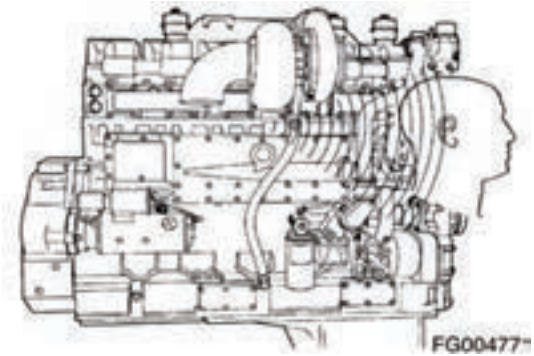


Figure 36

Air Tanks and Reservoirs

Drain

If automatic purging or spitter valves are used, confirm the valves are operating correctly. If a manual drain valve is used on the wet tank, open the draincock on the wet tank to drain any moisture accumulated in the air system. If oil is present, the air compressor system must be checked. Contact your Cummins Authorized Repair Location.

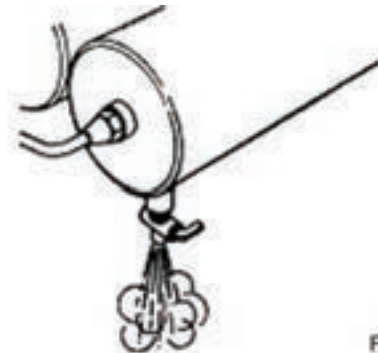


Figure 37

Crankcase Breather Tube

Maintenance Check

Inspect the breather tube for sludge, debris, or ice in the tube. Inspect the tube more frequently in icy conditions.



Figure 38

Fuel-Water Separator



WARNING!

Drain the water-fuel separator into a container and dispose of in accordance with local environmental regulations.



CAUTION!

When closing the drain valve, do not overtighten the valve. Overtightening can damage the threads.

Drain

Cummins Inc. requires a fuel-water separator or fuel filter be installed in the fuel supply system.

Drain the water and sediment from the separator daily.

Canister Type

Shut off the engine.

Pull up on the drain valve lever until fluid drains out of the drain tube. Drain the filter sump until clear fuel is visible.

Push up on the drain valve until fluid drains out of the drain tube.

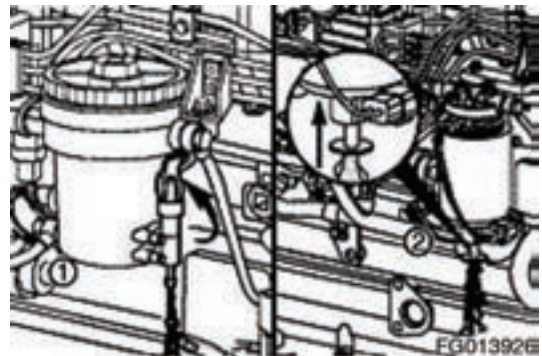


Figure 39

Spin-on Type

Shut off the engine.

Use your hand to open the drain valve. Turn the valve counterclockwise approximately 3 1/2 turns until the valve drops down 25.4mm (1 in) and draining occurs.

Drain the filter sump until clear fuel is visible.



CAUTION!

When closing the drain valve, do not overtighten the valve. Overtightening can damage the threads.

To close the valve, lift the valve and turn clockwise until it is hand-tight.

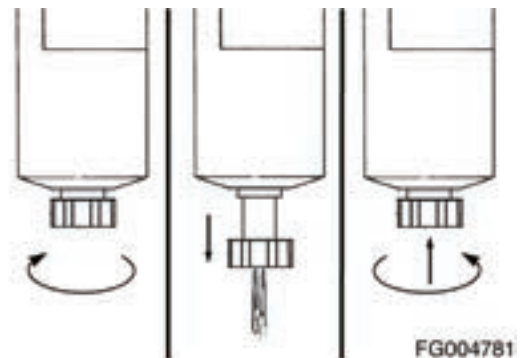


Figure 40

Lubricating Oil Level

Maintenance Check



CAUTION!

Never operate the engine with oil level below the L (low) mark or above the H (high) mark. Poor engine performance or engine damage can occur.

The engine must be level when checking the oil level to make sure the measurement is correct.

Shut off the engine for an accurate reading.

Wait at least 15 minutes after shutting off the engine to check the oil level. This allows time for the oil to drain into the oil pan.

For additional lubricating oil recommendations and oil pan capacity information, refer to "Maintenance Specifications" on page-245.

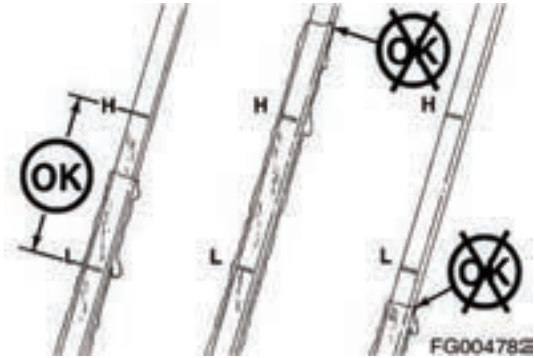


Figure 41

Drive Belts

Maintenance Check

Poly-Vee Belt

Inspect the belts daily. Check the belt for intersecting cracks. Traverse (across the belt width) cracks are acceptable. Longitudinal (direction of belt length) cracks that intersect with transverse cracks are not acceptable. Replace the belt if it is frayed or has pieces of material missing. Refer to Section A for belt adjustment and replacement procedures.

Belt damage can be caused by:

- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the side of belts.

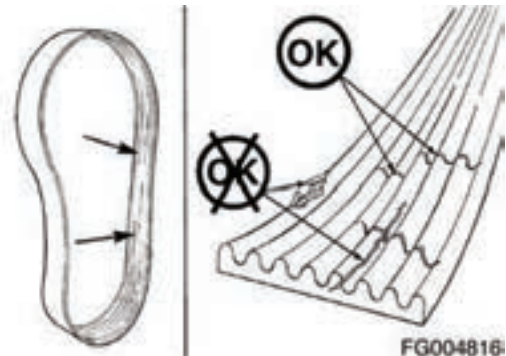


Figure 42

Cogged Belt

Inspect the belts daily. Replace the belts if they are cracked, frayed, or have chunks of material missing. Small cracks are acceptable.

Adjust the belts that have a glazed or shiny surface, which indicates belt slippage. Correctly installed and tensioned belts will show even pulley and belt wear. Refer to Section A for belt adjustment and replacement procedures.

Belt damage can be caused by:

- Incorrect tension
- Incorrect size or length
- Pulley misalignment
- Incorrect installation
- Severe operating environment
- Oil or grease on the belts

Measure the belt tension in the center span of the pulleys.

Refer to the Belt Tension Chart for the correct gauge and tension value for the belt width used.

An alternate method (deflection method) can be used to check belt tension by applying 110 N (25 lbf) force between the pulleys on v-belts. If the deflection is more than one belt thickness per foot of pulley center distance, the belt tension must be adjusted.

Refer to Section A for adjustment procedures.

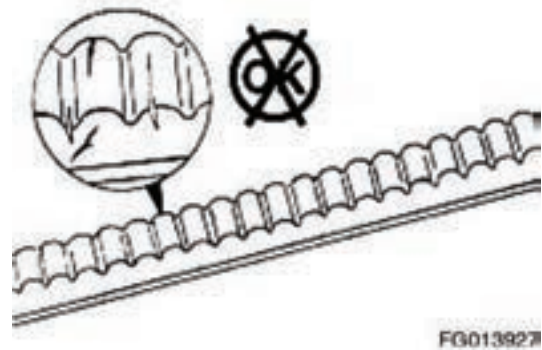


Figure 43

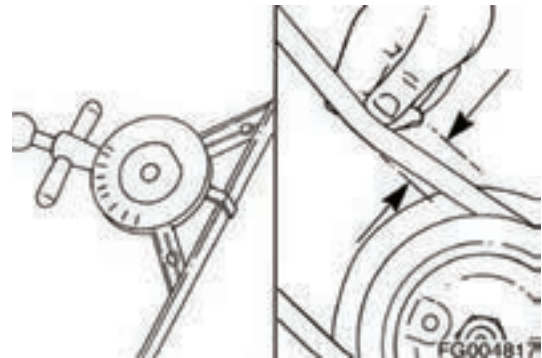


Figure 44

For cogged belts, make sure that the belt tension gauge is positioned so that the center tensioning leg is placed directly over the high point (hump) of a cog. Other positioning will result in incorrect measurement.

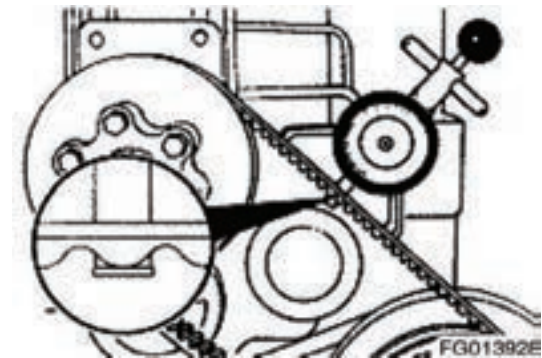


Figure 45

Air Cleaner Restriction

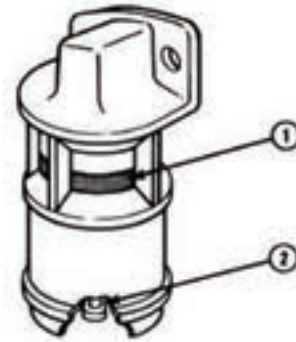
Maintenance Check

Mechanical Indicator

NOTE: Do not remove the felt washer from the indicator. The felt washer absorbs moisture.

A mechanical restriction indicator is available to indicate excessive air restriction through a dry-type air cleaner. This instrument can be mounted in the air cleaner outlet or on the instrument panel. The red flag (1) in the window gradually rises as the cartridge loads with dirt. After changing or replacing the cartridge, reset the indicator by pushing the reset button (2).

Restriction or vacuum indicators need to be installed as close as possible to the turbocharger air inlet in order to obtain a true indication of restrictions.



FG004783

Figure 46

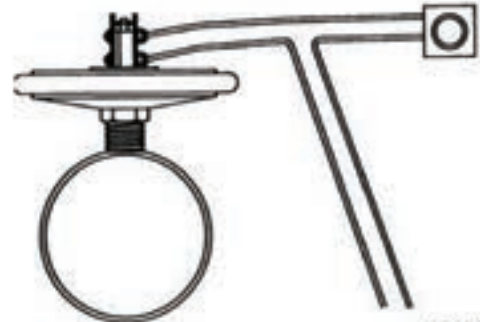


CAUTION!

**Never operate the engine without an air cleaner.
Intake air must be filtered to prevent dirt and debris from entering the engine and causing premature wear.**

Vacuum Indicator

Vacuum switches actuate a warning light on the instrument panel when the air restriction becomes excessive.



FG004784

Figure 47

Air Compressor (Not Used)

Maintenance Check

NOTE: Depending on application, it is possible engines will not be equipped with an air compressor.

Inspect compressor housing for cracks and damage.

Inspect hydraulic pump couplings for cracks, wear, or damage (if equipped).

Inspect air plumbing for splits or cracks.

Inspect the air compressor mounting nuts, including support bracket, for loose or damaged hardware.

Operate the engine and check for correct compressor operation and air, oil, and coolant leaks.

- Mounting 18 mm 77 n.m (57 ftlb)
- Bracket 10 mm 45 n.m (33 ftlb)

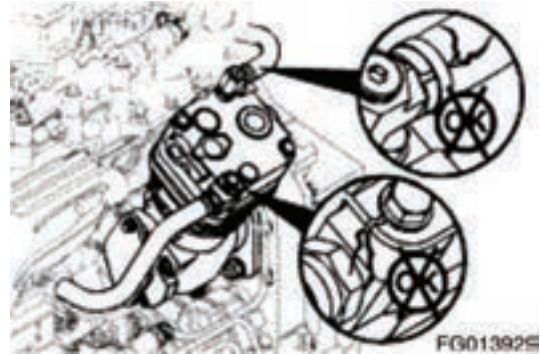


Figure 48

Charge-Air Cooler

Maintenance Check

Inspect the charge-air cooler (CAC) for dirt and debris blocking the fins. Check for cracks, holes, or other damage. If damage is found, refer to the vehicle, vessel, or equipment manufacturer.

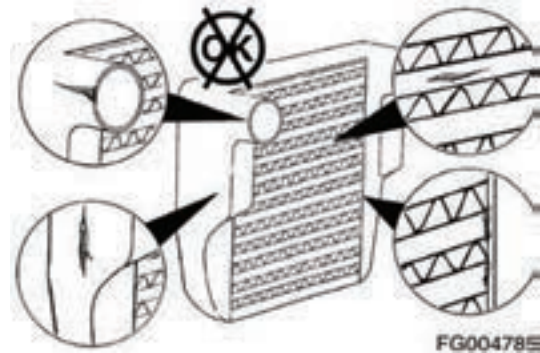


Figure 49

Charge-Air Piping

Maintenance Check

Inspect the charge-air piping and hoses for leaks, holes, cracks, or loose connections. Tighten the hose clamps if necessary. Refer to the vehicle or equipment manufacturer's specifications for the correct torque value.

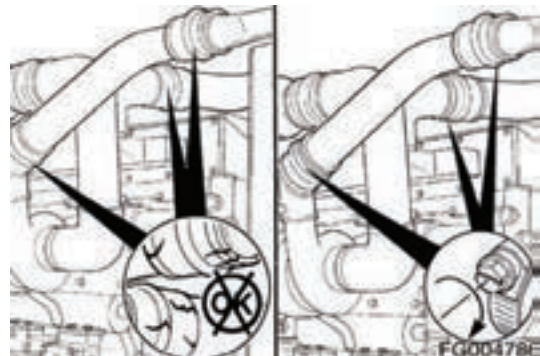


Figure 50

Radiator Hoses

Maintenance Check

Check all hoses for cracks, cuts, or collapsing.

NOTE: *The silicone engine coolant hose will exhibit swelling due to the elasticity of the hose.*

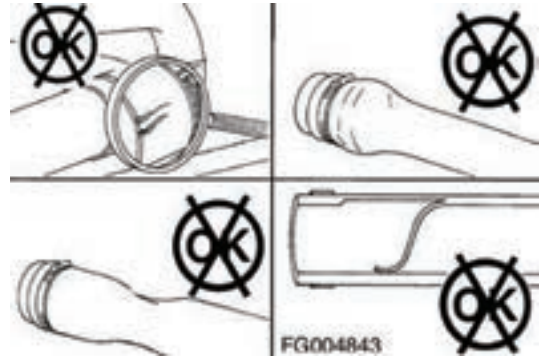


Figure 51

Air Intake Piping

Maintenance Check

Visually inspect the intake piping daily for wear points and damage to piping, loose clamps, or punctures that can damage the engine.

Replace damaged pipes, and tighten loose clamps, as necessary, to prevent the air system from leaking.

- Torque Value: 8 n.m (72 inlb)

Check for corrosion under the clamps and hoses of the intake system piping.

Corrosion can allow corrosive products and dirt to enter the intake system.

Disassemble and clean, as required.

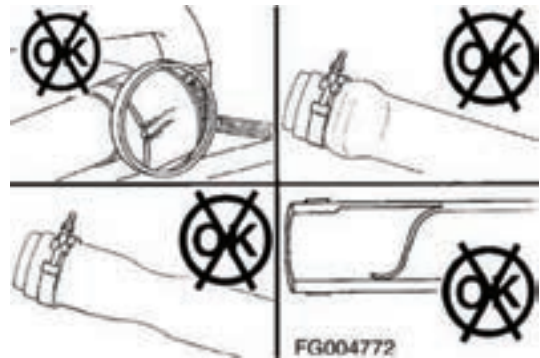


Figure 52

Fan, Cooling

Inspect for Reuse



WARNING!

Do not rotate the engine by pulling or prying on the fan. The fan blade(s) can be damaged and cause the fan to fail and cause personal injury or property damage. Use the accessory drive shaft or the crankshaft barring tool to rotate the crankshaft.

A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the cap screws, if necessary.

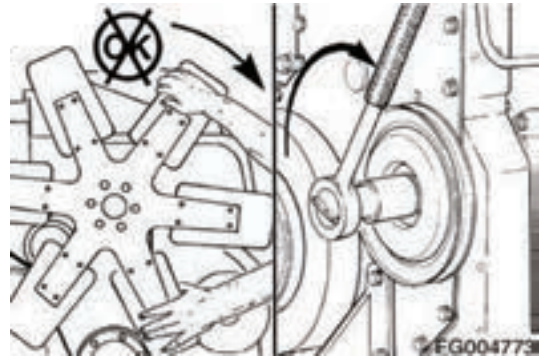


Figure 53

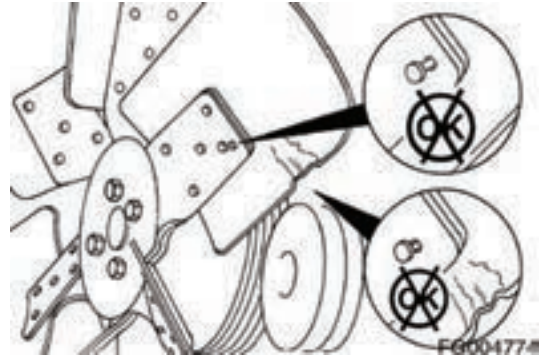


Figure 54



WARNING!

Do not straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause personal injury or property damage.

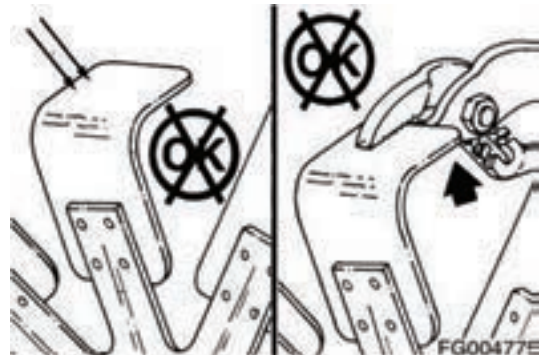


Figure 55

Replace original equipment fan that is damaged with a fan of the identical part number. Cummins Inc. must approve any other fan changes to be covered under warranty.

Refer to the vehicle or equipment manufacturer's specifications for cap screw torque.

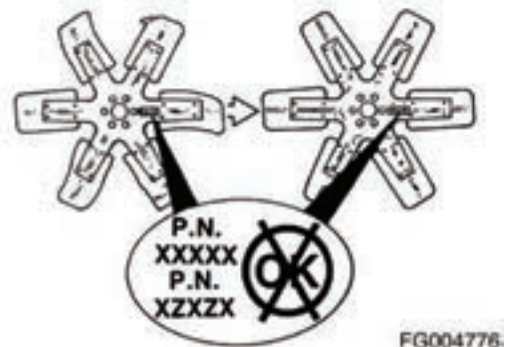


Figure 56

Coolant Level

Maintenance Check

WARNING!

Do not remove a pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (120°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

CAUTION!

Never use a sealing additive to stop leaks in the cooling system. This can result in cooling system plugging and inadequate coolant flow, causing the engine to overheat.

The coolant level must be checked daily.

CAUTION!

Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool to below 50°C [120°F] before adding coolant.

Make up coolant added to the engine must be mixed with the correct proportions of antifreeze, supplemental coolant additive, and water to avoid engine damage.

Coolant recommendations and specification details on correct mixing of coolant can be found in "Maintenance Specifications" on page-245.

Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or expansion tank.

NOTE: Some radiators have two fill necks, both of which must be filled when the cooling system is drained.

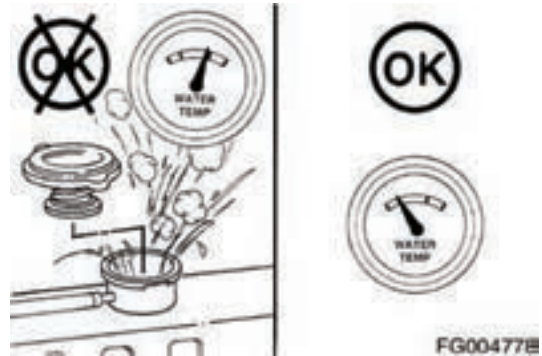


Figure 57

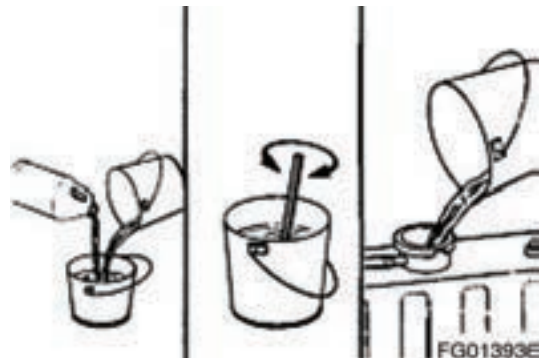


Figure 58

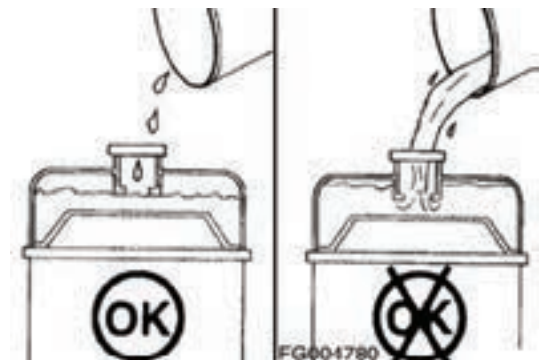


Figure 59

MAINTENANCE PROCEDURES AT 500 HOURS OR 6 MONTHS

Maintenance Procedures - Overview

General Information

All maintenance checks and inspections listed in previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval.

Cooling System

General Information



Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (120°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

NOTE: Never use a sealing additive to stop leaks in the coolant system. This can result in coolant system plugging and inadequate coolant flow, causing the engine to overheat.

The engine coolant level must be checked daily. Remove the pressure cap.



Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 50°C (120°F) before adding coolant.

On applications that use a coolant recovery system, check to make sure the coolant is at the appropriate level on the coolant recovery tank, for the engine temperature.

Many coolant recovery/expansion tanks, also called "top tanks", have sight glasses (1) or are made of a clear material (not shown) to aid in checking the coolant level (2) without removing the radiator cap.

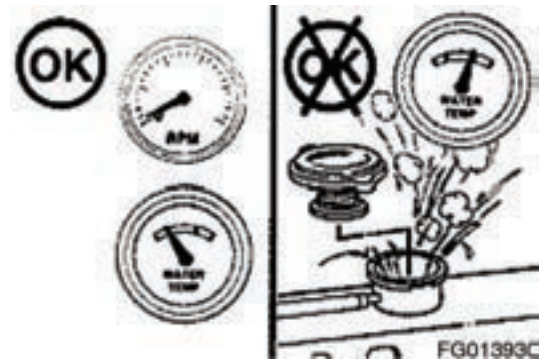


Figure 60

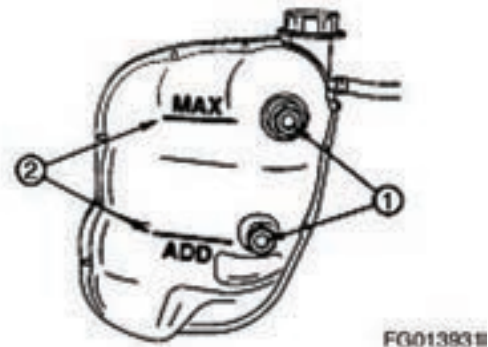


Figure 61

Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or recovery/expansion tank.

NOTE: *Some radiators have two fill necks, both of which must be filled when the cooling system is drained.*

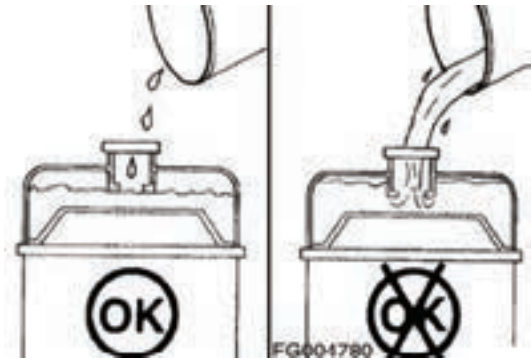


Figure 62

Maintenance Check



Over-concentration of antifreeze or use of high silicate antifreeze can cause damage to the engine.

Check the antifreeze concentration. Use a mixture of 50-percent water and 50percent ethylene glycol or propylene glycol-base antifreeze to protect the engine to -32°C (-25°F) year-around.

The Fleetguard® refractometer, Part Number C2800, provides a reliable, easy to read, and accurate measurement of freezing point protection and glycol (antifreeze) concentration.

Antifreeze is essential in every climate as it broadens the operating temperature by lowering the coolant freezing point and by raising its boiling point.

The corrosion inhibitors also protect the cooling system components from corrosion and provides longer component life.

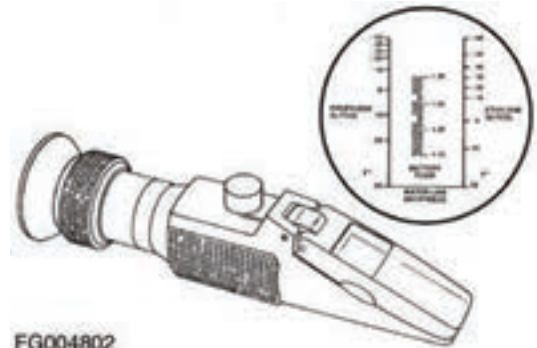


Figure 63

Drain



Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (120°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the radiator/expansion tank cap.

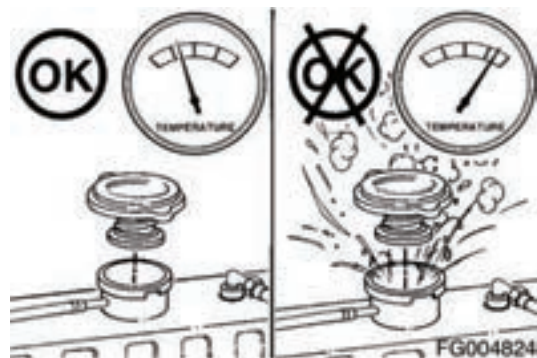


Figure 64



WARNING!

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Drain the cooling system by opening the drain valve on the radiator and removing the plug in the bottom of the water inlet. A drain pan with a capacity of 19 liters [5 gal] will be adequate in most applications.

Check for damaged hoses and loose or damaged hose clamps. Replace as required. Check the radiator for leaks, damage, and buildup of dirt. Clean and replace as required.

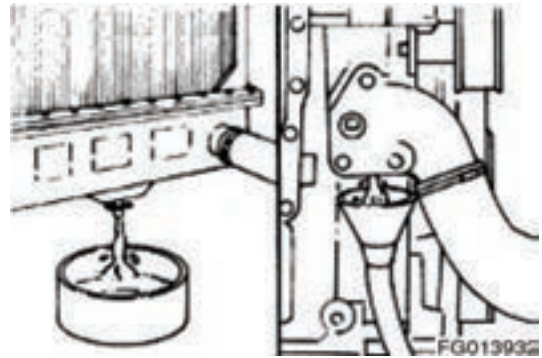


Figure 65

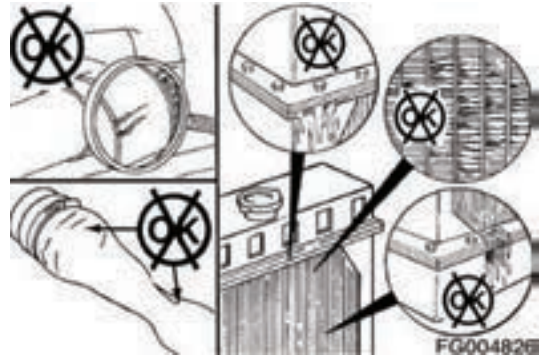


Figure 66

Flush



CAUTION!

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

This provides adequate venting for a fill rate of 19 liters (5 gal) per minute.

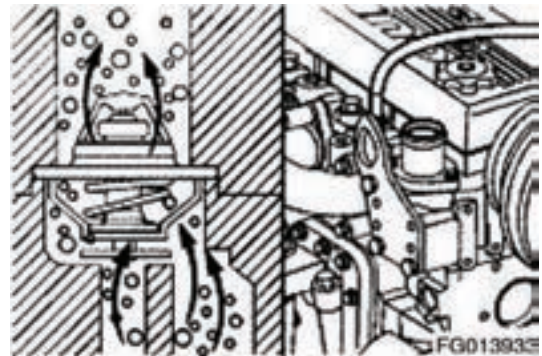


Figure 67

NOTE: An alternate to using sodium carbonate, as outlined in this procedure, is to use Restore™.

Restore™ is a heavy-duty cooling system cleaner that removes corrosion, silica gel, and other deposits. The performance of Restore™ is dependent on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning times, or the use of Restore Plus™. Up to twice the recommended concentration levels of Restore™ can be used safely. Restore Plus™ must be used only at its recommended concentration level. Extremely scaled or fouled systems can require more than one cleaning.



Figure 68

! CAUTION!

Do not install the radiator cap. The engine is to be operated without the cap for this process.

Fill the system with a mixture of sodium carbonate and water (or a commercially available equivalent).

NOTE: Adequate venting is provided for a fill rate of 19 liters (5 gal) per minute.

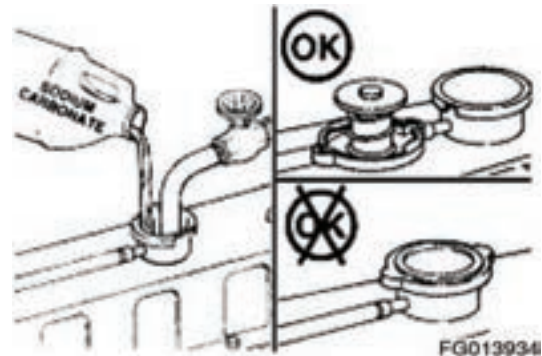


Figure 69

! WARNING!

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Operate the engine for 5 minutes with the coolant temperature above 80°C (176°F). Shut the engine off, and drain the cooling system.

Shut the engine off, and drain the cooling system.

Fill the cooling system with clean water.

NOTE: Do not install the radiator cap.

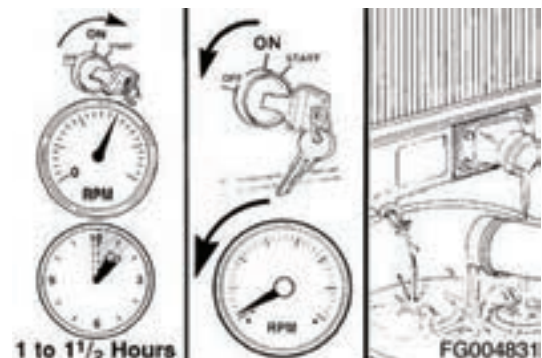


Figure 70

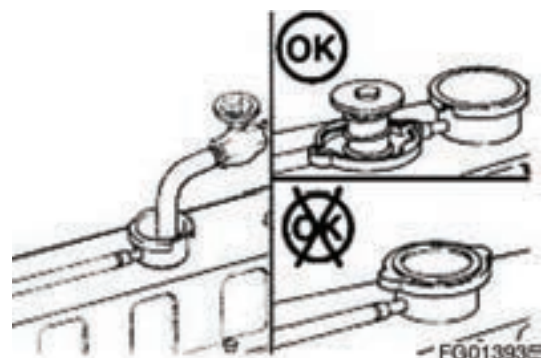


Figure 71

Operate the engine for 5 minutes with the coolant temperature above 80°C (176°F).

Shut off the engine and drain the cooling system.

NOTE: *If the water being drained is still dirty, the system must be flushed again until the water is clean.*

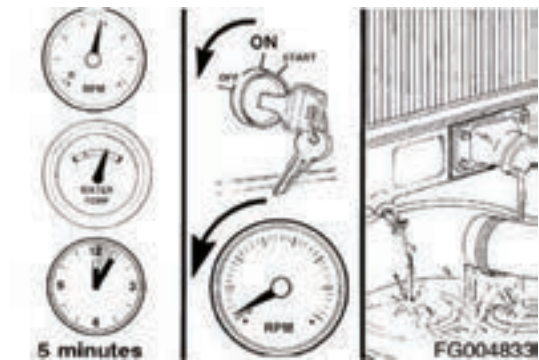


Figure 72

Fill

CAUTION!

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

The system has a design fill rate of 19 liters (5 gal) per minute.

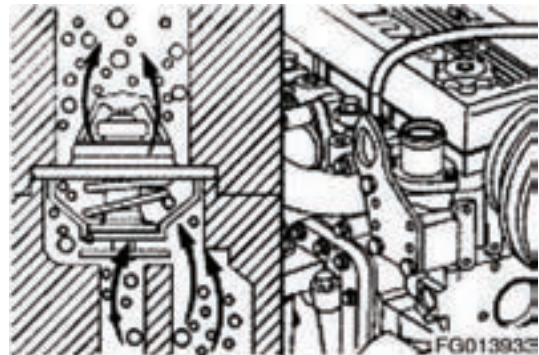


Figure 73

CAUTION!

Never use water alone for coolant. Damage from corrosion can be the result of using water alone for coolant.

Use a mixture of 50-percent water and 50percent ethylene glycol or propylene glycol antifreeze to fill the cooling system. For coolant recommendations and specifications.

For cooling system capacity, refer to "Cooling System" on page-248.

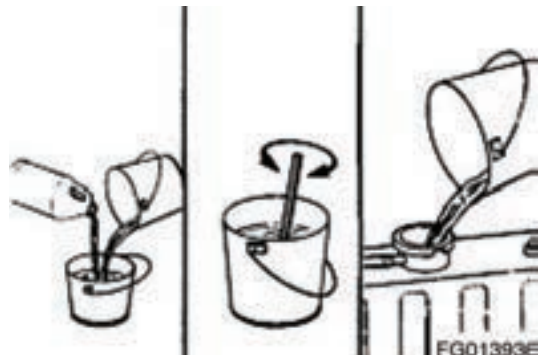


Figure 74



WARNING!

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (122°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Install the pressure cap. Operate the engine until it reaches a temperature of 80°C (180°F) and check for coolant leaks.

Check the coolant level again to make certain the system is full of coolant or that the coolant level has risen to the hot level in the recovery/expansion tank in the system, if so equipped.

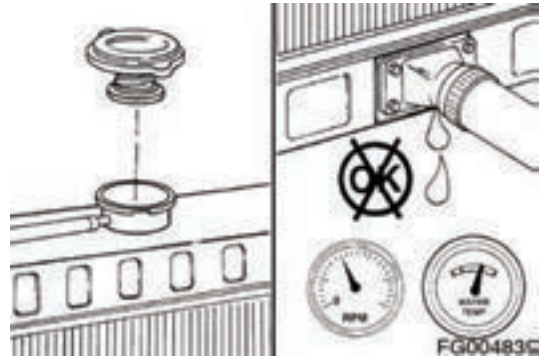


Figure 75

Fuel Filter (Spin-On Type)

Remove

Remove the spin-on fuel filter with fuel filter wrench, Part Number 3398231.

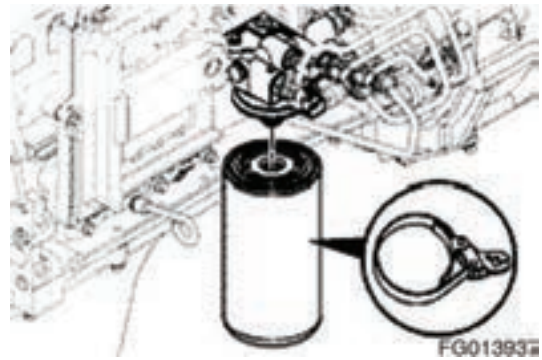


Figure 76

Install

NOTE: Do not pre-fill the on-engine fuel filter.



CAUTION!

Do not pre-fill the on-engine fuel filter with fuel. The system must be primed after the fuel filter is installed. Pre-filling the fuel filter can result in debris entering the fuel system and damaging fuel system components.

Lubricate the o-ring seal with clean lubricating oil.



Figure 77



CAUTION!

Do not pre-fill the on-engine fuel filter with fuel. The system must be primed after the fuel filter is installed. Pre-filling the fuel filter can result in debris entering the fuel system and damaging fuel system components.

Use the correct fuel filter. See Cummins/Fleetguard®/Nelson filter specifications for the correct part number.

Install the filter on the filter head. Tighten the filter until the gasket contacts the filter head surface.

Tighten the fuel filter an additional 3/4 turn after contact or consult to filter manufacturers instructions as specified by the filter manufacturer.

- Torque Value: 34 n.m (25ft-lb)

Prime fuel system after fuel filter installation.

Prime



WARNING!

The fuel pump high-pressure fuel lines and fuel rail contain very high-pressure fuel. Never loosen any fittings while the engine is running . Personal injury and property damage can result.

To prime the engine use the OEM installed priming device. Typically, a priming pump is installed at or near the pre-filter. See the OEM's instructions for the number of strokes (hand primer) or the cycle time (electric priming pump) needed to prime the low pressure system.

NOTE: *It is not necessary to vent air from the high pressure system before starting the engine.*

NOTE: *It is not necessary to pre-fill the on-engine fuel filter.*

Operate the engine and check for leaks.

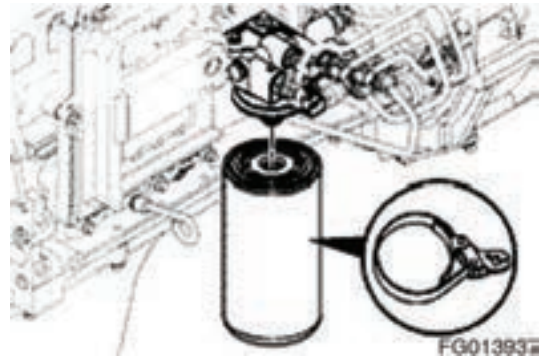


Figure 78

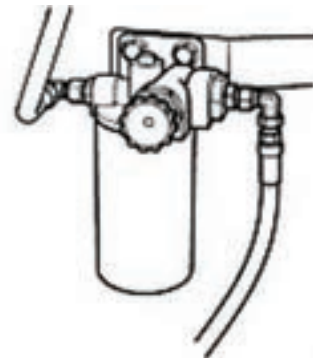


Figure 79

Lubricating Oil and Filters

Drain



WARNING!

Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

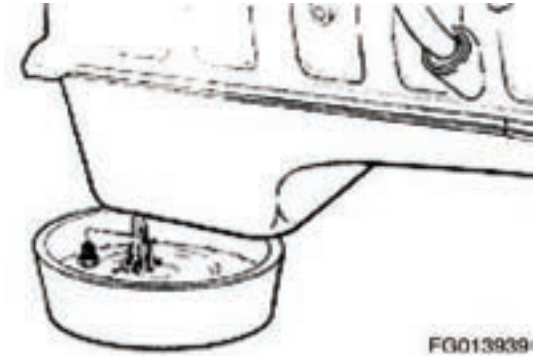


Figure 80



WARNING!

To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

Change lubricating oil and filter (s) at specified oil change interval. See the Maintenance Schedule to find the correct change interval for your application.

NOTE: For most engines, use a container that can hold at least 20 liters (21 qt) of lubricating oil. Some engines may be equipped with an increased capacity oil pan requiring a container that will hold 28 liters (30 qt) of lubricating oil.

Operate the engine until the water temperature reaches 60°C (140°F).

Shut off the engine.

Remove the oil drain plug. Drain the oil immediately to be sure all the oil and suspended contaminants are removed from the engine.

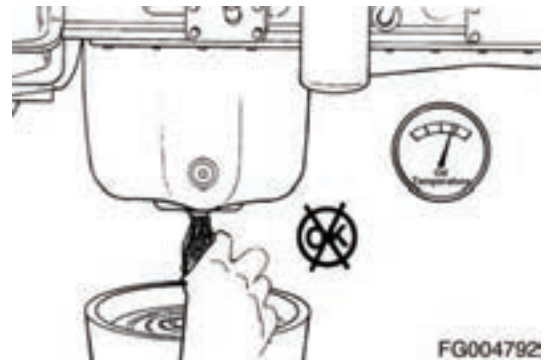


Figure 81

Remove

Clean the area around the lubricating oil filter head.

Use the oil filter wrench, Part Number 3400158, to remove the filter.

Clean the gasket surface of the filter head.

NOTE: *The o-ring can stick on the filter head. Make sure it is removed before installing the new filter.*

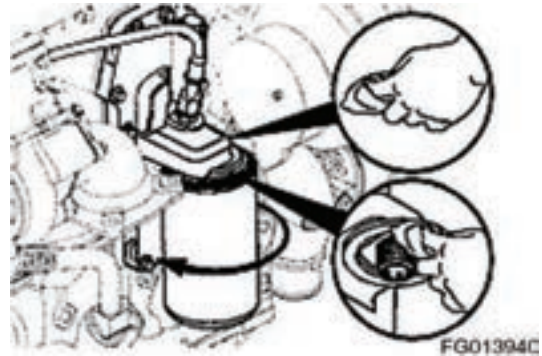


Figure 82

Install

Use the correct oil filter.

See Cummins® /Fleetguard® /Nelson filter specifications for the correct oil filter part number.

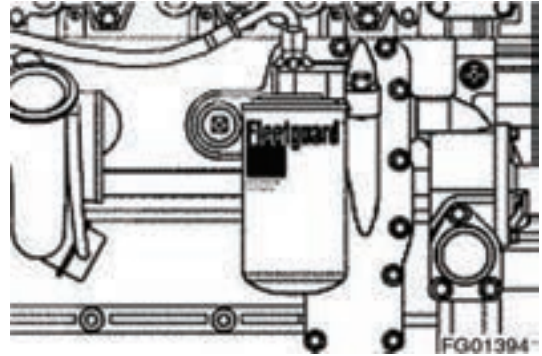


Figure 83

CAUTION!

The lack of lubrication during the delay until the filter is pumped full of oil at start-up can damage the engine.

Use clean 15W-40 oil to coat the gasket surface of the filter.

Fill the filter with clean 15W-40 oil.

NOTE: *Be careful that no debris is poured into the filter. If using an oil supply with a metallic or plastic seal under the cap, be careful to peel the seal back. Puncturing the seal with a knife or sharp object can create debris in the oil container.*

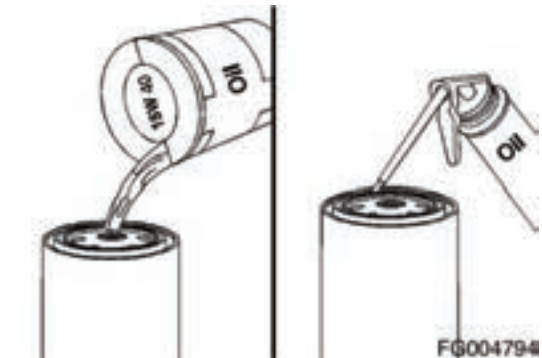


Figure 84

CAUTION!

Mechanical overtightening of filter can distort the threads or damage the filter element seal.

Install the filter on the oil filter head. Tighten the filter until the gasket contacts the filter head surface.

Tighten 3/4 to 1 turn after gasket makes contact with the filter head.

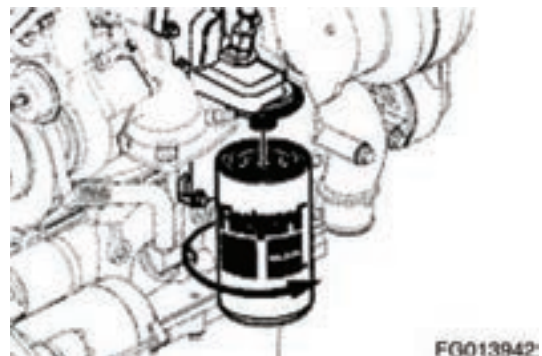


Figure 85

Fill

Clean and check the lubricating oil drain plug threads and sealing surface. Use new sealing washer, if damaged.

Install the lubricating oil pan drain plug.

Automotive and Industrial

Applications:

Steel Oil Pan	M18	M22
Drain Plug	60Nm	80Nm
Torque	Min 44 (ft-lb)	Min 59 (ft-lb)

Cast Aluminum Oil Pan	M22
Drain Plug	60Nm
Torque	Min 44 (ft-lb)

NOTE: Use a high quality 15W-40 multi viscosity oil, such as Cummins Premium Blue®, or its equivalent, in Cummins® engines. Choose the correct lubricating oil for your operating climate as outlined.

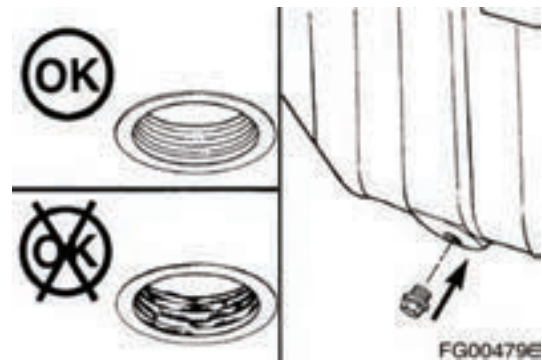


Figure 86



Figure 87

Idle the engine to inspect for leaks at the drain plug and, if replaced, the oil filter seal.

NOTE: Engine oil pressure must be indicated on the gauge within 15 seconds after starting. If oil pressure is not registered within 15 seconds, shut off the engine immediately to avoid engine damage. Confirm that the correct oil level is in the oil pan.

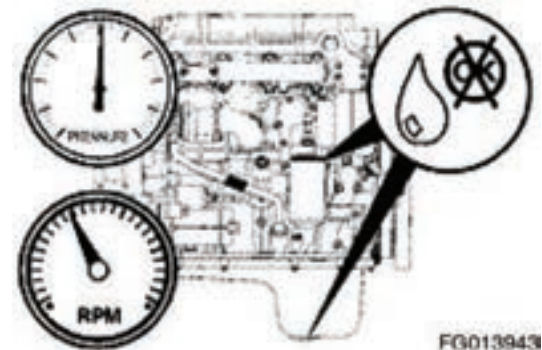


Figure 88

Shut off the engine. Wait approximately 5 minutes to let the oil drain from the upper parts of the engine. Check the level again.

Add oil as necessary to bring the oil level to the H (high) mark on the dipstick.

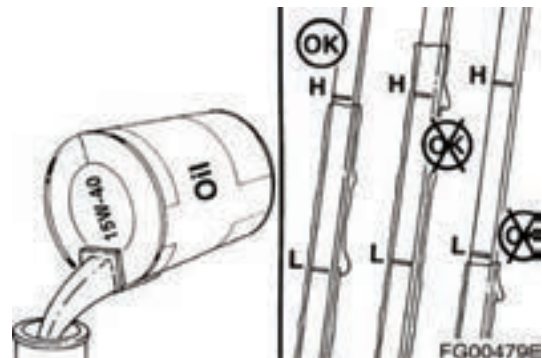


Figure 89

MAINTENANCE PROCEDURES AT 1,000 HOURS OR 1 YEAR

Maintenance Procedures - Overview

General Information

All maintenance checks and inspections listed in previous maintenance intervals must also be performed at this time, in addition to those listed under this maintenance interval.

Maintenance Check

With the engine stopped, check the tensioner arm, pulley and stops for cracks. If any cracks are found, the tensioner must be replaced.

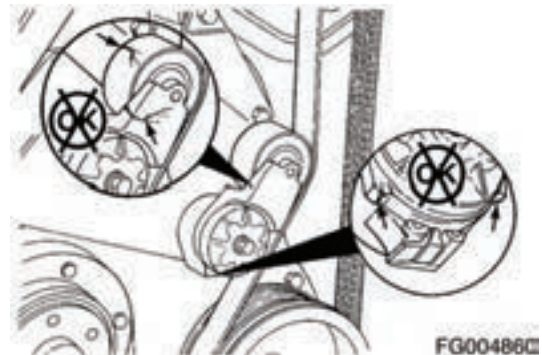


Figure 90

With the belt installed, verify that neither tensioner arm stops is in contact with the spring casing stop. If either of the stops is touching:

- Verify the correct belt part number is installed.
- If the correct belt is installed, replace the belt. Refer to "Drive Belt, Cooling Fan" on page-115.

After replacing the belt, if the tensioner arm stops are still in contact with the spring case stop, replace the tensioner.

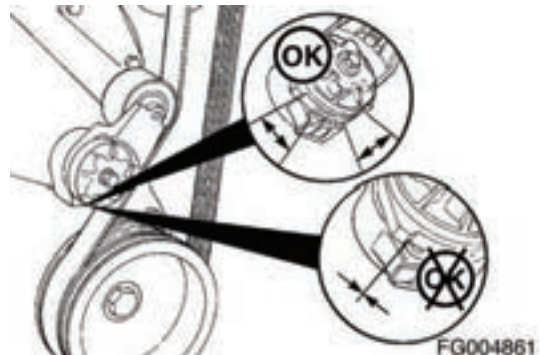


Figure 91

Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or close to the middle of, the pulley. Misaligned belts, either too far forward or backward, can cause belt wear, belt roll-off failures, or increase uneven tensioner bushing wear.

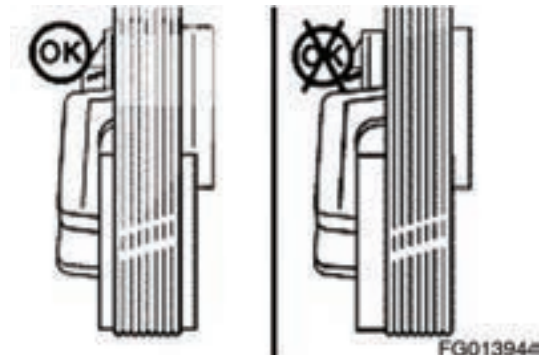


Figure 92

Remove the drive belt. Refer to Procedure "Drive Belt, Cooling Fan" on page-115.

With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If they are not touching, the tensioner must be replaced.

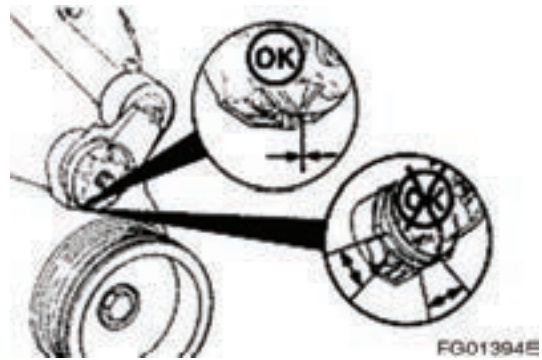


Figure 93

Fan Hub, Belt Driven

Maintenance Check

Remove the drive belt.

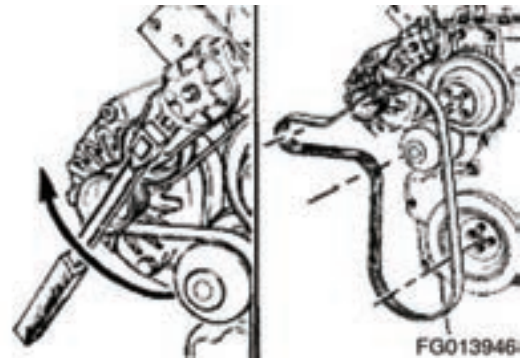


Figure 94

NOTE: *The fan hub must rotate without any wobble or excessive end play.*

- Fan Hub End Play 0.15mm MAX (0.006in)



Figure 95

MAINTENANCE PROCEDURES AT 2,000 HOURS OR 2 YEARS

Air Compressor Discharge Lines (Not Used)

General Information

All air compressors have a small amount of lubricating oil carryover that lubricates the piston rings and moving parts. When this lubricating oil is exposed to normal air compressor operating temperatures over time, the lubricating oil will form varnish or carbon deposits. If the following maintenance check are not performed, the air compressor piston rings will wear and not seal correctly.

Maintenance Check



WARNING!

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Shut off the engine.

Open the drain valve on the wet tank to release the system air pressure.

Remove the air compressor discharge line from the air compressor. Location of the air compressor discharge line can be found in Flow Diagram, Compressed Air System in "System Diagrams" on page-123.

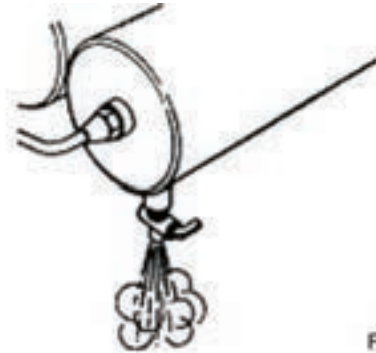


Figure 96

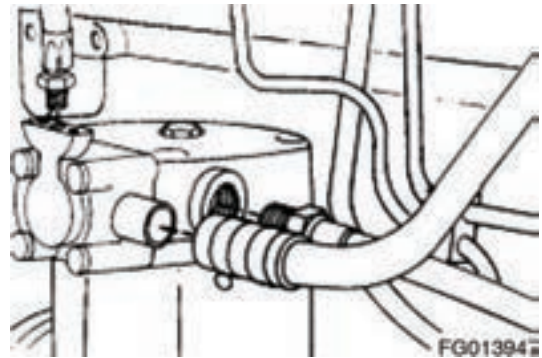
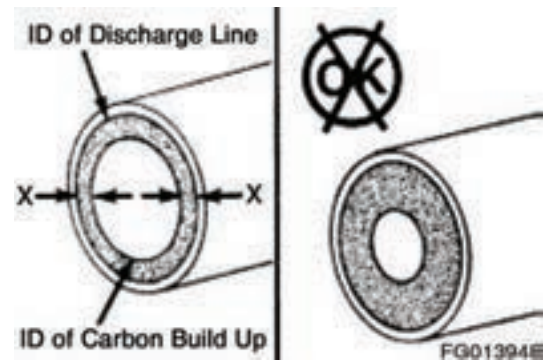
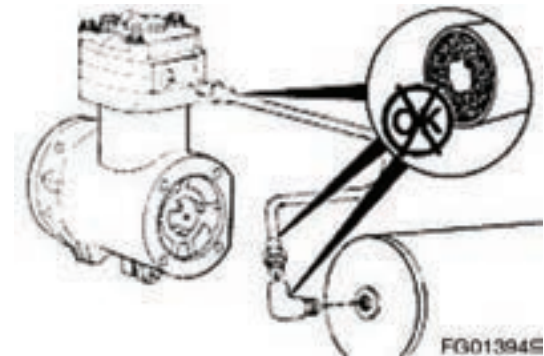


Figure 97

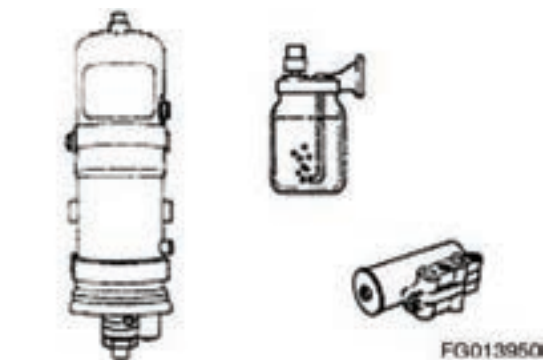
Measure the total carbon deposit thickness inside the air discharge line as shown. If the total carbon deposit ($X + X$) exceeds 2 mm [1/16 in], clean and inspect the cylinder head, the valve assembly, and the discharge line. Replace if necessary. Contact the Cummins Authorized Repair Location for procedures.



If the total carbon deposit exceeds specifications, continue checking the air discharge line connections up to the first tank until total carbon deposit is less than 2 mm [1/16 in]. Clean or replace any lines or connections that exceed this specification.



Inspect any air driers, splitter valves, pressure relief valves, and alcohol injectors for carbon deposits or malfunctioning parts. Inspect for air leaks. Maintain and repair the parts according to the manufacturer's specifications.



Cooling System

General Information



WARNING!

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (120°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

NOTE: Never use a sealing additive to stop leaks in the coolant system. This can result in coolant system plugging and inadequate coolant flow, causing the engine to overheat.



CAUTION!

Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 50°C (120°F) before adding coolant.

On applications that use a coolant recovery system, check to make sure the coolant is at the appropriate level on the coolant recovery tank, for the engine temperature.

Many coolant recovery/expansion tanks, also called "top tanks", have sight glasses (1) or are made of a clear material (not shown) to aid in checking the coolant level (2) without removing the radiator cap.

Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill or recovery/expansion tank.

NOTE: Some radiators have two fill necks, both of which must be filled when the cooling system is drained.

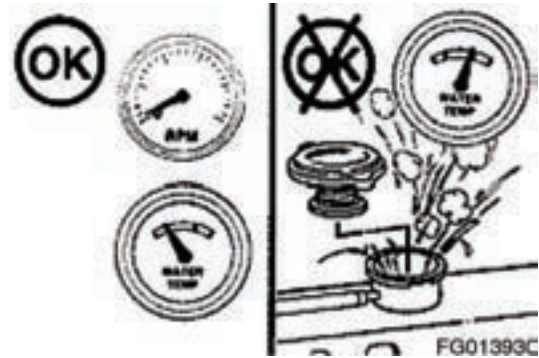


Figure 101

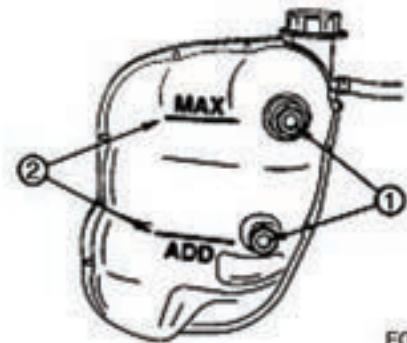


Figure 102

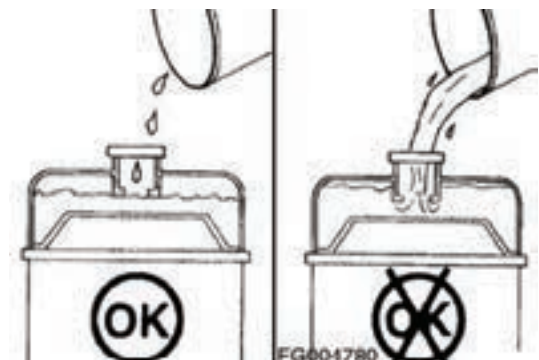


Figure 103

Drain



WARNING!

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (122°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the radiator/expansion tank cap.

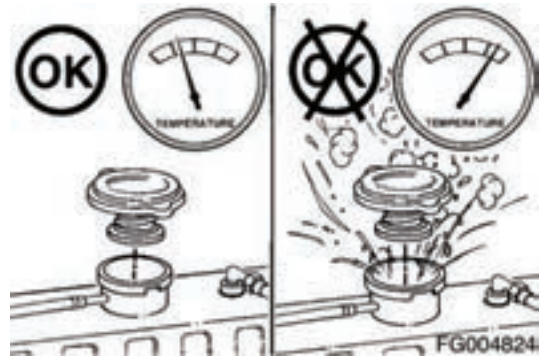


Figure 104



WARNING!

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

Drain the cooling system by opening the drain valve on the radiator and removing the plug in the bottom of the water inlet. A drain pan with a capacity of 19 liters (5 gal.) will be adequate in most applications.

Check for damaged hoses and loose or damaged hose clamps. Replace as required. Check the radiator for leaks, damage, and buildup or dirt. Clean and replace as required.

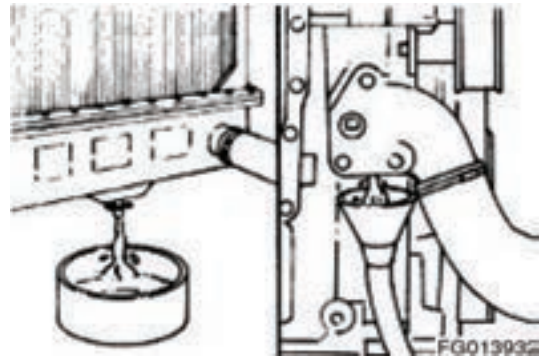


Figure 105

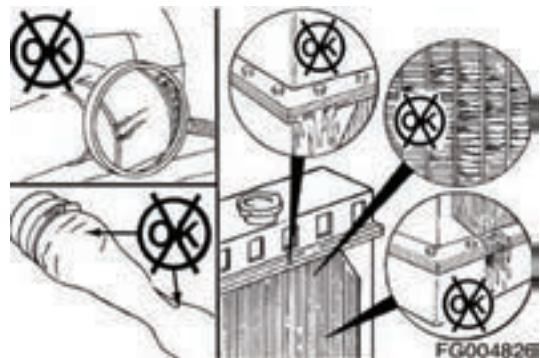


Figure 106

Flush



CAUTION!

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

This provides adequate venting for a fill rate of 19 liters (5 gal) per minute.

NOTE: *An alternate to using sodium carbonate, as outlined in this procedure, is to use Restore™.*

Restore™ is a heavy-duty cooling system cleaner that removes corrosion, silica gel, and other deposits. The performance of Restore™ is dependent on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of cleaners, higher temperatures, or longer cleaning times, or the use of Restore Plus™. Up to twice the recommended concentration levels of Restore™ can be used safely. Restore Plus™ must be used only at its recommended concentration level. Extremely scaled or fouled systems can require more than one cleaning.

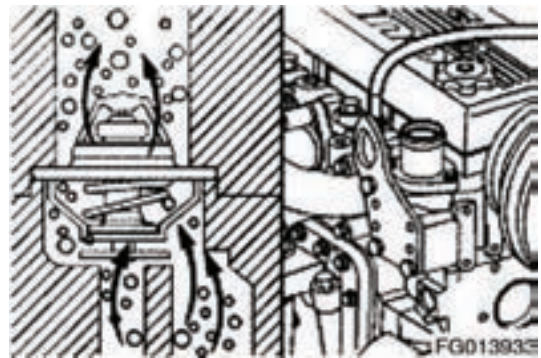


Figure 107



Figure 108



WARNING!

Do not install the radiator cap. The engine is to be operated without the cap for this process.

Fill the system with a mixture of sodium carbonate and water (or a commercially available equivalent).

NOTE: *Adequate venting is provided for a fill rate of 19 liters (5 gal.) per minute.*

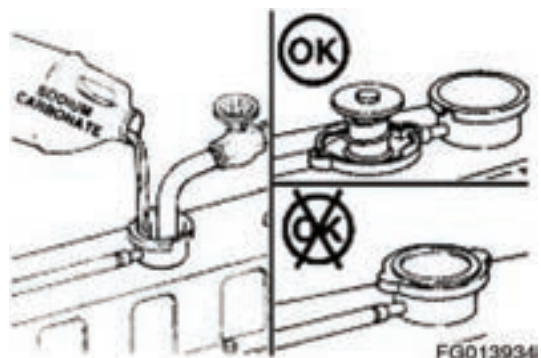


Figure 109



WARNING!

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

CAUTION!

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

Operate the engine for 5 minutes with the coolant temperature above 80°C (176°F).

Shut the engine off, and drain the cooling system.

Fill the cooling system with clean water.

NOTE: Do not install the radiator cap.

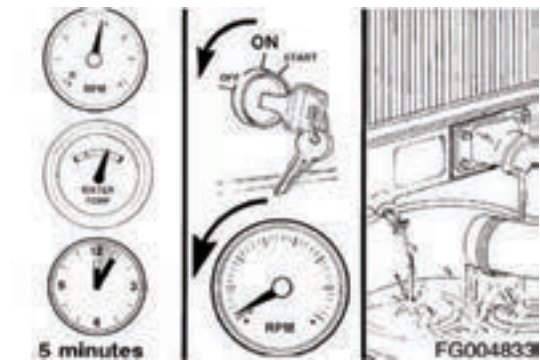


Figure 110

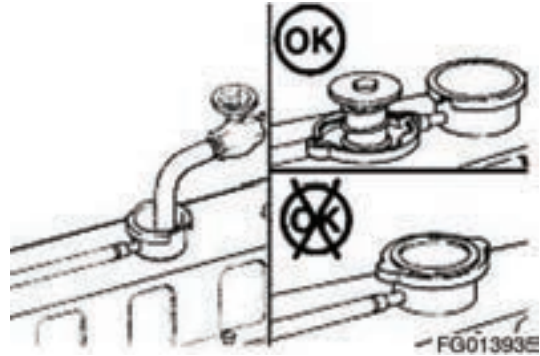


Figure 111

Operate the engine for 5 minutes with the coolant temperature above 80°C (176°F).

Shut the engine off, and drain the cooling system.

NOTE: If the water being drained is still dirty, the system must be flushed again until the water is clean.

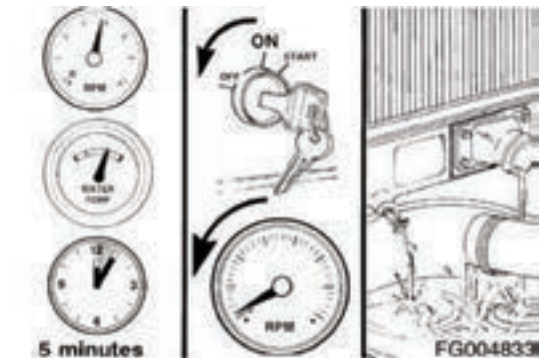


Figure 112

Fill



CAUTION!

The system must be filled properly to prevent air locks. During filling, air must be vented from the engine coolant passages. Wait 2 to 3 minutes to allow air to be vented; then add mixture to bring the level to the top.

To be sure air is vented during the fill process:

- The thermostat has check balls that allow air to vent through the thermostat when the thermostat is closed.
- A deaeration port is located next to the water outlet connection which connects to the top tank/coolant recovery tank of the cooling system.

The system has a design fill rate of 19 liters (5 gal) per minute.

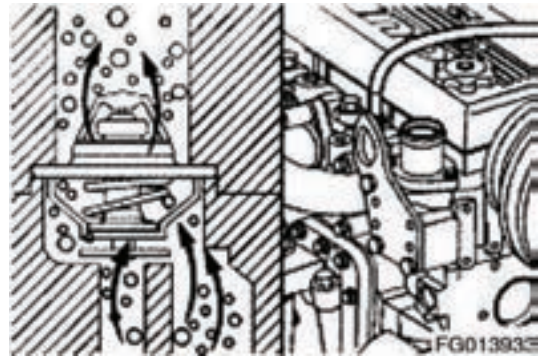


Figure 113



CAUTION!

Never use water alone for coolant. Damage from corrosion can be the result of using water alone for coolant.

Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol antifreeze to fill the cooling system. Refer to the Cummins Coolant Requirements and Maintenance, Bulletin 3666132, for engine coolant specifications.

For cooling system capacity, refer to "Cooling System" on page-86.

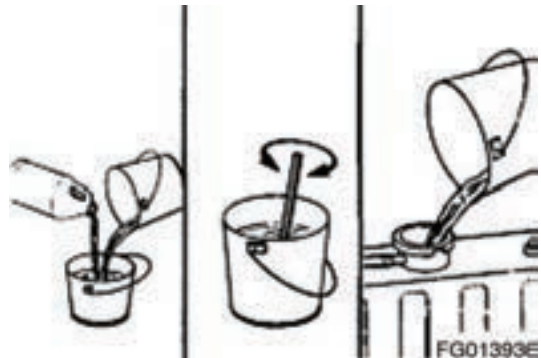


Figure 114



WARNING!

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (122°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Install the pressure cap. Operate the engine until it reaches a temperature of 80°C (180°F) and check for coolant leaks.

Check the coolant level again to make certain the system is full of coolant or that the coolant level has risen to the hot level in the recovery/expansion tank in the system, if so equipped.

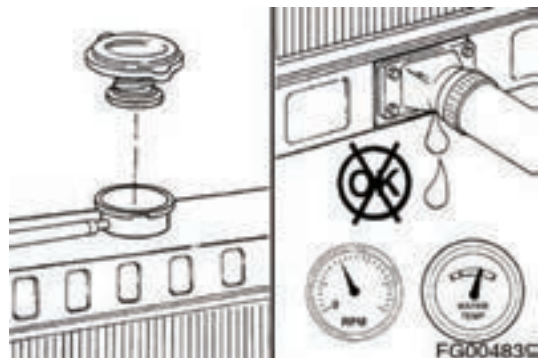


Figure 115

Vibration Damper, Rubber

Inspect

Check the index lines (A) on the damper hub (B) and the inertia member (C). If the lines are more than 1.59 mm [1/16 in] out of alignment, replace the damper.

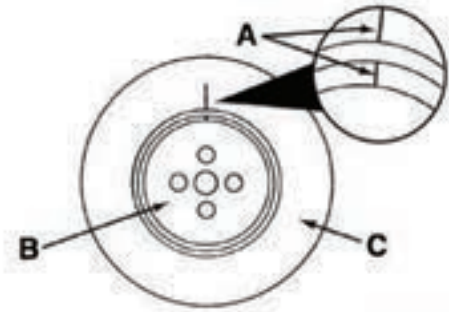


Figure 116

FG004840

Inspect the rubber member for deterioration. If pieces of rubber are missing or if the elastic member is more than 3.18 mm [1/8 in] below the metal surface, replace the damper.

Look for forward movement on the damper ring on the hub. Replace the vibration damper if any movement is detected.

For vibration damper location, refer to "Engine Diagrams" on page-30.

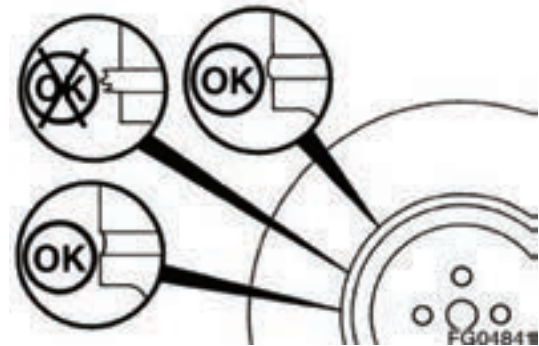


Figure 117

FG04841

Vibration Damper, Viscous

Inspect



The silicone fluid in the vibration damper will become solid after extended service and will make the damper inoperative. An inoperative vibration damper can cause major engine or drivetrain failures.

Check the vibration damper for evidence of fluid loss, dents, and wobble. Inspect the vibration damper thickness for any deformation or raising of the damper cover plate.

If any of these conditions are identified, contact your local Cummins Authorized Repair Location to replace the vibration damper.

For vibration damper location, refer to "Engine Identification" on page-26.

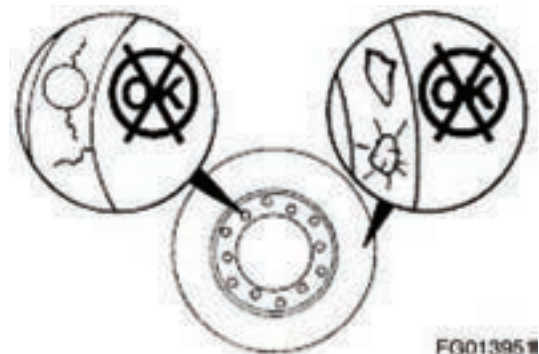


Figure 118

FG013951

MAINTENANCE PROCEDURES AT 5000 HOURS OR 4 YEARS

Overhead Set

Preparatory Steps



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the batteries.

Remove



WARNING!

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

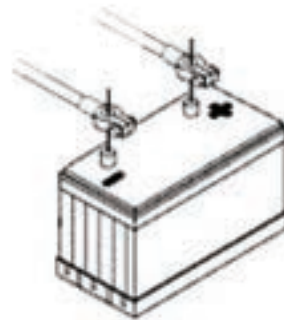
Prior to removing any components, clean around the mounting fasteners and sealing joints with compressed air to remove any loose debris.

Disconnect the breather tube connection at the back of the rocker lever cover.

In general, two type of breather tube connections are used at the rocker lever cover:

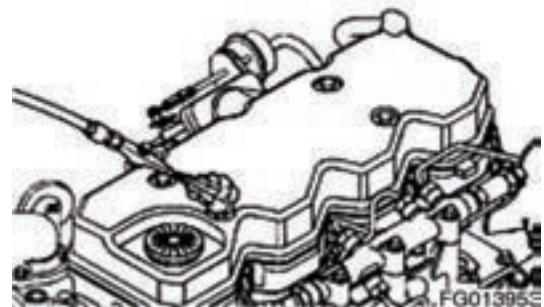
1. A clamping plate and capscrew hold the breather tube connection to the rocker lever cover. Remove the capscrew and clamping plate to disconnect the breather tube connection from the rocker lever cover.
2. 1 or 2 Capscrew(s) directly mount the breather tube connection to the rocker lever cover. Remove the capscrew(s) to disconnect the breather tube connection from the rocker lever cover.

NOTE: Some breather tube connections use internal Torx capscrews to secure the breather tube connection to the rocker lever cover.



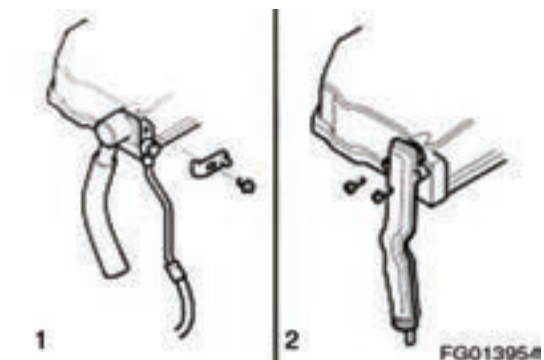
FG013952

Figure 119



FG013953

Figure 120



FG013954

Figure 121

If equipped, at the rear of the rocker lever cover, remove the banjo bolt and sealing washers connecting the breather oil drain line to the rocker lever cover.

NOTE: *Not all engines with an internal mounted crankcase breather are equipped with an external breather oil drain line. On some engines the breather oil drain line is internal to the breather connection tube (1).*

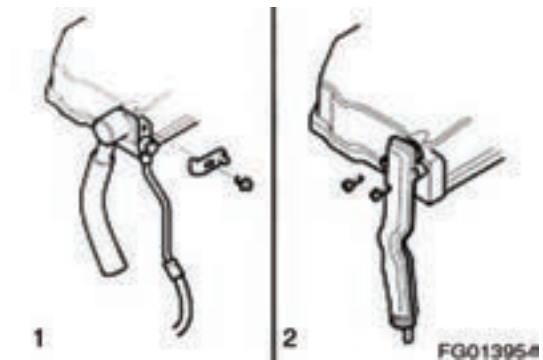


Figure 122

Do not remove the rocker lever gasket on engines in which the rocker lever cover gasket is fit into a groove at the base of the rocker lever cover. The gasket is reusable. Once the gasket is removed from the rocker lever cover it must be replaced.

Remove the mounting nuts and isolators from the rocker lever cover.

If equipped, it may be necessary to gently pry the breather tube connection from the back of the rocker lever cover while removing.

Remove the rocker lever cover.



Figure 123

NOTE: *Check the gasket while it is installed in the valve cover. Once the gasket is removed from the cover it must be replaced.*

Check the gasket for cracks on the sealing surface.

Replace the gasket if damage is present.

Replace the gasket if it is removed from the groove in the rocker lever cover.

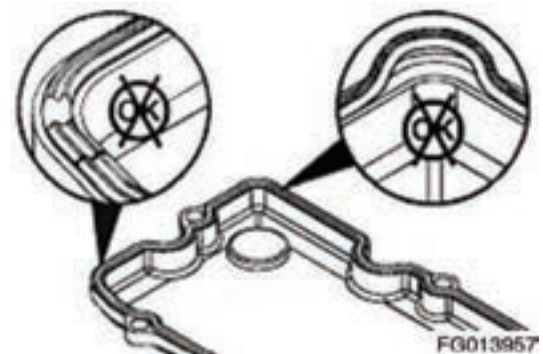


Figure 124

Inspect the rubber isolators for cracks.

Replace if cracked or broken.

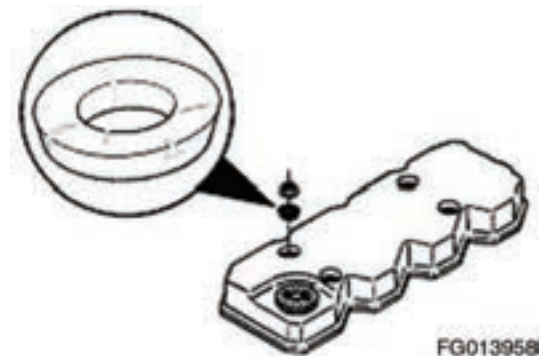


Figure 125

NOTE: *If the gasket has been removed from the rocker lever cover, a new gasket must be used.*

If replacing the rocker lever gasket, the following installation procedure must be used when installing the press-in gasket.

1. Press the molded gasket into the corners of the rocker lever cover
2. Press the remaining gasket into the rocker lever cover.

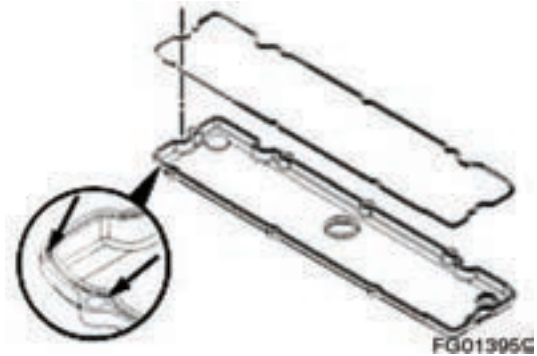


Figure 126

Adjust

NOTE: *Engine coolant temperature must be less than 60°C (140°F).*

Using the barring tool, Part Number 3824591, rotate the crankshaft until the Number 1 cylinder is at TDC.

TDC can be determined by the following method:

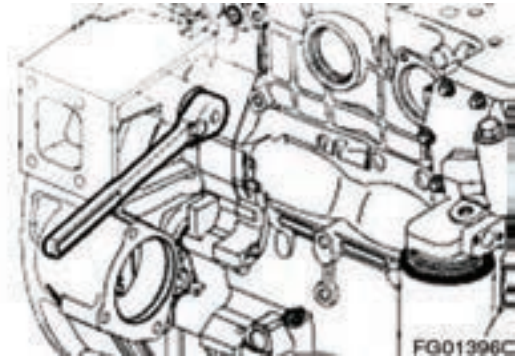


Figure 127

Align the vibration damper/crankshaft speed indicator ring so that the TDC indicator is at the 12 o'clock position. If both number 1 cylinder rocker levers are loose, move to the following steps. If both number 1 cylinder rocker levers are not loose, rotate the crankshaft 360 degrees.

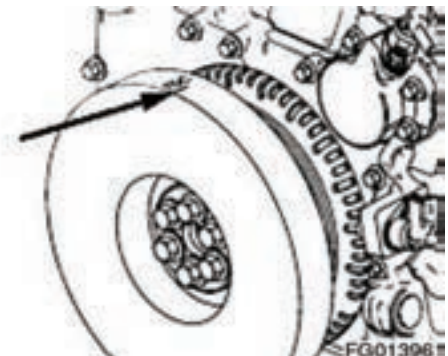


Figure 128

If no TDC mark is present on either the vibration damper or the crankshaft speed indicator ring, align the large gap in the crankshaft speed indicator ring to the 5-o'clock position (2). The dowel pin should also be visible in the 9-o'clock position (1). Check that both No. 1 cylinder rocker levers are loose. If they are not loose, rotate the crankshaft 360 degrees and recheck.

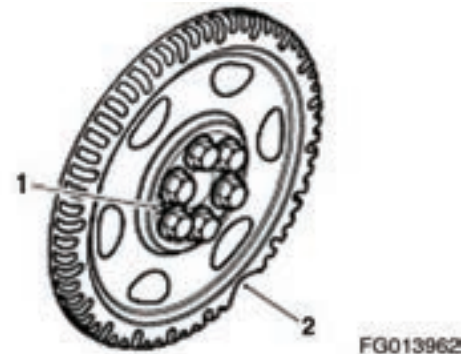


Figure 129

With the engine in this position, lash can be checked on the following rocker arms:

(E = exhaust, I = Intake)

Four-cylinder 1I, 1E, 2I, and 3E

Six-cylinder 1I, 1E, 2I, 3E, 4I, and 5E.

Lash Check Limits	
Intake	0.152mm MIN (0.006in)
Exhaust	0.381mm MAX (0.015in)
	0.381mm MIN (0.015in)
	0.762 MAX (0.030in)

NOTE: *Checking the overhead setting is usually performed as part of a troubleshooting procedure, and resetting is not required during checks as long as the lash measurements are within the above ranges.*

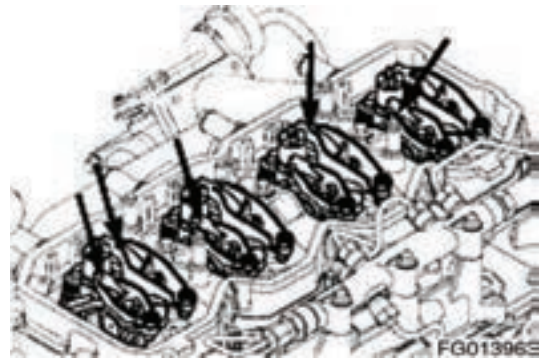


Figure 130



Figure 131

NOTE: *The clearance is correct when some resistance is "felt" when the feeler gauge is slipped between the crosshead and the rocker lever socket.*

Measure lash by inserting a feeler gauge between the crosshead and the rocker lever socket. If the lash measurement is out of specification, loosen the locknut, and adjust the lash to nominal specifications.

Lash Specifications		
	mm	in
Intake	0.254	0.010
Exhaust	0.508	0.020

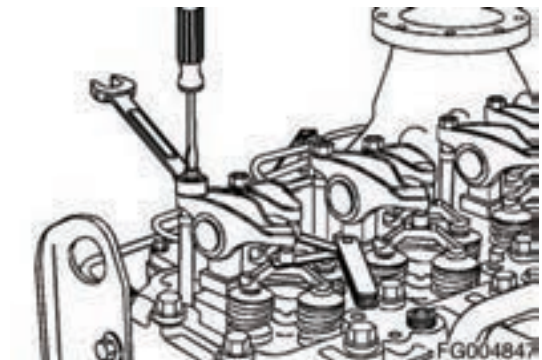


Figure 132

Tighten the locknut and remeasure.

- Torque Value 24 n.m (212 inlb)

Using barring tool, Part Number 3824591, rotate the crankshaft 360 degrees.

Following the same steps and specifications as previously stated, measure lash for the following rockers:

(E = Exhaust, I = Intake)

Four-cylinder 2E, 3I, 4E, and 4I:

Six-cylinder 2E, 3I, 4E, 5I, 6I, and 6E.

Reset if out of specification.

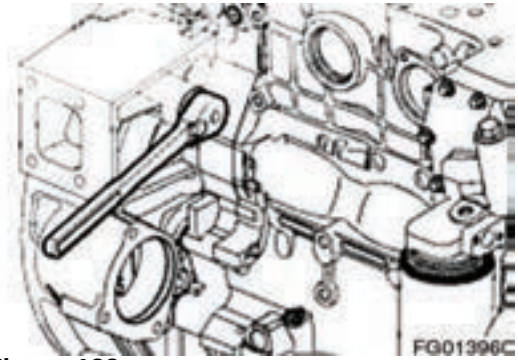


Figure 133

Install

Stud Mounted Rocker Lever Cover.

Install the rocker lever cover over the mounting capscrews.

Install the isolators and mounting nuts.

Tighten the mounting nuts.

- Torque Value 24 n.m (18 ftlb)



Figure 134

Capscrew Mounted Rocker Lever Cover.

Install the rocker lever cover.

Install the mounting capscrews and isolators.

Tighten the mounting capscrews.

- Torque Value 24 n.m (18 ftlb)

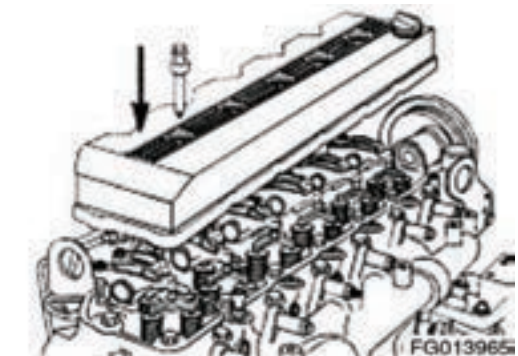


Figure 135

If equipped, at the rear of the rocker lever cover, install the banjo bolt and sealing washers connecting the breather oil drain line to the rocker lever cover.

- Torque Value 12 n.m (106 inlb)

NOTE: *Not all engines with an internal mounted crankcase breather are equipped with an external breather oil drain line. On some engines the breather oil drain line is internal to the breather connection tube (1).*

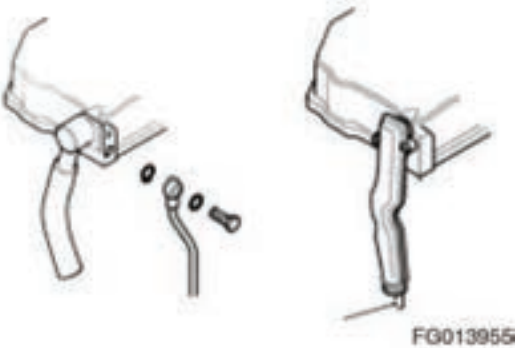


Figure 136

Prior to connecting the breather connection tube to the rocker lever cover, apply clean engine oil to the O-ring located on the breather tube connection.



Figure 137

FG01396#

Connect the breather tube connection to the rocker lever cover.

In general, two types of breather tube connections are used at the rocker lever cover:

1. A clamping plate and capscrew hold the breather tube connection to the rocker lever cover. Install the capscrew and clamping plate to connect the breather tube connection to the rocker lever cover.
2. 1 or 2 Capscrew(s) directly mount the breather tube connection to the rocker lever cover. Install the capscrew(s) to connect the breather tube connection to the rocker lever cover.

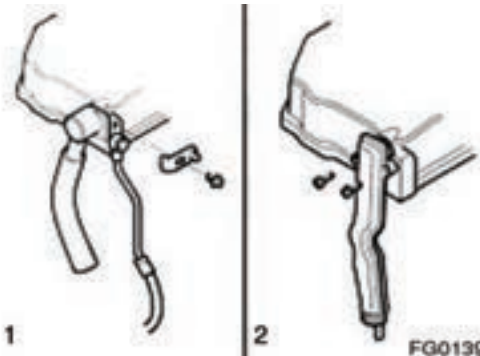


Figure 138

FG01395#

Tighten the Capscrew(s).

- Torque Value 10 n.m (89 inlb)

NOTE: Some breather tube connections use internal Torx capscrews to secure the breather tube connection to the rocker lever cover.

Finishing Steps



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the batteries.

Operate the engine and check for leaks.

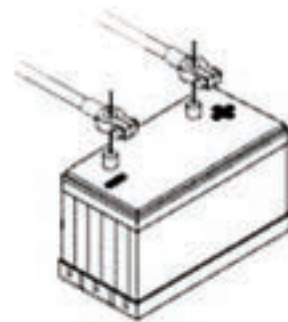


Figure 139

FG013952

Alternator

General Information

Due to the number of different alternator brands and configurations, the following procedure has been generalized to cover the most common configurations. Consult the alternator manufacturer for any information that is not covered in this procedure.



FG013967

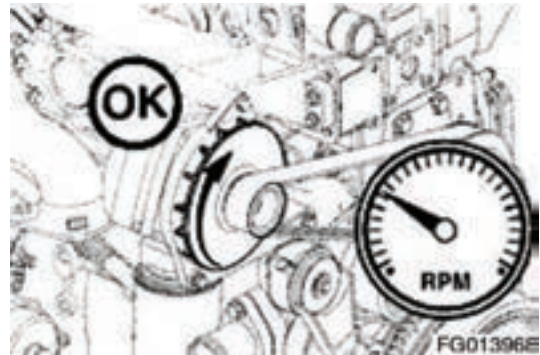
Figure 140

Initial Check

Check the drive belt and alternator pulley to be sure the alternator is rotating properly.

If any problems exist, check the following:

1. If the drive belt is slipping on the alternator pulley, refer to "Drive Belt, Cooling Fan" on page-115 to inspect the drive belt and Procedure 008-087 (Cooling Fan Belt Tensioner) in Section 8 to inspect the belt tensioner.
2. Remove the drive belt. Refer to "Drive Belt, Cooling Fan" on page-115. Check if the alternator pulley is loose on the shaft. If loose, remove the pulley and inspect for damage. Refer to the alternator manufacturer's and/or OEM instructions
3. If the alternator will not rotate or does not rotate freely, the alternator must be replaced. See the remove and install portion of this procedure.



FG013968

Figure 141



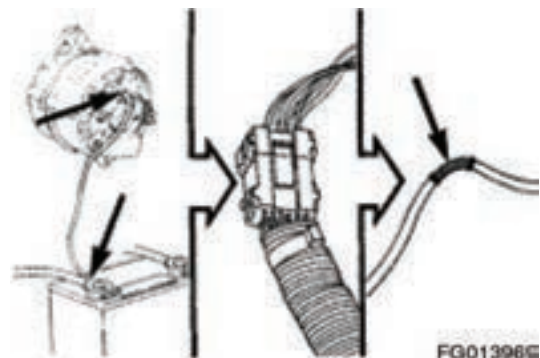
WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Check the battery and all wiring connections.

Inspect the wiring for defects.

Check all connections for tightness and cleanliness, including the slip connectors at the alternator and engine compartment bulkhead, and connections at the battery.



FG013969

Figure 142

Initial Check

NOTE: Any multimeter reading of zero voltage indicates an open circuit.

Check for open circuits.

Turn the keyswitch to the ON position.

Connect a multimeter, Part Number 3164488 or 3164489, to the following locations:

Delco Alternators

1. Alternator "BAT" terminal to ground
2. Alternator blade terminal "number 1" to ground
3. Alternator blade terminal "number 2" to ground.

Locate and repair the open circuit.

Connect a carbon-pile load (battery/alternator tester) across the batteries in one of the battery boxes.

Clamp an induction pickup-type ampere-hour meter around the battery cable; or use the digital multimeter, Part Number 3164488 or 3164489, with the clamp-on current probe, Part Number 3164490.

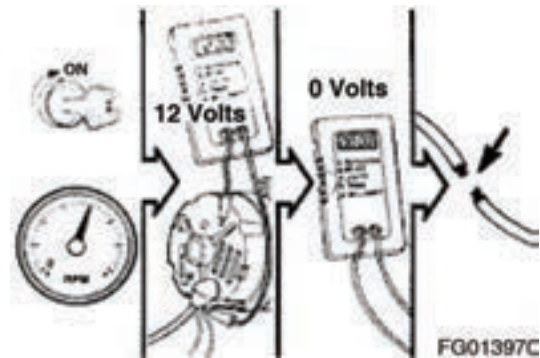


Figure 143

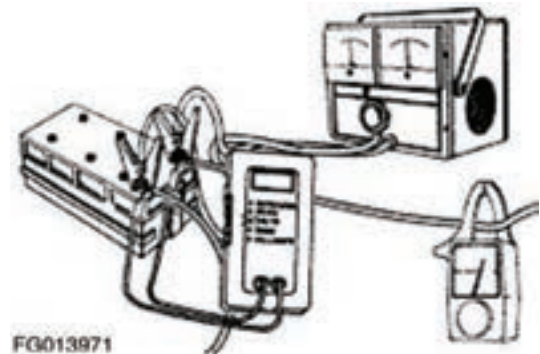


Figure 144



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



WARNING!

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

Disconnect any cables that lead to any other battery boxes in the circuit, negative (-) cables first.

Operate the engine at high idle; and measure the alternator voltage output to the batteries with digital multimeter, Part Number 3164488 or 3164489. Refer to the OEM specifications.

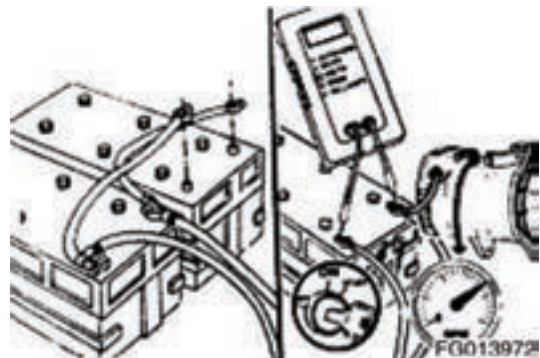


Figure 145

Operate the engine at high idle and adjust the carbon-pile load-testing equipment to apply the maximum rated amperage load to the alternator. Refer to the OEM specifications.

NOTE: *The alternator maximum rated amperage output is normally stamped or labeled on the alternator.*

Measure the alternator amperage output. Refer to the OEM specifications.

If the alternator output (amps) is not within 10 percent of rated output, repair or replace the alternator. Refer to the OEM troubleshooting and repair manual for repair procedures.

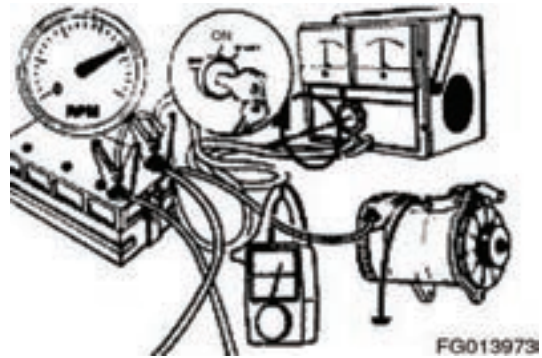


Figure 146



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

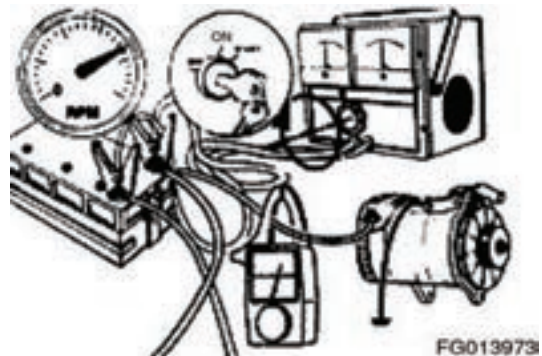


Figure 147



WARNING!

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

Shut off the engine, and remove the test equipment.

Connect all battery cables, negative (-) cable last.

Preparatory Steps



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



Figure 148



WARNING!

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

- Disconnect the batteries. Refer to the OEM instructions.
- Remove the drive belt from the alternator pulley. Refer to “Drive Belt, Cooling Fan” on page-115.
- Tag and label all wires on the alternator.
- Disconnect the wires.

Remove

Spool Mount

Remove the upper alternator link capscrew.

Remove the mounting capscrew and nut at the bottom of the alternator and alternator mounting bracket.

Remove the alternator.

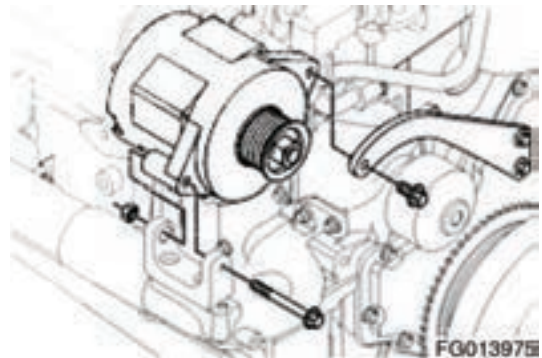


Figure 149

Pad Mount

Remove the alternator mounting capscrews.

Remove the alternator.

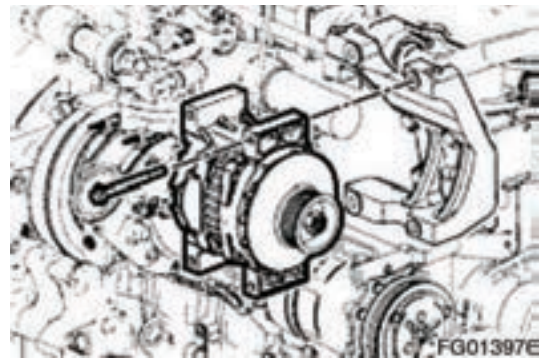


Figure 150

Hinge Mount

Remove the alternator link capscrew.

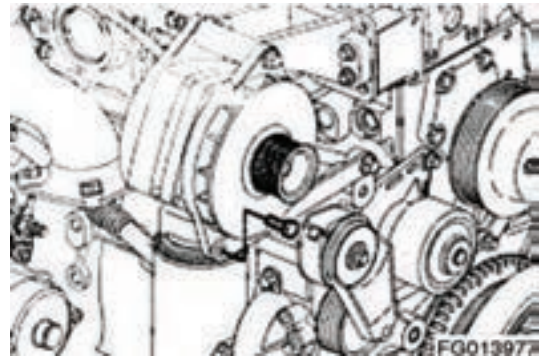


Figure 151

Remove the alternator mounting capscrew.

Remove the alternator.

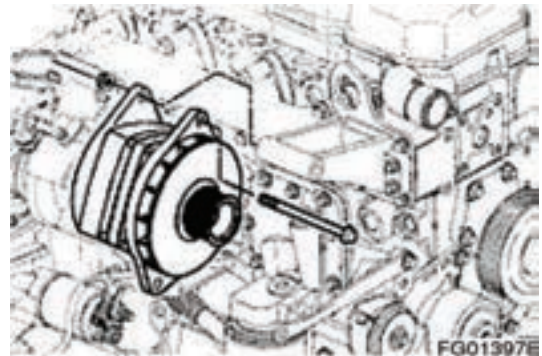


Figure 152

Install

Spool Mount

Install the alternator and the bottom alternator mounting capscrew and nut.

Install the upper alternator link mounting capscrew at the top of the alternator.

Tighten the capscrews.

Lower Mounting Capscrew	40 n.m (30 ft-lb)
Upper Link Mounting Capscrew	24 n.m (212 in-lb)

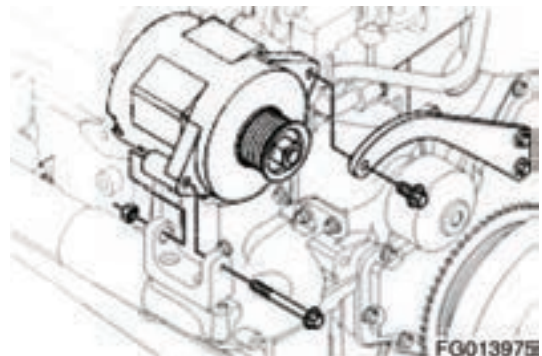


Figure 153

Pad Mount

Install the alternator.

Install and tighten the alternator mounting capscrews.

M10 Capscrew	36 n.m (27 ft-lb)
M12 Capscrew	64 n.m (47 ft-lb)

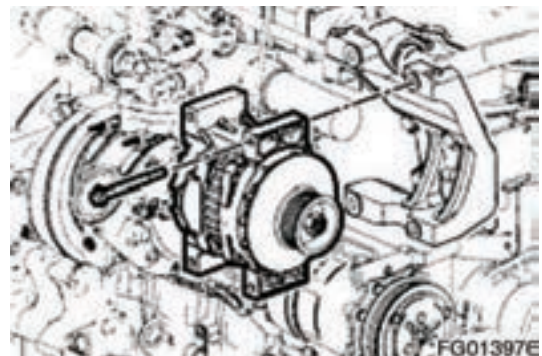


Figure 154

Hinge Mount

Install the alternator.

Install and tighten the alternator mounting capscrew.

- Torque Value 40 n.m (30 ft-lb)

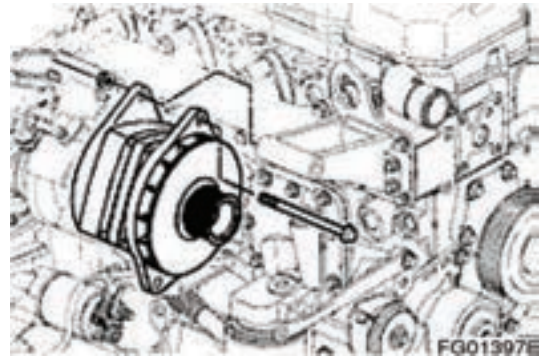


Figure 155

Install the alternator link capscrew.

- Torque Value 24 N•m (212 in-lb)

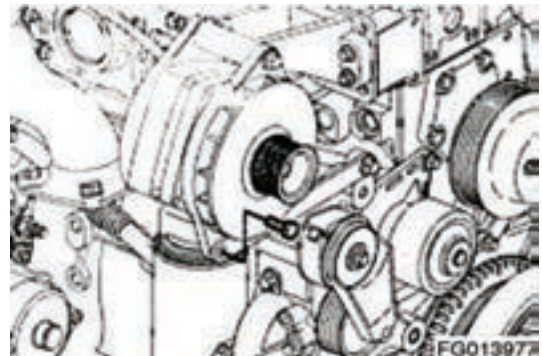


Figure 156

Finishing Steps



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



WARNING!

Acid is extremely dangerous and can damage the machinery and can also cause serious burns. Always provide a tank of strong soda water as a neutralizing agent when servicing the batteries. Wear goggles and protective clothing to reduce the possibility of serious personal injury.

- Connect all wires to the alternator.
- Install the drive belt. Refer to "Drive Belt, Cooling Fan" on page-115.
- Connect the batteries. Refer to the OEM instructions.
- Operate engine to check for proper operation.



Figure 157

Charge-Air Cooler

Clean

If the engine experiences a turbocharger failure or any other occasion where oil or debris is put into the charge air cooler, the charge air cooler must be cleaned.

Remove the charge air cooler piping and charge air cooler from the vehicle. Refer to the manufacturer's instructions.

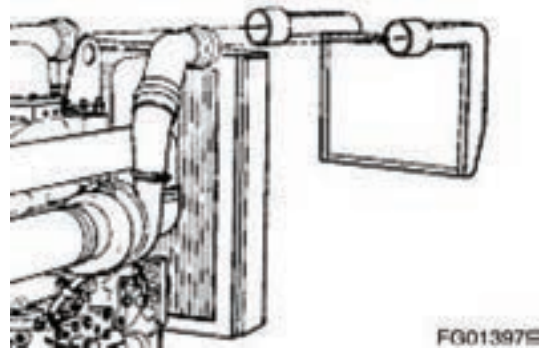


Figure 158



CAUTION!

Do not use caustic cleaners to clean the charge air cooler. Damage to the charge air cooler will result.

Flush the charge air cooler internally with solvent in the opposite direction of normal airflow. Shake the charge air cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed.

NOTE: *Be sure the tubes are in the vertical direction when flushing.*

If the debris cannot be totally removed from the charge air cooler, the charge air cooler must be replaced.

After the charge air cooler has been thoroughly cleaned of all oil and debris with solvent, wash the charge air cooler internally with hot soapy water to remove the remaining solvent. Rinse thoroughly with clean water.

Blow compressed air through the inside of the charge air cooler in the opposite direction of normal air flow until the charge air cooler is dry internally.

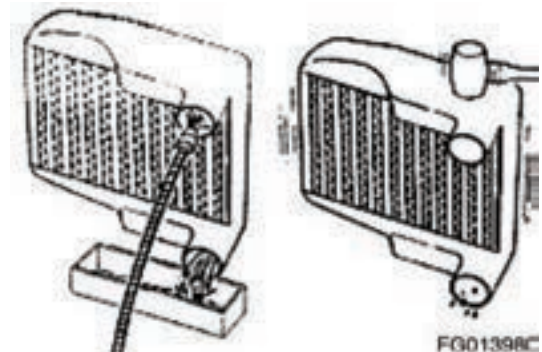


Figure 159



CAUTION!

The charge air cooler must be rinsed, dried, and free of solvent, oil, and debris or engine damage will result.

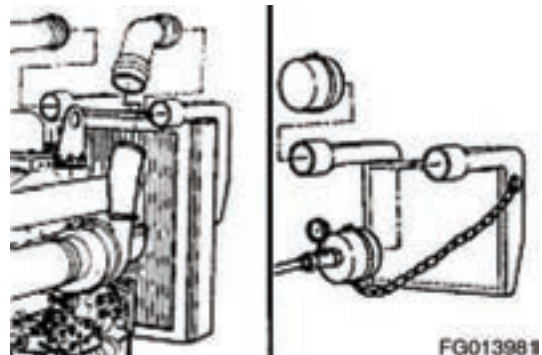


Figure 160

Inspect for Reuse

Inspect the charge air cooler for cracks, holes, or damage.

Inspect the tubes, the fins, and the welds for tears, breaks, or other damage. If any damage causes the charge air cooler to fail the air leak check mentioned earlier in this procedure, the charge air cooler must be replaced.

Install the charge air cooler and charge air cooler piping on the vehicle. Refer to the manufacturer's instructions.

NOTE: *Always clean and inspect the charge air cooler piping and hoses prior to installation.*

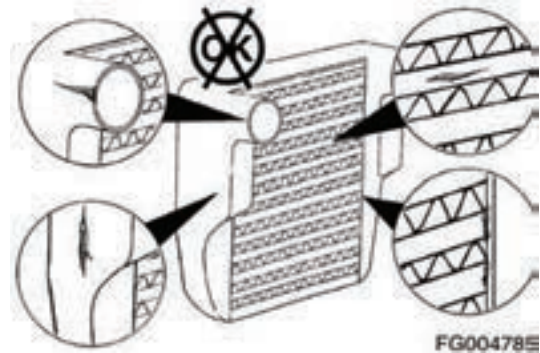


Figure 161

Leak Test

To check the charge air cooler for cracked tubes or header, remove the inlet and outlet hoses from the cooler. The charge air cooler does not have to be removed from the chassis.

WARNING!

To prevent possible injury if either plug blows off during the test, secure safety chains on the test plugs to any convenient capscrew on the radiator assembly. This test must not be performed without securely fastened safety chains.

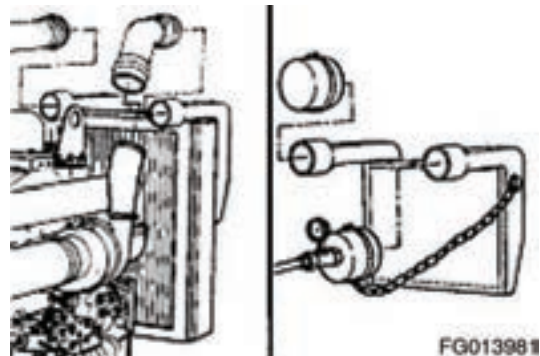


Figure 162

Install a plug or cap over the outlet side of the cooler. Install a pressure gauge and a regulated shop air supply line with a shutoff valve to the inlet side of the cooler.

Apply air pressure to the cooler until the pressure gauge reads a steady 207 kPa (30 psi) of air pressure.

Shut off the airflow to the cooler, and start a stopwatch at the same time. Record the leakage at 15 seconds.

If the pressure drop is 34 kPa (5 psi) or less in 15 seconds, the cooler is functioning properly.

If the pressure drop is greater than 34 kPa (5 psi) in 15 seconds, check all connections again.

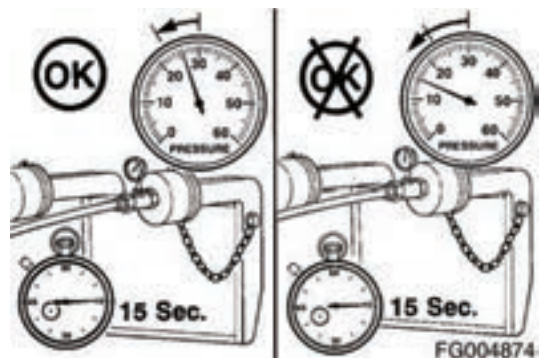


Figure 163

Determine if the pressure drop is caused by a leak in the charge air cooler or from a leaky connection. Use a spray bottle filled with soapy water applied to all hose connections, and watch for bubbles to appear at the location of the leak.

If the pressure drop is caused by a leaky connection, repair the connection, and repeat the test. If the leak is within the charge air cooler, repeat the test to verify the accuracy of the pressure drop measurement. Similar pressure drop readings must be obtained at least three consecutive tests before the reading can be considered accurate.

NOTE: *If a charge air cooler leaks more than 34 kPa (5 psi) in 15 seconds, it will appear as a major leak in a leak tank.*

If the pressure drop is greater than 34 kPa (5 psi) in 15 seconds, the charge air cooler must be replaced.

Refer to the manufacturer's repair manual for replacement instructions.

NOTE: *Charge air coolers are not designed to be 100-percent leak free. If the pressure drop is less than 34 kPa (5 psi) in 15 seconds, then the charge air cooler does not need to be replaced.*

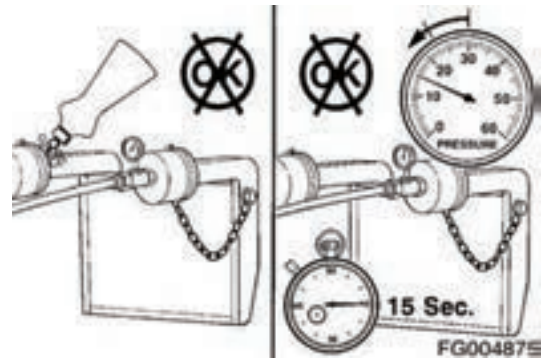


Figure 164

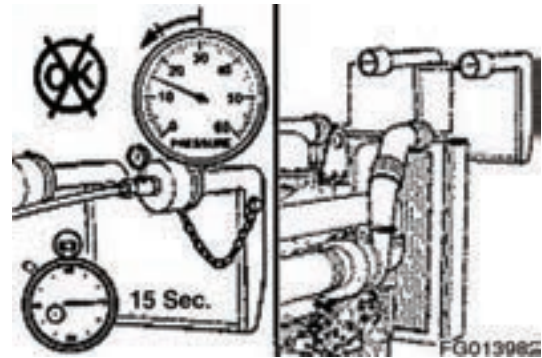


Figure 165

Temperature Differential Test

Inspect the charge air cooler fins for obstructions to airflow. Remove obstructions such as a winterfront or debris. Manually lock shutters in the open position if equipped.

Lock the fan drive in the ON mode to prevent erratic test results. This can be done by installing a jumper wire across the temperature switch.

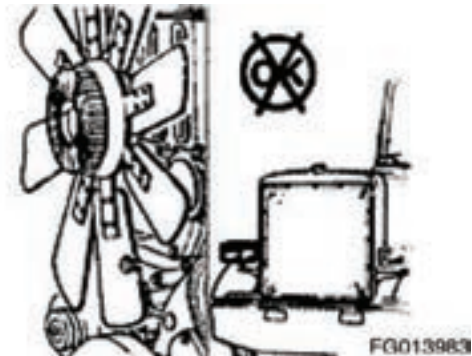


Figure 166

Install Fluke digital thermometer, Part No. 3822666, and thermocouple wire kit, Part No. 3822988, into the intake manifold at the 1/8-inch NPT tap near the air horn connection with the intake manifold.

Install another thermocouple at the air cleaner inlet to measure ambient air temperature.

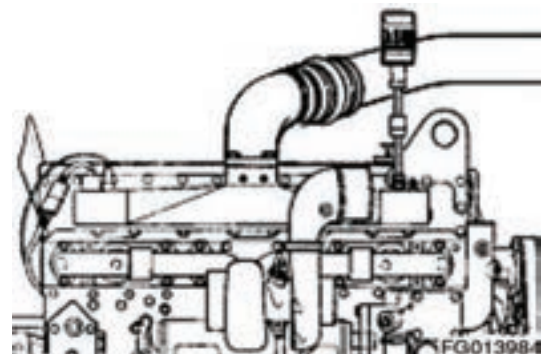


Figure 167

Perform a road test with the engine at peak power and a vehicle speed of 48 kph (30 mph) or greater.

Record the intake manifold temperature and the ambient air temperature.

Calculate the differential temperature:

$$\begin{aligned} & \text{Intake Manifold Temperature} \\ & - \text{Ambient Air Temperature} \\ & = \text{Differential Temperature} \\ & \text{Maximum Differential} \\ & \text{Temperature: } 28^{\circ}\text{C (} 50^{\circ}\text{F)} \end{aligned}$$

If the temperature differential is greater than the specifications, check the charge air cooler for dirt and debris on the fins and clean as necessary. If the problem still exists, check the charge air cooler for debris in the fins or between the charge air cooler and radiator. Confirm full fan engagement.

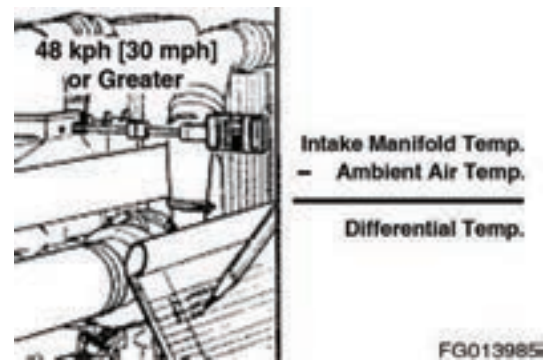


Figure 168

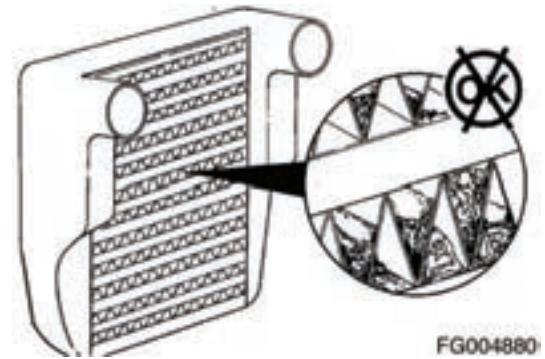


Figure 169

Pressure Differential Test

Preferred Method

Measure the charge air cooler system pressure drop with a mercury manometer, Part No. ST -1111-3.

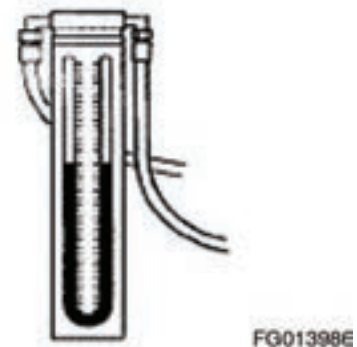


Figure 170

Install one end of a mercury manometer to the fitting in the turbocharger compressor outlet elbow.

Install the other end of the mercury manometer to the intake manifold.

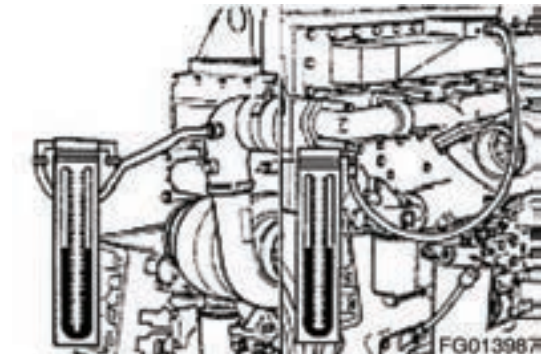


Figure 171

Operate the engine at rated rpm and load. Record the readings on the manometer.

If the differential pressure is greater than 152 mm Hg (6 in. Hg), check the charge air cooler and associated piping for plugging. Clean or replace if necessary.

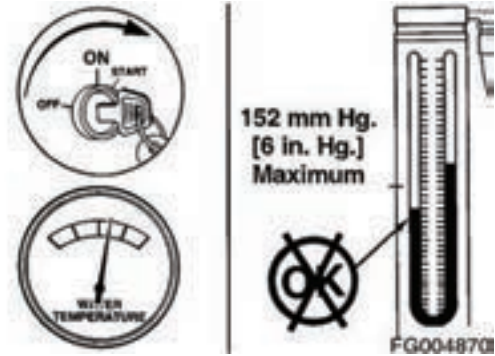


Figure 172

Optional Method

Obtain two (2) pressure gauges, Part No. ST-1273. Check both gauges on the same pressure source at 206 kPa (30 psi) for consistency.

Install pressure gauge, Part No. ST1273, to the 1/8-inch fitting in the turbocharger compressor outlet elbow.

Install the other pressure gauge in the intake manifold.

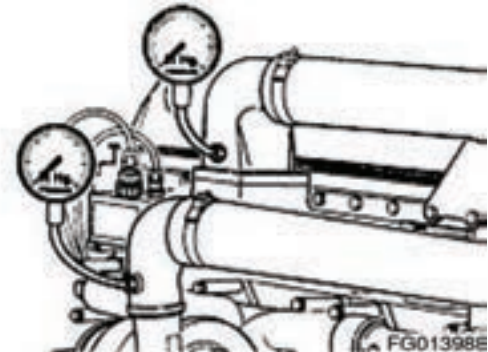


Figure 173

Operate the engine at rated rpm and load. Record the readings on the two gauges.

If the differential pressure is greater than 152 mm Hg (6 in. Hg), check the charge air cooler and associated piping for plugging, restrictions, or damage.

Clean or replace if necessary.

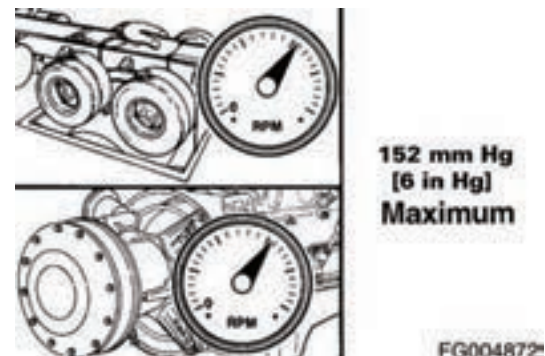


Figure 174

Coolant Thermostat

General Information

The thermostat controls the engine coolant temperature. When the coolant temperature is below the operating range, engine coolant is bypassed back to the inlet of the water pump. When the engine coolant temperature reaches the operating range, the thermostat opens, sealing off the bypass, forcing engine coolant to flow to the radiator or heat exchanger.

An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.

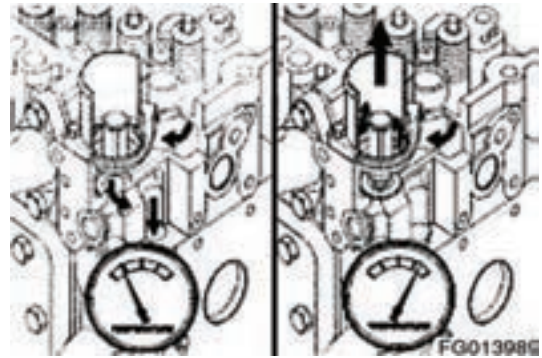


Figure 175



CAUTION!

Never operate the engine without a thermostat. Without a thermostat, the path of least resistance for the coolant is through the bypass to the water pump inlet. This can cause the engine to overheat.

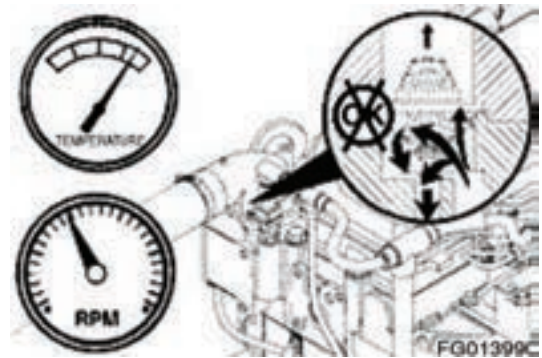


Figure 176



CAUTION!

A missing check ball can cause the engine to run cold, resulting in engine damage.

The thermostat contains two check balls to vent air past the thermostat when it is closed. This is needed for the cooling system to fill.

NOTE: Some off-highway applications use a thermostat with one check ball. When servicing a thermostat always be sure to replace with the same part number. Though an incorrect thermostat will physically fit, it will lead to improper engine operation.

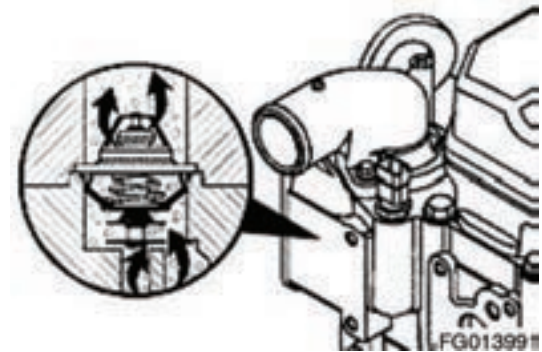


Figure 177

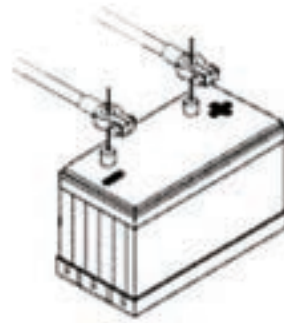
Preparatory Steps



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the batteries.



FG013952

Figure 178



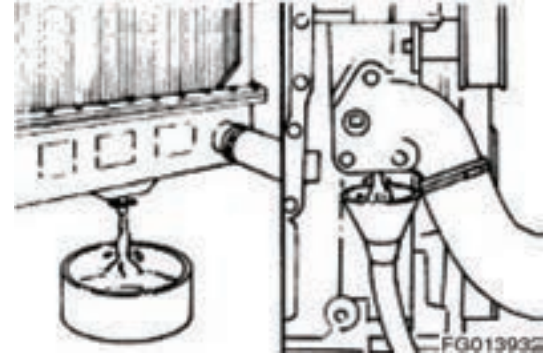
WARNING!

Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.



WARNING!

Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C (120°F) before removing the pressure cap. Heated coolant spray or steam can cause personal injury.



FG013932

Figure 179



CAUTION!

Use caution when draining coolant that coolant is not spilled or drained into the bilge area. Do not pump the coolant overboard. If the coolant is not reused, it must be discarded in accordance with local environmental regulations.

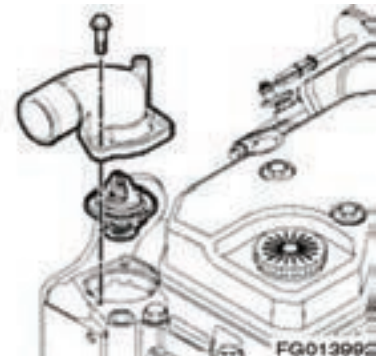
Drain the coolant below the level of the thermostat. Refer to "Cooling System" on page-72.

Remove

Remove the water outlet connection capscrews.

Remove the water outlet connection.

Remove the thermostat.



FG013992

Figure 180

Clean and Inspect for Reuse



CAUTION!

Do not let any debris fall into the thermostat cavity when cleaning the gasket surfaces. Damage to the cooling system and engine can occur.

Clean the mating surfaces with a gasket scraper and a clean cloth.

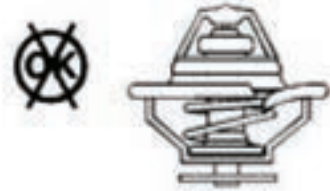


Figure 181

FG013994

Inspect the thermostat for cracks, tears, damage, missing soft seat.

Remove and discard the gasket.

NOTE: *Do not allow the thermostat or thermometer to touch the container.*

Suspend the thermostat and a 100°C (212°F) thermometer in a container of water.

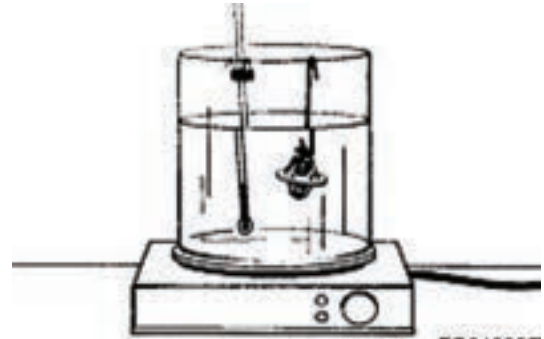


Figure 182

FG013995

Heat the water and check the thermostat as follows:

The nominal operating temperature is stamped on the thermostat. The thermostat must meet the following criteria:

- It must begin to open within 1°C (2°F) of nominal temperature.
- It must be fully open within 12°C (22°F) of nominal temperature.

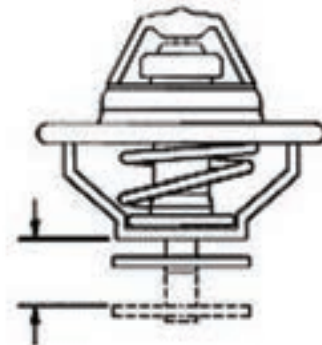


Figure 183

FG013996

Thermostat Opening Temperatures -Automotive Applications

	celsius		fahrenheit
Initial Opening Temperature	81	Min	178
Fully Opening Temperature	83	Max	182
	94	Max	202

Thermostat Opening Temperatures -Industrial Engines

	celsius		fahrenheit
Initial Opening Temperature	87	Min	188
Fully Opening Temperature	89	Max	192
	96	Max	205

Install



CAUTION!

Always use the correct thermostat and do not operate the engine without a thermostat installed. The engine can overheat if operated without a thermostat because the path of least resistance for the coolant is through the bypass to the pump inlet. An incorrect thermostat can cause the engine to overheat or run too cold.

Install the thermostat into the thermostat housing.

NOTE: Make sure a new thermostat seal is installed on the outer lip of the thermostat flange every time the thermostat is reinstalled.

Install the water outlet connection and mounting capscrews.

Tighten the capscrews.

- Torque Value: 10 N•m (89 in.lb)

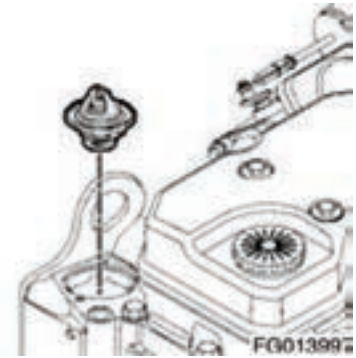


Figure 184

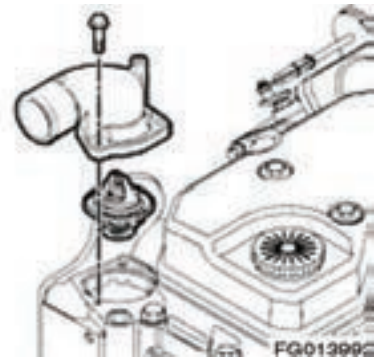


Figure 185

Finishing Steps



CAUTION!

Always vent the engine during filling to remove air from the coolant system, or overheating can result.

Fill the cooling system. Refer to "Cooling System" on page-72.



Figure 186



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

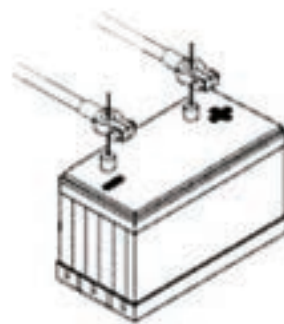


Figure 187

Connect the batteries.

Operate the engine and check for leaks.

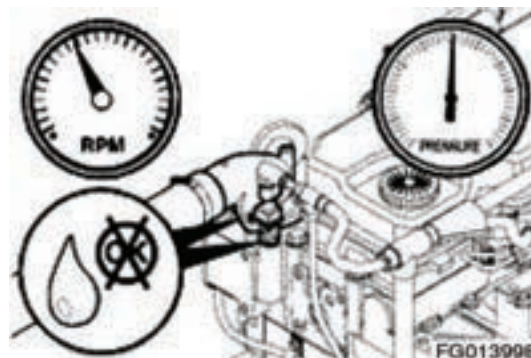


Figure 188

Cooling Fan Belt Tensioner

Maintenance Check

With the engine stopped, check the tensioner arm, pulley and stops for cracks. If any cracks are found, the tensioner must be replaced.

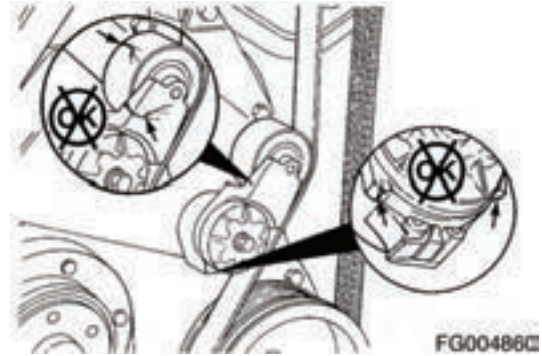


Figure 189

With the belt installed, verify that neither tensioner arm stops is in contact with the spring casing stop. If either of the stops is touching:

- Verify the correct belt part number is installed.
- If the correct belt is installed, replace the belt. Refer to "Drive Belt, Cooling Fan" on page-115.

After replacing the belt, if the tensioner arm stops are still in contact with the spring case stop, replace the tensioner.

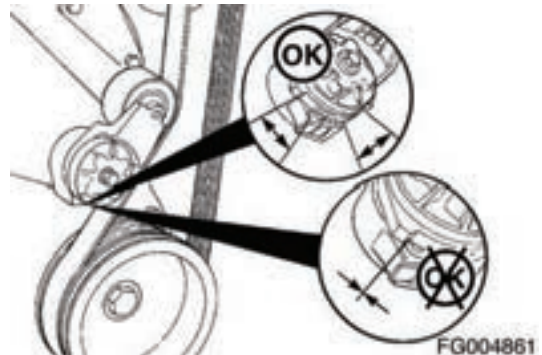


Figure 190

Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or close to the middle of, the pulley. Misaligned belts, either too far forward or backward, can cause belt wear, belt roll-off failures, or increase uneven tensioner bushing wear.

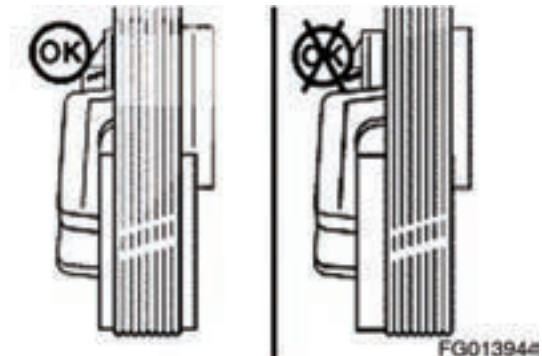


Figure 191

Remove the drive belt. Refer to "Drive Belt, Cooling Fan" on page-115.

With the belt removed, verify that the tensioner arm stop is in contact with the spring case stop. If they are not touching, the tensioner must be replaced.

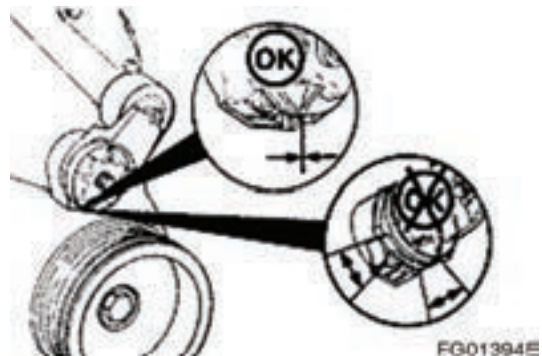


Figure 192

Drive Belt, Cooling Fan

Remove

Lift the tensioner to remove the drive belt.

NOTE: The belt tensioner winds in the direction that the spring tang is bent over the tensioner body. To loosen the tension on the belt, rotate the tensioner to wind the spring tighter.



CAUTION!

Always vent the engine during filling to remove air from the coolant system, or overheating can result.

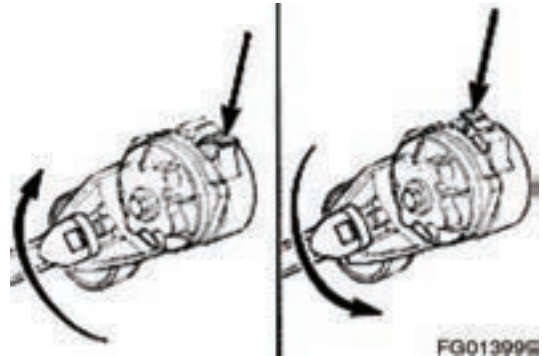


Figure 193

Inspect for Reuse

Inspect the drive belt for:

- Cracks
- Glazing
- Tears or cuts
- Hardening
- Excessive wear.



Figure 194

Install



CAUTION!

The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

Lift the tensioner to install the drive belt.

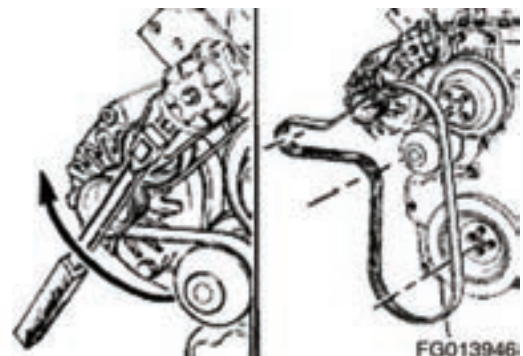


Figure 195

Fan Spacer and Pulley

Preparatory Steps

- Remove the drive belt.

NOTE: *Loosen the capscrews before removing the belt, and tighten the capscrews after the belt is installed.*

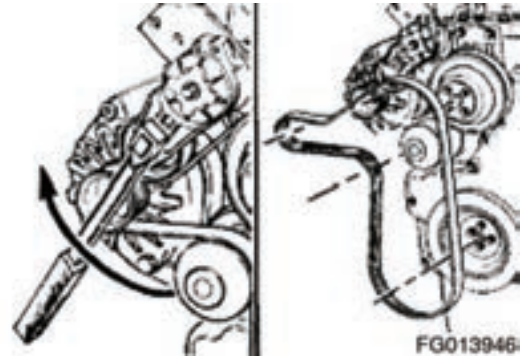


Figure 196

Remove

Remove the four capscrews, fan, and spacer.

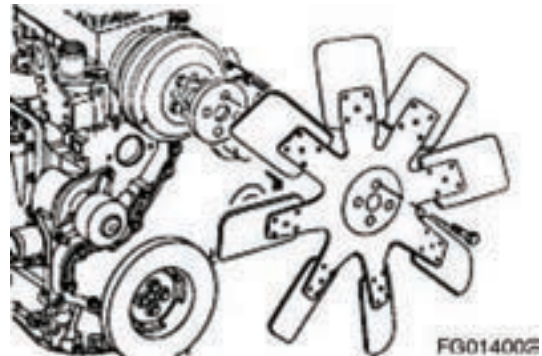


Figure 197

Inspect for Reuse

Inspect the fan pulley for cracks near bolt holes.

Check for cracks, loose rivets, and bent or loose blades.

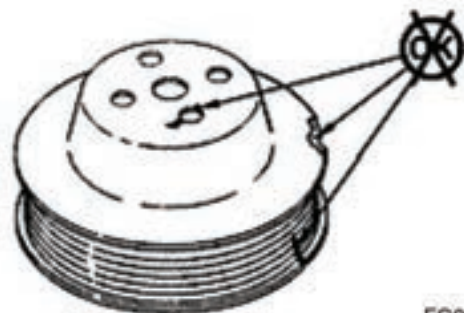


Figure 198

Install

3/8-Inch Square Drive

Lift the tensioner, and install the belt.

If difficulty is experienced installing the drive belt (the belt seems too short), position the belt over the grooved pulleys first; then, while holding the tensioner up, slide the belt over the water pump pulley.

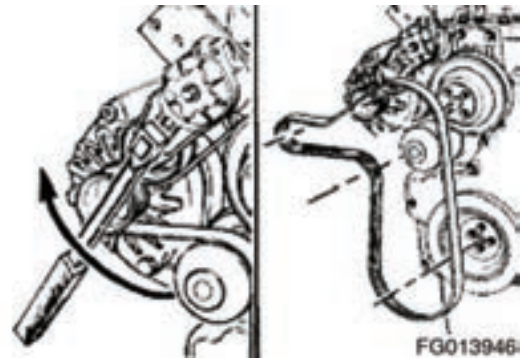


Figure 199

Install the four capscrews, fan, and spacer.

Wrench	
10 mm	Torque Valve 24 N•m (212 in-lb)
13 mm	Torque Valve 43 N•m (32 ft-lb)

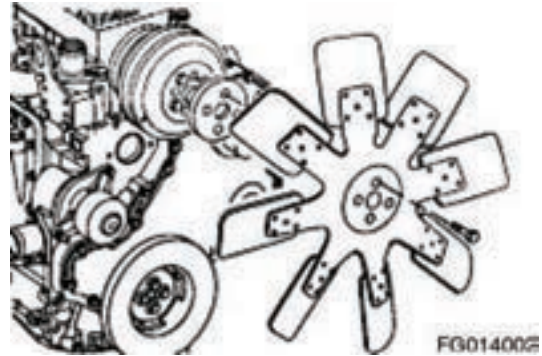


Figure 200

Starting Motor

Rotation Check

If the starter solenoid is making a sound but the engine is not rotating, turn the keyswitch to the OFF position, and attempt to bar the crankshaft in both directions.

Bar the engine using the barring tool, Part Number 3824591.

If the crankshaft will bar over, attempt to start the engine. If the starter motor cranks the engine, check the starter motor pinion gear and flywheel ring gear for damage.

If damage to the starter motor pinion gear and/or flywheel ring gear is found when replacing the components, make sure to measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear. Follow the measure step of this procedure.

If the crankshaft does not rotate or requires more than the normal effort to bar, check for an internal malfunction or a problem with the drive unit and/or accessories.

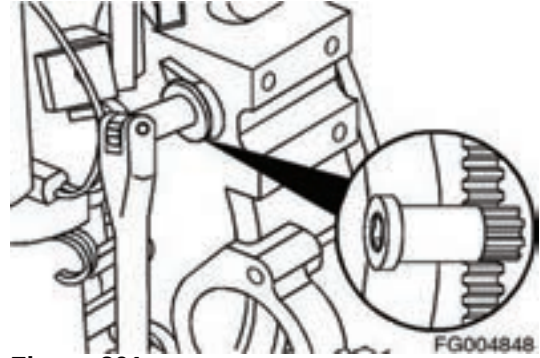


Figure 201

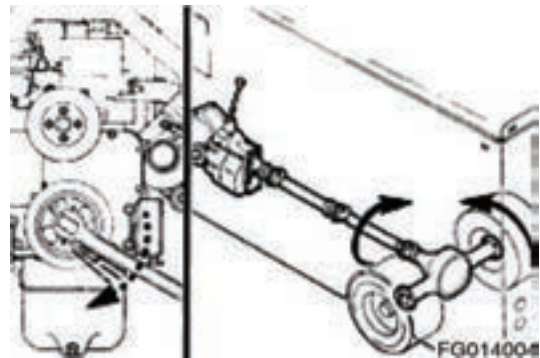


Figure 202

If the engine cranking speed is too slow/will not crank at all and the engine rotates freely:

Make sure the wiring connections are clean, tight and not damaged.

Check the battery voltage. Refer to the OEM service manual and/or manufacturer for specifications.

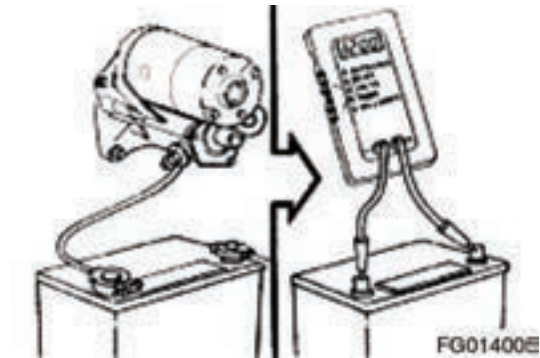


Figure 203

Check the voltage at the starting motor during cranking. If the voltage drops more than 2.4 VDC on a 12-VDC system and 4.8 VDC on a 24-VDC system, check that all connections are clean and tight.

If the cables are correct and the voltage drop exceeds the limit, replace the starting motor.

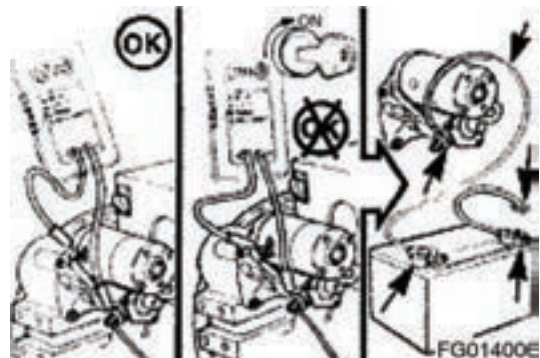


Figure 204

Remove



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Disconnect the ground cable from the battery terminal.

Identify each wire with a tag indicating location on starting motor.

Remove the electrical connections from the starting motor.

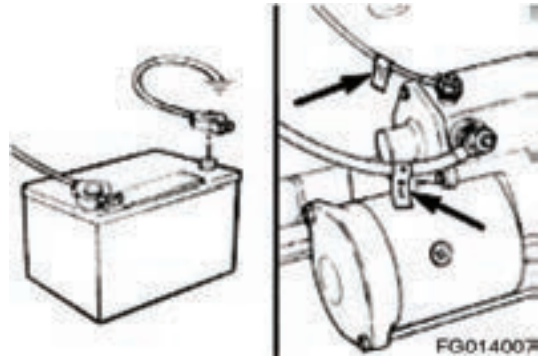


Figure 205



WARNING!

When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.



WARNING!

Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Prior to removing the starter, use steam to clean the area around the starting motor to prevent debris from entering the flywheel housing.

Dry with compressed air.

Remove the three capscrews and the starting motor.

NOTE: *If equipped with a starting motor spacer, remove the spacer and clean all surfaces between the starting motor, starting motor spacer, and flywheel housing with a wire brush.*

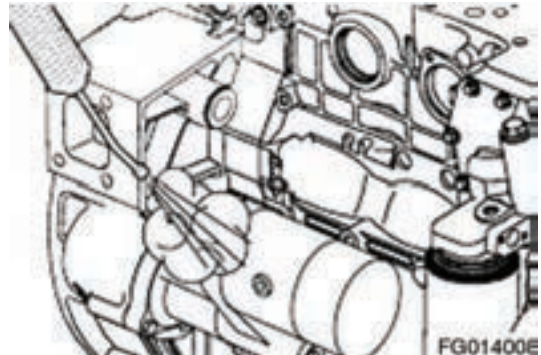


Figure 206

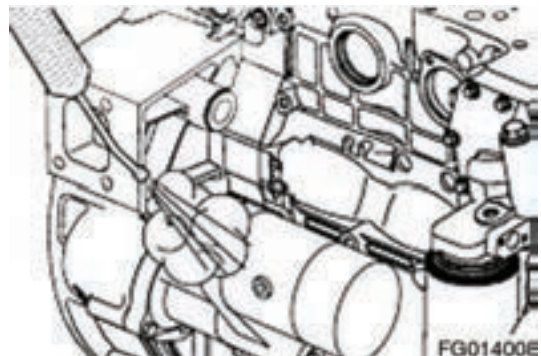


Figure 207

Clean and Inspect for Reuse

For engines that use wet flywheel housings, clean any left over sealant from the starting motor mounting flange on both the flywheel housing and starting motor. Make sure these surfaces are clean of oil and debris.

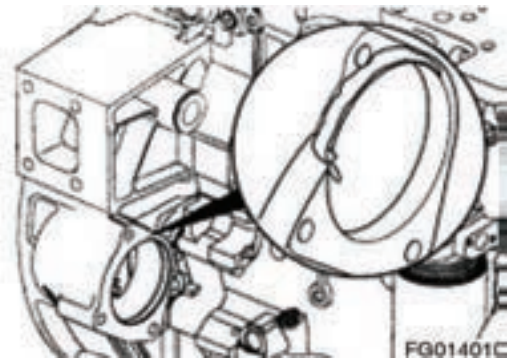


Figure 208

Inspect the starter motor pinion gear and/or flywheel ring gear for chipping or uneven wear.

NOTE: *If the starter motor pinion gear and/or flywheel ring gear teeth are damaged, they must be replaced.*

Refer to a Cummins Authorized Repair Facility.



Figure 209

Measure

Using an inside micrometer or a vernier caliper, measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear.

NOTE: *Include any spacers previously removed when completing the measurement.*

Starting Motor Spacing		
49.28 mm	Min	1.94 in
52.32 mm	Max	2.06 in

Add or remove spacers as necessary to achieve the correct starting motor spacing.

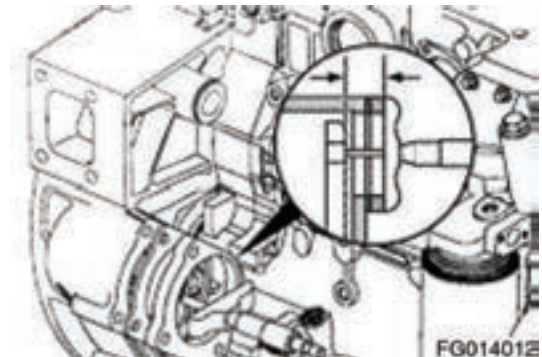


Figure 210

Install

For engines with wet flywheel housings, apply a 1.5 to 2.0 mm (0.06 to 0.09 in) wide bead of sealant, Part Number 3164067 to the flywheel housing starting motor mounting flange.

NOTE: *If a starting motor spacer is required, make to apply sealant to the side of the spacer that contacts the starting motor.*

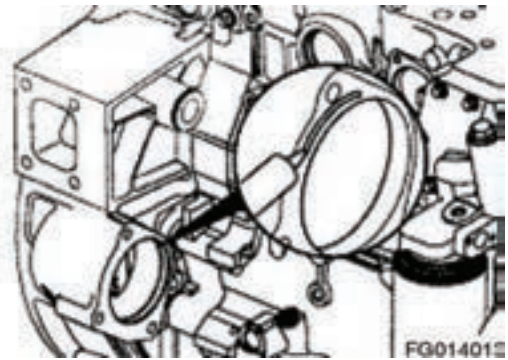


Figure 211

Install the three capscrews, the starting motor, and starting motor spacer (if required).

- Torque Value 43 N•m (32 ft-lb)

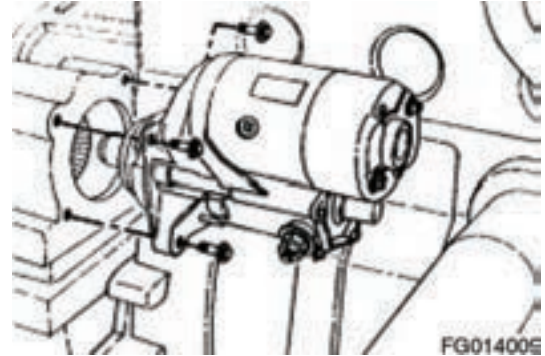


Figure 212

Cummins Branded Starters



CAUTION!

Do not overtighten the electrical connections. Starter damage can result.

NOTE: *Use the location tags to help identify where each wire connection goes.*

Connect the electrical connections to the starter motor.

M5	4 N•m	35 in-lb
M10	21 N•m	185 in-lb

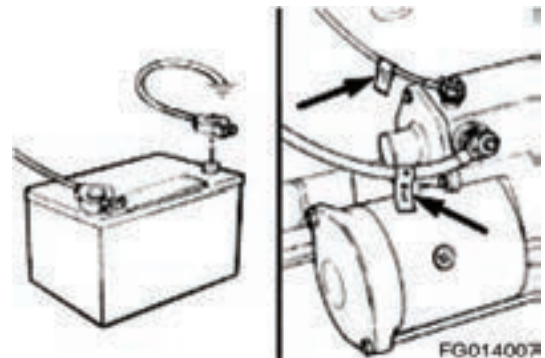


Figure 213



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the ground cable to the battery terminal.

Non-Cummins Branded Starters



CAUTION!

Do not overtighten the electrical connections. Starter damage can result.

NOTE: *Use the location tags to help identify where each wire connection goes.*

Install the starter motor electrical connections.

For Non-Cummins branded starters, refer to the Original Equipment Manufacturer (OEM) manual for torque specifications.



WARNING!

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the ground cable to the battery terminal.

SYSTEM DIAGRAMS

General Information

The following drawings show the flow through the engine systems. Although parts can change between different applications and installations, the flow remains the same. The systems shown are:

- Fuel System
- Lubricating Oil System
- Coolant System
- Intake Air System
- Exhaust System
- Compressed Air System.

Knowledge of the engine systems can help you in troubleshooting, service, and general maintenance of your engine.

Fuel System

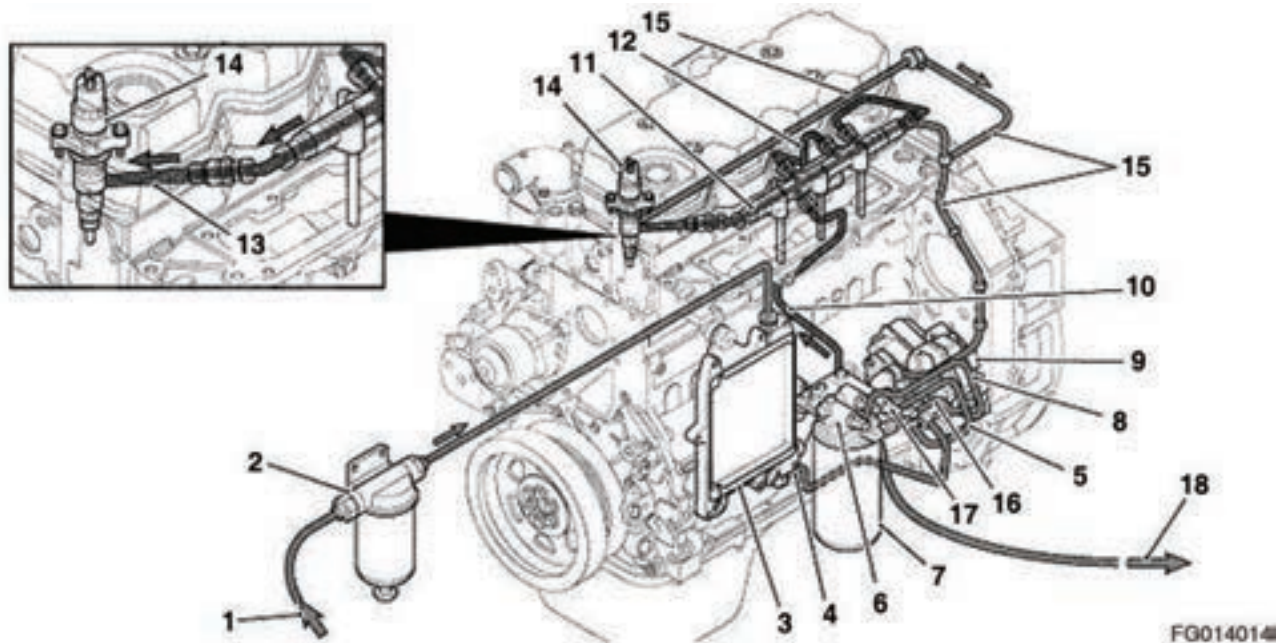


Figure 214

Reference Number	Description
1	Fuel From Supply Tank
2	Water/Fuel Separator (not mounted on engine)
3	Ecm Cooling Plate
4	To Fuel Gear Pump
5	To Fuel Filter
6	Fuel Filter Head
7	Fuel Filter
8	To High-pressure Pump
9	High-Pressure Pump
10	To Fuel Rail

Reference Number	Description
11	Fuel Rail
12	To Injectors
13	High-Pressure Connector
14	Injector
15	Fuel Return from Injectors and Fuel Rail to Fuel Filter Head
16	Fuel Return from High-pressure Pump to Fuel Filter Head
17	Fuel Return Manifold
18	To Fuel Supply Tank

NOTE: Engines are either equipped with an air cooled or fuel cooled ECM. If an air cooled ECM is used, the fuel enters the engine from the OEM connection at the gear pump inlet.

With Electric Lift Pump

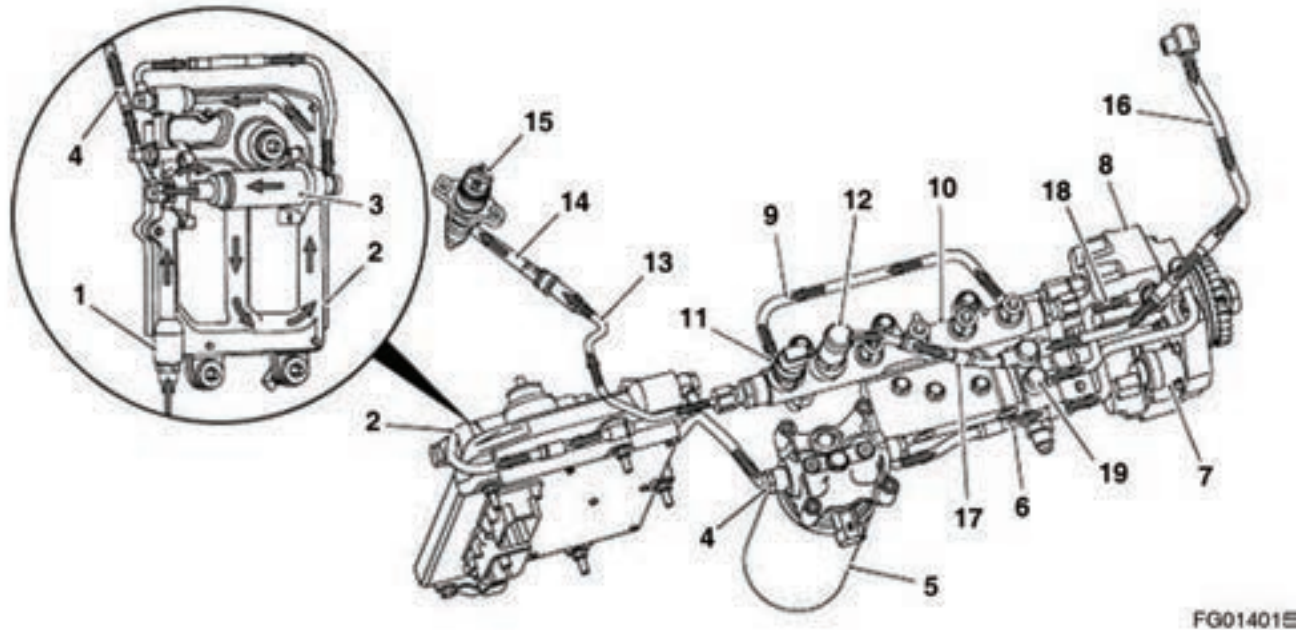
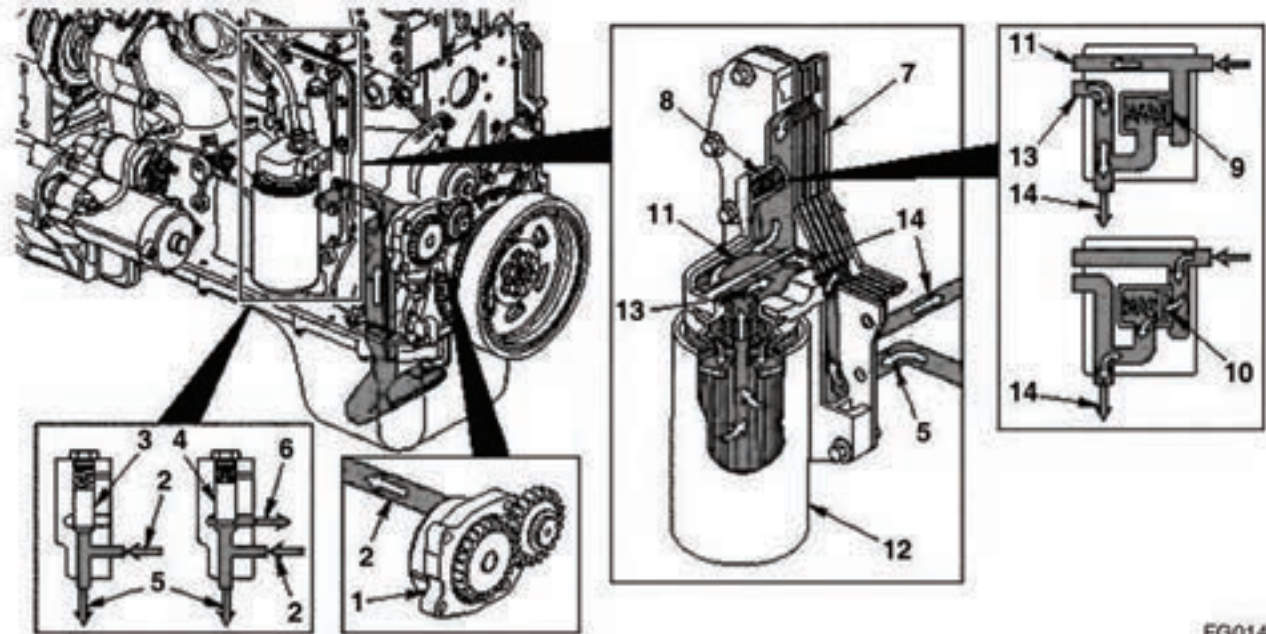


Figure 215

Reference Number	Description
1	Fuel Inlet -ECM Cooling Plate
2	ECM Cooling Plate
3	Lift Pump
4	Fuel Line (from Lift Pump to Fuel Filter)
5	Fuel Filter
6	Fuel Pump Inlet to Gear Pump
7	EFC Actuator
8	Fuel Pump
9	High-Pressure Fuel Line (Fuel Pump to Rail)
10	Fuel Rail

Reference Number	Description
11	Fuel Rail Pressure Sensor
12	Fuel Pressure Relief Valve
13	High-Pressure Fuel Line (Fuel Rail to Fuel Injector)
14	High-Pressure Connector to Fuel Injector
15	Fuel Injector
16	Injector Return Line
17	Pressure Relief Return Line
18	Fuel Pump Return Line
19	Fuel Return Manifold

Lubricating Oil System

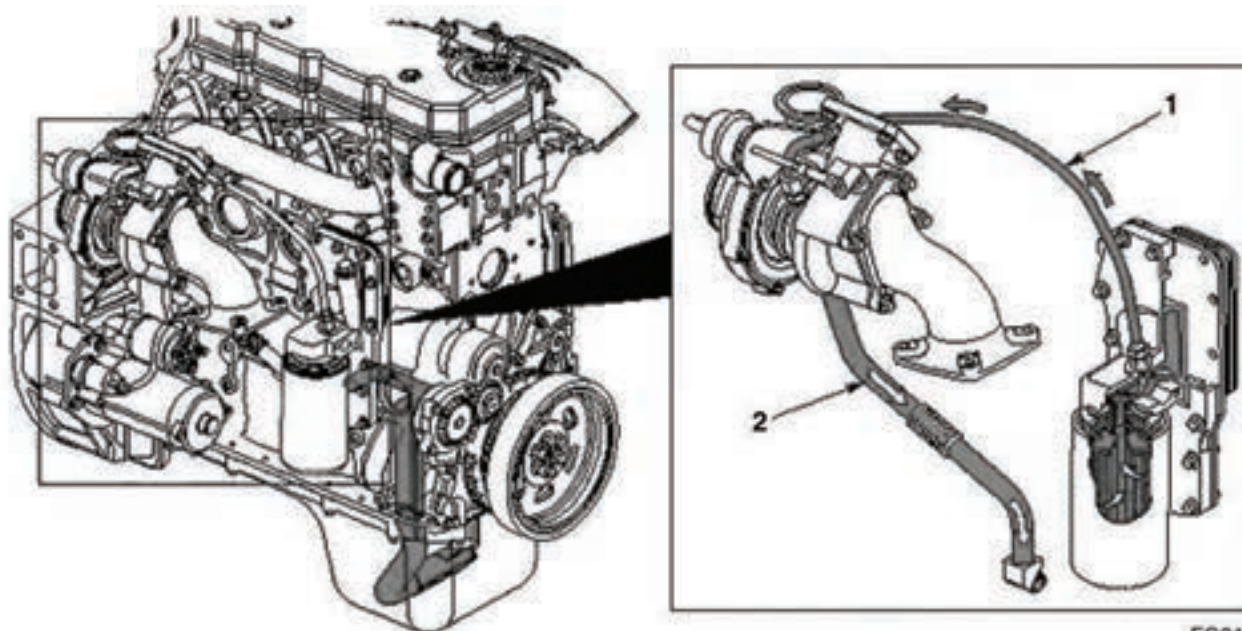


FG014016

Figure 216

Reference Number	Description
1	Gerotor Lubricating Oil Pump
2	From Lubricating Oil Pump
3	Pressure Regulating Valve Closed
4	Pressure Regulating Valve Open
5	To Lubricating Oil Cooler
6	To Lubricating Oil Pan
7	Lubricating Oil Cooler

Reference Number	Description
8	Filter Bypass Valve
9	Filter Bypass Valve Closed
10	Filter Bypass Valve Open
11	To Lubricating Oil Filter
12	Full-flow Lubricating Oil Filter
13	From Lubricating Oil Filter
14	Main Lubricating Oil Rifle



FG014017

Figure 217 Lubrication for the Turbocharger

Reference Number	Description
1	Turbocharger Lubricating Oil Supply

Reference Number	Description
2	Turbocharger Lubricating Oil Drain

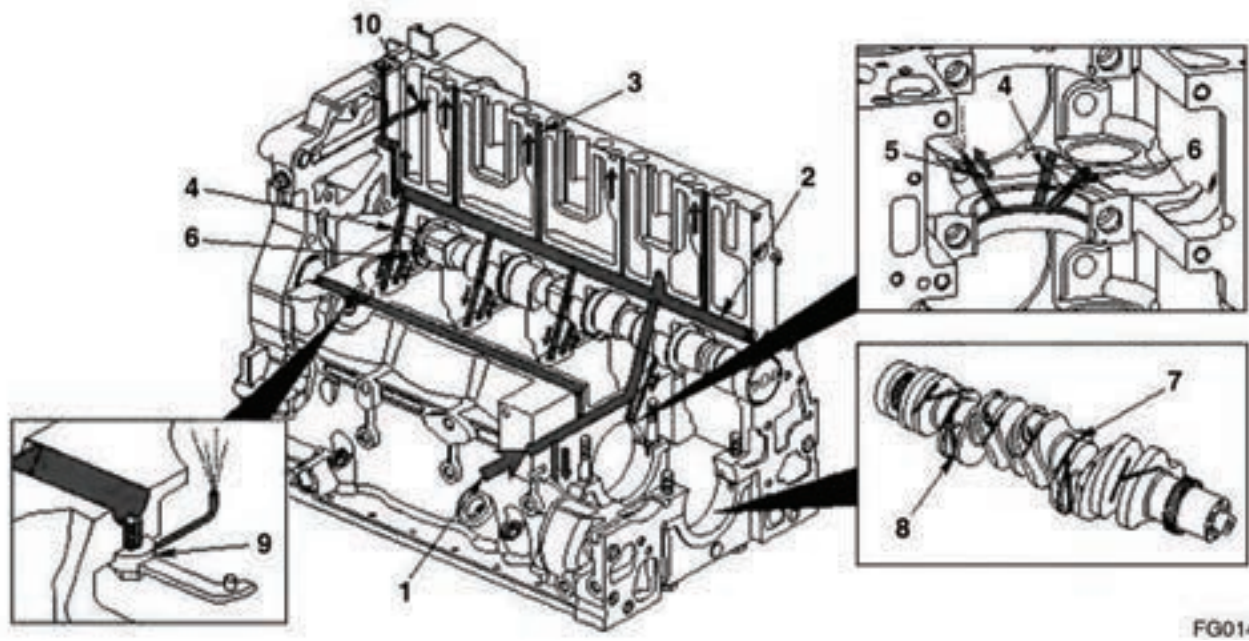
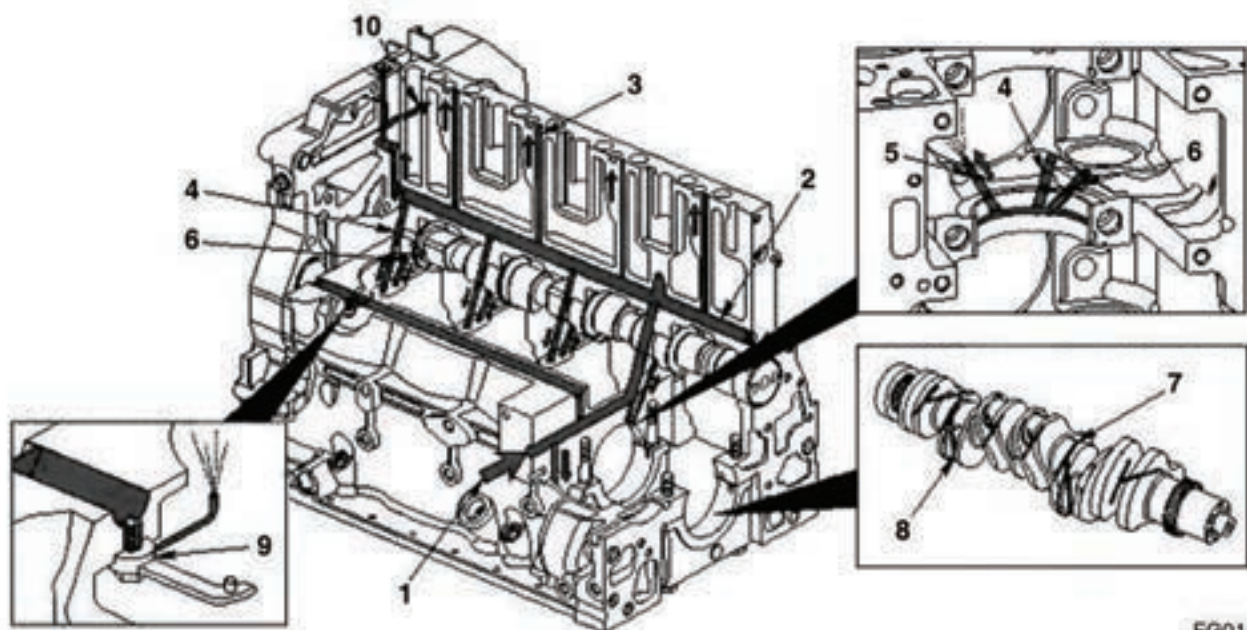


Figure 218 Lubrication for the Power Components

Reference Number	Description
1	From lubricating oil cooler
2	Main lubricating oil rifle
3	To valve train
4	From main lubricating oil rifle
5	To piston-cooling nozzle
6	To camshaft

Reference Number	Description
7	Crankshaft main journal
8	Oil supply to rod bearings
9	Directed piston-cooling nozzle
10	To internal lubrication of air compressor



FG01401B

Figure 219 Lubrication for the Overhead Components

Reference Number	Description
1	Main lubricating oil rifle
2	Rocker lever support
3	Transfer slot

Reference Number	Description
4	Rocker lever shaft
5	Rocker lever bore
6	Rocker lever

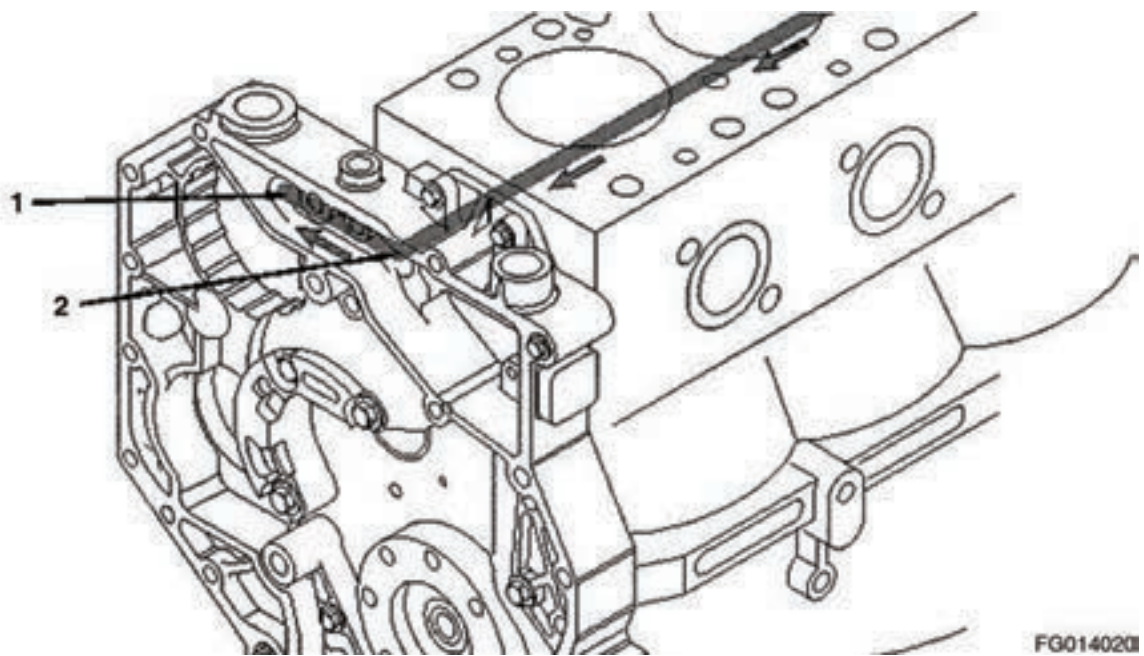


Figure 220 Lubrication for the Accessory Drive

Reference Number	Description
1	Oil Feed from Block

Reference Number	Description
2	Oil Supply to Accessory Drive

NOTE: *Oil returns to pan through the gear housing*

Cooling System

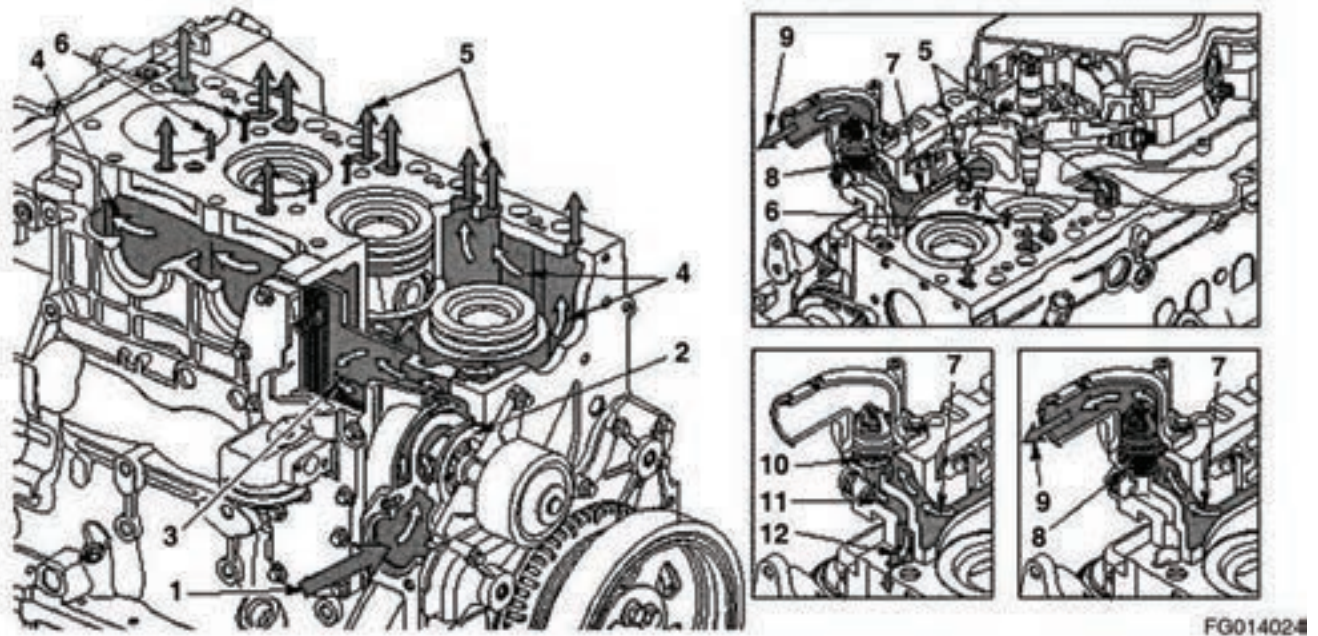
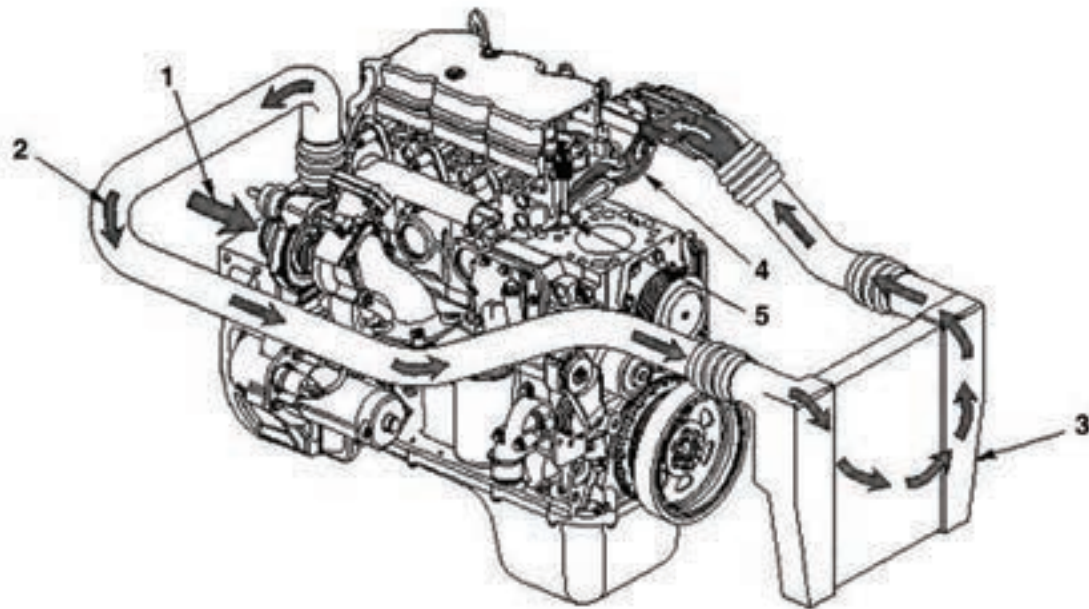


Figure 221

Reference Number	Description
1	Coolant Inlet
2	Pump Impeller
3	Coolant Flow Past Lubricating Oil Cooler
4	Coolant Flow Past Cylinders
5	Coolant Flow From Cylinder Block to Cylinder Head
6	Coolant Flow Between Cylinders

Reference Number	Description
7	Coolant Flow to Thermostat Housing
8	Coolant Bypass Passage
9	Coolant Flow Back to Radiator
10	Bypass Open
11	Coolant Bypass in Cylinder Head
12	Coolant Flow to Water Pump Inlet

Air Intake System



FG014025

Figure 222

Reference Number	Description
1	Intake Air Inlet to Turbocharger
2	Turbocharger Air to Charge Air Cooler
3	Charge Air Cooler

Reference Number	Description
4	Intake Manifold (Integral Part of the Cylinder Head)
5	Intake Valve

Exhaust System

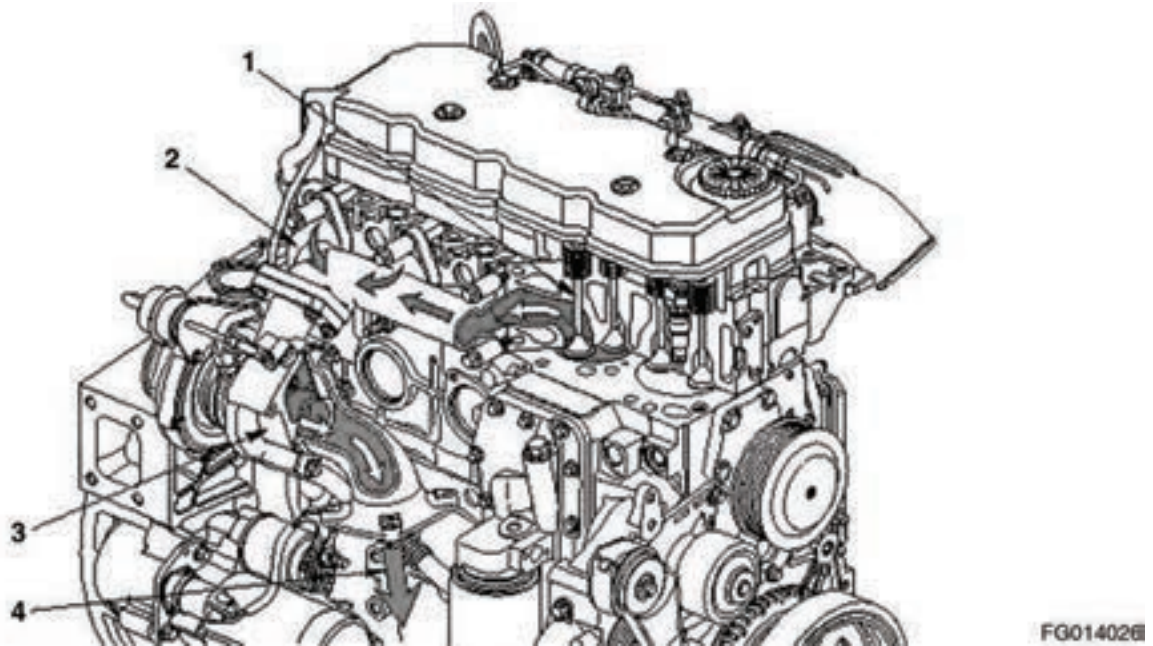
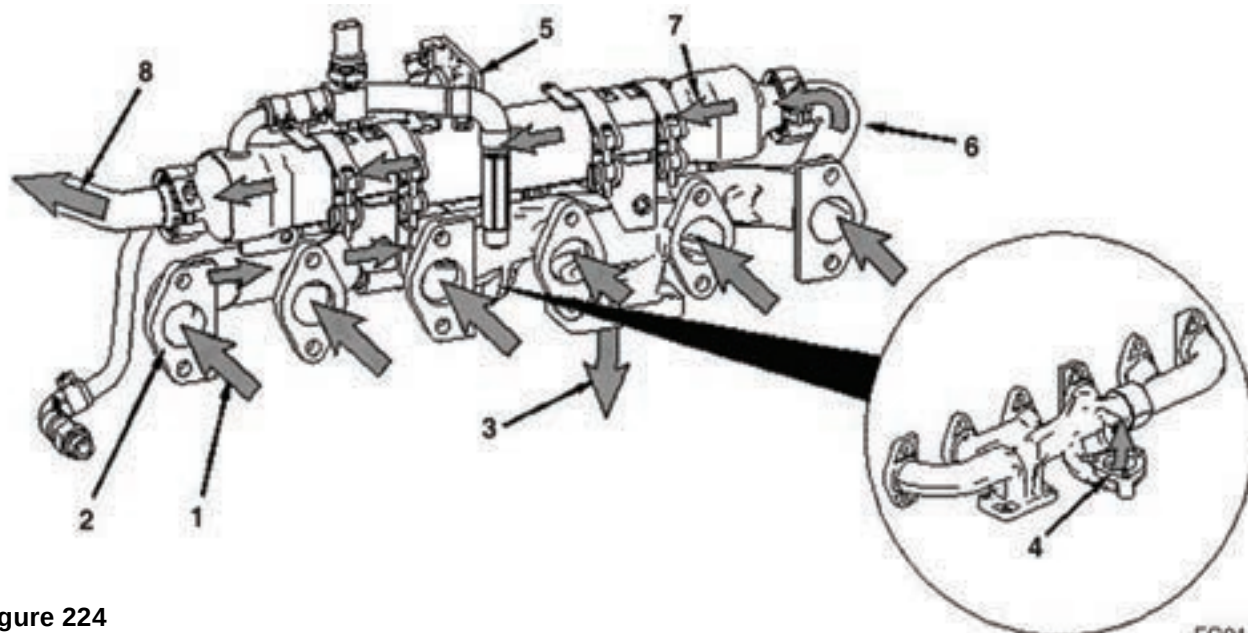


Figure 223

Reference Number	Description
1	Exhaust valve
2	Exhaust manifold

Reference Number	Description
3	Turbocharger
4	Turbocharger exhaust outlet

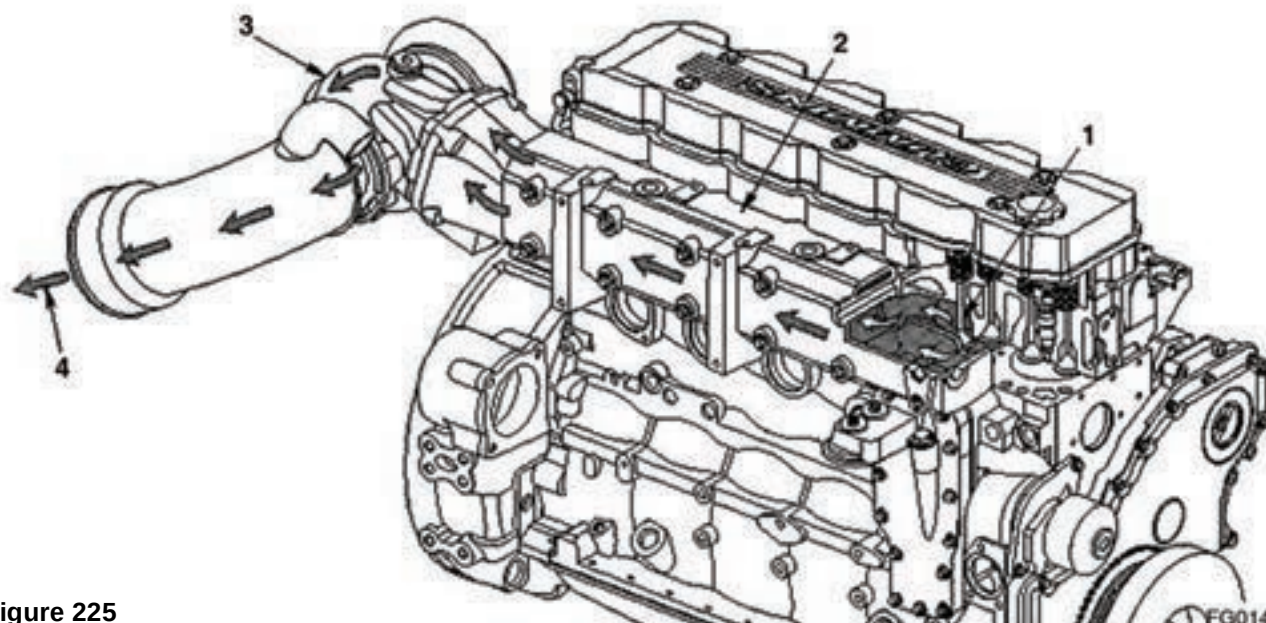


FG014027

Figure 224

Reference Number	Description
1	Exhaust Gas to Manifold
2	Exhaust Manifold
3	Exhaust Gas to Turbocharger
4	Exhaust Gas to EGR Valve
5	EGR Valve

Reference Number	Description
6	Exhaust Gas from EGR Valve to EGR Cooler Connection
7	EGR Cooler
8	Cooled Exhaust Gas to EGR Connection Tube and EGR Mixer



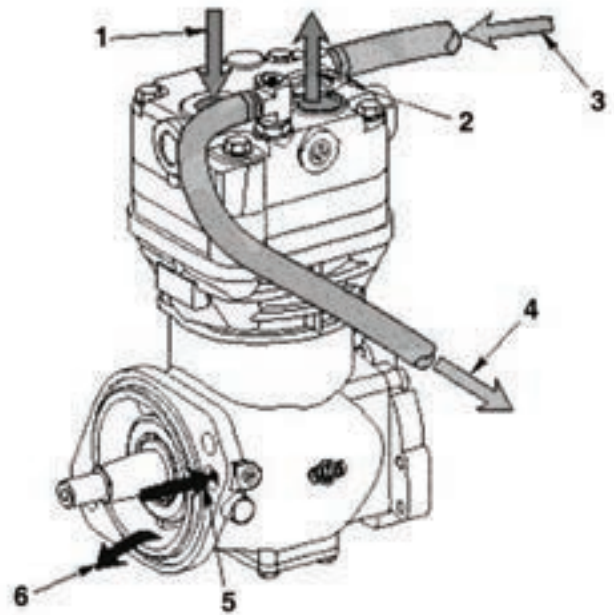
FG014028

Figure 225

Reference Number	Description
1	Exhaust valve
2	Exhaust Manifold (Wet)

Reference Number	Description
3	Turbocharger (Water Cooled)
4	Exhaust Outlet

Compressed Air System



FG014029

Figure 226

Reference Number	Description
1	Air In
2	Air out
3	Coolant In
4	Coolant Out

Reference Number	Description
5	Lubricating Oil in (Internal to the Gear Housing)
6	Lubricating Oil out (Internal to the Gear Housing)

SERVICE LITERATURE

Additional Service Literature

General Information

The following publications can be purchased.

Bulletin Number	Title of Publication
3379000	Air for Your Engines
3379001	Fuel for Cummins Engines Bulletin
3379009	Operation -Cold Weather Bulletin
3810340	Cummins Engine Oil Recommendations Bulletin
3666132	Coolant Requirements and Maintenance Bulletin
4021524	QSB4.5 CM850 Electronic Control Module Wiring Diagram
4021416	Troubleshooting and Repair Manual, CM850 Electronic Control System QSB4.5 Engines

Service Literature Ordering Location

Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at 1-800-646-5609 or Order online at www.powerstore.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contains only the new factory parts that were used to build your engine.

The catalog cover, and the content, is customized with you in mind. You can use it in your shop, at your work site, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number. Your name and engine model identification even appears on the catalog spine. Everybody will know that Cummins created a catalog specifically for you.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to the Cummins Electronic Parts Catalog or the Cummins Parts Microfilm System.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

North American customers can contact their Cummins Distributor or call Gannett Direct Marketing Services at 1-800-646-5609 and order by credit card. Outside North America order on-line or make an International call to Gannett at (++)502-454-6660.

Ordering On-Line

The Customized Parts Catalog can be ordered On-Line from the Cummins Powerstore by credit card. Contact the Powerstore at WWW.POWERSTORE.CUMMINS.COM

Contact GDMS or the CUMMINS POWERSTORE for the current price; Freight may be an additional expense.

Information we need to take your Customized Parts Catalog Order. This information drives the cover content of the CPC.

- Customer Name
- Street Address
- Company Name (optional)
- Telephone no.
- Credit Card No.
- Cummins Engine Serial Number (located on the engine data plate)
- Please identify the required media: Printed Catalog, CD-ROM, or PDF File

Unfortunately not all Cummins Engines can be supported by this parts catalog. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

Customized Parts Catalogs are produced specifically for a single customer. This means they are not returnable for a refund. If we make an error and your catalog is not usable, we will correct that error by sending you a new catalog.

Component Manufacturers Addresses

NOTE: *The following list contains addresses and telephone numbers of suppliers of accessories used on Cummins engines. Suppliers can be contacted directly for any specifications not covered in this manual.*

Air Compressors	Air Cylinders	Air Heaters
Bendix Heavy Vehicles Systems Div. of Allied Automotive 901 Cleveland Street Elyria, OH 44036 Telephone: (216) 329-9000 Holset Engineering Co., Inc. 1320 Kemper Meadow Drive Suite 500 Cincinnati, OH 45240 Telephone: (513) 825-9600 Midland-Grau Heavy Duty Systems Heavy Duty Group Headquarters 10930 N. Pamona Avenue Kansas City, MO 64153 Telephone: (816) 891-2470	Bendix Ltd. Douglas Road Kingswood Bristol England Telephone: 0117-671881 Catching Engineering 1733 North 25th Avenue Melrose Park, IL 60160 Telephone: (708) 344-2334 TEC - Hackett Inc. 8909 Rawles Avenue Indianapolis, IN 46219 Telephone: (317) 895-3670	Fleetguard, Inc. 1200 Fleetguard Road Cookeville, TN 38502 Telephone: (615) 526-9551 Kim Hotstart Co. P.O. Box 11245 Spokane, WA 99211-0245 Telephone: (509) 534-6171
Air Starting Motors	Alternators	Auxiliary Brakes
Ingersoll Rand Chorley New Road Horwich Bolton Lancashire England BL6 6JN Telephone: 01204-65544 Ingersoll-Rand Engine Starting Systems 888 Industrial Drive Elmhurst, IL 60126 Telephone: (708) 530-3875 StartMaster Air Starting Systems A Division of Sycon Corporation 9595 Cheney Avenue P. O. Box 491 Marion, OH 43302 Telephone: (614) 382-5771	Robert Bosch Ltd. P.O. Box 98 Broadwater Park North Orbital Road Denham Uxbridge Middlesex UD9 5HG England Telephone: (0)1895-838383 Prestolite Electrics Cleveland Road Leyland PR5 1XB England Telephone: (0)1772-421663 C. E. Niehoff and Co. 2021 Lee Street Evanston, IL 60202 Telephone: (708) 866-6030 Delco-Remy America 2401 Columbus Avenue P.O. Box 2439 Anderson, IN 46018 Telephone: (317) 646-3528 Leece-Neville Corp. 400 Main Street Arcade, NY 14009 Telephone: (716) 492-1700	The Jacobs Manufacturing Company Vehicle Equipment Division 22 East Dudley Town Road Bloomfield, CT 06002 Telephone: (203) 243-1441

Belts	Catalytic Converters	Coolant Level Switches
T.B.A. Belting Ltd. P.O. Box 77 Wigan Lancashire WN2 4XQ England Telephone: (0)1942-259221 Dayco Mfg. Belt Technical Center 1955 Enterprize Rochester Hills, MI 48309 Telephone: (810) 853-8300 Gates Rubber Company 900 S. Broadway Denver, CO 80217 Goodyear Tire and Rubber Company Industrial Products Div. 2601 Fortune Circle East Indianapolis, IN 46241 Telephone: (317) 898-4170	Donaldson Company, Inc. 1400 West 94th Street P.O. Box 1299 Minneapolis, MN 55440 Telephone: (612) 887-3835 Nelson Division Exhaust and Filtration Systems 1801 U.S. Highway 51 P.O. Box 428 Stoughton, WI 53589 Telephone: (608) 873-4200 Walker Manufacturing 3901 Willis Road P.O. Box 157 Grass Lake, MI 49240 Telephone: (517) 522-5500	Robertshaw Controls Company P.O. Box 400 Knoxville, TN 37901 Telephone: (216) 885-1773
Clutches	Coolant Heaters	Drive Plates
Twin Disk International S.A. Chaussee de Namur Nivelles Belguim Telephone: 067-224941 Twin Disk Incorporated 1328 Racine Street Racine, WI 53403 Telephone: (414) 634-1981	Fleetguard, Inc. 1200 Fleetguard Road Cookeville, TN 38502 Telephone: (615) 526-9551	Detroit Diesel Allison Division of General Motors Corporation P.O. Box 894 Indianapolis, IN 46206-0894 Telephone: (317) 242-5000
Electric Starting Motors	Electronic Switches	Engine Protection Controls
Prestolite Electrics Cleveland Road Leyland PR5 1XB England Telephone: 01772-421663 Delco-Remy America 2401 Columbus Avenue P.O. Box 2439 Anderson, IN 46018 Telephone: (317) 646-3528 Leece-Neville Corp. 400 Main Street Arcade, NY 14009 Telephone: (716) 492-1700 Nippondenso Inc. 2477 Denso Drive P.O. Box 5133 Southfield, MI 48086 Telephone: (313) 350-7500	Cutler-Hammer Products Eaton Corporation 4201 N. 27th Street Milwaukee, WI 53216 Telephone: (414) 449-6600	Flight Systems Headquarters Hempt Road P.O. Box 25 Mechanicsburg, PA 17055 Telephone: (717) 697-0333 The Nason Company 2810 Blue Ridge Blvd. West Union, SC 29696 Telephone: (803) 638-9521 Teddington Industrial Equipment Windmill Road Sunbury on Thames Middlesex TW16 7HF England Telephone: (0)9327-85500

Fan Clutches	Fans	Fault Lights
Kysor Cooling Systems N.A. 6040 West 62nd Street Indianapolis, IN 46278 Telephone: (317) 328-3330 Holset Engineering Co. Ltd. ST Andrews Road Huddersfield, West Yorkshire England HD1 6RA Telephone: (0)1484-22244 Horton Industries, Inc. P.O. Box 9455 Minneapolis, MN 55440 Telephone: (612) 378-6410 Rockford Clutch Company 1200 Windsor Road P.O. Box 2908 Rockford, IL 61132-2908 Telephone: (815) 633-7460	Trufflo Ltd. Westwood Road Birmingham B6 7JF England Telephone: (0)121-3283041 Hayes-Albion Corporation Jackson Manufacturing Plant 1999 Wildwood Avenue Jackson, MI 49202 Telephone: (517) 782-9421 Engineered Cooling Systems, Inc. 201 W. Carmel Drive Carmel, IN 46032 Telephone: (317) 846-3438 Brookside Corporation P.O. Box 30 McCordsville, IN 46055 Telephone: (317) 335-2014 TCF Aerovent Company 9100 Purdue Rd., Suite 101 Indianapolis, IN 46268-1190 Telephone: (317) 872-0030 Kysor-Cadillac 1100 Wright Street Cadillac, MI 49601 Telephone: (616) 775-4681 Schwitzer 6040 West 62nd Street P.O. Box 80-B Indianapolis, IN 46206 Telephone: (317) 328-3010	Cutler-Hammer Products Eaton Corporation 4201 N. 27th Street Milwaukee, WI 53216 Telephone: (414) 449-6600
Filters	Flexplates	Fuel Coolers
Fleetguard International Corp. Cavalry Hill Industrial Park Weedon Northampton NN7 4TD England Telephone: 01327-341313 Fleetguard, Inc. 1200 Fleetguard Road Cookeville, TN 38502 Telephone: 1-800-22-Filters (1-800-223-4583)	Corrugated Packing and Sheet Metal Hamsterley Newcastle Upon Tyne England Telephone: (0)1207-560-505 Allison Transmission Division of General Motors Corporation P.O. Box 894 Indianapolis, IN 46206-0894 Telephone: (317) 242-5000 Midwest Mfg. Co. 29500 Southfield Road, Suite 122 Southfield, MI 48076 Telephone: (313) 642-5355 Wohlert Corporation 708 East Grand River Avenue P.O. Box 20217 Lansing, MI 48901 Telephone: (517) 485-3750	Hayden, Inc. 1531 Pomona Road P.O. Box 848 Corona, CA 91718-0848 Telephone: (909) 736-2665

Fuel Pumps	Fuel Warmers	Gauges
Robert Bosch Corp. Automotive Group 2800 South 25th Ave. Broadview, IL 60153	Fleetguard, Inc. 1200 Fleetguard Road Cookeville, TN 38502 Telephone: (615) 526-9551	Grasslin U.K. Ltd. Vale Rise Tonbridge Kent TN9 1TB England Telephone: (0)1732-359888 Datcon Instruments P.O. Box 128 East Petersburg, PA 17520 Telephone: (717) 569-5713 Rochester Gauges, Inc. 11616 Harry Hines Blvd. P.O. Box 29242 Dallas, TX 75229 Telephone: (214) 241-2161
Governors	Heat Sleeves	Hydraulic and Power Steering Pumps
Woodward Governor Co. P.O. Box 1519 Fort Collins, CO 80522 Telephone: (303) 482-5811 (800) 523-2831 Barber Colman Co. 1354 Clifford Avenue Loves Park, IL 61132 Telephone: (815) 637-3000 United Technologies Diesel Systems 1000 Jorie Blvd. Suite 111 Oak Brook, IL 69521 Telephone: (312) 325-2020	Bentley Harris Manufacturing Co. 100 Bentley Harris Way Gordonville, TN 38563 Telephone: (313) 348-5779	Honeywell Control Systems Ltd. Honeywell House Arlington Business Place Bracknell Berks RG12 1EB Telephone: (0)1344-656000 Sperry Vickers P.O. Box 302 Troy, MI 48084 Telephone: (313) 280-3000 Z.F. P.O. Box 1340 Grafvonsoden Strasse 5-9 D7070 Schwaebisch Gmuend Germany Telephone: 7070-7171-31510
In-Line Connectors	Oil Heaters	Prelubrication Systems
Pioneer-Standard Electronics, Inc. 5440 Neiman Parkway Solon, OH 44139 Telephone: (216) 349-1300 Deutsch Industrial Products Division 37140 Industrial Avenue Hemet, CA 92343 Telephone: (714) 929-1200	Fleetguard, Inc. 1200 Fleetguard Road Cookeville, TN 38502 Telephone: (615) 526-9551 Kim Hotstart Co. P.O. Box 11245 Spokane, WA 99211-0245 Telephone: (509) 534-6171	RPM Industries, Inc. Suite 109 55 Hickory Street Washington, PA 15301 Telephone: (412) 228-5130
Radiators	Throttle Assemblies	Torque Converters
JB Radiator Specialties, Inc. P.O. Box 292087 Sacramento, CA 95829-2087 Telephone: (916) 381-4791 The GandO Manufacturing Company 100 Gando Drive P.O. Box 1204 New Haven, CT 06505-1204 Telephone: (203) 562-5121 Young Radiator Company 2825 Four Mile Road Racine, WI 53404 Telephone: (910) 271-2397 L and M Radiator, Inc. 1414 East 37th Street Hibbing, MN 55746 Telephone: (218) 263-8993	Williams Controls, Inc. 14100 SW 72nd Avenue Portland, OR 97224 Telephone: (503) 684-8600	Twin Disk International S.A. Chaussee de Namur Nivelles Belgium Telephone: 067-224941 Twin Disk Incorporated 1328 Racine Street Racine, WI 53403-1758 Telephone: (414) 634-1981 Rockford Powertrain, Inc. Off-Highway Systems 1200 Windsor Road P.O. Box 2908 Rockford, IL 61132-2908 Telephone: (815) 633-7460 Modine Mfg. Co. 1500 DeKoven Avenue Racine, WI 53401 Telephone: (414) 636-1640

SERVICE ASSISTANCE

Routine Service and Parts

Personnel at your authorized dealer and Cummins Authorized Repair Locations can assist you with the correct operation and service of your engine. Cummins has a worldwide service network of more than 5,000 Distributors and Dealers who have been trained to provide sound advice, expert service, and complete parts support. Check the telephone directory yellow pages or refer to the directory in this section for the nearest Cummins Authorized Repair Location.

Emergency and Technical Service

The Cummins Customer Assistance Center provides a 24- hour, toll free telephone number to aid in technical and emergency service when a Cummins Authorized Repair Location cannot be reached or is unable to resolve an issue with a Cummins product.

If additional assistance is required, call Toll-Free:

1-800-DIESELS (1-800-343-7357)

- Includes all 50 states, Bermuda, Puerto Rico, Virgin Islands, and the Bahamas.
- Outside of North America contact your Regional Office. Telephone numbers and addresses are listed in the International Directory.

Problem Solving

Normally, any problem that arises with the sale, service, or repair of your engine can be handled by a Cummins Authorized Repair Location in your area. Refer to the telephone directory yellow pages for the one nearest you. If the problem has not been handled satisfactorily, follow the steps outlined below:

1. If the disagreement is with a Dealer, talk to the Cummins Distributor with whom he has his service agreement.
2. If the disagreement is with a Distributor, call the nearest Cummins Division or Regional Office; however, most problems are solved below the Division or Regional office level. Telephone numbers and addresses are listed in this section. Before calling, write down the following information:
 - A. Engine model and serial number
 - B. Type and make of equipment
 - C. Total kilometers [miles] or hours of operation
 - D. Warranty start date

- E. Nature of problem
 - F. Summary of the current problem arranged in the order of occurrence
 - G. Name and location of the Cummins Distributor or Dealer
3. If a problem cannot be resolved satisfactorily through your Cummins Authorized Repair Location or Division Office, write to:

Cummins Customer Assistance Center - 41403, Cummins Inc.,
Box 3005, Columbus, IN 47202-3005

Division and Regional Offices - Locations

Australia Regional Office	Cummins Engine Company Pty. Ltd.	2 Caribbean Drive Scoresby, Victoria 3179 Australia Telephone: (61-3) 9765-3222 FAX: (61-3) 9763-0079 NOTE: <i>This office also serves New Zealand.</i>
Cummins Americas Regional Office	Cummins America Inc.	3350 SW 148 Avenue Suite 205 Miramar, FL 33027 Telephone: (1-954) 431-5511 FAX: (1-954) 433-5797 NOTE: <i>This office serves Puerto Rico and South America excluding Brazil.</i>
China-Beijing	Cummins (China) Investment Co. Ltd	28F, Tower A, GATEWAY, No.18, Xiaguangli North Road, East Third Ring, Chaoyang District Beijing, Beijing ZIP / Postal Code: 100027 China Telephone: (86-10) 84548888 FAZ: (86-10) 67876347
Brazil	Cummins Brasil Ltda.	Rua Jati, 266 07180-900 Guarulhos Sao Paulo Brazil Phone: (55-11) 6465-9811 Fax: (55-11) 6412-1483
Daventry	Cummins Engine Company Ltd (Africa)	Royal Oak Way South Daventry, Northants ZIP / Postal Code: NN11 5NU United Kingdom Telephone: (44-1327) 886000 Telefax: (44-1327) 886106
	Cummins Engine Co. Ltd (Serving Czech Republic)	
	Cummins Engine Company Ltd (Middle East)	
Dubai-United Arab Emirates	Cummins Middle East FZE	Units ZF 5/6 Jebel Ali Free Zone P.O.Box No 17636 Dubai United Arab Emirates Phone: (971-4) 883 8998 Fax: (971-4) 883 7971
India-Pune	Cummins India Ltd.	Kothrud Pune, Maharashtra ZIP / Postal Code: 411029 India Telephone: (91-20) 2538-5435 / 0240 / 1105 Telefax: (91-20) 2538-0125
Korea-Seoul	Cummins Korea Ltd.	25th floor, ASEM tower, 159-1, Samsung-Dong Kangnam-ku, Seoul ZIP / Postal Code: 135-798 South Korea Telephone: (82-2) 3420-0901 Telefax: (82-2) 3452-4113 / 539-6569

SLP Mexico	Cummins, S. de R.L. de C.V.	Arquimedes No. 209 Col. Polanco Mexico, Distrito Federal ZIP / Postal Code: 11560 Mexico Telephone: (52-5) 254-3822 / 3783 / 3622 Telefax: (52-5) 254-3645
Russia-Moscow	Cummins Engine Company, Inc.	Park Place Office E708, 113/1 Leninskiy Prospect Moscow ZIP / Postal Code: 117198 Russia Telephone: (7-495) 956-51-22 / 23 Telefax: (7-495) 956-53-62
Singapore	Cummins Diesel Sales Corporation	8 Tanjong Penjuru Singapore ZIP / Postal Code: 609019 Singapore Telephone: (65) 6265-0155

Distributors and Branches - United States

Alabama	Birmingham	Cummins Mid-South, LLC 2200 Pinson Highway P.O. Box 1147 Birmingham, AL 35217 Telephone: (205) 841-0421 FAX: (205) 849-5926
Alabama	Mobile	Cummins Mid-South, LLC 1924 N. Beltline Hwy. Mobile, AL 36617 Telephone: (334) 456-2236 FAX: (334) 452-6419
Alaska	Anchorage	Cummins Northwest, Inc. 2618 Commercial Drive Anchorage, AK 99501-3095 Telephone: (907) 279-7594 FAX: (907) 276-6340
Arizona	Phoenix	Cummins Rocky Mountain, LLC 2239 N. Black Canyon Hgwy Phoenix, AZ 85009 Telephone: (602) 252-8021 FAX: (602) 253-6725
Arkansas	Little Rock	Cummins Mid-South, Inc. 6600 Interstate 30 Little Rock, AR 72209 Telephone: Sales: (501) 569-5600 Service: (501) 569-5656 Parts: (501) 569-5613 FAX: (501) 565-2199
California	San Leandro	Cummins West, Inc. 14775 Wicks Blvd. San Leandro, CA 94577-6779 Telephone: (510) 351-6101 FAX: (510) 352-3925
California	Arcata	Cummins West, Inc. 4751 West End Road Arcata, CA 95521 Telephone: (707) 822-7392 FAX: (707) 822-7585
California	Bakersfield	Cummins West, Inc. 4601 East Brundage Lane Bakersfield, CA 93307 Telephone: (805) 325-9404 FAX: (805) 861-8719
California	Fresno	Cummins West, Inc. 5333 N Comelia Ave Fresno, CA 93722 Telephone: (559) 277-6760 FAX: (559) 277-6769
California	Redding	Cummins West, Inc. 20247 Charlanne Drive Redding, CA 96002 Telephone: (530) 222-4070 FAX: (530) 224-4075
California	Stockton	Cummins West, Inc. 5250 Claremont Ave Suite 204 Stockton, California 95207, USA Telephone: (209) 472-3460 FAX: (209) 472-3450

California	West Sacramento	Cummins West, Inc. 875 Riverside Parkway West Sacramento, CA 95605-1502 Telephone: (916) 371-0630 FAX: (916) 371-2849
California	Los Angeles	Cummins Cal Pacific Inc. 1939 Deere Avenue (Irvine) Irvine, CA 92606 Telephone: (949) 253-6000 FAX: (949) 253-6070
California	Montebello	Cummins Cal Pacific Inc. 1105 South Greenwood Avenue Montebello, CA 90640 Telephone: (323) 728-8111 FAX: (323) 889-7499
California	Bloomington	Cummins Cal Pacific Inc. 3061 S. Riverside Avenue Bloomington, CA 92316 Telephone: (909) 877-0433 FAX: (909) 877-3787
California	San Diego	Cummins Cal Pacific Inc. 310 N. Johnson Avenue El Cajon, CA 92020 Telephone: (619) 593-3093 FAX: (619) 593-0600
California	Ventura	Cummins Cal-Pacific Inc. 3958 Transport St. Ventura, CA 93003 Telephone: (805) 644-7281 FAX: (805) 644-7284
Colorado	Denver	Cummins Rocky Mountain, Inc. 8211 East 96th Ave Henderson, Colorado 80640 Telephone: (303) 287-0201 FAX: (303) 288-7080
Colorado	Grand Junction	Cummins Rocky Mountain, Inc. 2380 U.S. Highway 6 and 50 P.O. Box 339 Grand Junction, CO 81501 Telephone: (970) 242-5776 FAX: (970) 243-5495
Connecticut	Rocky Hill	Cummins Metropower, Inc. 914 Cromwell Ave. Rocky Hill, CT 06067 Telephone: (860) 529-7474 FAX: (860) 529-7524
Florida	Ft. Myers	Cummins Power South, LLC 2671 Edison Avenue Ft. Myers, FL 33916 Telephone: (941) 337-1211 FAX: (941) 337-5374
Florida	Jacksonville	Cummins Power South 755 Pickettville Rd. Jacksonville, FL 32220 Telephone: (904) 378-1902 FAX: (904) 378-1904

Florida	Hialeah (Miami)	Cummins South Power, LLC 9900 N.W. 77th Avenue Hialeah Gardens, FL 33016 Telephone: (305) 821-4200 FAX: (305) 557-2992
Florida	Ocala	Cummins South Power, LLC 321 Southwest 52nd Ave. Ocala, FL 34474-1892 Telephone: (352) 861-1122 FAX: (352) 861-1130
Florida	Orlando	Cummins South Power, LLC 4020 North Orange Blossom Trail Orlando, FL 32810 Telephone: (407) 298-2080 FAX: (407) 290-8727
Florida	Tampa	Cummins South Power, LLC Corporate Office. 5421 N. 59th Street Tampa, FL 33610 Telephone: (813) 621-7202 FAX: (813) 621-8250
Florida	Tampa	Cummins South Power, LLC 5906 Breckenridge Parkway Suite J Tampa, FL 33610 Telephone: (813) 664-5868 FAX: (813) 623-5442
Florida	Tampa	Cummins South Power, LLC 5912 E. Hillsborough Avenue Tampa, FL 33610 Telephone: (813) 626-1101 FAX: (813) 628-8888
Florida	Tampa	Cummins Power South, LLC 6606 N. 56th Street Tampa, FL 33610 Telephone: (813) 623-3330 FAX: (813) 628-4162
Georgia	Atlanta	Cummins South, Inc. 5125 Georgia Highway 85 College Park, GA 30349 Telephone: (404) 763-0151 FAX: (404) 766-2132
Georgia	Atlanta	Cummins South, Inc. 100 University Ave. S.W. Atlanta, Georgia 30315-2202 Telephone: (404) 527-7800 FAX: (404) 527-7832
Georgia	Albany	Cummins South, Inc. 1915 W. Oakridge Drive Albany, GA 31707-4938 Telephone: (912) 888-6210 FAX: (912) 883-1670
Georgia	Augusta	Cummins South, Inc. 1255 New Savannah Road Augusta, GA 30901-3891 Telephone: (706) 722-8825 FAX: (706) 722-7553

Georgia	Savannah	Cummins South, Inc. 8 Interchange Court Savannah, GA 31401-1627 Telephone: (912) 232-5565 FAX: (912) 232-5145
Hawaii	Kapolei Distributor	Cummins West Inc. 91-230 Kalaeloa Blvd. Kapolei, HI 96707 Telephone: (808) 682-8110 FAX: (808) 682-8477
Idaho	Boise	Cummins Rocky Mountain, LLC 8949 So. Federal Way City Boise, Idaho 84716 Telephone: (208) 336-5000 FAX: (208) 338-5436
Illinois	Chicago	Cummins Power, LLC 7145 Santa Fe Drive Hodgkins, IL 60525 Telephone: (708) 579-9222 FAX: (708) 352-7547
Illinois	Bloomington	Cummins Mid-States Power, Inc. (at U.S. 51 N and I-55) 414 W. Northtown Road Bloomington-Normal, IL 61761 Telephone: (309) 452-4454 FAX: (309) 452-1642
Illinois	Onan Branch	Cummins/Onan Northern Illinois 8745 W. 82nd Place Justin, IL 60458 Telephone: (708) 563-7070 FAX: (708) 563-7095
Illinois	Madison	Cummins Mid-South, LLC 222 SR-203 Madison, Illinois 62060 Telephone: (618) 798-9512 FAX: (618) 798-9521
Illinois	Rock Island	Cummins Central Power, LLC 7820 - 42nd Street West Rock Island, IL 61201 Telephone: (309) 787-4300 FAX: (309) 787-4397
Indiana	Indianapolis	Cummins Mid-States Power, Inc. P.O. Box 42917 3762 West Morris Street Indianapolis, IN 46242-0917 Telephone: (317) 243-7979 FAX: (317) 240-1925
Indiana	Indianapolis	Cummins Mid-States Power, Inc. P. O. Box 42917 3661 West Morris Street Indianapolis, IN 46241 Telephone: (317) 486-5287 FAX: (317) 486-5281
Indiana	Indianapolis	Cummins Mid-States Power, Inc. 4301 W. Morris St. 3762 West Morris Street Indianapolis, IN 46241 Telephone: (317) 240-1967 FAX: (317) 240-1975

Indiana	Evansville	Cummins Cumberland, Inc. 7901 Highway 41 North Evansville, IN 47725 Telephone: (812) 867-4400 FAX: (812) 867-4411
Indiana	Ft. Wayne	Cummins Mid-States Power, Inc. 3415 Coliseum Blvd. West (At Jct. I-69 and 30/33) Ft. Wayne, IN 46808 Telephone: (219) 482-3691 FAX: (219) 484-8930
Indiana	Gary	Cummins Northern Illinois, Inc. 1440 Texas Street Gary, IN 46402 Telephone: (219) 885-5591 FAX: (219) 883-4817
Indiana	Indianapolis	Cummins Mid-States Power, Inc. 3661 West Morris St Indianapolis, IN 46241 Telephone: (317) 486-5287 FAX: (317) 486-5281
Iowa	Cedar Rapids	Cummins Central Power, LLC 625 - 33rd Avenue SW Cedar Rapids, IA 52404 Telephone: (319) 366-7537 (24 hours) FAX: (319) 366-7562
Iowa	Des Moines	Cummins Central Power, LLC 1680 N.E. 51st Avenue Des Moines, IA 50313 Telephone: (515) 262-9591 Parts: (515) 262-9744 FAX: (515) 262-0626
Kansas	Colby	Cummins Central Power LLC 1880 South Range Colby, KS 67701 Telephone: (785) 462-3945 FAX: (785) 462-3970
Kansas	Garden City	Cummins Central Power LLC 1285 Acraway Garden City, KS 67846 Telephone: (316) 275-2277 FAX: (316) 275-2533
Kansas	Wichita	Cummins Central Power LLC 5101 North Broadway Wichita, KS 67219 Telephone: (316) 838-0875 FAX: (316) 838-0704
Kentucky	Louisville	Cummins Cumberland, Inc. (Corporate Office) 2301 Nelsonville Parkway Louisville, KY 40223 Telephone: (502) 254-7375 FAX: (502) 254-1215
Kentucky	Hazard	Cummins Cumberland, Inc. Highway 15 South Hazard, KY 41701 Telephone: (606) 436-5718 FAX: (606) 436-5038
Kentucky	Louisville	Cummins Cumberland, Inc. 9820 Bluegrass Parkway Louisville, KY 40299 Telephone: (502) 491-4263 FAX: (502) 499-0896

Maine	Scarborough	Cummins Northeast, Inc. 10 Gibson Road Scarborough, ME 04074 Telephone: (207) 883-8155 FAX: (207) 883-5526
Maryland	Baltimore	Cummins Power Systems, Inc. 1907 Park 100 Drive MD 21061 Telephone: (410) 590-8700 FAX: (410) 590-8731
Massachusetts	Boston	Cummins Northeast, Inc. 100 Allied Drive Dedham, MA 02026 Telephone: (781) 329-1750 FAX: (781) 329-4428
Massachusetts	Springfield	Cummins Northeast, Inc. 177 Rocus Street Springfield, MA 01104 Telephone: (413) 737-2659 FAX: (413) 731-1082
Michigan	Detroit (New Hudson)	Standby Power, Div. of Cummins Bridgeway, LLC 21810 Clessie Ct New Hudson, Michigan 48165 Telephone: (248) 573-160
Michigan	Detroit (New Hudson)	Cummins Bridgeway, LLC 54240 Grand River Ave New Hudson, Michigan 48165 Telephone: (517) 573-1900
Michigan	Grand Rapids	Cummins Bridgeway, LLC 3715 Clay Avenue, S.W. Grand Rapids, MI 49508 Telephone: (616) 538-2250 FAX: (616) 538-3830
Michigan	Grand Rapids	Standby Power, Inc. 7580 Expressway Drive S.W. Grand Rapids, MI 49548 Telephone: (616) 281-2211 FAX: (616) 281-3177
Michigan	Iron Mountain	Cummins NPower, LLC 1901 Stevenson Avenue Iron Mountain, MI 49801 Telephone: (906) 774-2424 FAX: (906) 774-1190
Michigan	Saginaw	Cummins Michigan, Inc. 722 N. Outer Drive Saginaw, MI 48605 Telephone: (989) 752-5200 FAX: (989) 752-4194
Minnesota	St. Paul	Cummins NPower, LLC 3030 Centre Pointe Drive Suite 500 Roseville, MN 55113 Telephone: (651) 636-1000 FAX: (651) 638-2442
Minnesota	Duluth	Cummins NPower, LLC 3115 Truck Center Drive Duluth, MN 55806-1786 Telephone: (218) 628-3641 FAX: (218) 628-0488
Mississippi	Jackson	Cummins Mid-South, LLC 325 New Highway 49 South Jackson, MS 39288-4224 Telephone: (601) 932-7016 FAX: (601) 932-7399

Missouri	Kansas City	Cummins Central Power, LLC 8201 NE Parvin Road Kansas City, MO 64161 Telephone: (816) 414-8200 FAX: (816) 414-8299
Missouri	Joplin	Cummins Central Power, LLC 3507 East 20th Street Joplin, MO 64801 Telephone: (417) 623-1661 FAX: (417) 623-1817
Missouri	Springfield	Cummins Central Power, LLC 3637 East Kearney Springfield, MO 65803 Telephone: (417) 862-0777 FAX: (417) 862-4429
Missouri	Columbia	Cummins Mid-South, LLC 5221 Highway 763 North Columbia, MO 65205 Telephone: (314) 449-3711 FAX: (314) 449-3712
Missouri	Sikeston	Cummins Mid-South, LLC 101 Keystone Drive Sikeston, MO 63801 Telephone: (573) 472-0303 FAX: (573) 472-0306
Missouri	Industrial Power Branch	Cummins Mid-South, LLC 3256 E. Outer Road Scott City, MO 63780 Telephone: (573) 335-7399 FAX: (573) 335-7062
Montana	Billings	Cummins Rocky Mountain, LLC. 5151 Midland Road Billings, MT 59101 Telephone: (406) 245-4194 FAX: (406) 245-7923 Tool Free#: (800) 332-7788
Montana	Missoula	Cummins Northwest, Inc. 4950 North Reserve Street Missoula, MT 59802-1498 Telephone: (406) 728-1300 FAX: (406) 728-8523
Nebraska	Omaha	Cummins Great Plains Diesel, Inc. 5515 Center Street Omaha, NE 68106 Telephone: (402) 551-7678 (24 Hours) FAX: (402) 551-1952
Nebraska	Kearney	Cummins Central Power, LLC 515 Central Avenue Kearney, NE 68847 Telephone: (308) 234-1994 FAX: (308) 234-5776
Nevada	Elko	Cummins Rock Mountain, LLC 5370 East Idaho Street Elko, NV 89801 Telephone: (702) 738-6405 FAX: (702) 738-1719
Nevada	Las Vegas	Cummins Rock Mountain, LLC 2750 Losee Road North Las Vegas, NV 89030 Telephone: (702) 399-2614 FAX: (702) 399-7457
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Country	
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Covered: South Korea	

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Cummins, S. de R.L. de C.V. Arquimedes No. 209 Col. Polanco 4605 Modern Lane Mexico, Distrito Federal	ZIP / Postal Code: 11560 Mexico Telephone: (52-5) 254-3822 / 3783 / 3622 Fax: (52-5) 254-3645
Country	
Covered: Mexico Guatemala Honduras	Costa Rica Nicaragua Panama

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	Azerbaijan
	Belarus
	Tajikistan
	Georgia
	Kyrgyzstan
	Kazakhstan
	Moldova
	Russia
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Country	
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	Cambodia
	Indonesia
	Laos
	Malaysia
	Philippines
	Singapore
	Sri Lanka
	Thailand
	Vietnam

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	Chile
	Colombia
	Costa Rica
	Dominican Republic
	Ecuador
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	Guatemala
	Honduras
	Nicaragua
	Panama
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	Peru Uruguay
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TROUBLESHOOTING SYMPTOMS

Troubleshooting Procedures and Techniques

General Information

This guide describes some typical engine operating problems, their causes, and some acceptable corrections to those problems. Unless noted otherwise, the problems listed are those which an operator can diagnose and repair.



WARNING!

Performing troubleshooting procedures NOT outlined in this section can result in equipment damage or personal injury or death. Troubleshooting must be performed by trained, experienced technicians. Consult a Cummins Authorized Repair Location for diagnosis and repair beyond that which is outlined, and for symptoms not listed in this section. Before beginning any troubleshooting, refer to General Safety Instructions in Section i of this manual.

Follow the suggestions below for troubleshooting:

- Study the complaint thoroughly before acting
- Refer to the engine system diagrams
- Do the easiest and most logical things first
- Find and correct the cause of the complaint

Troubleshooting Symptoms Charts

General Information

Use the charts on the following pages of this section to aid in diagnosing specific engine symptoms. Read each row of blocks from top to bottom. Follow through the chart to identify the corrective action.



WARNING!

Troubleshooting presents the risk of equipment damage, personal injury or death. Troubleshooting must be performed by trained, experienced technicians.

Air Compressor Air Pressure Rises Slowly

Cause	Correction
STEP 1 Air intake system restriction to air compressor is excessive OK Go To Next Step	Replace the air compressor air cleaner (if installed). Check the air intake piping. Check engine air intake restriction if the air compressor inlet is plumbed to the vehicle or equipment intake system. Refer to "Section 3" on page-60 and "Section 4" on page-60.
STEP 2 Air system leaks OK Go To Next Step	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manuals.
STEP 3 Carbon buildup is excessive in the air discharge line, downstream air valves, or cylinder head OK Go To Next Step	Check for carbon buildup. Replace the air compressor discharge line and cylinder head assembly if necessary. Refer to "Section 7" on page-60.
STEP 4 Contact a Cummins Authorized Repair Facility	

Air Compressor Cycles Frequently

Cause	Correction
STEP 1 Air system leaks OK Go To Next Step	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manuals.
STEP 2 Carbon buildup is excessive in the air discharge line, downstream air valves, or cylinder head OK Go To Next Step	Check for carbon buildup. Replace the air compressor discharge line and cylinder head assembly if necessary. Refer to "Section 7" on page-60.
STEP 3 Air compressor pumping time is excessive OK Go To Next Step	Replace the desiccant cartridge on the Turbo/CR 2000 air dryer. Refer to the OEM service manual. Check the air compressor duty cycle. Install a larger air compressor, if necessary. Refer to an Authorized Cummins Repair Facility.
STEP 4 Contact a Cummins Authorized Repair Facility	

Air Compressor Noise is Excessive

Cause	Correction
<u>STEP 1</u> Carbon buildup is excessive in the air discharge line, downstream air valves, or cylinder head OK Go To Next Step	Check for carbon buildup. Replace the air compressor discharge line and cylinder head assembly if necessary. Refer to "Section 7" on page-60.
<u>STEP 2</u> Air compressor is sending air pulses into the air tanks OK Go To Next Step	Install a ping tank between the air dryer and the wet tank. Refer to the manufacturer's instructions.
<u>STEP 3</u> Ice buildup in the air system components OK Go To Next Step	For all models, check for ice in low spots of the air discharge line, dryer inlet, and elbow fittings. On Holset® models, also check the Econ valve (if equipped). Refer to the OEM service manual.
<u>STEP 4</u> Contact a Cummins Authorized Repair Facility	

Air Compressor Pumping Excess Lubricating Oil into the Air System

Cause	Correction
<u>STEP 1</u> Lubricating oil drain interval is excessive OK Go To Next Step	Verify the correct lubricating oil drain interval. Refer to "Maintenance Guidelines" on page-59.
<u>STEP 2</u> Air intake system restriction to air compressor is excessive OK Go To Next Step	Replace the air compressor air cleaner (if installed). Check the air intake piping. Check engine air intake restriction if the air compressor inlet is plumbed to the vehicle or equipment intakesystem. Refer to "Section 3" on page-60.
<u>STEP 3</u> Air compressor pumping time is excessive OK Go To Next Step	Replace the desiccant cartridge on the Turbo/CR 2000 air dryer. Refer to the OEM service manual. Check the air compressor duty cycle. Install a larger air compressor, if necessary. Refer to an Authorized Cummins Repair Facility.
<u>STEP 4</u> Carbon buildup is excessive in the air discharge line, check valve, or cylinder head OK Go To Next Step	Check for carbon buildup. Replace the air compressor discharge line, if necessary. Refer to "Section 7" on page-60.
<u>STEP 5</u> Contact a Cummins Authorized Repair Facility	

Air Compressor Will Not Maintain Adequate Air Pressure (Not Pumping Continuously)

Cause	Correction
<u>STEP 1</u> Air system leaks OK Go To Next Step	Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manual.
<u>STEP 2</u> Contact a Cummins Authorized Repair Facility	

Air Compressor Will Not Stop Pumping

Cause

STEP 1

Air system leaks

OK

Go To Next Step

STEP 2

Contact a Cummins Authorized Repair Facility

Correction

Block the vehicle wheels and check the air system for leaks with spring brakes applied and released. Check for leaks from the air compressor gaskets and the air system hoses, fittings, tanks, and valves. Refer to the OEM service manual.

Alternator Not Charging or Insufficient Charging

Cause	Correction
STEP 1 Alternator pulley is loose on the shaft OK Go To Next Step	Tighten the pulley. Refer to OEM service manual.
STEP 2 Batteries have malfunctioned OK Go To Next Step	Check the condition of the batteries. Replace the batteries, if necessary. Refer to OEM service manual.
STEP 3 Battery cables or connections are loose, broken, or corroded (excessive resistance) OK Go To Next Step	Check the battery cables and connections.
STEP 4 Alternator is overloaded, or alternator capacity is below specification OK Go To Next Step	Install an alternator with a higher capacity. Refer to the OEM service manual.
STEP 5 Alternator or voltage regulator is malfunctioning OK Go To Next Step	Test the alternator output. Replace the alternator or voltage regulator if necessary. Refer to the OEM service manual.
STEP 6 Battery temperature is above specification OK Go To Next Step	Position the batteries away from heat sources. Refer to the OEM service manual.
STEP 7 Electrical system is "open" (blown fuses, broken wires, or loose connections) OK Go To Next Step	Check the fuses, wires, and connections. Refer to the OEM service manual and the manufacturer's wiring diagram.
STEP 8 Vehicle gauge is malfunctioning OK Go To Next Step	Check the vehicle gauge. Refer to the OEM service manual.
STEP 9 Contact a Cummins Authorized Repair Facility	

Alternator Overcharging

Cause	Correction
STEP 1 Battery have failed OK Go To Next Step	Check the condition of the batteries. Replace the batteries, if necessary. Refer to the OEM service manual.
STEP 2 Voltage regulator is malfunctioning OK Go To Next Step	Check the voltage regulator. Replace the voltage regulator, if necessary. Refer to an Authorized Cummins Repair Facility.
STEP 3 Contact a Cummins Authorized Repair Facility	

Coolant Contamination

Cause	Correction
STEP 1 Coolant is rusty and has debris OK Go To Next Step	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Refer to "Section 7" on page-60.
STEP 2 Transmission oil cooler or torque converter cooler is leaking OK Go To Next Step	Check the transmission oil cooler and torque converter cooler for coolant leaks. Refer to the OEM service manual.
STEP 3 Lubricating oil cooler is leaking OK Go To Next Step	Check the lubricating oil cooler for coolant leaks and cracks. Refer to a Cummins Authorized Repair Facility.
STEP 4 Cylinder head gasket is leaking OK Go To Next Step	Check the cylinder head gasket. Refer to a Cummins Authorized Repair Facility.
STEP 5 Contact a Cummins Authorized Repair Facility	

Coolant Loss - External

Cause	Correction
<u>STEP 1</u> Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 2</u> External coolant leak	Inspect the engine for coolant leaking from hoses, draincocks, water manifold, jumper tubes, expansion and pipe plugs, fittings, radiator core, air compressor and cylinder head gaskets, lubricating oil cooler, water pump seal, cylinder block, and OEM-mounted components that have coolant flow. Refer to Section A.
OK Go To Next Step	
<u>STEP 3</u> Radiator cap is not correct, is malfunctioning, or has low-pressure rating	Check the radiator pressure cap. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 4</u> Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to "Section 4" on page-60.
OK Go To Next Step	
<u>STEP 5</u> Coolant fill line is restricted or obstructed	Check the coolant fill line for restrictions or obstructions. Refer to "Section 7" on page-60.
OK Go To Next Step	
<u>STEP 6</u> Coolant is rusty and has debris	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Refer to "Section 7" on page-60.
OK Go To Next Step	
<u>STEP 7</u> Engine is overheating	Refer to the Coolant Temperature is Above Normal -Sudden Overheat or the Coolant Temperature is Above Normal - Gradual Overheat symptom tree.
OK Go To Next Step	
<u>STEP 8</u> Contact a Cummins Authorized Repair Facility	

Coolant Temperature Above Normal - Gradual Overheat

Cause	Correction
STEP 1 Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to "Section 4" on page-60 and OEM service manual.
OK Go To Next Step	
STEP 2 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm² (60 in²) of opening at all times. Refer to "Operating Instructions" on page-48.
OK Go To Next Step	
STEP 3 Coolant level is below specification	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to "Section 7" on page-60.
OK Go To Next Step	
STEP 4 Electronic fault codes are active	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 5 Fan shroud is damaged or missing or the air recirculation baffles are damaged or missing	Inspect the shroud and the recirculation baffles. Repair, replace, or install, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Lubricating oil is contaminated with coolant or fuel	Refer to the Lubricating Oil Contaminated symptom tree.
OK Go To Next Step	
STEP 7 Cooling system hose is collapsed, restricted, or leaking	Inspect the hoses. Refer to "Section 4" on page-60.
OK Go To Next Step	
STEP 8 Coolant mixture of antifreeze and water is not correct	Verify the concentration of antifreeze in the coolant. Add antifreeze or water to correct the concentration. Refer to "Section 5" on page-60 and "Maintenance Specifications" on page-245.
OK Go To Next Step	
STEP 9 Lubricating oil level is above or below specification	Check the oil level. Add or drain oil, if necessary. Refer to "Section 3" on page-60. Use the oil recommended in "Maintenance Specifications" on page-245.

Cause	Correction
OK Go To Next Step	
<u>STEP 10</u> Coolant temperature gauge is malfunctioning	Test the temperature gauge. Repair or replace the gauge, if necessary.
OK Go To Next Step	
<u>STEP 11</u> Fan drive belt is loose, tight, or not in alignment	Check the fan drive belt. Refer to "Section 4" on page-60 4.
OK Go To Next Step	
<u>STEP 12</u> Vehicle cooling system is not adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM specifications.
OK Go To Next Step	
<u>STEP 13</u> Contact a Cummins Authorized Repair Facility	

Coolant Temperature Above Normal - Sudden Overheat

Cause	Correction
<u>STEP 1</u> Coolant level is below specification OK Go To Next Step	Inspect the engine and cooling system for external coolant leaks. Repair if necessary. Add coolant. Refer to "Section 3" on page-60.
<u>STEP 2</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Air in the cooling system OK Go To Next Step	Inspect and vent the cooling system. Refer to "Section 7" on page-60.
<u>STEP 4</u> Fan drive belt is broken OK Go To Next Step	Check the fan drive belt. Replace the belt, if necessary. Refer to Section A.
<u>STEP 5</u> Radiator cap is not correct, is malfunctioning, or has low-pressure rating OK Go To Next Step	Check the radiator pressure cap. Refer to the OEM service manual
<u>STEP 6</u> Cooling system hose is collapsed, restricted, or leaking OK Go To Next Step	Inspect the hoses. Refer to "Section 4" on page-60.
<u>STEP 7</u> Coolant temperature gauge is malfunctioning OK Go To Next Step	Test the temperature gauge. Repair or replace the gauge, if necessary.
<u>STEP 8</u> Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris OK Go To Next Step	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to "Section 4" on page-60 and the OEM service manual.
<u>STEP 9</u> Cold weather radiator cover or winterfront is closed OK Go To Next Step	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm² (60 in²) of opening at all times. Refer to "Operating Instructions" on page-48.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Coolant Temperature Below Normal

Cause	Correction
<u>STEP 1</u> Coolant temperature gauge or sensor is malfunctioning OK Go To Next Step	Test the gauge and the sensor. Repair or replace, if necessary. Refer to OEM service manual.
<u>STEP 2</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Engine is operating at low ambient temperature OK Go To Next Step	Check the winterfront, shutters, and under the hood air. Use under-the-hood intake air in cold weather. Refer to Cold Weather Operation and "Operating Instructions" on page-48 .
<u>STEP 4</u> Fan drive or fan controls are malfunctioning OK Go To Next Step	Check the fan drive and controls. Refer to the OEM service manual.
<u>STEP 5</u> Coolant temperature gauge malfunctioning OK Go To Next Step	Test the temperature gauge. Repair or replace the gauge, if necessary.
<u>STEP 6</u> Thermostat is not correct or is malfunctioning OK Go To Next Step	<i>Check the thermostat for the correct part number and for correct operation. Contact a Cummins Authorized Repair Facility.</i>
<u>STEP 7</u> Contact a Cummins Authorized Repair Facility	

Engine Acceleration or Response Poor

Cause	Correction
STEP 1 Operator technique is not correct OK Go To Next Step	Refer to "Operating Instructions" on page-48 .
STEP 2 Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
STEP 3 Vehicle parasitics are excessive OK Go To Next Step	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.
STEP 4 Clutch is malfunctioning or is not correct OK Go To Next Step	Compare the drivetrain specifications to Cummins recommendations. Check the clutch for correct operation. Refer to the OEM service manual.
STEP 5 Drivetrain is not correctly matched to the engine OK Go To Next Step	Check for correct gearing and drivetrain components. Refer to the OEM vehicle specifications.
STEP 6 Electronic fault codes are active. OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
STEP 7 Fuel leak OK Go To Next Step	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
STEP 8 Intake manifold air temperature is above specification OK Go To Next Step	Refer to Intake Manifold Air Temperature Above Specification symptom tree.
STEP 9 Charge air cooler is restricted or leaking OK Go To Next Step	Inspect the charge air cooler for air restrictions or leaks. Refer to "Section 4" on page-60.
STEP 10 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.

Cause	Correction
OK Go To Next Step	
<u>STEP 11</u> Air intake or exhaust leaks	<i>Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to "Section 4" on page-60.</i>
OK Go To Next Step	
<u>STEP 12</u> Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to "Section 4" on page-60.
OK Go To Next Step	
<u>STEP 13</u> Fuel grade is not correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
OK Go To Next Step	
<u>STEP 14</u> Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
OK Go To Next Step	
<u>STEP 15</u> Fuel supply is not adequate	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
OK Go To Next Step	
<u>STEP 16</u> Contact a Cummins Authorized Repair Facility	

Engine Difficult to Start or Will Not Start (Exhaust Smoke)

Cause	Correction
<u>STEP 1</u> Starting procedure is not correct OK Go To Next Step	Verify the correct starting procedure. Refer to "Operating Instructions" on page-48.
<u>STEP 2</u> Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
<u>STEP 3</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 4</u> Starting aid, if necessary for cold weather, is malfunctioning OK Go To Next Step	Check for correct operation of the cold weather starting aid. Refer to Cold Weather Starting Aids in "Operating Instructions" on page-48. Refer to the manufacturer's instructions.
<u>STEP 5</u> Engine block heater is malfunctioning (if equipped) OK Go To Next Step	Check the electrical sources and wiring to the cylinder block heater. Replace the block heater, if necessary. Refer to the OEM service manual.
<u>STEP 6</u> Fuel heater is malfunctioning (if equipped) OK Go To Next Step	Check the fuel heater and replace, if necessary. Refer to the manufacturer's instructions.
<u>STEP 7</u> Battery voltage is low OK Go To Next Step	Check the batteries and the unswitched battery supply circuit. Refer to the OEM service manual.
<u>STEP 8</u> Keyswitch circuit is malfunctioning OK Go To Next Step	Check the vehicle keyswitch circuit. Refer to the OEM service manual.
<u>STEP 9</u> Engine cranking speed is too slow OK Go To Next Step	If the cranking speed is slower than 150 rpm, refer to the Engine Will Not Crank or Cranks Slowly symptom tree.
<u>STEP 10</u> Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

Cause	Correction
OK Go To Next Step	
STEP 11 Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
STEP 12 Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
OK Go To Next Step	
STEP 13 Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to "Section 4" on page-60.
OK Go To Next Step	
STEP 14 Fuel grade is not correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
OK Go To Next Step	
STEP 15 Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
OK Go To Next Step	
STEP 16 Fuel supply is not adequate	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
OK Go To Next Step	
STEP 16 Contact a Cummins Authorized Repair Facility	

Engine Difficult to Start or Will Not Start (No Exhaust Smoke)

Cause	Correction
<u>STEP 1</u> Starting procedure is not correct OK Go To Next Step	Verify the correct starting procedure. Refer to "Operating Instructions" on page-48.
<u>STEP 2</u> Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
<u>STEP 3</u> Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high- quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
<u>STEP 4</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 5</u> OEM engine protection system is malfunctioning OK Go To Next Step	Isolate the OEM engine protection system. Follow the OEM service manuals to check for a malfunction.
<u>STEP 6</u> Battery voltage is low OK Go To Next Step	Check the batteries and the unswitched battery supply circuit. Refer to the OEM service manual.
<u>STEP 7</u> Keyswitch circuit is malfunctioning OK Go To Next Step	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to an Authorized Cummins Repair Facility.
<u>STEP 8</u> Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open OK Go To Next Step	Check the battery connections. Refer to the OEM service manual.
<u>STEP 9</u> Moisture in the wiring harness connectors OK Go To Next Step	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
<u>STEP 10</u> Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.

Cause	Correction
OK Go To Next Step	
<u>STEP 11</u> Electronic control module (ECM) is locked up	Disconnect the battery cables for 30 seconds. Connect the battery cables, and start the engine.
OK Go To Next Step	
<u>STEP 12</u> Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
OK Go To Next Step	
<u>STEP 13</u> Fuel supply is not adequate	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
OK Go To Next Step	
<u>STEP 14</u> Fuel drain backup	Verify the fuel return line is plumbed to the bottom of the fuel tank.
OK Go To Next Step	
<u>STEP 15</u> Contact a Cummins Authorized Repair Facility	

Engine Noise Excessive

Cause	Correction
<u>STEP 1</u> Fan drive belt is loose, tight, or not in alignment OK Go To Next Step	Check the fan drive belt. Refer to "Section 3" on page-60.
<u>STEP 2</u> Lubricating oil is thin or diluted OK Go To Next Step	Refer to the Lubricating Oil Specifications in "Maintenance Specifications" on page-245.
<u>STEP 3</u> Vibration damper is damaged OK Go To Next Step	Inspect the vibration damper. Refer to "Section 7" on page-60.
<u>STEP 4</u> Air intake or exhaust leaks OK Go To Next Step	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to "Section 3" on page-60.
<u>STEP 5</u> Air intake system restriction is above specification OK Go To Next Step	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to "Section 4" on page-60.
<u>STEP 6</u> Coolant temperature is above specification OK Go To Next Step	Refer to the Coolant Temperature is Above Normal -Sudden Overheater the Coolant Temperature is Above Normal - Gradual Overheat symptom tree.
<u>STEP 7</u> Engine mounts are worn, damaged, or not correct OK Go To Next Step	Check the engine mounts. Refer to the OEM service manual.
<u>STEP 8</u> Fan clutch, hydraulic pump, or refrigerant compressor noise is excessive OK Go To Next Step	Isolate each component and check for noise. Refer to the OEM service manual.
<u>STEP 9</u> Fan is loose, damaged, or has excessive hub bearing end play OK Go To Next Step	Check the fan. Refer to "Section 3" on page-60.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Engine Noise Excessive - Combustion Knocks

Cause	Correction
<u>STEP 1</u> Engine is operating at low ambient temperature OK Go To Next Step	Check the winterfront, shutters, and under-the-hood air. Use under-the-hood intake air in cold weather. Refer to Cold temperature Weather Operation, see Bulletin 3387266, and "Operating Instructions" on page-48.
<u>STEP 2</u> Ether starting aid is malfunctioning OK Go To Next Step	Repair or replace the ether starting aids Refer to the manufacturer's instructions.
<u>STEP 3</u> Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high- quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245
<u>STEP 4</u> Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
<u>STEP 5</u> Coolant temperature is below specification OK Go To Next Step	Refer to the Coolant Temperature Below Normal symptom tree.
<u>STEP 6</u> Contact a Cummins Authorized Repair Facility	

Engine Power Output Low

Cause	Correction
<u>STEP 1</u> Electronic fault codes are active.	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility
OK Go To Next Step	
<u>STEP 2</u> Fuel grade is not correct for the application or the fuel quality is poor	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
OK Go To Next Step	
<u>STEP 3</u> Engine is operating above recommended altitude	Engine power decreases above recommended altitude. Refer to the OEM's altitude operation guidelines.
OK Go To Next Step	
<u>STEP 4</u> Tachometer is not calibrated or is malfunctioning	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 5</u> Intake and exhaust system restricted	Check the intake and exhaust systems for restrictions. Inspect the intake air filter and replace as necessary.
OK Go To Next Step	
<u>STEP 6</u> Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to "Section 4" on page-60.
OK Go To Next Step	
<u>STEP 7</u> Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to "Section 4" on page-60.
OK Go To Next Step	
<u>STEP 8</u> Air leak between the turbocharger and the intake manifold	Check for leaks in the air crossover tube, charge air cooler connections, hoses, or through holes in the manifold cover and repair or replace if necessary. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 9</u> Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to "Section 4" on page-60.

Cause	Correction
OK Go To Next Step	
<u>STEP 10</u> Fuel leak	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 11</u> Air in the fuel system	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
OK Go To Next Step	
<u>STEP 12</u> Fuel supply is not adequate	Check the flow through the filter to locate the source of the restriction. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 13</u> Fuel return restriction excessive	Inspect the fuel return lines for restrictions. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 14</u> Fuel filter or fuel suction line is restricted	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
OK Go To Next Step	
<u>STEP 15</u> Vehicle parasitics are excessive	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 16</u> Lubricating oil level above specification	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to "Maintenance Specifications" on page-245.
OK Go To Next Step	
<u>STEP 17</u> Contact a Cummins Authorized Repair Facility	

Engine Runs Rough at Idle

Cause	Correction
<u>STEP 1</u> Engine is cold OK Go To Next Step	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree.
<u>STEP 2</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Idle speed is set too low for accessories OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
<u>STEP 4</u> Fuel filter or fuel suction line is restricted OK Go To Next Step	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
<u>STEP 5</u> Fuel supply is not adequate OK Go To Next Step	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
<u>STEP 6</u> Engine mounts are worn, damaged, or not correct OK Go To Next Step	Check the engine mounts. Refer to the OEM service manual.
<u>STEP 7</u> Moisture in the wiring harness connectors OK Go To Next Step	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
<u>STEP 8</u> Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
<u>STEP9</u> Contact a Cummins Authorized Repair Facility	

Engine Runs Rough or Misfires

Cause	Correction
<u>STEP 1</u> Engine is cold OK Go To Next Step	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree.
<u>STEP 2</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary. Vent air from the system. Refer to "Section 5" on page-60.
<u>STEP 4</u> Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
<u>STEP 5</u> Fuel leak OK Go To Next Step	Check the fuel lines, fuel connections, and fuel filters for leaks. Refer to the OEM service manual.
<u>STEP 6</u> Fuel filter is plugged OK Go To Next Step	Measure the fuel pressure before and after the fuel filter. Refer to "Section 5" on page-60.
<u>STEP 7</u> Fuel supply is not adequate OK Go To Next Step	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
<u>STEP 8</u> Fuel lift pump is malfunctioning OK Go To Next Step	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to an Authorized Cummins Repair Facility.
<u>STEP 9</u> Engine mounts are worn, damaged, or not correct OK Go To Next Step	Check the engine mounts. Refer to the OEM service manual.

Cause

Correction

STEP 10

Moisture in the wiring harness connectors

Dry the connectors with Cummins electronic cleaner, Part Number 3824510.

OK

Go To Next Step

STEP 11

Contact a Cummins Authorized Repair Facility

Engine Shuts Off Unexpectedly or Dies During Deceleration

Cause	Correction
STEP 1 Engine will not restart OK Go To Next Step	Refer to the Engine Difficult to Start or Will Not Start symptom tree.
STEP 2 Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
STEP 3 Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
STEP 4 Idle shutdown or PTO shutdown features are activated OK Go To Next Step	Check the time limit on idle and PTO shutdowns with an electronic service tool. Refer to Electronic Controlled Fuel System in "Operating Instructions" on page-48.
STEP 5 Moisture in the wiring harness connectors OK Go To Next Step	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
STEP 6 OEM engine protection system is malfunctioning OK Go To Next Step	Isolate the OEM engine protection system. Follow the OEM service manuals to check for a malfunction.
STEP 7 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open OK Go To Next Step	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to the OEM service manual.
STEP 8 Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary. Refer to "Section 5" on page-60.
STEP 9 Contact a Cummins Authorized Repair Facility	

Engine Speed Surges at Low or High Idle

Cause	Correction
<u>STEP 1</u> Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
<u>STEP 2</u> Engine idle speed is set too low OK Go To Next Step	Adjust the idle speed. Refer to an Authorized Cummins Repair Facility.
<u>STEP 3</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Moisture in the wiring harness connectors OK Go To Next Step	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
<u>STEP 4</u> Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary. Vent air from the system. Refer to "Section 5" on page-60.
<u>STEP 5</u> Fuel filter is plugged OK Go To Next Step	Measure the fuel pressure before and after the fuel filter. Refer to "Section 5" on page-60.
<u>STEP 6</u> Fuel supply is not adequate OK Go To Next Step	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
<u>STEP 7</u> Fuel lift pump is malfunctioning OK Go To Next Step	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to an Authorized Cummins Repair Facility.
<u>STEP 8</u> Fuel grade is not correct for the OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
<u>STEP 9</u> Contact a Cummins Authorized Repair Facility	

Engine Speed Surges Under Load or in Operating Range

Cause	Correction
STEP 1 Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
STEP 2 Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
STEP 3 Moisture in the wiring harness connectors OK Go To Next Step	Dry the connectors with Cummins electronic cleaner, Part Number 3824510.
STEP 4 Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary. Vent air from the system. Refer to "Section 5" on page-60.
STEP 5 Fuel filter is plugged OK Go To Next Step	Measure the fuel pressure before and after the fuel filter. Refer to "Section 5" on page-60.
STEP 6 Fuel supply is not adequate OK Go To Next Step	Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.
STEP 7 Idling with excessive load OK Go To Next Step	Use the PTO feature for loaded conditions at low engine speeds. Refer to "Operating Instructions" on page-48.
STEP 8 Vehicle parasitics are excessive OK Go To Next Step	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.
STEP 9 Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.

Cause

Correction

STEP 10

Clutch is malfunctioning or is not correct

Compare the drivetrain specifications to Cummins recommendations. Check the clutch for correct operation. Refer to the OEM service manual.

OK

Go To Next Step

STEP 11

Contact a Cummins Authorized Repair Facility

T Engine Speed Surges in PTO or Cruise Control

Cause

Correction

STEP 1

Engine speed also surges at idle

Refer to Engine Speed Surges at Low or High Idle symptom tree.

OK

Go To Next Step

STEP 2

Engine speed surges while in the normal operating range and not in PTO or cruise control

Refer to Engine Speed Surges Under Load or in Operating Range symptom tree.

OK

Go To Next Step

STEP 3

Electronic fault codes are active

For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.

OK

Go To Next Step

STEP 4

Moisture in the wiring harness connectors

Dry the connectors with Cummins electronic cleaner, Part Number 3824510.

OK

Go To Next Step

STEP 5

Fuel filter is plugged

Measure the fuel pressure before and after the fuel filter. Refer to "Section 5" on page-60.

OK

Go To Next Step

STEP 6

Fuel supply is not adequate

Check the flow through the filter to locate the source of the restriction. Refer to "Section 5" on page-60.

OK

Go To Next Step

STEP 7

Contact a Cummins Authorized Repair Facility

Engine Starts But Will Not Keep Running

Cause	Correction
STEP 1 Fuel level is low in the tank OK Go To Next Step	Fill the supply tank. Refer to the OEM service manual.
STEP 2 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open OK Go To Next Step	Check the battery connections. Refer to the OEM service manual.
STEP 3 Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
STEP 4 Idle speed is set too low for accessories OK Go To Next Step	Check and adjust the low-idle screw. Refer to a Cummins Authorized Repair Facility.
STEP 5 Engine-driven units are engaged OK Go To Next Step	Disengage engine-driven units. Refer to the OEM service manual.
STEP 6 Air in the fuel system OK Go To Next Step	Check for air in the fuel system. Tighten or replace the fuel connections, fuel lines, fuel tank standpipe, and fuel filters as necessary.
STEP 7 Fuel filter or fuel suction line is restricted OK Go To Next Step	Replace the fuel filter. Refer to "Section 5" on page-60. Check the fuel suction line for restriction "Section 5" on page-60.
STEP 8 Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications in "Maintenance Specifications" on page-245.
STEP 9 Contact a Cummins Authorized Repair Facility	

Engine Vibration Excessive

Cause	Correction
<u>STEP 1</u> Belt-driven accessories are malfunctioning OK Go To Next Step	Check the fan hub, alternator, refrigerant compressor, and hydraulic pump for interference. Isolate belt-driven accessories and check for vibration. Refer to "Section 3" on page-60 and "Section 4" on page-60.
<u>STEP 2</u> Air compressor pumping time is excessive OK Go To Next Step	Refer to the Air Compressor Cycles Frequently symptom tree.
<u>STEP 3</u> Engine idle speed is set too low (electronically controlled fuel systems) OK Go To Next Step	Verify the correct idle speed setting. Increase the idle speed with the idle increment switch or an electronic service tool. Refer to "Operating Instructions" on page-48.
<u>STEP 4</u> Engine mounts are worn, damaged, or not correct OK Go To Next Step	Check the engine mounts. Refer to the OEM service manual.
<u>STEP 5</u> Fan is loose, damaged, or has excessive hub bearing end play OK Go To Next Step	Check the fan. Refer to "Section 3" on page-60.
<u>STEP 6</u> Engine is misfiring OK Go To Next Step	Refer to the Engine Runs Rough or Misfires symptom tree.
<u>STEP 7</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 8</u> Vibration damper is damaged OK Go To Next Step	Inspect the vibration damper. Refer to "Section 7" on page-60.
<u>STEP 9</u> Alternator bearing worn or damaged OK Go To Next Step	Clean and replace the alternator. Refer to the OEM service manual.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Engine Will Not Crank or Cranks Slowly (Air Starter)

Cause	Correction
STEP 1 Air pressure is low in the air tanks OK Go To Next Step	Increase air pressure with an external air source. Refer to the OEM service manual.
STEP 2 Engine-driven units are engaged OK Go To Next Step	Disengage engine-driven units. Refer to the OEM service manual.
STEP 3 Lubricating oil level above specification OK Go To Next Step	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to "Maintenance Specifications" on page-245.
STEP 4 Lubricating oil does not meet specifications for operating conditions OK Go To Next Step	Change the oil and filters. Refer to "Section 5" on page-60. Use the oil recommended in "Maintenance Specifications" on page-245.
STEP 5 Electrical system is "open" (blown fuses, broken wires, or loose connections) OK Go To Next Step	Check the fuses, wires, and connections. Refer to the OEM service manual and manufacturer's wiring diagram.
STEP 6 Battery charge is low OK Go To Next Step	Check battery. If the battery is low, check the alternator for proper charging. Charge the battery, and replace if necessary. Refer to the OEM service manual.
STEP 7 Keyswitch circuit is malfunctioning OK Go To Next Step	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to the OEM service manual.
STEP 8 Starter solenoid is not receiving voltage OK Go To Next Step	Check the battery supply to the starter solenoid. Refer to the OEM service manual.
STEP 9 Starting motor is malfunctioning or starting motor is not correct OK Go To Next Step	Check the starting motor operation. Compare the starting motor with the engine and vehicle specifications. Refer to the manufacturer's instructions.
STEP 10 Contact a Cummins Authorized Repair Facility	

Engine Will Not Crank or Cranks Slowly (Electric Starter)

Cause	Correction
<u>STEP 1</u> Battery are cold OK Go To Next Step	Check the battery heater. Refer to the manufacturer's instructions.
<u>STEP 2</u> Battery cables or connections are loose, broken, or corroded (excessive resistance) OK Go To Next Step	Check the battery cables and connections.
<u>STEP 3</u> Electrical system is "open" (blown fuses, broken wires, or loose connections) OK Go To Next Step	Check the fuses, wires, and connections. Refer to the OEM service manual and manufacturer's wiring diagram.
<u>STEP 4</u> Battery charge is low OK Go To Next Step	Check battery. If the battery is low, check the alternator for proper charging. Charge the battery, and replace if necessary. Refer to the OEM service manual.
<u>STEP 5</u> Keyswitch circuit is malfunctioning OK Go To Next Step	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to the OEM service manual.
<u>STEP 6</u> Starter solenoid is not receiving voltage OK Go To Next Step	Check the battery supply to the starter solenoid. Refer to the OEM servicemanual.
<u>STEP 7</u> Engine-driven units are engaged OK Go To Next Step	Disengage engine-driven units. Refer to the OEM service manual.
<u>STEP 8</u> Lubricating oil level above specification OK Go To Next Step	Check the oil level. Verify the oil pan capacity. Fill the system to the specified level. Refer to "Maintenance Specifications" on page-245.
<u>STEP 9</u> Lubricating oil does not meet specifications for operating conditions OK Go To Next Step	Change the oil and filters. Refer to "Section 5" on page-60. Use the oil recommended in "Maintenance Specifications" on page-245.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Engine Will Not Reach Rated Speed (RPM)

Cause	Correction
<u>STEP 1</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 2</u> Vehicle speed is too low for adequate cooling with high engine load OK Go To Next Step	Reduce the engine load. Increase the engine (fan) rpm by downshifting.
<u>STEP 3</u> Tachometer is not calibrated or is malfunctioning OK Go To Next Step	Compare the tachometer reading with a handheld tachometer or an electronic service tool reading. Calibrate or replace the tachometer as necessary. Refer to the OEM service manual.
<u>STEP 4</u> Air-fuel tube leaking, wastegate diaphragm ruptured, or wastegate plumbing damaged OK Go To Next Step	Tighten the fittings, repair plumbing, replace wastegate diaphragm. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
<u>STEP 5</u> Charge air cooler restricted (if equipped) OK Go To Next Step	Inspect the air cooler for internal and external restrictions. Replace the restricted cooler if necessary. Refer to the OEM service manual.
<u>STEP 6</u> Fuel supply is not adequate OK Go To Next Step	Check the flow through the filter to locate the source of the restriction. Refer to the OEM service manual.
<u>STEP 7</u> Exhaust back pressure too high OK Go To Next Step	Measure and correct if above specification. Refer to an Authorized Cummins Repair Facility.
<u>STEP 8</u> Fuel lift pump is malfunctioning OK Go To Next Step	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to an Authorized
<u>STEP 9</u> Vehicle parasitics are excessive OK Go To Next Step	Check the vehicle brakes for dragging, transmission malfunction, cooling fan operation cycle time, and engine-driven units. Refer to the OEM service manual.

Cause

Correction

STEP 10

Engine power output is low

OK

Go To Next Step

Refer to the Engine Power Output Low symptom tree.

STEP 11

Contact a Cummins Authorized Repair Facility

Fault Code Warning Lights Stay On (No Apparent Reason)

Cause	Correction
STEP 1 Diagnostic shorting plug is installed	Remove the diagnostic shorting plug.
OK Go To Next Step	
STEP 2 Diagnostic switch is in the ON position	Turn off the diagnostic switch.
OK Go To Next Step	
STEP 3 Electronic fault codes are active	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
STEP 4 Contact a Cummins Authorized Repair Facility	

Fault Code Warning Lights Do Not Illuminate

Cause	Correction
STEP 1 Key switch is in the OFF position	Turn the starter switch to the ON position.
OK Go To Next Step	
STEP 2 Battery voltage supply to the electronic control module (ECM) is low, interrupted, or open	Check the battery connections, the fuses, and the unswitched battery supply circuit. Refer to Procedure 013-009.
OK Go To Next Step	
STEP 3 Idle shutdown or PTO shutdown features are activated	Check the time limit on idle and PTO shutdowns with an electronic service tool. Refer to the appropriate electronic service tool.
OK Go To Next Step	
STEP 4 Contact a Cummins Authorized Repair Facility	

Fuel Consumption Excessive

Cause	Correction
<u>STEP 1</u> Operator technique is not correct OK Go To Next Step	Explain correct engine operation to the operator. Refer to Operating Instructions, Procedure 101-999.
<u>STEP 2</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes, Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 3</u> Fuel leak OK Go To Next Step	Check the fuel lines, fuel connections, and fuel filters for leaks. Check the fuel lines to the supply tanks. Refer to the OEM service manual.
<u>STEP 4</u> Hubometer or odometer is miscalibrated OK Go To Next Step	Check the hubometer and odometer calibrations. Calibrate or replace the hubometer or odometer, if necessary. Calculate fuel consumption with new mileage figures.
<u>STEP 5</u> Hour meter is miscalibrated OK Go To Next Step	Check the hour meter. Calibrate or replace the hour meter if necessary. Calculate fuel consumption with new figures.
<u>STEP 6</u> Air intake or exhaust leaks OK Go To Next Step	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-033.
<u>STEP 7</u> Air intake system restriction is above specification OK Go To Next Step	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-058.
<u>STEP 8</u> Equipment and environmental factors are affecting fuel consumption OK Go To Next Step	Consider ambient temperatures, wind, tire size, axle alignment, routes, and use of aerodynamic aids when evaluating fuel consumption.
<u>STEP 9</u> Lubricating oil level is above specification OK Go To Next Step	Check the oil level. Verify the dipstick calibration and oil pan capacity. Fill the system to the specified level. Refer to Procedure 007-043.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Fuel in Coolant

Cause

STEP 1

Bulk coolant supply is contaminated

OK

Go To Next Step

STEP 2

Contact a Cummins Authorized Repair Facility

Correction

Check the bulk coolant supply. Drain the coolant and replace with noncontaminated coolant. Replace the coolant filters. Replace the coolant filter. Refer to Procedure 008-006.

Fuel in the Lubricating Oil

Cause

STEP 1

Engine idle time is excessive

OK

Go To Next Step

STEP 2

Bulk coolant supply is contaminated

OK

Go To Next Step

STEP 3

Contact a Cummins Authorized Repair Facility

Correction

Low oil and coolant temperatures can be caused by long idle time (greater than 10 minutes). Shut off the engine rather than idle for long periods. If idle time is necessary, raise the idle speed.

Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filters.

Intake Manifold Air Temperature Above Specification

Cause	Correction
STEP 1 Charge air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 and the OEM service manual.
OK Go To Next Step	
STEP 2 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm² (60 in²) of opening at all times. Refer to Procedure 101- 004.
OK Go To Next Step	
STEP 3 Fan drive belt or water pump belt is broken	Check the fan drive belt and water pump belt. Replace the belts if necessary. Refer to Section A.
OK Go To Next Step	
STEP 4 Fan shroud is damaged or missing or the air recirculation baffles are damaged or missing	Inspect the shroud and the recirculation baffles. Repair, replace, or install, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 5 Radiator shutters are not opening completely or the shutterstat setting is wrong	Inspect the radiator shutters. Repair or replace if necessary. Refer to the manufacturer's instructions. Check the shutterstat setting. Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Vehicle speed is too low for adequate cooling with high engine load	Reduce the engine load. Increase the engine (fan) rpm by downshifting.
OK Go To Next Step	
STEP 7 Vehicle cooling system is not adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM service manual.
OK Go To Next Step	
STEP 8 Intake manifold temperature gauge is malfunctioning, if equipped	Test the temperature gauge. Refer to the OEM service manual.
OK Go To Next Step	
STEP 9 Fan is not an adequate size for the application	Verify that the fan is the correct size. Refer to the OEM service manual.
OK Go To Next Step	
STEP 10 Contact a Cummins Authorized Repair Facility	

Intake Manifold Pressure (Boost) is Below Normal

Cause	Correction
<u>STEP 1</u> Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-033.
OK Go To Next Step	
<u>STEP 2</u> Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-058.
OK Go To Next Step	
<u>STEP 3</u> Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027.
OK Go To Next Step	
<u>STEP 4</u> Electronic fault codes are active	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes, Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
<u>STEP 5</u> Engine power output is low	Refer to Engine Power Output is Low symptom tree.
OK Go To Next Step	
<u>STEP 6</u> Contact a Cummins Authorized Repair Facility	

Lubricating Oil Consumption Excessive

Cause	Correction
STEP 1 Crankcase ventilation system is plugged OK Go To Next Step	Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018.
STEP 2 Lubricating oil does not meet specifications for operating conditions OK Go To Next Step	Change the oil and filters. Refer to Procedure 007- 002. Use the oil recommended in "Maintenance Specifications" on page-245.
STEP 3 Lubricating oil drain interval is excessive OK Go To Next Step	Verify the correct lubricating oil drain interval. Refer to Procedure 102-002.
STEP 4 Lubricating oil leak (external) OK Go To Next Step	Inspect the engine for external oil leaks. Tighten the cap screws, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to Lubricating Oil Recommendations and Specifications.
STEP 5 Verify the oil consumption rate OK Go To Next Step	Check the amount of oil added versus the mileage.
STEP 6 Air compressor is pumping lubricating oil into the air system OK Go To Next Step	Check the air lines for carbon buildup and lubricating oil. Refer to Procedure 012-014.
STEP 7 Contact a Cummins Authorized Repair Facility	

Lubricating Oil Contaminated

Cause	Correction
<u>STEP 1</u> Lubricating oil sludge is excessive OK Go To Next Step	Change the oil and filters. Refer to the Lubricating Oil Sludge in the Crankcase Excessive symptom tree.
<u>STEP 2</u> Lubricating oil is contaminated with coolant or fuel OK Go To Next Step	Change the oil and filters. Refer to "Section 5" on page-60. Use the oil recommended in "Maintenance Specifications" on page-245.
<u>STEP 3</u> Fuel lift pump is malfunctioning OK Go To Next Step	Check the fuel lift pump for correct operation. Check the pump output pressure. Replace the fuel lift pump if necessary. Refer to an Authorized Cummins Repair Facility.
<u>STEP 4</u> Bulk oil supply is contaminated OK Go To Next Step	Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filters.
<u>STEP 5</u> Contact a Cummins Authorized Repair Facility	

Lubricating Oil Loss

Cause	Correction
<u>STEP 1</u> Lubricating oil leak (external)	Inspect the engine for external oil leaks. Tighten the capscrews, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 2</u> Lubricating oil level is below specification	Check the oil level. Verify the dipstick calibration and the oil pan capacity. Fill the system to the specified level. Refer to "Maintenance Specifications" on page-245.
OK Go To Next Step	
<u>STEP 3</u> Lubricating oil does not meet specifications for operating conditions	Change the oil and filters. Refer to "Section 5" on page-60. Use the oil recommended in "Maintenance Specifications" on page-245.
OK Go To Next Step	
<u>STEP 4</u> Lubricating oil pressure switch, gauge, or sensor is malfunctioning or is not in the correct location	Check the oil pressure switch, gauge, or sensor for correct operation and location. Refer to an Authorized Cummins Repair Facility.
OK Go To Next Step	
<u>STEP 5</u> Electronic fault codes are active	For instructions on how to read active fault codes, refer to "Operating Instructions" on page-48. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
<u>STEP 6</u> Lubricating oil cooler is leaking	Check the lubricating oil cooler for coolant leaks and cracks. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	
<u>STEP 7</u> Air compressor is pumping lubricating oil into the air system	Check the air lines for carbon buildup and lubricating oil. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	
<u>STEP 8</u> Blowby excessive	Check for excessive blowby. Refer to the OEM service manual or an Authorized Cummins Repair Facility.
OK Go To Next Step	
<u>STEP 9</u> Turbocharger oil seal is leaking	Check the turbocharger for oil seals and for leaks. Refer to the Turbocharger Leaks Engine Oil or Fuel symptom tree.
OK Go To Next Step	
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Lubricating Oil Pressure High

Cause	Correction
<u>STEP 1</u> Coolant temperature is above specification OK Go To Next Step	Refer to the Coolant Temperature Below Normal symptom tree.
<u>STEP 2</u> Lubricating oil does not meet specifications for operating conditions OK Go To Next Step	Change the oil and filters. Refer to Procedure 007- 002. Use the oil recommended in "Maintenance Specifications" on page-245.
<u>STEP 3</u> Lubricating oil pressure switch, gauge, or sensor is malfunctioning or is not in the correct location OK Go To Next Step	Check the oil pressure switch, gauge, or sensor for correct operation and location. Refer to the OEM service manual.
<u>STEP 4</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes, Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 5</u> Contact a Cummins Authorized Repair Facility	

Lubricating Oil Pressure Low

Cause	Correction
<u>STEP 1</u> Engine angularity during operation exceeds specification OK Go To Next Step	Refer to the engine data sheet.
<u>STEP 2</u> Lubricating oil does not meet specifications for operating conditions OK Go To Next Step	Change the oil and filters. Refer to Procedure 007- 002. Use the oil recommended in "Maintenance Specifications" on page-245.
<u>STEP 3</u> Lubricating oil is diluted with water OK Go To Next Step	Check for a missing dipstick, rain caps, or oil fill caps. Change the oil. Refer to the OEM service manual.
<u>STEP 4</u> Lubricating oil filter is plugged OK Go To Next Step	Change the oil and filter. Refer to Section Procedure 007-002. Use the oil recommended in "Maintenance Specifications" on page-245.
<u>STEP 5</u> Lubricating oil is contaminated with coolant or fuel OK Go To Next Step	Refer to the Lubricating Oil Contaminated symptom tree.
<u>STEP 6</u> Lubricating oil leak (external) OK Go To Next Step	Inspect the engine for external oil leaks. Tighten the cap screws, pipe plugs, and fittings. Replace gaskets, if necessary. Refer to Procedure 018-003.
<u>STEP 7</u> Lubricating oil level is above or below specification OK Go To Next Step	Check the oil level. Add or drain oil, if necessary. Refer to Procedure 007-002.
<u>STEP 8</u> Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes, Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
<u>STEP 9</u> Lubricating oil pressure switch, gauge, or sensor is malfunctioning or is not in the correct location OK Go To Next Step	Check the oil pressure switch, gauge, or sensor for correct operation and location. Refer to the OEM service manual.
<u>STEP 10</u> Contact a Cummins Authorized Repair Facility	

Lubricating Oil Sludge in the Crankcase Excessive

Cause		Correction
<u>STEP 1</u> Bulk oil supply is contaminated		Check the bulk oil supply. Drain the oil and replace with noncontaminated oil. Replace the oil filters.
OK Go To Next Step		
<u>STEP 2</u> Coolant temperature is below specification		Refer to the Coolant Temperature Below Normal symptom tree.
OK Go To Next Step		
<u>STEP 3</u> Crankcase ventilation system is plugged		Check and clean the crankcase breather and vent tube. Refer to Procedure 003-018.
OK Go To Next Step		
<u>STEP 4</u> Fuel grade is not correct for the application or the fuel quality is poor		Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications Procedure 018-002.
OK Go To Next Step		
<u>STEP 5</u> Lubricating oil does not meet specifications for operating conditions		Change the oil and filters. Refer to Procedure 018- 003. Use the oil recommended in "Maintenance Specifications" on page-245.
OK Go To Next Step		
<u>STEP 6</u> Contact a Cummins Authorized Repair Facility		Change the oil and filters. Refer to Procedure 018- 003. Use the oil recommended in "Maintenance Specifications" on page-245.

Smoke, Black - Excessive

Cause	Correction
<u>STEP 1</u> Electronic fault codes are active	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
OK Go To Next Step	
<u>STEP 2</u> Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-033.
OK Go To Next Step	
<u>STEP 3</u> Air intake or exhaust leaks	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to the OEM service manual.
OK Go To Next Step	
<u>STEP 4</u> Charge air cooler is restricted or leaking	Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027.
OK Go To Next Step	
<u>STEP 5</u> Contact a Cummins Authorized Repair Facility	

Smoke, White - Excessive

Cause	Correction
STEP 1 Starting procedure is not correct OK Go To Next Step	Verify the correct starting procedure. Refer to "Operating Instructions" on page-48.
STEP 2 Engine is cold OK Go To Next Step	Allow the engine to warm to operating temperature. If the engine will not reach operating temperature, refer to the Coolant Temperature Below Normal symptom tree.
STEP 3 Engine is operating at low ambient temperature OK Go To Next Step	Check the winterfront, shutters, and under the hood air. Use under-the-hood intake air in cold weather. Refer to Cold Weather Operation, Bulletin 3387266.
STEP 4 Electronic fault codes are active OK Go To Next Step	For instructions on how to read active fault codes, refer to Diagnostic Fault Codes Procedure 101-007. If fault codes are active, contact a Cummins Authorized Repair Facility.
STEP 5 Starting aid is malfunctioning OK Go To Next Step	Check for correct operation of coldstarting aid. Refer to Cold Weather Starting Aids in "Operating Instructions" on page-48. Refer to the manufacturer's instructions.
STEP 6 Coolant temperature is below specification OK Go To Next Step	Refer to the Coolant Temperature is Below Normal symptom tree.
STEP 7 Fuel grade is not correct for the application or the fuel quality is poor OK Go To Next Step	Operate the engine from a tank of high-quality fuel. Refer to Fuel Recommendations and Specifications Procedure 018-002.
STEP 8 Air intake or exhaust leaks OK Go To Next Step	Check for loose or damaged piping connections and missing pipe plugs. Check the turbocharger and exhaust manifold mounting. Refer to Procedure 010-033.
STEP 9 Air intake system restriction is above specification	Check the air intake system for restriction. Clean or replace the air filter and inlet piping as necessary. Refer to Procedure 010-058.

Cause

Correction

OK
Go To Next Step

STEP 10

Charge air cooler is restricted or leaking

Inspect the charge air cooler for air restrictions or leaks. Refer to Procedure 010-027.

OK
Go To Next Step

STEP 11

Contact a Cummins Authorized Repair Facility

Turbocharger Leaks Engine Oil or Fuel

Cause		Correction
<u>STEP 1</u> Engine is operating for extended periods under light- or no-load conditions (slobbering)		Review the engine operating instructions in "Operating Instructions" on page-48.
OK Go To Next Step		
<u>STEP 2</u> Lubricating oil or fuel is entering the turbocharger		Remove the intake and exhaust piping, and check for oil or fuel.
OK Go To Next Step		
<u>STEP 3</u> Turbocharger oil drain line is restricted		Remove the turbocharger oil drain line and check for restriction. Clean or replace the oil drain line. Refer to an Authorized Cummins Repair Facility.
OK Go To Next Step		
<u>STEP 4</u> Turbocharger oil supply line loose or leaking		Check and tighten oil supply line fitting (s), if necessary. Refer to an Authorized Cummins Repair Facility.
OK Go To Next Step		
<u>STEP 5</u> Contact a Cummins Authorized Repair Facility		

MAINTENANCE SPECIFICATIONS

General Engine

Listed below are the general specifications for this engine.

Item	Specifications
Bore x Stroke	107 mm (4.21 in) x 124 mm (4.88in)
Horsepower	Refer to engine data plate
Displacement	
Four-Cylinder Engine	4.5 liters (274 C.I.D.)
Six-Cylinder Engine	6.7 liters (409 C.I.D.)
Firing Order	
Four-Cylinder Engine	1.3.4.2
Six-Cylinder Engine	1.5.3.6.2.4
Engine Weight (with standard accessories):	
Dry Weight for 4.5 liters (274 C.I.D.)	374 kg (825 lb)
Dry Weight for 6.7 liters (409 C.I.D.)	485 kg (1070 lb)
Crankshaft Rotation (viewed from front of the engine)	Clockwise
Valve Clearance:	
Intake	0.254 mm (0.010 in)
Exhaust	0.508 mm (0.020 in)
NOTE: The engine features a no-adjust overhead. The valve train is designed such that adjustment of the valve lash is not required for normal service during the first 241,402 km (150,000 mi, 5000 hr). The valve train operates acceptably within the limits of 0.152-to 0.381-mm (0.006-to 0.015-in) intake valve lash and 0.381-to 0.762-mm (0.015-to 0.030-in) exhaust valve lash. It is recommended that the valve lash be checked around 241,402 km (150,000 mi, 5000 hr) and every 81,000 km (50,000 mi, 2000 hr) thereafter.	

Fuel System

Preparatory Steps

For performance and fuel rate values, refer to the Engine Data Sheet

Cummins Common Rail Fuel System	Specifications
Maximum Fuel Inlet Restriction -With gear pump only (no engine mounted electric fuel lift pump) (at gear pump inlet)	69 kPa (10 psi)
Rail Pressure - 4.5 liters (274 C.I.D.) and 6.7 liters (409 C.I.D.)	250 to 1600 bar (3,626 to 23,206 psi)
Fuel Pressure Range at Fuel Filter Inlet and Outlet (engine cranking) -With gear pump only (no electric fuel lift pump)	303 to 1103 bar (44 to 160 psi)
Fuel Pressure Range at Fuel Filter Inlet and Outlet (engine running) -With gear pump only (no electric fuel lift pump)	503 to 1303 bar (73 to 189 psi)
Maximum Pressure Drop across Fuel Filter - With gear pump only (no electric fuel lift pump)	200kPa (29 psi)
Maximum Fuel Drain Line Restriction	19kPa (2.7 psi)
Maximum Fuel Inlet Temperature	70°C (158°F)

Lubricating Oil System

All Applications Except Marine	Specifications
Oil Pressure	
Low Idle (minimum allowed)	69 kPa (10 psi)
At Rated (minimum allowed)	207 kPa (30 psi)
Oil-regulating valve-opening pressure range to 517 kPa (75 psi)	448 kPa (65 psi)
Oil filter differential pressure to open bypass	345 kPa (50 psi)
Lubricating Oil Filter Capacity	0.95 liters (1 qt)
Oil Capacity of Standard Engine (four-cylinder) 4.5 liters (275 C.I.D.) Engines (Suspended Oil Pan)	
Pan only	11 liters (11.6 qt)
Total system	13 liters (13.7 qt)
High to low (on dipstick)	1.9 liters (2.0 qt)
Oil Capacity of Standard Engine (four-cylinder) 4.5 liters (275 C.I.D.) Engines (Aluminium Oil Pan)	
Pan only	13 liters (13.7 qt)
Total system	15 liters (15.9 qt)
High to low (on dipstick)	3.0 liters (3.2 qt)
Oil Capacity of Standard Engine (four-cylinder) 4.5 liters (275 C.I.D.) Engines (High Capacity Oil Pan)	
Pan only	16 liters (16.9 qt)
Total system	18 liters (19 qt)
High to low (on dipstick)	6.0 liters (6.3 qt)
Oil Capacity of Standard Engine (six-cylinder) 6.7 liters (409 C.I.D.) Engines (Standard Oil Pan)	
Pan only	14.2 liters (15.0 qt)
Total system	16.7 liters (17.6 qt)
High to low (on dipstick)	1.9 liters (2.0 qt)
Oil Capacity of Standard Engine (six-cylinder) 6.7 liters (409 C.I.D.) Engines (Suspended Oil Pan)	
Pan only	17.2 liters (18.5 qt)
Total system	19.7 liters (20.8 qt)
High to low (on dipstick)	2.8 liters (3.0 qt)
Oil Capacity of Standard Engine (six-cylinder) 6.7 liters (409 C.I.D.) Engines (High Capacity Oil Pan)	
Pan only	23.9 liters (25.3 qt)
Total system	26.4 liters (27.9 qt)
High to low (on dipstick)	7.4 liters (7.8 qt)
Maximum Oil Temperature	
For 4.5 liters (275 C.I.D.) 6.7 liters (409 C.I.D.) Engines	138°C (280°F)
NOTE: If the type/oil capacity of the oil pan is not known: 1. Contact a local Cummins Distributor/Dealer. 2. Determine the capacity of the oil pan option for the engine being serviced by using QuickServe[®]Online and the engine serial number. 3. Fill the lubricating oil pan to the smallest oil pan capacity listed for the engine being serviced. Then add 0.95 liters [1 qt] of oil at a time until it reaches the high mark on the dipstick. Record the number of quarts added so that capacity is known the next time the oil is drained.	

Cooling System

All Applications Except Marine	Specifications
Coolant Capacity (four-cylinder engine only)	8.5 liters (2.2 qt)
Coolant Capacity (six-cylinder engine only)	10 liters (2.6 qt)
Standard Modulating Thermostat - Range - Industrial Applications	88 to 97°C (190 to 207°F)
Maximum Allowed Operating Temperature - Industrial Applications	107°C (225°F)
Minimum Recommended Operating Temperature	71°C (160°F)
Minimum Recommended Pressure Cap - Industrial Applications	50 kPa (7 psi)

Air Intake System

Item	Specifications
Maximum Intake Restriction (clean air filter element) H ₂ O (10.0 in H ₂ O)	254 mm
Maximum Intake Restriction (dirty air filter element) H ₂ O (10.0 in H ₂ O)	635 mm

Exhaust System

Item	Specifications
Maximum Back Pressure measured at the turbocharger outlet (exhaust manifold outlet for naturally aspirated engines):	
Without Exhaust Catalyst	10 kPa (1.5 psi)
With Exhaust Catalyst	15 kPa (2.2 psi)

Electrical System

Specifications

Recommended Battery Capacity

System Voltage		Ambient Temperatures		
	18°C [0°F]		-29°C [-20°F]	
	Cold Cranking Amperes	Reserve Capacity (Minutes) ¹	Cold Cranking Amperes	Reserve Capacity (Minutes) ¹
6 cylinder engines				
12-VDC	1500	260	1900	260
24-VDC ²	750	130	950	130
4 cylinder engines				
12-VDC	1200	260	1500	260
24-VDC ²	600	260	750	260
¹ The number of plates within a given battery size determines reserve capacity. Reserve capacity is the length of time for which a battery at 27°C (80°F) can supply 25 amperes at 10.5 VDC or greater.				
² Cold cranking amp(s)(CCA) ratings are based on two 12-VDC batteries in series.				

Batteries (Specific Gravity)

Specific Gravity at 27°C (81°F)	State of Charge
1.260 to 1.280	100%
1.230 to 1.250	75%
1.200 to 1.220	50%
1.170 to 1.190	25%
1.110 to 1.130	Discharged

Cummins/Fleetguard® Filter Specifications

General Information

Fleetguard® Nelson is a subsidiary of Cummins Inc. Fleetguard/Nelson filters are developed through joint testing at Cummins® and Fleetguard®/Nelson. Fleetguard®/Nelson filters are standard on new Cummins® engines. Cummins Inc. recommends their use.

Fleetguard®/Nelson products meet all Cummins® Source Approval Test standards to provide the quality filtration necessary to achieve the engine's design life. If other brands are substituted, the purchaser should insist on products that the supplier has tested to meet Cummins high-quality standards.

Cummins Inc. can not be responsible for problems caused by non-genuine filters that do not meet Cummins Inc. performance or durability requirements.

Filter Part Numbers (All Applications Except Marine)			
	Lubricating Oil Filter	Fuel Filter (Primary)	Fuel Filter (Prefilter with WIF Sensor)
Cummins® Part Number	3937736	3978040	3973233
Fleetguard®/Nelson Part Number	LF3970	FF5421	FS19732

Fuel Recommendations and Specifications

Fuel Recommendations



WARNING!

Do not mix gasoline, alcohol, or gasohol with diesel fuel. This mixture can cause an explosion.



CAUTION!

Due to the precise tolerances of diesel injection systems, it is extremely important that the fuel be kept clean and free of dirt or water. Dirt or water in the system can cause severe damage to both the fuel pump and the fuel injectors.



CAUTION!

Lighter fuels can reduce fuel economy or possibly damage fuel system components.

Cummins Inc. recommends the use of ASTM number 2D fuel. The use of number 2 diesel fuel will result in optimum engine performance.

At operating temperatures below 0°C (32°F), acceptable performance can be obtained by using blends of number 2D and number 1D.

The following chart lists acceptable substitute fuels for this engine.

Acceptable Substitute Fuels									
No. 1D Diesel (1) (2) (3)	No. 2D Diesel (3)	No. 1K Kerosene	Jet-A	Jet-A1	JP-5	JP-8	Jet-B	JP-4	CITE
A	OK	Not OK	A	A	A	A	Not OK	Not OK	Not OK
An "A" means OK only if fuel lubricity is adequate. This means the BOCLE number is 3100 or greater as measured by ASTM specification D6078, Scuffing Load Ball On Cylinder Evaluator (SLBOCLE). Lubricity can also be measured by ASTM, specification D6079, ISO 12156, High Frequency Reciprocating Rig (HFRR) in which the fuel must have a wear scar diameter of 0.45 mm [0.02 in] or less.									
Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is not warrantable.									
Winter blend fuels, such as found at commercial fuel-dispensing outlets, are combinations of number 1D and 2D diesel fuels and are acceptable.									

NOTE: *Cummins Inc. recommends that the cetane number of diesel fuel be a minimum of 45 for engines that are expected to operate at temperatures below 0°C (32°F) and a minimum of 40 for engines that are operated at temperatures above 0°C (32°F).*

NOTE: *Using diesel fuel with lower than recommended cetane number can cause hard starting, instability, and excessive white smoke. To maintain satisfactory operation at low ambient temperatures, it is important to specify diesel fuel of the correct cetane number.*

Additional information for fuel recommendations and specifications can be found in Fuel for Cummins Engines, Bulletin 3379001. See ordering information in the back of this manual.

Lubricating Oil Recommendations and Specifications

General Information



CAUTION!

The fuel sulphur content should not exceed 0.5 mass percent sulphur. If the fuel sulphur content is greater than 0.5 mass percent sulphur, seek advice from your local Cummins Distributor. For recommendations of fuel for Cummins engines, refer to Fuel for Cummins Engines, Bulletin 3379001.

Extending the oil and filter change interval beyond therecommendations will decrease engine life due tofactors such as corrosion, deposits and wear.

Cummins does not recommend the use of A.C.E.A. E4/MB 228.5 formulation oils, which do not attain one or more of the following lubricant qualifications: A.P.I. CH-4, CI-4, A.C.E.A. E5, E7, C.E.S. 20071, C.E.S. 20072, C.E.S. 20076, C.E.S. 20077, C.E.S. 20078.

If A.C.E.A. E4/MB 228.5 formulation oils, which do not comply with the oil specifications listed above, are used in Cummins automotive engines, problems such as wear to overhead, sliding tappets, camshaft and crankshaft bearings may be experienced.

The use of a synthetic-base oil does not justify extended oil change intervals. Extended oil change intervals can decrease engine life due to factors such as corrosion, deposits, and wear.

NOTE: *The responsibility is with the owner. If recommendations are ignored, warranty could be affected.*

NOTE: *A.C.E.A. = Association des Constructeurs Europeen d'Automobiles, A.P.I. = American Petroleum Institute and C.E.S. = Cummins Engineering Standard.*

Cummins Inc. recommends the use of a high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline Premium Blue[®], which meets or exceeds the American Petroleum Institute (API) performance classification CH-4/SJ or CI-4/SK and the Association des Constructeurs Europeen d'Automobiles (A.C.E.A.) performance classification E5 or E7.

Cummins Engine Standard Classification (CES)	American Petroleum Institute Classification (API)	European Classification (ACEA)	Comments
	API CD API CE	ACEA E-1, ACEA E-2	OBSOLETE. DO NOT USE.
CES-20075	API CF-4/SG, API CG-4/SH	ACEA E-3	Minimum acceptable oil classification for Midrange engines.
CES-20071, CES-20072, CES-20076, CES-20077	API CH-4/SJ	ACEA E-5, E-7	Good oil classification for Midrange engines without EGR.
CES-20078	API CI-4/SK		Excellent oil for midrange engines.

CG-4/SH and E-3 oils can be used in areas where none of the recommended oils are available, but the oil drain interval must be reduced by one half of the interval given in the maintenance schedule. See the oil drain interval information in "Maintenance Guidelines" on page-59.

A sulfated ash limit of 1.0 mass percent is suggested for optimum valve and piston deposit, and oil consumption control. The sulfated ash must not exceed 1.85 mass percent.

Special "break-in" oils are not recommended for use in new or rebuilt Cummins engines. Use the same lubricating oil that will be used in normal engine operations.

Use of "synthetic engine oils" (those made with API group 3 or group 4 base stocks) is permitted subject to the same performance and viscosity limitations of petroleum (mineral) based engine oils. The same oil change intervals must be applied to synthetic oils that are applied to petroleum (mineral) based engine oils.

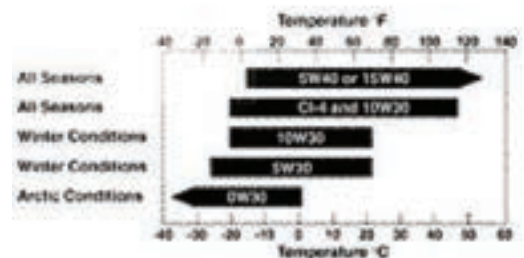
For further details and discussion of engine lubricating oils for Cummins engines, refer to Cummins Engine Oil Recommendations, Bulletin 3810340.

Cummins' primary recommendation is for the use of 15W-40 multigrade for normal operation at ambient temperatures above -15°C (5°F). The use of multigrade oil reduces deposit formation, improves engine cranking in low temperature conditions and increases engine durability by maintaining lubrication during high temperature operating conditions.

Since multigrade oils have been shown to provide approximately 30 percent lower oil consumption, compared with monograde oils, it's important to use multigrade oils to be certain your engine will meet applicable emissions requirements. While the preferred viscosity grade is 15W-40, lower viscosity multigrades can be used in colder climates. See the accompanying chart.

Oils meeting a 10W30 viscosity grade, must meet a minimum High Temperature/High Shear viscosity of 3.5 cSt., and ring wear/liner wear requirements of Cummins and Mack tests. Thus, they can be used over a wider temperature range than 10W30 oils meeting older API performance classifications. As these oils will have directionally thinner oil films than 15W40 oils, top quality Fleetguard® filters must be used above 20°C (70°F).

Some oil suppliers might claim better fuel economy for these oils. Cummins can neither approve nor disapprove any product not manufactured by Cummins Inc. These claims are between the customer and oil supplier. Obtain the oil supplier's commitment that the oil will give satisfactory performance in Cummins' engines or do not use the oil.



FG014030

Figure 227



CAUTION!

An SAE 10W30 designation on a product is a viscosity designation only. This designation alone does not imply that the product meets Cummins requirements. Only 10W30 oils with diesel performance credentials listed in table above can be used in Cummins Engines if the reduced ambient temperature indicated in chart above is observed.

An example of the API service symbols are shown in the accompanying illustration. The upper half of the symbol displays the appropriate oil categories.

The center section identifies the SAE oil viscosity grade.



Figure 228

As the engine oil becomes contaminated, essential oil additives are depleted. Lubricating oils protect the engine as long as these additives are functioning properly. Progressive contamination of the oil between oil and filter change intervals is normal. The amount of contamination will vary depending on the operation of the engine, kilometers or miles on the oil, fuel consumed, and new oil added.

Extending oil and filter change intervals beyond the recommendations will decrease engine life due to factors such as corrosion, deposits, and wear.

See the oil drain chart in "Maintenance Guidelines" on page-59 to determine which oil drain interval to use for your application.

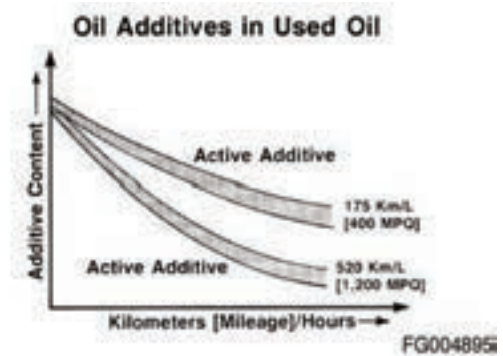


Figure 229

New Engine Break-in Oils

Special "break-in" engine lubricating oils are not recommended for new or rebuilt Cummins engines. Use the same type of oil during the break-in as is used in normal operation.

Additional information regarding lubricating oil availability throughout the world is available in the EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines. The data book can be ordered from the Engine Manufacturers Association, Two North LaSalle Street - Suite 2200, Chicago, IL, U.S.A. 60602. The telephone number is (312) 827-8733.



CAUTION!

A sulfated ash limit of 1.85 percent has been placed on all engine lubricating oils recommended for use in Cummins engines. Higher ash oils can cause valve and/or piston damage and lead to excessive oil consumption.



CAUTION!

The use of a synthetic-base oil does not justify extended oil change intervals. Extended oil change intervals can decrease engine life due to factors such as corrosion, deposits, and wear.

Coolant Recommendations and Specifications

Fully Formulated Coolant/Antifreeze

Cummins Inc. recommends the use of fully formulated antifreeze/coolant meeting Cummins Engineering Standards (C.E.S.) 14603. For further details and discussion of coolant for Cummins® engines, refer to Coolant Requirements and Maintenance, Bulletin 3666132.

Typically, antifreeze/coolants meeting ASTM4985 (GM6038M specification) or ASTM D6210 criteria are acceptable

antifreeze/coolants for engines covered by the manual.

Low-silicate antifreeze/coolants meeting ASTM D4985 (GM6038M specification) are not adequate for extended service intervals.

Cummins Inc. recommends using either a 50/50 mixture of good-quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system.

Good-quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.

Water Quality	
Calcium Magnesium (hardness)	Maximum 170 ppm as (CaCO ₃ + MgCO ₃)
Chloride	40 ppm as (Cl)
Sulfur	100 ppm as (SO ₄)

Cummins Inc. recommends using Fleetguard® Compleat. It is available in both glycol forms (ethylene and propylene).

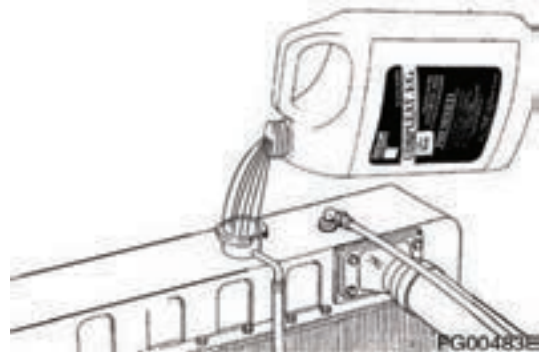


Figure 230



Figure 231

Fully formulated antifreeze must be mixed with good-quality water at a 50/50 ratio (40-to 60-percent working range). A 50/50 mixture of antifreeze and water gives a 36°C (-33°F) freezing point and a 108°C (226°F) boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze is at 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.

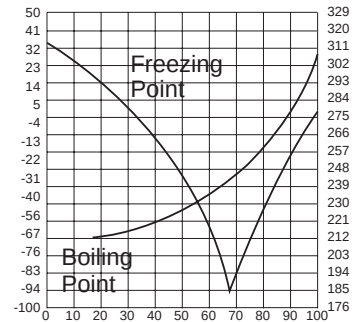


Figure 232

A refractometer must be used to measure the freezing point of the coolant accurately. Use Fleetguard® refractometer, Part Number C2800.

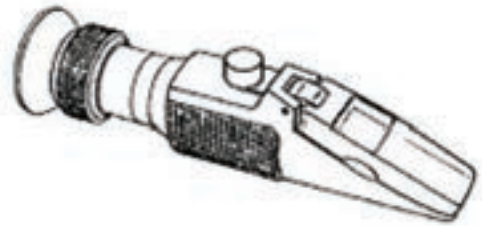


Figure 233

Do not use a floating ball hydrometer. The use of floating ball hydrometers can give an incorrect reading.

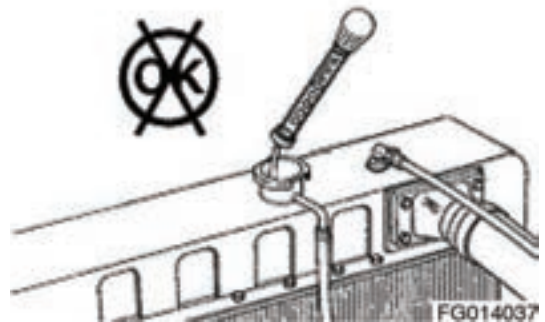


Figure 234

Cooling System Sealing Additives

Do not use sealing additives in the cooling system. The use of sealing additives will:

- Buildup in coolant low-flow areas
- Plug the radiator and oil cooler
- Possibly damage the water pump

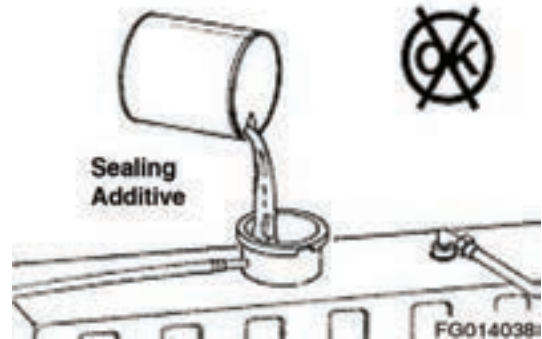


Figure 235

Cooling System Soluble Oils

Do not use soluble oils in the cooling system. The use of soluble oils will:

- Corrode brass and copper
- Damage heat transfer surfaces
- Damage seals and hoses.

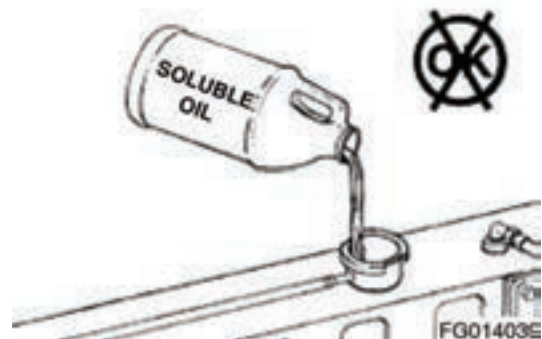


Figure 236

Drive Belt Tension

Tension Chart

SAE Belt Size	Belt Tension Gauge Part No.		Belt Tension New		Belt Tension Range Used*	
	Click-type	Burroughs	N	lbf	N	lbf
0.380 in	3822524		620	140	270 to 490	60 to 110
0.440 in	3822524		620	140	270 to 490	60 to 110
1/2 in	3822524	ST-1138	620	140	270 to 490	60 to 110
11/16 in	3822524	ST-1138	620	140	270 to 490	60 to 110
3/4 in	3822524	ST-1138	620	140	270 to 490	60 to 110
7/8 in	3822524	ST-1138	620	140	270 to 490	60 to 110
4 rib	3822524	ST-1138	620	140	270 to 490	60 to 110
5 rib	3822524	ST-1138	670	150	270 to 530	60 to 120
6 rib	3822525	ST-1293	710	160	290 to 580	65 to 130
8 rib	3822525	ST-1293	890	200	360 to 710	80 to 160
10 rib	3822525	3823138	1110	250	440 to 890	100 to 200
12 rib	3822525	3823138	1330	300	530 to 1070	120 to 240
12 rib K section	3822525	3823138	1330	300	890 to 1070	200 to 240

NOTE: *This chart does not apply to automatic belt tensioners.*

- * A belt is considered used if it has been in service for ten minutes or longer.
If used belt tension is less than the minimum value, tighten the belt to the maximum used belt value.

Engine Component Torque Values

Torque Table

Component	Torque Value	
	Nm	ft lb
Alternator Link	24	18
Alternator Mounting Bolt	43	32
Belt Tensioner Mounting	43	32
Crankshaft Damper and Pulley	200	148
Crossover Clamp	5	44 in-lb
Tee Bolt Type Clamp	8	71 in-lb
Exhaust Outlet Pipe, V Band Clamp	8	71 in-lb
Fan Bracket Mounting	24	18
Fan Pulley	43	32
Fuel Filter	Refer to Manufacturer's Specifications	
Lubricating Oil Filter	Refer to Manufacturer's Specifications	
Lubricating Oil Pan Drain Plug		
Steel Oil Pan	80	59
Cast Aluminum Oil Pan	60	44
Composite Oil Pan	60	44
Lubricating Oil Pan Heater Plug	120	89
Starting Motor Mounting	43	32
Rocker Lever Cover	12	106 in-lb

Sealants

General Information

Use the sealants listed below or sealants containing equivalent properties.

Item Description	Cummins Part Number	Generic Description
Pipe Plugs	3375066	Teflon Pipe Sealant
Cup Plugs	3375068	Sealant
O-rings	3163087	Assembly Lube
Oil Pan at T-Joint	3164067	RTV Sealant
Flywheel Housing to Rear Gear Housing Joint	3164070	RTV Sealant
Front Gear Cover to Block Joint	3164070	RTV Sealant
Rear Gear Housing to Block Joint	3164070	RTV Sealant
Intake Manifold to Cylinder Head Joint	3164070	RTV Sealant

Cap Screw Markings and Torque Values

General Information

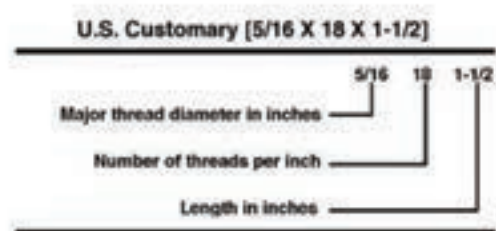
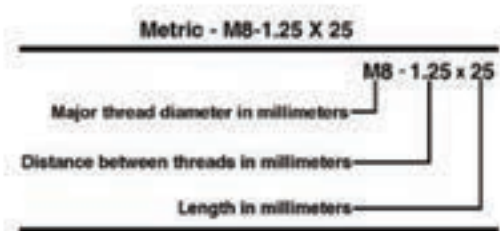


CAUTION!

When replacing cap screws, always use a cap screw of the same measurement and strength as the cap screw being replaced. Using the wrong cap screws can result in engine damage.

Metric cap screws and nuts are identified by the grade number stamped on the head of the cap screw or on the surface of the nuts. U.S. Customary cap screws are identified by radial lines stamped on the head of the cap screw.

The following examples indicate how cap screws are identified.



FG004897

Figure 237

NOTE: Always use the torque values listed in the following tables when specific torque values are not available.

Do not use the torque values in place of those specified in other sections of this manual.

The torque values in the table are based on the use of lubricated threads.

When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

Cap Screw Markings and Torque Values - Metric

Commercial Steel Class												
	8.8				10.9				12.9			
Cap Screws Head Markings												
												
Body Size	Torque				Torque				Torque			
Diameter	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
mm	Nm	ft lb	Nm	ft lb	Nm	ft lb	Nm	ft lb	Nm	ft lb	Nm	ft lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	-	-	550	400	-	-	-	-	-	-

Cap Screw Markings and Torque Values - U.S. Customary

SAE Grade No.	5				8			
Cap Screws Head Markings								
These are all SAE Grade 5 (3 line)								
								
Cap Screw Torque - Grade 5 Cap Screw					Cap Screw Torque - Grade 8 Cap Screw			
Cap Screw Body Size	Cast Iron		Aluminum		Cast Iron		Aluminum	
	Nm	ft lb	Nm	ft lb	Nm	ft lb	Nm	ft lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35
7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

WARRANTY

All Engines United States and Canada Industrial (Off-Highway)

Coverage

Products Warranted

This warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in industrial (off-highway) applications in the United States* and Canada, except for Engines used in marine, generator drive and certain defense applications, for which different warranty coverage is provided.

Base Engine Warranty

This warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failures).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, Coverage continues until the end of the first year.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This Coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000* hours of operation from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or from when the Engine has been operated for 50 hours, whichever occurs first.

*3,000 hours for A series engines.

Consumer Products

The warranty on Consumer Products in the United States is a LIMITED warranty. CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Any implied warranties applicable to Consumer Products in the United States terminate concurrently with the expiration of the express warranties applicable to the product. In the United States, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied warranty lasts, so the limitations or exclusions herein may not apply to you.

These warranties are made to all Owners in the chain of distribution, and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins' Responsibilities

During The Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements, and other maintenance items that are not reusable due to the Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered part.

Owner's Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items provided during warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine and Extended Major Components Warranties

Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the Engine available for repair by such facility. Locations in the United States and Canada are listed in the Cummins Off Highway Authorized Dealer Directory.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; over fueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

For power units and fire pumps (package units), this warranty applies to accessories, except for clutches and filters, supplied by Cummins which bear the name of another company.

Except for power units and fire pumps, this warranty does not apply to accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans**, air-conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, and non-Cummins fan drives, engine compression brakes and air compressors.

Cummins Compusave units are covered by a separate warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins-approved rebuilt parts, or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins-approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining coverage hereunder.

For all A Series Applications, including industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, \$0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAR-OUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Emission Warranty

Products Warranted

This emission warranty applies to new Engines marketed by Cummins that are used in the United States* in vehicles designed for Industrial off-highway use. This warranty applies to Engines delivered to the ultimate purchaser on or after April 1, 1999 for engines up to 750 horsepower, on or after January 1, 2000 for engines 751 horsepower and over.

Coverage

Cummins warrants to the ultimate purchaser and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by Cummins with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods: (A) Five years or 3,000 hours of operation, whichever occurs first, as measured from the date of delivery of the Engine to the ultimate purchaser, or (B) The Base Engine Warranty.

If the vehicle in which the Engine is installed is registered in the state of California, a separate California Emission Warranty also applies.

Limitations

Failures, other than those resulting from defects in materials, or workmanship, are not covered by this warranty.

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolant or lubricants; over fueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect fuel or by water, dirt or other contaminants in the fuel.

Cummins is not responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all business costs or other losses resulting from a Warrantable Failure.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

* Includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands.

** Alternators, starters, and fans ARE covered for the duration of the base engine warranty on A series and B3.3 engines.

*** Emissions Warranty for B LPG Industrial Off-Highway engines is 5 Years / 3,500 Hours.

All Engines International Industrial (Off-Highway)

Coverage

Products Warranted

This warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in industrial (off-highway) applications anywhere in the world where Cummins-approved service is available, except the United States* and Canada. Different warranty coverage is provided for Engines used in marine, generator drive and certain defense applications.

Base Engine Warranty

This warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failure).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, coverage continues until the end of the first year.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000* hours of operation, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or from when the Engine has been operated for 50 hours, whichever occurs first.

*3,000 hours for A series engines.

These warranties are made to all Owners in the chain of distribution, and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins' Responsibilities

During the Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements, and other maintenance items that are not reusable due to a Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During the Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered part.

Owner's Responsibilities

During the Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during warranty repairs unless such items are not reusable due to the Warrantable Failure.

During the Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During the Base Engine and Extended Major Components Warranties

Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the product available for repair by such facility. Locations are listed in the Cummins International Sales and Service Directory.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; over fueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil or fuel or by water, dirt or other contaminants in the fuel or oil.

For power units and fire pumps (package units) the warranty applies to accessories, except for clutches and filters supplied by Cummins which bear the name of another company.

Except for the accessories noted previously, Cummins does not warrant accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans*, air-conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, non-Cummins fan drives, and air cleaners.

Cummins Compusave units are covered by a separate warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins-approved rebuilt parts, or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins-approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining coverage hereunder.

For all A Series Applications, including industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, \$0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAR-OUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In case of consumer sales, in some countries, the Owner has statutory rights which cannot be affected or limited by the terms of this warranty.

Nothing in this warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Alternators, starters, and fans ARE covered for the duration of the base engine warranty on A series and B3.3 engines.

California Emission Control System Warranty, Off-Highway

Products Warranted

This Emission Control System Warranty applies to off-road diesel engines certified with the California Air Resources Board beginning with the year 1996 for engines up to 750 horsepower, beginning with the year 2000 for 751 horsepower and over, marketed by Cummins, and registered in California for use in industrial off-highway applications.

Your Warranty Rights and Obligations

The California Air Resources Board and Cummins Engine Company, Inc., are pleased to explain the emission control system warranty on your engine. In California, new off-road diesel engines must be designed, built and equipped to meet the State's stringent anti-smog standards. Cummins must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Cummins will repair your off-road diesel engine at no cost to you including diagnosis, parts and labor.

Manufacturer's Warranty Coverage

This warranty coverage is provided for 5 years or 3,000 hours of engine operation, whichever first occurs from the date of delivery of the engine to the first user. If any emission-related part on your engine is defective, the part will be repaired or replaced by Cummins.

Coverage

This emission control system warranty applies only to the following A series, B3.3, B3.9, B4.5s, B5.9, B6.7s, QSB3.9- 30, QSB4.5-30, QSB5.9-30, QSB5.9-44, C8.3, QSC8.3, and QSL9 emission control parts:

Fuel Pump	Intake Manifold
Static Timing	Charge Air Cooler
Delivery Valve	Aftercooler
Injection Control Valve Module	
	Exhaust Manifold
Injectors	
Calibration	Oxidation Catalyst
Needle	
Nozzle	Electronic Control System
Spring	Control Module
	Boost Pressure Sensor
Turbocharger	Coolant Temperature Sensor
Compressor Wheel	Fuel Pressure Sensor
Turbine Wheel	
Turbine Oil Seal	
Wastegate Valve	

Owner's Warranty Responsibilities

As the off-road diesel engine owner, you are responsible for the performance of the required maintenance listed in your Cummins Operation and Maintenance Manual. Cummins recommends that you retain all receipts covering maintenance on your off-road diesel engine, but Cummins cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.

You are responsible for presenting your off-road diesel engine to a Cummins dealer as soon as a problem exists. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

As the off-road diesel engine owner, you should also be aware that Cummins may deny you warranty coverage if your off-road diesel engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.

If you have any questions regarding your warranty rights and responsibilities, you should contact Cummins Customer Assistance Department at 1-800-343-7357 (1-800-DIESELS) or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731.

Prior to the expiration of the applicable warranty, Owner must give notice of any warranted emission control failure to a

Cummins distributor, authorized dealer or other repair location approved by Cummins and deliver the engine to such facility for repair. Repair locations are listed in Cummins United States and Canada Service Directory.

Owner is responsible for incidental costs such as: communication expenses, meals, lodging incurred by Owner or employees of Owner as a result of a warrantable failure.

Owner is responsible for business costs and losses, "downtime" expenses, and cargo damage resulting from a warrantable failure. CUMMINS IS NOT RESPONSIBLE FOR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCIDENTAL OR CONSEQUENTIAL DAMAGES INCLUDE BUT ARE NOT LIMITED TO FINES, THEFT, VANDALISM OR COLLISIONS.

Replacement Parts

Cummins recommends that any service parts used for maintenance, repair or replacement of emission control systems be new, genuine Cummins or Cummins approved rebuilt parts and assemblies, and that the engine be serviced by a Cummins distributor, authorized dealer or the repair location approved by Cummins. The owner may elect to have maintenance, replacement or repair of the emission control parts performed by a facility other than a Cummins distributor, an authorized dealer or a repair location approved by Cummins, and may elect to use parts other than new genuine Cummins or Cummins approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts will not be covered under this emission control system warranty.

Cummins Responsibilities

Repairs and service will be performed by any Cummins distributor, authorized dealer or other repair location approved by Cummins using new, genuine Cummins or Cummins approved rebuilt parts and assemblies. Cummins will repair any of the emission control parts found by Cummins to be defective without charge for parts or labor (including diagnosis which results in determination that there has been a failure of a warranted emission control part).

Emergency Repairs

In the case of an emergency where a Cummins distributor, authorized dealer, or other repair location approved by Cummins is not available, repairs may be performed by any available repair location using any replacement parts. Cummins will reimburse the Owner for expenses (including diagnosis), not to exceed the manufacturer's suggested retail price for all warranted parts replaced and labor charges based on the manufacturer's recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate. A part not being available within 30 days or a repair not being complete within 30 days constitutes an emergency. Replaced parts and paid invoices must be presented at a Cummins authorized repair facility as a condition of reimbursement for emergency repairs not performed by a Cummins distributor, authorized dealer, or other repair location approved by Cummins.

Warranty Limitations

Cummins is not responsible for failures resulting from Owner or operator abuse or neglect, such as: operation without adequate coolant, fuel or lubricants; over fueling; overspeeding; lack of maintenance of lubricating, cooling or air intake systems; improper storage, starting, warm-up, run-in or shutdown practices.

The manufacturer warrants to the ultimate purchaser and each subsequent purchaser that the engine is designed, built, and equipped so as to conform with all applicable regulations adopted by the Air Resources Board, and that it is free from defects in materials and workmanship which cause the failure of a warranted part.

Any warranted part which is not scheduled for replacement as required maintenance, or which is scheduled only for regular inspection to the effect of "repair or replace as necessary" is warranted for the warranty period.

Any warranted part which is scheduled for replacement as required maintenance is warranted for the period of time before the first scheduled replacement point for that part.

The owner will not be charged for diagnostic labor which leads to the determination that a warranted part is defective, if the diagnostic work is performed at a warranty station.

The manufacturer is liable for damages to other engine components caused by the failure under warranty of any warranted part.

Cummins is not responsible for failures resulting from improper repair or the use of parts which are not genuine Cummins or Cummins approved parts.

These warranties, together with the express commercial warranties and emission warranty are the sole warranties of Cummins. There are no other warranties, express or implied, or of merchantability or fitness for a particular purpose.

Drive Coupling (Main Pump)

Edition 1

MEMO

Table of Contents

Drive Coupling (Main Pump)

Safety Precautions	5
Applicable Models	5
Drive Coupling	7
Special Tools	8
Installation of Drive Coupling	9
Installation Procedure	10

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

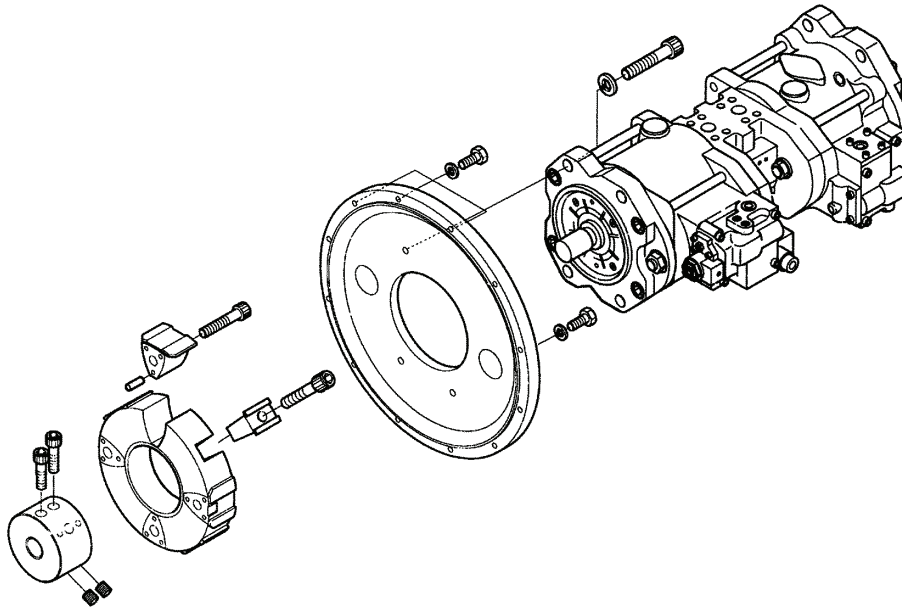
The contents of this section apply to the following models and serial number ranges.

MODEL	SERIAL NUMBER RANGE
DX140LC	5001 and Up
DX140LCR	5001 and Up

DRIVE COUPLING

It is very important to set specified clearance between the end of the pump drive shaft (the "Dimension H" described below) and the coupling hub surface when installing the main pump in the engine.

The Figure 1 shows installation of a typical drive coupling.



HAAA8380

Figure 1

SPECIAL TOOLS

This tool is used to adjust the clearance, referred to as "Measure H" in the installation instructions below, between the pump drive shaft and the front side of the drive coupling hub (4, Figure 2).

NOTE: *Dimensions A and B are the same as Measure H in Figure 3. Two tools in the figure below are designed for various models, while only their one end may be used in some special models.*

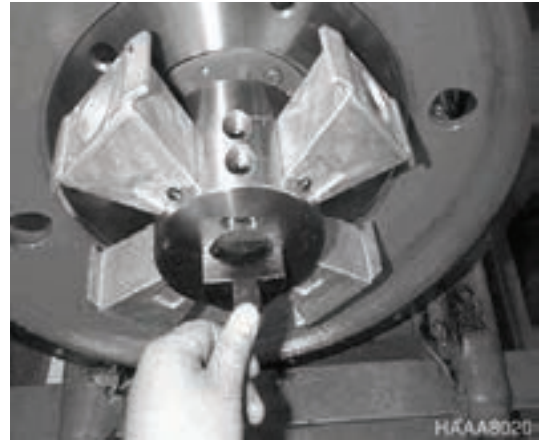
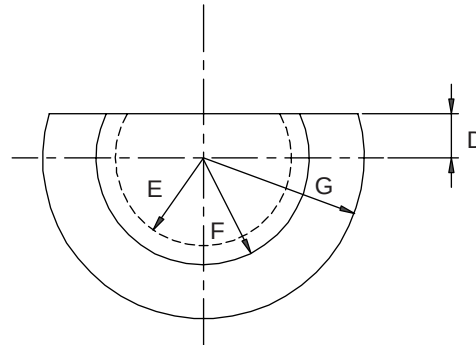
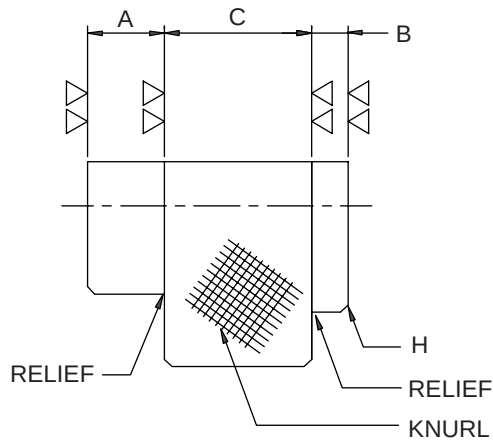


Figure 2



HAAA8360

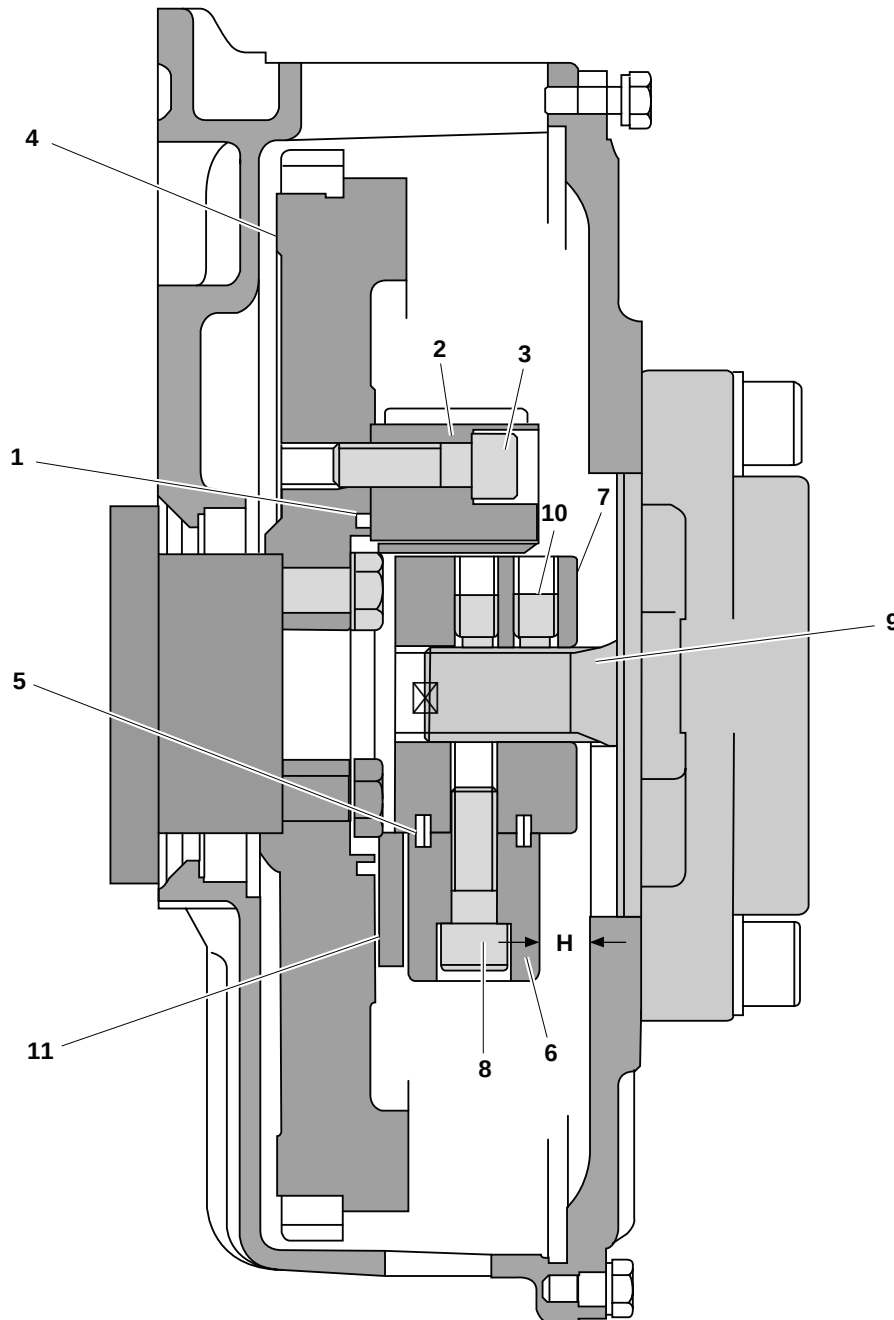
Figure 3

MODEL	A	B	C	D	E	F	G	H
DX140LC DX140LCR	10.5 ± 0.1mm	5.0 ± 0.1mm	20.0mm	7.0 mm	Radius, 12.0 mm	Radius, 14.0 mm	Radius, 25.0 mm	1.0 mm X 45°

INSTALLATION OF DRIVE COUPLING

Follow the installation dimensions and procedures whenever installing the drive coupling in the main pump.

NOTE: *Failure to follow the procedures results in noise and the shortage of the service life of the drive coupling or the main pump.*



FG009655

Figure 4 INSTALLATION OF DRIVE COUPLING

Parts and Torques			
References	Parts	Q'ty	Torque
1	Spring Pin	4	
2	Insert	4	
3	Bolt	4	Ta
4	Fly Wheel	1	
5	Spring Pin	8	
6	Insert	4	
7	Hub	1	
8	Bolt	4	Ta
9	Pump Shaft	1	
10	Fixing Nut	2	Tb
11	Element	1	

Ensure to follow the specification of Measure H from the front hub surface to the pump shaft and tightening torques of bolts and screws.

MODEL	Coupling Part Reference	Measure H	Torque of Ta	Torque of Tb
DX140LC DX140LCR	2414-9009A	3.0 - 7.0 mm	21 - 23 kgf•m	10 - 12 kgf•m

Installation Procedure

NOTE: Refer to Figure 5 for the installation procedure.

1. Install spring pin (1) and then insert (2) with bolt (3) into engine fly wheel (4).

NOTE: Tighten the bolt using the torque T_a value specified in the table.

2. Install two spring pins (5) and then insert (6) in bolt (8) of hub (7).

NOTE: Tighten the bolt using the torque T_a value specified in the table.

3. Install the fly wheel cover in the main pump with bolts.

4. Connect hum (7) with pump shaft (9) as referred to as Measure H in Table 1 and fix its position with screws (10).

NOTE: Tighten the screws using the torque T_b value specified in the table.

NOTE: Apply Loctite #262 to fixing screws (10).

5. Install element (11) in between the engine fly wheel (4) and the insert.
6. Install the main pump and hub (7) by gently pushing them with element (11).
7. Bolt down the fly wheel cover and the pump housing on the fly wheel housing.

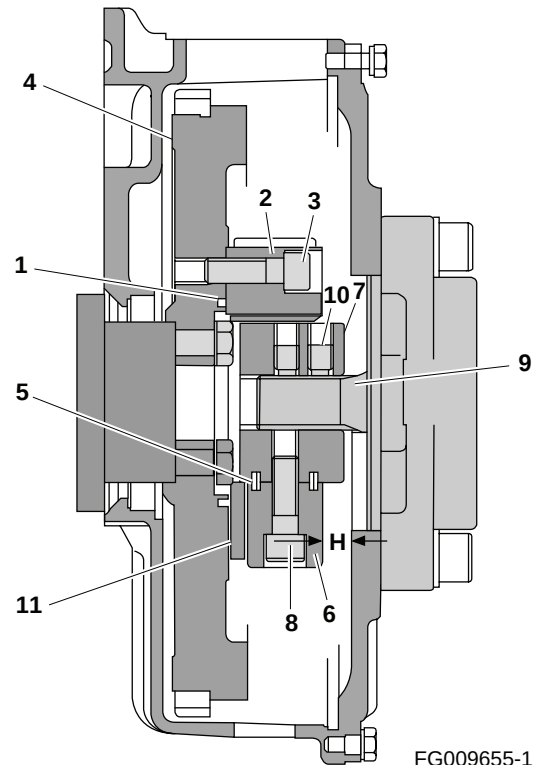


Figure 5



CAUTION

Apply the adhesive to bolts (3 and 8) to prevent the loosening of seals. Do not use additional adhesive nor any oil or cleaning solvent. As element (11) cannot resist adhesive, oil, and grease, take care not have it exposed to such materials.

Remove oil and dust on the fly wheel cover and the pump shaft before assembly.

Adjust the arrangement allowance between the pump and the engine at below 0.6 mm (0.023 in).

Hydraulics

Hydraulic System Troubleshooting, Testing and Adjustment

Edition 1

MEMO

Table of Contents

Hydraulic System Troubleshooting, Testing and Adjustment

Safety Precautions	5
Applicable Models	5
Hydraulic System - General Notes	6
Hydraulic Schematic.....	7
General Notes	7
Operation of Working Components	9
Boom Operating Circuit.....	9
Boom Up Circuit	9
Boom Down Circuit.....	9
Arm Operating Circuit.....	10
Arm Crowd Circuit	10
Arm Dump Circuit	10
Bucket Operating Circuit	11
Bucket Crowd Circuit.....	11
Bucket Dump Circuit.....	11
Swing Operating Circuit.....	11
Right Swing Operating Circuit	12
Left Swing Operating Circuit.....	12
Swing Relief Valve and Makeup Valve.....	12
Travel Operating Circuit	12
Forward Travel Circuit	13
Reverse Travel Circuit.....	13
Procedural Troubleshooting Baseline	
Recommendations.....	14
Initial Checks and Tests to Establish Operating Condition of the Excavator	14
Pilot Pressure	16
Adjustment and Testing.....	16
Power Mode Valve	17
Current Signal and Hydraulic Pressure Adjustments	17
Swing Priority Valve.....	18

Control Valve Pressure and Current Adjustments.....	18
Pressure Up Valve.....	19
Checks and Adjustments.....	19
Pump Input Power Control	21
Pump Regulator Adjustment	21
Flow Meter and Flow Meter Kit Installation and Testing.....	25
Swing System Troubleshooting	27
Precautions/Initial Checks	27
Swing Relief Valve Checking and Adjustment	28
Troubleshooting – Swing Gearbox	30
Troubleshooting – Hydraulic Problems.....	31
Troubleshooting – Control Valve	33
Troubleshooting – Travel Control Valve	34
Troubleshooting – Joystick Control Valve.....	35

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.

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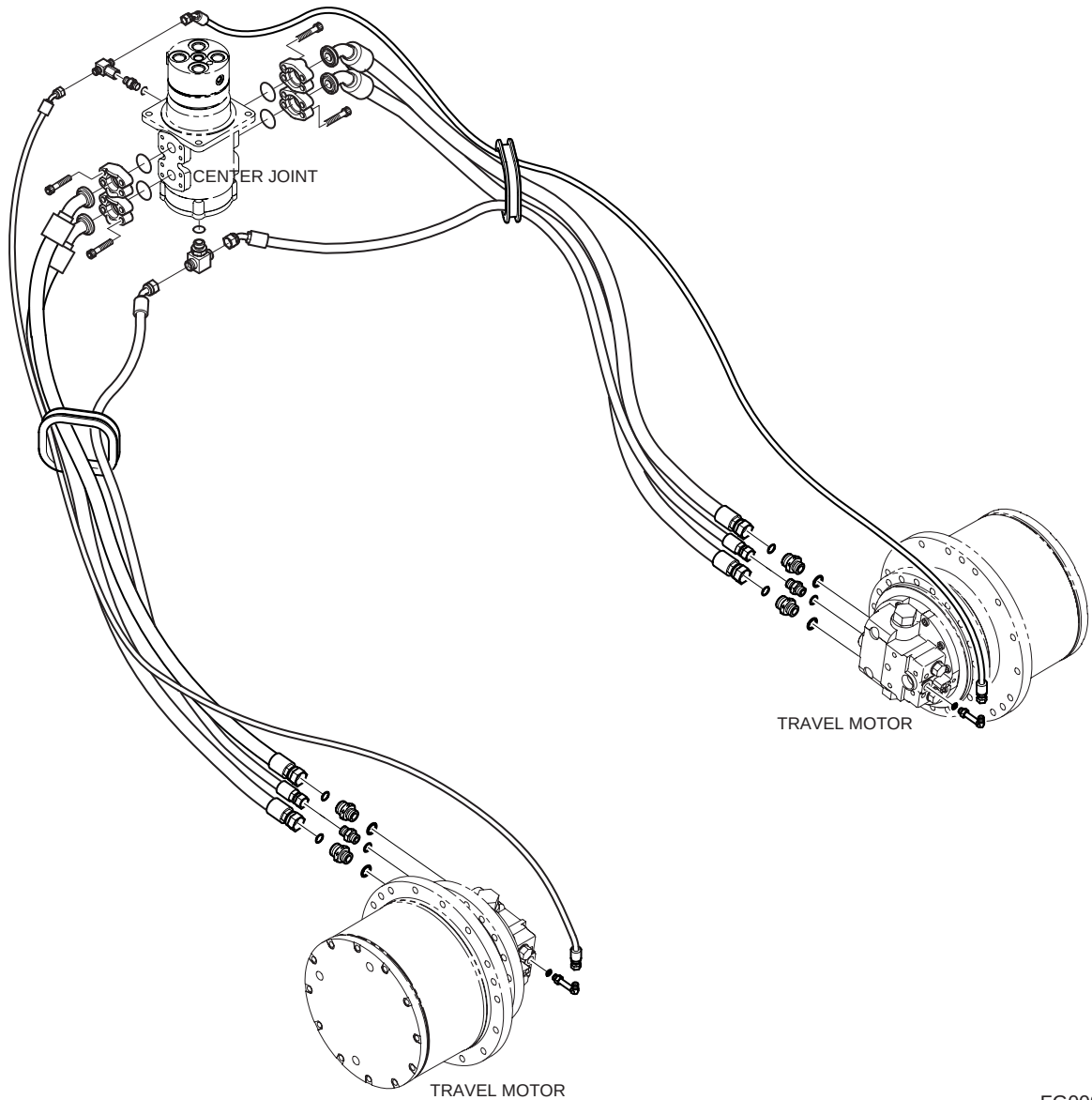
Remember, that ultimately safety is your own personal responsibility.

APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX140LCR	5001 and Up

HYDRAULIC SYSTEM - GENERAL NOTES



FG009803

Figure 1

The hydraulic system has several improvements over conventional hydraulic systems - including cross-sensing total horsepower control - to maximize output efficiency.

The system features an electronically controlled output optimization system, which allows the operator to choose between two, distinctly different power modes: high-output/rapid cycling maximum speed power mode, and a standard power mode for most types of general operation.

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. Two main pumps (a right side pump and a left side pump) make up the main pump assembly.
- Hydraulic output from the right side pump is transmitted to the right side of the control valve. Output from the left side 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 the right pump in the pump assembly, operates valve spools for left 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 the left pump in the pump assembly, has control spools for right travel, swing, boom and arm function.
- 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 right travel or left travel control spools are shifted, output from the main pump assembly flows through the center joint to one or both of the axial piston motors driving the side frame crawler tracks. A pilot valve connected to the swash plate of each travel motor changes motor capacity (and output) in direct proportion to the position of the travel switch selected by the operator.

- 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 80 mesh, 177 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.

A selection valve in the travel circuit can be used to provide constant high torque/low speed travel, or variable speed/variable torque output for travel. To prevent sliding during simultaneous travel and boom/arm/bucket operation, select the high torque/low speed travel position.

OPERATION OF WORKING COMPONENTS

Boom Operating Circuit

The boom operating circuit includes the right and left 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 360 kg/cm^2 (5,112 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 BOOM1 and BOOM2 spools of the control valve simultaneously. When secondary pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 130 psi), boom control valve spools open and oil from both pumps goes to the boom cylinder.

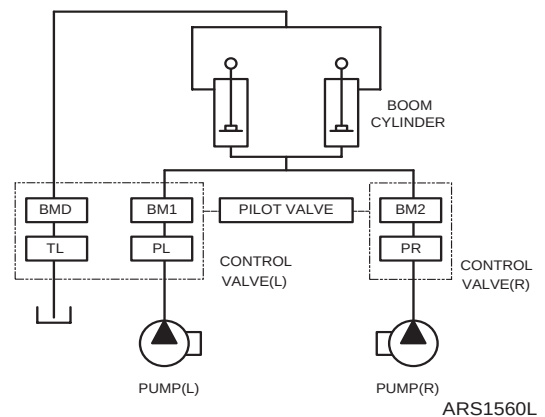


Figure 2

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 BOOM1 spool of the control valve. When secondary pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 130 psi), the BOOM1 spool on the right side of the control valve opens so that oil from only one pump (PUMP (rear)) assembly goes to the boom cylinder for boom lowering.

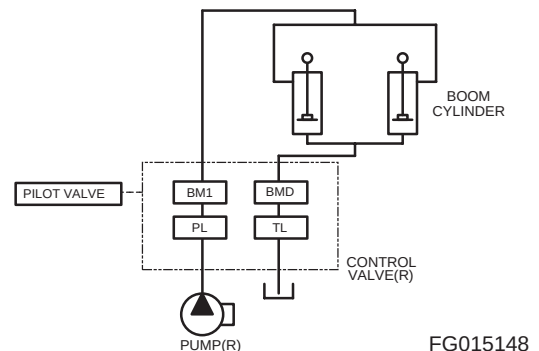


Figure 3

Arm Operating Circuit

The arm operating circuit includes both the front and rear hydraulic main pumps, the right and left halves of 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 360 kg/cm^2 (5,112 psi) have been installed at the AM 1 and AMD 1 ports on the right 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 makeup 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 AM1 and AM2 spools of the control valve simultaneously.

When secondary pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 130 psi), the arm control valve spools AM1 and AM2 open. 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 arm cylinder could suddenly be forced out by the weight of the arm and bucket. 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.

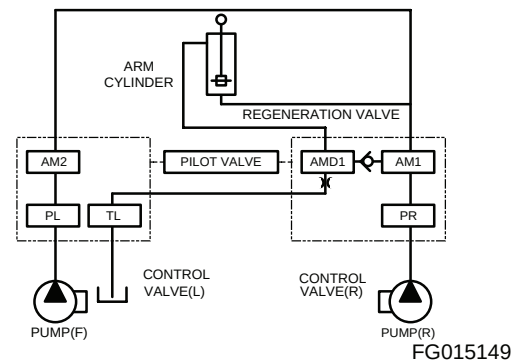


Figure 4

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 spools AM1 and AM2 of the control valve simultaneously.

When pilot pressure reaches $7 - 9 \text{ kg/cm}^2$ (100 - 130 psi), the control spools open, allowing oil from PUMP (F) and PUMP (R) to flow to the arm cylinder.

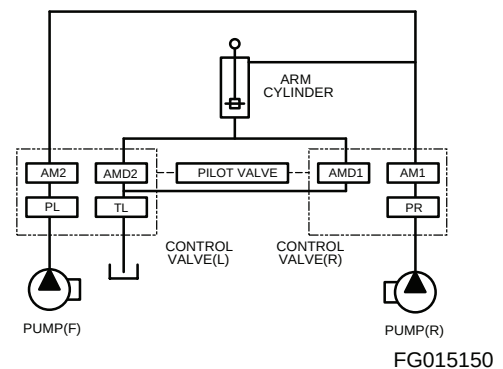


Figure 5

Bucket Operating Circuit

The bucket operating circuit includes the left main pump, the left half of the control valve and the bucket cylinder. 350 kg/cm² (4,978 psi) overload relief valves at BKT and BKTD 1 ports of the control valve protect the circuit and its components from being damaged.

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 rear main pump flows to the bucket cylinder.

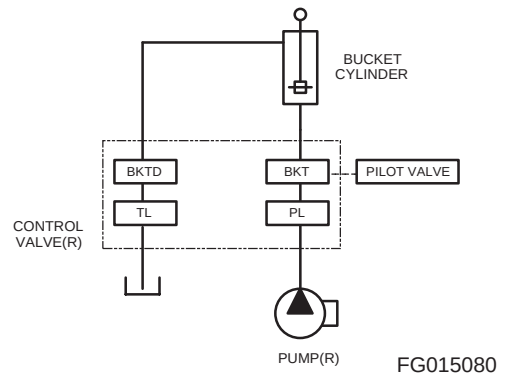


Figure 6

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 rear main pump to the cylinder.

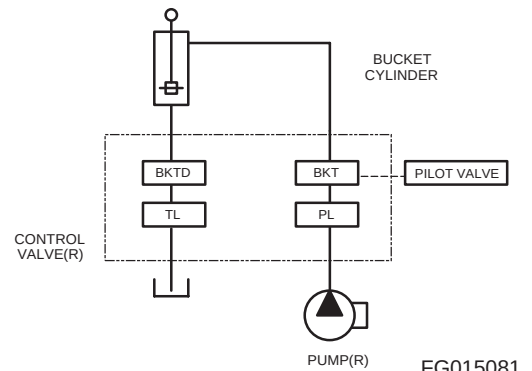


Figure 7

Swing Operating Circuit

The swing operating circuit consists of the front main 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, an electrical sensor in the control circuit activates a valve to automatically engage a mechanical brake.

Forward Travel Circuit

When the right and left travel control levers are pushed forward, output from both of the main pumps is directed through the PR, PL, TRRF, and TRLF ports on the control valve, through the upper works center joint, to the travel motors on each side of the machine.

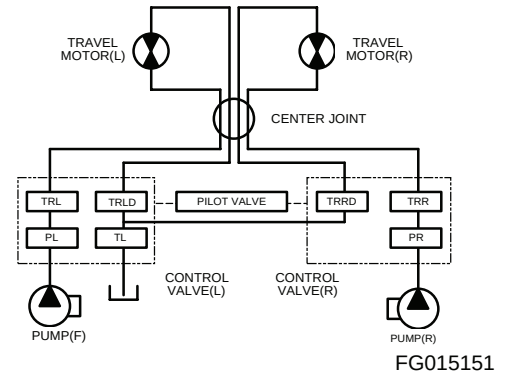


Figure 10

Reverse Travel Circuit

When the right and left travel control levers are pushed backward, output from both main pumps is directed through the PR, PL, TRRR, and TRLR ports on the control valve, through the upper works center joint, to the travel motors.

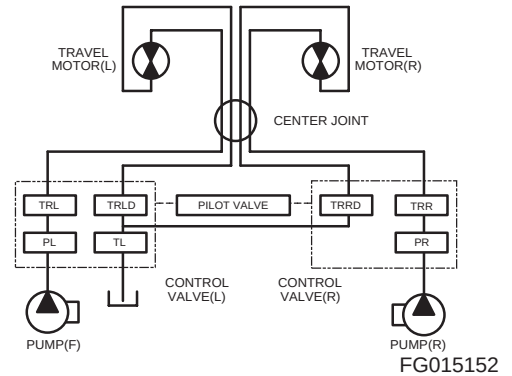


Figure 11

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 1,950 rpm with no load.
- at 1,950 rpm stall load.

If engine rpm drops excessively with a load or fails to surpass rated speed (1,850 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, check the EPOS trouble codes at display.

Unless any EPOS trouble codes are displayed, 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)
- Power boost circuit.
- 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

WARNING

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	40 ± 5 bar (580 ± 73 psi)	40 ± 5 bar (580 ± 73 psi)

POWER MODE VALVE

Current Signal and Hydraulic Pressure Adjustments



WARNING

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.

The electromagnetic pressure proportioning control (EPPR) "power mode" valve is on the underside of the inclined plate, located main frame center, above center joint. To test and adjust power shift current and pressure through the power mode valve a multilead jumper harness is required. The jumper harness (which is available through DOOSAN After Sales Service, or could be spliced together from commonly available, purchased parts) has extra leads so that a VOM meter can be connected to the circuit.

To set up the testing equipment, shut down engine and disconnect the single electrical lead from the power mode valve. Attach the jumper harness to the terminal on the valve, connect the test leads of the multimeter to the extra leads on the harness and reconnect the valve electrical lead.

Vent the lever on top of the hydraulic tank to relieve pressure and connect an in-line "T-style" adapter to the valve pressure port. Install a 60 bar (1,000 psi) test gauge in the adapter.

Restart the engine and increase engine rpm by turning the speed control to the maximum speed setting. Warm up the engine and hydraulic system until hydraulic oil temperature is at least 45°C (113°F). Select Power Mode on the Instrument Panel. Check current readings (in milliamps) on the VOM meter and hydraulic pressure gauge readings and make sure both conform to the values in the table below.

NOTE: *If recorded values do not conform to the specified current or pressure in the table, back off the lock nut on the end of the valve, turn the adjusting screw 1/4 turn and recheck current and pressure. Repeat adjustment as required to obtain specified performance and retighten the valve lock nut.*

Mode	Engine RPM	Current	Pressure
Power Mode	High Idle: 1,900 rpm	150 ± 20 mA Mid-range value corresponding to engine rpm for both current and hydraulic pressure readings.	0 bar (0 psi)
Standard Mode	High Idle: 1,850 rpm	250 mA	9 bar (130.5 psi)

SWING PRIORITY VALVE

Control Valve Pressure and Current Adjustments

WARNING

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.

The swing priority control valve is inside the compartment behind the cabin.

The same jumper harness used for testing the power mode (EPOS) control valve is used to test this valve. Shut down engine, disconnect either of the electrical leads and connect the test equipment to that side of the valve. An in-line "T-style" gauge adapter can be used to connect a 60 bar/870 psi (1,000 psi) test gauge to the outlet (pressure) side of the valve. Set the engine control speed dial to maximum and warm up the engine to at least 45°C (113°F) before making any tests.

NOTE: *Vent air from the hydraulic system before installing test equipment. Use the lever on the reservoir, while the engine is running. Pour clean replacement fluid back into the system if excessive fluid was lost.*

To verify operation of the swing priority solenoid valve, connect test equipment and begin testing with the work mode switch set to "digging" (the state turning off the "trenching" light) and the engine speed control dial at the maximum rpm position.

Operate the swing motor in both directions. Measure signal current and hydraulic pressure through the valve and record the highest and lowest values as the swing motor rotate clockwise and counterclockwise several times. Reset the work mode control to "trenching" mode and repeat the same tests.

Valve Function / Work Mode	Signal Voltage	Hydraulic Pressure
Swing Priority / Digging	0 V	0 bar (0 psi)
Swing Priority / Trenching	20 - 30 V	20 - 40 bar (290 - 580 psi)

NOTE: *If recorded values do not conform to the specified current or pressure in the table, readjust as required.*

PRESSURE UP VALVE

Checks and Adjustments

WARNING

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 to install an in-line "T-style" adapter and test gauge (60 bar/1,000 psi) at the pilot pump signal port relief valve outlet.

Start the engine and turn the engine speed dial to maximum. When normal operating temperature is reached:

- Check pilot pressure and readjust it, if required:
- Select the Instrument Panel rear pump "pressure display".
- Select Power Mode.
- Stall the boom cylinder (towards the extend side).
- Read rear pump pressure on the Instrument Panel display.

Repeat all tests with and without "pressure up" selected through the console rocker switch and joystick button.

If the two-stage main relief valve was not set correctly and main relief high-stage pressure ("pressure up") is outside the tolerance range, begin valve adjustment by loosening the outside (widest diameter) lock nut on the relief valve. Turn the adjusting screw clockwise to increase pressure, or counterclockwise to decrease it. Pressure must be 350 bars (5075 psi), or up to 10 bars (145 psi) higher.

Because one adjustment can affect the other, check low-stage main relief pressure by repeating the cylinder stall test without "pressure up." Readjust standard relief pressure by turning the innermost (smallest diameter) screw clockwise to increase the setting, or counterclockwise to decrease it. Pressure should be at least 330 bars (4,785 psi), but less than 335 bars (4,858 psi).

IMPORTANT

Pressure adjustments and checks cannot be made if pilot pressure is outside the specified range. Refer to the pilot pump adjustment procedure if required, then proceed with any necessary adjustments to main relief pressure settings.

Power Mode	Operation	Main Pressure and Tolerance	Pilot Pressure and Tolerance
Power Mode	Neutral, No Operation	20 - 40 bar (290 - 580 psi)	30 bar +10 bar (435 psi +145 psi)
Power Mode	Cylinder Stall	330 bar +5 bar (4,785 psi +75 psi)	30 bar +10 bar (435 psi +145 psi)
Power Mode W/ Pressure Up	Cylinder Stall	350 bar +10 bar 5,075 psi +145 psi	30 bar +10 bar (435 psi +145 psi)

NOTE: *The electrical pressure up (power boost) solenoid valve alongside the swing priority solenoid and arm speed control solenoid, in compartment rear of the operator's cabin, must be operating correctly, or pressure tests and further adjustments cannot be made.*

PUMP INPUT POWER CONTROL

Pump Regulator Adjustment

WARNING

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.

To perform these adjustments accurately the use of a flow meter is strongly recommended, as is consulting the factory (before starting work) to validate the need for making regulator adjustments. Vent hydraulic pressure from the reservoir before breaking the seal on fittings to install the flow meter kit. (Refer to the "Flow meter Installation and Testing" procedure.)

IMPORTANT

Before starting this procedure or going onto make any changes of adjustment settings:

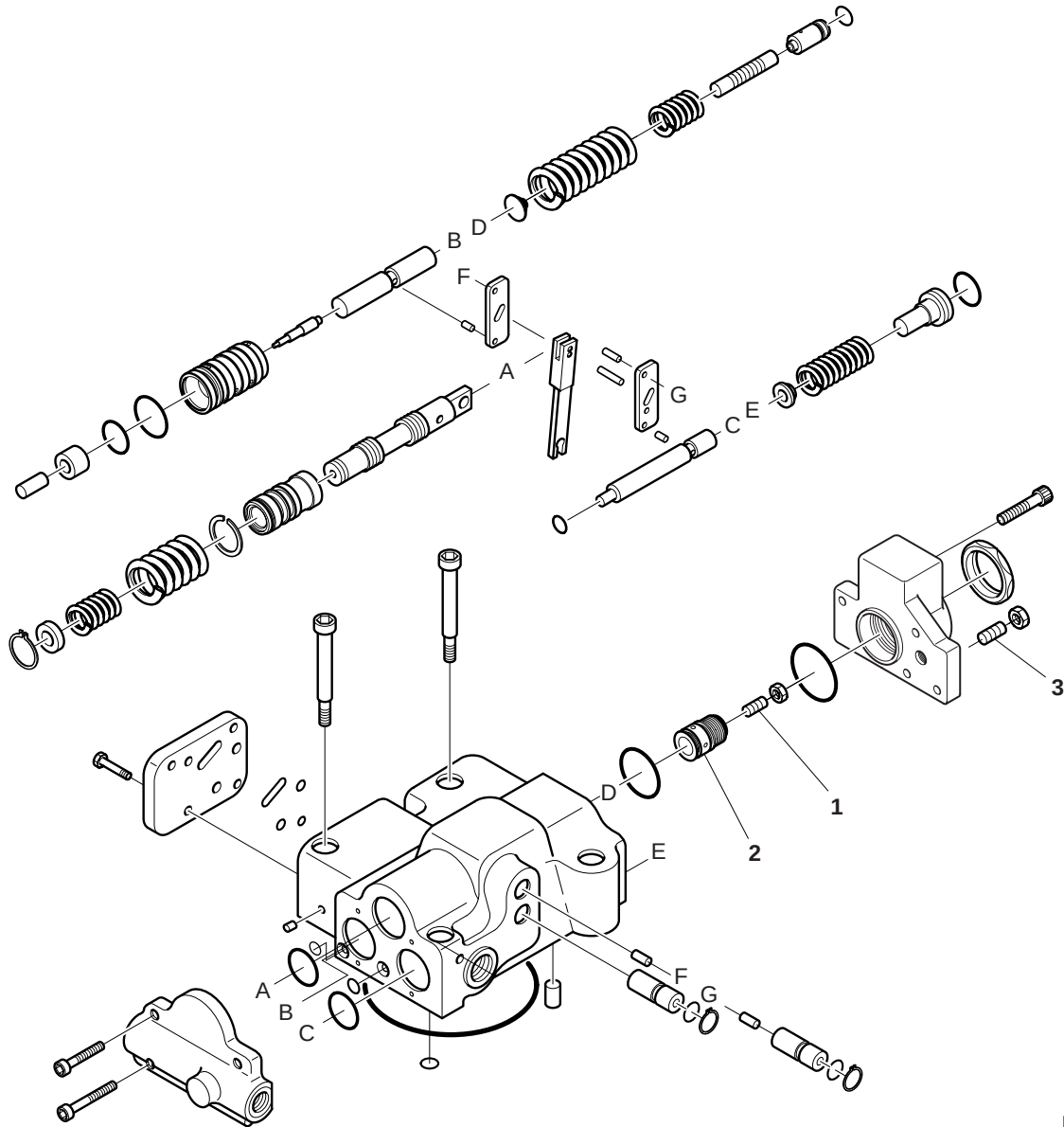
- **Verify engine output to the rated speed – $1,950 \pm 50$ rpm.**
 - **Permanently mark setscrew positions at the current regulator control setting.**
-

Use a scribe or other permanent marker to identify a reference point on adjusting screws with a corresponding reference on the body of the valve. The adjustment process affects a complex balance and could require some time to complete. If adjustment has to be interrupted or postponed, reference marks at the adjustment point allow immediate restoration of original performance.

This adjustment procedure is normally performed:

- If the engine is being consistently overloaded (and engine troubleshooting shows engine performance to be at or above rated output).
- If reduced cylinder speed and diminished work performance provide an indication that rated, maximum pump flow may not be available (and all other troubleshooting gives no indication of other flaws or hydraulic system defects).
- If pump output is out of balance and one pump is failing to keep up with the output flow of the other.

To check pump imbalance without a flow meter, travel the excavator forward on flat, level terrain. If the machine veers off despite neutral control input and even, balanced track adjustment, the pump which supplies output to the track frame toward which the excavator is veering is weak.



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Figure 12

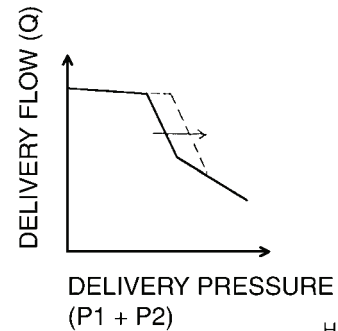
Refer to the illustration of the pump regulator control valve (Figure 12) for the location of adjustment screws (1, 2 and 3). There are two different adjustments, along with the Negacon, negative control, adjustment screw (3, directly below 1 and 2). Each one of the adjustment procedures could affect the setting of the others.

Check and record the arm dump speed performance test before and after input power adjustment, whether or not a flow meter is used.

NOTE: *Regulator adjustments affect total cumulative horsepower, since each regulator compensates for the output of the other. It is not necessary to adjust both regulators at the same time, but after checking or adjusting one of them, the remaining unit should also be checked.*

Start the engine and turn the engine speed dial to maximum. When normal operating temperature is reached, loosen the largest diameter lock nut around the adjustment screw (2) for the outer regulator spring. Tightening the screw shifts the P/Q (Pressure/Flow) control curve to the right, and increases compensating control pressure.

On the other hand, if the persistent cause of performance problems is engine overloading, decreasing the adjustment by turning the larger diameter adjusting screw (2) out will decrease pump input horsepower. 1/4 turn on the adjusting screw is equal to approximately 17 horsepower.



HAAD4090

Figure 13

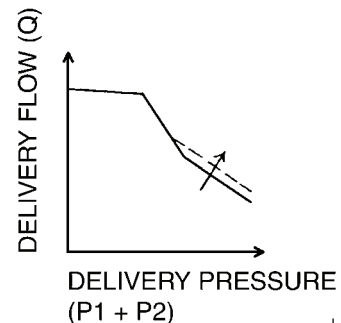
IMPORTANT

Because changing the position of adjusting screw (2) also affects the setting of the adjustment for the inner spring, the smaller diameter adjusting screw (1), turn in the inner screw 198° (slightly more than 1/2 turn, 180°) before screw (2) is backed out 1/4 turn (90°).

NOTE: *For each full turn of adjustment on the larger diameter screw (2), the square-tipped adjusting screw should be turned in the opposite direction 2.2 turns to avoid changing inner spring adjustment.*

Pump input power adjustments are normally made in small increments, 1/4 turn (90°) or less, each time.

Turning the square-tipped, smaller diameter screw (1) clockwise moves the flow curve up, increasing flow and then input horsepower.

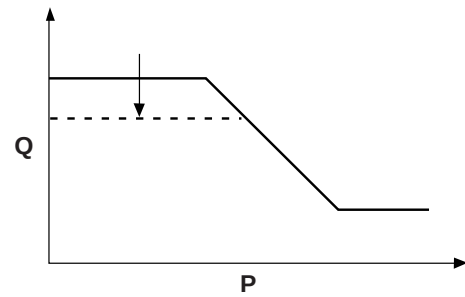


HAAD4100

Figure 14

The adjusting screw (1, Figure 12) affects the delivery rate (Q) of the pump. Tightening the adjusting screw decreases the maximum cut flow (as shown in Figure 15) while backing out the screw increases cut flow delivery rate.

Balance both pumps for equal output.



HDA3008L

Figure 15

FLOW METER AND FLOW METER KIT INSTALLATION AND TESTING

Checking regulator and pump output, to assess the output balance between the front and rear pumps and to verify operating adjustment of each regulator, will require installation of a flow meter.

The After Sales Service department of the nearest local DOOSAN dealer can assist you with these tests or, if you prefer carrying out your own testing, they should be able to help in putting together a hose and fitting kit (or the required dimensions and specifications for hoses and fittings) to allow you to install a flow meter downstream from the main pump assembly.

Installation and Testing Procedure

- Shut down engine and operate controls to release hydraulic pressure from the accumulator.
- Vent the reservoir to release all pressure from the hydraulic system.
- Remove guard panels from around the main pump assembly.
- Disconnect the main pump discharge output line. Install the input flange of the flow meter on the pump end of the output line.
- Cap off the unused (input) end of the pump discharge line with a blocking flange.
- Connect a premeasured length of hydraulic hose, between the output end of the flow meter assembly and the top of the reservoir. Use appropriate fittings and adapter flanges to guarantee a pressure tight seal.

NOTE: *Be sure to maintain even tightening torque on all flange fittings. Use Loctite brand "PST 545" (or an alternate manufacturer's hydraulic system joint seal) if required, to give an airtight seal.*

- An assistant – who must remain at the operator's control station at all times – should restart the engine and run it long enough (at minimum rpm) to de-aerate the system and warm up the engine and hydraulic system to operating temperature.

Record the values of all test results in three columns, comparing 1) pump pressure (from the instrument panel display) with 2) measured flow, in gallons or liters per minute, from the installed flow meter.

The third column of test results should provide a record of engine rpm measured during each of the following tests – with the engine speed control dial set at maximum, the power mode selector at Power Mode and the work mode selector at digging mode:

- Unloaded maximum engine speed baseline test (all controls in neutral).
- Front pump test – operate "travel right" lever. Record values at all specified pressures.
- Rear pump test – operate "travel left" lever. Record values at all specified pressures.

Record the values for each of the three tests (neutral, travel right and travel left) at the following pump pressure levels, with travel speed control set at "high speed."

Engine RPM	Pressure	Flow
	100 kg/cm ² (1,422 psi)	
	135 kg/cm ² (1,930 psi)	
	180 kg/cm ² (2,560 psi)	
	240 kg/cm ² (3,413 psi)	
	320 kg/cm ² (4,550 psi)*	
	*See below note.	

Compare recorded values with output shown in the P-Q curve in the specifications section of this book.

If test results do not measure up to specified values, pump output tests can be repeated using different control levers. Recheck front pump operation while stroking the bucket cylinder out lever, and the rear pump by actuating the swing control lever.

NOTE: *When testing bucket and swing functions, read maximum flow tests at 330 kg/cm² (4,785 psi), not 350 kg/cm² (5075 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 into a clean, clear container. Look for metal shavings/grit, cloudiness/water or foam/air bubbles in the oil.
NOTE: *Dispose of drained fluids according to local regulations.*
- 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 270 and 280 bar (3,916 psi and 4,060 psi), with both swing locks engaged. With swing locks released, during full acceleration and deceleration, pressure should approach 250 bar (3,625 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 13 bar (190 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 (190 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-diagnostic 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 "fail-safe" 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 "03" 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

Table of Contents

Accumulator

Safety Precautions	5
Applicable Models	5
General Description	6
Specifications	8

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up
DX340LC	5001 and Up
DX420LC	5001 and Up
DX480LC	5001 and Up
DX520LC	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

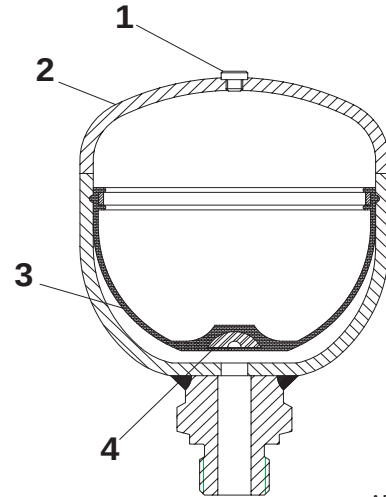


Figure 1

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.

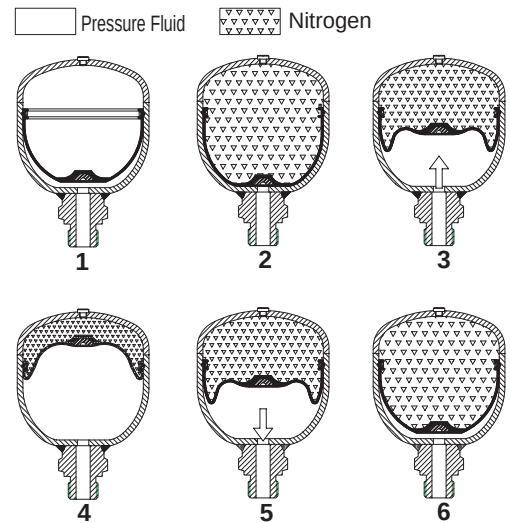


Figure 2

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 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
DX140LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX140LCR	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX180LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX225LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX225NLC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX255LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX300LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX340LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX420LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX480LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)
DX520LC	S/N 5001 and Up	Pilot	10 kg/cm ² (140 psi)	320 cc (19.53 in ³)

Center Joint (Swivel)

Edition 1

MEMO

Table of Contents

Center Joint (Swivel)

Safety Precautions	5
Applicable Models	5
General Description	6
Parts List	7
Troubleshooting, Testing and Adjustment	8
Inspection	8
Testing	8
Disassembly	9
Reassembly	10

MEMO

SAFETY PRECAUTIONS



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APPLICABLE MODELS

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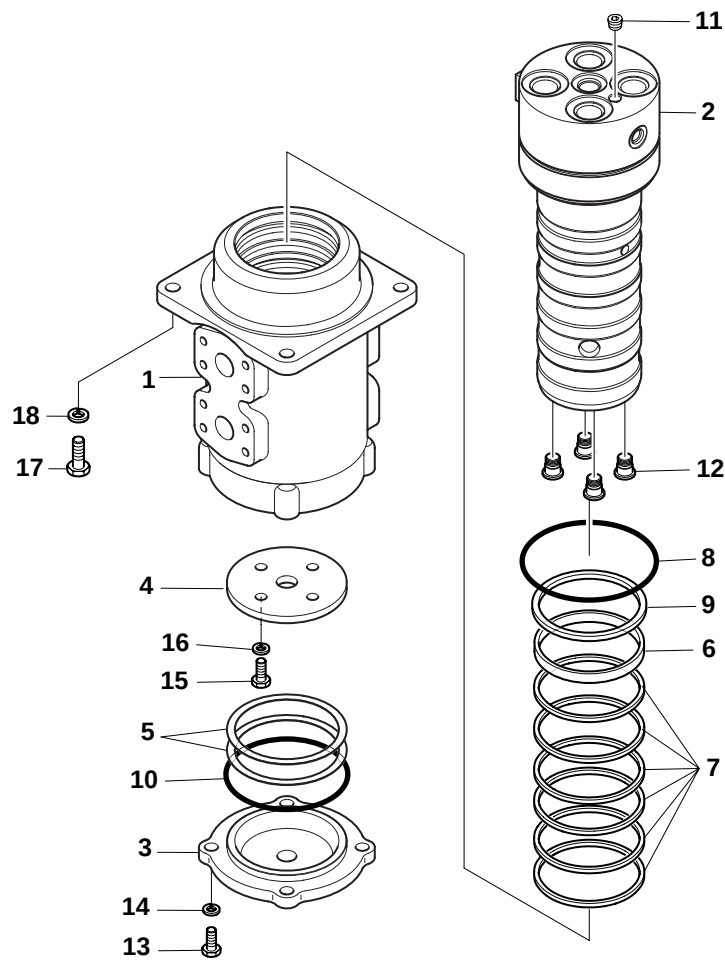
MODEL	SERIAL NUMBER RANGE
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up

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



FG000536

Figure 1

Reference Number	Description
1	Body
2	Spindle
3	Cover
4	Spacer
5	Shim
6	Wear Ring
7	Slipper Ring
8	O-ring
9	O-ring

Reference Number	Description
10	O-ring
11	Plug
12	Plug
13	Bolt
14	Spring Washer
15	Bolt
16	Spring Washer
17	Bolt
18	Spring Washer

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).

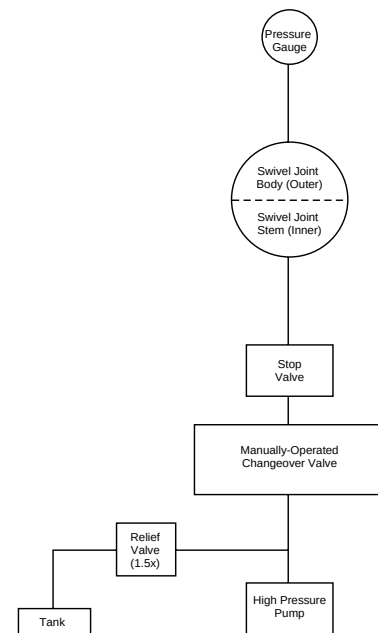


Figure 2

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. Clean off the exterior of the swivel joint after it has been removed.
2. Scribe or otherwise mark a line across the cover and the body of the center joint, to allow reassembly in the same configuration.
3. Unbolt the four 12 mm fasteners holding the cover. Use a vise or V-block to hold the assembly in place.
4. Remove the cover, withdraw the O-ring and remove the retaining ring holding the thrust plate, taking care to support the spindle assembly, so that it will not separate and fall out when retaining ring is removed.
5. If the spindle assembly doesn't separate easily when the thrust plate and retaining ring are removed, use a wooden block and hammer to drive it out of the housing.
6. O-rings and seals should be replaced whenever the assembly is being overhauled or rebuilt. For repair procedures or emergency tear down, use a thin but rounded tip, smoothedge scraper or spatula to remove O-rings or seals, to avoid causing damage to those that must be reused.

NOTE: *The "backup ring" shown in the assembly drawing (above the swivel joint spindle 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 spindle.*

7. 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.

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

Table of Contents

Cylinders

Safety Precautions	5
Applicable Models	5
General Description	6
Theory of Operation	6
Parts List	7
Special Tools and Materials	9
Piston Nut	9
Piston Jig	10
Steel Bushing Jig	12
Dust Wiper Jig	14
Slipper Seal Jig	16
Slipper Seal Straightening Jig	17
Disassembly	18
Reassembly	23

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
DX140LCR	5001 and Up
DX140LC	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up
DX340LC	5001 and Up
DX420LC	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

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 D (Figure 1).

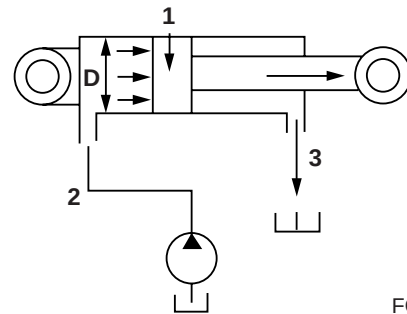
$$F_1 = P \times \frac{\pi D^2}{4}$$

(P: Pressure, π = 3.14, D: Cylinder Inside Diameter)

1	Cylinder Inside Diameter - D
2	Oil Path A
3	Oil Path B
4	Rod Diameter - R

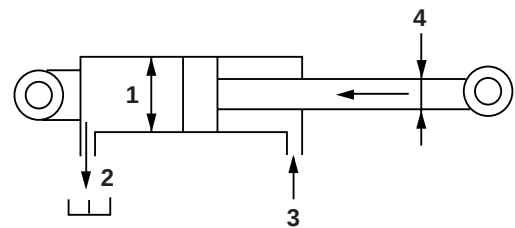
When the cylinder rod is retracted, oil flow through the circuit from the pump to the front side of the cylinder generates a force (F2) that can be expressed by the formula in which the diameter of the piston rod is expressed by R, and the other two terms are the same as in the preceding expression.

$$F_2 = P \times \frac{\pi(D^2 - R^2)}{4}$$



FG001456

Figure 1



FG001458

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 extend a cylinder than it does to retract it.

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

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

$$Q_1 > Q_2$$

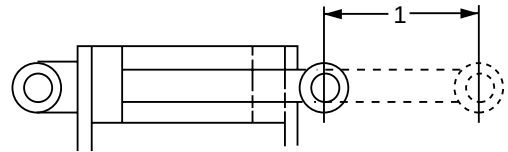


Figure 3

FG001459

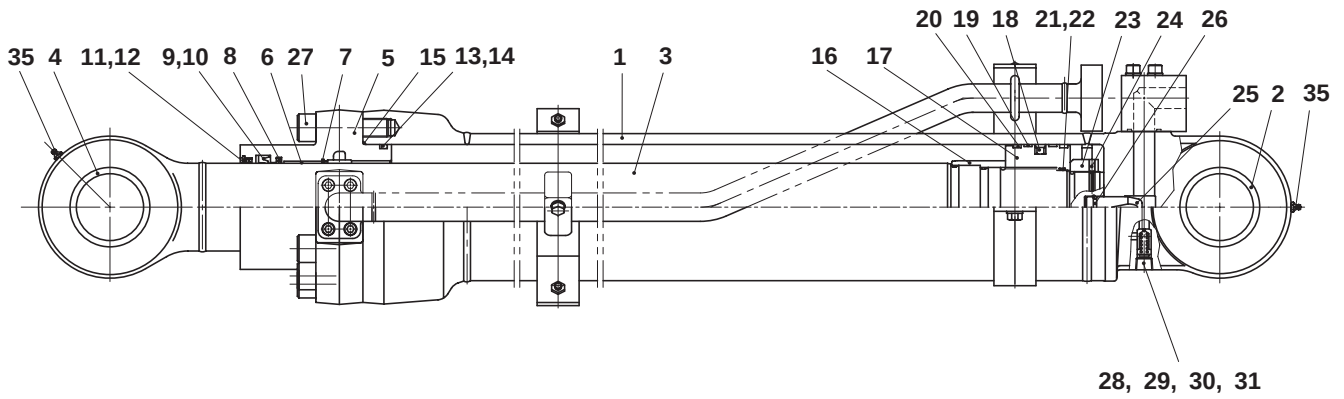
Parts List

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.

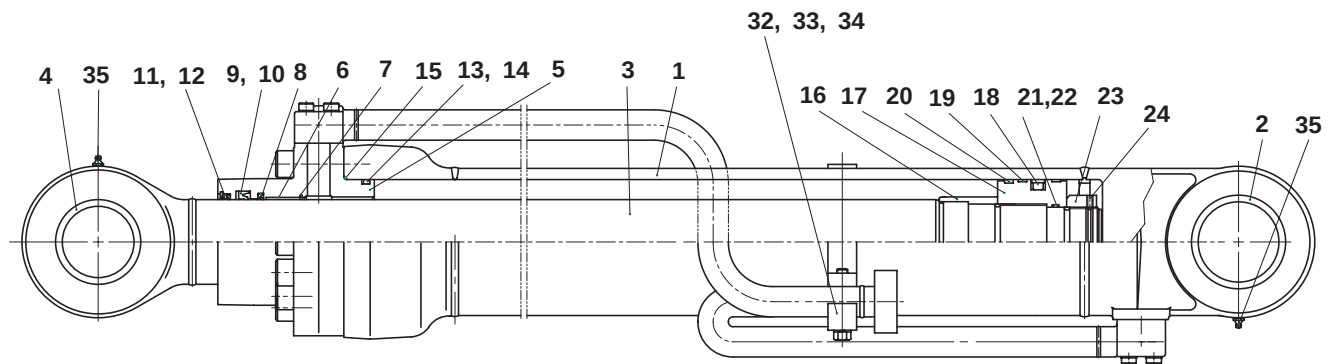
Cross section in Figure 5 shows a boom cylinder.

The bucket and boom cylinders are identical and differ only in the attached pipes.



FG005226

Figure 4



FG005227

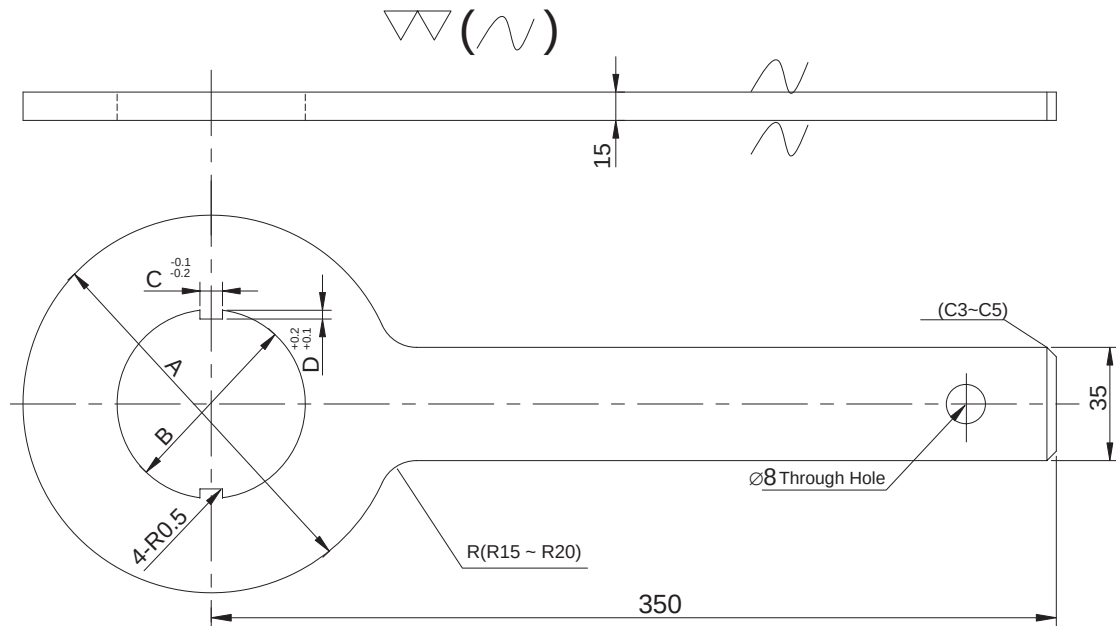
Figure 5

Reference Number	Description
1	Tube Assembly
2	Bushing
3	Rod Assembly
4	Bushing
5	Rod Cover
6	DD-Bushing
7	Retaining Ring
8	Buffer Seal
9	U-Packing
10	Backup Ring
11	Dust Wiper
12	Retaining Ring
13	O-ring
14	Backup Ring
15	O-ring
16	Cushion Ring
17	Piston
18	Slipper Seal

Reference Number	Description
19	Wear Ring
20	Ring
21	O-ring
22	Backup Ring
23	Piston Nut
24	Set Screw
25	Socket Head Bolt
26	Pipe Band Assembly
27	Hex Socket Bolt
28	Check Valve
29	Spring
30	Spring Support
31	Hex Socket Plug
32	Spring Washer
33	Hex Bolt
34	Pipe Assembly
35	Grease Nipple

SPECIAL TOOLS AND MATERIALS

Piston Nut



ARS4730L

Figure 6

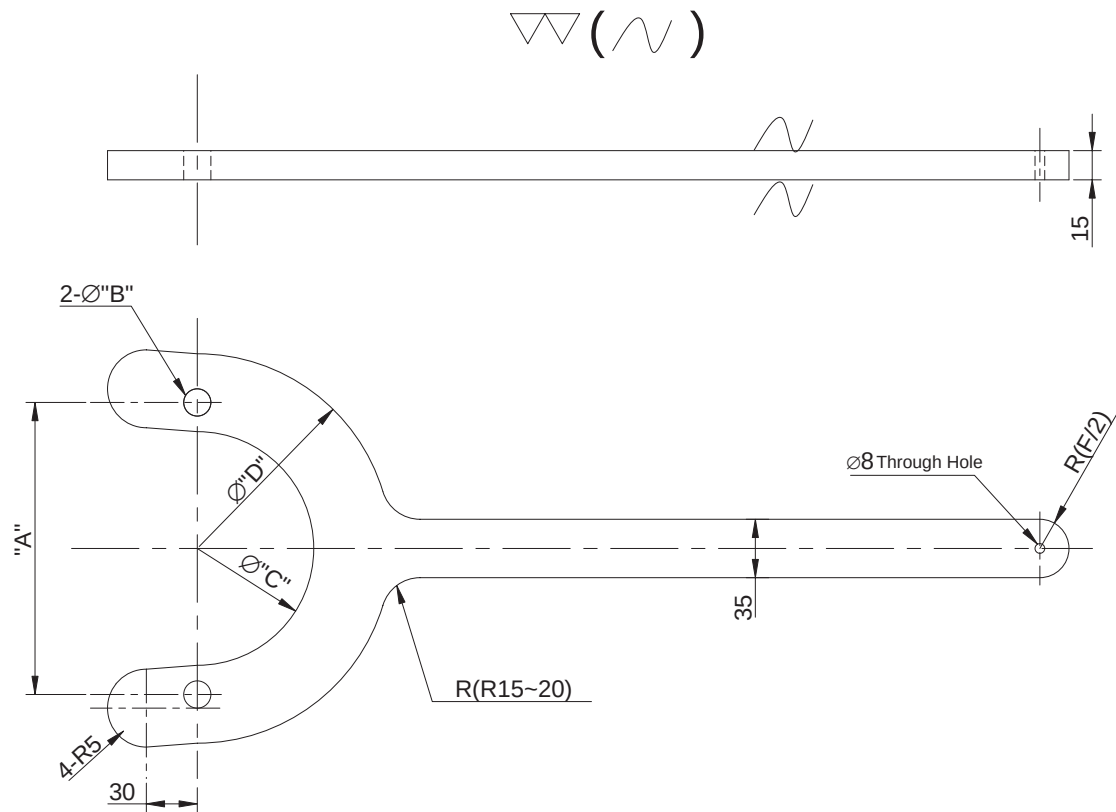
Material SM45C (AISI 1045)

Rockwell Harden from 22 - 27

Oil Quench

MODEL	CYLINDER	ØA	ØB	C	D	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	125.0 mm (4.92 in)	85.0 mm (3.35 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	130.0 mm (5.12 in)	90.0 mm (3.54 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	115.0 mm (4.53 in)	75.0 mm (2.95 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
DX180LC	BOOM	130.0 mm (5.12 in)	90.0 mm (3.54 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	140.0 mm (5.52 in)	98.0 mm (3.86 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	125.0 mm (4.92 in)	85.0 mm (3.35 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
DX225LC	BOOM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	130.0 mm (5.11 in)	89.0 mm (3.50 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
DX225NLC	BOOM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	130.0 mm (5.11 in)	89.0 mm (3.50 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
DX255LC	BOOM	140.0 mm (5.52 in)	98.0 mm (3.86 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	140.0 mm (5.52 in)	98.0 mm (3.86 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
DX300LC	BOOM	142.0 mm (5.59 in)	102.0 mm (4.02 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	147.0 mm (5.79 in)	107.0 mm (4.21 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	S/ARM
	BUCKET	140.0 mm (5.52 in)	98.0 mm (3.86 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	S/BUCKET
DX340LC	BOOM	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	OPT BOOM
	ARM	147.0 mm (5.79 in)	107.0 mm (4.21 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	OPT ARM
	BUCKET	145.0 mm (5.71 in)	105.0 mm (4.13 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	OPT BUCKET
DX420LC	BOOM	147.0 mm (5.79 in)	107.0 mm (4.21 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	ARM	147.0 mm (5.79 in)	107.0 mm (4.21 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	
	BUCKET	155.0 mm (6.10 in)	115.0 mm (4.53 in)	12.0 mm (0.47 in)	5.0 mm (0.20 in)	

Piston Jig



ARS4740L

Figure 7

Material SM45C (AISI 1045)

Rockwell Harden from 22 - 27

Oil Quench

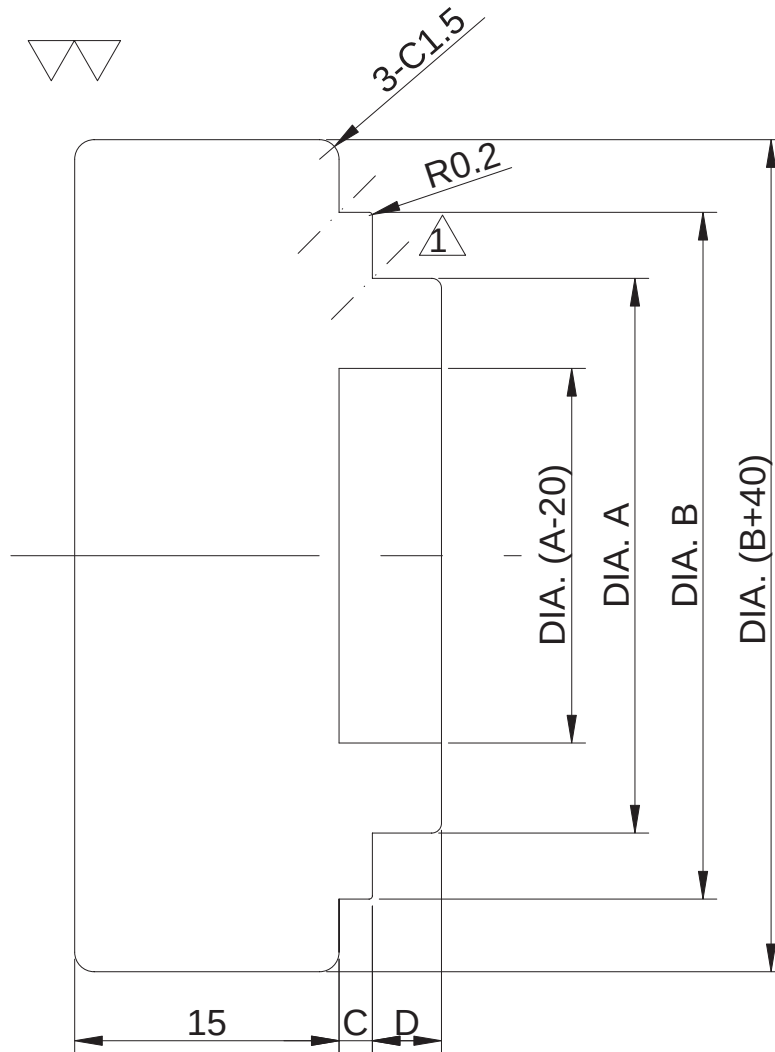
MODEL	CYLINDER	A (±0.1)	ØB	ØC	ØD	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	80.0 mm (3.15 in)	11.0 mm (0.43 in)	58.0 mm (2.28 in)	110.0 mm (4.33 in)	
	ARM	80.0 mm (3.15 in)	11.0 mm (0.43 in)	58.0 mm (2.28 in)	110.0 mm (4.33 in)	
	BUCKET	70.0 mm (2.76 in)	11.0 mm (0.43 in)	46.0 mm (1.81 in)	95.0 mm (3.74 in)	
DX180LC	BOOM	90.0 mm (3.54 in)	11.0 mm (0.43 in)	63.0 mm (2.48 in)	115.0 mm (4.53 in)	
	ARM	96.0 mm (3.78 in)	13.0 mm (0.51 in)	69.0 mm (2.72 in)	130.0 mm (5.12 in)	
	BUCKET	80.0 mm (3.15 in)	11.0 mm (0.43 in)	58.0 mm (2.28 in)	110.0 mm (4.33 in)	
DX225LC	BOOM	90.0 mm (3.54 in)	11.0 mm (0.43 in)	63.0 mm (2.48 in)	115.0 mm (4.53 in)	
	ARM	110.0 mm (4.33 in)	13.0 mm (0.51 in)	75.0 mm (2.95 in)	140.0 mm (5.51 in)	
	BUCKET	90.0 mm (3.54 in)	11.0 mm (0.43 in)	63.0 mm (2.48 in)	115.0 mm (4.54 in)	
DX225NLC	BOOM	90.0 mm (3.54 in)	11.0 mm (0.43 in)	63.0 mm (2.48 in)	115.0 mm (4.53 in)	
	ARM	110.0 mm (4.33 in)	13.0 mm (0.51 in)	75.0 mm (2.95 in)	140.0 mm (5.51 in)	
	BUCKET	90.0 mm (3.54 in)	11.0 mm (0.43 in)	63.0 mm (2.48 in)	115.0 mm (4.54 in)	
DX255LC	BOOM	96.0 mm (3.78 in)	13.0 mm (0.51 in)	69.0 mm (2.72 in)	130.0 mm (5.12 in)	
	ARM	110.0 mm (4.33 in)	13.0 mm (0.51 in)	76.0 mm (2.99 in)	140.0 mm (5.51 in)	
	BUCKET	96.0 mm (3.78 in)	13.0 mm (0.51 in)	69.0 mm (2.72 in)	130.0 mm (5.12 in)	
DX300LC	BOOM	110.0 mm (4.33 in)	13.0 mm (0.51 in)	76.0 mm (2.99 in)	140.0 mm (5.51 in)	
	ARM	120.0 mm (4.72 in)	13.0 mm (0.513 in)	85.0 mm (3.35 in)	150.0 mm (5.91 in)	S/ARM
	BUCKET	110.0 mm (4.33 in)	13.0 mm (0.51 in)	76.0 mm (2.99 in)	140.0 mm (5.51 in)	S/BUCKET
DX340LC	BOOM	120.0 mm (4.72 in)	13.0 mm (0.51 in)	85.0 mm (3.35 in)	150.0 mm (5.91 in)	OPT BOOM
	ARM	130.0 mm (5.12 in)	13.0 mm (0.513 in)	93.0 mm (3.66 in)	165.0 mm (6.50 in)	OPT ARM
	BUCKET	120.0 mm (4.72 in)	13.0 mm (0.51 in)	85.0 mm (3.35 in)	150.0 mm (5.91 in)	OPT BUCKET
DX420LC	BOOM	130.0 mm (5.12 in)	13.0 mm (0.51 in)	93.0 mm (3.66 in)	165.0 mm (6.50 in)	
	ARM	130.0 mm (5.12 in)	13.0 mm (0.513 in)	93.0 mm (3.66 in)	165.0 mm (6.50 in)	
	BUCKET	130.0 mm (5.12 in)	13.0 mm (0.51 in)	93.0 mm (3.66 in)	165.0 mm (6.50 in)	



1 Place: Finally work to used DNMG Tip <Nose R0.4>

MODEL	CYLINDER	$\varnothing A_{-0.05}^{-0.15}$	$\varnothing B (\pm 0.1)$	E	$F_{+0.05}^0$	Part	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	71.0 mm (2.80 in)	86.0 mm (3.39 in)	40.0 mm (1.57 in)	6.5 mm (0.26 in)		
	ARM	71.0 mm (2.80 in)	86.0 mm (3.39 in)	40.0 mm (1.57 in)	7.0 mm (0.28 in)		
	BUCKET	65.0 mm (2.56 in)	80.0 mm (3.14 in)	30.0 mm (1.81 in)	6.0 mm (0.24 in)		
DX180LC	BOOM	71.0 mm (2.80 in)	86.0 mm (3.39 in)	50.0 mm (1.97 in)	6.0 mm (0.24 in)		
	ARM	71.0 mm (2.80 in)	86.0 mm (3.39 in)	50.0 mm (1.97 in)	6.0 mm (0.24 in)		
	BUCKET	71.0 mm (2.80 in)	86.0 mm (3.39 in)	50.0 mm (1.97 in)	6.0 mm (0.24 in)		
DX225LC	BOOM	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
	ARM	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
	BUCKET	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
DX225NLC	BOOM	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
	ARM	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
	BUCKET	80.0 mm (3.15 in)	95.0 mm (3.74 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		
DX255LC	BOOM	90.0 mm (3.54 in)	105.0 mm (4.13 in)	40.0 mm (1.58 in)	7.0 mm (0.28 in)		
	ARM	80.0 mm (3.15 in)	95.0 mm (3.74 in)	35.0 mm (1.38 in)	6.5 mm (0.26 in)		
	BUCKET	80.0 mm (3.15 in)	95.0 mm (3.74 in)	35.0 mm (1.38 in)	6.5 mm (0.26 in)		
DX300LC	BOOM	90.0 mm (3.54 in)	105.0 mm (4.13 in)	40.0 mm (1.58 in)	7.0 mm (0.28 in)		
	ARM	90.0 mm (3.54 in)	105.0 mm (4.13 in)	40.0 mm (1.58 in)	6.5 mm (0.26 in)		S/ARM
	BUCKET	90.0 mm (3.54 in)	105.0 mm (4.13 in)	40.0 mm (1.58 in)	7.0 mm (0.28 in)		S/BUCKET
DX340LC	BOOM	100.0 mm (3.94 in)	115.0 mm (4.53 in)	45.0 mm (1.77 in)	7.5 mm (0.30 in)		OPT BOOM
	ARM	100.0 mm (3.94 in)	115.0 mm (4.53 in)	45.0 mm (1.77 in)	7.5 mm (0.30 in)		OPT ARM
	BUCKET	100.0 mm (3.94 in)	115.0 mm (4.53 in)	45.0 mm (1.77 in)	7.5 mm (0.30 in)		OPT BUCKET
DX420LC	BOOM	110.0 mm (4.33 in)	130.0 mm (5.12 in)	70.0 mm (2.76 in)	11.0 mm (0.43 in)		
	ARM	110.0 mm (4.33 in)	130.0 mm (5.12 in)	70.0 mm (2.76 in)	11.0 mm (0.43 in)		
	BUCKET	110.0 mm (4.33 in)	130.0 mm (5.12 in)	70.0 mm (2.76 in)	11.0 mm (0.43 in)		

Dust Wiper Jig



ARS4760L

Figure 9

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	$\varnothing A_{-0.3}^{-0.2}$	$\varnothing B_{-0.3}^{-0.2}$	$C_{-0.1}^0$	D	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	75.0 mm (2.95 in)	89.0 mm (3.50 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
	ARM	80.0 mm (3.15 in)	94.0 mm (3.70 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
	BUCKET	65.0 mm (2.56 in)	79.0 mm (3.11 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
DX180LC	BOOM	80.0 mm (3.15 in)	94.0 mm (4.29 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
	ARM	90.0 mm (3.54 in)	104.0 mm (4.10 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
	BUCKET	75.0 mm (2.95 in)	89.0 mm (3.50 in)	6.0 mm (0.24 in)	7.0 mm (0.28 in)	
DX225LC	BOOM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	ARM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	BUCKET	80.0 mm (3.15 in)	94.0 mm (3.70 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
DX225NLC	BOOM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	ARM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	BUCKET	80.0 mm (3.15 in)	94.0 mm (3.70 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
DX255LC	BOOM	90.0 mm (3.54 in)	104.0 mm (4.10 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	ARM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	BUCKET	90.0 mm (3.54 in)	104.0 mm (4.10 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
DX300LC	BOOM	95.0 mm (3.74 in)	109.0 mm (4.29 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	ARM	105.0 mm (4.13 in)	121.0 mm (4.76 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	S/ARM
	BUCKET	90.0 mm (3.54 in)	104.0 mm (4.10 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	S/BUCKET
DX340LC	BOOM	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	OPT BOOM
	ARM	115.0 mm (4.53 in)	131.0 mm (5.16 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	OPT ARM
	BUCKET	100.0 mm (3.94 in)	114.0 mm (4.49 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	OPT BUCKET
DX420LC	BOOM	115.0 mm (4.53 in)	131.0 mm (5.16 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	ARM	120.0 mm (4.72 in)	136.0 mm (5.35 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	
	BUCKET	110.0 mm (4.33 in)	126.0 mm (4.96 in)	6.0 mm (0.24 in)	7.0 mm (2.28 in)	

Slipper Seal Jig

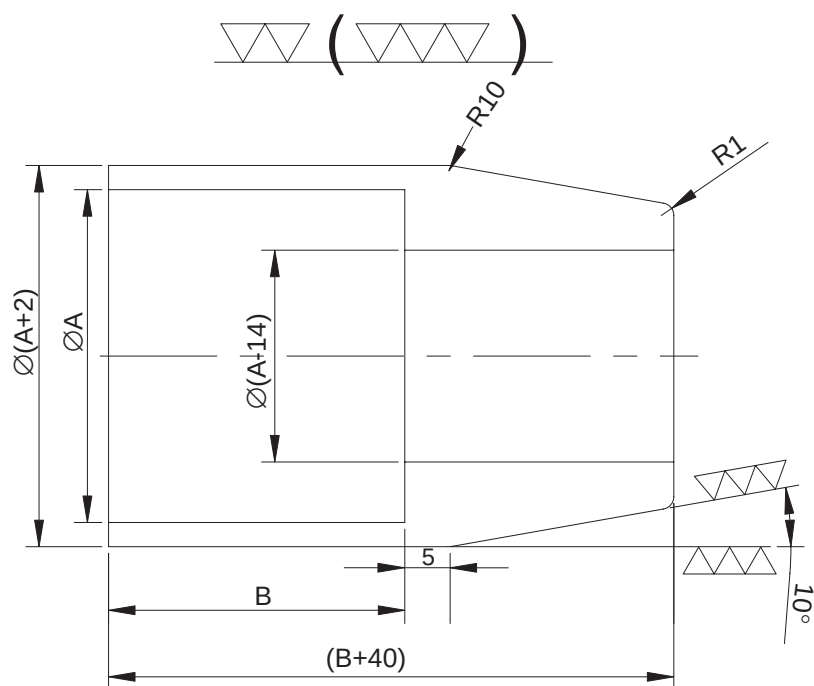


Figure 10

ARS4770L

MODEL	CYLINDER	$\varnothing A^{+0.2}_{+0.1}$	$B^{+0.2}_{+0.1}$	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	110.0 mm (4.33 in)	28.5 mm (1.12 in)	
	ARM	115.0 mm (4.53 in)	28.5 mm (1.12 in)	
	BUCKET	95.0 mm (3.74 in)	28.5 mm (1.12 in)	
DX180LC	BOOM	115.0 mm (4.53 in)	28.5 mm (1.12 in)	
	ARM	125.0 mm (4.92 in)	28.5 mm (1.12 in)	
	BUCKET	110.0 mm (4.33 in)	28.5 mm (1.12 in)	
DX225LC	BOOM	140.0 mm (5.51 in)	28.5 mm (1.12 in)	
	ARM	150.0 mm (5.91 in)	28.5 mm (1.12 in)	
	BUCKET	120.0 mm (4.72 in)	28.5 mm (1.12 in)	
DX225NLC	BOOM	140.0 mm (5.51 in)	28.5 mm (1.12 in)	
	ARM	150.0 mm (5.91 in)	28.5 mm (1.12 in)	
	BUCKET	120.0 mm (4.72 in)	28.5 mm (1.12 in)	
DX255LC	BOOM	130.0 mm (5.12 in)	28.5 mm (1.12 in)	
	ARM	140.0 mm (5.51 in)	28.5 mm (1.12 in)	S/ARM
	BUCKET	130.0 mm (5.12 in)	28.5 mm (1.12 in)	S/BUCKET
DX300LC	BOOM	140.0 mm (5.51 in)	28.5 mm (1.12 in)	
	ARM	150.0 mm (5.91 in)	28.5 mm (1.12 in)	S/ARM
	BUCKET	140.0 mm (5.51 in)	28.5 mm (1.12 in)	S/BUCKET
DX340LC	BOOM	150.0 mm (5.91 in)	28.5 mm (1.12 in)	OPT BOOM
	ARM	170.0 mm (6.69 in)	34.5 mm (1.36 in)	OPT ARM
	BUCKET	150.0 mm (5.91 in)	28.5 mm (1.12 in)	OPT BUCKET
DX420LC	BOOM	165.0 mm (6.50 in)	34.5 mm (1.36 in)	OPT BOOM
	ARM	180.0 mm (7.09 in)	41.5 mm (1.63 in)	OPT ARM
	BUCKET	160.0 mm (6.30 in)	34.5 mm (1.36 in)	OPT BUCKET

Slipper Seal Straightening Jig

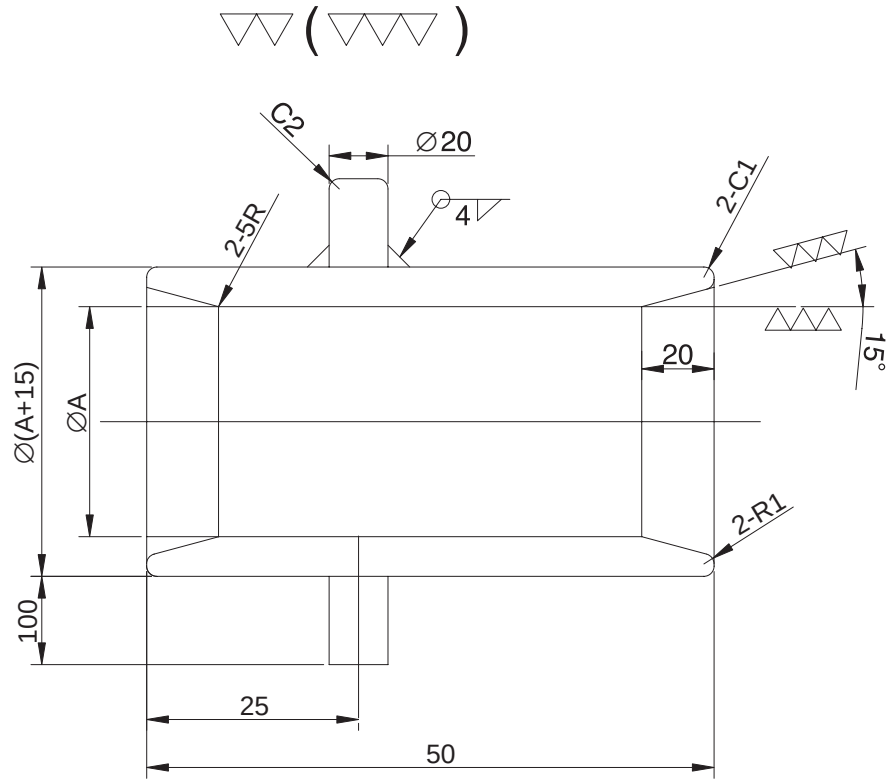


Figure 11

ARS4780L

MODEL	CYLINDER	$\varnothing A_{+0.1}^{+0.2}$	MODEL (CYLINDER)
DX140LC / DX140LCR	BOOM	110.0 mm (4.33 in)	
	ARM	115.0 mm (4.53 in)	
	BUCKET	95.0 mm (3.74 in)	
DX180LC	BOOM	115.0 mm (4.53 in)	
	ARM	125.0 mm (4.92 in)	
	BUCKET	110.0 mm (4.33 in)	
DX225LC	BOOM	140.0 mm (5.51 in)	
	ARM	150.0 mm (5.91 in)	
	BUCKET	120.0 mm (4.72 in)	
DX225NLC	BOOM	140.0 mm (5.51 in)	
	ARM	150.0 mm (5.91 in)	
	BUCKET	120.0 mm (4.72 in)	
DX255LC	BOOM	130.0 mm (5.12 in)	
	ARM	140.0 mm (5.51 in)	S/ARM
	BUCKET	130.0 mm (5.12 in)	S/BUCKET
DX300LC	BOOM	140.0 mm (5.51 in)	
	ARM	150.0 mm (5.91 in)	S/ARM
	BUCKET	140.0 mm (5.51 in)	S/BUCKET
DX340LC	BOOM	150.0 mm (5.91 in)	OPT BOOM
	ARM	170.0 mm (6.69 in)	OPT ARM
	BUCKET	150.0 mm (5.91 in)	OPT BUCKET
DX420LC	BOOM	165.0 mm (6.50 in)	OPT BOOM
	ARM	180.0 mm (7.09 in)	OPT ARM
	BUCKET	160.0 mm (6.30 in)	OPT BUCKET

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.

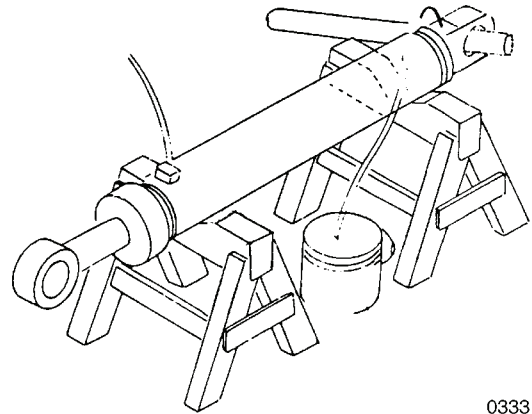


Figure 12

0333

2. Position piston rod so that it is extended approximately one half meter (20").

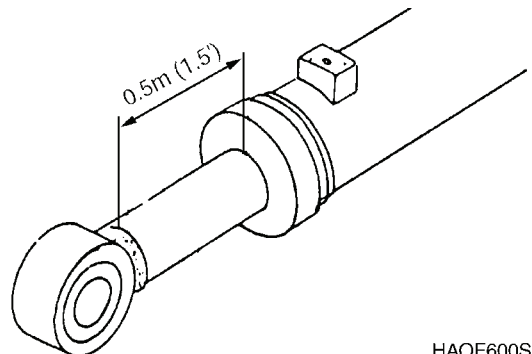


Figure 13

HAOF600S

3. Remove bolts (27) 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.

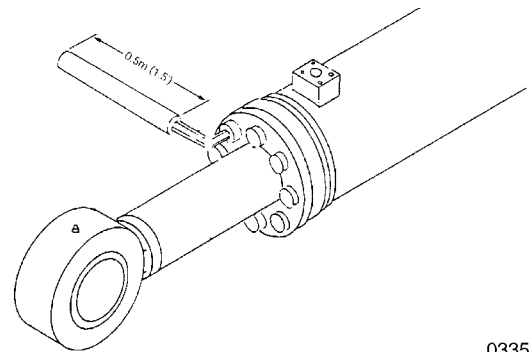
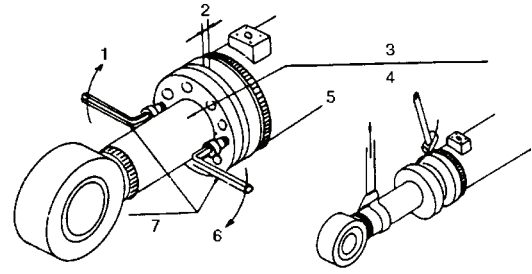


Figure 14

0335

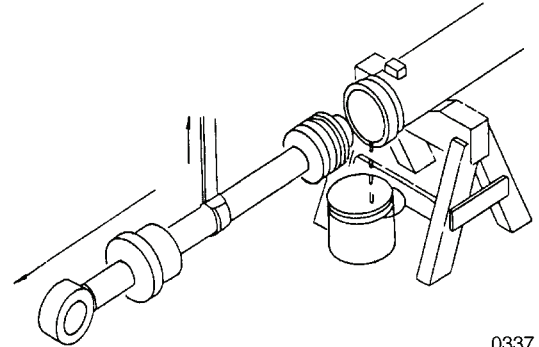
4. Tap two bolts into cover of cylinder head, 180° apart. Tighten them in a staggered, even sequence, to back off piston rod end cover from edge of cylinder wall. Look for adequate clearance between cover and end of cylinder wall before using a plastic or other soft-faced hammer for final disassembly.



HAOF610S

Figure 15

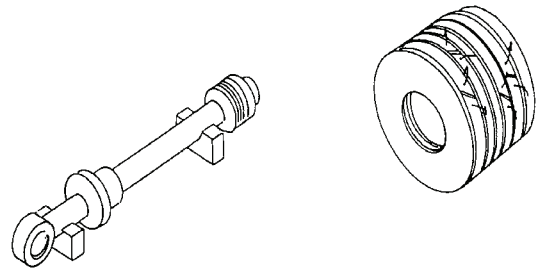
5. Begin withdrawing piston rod assembly, away from cylinder. Attach a lifting support when final 1/3 of rod is still inside barrel of cylinder. Prepare support blocks for piston rod before it has been completely withdrawn.



0337

Figure 16

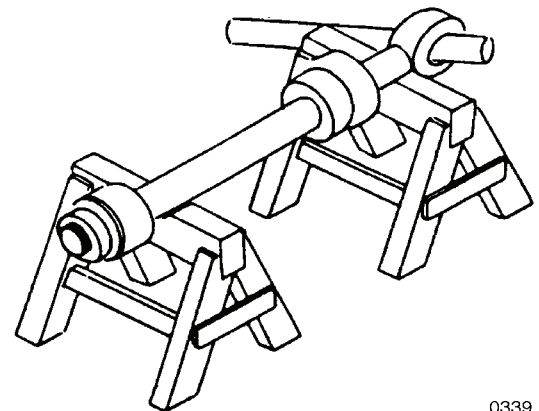
6. Lower piston rod to support blocks and detach wear ring (outer surface) (19) from end of rod.



HAOF620S

Figure 17

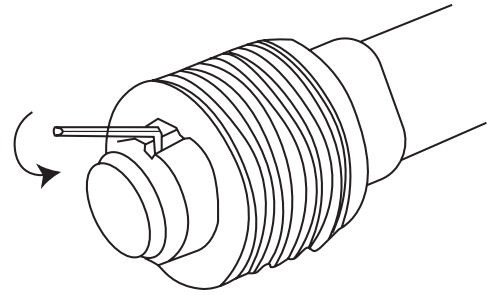
7. Immobilize piston rod by inserting a wooden or other nonscoring, nonmetallic support through end of rod.



0339

Figure 18

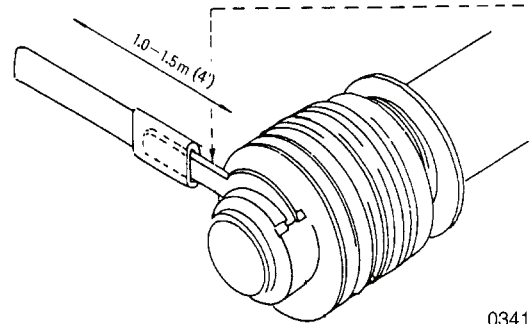
8. Remove set screw using socket wrench.



HAOF340L

Figure 19

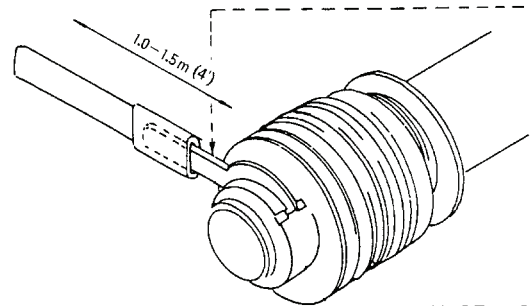
9. Fabricate or purchase a piston nut removal wrench. (Dimensions are called off at beginning of this procedure. This tool may also be ordered through your local *DOOSAN* Parts distributor). Remove nut from end of piston.



0341

Figure 20

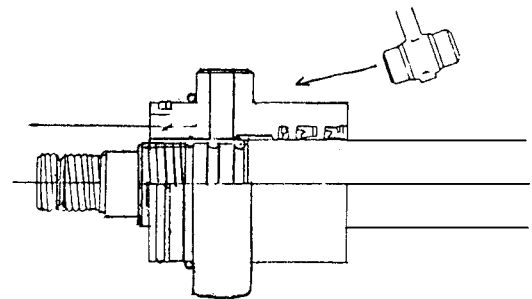
10. Use second piston tool described at beginning of this procedure to separate piston. Detach cushion ring (16), taking care not to damage cushion ring.



HAOF630S

Figure 21

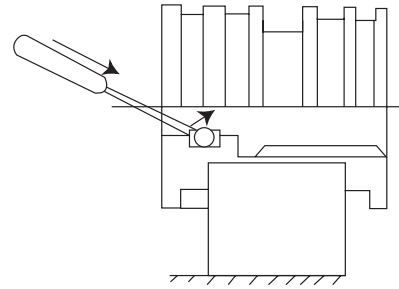
11. Use a plastic hammer to evenly pull off rod cover (5) from end of piston rod. Be careful not to damage rod bushing (6) and dust wiper, U-packing and other seals.



HAOF350S

Figure 22

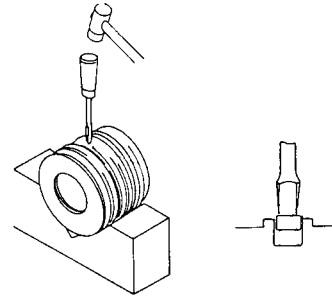
12. Use a dull, rounded tip tool to pry off O-ring (13) and backup ring (14).



HAOF37OL

Figure 23

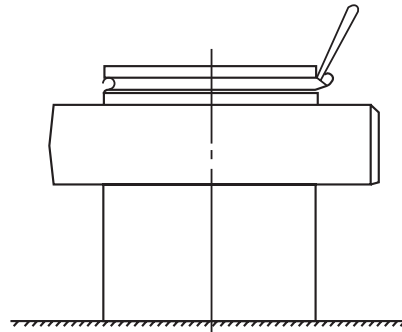
13. Find a screwdriver with an appropriate width tip to facilitate removal of slipper seal (18), wear ring (19) and slide ring (20) from piston (17).



0345

Figure 24

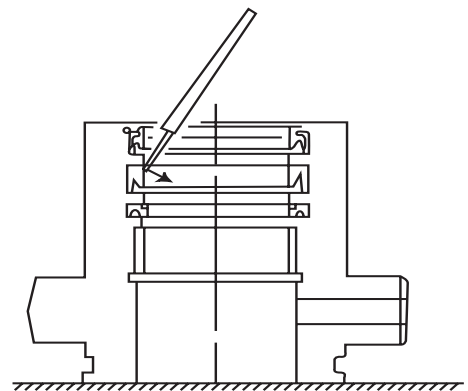
14. Remove O-ring (21) and backup ring (22) from cylinder head.



HAOF38OS

Figure 25

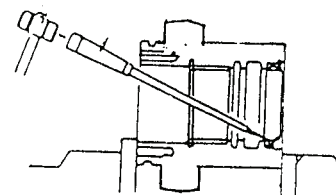
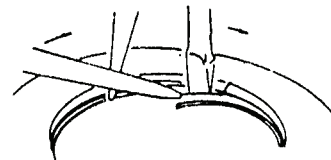
15. During disassembly of cylinder head, be careful not to damage buffer seal (8) and U-packing (9).



HAOF39OL

Figure 26

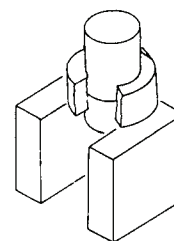
16. Disassemble retaining ring (12) and dust wiper (11).
Separate retaining ring (7) and rod bushing (6).



HAOF400S

Figure 27

17. Force out pin bushing (2), (4) from body of cylinder.



0349

Figure 28

REASSEMBLY

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 reassembly 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 reassembly procedure.

NOTE: Reassemble the subassemblies of the cylinder in the following order:

1. Body of the cylinder.
2. Piston rod.
3. Piston assembly.
4. Cylinder head assembly.

1. Reassemble pin bushing (2), (4) to piston rod and body of cylinder.
2. Following reassembly of rod cover components, install the dust wiper (11) and rod bushing (6) to the rod cover (5). Insert retaining rings (7 and 12).

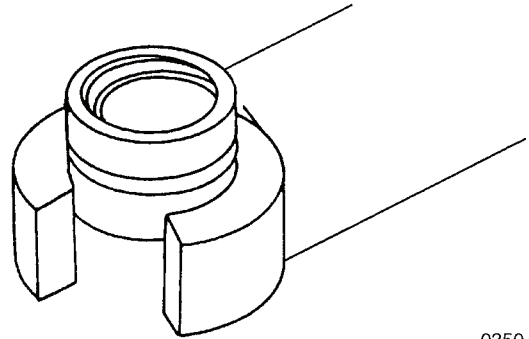


Figure 29

0350

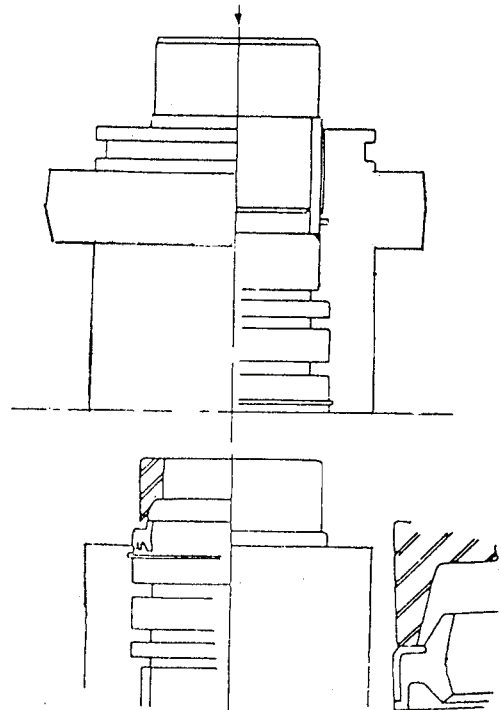


Figure 30

HAOF440S

3. Prelubricate O-rings and seals before reassembly (Figure 31).

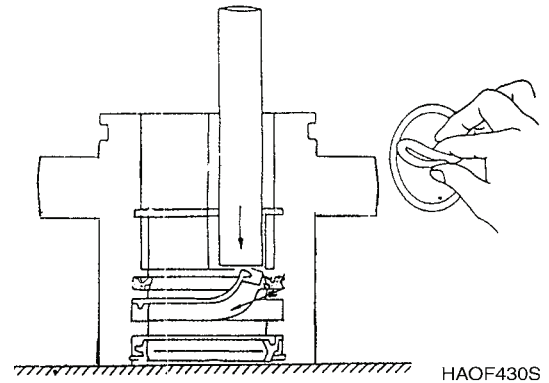


Figure 31

HAOF430S

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.

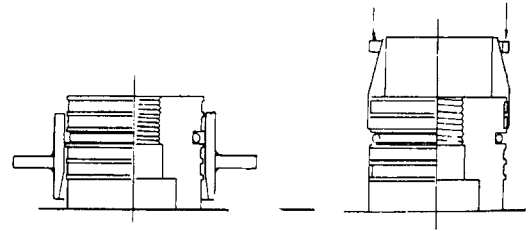


Figure 32

0353

5. Immobilize piston rod on solid support blocks. Assemble O-ring (21) and backup ring (22). Prepare to attach rod cover assembly to piston rod. Push rod cover by tightening piston nut (23).

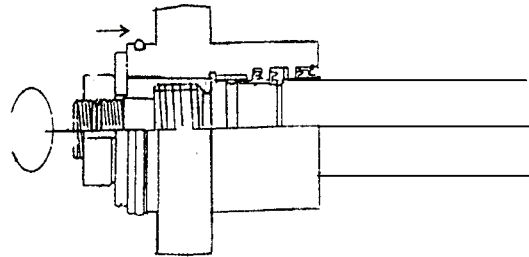


Figure 33

HAOF450S

6. Assemble cushion ring (16) and attach piston assembly to piston rod.

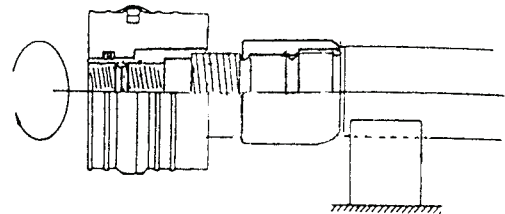


Figure 34

HAOF460S

7. Use specially fabricate or factory sourced tool to tighten piston nut (23).

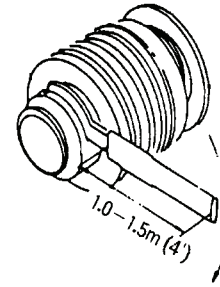


Figure 35

0356

8. Assemble wear ring (19), slide ring (20) and set screw (24) to piston assembly.

Reference Number	Description
1	Set Screw

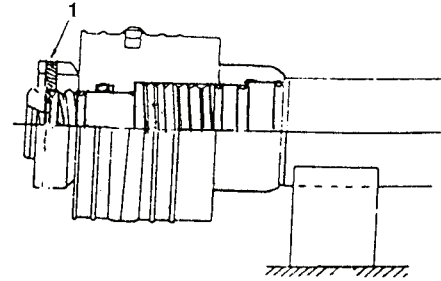


Figure 36

HAOF470S

9. Immobilize body of cylinder before reassembly.

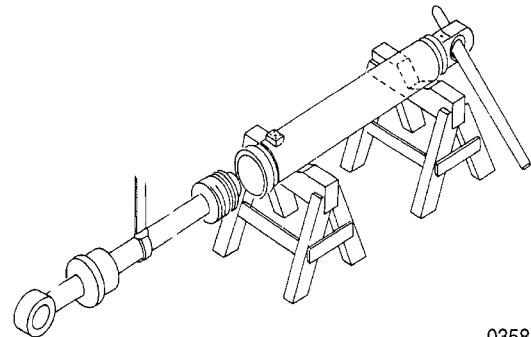


Figure 37

0358

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.

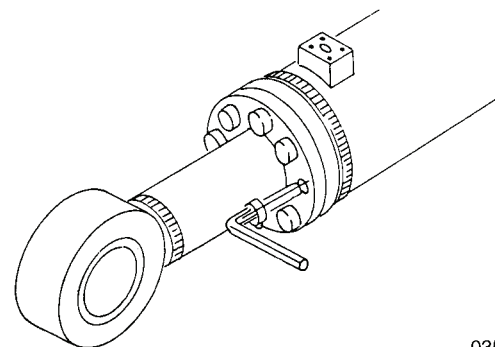


Figure 38

0359

Swing Motor

Edition 1

MEMO

Table of Contents

Swing Motor

Safety Precautions	5
Applicable Models	5
Instruction Manual	6
Indication of Type	6
Specifications	7
Construction and Principles of Working	8
Precaution in Use	15
Troubleshooting.....	19
Maintenance Manual	22
Disassembling and Assembling	22
Maintenance Standards	35

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
DX140LCR	5001 and Up

TSM 72 CH B — 10 A -03 / 270



Specifications

Name	TSM72CHB-10A-03/270-IRV
Displacement (cc•rev)	72
Pressure (kg•cm ²)	270
Theoretical output torque (kgf•m)	30.9
Rated flow (min)	132
Maximum speed (rpm)	1,833
Brake torque (kgf•m)	36.8
Brake release pressure (kgf•cm ²)	24
Weight (kgf)	41.3

NOTE: **1. The theoretical value at the rated pressure, not including mechanical efficiency.*

**2. The theoretical value at the rated pressure and the max. speed.*

Construction and Principles of Working

Construction

The Construction

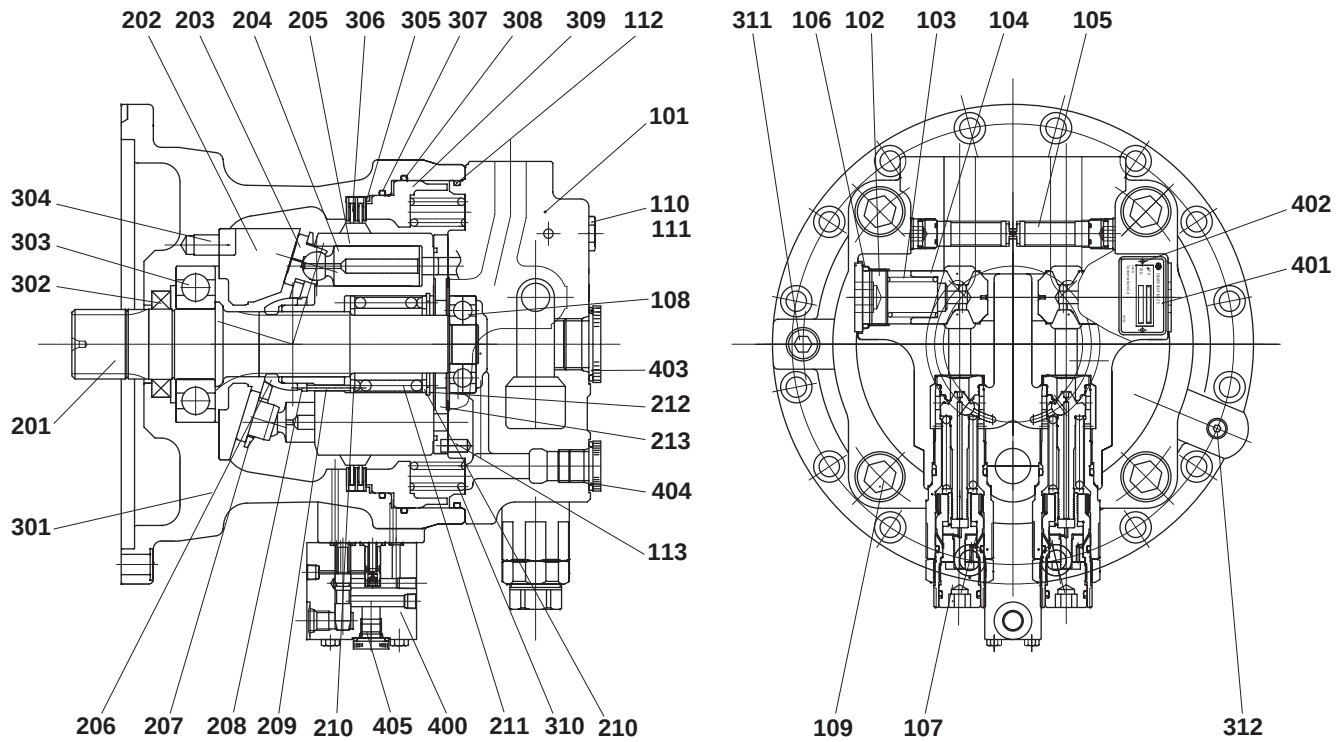


Figure 1 Construction of Motor

Parts No. and Names

Reference Number	Description
101	Valve Casing
102	Plug
103	Spring
104	Plunger
105	Swing Reactionless Valve Ass'y
106	O-ring
107	Relief Valve
108	Ball Bearing
109	Socket Bolt
110	Vp Plug
111	O-ring
112	O-ring
113	Pin Spring
201	Driveshaft
202	Swash Plate
203	Shoe
204	Piston
205	Cylinder Block
206	Thrust Ball
207	Retainer Plate
208	Collar

Reference Number	Description
209	Roller
210	Washer
211	Spring
212	Ring Snap
213	Valve Plate
301	Casing
302	Oil Seal
303	Ball Bearing
304	Parallel Pin
305	Separation Plate
306	Friction Plate
307	O-ring
308	O-ring
309	Brake Piston
310	Brake Spring
311	PT-plug
312	PT-plug
400	Brake Valve
401	Nameplate
402	Rivet Screw

Principles of Working

Motor Part

High-pressure oil from the control valve is routed through valve casing and valve plate to pistons. When the oil enters the cylinder bores through port, it forces the pistons against the fixed inclined swash plate (F1,F2). The force (F2) causes the piston shoes to slide on the swash plate forcing the rotating group to turn, thereby rotating the output shaft.

During the second half of the motor's revolution, low-pressure oil is discharged as the pistons ride toward a higher position on the shoe plate.

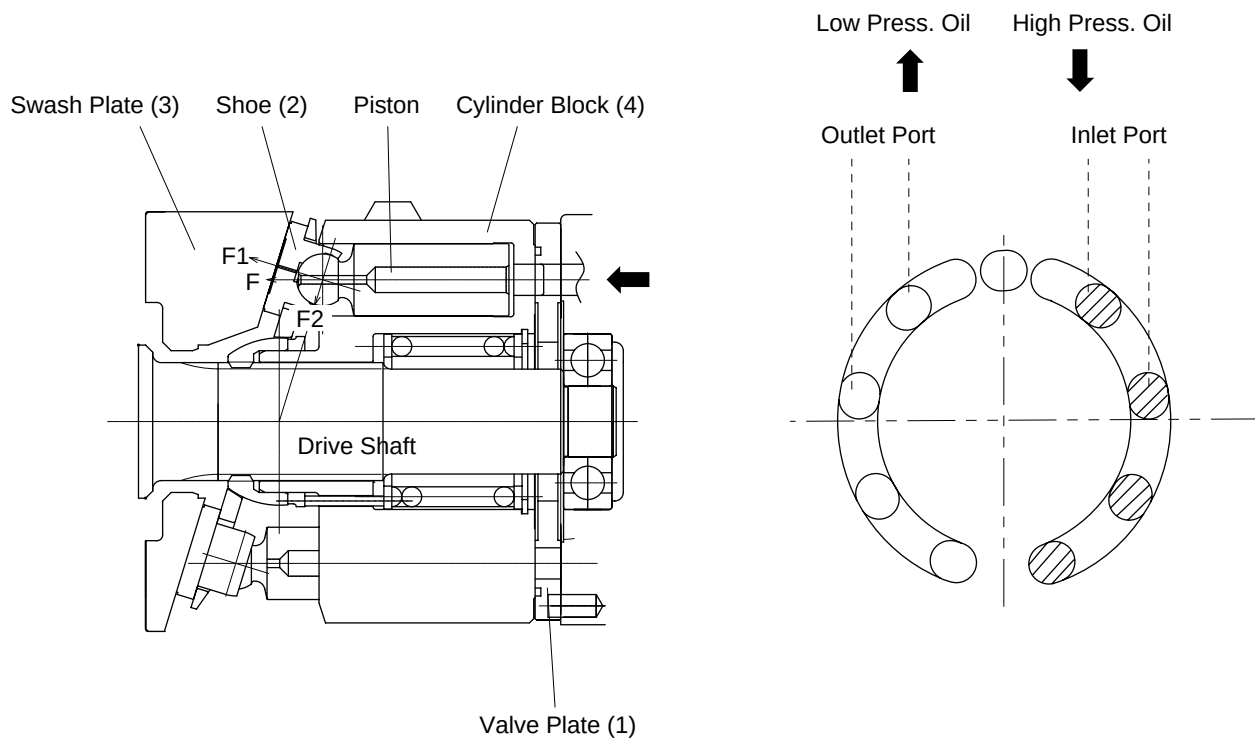
A small amount of supply oil flows through the center of each piston to lubricate the piston ball joint and the piston shoe face. The motor is internally lubricated from leakage inside the motor.

To reverse rotation, system oil flow is changed from inlet port to outlet port and viceversa. Theoretical output torque is as follow formula.

$$T = \frac{p \times q}{2 \times \pi}$$

p : Effective Pressure (kg•cm²)

q : Displacement (cc/rev)



FG007419

Figure 2 Diagram Showing the Working Explanation

Valve Casing Part

1. Anticavitation Check Valve

The motor can be rotated faster than supplied oil flow because there is no counterbalancing valve to prevent over speed ;

to prevent cavitation of the motor, oil compensation insufficient flow is drawn through the anti-cavitation check valve.

2. Relief Valve: KRD22EK10C (See Figure 4 on page -12)

We consider that port P is applied pressure by tank pressure.

Port P, R are affected by tank pressure at first, as shown fig. 3-(1). The relief valve starts operating when the force that is determined by multiply the pressure area (A1) of plunger (301) by pressure P1 is equal to the sum spring (321) force (Fsp) and the force that is determined by multiply the pressure area (A2) by pressure Pg of room 'g' in the plunger (301).

Here, Pg is the pressure of room 'g' applied pressure by passing oil through orifice m. If Pg arrives at the pressure which is determined by spring (321) pushing the piston (302), the piston move to left side. when piston (302) move left side, room 'h' operates as damping room because of orifice (n) which is designed at the side of adjustment plug (401) and piston (302). Because of this mechanism, the pressure of room 'g' increases smoothly while the piston (302) reaches end of adjustment plug (401). (Figure 4-(2))

$$P1 \times A1 = Fsp + Pg \times A2$$

$$P1 = \frac{Fsp + Pg \times A2}{A1}$$

If the piston (302) reaches end of adjustment plug (401), it doesn't move left side anymore. So, the pressure of room 'g' is Ps and spring (321) force is Fsp. (Figure 4-(3)) Therefore, the pressure P changes as shown Figure 4-(4). The pressure (Ps) of last state is following equation.

$$P1 \times A1 = Fsp' + Pg \times A2$$

$$P1 = \frac{Fsp'}{A1 - A2}$$

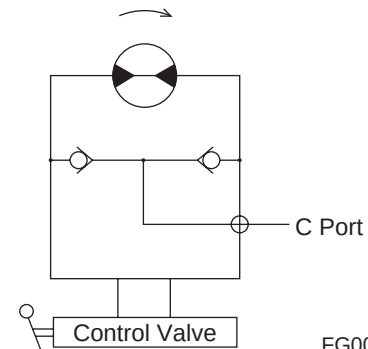
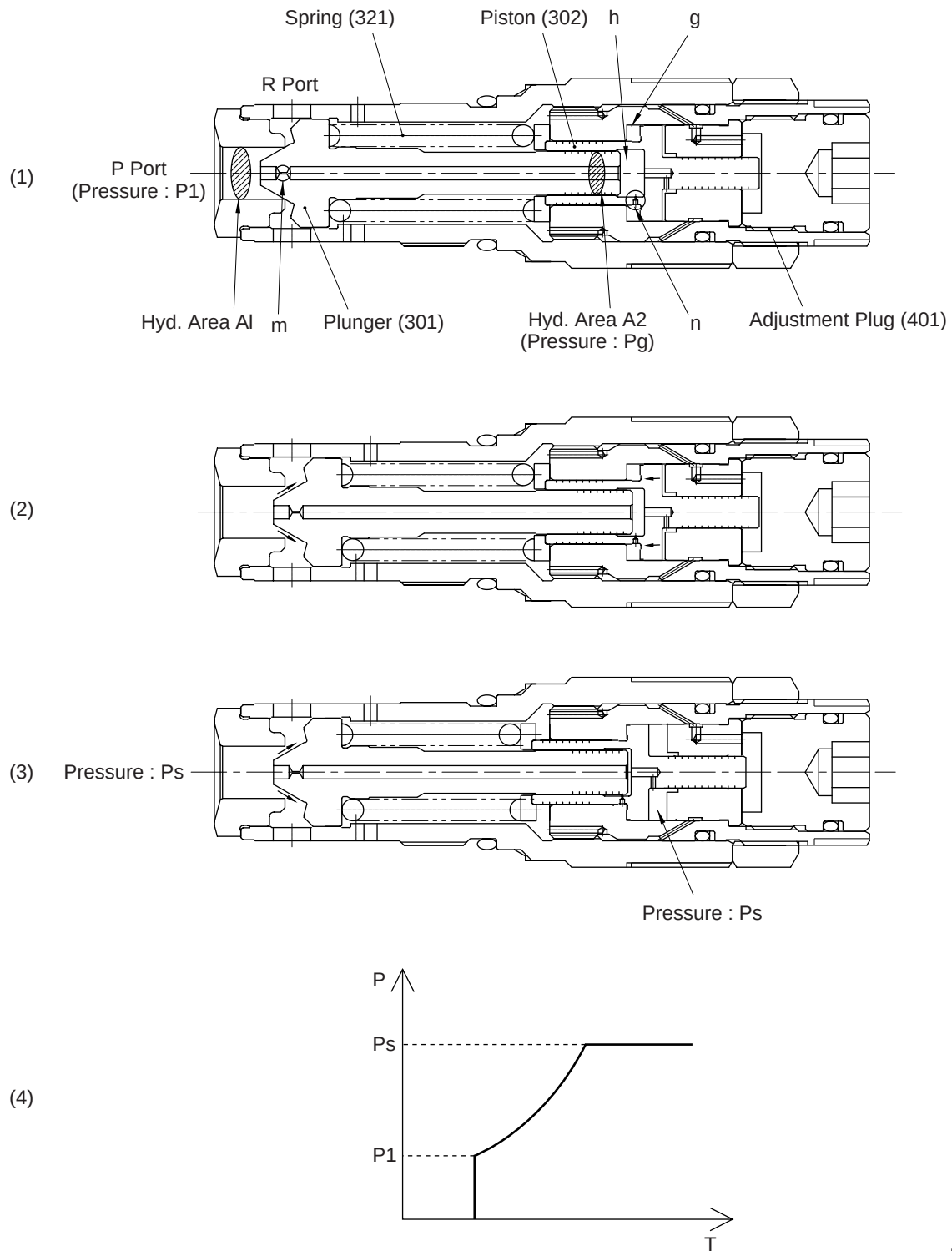


Figure 3

FG007421



FG007422

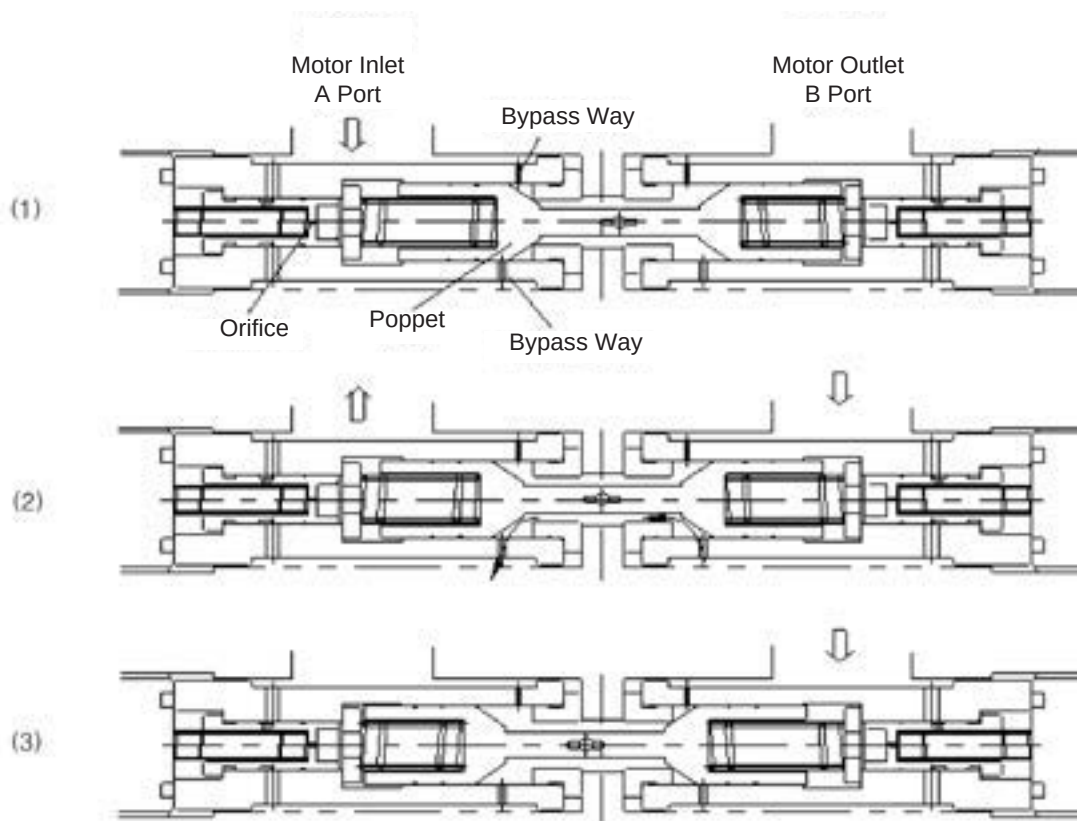
Figure 4 Relief Valve : KRD22EK10C Working Description

3. Swing Reactionless Valve

By the spool's shift in the main control valve, oil is supplied to Hydraulic motor's A port (or B port), and moving the poppet of reactionless valve, blocks the bypass and operates swing-device. (Figure 5-(1))

Returning the spool to neutral position, block the two ports of Hydraulic motor, but the swing-device tends to swing by inertia-force. The swing force is transmitted to hydraulic motor by reduction gear. After stops the swing-device by brake pressure which is created in B port (or A port) and tends to shift to the opposite direction. Because of the brake pressure, the swing device stop, first, and tends to reverse. Although the oil pressure of B port tries to shift the poppet to left side, delays the operating by the orifice of the A port. At this time, forms bypass between A port and B port, and the pressure oil in B port flows into A port through the bypass. (Figure 5-(2))

And the B side poppet moves to left side till blocking the bypass. (Figure 5-(3)) At the reverse pressure generating process of B port, this process prevents the reverse and stop the motor by bypassing the pressure oil to A port.

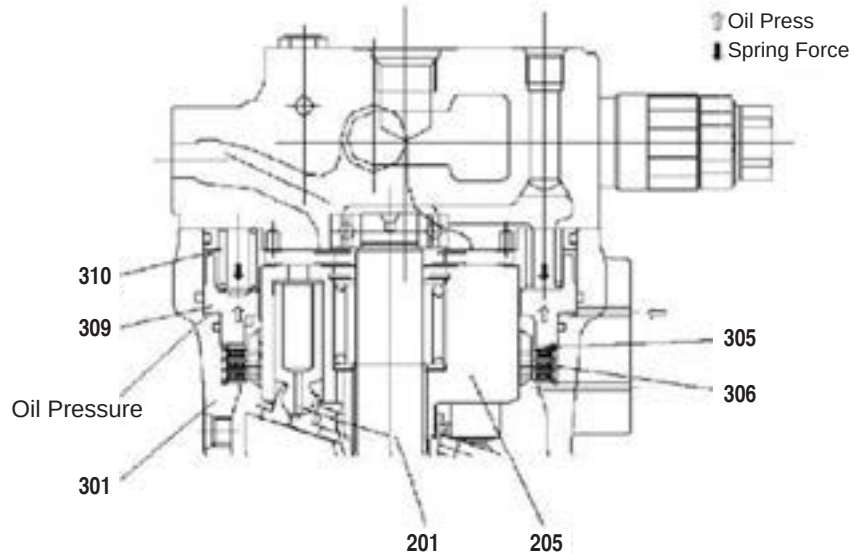


FG0074231

Figure 5 Swing Reactionless Valve Working Description

4. Brake Part

The swing brake is spring applied and hydraulically released. Friction plate are splined to and rotate with cylinder block (111). separation plates (743) are splined to the motor casing (301). When the swing controller blocks pilot pressure at port (SH), the brake springs (712) force on brake piston (702) squeeze the separation and friction plates together to prevent the upper structure from swinging.



FG007424

Figure 6 Brake Working Description

Precaution in Use

Inspection

Before installation of a new motor, inspect the following items.

1. Inspect whether or not there is any damage during transit, or if any parts are lost missing.
2. Inspect each tightened part is loosened or not.
3. Check whether or not covers for flange surface and drain port are perfect, and the inside of the motor is dirty with intruded dust.

Rotation Direction

The relation between the oil flow and the revolutionary direction of the shaft is self-explanatory as shown in Figure 7 and table.

The revolutionary direction of a motor vary according to the slope surface of casing.

Pay attention to discriminate between geometry of casing and the direction of flange as the direction of tilting angle.

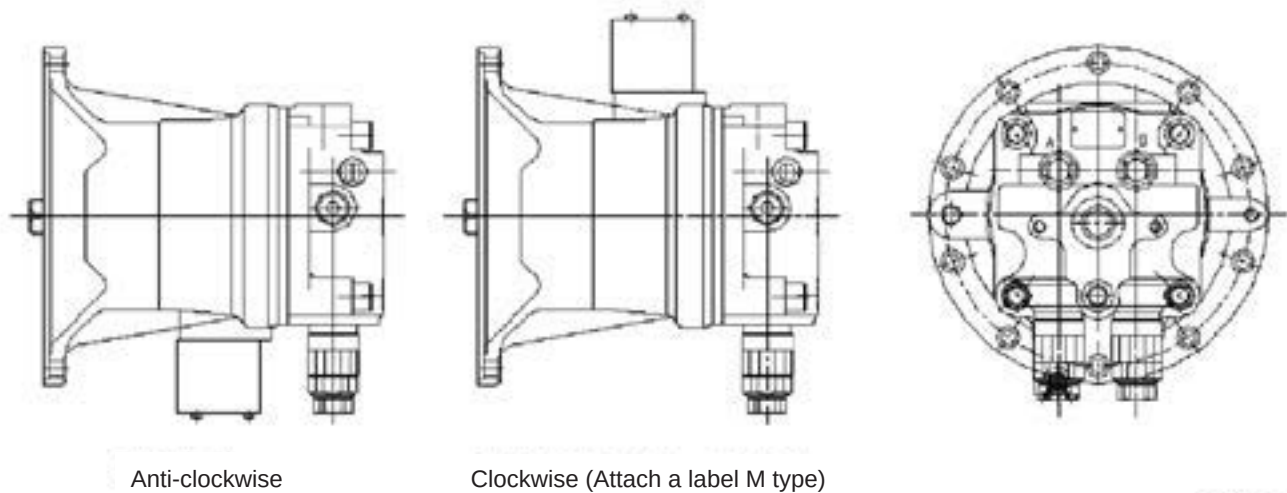


Figure 7 Brake Working Description

Direction	Inlet Port	Outlet Port	Revolutionary Direction of Shaft Facing the Shaft Side
counterclockwise	A	B	Right-handed
Clockwise	B	A	Left-handed

External Load of Shaft

Pay attention to the shaft of motor in order not to applied radial and thrust load.

Hydraulic Fluids and Range of Temperature

1. Mineral Oil

Please use a highly viscosity index working fluid which has additions of anti-foam agent, oxidation inhibitors, corrosion inhibitors, viscosity index improvers, oiliness agent and the oil with a high viscosity.

2. Optimum viscosity and temperature (Figure 8)

To obtain the highest performance of the motor, oil which has a viscosity in a range of 10 to 200 cst is most suitable. But, it can be used a viscosity in a range of 10 to 1000 cst. The range of working temperature is limits to -25 °C - -100 °C because of the oil seal, O-ring. Further, the deterioration of the working fluid becomes excessive beyond 65 °C ; therefore, it is desirable not to exceed 60 °C.

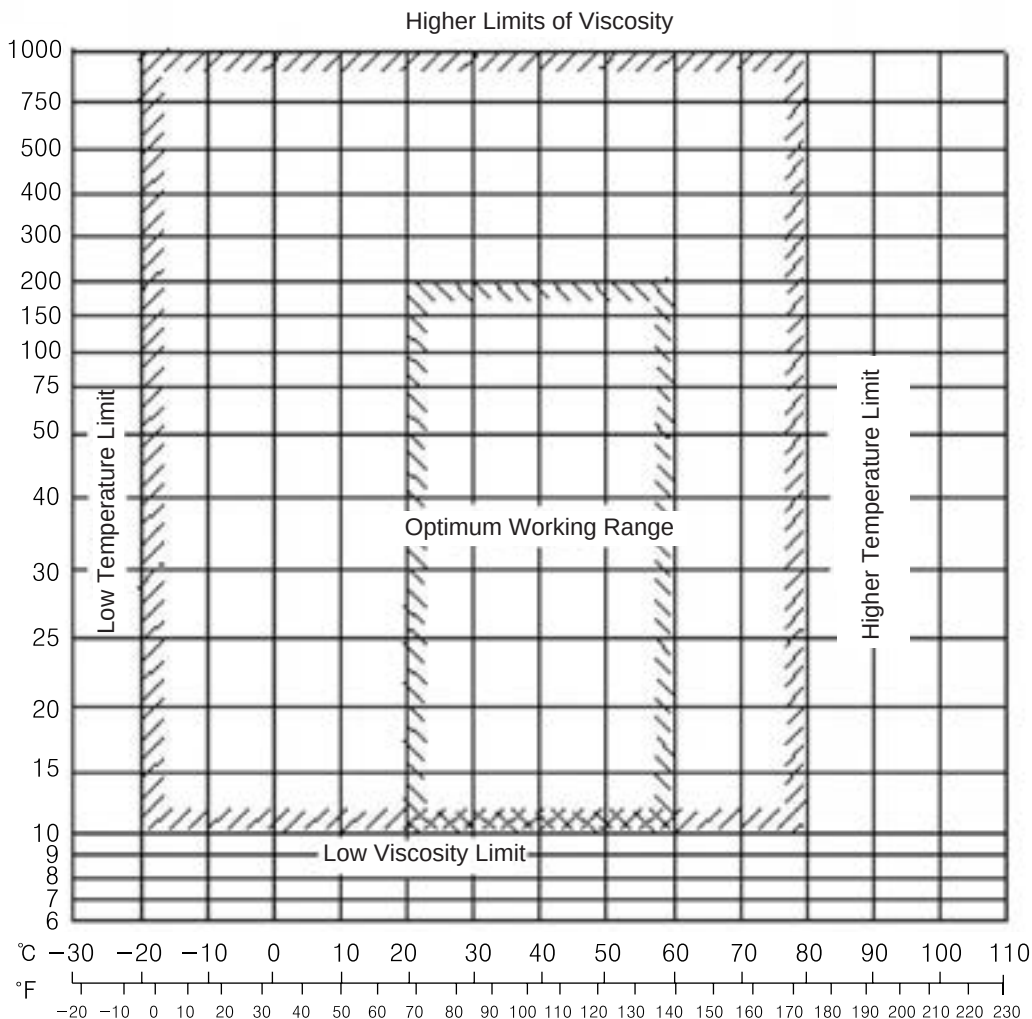


Figure 8 The Proper Range of Viscosity and Temperature

FG007426

3. Except Mineral Oil

Incase if using special fluid (phosphate ester compounds, water-glycol, fluid fatty acid ester compound, etc.), please consult us for instruction before use.

Filter

If fine particles of dirt and metal are mixed with oil, they enter into sliding surfaces and accelerate wear in each part, and in the worst case seizure will be likely to occur.

It is recommended, therefore, that the customer not only will take necessary measures to prevent oil from contamination with such fine particles but also to provide an oil filter in the circuit without fail. For satisfactory service life of these motors in application, the operating fluid should be continuously filtered to the minimum cleanliness level of class 9 of NAS. Also, install a 10 μ filter in the hydraulic circuit and MILLIPRE FILTER pollution level recommends below 2 - 4mg/100cc.

Installation and Piping

1. When the motor is installed that its shaft turns downside.
2. The motor should be installed that it is concentricity below 0.05 mm.
3. The tightening torque of bolts for fixing the motor to the bracket is shown in assembly drawing the customer's reference.
4. Since the casing inside is always kept filled with oil, the drain must be returned to the tank through the return pipe which is once raised higher tank that of the motor itself as shown in Figure 9.
5. Motors will tolerate in the casing pressure up to maximum 3 kg $\cdot$ cm², but for common pressure, 2 kg $\cdot$ cm² below should be kept.
6. Piping should be cleaned and flashing well.
7. Be care to as the installation to piping.
8. Use the drain pipe bigger than the port size and form shortly as possible as.

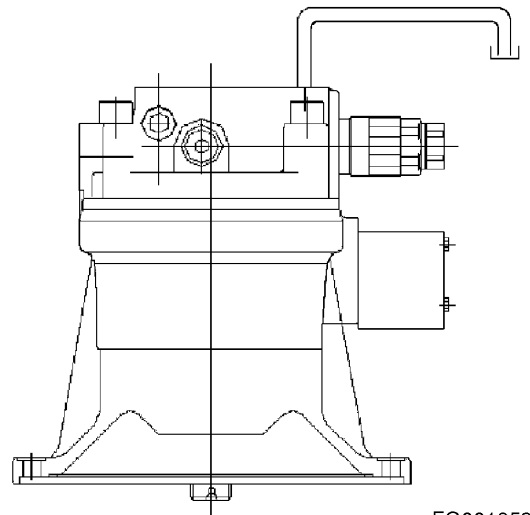


Figure 9

FG001853

Oil Filling and Air Bleeder

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

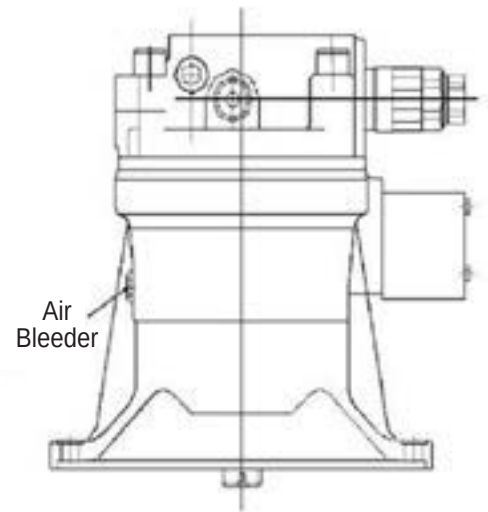
In the motor, there are many kinds of high-speed sliding surface like bearing, piston, shoe, spherical bushing, and etc. So If there isn't enough oil, can make some problem like sticking or breaking in those parts.

Use the PF 1/4 port for venting air.

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

Precaution in Starting Operations

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



FG007427

Figure 10

Troubleshooting

General Cautions

Here, counter-measures to be taken when troubles have happened while the motor is in operation are described.

As for general precaution.

1. Consider a cause of the trouble before repairing Before setting to work, think whether the same thing has happened before or not.

Also, think again whether it is the motor that is in trouble.

2. Be careful of dust

It is not too much to say that most troubles are ascribed to dust so measures for dust prevention is taken into consideration with utmost care in the case of partial disassembling.

3. Handling part

Pay attention to the handling of parts not to injure them, especially to moving parts such as pistons, bearing and valves etc.

4. Pay attention to work the handling of O-ring, gasket Once seals have been disassembled, they should be replaced even if damage is not observed.

Investigation Manner of the Motor Body

It is extremely difficult to trace trouble in the hydraulic circuits. Inspect the following items and investigation whether or not the fault is caused by the motor.

1. Inspection the oil in casing

Remove the drain plug and inspect the hydraulic oil in the casing. If a large amount of metallic particles come out with the oil, you should suspect a failure of internal parts.

2. Presence of abnormal noise

Check whether the motor emits an abnormal noise.

3. Pressure measurement of various points.

Measure pressures at various points and check for faults, instead of disassembling parts at random.

4. Measurement of drain quantity

A. In the case of locking the swing and adding the pressure oil to motor, it's normal the drain rate would be about under 25 (10)lpm

B. In normal swing mode, the drain rate would be under 2 (1)lpm

Where () is TSM72.

Condition and Countermeasures of Troubles

1. Motor does not rotation

Condition	Cause	Remedy
The pressure of the circuit is not increasing	1. Setting pressure of relief valve is incorrect. 2. Working defectiveness of relief valve. 1) Plunger stick. 2) Close up an orifice hole of plunger. 3. Seat defectiveness of plunger.	1. Reset the pressure to correct value. 2. 1) Revise or exchange of stick face. 2) disassembly or cleaning. 3. Replace for damaged seat part.
The pressure of the circuit is increasing	1. Overload. 2. Stick of motion portion. 3. The brake does not release. 4. Stick of brake piston. 5. Stick of friction plate.	1. Load removes. 2. Do repair or inspect the piston/shoe, cylinder block, valve plate etc. 3. 1) Do repair or inspect circuit 2) Check for the break valve. 3) Assembly and inspection. 4) Assembly and inspection. Replace for the stick parts.

2. The revolutionary direction is reverse

Condition	Cause	Remedy
The revolutionary direction is reverse	1. The revolutionary direction of motor is reverse. 2. The inlet and outlet in piping is reversely connected.	1. Reassemble them after disassembling. 2. Correct piping.

3. The number of revolution does not reach the established value

Condition	Cause	Remedy
The number of revolution does not reach the established value	1. The volume of flowing is not sufficient. 2. The temperature is too high and too much oil is leaking. 3. Valves/pistons/rings etc. are worn away and broken.	1. Check discharge volume of pump and circuit up to the motor. 2. Reduce the oil temperature. 3. Replace it.

4. Brake torque is not sufficient.

Condition	Cause	Remedy
Brake torque is not sufficient	1. Friction plates are worn. 2. Brake piston is becoming stick. 3. Brake releasing pressure is not working. 4. Spline of friction plates are damaged.	1. Disassembly or inspection. When it is worn better than standard, replace it. 2. Disassembly or inspection 3. 1) Check for the circuit. 2) Check for the brake valve 4. Disassembly or inspection. 1) Replace for damaged parts.

5. Motor is much slip

Investigates the DRAIN quantity for motor.

Normal: app. 200cc/min (TSM140:500cc/min)

Condition	Cause	Remedy
Motor is much slip	1. Working defectiveness of relief valve is the same 1) an item. 2. Seat defectiveness of plunger.	1. It is the same 1) an item 2. Replace it.

6. Oil Leak

A. Oil leak from the oil seal

Condition	Cause	Remedy
Oil leak from the oil seal	1. The lip is dirty or damaged. 2. The shaft may be damaged or worn out. 3. The lib is damaged too high-pressure in the casing. 4. The shaft is rusty.	1. Replace the oil seal. 2. Replace the driving shaft or defective centering of the driving shaft. 3. It repairs the drain piping which is closed up. 4. Disassemble, repair, and replace the oil seal.

B. Oil leak from the blind and union

Condition	Cause	Remedy
Oil leak from the blind and union	1. O-ring is not in. 2. O-ring is broken. 3. Seal face is defective. 4. The bolt is loose or not tightened.	1. Insert O-ring. 2. Replace it. 3. Disassemble or repair. 4. Tighten adequately or replace it.

MAINTENANCE MANUAL

Disassembling and Assembling

Tightening Torque of Bolts

In table 1. is shown tightening torque of bolts used in motor. In case of reassembling, tighten accurately each bolt in accordance with table 1.

Table 1

() : TSM72

Bolt Size	Name	Tightening Torque (kg•cm)	Part No.
M6	Hexagon Bolt	120 ± 20	400
M20 (M16)	Hexagon Socket Bolt	4400 ± 660 (2400 ± 360)	109
M22	RO Plug	1100 ± 100	105
M36 (M24)	RO Plug	2450 ± 250 (1300 ± 100)	105
PF 1/4	Plug	370 ± 20	111
M33	Relief Valve	1800 ± 100	105

Necessary Tools

In table 2, 3 Figure 11. is shown necessary tools for disassembling and reassembling.

Table 2

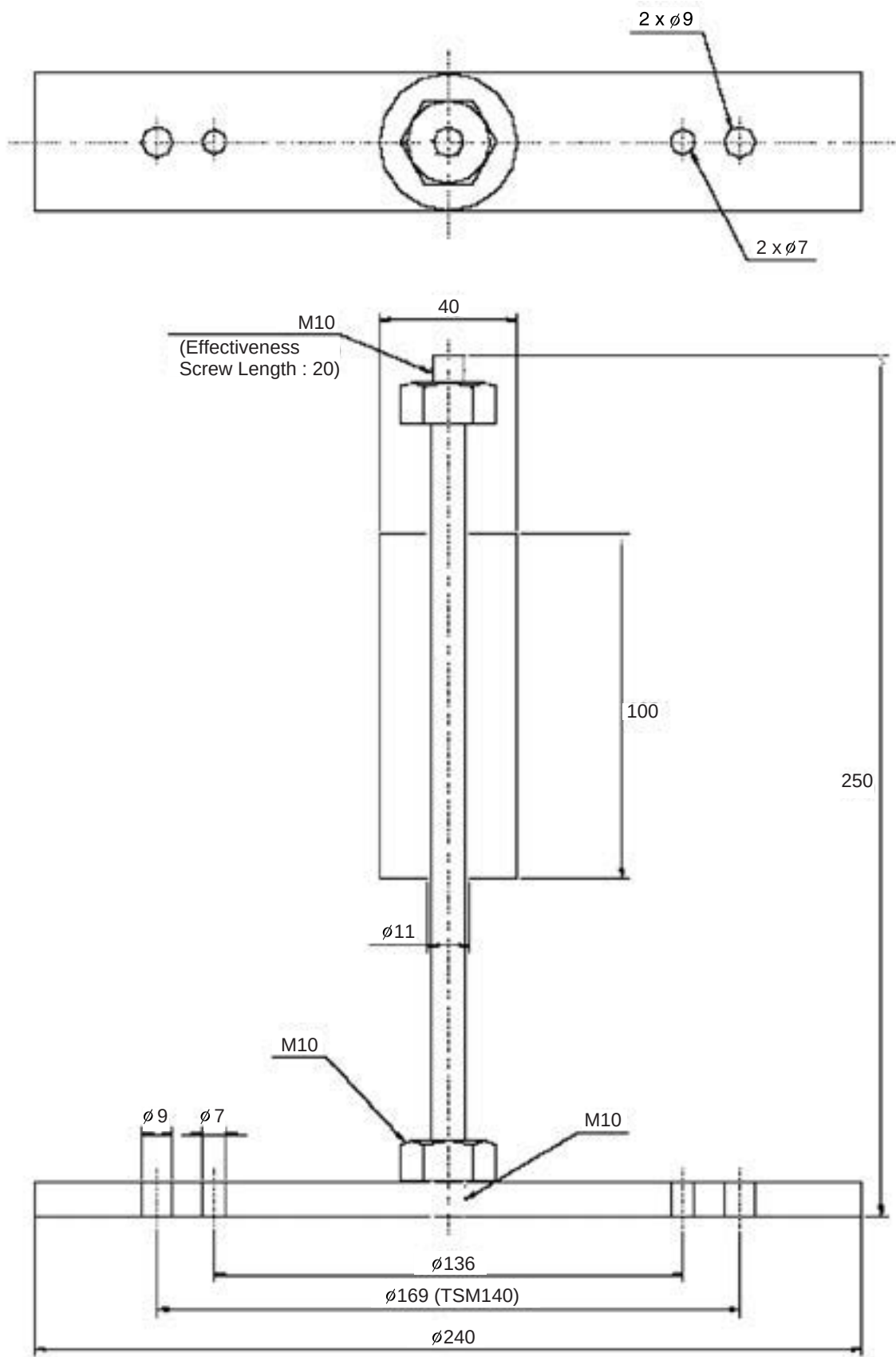
() : TSM72

Name	Size	2-face width	Application part	Tool
Hexagon bolt	M6	10	Brake valve	Hexagon wrench socket wrench
Hexagon socket bolt	M20 (M16)	17 (14)		Hexagon wrench
Plug	M22	10	RO plug	Hexagon wrench
Plug	M36 (M24)	17 (12)	RO plug	Hexagon wrench
Plug	VP-1/4	19	VP plug	Hexagon wrench socket wrench
		36	Relief valve	Hexagon wrench socket wrench

Table 3 etc.

() : TSM72

Tool	Spec.	Dimensions
Pliers (For lock ring)		For Ø65 axis (Ø50)
Driver		- Type 2EA
Steel rod		About 10 x 8 x 200 1EA
Hammer		One each of plastic hammer and metal hammer.
Torque wrench		Torque range • For 100 - 450 kg•cm • For 400 - 1,800 kg•cm • For 1,200 - 4,800 kg•cm
Slide hammer bearing pliers		
Special tool for removing the break piston		25page reference



FG007428

Figure 11 Special Tool for Removing the Brake Piston

Procedures for Disassembly

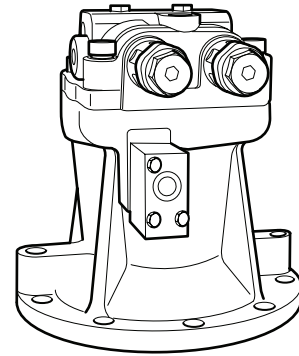
Please use the following procedures for the inspection and repair of the motor.

Numerals given in parentheses following the parts names indicate the parts number shown by the drawing in the instruction and maintenance manual.

1. Wind the wire rope at motor outside, lift up the motor, and clean the motor with cleaning oil.

After cleaning, dry with compressed air.

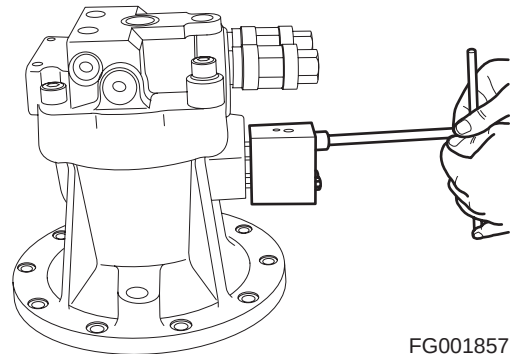
2. Draw the oil out of the casing (301).
3. Mount on a suitable table for the driven-axis (201) below.
Before disassembling make a match mark on motor casing (301) and valve casing (101).



FG001856

Figure 12

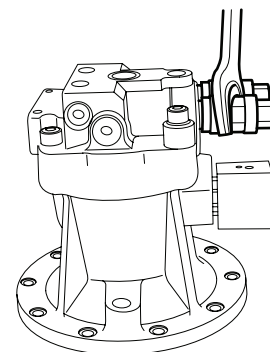
4. Remove brake valve (400).



FG001857

Figure 13

5. Remove relief valve (107) from valve casing (101).



FG001858

Figure 14

6. Remove RO plug (102) and take out spring (103) and plunger (104) from valve casing (101).

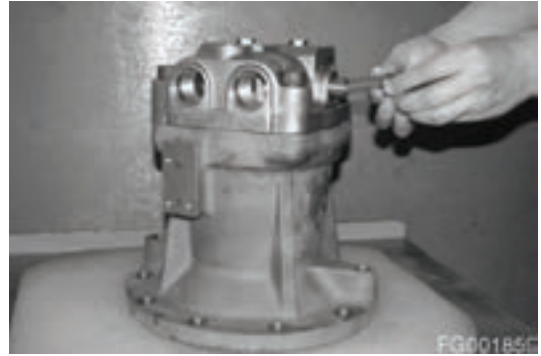


Figure 15

7. Remove swing reactionless valve ass'y (105) from valve casing (101).



Figure 16

8. Remove hex socket bolts (109, 110) and disassemble valve casing (101) from casing (301) (When loosening bolts, the valve casing will be raised by brake springs (310). Remove valve plate (213) from the valve casing (101).



Figure 17

9. Remove brake springs (310) from the brake piston (309).

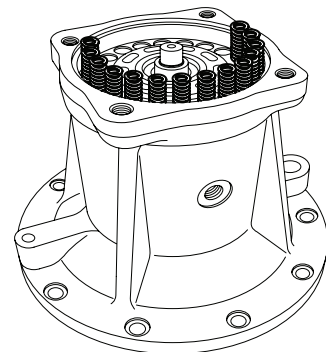


Figure 18

10. Disassemble brake piston (309) from casing (301) by using the special tool for removing the brake piston.

Lit it up straight by using the bolt hole in the brake piston.



Figure 19

11. After placing the motor horizontally, take out cylinder block (205) from casing (301).

Remove piston ass'y (203, 204), retainer (207), spherical bushing (206), spacer (208).

When taking out the cylinder block, be careful not to pull out roller (209).

Be careful not to damage the sliding parts of the cylinder block, spherical bushing and shoe.

And washer (210, 2EA), spring (211), retaining ring (212) are not disassemble at the disassembled cylinder block.



Figure 20

12. Pull out friction plate (306, 2EA) and separation plate (305, 3EA) from casing (301).

(TSM72 : friction plate : 3EA

separation plate : 4EA)



Figure 21

13. Remove swash plate (202) and driveshaft with ball bearing (303) from casing (301)

Be careful not to damage the ball bearing (303) and oil seal contact surface.

If you beat a driveshaft end with plastic hammer, it is easy to be disassembled.

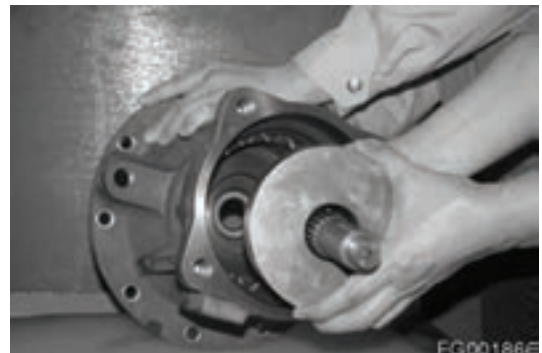


Figure 22

14. Do next step if required.

A. Remove parallel pin (304) from casing (301).

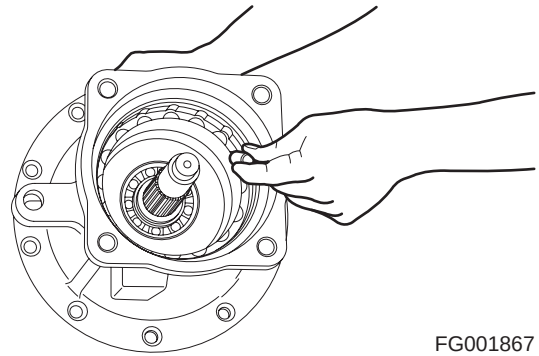


Figure 23

FG001867

B. Remove ball bearing (303) with a press from the driveshaft (201).

Strike the rod lightly and do not reuse the disassembling bearing.

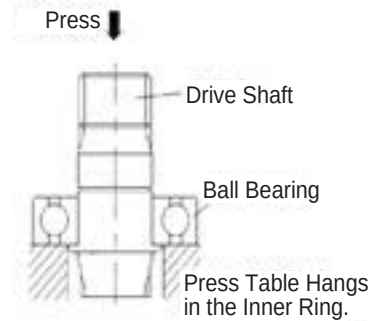


Figure 24

FG007429

C. Take out oil seal (302) from the casing (301) with a using of tool.

Do not reuse the disassembling oil seal (302).

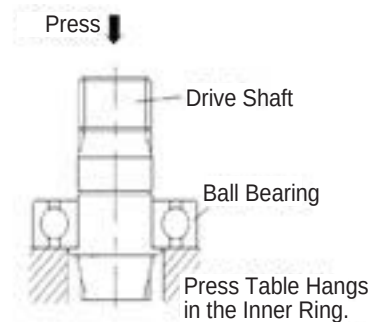


Figure 25

FG007429

D. Take out ball bearing from the valve casing (303).

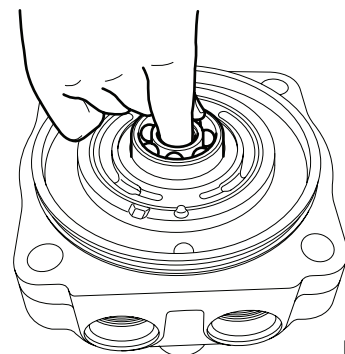


Figure 26

FG001870

15. Disassembling is finished, check each component throughly.

Procedures for Assembly

Following are caution to be specially borne in mind.

- A. Rework damaged parts and before assembling, prepare all parts to be replaced.
 - B. Clean all parts and dry with compressed air.
 - C. Coat the sliding parts and bearing with clean hydraulic oil.
 - D. Replace O-ring, oil seal.
 - E. For the mounting of bolts to install the various parts, please use a torque wrench, etc. and tighten the bolts with the torque shown in table 1.
1. Place casing (301) on the work table with the valve casing side downward.

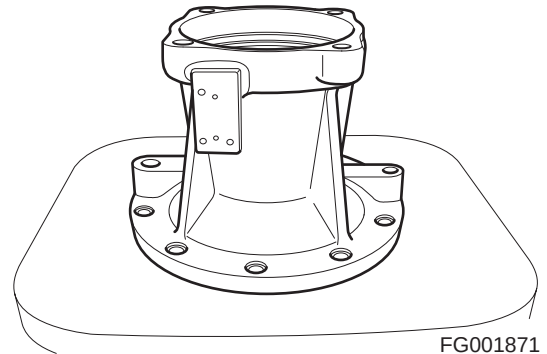


Figure 27

2. (It is necessary when oil seal was disassembled from the casing.)

Insert oil seal (302) at the casing (301) with a using of tool.

(Be careful to note the direction of oil seal. and insert until fully seated at the casing end.)

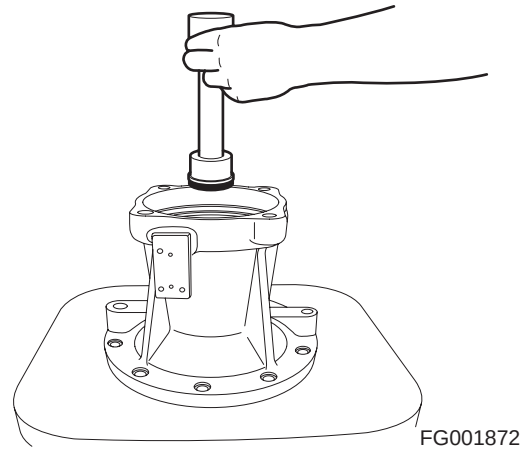


Figure 28

3. (It is necessary when ball bearing was disassembled from the driveshaft.)

Ball bearing (303) is press fit by the heat to driveshaft (201).

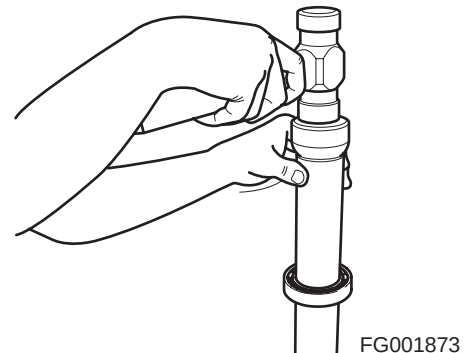


Figure 29

4. Insert the driveshaft (101) complete with ball bearing into casing (301).

Impact the outside surface of outer loop uniformly till stop at casing section.

Coat the lip of the oil seal with grease and tape the shaft spline for the protection of spline.

Tap evenly.



Figure 30

5. (It is necessary when parallel pin was disassembled from the casing.)

Assemble parallel pin (304) to casing (301).

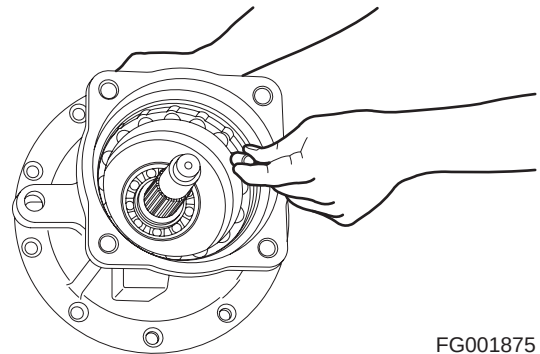


Figure 31

6. Assemble swash plate (202) to casing (301).

If casing is horizontal position from the bottom, It is easy to work.

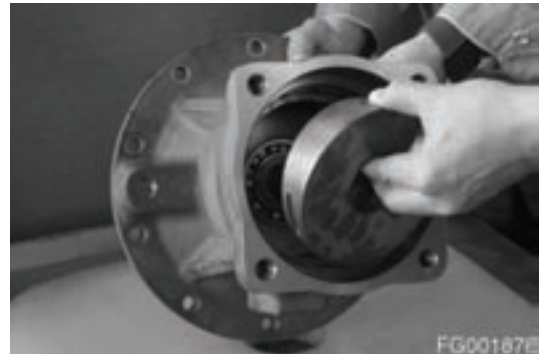


Figure 32

7. Insert roller (209) to cylinder block (205).

Make sure that cylinder block is assembled with all component.

(washer (210), spring (211), ring snap (212))

(Be careful not to damage the sliding surface of the cylinder block. Insert roller to each hole one by one.)



Figure 33

8. Place spacer (208), spherical bushing (206) to the cylinder block (205).



Figure 34

9. Assemble the retainer with the piston sub assembly (203, 204) unit to the cylinder block (205).



Figure 35

10. Insert cylinder block to driveshaft (101) aligning the spline.



Figure 36

11. Place casing (301) downward and assemble separation plate (305, 3EA) and friction plate (306, 2EA) in sequence.
Align 4 tangs to the notches.
Align cut the jaw and assemble that part.
(TSM72 : friction plate : 3EA
separation plate : 4EA)

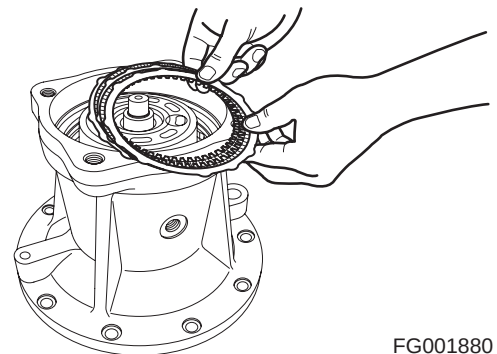


Figure 37

12. Mount O-ring (307, 308) to casing (301).

(Coat the O-rings with grease. O-ring can be protected by grease.)

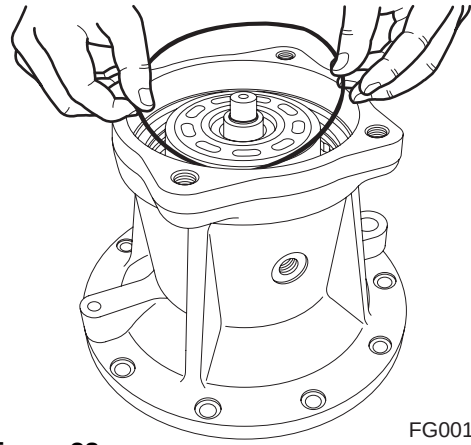


Figure 38

FG001881

13. Assemble brake piston (309) to casing (301).

The piston is difficult to assemble because of the restriction of the O-ring; screw in two M8 bolts on the brake piston and tap them gently with plastic hammer.

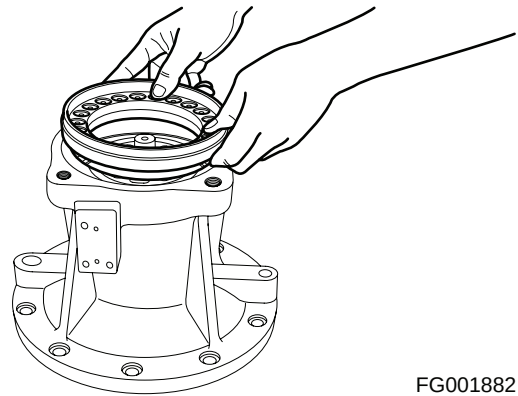


Figure 39

FG001882

14. Assemble brake springs (310) into brake piston (309).

Confirm the springs are fitted to the brake piston completely.

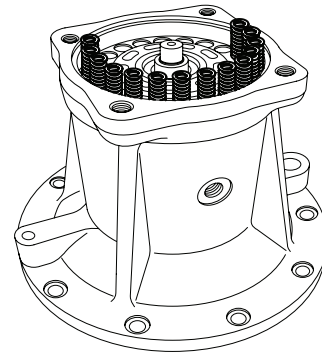


Figure 40

FG001862

15. (It is necessary when ball bearing (108) was disassembled from the valve casing.)

Assemble of ball bearing (108).

Insert it to valve casing (101) while tapping it lightly.

Tap evenly on the outer diameter of the outer race with a brass drift until it completely stops.

Do not use a steel punch or bar on the bearing since it can chip or crack the race.

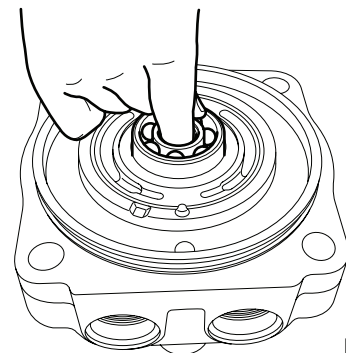


Figure 41

FG001884

16. Assemble valve plate (231) to valve casing (101) and fit O-ring (113).

Be careful to note the direction of the valve plate.

Mount the valve plate with its round part toward the opposite side of the flange.

Coat lightly with grease.



Figure 42

17. Mount valve casing (101) to casing (301) and tighten hex socket bolts (109, 110) to specification.

Be careful to note the mounting direction of the valve casing.

(Reference to the drawing)

Be careful not to drop the valve plate or let the brake springs pop out.

Tighten the bolts evenly.



Figure 43

18. Install plunger (104) and spring (103) to valve casing (101) and tighten RO plug (102) with O-ring (106).

Confirm the smooth movement of the plunger before installing the plug.



Figure 44

19. Install swing reactionless valve ass'y (105) to valve casing (101).

Confirm the spring in the swing reactionless valve ass'y (105).



Figure 45

20. Assemble relief valve (107) with O-ring to valve casing (101).

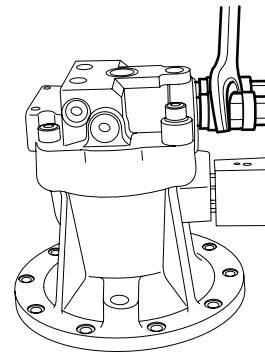


Figure 46

FG001858

21. Assemble brake valve (400) to casing (301) and tightening the hex socket bolts to specified torque.

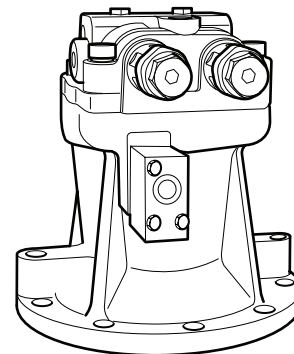


Figure 47

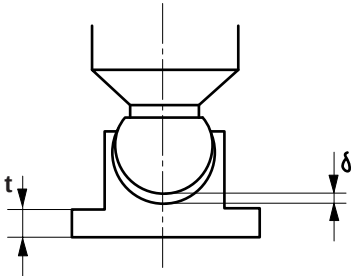
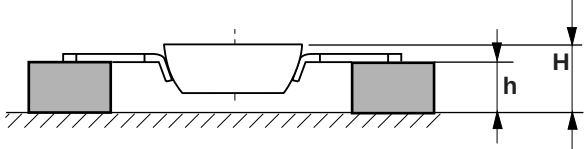
FG001856

22. The assembly is completed.

Maintenance Standards

Standards for Replacement of Worn Parts

If the various parts of the motor have been worn out beyond the following standard values, please replace them. But this shall apply only to those cases when is no remarkable outside damage.

Item	Standard dimension (mm)	Recommended value for replacement (mm)	Remedy
Clearance between piston and cylinder bore	0.025 (0.036)	0.055 (0.066)	Replace piston or cylinder block.
Gap between piston and caulked part of shoe (δ)	0.05	0.2	Replace piston or shoe.
Thickness of shoe (t)	4.5 (6.5)	4.3 (6.2)	Replace piston or shoe.
Assembled height of retainer (H-h)	10.8 (13.0)	10.3 (12.5)	Replace sperical bushing and retainer as a pair.
Thickness of friction plate	3.5	3.1	Replace it.
 Gap between piston and caulked part of shoe (δ). Thickness of shoe (t)		 Assembled height of retainer (H-h)	

Standard for Correcting Sliding Surfaces

If the surface roughness of the sliding surface of a part exceeds the following standard, correct it or replace the part.

Table 4 Revise standard

Item	Surface roughness	Roughness requiring correction
Shoe	0.8 - Z (Ra=0.2) (LAPPING)	3 - Z (Ra=0.8)
Swash Plate	0.4 - Z (Ra=0.1) (LAPPING)	3 - Z (Ra=0.8)
Cylinder Block	1.6 - Z (Ra=0.4) (LAPPING)	12.5 - Z (Ra=3.2)
Valve Plate	0.8 - Z (Ra=0.2) (LAPPING)	6.3 - Z (Ra=1.6)

NOTE: Lap each sliding surface to a standard roughness level or finer.

If the sliding surface of the cylinder block, valve plate, retaining plate

Travel Moter

Edition 1

MEMO

Table of Contents

Travel Moter

Safety Precautions	5
Applicable Models	5
Product Overview	6
General Specifications	6
External Dimensions.....	7
General Description.....	8
Operating Description.....	11
Reduction Gear	11
Hydraulic Drives	12
Precautions for Use	20
Installation (Refer to Diagram of External Dimensions)	20
Tubing	21
Fluid Selection.....	21
Maintenance and Inspection.....	22
Daily Inspection	22
Changing Fluid	23
Changing Lubrication	23
Seals Table.....	25
Troubleshooting.....	26
Outline of Maintenance.....	28
Tools.....	28
Bolts	28
Equipments	29
Fabricated Tools.....	29
Torque	33
Weight Table	33
Disassembling	34
Work Preparation	34
General Precautions for Work	34
Disassembling Order	35
Maintenance Standards.....	52

Seals	52
Maintenance Standards for Wearable Parts	52
Assembling	54
Preparation	54
General Precautions for Assembling Work	54
Order of Assembling.....	55

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
DX140LC	5001 and Up
DX140LCR	5001 and Up

PRODUCT OVERVIEW

This product is a hydraulic driven rotary actuator.

The product contains a reduction gear, hydraulic motor, brake valve and parking brake in one compact unit. It has been developed for use as an actuator for application requiring low-rpm, high torque operation such as construction and marine machinery.

General Specifications

ITEM		UNITS	Spec
Rated Output Torque		kgf·m	2100
Max. Speed		min ⁻¹	60
Reduction Ratio			1/54.0
Hydraulic Motor	Max. Displacement	cc/rev	82.8
	Max. Speed	min ⁻¹	3000
	Max. Pressure	kgf/cm ²	355
	2-speed Control Press	kgf/cm ²	20 ~ 70
Parking Brake	Brake Torque (min)	kgf·m	21
	Brake Free Pressure	kgf/cm ²	7.7



Travel Moter

GENERAL DESCRIPTION

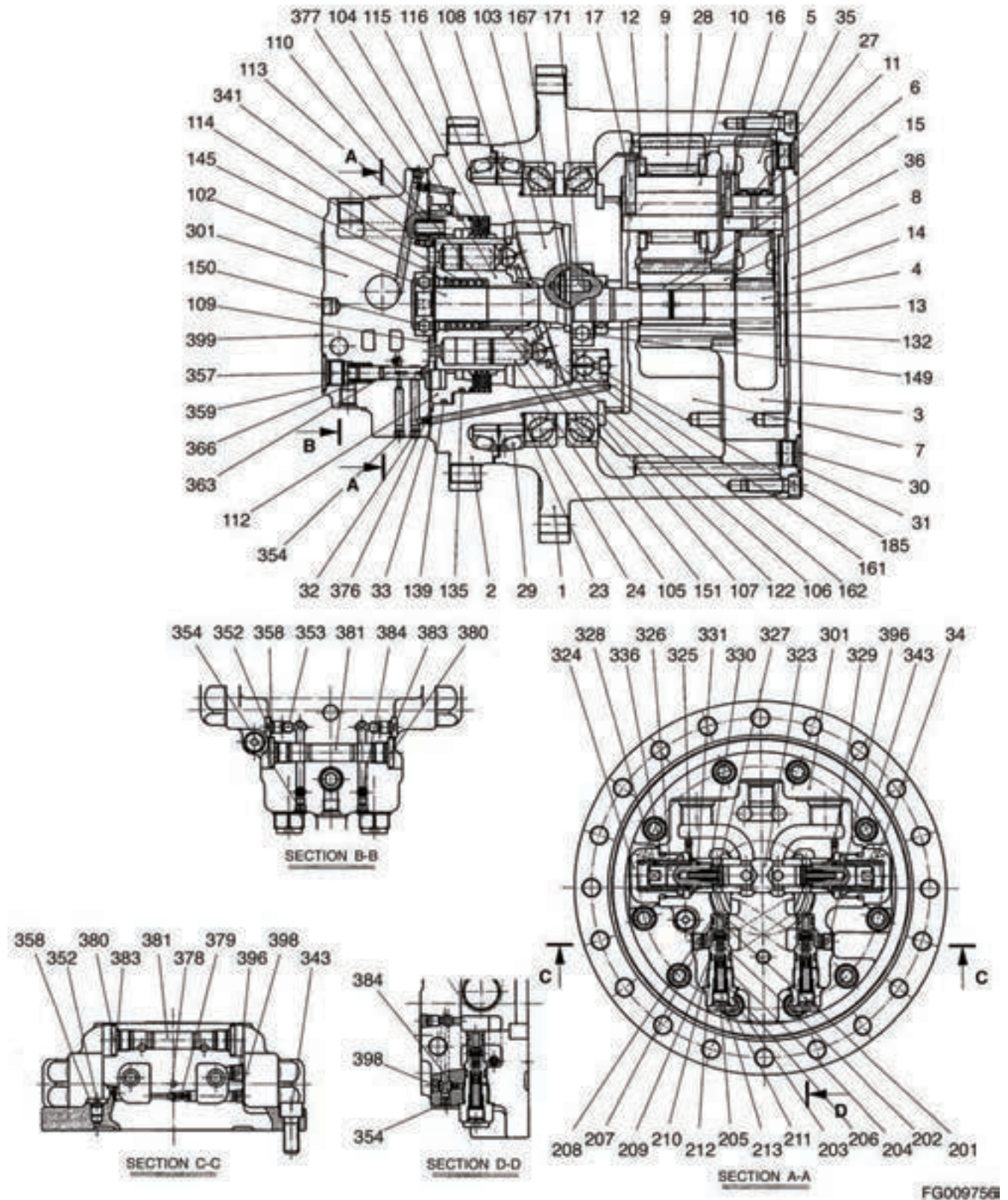


Figure 2

Reference Number	Description	Q'ty
1	Hub	1
2	Spindle	1
	Carrier Assembly (1)	1
3	Carrier (1)	1
5	Planetary Gear (1)	3
6	Carrier Pin (1)	3
11	Thrust Washer (1)	6
16	Parallel Pin (1)	3
27	Needle Roller Bearing	3
	Carrier Assembly (2)	1
7	Carrier (2)	1
9	Planetary Gear (2)	3
10	Carrier Pin (2)	3
12	Thrust Washer (2)	6
17	Parallel Pin (2)	3
28	Needle Roller Bearing	3
4	Sun Gear (1)	1
8	Sun Gear (2)	1
13	Thrust Plate	1
14	Cover	1
15	Coupling	1
22	Lock Washer	2
23	Shim	1
24	Angular Ball Bearing	2
	Floating Seal Kit	1
29	Floating Seal	2
30	Plug	3
31	O-ring	3
32	O-ring	1
33	O-ring	2
34	Parallel Pin	2
35	Hex. Socket Bolt	12
36	Snap Ring for Hole	1
102	Shaft	1
103	Swash Plate	1
	Cylinder & Piston Kit	1
	Piston Kit	1
	Piston Assembly	9
105	Piston	1
106	Shoe	1
104	Cylinder Block	1
107	Retainer Plate	1
108	Thrust Ball	1

Reference Number	Description	Q'ty
109	Timing Plate	1
110	Washer	2
112	Piston	1
113	Spring	10
114	Spring	1
115	Friction Plate	3
116	Mating Plate	4
132	Oil Seal	1
135	O-ring	1
139	O-ring	1
145	Snap Ring	1
149	Ball Bearing	1
150	Ball Bearing	1
151	Needle Roller	3
	Piston Assembly	1
161	Piston	1
162	Shoe	1
167	Pivot	2
171	Parallel Pin	2
185	Spring	1
	Relief Assembly	2
201	Valve Seat	1
202	Valve	1
203	Sleeve	1
204	Collar	1
205	Plug	1
206	Spring	1
207	O-ring	1
208	Back up Ring	2
209	O-ring	1
210	Back up Ring	2
211	O-ring	1
212	O-ring	1
213	Shim	1
	Rear Flange Assembly	1
	Rear Flange Kit	1
	Spool Assembly	1
323	Spool	1
326	Plug	2
327	Valve	2
330	Spring	2
331	O-ring	2
301	Rear Flange	1

Reference Number	Description	Q'ty
324	Plug	2
325	Washer	2
328	Spring	2
329	Orifice	2
336	O-ring	2
352	Plug	3
353	Steel Ball	2
354	Hex. Socket Plug	5
357	Plug	1
358	O-ring	3
359	O-ring	1
363	Spool	1
366	Spring	1
376	Orifice	1
377	Filter	1
378	Steel Ball	1

Reference Number	Description	Q'ty
379	Plug	1
380	Plug	2
381	Piston	1
383	O-ring	2
384	Orifice	2
396	Hex. Socket Plug	2
398	Hex. Socket Plug	5
399	Name Plate	1
341	Parallel Pin	1
343	Hex. Socket Bolt	10

OPERATING DESCRIPTION

Reduction Gear

Function

This reduction gear unit is composed of two stage planetary gear mechanism.

The reduction gear reduces the high speed of hydraulic motor and converts it low-speed, high-torque rotation.

Operating Description

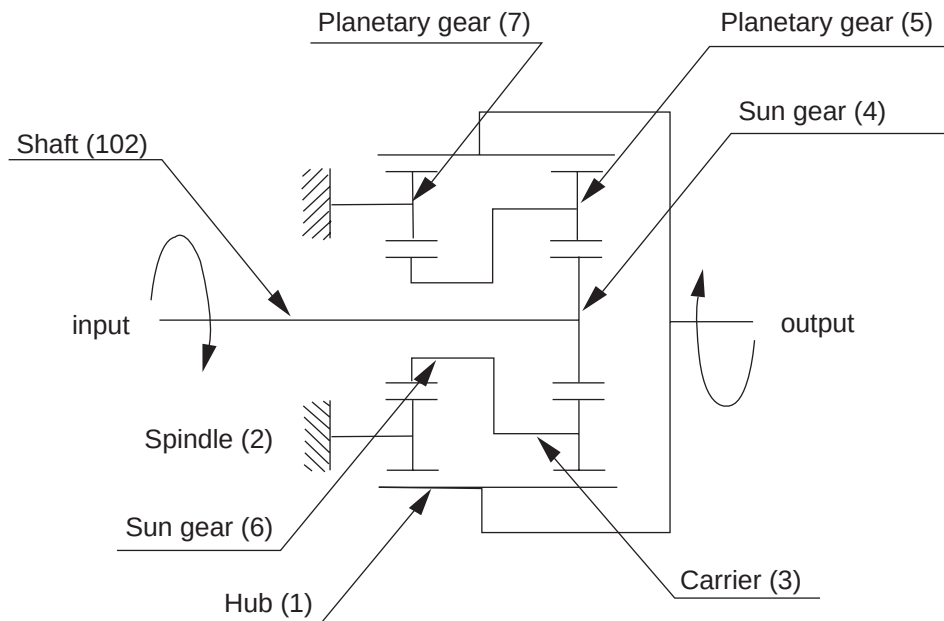
The rotation of hydraulic motor shaft is transmitted to sun gear (4) of the first stage which is linked with shaft (102) in spline.

At that time, the hub (1) is rotated by the rotation of the planetary gears (5).

The hub (1) rotation is transmitted to carrier (3) which connected to planetary gears (5), and that causes sun gear (6) rotation of the second stage.

The rotation of sun gear (6) is transmitted to the hub via three planetary gears (7) of the second stage.

The generated rotation of reduction gear is output rotation.



FG009760

Figure 3

Hydraulic Drives

Function

1. Hydraulic Motor

This hydraulic motor is a swash plate type axial piston motor, converting the hydraulic force from the pump to rotary motion.

2. Brake Valve

A. Controls inertia when stopping the hydraulic motor, in order to provide smooth stopping.

B. Prevents runaway rotation when the hydraulic motor is rotated by external force.
This is done by preventing hydraulic cavitation.

C. Prevents the generation of abnormally high pressure when the hydraulic motor is stopped suddenly.

3. Parking Brake

The parking brake prevents the hydraulic motor from being rotated by external force while stopped. A friction plate type mechanism is used, constructed so as to form one unit with the hydraulic motor.

4. High-Low 2-Speed Switching Mechanism

Switches the hydraulic motor between high speed rotation with low torque, and low speed rotation with high torque.

Operating Principles and Description

1. Hydraulic Motor

Hydraulic fluid fed from the hydraulic pump enters the GM motor through the rear flange (101), passes through the brake valve and timing plate (109) and enters the cylinder block (104). This hydraulic fluid is fed only into one side of a line connecting the upper and lower dead points (Y1-Y2) of the piston stroke (105). The hydraulic fluid pushes each of the pistons (105), creating force $F(=P \times A)$. This force operates on the oblique surface of the swash plate (103). Force F is separated into components F_2 and F_3 according to the angle θ of the oblique surface. Of the two components, the radial component force F_3 generates torque $(=F_3 \times r_i)$. The sum of the torque $T(=\sum(F_3 \times r_i))$ of each of the pistons (105) is the rotary force of the hydraulic motor. This rotary force passes through the pistons (105) and rotates the cylinder block (104) and the shaft (102).

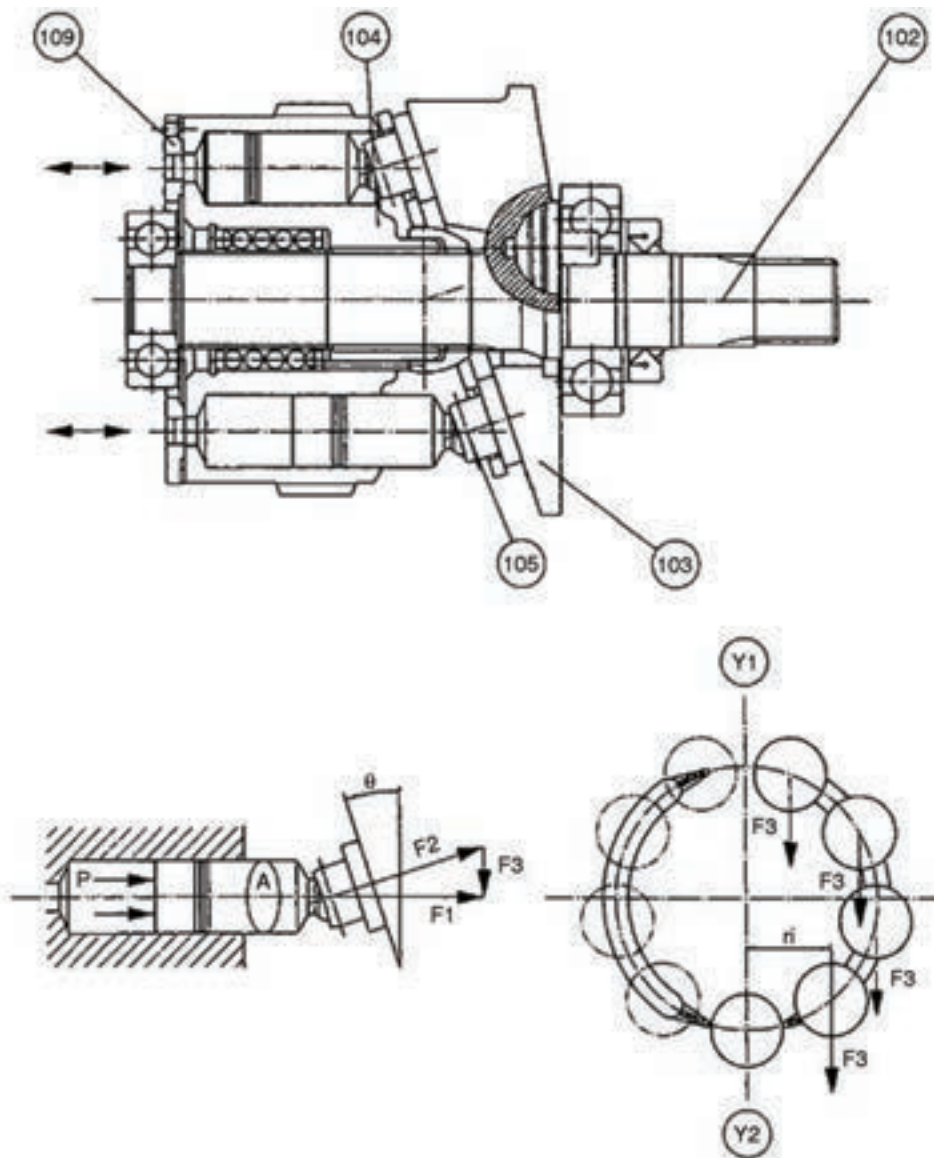


Figure 4

FG0097611

2. Brake Valve

A. Operation (Brake released)

The pressure oil is led to through port (A), opens valve (327), and led to port (C) on the section side of hydraulic motor to rotate hydraulic motor.

At the same time, the pressure oil enters chamber (a) through orifice (329), and exerts on the end of spool (323) to generate the force.

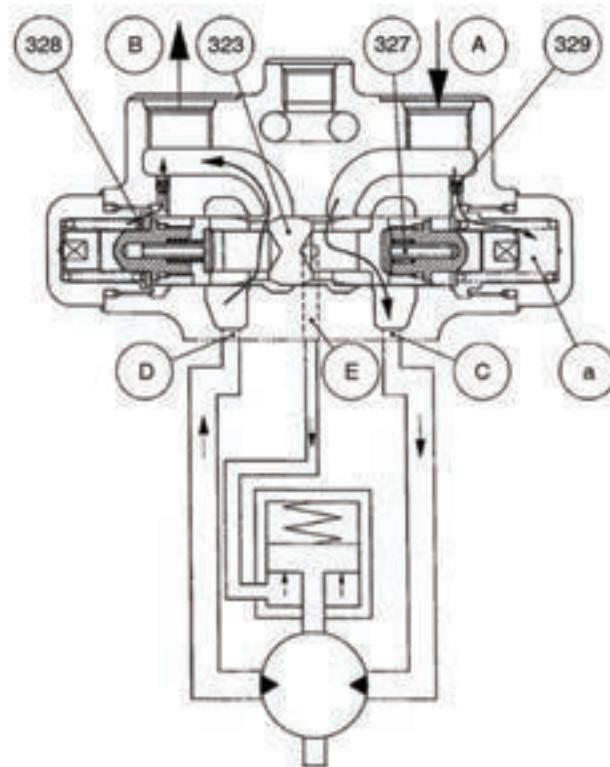
Then the force of spring (328) slides the spool (323) placed on the neutral position leftward.

The sliding of spool (323) forms the space (passage) between spool (323) and rear flange (301) with spool groove.

This passage is connected to port (D) and port (B) of the return circuit of the hydraulic motor, and the returns oil returns to tank side, enabling hydraulic motor to rotate.

Then, the sliding of spool (323) leads pressure oil to port (E). The pressure oil led to port (E) moves piston (112) of parking brake, and releases parking braking force. (For details, refer to item "Parking brake".)

If pressurized oil is supplied from port (B), the movements of spool (323) and valve (327) are reversed so that the hydraulic motor is rotated reversely.



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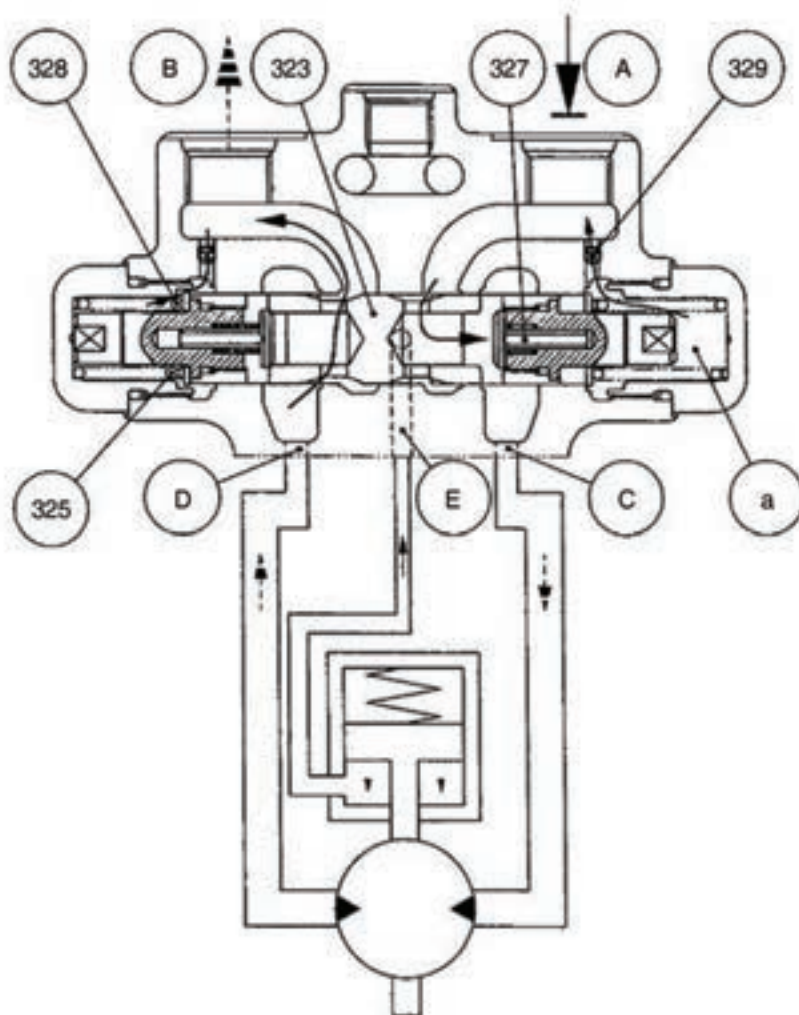
Figure 5

B. Stop / Stall (Braking Operation)

If pressurized oil supply through the port (A) is suspended while traveling, the hydraulic force to push up the spool (323) is lost, and the spool (323) which is slid to left side, tries to return to the neutral position due to the spring (328) force. At that time, through the oil in the chamber (a) tries to flow out to the port (A) side through the orifice (329), its flow is restricted and some back pressure is generated by the throttle effect in the orifice (329) controlling the return speed of the spool (323). At the same time, the hydraulic motor tries to rotate with its inertia force even though the pressurized oil is suspended, and the return oil from the hydraulic motor tries to return to the port (B) side from the port (D) through the passages on spool groove and rear flange(30I).

When the spool (323) entirely return to neutral position, the passage on the hydraulic motor of the oil return side is completely closed by the spool (323), and the hydraulic motor ceases its rotation. While machine working, the brake valve smoothly stops rotation of the hydraulic motor which tries to rotate with its inertia force, by means of throttling the return side passage of the hydraulic motor, generating back pressure due to shape of the spool groove and controlling the return speed of the spool. On the other hand, when braking is operated, the hydraulic motor tries to rotate with its inertia force and to intake oil with its pumping function. However, because the intake side is closed its passage with the spool (323), the oil supply is suspended. This causes cavitation in the hydraulic motor. To prevent the cavitation, the valve (327) is operated by very slight negative pressure to open the passages of port (A) side and intake port (C) of the hydraulic motor.

And when pressurized oil is supplied through the port (B), each motion of the mentioned parts above becomes symmetrical right and left to stop the hydraulic motor.



FG009763

Figure 6

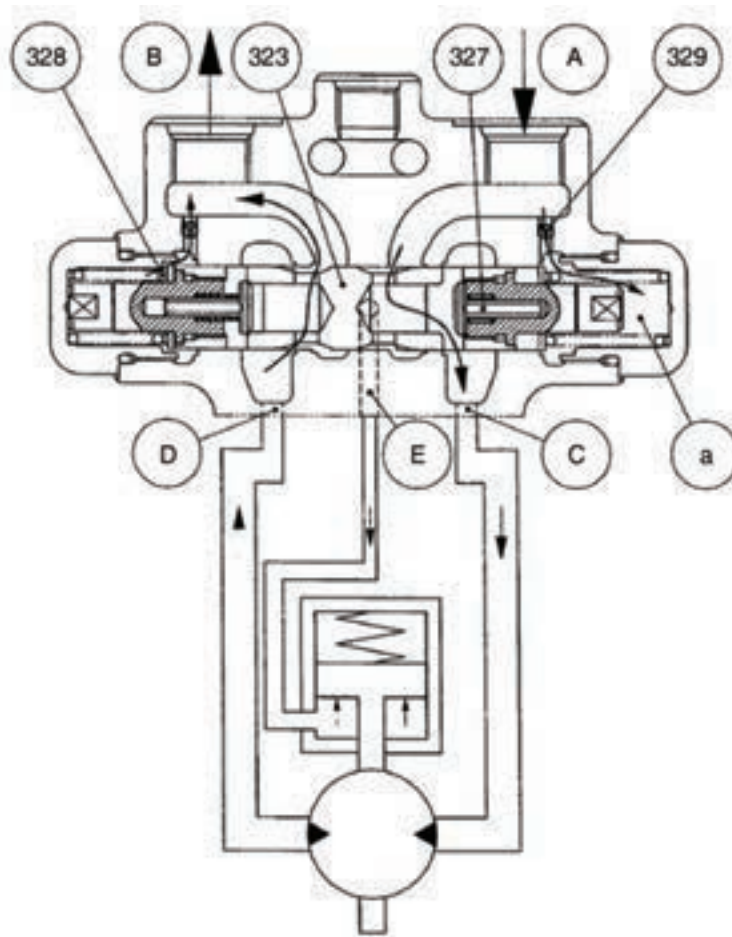
C. Self-traveling

While machine is being operated, as the travel speed is increased due to steep slope, the oil flow rate of the hydraulic motor is higher than the supply flow rate of the hydraulic oil pump.

The rotation of the hydraulic motor in this case is called a self-traveling. (Overrun)

While self-traveling, the pressure is lowered similar to the stopping condition. Then brake valve is moved similar to the stopping condition, throttles passage in the return side of hydraulic motor, and generate backing pressure.

In addition, the force of inertia decreases the revolution of hydraulic motor to revolution having a balance with the supply flow rate of pump.



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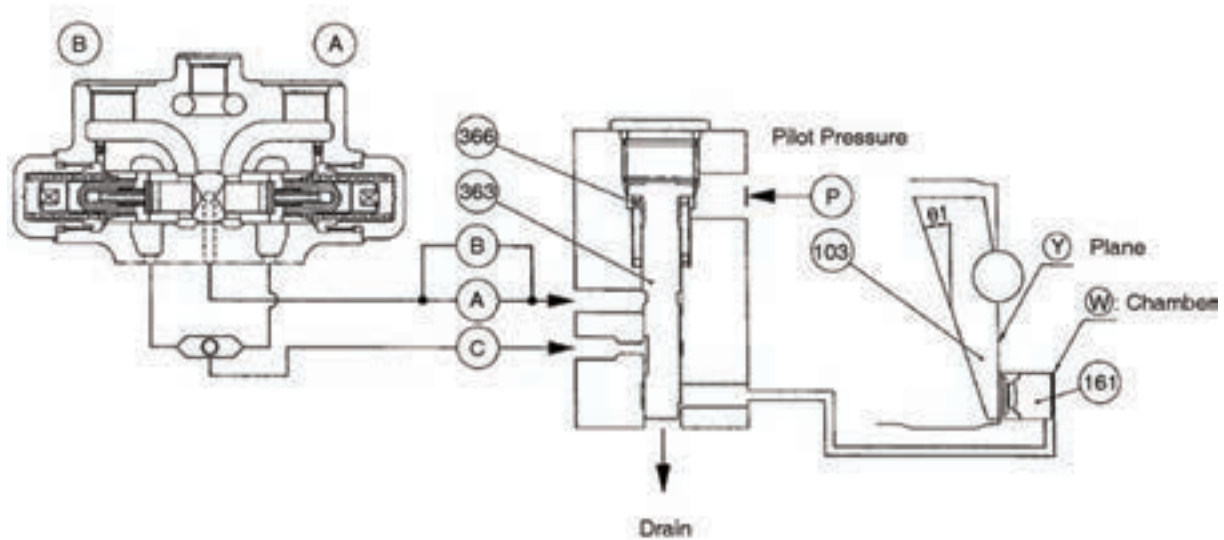
Figure 7

3. High-Low 2-Speed Switching Mechanism

A. Low Speed

When the pilot pressure is not supplied through the port (P), the valve (363) is pushed up to the upper position due to the spring (366) force and pressurized oil through the port (A) or (B), the pressurized oil is cut off at port (C), and oil in the chamber (W) is released into the drain (motor case) through the valve (363).

Accordingly, the tilt angle of the swash plate (103) becomes the maximum θ_1 resulting the maximum stroke volume and low speed rotation of the hydraulic motor.

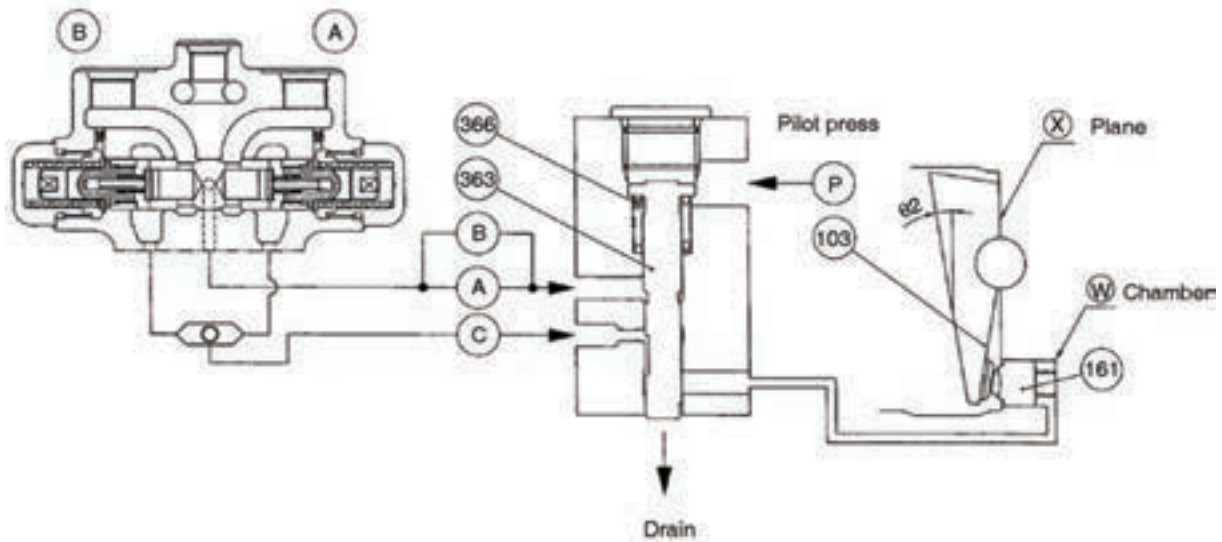


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Figure 8

B. High Speed

When the pilot pressure is supplied through the port (D), it defeats the spring (366) force and pressurized oil through the port (A) or (B) to push down the valve (363) to lower position, the pressurized oil at the port (C) is led to the chamber (P) through the valve (363), and the piston (161) pushes the swash plate (103) up to the plane X and maintain it at its position. At that time, the tilt angle of the swash plate becomes the minimum θ_2 resulting the minimum stroke volume and high speed rotation of the hydraulic motor.



FG009766

Figure 9

PRECAUTIONS FOR USE

Installation (Refer to Diagram of External Dimensions)

Before installation remove plugs from oil level check ports, and confirm that reduction gear oil has penetrated as far as the oil level check ports.



CAUTION

When lifting a GM motor for transportation or installation, never enter the area below the GM motor. Serious injury may result.

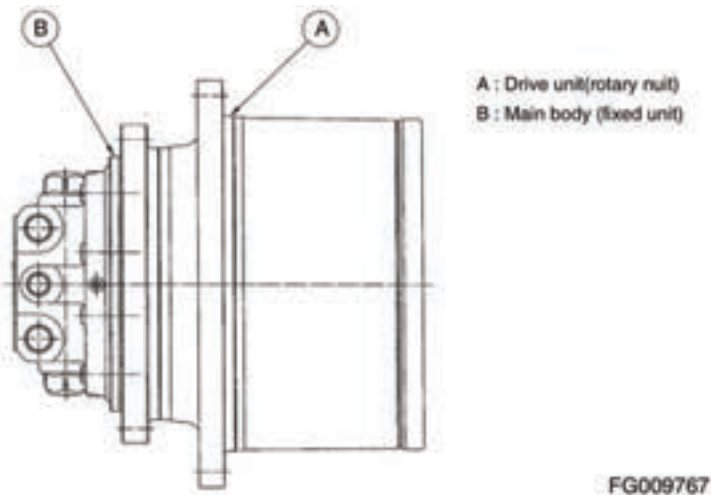


Figure 10

During installation, never hit the GM motor with a hammer or similar instrument.

NOTE: Use mounting bolts of JIS strength class 10.9 or equivalent.

Mounting Bolt Torque

	Q'ty	Thread Dimensions	Torque	Bolts Strength Class
Main Unit Mounting Bolts	20	M16 (P2.0)	252 ± 39.2N•m (25.7 ± 4.0 kg•m)	JIS B1051 Class 10.9 or Higher
Drive Unit Mounting Bolts	15	M16 (P2.0)	252 ± 39.2N•m (25.7 ± 4.0 kg•m)	

Tubing

During delivery, ports are covered with plugs or other coverings. This is to prevent entry of dust, welding scale, etc. Coverings should be removed before connecting tubing.



CAUTION

Before connecting tubing, confirm the direction of GM motor rotation, and the position of the ports. (Refer to Diagram of External Dimensions.) Failure to do so may result in reverse rotation, or injury.

NOTE: Before operating the motor, always fill the motor casing with hydraulic fluid.
Required oil volume in casing : 1.0 liters
Failure to do this may result in early damage to the hydraulic motor.

Select tubing sizes for drain port back pressure of 0.2MPa (2kgf/cm²) (maximum 0.69MPa (7kgf/cm²) at peak) or less.

Fluid Selection

Selection of hydraulic fluid-recommended grades

1. Use ISO VG32 or VG46 anti-friction hydraulic fluid.
2. Control hydraulic fluid purity to NAS Class 9 or better.
3. Ensure that the working fluid operating temperature range and viscosity range do not exceed the following limits.
Operating temperature range : -10 to +80
Effective viscosity range : 15 to 500 mm²/s
4. Consult the manufacturer before using any hydraulic fluid other than listed below.

Grade	Viscosity (40°C)	32 (mm ² /s)	46 (mm ² /s)	56 (mm ² /s)
	ISO equivalent	VG 32	VG 46	*VG 56
Supplier	Showa Shell	Shell Tellas Oil 32	Shell Tellas Oil 46	Shell Tellas Oil 56
	Idemitsu	Daphne Super Hydro A32	Daphne Hydraulic Fluid A46	
	Cosmo	Cosmo Hydro AW32	Cosmo Hydro AW46	(Cosmo Hydro AW56)
	Nippon Oil	Super Highland 32	Super Highland 46	Super Highland 56
	Mobil	DTE Oil 24	DTE Oil 25	
	Japan Energy	JOMO Hydrax 32	JOMO Hydrax 46	
* VG56 is the support viscosity grade that is prescribed by JIS. However, it was abolished in March, 1983. Please use other viscosity grades as much as possible.				

MAINTENANCE AND INSPECTION

Daily Inspection

The following daily maintenance and inspection items should be verified before operating the GM motor.



CAUTION

Except for confirmation of the following third abnormal sounds, maintenance and inspection must always be performed when the product is stopped. Inspection during operation may cause injury or burns. Also, confirmation of abnormal sounds should be performed in a safe area. Touching or approaching the product during operation may cause injury or burns.

1. No oil leakage (Hydraulic fluid, lubricating oil)
 2. No loose bolts
 3. No abnormal sounds
 4. Casing temperature not abnormally high
(Maximum external casing temperature during continuous operation = 80°C)
 5. Change interval of lubricating oil.(Refer to 5-4)
-



CAUTION

Immediately after operation, the casing is hot. To prevent burns, use a thermometer to measure temperature and do not touch directly with the hands.

Changing Fluid

The standard interval for changing hydraulic fluid is every 1000 hours or one year.

Hydraulic fluid may be changed within the standard interval if there is significant reduction in volume, subject to the following standards.

Test item	Change standard
Viscosity change (40°C)	± 10%
Total oxidation (mg KOH/g)	Consult oil supplier. Additive types vary according to manufacturer.
Water content (%)	0.1%
Impurities	10 mg/100ml
Impurities (%)	0.05%

Changing Lubrication

Reduction gear lubricating oil (gear oil) is added at time of delivery.

1. Selecting Gear Oil - Recommended Grades
 - A. Use SAE 90 equivalent gear oil (API type GL-4 or higher) with ultra-high pressure additives.
 - B. Recommended product names follow:

Supplier	Product Name
Idemitsu	Appoloil Gear HE 90
Esso	Esso Gear Oil GP 90
Showa Shell	Shell Spirax EP 90
Cosmo	Cosmo Gear Oil GL-4 90
Nippon Oil	Hypoid Gear Oil SP 90
Mobil	Mobilube HD 90
Japan Energy	Gear 4

2. Gear Oil Change Interval
 - A. First change (initial change after starting operation) after 500 hours
 - B. Second and following changes: after 1000 hours or one year
 - C. Change standard

Test item	Change standard
Viscosity change (40°C) (mm ² /s)	10% or less of new oil.
Water content (%)	0.2 % or less.

Avoid mixing different types of lubricating oils. When changing the type of lubrication oil, be sure to flush the interior of the reduction gear.

3. Gear Oil Change Volume : 2.1 liters
4. Gear Oil Change Procedure



CAUTION

Immediately after operation, the case may be extremely hot. Touching with the hands may cause burns.

Also, removing port plugs while hot may cause hot oil to spray out as pressure is reduced in the reduction gear, possibly causing burns. Allow the case temperature to cool sufficiently before changing oil.

NOTE: *If gear oil volume is reduced for any reason, be sure to confirm the cause and take appropriate measures before filling with gear oil.*

When removing gear oil, always dispose of old oil in an approved container rather than on the ground. Also, take care to observe applicable laws and regulations regarding disposal.

Oil may spray out when plugs are removed.

Turn the plug slowly and allow internal pressure to escape before removing.

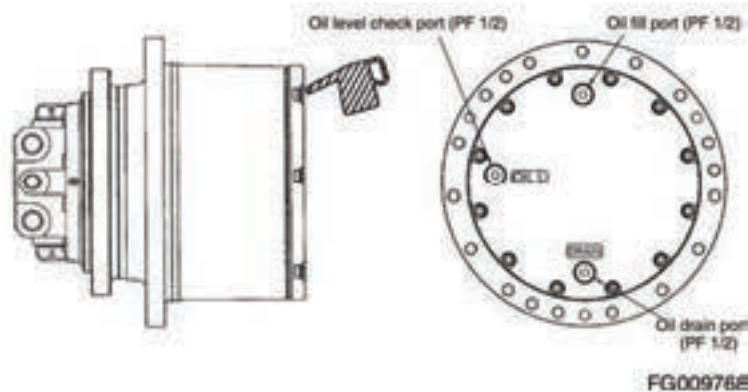


Figure 11

1. Stop the GM motor when the oil fill check port is at the top and the oil drain port is at the bottom (Figure 11).
2. Place the waste oil receptacle below the GM motor.
3. To change oil, remove the plugs on the 3 ports, and drain the gear oil.
To fill oil, do not remove the plugs from the drain ports.
 - Tightening torque: 98.1 ± 19.6 N-m (10.0 ± 2.0 kgf-m)After draining the oil, replace the plug on the oil drain port.

- Tightening torque: 98.1 ± 19.6 N-m (10.0 ± 2.0 kgf-m)
4. Add gear oil to the oil fill port.
Stop filling just before the gear oil overflows at the oil level check port.
 5. Re-place the plugs on the oil fill ports and level check port.
 - Tightening torque: 98.1 ± 19.6 N-m (10.0 ± 2.0 kgf-m)
 6. Re-place the plugs on the oil fill port.
 - Tightening torque: 98.1 ± 19.6 N-m (10.0 ± 2.0 kgf-m)

SEALS TABLE

Handle sealing parts carefully.

Once disassembled, replace to the new parts even though no damage is observed.

No.	Name of Part	Code	Q'ty	Remarks
1	O-ring	JIS B 2401-P18-90	3	31
			2	212
			1	359
2	Floating Seal	ES100-209-B-A-627	2	29
3	O-ring	ARP568-261-70	1	32
4	O-ring	JIS B 2401-P7-90	2	33
5	Oil Seal	TCZ28 X 48 x 10 x 11.3	1	132
6	O-ring	50OD2039-00	1	135
7	O-ring	60OD2039-00	1	139
8	O-ring	JIS B 2401-PIOA-90	2	207
9	O-ring	JIS B 2401-P14-90	2	209
			2	383
10	O-ring	JIS B 2401-P11-90	2	211
11	O-ring	JIS B 2401-P32-90	2	336
12	O-ring	JIS B 2401-P8-90	3	358
13	Back up Ring	JIS B 2407-T2-PIOA	4	208
14	Back up Ring	JIS B 2407-T2-P14	4	210

TROUBLESHOOTING

Please contact our company, when the disposal to which "O" mark is attached is required.

Problem 1	Problem 2	Possible Cause	Action	
Motor does not turn	Pressure will not increase	Relief set pressure is too low	Check the main relief valve	
		Pump failure	Repair	
		Direction switching valve is damaged	Repair	
	Pressure does increase	Brake valve failure	Replace or repair brake valve	O
		Hydraulic motor failure	Repair	O
		Gear (reduction) damage	Replace GM motor	O
		Excessive load applied	Remove excessive load	
		Orifice of parking brake line is blocked.	Remove the foreign materials.	
Oil leakage	Leaking from mating surface	Flaws in surface	Repair flaws with grinder, sand-paper, etc.	O
		Bolts loose	Retighten	
	Leaking from case	Plug loose	Retighten	
		Cracked by stone etc.	Replace GM motor	O
	Leaking from floating seal	Worn-out sliding surface	Replace GM motor	O
		O-ring creepage	Replace GM motor	O
	Leaking from hydraulic motor	Bolts loose	Retighten	
		O-ring damaged	Replace O-ring	O
		Seal surface flawed	Repair flaws with grinder, sand-paper, etc.	O
During use on a sloping road, rotates under load	increased leakage of working fluid	Reduced hydraulic motor capacity	Replace GM motor	O
		Increased internal brake valve leakage	Replace or repair brake valve	O
	Parking brake does not function	Spring damage	Replace spring	O
		Friction plate worn down	Replace friction plate, mating plate	O
Reduction gear case surface temperature too high		Shotage gear oil	Fit to recommended level	
		Pitching in bearings	Replace GM motor	O
		Working oil in gear case	Replace oil seal	O

Problem 1	Problem 2	Possible Cause	Action	
Meanders when used as drive motor	Occurs at low pressure	Left-right ejection volume imbalance	Repair pump	
		Left-right hydraulic motor drain volume imbalance	Replace GM motor	O
	Occurs at high pressure	Left-right ejection volume imbalance	Repair pump	
		Left-right hydraulic motor drain volume imbalance	Replace GM motor	O
		Left-right brake valve operation imbalance	Replace brake valve	O
		Left or right control valve has low relief pressure	Set pressure correctly, or replace relief valve	
Speed too slow	Pump ejection volume too low	Pump not operating properly	Repair or replace pump	
		High oil leakage outside pump	Repair or replace pump	
		High oil leakage outside hydraulic motor	Replace GM motor	O
Abnormal sounds	From GM motor	Hydraulic motor or reduction gear damage	Replace GM motor	O
	From tubing	Tubing vibration occurring	Clamp tubing	
2 -speed switching does not function	Does not switch low to high speed	High pressure selection check valve malfunction	Inspect, repair or replace	O
		Switching valve malfunction	Repair or replace	O
		Pilot pressure too low	Set to required pressure	
	Does not switch from high to low speed	2-speed switching piston malfunction	Repair or replace	O
		Switching valve malfunction	Repair or replace	O
		2-speed switching piston malfunction	Repair or replace	O

OUTLINE OF MAINTENANCE

Tools

No.	Name	Type · Specification	Q'ty
1	Hex-Spanner	2.5 (M5), 3 (M6), 4 (NPTF 1/16), 5 (PF 1/8), 6 (PF 1/4) 8 (M10,PF 3/8), 10 (M12,PF 1/2)	1
2	Socket Wrench (Ratchet Handel) (JIS B 4641)	Tumbler type	1
3	Torque Wrench (JIS B 4650)	Dial type : 50[N] , Dial type : 100[N], Dial type : 300[N] , Dial type : 560[N]	1
4	Adaptor for Torque Wrench		1
5	Hex-Socket	Diagonal size 24 mm, 41 mm	1
6	Extension Bar (JIS B 4637)	150 mm	1
7	Hammer	Various	1
8	Plastic Hammer	L = 400 mm	1
9	O-Driver (JIS B 4609)	50 mm, 150 mm	1
10	Retainer Ring Plier	For axle, For groove	1
11	Plier (JIS B 4623)	200 mm	1
12	Lifting Device	Lifting Load : 2940[N], 300[kg] min. Eye-bolt (M16) Eye-bolt (M12) Eye bolt (PF 1/2) Hooked wire	1 Set 2 3 2 1
13	Container	General: W450 X D300 X 120 mm	2
14	Leather Gloves		1 Pair

Bolts

No.	Name	Type · Size	Q'ty
1	Long Hex-Bolt	M12(P1.5) x 40 mm	2

Equipments

Application (Use or P/N)	Name	Type · Specification	Q'ty
Assembling & Disassembling	Work Bench		1
Washing (product & parts)	Wash Tank	Washing·final washing	1
24, 104, 149	Press Work Bench	24 : press Cap. 9800[N] (1000[kgf]) min. 104 : press cap. 1960[N] (200[kgf]) min. 149 : press cap 1960[N] (200[kgf]) min.	1
149	Heating Tank	Heating Cap : 100°C min Volume: 500 X 500 X 500 min	1
Drying after Washing	Compressed Air	0.29~0.49 [MPa] 3~5 kg·cm ²	1

Fabricated Tools

- work bench for travel motor
 - For easy and safe work of disassembling and assembling travel motor.

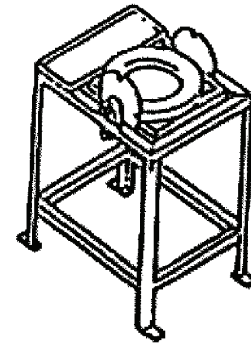


Figure 12

FG009804

- Pressing Tool (I)
 - Used for inserting Spring (114), Washer (110), or Snap Ring (145) into the Cylinder Block (104).
 - Used for removing the Spring (114) from Cylinder Block (104).

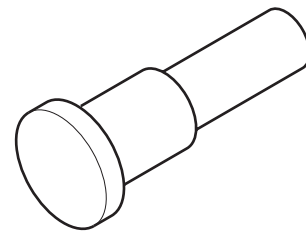
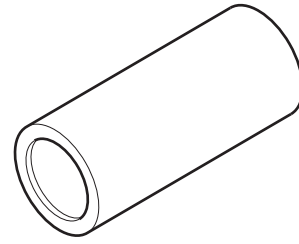


Figure 13

FG009805

3. Pressing Tool (II)

- Used for removing the Deep Groove Ball Bearing (149) from Shaft (102).

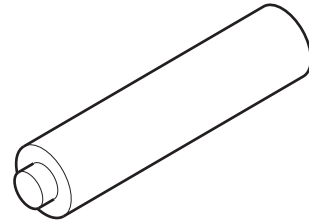


FG009806

Figure 14

4. Oil Seal Inserter

- Used for pressure-inserting Oil Seal (132) into the oil seal groove on the Spindle (2).

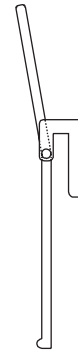


FG009807

Figure 15

5. Lock Washer Inserter

- Used to insert Lock Washer (22) into the inlet of the Spindle (2).



FG009808

Figure 16

6. Main Bearing Inserter

- Used to insert Angular Ball Bearing (24) into the hub (1).

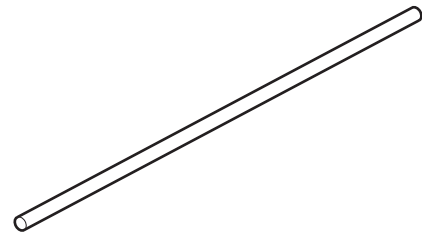


FG009809

Figure 17

7. Steel Rod (I)

- Used to remove Angular Ball Bearing (24) from the hub.



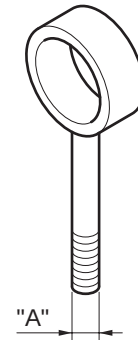
FG009810

Figure 18

8. Long Eye Bolt

- Used to hang Travel Motor, Spindle (2), and Hub (1).

Use	"A"
Hub	M 16
Hub	M 10
Spindle	M 16
Travel Motor	M 16

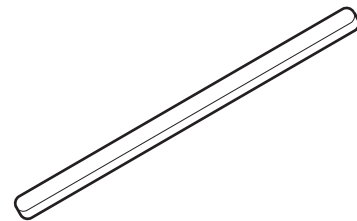


FG009811

Figure 19

9. Blade

- Used to remove Timing Plate[109] from Rear Flange (301).



FG009812

Figure 20

10. Floating Seal Assembler (I)

- Used to assemble Floating Seal[29] with Hub (1).

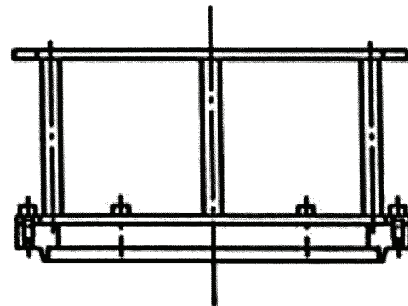


FG009813

Figure 21

11. Floating Seal Assembler (II)

- Use to assemble Floating Seal[29] with Hub[1] and Spindle (2).

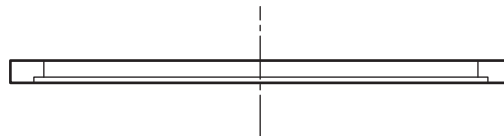


FG009814

Figure 22

12. Floating Seal Assembler (III)

- Use to assemble Floating Seal[29] with Spindle (2).



FG009815

Figure 23

Torque

Parts (Structural Diagram)	Bolts & Nuts		Hex-2 Face Width (mm)	Q'ty	Torque (N•m)
	Name	Spec.			
30, 357	Plug	PF 1/2	10	4	98.1 ± 19.6 (10.0 ± 2.0)
35	Hex Groove	M10 (P1.5)	8	12	66.7 ± 3.92 (6.8 ± 0.4)
203	Sleeve (assembling Relief Valve)	PF 1/2	24 (Socket)	2	98.1 ± 19.6 (10.0 ± 2.0)
205	Plug	PF 1/4	6	2	29.4 ± 4.90 (3.0 ± 0.5)
324	Plug	M36 (P1.5)	41 (Socket)	2	441 ± 39.2 (45.0 ± 4.0)
343	Hex Groove Bolt	M12 (P1.75)	10	10	102 ± 15.7 (10.4 ± 1.6)
352	Plug	PF 1/8	5	3	12.3 ± 2.45 (1.25 ± 0.25)
354	Hex Groove Plug	NDTF 1/16	4	5	9.81 ± 1.96 (1.0 ± 0.2)
380	Plug	PF 3/8	8	2	58.8 ± 9.81 (6.0 ± 1.0)
396	Hex Groove Plug	PT 1/4	6	2	29.4 ± 4.90 (3.0 ± 0.5)
398	Hex Groove Plug	PT 1/8	5	5	12.3 ± 2.45 (1.25 ± 0.25)

Weight Table

Parts (Structural Diagram)	Name	Mass (kg)
Travel Motor Assembly		Approx. 145
1	Hub	Approx. 46
2	spindle	Approx. 27
3	Carrier (1) Assembly	Approx. 12
7	Carrier (2) Assembly	Approx. 24
301	Rear Flange Assembly	Approx. 13

NOTE: Use crane to lift up heavy objects. Otherwise, may result in injury in back.

DISASSEMBLING

Work Preparation

Prepare following for disassembling;

1. Work Bench
 - Prepare the work bench for Travel Motor.
 - The bench must be rigid enough for the disassembling and reassembling the internal parts of the Travel Motor.

The bench must have sufficient area to place all the parts.

The bench must be stabilized to prevent fall or movement of parts during work
 - The bench must be covered with rubber or vinyl sheet.
2. Tools and Devices
 - Prepare the tools and devices listed in the paragraph

General Precautions for Work



CAUTION

Parts are slippery by gear oil or hydraulic oil.

Take care not to fall or drop the parts to prevent injury and damage to parts.



CAUTION

Kerosene or other inflammable solvent is used for parts washing.

Take utmost care when handling such inflammable solvents to prevent fire.

1. Prepare check list including the characteristics of anomalies before starting the disassembling work. Keep the order of disassembling.
2. All the parts are precision parts. Take care for handling, without collision or dropping.

NOTE: *Take care not to cut hands when handling sharp edged parts.*

3. Even hard and rigid parts must not be knocked or exerted with excessive force. Otherwise, the part may become unable to assemble or degraded in performance. Work with patience and care.
4. Take measures of rust or dust proofing if disassembled parts have to be left unassembled for a long while. Otherwise, the part may be degraded with rust.
5. Mark the fitting surfaces during disassembling.
6. Arrange the disassembled parts in order to prevent damage or loss of the parts.
7. Seals, in principle, have to be replaced when disassembled, even though they look good. Prepare replacement parts before disassembling.
8. The photos and pictures show typical models. Certain parts may differ from the actual parts, but the order of disassembling is the same.

Disassembling Order

1. Washing the Travel Motor

- A. Joint and tighten eye bolts in the M16 bolt holes on the Spindle (2). Lift the Travel Motor with a crane and move it to the Wash Tank.

NOTE: *Place the two eye bolts symmetrically in the M16 bolt holes on the spindle.*

- B. Wash the Travel Motor with brush.

NOTE: *Wash the groove (for floating Seal) between the Hub (1) and Spindle (2) clean, where there is dust or foreign matter.*

2. Mounting the Travel Motor

- A. Place the Travel Motor on the work bench.

NOTE: *Insert the Travel Motor into the mounting hole on the work bench lightly, while matching the screw hole on the Spindle (2) with the screw hole on the work bench.*

- B. Mount the Travel Motor with two hex-groove bolts on symmetric position.



CAUTION

Tighten the hex-groove bolt sufficiently. Otherwise, the Travel Motor may fall down when overturned for work.

3. Removing the Lubricant

- A. Lay down the Travel Motor(with the outlet port pointing downward).
- B. Loosen the Plug (30) at the oiling port to release the pressure in the reduction gear, and tighten the plug lightly.

NOTE: *If the reduction gear was not depressurized, lubricant may eject out when the plug on the discharge port is loosened.*

- C. Place a container at the end of the oil discharge port, take the plug out slowly to discharge the lubricant.

NOTE: *The container must be large enough to receive the lubricant in the reduction gear, which is 2.1L.*

- D. If the lubricant does not come out smoothly, remove the plug on the oiling port slowly.
- E. Remove the O-ring (31) from the Plug which was taken out.

NOTE: *Once disassembled, the O-ring (31) must be replaced with a new one, to prevent oil leak.*

4. Removing the Cover

- A. Turn the Travel Motor over(with the Reduction Gear facing upwards)
- B. Remove the 12-M10 bolt (35).
- C. Seal is applied on the fitting surfaces of the Cover (14) and Hub (1). Insert a metal rod on the top of the Cover, knock the rod to the upside of the slope to remove the Cover.



CAUTION

When knocked towards the upside of the slope, the Cover may bound up or fall down. Take care of your foot not to be hurt with the falling Cover.

- D. Joint an eye bolt at the PF1/2 Port, lift the Cover (14) up from the Hub and move it.



Figure 24



Figure 25

5. Removing the Thrust Plate

- A. Remove the Thrust Plate (13).



Figure 26

6. Removing the 1st Stage Gears

- A. Remove the Sun Gear (1, 4).

NOTE: Take care not to drop the Sun Gear (1) down, which is slippery with lubricant.



Figure 27

- B. Join bolts in the three M12 Tabs on the Carrier (1, 3). Lift the Carrier Assembly (1) with crane and move it.

NOTE: When lifting the Carrier (1) Assembly up, align the center lines of the Hub (1) and the Carrier Assembly (1), and lift up slowly in order to prevent the end of the Planetary Gear (1, 5) damaging the teeth inside the Hub.



Figure 28

7. Removing the Coupling

- A. Remove the Coupling (15) from the Shaft (102).



Figure 29

8. Removing the 2nd Stage Gears

- A. Join eye bolts in the 3 M12 Tabs, for hanging, on the 3 points of the Carrier (2, 7). Lift the Carrier Assembly (2) with crane and move it.

NOTE: When lifting the Carrier Assembly (2) up, align the center lines of the Hub (1) and the Carrier Assembly (2), and lift up slowly in order to prevent the end of the Planetary Gear (2, 9) damaging the teeth inside the Hub.

- B. Remove the Sun Gear (2, 8).

NOTE: Take care not to drop the Sun Gear(2) down, which is slippery with lubricant.

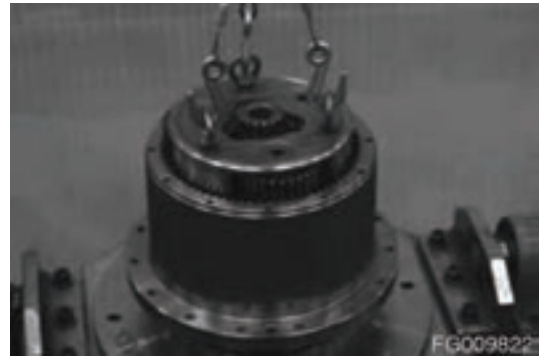


Figure 30

9. Removing the Lock Washer

- A. Fix on the turn-over table using the M14 hole of the Hub (1).



Figure 31

- B. Place (-) screw drive, or an equivalent tool, at the skimmer of the 2 Lock Washers (22). Knock the driver head with a hammer towards the bottom of the slope to remove the Lock Washer.



Figure 32

10. Removing the Hub

- A. Remove the hex-groove bolt joining the Hub and the turn-over table.
- B. Mount an eye bolt (M10) on the Hub and lift it up with crane.



WARNING

Lift the Hub up keeping it parallel with the Spindle shaft, slowly. If hung with an angle, large force has to be exerted, resulting in the fracture of the hanging device or eye bolt, and injury to the worker. If the Hub would not come out easily, do not hang it with excessive force, but use press to take it out safely.

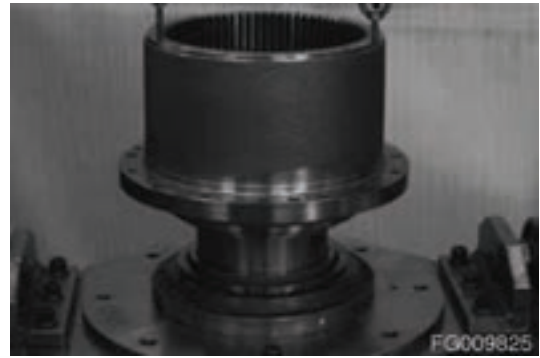


Figure 33

11. Removing the Floating Seal

- A. Exert force with hand on the inner side of the Floating Seal[29] towards upside.

NOTE: *Wear gloves to prevent cutting hand by the edge of the Floating Seal.*

If solidified with soil inside, remove it with (-) screw drive or similar tools as leverage.



Figure 34

12. Removing the Angular Ball Bearing

- A. Place a pin punch on the edge of the outer ring of the Angular Ball Bearing (24) at 3 or 5 points which divide the ring in equal intervals. Hammer the punch to take out the Bearing small by small.

NOTE: *Do not hammer the inner ring of the Angular Ball Bearing. If the inner ring is damaged, the Bearing cannot be used. Therefore, do not knock the inner ring, unless the Bearing is to be replaced.*

When the outer ring of the Ball Bearing (24) is out of the Hub (1), the Bearing falls down. Place a pan covered with rubber mat to receive the Bearing.



Figure 35

13. Removing the Rear Flange

- A. Turn the Travel Motor over (with Motor side up).

NOTE: *Following procedures are for removing the Plug easily, when disassembling the inside of the Rear Flange.*

Loosen the Plug so that it can be removed with hand.

Do not loosen the Plug unless the Rear Flange inside is to be disassembled.

- B. Loosen the two Plugs (324).

NOTE: *Following procedures are for removing the Plug easily, when disassembling the inside of the Rear Flange.*

Do not loosen the Plug unless the Rear Flange inside is to be disassembled.

When the Plug (324) becomes loose, the Spring (328) can move easily. Therefore, the Plug (324) and the Spring (328) may be ejected out. Therefore, care must be taken for this work.

- C. Loosen the two Plugs (380).

- D. Loosen the two Plugs (352).

- E. Loosen the Plug (357).

- F. Loosen the two Relief Valve Assemblies (including 203).



Figure 36



Figure 37



Figure 38

- G. Remove the two Relief Valve Assemblies (including 203).

NOTE: *Do not reuse the removed O-rings (207, 209, 212) and Back-up Rings (208, 210).*



Figure 39

- H. Unscrew the ten hex groove bolts (343) and remove them from the Rear Flange (301).

- I. Remove the Rear Flange (301) from the Spindle[2].

NOTE: *Hold the Rear Flange with both hands, lift it up carefully to remove it. If removed with excessive force or by knocking, the Timing Plate (109) may be fall down and damaged. Care should be taken when removing the Rear Flange.*



Figure 40

- J. Remove the two parallel Pins (34) from the Spindle (2).



Figure 41

- K. Remove the two O-rings (32, 33) from the Spindle (2).

NOTE: *Do not reuse the removed O-rings (32, 33).*



Figure 42

14. Disassembling the Rear Flange Assembly

- A. Place the Rear Flange (301) with the fitting surface with the Spindle (2) upside.
- B. Remove the Timing Plate (109) from the Rear Flange (301).

NOTE: *Removing the Rear Flange (301) may require some force because of the oil on the fitting surface. Insert a blade in the groove of the fitting surface on the Rear Flange (301) and lift the Timing Plate (109) up softly to remove it. Do not use sharp tools, such as screw driver, which may scratch the fitting surface, resulting in oil leak.*



Figure 43

- C. Remove the deep groove Ball Bearing (150) from the Rear Flange (301).



Figure 44

- D. Remove the Parallel Pin (341) from the Rear Flange (301).



Figure 45

15. Disassembling the Brake Valve Parts in the Rear Flange

- A. Remove the two Plugs (324) from the Rear Flange (301).
- B. Remove the Washers (325) and springs (328), 2 each, from the Rear Flange (301).



Figure 46

- C. Remove the Spool (323) from the Rear Flange (301).

NOTE: *Tilt the Plug Port of the Rear Flange (301), then the Spool (323) will slide out. Take it by lifting the front end.*



Figure 47

- D. Remove the O-ring (336) from the Plug (324).

NOTE: *Do not reuse the removed O-ring (336).*



Figure 48

16. Disassembling the 2-Speed Switching Spool

- A. From the Rear Flange (301), remove the Plug (357).
- B. Remove the O-ring (359) from the Plug (357).

NOTE: Do not reuse the removed O-ring (359).



Figure 49

- C. Remove the Spool (363) and spring (366) from the Rear Flange (301).



Figure 50

17. Disassembling the Piston

- A. From the Rear Flange (301), remove the two Plugs (380).
- B. Remove the O-ring (383) from the Plug (380).

NOTE: Do not reuse the removed O-ring (383).



Figure 51

- C. Remove the Piston (381) from the Rear Flange (301).



Figure 52

18. Disassembling the Check Valve Ball

- A. From the Rear Flange (301), remove the two Plugs (352).
- B. Remove the O-ring[358] from the Plug (352).

NOTE: Do not reuse the removed O-ring (358).



Figure 53

- C. Remove the Steel Ball (353) from the Rear Flange (301).

NOTE: If it is difficult to remove the Steel Ball, use a magnet.



Figure 54

19. Disassembling the Packing Brake



If compressed air is injected in rapidly, the Piston (112) may be ejected out from the Spindle (2), resulting in injury or damage. Cover the Piston (112) to protect it.

- A. Inject the compressed air into the hole in the Packing Brake path of the Spindle 2, and take the Piston (112) out from the Spindle 2.



Figure 55

- B. Remove the O-rings (135, 139) out from the Piston (112).

NOTE: Do not reuse the removed O-rings (135, 139).



Figure 56

20. Disassembling the Hydraulic Motor Parts

NOTE: Oil will come out when the Travel Motor is laid down. Place an oil pan under the Travel Motor.

- A. Lay the Travel Motor down in 90 degrees.
- B. Remove the oil in the Travel Motor.
- C. Select the four Opposite Plates (116) and the three Friction Plates (115).



Figure 57

- D. Turn the Cylinder Block (104) by 2~3 rounds with hands, and remove the Shoe[106] attached to the Swash Plate (103).

NOTE: If the Cylinder Block (104) is removed in this state, the Shoe (106) remains in the Swash Plate (103), and the parts (Piston (105), Shoe (106) etc.) will be separated from the Cylinder Block (104) and fall inside the Spindle (2). So care must be taken in this state.



Figure 58

- E. Remove the Cylinder Block (104) from out of the Shaft (102).
- F. Remove the Piston Assembly (Piston (105), Shoe (106)) and the Retainer Plate (107) from the Cylinder Block (104).

NOTE: Remove the Piston Assembly together with the Retainer Plate (107) by holding the Retainer Plate with both hands.

The Piston (105) and the Shoe (106) are jointed by being tightened on the spherical surface of the Piston. The Shoe (106) cannot be separated from the Piston (105) without damaging the Shoe (106).

Therefore, if replacement is required, replace them as a single unit(hereinafter, will be referred to as the Piston Assembly.



Figure 59

- G. From the Retainer Plate (107), take the Piston Assemblies (105, 106) out (9 sets).



Figure 60

- H. Remove the Thrust Ball (108) from the Cylinder Block (104).



Figure 61

- I. Remove the three Collars (151) from the Cylinder Block (104).



Figure 62

21. Removing the Spring from the Cylinder Block

- A. Place the Cylinder Block (104) on the press work bench.

NOTE: *Spring (114) should be taken out only for replacement.*

To remove the Spring (114), align the axes of the press tool(•x) and the Washer (110), to prevent damage to the Cylinder Block (104) by contact.

Cover the Cylinder Block (104) up with vinyl sheet to prevent damage on the surface of the Cylinder Block (104).



Figure 63

- B. Place the press tool (1) on the Washer (110), press the tool (1) strongly with a press, and remove the THS Snap Ring (145) out from the snap ring groove on the Cylinder Block (104), with a snap ring plier.



CAUTION

Release the press slowly. If released suddenly, the Spring (114) may be ejected out giving injury.

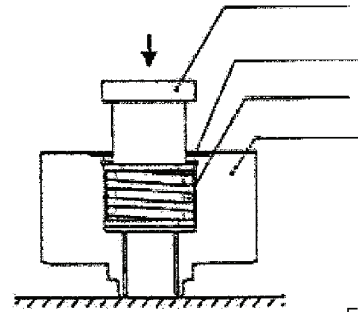


Figure 64

- C. From the Cylinder Block (104), remove the THS Snap Ring (145), Washer (110), Spring (114), and Washer (110).



Figure 65

22. Removing the Swash Plate

- A. Remove the Swash Plate (103) from the Shaft (102).

NOTE: Take care when removing the Swash Plate (103), because the Pivot (167) may be attached to the Swash Plate (103).



Figure 66

- B. Remove the Shaft (102) from the Spindle (2).

At this time, the deep grooved Ball Bearing (149) will be separated being attached on the Shaft.

NOTE: Shaft (102) can be easily removed by knocking the end of the Shaft on the Reduction Gear side with a plastic hammer. Take care not to strike the Shaft, or it may bound.

- C. Remove two (each) Pivots (167) and Parallel Pins (171) from the Spindle (2).



Figure 67

- D. Remove the 2-speed switching Piston Assembly and the Spring (185) from the Spindle (2).



Figure 68

23. Removing the Deep Grooved Ball Bearing

NOTE: Remove the Deep Grooved Ball Bearing only for replacement.

- A. Place a press tool (II) on the press work bench, and insert the Shaft (102) in it.
- B. Press the end of the Shaft with the press to remove the Inner Ring[149] of the Deep Grooved Ball Bearing from the Shaft[102].

NOTE: Do not reuse the Deep Grooved Ball Bearing.

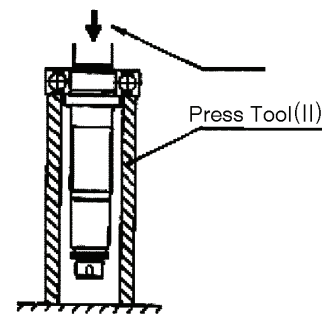


Figure 69

24. Removing the Parts on the Spindle

- A. Remove the Seal (23) from the Spindle (2).



Figure 70

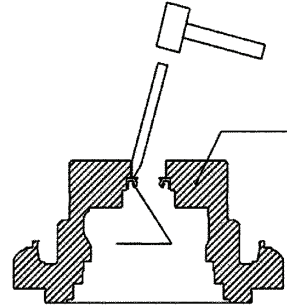
- B. Remove the Floating Seal (29) from the Spindle (2).



Figure 71

- C. Remove the Oil Seal 132 from the Spindle (2).

NOTE: Do not reuse the removed Floating Seal (29) and Oil Seal (132).



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Figure 72

25. Washing the Parts

- A. Classify the Hub[1], Spindle (2), Cover[14], Rear Flange (301) and other parts.
- B. Wash the Hub (1) Spindle (2) Cove (14) Rear Flange (301) in the wash tank.

NOTE: Remove soil on the surface carefully.

Kerosene used for washing is highly inflammable. Be careful to prevent fire.

NOTE: if the parts are dirty, leave it in the solvent for a while, until the dust, soil, and grease are separated and float up. Do not wash dirty parts from the start, or the dirt may scratch the surfaces.

- C. Wash the other parts in a wash tank with kerosene.



Figure 73

26. Final Washing

- A. Put the parts in the finish washing tank containing kerosene. Rotate the parts slowly, wash them clean to the inside.



Figure 74

- B. Wipe the kerosene on the parts with clean cloth.

NOTE: *Dry the inside of the Hub[1] and Spindle[2] with compressed air, where there is no dust and moisture.*

After drying, apply hydraulic oil on the surface of the parts.

Leave the Rear Flange[301], hydraulic motor parts, and gears in a place free from dust and moisture to dry up. When dried, apply hydraulic oil on their surfaces.



Figure 75

MAINTENANCE STANDARDS

GM Motor has to be disassembled and inspected in compliance with this standard. Take utmost care not to scratch on the moving and reciprocating surfaces.

Seals

Seals (O-ring, oil seals, floating seas) must be replaced with new seals, regardless of the damage, once disassembled.

Maintenance Standards for Wearable Parts

- Any parts which show visible defect must be replaced with new ones.
- Replace the parts which show following defects.

Part No.	Name	Defect Description	Standard Size	Allowable Range
1	Hub	- Any major visible defect. - Pinching on the tooth of ring gear. - Abnormal wear such as scratch.	-	-
2	Spindle	- Any major visible defect. - Abnormal wear such as scratch.	-	-
3, 7	Carrier Assembly	Abnormal wear such as scratch.	-	-
4 8 5 9	Sun Gear 1 Sun Gear 2 Planetary Gear 1 Planetary Gear 2	- Pinching on tooth. - Breaking on the working surface of bearing.	-	-
24	Ball Bearing	- Dent. - Breaking. - Biased wear.	-	-
301	Rear Flange	Scratch on the reciprocating surface between the Spools (323, 363) and Piston (381).	-	-
102	Shaft	- Wear on the fitting surface with the Oil Seal [132]. - Worn spline.	-	-
103	Swash Plate	Sooting.	-	-
104	Cylinder Block	- Worn spline. - Serious wear on the inside of the bore. - Scratch or biased wear on the reciprocating surface with the Timing Plate (109).	-	-
105 106	Piston Assembly Piston Shoe	- Skimmer on the axial direction of the Piston (105) and Shoe (106). - Abnormal, biased wear of Shoe (106).	Skimmer 0.15 mm	Skimmer 0.15 mm

Part No.	Name	Defect Description	Standard Size	Allowable Range
107	Retainer Plate	· Biased wear on the reciprocating surface with the Shoe (106) · Scratch or biased wear on the reciprocating surface with the Thrust Ball (108).	-	-
108	Thrust Ball	· Biased wear on the spherical reciprocating surface with the Retainer Plate (107).	-	-
109	Timing Plate	· Sooting or biased wear on the reciprocating surface.	-	-
115 116	Friction Plate Opposite Plate	· Biased wear on both ends. · The torque is different from the specified value. · Sooting.	Braking Torque 206 N•m (21.0 kgf•m), min.	Braking Torque 206 N•m (21.0 kgf•m), min.
105	Piston	· Scratch or dent on outer surface.	-	-
149 150	Deep Grooved Ball Bearing	· Dent. · Breaking. · Wear.	-	-
161 162	2-Speed Piston Kit Piston Shoe	· Abnormal wear on outer surface. · Abnormal, biased wear on Shoe.	-	-
323 363	Spool	· Biased wear on outer surface. · Dent on outer surface.	-	-
381	Piston	· Scratch on outer surface.	-	-

ASSEMBLING

Assembling, in principle, shall be carried out in the reverse order of the disassembling.

Preparation

Prepare work table, tools, devices, same as those described in the Disassembling Section.

General Precautions for Assembling Work

1. Cautions for assembling work, in principle, are same as those defined in the Disassembling Section.
2. Remove any metallic particle and foreign matters from all the parts. Check and remove rust or scratch with oil stone.
3. Replace O-ring, Oil Seals and Floating Seals with new ones.
4. Remove the residual adhesive in the screw holes (12) on the Hub (1) through the M10 P1.5 tab.

Wash, degrease the screw holes, blow the holes with compressed air to remove residual wash liquid.

Replace the hex-groove bolts (35) with new ones.

5. When assembling the O-ring, Oil seals and floating seals, take care not to damage them (apply a small amount of grease for smoothness).
6. Be sure to apply clean machine oil (NAS Class 9 or better) on the moving and reciprocating surfaces of the hydraulic motor and valves
7. Do not wear cloth gloves while assembling to prevent malfunction by residual fibers.
8. Tighten the bolts and Plugs by the torque specified in the See "Torque" on page -33.
9. Plug all ports to prevent dust after assembling.
10. The photos and pictures are on the typical model. Partial difference may exist, however, the order of assembling procedures are the same.

Order of Assembling

When replacing and reassembling parts, pre-pressure adjustment of Ball Bearing is required. Therefore, make sure that the parts below have been replaced before assembling.

NOTE: Replacement parts for pre-pressure adjustment of Ball Bearing .Hub (1), Spindle (2), Ball Bearing (24)

NOTE: When replacing and reassembling the above listed parts, make sure to use the pre-adjusted parts. Otherwise, the Travel Motor may mal function resulting in earlier damage.

1. Assembling the Hub

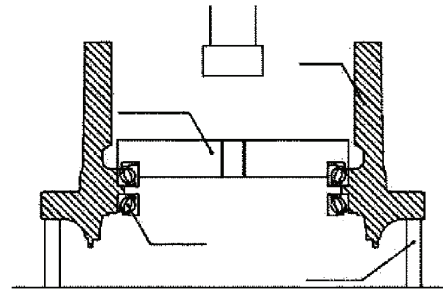
- A. Place the Hub[1] on the press work bench.
- B. Insert the Ball Bearing (24) into the Hub[1]. Place the press fitting tool on the outer ring of the Ball Bearing (24), press it with press to insert into the Hub[1].
- C. Turn the Hub (1) upside down.
- D. Press fit the Ball Bearing (24) into the Hub (1), in the same method as B.

NOTE: Take care that the Ball Bearing (24) is assembled in the correct direction.

- E. Apply grease on the O-ring of the Floating Seal (29). Insert the Floating Sel[29] into the groove on the Hub (1).

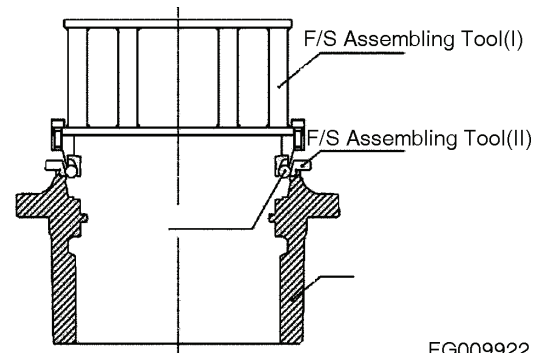
NOTE: When applying grease on the O-ring of the Floating Seal (29), take the O-ring off of the Floating Seal (29) and apply grease on the whole surface of the O-ring, thin and evenly.

NOTE: To assemble the Floating Seal[29], place the F/S assembling tool (I), Floating Seal[29], and F/S assembling tool (II), in the listed order, and press until the F/S assembling tool (II) touches the F/S assembling tool (I). Remove the F/S assembling tools and confirm that the end surface of the Hub is within 1 mm difference with the floating seal surface.



FG009868

Figure 76



FG009922

Figure 77

2. Assembling the Spindle Part

- A. Apply grease on the O-ring of the Floating Seal[29]. Insert the Floating Seal (29) into the floating seal groove on the Spindle (2).

NOTE: To assemble the Floating Seal (29), place the F/S assembling tool (I), Floating Seal (29), and F/S assembling tool (II), in the listed order, and press until the F/S assembling tool (II) touches the F/S assembling tool (I). Remove the F/S assembling tools and confirm that the end surface of the Hub is within 1 mm difference with the floating seal surface.

- B. Join two eye bolts on the Spindle (2) at symmetric position.
- C. Place the Spindle (2) on the work bench with the hex-groove bolts are on symmetric position.



CAUTION

Tighten the hex-groove bolt sufficiently. Otherwise, the Travel Motor may fall down when turned over.

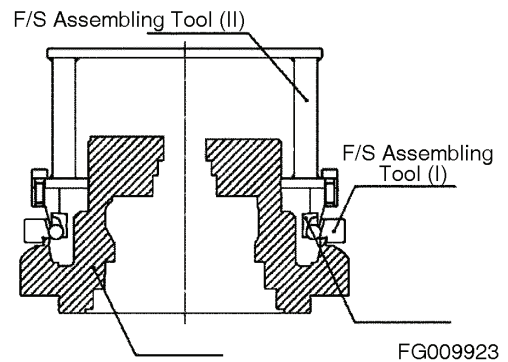


Figure 78

FG009923



Figure 79

3. Adjusting the Pre-pressure of the Angular Ball Bearing

NOTE: When the Hub (1), Angular Ball Bearing (24) or Spindle (2) is replaced, carry out pre=pressure adjustment. If the pre-pressure is not appropriate, the Angular Ball Bearing may be fractured soon.

A. Insert the Lock Washer (22) in the Spindle (2), and measure size C.

B. Measure the width D of the Angular Ball Bearing.

NOTE: Turn Hub (1) and Angular Ball Bearing (24) by a few rounds to remove loose, before measuring the size.

C. Deduct size C with D. Select the Seam (23) for which the skimmer is +0.13 mm ~ +0.17 mm in the Table below.

Symbol	T mm
A	0.9
B	1.0
C	1.1
D	1.2
E	1.3
F	1.4
G	1.5
H	1.6
I	1.7
J	1.8
K	1.9
L	2.0

D. Mount the Seam (23) on the Spindle (2).

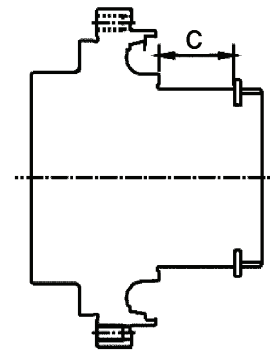


Figure 80

FG009872

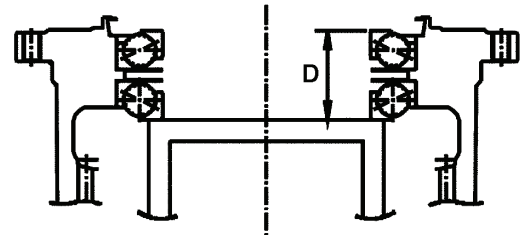


Figure 81

FG009873



Figure 82

FG009874

4. Assembling the Hub

- A. Align the central axes of the hung Hub[1] and Spindle (2) straight, lower the Spindle (2) slowly and insert into the Angular Ball Bearing (24).

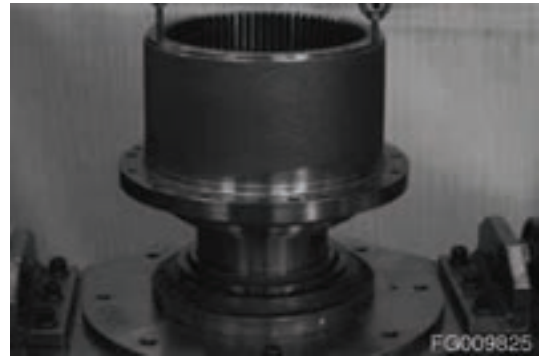


Figure 83

- B. Tighten a lock hex-groove bolt in the $\varnothing 14$ hole of the Hub to fix with the work bench.
- C. Place a metal rod on the inner ring of the Angular Ball Bearing (24) on the reduction gear side, knock it lightly with a hammer to remove looseness of the inner ring.



Figure 84

- D. Place the Lock Washer (22) on the groove on the Spindle (2).

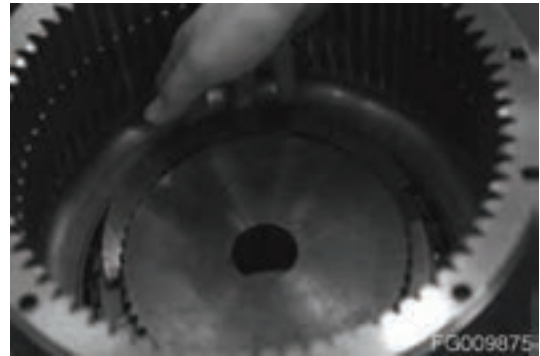


Figure 85

- E. Insert the Lock Washer (22) into the Spindle groove with a tool.

NOTE: When assembling the Carrier (2, 7), insert the Lock Washer (22) fully into the groove to avoid interference with the Lock Washer (22).

- F. Remove the Lock Hex-Groove Bolt which has been connecting the Hub (1) with the workbench.
- G. Turn the Hub (1) by 2-3 turns.

NOTE: Turning the Hub (1) will settle the fitting surface of the Floating Seal (29) to prevent leak.

- H. Turn the work bench so that the Motor faces upward.

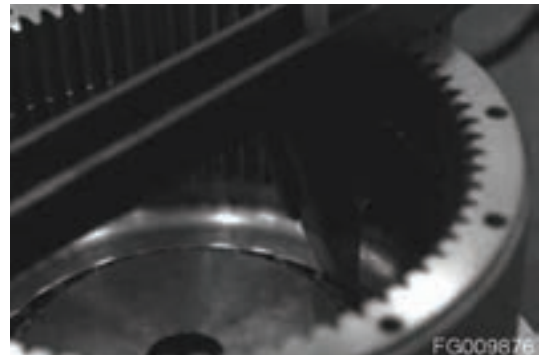


Figure 86

5. Assembling the Motor Parts in the Spindle

- A. Insert the Oil Seal (132) into the Spindle[2] using oil seal press-fitting tool and hammer.

NOTE: When assembling the Oil Seal, apply lithium grease on the Oil Seal lip

Take care that the assembling direction of the Oil Seal (132) is correct.

- B. Assemble the two Parallel Pins (171) into the pin holes of the Spindle (2).
- C. Apply lithium grease on the semi-spherical surface of the two Pivots (167) and press-fit them into the Parallel Pins (171) which are inserted in the Spindle (2).
- D. Apply grease on the Spring (185) and assemble it with the Piston Assembly Piston (161), Shoe (162).
- E. Apply machine oil on the reciprocating surface of the Piston Assembly and mount it into the Piston hole on the Spindle (2).
- F. Insert the two Parallel Pins (34) into the pin groove on the fitting surface of the Rear Flange of the Spindle (2).

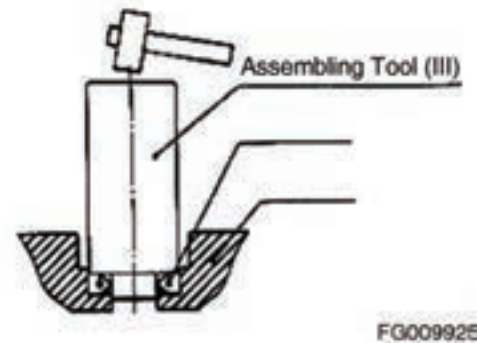


Figure 87



Figure 88

6. Assembling the Shaft



Wear leather gloves during the inserting work, to prevent burn.

- A. Put the Deep Grooved Ball Bearing (149) into the heating tank, heat it for 10 minutes at $100 \pm 10^{\circ}\text{C}$, and insert it onto the Shaft (102).

- B. Turn the Travel Motor by 90 degrees.
- C. Insert the Shaft (102) into the Spindle (2).

NOTE: Insert the Shaft[102] slowly into the Spindle (2) so that the lip of the Oil Seal (132) inserted into the Spindle is not damaged.

Damaged lip will cause oil leak, resulting in the earlier failure of the Travel Motor.

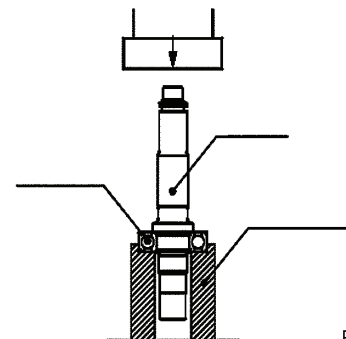


Figure 89



Figure 90

- D. Insert the Swash Plate (103) into the Spindle (2).

NOTE: Apply grease on the fitting surface of the Swash Plate (103) with the Spindle (2).

Insert the Swash Plate (103) into the Spindle (2) by matching the pivot mounting grooves on the Swash Plate (103) with the two Pivots (167) inserted onto the Spindle (2).



Figure 91

7. Assembling the Inner Parts of the Cylinder Block

NOTE: Insert the THS Snap Ring (145) with its sharp edge facing the inlet.

Insert the Washer (110) which contacts with the Fix Ring (145) with its sharp edge facing the Fix Ring (145).

- A. Insert the Washer (110), Spring (114), Washer (110), and THS Snap Ring, in the said order, into the Cylinder Block (104).
- B. Place the Cylinder Block (104) on the press work bench.



Figure 92



CAUTION

Take care to prevent the ejection of the Fix Ring which may occur if the plier tip slips out of the groove of the Fix Ring, when assembling the THS Snap Ring (145).

NOTE: The pressure of the Spring (114) must be 112N (115kgf) or more.

Protect the Cylinder Block (104) with a vinyl cover sheet to prevent damage on the contact surface with the Timing Plate (109).

- C. Place a press tool (I) on the Washer (110), press the tool with press, and assemble the THS Snap Ring (145) into the fix Ring Groove on the Cylinder Block (104) using fix ring plier.



Figure 93

8. Assembling the Hydraulic Motor Parts

- A. Insert the three needle-type Collars (151) into the groove on the Cylinder Block (104), and place the Thrust Ball (108) on them.



Figure 94

- B. Insert the nine Piston Assemblies into the Retainer Plate (107).

NOTE: Soak the whole assembly in machine oil.

- C. Assemble the Retainer Plate (107) and the nine Piston Assemblies with the Cylinder Block (104).

NOTE: Align the Retainer Plate (107) and the spherical surface of the Thrust Ball (108).



Figure 95

- D. Insert the Cylinder Block (104) into the Shaft (102).

NOTE: Align the splines on the Cylinder Block (104) with those on the Shaft (102).



Figure 96

- E. After assembling the Cylinder Block (104), turn the Cylinder Block (104) with hands to check if there is any looseness or clicking.

If it clicks, check the assembly.

NOTE: The Cylinder Block[104] cannot be lifted up after assembling.

If lifted up, the Thrust Ball[108] will be dropped, unable to rotate normally.



Figure 97

9. Assembling the Packing Brake

NOTE: Soak the Friction Plate (115) in machine oil before assembling.

- A. Turn the work bench by 90 degrees.
- B. On the Cylinder Block (104), assemble the four Opposite Plates (116) and the three Friction Plates in turns.
- C. Apply grease thinly and insert the O-rings (135, 139) into the O-ring groove on the Piston (112).



Figure 98

- D. Assemble the Piston (112) in the Spindle (2).

NOTE: In the event that the Piston (112) would not be inserted into the Spindle (2) due to the friction of the O-rings (135, 139), knock the end of the Piston (112) lightly with a plastic hammer.

Take care to prevent scratch on the O-ring when assembling the Piston (112).

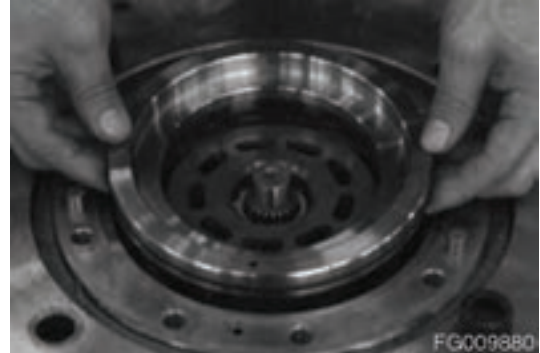


Figure 99

10. Assembling the 2-Speed Switching Spool in the Rear Flange

NOTE: Insert the Spring (366) and Spool (363) into the Rear Flange (301).

- A. Assemble the O-ring (359) on the Plug (357).

NOTE: Apply grease on the O-ring (359).



Figure 100

- B. Insert the Plug (357) into the Rear Flange (301).
- C. Tighten the Plug (357) with the Rear Flange (301) using a hex-wrench, temporarily.



Figure 101

11. Assembling the Check Ball Part

- A. Assemble the two O-rings (358) with the two Plugs (352).

NOTE: *Apply grease on the O-ring (358).*

- B. Insert the Steel Ball (353) into the Rear Flange (301).



Figure 102

- C. Tighten the Plug (352) with the Rear Flange (301) using a hex-wrench, temporarily.



Figure 103

12. Assembling the Piston

- A. Assemble the two O-rings (383) with the two Plugs (380).

NOTE: *Apply grease on the O-ring (383).*

- B. Insert the Piston (381) into the Rear Flange (301).



Figure 104

- C. Tighten the Plug (380) with the Rear Flange (301) using a hex-wrench, temporarily.



Figure 105

13. Reassembling the Brake Valve

- A. Insert the Spool (323) into the Rear Flange (301).

NOTE: Apply machine oil on the Spool (323) and insert the Spool (323) into the Rear Flange (301).

Align the center lines of the Spool (323) and the Rear Flange (301) to prevent the damage on the inner surface of the Rear Flange (301) and the outer surface of the Spool (323) by contact.

If the groove of the Rear Flange (301) or outer surface of the Spool (301) is damaged, internal leak may occur after the reassembling, resulting in the performance degradation of the Travel Motor.



Figure 106

- B. Assemble the O-ring (336) on the Plug (324).

NOTE: Apply grease on the O-ring (336).

- C. Insert Washer (325) and Spring (328) into the Plug (324).



Figure 107

- D. Insert the two Plugs (324) into the Rear Flange (301).

NOTE: Take care when inserting the Plug (324) into the Rear Flange (301) to prevent the deformation of the Spring (328).

- E. Tighten the two Plugs (324) on the Rear Flange (301) temporarily.



Figure 108

14. Assembling the Rear Flange Components

- A. Apply machine oil on the Deep Grooved Ball Bearing (150) and insert the Ball Bearing (150) into the Rear Flange (301).
- B. Insert the Parallel Pin (341) into the pin groove of the Rear Flange (301).
- C. Apply grease on the fitting surface of the Timing Plate (109) with the Rear Flange (301).



Figure 109

- D. Assemble the Timing Plate (109) with the Rear Flange (301) using the Parallel Pin (341) as the guide.

NOTE: Mount the Timing Plate (109) until it contacts with the Rear Flange (301). The contacting will prevent the Timing Plate (109) from being separated from the Rear Flange (301) when mounting the Rear Flange (301) on the Spindle (2).



Figure 110

- E. Mount the ten Springs (113) on the Rear Flange (301).

NOTE: Apply grease on the Springs (113) sufficiently to prevent being separated from the Rear Flange (301).



Figure 111

15. Connecting between the Rear Flange and Spindle

- A. Insert the two O-rings (32, 33) into the O-ring grooves on the Spindle (2).

NOTE: Do not apply grease on the O-rings (32, 33). If grease is applied, it may smear on the fitting surface between the Rear Flange (301) and Spindle (2) during Motor operation. The smearing may be mistaken as the oil leak.

- B. Pour 1.0 liter of hydraulic oil in the Spindle (2).



Figure 112

- C. Insert the Rear Flange (301) into the Spindle[2], aligning the pin groove on the Rear Flange (301) and the two Parallel pins inserted in the Spindle (2).
- D. Tighten the ten hex-grooved Bolts (343) to the Spindle (2) temporarily, using hex-wrench.



Figure 113

16. Tighten all parts by the specified torques.

- A. Tighten the ten hex-grooved Bolts (343) to the Spindle (2) by specified torque.

Torque : $102 \pm 15.7 \text{ N}\cdot\text{m}$ ($10.4 \pm 1.6 \text{ kgf}\cdot\text{m}$)



Figure 114

- B. Tighten the Plug (324) by specified torque.

Torque : $441 \pm 39.2 \text{ N}\cdot\text{m}$ ($45.0 \pm 4.0 \text{ kgf}\cdot\text{m}$)



Figure 115

- C. Tighten the Plug (380) by specified torque.

Torque : $58.8 \pm 9.81 \text{ N}\cdot\text{m}$ ($6.0 \pm 1.0 \text{ kgf}\cdot\text{m}$)



Figure 116

- D. Tighten the Plug (352) by specified torque.
Torque : $12.3 \pm 2.45 \text{ N}\cdot\text{m}$ ($1.25 \pm 0.25 \text{ kgf}\cdot\text{m}$)

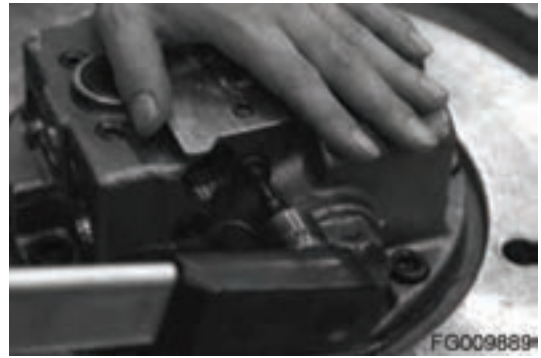


Figure 117

- E. Tighten the Plug (357) by specified torque.
Torque : $98.1 \pm 19.6 \text{ N}\cdot\text{m}$ ($10.0 \pm 2.0 \text{ kgf}\cdot\text{m}$)



Figure 118

17. Assembling the Relief Valve Assembly

- A. Mount the two Relief Valve Assemblies (including 203).



Figure 119

- B. Tighten the two Relief Valve Assemblies (including 203) by specified torque.

Torque : $98.1 \pm 19.6 \text{ N}\cdot\text{m}$ ($10.0 \pm 2.0 \text{ kgf}\cdot\text{m}$)



Figure 120

18. Assembling the 2-Step Gears

- A. Turn the work bench so that the Reduction Gear faces upwards.
- B. Assemble the Sun Gear(2, 8) with the Carrier (2, 7).
- C. Install eye bolts in the three M12 tabs for hanging on the Carrier(2, 7), use a crane to insert the Carrier Assembly (2).

NOTE: When inserting the Carrier Assembly (2), align the center lines of the Hub (1) and the Carrier Assembly (2) so that the edge of the Planetary Gear (2, 9) does not damage the inner teeth of the Hub (1), and insert the Carrier Assembly slowly.

Arrange the Planetary Gea (2, 9) and the Rear Flange (301) port as shown in the figure on left.

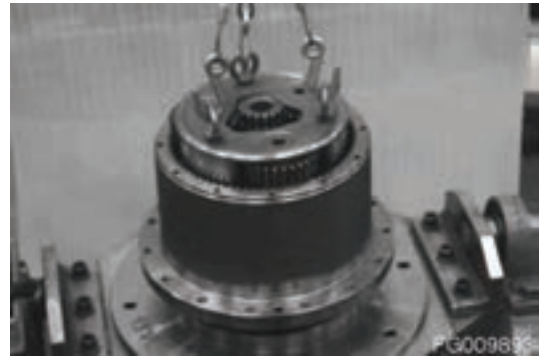
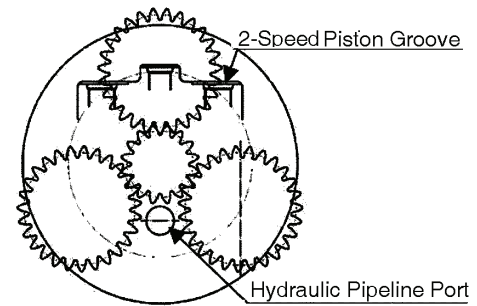


Figure 121



FG009927

Figure 122

19. Assembling the Coupling

- A. Assemble the Coupling (15) to the Shaft (102).



Figure 123

20. Assembling the 1st Stage Gears

- A. Insert the Carrier Assembly (1) for hanging in the Hub (1).

NOTE: When inserting the Carrier Assembly (1), align the center lines of the Hub (1) and the Carrier Assembly (1) so that the edge of the Planetary Gear (1, 5) does not damage the inner teeth of the Hub (1), and insert the Carrier Assembly slowly.



Figure 124

- B. Insert the Sun Gear (1, 4) into the Coupling (15), aligning the splines.

NOTE: *In the event that the Sun Gear (1, 4) cannot be inserted because the spline of the Sun Gear touches the teeth end of the Planetary Gear, as the gears are positioned such, slowly lift the Carrier Assembly (1) up until the Sun Gear (2, 8) leaves the Coupling, and then insert the Sun Gear (1, 4).*



Figure 125

- C. Assemble the Thrust Plate (13) with the Carrier (1, 3).



Figure 126

21. Assembling the Cover

- A. Apply Locktite 515, which is a sealant, on the fitting surface with the Cover (14) of the Hub (1).

NOTE: *Apply the sealant without interval.*

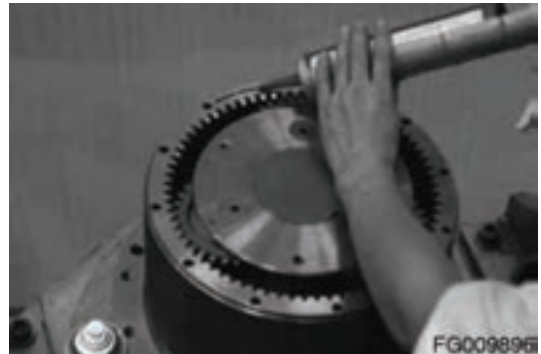


Figure 127

- B. Join eye bolts on the PF1/2 Port, place the Cover (14) on the Hub (1), matching the bolt groove position.

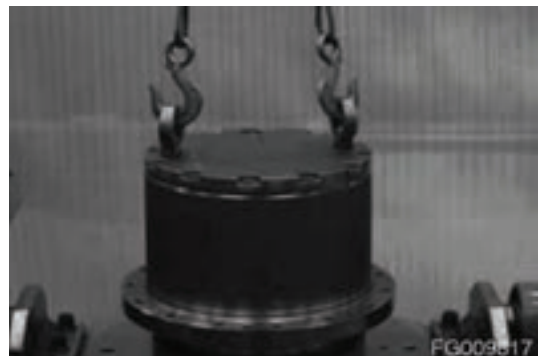


Figure 128

- C. Apply Loctite 242 on the tip of the hex-grooved Bolt (35), and tighten with specified torque.

Torque : $66.7 \pm 3.92 \text{ N}\cdot\text{m}$ ($6.8 \pm 0.4 \text{ kgf}\cdot\text{m}$)



Figure 129

22. Lubricant

- A. Supply lubricant through the lubricating port.

NOTE: Supply 2.1 liter of lubricant.



Figure 130

- B. Mount Plug (30) on each port and tighten with specified torque.

Torque : $98.1 \pm 19.6 \text{ N}\cdot\text{m}$ ($10.0 \pm 2.0 \text{ kgf}\cdot\text{m}$)



Figure 131

23. Removing the Travel Motor

- A. Turn the Travel Motor upside down (with the Motor side facing upward).
- B. Remove the Travel Motor fixing bolts from the work bench.
- C. Tighten the Eye Bolt (M16) in the screw hole of the Spindle (2).
- D. Join the hook and wire with the eye bolt, remove the Travel Motor from the work bench using a crane.

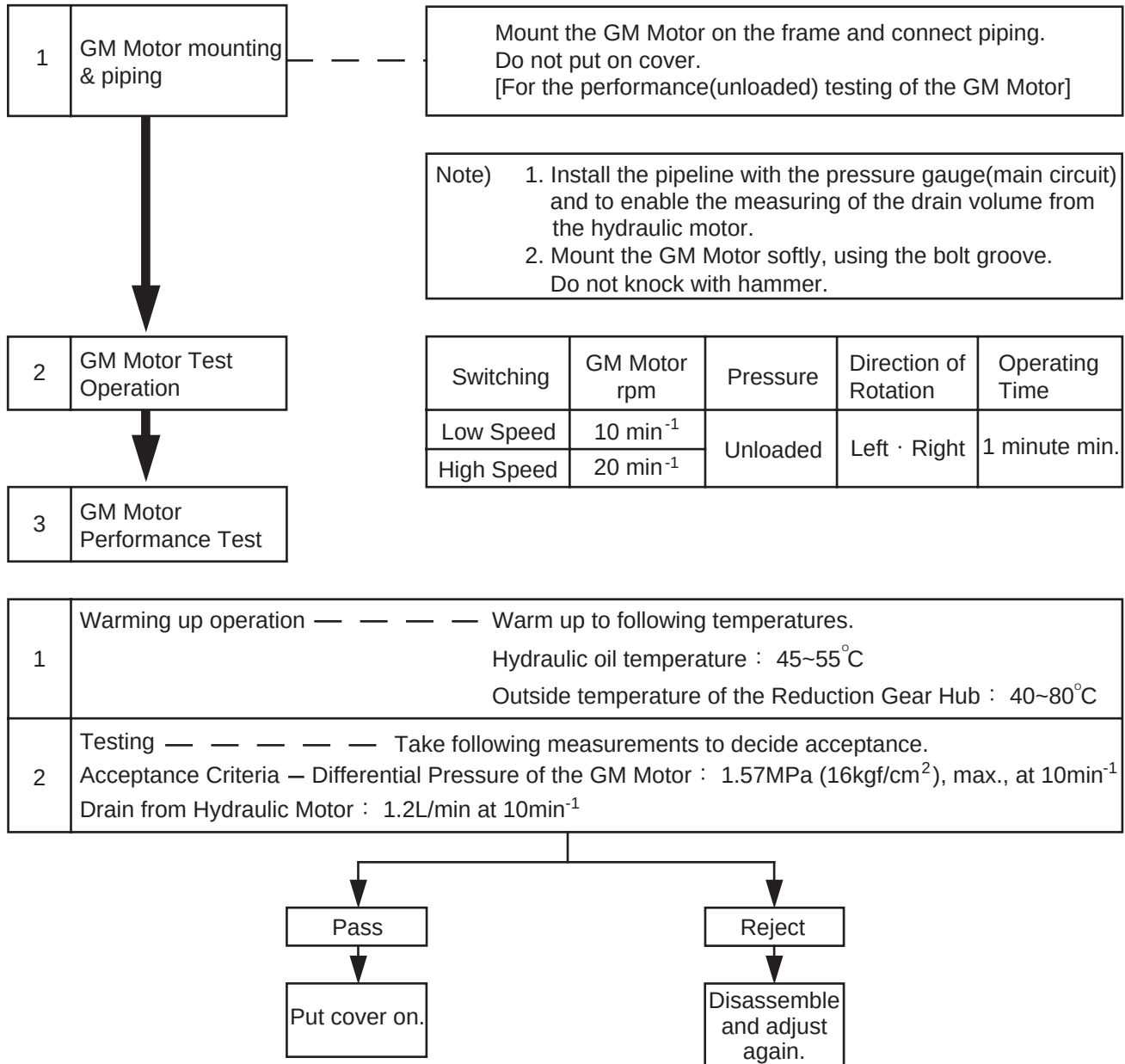
Performance Test

- When the maintenance work of the GM Travel Motor has been completed, conduct performance testing as follows.

1. Required Instruments

1	Pressure Gauge 3.43 MPa (35 kgf / cm ²)	2
2	Mass Cylinder (5 liter)	1
3	Stop Watch	1

2. Test procedures



Main Pump

Edition 1

MEMO

Table of Contents

Main Pump

Safety Precautions	5
Applicable Models	5
Disassembling and Reassembling Procedures	6
Tool	6
Disassembling Procedures.....	7
Reassembling procedures.....	11
Pump Maintenance Criteria	15
Worn Part Replacement Criteria	15
Installation of Tandem Type Double-pump	16
Construction of Tandem Type Double-Pump	17

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.

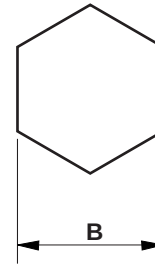
MODEL	SERIAL NUMBER RANGE
DX140LCR	5001 and Up

DISASSEMBLING AND REASSEMBLING PROCEDURES

Tool

The tools necessary to disassemble / reassemble K7V pump are shown in the following list.

The size of the bolts and plugs depend on the pump type.



FG015033

Figure 1

Tool Name & Size		O Necessary	Part Name			
Name	B	K7V63	Hexagon socket head cap screw	Pressure plug (PT screw)	ROH plug VP plug, UNF plug (PF screw)	Hexagon socket head set screw
Allen wrench	2		–	–	–	M4
	2.5		–	–	–	M5
	3		–	–	–	M6
	4	O	M5	Rc1/16	–	M8
	5	O	M6	Rc1/8	–	M10
	6	O	M8	Rc1/4	G1/4	M12, M14
	8	O	M10	Rc3/8	G3/8	M16, M18
	10	O	M12	Rc1/2	G1/2	M20
	12		M14	–	–	–
	14	O	M16, M18	Rc3	G3/4	–
	17	O	M20, M22	Rc1	G1	–
	19		M24, M27	–	–	–
Double ring spanner, socket wrench Double (single) open end spanner	19		M12	–	G 1/4	–
	22		–	–	3/4-16UNF	–
	24	O	M16	–	–	–
	27		M18	–	G 1/2	–
	30		M20	–	–	–
	32		–	–	1 1/16-12UN	–
	36		–	–	G 3/4	–
	41	O	–	–	G 1	–
	46		M30	–	–	–
	50		–	–	G1 1/4	–
	55		M36	–	G1 1/2	–
Adjustable angle wrench	-	Medium size, 1set				
Torque wrench	–	O	Capable tightening with the specified torques			

Disassembling Procedures

For disassembling the pump, read this section thoroughly and then disassemble it in the following sequence. The figures in parentheses after part names show the items in Attached Dwg.1 Construction of tandem type double-pump.

1. Select place for disassembling.



CAUTION

Select clean place.

Spread rubber sheet, cloth or so on workbench top to prevent parts from being damaged.

2. Remove dust, rust, etc, from pump surfaces with cleaning oil or so on.
 3. Remove drain port plug (468) and drain oil from pump casing (271, 272)
-



CAUTION

For tandem type pump, remove plugs of both front and rear pumps.

4. Remove hexagon socket (412, 413) and remove regulator.
-



CAUTION

Refer to maintenance manual of regulator for its disassembling.

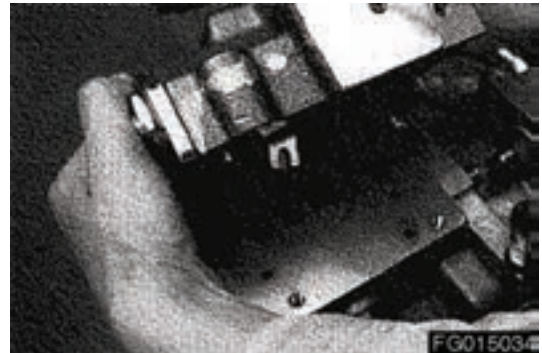


Figure 2

5. Place pump horizontally on workbench with its regulator-fitting surface down, and remove flange socket (435) and remove PTO unit (05).
-



CAUTION

Be careful about the attaching direction of the PTO unit (05).

Before bringing regulator fitting surface down, spread rubber sheet on workbench without fail to prevent this surface from being damaged.

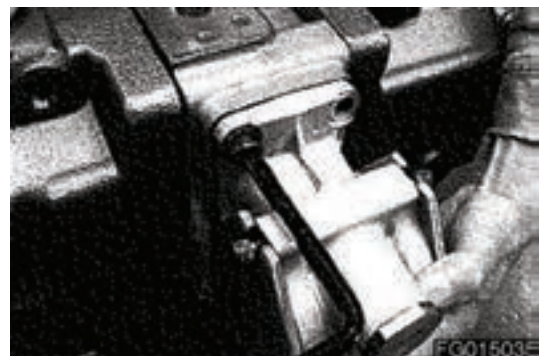


Figure 3

In case the pump is provided without the PTO unit (05), remove the cover (326) with the hexagon socket head cap screws (414).

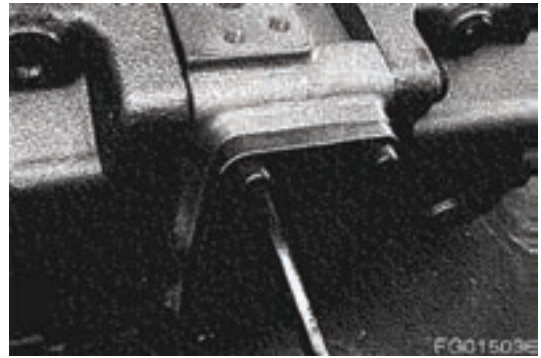


Figure 4

6. Remove flange socket (435) and remove gear-pump (04).



Figure 5

7. Loosen hexagon socket head bolts (401) which tighten pump casing (271, 272) and valve block (312).

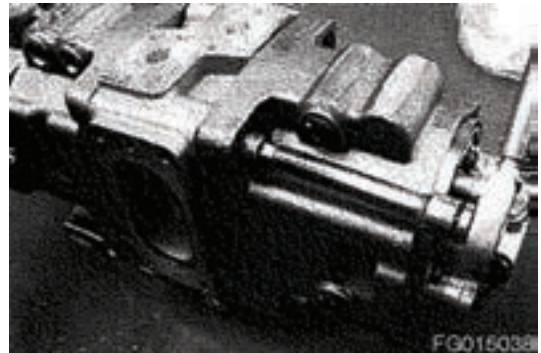


Figure 6

8. Place pump horizontally on workbench with its regulator-fitting surface down, and separate pump casing (271, 272) from valve block (312).

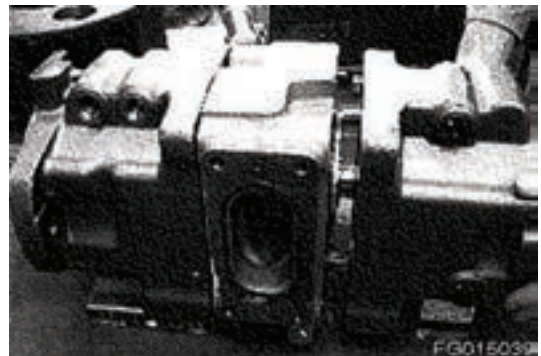


Figure 7

9. Pull out cylinder (141), pistons (151), set plate (153), spherical bush (156) and cylinder springs (157) simultaneously from pump casing (271, 272) straightly over drive shaft (111, 113)



CAUTION

Take care not to damage sliding surfaces of cylinder (141), spherical bush (156), shoes (152), swash plate (212), etc.

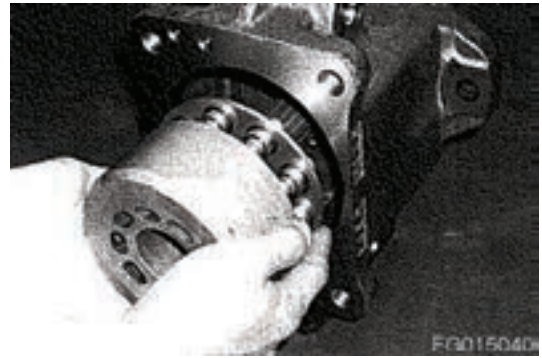


Figure 8

10. Remove hexagon socket head bolts (406) and then seal cover (F, 261).



CAUTION

In the case removing it is difficult and hooking pull thin rod into notch, and the cover can be removed easily.

Since oil seal is fitted on seal cover (F, 261), take care not to damage it at removing the cover.

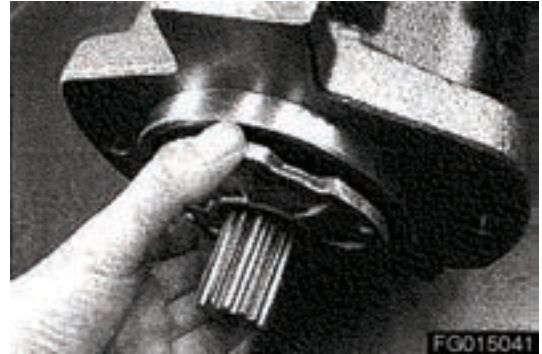


Figure 9

11. Tapping shaft ends of drive shafts (111, 113) lightly with plastic hammer, remove it from pump casing (271, 272).

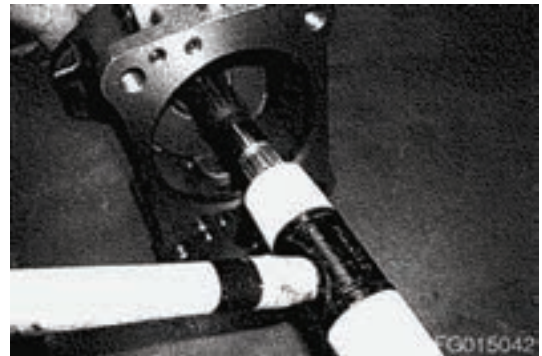


Figure 10

12. Remove shoe plate (211) and swash plate (212) from pump casing (271, 272)

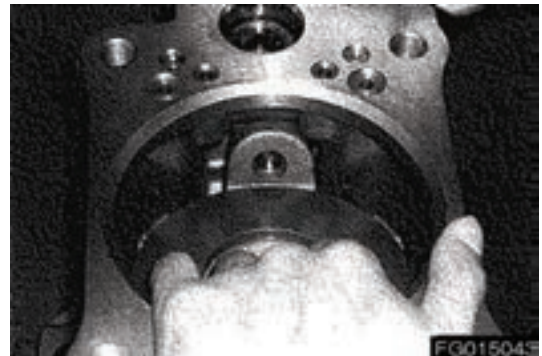


Figure 11

13. Remove valve plates (313, 314) from valve block (312).



CAUTION

These may be removed in Work 8.

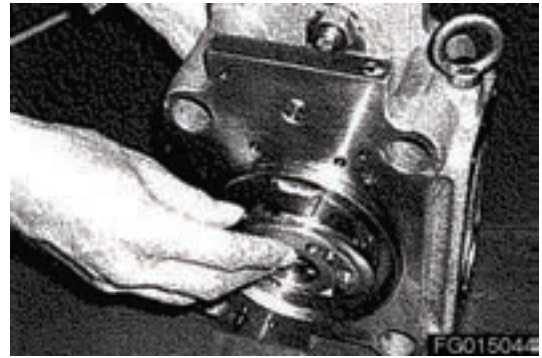


Figure 12

14. If necessary, remove stopper (L, 534), Qmin.plug (533), servo piston (532) and tilting pin (531) from pump casing (271, 272), and needle bearing (124) from valve block.



CAUTION

1. When removing tilting pin, use a protector to prevent pin head from being damaged.
 2. Since lock-tight is applied to fitting areas of tilting pin (531) and servo piston (532), take care not to damage servo piston (532).
 3. Do not remove needle bearing (124) as far as possible, except the case that considered to be out of its life span.
 4. Do not loosen hexagon nuts of valve block (312) and Qmin.plug (533). If loosened, flow setting will be changed.
-

Reassembling procedures

For reassembling reverse the disassembling procedures, paying attention to the following items.

1. Do not fail to repair the parts damaged during disassembling, and repair replacement parts in advance.
2. Clean each part fully with cleaning oil and dry it with compressed air.
3. Do not fail to apply clean working oil to sliding sections, bearings, etc. before assembling them.
4. In principle, replace seal parts, such as O-rings, oil seals, etc.
5. For fitting bolts, plug, etc., prepare a torque wrench or so on, and tighten them with torques shown in Section 2-3.
6. For the double-pump, take care not to mix up parts of the front pump with those of the rear pump.
7. Fit tilting bush (214) of swash plate (212) to tilting pin (531), and fit swash plate (212) with shoe plate (211) to swash plate support (251) correctly.



CAUTION

In case the servo piston, tilting pin stopper (L), stopper (S), and Qmin.plug have been removed, attached them to the pump casing in advance.

In the tightening work of the servo piston and the tilting pin, use the tool not to damaged the head of the tilting pin and the feed back pin. Besides, apply Loctite (of medium strength) to the thread portion.

Confirm with fingers of both hands that swash plate can be removed smoothly.

Apply grease to sliding sections of swash plate (212) and swash plate support (251), and drive shaft (111, 113) can be fitted easily.

Take care not to damage shoe plate (211) surface.

8. To pump casing (271, 272), fit drive shaft (111, 113) set with bearing (123), bearing spacer (127) and stop ring (824).

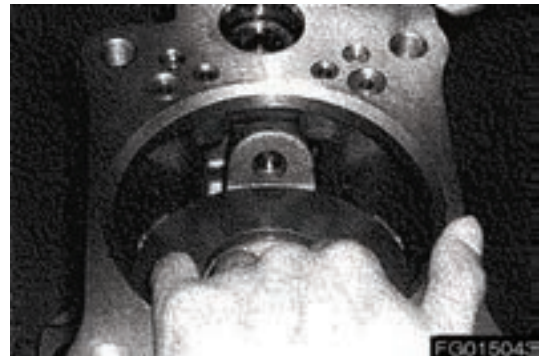


Figure 13

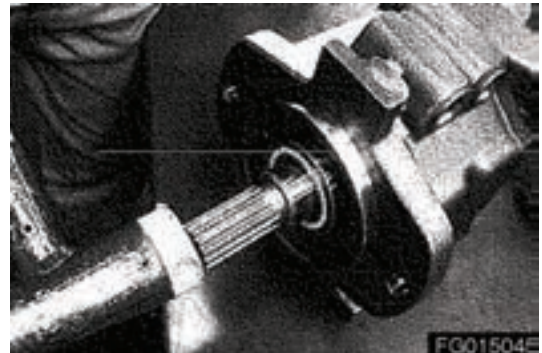


Figure 14

9. In assemble of front pump, assemble seal cover (F, 261) to pump casing (271) and fix it with hexagon socket head bolts (406).

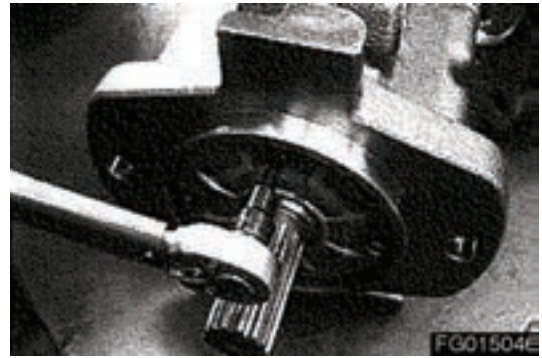


Figure 15

10. Assemble piston cylinder subassembly [cylinder (141), piston subassembly (151, 152), set plate (153), spherical bush (156) and cylinder spring (157)]. Fitting spline phases of cylinder, spherical bush (156) and drive shaft (111, 113), insert piston cylinder subassembly into pump casing (271, 272).

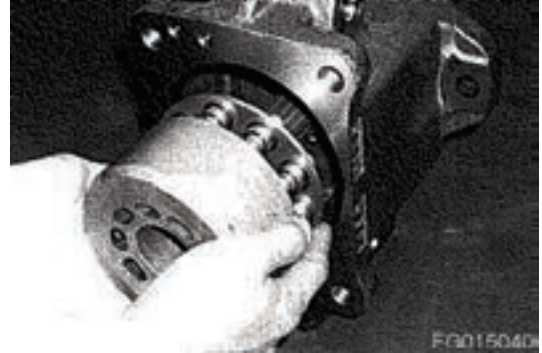


Figure 16

11. Fit valve plate (313, 314) to valve block (312), spring pin (886) into pin hole.



CAUTION

Take care not to mistake suction / delivery directions of valve plate (312).

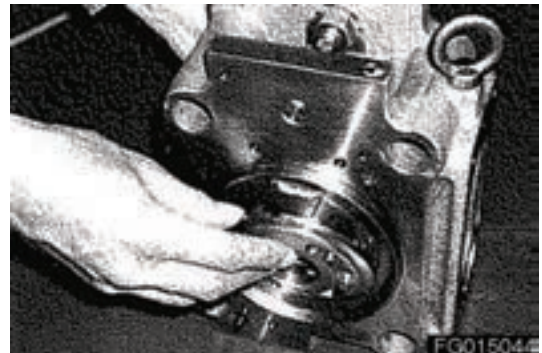


Figure 17

12. Place pump horizontally on workbench with its regulator-fitting surface down, and attach pump casing (271, 272) to valve block (312). Fit 1st gear (116) simultaneously.



CAUTION

Before bringing regulator-fitting surface down, spread rubber sheet on workbench without fail to prevent this surface from being damaged.

Take care not to mistake direction of valve block (312). [Clockwise rotation (viewed from input shaft side)]. Fit the valve block (312) with suction flange left when regulator side below, viewed from front side.

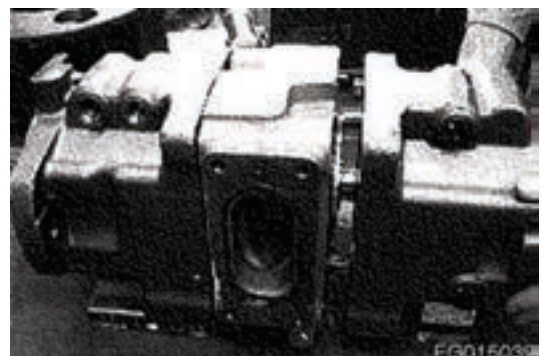


Figure 18

13. Fit valve block (312) to pump casing (271, 272) with hexagon socket head bolts (401).

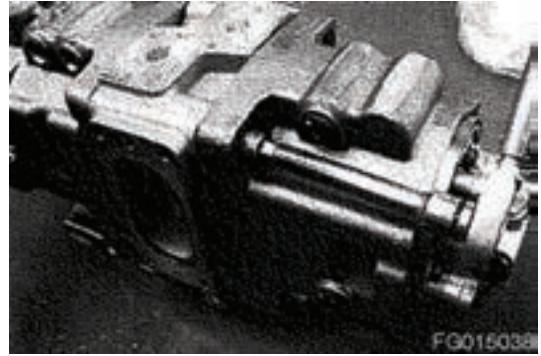


Figure 19

14. Fit gear-pump (04) to pump casing (272) with hexagon socket head bolts (435).



Figure 20

15. Attach the PTO unit (05) by fastening the flange socket (435) to the valve block (312).

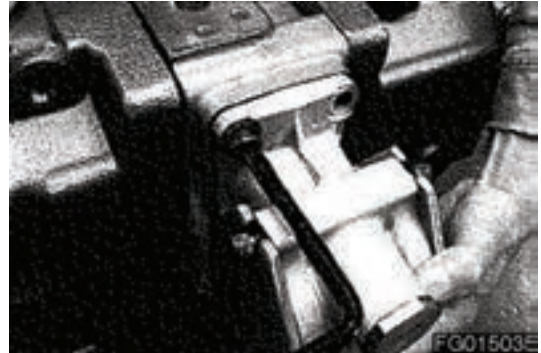


Figure 21

In case the pump is not provided with the PTO unit (05), attach the cover (326) with the hexagon socket head cap screw (414).



Figure 22

16. Putting feedback lever (611) of regulator into feedback pin (548) of tilting pin (531), fit regulator with hexagon socket head bolts (415).



CAUTION

Take care not to mix up regulator of front pump and that of rear pump.

17. Fit drain port plug (468).
This is the end of reassembling procedures.

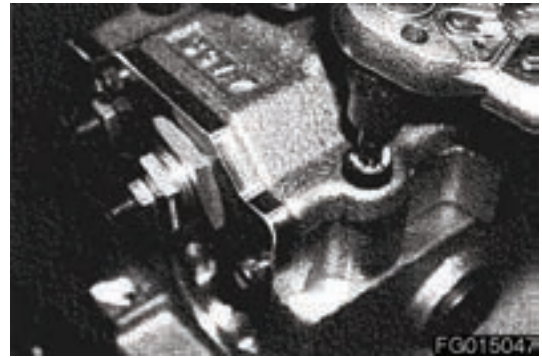


Figure 23

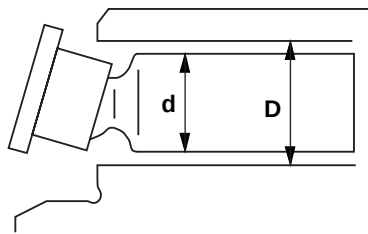
PUMP MAINTENANCE CRITERIA

Worn Part Replacement Criteria

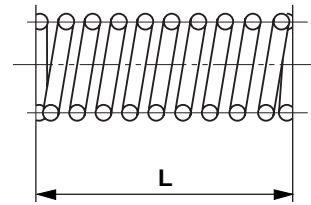
When a part exceeds any of the following criteria, replace or readjust it.

However, when a part is damaged seriously in appearance, replace it without fail.

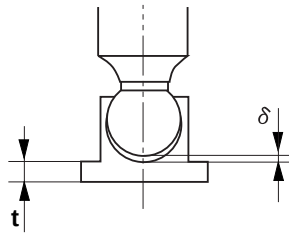
Part name & inspection	Standard Dimension / Recommended replacement value	Countermeasures
	Pump type	
	K7V63	
Clearance between Piston & cylinder bore (D-d)	0.032 / 0.056	Replace piston or cylinder.
Play between piston & shoe/calking section (δ)	0~0.1 / 0.3	Replace assembly of piston & shoe.
Thickness of shoe (t)	3.9 / 3.7	Replace assembly of piston & shoe.
Free height of cylinder spring (L)	41.1 / 40.3	Replace cylinder spring.
Combined height of set plate & spherical bush (H-h)	17.0 / 15.8	Replace set plate or spherical bush



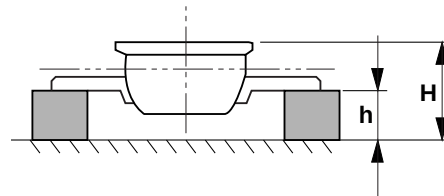
Clearance between piston & cylinder bore (D-d)



Free height of cylinder spring : L



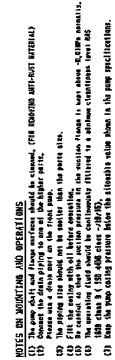
Play between piston & shoe : δ
Thickness of shoe : t



Combined height of set plate & spherical bush : H-h

FG015048

Figure 24



FG015049

Construction of Tandem Type Double-Pump

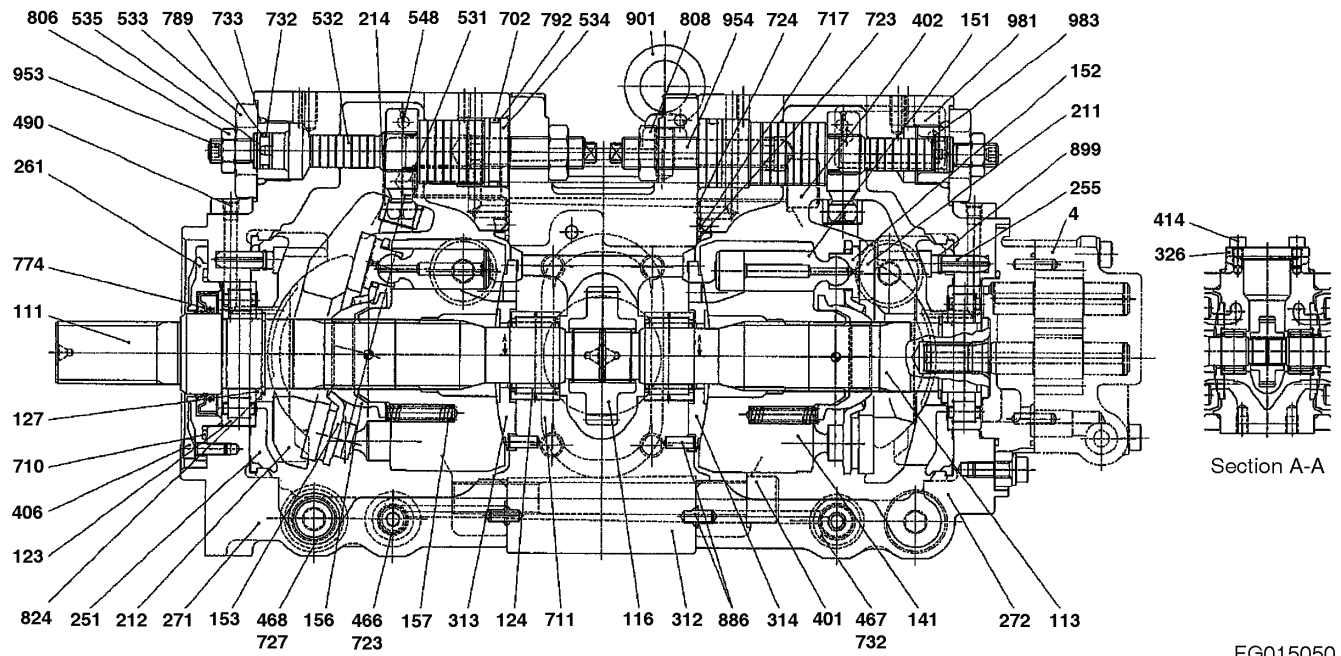


Figure 26

FG015050

Reference Number	Description
4	Gear Pump
111	Drive Shaft (F)
113	Drive Shaft (R)
116	1st Gear
123	Roller Bearing
124	Needle Bearing
127	Bearing Spacer
141	Cylinder Block
151	Piston
152	Shoe
153	Set Plate
156	Spherical Bush
157	Cylinder Spring
211	Shoe Plate
212	Swash Plate
214	Tilting Bush
251	S.P. Support
255	Lock Pin
261	Seal Cover (F)
271	Pump Casing (F)
272	Pump Casing (R)
312	Valve Block
313	Valve Plate (R)
314	Valve Plate (L)
326	Cover
401	Hex Screw Bolt
402	Hex Screw Bolt
406	Hex Screw Bolt
414	Hex Screw Bolt
466	Plug
467	Plug

Reference Number	Description
468	Plug
490	Plug
531	Tilting Pin
532	Servo Piston
533	Qmin.Plug
534	Stopper (L)
535	Stopper (S)
548	Feedback Pin
702	O-ring
710	O-ring
711	O-ring
717	O-ring
723	O-ring
724	O-ring
727	O-ring
732	O-ring
733	O-ring
774	Oil Seal
789	Backup Ring
792	Backup Ring
806	Nut
808	Nut
824	Snap Ring
886	Spring Pin
899	C-Ring
901	Eye Bolt
953	Set Screw
954	Adjusting Screw
981	Name Plate
983	Pin

Main Control Valve

Edition 1

MEMO

Table of Contents

Main Control Valve

Safety Precautions	5
Applicable Models	5
General Description	7
Theory of Operation	8
Composite Operation	19
Anti-drift Valve	20
Disassembly	22
Precautions for Disassembly	22
Disassembling Procedures	22
Washing	28
Inspection	28
Assembling	29
Sub-Assembly	29
Assembling Control Valve	32
Relief Valve	38
Main Relief Valve	38
Overload Relief Valve	42
Negacon Relief Valve	45
Adjusting Relief Valve	47
Installation	48
Operation	48
Control Valve Specification	49
Troubleshooting	50
Control Valve: overall	50
Hydraulic System: Overall	51

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up

GENERAL DESCRIPTION

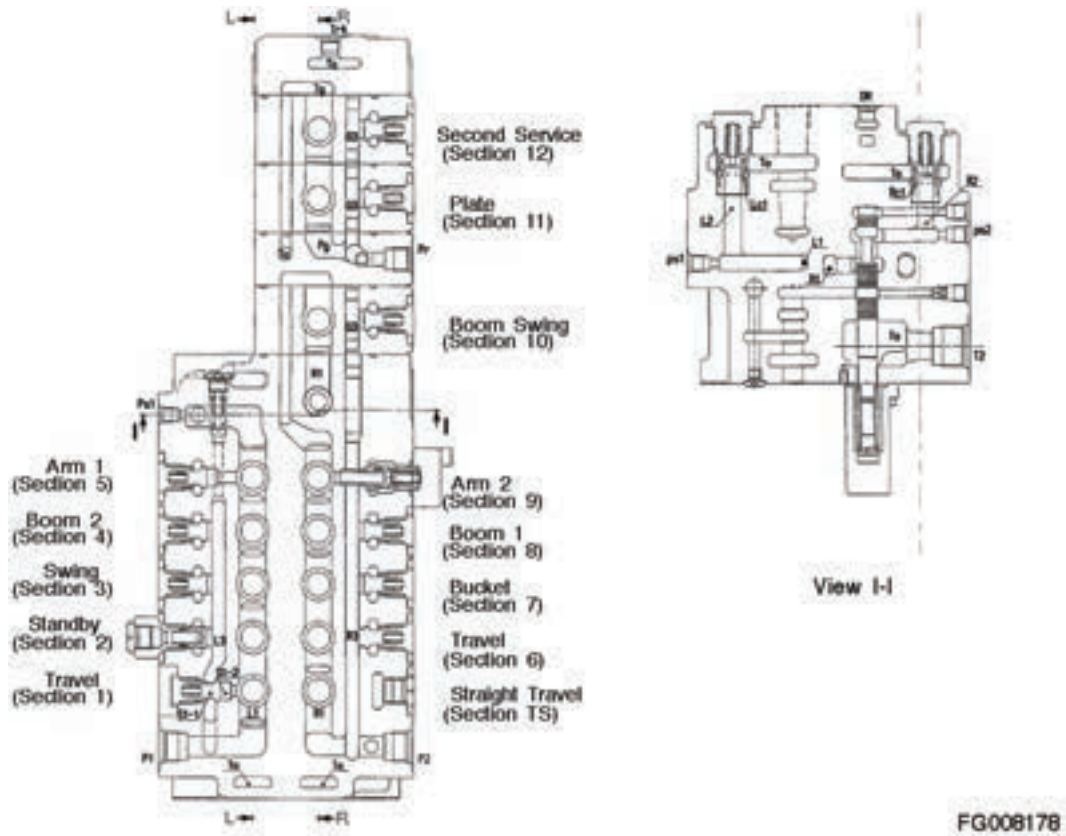


Figure 1

Theory of Operation

Service Spool Movement

Remove the stopper plug of both pilot caps before using this section.

When necessary, replace the shut-off valve with an overload relief valve and remove the plug at port (P4).

When the spool is moved by being pressurized through the pilot port (pb2) (pa2) of the first service (Section 2), the neutral path (L1) will be closed. The oil supplied through port (P1) flows through the parallel path (L3) load check valve (S2-1), path (S2-2), and spool head to port (B2) (A2). Lubricant oil returns from (A2) (B2) to the tank path Ta via the spool head.

This section makes use of the load check valve which allows external joining at the (P4) port.

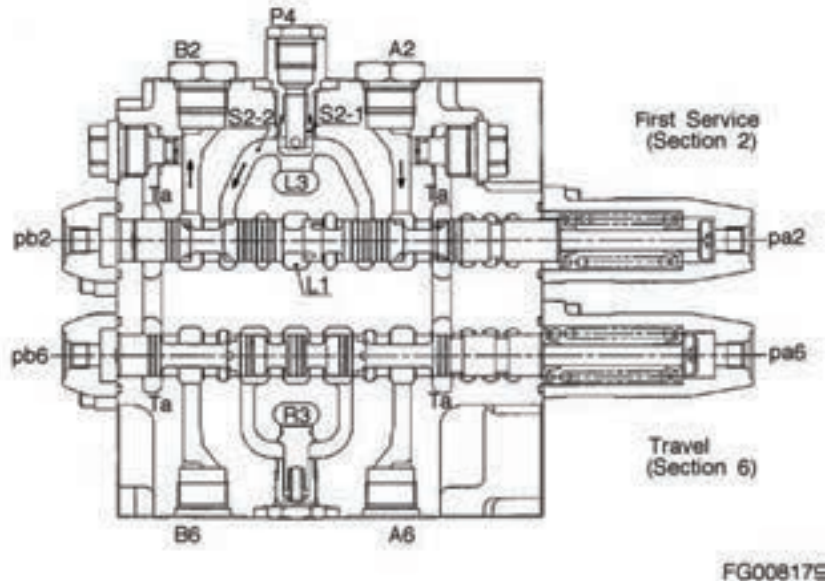


Figure 2

Swing Spool Movement

When the swing spool is moved by being pressurized through the pilot port (pb3) (pa3) of the swing (Section 3), the neutral path (L1) will be closed.

The oil supplied through port P1 flows from the parallel path (L3), via the load check valve (S3-1), path (S3-2), and the spool head to the (B3) (A3) port.

Lubricant oil returns to the tank path Ta from (A3) (B3) via the spool head.

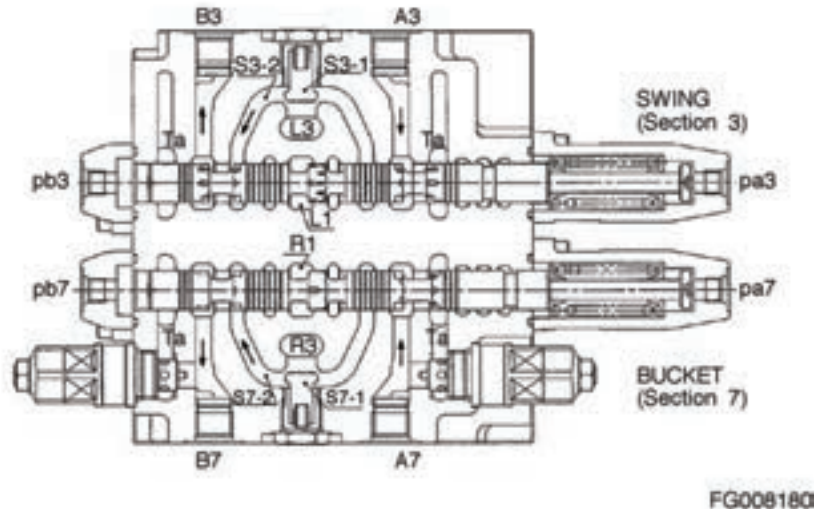


Figure 3

Bucket Spool Movement

When the bucket spool is moved by being pressurized through the pilot port (pb7) (pa7) of the bucket (Section 7) the neutral path (R1) will be closed.

The oil supplied through port (P2) flows from the parallel path R3 to port (B7) (A7) via the load check valve (S7-1) path (S7-2) and spool head.

Lubricant oil returns to the tank path Ta from (A7) (B7) via spool head.

Boom Spool Movement

1. Neutral

This valve incorporates an anti-drift valve on the bottom of the cylinder of boom 1.

In a neutral state, the poppet (AD1) is fully seated by the pressure at port (A8) which is applied to the spring chamber (AD5) through the path (AD2), poppet (AD3), and path (AD4).

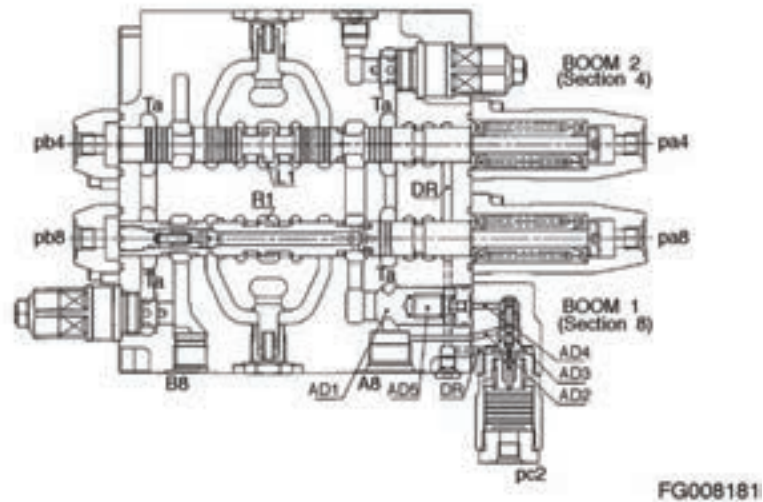


Figure 4

2. Upward

When the boom1 spool is moved by being pressurized through the pilot port pa8 of the boom1 (Section 8, Figure 5), the neutral path (R1, Figure 5) will be closed.

The oil supplied through port P1 flows from the parallel path (R3, Figure 5) to port (A8, Figure 5) via the load check valve (S8-1, Figure 5) and spool head.

When the boom2 (Figure 5) spool is also moved by being pressurized through the pilot port (pa4, Figure 5) of boom2, the neutral path (L1, Figure 5) will be closed. The oil supplied through port (P1, Figure 5) joins in port A8 via the parallel path (L3, Figure 5), load check valve (S4-1, Figure 5), spool head and path (7, Figure 5). Lubricant oil returns to the tank path (Ta, Figure 5) from port B8 via the spool head.

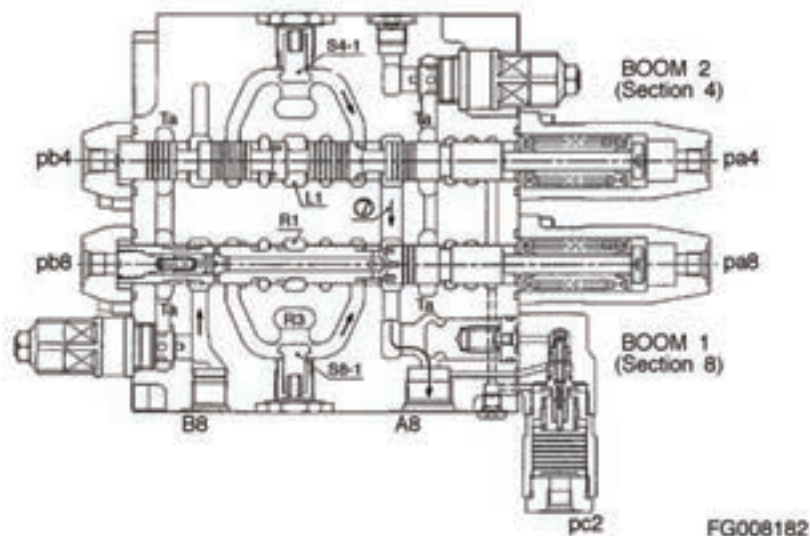


Figure 5

3. Downward (recycle)

When the boom1 (Section 8) spool is moved by being pressurized through the pilot port pb8 of the boom1, the neutral path (R1) will be closed. The oil supplied through port P2 flows from the parallel path (R3) to port B8 via the load check valve (S8-1) and spool head.

At the same time, when the poppet (AD3) of the anti-drift valve is moved by pressurizing port pc2 to depressurize the spring chamber (AD5), the poppet (AD1) will be opened, enabling the lubricant oil to return from port A8 to the tank path (Ta). A portion of the lubricant oil pushes open the poppet (S8-3) inside the boom1 spool, flows through path (S8-2) and joins at port B8 to prevent cavitation on the cylinder load side.

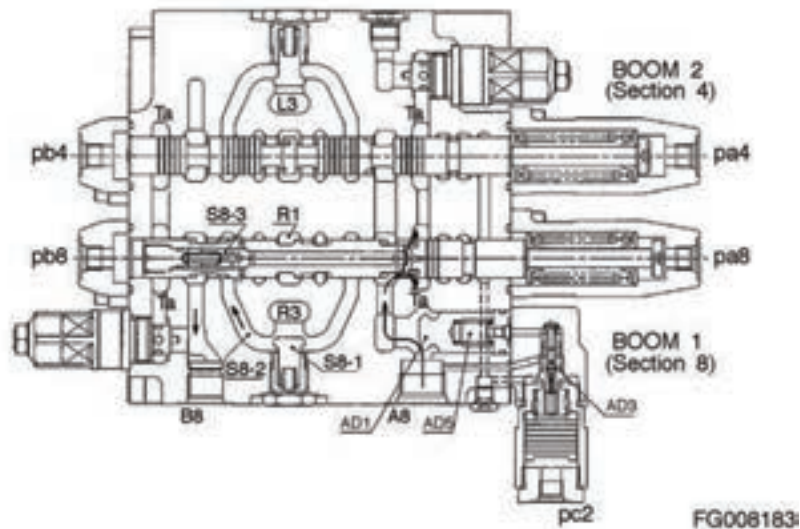


Figure 6

Arm Spool Movement

1. Dump (2 speed convergence)

When the arm1 (Section 5) spool is moved by being pressurized through the pilot port pa5 of the arm1, the oil supplied through the P1 port flows from the neutral path (R1) to the A5 port via load the check valve (S5-1), path (S5-2) and spool head.

When the arm2 (Section 9) spool is also moved by being pressurized through the pilot port pa9 of the arm2, the oil supplied through port P2 flows from neutral path(R1) to join at port A5 via the load check valve (S9-1) path (S9-2), spool head, and path (10). At the same time, a portion of the oil from port P2 flows from path[R3] to port A5 via the orifice (S9-3), check valve(S9-4), path (S9-2) and path (10). The lubricant oil returns to the tank path (Ta) from port B5 via the spool head of arm1; at the same time, it returns to the tank path (Ta) from path (11) via the spool head of arm2.

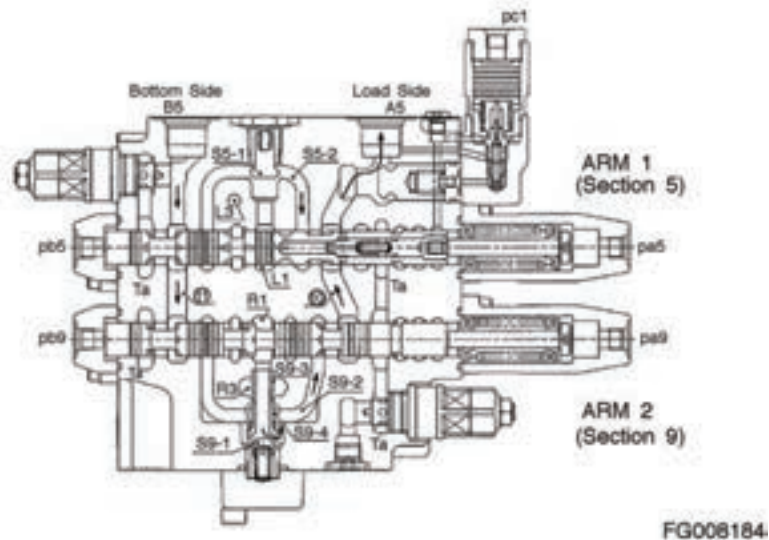


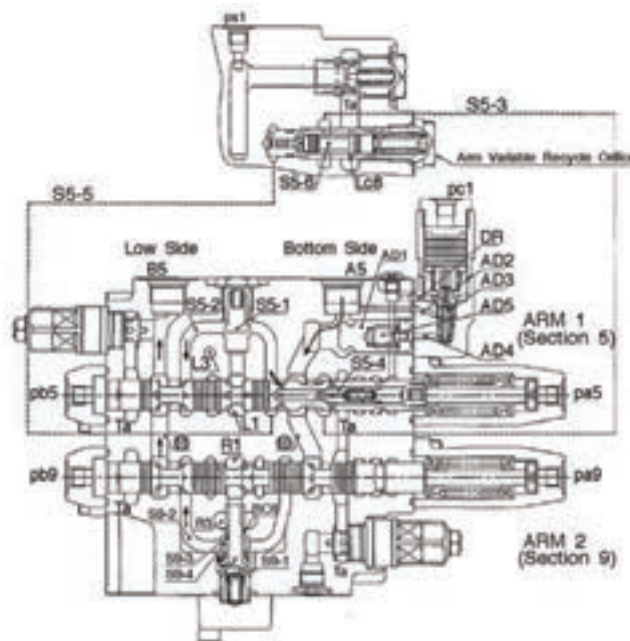
Figure 7

2. Crowd (2 speed convergence)

When the arm1 spool is moved by being pressurized through the pilot port pb5 of the arm1 (Section 5), the oil supplied from port P1 flows from the parallel path (L1) to port B5 via the load check valve (S5-1), path (S5-2), and spool head.

When the arm2 spool is moved by being pressurized through the pilot port pb9 of the arm2 (Section 9), the oil supplied through the P2 port will join at port B5 via the parallel path (R1), load check valve (S9-1), path (S9-2), spool head, and path (11). At the same time, a portion of the oil from port P2 flows to port B5 through the path (R3), orifice(S9-3), check valve(S9-4), path(S9-2), and path (11).

When the anti-drift valve spool (AD3) is moved by being pressurized through the Pc1 port to depressurize the spring chamber (AD5), the poppet (AD1) will be opened and the lubricant oil in the A5 port will return to the tank path (Ta) via the spool head, path (S5-3), and arm variable recycle orifice (LC8). A portion of the lubricant oil pushes the poppet (S5-4) in the arm1 spool open, flows through path (S5-2) and joins at port B5 to accelerate the cylinder, preventing cavitation on the bottom side.



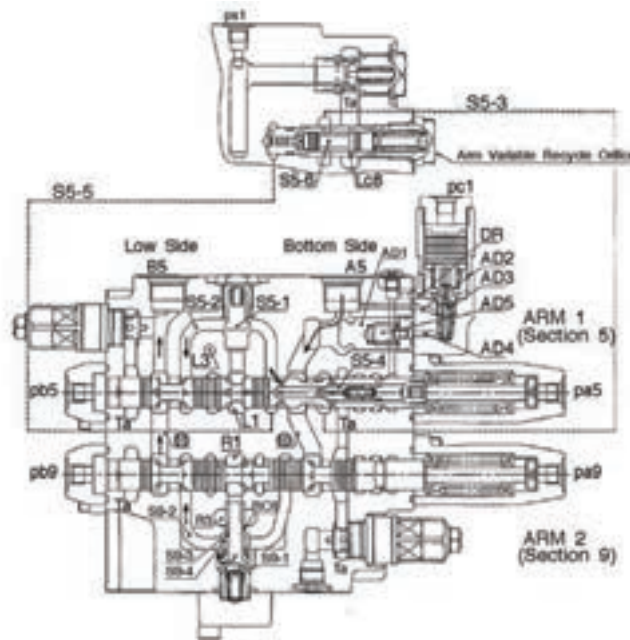
FG008185

Figure 8

3. Variable Recycle (at crowd control)

In arm crowd operation, the spool (S5-6) will stroke according to the pressure in the path (S5-2) induced through the path (S5-5), to change the position of the arm variable recycle orifice (Lc8). When the pressure in path (S5-2) is high, the stroke of the spool (S5-6) will be increased, which will increase the opening of the orifice (Lc8). Conversely, if the pressure in the path (S5-2) is low, the stroke of the spool (S5-6) will be decreased, which will decrease the opening of the orifice (Lc8).

Therefore, the recycle oil volume varies in accordance with the bottom pressure of the arm cylinder.



FG008185

Figure 9

Parallel Orifices for Arm

In the arm parallel circuit of this valve, both arm1 (Section 5) and arm2 (Section 9) are equipped with orifices, which control the arm speed even in composite operation. The parallel circuit of arm2 (section 9) is throttled at the orifice (Rc6) of the sleeve (S9-3) in the parallel path (R3), and connected with path (S9-2) through the poppet (S9-4).

The parallel circuit of the arm1 (Section 5) pushes open the poppet (S5-8) in the parallel path (L3), is throttled by the orifice (Lc9) of the parallel variable orifice spool, and connected with the path (S5-2, Figure 11). The throttle volume of orifice (Lc9) can be controlled by the pressure at the pilot port (pbu) (Pc3).

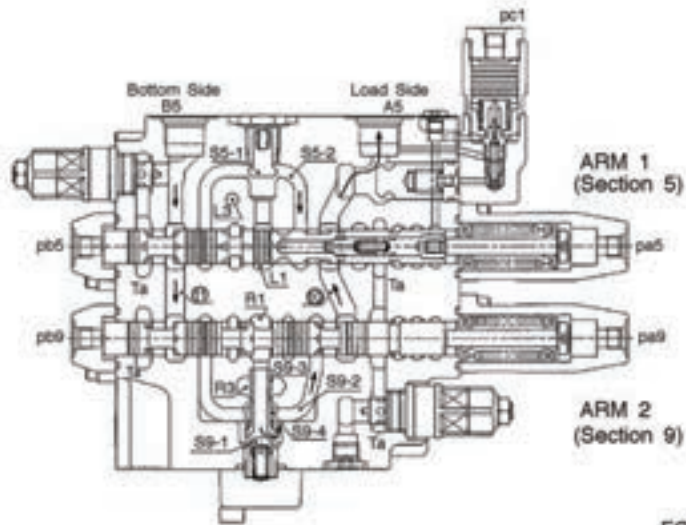


Figure 10

FG008184

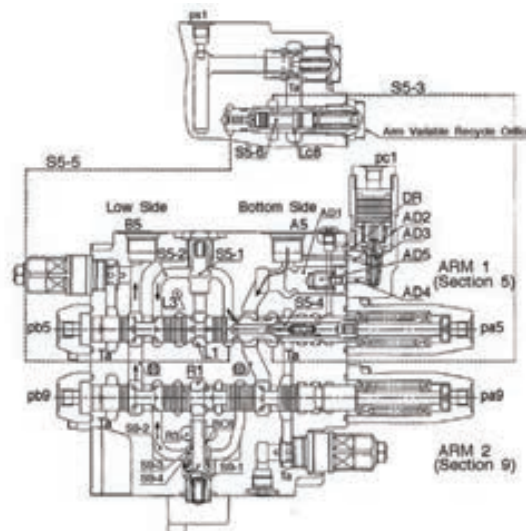


Figure 11

FG008185

Neutral Cut Spool Movement (First Service convergence)

This valve is equipped with a neutral cut spool at the downstream end (upstream of the low pressure relief valve) of the neutral path (R1). When port (pcc) is pressurized to move the neutral cut spool (R), the neutral path (R1) will be closed. Accordingly, the flow to the negacon relief valve (Rc1) is shut-off, changing the pressure of the ps2 signal.

In the meantime, the oil supplied through the P2 port joins into the path (S2-2) via (P4, Figure 2) with the external device check as media and via the empty part of the poppet (S2-1) of the first service.

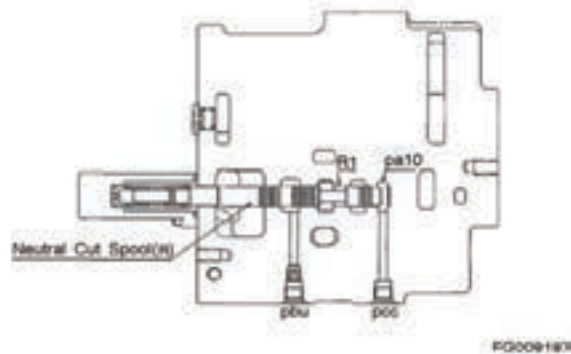


Figure 12

Add-on Spool Movement

As a representative example, the second service is illustrated.

When the spool is moved by pressure in the pilot port prb3 [pra3] of the second service (Section 12), the neutral path (pg) will be closed. The oil supplied through port Pr flows to port BR3 (AR3) via the parallel path (G3), load check valve (S12-1), path (S12-2), and spool head.

Lubricant oil returns to the tank path (Ta) from AR3 (BR3) via the spool head.

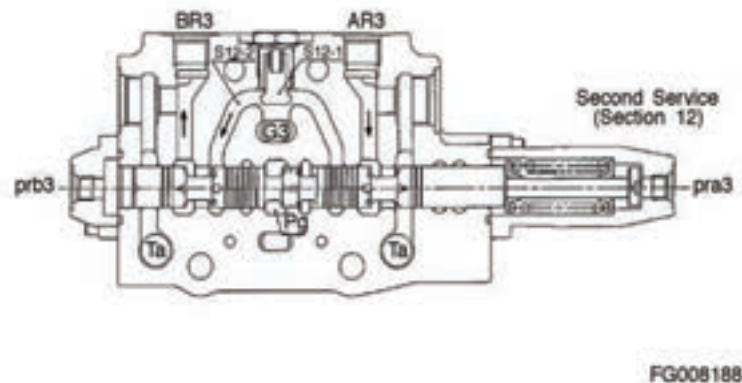


Figure 13

Relief Valve

1. Main Relief Valve in the Body

The oil supplied through ports P1 and P2 is guided to the main relief valve via the poppet (LP), and via the poppet (RP) and path (3) respectively. The maximum pressure of the P1 and P2 side pumps is controlled by activation of the main relief valve.

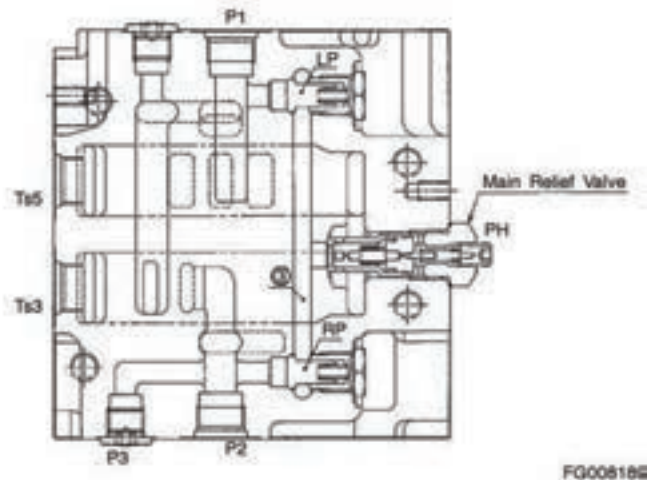


Figure 14

2. Relief Valve for Add-on Pr

The oil supplied through port Pr is guided to the main relief valve. The maximum pressure of the Pr pump is controlled by activation of the main relief valve.

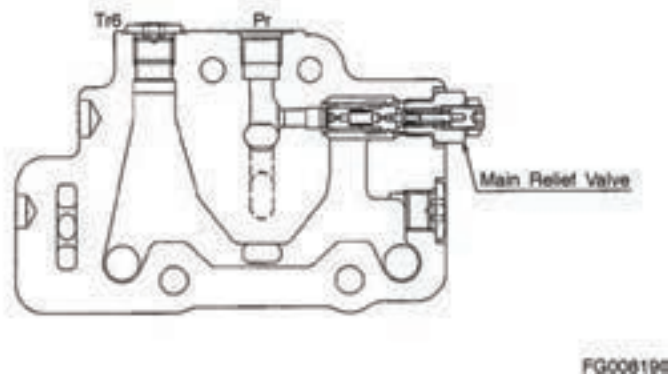


Figure 15

3. Overload Relief Valve

Each cylinder port of each section is installed with overload relief valves which prevent excessive pressure in the actuator generated by external force.

Additionally, these relief valves prevent cavitation by sucking in oil from the tank when the cylinder port pressure is negative.

Composite Operation

Travel Composite Operation

During simultaneous operation of traveling and left-right turn (forward, backward or spin turn), when an operation other than travel is carried out at the same time, or during any operation except travel, when simultaneous operations of travel and left-right turn are carried out, the oil supplied from port PP is isolated from the tank path (Ta) at the signal land part of a section except the travel moved by the land (Lc4), (Lc7), (Rc3), and (Rc5), raising the pressure in the signal path up to the relief setting pressure of the signal oil source.

The straight travel spool is moved by the rise of the signal pressure, together with the pressure in the PT and PA ports. When the straight travel spool is moved, the oil supplied through port P1 flows to travel (Section1) via the neutral path (L1) and, at the same time, flows to the travel (Section 6) through the path (2), straight travel spool head, and neutral path (R1)

The oil supplied through port P2 flows to the parallel path (L3) via the straight travel spool head and path (1).

Travel (Section1 and 6) is operated by the oil supplied through port P1, and devices other than travel are operated by the oil supplied through port P2; therefore, fluctuation in travel can be prevented even in composite operation combined with travel left-right operation and other devices.

In the event that the load pressure of other sections is higher than that of the travel (Section 6), a portion of the oil supplied through port P2 pushes open the poppet (S6-2), passes through the orifice at the end of the poppet, and joins into path (S-1), resulting in travel speed reduction shock as the movement of the straight travel valve is relieved.

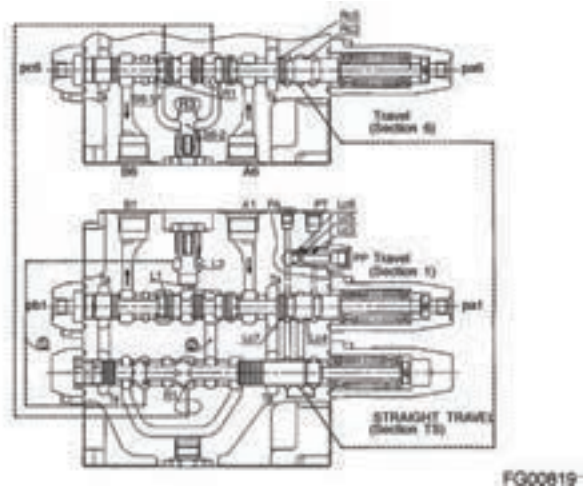


Figure 16

Anti-drift Valve

An anti-drift valve is installed in the cylinder port on the side of the arm load (arm bottom) which prevents the unwanted self-lowering of the arm (boom) cylinder.

In the neutral state (Figure 14), cylinder port pressure is guided to the spring chamber (AD5) through path (AD2), poppet (AD3) gap, and path (AD4).

The poppet (AD1) is fully seated by the differential pressure generated by the spring force and the area difference of the poppet.

In arm damp (boom upward) operation (Figure 17), the oil supplied from the pump pushes the poppet (AD1) open and flows into the cylinder port.

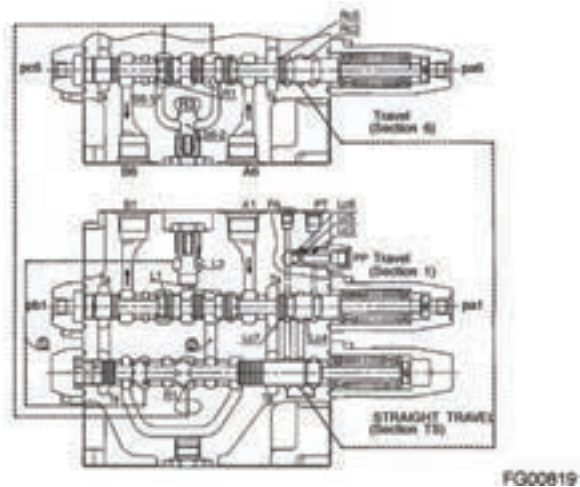


Figure 17

In the arm crowd operation (boom upward), pc1 (pc2) is pressurized to move the poppet (AD3) in order to induce the oil in the spring chamber (AD5) to the drain path (DR) via the poppet (AD3) gap and spool (AD6) gap; consequently, the poppet (AD1) is opened and the lubricant oil in the cylinder port flows to the tank path (Ta) via the spool.

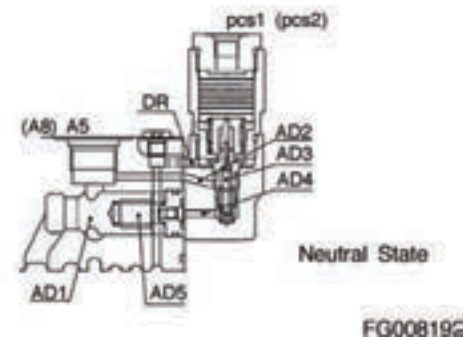
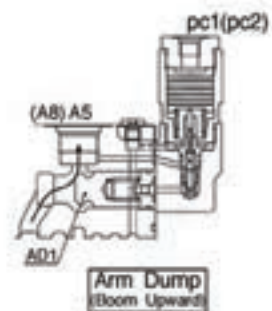
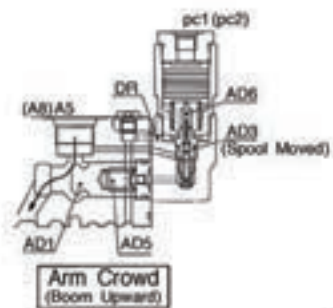


Figure 18



FG008193

Figure 19



FG008194

Figure 20

DISASSEMBLY

Precautions for Disassembly

1. On a level surface, place the main equipment on the level and place all other working devices on the ground.

Ensure that neither the traveling nor the swing motion is self-activated.

Stop the engine and release the pressure from all actuators.



CAUTION

If the valve assembly is replaced or the valve is disassembled under pressurized conditions, there is a danger that high pressure oil may be expelled or parts may eject suddenly. When disassembling, ground the bucket and fully release the pressure in the oil circuit.

2. Release air pressure from the tank.
3. Clean the working place so that no foreign matter can enter into the valve when disassembling.
4. Tag disassembled parts so that they can be easily and correctly identified for reassembling.
5. Replace all seals (o-rings, backup rings) with new ones
6. Spools are matched with the respective valve housing and sleeves. Therefore, spools must not be replaced.

Disassembling Procedures

In this disassembly section, the parts for assembly are identified by

Disassembly of Main Spool

1. Unscrew the socket head bolt (width across flats of hole: 6), disassemble the long cap.
Remove the o-ring from the groove of the valve housing.
2. Unscrew the socket head bolt (width across flats of hole: 5), disassemble the cap.
Remove the o-ring from the cap.
3. Pick out the spools as in sub-assembly state from the valve housing.



CAUTION

Spools must be picked out straight so that they are not dented or scratched. Dents or scratches may damage the wall of the body hole when picking out, making reassembly difficult or impossible. Furthermore, when assembled, it may cause malfunction. Each spool has to be tagged so that it can be reassembled in the correct place. If incorrectly assembled, the actuator will not function properly and may be very dangerous.

4. Unscrew the socket head bolt (width across flats of hole: 6), disassemble the short cap.

Remove the o-ring from the groove of the valve housing.

5. Unscrew the spool end [said new part No.-4] (width across flats of hole: 6) from the spool, remove the spring seat [said new part No. -2] and spring [said new part No. -3].

6. Unscrew the spool end (width across flats of hole: 6) of the spool, remove the spring seat and spring.

Disassemble the plug (groove width: 3), remove poppet, spring, O-ring, and back-up ring.

7. Unscrew the spool end (width across flats of hole: 6) of the spool, remove the spring seat and spring.

Disassemble the plug (groove width: 3), remove the poppet, spring, O-ring, and back-up ring.



CAUTION

When disassembling the spool assembly, use the wooden vise to fix the spool so that the spool is not damaged. In order to prevent the bending of the spool, grip the spool as close to the end as possible. Adhesive is applied on the thread of the spool end. Heat up the outside of the spool end (thread) with an industrial dryer or similar tool, until the spool end can be easily tightened (standard heating temperature: 200~250°C). In the event of excessive heating, the spring may be degraded by thermal deformation. In such cases, replace with a new spring. Do not touch the heated spool as you may be burnt.

Disassembly of Sub-Spool

1. Unscrew the spool end (width across flats: 5) of the spool, remove the spring seat and spring.
2. Adhesive is applied on the thread connecting the spool and spool end. Refer to (Caution: 3) when disassembling them.

Disassembly of Sub-Spool

1. Disassemble the plug (width across flats: 32), remove the O-ring.
2. Remove the spring and spool.
3. Use a needle to pick the inside of the front hole of the sleeve to take out the sleeve. The piston will come out together with the sleeve.
4. Remove the back-up ring and O-ring.

Disassembly of Boom, Arm Anti-Drift Valve

1. Unscrew the socket head bolt (width across flats: 6), remove body assembly, and remove the O-ring from the groove of the valve housing.



CAUTION

When disassembling this part with the control valve mounted on the equipment, parts may be ejected by the inner pressure. Unscrew the socket head bolt slowly, and then disassemble when it is certain that the inner pressure has been fully released.

2. Remove space assembly using the M6x1.0 bolt, remove the O-ring and back-up ring.
3. Remove the spring and poppet.
4. Grip the body assembly with a wooden vise so that the contacting surface on the O-ring mounting side is not damaged.
5. Unscrew the plug assembly (width across flats: 38), remove the O-ring.
6. Remove the piston, spool and spring.
7. Disassemble the plug (width across flats: 38), remove the O-ring.



CAUTION

When disassembling this part with the control valve mounted on the equipment, parts may be ejected by the inner pressure. Unscrew the plug slowly, and then disassemble when it is certain that the inner pressure has been fully released.

8. Remove the sleeve and poppet.
From the outside of the sleeve, remove the O-rings and back-up rings.
9. Remove the spring seat and spring from the hole.

Disassembly of Travel Right, Swing, Bucket, Boom1, 2, Arm1, Boom Swing, Blade, Second Service, Load check Valve

1. Disassemble the plug (width across flats: 27) of the load check valve, remove the O-rings.
2. Remove the spring and poppet.

Disassembly of Check Valve in the Straight Travel Orifice (travel left section)

1. Disassemble the plug (width across flats: 27) of the straight travel orifice, remove the O-ring from the plug.
2. Remove the poppet and spring.

Disassemble of Arm2 Load Check Valve

1. Unscrew the socket head bolt (width across flats: 8), remove the flange from the body.
Remove the O-ring from the groove of the valve housing.
2. Take out the sleeve, springs and poppets.



CAUTION

Do not let the spring fall on the floor. If it falls, debris may enter the main spool's sliding part, which could cause the spool to stick, resulting in uncontrollable running of the actuator.

Disassembly of the External Convergence Check Valve of the First Service

1. Disassemble the plug (width across flats: 32), remove the O-ring from the plug.
2. Take out the spring and poppet.
3. Disassemble the plug assembly (width across flats: 27), remove the O-ring.

Disassembly of the Common Check Valve

1. Disassemble the plug (width across flats: 27) of the check valve, remove the O-ring from the plug.
2. Take out the spring and poppet.

Disassembly of the Arm1 Semi Para Check Valve

1. Disassemble the plug assembly (width across flats: 8), remove the O-ring.
2. Take out the spring and poppet.

Disassembly of the Relief Valve

1. Remove the overload relief valve (width across flats: 32) from the main body valve and the spool section of the add-on.
2. Remove the main relief valve (width across flats: 32) from main body valve, remove (width across flats: 24) from the inlet section of the add-on.
3. Take out the negacon relief valve (width across flats: 32) from the main body valve.



CAUTION

The relief valve itself is not subject to disassembly. Any disassembling / reassembling / adjusting of the relief valve shall be excluded from the warranty.

Disassembly of the Shut-off Valve

1. Disassemble the plug assembly (width across flats: 32), remove the O-ring and back-up ring.
 - Not used in this valve.

Disassembly of Other Plugs

1. Disassemble the plug assembly (width across flats: 19) of PP port, remove the O-ring.
2. Disassemble the plug (width across flats: 19) in the preliminary section cap part, remove the O-ring.
3. Disassemble the G1/8 plug (width across flats: 5, 3 in all) remove the O-ring.
4. Disassemble the G3/8 plug (width across flats: 8, 4 in all), remove the O-ring.
5. Disassemble the G1/2 plug (width across flats: 10, 2 in all), remove the O-ring.
6. Disassemble the G3/4 plug (width across flats: 36, 2 in all), remove the O-ring.
7. Disassemble the 7/8-14 UN plug (width across flats: 27), remove the O-ring.

Disassembly of the Add-on Section

1. Remove the hex nut (width across flats: 19) (width across flats: 22).
2. Take out the outlet housing.
3. Take out the valve housing for the spool section, remove the O-ring on the contact surface.
4. Take out the inlet housing, remove the O-ring on the contact surface.
5. Remove the O-ring on the main body contact surface.
6. Unscrew the tie rod and remove from the main body valve housing.



CAUTION

When taking out the add-on section, be very careful not to dent or scratch the contact surfaces. Dents or scratches may cause an oil leak at the contacting surface, resulting in malfunction.

In addition, take care that foreign matter does not enter the oil path. If foreign matter touches the spool sliding surface, the spool may get stuck, causing bad seating in the load check valve and resulting in the uncontrolled running of the actuator.

WASHING

All disassembled parts have to be washed clean with mineral oil.

Dry with compressed air. Place them on a clean sheet of paper or a vinyl sheet.

INSPECTION

Carry out a visual inspection on all parts for any foreign matter, scratches, or other defects.

1. Inspect the seat of the load check valve in the valve housing for any scratches, dents, dust, or corrosion. Small scratches may be removed with an oil stone.
2. Inspect the spool for any scratches or dents. Small scratches may be removed with an oil stone.
3. Test sliding surfaces by moving lightly. All grooves and paths must be free from foreign matter.
4. If a spring is broken, seriously deformed, or worn, replace it immediately.
5. If the performance of the relief valve is unsatisfactory, check in accordance with Clause 6, Relief Valve Maintenance.
6. All removed O-rings and back-up rings must be replaced with new ones.
7. Remove the cap and plug, check for any residual painting around the body holes or plugs positions (paint or coating debris left in the valve will cause malfunctions or oil leaks).

ASSEMBLING



CAUTION

Check number of parts, assembling position, and necessary tools before starting assembly.

Sub-Assembly

Before assembling the parts into valve housing, sub-assemble the necessary parts.

Main Spool

1. Apply adhesive on the threads of spool.

Fix spring seat, spring, and spool end then fix spool with wooden vise and tighten spool end.

Torque: 9.8~11.8N•m



CAUTION

Do not apply adhesive excessively. Fix the spool as near to the spool end as possible so that the tightening torque does not bend the spool. Excessive torque may result in spool expansion, causing the spool to stick and uncontrolled running of the actuator. Hereafter, heed this caution when applying adhesive.



CAUTION

Note that the spring in boom 2 spool and the straight travel spool differ from other parts. Mistakes in assembly may cause a malfunction of the actuator.

2. Assemble poppet and spring in the spool.

Apply adhesive on the spool thread.

Fix the spool with the wooden vise.

Apply adhesive to the tread of the plug.

Insert the plug which is fitted with an O-ring and back-up ring.

Torque: 9.8~11.8 N•m.

Assemble spring seat, spring and spool end, and fix spool end.

Torque: 9.8~11.8 N•m.

3. Insert poppet and spring into the hollow of the spool.

Apply adhesive to the thread of the spool for plug fitting.

Insert the plug assembled with an O-ring and back-up ring.

Torque: 9.8~11.8 N•m.

Apply adhesive to the thread of the spool which is assembled with the spool end.

Fix spring seat, spring and spool end. Fix the spool with a wooden vise, and tighten the spool end.

Torque: 9.8~11.8 N•m.



CAUTION

Be careful when the inserting positions of the O-ring and back-up ring. If they are inserted wrongly, the O-ring may be cut and will not work properly.

Sub Spool

1. Apply adhesive to the thread of the spool.
2. Fix spring seat, spring and spool end. Fix spool with a wooden vise and tighten the spool end.

Torque: 19~22 N•m.

Sub-Spool Part

1. Insert back-up ring and O-ring into sleeve.
2. Insert piston into the sleeve fitted with seal.
3. Insert spool into the sleeve.

Boom, Arm Anti-Drift Valve

1. Insert O-ring and back-up ring into the outer groove of the sleeve.



CAUTION

Make sure the inserting positions of the O-ring and back-up ring are correct. If wrong, the O-ring may be cut causing the self-lowering of the actuator.

2. Insert poppet and spool into the hole of the sleeve, making sure the direction is correct.
3. Attach spring seat to the groove at the end of the poppet, place spring and insert into the body hole together with the sleeve.

4. Fix the body at the contacting surface on the O-ring side using a wooden vise to prevent scratching.



CAUTION

It is recommended to apply grease on the spring and spring seat so that both can be correctly positioned on the poppet. If the spring is not correctly positioned on the spring seat, it may be damaged and spring debris may surround the oil path, resulting in malfunction.

5. Insert spring and piston into plug.
6. Fix the plug assembly attached with the O-ring to the plug.
Torque: 147~157 N•m.
7. Fix the plug attached with O-ring to the body.
Torque: 147~167 N•m.

Shut-Off Valve

1. Assemble the O-ring and back-up ring to the plug.



CAUTION

Make sure that the O-ring and back-up ring are correctly positioned. If the positions of the two rings are reversed, the O-ring may be cut causing the actuator to malfunction.

Assembling Control Valve

Assembling Add-on Section

1. Install tie rod in the main body valve housing.



CAUTION

Tighten the tie rod to effectively thread the end. If the thread cannot perform its proper function, an oil leak may occur at the contact surfaces due to the insufficient jointing force of the add-on section, causing malfunction.

Furthermore, the threads may be broken by overload, resulting in malfunction.

2. Install the O-ring on the contact surface of the main body.
3. Using the tie rod as a guide, mount the inlet housing on the main body valve housing. Install the O-ring on the contact surface.
4. Using the tie rod as a guide, mount the valve housing for the spool section on the inlet housing. Install the O-ring on the contact surface.
5. Using the tie rod as a guide, mount the outlet housing on the valve housing for spool section.



CAUTION

When inserting the add-on section, take care not to dent or scratch the contact surfaces. Otherwise, oil may leak at the contacting surface causing malfunction. Also, take care that foreign material on the contact surface do not cause the O-ring to drop out or change position.



CAUTION

When installing the add-on section, the tie rod must be used as a guide for correct positioning. Otherwise, the O-ring on the contact surface may be separated, causing oil leak and malfunction.

6. Insert the hex nut into the tie rod and tighten them.

Torque: 152±7N•m

Insert the hex nut into the tie rod and tighten them.

Torque: 93±4N•m



CAUTION

The hex nut must be tightened to the specified torque. At smaller torque, oil may leak at the contact surface due to insufficient tightening force. At too strong torque, the spool may be stuck due to the torsion of the spool section valve housing, causing uncontrollable activation of the actuator. Tighten the two uniformly.



CAUTION

This control valve is designed to allow the addition of the add-on section, which is supplied as a kit. When adding the add-on section, follow the instructions for disassembly and reassembly.

Assembling Right Travel, Swing, Bucket, Boom1, 2, Arm1, and Blade Load Check Part

1. Insert the poppet and spring into the valve housing.
2. Insert the plug assembled with O-ring and tighten them.

Torque: 103~113N•m.

Assembling Arm2 Load Check Valve Part

1. Insert the spring and poppet on the outside of the sleeve. With the poppet and spring inside the sleeve, insert them into the valve housing.
2. Mount the O-ring on the valve housing groove. Mount the flange and tighten with socket head bolt.

Torque: 39~44N•m.



CAUTION

When assembling the flange, the spring must be inserted into the flange position. Otherwise, the spring may be damaged. Socket head bolt must be tightened uniformly and firmly. Hereinafter, when tightening flanges, follow the instructions given under Caution 20.

Assembling Travel Orifice (left travel section) Check Valve

1. Insert the poppet and spring into the valve housing.
2. Insert the plug assembled with the O-ring and tighten.

Torque: 103~113N•m



CAUTION

When installing the plug [19], the spring [17] must be inserted into the plug completely. If the spring is not fully inserted, it may be broken.

Hereafter in this manual, plugs should be tightened in compliance with this caution.

First Service, Assembling External Joint Flow Check Valve

1. Insert the poppet and spring into the valve housing.
2. Insert the plug assembled with the O-ring and tighten.

Torque: 103~113N•m.

3. Insert the plug assembly inserted with the O-ring and tighten them.

Torque: 89~97N•m.

Assembling Common Check Valve

1. Insert the poppet and spring into the valve housing.
2. Insert the plug inserted with the O-ring, and tighten the plug.

Torque: 103~113N•m.

Assembling Arm1 Semi Para Check Valve

1. Insert the poppet and spring.
2. Tighten the plug assembled with the O-ring.

Torque: 73~79N•m.

Assembling Boom, Arm Anti-Drift Valve

1. Insert the O-ring into the contact surface.
2. Insert the poppet into the valve housing
3. Insert the spacer attached with the O-ring and back-up ring into the valve housing together with the spring.



CAUTION

Insert the spring carefully so that it is located in the spacer position correctly. If the spring is not located in the spacer position correctly, it may be broken by the poppet, and its debris may clog the oil path, causing malfunction.

4. Insert the socket head bolt into the body assembly and tighten them.

Torque: 20~25N•m.

Assembling Relief Valve

1. Insert the overload relief valves and tighten them: total 8.

Torque: 78~88N•m.

2. Insert the main body relief valves and tighten them.

Torque: 78~88N•m.

3. Insert the add-on main relief valves and tighten them.

Torque: 49~59N•m.

4. Insert the negacon relief valves and tighten them.

Torque: 103~113N•m.

Assembling Sub-Spool

1. Insert the spool assembly into the original place.

2. Install the cap attached with the O-ring.

Insert the socket head bolts into the cap and tighten them.

Torque: 8.8~10.5N•m.



CAUTION

Insert the spool slowly, right into the hole. After insertion, move the spool with the hand to check if there is any clogged or uneven feeling. If clogged or uneven, the spool may not function properly.

Hereinafter in this manual, follow this caution when assembling the spool.

Assembling Sub Spool

1. Insert the spool assembly into the original place.
2. Insert the spring.
3. Insert the plug [attached with the O-ring, and tighten the plug.

Torque: 103~113N•m.

Assembling Main Spool

1. Insert the O-ring into the valve housing.
2. Install the short cap] in the straight travel spool.
Install to other spools.
Insert the socket head bolt into the short cap, and tighten it.
Torque: 20~25N•m.
3. As a sub-assembly, insert the spools into their respective (original) holes.

4. Install the long cap in the straight travel spool [10].
Install the long cap in the other spools.
Insert the socket head bolt into the long cap, and tighten it.
Torque: 20~25N•m.



CAUTION

When inserting the cap, be careful not to allow the O-ring to separate on the contact surface.

Assembling Other Plugs

1. Insert the plug assembly assembled with the O-ring.
Torque: 205~227N•m.
2. Insert the plug assembly assembled with the O-ring.
Torque: 73~79N•m.
3. Insert the plug assembly assembled with the O-ring.
Torque: 13.5~16.5N•m.
4. Insert the plug assembly assembled with the O-ring.
Torque: 103~113N•m.
5. Insert the plug assembly assembled with the O-ring.
Torque: 116~128N•m.
6. Insert the plug assembly assembled with the O-ring.
Torque: 49~59N•m.
7. Insert the plug assembly assembled with the O-ring.
Torque: 19~22N•m.



CAUTION

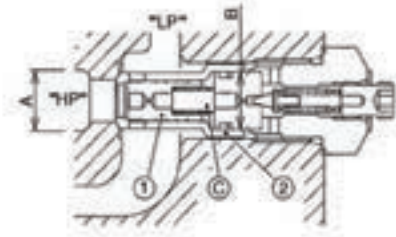
When assembled, check for any omitted or loose parts. If loose, oil may leak. Specified torque values are all in wet condition (applied with oil).

RELIEF VALVE

Main Relief Valve

Body Main Relief Valve Operation

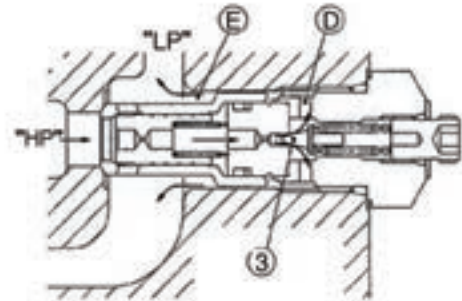
1. This relief valve is inserted between the neutral path "HP" and low pressure path "LP", oil is filled in the inner space (C) through the orifice of the main poppet (1). The sleeve (2) and main poppet (1) are securely seated by the areal difference between "A" and "B".



FG008195

Figure 21

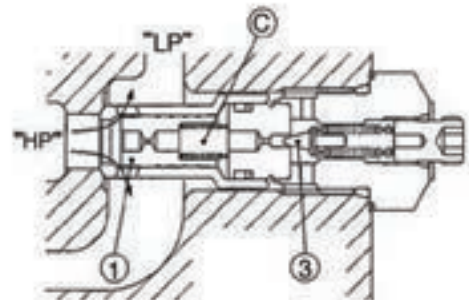
2. When the pressure in the neutral path "HP" reaches the preset pilot spring force, the pilot poppet will be opened. Oil flows around the pilot poppet (3), through the drill hole (D) and circular gap (E), and is guided to the tank path "LP".



FG008196

Figure 22

3. When the pilot poppet (3) is opened, the pressure in the inner space (C) is decreased to open the main poppet (1). Therefore, the oil in "HP" flows directly through path "LP".



FG008197

Figure 23

Disassembling / Reassembling Body Main Relief Valve

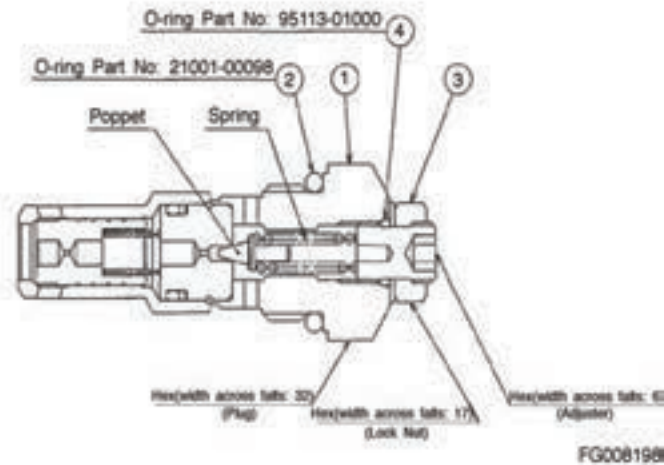


Figure 24

Disassembling

1. This part is replaced by assembly.
2. When replacing, unscrew plug <width across flats: 32> with spanner, remove O-ring.
3. If oil leaks at the adjuster kit, disassemble adjuster kit and replace O-ring.



CAUTION

When disassembling the adjuster kit, parts may be ejected by the spring. Be careful not to lose the poppet.

Assembling

1. Check if there is dust, paint, etc., on the thread of the plug. Insert a new O-ring.
2. Clean the relief mounting part of the valve housing. Install a relief valve and insert the plug.
Torque: 59~69N•m.
3. When the adjuster kit is disassembled, clean the threads. Adjust pressure in compliance with the clause.



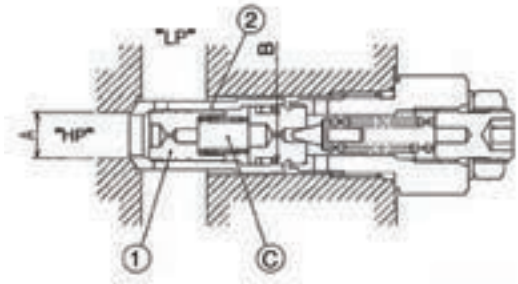
CAUTION

In the above instructions, the specified torques values are for wet conditions (applied with oil).

Add-on Main Relief Valve Operation

1. This relief valve is inserted between the neutral path "HP" and the tank path "LP". Oil is filled into the inner space (C) through the orifice of the main poppet .

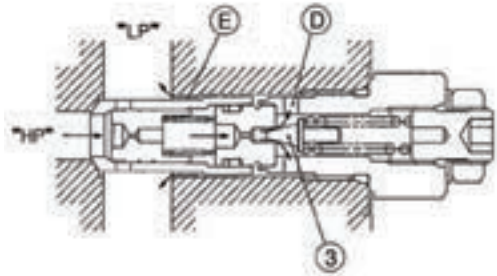
The sleeve (2) and main poppet (1) are securely seated by the areal difference between "A" and "B".



FG008199

Figure 25

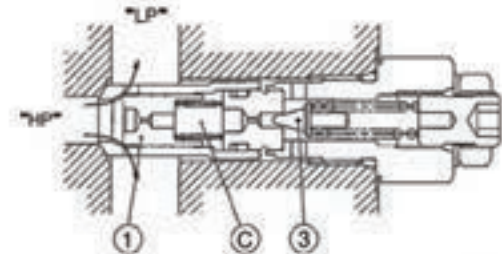
2. When the pressure in the neutral path "HP" reaches the preset pilot spring force, the pilot poppet (3) will be opened. Oil flows around the pilot poppet (3), through the drill hole (E) and circular gap (D), and is guided to the tank path "LP".



FG00820C

Figure 26

3. When the pilot poppet (3) is opened, the pressure in the inner space (C) is decreased to open the main poppet (1). Therefore, the oil in "HP" flows directly through path "LP".



FG00820

Figure 27

Disassembling / Reassembling Add-on Main Relief Valve

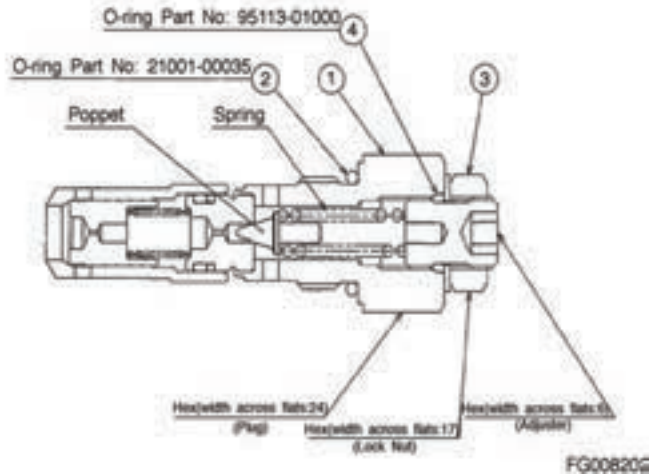


Figure 28

Disassembling

1. This part is replaced by assembly.
2. When replacing, unscrew the plug (width across flats: 32) with a spanner, then remove the O-ring.
3. If oil leaks at the adjuster kit, disassemble the adjuster kit and replace the O-ring.



CAUTION

When disassembling the adjuster kit, parts may be ejected by the spring. Be careful not to lose the poppet.

Assembling

1. Check for dust, paint, etc., on the thread of the plug. Insert the new O-ring.
2. Clean the relief mounting part of the valve housing. Install the relief valve, insert plug.
Torque: 59~69N•m.
3. When the adjuster kit is disassembled, clean the threads. Adjust pressure in compliance with the clause.



CAUTION

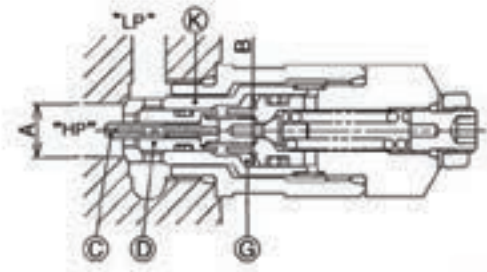
In the above instructions, the specified torques values are for wet conditions (applied with oil).

Overload Relief Valve

Relief Valve Operation

1. This relief valve is inserted between the neutral path "HP" and tank path "LP". Oil is filled in the inner space (G) through the orifice of the piston (C).

The sleeve (K) and main poppet (D) are securely seated by the areal difference between "A" and "B".

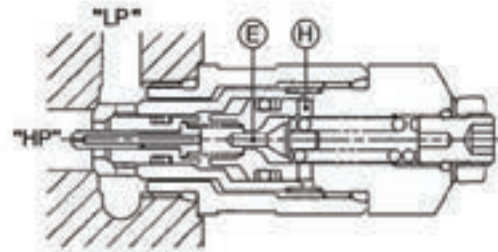


FG008203

Figure 29

2. When the pressure in the cylinder port "HP" reaches the preset spring force of the pilot poppet (E), the pilot poppet (E) will be opened.

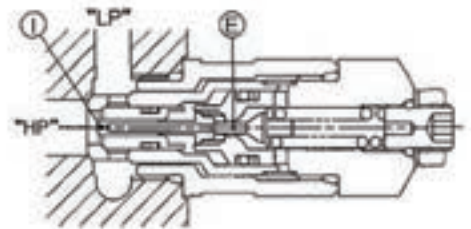
Oil flows around the poppet, through the drill hole (H), and is guided to the low pressure path "LP".



FG008204

Figure 30

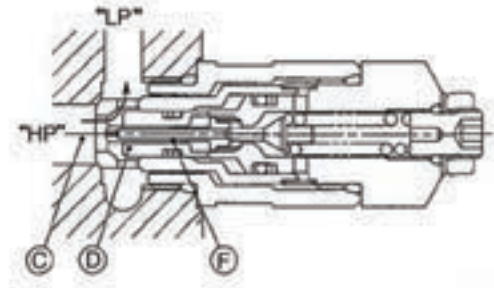
3. The pilot poppet (E) opens to make the oil flow through the orifice (1) of piston (C), differential pressure is generated between path "HP" and the back side of the piston (C) to move the piston (C) to seat the poppet (E).



FG008261

Figure 31

4. For the oil flow through the path "HP" and poppet (D), the pressure difference increases due to throttling by the poppet (D), circular gap of piston (C), and orifice. The poppet (D) is opened by the differential pressure and oil flows directly through path "LP".

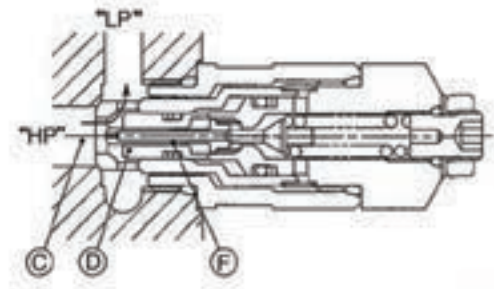


FG008262

Figure 32

Suction operation

1. This relief valve is equipped with an anti-void unit in the cylinder port "HP", which supplies oil when cavitation occurs. In the low pressure side "LP", when the pressure in the cylinder port "HP" is low, the sleeve (K) is opened by the differential pressure generated by the areal difference between "A" and "B". Oil flows from the low pressure side "LP" into the cylinder port "HP" to prevent cavitation.



FG008262

Figure 33

Disassembling / Reassembling Overload Relief Valve

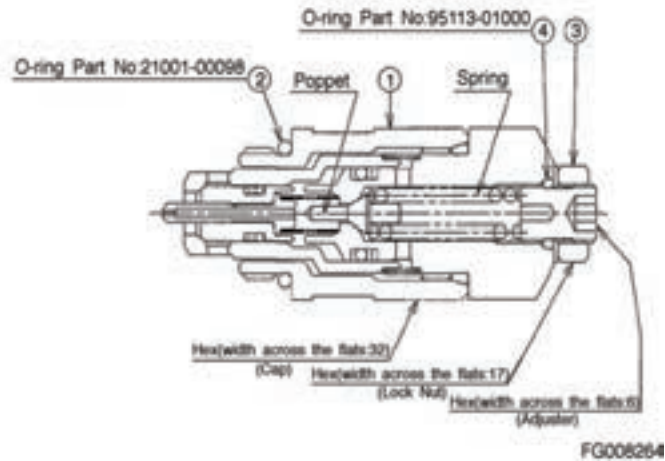


Figure 34

Disassembling

1. This part is designed to be replaced by assembly.
2. When replacing, unscrew the cap (hex, width across the flats: 32) with spanner, and remove the O-ring.
3. If oil leaks at the adjuster kit, unscrew the adjuster kit and replace the O-ring.



CAUTION

When disassembling the adjuster kit, parts may be ejected by the spring. Be careful not to lose the poppet.

Assembling

1. Check for dust, paint, or dirt on the threaded part of the cap, insert a new O-ring.
2. Clean the relief valve mounting of the valve housing, assemble the relief valve, and insert the cap (width across the flats: 32).
Torque: 78~88N•m.
3. If the adjuster kit is disassembled, clean the threaded part and adjust the pressure in compliance with the clause.



CAUTION

The specified torque values are all for wet conditions (applied with oil).

Negacon Relief Valve

Negacon Relief Valve Operation

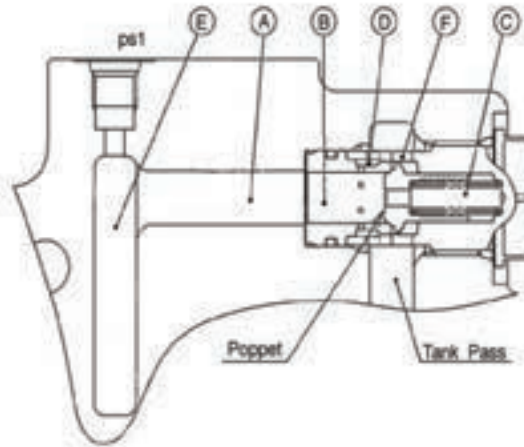


Figure 35

FG008265

Generation of Signal Pressure

The oil supplied through the pump port (P1) flows to the tank path through the neutral path (L1) and the negacon orifice (D) at the neutral downstream path (A).

In this process, pressure is generated in the path (B) by the negacon orifice (D), and the pressure is induced in the negacon signal pressure port (Ps1) through path (E).

When the main spool that is upstream of the neutral downstream path (A) is activated, the oil flow through the neutral downstream path (A) is decreased and the negacon signal pressure is reduced.

Relief Operation

In the event that there is excessive oil flow in the neutral downstream path (A), the pressure generated in path (B) by the negacon orifice (D) is induced to the back chamber (C) of the poppet. The poppet is activated by the differential pressure generated by the difference in the hydraulic area between the path (B) and the back chamber (C). When this poppet is activated, oil flows to the tank path (Ta) through path (B) and the drill hole path (F) of the plug, preventing excessive pressure in the negacon signal pressure port.

Disassembling / Reassembling Negacon Relief Valve

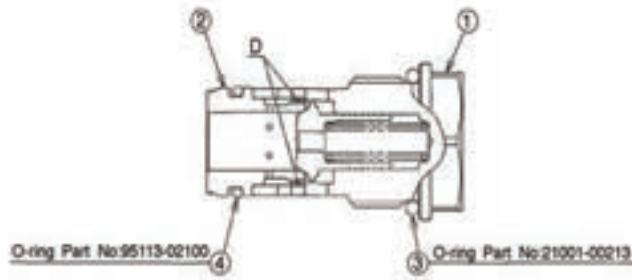


Figure 36

FG00826E

Disassembly

1. This part is designed to be assembly-replaced without disassembly, in order for the press-in at the "D" part.

Assembling

1. Check for dust, paint or any dirt on the threaded part of the plug , and insert a new O-ring.
2. Insert a new O-ring into sleeve.
3. Clean the relief valve mounting of the valve housing, insert the plug (width across the flats: 46) of the relief assembly.

Torque: 103~113N•m.



CAUTION

The specified torque values are all for wet conditions (applied with oil).

Adjusting Relief Valve

Main Relief Valve (common for body and add-on)

1. This part is designed for non-disassembly and is not subject to readjustment. If pressure is adjusted, we cannot guarantee its proper operation.
2. Install a precise pressure gauge at the circuit inlet.
3. Run the pump at the rated rpm.
4. Move the spool in the control valve, read the pressure gauge indication at the end of the cylinder stroke.



CAUTION

Move the spool of the actuator, for which the set pressure of the overload relief valve is higher than that of the main relief valve actuator spool.

5. Turn the adjuster clockwise until the desired pressure is obtained.
17.8MPa of pressure is increased by a turn of the adjuster.
6. When the desired pressure is reached, and press the adjuster so that it does not rotate, then tighten the lock nut.
Torque: 27~31N•m
7. Raise the pressure again to check that the specified pressure is obtained.

Overload Relief Valve



CAUTION

If the set pressure is higher than that of the main relief valve, it will be activated during the following adjustment. Therefore, it will not be possible to adjust the overload relief valve. Do not disassemble or adjust it. Replace with a complete set of relief valves in assembly.

1. This part is designed for non-disassembly and should not be adjusted. Replace by assembly. If the pressure has been adjusted, we cannot not guarantee its proper operation.
2. Move the control valve spool, and read the pressure gauge indication at the end of the cylinder stroke.

3. Turn the adjuster clockwise until the desired pressure is reached.
21.2MPa of pressure is increased by each turn of the adjuster.
4. When the specified pressure is reached, press the adjuster so that it does not rotate, and tighten the lock nut.
Torque: 27~31N.m
5. Raise the pressure again to check the rated pressure has been obtained.

INSTALLATION

1. Piping should not exert unnecessary force on the valves.
2. Bolts must be tightened uniformly.
3. Welding work near the valves may damage the seals due to excessive heat or flame.
4. Keep the ports covered until connected with a pipe in order to prevent dust.

OPERATION

1. Check that the hydraulic circuit and oil are clean before operation.
2. Oil must be hydraulic oil, with an aniline point of 82~113°C
3. Keep the relief valve below the specified pressure.
4. The pressure difference between the main relief valve and the overload relief valve should be set at a minimum of 2.0MPa.
5. Perform deaeration and warming up before operation.
 - In particular, when the temperatures of the hydraulic oil and valve are low, observe the following instructions in order to prevent the stick of the spool by thermal shock;
 - Do not operate the main relief valve and overload relief valve abruptly without a proper time interval. Let the hydraulic oil circulate in each actuator to warm up all the parts uniformly.
 - Fine or complex operations which may cause local overheating at the orifices of each part should not be done abruptly at low temperature.

CONTROL VALVE SPECIFICATION

Item	Specification
Rated Flow(main body)	160L/min (At neutral: 30L/min)
Max. Pressure(main body)	35MPa
Rated Flow(Add-on Pr)	70L/min
Max. Pressure(Add-on Pr)	28MPa
Allowable Back-pressure	Peak Pressure: 1.5MPa max. (Operating Pressure: 0.5MPa max.)
Allowable Oil Temperature	Operating: -25~80°C
	Instantaneous: 100°C max.
	(seal: nitrile rubber)

TROUBLESHOOTING

Control Valve: overall

Problem	Possible Cause	Remedy
Spool does not stroke.	Oil temperature is too high.	Remove obstructions in the piping line, which may resist oil flow.
	Hydraulic oil is contaminated.	Replace hydraulic oil, wash circuit.
	Piping port joint is loose.	Check torque.
	Valve housing is torqued after installation.	Check by unscrewing joint bolts.
	Pressure is too high.	Install pressure gauge to check pressure at pump and cylinder port.
	Spool is bent.	Replace with valve assembly.
	Return spring is damaged.	Replace damaged part.
	Spring or cap is separated.	Unscrew cap to fix, and tighten it.
	Temperature distribution in valve is not uniform.	Warm up the whole circuit.
	Dust in valve.	Remove dust.
	Insufficient pilot pressure	Check pilot valve and pilot relief pressure.
Cannot maintain load.	Cylinder oil leak.	Check cylinder seal.
	Oil is bypassed in spool.	Check if spool is scratched.
	Oil leak at overload relief valve oil.	Wash valve housing seat and relief valve seat.
	Oil leak at anti-drift valve.	Disassemble anti-drift valve, wash all the seats clean. If seat is scratched, replace the poppet, or lap the poppet and seat. If the anti-drift valve spool has a problem, spool and sleeve must be replaced together (they are match-finished).
When the spool is moved from neutral to higher position, load carrying capacity is reduced.	Dust in load check valve.	Disassemble and wash check valve.
	Poppet or seat of valve is scratched.	Replace poppet or lap poppet and seat.

Relief valve

Problem	Possible Cause	Remedy
Pressure does not rise at all	Main poppet, sleeve or pilot poppet is stuck open; or there is dust in the valve seat.	Replace relief valve.
Relief pressure is unstable	Pilot poppet seat is scratched.	
	Piston or main poppet is stuck.	
Relief pressure fluctuates	Seat worn by dust.	Reset the pressure, and tighten the lock nut by specified torque.
	Loose lock nut or adjuster	
Oil leak	Relief valve seat is damaged.	Replace relief valve.
	Parts are stuck with dust.	Replace the O-ring in the adjuster or installation part.
	O-ring is worn.	

Hydraulic System: Overall

Problem	Possible Cause	Remedy
Hydraulic system is not in good condition, or does not function at all.	Pump failure	Check pressure, or replace pump.
	Relief valve failure	Replace relief valve.
	Cylinder failure	Repair or replace.
	Pump load pressure is too heavy.	Check circuit pressure.
	Valve is cracked.	Replace with valve assembly.
	Spool does not stroke in full travel.	Check spool movement.
	Tank oil level is too low.	Refill hydraulic oil.
	Filter in the circuit is clogged.	Wash or replace filter.
	Circuit piping line is throttled.	Check piping.

Remote Control Valve (Work Lever / Joystick)

Edition 1

MEMO

Table of Contents

Remote Control Valve (Work Lever / Joystick)

Safety Precautions	5
Applicable Models	5
General Description	7
Theory of Operation	7
Parts List	8
Specifications	10
Torques	10
Tools and Materials	10
Disassembly	11
Cleaning and Inspection (Wear Limits and Tolerances).....	14
Reassembly	15
Start-up Procedures	21

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5434 and Up
DX225NLC	5001 and Up
DX225LL	5001 and Up
DX300LL	5001 and Up
DX300LC	7440 and Up
DX340LC	5980 and Up
DX350LC	5980 and Up
DX380LC	5109 and Up

GENERAL DESCRIPTION

Theory of Operation

Structure

The remote control valve contains four push rods, spring holders, spools and return springs, which are in the valve casing. The valve works as a pressure reduction valve.

The housing has six ports, which include input port P, tank port T, and four secondary pressure ports.

The electric horn button is installed in the valve handle.

Gear pump pressure is used for operating control spools.

Function

1. Neutral Position

When the lever is in neutral mode, the spool is pushed upward by return spring. The force of balancing spring, which determines the secondary discharge pressure, is not transmitted to the spool. The input port is closed and the pressure of the output port is the same as the pressure of the tank port T.

2. Control Switch

Pressing of the push rod starts to press the balance spring, whose force is transferred to the spool to connect the P and T ports, transferring the pilot pressure. Output pressure acts on the bottom of the spool and press the spool upwards until it is balanced with the force of the balance spring.

In short, the second pressure (output pressure) changes in proportion to the pressing force of the balance spring.

Parts List

32 : 4-8
33 : 4, 5, 8, 13, 14
34 : 10-12, 16-18
35 : 11, 12, 15-18

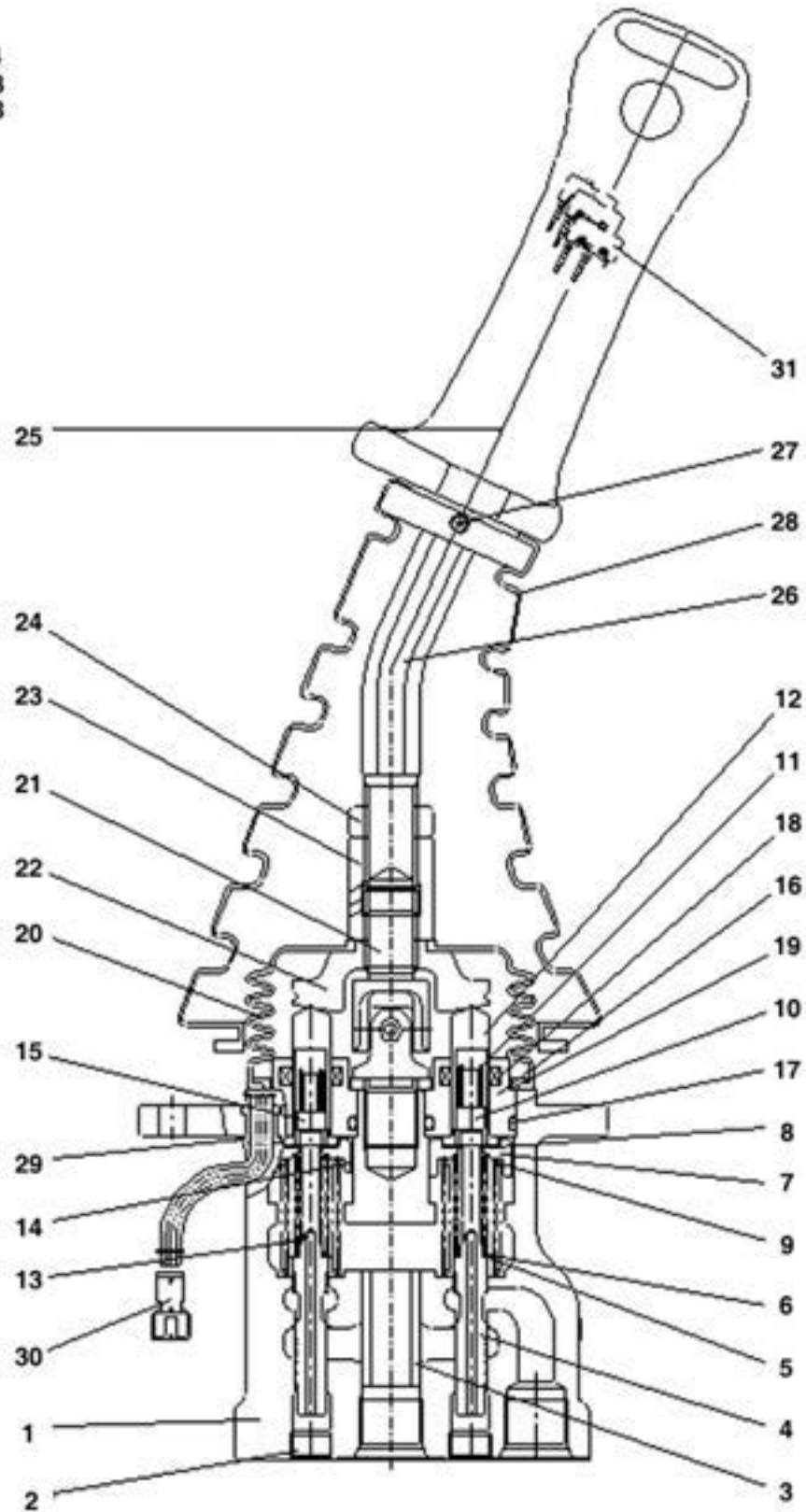


Figure 1

FG01349

Reference Number	Description
1	Case
2	Plug
3	Bushing
4	Spool
5	Shim
6	Spring
7	Spring Seat
8	Stopper
9	Spring
10	Stopper
11	Spring
12	Push Rod
13	Spring
14	Spring Seat
15	Stopper
16	Plug
17	O-ring
18	Rod Seal
19	Plate

Reference Number	Description
20	Boot
21	Joint Assembly
22	Swash Plate
23	Hex Nut
24	Nut
25	Handle Assembly (RH)
	Handle Assembly (LH)
26	Handle Bar
27	Spring Pin
28	Bellows
29	Bushing
30	Connector Assembly
31	Switch Kit
32	Spool Kit 1, 3
33	Spool Kit 2, 4
34	Plug Kit 1, 3
35	Plug Kit 2, 4
36	Handle Kit (RH)
37	Handle Kit (LH)

Specifications

Performance

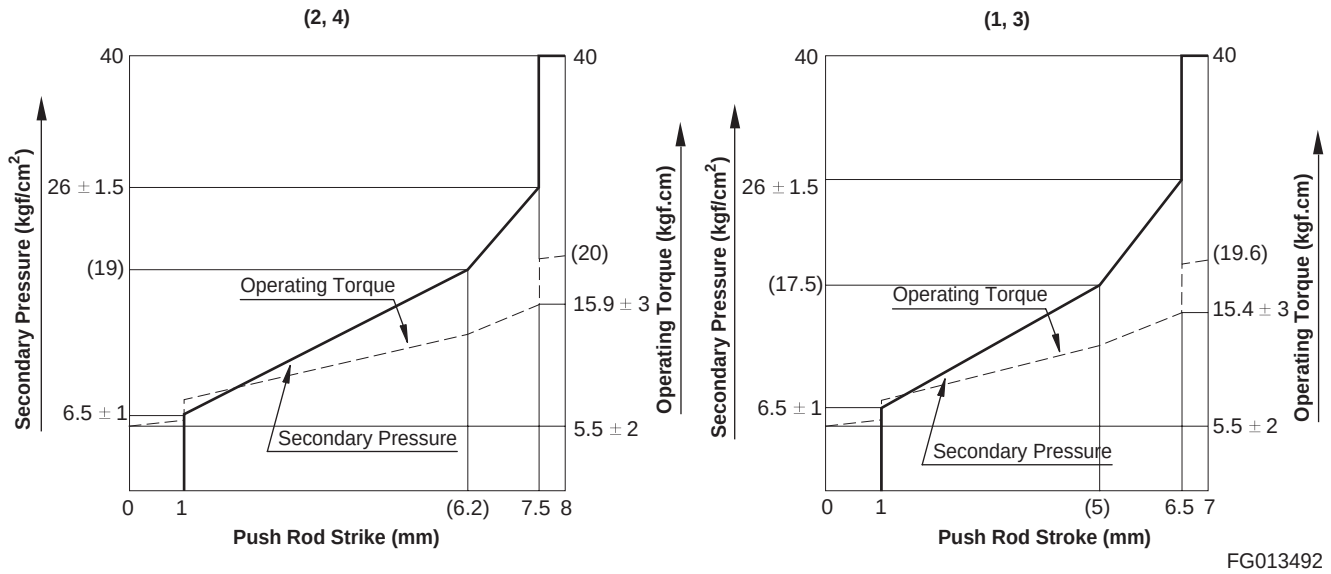


Figure 2

Torques

No.	Tool	Standard	Remark
2	Plug	PT 1/8	370 kg·cm (27 ft lb)
22	Swash Plate	27 mm	1,660 kg·cm (120 ft lb)
23	Hex Nut	22 mm	1,660 kg·cm (120 ft lb)
24	Nut	22 mm	1,660 kg·cm (120 ft lb)

TOOLS AND MATERIALS

No.	Tool	Standard	Remark
2	L-Wrench	PT1/8	plug
22	Spanner	27 mm	swash plate
23	Spanner	22 mm	hex nut
24	Spanner	22 mm	nut

DISASSEMBLY

1. Remove lead wire from bushing (29).



Figure 3

2. Remove lever assembly from case (1).



Figure 4

3. Remove hex nut (23) and swash plate (22) from case (1).



Figure 5

4. Remove joint assembly (21) from case (1).



Figure 6

5. Remove plate (19) from case (1).



Figure 7

6. Remove plug kit assembly, stopper and spring (11) from case (1).



Figure 8



Figure 9



Figure 10

7. Remove four spool kit assemblies from case (1).



Figure 11



Figure 12

8. The bushing (3) and plug cannot be removed from case (1).



Figure 13

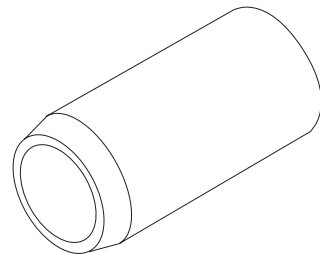


Figure 14

FG013505

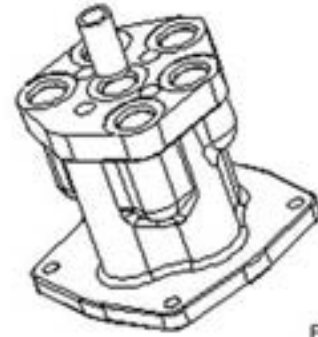


Figure 15

FG013506



Figure 16

FG013507

CLEANING AND INSPECTION (WEAR LIMITS AND TOLERANCES)

For general cleaning and inspection procedures, refer to "General Maintenance Procedures" section.

REASSEMBLY

1. Install four plugs (2) into case (1).



Figure 17



Figure 18

2. Install bushing (3) into case (1) using jig.

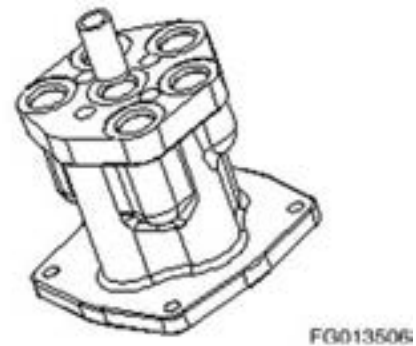


Figure 19

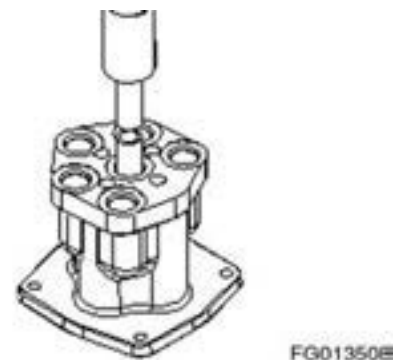


Figure 20

3. Take care when assembling spool kit assemblies (1 and 3, 2 and 4). (They should be assembled in same way).

The assembly order is; spool (4), shim (5), spring (6), spring seat (7), and stopper (8).



FG013509

Figure 21



FG013503

Figure 22

4. Install spring (9) into case (1).



FG013510

Figure 23

5. Install spool kit assembly into case (1). (The same way is used for four parts.)



FG013502

Figure 24

6. Assemble plug kit insert rod seal (18), O-ring (17), and push rod (12) into plug (16) in proper order.



FG013511

Figure 25



FG013512

Figure 26

7. Assemble four springs (11) and stoppers and insert assembled set in case (1) to form a plug kit assembly.

NOTE: Pay attention to measurement specifications of stoppers (1 and 3, 2 and 4).



FG013490

Figure 27



FG013501

Figure 28

8. Install plate (19) into case (1).



Figure 29

9. Install joint assembly (21) into case (1).



Figure 30

10. Install boot and swash plate (22) and hex nut (23) into case (1).



Figure 31



Figure 32

11. Insert bar and tighten it with a spanner to check balance of joint assembly.



Figure 33

12. Install bushing (29) into case (1).



Figure 34

13. Install lever assembly into case (1).



Figure 35

14. Put lead wire in bushing (29), tie it, and arrange boot.



Figure 36

15. Install lead wire terminal into connector terminal pressing them together.

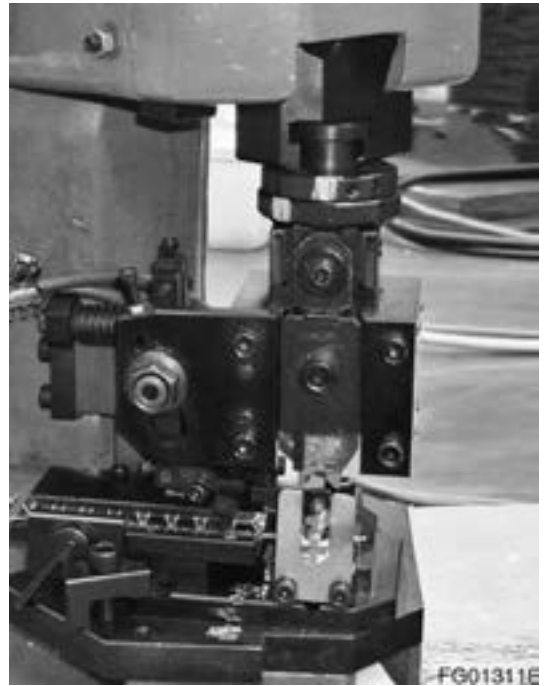


Figure 37

16. Assemble connector assembly (30), and connect it to lead wire terminal, and properly route wiring.



Figure 38



Figure 39

START-UP PROCEDURES

1. Start engine and set throttle at "LOW IDLE."
2. Set safety lever on "UNLOCK" position.

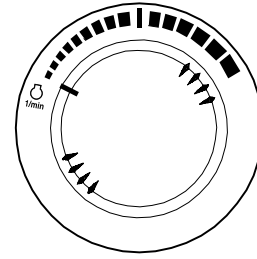


Figure 40

HAOB290L

3. Slowly cycle boom, arm, bucket cylinders and swing motor about five times without a load to vent air from pilot lines. Do this for five minutes.

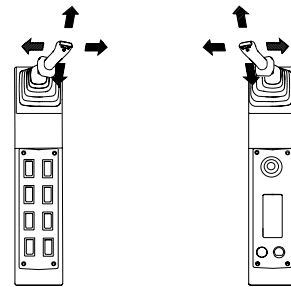


Figure 41

ARO0470L

Travel Control Valve (with Damper)

Edition 1

MEMO

Table of Contents

Travel Control Valve (with Damper)

Safety Precautions	5
Applicable Models	5
General Description	7
Theory of Operation	7
Pressure Reducing Valve	8
Operating Theory of Damper Mechanism	9
Causes of Faults and Measures	11
Parts List	12
Specification	14
Torques	14
Removal	15
Disassembly	16
Cleaning and Inspection (Wear Limits and Tolerances).....	18
Reassembly	19
Installation	24
Start-up Procedures	25

MEMO

SAFETY PRECAUTIONS



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APPLICABLE MODELS

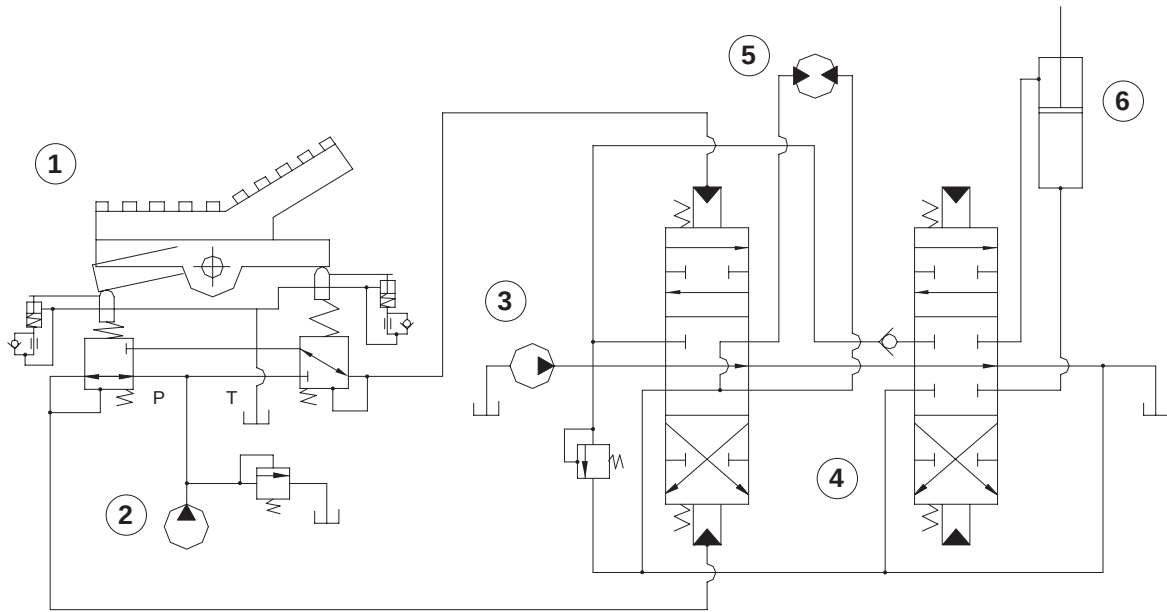
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DX225LL	5001 and Up
DX300LL	5001 and Up
DX300LC	7440 and Up
DX340LC	5980 and Up
DX350LC	5980 and Up
DX380LC	5109 and Up
DX420LC	5327 and Up
DX480LC	5221 and Up
DX520LC	5117 and Up

GENERAL DESCRIPTION

Theory of Operation

The damper valve is divided into two areas of operation. There is the pressure reducing valve (a) and the damper mechanism (b). The following hydraulic circuit is an example of a remotely located control valve.



ARS1810L

Figure 1

Reference Number	Description
1	Remote Control Valve
2	Pilot Pump
3	Main Pump

Reference Number	Description
4	Control Valve
5	Hydraulic Motor
6	Hydraulic Cylinder

Pressure Reducing Valve

1. Neutral Condition

If pedal is in neutral, spool is pushed up by return spring and spring seat. Port (P) is blocked by bottom part of spool and four operating ports (left forward and backward, right forward and backward) are connected to port (T) through inner hole of spool.

2. Half Operation Condition

If pedal is moved, push rod moves down, and they transmit this force through spring seat and control spring to spool. If spool is moved, primary pressure is transmitted through an inner hole of spool to operating port. If lever is stopped in middle position, compressed control spring force and secondary pressure transmitted through hole acts at bottom part of spool, balance is maintained by hydraulic force acted upward, and then this pressure is transmitted to traveling spool of control valve. That is, primary pressure is transmitted to operating port as secondary pressure equivalent to control spring force compressed by spool.

3. Full Operating Condition

If pedal is moved to a maximum, bottom part of push rod presses spool seat to a maximum, and compresses control spring to a maximum. Primary pressure is transmitted through inner hole of spool to operation port, secondary pressure transmitted through spool overcomes control spring force and pushes spool up, but spool is restricted by push rod and does not move any more. That is, when pedal lever is moved to a maximum, control spring does not function, spool is restricted by push rod, and then primary pressure equalizes to secondary pressure.

Operating Theory of Damper Mechanism

1. Operation When Operating Lever
When pushing pedal, pushing force pushing push rod and spool presses cylinder, return spring and hydraulic oil in cylinder is compressed, piston coming down with push rod compresses vibration prevention chamber of lower part, oil of vibration prevention chamber of lower part is flowed through orifice to oil pressure vibration prevention chamber of upper part of low pressure, at this time, ball check valve becomes closing condition because high pressure operates to vibration prevention chamber of lower part.
2. Operation When Operating Lever In Neutral Condition
Climbing restoring force acting on push rod, raises piston in oil pressure prevention chamber and compresses upper oil pressure prevention chamber. This compression operation of upper oil pressure prevention chamber prevents the push rod from quickly rising by restoring spring, and the damping force is generated.

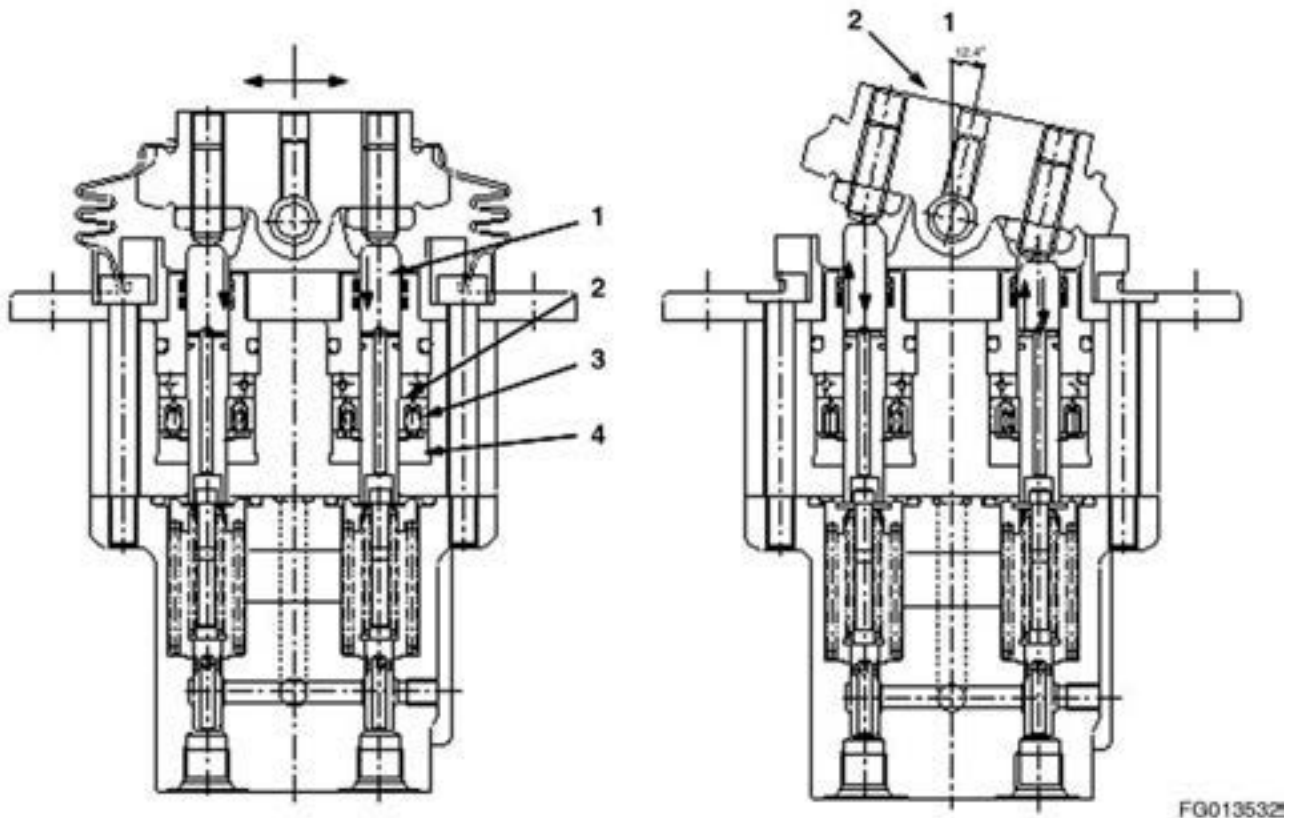


Figure 2

Reference Number	Description
1	Push Rod
2	Orifice
3	Piston
4	Piston Chamber

Reference Number	Description
1	Neutral Position
2	Maximum Operating Angle 12.4"

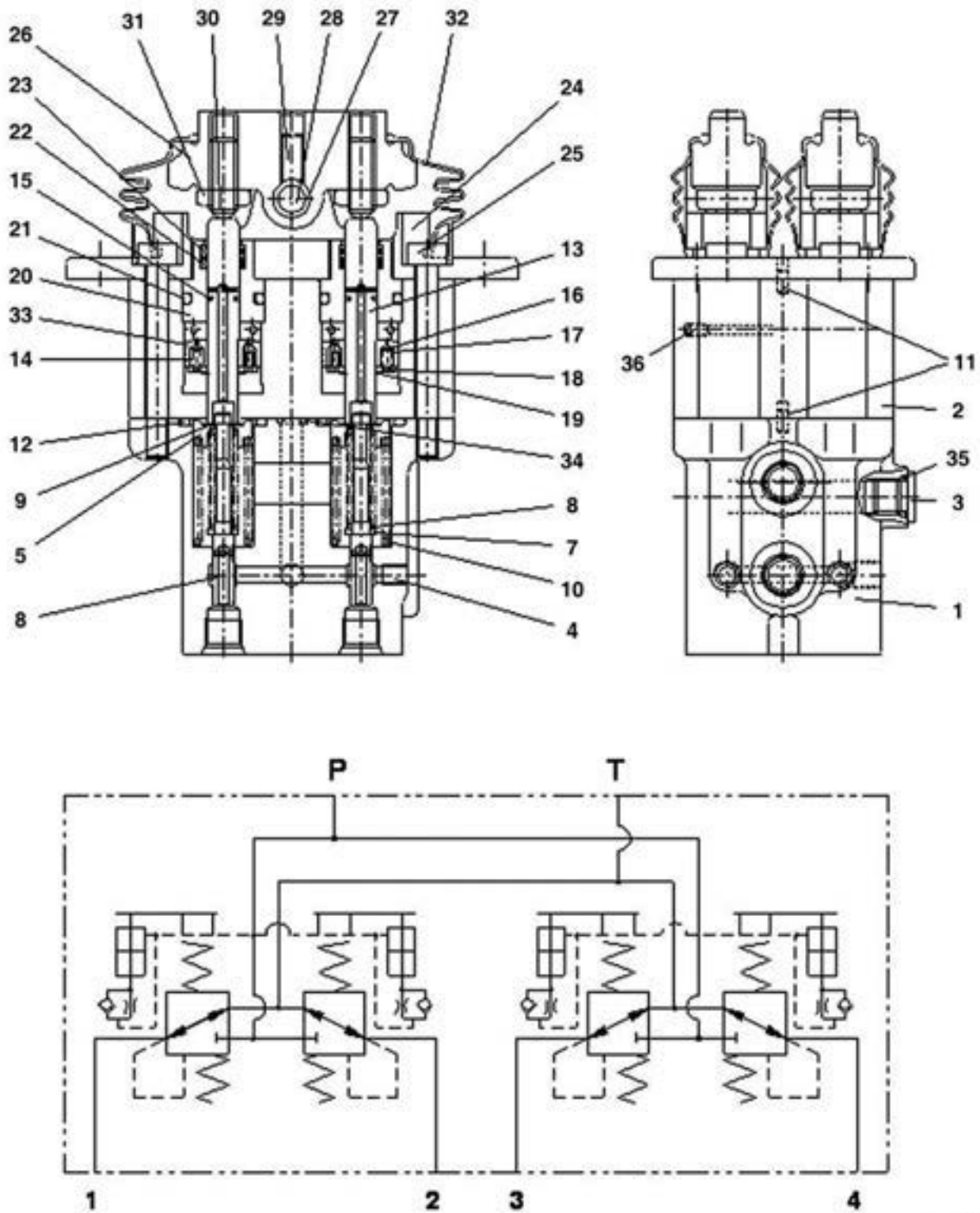
CAUSES OF FAULTS AND MEASURES

At times it may be difficult to pinpoint the source of the problem. The following table lists some of the possible problems, possible causes and remedies. Refer to this table for possible causes and remedies to assist in correcting the sometimes difficult problems.

The table only lists some general problems, possible causes and their remedies. In many cases the problem is not caused by the failure of a single part but, may be the result of a combination of problems from related parts and their components. Possible problems other than the ones list are not being specified but that is not to say that these are the only possible problems that can occur. The technician must diagnose the problem, considering all possible causes and repair the source of the malfunction.

Problem	Possible Cause	Remedy
Secondary pressure will not increase.	Low primary pressure.	Adjust primary pressure.
	Defective secondary pressure select spring.	Replace with new spring.
	Gap between damper spool and casing is abnormally large.	Replace damper spool casing assembly.
	Defective operating parts and components.	Disassemble/reassemble and replace defective parts.
Unstable secondary pressure.	Jamming of interconnected parts.	Repair/replace cause of jamming.
	Unstable tank line pressure.	Install direct line to hydraulic tank.
	Air in hydraulic lines.	Vent air from system.
Abnormally high secondary pressure.	High tank line pressure.	Install direct line to hydraulic tank.
	Jamming of interconnected parts.	Repair/replace cause of jamming.
No dampening.	Air in piston chamber.	Vent air from system.
	Jamming of interconnected parts.	Repair/replace cause of jamming.
	Worn damper springs.	Replace with new parts.
	Worn damper spool and housing.	Replace damper spool and housing assembly.
	Defective/damaged check valve.	Disassemble and examine check valve.
	Worn damper spool orifice.	Replace damper spool.
Damper spool feels heavy.	Defective interconnected components.	Repair/replace defective parts.
	Restricted movement of damper spool.	Repair/replace damaged piston.

Parts List



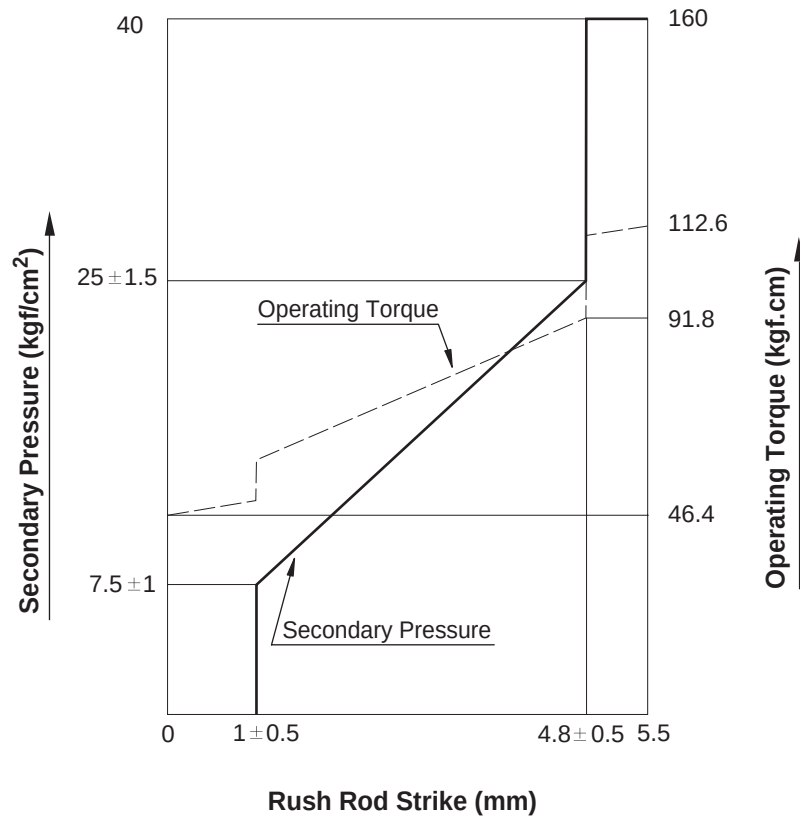
FG013533

Figure 3

Reference Number	Description
1	Body (1)
2	Body (2)
3	Plug
4	Plug
5	Spring Seat
6	Spring
7	Shim
8	Spool
9	Stopper
10	Spring
11	Spring Pin
12	O-ring
13	Push Rod
14	Spring Pin
15	Seal
16	Steel Ball
17	Spring
18	Plate
19	Snap Ring
20	Plug

Reference Number	Description
21	O-ring
22	Rod Seal
23	Dust Seal
24	Cover
25	Hex Socket Head Bolt
26	Cam
27	Bushing
28	Camshaft
29	Set Screw
30	Set Screw
31	Hex Nut
32	Bellows
33	Piston
34	O-ring
35	O-ring
36	Expand
37	Spool Kit
38	Plug Kit
39	Cam Kit

Specification



FG013534

Figure 4

Travel Control Valve	Specification
Type	Pilot Control (With Damper)
Pressure / Stroke	25 kg/cm ² @ 4.8 mm Stroke (356 psi @ 0.1890 in Stroke)
Weight	7.8 kg (17 lb)

Torques

No	Bolt Size	Tool	Tightening Torque
26	M6	PT1/8	88 kg•cm (6 ft lb)
30	M8	27 mm	100 kg•cm (7 ft lb)
32	M10	22 mm	440 kg•cm (32 ft lb)
37	M10	22 mm	440 kg•cm (32 ft lb)

REMOVAL

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 running while performing maintenance, always use extreme caution. Always have one person in the cab at all times. Never leave the cab with 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 a maintenance warning tag on controls.
10. Disconnect negative (-) battery cable leading to frame from battery.
11. Remove cabin under cover by loosening bolts.
12. Tag and disconnect hoses from pedal valve (1, Figure 6). Plug and cap hoses and ports to prevent contamination from entering hydraulic system or component.

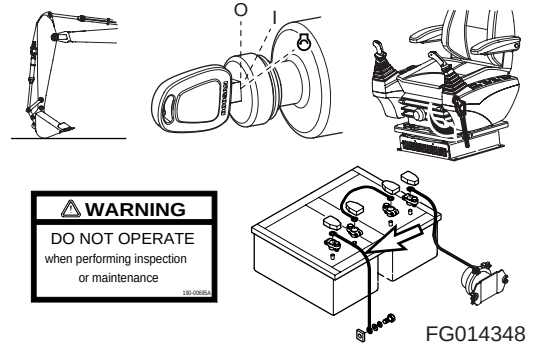


Figure 5

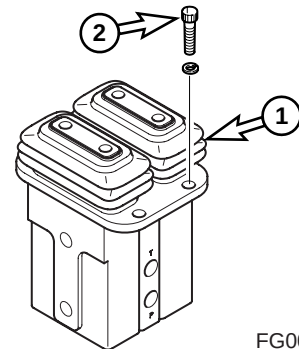


Figure 6

DISASSEMBLY

1. Remove bellows (32).



Figure 7

2. Remove set screw (29) from cam (26).



Figure 8

3. Remove cam shaft (28) from cam (26).



Figure 9

4. Remove hex nut (31) and set screw (30) from cam (27).



Figure 10

5. Remove hex socket head bolt (25) and cover (24) from each body (1 and 2).



Figure 11



Figure 12

6. Remove push rod assembly from body (2).



Figure 13

7. Remove body (2) from body (1).



Figure 14

8. Remove damper spool assembly and spring (10) from body (1).



Figure 15



Figure 16

9. Remove plug (3 and 4) and O-rings (12 and 34).



Figure 17

CLEANING AND INSPECTION (WEAR LIMITS AND TOLERANCES)

For general cleaning and inspection procedures, refer to "General Maintenance Procedures" section.

REASSEMBLY

1. Insert spring (10) into body (1).



Figure 18

2. Assemble in proper order, damper spool (8), shim (7), spring (6), spring seat (5) and stopper (9).



Figure 19

3. Install damper spool assembly into body (1).



Figure 20

4. Assemble body (2) onto body (1).



Figure 21

5. Assemble rod seal (22), dust seal (23) and O-ring (21) into plug (20).



Figure 22



Figure 23

6. Assemble seal (15), piston (33), steel ball (16), plate (18), spring (17) and snap ring (19) into push rod (13).



Figure 24

7. Assemble push rod and plug.



Figure 25

8. Install push rod assembly into body (2).



Figure 26

9. Install bushing (27) in cover (24) using jig.



Figure 27

10. Assemble cover (24) onto each body (1 and 2) and install hex socket head bolt (25) using torque wrench.



Figure 28

11. Install set screws (30) and hex nut (31) into cam (26) and tighten it.

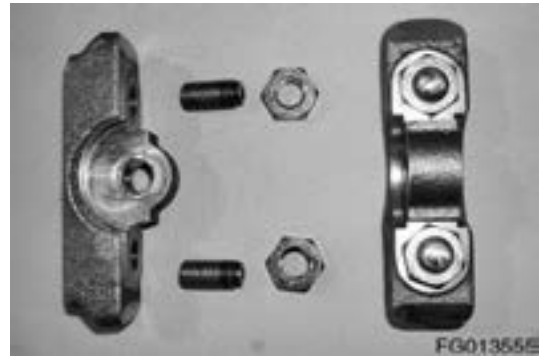


Figure 29



Figure 30

12. Position cam (26) on cover (24) and insert cam shaft (29) using hammer.



Figure 31

13. Install set screw (29) in cam (26) and tighten it using torque wrench.



Figure 32

14. Check cam balance.

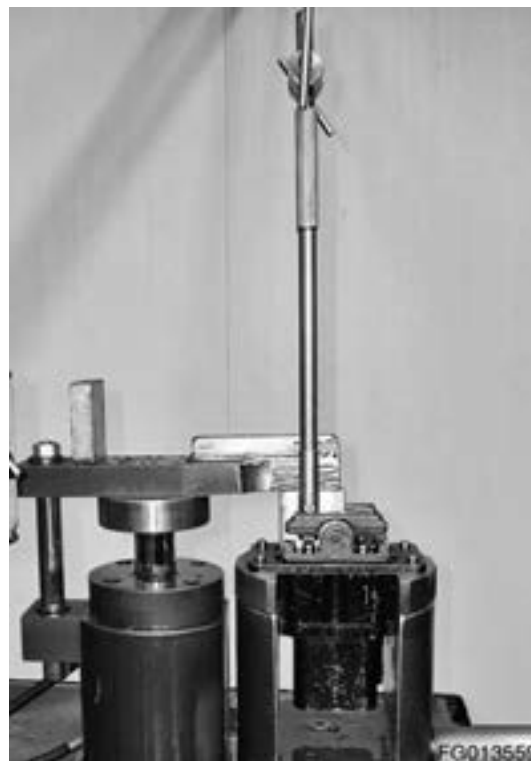


Figure 33

15. Install bellows.



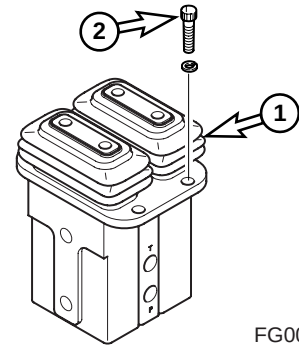
Figure 34



Figure 35

INSTALLATION

1. Position pedal valve (1, Figure 36) on cabin floor plate and install four bolts and washers (2).



FG003016

Figure 36

2. Install pedal brackets (3) and levers (4, Figure 37) on pedal valve and install four bolts and washers (2).
3. Install rubber boots (1, Figure 37).

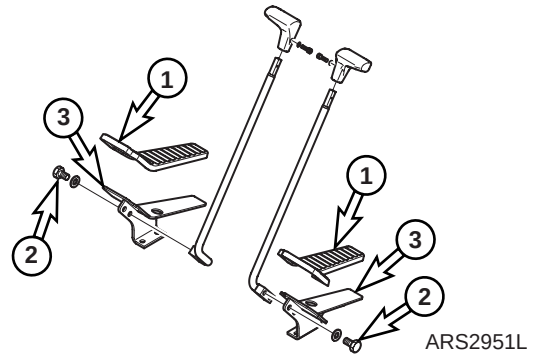
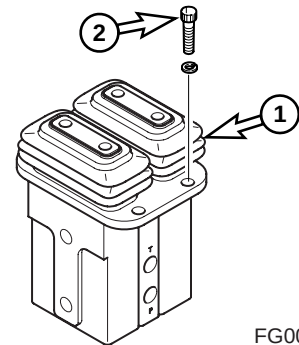


Figure 37

4. Connect hoses as tagged during removal to pedal valve (1, Figure 38).
5. Install cabin under cover by tightening bolts.



FG003016

Figure 38

START-UP PROCEDURES

1. Start engine and set throttle at "LOW IDLE."
2. Set safety lever on "UNLOCK" position.

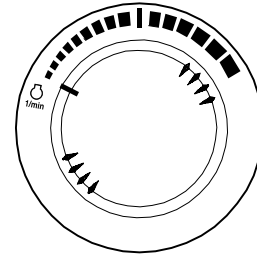


Figure 39

HAOB290L

3. Slowly push and pull both travel lever about five times without a load to vent air from pilot lines.

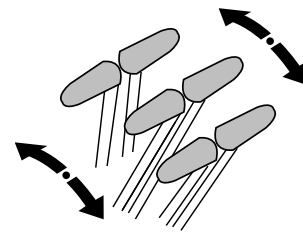


Figure 40

HAOB903L

Solenoid Valve Assembly

Edition 1

MEMO

Table of Contents

Solenoid Valve Assembly

Safety Precautions	5
Applicable Models	5
Parts List.....	6
Functions of 5-Solenoid Valve Assembly Package	7
Functions of Solenoid Valve Assembly Package	7
Assembly Diagram and Tools Required	9
Solenoid Valve Diagram.....	11
Check Points and Solutions for Problems	12

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.

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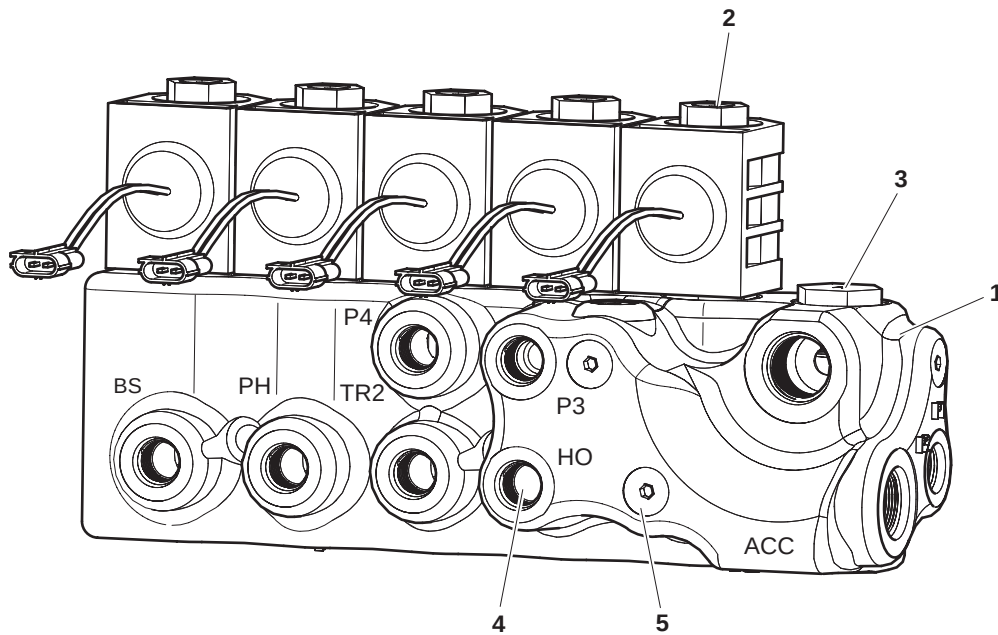
APPLICABLE MODELS

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

MODEL	SERIAL NUMBER RANGE
DX140LCR	5001 and Up

PARTS LIST

Components used for the solenoid valve package are the same as in the parts list below.



FG015005

Figure 1

Reference Number	Description	Sizes	Quantity	Remarks
1	Block Body	95x110x200	1	1-A1073-05-0
2	Solenoid valve	TF-S3A-00	5	C1, C2, C3, C4, C5
3	Check Valve	FD-DCP-0-A	1	C6
4	Plug	PF 1/4"	3	P4, P5, H0
5	Plug	PT 1/8"	9	

FUNCTIONS OF 5-SOLENOID VALVE ASSEMBLY PACKAGE

Functions of Solenoid Valve Assembly Package

This solenoid valve assembly package have the following functions.

1. Pilot cut-off
2. Breaker pressure supply
3. High travel speed
4. Main pressure increase
5. Work modes control - Swing Priority

Functions and Operations of Solenoid Valves

Reference Number	Function	Operations	Remarks
C1	Pilot cut-off	Provides pressure and oil coming from the pilot pump for the pilot pressure supply solenoid valve to drive each work system.	
C2	Breaker operation	Supplies pilot pressure for the breaker valve assembly and the breaker pressure supply solenoid valve.	
C3	High travel speed	Sets low travel speed and high travel speed, of shifts speed between both depending on the state of the solenoid valve operation or a signal detected in the e-EPOS controller.	
C4	Main pressure increase	Increases the pressure set for the main relief valve temporally to increase the excavation power.	
C5	Work modes control	Operating the C5 solenoid valve starts the Swing Priority valve of the main control valve to improve swing operation.	

Detailed Functions and Operations of Solenoid Valves

1. Pilot Cut-Off

It provides pressure and oil coming from the pilot pump for breaker solenoid valve (C2), high travel speed solenoid valve (C3), main pressure increase solenoid valve (C4), and the work modes control solenoid valve (C5). Push down the Cut-Off lever located on the left side of the driver's seat, and the electrical signal of the limit switch starts the pilot cut-off valve to supply pressure and oil to each pilot pressure supply solenoid valve.

2. Breaker pressure supply

Pressing the breaker switch on the joystick operates the breaker solenoid valve (C2) to supply pilot pressure to the option valve of the main control valve. The pressure switches the spool of the option valve, which transfers pressure and oil from the main pump to the breaker system for excavation.

3. High travel speed control

When the automatic travel switch is "Off", the travel speed switches to "0" (low speed); when the switch turned to the 1st place, the travel speed switches to "I" (high speed); when the switch turned to the 2nd place, the travel speed switches to "II", automatically. In this case, the high travel speed control shows "Off" when the automatic travel switch is "Off", "On" when it is in the 1st place, and "On/Off" when it is in the 2nd place. Specifically speaking, turning the automatic travel switch to the 2nd place, the e-EPOS controller detects the discharge pressure from the main pump, and automatically turns the high travel speed control "On" or "Off" depending on if the travel load is high or low to switch the travel speed to speed 1 or 2. The travel load is detected by 2 pressure sensors located on the discharge line of the front and rear pumps. If the load is high (pressure about $300 \text{ kgf}\cdot\text{cm}^2$), the solenoid valve turns "Off" for the travel at low; If the load is low (pressure about $160 \text{ kgf}\cdot\text{cm}^2$), the solenoid valve turns "On" for the travel at high. If the engine control dial is set equal and below 1400 RPM, however, the solenoid valve always turns "On" for the travel at low, though the automatic travel switch is set to the automatic travel (2nd place).

4. Boost main pressure

It increases the pressure of the main relief valve temporarily to increase the excavation power. Pressing the power boost switch on the work lever sends a signal of the e-EPOS controller to start the pressure increase solenoid valve. Then, as it turns "On", the pressure of the main relief valve increases about $330 \text{ kgf}\cdot\text{cm}^2$ to $350 \text{ kgf}\cdot\text{cm}^2$, which in turn increases the excavation power.

5. Work modes control

A work mode can be chosen as either Excavation or Trenching mode using a Trenching mode switch on the operation panel.

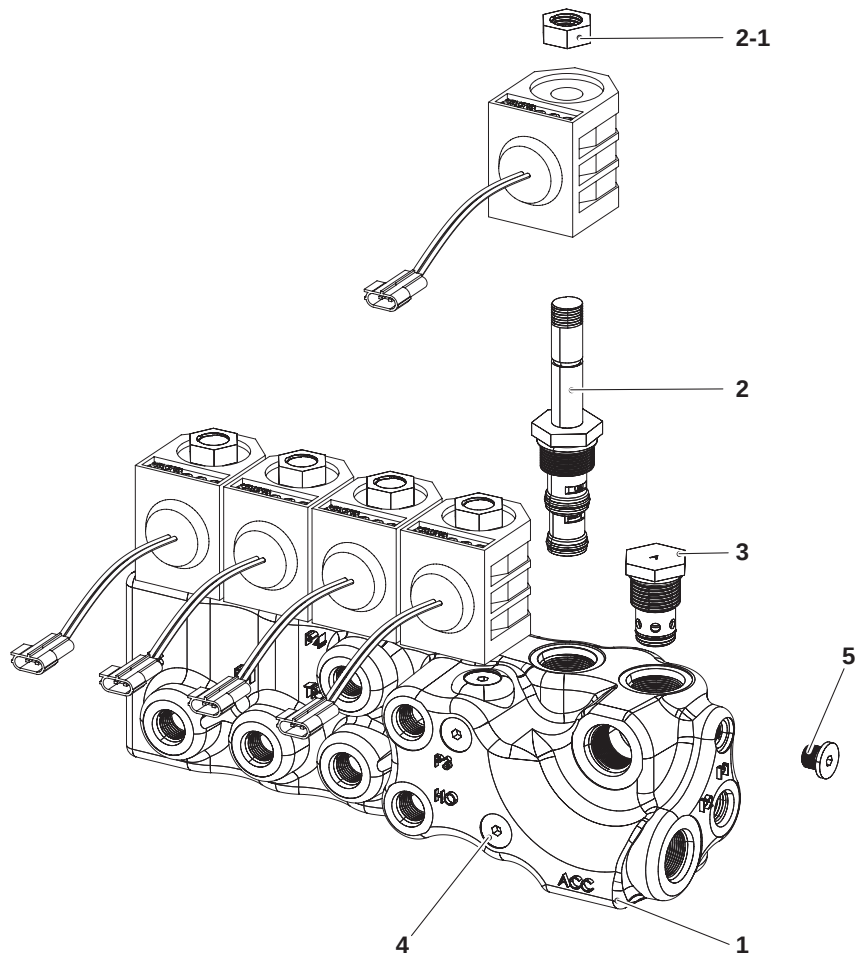
Turning on the Start-on switch, Excavation is automatically accepted as the work mode and the Swing Priority solenoid valve turns "Off".

This Excavation mode is used for ordinary excavation work, loading, and fast levelling work.

Choosing the Trenching mode on the operation panel the Swing Priority solenoid valve for the control valve turns "On" and starts to work, reducing the oil lines to booms and arms to increase the swing capacity.

Assembly Diagram and Tools Required

Table 1 shows assembly torques recommended for components of the solenoid valve package. Designated tools and torques should be followed.



FG015154

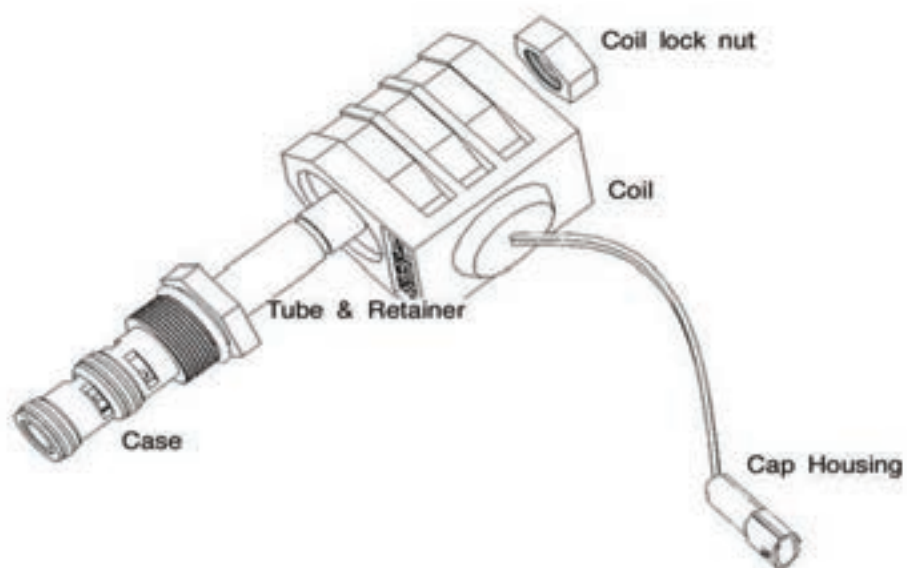
Figure 2

Reference Number	Components	Screw Sizes	Torques (kg/cm)	Tools
2	Solenoid valve	UNF7/8 - 14"	200 ± 25	Hex torque wrench/1", socket
2-1	Coil Lock Nut	UNF1/2 -20"	60 ± 2	Hex torque wrench/19 mm, socket
3	Check Valve	UNF7/8 - 14"	400 ± 2	Hex torque wrench/1", socket
4	PT 1/4" Plug	PF 1/4 19"	250 ± 25	Torque wrench/ 19 mm, socket
5	PT 1/8" Plug Bolt	PT 1/8 28"	280	Torque wrench/ 5 mm, wrench socket

Cautions During Disassembly and Reassembly

1. Wipe dust and dirt in the area where disassembly and reassembly will be performed.
2. For disassembly and reassembly, standard torques and tools stated in Table in should be used.
3. The directions of disassembly and reassembly are same as the "Disassembly Direction" and "Reassembly Direction" as shown in Figure 2.
4. Disassembly and reassembly of the solenoid valve
 - A. Remove the coil lock nut (2-1) by turning it in the Disassembly Direction.
 - Take care not to damage the valve tube and the retainer when disassembling the coil lock nut.
 - If the valve tube or the retainer is damaged (bent or deformed), the solenoid valve may not operate.
 - B. Grip the coil (2-2) with a hand and pull it out.
 - C. Remove the solenoid valve (2) by turning it in the Disassembly Direction.
 - D. Check disassembled components, and reassemble them in the reverse order of the disassembly.
 - E. Torque should not be excessive when assembling the solenoid valve and coil.
 - Excessive torque may damage the solenoid valve.
5. Take care not allow any contaminant to flow into the package valve during reassembly after disassembly and check procedures.
6. Every component should be washed out before reassembly.

Solenoid Valve Diagram



FG004537

Figure 3

Check Points and Solutions for Problems

Symptoms	Causes	How to Check	Solutions
Malfunction of solenoid valve	Foreign substance, dirt, dust in solenoid valve	Disassemble the solenoid valve concerned and check if there are any contaminant such as foreign substance and sludge between the case and the spool.	Remove contaminant, wash, and assemble compartments.
	Tube or retainer of solenoid valve damaged	Disassemble the solenoid valve concerned and check if there is any deformation (bending or reduction) in the tube or the retainer.	Replace the solenoid valve.
	Coil broken, short, or burnt	Disassemble the solenoid valve concerned and check the resistance of the coil. Spec : 26.7Ω @ 20°C Disconnection: ∞ Short: Low or excessive resistance Disassemble the solenoid valve concerned and check the outside of the coil to see if its molding is burnt and melted.	Replace the coil.
	Connector terminal earth defect	Check if the cap housing (where coil lead is attached) and the housing (across its length) are earthed properly.	Replace housing or terminal concerned.
Pilot pressure fails to generate	Pilot pressure	Remove the plug of the "P5" port, set up a pressure gage, and check the pilot pressure discharged from the pilot pump when operating the cut-off (C1) valve.	Refer to Causes and How to Check of the solenoid valve above.
	Pilot relief valve	Check if the relief valve installed in the pilot line operates properly. Check if pressure is bypassed due to the presence of foreign substance.	Remove foreign substance, reassemble, and replace the relief valve.
	Pilot pump	Check if the pilot pump works properly.	Replace the pilot pump.
	Pilot filter	Check if the mesh screen of the pilot filter is contaminated by foreign substance.	Wash, reassemble, and replace the filter
Poor Actuator Performance	Pilot system	Check any defect of the pilot system considering findings from "Pilot pressure fails to generate" category.	Treat defect(s) accordingly.
	Solenoid valve	Set up a pressure gage at each outlet port of the solenoid valve concerned (HO, TR2, PH, and SP ports) and check the pressure value discharged from the pilot pump when operating the solenoid valve.	Refer to causes and how to check of the solenoid valve above.
	Main control valve	Check if main control valve of each component works properly.	Treat according to findings.
	Other components	Check if each component works properly.	Treat according to findings.

Checking of Pilot Pressure for Defects

Port where pressure gage set up	Screw size	Remark
P1, P3, P4, P5, P6, TR2, PH, HO, SP	PF1/4" O ring BOSS	Operate the solenoid valve concerned (ON).

Breaker EPPR Valve (Opt)

Edition 1

MEMO

Table of Contents

Breaker EPPR Valve (Opt)

Safety Precautions	5
Applicable Models	5
Structure	6
Numbers and Names of Parts	6
Functions and Operation	7
Cautions for Operation	7
Maintenance Instructions.....	8
Maintenance	8
Disassembly	9
Assembly	10

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX140W	5001 and Up
DX160W	5001 and Up
DX180LC	5001 and Up
DX210W	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	5001 and Up
DX300LC	5001 and Up
DX340LC	5001 and Up
DX420LC	5001 and Up
DX480LC	5001 and Up
DX520LC	5001 and Up

STRUCTURE

Numbers and Names of Parts

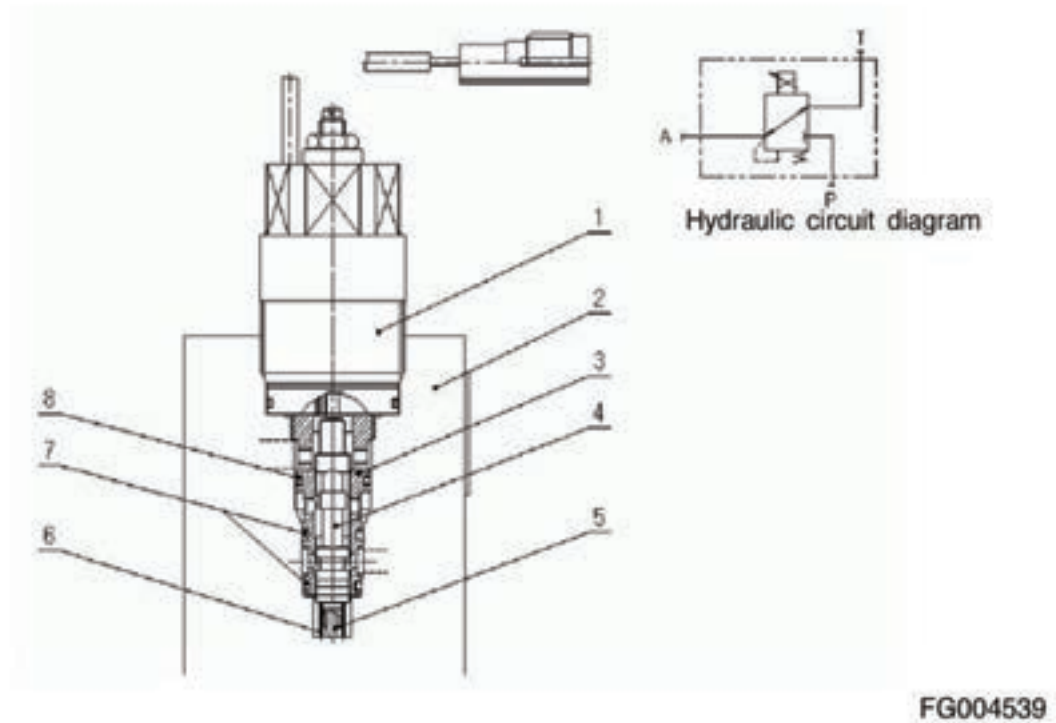


Figure 4

Reference Number	Description
1	Solenoid
2	Valve casing
3	Sleeve
4	Spool

Reference Number	Description
5	Pin
6	Spring
7	O-ring
8	O-ring

FUNCTIONS AND OPERATION

The proportional reducing valve shall be adjusted that its reduced pressure is proportional to the current of the solenoid.

The proportional solenoid shall be changed with pressure proportional to the electrical input signal. Flow increases corresponding to the force of the solenoid. As the solenoid (1) receives pressure, the spool (4) opens and oil flows from P to A. Pressure of the port A influences the top surface of the pin (5). When it reaches the valve set of the solenoid, the spool starts to move and oil flow from P to A decreases.

CAUTIONS FOR OPERATION

1. Wiring of the solenoid
 - The solenoid has no polarity.
2. Input electricity
 - Do not supply electric current more than 0.7A to the solenoid coil.
3. Adjustment screw
 - It was adjusted to the standard.
 - The pressure of the port A increases when turning the adjustment screw clockwise.
4. Symptoms and Solutions of Problems

Symptoms	Causes	Solutions
Pressure does not increase nor change	Poor wiring	Fix wiring
	Solenoid damaged	Replace the solenoid
	Piston or spool stuck	Fix, or clean and grind
	Amplifier damaged	Repair or replace the amplifier
Unnatural pressure change	Poor opening space Too wide Too narrow	Readjust
	Piston or spool stuck	Fix, or clean and grind
Unnatural pressure	Poor opening space Too wide Too narrow	Readjust
Slow reaction	Low pressure supplied	Readjust

MAINTENANCE INSTRUCTIONS

Maintenance

Bolt Tightening Torque

Table 1 shows torques used to tighten bolts of the motor.

Make sure that assembly work should be done according to Table 1.

Bolt Sizes	Names	Used Torques (kgf.cm)
M 35	Hex bolt	450 ± 50
M 10	Hex bolt	200 ± 20
NPTF 1/16	Plug	90

Tools Used for Disassembly and Assembly

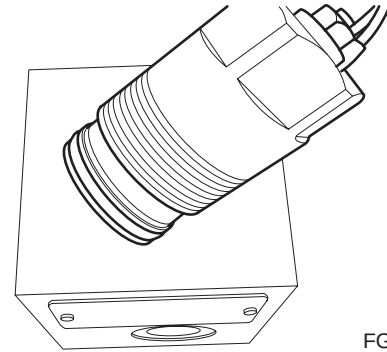
Table 2 shows tools necessary for disassembly and assembly.

As bolts and plugs to be used depend on types, they should be checked accordingly in advance.

For	Sizes	Used Torques	Used Tools
Solenoid	M 35	450 ± 50	Spanner
Sleeve	M 10	200 ± 20	Hex bar spanner
NPTF plug	1/16	90	Hex bar spanner

Disassembly

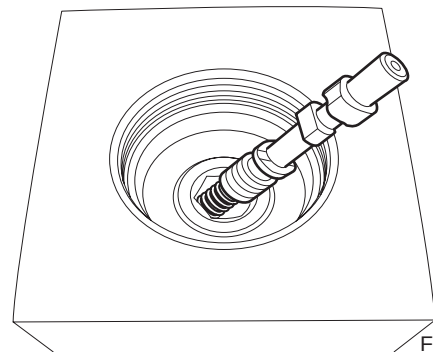
1. Determine a place for disassembly.
 - It should be clean.
 - Lay a rubber board or a cloth on the table and take care not to damage parts.
2. Remove dust and rust of the proportional pressure reducing valve with cleansing oil.
3. Disassemble the solenoid
 - Take care not to damage O-rings of the solenoid.



FG003690

Figure 5

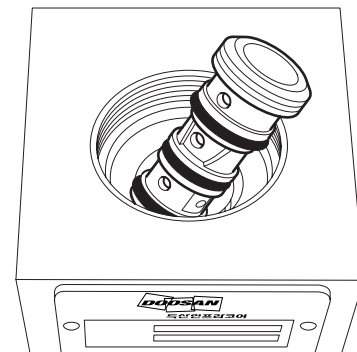
4. Disassemble the spool, the spring, and the pin.



FG003691

Figure 6

5. Disassemble the sleeve.
 - Take care not to damage O-rings of the sleeve.



FG003692

Figure 7

Assembly

Assembly shall be done in the reverse order of disassembly described above, taking into consideration the following points.

- Parts damaged during disassembly should be repaired without fail and spare parts should be prepared in advance.
- Every part should be cleaned enough with cleaning oil and dried with compressed air before starting assembly.
- Sliding parts and bearings should be applied clean active oil before their assembly.
- Basically, parts of the O-ring and the oil seal should be replaced.
- Use a torque wrench to tighten or engage bolts and plugs in accordance with reference torques as described in Maintenance Guide.

1. Assemble the sleeve.

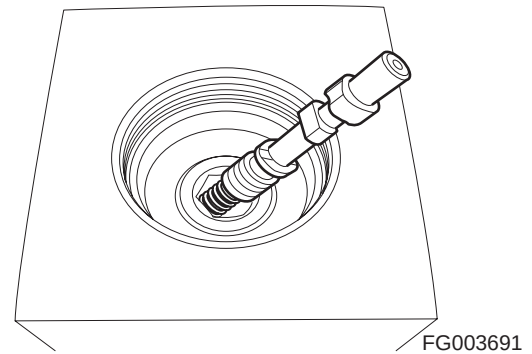


Figure 8

- Take care not to damage O-rings of the sleeve.



Figure 9

2. Assemble the spool, the spring, and the pin.

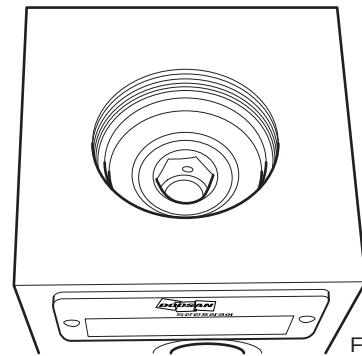


Figure 10

FG003693

- The spring and the pin should not be fell off.



Figure 11

FG003696

3. Assemble the solenoid correctly.

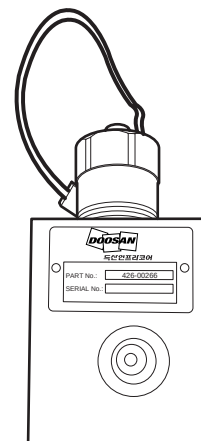
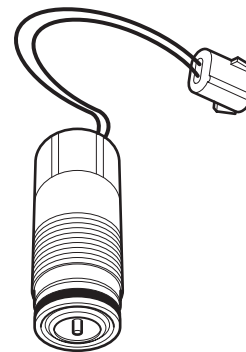


Figure 12

FG003697

- Take care not to damage O-rings of the solenoid.



FG003698

Figure 13

Hydraulic Schematic (DX140LCR)

Edition 1

MEMO

Table of Contents

Hydraulic Schematic (DX140LCR)

Safety Precautions	5
Applicable Models	5
DX140LCR	7

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
DX140LCR	5001 and Up

DX140LCR

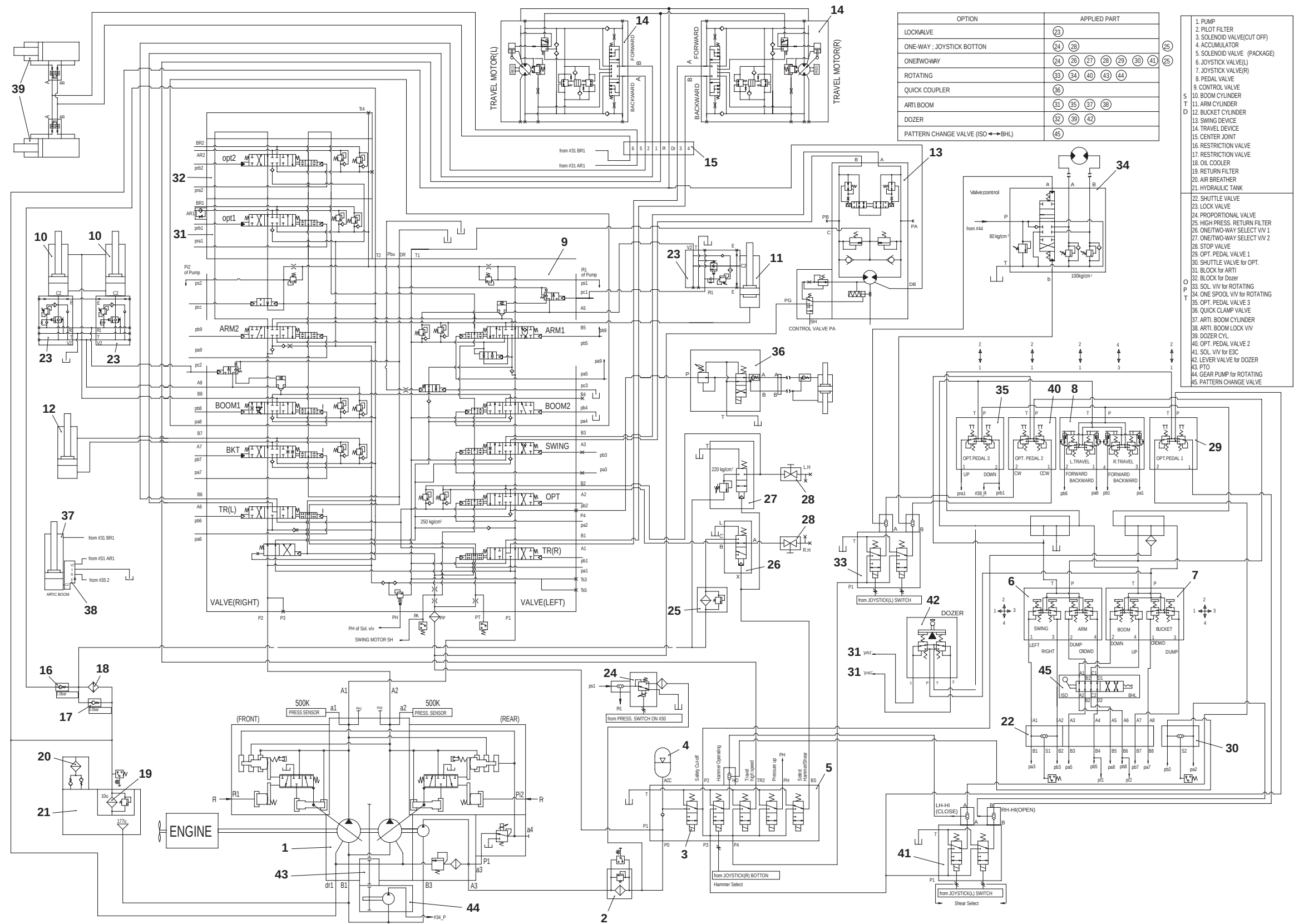


Figure 1

FG019261

Electrical System

Electrical System

Edition 1

MEMO

Table of Contents

Electrical System

Safety Precautions	6
Applicable Models	6
Introduction	7
Electrical Supply System	8
Engine Starting Circuit	10
Engine Preheating System	14
Engine Stop	16
Charging System	18
Monitoring System	19
Operation	24
Warning and Indicator Lights	26
Initial Operation	29
Mode Selector Switch	29
Graphic Information Area Display	30
Main Menu	32
Special Menu	36
Electronic Hydraulic Control System (e-EPOS) ..	54
Power Mode Control	56
Power / Economy Mode Control - Circuit Diagram	62
Engine Control System	64
Engine Control Dial	65
Engine Control Circuit Diagram	66
Automatic Deceleration Control (Auto Idle Control)	68
Engine Overheat Protection System	70
Power Boost Mode	72
Automatic Travel Speed Control	76
Self-diagnostic Function	79

Air Conditioner System	81
Troubleshooting	94
Weight of R134a Gas Used In Machines	96
Refrigerant System Repairs	97
Wiper System	105
Lighting System	108
Overload Warning Device.....	110
Audio Controller	111

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
DX140LCR	5001 and Up

INTRODUCTION

The electrical system for this equipment is DC 24 volts. The rated voltage for all electric components is 24 volts with the exception of the stereo and the air-conditioning control actuator. The system contains two 12 volt batteries connected in series 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 electrical system are listed in the following chart.

Electric 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 a battery, battery relay, starter switch, circuit breaker, fusible link and fuse box.

The negative terminal of the battery is grounded to the vehicle body.

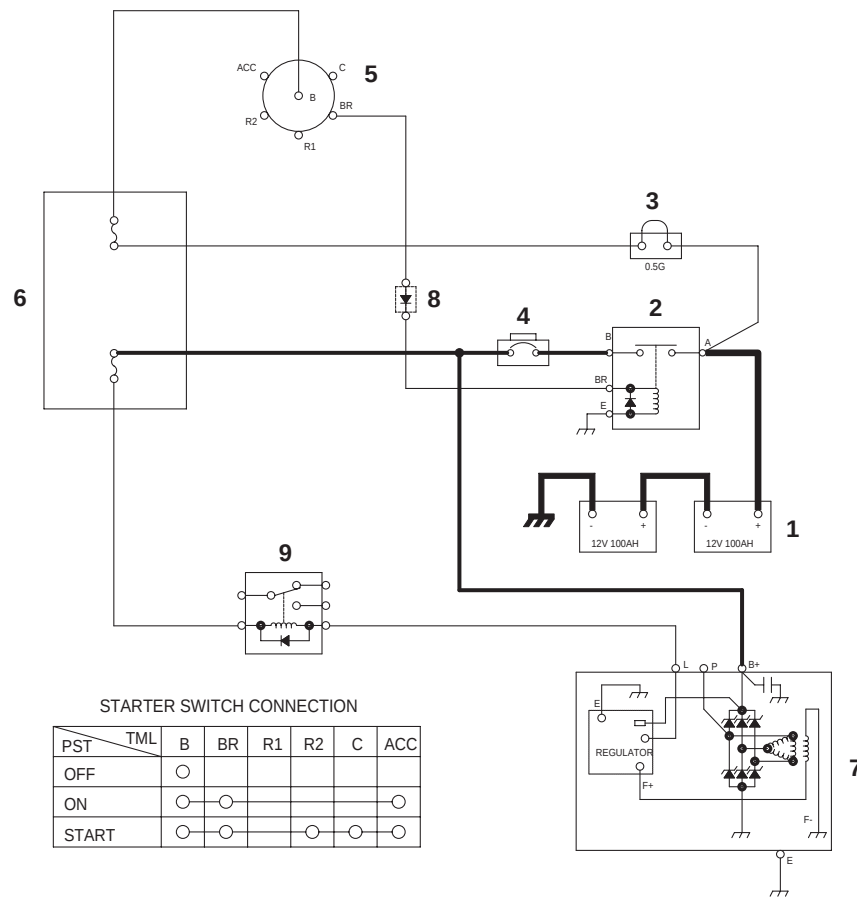
Even when the starter switch (5) is in the "OFF" position, electric current is supplied to the following components through battery (1) → fusible link (3) → fuse box (6).

1. Terminal "1" of DC-DC converter (for memory backup of stereo)
2. Terminal "B" of starter switch
3. Hour meter
4. Engine controller
5. Fuel feeder pump switch
6. Terminal "6" of wiper motor
7. Terminal "13" of wiper controller
8. Terminal "CN6-11" of instrument panel
9. Terminal "CN8-22" of air conditioner panel
10. Cabin light

When the starter switch (5) is in the "ON or START" positions, the current flows from the battery (1) → fusible link (3) → fuse box (6) → "B" terminal of starter switch (5) → "BR" terminal of starter switch (5) → "BR" terminal of battery relay (2) which activates the coil of the battery relay and the electric supply system is energized.

When the battery relay's contacts are connected, all electric devices can be operated.

While the engine is not running, the electric power for all electric devices are supplied by the battery. Once the engine is started the power is supplied from the alternator (7).



FG015054

Figure 1 ELECTRIC POWER CIRCUIT DIAGRAM

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

Reference Number	Description
6	Fuse Box
7	Alternator
8	Diode
9	Relay

ENGINE STARTING CIRCUIT

Start Operation

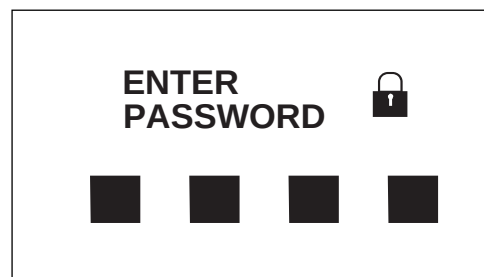
When the starter switch is turned to the "START" position, the "S" and "E" terminals of the starter controller (7) are connected. At this time the contacts in the starter relay (8) are closed by the current flow from the battery (1) → fusible link (3) → fuse box (6) → "B" terminal of starter switch (5) → "C" terminal of starter switch (5) → "30" terminal of starter relay (12) - "87a" terminal → "C" terminal of starter relay (8) - "D" terminal → "S" terminal of starter controller (7) - "E" terminal → ground.

When the contact point "B" and "PP" of starter relay (8) are connected, the pinion gear of the starter (9) 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 the battery relay (2) → "B" terminal of the battery relay (2, Figure 3) → "B" terminal of the starter (9). The starter motor is rotated and the engine is started.

If the instrument panel has the password function activated , input number should match the set number, otherwise the start circuit closes and the engine does not start.

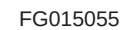
NOTE: *If the security system is "LOCKED," a four-digit password will be required to start the engine. If the system is "UNLOCKED," no password will be required and this display screen will not appear.*

In the event the security system is locked, current flows from battery (1) → fusible link (3) → fuse box (6) → "B" terminal of starter switch (5) → "ACC" terminal of starter switch (5) → "86" terminal of starter relay (12) → "85" terminal of starter relay (12) → "CN1-15" terminal of e-EPOS (13) → ground. This current flow causes the coil in starter relay (12) to be activated, opening contacts at "87a" terminal. This prevents starter relay (8) from functioning.



FG013717

Figure 2



FG015055

Reference Number	Description
8	Starter Relay
9	Starter
10	Alternator
11	Diode
12	Starter Relay 2
13	e-EPOS Controller

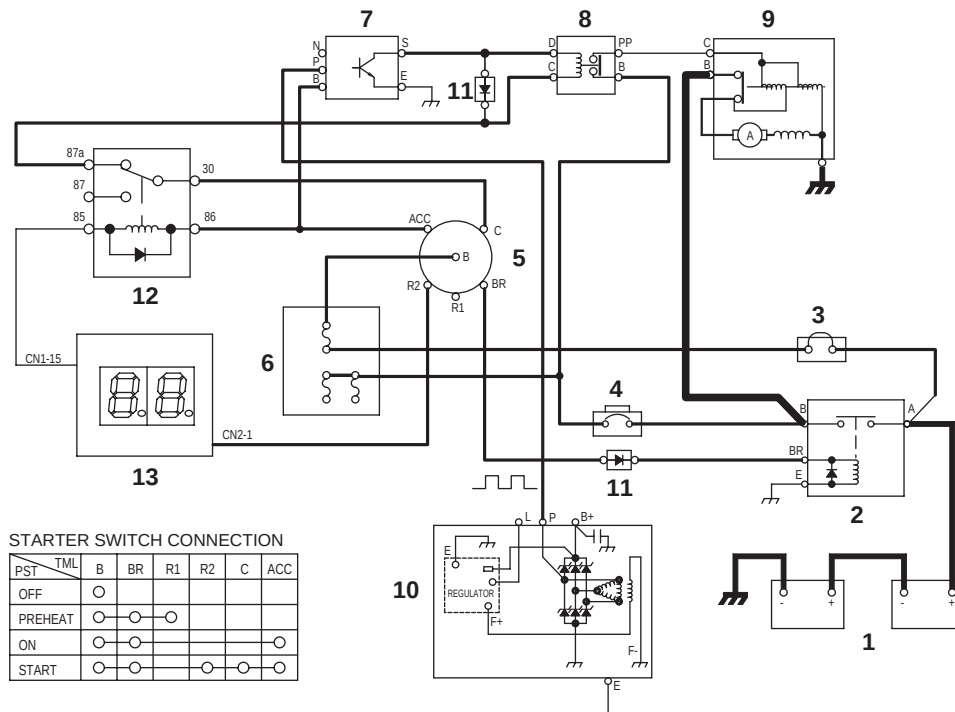
After Start

Once the engine has been started, the belt driven alternator (10) generates a current.

The output generated by the alternator (10) is a square wave pulse voltage through the "P" terminal and the frequency of the pulse voltage is proportional to the rotation of the alternator.

The starter controller (7) monitors the frequency of the output current. Once the frequency is equivalent to 500 rpm, it is sensed and the connection between "S" and "E" terminals and the connection between "B" and "PP" terminals are opened. As a result the rotation of the starter (9) is stopped. Once the engine is running, the starter (9) will not operate even if the starter switch (5) is moved to the start position, preventing possible damage to the starter.

Operation of the Start Circuit (2) - Immediately After Start



FG015056

Figure 4 OPERATION OF START CIRCUIT (2) - IMMEDIATELY AFTER START

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Starter Switch
6	Fuse Box
7	Starter Controller

Reference Number	Description
8	Starter Relay
9	Starter
10	Alternator
11	Diode
12	Starter Relay 2
13	e-EPOS Controller

ENGINE PREHEATING SYSTEM

An air heater (8) is installed in the intake manifold of the engine. When the starter switch (5) is turned "ON," the current flows from the battery (1) → fusible link (3) → fuse box (6) → "B" terminal of starter switch (5) → "BR" terminal of starter switch (5) → "1-39" terminal of engine controller (12), causing current to flow through "1-16" terminal of engine controller (12) → "C and D" terminals of preheat relay (7) → "1-04" terminals of engine controller (12) → ground.

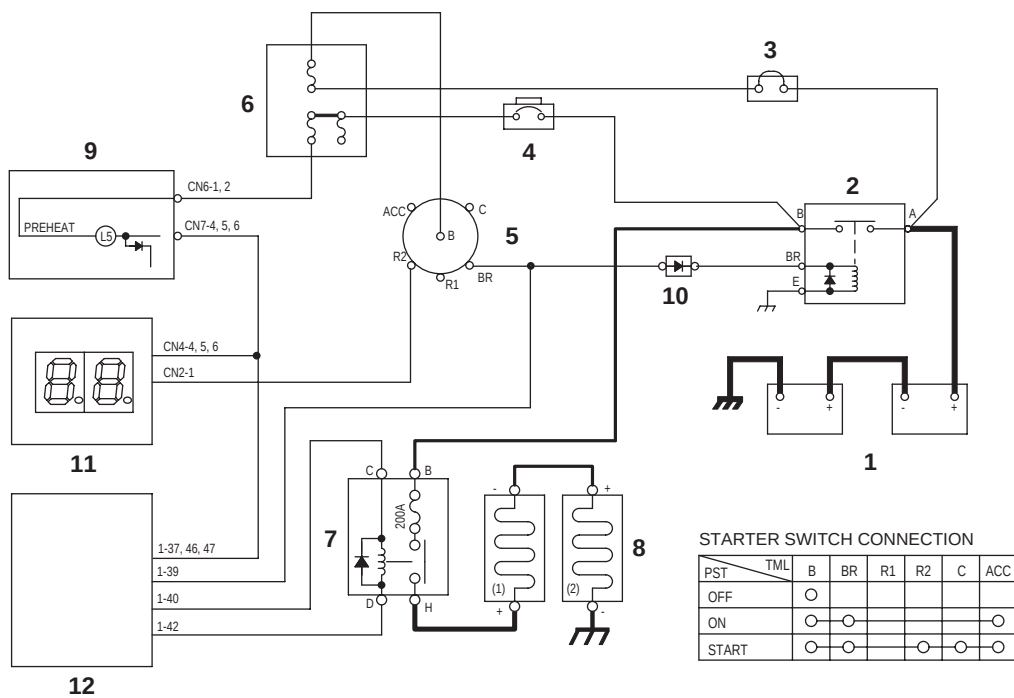
This current flow causes the coil in preheat relay (7) to be activated, closing contacts.

When the contacts of the preheat relay (7) are closed, the heating coils of the air heating device (8) are heated by current flowing from the battery (1) → battery relay (2) → preheat relay (7) → air heater (8) → ground.

The duration of the heating cycle depends on the temperature of engine coolant. The preheat indicator light in the instrument panel (9) will turn "ON" during preheating cycle.

The preheat relay (7) is controlled by the engine controller (12) and operates only at temperatures of 10°C (50°F) and below.

The longer the preheating period, the lower the temperature of coolant is.



FG015057

Figure 5 ENGINE PREHEAT CIRCUIT

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Starter Switch
6	Fuse Box

Reference Number	Description
7	Preheat Relay
8	Air Heater
9	Preheat Indicator Light
10	Diode
11	e-EPOS Controller
12	Engine Controller

ENGINE STOP

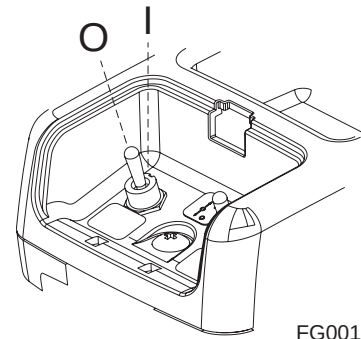
When starter switch (5) is turned "ON" the engine controller (8) is activated. The engine controller monitors and controls the engine including the injector solenoid (9). It controls the fuel deliver rate and the injection timing for each cylinder.

NOTE: *There is an individual injector solenoid (9) for each of the six cylinders. Only one solenoid is shown in Figure 7.*

When starter switch (5) is turned "OFF," the engine controller stops supplying power to the injector solenoid (9). This stops fuel from being injected into the engine cylinder, thus stopping the engine.

In the event that the engine can be shut down using the starter switch (5), an emergency stop switch (10) is provided to shut down engine. To activate the emergency stop switch, move it to the "I" (EMERGENCY STOP) position.

The emergency stop switch (10) is in its "O" (OFF) position during normal operation. The switch must be moved and held in the "I" (EMERGENCY STOP) position until the engine stops. When released it will automatically move back to the "O" (OFF) position.



FG001344

Figure 6 ENGINE EMERGENCY STOP SWITCH

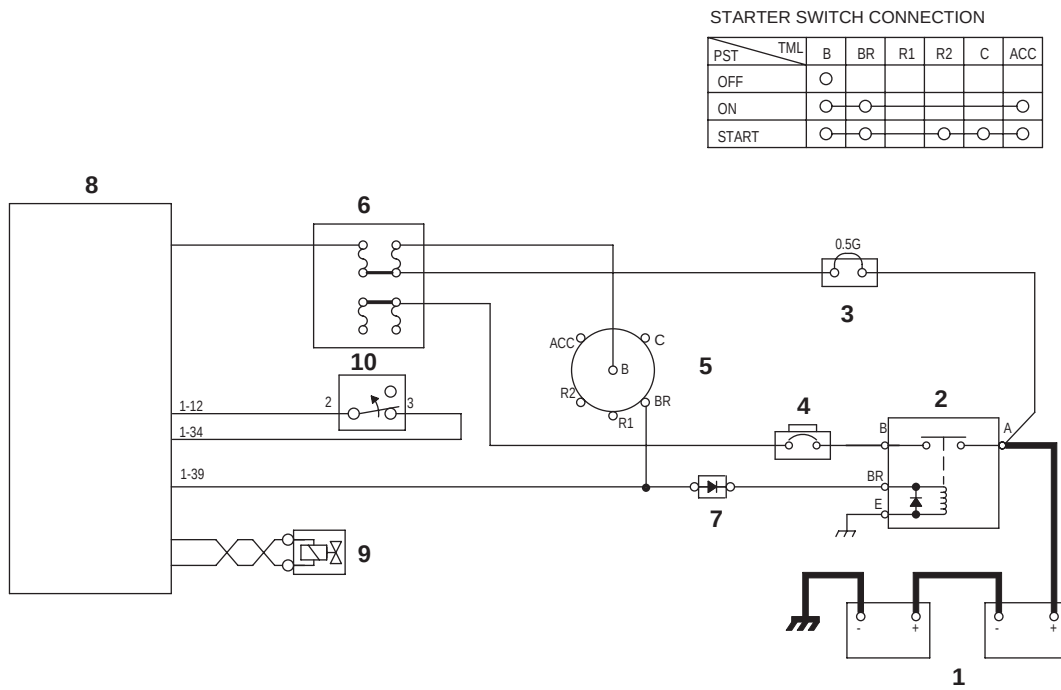


Figure 7 ENGINE STOP CIRCUIT

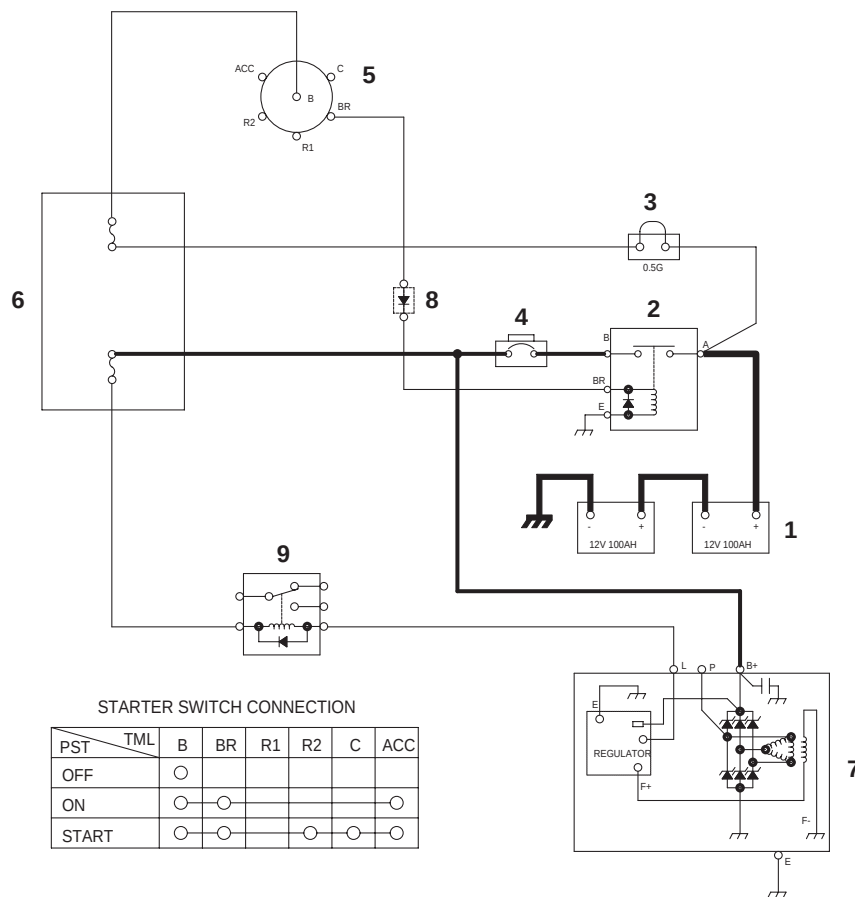
Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Circuit Breaker
5	Starter Switch

Reference Number	Description
6	Fuse Box
7	Diode
8	Engine Controller
9	Injector Solenoid
10	Emergency Stop Switch

CHARGING SYSTEM

When the starter switch (5) is turned to the "ON" position, an initial excited current flows to the field coil of the alternator (7) through the battery relay (2) and circuit breaker (4). When the engine is started from this condition the alternator (7) starts charging. The current flows from the "B(B+)" terminal of alternator (7) → circuit breaker (4) → battery relay (2) → battery (1).

The alternator also supplies electric current to other electrical components. When the alternator (7) starts to operate, a current flows from the "B+" terminal of alternator to fuse box (6), so other electrical components can be operated.



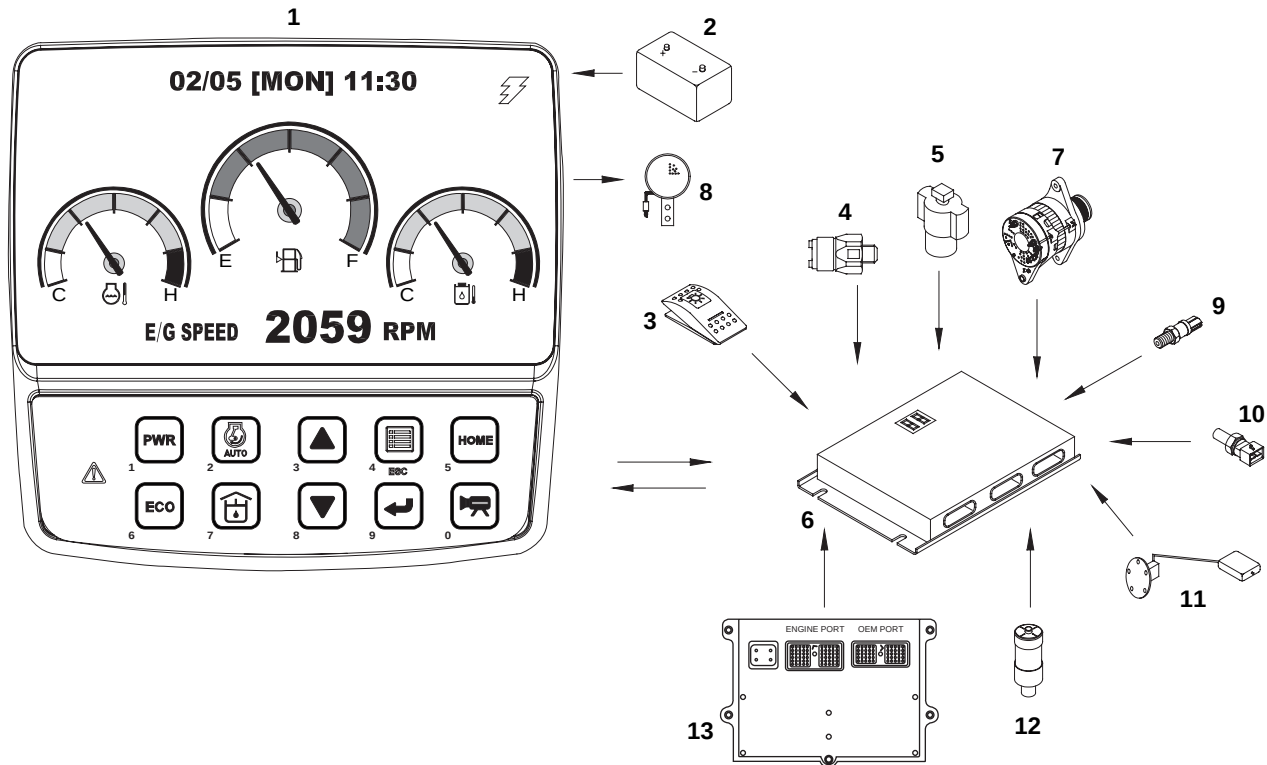
FG015054

Figure 8 CHARGING CIRCUIT

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

Reference Number	Description
6	Fuse Box
7	Alternator
8	Diode
9	Relay

MONITORING SYSTEM



FG015089

Figure 9

Reference Number	Description
1	Instrument Panel
2	Battery
3	Light Switch
4	Return Filter Switch
5	Pilot Filter Switch
6	e-EPOS Controller
7	Alternator

Reference Number	Description
8	Warning Buzzer
9	Pump Discharge Pressure Sensor
10	Hydraulic Oil Temperature Sensor
11	Fuel Sensor
12	Air Cleaner Indicator
13	Engine Controller

The monitoring system displays the various data and warning signals onto the instrument panel by processing the information gathered from the e-EPOS controller. It displays information selected by the operator.

Instrument Panel

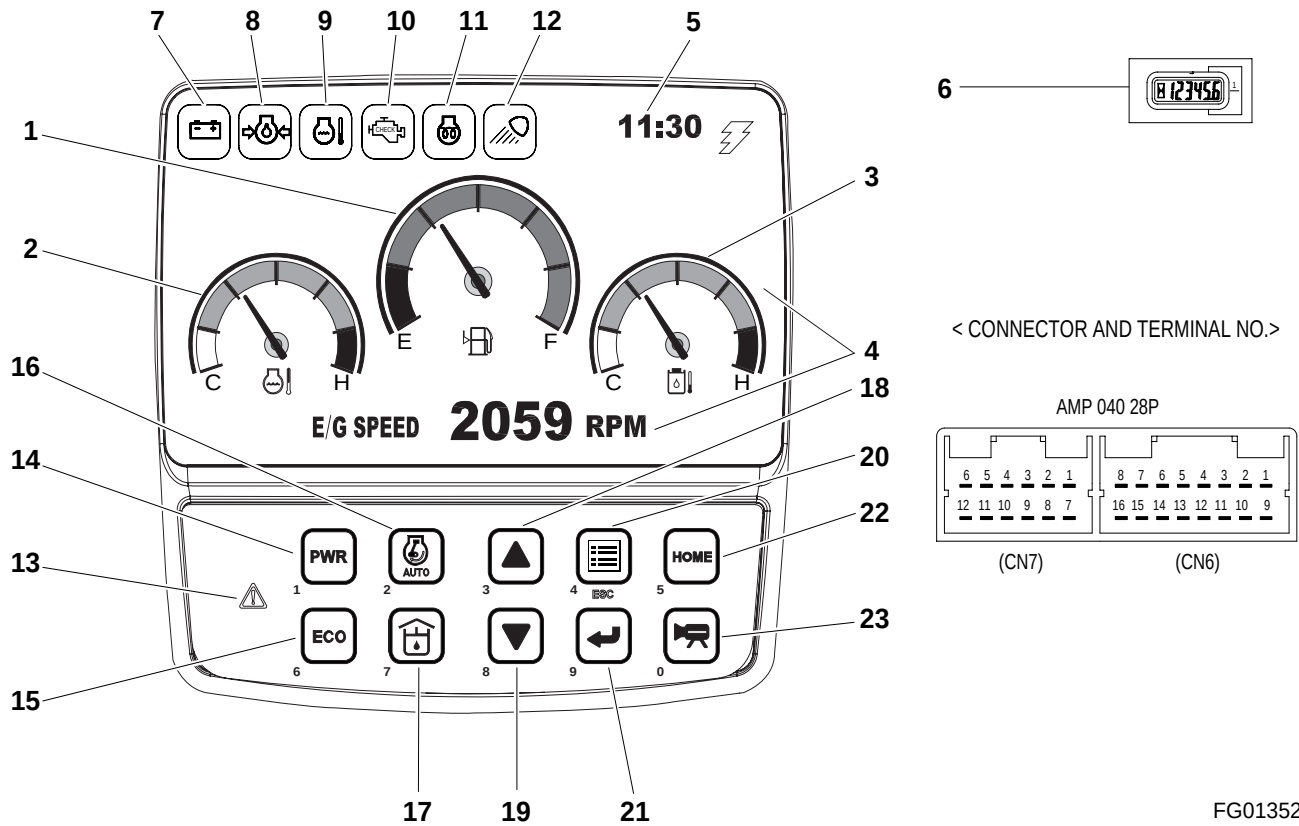


Figure 10

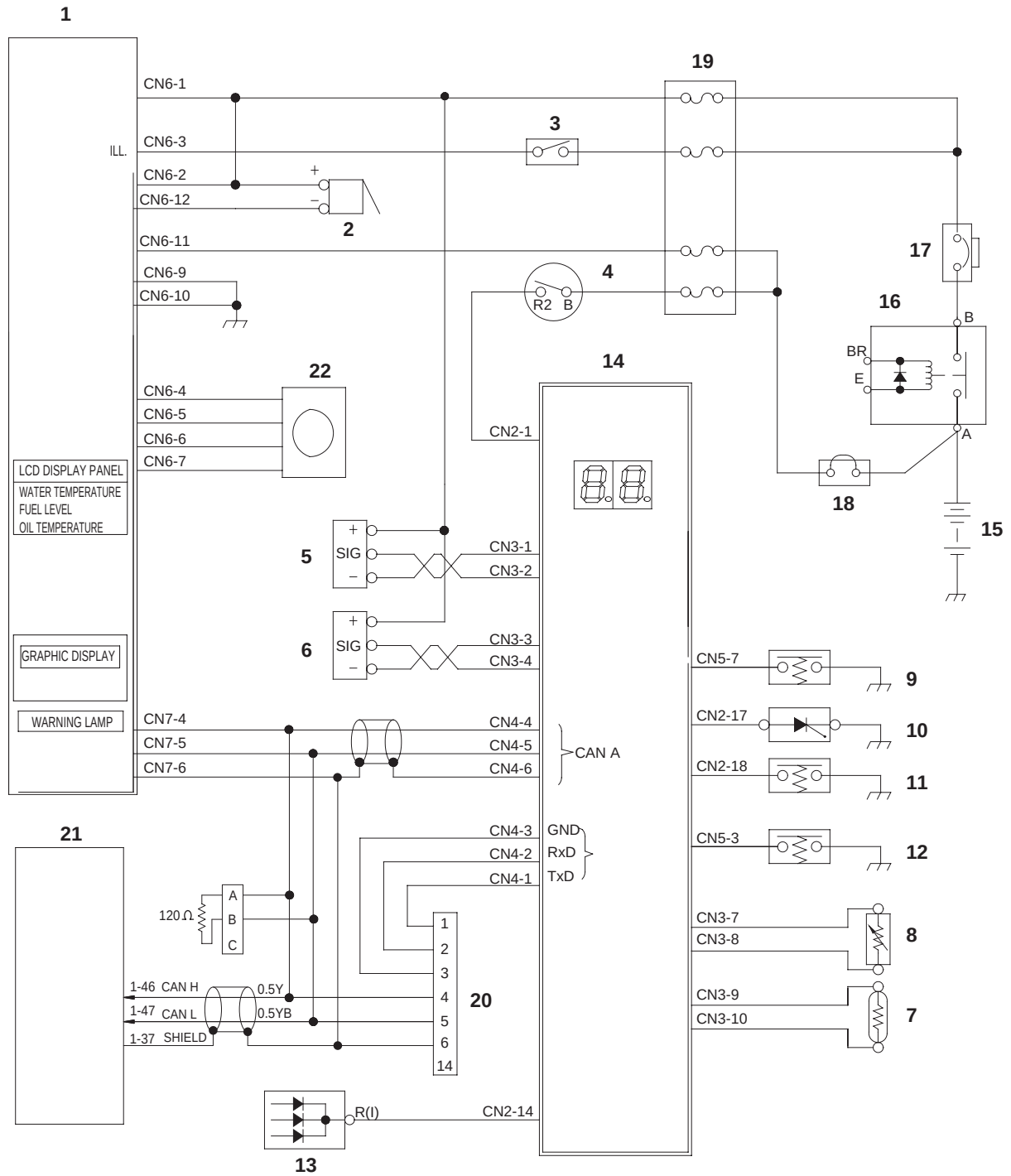
FG013521

Gauges	Warning Lights	Mode Selector Switches
1. Fuel Gauge	7. Charge Warning	14. Power Mode Selector Button
2. Engine Coolant Temperature Gauge	8. Engine Oil Pressure Warning	15. Economy Mode Selector Button
3. Hydraulic Oil Temperature Gauge	9. Engine Coolant Temperature Warning	16. Auto Idle Selector Button
4. Multifunction Gauge and Letter Information Area	10. Engine Check Warning	17. Flow Control Button
5. Digital Clock	11. Preheat Indicator	18. Up Arrow Button
6. Hour Meter	12. Work Light Indicator Light	19. Down Arrow Button
	13. Warning Light	20. Display Selector Button
		21. Selector Button
		22. Home Selector Button
		23. Camera Selector Button

When the engine starter switch is turned to the "I" (ON) position, all gauge bands, switch/button indicator lights and warning lights will turn "ON" and the alarm buzzer will sound about two seconds.

During this functional check, a LOGO will appear on the multi function gauge in the graphic information area

Monitoring System Schematic



FG015060

Figure 11

Reference Number	Description
1	Instrument Panel
2	Pilot Buzzer
3	Light Switch
4	Starter Switch
5	Front Pump Pressure Sensor
6	Rear Pump Pressure Sensor
7	Hydraulic Oil Temperature Sensor
8	Fuel Sensor
9	Pedal Pressure Switch (Optional)
10	Air Cleaner Indicator
11	Pilot Filter Switch

Reference Number	Description
12	Return Filter Switch
13	Alternator
14	e-EPOS Controller
15	Battery
16	Battery Relay
17	Circuit Breaker
18	Fusible Link
19	Fuse Box
20	Check Connector
21	Engine Controller
22	Rearview Camera

OPERATION

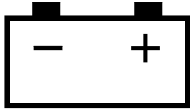
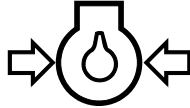
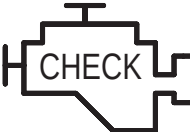
Instruments

Function	Display	Sensor Specification	
		Input Terminal	Input Specification
Coolant Temperature		ECU-CAN Communication	
Fuel Level		CN3-7 CN3-8	1/10 LCD (Red Zone) Blinking → over 5K ohms FULL → under 525 ohms
Hydraulic Oil Temperature		CN3-9 CN3-10	40°C (104°F) → 1,397 ohms 50°C (122°F) → 1,139 ohms 60°C (140°F) → 881 ohms 94°C (201°F) → 190 ohms 96°C (205°F) → 177 ohms (When reading increase)
Flow Adjusting		(Output Terminal) CN1-19 CN1-20	50 l/min → 615 mA 50 l/min → 519 mA 80 l/min → 482 mA 100 l/min → 409 mA (Default Set) 220 l/min → 335 mA 308 l/min → 300 mA

Function	Display	Sensor Specification	
		Input Terminal	Input Specification
Tachometer	E/G SPEED 1750 RPM	ECU-CAN Communication	N = 146 f / 60 N = Engine speed (rpm) f = Frequency of engine speed sensor (Hz)
Voltmeter	BATTERY 28.0 VOLT FG000050	CN2-14	0 - 32 VDC
Main pump discharge pressure (front pump)	FRONT PUMP 320 BAR FG000051	CN3-1 CN3-2	V = 0.00816 x P + 1.0 V: Sensor output voltage (V) P: Displayed pressure (Bar)
Main pump discharge pressure (rear pump)	REAR PUMP 313 BAR FG000052	CN3-3 CN3-4	

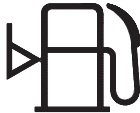
WARNING AND INDICATOR LIGHTS

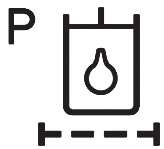
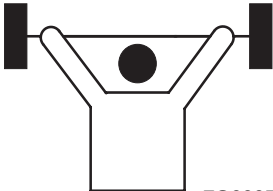
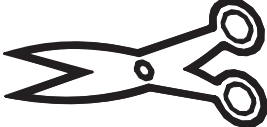
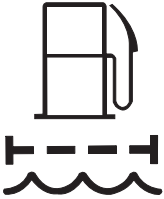
Indication of Warning Lights

Description	Symbol	Input Terminal	Operation	Remarks
Charge	 HAOA610L	CN2 - 14	This symbol appears in case of no charge [voltage of "R(I)" terminal is below $12 \pm 1V$] or overcharge [voltage of "R(I)" terminal is above 33(V)].	Normally, it lights when starting engine and is out after engine starts.
Engine Oil Pressure	 HAOA620L	ECU-CAN Communication	This symbol appears when engine oil pressure is below the reference.	After starting engine, if engine oil pressure is insufficient after 8 seconds, a warning buzzer will sound.
Engine Check	 FG000045	ECU-CAN Communication	This symbol appears in case of failure in engine system.	
Coolant Temperature	 HAOD350L	ECU-CAN Communication	This symbol appears when engine coolant temperature is above $107^{\circ}C$.	
Preheating	 HAOA639L	CN5-2	This symbol appears during preheating ("CN5-2" terminal voltage is below 2V) and disappears after completion of preheating.	Preheating period depends on coolant temperature. Min : 0 sec Max : 30 sec

Description	Symbol	Input Terminal	Operation	Remarks
Work Light	 HB4O2003	CN2 - 6	This symbol appears when work light turns "ON" (24V applied).	

Indication of Multifunction Gauge

Description	Symbol	Input Terminal	Operation	Remarks
Hydraulic Oil Temperature	 FG000056	CN3-9 CN3-10	When hydraulic oil temperature is above about 96°C.	
Fuel Exhausted	 FG000057	CN3-7 CN3-8	When fuel is almost exhausted.	
Air Cleaner	 FG000053	CN2-17	When air cleaner is clogged.	
Return Filter	 FG000054	CN5-3	When return filter pressure is above about 1.50 kg/cm ² (21 psi)	

Pilot Filter	 FG000055	CN2-18	When pilot filter pressure is above about 1 kg/cm ² (14 psi)	
Overload Warning	 FG000253	CN3-5 CN3-6	Warning buzzer also starts when boom pressure sensor output voltage is about 2.7V while overload warning switch is "ON."	It flickers in case of 2.71V and above and lights continuously in case of 2.8V and above (and warning buzzer also starts).
Boost	 FG000554	CN2-2	This symbol appears when boost is selected.	
Breaker	 FG001470	CN2-10	This symbol appears when breaker is selected.	
Shear	 FG001471	CN2-9	This symbol appears when shear is selected.	
Water Separator	 FG010520	CN3-19 CN3-20	This symbol appears when the water separator is full. This symbol appears when water separator sensor output voltage is about 1.5V below.	

INITIAL OPERATION

Item	Input (Terminal)	Output (Operation and initial setting mode)
Initial Operation	When "CN6-1,2" is applied battery voltage (starter switch shifts from "OFF" to "ON")	- LCD, all of LED and warning lights are turned "ON" and turned "OFF" after about 2 seconds. - Warning buzzer is activated and turned "OFF" after about 2 seconds. - Power mode: Standard mode. - Auto Idle: High Output (Activation). - Display: Indicating coolant temperature, Fuel level, Hydraulic oil temperature, Engine speed. - Clock: Current time display.

NOTE: Refer to method for setting clock in operation manual for setting time.

MODE SELECTOR SWITCH

Power Mode / Trenching Mode Switch

Operation Mode		Output Check (Operation mode display)	e-EPOS Output		
			Electromagnetic Proportional Reducing Valve (E.P.P.R Valve) Current (mA)	Swing Priority Solenoid Valve	7-Segment Display
Power Mode	Power Mode	ON	No-load: 150 ± 20mA Load: Variable output (Max. current: 400 ± 20mA)	-	9 x
	Standard Mode	OFF	No-load: 300 ± 20mA Load: Variable output (Max. current: 600 ± 60mA)	-	7 x
	Economy Mode		No-load: 350 ± 20mA Load: Variable output (Max. current: 600 ± 60mA)	-	5 x

NOTE: When the engine speed is below 1,000 rpm, the output current of E.P.P.R valve is fixed to be 600 ± 60mA.

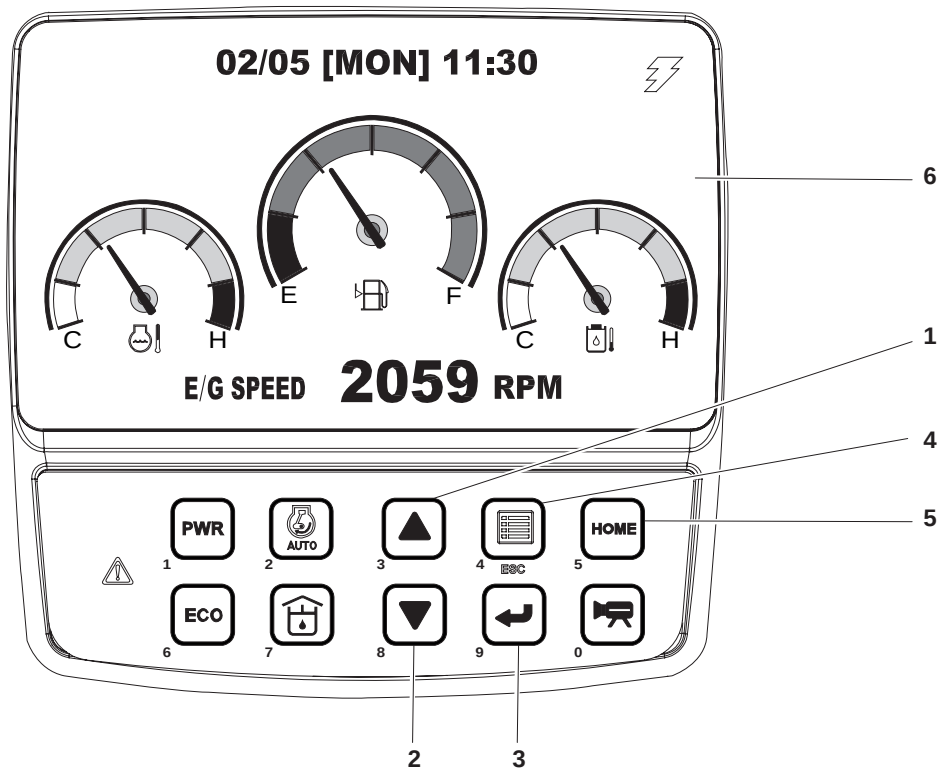
Auto Idle Switch

Operation Mode		Output Check (Operation mode display LED)
Auto Idle	Activation	ON
	Cancellation	OFF

GRAPHIC INFORMATION AREA DISPLAY

Overview

Many kinds of condition of machine are displayed on the letter information display department. The information display department is divided into two menus. One is main menu for user and the other is special menu for specialist. These menus can be moved from normal display mode by the combination of selector buttons.



FG013562

Figure 12

Selector Buttons	Graphic Display Area
1. Up Arrow Button	5. Home Button
2. Down Arrow Button	6. Letter Information Display Department
3. Enter Button	
4. Escape Button	

Main Menus for the Graphic Display Area

1. Main menu: Language setting, Time setting, Filter/Oil information, Brightness adjustment, Password
2. Special menu: Information of machine status, failure information, Information of machine operation.

Menu Selector Buttons

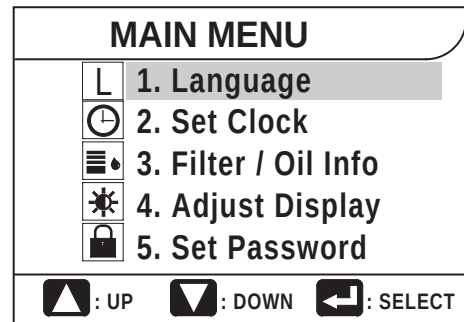
1. Up Arrow Button (▲, 1 on Figure 12): Move the cursor to up, left and previous screen.
2. Down Arrow Button (▼, 2 on Figure 12): Move the cursor to down, right and next screen.
3. Enter Button (↵, 3 on Figure 12): Move the menu to selected mode. When setting the menu, this button is used to function as the selector button.
4. Escape Button (ESC, 4 on Figure 12): Move a screen to previous menu or main menu.
5. Home Button (HOME, 5 on Figure 12): Move a screen to default menu.

MAIN MENU

When the "ESC" button is pressed for more than 3 seconds, the main menu screen is displayed.

Main menu offers sub-menus (language setting, time setting, or filter/oil information, brightness adjustment, password) to the operator.

Refer to the "Operation and Maintenance Manual" for details.



FG013563

Figure 13

Language

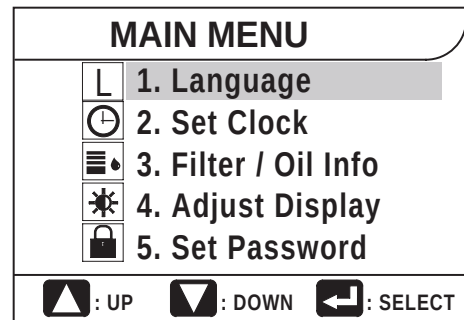
Put the cursor on Language in the main menu and put the Enter Button (↵, 3 on Figure 12) and the language select view appears.

The default language is Korean, but it will memorize and use the newly set language.

Use the Up Arrow Button (▲, 1 on Figure 12) or Down Arrow Button (▼, 2 on Figure 12) to move cursor to a language to be selected on the Language Select display and press the Enter Button (↵, 3 on Figure 12) and the selected language is indicated in the right bottom of the screen.

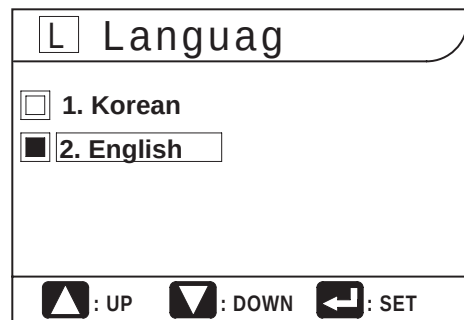
At this point pressing the Enter Button (↵, 3 on Figure 12) or the Escape Button (ESC, 4 on Figure 12) more than 1 second brings the main menu with changed language and then pressing the ESC button again shows the default view.

Without pressing a button more than 20 seconds, the default view appears.



FG013563

Figure 14



FG013564

Figure 15

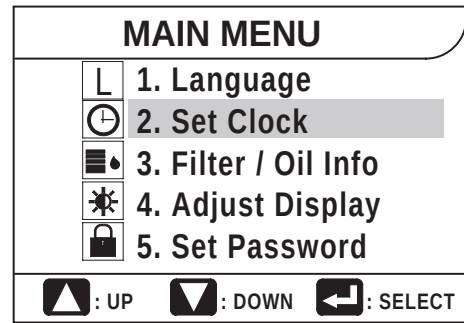
Set Clock

It is used to adjust time of the digital clock.

Pressing the Enter Button (↵, 3 on Figure 12) in the Main Menu after putting cursor on Set Clock brings Set Clock display.

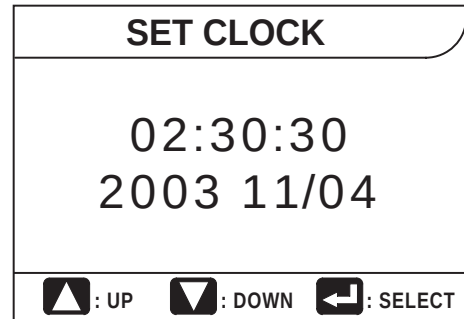
Without pressing a button more than 20 seconds, the default view appears.

Please refer to the Operation Manual for detailed information on Time Setting.



FG013565

Figure 16



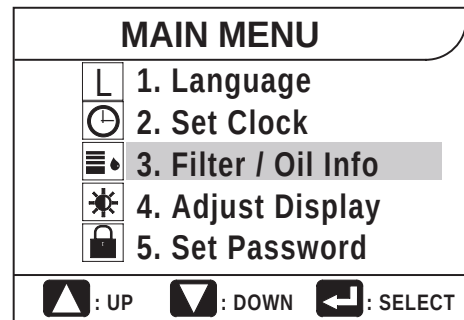
FG013566

Figure 17

Filter/Oil Info

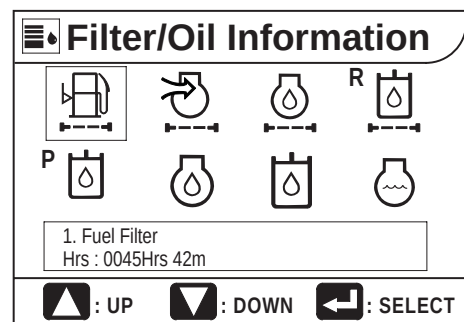
This mode displays total operating hours of filters and oils.

After changing the filter and oil, reset the operating hour and then the operating hours until the next service interval can be easily checked.



FG013567

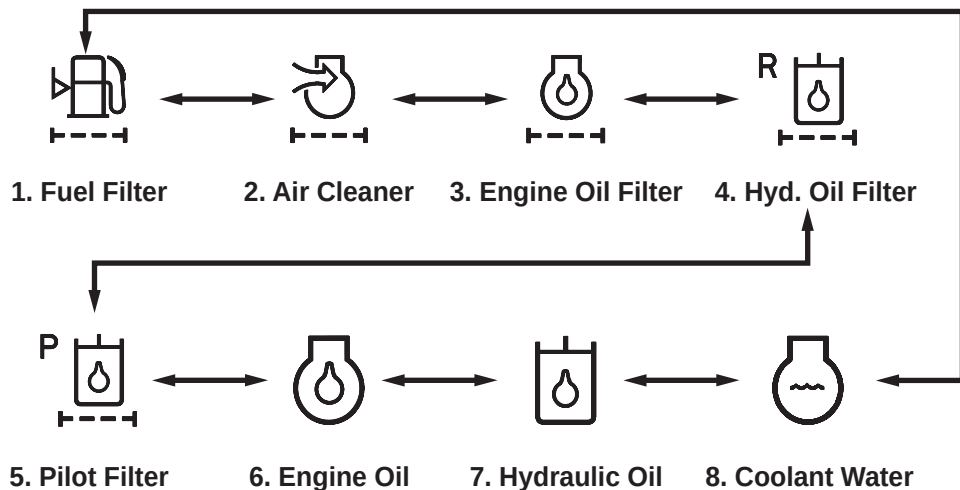
Figure 18



FG013568

Figure 19

Menu Display Order and Icon Explanation



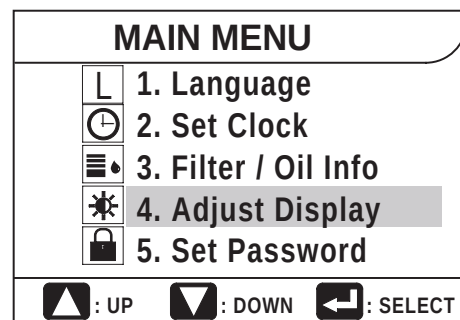
FG001358

Figure 20

Adjust Display

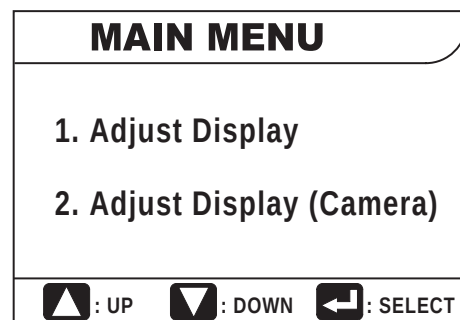
Pressing the Enter Button (↵, 3 on Figure 12) in the main menu after putting cursor on Adjust Display brings Adjust Display.

Screen brightness, contrast, back light can be adjusted using the Up Arrow Button (▲, 1 on Figure 12) or the Down Arrow Button (▼, 2 on Figure 12).



FG013569

Figure 21



FG013835

Figure 22

Day Mode

The default brightness is set to 50%.

The default contrast is set to 50%.

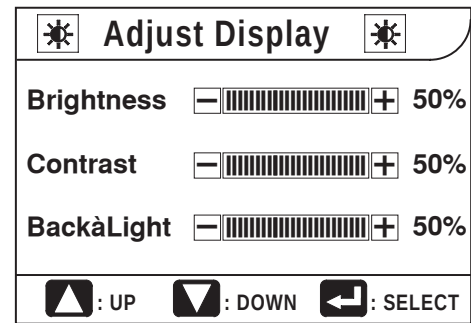
The default back light is set to 90%.

Night Mode

The default brightness is set to 50%.

The default contrast is set to 30%.

The default back light is set to 10%.



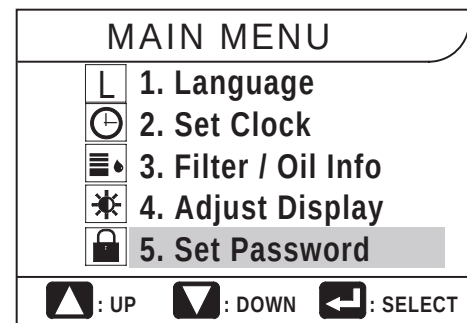
FG013570

Figure 23

Set Password

This menu is used to apply (lock), release, or change password.

Please refer to the Operation Manual for detailed information on Password Setting.



FG013571

Figure 24

SPECIAL MENU

In this menu, many types of operating conditions and functions can be accessed and displayed, including the e-EPOS controller. This menu is mainly used for machine testing and failure diagnostics.

The special menu offers three sub-menus:

1. Machine status.
2. Failure information.
3. Information on machine operation.

Entering/Accessing and Exiting/Escaping Menus

Entering/Accessing Menus

When normal mode screen is displayed, if the enter button (↵, 3) and escape button (ESC, 4) are pressed simultaneously for more than 3 seconds, normal mode screen (Figure 26) will be changed to special menu screen (Figure 27).

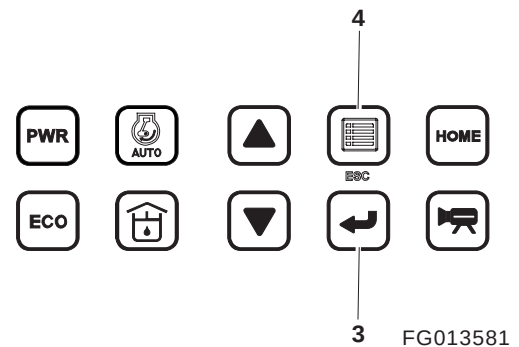


Figure 25

Normal Mode Screen

NOTE: Normal mode screen can display many kinds of display mode by selecting, for example, engine speed (RPM), battery voltage (VOLT), front pump pressure (BAR), rear pump pressure (BAR) and so on by selecting.

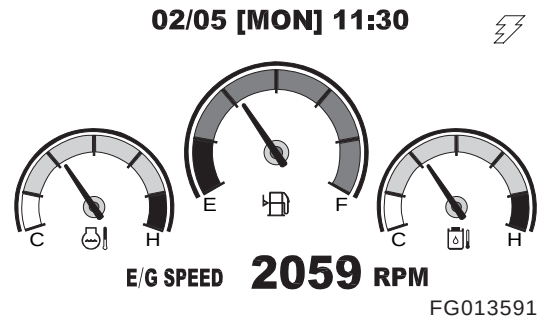
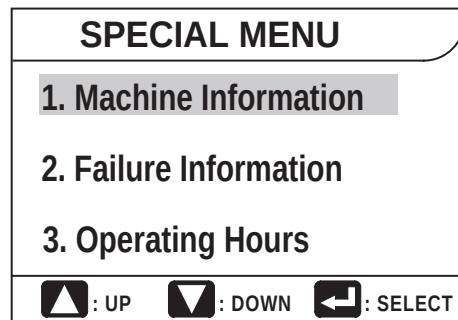


Figure 26

Special Menu Screen

NOTE: Displayed language on the special menu screen consists of Korean and English.

If any language except for Korean is selected during language selection mode of main menu, only English will be displayed on special menu screen.



FG013592

Figure 27

Exiting/Escaping Menus

1. If escape button (ESC, 4 on Figure 25) is pressed for more than 1 second, the special menu screen will be returned to the normal mode screen.
2. If this special menu is "ON" without any activity, for more than 20 seconds, it will turn to the normal mode screen.
3. After the turning starter switch to the "OFF" position, turn it back to the "ON" position, and the normal mode screen displayed once again.

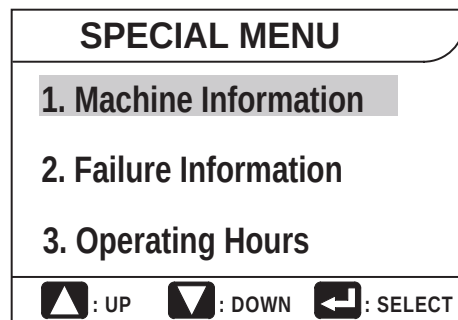
Special Menu Selections

Submenu Selection Method

Various sub-menus can be selected by pressing "Up (▲, 1 on Figure 25)" and "Down (▼, 2 on Figure 25)" button.

Move the cursor to desired menu and a selected menu will be inverse displayed.

When the selected menu is inverse displayed, press the "Enter (↵, 3 on Figure 25)" button for menu selection.

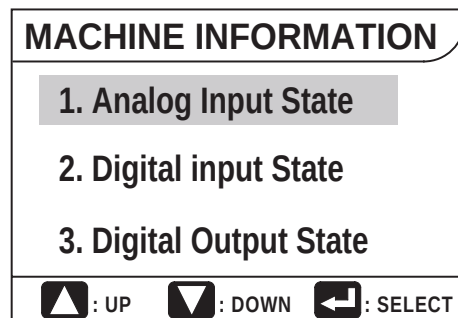


FG013592

Figure 28

Information of Machine Status

1. Entering Sub-menus: When cursor is located on "Machine Info" of special menu screen, press "Enter (↵, 3 on Figure 25)" button and the "Machine Info" will be displayed.
2. Exiting Sub-menus: If escape button (ESC, 4 on Figure 25) is pressed for more than 1 second, display will be turned to previous screen.



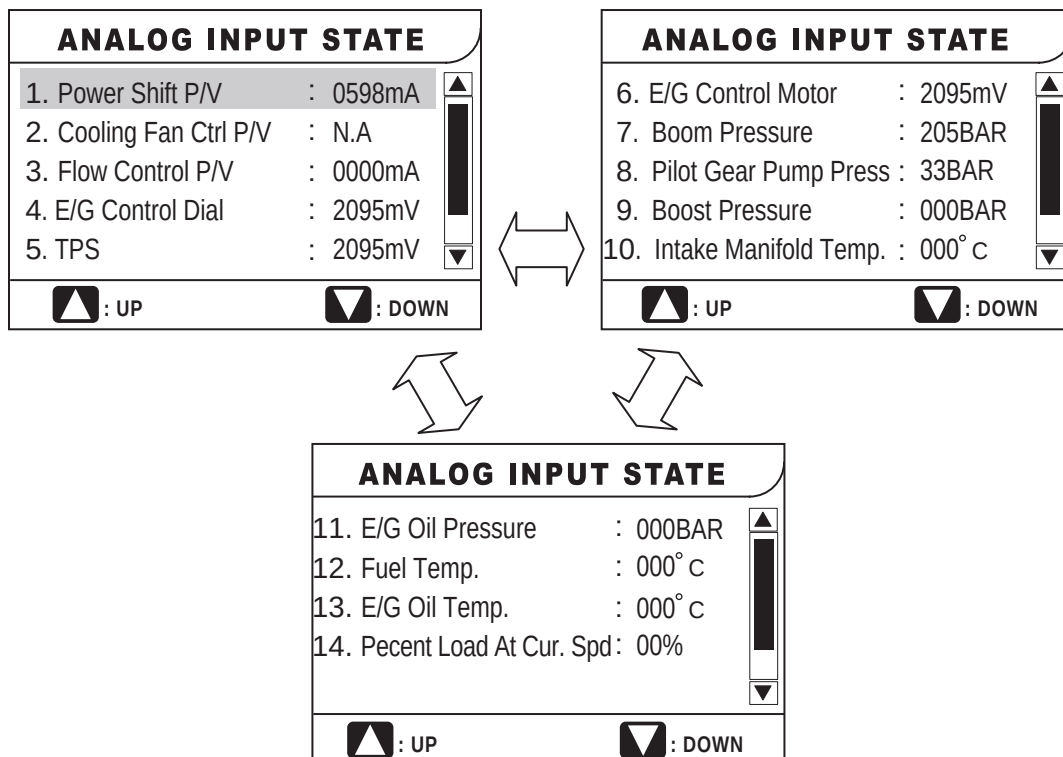
FG013593

Figure 29

Analog Inputs Description

Analog Input Items	Display	Remark
1. Pump P/V	mA	Current in pump proportional valve.
2. Cooling Fan P/V	mA	N.A.
3. Flow Control P/V	mA	Current in flow control proportional valve.
4. Dial	mV	Indicating dial voltage.
5. TPS	mV	N.A.
6. E/G Control Motor	mV	N.A.
7. Boom Pressure	BAR	Boom cylinder head pressure.
8. Pilot Gear Pump Press	BAR	N.A.
9. Boost Pressure	BAR	Pump pressure for boost.
10. Intake Manifold Temperature	°C	Temperature of air incoming to intake manifold.
11. E/G Oil Pressure	BAR	Engine oil pressure.
12. Fuel Temperature	°C	Fuel temperature.
13. E/G Oil Temperature	°C	Engine oil temperature.
14. Load At Current Speed	%	Current load ratio of equipment.

Submenu Selections



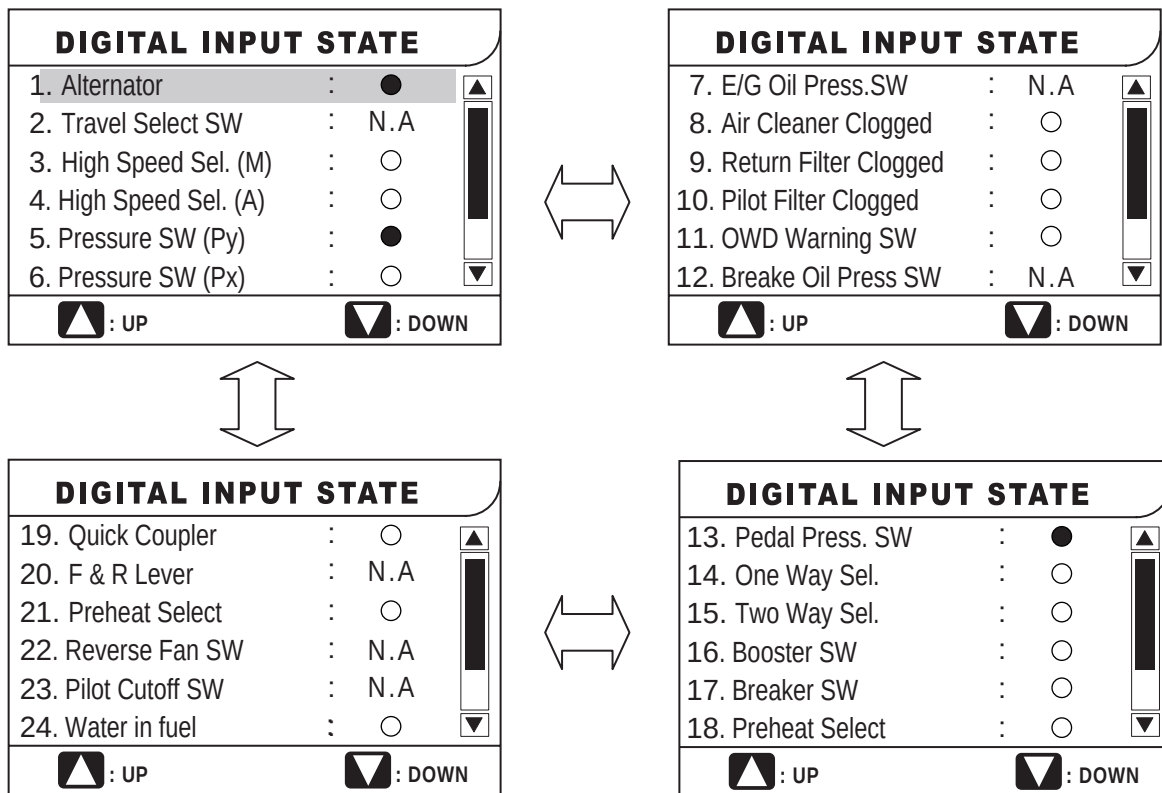
FG013594

Figure 30

Digital Inputs Descriptions

Digital Inputs Items	Mark	Remark
1. Alternator	ON / OFF	Lights up when output at alternator "R(I)" terminal is above 12 ±1V.
2. Travel Select SW		N.A. (only for wheel type equipment)
3. High Speed Sel. SW (M)		Lights up when the travel speed selector switch is set to the "I" position.
4. High Speed Sel. SW (A)		Lights up when the travel speed selector switch is set to the "II" position.
5. Pressure SW (Py)		Lights up when the pressure switch (Py) is "ON."
6. Pressure SW (Px)		Lights up when the pressure switch (Px) is "ON."
7. E/G Oil Press. SW		N.A. (only for mechanical engine)
8. Air Cleaner Clogged		Lights up when the air cleaner indicator contact is "ON."
9. Return Filter Clogged		Lights up when the return filter pressure switch is "ON."
10. Pilot Filter Clogged		Lights up when the pilot filter pressure switch is "ON."
11. OWD Warning SW		Lights up when the overload warning selector switch is "ON."
12. Brake Oil Press. SW		N.A. (only for wheel type equipment)
13. Pedal Press. SW		Lights up when the pedal pressure switch is ON.
14. One Way Sel. SW		Lights up when the selector switch is turned to breaker.
15. Two-way Sel. SW		Lights up when the Selector Switch is turned to "SHEAR."
16. Power Max. SW		Lights up when the boost button is "ON" with the Select switch turned to "BOOST."
17. Breaker SW		Lights up when the boost button is "ON" with the selector switch turned to "BREAKER."
18. Preheat Select		N.A.
19. Quick Coupler		Lights up when the Quick Coupler switch is "ON."
20. F and R Lever		N.A. (only for wheel type equipment)
21. Preheat Select		Lights up during preheating (CN5-2) terminal voltage is below 2V.
22. Reverse Fan SW		N.A.
23. Pilot Cutoff SW		N.A.
24. Water in fuel		Lights up when WIF sensor is "ON."

Menu Select



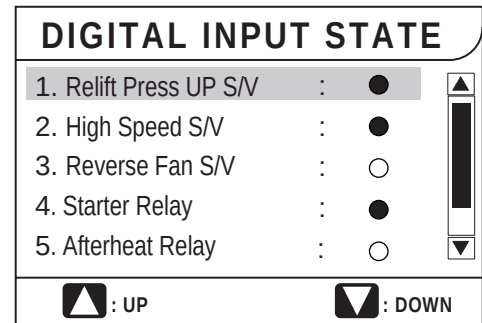
FG013611

Figure 31

Digital Outputs Descriptions

Digital Outputs Items	Mark	Remark
1. Relief Press. Up S/V	ON / OFF	Lights up when the relief press up solenoid valve is "ON."
2. High Speed S/V		Lights up when the high speed solenoid valve is "ON."
3. Reverse Fan S/V		N.A.
4. Starter Relay		When the starter relay is "ON."
5. After Heat Relay		N.A.

Menu Select

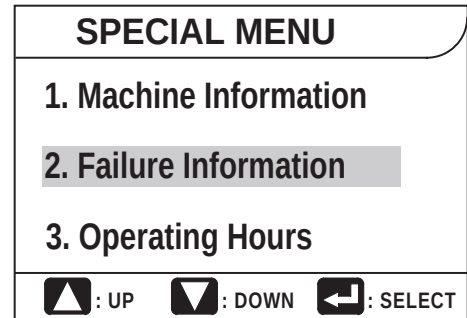


FG013612

Figure 32

Failure Information

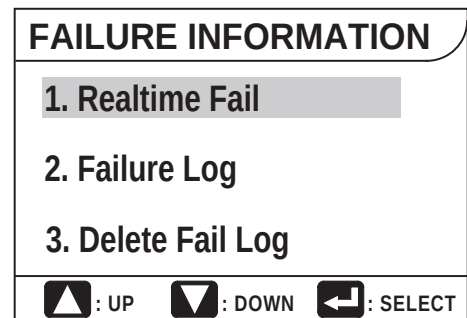
- Entering Sub-menus: When a cursor is located in "Failure Info" of special menu screen press enter button (↵, 3 on Figure 25) and "Failure Info" screen is displayed.
- Exiting Sub-menus: If escape button (ESC, 4 on Figure 25) is pressed for more than 1 second, this information screen will be returned to previous screen.



FG013613

Figure 33

- * Real-time Failure:
Current status of failure is displayed.
- * Failure Log:
Memorized record of past failure is displayed.
- * Delete Fail Log:
This mode is used to delete all of the memorized record of past failure.



FG013614

Figure 34

A. Current failure information

Current status of failure is displayed (Failure code, failure contents).

When a number of failures are produced, failure information can be checked using "UP" (▲, 1 on Figure 25) or "DOWN" (▼, 2 on Figure 25) button.

* 1/2: A serial number of current failure/ total quantity of failure.

* Vxxx-xx: Vxxx is a unique code and xx is a FMI (Failure Mode Identifier) number.

- V: Machine related failure code

- E: Engine related failure code

Refer to the failure information code for unique codes and FMI numbers.

This example shows one of two failures.

B. Past failure information

Memorized record of past failure is displayed (Failure code, failure contents).

When a number of failures are produced, failure information can be checked using "UP" (▲, 1 on Figure 25) or "DOWN" (▼, 2 on Figure 25) button.

NOTE: " Number: xxx ": "xxx" means that the totally counted number of the same failure.

" Period:xxxxxHrxxm ": It indicates the period for which machine has operated until a failure takes place. (For more than two occurrences of the same failure, until the first occurrence time.)

C. Failure record deletion

This mode is used to delete the memorized record of past failure. If this mode is selected, all records will be deleted.

When "YES" (◀, 3 on Figure 25) button is pressed, the memorized record will be deleted.

At this time, deletion signal will be displayed and the screen will move to previous menu after deletion.

This screen will be displayed during 3 seconds.

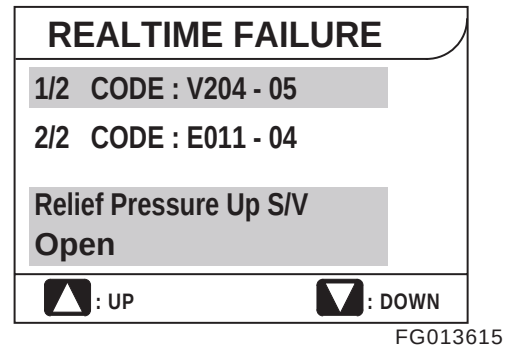


Figure 35

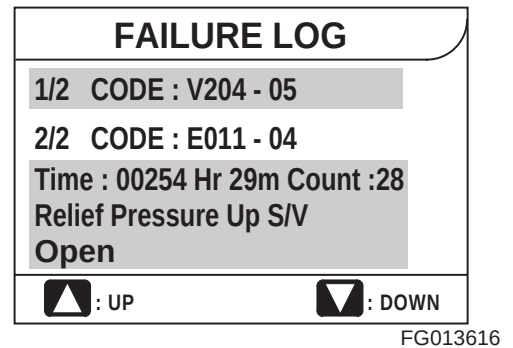


Figure 36

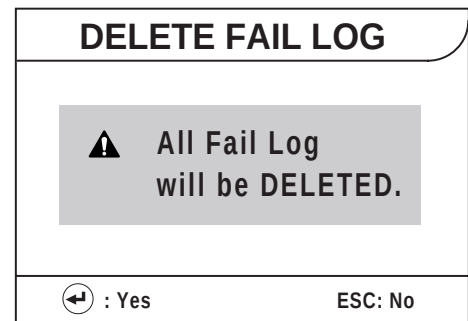
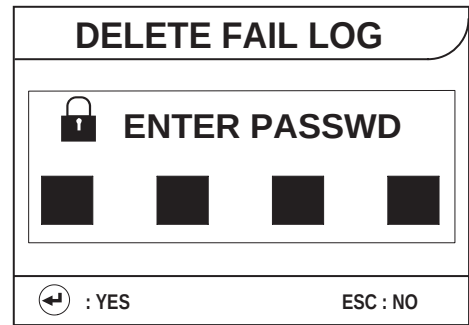


Figure 37

Input your password with one of No. 1 - 8 switches.

When "NO" (ESC, 4 on Figure 25) button is pressed, the screen will recover to previous menu without deletion.

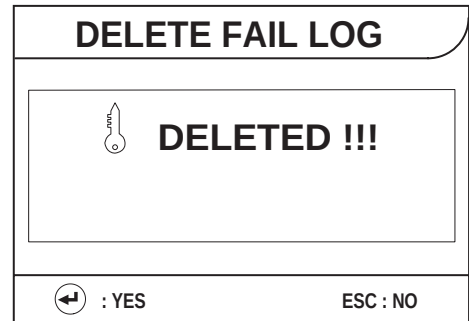


FG013618

Figure 38

Delete Completed screen will appear 3 seconds and the screen will move to Failure Info screen.

It has been shown 3 seconds upon deleting Fail Log.

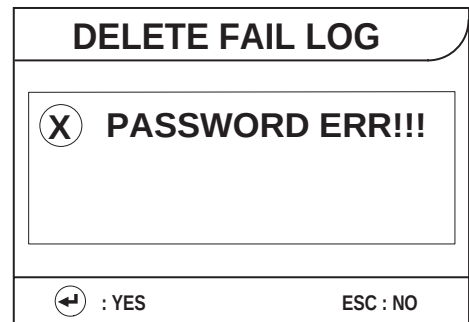


FG013619

Figure 39

The screen shown on the left will appear 3 seconds in case of wrong password input and then Enter Password screen appears again.

It has been shown 3 seconds in case of password failure.



FG013620

Figure 40

Failure Information Code at Machine Side

Code	Failure Component	Measuring Points	Correct Value		Remarks
			Active	Passive	
V201	Gauge Panel Communication Error	CN7-4 CN7-5	-	$R = 60 \pm 5 \Omega$	It is a composite resistance of CAN line. This value has to be measured by connected condition of CAN line.
V202	ECU Communication Error	CN4-4 CN4-5	-	$R = 60 \pm 5 \Omega$	
V210	Pump P/V	CN1-10 CN1-21	-	$R = 18 \pm 2 \Omega$ (25°C (77°F))	Pump proportional pressure reducing valve.
V211	Cooling Fan P/V		-	-	N.A.
V212	Flow Control P/V	CN1-19 CN1-20	-	$R = 14 \pm 2 \Omega$ (25°C (77°F))	Flow control proportional pressure reducing valve.
V213	Relief Pressure Up S/V	CN1-1 CN1-11	$V = V_volt$ (Note 4.)	$R = 26.2 \pm 2 \Omega$ (25°C (77°F))	Breaker/boost/shear selector switch has to be selected as a boost function and the boost switch on the right-hand joystick is "ON" status.
V214	High Speed S/V	CN1-1 CN1-12	$V = V_volt$	$R = 26.2 \pm 2 \Omega$ (25°C (77°F))	Voltage is only measured when the pressure switch (Py) is turned "ON."
V216	Reverse Fan Speed S/V		-	-	N.A.
V217	Starter Relay	CN1-1 CN1-15	$V = V_volt$	-	It has to be measured in engine start up state.
V218	After Heat Relay	1-16 1-04	-	-	N.A.
V220	Front Pump Press. Sensor	CN3-1 CN3-2	$V = 1V$	-	It has to be measured in engine stop state.
V221	Rear Pump Press. Sensor	CN3-3 CN3-4	$V = 1V$	-	

Code	Failure Component	Measuring Points	Correct Value		Remarks
			Active	Passive	
V222	Hyd. Oil Temperature Sensor	CN3-9 CN3-10	-	$R = 2.45 \pm 0.25 \text{ k}\Omega$ (25°C (77°F)) $R = 320 \pm 32 \Omega$ (80°C (176°F))	
V223	Water Temperature Sensor		-	-	N.A.
V224	Engine Speed Sensor		-	-	N.A.
V225	Fuel Level Sensor	CN3-7 CN3-8	-	Empty: $5 \pm 0.25 \text{ k}\Omega$ Full: $320 \pm 32 \Omega$	
V226	Alternator Potential	CN2-14 CN1-8	$V = 2 \pm 1V$	-	It has to be measured in engine stop state.
V227	Dial	CN3-16 CN3-17	-	$R = 1.0 \pm 0.3 \text{ k}\Omega$ $R = 4.0 \pm 1.5 \text{ k}\Omega$	
V228	Tps (Wheel)		-	-	N.A.
V229	Parking Brake Press. Sensor		-	-	N.A.
V230	E/g Control Motor Sensor		-	-	N.A.
V232	Water Separator Sensor	CN3-19 CN3-20	$V = 0.5V$ less than $V = 4.5V$ excess	-	N.A.

NOTE:

1. Active value: Starter switch has to be turned "ON"
Measuring points between component and wire harness have to be connected.
2. Passive value: Starter switch has to be turned "OFF"
Measuring points between component and wire harness have to be disconnected.
3. Measuring points are engine controller's points and passive value is each component's value.
4. V_{batt} : Source power of equipment.

Failure Information Code at Engine Side

Code	Failure Component	Measuring Points	FMI	Operation when failure occurs	Trouble shooting
E0111	ECU internal circuit defect		12	Engine start failure	Check power supply circuit, reinstall program, replace ECM
E0115	Crank/Cam sensor signal defect	1-27, 1-48 1-26, 1-47	2	Engine output abnormality, engine start	Check engine position sensor/speed sensor related
E0122	Inhalation pressure sensor circuit defect	1-44, 1-47	3	Lack of engine output	Check related circuit, connector and sensor
E0123	Inhalation pressure sensor circuit defect	1-44, 1-47	4	Lack of engine output	Check related circuit, connector and sensor
E0124	Inhalation pressure defect		16		
E0135	Oil pressure sensor circuit defect	1-13, 1-38	3	Engine protecting function loss	Check related circuit, connector and sensor
E0141	Oil pressure sensor circuit defect	1-13, 1-38	4	Engine protecting function loss	Check related circuit, connector and sensor
E0143	Oil pressure defect		18	Engine protecting function activation	Check oil filter and the amount of engine oil.
E0144	Coolant temperature sensor circuit defect	1-15, 1-38	3	Related engine protecting function loss, ceruse	Check related circuit, connector and sensor
E0145	Coolant temperature sensor circuit defect	1-15, 1-38	4	Related engine protecting function loss, smoke	Check related circuit, connector and sensor
E0146	Coolant temperature defect		1	Engine protecting function activation	Check the facts related to coolant temperature
E0151	Coolant temperature defect	1-15, 1-38	0	Engine protecting function activation	Check the facts related to coolant temperature
E0153	Inhalation temperature sensor circuit defect	1-23, 1-47	3	Related engine protecting function loss, ceruse	Check related circuit, connector and sensor
E0154	Inhalation temperature sensor circuit defect	1-23, 1-47	4	Related engine protecting function loss, ceruse	Check related circuit, connector and sensor
E0155	Inhalation temperature defect		0	Engine protecting function activation	Check the facts related to excess inhalation temperature
E0187	sensor	1-44, 1-47	4	Engine output fall, engine protecting function loss	Check ECM power supply circuit
E0221	Air pressure sensor circuit defect	1-3, 1-33	3	Engine output fall	Check related circuit, connector and sensor
E0222	Air pressure sensor circuit defect	1-3, 1-33	4	Engine output fall	Check related circuit, connector and sensor
E0227	Sensor supply circuit 2 defect	1-37, 1-47	3	Engine output fall, engine protecting function loss	Check ECM power supply circuit

Code	Failure Component	Measuring Points	FMI	Operation when failure occurs	Trouble shooting
E0234	Crank/Cam sensor defect		0	Excess of engine permitted rpm	Operator's training
E0238	Sensor supply circuit 3 defect	1-16	4		
E0271	Fuel pump circuit defect	1-2, 1-32	4	Engine output fall, abnormal operation	Check related circuit, connector and sensor
E0272	Fuel pump circuit defect	1-2, 1-32	3	Engine output fall, abnormal operation	Check related circuit, connector and sensor (ECM)
E0281	Fuel pump defect		7		
E0285	SAE J1939 communication time-out		9		
E0287	SAE J1940 communication time-out		13		
E0319	Present time misrepresentation	1-35, 1-42	2		
E0322	Injector circuit no.1 defect	1-45, 1-53	5	Injector no.1 stop	Check related circuit, connector and sensor
E0323	Injector circuit no.5 defect	1-46, 1-60	5		
E0324	Injector circuit no.3 defect	1-55, 1-52	5		
E0325	Injector circuit no.6 defect	1-57, 1-59	5		
E0331	Injector circuit no.2 defect	1-54, 1-51	5		
E0332	Injector circuit no.4 defect	1-56, 1-58	5		
E0334	Engine coolant temperature defect	1-15, 1-38	2		
E0342	Discordance of electronic compensation code		13		
E0343	ECU internal hardware warning defect		12	Periodic engine output fall	Check related circuit, connector and sensor (ECM)
E0351	Injector power supply defect		12		
E0352	Sensor supply circuit 1 defect	1-33, 1-38	4	Engine output fall	Check related circuit, connector and sensor (ECM)
E0386	Sensor supply circuit 1 defect	1-33, 1-38	3	Engine output fall	Check related circuit, connector and sensor (ECM)
E0415	Engine oil pressure defect		1	Engine protecting function activation	
E0431	Accelerator pedal idle switch defect	1-1, 1-11	2	N/A	Check related circuit, connector and sensor (ECM)
E0432	Accelerator pedal idle switch defect	1-1, 1-11	13		Check related circuit, connector and sensor (ECM)

Code	Failure Component	Measuring Points	FMI	Operation when failure occurs	Trouble shooting
E0435	Engine oil pressure defect	1-17	2	Engine protecting function loss	Check related circuit, connector and sensor
E0441	Battery voltage defect	3-1, 3-2 3-3, 3-4	18	Engine hunting	Check related circuit and connector (OEM)
E0442	Battery voltage defect	3-1, 3-2 3-3, 3-4	16	N/A	Check related circuit and connector (OEM)
E0449	Rail pressure defect		0	Fuel pump damage possibility	Check related circuit, connector and sensor
E0451	Rail pressure sensor circuit defect	1-25, 1-47	3	Engine protecting function activation, output	Check related circuit, connector and sensor
E0452	Rail pressure sensor circuit defect	1-25, 1-47	4	Engine protecting function activation, output	Check related circuit, connector and sensor
E0488	Inhalation temperature defect		16	Engine output fall	Check related circuit, connector and sensor
E0553	Rail pressure defect		16		
E0554	Rail pressure defect		2		
E0559	Rail pressure defect		18		
E0689	Crank/Cam sensor defect		2		
E0731	Crank/Cam sensor alignment discordance		7		
E0757	ECU date loss		31		
E0778	Crank/Cam sensor defect		2		
E1117	Starter switch ON power defect		2		
E2185	Sensor power supply circuit 4 defect	1-22, 1-23	3		
E2186	Sensor power supply circuit 4 defect	1-22, 1-23	4		
E2249	Rail pressure defect		1		
E2265	Fuel lift pump circuit	1-1, 1-11	3		
E2266	Fuel lift pump circuit	1-1, 1-11	4		
E2311	Fuel pump circuit defect	1-2, 1-32	31		
E2321	Crank/Cam sensor defect		2		
E2322	Crank/Cam sensor defect		2		
E2555	Inhalation heater defect	1-40, 1-42	3		
E2556	Inhalation heater defect	1-40, 1-42	4		
E2973	Inhalation pressure defect		2		

- NOTE:**
1. Active value: Starter switch has to be turned "ON"
Measuring points between component and wire harness have to be connected.
 2. Passive value: Starter switch has to be turned "OFF"
Measuring points between component and wire harness have to be disconnected.
 3. Measuring points are engine controller's points and passive value is each component's value.
 4. V_batt: Source power of equipment.

FMI (Failure Mode Identifier)

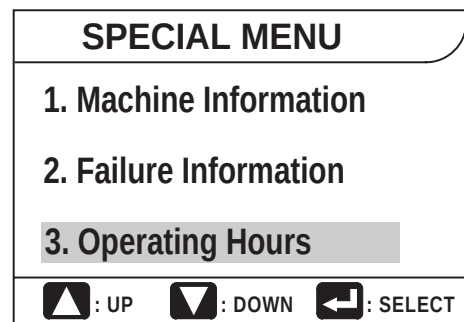
FMI 0	Above normal range (DATA VALID but ABOVE NORMAL OPERATIONAL RANGE)
FMI 1	Below normal range (DATA VALID but BELOW NORMAL OPERATIONAL RANGE)
FMI 2	Incorrect signal (DATA ERRATIC, INTERMITTENT OR INCORRECT)
FMI 3	Voltage above normal (VOLTAGE ABOVE NORMAL OR SHORTED TO HIGH SOURCE)
FMI 4	Voltage below normal (VOLTAGE BELOW NORMAL OR SHORTED TO LOW SOURCE)
FMI 5	Current below normal (CURRENT BELOW NORMAL OR OPEN CIRCUIT)
FMI 6	Current above normal (CURRENT ABOVE NORMAL OR GROUNDED CIRCUIT)
FMI 8	Abnormal signal (ABNORMAL FREQUENCY OR PULSE WIDTH OR PERIOD)
FMI 9	Abnormal renewal
FMI 11	Failure mode not identifiable (ROOT CAUSE NOT KNOWN - Malfunction)
FMI 12	Failure
FMI 31	NOT AVAILABLE OR CONDITION EXISTS

Information of Machine Operation

Accumulated operation hour of each mode and status is displayed.

1. Operating Hour Information

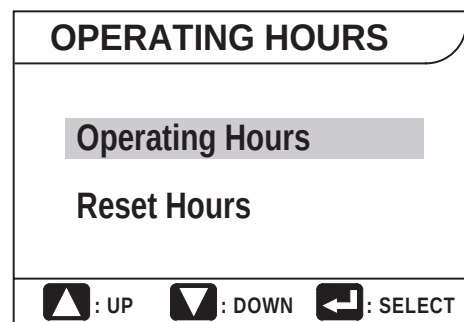
- A. Entering Sub-menus: When a cursor is located in "Operating Hrs" of special menu screen (Figure 41) press enter button (↵, 3 on Figure 25) and "Operating Hrs" screen will be displayed (Figure 42).



FG013621

Figure 41

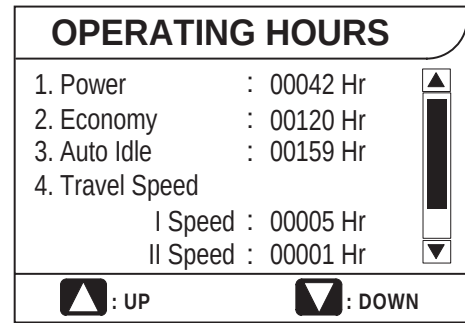
- B. Information screen of machine operation (Figure 42).



FG013622

Figure 42

- C. Operating Hours Screen
- D. Exiting Sub-menus: If escape button (ESC, 4 on Figure 25) is pressed for more than 1 second, this information screen will be returned to previous screen.



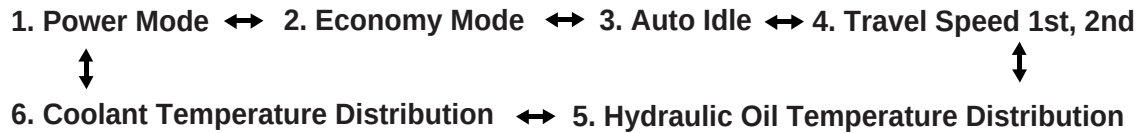
FG013623

Figure 43

Information contents of operation hour

Item	Information Contents	Detection Method
Power Mode	Operation hours used power mode are displayed.	Power mode switch (Instrument panel) - "ON" status and Alternator signal (CN2-14) is "HI"
Economy Mode	Operation hours used economy mode are displayed.	Economy mode switch (Instrument panel) - "ON" status and Alternator signal (CN2-14) is "HI"
Auto Idle	Operation hours used auto idle status are displayed.	Auto idle switch (Instrument panel) - "ON" status and Alternator signal (CN2-14) is "HI"
Travel Speed: -1st - 2nd	Operation hours used low speed and high speed are displayed.	1st: High speed s/v "OFF" status 2nd: High speed s/v and travel pressure switch "Py" (control valve) - "ON" status.
Hydraulic Oil Temperature Distribution (°C (°F))	Temperature of hydraulic oil is classified 6 steps. And operation hours of each step are displayed Under 30°C (87°F) 31 - 50°C (88 - 123°F) 51 - 75°C (124 - 168°F) 76 - 85°C (169 - 186°F) 86 - 95°C (187 - 203°F) Over 96°C (204°F)	The resistance delivered from temperature sensor of hydraulic oil is classified 6 steps. And operation hours of each step are displayed. (Alternator output HI status)
Coolant Temperature Distribution (°C (°F))	Temperature of coolant is classified 6 steps. And operation hours of each step are displayed. Under 40°C (105°F) 41 - 60°C (106 - 141°F) 61 - 85°C (142 - 186°F) 86 - 95°C (187 - 204°F) 96 - 105°C (205 - 222°F) Over 106°C (223°F)	The resistance delivered from coolant sensor is classified 6 steps. And operation hours of each step are displayed. (Alternator output HI status)

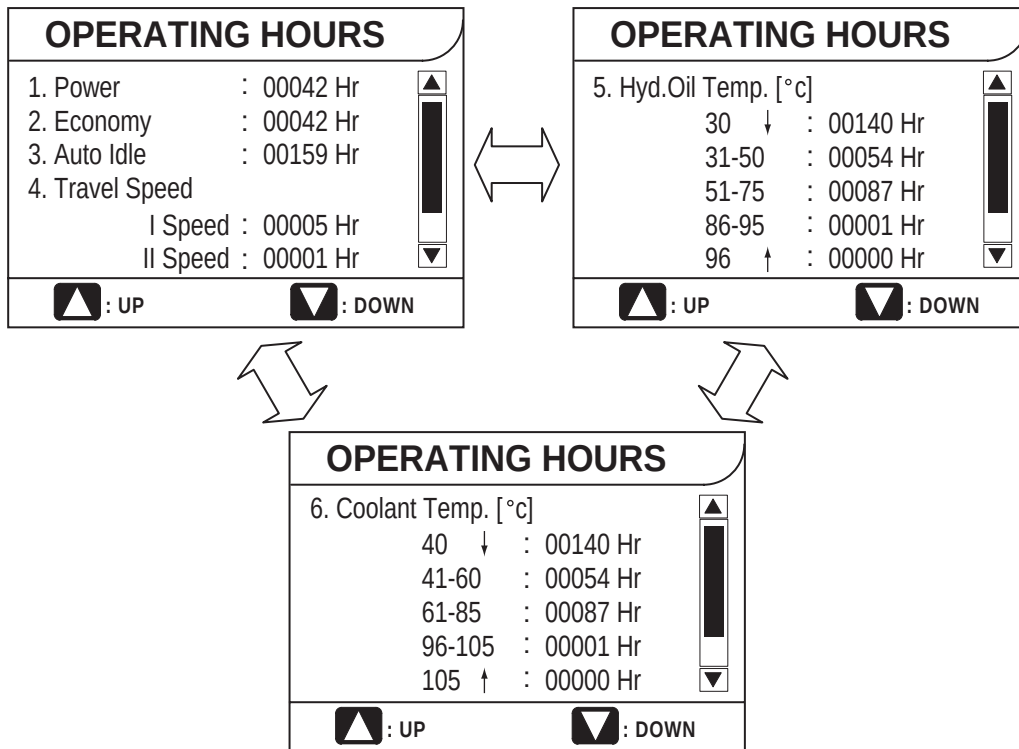
Menu Selection of Operation Hour Information



FG013856

Figure 44

Example of Machine Operation Info Screen

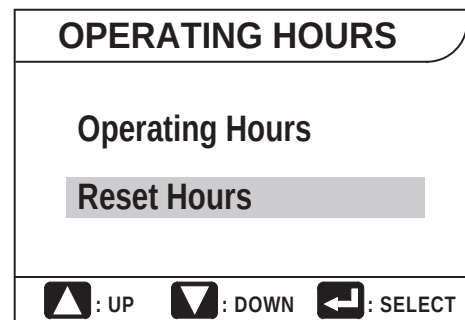


FG013624

Figure 45

2. Operation hour reset

- A. Entering Sub-menus: When cursor is located in "Reset Hrs" of information screen of operating hours press enter button (↵, 3 on Figure 25) and "Machine Operation Info" screen will be displayed.



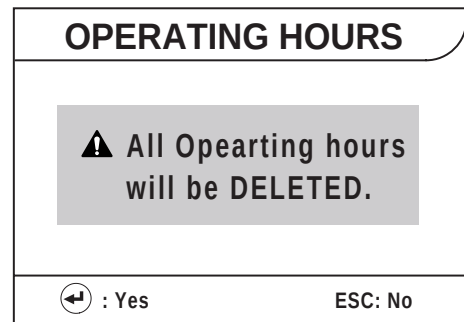
FG013625

Figure 46

- B. Reset screen of operation hour
- C. Exiting Sub-menus: If escape button (ESC, 4 on Figure 25) is pressed for more than 1 second, this information screen will be returned to previous screen.

NOTE: When "YES" (←, 3 on Figure 25) button is pressed, operation hours will reset. At this time, resetting signal will be displayed and the screen will move to previous menu after resetting.

NOTE: When "NO" (ESC, 4) button is pressed, the screen will recover to previous menu without resetting.

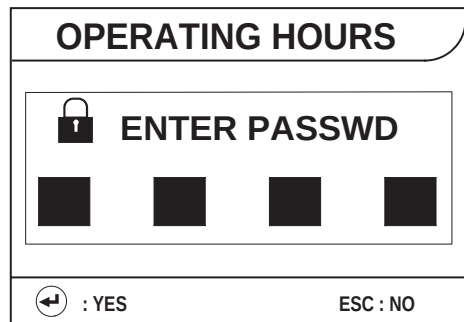


FG013626

Figure 47

Machine Operation Info Screen

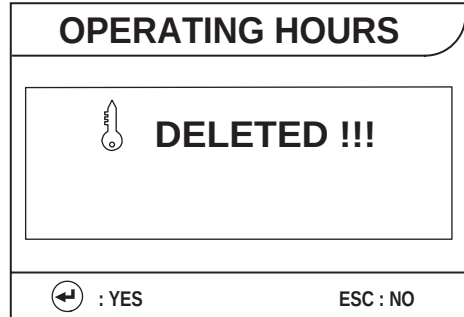
1. If you press the YES" (←, 3 on Figure 25) button, password entrance screen appears.



FG013627

Figure 48

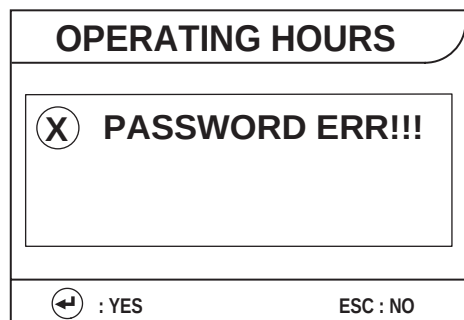
2. When right password is input, machine operation periods will be deleted and Reset Completed screen will appear 3 seconds.



FG013628

Figure 49

3. If you press the "NO" (ESC, 4) button, the previous screen appears without resetting operation periods.

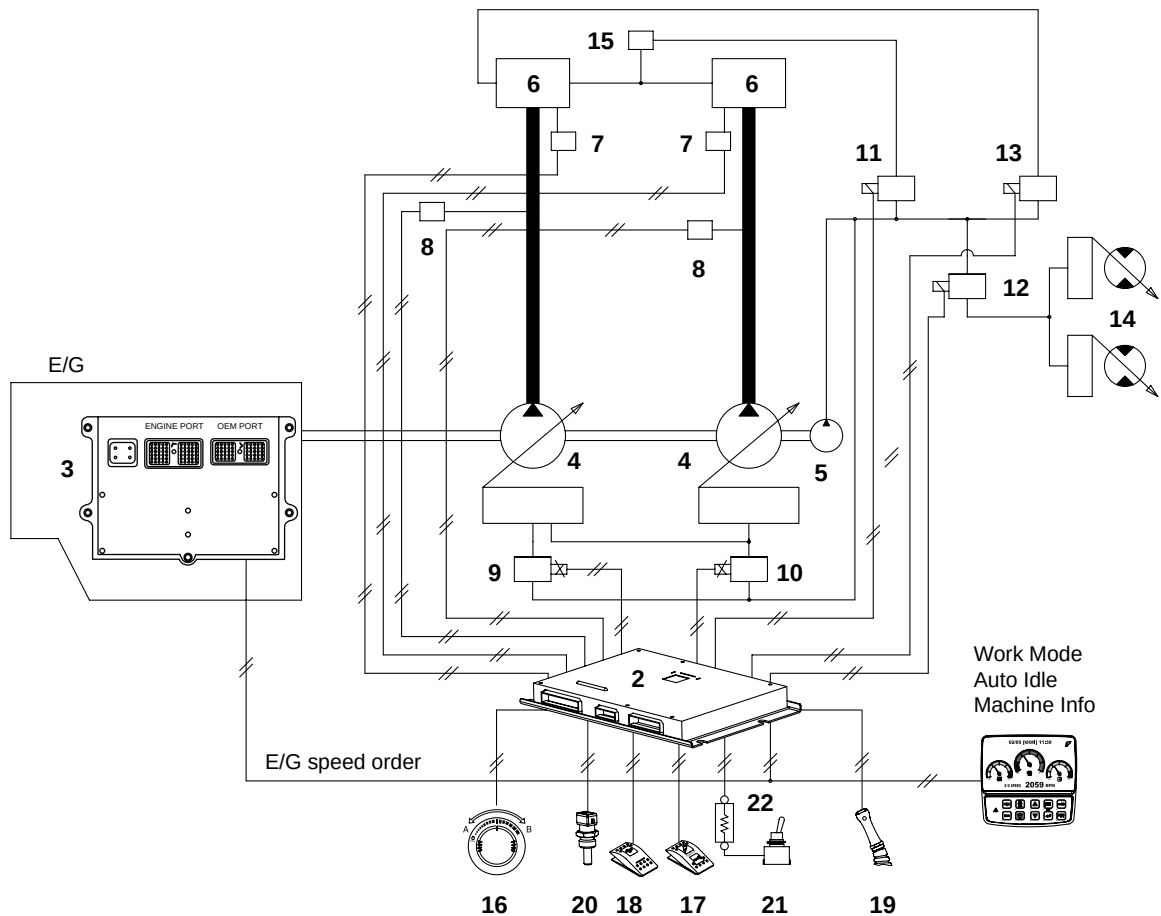


FG013629

Figure 50

ELECTRONIC HYDRAULIC CONTROL SYSTEM (e-EPOS)

Control System Schematic



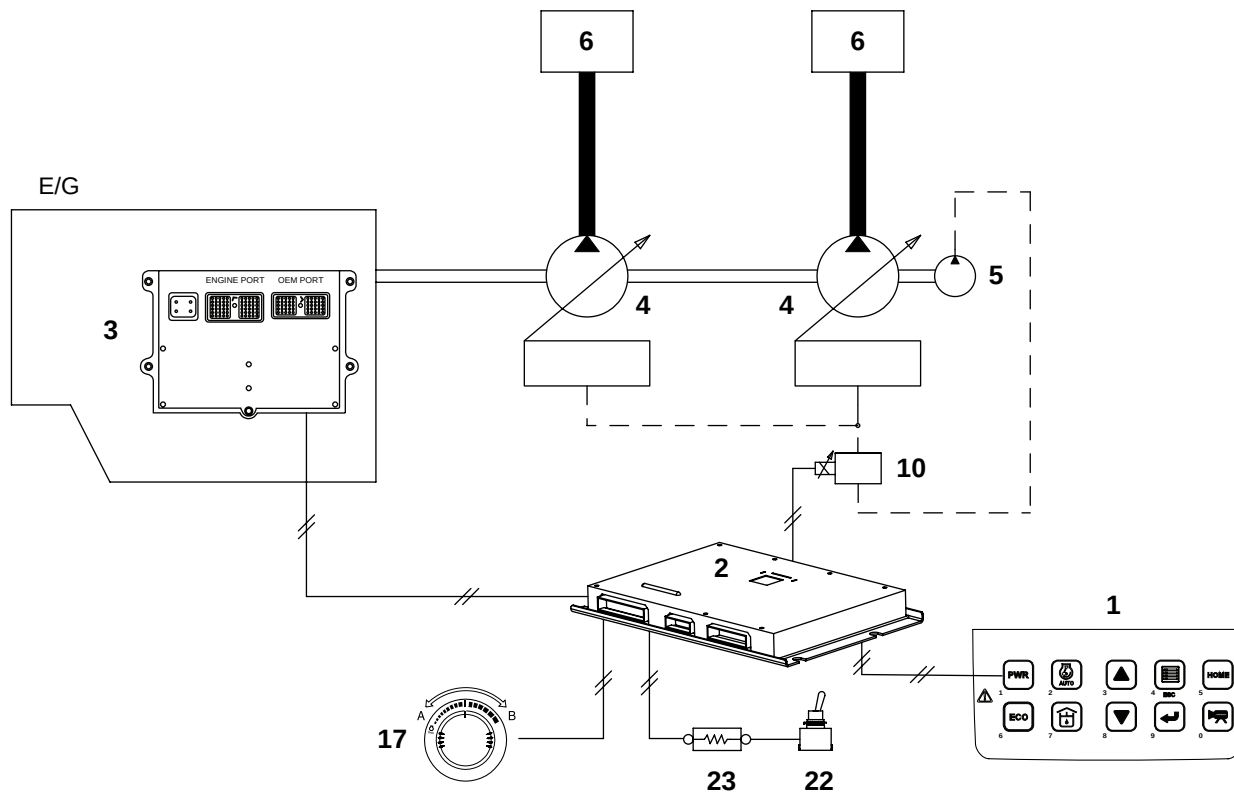
FG015090

Figure 51

Reference Number	Description
1	Instrument Panel
2	e-EPOS Controller
3	Engine Controller (ECU)
4	Main Pump
5	Aux Pump
6	Control Valve
7	Pressure Switch
8	Pump Pressure Sensor
9	Electromagnetic Proportional Pressure Reducing Valve (Attachment)
10	Electromagnetic Proportional Pressure Reducing Valve (Mode Control)

Reference Number	Description
11	Solenoid Valve (Boost)
12	Solenoid Valve (High Speed)
13	Solenoid Valve (Breaker)
14	Travel Motor
15	Main Relief Valve
16	Engine Control Dial
17	Breaker/Boost/Shear Selector Switch
18	Auto Travel Selector Switch
19	Boost Switch (Right Work Lever)
20	Sensor
21	Aux Mode Switch
22	Aux Mode Resistor

POWER MODE CONTROL



FG015091

Figure 52

Reference Number	Description
1	Instrument Panel (Power Mode Selector Switch)
2	e-EPOS Controller
3	Engine Controller (ECU)
4	Main Pump
5	Aux Pump
6	Control Valve

Reference Number	Description
10	Electromagnetic Proportional Pressure Reducing Valve (Mode Control)
17	Engine Control Dial
22	Aux Mode Switch
23	Aux Mode Resistor

The power mode switch permits the selection of the appropriate engine power depending on the working condition. One of the two, Power Mode or Standard Mode, setting can be selected. When the engine starter switch is turned "ON," the power mode is automatically defaulted to standard mode. The desired mode can be selected by pressing the selector button on the instrument panel. When the power mode is selected, the indicator light will turn "ON" to display the selected mode.

The quantity of oil discharged by the pump and the engine speed are determined by the mode selected by the operator. The pump output in each mode is determined by the mode selection and is listed in the following table

Mode	Standard Mode	Power Mode
Output (%)	Approximately 85%	100%

Operation

1. Power Mode

This mode should be selected for high speed work. In this mode the engine output is most efficiently utilized due to the discharged oil volume being controlled based on the equivalent horsepower curve at various loaded pressures. The e-EPOS controller compares the target engine speed with the actual engine speed and controls the signal to the E.P.P.R. (Electromagnetic Proportional Pressure Reducing) valve which in turn varies the pump output quantity.

If the load increases, the engine speed will fall below the rated speed. When this occurs, the controller senses this decrease and immediately reduces the pump discharge volume to maintain the engine speed at the rated level.

On the other hand, if the load is decreased the controller increases the discharge volume of the pump to maintain the engine speed at the rated level.

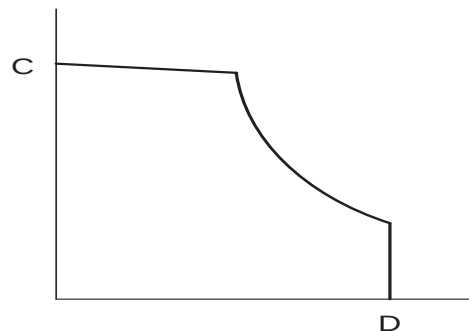
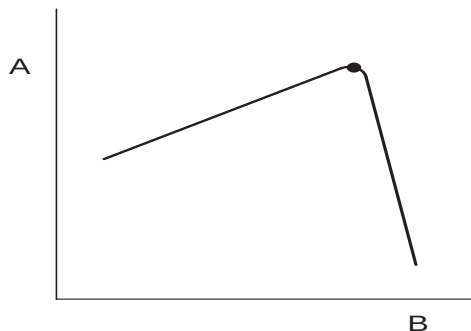
By repeating these control operations, the engine speed is maintained at the rated speed so that maximum power can be generated.

In Power Mode, the e-EPOS controller receives engine speed signals from the engine control dial and the engine controller (ECU) and converts it to an operating signal current and is then transferred to the pump's E.P.P.R valve. At this time the E.P.P.R. valve converts the electric signal to the corresponding control pressure and sends it to the two pumps, adjusting the pump discharge volume to the desired level.



FG013632

Figure 53



FG000580

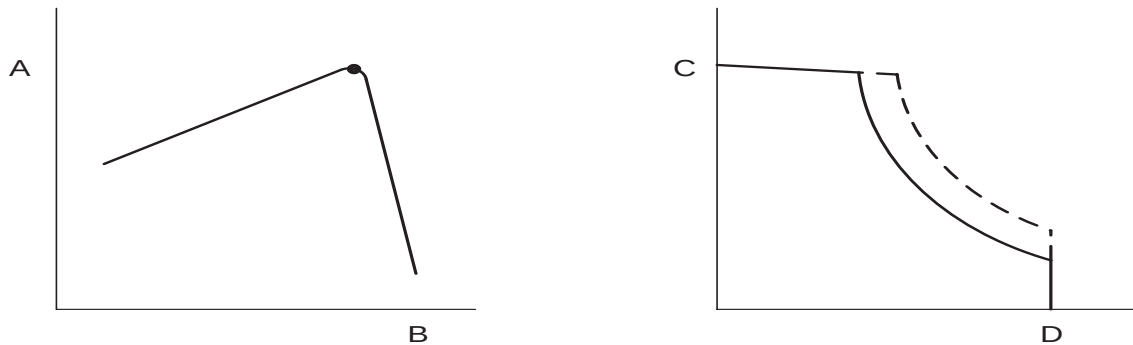
Figure 54

Reference Number	Description
A	Engine Horsepower (hp)
B	Engine Speed (rpm)
C	Pump Discharge Volume (lpm)

Reference Number	Description
D	Pump Discharge Pressure (kg/cm ²)

2. Standard Mode

Standard Mode is used for general work. When this mode is selected it will reduce noise and fuel consumption in comparison with Power Mode. The epos controller compares the target engine speed with the actual engine speed and controls the signal to the E.P.P.R. valve which in turn varies the pump output quantity and it is the same method with power volume.



FG000581

Figure 55

Reference Number	Description
A	Engine Horsepower (hp)
B	Engine Speed (rpm)

Reference Number	Description
C	Pump Discharge Volume (lpm)
D	Pump Discharge Pressure (kg/cm ²)

3. Economy Mode

Economy mode is used for light loading work. When this mode is selected, it will reduce noise and fuel consumption in comparison with standard mode.

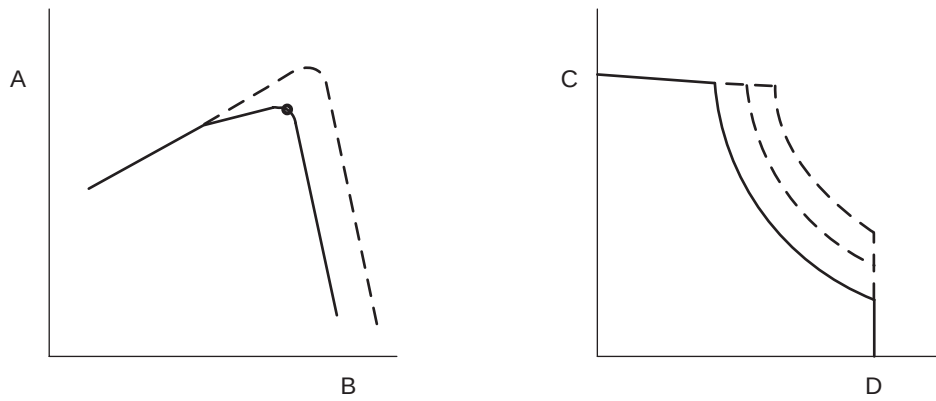
Engine torque curve is changed by ECU.

The e-EPOS controller compares the target engine speed with the actual engine speed and controls the signal to the E.P.P.R. valve which in turn varies the pump output quantity and it is the same method with power volume.



FG013671

Figure 56



FG013633

Figure 57

Reference Number	Description
A	Engine Horsepower (hp)
B	Engine Speed (rpm)

Reference Number	Description
C	Pump Discharge Volume (lpm)
D	Pump Discharge Pressure (kg/cm ²)

4. Operation in case of failure in the control system (Aux mode operation)

Though it is impossible to control current of the E.P.P.R (Electromagnetic Proportional Pressure Reducing) Valve controlling the discharge volume of pump due to fault in control system, the machine can be operated in the aux mode.

Upon turning "ON" the aux mode switch, the E.P.P.R Valve controlling the discharge volume of pump comes into contact with the aux mode resistor to let current of a certain value flow. At this time, the discharge volume of pump follow the control by the pump regulator, nearly at quantity roughly similar to that in the standard mode.

POWER / ECONOMY MODE CONTROL - CIRCUIT DIAGRAM

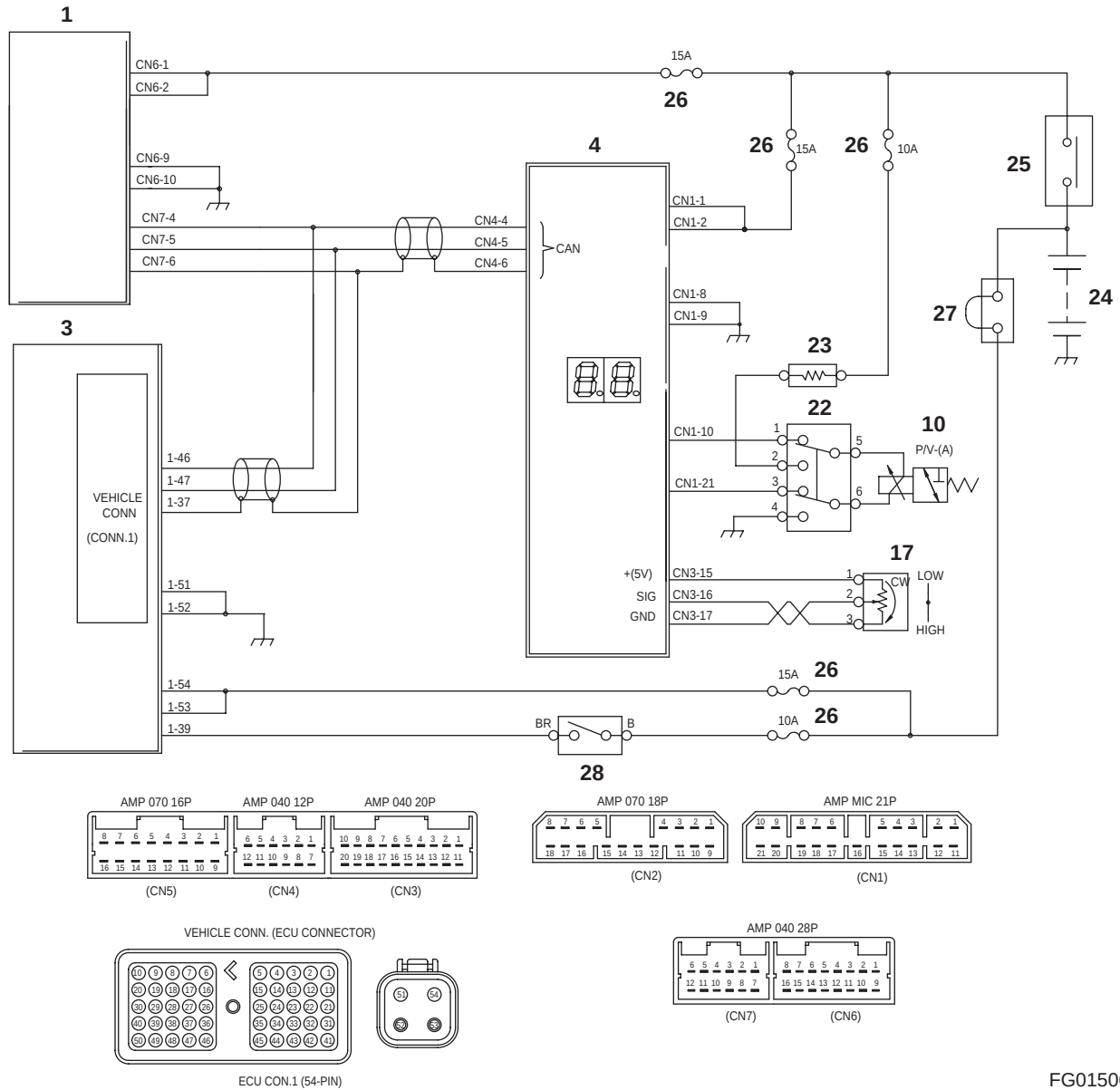


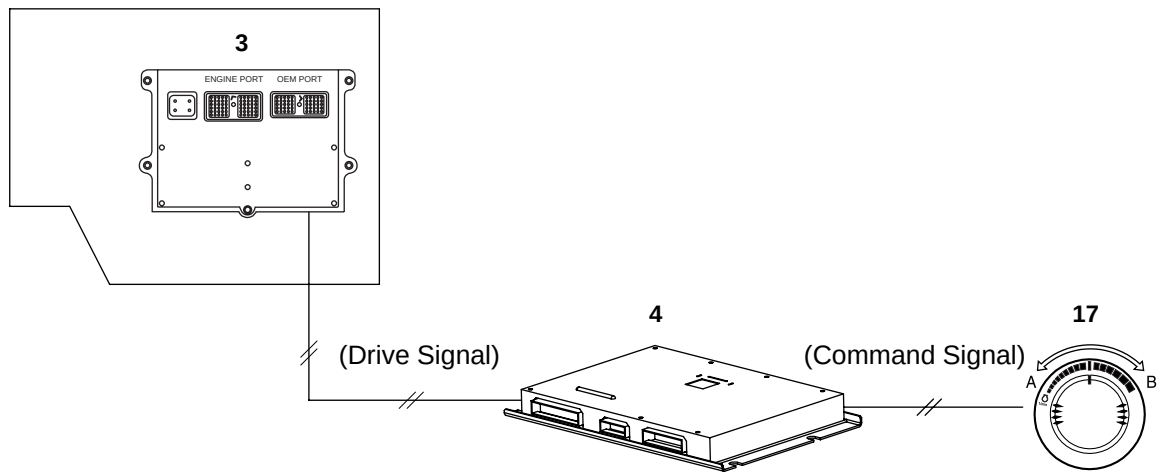
Figure 58

FG015063

Reference Number	Description
1	Instrument Panel
3	Engine Controller
4	e-EPOS Controller
10	E.P.P.R. Valve (Electromagnetic Proportional Pressure Reducing)
17	Engine Control Dial
22	Aux Mode Switch

Reference Number	Description
23	Aux Mode Resistor
24	Battery
25	Battery Relay
26	Fuse
27	Fusible Link
28	Starter Switch

ENGINE CONTROL SYSTEM



FG015092

Figure 59

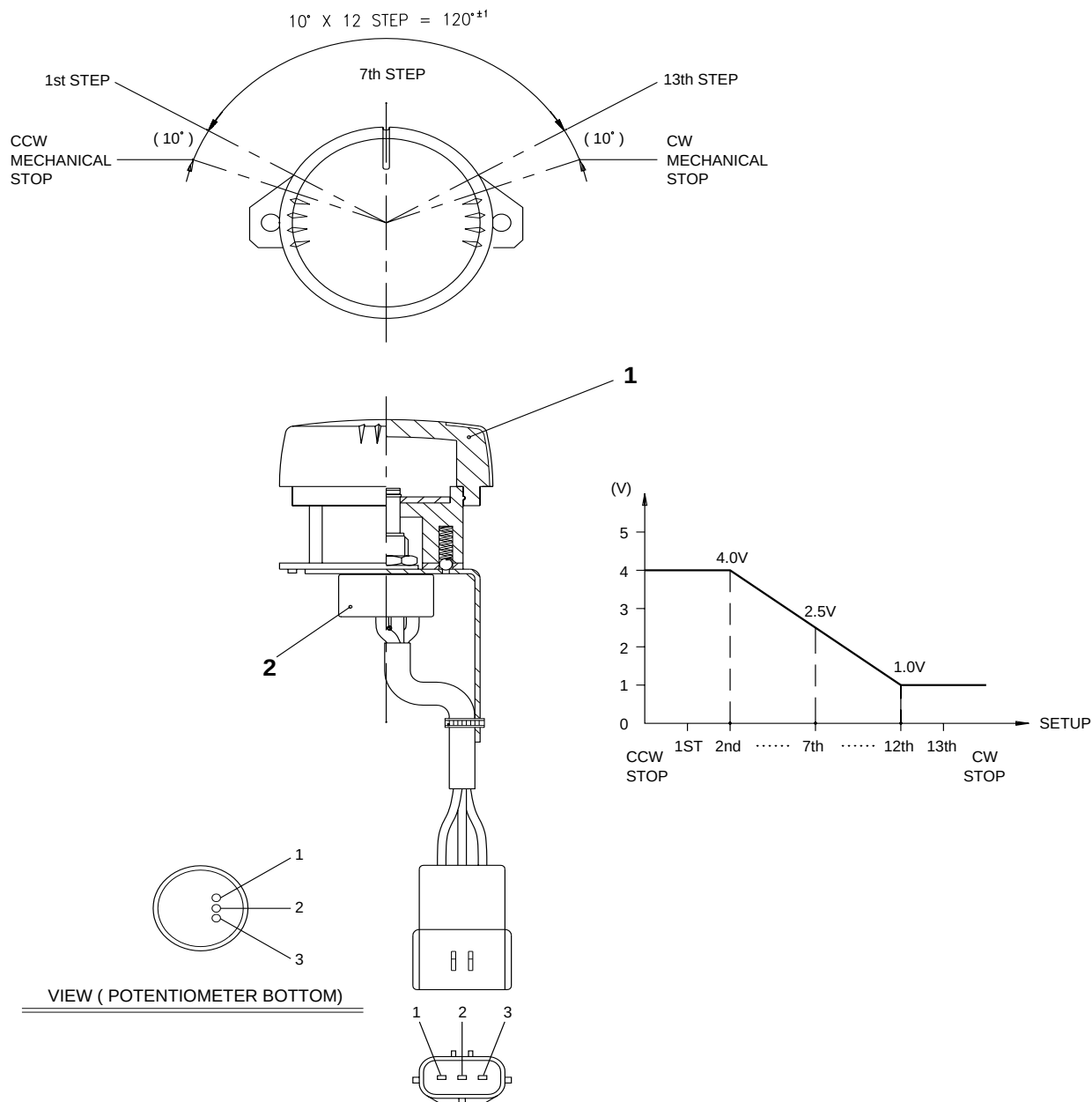
Reference Number	Description
3	Engine Controller
4	e-EPOS Controller

Reference Number	Description
17	Engine Control Dial

When the engine control dial is moved the output voltage changes according to the dial position.

The e-EPOS controller converts this output voltage of dial to digital signal and sends it to the engine controller by CAN line. According to the dial command, the quantity of fuel injection is adjusted.

ENGINE CONTROL DIAL



FG000866

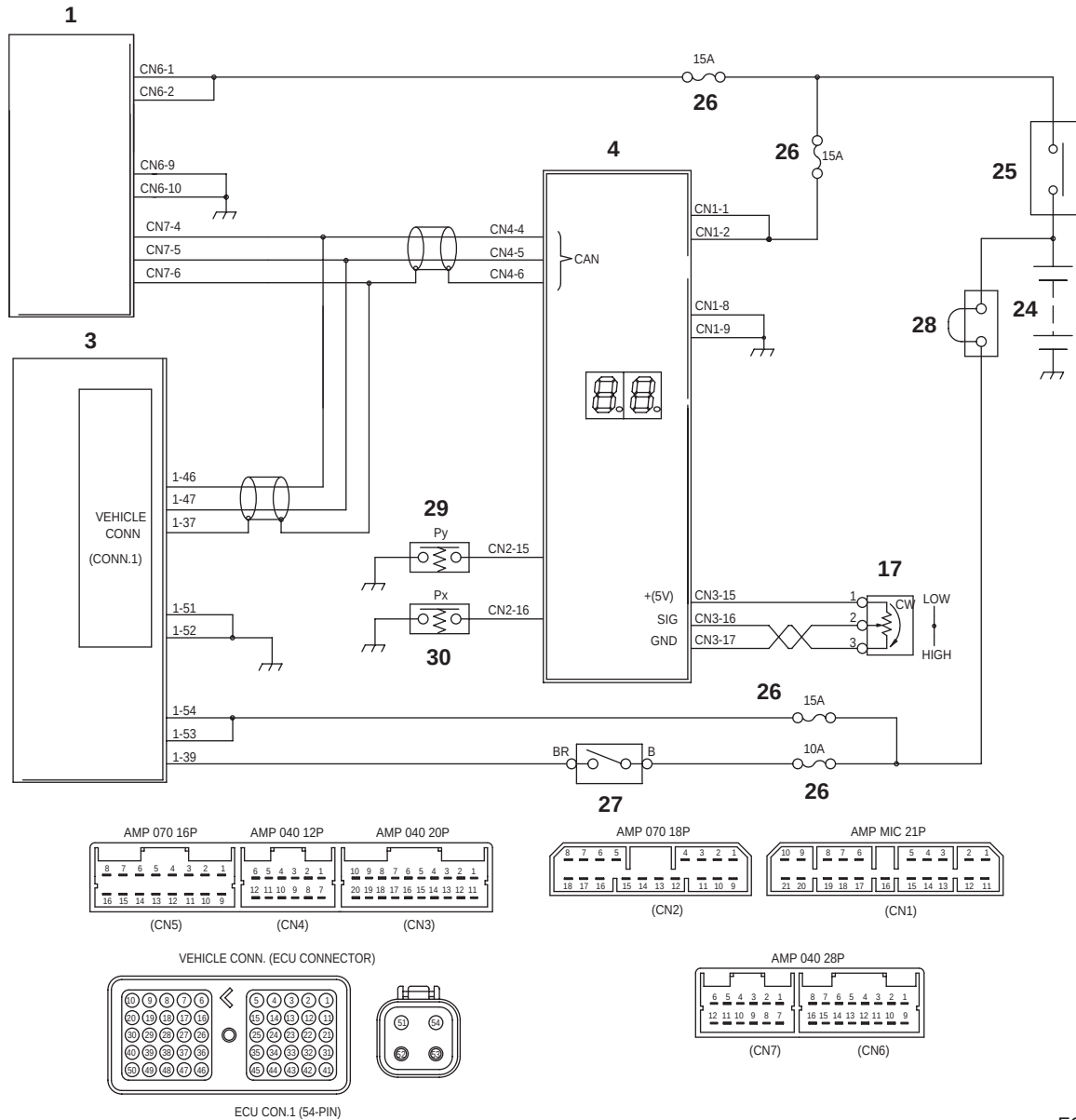
Figure 60

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 the 5 V supplied from the e-EPOS controller as shown in the graph.

ENGINE CONTROL CIRCUIT DIAGRAM



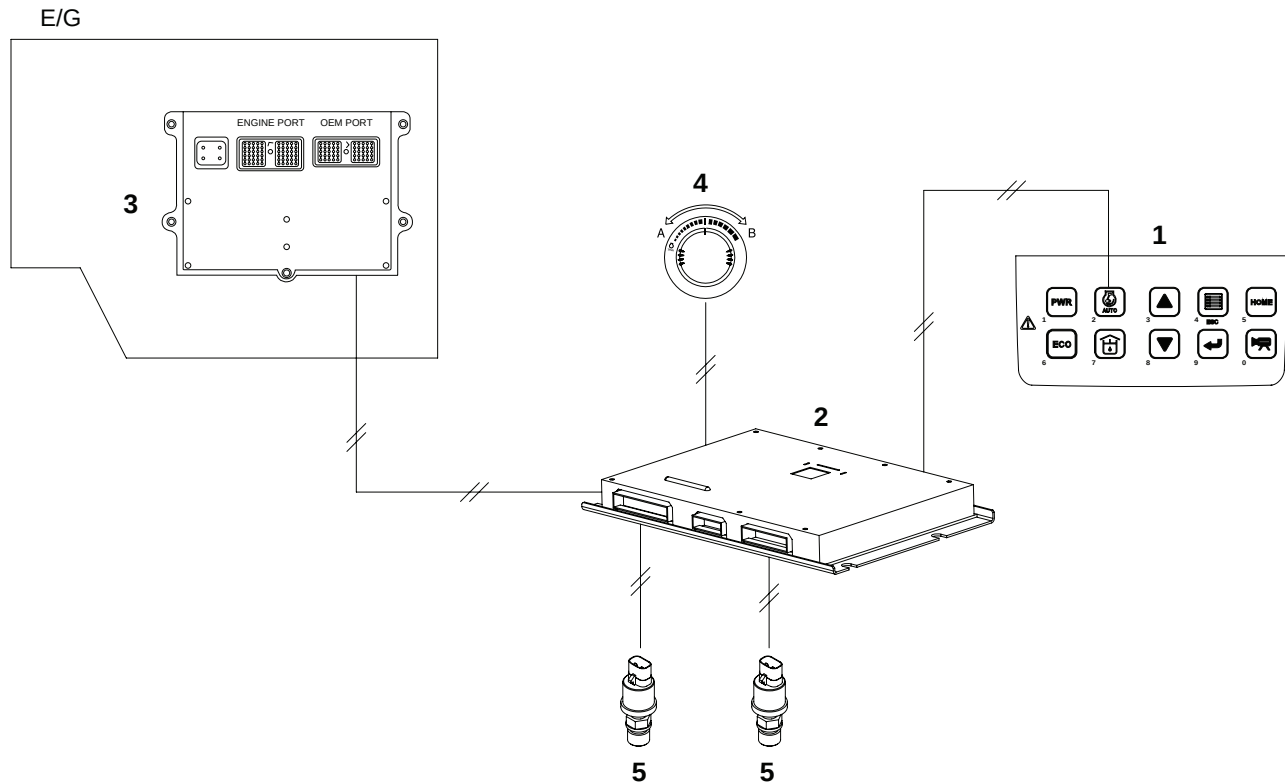
FG015065

Figure 61

Reference Number	Description
1	Instrument Panel
3	Engine Controller
4	e-EPOS Controller
17	Engine Control Dial
24	Battery
25	Battery Relay

Reference Number	Description
26	Fuse
27	Starter Switch
28	Fusible Link
29	Pressure Switch (Py)
30	Pressure Switch (Px)

AUTOMATIC DECELERATION CONTROL (AUTO IDLE CONTROL)



FG015093

Figure 62

Reference Number	Description
1	Instrument Panel (Auto Idle Switch)
2	e-EPOS Controller

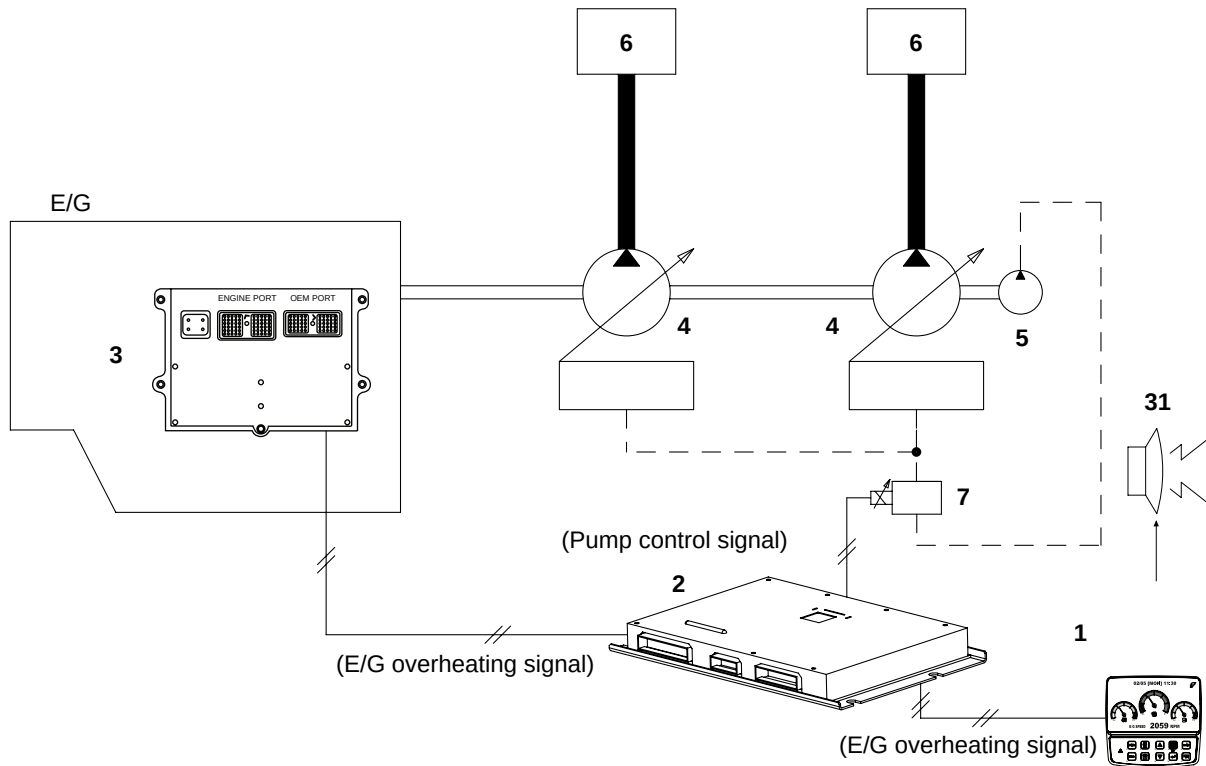
Reference Number	Description
3	Engine Controller
4	Engine Control Dial
5	Pressure Switch

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 this switch in the select position. Approximately 4 seconds after this function is selected, if all work levers are in the neutral position, the e-EPOS controller compares the automatic reduction signal with the signal set by engine control dial. The lower of the two signals is selected, the e-EPOS controller sends a signal to the engine controller to control the engine speed.

The neutral status of the machine is detected by the two pressure switches in the control valve. When the work levers are in the neutral position, the switch is in the "OFF" position.

ENGINE OVERHEAT PROTECTION SYSTEM



FG015094

Figure 63

Reference Number	Description
1	Instrument Panel
2	e-EPOS Controller
3	Engine Controller
4	Main Pump
5	Aux Pump

Reference Number	Description
6	Control Valve
10	E.P.P.R. Valve (Electromagnetic Proportional Pressure Reducing Valve)
31	Warning Buzzer

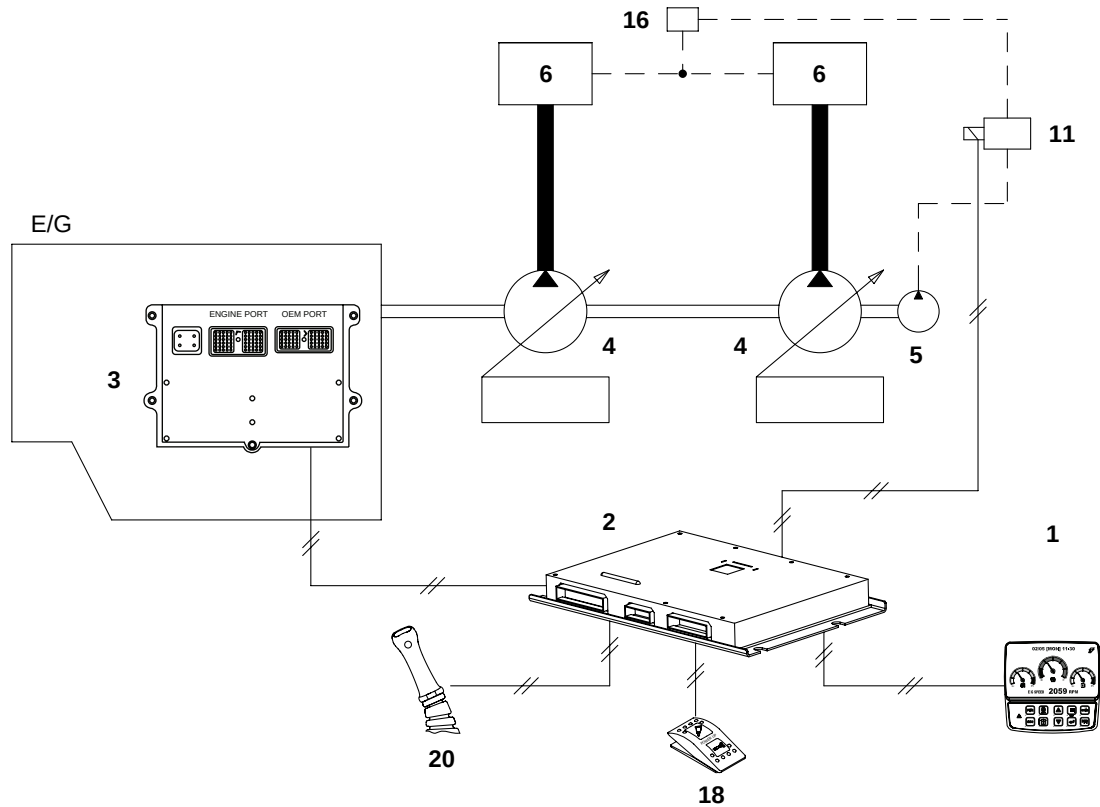
When the engine coolant temperature increases to over 107°C (225°F), the engine controller detects it from the sensor mounted in the coolant line and will send a signal to the e-EPOS controller. The e-EPOS controller sends a overheat signal to the instrument panel turning "ON" the warning light and buzzer simultaneously.

Also, the e-EPOS controller returns an overheat signal to the engine controller and changes power mode to standard mode. The engine speed is then set to a low speed by the engine controller.

When coolant temperature falls below 95°C (203°F), normal operation will resume.

POWER BOOST MODE

Operation



FG015095

Figure 64

Reference Number	Description
1	Instrument Panel
2	e-EPOS Controller
3	Engine Controller
4	Main Pump
5	Aux Pump
6	Control Valve

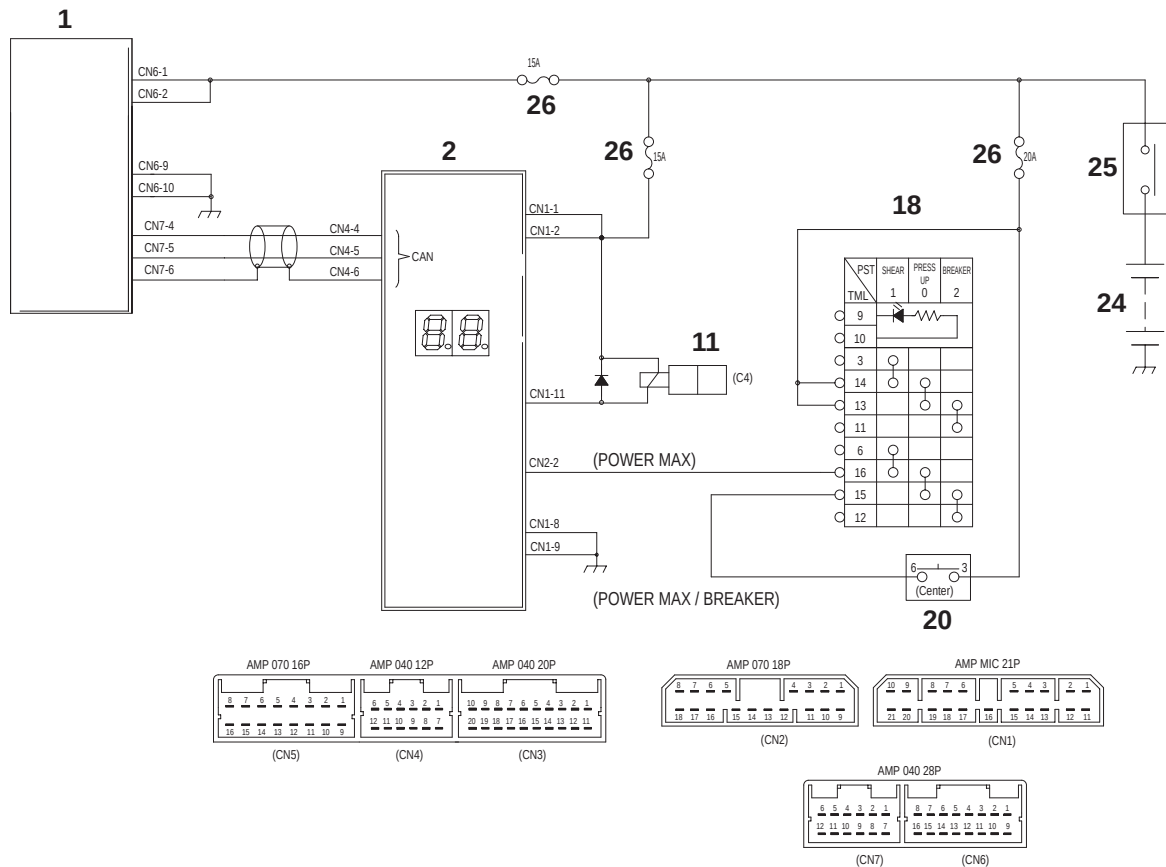
Reference Number	Description
11	Solenoid Valve (Boost)
16	Main Relief Valve
18	Breaker/Boost/Shear Selector Switch
20	Power Boost Switch (Top of Right Work Lever)

The Power Boost function is used to temporarily increase the main relief pressure to enhance excavation ability. When the breaker/boost/shear selector switch is set to "BOOST" and the power boost button on the center of the right-hand work lever (joystick) is pressed during work, the e-EPOS controller will activate the power boost solenoid valve and increase the relief valve pressure from 330 - 350 kg/cm² (4,700 - 5,000 psi). The excavation ability is increased by approximately 6%.

When the power boost function is in activated, a power boost symbol appears on the information display department of instrument panel.

NOTE: *Do not use this switch for more than 10 seconds.*

Power Boost Control - Circuit Diagram



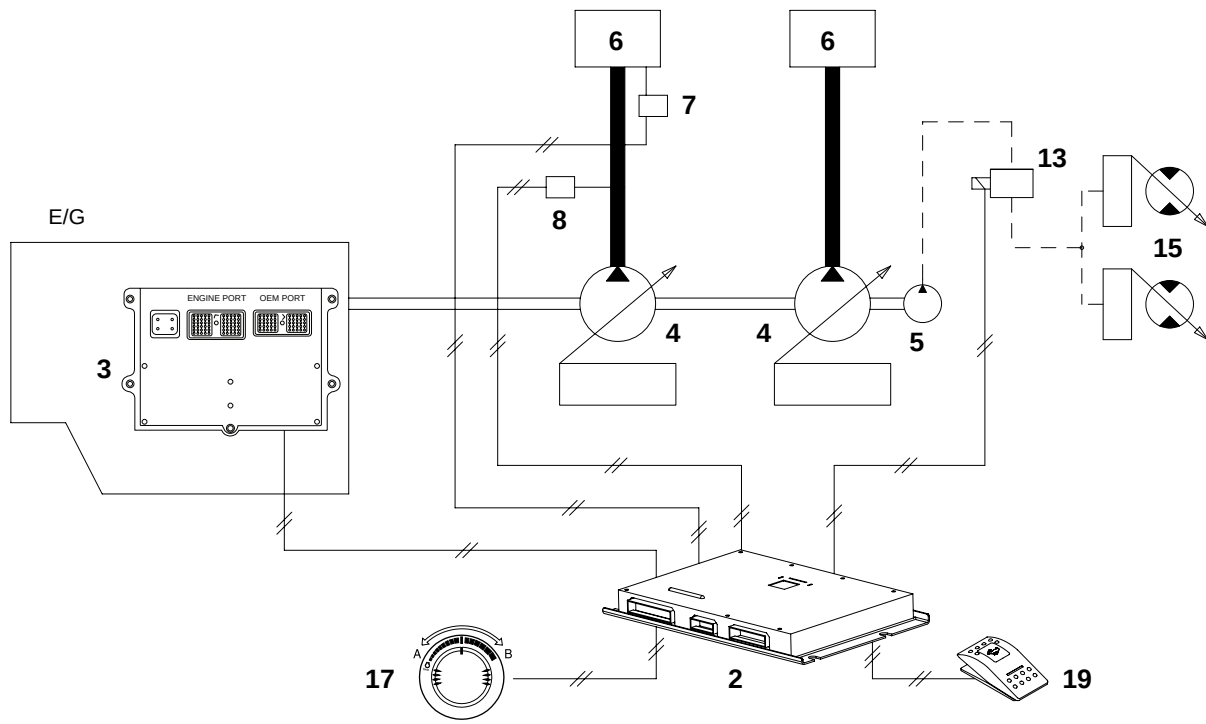
FG000586

Figure 65

Reference Number	Description
1	Instrument Panel
2	e-EPOS Controller
11	Solenoid Valve (Pressure Up)
18	Breaker/Boost/Shear Selector Switch

Reference Number	Description
20	Power Boost Switch (Top of Right Work Lever)
24	Battery
25	Battery Relay
26	Fuse

AUTOMATIC TRAVEL SPEED CONTROL



FG015096

Figure 66

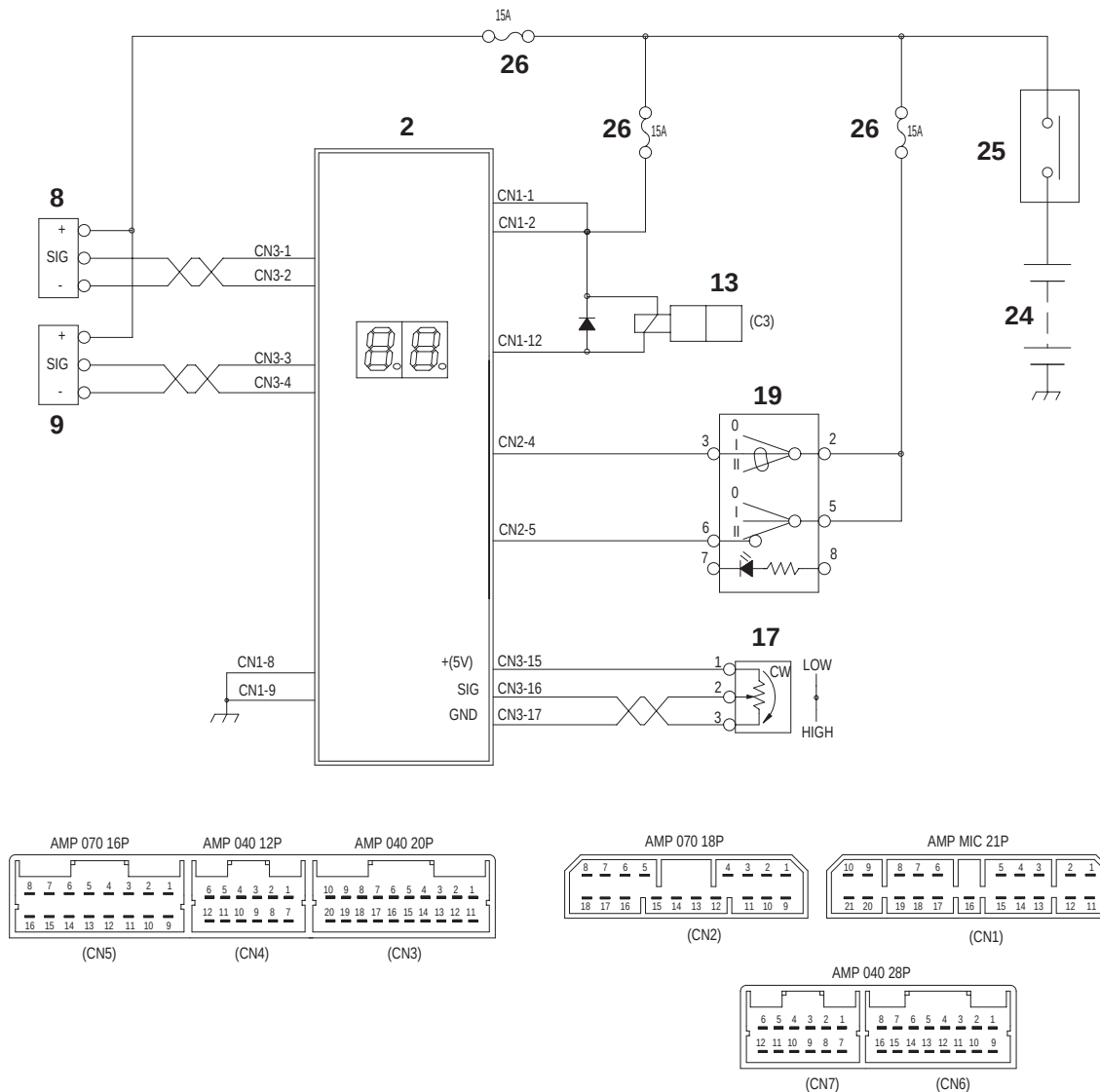
Reference Number	Description
2	e-EPOS Controller
3	Engine Controller
4	Main Pump
5	Aux Pump
6	Control Valve
7	Pressure Switch (Py Port)

Reference Number	Description
8	Pump Pressure Sensor
13	Solenoid Valve (High speed)
15	Travel Motor
17	Engine Control Dial
19	Selector Switch For Automatic Travel

If the automatic travel speed control switch is set to the "OFF" position, the travel motor will run in the I-speed (low speed) range. If the selector switch is set to the "I" position, the travel motor will run in the II-speed (high speed) range. If the selector switch is set to the "II" position, the e-EPOS controller will monitor the main pump discharge pressure and automatically select the "ON" - "OFF" status of the II - speed travel solenoid valve based on the travel load. The travel speed is changed between the I-speed and the II-speed mode.

The travel load is monitored by the two pressure sensors in the discharge lines of the front (upper) and rear (lower) pumps. When the travel load is high (pressure over 300 kg/cm^2 (4,300 psi) the solenoid valve is turned "OFF" and I-speed (low) is selected. In the case when the travel load is low (pressure under 160 kg/cm^2 (2,280 psi), the solenoid valve will be turned "ON" and the II-speed will be selected. But, if the engine speed control switch dial is set below approximately 1400 rpm, the travel speed will be set to I-speed mode.

Automatic Travel Speed Control - Circuit Diagram



FG000587

Figure 67

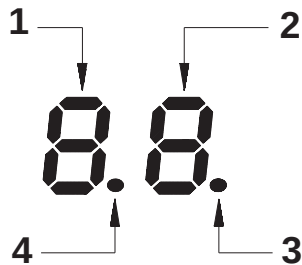
Reference Number	Description
2	e-EPOS Controller
8	Pressure Sensor (Front Pump)
9	Pressure Sensor (Rear Pump)
13	Solenoid Valve (High speed)
17	Engine Control Dial

Reference Number	Description
19	Selector Switch For Automatic Travel
24	Battery
25	Battery Relay
26	Fuse

SELF-DIAGNOSTIC FUNCTION

e-EPOS Controller

The system operation status and malfunction codes can be checked through the display on top of the e-EPOS controller box the rear cover behind the operator's seat.



FG000588

Figure 68

Reference Number	Description
1	Upper Digit
2	Lower Digit
3	Engine Speed Monitor LED (Flash Interval Increases With Engine Speed.)

Reference Number	Description
4	Power Monitor (Stays "ON" While Power Is In Normal Range,)

1. Power Monitor

This LED is turned "OFF" when the input voltage to the e-EPOS controller is below 18.5 ± 1 V or above 32.5 ± 1 V. Stays "ON" while in normal range.

2. Engine Speed Monitor

This LED light flashes according to the engine speed. The flashing interval is proportional to the engine speed.

3. Normal Operation Display Readout

Mode Selection		Display Readout		Operation Status
		Upper Digit	Lower Digit	
Power Mode	Power Mode	9 HAOH340L	0 HAOH370L	Normal Operation Power Mode
	Standard Mode	7 HAOH350L	0 HAOH370L	Normal Operation Standard Mode
	Economy Mode	5 FG013637	0 HAOH370L	Normal Operation Economy Mode

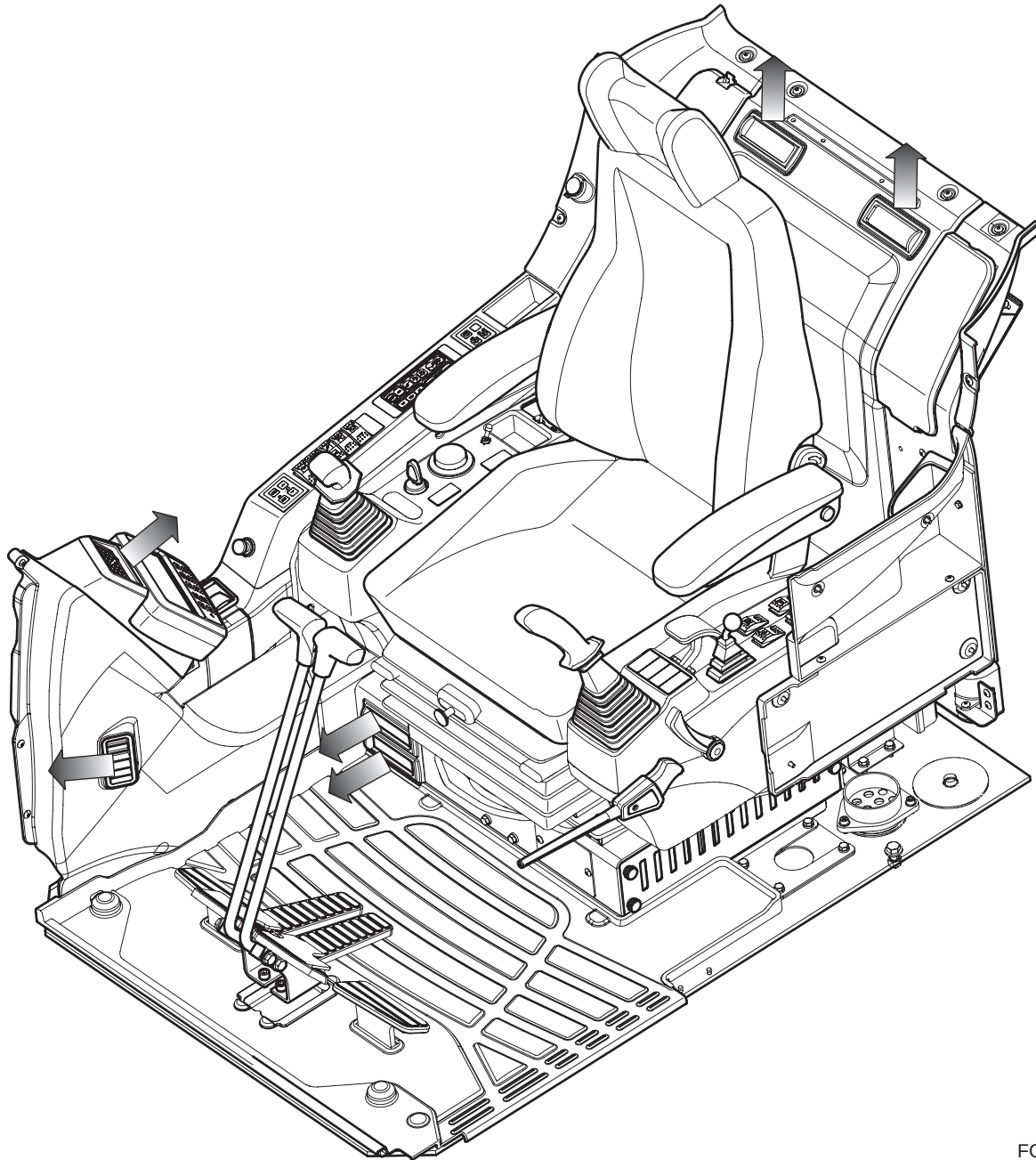
4. Communication Monitor

What are shown in the 7-SEGMENT LED are same as those in the Error Codes.

Error Code	Indication Code	Fault Location
V201	01	Communication error in instrument panel.
V202	02	Communication error in engine controller.

AIR CONDITIONER SYSTEM

Outline



FG014384

Figure 69

Solid-type heater and air conditioner are installed in the cover below the operator's seat.

Temperature of the operator's room is adjusted automatically to the temperature set by operator.

Internal and External Filters

Internal and external air purification filters are installed for the operator's room.

Filters should be cleaned every 500 hours.

If machine operates in an excessively contaminated environment, filters should be cleaned more frequently and if necessary, replaced with new ones.

How to Check Internal Air Filter

1. Open cover by turning knob indicated and mounted on the lower end of operator's seat.
2. Disassemble internal filter, then clean the polluted filter using compressed air.
3. Assemble it by closing the cover and turning the knob.

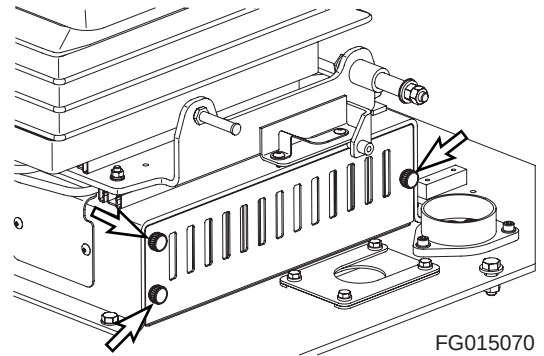


Figure 70

How to Check External Air Filter

1. Open cover by turning knob mounted on the backside of operator's seat.
2. Disassemble internal filter, then clean the polluted filter using compressed air.
3. Assemble it by closing the cover and turning the knob.

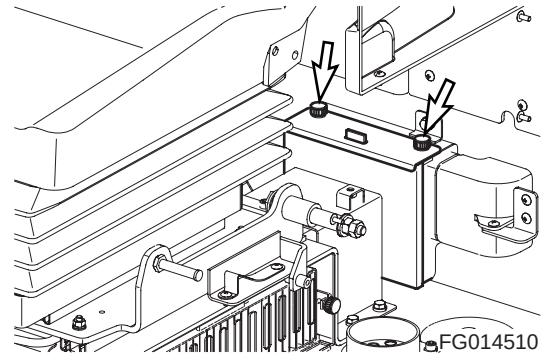


Figure 71

Air-Conditioning System Layout

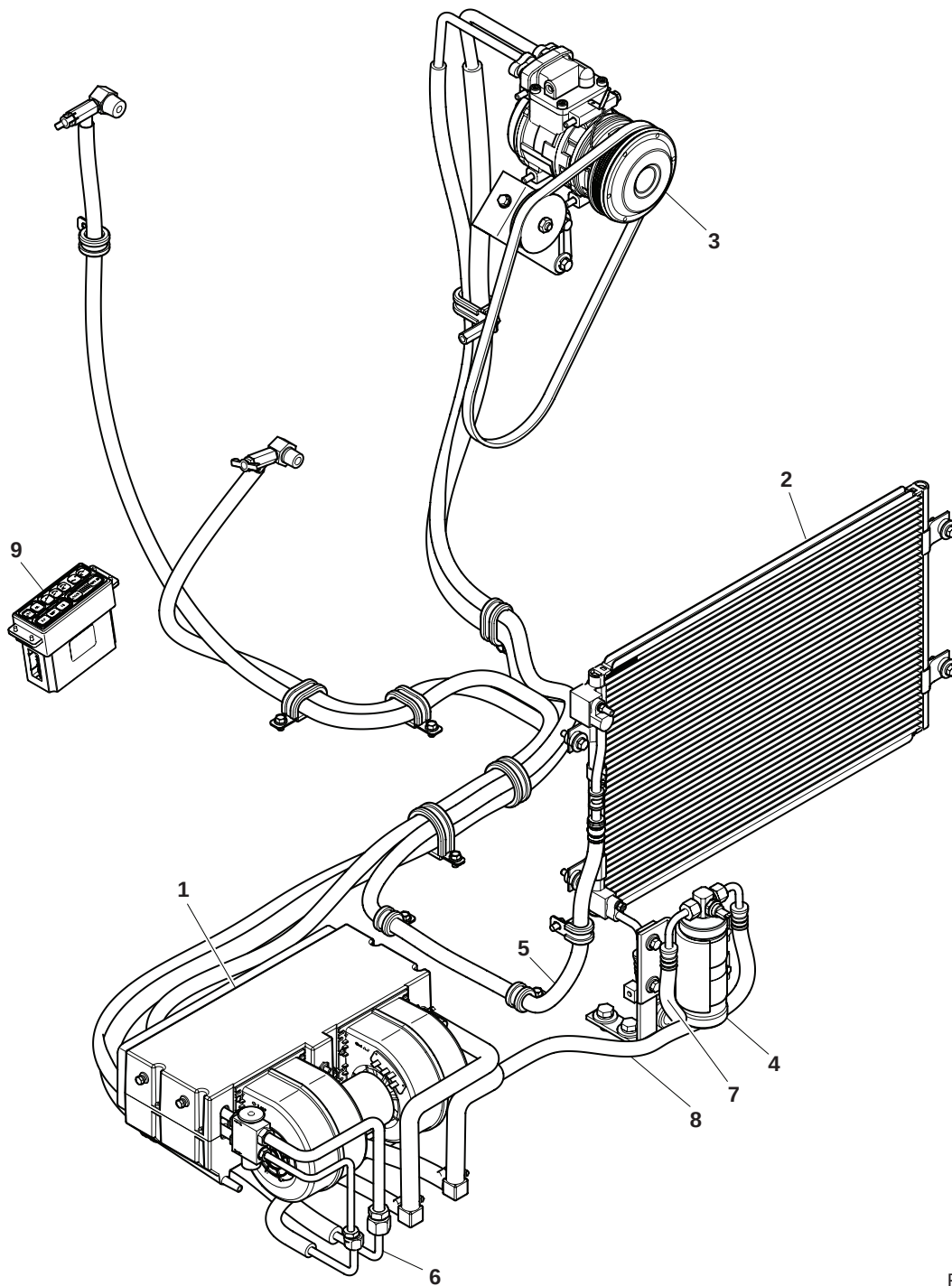


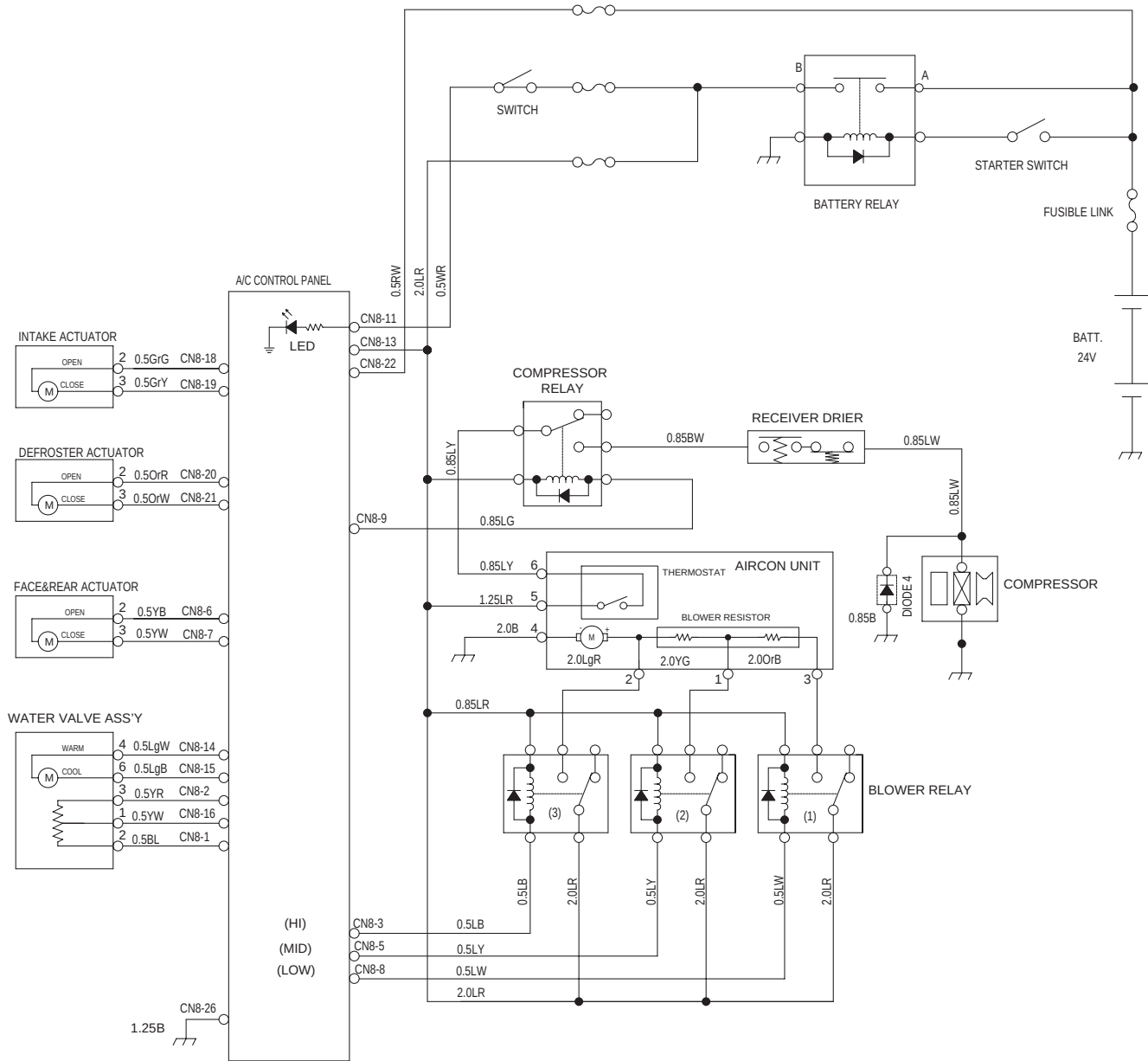
Figure 72

FG015075

Reference Number	Description
1	Air Conditioner/heater Unit
2	Condenser
3	Compressor
4	Receiver Dryer
5	Discharge Hose

Reference Number	Description
6	Suction Hose
7	Liquid Hose (1)
8	Liquid Hose (2)
9	Control Panel

Air Conditioner/heater Circuit Diagram

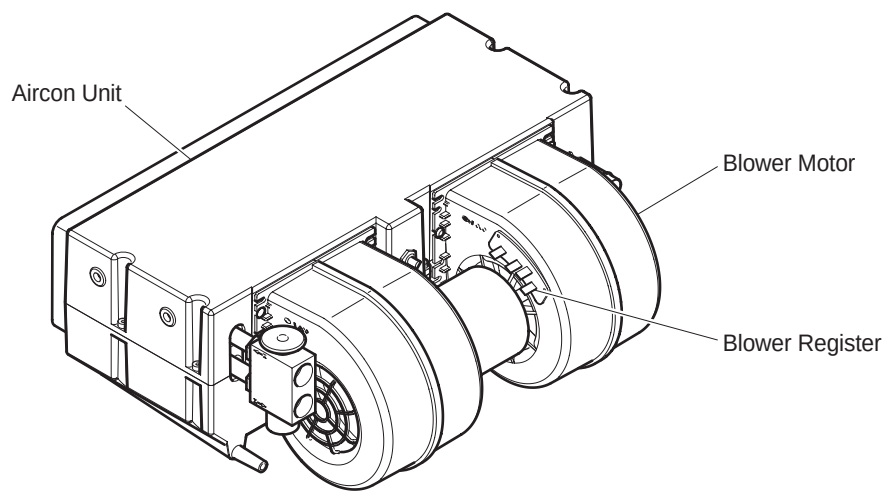


FG015071

Figure 73

Air Conditioner/heater Unit

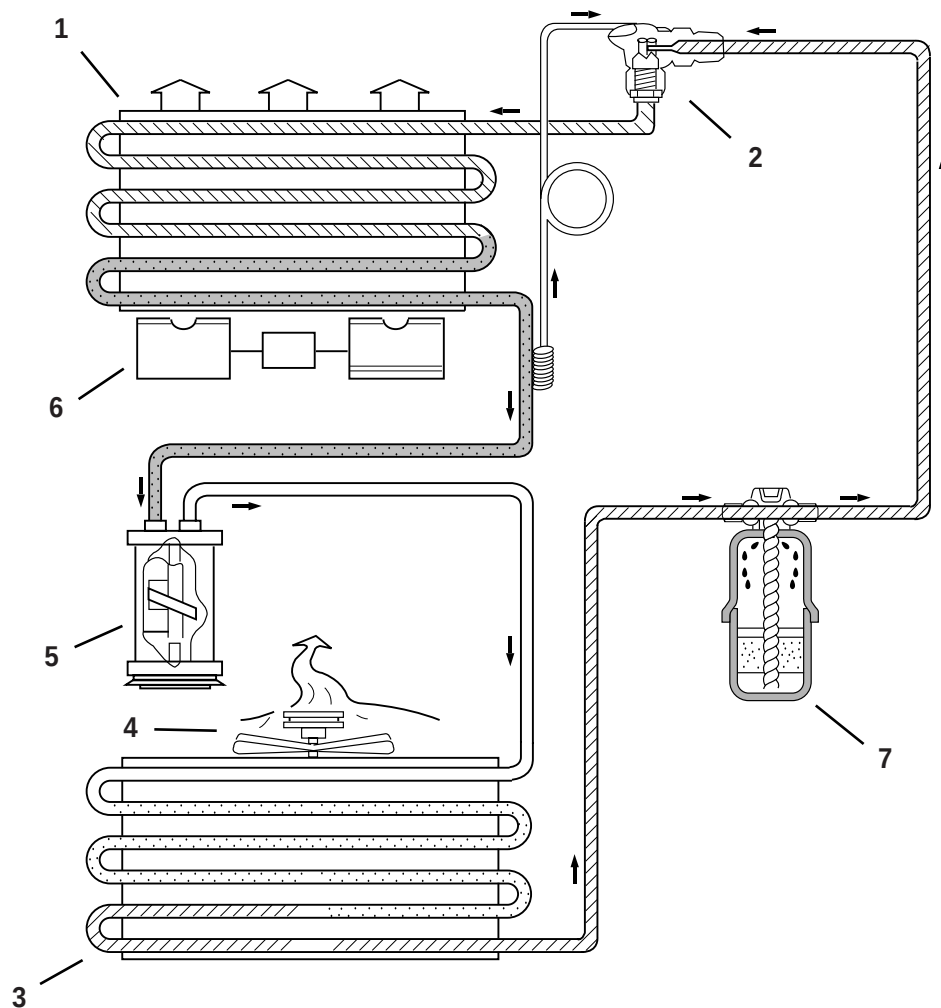
Air Flow Diagram



FG015097

Figure 74

REFRIGERANT CIRCULATION



HBOI020L

Figure 75

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

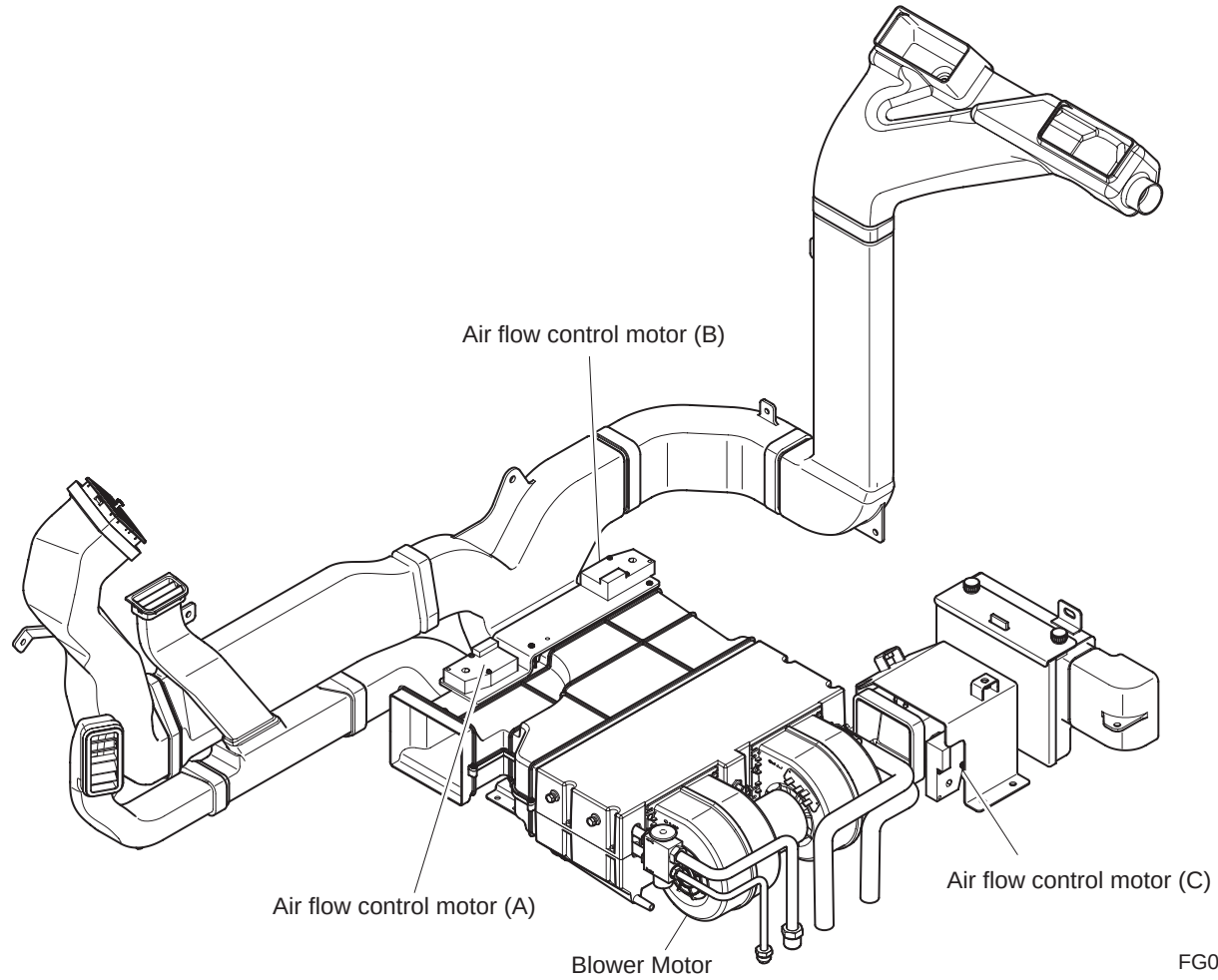
- Refrigerant (R134a) is compressed to approximately 15 kg/cm² (210 psi) within the compressor.
- The compressed refrigerant flows into the condenser at high temperature (approximately 80°C (176°F)).
- The refrigerant in the condenser is cooled to approximately 60° by the condenser fan. At this time 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 Flow Control

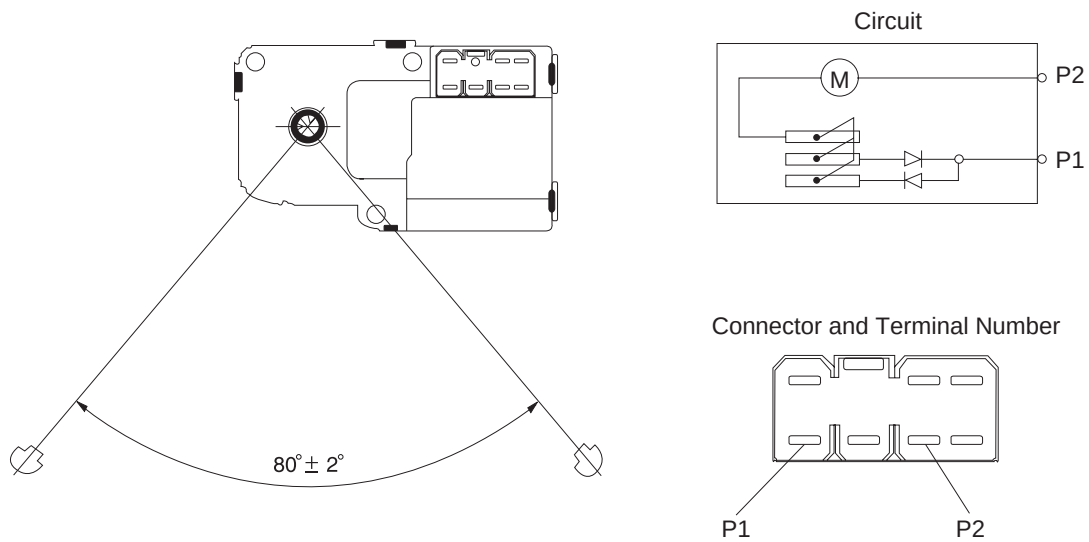


FG015098

Figure 76

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

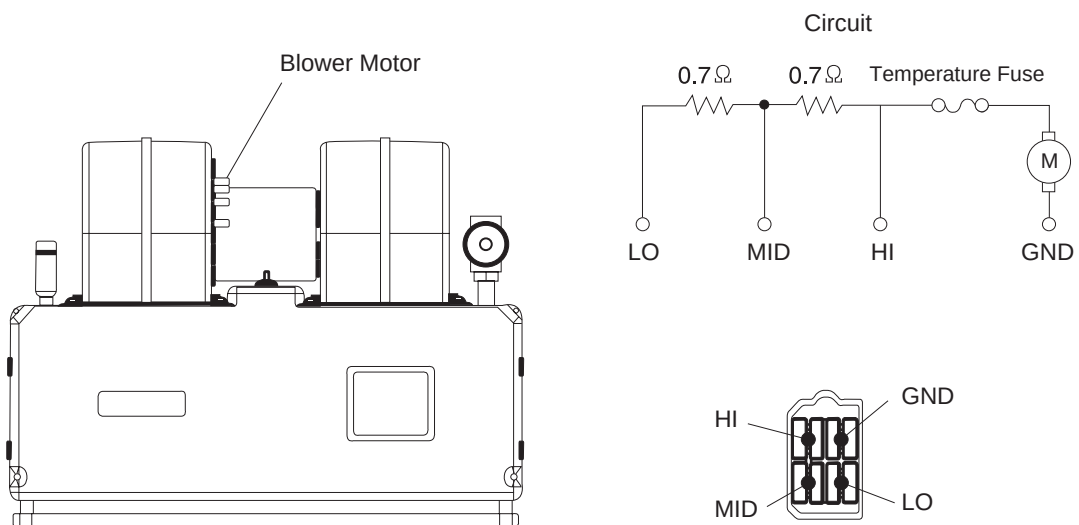
Air Flow Control Motor



FG015099

Figure 77

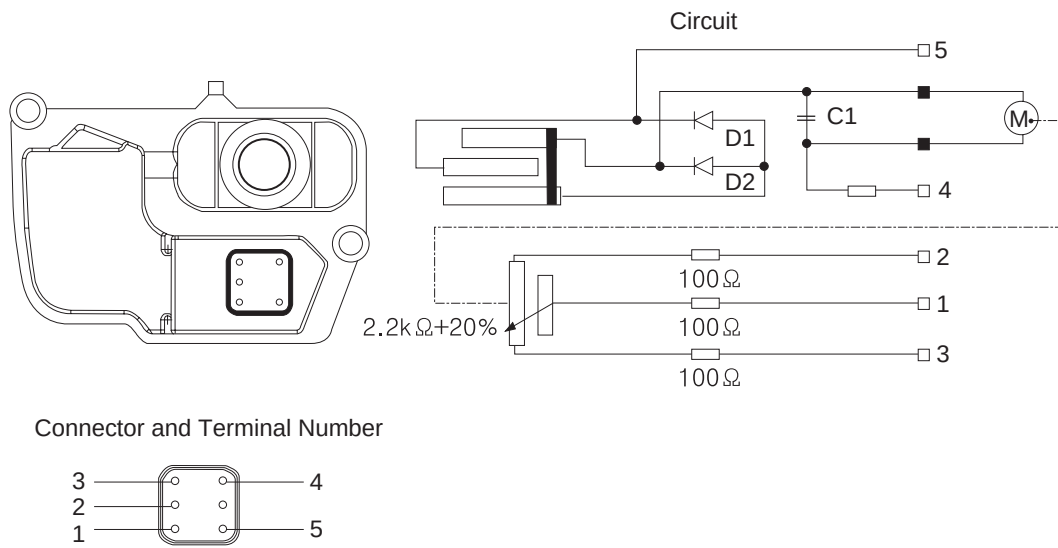
Blower Motor



FG015100

Figure 78

Coolant Flow Control Valve



FG015101

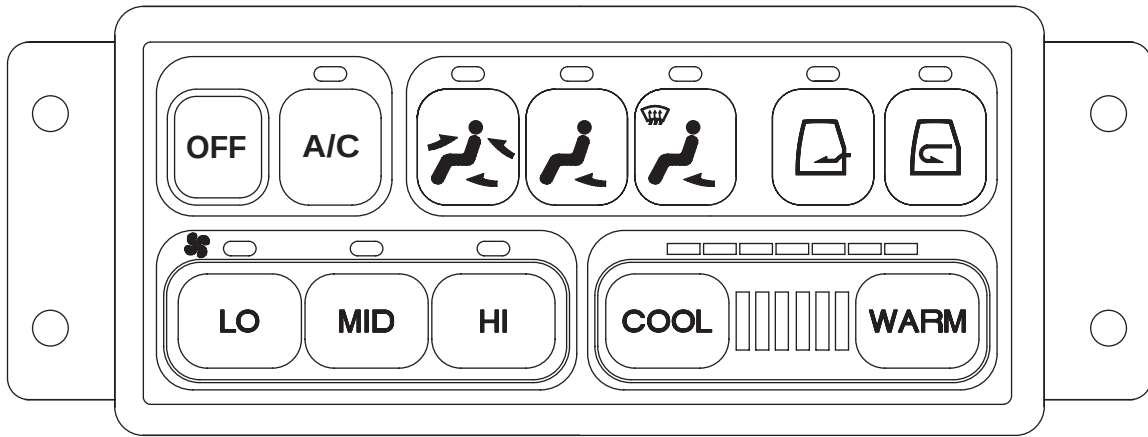
Figure 79

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

Control Panel

Appearance and Terminal Arrangement



FG015072

Figure 80

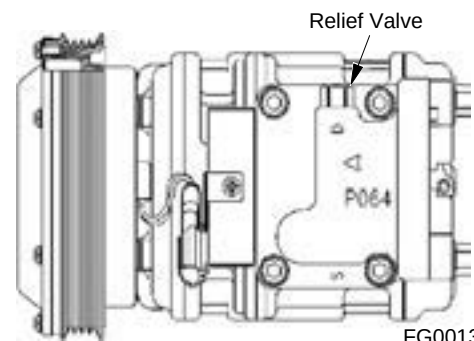
Refer to "Air Conditioner and Heater" of operation manual.

Compressor

Categories	Specifications
Output	155.3 cc/rev
Oil Level	120 cc (ND-OIL8)
Refrigerant	R134a
Rated Voltage	24V
Relief Valve	Open: 35 - 42.2 kg/cm ² G Close: 28.1 kg/cm ² G

Compressor sucks in refrigerant which evaporates completely in the evaporator and discharges it to the condenser.

Refrigerant undergoes repeated status change in the order of liquid, gas, and liquid in the freezing cycle, and the compressor makes evaporated refrigerant a high temperature and high-pressured gas to freeze it in the condenser.



FG001365

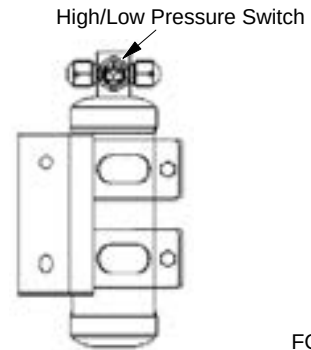
Figure 81

Receiver Dryer

The receiver dryer reserves refrigerant enough to ensure smooth freezing cycle responding immediately to the change of level in the freezing cycle.

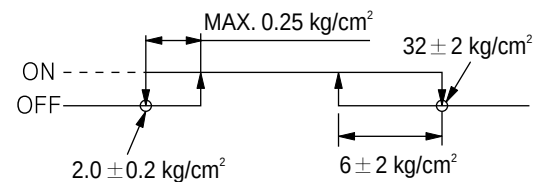
As liquid refrigerant from the condenser may contain refrigerant gas with bubbles whose presence in the expansion valve decreases the freezing power excessively, it separates liquid and gas and sends liquid only to the expansion valve.

Water in refrigerant shall be eliminated with dryer and through filter.



FG001366

Figure 82



FG001462

Figure 83

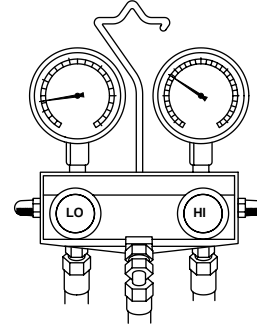
Volume of refrigerant by model

Model	Volume of Refrigerant
DX140LCR	550 ± 20 grams
DX140LC	800 ± 20 grams
DX225LC	800 ± 20 grams
DX225NLC	800 ± 20 grams
DX300LC	800 ± 20 grams
DX340LC	800 ± 20 grams
DX420LC	800 ± 20 grams
DX480LC	800 ± 20 grams
DX520LC	800 ± 20 grams

TROUBLESHOOTING

Refrigerant Pressure Check

1. Open all doors and windows.
2. Install manifold gauge set.
3. Start engine and maintain engine speed at 1,800 - 2,000 rpm.



HDA6074L

Figure 84

4. Check high / low-pressure of refrigerant.

1	High-pressure: 8.0 - 10.0 kg/cm ² (114 - 142 psi)		
	Low-pressure: Approximately 1.0 kg/cm ² (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/cm ² (327 psi)		
	Low-pressure: Approximately 2.5 - 3.0 kg/cm ² (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/cm ² (285 - 356 psi)		
	Low-pressure: Approximately 2.5 - 3.5 kg/cm ² (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 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: 13.0 - 19.0 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 - 18 kg/cm ² (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: <i>When the absorbed moisture freezes the pressure readings may look normal. Careful readings should be made to determine whether pressure is in normal range.</i>
	1. Recover any remaining refrigerant. 2. Vacuum out system. 3. Recharge system.
	NOTE: <i>If the system has been exposed to the air for a long period of time, replace the receiver dryer.</i>

6	High-pressure: Over 22.0 - 23 kg/cm ² (313 - 327 psi)		
	Low-pressure: 2.5 kg/cm ² (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 - 11.0 kg/cm ² (100 - 156 psi)
	Low-pressure: 4.0 - 6.0 kg/cm ² (57 - 85 psi)
Possible Cause: Low refrigerant pressure due to poor compressor compression.	
Inspect and replace compressor if necessary.	

WEIGHT OF R134a GAS USED IN MACHINES

Model	Weight of Gas
DX140LCR	550 ± 20 grams (19.3 ± 0.7 oz)
DX140LC	800 ± 20 grams (28 ± 0.7 oz)
DX225LC	800 ± 20 grams (28 ± 0.7 oz)
DX225NLC	800 ± 20 grams (28 ± 0.7 oz)
DX300LC	800 ± 20 grams (28 ± 0.7 oz)
DX340LC	800 ± 20 grams (28 ± 0.7 oz)
DX420LC	800 ± 20 grams (28 ± 0.7 oz)
DX480LC	800 ± 20 grams (28 ± 0.7 oz)
DX520LC	800 ± 20 grams (28 ± 0.7 oz)

REFRIGERANT SYSTEM REPAIRS

WARNING

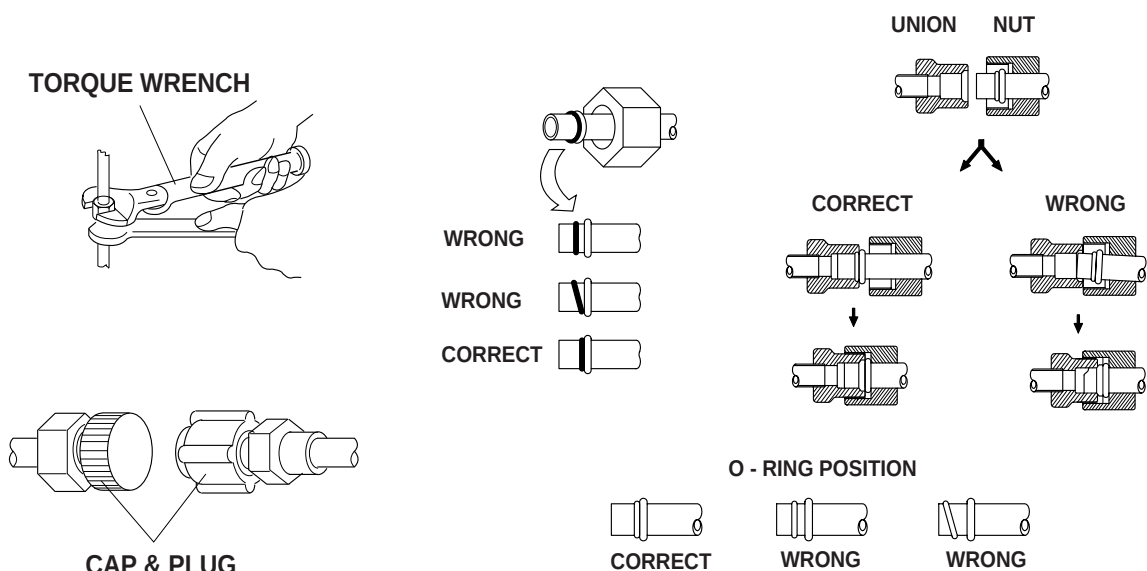
Always wear protective glasses and gloves when handling refrigerant. If refrigerant comes in contact with the skin or eyes, immediately flush with clean, running water and consult a physician.

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



HDA6066L

Figure 85

The following procedures should be observed for safe handling of refrigerant during vacuum and charging process.

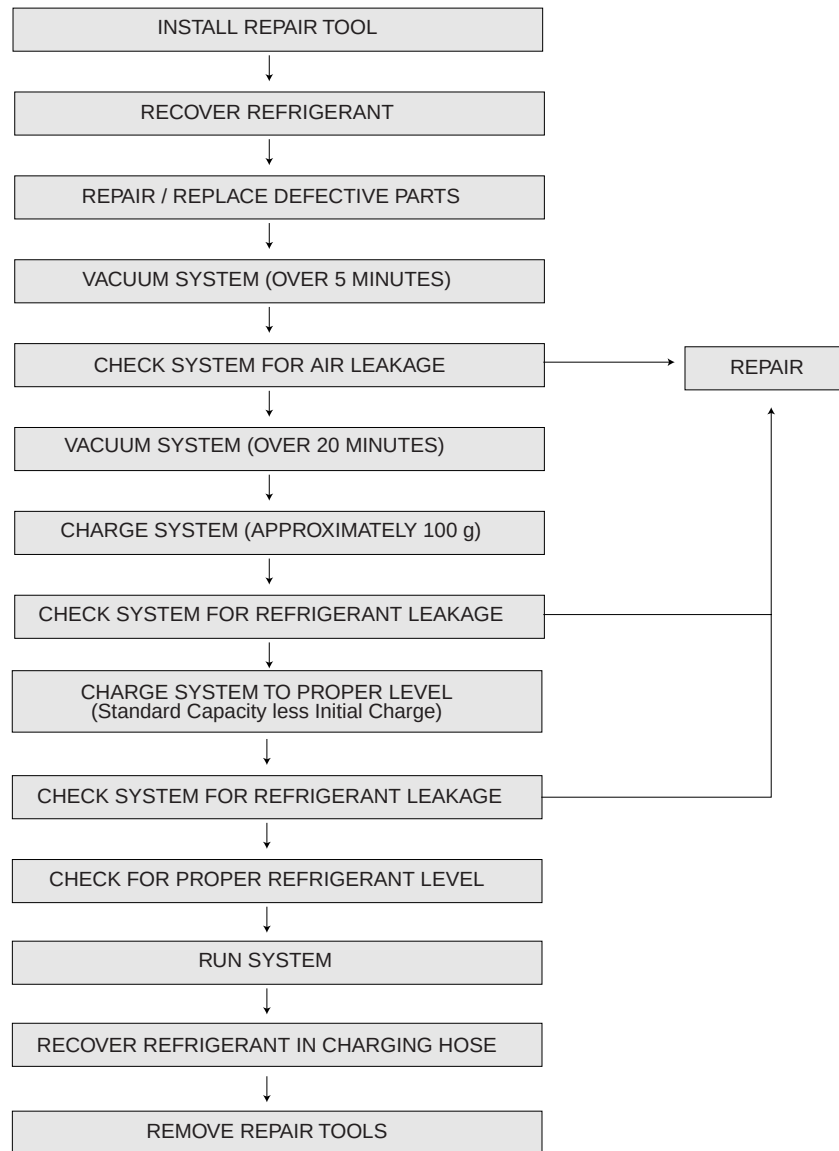
1. Use an approved recovery / charging device which can safely perform vacuum and charge work simultaneously.
2. The new refrigerant has improved cooling characteristics than the old type and care should be used not to overcharge the system.

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 86

Refrigerant Recovery

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

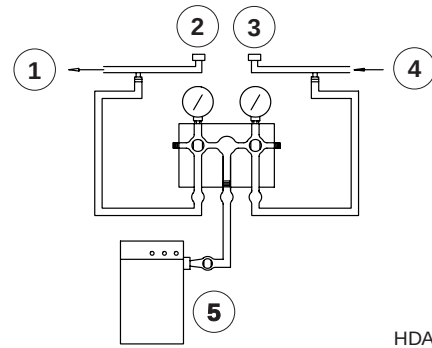
1. Attach the manifold gauges and the refrigerant recovery unit to the refrigerant lines as shown.

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 87

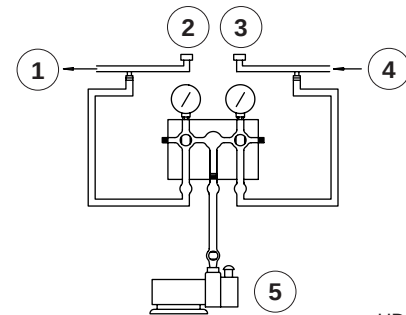
Vacuumping Refrigerant System

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 88

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 counterclockwise 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 disk 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 counterclockwise 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.

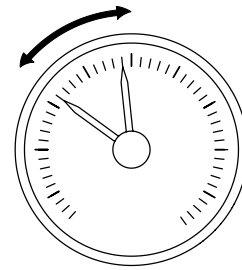


Figure 89

HDA6069L

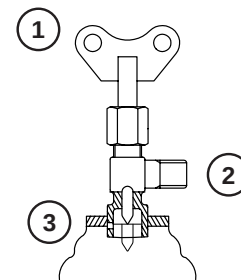


Figure 90

HDA6070L

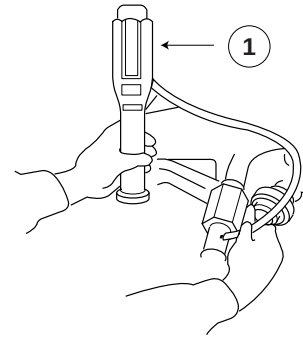
Leakage Check

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 91



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.

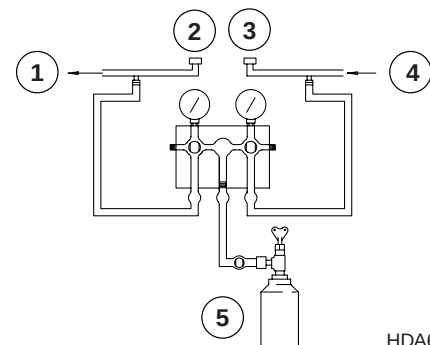
NOTE: First charge the refrigerant system with 100g (3.5 ounces) of refrigerant with the engine off. Then using the manifold gauges as a guide fully charge the system with the engine running.

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 92

3. If refrigerant does not flow freely into system, try starting engine first before operating air conditioner.
 - Temperature control switch setting: Maximum CoolingBlower 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 (22 - 50 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.**

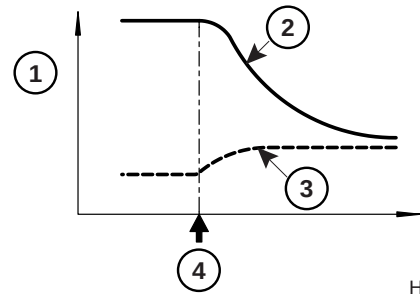
-
5. Close low-pressure side valve.
 6. Shut off engine and close refrigerant supply container adapter valve. Disconnect manifold gauge hoses from vehicle.

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 93

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-conditioning unit.
After stopping engine, insert detector probe into drain hose. (Leave inserted for 10 seconds minimum.)

NOTE: When inspecting leakage from the air-conditioning unit, perform the inspection in a well ventilated area.

WIPER SYSTEM

Wiper Circuit

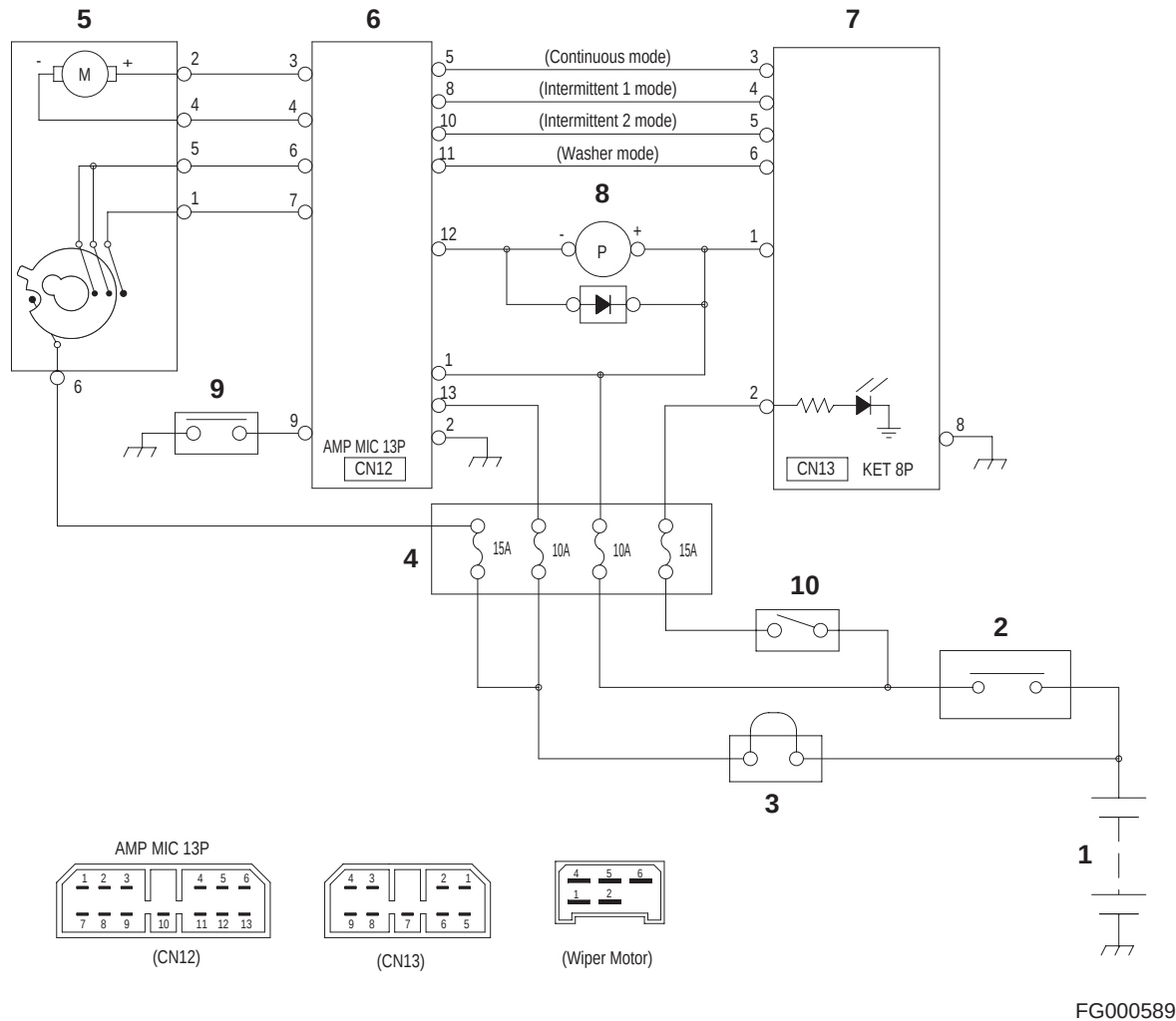


Figure 94

Reference Number	Description
1	Battery
2	Battery Relay
3	Fusible Link
4	Fuse Box
5	Wiper Motor

Reference Number	Description
6	Wiper Controller
7	Wiper Switch Panel
8	Window Washer
9	Wiper Cutoff Switch
10	Light Switch

Wiper operation

Continuous operation

- Operation of wiper motor

Pressing the successive operation switch on the wiper switch panel (7) changes the voltage of the "5" terminal of the wiper controller (6) from HIGH (about $5.5 \pm 0.5V$) to LOW ($0+0.5V$) and also current flows via the "3" terminal of the wiper controller (6) → the "2" and "4" terminals of the wiper motor (5) → the "4" terminal of the wiper controller (6) to run the wiper motor (5) continuously.

- Stop of wiper motor

Pressing again the successive operation switch on the wiper switch panel (7) changes the voltage of the "5" terminal of the wiper controller (6) from LOW ($0+0.5V$) to HIGH (about $5.5 \pm 0.5V$). As the "5" and "6" terminals of the wiper motor are connected still that power is supplied to the "6" terminal of the wiper controller (6),

However, the controller (6) runs the wiper motor continuously and then rotates the motor reversely by letting current flow via the "4" terminal of the wiper controller (6) → the "2" and "4" terminals of the wiper motor (5) → the "3" terminal of the wiper controller (6) when the "1" and "6" terminals of the wiper motor (5) are connected and thus power voltage is supplied to the "7" terminal of the wiper controller (6).

The Wiper motor (5) stops reverse revolution when the contact of a cam switch connected to the "6" terminal of the wiper motor (5) moves to an insulation area of the cam plate to disconnect the "5" and "6" terminals of the wiper motor (5).

When the wiper motor (5) stops, arm and blade connected to it move to the stop positions of the right pole in the cabin.

Intermittent operation

- Intermittent 1st (3-second)

Pressing once the Intermittent switch in the switch panel (7) changes voltage of the "8" terminal in the wiper controller (6) from HIGH (about $5.5 \pm 0.5V$) to LOW ($0+0.5V$) and current flows through the "3" terminal in the wiper controller (6) → the "2" and "4" terminals in the wiper motor (5) → the "4" terminal in the wiper controller (6) to start the cycle that wiper stops 3 seconds after every operation.

- Intermittent 2nd (6-second)

Pressing twice the Intermittent switch in the switch panel (7) changes voltage of the "10" terminal in the wiper controller (6) from HIGH (about $5.5 \pm 0.5V$) to LOW ($0+0.5V$) and current flows through the "3" terminal in the wiper controller (6) → the "2" and "4" terminals in the wiper motor (5) → the "4" terminal in the wiper controller (6) to start the cycle that wiper stops 6 seconds after every operation.

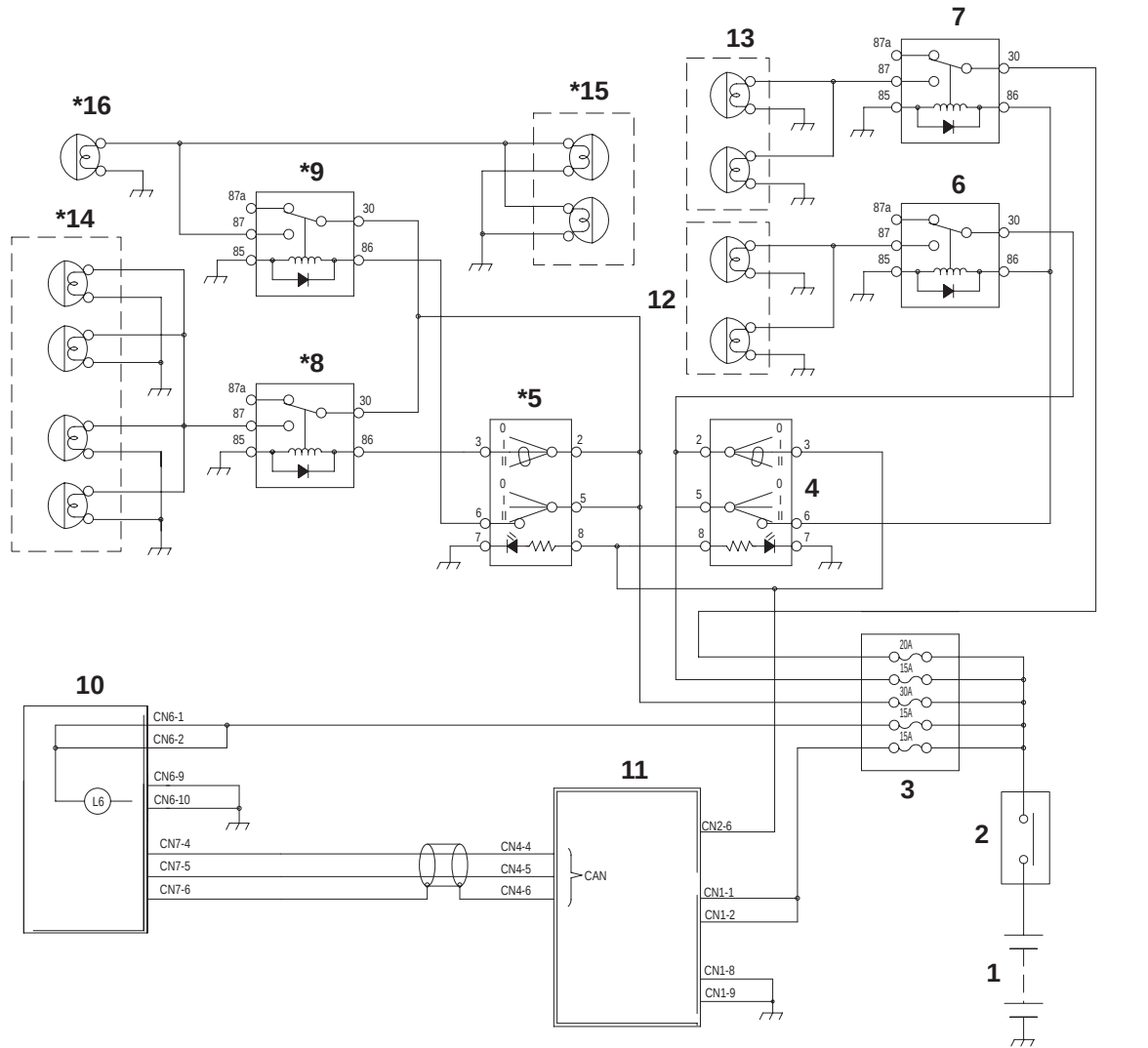
- Stopping the intermittent action

Pressing three times the Intermittent switch in the switch panel (7) while the wiper is operating stops the action of the wiper motor.

NOTE: *The wiper system does not work when the wiper cutoff switch (9) is "ON."*

LIGHTING SYSTEM

Lighting System Circuit Diagram



FG000590

Figure 95

Reference Number	Description
1	Battery
2	Battery Relay
3	Fuse Box
4	Light Switch
5	Cabin Light Switch
6	Headlight Relay (Work Light Indicate Light)
7	Work Light Relay
8	Front Cabin Light Relay

Reference Number	Description
9	Front Cabin Light / Rear Work Light Relay
10	Instrument Panel
11	e-EPOS Controller
12	Headlight (2 ea.)
13	Work Light (2 ea.)
14	Front Cabin Light (4 ea.)
15	Rear Cabin Light (2 ea.)
16	Rear Work Light (1 ea.)

NOTE: The "*" mark are optional parts.

Kind of Light

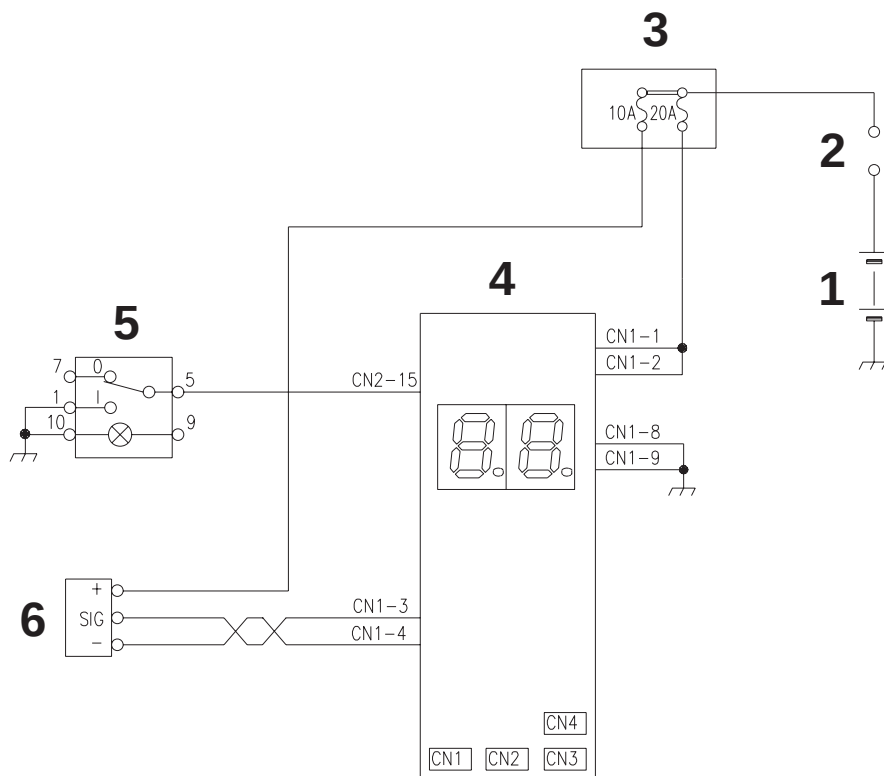
The lighting system is consists of headlights, work lights, cabin lights (optional), relays and switches.

Operation

Switch	Position	Connected Terminal of switch	Activated Relay	Lit Light
Light Switch	1	"2-3" Terminal	-	Illumination Light of Switch
	2	"2-3" Terminal	-	Illumination Light of Switch
		"5-6" Terminal	Headlight Relay	Headlight (2 Ea.)
			Work Relay	Work Light (2 Ea.) Symbol Light of Work Light
Cabin Light Switch	1	"2-3" Terminal	Front Cabin Light Relay	Front Cabin Light (2 Ea.) or Front Cabin Light (4 Ea.)
	2	"2-3" Terminal	Front Cabin Light Relay	Front Cabin Light (2 Ea.) or Front Cabin Light (4 Ea.)
		"5-6" Terminal	Rear Cabin Light Relay / Rear Work Light Relay	Rear Cabin Light (2 Ea.) and Rear Work Light (1 Ea.)

OVERLOAD WARNING DEVICE

Overload Warning Device Circuit Diagram



ARS1260L

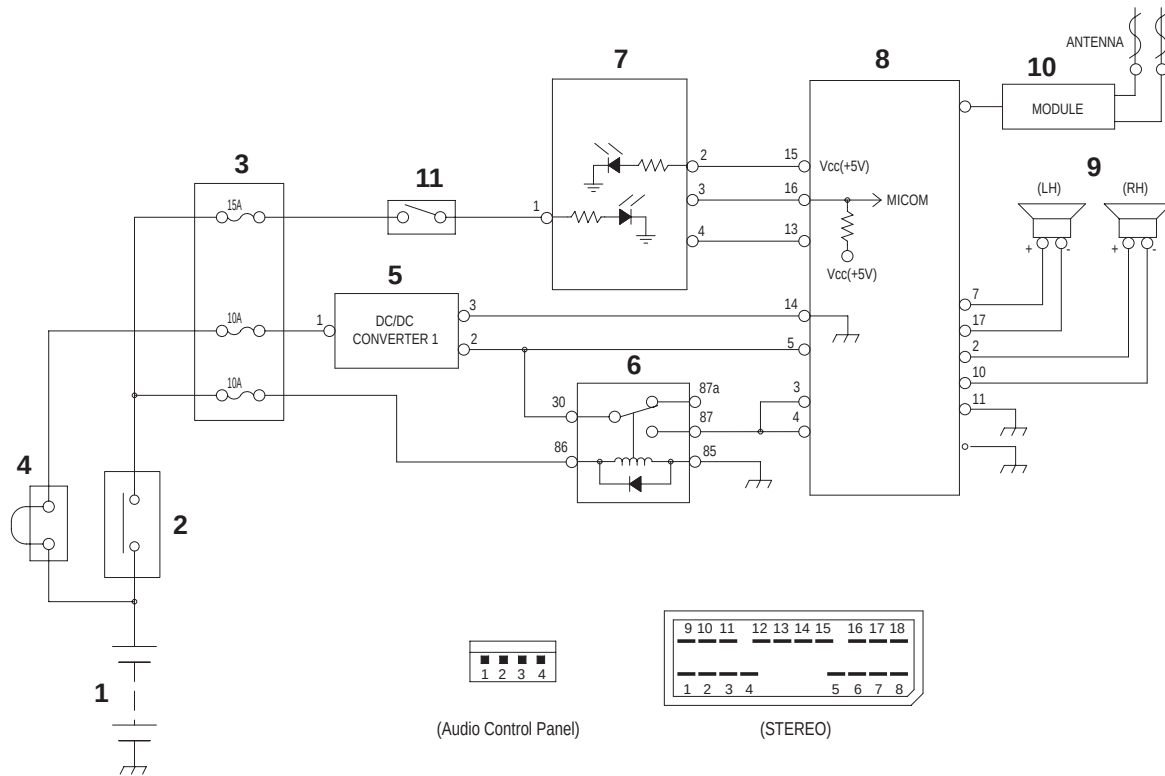
Figure 96

Reference Number	Description
1	Battery
2	Battery Relay
3	Fuse Box

Reference Number	Description
4	e-EPOS Controller
5	OWD Selector Switch
6	Pressure Sensor

AUDIO CONTROLLER

Audio Controller Circuit Diagram



FG000591

Figure 97

Reference Number	Description
1	Battery
2	Battery Relay
3	Fuse Box
4	Fusible Link
5	Converter
6	Stereo Relay

Reference Number	Description
7	Audio Control Panel
8	Stereo
9	Speaker
10	Antenna Module
11	Light Switch

Operations Via Audio Control Panel

Switch	Connected Terminal of switch	Measured values	Operations
PWR	"3-4"	$4.36 \pm 0.2V$	Stereo ON, OFF
▲		$1.24 \pm 0.2V$	Volume up
▼		$0 \pm 0.2V$	Volume down
SCAN		$2.49 \pm 0.2V$	Frequency selection

Electrical Schematic (DX140LCR)

Edition 1

MEMO

Table of Contents

Electrical Schematic (DX140LCR)

Safety Precautions	5
Applicable Models	5
DX140LCR	7

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
DX140LCR	5001 and Up



Electrical Schematic (DX140LCR)

Attachments

Boom and Arm

Edition 1

MEMO

Table of Contents

Boom and Arm

Safety Precautions	5
Applicable Models	5
Front Attachment Pin Specifications.....	6
One-Piece Boom	6
Two-Piece Boom	7
Front Attachment - Removal and Installation.....	8
Arm Removal Procedure	8
Boom Removal Procedure	10
Installation	11
Arm Installation Procedure	11
Boom Installation Procedure	11
Start-up Procedures	11

MEMO

SAFETY PRECAUTIONS



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APPLICABLE MODELS

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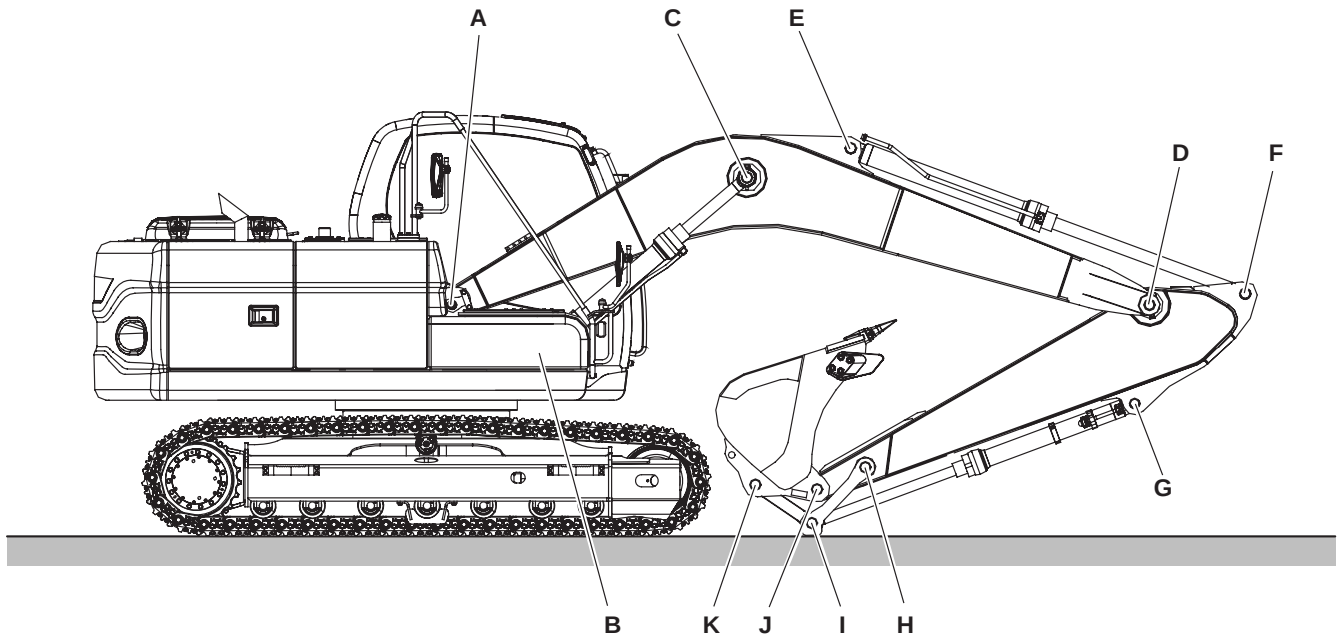
MODEL	SERIAL NUMBER RANGE
DX140LC	5001 and Up
DX140LCR	5001 and Up

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.

One-Piece Boom



FG009704

Figure 1

Mounting Pin	Diameter, mm (Inches)	Length, mm (Inches)
A	71 mm (2.80 in)	678 mm (26.69 in)
B	71 mm (2.80 in)	207 mm (8.15 in)
C	71 mm (2.80 in)	687 mm (27.05 in)
D	71 mm (2.80 in)	429 mm (16.89 in)
E	71 mm (2.80 in)	217 mm (8.54 in)
F	71 mm (2.80 in)	217 mm (8.54 in)
G	65 mm (2.56 in)	203 mm (7.99 in)
H	65 mm (2.56 in)	384 mm (15.12 in)
I	65 mm (2.56 in)	441 mm (17.36 in)
J	65 mm (2.56 in)	384 mm (15.12 in)
K	65 mm (2.56 in)	441 mm (17.36 in)

Two-Piece Boom

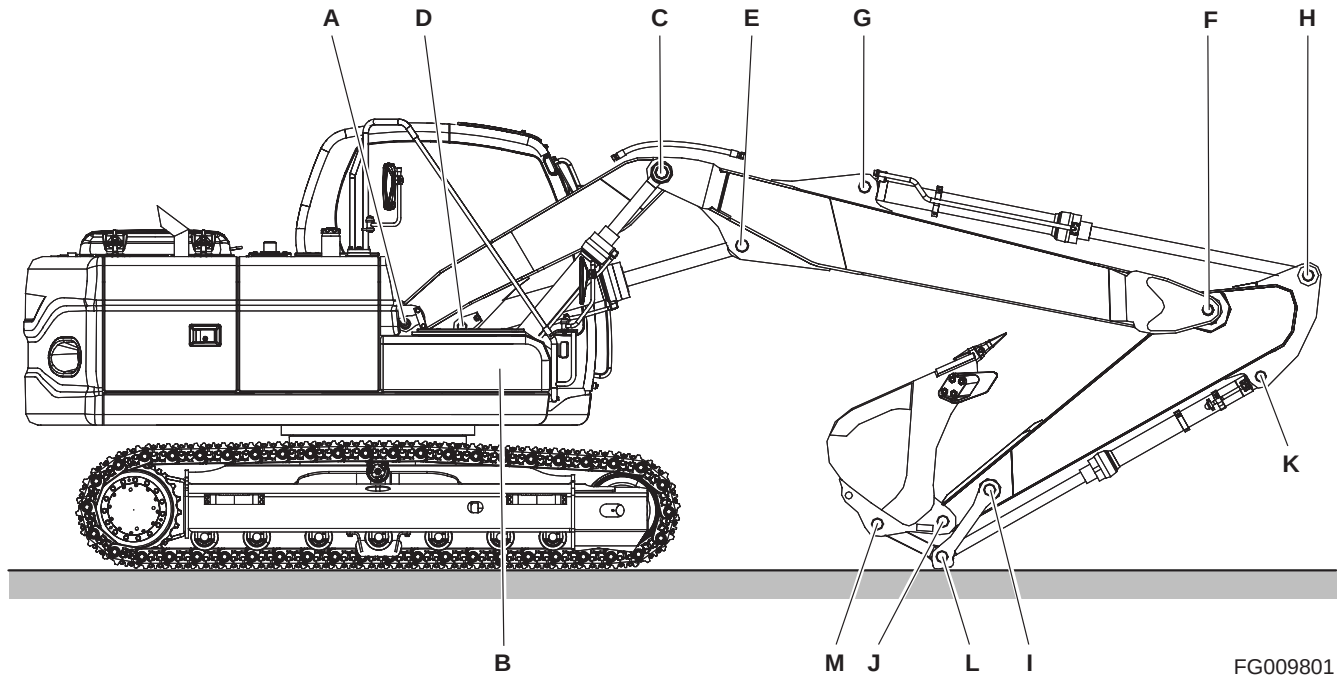


Figure 2

Mounting Pin	Diameter, mm (Inches)	Length, mm (Inches)
A	71 mm (2.80 in)	678 mm (26.69 in)
B	71 mm (2.80 in)	207 mm (8.15 in)
C	80 mm (2.80 in)	687 mm (27.05 in)
D	71 mm (2.80 in)	429 mm (16.89 in)
E	71 mm (2.80 in)	217 mm (8.54 in)
F	71 mm (2.80 in)	217 mm (8.54 in)
G	65 mm (2.56 in)	203 mm (7.99 in)
H	65 mm (2.56 in)	384 mm (15.12 in)
I	65 mm (2.56 in)	441 mm (17.36 in)
J	65 mm (2.56 in)	384 mm (15.12 in)
K	65 mm (2.56 in)	441 mm (17.36 in)
L	65 mm (2.56 in)	384 mm (15.12 in)
M	65 mm (2.56 in)	441 mm (17.36 in)

FRONT ATTACHMENT - REMOVAL AND INSTALLATION

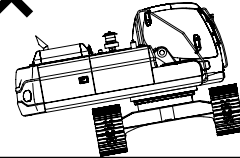
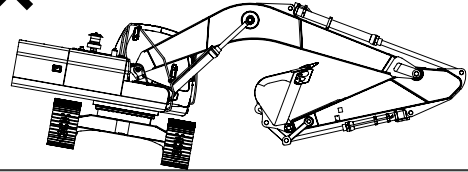


DANGER

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.



FG000371

Figure 3

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.

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 756 kg [1,667 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

Table of Contents

Bucket

Safety Precautions	5
Applicable Models	5
Bucket Tooth Inspection and Replacement.....	6
Bucket O-ring Replacement	7
Bucket Attachment, Removal and Reversal	9
Detaching the Bucket	9
Attaching the Bucket	9
Reversing the Bucket	10

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
DX140LC	5001 and Up
DX140LCR	5001 and Up
DX180LC	5001 and Up
DX225LC	5001 and Up
DX225NLC	5001 and Up
DX255LC	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.

Bucket teeth are usually replaced in sets but it may sometimes be necessary to replace individual teeth.

Look for the following indications of wear or damage:

- Lock pins protrude unevenly on one side.
- Lock pins have been worn down so far that they no longer make full contact through the length of the pin hole.
- Lock washers or pins show obvious damage or weakness.
- Wear points on the working surfaces of tooth points - pits, cracks, chips or craters - are larger than 8 mm to 10 mm (1/3" to 1/2") across.

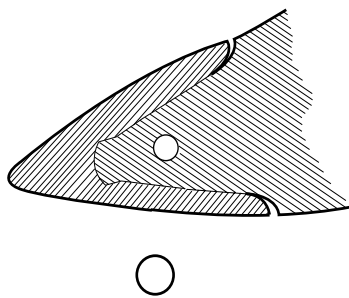
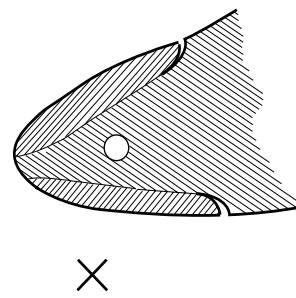


Figure 1



HAOC680L

1. On a routine basis, inspect the bucket teeth to make sure that tooth wear or breakage has not developed. Do not allow the replaceable bucket teeth to wear down to the point that the bucket adapter is exposed. See Figure 1.
2. To replace a tooth (1, Figure 2), use a hammer and punch to drive the locking pin (2) and lock washer (3) out of the tooth adapter (4).
3. Once the worn tooth has been removed, use a putty knife to scrape the adapter as clean as possible.
4. Slide the new tooth into position and insert the lock washer.
5. Insert the locking pin into the tooth and with a hammer, drive the pin in until the lock washer seats in the locking groove.

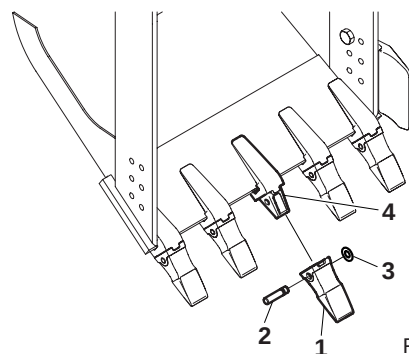


Figure 2

FG000346

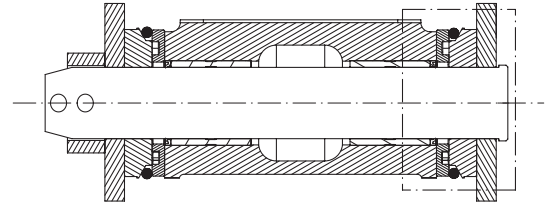
BUCKET O-RING REPLACEMENT



WARNING

Due to possibility of flying metal objects, always wear safety helmet, protective gloves and eye protection when changing pins.

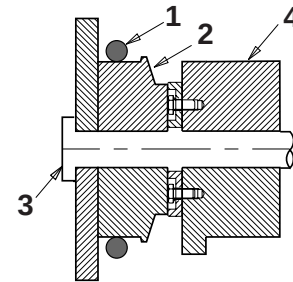
1. Inspect the bucket O-rings on a routine basis. If worn or damaged, replacement is necessary.



FG007780

Figure 3

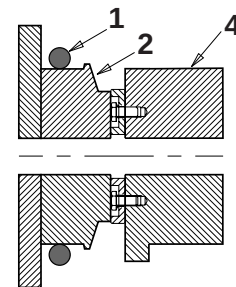
2. Roll the old O-ring (1, Figure 4) onto the boss (2) around the bucket pin (3). Remove the bucket pin and move the arm or bucket link (4) out of the way.



ARO1390L

Figure 4

3. Remove the old O-ring and temporarily install the new O-ring (1, Figure 5) onto the bucket boss (2). Make sure that the O-ring groove on both the bucket link (4) and boss have been cleaned.
4. Realign the arm or link with the bucket pin hole and insert the bucket pin (3, Figure 4).



ARO1391L

Figure 5

5. Roll the new O-ring (1, Figure 6) into the O-ring groove.

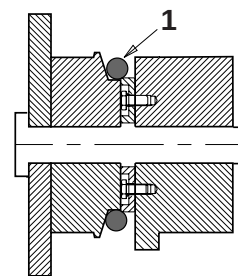


Figure 6

ARO1392L

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 an unstressed pin position is located.



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 reassembly.

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.

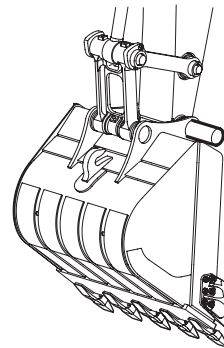


Figure 7

FG000606

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.

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.

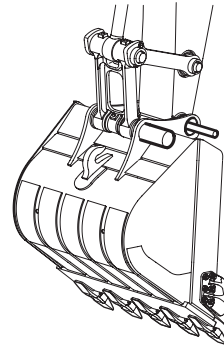


Figure 8

FG000607

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.

DOOSAN

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